
Appendix B

Clarence Colliery – 918 Panel Subsidence Predictions and Impact Assessment Report (MSEC 2026)

Centennial Coal:
Clarence Colliery – 918 Panel
Subsidence Predictions and Impact Assessment Report

DOCUMENT REGISTER

Revision	Description	Author	Checker	Date
01	Draft issue	DK	KK/JB	Aug 2025
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A	Final issue	DK		Nov 2025
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Report produced to: Inform the Clarence Colliery 918 Panel Extraction Plan Application to NSW Department of Planning, Housing and Infrastructure (DPHI) and the Clarence Colliery 918 Panel EPBC Referral (2024/09856) Preliminary Documentation to Department of Climate Change, Energy, the Environment and Water (DCCEEW-Commonwealth)

Centennial Coal Pty Limited (Centennial) operates Clarence Colliery (Clarence) which is located in the Western Coalfield of New South Wales (NSW). Centennial is preparing an Extraction Plan for the secondary (partial) extraction of 918 Panel (comprising sub-panels 918A, 918B1 and 918B2) in the Katoomba Seam (the Project). The 918 Panel is proposed to be extracted by the Panel and Pillar Partial Extraction (shortwall) mining technique.

Development consent DA-504-00 enables (via a DPHI extraction plan approval) Clarence Colliery to be able to undertake second workings (partial extraction) in 918 Panel provided that the proposed secondary extraction does not result in subsidence exceeding 100 mm, tilt exceeding 3 mm/m and horizontal strain exceeding 2 mm/m (compressive and tensile).

The predicted i.e. two-dimensional vertical subsidence profiles for the 918A, 918B1 and 918B2 sub-panels in the Katoomba Seam were determined by Strata Control Technologies (SCT, 2026) and provided to Mine Subsidence Engineering Consultants (MSEC). MSEC has been commissioned by Centennial to develop three-dimensional subsidence predictions for 918A, 918B1 and 918B2 sub-panels based on the two-dimensional analytical modelling carried out by SCT (2026) and to prepare a subsidence impact assessment report.

The maximum predicted total subsidence effects for the 918A, 918B1 and 918B2 sub-panels based on the three-dimensional subsidence model are:

- 76 mm \pm 20 mm vertical subsidence, as predicted by SCT (2026);
- 0.6 mm/m tilt (i.e. 0.06 % or 1 in 1667);
- 0.02 km⁻¹ hogging curvature (i.e. minimum radius of curvature of 50 km);
- 0.03 km⁻¹ sagging curvature (i.e. minimum radius of curvature of 33 km); and
- 0.3 mm/m tensile and 0.3 mm/m compressive strains.

The *Study Area* is defined as the surface area that is likely to be affected by the extraction of the 918A, 918B1 and 918B2 sub-panels. This area is defined by the greater of the 35° angle of draw and the predicted 20 mm subsidence contour. The surface features located outside this area that could experience far-field horizontal or valley-related movements and could be sensitive to these effects have also been included in the assessments provided in this report.

The natural and built features are shown in Drawing Nos. MSEC1493-08 to MSEC1493-10. The surface features located within the Study Area include:

- Bungleboori Creek and Paddy's Creek and several first order tributaries. The first order streams are ephemeral while the third order section of Bungleboori Creek flows perennially within the Lower Nine Mile Shrub Swamp;
- five cliffs, seven minor cliffs and three pagodas are located within or partly within the Study Area, but none of these are located directly above the proposed 918A, 918B1 and 918B2 sub-panels;
- steep slopes along the alignments of the tributaries directly above the sub-panels;
- Paddy's Creek Hanging Swamp which is located partly above the proposed 918B2 sub-panel;
- Gardens of Stone State Conservation Area is located within the Study Area;
- unsealed roads and tracks above Panel 918A; and
- one Aboriginal heritage site located directly above 918A sub-panel, comprising an isolated open artefact find (Site 45-1-2842) and one Aboriginal heritage site located 220 metres northwest of 918B1 sub-panel, comprising a rock shelter with art (Site 45-1-2950).

Blue Mountains National Park is located more than 5 km from the Study Area.

The natural and built features are predicted to experience low levels of vertical subsidence and horizontal movements. The corresponding curvatures and strains are expected to be in the order of survey tolerance, i.e. not measurable.

Adverse physical impacts to the natural and built features are not expected due to the extraction of the proposed sub-panels. Impacts have not been observed at similar surface features above the existing panels at Clarence, where the predicted vertical subsidence was up to approximately 100 mm i.e. higher than predicted for the proposed extraction of the 918 sub-panels.

Further assessments of natural and built features have been undertaken by the other specialist consultants on the Project, and the findings in this report should be read in conjunction with the findings in all other relevant reports.

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Drawings

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

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1.1. Background

Centennial Coal Pty Limited (Centennial) operates Clarence Colliery (Clarence) which is located in the Western Coalfield of New South Wales (NSW). Centennial is preparing an Extraction Plan for the secondary (partial) extraction of 918 Panel (comprising sub-panels 918A, 918B1 and 918B2) in the Katoomba Seam (the Project). The 918 Panel is proposed to be extracted by the Panel and Pillar Partial Extraction (shortwall) mining technique.

Note that *918 Panel* in this report refers collectively to the *918A, 918B1 and 918B2 sub-panels*.

The layout of sub-panels 918A, 918B1 and 918B2 is shown in Drawing Nos. MSEC1493-01 and MSEC1495-02 in Appendix D. The proposed sub-panels have also been overlaid on an orthophoto of the area in Fig. 1.1. The Study Area is defined in Section 2.1.

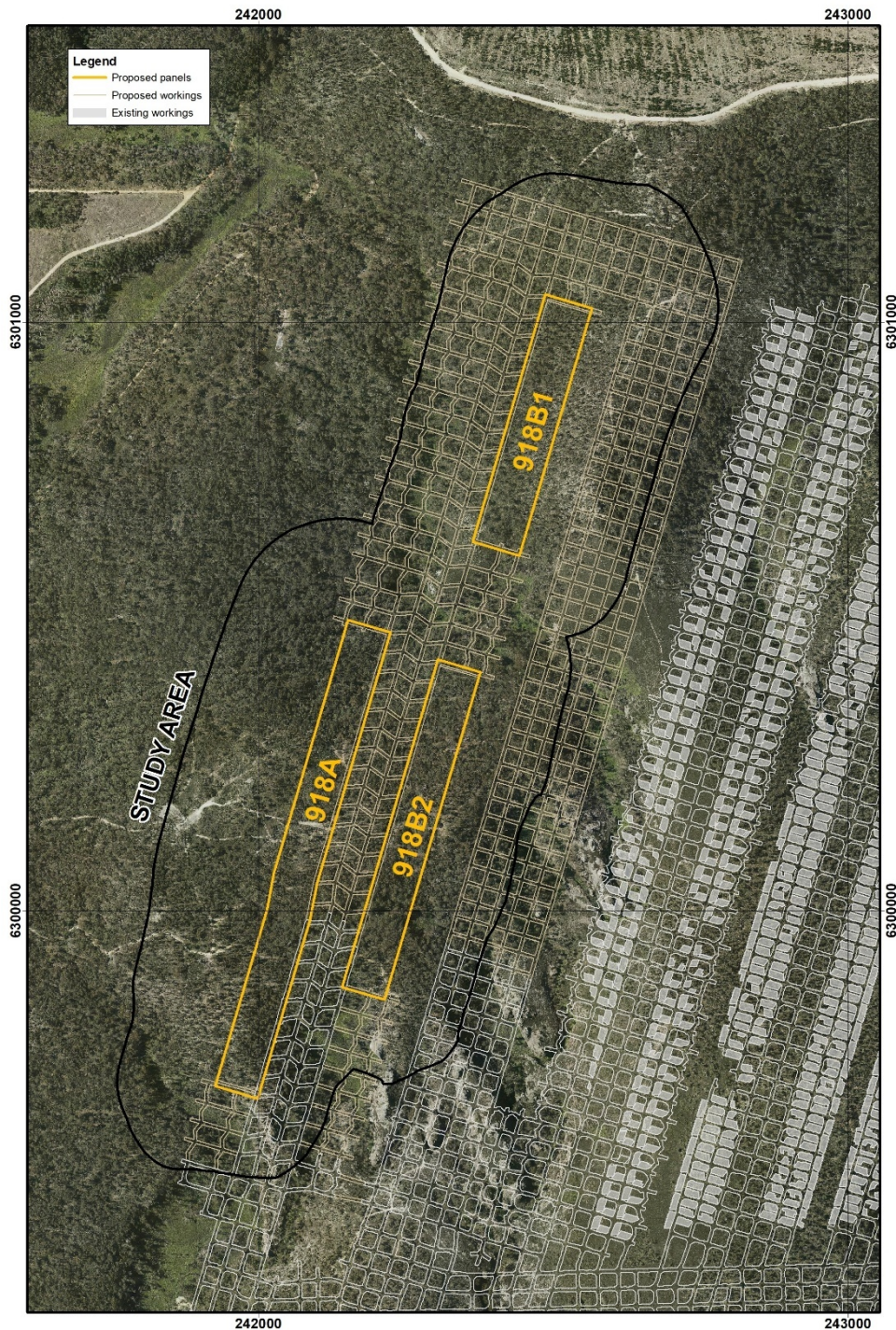


Fig. 1.1 Orthophotograph showing locations of sub-panels 918A, 918B1 and 918B2

Development consent DA-504-00 enables (via a DPHI extraction plan approval) Clarence Colliery to be able to undertake second workings (partial extraction) in 918 Panel provided that the proposed secondary extraction does not result in subsidence exceeding 100 mm, tilt exceeding 3 mm/m and horizontal strain exceeding 2 mm/m (compressive and tensile).

The predicted two-dimensional vertical subsidence profiles for 918A, 918B1 and 918B2 sub-panels in the Katoomba Seam were determined by Strata Control Technologies (SCT, 2026) using numerical modelling and provided to Mine Subsidence Engineering Consultants (MSEC).

Centennial has engaged MSEC to prepare three-dimensional predicted subsidence contours for 918A, 918B1 and 918B2 sub-panels based on the subsidence predictions provided by SCT (2026) and to assess the potential impacts on the surface features. The scope of work does not include the development of an independent subsidence prediction model.

The Incremental Profile Method (IPM) has been calibrated to be consistent with the provided two-dimensional subsidence predictions (SCT, 2026). The IPM has then been used to develop three-dimensional subsidence contours for sub-panels 918A, 918B1 and 918B2.

MSEC has been commissioned by Centennial to:

- Develop three-dimensional subsidence contours for sub-panels 918A, 918B1 and 918B2 based on the two-dimensional analytical modelling carried out by SCT (2026);
- identify the natural and built features located above and near to sub-panels 918A, 918B1 and 918B2;
- provide subsidence predictions for each of these natural and built features;
- prepare impact assessments, in conjunction with other specialist consultants, for each of these natural and built features; and
- provide recommendations for monitoring and management measures

This report will inform the Extraction Plan Application and EPBC Referral (2024/09856) Preliminary Documentation which will be submitted to NSW DPHI and Commonwealth DCCEEW respectively. In some cases, this report will refer to other sources of information on specific natural and built features, and these reports should be read in conjunction with this report.

Chapter 1 provides a general introduction to the study, which includes a description of the mining geometry and geological details of the area.

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

Chapter 3 includes overviews of mine subsidence effects and the methods that have been used to predict the mine subsidence effects for sub-panels 918A, 918B1 and 918B2.

Chapter 4 provides the maximum predicted subsidence effects due to the extraction of sub-panels 918A, 918B1 and 918B2.

Chapters 5 and 6 provide the predictions and impact assessments for each of the natural and built features that have been identified within the Study Area.

Chapter 7 recommends monitoring for the project.

1.2. Mining geometries

918 Panel is proposed to be extracted in the north of Clarence Colliery and to the west of the previously partially extracted Panels 906, 908 and 910 and the first workings 900 Panel. The proposed 918 Panel includes both first and second workings and comprises secondary shortwall extraction on either side of a central spine pillar.

To avoid directly mining directly beneath most of the swamps above the 918 Panel, the 918A sub-panel has been shortened at the southern and northern ends and the 918B sub-panel has been split into a 918B1 sub-panel and a 918B2 sub-panel. The sub-panels are planned to be extracted in the following order and direction:

- Panel 918A, commencing at the southern end and mining towards the north;
- Panel 918B1, commencing at the northern end and mining towards the south; and
- Panel 918B2, commencing at the northern end and mining towards the south.

A summary of the panel dimensions, as adopted in modelling by SCT (2026), is provided in Table 1.1.

Table 1.1 Summary of mining geometry for proposed 918 Panel (after SCT, 2026)

Sub-Panel	Sub-Panel void length (m)	Sub-Panel void width (m)	Spine pillar width (m)
918A	823	75	N/A
918B1	438	83	N/A
918B2	580	75	84-90

1.3. Surface and seam levels

The surface level contours are shown in Drawing No. MSEC1493-03.

The land above the 918 Panel is located in the upper catchment of Bungleboori Creek and tributaries. The land drains through swamps generally from the north towards the eastern and southern sides of the mining area. Surface levels within the Study Area vary from a high point of approximately 1144 metres above Australian Height Datum (mAHD) to the north of sub-panel 918B1 to a low point of approximately 1014 mAHD on Paddys Creek, to the south of sub-panel 918B2.

The seam floor contours for the Katoomba Seam are shown in Drawing No. MSEC1493-04. The seam floor within the Study Area dips gently and relatively evenly towards the north-east.

The seam thickness contours for the Katoomba Seam are shown in Drawing No. MSEC1493-05. The seam thickness within the Study Area varies between 1.5 m near the northern end of sub-panel 918A and 3.0 m near the northern end of sub-panel 918B1. The seam thickness for the 918 panels varies between 1.9 m and 2.3 m.

The depth of cover contours for the Katoomba Seam are shown in Drawing No. MSEC1493-06. The depths of cover within the Study Area vary between a minimum of 174 m near the southern end of sub-panel 918B2 and a maximum of 329 m near the northern end of sub-panel 918B1. The depths of cover directly above the 918 panels vary between 227 m and 294 m.

The surface levels and the levels of the Katoomba Seam are illustrated along prediction lines across the sub-panels in Fig. 1.2 and Fig. 1.3. The locations of these sections are shown in Drawings Nos. MSEC1493-11, MSEC1493-12 and MSEC1493-13. The Study Area is defined in Section 2.1 and represents an angle of draw of 35° around the limits of second workings and the predicted 20 mm subsidence contour, which is greater.

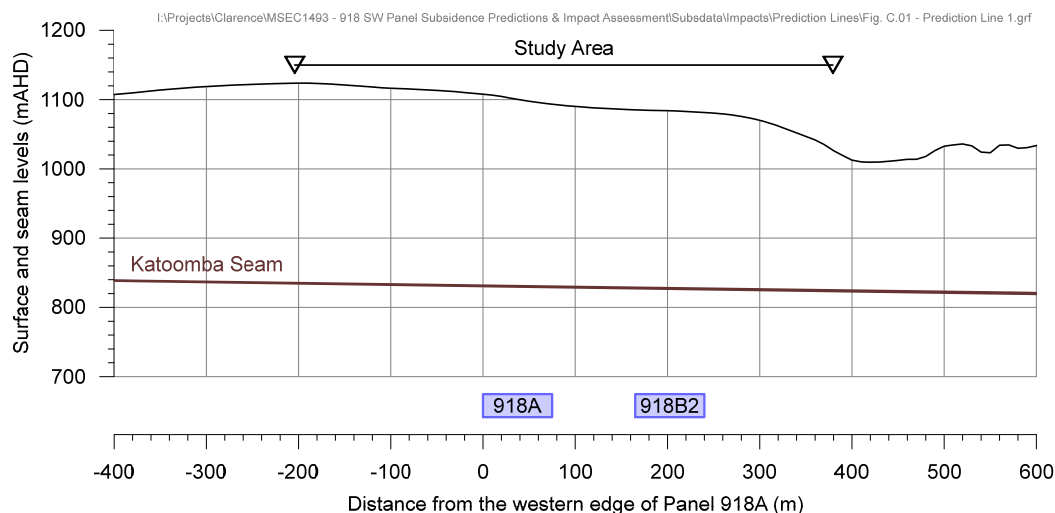


Fig. 1.2 Surface and seam levels transverse to Sub-Panels 918A and 918B2

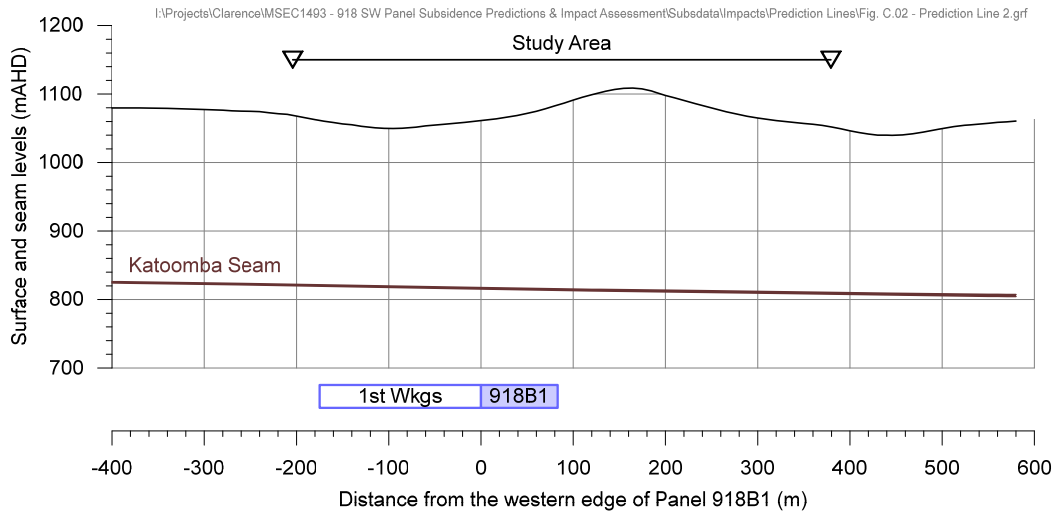


Fig. 1.3 Surface and seam levels transverse to Sub-Panel 918B1

1.4. Geological details

Clarence is located in the Western Coalfield of the Sydney Basin. The general stratigraphy of the Western Coalfield is shown in Table 1.2. An illustrative representation of the stratigraphy has been provided by SCT (2026), which is reproduced in Fig. 1.4.

Table 1.2 General stratigraphy of the Western Coalfield

Period	Group	Subgroup	Member
		Burralow Formation	
Triassic	Narrabeen Group	Grose	Banks Wall Sandstone
			Mount York Claystone
			Burra-Moko
			Head Sandstone
		Caley Formation	
Permian	Illawarra Coal Measures	Wallerawang	Katoomba Seam Middle River Seam
		Charbon	
		Cullen Bullen	Lithgow/Lidsdale Seam
		Nile	

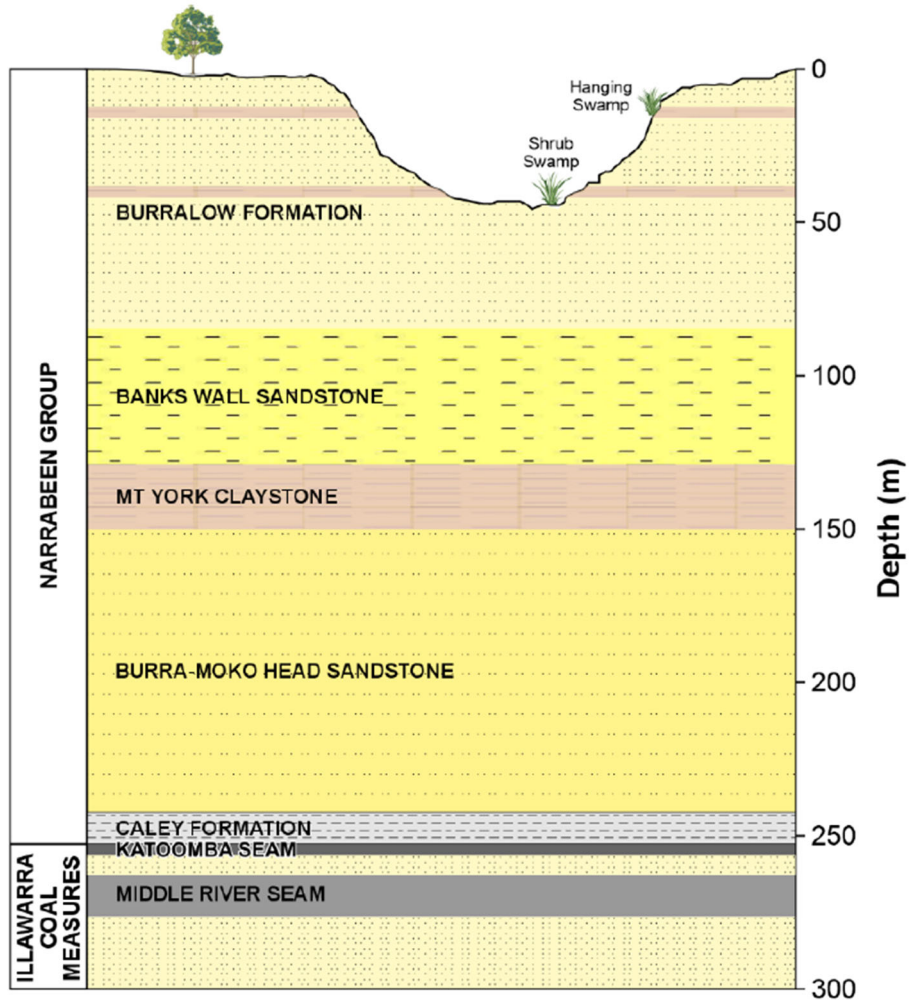


Fig. 1.4 Stratigraphy at Clarence Colliery (SCT, 2026)

The surface lithology in the area is shown in Fig. 1.5 which shows the 918A, 918B1 and 918B2 sub-panels overlaid on the *Geological Series Sheet 8931*, published by the Department of Mineral Resources (DMR, 1992), now known as the NSW Resources Regulator.

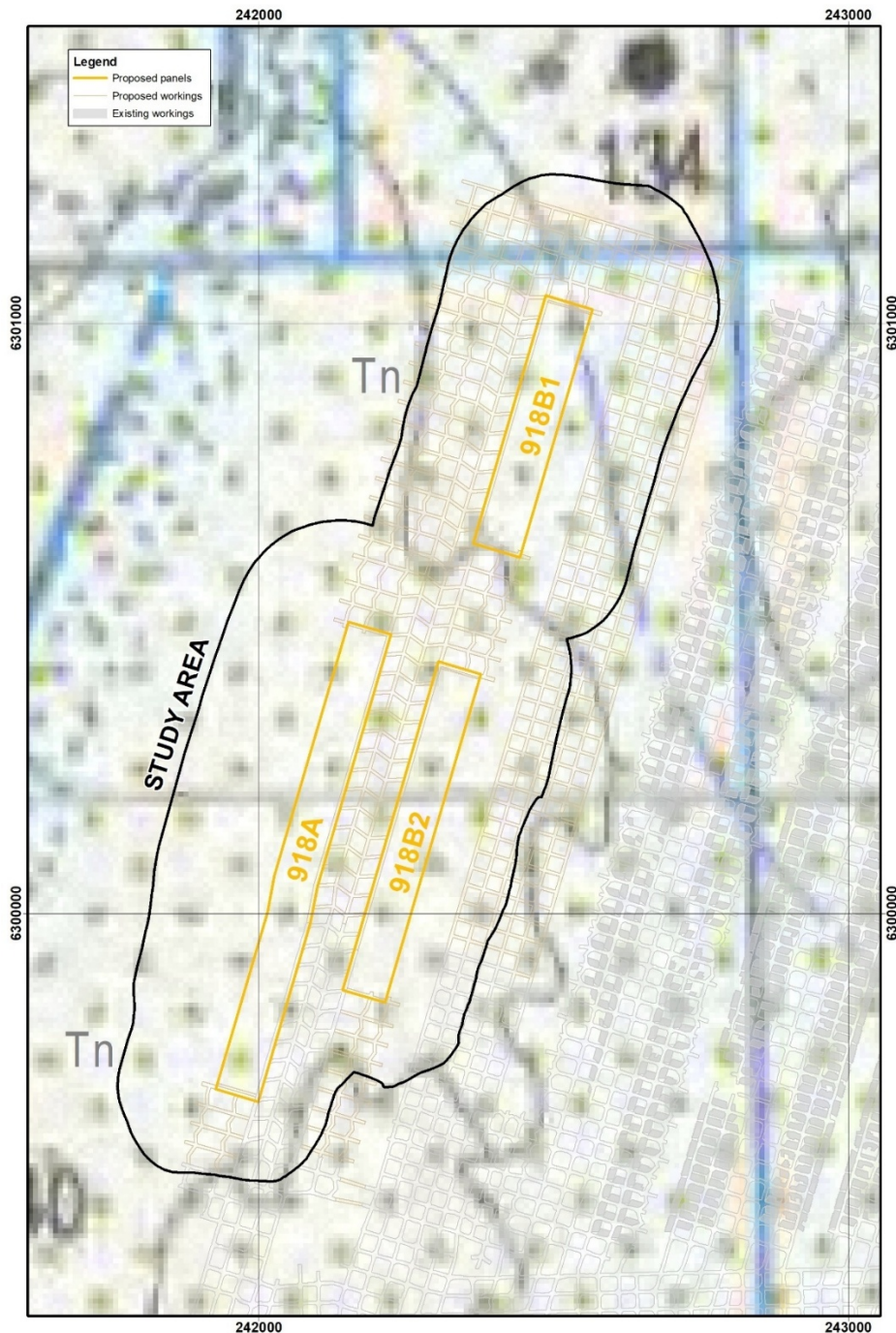


Fig. 1.5 Panels 918A, 918B1 and 918B2 overlaid on Geological Map Series 8931 (DMR, 1992)

The surface lithology directly above the proposed panels generally comprises the Buralow Formation of the Triassic Narrabeen Group (Tn). Quaternary alluvium (Qs) is present along the streams. Further detailed information on surface lithology is provided by SCT (2026), which shows that Banks Wall Sandstone is exposed along Bungleboori Creek, downstream of where it flows between sub-panels 918B1 and 918B2.

The mapped and inferred geological structures at Clarence are shown in Drawing No. MSEC1493-07. The identified faults are orientated approximately north-west to south-east and there are several mapped or inferred faults that cross the proposed 918 sub-panels.

Clarence have characterised Type 1a faults with widths greater than 3 metres. Type 1b faults are associated with major washouts. Type 3a faults are associated with minor washouts and Type 3b are projected faults with unknown severity.

The locations and sizes of the geological structures will be better defined through ongoing investigations and the development of the first workings of the 918 sub-panels.

2.1. Definition of the Study Area

The Study Area is defined as the surface area that could be affected by the mining of the 918A, 918B1 and 918B2 sub-panels. This area represents the minimum extent for the assessments for the conventional ground movements (i.e. vertical subsidence and its associated effects).

The extent of the Study Area has been calculated by combining the areas bounded by the following limits:

- a 35° angle of draw line from the extents of secondary extraction for the 918A, 918B1 and 918B2 sub-panels; and
- the predicted limit of vertical subsidence, taken as the 20 mm subsidence contour, due to the extraction of the 918A, 918B1 and 918B2 sub-panels.

The depth of cover contours for the Katoomba Seam are shown in Drawing No. MSEC1493-06. The depths of cover directly above the 918 panels vary between 227 m and 294 m. The 35° angle of draw line has therefore been determined around the limits of the secondary extraction areas at a horizontal distance varying between 161 m and 206 m.

The predicted limit of vertical subsidence, taken as the predicted total 20 mm subsidence contour, has been determined using the calibrated Incremental Profile Method. The subsidence model and its calibration are described in Chapter 3. The predicted total subsidence contours due to the extraction of the 918A, 918B1 and 918B2 sub-panels, including the predicted 20 mm subsidence contour, are shown in Drawing No. MSEC1495-13.

The predicted 20 mm subsidence contour is generally located inside the 35° angle of draw, with the exception of a small section in the south-eastern corner near the bend on Paddy's Creek.

A line has therefore been drawn defining the Study Area, based upon the 35° angle of draw line and the predicted 20 mm subsidence contour, whichever is greater. This area is referred to as the Study Area and it is shown in Drawing Nos. MSEC1493-01 to MSEC1493-10.

2.2. Overview of the natural and built features within the Study Area

The major natural and built features within the Study Area can be seen in a 1:25,000 Topographic Map of the area, published by DSC Spatial Services, Series Sheet 8931-3S (DSC, 2022). The 918A, 918B1 and 918B2 sub-panels and the Study Area have been overlaid on an extract of this map in Fig. 2.1.

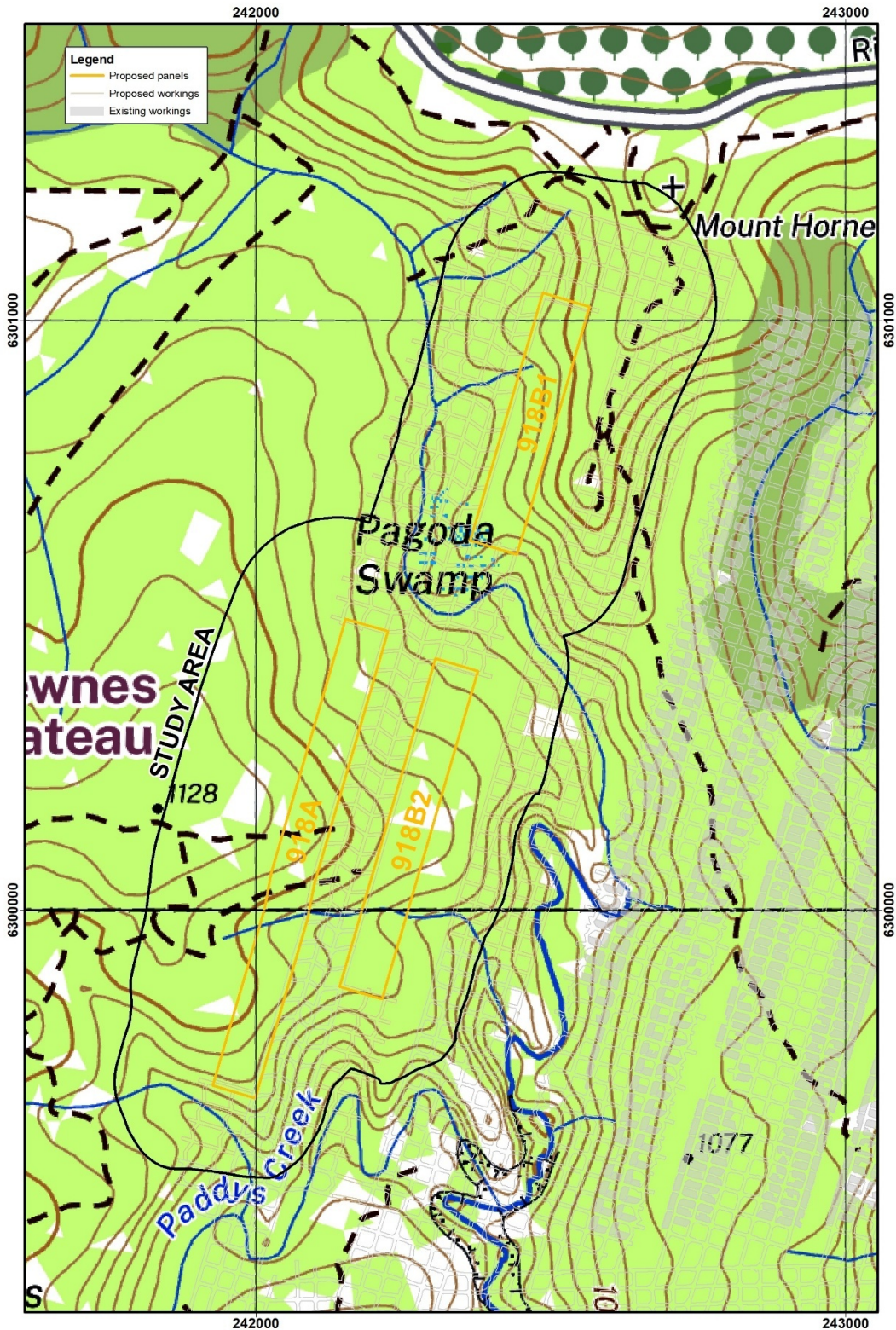


Fig. 2.1 Sub-Panels 918A, 918B1 and 918B2 overlaid on DSC Spatial Services Series Sheet Lithgow 8931-3S (DSC, 2022)

A summary of the natural and built features within the Study Area is provided in Table 2.1. The locations of these features are shown in Drawing Nos. MSEC1493-08 to MSEC1493-10. Descriptions, predictions and impact assessments for each of the natural and built features are provided in Chapters 5 and 6.

