REPORT: SUBSIDENCE PREDICTIONS AND IMPACT ASSESSMENTS

South32

Illawarra Coal

SOUTH32 ILLAWARRA COAL:

Dendrobium Mine – Area 3B

The Effects of the Proposed Modified Commencing Ends of Longwalls 15 to 18 in Area 3B at Dendrobium Mine on the Subsidence Predictions and Impact Assessments

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Report produced for: Support the Application for the Proposed Modifications to the Commencing Ends of Longwalls 15 to 18 in Area 3B at Dendrobium Mine, which will be issued to the Department of Planning and Environment – Resource Regulator

Previous reports:

WKA77 (January 2001) – Dendrobium Mine Project – Report on the Prediction of Mining Subsidence Parameters and the Assessment of Impacts on Surface Infrastructure – Longwalls 1 to 18 (In support of the EIS).

MSEC311 (October 2007) – The Prediction of Subsidence Parameters and the Assessment of Mine Subsidence Impacts on Natural Features and Surface Infrastructure Resulting from the Extraction of Proposed Longwalls 6 to 10 in Area 3A and Future Longwalls in Areas 3B and 3C at Dendrobium Mine (In Support of the SMP Application and the Modification to the Development Consent).

MSEC459 (September 2012) – Dendrobium Area 3B – Longwalls 9 to 18 – Subsidence Predictions and Impact Assessments for Natural Features and Surface Infrastructure in Support of the SMP Application.

MSEC792 (December 2015) – Dendrobium Area 3B – Longwalls 12 to 18 – Review of the Subsidence Predictions and Impact Assessments for Natural and Built Features in Dendrobium Area 3B based on Observed Movements and Impacts during Longwalls 9 and 10.

MSEC865 (November 2016) – Dendrobium Area 3B – The Effects of the Proposed Modifications to the Ends of Longwalls 12 to 18 in Area 3B at Dendrobium Mine on the Subsidence Predictions and Impact Assessments.

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

Introduction to Longwall Mining and Subsidence (Revision A)

General Discussion of Mine Subsidence Ground Movements (Revision A)

Mine Subsidence Damage to Building Structures (Revision A)

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1.1. Background

Mine Subsidence Engineering Consultants (MSEC) was previously commissioned by Illawarra Coal (IC) to prepare subsidence predictions and impact assessments for the proposed Longwalls 9 to 18 in Area 3B at Dendrobium Mine. Report No. MSEC459 (Rev. B) was issued in September 2012, which supported the Subsidence Management Plan (SMP) Application for these longwalls.

IC subsequently modified the commencing (i.e. western) ends of Longwalls 10 to 14 and the finishing (i.e. eastern) ends of Longwalls 11, 12 and 14. MSEC prepared Reports Nos. MSEC651 (Rev. A), MSEC652 (Rev. B), MSEC785 (Rev. A) and MSEC865 (Rev. A) in support of the Modification Applications for these longwalls.

The subsidence prediction model was also reviewed and re-calibrated, based on the updated monitoring data from Longwalls 7 and 8 in Area 3A and Longwalls 9 and 10 in Area 3B. The subsidence predictions and impact assessments for the natural and built features were updated based on the re-calibrated subsidence model and provided in Report No. MSEC792 (Rev. C).

The longwall layout that includes the longwall modifications indicated in Reports Nos. MSEC651, MSEC652, MSEC785 and MSEC865 and based on the re-calibrated subsidence model described in Report No. MSEC792 is referred to as the *Previous Layout* in this report.

IC now proposes to shorten the commencing (i.e. western) ends of Longwalls 15 to 18 so that these longwalls are located at a minimum distance of 300 m from the Full Supply Level (FSL) of Lake Avon, also known as the Avon Reservoir. The maximum height of extraction in the Wongawilli Seam for these longwalls is also proposed to be reduced from 4.6 m to 3.9 m. The longwall layout that includes these proposed modifications is referred to as the *Modified Layout* in this report.

The Previous Layout and Modified Layout of the longwalls in Dendrobium Area 3B are shown in Drawing No. MSEC914-01, in Appendix A. MSEC has been commissioned by IC to assess the effects of the proposed modifications to the commencing ends and the extraction heights for Longwalls 15 to 18 on the subsidence predictions and impact assessments that were previously provided in Report No. MSEC865 based on the re-calibrated subsidence model.

This report provides information that will support an application for a Variation to the Approved SMP, which will be submitted to the Department of Planning and Environment – Resources Regulator.

1.2. Mining geometry

The Previous and Modified Layouts of the longwalls in Dendrobium Area 3B are overlaid in Drawing No. MSEC914-01. A summary of the dimensions of the longwalls for both these layouts is provided in Table 1.1.

Table 1.1 Dimensions of Longwalls 15 to 18 based on the Previous and Modified Layouts

Layout	Longwall	Overall void length including installation heading (m)	Overall void width including first workings (m)	Overall tailgate chain pillar width (m)
Previous Layout (MSEC865)	LW15	2049	305	45
	LW16	1945	305	45
	LW17	2082	305	45
	LW18	1990	305	45
Modified Layout (MSEC914)	LW15	1963	305	45
	LW16	1874	305	45
	LW17	2013	305	45
	LW18	1928	305	45

IC proposes to shorten the commencing ends by: 86 m for Longwall 15, 71 m for Longwall 16, 69 m for Longwall 17 and 62 m for Longwall 18. The longwall void widths and the chain pillar widths are not proposed to be modified.

The longwalls will be extracted from the Wongawilli Seam. The depths of cover contours for this seam are shown in Drawing No. MSEC914-02. The depths of cover directly above Longwalls 15 to 18 vary between 280 and 395 m.

The Wongawilli Seam dips from the south towards the north with an average grade across the mining area of approximately 2 %, or 1 in 50. The depth of cover, therefore, generally decreases above successive longwalls in the series. The maximum seam dip is around 10 %, or 1 in 10, which occurs locally in the south-eastern corner of the mining area.

The levels of the natural surface and the Wongawilli Seam are illustrated along Cross-section 1 in Fig. 1.1. The location of this cross-section is shown in Drawing No. MSEC914-01.

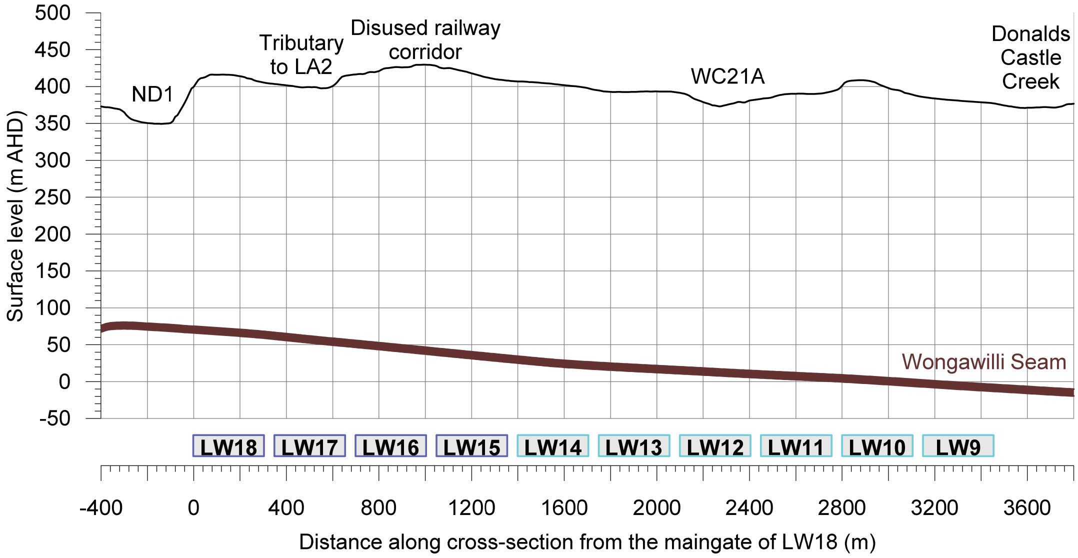


Fig. 1.1 Surface and seam levels along Cross-section 1

The Wongawilli Seam in Area 3B is nominally 10 m thick and contains numerous bands of non-coal material. The economic section of the Wongawilli Seam is the basal 3 to 5 m. The maximum extraction height in the Wongawilli Seam for Longwalls 15 to 18 is 4.6 m based on the Previous Layout and is 3.9 m based on the Modified Layout.

2.1. Maximum predicted conventional subsidence parameters

The Incremental Profile Method (IPM) was previously used to predict the conventional subsidence parameters resulting from the extraction of Longwalls 9 to 18, based on the SMP Layout, and these predictions are provided in Report No. MSEC459. This method was also used to predict the parameters based on the Previous Layout, which included the modified commencing and finishing ends of Longwalls 10 to 14, and these are provided in Reports Nos. MSEC651, MSEC652, MSEC785 and MSEC865.

The subsidence model was also reviewed, based on the updated monitoring data from Longwalls 7 and 8 in Area 3A and Longwalls 9 and 10 in Area 3B, which was summarised in Report No. MSEC792. The review found that the subsidence prediction model provides reasonable predictions of vertical subsidence for the longwalls in Areas 1, 2 and 3A at the mine. However, the maximum observed vertical subsidence in Area 3B is around 30 % greater than the maxima predicted for Longwalls 9 and 10 in Area 3B. The higher magnitudes of vertical subsidence are the result of the higher depth of cover and wider longwall widths in Area 3B, resulting in increased pillar compression.

The IPM was recalibrated by increasing the predicted vertical subsidence by 30 %. The subsidence predictions and impact assessments for the natural and built features were updated based on the re-calibrated subsidence model and provided in Report No. MSEC792. The predictions and impact assessments for the Previous Layout, provided in Report No. MSEC865, are also based on the re-calibrated subsidence model.

The re-calibrated IPM has now been used to predict the conventional subsidence parameters resulting from the extraction of Longwalls 15 to 18, based on the Modified Layout, which includes the approved modified commencing and finishing ends of Longwalls 10 to 14, as well as the proposed modified commencing ends of Longwalls 15 to 18. The maximum extraction height has also been reduced from 4.6 m to 3.9 m for these longwalls.

The predicted total subsidence contours due to the extraction of Longwalls 9 to 18, based on the Modified Layout, are shown in Drawing No. MSEC914-05. The predicted total 20 mm subsidence contour, based on the Previous Layout, is also shown in this drawing for comparison.

A summary of the maximum predicted values of incremental conventional subsidence, tilt and curvature due to the extraction of each of the Longwalls 15 to 18, based on both the Previous and Modified Layouts, is provided in Table 2.1. It is noted, that these parameters are the maxima anywhere above these longwalls (i.e. not necessarily at the longwall commencing ends). The predictions for both layouts are based on the re-calibrated subsidence model.

Table 2.1 Maximum predicted incremental conventional subsidence, tilt and curvature resulting from the extraction of Longwalls 15 to 18 based on the Previous and Modified Layouts

Layout	Longwall	Maximum predicted incremental subsidence (mm)	Maximum predicted incremental tilt (mm/m)	Maximum predicted incremental hogging curvature (km^{-1})	Maximum predicted incremental sagging curvature (km^{-1})
Previous Layout (MSEC865)	LW15	2850	35	0.60	0.80
	LW16	2700	35	0.75	0.80
	LW17	2800	40	1.0	1.0
	LW18	3000	40	0.90	0.90
Modified Layout (MSEC914)	LW15	2650	30	0.55	0.70
	LW16	2450	30	0.60	0.70
	LW17	2550	35	0.85	0.90
	LW18	2750	35	0.80	0.80

The maximum predicted incremental vertical subsidence, tilt and curvatures for Longwalls 15 to 18 reduce due to the proposed modifications. These changes are predominately due to the reduction in the maximum extraction height from 4.6 m to 3.9 m. The predicted subsidence parameters also slightly reduce due to the proposed shortened commencing ends of these longwalls, as the minimum depths of cover slightly increase in these locations.

A summary of the maximum predicted values of total conventional subsidence, tilt and curvature resulting from the extraction of Longwalls 9 to 18, based on both the Previous and Modified Layouts, is provided in Table 2.2. It is noted, that these parameters are the maxima anywhere above the mining area. The predictions for both layouts are based on the re-calibrated subsidence model.

Table 2.2 Maximum predicted total conventional subsidence, tilt and curvature resulting from the extraction of Longwalls 9 to 18 based on the Previous and Modified Layouts

Layout	Longwalls	Maximum predicted total subsidence (mm)	Maximum predicted total tilt (mm/m)	Maximum predicted total hogging curvature (km^{-1})	Maximum predicted total sagging curvature (km^{-1})
Previous Layout (MSEC865)	LW9 to LW18	3600	50	1.4	1.4
Modified Layout (MSEC914)	LW9 to LW18	3500	40	1.2	1.2

The maximum predicted total vertical subsidence, tilt and curvatures due to Longwalls 9 to 18 reduce due to the proposed modifications. Again, these changes are predominately due to the reduction in the maximum extraction height for Longwalls 14 to 18 from 4.6 m to 3.9 m.

The maximum predicted vertical subsidence based on the Modified Layout is 3500 mm, which occurs above the eastern end of Longwall 12, and represents 76 % of the maximum extraction height of 4.6 m in that location. The maximum predicted tilt is 40 mm/m (i.e. 4 % or 1 in 25) and the maximum predicted hogging and sagging curvatures are both 1.2 km^{-1} (i.e. minimum radius of curvature of 0.8 km).

Although the maximum predicted subsidence parameters reduce due to the proposed modifications, the locations of the maximum predicted longitudinal tilts, curvatures and strains move due to the shortened commencing ends of Longwalls 15 to 18. The predicted parameters locally increase adjacent to the modified commencing ends, whilst these parameters locally decrease adjacent to the previous commencing ends. However, the predicted longitudinal tilts, curvatures and strains are less than the maxima that are orientated transverse to the longwalls.

This is illustrated in Figs. A.01 to A.04, in Appendix A, which show the profiles of predicted total vertical subsidence, tilt and curvature along Prediction Lines 1 to 4 taken through the commencing ends of Longwalls 15 to 18. The locations of these prediction lines are shown in Drawing No. MSEC914-05.

It can be seen from Figs. A.01 to A.04, that the predicted maximum longitudinal tilts and longitudinal curvatures move towards the east (i.e. right-side of the figures) as a result of the proposed modified commencing ends. The magnitudes of the longitudinal components, based on the Modified Layout, are less than those based on the Previous Layout, which is predominately due to the reduction in the maximum extraction height.

2.2. Predicted strains

The prediction of strain is more difficult than the prediction of subsidence, tilt and curvature. The reason for this is that strain is affected by many factors, including ground curvature and horizontal movement, as well as local variations in the near surface geology, the locations of pre-existing natural joints at bedrock, the depth of bedrock and the magnitudes of horizontal in situ compressive stresses within the various strata layers. Survey tolerance can also represent a substantial portion of the measured strain, in cases where the strains are of a low order of magnitude. The profiles of observed strain, therefore, can be irregular even when the profiles of observed subsidence, tilt and curvature are relatively smooth.

In previous MSEC subsidence reports, predictions of conventional strain were provided based on the best estimate of the relationship between curvature and strain. Similar relationships have been proposed by other authors. The reliability of the strain predictions was highlighted in these reports, where it was stated that measured strains can vary considerably from the predicted conventional values. Adopting a linear relationship between curvature and strain provides a reasonable prediction for the maximum conventional tensile and compressive strains. The locations that are predicted to experience hogging or convex curvature are expected to be net tensile strain zones and locations that are predicted to experience sagging or concave curvature are expected to be net compressive strain zones.

In the Southern Coalfield, it has been found that a factor of 15 provides a reasonable relationship between the maximum predicted curvatures and the maximum predicted conventional strains. The maximum predicted total conventional strains due to the extraction of each of the Longwalls 12 to 18, based on applying a factor of 15 to the maximum predicted conventional curvatures, are 20 mm/m tensile and compressive, for both the Previous and Modified Layouts.

At a point, however, there can be considerable variation from the linear relationship, resulting from non-conventional movements or from the normal scatters which are observed in strain profiles. When expressed as a percentage, observed strains can be many times greater than the predicted conventional strain for low magnitudes of curvature. In this report, therefore, we have provided a statistical approach to account for the variability, rather than providing a single predicted conventional strain.

The range of potential strains above Longwalls 15 to 18 has been determined using monitoring data from Dendrobium Mine, as well as previously extracted longwalls in the NSW Coalfields where the mine geometries are reasonably similar to that at the Mine. The analysis includes two monitoring lines from Dendrobium Area 3A (SCW North and South Lines) and 34 monitoring lines from the Hunter and Newcastle Coalfields. Comparisons of the longwall void widths, depths of cover, longwall width-to-depth ratios and extraction heights are provided in Table 2.3.

Table 2.3 Comparison of the mine geometry for Dendrobium Longwalls 15 to 18 with the longwalls from the NSW Coalfields used in the strain analysis

Parameter	Dendrobium Longwalls 15 to 18		Longwalls used in strain analysis	
	Range	Average	Range	Average
Longwall width	305	305	160 ~ 200	175
Depth of cover	280 ~ 395	360	150 ~ 250	175
W/H ratio	0.77 ~ 1.1	0.9	0.8 ~ 1.2	1.03
Extraction height	3.9	3.9	3.8 ~ 4.8	4.5

It can be seen from the above table, that the range of the longwall width-to-depth ratios used in the strain analysis is similar to but slightly higher, on average, than the range of width-to-depth ratios for Dendrobium Longwalls 15 to 18. The average extraction height for the longwalls used in the strain analysis is greater than the maximum extraction height for Dendrobium Longwalls 15 to 18. The strain analysis, therefore, should provide a reasonable, if not, conservative indication of the range of potential strains resulting from the extraction of the longwalls at Dendrobium Mine.

The data used in the analysis of observed strains included those resulting from both conventional and non-conventional anomalous movements, but did not include those resulting from valley related movements, which are addressed separately in this report. The strains resulting from damaged or disturbed survey marks have also been excluded.

The survey database has been analysed to extract the maximum tensile and compressive strains that have been measured at any time during the extraction of the previous longwalls in the NSW Coalfields, for survey bays that were located directly above goaf or the chain pillars that are located between the extracted longwalls. A number of probability distribution functions were fitted to the empirical data. It was found that a *Generalised Pareto Distribution (GPD)* provided a good fit to the raw strain data.

The histogram of the maximum observed tensile and compressive strains measured in survey bays above goaf, for monitoring lines from the NSW Coalfields, is provided in Fig. 2.1. The probability distribution functions, based on the fitted GPDs, have also been shown in this figure.

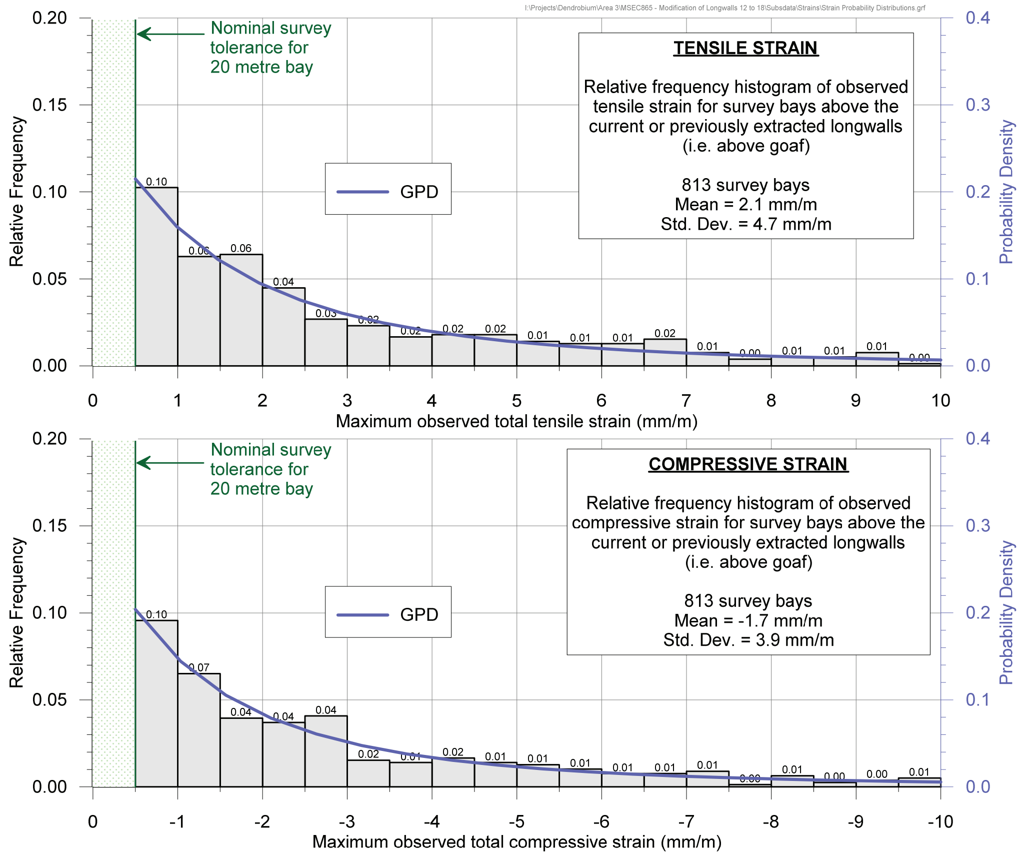


Fig. 2.1 Distributions of the measured maximum tensile and compressive strains during the extraction of previous longwalls in the NSW Coalfields for bays located above goaf

Confidence levels have been determined from the empirical strain data using the fitted GPDs. In the cases where survey bays were measured multiple times during the extraction of a longwall, the maximum tensile strain and the maximum compressive strain were used in the analysis (i.e. single tensile strain and single compressive strain measurement per survey bay).

The 95 % confidence levels for the maximum total strains that the individual survey bays experienced at any time during mining were 9 mm/m tensile and 8 mm/m compressive. The 99 % confidence levels for the maximum total strains that the individual survey bays experienced at any time during mining were 22 mm/m tensile and 20 mm/m compressive.

