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11 March 2011

Industry & Investment NSW
P.O. Box 344
Hunter Region Mail Centre NSW 2310

Attn: Paul Langley, Subsidence Executive Officer

Dear Paul

Application for Variation to West Cliff Longwall 34-36 SMP Approved Mine Plan – Reduction in Longwall 35 Void

Pursuant to Condition 1 of the Subsidence Management Plan Approval for Longwalls 34-36 dated 6 August 2010, approval is sought to vary the area of extraction as shown on Approved Plan AS-2226.

Approval is sought to reduce the length of Longwall 35 (void) by 750m at the western end as shown on attached Approved Plan AS-2226.

The variation is required due to the operational issues associated with the effectiveness of gas drainage and compliance with the West Cliff Outburst Management Plan.

The proposed shortening of Longwall 35 equates to approximately 790,000 tonnes of in-situ coal which will not be mined.

The impact of the reduction in length of Longwall 35 has been assessed by Mine Subsidence Engineering Consultants as the same or less than the previous layout.

Pursuant to Condition 1 of the SMP Approval, Illawarra Coal seeks Approval of the new Approved Plan, AS-2226.

If you have any queries please contact the undersigned.

Yours sincerely,

Richard Walsh
Manager Approvals

Att: 3 A0 Plan AS-2226 Variation to Approved Plan signed by the Operations Manager 9 March 2011
2 A0 Plan AS-2227 Plan 2 - Surface Features
MSEC Report 463 Dated 1 March 2011

BHP BILLITON ILLAWARRA COAL:

West Cliff Colliery – Longwall 35

The Effects of the Proposed Modified Commencing End of Longwall 35 on Previous Subsidence Predictions and Impact Assessments

DOCUMENT REGISTER

Revision	Description	Author	Checker	Date
01	Draft Issue	JB	-	22nd Feb 11
A	Final Issue	JB	PLD	1st Mar 11

Report produced to:- Support the Application to Modify the Commencing End of West Cliff Longwall 35 to be assessed by Industry and Investment NSW.

Previous reports:- MSEC326 (Revision C – December 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 34 to 36 in Area 5 at West Cliff Colliery (In Support of the SMP Application).

MSEC344 (Revision B – February 2008) - Predicted Subsidence Parameters at the Sydney Catchment Authority Infrastructure Resulting from Alternative Layouts of West Cliff Longwalls 34 to 36.

MSEC386 (Revision B – December 2008) - The Effects of Five Optional Modified Commencing Ends of Longwall 34 at West Cliff Colliery on the Previous Subsidence Predictions and Impact Assessments.

MSEC444 (Revision B – February 2010) - The Effects of the Proposed Modified Finishing End of Longwall 34 at West Cliff Colliery on Previous 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)

CONTENTS

LIST OF TABLES, FIGURES AND DRAWINGS

Tables

Tables are prefaced by the number of the chapter in which they are presented.

Figures

Figures are prefaced by the number of the chapter or the letter of the appendix in which they are presented.

Drawings

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

Drawing No.	*Description*	*Revision*
MSEC463-01	General Layout	A
MSEC463-02	Depth of Cover Contours	A
MSEC463-03	Natural Features	A
MSEC463-04	Water and Gas Infrastructure	A
MSEC463-05	Electrical and Telecommunications Infrastructure	A
MSEC463-06	Building Structures, Farm Dams, Archaeological Sites and Survey Marks	A
MSEC463-07	Predicted Incremental Subsidence Contours due to Longwall 35	A
MSEC463-08	Predicted Total Subsidence Contours due to Longwalls 29 to 36	A

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 34 to 36 at West Cliff Colliery. Report No. MSEC326 (Revision C) was issued in December 2007, which supported the SMP Application for these longwalls.

IC then modified Longwall 34 by shortening the commencing (western) end by 895 metres from that indicated in the SMP Application. Report No. MSEC386 (Revision B) was issued in December 2008, which supported the application for the modification of the commencing end of Longwall 34.

IC then modified Longwall 34 by shortening the finishing (eastern) end by 125 metres from that indicated in the SMP Application. Report No. MSEC444 (Revision B) was issued in February 2010, which supported the application for the modification of the finishing end of Longwall 34.

IC now proposes to shorten the commencing (western) end of Longwall 35 by 750 metres from that indicated in the SMP Application. This report provides information that will support a Variation to the Approved Subsidence Management Plan.

The longwall layout adopted in Report No. MSEC326, which supported the SMP Application for Longwalls 34 to 36, is referred to as the *SMP Layout* in this report. The longwall layout adopted in Report No. MSEC444, which includes the modified commencing and finishing ends of Longwall 34, is referred to as the *Previous Layout* in this report. The longwall layout that includes the previous modifications and the proposed shortened commencing end of Longwall 35 is referred to as the *Modified Layout* in this report.

1.2. Mining Geometry

The Previous and Modified Layouts of the longwalls at West Cliff Colliery are overlaid in Drawing No. MSEC463-01, in Appendix B. A summary of the dimensions of Longwall 35 for both these layouts is provided in Table 1.1.

Table 1.1 Dimensions of the Proposed Longwall 35 Based on the Previous and Modified Layouts

Layout	Overall Void Length Including Installation Heading (m)	Overall Void Width Including First Workings (m)	Overall Tailgate Chain Pillar Width (m)
Previous Layout	4240	305	42
Modified Layout	3490	305	42

The longwall is proposed to be extracted from the Bulli Seam. The depths of cover contours for this seam are shown in Drawing No. MSEC463-02. The depth of cover directly above the commencing end of Longwall 35 is around 520 metres, based on the Previous Layout, and is around 500 metres, based on the Modified Layout.

The thickness of the Bulli Seam at the commencing end of Longwall 35 is around 2.65 metres, based on the Previous Layout, and is around 2.35 metres, based on the Modified Layout. IC proposed to extract a minimum seam thickness of 2.4 metres.

2.0 THE EFFECTS OF THE PROPOSED MODIFIED COMMENCING END OF LONGWALL 35 ON THE MAXIMUM PREDICTED SUBSIDENCE PARAMETERS

2.1. Maximum Predicted Conventional Subsidence Parameters

The Incremental Profile Method was previously used to predict the conventional subsidence parameters resulting from the extraction of Longwalls 29 to 36, based on the SMP Layout, and these predictions were provided in Report No. MSEC326. The Incremental Profile Method was also used to predict the conventional subsidence parameters resulting from the extraction of Longwalls 29 to 36, based on the Previous Layout, which were provided in Report No. MSEC444.

The Incremental Profile Method has now been used to predict the conventional subsidence parameters resulting from the extraction of Longwalls 29 to 36, based on the Modified Layout. The predicted incremental subsidence contours due to the extraction of Longwall 35, based on the Modified Layout, are shown in Drawing No. MSEC463-07. The predicted total subsidence contours resulting from the extraction of Longwalls 29 to 36, based on the Modified Layout, are shown in Drawing No. MSEC463-08. The predicted incremental and total 20 mm subsidence contours, based on the Previous Layout, are also shown in these drawings for comparison.

A summary of the maximum predicted values of incremental conventional subsidence, tilt and curvature due to the extraction of Longwall 35, based on both the Previous and Modified Layouts, is provided in Table 2.1.

Table 2.1 Maximum Predicted Incremental Conventional Subsidence, Tilt and Curvature Resulting from the Extraction of Longwall 35 Based on the Previous and Modified Layouts

Layout	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	785	5.8	0.05	0.12
Modified Layout	785	5.8	0.05	0.12

It can be seen from the above table, that the maximum predicted incremental conventional subsidence parameters, due to the extraction of Longwall 35, do not change as a result of the proposed modification to the longwall commencing end.

Although the predicted maxima do not change, the locations of the predicted maximum longitudinal tilt and curvatures change as a result of the proposed modification to the longwall commencing end. This is illustrated in Fig. A.01, in Appendix A, which shows the profiles of predicted incremental subsidence, tilt and curvature along Prediction Line 1, which has been taken through the commencing end of Longwall 35, as shown in Drawings Nos. MSEC463-07 and MSEC463-08.

It can be seen from Fig. A.01, that the predicted longitudinal tilt and curvatures at the commencing end of Longwall 35 have moved around 750 metres towards the east as a result of the proposed modification. It can also be seen, that the magnitudes of the predicted longitudinal tilt and curvatures, based on the Modified Layout, are similar to those predicted based on the Previous Layout.

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, and the depth of bedrock. 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 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 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 incremental conventional strains due to the extraction of Longwall 35, based on applying a factor of 15 to the maximum predicted incremental conventional curvatures, are 0.8 mm/m tensile and 1.8 mm/m 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 strains for low magnitudes of curvature. In this report, therefore, we have provided a statistical approach to account for the variability, instead of just providing a single predicted conventional strain.

The range of potential strains above Longwall 35 has been determined using monitoring data from the previously extracted longwalls in the Southern Coalfield. The monitoring data was used from West Cliff Colliery, as well as the nearby Appin, Tower and Tahmoor Collieries, where the overburden geology and mining geometry are reasonably similar to the proposed longwalls. The range of strains measured during the extraction of these longwalls should, therefore, provide a reasonable indication of the range of potential strains for the proposed longwall.

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 total tensile and compressive strains that have been measured at any time during mining, 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 total tensile and compressive strains measured in survey bays above goaf, for the previously extracted longwalls from the Southern Coalfield, is provided in Fig. 4.1. The probability distribution functions, based on the fitted GPDs, have also been shown in this figure.

