Illawarra Coal

West Cliff Colliery
Area 5

REPORT

on

THE PREDICTION OF SUBSIDENCE PARAMETERS AND THE ASSESSMENT OF MINE SUBSIDENCE IMPACTS ON NATURAL FEATURES AND SURFACE INFRASTRUCTURE RESULTING FROM THE EXTRACTION OF PROPOSED LONGWALLS 34 TO 36 IN AREA 5 AT WEST CLIFF COLLIERY IN SUPPORT OF THE SMP APPLICATION

Mine Subsidence Engineering Consultants
Level 1, 228 Victoria Avenue – Chatswood – NSW 2067
PO Box 3047 – Willoughby North – NSW 2068
Tel. (02) 9413 3777 Fax. (02) 9413 3822
Email: enquiries@minesubsidence.com

www.minesubsidence.com

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

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

EXECUTIVE SUMMARY

BHP Billiton Illawarra Coal (IC) proposes to continue its underground coal mining operations at West Cliff Colliery, which is located in the Southern Coalfield of New South Wales, by extracting coal from the Bulli Seam using longwall mining techniques. IC are seeking approval to extract Longwalls 34 to 36, which are located immediately north of the approved Longwalls 29 to 33. The overall layout of the longwalls at West Cliff Colliery is shown in Drawing No. MSEC326-01, which together with all other drawings is included in Appendix G.

Mine Subsidence Engineering Consultants (MSEC) has been commissioned by IC to study the current mining proposals, to identify all the natural features and items of surface infrastructure and to prepare subsidence predictions and impact assessments for the proposed Longwalls 34 to 36.

The general SMP Area has been defined, as a minimum, as the surface area enclosed by a 35 degree angle of draw line from the limit of proposed mining and by the predicted 20 mm subsidence contour resulting from the extraction of the proposed Longwalls 34 to 36. The general SMP Area has been extended to include any other feature outside this area which could be subjected to valley related or far-field horizontal movements and could be sensitive to such movements.

A number of natural features and items of surface infrastructure have been identified within the general SMP Area, including the Georges River, drainage lines, cliffs, steep slopes, roads, water pipelines, sections of the Upper Canal system, gas pipelines, electrical services, telecommunications services and building structures. A number of other natural features and items of surface infrastructure, which are located outside the general SMP Area and for which assessments have been made, include sections of the Georges River and drainage lines, sections of the Upper Canal and Devines Tunnel, groundwater bores and survey control marks, within the limits of the predicted valley related or far-field movements.

A number of variations in the layout of Longwalls 34 to 36 were considered as part of the process to develop the final mining geometry. These included variations in the locations of the ends of the longwalls relative to the Georges River. It can be seen from the two examples provided in Appendix C, that the predicted subsidence, upsidence and closure movements along the Georges River, for the case where the river is directly mined beneath, are significantly greater than those predicted for the cases where the longwalls do not mine beneath the river. The proposed layout has been optimised to maximise the extraction of coal while significantly reducing the level of impact on the Georges River. The analysis also shows that very large tonnages of additional coal are required to be sterilised to achieve relatively small additional reductions in the maximum predicted movements along the river.

Chapter 1 of this report provides a general introduction to the study, which also includes a description of the mining geometry and geological details of the proposed mining area. Chapter 2 identifies all natural features and items of surface infrastructure within the SMP Area. Chapter 3 includes a brief overview of longwall mining, the development of mine subsidence and the methods that have been used to predict the mine subsidence movements resulting from the extraction of the proposed longwalls.

Chapter 4 provides the maximum predicted systematic subsidence parameters resulting from the extraction of the proposed longwalls. Chapter 5 provides the predicted systematic subsidence and valley related movements for each natural feature and item of surface infrastructure which was described in Chapter 2. The impact assessments and recommendations for each of these features are also provided, which have been based on the predicted subsidence parameters. Chapter 6 provides recommendations for ground monitoring.

The assessments in this report indicate that the levels of impact on the natural features and items of surface infrastructure are not significant and can be managed by the preparation and implementation of management strategies. It should be noted, however, that more detailed assessments of some natural features and items of surface infrastructure have been undertaken by other consultants, and the findings in this report should be read in conjunction with the findings in all other relevant reports.

Monitoring of ground movements is recommended, as subsidence occurs, so that the observed ground movements can be compared with those predicted and to allow regular reviews of the predictions and impact assessments in the light of measured data.

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CHAPTER 1. BACKGROUND

1.1. Introduction

BHP Billiton Illawarra Coal (IC) proposes to continue its underground coal mining operations at West Cliff Colliery, which is located in the Southern Coalfield of New South Wales, by extracting coal from the Bulli Seam using longwall mining techniques. IC are seeking approval to extract Longwalls 34 to 36, which are located immediately north of the approved Longwalls 29 to 33. The overall layout of the longwalls at West Cliff Colliery is shown in Drawing No. MSEC326-01, which together with all other drawings is included in Appendix G.

Mine Subsidence Engineering Consultants (MSEC) has been commissioned by IC to study the current mining proposals, to identify all the natural features and items of surface infrastructure and to prepare subsidence predictions and impact assessments for the proposed Longwalls 34 to 36. This report provides information that will support the SMP Application to the Department of Primary Industries (DPI SMP Guideline, 2003), as summarised in Table 1.1.

Table 1.1 Information Provided in Support of the SMP Application

Information	Section of the Guideline for "Applications for Subsidence Management Approvals"
The SMP Area or Application Area	Section 6.2
Site Conditions of the SMP Area	Section 6.4
Characterisation of Surface and Sub-surface Features within the SMP Area	Section 6.6
Subsidence Prediction	Section 6.7
Subsidence Impacts	Section 6.10.1
Impact Assessment based on Increased Subsidence Predictions	Section 6.10.3

In some cases, the report will refer to other sources for information on specific natural features and items of surface infrastructure. The report will also provide information to assist the risk assessment section for the SMP Application (DPI SMP Guideline, 2003, Section 6.10.2).

A number of natural features and items of surface infrastructure have been identified in the vicinity of the proposed longwalls, including the Georges River, drainage lines, cliffs, steep slopes, roads, water pipelines, the Upper Canal system, gas pipelines, electrical services, telecommunications services, groundwater bores, survey control marks and building structures. A description of each of these features is provided in Chapter 2. The major natural features and items of surface infrastructure can be seen in Fig. 1.1, which shows the proposed Longwalls 34 to 36 and the general SMP Area, which is defined in Chapter 2.1, overlaid on an orthophoto of the area.

Chapter 3 includes a brief overview of longwall mining, the development of mine subsidence and the methods that have been used to predict the mine subsidence movements resulting from the extraction of the proposed longwalls.

Chapter 4 provides the maximum predicted systematic subsidence parameters resulting from the extraction of the proposed longwalls. Chapter 5 provides the predicted systematic subsidence parameters and impact assessments for the natural features and items of surface infrastructure within the SMP Area. The impact assessments and recommendations for each of these features have been made based on the predicted subsidence parameters.

Chapter 6 provides recommendations for ground monitoring for the proposed longwalls.

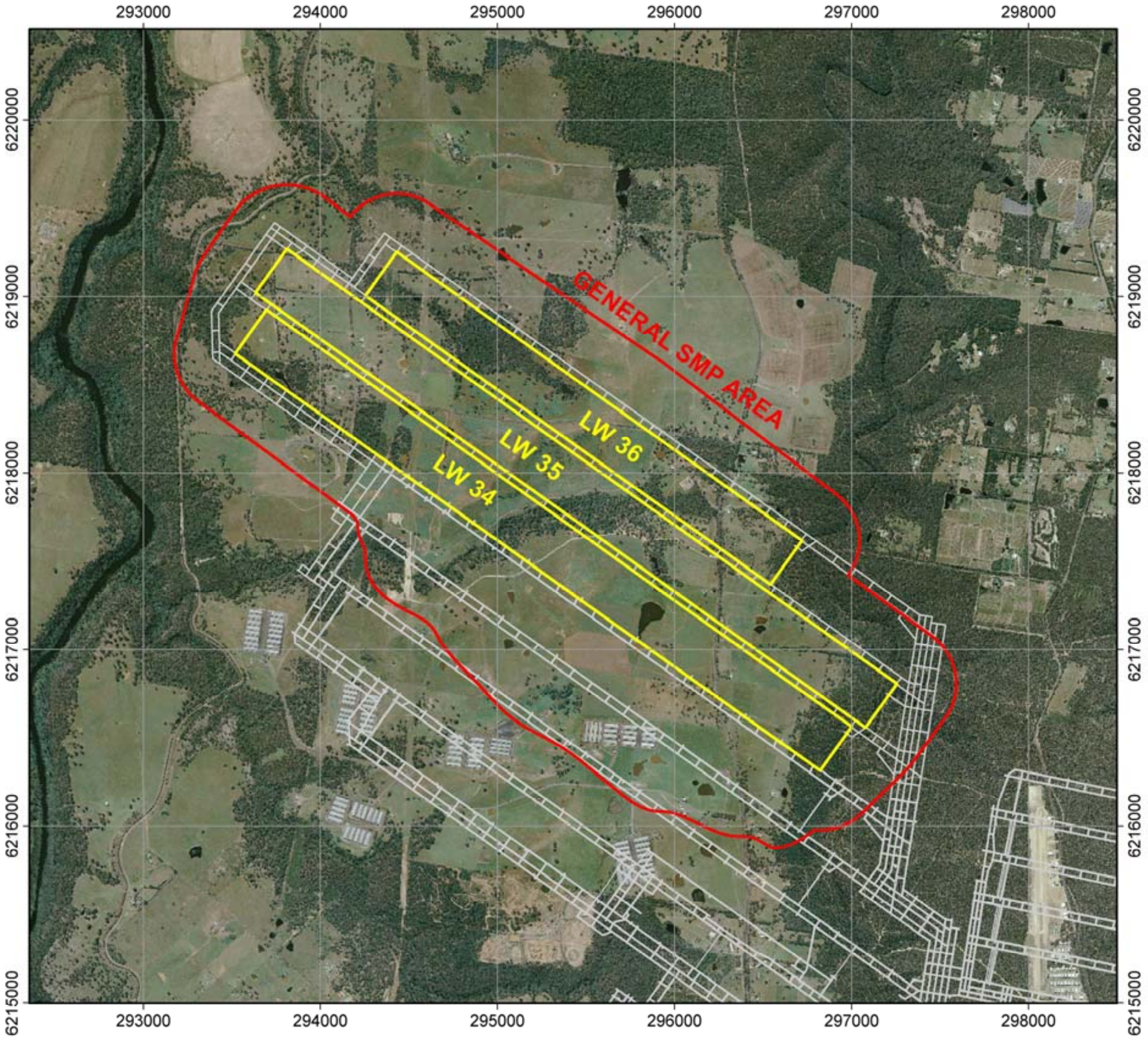


Fig. 1.1 Aerial Photograph Showing Longwalls 34 to 36 and the General SMP Area

1.2. Development of the Longwall Layout

A number of variations in the layout of Longwalls 34 to 36 were considered as part of the process to develop the final mining geometry. These included variations in the locations of the ends of the longwalls relative to the Georges River. Two examples of the longwall layouts which were considered as part of this process are provided in Appendix C at the end of this report.

The first example compares the predicted movements along the Georges River in the cases where the river is directly mined beneath and for offsets of 0, 100, 200, 300 and 400 metres from the river for Longwalls 34 to 36. The second example compares the predicted movements along the Georges River in the cases where the river is directly mined beneath and for offsets of 0, 100, 200, 300 and 400 metres from the river for Longwall 35 only.

For each example, the predicted systematic subsidence, valley related movements and tonnage of sterilised coal are shown for the range of longwall offsets from the river. It can be seen from these examples, that the maximum predicted subsidence, upsidence and closure movements along the Georges River, for the case where the river is directly mined beneath, are significantly greater than those predicted for the cases where the longwalls do not mine beneath the river. In the case where the river is directly mined beneath, the maximum predicted subsidence, upsidence and closure movements along the river are 6 times, 2 times and 2 times greater, respectively, than those predicted for the cases where the longwalls do not mine beneath the river.

It can also be seen from these examples, that the maximum predicted closure along the Georges River does not significantly decrease as the longwalls are progressively set back from the river. The reason for this is that the maximum predicted closure occurs adjacent to the maingate of Longwall 35 and the maximum component of this closure movement occurs as a result of the extraction of this longwall. To gain significant reductions in the maximum predicted closure, therefore, a very large set back of Longwall 35 is required. Based on Example 2, in order to reduce the maximum predicted closure along the Georges River from 210 mm to 175 mm, a total of 500,000 tonnes of additional coal would have to be sterilised.

1.3. Mining Geometry

The proposed layout of Longwalls 34 to 36 within the Bulli Seam is shown in Drawing No. MSEC326-01. A summary of the proposed dimensions of these longwalls is provided in Table 1.2.

Table 1.2 Proposed Dimensions of Longwalls 34 to 36

Longwall	Overall Length (m)	Void Width Including Headings (m)	Solid Chain Pillar Width (m)
Longwall 34	4065	305	42
Longwall 35	4235	305	42
Longwall 36	2815	305	42

The depth of cover to the Bulli Seam within the general SMP Area varies between a minimum of 450 metres, in the base of the Georges River valley, and a maximum of 550 metres, above Longwall 32. The depth of cover directly above the proposed longwalls varies between 470 metres and 540 metres. The seam floor within the general SMP Area generally dips from the east to the west.

The seam thickness within the proposed longwall goaf areas varies between a minimum of 2.2 metres, near the commencing (western) end of Longwall 36, and a maximum of 2.65 metres, near the finishing (eastern) end of Longwalls 34. The proposed longwalls will extract a minimum height of 2.4 metres where the seam thickness is less than 2.4 metres and will extract the full height where the seam thickness is greater than 2.4 metres.

The surface level contours, seam floor contours, seam thickness contours and depth of cover contours are shown in Drawings Nos. MSEC326-02, MSEC326-03, MSEC326-04 and MSEC326-05, respectively.

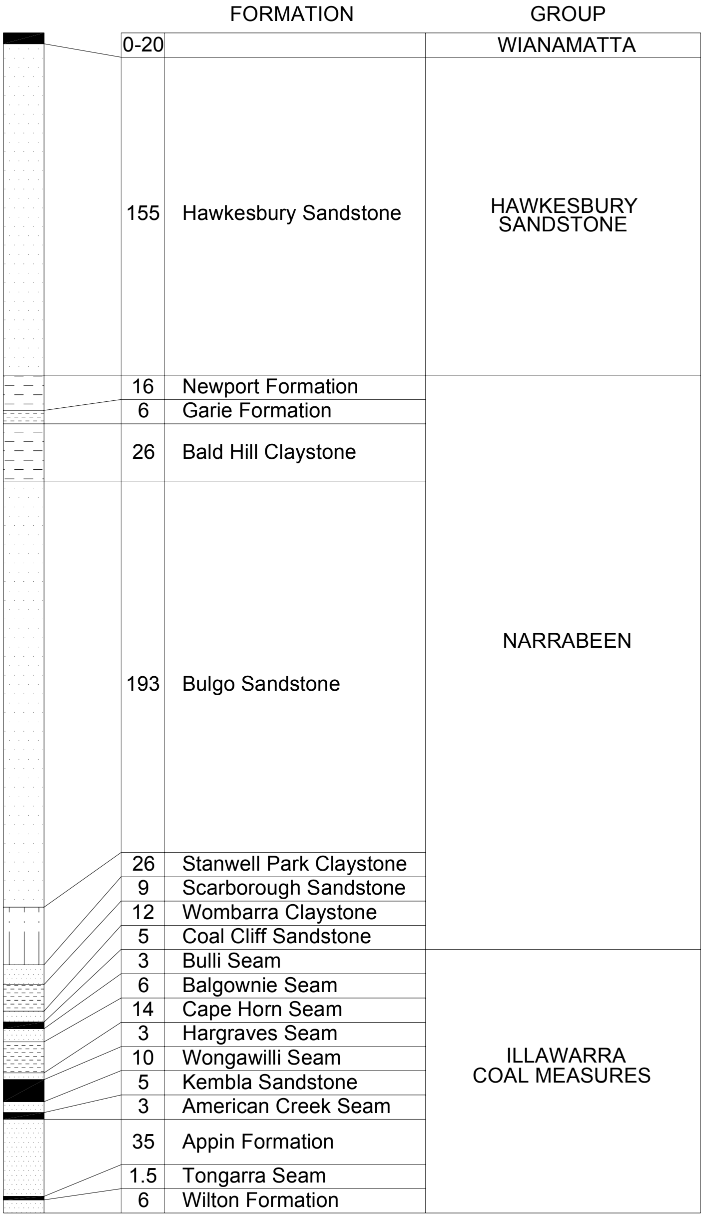
1.4. Geological Details

West Cliff Colliery lies in the southern part of the Permo-Triassic Sydney Basin, within which the main coal bearing sequence is the Illawarra Coal Measures, of Late Permian age. The Illawarra Coal Measures contain numerous workable seams, the uppermost of which is the Bulli Seam.

All of the sediments that form the overburden to the Bulli Seam belong to the Hawkesbury Tectonic Stage, which comprises three stratigraphic divisions. The lowest division is the Narrabeen Group, which is subdivided into a series of interbedded sandstone and claystone units. It ranges in age from Lower to Middle Triassic and varies in thickness up to 310 metres. Overlying the Narrabeen Group is the Hawkesbury Sandstone Group, which is a series of bedded sandstone units which dates from the Middle Triassic and has a thickness of up to 185 metres. Above the Hawkesbury is the Wianamatta Group, which consists of shales and siltstones and is poorly represented in this region, having a thickness of only a few tens of metres. A typical stratigraphic section for the West Cliff Colliery area is shown in Fig. 1.2.

The major sandstone units are interbedded with other rocks and, though shales and claystones are quite extensive in places, the sandstone predominates. The major sandstone units are the Scarborough, the Bulgo and the Hawkesbury Sandstones and these units vary in thickness from a few metres to as much as 200 metres. The rocks exposed in the river gorges and creek alignments belong to the Hawkesbury Group. The other rocks generally exist in discreet but thinner beds of less than 15 metres thickness, or are interbedded as thin bands within the sandstone.

The major claystone unit is the Bald Hill Claystone, which lies above the Bulgo Sandstone at the base of the Hawkesbury Sandstone. This claystone varies in thickness and is, in some places, more than 25 metres thick. Due to the nature of the clay, which swells when it is wetted, it tends to act as an aquiclude or aquitard.



	FORMATION	GROUP
0-20		WIANAMATTA
155	Hawkesbury Sandstone	HAWKESBURY SANDSTONE
16	Newport Formation	NARRABEEN
6	Garie Formation	
26	Bald Hill Claystone	
193	Bulgo Sandstone	
26	Stanwell Park Claystone	
9	Scarborough Sandstone	
12	Wombarra Claystone	
5	Coal Cliff Sandstone	
3	Bulli Seam	ILLAWARRA COAL MEASURES
6	Balgownie Seam	
14	Cape Horn Seam	
3	Hargraves Seam	
10	Wongawilli Seam	
5	Kembla Sandstone	
3	American Creek Seam	
35	Appin Formation	
1.5	Tongarra Seam	
6	Wilton Formation	

Fig. 1.2 Typical Stratigraphic Section – Southern Coalfield

The geological structures which have been identified at seam level are shown in Drawing No. MSEC326-06. The geological features identified at seam level within the SMP Area include the minor faulting zone, which crosses near the mid-lengths of Longwalls 34 to 36, and the series of faults located to the north of Longwall 36. The likelihood of irregular subsidence profiles resulting from near surface geological features is discussed in Section 5.33.4.

The surface geology within the SMP Area can be seen in Fig. 1.3, which shows the proposed longwalls overlaid on Geological Series Sheet 9029-9129, which is published by the DPI.

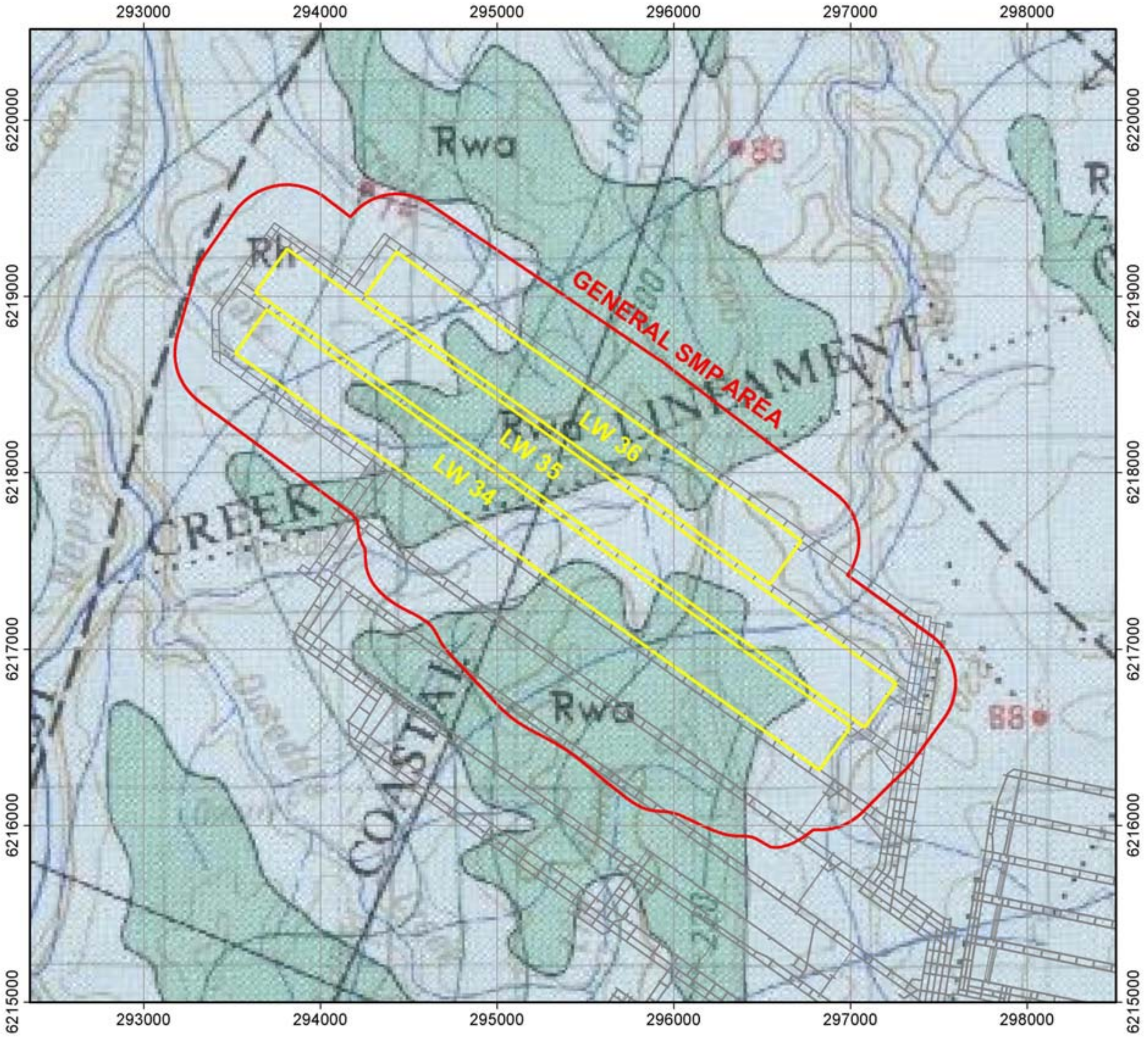


Fig. 1.3 Surface Geology within the SMP Area (DPI Geological Series Sheet 9029-9129)

It can be seen from the above figure that the surface geology within the SMP Area comprises areas of the Hawkesbury Sandstone Group (Rh) and areas of the Wianamatta Group (Rwa).

CHAPTER 2. IDENTIFICATION OF SURFACE FEATURES

2.1. The SMP Area and the General SMP Area

The *SMP Area* has been defined as the surface area that is likely to be affected by the proposed mining of Longwalls 34 to 36 in the Bulli Seam at West Cliff Colliery. The extent of the SMP Area has been calculated by combining the areas bounded by the following limits:-

- The 35 degree angle of draw line,
- The predicted vertical limit of subsidence, taken as the 20 mm subsidence contour, and
- Features sensitive to far-field movements.

The 35 degree angle of draw line is described as the "surface area defined by the cover depths, angle of draw of 35 degree and the limit of the proposed extraction area in mining leases of the Southern Coalfield", as stated in Section 6.2 of the Department of Primary Industries (DPI) SMP Guideline 2003. Given that the depth of cover above the proposed longwalls varies between 470 metres and 540 metres, the 35 degree angle of draw line has been conservatively determined by drawing a line that is a horizontal distance varying between 330 and 380 metres from the proposed extraction areas of Longwalls 34 to 36.

The predicted limit of vertical subsidence, taken as the predicted 20 mm subsidence contour resulting from the extraction of Longwalls 34 to 36, has been determined using the Incremental Profile Method, which is described in Section 3.4. Further details on the Incremental Profile Method are provided in the background report entitled *General Discussion on Mine Subsidence Ground Movements* which can be obtained from *www.minesubsidence.com*. The predicted 20 mm subsidence contour is typically located within the 35 degree angle of draw line, however, it extends beyond the draw line above the adjacent Longwalls 29 to 33.

A line has therefore been drawn defining the *general SMP Area*, based upon the 35 degree angle of draw line and the predicted 20 mm subsidence contour, and is shown in Drawing No. MSEC326-01. There are areas that lie outside the general SMP Area that are expected to experience either far-field movements, or valley related upsidence and closure movements. The features which may be sensitive to such movements have been identified in this report and have been included as part of the assessments. The features that have been included within the SMP Area, beyond the extent of the general SMP Area, are listed below:-

- The Georges River, creeks and gullies within the predicted limits of 20 mm upsidence and 20 mm closure resulting from the extraction of Longwalls 34 to 36,
- The sections of the Upper Canal system within the predicted limits of 20 mm upsidence and 20 mm closure at the drainage line crossings resulting from the extraction of Longwalls 34 to 36,
- Groundwater bores within the predicted limit of far-field horizontal movements, and
- Survey Control Marks within the predicted limit of far-field horizontal movements.

2.2. General Description of the Natural Features and Items of Surface Infrastructure

The major natural features and items of surface infrastructure within the SMP Area can be seen in the 1:25,000 Topographic Map of the area, published by the Central Mapping Authority (CMA), numbered APPIN 9029-1-S. The proposed Longwalls 34 to 36 and the general SMP Area have been overlaid on an extract of this CMA map, which are shown in Fig. 2.1.

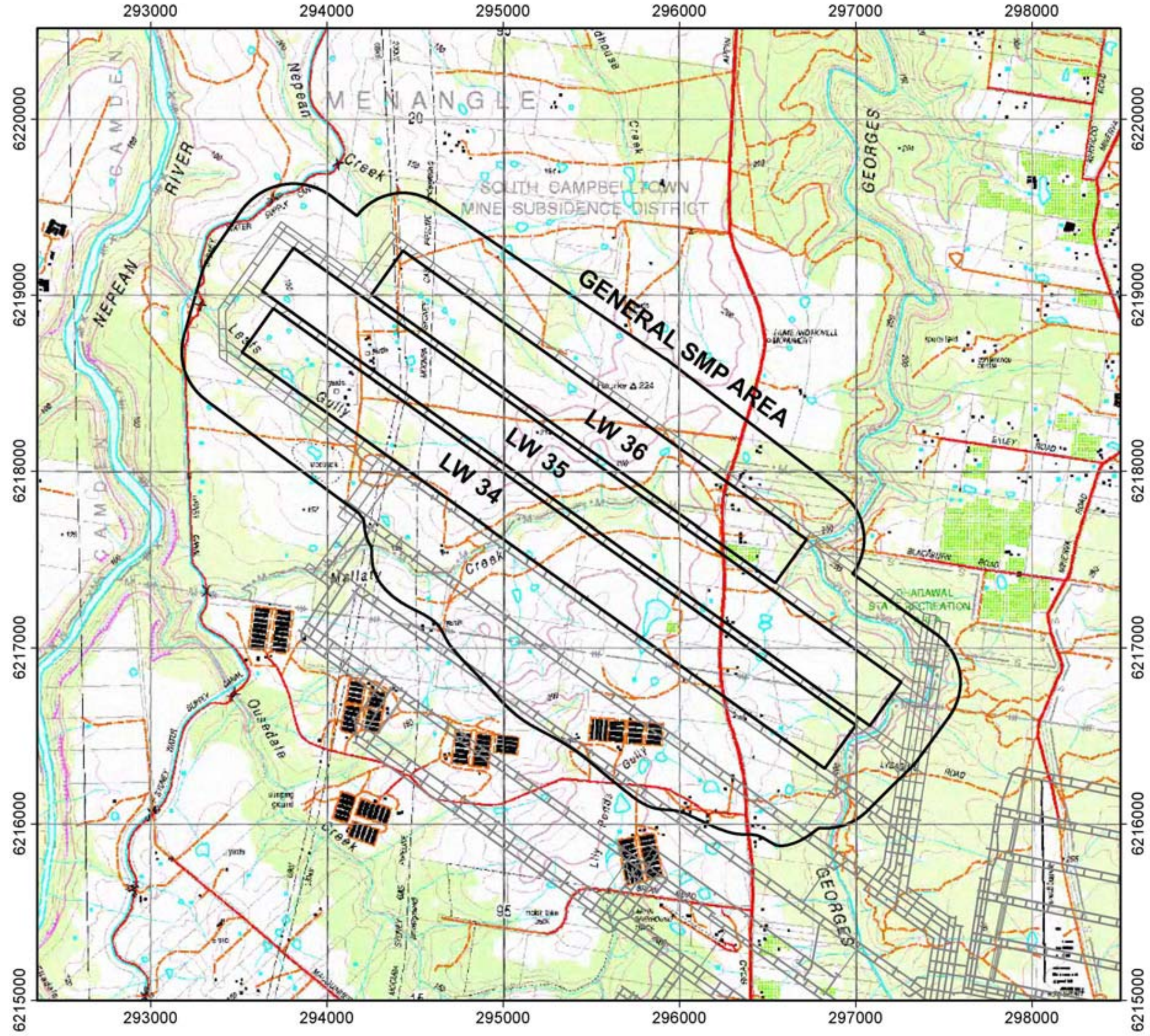


Fig. 2.1 Longwalls 34 to 36 and the General SMP Area Overlaid on Part CMA Map Numbered APPIN 9029-1-S

The following sections in this chapter identify and describe all of the major natural features and items of surface infrastructure that lie within the SMP Area. A summary of these features is provided in Table 2.1, which follows the list included in Appendix B of the DPI SMP Guideline.

Further details identifying areas of environmental sensitivity, as defined in DPI SMP Guideline, are provided in Section 2.3. The natural features and items of surface infrastructure within the SMP Area, which are further defined by specific studies, are illustrated in Drawings Nos. MSEC326-07 to MSEC326-27.

Table 2.1 Natural Features and Surface Improvements within the SMP Area

Item	Within SMP Area	Environmentally Sensitive Area	Section Number Reference
NATURAL FEATURES			
Catchment Areas or Declared Special Areas			
Rivers or Creeks	✓	✓	2.4.2 & 2.4.3
Aquifers or Known Groundwater Resources			2.4.4
Springs	✓		2.4.5
Sea or Lakes			
Shorelines			
Natural Dams			
Cliffs or Pagodas	✓	✓	2.4.9
Steep Slopes	✓		2.4.10
Escarpments			
Land Prone to Flooding or Inundation			
Swamps, Wetlands or Water Related Ecosystems	✓		2.4.13
Threatened, Protected Species or Critical Habitats	✓	✓	2.4.14
National Parks or Wilderness Areas			
State Recreational or Conservation Areas	✓	✓	2.4.16
State Forests			
Natural Vegetation	✓		2.4.18
Areas of Significant Geological Interest			
Any Other Natural Feature Considered Significant			
PUBLIC UTILITIES			
Railways			
Roads (All Types)	✓		2.5.2
Bridges			
Tunnels	✓		2.5.6.2
Culverts	✓		2.5.6.2 & 2.8.3
Water, Gas or Sewerage Pipelines	✓	✓	2.5.6, 2.5.8, & 2.8.3
Liquid Fuel Pipelines			
Electricity Transmission Lines or Associated Plants	✓	✓	2.5.10
Telecommunication Lines or Associated Plants	✓	✓	2.5.11
Water Tanks, Water or Sewage Treatment Works			
Dams, Reservoirs or Associated Works			
Air Strips			
Any Other Public Utilities			
PUBLIC AMENITIES			
Hospitals			
Places of Worship			
Schools			
Shopping Centres			
Community Centres			
Office Buildings			
Swimming Pools			
Bowling Greens			
Ovals or Cricket Grounds			
Racecourses			
Golf Courses			
Tennis Courts			
Any Other Public Amenities			
FARM LAND AND FACILITIES			
Agricultural Utilisation, Agricultural Improvements or Agricultural Suitability of Farm Land	✓		2.7.1
Farm Buildings or Sheds	✓		2.7.2 & 2.7.3
Gas or Fuel Storages	✓		2.7.4
Poultry Sheds	✓		2.8.3
Glass Houses or Green Houses			
Hydroponic Systems			
Irrigation Systems			
Fences	✓		2.7.9
Farm Dams	✓		2.7.10
Wells or Bores	✓		2.7.11
Any Other Farm Features			
INDUSTRIAL, COMMERCIAL AND BUSINESS ESTABLISHMENTS			
Factories			
Workshops			
Business or Commercial Establishments or Improvements	✓		2.8.3
Gas or Fuel Storages or Associated Plants			
Waste Storages and Associated Plants			
Buildings, Equipment or Operations that are Sensitive to Surface Movements			
Surface Mining (Open Cut) Voids and Rehabilitated Areas			
Mine Infrastructure Including Tailings Dams or Emplacement Areas			
Any Other Industrial, Commercial or Business Features			
AREAS OF ARCHAEOLOGICAL OR HERITAGE SIGNIFICANCE	✓	✓	2.9 & 2.10
ITEMS OF ARCHITECTURAL SIGNIFICANCE			
PERMANENT SURVEY CONTROL MARKS	✓		2.12
RESIDENTIAL ESTABLISHMENTS			
Houses	✓		2.13.1
Flats or Units			
Caravan Parks			
Retirement or Aged Care Villages			
Associated Structures such as Workshops, Garages, On-Site Waste Water Systems, Water or Gas Tanks, Swimming Pools or Tennis Courts	✓		2.7.2 & 2.7.3
Any Other Residential Features	✓		2.13.6
ANY OTHER ITEM OF SIGNIFICANCE			

2.3. Areas of Environmental Sensitivity

This section provides a brief summary of features identified as "Areas of Environmental Sensitivity" within the SMP Area, as defined in Section 6.6.3 of the DPI SMP Guideline. Further details on each of these features are provided in subsequent sections of this report.

Table 2.2 Summary of Areas of Environmental Sensitivity within the SMP Area

No.	Description	Within SMP Area	Details	Section No. Ref.
1	Land reserved as a State Conservation Area under the *National Parks and Wildlife Act 1974*	✓	Dharawal State Conservation Area	2.4.16
2	Land declared as an Aboriginal Place under the *National Parks and Wildlife Act 1974*	None		
3	Land identified as *Wilderness* by the Director, National Parks and Wildlife under the *Wilderness Act 1987*	None		
4	Land subject to a 'conservation agreement' under the *National Parks and Wildlife Act 1974*	None		
5	Land acquired by the Minister for the Environment under Part 11 of the *National Parks and Wildlife Act 1974*	None		
6	Land within State forests mapped as Forestry Management Zone 1, 2 or 3	None		
7	Wetlands mapped under SEPP 14 – Coastal Wetlands	None		
8	Wetlands listed under the Ramsar Wetlands Convention	None		
9	Lands mapped under SEPP 26 – Coastal Rainforests	None		
10	Areas listed on the Register of the National Estate	None		
11	Areas listed under the *Heritage Act 1977* for which a plan of management has been prepared	None		
12	Land declared as critical habitat under the *Threatened Species Conservation Act 1995*	None		
13	Land within a restricted area prescribed by a controlling water authority	None		
14	Land reserved or dedicated under the *Crown Lands Act 1989* for the preservation of flora, fauna, geological formations or other environmental protection purpose	None		
15	Significant surface watercourses and groundwater resources identified through consultation with relevant government agencies	✓	The Georges River	2.4.2
16	Lake foreshores and flood prone areas	None		
17	Cliffs, escarpments and other significant natural features	✓	Cliffs	2.4.9
18	Areas containing significant ecological values	None		
19	Major surface infrastructure	✓	1200mm Water Pipeline, The Upper Canal system, Devines Tunnel, Alinta EGP and AGN Natural Gas Pipelines, Gorodok Ethane Pipeline, 330kV Transmission Line, Optical Fibre Cable.	2.5.6 2.5.8 2.5.10 2.5.11
20	Surface features of community significance (including cultural, heritage or archaeological significance)	✓	The Georges River	2.4.2
21	Any other land identified by the Department to the titleholder	None		

2.4. Natural Features

2.4.1. Catchment Areas or Declared Special Areas

There are no drinking water catchment areas or declared special areas within the SMP Area. The land east of Appin Road (ie: 25 % of the general SMP Area) forms part of the catchment for the Georges River and the land west of Appin Road (ie: 75 % of the general SMP Area) forms part of the catchment for the Nepean River.