2.3. Maximum predicted valley related movements

The predicted valley related movements along the watercourses in Area 3B have been determined using the methods outlined in ACARP Research Project No. C9067, which were published in the handbook entitled "*Management Information Handbook on the Undermining of Cliffs, Gorges and River Systems*", issued in September 2002. Details on the ACARP Method are provided in the background report entitled "*General Discussion on Mine Subsidence Ground Movements*" which can be obtained from *www.minesubsidence.com*.

The predicted upsidence and closure movements along the watercourses have been determined from the empirical database based on their lateral and longitudinal distances from the extracted longwalls, the depths of the valleys and the maximum predicted incremental subsidence resulting from the extraction of each longwall.

The maximum predicted upsidence and closure movements for the watercourses located above or in the vicinity of Longwalls 15 to 18 remain the same or slightly reduce due to the proposed modifications. The changes are predominately due to the reduction in the maximum extraction height from 4.6 m to 3.9 m. The predicted valley effects also slightly reduce due to the shortened commencing ends of Longwalls 15 to 18, where the watercourses cross directly above or near to the longwall commencing ends.

Further discussions on the effects of the proposed longwall modifications on the predicted valley related movements for the watercourses are provided in Chapter 3.

3.0 THE EFFECTS OF THE PROPOSED MODIFICATIONS ON THE PREDICTIONS AND IMPACT ASSESSMENTS FOR THE NATURAL AND BUILT FEATURES

3.1. The Modification Area

The maximum predicted subsidence parameters for Longwalls 15 to 18 decrease due to the proposed modifications. The changes are predominately due to the reduction in the maximum extraction height from 4.6 m to 3.9 m. The *Modification Area* has therefore been defined based on the following:

- 35° angle of draw line from the full extents of Longwalls 15 to 18, based on both Previous and Modified Layouts; and
- The limit where the change in the predicted vertical subsidence, resulting from the proposed modifications to the longwall commencing ends and extraction heights, is greater than 20 mm. The 20 mm subsidence contour extends outside the 35° angle of draw line on the northern side of Longwall 15 but, otherwise, is located within the angle of draw line.

The extent of the Modification Area is shown in Drawing No. MSEC914-01, in Appendix A. The maximum predicted subsidence parameters for the natural and built features located within the Modification Area decrease. The extent of subsidence and, hence, the extents of the surface features affected by subsidence reduce due to the proposed shortened commencing ends of the longwalls.

The assessed levels of potential impact for the natural and built features, based on the Modified Layout, are similar to or less than those assessed based on the Previous Layout. The recommendations and the management strategies for the natural and built features, therefore, do not change from those previously provided in Reports Nos. MSEC459, MSEC651, MSEC652, MSEC785, MSEC792, MSEC865 and the SMP Application.

However, the locations of the maximum predicted longitudinal tilts, curvatures and strains move due to the shortened commencing ends of Longwalls 15 to 18. The predicted subsidence parameters for the natural and built features located above and adjacent to the longwall commencing ends, therefore, could locally increase or decrease in those locations.

The predictions and impact assessments for the natural and built features located close to the modified longwall commencing ends, therefore, have been reviewed. Specific assessments have been undertaken for the surface features located within the Study Area, as defined in the following section.

3.2. The Study Area

The *Study Area* has been defined based on the following:

- 35° angle of draw line from the longwall commencing ends, based on both the original position (i.e. Previous Layout) and the modified position (i.e. Modified Layout); and
- The limit where the change in the predicted vertical subsidence, resulting from the proposed modifications to the longwall commencing ends only, is greater than 20 mm. The 20 mm subsidence contour extends outside the 35° angle of draw line on the northern and eastern sides of the longwall commencing ends but, otherwise, is located within the angle of draw line.

The extent of the Study Area is shown in Drawing No. MSEC914-01, in Appendix A. There are natural and built features located within this area, which are shown in Drawings Nos. MSEC914-03 and MSEC914-04, respectively. There are also features that are located outside the Study Area, which could experience far-field or valley related movements, and could be sensitive to such movements, and these features have also been included as part of the assessments.

The Study Area based on a 600 m boundary is also shown in Drawing No. MSEC914-01. The features that are located within the 600 m boundary that are predicted to experience valley related movements and could be sensitive to these movements have been included in the assessments provided in this report. These features include the streams and valley infill swamps.

There are additional features that are located outside the 600 m boundary that could experience either far-field horizontal movements or valley related movements. The surface features that could be sensitive to such movements have been identified and have also been included in the assessments provided in this report. These features include the reservoirs, dam walls and survey control marks.

The predicted conventional vertical subsidence at the natural and built features located within the Study Area, based on the Modified Layout, are similar to or less than those based on the Previous Layout. The predicted conventional tilts and curvatures at these features, based on the Modified Layout, however, could be greater or lesser than those predicted based on the Previous Layout, depending on their position relative to the longwall commencing ends.

The effects of the proposed modifications to the commencing ends and the maximum extraction heights for Longwalls 15 to 18 on the subsidence predictions and impact assessments for these features are provided in the following sections.

3.3. Drainage Lines

The locations of the drainage lines are shown in Drawing No. MSEC914-03.

The drainage lines located partially or entirely within the Study Area based on the 35° angle of draw line include: LA2, LA3, LA4A, ND1 and their associated tributaries. The additional drainage lines located partially or entirely within the Study Area based on the 600 m boundary include: LA1, LA4B, LA5, ND2 and their associated tributaries.

The predicted profiles of total vertical subsidence, upsidence and closure along Drainage Lines LA2, LA3, LA4A and ND1 are provided in Figs. A.05, A.06, A.07 and A.08, respectively, in Appendix A. A summary of the maximum predicted total vertical subsidence, upsidence and closure for these drainage lines, based on the Previous and Modified Layouts, is provided in Table 3.1. The values in this table are the maxima within the Study Area resulting from the extraction of Longwalls 9 to 18.

Table 3.1 Maximum predicted total subsidence, upsidence and closure for the drainage lines

Location	Layout	Maximum predicted total subsidence (mm)	Maximum predicted total upsidence (mm)	Maximum predicted total closure (mm)
LA2	Previous Layout	3400	650	675
	Modified Layout	3150	650	650
LA3	Previous Layout	1200	425	450
	Modified Layout	550	400	400
LA4A	Previous Layout	1700	200	200
	Modified Layout	1600	200	200
ND1	Previous Layout	< 20	70	90
	Modified Layout	< 20	60	80

The maximum predicted vertical subsidence for Drainage Lines LA2, LA3 and LA4A reduce due to the proposed modifications. The maximum predicted vertical subsidence for Drainage Line ND1 is less than 20 mm based on both the Previous and Modified Layouts.

The maximum predicted upsidence and closure for the drainage lines, based on the Modified Layout, are the same or slightly less than the maxima predicted based on the Previous Layout. These parameters slightly reduce for Drainage Lines LA2, LA3 and ND1 as they are located in close proximity to the modified longwall commencing ends.

The maximum predicted tilts, curvatures and strains for the drainage lines within the Study Area, based on the Modified Layout, are similar to, but less than the maxima predicted based on the Previous Layout. The locations of the maximum tilts, curvatures and strains along Drainage Lines LA2 and LA3 move further upstream as they cross directly above the commencing ends of Longwalls 16 and 17.

The natural grades and the predicted post-mining grades along Drainage Lines LA2 and LA3 are illustrated in Fig. 3.1 and Fig. 3.2, respectively. The post-mining grades have been shown for both the Previous and Modified Layouts.

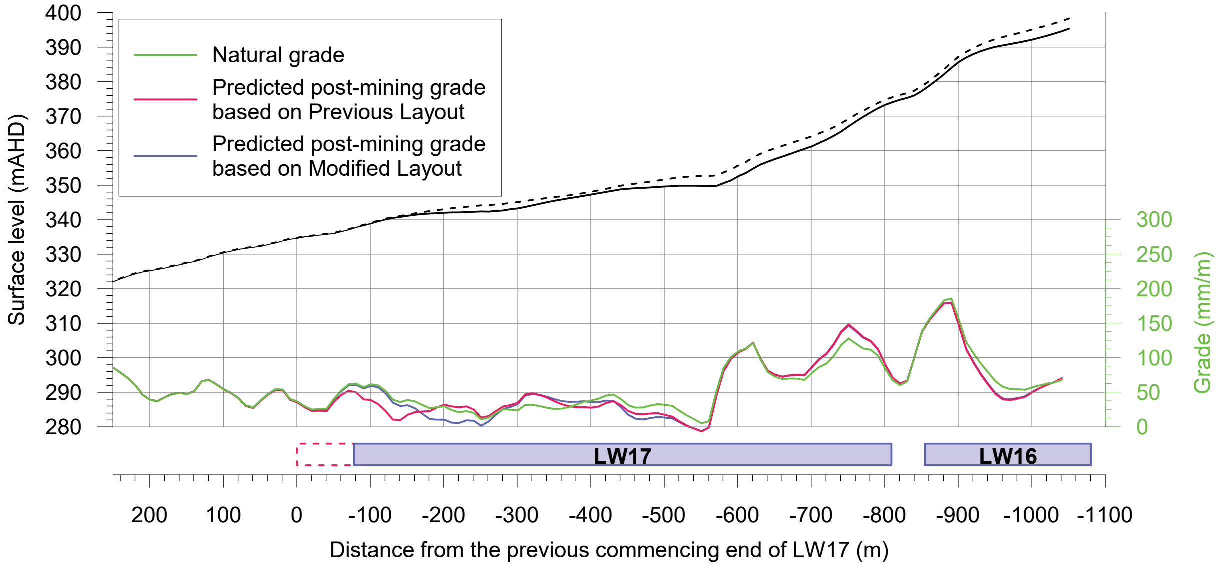


Fig. 3.1 Natural and predicted post mining surface levels along Drainage Line LA2

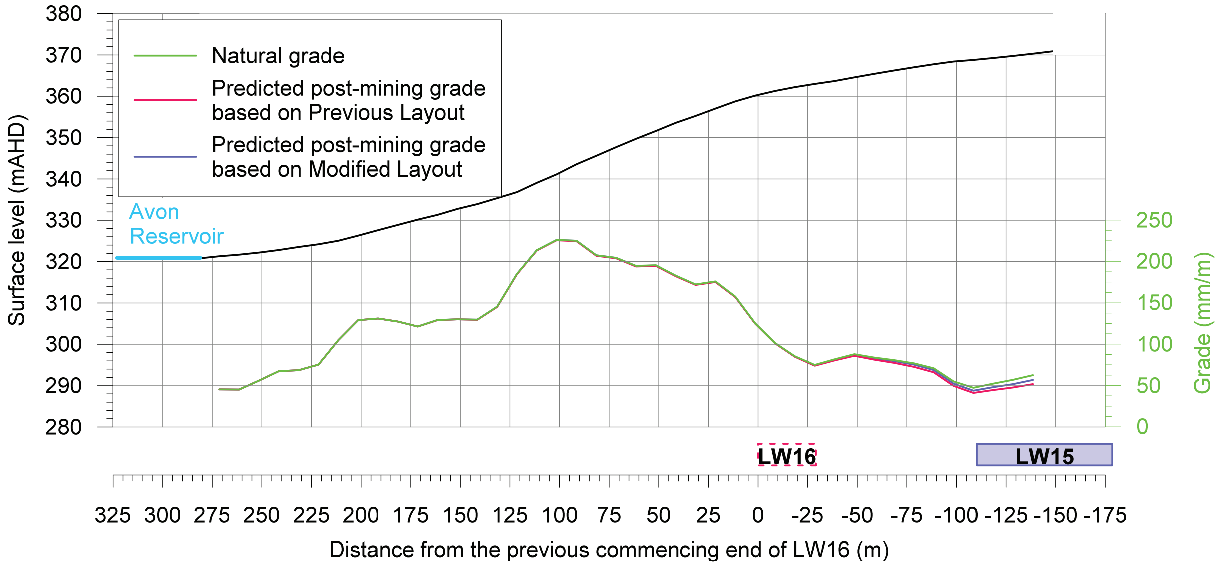


Fig. 3.2 Natural and predicted post mining surface levels along Drainage Line LA3

It can be seen from Fig. 3.1, that there is a possible reversal of grade along Drainage Line LA2 directly above Longwall 17, at a distance of -550 m from the previous longwall commencing end. However, the post-mining grade based on the Modified Layout is similar to that based on the Previous Layout in that location. There is also a reduction in stream grade along Drainage Line LA2 upstream of the longwall commencing end. The reduction in grade slightly increases and moves further upstream due to the proposed modifications.

It is possible that there could be localised areas along Drainage Line LA2 that could experience small increases in the levels of ponding or flooding, where the post-mining grades are small. However, the length of this drainage line that is directly mined beneath reduces by 75 m due to the proposed modifications. It is considered, therefore, that the overall potential for impacts on this drainage line reduces.

It can be seen from Fig. 3.2 that there are no substantial changes in grade along Drainage Line LA3 based on both the Previous and Modified Layouts. Similarly, the predicted changes in grade for the other drainage lines in the Study Area, based on the Modified Layout, are similar to or less than those predicted based on the Previous Layout, as they do not cross directly above the longwall commencing ends.

The assessed levels of potential impact for the drainage lines, based on the Modified Layout, are similar to or less than those assessed based on the Previous Layout. The recommendations and the management strategies for the drainage lines, therefore, do not change from those previously provided in Reports Nos. MSEC459, MSEC651, MSEC652, MSEC785, MSEC792, MSEC865 and the SMP Application.

3.4. Cliffs

There are no cliffs identified within the Study Area. The nearest cliffs are located along Wongawilli Creek, at distances more than 2 km from the commencing ends of Longwalls 15 to 18. The impact assessments and proposed management strategies for the cliffs, therefore, do not change from those previously provided in Reports Nos. MSEC459, MSEC651, MSEC652, MSEC785, MSEC792, MSEC865 and the SMP Application.

3.5. Rock outcrops

The rock outcrops are located across the Study Area and directly above the longwalls based on both the Previous and Modified Layouts. These features therefore could experience the full range of predicted movements as summarised in Chapter 2. The maximum predicted subsidence parameters for the rock outcrops, based on the Modified Layout, are less than the maxima predicted based on the Previous Layout. The extent of subsidence and, therefore, the number of rock outcrops affected by subsidence also reduce due to the proposed modifications.

The assessed levels of potential impact for the rock outcrops, based on the Modified Layout, are similar to or less than those assessed based on the Previous Layout. The recommendations and the management strategies for the rock outcrops, therefore, do not change from those previously provided in Reports Nos. MSEC459, MSEC651, MSEC652, MSEC785, MSEC792, MSEC865 and the SMP Application.

3.6. Steep slopes

Steep slopes have been defined as the areas of land having natural gradients greater than 1 in 3 (i.e. 33 % or an angle to the horizontal of 18°). The locations of the steep slopes are shown in Drawing No. MSEC914-03. The steep slopes have been identified within the Study Area and above the longwalls, predominately along the alignments of the drainage lines.

The steep slopes could experience the full range of predicted movements as summarised in Chapter 2. The maximum predicted subsidence parameters for the steep slopes, based on the Modified Layout, are less than the maxima predicted based on the Previous Layout. The extent of subsidence and, therefore, the area of the steep slopes affected by subsidence also reduce due to the proposed modifications.

The assessed levels of potential impact for the steep slopes, based on the Modified Layout, are similar to or less than those assessed based on the Previous Layout. The recommendations and the management strategies for the steep slopes, therefore, do not change from those previously provided in Reports Nos. MSEC459, MSEC651, MSEC652, MSEC785, MSEC792, MSEC865 and the SMP Application.

3.7. Upland swamps

The locations of the upland swamps are shown in Drawing No. MSEC914-03.

There are two swamps located within the Study Area based on the 35° angle of draw. Den23 is positioned above and near to the commencing ends of Longwalls 15 and 16 and Swamp Den11 is positioned 200 m north of the commencing end of Longwall 15. There is one additional swamp partially located within the Study Area based on the 600 m boundary, being Den35b, which is positioned 75 m south of the maingate of Longwall 18.

A summary of the maximum predicted total conventional subsidence, tilt and curvatures for the upland swamps, based on the Previous and Modified Layouts, is provided in Table 3.2. The values in this table are the maxima within 20 m of the mapped extents of the upland swamps resulting from the extraction of Longwalls 9 to 18.

Table 3.2 Maximum predicted total vertical subsidence, tilt and curvatures for the upland swamps

Location	Layout	Maximum predicted total subsidence (mm)	Maximum predicted total tilt (mm/m)	Maximum predicted total hogging curvature (km^{-1})	Maximum predicted total sagging curvature (km^{-1})
Den11	Previous Layout	2700	25	0.40	0.45
	Modified Layout	2400	25	0.40	0.45
Den23	Previous Layout	3350	35	0.60	0.80
	Modified Layout	3000	30	0.55	0.70
Den35b	Previous Layout	< 20	< 0.5	< 0.01	< 0.01
	Modified Layout	< 20	< 0.5	< 0.01	< 0.01

The maximum predicted vertical subsidence for Den11 and Den23, based on the Modified Layout, are less than the maxima predicted based on the Previous Layout. Similarly, the predicted tilts and curvatures for Den23 reduce due to the proposed modifications. The maximum predicted tilt and curvatures for Den11 remain the same, as the changes are less than the rounding adopted for the values presented in Table 3.2 and, therefore, are within the order of accuracy of the prediction method.

Den35b is predicted to experience less than 20 mm vertical subsidence based on both the Previous and Modified Layout. This swamp is not expected to experience measurable conventional tilts, conventional curvatures or conventional strains based on both these layouts.

A summary of the maximum predicted total upsidence and closure for the upland swamps, based on the Previous and Modified Layouts, is provided in Table 3.3. The valley related movements occur along the drainage lines that are associated with the swamps. The values in this table are the maxima within the mapped extents of the upland swamps resulting from the extraction of Longwalls 9 to 18.

Table 3.3 Maximum predicted total upsidence and closure for the upland swamps

Location	Layout	Maximum predicted total upsidence (mm)	Maximum predicted total closure (mm)
Den11	Previous Layout	250	250
	Modified Layout	225	225
Den23	Previous Layout	350	225
	Modified Layout	325	225
Den35b	Previous Layout	175	450
	Modified Layout	175	450

The maximum predicted upsidence for Den11 and Den23, based on the Modified Layout, are slightly less than the maxima predicted based on the Previous Layout. The magnitudes of upsidence reduce at these swamps due to their proximity of the modified longwall commencing ends and the reduction in the maximum extraction height.

The maximum predicted closures for Den11 and Den23 and the maximum predicted upsidence and closure for Den35b, based on the Modified Layout, are the same as the maxima predicted based on the Previous Layout. That is, the changes in these parameters are less than the rounding adopted for the values presented in Table 3.3 and, therefore, are within the order of accuracy of the prediction method.

The assessed levels of potential impact for the upland swamps, based on the Modified Layout, are similar to or slightly less than those assessed based on the Previous Layout. The recommendations and the management strategies for the swamps, therefore, do not change from those previously provided in Reports Nos. MSEC459, MSEC651, MSEC652, MSEC785, MSEC792, MSEC865 and the SMP Application.

3.8. Lake Avon

The location of Lake Avon is shown in Drawing No. MSEC914-03.

Lake Avon is located to the west of Longwalls 15 to 18. A summary of the minimum distances of the longwalls from the FSL of Lake Avon is provided in Table 3.4.

Table 3.4 Minimum distances between the longwalls and Lake Avon

Layout	Longwall	Minimum distance to the FSL of Lake Avon (m)
Previous Layout (MSEC865)	LW15	260
	LW16	230
	LW17	240
	LW18	245
Modified Layout (MSEC914)	LW15	300
	LW16	300
	LW17	310
	LW18	300

The distances of the longwalls from Lake Avon increase as a result of the modified commencing ends. The minimum distance of Longwalls 15 to 18 from the FSL of Lake Avon is 230 m based on the Previous Layout and is 300 m based on the Modified Layout.

Lake Avon is predicted to experience less than 20 mm vertical subsidence due to Longwalls 15 to 18 based on both the Previous and Modified Layouts. Whilst the lake could experience very low levels of vertical subsidence, it is not expected to experience measurable conventional tilts, conventional curvatures or conventional strains.

A summary of the maximum predicted total upsidence and closure for Lake Avon, based on the Previous and Modified Layouts, is provided in Table 3.5. The values in this table are the maxima within the Study Area resulting from the extraction of Longwalls 9 to 18.

Table 3.5 Maximum predicted total upsidence and closure for Lake Avon

Location	Layout	Maximum predicted total upsidence (mm)	Maximum predicted total closure (mm)
Lake Avon	Previous Layout	50	100
	Modified Layout	40	80

The maximum predicted total upsidence and closure for Lake Avon, based on the Modified Layout, are slightly less than the maxima predicted based on the Previous Layout. The predicted valley related effects reduce due to the increased distances of the longwall commencing ends from the lake.

The lake could also experience far-field horizontal movements due to the extraction of the longwalls. The predicted far-field horizontal movements at Lake Avon, based on the Modified Layout, are slightly less than those predicted based on the Previous Layout.

The Avon Dam Wall is located approximately 7 km north-west of the commencing ends of Longwalls 15 to 18. At this distance, the dam wall is not expected to experience measurable mine subsidence movements due to the extraction of these longwalls.

The assessed levels of potential impact for Lake Avon slightly reduce as a result of the proposed modifications to the commencing ends of Longwalls 15 to 18. The recommendations and the management strategies for the lake, therefore, do not change from those previously provided in Reports Nos. MSEC459, MSEC651, MSEC652, MSEC785, MSEC792, MSEC865 and the SMP Application.

3.9. Fire trails

The fire trails are located across the Study Area and directly above the longwalls based on both the Previous and Modified Layouts. These trails therefore could experience the full range of predicted movements as summarised in Chapter 2. The maximum predicted subsidence parameters for the fire trails, based on the Modified Layout, are less than the maxima predicted based on the Previous Layout. The extent of subsidence and, therefore, the overall length of the fire trails affected by subsidence reduce due to the proposed modifications.

The assessed levels of potential impact for the fire trails, based on the Modified Layout, are similar to or less than those assessed based on the Previous Layout. The recommendations and the management strategies for the fire trails, therefore, do not change from those previously provided in Reports Nos. MSEC459, MSEC651, MSEC652, MSEC785, MSEC792, MSEC865 and the SMP Application.

