



# Metropolitan Coal Mine



## Appendix A Subsidence Assessment



**Peabody**





METROPOLITAN COAL PROJECT:

## **Metropolitan Coal Mine – Longwalls 317 and 318 Modification**

Subsidence Predictions and Impact Assessments for the Natural  
and Built Features in Support of the Modification

## DOCUMENT REGISTER

| Revision | Description | Author | Checker | Date        |
|----------|-------------|--------|---------|-------------|
| 01       | Draft Issue | PD     |         | 13 Mar 2025 |
| 01       | Draft Issue | PD     |         | 09 May 2025 |
| A        | Final Issue | PD     |         | 16 Jun 2025 |
|          |             |        |         |             |
|          |             |        |         |             |
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|          |             |        |         |             |

Report produced to:- Support the Modification for submission to the Department of Planning, Housing and Infrastructure (DPHI).

Associated reports:- MSEC285 (Revision C) – Metropolitan Colliery - The Prediction of Subsidence Parameters and the Assessment of Subsidence Impacts on Natural Features and Surface Infrastructure Resulting from the Proposed Extraction of Longwalls 20 to 44 at Metropolitan Colliery in Support of a Part 3A Application.

MSEC403 (May 2009) – Metropolitan Colliery – Approved Layout (Longwalls 20 to 27 and 301 to 317) Technical discussion on Proposed Modification of Longwall Layout Orientation.

MSEC736-02 (Revision A, April 2015) – Metropolitan Colliery – Proposed Longwalls 301 to 317 – Technical Discussion on Proposed Modification of Approved Layout.

Background reports available at [www.minesubsidence.com](http://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)

Metropolitan Collieries Pty Ltd (Metropolitan Coal) proposes to continue its underground coal mining operations within the Bulli Seam at Metropolitan Colliery (Metropolitan Coal Mine), which is located in the Southern Coalfield of New South Wales. Metropolitan Coal proposes to extract the next longwalls in the current series, referred to as Longwalls 317 and 318.

Metropolitan Coal was granted Project Approval (08\_0149) by the Minister for Planning on 22 June 2009. The Project Approval included a layout for Longwalls 301 to 317 referred to as the Preferred Project Layout. The longwalls based on the Preferred Project Layout comprised 163 metres (m) panel widths (void) with 45 m pillars (solid) beyond 500 m from the Woronora Reservoir, and 138 m panel widths (void) with 70 m pillars (solid) within 500 m of the Woronora Reservoir.

In April 2015, Metropolitan Coal received approval from the then Department of Planning, Industry and Environment for changes to Longwalls 301 to 317, by rotating them in an anti-clockwise direction by approximately six degrees (°).

An application for the Longwalls 311 to 316 Extraction Plan was made in July 2024. Approval for the extraction of Longwall 311 was granted on 19 October 2024 and extraction of Longwalls 312 to 316 is awaiting approval. The longwall layout based on the Longwalls 311 to 316 Extraction Plan, including the layout of Longwall 317 based on the April 2015 approval is referred to as the Approved Layout in this report. Metropolitan Coal propose to submit a modification application for Longwall 317 and Longwall 318 based on a Modified Layout comprising a change in length for Longwall 317 and the addition of Longwall 318. The application also includes a widening of the tailgate pillars for Longwalls 316 to 318 to 55 m to reduce subsidence effects on upland swamps. Mine Subsidence Engineering Consultants Pty Ltd has prepared this report to support the Longwalls 317 and 318 Modification.

A Study Area has been identified around the Modified Layout based on the further limit of the 35° angle of draw line and predicted vertical limit of subsidence.

A number of features have been identified within or in the vicinity of the Study Area including:

- watercourses;
- cliffs;
- steep slopes;
- swamps;
- unsealed tracks and trails;
- monitoring equipment; and,
- Aboriginal cultural heritage sites.

Other than the existing monitoring equipment, unsealed tracks and trails, there are no built features located within the Study Area.

The predicted subsidence effects and impact assessments for the natural and built features resulting from extraction of Longwalls 317 and 318 (including the effects of the previous Longwalls 301 to 316), based on the Modified Layout, have been compared with predicted effects and impact assessments for the Approved Layout for these longwalls at Metropolitan Coal Mine.

The changes from the Approved Layout generally result in an increase in the predicted subsidence parameters where the longwall footprints have increased. Where there is an increase in the predicted subsidence parameters at surface features, the magnitudes of the predicted subsidence parameters and the resulting assessed impacts are similar to or less than those for similar surface features located above the previously extracted or approved longwalls. The effect of the widened tailgate pillars for Longwalls 316 to 318 reduces the predicted incremental subsidence parameters by approximately 18 per cent.

There are no major watercourses within the Study Area. The majority of the tributaries within the Study Area are located outside the Longwall 317 and 318 footprints and are not expected to experience significant subsidence effects from the Modification.

Three swamps are listed in the performance measures in the Project Approval (08\_0149) (Swamps S76, S77 and S92). Swamp S92 is located outside the Study Area. Swamps S76 and S77 are located closer to Longwall 317 and would experience subsidence effects due to the extraction of Longwalls 317 and 318 of the Modification. The maximum predicted subsidence parameters for these swamps are located at the eastern sides of these swamps and do not change significantly for the Modification.

The largest swamp within the Study Area is S106. The predicted maximum subsidence at Swamp S106 increases from 350 millimetres (mm) based on the Approved Layout to 750 mm based on the Modification.



The maximum predicted tilt and strains do not change. The maximum predicted tensile strain for this swamp is less than 0.5 mm and as a result the risk of tensile cracking is reduced.

Aboriginal heritage sites are located across the Study Area. The magnitudes of predicted tilt and curvature for the majority of the Aboriginal heritage sites are small due to site locations above narrow geometry and solid coal. Impacts to the sites located above solid coal are considered unlikely. While surface fracturing of the bedrock can occur outside the longwall layouts such fracturing is minor and isolated and the likelihood of fracturing impacting the Aboriginal Heritage Sites outside the longwall layouts is considered to be low.

Sites NT7, NT8, NT17, NT29, NT46, NT52, and NT53 are located in shallow valley profiles and are not expected to experience significant valley closure. NT9 and NT21 are located within deeper and more incised valley profiles and could experience valley closure and associated cracking in the based of the valley profile.

In conclusion, no changes to Subsidence Impact Performance Measures outlined in the Project Approval (08\_0149) would be required for the Modification.

Metropolitan Coal Mine have established a comprehensive subsidence monitoring program for the proposed extraction of Longwalls 311 to 316, to observe subsidence related movements at critical features, and to validate subsidence predictions. The monitoring program should be extended for the proposed Longwalls 317 and 318 Modified Layout.

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| MSEC1319-03        | Seam Floor Contours                                            | A               |
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| MSEC1319-05        | Depth of Cover Contours                                        | A               |
| MSEC1319-06        | Geological Structures                                          | A               |
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### 1.1. Background

Metropolitan Collieries Pty Ltd (Metropolitan Coal) is a wholly owned subsidiary of Peabody Energy Australia Pty Ltd (Peabody) and operates Metropolitan Colliery (Metropolitan Coal Mine), which is located in the Southern Coalfield of New South Wales (NSW). Metropolitan Coal has extracted Longwalls 1 to 27, 301 to 311, at the Metropolitan Coal Mine.

Metropolitan Coal submitted the Metropolitan Coal Project Environmental Assessment (Metropolitan Coal Project EA) for the extraction of Longwalls 20 to 44 at the Metropolitan Coal Mine in 2008 (Helensburgh Coal Pty Ltd, 2008). Mine Subsidence Engineering Consultants Pty Ltd (MSEC) prepared Report No. MSEC285 (Rev. C) that provided the subsidence predictions and impact assessments for these longwalls in support of the Metropolitan Coal Project EA.

Metropolitan Coal submitted the Metropolitan Coal Project Preferred Project Report (Helensburgh Coal Pty Ltd, 2009), with changes to the layout used in the Metropolitan Coal Project EA. MSEC prepared Report No. MSEC403 that provided an assessment of the Preferred Project Layout in support of the Preferred Project Report. The longwalls based on the Preferred Project Layout comprised 163 metres (m) panel widths (void) with 45 m pillars (solid) beyond 500 m from the Woronora Reservoir, and 138 m panel widths (void) with 70 m pillars (solid) within 500 m of the Woronora Reservoir. The Minister for Planning granted Peabody approval for the Preferred Project Layout on 22 June 2009 (Project Approval [08\_0149]).

Metropolitan Coal subsequently modified the northern series of longwalls, now referred to as Longwalls 301 to 317, by rotating them in an anti-clockwise direction by approximately six degrees (°). MSEC prepared the letter Report No. MSEC736-02 (Rev. A) that provided the updated subsidence predictions and impact assessments in support of the application. Metropolitan Coal received approval from the Department of Planning, Industry and Environment (now known as the Department of Planning, Housing and Infrastructure) for the orientation change in April 2015.

An application for the Longwalls 311 to 316 Extraction Plan was made in July 2024. Approval for the extraction of Longwall 311 was granted on 19 October 2024 and extraction of Longwalls 312 to 316 is planned for June 2025. The longwall layout based on the Longwalls 311 to 316 Extraction Plan, including the layout of Longwall 317 based on the April 2015 approval is referred to as the Approved Layout in this report.

Metropolitan Coal propose to submit a modification application for Longwall 317 and Longwall 318 based on a Modified Layout comprising a change in length for Longwall 317 and the addition of Longwall 318 (referred to as the Modification).

In summary, the Modification would comprise the following key components (Fig 1.1):

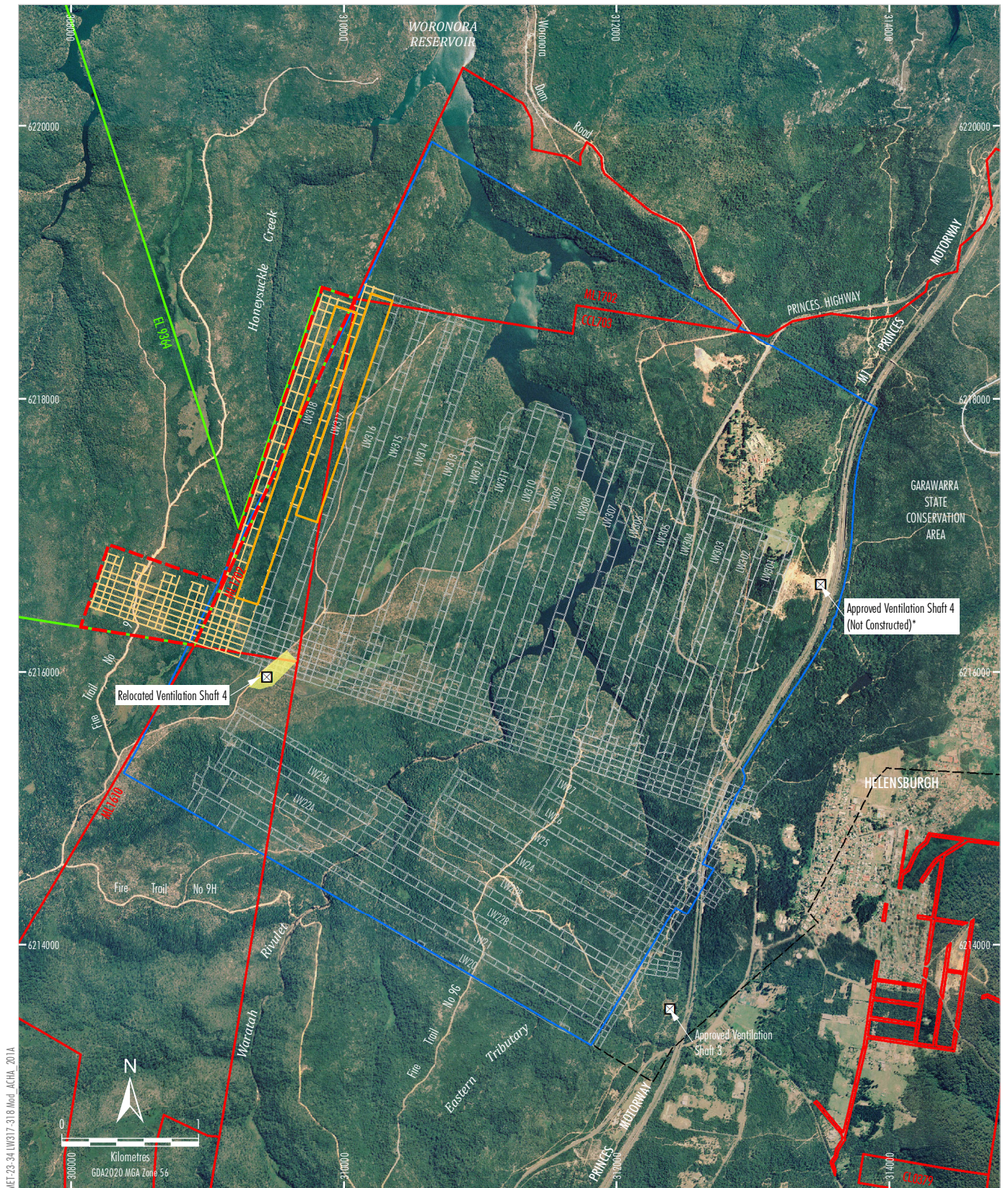
- extension of the approved Longwall 317 to the north;
- addition of Longwall 318 to the west of the approved longwalls;
- extension of the approved 300-series Mains to the west;
- extraction of an additional 3.2 million tonnes (Mt) of run-of-mine (ROM) coal;
- relinquishment of 14 Mt of approved ROM coal;
- relocation of the approved (but not yet constructed) Ventilation Shaft 4;
- continued transportation of coal rejects off-site for the life of the mine via a combination of rail and road; and
- relinquishment of approved surface development and underground mining areas.

MSEC has prepared this subsidence report to support the Longwalls 317 and 318 Modification. The approved Metropolitan Coal Mine longwalls, Longwalls 301-317, are referred to as the Approved Layout in this report. The proposed modifications to the longwall layouts include changes to commencing and finishing ends of Longwall 317 and addition of Longwall 318. The Modification application also includes a widening of the tailgate pillars for Longwalls 316 to 318 to 55 m, as detailed in Section 1.2. The modified longwalls, Longwalls 317 and 318 are referred to as the Modified Layout in this report.

A Study Area has been identified around the Modified Layout based on the 35° angle of draw line and predicted vertical limit of subsidence.

Chapter 2 defines the Study Area and provides a summary of the natural and built features within this area.





Source: Land and Property Information (2015); Date of Aerial Photography 1998; Department of Industry (2015); Metropolitan Coal (2025)

#### LEGEND

- ▬ Mining Lease Boundary
- ▬ Exploration Licence (EL 9364)
- ▬ Indicative Mining Lease Application Area
- ▬ Railway
- ⊠ Shafts
- ▬ Project Underground Mining Area
- ▬ Longwalls 20-27 and 301-317
- ▬ Existing Underground Access Drive (Main Drift)
- ▬ Existing Approved Underground Development

- ▬ Proposed First Workings
- ▬ Indicative Longwalls 317 and 318 Extraction Area
- ▬ Relocated Ventilation Shaft 4

#### Note:

The Longwalls 301 to 316 layout shown reflects the layouts in the approved and proposed Extraction Plans.

\* The approved location of Ventilation Shaft 4 following completion of construction is shown. The construction footprint would be of a similar size to the proposed Relocated Ventilation Shaft 4.

**Peabody**

METROPOLITAN COAL

Modified General Arrangement

Fig 1.1



Chapter 3 includes overviews of the mine subsidence parameters and the methods that have been used to predict the mine subsidence movements resulting from the extraction of the longwalls.

Chapter 4 provides the maximum predicted subsidence parameters resulting from the extraction of Longwalls 317 and 318 (including the effects of the previous Longwalls 301 to 316) based on the Modified Layout. Comparisons of these predictions with the maxima based on the Approved Layout are also provided in this chapter.

Chapters 5 through 11 provide the descriptions, predictions and impact assessments for each of the natural and built features within the Study Area based on the Modified Layout. Comparisons of the predictions for each of these features with those based on the Approved Layout are provided in these chapters. The impact assessments and recommendations have also been provided based on the Modified Layout.

## 1.2. Mining Geometry

The layout of Longwalls 317 and 318 is shown in Drawing No. MSEC1319-01 in Appendix E. A summary of the proposed longwall dimensions for the Approved and Modified Layouts is provided in Table 1.1. The Modified Layout includes an increase in length of Longwall 317 at the northern (commencing) end by 703 m, a reduction in length of Longwall 317 at the southern (finishing) end by 67 m, and the addition of Longwall 318. The Modification Layout includes all longwalls, including the extension to Longwall 317 and additional of Longwall 318. Compared to the Preferred Project Layout, the Modification Layout incorporates widening of the tailgate pillars for Longwalls 316 to 318 from 45 m to 55 m to reduce subsidence effects on upland swamps by limiting the predicted conventional tensile strain for swamps in the vicinity of Longwalls 317 and 318 to no greater than 0.5 mm/m. The Modification Layout also includes shortening of the finishing end of Longwall 317 to reduce subsidence effects to Swamp S106. The Approved and Modification Layouts also incorporate the relinquishment of underground mining areas in the Preferred Project Layout. The Approved Layout provided in Table 1.1 includes all longwalls up to the approved length of Longwall 317.

**Table 1.1 Geometry of the Longwalls 317 and 318 based on the Approved and Modified Layout**

| Layout          | Longwall | Void Length Including Installation Heading (m) | Overall Void Width Including First Workings (m) | Overall Tailgate Chain Pillar Width (m) |
|-----------------|----------|------------------------------------------------|-------------------------------------------------|-----------------------------------------|
| Approved Layout | LW317    | 724                                            | 163                                             | 45                                      |
| Modified Layout | LW317    | 2,360                                          | 163                                             | 55                                      |
|                 | LW318    | 2,258                                          | 163                                             | 55                                      |

## 1.3. Surface Topography

The surface level contours in the vicinity of Longwalls 317 and 318 are shown in Drawing No. MSEC1319-02, which were generated from an airborne laser scan of the area.

Surface levels above Longwalls 317 and 318 vary from approximately 295 metres Australian Height Datum (m AHD) above Longwall 317 finishing end to 230 m AHD above the Longwall 317 commencing end. The natural surface slopes predominantly to the west towards the Honeysuckle Creek.

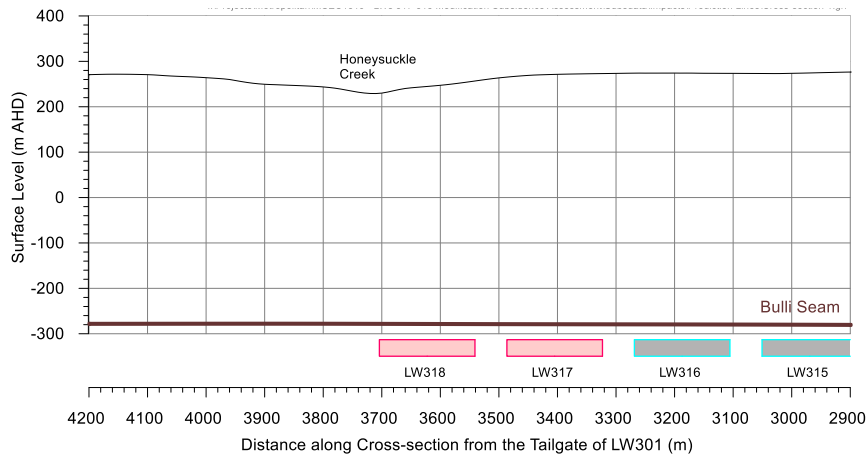
## 1.4. Seam Information

The seam floor contours, seam thickness contours and depth of cover contours for the Bulli Seam are shown in Drawings Nos. MSEC1319-03, MSEC1319-04 and MSEC1319-05, respectively.

The depth of cover to the Bulli Seam within the Study Area varies between a minimum of 510 m, at the Longwall 317 commencing end to, to a maximum of 545 m, near the southern end of Longwall 317.

The seam floor within the Study Area generally dips from the south-west to the north-east. The seam thickness within the Longwalls 317 and 318 footprint varies between approximately 2.55 m and 2.65 m. The longwall would extract a minimum height of 2.8 m.

The variations in the surface and seam levels across the mining area are illustrated along Cross-section 1 in Fig. 1.2. The location of this section is shown in Drawings No. MSEC1319-05.



**Fig. 1.2 Surface and Seam Levels along Cross-section 1**

## 1.5. Geological Details

The main geological features mapped at seam level in the vicinity of the Modification are shown in Drawing No. MSEC1319-06.

No structures have been identified to date within the Study Area of Longwalls 317 and 318. Structures have been identified within the footprint of previously approved longwalls. It is expected that some structures would be identified within ongoing exploration and development. The structures identified within and near the previously approved longwalls includes minor discontinuous faulting. Mapped structures generally have negligible vertical displacement and are mainly strike, slip features.

The nearest significant geological feature is the regional Metropolitan Fault which is over approximately 1.6 kilometres (km) from Longwall 317. The Metropolitan Fault has a north-west to south-east strike and dips to the north east.

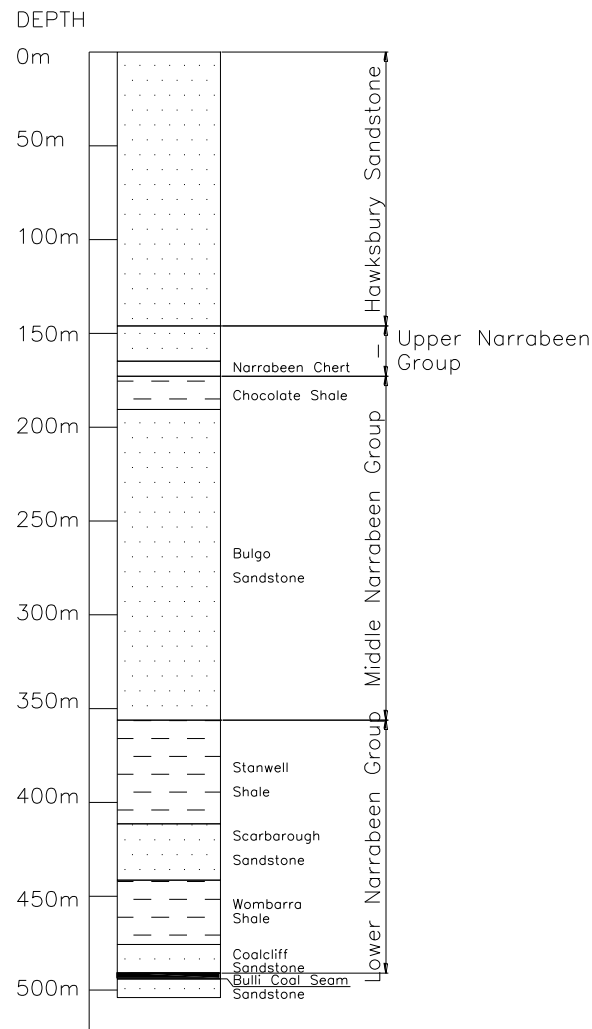
A typical stratigraphic section for the Study Area is shown in Fig. 1.3. The sandstone and shale units vary in thickness from a few metres to over 160 m. The major sandstone units are interbedded with other rocks and, though shales and claystones are quite extensive in places, the sandstone predominates.

The major sedimentary units in the Metropolitan Coal Mine area are, from the top down:

- Hawkesbury Sandstone; and
- the Upper, Middle and Lower Narrabeen Group.

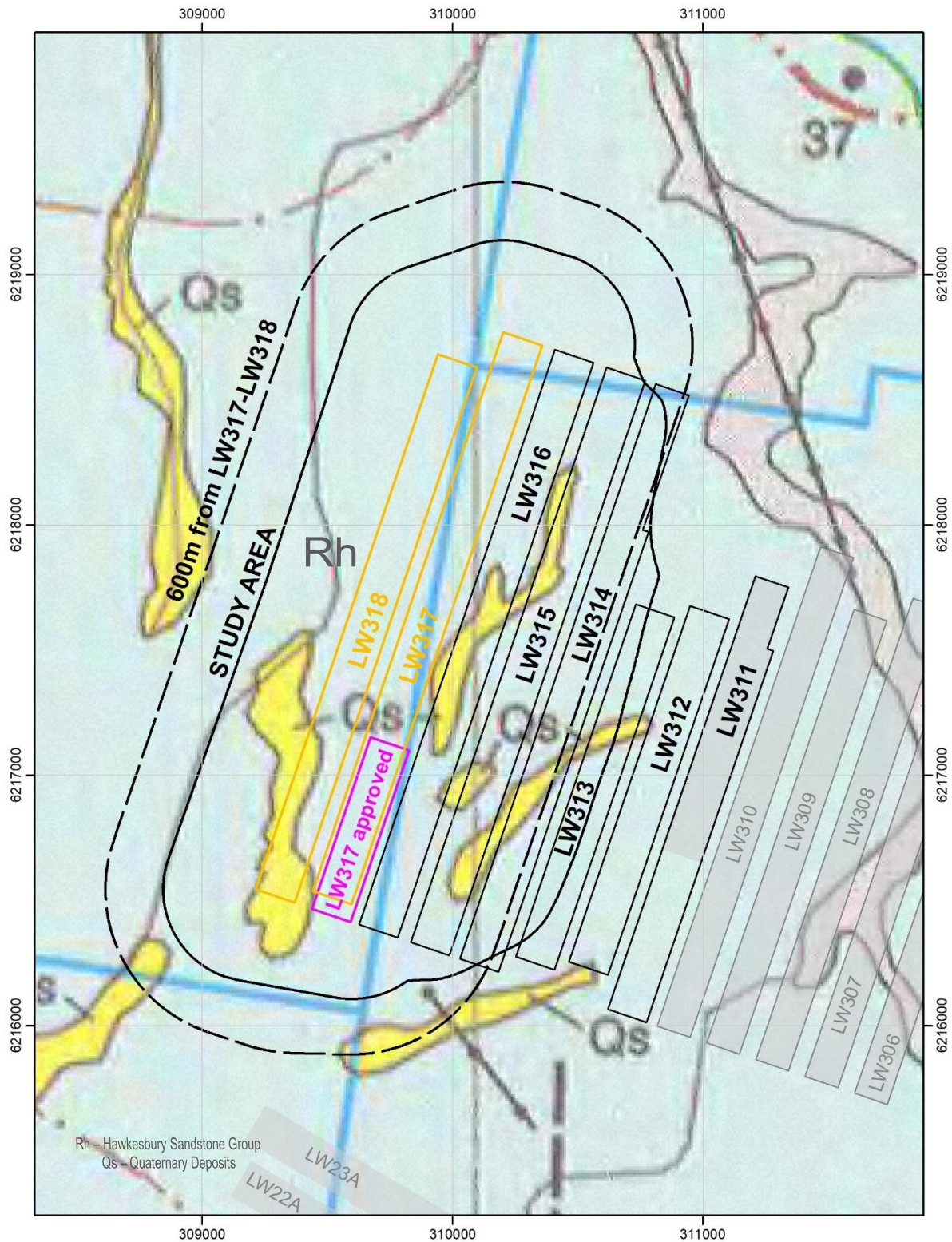
The Narrabeen Group contains the Newport Formation (sometimes referred to as the Gosford Formation), the Bald Hill Claystone (also referred to as Chocolate Shale), the Bulgo Sandstone, the Stanwell Park Claystone/Shale, the Scarborough Sandstone, the Wombarra Shale and the Coal Cliff Sandstone.

The surface geology within the Study Area can be seen in Fig. 1.4, which shows the proposed longwalls overlaid on Geological Series Sheet 9029-9129, which is published by the then NSW Department of Industry – Division of Resources and Energy (DRE).



**Fig. 1.3 Stratigraphic Section**





**Fig. 1.4 Surface Lithology within the Study Area (DRE Geological Series Sheet 9029-9129)**

It can be seen from the above Fig. 1.4 that the surface lithology in the vicinity of the proposed Longwalls 317 and 318 comprises Hawkesbury Sandstone Group (Rh) and Quaternary Deposits (Qs).

### 2.1. Definition of the Study Area

The Study Area is defined as the surface area that is likely to be affected by the proposed mining of the Modification in the Bulli Seam at the Metropolitan Coal Mine. The surface features included in the Study Area are those features within areas bounded by the following limits:

- a 35° angle of draw line from the proposed extent of Longwalls 317 and 318; and
- the predicted limit of vertical subsidence, taken as the predicted additional 20 millimetres (mm) subsidence contour resulting from the extraction of the proposed Longwalls 317 and 318.

The depth of cover contours are shown in Drawing No. MSEC1319-05. It can be seen from this drawing that the depth of cover directly above the proposed Longwalls 317 and 318 varies between a minimum of 510 m and a maximum of 545 m. The 35° angle of draw line, therefore, has been determined by drawing a line that is a horizontal distance varying between 357 m and 382 m from Longwalls 317 and 318. The predicted limit of vertical subsidence, taken as the predicted additional 20 mm subsidence contour, has been determined using the calibrated Incremental Profile Method, which is described in Chapter 3.

The line defining the Study Area, based on the further extent of the 35° angle of draw and the predicted additional 20 mm subsidence contour is shown in Drawing No. MSEC1319-01.

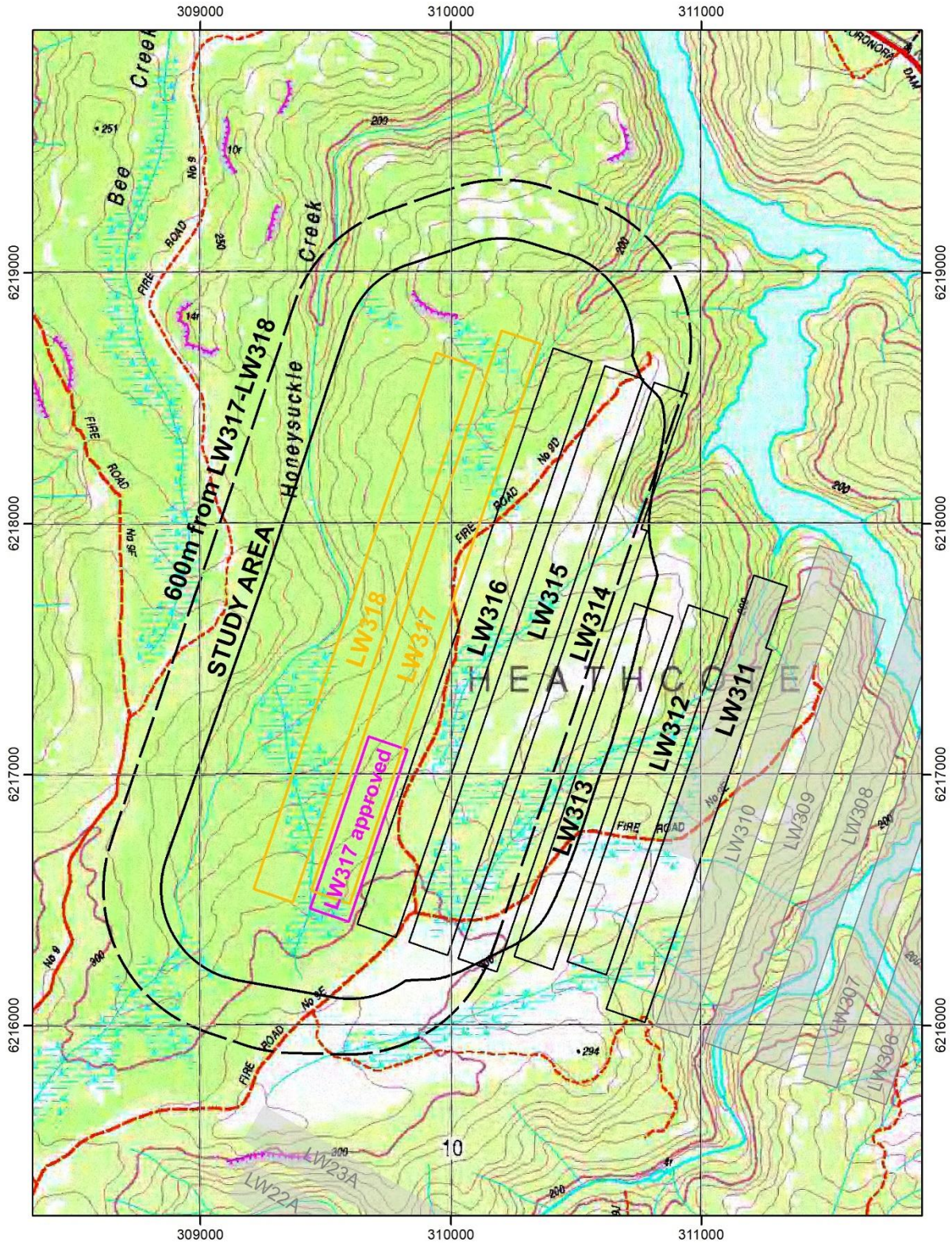
There are features that lie outside the Study Area that may experience either far-field movements, or valley related movements. The surface features which are sensitive to such movements have been identified and have been included in the assessments provided in this report.

The natural features within 600 m of the proposed Longwalls 317 and 318 are also considered in this report. Other natural features located outside the 600 m boundary which may be sensitive to far-field or valley related movements have also been considered where relevant.

### 2.2. Natural and Built Features within the Study Area

Many natural and built features within the Study Area can be seen in the 1:25,000 Topographic Map of the area, published by the Central Mapping Authority (CMA), numbered APPIN 9029-1S. The proposed Longwalls 317 and 318 have been overlaid on an extract of this CMA map in Fig. 2.1.





**Fig. 2.1 The Proposed Longwalls 317 and 318 Overlaid on CMA Map No. Appin 9029-1S**

A summary of the natural and built features within the Study Area, or relevant to this report with respect to potential far-field movements is provided in Table 2.1. The locations of these features are shown in Drawings Nos. MSEC1319-07 to MSEC1319-09, in Appendix E.

The descriptions, predictions and impact assessments for the natural and built features are provided in Chapters 5 through to 11. The section number references are provided in Table 2.1.