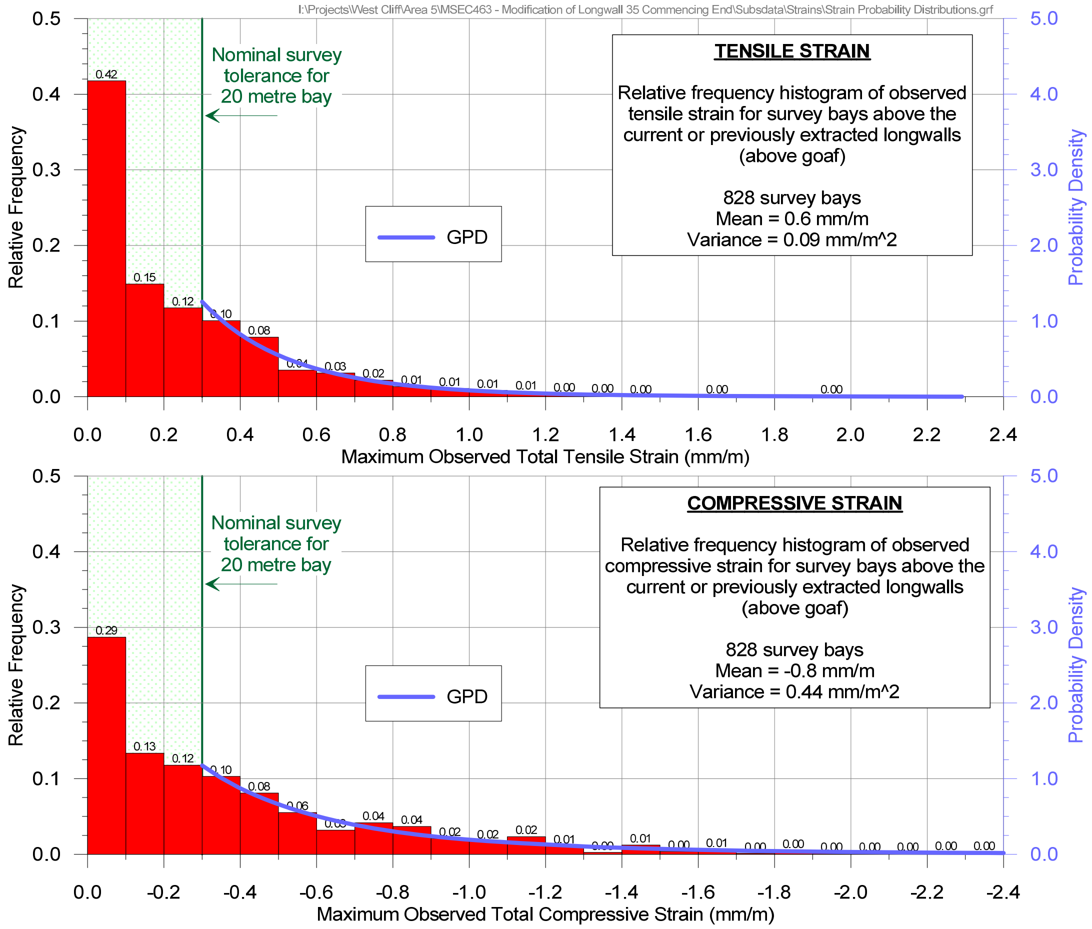


Fig. 2.1 Distributions of the Maximum Observed Total Tensile and Compressive Strains during the Extraction of Previous Longwalls for Survey Bays Located Above Goaf

It is noted, that the T-Line in Appin Area 4 was not included in the analysis of strains. A compressive strain of 16.6 mm/m occurred along the T-Line above Appin Longwall 408, which was the result of movements along a low angle thrust fault which daylighted above the Cataract Tunnel. This was an extreme case for the Southern Coalfield and, since no such faults have been identified within the Study Area, the T-Line was not included in the strain analysis, as it would have otherwise skewed the results.

The averages of the maximum strains that the individual survey bays experienced at any time during mining were 0.6 mm/m tensile and 0.8 mm/m compressive. The maximum strains that any survey bay experienced at any time during mining were 2.3 mm/m tensile and 5.1 mm/m compressive.

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 a longwall extraction, 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 strains that the individual survey bays experienced at any time during mining were 0.8 mm/m tensile and 1.5 mm/m compressive. The 99 % confidence levels for the maximum strains that the individual survey bays experienced at any time during mining were 1.3 mm/m tensile and 2.7 mm/m compressive.

2.3. Maximum Predicted Valley Related Movements

The predicted valley related movements along the watercourses at West Cliff Colliery 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 predicted upsidence and closure movements for the watercourses near the commencing end of Longwall 35 are discussed further in Chapter 3.

For the watercourses which are located directly above Longwall 35, the predicted maximum upsidence and closure movements do not change as a result of the proposed modification to the commencing end of this longwall.

For the watercourses which are located outside the extents of Longwall 35, the predicted maximum upsidence and closure movement, based on the Modified Layout, are similar to or less than the maxima predicted based on the Previous Layout, depending on the relative location to the commencing end of this longwall.

3.0 THE EFFECTS OF THE PROPOSED MODIFIED COMMENCING END OF LONGWALL 35 ON THE PREDICTIONS AND IMPACT ASSESSMENTS FOR THE NATURAL FEATURES AND ITEMS OF SURFACE INFRASTRUCTURE

3.1. The Study Area

The *Study Area* has been defined as the zone where the predicted mine subsidence parameters, based on the Modified Layout, are different to those predicted based on the Previous Layout. The Study Area has been based on the following:-

- 35 degree angle of draw line from the longwall commencing end, 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 modification to the longwall commencing end, is greater than 20 mm. In all locations, this limit is located within the 35 degree angle of draw line.

The extent of the Study Area is shown in Drawing No. MSEC463-01. There are a number of natural features and items of infrastructure located within this area, which are shown in Drawings Nos. MSEC463-03 to MSEC463-06. There are also a number of features which are located outside the Study Area, which could experience valley related or far-field movements, and could be sensitive to such movements, and these features have also been included as part of the assessments.

The natural features and items of surface infrastructure which have been included in the assessments provided in this report are:-

- Drainage Lines,
- The Upper Canal, Devines Tunnels and Associated Infrastructure,
- Water and Gas Pipelines,
- 330kV Transmission Line,
- 66kV and 11kV Powerlines,
- Copper Telecommunications Cables,
- Fences,
- Farm Dams,
- Building Structures
- Archaeological Sites, and
- Survey Control Marks.

The predicted vertical subsidence at the natural features and items of infrastructure 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 less than those based on the Previous Layout, depending on their position relative to the longwall commencing end.

The effects of the proposed modification to the commencing end of Longwall 35 on the subsidence predictions and impact assessments for these features are provided in the following sections.

3.2. Drainage Lines

The locations of the drainage lines in the vicinity of Longwall 35 are shown in Drawing No.MSEC463-03. There are no major drainage lines which are located directly above Longwall 35 within the Study Area.

Leafs Gully is partially located within the Study Area and is at a minimum distance of 300 metres south-west of Longwall 35, based on the Previous Layout. The gully is located at a distance of 380 metres south of the commencing end of Longwall 35, based on the Modified Layout.

A tributary to Nepean Creek is also partially located within the Study Area and is at a minimum distance of 110 metres north-east of Longwall 35, based on the Previous Layout. The tributary is located at a distance of 190 metres north of the commencing end of Longwall 35, based on the Modified Layout

As the drainage lines are located outside the extents of Longwall 35, the predicted mine subsidence parameters at these features, based on the Modified Layout, are similar to or less than those predicted based on the Previous Layout.

In consequence, the assessed levels of impact for the drainage lines do not change or reduce as a result of the proposed modification of the longwall commencing end. The proposed management strategies for the drainage lines, therefore, are the same as those previously provided in Report No. MSEC326 and the SMP Application.

3.3. SCA Infrastructure

The locations of the Sydney Catchment Authority (SCA) infrastructure in the vicinity of Longwall 35 are shown in Drawing No.MSEC463-04. The infrastructure includes the Upper Canal, Devines Tunnels and associated infrastructure. A summary of the minimum distances of the SCA infrastructure from the commencing end of Longwall 35, based on both the Previous and Modified Layouts, is provided in Table 3.1.

Table 3.1 Minimum Distances between the SCA Infrastructure and the Commencing End of Longwall 35

SCA Infrastructure	Minimum Distance to Commencing End of Longwall 35 (m)	
	Previous Layout	Modified Layout
Upper Canal	275	950
Devines Tunnel No. 1	1200	1275
Devines Tunnel No. 2	525	1050
Mallaty Creek Aqueduct	1550	1550
Concrete Aqueduct C	1400	1425
Concrete Aqueduct D	1150	1225
Leafs Gully Aqueduct	375	1075
Nepean Creek Aqueduct	500	950

It can be seen from the above table, that the distances between the SCA infrastructure and the commencing end of Longwall 35 increase by up to 700 metres, as a result of the proposed modification. The SCA infrastructure are located at distances around or greater than 1 kilometre from the commencing end of Longwall 35, based on the Modified Layout.

At these distances, the predicted incremental subsidence, upsidence and closure movements at the infrastructure, due to the extraction of Longwall 35, are less than the order of survey tolerance. It is unlikely, therefore, that the SCA infrastructure would be impacted by the conventional and valley related movements resulting from the extraction of Longwall 35, even if the predicted movements were increased by a factor of 2 times.

The SCA infrastructure could be subjected to far-field horizontal movements as a result of the extraction of the Longwall 35. Far-field horizontal movements have, in the past, been observed at similar distances as the SCA infrastructure is from the proposed longwall, however, these movements tend to be bodily movements associated with very low levels of strain. It is unlikely, therefore, that the SCA infrastructure would be impacted by the far-field horizontal movements resulting from the extraction of the Longwall 35, even if the predicted movements were increased by a factor of 2 times.

A summary of the maximum predicted total subsidence, upsidence, closure and minimum radii of curvature at the SCA aqueducts, resulting from the extraction of Longwalls 34 to 36, is provided in Table 3.2. The results in this table are based on the Modified Layout.

Table 3.2 Maximum Predicted Total Subsidence Parameters at the SCA Infrastructure Resulting from the Extraction of Longwalls 34 to 36 Based on the Modified Layout

SCA Infrastructure	Maximum Predicted Total Subsidence (mm)	Maximum Predicted Total Upsidence (mm)	Maximum Predicted Total Closure (mm)	Minimum Predicted Radius of Curvature (km)
Mallaty Creek Aqueduct	< 3	< 3	< 3	> 50
Concrete Aqueducts C and D	< 3	NA	NA	> 50
Leafs Gully Aqueduct	< 3	< 3	4	> 50
Nepean Creek Aqueduct	< 3	< 3	< 3	> 50

It can be seen from the above table, that the SCA aqueducts are predicted to experience very small mine subsidence movements, as the result of the extraction of Longwalls 34 to 36, which are generally in the order of survey tolerance.

The predicted movements provided in Table 3.2 are the same as those previously provided for *Layout C* in the letter issued to the SCA (dated 29th July 2010) entitled *Subsidence Predictions for the SCA Infrastructure based on the Actual Commencing End of West Cliff Longwall 34 and the Proposed Commencing End of West Cliff Longwall 35*.

The SCA infrastructure was previously assessed based on the predicted movements provided in this letter so that any necessary preventive measures could be established. Provided than the necessary preventive measures have been undertaken, it is unlikely that the SCA infrastructure would experience any adverse impacts resulting from the extraction of Longwall 35.

3.4. Water and Natural Gas Pipelines

A pipeline easement crosses above the western end of Longwall 35 as shown in Drawing No.MSEC463-04. There are four pipelines within the easement, being a 1200 mm diameter treated water gravity main and three natural gas pipelines.

The profiles of predicted subsidence, tilt and curvature along the pipeline easement, resulting from the extraction of Longwalls 29 to 36, are shown in Fig. A.02, in Appendix A. The predicted profiles based on the Previous Layout are shown as the cyan lines and the predicted profiles based on the Modified Layout are shown as the blue lines.

It can be seen from Fig. A.02, that the predicted incremental profiles due to the extraction of Longwall 35 (i.e. dashed lines), based on the Modified Layout, are similar to those based on the Previous Layout. That is, the proposed modification does not result in any significant change in the predicted movements along the alignment of the pipeline easement resulting from the extraction of Longwall 35.

It can also be seen from Fig. A.02, that the predicted total profiles resulting from the extraction of Longwalls 29 to 36 (i.e. solid lines), based on the Modified Layout, are less than those predicted based on the Previous Layout above Longwall 36. The reason for this, is that the shortened commencing end of Longwall 35 results in Longwall 36 partially transitioning from a second to a first panel in a series in this location and, hence, the incremental subsidence due to Longwall 36 is reduced.