2.4.2. Rivers

The Georges River crosses the eastern side of the general SMP Area, the location of which is shown in Drawing No. MSEC326-07. The proposed Longwalls 34 to 36 mine up to the Georges River, but do not mine directly beneath the river.

The total length of the Georges River within the general SMP Area, which is defined by the 35 degree angle of draw line and the predicted 20 mm subsidence contour, is approximately 2.8 kilometres. The sections of the Georges River outside the general SMP Area but within the predicted limits of 20 mm upsidence and 20 mm closure, resulting from the extraction of Longwalls 34 to 36, have also been included within the SMP Area. This includes the 550 metre length of river immediately north of the general SMP Area.

The Georges River commences south of Appin and flows northward towards Liverpool, the river then flows eastward along the southern fringe of the Sydney metropolitan area and discharges into Botany Bay. The total length of the Georges River is approximately 100 kilometres. The section of river within the SMP Area forms part of the upper reaches of the Georges River.

The section of river within the SMP Area is moderately incised, with Hawkesbury Sandstone to the east and Wianamatta Shale outcrops to the west (IC, 2004a). The overall height of the Georges River valley within the SMP Area varies between 15 metres and 40 metres. The base of the river is Hawkesbury Sandstone.

The Georges River has been defined as an *area of environmental sensitivity* for the purposes of the SMP Application.

Description of Georges River within SMP Area

The river consists of a series of pools and rock bars, with small races over the rock bars. IC undertook geomorphological and geological mapping along the Georges River in 1999 and 2007. The locations of the mapped pools, rock bars, riffles, boulder fields and islands along the Georges River are shown in Drawing No. MSEC326-08. The extent of the SMP Area, including the sections of the river predicted to experience more than 20 mm additional upsidence and 20 mm additional closure, resulting from the extraction of Longwalls 34 to 36, lies between Rock Bar 37 and Rock Bar 65.

The gradient of the river is moderately steep with a fall of approximately 22 metres within the general SMP Area, which infers an average gradient of approximately 8 mm/m. The natural gradient of the river varies within the SMP Area between a minimum of less than 1 mm/m and a maximum of 50 mm/m.

The pools within the SMP Area are generally shallow. The lengths of the pools along the river vary between 5 and 315 metres, with the average lengths of the pools being approximately 70 metres. The longest pool within the SMP Area is Pool 61.

The rock bars within the SMP Area are generally low with small hydraulic gradients between upstream and downstream pools. Many of the rock bars are submerged during moderate flows. The lengths of the rock bars along the river vary between 3 and 145 metres, with the average lengths of the rock bars being approximately 25 metres. The longest rock bar within the SMP Area is Rock Bar 41.

Typical photographs of the Georges River within the SMP are provided in Fig. 2.2 to Fig. 2.5.

Fig. 2.2 Typical Stretch of the Georges River within the SMP Area – Pool 40

Fig. 2.3 Typical Stretch of the Georges River within the SMP Area – Rock Bar 45

Fig. 2.4 Typical Stretch of the Georges River within the SMP Area – Pool 57

Fig. 2.5 Typical Stretch of the Georges River within the SMP Area – Pool 60

Water Flows in the Georges River

The surface water flows in the Georges River, within the SMP Area, are derived from two main sources, being flows sourced from the catchment areas and flows sourced from the Licensed Discharges from Appin and West Cliff Collieries. Interaction between the surface and groundwater systems have been observed along the Georges River and the river is categorised as a *losing* system for most of the time, where the predominant movement is from the surface water to the groundwater system (IC, 2004a).

The catchment area for the upstream sections of the river includes rural properties to the west, where surface runoff is retained by numerous farm dams. Natural vegetation is typically located within the catchment area on the eastern side of the river.

Low to moderate water flows upstream of the licensed discharges have been routinely measured at a site called Upper Flow Station by IC and its consultants since October 2002, and the results are summarised in Table 2.3.

Table 2.3 Summary of Flow Rates recorded at Upper Flow Station

Period of Data :-	**16th Oct 2002 to 19th July 2005**
Total No. of Recordings	92 recordings
Minimum Flow	0.0 ML/day
Maximum Discharge	4.2 ML/day
Mean Flow Rate	0.3 ML/day
Median Flow Rate	0.1 ML/day

It can be seen from the above table that the flows upstream of the licensed discharges are relatively low.

The licensed discharges from Appin and West Cliff Collieries are the main source of low flow for the section of river within the SMP Area. The Appin Colliery discharge enters the Georges River via a small tributary upstream of Jutts Crossing. The West Cliff Colliery discharge enters Brennans Creek and is retained by Brennans Creek Dam. Water is released from the dam via a scour valve at its base. This discharge, along with other water that has leaked through the dam wall, is released via the Reclaim Pond (Point 10) into Brennans Creek, which flows into the Georges River. In addition to these flows, Brennans Creek Dam occasionally overtops during large rainfall events.

The discharges from Brennans Creek are currently controlled by a water management system which has been in place since the 2nd August 2004. The aim of discharge management (Pollution Reduction Program No. 7) is to restrict discharges from Point 10 to a maximum pH limit of 8.5 (Ecoengineers, 2005). In order to meet this aim, water is regularly discharged from the dam so that uncontrolled spillage during rainfall events can be minimised.

Given that the flow conditions within the Georges River are modified by the releases, which will continue during the SMP period, the baseline information that has been used to describe the current flow conditions within the SMP Area has been restricted to the period of time from which the releases began.

During this baseline period, however, remediation works were conducted by IC in previously affected sections of the Georges River and no water was discharged from either Colliery for short periods during the works in the river. The water flows during this period are therefore not representative of the flow conditions that occur within the SMP Area. The rehabilitation works along the river have been finalised.

Daily discharges from Appin and West Cliff Collieries have been examined for the period between 2nd August 2004 and 20th October 2005 and are summarised in Table 2.4. The results do not include the period of remediation works, which occurred on two occasions, and comprised a total of 41 days.

Table 2.4 Summary of Measured Discharges from Appin and West Cliff Collieries

	Appin Discharge	**West Cliff Colliery Point 10 Discharge**	**Brennans Creek Dam Spills**	**Combined Discharge & Spills**
Period of Data :-	**2nd August 2004 to 20th October 2005**			
Total No. of Recordings	403 days	403 days	403 days	403 days
Total No. of Days of Zero Flow	194 days	0 days	336 days	0 days
Minimum Flow	0.0 ML/day	0.01 ML/day	0.0 ML/day	0.2 ML/day
Maximum Flow	2.0 ML/day	1.7 ML/day	4.6 ML/day	7.2 ML/day
Mean Flow Rate	0.6 ML/day	0.9 ML/day	0.1 ML/day	1.6 ML/day
Median Flow Rate	0.1 ML/day	0.9 ML/day	0.0 ML/day	1.5 ML/day

In general, the water flows along the Georges River within the SMP Area are continuous as there is always some water being discharged into the river. It is postulated, however, that if the licensed discharges were not released into the river, the water flows would not be continuous along many sections of the river. In times of dry weather, the river has been known to consist of a series of disconnected pools, some of which were completely or partially drained.

The calculated frequencies of combined discharge and spill flow rates from Appin and West Cliff Collieries are shown in Table 2.5 for the period between 2nd August 2004 and 20th October 2005.

Table 2.5 Percentage of Measured Combined Discharge and Spills from Appin and West Cliff Collieries less than or equal to Selected Flow Rates

FLOW RATE (ML/day)	(%)
0.0	0.0
0.5	1.2
1.0	23.3
1.5	49.4
2.0	71.0
2.5	89.6
3.0	95.0
3.5	97.0
4.0	97.3
4.5	98.8
5.0	99.5
5.5	99.8
6.0	99.8
6.5	99.8
7.0	99.8
7.5	100.0
8.0	100.0

It can be seen from the above table that combined discharges and spills are typically in the range of 0.5 to 3 ML/day. Flows less than or equal to 0.5 ML/day are quite rare as they have only occurred for 1.2 % of the time.

IC has provided information to assist in understanding water flows in the Georges River. The information has been gathered from field investigations undertaken by the Colliery and its consultants. Investigations include water flow monitoring and water depth monitoring.

Water depth monitoring has been undertaken in pools along the Georges River upstream of the proposed longwalls. Water depths were measured from a fixed nail located on the banks of each pool. It can be seen from the results, between the period of 2nd August 2004 and 20th October 2005, that water is retained in each of the pools when some water is discharged upstream. Combined mine discharge and spill flows were typically between 1 and 2 ML/day during this period. There were two periods of 19 and 20 consecutive days, in which flows were typically between 0.6 and 1.0 ML/day.

The results of the depth monitoring also shows that some pools completely or partially drained when upstream entry flows were stopped. Upstream flows were stopped on two occasions in 2005, when remediation works were conducted in sections of the Georges River upstream of the SMP Area. The water levels in Pools 31 to 33 were observed to fall within one to two weeks of cessation of flow, and Pools 31 and 32 were observed to completely drain. The water levels in Pools 30 and 33 were also observed to fall during the period in which flows were typically between 0.6 and 1.0 ML/day.

It is noted that some discrepancies are apparent in the depth monitoring results for Pools 30 to 33.

- While the water level in Pool 30 was observed to fall during a period of low flow, it was observed to rise when other pools were observed to completely or partially drain.
- Pool 32 was observed to completely drain while all other pools appear to have been fully recharged.

It is also noted that water levels were not monitored in Pools 35 to 39 during the remediation period and it is therefore not known whether flow diversions also occur in these pools when upstream flows were small. It is recommended, therefore, that depth monitoring continue at the pools upstream and within the SMP Area, particularly if future remediation works are undertaken.

The results of water depth monitoring suggest that surface flow diversions occur in the pools and rock bars between Pools 31 and 33, and possibly Pool 30, upstream of the SMP Area. Further evidence is provided by Strata Control Technologies (pers. comm., 17 Oct 2005), who have installed extensometers in Rock Bar 34 as part of an ongoing research project. Fracturing has been observed at a number of depth horizons in the rock bar in holes that were drilled for the extensometers. The observations were made in November 2004.

It is likely that the observed surface water flow diversions have occurred as a result of natural weathering and erosion. However, given that the observations of surface flow diversions were made after the completion of Longwall 29, there is some possibility that the surface flow diversions may have occurred as the result of far-field movements. There was, unfortunately, limited opportunity to determine whether there were any surface water flow diversions prior to the commencement of Longwall 29 because water was consistently being discharged into the river from Appin and West Cliff Collieries. However, given that the rock bars are located approximately 240 metres to 350 metres from the side of Longwall 29, it is more likely that the flow diversions were naturally formed. The observed and predicted ground movements in the vicinity of these rock bars are very small.

Water flows in the Georges River have generally been determined by calculating measured cross-sectional areas and velocities of the stream in a defined channel. In some cases, water flows have been measured by calculating the depth of water passing through a temporary V-notch weir. The monitoring of surface water flows has been undertaken at the few suitable locations in the area, the majority of which have been measured just upstream of the general SMP Area. Flow monitoring at the majority of these sites have been limited to one or two measurements. However, some regular flow monitoring has been undertaken at Sites RB25, RB25B and RB36.

It was found from the results that when flows were measured at Sites RB36 and RB25 or RB25B on the same day, the measured flow rates were reasonably similar. The flow rates were also generally less than the combined discharge flows during periods of dry weather. This reduction in flow may be due to net transfer of surface water into the groundwater system. Alternatively, it may indicate the amount of surface water that does not flow through the main channel or temporarily constructed V-notch weir at the location that was used to measure water flows.

A summary of flow rates at all three sites is provided in Table 2.6 for the period between 3rd August 2004 and 21st July 2005.

Table 2.6 Summary of Flow Rates at Sites RB25, RB25B and RB36

	RB25 or RB25B (u/s SMP Area)	**RB36 (within SMP Area)**
No. of Recordings	17	14
Minimum Flow Rate	0.04 ML/day	0.09 ML/day
Maximum Flow Rate	2.2 ML/day	5.8 ML/day
Mean Flow Rate	1.0 ML/day	1.7 ML/day
Median Flow Rate	1.0 ML/day	1.4 ML/day

It can be seen from the above table that the mean and median flow rates at the upstream site are slightly less than those at Site RB36. The flow rates are generally lower than the combined discharge and spill rates. However, it is noted that the samples are limited in number and some of them have been recorded on different days. It is therefore considered that there is insufficient information to determine whether there is any net diversion of surface water between the upstream discharge points, RB25 and RB25B, and RB36. The measured flows in the Georges River merely confirm that flow rates are similar in magnitude to the combined flows from the licensed discharges and spills.

It is also noted that due to restrictions on access, that flow monitoring is generally not conducted during significant rainfall events and this precludes the collection of data during significant catchment runoff. Automated monitoring equipment previously installed in this area of the Georges River has been vandalised such that it is inoperative.

Water Quality in the Georges River

The water quality in the Georges River within the SMP Area is predominantly dependent on the characteristics of the licensed discharges, particularly during times of dry weather. This is illustrated by Fig. 2.6, which shows the flow rate at the Upper Flow Station as a proportion of the combination of flow at the Upper Flow Station and the licensed discharge from Appin and West Cliff Collieries.

During times of low flow (as observed at the Upper Flow Station), the flows within the SMP Area are mostly sourced from the licensed discharges. In times of wet weather, the proportion of flows sourced from the catchment area increases. The quality of water, therefore, varies depending on the contribution of each source to the overall flow.

The quality of surface flows in the Georges River within the SMP Area is discussed in a report by Ecoengineers (2007).

Subsdata/…/ Fig. X.XX - Georges River - Proportional Flows by Time - Upstream.grf

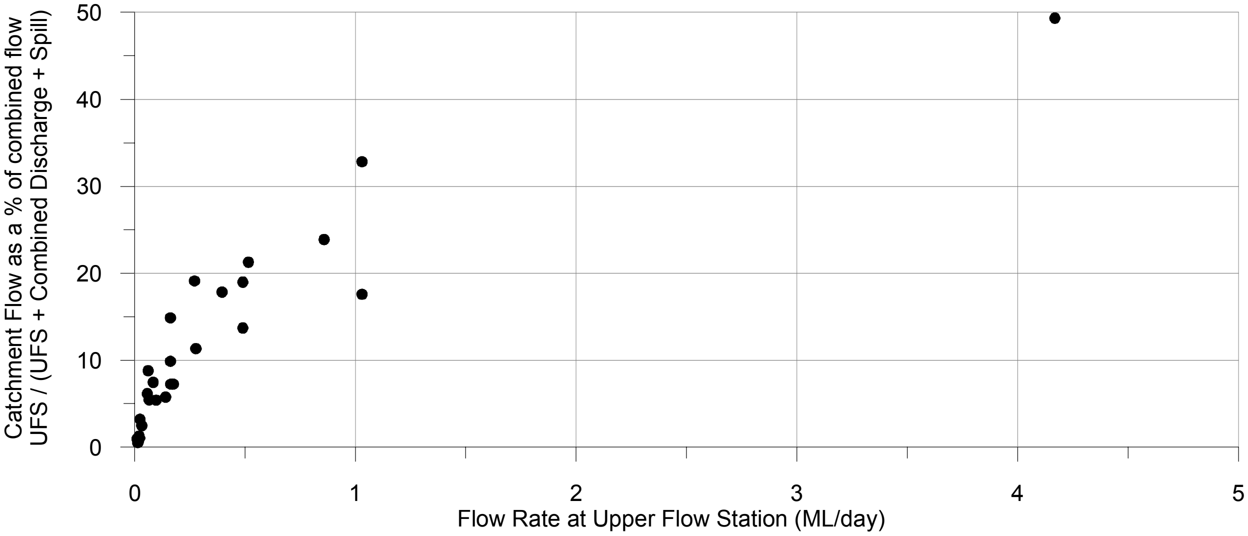


Fig. 2.6 Contribution of Surface Water Flows along the Georges River within SMP Area

2.4.3. Drainage Lines

The locations of the major drainage lines within the SMP Area are shown in Drawing No. MSEC326-07. The land in the eastern part of the SMP Area generally drains into the Georges River, while the land in the central and western parts of the SMP Area generally drains into Mallaty Creek, Leafs Gully and Nepean Creek, which inturn drain into the Nepean River. Descriptions of the major drainage lines within the SMP Area are provided below:-

Mallaty Creek is an ephemeral creek which is located directly above the proposed Longwalls 34 to 36. The creek generally flows in a westerly direction until it joins Ousedale Creek, approximately 1.4 kilometres south-west of Longwall 34. The natural gradient of the creek within the general SMP Area varies between 10 mm/m and 100 mm/m, with an average gradient of approximately 30 mm/m.

Leafs Gully is an ephemeral gully which is located directly above proposed Longwalls 34 and 35. The gully generally flows in a north-westerly direction until it joins the Nepean River approximately 830 metres west of Longwall 35. The natural gradient of the gully within the general SMP Area varies between 10 mm/m and 125 mm/m, with an average gradient of approximately 50 mm/m.

Nepean Creek is an ephemeral creek which is located directly above the proposed Longwall 36. The creek generally flows in a north-westerly direction until it joins Menangle Creek approximately 2.8 kilometres north of Longwalls 35 and 36. The natural gradient of the creek within the general SMP Area varies between 10 mm/m and 150 mm/m, with an average gradient of approximately 40 mm/m.

There are also a number of tributaries within the SMP Area, the locations of which are shown in Drawing No. MSEC326-07. The tributaries are located directly above and across the extents of the proposed longwalls.

2.4.4. Aquifers and Known Ground Water Resources

There are no registered groundwater bores within the general SMP Area. There are, however, a number of registered groundwater bores in the vicinity of the proposed longwalls, the locations of which are shown in Drawing No. MSEC326-27 and details provided in Section 2.7.11. The work summary sheets provided by DIPNR, however, indicate that the intended use for the majority of these bores is for irrigation or stock, rather than for the supply of potable water.

2.4.5. Springs

A number of small groundwater seeps have been identified within the SMP Area, the locations of which are shown in Drawing No. MSEC326-08.

2.4.6. Seas or Lakes

There are no seas or lakes within the SMP Area.

2.4.7. Shorelines

There are no shorelines within the SMP Area.

2.4.8. Natural Dams

There are no natural dams within the SMP Area. There are, however, a number of farm dams within the SMP Area, which are described in Section 2.7.10.

2.4.9. Cliffs and Natural Rock Formations

For the purposes of this report, a cliff has been defined as a continuous rockface having a minimum height of 10 metres and a minimum slope of 2 to 1, ie: having a minimum angle to the horizontal of 63°. The locations of cliffs within the SMP Area were determined from site investigations and from the 2 metre surface level contours which were generated from an aerial laser scan of the area.

Cliffs were identified in two locations, referred to as GR-CF01 and GR-CF02, which are shown in Drawing No. MSEC326-09 and details are provided in Table 2.7.

Table 2.7 Details of Cliffs within the SMP Area

Cliff ID	Overall Length (m)	Maximum Height (m)	Maximum Overhang (m)
GR-CF01	65	10	5
GR-CF02	80	15	6 ~ 8

The two identified cliffs are located along the alignment of the Georges River and have formed from the Hawkesbury Sandstone. Photographs of the Cliffs GR-CF01 and GR-CF02 are shown in Fig. 2.7 and Fig. 2.8, respectively.

Fig. 2.7 Photograph of Cliff GR-CF01

Fig. 2.8 Photograph of Cliff GR-CF02

Cliff GR-CF01 is situated on the outside of a bend in the Georges River directly above the finishing (eastern) end of Longwall 35. The section of cliff line greater than 10 metres in height is 65 metres long, however, the cliff line continues around the bend of the river at a height of less than 10 metres, as shown in Drawing No. MSEC326-09. Archaeological Sites 52-2-2234 and 52-2-2243, which are described in Section 2.9, are associated with this cliff line.

Cliff GR-CF02 is situated on relatively straight section of the Georges River and is located at a distance of 50 metres north-east of the finishing (eastern) end of Longwall 36, at its closest point to the proposed longwalls. The section of cliff line greater than 10 metres in height is 80 metres long, however, the cliff line continues to the goaf edge of Longwall 36 at a height of less than 10 metres, as shown in Drawing No. MSEC326-09.

Cliffs GR-CF01 and GR-CF02 have been defined as *areas of environmental sensitivity* for the purposes of the SMP Application.

There were also cliffs identified along the Nepean River and Ousedale Creek, south of the proposed longwalls. These cliffs are located more than 800 metres from the proposed longwalls and unlikely, therefore, to be subjected to any significant systematic, valley related, or far-field horizontal movements.

Rock outcrops have been identified across the SMP Area, generally within the valleys of the Georges River, Mallaty Creek and other major drainage lines.

The rock outcrops along the Georges River have formed from the Hawkesbury Sandstone and have heights typically ranging between 5 and 10 metres with overhangs up to 5 metres. Archaeological Sites 52-2-2241, 52-2-2242 and 52-2-2244, which are described in Section 2.9, are associated with rock outcrops. The locations of the identified rock outcrops along the alignment of the Georges River within the SMP Area, having heights between 5 and 10 metres, are shown in Drawing No. MSEC326-09. A photograph of a typical rock outcrop along the Georges River is shown in Fig. 2.9.

Fig. 2.9 Photograph of a Typical Rock Outcrop along the Georges River

The rock outcrops located along Mallaty Creek, other major drainage lines and elsewhere within the SMP Area are generally discontinuous and have heights typically less than 5 metres.

2.4.10. Steep Slopes

A number of areas containing steep slopes have been identified within the SMP Area. The reason for identifying steep slopes is to highlight areas in which existing ground slopes may be marginally stable. For the purposes of this report, a steep slope has been defined as an area of land having a natural gradient between 1 in 3 (ie: a grade of 33 %, or an angle to the horizontal of 18°) and 2 in 1 (ie: a grade of 200 %, or an angle to the horizontal of 63°).

The maximum slope of 2 to 1 represents the threshold adopted for defining a cliff. The minimum slope of 1 to 3 represents a slope that would generally be considered stable for slopes consisting of rocky soils or loose rock fragments. Clearly the stability of natural slopes varies depending on their soil or rock types, and in many cases, natural slopes are stable at much higher gradients than 1 to 3, for example talus slopes in Hawkesbury Sandstone.

The areas of steep slopes were identified from the 2 metre surface level contours which were generated from an aerial laser scan of the area, and the locations have been shown in Drawing No. MSEC326-09. The steepest slopes within the SMP Area were identified within the valleys of the Georges River, Mallaty Creek and Leafs Gully. The steep slopes typically have natural gradients between 1 in 3 (ie: a grade of 33 %, or an angle to the horizontal of 18°) and 1 in 2 (ie: 50 %, or an angle to the horizontal of 27°), with isolated areas having natural gradients of up to 1 in 1.5 (ie: 67 %, or an angle to the horizontal of up to 34°).

The surface within the SMP Area generally consists of soils derived from Hawkesbury Sandstone and Wianamatta Shale, as can be inferred from Fig. 1.3, which are in varying stages of weathering and fracturing. The majority of the slopes are stabilised, to some extent, by the natural vegetation.

2.4.11. Escarpments

There are no escarpments within the SMP Area.

2.4.12. Land Prone to Flooding or Inundation

The land within the SMP Area drains freely into the Georges and Nepean Rivers and no areas would be considered flood prone. The banks and the narrow river flats along the Georges River, however, are susceptible to inundation during major flood events. There is no development of infrastructure within the valley of the Georges River.

2.4.13. Wetlands and Swamps

There are no swamps or wetlands within the SMP Area. There are, however, water-related ecosystems within the SMP Area, in particular, along the Georges River and the major drainage lines. These have been investigated and are described in the reports by Biosis (2007a) and The Ecology Lab (2007).

2.4.14. Threatened, Protected Species or Critical Habitats

There are no lands within the SMP Area that have been declared as critical habitat under the *Threatened Species Conservation Act 1995*. There are, however, threatened and protected species within the SMP Area which are described in the report by Biosis (2007a) and The Ecology Lab (2007).

2.4.15. National Parks or Wilderness Areas

There are no National Parks or any land identified as wilderness under the *Wilderness Act 1987* within the SMP Area.

2.4.16. State Recreation Areas and State Conservation Areas

The *Dharawal State Conservation Area* partially extents into the north-eastern corner of the SMP Area, the location of which is shown in Drawing No. MSEC326-01. There are no other State Recreation Areas or State Conservation Areas within the SMP Area.

2.4.17. State Forests

There are no State Forests within the SMP Area.

2.4.18. Natural Vegetation

The land within the SMP Area has generally been cleared for farm, commercial and private use. There are a number of areas which have natural vegetation, which are primarily located along the Georges River and along the alignments of the major drainage lines. A detailed survey of the natural vegetation has been undertaken and is described in the report by Biosis (2007a).

2.4.19. Areas of Significant Geological Interest

There are no areas of significant geological interest within the SMP Area.

2.4.20. Any Other Natural Feature Considered Significant

There are no other significant natural features within the SMP Area.

2.5. Public Utilities

2.5.1. Railways

There are no railways within the SMP Area.

2.5.2. Roads

The locations of the roads within the SMP Area are shown in Drawing No. MSEC326-10. The only public road within the SMP Area is **Appin Road** which crosses the eastern ends of proposed Longwalls 34 and 36. The road has a bitumen seal with table drains and grass verges and is owned and maintained by the Roads and Traffic Authority.

There are also private roads within the SMP Area which connect the rural properties with Appin Road which are typically unsealed. The main access road and the internal roads within the Inghams Farm Complex are sealed. The maintenance road associated with the Upper Canal is discussed in Section 2.5.6.2.

2.5.3. Bridges

There are a number of bridges associated with the Upper Canal and its maintenance road which are discussed in Section 2.5.6.2. There are no other bridges within the SMP Area.

2.5.4. Tunnels

Devines Tunnels Nos. 1 and 2 are located to the south and partially within the general SMP Area, which are described in Section 2.5.6.2. There are no other tunnels within the SMP Area.

2.5.5. Drainage Culverts

There are no identified drainage culverts on public land within the SMP Area. There are, however, drainage culverts on private land, which are described in the Property Subsidence Management Plans (PSMPs), along the Upper Canal, which are described in Section 2.5.6.2, and on the Inghams Farm Complex, which are described in Section 2.8.3.

2.5.6. Water, Gas or Sewerage Pipelines

The water services within the vicinity of the proposed longwalls include the Macarthur Water Supply System, the Sydney Catchment Authority infrastructure and the Sydney Water infrastructure. The locations of the water services are shown in Drawing No. MSEC326-11 and are described in the following sections. The gas pipelines within the SMP Area are shown in Drawing No. MSEC326-12 and are described in Section 2.5.8.

2.5.6.1. Macarthur Water Supply System

The 1200 mm diameter treated water gravity main, which is owned by United Utilities, is located within the pipeline easement which crosses the western ends of the proposed longwalls. The pipeline forms part of the Macarthur Water Supply System and runs from the Macarthur Water Filtration Plant, which is located south of the township of Appin, to Mount Sugarloaf, where it then supplies water to Campbelltown and surrounding townships.

2.5.6.2. Sydney Catchment Authority Infrastructure

The Sydney Catchment Authority owns infrastructure in the vicinity of the proposed longwalls, including the Upper Canal, Devines Tunnels Nos. 1 & 2 and associated infrastructure. These are described below.

The Upper Canal

The Upper Canal crosses the western side of the general SMP Area and is located at a distance of 290 metres north-west of Longwall 35, at its closest point to the proposed longwalls. The canal crosses a number of drainage lines and, therefore, may be subjected to valley related movements, as well as far-field effects. The Upper Canal may be sensitive to these movements and, therefore, the sections of the canal beyond the general SMP Area but within the predicted limits of 20 mm upsidence and 20 mm closure, resulting from the extraction of Longwalls 34 to 36, have been included within the SMP Area.

The open section of the Upper Canal commences at the northern end of the Cataract Tunnel, which is approximately 10 kilometres downstream of the Pheasant's Nest Weir. From the tunnel mouth, the tunnel gradient of 0.66 metres per kilometre is maintained for a further distance of 345 metres. Over this length the Upper Canal is a cutting in the natural rock with a width of 2.74 metres.

Downstream of this section, the canal has vertical masonry walls and is widened to approximately 3.8 metres. It continues essentially in this form, at a fall of 0.33 metres per kilometre, to Devines Tunnel No. 1, which is located south of the proposed longwalls. The open section of the Upper Canal continues to the north of Devines Tunnel No. 2 and crosses the western side of the general SMP Area. There is also an open section of canal between Devines Tunnels Nos. 1 and 2. When running full, the depth of water in the Upper Canal is approximately 2.44 metres leaving a nominal freeboard of 500 mm.

The Upper Canal system has been defined as an *area of environmental sensitivity* for the purposes of the SMP Application.

Wrought Iron Aqueducts

Wrought iron aqueducts have been used where the Upper Canal crosses the major drainage lines. The aqueducts are located outside the general SMP Area, however, they have been included within the SMP Area as they could be subjected to valley related movements.

The wrought iron aqueducts closest to the general SMP Area cross Leafs Gully (A5) and Nepean Creek (A6) and are located at distances of 400 metres to the west and 500 metres to the north of Longwall 35, respectively, at their closest points to the proposed longwalls.

There is also a wrought iron aqueduct which crosses Mallaty Creek (A4) which is located at a distance of 1.2 kilometres south of Longwall 34, at its closest points to the proposed longwalls. Mitigation measures have been provided at this aqueduct to accommodate the predicted movements resulting from the extraction of Longwalls 29 to 33.

The aqueducts across Leafs Gully, Nepean Creek and Mallaty Creek are wrought iron pipes of 2.19 metre diameter, with lengths of 82 metres, 46 metres and 52 metres, respectively. The aqueducts are multi-span structures supported on masonry piers and concrete pad foundations.

Concrete Aqueducts

Concrete Aqueducts C and D have been used where the Upper Canal crosses two unnamed creeks north of Mallaty Creek. The concrete aqueducts are located outside the general SMP Area, however, they have been included within the SMP Area as they could be subjected to valley related movements.

Aqueducts C and D are located south of Devines Tunnel No. 1 and between Devines Tunnels Nos. 1 and 2, respectively, and are located 1050 metres and 800 metres to the south of the Longwall 34, respectively, at their closest points to the proposed longwalls. Mitigation measures have been provided at these aqueducts to accommodate the predicted movements resulting from the extraction of Longwalls 29 to 33.

Drainage Culverts and Flumes

Drainage ditches are provided along the Upper Canal to intercept surface water draining from farms and other properties alongside the canal, and prevent it flowing into the canal. Drainage culverts and flumes have been introduced, wherever necessary, to carry the flow of surface water from the ditches across the canal and into local watercourses.

The drainage culverts and flumes are of relatively small diameter and are short in length, but they are important because they prevent the surface water run-off entering the Upper Canal and contaminating the water supply.

Roads associated with the Upper Canal

The access road alongside the Upper Canal is paved in two concrete strips and provides vehicular access for operation and maintenance of the canal. The other access roads are generally unsealed gravel roads.

Bridges Associated with the Upper Canal

There are three small bridges where the access road crosses the major drainage lines. The bridges are located outside the general SMP Area, however, they have been included within the SMP Area as they could be subjected to valley related movements.

The bridges closest to the general SMP Area cross Leafs Gully (RB5) and Nepean Creek (RB6) and are located at distances of 400 metres to the west and 500 metres to the north of Longwall 35, respectively, at their closest points to the proposed longwalls. There is also a bridge which crosses Mallaty Creek (RB4) which is located at a distance of 1.2 kilometres to the south of Longwall 34, at its closest points to the proposed longwalls. These bridges are light steel structures with timber decks that carry the vehicular access road alongside the Upper Canal.

Devines Tunnels Nos. 1 and 2

Devines Tunnel is made up of two sections, known as Devines Tunnel No. 1, between two unnamed creeks north of Mallaty Creek, and Devines Tunnel No. 2, between the northern unnamed creek and Leafs Gully. A short length of open canal joins the two sections of tunnel.

Devines Tunnel No. 2 crosses the western side of the general SMP Area and is located at a distance of 330 metres to the west of Longwall 34, at its closest point to the proposed longwalls. Devines Tunnel No. 1 and the section of Devines Tunnel No. 2 located outside the general SMP Area could be subjected to far-field movements, resulting from the extraction of the proposed longwalls and, therefore, have also been included within the SMP Area.

Devines Tunnels Nos. 1 and 2 are both unlined rock tunnels, approximately 3.2 metres wide and, when flowing at maximum capacity, the have a water depth of 2.44 metres. The gradients of the tunnels are 0.66 metres per kilometre. Devines Tunnel No. 1 is approximately 183 metres long and Devines Tunnel No. 2 is approximately 817 metres long. The surface levels over the lengths of the tunnels vary between 128 metres and 143 metres AHD and the maximum depth of cover is approximately 15 metres.

The open section of canal between the two tunnels is approximately 2.74 m wide and, when flowing at maximum capacity, has a water depth of 2.44 metres leaving a nominal freeboard of 500 mm. The open section of canal is approximately 97 metres in length and has the same gradient as the tunnels.

Devines Tunnels Nos. 1 and 2 have been defined as *areas of environmental sensitivity* for the purposes of the SMP Application.

2.5.6.3. Sydney Water Infrastructure

The main water service line, which supplies properties in Appin from the Appin Reservoir, is laid beside Appin Road and crosses diagonally over the eastern ends of the proposed longwalls. This pipeline, which is owned by Sydney Water, is a 100 mm diameter Cast Iron Cement Lined (CICL) pipeline.

2.5.6.4. Other Water Infrastructure

There are water services within Inghams Farm Complex which are described in Section 2.8.3.

2.5.7. Sewerage Pipelines and Sewerage Treatment Works

There are no sewerage pipelines or Sewage Treatment Works within the SMP Area. The properties within the SMP Area have local sewer connections to septic tanks or package treatment plants.

2.5.8. Gas Pipelines

There are three gas pipelines which cross the SMP Area, being the Alinta EGP and AGN Natural Gas Pipelines and the Gorodok Ethane Pipeline. All three pipelines are located within an easement, which crosses over the western ends of the proposed longwalls, as shown in Drawing No. MSEC326-12. The gas pipelines have been defined as *areas of environmental sensitivity* for the purposes of the SMP Application. A description of each pipeline is provided below.

2.5.8.1. Alinta EGP Natural Gas Pipeline

The Alinta EGP Natural Gas Pipeline, previously known as the Eastern Gas Pipeline, was constructed in the year 2000. The pipeline is a fully welded steel pipeline, 450 mm in diameter, laid below ground with a minimum cover of 600 mm. The Alinta EGP Natural Gas Pipeline was designed to accommodate subsidence and was approved by the Mine Subsidence Board.

2.5.8.2. Alinta AGN Natural Gas Pipeline

The Alinta AGN Natural Gas Pipeline, previously known as the AGL High Pressure Natural Gas Pipeline, was completed prior to 1976 and forms part of the Sydney Region Trunk Distribution System. The pipeline is a fully welded steel pipeline, 864 mm in diameter, which is laid below ground with a minimum cover of 800 mm.

The as-built alignment drawing, number 1-AA-1129, provided by the Australian Gas Light Company, indicates that the majority of the pipeline has a wall thickness of 9.2 mm and is graded GR5LX-X65. Some sections of the pipeline where laid beneath roads have a wall thickness of 13.3 mm.

The Alinta AGN Natural Gas Pipeline was built without Mine Subsidence Board approval within the Appin Mine Subsidence District, which is located south of Mallaty Creek. The pipeline, however, was built prior to the declaration of the South Campbelltown Mine Subsidence District, which is located north of Mallaty Creek, and is consequently covered by the later proclamation of this district.