3.10. Disused Maldon-Dombarton Railway Corridor

The location of the disused Maldon-Dombarton Railway Corridor is shown in Drawing No. MSEC914-04.

The disused railway corridor crosses directly above Longwalls 15 to 18 and is located more than 0.5 km from the commencing ends of these longwalls based on both the Previous and Modified Layouts. The maximum predicted subsidence parameters for the disused railway corridor, based on the Modified Layout, are less than the maxima predicted based on the Previous Layout due to the reduction in the maximum extraction height.

The impact assessments and proposed management strategies for the disused Maldon-Dombarton Railway Corridor, therefore, do not change from those previously provided in Reports Nos. MSEC459, MSEC651, MSEC652, MSEC785, MSEC792, MSEC865 and the SMP Application.

3.11. Aboriginal heritage sites

The locations of the Aboriginal heritage sites are shown in Drawing No. MSEC914-04.

There are three sites that are located within the Study Area based on the 35° angle of draw, being Site Refs. 52-2-1771 (shelter with deposit), 52-2-2248 (shelter with art) and 52-2-3068 (shelter with art and grinding grooves).

There are four additional sites that are located within the Study Area based on the 600 m boundary, being Site Refs. 52-2-1772 (shelter with art), 52-2-1773 (shelter with deposit), 52-2-1774 (shelter with art) and 52-2-3646 (shelter with art).

A summary of the maximum predicted total vertical subsidence, tilt and curvatures for the Aboriginal heritage sites, based on the Previous and Modified Layouts, is provided in Table 3.6. The values are the maxima within 20 m of the sites resulting from the extraction of Longwalls 9 to 18.

Table 3.6 Maximum predicted total vertical subsidence, tilt and curvatures for the Aboriginal heritage sites

Layout	Site Ref.	Maximum predicted total subsidence (mm)	Maximum predicted total tilt (mm/m)	Maximum predicted total hogging curvature (km^{-1})	Maximum predicted total sagging curvature (km^{-1})
Previous Layout (MSEC865)	52-2-1771	< 20	< 0.5	< 0.01	< 0.01
	52-2-1772	< 20	< 0.5	< 0.01	< 0.01
	52-2-1773	< 20	< 0.5	< 0.01	< 0.01
	52-2-1774	< 20	< 0.5	< 0.01	< 0.01
	52-2-2248	550	15	0.35	0.01
	52-2-3068	1500	25	0.85	0.35
	52-2-3646	< 20	< 0.5	< 0.01	< 0.01
Modified Layout (MSEC914)	52-2-1771	< 20	< 0.5	< 0.01	< 0.01
	52-2-1772	< 20	< 0.5	< 0.01	< 0.01
	52-2-1773	< 20	< 0.5	< 0.01	< 0.01
	52-2-1774	< 20	< 0.5	< 0.01	< 0.01
	52-2-2248	200	6	0.15	0.01
	52-2-3068	750	20	0.80	0.06
	52-2-3646	< 20	< 0.5	< 0.01	< 0.01

Site Refs. 52-2-1771, 52-2-1772, 52-2-1773, 52-2-1774 and 52-2-3646 are predicted to experience less than 20 mm vertical subsidence based on both the Previous and Modified Layouts. Whilst these sites could experience very low levels of vertical subsidence, they are not expected to experience measurable conventional tilts, conventional curvatures or conventional strains.

The maximum predicted conventional subsidence parameters for Site Refs. 52-2-2248 and 52-2-3068, based on the Modified Layout, are similar to or less than the maxima predicted based on the Previous Layout. The predicted parameters for these two sites generally decrease since they are located close to the modified commencing end of Longwall 18 and due to the reduction in the maximum extraction height.

Some sites are located along the alignments of the drainage lines and, therefore, could experience valley related effects. The rock shelters are positioned on the valley sides and, therefore, are unlikely to experience the valley related upsidence or compressive strain due to valley closure movements. The maximum predicted valley related effects for the sites are the same or slightly reduce as a result of the proposed modifications.

The assessed levels of potential impact for the Aboriginal heritage sites, based on the Modified Layout, are similar to or less than those assessed based on the Previous Layout. The recommendations and the management strategies for these sites, therefore, do not change from those previously provided in Reports Nos. MSEC459, MSEC651, MSEC652, MSEC785, MSEC792, MSEC865 and the SMP Application.

3.12. Survey control marks

The locations of the survey control marks in Area 3B are shown in Drawing No. MSEC914-04.

The survey control marks are located across the Study Area and directly above the longwalls based on both the Previous and Modified Layouts. These features therefore could experience the full range of predicted movements as summarised in Chapter 2. It is also likely that other survey control marks located outside and in the vicinity of the Study Area could also be affected by far-field horizontal movements.

The maximum predicted subsidence parameters for the survey control marks, based on the Modified Layout, are less than the maxima predicted based on the Previous Layout. The extent of the far-field horizontal movements outside of mining does not significantly change as a result of the proposed modifications.

The assessed levels of potential impact for the survey control marks, based on the Modified Layout, are similar to or slightly less than those assessed based on the Previous Layout. The recommendations and the management strategies for these sites, therefore, are the same as those previously provided in Reports Nos. MSEC459, MSEC651, MSEC652, MSEC785, MSEC792, MSEC865 and the SMP Application.

3.13. Summary

The maximum predicted incremental and total vertical subsidence for Longwalls 15 to 18, based on the Modified Layout, are less than the maxima predicted based on the Previous Layout. These changes are predominately due to the reduction in the maximum extraction height from 4.6 m to 3.9 m. The extent of subsidence also reduces due to the proposed shortened commencing ends of these longwalls.

The maximum predicted conventional tilts, curvatures and strains directly above Longwalls 15 to 18 also reduce. The locations of the maximum predicted longitudinal tilts and curvatures at the longwall commencing ends move between 60 to 90 m towards the east. However, these longitudinal parameters are less than the maxima that occur transverse to the longwalls.

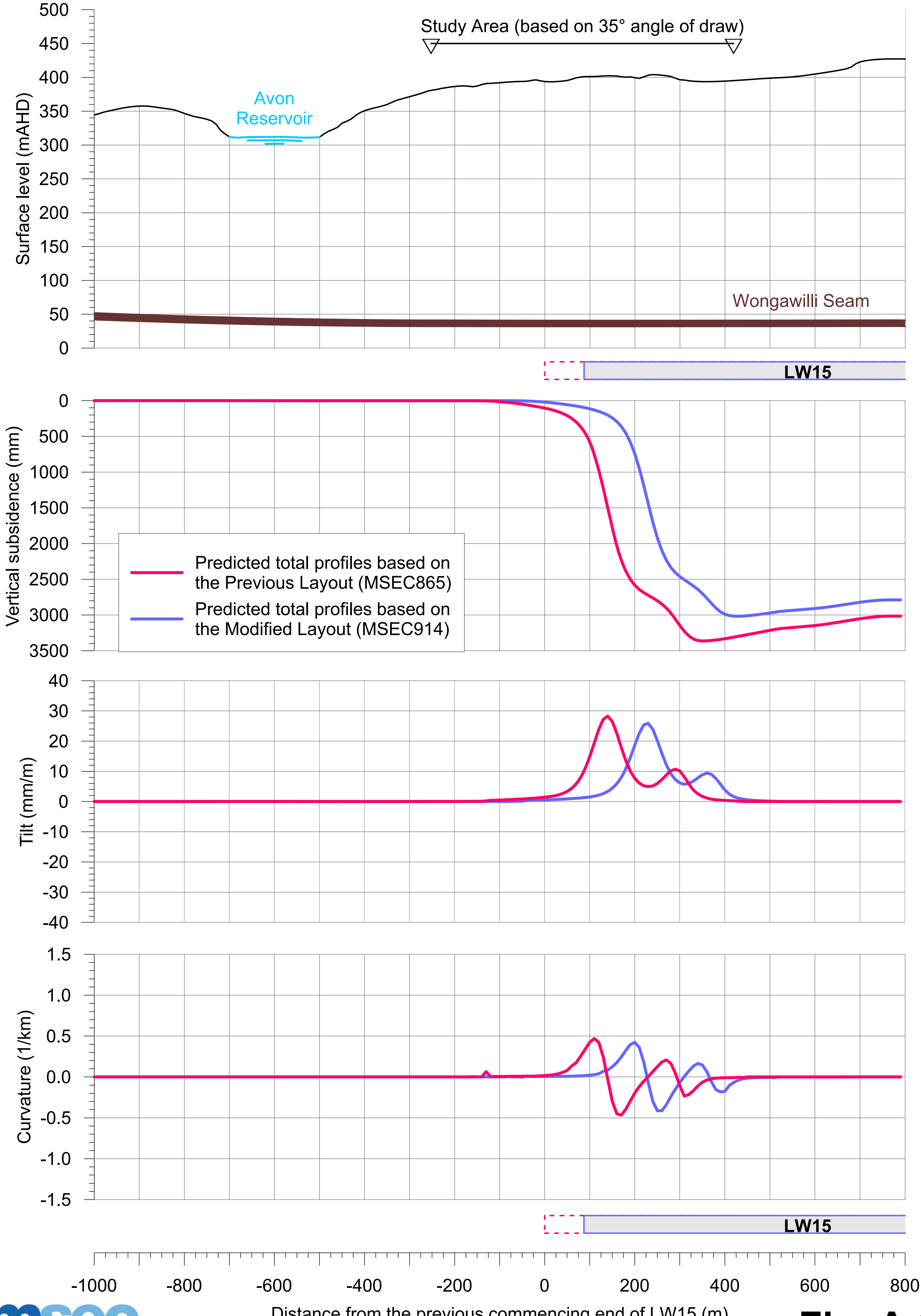
The maximum predicted valley related upsidence and closure movements directly above Longwalls 15 to 18, based on the Modified Layout, are similar to or slightly less than the maxima predicted based on the Previous Layout. The predicted upsidence and closure along the streams and valleys reduce where they are located in close proximity to the commencing ends of Longwalls 15 to 18.

The maximum predicted subsidence parameters for the natural and built features, based on the Modified Layout, are less than the maxima predicted based on the Previous Layout. The predicted tilts, curvatures and strains slightly increase where the surface features are located close to the modified longwall commencing ends, including Drainage Line LA2, rock outcrops, steep slopes and fire trails. However, the extents or areas of these features that are directly mined beneath reduce as a result of the proposed modified commencing ends. It is considered, therefore, that the overall levels of potential impact for these surface features reduce.

The assessed levels of potential impact for the natural and built features are the same or reduce as a result of the proposed modifications to the commencing ends and the maximum extraction heights for Longwalls 15 to 18. The recommendations and the management strategies for these surface features, therefore, are the same as those previously provided in Reports Nos. MSEC459, MSEC651, MSEC652, MSEC785, MSEC792, MSEC865 and the SMP Application.

APPENDIX A. FIGURES AND DRAWINGS

Predicted profiles of vertical subsidence, tilt and curvature along Prediction Line 1 due to the extraction of Longwalls 9 to 18



msec

Fig. A.01

Predicted profiles of vertical subsidence, tilt and curvature along Prediction Line 2 due to the extraction of Longwalls 9 to 18

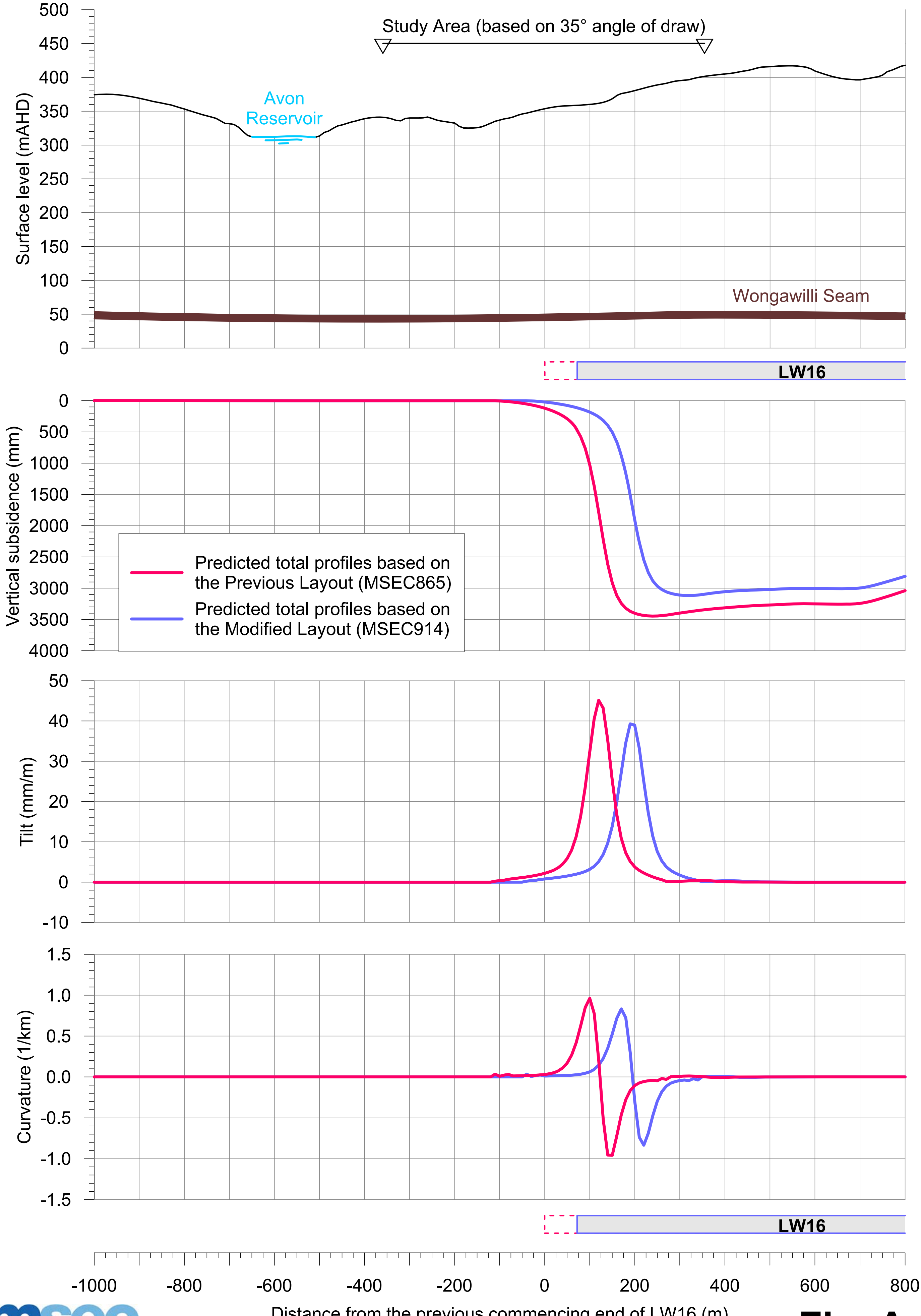


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Fig. A.02

Predicted profiles of vertical subsidence, tilt and curvature along Prediction Line 3 due to the extraction of Longwalls 9 to 18

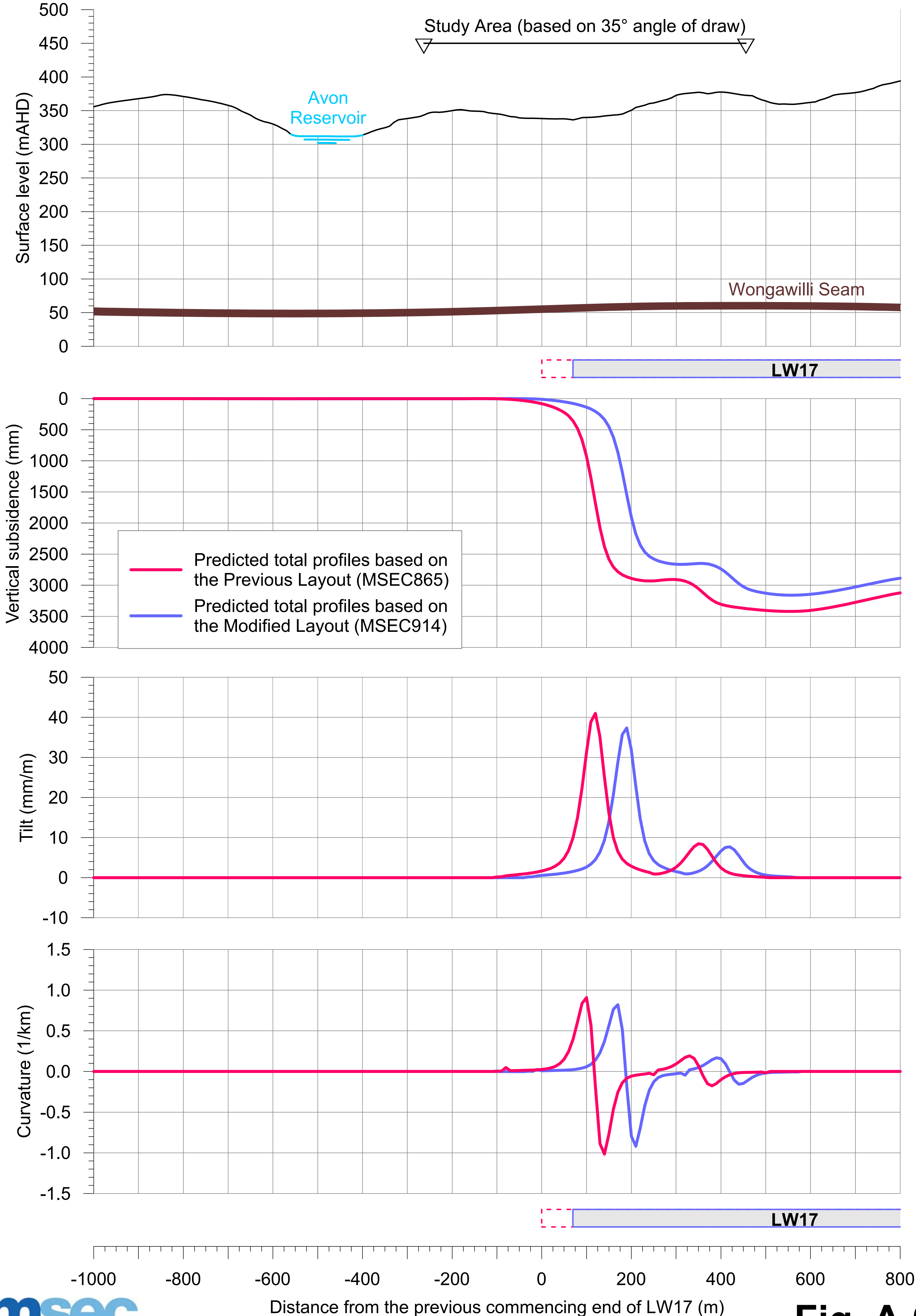
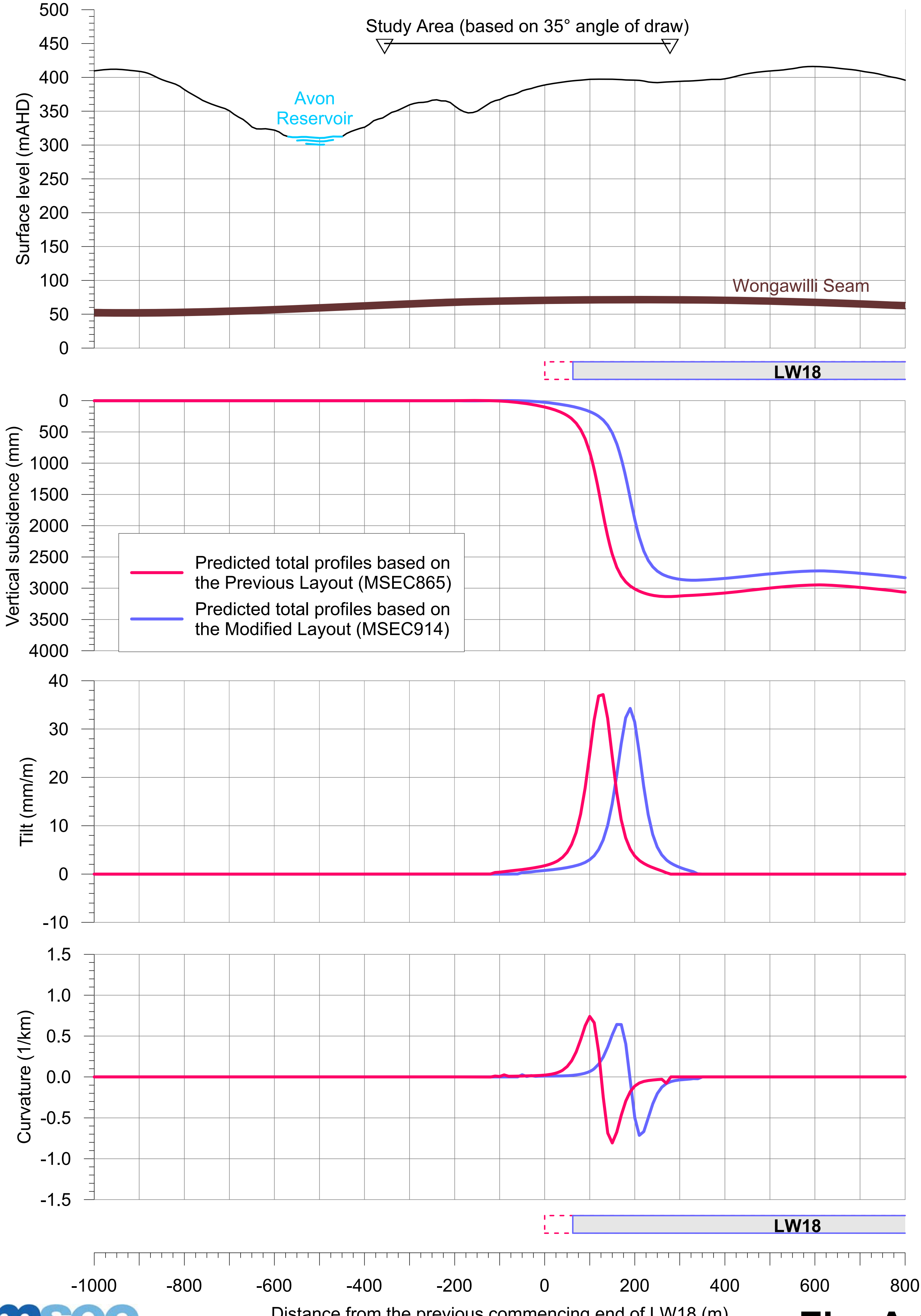