A summary of the maximum predicted total subsidence, tilt and curvature along the alignment of the pipeline easement within the Study Area, resulting from the extraction of Longwalls 29 to 36, is provided in Table 3.3. The results are provided for both the Previous and Modified Layouts.

Table 3.3 Maximum Predicted Total Subsidence, Tilt and Curvature along the Alignment of the Pipeline Easement within the Study Area Resulting from the Extraction of Longwalls 29 to 36

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})
Previous Layout	800	5.0	0.03	0.09
Modified Layout	700	3.5	0.02	0.04

It can be seen from the above table, that the that the maximum predicted total subsidence parameters along the alignment of the pipeline easement within the Study Area, based on the Modified Layout, are less than those predicted based on the Previous Layout.

A summary of the maximum predicted incremental tilt and curvatures across the alignment of the pipeline easement within the Study Area, due to the extraction of Longwall 35, is provided in Table 3.4.

Table 3.4 Maximum Predicted Incremental Tilt and Curvatures Across the Alignment of the Pipeline Easement within the Study Area Resulting from the Extraction of Longwall 35

Layout	Maximum Predicted Incremental Tilt Across Alignment (mm/m)	Maximum Predicted Incremental Hogging Curvature Across Alignment (km^{-1})	Maximum Predicted Incremental Sagging Curvature Across Alignment (km^{-1})
Previous Layout	3.5	0.01	0.01
Modified Layout	3.5	0.01	0.01

It can be seen from the above table, that the maximum predicted incremental tilt and curvatures across the alignment of the pipeline easement within the Study Area, based on the Modified Layout, are the same as those predicted based on the Previous Layout.

The pipelines will also experience valley related movements at the drainage line crossings. As Longwall 35 is proposed to be shortened, the predicted upsidence and closure movements at the drainage lines, based on the Modified Layout, are similar to or less than those predicted base on the Previous Layout.

In consequence, the assessed levels of impact for the water and gas pipelines do not change or reduce as a result of the proposed modification of the longwall commencing end. The proposed management strategies for the pipelines, therefore, are the same as those previously provided in Report No. MSEC326 and the SMP Application.

3.5. 330kV Transmission Line

The location of the Avon to Macarthur Substation 330 kV Transmission Line (No. 17) is shown in Drawing No. MSEC463-05. The transmission line crosses above the western end of Longwall 35. The transmission line comprises aerial cables which are not adversely affected by curvature or ground strain. The transmission towers, however, could be affected by curvature and ground strain, as well as tilt, in the locations of the towers.

The profiles of predicted subsidence, tilt along and tilt across the alignment of the 330 kV Transmission Line, resulting from the extraction of Longwalls 29 to 36, are shown in Fig. A.03, in Appendix A. The predicted profiles based on the Previous Layout are shown as the cyan lines and the predicted profiles based on the Modified Layout are shown as the blue lines.

A summary of the maximum predicted total subsidence, tilt along and tilt across the alignment of the 330 kV Transmission Line within the Study Area, resulting from the extraction of Longwalls 29 to 36, is provided in Table 3.5. The results are provided for both the Previous and Modified Layouts.

Table 3.5 Maximum Predicted Total Subsidence, Tilt Along and Tilt Across the Alignment of the 330 kV Transmission Line within the Study Area Resulting from the Extraction of Longwalls 29 to 36

Layout	Maximum Predicted Total Subsidence (mm)	Maximum Predicted Total Tilt Along Alignment (mm/m)	Maximum Predicted Total Tilt Across Alignment (mm/m)
Previous Layout	700	2.5	3.5
Modified Layout	400	2.0	3.0

It can be seen from the above table, that the that the maximum predicted total subsidence, tilt along and tilt across the alignment of the 330 kV Transmission Line within the Study Area, based on the Modified Layout, are less than those predicted based on the Previous Layout.

There are two transmission towers located within the Study Area, being Towers 80 and 81, which are shown in Drawing No. MSEC463-05. Tower 80 is a tension tower and a cruciform base has been installed as part of the management strategies for this tower.

A summary of the maximum predicted total subsidence, tilt and curvatures at these towers, resulting from the extraction of Longwalls 29 to 36, is provided in Table 3.6. The results are provided for both the Previous and Modified Layouts. The predicted parameters are the maxima within a 20 metre radius of the tower centrelines. The predicted tilts and curvatures are the maxima at any time during the mining period.

Table 3.6 Maximum Predicted Total Subsidence, Tilt and Curvatures at the Transmission Towers within the Study Area Resulting from the Extraction of Longwalls 29 to 36

Tower	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})
80	Previous Layout	275	2.5	0.02	< 0.01
	Modified Layout	275	2.5	0.02	< 0.01
81	Previous Layout	400	4.5	0.04	0.04
	Modified Layout	300	3.5	0.03	0.03

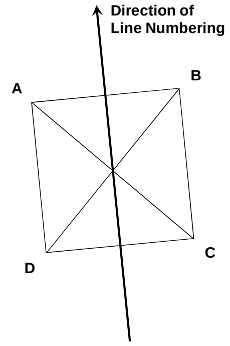
It can be seen from the above table, that the that the maximum predicted total subsidence, tilt and curvatures at the two transmission towers within the Study Area, based on the Modified Layout, are similar to or less than those predicted based on the Previous Layout.

The predicted changes in the K-Point distances have been determined by multiplying the initial distances by the predicted conventional ground strains, which were determined by applying a factor of 15 to the predicted conventional curvatures, as described in Section 2.2. Tower 80 has a cruciform base and, therefore, the K-Point distances are restrained from moving.

A summary of the maximum predicted changes in the K-Point distances for Tower 81, resulting from the extraction of Longwalls 29 to 36, is provided in is provided in Table 3.7. The results are based on the predicted maximum conventional strains at the tower resulting from the Modified Layout.

Table 3.7 Maximum Predicted Changes in K-Point Distances for Tower 81 Resulting from the Extraction of Longwalls 29 to 36 Based on the Modified Layout

Tower	K-Point	Initial Distance (m)	Maximum Predicted Increase in K-Point Distance (mm)	Maximum Predicted Decrease in K-Point Distance (mm)
81	A to B	8.432	+4	-4
	B to C	4.051	+2	-2
	C to D	8.823	+4	-4
	D to A	3.855	+2	-2



Plan of Towers

It is noted, that actual strains and, hence, the actual changes in the K-Point distances could be greater than those predicted as a result of, amongst other things, non-conventional anomalous movements. The range of potential strains above the longwalls at West Cliff Colliery are expected to be similar to those previously experience in the Southern Coalfield, which was discussed in Section 2.2.

Tower 81 is located directly above the proposed Longwall 36 and, therefore, the probabilities of exceedance for strain are expected to be similar to those based on the GPDs fitted to the measured strains for survey bays above goaf in the Southern Coalfield, which were illustrated in Fig. 2.1.

The 95 % confidence levels for the maximum strains that the individual survey bays experienced at any time during mining, based on the fitted GPDs, are 0.8 mm/m tensile and 1.5 mm/m compressive. A summary of the 95 % confidence levels for the changes in K-Point distances for Tower 81 is provided in Table 3.8. These results are based on measured strains over 20 metre survey bays and, therefore, they assume that the distributions of strain over these bays are relatively uniform.

Table 3.8 95 % Confidence Levels for Changes in K-Point Distances for Tower 81

Tower	K-Point	Initial Distance (m)	Maximum Predicted Increase in K-Point Distance (mm)	Maximum Predicted Decrease in K-Point Distance (mm)
81	A to B	8.432	+7	-13
	B to C	4.051	+3	-6
	C to D	8.823	+7	-13
	D to A	3.855	+3	-6

Tower 81 is located above Longwall 36 and, therefore, the changes in the K-Point distances occur primarily as the result of the extraction of this future longwall.

It is recommended that the predicted movements are provided to TransGrid, so that the stability and structural integrity of the transmission towers can be reviewed based on the latest movements. With the necessary amendments to the management strategies in place, it is expected that the 330 kV Transmission Line can be maintained in a safe and serviceable condition throughout the mining period.

3.6. 66kV and 11kV Powerlines

The locations of the 66 kV and 11 kV powerlines are shown in Drawing No. MSEC463-05. The 66 kV powerline crosses above the western end of Longwall 35 and is located adjacent to the 330 kV Transmission Line. The 11 kV powerline crosses above Longwall 35 towards the middle of the longwall. The powerlines comprise aerial cables and, therefore, are not adversely affected by curvature or ground strain.

The profiles of predicted subsidence, tilt along and tilt across the alignment of the 66 kV powerline, resulting from the extraction of Longwalls 29 to 36, are similar to the adjacent 330 kV Transmission Line, which are shown in Fig. A.03, in Appendix A. The predicted profiles based on the Previous Layout are shown as the cyan lines and the predicted profiles based on the Modified Layout are shown as the blue lines.

A summary of the maximum predicted total subsidence, tilt along and tilt across the alignments of the 66 kV and 11 kV powerlines within the Study Area, resulting from the extraction of Longwalls 29 to 36, is provided in Table 3.9. The results are provided for both the Previous and Modified Layouts.

Table 3.9 Maximum Predicted Total Subsidence, Tilt Along and Tilt Across the Alignments of the 66 kV and 11 kV Powerlines within the Study Area Resulting from the Extraction of LWs 29 to 36

Location	Layout	Maximum Predicted Total Subsidence (mm)	Maximum Predicted Total Tilt Along Alignment (mm/m)	Maximum Predicted Total Tilt Across Alignment (mm/m)
66 kV Powerline	Previous Layout	700	3.0	3.5
	Modified Layout	300	1.5	3.0
11 kV Powerline	Previous Layout	450	3.0	1.0
	Modified Layout	450	3.0	1.0

It can be seen from the above table, that the maximum predicted total subsidence parameters for the 66 kV and 11kV powerlines within the Study Area, based on the Modified Layout, are similar to or less than those predicted based on the Previous Layout.

In consequence, the assessed levels of impact for the 66 kV and 11 kV powerlines do not change or reduce as a result of the proposed modification of the longwall commencing end. The proposed management strategies for the powerlines, therefore, are the same as those previously provided in Report No. MSEC326 and the SMP Application.

3.7. Copper Telecommunications Cables

The locations of the copper telecommunications cables are shown in Drawing No. MSEC463-05. The copper cables cross Longwall 35 towards the middle of the longwall. The copper cables are direct buried and, therefore, are not adversely affected by tilt.

A summary of the maximum predicted total subsidence and curvatures for the copper telecommunications cables within the Study Area, resulting from the extraction of Longwalls 29 to 36, is provided in Table 3.10. The results are provided for both the Previous and Modified Layouts.