2.5.8.3. Gorodok Ethane Pipeline

The Gorodok Ethane Pipeline is a fully welded steel pipeline, 203 mm in diameter, which is laid below ground with a minimum cover of 800 mm. It is a high pressure main with a wall thickness of 8 mm, which operates at a pressure of up to 15 MPa.

The pipeline was designed to AS2885, constructed under the Pipeline Authority Act, and is licensed by the Department of Energy. The Gorodok Ethane Pipeline was not approved by the Mine Subsidence Board.

2.5.9. Liquid Fuel Pipelines

There are no liquid fuel pipelines within the SMP Area.

2.5.10. Electrical Services

The locations of the electrical services within the SMP Area are shown in Drawing No. MSEC326-13. The major electrical services include the 330 kV transmission line, which is owned by TransGrid, and the 66 kV, 11 kV and low voltage powerlines, all of which are owned by Integral Energy.

The Sydney West – Avon 330 kV Transmission Line is the largest of the electrical services in the SMP Area, which crosses the western ends of the proposed longwalls. The conductors and earth wires are generally carried on steel lattice suspension towers, which are spaced approximately 300 metres to 600 metres apart. Each tower has been given a unique identification number, which are shown in Drawing No. MSEC326-13. Tower number 105 is a tension tower which is located above the chain pillar between Longwalls 34 and 35.

The 330 kV transmission line is a major item of infrastructure and, therefore, has been defined as an *area of environmental sensitivity* for the purposes of the SMP Application.

A 66kV powerline runs along the western side of the 330 kV transmission line, which also crosses over the western ends of the proposed longwalls. The copper cables are supported by timber or concrete poles which are spaced approximately 100 to 340 metres apart.

An 11kV powerline and low voltage powerlines generally follow the alignment of Appin Road, which cross over the eastern ends of the proposed longwalls. Two 11 kV powerlines branch off the main 11 kV powerline along Appin Road and provide power to the private properties and the Inghams Farm Complex located west of the road. The copper cables are supported by timber or concrete poles.

There are no underground electrical services identified within the SMP Area.

2.5.11. Telecommunications Services

The locations of the telecommunication services within the SMP Area are shown in Drawing No. MSEC326-14. The telecommunication services include a direct buried optical fibre cable and direct buried copper telecommunications cables, all of which are owned by Telstra.

The major telecommunications service is the interstate F HOME 2005 optical fibre cable, which is laid alongside Appin Road within the SMP Area. The optical fibre cable is a major item of infrastructure and, therefore, has been defined as an *area of environmental sensitivity* for the purposes of the SMP Application.

The copper trunk cables C CBTN 104 and C CBTN 105, which are 20 pair cables between the Appin and Campbelltown exchanges, are laid along the western side of Appin Road within the SMP Area. The Appin to Campbelltown subscriber distribution cable C CBTN 423 is a 54 pair cable, which is located to the west of Appin Road and feeds subscribers in the rural area directly from the exchanges.

The main local distribution cables, which serves the Inghams Farm Complex and rural properties to the west of Appin Road are laid directly in the ground. The subscriber distribution network also includes some aerial cables in connections to individual properties.

2.5.12. Water Tanks, Water and Sewerage Treatment Works

There are no Water or Sewage Treatment Works within the SMP Area. There are, however, a number of privately owned water storage tanks on the rural and commercial properties, which are described in Sections 2.7.3 and 2.8.3. The rural properties within the SMP Area also have on-site waste systems.

2.5.13. Dams, Reservoirs and Associated Works

There are no public dams, reservoirs or associated works within the SMP Area.

2.5.14. Air Strips

There are no air strips within the SMP Area.

2.5.15. Any Other Public Utilities

There are no other public utilities within the SMP Area.

2.6. Public Amenities

2.6.1. Hospitals

There are no hospitals within the SMP Area.

2.6.2. Places of Worship

There are no places of worship within the SMP Area.

2.6.3. Schools

There are no schools within the SMP Area.

2.6.4. Shopping Centres

There are no shopping centres within the SMP Area.

2.6.5. Community Centres

There are no community centres within the SMP Area.

2.6.6. Office Buildings

There are no office buildings within the SMP Area.

2.6.7. Swimming Pools

There are no public swimming pools within the SMP Area.

2.6.8. Bowling Greens

There are no bowling greens within the SMP Area.

2.6.9. Ovals or Cricket Grounds

There are no ovals or cricket grounds within the SMP Area.

2.6.10. Racecourses

There are no racecourses within the SMP Area. The closest racecourse is the Appin Way Greyhound Track, which is located over 1 kilometre south-west of the proposed Longwall 34.

2.6.11. Golf Courses

There are no golf courses within the SMP Area.

2.6.12. Tennis Courts

There are no tennis courts within the SMP Area.

2.6.13. Any Other Public Amenities

There are no other public amenities within the SMP Area.

2.7. Farm Land or Facilities

2.7.1. Agriculture Utilisation and Agriculture Improvements

The land within the SMP Area is predominantly cleared pasture, which is mainly used for light grazing for cattle and horses on private properties, as well as for poultry farming within the Inghams Farm Complex. The Inghams Farm Complex is discussed in Section 2.8.3. Features on the rural properties are discussed in the following sections.

2.7.2. Farm Buildings and Sheds

There are 153 rural building structures (Structure Type R) that have been identified within the SMP Area, which includes sheds, garages and other non-residential building structures. The locations of the rural building structures within the SMP Area are shown in Drawings Nos. MSEC326-15 to MSEC326-26 and details are provided in Table E.01 in Appendix E.

The rural building structures typically comprise steel or timber frames with corrugated metal cladding. The locations, maximum lengths and heights of the structures, which are provided in Table E.01, were determined from field investigations and from an aerial photograph of the area.

2.7.3. Tanks

There are 90 tanks (Structure Type T) that have been identified within the SMP Area. The locations of the tanks within the SMP Area are shown in Drawings Nos. MSEC326-15 to MSEC326-26 and details are provided in Table E.02 in Appendix E.

The locations and sizes of the tanks, which are provided in Table E.02, were determined from field investigations and from an aerial photograph of the area.

2.7.4. Gas and Fuel Storages

There are fuel storages on the Inghams Farm Complex, which are shown in Drawing No. MSEC326-12, however, these are located outside the general SMP Area.

2.7.5. Poultry Sheds

There are a number of poultry sheds within the Inghams Farm Complex, which are described in Section 2.8.3.

2.7.6. Glass Houses

There are no known glass houses within the SMP Area.

2.7.7. Hydroponic Systems

There are no known hydroponic systems within the SMP Area.

2.7.8. Irrigation Systems

There are no known irrigation systems within the SMP Area.

2.7.9. Fences

A number of fences have been identified within the SMP Area. The majority of fences mark property boundaries and are constructed with timber or steel posts and with fencing wire or timber railings.

2.7.10. Farm Dams

There are 75 farm dams (Structure Type D) that have been identified within the SMP Area. The locations of the farm dams are shown in Drawings Nos. MSEC326-15 to MSEC326-26 and details are provided in Table E.03 in Appendix E.

The maximum lengths of the farm dams vary between 5 and 215 metres and the surface areas of the farm dams vary between 15 and 4600 square metres. The largest dam within the SMP Area is Dam F05d2. The dams are typically of earthen construction and have been established by localised cut and fill operations within the natural drainage lines.

2.7.11. Wells and Bores

There are no registered groundwater bores within the SMP Area. There are, however, a number of groundwater bores identified in the vicinity of the proposed longwalls which could be affected by far-field movements. The locations of these bores are shown in Drawing No. MSEC326-27 and details are provided in Table 2.8.

Table 2.8 Registered Groundwater Bores in the Vicinity of the Proposed Longwalls

Bore ID	MGA Easting (m)	MGA Northing (m)	Diameter (mm)	Depth (m)
GW005316	295335	6219725	152	36.5
GW060888	294675	6215680	N/A	394.8
GW062169	294740	6215560	165	100.0
GW072454	297710	6218063	125	162.0

The work summary sheets provided by DIPNR indicate that the intended use of the majority of bores is for irrigation or stock, rather than for the supply of potable water.

2.7.12. Any Other Farm Features

There are no other significant farm features within the SMP Area.

2.8. Industrial, Commercial or Business Establishments

2.8.1. Factories

There are no factories within the SMP Area.

2.8.2. Workshops

There are no workshops within the SMP Area.

2.8.3. Business or Commercial Establishments or Improvements

Inghams Farm No. 3, which is part of the Inghams Farm Complex, is located within the SMP Area, and comprises commercial chicken sheds, administration buildings, residential buildings, sheds and tanks. The locations of these building structures and tanks are shown in Drawings Nos. MSEC326-24 and MSEC326-25 and details are provided in Tables E.01 and E.02 in Appendix E.

There are 16 commercial chicken sheds on Inghams Farm No. 3 within the SMP Area, which vary in length between 75 metres and 115 metres, and vary in width between 15 metres and 20 metres. The sheds comprise steel portal frames founded on concrete strip footings with timber infill framing between the external columns of the portals. The walls are clad in fibre-cement sheeting and the roofs are clad in corrugated steel sheeting. The floors of the sheds are essentially compacted earth, though they were originally sealed with tarmac. The soil is covered with a layer of fibrous litter, which is replaced on a regular basis, before each new batch of chickens is introduced to the sheds. The sheds have forced ventilation and gas fired heating systems, so that the environmental conditions within the sheds can be maintained at the required standard throughout the growing period.

There are 29 ancillary buildings and sheds on Inghams Farm No. 3 within the SMP Area. The lengths of these building structures range between 1 metre and 18 metres. There are also 19 water storage tanks on Inghams Farm No. 3 within the SMP Area. The diameters of these tanks range between 1.5 metres and 2 metres.

The main access road and internal roads within the Inghams Farm No. 3 are sealed. There is one identified drainage culverts on the farm within the SMP Area. The locations of the roads and the drainage culvert on the farm within the SMP Area are shown in Drawing No. MSEC326-10.

The Inghams Farm Complex obtains water from the main service line along Appin Road and can extract water directly from the Upper Canal. The pipelines on Inghams Farm No. 3 within the SMP Area are gravity mains which source water from the storages tanks which are located outside the SMP Area. The water from the canal is treated by chlorine dosing on site before it is pumped into the storage tanks.

2.8.4. Gas or Fuel Storages and Associated Plant

There are no known gas or fuel storages or associated plant within the SMP Area. The closest identified fuel storages are the two diesel storage tanks on the Inghams Farm Complex, shown in Drawing No. MSEC326-12, which are located over 1 kilometre south of proposed Longwall 34.

2.8.5. Waste Storages and Associated Plant

There are no waste storages or associated plant within the SMP Area.

2.8.6. Buildings, Equipment or Operations that are Sensitive to Surface Movements

There are no known buildings, equipment or operations that are sensitive to surface movements within the SMP Area.

2.8.7. Surface Mining (Open Cut) Voids and Rehabilitated Areas

There are no surface mining (open cut) voids or rehabilitated areas within the SMP Area.

2.8.8. Mine Infrastructure Including Tailings Dams or Emplacement Areas

There is no mine infrastructure within the SMP Area.

2.8.9. Any Other Industrial, Commercial or Business Features

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

2.9. Items of Archaeological Significance

There are no lands within the SMP Area declared as an Aboriginal Place under the *National Parks and Wildlife Act 1974*. There are, however, nine archaeological sites which have been identified within the SMP Area, the locations of which are shown in Drawing No. MSEC326-27 and details are provided in Table 2.9.

Table 2.9 Archaeological Sites within the SMP Area

Recording Code	Site Name	Recording Type
52-2-0021	Douglas Park	Open Camp Site
52-2-2234	Georges River No. 1	Shelter with Art
52-2-2237	Ousedale Creek 3	Shelter with Art Shelter with Deposit
52-2-2241	Georges River No. 5	Shelter with Art
52-2-2242	Georges River No. 4	Shelter with Art
52-2-2243	Georges River No. 2	Shelter with Art Shelter with Deposit
52-2-2244	Georges River No. 3	Shelter with Art
52-2-2265	Leafs Gully 1	Stone artefact scatter
52-2-2266	Georges River 2	Stone artefact scatter

Detailed descriptions of the archaeological sites within the SMP Area are provided in the report by Biosis (2007b).

2.10. Items of Historical or Heritage Significance

The Upper Canal, which crosses the western side of the general SMP Area, is listed on the Heritage Register and is described in Section 2.5.6.2. There are no other items listed on the *NSW Heritage Act 1977* identified within the SMP Area.

There are four historic sites within the SMP Area, which are shown in Drawing No. MSEC326-27. The Bridge and Road Remains Site (WH1) is located east of Longwall 33 and consist of eight postholes cut into the sandstone bed of the Georges River. The remains of timber posts and cement packing are present in some of the holes.

The Grave Site (WH2), the House Site (WH3) and the Pub/Cellar Site (WH4) are all located over the eastern end of Longwall 33. The Grave Site consists of scattered sandstone blocks which are reminiscent of early settler graves. The House Site is the remains of an early settler house and consists of a large flagstone, discontinuous lines of sandstone blocks, a concrete slab and a concrete footpath. The Pub/Cellar Site consists of discontinuous lines of sandstone blocks, which may continue down below the surface to form the walls of a cellar.

Further details of the historic sites are provided in the report by Biosis (2007b).

2.10.1. Items on the Register of the National Estate

There are no items on the *Register of National Estate* within the SMP Area. The Upper Nepean Water Catchment, however, is listed as an indicative place on the Register of the National Estate.

2.11. Items of Architectural Significance

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

2.12. Permanent Survey Control Marks

There are a number of survey control marks in the vicinity of the proposed longwalls, the locations of which are shown in Drawing No. MSEC326-27. Ten survey control marks have been identified within the general SMP Area, details of which are provided in Table 2.10.

Table 2.10 Locations of the Survey Control Marks within the General SMP Area

Mark	Approximate MGA Easting	Approximate MGA Northing
PM 10770	295170	6218045
PM 14762	296340	6217830
PM 21634	296235	6217785
PM 25139	296240	6217455
PM 33063	296295	6216560
PM 82965	294540	6218375
SS 13273	296350	6217915
SS 16105	296415	6216080
SS 19707	296280	6216545
TS 12008	295735	6218480

2.13. Residential Establishments

2.13.1. Houses

There are 28 houses located within the SMP Area, of which 24 are single-storey houses with lengths less than 30 metres (Type H1), two are single-storey houses with lengths greater than 30 metres (Type H2) and two are double-storey houses with lengths less than 30 metres (Type H3). There are no double-storey houses with lengths greater than 30 metres (Type H4) identified within the SMP Area.

The locations of the houses within the SMP Area are shown in Drawings Nos. MSEC326-15 to MSEC326-26 and details are provided in Tables E.01 in Appendix E. The locations and sizes of the houses were determined from an aerial photograph of the area. The heights and types of construction of the houses were established from field investigations.

The distribution of the maximum plan dimensions of the houses within the SMP Area is provided in Fig. 2.10. The distributions of the wall and roof constructions of the houses within the SMP Area are provided in Fig. 2.11. The distribution of the footing types of the houses within the SMP Area is provided in Fig. 2.12.

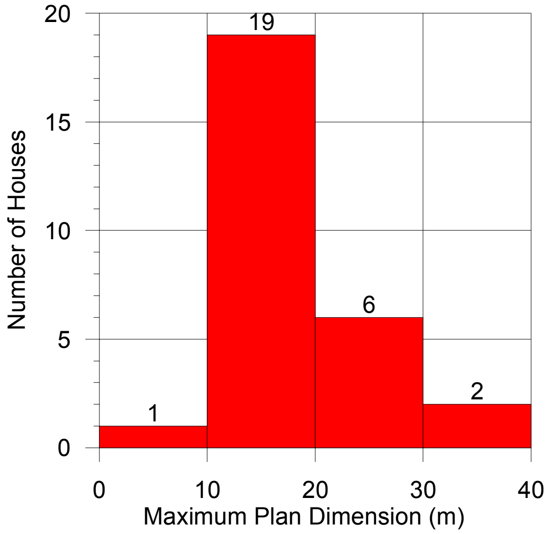


Fig. 2.10 Distribution of Maximum Plan Dimension of Houses within the SMP Area

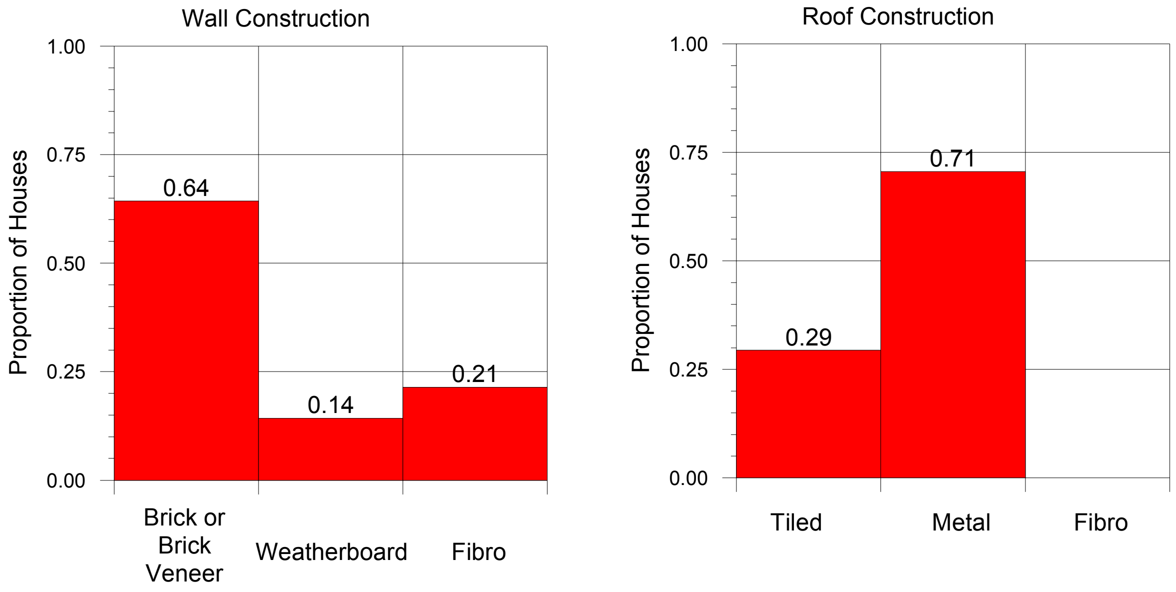


Fig. 2.11 Distribution of Wall and Roof Construction of Houses within the SMP Area

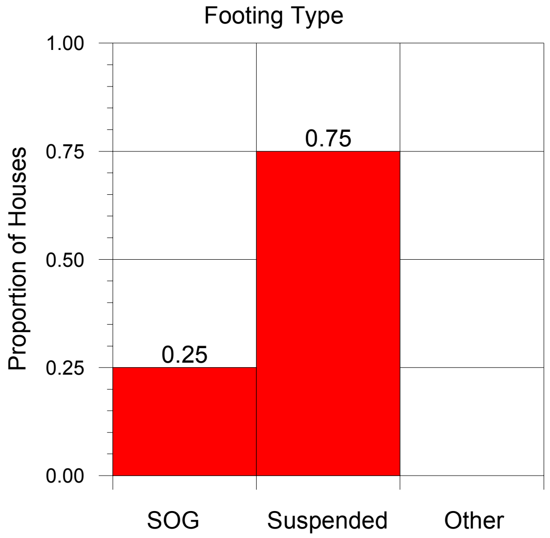


Fig. 2.12 Distribution of Footing Type of Houses within the SMP Area

The ages of the houses range from less than 6 months old up to 70 years old, with an average age in the order of 20 to 40 years. To date, Cardno Forbes Rigby has inspected all but two houses within the SMP Area, being Structures Refs. D01a and D08a, and have found them to be in sound conditions. Details of these inspections are provided in the Property Subsidence Management Plans (PSMPs).

2.13.2. Flats or Units

There are no flats or units within the SMP Area.

2.13.3. Caravan Parks

There are no caravan parks within the SMP Area.

2.13.4. Retirement or Aged Care Villages

There are no retirement or aged care villages within the SMP Area.

2.13.5. Any Other Associated Structures

Descriptions of rural building structures and tanks are provided in Sections 2.7.2 and 2.7.3.

2.13.6. Any Other Residential Feature

There are three privately owned swimming pools (Structure Type P) which have been identified within the SMP Area, being Structures Refs. A32p01, D08p01 and G03p01. The locations of the swimming pools are shown in Drawings Nos. MSEC326-17, MSEC326-23 and MSEC326-26 and details are provided in Table 2.11.

Table 2.11 Details of Swimming Pools within the SMP Area

Pool	Easting	Northing	Description
A32p01	296390	6216630	In ground fibreglass pool approx. 9m x 3.5m
D08p01	296460	6218120	Details not available
G03p01	294270	6218520	In ground fibreglass pool approx. 9m x 3.5m

All of the houses within the SMP Area have on-site waste systems. Many of the houses within the SMP Area also have concrete driveway pavements or footpaths.

2.14. Any Other Items

There are no other significant items within the SMP Area.

2.15. Any Known Future Developments

It is likely that there will be future development of houses and possible future development of residential subdivisions within the SMP Area. AGL had previously proposed to construct a Gas Fired Power Station near Leafs Gully within the SMP Area. It is understood, however, that this application was withdrawn in February 2007. There are no other known future developments within the SMP Area.

CHAPTER 3. OVERVIEW OF LONGWALL MINING, THE DEVELOPMENT OF SUBSIDENCE AND THE METHODS USED TO PREDICT THE MINE SUBSIDENCE PARAMETERS FOR THE PROPOSED LONGWALLS

3.1. Introduction

This chapter provides a brief overview of longwall mining, the development of mine subsidence and the methods that have been used to predict the mine subsidence movements resulting from the extraction of the proposed longwalls. Further details on longwall mining, the development of subsidence the methods used to predict mine subsidence movements are provided in the background reports entitled *Introduction to Longwall Mining and Subsidence* and *General Discussion on Mine Subsidence Ground Movements* which can be obtained from *www.minesubsidence.com*.

3.2. Overview of Longwall Mining

The coal at the project is proposed to be extracted using longwall mining techniques. A cross-section along the length of a typical longwall at the coal face is shown in Fig. 3.1.

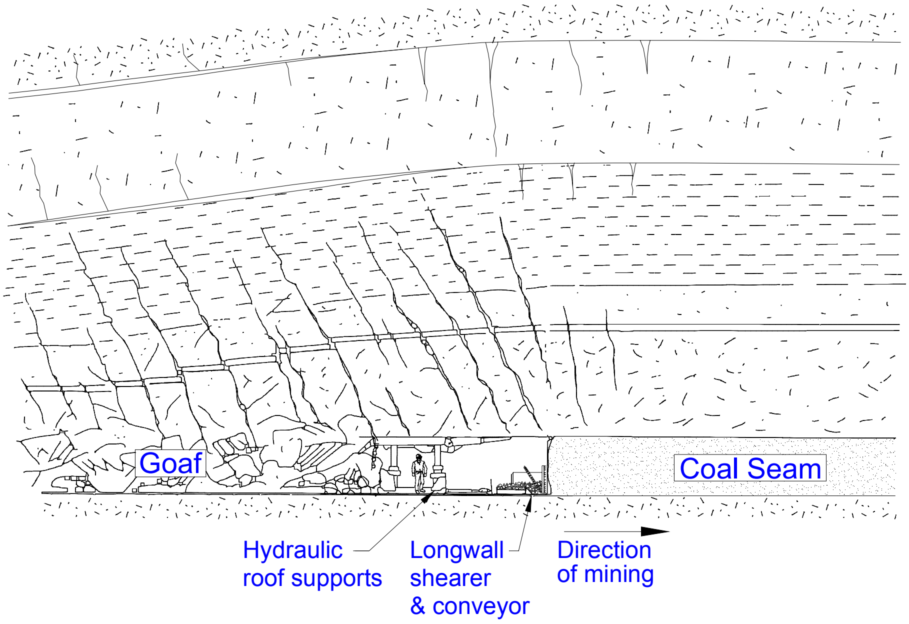


Fig. 3.1 Cross-section along the Length of a Typical Longwall at the Coal Face

The coal is removed by a shearer which cuts the coal from the coal face on each pass as it traverses the width of the longwall. The roof at the coal face is supported by a series of hydraulic roof supports, which temporarily hold up the roof strata, and provides a working space at the coal face. The coal is then transported by a face conveyor belt which is located behind the shearer. As the coal is removed from each section of the coal face, the hydraulic supports are stepped forward, and the coal face progresses (retreats) along the length of the longwall.

The strata directly behind the hydraulic supports, immediately above the coal seam collapses into the void that is left as the coal face retreats. The collapsed zone comprises of loose blocks and can contain large voids. Immediately above the collapsed zone, the strata remains relatively intact and bends into the void, resulting in new vertical factures, opening up of existing vertical fractures and bed separation. The amount of strata sagging, fracturing and bed separation reduces towards the surface.

At the surface, the ground subsides vertically as well as moves horizontally towards the centre of the mined goaf area. The maximum subsidence at the surface varies, depending on a number of factors including longwall geometry, depth of cover, extracted seam thickness and geology. The maximum achievable subsidence in the Southern Coalfield is 65 % of the extracted seam thickness.

3.3. Overview of Systematic Subsidence Movements

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

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

- **Tilt** is the change in the slope of the ground as a result of differential subsidence, and is calculated as the change in subsidence between two points divided by the distance between those points. Tilt is, therefore, the first derivative of the subsidence profile. Tilt is usually expressed in units of *millimetres per metre (mm/m)*. A tilt of 1 mm/m is equivalent to a change in grade of 0.1 %, or 1 in 100.

- **Curvature** is the second derivative of subsidence, or the rate of change of tilt, and is calculated as the change in tilt between two adjacent sections of the tilt profile divided by the average length of those sections. Curvature is usually expressed as the inverse of the **Radius of Curvature** with the units of *1/kilometres (1/km)*, but the value of curvature can be inverted, if required, to obtain the radius of curvature, which is usually expressed in *kilometres (km)*.

- **Strain** is calculated as the change in horizontal distance between two points on the ground, divided by the original horizontal distance between them. Strain is typically expressed in units of *millimetres per metre (mm/m)*. **Tensile Strains** occur where the distance between two points increases and **Compressive Strains** occur where the distance between two points decreases. So that ground strains can be compared between different locations, they are typically measured over bay lengths that are equal to the depth of cover between the surface and seam divided by 20.

A cross-section through a typical single longwall panel showing typical profiles of systematic subsidence, tilt, curvature and strain is provided in Fig. 3.2.

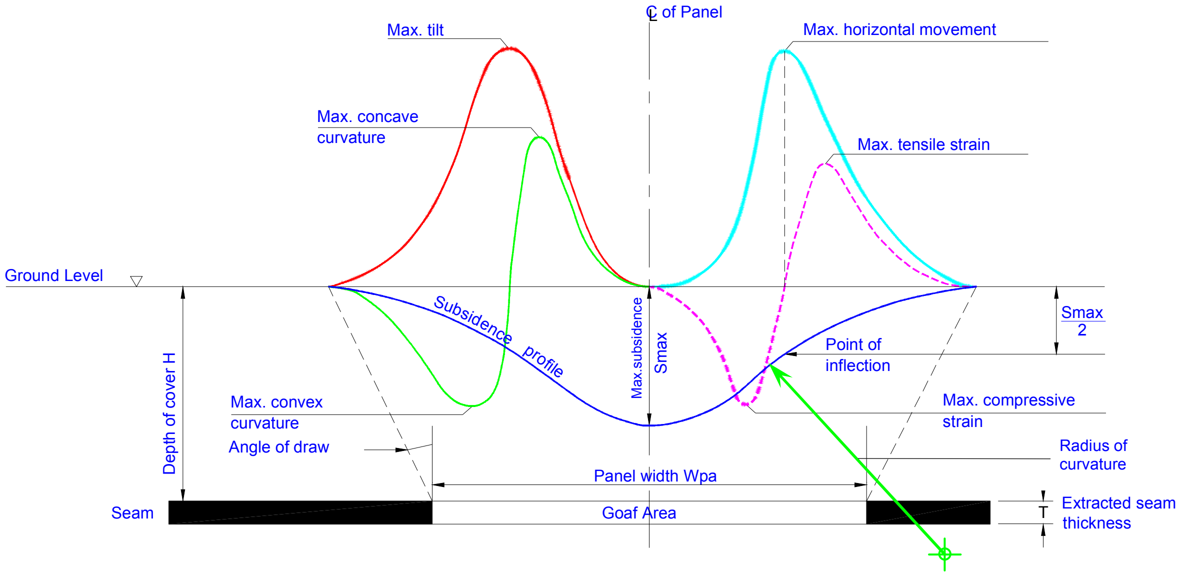


Fig. 3.2 Typical Profiles of Systematic Subsidence Parameter for a Single Longwall Panel

The definitions of incremental, cumulative, total and travelling subsidence parameters are defined as follows:-

- **Incremental** subsidence parameters provided in this report are the additional subsidence, tilts, curvatures and strains which occur due to the extraction of a single longwall. Observed incremental subsidence profiles are determined by subtracting the observed subsidence profiles before from the observed subsidence profiles after the extraction of each longwall.
- **Cumulative** subsidence parameters provided in this report are the accumulated subsidence, tilts, curvatures and strains which occur due the extraction of a number of longwalls within the series of longwalls.
- **Total** subsidence parameters provided in this report are the accumulated subsidence, tilts, curvatures and strains which occur due to the extraction of all longwalls within the series of longwalls.
- **Travelling** subsidence parameters provided in this report are the transient tilts, curvatures and strains which occur as the longwall extraction faces mine directly beneath a point. The maximum travelling tilts, curvatures and strains are typically aligned along the longitudinal axes of the longwalls, with the maximum values typically occurring at the locations of maximum incremental subsidence for each longwall.

3.4. The Incremental Profile Method

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

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

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

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

Further details on the Incremental Profile Method are provided in the background report entitled *General Discussion on Mine Subsidence Ground Movements* which can be obtained from *www.minesubsidence.com*. The standard Southern Coalfield profiles from the database, based on monitoring data predominantly from the Bulli Seam, were used to predict the systematic subsidence, tilt, curvature and strain profiles for the proposed longwalls.

The model uses the surface level contours, seam floor contours and seam thickness contours to make predictions, which are shown in Drawings Nos. MSEC326-02, MSEC326-03 and MSEC326-04, respectively. The identified geological structures at seam level are shown in Drawing No. MSEC326-06. The surface and seam information shown in these drawings was provided in IC.

Predictions have been made at points on regular grids orientated north-south and east-west across the SMP Area. A grid spacing of 10 metres in each direction was adopted, which provides sufficient resolution for the generation of subsidence, tilt and strain contours.

The maximum predicted systematic subsidence parameters resulting from the extraction of the proposed longwalls are provided in Chapter 4. The predicted subsidence parameters at the natural features and items of surface infrastructure within the SMP Area are provided in Chapter 5.

3.5. Overview of Non-Systematic Subsidence Movements

Non-systematic subsidence movements include far-field horizontal movements, irregular subsidence movements and valley related movements. These movements are briefly described below and further details are provided in the background report entitled *General Discussion on Mine Subsidence Ground Movements* which can be obtained at *www.minesubsidence.com*.

3.5.1. Far-field Movements

In addition to the systematic horizontal movements which occur above and adjacent to extracted longwalls, far-field horizontal movements have been observed at considerable distances from extracted longwalls. Such movements are predictable and occur whenever significant excavations occur at the surface or underground.

Far-field horizontal movements tend to be bodily movements towards the extracted goaf area and are accompanied by very low levels of strain. These movements generally do not result in impact, except where they occur at large structures which are very sensitive to differential horizontal movements. Far-field horizontal movements and the method used to predict such movements are described in Section 5.33.2.

3.5.2. Irregular Subsidence Movements

Irregular subsidence movements can result from near surface geological structures, including faults, dykes, and abrupt changes in geology. The presence of these features near the surface can result in a bump in the subsidence profile, which is accompanied by locally higher tilts and strains.

Irregular subsidence movements can also occur at shallow depths of cover, where the collapsed zone above the extracted longwalls extends near to the surface. In this situation, the resulting subsidence profile become very erratic, which is accompanied by higher tilts and strains.

The non-systematic tilts and strains resulting from irregular subsidence movements can be much greater than those resulting from the normal systematic subsidence movements. Irregular subsidence movements and the impacts resulting from such movements are described further in Sections 5.33.4.

3.5.3. Valley Related Movements

The watercourses within the SMP Area may be subjected to valley related movements, which are commonly observed along river and creek alignments in the Southern Coalfield. Valley related movements are a natural phenomenon, resulting from the formation and ongoing development of the valley, as illustrated in Fig. 3.3.

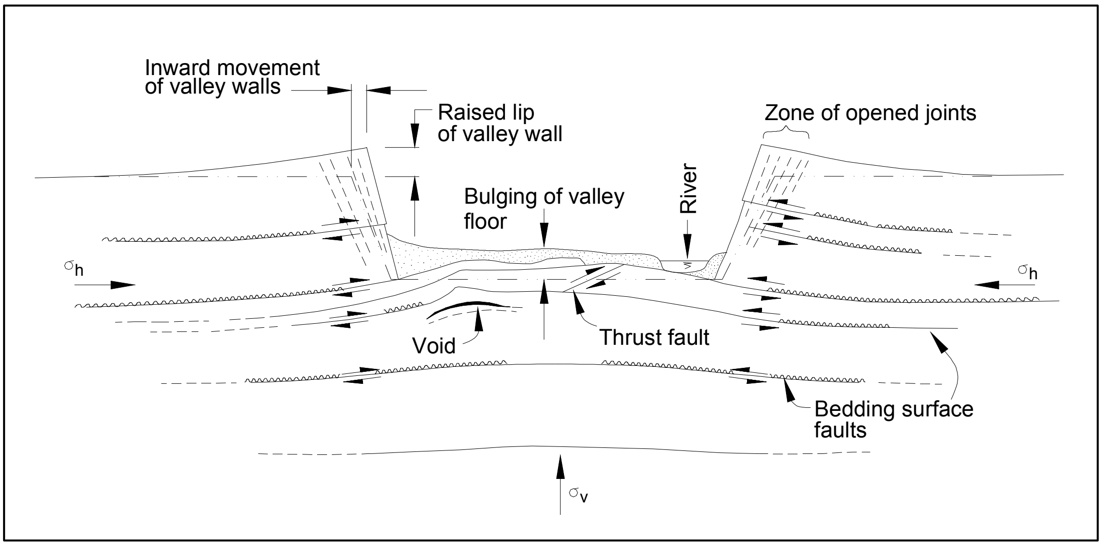


Fig. 3.3 **Valley Formation in Flat-Lying Sedimentary Rocks (after Patton and Hendren 1972)**

Valley related movements can be accelerated by mine subsidence and are described by the following parameters:-

- **Upsidence** is the reduced subsidence, or the net uplift within the base of a valley and is typically expressed in units of *millimetres (mm)*. Upsidence results from the dilation or buckling of near surface strata in the base of the valley which results from the redistribution of the horizontal in situ stresses around the extracted voids and collapsed zones above extracted longwalls.
- **Closure** is the reduction in the horizontal distance between the valley sides and is expressed in units of *millimetres (mm)*. Closure also results from the redistribution of horizontal in situ stresses around the extracted voids and collapsed zones above extracted longwalls.
- **Compressive Strains** occur within the bases of valleys as the result of valley closure movements and are calculated as the decrease in horizontal distance over a standard bay length, divided by the original bay length. **Tensile Strains** also occur adjacent to the valleys as the result of valley closure movements and are calculated as the increase in horizontal distance over a standard bay length, divided by the original bay length. So that ground strains can be compared between different locations, they are typically measured over bay lengths that are equal to the depth of cover between the surface and seam divided by 20. Compressive and tensile strains due to valley closure movements are typically expressed in units of *millimetres per metre (mm/m)*.

The predicted valley related movements resulting from the extraction of the proposed longwalls at the project were made using the empirical method outlined in ACARP Research Project No. C9067 (Waddington et al, 2002).

CHAPTER 4. MAXIMUM PREDICTED SYSTEMATIC SUBSIDENCE PARAMETERS FOR THE PROPOSED LONGWALLS 34 TO 36

4.1. Introduction

The following sections provide the maximum predicted systematic subsidence parameters resulting from the extraction of proposed Longwalls 34 to 36 in Area 5 at West Cliff Colliery. The predicted subsidence parameters and the impact assessments for the natural features and items of surface infrastructure located within the SMP Area are provided in Chapter 5.