**Table 2.1 Natural and Built Features**

| Item                                                                                                                               | Within Study Area | Section Number Reference |
|------------------------------------------------------------------------------------------------------------------------------------|-------------------|--------------------------|
| <b>NATURAL FEATURES</b>                                                                                                            |                   |                          |
| Catchment Areas or Declared Special Areas                                                                                          | ✓                 | 5.2                      |
| Rivers or Creeks                                                                                                                   | ✓                 | 5.3 to 5.5               |
| Aquifers or Known Groundwater Resources                                                                                            | ✓                 | 5.6                      |
| Springs                                                                                                                            | x                 |                          |
| Sea or Lake                                                                                                                        | x                 |                          |
| Shorelines                                                                                                                         | x                 |                          |
| Natural Dams                                                                                                                       | x                 |                          |
| Cliffs or Pagodas                                                                                                                  | ✓                 | 5.7 & 5.8                |
| Steep Slopes                                                                                                                       | ✓                 | 5.9                      |
| Escarpments                                                                                                                        | x                 |                          |
| Land Prone to Flooding or Inundation                                                                                               | x                 |                          |
| Swamps, Wetlands or Water Related Ecosystems                                                                                       | ✓                 | 5.10                     |
| Threatened or Protected Species                                                                                                    | ✓                 | 5.11                     |
| National Parks                                                                                                                     | x                 |                          |
| State Forests                                                                                                                      | x                 |                          |
| State Conservation Areas                                                                                                           | x                 |                          |
| Natural Vegetation                                                                                                                 | ✓                 | 5.12                     |
| Areas of Significant Geological Interest                                                                                           | x                 |                          |
| Any Other Natural Features Considered Significant                                                                                  | x                 |                          |
| <b>PUBLIC UTILITIES</b>                                                                                                            |                   |                          |
| Railways                                                                                                                           | x                 |                          |
| Roads (All Types)                                                                                                                  | ✓                 | 6.1 to 6.2               |
| Bridges                                                                                                                            | x                 |                          |
| Tunnels                                                                                                                            | x                 |                          |
| Culverts                                                                                                                           | x                 |                          |
| Water, Gas or Sewerage Infrastructure                                                                                              | x                 |                          |
| Liquid Fuel Pipelines                                                                                                              | x                 |                          |
| Electricity Transmission Lines or Associated Plants                                                                                | x                 |                          |
| Telecommunication Lines or Associated Plants                                                                                       | x                 |                          |
| Water Tanks, Water or Sewage Treatment Works                                                                                       | x                 |                          |
| Dams, Reservoirs or Associated Works                                                                                               | x                 | 6.3                      |
| Air Strips                                                                                                                         | x                 |                          |
| Any Other Public Utilities                                                                                                         | x                 |                          |
| <b>PUBLIC AMENITIES</b>                                                                                                            |                   |                          |
| Hospitals                                                                                                                          | x                 |                          |
| Places of Worship                                                                                                                  | x                 |                          |
| Schools                                                                                                                            | x                 |                          |
| Shopping Centres                                                                                                                   | x                 |                          |
| Community Centres                                                                                                                  | x                 |                          |
| Office Buildings                                                                                                                   | x                 |                          |
| Swimming Pools                                                                                                                     | x                 |                          |
| Bowling Greens                                                                                                                     | x                 |                          |
| Ovals or Cricket Grounds                                                                                                           | x                 |                          |
| Race Courses                                                                                                                       | x                 |                          |
| Golf Courses                                                                                                                       | x                 |                          |
| Tennis Courts                                                                                                                      | x                 |                          |
| Any Other Public Amenities                                                                                                         | x                 |                          |
| <b>FARM LAND AND FACILITIES</b>                                                                                                    |                   |                          |
| Agricultural Utilisation or Agricultural Suitability of Farm Land                                                                  | x                 | 8.1                      |
| Farm Buildings or Sheds                                                                                                            | x                 |                          |
| Tanks                                                                                                                              | x                 |                          |
| Gas or Fuel Storages                                                                                                               | x                 |                          |
| Poultry Sheds                                                                                                                      | x                 |                          |
| Glass Houses                                                                                                                       | x                 |                          |
| Hydroponic Systems                                                                                                                 | x                 |                          |
| Irrigation Systems                                                                                                                 | x                 |                          |
| Fences                                                                                                                             | x                 |                          |
| Farm Dams                                                                                                                          | x                 |                          |
| Wells or Bores                                                                                                                     | x                 |                          |
| Any Other Farm Features                                                                                                            | x                 |                          |
| <b>INDUSTRIAL, COMMERCIAL AND BUSINESS ESTABLISHMENTS</b>                                                                          |                   |                          |
| Factories                                                                                                                          | x                 |                          |
| Workshops                                                                                                                          | x                 |                          |
| Business or Commercial Establishments or Improvements                                                                              | x                 |                          |
| Gas or Fuel Storages or Associated Plants                                                                                          | x                 |                          |
| Waste Storages or Associated Plants                                                                                                | x                 |                          |
| Buildings, Equipment or Operations that are Sensitive to Surface Movements                                                         | x                 |                          |
| Surface Mining (Open Cut) Voids or Rehabilitated Areas                                                                             | x                 |                          |
| Mine Infrastructure Including Tailings Dams or Emplacement Areas                                                                   | x                 |                          |
| Any Other Industrial, Commercial or Business Features                                                                              | x                 |                          |
| <b>AREAS OF ARCHAEOLOGICAL OR HERITAGE SIGNIFICANCE</b>                                                                            |                   |                          |
|                                                                                                                                    | ✓                 | 10.1 & 10.2              |
| <b>ITEMS OF ARCHITECTURAL SIGNIFICANCE</b>                                                                                         |                   |                          |
|                                                                                                                                    | x                 |                          |
| <b>PERMANENT SURVEY CONTROL MARKS</b>                                                                                              |                   |                          |
|                                                                                                                                    | x                 | 10.4                     |
| <b>RESIDENTIAL ESTABLISHMENTS</b>                                                                                                  |                   |                          |
| Houses                                                                                                                             | x                 |                          |
| Flats or Units                                                                                                                     | x                 |                          |
| Caravan Parks                                                                                                                      | x                 |                          |
| Retirement or Aged Care Villages                                                                                                   | x                 |                          |
| Associated Structures such as Workshops, Garages, On-Site Waste Water Systems, Water or Gas Tanks, Swimming Pools or Tennis Courts | x                 |                          |
| Any Other Residential Features                                                                                                     | x                 |                          |
| <b>ANY OTHER ITEM OF SIGNIFICANCE</b>                                                                                              |                   |                          |
|                                                                                                                                    | x                 |                          |
| <b>ANY KNOWN FUTURE DEVELOPMENTS</b>                                                                                               |                   |                          |
|                                                                                                                                    | x                 |                          |



#### 3.1. Introduction

This chapter provides overviews of mine subsidence parameters and the methods that have been used to predict the mine subsidence movements resulting from the extraction of the proposed Longwalls 317 and 318. Further details on longwall mining, the development of subsidence and the methods used to predict mine subsidence movements are provided in the background reports entitled *Introduction to Longwall Mining and Subsidence* and *General Discussion on Mine Subsidence Ground Movements* which can be obtained from [www.minesubsidence.com](http://www.minesubsidence.com).

#### 3.2. Overview of Conventional Subsidence Parameters

The normal ground movements resulting from the extraction of longwalls are referred to as conventional or systematic subsidence movements. These movements are described by the following parameters:

- **Subsidence** usually refers to vertical displacement of a point, but subsidence of the ground actually includes both vertical and horizontal displacements. These horizontal displacements in some cases, where the subsidence is small beyond the longwall goaf edges, can be greater than the vertical subsidence. Subsidence is usually expressed in units of *mm*.
- **Tilt** is the change in the slope of the ground as a result of differential subsidence, and is calculated as the change in subsidence between two points divided by the distance between those points. Tilt is, therefore, the first derivative of the subsidence profile. Tilt is usually expressed in units of *millimetres per metre (mm/m)*. A tilt of 1 mm/m is equivalent to a change in grade of 0.1 per cent (%), or 1 in 1000.
- **Curvature** is the second derivative of subsidence, or the rate of change of tilt, and is calculated as the change in tilt between two adjacent sections of the tilt profile divided by the average length of those sections. Curvature is usually expressed as the inverse of the **Radius of Curvature** with the units of *1/kilometre (km<sup>-1</sup>)*, but the values of curvature can be inverted, if required, to obtain the radius of curvature, which is usually expressed in *kilometres (km)*.
- **Strain** is the relative differential horizontal movements of the ground. **Normal strain** is calculated as the change in horizontal distance between two points on the ground, divided by the original horizontal distance between them. Strain is typically expressed in units of *millimetres per metre (mm/m)*. **Tensile Strains** occur where the distance between two points increases and **Compressive Strains** occur when the distance between two points decreases. So that ground strains can be compared between different locations, they are typically measured over bay lengths that are equal to the depth of cover between the surface and seam divided by 20.

Whilst mining induced normal strains are measured along monitoring lines, ground shearing can also occur both vertically and horizontally across the directions of monitoring lines. Most of the published mine subsidence literature discusses the differential ground movements that are measured along subsidence monitoring lines, however, differential ground movements can also be measured across monitoring lines using three dimensional (3D) survey monitoring techniques.

- **Horizontal shear deformation** across monitoring lines can be described by various parameters including horizontal tilt, horizontal curvature, mid-ordinate deviation, angular distortion and shear index. It is not possible, however, to determine the horizontal shear strain across a monitoring line using two dimensional (2D) or 3D monitoring techniques.

High deformations along monitoring lines (i.e. normal strains) are generally measured where high deformations have been measured across the monitoring line (i.e. shear deformations).

Conversely, high deformations across monitoring lines are also generally measured where high normal strains have been measured along the monitoring line.

The **incremental** subsidence, tilts, curvatures and strains are the additional parameters which result from the extraction of each longwall. The **total** subsidence, tilts, curvatures and strains are the accumulative parameters after the completion of each longwall within a series of longwalls. The **travelling** tilts, curvatures and strains are the transient movements as the longwall extraction face mines directly beneath a given point.

### 3.3. Far-field Movements

The measured horizontal movements at survey marks which are located beyond the longwall goaf edges and over solid unmined coal areas are often much greater than the observed vertical movements at those marks. These movements are often referred to as *far-field movements*.

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

In some cases, higher levels of far-field horizontal movements have been observed where steep slopes or surface incisions exist nearby, as these features influence both the magnitude and the direction of ground movement patterns. Similarly, increased horizontal movements are often observed around sudden changes in geology or where blocks of coal are left between longwalls or near other previously extracted series of longwalls. In these cases, the levels of observed subsidence can be slightly higher than normally predicted, but these increased movements are generally accompanied by very low levels of tilt and strain.

Far-field horizontal movements and the method used to predict such movements are described further in Section 4.6.

### 3.4. Overview of Non-Conventional Subsidence Movements

Conventional subsidence profiles are typically smooth in shape and can be explained by the expected caving mechanisms associated with overlying strata spanning the extracted void. Normal conventional subsidence movements due to longwall extraction are easy to identify where longwalls are regular in shape, the extracted coal seams are relatively uniform in thickness, the geological conditions are consistent and surface topography is relatively flat.

As a general rule, the smoothness of the profile is governed by the depth of cover and lithology of the overburden, particularly the near surface strata layers. Where the depth of cover is greater than say 400 m, such as the case within the Study Area, the observed subsidence profiles along monitoring survey lines are generally smooth. Where the depth of cover is less than say 100 m, the observed subsidence profiles along monitoring lines are generally irregular. Very irregular subsidence movements are observed with much higher tilts and strains at very shallow depths of cover where the collapsed zone above the extracted longwalls extends up to or near to the surface.

Irregular subsidence movements are occasionally observed at the deeper depths of cover along an otherwise smooth subsidence profile. The cause of these irregular subsidence movements can be associated with:

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

Non-conventional movements due to geological conditions and valley related movements are discussed in the following sections.

#### 3.4.1. Non-conventional Subsidence Movements due to Changes in Geological Conditions

It is possible that surface features located above the longwalls could experience localised and elevated strains due to unknown geological structures (i.e. anomalies). Non-conventional or anomalous movements have not been identified during the extraction of Longwalls 301 to 311 at the Metropolitan Coal Mine. It is believed that most non-conventional ground movements are the result of the reaction of near surface strata to increased horizontal compressive stresses due to mining operations. Some of the geological conditions that are believed to influence these irregular subsidence movements are the blocky nature of near surface sedimentary strata layers and the possible presence of unknown faults, dykes or other geological structures, cross bedded strata, thin and brittle near surface strata layers and pre-existing natural joints. The presence of these geological features near the surface can result in a bump in an otherwise smooth subsidence profile and these bumps are usually accompanied by locally increased tilts and strains.

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

It is not possible to predict the locations and magnitudes of non-conventional anomalous movements. In some cases, approximate predictions for the non-conventional ground movements can be made where the underlying geological or topographic conditions are known in advance. It is expected that these methods will improve as further knowledge is gained through ongoing research and investigation.

In this report, non-conventional ground movements are being included statistically in the predictions and impact assessments, by basing these on the frequency of past occurrence of both the conventional and non-conventional ground movements and impacts. The analysis of strains provided in Section 4.4 includes those resulting from both conventional and non-conventional anomalous movements. The impact assessments for the natural and built features, which are provided in Chapters 5 through to 11, include historical impacts resulting from previous longwall mining which have occurred as the result of both conventional and non-conventional subsidence movements.

### 3.4.2. Non-conventional Subsidence Movements due to Steep Topography

Non-conventional movements can also result from downslope movements where longwalls are extracted beneath steep slopes. In these cases, elevated tensile strains develop near the tops and along the sides of the steep slopes and elevated compressive strains develop near the bases of the steep slopes. The potential impacts resulting from down slope movements include the development of tension cracks at the tops and sides of the steep slopes and compression ridges at the bottoms of the steep slopes.

Further discussions on the potential for down slope movements for the steep slopes within the Study Area are provided in Section 5.9.

### 3.4.3. Valley Related Movements

Watercourses may be subjected to valley related movements, which are commonly observed along river and creek alignments in the Southern Coalfield. Valley bulging movements are a natural phenomenon, resulting from the formation and ongoing development of the valley, as illustrated in Fig. 3.1. The potential for these natural movements is influenced by the geomorphology of the valley.

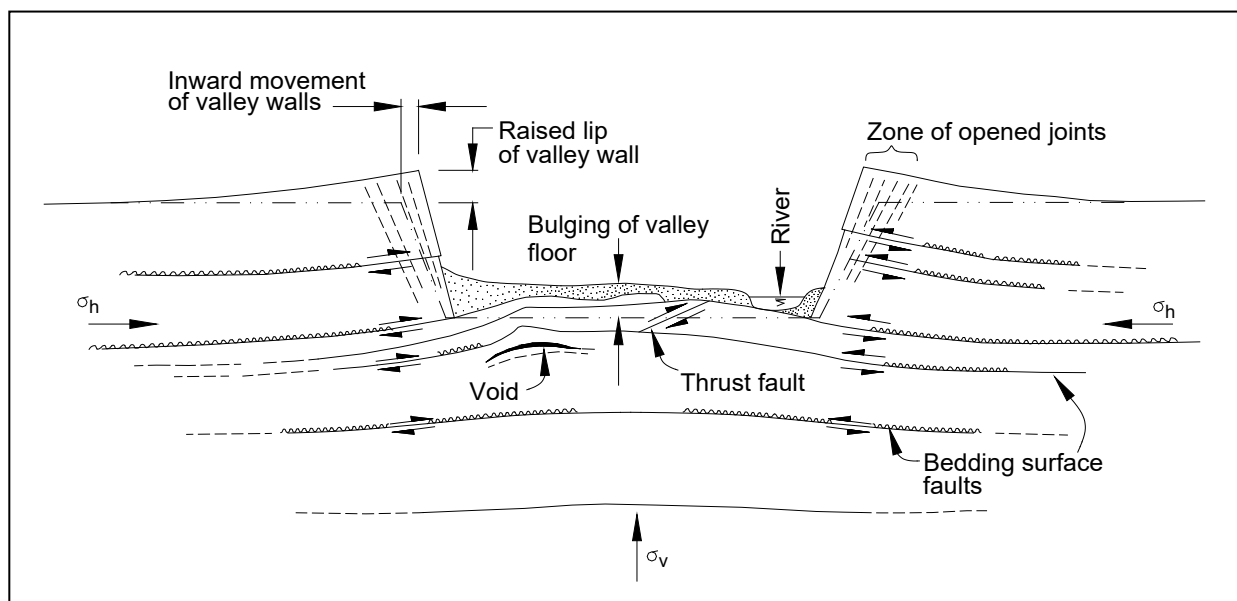


Fig. 3.1 Valley Formation in Flat-lying Sedimentary Rocks (after Patton and Hendren 1972)



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

- **Upsidence** is the reduced subsidence, or the relative uplift within a valley which results from the dilation or buckling of near surface strata at or near the base of the valley. The magnitude of upsidence, which is typically expressed in the units of *millimetres (mm)*, is the difference between the observed subsidence profile within the valley and the conventional subsidence profile which would have otherwise been expected in flat terrain.
- **Closure** is the reduction in the horizontal distance between the valley sides. The magnitude of closure, which is typically expressed in the units of *mm*, is the greatest reduction in distance between any two points on the opposing valley sides.
- **Compressive Strains** occur within the bases of valleys as a result of valley closure and upsidence movements. **Tensile Strains** also occur in the sides and near the tops of the valleys as a result of valley closure movements. The magnitudes of these strains, which are typically expressed in the units of *mm/m*, are calculated as the changes in horizontal distance over a standard bay length, divided by the original bay length.

The predicted valley related movements resulting from the extraction of the proposed longwalls were made using the empirical method outlined in ACARP Research Project No. C9067 (Waddington and Kay, 2002). Further details can be obtained from the background report entitled *General Discussion on Mine Subsidence Ground Movements* which can be obtained at [www.minesubsidence.com](http://www.minesubsidence.com).

### 3.5. The Incremental Profile Method

The predicted conventional subsidence parameters for the longwalls were determined using the Incremental Profile Method, which was developed by MSEC, formally known as Waddington Kay and Associates. The method is an empirical model based on a large database of observed monitoring data from previous mining within the Southern, Newcastle, Hunter and Western Coalfields of NSW and from mining in the Bowen Basin in Queensland.

The database consists of detailed subsidence monitoring data from many mines and collieries in NSW including: Angus Place, Appin, Baal Bone, Bellambi, Beltana, Blakefield South, Bulli, Carborough Downs, Chain Valley, Clarence, Coalcliff, Cook, Cooranbong, Cordeaux, Corrimal, Cumnock, Dartbrook, Delta, Dendrobium, Eastern Main, Ellalong, Fernbrook, Glennies Creek, Grasstree, Gretley, Invincible, John Darling, Kemira, Kestrel, Lambton, Liddell, Mandalong, Metropolitan, Mt. Kembla, Moranbah, Munmorah, Nardell, Newpac, Newstan, Newvale, Newvale 2, South Bulga, South Bulli, Springvale, Stockton Borehole, Teralba, Tahmoor, Tower, Wambo, Wallarah, Western Main, Ulan, United, West Cliff, West Wallsend, and Wyee.

The database consists of the observed incremental subsidence profiles, which are the additional subsidence profiles resulting from the extraction of each longwall within a series of longwalls. It can be seen from the normalised incremental subsidence profiles within the database, that the observed shapes and magnitudes are reasonably consistent where the mining geometry and local geology are similar.

Subsidence predictions made using the Incremental Profile Method use the database of observed incremental subsidence profiles, the longwall geometries, local surface and seam information and geology. The method has a tendency to over-predict the conventional subsidence parameters (i.e. is slightly conservative) where the mining geometry and geology are within the range of the empirical database. The predictions can be further tailored to local conditions where observed monitoring data is available close to the mining area.

Further details on the Incremental Profile Method can be obtained from [www.minesubsidence.com](http://www.minesubsidence.com).

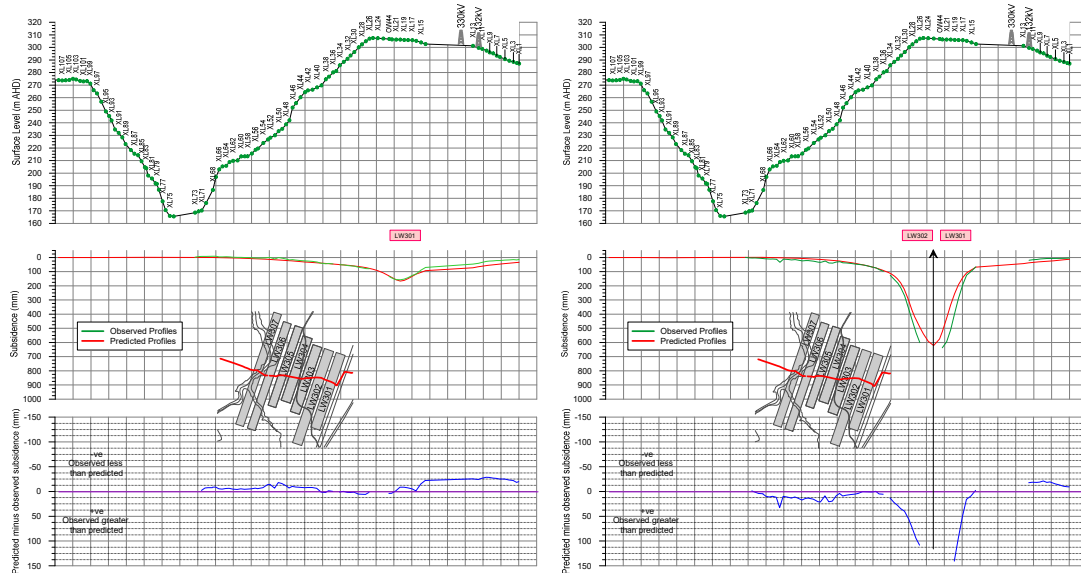
### 3.6. Calibration of the Incremental Profile Method

The standard Incremental Profile Method as used for the Southern Coalfield was calibrated to local conditions for the Metropolitan Coal Project EA using observed monitoring data above the previously extracted longwalls at the Metropolitan Coal Mine. The calibration of the Incremental Profile Method is outlined in detail in the MSEC285 report. The calibrated model predicts subsidence greater than the standard model so as to account for the local geology at the Metropolitan Coal Mine.

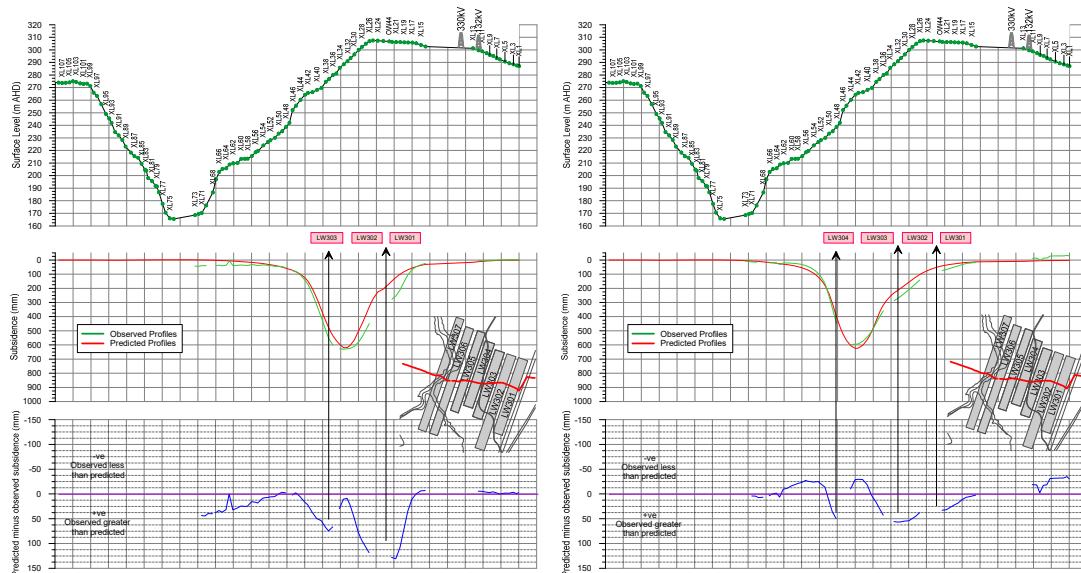
With continued longwall extraction in a northerly direction the longwall panel void widths have remained constant from Longwall 11 with a void width of 163 m. Recent longwall void widths have reduced to 138 m. Pillar widths have generally increase from 35 m for Longwalls 1 to 18, to 45 m for Longwalls 301 to 305.

Pillar widths for Longwalls 20 to 27 varied from approximately 40 m to 50 m. The average depth of cover above the extracted longwalls has also generally increased to the north from approximately under 450 m above Longwalls 1 to 18, to over 500 m above the 300 series longwalls. For each extracted longwall, the magnitude of maximum observed subsidence has generally been less than predicted, however the cumulative maximum subsidence over several longwalls had increased to be greater than predicted.

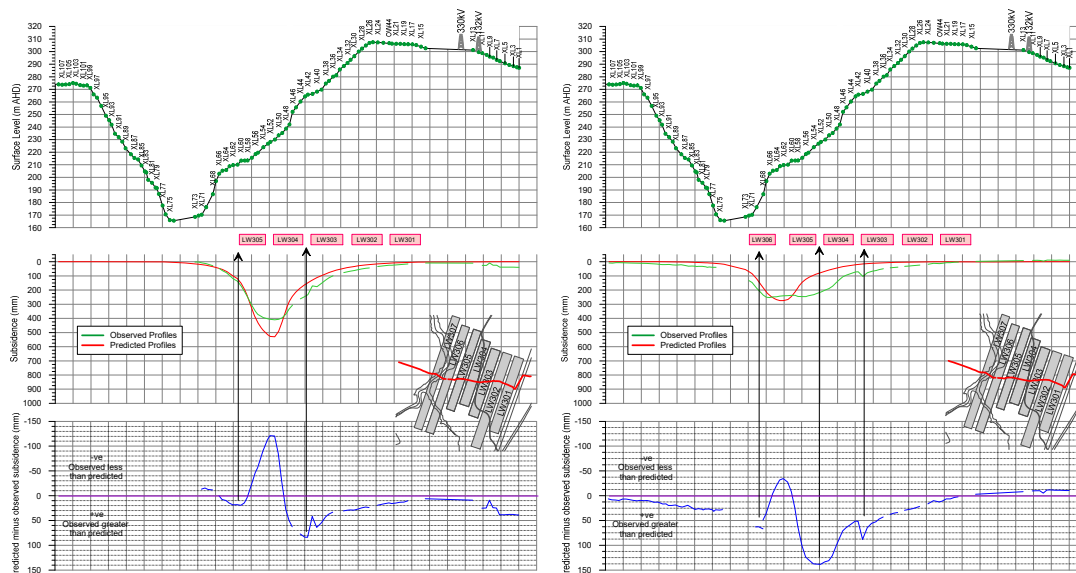
In order to assess the greater than predicted subsidence, a review was carried out on the predicted and observed data for the incremental subsidence profiles along the 300XL line. For each extracted longwall the incremental predicted profile was subtracted from the observed profile. The resulting graphs showed areas along the monitoring line where observed incremental subsidence was greater than predicted, as positive values, and areas where observed incremental subsidence was less than predicted, as negative values. The results for Longwalls 301 to 307 are shown below in Fig. 3.2 to Fig. 3.5.



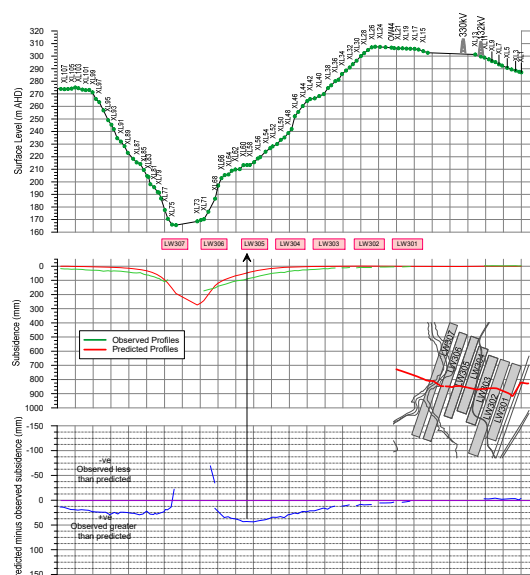
**Fig. 3.2 300XL Line Incremental Subsidence – Longwall 301 and Longwall 302**



**Fig. 3.3 300XL Line Incremental Subsidence – Longwall 303 and Longwall 304**



**Fig. 3.4 300XL Line Incremental Subsidence – Longwall 305 and Longwall 306**



**Fig. 3.5 300XL Line Incremental Subsidence – Longwall 307**

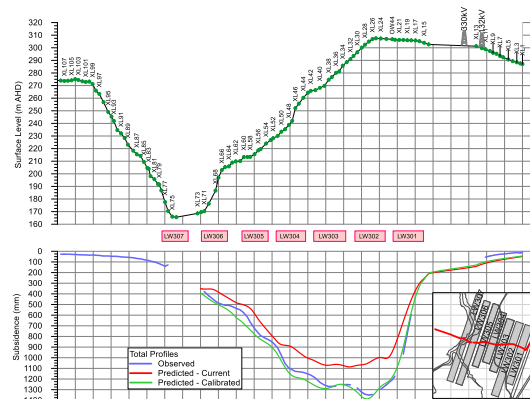
The different profiles in Fig. 3.2 to Fig. 3.5 show that typically the maximum incremental observed subsidence is close to or less than predicted with the location of maximum incremental subsidence at the tailgate pillar of the extracted longwall.

Where three or more longwalls have been extracted, observed subsidence is greater than predicted above the tailgate pillar for the previously extracted longwall, with a difference of up to almost 150 mm. In several of the profiles, observed subsidence is slightly greater than predicted directly above the centreline of the extracted longwall, with a difference of up to approximately 50 mm. Greater than predicted subsidence also appears to have occurred with the extraction of Longwall 302, however the survey pegs at the location of maximum subsidence were damaged therefore the profile at this location is not clearly defined.

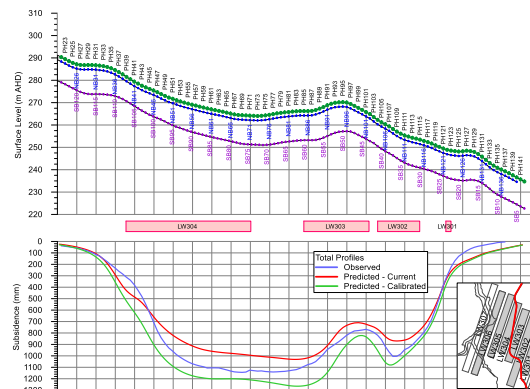


The assessment of the 300XL line indicated that additional minor subsidence is occurring at the pillars between previously extracted longwalls. The additional subsidence indicates that the coal pillars between previously extracted longwalls are experiencing more pillar squashing than predicted. The additional subsidence above the pillars has resulted in observed maximum total subsidence exceeding predicted maximum subsidence by 17 % along this monitoring line. The profiles of predicted vertical subsidence are generally consistent with observed vertical subsidence. With the exception of isolated locations, predicted tilt and curvature are generally consistent with predictions.

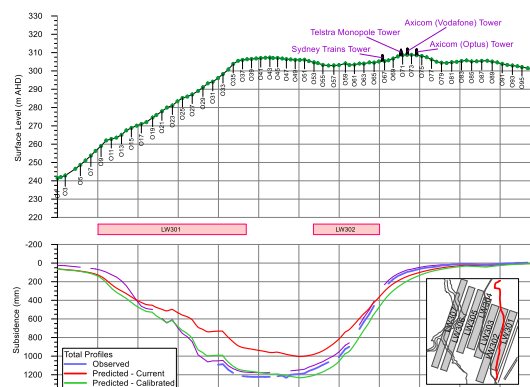
An adjustment was made to the Incremental Profile Method prediction model based on the outcomes of the abovementioned 300XL Line assessment. A comparison of the model output is provided below in Fig. 3.6, Fig. 3.7, and Fig. 3.8 for the 300XL Line, Princes Highway Line and Optic Water Line respectively. The comparison is made with observed monitoring data to the end of Longwall 307. In each figure the observed monitoring data is shown by a blue line, with the existing subsidence prediction model output in red and the calibrated subsidence prediction model output in green.



**Fig. 3.6 300XL Line – Comparison of Observed and Predicted Subsidence Profiles**



**Fig. 3.7 Princes Highway Line – Comparison of Observed and Predicted Subsidence Profiles**



**Fig. 3.8 Optic Water Line – Comparison of Observed and Predicted Subsidence Profiles**

The calibration for the Incremental Profile Method model results in an increase in vertical subsidence, however the magnitudes of predicted tilt and curvature do not change significantly.

### 3.7. Reliability of the Predicted Conventional Subsidence Parameters

The Incremental Profile Method is based upon a large database of observed subsidence movements in the Southern Coalfield and has been found, in most cases, to give reasonable, if not, conservative predictions of maximum subsidence, tilt and curvature following calibration. The predicted profiles obtained using this method also reflect the way in which each parameter varies over the mined area and indicate the movements that are likely to occur at any point on the surface.

The following findings have been previously documented in relation to the Incremental Profile Method:

- The observed subsidence profiles reasonably match those predicted using the standard or calibrated prediction curves. While there is reasonable correlation, it is highlighted that in some locations away from the points of maxima and, in particular beyond the longwall goaf edges, that the observed subsidence can exceed that predicted. In these locations, however, the magnitude of subsidence is low and there were no associated significant tilts, curvatures and strains.
- In some cases, however, the observed subsidence has exceeded those predicted. It is highlighted, that in one rare case in the Southern Coalfield, the maximum observed subsidence substantially exceeded that predicted above Longwall 24A and parts of Longwalls 25 to 27 at Tahmoor Colliery. In the Tahmoor cases, the maximum observed subsidence of 1,169 mm and 1,216 mm, or 54 % and 55 % of the extracted seam thicknesses, were more than double the predicted amounts of 500 mm and 600 mm, or 23 % and 27 % of the extracted seam thickness. This was a very unusual and rare event for the Southern Coalfield and geotechnical advice indicates the cause was unusual geology (Gale W & Shephard, *Investigation into Abnormal Increased Subsidence above Longwall Panels at Tahmoor Colliery NSW*, MSTS Conference, 2011). The abnormal subsidence was found to be associated with the localised weathering of joint and bedding planes above a depressed water table adjacent to the incised Bargo River Gorge. Similar increased subsidence has not been observed beside other incised gorges. To put this in perspective, the surface area that was affected by increased subsidence at Tahmoor represents less than 1 % of the total surface area affected by longwall mining in the Southern Coalfield.
- The observed tilt profiles also reasonably matched the predicted profiles using the standard or calibrated prediction curves.

The prediction of the conventional subsidence parameters at a specific point is more difficult. Variations between predicted and observed parameters at a point can occur where there is a lateral shift between the predicted and observed subsidence profiles, which can result from seam dip or variations in topography. In these situations, the lateral shift can result in the observed parameters being greater than those predicted in some locations, with the observed parameters being less than those predicted in other locations.

The prediction of strain at a point is even more difficult as there tends to be a large scatter in observed strain profiles. It has been found that measured strains can vary considerably from those predicted at a point, not only in magnitude, but also in sign, that is, the tensile strains have been observed where compressive strains were predicted, and vice versa. For this reason, the prediction of strain in this report has been based on a statistical approach, which is discussed in Section 4.4.

The tilts, curvatures and strains observed at the streams are likely to be greater than the predicted conventional movements, as a result of valley related movements, which is discussed in Section 3.4.3. Specific predictions of upsidence, closure and compressive strain due to the valley related movements are provided for the streams in Sections 5.3 to 5.5. The impact assessments for the streams are based on both the conventional and valley related movements.