Table 3.10 Maximum Predicted Total Subsidence and Curvatures for the Copper Telecommunications Cables within the Study Area Resulting from the Extraction of LWs 29 to 36

Location	Layout	Maximum Predicted Total Subsidence (mm)	Maximum Predicted Total Hogging Curvature (km^{-1})	Maximum Predicted Total Sagging Curvature (km^{-1})
Copper Cables	Previous Layout	550	0.03	0.05
	Modified Layout	550	0.03	0.05

It can be seen from the above table, that the that the maximum predicted total subsidence parameters for the copper telecommunications cables within the Study Area, based on the Modified Layout, are the same as those predicted based on the Previous Layout.

The maximum predicted conventional strains within the Study Area, based on applying a factor of 15 to the maximum predicted conventional curvatures, are 0.5 mm/m tensile and 0.8 mm/m compressive, for both the Previous and Modified Layouts.

The strain analysis described in Section 2.2 was based on the measured strains in individual survey bays and, therefore, is not relevant to linear features, such as the copper telecommunications cables. It is more appropriate to assess the frequency of observed maximum strains along whole monitoring lines, rather than for individual survey bays. That is, an analysis of the maximum strains anywhere along the monitoring lines, regardless of where the strain actually occurs.

A total of 44 monitoring lines were adopted in the strain analysis. There were 14 monitoring lines (i.e. 32 %) that had recorded maximum total tensile strains greater than 1 mm/m and there was 1 monitoring line (i.e. 2 %) that had a recorded maximum total tensile strain greater than 2 mm/m. There were 14 monitoring lines (i.e. 32 %) that had recorded maximum total compressive strains greater than 2 mm/m and there were 6 monitoring lines (i.e. 14 %) that had recorded maximum total compressive strains greater than 3 mm/m.

The predicted strains along the copper telecommunications cables are not expected to change as the result of the proposed modification to the commencing end of Longwall 35.

In consequence, the assessed levels of impact for the copper telecommunications cables do not change or reduce as a result of the proposed modification of the longwall commencing end. The proposed management strategies for the copper cables, therefore, are the same as those previously provided in Report No. MSEC326 and the SMP Application.

3.8. Fences

The fences are located across the Study Area and, therefore, are expected to experience the full range of predicted subsidence movements. A summary of the maximum predicted incremental subsidence parameters, due to the extraction of Longwall 35, is provided in Table 2.1. It can be seen from this table, that the maximum predicted subsidence parameters do not change, as a result of the proposed modification. The overall levels of the mine subsidence movement across the Study Area are also not expected to change.

In consequence, the assessed levels of impact for the fences do not change as a result of the proposed modification of the longwall commencing end. The proposed management strategies for the fences, therefore, are the same as those previously provided in Report No. MSEC326 and the SMP Application.

3.9. Farm Dams

The locations of the farm dams in the vicinity of Longwall 35 are shown in Drawing No. MSEC463-06. There are 18 farms dams which have been identified within the Study Area. There are seven farm dams located directly above Longwall 35, based on the Previous Layout, and there are five farm dams located directly above Longwall 35 based on the Modified Layout. The farm dams have maximum lengths varying between 10 metres and 160 metres and surface areas varying between 60 m^2 and 3200 m^2.

A summary of the maximum predicted total subsidence, tilt and curvatures at the farm dams, resulting from the extraction of Longwalls 29 to 36, is provided in Table 3.11. The results are provided for both the Previous and Modified Layouts. The predicted parameters are the maxima within a 20 metre radius of the farm dams. The predicted tilts and curvatures are the maxima at any time during the mining period.

Table 3.11 Maximum Predicted Total Subsidence, Tilt and Curvature at the Farm Dams within the Study Area Resulting from the Extraction of Longwalls 29 to 36

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})
Farm Dams	Previous Layout	825	6.0	0.03	0.12
	Modified Layout	825	5.5	0.03	0.12

It can be seen from the above table, that the that the maximum predicted total subsidence, tilt and curvatures at the farm dams within the Study Area, based on the Modified Layout, are similar to or slightly less than those predicted based on the Previous Layout. Also, the number of farm dams directly mined beneath by Longwall 35 reduces from seven to five as a result of the proposed longwall modification.

The maximum predicted conventional strains, based on applying a factor of 15 to the maximum predicted conventional curvatures, are 0.5 mm/m tensile and 1.8 mm/m compressive, for both the Previous and Modified Layouts. The 95 % confidence levels for strain at the farm dams are expected to be similar to those for strains previously measured in survey bays above goaf in the Southern Coalfield, which was discussed in Section 2.2. The predicted strains at the farm dams are not expected to change as the result of the proposed modification to the commencing end of Longwall 35.

In consequence, the assessed levels of impact for the farm dams do not change or reduce as a result of the proposed modification of the longwall commencing end. The proposed management strategies for the farm dams, therefore, are the same as those previously provided in Report No. MSEC326 and the SMP Application.

3.10. Building Structures

The locations of the building structures in the vicinity of Longwall 35 are shown in Drawing No. MSEC463-06. There are four houses which have been identified within the Study Area, being Refs. G01i, G02c, G03a and G05a. There are also 29 rural structures within the Study Area, which include sheds, garages and other non-residential building structures.

A summary of the maximum predicted total subsidence, tilt and curvatures at the houses within the Study Area, resulting from the extraction of Longwalls 29 to 36, is provided in Table 3.12. A summary of the maximum predicted total subsidence, tilt and curvatures at the rural structures within the Study Area, resulting from the extraction of Longwalls 29 to 36, is provided in Table 3.13. The predicted parameters are the maxima within a 20 metre radius of the structures. The predicted tilts and curvatures are the maxima at any time during the mining period.

Table 3.12 Maximum Predicted Total Subsidence, Tilt and Curvature at the Houses within the Study Area Resulting from the Extraction of Longwalls 29 to 36

House Ref.	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})
G01i	Previous Layout	50	< 0.5	< 0.01	< 0.01
	Modified Layout	< 20	< 0.5	< 0.01	< 0.01
G02c	Previous Layout	100	1.5	0.02	< 0.01
	Modified Layout	20	< 0.5	< 0.01	< 0.01
G03a	Previous Layout	175	2.0	0.02	< 0.01
	Modified Layout	75	1.0	0.01	< 0.01
G05a	Previous Layout	600	3.5	0.02	0.06
	Modified Layout	50	0.5	< 0.01	< 0.01

Table 3.13 Maximum Predicted Total Subsidence, Tilt and Curvature at the Rural Structures within the Study Area Resulting from the Extraction of Longwalls 29 to 36

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})
Rural Structures	Previous Layout	625	3.5	0.03	0.06
	Modified Layout	75	1.0	0.01	< 0.01

It can be seen from the above tables, that the that the maximum predicted total subsidence, tilt and curvatures at the houses and rural structures within the Study Area, based on the Modified Layout, are less than those predicted based on the Previous Layout. Also, there are no houses directly mined beneath by Longwall 35 based on the Modified Layout.

The maximum predicted conventional strains at the building structures, based on applying a factor of 15 to the maximum predicted conventional curvatures, are less than 0.2 mm/m tensile and compressive, based on the Modified Layout.

The strain analysis described in Section 2.2 was based on the measured strains above goaf and, therefore, is not relevant for the houses, which are located above solid coal based on the Modified Layout. An analysis of strain similar to that described in Section 2.2 has been undertaken, but using the strains measured above solid coal, between 0 metres and 200 metres from the previously extracted longwalls.

The averages of the maximum strains that the individual survey bays above solid coal experienced at any time during mining were 0.5 mm/m tensile and 0.4 mm/m compressive. The maximum strains that any survey bay above solid coal experienced at any time during mining were 1.3 mm/m both tensile and compressive.

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 a longwall extraction, 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 strains that the individual survey bays above solid coal experienced at any time during mining were 0.6 mm/m tensile and 0.4 mm/m compressive. The 99 % confidence levels for the maximum strains that the individual survey bays above solid coal experienced at any time during mining were 0.8 mm/m tensile and 0.7 mm/m compressive.

The predicted strains at the building structures are expected to reduce as the result of the proposed modification to the commencing end of Longwall 35.

In consequence, the assessed levels of impact for the houses and rural structures reduce as a result of the proposed modification of the longwall commencing end. The proposed management strategies for the building structures, therefore, are the same as those previously provided in Report No. MSEC326 and the SMP Application.

3.11. Archaeological Sites

The locations of the archaeological sites are shown in Drawing No. MSEC463-06. There is one archaeological site identified within the Study Area, being Site Ref. 52-2-2265, which is located 160 metres south of Longwall 35. This site comprises of stone artefact scatters.

A summary of the maximum predicted total subsidence, tilt and curvatures at this site, resulting from the extraction of Longwalls 29 to 36, is provided in Table 3.14. The results are provided for both the Previous and Modified Layouts. The predicted parameters are the maxima within a 20 metre radius of the site. The predicted tilts and curvatures are the maxima at any time during the mining period.

Table 3.14 Maximum Predicted Total Subsidence, Tilt and Curvature at the Archaeological Site within the Study Area Resulting from the Extraction of Longwalls 29 to 36

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})
52-2-2265	Previous Layout	75	0.5	< 0.01	< 0.01
	Modified Layout	50	< 0.5	< 0.01	< 0.01

It can be seen from the above table, that the that the maximum predicted total subsidence, tilt and curvatures at the archaeological site, based on the Modified Layout, are similar to or less than those predicted based on the Previous Layout.

The maximum predicted conventional strains, based on applying a factor of 15 to the maximum predicted conventional curvatures, are less than 0.2 mm/m tensile and compressive, for both the Previous and Modified Layouts.

The strain analysis described in Section 2.2 was based on the measured strains above goaf and, therefore, is not relevant for the archaeological site, which is located above solid coal. An analysis of strain similar to that described in Section 2.2 has been undertaken, but using the strains measured above solid coal, between 0 metres and 200 metres from the previously extracted longwalls. The results of this analysis are described in Section 3.10 for building structures.

The predicted strains at the archaeological sites are not expected to change as the result of the proposed modification to the commencing end of Longwall 35.

In consequence, the assessed levels of impact for the archaeological site do not change or reduce as a result of the proposed modification of the longwall commencing end. The proposed management strategies for the archaeological site, therefore, are the same as those previously provided in Report No. MSEC326 and the SMP Application.

3.12. Survey Control Marks

The locations of the state survey control marks are shown in Drawing No. MSEC463-06. There are two marks located on the perimeter of the Study Area, being Refs. PM 82965 and PM49019, with more marks located immediately outside the Study Area.

There is one state survey control mark situated above Longwall 35, being Ref. PM82965, which is located at a distance of 360 metres from the modified commencing end. The predicted mine subsidence parameters at this survey control mark, based on the Modified Layout, are similar to, if not, less than those predicted based the Previous Layout. Similarly, the predicted far-field horizontal movements at the survey control marks in the vicinity of Longwall 35 are similar to, if not, less than those predicted based on the Previous Layout.

In consequence, the assessed levels of impact for the survey control marks do not change or reduce as a result of the proposed modification of the longwall commencing end. The proposed management strategies for the state survey control marks, therefore, are the same as those previously provided in Report No. MSEC326 and the SMP Application.