It should be noted that the predicted systematic subsidence parameters were obtained using the standard Incremental Profile Model for the Southern Coalfield, which are based on monitoring data predominantly from the Bulli Seam. The maximum predicted subsidence parameters and the predicted subsidence contours provided in this report show the systematic movements and do not include the valley related upsidence and closure movements, nor the effects of faults and other geological structures. Such effects have been addressed separately in the impact assessments for each feature provided in Chapter 5.

4.2. Maximum Predicted Systematic Subsidence Parameters for Longwalls 34 to 36

The locations of the proposed Longwalls 34 to 36 are shown in Drawing No. MSEC326-01 in Appendix G. The predicted cumulative systematic subsidence contours, due to the extraction of Longwalls 34 to 36 only, are shown in Drawing No. MSEC326-28. The predicted cumulative systematic subsidence contours, after the extraction of each proposed longwall, are shown in Drawings Nos. MSEC326-29 to MSEC326-31.

A summary of the maximum predicted incremental systematic subsidence parameters, due to the extraction of each proposed longwall, is provided in Table 4.1. A summary of the maximum predicted cumulative systematic subsidence parameters, after the extraction of each proposed longwall, is provided in Table 4.2. A summary of the maximum predicted travelling tilts and strains, during the extraction of each proposed longwall, is provided in Table 4.3.

Table 4.1 Maximum Predicted Incremental Systematic Subsidence Parameters due to the Extraction of Each Proposed Longwall 34 to 36

Longwall	Maximum Predicted Incremental Subsidence (mm)	Maximum Predicted Incremental Tilt (mm/m)	Maximum Predicted Incremental Tensile Strain (mm/m)	Maximum Predicted Incremental Compressive Strain (mm/m)
Due to LW34	810	5.9	0.8	1.8
Due to LW35	785	5.8	0.8	1.7
Due to LW36	765	5.7	0.8	1.8

Table 4.2 Maximum Predicted Cumulative Systematic Subsidence Parameters after the Extraction of Each Proposed Longwall 34 to 36

Longwall	Maximum Predicted Cumulative Subsidence (mm)	Maximum Predicted Cumulative Tilt (mm/m)	Maximum Predicted Cumulative Tensile Strain (mm/m)	Maximum Predicted Cumulative Compressive Strain (mm/m)
After LW34	1250	5.9	1.1	2.0
After LW35	1250	6.0	1.1	2.0
After LW36	1250	6.0	1.1	2.0

The values provided in the above table are the maximum predicted cumulative systematic subsidence parameters which occur within the general SMP Area, including the predicted movements resulting from the extraction of Longwalls 29 to 33.

Table 4.3 Maximum Predicted Travelling Subsidence Parameters during the Extraction of Each Proposed Longwall 34 to 36

Longwall	Maximum Predicted Travelling Tilt (mm/m)	Maximum Predicted Travelling Tensile Strain (mm/m)	Maximum Predicted Travelling Compressive Strain (mm/m)
During LW34	2.9	0.4	0.3
During LW35	2.9	0.4	0.3
During LW36	2.8	0.4	0.3

The maximum predicted cumulative systematic subsidence of 1250 mm occurs above Longwall 32, after the extraction of Longwall 34. The maximum predicted cumulative systematic tilt of 6.0 mm/m (ie: 0.6 %), which represents a change in grade of 1 in 165, occurs adjacent to the maingate of Longwall 36. The maximum predicted travelling systematic tilt of 2.9 mm/m (ie: 0.3 %), which represents a change in grade of 1 in 345, occurs during the extraction of Longwalls 34 and 35.

The maximum predicted cumulative systematic tensile and compressive strains of 1.1 mm/m and 2.0 mm/m, respectively, occur adjacent to the maingate of Longwall 34 and above Longwall 32, respectively. The minimum radii of curvatures associated with the maximum predicted cumulative systematic tensile and compressive strains are 14 kilometres and 7.5 kilometres, respectively. The minimum radii of curvatures associated with the maximum predicted travelling tensile and compressive strains of 0.4 mm/m and 0.3 mm/m are 38 kilometres and 50 kilometres, respectively.

4.3. Maximum Predicted Systematic Subsidence Parameters along Prediction Line 1

The predicted systematic subsidence parameters have been determined along Prediction Line 1, the location of which is shown in Drawings Nos. MSEC326-28 to MSEC326-31. The predicted profiles of systematic subsidence, tilt and strain along this prediction line are shown in Fig. F.01 in Appendix F. This figure illustrates the variations in the predicted systematic subsidence parameters above the previously extracted and proposed longwalls.

A summary of the maximum predicted cumulative systematic subsidence parameters along Prediction Line 1, after the extraction of each proposed longwall, is provided in Table 4.4. The maximum predicted systematic subsidence parameters along this prediction line, which were determined using the Incremental Profile Method, are compared to those obtained using the Departments Method in Section 5.34.

Table 4.4 Maximum Predicted Cumulative Systematic Subsidence Parameters along Prediction Line 1 Resulting from the Extraction of Longwalls 29 to 36

Longwall	Maximum Predicted Cumulative Subsidence (mm)	Maximum Predicted Cumulative Tilt (mm/m)	Maximum Predicted Cumulative Tensile Strain (mm/m)	Maximum Predicted Cumulative Compressive Strain (mm/m)
After LW33	1145	5.4	0.9	1.6
After LW34	1210	5.5	1.0	1.6
After LW35	1215	5.7	1.0	1.6
After LW36	1215	5.9	1.1	1.7

The values provided in the above table are the maximum predicted cumulative systematic subsidence parameters along Prediction Line 1 which occur within the general SMP Area, including the predicted movements resulting from the extraction of Longwalls 29 to 33.

CHAPTER 5. PREDICTED SUBSIDENCE PARAMETERS AND IMPACT ASSESSMENTS FOR THE NATURAL FEATURES AND ITEMS OF SURFACE INFRASTRUCTURE

5.1. Introduction

The following sections provide the predicted subsidence parameters for the natural features and items of surface infrastructure within the SMP Area. Impact assessments have been made for each of these features based on the predicted subsidence parameters. All significant natural features and items of surface infrastructure located outside the general SMP Area, which may be subjected to valley related or far-field horizontal movements and may be sensitive to these movements, have also been included as part of these assessments.

It is possible for the actual subsidence parameters to be slightly greater or less than those predicted for isolated features, depending on their relative position within the subsidence trough, so an additional factor of safety has been applied by taking the predicted maximum values of subsidence, tilt, curvature and strain within 20 metres of the perimeter of each feature. The predictions should, therefore, provide the best available indication of the overall subsidence parameters that are likely to be experienced by each feature.

5.2. The Georges River

The location of the Georges River is shown in Drawing No. MSEC326-07. The predictions and impact assessments for the river are provided in the following sections.

5.2.1. Predictions for the Georges River

The predicted profiles of incremental and cumulative subsidence, upsidence and closure along the Georges River, after the extraction of each proposed longwall, are shown in Fig. F.02 in Appendix F. A summary of the maximum predicted values of cumulative subsidence, upsidence and closure anywhere along the river within the SMP Area, after the extraction of each proposed longwall, is provided in Table 5.1.

Table 5.1 Maximum Predicted Cumulative Subsidence, Upsidence and Closure at the Georges River Resulting from the Extraction of Longwalls 29 to 36

Longwall	Maximum Predicted Cumulative Subsidence (mm)	Maximum Predicted Cumulative Upsidence (mm)	Maximum Predicted Cumulative Closure (mm)
After LW33	45	120	95
After LW34	95	135	120
After LW35	200	210	190
After LW36	200	210	210

The predicted subsidence values provided in the above table are the maximum values which occur along the Georges River within the general SMP Area, including the predicted movements resulting from the extraction of Longwalls 29 to 33. The predicted upsidence and closure movements in the above table are the maximum values which occur along the Georges River within the predicted limits of 20 mm additional upsidence and 20 mm additional closure, due to the extraction of Longwalls 34 to 36, but also include the predicted movements resulting from the extraction of Longwalls 29 to 33.

The profile of equivalent valley height that was used to determine the predicted valley related upsidence and closure movements along the river is shown in Fig. F.02. The equivalent valley height is calculated by multiplying the measured overall valley height by a factor which reflects the shape of the valley. The overall valley height is measured after examining the terrain across the valley within a radius of half the depth of cover. The factor varies from 1.0, for steeply sided valleys in flat terrain, to less than 0.5, for valleys of flatter profile in undulating terrain. An equivalent valley height factor of 0.75 was adopted for the Georges River.

The predicted changes in surface level along the alignment of the river are illustrated by the predicted net vertical movement profiles that are shown in Fig. F.02, which have been determined by the addition of the predicted subsidence and upsidence movements. A summary of the maximum predicted cumulative net vertical movements, after the extraction of each proposed longwall, is provided in Table 5.2.

Table 5.2 Maximum Predicted Cumulative Net Vertical Movements Resulting from the Extraction of Longwalls 29 to 36

Longwall	Maximum Predicted Cumulative Subsidence plus Upsidence (mm)	
	Net Subsidence	Net Uplift
After LW33	-	75
After LW34	-	75
After LW35	-	80
After LW36	-	115

The predicted systematic tilts and strains along the alignment of the river, after the extraction of each proposed longwall, are shown in Table 5.3. The Georges River is located adjacent to the finishing ends of Longwalls 34 to 36 and, therefore, is also likely to experience the longitudinal systematic strains off the ends of these longwalls, which are essentially orientated across the river. A summary of the maximum predicted systematic strains across the alignment of the river, after the extraction of each proposed longwall, is also provided in Table 5.3.

Table 5.3 Maximum Predicted Cumulative Systematic Tilts and Strains at the Georges River Resulting from the Extraction of Longwalls 29 to 36

Longwall	Maximum Predicted Cumulative Systematic Tilt along Alignment (mm/m)		Maximum Predicted Cumulative Systematic Strain along Alignment (mm/m)		Maximum Predicted Cumulative Systematic Strain across Alignment (mm/m)	
	Increase in Gradient	Decrease in Gradient	Tensile Strain	Comp. Strain	Tensile Strain	Comp. Strain
After LW33	< 0.1	0.2	< 0.1	< 0.1	0.1	< 0.1
After LW34	0.3	0.7	0.1	0.2	0.2	< 0.1
After LW35	0.8	0.8	0.1	0.4	0.4	< 0.1
After LW36	0.8	0.8	0.1	0.4	0.4	< 0.1

The locations of the rock bars and riffles along the Georges River are shown in Drawing No. MSEC326-08 and in Fig. F.02. A summary of the maximum predicted values of total subsidence, upsidence and closure movements at each of these features within the SMP Area, after the extraction of the proposed longwalls, is provided in Table 5.4.

Table 5.4 Maximum Predicted Total Subsidence, Upsidence and Closure Movements at the Rock Bars and Riffles along the Georges River Resulting from the Extraction of Longwalls 29 to 36

Feature	Label	Maximum Predicted Total Subsidence (mm)	Maximum Predicted Total Upsidence (mm)	Maximum Predicted Total Closure (mm)
Rock Bars	RB37	65	140	135
	RB38	70	145	120
	RB39	75	125	125
	RB40	100	150	130
	RB40A	120	155	125
	RB40B	160	180	125
	RB40C	190	210	130
	RB41	190	210	130
	RB42	90	140	120
	RB43	80	130	115
	RB44	80	155	115
	RB45	95	170	115
	RB47	25	80	85
	RB48	10	55	70
	RB49	10	50	70
	RB51	10	60	80
	RB52	20	75	105
	RB53	15	80	125
	RB54	20	90	160
	RB55	30	105	195
	RB56A	30	115	205
	RB56B	30	115	205
	RB57	30	115	200
	RB59	35	145	195
	RB60	30	110	160
	RB61	30	100	150
	RB62	< 20	40	55
	RB63	< 20	35	40
	RB64	< 20	25	25
	RB65	< 20	20	< 20
Riffles	RF56	30	115	205
	RF58	25	125	195

5.2.2. Impact Assessments for the Georges River

The impact assessments for the Georges River, based on the predicted systematic and valley related movements, are provided in the following sections. The findings in the following sections should be read in conjunction with the other relevant technical reports attached to the SMP Application.

5.2.2.1. The Potential for Increased Levels of Ponding, Flooding and Scouring

The Georges River is a permanent stream where surface water flows are derived from the catchment areas as well as from the Licensed Discharges from Appin and West Cliff Collieries. The larger pools in the river are permanent and naturally develop upstream of the rock bars, riffles and boulder fields, which are shown in Drawing No. MSEC326-08, as well as at the sediment and debris accumulations.

Mining can potentially result in increased levels of ponding and some minor flooding of the adjacent riparian areas in locations where the mining induced tilts oppose and are greater than the natural river gradients. Mining can also potentially result in an increased likelihood of scouring of the river banks in the locations where the mining induced tilts considerably increase the natural river gradients.

The maximum predicted systematic increasing and decreasing tilts along the Georges River, resulting from the extraction of the proposed longwalls, are both 0.8 mm/m (ie: less than 0.1 %), or a change in grade of 1 in 1250. The natural gradient of the Georges River within the SMP Area varies between a minimum of less than 1 mm/m and a maximum of 50 mm/m, with an average natural gradient of approximately 8 mm/m.

Although the river has a relatively shallow natural gradient within the SMP Area, it is unlikely that there would be any significant increases in the levels of ponding, flooding, or scouring of the river banks, as the maximum predicted changes in grade along the river are very small, being less than 0.1 %. It is possible, however, that there could be some very localised increased levels of ponding or flooding where the predicted maximum tilts coincide with existing pools, steps or cascades along the river, however, any changes are not expected to result in a significant impact.

5.2.2.2. The Potential for Changes in Stream Alignment

The potential for changes in stream alignment can occur due to changes in the cross-bed gradients resulting from mining-induced systematic or valley related movements. The potential for mining-induced changes in the stream alignment depends upon the mining-induced ground movements, the natural river cross-bed gradients, as well as the depth, velocity and rate of surface water flows.

Changes in stream alignment can potentially impact upon the river if they affect riparian vegetation, or the changes result in additional scouring of the river banks. The potential for changes in stream alignment are generally limited to sections of river where surface flows are confined to shallow streams over a relatively flat river bed.

The maximum predicted systematic tilt across the alignment of the river, resulting from the extraction of the proposed longwalls, is 1.5 mm/m (ie: 0.2 %), or a change in cross-bed gradient of 1 in 665, which occurs adjacent to the finishing (eastern) end of Longwall 35.

The maximum predicted total upsidence along the river, resulting from the extraction of the proposed longwalls, is 210 mm, which occurs adjacent to the finishing (eastern) end of Longwall 34. Based on an idealised upsidence profile, as shown in Fig. 1.25 in the background report entitled *General Discussion of Mine Subsidence Ground Movements* which can be obtained at *www.minesubsidence.com*, the predicted upsidence spike of 140 mm (ie: $^2/_3$ of total) is distributed across a width of approximately 50 metres. The maximum predicted tilt across the alignment of the river, resulting from the maximum predicted upsidence movement is, therefore, approximately 6 mm/m (ie: 0.6 %), or a change in cross-bed gradient of 1 in 165.

The predicted changes in the cross-bed gradients are very small and are expected to be an order of magnitude smaller than the natural river cross-bed gradients. The potential impacts associated with changes in the stream alignment, resulting from the extraction of the proposed longwalls are, therefore, not expected to be significant.

The potential impacts of the changes in the stream alignment are expected to be minor when compared to the changes in the river depth and width that occur during times of high flow in the river. The potential impacts of scouring are also likely to be minimal due to the nature of the sandstone river bed.

In the locations where the river bed comprises sediments and deposited debris, rainfall events could also result in changes in the stream alignment. In a big storm event, even rocks and vegetation can be carried away downstream. The increased flow velocities in such events are likely to be an order of magnitude greater than those resulting from mining induced changes to bed gradients.

5.2.2.3. The Potential for Fracturing of Bedrock and Surface Water Flow Diversions

Fractures and joints in bedrock and rock bars occur naturally from erosion and weathering processes and from natural valley bulging movements. Where longwall mining occurs in the vicinity of rivers and creeks, mine subsidence movements can result in additional fracturing or the reactivation of existing joints. The precise causes of these mining-induced fractures are difficult to determine as the mechanisms are complex, although the main mining-related mechanisms are the systematic subsidence and valley related movements.

Diversions of surface water flows also occur naturally from erosion and weathering processes and from natural valley bulging movements. Mining-induced surface water flow diversions into near surface subterranean flows occur where there is an upwards thrust of bedrock, resulting in the redirection of some water flows into the dilated strata beneath the river bed. The water generally reappears further downstream of the fractured zone as the water is only redirected below the river bed for a certain distance.

Mining-induced surface water flow diversions due to rock bar leakage occur in a similar manner to the above mechanism, except that the rock bar is elevated above the rest of the river bed and the near surface watertable. The rate of leakage is dependent, among other things, on the extent of horizontal fracturing over the depth of the rock bar and the water level. Rock bars leak at a higher rate when the pool is full, as there is access to all drainage paths and the water head is at its greatest. As the pool level falls, the drainage rate reduces as the water head falls and access is restricted to drainage paths near the base of the rock bar.

The types of surface water flow diversions mentioned above are illustrated in Fig. 5.1.

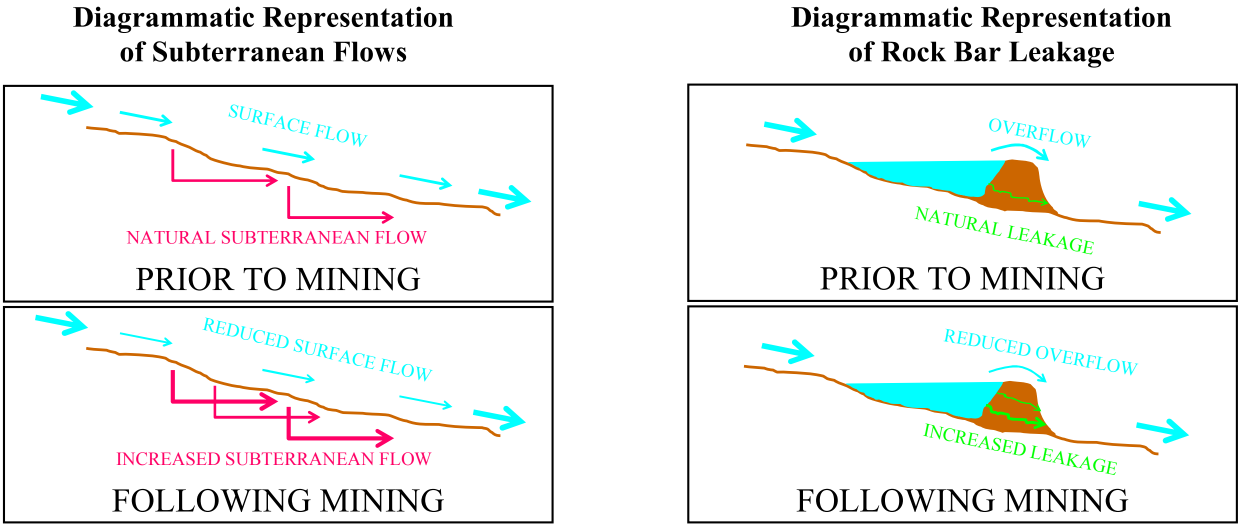


Fig. 5.1 Types of Surface Water Flow Diversions

Interactions between the surface water and groundwater systems have been observed along the Georges River and the river is categorised as a *losing* system for most of the time, where the predominant movement is from the surface water to the groundwater system (IC, 2004a).

In times of extended drought, such as has recently occurred, the groundwater table can be lowered considerably. In these drought conditions, surface water flows can be naturally diverted through the existing joints into a lower groundwater system and, where mining induced fractures occur, additional surface water diversions can occur into the groundwater system. Following periods of groundwater recharge rain events, the groundwater levels are expected to return to higher levels, reducing the diversion of surface water flows into the groundwater system.

The surface water which is diverted into the groundwater system is not drawn upon, utilised or lost from the region and, hence, the diverted surface water is not viewed as a loss of water from the system. Over time, the subterranean flow channels and fractures can become blocked with debris and sediment and, therefore, the diversion of surface water into subterranean flows can reduce over time.

The experience gained from previous longwall mining in the Southern Coalfield indicates that mining-induced fracturing in bedrock and rock bars are commonly found in sections of rivers and creeks that are located directly above extracted longwalls. However, minor fracturing has also been observed in locations beyond extracted longwall goaf edges, the majority of which have been within the limit of systematic subsidence. In a few isolated cases, minor fracturing has been observed up to 400 metres outside extracted longwall goaf edges.

Where West Cliff Longwalls 5A1 to 5A4 previously mined directly beneath the Georges River, a number of impacts were observed including:-

- Release of strata gas from the river bed at some locations, including Jutts Crossing and Marhnyes Hole,
- Fractures at rock bars and in the river bed at Pools 8, 9, 14, 15, 16B and 17,
- Reduced water levels in pools with fracturing, including complete draining of Pools 8, 9 and 16B, for short periods of time during low flow conditions, and
- Formation of a spring at Pool 11.

The locations and details of the impacts that were observed along the Georges River during the extraction of Longwalls 5A1 to 5A4 are provided in Appendix D.2. The impacts occurred primarily in the vicinity of Jutts Crossing and Marhnyes Hole and Pools 16B and 17, which are briefly summarised below.

Jutts Crossing (RB10) is located directly above the chain pillar between Longwalls 5A1 and 5A2. No adverse impacts were observed at Jutts Crossing during the extraction of Longwall 5A1. In August 2000, during the extraction of Longwall 5A2, fractures were observed in the bedrock at Jutts Crossing. In November 2000, Pools 8, 9 and 10 upstream of Jutts Crossing were observed to lose water and then to completely drain during times of low flow. At that stage of mining, the predicted upsidence and closure movements at the rock bar were 220 mm and 235 mm, respectively.

The Marhnyes Hole area consists of two pools along the Georges River, designated Pools 14 and 15, which are separated by Rock Bar 15. The downstream pool, being Pool 15, is contained by Rock Bar 16. Marhnyes Hole is located above Longwall 5A4. No major impacts were observed at Marhnyes Hole during the extraction of Longwalls 5A1 to 5A3.

Longwall 5A4 mined directly beneath Marhnyes Hole in September 2002 and minor fracturing was observed when the extraction face was directly beneath the rock bar. The water level in the upstream pool, being Pool 14, began to fall when the longwall face was approximately 140 metres past the rock bar. The water level in the downstream pool, being Pool 15, started to fall shortly after, when the longwall face was approximately 180 metres past. At that stage of mining, the predicted upsidence and closure movements at the rock bar were 185 mm and 210 mm, respectively.

Where West Cliff Longwalls 29 and 31 mined immediately adjacent to the Georges River, gas bubbles were observed in the river. There were no other impacts observed along the Georges River resulting from the extraction of these longwalls. At the completion of these longwalls, the maximum predicted upsidence and closure at the Georges River were 70 mm and 135 mm, respectively.

The proposed Longwalls 34 to 36 mine up to, but not beneath the Georges River. The maximum predicted total systematic tensile and compressive strains at the Georges River, resulting from the extraction of the proposed longwalls, are both 0.4 mm/m and the associated minimum radius of curvature is 38 kilometres.

The fracturing of sandstone due to systematic subsidence movements has generally not been observed in the Southern Coalfield where the systematic tensile and compressive strains have been less than 0.5 mm/m and 2 mm/m, respectively. It is unlikely, therefore, that the maximum predicted systematic strains at the Georges River, resulting from the extraction of the proposed longwalls, would be of sufficient magnitude to result in any significant fracturing in the sandstone bedrock or result in any significant surface water flow diversions.

Elevated compressive strains across the alignment of the Georges River are likely to result from the valley related movements. The maximum predicted total upsidence and closure movements at the river, resulting from the extraction of the proposed longwalls, are both 210 mm. The compressive strains resulting from valley related movements are more difficult to predict than systematic strains, especially where rivers and creeks are located above solid coal, ie: outside the areas located directly above extracted longwalls, such as the case for the Georges River.

The potential for the fracturing of bedrock and, hence, the potential for surface water flow diversions along the Georges River, resulting from the predicted upsidence and closure movements have, therefore, been assessed by comparing the predicted movements along the river with the back-predicted movements along a number of rivers and creeks which have been affected by mining within the Southern Coalfield.

The selected case studies include the following:-

- West Cliff Longwalls 5A1 to 5A4 which mined adjacent to and directly beneath the Georges River,
- West Cliff Longwalls 29 and 31 which mined adjacent to the Georges River,
- Appin Longwalls 301 and 302 which mined adjacent to the Cataract River,
- Tahmoor Longwalls 14 to 19 which mined adjacent to and directly beneath the Bargo River,
- Elouera Longwalls 1 to 10 which mined adjacent to and directly beneath Wongawilli Creek,
- Elouera Longwalls 1 to 10 which mined adjacent to and directly beneath Native Dog Creek, and
- Dendrobium Longwalls 1 and 2 which mined adjacent to Kembla Creek.

The extraction dates of these longwalls are provided in Table D. 1 in Appendix D.

Brief descriptions of West Cliff Longwalls 5A1 to 5A4, 29 and 31 case studies were provided earlier and detailed descriptions of these case studies, as well as detailed descriptions of the other case studies are provided in Appendix D at the end of this report. The case studies include a range of longwall geometries, mining details, longwall offsets from river and creek valleys and heights and shapes of river and creek valleys.

To allow comparisons between the case studies and the proposed longwalls, the back-predicted upsidence and closure movements for the case studies were determined using the ACARP Method (Waddington et al, 2002), which is the same method that has been used to predict the upsidence and closure movements for the proposed Longwalls 34 to 36.

Observed valley related movements were not used in these comparisons because the mining geometries and valley geometries for the case studies are different to those for the proposed longwalls. By using the ACARP Method of prediction for valley related movements, however, the mining geometries and valley geometries for the case studies are normalised and comparisons can be made with the predictions for the proposed Longwalls 34 to 36.

The back-predicted total upsidence and closure movements and the observed impacts for each case study are shown in Fig. 5.2. Minor impacts, such as isolated fracturing, gas release and iron staining, are shown as circles in this figure. Significant impacts, including major fracturing and surface water flow diversions, are shown as crosses in this figure. The maximum predicted total upsidence and closure movements along the Georges River, resulting from the extraction of Longwalls 34 to 36, are also shown in this figure for comparison.

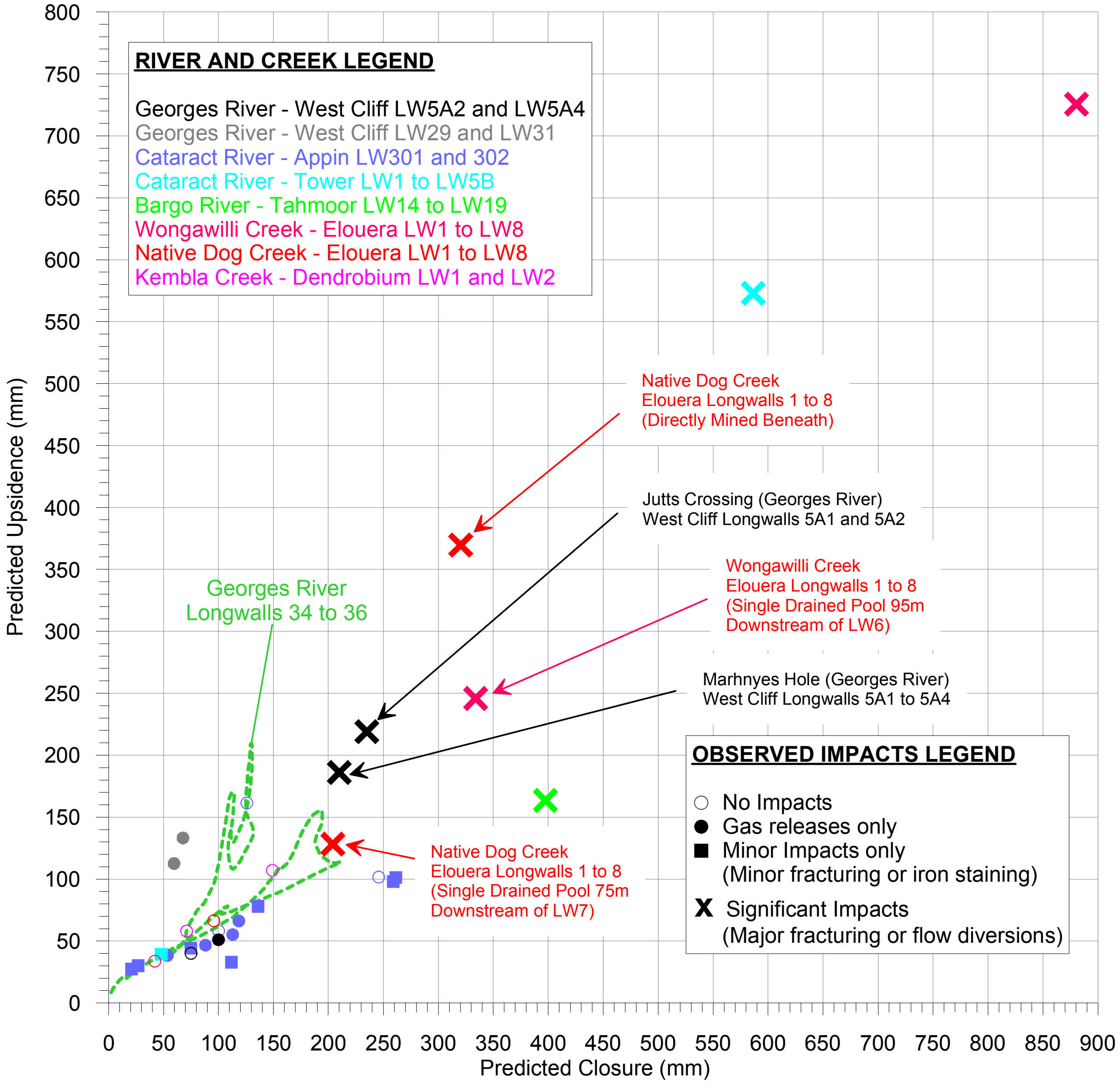


Fig. 5.2 Back-Predicted Upsidence and Closure and the Observed Impacts for the Case Studies

The natural pools along the Georges River are controlled by the rock bars and riffles, the locations of which are shown in Drawing No. MSEC326-08 in Fig. F.02. The maximum predicted total upsidence and closure movements at the rock bars along the river, resulting from the extraction of the proposed Longwalls 34 to 36, are compared with the back-predicted movements for the case studies in Fig. 5.3.

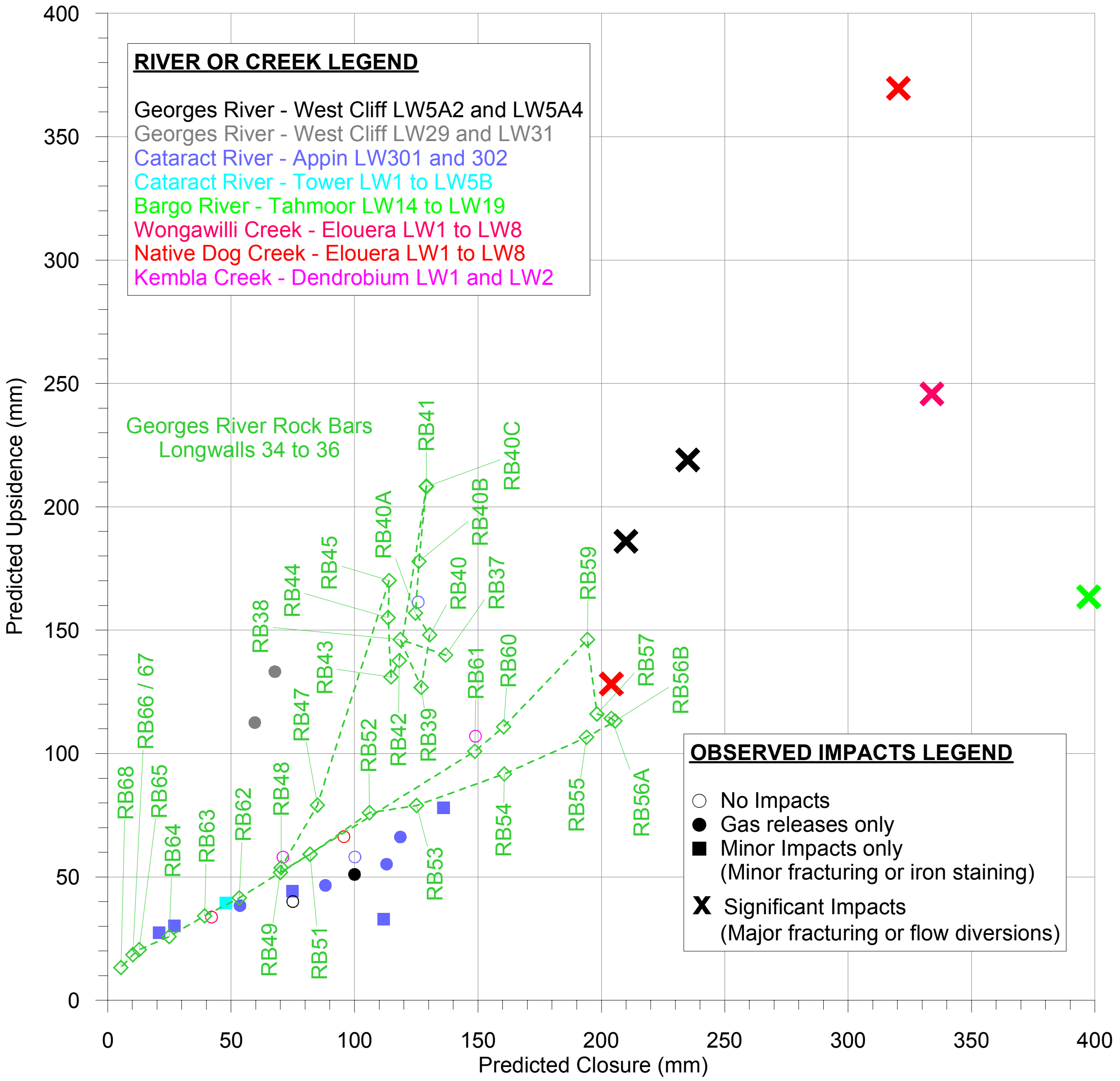


Fig. 5.3 Comparison of Predicted Upsidence and Closure at the Rock Bars along the Georges River with Back-Predicted Movements and Observed Impacts for the Case Studies

It can be seen from Fig. 5.2, that only minor impacts occurred where the back-predicted closure and back-predicted upsidence for the case studies were typically less than 150 mm and 125 mm, respectively. It can also be seen from this figure that the commencement of significant impacts occurred where both the back-predicted closure and back-predicted upsidence for the case studies were greater than 200 mm and 125 mm, respectively.

It should be noted that the predicted and back-predicted upsidence and closure movements made using the ACARP Method use very conservative prediction curves. The observed valley related movements, therefore, are typically found to be much less than those predicted using this method. Comparisons between predicted and observed upsidence and closure movements in the valley related movements database are provided in Fig. 5.4 and Fig. 5.5, respectively.

It has been found, in the majority of cases, that the observed valley related movements are typically between 50 % and 100 % of those predicted and in some cases the observed movements are less than 25 % of those predicted. In rare cases, it has been found that the observed movements exceed those predicted, which is generally the result of weak near surface geology.