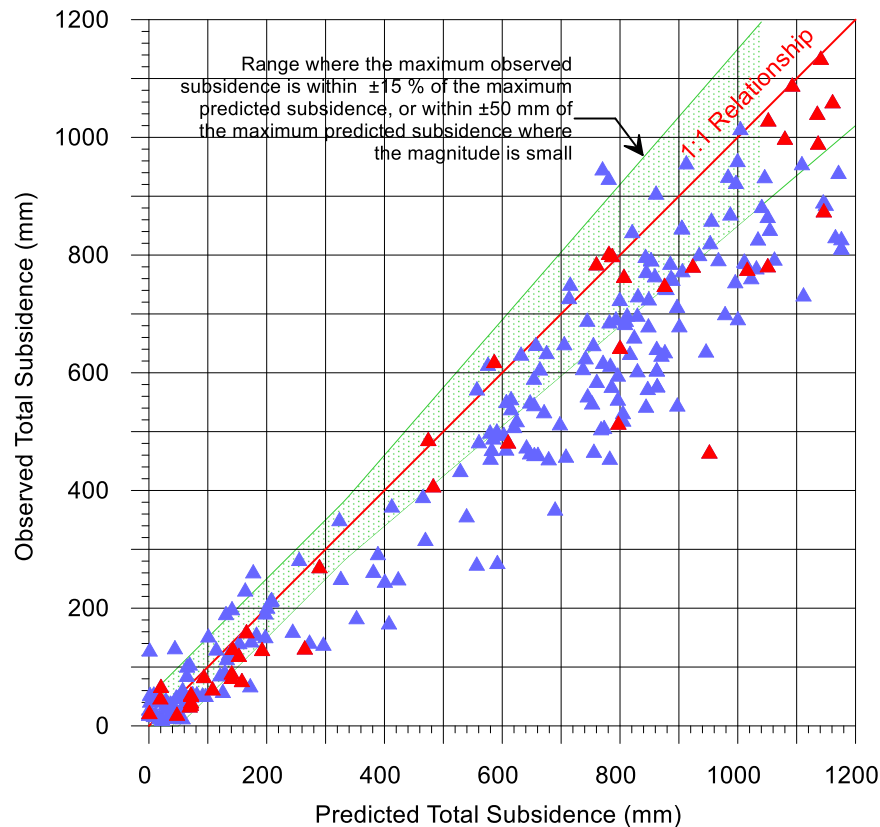
It is also likely that some localised irregularities would occur in the subsidence profiles due to near surface geological features. The irregular movements are accompanied by elevated tilts, curvatures and strains, which often exceed the conventional predictions. In most cases, it is not possible to predict the locations or magnitudes of these irregular movements. For this reason, the strain predictions provided in this report are based on a statistical analysis of measured strains in the Southern Coalfield, including both conventional and non-conventional anomalous strains, which is discussed in Section 4.4. Further discussions on irregular movements are provided in Section 4.7.

The Incremental Profile Method approach allows site specific predictions for each natural and built feature and hence provides a more realistic assessment of the subsidence impacts than by applying the maximum predicted parameters at every point, which would be overly conservative and would yield an excessively overstated assessment of the potential subsidence impacts.

It is expected, therefore, that the calibrated Incremental Profile Method should generally provide reasonable, if not, slightly conservative predictions for conventional subsidence, tilt and curvature resulting from the extraction of the proposed longwalls. Allowance should, however, be made for the possibility of observed movements exceeding those predicted as the result of anomalous or non-conventional movements, or for greater subsidence, to occur in some places.

The reliability of the predictions obtained using the standard Incremental Profile Method is illustrated by comparing the magnitudes of observed movements with those predicted for previously extracted longwalls in the Southern Coalfield. The comparisons have been made for monitoring lines at Metropolitan Coal Mine and the nearby Appin Colliery (Areas 3, 4 and 7), Tower Colliery and West Cliff Colliery (Area 5).

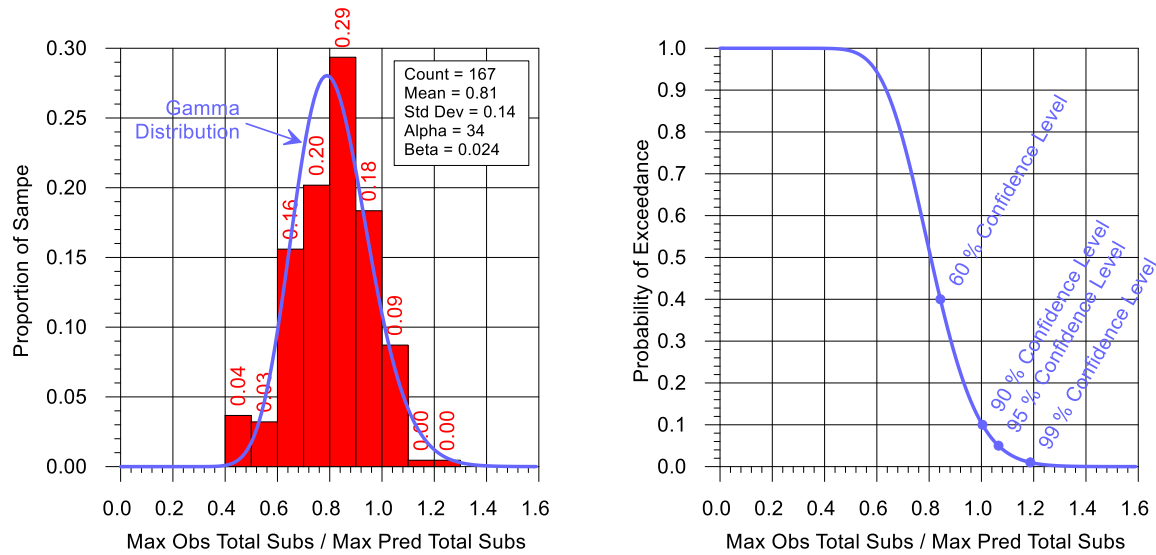
The comparison between the maximum observed total subsidence and the maximum predicted total subsidence for the monitoring lines is illustrated in Fig. 3.9. The results shown in this figure are the maximum observed and predicted subsidence for each monitoring line at the completion of each longwall. The results for Metropolitan Coal Mine have been presented as red data points based on predicted subsidence following calibration.



**Fig. 3.9 Comparisons between Maximum Observed Incremental Subsidence and Maximum Predicted Incremental Subsidence for the Previously Extracted Longwalls in the Southern Coalfield**

It can be seen from the above figure, that in most cases the observed subsidence was typically less than that predicted. The observed subsidence exceeded that predicted in some cases, but was typically less than  $+ 15\%$  or  $+ 50$  mm of the prediction. In the locations where the magnitude of subsidence was small (i.e. beyond the limits of the active longwall), the observed subsidence was typically within  $\pm 100$  mm of the prediction.

The distribution of the ratio of the maximum observed to maximum predicted incremental subsidence for the monitoring lines is illustrated in Fig. 3.10 (left). A gamma distribution has been fitted to the results and is also shown in Fig. 3.10.



**Fig. 3.10 Distribution of the Ratio of the Maximum Observed to Maximum Predicted Incremental Subsidence for Previously Extracted Longwalls in the Southern Coalfield**

The probabilities of exceedance have been determined, based on the gamma distribution, which is shown in Fig. 3.10 (right). It can be seen from this figure that, based on the monitoring data from the Southern Coalfield, there is an approximate 90 % confidence level that the maximum observed incremental subsidence would be less than the maximum predicted incremental subsidence using the standard model.



#### 4.1. Introduction

The following sections provide the maximum predicted conventional subsidence parameters resulting from the extraction of proposed Longwalls 317 and 318 (Modified Layout). The predicted subsidence parameters and the impact assessments for the natural and built features are provided in Chapters 5 to 11.

It should be noted that the predicted conventional subsidence parameters were obtained using the Incremental Profile Method for the Southern Coalfield, which was calibrated to local conditions based on the available monitoring data from Metropolitan Coal Mine.

The maximum predicted subsidence parameters and the predicted subsidence contours provided in this report describe and show the conventional movements and do not include the valley related upsidence and closure movements. Such effects have been addressed separately in the impact assessments for each feature provided in Chapters 5 to 11.

#### 4.2. Maximum Predicted Conventional Subsidence, Tilt and Curvature

The maximum predicted conventional subsidence parameters resulting from the extraction of Longwalls 317 and 318 were determined using the calibrated Incremental Profile Method, which was described in Chapter 3. A summary of the maximum predicted values of incremental conventional subsidence, tilt and curvature, due to the extraction of Longwalls 317 and 318 based on the Modified Layout, is provided in Table 4.1. The predicted additional subsidence contours resulting from the extraction of Longwalls 317 and 318 are shown in Drawing No. MSEC1319-10.

**Table 4.1 Maximum Predicted Incremental Conventional Subsidence, Tilt and Curvature Resulting from the Extraction of Longwalls 317 and 318**

| Longwall     | Maximum Predicted Incremental Conventional Subsidence (mm) | Maximum Predicted Incremental Conventional Tilt (mm/m) | Maximum Predicted Incremental Conventional Hogging Curvature (km <sup>-1</sup> ) | Maximum Predicted Incremental Conventional Sagging Curvature (km <sup>-1</sup> ) |
|--------------|------------------------------------------------------------|--------------------------------------------------------|----------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| Due to LW317 | 500                                                        | 3.5                                                    | 0.03                                                                             | 0.07                                                                             |
| Due to LW318 | 500                                                        | 2.5                                                    | 0.02                                                                             | 0.03                                                                             |

The predicted total conventional subsidence contours after the extraction of Longwalls 317 and 318 are shown in Drawing No. MSEC1319-11. The predicted total conventional subsidence contours include predictions for all longwalls extracted prior to Longwalls 317 and 318.

A summary of the maximum predicted values of total conventional subsidence, tilt and curvature, within the Study Area, after the extraction of Longwalls 316 to 318 based on the Modified Layout, is provided in Table 4.2. The predicted tilts provided in Table 4.2 are the maxima after the completion of each longwall. The predicted curvatures are the maxima at any time during or after the extraction of each of the longwalls.

**Table 4.2 Maximum Predicted Total Conventional Subsidence, Tilt and Curvature within the Study Area after the Extraction of Longwalls 316 to 318**

| Longwalls              | Maximum Predicted Total Conventional Subsidence (mm) | Maximum Predicted Total Conventional Tilt (mm/m) | Maximum Predicted Total Conventional Hogging Curvature (km <sup>-1</sup> ) | Maximum Predicted Total Conventional Sagging Curvature (km <sup>-1</sup> ) |
|------------------------|------------------------------------------------------|--------------------------------------------------|----------------------------------------------------------------------------|----------------------------------------------------------------------------|
| After LW316 (Approved) | 1450                                                 | 6.5                                              | 0.07                                                                       | 0.08                                                                       |
| After LW317 (Modified) | 1500                                                 | 6.5                                              | 0.07                                                                       | 0.08                                                                       |
| After LW318 (Modified) | 1500                                                 | 6.5                                              | 0.07                                                                       | 0.08                                                                       |

The maximum predicted total subsidence resulting from the extraction of Longwalls 317 and 318 is 1500 mm, which represents around 54 % of the minimum extraction height of 2.8 m. The maximum predicted total conventional tilt is 6.5 mm/m (i.e. 0.65 %), which represents a change in grade of 1 in 155.

The maximum predicted total conventional curvatures are  $0.07 \text{ km}^{-1}$  hogging and  $0.08 \text{ km}^{-1}$  sagging, which represent minimum radii of curvature of 14 km and 13 km, respectively.

The predicted conventional subsidence parameters vary across the Study Area as the result of, amongst other factors, variations in the depths of cover and extraction heights. To illustrate this variation, the predicted profiles of conventional subsidence, tilt and curvature have been determined along Prediction Line 1, the location of which is shown in Drawing No. MSEC1319-11.

The predicted profiles of vertical subsidence, tilt and curvature along Prediction Line 1, resulting from the extraction of Longwalls 317 and 318, are shown in Fig. C.01 in Appendix C. The predicted incremental profiles along the prediction line, due to the extraction of Longwalls 317 and 318 for the Modified Layout, are shown as dashed black lines. The predicted total profiles along the prediction line, after the extraction of Longwalls 317 and 318 for the Modified Layout, are shown as solid blue lines. The range of predicted curvatures in any direction to the prediction lines, at any time during or after the extraction of the longwalls for the Modified Layout, are shown by the grey shading. The predicted total profiles based on the Approved Layout are shown as the red lines for comparison.

The reliability of the predictions of subsidence, tilt and curvature, obtained using the Incremental Profile Method, is discussed in Section 3.7.

#### 4.3. Comparison of Maximum Predicted Conventional Subsidence, Tilt and Curvature

The comparison of the maximum predicted subsidence parameters resulting from the extraction of Longwalls 317 and 318 based on the Modified Layout with those based on the Approved Layout for Longwall 317 is provided in Table 4.3. The values are the maxima within the Study Area.

**Table 4.3 Comparison of Maximum Predicted Conventional Subsidence Parameters based on the Approved Layout and the Modified Layout**

| Layout          | Maximum Predicted Total Conventional Subsidence (mm) | Maximum Predicted Total Conventional Tilt (mm/m) | Maximum Predicted Total Conventional Hogging Curvature ( $\text{km}^{-1}$ ) | Maximum Predicted Total Conventional Sagging Curvature ( $\text{km}^{-1}$ ) |
|-----------------|------------------------------------------------------|--------------------------------------------------|-----------------------------------------------------------------------------|-----------------------------------------------------------------------------|
| Approved Layout | 1500                                                 | 6.5                                              | 0.08                                                                        | 0.08                                                                        |
| Modified Layout | 1500                                                 | 6.5                                              | 0.07                                                                        | 0.08                                                                        |

It can be seen from Table 4.3, that the maximum predicted total subsidence, tilt and hogging and sagging curvature based on the Modified Layout are unchanged or similar compared to those based on the Approved Layout.

The maximum predicted subsidence parameters based on the Approved Layout and Modified Layout occur to the east of Longwalls 317 and 318. While the maxima for both layouts are similar, there is a general increase in the predicted subsidence parameters based on the Modified Layout to the north and west of the Approved Layout, where the longwall panel footprints have increased.

#### 4.4. Predicted Strains

The prediction of strain is more difficult than the predictions of subsidence, tilt and curvature. The reason 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 average 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 predicted maximum curvatures and the predicted maximum conventional strains. Predicted strains using this relationship are typically rounded to the nearest 0.5 mm/m.

The maximum predicted conventional strains resulting from the extraction of Longwalls 317 and 318 for the Modified Layout, based on applying a factor of 15 to the maximum predicted total curvatures, are 1.5 mm/m tensile and compressive.

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, instead of just providing a single predicted conventional strain.

The range of potential strains above the proposed Longwalls 317 and 318 has been determined using monitoring data from the previously extracted longwalls in the Southern Coalfield. The monitoring data was used from the nearby Appin, Tower, West Cliff and Tahmoor Collieries, where the overburden geology and depths of cover are reasonably similar to the proposed longwalls. The panel widths at these collieries are greater than those at Metropolitan Coal Mine and, therefore, the statistical analyses should provide a reasonable, if not, conservative indication of the range of potential strains for the proposed longwalls.

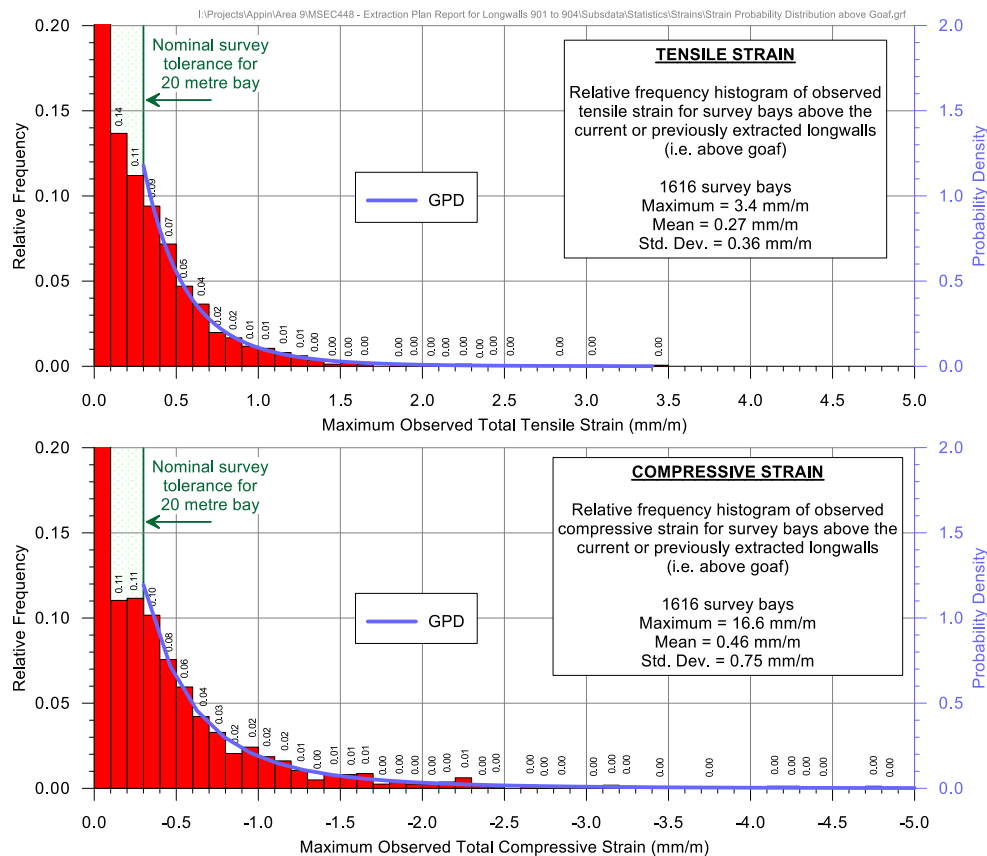
The data used in the analysis of observed strains included those resulting from both conventional and non-conventional anomalous movements, but did not include those resulting from valley related movements, which are addressed separately in this report. The strains resulting from damaged or disturbed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

#### **4.4.1. Analysis of Strains Measured in Survey Bays**

For features that are in discrete locations, such as building structures, farm dams and aboriginal heritage sites, it is appropriate to assess the frequency of the observed maximum strains for individual survey bays.

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 Southern Coalfield, for survey bays that were located directly above goaf or the chain pillars that are located between the extracted longwalls.

The histogram of the maximum observed tensile and compressive strains measured in survey bays above goaf, for monitoring lines from the Southern Coalfield, is provided in Fig. 4.1. The probability distribution functions, based on the fitted Generalised Pareto Distributions (GPDs), have also been shown in this figure.



**Fig. 4.1 Distributions of the Measured Maximum Tensile and Compressive Strains during the Extraction of Previous Longwalls in the Southern Coalfield for Bays Located Above Goaf**

Confidence levels have been determined from the empirical strain data using the GPD. 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 per longwall).

A summary of the probabilities of exceedance for tensile and compressive strains for survey bays located above goaf, based on the fitted GPDs, is provided in Table 4.4.

**Table 4.4 Probabilities of Exceedance for Strain for Survey Bays above Goaf**

| Strain (mm/m) |      | Probability of Exceedance |
|---------------|------|---------------------------|
| Compression   | -6.0 | 1 in 500                  |
|               | -4.0 | 1 in 175                  |
|               | -2.0 | 1 in 35                   |
|               | -1.0 | 1 in 10                   |
|               | -0.5 | 1 in 3                    |
|               | -0.3 | 1 in 2                    |
| Tension       | +0.3 | 1 in 3                    |
|               | +0.5 | 1 in 6                    |
|               | +1.0 | 1 in 25                   |
|               | +2.0 | 1 in 200                  |
|               | +3.0 | 1 in 1,100                |

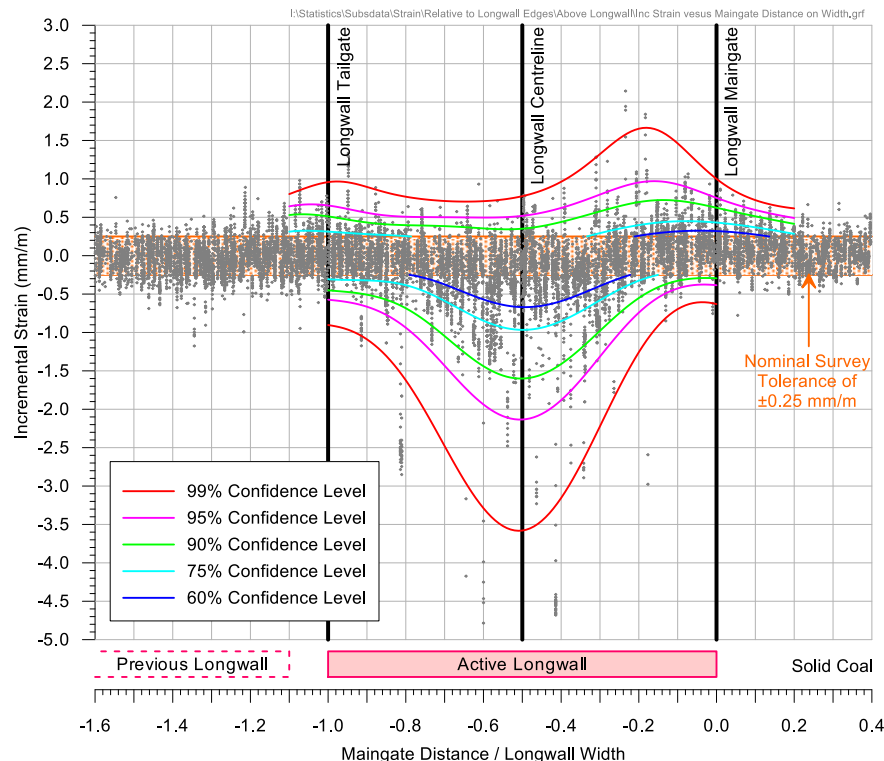
The 95 % confidence levels for the maximum total strains that the individual survey bays above goaf experienced at any time during mining were 0.9 mm/m tensile and 1.6 mm/m compressive. The 99 % confidence levels for the maximum total strains that the individual survey bays above goaf experienced at any time during mining were 1.6 mm/m tensile and 3.2 mm/m compressive.



It is noted that the maximum observed compressive strain of 16.6 mm/m, which occurred along the T-Line at the surface above Appin Longwall 408, was the result of movements along a low angle thrust fault which daylighted above the Cataract Tunnel. All remaining compressive strains were less than 7 mm/m. The inclusion of the strain at the fault above Appin Longwall 408 has a substantial influence on the probabilities of exceeding the strains provided in Table 4.4, particularly at the high magnitudes of strain.

The probabilities for survey bays located above goaf are based on the strains measured anywhere above the previously extracted longwalls in the Southern Coalfield. As described previously, tensile strains are more likely to develop in the locations of hogging curvature and compressive strains are more likely to develop in the locations of sagging curvature.

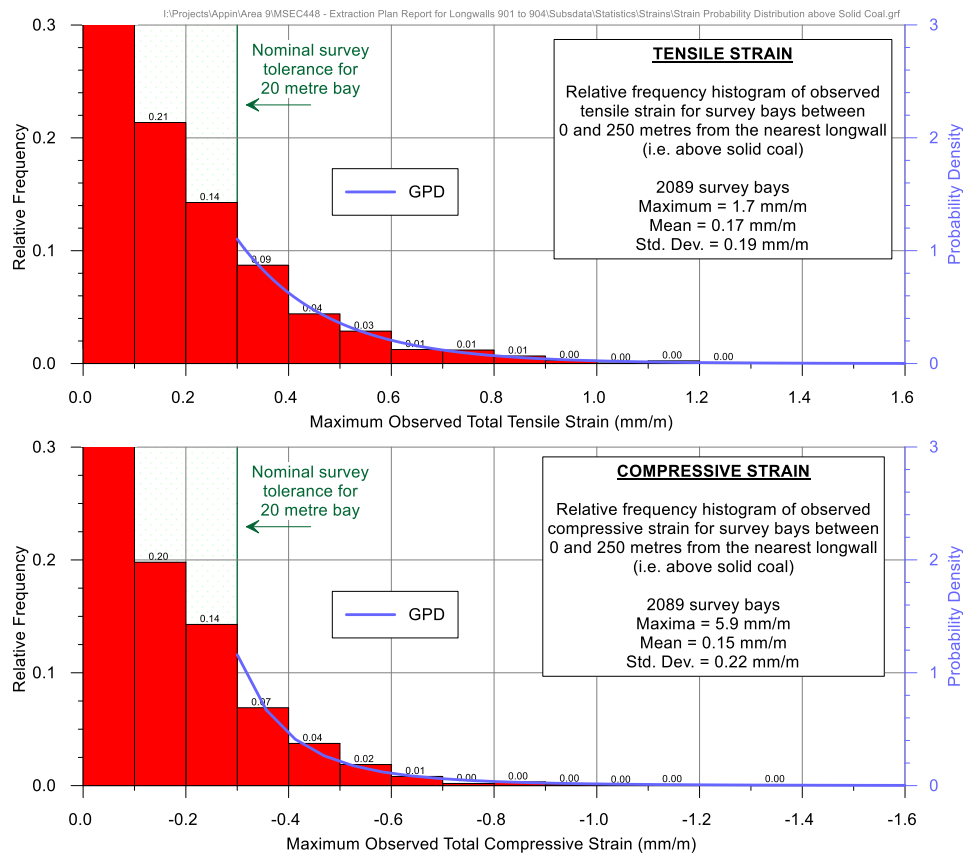
This is illustrated in Fig. 4.2, which shows the distribution of incremental strains measured above previously extracted longwalls in the Southern Coalfield. The distances have been normalised, so that the locations of the measured strains are shown relative to the longwall maingate and tailgate sides. The approximate confidence levels for the incremental tensile and compressive strains are also shown in this figure, to help illustrate the variation in the data.



**Fig. 4.2 Observed Incremental Strains versus Normalised Distance from the Longwall Maingate for Previously Extracted Longwalls in the Southern Coalfield**

The survey database has also 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 Southern Coalfield, for survey bays that were located outside and within 250 m of the nearest longwall goaf edge, which has been referred to as “*above solid coal*”.

The histogram of the maximum observed tensile and compressive strains measured in survey bays above solid coal, for monitoring lines in the Southern Coalfield, is provided in Fig. 4.3. The probability distribution functions, based on the fitted GPDs, have also been shown in this figure.



**Fig. 4.3 Distributions of the Measured Maximum Tensile and Compressive Strains during the Extraction of Previous Longwalls in the Southern Coalfield for Bays Located Above Solid Coal**

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).

A summary of the probabilities of exceedance for tensile and compressive strains for survey bays located above solid coal, based the fitted GPDs, is provided in Table 4.5.

**Table 4.5 Probabilities of Exceedance for Strain for Survey Bays Located Above Solid Coal**

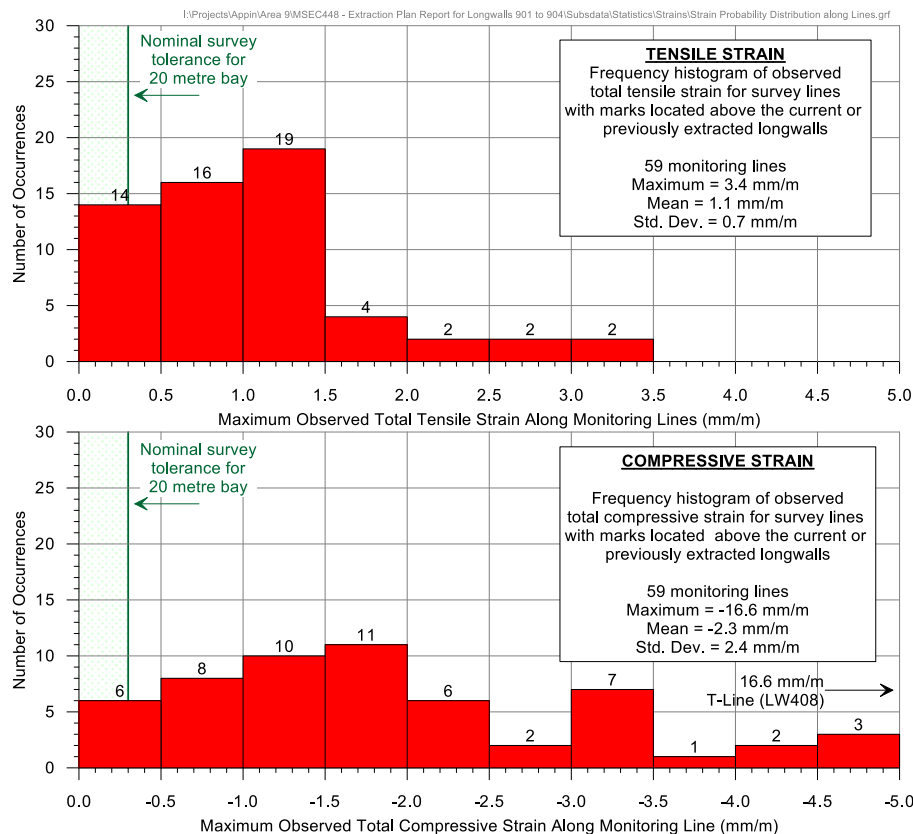
| Strain (mm/m) |      | Probability of Exceedance |
|---------------|------|---------------------------|
| Compression   | -2.0 | 1 in 2,000                |
|               | -1.5 | 1 in 800                  |
|               | -1.0 | 1 in 200                  |
|               | -0.5 | 1 in 25                   |
|               | -0.3 | 1 in 7                    |
| Tension       | +0.3 | 1 in 5                    |
|               | +0.5 | 1 in 15                   |
|               | +1.0 | 1 in 200                  |
|               | +1.5 | 1 in 2,500                |

The 95 % confidence levels for the maximum total strains that the individual survey bays above solid coal experienced at any time during mining were 0.6 mm/m tensile and 0.5 mm/m compressive. The 99 % confidence levels for the maximum total strains that the individual survey bays above solid coal experienced at any time during mining were 0.9 mm/m tensile and 0.8 mm/m compressive.

#### 4.4.2. Analysis of Strains Measured Along Whole Monitoring Lines

For linear features such as roads, cables and pipelines, 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.

The histogram of maximum observed tensile and compressive strains measured anywhere along the monitoring lines, at any time during or after the extraction of the previous longwalls in the Southern Coalfield, is provided in Fig. 4.4.



**Fig. 4.4 Distributions of Measured Maximum Tensile and Compressive Strains along the Monitoring Lines during the Extraction of Previous Longwalls in the Southern Coalfield**

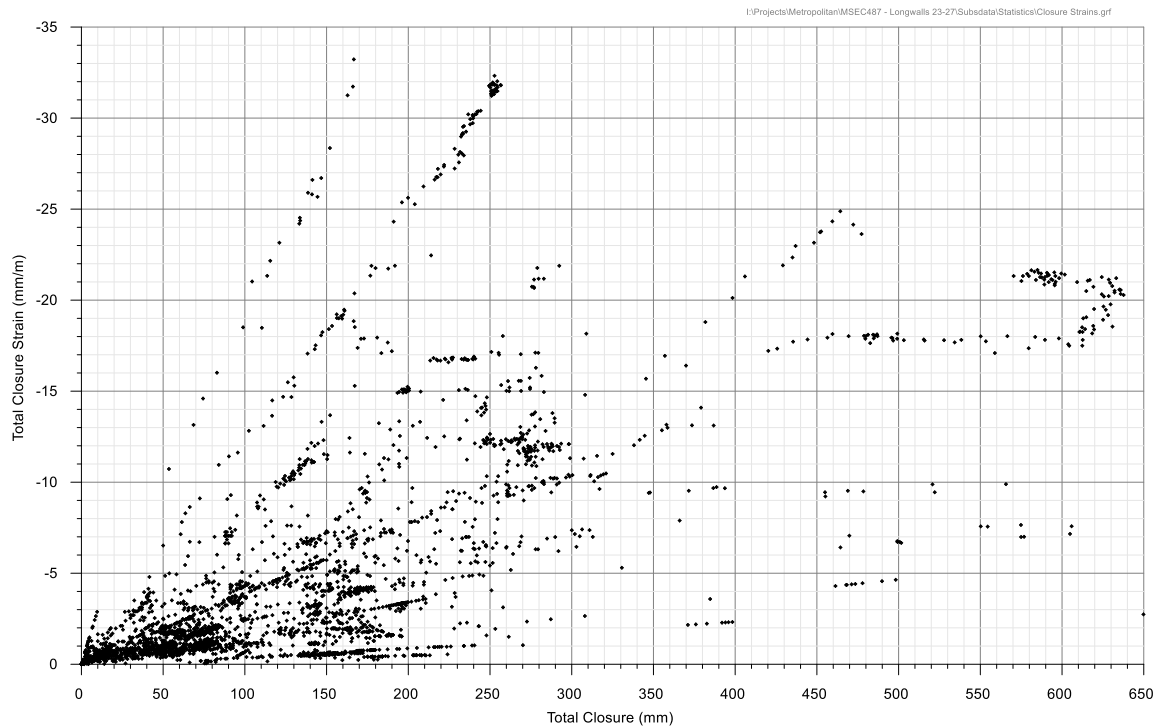
It can be seen from Fig. 4.4, that 30 of the 59 monitoring lines (i.e. 51 %) have recorded maximum total tensile strains of 1 mm/m, or less, and that 53 monitoring lines (i.e. 89 %) have recorded maximum total tensile strains of 2 mm/m, or less. It can also be seen, that 35 of the 59 monitoring lines (i.e. 59 %) have recorded maximum compressive strains of 2 mm/m, or less, and that 51 of the monitoring lines (i.e. 86 %) have recorded maximum compressive strains of 4 mm/m, or less.

#### 4.4.3. Analysis of Strains Resulting from Valley Closure Movements

The streams within the Study Area may experience localised and elevated compressive strains resulting from valley related movements. The strains resulting from valley related movements are more difficult to predict than strains in flatter terrain, as they are dependent on many additional factors, including the valley shape and valley height, the valley geomorphology and the local geology in the valley base.

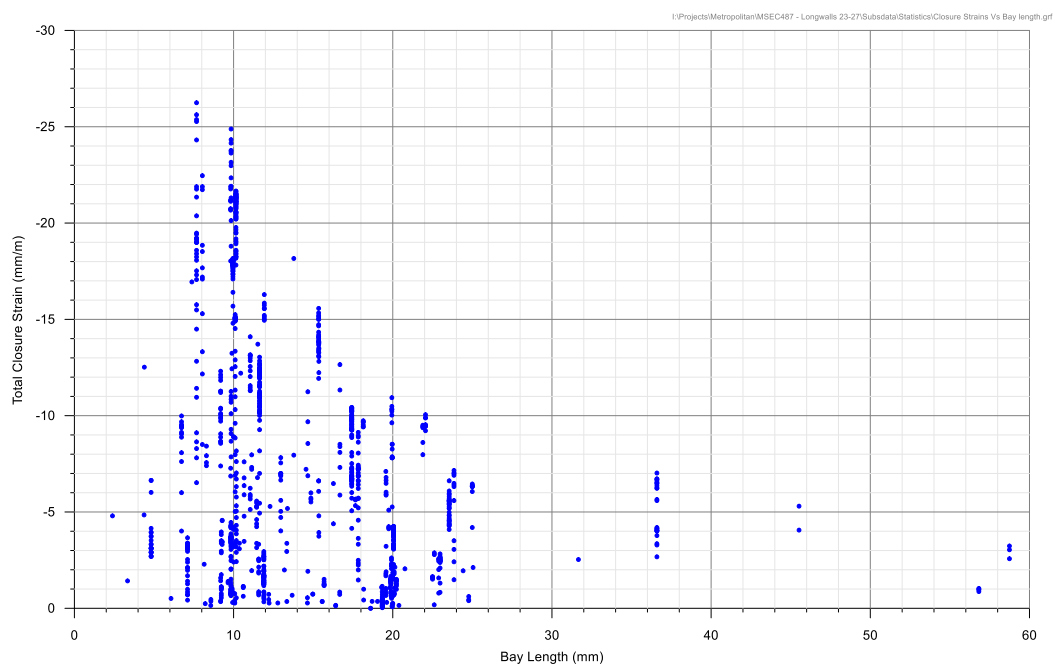
The predicted strains resulting from valley related movements, for the streams located directly above the proposed longwalls based on the Modified Layout, have been assessed using the monitoring data for longwalls which have previously mined directly beneath streams in the Southern Coalfield.

The relationship between total closure strain and total closure movement, based on monitoring data for longwalls which have previously mined directly beneath streams in the Southern Coalfield, is provided in Fig. 4.5.