Table 2.1 Natural and built features within the Study Area

Item	Within Study Area	Section Number	Item	Within Study Area	Section Number
NATURAL FEATURES			FARM LAND AND FACILITIES		
Drinking Water Catchment Areas or Declared Special Areas	x		Agricultural Utilisation or Agricultural Suitability of Farm Land	x	
Streams	✓	5.3	Farm Buildings or Sheds	x	
Aquifers or Known Groundwater Resources	✓	5.4	Tanks	x	
Springs or Groundwater Seeps	✓	5.5	Gas or Fuel Storages	x	
Sea or Lake	x		Poultry Sheds	x	
Shorelines	x		Glass Houses	x	
Natural Dams	x		Hydroponic Systems	x	
Cliffs or Pagodas	✓	5.6	Irrigation Systems	x	
Steep Slopes	✓	5.7	Fences	x	
Escarments	x		Farm Dams	x	
Land Prone to Flooding or Inundation	x	5.8	Wells or Bores	✓	6.5
Swamps or Wetlands	✓	5.9	Any Other Farm Features	x	
Water Related Ecosystems	✓	5.10			
Threatened or Protected Species	✓	5.11	INDUSTRIAL, COMMERCIAL AND BUSINESS ESTABLISHMENTS		
Lands Defined as Critical Habitat	x		Factories	x	
National Parks	x	5.12	Workshops	x	
State Forests	x		Business or Commercial Establishments or Improvements	x	
State Recreation or Conservation Areas	✓	5.13	Gas or Fuel Storages or Associated Plants	x	
Natural Vegetation	✓	5.14	Waste Storages or Associated Plants	x	
Areas of Significant Geological Interest	x		Buildings, Equipment or Operations that are Sensitive to Surface Movements	x	
Any Other Natural Features Considered Significant	x		Surface Mining (Open Cut) Voids or Rehabilitated Areas	x	
PUBLIC UTILITIES			Mine Related Infrastructure Including Exploration Bores and Gas Wells	x	
Railways	x		Any Other Industrial, Commercial or Business Features	x	
Roads (All Types)	✓	6.2	AREAS OF ARCHAEOLOGICAL SIGNIFICANCE		
Bridges	x			✓	6.8
Tunnels	x		AREAS OF HISTORICAL SIGNIFICANCE		
Culverts	x			x	
Water, Gas or Sewerage Infrastructure	x		ITEMS OF ARCHITECTURAL SIGNIFICANCE		
Liquid Fuel Pipelines	x			x	
Electricity Transmission Lines or Associated Plants	x		PERMANENT SURVEY CONTROL MARKS		
Telecommunication Lines or Associated Plants	x			x	
Water Tanks, Water or Sewage Treatment Works	x		RESIDENTIAL ESTABLISHMENTS		
Dams, Reservoirs or Associated Works	x		Houses	x	
Air Strips	x		Flats or Units	x	
Any Other Public Utilities	x		Caravan Parks	x	
PUBLIC AMENITIES			Retirement or Aged Care Villages	x	
Hospitals	x		Associated Structures such as Workshops, Garages, On-Site Waste Water Systems, Water or Gas Tanks, Swimming Pools or Tennis Courts	x	
Places of Worship	x		Any Other Residential Features	x	
Schools	x		ANY OTHER ITEM OF SIGNIFICANCE		
Shopping Centres	x			x	
Community Centres	x		ANY KNOWN FUTURE DEVELOPMENTS		
Office Buildings	x			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				

3.1. Introduction

The following sections provide overviews of conventional and non-conventional mine subsidence effects and the methods that have been used to predict these movements. Further information is also provided in the background reports, which can be obtained from www.minesubsidence.com.

3.2. Overview of conventional subsidence effects

The normal ground movements resulting from the mining of panels are referred to as conventional or systematic subsidence effects. These effects 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 panel edges, can be greater than the vertical subsidence. Subsidence is usually expressed in units of *millimetres (mm)*.
- **Tilt** is the change in the slope of the ground as a result of differential subsidence and is calculated as the change in subsidence between two points divided by the distance between those points. Tilt is, therefore, the first derivative of the subsidence profile. Tilt is usually expressed in units of *millimetres per metre (mm/m)*. A tilt of 1 mm/m is equivalent to a change in grade of 0.1 % or 1 in 1000.
- **Curvature** is the second derivative of subsidence, or the rate of change of tilt, and is calculated as the change in tilt between two adjacent sections of the tilt profile divided by the average length of those sections. Curvature is usually expressed as the inverse of the **Radius of curvature** with the units of *1/kilometres (km⁻¹)*, 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 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 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), and vice versa.

The **incremental** subsidence, tilts, curvatures and strains are the additional parameters which result from the mining of each panel. The **cumulative** subsidence, tilts, curvatures and strains are the accumulated parameters which result from the mining of a series of panels. The **total** subsidence, tilts, curvatures and strains are the final parameters at the completion of a series of panels. The **travelling** tilts, curvatures and strains are the transient movements as the panel 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 panels and over solid unmined coal areas are generally 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 mining area and are accompanied by very low levels of strain. These movements generally do not result in impacts on natural features or built environments, except where they are experienced by large structures which are very sensitive to differential horizontal movements.

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 panels or near other previously extracted series of panels. In these cases, the levels of measured 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 effects

Conventional subsidence profiles are typically smooth in shape and can be explained by the expected caving mechanisms and pillar compression associated with overlying strata spanning the mined void. Normal conventional subsidence movements due to secondary extraction are easy to identify where panels 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 shallow, say less than 100 m, the observed subsidence profiles along monitoring lines are generally irregular. Very irregular subsidence movements are observed with much higher tilts, curvatures and strains at very shallow depths of cover where the collapsed zone above the extracted panels extend up to or near to the surface.

The depths of cover directly above the proposed 918 Panels varies between 227 m and 294 m. The subsidence due to the extraction of the proposed panels is predominately caused by pillar compression, rather than sag subsidence, and therefore the potential for irregular movements is reduced.

However, 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:

- geological structures or changes in surface geology;
- steep topography; and
- valley-related mechanisms.

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

3.4.1. Non-conventional subsidence movements due to geological conditions

It is believed that most non-conventional ground movements are a result of the reaction of near surface strata to increased horizontal compressive stresses due to mining operations. 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 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, curvatures 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 currently not possible to accurately 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 and 6, include historical impacts resulting from previous 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 increased horizontal movements in the downslope direction where panels are extracted beneath steep slopes. In these cases, elevated tensile strains develop near the tops and sides of the steep slopes and elevated compressive strains develop near the bases of the steep slopes. Potential impacts resulting from the increased horizontal movements in the downslope direction 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 increased horizontal movements for the steep slopes within the Study Area are provided in Section 5.7.

3.4.3. Valley-related effects

The streams within the Study Area could be affected by valley-related movements, which are commonly observed along streams in the NSW coalfields. 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.

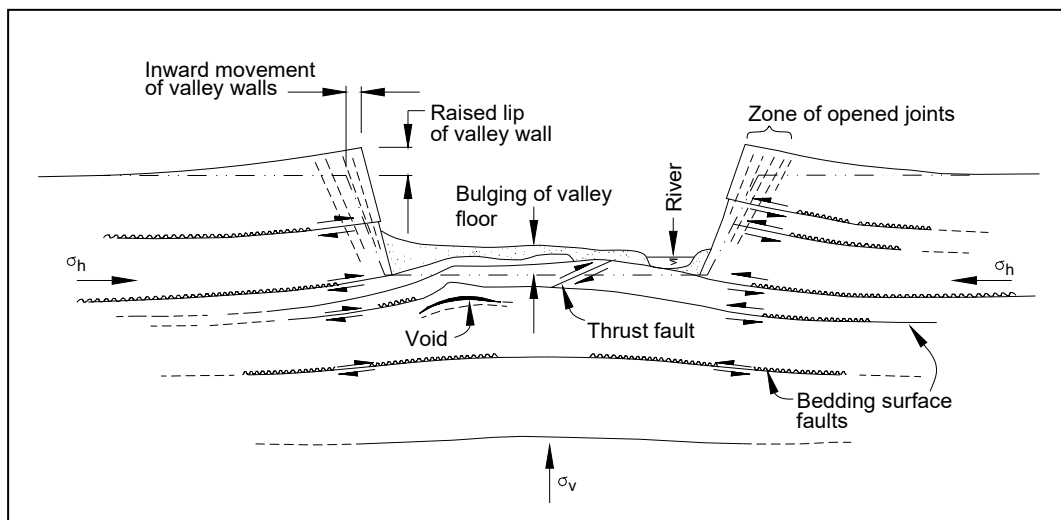


Fig. 3.1 Valley formation in flat-lying sedimentary rocks (after Patton and Hendren 1972)

Valley-related movements can be caused by, or accelerated by, mine subsidence as the result of several factors, including the redistribution of horizontal in situ stresses and downslope 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 *millimetres (mm)*, is the greatest reduction in horizontal 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 *millimetres per metre (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 for the streams due to the proposed panels have been determined using the empirical method outlined in ACARP Research Project No. C9067 (Waddington and Kay, 2002), referred to as the 2002 ACARP method in this report. This method has been used for the previous studies in the Western Coalfield.

The empirical prediction method has been refined based on further research undertaken as part of ACARP Research Project No. 18015 (Kay and Waddington, 2014), referred to as the 2014 ACARP method in this report. This method only provides predictions for valley closure and not for upsidence.

The predictions based on the 2002 ACARP method can be directly compared with the predictions provided in previous MSEC subsidence reports and with other case studies. This method has also been more widely used and tested than the more recent 2014 ACARP method. The assessments provided in this report, therefore, have been based on the predictions obtained using the 2002 ACARP method.

The predicted strains resulting from valley-related movements have been determined using the monitoring data for panels and longwalls which have previously mined directly beneath and adjacent to streams in the NSW coalfields. The predicted valley-related strains are discussed with the impact assessments for the streams provided in Chapter 5.

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.

3.5. Subsidence predictions by SCT (2026)

SCT (2026) has provided two-dimensional, vertical subsidence prediction profiles using numerical modelling methods, based on the site-specific geotechnical characteristics of the proposed 918 Panel layout and overburden.

Whilst Clarence has yet to conduct panel-and-pillar partial extraction using the shortwall mining method, there are nearby examples of secondary extraction of Panels 910 to 906, which have mining geometries and extraction ratios that are similar to the proposed 918 sub-panels. A key difference, however, is that the spine pillar between Panels 918A and 918B2 is 84 to 90 metres, which is substantially greater than the pillar widths between Panels 910 to 906 (56 to 60 metres), as shown in Fig. 3.2.

SCT (2026) developed and validated its model primarily on observations during the extraction of Panels 910 to 906, which are located to the east of the proposed 918 Panel. Observed subsidence movements during the extraction of Panels 910 to 906 are discussed in the following section.

Following feedback provided by the Independent Expert Advisory Panel for Mining (IEAPM) in January 2026, SCT has revised its numerical model and conducted additional sensitivity analyses. The predicted subsidence from the revised models were less than the predicted subsidence by the original model. In light of the findings, the results from original subsidence model were used for the subsidence impact assessment.

3.6. Observed subsidence during extraction of Clarence Panels 910 to 906

Monitoring during and after the extraction of Panels 910 to 906 provides the most relevant case study for assessment of potential subsidence movements due to the extraction of the proposed 918 sub-panels. A map showing the locations and key dimensions of Panels 910 to 906 and proposed 918 sub-panels is shown in Fig. 3.2.

A comparison of mining geometries is provided in Table 3.1.

Table 3.1 Comparison between Panel 918 and previous Panels 908-910

Panels	Panels 910 to 906	Panel 918
No. of panels	3	1
Depth of cover (directly above panels)	260 to 320 m (900D Line)	227 to 294 m
Extraction Height	3 m	1.9 to 2.3 m
Spine pillar heights	3 m	2.8 m
Panel widths	82 m	75 m (918A + 918B2) 83m (918B1)
Spine pillar widths	56-60 m	84-90 m
Barrier pillar widths	42 m	N/A

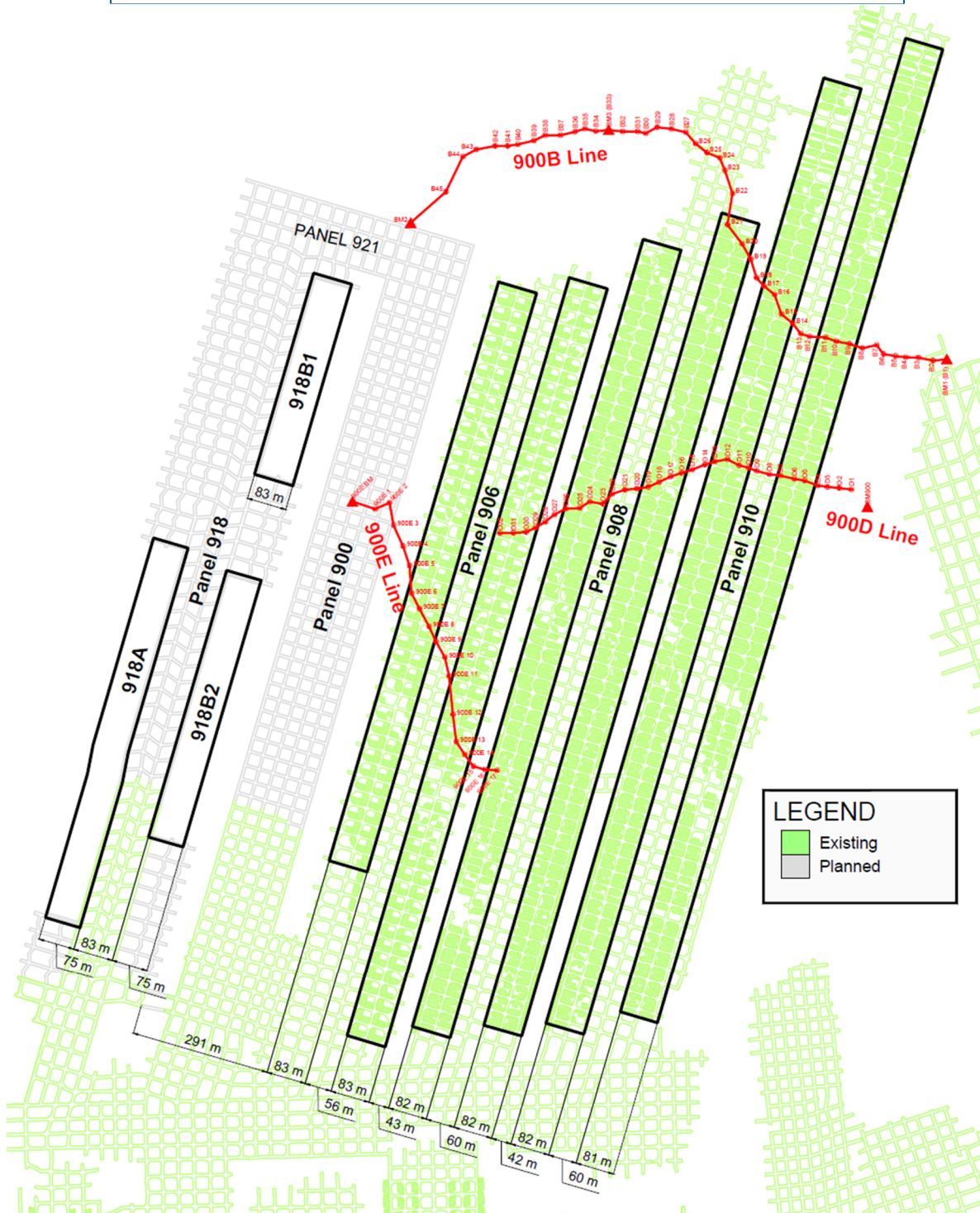


Fig. 3.2 Panels 910 to 906 and proposed 918 Panel at Clarence Colliery

Observed subsidence and tilt along the 900B and 900D survey lines are shown in Fig. 3.3 and Fig. 3.4.

Clarence Colliery advised that Panels 908 and 910 were allowed to flood once partial extraction had been completed for each panel. This information has also been included in the timeline graphs.

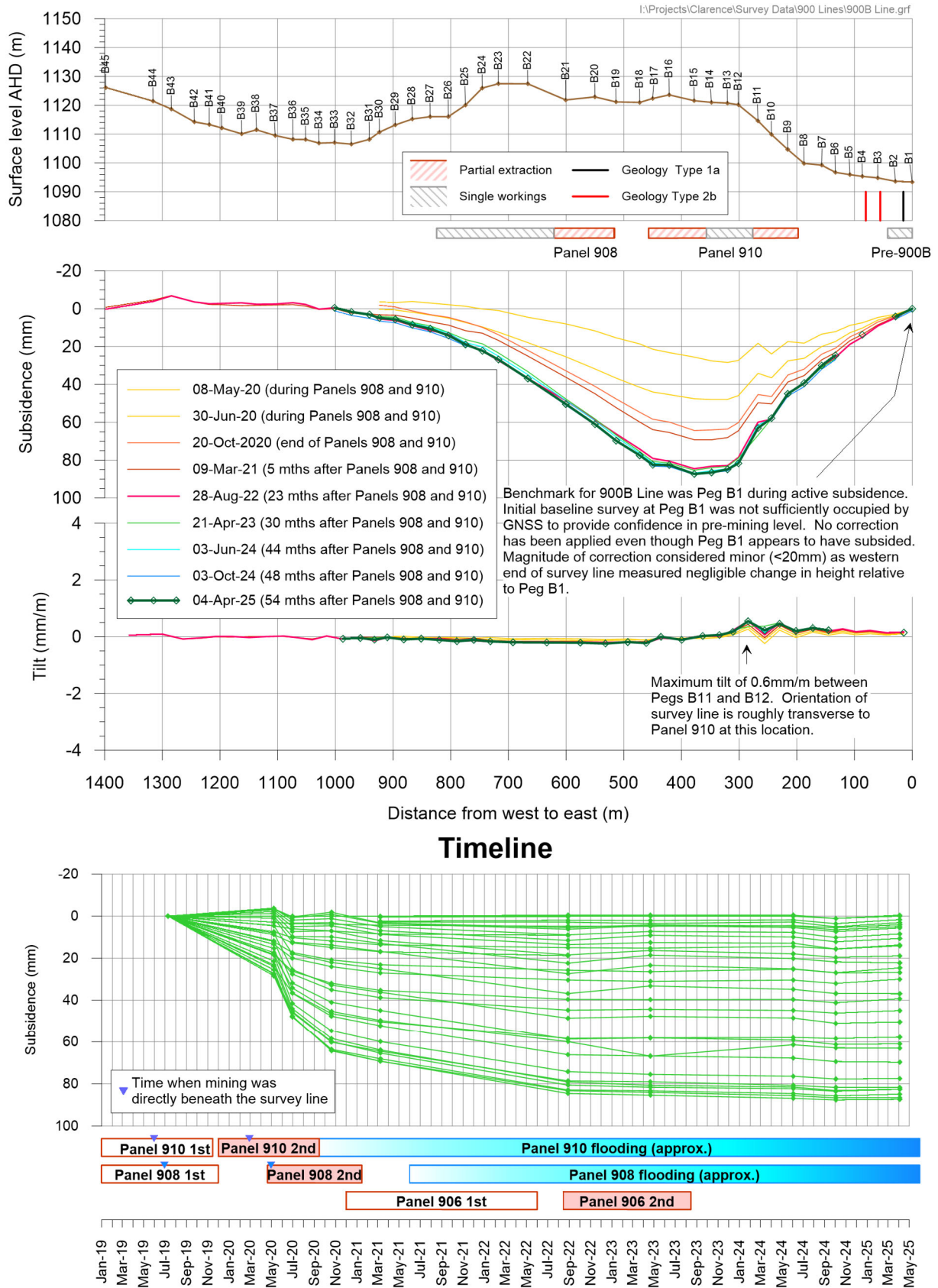


Fig. 3.3 Observed subsidence and tilt along the 900B Line

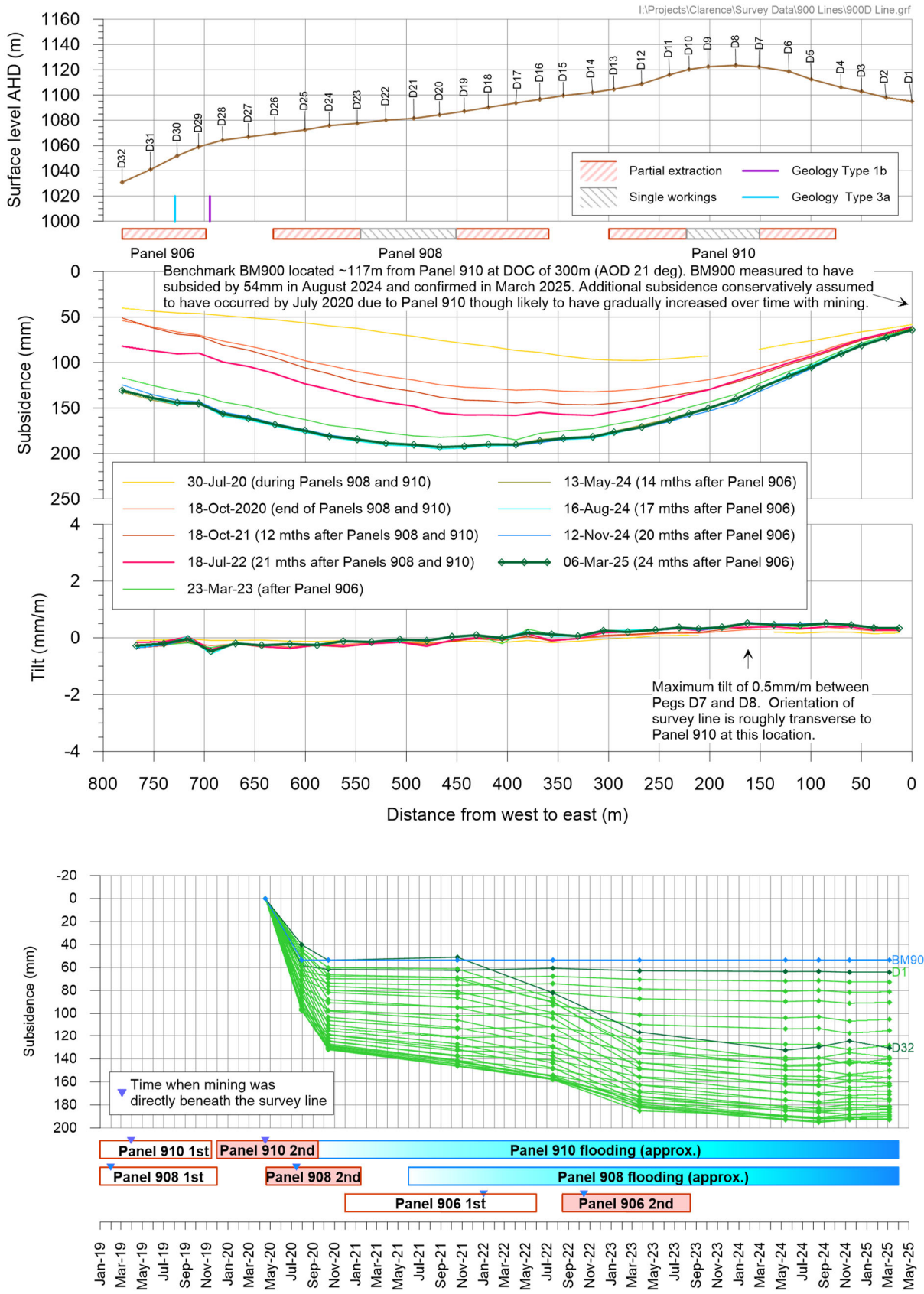


Fig. 3.4 Observed subsidence and tilt along the 900D Line

It can be seen from Fig. 3.3 and Fig. 3.4 that rates of change in vertical subsidence have reduced to low levels along both monitoring lines, indicating that the majority of residual subsidence movements have developed.

The surveys along the 900B and 900D Line have been conducted by digital level, relative to survey benchmarks that were placed to the side of Panel 910. The benchmarks were installed with the expectation that they would not subside during and after the mining period.

At the time the benchmarks were installed, Clarence conducted baseline GNSS surveys of Easting, Northing and Height of the benchmarks, using a portable GNSS unit. The accuracy of the baseline GNSS survey is dependent on the length of time the portable GNSS unit occupies the benchmark.

It can be seen from Fig. 3.3 and Fig. 3.4 that the observed subsidence profiles along the 900B and 900D Line do not asymptote towards zero to the side of Panel 910. This raised concerns that the benchmarks may have experienced low level subsidence and the survey results along the 900B and 900D Lines may have missed some vertical subsidence. Clarence conducted a review of the benchmarks in 2024.

In the case of the 900B Line:

- Peg B1 had been adopted as the benchmark. Peg B1 is located approximately 190 metres from the edge of Panel 910. At a depth of cover of 300 metres, the vertical angle to Peg B1 from the edge of Panel 910 is 32 degrees.
- The Clarence survey review found that the baseline GNSS survey did not occupy Peg B1 for a sufficient period of time to be confident about its pre-mining level.
- It can also be seen, however, that the observed subsidence profile has very long, asymptotic tail to the west towards zero subsidence, well past the mine workings.
- Whilst no correction has been applied to the survey results (i.e. "subsidence" of Peg B1 is recorded as zero), it is considered that very little additional subsidence appears to have occurred at Peg B1.
- Any correction would be less than 20 mm based on the fact that average uplift beyond Peg B35 was 3 mm, with a maximum uplift of 7 mm. Peg B35 is located approximately 260 metres from the closest corner of Panel 908. At a depth of cover of 290 metres, the vertical angle to Peg B1 to the corner of Panel 908 is 42°.

In the case of the 900D Line:

- BM900 had been adopted as the benchmark. BM900 is located approximately 117 m from the edge of Panel 910. At a depth of cover of 300 m, the vertical angle to BM900 from the edge of Panel 910 is 21°.
- The Clarence survey review found that the baseline GNSS survey had occupied BM900 for a sufficient period of time to be reasonably confident about its pre-mining level. This allowed Clarence survey to measure a change in level from BM900's post-mining level, which was surveyed with results presented below.
 - A post-mining GNSS survey was conducted on 5, 15 and 23 August 2024. The surveys found an average difference in level of 54 mm since the baseline survey, with a variation of ± 15 mm.
 - A second post-mining GNSS survey was conducted on 21, 25 and 26 March 2025. The surveys found an average difference in level of 44 mm since the baseline survey, with a variation of -6 mm to 12 mm.
- Based on the August 2024 surveys, Clarence have adopted a correction of 54 mm. The results of the March 2025 surveys are within survey accuracy of the August 2024 surveys.
- The subsidence results for the 900D Line were, therefore, increased by 54 mm. The adjustment was conservatively applied to all survey results as the majority of the subsidence movements at BM900 would have occurred due to the extraction of Panel 910.
- It is likely, however, that BM900 would have experienced some subsidence after the first survey on 30 July 2020 due to the extraction of Panel 908 and long-term residual subsidence. Peg D1, for example, was measured to subside an additional 5 mm relative to BM900 after 30 July 2020.
- It is also noted that survey tolerance of the baseline GNSS survey and post-mining GNSS surveys of the benchmark are in the order of ± 15 mm.

The most relevant surveys for 918 Panel would be those that occurred after Panel 910 was extracted and before Panel 908 was extracted. Unfortunately the two panels were extracted almost concurrently, with only a short delay of approximately three months between the commencement of Panel 910 and the commencement of Panel 908. Stages of extraction of Panels 910 and 908 are shown in Fig. 3.5.

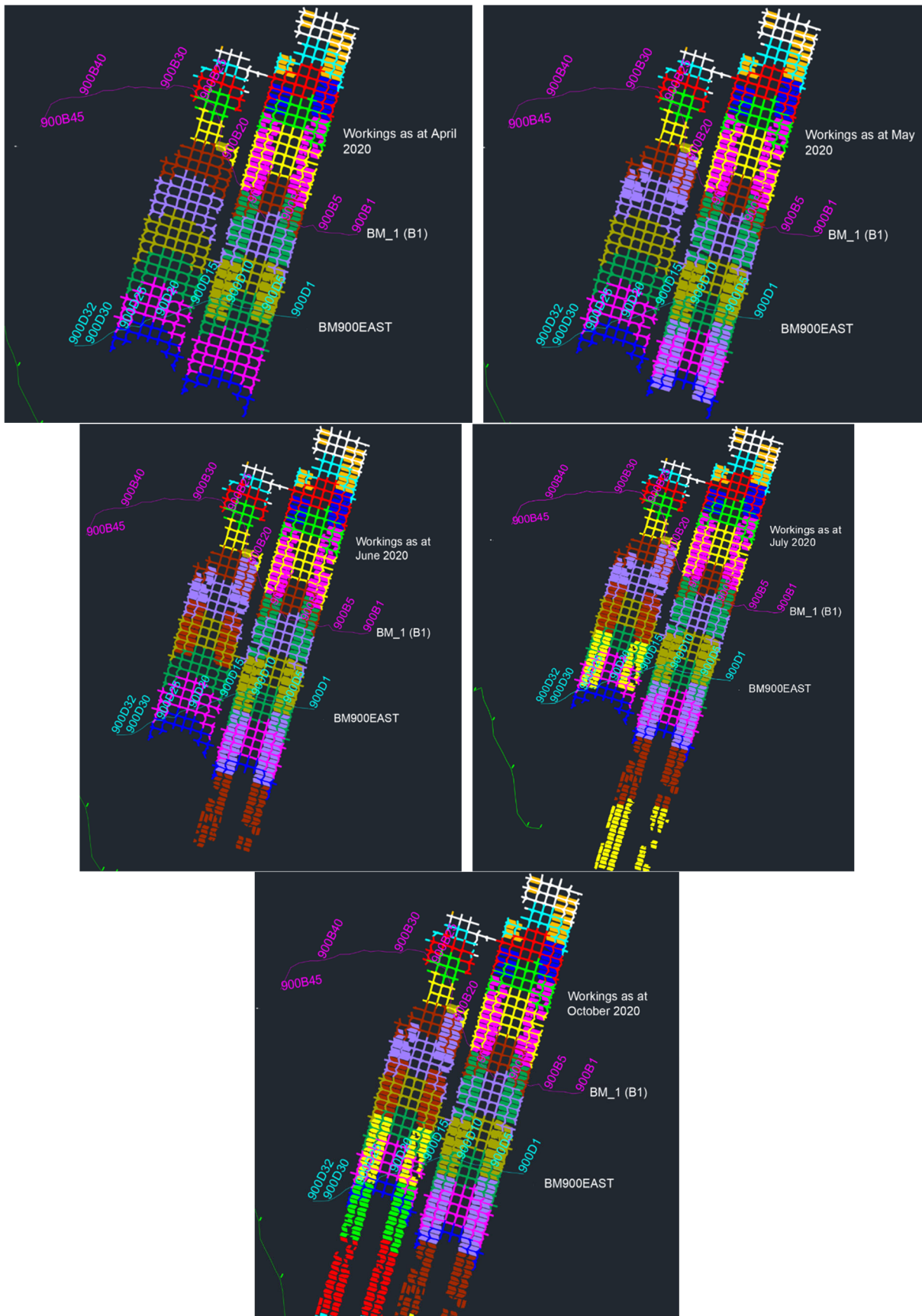


Fig. 3.5 Stages of Extraction of Panels 910 and 908 at the end of each month

In the case of the 900B Line:

- The first survey on 8 May 2020 measured a maximum subsidence 28 mm. This measurement could be considered to be completely due to the mining of Panel 910 as the length of extraction of Panel 908 was very small at the time of survey and would have resulted in negligible subsidence. The location of maximum subsidence was close to the centreline of Panel 910, as expected at this stage.
- The length of extraction of Panel 910 on 8 May 2020 was approximately 800 metres and the working face was approximately 300 metres past the 900B Line. At a depth of cover of approximately 300 metres, it is likely that some minor, additional subsidence would have developed in the short term as the working face moved further away after the survey.
- By the time of the next survey on 30 June 2020, however, the mining of Panel 908 would have resulted in some subsidence along the 900B Line. Maximum subsidence had increased to 48 mm and the shape of the observed subsidence profile had widened to the west as at 30 June 2020, indicating that some subsidence due to the mining of Panel 908 had already developed along the survey line.
- Based on the above, Panel 910 was likely to have resulted in 30 mm (8 May) to 50 mm (30 June) of active subsidence movement.
- It can also be seen, however, that a significant amount of residual subsidence developed gradually after the extraction of Panels 910 and 908. Final maximum subsidence was 88 mm, which represents approximately 80% of additional subsidence since 30 June, or 36% of additional subsidence since 20 October 2020, after the completion of Panels 910 and 908.
- Whilst the 900B Line would have experienced full subsidence due to the extraction of Panel 910, it is located approximately 150 metres from the staggered commencing ends of Panel 908. It is likely that maximum subsidence along the 900B Line would have increased slightly if Panel 908 had commenced further to the north.