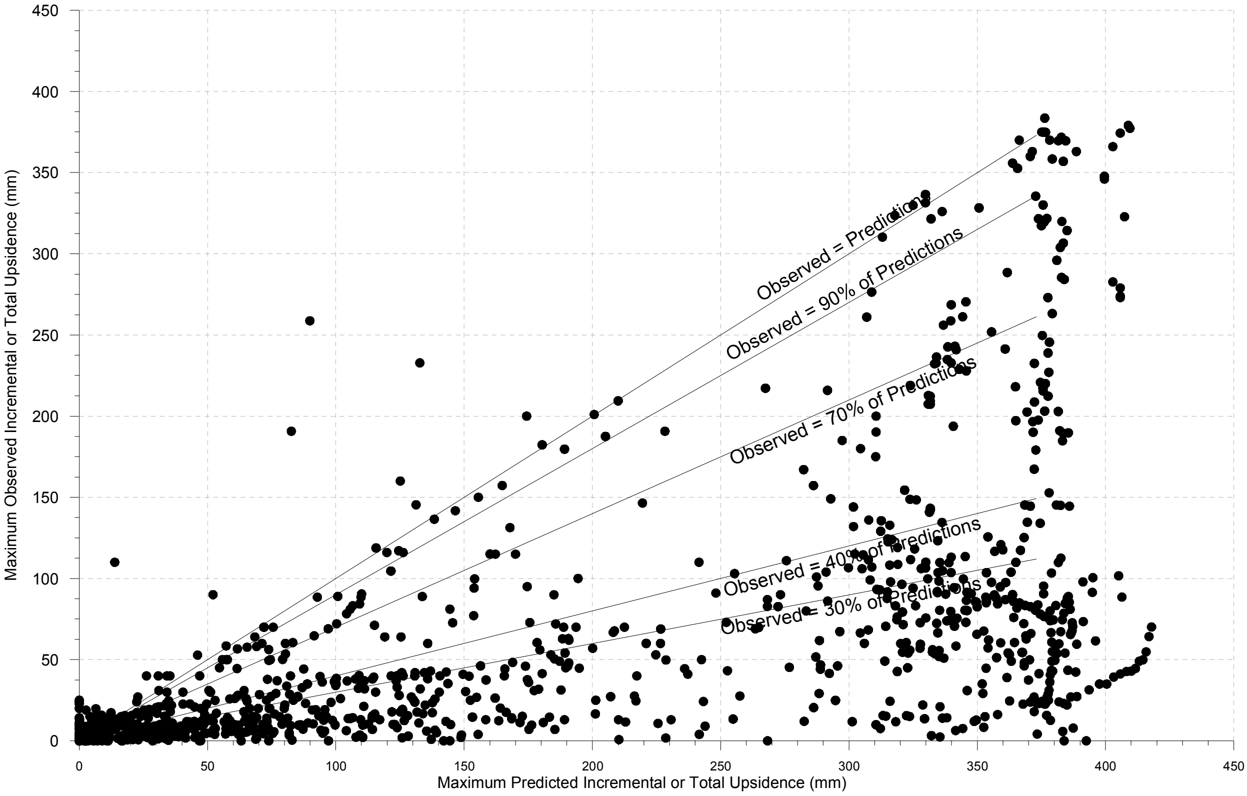


Fig. 5.4 Comparison of Predicted and Observed Upsidence Movements in Database

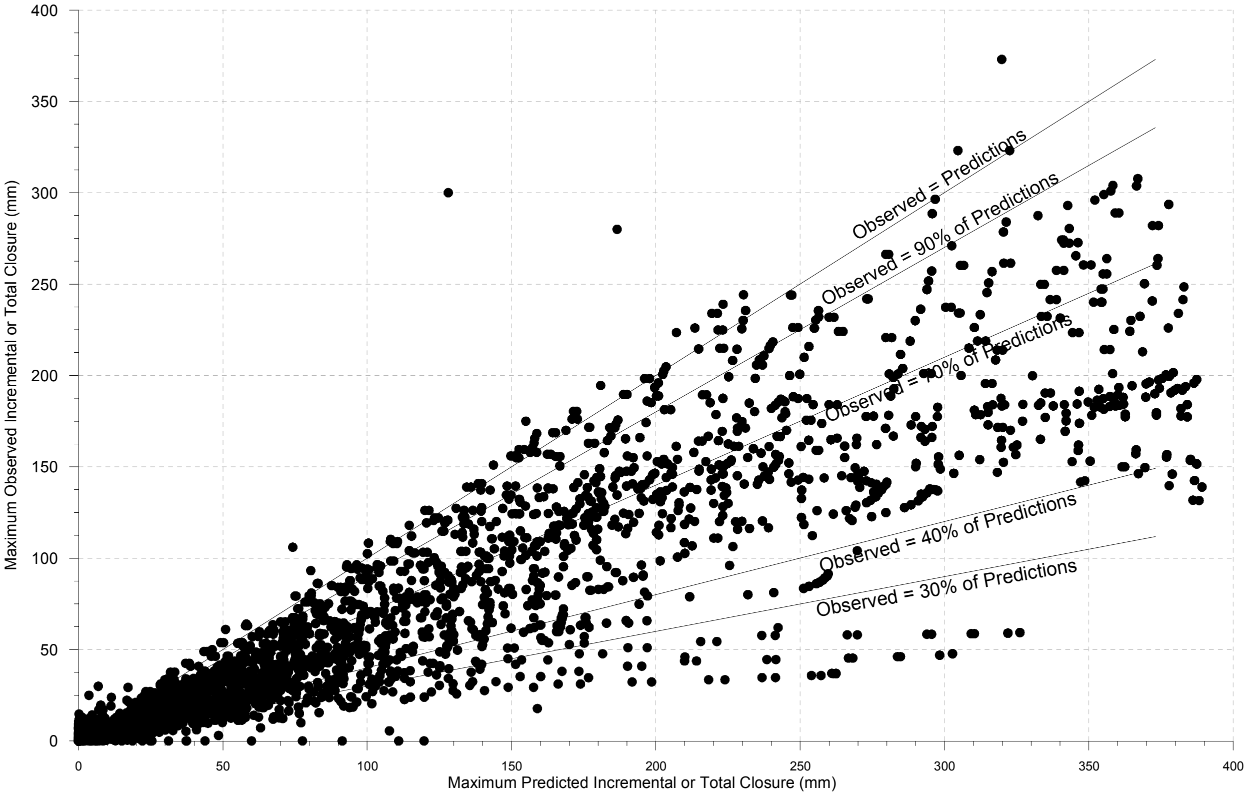


Fig. 5.5 Comparison of Predicted and Observed Closure Movements in Database

While both upsidence and closure movements have been back-predicted, it is our opinion that the most relevant parameter for assessing the potential for significant impacts along the Georges River are the predicted closure movements. This opinion is based on information that is currently available and is made for the following reasons:-

- Closure is the measure of macro valley movements and, therefore, there is less variation in the observed closure movements between adjacent cross-sections within a valley. As a result, there is less scatter in the observed closure movement data in the empirical database, which can be seen in Fig. 5.5.
- Upsidence is the measure of micro valley movements in the base of the valley, which can vary significantly between adjacent cross-sections due to variations in near surface geology, whether failure of the bedrock occurs and the nature of bedrock failure. As a result, there is greater scatter in the observed upsidence movement data in the empirical database, which can be seen in Fig. 5.4.
- The observed upsidence movements in the empirical database are also influenced by the placement of survey pegs, which can miss the point of maximum upsidence within the cross-section and measurements can vary significantly between adjacent cross-sections.

Based on the above reasons, the predicted closure movements are considered to be more reliable than the predicted upsidence movements. Although fracturing and dilation of underlying strata and, hence, the potential for surface water flow diversions result from upsidence movements, the correlation between closure and upsidence movements, which can be seen in Fig. 5.2 and Fig. 5.3, allows us to use the predicted closure movements to assess the potential for these impacts.

It can be seen from Fig. 5.2, that the maximum predicted closure movements along the Georges River, resulting from the extraction of proposed Longwalls 34 to 36, are generally less than those back-predicted for all case studies which had observed significant impacts. The exception to this is a 110 metre section of Georges River, adjacent to the maingate of proposed Longwall 35, where the predicted closure exceeds the back-predicted closure for one case study which had an observed significant impact, being the single drained pool along Native Dog Creek which was located 75 metres downstream of the Elouera Longwall 7.

It can also be seen from Fig. 5.3, that the maximum predicted closure at the identified rock bars along the Georges River, resulting from the extraction of the proposed Longwalls 34 to 36, are generally less than those back-predicted for all case studies which had observed significant impacts. The exceptions to this are Rock Bars 56A and 56B, which are located adjacent to the maingate of proposed Longwall 35, where the predicted closures exceed the back-predicted closure for Native Dog Creek case study. It should be noted, that the back-predicted closures at Rock Bars 55, 57 and 59 are of a similar magnitude to that back-predicted for the Native Dog Creek case study.

The maximum predicted upsidence along the Georges River, resulting from the extraction of the proposed Longwalls 34 to 36, is less than those back-predicted for all but three case studies which had observed significant impacts. However, the following should be noted for these case studies:-

- The back-predicted upsidence of 130 mm along Native Dog Creek was accompanied by a back-predicted closure of greater than 200 mm. The impact associated with these movements was a single drained pool located at a distance of 75 metres from the longwalls,
- The back-predicted upsidence of 165 mm along the Bargo River was accompanied by a very large back-predicted closure of 400 mm, and
- The back-predicted upsidence of 185 mm along the Georges River was accompanied by a back-predicted closure of greater than 200 mm. The impact associated with these movements occurred at Marhnyes Hole which was directly mined beneath by the longwalls.

As described previously, predicted closure is considered to be the more reliable parameter for assessing impacts along rivers and creeks. The case studies, therefore, indicate that a maximum predicted closure of 200 mm is an appropriate level for assessing the likelihood for significant impacts on the Georges River. Similar case studies have also been assessed for rivers and creeks located over previously extracted longwalls at other Collieries within the Southern Coalfield and similar results have been found.

It should be noted that the case studies occurred during a time of severe drought and the surface water and groundwater levels around the rivers and creeks are likely to have been at lower levels and, hence, the rate of surface water diversion would have been much greater than during normal periods. In this regard, the selected limit for surface water flow diversions is considered to be conservative and represents significant protection against flow diversions, even in drought periods.

The proposed Longwalls 34 to 36 mine up to, but not beneath the Georges River. The impacts at Jutts Crossing and Marhnyes Hole occurred only after Longwalls 5A2 and 5A4 mined past these rock bars by distances greater than 100 metres. In addition to this, the maximum predicted total closure movements along the Georges River, resulting from the extraction of the proposed Longwalls 34 to 36, are generally less than 200 mm. The exception to this is a 110 metre section of river which is located adjacent to the maingate of Longwall 35, which includes Rock Bars 56A and 56B.

It has been assessed, therefore, that minor fracturing could occur along the Georges River as a result of the extraction of the proposed longwalls. While it is possible for fracturing to occur anywhere along the river, the most likely area is adjacent to the maingate of Longwall 35, where the predicted movements are the greatest. It is possible that minor fractures could occur up to 400 metres from the proposed longwalls.

Given that any fracturing of the river bed is likely to be minor and localised in nature, it is unlikely that any remediation would be required following mining. In the unlikely event that any large surface fractures were to occur that resulted in pool water loss, it is recommended that they be sealed. Successful remediation has occurred in the Georges River at rock bars that have been directly mined beneath by previous longwalls.

As described in Section 2.4.2 and Appendix D.2, natural flow diversions have been observed along sections of the Georges River which have not been affected by mining. It is therefore possible, however unlikely, that the extraction of the proposed longwalls could slightly increase the current rate of surface water flow diversions in the river. It should be noted, however, that there have been no reported significant increases in surface flow diversions in rivers which have been previously mined adjacent to but not directly underneath.

The depth of surface water flow diversions as a result of longwall mining has been estimated to be less than 10 to 15 metres. Recent studies into the depth of dilation of the near-surface strata due to upsidence and closure have been reported by Mills and Huuskes (2004). Extensometer readings were taken at five depths up to a maximum of 27.2 metres across a creek valley with a valley height of approximately 60 metres. The valley was directly mined beneath by a series of longwalls. Maximum incremental subsidence across a nearby monitoring line was approximately 500 mm, with maximum observed total subsidence of approximately 1300 mm. In this case, extensometer readings indicated that the bedrock had dilated vertically from deeper strata by 140 mm at the surface, but the dilation only extended to a depth of only 9 metres from the surface.

The depth of dilation at Marhnyes Hole was measured during the extraction of Longwall 5A4 and has been reported by SCT (2003). Extensometer readings were taken at six depths up to a maximum of 39 metres adjacent to Rock Bar 15 and at Rock Bar 16. The extensometer readings at Rock Bar 16 indicated that the bedrock had dilated to a depth of 20 metres and was essentially uniform throughout the strata, but was slightly higher between the depths of 10 and 16 metres. The vertical dilation of the strata at Rock Bar 15 was largely influenced by the 20 metre deep stress relieving slot, which prevented dilation of the strata up to a depth of 15 metres. The extensometer readings at Rock Bar 15 indicated that the bedrock had dilated to a depth of 28 metres, but was mainly concentrated between the depths of 15.5 and 23 metres. It is difficult to infer what the dilation at Rock Bar 15 would have been without the stress relieving slot.

A number of Collieries in the Southern Coalfield have undertaken field investigations into the location and extent of surface water flow diversions during and following longwall mining operations that have occurred in the vicinity of rivers and creeks. These include West Cliff Colliery beneath or near the Georges River, Tower and Appin Colliery beneath or near the Cataract River, and Tahmoor Colliery beneath or near the Bargo River.

The following comments are made from these observations:-

- The rate of natural surface water flow diversions (or pre-mining surface water flow diversions) has not been well understood due to the limited pre-mining investigations that were undertaken. Knowledge in this area is presently increasing. Surface water flow diversions have been recently observed in sections of the Cataract, Georges and Bargo Rivers that have not been affected by previous mining.
- Observations indicate that mining-induced surface water flow diversions are generally limited to sections of river that are located within the limit of subsidence.
- Pools that are located near the ends of Longwalls 29 and 31 in the Georges River have not been observed to completely or even partially drain under periods of low flow. Some pools further downstream from the end of Longwall 29 have been observed to drain, although it is considered likely that these are due to natural rock bar leakages.
- Periodic monitoring of surface water flows in the Georges River during the extraction of Longwalls 5A1 to 5A4 indicate that surface water flow diversions did not begin until the longwalls passed directly beneath the river.
    - No surface water flow diversions were observed during the extraction of Longwall 5A1.
    - Surface water flow diversions were not observed during the extraction of Longwall 5A2 until the longwall had passed directly beneath the river, when Pools 8, 9 and 10 were observed to drain during low flows.
    - Surface water flow diversions were not observed at Marhnyes Hole until Longwall 5A4 had passed directly beneath the river. The water levels in the pools were not observed to fall until the longwall had passed directly beneath and progressed beyond the river by 100 to 180 metres (IC, 2002, IC, 2004a). It was found that the pools in the Georges River above Longwalls 5A2 to 5A4 could remain full with flows of 1.9 ML/day (IC, 2002).
- In the Cataract River, the only known location of surface water flow diversion beyond the goaf area was observed near the commencing end of Longwall 405. Flow diversions of approximately 2 ML/day have been observed in this location and approximately 7 metres of the rock bar, including a waterfall, have been observed to stop flowing during very low flows. However, while the amount of pre-mining investigations was limited, subterranean flows were observed through a rock pool prior to mining. It is difficult to determine whether the flow diversion had increased as a result of mining.
- Dry sections were observed in the Bargo River following a prolonged period of very low flows. The furthest distance of observed surface water flow diversions from the extracted longwalls was approximately 125 metres.

Baseline pool depth monitoring indicates that pools may fully or partially drain if the licensed discharges were reduced. It appears, however, that the pools remain full or at least retain water when there is some flow. Upon examination of baseline entry flows into the river, not including periods when remediation works were undertaken, it appears that discharges of less than 0.5 ML/day occurred less than 2 % of the time, and discharges of less than 1 ML/day occurred less than 24 % of the time (Refer to Table 2.5).

When periods of very low flow have occurred, water depth monitoring indicates that the pools have not completely drained. The maximum duration of flows less than 1 ML/day between August 2004 and July 2005 was 20 consecutive days, during which most flows were between 0.6 and 1.0 ML/day.

Whilst significant increases in flow diversions are not likely to occur as a result of the extraction of the proposed longwalls, it is possible that sections of river may become dry, depending on the rate of the licensed discharges from Appin and West Cliff Collieries, particularly during times of low rainfall. This is because pre-existing flow diversions are already known to exist in the river. It is suspected that the river would consist of a series of disconnected or drained pools during periods of low rainfall if the licensed discharges did not enter the river.

It is recommended that current flow conditions be maintained during the mining period so that field monitoring can determine whether any increased flow diversions occur as a result of the extraction of the proposed longwalls. If the licensed discharges were changed during the mining period, it would be difficult to compare future flow conditions with the baseline data. It is further recommended that water flow and quality monitoring be continued prior to, during and following the mining period.

While the likelihood of significant increases in flow diversions is considered to be relatively low, it is recommended that any flow diversions be restored by remediation works, which have previously been successfully undertaken in the Georges River. With the current flow regime within the Georges River and with the implementation of remediation works similar to those previously undertaken along the river, it is unlikely that there would be a significant impact on the Georges River resulting from the extraction of the proposed longwalls.

5.2.2.4. The Potential for Ground Water Inflows

There are a number of minor groundwater seeps identified within the SMP Area, which are shown in Drawing No. MSEC326-08. No springs developed along the Georges River during the extraction of Longwalls 29 and 31, which did not mine directly beneath the river. A spring, however, developed along the Georges River at Pool 11, which is located directly above Longwall 5A2, after the river was directly mined beneath by this longwall.

Although the proposed longwalls do not mine directly beneath the Georges River, it is possible that mining-induced springs could develop following the extraction of the proposed longwalls. The chemical characteristics of groundwater seeps and spring suggest that the water passes through upland Wianamatta Shale and permeates through natural or mining-induced fractures in the Hawkesbury Sandstone before emerging in the Georges River.

Vertical dilation between the Wianamatta Shale and Hawkesbury Sandstone is possible along the tributaries to the Georges River, particularly if the thickness of the Shale is less than 10 to 15 metres, as field studies suggest that the vertical dilation in creeks and rivers extend, as a maximum, to these depths (Mills and Huuskes, 2004). Where these tributaries flow into the Georges River, however, the vertical dilation is expected to be small as they are located at the ends of the proposed longwalls.

Further discussion on the likely impacts of springs is provided in a report by Ecoengineers (2007).

5.2.2.5. The Potential Impacts on Water Quality

Mine subsidence can potentially impact on the quality of water in the river due to leaching of minerals from freshly fractured bedrock and from increased inputs from groundwater to surface water flow. Such impacts tend to be temporary, localised and associated with low flow conditions. An investigation into the potential impacts of mine subsidence on water quality in the creeks has been undertaken and described in the report by Ecoengineers (2007).

5.2.2.6. The Potential Impacts on Flora and Fauna

Mine subsidence can potentially impact on flora and fauna within the alignments of rivers. Flora could be adversely affected by the emission of gas at the surface and habitats can be affected by the fracturing of bedrock and the cracking of soils. The potential impact of mine subsidence on flora and fauna are provided in the reports by The Ecology Lab (2007) and by Biosis (2007a).

5.2.3. Impact Assessments for the Georges River Based on Increased Predictions

If the predicted systematic tilts along the Georges River were increased by factors of up to 2 times, the maximum predicted changes in grade along the river would be 1.6 mm/m (ie: 0.2 %), or a change in grade of 1 in 625. The maximum predicted changes in grade would still be significantly less than average natural river gradient, which is approximately 8 mm/m within the SMP Area and unlikely, therefore, to result in a significant impact.

If the predicted systematic strains at the Georges River were increased by factors of up to 2 times, the maximum predicted tensile and compressive strains would both be 0.8 mm/m. Minor fracturing could occur along river where the maximum predicted tensile strain exceeds 0.5 mm/m, immediately adjacent to the finishing ends of the proposed longwalls. Elsewhere, the maximum predicted systematic tensile strain would still be less than 0.5 mm/m and unlikely, therefore, to result in any significant fracturing in the river bed.

If the predicted valley related upsidence and closure movements were increased by factors of up to 2 times, it is likely that fracturing and dilation of the river bed would occur, which could result in some surface water flow diversions. It should be noted, however, that the method used to predict the valley related movements adopts very conservative prediction curves and it is unlikely, therefore, that these movements would be exceeded by any more than 15 %.

5.2.4. Recommendations for the Georges River

It is recommended that Georges River is monitored during the extraction of the proposed Longwalls 34 to 36. It is also recommended that management strategies are developed for the river, such that any impacts can be identified and remediated accordingly. With these strategies in place, it is unlikely that there would be a significant impact on the river resulting from the extraction of the proposed longwalls.

5.3. The Nepean River

The Nepean River is located outside the general SMP Area and is at a distance of 800 metres west of Longwalls 34 and 35, at its closest point to the proposed longwalls. It is unlikely, therefore, that the river would be subjected to any significant systematic subsidence movements resulting from the extraction of the proposed longwalls, even if the predictions were increased by a factor of 2 times.

The Nepean River could be subjected to very small valley related movements resulting from the extraction of the proposed longwalls. The maximum predicted upsidence and closure movements at the river, resulting from the extraction of the Longwalls 34 to 36, are both less than 20 mm. It is unlikely, therefore, that the river would be impacted by valley related movements resulting from the extraction of the proposed longwalls, even if the predictions were increased by a factor of 2 times.

The Nepean River could be subjected to very small far-field horizontal movements as a result of the extraction of the proposed longwalls. Far-field horizontal movements have, in the past, been observed at similar distances as the river is from the proposed longwalls, however, these movements tend to be bodily movements associated with very low levels of strain. It is unlikely, therefore, that the Nepean River would be impacted by far-field horizontal movements resulting from the extraction of the proposed longwalls.

5.4. Drainage Lines

The locations of the drainage lines within the SMP Area are shown in Drawing No. MSEC326-07. The predictions and impact assessments for the major drainage lines are provided in the following sections.

5.4.1. Predictions for the Drainage Lines

The predicted profiles of incremental and cumulative subsidence, upsidence and closure along Mallaty Creek, Leafs Gully and Nepean Creek, resulting from the extraction of the proposed longwalls, are shown in Figs. F.03, F.04 and F.05, respectively, in Appendix F. A summary of the maximum predicted values of cumulative subsidence, upsidence and closure anywhere along these drainage lines within the SMP Area, after the extraction of each proposed longwall, is provided in Table 5.5.

Table 5.5 Maximum Predicted Cumulative Subsidence, Upsidence and Closure at the Drainage Lines Resulting from the Extraction of Longwalls 29 to 36

Drainage Line	Longwall	Maximum Predicted Cumulative Subsidence (mm)	Maximum Predicted Cumulative Upsidence (mm)	Maximum Predicted Cumulative Closure (mm)
Mallaty Creek	After LW33	895	400	525
	After LW34	1125	545	635
	After LW35	1180	620	700
	After LW36	1185	660	735
Leafs Gully	After LW33	305	45	40
	After LW34	730	80	80
	After LW35	930	120	105
	After LW36	970	125	120
Nepean Creek	After LW33	< 20	< 20	< 20
	After LW34	< 20	< 20	< 20
	After LW35	< 20	< 20	25
	After LW36	530	80	55

The maximum predicted subsidence provided in the above table are the maximum values which occur within the general SMP Area, including the predicted movements resulting from the extraction of Longwalls 29 to 33. The maximum predicted upsidence and closure movements in the above table are the maximum values which occur within the predicted limits of 20 mm additional upsidence and 20 mm additional closure, due to the extraction of Longwalls 34 to 36, but also include the predicted movements resulting from the extraction of Longwalls 29 to 33.

The profiles of the equivalent valley heights that were used to determine the predicted valley related upsidence and closure movements along the drainage lines are shown in Figs. F.03 to F.05. An equivalent valley height factor varying between 0.5 and 0.85 were adopted for the drainage lines.

The predicted changes in surface level along the alignments of the drainage lines are illustrated by the predicted net vertical movement profiles that are shown in Figs. F.03 to F.05, which have been determined by the addition of the predicted subsidence and upsidence movements. A summary of the maximum predicted cumulative net vertical movements along the alignments of drainage lines, after the extraction of each proposed longwall, is provided in Table 5.6. The predicted systematic changes in gradient and the predicted systematic strains along the alignments of the drainage lines are also shown in this table.

Table 5.6 Maximum Predicted Cumulative Net Vertical Movements, Systematic Changes in Gradient and Systematic Strains along the Alignments of the Drainage Lines Resulting from the Extraction of Longwalls 29 to 36

Drainage Line	Longwall	Maximum Predicted Cumulative Subsidence plus Upsidence (mm)		Maximum Predicted Cumulative Systematic Tilt (mm/m)		Maximum Predicted Cumulative Systematic Strain (mm/m)	
		Net Subsidence	Net Uplift	Increase in Gradient	Decrease in Gradient	Tensile Strain	Comp. Strain
Mallaty Creek	After LW33	580	85	4.5	2.5	0.6	1.0
	After LW34	640	45	4.6	2.2	0.7	1.1
	After LW35	630	25	4.3	2.4	0.7	1.1
	After LW36	750	< 20	5.3	2.4	0.7	1.2
Leafs Gully	After LW33	260	< 20	1.4	2.4	0.2	0.8
	After LW34	675	< 20	4.4	2.0	1.1	1.0
	After LW35	845	< 20	3.1	2.6	0.8	0.8
	After LW36	900	< 20	2.7	2.7	0.7	0.8
Nepean Creek	After LW33	< 20	< 20	< 0.1	< 0.1	< 0.1	< 0.1
	After LW34	< 20	< 20	< 0.1	< 0.1	< 0.1	< 0.1
	After LW35	< 20	< 20	0.1	0.1	< 0.1	< 0.1
	After LW36	455	< 20	3.4	3.3	1.0	1.6

There are also a number of tributaries to the Georges River, Mallaty Creek and Leafs Gully which are located across the SMP Area and are likely, therefore, to experience the full range of predicted systematic subsidence movements. The maximum predicted systematic tilt, tensile strain and compressive strain within the SMP Area are 6.0 mm/m, 1.1 mm/m and 2.0 mm/m, respectively.

5.4.2. Impact Assessments for the Drainage Lines

The maximum predicted systematic tilts along the alignments of Mallaty Creek, Leafs Gully and Nepean Creek are 5.3 mm/m (ie: 0.5 %), 4.4 mm/m (ie: 0.4 %) and 3.4 mm/m (ie: 0.3 %), respectively, or changes in grade of 1 in 190, 1 in 225 and 1 in 295, respectively. The maximum predicted systematic tilt along the alignments of the tributaries within the SMP Area is 6.0 mm/m (ie: 0.6 %), or a change in grade of 1 in 165.

The natural grade along the alignment of Mallaty Creek within the general SMP Area varies between a minimum of 10 mm/m and a maximum of 100 mm/m, with an average natural grade of 30 mm/m. The natural grade along the alignment of Leafs Gully within the general SMP Area varies between a minimum of 10 mm/m and a maximum of 125 mm/m, with an average natural grade of 50 mm/m. The natural grade along the alignment of Nepean Creek within the general SMP Area varies between a minimum of 10 mm/m and a maximum of 150 mm/m, with an average natural grade of 40 mm/m.

The predicted systematic tilts along the alignments of the drainage lines are small when compared to the existing natural grades and are unlikely, therefore, to result in any significant increases in the levels of ponding, flooding or scouring. The predicted changes in the surface level along the alignments of Mallaty Creek and Leafs Gully, resulting from the extraction of Longwalls 29 to 36, are also illustrated in Fig. 5.6 and Fig. 5.7.

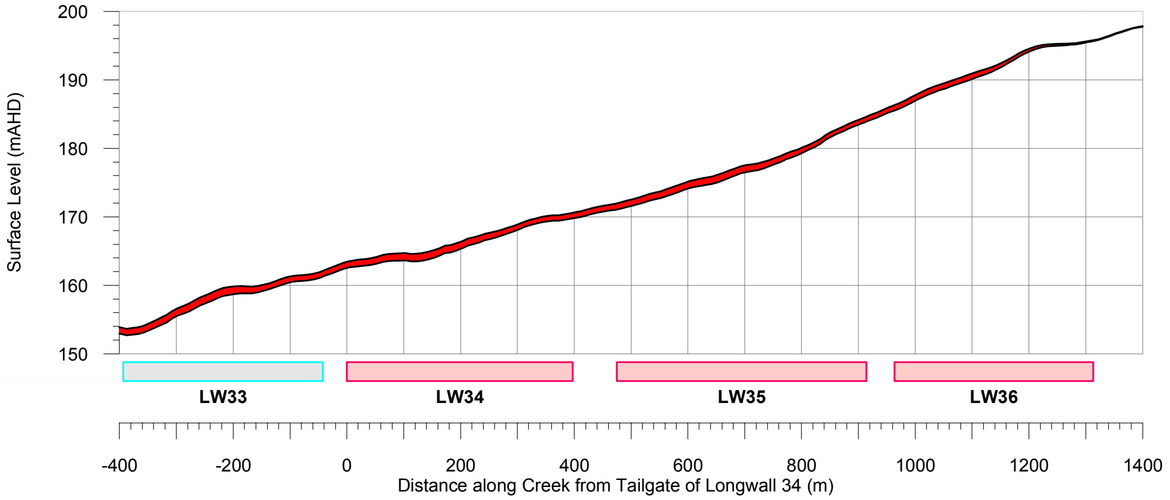


Fig. 5.6 **Initial and Final Surface Levels along the Alignment of Mallaty Creek**

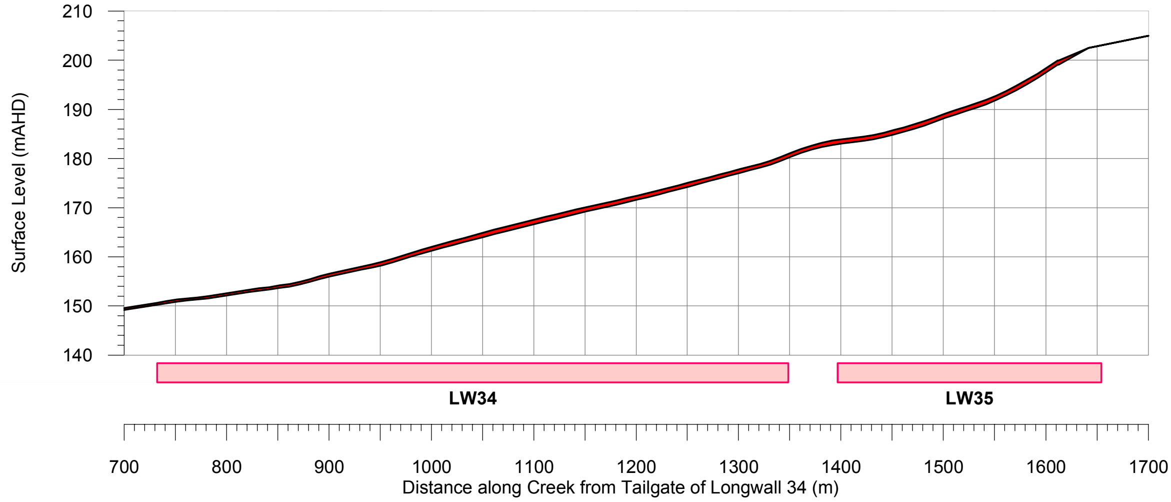


Fig. 5.7 **Initial and Final Surface Levels along the Alignment of Leafs Gully**

It is possible that there could be very localised areas along the drainage lines which could experience a small increase in the levels of ponding and flooding, where the predicted maximum tilts occur at locations with small natural gradients. As the predicted maximum systematic tilts are less than 1 %, however, any changes are expected to be minor and not result in a significant impact on the drainage lines.

The maximum predicted systematic tensile strains along the alignments of Mallaty Creek, Leafs Gully and Nepean Creek are 0.7 mm/m, 1.1 mm/m and 1.0 mm/m, respectively, and the associated minimum radii of curvatures are 21 kilometres, 14 kilometres and 15 kilometres, respectively. The maximum predicted systematic tensile strain along the alignments of the tributaries within the SMP Area is 1.1 mm/m and the associated minimum radius of curvature is 14 kilometres.

Fracturing of the uppermost bedrock has been observed in the past where the systematic tensile strains have been greater than 0.5 mm/m. It is likely, therefore, that some fracturing would occur in the uppermost bedrock based on the predicted maximum systematic tensile strains. Where the drainage lines have alluvial beds above the bedrock, it is unlikely that the fracturing resulting from the systematic tensile strains would be seen at the surface.

The maximum predicted systematic compressive strains along the alignments of Mallaty Creek, Leafs Gully and Nepean Creek are 1.2 mm/m, 1.0 mm/m and 1.6 mm/m, respectively, and the associated minimum radii of curvatures are 13 kilometres, 15 kilometres and 9.4 kilometres, respectively. The maximum predicted systematic compressive strain along the alignments of the tributaries is 2.0 mm/m and the associated minimum radius of curvature is 7.5 kilometres.

Buckling and dilation of the uppermost bedrock has been observed in the past where the compressive strains have been greater than 2 mm/m. The predicted systematic compressive strains along the alignments of Mallaty Creek, Leafs Gully and Nepean Creek are all less than 2 mm/m and are unlikely, therefore, to result in the buckling and dilation of the uppermost bedrock. The maximum predicted systematic compressive strain along the tributaries may, however, be of sufficient magnitude to result in some buckling and dilation of the uppermost bedrock.

Surface cracking as the result of systematic subsidence movements at depths of cover greater than 500 metres, such as at West Cliff Colliery, has generally been observed in the past to be isolated and of a minor nature. It has also been observed in the past, that surface cracking as the result of systematic subsidence movements only occurs within the top few metres of the surface soils or bedrock and tends to be filled with alluvial materials during subsequent flow events.

Elevated compressive strains across the alignments of the drainage lines are likely to result from the valley related movements. The maximum predicted closure movements at Mallaty Creek, Leafs Gully and Nepean Creek are 735 mm, 120 mm and 55 mm, respectively. The maximum predicted closure movement at the tributaries within the SMP Area are expected to be less than 50 mm.

The compressive strains resulting from valley related movements are more difficult to predict than systematic strains. The relationship between closure movements and compressive strains due to closure movements, based on previous mining directly beneath creeks and rivers in the Southern Coalfield, is provided in Fig. 5.8. Based on this figure, it is expected that the compressive strains due to closure movements at the drainage lines which are directly mined beneath by the proposed Longwalls 34 to 36 would be much greater than 2 mm/m.

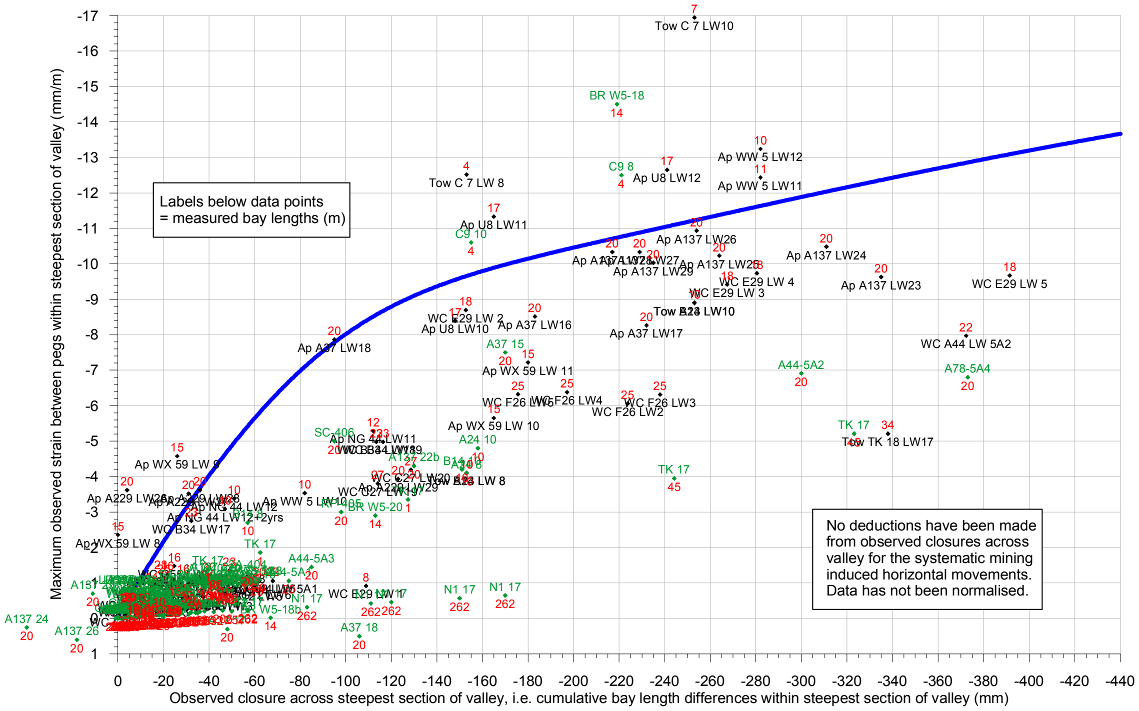


Fig. 5.8 Graph of Maximum Compressive Strain versus Valley Closure Movements for Creeks and Rivers Directly Mined Beneath

It is possible, therefore, that some compressive buckling and dilation of the uppermost bedrock could occur along the alignments of Mallaty Creek and Leafs Gully and, to a lesser extent, along the alignments of Nepean Creek and the tributaries within the SMP Area. It has been observed in the past, that the depth of buckling and dilation of the uppermost bedrock, resulting from valley related movements, is generally less than 10 to 15 metres.