Fig. A.03

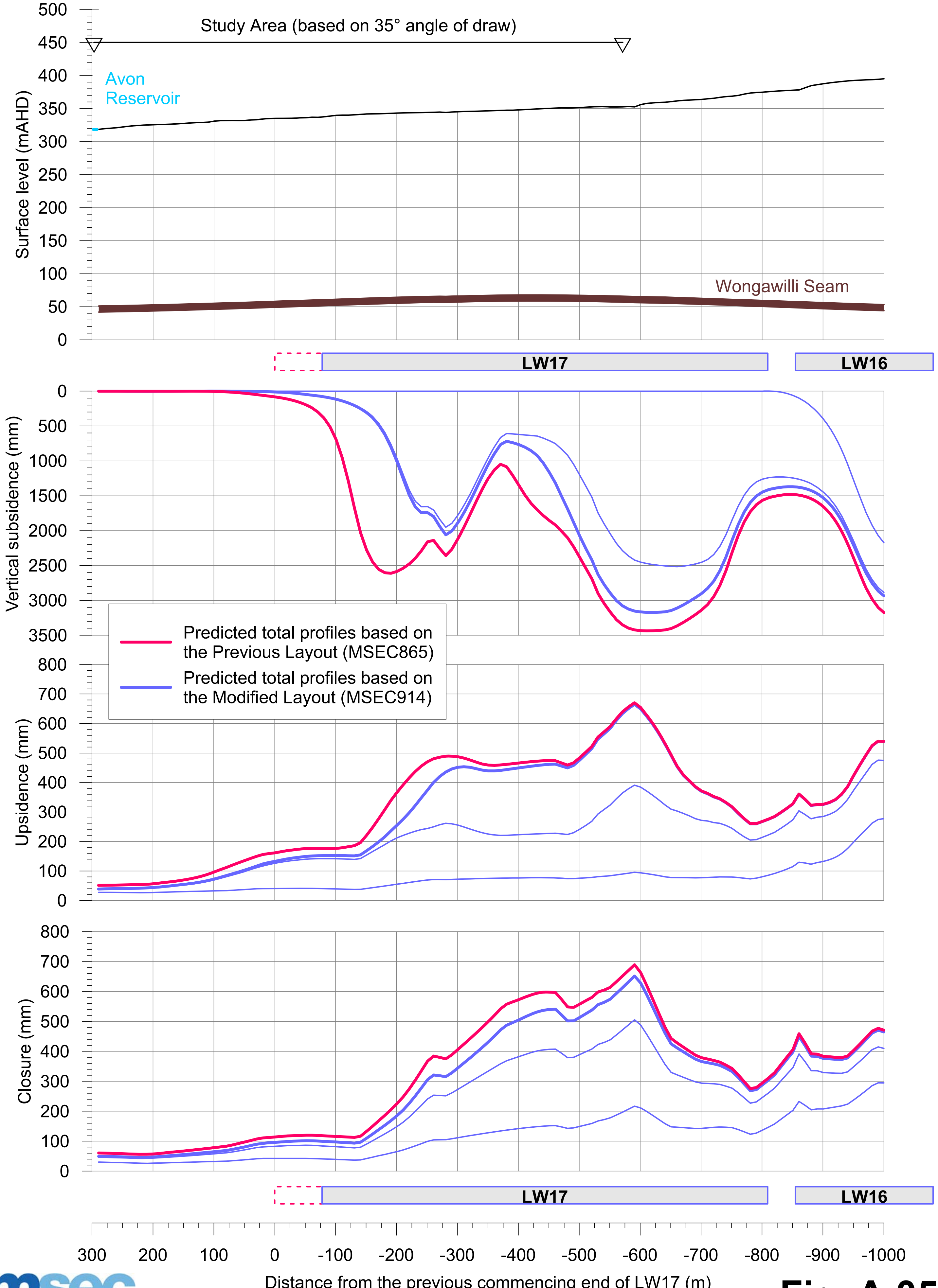
Predicted profiles of vertical subsidence, tilt and curvature along Prediction Line 4 due to the extraction of Longwalls 9 to 18



msec

Fig. A.04

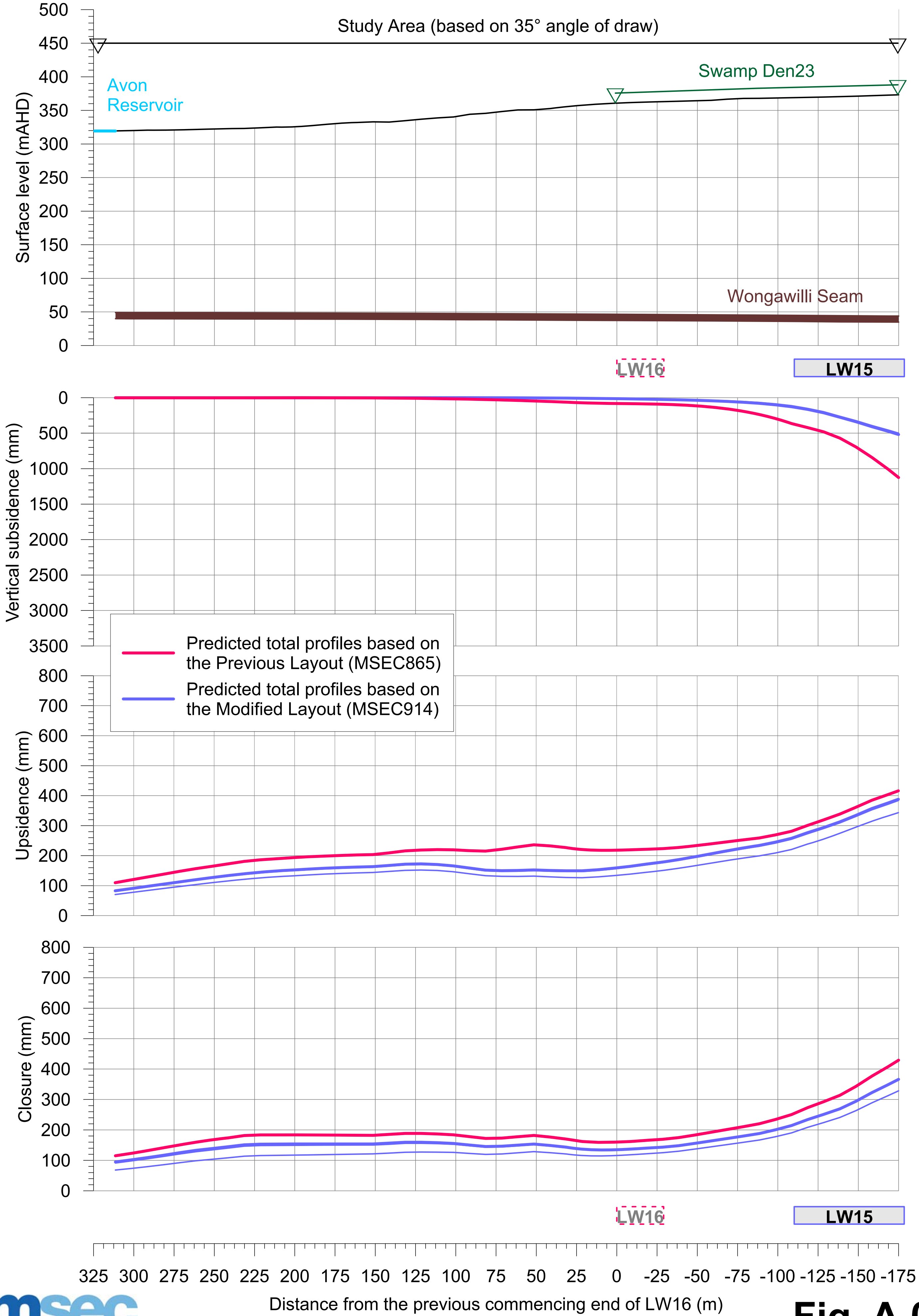
Predicted profiles of vertical subsidence, upsidence and closure along Drainage Line LA2 due to the extraction of Longwalls 9 to 18



msec

Fig. A.05

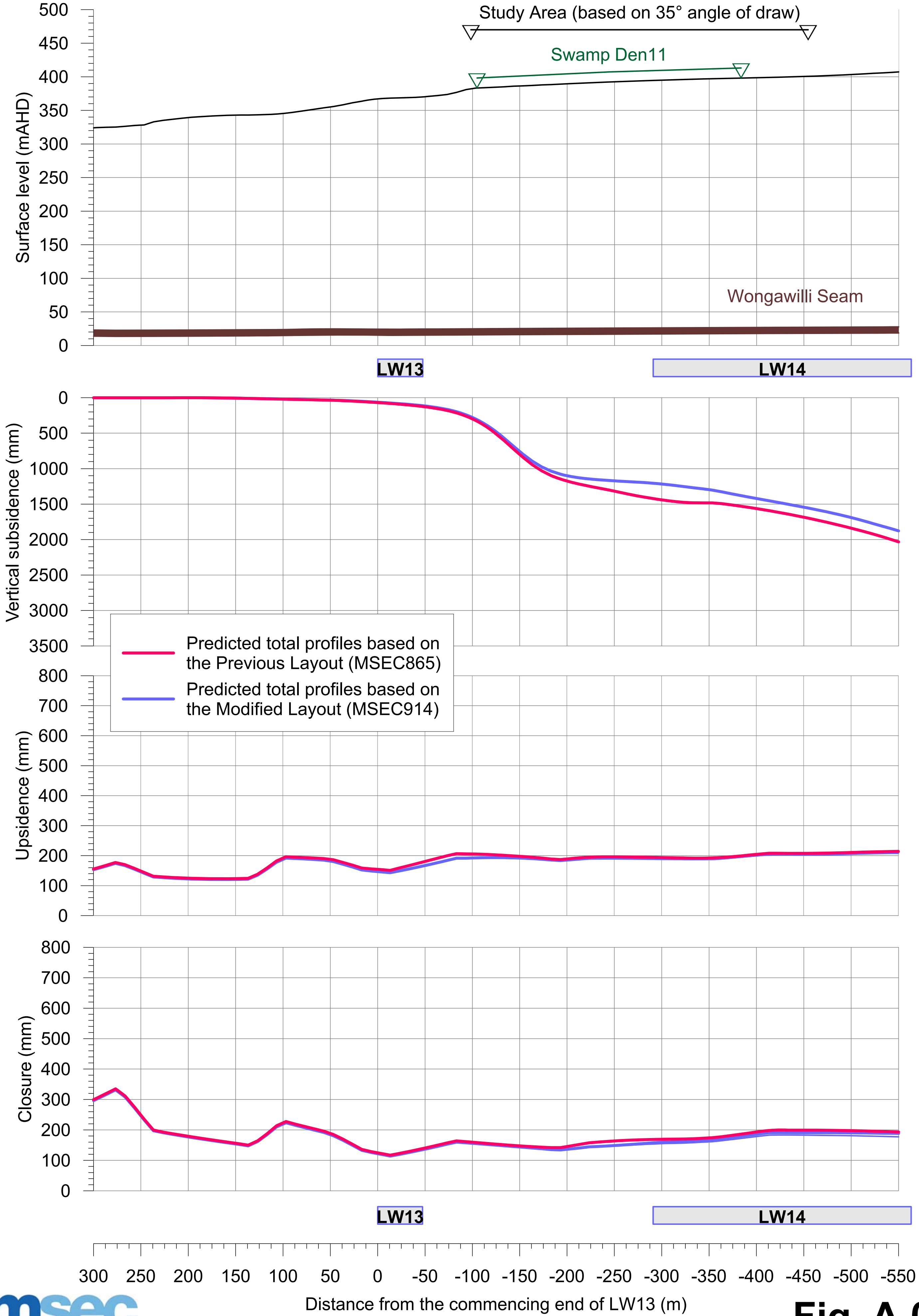
Predicted profiles of vertical subsidence, upsidence and closure along Drainage Line LA3 due to the extraction of Longwalls 9 to 18



msec

Fig. A.06

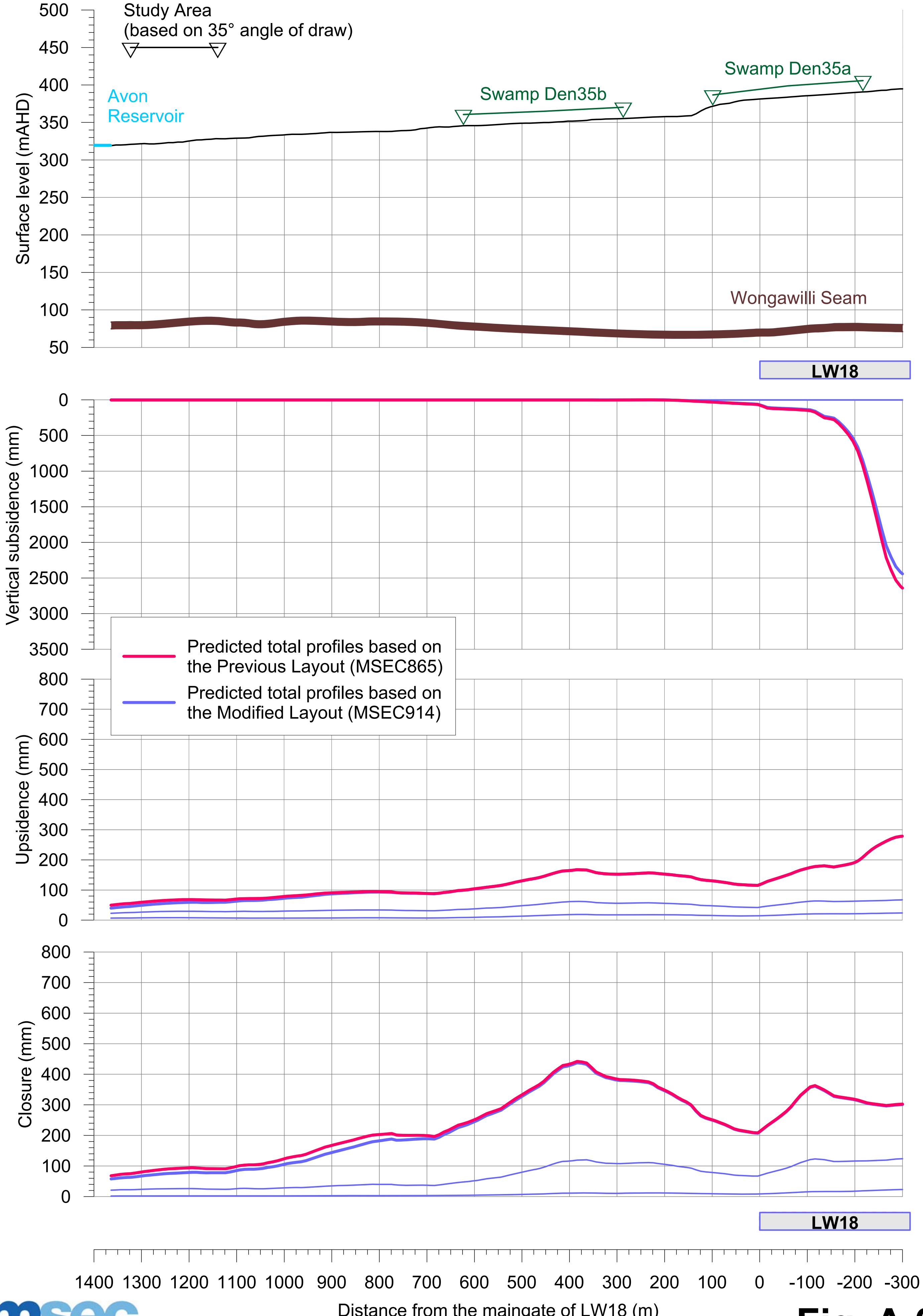
Predicted profiles of vertical subsidence, upsidence and closure along Drainage Line LA4A due to the extraction of Longwalls 9 to 18



msec

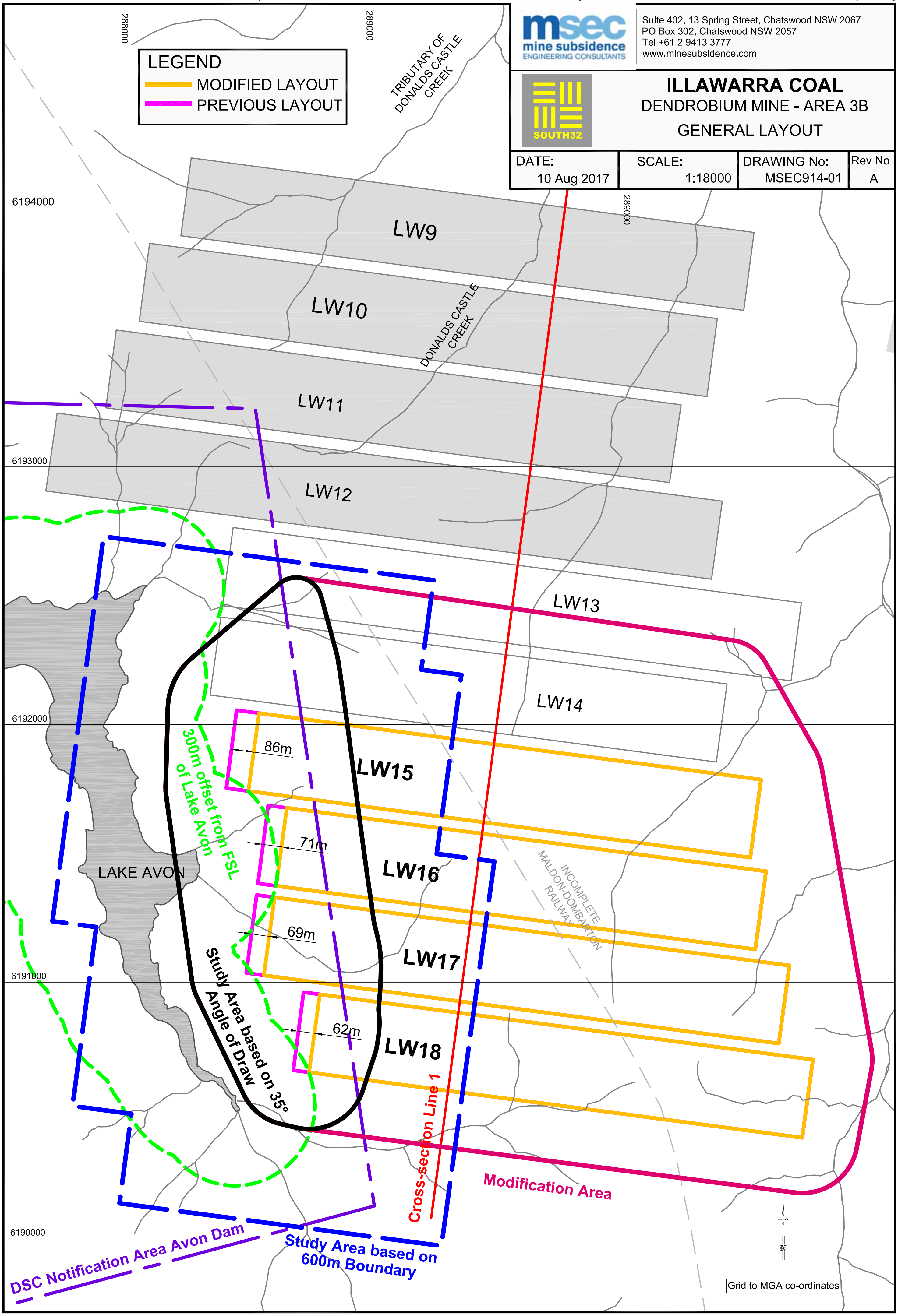
Fig. A.07

Predicted profiles of vertical subsidence, upsidence and closure along Drainage Line ND1 due to the extraction of Longwalls 9 to 18