In the case of the 900D Line:

- The first survey was on 30 July 2020, when the working face of Panel 910 had moved well away from the 900D Line. By this time, however, the working face of Panel 908 had already commenced mining directly beneath the survey line.
- As the location of maximum subsidence on 30 July was shifted to the west of the Panel 910 centreline, it is considered that some subsidence due to the mining of Panel 908 had already developed along the survey line.
- Maximum subsidence was 98 mm as at 30 July 2020, though 54 mm of this amount is attributed to a post-mining re-assessment of the benchmark.
- It can also be seen that a significant amount of residual subsidence developed gradually after the extraction of Panels 910 and 908. Final maximum subsidence in July 2022 was 158 mm, which represents approximately 20% of additional subsidence since 18 October 2020, after the completion of Panels 910 and 908.
- The 900D Line then experienced additional subsidence due to the extraction of Panel 906.

In light of the above observations along the 900B and 900D Lines, it is challenging to determine exactly how much subsidence developed due to the extraction of Panel 910 only. Complexities arise due to the influence of Panel 908 at the time of surveys on both survey lines, the effects of long-term residual subsidence and uncertainties in the stability of the benchmarks. SCT (2026) has modelled maximum subsidence due to the extraction of Panel 910 to be 91 mm, which appears reasonable.

It is also challenging to determine the extent to which subsidence reduces to 20 mm beyond the side of Panel 910 (i.e. the angle of draw). A plan showing observed vertical subsidence as at July / August 2022 is shown in Fig. 3.6. The surveys in July and August 2022 were selected as they were the last surveys that were conducted before the secondary extraction of Panel 906.

- If the results along the 900B Line are examined in isolation, vertical subsidence of 20 mm occurred close to Peg B5, which is located 85 metres from the side of Panel 910. At a depth of cover of 300 metres, this represents an angle of draw of 16°.
- If the results along the 900D Line are examined in isolation, the survey line does not extend sufficiently beyond the side of Panel 910 to measure 20 mm of subsidence.
 - If 20 mm of vertical subsidence occurred at an angle of draw of 26.5° (i.e. 150 metres from the edge of Panel 910), the average tilt from this location and BM900 would be 1 mm/m (34 mm over 33 metres). This magnitude of tilt is unrealistic given that maximum tilt directly above Panel 910 was 0.5 mm/m.
 - If 20 mm of vertical subsidence occurred at an angle of draw of 35° (i.e. 210 metres from the edge of Panel 910), the average tilt from this location and BM900 would be 0.37 mm/m (34 mm over 93 metres). This magnitude of tilt may also be slightly more than expected, although it is in the right ballpark.

- When the results from the 900B Line and 900D Line are examined together, it can be seen from Fig. 3.6 that subsidence at BM900 is approximately 42 mm greater than the pegs that are located at an equivalent offset distance to the side of Panel 910 on the 900B Line.
 - The discrepancy between the results may be explained by the challenges associated with the benchmarks.
 - Whilst it cannot be proven, the actual angle of draw may lie somewhere between the 16 degrees inferred from the 900B Line and the 35° inferred from the 900D Line.
- In light of the above, the predicted subsidence profiles for the proposed extraction of 918 Panel have been designed conservatively to achieve an angle of draw of 35°. This is consistent with the 54 mm subsidence correction at BM 900. The predicted subsidence profile for the proposed 918 Panel have developed to achieve this outcome.
- Clarence has installed a network of GNSS units as part of its monitoring program for the proposed Panel 918. The GNSS units have been installed for some time and are well established (refer Section 7.3 of this report for more information). The GNSS units do not require benchmarks as their positions are determined from satellites.
- Clarence has also installed ground survey lines. The benchmarks have been placed sufficiently further away from 918 Panel to remain stable (refer 918 Panel Subsidence Monitoring Program (MSEC, 2026)). The horizontal and vertical positions of the benchmarks will also be established accurately. It will also be possible to correlate the results from the ground surveys with the results from the GNSS units.

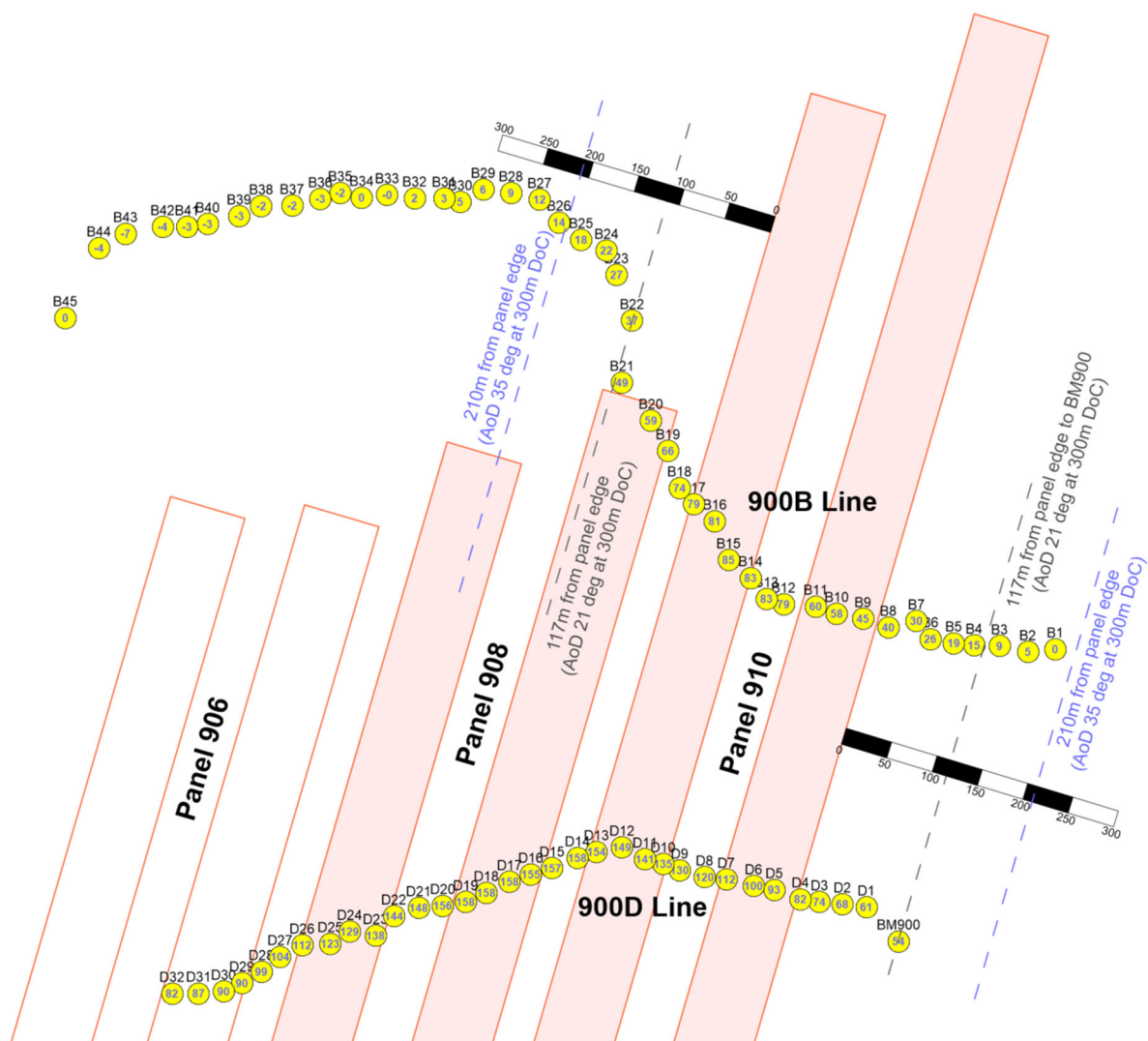


Fig. 3.6 Observed vertical subsidence as at July and August 2022 above Panels 910 and 908

3.7. Developing predicted subsidence profiles using the Incremental Profile Method

The Incremental Profile Method (IPM) has been used to prepare three-dimensional predicted subsidence contours for the 918A, 918B1 and 918B2 sub-panels based on the predicted two-dimensional subsidence profiles determined by SCT (2026). SCT's prediction model was validated against observed subsidence profiles along the nearby 900B Line and 900 D Line. These survey lines measured subsidence due to previously extracted Panels 906, 908 and 910.

Subsidence profiles were developed to reasonably match the shape of SCT's predicted subsidence profiles at depths of cover of 180 m and 280 m. The IPM model adjusts the profiles within the Study Area based on actual depths of cover and seam thickness, interpolating between the two profiles at 180 m and 280 m.

Whilst the north-eastern corner of sub-Panel 918B1 has depths of cover between 280 m and 294 m, the north-western corner of sub-Panel 918B1 has depths of cover between 265 m and 280 m, such that the average depth of cover across the width of the northern end of sub-Panel 918B1 is approximately 280 m. As the IPM model makes predictions based on the average depth of cover across the width of a panel, the IPM model, therefore, was not required to extrapolate beyond SCT's predicted subsidence profiles.

As shown in Fig. 32 of SCT's (2026) report, the boundary conditions of the numerical model has resulted in predicted subsidence profiles that do not asymptote to zero. The subsidence profiles were, therefore, adjusted to achieve an angle of draw of approximately 35° for the reasons discussed in Section 3.6.

The predicted subsidence profiles along Prediction Lines 1 and 2 across the Study Area are shown in Figures C.01 and C.02 in Appendix C. The locations of these prediction lines are shown in Drawing Nos. MSEC1493-11 to MSEC1493-13.

The depths of cover directly above the 918 panels vary between 227 m and 294 m. It can be seen that the predicted subsidence profiles are closer to SCT's modelled profile at 280 m than the modelled profile at 180 m.

Following feedback provided by the Independent Expert Advisory Panel for Mining (IEAPM) in January 2026, SCT has revised its numerical model and conducted additional sensitivity analyses. A comparison between SCT's original model (2025) and revised model based on reduced stiffness (2026) is provided in Figure C.01.

It can be seen from Fig. C.01 that predicted subsidence by the revised model is less than originally predicted. Given that the predicted subsidence profiles by the IPM model are more conservative than the revised model, no further adjustments were applied to the IPM model in light of the results from the revised numerical model.

4.1. Introduction

The predicted three-dimensional subsidence contours for the 918A, 918B1 and 918B2 sub-panels has been developed based on the predicted subsidence profiles provided by SCT (2026) using numerical modelling, and analyses of observed angles of draw to the side of previously extracted Panel 910, as discussed in Section 3.6.

The maximum predicted subsidence effects and the predicted subsidence contours provided in this report describe and show the conventional movements and these do not include the valley-related upsidence and closure effects or anomalous movements. Such effects are addressed separately in the impact assessments for each feature provided in Chapters 5 and 6.

4.2. Maximum predicted vertical subsidence, tilt and curvature

The maximum predicted total vertical subsidence provided by SCT (2026) is 76 mm ± 20 mm.

The predicted incremental vertical subsidence contours produced by the IPM due to the mining of sub-Panel 918A are shown in Drawing No. MSEC1493-11. Note that the total (i.e. cumulative) subsidence contours are shown for sub-panels 918B1 and 918B2 rather than the incremental contours.

A summary of the maximum predicted values of incremental conventional vertical subsidence, tilt and curvature due to the extraction of the 918A, 918B1 and 918B2 sub-panels is provided in Table 4.1. The incremental values are the additional movements due to the extraction of each sub-panel.

Table 4.1 Maximum predicted incremental vertical subsidence, tilt and curvature due to the extraction of each of the 918A, 918B1 and 918B2 sub-panels

Due to Sub-Panel	Maximum predicted incremental subsidence (mm)	Maximum predicted incremental tilt (mm/m)	Maximum predicted incremental hogging curvature (km ⁻¹)	Maximum predicted incremental sagging curvature (km ⁻¹)
918A	50	0.5	0.01	0.01
918B1	60	0.6	0.01	0.01
918B2	50	0.5	0.02	0.03

The predicted total vertical subsidence contours after the mining of sub-panels 918B1 and 918B2 are shown in Drawing Nos. MSEC1493-12 and MSEC1493-13, respectively.

A summary of the maximum predicted values of total vertical subsidence, tilt and curvature derived using the IPM is provided in Table 4.2. The total values are the accumulated movements after the extraction of each sub-panel.

Table 4.2 Maximum predicted total vertical subsidence, tilt and curvature after the extraction of each of the 918A, 918B1 and 918B2 sub-panels

After Panel	Maximum predicted total vertical subsidence (mm)	Maximum predicted total tilt (mm/m)	Maximum predicted total hogging curvature (km ⁻¹)	Maximum predicted total sagging curvature (km ⁻¹)
918A	50	0.5	0.01	0.01
918B1	60	0.6	0.01	0.01
918B2	76	0.6	0.02	0.03

The maximum predicted total vertical subsidence is 76 mm ± 20 mm, as predicted by SCT (2026). The greatest subsidence occurs directly above sub-panels 918A and 918B2 where two sub-panels were extracted adjacent to each other and the depth of cover is greatest.

The maximum predicted total tilt is 0.6 mm/m (i.e. 0.06 % or 1 in 1667). The maximum predicted total conventional curvatures are 0.02 km⁻¹ hogging and 0.03 km⁻¹ sagging and they represent minimum radii of curvature of 100 km and 33 km, respectively.

The predicted conventional subsidence effects vary across the Study Area as the result of, amongst other factors, variations in the depths of cover, pillar widths, mining heights and overburden geology. To illustrate this variation, the subsidence effects have been determined along two prediction lines.

The predicted profiles of total vertical subsidence, tilt and curvature along Prediction Lines 1 and 2 are illustrated in Figs. C.01 and C.02, respectively, in Appendix C. The locations of these prediction lines are shown in Drawing Nos. MSEC1493-11, MSEC1493-12 and MSEC1493-13. Prediction Line 1 has been taken transverse to the proposed 918A and 918B2 sub-panels over their northern halves. Prediction Line 2 has been taken transverse to sub-panel 918B1 near its mid-length.

4.3. Reliability of subsidence modelling results for subsidence and tilt

SCT (2026) advises that a variance of ± 20 mm be applied to its modelled maximum subsidence estimates.

The predicted subsidence profiles using the IPM Model also, therefore, include a variance of ± 20 mm for predicted maximum subsidence. Variations between actual and predicted subsidence are expected to occur for a variety of reasons, of which survey tolerance is one. Variations also occur due to environmental effects such as seasonal changes in temperature or moisture, and can also occur due to variations in topography and depths of cover and variations in geology of the overburden.

Whilst variations are expected to occur, SCT's model has been validated primarily from observations during the extraction of Panels 910 to 906, which are located adjacent to the proposed 918 Panel. SCT subsequently revised its numerical model and conducted additional sensitivity analyses in 2026 following feedback provided by the IEAPM. The predicted subsidence from the revised models were less than the predicted subsidence by the original model.

The shapes of the predicted profiles in the IPM Model are based on the modelled profiles by SCT (2026). The predicted maximum tilts due to the extraction of 918 Panel are considered to be reasonably conservative because they are similar in magnitude to the observed maximum tilts along the 900B and 900D Lines, even though maximum observed total subsidence along the 900B and 900D Lines were greater than the predicted maximum total subsidence of 76 mm due to the extraction of 918 Panel.

It can be seen that a predicted 10 mm subsidence contour has been provided in Drawing Nos. MSEC1493-12 and MSEC1493-13. The predicted 10 mm subsidence contour is not normally displayed but it was requested to be displayed by the Independent Expert Advisory Panel for Mining (IEAPM) in April 2024, when it conducted a review of the previously proposed 918 and 920 Panels. Please note that there is a greater potential for variation between actual and predicted 10 mm subsidence for the reasons that were discussed above. The predicted 10 mm subsidence contour should, therefore, be considered as an approximation.

4.4. Predicted strains

The prediction of strain is more difficult than the predictions of subsidence, tilt and curvature. The reason for this is that strain is affected by many factors, including ground curvature and horizontal movement, as well as local variations in the near-surface geology, the locations of pre-existing natural joints at bedrock, and the depth of bedrock beneath the surface soils. 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 measured strain, therefore, can be irregular even when the profiles of measured subsidence, tilt and curvature are relatively smooth.

Predicted strains based on predicted conventional curvature

Predictions of conventional strain have typically been 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 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 the locations that are predicted to experience sagging or concave curvature are expected to be net compressive strain zones. In the Western Coalfield, it has been found that a factor of 10 provides a reasonable relationship between the predicted maximum curvatures and the predicted maximum conventional strains.

The maximum predicted conventional strains due to the proposed extraction of the 918A, 918B1 and 918B2 sub-panels, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 0.2 mm/m tensile and 0.3 mm/m compressive, i.e. in the order of survey tolerance. These strains represent typical values when the ground subsides regularly with no localised or elevated strains due to near-surface geological structures or valley closure effects. The maximum strains can be much greater than these typical values, especially in the locations of near-surface geological structures and in the bases of valleys.

At a point, there can also 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, measured strains can be many times greater than the predicted conventional strain for low magnitudes of curvature. In this report, therefore, we have provided a statistical approach to account for the variability, rather than just providing a single predicted conventional strain.

Statistical analysis of observed strains due to previous extraction at similar magnitudes of subsidence

There is limited strain monitoring data at Clarence. Strain was measured using steel tape along the 700A and 700B Lines above the previously partially extracted 700 series panels. The observed subsidence, tilt and strain along the 700A and 700B Lines are shown in Fig. 4.1 and Fig. 4.2, respectively.

It can be seen that measured vertical subsidence was similar order of magnitude though slightly less than the maximum subsidence that is predicted to occur due to the proposed extraction of Panel 918.

It can be seen from Fig. 4.1 and Fig. 4.2 that the measured strain profiles for the 700A and 700B Lines show several pairs of equal-opposite spikes of tensile and compressive strains. The elevated strains were caused by disturbed survey marks. Elsewhere, only low-level strains were measured that were similar to the order of survey tolerance. As measured strains were within survey tolerance, Clarence Colliery received approval from the NSW Resources Regulator to cease strain survey monitoring after the extraction of Panels 702 to 716 in 2013.

It is further noted that the 700A and 700B Lines both crossed streams. No elevated compressive strains (valley closure) and no bumps in the subsidence profile (upsidence) were observed at these locations.

An alternative method for predicting strain is to conduct statistical analyses of ground monitoring data. The range of potential strains for proposed 918 Panel has been assessed based on strain monitoring data for panels and longwalls elsewhere in the NSW coalfields. The strain data has been based on that measured above partial or total extraction areas where the maximum measured vertical subsidence was less than 100 mm, as for the proposed 918 Panel. While the data has been obtained from monitoring data based on different mining geometries and depths of cover, it should provide a reasonable indication of the range of potential strains for the proposed panels.

There are over 5000 available measurements of strains above partial or total extraction areas where the maximum measured vertical subsidence was less than 100 mm. The majority (approximately 95 %) of the measured strains were in the order of survey tolerance, taken as 0.3 mm/m. The 95th percentiles therefore are approximately 0.3 mm/m tensile and compressive.

The maximum predicted strains for 918 Panel have therefore been taken as 0.3 mm/m tensile and compressive. While strains greater than 0.3 mm/m can occur, the rate of occurrence is expected to be approximately 5 %.

A summary of the maximum predicted strains for 918 Panel is provided in Table 4.3. The strains have been derived using a statistical analysis of ground monitoring data from the NSW coalfields where the measured subsidence was less than 100 mm.

Table 4.3 Maximum predicted total strains due to the extraction of Panel 918

Panel	Maximum predicted strains based on the 95 th percentiles (mm/m)	
	Tensile strain	Compressive strain
Panel 918	0.3	0.3

Based on the information presented above, it is expected that ground strains during the proposed extraction of 918 Panel will be small (i.e. 0.3 mm/m tensile and compressive) and similar to the order of survey tolerance.

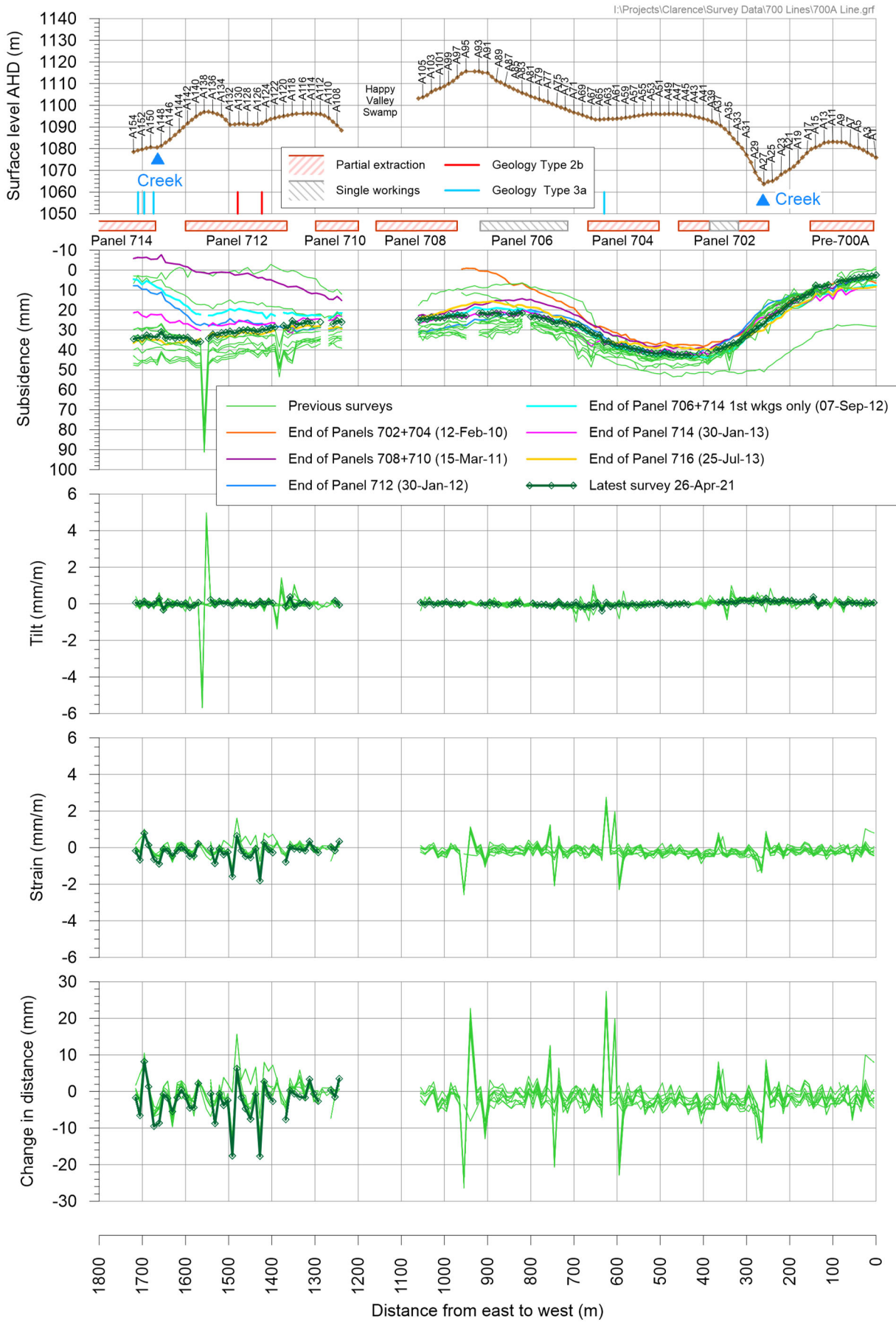


Fig. 4.1 Observed subsidence, tilt and strain along the 700 A Line due to the partial extraction of Panels 702 to 716

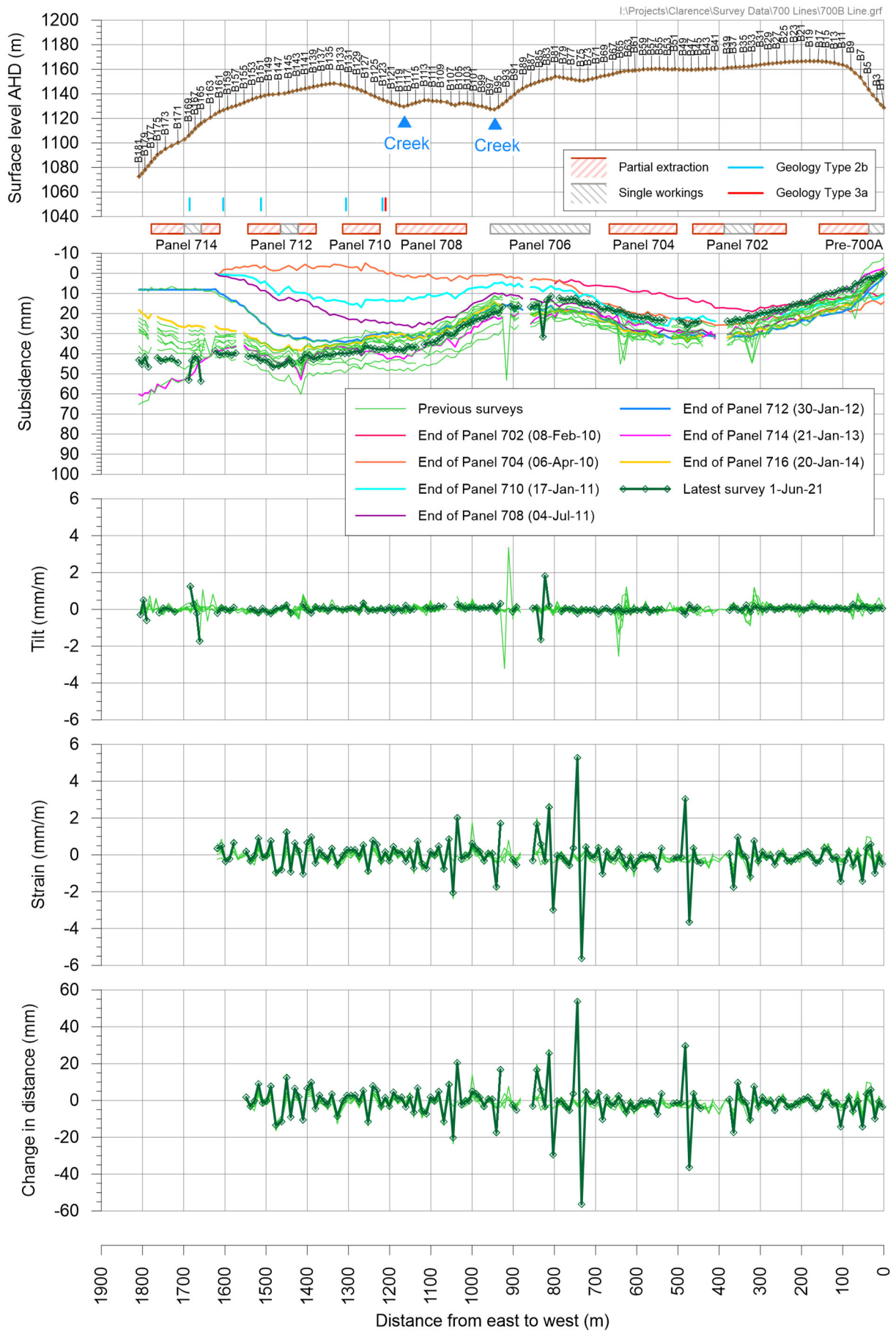


Fig. 4.2 Observed subsidence, tilt and strain along the 700 B Line due to the partial extraction of Panels 702 to 716

4.5. Comparison of maximum predicted and allowable subsidence effects

Schedule 3, Condition 1 of the Development Consent (DA 504-00, as modified) provides the allowable subsidence effects due to partial extraction at Clarence. A comparison of the maximum predicted and allowable subsidence effects for the proposed 918 Panel is provided in Table 4.4.

Table 4.4 Comparison of maximum predicted and allowable subsidence effects for the proposed Panel 918

Level of extraction	Type	Maximum total vertical subsidence (mm)	Maximum total tilt (mm/m)	Maximum total tensile or compressive strain (mm/m)
Partial extraction	Predicted	76	0.6	0.3
	Allowable	100	3.0	2.0

The maximum predicted subsidence effects are therefore less than the maximum allowable subsidence effects outlined in Schedule 3, Condition 1 of the Development Consent (DA 504-00, as modified).

Whilst the predicted total vertical subsidence is relatively close in magnitude to the allowable limit of 100 mm, it is noted that the predicted maximum tilts and strains are substantially less than the allowable limits.

- As discussed in Section 3.6, previously observed tilts due to the previous extraction of Panels 910 to 906 along the 900B and 900D Lines were also 0.6 mm/m, even though observed maximum subsidence was greater than 100 mm.
- As discussed in Section 4.4, previously observed ground strains during the extraction of Panels 702 to 716 were within survey tolerance.

The potential for mine subsidence impacts and environmental consequences are influenced more strongly by differential subsidence movements, such as tilt, curvature and strain rather than maximum vertical subsidence.

As subsidence is predicted to incrementally increase as each sub-panel is extracted in stages, it will be possible to monitor and review observed subsidence movements during the extraction of each sub-panel. This will allow Clarence to adapt its mine plan prior to the extraction of subsequent sub-panels to ensure compliance with the Development Consent. It is recommended, therefore, that Clarence implement an Adaptive Management Plan, which is described in the Subsidence Monitoring Program.

4.6. Predicted far-field horizontal movements

Previously surveyed far-field monitoring at Clarence consists of 3D survey marks located along the side of Farmers Creek, upstream of Lithgow No. 2 Dam. The marks were surveyed during the partial extraction of Panels 708, 712, 714, 716 and 707. The measured incremental movements were typically within the survey tolerance of ± 25 mm at distances of approximately 0.42 km to 1.3 km from the active panels.

Clarence also advises that when it conducted its review of benchmark BM900 for the 900D Line, the post-mining GNSS surveys also measured eastings and northings, which can be compared to the results of the pre-mining, baseline GNSS survey. It was found that BM900 had moved 38 mm to the west, towards Panel 910.

An empirical database of measured far-field horizontal movements has been compiled using monitoring data from the Southern and Western Coalfields. While this data is predominately obtained from longwall mining, the data has been filtered to only use data where the maximum vertical subsidence above the mining area is less than 100 mm, as for the proposed 918 Panel. At these lower levels of vertical subsidence, the majority of subsidence develops from compression of the pillars and solid coal.

The measured incremental far-field horizontal movements (for cases where the maximum measured incremental vertical subsidence is less than 100 mm) versus the distance from the active panel are shown in Fig. 4.3. The measured values (y-axis) are the observed incremental movements during the extraction of each panel. The distances (x-axis) are of the survey marks from the active panel, where these are located above solid coal (i.e. outside of previously extracted panels).