3.13. Summary

The maximum predicted incremental conventional subsidence parameters, due to the extraction of Longwall 35, do not change as a result of the proposed modification to the longwall commencing end. Similarly, the maximum predicted total conventional subsidence parameters, resulting from the extraction of Longwalls 29 to 36, also do not change as a result of the proposed modification.

Although the predicted maxima do not change, the locations of the predicted longitudinal tilt and curvatures change as a result of the proposed modification to the longwall commencing end. As shown in Fig. A.01, the predicted longitudinal tilt and curvature at the commencing end of Longwall 35 have moved around 750 metres towards the east as a result of the proposed modification.

The maximum predicted mine subsidence parameters for the natural features and surface infrastructure, based on the Modified Layout are, in all cases, similar to or less than those predicted based on the Previous Layout.

In consequence, the assessed levels of impact for the natural features and surface infrastructure do not change or reduce as a result of the proposed modification of the longwall commencing end. The proposed management strategies for all features, therefore, are the same as those previously provided in Report No. MSEC326 and the SMP Application.

APPENDIX A. FIGURES

Predicted Profiles of Incremental Subsidence, Tilt and Curvature along Prediction Line 1 Resulting from the Extraction of Longwall 35

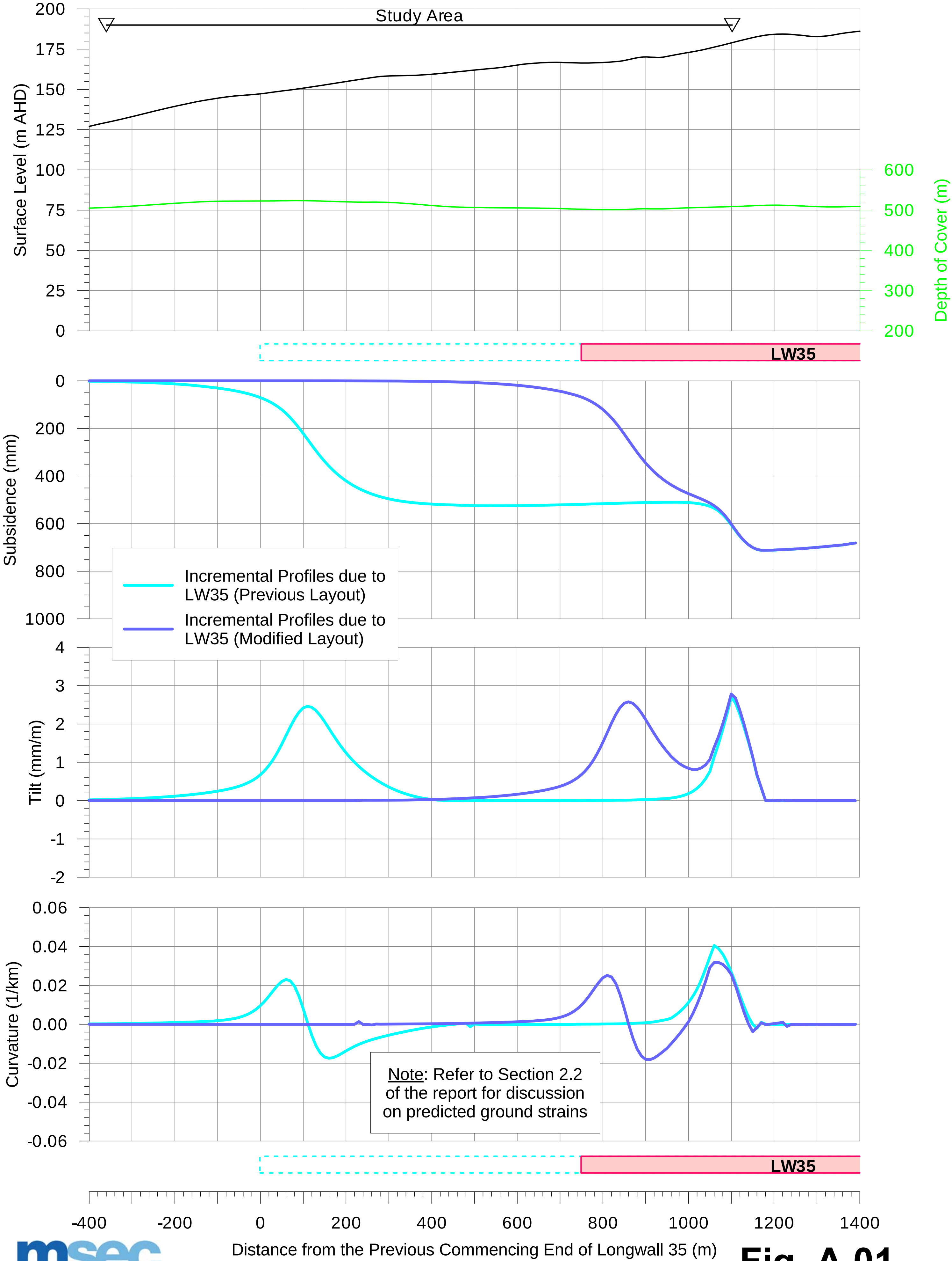


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Fig. A.01

Predicted Profiles of Subsidence, Tilt and Curvature along the Pipeline Easement Resulting from the Extraction of Longwalls 29 to 36

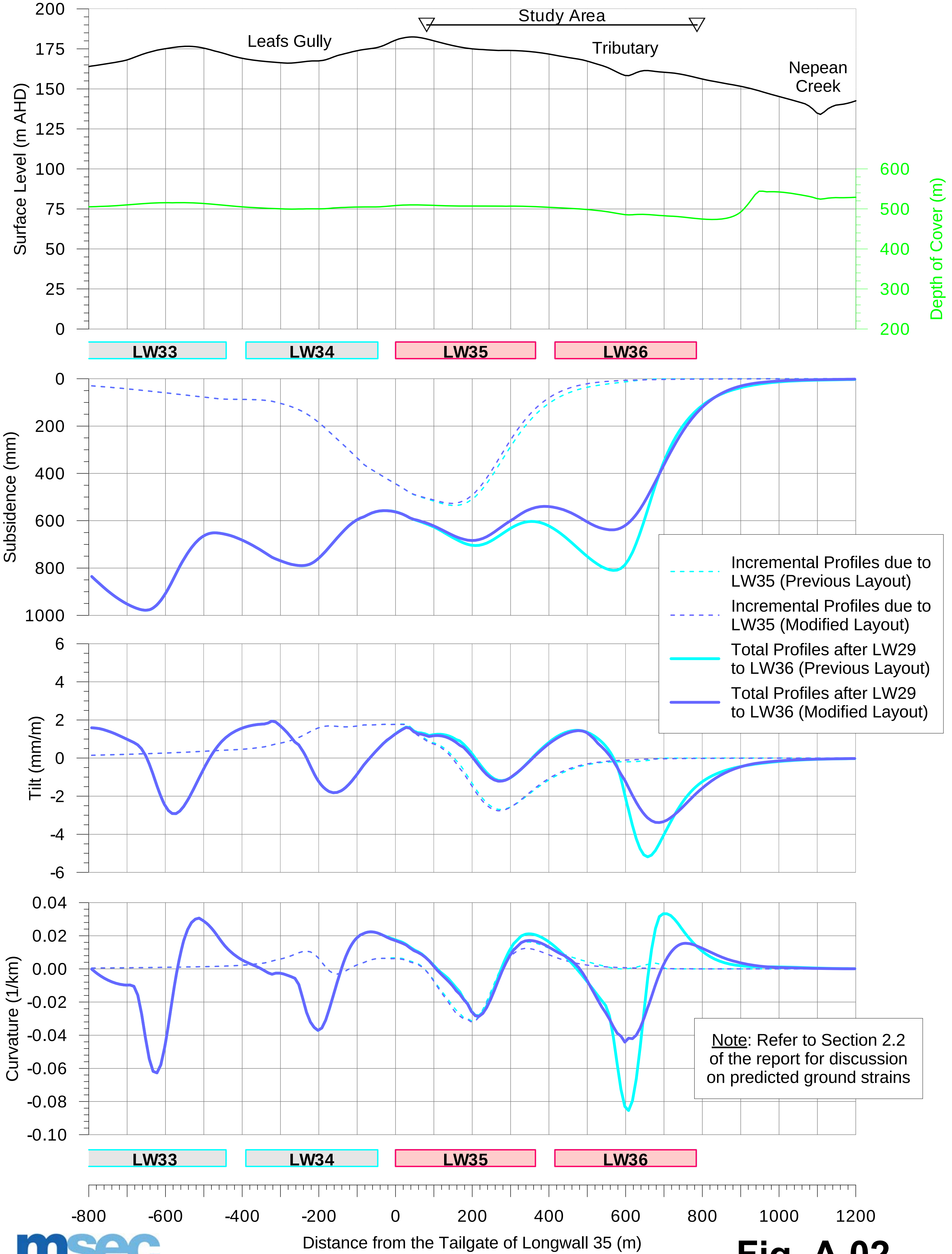

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Fig. A.02

Predicted Profiles of Subsidence, Tilt Along and Tilt Across the 330kV Transmission Line Resulting from the Extraction of LWs 29 to 36