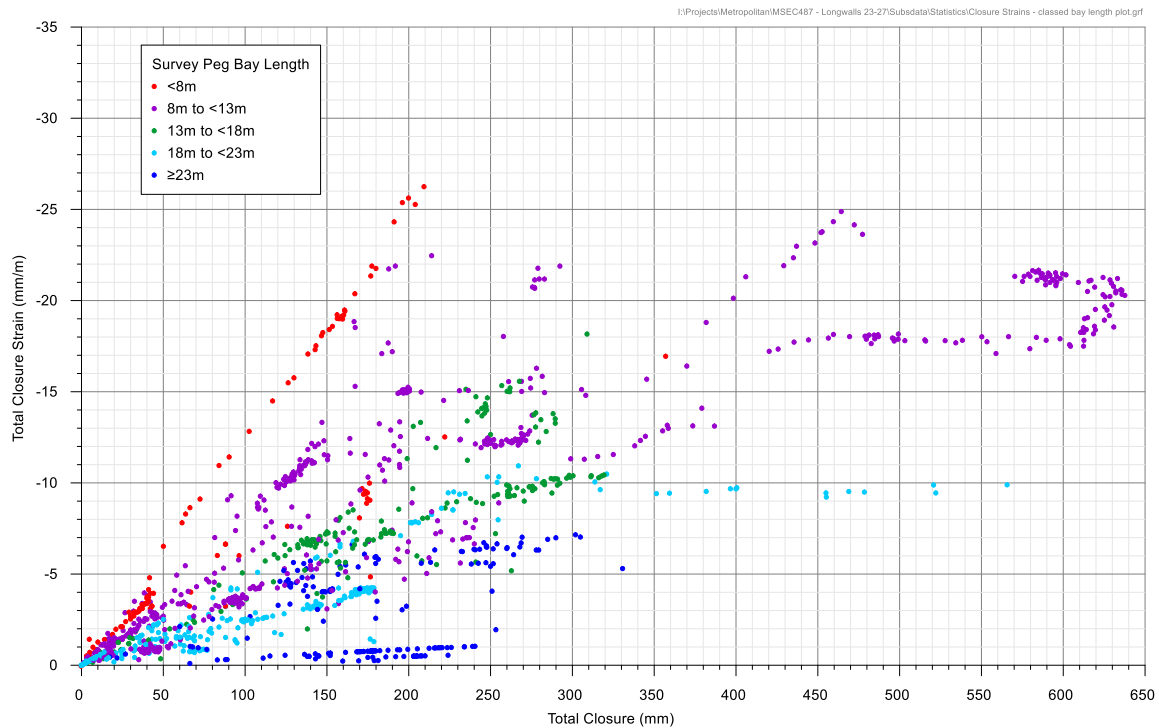
**Fig. 4.5 Total Closure Strain versus Total Closure Movement Based on Monitoring Data for Streams Located Directly Above Longwalls in the Southern Coalfield**

It can be seen from Fig. 4.5 that total compressive strains up to approximately 20 mm/m to 25 mm/m have been measured for total closures varying between approximately 150 mm to 650 mm. It should be noted, however, that the measured compressive strain is dependent on the length of the survey bay in which the strain was measured. Typical measurements and predictions of conventional strain are based on an approximate survey bay length of 20 m in the Southern Coalfield. Where survey lines are established across streams, for the purposes of measuring valley closure movements, they are often established with survey bay lengths shorter than 20 m in order to provide greater detail and these should not be compared to strain measurements and predictions based on 20 m bay lengths. The bay lengths for the data presented in Fig. 4.5 have been plotted below in a graph of bay length versus total closure (Fig. 4.6) and have been reproduced in Fig. 4.7 to show the distribution of bay lengths.



**Fig. 4.6 Total Closure Strain versus Bay Length Based on Monitoring Data for Streams Located Directly Above Longwalls in the Southern Coalfield**





**Fig. 4.7 Total Closure Strain versus Total Closure Movement Based on Monitoring Data for Streams Located Directly Above Longwalls in the Southern Coalfield**

It can be seen from Fig. 4.6 and Fig. 4.7 that the majority of the data with high compressive strains has been measured over bay lengths much less than 20 m. The maximum measured compressive strain for an approximate 20 m bay length is 11 mm/m as indicated by the cyan coloured points in Fig. 4.7. High compressive strains resulting from valley closure movements often concentrate towards the base of a valley. On this basis, predicted strains have been estimated for a typical 20 m bay length by applying the predicted valley closure over a 20 m length.

#### 4.4.4. Analysis of Shear Strains

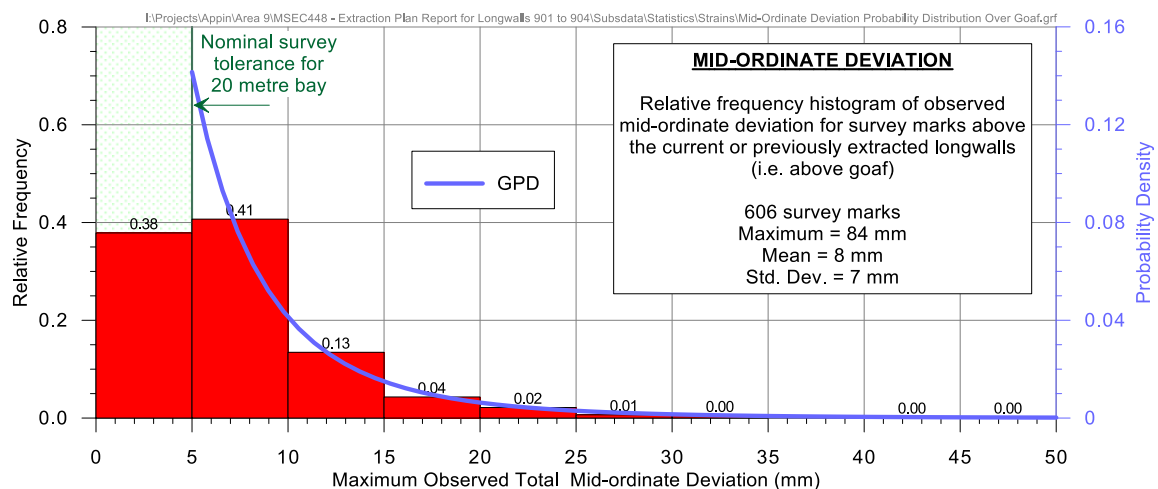
As described in Section 3.2, ground strain comprises two components, being normal strain and shear strain, which can be interrelated using Mohr's Circle. The magnitudes of the normal strain and shear strain components are, therefore, dependant on the orientation in which they are measured. The maximum normal strains, referred to as the principal strains, are those in the direction where the corresponding shear strain is zero.

Normal strains along monitoring lines can be measured using 2D and 3D techniques, by taking the change in horizontal distance between two points on the ground and dividing by the original horizontal distance between them. This provides the magnitude of normal strain along the orientation of the monitoring line and, therefore, this strain may not necessarily be the maximum (i.e. principal) normal strain.

Shear deformations are more difficult to measure, as they are the relative horizontal movements perpendicular to the direction of measurement. However, 3D monitoring techniques provide data on the direction and the absolute displacement of survey pegs and, therefore, the shear deformations perpendicular to the monitoring line can be determined. But, in accordance with rigorous definitions and the principles of continuum mechanics, (e.g. Jaeger, 1969), it is not possible to determine horizontal shear strains in any direction relative to the monitoring line using 3D monitoring data from a straight line of survey marks.

As described in Section 3.2, shear deformations perpendicular to monitoring lines can be described using various parameters, including horizontal tilt, horizontal curvature, mid-ordinate deviation, angular distortion and shear index. In this report, mid-ordinate deviation has been used as the measure for shear deformation, which is defined as the differential horizontal movement of each survey mark, perpendicular to a line drawn between two adjacent survey marks.

The frequency distribution of the maximum mid-ordinate deviation measured at survey marks above goaf, for previously extracted longwalls in the Southern Coalfield, is provided in Fig. 4.8. As the typical bay length was 20 m, the calculated mid-ordinate deviations were over a chord length of 40 m. The probability distribution function, based on the fitted GPD, has also been shown on Fig. 4.8.



**Fig. 4.8 Distribution of Measured Maximum Mid-ordinate Deviation during the Extraction of Previous Longwalls in the Southern Coalfield for Marks Located Above Goaf**

A summary of the probabilities of exceedance for horizontal mid-ordinate deviation for survey bays located above goaf, based the fitted GPD, is provided in Table 4.6.

**Table 4.6 Probabilities of Exceedance for Mid-Ordinate Deviation for Survey Marks above Goaf for Monitoring Lines in the Southern Coalfield**

| Horizontal Mid-ordinate Deviation (mm)           |    | Probability of Exceedance |
|--------------------------------------------------|----|---------------------------|
| Mid-ordinate Deviation<br>over 40 m Chord Length | 10 | 1 in 4                    |
|                                                  | 20 | 1 in 20                   |
|                                                  | 30 | 1 in 70                   |
|                                                  | 40 | 1 in 175                  |
|                                                  | 50 | 1 in 400                  |
|                                                  | 60 | 1 in 800                  |
|                                                  | 70 | 1 in 1,400                |
|                                                  | 80 | 1 in 2,300                |

The 95 % and 99 % confidence levels for the maximum total horizontal mid-ordinate deviation that the individual survey marks located above goaf experienced at any time during mining were 20 mm and 35 mm, respectively.

#### 4.5. Predicted Conventional Horizontal Movements

The predicted conventional horizontal movements over the proposed Longwalls 317 and 318 are calculated by applying a factor to the predicted conventional tilt values. In the Southern Coalfield a factor of 15 is generally adopted, being the same factor as that used to determine conventional strains from curvatures, and this has been found to give a reasonable correlation with measured data. This factor would in fact vary and would be higher at low tilt values and lower at high tilt values. The application of this factor would therefore lead to over-prediction of horizontal movements where the tilts are high and under-prediction of the movements where the tilts are low.

The maximum predicted total conventional tilt within the Study Area, at any time during or after the extraction of the proposed Longwalls 317 and 318, is 6.5 mm/m. The maximum predicted conventional horizontal movement is, therefore, approximately 98 mm.

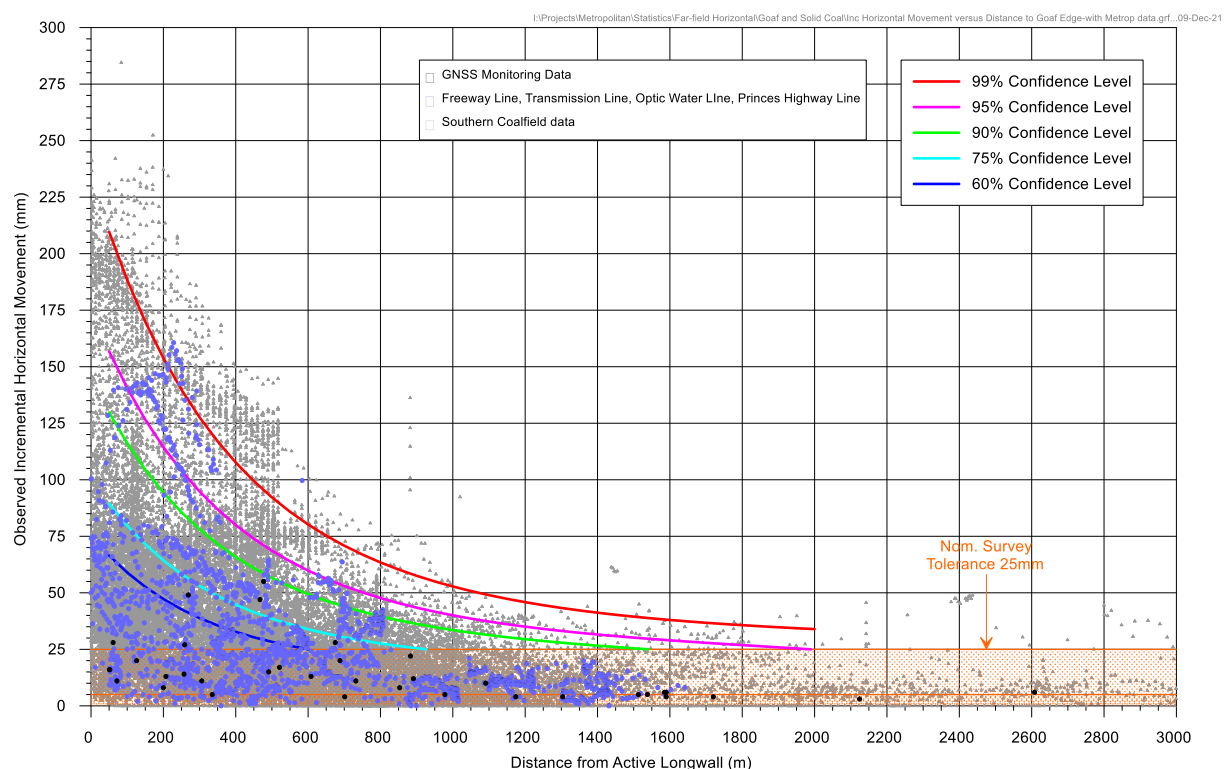
Conventional horizontal movements do not directly impact on natural or built features, rather impacts occur as a result of differential horizontal movements. Strain is the rate of change of horizontal movement. The impacts of strain on the natural and built features are addressed in the impact assessments for each feature, which have been provided in Chapters 5 to 11.

#### 4.6. Predicted Far-field Horizontal Movements

In addition to the conventional subsidence movements that have been predicted above and adjacent to the proposed longwalls, and the predicted valley related movements along the streams, it is also likely that far-field horizontal movements would be experienced during the extraction of the proposed longwalls.

An empirical database of observed incremental far-field horizontal movements has been compiled using monitoring data from the NSW Coalfields, but predominantly from the Southern Coalfield. The far-field horizontal movements resulting from longwall mining were generally observed to be orientated towards the extracted longwall. At very low levels of far-field horizontal movements, however, there was a high scatter in the orientation of the observed movements, particularly in areas of sloping terrain.

The observed incremental far-field horizontal movements, resulting from the extraction of longwalls in the Southern Coalfield, are provided in Fig. 4.9. The data is based on survey marks in any location above goaf (i.e. above the currently mined or previously mined longwalls) or above solid coal (i.e. unmined areas of coal). The confidence levels, based on fitted GPDs, have also been shown in this figure to illustrate the spread of the data. Monitoring data collected from Metropolitan Coal Mine during the extraction of Longwalls 301 to 310 is also included.



**Fig. 4.9 Observed Incremental Far-Field Horizontal Movements from the Southern Coalfield (Solid Coal)**

As successive longwalls within a series of longwalls are mined, the magnitudes of the incremental far-field horizontal movements decrease. This is possibly due to the fact that once the in-situ stresses within the strata have been redistributed around the collapsed zones above the first few extracted longwalls, the potential for further movement is reduced. The total far-field horizontal movement is not, therefore, the sum of the incremental far-field horizontal movements for the individual longwalls.

The predicted far-field horizontal movements resulting from the extraction of the proposed longwalls tend to be bodily movements towards the extracted goaf area, and are accompanied by very low levels of strain, which are generally less than the order of survey tolerance. While the impacts of far-field horizontal movements on the natural and built features within the vicinity of the Study Area are not expected to be significant, there are structures which are sensitive to small differential movements, including roads and road bridges which are discussed in Section 6.0 .

## 4.7. Non-Conventional Ground Movements

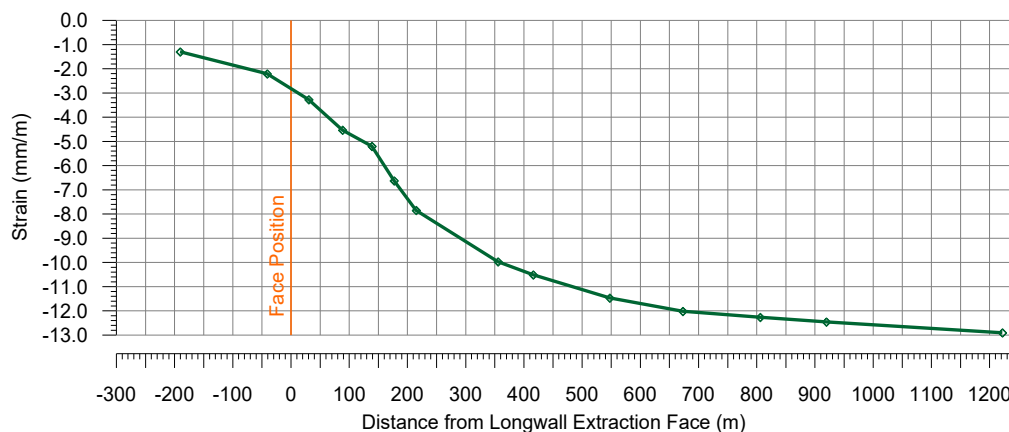
It is possible non-conventional ground movements would occur within the Study Area, due to near surface geological conditions, steep topography and valley related movements, which were discussed in Section 3.4. These non-conventional movements are often accompanied by elevated tilts and curvatures which are likely to exceed the conventional predictions.

Specific predictions of upsidence, closure and compressive strain due to the valley related movements are provided for the streams in Sections 5.3 to 5.5. The impact assessments for the streams are based on both the conventional and valley related movements. The potential for non-conventional movements associated with steep topography is discussed in the impact assessments for the steep slopes provided in Section 5.9.

In most cases, it is not possible to predict the exact locations or magnitudes of the non-conventional anomalous movements due to near surface geological conditions. For this reason, the strain predictions provided in this report are based on a statistical analysis of measured strains in the Southern Coalfield, including both conventional and non-conventional anomalous strains, which is discussed in Section 4.4. In addition to this, the impact assessments for the natural and built features, which are provided in Chapters 5 to 11, include historical impacts resulting from previous longwall mining which have occurred as a result of both conventional and non-conventional subsidence movements.

The largest known case of non-conventional movement in the Southern Coalfield occurred above Appin Longwall 408. In this case, a low angle thrust fault was re-activated in response to mine subsidence movements, resulting in differential vertical and horizontal movements across the fault. Observations at the site showed that the non-conventional movements developed gradually and over a period of time. Regular ground monitoring across the fault indicated that the rate of differential movement was less than 0.5 mm per day at the time non-conventional movements could first be detected. Subsequently as mining progressed, the rate of differential movement increased to a maximum of 28 mm per week.

The development of strain at the low angle thrust fault, as measured along the T-Line during the extraction of Appin Longwall 408, is illustrated in Fig. 4.10. Photographs of the anomalous ground movements associated with this fault are provided in the photographs in Fig. 4.11 and Fig. 4.12.



**Fig. 4.10 Development of Strain at the Low Angle Thrust Fault Measured Along the T-Line During the Extraction of Appin Longwall 408**



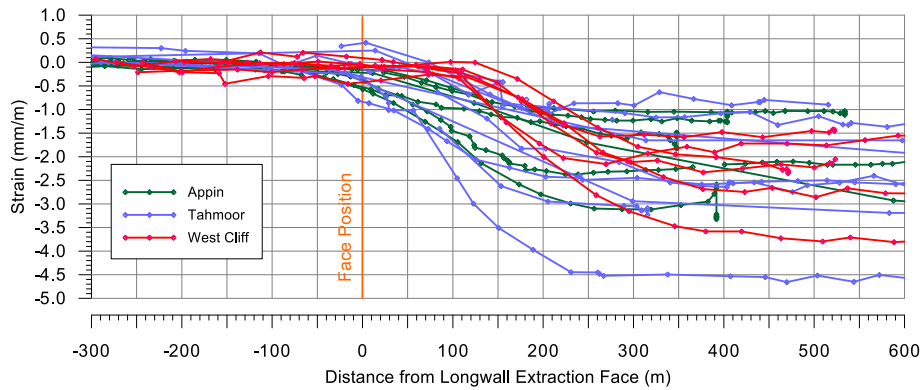


**Fig. 4.11 Surface Compression Humping Due to Low Angle Thrust Fault**



**Fig. 4.12 Surface Compression Humping Due to Low Angle Thrust Fault**

The developments of strain at anomalies identified in the Southern Coalfield and elsewhere, excluding the low angle thrust fault discussed previously, are illustrated in Fig. 4.13. It can be seen from this figure, that the non-conventional movements develop gradually. For these cases, the maximum rate of development of anomalous strain was 2 mm/m per week. Based on the previous experience of longwall mining in the Southern Coalfield and elsewhere, it has been found that non-conventional anomalous movements can be detected early by regular ground monitoring and visual inspections.



**Fig. 4.13 Development of Non-Conventional Anomalous Strains in the Southern Coalfield**

A study of anomalies for the majority of ground survey data within the Southern Coalfield was undertaken in 2006 by MSEC. Forty-one (41) monitoring lines were examined for anomalies, which represent a total of 58.2 km of monitoring lines, and approximately 2,980 survey pegs. The monitoring lines crossed over 75 longwalls. The selected lines represented all the major lines over the subsided areas, and contained comprehensive information on subsidence, tilt and strain measurements. A total of 20 anomalies were detected, of which four were considered to be significant. The observed anomalies affected 41 of the approximately 2,980 survey pegs monitored. This represented a frequency of 1.4 %.

The above estimates are based on ground survey data that crossed only a small proportion of the total surface area affected by mine subsidence. Recent mining beneath urban and semi-rural areas at Tahmoor and Thirlmere by Tahmoor Colliery Longwalls 22 to 25 provides valuable “whole of panel” information. A total of approximately 35 locations (not including valleys) have been identified over the four extracted longwalls. The surface area directly above the longwalls is approximately 2.56 square kilometres (km<sup>2</sup>). This equates to a frequency of 14 sites per km<sup>2</sup> or one site for every 7 hectares.

#### 4.8. General Discussion on Mining Induced Ground Deformations

Longwall mining can result in surface cracking, heaving, buckling, humping and stepping at the surface. The extent and severity of these mining induced ground deformations are dependent on a number of factors, including the mine geometry, depth of cover, overburden geology, locations of natural jointing in the bedrock and the presence of near surface geological structures.

Faults and joints in bedrock develop during the formation of the strata and from subsequent de-stressing associated with movement of the strata. Longwall mining can result in additional fracturing in the bedrock, which tends to occur in the tensile zones, but fractures can also occur due to buckling of the surface beds in the compressive zones. The incidence of visible cracking at the surface is dependent on the pre-existing jointing patterns in the bedrock as well as the thickness and inherent plasticity of the soils that overlie the bedrock.

Surface cracking in soils as a result of conventional subsidence movements is not commonly observed where the depths of cover are greater than approximately 400 m, and any cracking that has been observed has generally been isolated and of a minor nature.

Cracking is found more often in the bases of stream valleys due to the compressive strains associated with upsidence and closure movements. The likelihood and extent of cracking along the streams within the Study Area are discussed in Sections 5.3 to 5.5. Cracking can also occur at the tops and on the sides of steep slopes as a result of downslope movements.

Surface cracks are more readily observed in built features such as road pavements. In the majority of these cases no visible ground deformations can be seen in the natural ground adjacent to the cracks in the road pavements. In rare instances more noticeable ground deformations, such as humping or stepping of the ground can be observed at thrust faults. Examples of ground deformations previously observed in the Southern Coalfield, where the depths of cover exceed 400 m, are provided in the photographs in Fig. 4.14 to Fig. 4.17 below.



**Fig. 4.14 Surface Compression Buckling Observed in a Pavement**



**Fig. 4.15 Surface Tension Cracking Along the Top of a Steep Slope**



**Fig. 4.16 Surface Tension Cracking Along the Top of a Steep Slope**



**Fig. 4.17      Fracturing and Bedding Plane Slippage in Sandstone Bedrock in the Base of a Stream**

Localised ground buckling and shearing can occur wherever faults, dykes and abrupt changes in geology occur near the ground surface. The identified geological structures at seam level within the Study Area are discussed in Section 1.5. Discussions on irregular ground movements are provided in Section 4.7.



## 5.0 DESCRIPTIONS, PREDICTIONS AND IMPACT ASSESSMENTS FOR THE NATURAL FEATURES

The following sections provide the descriptions, predictions of subsidence movements and impact assessments for the natural features located within the Study Area for Longwalls 317 and 318 and selected features located outside the Study Area. The predicted parameters for each of the natural features have been compared to the predicted parameters based on the Approved Layout. Supporting impact assessments for the natural features have also been undertaken by other specialist consultants for the Modified Layout.

Impact assessments for some natural features have also been provided by the other specialist consultants on the project. The assessments provided in this chapter should be read in conjunction with the assessments provided in all other relevant reports accompanying this application.

### 5.1. Natural Features

As listed in Table 2.1, the following natural features were not identified within the Study Area nor in the immediate surrounds:

- springs;
- seas or lakes;
- shorelines;
- natural dams;
- escarpments;
- land prone to flooding or inundation;
- national parks;
- state forests;
- state recreation or conservation areas;
- areas of significant geological interest; and
- other significant natural features.

The following sections provide the descriptions, predictions and impact assessments for the natural features which have been identified within or in the vicinity of the Study Area.

### 5.2. Catchment Areas and Declared Special Areas

The Study Area lies within the Woronora Special Area, which is controlled by WaterNSW. The Study Area is situated greater than 3.2 km south of the Dams Safety NSW Notification Area for the Woronora Reservoir, which is also known as Lake Woronora. As such, there would be no predicted subsidence impacts to the Woronora Reservoir dam wall.

The Woronora Special Area provides the main water supply for the Sutherland region, via the Woronora Reservoir.

The Woronora Reservoir full supply level is outside the Study Area and is 720 m to the north-east of Longwall 317 at the nearest point. At this distance, the Woronora Reservoir is not predicted to experience adverse effects from the Modified Layout.

### 5.3. Rivers, Creeks and Tributaries

#### 5.3.1. Description of the Rivers, Creeks and Tributaries

Significant nearby Rivers and Creeks include the Waratah Rivulet and Woronora River which flow to the north-east and into the Woronora Reservoir and form the two main arms of the reservoir. The Waratah Rivulet is located to the south-east of the Study Area and is approximately 1.4 km from Longwall 317 at its nearest point. The Woronora River is located to the west of the Study Area and is approximately 2 km from Longwall 318 at its nearest point. At these distances, these features are unlikely to experience adverse effects from the Modified Layout.

Tributaries within the Study Area include Tributary R, Tributary S, Tributary U and Honeysuckle Creek. Only the upper reaches of Tributary U is located above the Modified Layout. Tributary R and S are located above the previous Longwalls 311 to 316 and Tributary U is located above the northern end of Longwall 317 of the Modification. The reaches of Tributary R, S and U that are within the Study Area are first order, with Tributary U and R second order streams at the full supply level of the Woronora Reservoir, located outside of the Study Area. The total length of the sections of Tributary R, S and U within the Study Area are approximately 720 m, 1,420 m and 740 m, respectively.

Honeysuckle Creek is located west of Longwall 318 and is above the Longwall 318 main gate at its nearest point at which it is a second order stream. The upper reach of Honeysuckle Creek is a first order stream with a first order tributary of Honeysuckle Creek overlying Longwall 318 of the Modification. Permanent pools within Honeysuckle Creek were identified as bedrock confined with flow controlled by in-stream rockbars and/or boulder fields.

### 5.3.2. Predictions for the Tributaries

The predicted profiles of vertical subsidence, upsidence and closure along Tributary R, Tributary S, Tributary U and Honeysuckle Creek resulting from the extraction of Longwalls 317 and 318 (based on the Modified Layout), are shown in Fig. C.02, Fig. C.03, Fig. C.04, and Fig. C.05 respectively in Appendix C. The predicted incremental profiles along the tributaries, due to the extraction of Longwalls 317 and 318, are shown as dashed black lines. The predicted total profiles are shown as solid blue lines. The predicted total profiles based on the Approved Layout are shown as the solid red lines for comparison.

A summary of the maximum predicted values of total subsidence, upsidence and closure within the Study Area for the Tributaries and Honeysuckle Creek based on the Approved Layout and Modified Layout is provided in Table 5.1. The compressive strains due to valley closure effects have also been provided (based on the method outlined in Section 4.4.3).

**Table 5.1 Maximum Predicted Total Subsidence, Upsidence, Closure and Compressive Strain for the Tributaries within the Study Area based on the Approved Layout and Modified Layout**

| Tributary         | Layout          | Maximum Predicted Total Vertical Subsidence (mm) | Maximum Predicted Total Upsidence (mm) | Maximum Predicted Total Closure (mm) | Maximum Predicted Closure Strain based on a 20 m Bay Length (mm/m) |
|-------------------|-----------------|--------------------------------------------------|----------------------------------------|--------------------------------------|--------------------------------------------------------------------|
| Tributary R       | Approved Layout | 1500                                             | 925                                    | 1050                                 | 11                                                                 |
|                   | Modified Layout | 1500                                             | 950                                    | 1050                                 | 11                                                                 |
| Tributary S       | Approved Layout | 1150                                             | 300                                    | 500                                  | 11                                                                 |
|                   | Modified Layout | 1250                                             | 325                                    | 550                                  | 11                                                                 |
| Tributary U       | Approved Layout | 140                                              | 140                                    | 200                                  | 11                                                                 |
|                   | Modified Layout | 875                                              | 425                                    | 525                                  | 11                                                                 |
| Honeysuckle Creek | Approved Layout | < 20                                             | < 20                                   | < 20                                 | 4                                                                  |
|                   | Modified Layout | 225                                              | 150                                    | 350                                  | 11                                                                 |

A summary of the maximum predicted additional values of upsidence and closure within the Study Area for the Tributaries, based on the Approved Layout Longwall 317 and Modified Layout Longwall 317 and 318 is provided in Table 5.2.

The maximum predicted total vertical subsidence along Tributary R, S and U based on the Modified Layout is 1500 mm, 1250 mm and 875 mm, respectively. The maximum predicted total closure for Tributary R, S and U is 1050 mm, 550 mm and 525 mm, respectively. The maximum predicted closure strain based on a 20 m bay length for Tributary R, S and U is 11 mm/m. The maximum predicted total vertical subsidence and maximum predicted total closure are the same for the Modified Layout and Approved Layout for Tributary R and the maximum predicted total upsidence slightly increases for the Modified Layout for Tributary R. The maximum predicted total vertical subsidence, total upsidence and total closure increases for Tributary S and U based on the Modified Layout. The maximum predicted closure strain is the same for the Modified Layout for Tributary R, S and U.

The maximum predicted total vertical subsidence Honeysuckle Creek based on the Modified Layout is 225 mm. The maximum predicted total closure for Honeysuckle Creek based on the Modified Layout is 350 mm and the maximum predicted closure strain based on a 20 m bay length is 11 mm/m. The maximum predicted total vertical subsidence, total upsidence, total closure and closure strain increases for Honeysuckle Creek based on the Modified Layout.

**Table 5.2 Maximum Predicted Additional Subsidence, Upsidence, and Closure for the Tributaries within the Study Area based on the Approved Layout and Modified Layout**

| Tributary         | Layout          | Maximum Predicted Additional Vertical Subsidence (mm) | Maximum Predicted Additional Upsidence (mm) | Maximum Predicted Additional Closure (mm) |
|-------------------|-----------------|-------------------------------------------------------|---------------------------------------------|-------------------------------------------|
| Tributary R       | Approved Layout | 140                                                   | < 20                                        | < 20                                      |
|                   | Modified Layout | 150                                                   | 20                                          | < 20                                      |
| Tributary S       | Approved Layout | 550                                                   | < 20                                        | < 20                                      |
|                   | Modified Layout | 650                                                   | 30                                          | 40                                        |
| Tributary U       | Approved Layout | < 20                                                  | 40                                          | 40                                        |
|                   | Modified Layout | 800                                                   | 350                                         | 330                                       |
| Honeysuckle Creek | Approved Layout | < 20                                                  | 30                                          | 80                                        |
|                   | Modified Layout | 225                                                   | 140                                         | 350                                       |

It can be seen from Table 5.1 and Table 5.2 that there is a slight increase in predicted subsidence parameters for Tributary S and Tributary R and a greater increase in predicted subsidence parameters for Tributary U and Honeysuckle Creek. The increases in predicted subsidence parameters are due to the increased longwall footprint of the Modified Layout.

### 5.3.3. Impact Assessments and Recommendations for the Tributaries

It can be seen from Fig. C.02 and 03 that the increases in predicted valley closure are small for Tributary R and Tributary S. The increased valley closure for Tributary U and Honeysuckle Creek shown in Fig. C.04 and 05 are greater.

The impact assessments for Tributary R and S based on the Modified Layout are the same as those based on the Approved Layout due to the minor increase in predicted valley related movements.

While there is an increase in predicted valley related movements due to the Modified Layout for Tributary U and Honeysuckle Creek compared to those based on the Approved Layout, the magnitude of predicted valley related movements for Tributary U and Honeysuckle Creek based on the Modified Layout are similar to or less than the predicted valley related movements for other tributaries located above the previously extracted and approved longwalls.

While the magnitude of maximum predicted valley closure and valley closure strain in Tributary U and Honeysuckle Creek are considered sufficient to increase the risk of impact to these streams, the risk of impact diminishes away from the maxima. The overall potential impacts on the tributaries within the Study Area, based on the Modified Layout, are similar to those assessed for the Approved Layout. A summary of potential impacts to the tributaries is provided below:

- cracking in the bedrock along base of the tributaries and fracturing and dilation of the underlying strata above and immediately adjacent to the proposed longwalls;
- leakage from pools where cracking in the bedrock occurs; and
- potential loss of surface water flow by diversion through subsurface fractures.

The risk of impact to the tributaries is reduced where the tributaries are located outside the Modification longwall footprints. The risk of impact to the tributaries is also reduced where the magnitudes of predicted valley related movements are lower, typically due to lower valley heights within shallow valley profiles. The shallow valley profiles occur in the upper reaches of Tributaries R, S and U.

It is recommended that management strategies are developed for the Tributaries R, S and U and Honeysuckle Creek such that impacts can be identified and remediated, as and if they are required. These management strategies would be similar to those outlined in the Longwalls 311-316 Extraction Plan (Metropolitan Coal, 2024), including surface water monitoring program and remediation of watercourses, where required.

5.4. Woronora Reservoir

The Woronora Reservoir is located to the east and north of the Study Area and is approximately 720 m from Longwall 317 at its nearest point. At this distance, the Woronora Reservoir is not predicted to experience adverse effects from the Modified Layout.

5.5. Other Tributaries

There are other smaller tributaries located within the Study Area and above Longwalls 317 and 318, some of which are as shown in Drawing No. MSEC1319-07. These streams consist of shallow drainage lines from the topographical high points, forming tributaries where valley heights increase and drain into the larger tributaries.

The tributaries are located directly above Longwalls 317 and 318 and could, therefore, experience the full range of predicted subsidence movements, as discussed in Section 4.2.

The predicted upsidence and closure at the tributaries based on the Modified Layout are generally greater than those based on the Approved Layout, however the maxima are similar to or less than those elsewhere based on the Approved Layout. The overall potential impacts on the tributaries above Longwalls 317 and 318, based on the Modified Layout, are therefore similar to those assessed for the Approved Layout. A summary of potential impacts to the tributaries is provided below:

- cracking in the bedrock along base of the tributaries and fracturing and dilation of the underlying strata above and immediately adjacent to the proposed longwalls;
- leakage from pools where cracking in the bedrock occurs; and
- potential loss of surface water flow by diversion through subsurface fractures.

5.6. Aquifers and Known Groundwater Resources

The aquifers and groundwater resources within the vicinity of the Modified Layout have been described in the Groundwater Assessment report by Australasian Groundwater & Environmental Consultants Pty Ltd (AGE) (2025) in Appendix B of the Metropolitan Coal Longwalls 317 and 318 Modification Report.

5.7. Cliffs and Overhangs

Consistent with the Project Approval, cliffs have been defined as a continuous rock face, including overhangs, having a minimum height of 10 m and a slope of greater than 66° (2 to 1). The locations of the cliffs were determined from site inspections and from an aerial laser scan of the area.