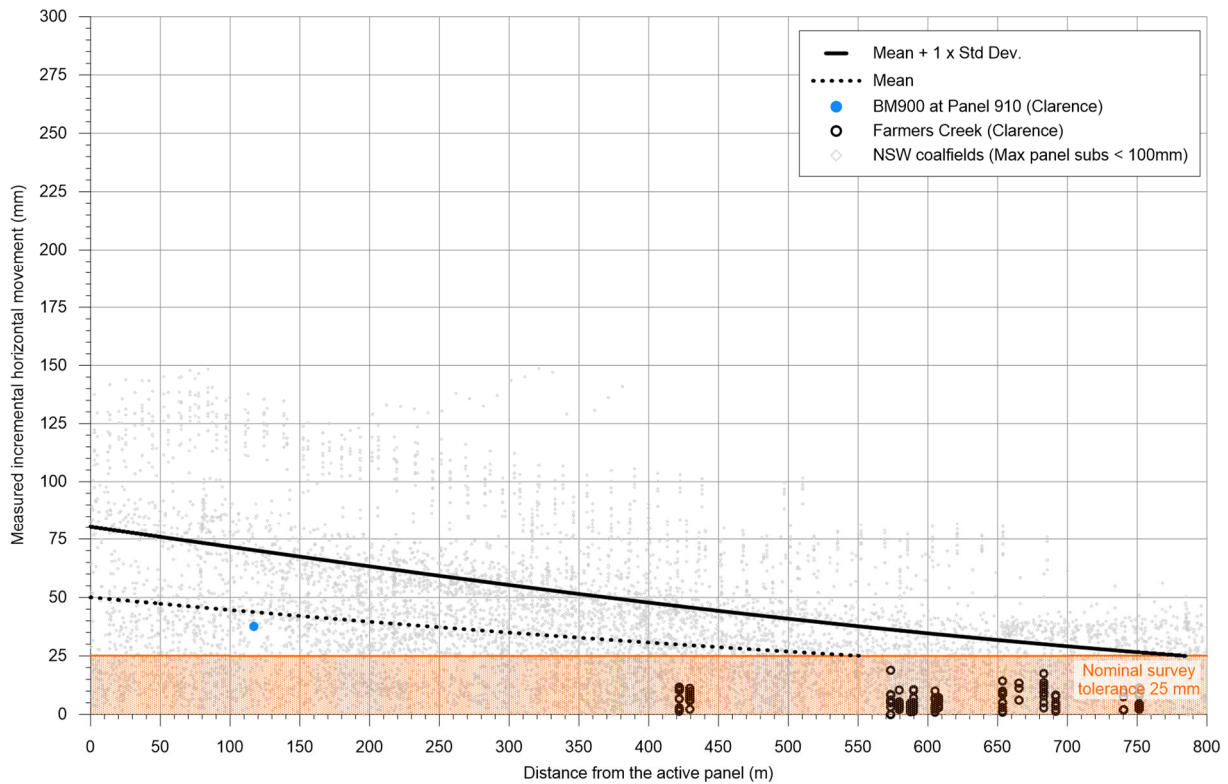


Fig. 4.3 Measured incremental far-field horizontal movements for cases where the maximum measured incremental vertical subsidence is less than 100 mm)

The fitted mean and one standard deviation curves are shown in Fig. 4.3 to illustrate the range of measured movements. At a distance of 600 m from the active panel, the measured incremental horizontal movement is less than 25 mm based on the mean and approximately 35 mm at one standard deviation. These predictions are likely to be conservative, as they are based on monitoring data that includes wider longwalls, where the potential for the redistribution of horizontal in situ stress is greater than for the proposed panels.

The far-field horizontal movements resulting from mining are generally orientated towards the extracted panels. At very low levels of far-field horizontal movements, however, there is a high scatter in the orientation of the measured movements.

The predicted far-field horizontal movements due to mining the proposed 918 Panel are expected to be small and could only be detected by precise surveys. Such movements tend to be bodily movements towards the mining area and are accompanied by very low levels of strain, generally in the order of survey tolerance (i.e. less than 0.3 mm/m). Potential impacts of far-field horizontal movements on the natural and built features within the vicinity of the panels are not expected to be significant.

As discussed in Clarence Colliery's Subsidence Monitoring Program (MSEC, 2026), GNSS units have been installed or are proposed to be installed above and to the side of the proposed 918 Panel. The GNSS units will gather valuable information on horizontal movements due to the extraction of the proposed 918 Panel.

4.7. Non-conventional ground movements

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

Numerical modelling by SCT (2026) suggests that the ground surface will experience closure of approximately 70 to 75 mm across the width of Panel 918. As SCT advises, the model has not been exhaustively validated though modelled horizontal movements were in the realm of measured horizontal movements at Airly Mine during the extraction of miniwalls MW13-16. Whilst the ground surface may experience closure across Panel 918, it is uncertain whether closure will concentrate within a valley.

The potential for non-conventional movements is considered to be very low due to the low levels of subsidence that are predicted to occur. Survey monitoring lines above previously extracted areas at Clarence have typically been installed in plateau areas, with only the 700A and 700B Lines crossing valleys, as presented in Fig. 4.1 and Fig. 4.2. No elevated compressive strains (valley closure) and no bumps in the subsidence profile (upsidence) were observed at these locations.

As discussed in Clarence Colliery's Subsidence Monitoring Program (MSEC, 2026) and Section 7 of this report, GNSS units are proposed to be installed above and to the side of proposed 918 Panel. In some cases, pairs of GNSS units have been installed on either side of valleys including Bungleboori Creek and Paddy's Creek. The GNSS units will gather valuable information on valley closure movements due to the extraction of the proposed 918 Panel.

In addition, the 900H Line crosses Bungleboori Creek to the side of sub-panel 918B1. The 900H Line is proposed to be surveyed as a 3D traverse, which provide information on absolute horizontal movements, ground strains and valley closure across Bungleboori Creek and sub-panel 918B1.

5.1. Introduction

The following sections provide the descriptions, predictions and impact assessments for the natural features identified within the Study Area, as summarised in Chapter 2. The natural features located outside the Study Area, which may be subjected to valley-related or far-field horizontal movements and may be sensitive to these effects, have also been included as part of these assessments.

5.2. Catchment Areas and Declared Special Areas

There are no drinking water catchments or declared special areas within the Study Area. There are local catchment areas associated with the streams within the Study Area, which are discussed in Section 5.3.

5.3. Streams

5.3.1. Description of the streams

The streams and tributaries are shown in Drawing No. MSEC1493-08.

The Study Area includes parts of the catchments of Bungleboori Creek and Paddy's Creek. Paddy's Creek is itself a tributary of Bungleboori Creek and discharges into Bungleboori Creek approximately 275 m south of the Study Area. Bungleboori Creek discharges into the Wollangambe River approximately 23 km downstream.

Descriptions of the streams within the Study Area are provided by GHD (2025).

The Study Area is located in the upper reaches of Bungleboori Creek, which enters from the north-western side of the Study Area. The creek is fed predominantly by shallow groundwater with ephemeral flows to the south as a third order stream. There is no proposed extraction directly beneath Bungleboori Creek.

Paddy's Creek crosses the southern end of the Study Area as an ephemeral second order stream, fed predominantly by shallow groundwater and flows into Bungleboori Creek downstream of the Study Area. There is no proposed extraction directly beneath Paddy's Creek.

A first order, ephemeral tributary to Bungleboori Creek is located directly above the 918A sub-panel and crosses directly above the 918B2 sub-panel before draining into Bungleboori Creek downstream of the Study Area.

A small first order, unnamed tributary to Bungleboori Creek is located to the north of sub-panel 918B1 and drains west out of the Study Area into Bungleboori Creek. There is no proposed extraction directly beneath this first order, ephemeral tributary.

The upper reaches of the streams within the Study Area are generally gently graded within relatively shallow incisions into the natural surface soils, which are derived from the Burrellow Formation or Banks Wall Sandstone of the Triassic Narrabeen Group. Bungleboori Creek transitions from these gentle slopes into a steep valley, and both Bungleboori Creek and Paddy's Creek transition into steep, narrow bedrock gorges downstream (to the east and south) of the Study Area.

The drainage lines of Bungleboori Creek and Paddy's Creek and their tributaries are associated with Temperate Highland Peat Swamps on Sandstone (THPSS), as described in Section 5.9.



Photograph courtesy Centennial Coal

Fig. 5.1 Upper reaches of Bungleboori Creek, looking downstream in the vicinity of minor cliff MC_32

Within the Study Area, the average natural grades are 30 mm/m (i.e. 3.0 % or 1 in 33) along Bungleboori Creek and 155 mm/m (i.e. 15.5 % or 1 in 6) along the Tributary to Bungleboori Creek which crosses sub-panels 918A and 918B2.

Further descriptions of the streams are provided by the specialist consultant on the Project.

5.3.2. Predictions for the streams

The predicted profiles of total vertical subsidence, tilt and curvature along Bungleboori Creek and Tributary to Bungleboori Creek are illustrated in Figs. C.03 and C.04, respectively, in Appendix C. A summary of the maximum predicted values of total vertical subsidence, tilt and curvatures for these streams based on the three-dimensional subsidence model is provided in Table 5.1.

Table 5.1 Maximum predicted total vertical subsidence, tilt and curvatures for the streams

Stream	Stream Order	Maximum predicted total vertical subsidence (mm)	Maximum predicted total tilt (mm/m)	Maximum predicted total hogging curvature (km ⁻¹)	Maximum predicted total sagging curvature (km ⁻¹)
Bungleboori Creek	Third order	40	0.5	< 0.01	< 0.01
Tributary to Bungleboori Creek	First order	70	0.5	0.01	0.01

The maximum predicted total vertical subsidence movements for the streams are 70 mm or less. While these streams are predicted to experience low levels of vertical subsidence, they are not predicted to experience measurable tilts or curvatures, i.e. the movements are expected to be in the order of survey tolerance.

The maximum predicted conventional strains for the streams, based on applying a factor of 10 to the maximum predicted conventional curvatures, are less than 0.3 mm/m tensile and compressive, i.e. in the order of survey tolerance.

Non-conventional strains due to valley closure are not expected to develop given the low-level vertical subsidence that is predicted to occur.

Survey monitoring lines above previously extracted areas at Clarence have typically been installed on ridges and in plateau areas, with only the 700A and 700B Lines crossing valleys, as presented in Fig. 4.1 and Fig. 4.2. No elevated compressive strains (valley closure) and no bumps in the subsidence profile (upsidence) were observed at these locations.

A prediction of valley closure and upsidence was conducted using the 2002 ACARP valley closure prediction model. Whilst predicted maximum closure and upsidence were approximately 25 mm for both Bungleboori Creek and the Tributary to Bungleboori Creek, the prediction model is based primarily on empirical data gathered from underground mining in the Southern Coalfield, where the magnitudes of observed subsidence are substantially greater than predicted for 918 Panel. The predicted compressive strains due to the valley closure effects are 0.3 mm/m or less along both streams.

5.3.3. Impact assessments for streams

The impact assessments for the streams are provided in the following sections. The assessments provided in this report should be read in conjunction with the assessments provided by the other specialist consultants on the Project.

Potential for increased levels of ponding, flooding and scouring

In some cases, mining can potentially result in increased levels of ponding in locations where the mining-induced tilts oppose and are greater than the natural stream gradients that exist before mining. Mining can also potentially result in an increased likelihood of scouring of the stream beds in the locations where the mining-induced tilts considerably increase the natural stream gradients that exist before mining.

The proposed extraction of the 918A, 918B1 and 918B2 sub-panels is expected to result in tilts along the alignments of the streams of 0.5 mm/m (i.e. 0.05 % or 1 in 2000) or less. The predicted mining-induced tilts are very small compared to the average natural grades of the streams within the Study Area, which are 30 mm/m (i.e. 3.0 % or 1 in 33) for Bungleboori Creek and 155 mm/m (i.e. 15.5 % or 1 in 6) for the tributary to Bungleboori Creek which crosses sub-panels 918A and 918B2.

It is unlikely, therefore, that the mining-induced tilts would have an adverse impact on ponding, flooding and scouring of the streams. No adverse impacts to streams have previously been observed due to partial extraction directly beneath streams at Clarence (Centennial, 2023, 2024, 2025a and 2025b), even where subsidence movements have been in the order of 100 mm to 200 mm.

Potential for cracking in the stream beds and fracturing of bedrock

Fracturing in bedrock has been observed due to previous mining in the NSW coalfields where the tensile strains have been greater than 0.5 mm/m or where the compressive strains have been greater than 2 mm/m.

The maximum predicted strains above the 918 Panel are 0.3 mm/m tensile and compressive. It is considered unlikely, therefore, that fracturing of the bedrock would occur beneath the surface soils of the streams within the Study Area.

The mining-induced opening based on a maximum predicted tensile strain of 0.3 mm/m and an average joint spacing of 10 m is approximately 3 mm. It is unlikely that surface cracking would be visible at the surface due to the plastic nature of the overlying soils along the alignments of the streams.

Surface cracking has not previously been observed along the streams due to partial extraction directly beneath them at Clarence (Centennial, 2023, 2024, 2025a and 2025b), even where subsidence movements have been in the order of 100 mm to 200 mm. It is therefore considered unlikely that surface cracking would develop along the streams within the Study Area due to the extraction of the 918 sub-panels.

5.3.4. Impact assessments for the streams based on the actual movements exceeding predictions

The maximum tilts for the tributaries if the actual movements exceeded the predictions by a factor of two times would be 0.6 mm/m for Bungleboori Creek and 0.8 mm/m for the Tributary to Bungleboori Creek. The maximum tilts for Paddy's Creek and the tributaries to Bungleboori Creek would be less than 0.5 mm/m.

The changes in grade along the tributaries would still be small compared to their existing average natural grades (i.e. 30 mm/m and 155 mm/m) if the actual mining-induced tilts exceeded the predictions by a factor of two times. It would still be unlikely, therefore, that the mining-induced tilts would have an adverse impact on ponding, flooding and scouring of the streams.

The maximum strains for the tributaries if the actual movements exceeded the predictions by a factor of two times would be 0.6 mm/m tensile and compressive.

It is possible that minor and isolated fracturing could occur in the bedrock below the tributaries if the actual mining-induced strains exceed the predictions by a factor of two. However, it would still be unlikely that cracking would be visible at the surface due to the plastic nature of the overlying soils along the alignments of the streams.

This is supported by the observations that surface cracking has not previously been observed along the streams due to partial extraction directly beneath them at Clarence (Centennial, 2023, 2024, 2025a and 2025b), even where actual subsidence movements have been in the order of two times those predicted for the proposed panels.

It is therefore considered unlikely that adverse impacts would occur along the streams within the Study Area due to the extraction of the proposed 918 Panel, even if the actual movements exceeded the predictions by a factor of two times.

5.3.5. Recommendations for streams

It is recommended that Clarence monitor the condition of streams within the Study Area prior to, during and after mining. Monitoring and management of potential impacts on streams is described in the 918 Panel Water Management Plan (Centennial, 2025d). Monitoring includes visual inspections and surface level and water quality monitoring of the streams within the Study Area before, during and after the extraction of 918 Panel.

5.4. Aquifers and known groundwater resources

Descriptions, predictions and the assessment of potential impacts on the aquifers and groundwater resources within the Study Area are provided by SCT (2026) and the specialist groundwater consultant JBSG, (2026) on the Project.

SCT advises that the groundwater system at Clarence consists of an upper (shallow and perched) water table and a lower (deep) water table. The groundwater data indicates that the Mt York Claystone, which is approximately 110 metres above the 918 Panel, forms the lower boundary of the upper water table. SCT (2026) advises that modelling assessment indicates mining-induced caving fractures extend to a maximum of 90 metres above the mining horizon.

Clarence's experience and groundwater observations from partial pillar extraction using single and double-sided lifting indicates that these mining methods do not reduce the pore pressure in the upper water table where panel widths are similar to the proposal 918 Panel (SCT, 2026). SCT (2026) advises that pore pressure reduction is likely to occur below the Mt York Claystone but not reduce pore pressure in the perched and shallow water tables.

Further details are provided in the reports by SCT (2026) and JBSG (2026).

It is recommended that Clarence monitor the condition of groundwater within the Study Area prior to, during and after mining. Monitoring and management of potential impacts on groundwater is described in the 918 Panel Water Management Plan (Centennial, 2025d). Monitoring includes groundwater level, piezometer and water quality monitoring before, during and after the extraction of 918 Panel.

5.5. Springs and groundwater seeps

There are natural springs and groundwater seeps within the Study Area, which are described by the specialist groundwater consultant (JBSG, 2026) on the Project.

5.6. Cliffs, minor cliffs, pagodas and gorges

5.6.1. Description of the cliffs, minor cliffs, pagodas and gorges

The cliffs, minor cliffs and pagodas are shown in Drawing No. MSEC1495-09.

The definitions of a cliff, minor cliff and pagoda adopted in this report are provided below:

Cliff	A continuous rock face, including overhangs, with a minimum length of 20 m, a minimum height of 10 m and a minimum slope of 2 to 1 (i.e. 63.4°).
Minor Cliff	A continuous rock face, including overhangs, with a minimum length of 20 m, height between 5 m and 10 m and a minimum slope of 2 to 1 (i.e. 63.4°).
Pagoda	A conical or sub-conical rock formation, whether smooth, platy, stepped, or terraced.
Gorge	A deep, narrow valley with cliffs on both sides.

Cliffs, minor cliffs and pagodas were identified by others using a combination of desktop analyses of topographic and photographic (aerial and drone) data and field surveys by Centennial. The cliffs are generally located along Bungleboori Creek and the lower reaches of Paddy's Creek. Three pagodas have been identified at the southern end of the Study Area beyond sub-panel 918A.

A summary of the cliffs, minor cliffs and pagodas identified within the Study Area is provided in Table 5.2.

Table 5.2 Cliffs, minor cliffs and pagodas identified within the Study Area

Reference	Type	Overall length measured using LiDAR (m)	Maximum height measured using LiDAR(m)	Location
C_01	Cliff	62	14	40 m southeast of Panel 918A
C_15	Cliff	27	16	115 m southeast of Panel 918A
C_18	Cliff	31	14	85 m south of Panel 918B2
C_23	Cliff	100	18	100 m east of Panel 918B2
C_37	Cliff	82	15	105 m south of Panel 918B2
MC_03	Minor cliff	20	8	30 m east of Panel 918A
MC_05	Minor cliff	26	8	30 m east of Panel 918A
MC_16	Minor cliff	34	9	105 m southeast of Panel 918A
MC_25	Minor cliff	31	6	110 m east of Panel 918B2
MC_32	Minor cliff	31	7	95 m northeast of Panel 918A
MC_33	Minor cliff	51	6	45 m southwest of Panel 918B1
MC_42	Minor cliff	23	6	125 m southeast of Panel 918B2
P_08	Pagoda	5	3	130 m southeast of Panel 918A
P_09	Pagoda	13	3	115 m southeast of Panel 918A
P_48	Pagoda	5	2	90 m southeast of Panel 918A

There are five cliffs, seven minor cliffs and three pagodas identified entirely within or partly within the Study Area. None of the cliffs, minor cliffs or pagodas are located directly above the proposed 918A, 918B1 and 918B2 sub-panels. No gorges were identified within the Study Area.

The cliffs are formed in the Banks Wall Sandstone (SCT, 2026) and natural weathering processes were observed throughout the Study Area and surrounding areas. Naturally weathered features observed around the cliffs, minor cliffs and pagodas include small overhangs, vertical joints, and differential weathering of horizontal bands within the cliffs. Examples of these are shown in photographs of cliffs, minor cliffs and rock features located within 100 m of the proposed 918 sub-panels, included as Fig. 5.2 to Fig. 5.6.



Fig. 5.2 Cliff C_01 located 40 m south-east of Panel 918A (Centennial, 2025c)



Fig. 5.3 Cliff C_18 located 85 m south of Panel 918B2 (Centennial, 2025c)



Fig. 5.4 Cliff C_23 located 100 m east of Panel 918B2 (Centennial, 2025c)



Fig. 5.5 Minor cliff MC_03 located 30 m east of Panel 918A (Centennial, 2025c)



Fig. 5.6 Pagodas P_08 and P_09 located south of Panel 918A in the vicinity of Paddy's Creek Shrub Swamp (Centennial, 2025c)

5.6.2. Predictions for the cliffs, minor cliffs and pagodas

A summary of the maximum predicted values of total vertical subsidence, tilt and curvatures for the cliffs, minor cliffs and pagodas based on the three-dimensional subsidence model is provided in Table 5.3. The values are the maximum predicted subsidence effects within 20 m of the mapped extents of the cliffs after the extraction of the three 918 sub-panels.

The maximum predicted vertical subsidence for the cliffs and minor cliffs is 40 mm. While these features could experience low levels of vertical subsidence, they are not expected to experience measurable tilts, curvatures or strains.

Similarly, the three pagodas within the Study Area boundary are not expected to experience measurable subsidence, tilts, curvatures or strains.

Table 5.3 Maximum predicted total vertical subsidence, tilt and curvatures for the cliffs, minor cliffs and pagodas

Feature	Location	Maximum predicted total vertical subsidence (mm)	Maximum predicted total tilt (mm/m)	Maximum predicted total hogging curvature (km ⁻¹)	Maximum predicted total sagging curvature (km ⁻¹)
C_01	40 m southeast of Panel 918A	25	< 0.5	< 0.01	< 0.01
C_15	115 m southeast of Panel 918A	< 20	< 0.5	< 0.01	< 0.01
C_18	85 m south of Panel 918B2	25	< 0.5	< 0.01	< 0.01
C_23	100 m east of Panel 918B2	20	< 0.5	< 0.01	< 0.01
C_37	105 m south of Panel 918B2	20	< 0.5	< 0.01	< 0.01
MC_03	30 m east of Panel 918A	30	< 0.5	< 0.01	< 0.01
MC_05	30 m east of Panel 918A	40	< 0.5	< 0.01	< 0.01
MC_16	105 m southeast of Panel 918A	< 20	< 0.5	< 0.01	< 0.01
MC_25	110 m east of Panel 918B2	25	< 0.5	0.01	< 0.01
MC_32	95 m northeast of Panel 918A	< 20	< 0.5	< 0.01	< 0.01
MC_33	45 m southwest of Panel 918B1	35	0.5	0.01	< 0.01
MC_42	125 m southeast of Panel 918B2	< 20	< 0.5	< 0.01	< 0.01
P_08	130 m southeast of Panel 918A	< 20	< 0.5	< 0.01	< 0.01
P_09	115 m southeast of Panel 918A	< 20	< 0.5	< 0.01	< 0.01
P_48	90 m southeast of Panel 918A	< 20	< 0.5	< 0.01	< 0.01

The maximum predicted conventional strains for the cliffs, minor cliffs and pagodas, based on applying a factor of 10 to the maximum predicted conventional curvatures, are less than 0.3 mm/m tensile and compressive, i.e. in the order of survey tolerance. Non-conventional strains are not expected to develop given the low-level predicted vertical subsidence that develops due to pillar compression rather than sag subsidence.

5.6.3. Impact assessments for cliffs, minor cliffs and pagodas

The cliffs, minor cliffs and pagodas are predicted to experience very low-level subsidence effects due to the extraction of the proposed 918 Panels. The mining-induced tilts, curvatures and strains are not expected to be measurable.

The cliffs and minor cliffs are also located in isolated locations and are relatively short in length, which limits the potential for mining-induced ground strains to accumulate and build up stress along the cliff lines. Pagodas are by their nature isolated structures with relatively small perimeter lengths, which similarly limits the potential for mining-induced ground strains to accumulate and build up stress within these features.

Adverse impacts have not previously been observed due to partial extraction directly beneath or adjacent to cliffs, minor cliffs or pagodas at Clarence. This includes cliffs that were directly mined beneath or adjacent to previously extracted Panels 910 to 906 (Centennial, 2023, 2024 and 2025a).

Based on the low-level predicted subsidence effects and the observations of cliffs located above previous mining at Clarence, it is considered unlikely that the cliffs, minor cliffs or pagodas within the Study Area would experience adverse impacts due to the extraction of the proposed 918A, 918B1 and 918B2 sub-panels.

5.6.4. Impact assessments for the cliffs based on the actual movements exceeding predictions

The maximum tilts for the cliffs, minor cliffs and pagodas if the actual movements exceeded the predictions by a factor of two times would be 1.0 mm/m at MC_33 and less than 0.8 mm/m at the remaining cliffs, minor cliffs and pagodas.

The changes in slope of the rockfaces would be very small (i.e. in the order of 1 %) and would still be unlikely to have an adverse impact on the cliffs.

The maximum strains for the cliffs, minor cliffs and pagodas if the actual movements exceeded the predictions by a factor of two times would be less than 0.6 mm/m tensile and compressive. The predicted strains at the cliffs, minor cliffs and pagodas located more than 50 m from the sub-panels would still be less than 0.3 mm/m.

It is possible but unlikely that minor and isolated fracturing could occur in the rockfaces closest to the mining area (i.e. C_01, MC_03, MC_05 and MC_33) if the actual mining-induced strains exceed the predictions by a factor of two times. However, it would still be unlikely that rockfalls or cliff instabilities would occur.

This is supported by the observations that adverse impacts have not previously been observed at the cliffs due to partial extraction adjacent beneath them at Clarence (Centennial, 2023, 2024 and 2025a), even where actual subsidence movements have been in the order of two times those predicted for the proposed panels.

It is therefore considered unlikely that adverse impacts would occur to the cliffs, minor cliffs or pagodas within the Study Area due to extraction of the proposed 918A, 918B1 and 918B2 sub-panels, even if the actual movements exceeded the predictions by a factor of two times.

5.6.5. Recommendations for cliffs

It is recommended that visual inspections are carried out of the cliffs, minor cliffs and pagodas within the Study Area after the extraction of 918 Panel. Monitoring and management of potential impacts on cliffs is described in the 918 Panel Land Management Plan (Centennial, 2025c). Monitoring includes visual inspections and ground surveys before, during and after the extraction of 918 Panel. Monitoring data from existing and proposed survey lines and GNSS units will be compared to the predictions presented in Table 5.3, to verify the subsidence model.

5.7. Steep slopes

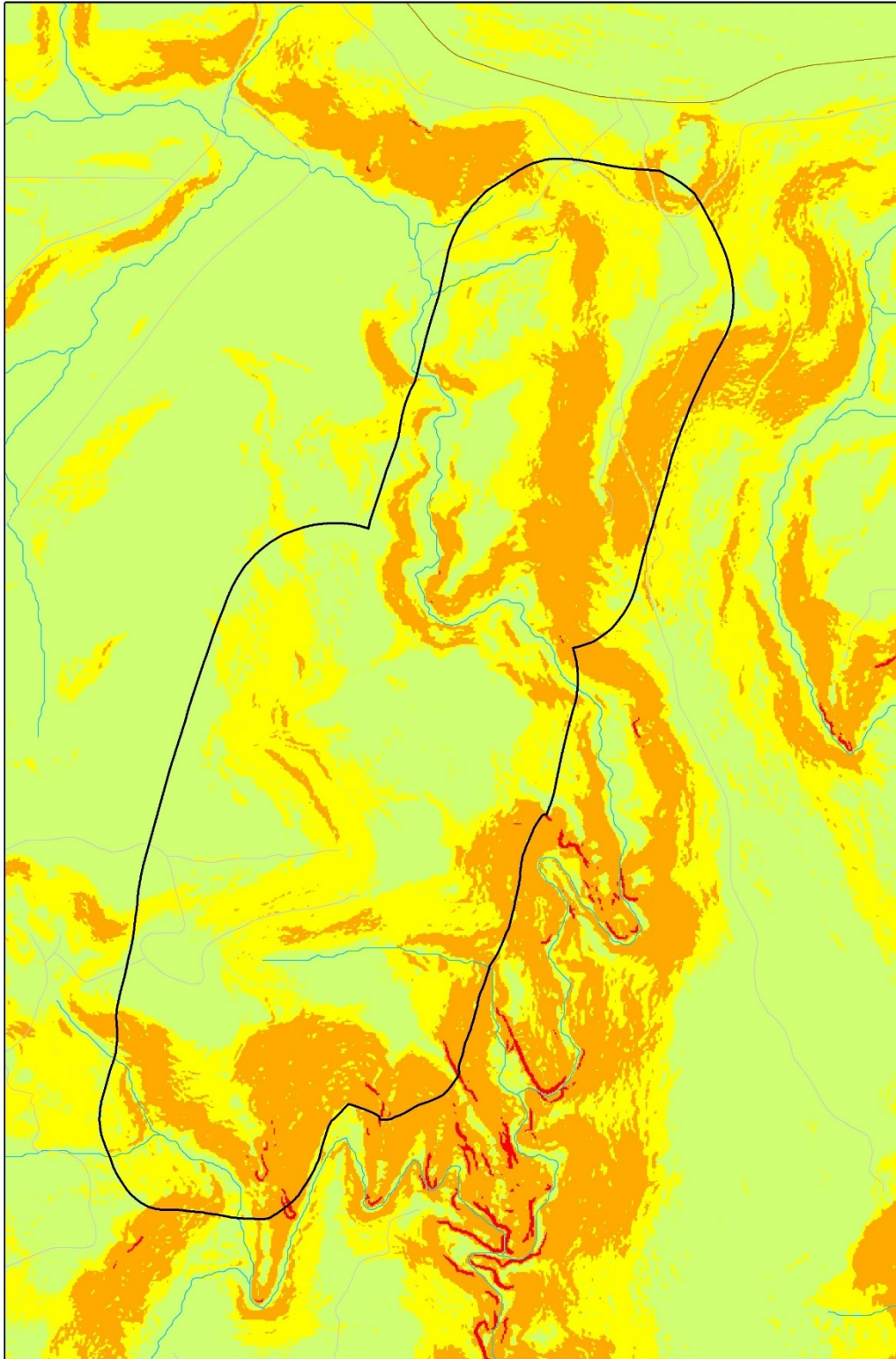
5.7.1. Descriptions of the steep slopes

The steep slopes are shown in Drawing No. MSEC1493-09. The definition of a steep slope adopted in this report is provided below:

Steep slope An area of land having a natural gradient between 1 in 3 (i.e. 33 % or 18.3°) and 2 in 1 (i.e. 200 % or 63.4°).

A detailed study has been carried out on the topography within the Study Area, using a combination of desktop analyses of topographic and field investigations. The steep slopes comprise 25% of the Study Area and are generally located along the alignments of the streams and tributaries within the Study Area.

The surface topography has been further classified as *Gentle* (0° to 10°), *Moderate* (10° to 18°), *Steep* (18° to 63.4°) and *Cliffs* (greater than 63.4°) consistent with descriptions published by the Australian Geomechanics Society (AGS, 2007). These surface slope classifications are illustrated in Fig. 5.7.



Legend

- Hydroline (EMM)
- Local road (DSC Spatial Services)
- Vehicle track (DSC Spatial Services)
- Angle of draw
- Gentle (0° to 10°)
- Moderate (10° to 18°)
- Steep (18° to 63.4°)
- Cliff (> 63.4°)



Fig. 5.7 Surface slope classification

A summary of the slope classifications within the Study Area is provided in Table 5.4. The majority of the terrain consists of gentle and moderate slopes.

Table 5.4 Slope classification within the Study Area

Slope Description	Grade (%)	Slope (°)	Slope (rise:run)	Area (ha)	Area (%)
Gentle	< 18 %	< 10°	< 1:6	32.0	36.6%
Moderate	18 % to 33 %	10° to 18.3°	1:6 to 1:3	33.5	38.3%
Steep	33 % to 200 %	18.3° to 63.4°	1:3 to 2:1	21.9	25.0%
Cliff	> 200 %	> 63.4°	> 2:1	< 0.2	< 0.5%
Total				87.5	100%

5.7.2. Predictions for the steep slopes

A summary of the maximum predicted values of total vertical subsidence, tilt and curvatures for the steep slopes based on the three-dimensional subsidence model is provided in Table 5.5. The values are the maximum predicted subsidence effects within the mapped extents of the steep slopes after the extraction of all panels.

Table 5.5 Maximum predicted total vertical subsidence, tilt and curvatures for the steep slopes

Location	Maximum predicted total vertical subsidence (mm)	Maximum predicted total tilt (mm/m)	Maximum predicted total hogging curvature (km ⁻¹)	Maximum predicted total sagging curvature (km ⁻¹)
Steep slopes above Panel 918A	50	< 0.5	< 0.01	< 0.01
Steep slopes above Panel 918B1	60	0.5	0.01	< 0.01

The maximum predicted total vertical subsidence for the steep slopes is 60 mm. The maximum predicted tilt is 0.5 mm/m (i.e. 0.05 % or 1 in 2000). The maximum predicted curvatures are 0.01 km⁻¹ hogging and less than 0.01 km⁻¹ sagging and they represent minimum radii of curvature of 100 km and greater than 100 km, respectively. The maximum predicted subsidence effects for the mapped steep slopes occur above the eastern end of Panel 918B1.