msec

Fig. A.08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SOUTH32
ILLAWARRA COAL
DENDROBIUM MINE - AREA 3B
GENERAL LAYOUT
DATE:
10 Aug 2017
SCALE:
1:18000
DRAWING No:
MSEC914-01
Rev No
A
LEGEND
MODIFIED LAYOUT
PREVIOUS LAYOUT
288000
289000
6194000
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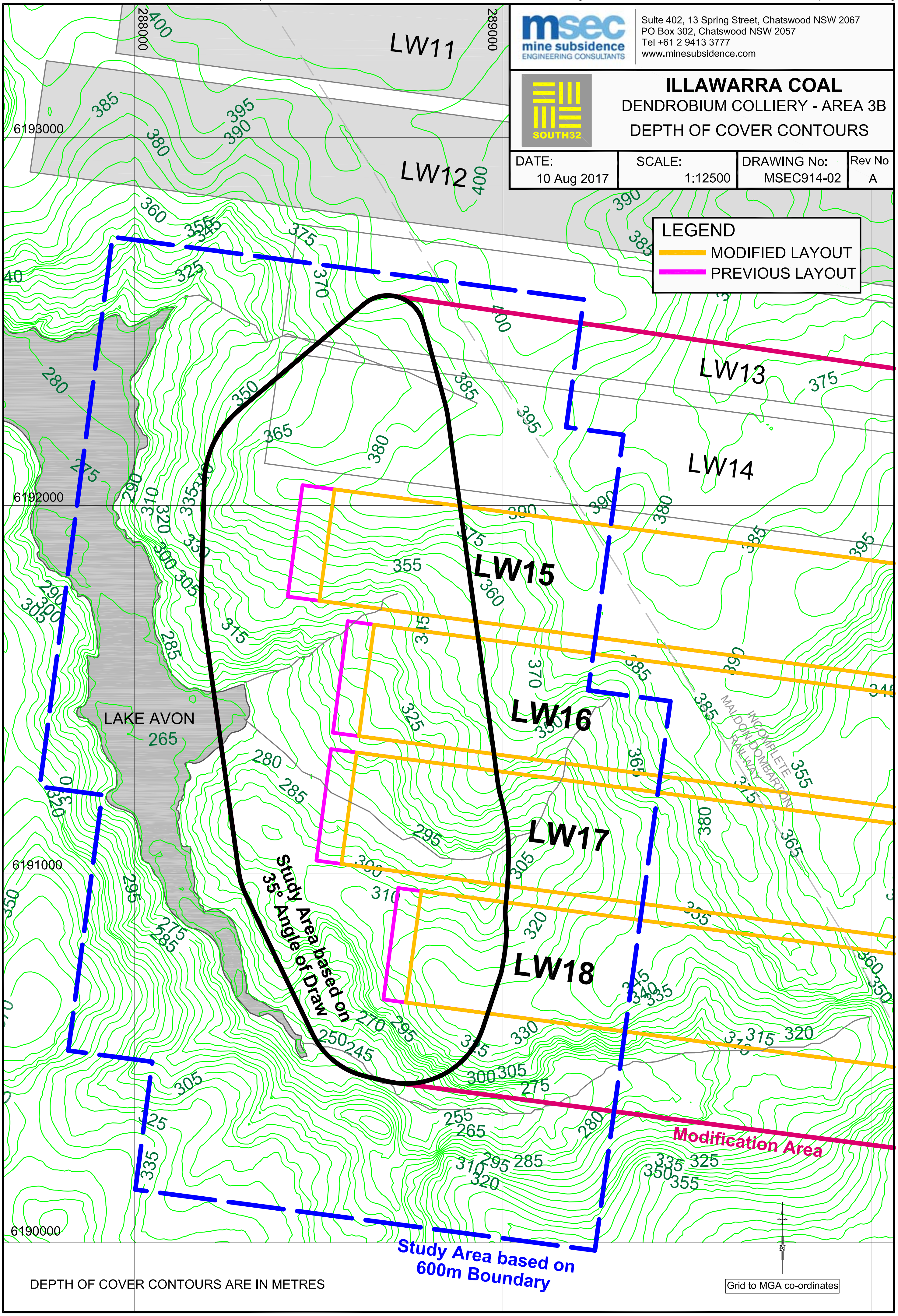
TRIBUTARY OF DONALDS CASTLE CREEK
DONALDS CASTLE CREEK
LW9
LW10
LW11
LW12
LW13
LW14
LW15
LW16
LW17
LW18
86m
71m
69m
62m
300m offset from FSL of Lake Avon
LAKE AVON
Study Area based on 35° Angle of Draw
INCOMPLETE MALDON-DOMBARTON RAILWAY
Cross-section Line 1
Modification Area
DSC Notification Area Avon Dam
Study Area based on 600m Boundary
Grid to MGA co-ordinates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ILLAWARRA COAL
DENDROBIUM COLLIERY - AREA 3B
DEPTH OF COVER CONTOURS
DATE: 10 Aug 2017
SCALE: 1:12500
DRAWING No: MSEC914-02
Rev No A
LEGEND
MODIFIED LAYOUT
PREVIOUS LAYOUT
LW11
LW12
LW13
LW14
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LW16
LW17
LW18
LAKE AVON
265
288000
289000
6193000
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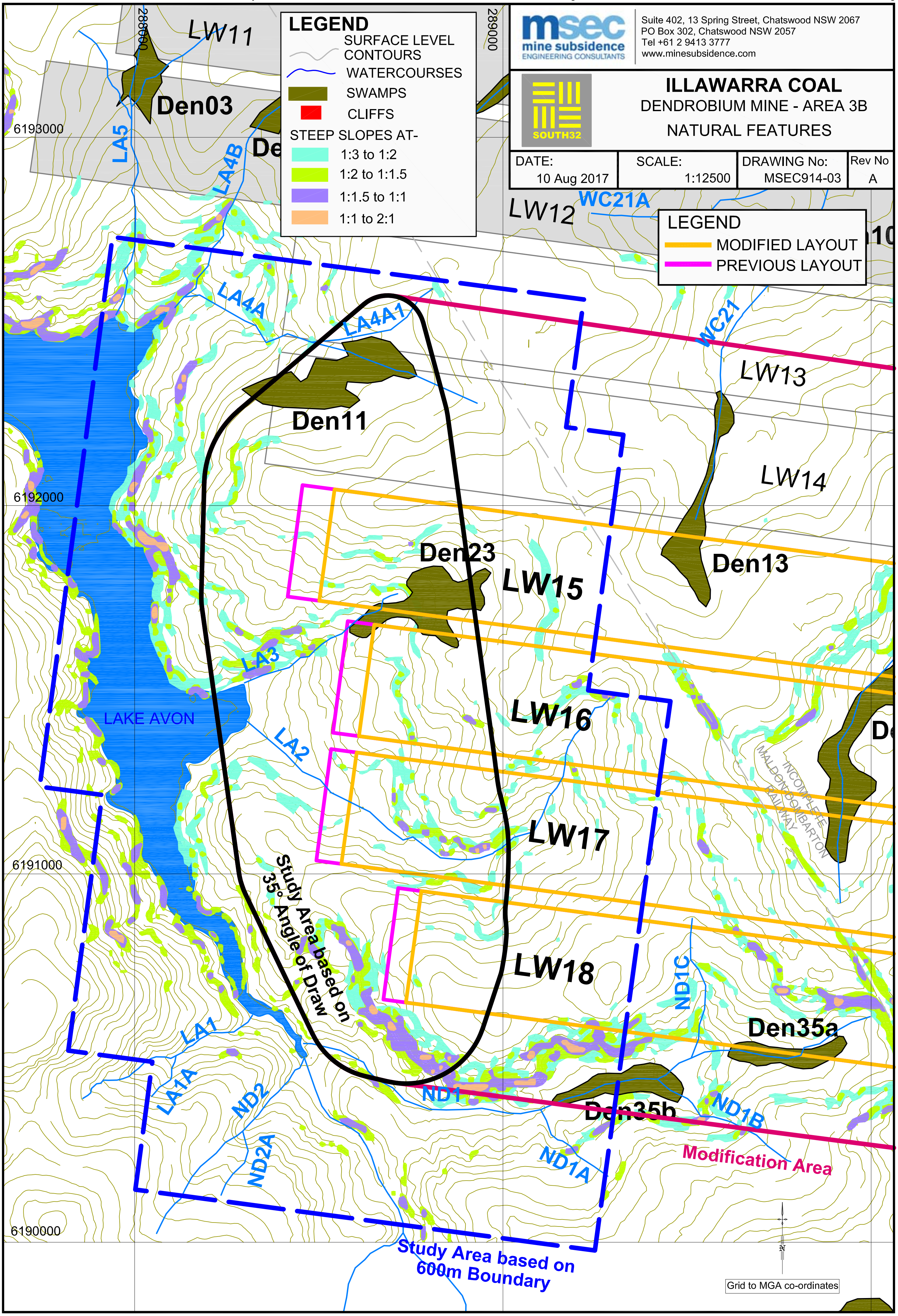
6191000
6190000
Study Area based on 35° Angle of Draw
Study Area based on 600m Boundary
Modification Area
INCOMPLETE MALDON-DOMBARTON RAILWAY
DEPTH OF COVER CONTOURS ARE IN METRES
Grid to MGA co-ordinates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SOUTH32
ILLAWARRA COAL
DENDROBIUM MINE - AREA 3B
NATURAL FEATURES
DATE: 10 Aug 2017
SCALE: 1:12500
DRAWING No: MSEC914-03
Rev No A
LEGEND
SURFACE LEVEL CONTOURS
WATERCOURSES
SWAMPS
CLIFFS
STEEP SLOPES AT-
1:3 to 1:2
1:2 to 1:1.5
1:1.5 to 1:1
1:1 to 2:1
LEGEND
MODIFIED LAYOUT
PREVIOUS LAYOUT
LW11
LW12
LW13
LW14
LW15
LW16
LW17
LW18
Den03
Den11
Den13
Den23
Den35a
Den35b
LA5
LA4B
LA4A
LA4A1
LA3
LA2
LA1
LA1A
WC21A
WC21
ND1
ND1A
ND1B
ND1C
ND2
ND2A
LAKE AVON
6193000
6192000
6191000
6190000
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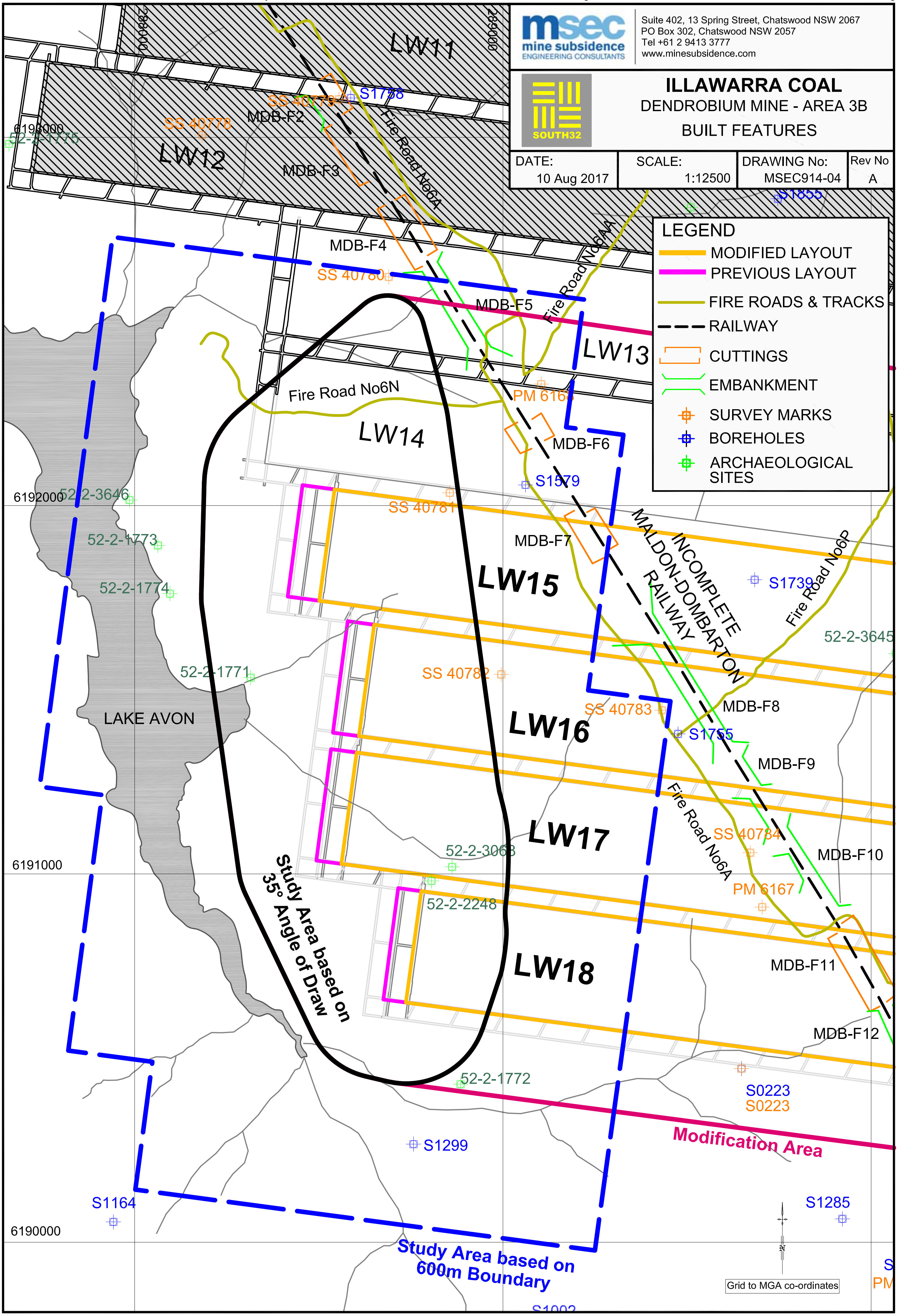
Study Area based on 35° Angle of Draw
Study Area based on 600m Boundary
Modification Area
INCOMPLETE MALDON-DOMBARTON RAILWAY
Grid to MGA co-ordinates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SOUTH32
ILLAWARRA COAL
DENDROBIUM MINE - AREA 3B
BUILT FEATURES
DATE: 10 Aug 2017
SCALE: 1:12500
DRAWING No: MSEC914-04
Rev No A
LEGEND
MODIFIED LAYOUT
PREVIOUS LAYOUT
FIRE ROADS & TRACKS
RAILWAY
CUTTINGS
EMBANKMENT
SURVEY MARKS
BOREHOLES
ARCHAEOLOGICAL SITES
LW11
LW12
LW13
LW14
LW15
LW16
LW17
LW18
LAKE AVON
INCOMPLETE MALDON-DOMBARTON RAILWAY
Fire Road No6A
Fire Road No6AA
Fire Road No6N
Fire Road No6P
MDB-F2
MDB-F3
MDB-F4
MDB-F5
MDB-F6
MDB-F7
MDB-F8
MDB-F9
MDB-F10
MDB-F11
MDB-F12
SS 40778
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SS 40780
SS 40781
SS 40782
SS 40783
SS 40784
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6193000
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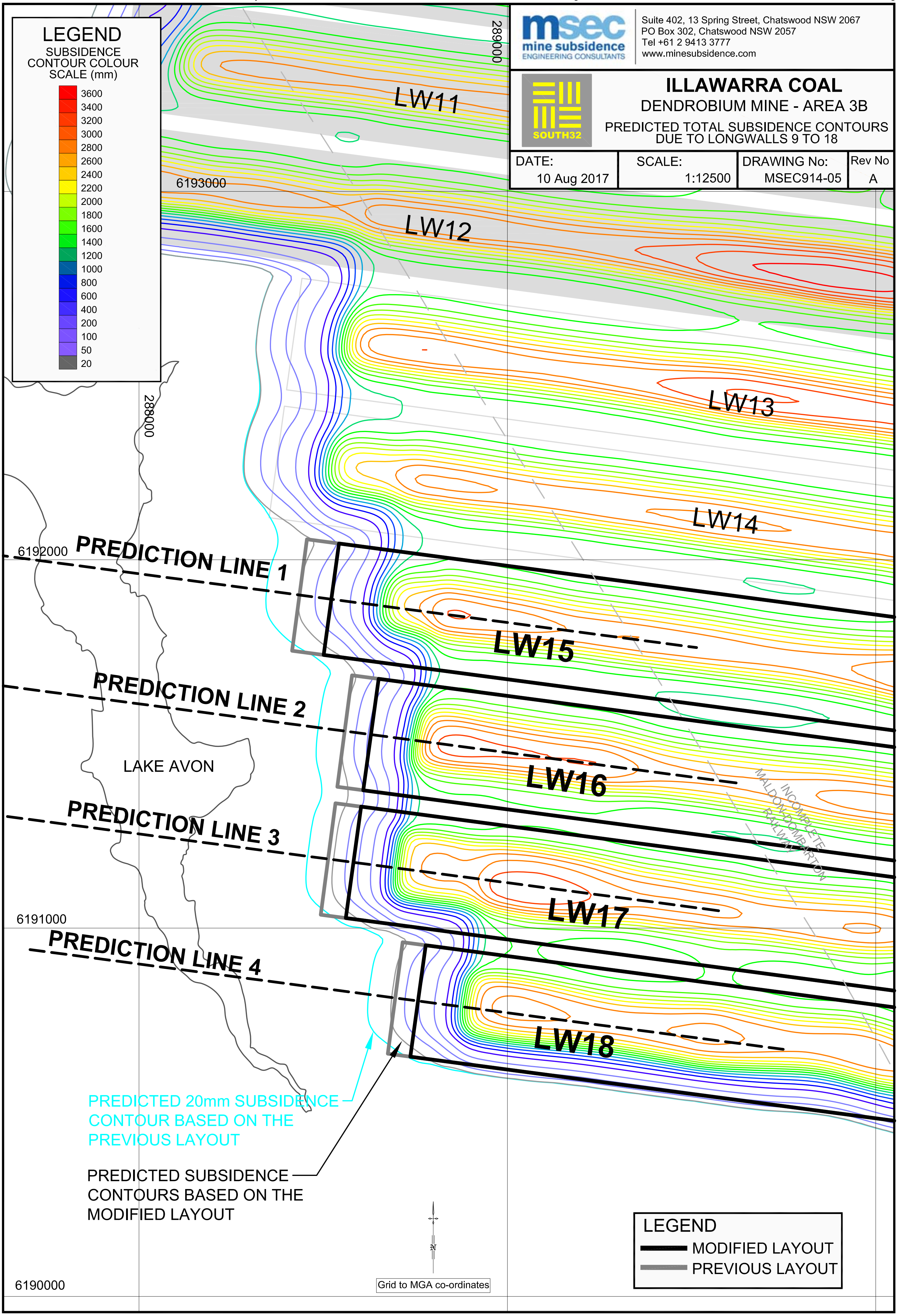
Study Area based on 35° Angle of Draw
Study Area based on 600m Boundary
Modification Area
Grid to MGA co-ordinates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3200
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
100
50
20
msec
mine subsidence
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PREDICTED TOTAL SUBSIDENCE CONTOURS
DUE TO LONGWALLS 9 TO 18
DATE: 10 Aug 2017
SCALE: 1:12500
DRAWING No: MSEC914-05
Rev No A
289000
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6192000
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LW11
LW12
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LW15
LW16
LW17
LW18
PREDICTION LINE 1
PREDICTION LINE 2
PREDICTION LINE 3
PREDICTION LINE 4
LAKE AVON
INCOMPLETE MALDON-DOMBARTON RAILWAY
PREDICTED 20mm SUBSIDENCE CONTOUR BASED ON THE PREVIOUS LAYOUT
PREDICTED SUBSIDENCE CONTOURS BASED ON THE MODIFIED LAYOUT
LEGEND
MODIFIED LAYOUT
PREVIOUS LAYOUT
Grid to MGA co-ordinates

mine subsidence
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5th October 2017

Gary Brassington
South32 Illawarra Coal
Level 3, Enterprise 1
Innovation Campus, Squires Way
North Wollongong NSW 2500

For the attention of Mr. Gary Brassington

Dear Gary,

Dendrobium Area 3B – Addendum letter report for Report No. MSEC914 (Rev. A)
Supplementary predictions for the streams and swamps

The subsidence prediction model for Dendrobium Mine was reviewed and re-calibrated based on updated monitoring data from Longwalls 7 and 8 in Area 3A and Longwalls 9 and 10 in Area 3B. The subsidence predictions and impact assessments for the natural and built features based on the re-calibrated subsidence model were provided in Report No. MSEC792 (Rev. C).

IC then proposed to shorten the commencing (i.e. western) ends of Longwalls 15 to 18 so that these longwalls are located at a minimum distance of 300 m from the Full Supply Level of Lake Avon. The maximum height of extraction in the Wongawilli Seam for these longwalls was also proposed to be reduced from 4.6 m to 3.9 m.

The updated subsidence predictions and impact assessments for Longwalls 15 to 18, based on the proposed modified commencing ends and proposed modified extraction heights, were provided in Report No. MSEC914 (Rev. A). This addendum letter report provides additional information on the predictions for the streams and swamps based on the mining layout adopted in Report No. MSEC914.

Stream grades

There are unnamed drainage lines that are located directly above Longwalls 9 to 18 in Area 3B, including Drainage Lines DC13, LA3, LA4, LA4B, LW5, ND1, WC15 and WC21. A summary of the maximum predicted vertical subsidence, upsidence and closure for these drainage lines, based on the mining layout adopted in Report No. MSEC914, is provided in Table 1.

Table 1 Maximum predicted total vertical subsidence, upsidence and closure for the drainage line due to the extraction of Longwalls 9 to 18

Stream Ref.	Maximum predicted total vertical subsidence (mm)	Maximum predicted total upsidence (mm)	Maximum predicted total closure (mm)
DC13	2050	250	225
LA3	550	400	400
LA4A	1950	200	325
LA4B	2700	175	325
LA5	2700	80	125
ND1	2550	275	425
WC15	3100	650	600
WC21	3500	700	650

It is noted, that the maximum predicted vertical subsidence, upsidence and closure for Drainage Lines LA4A and ND1, provided in Table 1, are greater than those presented in Report No. MSEC914. The reason being the values in Table 1 are the maxima anywhere along the drainage lines, whereas the values in Report No. MSEC914 are the maxima within the Modification Area only (i.e. near the modified commencing ends of Longwalls 15 to 18).

The natural grades and the predicted post mining grades along Drainage Lines DC13, LA3, LA4, LA4B, LW5, ND1, WC15 and WC21, based on the mining layout adopted in Report No. MSEC914, are illustrated in Figure 1 to Figure 8.