The Project Approval lists the following Subsidence Impact Performance Measures for cliffs:

| Land   |                                                                                                                                  |
|--------|----------------------------------------------------------------------------------------------------------------------------------|
| Cliffs | Less than 3% of the total length of cliffs (and associated overhangs) within the mining area experience mining induced rock fall |

The locations of the cliffs and overhangs within the Study Area and surrounds are shown in Drawing No. MSEC1319-07. One cliff is located within the Study Area (COH19) and within 600 m of Longwalls 317 and 318. Cliff COH19 is located above Longwall 314.

The descriptions, predictions and impact assessments for cliff are provided in the following sections.



### 5.7.1. Descriptions of the Cliffs and Overhangs

Details of Cliff COH19 are provided in Table 5.3. There are also a number of rock ledges, which are located across the Study Area, generally within the valleys of the drainage lines. Rock ledges are discussed in Section 5.8.

**Table 5.3 Details of Cliffs and Overhangs within 600 metres of Longwalls 317 and 318**

| ID    | Approx. Overall Length (m) | Approx. Maximum Height (m) | Approx. Maximum Overhang Depth (m) |
|-------|----------------------------|----------------------------|------------------------------------|
| COH19 | 60                         | 11                         | ~*                                 |

\*Depth of overhang to be verified by site survey.

### 5.7.2. Predictions for the Cliffs and Overhangs

A summary of the maximum predicted values of total conventional subsidence, tilt and curvature for the Cliff COH19, resulting from the Modified Layout, is provided in Table 5.4. The predicted tilts provided in Table 5.4 are the maxima after the completion of Longwalls 317 and 318. The predicted curvatures are the maxima at any time during or after the extraction of Longwalls 317 and 318.

**Table 5.4 Maximum Predicted Total Conventional Subsidence, Tilt and Curvature for the Cliff COH19 after the Extraction of Longwall 318**

| ID    | Maximum Predicted Total Conventional Subsidence (mm) | Maximum Predicted Total Conventional Tilt (mm/m) | Maximum Predicted Total Conventional Hogging Curvature (km <sup>-1</sup> ) | Maximum Predicted Total Conventional Sagging Curvature (km <sup>-1</sup> ) |
|-------|------------------------------------------------------|--------------------------------------------------|----------------------------------------------------------------------------|----------------------------------------------------------------------------|
| COH19 | 750                                                  | 6.5                                              | 0.07                                                                       | 0.04                                                                       |

The predicted strains for Cliff COH19 are provided in Table 5.5. The values have been provided for conventional movements (based on 15 times the curvature) and for non-conventional anomalous movements (based on the statistical analysis provided in Section 4.4.1).

**Table 5.5 Predicted Strains for Cliffs and Overhangs based on Conventional and Non-conventional Anomalous Movements**

| ID    | Type        | Conventional based on 15 times Curvature | Non-conventional based on the 95 % Confidence Level | Non-conventional based on the 99 % Confidence Level |
|-------|-------------|------------------------------------------|-----------------------------------------------------|-----------------------------------------------------|
| COH19 | Tension     | 1.0                                      | 0.9                                                 | 1.6                                                 |
|       | Compression | 1.0                                      | 1.6                                                 | 3.2                                                 |

Cliff COH19 is located across Tributary S and may experience valley related closures due to the extraction of the Modification. A summary of the maximum predicted upsidence and closure for Cliff COH19, after the extraction of Longwalls 317 and 318 for the Modified Layout, is provided in Table 5.6. The compressive strains due to valley closure effects have also been provided (based on the discussion in Section 4.4.3).

**Table 5.6 Maximum Predicted Total Upsidence, Closure and Valley Related Strain for Cliff COH19 after the Extraction of Longwall 318**

| Location | Maximum Predicted Total Upsidence (mm) | Maximum Predicted Total Closure (mm) | Maximum Predicted Closure Strain based on a 20 m Bay Length (mm/m) |
|----------|----------------------------------------|--------------------------------------|--------------------------------------------------------------------|
| COH19    | 250                                    | 400                                  | 11                                                                 |

### 5.7.3. Comparison of the Predictions for the Cliffs and Overhangs

The comparison of the maximum predicted subsidence parameters for Cliff COH19 based on the Modified Layout, with those based on the Approved Layout is provided in Table 5.7.

**Table 5.7 Comparison of Maximum Predicted Conventional Subsidence Parameters for Cliff COH19 based on the Modified Layout and the Approved Layout**

| ID    | Layout          | Maximum Predicted Total Conventional Subsidence (mm) | Maximum Predicted Total Conventional Tilt (mm/m) | Maximum Predicted Total Conventional Hogging Curvature (km <sup>-1</sup> ) | Maximum Predicted Total Conventional Sagging Curvature (km <sup>-1</sup> ) |
|-------|-----------------|------------------------------------------------------|--------------------------------------------------|----------------------------------------------------------------------------|----------------------------------------------------------------------------|
| COH19 | Approved Layout | 750                                                  | 6.5                                              | 0.07                                                                       | 0.04                                                                       |
|       | Modified Layout | 750                                                  | 6.5                                              | 0.07                                                                       | 0.04                                                                       |

Predicted subsidence parameters based on the Modified Layout is the same as those based on the Approved Layout.

#### 5.7.4. Impact Assessments for the Cliffs

A discussion of the impact assessments for the cliffs and overhangs is provided in Section 5.6.2 of the MSEC285 Report for the Metropolitan Coal Project EA Layout. The impact assessments for the cliffs and overhangs in the MSEC285 report included the following points:

- Based on comparisons with other mines in the Southern Coalfield where cliff lines have been undermined, the lengths of potential cliff instabilities are expected to be less than 3 % of the lengths of these cliffs. (It is noted that the cliffs and overhangs are no longer located above the currently proposed Longwalls 317 and 318).
- One of the most significant risks associated with cliff instabilities is the potential to cause injury to people or loss of life. All of the cliffs and overhangs are located within the Woronora Special Area that is owned and administered by the Sydney Catchment Authority (SCA) and, whilst the area is generally not available for public access, it is possible that the area could be visited during the mining period. It is recommended, therefore, that persons who enter the area in the vicinity of the cliffs and overhangs are made aware of the potential for rockfalls resulting from the extraction of the proposed longwalls by appropriate signs and, if required, temporary fencing, that should be prepared in consultation with the SCA. The conditions of the cliffs should be monitored throughout the mining period and until such time as there are no significant changes in measured ground movements.
- The aesthetics of the landscape could be temporarily altered by isolated rock falls and whilst these would typically occur off pre-existing natural joints, they could result in the exposure of a fresh face of rock and debris scattered around the base of the cliff. As with naturally occurring instabilities, the exposed fresh rockface weathers and erodes over time to a point where it blends in with the remainder of the cliff face and in time the vegetation below the cliff regenerates. If a cliff or overhang instability were to occur, however, the appearance of the landscape could be restored, if necessary, by revegetation below the cliff or overhang.

The potential for rock falls at Cliff COH19 based on the Modified Layout, are the same as those based on the Approved Layout. Based on comparisons with other mines in the Southern Coalfield where cliff lines have been undermined, the lengths of potential cliff instabilities are expected to be less than 3 % of the total length of the cliffs and overhangs within the mining domain. The likelihood of rockfalls at Cliff COH19 is considered to be higher due to the locations above extracted longwalls and alignment oriented across Tributary S.

Although isolated rock falls have been observed over solid coal outside the extracted goaf areas of longwall mining in the Southern Coalfield, there have been no recorded cliff instabilities outside the extracted goaf areas of longwall mining in the Southern Coalfield. It is possible that isolated rock falls could occur as a result of the extraction of the proposed longwalls. It is not expected, however, that any large cliff instabilities would occur outside the longwall footprints as a result of the extraction of the Modification.

It is recommended that the baseline condition of the cliffs should be documented and photographed prior to mining and monitored during mining.

Given the assessments above, no changes to the minor cliffs and rock face features Subsidence Impact Performance Measure outlined in the Project Approval (08\_0149) would be required for the Modification.

## 5.8. Rock Ledges

There are rock ledges, also called rock outcrops and minor cliffs, located across the Study Area.

The rock ledges would experience the full range of predicted subsidence movements, as summarised in Table 4.1 and Table 4.2. The maximum predicted subsidence parameters for the rock ledges, based on the Modified Layout for Longwalls 317 and 318 are the same as those based on the Approved Layout. There would however be an increase in the predicted subsidence parameters for the rock ledges where there is an increase in the longwall footprints. While there is an increase in the predicted subsidence parameters above the new longwall footprints, the maxima would be similar to or less than the predicted subsidence parameters above the approved longwalls.

The potential impacts on the rock ledges, based on the Modified Layout, therefore, are the same as those assessed based on the Approved Layout, specifically, the potential for fracturing of sandstone and subsequent rockfalls, particularly where the rock ledges are marginally stable.

There is an increase in the predicted subsidence parameters for rock ledges where there is an increase in the longwall footprints, however, the incremental increase is unlikely to materially change the risk of rockfalls or rock ledge instabilities in the areas where Broad-headed Snake (Niche 2025a) was recorded or areas of mapped breeding habitat.

## 5.9. Steep Slopes

The locations of steep slopes are shown on Drawing No. MSEC1319-07. Steep slopes are presented based on the definition used in the subsidence assessment for the Metropolitan Coal Project EA and MSEC285 Report (a natural gradient between 18° and 63°) and also based on the definition in the Project Approval (08\_0149) (a natural gradient between 33° and 66°). There is only one small area of steep slopes located above Longwalls 317 and 318, located at the northern end of Longwall 317.

The steep slope at the northern end of Longwall 317 would experience only minor predicted subsidence parameters, with vertical subsidence of less than 150 mm, and negligible tilt and curvature.

The steep slopes are expected to experience negligible predicted subsidence parameters and impacts due to the extraction of Longwalls 317 and 318 are not expected.

It is recommended that steep slopes are managed via a land management plan similar to those prepared for the previous approved longwalls.

## 5.10. Swamps, Wetlands and Water Related Ecosystems

### 5.10.1. Descriptions of the Swamps

The locations of the swamps are shown in Drawing No. MSEC1319-07. The mapped extents of these swamps are based on field inspections and validation by Niche Environment and Heritage Pty Ltd (Niche). There are 41 swamps located within the Study Area. There are a further 10 swamps that are located outside the Study Area but are either partially, or fully within 600 m of Longwalls 317 and 318.

Three swamps are listed in the performance measures in the Project Approval (08\_0149) (Swamps S76, S77 and S92). The impact performance measure for Swamp S92 is “*Negligible environmental consequences*” and for Swamps S76 and S77 is “*Negligible environmental consequences to Threatened Species, Populations, and Ecological Communities*” which were set through condition 4, Schedule 3 of the Project Approval (08\_0149) which states: “*The Proponent shall not undermine Swamps 76, 77 and 92 without the written approval of the Director General.*” Swamp S76 is located above the middle of Longwalls 315 and 316 and follows the alignment of Tributary S. Swamp S77 is located above the southern half of Longwalls 312 to 315 and follows the alignment of Tributary R. Swamp S92 near the finishing end of Longwall 312 and follows the alignment of Tributary P. Swamp S92 is located outside the Study Area for Longwalls 317 and 318 but is within 600 m of these longwalls.

Detailed descriptions of the swamps within the Study Area are provided in the Metropolitan Coal Longwalls 317 and 318 Biodiversity Development Assessment Report prepared by Niche (2025a).

### 5.10.2. Predictions for the Swamps

The maximum predicted subsidence parameters for each of the swamps located within the Study Area and within 600 m of Longwalls 317 and 318 are provided in Table D.01, in Appendix D. The predictions have been provided based on the Modified Layout and the Approved Layout.

A summary of the maximum predicted values of total conventional subsidence, tilt and curvature for the swamps, resulting from the Modified Layout, is provided in Table 5.8.

The predicted tilts provided in Table 5.8 are the maxima after the completion of Longwall 318. The predicted curvatures are the maxima at any time during or after the extraction of Longwalls 317 and 318.

**Table 5.8 Maximum Predicted Total Conventional Subsidence, Tilt and Curvature for the Swamps within 600 m of Longwalls 317 and 318 and within the Study Area based on the Modified Layout**

| Location | Maximum Predicted Total Conventional Subsidence (mm) | Maximum Predicted Total Conventional Tilt (mm/m) | Maximum Predicted Total Conventional Hogging Curvature (km <sup>-1</sup> ) | Maximum Predicted Total Conventional Sagging Curvature (km <sup>-1</sup> ) |
|----------|------------------------------------------------------|--------------------------------------------------|----------------------------------------------------------------------------|----------------------------------------------------------------------------|
| Bee Ck   | < 20                                                 | < 0.5                                            | < 0.01                                                                     | < 0.01                                                                     |
| S14      | < 20                                                 | < 0.5                                            | < 0.01                                                                     | < 0.01                                                                     |
| S74      | 950                                                  | 4.0                                              | 0.03                                                                       | 0.06                                                                       |
| S75      | 1100                                                 | 2.0                                              | 0.04                                                                       | 0.04                                                                       |
| S76      | 1250                                                 | 1.5                                              | 0.03                                                                       | 0.03                                                                       |
| S77      | 1450                                                 | 4.5                                              | 0.04                                                                       | 0.04                                                                       |
| S91      | 1050                                                 | 6.0                                              | 0.03                                                                       | 0.03                                                                       |
| S92      | 575                                                  | 5.0                                              | 0.03                                                                       | 0.02                                                                       |
| S93      | 20                                                   | < 0.5                                            | < 0.01                                                                     | < 0.01                                                                     |
| S99      | < 20                                                 | < 0.5                                            | < 0.01                                                                     | < 0.01                                                                     |
| S101     | < 20                                                 | < 0.5                                            | < 0.01                                                                     | < 0.01                                                                     |
| S102     | < 20                                                 | < 0.5                                            | < 0.01                                                                     | < 0.01                                                                     |
| S103     | < 20                                                 | < 0.5                                            | < 0.01                                                                     | < 0.01                                                                     |
| S104     | < 20                                                 | < 0.5                                            | < 0.01                                                                     | < 0.01                                                                     |
| S105     | 80                                                   | 1.0                                              | < 0.01                                                                     | < 0.01                                                                     |
| S106     | 750                                                  | 3.5                                              | 0.03                                                                       | 0.02                                                                       |
| S107     | 350                                                  | 3.5                                              | 0.03                                                                       | < 0.01                                                                     |
| S108     | 225                                                  | 2.0                                              | 0.03                                                                       | < 0.01                                                                     |
| S109     | 80                                                   | 1.0                                              | 0.01                                                                       | < 0.01                                                                     |
| S110     | < 20                                                 | < 0.5                                            | < 0.01                                                                     | < 0.01                                                                     |
| S111a    | < 20                                                 | < 0.5                                            | < 0.01                                                                     | < 0.01                                                                     |
| S111b    | < 20                                                 | < 0.5                                            | < 0.01                                                                     | < 0.01                                                                     |
| S112     | < 20                                                 | < 0.5                                            | < 0.01                                                                     | < 0.01                                                                     |
| S113     | 975                                                  | 2.5                                              | 0.02                                                                       | 0.02                                                                       |
| S114     | 1050                                                 | 2.0                                              | 0.02                                                                       | 0.02                                                                       |
| S115     | 1050                                                 | 1.5                                              | 0.02                                                                       | 0.02                                                                       |
| S116     | 550                                                  | 3.0                                              | 0.01                                                                       | 0.02                                                                       |
| S117     | 775                                                  | 3.0                                              | 0.01                                                                       | 0.02                                                                       |
| S118     | 575                                                  | 3.0                                              | 0.01                                                                       | 0.02                                                                       |
| S119     | 975                                                  | 3.0                                              | 0.01                                                                       | 0.03                                                                       |
| S120     | 325                                                  | 3.0                                              | 0.02                                                                       | < 0.01                                                                     |
| S121     | 625                                                  | 3.0                                              | 0.01                                                                       | 0.02                                                                       |
| S122     | 150                                                  | 1.5                                              | 0.01                                                                       | < 0.01                                                                     |
| S123     | 100                                                  | 1.0                                              | 0.01                                                                       | < 0.01                                                                     |
| S124     | 70                                                   | 1.0                                              | < 0.01                                                                     | < 0.01                                                                     |
| S125a    | 20                                                   | < 0.5                                            | < 0.01                                                                     | < 0.01                                                                     |
| S125b    | < 20                                                 | < 0.5                                            | < 0.01                                                                     | < 0.01                                                                     |
| S126a    | < 20                                                 | < 0.5                                            | < 0.01                                                                     | < 0.01                                                                     |
| S126b    | < 20                                                 | < 0.5                                            | < 0.01                                                                     | < 0.01                                                                     |
| S126c    | < 20                                                 | < 0.5                                            | < 0.01                                                                     | < 0.01                                                                     |
| S127     | 375                                                  | 3.5                                              | 0.03                                                                       | < 0.01                                                                     |
| S128     | 750                                                  | 3.5                                              | 0.02                                                                       | 0.05                                                                       |
| S129     | 100                                                  | 1.0                                              | < 0.01                                                                     | < 0.01                                                                     |
| S130     | 1000                                                 | 2.0                                              | 0.03                                                                       | 0.04                                                                       |
| S131     | 30                                                   | < 0.5                                            | < 0.01                                                                     | < 0.01                                                                     |
| S132     | 30                                                   | < 0.5                                            | < 0.01                                                                     | < 0.01                                                                     |
| S135     | 250                                                  | 2.5                                              | 0.02                                                                       | < 0.01                                                                     |
| S136     | < 20                                                 | < 0.5                                            | < 0.01                                                                     | < 0.01                                                                     |
| S138     | < 20                                                 | < 0.5                                            | < 0.01                                                                     | < 0.01                                                                     |
| S139     | 1250                                                 | 2.0                                              | 0.04                                                                       | 0.07                                                                       |
| S140     | 60                                                   | 0.5                                              | < 0.01                                                                     | < 0.01                                                                     |



The maximum predicted strains for the swamps located above Longwalls 317 and 318 are provided in Table 5.9. The values have been derived for conventional movements (based on 15 times the curvature) and for non-conventional anomalous movements (based on the statistical analysis provided in Section 4.4.1).

**Table 5.9 Maximum Predicted Strains for the Swamps Located Directly Above Longwalls 317 and 318 based on Conventional and Non-Conventional Anomalous Movements**

| Type        | Conventional based on 15 times Curvature | Non-conventional based on the 95 % Confidence Level | Non-conventional based on the 99 % Confidence Level |
|-------------|------------------------------------------|-----------------------------------------------------|-----------------------------------------------------|
| Tension     | 0.5                                      | 0.9                                                 | 1.6                                                 |
| Compression | 1.0                                      | 1.6                                                 | 3.2                                                 |

A number of the swamps within the Study Area are located along the alignments of tributaries and, therefore, could experience valley related effects (i.e. closure, upsidence or associated compressive strain). A summary of the maximum predicted upsidence and closure for these swamps, after the extraction of Longwalls 317 and 318 for the Modified Layout, is provided in Table 5.10. The compressive strains due to valley closure effects have also been provided (based on the discussion in Section 4.4.3).

**Table 5.10 Maximum Predicted Total Upsidence, Closure and Valley Related Strain for the Swamps within the Study Area after the Extraction of Longwall 318**

| Location  | Maximum Predicted Total Upsidence (mm) | Maximum Predicted Total Valley Closure (mm) | Maximum Predicted Closure Strain based on a 20 m Bay Length (mm/m) |
|-----------|----------------------------------------|---------------------------------------------|--------------------------------------------------------------------|
| Bee Creek | < 20                                   | < 20                                        | < 1                                                                |
| S14       | < 20                                   | 20                                          | < 1                                                                |
| S76       | 175                                    | 125                                         | 5                                                                  |
| S77       | 325                                    | 325                                         | 11                                                                 |
| S92       | 175                                    | 80                                          | 4                                                                  |
| S93       | < 20                                   | < 20                                        | < 1                                                                |
| S106      | 50                                     | 20                                          | < 1                                                                |

### 5.10.3. Comparison of the Predictions for the Swamps

The comparison of the maximum predicted subsidence parameters for the swamps within the Study Area and within 600 m of Longwalls 317 and 318, with those based on the Approved Layout is provided in Table D.01, in Appendix D.

The maximum predicted subsidence for the swamps, based on the Modified Layout for Longwalls 317 and 318 are greater than the maxima predicted based on the Approved Layout at 28 swamps (55%), and equal to or lower at 23 swamps (45%). The predicted tilt based on the Modified Layout is greater than the Approved Layout at 17 swamps (33%) and equal to or lower at 34 swamps (67%). The predicted hogging and sagging curvature based on the Modified Layout for Longwalls 317 and 318 are low in magnitude and are similar to or less than the maxima predicted based on the Approved Layout for the majority of swamps.

With the exception of Swamp S106, the predicted valley closure for the swamps based on the Approved Layout is the same as that for the Modified Layout. The predicted valley closure for Swamp S106 is 20 mm and is considered unlikely to result in valley related impact to the swamp.

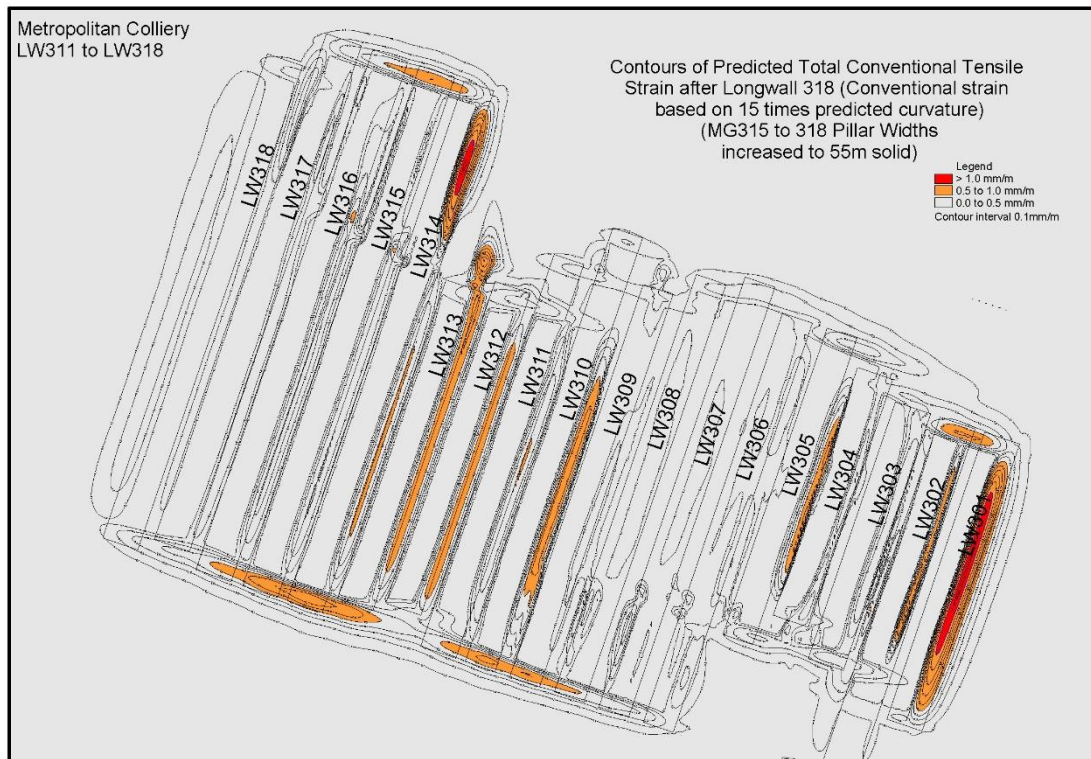
The Modification Layout, includes the widening of the tailgate pillars for Longwalls 316 to 318 by 10 m, to 55 m. The purpose of the increased pillar width was to reduce the subsidence parameters, particularly the predicted conventional tensile ground strain in and around swamps to no greater than 0.5mm/m, in response to feedback on swamp subsidence from the Independent Expert Advisory Panel for Mining (IEAPM) during the review of Longwalls 311 to 316 Extraction Plan. In review of the Russell Vale Expansion Project (IEAPM 2020), IEAPM make the following comments:

*“It is common in subsidence engineering to associate the onset of tensile cracking with a tensile strain of 0.5 mm/m. Once fractures are initiated, further extension of the ground surface tends to be concentrated at these fracture sites. That is, strain is no longer uniformly distributed. In virgin conditions, the impact of a tensile strain of 0.5 mm/m is most likely to result in a hairline fracture, in which case it is of little*

consequence to the integrity of an overlying swamp. Thereafter, incremental strain is most likely to cause existing cracks to become wider and deeper, until a tipping point is reached where the width and depth of the crack/s (the subsidence impact) have serious negative consequences for the moisture retaining capacity of that portion of a swamp overlying the fracture/s.”

The 10m increased pillar width results in a reduction in the predicted incremental subsidence parameters by approximately 18 % compared to the 45 m pillar width based on the Approved Layout.

A contour plot of the predicted conventional tensile strain based on the Modification is shown in Fig. 5.1. It can be seen in this figure that the predicted conventional total tensile strain above and in the vicinity of Longwalls 317 and 318 is predominantly less than or equal to 0.5 mm/m. The contours show predicted strains greater than 0.5mm/m over the previous approved longwalls and low strains above Longwalls 306 to 308 where narrow longwall geometry was extracted beneath the Woronora Reservoir.



**Fig. 5.1 Predicted Total Conventional Tensile Strain Contours**

#### 5.10.4. Impact Assessments and Recommendations for the Swamps

The predicted vertical subsidence increases at several swamps due to the increased length of Longwall 317 and the addition of Longwall 318. The additional vertical subsidence due to Longwalls 317 and 318 of the Modification are shown in Drawing No. MSEC1319-10. Whilst the predicted tilt and curvatures increase at a number of swamps, the maximum values are similar to or less than the maxima predicted for other swamps located above the previously extracted longwalls at the Metropolitan Coal Mine. The potential impacts for the swamps, based on the Modified Layout, therefore, are similar to those assessed based on the Approved Layout.

Cracking of the bedrock within upland swamps is expected to be isolated and of a minor nature, due to the relatively low magnitudes of the predicted curvatures and strains and the relatively high depths of cover. The minor cracking within the swamps would generally not be expected to propagate through swamp soil profiles. As noted in Section 5.10.2 the predicted total tensile strain due to the extraction of Longwalls 317 and 318 based on the Modification are reduced due to the widened tailgate pillars for Longwalls 316 to 318. As a result of lower predicted total tensile strain, the risk of tensile cracking in the bedrock is also reduced.

An increased risk of cracking may occur due to valley closure along the alignments of tributaries. The cracking risk due to valley closure is greater where the predicted valley closure increases, generally at the downstream ends of the tributaries where valley profiles increase. The majority of predicted valley closure

from Table 5.10 is below 130 mm, with the exception of S77. As discussed above, with the exception of Swamp S106, the predicted valley closure for the swamps based on the Approved Layout is the same as that for the Modified Layout.

Whilst swamp grades vary naturally, the predicted maximum mining-induced tilts are generally much lower than the existing natural grades within the swamps. At some locations where natural grades are shallow, the predicted tilts may result in more significant changes to grade within the swamps. The predicted tilts would generally not be expected to have a significant effect on the overall gradient of the swamps or the flow of surface water.

Three swamps are listed in the performance measures in the Project Approval (08\_0149) (Swamps S76, S77 and S92). The impact performance measure for Swamp S92 is “*Negligible environmental consequences*” and for Swamps S76 and S77 is “*Negligible environmental consequences to Threatened Species, Populations, and Ecological Communities*” which were set through condition 4, Schedule 3 of the Project Approval (08\_0149) which states: “*The Proponent shall not undermine Swamps 76, 77 and 92 without the written approval of the Director General.*”

Swamp S92 is located outside the Study Area and a small portion of the swamp is located within the 600 m offset line as shown in Drawing No. MSE1319-07. Swamps S76 and S77 are located closer to Longwall 317 and would experience subsidence effects due to the extraction of Longwalls 317 and 318 of the Modification. The maximum predicted subsidence parameters for these swamps are located at the eastern sides of these swamps and do not change significantly for the Modification.

The largest swamp within the Study Area is S106, which is located above the southern end of Longwall 318 and the finishing end of Longwall 317. The predicted maximum subsidence at Swamp S106 increases from 350 mm based on the Approved Layout to 750 mm based on the Modified Layout. The maximum predicted tilt and strains do not change. The maximum predicted conventional tensile strain for this swamp is less than 0.5 mm/m and as a result the risk of tensile cracking is reduced. Predictions of valley closure are provided for this swamp, however, they are applicable to only a small section of the swamp that is located within the alignment of Honeysuckle Creek. The predicted valley closure is small and is not expected to result in an impact to the swamp.

As described in Section 5.10.3, the original Longwalls 317 and 318 layout geometry for the Modification, as per the Scoping Letter submitted in October 2023, was based on pillar widths of 45 m (solid) consistent with the longwall geometry in Project Approval (08\_0149). The Modification Longwalls 317 and 318 geometry was changed to pillar widths of 55 m (i.e. 10 m wider than the original design). This results in a predicted conventional tensile strain at the surface of no greater than 0.5 mm/m for all upland swamps in the Modification area.

The recommendations and management strategies for the swamps based on the Modified Layout are the same as those based on the Approved Layout. Management strategies include avoidance and minimisation of impacts or survey monitoring and remediation if impacts are observed. It is difficult to monitor ground strains within the swamps as significant vegetation clearing is required to install ground survey monitoring marks. Ground strains can be monitored in some cases at suitable nearby representative locations outside the swamp footprint. Where valley closure is predicted, survey monitoring across the valley could be carried out with minimal vegetation clearing. Monitoring of surface and groundwater are carried out in the swamps in addition to any survey monitoring to assess the potential response to subsidence effects. It is recommended that Trigger Action Response plans prepared for Swamps S76, S77 and S92 are continued for Swamps S76 and S77 during the extraction of Longwalls 317 and 318. A monitoring programme similar to swamps S76, S77 and S92 could be developed for Swamp S106.

### 5.11. Threatened, Protected Species or Critical Habitats

There are no lands within the Study Area that have been declared as critical habitat under the *Biodiversity Conservation Act 2016*. However, threatened species and ecological communities are known to occur within the Study Area as described in the Biodiversity Development Assessment Report by Niche (Niche, 2025a).

The effects of subsidence on threatened species, populations and ecological communities within the Study Area are considered in the Biodiversity Development Assessment report by (Niche, 2025a) in Appendix D of the Metropolitan Coal Longwalls 317 and 318 Modification Report.

### 5.12. Natural Vegetation

The vegetation within the Study Area generally consists of native bushland. A detailed survey of the natural vegetation was undertaken for the Metropolitan Coal Project EA (Bangalay Botanical Surveys, 2008). Niche

undertook further survey works as part of the Longwalls 317 and 318 Biodiversity Development Assessment Report (Niche, 2025a)

Natural vegetation covers the majority of the Study Area. The natural vegetation could, therefore, experience the full range of predicted subsidence movements, as summarised in Table 4.1 and Table 4.2.

The maximum predicted subsidence parameters for the natural vegetation, based on the Modified Layout for Longwalls 317 and 318 are the same as those based on the Approved Layout. There would however be an increase in the predicted subsidence parameters for the natural vegetation where there is an increase in the longwall footprints. While there is an increase in the predicted subsidence parameters above the new longwall footprints, the maxima would be similar to or less than the predicted subsidence parameters above the approved longwalls.

The potential impacts on the natural vegetation, based on the Modified Layout, therefore, are the same as those assessed based on the Approved Layout.

The effects of subsidence on flora and fauna within the Study Area are further considered in the Biodiversity Development Assessment Report by (Niche) (2025a) in Appendix D of the Metropolitan Coal Longwalls 317 and 318 Modification Report.

### **5.13. Areas of Significant Geological Interest**

There are no areas of significant geological interest within the Study Area. A brief description of the geology within the Study Area is provided in Section 1.5.

The following sections provide the descriptions, predictions of subsidence movements and impact assessments for the public utilities located within the Study Area for Longwalls 317 and 318. The predicted parameters for each of the built features have been compared to the predicted parameters based on the Approved Layout.

As listed in Table 2.1, the following public utilities were not identified within the Study Area nor in the immediate surrounds:

- Tunnels;
- Roads;
- Bridges;
- Railways;
- Electrical Infrastructure;
- Telecommunications Infrastructure;
- Water Tanks, Water and Sewage Treatment Works;
- Gas pipelines;
- Liquid fuel pipelines;
- Water, Gas or Sewerage Infrastructure;
- Water and sewage treatment works; and
- Air strips.

### 6.1. Roads

The nearest road is Woronora Dam Road which is a concrete paved road that connects the Old Princes Highway to Woronora Dam. Woronora Dam Road is located outside the Study Area boundary to the north of Longwalls 317 and 318 and is located over 1,750 m from Longwall 317 at the nearest point. The location of the Woronora Dam Road is shown in Drawing No. MSEC1319-08. A powerline and Telstra copper cable and optical fibre lines also follow the route of the Woronora Dam Road shown in Drawing No. MSEC1319-08.

At a distance of 1,750 m or more from Longwalls 317 and 318, the road is located outside the Study Area and is not expected to experience measurable conventional vertical subsidence, tilts, curvatures or strains (i.e. no greater than survey accuracy), or far-field horizontal movement as a result of the Modification.

Given the large distance from the Modified Layout it is unlikely that the Woronora Dam Road and associated infrastructure would experience adverse impacts as a result of Longwalls 317 and 318.

### 6.2. Fire Trails and Four Wheel Drive Tracks

The locations of the unsealed four wheel drive tracks and fire roads within and adjacent to the Study Area are shown in Drawings Nos. MSEC1319-08 and MSEC1319-09. There are two fire roads, 9E and 9D located within the Study Area. The fire roads are located above the longwall panels and could experience the full range of subsidence movements which are provided in Chapter 4.

Fire Road 9E is located in the south-east of the Study Area above Longwalls 314 and 315 and is expected to experience only minor movements due to the Modified Layout. Fire Road 9D is located above Longwalls 315 to 317 and would experience an increase in predicted subsidence parameters based on the Modified Layout compared with those based on the Approved Layout. While there is an increase in the predicted subsidence parameters above the new longwall footprints, the maxima would be similar to or less than the predicted subsidence parameters above the approved longwalls.

The potential impacts for the unsealed four wheel drive tracks and fire roads, based on the Modified Layout, are therefore similar to those assessed based on the Approved Layout. Impact assessments for the fire trails and four wheel drive tracks are provided in Section 5.13 of the MSEC285 Report.



It is possible that the four wheel drive tracks and fire roads could experience surface cracking during the mining period, particularly where the tracks and roads are located near the tops of existing slopes. The size and extent of surface tension cracking on slopes is expected to be minor and similar to that observed during the extraction of previous longwalls at the Metropolitan Coal Mine. Further discussion on mining induced ground deformations is provided in Section 4.8.

It is recommended that unsealed four wheel drive tracks and fire roads are managed via a land management plan similar to those prepared for the previous approved longwalls.

### **6.3. Dams, Reservoirs or Associated Works**

The full supply level of the Woronora Reservoir is located outside the Study Area and is discussed in Section 5.4.

The Woronora Dam wall is located approximately 4.8 km from the commencing end of Longwall 318 and the distance from the labyrinth spillway, which is to the south of the dam wall, is approximately 4.4 km.

The dam wall and spillway are located at large distances from Longwalls 317 and 318. It is not expected, therefore, that measurable conventional subsidence movements would occur at the dam wall and spillway.

Far-field horizontal movements have been measured up to distances of approximately 4 km from active longwalls, however, almost all of the measured data beyond approximately 2.5 km is within the order of survey tolerance or accuracy. A discussion of far-field horizontal movements is provided in Section 4.6.