The maximum predicted conventional strains for the steep slopes, based on applying a factor of 10 to the maximum predicted conventional curvatures, are less than 0.3 mm/m tensile and compressive, i.e. in the order of survey tolerance. Non-conventional strains are not expected to develop given the low-level predicted vertical subsidence that develops due to pillar compression rather than sag subsidence.

5.7.3. Impact assessments for the steep slopes

The maximum predicted tilt for the steep slopes is orders of magnitude less than the natural grades. The mining-induced strains are not expected to be measurable.

Adverse impacts have not previously been observed due to partial extraction directly beneath steep slopes at Clarence (Centennial, 2023, 2024 and 2025a), even where actual vertical subsidence movements have been in the order of 100 mm to 200 mm. Based on the above and the low-level predicted subsidence effects, it is considered unlikely that surface cracking would develop along the steep slopes within the Study Area due to the extraction of the 918 sub-panels.

5.7.4. Impact assessments for the steep slopes based on the actual movements exceeding predictions

The maximum tilts for the steep slopes if the actual movements exceeded the predictions by a factor of two times would be 1.0 mm/m above Panel 918B1 and less than 1.0 mm/m elsewhere.

The changes in grade of the steep slopes would be very small (i.e. in the order of 1 %) and would be an order of magnitude less than the natural grades (which are greater than 33 mm/m or 33 %). It would still be unlikely that the mining-induced tilts would have an adverse impact on the steep slopes.

The maximum strains for the steep slopes if the actual movements exceeded the predictions by a factor of two times would be less than 0.6 mm/m tensile and compressive.

It is possible that minor and isolated fracturing could occur in the bedrock below the steep slopes if the actual mining-induced strains exceed the predictions by a factor of two. However, it would still be unlikely that cracking would be visible at the surface due to the plastic nature of the overlying soils. It would also be unlikely that large-scale slope instabilities would occur along the steep slopes due to the low-level movements.

This is supported by the observations that adverse impacts have not previously been observed at the steep slopes due to partial extraction directly beneath them at Clarence (Centennial, 2024 and 2025), even where actual subsidence movements have been in the order of two times those predicted for the proposed panels.

It is therefore considered unlikely that adverse impacts would occur to the steep slopes within the Study Area due to the extraction of the 918 sub-panels, even if the actual movements exceeded the predictions by a factor of two times.

5.7.5. Recommendations for the steep slopes

It is recommended that visual inspections are carried out of the steep slopes above the mining area after the extraction of 918 Panel. Monitoring and management of potential impacts on steep slopes is described in the 918 Panel Land Management Plan (Centennial, 2025c). Monitoring includes visual inspections and ground surveys before, during and after the extraction of 918 Panel. Monitoring data from existing and proposed survey lines and GNSS units will be compared to the predictions presented in Table 5.5, to verify the subsidence model. In particular, the proposed extension of the 900H-Line above and to the east of the 918B1 panel will cross identified steep slopes within the Study Area.

5.8. Land prone to flooding or inundation

The terrain within the Study Area is located in the upper reaches of the stream catchments. There is no land considered to be prone to flooding within the Study Area.

5.9. Swamps

5.9.1. Descriptions of the swamps

The swamps as mapped by RPS (2025) are shown in Drawing No. MSEC1493-08.

The swamps in the region are examples of Temperate Highland Peat Swamps on Sandstone (THPSS) and include both *Newnes Plateau Shrub Swamps* (shrub swamps) and *Newnes Plateau Hanging Swamps* (hanging swamps), together referred to as "swamps". The swamps within the Study Area are predominantly shrub swamps along the drainage lines of Bungleboori Creek and Paddy's Creek and their tributaries.

The swamps have generally formed and are best developed and larger within broader valleys on the Buralow Formation, where they are fed predominantly by perched and shallow groundwater systems and also minor, rainfall-activated watercourses flowing down the valley sides. The lower catchment swamps are formed within slightly more incised valleys on the Banks Wall Sandstone.

A summary of the swamps identified within the Study Area is provided in Table 5.6. Note that there are several discrete swamps with the same name within the Study Area.

Table 5.6 Swamps identified within the Study Area

Name	Type	Location	Photograph
Lower Nine Mile Swamp	Shrub	Along Bungleboori Creek: north of Panels 918A and 918B2 and south of Panel 918B1; also east of Panel 918B2	Fig. 5.8
Lower Nine Mile Swamp	Hanging	Adjacent to Bungleboori Creek: north of Panel 918A; also east of Panel 918B2; also south-east of Panel 918B2	Fig. 5.9
Paddy's Creek	Shrub	Along Tributary to Paddy's Creek, south of Panel 918A	Fig. 5.10
Paddy's Creek	Hanging	Along Tributary to Bungleboori Creek, upstream end directly above edge of Panel 918B2; also east of Panel 918A and south of Panel 918B2	Fig. 5.11

The remaining swamps outside of the Study Area are located approximately 130 m from Panels 918A, 918B1 and 918B1 at their closest point. These remaining swamps are not anticipated to experience measurable conventional or far-field effects due to the extraction of the proposed sub-panels and therefore they have not been considered further in this report.

The shrub swamps are listed as an endangered ecological community (EEC) under the NSW *Biodiversity Conservation Act 2016* and provide important habitat for a range of plants and animals. The shrub and hanging swamps have been classified as *Temperate Highland Peat Swamps on Sandstone* (THPSS) under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

Further descriptions of the swamps within the Study Area are provided by RPS (2025) and GHD (2025).



Fig. 5.8 Lower section of Lower Nine Mile Shrub Swamp from monitoring point BC3 on Bungleboori Creek between sub-panels 918B1 and 918B2 (GHD, 2025)



Fig. 5.9 Lower Nine Mile Hanging Swamp at sharp bend in Bungleboori Creek to the east of sub-panel 918B2 (GHD, 2025)



Fig. 5.10 Paddy's Creek Shrub Swamp from monitoring point PC1_1 on Paddy's Creek to the south of sub-panel 918A (GHD, 2025)



Fig. 5.11 Paddy's Creek Hanging Swamp, viewed to NNW from monitoring point PC2 on Paddy's Creek (GHD, 2025)

5.9.2. Predictions for the swamps

The predicted profiles of total vertical subsidence, tilt and curvature along Bungleboori Creek and Tributary to Bungleboori Creek are provided in Figs. C.03 and C.04, respectively, in Appendix C. The locations of the swamps are shown on these figures.

A summary of the maximum predicted total vertical subsidence, tilt and curvatures for the swamps within the Study Area based on the three-dimensional subsidence model is provided in Table 5.7. The values are the maximum predicted subsidence effects within 20 m of the mapped extents of the swamps after the extraction of all panels.

It is noted that the maximum predicted subsidence effects for the swamps provided in Table 5.7 are, in some cases, greater than the maximum predicted subsidence effects for the tributaries provided in Table 5.1 and illustrated in Figs. C.03 to C.04. The reason is the swamps extend over a wider area above the panels including the 20 m offset around their mapped boundaries. Also, the predicted tilts and strains for the swamps are the maximum in any direction, rather than along the alignments of the tributaries.

Table 5.7 Maximum predicted total vertical subsidence, tilt and curvature for the swamps

Location	Maximum predicted total vertical subsidence (mm)	Maximum predicted total tilt (mm/m)	Maximum predicted total hogging curvature (km ⁻¹)	Maximum predicted total sagging curvature (km ⁻¹)
Lower Nine Mile Shrub Swamp (Bungleboori Creek)	40	0.5	0.01	< 0.01
Lower Nine Mile Hanging Swamp (Bungleboori Creek and Tributary to Bungleboori Creek)	40	0.5	0.01	< 0.01
Paddy's Creek Shrub Swamp (Tributary to Paddy's Creek)	< 20	< 0.5	< 0.01	< 0.01
Paddy's Creek Hanging Swamp (Tributary to Bungleboori Creek and Paddy's Creek)	60	0.5	0.01	0.02

The maximum predicted vertical subsidence for the swamps is 60 mm. The maximum predicted tilt is 0.5 mm/m (i.e. 0.05 % or 1 in 2000). The maximum predicted total conventional curvatures are 0.01 km⁻¹ hogging and 0.02 km⁻¹ sagging and they represent minimum radii of curvature of 100 km and 50 km, respectively. The maximum predicted subsidence effects for the swamps occur at Paddy's Creek Hanging Swamp along Tributary to Bungleboori Creek above the eastern edge of Panel 918B2.

The maximum predicted conventional strains for the swamps, based on applying a factor of 10 to the maximum predicted conventional curvatures, are less than 0.3 mm/m tensile and compressive, i.e. in the order of survey tolerance.

As discussed in Section 5.3.2, the potential for non-conventional valley closure and upsidence movements is considered to be low given the low-level predicted vertical subsidence that is predicted to occur.

Predicted total vertical subsidence contours are shown for swamps along Bungleboori Creek, Tributary to Bungleboori Creek and Paddy's Creek near Panels 918A, 918B1 and 918B2 in Fig. 5.12. The maximum predicted vertical subsidence movements provided in Table 5.7 are greater than those illustrated by the contours, as they are the maximum values within 20 m of the mapped extents of the swamps.

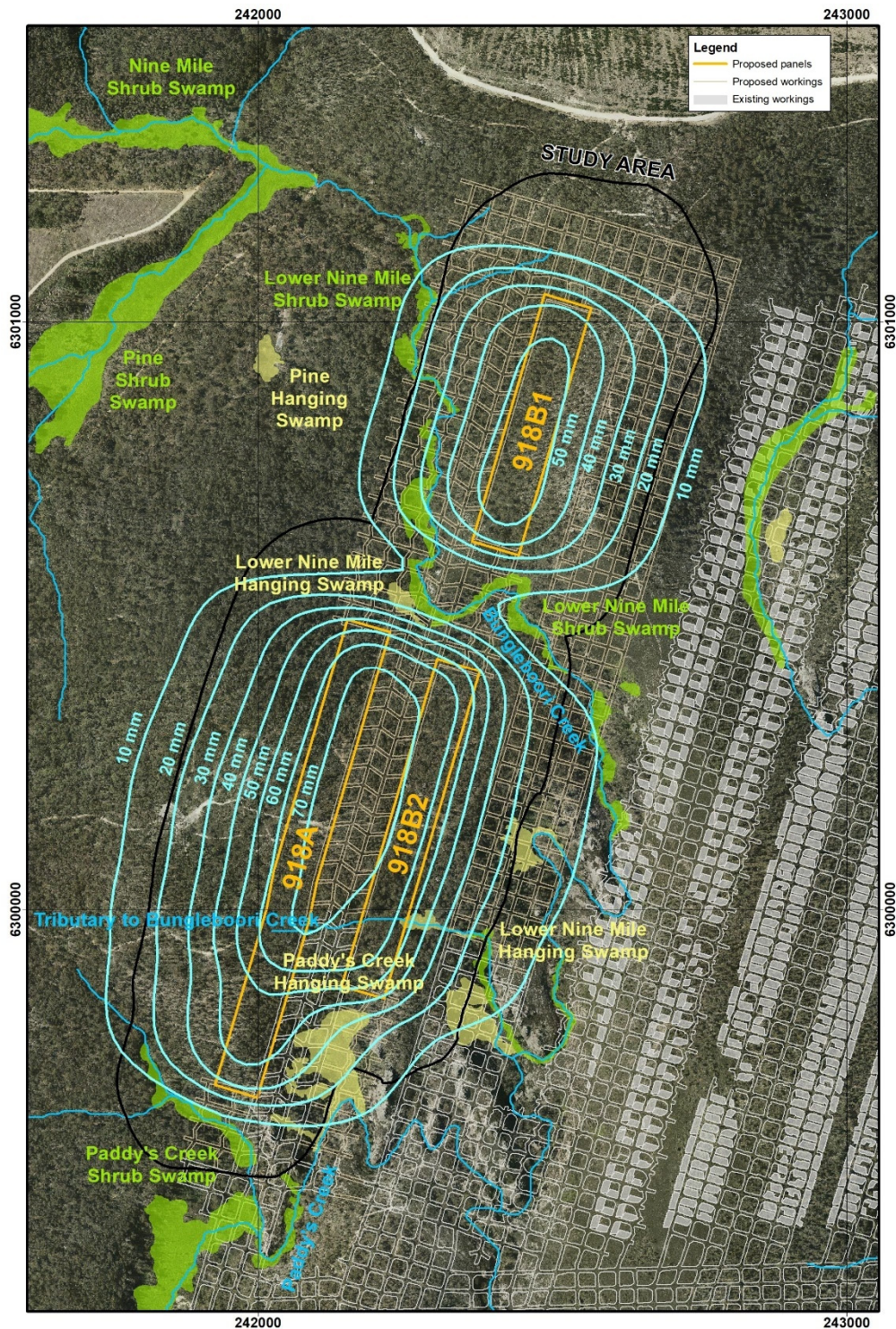


Fig. 5.12 Predicted total vertical subsidence for swamps due to the extraction of Panels 918A, 918B1 and 918B2

5.9.3. Impact assessments for the swamps

The assessments of the potential physical impacts (i.e. soil cracking and rock fracturing) on the swamps are provided in the following sections. The assessments of the potential environmental consequences are provided in the reports by the other specialist consultants on the Project. The discussions provided in this report should be read in conjunction with those provided in the reports by the other specialist consultants.

Potential for changes in surface water flows due to mining-induced tilts

Mining can potentially affect surface water flows through swamps, if the mining-induced tilts are much greater than the natural gradients, potentially resulting in increased levels of ponding or scouring, or affecting the distribution of the water within the swamps.

The maximum predicted tilt for the swamps is 0.5 mm/m (i.e. 0.05 % or 1 in 2000). The maximum predicted tilt along the alignment of the streams within the swamps is less than 0.5 mm/m (i.e. 0.05 % or 1 in 2000). The predicted mining-induced tilts are very small compared to the average natural grades of the streams within the Study Area which vary between 30 mm/m (i.e. 3.0 % or 1 in 33) and 155 mm/m (i.e. 15.5 % or 1 in 6).

It is unlikely, therefore, that the mining-induced tilts would have an adverse impact on ponding, flooding and scouring of the swamps. No adverse impacts to swamps have previously been observed due to partial extraction directly beneath swamps at Clarence (Centennial, 2023, 2024, 2025a and 2025b), even where actual subsidence movements have been in the order of 100 mm to 200 mm. This includes parts of the Paddy's Creek Shrub Swamp located at the southern end of the Study Area.

Potential for cracking in the swamps and fracturing of bedrock

Fracturing in bedrock has been observed due to previous mining in the NSW coalfields where the tensile strains have been greater than 0.5 mm/m or where the compressive strains have been greater than 2 mm/m.

The predicted strains above the 918 sub-panels are less than 0.3 mm/m tensile and compressive, i.e. in the order of survey tolerance. It is considered unlikely, therefore, that fracturing of the bedrock would occur beneath the surface soils of the swamps within the Study Area.

The mining-induced opening based on a maximum predicted tensile strain of less than 0.3 mm/m and an assumed average joint spacing of 10 m is approximately 3 mm. It is unlikely that surface cracking would be visible at the surface due to the plastic nature of the overlying soils within the swamps and highly unlikely that it would induce a perceptible impact on groundwater levels.

Surface cracking has not previously been observed at the swamps due to partial extraction directly beneath them at Clarence (Centennial, 2023, 2024, 2025a and 2025b). Furthermore, groundwater monitoring within those swamps has not detected perceptible impacts on groundwater levels during the extraction of Panels 910 to 906 beneath Pagoda Swamp (i.e. groundwater has not drained) (SCT, 2026). It is therefore considered unlikely that surface cracking would develop at the swamps within the Study Area due to the extraction of Panels 918A, 918B1 and 918B2.

Further discussions on the potential impacts on the swamps are provided by the specialist ecology, surface water and groundwater consultants on the Project.

5.9.4. Impact assessments for the swamps based on the actual movements exceeding predictions

The maximum tilts for the swamps if the actual movements exceeded the predictions by a factor of two times would be 1 mm/m at the Lower Nine Mile Hanging Swamp and Lower Nine Mile Shrub Swamp along Bungleboori Creek, and less than 1.0 mm/m at the remaining swamps.

The changes in grade within the swamps would still be small compared to their existing average natural grades along the tributaries within the swamps or on the valley-sides (i.e. 30 mm/m to 155 mm/m or greater) even if the actual mining-induced tilts exceeded the predictions by a factor of two times. It would still be unlikely, therefore, that the mining-induced tilts would have an adverse impact on ponding, flooding and scouring of the swamps.

The maximum strains for the swamps if the actual movements exceeded the predictions by a factor of two times would be less than 0.6 mm/m tensile and compressive.

It is possible that minor and isolated fracturing could occur in the bedrock below the swamps if the actual mining-induced strains exceed the predictions by a factor of two times. However, it would still be unlikely that cracking would be visible at the surface due to the plastic nature of the overlying soils within the swamps and highly unlikely that it would induce a perceptible impact on groundwater levels.

This is supported by the observations that surface cracking has not previously been observed within swamps due to partial extraction directly beneath them at Clarence (Centennial, 2023, 2024, 2025a and 2025b).

It is therefore considered unlikely that adverse impacts would occur to the swamps within the Study Area due to the extraction of the 918 sub-panels, even if the actual movements exceeded the predictions by a factor of two times.

5.9.5. Recommendations for the swamps

It is recommended that visual inspections, groundwater and biodiversity monitoring are carried out of the swamps above and adjacent to the mining area after the extraction of 918 Panel. Monitoring and management of potential impacts on swamps is described in the 918 Panel Water Management Plan (Centennial, 2025d). Monitoring includes visual inspections and ground surveys before, during and after the

extraction of 918 Panel. Clarence also propose to conduct shallow groundwater monitoring in or around swamps within the Study Area.

5.10. Water related ecosystems

The water related ecosystems within the Study Area are described in the 918 Panel Biodiversity Management Plan (RPS, 2025).

5.11. Threatened or protected species

The threatened and Protected species within the Study Area are described in the 918 Panel Biodiversity Management Plan (RPS, 2025).

5.12. National Parks or Wilderness Areas

There are no National Parks or Wilderness Areas within the Study Area.

The Blue Mountains National Park is located outside the Study Area, and the boundary of the National Park is located more than 5 km to the east and south-east of the proposed Panel 918.

At these distances, the Blue Mountains National Park is not expected to experience measurable conventional subsidence effects due to the extraction of the 918 sub-panels, even if the actual movements exceeded by the predictions by a factor of two times.

5.13. State Forests, State Recreation or Conservation Areas

The Study Area is located within the *Gardens of Stone State Conservation Area* (GoS SCA), which is managed by the National Parks and Wildlife Service (NPWS). The State Conservation Area was formally proclaimed on 6 May 2022. The GoS SCA Plan of Management (DPE, 2022) outlines the strategic objectives to meet the park's cultural and natural values. The Plan outlines the interaction of mining operations and park management.

The potential impacts to the GoS SCA include changes in surface water, changes to groundwater and surface cracking. As discussed in Sections 5.3 to 5.9, there are no adverse changes anticipated for surface water flows along the streams and swamps, and no adverse physical impacts (i.e. surface cracking or rock fracturing) anticipated for the streams, cliffs, steep slopes, natural vegetation and fauna and swamps within the Study Area. This includes experiences observed due to partial extraction of Panels 910 to 906, where subsidence movements have been in the order of two times those predicted for the proposed panels.

Further discussions on the potential impacts are provided by the specialist ecology, surface water and groundwater consultants on the Project.

No adverse impacts are anticipated to public safety along the tracks and trails within the Study Area, which is discussed in Section 6.2. No adverse impacts are anticipated for heritage sites within the Study Area, which is discussed in Section 6.8.

5.14. Natural vegetation

The vegetation within the Study Area comprises natural bush. A detailed survey of the natural vegetation has been undertaken and is described in the 918 Panel Biodiversity Management Plan (RPS, 2025).

The following sections provide the descriptions, predictions and impact assessments for the built features within the Study Area. The major built features located outside the Study Area, which may be subjected to far-field or valley-related movements and may be sensitive to these effects, have also been included as part of these assessments.

6.1. Public utilities and amenities

As listed in Table 2.1, there are no public utilities or amenities identified within the Study Area, apart from unsealed roads and tracks. The descriptions, predictions and impact assessments for the roads and tracks are provided in the following sections.

6.2. Unsealed roads and tracks

6.2.1. Descriptions for the unsealed roads and tracks

The unsealed roads and tracks as detailed and mapped by Centennial in the 918 Panel Built Features Management Plan (Centennial, 2025e) are shown in Drawing No. MSEC1493-10.

Waratah Ridge Road is located approximately 170 m to the north of the Study Area

The tracks within the Study Area are mainly utilised by NPWS, by Clarence Colliery to access subsidence environmental monitoring and exploration borehole sites and by the public. These roads and tracks are accessed usually by 4WD vehicles, motorbikes, bicycle, horse riding or on foot.

Unsealed roads and tracks cross directly above sub-panel 918A. There are also other unsealed roads and tracks located within the Study Area but not directly above the proposed sub-panels.

6.2.2. Predictions for the unsealed roads and tracks

There are two unsealed tracks located directly above Panel 918A and there are other unsealed tracks located within the Study Area but outside the extents of the proposed panels. These roads and tracks could therefore experience the full range of predicted subsidence effects for these panels.

A summary of the maximum predicted values of total vertical subsidence, tilt and curvatures for the unsealed roads and tracks within the Study Area based on the three-dimensional subsidence model is provided in Table 6.1.

Table 6.1 Maximum predicted total vertical subsidence, tilt and curvatures for the unsealed roads and tracks

Location	Maximum predicted total vertical subsidence (mm)	Maximum predicted total tilt (mm/m)	Maximum predicted total hogging curvature (km ⁻¹)	Maximum predicted total sagging curvature (km ⁻¹)
Unsealed roads and tracks	76	0.6	0.01	0.02

The maximum predicted vertical subsidence for the unnamed roads and tracks is 76 mm ± 20 mm. The maximum predicted tilt is 0.6 mm/m (i.e. 0.05 % or 1 in 1667). The maximum predicted total conventional curvatures are 0.01 km⁻¹ hogging and 0.02 km⁻¹ sagging and they represent minimum radii of curvature of 100 km and 50 km, respectively. The maximum predicted subsidence effects for the unsealed roads and tracks occur above Panel 918A.

The maximum predicted conventional strains for the unsealed roads and tracks, based on applying a factor of 10 to the maximum predicted conventional curvatures, are less than 0.3 mm/m tensile and compressive, i.e. in the order of survey tolerance. Non-conventional strains are not expected to develop given the low-level predicted vertical subsidence that develops due to pillar compression rather than sag subsidence.

6.2.3. Impact assessments for the unsealed roads and tracks

The predicted strains above the sub-panels are less than 0.3 mm/m tensile and compressive. It is considered unlikely, therefore, that fracturing would occur along the unsealed roads and tracks within the Study Area.

Surface cracking has not been observed along the unsealed roads and tracks above the existing panels at Clarence (Centennial, 2023, 2024 and 2025a). It is therefore considered unlikely that surface cracking would develop along the unsealed roads and tracks within the Study Area due to the extraction of the 918 sub-panels. Cracks can be readily repaired in the unlikely event that they are observed during mining.

6.2.4. Impact assessments for the unsealed roads and tracks based on the actual movements exceeding predictions

The maximum tilts for the unsealed roads and tracks if the actual movements exceeded the predictions by a factor of two times would be 1.0 mm/m. Tilts of these magnitudes are still unlikely to have adverse impacts on the serviceability or safety of the unsealed roads and tracks.

The maximum strains for the unsealed roads and tracks if the actual movements exceeded the predictions by a factor of two times would be 0.6 mm/m tensile and compressive.

It is possible that minor and isolated fracturing could occur in the bedrock below the unsealed roads and tracks if the actual mining-induced strains exceed the predictions by a factor of two times. However, it would still be unlikely that cracking would be visible at the surface due to the plastic nature of the unsealed road surfaces.

This is supported by the observations that surface cracking has not previously been observed along the unsealed roads and tracks due to partial extraction directly beneath them at Clarence, even where subsidence movements have been in the order of two times those predicted for the proposed panels.

It is therefore considered unlikely that adverse impacts would occur to the unsealed roads and tracks within the Study Area due to the extraction of sub-panels 918A, 918B1 and 918B2, even if the actual movements exceeded the predictions by a factor of two times.

6.2.5. Recommendations for the unsealed roads and tracks

It is recommended that visual inspections of the unsealed roads and tracks above the mining area are carried out before, during and after the extraction of each panel. Monitoring and management of potential impacts on steep slopes is described in the 918 Panel Built Features Management Plan (Centennial, 2025e). Monitoring includes visual inspections and ground surveys before, during and after the extraction of 918 Panel.

6.3. Drainage culverts

As listed in Table 2.1, there are no drainage culverts identified within the Study Area.

6.4. Fences

As listed in Table 2.1, there are no fences that have been identified within the Study Area.

6.5. Registered groundwater bores and other boreholes

The registered groundwater bores and other boreholes are shown in Drawing No. MSEC1493-10.

JBSG (2026) advise that there are no registered groundwater bores within the Study Area, however there are three registered bores located approximately 350 m and 380 m north-west of the Study Area. The recorded purpose of these groundwater bores is for “monitoring” and the status is recorded as “functioning” or “functional”.

The predicted vertical subsidence for the registered groundwater bores is less than 20 mm. While the bores could experience very low levels of vertical subsidence, it is not expected they would experience measurable tilts, curvatures or strains, even if the actual movements exceeded the predictions by a factor of two times.

However, these movements are expected to be very small given that the subsidence due to the extraction of the proposed panels is predominately caused by pillar compression, rather than sag subsidence.

JBSG (2026) advise that there are no groundwater bore users within the Study Area.

Further discussions on the potential impacts on groundwater resources are provided by JBSG (2026).

6.6. Industrial, commercial or business establishments

As listed in Table 2.1, there were no industrial, commercial or business establishments identified within the Study Area.

6.7. Mining infrastructure

There is no mining infrastructure within the Study Area apart from the exploration drillholes, subsidence and environmental monitoring infrastructure. It is possible that fracturing and shearing could occur in the drillholes as the result of mining. It is recommended that the exploration drillholes are grouted and capped prior to being directly mined beneath.

6.8. Aboriginal heritage sites

6.8.1. Descriptions of the Aboriginal heritage sites

The Aboriginal heritage sites as provided in the 918 Panel Heritage Management Plan (Umwelt, 2025) are shown in Drawing No. MSEC1493-10.

There are three Aboriginal heritage sites located within the Study Area, of which two are located at the same location. A field survey was completed of the Study Area by the RAPs and Umwelt.

A summary of the Aboriginal heritage sites identified within the Study Area is provided in Table 6.2. The sites are registered on the Aboriginal Heritage Information Management System (AHIMS) database.

Table 6.2 Aboriginal heritage sites identified within the Study Area

Reference	Site name	Type	Location
45-1-0182	Mt Horne 2 Newnes SF SWD SWA	Rock Shelter with Art	210 m northeast of Panel 918B1
45-1-2842	CLR20_QF (20B_IF)	Open Artefact Site	Directly above the southern end of Panel 918A
45-1-2950	Newnes SF 45-1-0004 Southeastern Shelter 2	Rock Shelter with Art	230 m northeast of Panel 918B1

Further descriptions of the Aboriginal heritage sites within the Study Area are provided by Umwelt (2025).

6.8.2. Predictions for the Aboriginal heritage sites

A summary of the maximum predicted values of total vertical subsidence, tilt and curvatures for the Aboriginal heritage sites within the Study Area based on the three-dimensional subsidence model is provided in Table 6.3. The values are the maximum predicted subsidence effects within 20 m of the sites after the extraction of all panels.

Table 6.3 Maximum predicted total vertical subsidence, tilt and curvatures for the Aboriginal heritage sites

Reference	Maximum predicted total vertical subsidence (mm)	Maximum predicted total tilt (mm/m)	Maximum predicted total hogging curvature (km ⁻¹)	Maximum predicted total sagging curvature (km ⁻¹)
45-1-0182	< 20	< 0.5	< 0.01	< 0.01
45-1-2842	40	< 0.5	< 0.01	< 0.01
45-1-2950	< 20	< 0.5	< 0.01	< 0.01

The maximum predicted vertical subsidence for the Aboriginal heritage sites is 40 mm. The maximum predicted tilt is less than 0.5 mm/m (i.e. < 0.05 % or 1 in 2000). The maximum predicted curvatures are less than 0.01 km⁻¹ hogging and sagging and they represent minimum radii of curvature greater than 100 km.

The maximum predicted conventional strains for Site 45-1-2842, based on applying a factor of 10 to the maximum predicted conventional curvatures, are less than 0.3 mm/m tensile and compressive, i.e. in the order of survey tolerance. Non-conventional strains are not expected to develop given the low-level predicted vertical subsidence that develops due to pillar compression rather than sag subsidence.

Sites 45-1-0182 and 45-1-2950 are located just within the Study Area and 210 and 230 metres north-west of Panel 918B1, respectively. At this distance, the sites are predicted to experience less than 20 mm vertical subsidence, with negligible tilt, curvature and strain.

6.8.3. Impact assessments for the Aboriginal heritage sites

Site 45-1-2842 (CLR20_QF (20B_IF) is an isolated open artefact site. Sites 45-1-0182 (Mt Horne 2 Newnes SF SWD SWA) and 45-1-2950 (Newnes SF 45-1-0004 Southeastern Shelter 2) are a rock shelter with art. These sites will not be adversely impacted by the very low-level predicted subsidence effects. Also, surface cracking is not anticipated due to the extraction of the proposed sub-panels.

There are some Aboriginal heritage sites located just outside of the Study Area. These are not predicted to experience measurable subsidence effects. Adverse impacts are therefore not anticipated at any of these sites.

It is therefore considered unlikely that the Aboriginal heritage sites within and adjacent to the Study Area would experience adverse impacts due to the extraction of sub-panels 918A, 918B1 and 918B2. Further discussions are provided by Umwelt (2025).

6.8.4. Impact assessments for the Aboriginal heritage sites based on the actual movements exceeding predictions

The maximum tilts for the Aboriginal heritage site if the actual movements exceeded the predictions by a factor of two times would be less than 1 mm/m. Tilt does not adversely impact the isolated find at Site 45-1-2842.

The maximum strains for Site 45-1-2842 if the actual movements exceeded the predictions by a factor of two times would be less than 0.6 mm/m tensile and compressive. It is unlikely that minor and isolated fracturing could occur near Site 45-1-2842 if the actual mining-induced strains exceed the predictions by a factor of two.

The maximum tilts and strains at Sites 45-1-0182 and 45-1-2950 remain negligible if actual movements exceeded the predictions by a factor of two times. It is unlikely that adverse impacts will occur if the actual mining-induced strains exceed the predictions by a factor of two.

This is supported by the observations that adverse impacts have not previously been observed due to partial extraction at Clarence (Centennial, 2023, 2024 and 2025a), even where actual subsidence movements have been in the order of two times those predicted for the proposed 918 sub-panels.

It is therefore considered unlikely that adverse impacts would occur at the Aboriginal heritage sites within and in the vicinity of the Study Area due to the extraction of sub-panels 918A, 918B1 and 918B2, even if the actual movements exceeded the predictions by a factor of two times.

6.8.5. Recommendations for the Aboriginal heritage sites

It is recommended that a visual inspection is carried out at Site 45-1-2842 after the extraction of sub-panel 918A and again after the extraction of sub-panel 918B2. It is recommended that a visual inspection is carried out at Sites 45-1-0182 and 45-1-2950 after the extraction of sub-panel 918B1. Monitoring and management of potential impacts on Aboriginal heritage sites is described in the 918 Panel Heritage Management Plan (Umwelt, 2025).

6.9. Historic sites

As listed in Table 2.1, there were no historic sites identified within the Study Area.