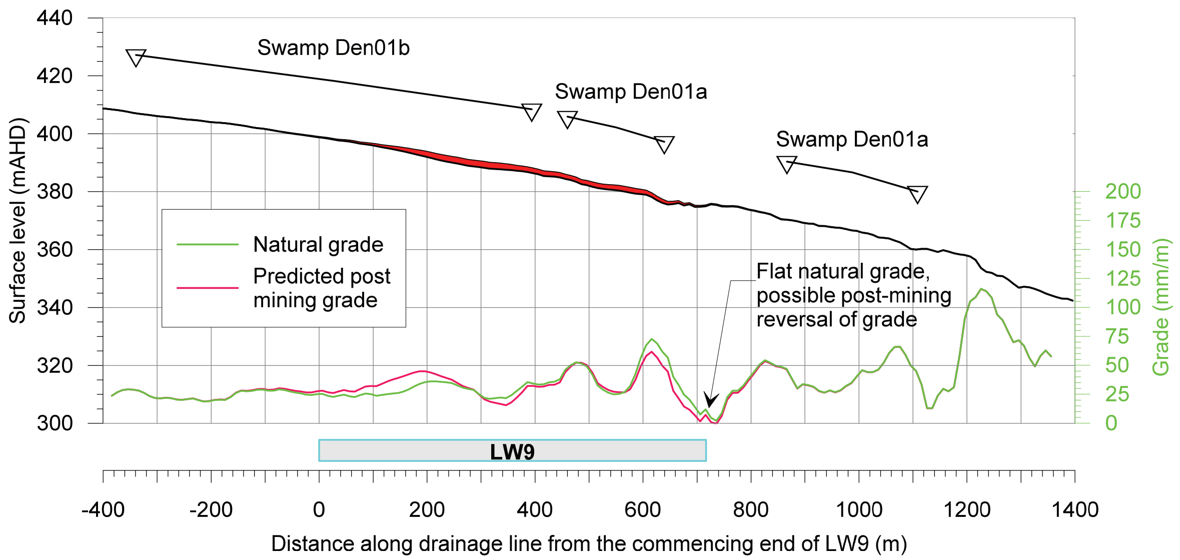

Figure 1 Natural and predicted post mining surface levels along Drainage Line DC13

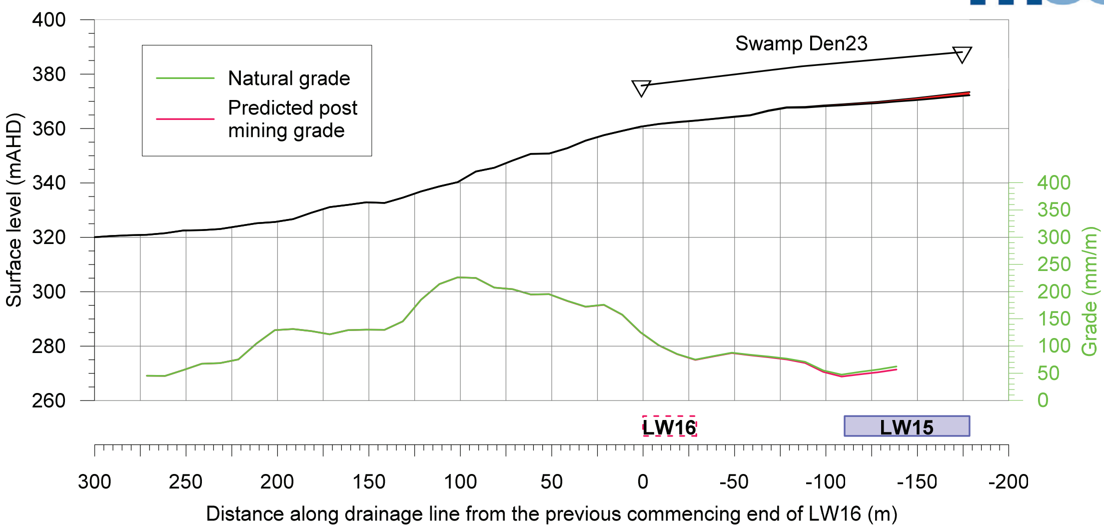

Figure 2 Natural and predicted post mining surface levels along Drainage Line LA3

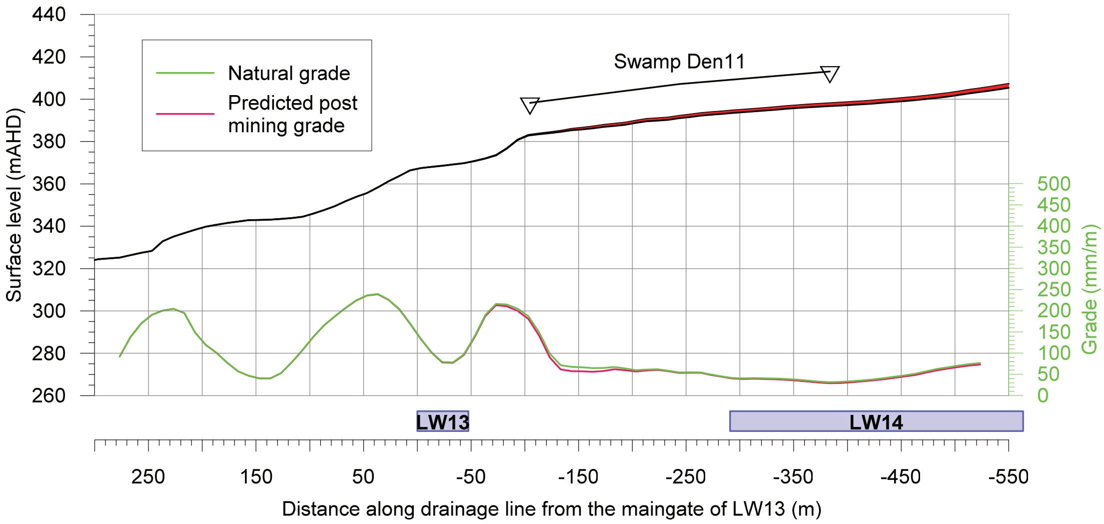

Figure 3 Natural and predicted post mining surface levels along Drainage Line LA4

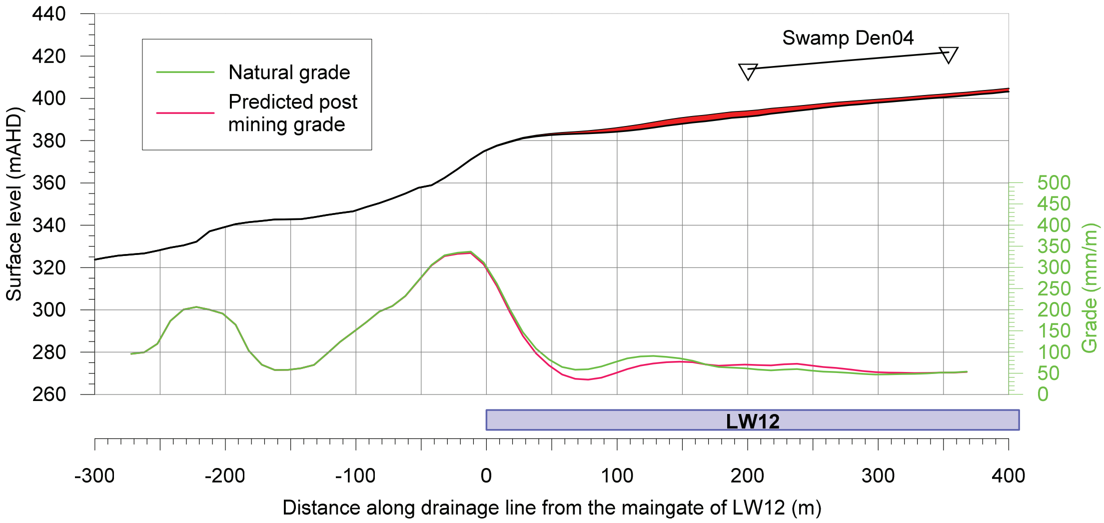

Figure 4 Natural and predicted post mining surface levels along Drainage Line LA4B

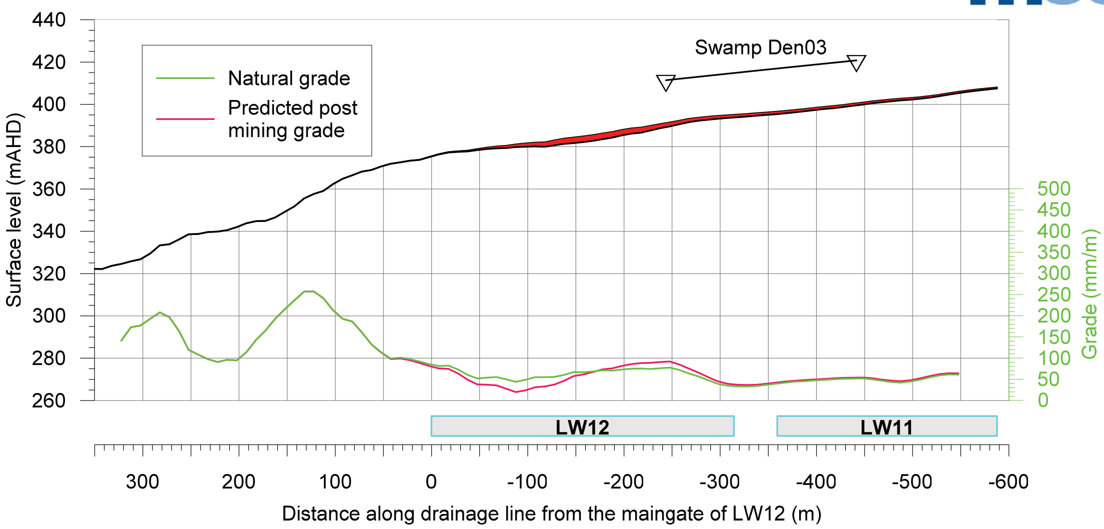

Figure 5 Natural and predicted post mining surface levels along Drainage Line LA5

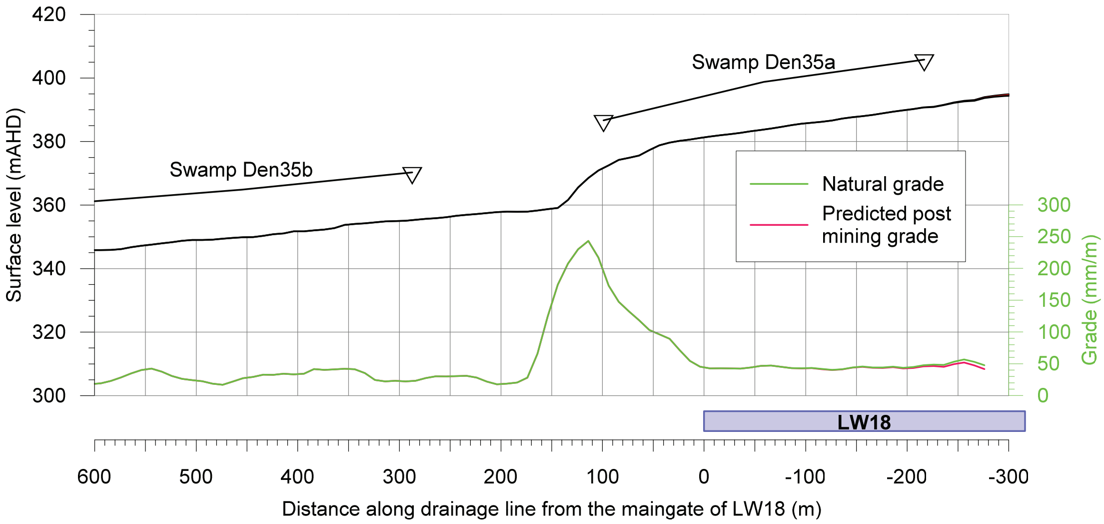

Figure 6 Natural and predicted post mining surface levels along Drainage Line ND1

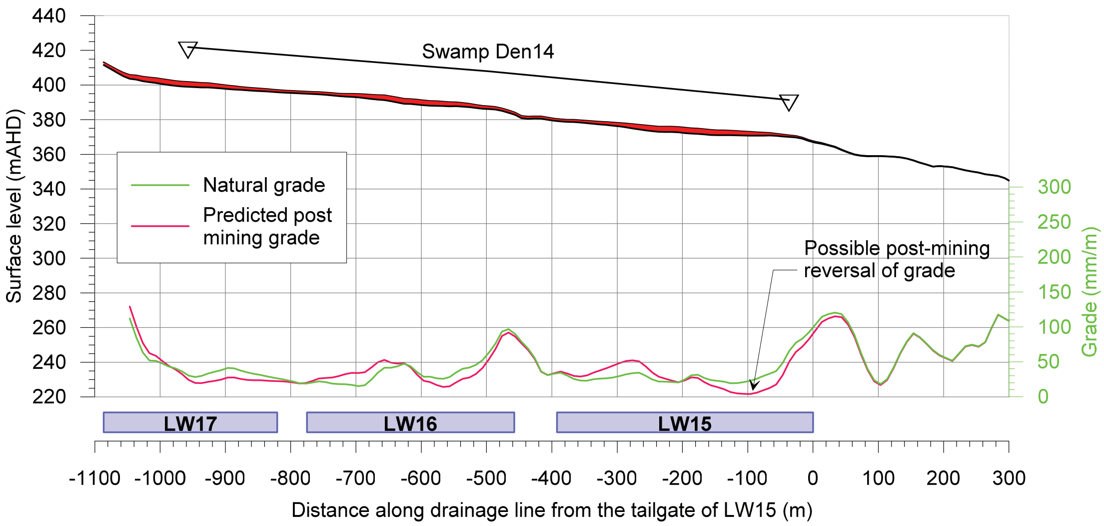

Figure 7 Natural and predicted post mining surface levels along Drainage Line WC15

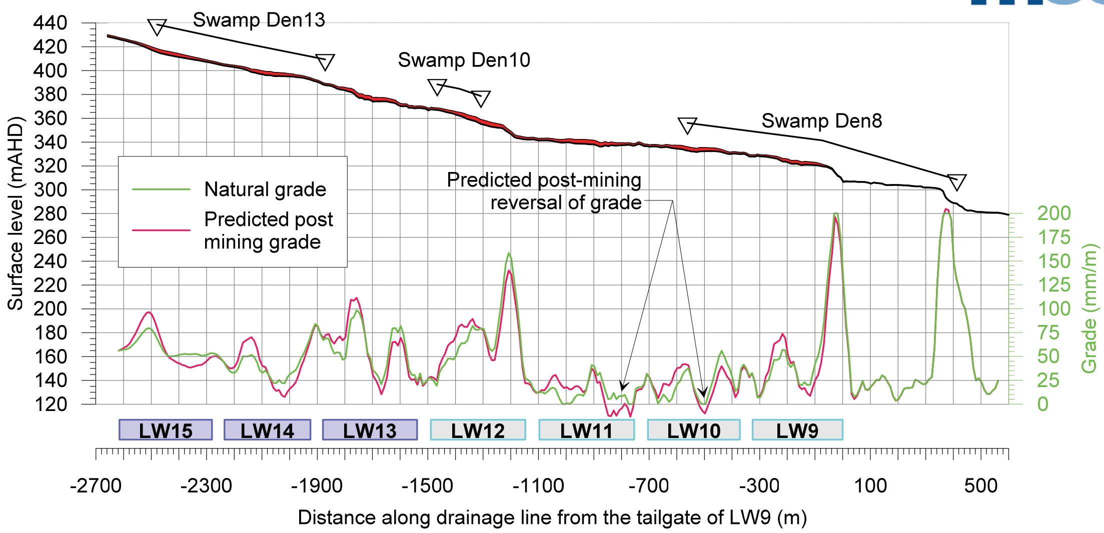

Figure 8 Natural and predicted post mining surface levels along Drainage Line WC21

Swamps

There are 13 swamps that are located directly above Longwalls 9 to 18 in Area 3B. A summary of the maximum predicted total vertical subsidence, tilt and curvature for the swamps, due to the extraction of Longwalls 9 to 18, is provided in Table 2.

Table 2 Maximum predicted total vertical subsidence, tilt and curvature for the swamps due to the extraction of Longwalls 9 to 18

Swamp Ref.	Maximum predicted total vertical subsidence (mm)	Maximum predicted total tilt (mm/m)	Maximum predicted total hogging curvature (km^{-1})	Maximum predicted total sagging curvature (km^{-1})
Den01a	2600	25	0.35	0.50
Den01b	2100	20	0.25	0.40
Den03	2750	20	0.30	0.40
Den04	2700	17	0.20	0.40
Den05	2700	25	0.40	0.55
Den08	3200	30	0.60	0.75
Den10	3500	35	0.70	0.85
Den11	2400	25	0.40	0.45
Den13	2850	30	0.50	0.65
Den14	3100	30	0.60	0.75
Den23	3000	30	0.55	0.70
Den35a	1150	30	0.60	0.08
Den35b	< 20	< 0.5	< 0.01	< 0.01

The swamps are located near the bases of drainage lines and, therefore, could experience valley related movements. A summary of the maximum predicted valley related upsidence and closure movements for the swamps as well as the maximum predicted conventional closures is provided in Table 3. It is noted, that the conventional closures are normally provided separately to the valley related closures, as the associated conventional strains are distributed across the longwalls, as opposed to the valley related compressive strains which are concentrated in the valley bases. Also, in most cases, the valley related closures and conventional closures are orientated obliquely to each other.

Table 3 Maximum predicted total valley related upsidence, valley related closure and conventional closure for the swamps due to the extraction of Longwalls 9 to 18

Swamp Ref.	Maximum predicted total upsidence (mm)	Maximum predicted total valley related closure (mm)	Maximum predicted total conventional closure (mm)
Den01a	300	200	325
Den01b	200	150	325
Den03	150	100	275
Den04	175	175	225
Den05	375	275	350
Den08	700	700	275
Den10	275	275	325
Den11	225	225	200
Den13	400	400	275
Den14	625	600	400
Den23	325	275	175
Den35a	200	350	< 50
Den35b	175	450	< 50

The predicted conventional hogging curvature (i.e. blue contours with positive magnitudes) and sagging curvature (i.e. red contours with negative magnitudes) are illustrated in: Figure 9 for Swamps Den01a and Den01b; Figure 10 for Swamps Den03 and Den04; Figure 11 for Swamp Den05; Figure 12 for Swamp Den08; Figure 13 for Swamps Den10 and Den13; Figure 14 for Swamps Den11 and Den23; Figure 15 for Swamp Den14; and Figure 16 for Swamp Den35a. It is noted that the hogging and sagging curvature contours cross in some locations, such as near the corners of the longwalls, which signifies that these components of curvature occur in orthogonal directions.

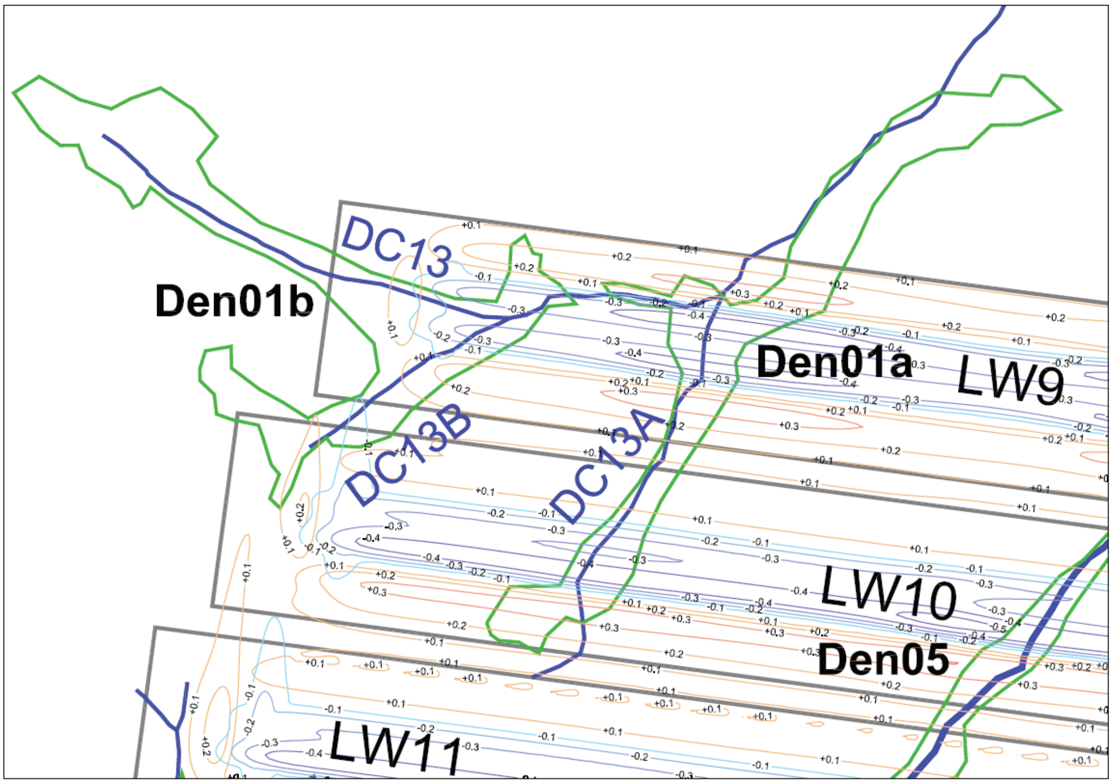

Figure 9 Predicted total hogging and sagging curvatures for Swamps Den01a and Den01b

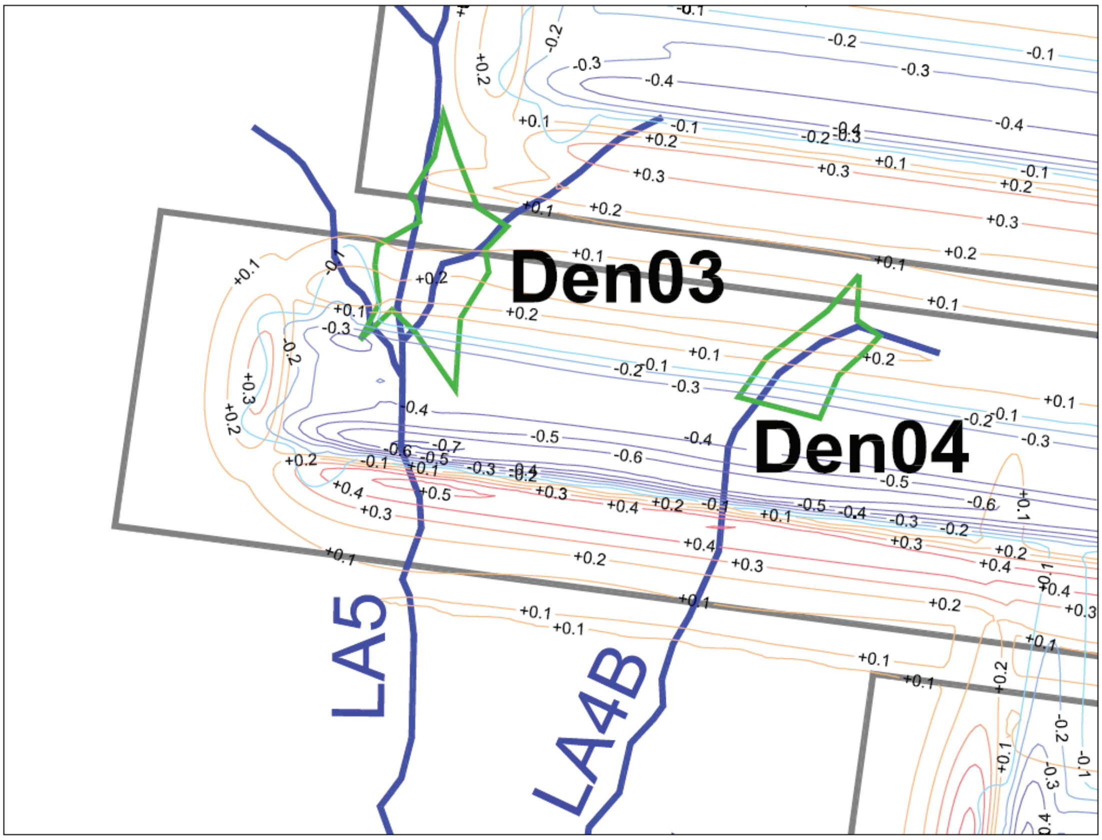

Figure 10 Predicted total hogging and sagging curvatures for Swamps Den03 and Den04