It is unlikely that far-field movements would be observed at the distances of the dam wall and spillway from Longwalls 317 and 318.

As listed in Table 2.1, the following public amenities were not identified within the Study Area nor in the immediate surrounds:

- Hospitals;
- Places of worship;
- Schools;
- Office Buildings;
- Shopping centres;
- Community centres;
- Swimming pools;
- Bowling greens;
- Ovals or cricket grounds;
- Racecourses;
- Clubs;
- Golf courses; and
- Tennis courts.

## 8.0 DESCRIPTIONS, PREDICTIONS AND IMPACT ASSESSMENTS FOR THE FARM LAND AND FARM FACILITIES

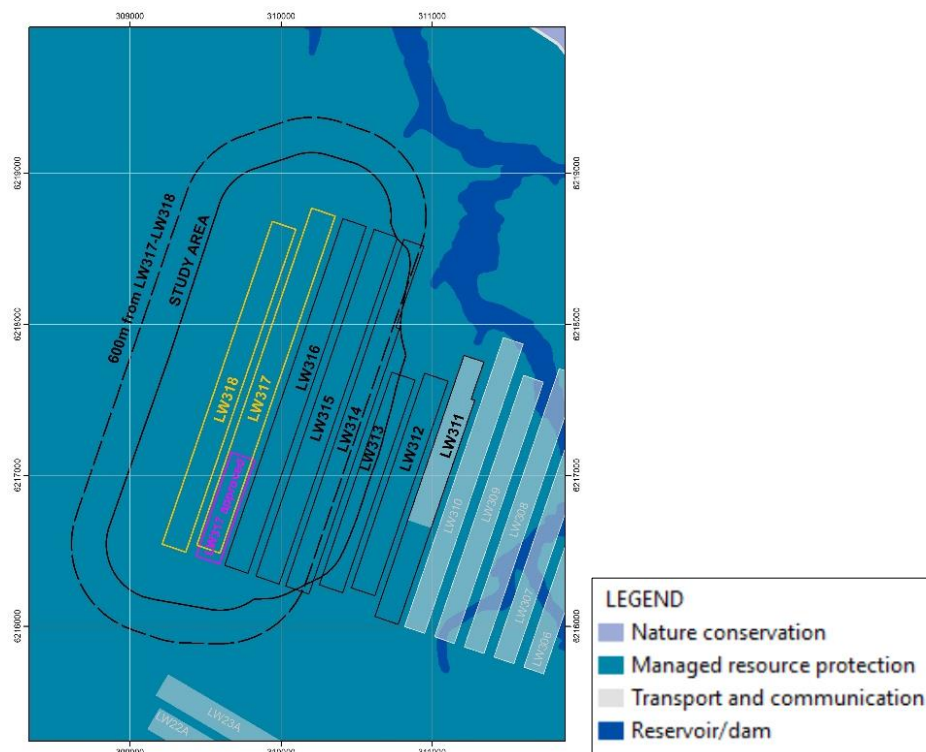
The following section provides the descriptions, predictions of subsidence movements and impact assessments for the farm land and facilities located within the Study Area for Longwalls 317 and 318.

As listed in Table 2.1, the following farm land facilities were not identified within the Study Area nor in the immediate surrounds:

- Farm buildings or sheds;
- Fences;
- Tanks;
- Gas or fuel storages;
- Poultry sheds;
- Glass houses;
- Hydroponic systems;
- Irrigation systems;
- Farm Dams; and
- Wells or Bores.

### 8.1. Agricultural Utilisation

The agricultural land classification types in the vicinity of the proposed Longwalls 317 and 318 are illustrated in Fig. 8.1.



**Fig. 8.1 Agricultural Land Classification within the Study Area (NSW DII, 2008)**

It can be seen from the above figure, that the land classification within the Study Area is Water Catchment. There are no known agricultural activities within the Study Area.

## 9.0 DESCRIPTIONS, PREDICTIONS AND IMPACT ASSESSMENTS FOR THE INDUSTRIAL, COMMERCIAL AND BUSINESS ESTABLISHMENTS

As listed in Table 2.1, the following Industrial, Commercial and Business Establishments were not identified within the Study Area nor in the immediate surrounds:

- Factories;
- Workshops;
- Business or commercial establishments or improvements;
- Gas or fuel storages and associated plant;
- Waste storages and associated plant;
- Exploration bores;
- Buildings, equipment or operations that are sensitive to surface movements; and
- Surface mining (open cut) voids and rehabilitated areas.

### 9.1. Any Other Industrial, Commercial or Business Features

There are no other industrial, or commercial, or business features within the Study Area.

## 10.0 DESCRIPTIONS, PREDICTIONS AND IMPACT ASSESSMENTS FOR AREAS OF ARCHAEOLOGICAL AND HERITAGE SIGNIFICANCE

The following sections provide the descriptions, predictions of subsidence movements and impact assessments for the archaeological and heritage sites located within the Study Area for Longwalls 317 and 318. The predicted parameters for each of the features have been compared to the predicted parameters based on the Approved Layout.

### 10.1. Aboriginal Heritage Sites

#### 10.1.1. Descriptions of the Aboriginal Heritage Sites

The detailed descriptions of the Aboriginal heritage sites are provided in the baseline reports prepared by Niche. There are 25 Aboriginal heritage sites that have been identified within the Study Area and an additional four sites that have been included for this modification subsidence assessment (total 29 sites). The locations of these sites are shown in Drawing No. MSEC1319-09.

The descriptions of the Aboriginal heritage sites within and near the Study Area are provided in Table D.02, in Appendix D. Of the 29 sites, 15 are within shelters (sandstone overhangs), 12 have grinding grooves and 12 have art.

The subsidence impact performance measures in the Project Approval 08\_0149 for Aboriginal heritage sites are set out in Schedule 3 Table 1 which states: *“Less than 10% of Aboriginal heritage sites within the mining area are affected by subsidence impacts.”*

#### 10.1.2. Predictions for the Aboriginal Heritage Sites

The maximum predicted subsidence parameters for each of the Aboriginal heritage sites located within the Study Area is provided in Table D.02, in Appendix D. The predictions have been provided based on the Modified Layout and Approved Layout.

A summary of the maximum predicted values of total conventional subsidence, tilt and curvature for the sites, resulting from the Modified Layout, is provided in Table 10.1. The predicted tilts provided in Table 10.1 are the maxima after the completion of Longwalls 317 and 318. The predicted curvatures are the maxima at any time during or after the extraction of Longwalls 317 and 318.



**Table 10.1 Maximum Predicted Total Conventional Subsidence, Tilt and Curvature for the Aboriginal Heritage Sites within the Study Area After the Extraction of Longwalls 317 and 318**

| Site  | Maximum Predicted Total Conventional Subsidence (mm) | Maximum Predicted Total Conventional Tilt (mm/m) | Maximum Predicted Total Conventional Hogging Curvature (km <sup>-1</sup> ) | Maximum Predicted Total Conventional Sagging Curvature (km <sup>-1</sup> ) |
|-------|------------------------------------------------------|--------------------------------------------------|----------------------------------------------------------------------------|----------------------------------------------------------------------------|
| MET9  | 325                                                  | 3.0                                              | 0.02                                                                       | < 0.01                                                                     |
| MET10 | 275                                                  | 2.5                                              | 0.02                                                                       | < 0.01                                                                     |
| MET11 | < 20                                                 | < 0.5                                            | < 0.01                                                                     | < 0.01                                                                     |
| NT 3  | 80                                                   | 0.5                                              | < 0.01                                                                     | < 0.01                                                                     |
| NT 4  | 500                                                  | 4.0                                              | 0.01                                                                       | 0.02                                                                       |
| NT 5  | 225                                                  | 2.5                                              | 0.03                                                                       | 0.01                                                                       |
| NT 6  | 1050                                                 | 1.0                                              | 0.02                                                                       | 0.03                                                                       |
| NT 7  | 1150                                                 | 0.5                                              | 0.03                                                                       | 0.03                                                                       |
| NT 8  | 775                                                  | 5.5                                              | 0.04                                                                       | 0.03                                                                       |
| NT 9  | 500                                                  | 5.5                                              | 0.07                                                                       | < 0.01                                                                     |
| NT 10 | 575                                                  | 3.0                                              | 0.01                                                                       | 0.02                                                                       |
| NT 12 | 575                                                  | 3.0                                              | 0.01                                                                       | 0.02                                                                       |
| NT 13 | 650                                                  | 2.0                                              | 0.01                                                                       | 0.01                                                                       |
| NT 17 | 650                                                  | 2.5                                              | 0.02                                                                       | 0.02                                                                       |
| NT 18 | < 20                                                 | < 0.5                                            | < 0.01                                                                     | < 0.01                                                                     |
| NT 21 | 40                                                   | < 0.5                                            | < 0.01                                                                     | < 0.01                                                                     |
| NT 22 | < 20                                                 | < 0.5                                            | < 0.01                                                                     | < 0.01                                                                     |
| NT 23 | < 20                                                 | < 0.5                                            | < 0.01                                                                     | < 0.01                                                                     |
| NT 25 | < 20                                                 | < 0.5                                            | < 0.01                                                                     | < 0.01                                                                     |
| NT 30 | 250                                                  | 3.0                                              | 0.03                                                                       | < 0.01                                                                     |
| NT 46 | 1250                                                 | < 0.5                                            | 0.02                                                                       | 0.02                                                                       |
| NT 51 | < 20                                                 | < 0.5                                            | < 0.01                                                                     | < 0.01                                                                     |
| NT 52 | < 20                                                 | < 0.5                                            | < 0.01                                                                     | < 0.01                                                                     |
| NT 53 | 30                                                   | < 0.5                                            | < 0.01                                                                     | < 0.01                                                                     |
| NT 54 | 80                                                   | 1.0                                              | 0.01                                                                       | < 0.01                                                                     |
| NT 80 | 80                                                   | 1.0                                              | 0.02                                                                       | < 0.01                                                                     |
| NT 87 | 20                                                   | < 0.5                                            | < 0.01                                                                     | < 0.01                                                                     |
| NT49  | < 20                                                 | < 0.5                                            | < 0.01                                                                     | < 0.01                                                                     |
| NT50  | < 20                                                 | < 0.5                                            | < 0.01                                                                     | < 0.01                                                                     |

The maximum predicted conventional tilt for the sites is 5.5 mm/m (i.e. 0.55 %, or 1 in 180). The maximum predicted conventional curvatures are 0.07 km<sup>-1</sup> hogging and 0.03 km<sup>-1</sup> sagging, which equate to minimum radii of curvature of greater than 14 km and 33 km respectively.

The predicted strains for the Aboriginal heritage sites located above solid coal are provided in Table 10.2. The values have been provided for conventional movements (based on 15 times the curvature) and for non-conventional anomalous movements (based on the statistical analysis above solid coal provided in Section 4.4.1).

**Table 10.2 Predicted Strains for the Aboriginal Heritage Sites above Solid Coal based on Conventional and Non-conventional Anomalous Movements**

| Type        | Conventional based on 15 times Curvature (mm/m) | Non-conventional based on the 95 % Confidence Level (mm/m) | Non-conventional based on the 99 % Confidence Level (mm/m) |
|-------------|-------------------------------------------------|------------------------------------------------------------|------------------------------------------------------------|
| Tension     | < 0.5                                           | 0.5                                                        | 0.8                                                        |
| Compression | < 0.5                                           | 0.6                                                        | 0.9                                                        |

The predicted strains for the Aboriginal heritage sites located above longwall panels is provided in Table 10.3. The values have been provided for conventional movements (based on 15 times the curvature) and for non-conventional anomalous movements (based on the statistical analysis above goaf provided in Section 4.4.1).

**Table 10.3 Predicted Strains for the Aboriginal Heritage Sites above Goaf based on Conventional and Non-conventional Anomalous Movements**

| Type        | Conventional based on 15 times Curvature (mm/m) | Non-conventional based on the 95 % Confidence Level (mm/m) | Non-conventional based on the 99 % Confidence Level (mm/m) |
|-------------|-------------------------------------------------|------------------------------------------------------------|------------------------------------------------------------|
| Tension     | 1.5                                             | 0.9                                                        | 1.6                                                        |
| Compression | 1.0                                             | 1.6                                                        | 3.2                                                        |

It can be seen from Table D.02 in Appendix D that there is an increase in the predicted vertical subsidence at 18 of the sites and a reduction or no change at 11 sites based on the Modified Layout after Longwall 318 when compared to the Approved Layout. The potential for impacts on these sites does not result from absolute vertical subsidence, but rather the differential movements (i.e. tilt, curvature and strain).

The predicted tilt increases at 11 of the 29 Aboriginal heritage sites based on the Modified Layout. The hogging and sagging curvatures based on the Modified Layout after Longwall 318 increase at 8 and 6 sites respectively compared to the Approved Layout.

The predicted tilt increases at approximately 38% of the Aboriginal heritage sites and the predicted hogging and sagging curvature increase at a small number of sites. However, the maximum tilt and curvatures are similar to or less than the maxima predicted for other Aboriginal heritage sites located above the previously extracted longwalls at Metropolitan Coal Mine. The potential impacts for these sites based on the Modified Layout, therefore, are similar to or less than those assessed based on the Approved Layout.

### 10.1.3. Impact Assessments and Recommendations for the Aboriginal Heritage Sites

The potential impacts for the Aboriginal heritage sites, based on the Modified Layout, are similar to or less than those based on the Approved Layout. The assessments of the potential impacts for the Aboriginal heritage sites were provided in Section 5.24.2 of Report No. MSEC285, which supported the Metropolitan Coal Project EA and Approved Layout.

The magnitudes of predicted tilt and curvature for the majority of the Aboriginal heritage sites are small due to site locations above narrow geometry and solid coal. Impacts above the Modified Layout, including fracturing of bedrock, rockfalls and shear of bedding planes within shelters is expected to be minor and isolated, consistent with the impacts observed above the previously extracted longwalls at Metropolitan Coal Mine. The likelihood of fracturing impacting the Aboriginal Heritage Sites located above the Modified Layout is considered to be low. Impacts to the sites located above solid coal are considered unlikely. While surface fracturing of the bedrock can occur outside the longwall layouts, as discussed in Section 4.8, such fracturing is minor and isolated and the likelihood of fracturing impacting the Aboriginal Heritage Sites outside the longwall layouts is considered to be low.

Some sites are located close to or at the base of tributaries and could therefore experience valley related movements. The sites most likely to experience valley related movements include NT7 to NT9, NT17, NT21, NT29, NT46, NT49 to NT53, MET9 and MET11. With the exception of NT9, NT21 and MET11, the sites are located in shallow valley profiles and are not expected to experience any significant valley closure. NT9, NT21 and MET11 are located within deeper and more incised valley profiles and could experience valley closure of up to 250 mm, 350 mm, and 50 mm respectively. Potential impacts resulting from valley closure are discussed in Sections 5.4 and 5.5, which includes potential cracking in the bedrock along base of the tributaries and fracturing and dilation of the underlying strata above and immediately adjacent to the proposed longwalls. Of the 14 grinding groove locations within the Study Area, sites NT9 and NT21 are at greatest risk of cracking due to valley closure. Impacts to grinding grooves have not been observed to date at Metropolitan Coal Mine.

To date, the cumulative percentage of sites affected by subsidence impacts at Metropolitan Coal Mine is less than 2 % (Niche 2025b). Impacts have been recorded at 13 sites out of 143 identified sites, with two resulting in impacts to Aboriginal heritage features, both being cracks through motifs and hand stencils.

Given the above, no changes to the Aboriginal heritage site Subsidence Impact Performance Measure outlined in the Project Approval (08\_0149) would be required for the Modification. The management strategies for the Aboriginal heritage sites are the same as those based on the Approved Layout.

Further details and discussions on the potential impacts on the archaeological sites resulting from the extraction of the Modified Layout are provided in the report by Niche (2025b). Management of Aboriginal heritage sites would be outlined in the Metropolitan Coal Mine Heritage Management Plan.

## 10.2. European Heritage Sites

There are no European Heritage sites within the Study Area.

## 10.3. Items of Architectural Significance

There are no items of architectural significance within the Study Area.

## 10.4. Survey Control Marks

There are no survey control marks within the Study Area. The survey control marks near the Study Area are shown in Drawing No. MSEC1319-09. The locations and details of the survey control marks were obtained from the *Land and Property Management Authority* using the *SCIMS Online* website (Land and Property Management Authority, 2016). The nearest survey control mark is over 1.6 km from Longwall 317.

The survey control marks are likely to experience far-field horizontal movements as the longwalls are mined. Far-field horizontal movements have been measured up to distances of approximately 4 km from active longwalls, however, almost all of the measured data beyond approximately 2.5 km is within the order of survey tolerance or accuracy. A discussion of far-field horizontal movements is provided in Section 4.6.

It would be necessary on the completion of Longwalls 317 and 318, when the ground has stabilised, to re-establish the coordinates for marks. It is recommended the survey control network be re-established following the completion of mining activities in consultation with Land and Property Information NSW, as required by the *Surveyor General's Directions No. 11 Preservation of Survey Infrastructure*."

## 10.5. National Heritage Places

The Modification was referred to the Commonwealth Minister for the Environment and Water in January 2025 (EPBC 2025/10103) (the proposed action). A delegate of the Commonwealth Minister determined on 22 April 2025 that the proposed action is a "controlled action" and therefore, the action requires approval under the EPBC Act, including an assessment of potential impacts on National Heritage Places. The delegate considered National Heritage Places to be a controlling provision, prompting further assessment. There are no listed National Heritage Places within the Study Area for the Modification or its immediate vicinity. The nearest listed National Heritage Place is the Royal National Park and Garawarra State Conservation Area located east of the Princes Motorway, approximately 3 km from the Modification. As such, the Royal National Park and Garawarra State Conservation Area is not anticipated to experience any subsidence effects due to the Modification.

## 11.0 DESCRIPTIONS, PREDICTIONS AND IMPACT ASSESSMENTS FOR THE RESIDENTIAL BUILDING STRUCTURES

As listed in Table 2.1, the following residential features were not identified within the Study Area nor in the immediate surrounds:

- Flats or Units;
- Caravan Parks;
- Tennis courts;
- Swimming pools;
- On-site water systems; and
- Any other residential features.

## 12.0 RECOMMENDED MONITORING PROGRAM

Table 12.1 provides a summary of the recommended management measure and monitoring program for natural and built features within the Study Area for Longwalls 317 and 318. There are no additional subsidence monitoring locations or methods recommended beyond those to be implemented under the Longwalls 311-316 Subsidence Monitoring Program.

**Table 12.1 Summary of Recommended Monitoring for Features within the Study Area**

| Feature Within Study Area                                                 | Recommendation Management and Monitoring                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|---------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Tributaries R, S and U and Honeysuckle Creek                              | Management strategies developed such that impacts can be identified and remediated, as and if they are required. These management strategies would be similar to those outlined in the Longwalls 311-316 Extraction Plan (Metropolitan Coal, 2024), including surface water monitoring program and remediation of watercourses, where required.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Cliff                                                                     | Baseline condition of the cliffs should be documented and photographed prior to mining and monitored during mining.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Steep Slopes                                                              | Managed via a land management plan similar to those prepared for the previous approved longwalls.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Swamps                                                                    | Management strategies include avoidance and minimisation of impacts or survey monitoring and remediation if impacts are observed. It is difficult to monitor ground strains within the swamps as significant vegetation clearing is required to install ground survey monitoring marks. Ground strains can be monitored in some cases at suitable nearby representative locations outside the swamp footprint. Where valley closure is predicted, survey monitoring across the valley could be carried out with minimal vegetation clearing. Monitoring of surface and groundwater are carried out in the swamps in addition to any survey monitoring to assess the potential response to subsidence effects. It is recommended that Trigger Action Response plans prepared for Swamps S76, S77 and S92 are continued for Swamps S76 and S77 during the extraction of Longwalls 317 and 318. A monitoring programme similar to swamps S76, S77 and S92 could be developed for Swamp S106.<br>Further management measures and monitoring are described in the Biodiversity Development Assessment Report (Niche, 2025a). |
| Aboriginal cultural heritage sites                                        | The management strategies for the Aboriginal heritage sites are the same as those based on the Approved Layout. Further detail is provided in the Aboriginal Cultural Heritage Assessment (Niche, 2025b)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Survey Control Marks                                                      | Recommended the survey control network be re-established following the completion of mining activities in consultation with Land and Property Information NSW, as required by the "Surveyor General's Directions No.11 Preservation of Survey Infrastructure."                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Fire Trails                                                               | Managed via a land management plan similar to those prepared for the previous approved longwalls.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Threatened, Protected Species or Critical Habitats and Natural Vegetation | Management measures and monitoring are described in the Biodiversity Development Assessment Report (Niche, 2025a).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |



## **APPENDIX A. GLOSSARY OF TERMS AND DEFINITIONS**

# Glossary of Terms and Definitions

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

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

|                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|----------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Shear deformations</b>  | The horizontal displacements that are measured across monitoring lines and these can be described by various parameters including; horizontal tilt, horizontal curvature, mid-ordinate deviation, angular distortion and shear index.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>Strain</b>              | <p>The change in the horizontal distance between two points divided by the original horizontal distance between the points, (i.e. strain is the relative differential displacement of the ground along or across a subsidence monitoring line). Strain is dimensionless and can be expressed as a decimal, a percentage or in parts per notation.</p> <p><b>Tensile Strains</b> are measured where the distance between two points or survey pegs increases and <b>Compressive Strains</b> where the distance between two points decreases. Whilst mining induced <b>strains</b> are measured <b>along</b> monitoring lines, ground <b>shearing</b> can occur both vertically, and horizontally <b>across</b> the directions of the monitoring lines.</p> |
| <b>Sub-critical area</b>   | An area of panel smaller than the critical area.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>Subsidence</b>          | <p>The vertical movement of a point on the surface of the ground as it settles above an extracted panel, but, 'subsidence of the ground' in some references can include both a vertical and horizontal movement component. The vertical component of subsidence is measured by determining the change in surface level of a peg that is fixed in the ground before mining commenced and this vertical subsidence is usually expressed in units of <i>millimetres (mm)</i>. Sometimes the horizontal component of a peg's movement is not measured, but in these cases, the horizontal distances between a particular peg and the adjacent pegs are measured.</p>                                                                                          |
| <b>Super-critical area</b> | An area of panel greater than the critical area.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>Tilt</b>                | The change in the slope of the ground as a result of differential subsidence, and is calculated as the change in subsidence between two points divided by the horizontal distance between those points. Tilt is, therefore, the first derivative of the subsidence profile. Tilt is usually expressed in units of <i>millimetres per metre (mm/m)</i> . A tilt of 1 mm/m is equivalent to a change in grade of 0.1 %, or 1 in 1000.                                                                                                                                                                                                                                                                                                                       |
| <b>Uplift</b>              | An increase in the level of a point relative to its original position.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Upsidence</b>           | Upsidence results from the dilation or buckling of near surface strata at or near the base of the valley. The magnitude of upsidence, which is typically expressed in the units of <i>millimetres (mm)</i> , is the difference between the observed subsidence profile within the valley and the conventional subsidence profile which would have otherwise been expected in flat terrain.                                                                                                                                                                                                                                                                                                                                                                |

## APPENDIX B. REFERENCES

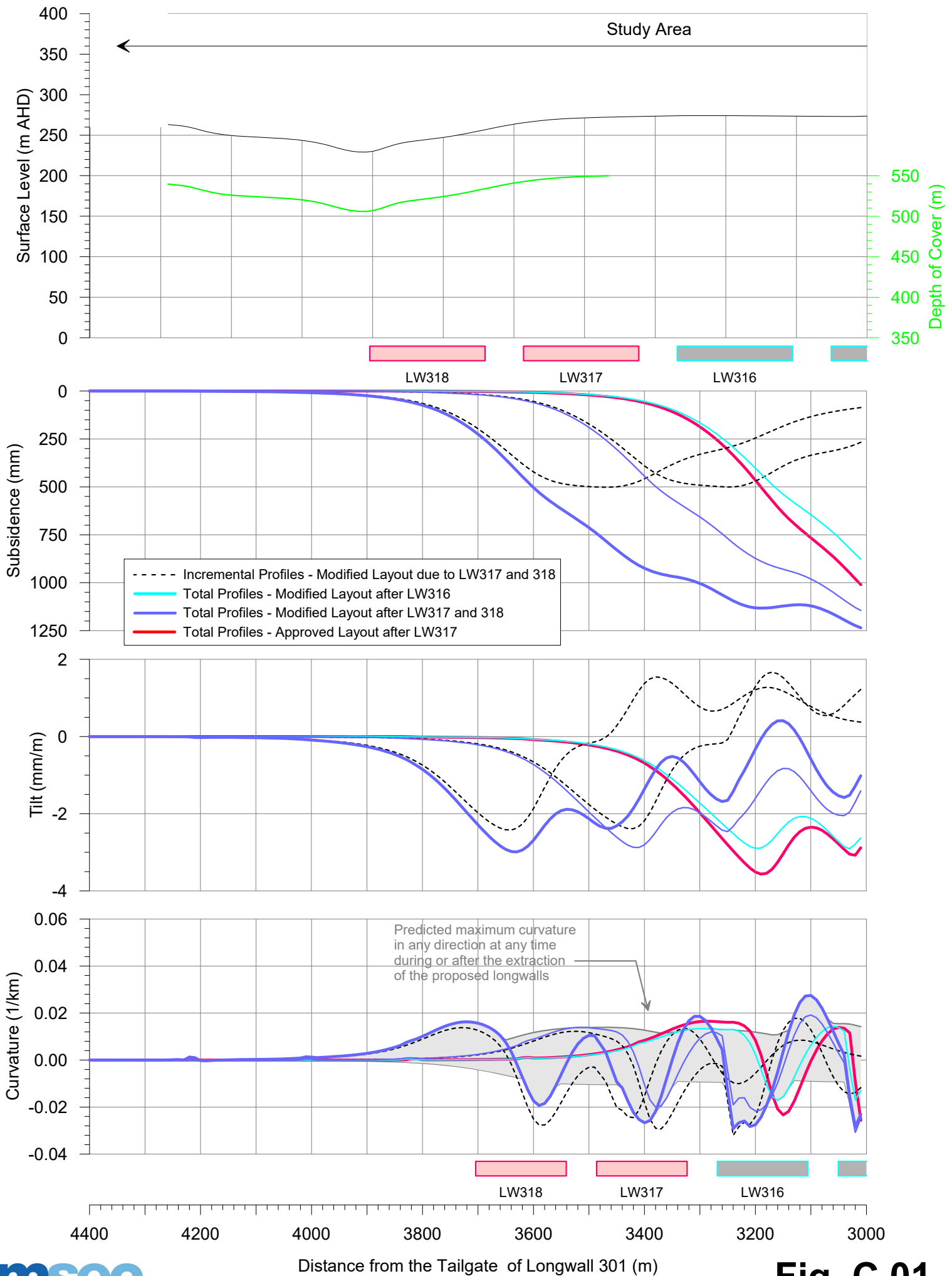
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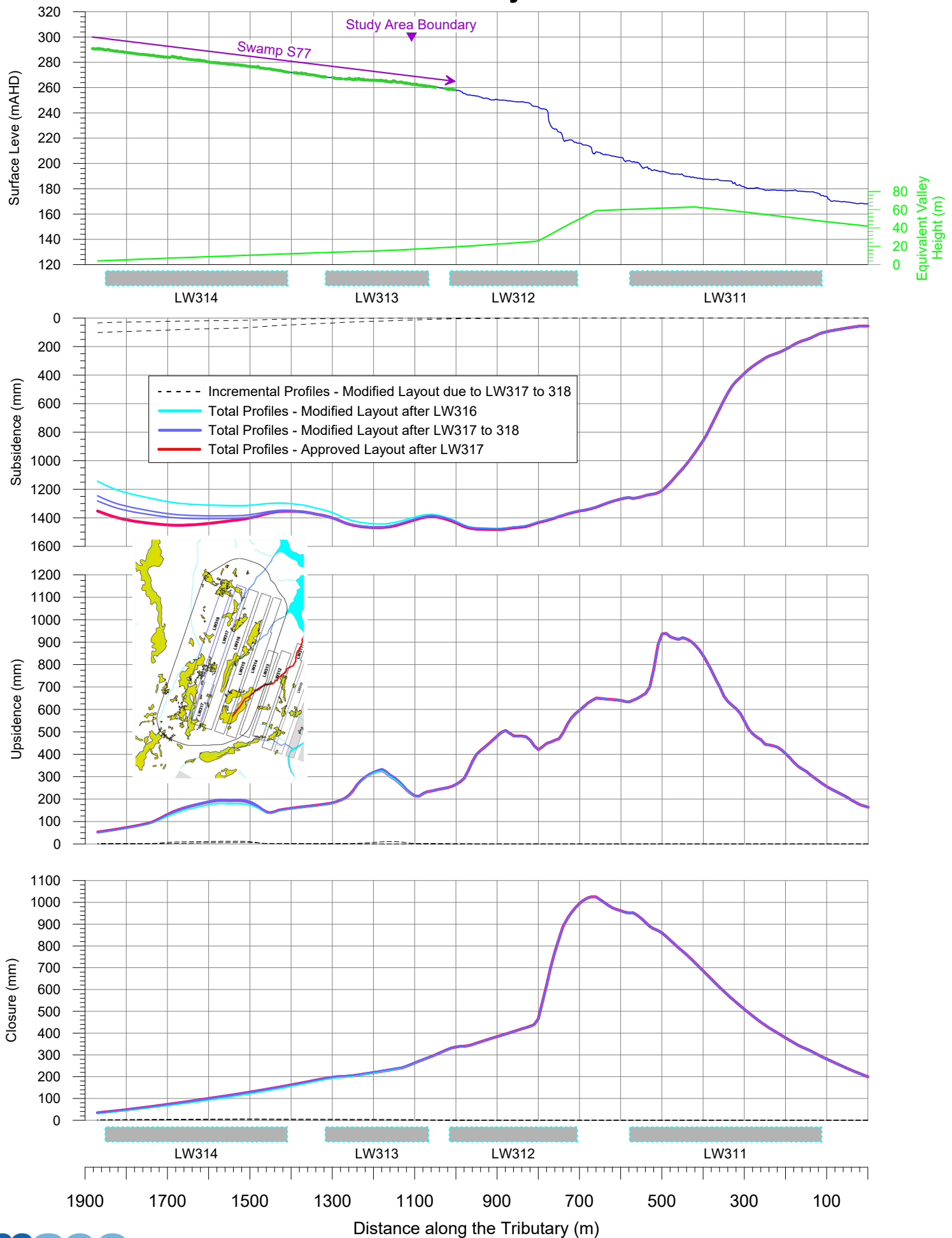


## APPENDIX C. FIGURES

# Predicted Profiles of Conventional Subsidence, Tilt and Curvature along Prediction Line 1 due to LW317 and 318



# Predicted Profiles of Subsidence, Upsidence and Closure along Tributary R due to LW317 and 318 Modification Layout



# Predicted Profiles of Subsidence, Upsidence and Closure along Tributary S due to LW317 and 318 Modification Layout

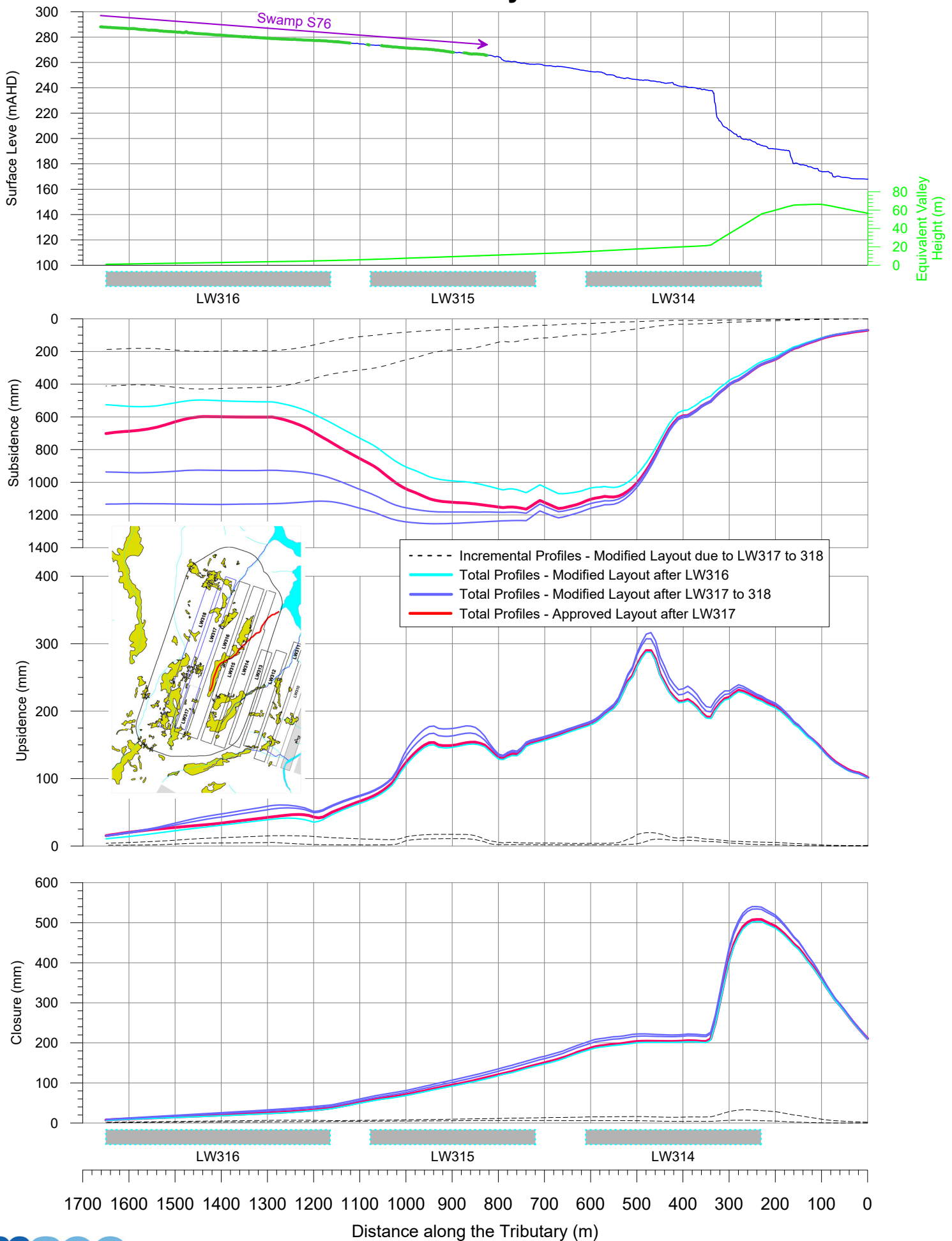
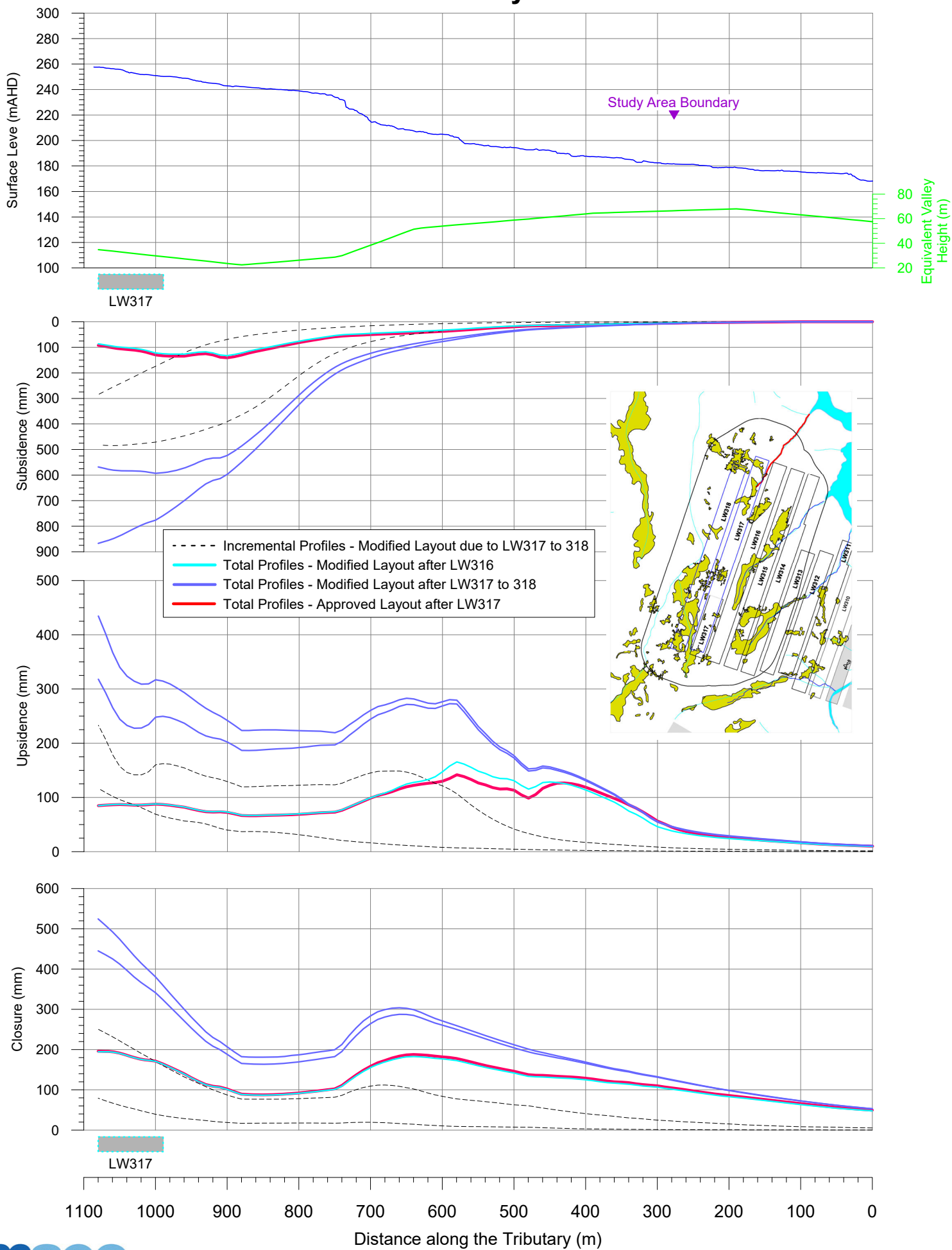