6.10. State survey control marks

Details of the survey control marks in the area were obtained from *Spatial Services* using the *SCIMS Online* website (SCIMS, 2025). There are no state survey marks located within or near the Study Area.

The nearest state survey mark is SS21312 N which is located 800 m north of the Study Area. At this or greater distance, survey control marks in the area will not experience conventional subsidence effects. However, it is possible that the survey marks could be affected by very small far-field horizontal movements. Far-field horizontal movements and the methods used to predict such movements are described further in Sections 3.3 and 4.6.

It is recommended that any survey control marks which are required for future use are re-established after the completion of mining in the area and after the ground has stabilised. Consultation between Clarence and Spatial Services will be required to ensure that these survey control marks are reinstated at the appropriate time, as required.

MSEC has developed a Subsidence Monitoring Program in consultation with Clarence Colliery for the extraction of 918 Panel (MSEC, 2026). A plan showing planned monitoring is provided in Drawing No. MSEC1493-14.

7.1. Ground survey lines

Two ground survey lines, the 900F Line and 900H Line are planned to monitor vertical subsidence during the extraction of 918 Panel, with pegs spaced nominally every 20 metres. The survey data will provide subsidence and tilt profiles across the proposed 918 sub-panels, which can be used to compare with predictions and compliance against DA 504-00 Subsidence Impact Assessment Criteria, as described below.

900F Line:

- The pegs along the 900F Line will be surveyed by digital level to measure subsidence and tilt.
- GNSS units have been installed along the survey line for continuously measuring horizontal movements and subsidence. The GNSS measurements can also be used to calculate changes in horizontal distances and average ground strain between the GNSS units.
- The benchmark for the 900F Line is Peg 900F-02, which is located approximately 556 metres from the western side of sub-panel 918A, at an angle of draw of approximately 63 degrees. The western end of the 900F Line is sufficiently long to measure the location of the 20 mm limit of subsidence and calculate an angle of draw.
- The eastern end of the 900F Line is located approximately 68 metres from the eastern side of sub-panel 918B2. The steep terrain at a sharp bend in Bungleboori Creek presents a challenge for extending the 900F Line beyond the Study Area to the east. GNSS 900_G10 has been installed to measure vertical subsidence beyond the eastern end of the 900F line and potential valley closure across Bungleboori Creek. GNSS 900_G10 is located approximately 260 metres from the eastern side of sub-panel 918B2, at an angle of draw of approximately 45 degrees.

900H Line:

- The survey pegs along the 900H Line will be surveyed by 3D traverse and by digital level. This will provide information on absolute horizontal movements, ground strains and valley closure across Bungleboori Creek and sub-panel 918B1.
- The benchmark for the 900H Line is Peg 900H-01, which is located approximately 252 metres from the western side of sub-panel 918B1, at an angle of draw of approximately 45 degrees. The western end of the 900H Line is sufficiently long to measure the location of the 20 mm limit of subsidence and calculate an angle of draw.
- The eastern end of the 900H Line is located approximately 68 metres from the eastern side of sub-panel 918B1, at an angle of draw of approximately 39 degrees. The eastern end of the 900H Line is sufficiently long to measure the location of the 20 mm limit of subsidence and calculate an angle of draw.

7.2. GNSS monitoring

Global Navigation Satellite System (GNSS) units are fixed survey stations that continuously measure their absolute horizontal and vertical positions in real time. The GNSS units are mounted on a pole that is fixed to rock or driven to refusal in soil.

Clarence has installed and continuously monitored GNSS units above the proposed 918 Panel since July 2023. Additional GNSS units were installed in June 2024 and further GNSS units are proposed to be installed. The layout of the GNSS units have been designed to monitor:

- The development of vertical subsidence and horizontal movements directly above the sub-panel centrelines and centreline of the spine pillar between sub-panels 918A and 918B2. In conjunction with the results of surveys along the 900F and 900H Lines, the results from the GNSS units can be used to compare with predictions and compliance against DA 504-00 Subsidence Impact Assessment Criteria.
- The development of vertical subsidence and horizontal movements beyond the ends of the proposed sub-panels at the sub-panel centrelines.
- The development of vertical subsidence and horizontal movements near creeks, swamps and cliff lines. Pairs of GNSS units have been placed across Bungleboori Creek and Paddy's Creek. Whilst valley closure has not been measured previously at Clarence, there are only a limited number of available survey lines that have crossed over creeks (700A and 700B Lines). The units will provide information on valley closure (if any) to the sides of Panel 918. This will provide an

important case study to assist with planning of future mining adjacent to deeply incised valleys and gorges at Clarence.

7.3. Assessment of baseline GNSS monitoring at Clarence

Whilst there have been strong improvements in GNSS technology over time, the GNSS monitoring results can be affected by environmental and other effects. It is important to take these effects into account when assessing monitoring data, particularly when one objective of monitoring is to determine if mining-induced movements comply with Condition 1 of the Development Consent DA 504-00, which includes low level subsidence limits.

The long period of baseline data has provided useful information on environmental and other effects on GNSS measurements.

Short term environmental or other effects

Short term environmental effects are generally due to atmospheric disturbances (e.g. solar flares) or satellite configurations (Nicholson et al, 2025).

An example of short term effects is shown in Fig. 7.1 at GNSS 900_04 at Clarence. Some effects continue for many weeks and others occur only over a day. Some of the short term effects have been successfully addressed by improvements in data processing but multiple examples are visible in Fig. 7.1.

Long term environmental or other effects

Baseline GNSS monitoring at Clarence have noticed seasonal changes in height at some GNSS units. The changes involve cyclical rising and falling of heights over long periods of time. The example shown in Fig. 7.1 at GNSS 900_04 at Clarence represents the largest observed within the Clarence GNSS network, with seasonal changes in height $\pm 8\text{mm}$. GNSS 900_04 was installed in soil.

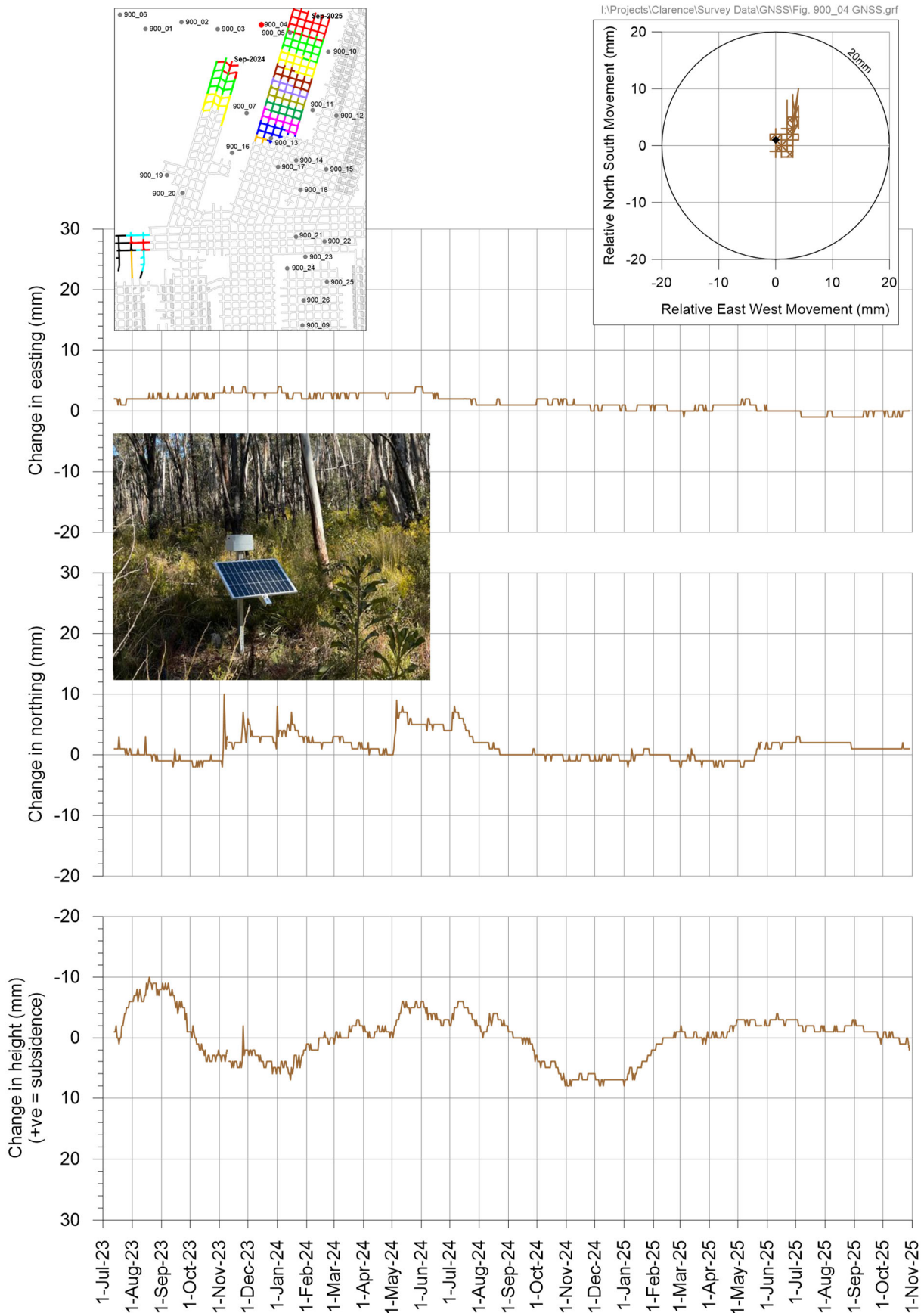


Fig. 7.1 Observed changes in easting, northing and height at GNSS 900_04 at Clarence

Some GNSS units that were installed in rock, such as GNSS 900_25, recorded very little seasonal changes over time, as shown in Fig. 7.2.

Clarence Colliery - GNSS Monitoring

Site 900_25 - bolted in rock

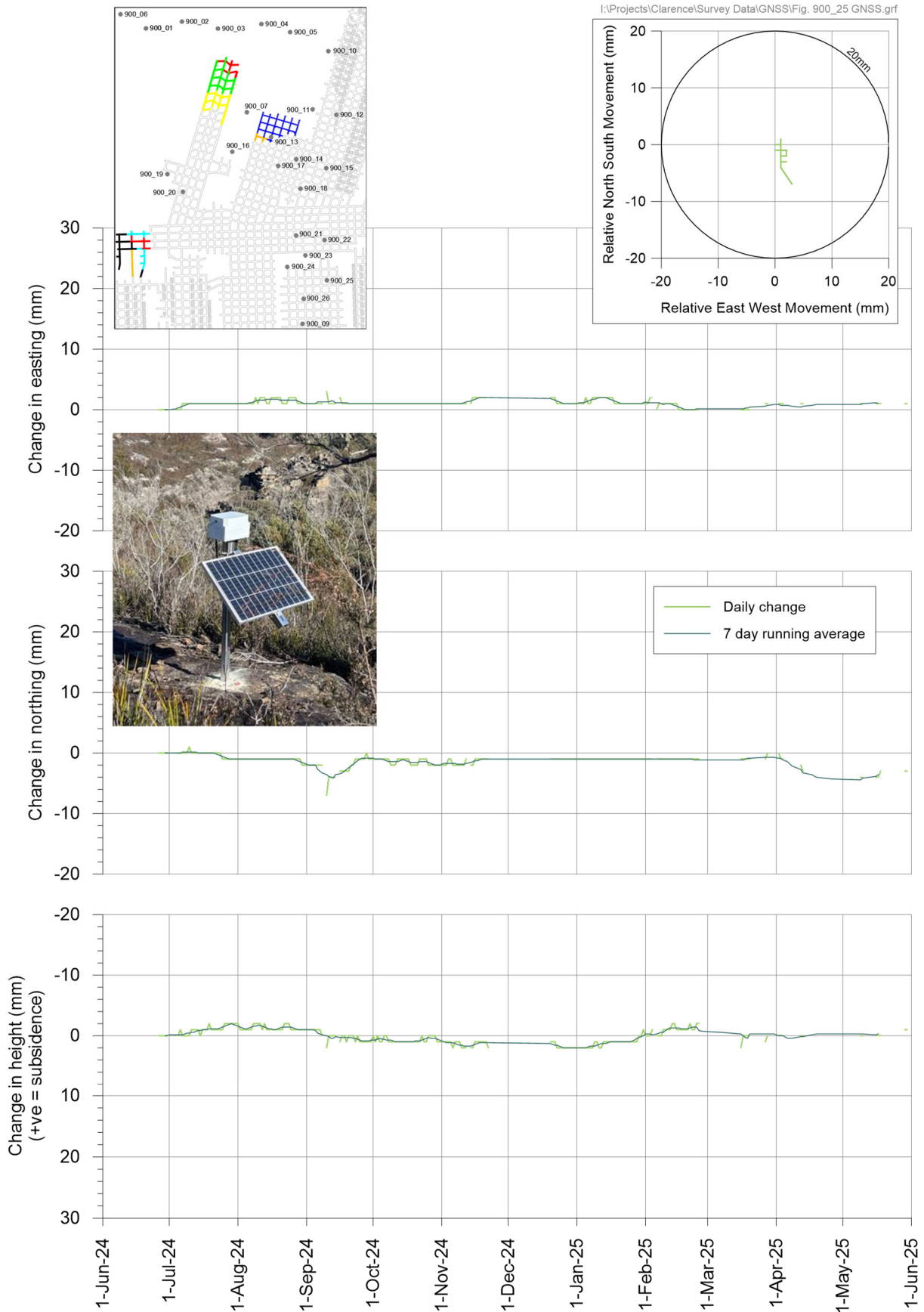


Fig. 7.2 Observed changes in easting, northing and height at GNSS 900_25 at Clarence

A study has been conducted of baseline GNSS monitoring results at Clarence, including consideration of the method of installation (soil or rock) and in which geological formation the units have been installed.

Summary plots of observed changes in eastings, northings and heights for GNSS units at Clarence are provided in Fig. 7.3, Fig. 7.4 and Fig. 7.5. The GNSS units have been grouped into those with posts driven into soil, and those that have been bolted on either Burralow Sandstone or Banks Wall Sandstone.

The results demonstrate that:

- Seasonal changes in height have been observed at most GNSS sites.
 - While seasonal changes in soil were expected, many of the GNSS units that were bolted onto rock have also recorded seasonal changes.
 - In some cases, such as GNSS 900_19 and GNSS 900_20 on the edge of a swamp in Paddy's Creek, GNSS 900_19 recorded a gradual uplift while GNSS 900_20 recorded a gradual settlement before recording no further change in recent months.
- Observed changes in eastings and northings are generally less than observed changes in height.
 - Whilst most the measured changes are oscillating near zero, some have recorded a gradual drift, such as GNSS 900_02 in soil and GNSS 900_07 in rock.

The observations demonstrate that seasonal changes and other environmental effects can be detected by GNSS units. It is recommended that the review of subsidence monitoring data take environmental effects into account when assessing whether mining-induced movements comply with development consent conditions.

It can be seen in Fig. 7.1, for example, that the baseline height for GNSS 900_04 has been provisionally set to equal the average measured height over the two-year period between July 2023 and July 2025. The same approach has been adopted for all GNSS units that have been installed on posts that were driven into soil, as shown in Fig. 7.3.

Clarence Colliery - GNSS Monitoring

Sites deep driven in to soil

I:\Projects\Clarence\Survey Data\GNSS\Fig. 900 GNSS - Soil.grf

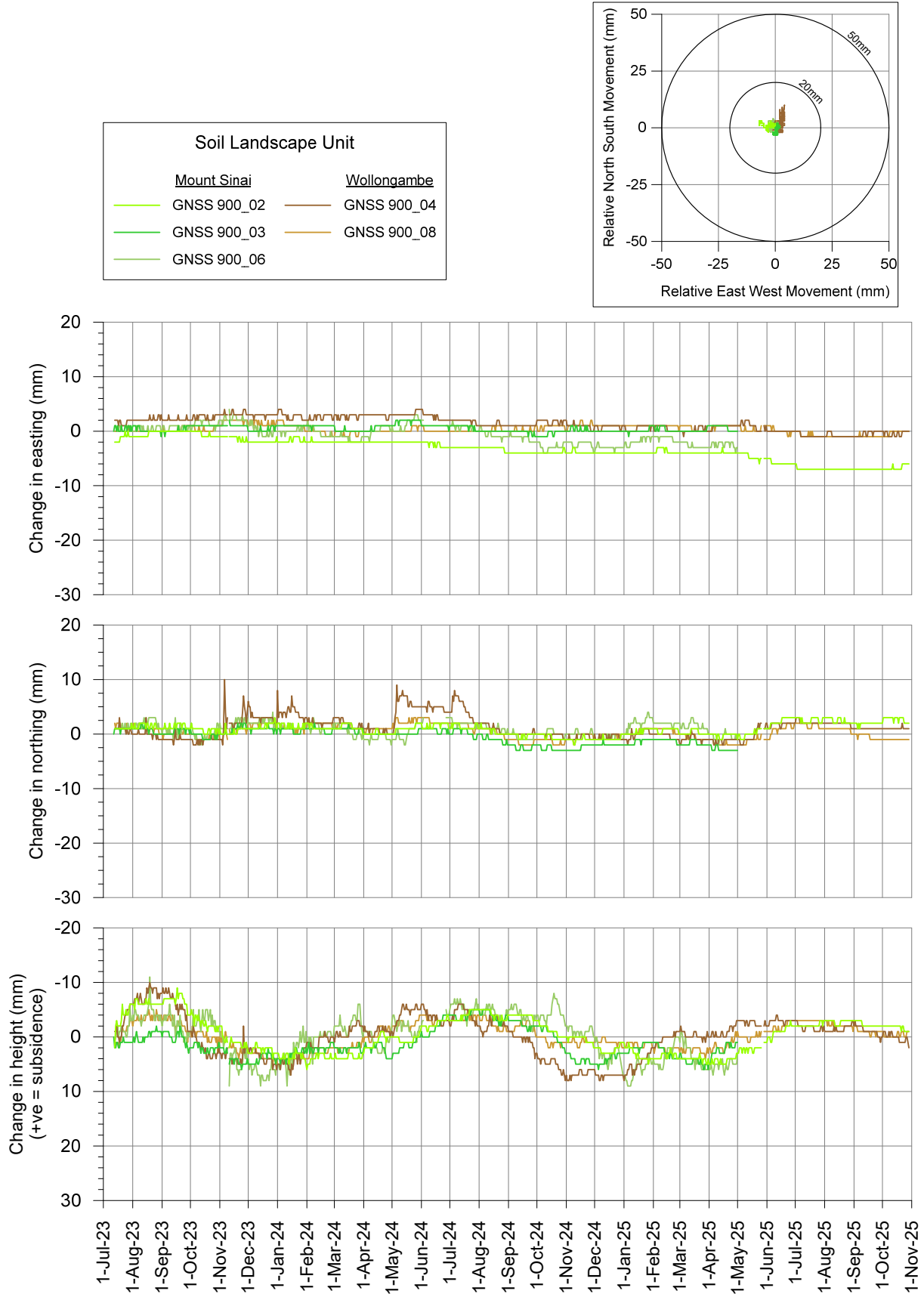


Fig. 7.3 Observed changes in easting, northing and height for sites driven into soil at Clarence

Clarence Colliery - GNSS Monitoring Sites bolted on rock

I:\Projects\Clarence\Survey Data\GNSS\Fig. 900 GNSS - Rock (Burralow).grf

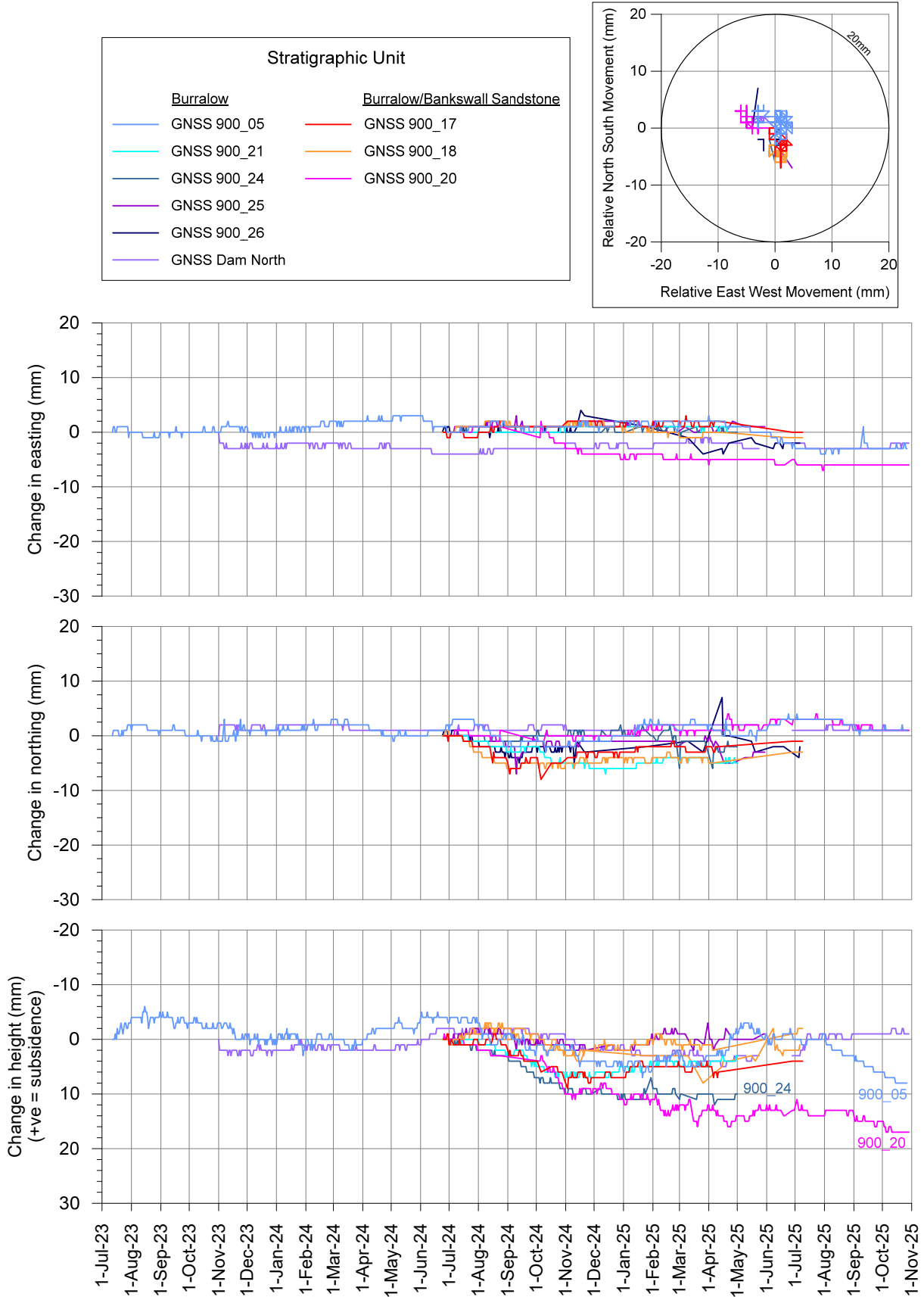


Fig. 7.4 Observed changes in easting, northing and height for sites bolted on rock (Burralow Sandstone)

Clarence Colliery - GNSS Monitoring Sites bolted on rock

I:\Projects\Clarence\Survey Data\GNSS\Fig. 900 GNSS - Rock (Banks Wall Sandstone).grf

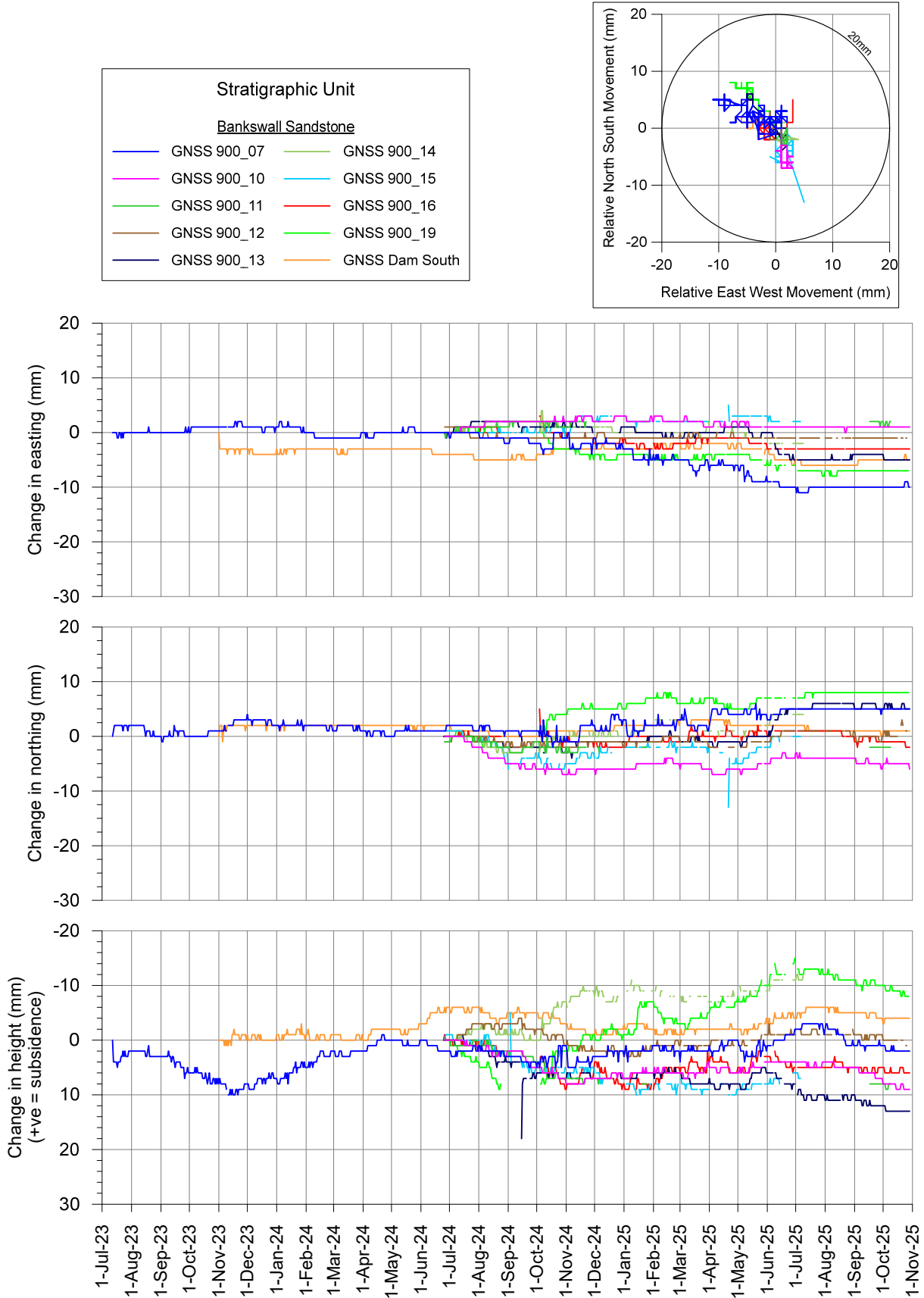


Fig. 7.5 Observed changes in easting, northing and height for sites bolted on rock (Banks Wall Sandstone)

APPENDIX A. GLOSSARY OF TERMS AND DEFINITIONS

Glossary of Terms and Definitions

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

Angle of draw	The angle of inclination from the vertical of the line connecting the goaf edge of the workings and the limit of subsidence (which is usually taken as 20 mm of subsidence).
Chain pillar	A block of coal left unmined between the longwall extraction panels.
Cover depth (H)	The depth from the surface to the top of the seam. Cover depth is normally provided as an average over the area of the panel.
Cliffs	Continuous rockfaces having minimum heights of 10 metres, minimum lengths of 20 metres and minimum slopes of 2 to 1, i.e. having minimum angles to the horizontal of 63°
Closure	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.
Critical area	The area of extraction at which the maximum possible subsidence of one point on the surface occurs.
Curvature	The change in tilt between two adjacent sections of the tilt profile divided by the average horizontal length of those sections, i.e. curvature is the second derivative of subsidence. Curvature is usually expressed as the inverse of the Radius of Curvature with the units of <i>1/kilometres (km⁻¹)</i> , but the value of curvature can be inverted, if required, to obtain the radius of curvature, which is usually expressed in <i>kilometres (km)</i> . Curvature can be either hogging (i.e. convex) or sagging (i.e. concave).
Extracted seam	The thickness of coal that is extracted. The extracted seam thickness is thickness normally given as an average over the area of the panel.
Effective extracted seam thickness (T)	The extracted seam thickness modified to account for the percentage of coal left as pillars within the panel.
Face length	The width of the coalface measured across the longwall panel.
Far-field movements	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.
Goaf	The void created by the extraction of the coal into which the immediate roof layers collapse.
Goaf end factor	A factor applied to reduce the predicted incremental subsidence at points lying close to the commencing or finishing ribs of a panel.
Horizontal displacement	The horizontal movement of a point on the surface of the ground as it settles above an extracted panel.
Inflection point	The point on the subsidence profile where the profile changes from a convex curvature to a concave curvature. At this point the strain changes sign and subsidence is approximately one half of S max.
Incremental subsidence	The difference between the subsidence at a point before and after a panel is mined. It is therefore the additional subsidence at a point resulting from the excavation of a panel.
Minor Cliffs	Continuous rockfaces having heights between 5 metres and 10 metres, minimum lengths of 20 metres and a minimum slope of 2 to 1.
Panel	The plan area of coal extraction.
Panel length (L)	The longitudinal distance along a panel measured in the direction of (mining from the commencing rib to the finishing rib.
Panel width (Wv)	The transverse distance across a panel, usually equal to the face length plus the widths of the roadways on each side.
Panel centre line	An imaginary line drawn down the middle of the panel.