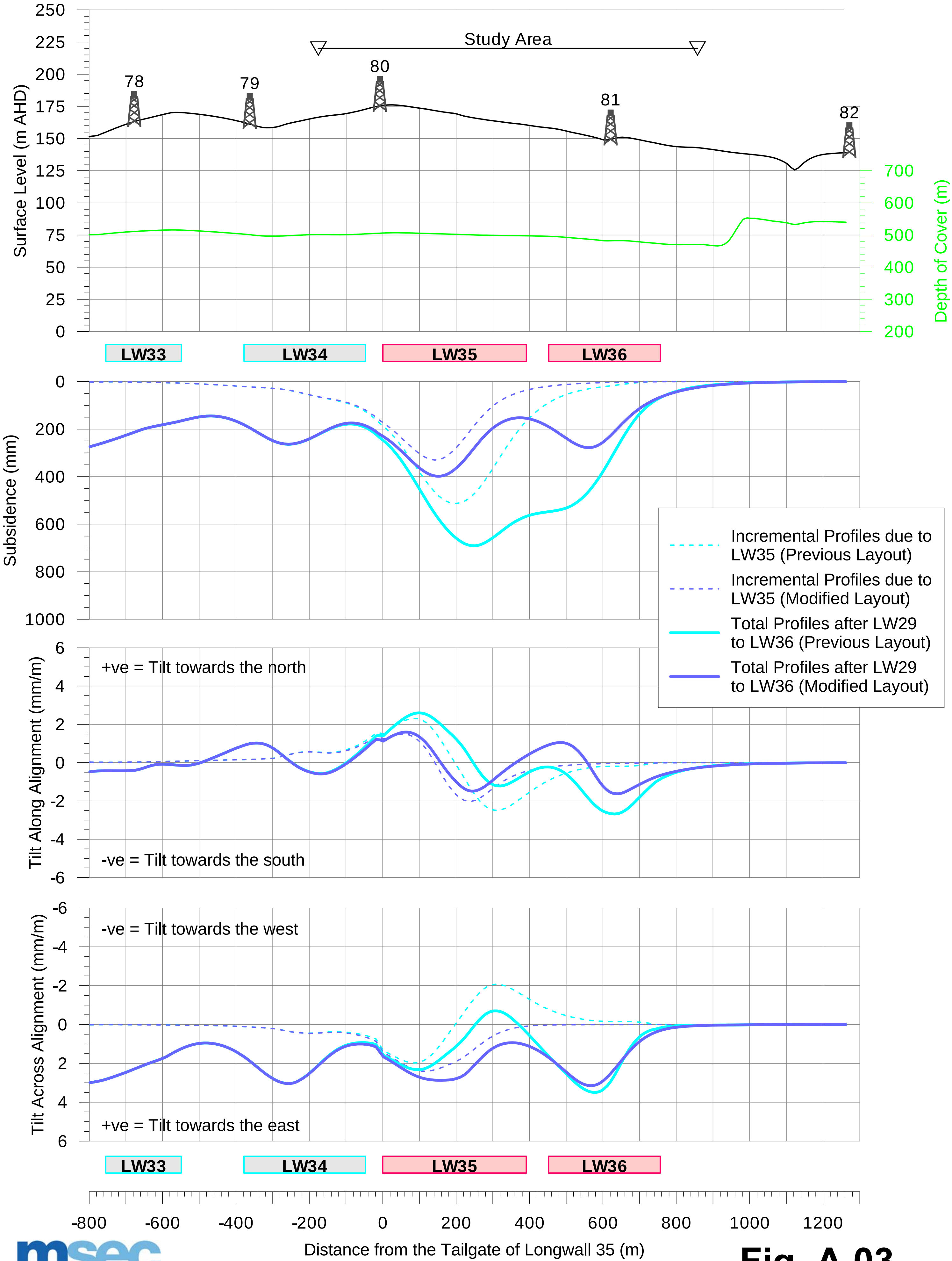

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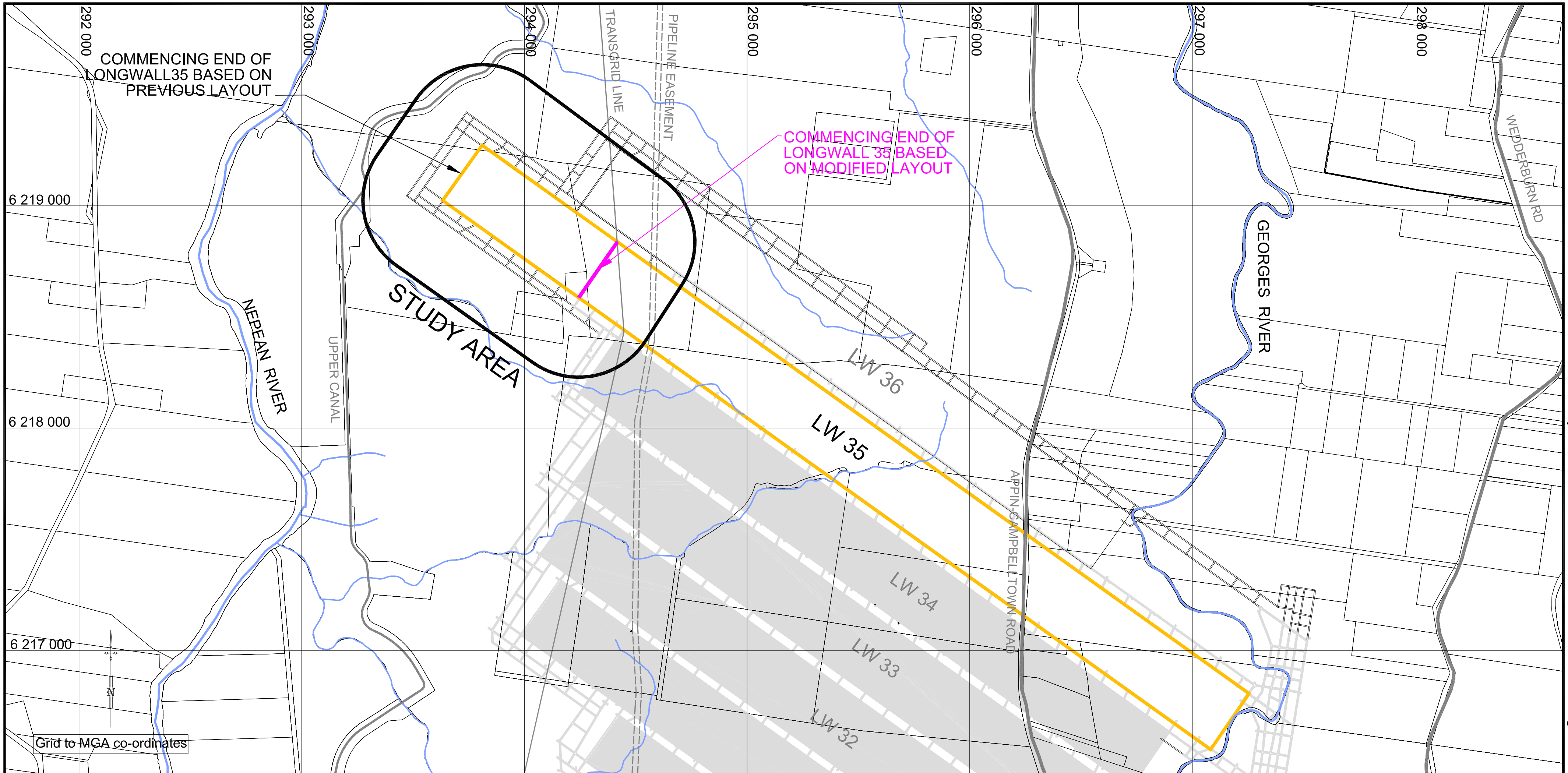
Fig. A.03

APPENDIX B. DRAWINGS



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WEST CLIFF COLLIERY AREA 5
MODIFIED COMMENCING END TO LW 35
GENERAL LAYOUT

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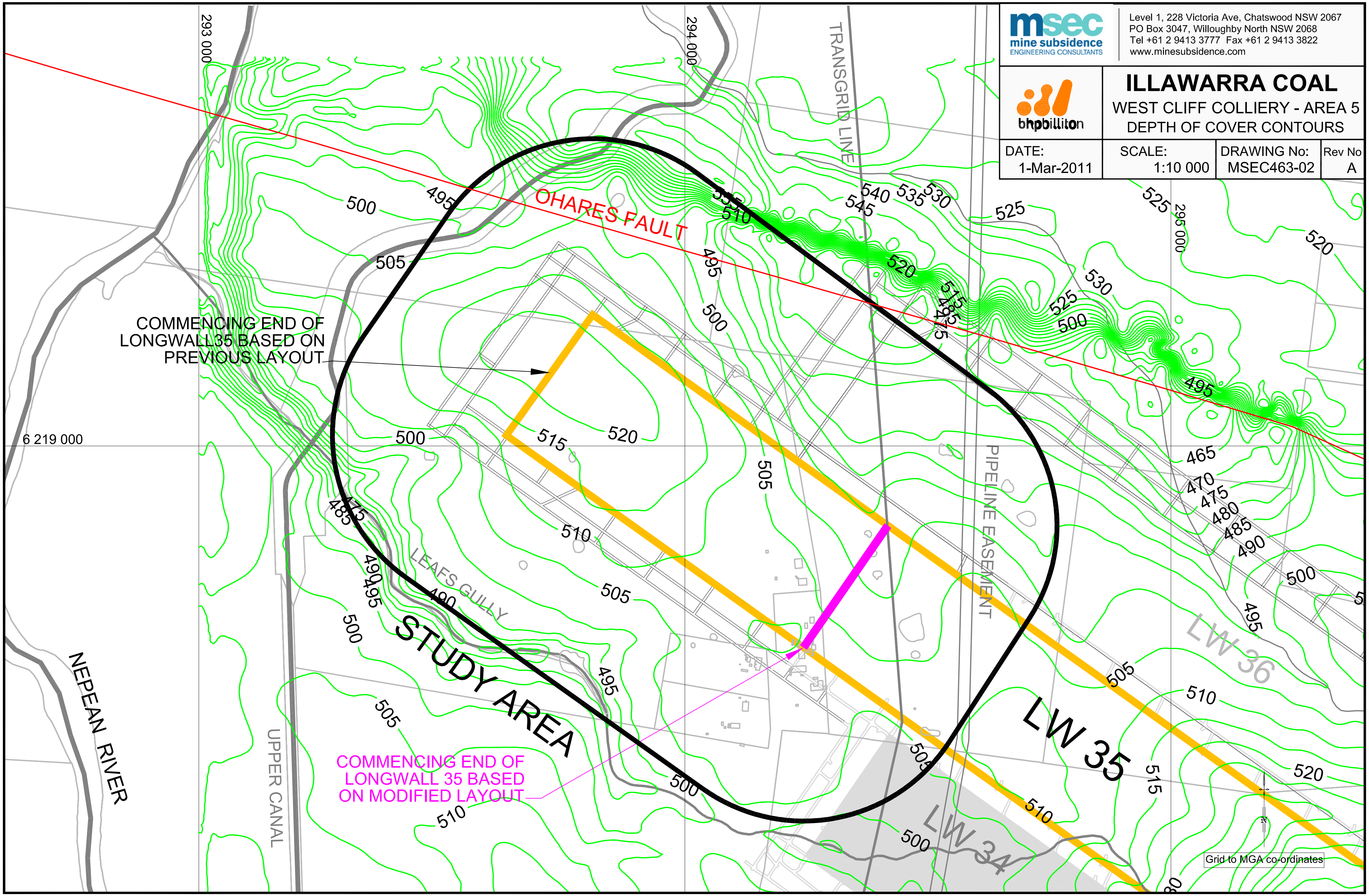