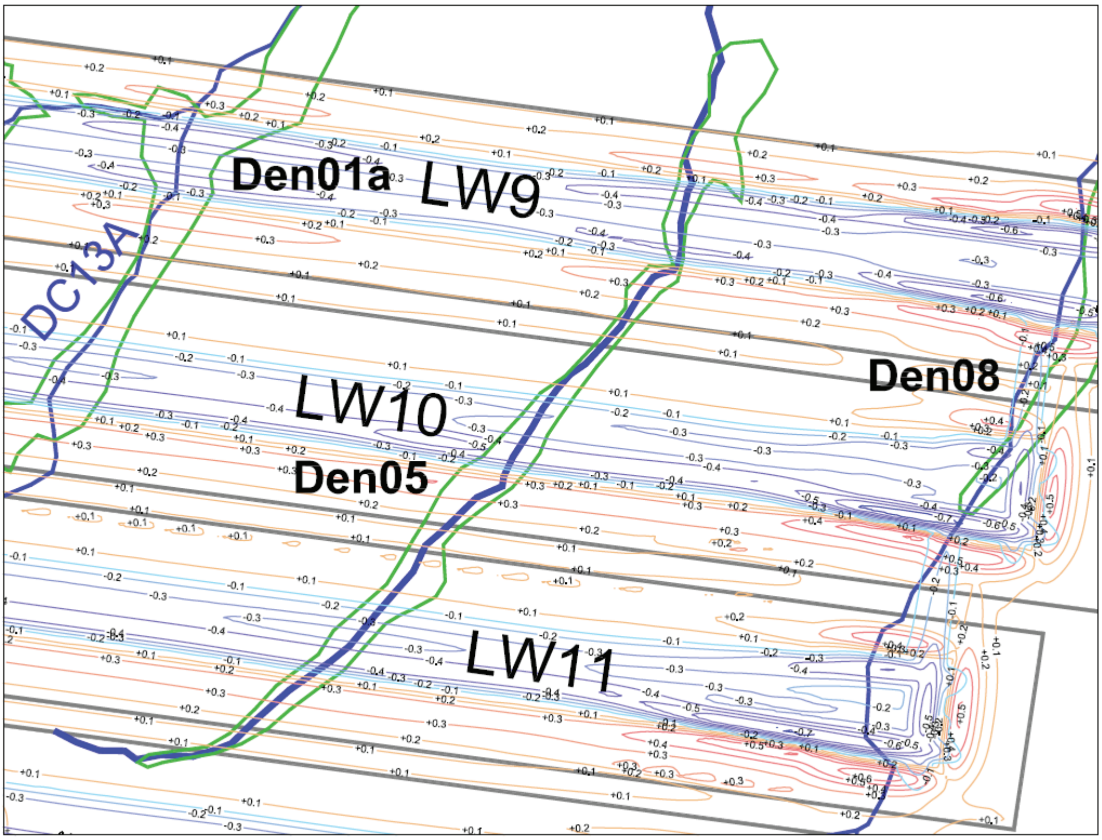

Figure 11 Predicted total hogging and sagging curvatures for Swamp Den05

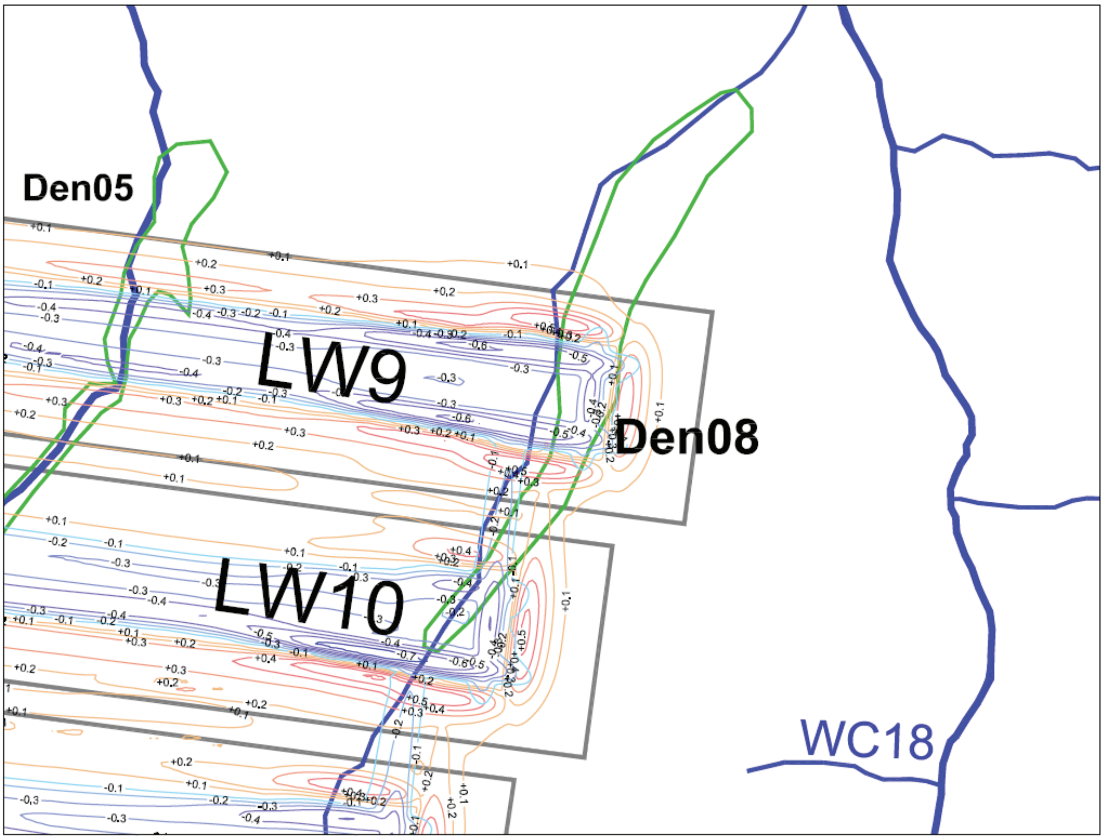

Figure 12 Predicted total hogging and sagging curvatures for Swamp Den08

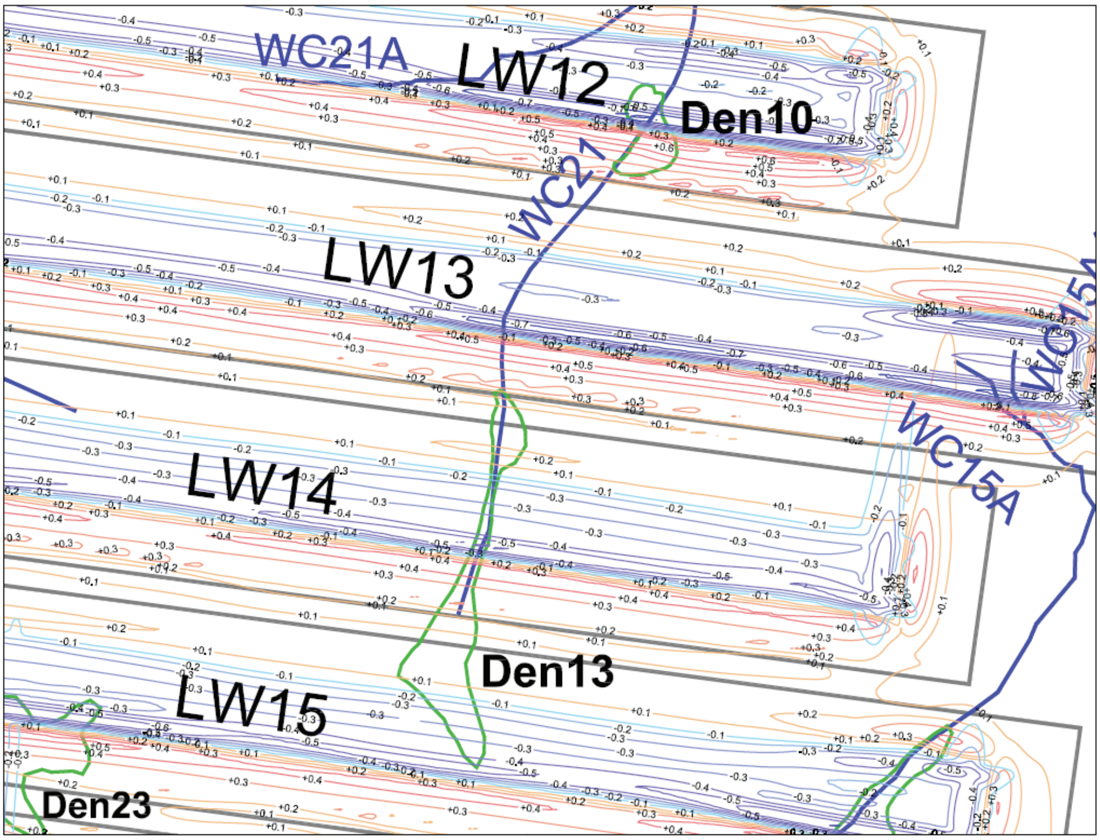

Figure 13 Predicted total hogging and sagging curvatures for Swamps Den10 and Den13

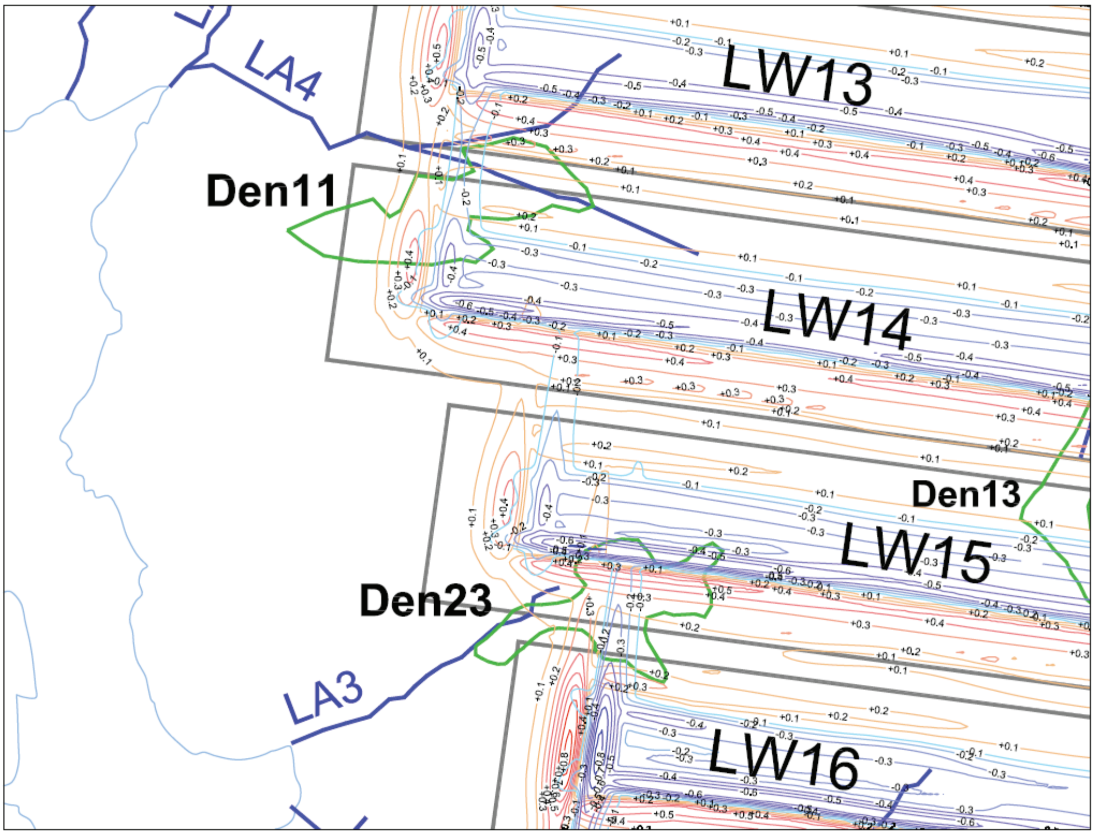

Figure 14 Predicted total hogging and sagging curvatures for Swamps Den11 and Den23

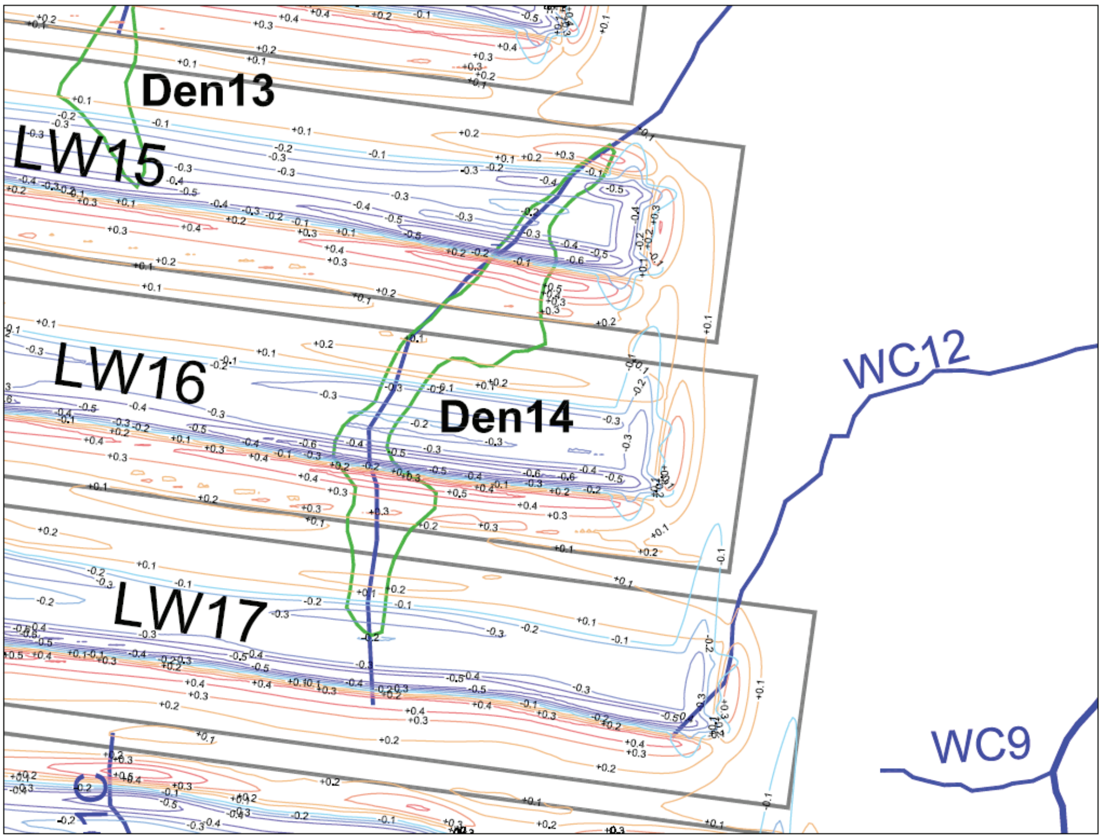

Figure 15 Predicted total hogging and sagging curvatures for Swamp Den14

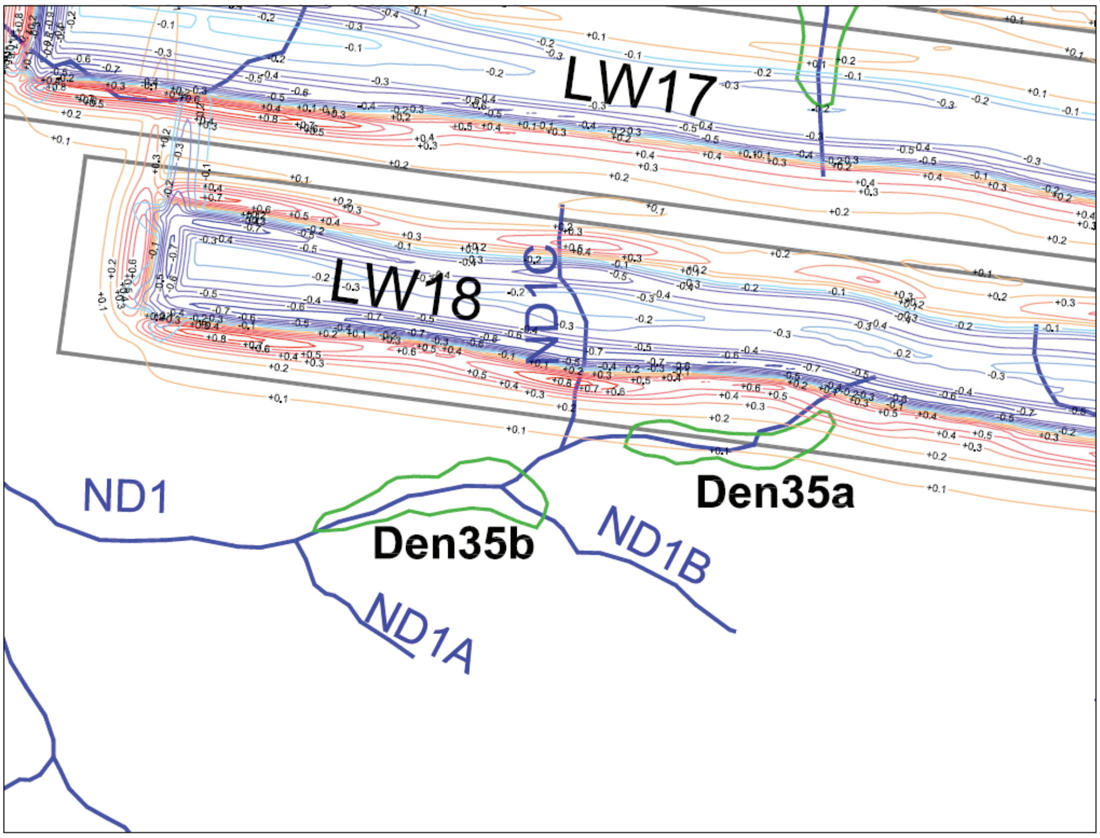

Figure 16 Predicted total hogging and sagging curvatures for Swamp Den35a

The comparisons between the existing (black) and predicted post-mining (red) surface level contours for Swamps Den01a, Den01b, Den03, Den04, Den05, Den08, Den10, Den11, Den13, Den14, Den23, Den35a and Den35b are provided in Figure 17 to Figure 24.