Where the drainage lines have alluvial beds above the sandstone bedrock, it is unlikely that fracturing in the bedrock would be seen at the surface. In the event that surface cracking occurs in these locations within the alignments of the drainage lines, the cracks are likely to be filled with the alluvial materials during subsequent flow events.

Where the bases of the drainage lines have exposed bedrock, there may be some diversion of surface water flows into the dilated strata beneath them and the draining of the pools which exist within the alignments. It is unlikely that there would be any net loss of water from the catchment, however, as the depth of dilation in rivers and creeks has generally been observed in the past to be less than 10 to 15 metres and, therefore, any diverted surface water is likely to re-emerge into the catchment further downstream.

The drainage lines are ephemeral and so water typically flows during and for periods of time after each rain event. In times of heavy rainfall, the majority of the runoff would flow over the beds and would not be diverted into the dilated strata below. In times of low flow, however, some of the water could be diverted into the dilated strata below the beds and this could affect the quality and quantity of the water flowing in the drainage lines. It is unlikely, however, that this would result in a significant impact on the overall quantity and quality of water flowing from the catchment.

Where Appin Longwalls 301 and 302 were mined beneath four creeks, including their tributaries, there was no reported fracturing resulting in surface water flow diversions. The maximum predicted systematic tensile and compressive strains at the creeks above Appin Longwalls 301 and 302 were similar to those predicted along the drainage lines within the SMP Area. The predicted valley related closure movements along the creeks above Appin Longwalls 301 and 302 were, however, less than those predicted for the drainage lines within the SMP Area.

Where Dendrobium Longwalls 1 and 2 were mined beneath six drainage lines, including their tributaries, fracturing was observed in only one of these drainage lines. The maximum predicted systematic tensile and compressive strains at the drainage lines above Dendrobium Longwalls 1 and 2 were significantly greater than those predicted along the drainage lines within the SMP Area. It is expected, therefore, that the proportion of drainage lines being impacted by fracturing within the SMP Area would be significantly less than that observed at Dendrobium, which was in the order of 15 % of the drainage lines which were directly mined beneath.

5.4.3. Impact Assessments for the Drainage Lines Based on Increased Predictions

If the predicted systematic tilts along the alignments of the drainage lines were increased by factors of up to 2 times, the maximum predicted changes in gradient would be in the order of 1 %, which is still small when compared to the existing natural gradients. It is possible that there could be localised areas along the drainage lines which could experience a small increase in the levels of ponding and flooding, however, any changes are expected to be minor and not result in a significant impact on the drainage lines.

If the predicted systematic strains at the drainage lines were increased by factors of up to 2 times, the likelihood and extent of cracking in the beds and the likelihood and extent of fracturing and dilation in the bedrock would increase accordingly directly above the proposed longwalls. The predicted systematic strains would still be less than those predicted along the drainage lines above Dendrobium Longwalls 1 and 2, where minor fracturing was observed in only one of the six drainage lines directly mined beneath.

If the predicted valley related movements at the drainage lines were increased by factors of up to 2 times, the likelihood and extent of fracturing and dilation of the uppermost bedrock would increase accordingly directly above and adjacent to the proposed longwalls. It should be noted, however, that the method used to predict the valley related movements adopts very conservative prediction curves and it is unlikely, therefore, that these movements would be exceeded by any more than 15 %.

5.4.4. Recommendations for the Drainage Lines

It is recommended that the drainage lines are visually monitored during the extraction of the proposed longwalls. It is also recommended that management strategies are developed for the drainage lines, such that any impacts can be identified and remediated accordingly. With these strategies in place, it is unlikely that there would be a significant impact on the drainage lines resulting from the extraction of the proposed longwalls.

5.5. Cliffs

The locations of the cliffs within the SMP Area are shown in Drawing No. MSEC326-09. The predictions and impact assessments for the cliffs are provided in the following sections.

5.5.1. Predictions for the Cliffs

A summary of the maximum predicted values of systematic subsidence, tilt and strain at the cliffs within the SMP Area, at any time during or after the extraction of the proposed longwalls, is provided in Table 5.7.

Table 5.7 Maximum Predicted Systematic Subsidence, Tilt and Strain at the Cliffs within the SMP Area Resulting from the Extraction of Longwalls 29 to 36

Cliff	Maximum Predicted Cumulative Subsidence (mm)	Maximum Predicted Cumulative or Travelling Tilt (mm/m)	Maximum Predicted Cumulative or Travelling Tensile Strain (mm/m)	Maximum Predicted Cumulative or Travelling Compressive Strain (mm/m)
GR-CF01	130	1.7	0.4	0.2
GR-CF02	30	0.3	0.1	< 0.1

The values provided in the above table are the maximum predicted parameters which occur within a distance of 20 metre from the identified extents of the cliffs. The predicted tilts and strains are the maximum values which occur anytime during or after the extraction of the proposed longwalls.

5.5.2. Impact Assessments for the Cliffs

The maximum predicted systematic tilts at Cliffs GR-CF01 and GR-CF02, resulting from the extraction of the proposed longwalls, are 1.7 mm/m (ie: 0.2 %) and 0.3 mm/m (ie: less than 0.1 %), respectively, or changes in grade of 1 in 590 and 1 in 3335, respectively.

Tilt does not directly induce differential movements along cliffs, which is the main cause of cliff instabilities. Tilt, however, can increase the overturning moments in steep or overhanging cliffs which, if of sufficient magnitude, could result in toppling type failures. The predicted tilts at Cliffs GR-CF01 and GR-CF02 and are very small in comparison to the existing slopes of the cliff faces and are unlikely, therefore, to result in topping type failures in these cases.

It is possible, however, that if the systematic strains are of sufficient magnitude, sections of rock could fracture along existing bedding planes or joints and become unstable, resulting in sliding or toppling type failures along the cliffs.

The maximum predicted systematic tensile strains at Cliffs GR-CF01 and GR-CF02, resulting from the extraction of the proposed longwalls, are 0.4 mm/m and 0.1 mm/m, respectively, and the associated minimum radii of curvatures are 38 kilometres and 150 kilometres, respectively. The maximum predicted systematic compressive strains at Cliffs GR-CF01 and GR-CF02, resulting from the extraction of the proposed longwalls, are 0.1 mm/m and less than 0.1 mm/m, respectively, and the associated minimum radii of curvatures are 150 kilometres and greater than 150 kilometres, respectively.

Fracturing of sandstone has generally not been observed in the Southern Coalfield where the systematic tensile and compressive strains have been less than 0.5 mm/m and 2 mm/m, respectively. It is unlikely, therefore, that the predicted maximum systematic strains at Cliffs GR-CF01 and GR-CF02 would be of sufficient magnitude to result in the fracturing of sandstone.

Cliff GR-CF01 is located directly above the finishing (eastern) end of Longwall 35 and Cliff GR-CF02 is located adjacent to the finishing (eastern) end of Longwall 36. Cliff instabilities have been observed in the past along cliff lines which have been located above extracted longwalls. It is possible, therefore, that cliff instabilities could occur at Cliff GR-CF01 and, to a lesser extent, at Cliff GR-CF02 as a result of the extraction of the proposed longwalls.

It is extremely difficult to assess the likelihood of cliff instabilities based upon predicted ground movements. The likelihood of a cliff becoming unstable is dependent on a number of factors which are difficult to fully quantify. These include jointing, inclusions, weaknesses within the rockmass and water pressure and seepage flow behind the rockface. Even if these factors could be determined, it would still be difficult to quantify the extent to which these factors may influence the stability of a cliff naturally or when it is exposed to mine subsidence movements.

The approach taken in this report was to compare the identified cliffs within the SMP Area with two case studies from the Southern Coalfield, being Appin Longwalls 301 and 302 and Dendrobium Longwalls 1 and 2. These case studies are described below:-

Appin Longwalls 301 and 302

Appin Longwalls 301 and 302 mined adjacent to a number of cliff lines located along the Cataract River Gorge. A total of 68 cliffs were identified within the application area having continuous lengths ranging between 5 and 230 metres and overall heights ranging between 10 and 37 metres. The cliffs have formed from the Hawkesbury Sandstone.

Appin Longwalls 301 and 302 have void widths of 260 metres and a solid chain pillar width of 40 metres and were extracted from the Bulli Seam at a depth of cover of 500 metres. The maximum predicted systematic tensile and compressive strains, resulting from the extraction of these longwalls, were 1.1 mm/m and 2.2 mm/m, respectively.

The longwalls mined to within 50 metres of the identified locations of the cliffs. The maximum predicted systematic tensile and compressive strains at the cliffs were 0.2 mm/m and 0.1 mm/m, respectively. There were no cliff instabilities observed as a result of the extraction of Appin Longwalls 301 and 302. There were, however, five minor rockfalls or disturbances which occurred during the mining period, of which, three were considered likely to have occurred due to natural causes. The width of cliff line disturbed as a result of the extraction of Appin Longwalls 301 and 302 was, therefore, estimated to be less than 1 % of the total plan length of cliff line within the application area.

Dendrobium Longwalls 1 and 2

Dendrobium Longwalls 1 and 2 mined directly beneath a ridgeline which consists of a number discontinuous cliffs having overall heights of up to 10 metres. The cliffs have formed from the Hawkesbury Sandstone.

Dendrobium Longwalls 1 and 2 have void widths of 245 metres and a solid chain pillar width of 50 metres and were extracted from the Wongawilli Seam at a depth of cover ranging between 170 and 320 metres. The maximum predicted systematic tensile and compressive strains, resulting from the extraction of these longwalls, were 5 mm/m and 11 mm/m, respectively.

The longwalls mined directly beneath the ridgeline and, therefore, the cliffs were subjected to the full ranges of predicted systematic subsidence movements. There were eight cliff instabilities observed during the extraction of Dendrobium Longwalls 1 and 2 having a total length of disturbance of approximately 135 to 175 metres. The total plan length of ridgeline located directly above the longwalls is approximately 1800 to 2000 metres. It should be noted that there are two levels of cliff in some locations and, therefore, the total length of cliffline is greater than the total plan length of the ridgeline.

The length of ridgeline disturbed as a result of the extraction of Dendrobium Longwalls 1 and 2 was, therefore, estimated to be between 7 and 10 % of the total plan length of ridgeline located directly above the longwalls. The length of rockfalls which occurred as a result of the extraction of Dendrobium Longwalls 1 and 2 was, however, less than the length of disturbed ridgeline.

Summary

The extent of any potential cliff instabilities at Cliffs GR-CF01 and GR-CF02 are expected to be similar to, or slightly greater than that observed as a result of Appin Longwalls 301 and 302, and significantly less than that observed as a result of Dendrobium Longwalls 1 and 2. The reasons for this are:-

- Cliffs GR-CF01 and GR-CF02 are located directly above and adjacent to the finishing ends of West Cliff Longwalls 35 and 36, respectively, where as Appin Longwalls 301 and 302 are located at a minimum distance of 50 metres from the cliffs along the Cataract River Gorge and Dendrobium Longwalls 1 and 2 mined directly beneath the ridgeline,
- The maximum predicted systematic tensile and compressive strains at Cliffs GR-CF01 and GR-CF02 of 0.4 mm/m and 0.2 mm/m, respectively, are slightly greater than those predicted for the cliffs adjacent to Appin Longwalls 301 and 302 of 0.2 mm/m and 0.1 mm/m, respectively, and are significantly less than those predicted for the cliffs above Dendrobium Longwalls 1 and 2 of 5 mm/m and 11 mm/m, respectively, and
- The overall heights of Cliffs GR-CF01 and GR-CF02 of 10 and 15 metres, respectively, are similar to, or less than those for the cliffs adjacent to Appin Longwalls 301 and 302, which range between 10 and 37 metres, and are slightly greater than those for the cliffs above Dendrobium Longwalls 1 and 2, which range up to 10 metres.

The lengths of potential cliff instabilities along Cliffs GR-CF01 and GR-CF02, resulting from the extraction of the Longwalls 34 to 36 are, therefore, expected to be between 1 and 7 % of the lengths of these cliffs. It is expected that the potential impacts at Cliffs GR-CF01 and GR-CF02 would be at the lower end of this range, that is, significantly less than 7 % of the total lengths of cliff, as the predicted movements at these cliffs are closer to those predicted at the cliffs adjacent to Appin Longwalls 301 and 302, than those predicted at the cliffs directly mined beneath by Dendrobium Longwalls 1 and 2.

One of the most significant consequences associated with cliff instabilities is the potential to cause injury to people or death. Cliffs GR-CF01 and GR-CF02 are both located on the western bank of the Georges River on private land. The eastern bank of the river at each site is also private land. A limited section of the Georges River is accessible to the public through the Dharawal State Conservation Area, however, the cliffs are not located within the conservation area itself.

It is recommended, therefore, that persons who enter the area in the vicinity of the cliffs are made aware of the potential for rockfalls resulting from the extraction of the proposed longwalls. The conditions of the cliffs should be monitored throughout the mining period until such time that the mine subsidence movements have ceased, as may be required.

The aesthetics of the landscape could be temporarily altered by isolated rock falls, which would typically result in the exposure of a fresh face of rock and debris scattered around the base of the cliff or slope. As with naturally occurring instabilities, the exposed fresh rockface weathers and erodes over time to a point where it blends in with the remainder of the cliff face and vegetation below the cliff regenerates to cover the talus slope. If a cliff instability were to occur, however, the appearance of the landscape could be restored, if necessary, by the remediation of the rockface and vegetation below the cliff.

Cliff instabilities could impact on water quality if debris were to fall into the Georges River, or if water runoff over the debris were to reach the river. The potential impacts of mine subsidence on the water-related ecosystems within the SMP Area are discussed in the report by The Ecology Lab (2007) and Biosis Research (2007a). The potential impacts on water quality are discussed further in a report by Ecoengineers (2007).

5.5.3. Impact Assessments for the Cliffs Based on Increased Predictions

If the predicted systematic tilts were increased by factors of up to 2 times, the likelihood and extent of cliff instabilities would not significantly increase, as the changes in grade would still be small when compared to the existing slopes of the cliff faces.

If the predicted systematic strains were increased by factors of up to 2 times, the potential for cliff instabilities would increase accordingly. It would be expected, however, that the proportion of cliff line affected by cliff instabilities would still be significantly less than that observed as a result of the extraction of Dendrobium Longwalls 1 and 2.

5.5.4. Recommendations for the Cliffs

It is recommended that appropriate management strategies are put in place to ensure the safety of people that may be within the vicinity of the cliffs during the mining period. With these measures in place, it is unlikely that there would be a significant impact associated with the cliffs resulting from the extraction of the proposed longwalls.

It is recommended that the cliffs should be visually monitored during the mining period from a remote and safe location. It is also recommended that the existing condition of cliffs within the SMP Area should be documented and photographed prior to mining.

5.6. Rock Outcrops

The rock outcrops within the SMP Area are typically located within the valleys of the Georges River, Mallaty Creek and Leafs Gully. The rock outcrops located directly above the proposed longwalls are likely, therefore, to be subjected to the full range of predicted systematic subsidence movements.

The maximum predicted systematic tensile and compressive strains within the general SMP Area, resulting from the extraction of the proposed longwalls, are 1.1 mm/m and 2.0 mm/m, respectively. The minimum radii of curvatures associated with the maximum predicted systematic tensile and compressive strains are 14 kilometres and 7.5 kilometres, respectively.

Fracturing of sandstone has been observed in the Southern Coalfield in the past where the systematic tensile and compressive strains have been greater than 0.5 mm/m and 2 mm/m, respectively. It is likely, therefore, that the maximum predicted systematic strains are of sufficient magnitude to result in the fracturing of sandstone and, hence, the potential for rockfalls, particularly where the rocks are marginally stable. Such occurrences, however, would be expected to be rare.

It is recommended that visual inspections of the exposed rockfaces within the SMP Area should be undertaken during the mining period. Should any rockface appear to become unstable, management strategies should be put in place to prevent access and appropriate signs should be provided to warn of the possibility of rock falls.

5.7. Steep Slopes

The locations of the steep slopes within the SMP Area are shown in Drawing No. MSEC326-09. The predictions and impact assessments for the steep slopes are provided in the following sections.

5.7.1. Predictions for the Steep Slopes

The steep slopes within the SMP Area are typically located within the valleys of the Georges River, Mallaty Creek and Leafs Gully. The steep slopes are likely to be subjected to the full range of predicted systematic subsidence movements. A summary of the maximum predicted values of systematic subsidence, tilt and strain at the steep slopes, at any time during or after the extraction of the proposed longwalls, is provided in Table 5.8.

Table 5.8 Maximum Predicted Systematic Subsidence, Tilt and Strain at the Steep Slopes Resulting from the Extraction of Longwalls 29 to 36

Location	Maximum Predicted Cumulative Subsidence (mm)	Maximum Predicted Cumulative or Travelling Tilt (mm/m)	Maximum Predicted Cumulative or Travelling Tensile Strain (mm/m)	Maximum Predicted Cumulative or Travelling Compressive Strain (mm/m)
Steep Slopes	1250	6.0	1.1	2.0

5.7.2. Impact Assessments for the Steep Slopes

The maximum predicted systematic tilt at the steep slopes, resulting from the extraction of the proposed longwalls, is 6.0 mm/m (ie: 0.6 %), or a change in grade of 1 in 165. The steep slopes are more likely to be impacted by ground strains, rather than tilt, as the maximum predicted tilts at the steep slopes are small when compared to the existing natural gradients, which typically vary between 1 in 3 (ie: 33 %) to 1 in 2 (ie: 50 %), with isolated areas having existing natural gradients up to 1 in 1.5 (ie: 67 %).

The maximum predicted systematic tensile and compressive strains at the steep slopes, resulting from the extraction of the proposed longwalls, are 1.1 mm/m and 2.0 mm/m, respectively. The minimum radii of curvatures associated with the maximum predicted tensile and compressive strains are 14 kilometres and 7.5 kilometres, respectively.

Tensile strains greater than 0.5 mm/m or compressive strains greater than 2 mm/m may be of sufficient magnitude to result in the fracturing or buckling of the uppermost bedrock. The maximum predicted systematic strains at the steep slopes are likely, therefore, to be of sufficient magnitude to result in fracturing of the uppermost bedrock, which could result in surface cracking where the depths to bedrock are shallow.

Surface cracking in soils as the result of systematic subsidence movements is not commonly seen at depths of cover greater than 500 metres, such as at West Cliff Colliery, and any cracking that has been observed has generally been isolated and of a minor nature. It would be expected, therefore, that any surface cracking that occurs along the steep slopes, as a result of the extraction of the proposed longwalls, would be of a minor nature due to the relatively small magnitudes of predicted systematic strains and due to the relatively high depths of cover. Surface tensile cracking is generally limited to the top few metres of the surface soils.

Minor surface cracking tends to fill naturally, especially during rain events. If any significant cracking were to be left untreated, however, erosion channels could develop along the steep slopes. In this case, it is recommended that appropriate mitigation measures should be undertaken, including infilling of surface cracks with soil or other suitable materials, or by locally regrading and recompacting the surface. With these remediation measures in place, it is unlikely that there would be a significant impact on the environment.

The steep slopes within the SMP Area have natural gradients typically less than 1 in 2 and the depths of cover at the steep slopes are greater than 500 metres. It is unlikely, therefore, that the predicted systematic strains would be of sufficient magnitudes to result in the slippage of soils down the steep slopes or the development of tensile cracks at the tops of the slopes.

If movement of the surface soils were to occur during the extraction of the proposed longwalls, minor tension cracks at the tops of slopes and minor compression ridges at the bottoms of slopes may form. In some cases these cracks could lead to increased erosion of the surface and minor mitigation measures would be required, including infilling of the surface cracks with soil or other suitable materials and local regrading and recompacting of compression bumps. With these remediation measures in place, it is unlikely that there would be a significant impact on the environment.

5.7.3. Impact Assessments for the Steep Slopes Based on Increased Predictions

If the predicted systematic tilts were increased by factors of up to 2 times, the potential impacts on the steep slopes would not significantly increase, as the predicted tilts would still be much less than the natural surface gradients of the steep slopes within the SMP Area.

If the predicted systematic strains were increased by factors of up to 2 times, the extent of potential surface cracking would increase accordingly at the steep slopes located directly above the proposed longwalls. It is expected, however, that any surface cracking could still be remediated by infilling with soil or other suitable materials, or by locally regrading and compacting the surface. With these remediation measures in place, it is unlikely that there would be a significant impact on the environment.

5.7.4. Recommendations for the Steep Slopes

It is recommended that the steep slopes are visually monitored throughout the mining period and until any necessary remediation measures are completed. It is also recommended that management strategies should be developed to ensure that these measures are implemented.

5.8. Water-Related Ecosystems

There are water-related ecosystems within the SMP Area, particularly along the alignments of the Georges River, Mallaty Creek and Leafs Gully. The potential impacts of flooding, scouring and cracking in the beds of the watercourses within the SMP Area are discussed in Sections 5.2 to 5.4. The impacts on the water-related ecosystems within the SMP Area are discussed in the reports by The Ecology Lab (2007) and Biosis (2007a).

5.9. Threatened and Protected Species, Other Fauna and Natural Vegetation

The greatest potential for impacts on fauna and their habitats will occur where the disturbance of the soils and near surface strata are the greatest. This is more likely to occur where the levels of ground strain are the highest. The most important changes in the surface relating to subsidence will be changes in the surface water conditions. Where fauna and their habitats are reliant on these surface waters, some impacts are possible, which are discussed in the report by Biosis (2007a).

It is possible that cracking, in some cases, could be accompanied by methane gas emissions. Dieback was experienced in three locations when the longwalls at Tower Colliery mined beneath the Cataract River, but the areas affected by dieback were relatively small and have recovered since mining. The potential impacts of flooding, scouring and cracking in the beds of the Georges River, creeks and gullies are discussed in Sections 5.2 to 5.4.

An impact assessment for the threatened and protected species, other fauna and natural vegetation within the SMP Area are detailed in the reports by Biosis (2007a) and The Ecology Lab (2007).

5.10. Appin Road

The location of Appin Road is shown in Drawing No. MSEC326-10. The predictions and impact assessments for the road are provided in the following sections.

5.10.1. Predictions for Appin Road

The predicted profiles of incremental and cumulative systematic subsidence, tilt and strain along the alignment of Appin Road, resulting from the extraction of the proposed longwalls, are shown in Fig. F.06 in Appendix F. A summary of the maximum predicted values of cumulative systematic subsidence, tilt and strain along the alignment of the road, after the extraction of each proposed longwall, is provided in Table 5.9.

Table 5.9 Maximum Predicted Cumulative Systematic Subsidence, Tilt and Strain along the Alignment of Appin Road Resulting from the Extraction of Longwalls 29 to 36

Longwall	Maximum Predicted Cumulative Subsidence (mm)	Maximum Predicted Cumulative Tilt (mm/m)	Maximum Predicted Cumulative Tensile Strain (mm/m)	Maximum Predicted Cumulative Compressive Strain (mm/m)
After LW33	1150	3.6	0.6	0.9
After LW34	1170	4.7	0.7	1.1
After LW35	1175	4.6	0.8	1.2
After LW36	1175	5.0	0.8	1.3

The values provided in the above table are the maximum predicted cumulative systematic subsidence parameters which occur along the road within the general SMP Area, including the predicted movements resulting from the extraction of Longwalls 29 to 33.

The road will also be subjected to travelling tilts and strains as the extraction faces of the proposed longwalls pass beneath it. A summary of the maximum predicted travelling tilts and strains at the road, during the extraction of each proposed longwall, is provided in Table 5.10.

Table 5.10 Maximum Predicted Travelling Tilts and Strains at Appin Road during the Extraction of Longwalls 34 to 36

Longwall	Maximum Predicted Travelling Tilt (mm/m)	Maximum Predicted Travelling Tensile Strain (mm/m)	Maximum Predicted Travelling Compressive Strain (mm/m)
During LW34	2.7	0.4	0.3
During LW35	2.7	0.4	0.3
During LW36	2.7	0.4	0.3

Appin Road follows a ridgeline within the SMP Area and does not cross any significant drainage lines. It is unlikely, therefore, that the road would be subjected to any significant valley related upsidence or closure movements resulting from the extraction of the proposed longwalls.

5.10.2. Impact Assessments for Appin Road

The maximum predicted systematic tilt at the road within the general SMP Area, at any time during or after the extraction of the proposed longwalls, is 5.0 mm/m (ie: 0.5 %), or a change in grade of 1 in 200. The existing gradients along the alignment of the road within the general SMP Area vary up to 50 mm/m (ie: 5 %), with an average existing gradient of approximately 10 mm/m (ie: 1 %).

It is unlikely, therefore, that the predicted systematic tilts at the road would result in significant changes in surface water drainage, as the maximum predicted change in grade is less than 1 % and is much less than the typical existing gradients along the alignment of the road within the general SMP Area.

The maximum predicted systematic tensile and compressive strains at the road within the general SMP Area, at any time during or after the extraction of the proposed longwalls, are 0.8 mm/m and 1.3 mm/m, respectively. The minimum radii of curvatures associated with the maximum predicted systematic tensile and compressive strains are 19 kilometres and 12 kilometres, respectively.

The road is of flexible construction with a bitumen seal and is likely to tolerate strains of these magnitudes without significant impact. It is possible that minor cracking could occur in some places along the road, due to localised concentrations of tensile strains, and that minor rippling of the road surface could occur in other places, due to localised concentrations of compressive strains. There were no significant impacts observed along Appin Road after Longwall 31 mined beneath it.

As the magnitudes of the maximum predicted strains are relatively low, any such impacts are likely to be infrequent occurrences and of a minor nature. It is recommended that any impacts are remediated using normal road maintenance techniques. With these remediation measures implemented, it is expected that the road can be maintained in a safe and serviceable condition throughout the mining period.

5.10.3. Impact Assessments for Appin Road Based on Increased Predictions

If the predicted systematic tilts were increased by factors of up to 2 times, the maximum predicted tilt at the road within the general SMP Area would be 10 mm/m (ie: 1.0 %), or a change in grade of 1 in 100. It would still be unlikely that the predicted tilts would result in significant changes in surface water drainage, as the maximum predicted change in gradient is still less than the typical existing gradients along the alignment of the road within the general SMP Area.

If the maximum predicted systematic strains were increased by factors of up to 2 times, the likelihood and extent of cracking in the road surface would increase accordingly. As the magnitudes of the maximum predicted strains are relatively low, however, it would still be expected that any impacts could be easily repaired using normal road maintenance techniques. With these remediation measures implemented, it is expected that the road can be maintained in a safe and serviceable condition throughout the mining period.

5.10.4. Recommendations for Appin Road

The road should be inspected on a regular basis as the proposed longwalls are mined beneath it, so that any impacts can be identified and remediated accordingly. In this way, the road can be maintained in a safe and serviceable condition throughout the mining period. It is unlikely that the traffic signs and other road infrastructure would suffer any impact due to mine subsidence.

A management plan has been established for the public roads for Longwalls 29 to 33. It is recommended that the existing management plan be reviewed, in consultation with the Roads and Traffic Authority and the Wollondilly Shire Council, and that amendments are made to the plan, where necessary, to include the predicted movements resulting from Longwalls 34 to 36.

5.11. Other Roads

The predictions and impact assessments for the maintenance road associated with the Upper Canal are provided in Section 5.15.5. The predictions and impact assessments for the roads within the Inghams Farm Complex are provided in Section 5.28.2.

5.12. Bridges

The predictions and impact assessments for the road bridges associated with the Upper Canal are provided in Section 5.15.5.

5.13. Tunnels

The predictions and impact assessments for Devines Tunnels Nos. 1 and 2 are provided in Section 5.15.6.

5.14. Drainage Culverts

5.14.1. Predictions and Impact Assessments for the Road Drainage Culverts

There were no drainage culverts identified along Appin Road within the general SMP Area. There are, however, drainage culverts located along private driveways on the rural properties and on the Inghams Farm Complex within the general SMP Area. These drainage culverts could be subjected to the full range of predicted systematic subsidence movements.

The maximum predicted systematic tilt within the general SMP Area is 6.0 mm/m (ie: 0.6 %), or a change in grade of 1 in 165. Even if the maximum predicted tilt were to occur in the location of a drainage culvert, it would be unlikely to result in a significant impact on the serviceability of the culvert, as the maximum predicted tilt is less than 1 %.

The maximum predicted systematic tensile and compressive strains within the general SMP Area are 1.1 mm/m and 2.0 mm/m, respectively. Drainage culverts are relatively short, typically less than 4 metres in length, and it is unlikely, therefore, that ground strains of these magnitudes would be transferred into the drainage culverts.

The minimum radii of curvatures associated with the maximum predicted systematic tensile and compressive strains are 14 kilometres and 7.5 kilometres, respectively. The maximum predicted differential movements at the mid-lengths of the culverts, relative to the ends of the culverts, are less than 1 mm based on the minimum predicted radii of curvatures and are unlikely, therefore, to result in a significant impact.

It is possible, however, that the drainage culverts could experience some impacts due to localised strain concentrations above natural joints at rockhead, where the depths of the overlying soils are shallow. Any impacts on the drainage culverts would be expected to be of a relatively minor nature, which could be easily repaired or, if necessary, replaced. With any necessary remediation measures implemented, it is expected that the drainage culverts can be maintained in a serviceable condition throughout the mining period.

5.14.2. Other Culverts

The predictions and impact assessments for the culverts and flumes associated with the Upper Canal are provided in Section 5.15.4.

5.15. Sydney Catchment Authority Infrastructure

The locations of the Sydney Catchment Authority infrastructure in the vicinity of the proposed longwalls are shown in Drawing No. MSEC326-11. The predictions and impact assessments for the Sydney Catchment Authority infrastructure are provided in the following sections.

5.15.1. Predictions and Impact Assessments for the Upper Canal

The Upper Canal crosses the western side of the general SMP Area and is located at a distance of 290 metres north-west of Longwall 35, at its closest point to the proposed longwalls. The Upper Canal is located outside the predicted 20 mm subsidence contour and is unlikely, therefore, to be subjected to any significant systematic subsidence movements resulting from the extraction of the proposed longwalls, even if the predicted movements were increased by factors of up to 2 times.

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

It is expected that Upper Canal would remain in a serviceable condition during and after the extraction of the proposed Longwalls 34 to 36.

5.15.2. Predictions and Impact Assessments for the Wrought Iron Aqueducts

The Upper Canal crosses Leafs Gully and Nepean Creek via two wrought iron aqueducts, the locations of which are shown in Drawing No. MSEC326-11. A summary of the maximum predicted total subsidence, upsidence and closure movements at these aqueducts, after the extraction of the proposed longwalls, is provided in Table 5.11.

Table 5.11 Maximum Predicted Total Subsidence Upsidence and Closure Movements at the Wrought Iron Aqueducts Resulting from the Extraction of Longwalls 29 to 36

Aqueduct	Crossing	Maximum Predicted Total Subsidence (mm)	Maximum Predicted Total Upsidence (mm)	Maximum Predicted Total Closure (mm)
A5	Leafs Gully	5	20	25
A6	Nepean Creek	< 5	5	5

It is recommended that the predicted movements at the Leafs Gully and Nepean Creek Aqueducts, resulting from the extraction of the proposed longwalls, are reviewed by the SCA and that any necessary mitigation measures are implemented.

The Upper Canal also crosses Mallaty Creek via a wrought iron aqueduct, the location of which is shown in Drawing No. MSEC326-11. Mitigation measures have been provided at this aqueduct to accommodate the predicted movements resulting from the extraction of Longwalls 29 to 33.

The wrought iron aqueduct across Mallaty Creek (A4) is located at a distance of 1.2 kilometres south of Longwall 34, at its closest point to the proposed longwalls. It is unlikely, therefore, that this aqueduct would be subjected to any significant systematic or valley related movements resulting from the extraction of the proposed longwalls, even if the predicted movements were increased by factors of up to 2 times.

The wrought iron aqueducts across Leafs Gully, Nepean Creek and Mallaty Creek could be subjected to very small far-field horizontal movements as a result of the extraction of the proposed longwalls. The far-field horizontal movements at these aqueducts are expected to be bodily movements associated with very low levels of strain and are unlikely, therefore, to result in a significant impact, even if the predicted movements were increased by factors of up to 2 times.

With the implementation of any necessary mitigation measures, it is expected that wrought iron aqueducts can be maintained in a safe and serviceable condition during and after the extraction of the proposed Longwalls 34 to 36.

5.15.3. Predictions and Impact Assessments for the Concrete Aqueducts

The Upper Canal crosses two unnamed creeks via two concrete aqueducts, referred to as Aqueducts C and D, the locations of which are shown in Drawing No. MSEC326-11. Mitigation measures have been provided at concrete Aqueducts C and D to accommodate the predicted movements resulting from the extraction of Longwalls 29 to 33.

The aqueducts are located 1050 metres and 800 metres south of the Longwall 34, respectively, at their closest points to the proposed longwalls. It is unlikely, therefore, that the concrete aqueducts would be subjected to any significant systematic or valley related movements resulting from the extraction of the proposed longwalls, even if the predicted movements were increased by factors of up to 2 times.

The concrete aqueducts could be subjected to very small far-field horizontal movements as a result of the extraction of the proposed longwalls. The far-field horizontal movements at the concrete aqueducts are expected to be bodily movements associated with very low levels of strain and are unlikely, therefore, to result in impact, even if the predicted movements were increased by factors of up to 2 times.

It is expected that concrete Aqueducts C and D would remain in a safe and serviceable condition during and after the extraction of the proposed Longwalls 34 to 36.

5.15.4. Predictions and Impact Assessments for the Culverts and Flumes

The culverts and flumes along the Upper Canal are located outside the predicted 20 mm subsidence contour and are unlikely, therefore, to be subjected to any significant systematic subsidence movements resulting from the extraction of the proposed longwalls, even if the predicted movements were increased by factors of up to 2 times.

The culverts and flumes are located in small drainage ditches, which have very small effective valley heights, and are unlikely, therefore, to be subjected to any significant valley related movements resulting from the extraction of the proposed longwalls, even if the predicted movements were increased by factors of up to 2 times.

The culverts and flumes could be subjected to very small far-field horizontal movements as a result of the extraction of the proposed longwalls. The far-field horizontal movements at the culverts and flumes are expected to be bodily movements associated with very low levels of strain and are unlikely, therefore, to result in impact, even if the predicted movements were increased by factors of up to 2 times.

It is expected that culverts and flumes would remain in a serviceable condition during and after the extraction of the proposed Longwalls 34 to 36.

5.15.5. Predictions and Impact Assessments for the Maintenance Road and Bridges

The maintenance road associated with the Upper Canal is located outside the predicted 20 mm subsidence contour and is unlikely, therefore, to be subjected to any significant systematic subsidence movements resulting from the extraction of the proposed longwalls, even if the predicted movements were increased by factors of up to 2 times.

There are a number of bridges where the maintenance road crosses the drainage lines, the locations of which are shown in Drawing No. MSEC326-11. All of the bridges are located outside the general SMP Area. A summary of the maximum predicted total subsidence, upsidence and closure movements at the bridges, after the extraction of the proposed longwalls, is provided in Table 5.12.

Table 5.12 Maximum Predicted Total Subsidence, Upsidence and Closure Movements at the Bridges Resulting from the Extraction of Longwalls 29 to 36

Bridge	Crossing	Maximum Predicted Subsidence (mm)	Maximum Predicted Upsidence (mm)	Maximum Predicted Closure (mm)
RB4	Mallaty Creek	< 5	10	35
RB5	Leafs Gully	5	20	25
RB6	Nepean Creek	< 5	5	5

It is recommended that the predicted movements at the bridges, resulting from the extraction of the proposed longwalls, are reviewed by the SCA and that any necessary mitigation measures are implemented.

With the implementation of any necessary mitigation measures, it is expected that the bridges can be maintained in a safe and serviceable condition during and after the extraction of the proposed Longwalls 34 to 36.