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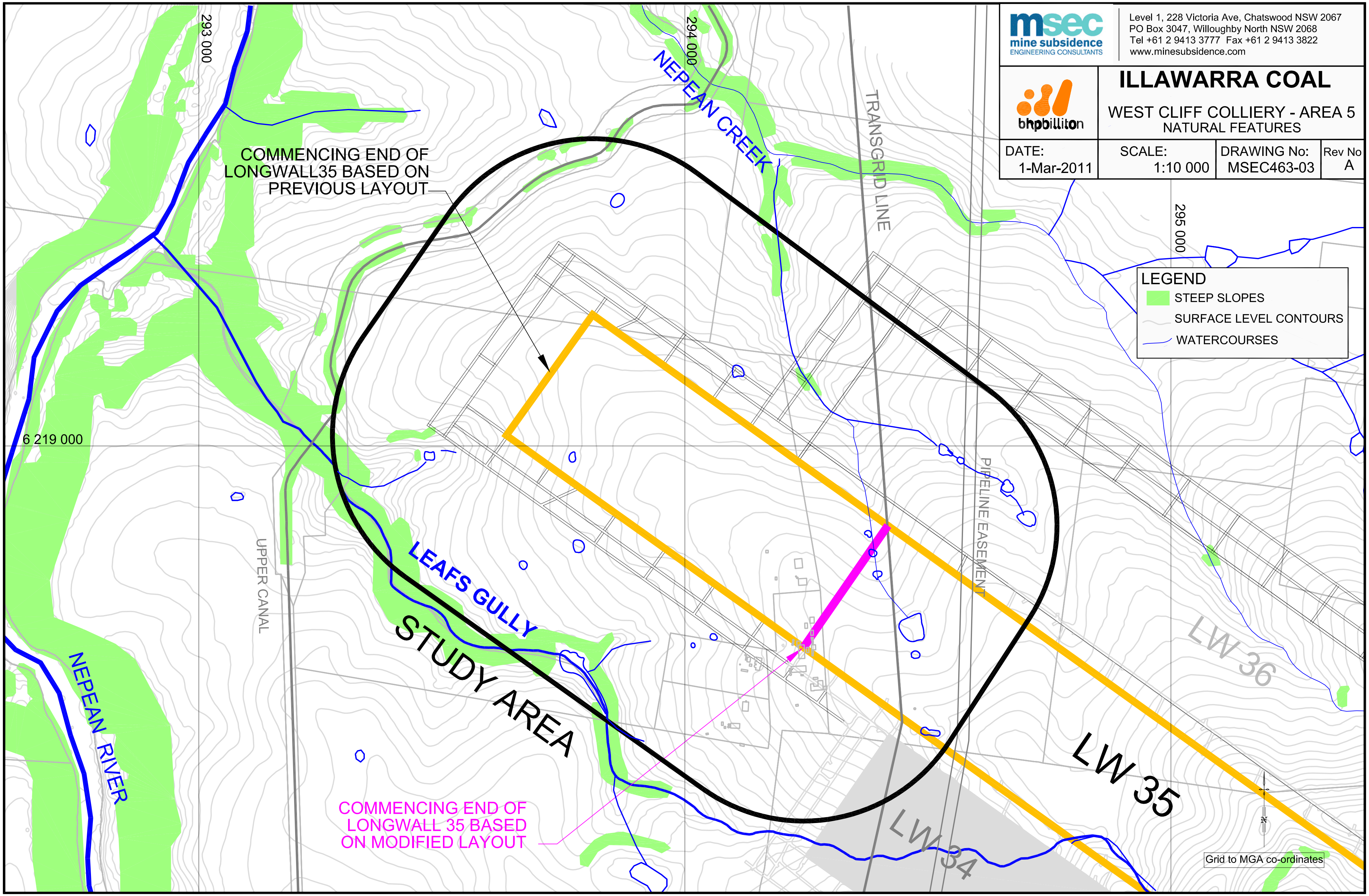

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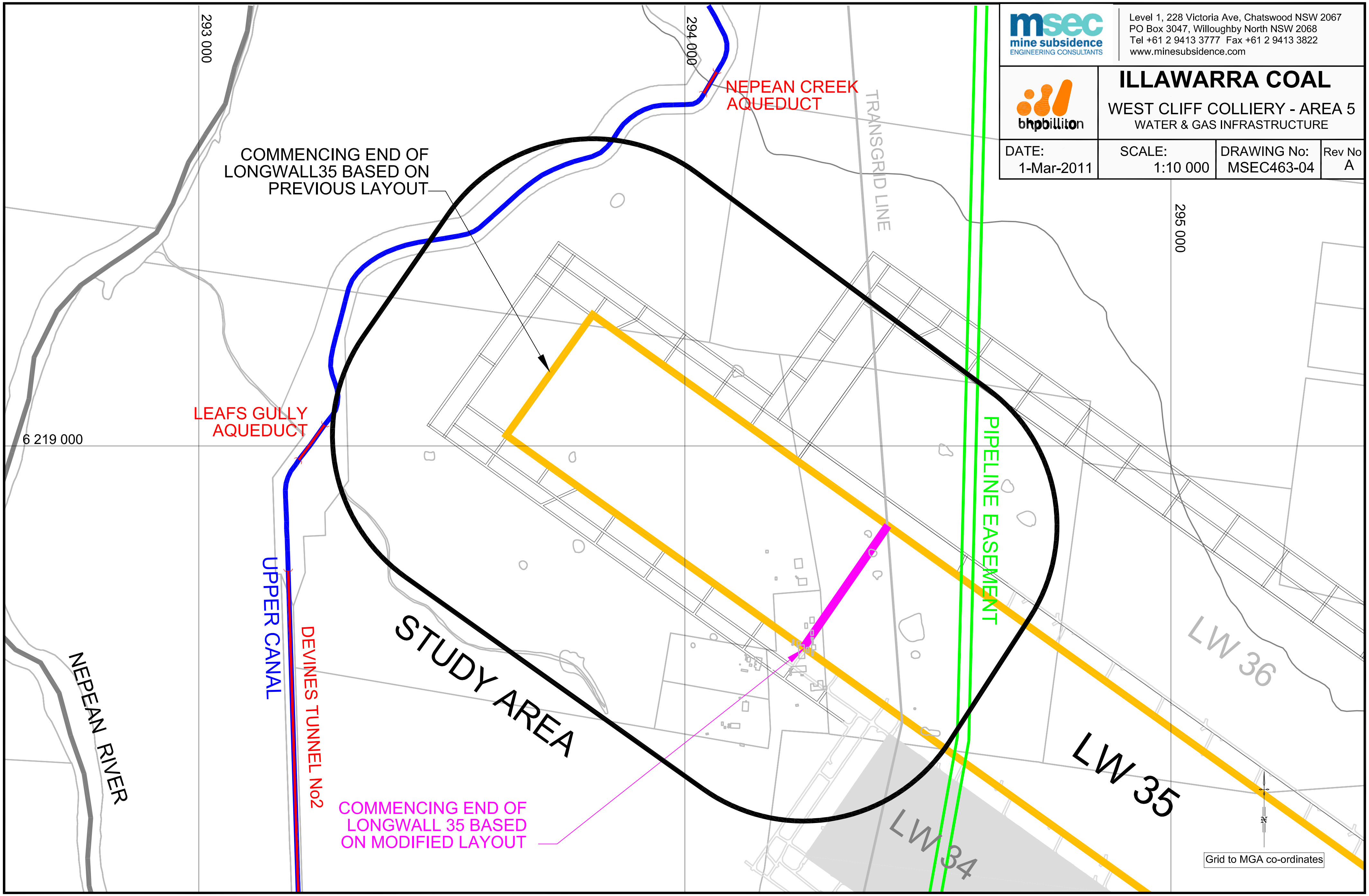

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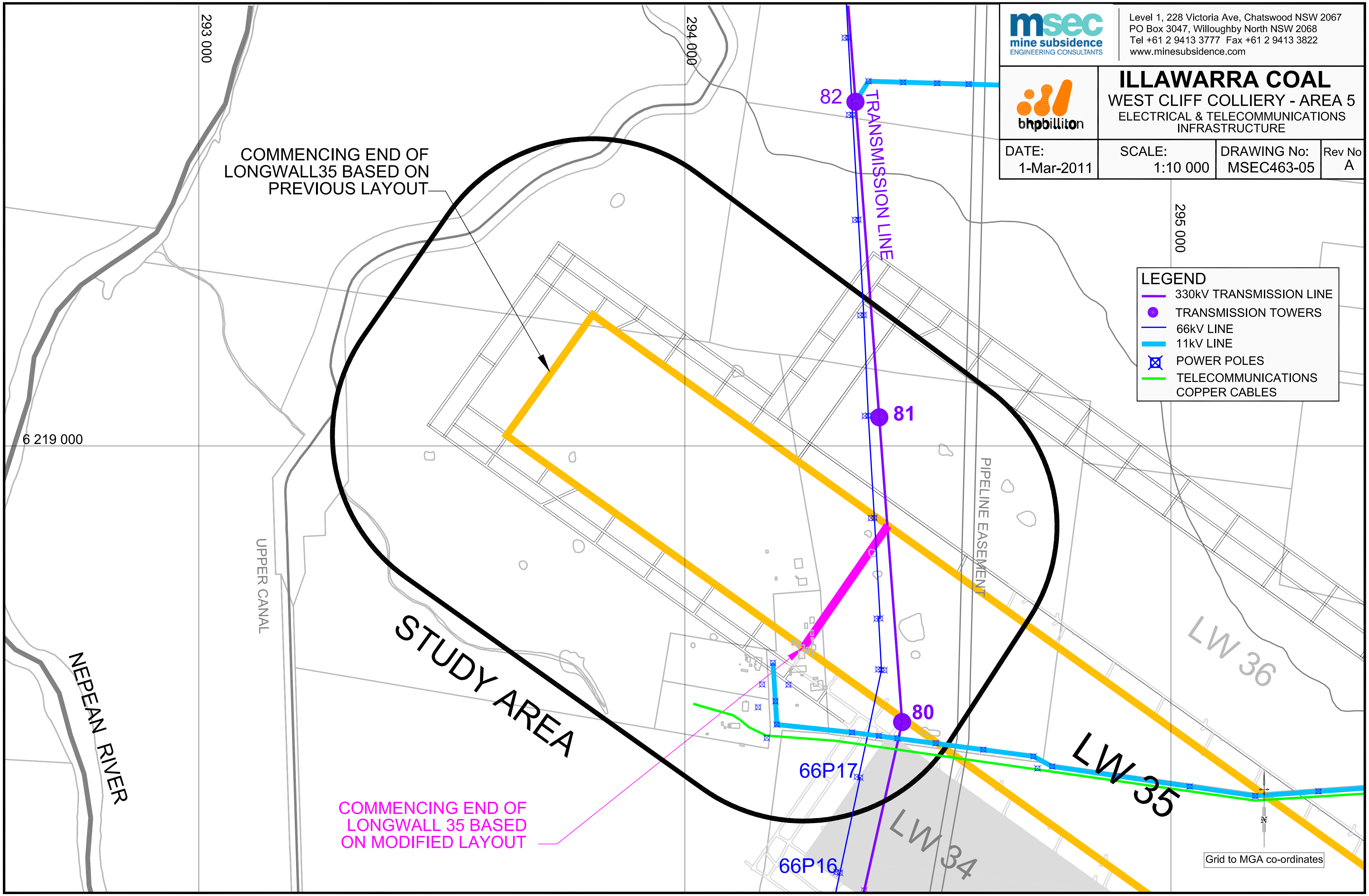