Pillar	A block of coal left unmined.
Pillar width (W_{pi})	The shortest dimension of a pillar measured from the vertical edges of the coal pillar, i.e. from rib to rib.
Shear deformations	The horizontal displacements that are measured across monitoring lines and these can be described by various parameters including; horizontal tilt, horizontal curvature, mid-ordinate deviation, angular distortion and shear index.
Strain	<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>Tensile Strains are measured where the distance between two points or survey pegs increases and Compressive Strains where the distance between two points decreases. Whilst mining induced strains are measured along monitoring lines, ground shearing can occur both vertically, and horizontally across the directions of the monitoring lines.</p>
Sub-critical area	An area of panel smaller than the critical area.
Subsidence	<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>
Subsidence Effects	The deformations of the ground mass surrounding a mine, sometimes referred to as 'components' or 'parameters' of mine subsidence induced ground movements, including vertical and horizontal displacements, tilts, curvatures, strains, upsidence and closure.
Subsidence Impacts	The physical changes or damage to the fabric or structure of the ground, its surface and natural features, or built structures that are caused by the subsidence effects. These impacts considerations can include tensile and shear cracking of the rock mass, localised buckling of strata, bed separation, rock falls, collapse of overhangs, failure of pillars, failure of pillar floors, dilation, slumping and also include subsidence depressions or troughs.
Subsidence Consequences	The knock-on results of subsidence impacts, i.e. any change in the amenity or function of a natural feature or built structure that arises from subsidence impacts. Consequence considerations include public safety, loss of flows, reduction in water quality, damage to artwork, flooding, draining of aquifers, the environment, community, land use, loss of profits, surface improvements and infrastructure. Consequences related to natural features are referred to as environmental consequences.
Super-critical area	An area of panel greater than the critical area.
Tilt	The change in the slope of the ground as a result of differential subsidence, and is calculated as the change in subsidence between two points divided by the horizontal distance between those points. Tilt is, therefore, the first derivative of the subsidence profile. Tilt is usually expressed in units of <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.
Uplift	An increase in the level of a point relative to its original position.
Upsidence	Upsidence results from the dilation or buckling of near surface strata at or near the base of the valley. The term uplift is used for the cases where the ground level is raised above the pre-mining level, i.e. when the upsidence is greater than the subsidence. 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

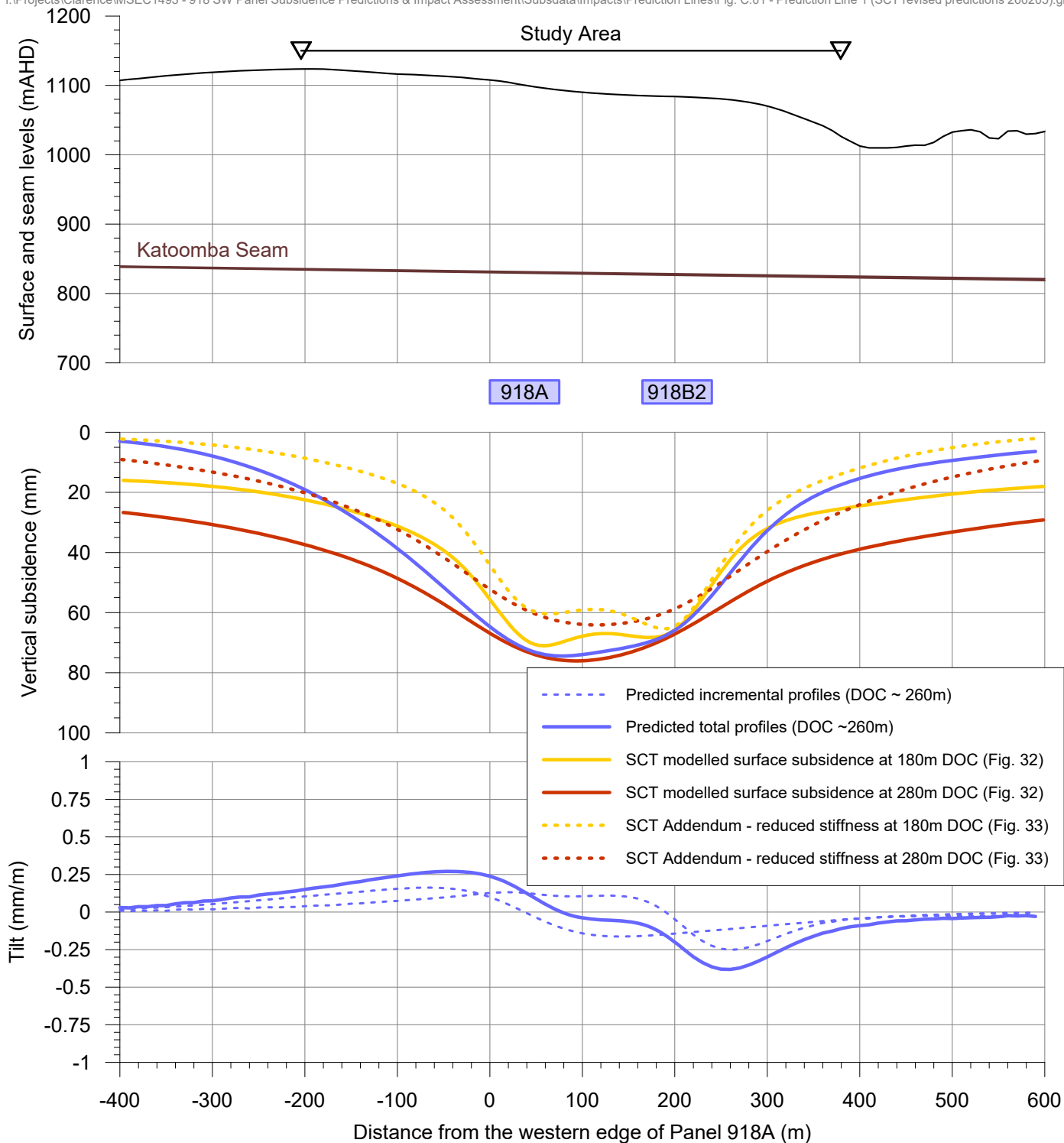
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APPENDIX C. FIGURES

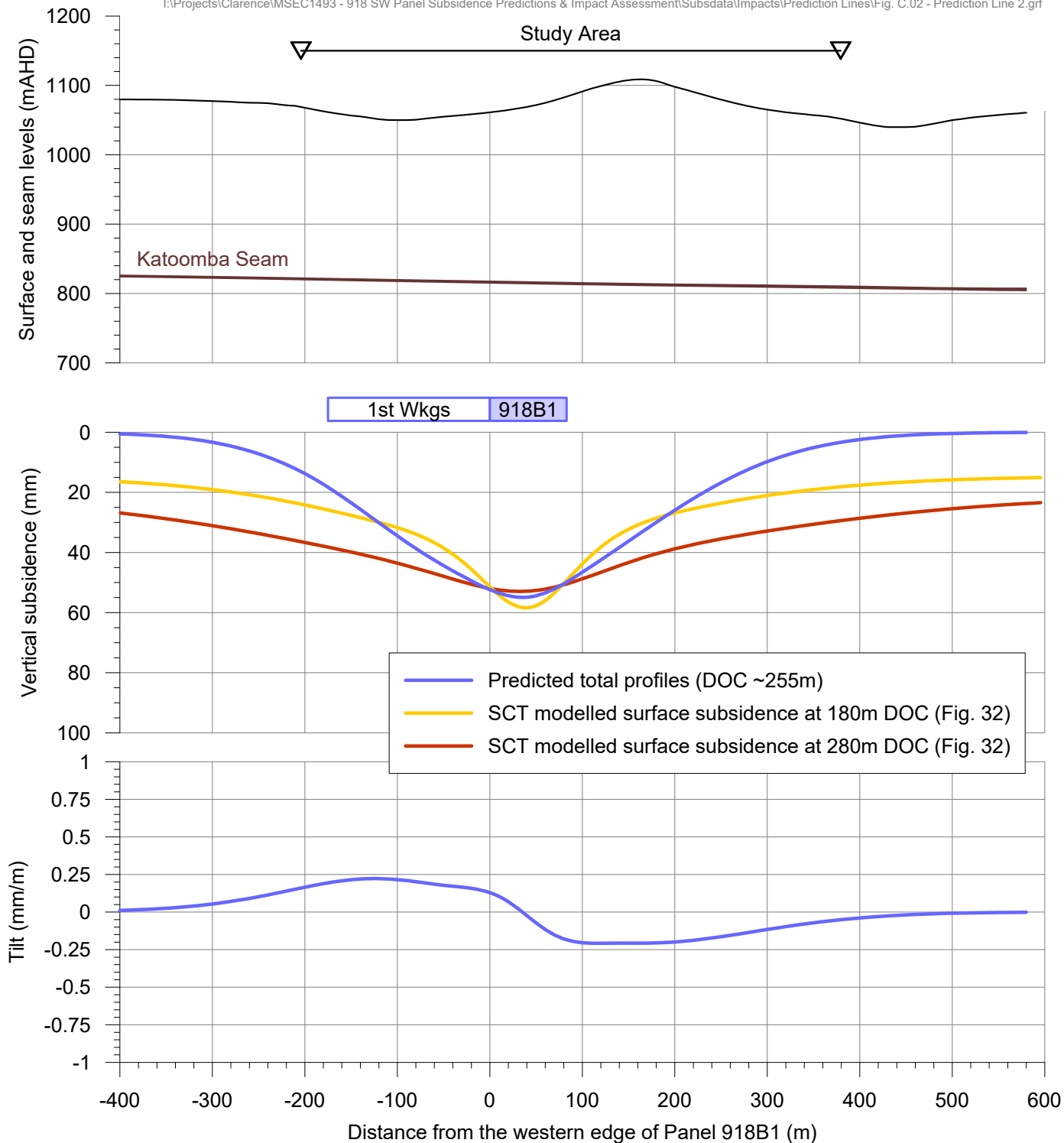
Predicted profiles of vertical subsidence, tilt and curvature along Prediction Line 1 due to the extraction of Panels 918A and 918B2

I:\Projects\Clarence\MSEC1493 - 918 SW Panel Subsidence Predictions & Impact Assessment\Subsdata\Impacts\Prediction Lines\Fig. C.01 - Prediction Line 1 (SCT revised predictions 260205).grf

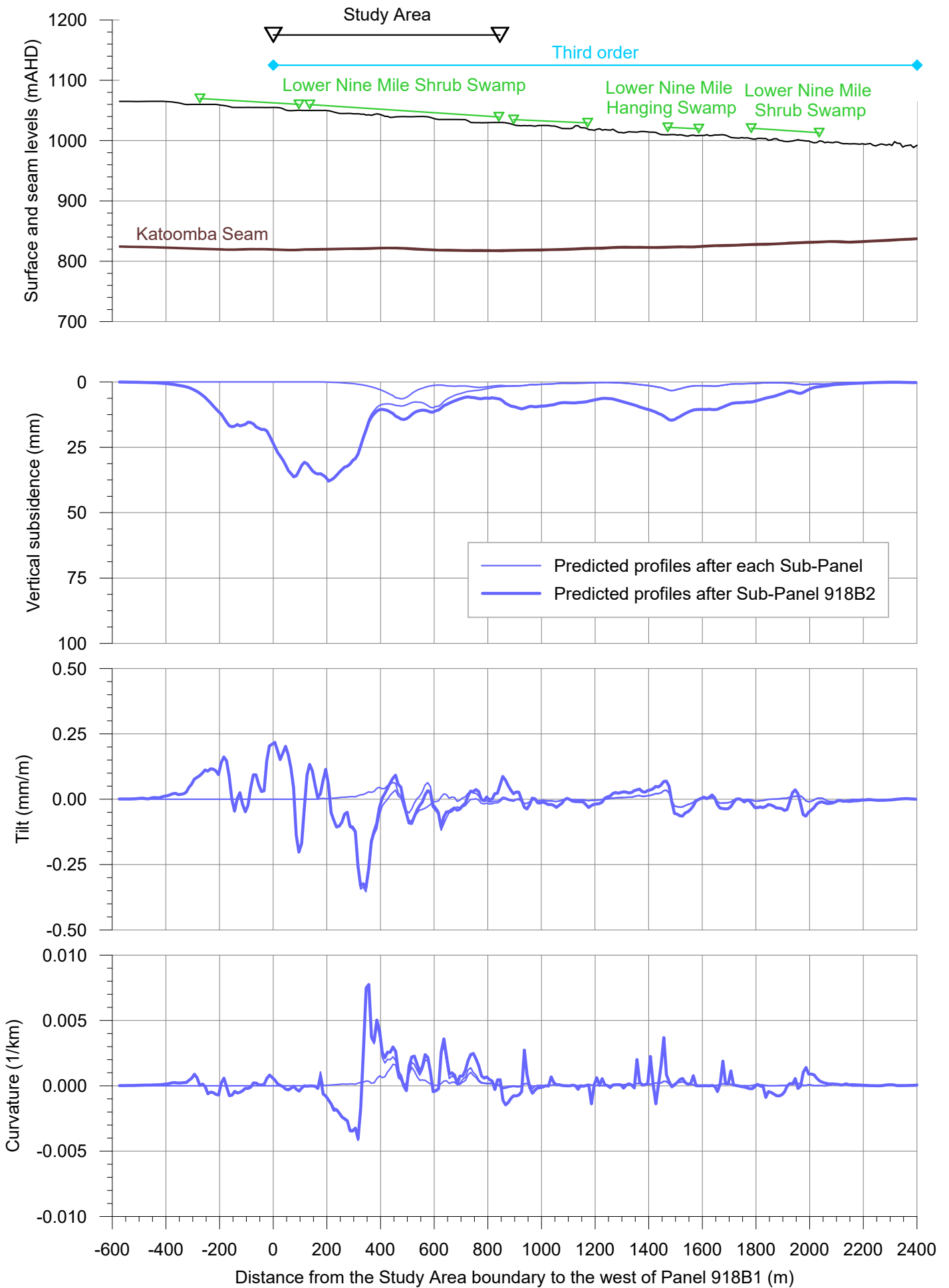


Predicted profiles of vertical subsidence, tilt and curvature along Prediction Line 2 due to the extraction of Panel 918B1

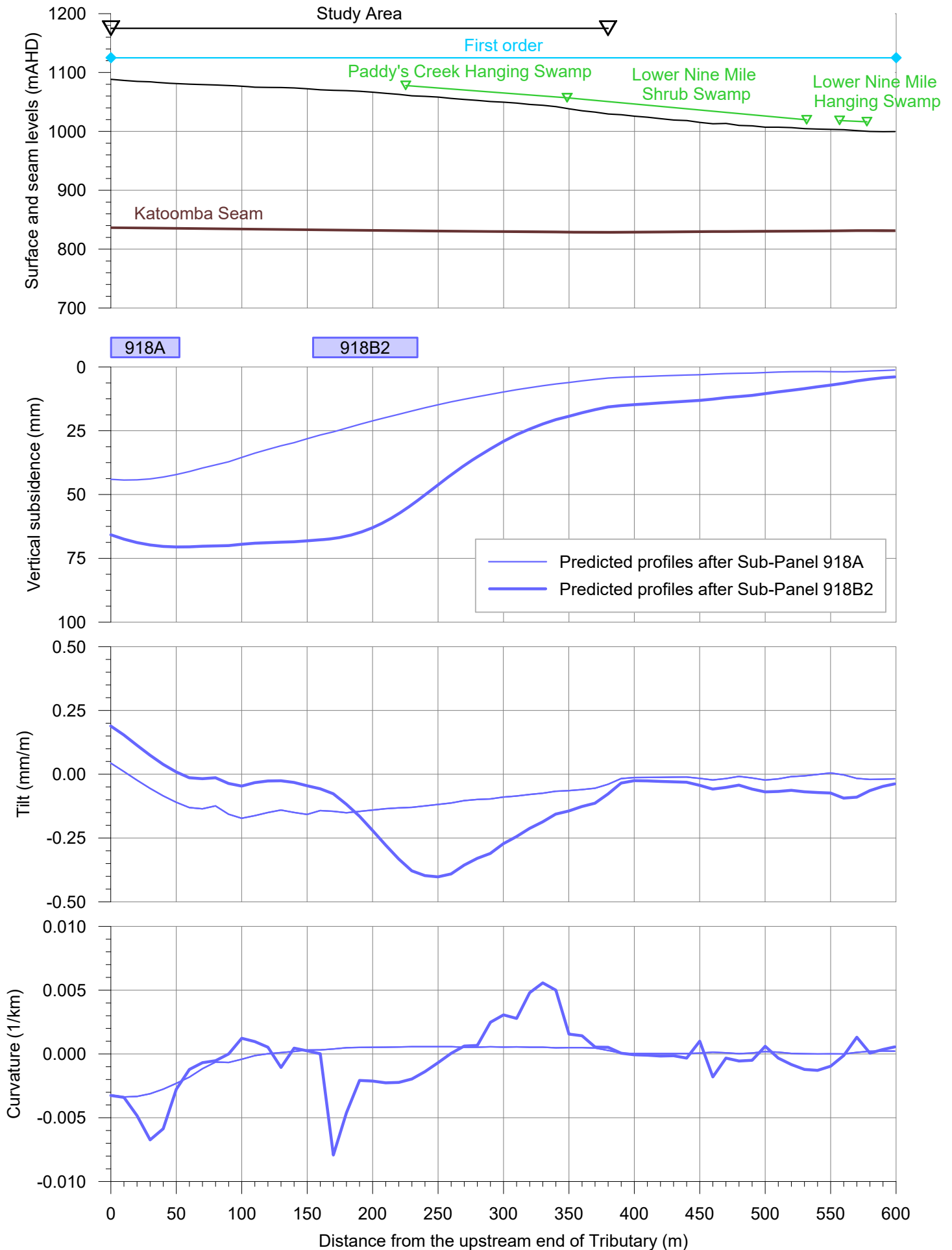
I:\Projects\Clarence\MSEC1493 - 918 SW Panel Subsidence Predictions & Impact Assessment\Subsdata\Impacts\Prediction Lines\Fig. C.02 - Prediction Line 2.grf



Predicted profiles of vertical subsidence, tilt and curvature along Bungleboori Creek due to the extraction of Panels 918A, 918B1 and 918B2



Predicted profiles of vertical subsidence, tilt and curvature along Tributary to Bungleboori Creek due to the extraction of Panels 918A, 918B1 and 918B2



APPENDIX D. DRAWINGS






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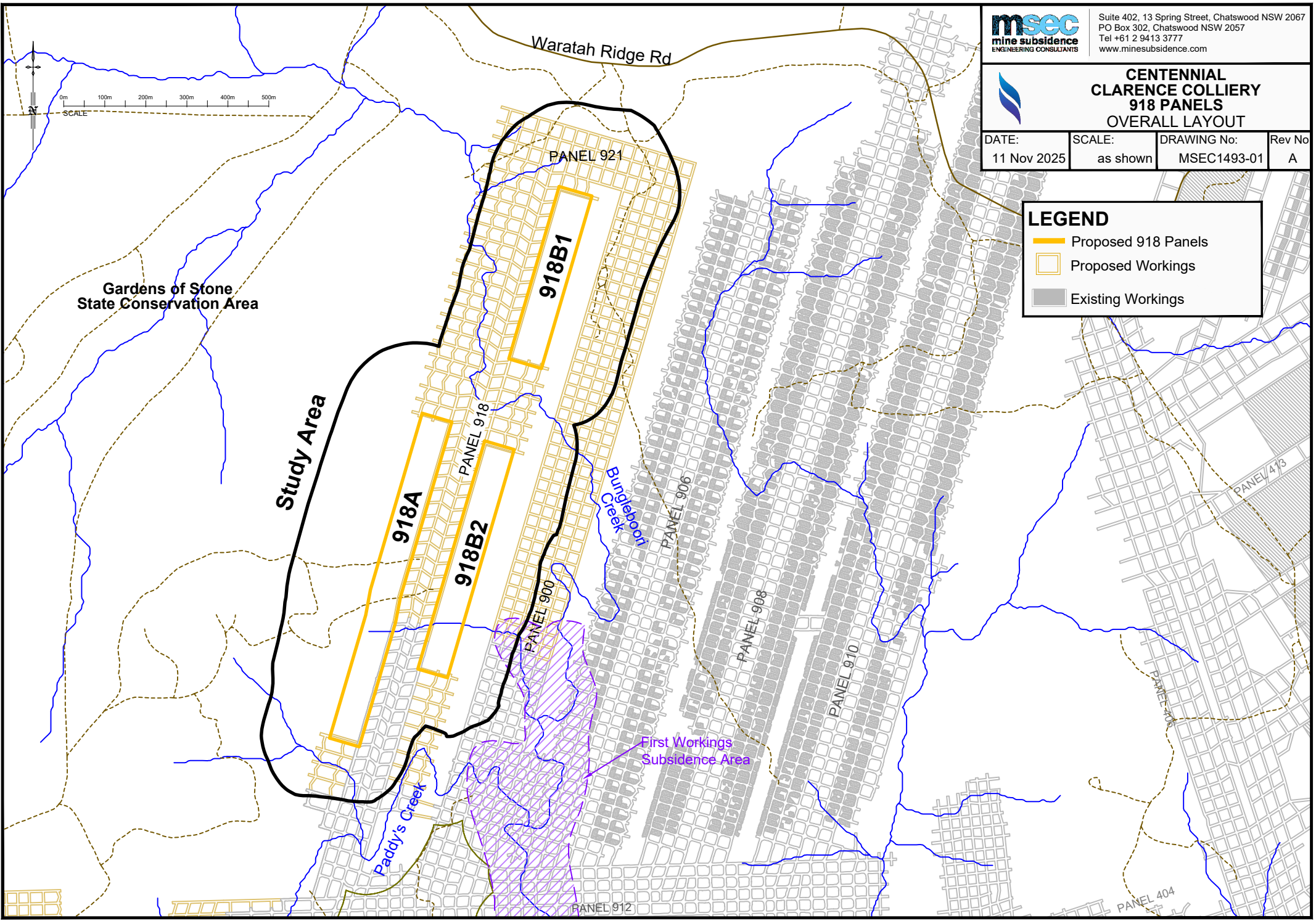


CENTENNIAL CLARENCE COLLIERY 918 PANELS OVERALL LAYOUT

DATE: 11 Nov 2025	SCALE: as shown	DRAWING No: MSEC1493-01	Rev No: A
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LEGEND

-  Proposed 918 Panels
-  Proposed Workings
-  Existing Workings








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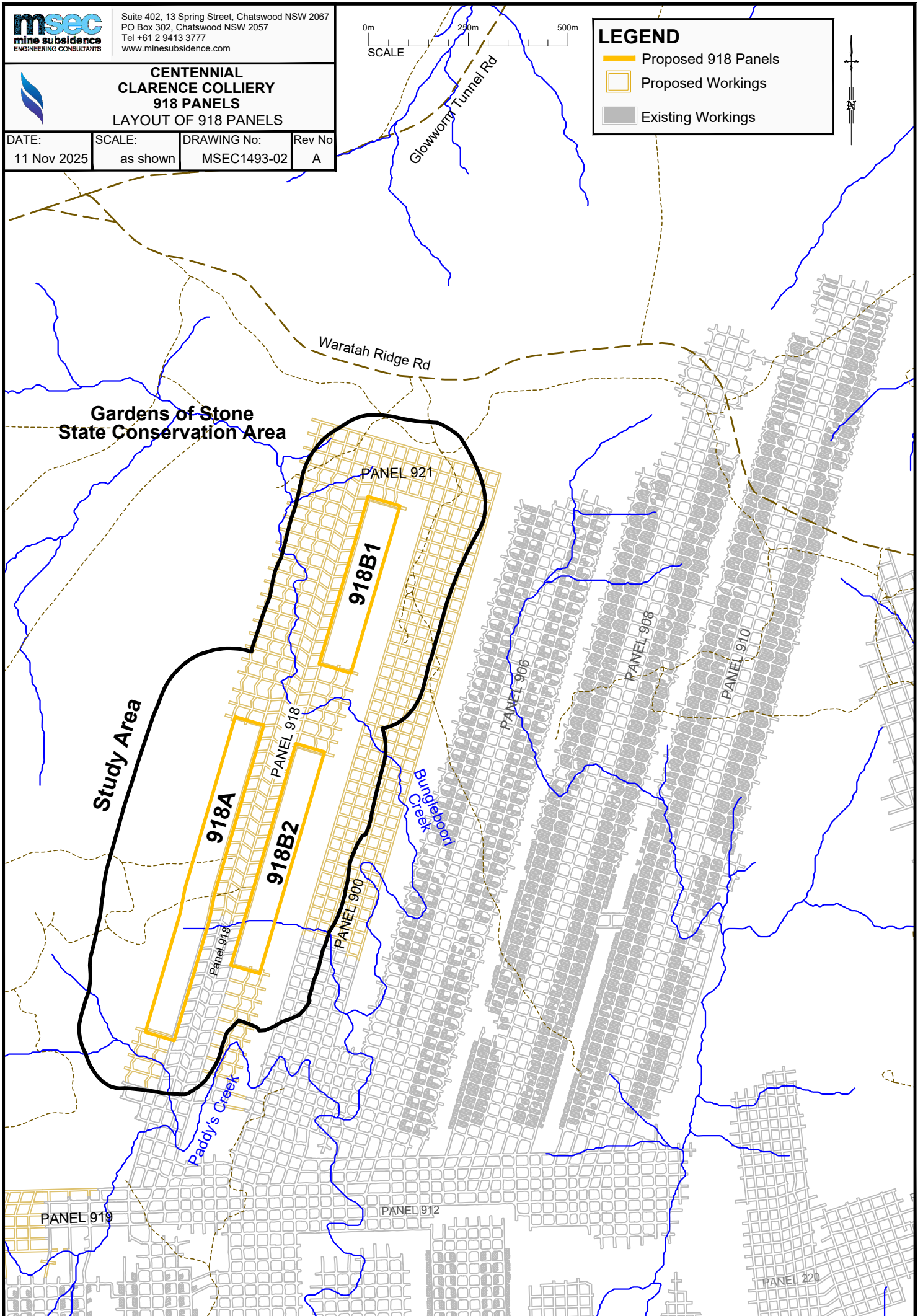
LEGEND

-  Proposed 918 Panels
-  Proposed Workings
-  Existing Workings



**CENTENNIAL
CLARENCE COLLIERY
918 PANELS
LAYOUT OF 918 PANELS**

DATE: 11 Nov 2025	SCALE: as shown	DRAWING No: MSEC1493-02	Rev No: A
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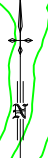
CENTENNIAL CLARENCE COLLIERY 918 PANELS SURFACE LEVEL CONTOURS

DATE: 11 Nov 2025	SCALE: as shown	DRAWING No: MSEC1493-03	Rev No A
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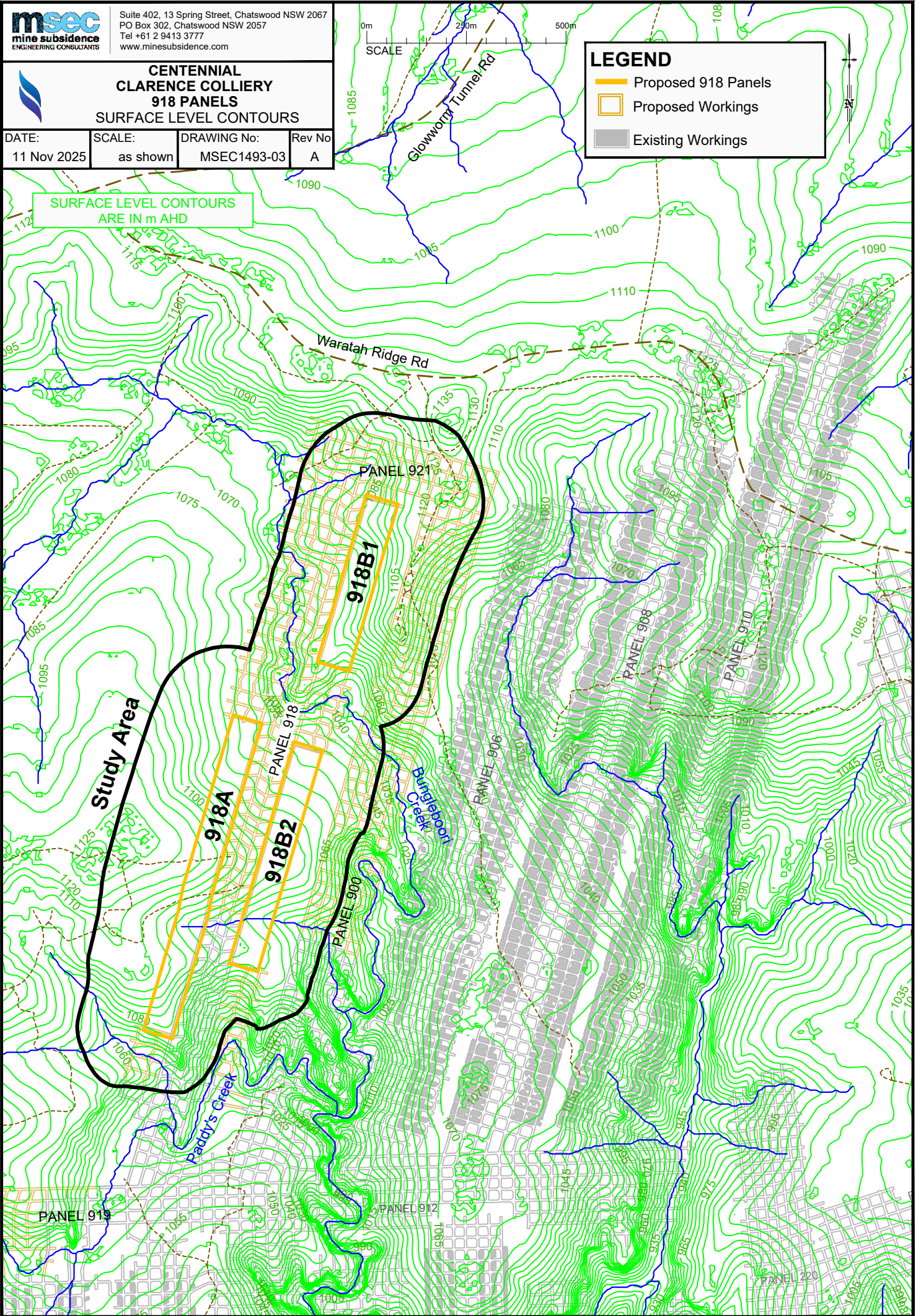


LEGEND

- Proposed 918 Panels
- Proposed Workings
- Existing Workings

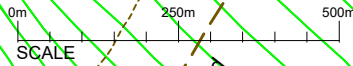


SURFACE LEVEL CONTOURS
ARE IN m AHD





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CENTENNIAL CLARENCE COLLIERY 918 PANELS