5.15.6. Predictions and Impact Assessments for Devines Tunnel

Devines Tunnel No. 1 is located outside the general SMP Area and is at a distance of 860 metres to the south of Longwall 34, at its closest point to the proposed longwalls. Devines Tunnel No. 2 crosses the western side of the general SMP Area and is at a distance of 330 metres to the west of Longwall 34, at its closest point to the proposed longwalls. It is unlikely, therefore, that the tunnels would be subjected to any significant systematic subsidence movements resulting from the extraction of the proposed longwalls.

The tunnels could be subjected to very small far-field horizontal movements as a result of the extraction of the proposed longwalls. Far-field horizontal movements have, in the past, been observed at similar distances as the tunnels are from the proposed longwalls, however, these movements tend to be bodily movements associated with very low levels of strain. It is unlikely, therefore, that the tunnels would be impacted by far-field horizontal movements resulting from the extraction of the proposed longwalls.

It is expected that Devines Tunnels Nos. 1 and 2 would remain in a safe and serviceable condition during and after the extraction of the proposed Longwalls 34 to 36.

5.15.7. Recommendations for the Upper Canal, Devines Tunnel and Associated Infrastructure

A management plan has been established for the Upper Canal, Devines Tunnel and associated infrastructure for Longwalls 29 to 33. It is recommended that the existing management plan be reviewed, in consultation with the SCA, and that amendments are made to the plan, where necessary, to include the predicted movements resulting from Longwalls 34 to 36.

5.16. Macarthur Water Supply System

The 1200 mm diameter treated water gravity main, which forms part of the Macarthur Water Supply System, crosses the SMP Area and its location is shown in Drawing No. MSEC326-11. The predictions and impact assessments for the pipeline are provided in the following sections.

5.16.1. Predictions for the 1200mm Diameter Water Pipeline

The predicted profiles of incremental and cumulative systematic subsidence, tilt and strain along the alignment of the 1200 mm diameter water pipeline, resulting from the extraction of the proposed longwalls, are shown in Fig. F.07 in Appendix F. A summary of the maximum predicted values of cumulative systematic subsidence, tilt and strain along the alignment of the pipeline, after the extraction of each proposed longwall, is provided in Table 5.13.

Table 5.13 Maximum Predicted Cumulative Systematic Subsidence, Tilt and Strain along the 1200mm Diameter Water Pipeline Resulting from the Extraction of Longwalls 29 to 36

Longwall	Maximum Predicted Cumulative Subsidence (mm)	Maximum Predicted Cumulative Tilt (mm/m)	Maximum Predicted Cumulative Tensile Strain (mm/m)	Maximum Predicted Cumulative Compressive Strain (mm/m)
After LW33	985	4.5	0.7	1.1
After LW34	1015	4.8	1.2	1.2
After LW35	1025	4.7	1.2	1.2
After LW36	1025	5.1	1.2	1.3

The values provided in the above table are the maximum predicted cumulative systematic subsidence parameters which occur along the pipeline within the general SMP Area, including the predicted movements resulting from the extraction of Longwalls 29 to 33. It should be noted, that the maximum predicted parameters after the extraction of Longwall 33 are different to those provided in Report No. MSEC208, due to the shortened commencing ends of Longwalls 32 and 33.

The pipeline will also be subjected to travelling tilts and strains as the extraction faces of the proposed longwalls pass beneath it. A summary of the maximum predicted travelling tilts and strains at the pipeline, during the extraction of each proposed longwall, is provided in Table 5.14.

Table 5.14 Maximum Predicted Travelling Tilts and Strains along the 1200mm Diameter Water Pipeline during the Extraction of Longwalls 34 to 36

Longwall	Maximum Predicted Travelling Tilt (mm/m)	Maximum Predicted Travelling Tensile Strain (mm/m)	Maximum Predicted Travelling Compressive Strain (mm/m)
During LW34	2.6	0.4	0.3
During LW35	2.5	0.4	0.3
During LW36	2.8	0.4	0.3

The pipeline crosses a number of drainage lines and could be subjected to upsidence and closure movements at these locations. The locations of the drainage line crossings are shown in Drawing No. MSEC326-11. A summary of the maximum predicted total upsidence and closure movements at the drainage line crossings, after the extraction of the proposed longwalls, is provided in Table 5.15.

Table 5.15 Maximum Predicted Total Upsidence and Closure Movements at the Drainage Line Crossings Resulting from the Extraction of Longwalls 29 to 36

Pipeline	Drainage Line	Maximum Cumulative Upsidence (mm)	Maximum Cumulative Closure (mm)
1200mm Water Pipeline	Mallaty Creek	455	645
	Leafs Gully	95	45
	Nepean Creek	15	10

The predicted net vertical movements along the pipeline easement were obtained by the addition of the predicted subsidence and upsidence movements. The predicted net horizontal movements along and across the pipeline easement were obtained by the addition of the predicted valley closure and systematic horizontal movements. The predicted profiles of net vertical movement, horizontal movement along and horizontal movement across the pipeline easement are shown in Fig. F.11 in Appendix F.

5.16.2. Impact Assessments for the 1200 mm Diameter Water Pipeline

The 1200 mm diameter water pipeline forms part of the Macarthur Water Supply System which was designed and constructed in 1994 to the Mine Subsidence Board's design requirements, which are summarised in Table 5.16.

Table 5.16 Mine Subsidence Board Design Requirements for the 1200 mm Diameter Pipeline

Subsidence Parameter	Mine Subsidence Board Design Requirements
Vertical Subsidence (mm)	1250
Tilt (mm/m)	8.0
Tensile Strain (mm/m)	1.5
Compressive Strain (mm/m)	2.5

It can be seen that the maximum predicted systematic subsidence, tilt and strains at the pipeline, which are summarised in Table 5.13 and Table 5.14, are less than the MSB minimum design requirements, which are summarised in Table 5.16. However, the maximum predicted valley related movements at the drainage line crossings, which are summarised in Table 5.15, are greater than the MSB minimum design requirements, which are summarised in Table 5.16.

Mitigative measures have been undertaken by United Utilities so that the water pipeline is able to accommodate the predicted movements at the Mallaty Creek crossing resulting from the extraction of Longwalls 29 to 38, based on a previous layout of Longwalls 34 to 36. It is recommended that the predicted movements resulting from Longwalls 34 to 36 are provided to United Utilities, so that an assessment can be undertaken to determine the adequacy of these mitigation measures to accommodate the predicted movements resulting from the current layout of the proposed longwalls.

It is also recommended that the predicted movements at the Leafs Gully and Nepean Creek crossings are provided to United Utilities, so that a detailed assessment of the pipeline can be undertaken based on the predicted movements resulting from the proposed longwalls. With the implementation of any necessary mitigative measures, it is expected that the pipeline can be maintained in a safe and serviceable condition throughout the mining period.

5.16.3. Impact Assessments for the 1200 mm Diameter Water Pipeline Based on Increased Predictions

The 1200 mm pipeline is a gravity water main and, therefore, is not affected to any great extent by local changes in gradient resulting from differential subsidence or tilt. It is unlikely, therefore, that the pipeline would experience a significant impact, even if the predicted systematic subsidence or tilts were increased by factors of up to 2 times.

If the predicted systematic strains were increased by a factor of 1.25 times, the maximum predicted tensile and compressive strains would still be less than the MSB minimum design requirements and it would be unlikely, therefore, that the pipeline would experience a significant impact. If the predicted systematic strains were increased by a factor of 1.5 times, the maximum predicted tensile strain would be greater than the MSB minimum design requirements, however, the maximum predicted compressive strain would still be less than the MSB minimum design requirements. If the predicted systematic strains were increased by a factor of 2 times, the maximum predicted tensile and compressive strains would both be greater than the MSB minimum design requirements.

5.16.4. Recommendations for the 1200 mm Diameter Water Pipeline

A management plan has been established for the 1200 mm water pipeline for Longwalls 29 to 33. It is recommended that the existing management plan be reviewed, in consultation with United Utilities, and amendments are made to the plan, where necessary, to include the predicted movements resulting from Longwalls 34 to 36.

5.17. Sydney Water Infrastructure

The main Sydney Water service line within the SMP Area is laid along Appin Road, the location of which is shown in Drawing No. MSEC326-11. The predictions and impact assessments for the pipeline are provided in the following sections.

5.17.1. Predictions for the Sydney Water Pipeline

The predicted profiles of systematic subsidence, tilt and strain along the alignment of the Sydney Water Pipeline are similar to those along Appin Road which are shown in Fig. F.06 in Appendix F. A summary of the maximum predicted values of cumulative systematic subsidence, tilt and strain along the alignment of the pipeline, after the extraction of each proposed longwall, is provided in Table 5.17.

Table 5.17 Maximum Predicted Cumulative Systematic Subsidence Parameters along the Sydney Water Pipeline along Appin Road Resulting from the Extraction of Longwalls 29 to 36

Longwall	Maximum Predicted Cumulative Subsidence (mm)	Maximum Predicted Cumulative Tilt (mm/m)	Maximum Predicted Cumulative Tensile Strain (mm/m)	Maximum Predicted Cumulative Compressive Strain (mm/m)
After LW33	1150	3.6	0.6	0.9
After LW34	1170	4.7	0.7	1.1
After LW35	1175	4.6	0.8	1.2
After LW36	1175	5.0	0.8	1.3

The values provided in the above table are the maximum predicted cumulative systematic subsidence parameters which occur along the pipeline within the general SMP Area, including the predicted movements resulting from the extraction of Longwalls 29 to 33.

The pipeline will also be subjected to travelling tilts and strains as the extraction faces of the proposed longwalls pass beneath it. A summary of the maximum predicted travelling tilts and strains at the pipeline, during the extraction of each proposed longwall, is provided in Table 5.18.

Table 5.18 Maximum Predicted Travelling Tilts and Strains along the Sydney Water Pipeline along Appin Road during the Extraction of Longwalls 34 to 36

Longwall	Maximum Predicted Travelling Tilt (mm/m)	Maximum Predicted Travelling Tensile Strain (mm/m)	Maximum Predicted Travelling Compressive Strain (mm/m)
During LW34	2.7	0.4	0.3
During LW35	2.7	0.4	0.3
During LW36	2.7	0.4	0.3

The pipeline is laid along Appin Road which follows a ridgeline within the general SMP Area and does not cross any significant drainage lines. It is unlikely, therefore, that the pipeline would be subjected to any significant valley related upsidence or closure movements resulting from the extraction of the proposed longwalls.

5.17.2. Impact Assessments for the Sydney Water Pipeline

The Sydney Water pipeline is a 100 mm diameter Cast Iron Cement Lined (CICL) pipeline. Details of the joints are not known, however, spigot and socketed joints are typically used for CICL pipelines. The pipe lengths and, hence, the joint spacings are also not known, however, it is expected that the pipe lengths will be between 3 and 5.5 metres.

The pipeline is a gravity main and is unlikely, therefore, to be affected to any great extent by changes in gradient due to subsidence or tilt. The maximum predicted systematic tensile and compressive strains at the pipeline are 0.8 mm/m and 1.3 mm/m, respectively, and the associated minimum radii of curvatures are 19 kilometres and 12 kilometres, respectively.

The maximum predicted systematic tensile and compressive strains, resulting from the extraction of the proposed longwalls, could result in movements of up to 10 mm at the joints. The minimum predicted radii of curvatures, resulting from the extraction of the proposed longwalls, could result in angular deviations of up to 0.1 degrees at the joints.

Spigot and socketed joints can typically tolerate axial movements of up to 40 mm and angular deviations of up to 3 degrees without significant impact. The ability of the pipe joints to withstand the predicted systematic subsidence movements will depend on how they were installed. If the pipe sections are not correctly joined at mid-socket length, or along curved sections of pipe which have existing angular deviations, the maximum allowable movement at the joints will be reduced. It is considered likely, however, that some tolerance will be available at the pipe joints.

The Sydney Water pipeline was previously mined beneath by West Cliff Longwalls 29 and 31 and there were no reported impacts. It should be noted, however, that the maximum predicted systematic tensile and compressive strains along the pipeline, resulting from the extraction of these longwalls, were 0.3 mm/m and 0.4 mm/m, respectively, which are 40 % and 30 %, respectively, of those predicted for the proposed longwalls.

Appin Longwalls 301 and 302 mined beneath a 150 mm diameter and a 300 mm diameter CICL pipeline. The maximum predicted systematic tensile and compressive strains along these pipelines were 0.7 mm/m and 1.2 mm/m, respectively, which are similar to those predicted for the Sydney Water pipeline along Appin Road. To date, two impacts on the CICL pipelines have been reported as a result of the extraction of Appin Longwalls 301 and 302, both being leaking joints, one at a creek crossing and the other at a location of maximum predicted systematic strain. Appin Longwalls 301 and 302 mined beneath a length of 580 metres of each of these pipelines, that is, a total length of 1,160 metres of CICL pipeline.

Tahmoor Longwalls 22, 23A, 23B and 24B have mined beneath a total length of 14,000 metres of CICL pipeline, having diameters ranging between 100 to 375 mm. The maximum predicted systematic tensile and compressive strains resulting from the extraction of these longwalls are similar to those resulting from the extraction of West Cliff Longwalls 34 to 36. To date, there has been only one reported impact on these pipelines, being a leaking joint, which resulted from a non-systematic movement due to a near surface geological feature.

It is possible, therefore, that the extraction of the proposed Longwalls 34 to 36 could result in some minor impacts, such as leaking joints, along the Sydney Water pipeline. Based on the experiences at Appin and Tahmoor Collieries, any impacts are expected to be infrequent and of a relatively minor nature. With the implementation of any necessary remediation measures, it is expected that the pipeline could be maintained in a serviceable condition throughout the mining period.

5.17.3. Impact Assessments for the Sydney Water Pipeline Based on Increased Predictions

If the predicted systematic subsidence or tilts along the Sydney Water pipeline were increased by factors of up to 2 times, it would be unlikely to result in a significant impact on the pipeline, as the pipeline is gravity main.

If the predicted systematic strains and curvatures along the pipeline were to be increased by factors of up to 2 times, the predicted movements at the joints would be translations of up to 20 mm and rotations of less than 0.1 degrees. It is possible that the pipe joints could still accommodate these predicted movements, however, the ability of the pipe joints to withstand these movements would depend on the installation of the pipeline which could have affected the existing tolerances.

Based on the experiences at Appin and Tahmoor Collieries, it would be expected that any impacts on the pipe joints would be relatively isolated, of a minor nature and easily repairable. With the implementation of any necessary remediation measures, it is expected that the pipeline can be maintained in a serviceable condition throughout the mining period.

5.17.4. Recommendations for the Sydney Water Pipeline

It is recommended that the predicted movements along the Sydney Water pipeline, resulting from the extraction of Longwalls 34 to 36, are reviewed by the Sydney Water, to assess any necessary strategies required for the proposed longwalls. With the implementation of any necessary strategies, it is expected that the pipeline can be maintained in a serviceable condition during and after the extraction of the proposed Longwalls 34 to 36.

5.18. Gas Pipelines

There are three gas pipelines which cross the SMP Area, being the Alinta EGP and AGN Natural Gas Pipelines and the Gorodok Ethane Pipeline. All three gas pipelines are located within the pipeline easement which is shown in Drawing No. MSEC326-12. The predictions and impact assessments for the pipelines are provided in the following sections.

5.18.1. Predictions for the Gas Pipelines

The predicted profiles of incremental and cumulative systematic subsidence, tilt and strain along the alignments the Alinta EGP Natural Gas Pipeline, the Alinta AGN Natural Gas Pipeline and the Gorodok Ethane Pipeline, resulting from the extraction of the proposed longwalls, are shown in Figs. F.08, F.09 and F.10, respectively, in Appendix F. A summary of the maximum predicted values of cumulative systematic subsidence, tilt and strain along the alignments of these pipelines, after the extraction of each proposed longwall, is provided in Table 5.19.

Table 5.19 Maximum Predicted Cumulative Systematic Subsidence, Tilt and Strain along the Alignments of the Gas Pipelines Resulting from the Extraction of Longwalls 29 to 36

Pipeline	Longwall	Maximum Predicted Subsidence (mm)	Maximum Predicted Tilt (mm/m)	Maximum Predicted Tensile Strain (mm/m)	Maximum Predicted Compressive Strain (mm/m)
Alinta EGP Natural Gas	After LW33	980	4.3	0.6	1.1
	After LW34	1010	3.6	0.7	1.1
	After LW35	1020	4.7	0.7	1.1
	After LW36	1020	5.1	0.7	1.2
Alinta AGN Natural Gas	After LW33	980	4.4	0.7	1.1
	After LW34	1015	4.1	0.7	1.5
	After LW35	1020	4.7	0.7	1.4
	After LW36	1020	5.1	0.7	1.4
Gorodok Ethane	After LW33	985	4.4	0.7	1.1
	After LW34	1015	4.6	0.7	1.2
	After LW35	1020	4.7	0.7	1.2
	After LW36	1020	5.1	0.7	1.2

The values provided in the above table are the maximum predicted cumulative systematic subsidence parameters which occur along the pipelines within the general SMP Area, including the predicted movements resulting from the extraction of Longwalls 29 to 33. It should be noted, that the maximum predicted parameters after the completion of Longwall 33 are different to those provided in Report No. MSEC208, due to the shortened commencing ends of Longwalls 32 and 33.

The gas pipelines will also be subjected to travelling tilts and strains as the extraction faces of the proposed longwalls pass beneath them. A summary of the maximum predicted travelling tilts and strains at the gas pipelines, during the extraction of each proposed longwall, is provided in Table 5.20.

Table 5.20 Maximum Predicted Travelling Tilt and Strains at the Gas Pipelines during the Extraction of Longwalls 34 to 36

Pipeline	Longwall	Maximum Predicted Travelling Tilt (mm/m)	Maximum Predicted Travelling Tensile Strain (mm/m)	Maximum Predicted Travelling Compressive Strain (mm/m)
Alinta EGP and AGN Natural Gas Pipelines & Gorodok Ethane Pipeline	LW34	2.6	0.4	0.3
	LW35	2.6	0.4	0.3
	LW36	2.7	0.4	0.3

The gas pipelines cross a number of drainage lines and could be subjected to upsidence and closure movements at these locations. The locations of the drainage line crossings are shown in Drawing No. MSEC326-12. A summary of the maximum predicted total upsidence and closure movements at the drainage line crossings, after the extraction of the proposed longwalls, is provided in Table 5.21.

Table 5.21 Maximum Predicted Total Upsidence and Closure Movements at the Drainage Line Crossings Resulting from the Extraction of Longwalls 29 to 36

Pipeline	Creek	Maximum Cumulative Upsidence (mm)	Maximum Cumulative Closure (mm)
Alinta EGP Natural Gas Pipeline	Mallaty Creek	465	610
	Leafs Gully	100	50
	Nepean Creek	15	15
Alinta AGN Natural Gas Pipeline	Mallaty Creek	470	620
	Leafs Gully	95	45
	Nepean Creek	15	15
Gorodok Ethane Pipeline	Mallaty Creek	455	635
	Leafs Gully	95	45
	Nepean Creek	15	10

The predicted net vertical movements along the pipeline easement were obtained by the addition of the predicted subsidence and upsidence movements. The predicted net horizontal movements along and across the pipeline easement were obtained by the addition of the predicted valley closure and systematic horizontal movements. The predicted profiles of net vertical movement, horizontal movement along and horizontal movement across the pipeline easement are shown in Fig. F.11 in Appendix F.

5.18.2. Impact Assessments and Recommendations for the Alinta EGP Natural Gas Pipeline

The Alinta EGP Natural Gas Pipeline is a welded steel pipe, 450 mm in diameter, which is generally considered to have considerable flexibility. The pipeline was constructed in accordance with minimum design requirements provided by the Mine Subsidence Board, which are summarised in Table 5.22.

Table 5.22 MSB Design Requirements for the Alinta EGP Natural Gas Pipeline

Subsidence Parameter	Mine Subsidence Board Design Requirements
Vertical Subsidence (mm)	1000
Tilt (mm/m)	6.0
Tensile Strain (mm/m)	2.0
Compressive Strain (mm/m)	2.0

The maximum predicted subsidence along the pipeline of 1020 mm is slightly greater than the MSB minimum design requirement of 1000 mm. However, the potential for impacts on the pipeline are not directly related to maximum subsidence, rather the potential for impacts are related to the maximum rates of change in subsidence, which are represented by the tilts and strains.

The maximum predicted systematic tilts and strains at the pipeline, which are summaries in Table 5.19 and Table 5.20, are less than the MSB minimum design requirements, which are summarised in Table 5.22. However, the maximum predicted valley related movements at the drainage line crossings, which are summarised in Table 5.21, are greater than the MSB minimum design requirements, which are summarised in Table 5.22.

Mitigative measures have been undertaken by Alinta so that the gas pipeline is able to accommodate the predicted movements at the Mallaty Creek crossing resulting from the extraction of Longwalls 29 to 38, based on a previous layout of Longwalls 34 to 36. It is recommended that the predicted movements resulting from Longwalls 34 to 36 are provided to Alinta, so that an assessment can be undertaken to determine the adequacy of these mitigation measures to accommodate the predicted movements resulting from the current layout of the proposed longwalls.

It is also recommended that the predicted movements at the Leafs Gully and Nepean Creek crossings are provided to Alinta, so that a detailed assessment of the pipeline can be undertaken based on the predicted movements resulting from the proposed longwalls. With the implementation of any necessary mitigative measures, it is expected that the pipeline can be maintained in a safe and serviceable condition throughout the mining period.

The gas pipeline is not affected to any great extent by local changes in gradient resulting from differential subsidence or tilt. It is unlikely, therefore, that the pipeline would experience a significant impact, even if the predicted systematic subsidence or tilts were increased by factors of up to 2 times.

If the predicted systematic strains were increased by a factor of 1.5 times, the maximum predicted tensile and compressive strains would still be less than the MSB minimum design requirements and it would be unlikely, therefore, that the pipeline would experience a significant impact. If the predicted systematic strains were increased by a factor of 2 times, the maximum predicted compressive strain would be greater than the MSB minimum design requirements, however, the maximum predicted tensile strain would still be less than the MSB minimum design requirements.

A management process has been established for the Alinta EGP Natural Gas Pipeline for Longwalls 29 to 33. It is recommended that the existing process be reviewed, in consultation with Alinta, and amendments are made to the process, where necessary, to include the predicted movements resulting from Longwalls 34 to 36.

5.18.3. Impact Assessments and Recommendations for the Alinta AGN Natural Gas Pipeline

The Alinta AGN Natural Gas Pipeline is a welded steel pipe, 864 mm in diameter, which is generally considered to have considerable flexibility. The greatest potential for impact along the pipeline will occur where it crosses Mallaty Creek and Leafs Gully and, to a lesser extent Nepean Creek, where the pipeline is likely to be subjected to valley related movements. It is unlikely that the maximum predicted systematic movements along the pipeline, away from the drainage line crossings, would result in a significant impact on the pipeline as a result of the extraction of the proposed longwalls.

Mitigative measures have been undertaken by Alinta so that the gas pipeline is able to accommodate the predicted movements at the Mallaty Creek crossing resulting from the extraction of Longwalls 29 to 38, based on a previous layout of Longwalls 34 to 36. It is recommended that the predicted movements resulting from Longwalls 34 to 36 are provided to Alinta, so that an assessment can be undertaken to determine the adequacy of these mitigation measures to accommodate the predicted movements resulting from the current layout of the proposed longwalls.

It is also recommended that the predicted movements at the Leafs Gully and Nepean Creek crossings are provided to Alinta, so that a detailed assessment of the pipeline can be undertaken based on the predicted movements resulting from the proposed longwalls. With the implementation of any necessary mitigative measures, it is expected that the pipeline can be maintained in a safe and serviceable condition throughout the mining period.

A management process has been established for the Alinta AGN Natural Gas Pipeline for Longwalls 29 to 33. It is recommended that the existing process be reviewed, in consultation with Alinta, and amendments are made to the process, where necessary, to include the predicted movements resulting from Longwalls 34 to 36.

5.18.4. Impact Assessments and Recommendations for the Gorodok Ethane Pipeline

The Gorodok Ethane Pipeline is a welded steel pipe, 203 mm in diameter, which is generally considered to have considerable flexibility. The greatest potential for impact along the pipeline will occur where it crosses Mallaty Creek and Leafs Gully and, to a lesser extent Nepean Creek, where the pipeline is likely to be subjected to valley related movements. It is unlikely that the maximum predicted systematic movements along the pipeline, away from the drainage line crossings, would result in a significant impact on the pipeline as a result of the extraction of the proposed longwalls.

Mitigative measures have been undertaken by Gorodok so that the gas pipeline is able to accommodate the predicted movements at the Mallaty Creek crossing resulting from the extraction of Longwalls 29 to 38, based on a previous layout of Longwalls 34 to 36. It is recommended that the predicted movements resulting from Longwalls 34 to 36 are provided to Gorodok, so that an assessment can be undertaken to determine the adequacy of these mitigation measures to accommodate the predicted movements resulting from the current layout of the proposed longwalls.

It is also recommended that the predicted movements at the Leafs Gully and Nepean Creek crossings are provided to Gorodok, so that a detailed assessment of the pipeline can be undertaken based on the predicted movements resulting from the proposed longwalls. With the implementation of any necessary mitigative measures, it is expected that the pipeline can be maintained in a safe and serviceable condition throughout the mining period.

A management process has been established for the Gorodok Ethane Pipeline for Longwalls 29 to 33. It is recommended that the existing process be reviewed, in consultation with Gorodok, and amendments are made to the process, where necessary, to include the predicted movements resulting from Longwalls 34 to 36.

5.19. 330 kV Transmission Line

The 330 kV transmission line crosses the western ends of the proposed Longwalls 34 to 36, the location of which is shown in Drawing No. MSEC326-13. The predictions and impact assessments for the transmission line are provided in the following sections.

5.19.1. Predictions for the 330 kV Transmission Line

The predicted profiles of incremental and cumulative systematic subsidence, tilt along and tilt across the alignment of the 330 kV transmission line, resulting from the extraction of the proposed longwalls, are shown in Fig. F.12 in Appendix F. The predicted profiles of incremental and cumulative systematic strain along the transmission line are similar to those along the adjacent 66 kV powerline, which are shown in Fig. F.13 in Appendix F.

A summary of the maximum predicted values of cumulative systematic subsidence, tilt along the alignment, tilt across the alignment and strain at the transmission line, after the extraction of each proposed longwall, is provided in Table 5.23.

Table 5.23 Maximum Predicted Cumulative Systematic Subsidence, Tilt Along, Tilt Across and Strain at the 330 kV Transmission Line Resulting from the Extraction of Longwalls 29 to 36

Longwall	Maximum Predicted Cumulative Subsidence (mm)	Maximum Predicted Cumulative Tilt Along Alignment (mm/m)	Maximum Predicted Cumulative Tilt Across Alignment (mm/m)	Maximum Predicted Cumulative Tensile Strain (mm/m)	Maximum Predicted Cumulative Compressive Strain (mm/m)
After LW33	320	1.5	2.9	0.3	< 0.1
After LW34	630	2.6	3.0	0.5	0.5
After LW35	815	4.4	3.7	0.5	0.9
After LW36	1010	3.4	3.3	0.5	1.0

The values provided in the above table are the maximum predicted cumulative systematic subsidence parameters which occur along the transmission line within the general SMP Area, including the predicted movements resulting from the extraction of Longwalls 29 to 33. It should be noted, that the maximum predicted parameters after the completion of Longwall 33 are different to those provided in Report No. MSEC208, due to the shortened commencing ends of Longwalls 32 and 33.

The transmission line will also be subjected to travelling tilts and strains as the extraction faces of the proposed longwalls pass beneath it. A summary of the maximum predicted travelling tilts and strains at the 330 kV transmission line, during the extraction of Longwalls 34 and 35, is provided in Table 5.24.

Table 5.24 Maximum Predicted Travelling Tilts and Strains at the 330 kV Transmission Line during the Extraction of Longwalls 34 and 35

Longwall	Maximum Predicted Travelling Tilt (mm/m)	Maximum Predicted Travelling Tensile Strain (mm/m)	Maximum Predicted Travelling Compressive Strain (mm/m)
During LW34	2.2	0.3	0.2
During LW35	2.6	0.4	0.3

There is one tension tower within the general SMP Area, being Tower 105, which is located above the chain pillar between proposed Longwalls 34 and 35. The remaining towers within the general SMP Area are suspension towers. A summary of the maximum predicted values of total systematic subsidence, tilt along the alignment, tilt across the alignment and strain at the towers within the general SMP Area, after the extraction of the proposed longwalls, is provided in Table 5.25.

Table 5.25 Maximum Predicted Total Systematic Subsidence, Tilt Along, Tilt Across and Strain at the Towers within the General SMP Area Resulting from the Extraction of Longwalls 29 to 36

Location	Maximum Predicted Total Subsidence (mm)	Maximum Predicted Total Tilt Along Alignment (mm/m)	Maximum Predicted Total Tilt Across Alignment (mm/m)	Maximum Predicted Total Tensile Strain (mm/m)	Maximum Predicted Total Compressive Strain (mm/m)
Tower 103	260	0.2	2.5	0.1	< 0.1
Tower 104	530	2.3	1.7	0.2	0.1
Tower 105	800	1.0	0.9	0.3	< 0.1
Tower 106	395	2.8	3.2	0.1	0.1

The values provided in the above table are the maximum predicted parameters within 20 metres of the centre of each tower, including the predicted movements resulting from the extraction of Longwalls 29 to 33.

5.19.2. Impact Assessments for the 330 kV Transmission Line

The cables along the 330 kV transmission line are not affected by ground strains, as they are supported by the towers above ground level. The cables can, however, be affected by the changes in bay lengths, ie: the distances between the towers at the level of the cables, which result from mining induced differential subsidence, horizontal ground movements and lateral movements at the tops of the towers due to tilting of the towers. The stabilities of the towers can also be affected by the mining induced tilts and ground strains at the location of each tower and by changes in the catenary profiles of the cables.

The maximum predicted systematic tilt at the transmission line anywhere within the general SMP Area is 4.4 mm/m (ie: 0.4 %), or a change in gradient of 1 in 225, which occurs adjacent to the maingate of Longwall 35. There are no towers located in the vicinity of the maximum predicted tilt.

The maximum predicted systematic tilt at the tower locations within the general SMP Area is 3.2 mm/m (ie: 0.3 %), or a change in grade of 1 in 315, which occurs at Tower 106 and is orientated across the alignment of the transmission line. The associated predicted systematic horizontal movement at the base of this tower is 50 mm. Based on a tower height of 50 metres, the maximum predicted systematic tilt and maximum predicted systematic horizontal movement at the base of Tower 106 results in a maximum predicted horizontal movement of 210 mm at the top of the tower, which is orientated across the alignment of the transmission line.

The predicted horizontal movements at the tops of the towers are expected to result in small changes in the catenary profiles of the aerial cables, which in turn could result in differential horizontal loads on the towers. Mitigative measures have been previously undertaken by TransGrid, including the installation of roller sheaves on some towers, to accommodate the predicted movement resulting from the extraction of Longwalls 29 to 33. It is recommended that the predicted movements along the transmission line, resulting from the extraction of Longwalls 34 to 36, are provided to TransGrid, so that an analysis can be undertaken to determine whether additional mitigative measures are required for proposed longwalls.

The maximum predicted systematic tensile and compressive strains at the transmission line anywhere within the general SMP Area are 0.5 mm/m and 1.0 mm/m, respectively, which occur above Longwall 35. There are no towers located in the vicinities of the maximum predicted systematic tensile and compressive strains.

The maximum predicted systematic tensile and compressive strains at the tower locations within the general SMP Area are 0.3 mm/m and 0.1 mm/m, respectively. The minimum radii of curvatures associated with the maximum predicted systematic tensile and compressive strains are 50 kilometres and 150 kilometres, respectively.

The maximum predicted systematic strains could result in increased stresses within the tower structural members. It is recommended that the predicted movements at the transmission towers are provided to TransGrid so that a detailed structural analysis of the towers can be undertaken. If required, any necessary mitigative measures should be established, so that the transmission line can be maintained in a safe and serviceable condition throughout the mining period. With the implementation of these management strategies, it is unlikely that there would be a significant impact on the transmission line resulting from the extraction of the proposed longwalls.

5.19.3. Impact Assessments for the 330 kV Transmission Line Based on Increased Predictions

If the predicted systematic tilts were increased by a factor of 2 times, the maximum predicted systematic tilt at the transmission line anywhere within the general SMP Area would be 8.8 mm/m, which occurs adjacent to the maingate of Longwall 35. The maximum predicted systematic tilt at the tower locations within the general SMP Area would be 6.4 mm/m, which occurs at Tower 106, and the resulting maximum predicted horizontal movement at the top of the tower would be 420 mm.

If the predicted systematic strains were increased by a factor of 2 times, the maximum predicted systematic tensile and compressive strains at the transmission line anywhere within the general SMP Area would be 1.0 mm/m and 2.0 mm/m, respectively, which occur above Longwall 35. The maximum predicted systematic tensile and compressive strains at the tower locations within the general SMP Area would be 0.6 mm/m and less than 0.2 mm/m, respectively.

It is recommended that appropriate factors of safety are applied in the detailed structural analysis of the transmission line undertaken by TransGrid. These factors of safety should be applied in the design of any mitigative measures required for the towers.

5.19.4. Recommendations for the 330 kV Transmission Line

It is recommended that the predicted movements at the 330 kV transmission line are provided to TransGrid so that a detailed structural analysis can be undertaken. It is also recommended that the transmission line is inspected by a suitably qualified person prior to mining to assess its existing condition. Suitable mitigative measures should be undertaken, based on the findings from the detailed structural analysis and the site inspection, such that the transmission line can be maintained in a safe and serviceable condition throughout the mining period.

With the implementation of any necessary mitigative measures, it is expected that the 330 kV transmission line can be maintained in a safe and serviceable condition during and after the extraction of the proposed Longwalls 34 to 36.

5.20. 66 kV and 11 kV Powerlines

The locations of the powerlines within the SMP Area are shown in Drawing No. MSEC326-13. The predictions and impact assessments for the powerlines are provided in the following sections.

5.20.1. Predictions for the 66 kV and 11 kV Powerlines

The 66 kV powerline crosses the western ends of the proposed Longwalls 34 to 36. The predicted profiles of incremental and cumulative systematic subsidence, tilt and strain along the alignment of the 66 kV powerline, resulting from the extraction of the proposed longwalls, are shown in Fig. F.13 in Appendix F.

The main 11 kV powerline within the SMP Area generally follows the alignment of Appin Road. The predicted profiles of incremental and cumulative systematic subsidence, tilt and strain along the alignment of the main 11 kV powerline, resulting from the extraction of the proposed longwalls, are similar to those along the Appin Road, which are shown in Fig. F.06 in Appendix F.

Two 11 kV powerlines branch off the main 11 kV powerline along Appin Road and provide power to the private properties and the Inghams Farm Complex located west of the road. The predicted profiles of incremental and cumulative systematic subsidence, tilt and strain along the alignments of the 11 kV powerline Branches 1 and 2, resulting from the extraction of the proposed longwalls, are shown in Figs. F.14 and F.15, respectively, in Appendix F.

A summary of the maximum predicted values of cumulative systematic subsidence, tilt and strain along the alignments of the 66 kV and 11 kV powerlines, after the extraction of each proposed longwall, is provided in Table 5.26.

Table 5.26 Maximum Predicted Cumulative Systematic Subsidence, Tilt and Strain along the Alignments of the Powerlines Resulting from the Extraction of Longwalls 29 to 36

Location	Longwall	Maximum Predicted Cumulative Subsidence (mm)	Maximum Predicted Cumulative Tilt (mm/m)	Maximum Predicted Cumulative Tensile Strain (mm/m)	Maximum Predicted Cumulative Compressive Strain (mm/m)
66 kV Powerline	After LW33	160	0.5	0.1	< 0.1
	After LW34	600	2.4	0.2	0.5
	After LW35	815	4.5	0.5	1.0
	After LW36	1010	3.5	0.5	1.0
11 kV Powerline (Adjacent to Appin Road)	After LW33	1150	3.6	0.6	0.9
	After LW34	1170	4.7	0.7	1.1
	After LW35	1175	4.6	0.8	1.2
	After LW36	1175	5.0	0.8	1.3
11 kV Powerline (Branch 1)	After LW33	< 20	< 0.1	< 0.1	< 0.1
	After LW34	510	1.9	0.1	0.3
	After LW35	765	2.6	0.1	0.3
	After LW36	1040	2.9	0.2	0.4
11 kV Powerline (Branch 2)	After LW33	1090	4.9	0.7	1.3
	After LW34	1145	3.8	0.8	1.3
	After LW35	1145	3.9	0.8	1.3
	After LW36	1145	3.7	0.8	1.3

The values provided in the above table are the maximum predicted cumulative systematic subsidence parameters which occur along the powerlines within the general SMP Area, including the predicted movements resulting from the extraction of Longwalls 29 to 33.