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BUILDING STRUCTURES, FARM DAMS, ARCHAEOLOGICAL SITES & SURVEY MARKS

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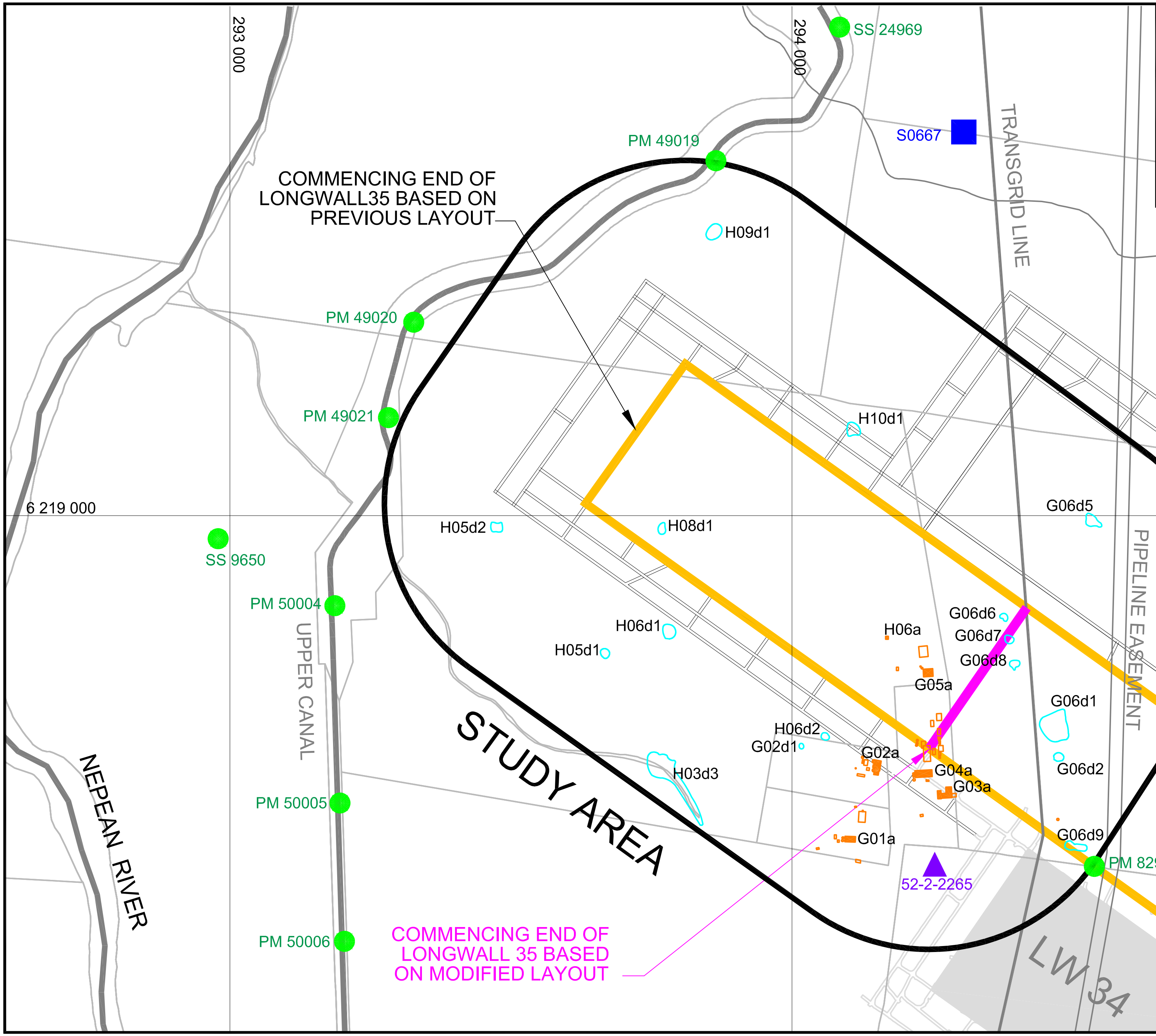

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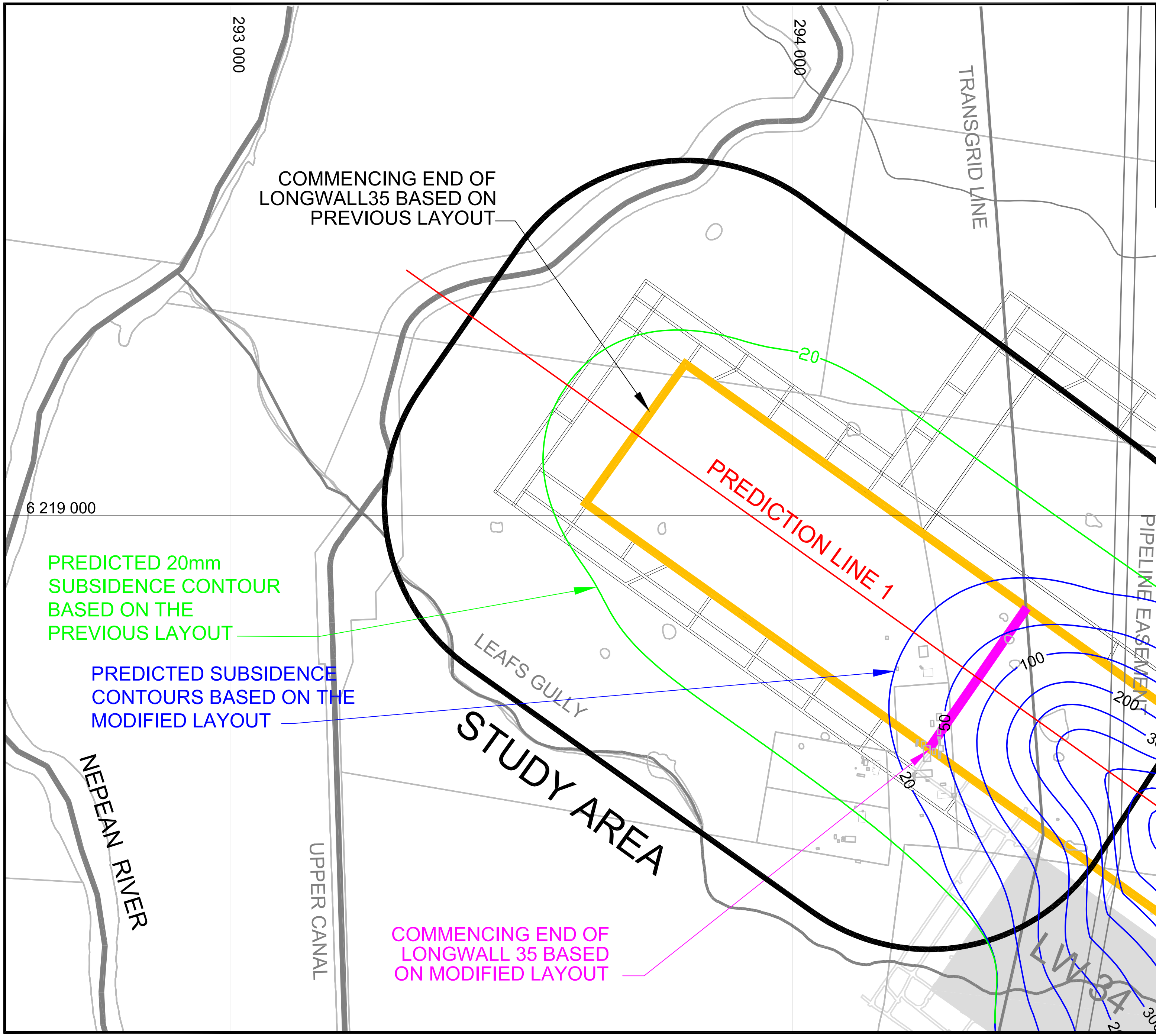

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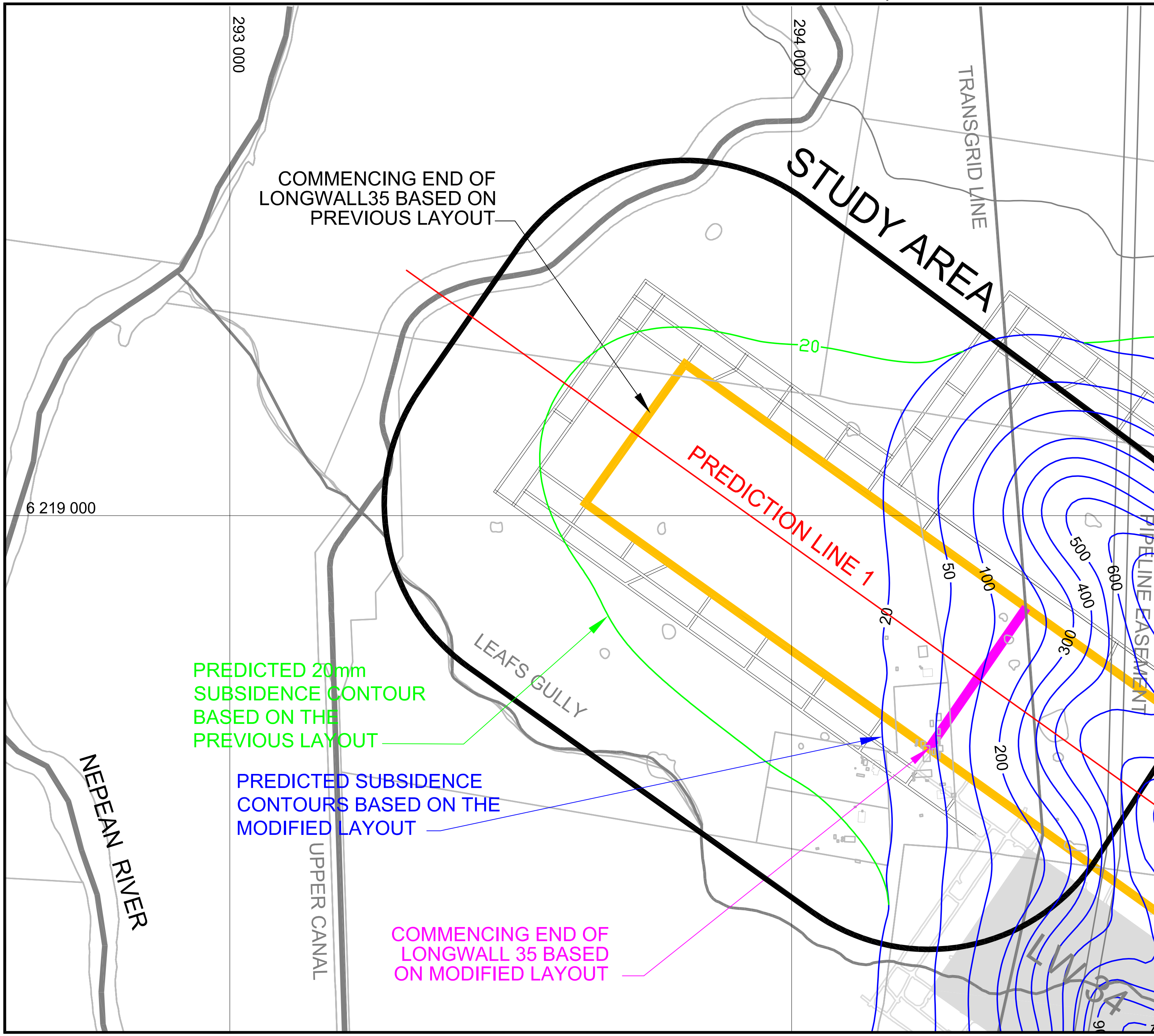

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