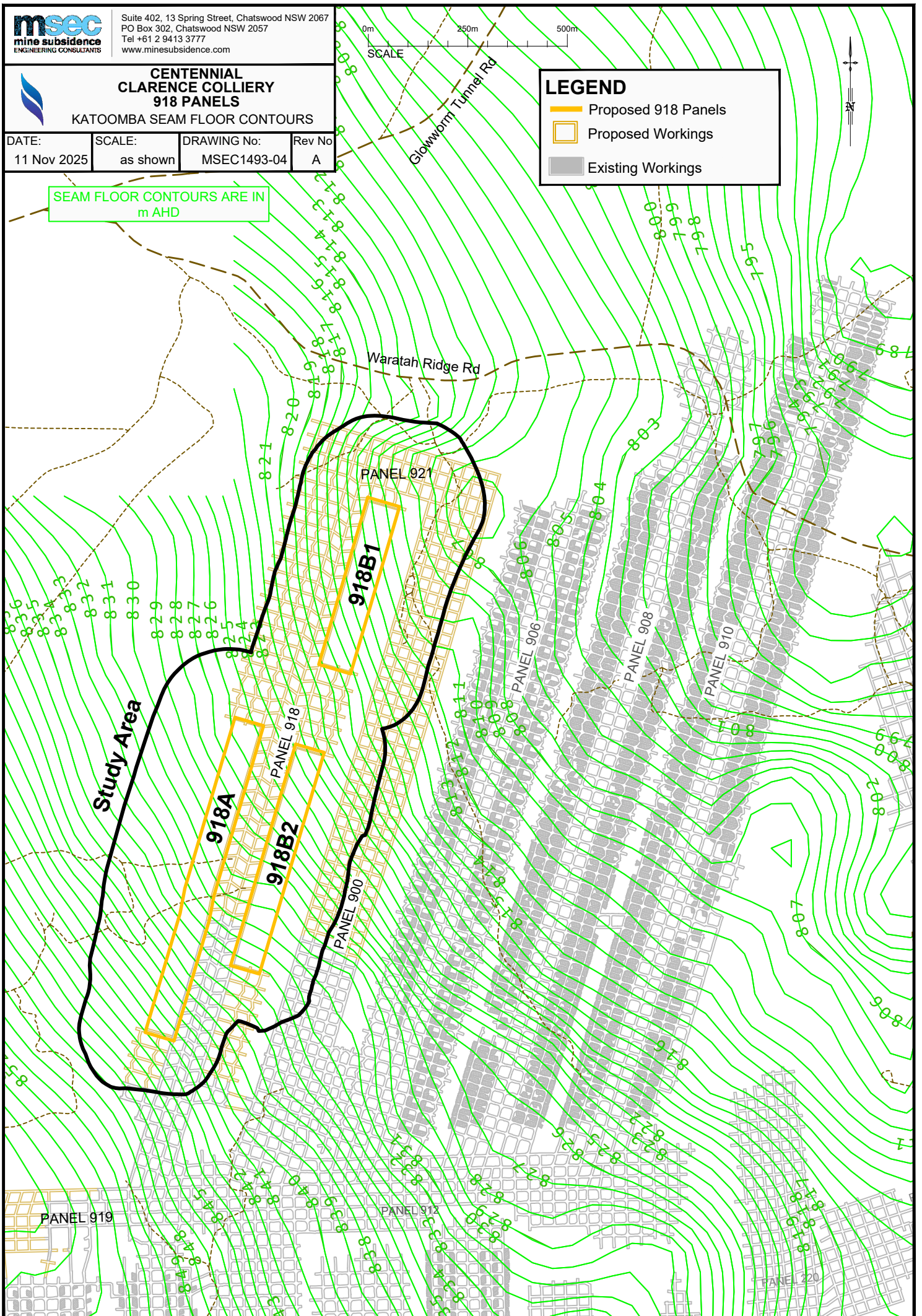
KATOOMBA SEAM FLOOR CONTOURS

DATE:	SCALE:	DRAWING No:	Rev No
11 Nov 2025	as shown	MSEC1493-04	A

LEGEND

- Proposed 918 Panels
- Proposed Workings
- Existing Workings

SEAM FLOOR CONTOURS ARE IN m AHD





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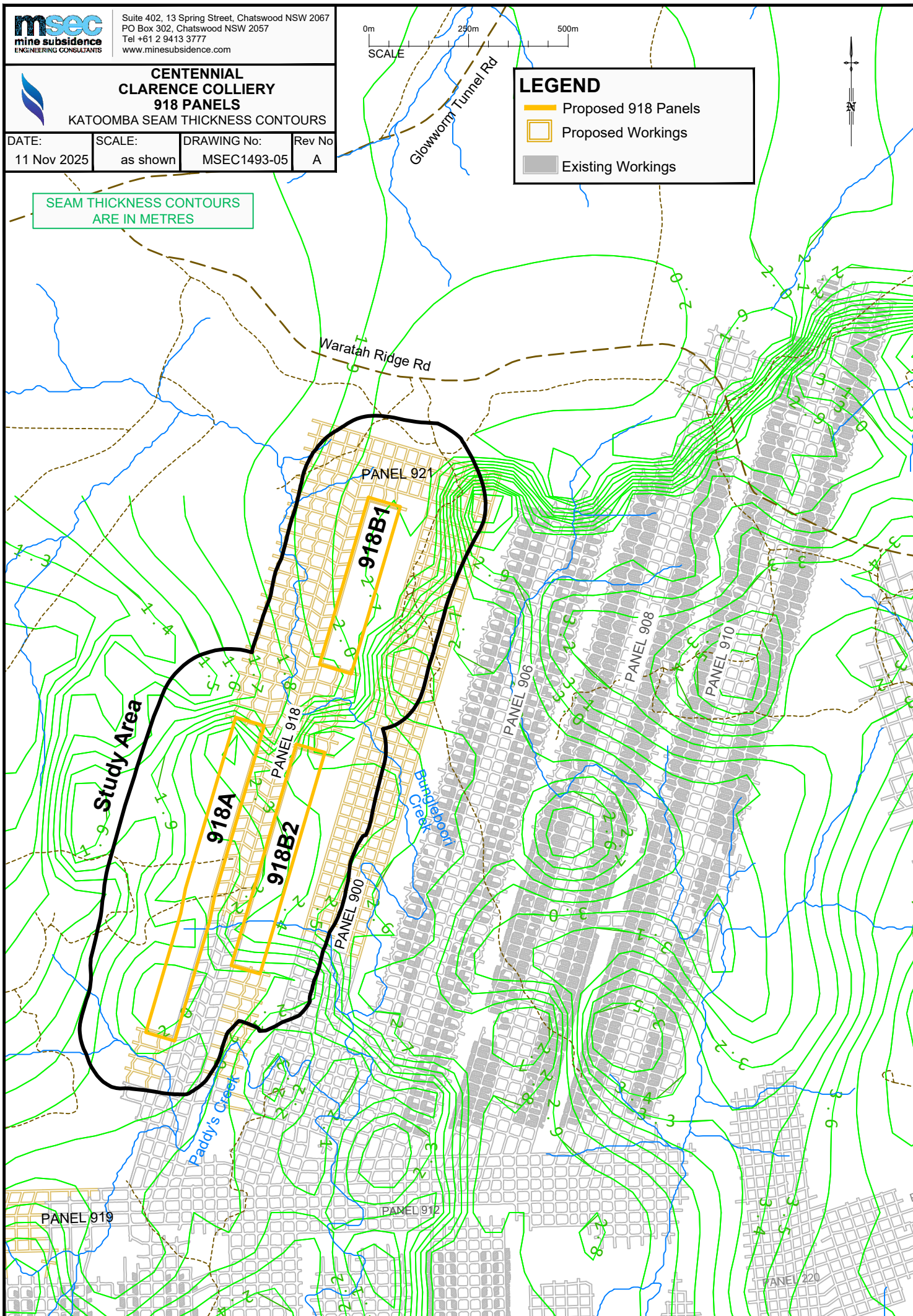
CENTENNIAL CLARENCE COLLIERY 918 PANELS KATOOMBA SEAM THICKNESS CONTOURS

LEGEND

- Proposed 918 Panels
- Proposed Workings
- Existing Workings

DATE:	SCALE:	DRAWING No:	Rev No
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SEAM THICKNESS CONTOURS ARE IN METRES





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CENTENNIAL CLARENCE COLLIERY 918 PANELS

KATOOMBA DEPTH OF COVER CONTOURS

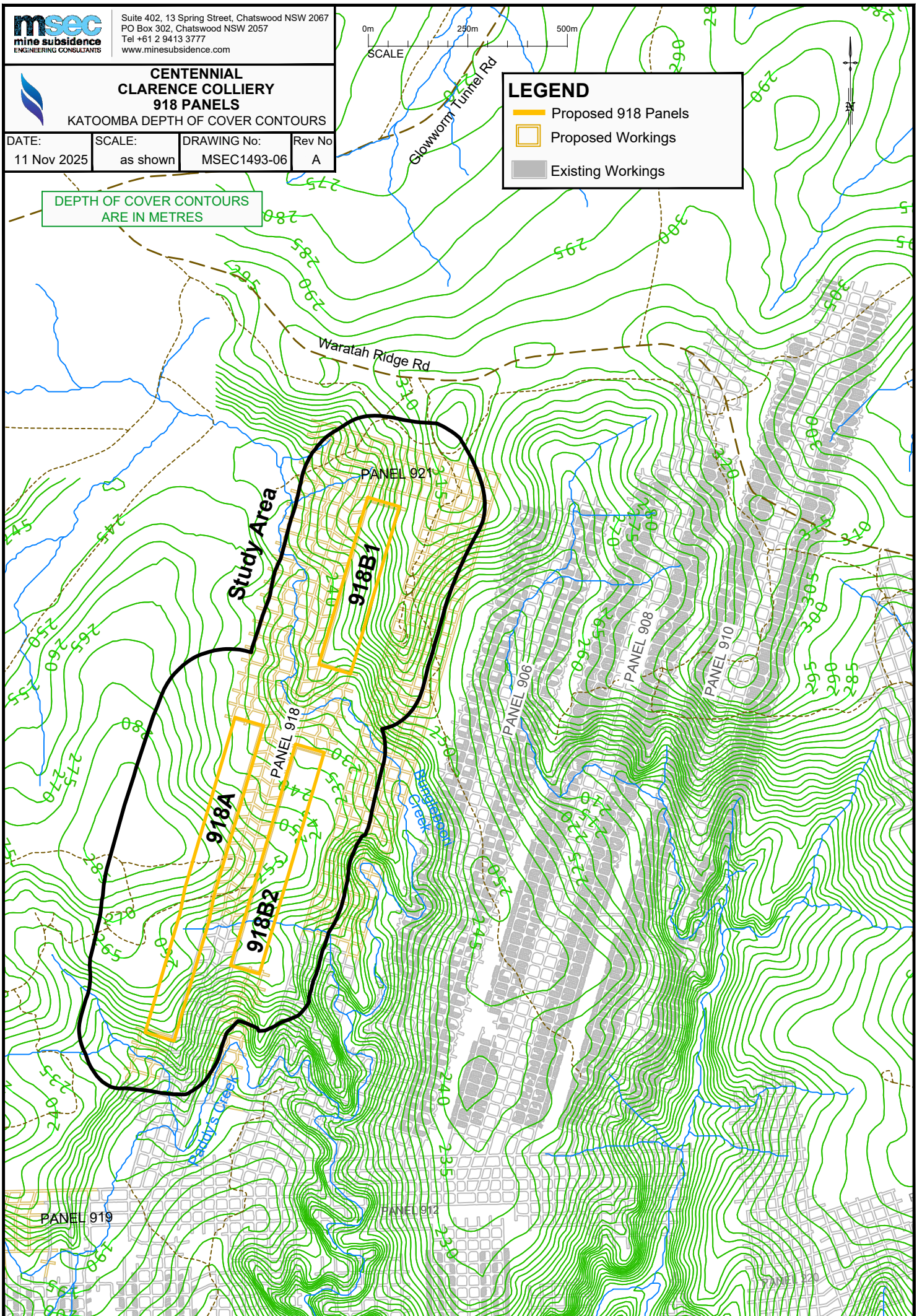
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LEGEND

- Proposed 918 Panels
- Proposed Workings
- Existing Workings

DEPTH OF COVER CONTOURS
ARE IN METRES





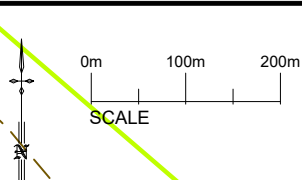
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CENTENNIAL CLARENCE COLLIERY 918 PANELS

GEOLOGICAL STRUCTURES AT SEAM

DATE: 11 Nov 2025	SCALE: as shown	DRAWING No: MSEC1493-07	Rev No: A
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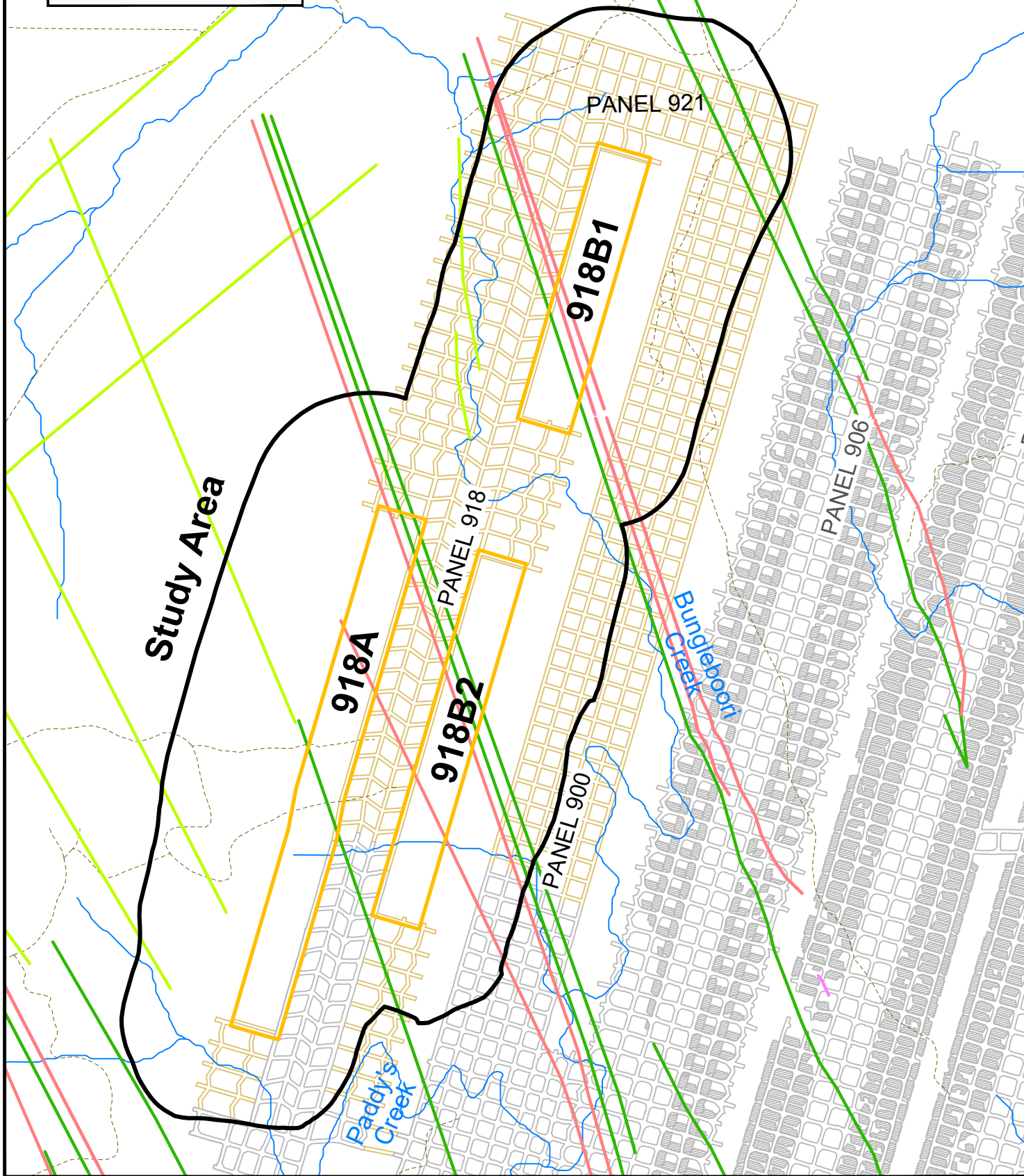


LEGEND

- Proposed 918 Panels
- Proposed Workings
- Existing Workings

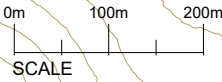
LEGEND FAULTS

- TYPE 1a
- TYPE 1b
- TYPE 3a
- TYPE 3b





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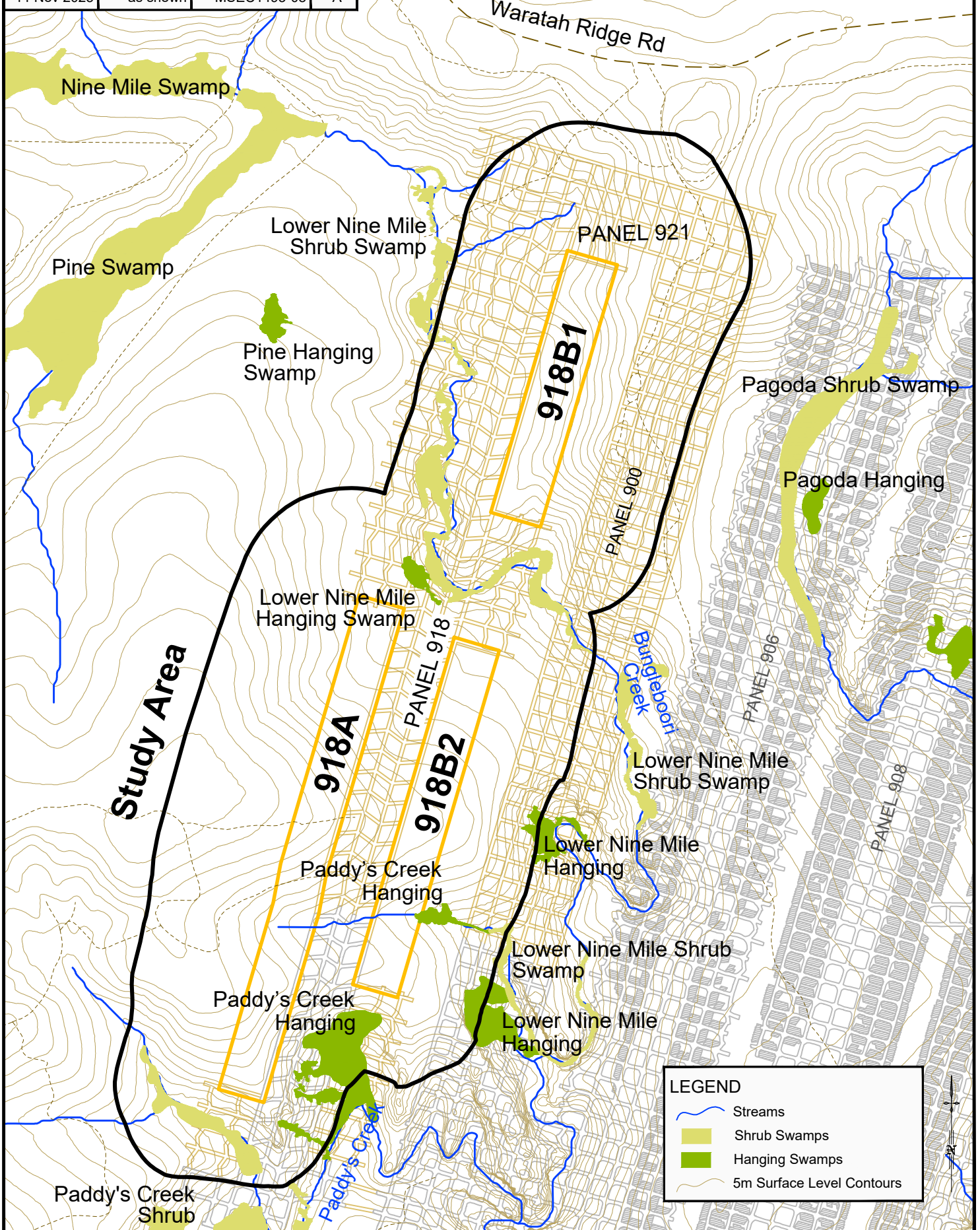


LEGEND

- Proposed 918 Panels
- Proposed Workings
- Existing Workings

**CENTENNIAL
 CLARENCE COLLIERY
 918 PANELS
 STREAMS & SWAMPS**

DATE: 11 Nov 2025	SCALE: as shown	DRAWING No: MSEC1493-08	Rev No: A
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LEGEND

- Streams
- Shrub Swamps
- Hanging Swamps
- 5m Surface Level Contours



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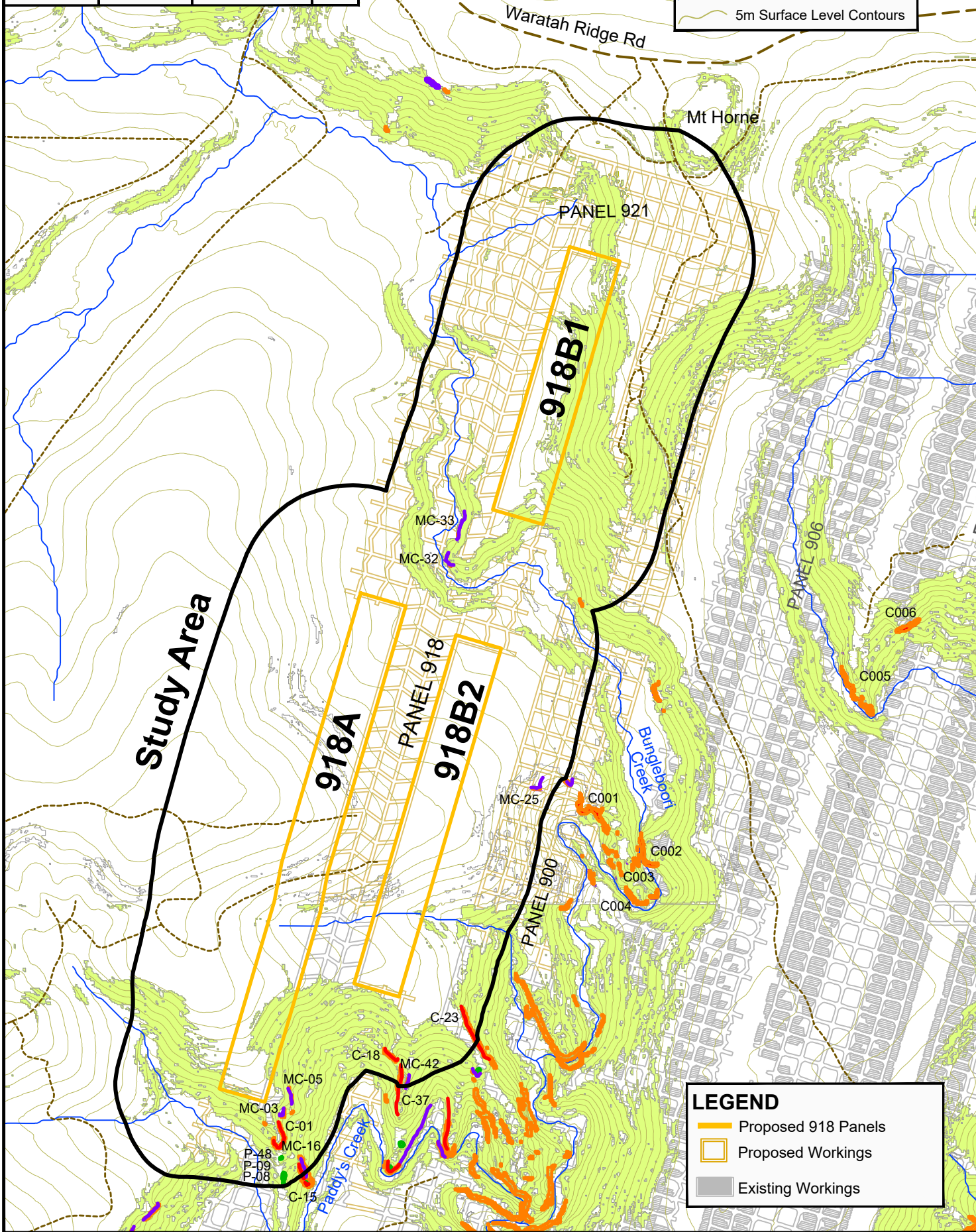
**CENTENNIAL
 CLARENCE COLLIERY
 918 PANELS
 CLIFFS, STEEP SLOPES & PAGODAS**

DATE: 11 Nov 2025	SCALE: as shown	DRAWING No: MSEC1493-09	Rev No: A
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LEGEND

- Cliffs (Site Verified)
- Cliffs (LIDAR)
- Pagodas
- Minor Cliffs
- Steep Slopes (> 1 in 3)
- Streams
- 5m Surface Level Contours

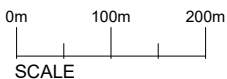


LEGEND

- Proposed 918 Panels
- Proposed Workings
- Existing Workings



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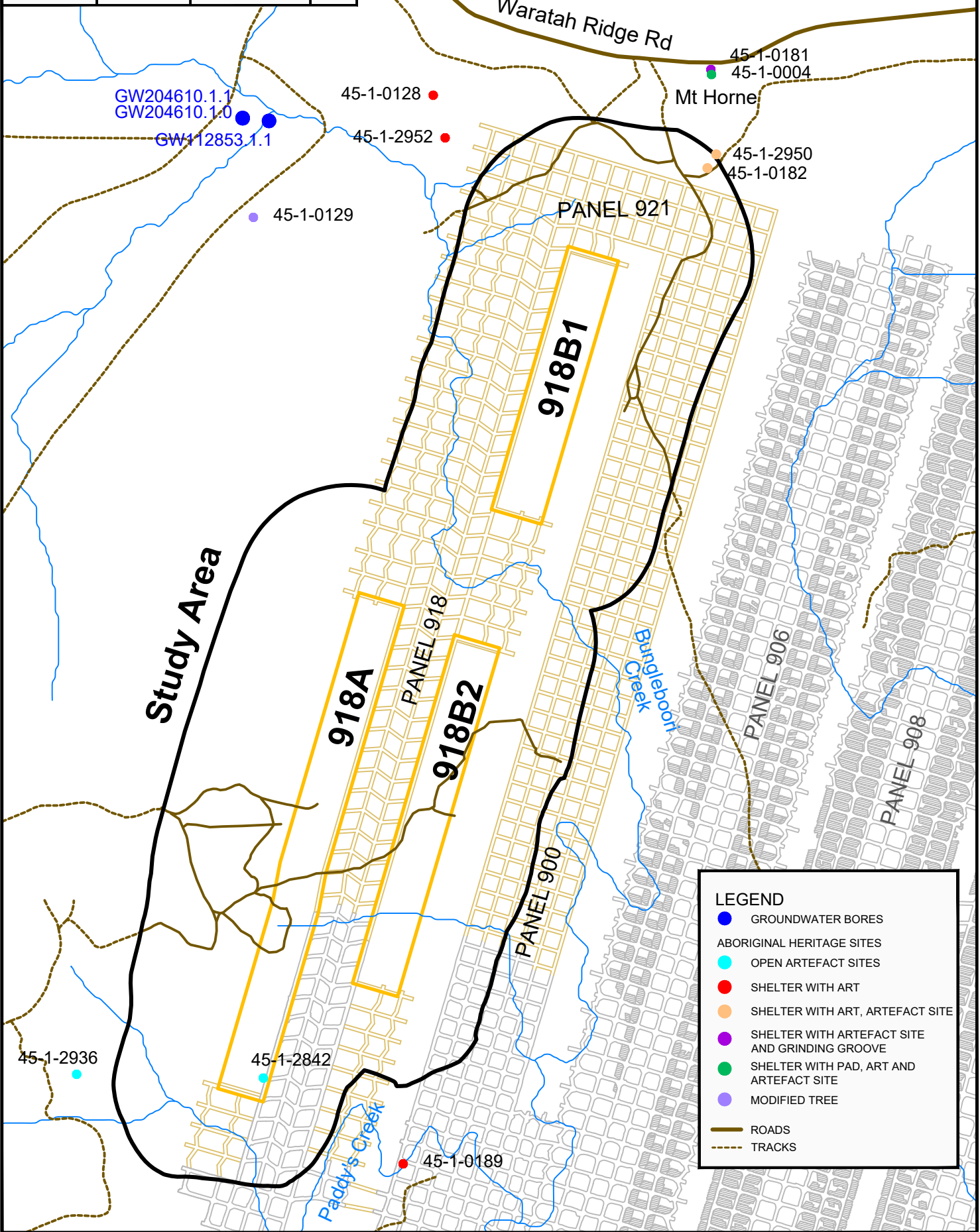
LEGEND

- Proposed 918 Panels
- Proposed Workings
- Existing Workings



CENTENNIAL CLARENCE COLLIERY 918 PANELS BUILT FEATURES

DATE: 11 Nov 2025	SCALE: as shown	DRAWING No: MSEC1493-10	Rev No: A
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LEGEND

- GROUNDWATER BORES
- ABORIGINAL HERITAGE SITES
- OPEN ARTEFACT SITES
- SHELTER WITH ART
- SHELTER WITH ART, ARTEFACT SITE
- SHELTER WITH ARTEFACT SITE AND GRINDING GROOVE
- SHELTER WITH PAD, ART AND ARTEFACT SITE
- MODIFIED TREE
- ROADS
- TRACKS



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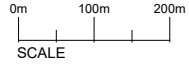


**CENTENNIAL
CLARENCE COLLIERY
918 PANELS**
PREDICTED SUBSIDENCE CONTOURS AFTER
918A PANEL

DATE: 11 Nov 2025	SCALE: as shown	DRAWING No: MSEC1493-11	Rev No: A
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Glowworm Tunnel Rd

NOTE:
The value of the Subsidence Contours, from the outside to the inside of the panels, are 10mm, 20mm, 30mm and so forth in 10mm increments.



Waratah Ridge Rd

PANEL 921

918B1

Bungleboori Creek

PANEL 906

PANEL 908

Prediction Line 1

918A

918B2

PANEL 900

Paddy's Creek

PANEL 919

PANEL 912



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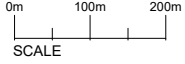


**CENTENNIAL
CLARENCE COLLIERY
918 PANELS**
PREDICTED TOTAL VERTICAL SUBSIDIENCE
CONTOURS AFTER 918B1 PANEL

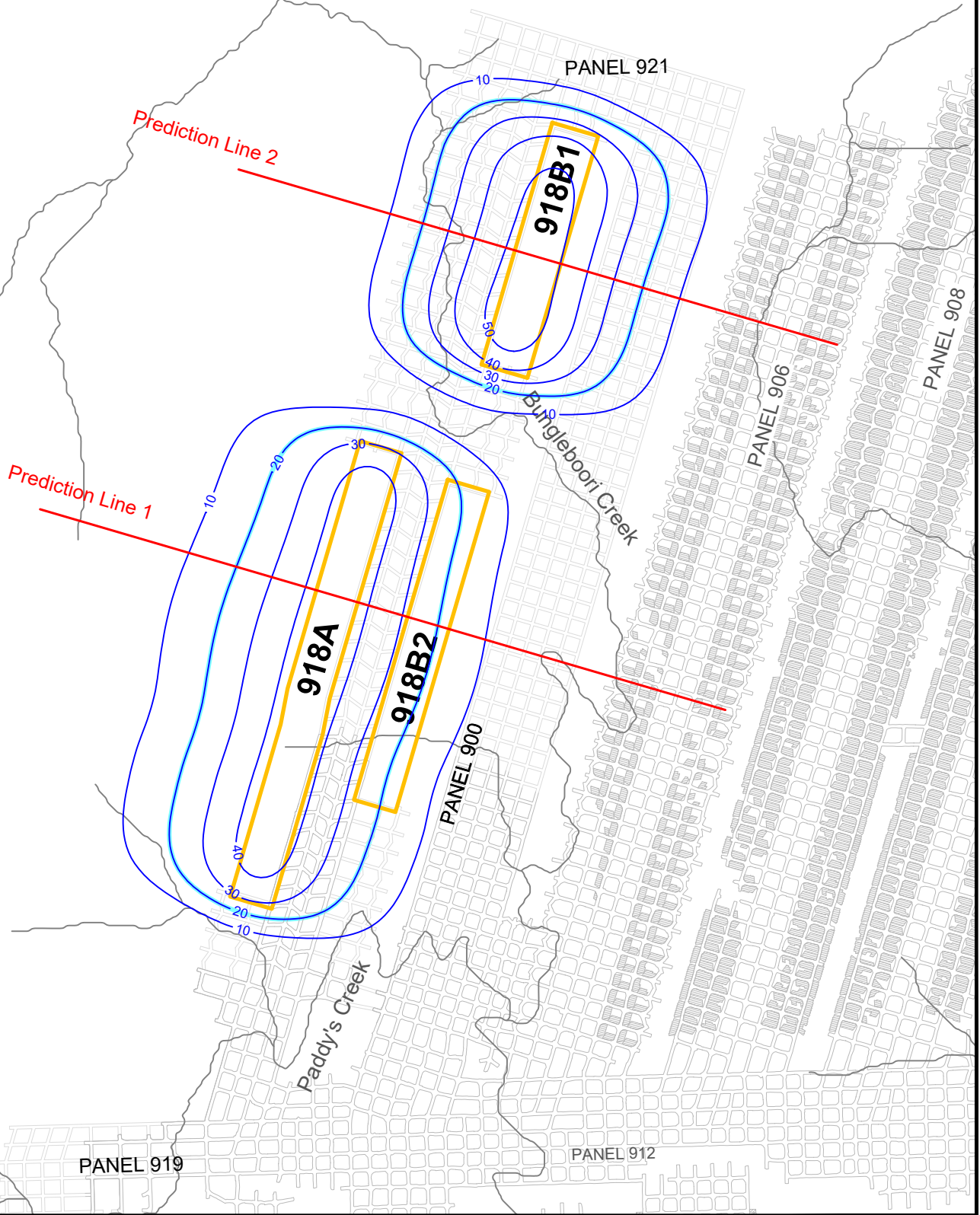
DATE:	SCALE:	DRAWING No:	Rev No
11 Nov 2025	as shown	MSEC1493-12	A

Glowworm Tunnel Rd

NOTE:
The value of the Subsidence Contours, from the outside to the inside of the panels, are 10mm, 20mm, 30mm and so forth in 10mm increments.



Waratah Ridge Rd





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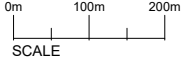


**CENTENNIAL
CLARENCE COLLIERY
918 PANELS**
PREDICTED TOTAL VERTICAL SUBSIDENCE
CONTOURS AFTER 918B2 PANEL

DATE: 11 Nov 2025	SCALE: as shown	DRAWING No: MSEC1493-13	Rev No: A
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Glowworm Tunnel Rd

NOTE:
The value of the Subsidence Contours, from the outside to the inside of the panels, are 10mm, 20mm, 30mm and so forth in 10mm increments.



Waratah Ridge Rd

PANEL 921

Prediction Line 2

918B1

PANEL 908

PANEL 906

Bungleboori Creek

Prediction Line 1

918A

918B2

PANEL 900

Paddy's Creek

PANEL 919

PANEL 912



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LEGEND

- EXISTING ACTIVE GNSS (incl. recovery ground mark)
- GNSS - PROPOSED (incl. recovery ground mark)
- EXISTING SURVEY LINES
- PROPOSED SURVEY LINES
- ROADS
- - - TRACKS



CENTENNIAL CLARENCE COLLIERY 918 PANELS
SUBSIDENCE MONITORING

DATE: 11 Nov 2025	SCALE: as shown	DRAWING No: MSEC1493-14	Rev No: A
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LEGEND

- Proposed 918 Panels
- Proposed Workings
- Existing Workings