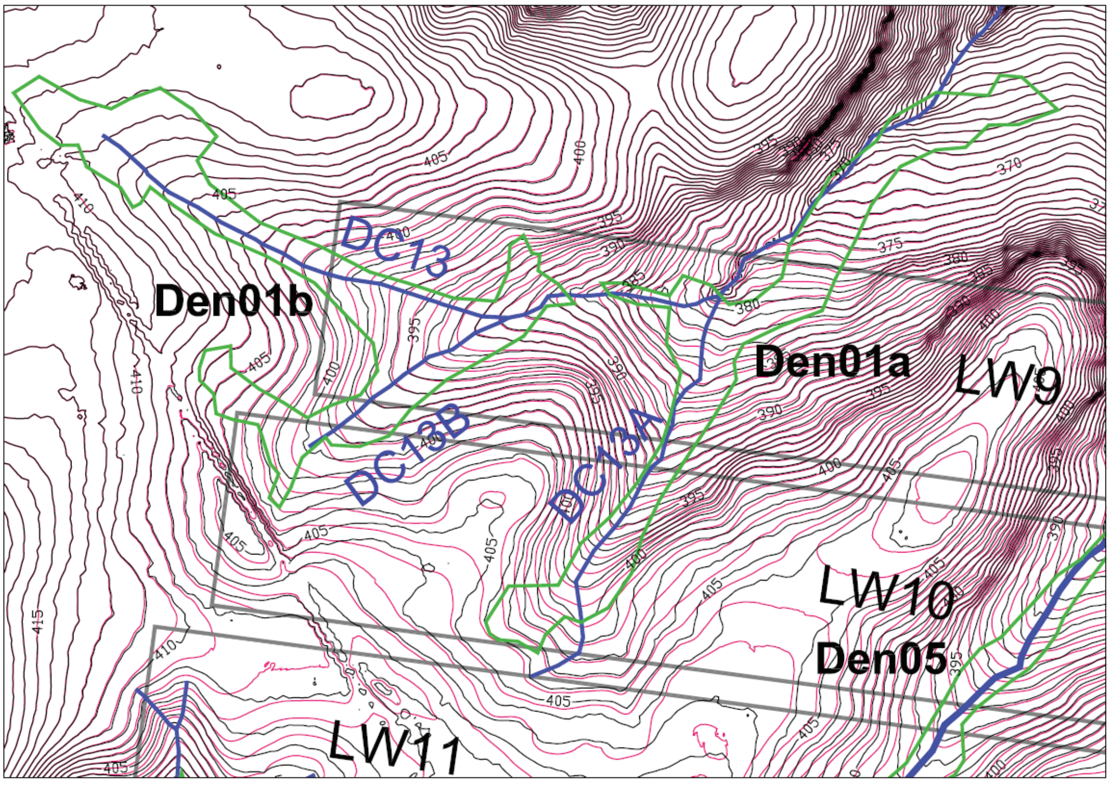

Figure 17 Existing and predicted post-mining surface levels for Swamps Den01a and Den01b

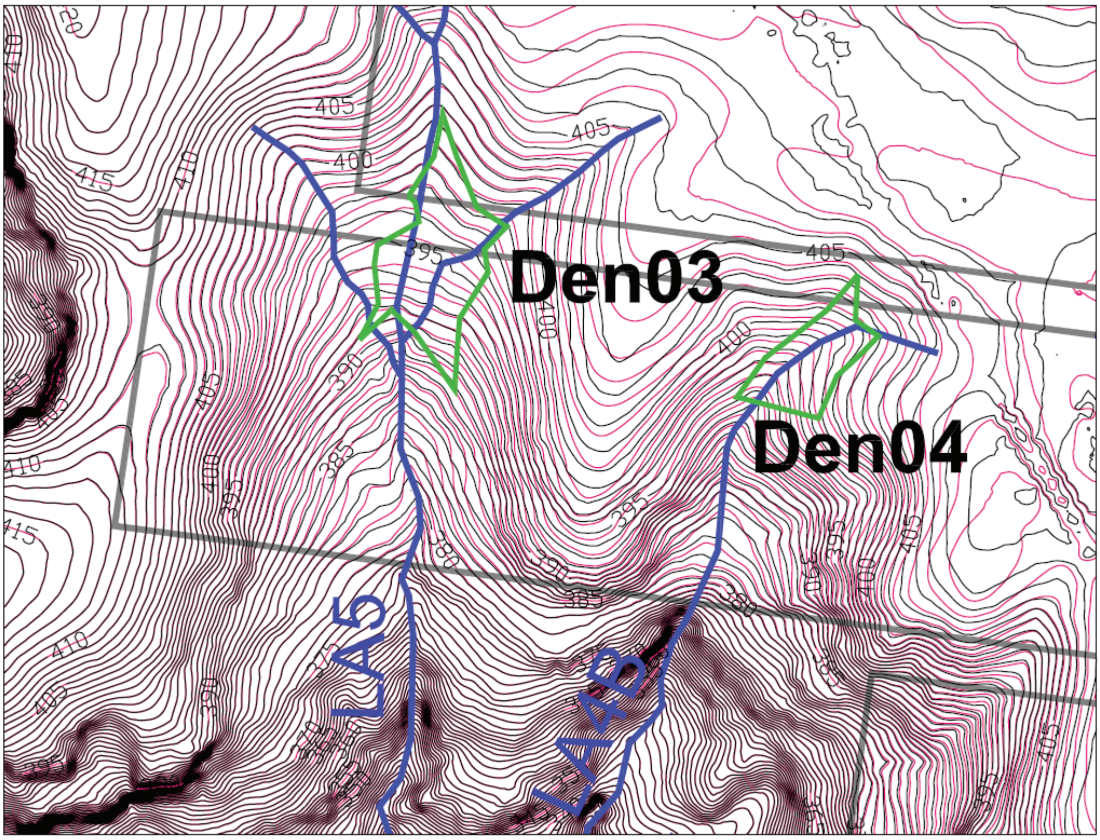

Figure 18 Existing and predicted post-mining surface levels for Swamps Den03 and Den04

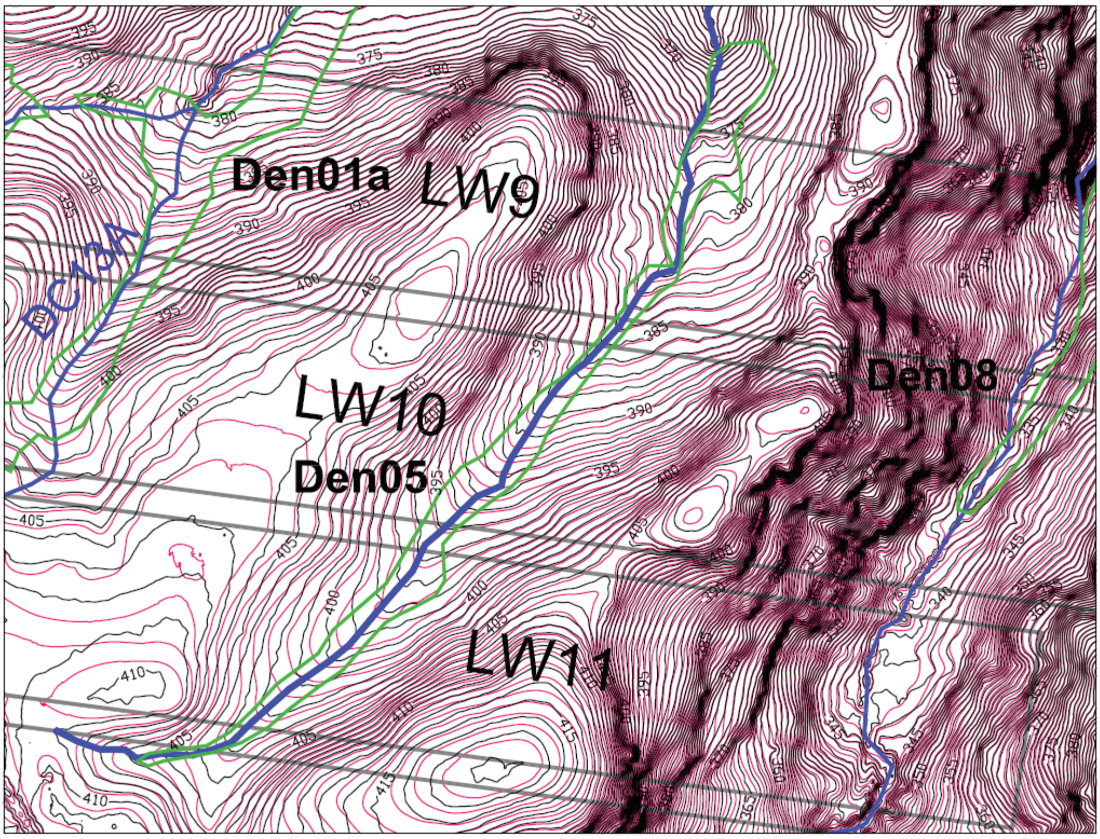

Figure 19 Existing and predicted post-mining surface levels for Swamp Den05

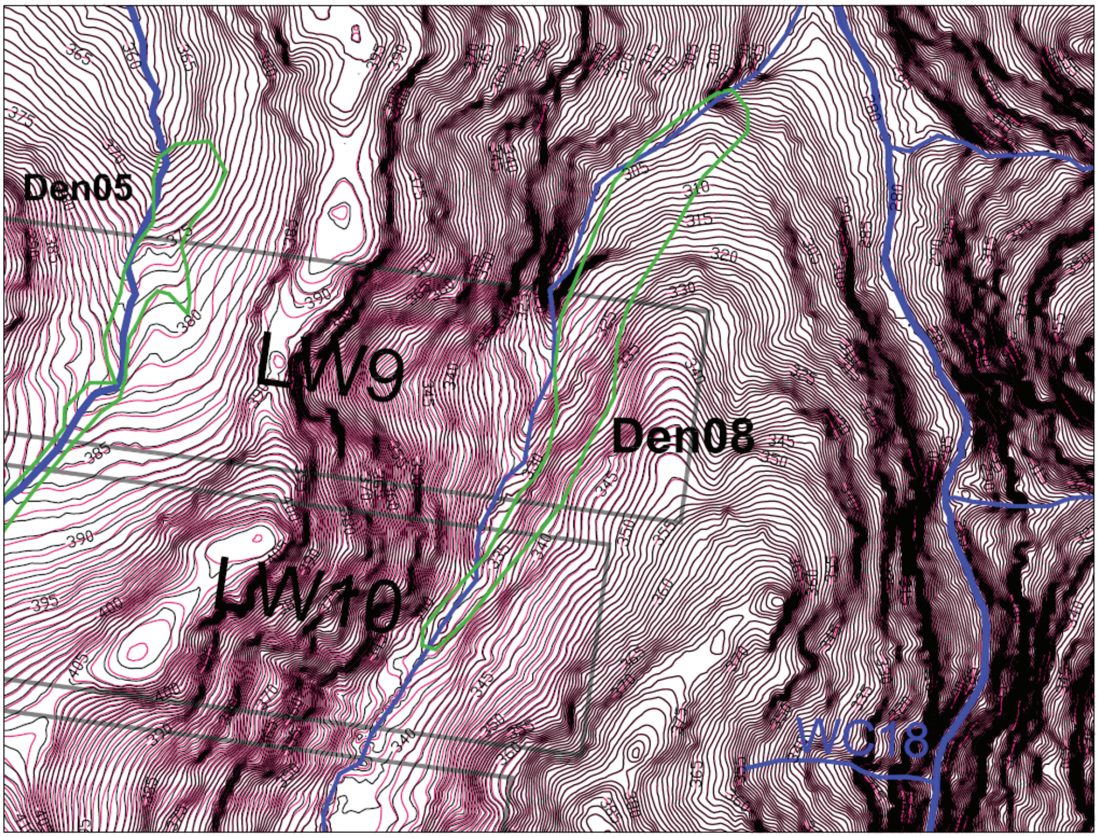

Figure 20 Existing and predicted post-mining surface levels for Swamp Den08

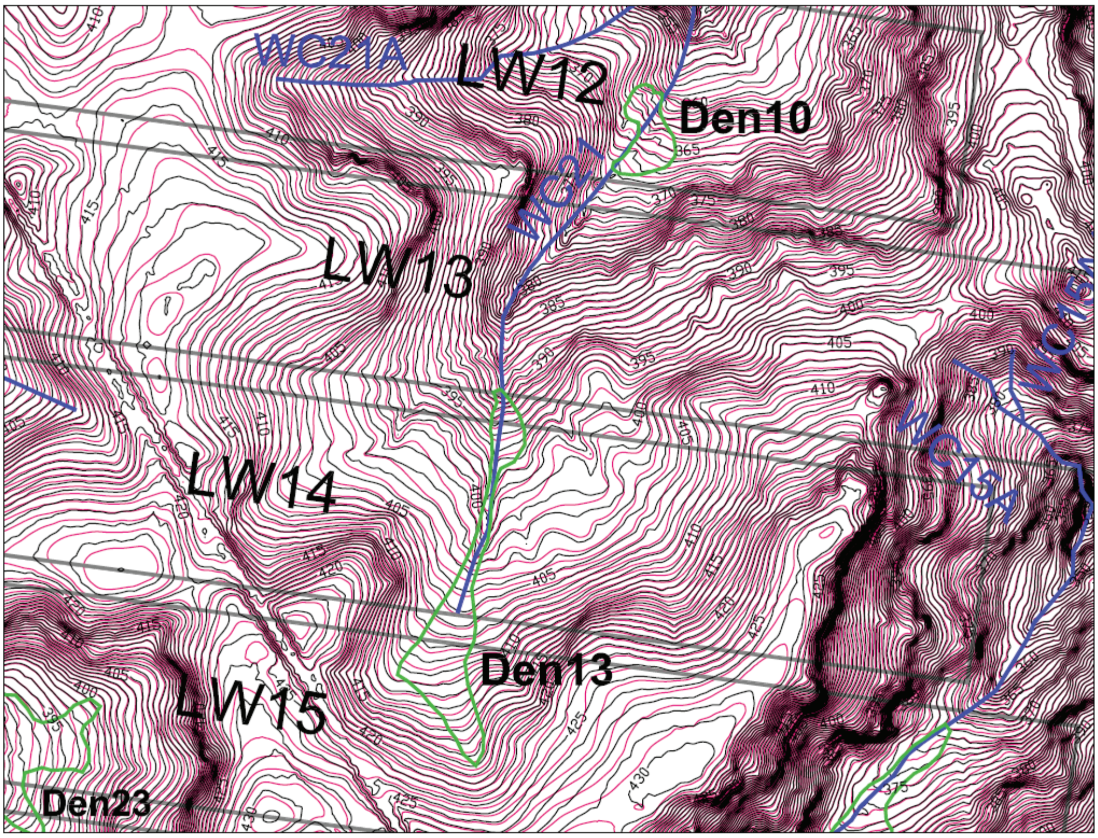

Figure 21 Existing and predicted post-mining surface levels for Swamps Den10 and Den13

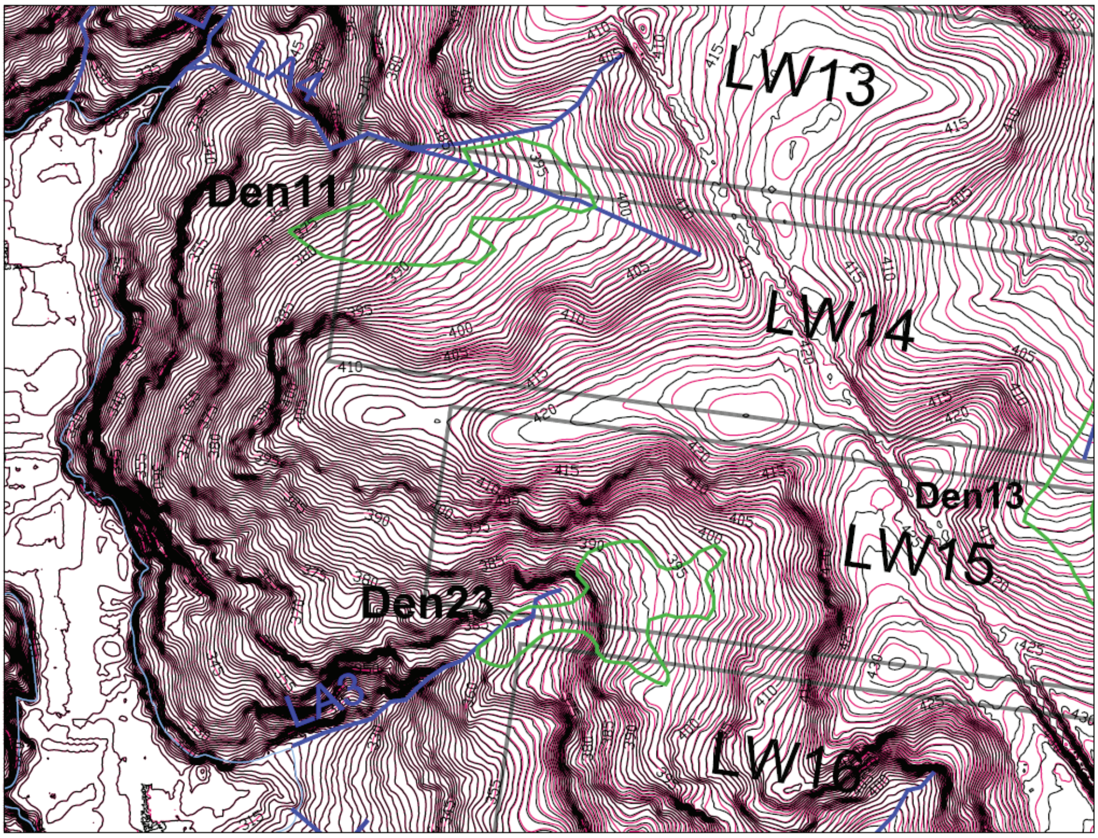

Figure 22 Existing and predicted post-mining surface levels for Swamps Den11 and Den23

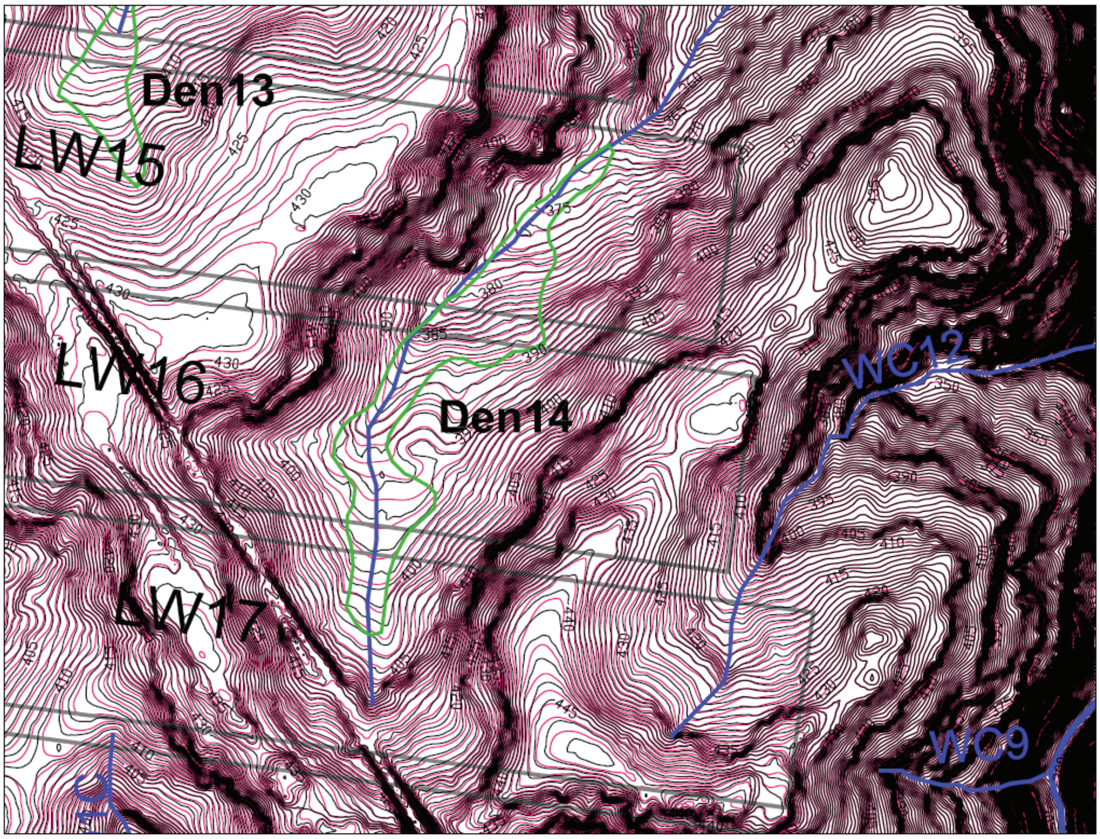

Figure 23 Existing and predicted post-mining surface levels for Swamp Den14

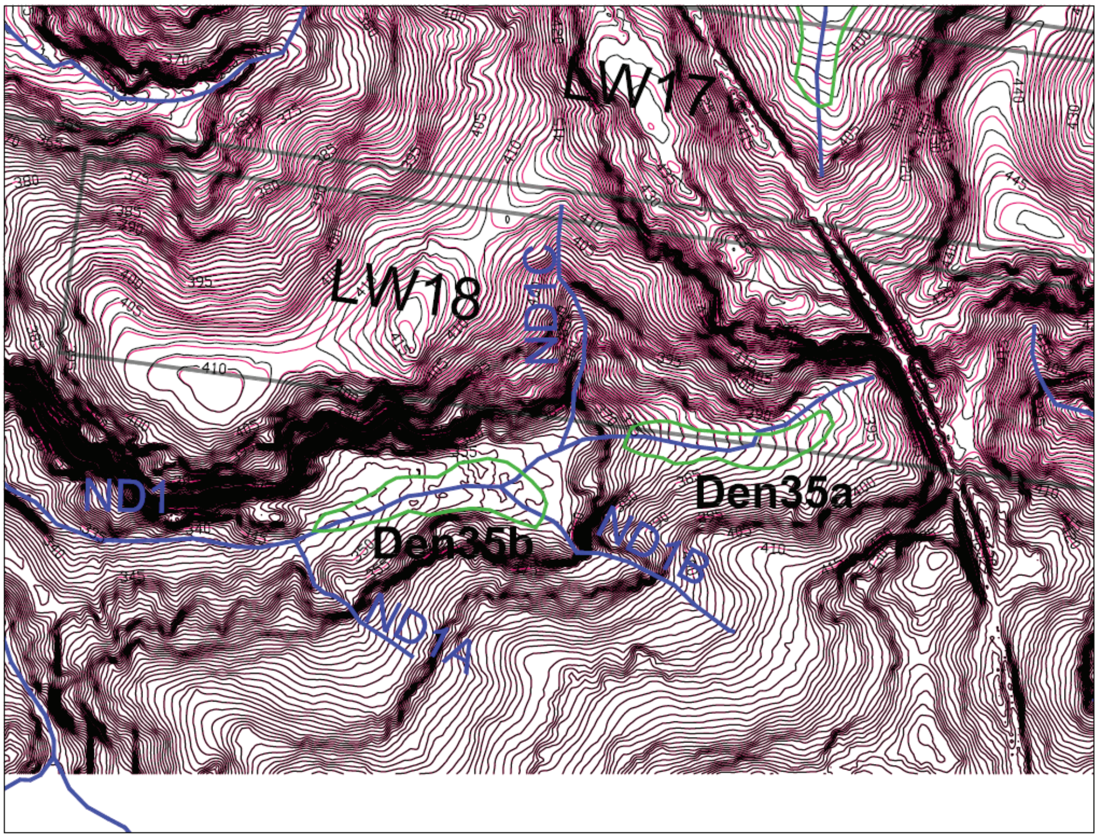

Figure 24 Existing and predicted post-mining surface levels for Swamp Den35a

Waterfall WC-WF54

Waterfall WC-WF54 is located along Wongawilli Creek approximately 130 m to the east of the finishing end of Longwall 18. A summary of the maximum predicted values of total vertical subsidence, upsidence and closure for the waterfall is provided in Table 4.

Table 4 Maximum predicted total vertical subsidence, upsidence and closure for Waterfall WC-WF54 due to the extraction of Longwalls 9 to 18

Feature	Longwalls	Maximum predicted total vertical subsidence (mm)	Maximum predicted total upsidence (mm)	Maximum predicted total closure (mm)
WC-WF54	LW9 to LW18	< 20	60	110

Waterfall WC-WF54 is predicted to experience less than 20 mm of vertical subsidence due to the extraction of Longwalls 9 to 18. Whilst the waterfall could experience very low levels of vertical subsidence, it is not expected to experience measurable tilts, curvatures or conventional strains.

I trust that the information provided is of assistance. If you have any questions or require further information, please email or call me on (02) 9413-3777.

Yours sincerely,

James Barbato

Mine Subsidence Engineering Consultants