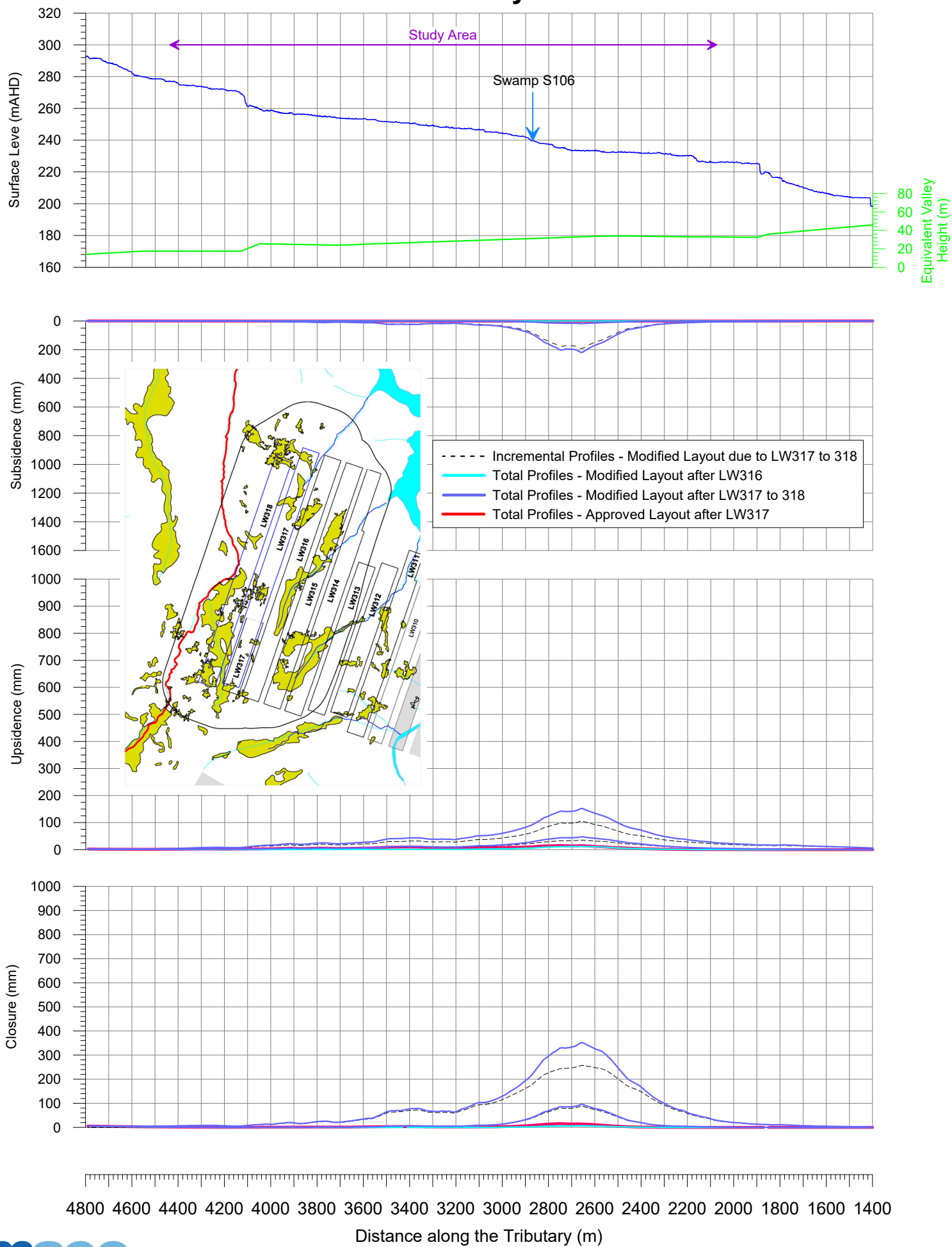
Fig. C.03

**Predicted Profiles of Subsidence, Upsidence and Closure along  
Tributary U due to LW317 and 318  
Modification Layout**





## Predicted Profiles of Subsidence, Upsidence and Closure along Honeysuckle Creek due to LW317 and 318 Modification Layout



## APPENDIX D. TABLES

# Table D.01 - Maximum Predicted Subsidence Parameters for the Swamps

| Swamp  | <i>Maximum Predicted Subsidence based on the Approved Layout after LW317 (mm)</i> | <i>Maximum Predicted Subsidence based on the Modified Layout after LW317 (mm)</i> | <i>Maximum Predicted Subsidence based on the Modified Layout after LW318 (mm)</i> | <i>Maximum Predicted Tilt based on the Approved Layout after LW317 (mm/m)</i> | <i>Maximum Predicted Tilt based on the Modified Layout after LW318 (mm/m)</i> | <i>Maximum Predicted Hogging Curvature based on the Approved Layout after LW317 (1/km)</i> | <i>Maximum Predicted Hogging Curvature based on the Modified Layout after LW318 (1/km)</i> | <i>Maximum Predicted Sagging Curvature based on the Approved Layout after LW317 (1/km)</i> | <i>Maximum Predicted Sagging Curvature based on the Modified Layout after LW318 (1/km)</i> |
|--------|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|-------------------------------------------------------------------------------|-------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|
| Bee Ck | < 20                                                                              | < 20                                                                              | < 20                                                                              | < 0.5                                                                         | < 0.5                                                                         | < 0.01                                                                                     | < 0.01                                                                                     | < 0.01                                                                                     | < 0.01                                                                                     |
| S14    | < 20                                                                              | < 20                                                                              | < 20                                                                              | < 0.5                                                                         | < 0.5                                                                         | < 0.01                                                                                     | < 0.01                                                                                     | < 0.01                                                                                     | < 0.01                                                                                     |
| S74    | 150                                                                               | 625                                                                               | 950                                                                               | 1.5                                                                           | 4.0                                                                           | 0.02                                                                                       | 0.03                                                                                       | < 0.01                                                                                     | 0.06                                                                                       |
| S75    | 750                                                                               | 900                                                                               | 1100                                                                              | 5.0                                                                           | 2.0                                                                           | 0.05                                                                                       | 0.04                                                                                       | 0.05                                                                                       | 0.04                                                                                       |
| S76    | 1200                                                                              | 1250                                                                              | 1250                                                                              | 4.0                                                                           | 1.5                                                                           | 0.02                                                                                       | 0.03                                                                                       | 0.04                                                                                       | 0.03                                                                                       |
| S77    | 1500                                                                              | 1450                                                                              | 1450                                                                              | 4.5                                                                           | 4.5                                                                           | 0.04                                                                                       | 0.04                                                                                       | 0.04                                                                                       | 0.04                                                                                       |
| S91    | 1100                                                                              | 1050                                                                              | 1050                                                                              | 6.5                                                                           | 6.0                                                                           | 0.03                                                                                       | 0.03                                                                                       | 0.04                                                                                       | 0.03                                                                                       |
| S92    | 575                                                                               | 575                                                                               | 575                                                                               | 5.0                                                                           | 5.0                                                                           | 0.03                                                                                       | 0.03                                                                                       | 0.02                                                                                       | 0.02                                                                                       |
| S93    | 20                                                                                | 20                                                                                | 20                                                                                | < 0.5                                                                         | < 0.5                                                                         | < 0.01                                                                                     | < 0.01                                                                                     | < 0.01                                                                                     | < 0.01                                                                                     |
| S99    | < 20                                                                              | < 20                                                                              | < 20                                                                              | < 0.5                                                                         | < 0.5                                                                         | < 0.01                                                                                     | < 0.01                                                                                     | < 0.01                                                                                     | < 0.01                                                                                     |
| S101   | < 20                                                                              | < 20                                                                              | < 20                                                                              | < 0.5                                                                         | < 0.5                                                                         | < 0.01                                                                                     | < 0.01                                                                                     | < 0.01                                                                                     | < 0.01                                                                                     |
| S102   | < 20                                                                              | < 20                                                                              | < 20                                                                              | < 0.5                                                                         | < 0.5                                                                         | < 0.01                                                                                     | < 0.01                                                                                     | < 0.01                                                                                     | < 0.01                                                                                     |
| S103   | < 20                                                                              | < 20                                                                              | < 20                                                                              | < 0.5                                                                         | < 0.5                                                                         | < 0.01                                                                                     | < 0.01                                                                                     | < 0.01                                                                                     | < 0.01                                                                                     |
| S104   | < 20                                                                              | < 20                                                                              | < 20                                                                              | < 0.5                                                                         | < 0.5                                                                         | < 0.01                                                                                     | < 0.01                                                                                     | < 0.01                                                                                     | < 0.01                                                                                     |
| S105   | < 20                                                                              | < 20                                                                              | 80                                                                                | < 0.5                                                                         | 1.0                                                                           | < 0.01                                                                                     | < 0.01                                                                                     | < 0.01                                                                                     | < 0.01                                                                                     |
| S106   | 350                                                                               | 225                                                                               | 750                                                                               | 3.5                                                                           | 3.5                                                                           | 0.02                                                                                       | 0.03                                                                                       | 0.01                                                                                       | 0.02                                                                                       |
| S107   | 375                                                                               | 225                                                                               | 350                                                                               | 4.0                                                                           | 3.5                                                                           | 0.04                                                                                       | 0.03                                                                                       | < 0.01                                                                                     | < 0.01                                                                                     |
| S108   | 225                                                                               | 150                                                                               | 225                                                                               | 2.5                                                                           | 2.0                                                                           | 0.03                                                                                       | 0.03                                                                                       | < 0.01                                                                                     | < 0.01                                                                                     |
| S109   | < 20                                                                              | < 20                                                                              | 80                                                                                | < 0.5                                                                         | 1.0                                                                           | < 0.01                                                                                     | 0.01                                                                                       | < 0.01                                                                                     | < 0.01                                                                                     |
| S110   | < 20                                                                              | < 20                                                                              | < 20                                                                              | < 0.5                                                                         | < 0.5                                                                         | < 0.01                                                                                     | < 0.01                                                                                     | < 0.01                                                                                     | < 0.01                                                                                     |
| S111a  | < 20                                                                              | < 20                                                                              | < 20                                                                              | < 0.5                                                                         | < 0.5                                                                         | < 0.01                                                                                     | < 0.01                                                                                     | < 0.01                                                                                     | < 0.01                                                                                     |
| S111b  | < 20                                                                              | < 20                                                                              | < 20                                                                              | < 0.5                                                                         | < 0.5                                                                         | < 0.01                                                                                     | < 0.01                                                                                     | < 0.01                                                                                     | < 0.01                                                                                     |
| S112   | < 20                                                                              | < 20                                                                              | < 20                                                                              | < 0.5                                                                         | < 0.5                                                                         | < 0.01                                                                                     | < 0.01                                                                                     | < 0.01                                                                                     | < 0.01                                                                                     |

# Table D.01 - Maximum Predicted Subsidence Parameters for the Swamps

| Swamp | Maximum Predicted Subsidence based on the Approved Layout after LW317 (mm) | Maximum Predicted Subsidence based on the Modified Layout after LW317 (mm) | Maximum Predicted Subsidence based on the Modified Layout after LW318 (mm) | Maximum Predicted Tilt based on the Approved Layout after LW317 (mm/m) | Maximum Predicted Tilt based on the Modified Layout after LW318 (mm/m) | Maximum Predicted Hogging Curvature based on the Approved Layout after LW317 (1/km) | Maximum Predicted Hogging Curvature based on the Modified Layout after LW318 (1/km) | Maximum Predicted Sagging Curvature based on the Approved Layout after LW317 (1/km) | Maximum Predicted Sagging Curvature based on the Modified Layout after LW318 (1/km) |
|-------|----------------------------------------------------------------------------|----------------------------------------------------------------------------|----------------------------------------------------------------------------|------------------------------------------------------------------------|------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| S113  | 700                                                                        | 600                                                                        | 975                                                                        | 3.5                                                                    | 2.5                                                                    | 0.02                                                                                | 0.02                                                                                | 0.02                                                                                | 0.02                                                                                |
| S114  | 875                                                                        | 750                                                                        | 1050                                                                       | 3.0                                                                    | 2.0                                                                    | 0.02                                                                                | 0.02                                                                                | 0.02                                                                                | 0.02                                                                                |
| S115  | 750                                                                        | 750                                                                        | 1050                                                                       | 3.5                                                                    | 1.5                                                                    | 0.02                                                                                | 0.02                                                                                | 0.02                                                                                | 0.02                                                                                |
| S116  | 40                                                                         | 80                                                                         | 550                                                                        | 0.5                                                                    | 3.0                                                                    | < 0.01                                                                              | 0.01                                                                                | < 0.01                                                                              | 0.02                                                                                |
| S117  | 100                                                                        | 250                                                                        | 775                                                                        | 1.5                                                                    | 3.0                                                                    | < 0.01                                                                              | 0.01                                                                                | < 0.01                                                                              | 0.02                                                                                |
| S118  | < 20                                                                       | 90                                                                         | 575                                                                        | < 0.5                                                                  | 3.0                                                                    | < 0.01                                                                              | 0.01                                                                                | < 0.01                                                                              | 0.02                                                                                |
| S119  | 150                                                                        | 600                                                                        | 975                                                                        | 1.5                                                                    | 3.0                                                                    | 0.01                                                                                | 0.01                                                                                | < 0.01                                                                              | 0.03                                                                                |
| S120  | < 20                                                                       | 30                                                                         | 325                                                                        | < 0.5                                                                  | 3.0                                                                    | < 0.01                                                                              | 0.02                                                                                | < 0.01                                                                              | < 0.01                                                                              |
| S121  | < 20                                                                       | 125                                                                        | 625                                                                        | < 0.5                                                                  | 3.0                                                                    | < 0.01                                                                              | 0.01                                                                                | < 0.01                                                                              | 0.02                                                                                |
| S122  | < 20                                                                       | < 20                                                                       | 150                                                                        | < 0.5                                                                  | 1.5                                                                    | < 0.01                                                                              | 0.01                                                                                | < 0.01                                                                              | < 0.01                                                                              |
| S123  | < 20                                                                       | < 20                                                                       | 100                                                                        | < 0.5                                                                  | 1.0                                                                    | < 0.01                                                                              | 0.01                                                                                | < 0.01                                                                              | < 0.01                                                                              |
| S124  | < 20                                                                       | < 20                                                                       | 70                                                                         | < 0.5                                                                  | 1.0                                                                    | < 0.01                                                                              | < 0.01                                                                              | < 0.01                                                                              | < 0.01                                                                              |
| S125a | < 20                                                                       | < 20                                                                       | 20                                                                         | < 0.5                                                                  | < 0.5                                                                  | < 0.01                                                                              | < 0.01                                                                              | < 0.01                                                                              | < 0.01                                                                              |
| S125b | < 20                                                                       | < 20                                                                       | < 20                                                                       | < 0.5                                                                  | < 0.5                                                                  | < 0.01                                                                              | < 0.01                                                                              | < 0.01                                                                              | < 0.01                                                                              |
| S126a | < 20                                                                       | < 20                                                                       | < 20                                                                       | < 0.5                                                                  | < 0.5                                                                  | < 0.01                                                                              | < 0.01                                                                              | < 0.01                                                                              | < 0.01                                                                              |
| S126b | < 20                                                                       | < 20                                                                       | < 20                                                                       | < 0.5                                                                  | < 0.5                                                                  | < 0.01                                                                              | < 0.01                                                                              | < 0.01                                                                              | < 0.01                                                                              |
| S126c | < 20                                                                       | < 20                                                                       | < 20                                                                       | < 0.5                                                                  | < 0.5                                                                  | < 0.01                                                                              | < 0.01                                                                              | < 0.01                                                                              | < 0.01                                                                              |
| S127  | 40                                                                         | 200                                                                        | 375                                                                        | < 0.5                                                                  | 3.5                                                                    | < 0.01                                                                              | 0.03                                                                                | < 0.01                                                                              | < 0.01                                                                              |
| S128  | 200                                                                        | 600                                                                        | 750                                                                        | 2.5                                                                    | 3.5                                                                    | 0.03                                                                                | 0.02                                                                                | < 0.01                                                                              | 0.05                                                                                |
| S129  | < 20                                                                       | 40                                                                         | 100                                                                        | < 0.5                                                                  | 1.0                                                                    | < 0.01                                                                              | < 0.01                                                                              | < 0.01                                                                              | < 0.01                                                                              |
| S130  | 500                                                                        | 825                                                                        | 1000                                                                       | 4.0                                                                    | 2.0                                                                    | 0.03                                                                                | 0.03                                                                                | 0.02                                                                                | 0.04                                                                                |
| S131  | < 20                                                                       | < 20                                                                       | 30                                                                         | < 0.5                                                                  | < 0.5                                                                  | < 0.01                                                                              | < 0.01                                                                              | < 0.01                                                                              | < 0.01                                                                              |
| S132  | < 20                                                                       | 20                                                                         | 30                                                                         | < 0.5                                                                  | < 0.5                                                                  | < 0.01                                                                              | < 0.01                                                                              | < 0.01                                                                              | < 0.01                                                                              |
| S135  | < 20                                                                       | 20                                                                         | 250                                                                        | < 0.5                                                                  | 2.5                                                                    | < 0.01                                                                              | 0.02                                                                                | < 0.01                                                                              | < 0.01                                                                              |
| S136  | < 20                                                                       | < 20                                                                       | < 20                                                                       | < 0.5                                                                  | < 0.5                                                                  | < 0.01                                                                              | < 0.01                                                                              | < 0.01                                                                              | < 0.01                                                                              |
| S138  | < 20                                                                       | < 20                                                                       | < 20                                                                       | < 0.5                                                                  | < 0.5                                                                  | < 0.01                                                                              | < 0.01                                                                              | < 0.01                                                                              | < 0.01                                                                              |
| S139  | 1150                                                                       | 1200                                                                       | 1250                                                                       | 4.0                                                                    | 2.0                                                                    | 0.04                                                                                | 0.04                                                                                | 0.08                                                                                | 0.07                                                                                |
| S140  | < 20                                                                       | < 20                                                                       | 60                                                                         | < 0.5                                                                  | 0.5                                                                    | < 0.01                                                                              | < 0.01                                                                              | < 0.01                                                                              | < 0.01                                                                              |

# Table D.01 - Maximum Predicted Subsidence Parameters for the Swamps

| Swamp  | <i>Predicted<br/>Conventional<br/>Tensile Strain<br/>based on the<br/>Approved<br/>Layout after<br/>LW317<br/>(mm/m)</i> | <i>Predicted<br/>Conventional<br/>Tensile Strain<br/>based on the<br/>Modified<br/>Layout after<br/>LW318<br/>(mm/m)</i> | <i>Predicted<br/>Conventional<br/>Compressive<br/>Strain based<br/>on the<br/>Approved<br/>Layout after<br/>LW317<br/>(mm/m)</i> | <i>Predicted<br/>Conventional<br/>Compressive<br/>Strain based<br/>on the<br/>Modified<br/>Layout after<br/>LW318<br/>(mm/m)</i> | <i>Maximum<br/>Predicted<br/>Upsidence<br/>based on the<br/>Approved<br/>Layout after<br/>LW317 (mm)</i> | <i>Maximum<br/>Predicted<br/>Upsidence<br/>based on the<br/>Modified<br/>Layout after<br/>LW318 (mm)</i> | <i>Maximum<br/>Predicted<br/>Closure<br/>based on the<br/>Approved<br/>Layout after<br/>LW317 (mm)</i> | <i>Maximum<br/>Predicted<br/>Closure based<br/>on the<br/>Modified<br/>Layout after<br/>LW318 (mm)</i> |
|--------|--------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|
| Bee Ck | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | < 20                                                                                                     | < 20                                                                                                     | < 20                                                                                                   | < 20                                                                                                   |
| S14    | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | < 20                                                                                                     | < 20                                                                                                     | 20                                                                                                     | 20                                                                                                     |
| S74    | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | 1.00                                                                                                                             | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S75    | 1.00                                                                                                                     | < 0.5                                                                                                                    | 1.00                                                                                                                             | 1.00                                                                                                                             | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S76    | < 0.5                                                                                                                    | < 0.5                                                                                                                    | 1.00                                                                                                                             | < 0.5                                                                                                                            | 150                                                                                                      | 175                                                                                                      | 125                                                                                                    | 125                                                                                                    |
| S77    | 1.00                                                                                                                     | 0.50                                                                                                                     | 1.00                                                                                                                             | 0.50                                                                                                                             | 325                                                                                                      | 325                                                                                                      | 325                                                                                                    | 325                                                                                                    |
| S91    | < 0.5                                                                                                                    | < 0.5                                                                                                                    | 1.00                                                                                                                             | < 0.5                                                                                                                            | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S92    | 1.00                                                                                                                     | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | 175                                                                                                      | 175                                                                                                      | 80                                                                                                     | 80                                                                                                     |
| S93    | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | < 20                                                                                                     | < 20                                                                                                     | < 20                                                                                                   | < 20                                                                                                   |
| S99    | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S101   | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S102   | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S103   | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S104   | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S105   | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S106   | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | < 20                                                                                                     | 50                                                                                                       | < 20                                                                                                   | 20                                                                                                     |
| S107   | 1.00                                                                                                                     | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S108   | 1.00                                                                                                                     | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S109   | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S110   | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S111a  | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S111b  | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S112   | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |



# Table D.01 - Maximum Predicted Subsidence Parameters for the Swamps

| Swamp | <i>Predicted<br/>Conventional<br/>Tensile Strain<br/>based on the<br/>Approved<br/>Layout after<br/>LW317<br/>(mm/m)</i> | <i>Predicted<br/>Conventional<br/>Tensile Strain<br/>based on the<br/>Modified<br/>Layout after<br/>LW318<br/>(mm/m)</i> | <i>Predicted<br/>Conventional<br/>Compressive<br/>Strain based<br/>on the<br/>Approved<br/>Layout after<br/>LW317<br/>(mm/m)</i> | <i>Predicted<br/>Conventional<br/>Compressive<br/>Strain based<br/>on the<br/>Modified<br/>Layout after<br/>LW318<br/>(mm/m)</i> | <i>Maximum<br/>Predicted<br/>Upsidence<br/>based on the<br/>Approved<br/>Layout after<br/>LW317 (mm)</i> | <i>Maximum<br/>Predicted<br/>Upsidence<br/>based on the<br/>Modified<br/>Layout after<br/>LW318 (mm)</i> | <i>Maximum<br/>Predicted<br/>Closure<br/>based on the<br/>Approved<br/>Layout after<br/>LW317 (mm)</i> | <i>Maximum<br/>Predicted<br/>Closure based<br/>on the<br/>Modified<br/>Layout after<br/>LW318 (mm)</i> |
|-------|--------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|
| S113  | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S114  | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S115  | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S116  | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S117  | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S118  | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S119  | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S120  | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S121  | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S122  | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S123  | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S124  | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S125a | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S125b | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S126a | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S126b | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S126c | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S127  | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S128  | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | 1.00                                                                                                                             | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S129  | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S130  | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | 1.00                                                                                                                             | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S131  | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S132  | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S135  | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S136  | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S138  | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S139  | 1.00                                                                                                                     | 0.50                                                                                                                     | 1.50                                                                                                                             | 1.00                                                                                                                             | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |
| S140  | < 0.5                                                                                                                    | < 0.5                                                                                                                    | < 0.5                                                                                                                            | < 0.5                                                                                                                            | -                                                                                                        | -                                                                                                        | -                                                                                                      | -                                                                                                      |

Note: Predicted conventional strains are based on 15 times curvature

## Table D.02 - Maximum Predicted Subsidence Parameters for the Aboriginal Heritage Sites

| Site  | Description                         | Maximum Predicted<br>Total Subsidence<br>based on the<br>Approved Layout<br>after LW317 (mm) | Maximum Predicted<br>Total Subsidence<br>based on the Modified<br>Layout after LW317<br>(mm) | Maximum Predicted<br>Total Subsidence<br>based on the Modified<br>Layout after LW318<br>(mm) | Maximum Predicted<br>Total Tilt based on the<br>Approved Layout<br>after LW317 (mm/m) | Maximum Predicted<br>Total Tilt based on the<br>Modified Layout after<br>LW318 (mm/m) |
|-------|-------------------------------------|----------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| MET9  | Grinding Groove(s)                  | < 20                                                                                         | 30                                                                                           | 325                                                                                          | < 0.5                                                                                 | 3.0                                                                                   |
| MET10 | Shelter                             | < 20                                                                                         | 20                                                                                           | 275                                                                                          | < 0.5                                                                                 | 2.5                                                                                   |
| MET11 | Grinding Groove(s)                  | < 20                                                                                         | < 20                                                                                         | < 20                                                                                         | < 0.5                                                                                 | < 0.5                                                                                 |
| NT 3  | Shelter with Art and PAD            | 80                                                                                           | 80                                                                                           | 80                                                                                           | 0.5                                                                                   | 0.5                                                                                   |
| NT 4  | Shelter with Art and PAD            | 275                                                                                          | 475                                                                                          | 500                                                                                          | 3.0                                                                                   | 4.0                                                                                   |
| NT 5  | Shelter with Art                    | 125                                                                                          | 200                                                                                          | 225                                                                                          | 1.5                                                                                   | 2.5                                                                                   |
| NT 6  | Shelter with Art                    | 1000                                                                                         | 1000                                                                                         | 1050                                                                                         | < 0.5                                                                                 | 1.0                                                                                   |
| NT 7  | Grinding Groove(s)                  | 1100                                                                                         | 1150                                                                                         | 1150                                                                                         | 1.0                                                                                   | 0.5                                                                                   |
| NT 8  | Grinding Groove(s), Rock Engraving  | 750                                                                                          | 750                                                                                          | 775                                                                                          | 5.5                                                                                   | 5.5                                                                                   |
| NT 9  | Shelter with PAD                    | 475                                                                                          | 475                                                                                          | 500                                                                                          | 5.5                                                                                   | 5.5                                                                                   |
| NT 10 | Shelter with Art and PAD            | < 20                                                                                         | 90                                                                                           | 575                                                                                          | < 0.5                                                                                 | 3.0                                                                                   |
| NT 12 | Grinding Groove(s)                  | < 20                                                                                         | 80                                                                                           | 575                                                                                          | < 0.5                                                                                 | 3.0                                                                                   |
| NT 13 | Shelter with Art                    | < 20                                                                                         | 150                                                                                          | 650                                                                                          | < 0.5                                                                                 | 2.0                                                                                   |
| NT 17 | Grinding Groove(s), Water Hole/Well | 175                                                                                          | 550                                                                                          | 650                                                                                          | 2.0                                                                                   | 2.5                                                                                   |
| NT 18 | Shelter with Art                    | < 20                                                                                         | < 20                                                                                         | < 20                                                                                         | < 0.5                                                                                 | < 0.5                                                                                 |
| NT 21 | Grinding Groove(s)                  | 20                                                                                           | 40                                                                                           | 40                                                                                           | < 0.5                                                                                 | < 0.5                                                                                 |
| NT 22 | Shelter with PAD                    | < 20                                                                                         | < 20                                                                                         | < 20                                                                                         | < 0.5                                                                                 | < 0.5                                                                                 |
| NT 23 | Shelter with Art and PAD            | < 20                                                                                         | < 20                                                                                         | < 20                                                                                         | < 0.5                                                                                 | < 0.5                                                                                 |
| NT 25 | Shelter with Art                    | < 20                                                                                         | < 20                                                                                         | < 20                                                                                         | < 0.5                                                                                 | < 0.5                                                                                 |
| NT 30 | Grinding Groove(s)                  | 80                                                                                           | 225                                                                                          | 250                                                                                          | 1.5                                                                                   | 3.0                                                                                   |
| NT 46 | Grinding Groove(s)                  | 1150                                                                                         | 1200                                                                                         | 1250                                                                                         | 1.0                                                                                   | < 0.5                                                                                 |
| NT 51 | Grinding Groove(s)                  | < 20                                                                                         | < 20                                                                                         | < 20                                                                                         | < 0.5                                                                                 | < 0.5                                                                                 |
| NT 52 | Grinding Groove(s), Water Hole/Well | < 20                                                                                         | < 20                                                                                         | < 20                                                                                         | < 0.5                                                                                 | < 0.5                                                                                 |
| NT 53 | Grinding Groove(s)                  | < 20                                                                                         | < 20                                                                                         | 30                                                                                           | < 0.5                                                                                 | < 0.5                                                                                 |
| NT 54 | Shelter with Art and PAD            | < 20                                                                                         | < 20                                                                                         | 80                                                                                           | < 0.5                                                                                 | 1.0                                                                                   |
| NT 80 | Shelter with Art                    | 80                                                                                           | 80                                                                                           | 80                                                                                           | 1.0                                                                                   | 1.0                                                                                   |
| NT 87 | Shelter with Artefact(s)            | < 20                                                                                         | < 20                                                                                         | 20                                                                                           | < 0.5                                                                                 | < 0.5                                                                                 |
| NT49  | Grinding Groove(s)                  | < 20                                                                                         | < 20                                                                                         | < 20                                                                                         | < 0.5                                                                                 | < 0.5                                                                                 |
| NT50  | Grinding Groove(s)                  | < 20                                                                                         | < 20                                                                                         | < 20                                                                                         | < 0.5                                                                                 | < 0.5                                                                                 |

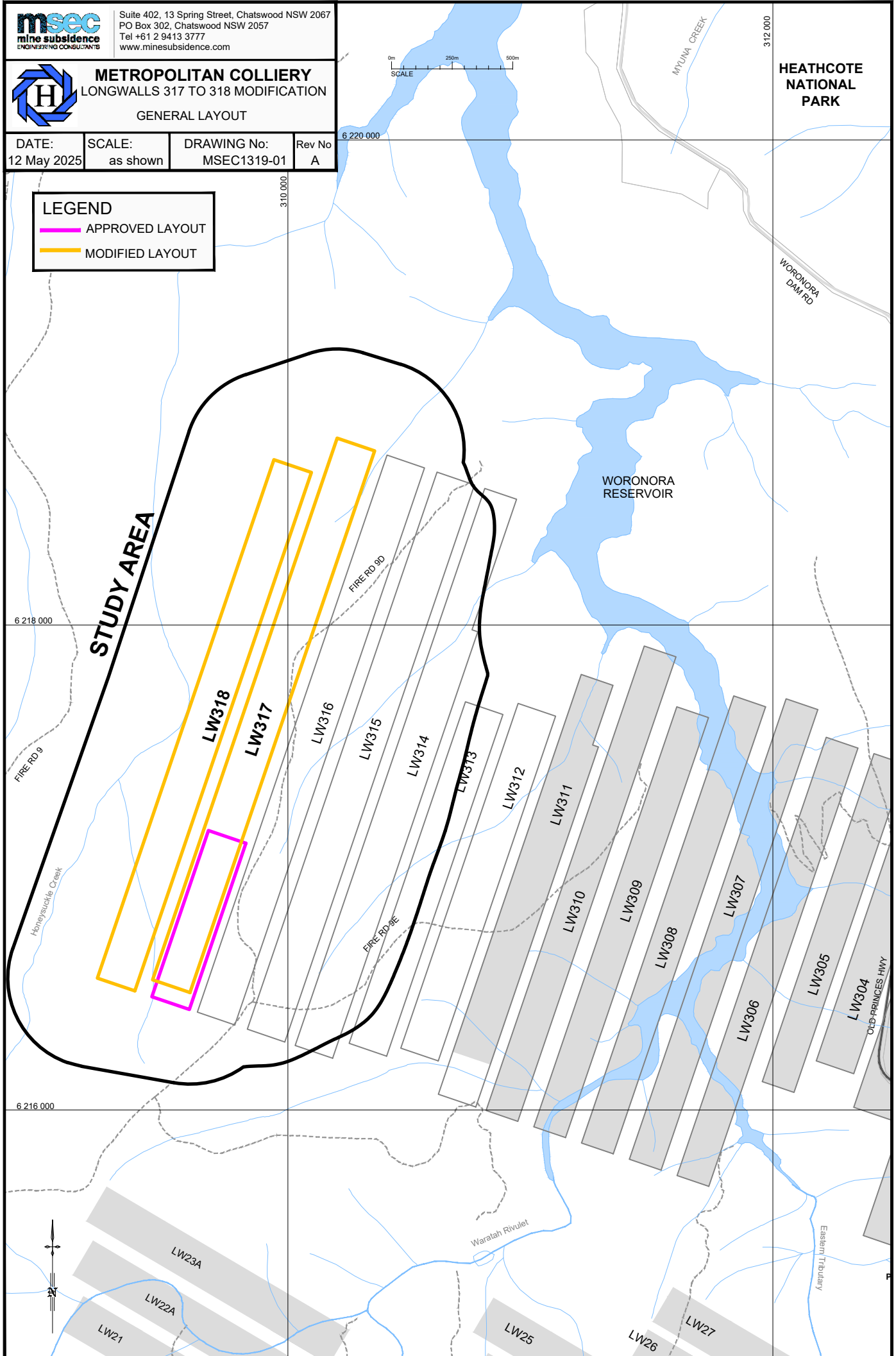
## Table D.02 - Maximum Predicted Subsidence Parameters for the Aboriginal Heritage Sites

| Site  | <i>Maximum Predicted Total Hogging Curvature based on the Approved Layout after LW317 (1/km)</i> | <i>Maximum Predicted Total Hogging Curvature based on the Modified Layout after LW318 (1/km)</i> | <i>Maximum Predicted Total Sagging Curvature based on the Approved Layout after LW317 (1/km)</i> | <i>Maximum Predicted Total Sagging Curvature based on the Modified Layout after LW318 (1/km)</i> | <i>Maximum Predicted Total Tensile Strain based on the Approved Layout after LW317 (mm/m)</i> | <i>Predicted Total Conventional Tensile Strain based on the Modified Layout after LW318 (mm/m)</i> | <i>Maximum Predicted Total Compressive Strain based on the Approved Layout after LW317 (mm/m)</i> |
|-------|--------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|
| MET9  | < 0.01                                                                                           | 0.02                                                                                             | < 0.01                                                                                           | < 0.01                                                                                           | < 0.5                                                                                         | < 0.5                                                                                              | < 0.5                                                                                             |
| MET10 | < 0.01                                                                                           | 0.02                                                                                             | < 0.01                                                                                           | < 0.01                                                                                           | < 0.5                                                                                         | < 0.5                                                                                              | < 0.5                                                                                             |
| MET11 | < 0.01                                                                                           | < 0.01                                                                                           | < 0.01                                                                                           | < 0.01                                                                                           | < 0.5                                                                                         | < 0.5                                                                                              | < 0.5                                                                                             |
| NT 3  | < 0.01                                                                                           | < 0.01                                                                                           | < 0.01                                                                                           | < 0.01                                                                                           | < 0.5                                                                                         | < 0.5                                                                                              | < 0.5                                                                                             |
| NT 4  | 0.02                                                                                             | 0.01                                                                                             | < 0.01                                                                                           | 0.02                                                                                             | < 0.5                                                                                         | < 0.5                                                                                              | < 0.5                                                                                             |
| NT 5  | 0.02                                                                                             | 0.03                                                                                             | < 0.01                                                                                           | 0.01                                                                                             | < 0.5                                                                                         | < 0.5                                                                                              | < 0.5                                                                                             |
| NT 6  | 0.02                                                                                             | 0.02                                                                                             | 0.03                                                                                             | 0.03                                                                                             | < 0.5                                                                                         | < 0.5                                                                                              | < 0.5                                                                                             |
| NT 7  | 0.03                                                                                             | 0.03                                                                                             | 0.04                                                                                             | 0.03                                                                                             | < 0.5                                                                                         | < 0.5                                                                                              | 1.0                                                                                               |
| NT 8  | 0.04                                                                                             | 0.04                                                                                             | 0.03                                                                                             | 0.03                                                                                             | 1.0                                                                                           | 1.0                                                                                                | 1.0                                                                                               |
| NT 9  | 0.07                                                                                             | 0.07                                                                                             | < 0.01                                                                                           | < 0.01                                                                                           | 1.5                                                                                           | 1.5                                                                                                | < 0.5                                                                                             |
| NT 10 | < 0.01                                                                                           | 0.01                                                                                             | < 0.01                                                                                           | 0.02                                                                                             | < 0.5                                                                                         | < 0.5                                                                                              | < 0.5                                                                                             |
| NT 12 | < 0.01                                                                                           | 0.01                                                                                             | < 0.01                                                                                           | 0.02                                                                                             | < 0.5                                                                                         | < 0.5                                                                                              | < 0.5                                                                                             |
| NT 13 | < 0.01                                                                                           | 0.01                                                                                             | < 0.01                                                                                           | 0.01                                                                                             | < 0.5                                                                                         | < 0.5                                                                                              | < 0.5                                                                                             |
| NT 17 | 0.03                                                                                             | 0.02                                                                                             | < 0.01                                                                                           | 0.02                                                                                             | < 0.5                                                                                         | < 0.5                                                                                              | < 0.5                                                                                             |
| NT 18 | < 0.01                                                                                           | < 0.01                                                                                           | < 0.01                                                                                           | < 0.01                                                                                           | < 0.5                                                                                         | < 0.5                                                                                              | < 0.5                                                                                             |
| NT 21 | < 0.01                                                                                           | < 0.01                                                                                           | < 0.01                                                                                           | < 0.01                                                                                           | < 0.5                                                                                         | < 0.5                                                                                              | < 0.5                                                                                             |
| NT 22 | < 0.01                                                                                           | < 0.01                                                                                           | < 0.01                                                                                           | < 0.01                                                                                           | < 0.5                                                                                         | < 0.5                                                                                              | < 0.5                                                                                             |
| NT 23 | < 0.01                                                                                           | < 0.01                                                                                           | < 0.01                                                                                           | < 0.01                                                                                           | < 0.5                                                                                         | < 0.5                                                                                              | < 0.5                                                                                             |
| NT 25 | < 0.01                                                                                           | < 0.01                                                                                           | < 0.01                                                                                           | < 0.01                                                                                           | < 0.5                                                                                         | < 0.5                                                                                              | < 0.5                                                                                             |
| NT 30 | 0.01                                                                                             | 0.03                                                                                             | < 0.01                                                                                           | < 0.01                                                                                           | < 0.5                                                                                         | < 0.5                                                                                              | < 0.5                                                                                             |
| NT 46 | 0.02                                                                                             | 0.02                                                                                             | 0.02                                                                                             | 0.02                                                                                             | < 0.5                                                                                         | < 0.5                                                                                              | < 0.5                                                                                             |
| NT 51 | < 0.01                                                                                           | < 0.01                                                                                           | < 0.01                                                                                           | < 0.01                                                                                           | < 0.5                                                                                         | < 0.5                                                                                              | < 0.5                                                                                             |
| NT 52 | < 0.01                                                                                           | < 0.01                                                                                           | < 0.01                                                                                           | < 0.01                                                                                           | < 0.5                                                                                         | < 0.5                                                                                              | < 0.5                                                                                             |
| NT 53 | < 0.01                                                                                           | < 0.01                                                                                           | < 0.01                                                                                           | < 0.01                                                                                           | < 0.5                                                                                         | < 0.5                                                                                              | < 0.5                                                                                             |
| NT 54 | < 0.01                                                                                           | 0.01                                                                                             | < 0.01                                                                                           | < 0.01                                                                                           | < 0.5                                                                                         | < 0.5                                                                                              | < 0.5                                                                                             |
| NT 80 | 0.02                                                                                             | 0.02                                                                                             | < 0.01                                                                                           | < 0.01                                                                                           | < 0.5                                                                                         | < 0.5                                                                                              | < 0.5                                                                                             |
| NT 87 | < 0.01                                                                                           | < 0.01                                                                                           | < 0.01                                                                                           | < 0.01                                                                                           | < 0.5                                                                                         | < 0.5                                                                                              | < 0.5                                                                                             |
| NT49  | < 0.01                                                                                           | < 0.01                                                                                           | < 0.01                                                                                           | < 0.01                                                                                           | < 0.5                                                                                         | < 0.5                                                                                              | < 0.5                                                                                             |
| NT50  | < 0.01                                                                                           | < 0.01                                                                                           | < 0.01                                                                                           | < 0.01                                                                                           | < 0.5                                                                                         | < 0.5                                                                                              | < 0.5                                                                                             |
|       |                                                                                                  |                                                                                                  |                                                                                                  |                                                                                                  |                                                                                               |                                                                                                    |                                                                                                   |

**Table D.02 - Maximum Predicted Subsidence Parameters for the  
Aboriginal Heritage Sites**

| Site  | Predicted Total<br>Conventional Comp.<br>Strain based on the<br>Modified Layout after<br>LW318 (mm/m) |
|-------|-------------------------------------------------------------------------------------------------------|
| MET9  | < 0.5                                                                                                 |
| MET10 | < 0.5                                                                                                 |
| MET11 | < 0.5                                                                                                 |
| NT 3  | < 0.5                                                                                                 |
| NT 4  | < 0.5                                                                                                 |
| NT 5  | < 0.5                                                                                                 |
| NT 6  | < 0.5                                                                                                 |
| NT 7  | 1.0                                                                                                   |
| NT 8  | 1.0                                                                                                   |
| NT 9  | < 0.5                                                                                                 |
| NT 10 | < 0.5                                                                                                 |
| NT 12 | < 0.5                                                                                                 |
| NT 13 | < 0.5                                                                                                 |
| NT 17 | < 0.5                                                                                                 |
| NT 18 | < 0.5                                                                                                 |
| NT 21 | < 0.5                                                                                                 |
| NT 22 | < 0.5                                                                                                 |
| NT 23 | < 0.5                                                                                                 |
| NT 25 | < 0.5                                                                                                 |
| NT 30 | < 0.5                                                                                                 |
| NT 46 | < 0.5                                                                                                 |
| NT 51 | < 0.5                                                                                                 |
| NT 52 | < 0.5                                                                                                 |
| NT 53 | < 0.5                                                                                                 |
| NT 54 | < 0.5                                                                                                 |
| NT 80 | < 0.5                                                                                                 |
| NT 87 | < 0.5                                                                                                 |
| NT49  | < 0.5                                                                                                 |
| NT50  | < 0.5                                                                                                 |
|       |                                                                                                       |

## **APPENDIX E. DRAWINGS**







Suite 402, 13 Spring Street, Chatswood NSW 2067  
PO Box 302, Chatswood NSW 2057  
Tel +61 2 9413 3777  
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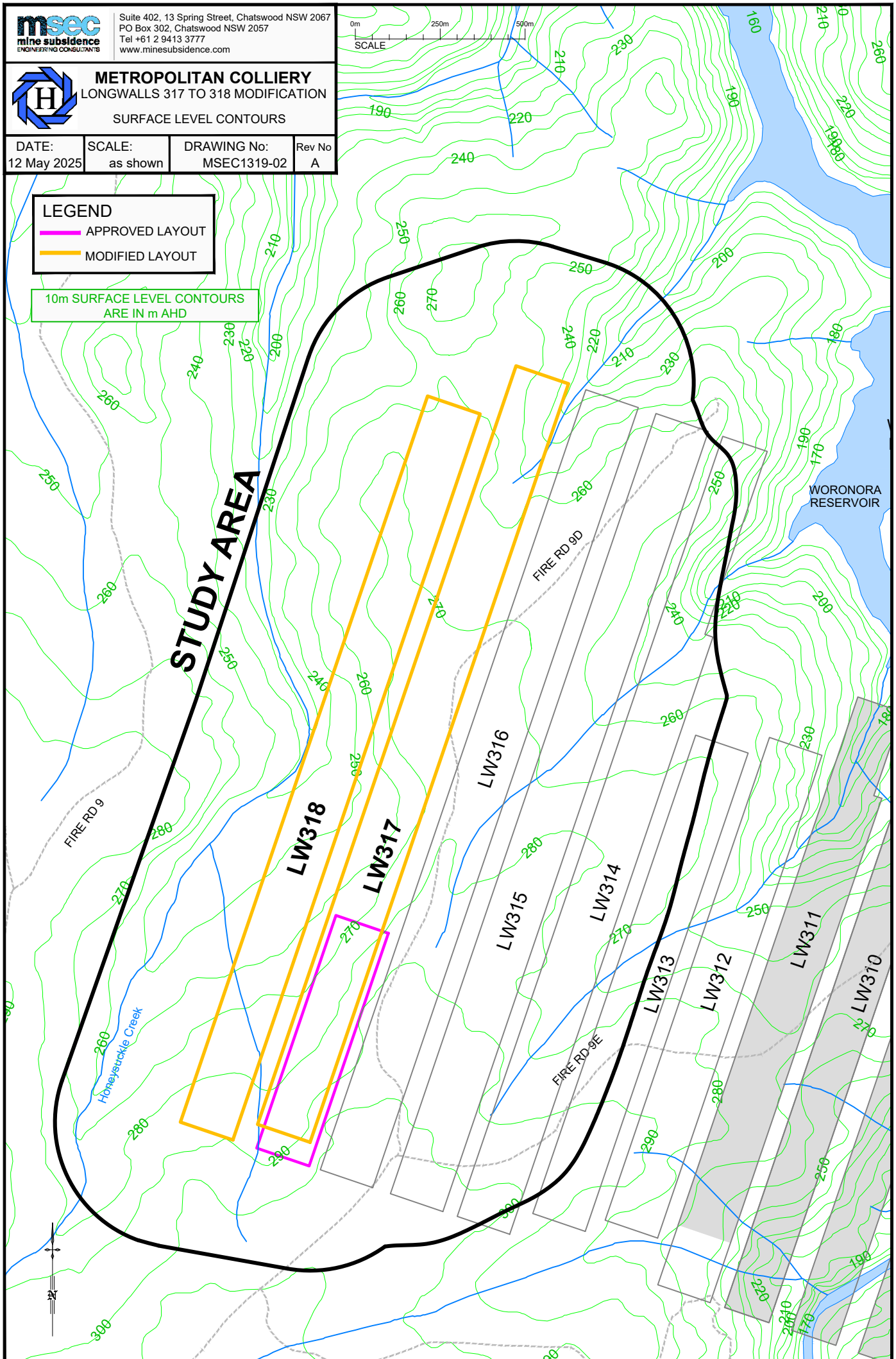
# METROPOLITAN COLLIERY LONGWALLS 317 TO 318 MODIFICATION SURFACE LEVEL CONTOURS

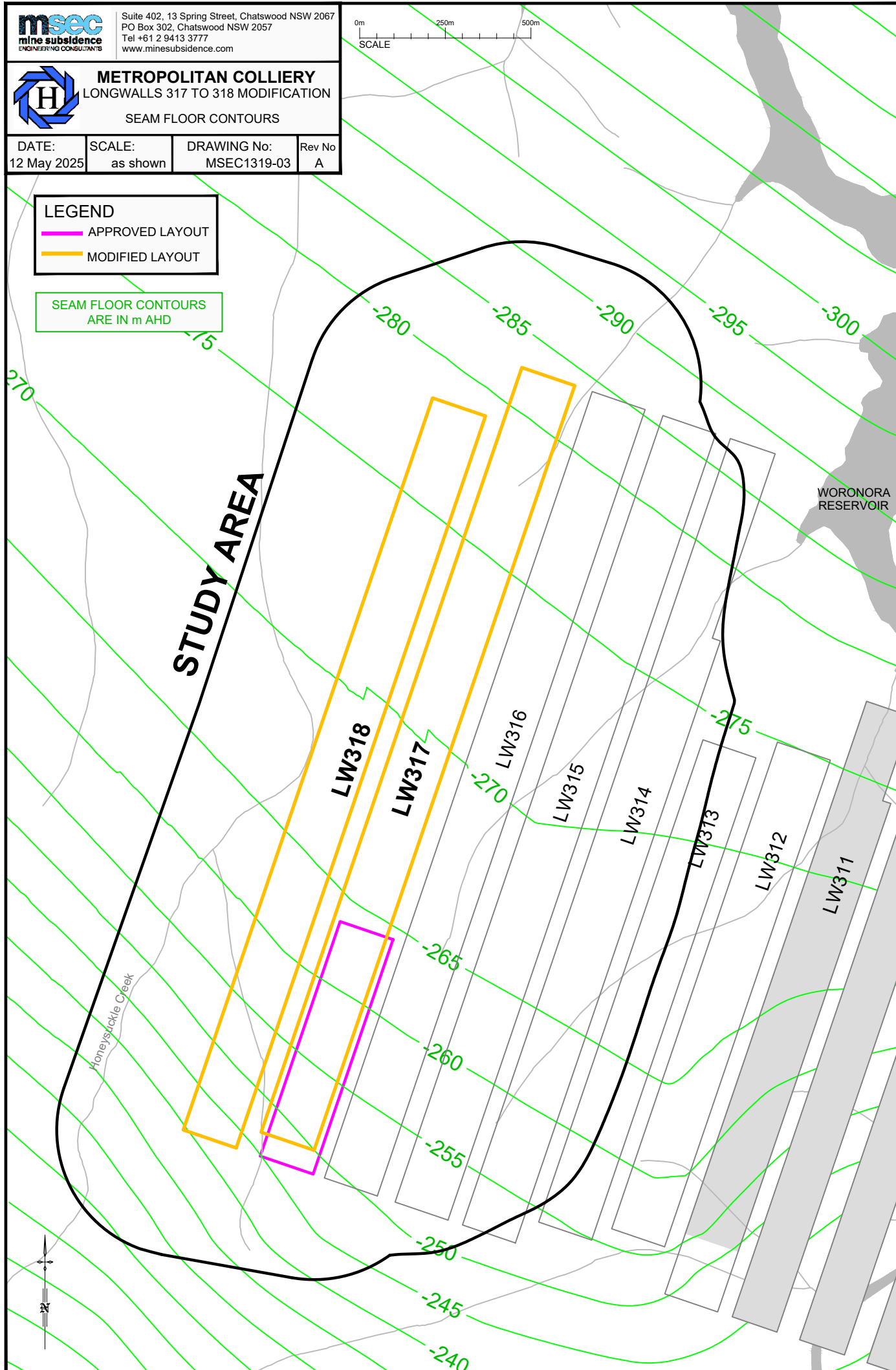
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| DATE:<br>12 May 2025 | SCALE:<br>as shown | DRAWING No:<br>MSEC1319-02 | Rev No<br>A |
|----------------------|--------------------|----------------------------|-------------|

## LEGEND

- APPROVED LAYOUT
- MODIFIED LAYOUT

10m SURFACE LEVEL CONTOURS  
ARE IN m AHD







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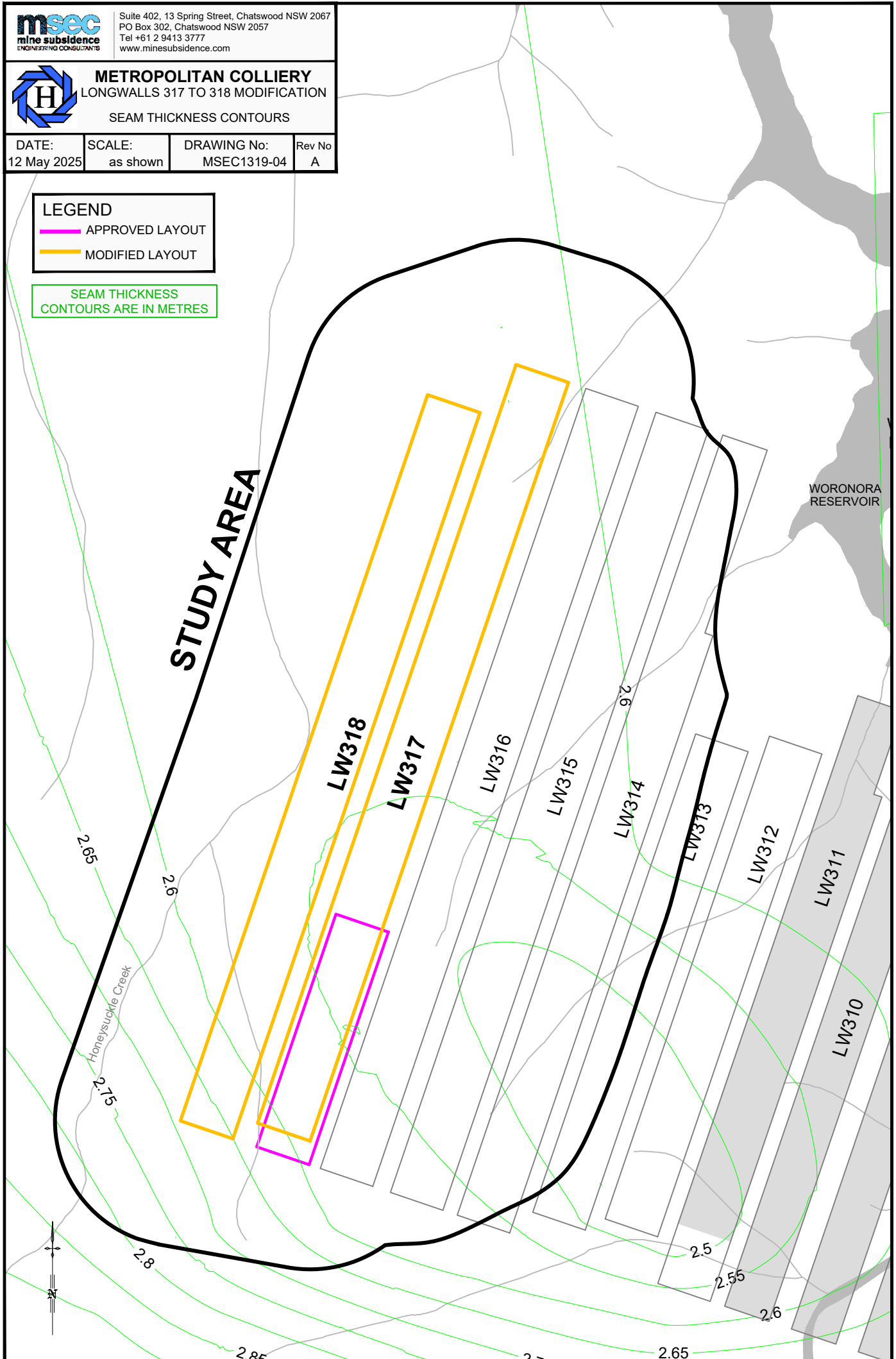
**METROPOLITAN COLLIERY**  
LONGWALLS 317 TO 318 MODIFICATION  
SEAM THICKNESS CONTOURS

|                      |                    |                            |             |
|----------------------|--------------------|----------------------------|-------------|
| DATE:<br>12 May 2025 | SCALE:<br>as shown | DRAWING No:<br>MSEC1319-04 | Rev No<br>A |
|----------------------|--------------------|----------------------------|-------------|

**LEGEND**

APPROVED LAYOUT  
 MODIFIED LAYOUT

SEAM THICKNESS  
CONTOURS ARE IN METRES







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# METROPOLITAN COLLIERY LONGWALLS 317 TO 318 MODIFICATION DEPTH OF COVER CONTOURS

|                      |                    |                            |             |
|----------------------|--------------------|----------------------------|-------------|
| DATE:<br>12 May 2025 | SCALE:<br>as shown | DRAWING No:<br>MSEC1319-05 | Rev No<br>A |
|----------------------|--------------------|----------------------------|-------------|

## LEGEND

- APPROVED LAYOUT
- MODIFIED LAYOUT

DEPTH OF COVER  
CONTOURS ARE IN METRES

**Cross section 1**

**STUDY AREA**

LW318

LW317

LW316

LW315

LW314

LW313

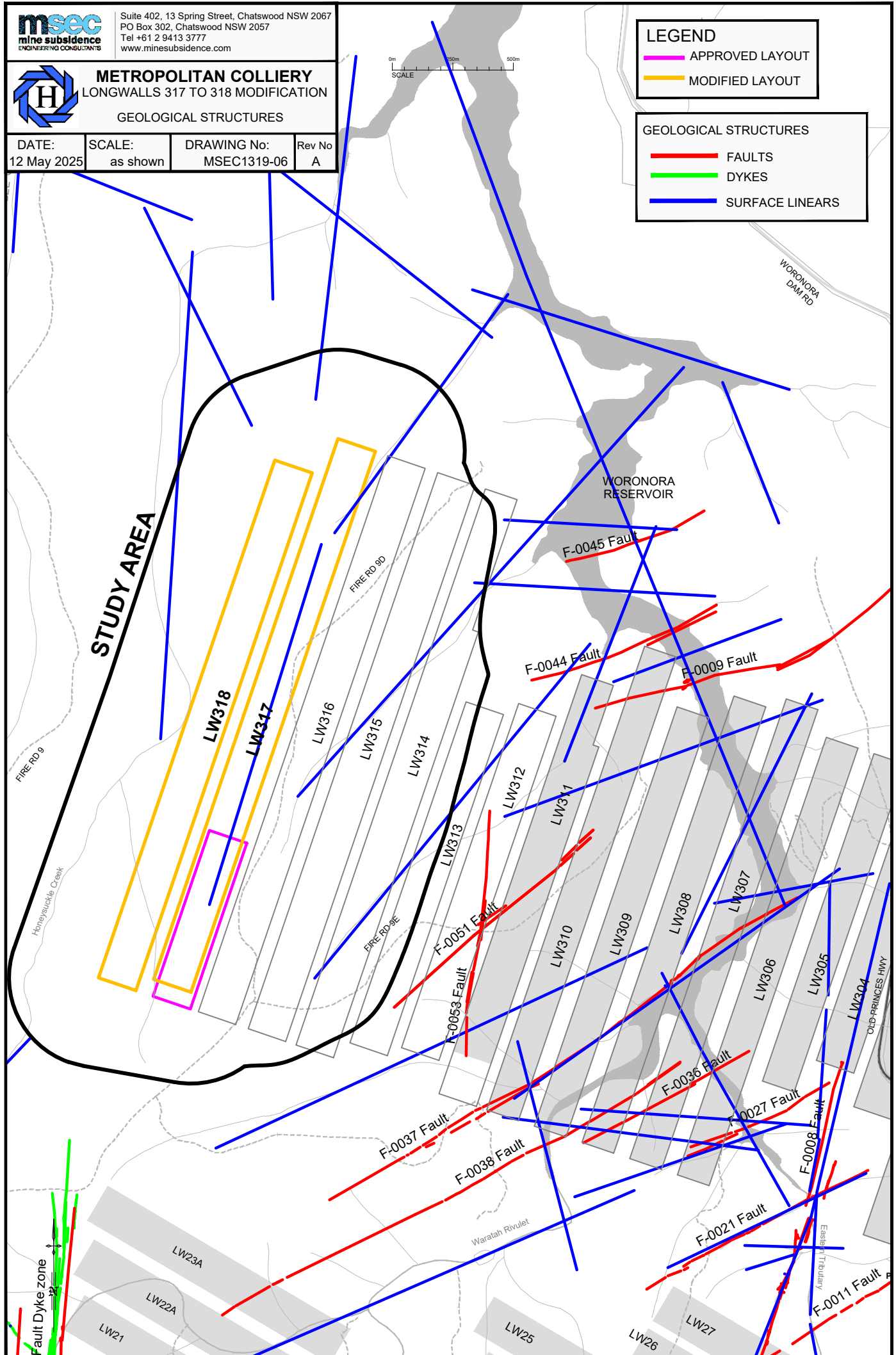
LW312

LW311

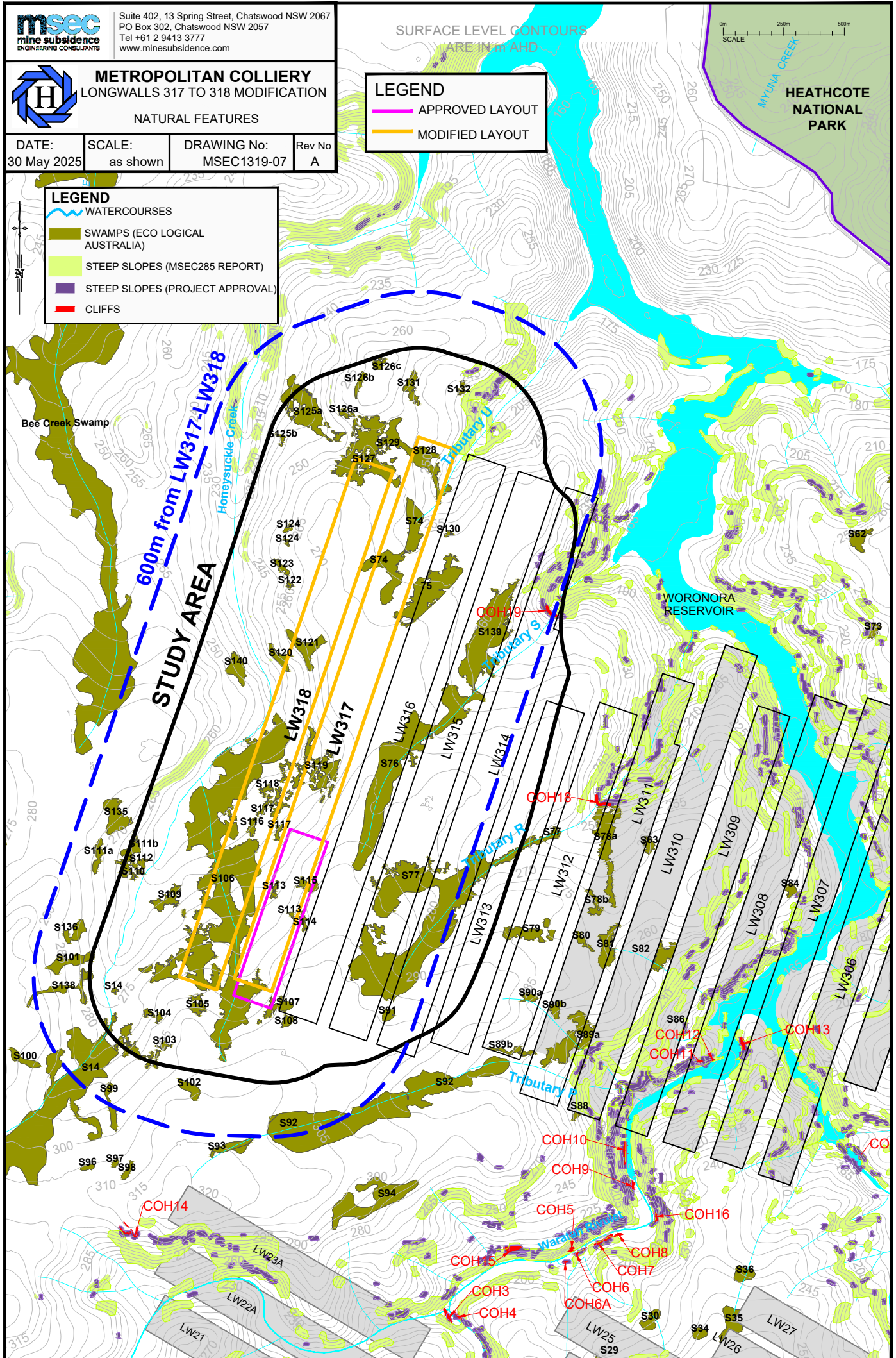
WORONORA  
RESERVOIR

Honeysuckle Creek

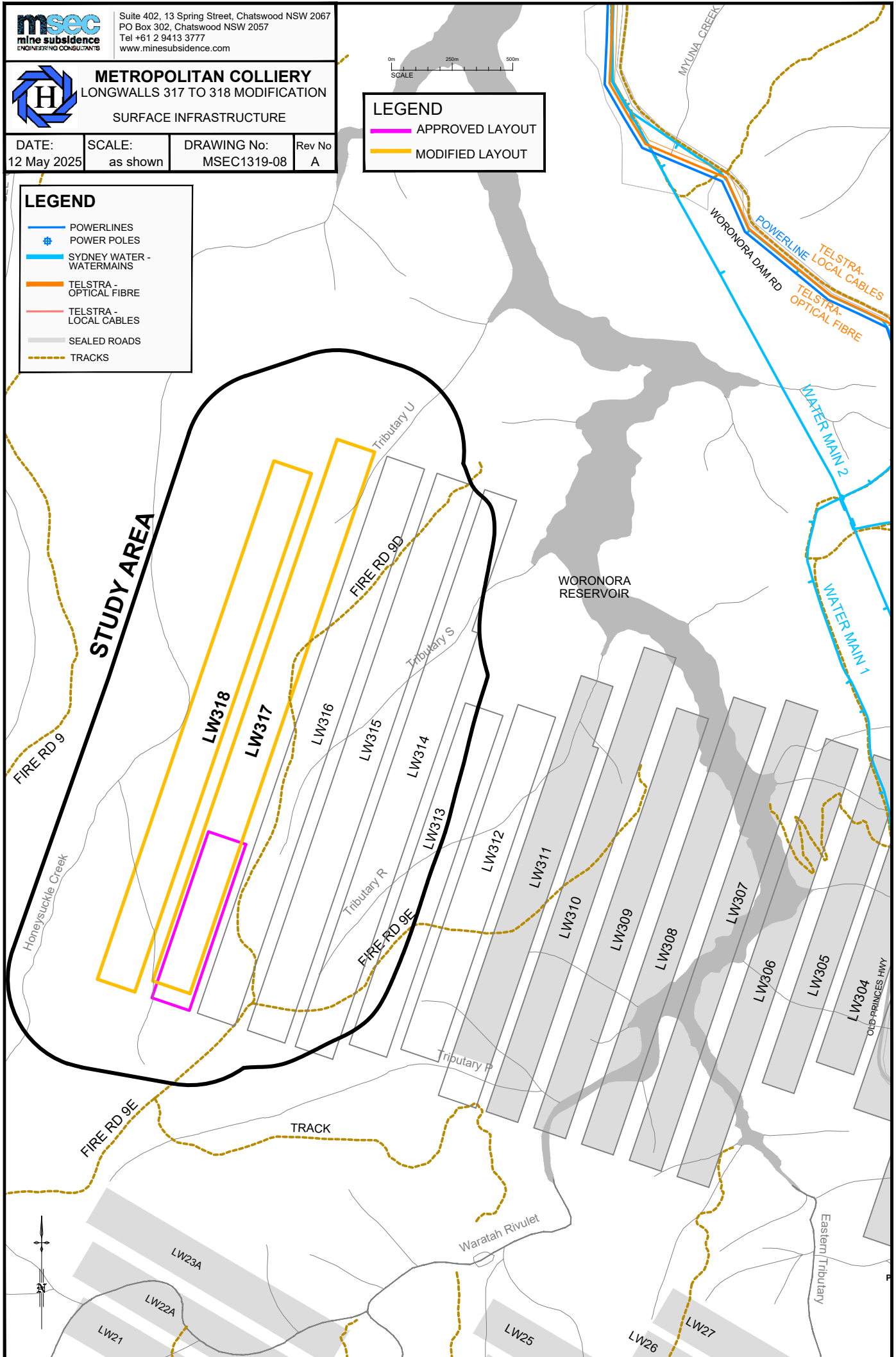
















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**METROPOLITAN COLLIERY**  
LONGWALLS 317 TO 318 MODIFICATION  
PREDICTED ADDITIONAL SUBSIDENCE  
CONTOURS DUE TO LW317 AND LW318

|                      |                    |                            |             |
|----------------------|--------------------|----------------------------|-------------|
| DATE:<br>12 May 2025 | SCALE:<br>as shown | DRAWING No:<br>MSEC1319-10 | Rev No<br>A |
|----------------------|--------------------|----------------------------|-------------|

0m 250m 500m  
SCALE

#### LEGEND

- APPROVED LAYOUT
- MODIFIED LAYOUT

PREDICTED SUBSIDENCE CONTOURS  
ARE IN MILLIMETRES (mm)

Prediction Line 1

Honeysuckle Creek

WORONORA  
RESERVOIR

LW318

LW317

LW316

LW315

LW314

LW313

LW312

LW311





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**METROPOLITAN COLLIERY**  
LONGWALLS 317 TO 318 MODIFICATION  
PREDICTED TOTAL SUBSIDENCE  
CONTOURS AFTER LW318

|                      |                    |                            |             |
|----------------------|--------------------|----------------------------|-------------|
| DATE:<br>12 May 2025 | SCALE:<br>as shown | DRAWING No:<br>MSEC1319-11 | Rev No<br>A |
|----------------------|--------------------|----------------------------|-------------|

**LEGEND**

- APPROVED LAYOUT
- MODIFIED LAYOUT

PREDICTED SUBSIDENCE CONTOURS  
ARE IN MILLIMETRES (mm)

0m 250m 500m  
SCALE

Prediction Line 1