The powerlines will also be subjected to travelling tilts and strains as the extraction faces of the proposed longwalls pass beneath them. A summary of the maximum predicted travelling tilts and strains at the 66 kV and 11 kV powerlines, during the extraction of the proposed longwalls, is provided in Table 5.27.

Table 5.27 Maximum Predicted Travelling Tilts and Strains at the 66 kV and 11 kV Powerlines during the Extraction of the Proposed Longwalls 34 to 36

Location	Longwall	Maximum Predicted Travelling Tilt (mm/m)	Maximum Predicted Travelling Tensile Strain (mm/m)	Maximum Predicted Travelling Compressive Strain (mm/m)
66 kV Powerline	During LW34	2.1	0.3	0.2
	During LW35	2.6	0.4	0.3
11 kV Powerline (Adjacent to Appin Road)	During LW34	2.7	0.4	0.3
	During LW35	2.7	0.4	0.3
	During LW36	2.7	0.4	0.3
11 kV Powerline (Branch 1)	During LW34	1.8	0.3	0.2
	During LW35	2.5	0.4	0.3
	During LW36	2.5	0.4	0.3
11 kV Powerline (Branch 2)	During LW34	2.5	0.4	0.3
	During LW35	2.7	0.4	0.3

5.20.2. Impact Assessments for the 66 kV and 11 kV Powerlines

The cables along the 66 kV and 11 kV powerlines are not affected by ground strains, as they are supported by the poles above ground level. The cables can, however, be affected by the changes in the bay lengths, ie: the distances between the poles at the height of the cables, which result from mining induced differential subsidence, horizontal ground movements and lateral movements at the tops of the poles caused by tilting of the poles. The stabilities of the poles can also be affected by the tilting of the poles and the changes in the catenary profiles of the cables.

The maximum predicted total systematic subsidence at the 66 kV and 11 kV powerlines within the general SMP Area is 1175 mm, which occurs along the powerline adjacent to Appin Road, above Longwall 33, after the extraction of Longwall 35. Based on a typical bay length of 50 metres between power poles, the maximum predicted total differential subsidence between the poles along the powerlines within the general SMP Area is 250 mm, which equates to a change in bay length of less than 1 mm, or less than 0.1 % of the original bay length.

The maximum predicted systematic tilt at the 66 kV and 11 kV powerlines within the general SMP Area is 5.0 mm/m (ie: 0.5 %), or a change in gradient of 1 in 200, which occurs along the powerline adjacent to Appin Road, above the maingate of Longwall 36. High tilts in the locations of the power poles could potentially impact on the cable catenaries or could result in stability problems in any tension poles that are supported by guy ropes. Overhead powerlines can typically tolerate tilts of up to 20 mm/m at the poles, without significant impacts on the cables or poles.

It is unlikely, therefore, that the predicted maximum systematic tilts would result in a significant impact on the powerlines. It is possible, however, that the predicted tilts could result in impacts on the powerlines if the poles have high existing tilts.

It is recommended, therefore, that the powerline is inspected by a suitably qualified person, to determine the existing condition and whether any mitigation measures are required, such as the installation of cable sheaves and guy ropes. With any required mitigative measures in place, it is unlikely that there would be a significant impact on the 66 kV or 11 kV powerlines resulting from the extraction of the proposed longwalls.

5.20.3. Impact Assessments for the 66 kV and 11 kV Powerlines Based on Increased Predictions

If the predicted tilts were increased by factors of up to 2 times, the maximum predicted tilt at the powerlines within the general SMP Area would be 10 mm/m, which occurs along the powerline adjacent to Appin Road, above the maingate of Longwall 36. As described previously, overhead powerlines can typically tolerate tilts of up to 20 mm/m at the poles, without significant impacts on the cables or poles. It is unlikely, therefore, that the powerlines would experience a significant impact resulting from the extraction of the proposed longwalls, even if the predicted tilts were exceeded by factors of up to 2 times.

5.20.4. Recommendations for the 66 kV and 11 kV Powerlines

It is recommended that the 66 kV and 11 kV powerlines are inspected by a suitably qualified person prior to mining, to determine the existing conditions, and whether any mitigation measures are required. It is also recommended that the powerlines are visually monitored as the proposed longwalls mine beneath them.

With the implementation of any necessary mitigative measures, it is expected that the 66 kV and 11 kV powerlines can be maintained in a safe and serviceable condition during and after the extraction of the proposed Longwalls 34 to 36.

5.21. Optical Fibre Cable

The optical fibre cable generally follows the alignment of Appin Road within the SMP Area, the location of which is shown in Drawing No. MSEC326-14. The predictions and impact assessments for the optical fibre cable are provided in the following sections.

5.21.1. Predictions for the Optical Fibre Cable

The predicted profiles of incremental and cumulative systematic subsidence, tilt and strain along the alignment of the optical fibre cable are similar to those along Appin Road, which are shown in Fig. F.06 in Appendix F. A summary of the maximum predicted values of cumulative systematic subsidence, tilt and strain along the alignment of the optical fibre cable, after the extraction of each proposed longwall, is provided in Table 5.28.

Table 5.28 Maximum Predicted Cumulative Systematic Subsidence, Tilt and Strain along the Optical Fibre Cable Resulting from the Extraction of Longwalls 29 to 36

Longwall	Maximum Predicted Cumulative Subsidence (mm)	Maximum Predicted Cumulative Tilt (mm/m)	Maximum Predicted Cumulative Tensile Strain (mm/m)	Maximum Predicted Cumulative Compressive Strain (mm/m)
After LW33	1150	3.6	0.6	0.9
After LW34	1170	4.7	0.7	1.1
After LW35	1175	4.6	0.8	1.2
After LW36	1175	5.0	0.8	1.3

The values provided in the above table are the maximum predicted cumulative systematic subsidence parameters which occur along the optical fibre cable within the general SMP Area, including the predicted movements resulting from the extraction of Longwalls 29 to 33.

The cable will also be subjected to travelling tilts and strains as the extraction faces of the proposed longwalls pass beneath it. A summary of the maximum predicted travelling tilts and strains at the optical fibre cable, during the extraction of each proposed longwall, is provided in Table 5.29.

Table 5.29 Maximum Predicted Travelling Tilts and Strains at the Optical Fibre Cable during the Extraction of Longwalls 34 to 36

Longwall	Maximum Predicted Travelling Tilt (mm/m)	Maximum Predicted Travelling Tensile Strain (mm/m)	Maximum Predicted Travelling Compressive Strain (mm/m)
During LW34	2.7	0.4	0.3
During LW35	2.7	0.4	0.3
During LW36	2.7	0.4	0.3

The optical fibre cable follows a ridgeline within the SMP Area and does not cross any significant drainage lines. It is unlikely, therefore, that the cable would be subjected to any significant valley related upsidence or closure movements resulting from the extraction of the proposed longwalls.

5.21.2. Impact Assessments for the Optical Fibre Cable

The optical fibre cable within the SMP Area is direct buried and, therefore, will not be affected by the tilts resulting from the extraction of the proposed longwalls. The cable, however, is likely to experience the ground strains resulting from the extraction of the proposed longwalls.

The maximum predicted systematic tensile and compressive strains at the optical fibre cable, at any time during or after the extraction of the proposed longwalls, are 0.8 mm/m and 1.3 mm/m, respectively. The minimum radii of curvatures associated with the maximum predicted systematic tensile and compressive strains are 19 kilometres and 12 kilometres, respectively.

Based on previous experience of mining beneath optical fibre cables, it has been found that optical fibre cables can typically tolerate tensile strains of up to 4 mm/m without significant impact. It is expected, therefore, that the optical fibre cable could tolerate the predicted systematic tensile strains resulting from the extraction of the proposed longwalls.

The tensile strains in the optical fibre cable can be higher, however, where the cable connects to the support structures, which may act as anchor points, preventing any differential movements that may have been allowed to occur with the ground. Tree roots have also been known to anchor cables to the ground. The extent to which the anchor points affect the ability of the cable to tolerate the mine subsidence movements depends on the cable size, type, age, installation method and ground conditions.

In addition to this, optical fibre cables contain additional fibre lengths over the sheath length, where the individual fibres are loosely contained within tubes. Compression of the sheath can transfer to the loose tubes and fibres and result in “micro-bending” of the fibres constrained within the tubes, leading to higher attenuation of the transmitted signal. If the maximum predicted systematic compressive strains were to be fully transferred into the optical fibre cable, the strains could be of sufficient magnitude to result in a reduction in the capacity of the cable or transmission loss.

The optical fibre cable along Appin Road was previously mined beneath by Longwalls 29 and 31 and there were no reported impacts. It should be noted, however, that the maximum predicted systematic tensile and compressive strains along the cable, resulting from the extraction of these longwalls, were 0.3 mm/m and 0.4 mm/m, respectively, which are 40 % and 30 %, respectively, of those predicted for the proposed longwalls.

Appin Longwalls 301 and 302 mined beneath an optical fibre cable and there were no reported impacts. The maximum predicted systematic tensile and compressive strains along this cable were 0.7 mm/m and 0.8 mm/m, respectively, which are similar to, but slightly less than those predicted for the cable along Appin Road. The cable also crosses a number of small drainage lines above Appin Longwalls 301 and 302 and the maximum predicted compressive strain due to closure movements was greater than 5 mm/m.

5.21.3. Impact Assessments for the Optical Fibre Cable Based on Increased Predictions

If the predicted systematic movements along the optical fibre cable were to be increased by factors of up to 2 times, the predicted systematic tensile strain along the cable would still be less than 4 mm/m and unlikely, therefore, to result in a significant impact on the cable. It would be possible, however, that elevated strains could occur at any anchor points along the cable during the extraction of the proposed longwalls. It is expected, however, that the cable can be maintained in a serviceable condition by monitoring and the implementation of suitable mitigation measures if elevated strains were detected.

5.21.4. Recommendations for the Optical Fibre Cable

It is recommended that the optical fibre cable is monitored during the extraction of the proposed longwalls using optical fibre sensing techniques, such as Optical Time Domain Reflector (OTDR) monitoring. Mitigation measures can be undertaken, such as excavating and exposing the cable, if a strain concentration is detected during mining. With the required mitigation measures in place, it is expected that the optical fibre cable can be maintained in a serviceable condition throughout the mining period.

A management plan has been established for the optical fibre cable for Longwalls 29 to 33. It is recommended that the existing management plan be reviewed, in consultation with Telstra, and that amendments are made to the plan, where necessary, to include the predicted movements resulting from Longwalls 34 to 36.

5.22. Copper Telecommunications Cables

The locations of the copper telecommunications cables within the SMP Area are shown in Drawing No. MSEC326-14. The predictions and impact assessments for the copper telecommunications cables are provided in the following sections.

5.22.1. Predictions for the Copper Telecommunications Cables

The C CBTN104/105 copper telecommunications cables generally follow the alignment of Appin Road within the SMP Area. The predicted profiles of incremental and cumulative systematic subsidence, tilt and strain along the alignments of these cables are similar to those along Appin Road, which are shown in Fig. F.06 in Appendix F.

The predicted profiles of incremental and cumulative systematic subsidence, tilt and strain along the alignment of the C CBTN 423 copper telecommunications cable, resulting from the extraction of the proposed longwalls, are shown in Fig. F.16 in Appendix F.

A summary of the maximum predicted values of cumulative systematic subsidence, tilt and strain along the copper telecommunications cables, after the extraction of each proposed longwall, is provided in Table 5.30.

Table 5.30 Maximum Predicted Cumulative Systematic Subsidence, Tilt and Strain along the Copper Telecommunications Cables Resulting from the Extraction of Longwalls 29 to 36

Location	Longwall	Maximum Predicted Cumulative Subsidence (mm)	Maximum Predicted Cumulative Tilt (mm/m)	Maximum Predicted Cumulative Tensile Strain (mm/m)	Maximum Predicted Cumulative Compressive Strain (mm/m)
C CBTN 104/105	After LW33	1150	3.6	0.6	0.9
	After LW34	1170	4.7	0.7	1.1
	After LW35	1175	4.6	0.8	1.2
	After LW36	1175	5.0	0.8	1.3
C CBTN 423	After LW33	1160	4.8	0.7	1.2
	After LW34	1225	4.6	0.7	1.2
	After LW35	1230	4.7	0.8	1.2
	After LW36	1230	3.6	0.8	1.2

The values provided in the above table are the maximum predicted cumulative systematic subsidence parameters which occur along the copper telecommunications cables within the general SMP Area, including the predicted movements resulting from the extraction of Longwalls 29 to 33.

The cables will also be subjected to travelling tilts and strains as the extraction faces of the proposed longwalls pass beneath them. A summary of the maximum predicted travelling tilts and strains at the copper telecommunications cables, during the extraction of each proposed longwall, is provided in Table 5.31.

Table 5.31 Maximum Predicted Travelling Tilts and Strains at the Copper Telecommunications Cables during the Extraction of Longwalls 34 to 36

Location	Longwall	Maximum Predicted Travelling Tilt (mm/m)	Maximum Predicted Travelling Tensile Strain (mm/m)	Maximum Predicted Travelling Compressive Strain (mm/m)
C CBTN 104/105	During LW34	2.7	0.4	0.3
	During LW35	2.7	0.4	0.3
	During LW36	2.7	0.4	0.3
C CBTN 423	During LW34	2.6	0.4	0.3
	During LW35	2.8	0.4	0.3

The predicted systematic subsidence parameters along the distribution telecommunication cables to the rural properties are similar to, or less than those predicted along the C CBTN104/105 and C CBTN423 cables. The impact assessments and proposed management strategies for the distribution telecommunications cables are, therefore, similar to those for the C CBTN104/105 and C CBTN423 cables which are provided in the following sections.

5.22.2. Impact Assessments for the Copper Telecommunications Cables

The copper telecommunication cables are direct buried and are unlikely, therefore, to be impacted by tilt. The cables, however, are likely to experience the ground strains resulting from the extraction of the proposed longwalls.

The maximum predicted systematic tensile and compressive strains at the direct buried copper telecommunication cables, at any time during or after the extraction of the proposed longwalls, are 0.8 mm/m and 1.3 mm/m, respectively. The minimum radii of curvatures associated with the maximum predicted systematic tensile and compressive strains are 19 kilometres and 12 kilometres, respectively.

The C CBTN423 copper telecommunications cable is an air filled lead sheathed cable which is more than 40 years old. Because of its age, the lead sheathing is likely to be brittle and, therefore, more susceptible to impact than more modern telecommunication cables. It is expected that the C CBTN423 cable would be able to tolerate tensile strains up to 4 mm/m without impact.

The C CBTN104/105 cables are more modern and constructed from reasonably elastic materials, which allow some elongation to take place without impact on the cables. Modern copper telecommunication cables can, in some cases, tolerate tensile strains of up to 20 mm/m without impact.

It is unlikely, therefore, that the copper telecommunication cables would be impacted by the predicted systematic strains resulting from the extraction of the proposed longwalls. It is possible, however, that the cables could experience locally elevated tensile strains where they are anchored to the ground by associated infrastructure, or by tree roots. It is unlikely at the magnitudes of the predicted systematic strains, however, that there would be a significant impact on the copper telecommunication cables at any anchor points.

The C CBTN104/105 and C CBTN423 copper telecommunications cables were previously mined beneath by Longwalls 29 and 31 and there were no reported impacts. It should be noted, however, that the maximum predicted systematic tensile and compressive strains along these cables, resulting from the extraction of these longwalls, were 0.4 mm/m and 0.4 mm/m, respectively, which are 50 % and 30 %, respectively, of those predicted for the proposed longwalls.

Appin Longwalls 301 and 302 mined beneath two direct buried copper telecommunications cables and there were no reported impacts. The maximum predicted systematic tensile and compressive strains along these cables were 0.7 mm/m and 1.2 mm/m, respectively, which are similar to those predicted for the C CBTN104/105 and C CBTN423 cables resulting from the extraction of the proposed longwalls.

5.22.3. Impact Assessments for the Copper Telecommunications Cables Based on Increased Predictions

If the predicted systematic movements along the copper telecommunications cables were increased by factors of up to 2 times, the predicted systematic tensile strains along the cables would still be less than 4 mm/m and unlikely, therefore, to result in a significant impact on the cables. It would be possible, however, that elevated strains could occur at any anchor points along the cables during the extraction of the proposed longwalls. It is unlikely at the magnitudes of the predicted systematic strains, however, that there would be a significant impact on the copper telecommunication cables at any anchor points, even if the predictions were exceeded by a factor of 2 times.

5.22.4. Recommendations for the Copper Telecommunications Cables

A management plan has been established for the copper telecommunications cables for Longwalls 29 to 33. It is recommended that the existing management plan be reviewed, in consultation with Telstra, and that amendments are made to the plan, where necessary, to include the predicted movements resulting from the extraction of the proposed Longwalls 34 to 36.

5.23. Rural Building Structures

There are 153 rural building structures (Structure Type R) that have been identified within the SMP Area, which include farm sheds, garages and other non-residential structures. The building structures associated with the Inghams Farm Complex have not been included, which are discussed separately in Section 5.28.1.

The locations of the rural building structures are shown in Drawings Nos. MSEC326-15 to MSEC326-26 and details are provided in Table E.01 in Appendix E. The impact assessments for the rural building structures within the SMP Area are provided in the following sections.

5.23.1. Predictions for the Rural Building Structures

Predictions of systematic subsidence, tilt and strain have been made at the centroid and at the vertices of each rural building structure, as well as eight equally spaced points placed radially around the centroid and vertices at a distance of 20 metres. In the case of a rectangular shaped structure, predictions have been made at a minimum of 45 points within and around the structure.

At these points, the maximum predicted values of systematic subsidence, tilt and strain have been determined during and after the extraction of each proposed longwall, for each rural building structure. An additional strain of 0.2 mm/m has been added to the magnitudes of the predicted strains, where the predicted subsidence is greater than 20 mm, to account for the scatter which is generally observed in strain profiles.

The assessed impacts on the rural building structures were determined using the method outline in the background report entitled *Mine Subsidence Damage to Building Structures (Revision A)* which can be obtained from *www.minesubsidence.com.*

The maximum predicted subsidence and the impact assessments for tilt and strain for each rural building structure within the SMP Area are provided in Table E.01. A summary of the tilt and strain impact assessments for the rural building structures within the SMP Area, after the extraction of each proposed longwall, is provided in Table 5.32.

Table 5.32 Summary of Impact Assessments for Tilt and Strain for the Rural Building Structures within the SMP Area after the Extraction of Each Proposed Longwall

Longwall	Tilt Impact Categories				Strain Impact Categories					
	Cat A	Cat B	Cat C	Cat D	Cat 0	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5
After LW34	143	10	0	0	140	11	2	0	0	0
After LW35	144	9	0	0	138	12	3	0	0	0
After LW36	132	21	0	0	134	16	3	0	0	0

It can be seen from the above table, that no rural building structures are assessed to experience a tilt impact greater than Category B. It can also be seen from the above table that no rural building structures are assessed to experience a strain impact greater than Category 2.

5.23.2. Impact Assessments for the Rural Building Structures

Mitigative measures are generally not recommended for rural building structures unless the impact assessments are Category D for tilt or Category 4 for strain, or greater. This is due to the flexible types of construction of these structures.

There are no rural building structures which are assessed to experience a Category D tilt impact or a Category 4 strain impact at any stage of the mining period. Details of the existing conditions of the rural building structures are provided in the Property Subsidence Management Plans (PSMPs). Where the rural building structures have been found to be in a sound existing condition, they are expected to remain in a safe and serviceable condition throughout the mining period. No mitigative measures are recommended for the rural building structures prior to the extraction of Longwalls 34 to 36.

The maximum predicted systematic tensile and compressive strains resulting from the extraction of Longwalls 34 to 36 are similar to the maximum predicted systematic tensile and compressive strains resulting from the extraction of Tahmoor Longwalls 22, 23A, 23B and 24B. At the time of writing this report, the longwalls at Tahmoor Colliery had mined directly beneath or adjacent to approximately 800 houses, rural building structures and public amenities. To date, there have been no reported impacts on the rural building structures resulting from the extraction of the longwalls at Tahmoor Colliery.

Any impacts on the rural building structures that might occur as a result of the extraction of the proposed longwalls are expected to be of a minor nature and be easily remediated using well established building techniques. With these remediation measures in place, it is unlikely that there would be a significant impact on rural building structures resulting from the extraction of the proposed longwalls.

5.23.3. Impact Assessments for the Rural Building Structures Based on Increased Predictions

If the predicted systematic subsidence parameters were to be increased by factors of 1.25 to 5 times, the potential impacts on the rural structures would increase accordingly. The impact assessments for tilt and strain for the rural building structures based on increased predictions are provided in Table E.01 and are summarised in Table 5.33.

Table 5.33 Summary of the Tilt and Strain Impact Assessments for the Rural Building Structures within the SMP Area Based on Increased Predictions

Increased Prediction	Number of Rural Structures with Tilt Impact Assessment for Increased Predictions				Number of Rural Structures with Strain Impact Assessment for Increased Predictions					
	Cat A	Cat B	Cat C	Cat D	Cat 0	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5
x 1.25	127	11	15	0	124	26	3	0	0	0
x 1.50	118	14	21	0	115	31	6	1	0	0
x 1.75	109	18	12	14	104	36	12	1	0	0
x 2.00	105	15	12	21	95	43	12	3	0	0
x 5.00	23	10	57	63	39	51	41	19	2	1

If the predictions were increased by a factor of 1.5 times, the maximum assessed tilt and strain impacts on the rural building structures would be Category C and Category 3, respectively. It would be expected, therefore, that no significant remediation measures would be required for the rural building structures, even if the predictions were exceeded by a factor of 1.5 times.

If the predictions were increased by a factor of 2 times, there would be 21 rural building structures assessed as Category D tilt impacts and three rural building structures assessed as Category 3 strain impacts. It would be expected, therefore, that some of these structures could required remediation measures for tilt, if the predictions were to be exceeded by a factor of 2 times. It would be expected, however, that all rural building structures would remain in a safe and serviceable condition throughout the mining period, even if the predictions were exceeded by a factor of 2 times.

5.23.4. Recommendations for the Rural Building Structures

The assessed impacts on the rural building structures resulting from the predicted systematic subsidence parameters can be managed with the implementation of suitable management strategies. It is recommended that the rural building structures are visually monitored during the extraction of the proposed longwalls. With these strategies in place, it is expected that the rural building structures would remain in a safe and serviceable condition throughout the mining period.

5.24. Tanks

There are 90 tanks (Structure Type T) that have been identified within the SMP Area. The locations of the tanks are shown in Drawings Nos. MSEC326-15 to MSEC326-26 and details are provided in Table E.02 in Appendix E. The impact assessments for the tanks within the SMP Area are provided in the following sections.

5.24.1. Predictions for the Tanks

Predictions of systematic subsidence, tilt and strain have been made at the centroid and at points located around the perimeter of each tank, as well as at points located at a distance of 20 metres from the perimeter of each tank. The maximum predicted systematic subsidence parameters for each tank within the SMP Area are provided in Table E.02. The tanks are located across the SMP Area and, therefore, are subjected to the full range of predicted systematic subsidence movements.

The maximum predicted systematic tilt at the tanks, after the completion of any or all of the proposed longwalls, is 6.0 mm/m (ie: 0.6 %), or a change in grade of 1 in 165. The maximum predicted systematic tensile and compressive strains at the tanks, at any time during or after the extraction of the proposed longwalls, are 1.1 mm/m and 1.7 mm/m, respectively, and the associated minimum radii of curvatures 14 kilometres and 8.8 kilometres, respectively.

5.24.2. Impact Assessments for the Tanks

Tilt can affect the serviceability of tanks by altering the water levels in the tanks, which can in turn affect the minimum level of water which can be released from the taps. The maximum predicted systematic tilt at the tanks within the SMP Area of 6.0 mm/m represents a change in grade of less than 1 % and is unlikely, therefore, to result in a significant impact on the serviceability of the tanks.

The maximum predicted systematic tensile and compressive strains at the tanks are 1.1 mm/m and 1.7 mm/m, respectively. The ground strains are unlikely to be transferred into the tanks where they are founded on a ground slab or on the natural ground. In these cases, it is unlikely that the tanks would be impacted by the predicted systematic strains.

It is possible, however, that buried water pipelines associated with the tanks within the SMP Area could be impacted by the predicted systematic strains, if they are anchored by the tanks, or by other structures in the ground. Any impacts are expected to be of a minor nature, including leaking pipe joints, and could be easily repaired. With these remediation measures in place, it would be unlikely that there would be a significant impact on the pipelines associated with the tanks.

5.24.3. Impact Assessments for the Tanks Based on Increased Predictions

If the predicted systematic subsidence parameters at the tanks were increased by factors of up to 2 times, the maximum predicted tilt at the tanks would be 12 mm/m, which is in the order of 1 % and unlikely, therefore, to result in a significant impact on the serviceability of the tanks.

It would be unlikely that the ground strains would be transferred into the tanks themselves, even if the predicted systematic strains were increased by factors of up to 2 times. The likelihood of impacts on the associated buried water pipelines would increase accordingly. At these magnitudes of predicted strain, however, it would be expected that any impacts would still be of a minor nature and could be easily repaired. With these remediation measures in place, it would be unlikely that there would be a significant impact on the pipelines associated with the tanks.

5.24.4. Recommendations for the Tanks

The assessed impacts on the tanks and associated infrastructure resulting from the predicted systematic subsidence parameters can be managed with the implementation of suitable management strategies. It is recommended that the tanks are visually monitored during the mining period.

5.25. Fences

There are a number of fences within the SMP Area which are constructed in a variety of ways, generally using either timber or metal materials. The fences are located across the SMP Area and are likely to be subjected to the full range of predicted systematic subsidence parameters. The maximum predicted systematic subsidence parameters within the SMP Area are summarised in Table 4.1 to Table 4.3.

The maximum predicted systematic tilt within the SMP Area is 6.0 mm/m (ie: 0.6 %), or a change in grade of 1 in 165. The maximum predicted systematic tensile and compressive strains within the SMP Area are 1.1 mm/m and 2.0 mm/m, respectively, and the associated minimum radii of curvatures are 14 kilometres and 7.5 kilometres, respectively.

Wire fences can be affected by tilting of the fence posts and by changes of tension in the fence wires due to strain as mining occurs. These types of fences are generally flexible in construction and can usually tolerate tilts of up to 10 mm/m and strains of up to 5 mm/m without significant impacts. It is unlikely, therefore, that the wire fences within the SMP Area would be impacted by the predicted systematic subsidence parameters resulting from the extraction of the proposed longwalls. Any impacts on the wire fences which occur as the result of mining are likely to be of a minor nature and relatively easy to remediate by re-tensioning the fencing wire, straightening the fence posts, and if necessary, replacing some sections of fencing.

Colorbond and timber paling fences are more rigid than wire fences and, therefore, are more susceptible to impacts resulting from mine subsidence movements. It is possible that these types of fences could be impacted at the magnitudes of predicted systematic strain. Any impacts on Colorbond or timber paling fences are expected to be of a minor nature and relatively easy to remediate or, where necessary, affected sections of fence replaced.

The assessed impacts on the fences resulting from the predicted systematic subsidence parameters can be managed with the implementation of suitable management strategies.

5.26. Farm Dams

There are 75 farms dams (Structure Type D) that have been identified within the SMP Area. The locations of the farm dams are shown in Drawings Nos. MSEC326-15 to MSEC326-26 and details are provided in Table E.03 in Appendix E. The predictions and impact assessments for the farm dams are provided in the following sections.

5.26.1. Predictions for the Farm Dams

Predictions of systematic subsidence, tilt and strain have been made at the centroid and at points located around the perimeter of each farm dam, as well as at points located at a distance of 20 metres from the perimeter of each farm dam.

The maximum predicted values of systematic subsidence, tilt and strain have been determined for each farm dam within the SMP Area, during and after the extraction of each proposed longwall. The maximum predicted systematic subsidence parameters at each farm dam are provided in Table E.03 and are summarised in Fig. 5.9, Fig. 5.10 and Fig. 5.11 below.

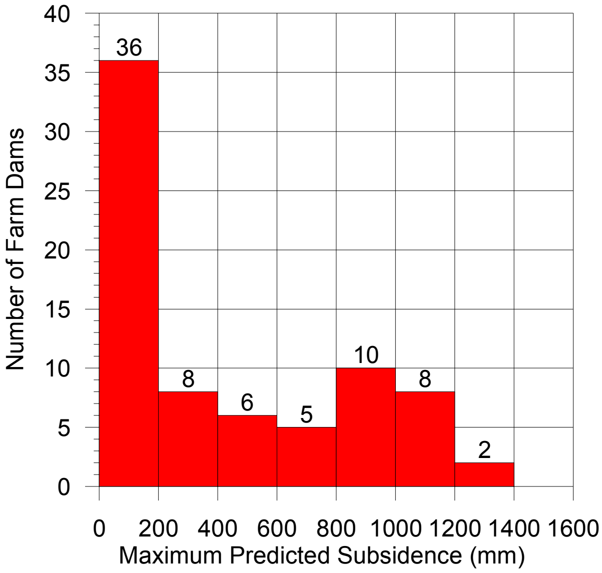


Fig. 5.9 Maximum Predicted Total Systematic Subsidence at the Farm Dams Resulting from the Extraction of the Longwalls 29 to 36

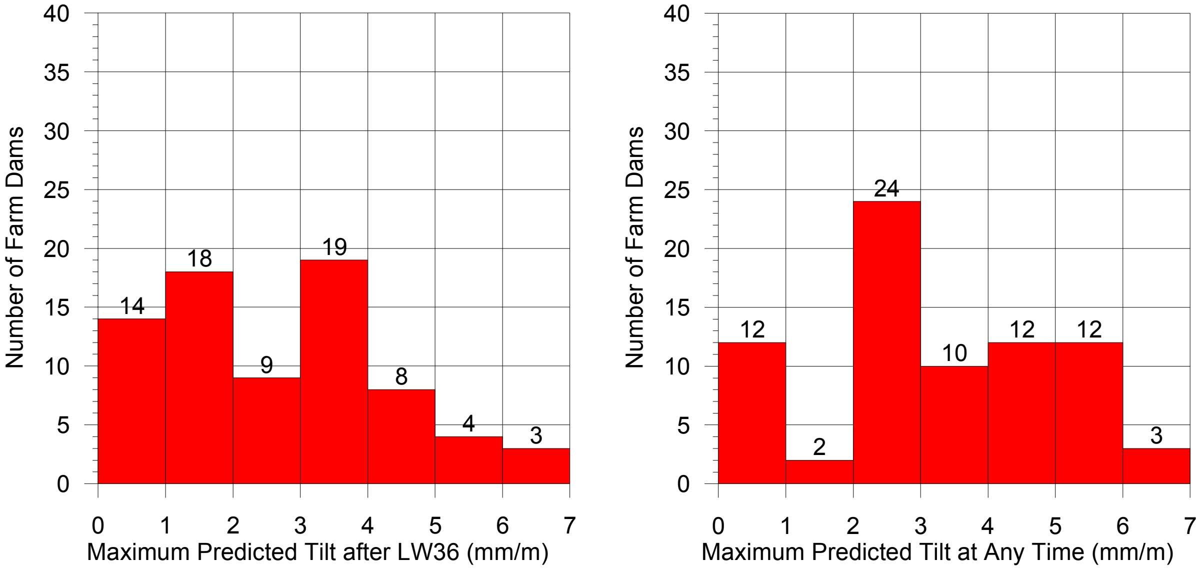


Fig. 5.10 Maximum Predicted Total Tilt after Longwall 36 (Left) and Maximum Predicted Travelling or Cumulative Tilt at Any Time during Longwalls 34 to 36 (Right) at the Farm Dams

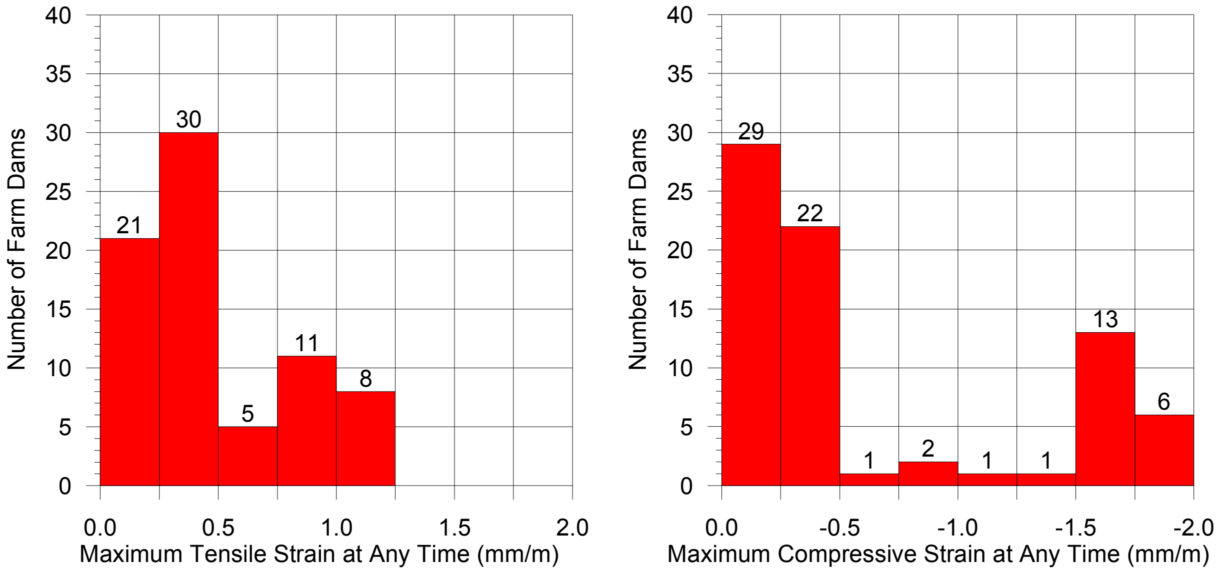


Fig. 5.11 Maximum Predicted Systematic Tensile Strain (Left) and Compressive Strain (Right) at the Farm Dams Resulting from the Extraction of Longwalls 29 to 36

The dams have typically been constructed within the drainage lines and, therefore, may be subjected to valley related movements resulting from the extraction of the proposed longwalls. The equivalent valley heights at the dams are very small and it is expected, therefore, that the predicted valley related upsidence and closure movements at the dam walls would be much less than the predicted systematic subsidence movements and, therefore, are not significant.

5.26.2. Impact Assessments for the Farm Dams

The maximum predicted systematic tilt at the farm dams within the SMP Area, at any time during or after the extraction of the proposed longwalls, is 6.0 mm/m (ie: 0.6 %), or a change in grade in 1 in 165. Mining induced tilts can affect the water levels around the perimeters of farm dams, with the freeboard increasing on one side and decreasing on the other. Large tilts can potentially reduce the storage capacity of farm dams, resulting in them to overflow, or affect the stability of the dam walls.

The maximum predicted changes in freeboard at the farm dams within the SMP Area were conservatively determined by applying the maximum predicted systematic tilts along the longest sides of the dams. The maximum predicted changes in freeboard at the farm dams are summarised in Table E.03.

Using this approach, the maximum predicted change in freeboard at the farm dams is 1200 mm, which occurs at Dam A39d02 after the extraction of proposed Longwall 34. This dam is located across the width of Longwall 34 and, therefore, the maximum increase in freeboard occurs near the centre of the dam, rather than at the ends of the dam, and the calculated change in freeboard is very conservative. The maximum predicted increase in freeboard at the centre of Dam A39d02, determined by taking the predicted subsidence at the centre of the dam from the average predicted subsidence at the ends of the dam, is 300 mm. The maximum predicted change in freeboard at the remaining dams is 450 mm, which occurs at Dam F05d02 after the extraction of Longwall 32.

The maximum predicted changes in freeboard are less than 500 mm and are unlikely, therefore, to result in a significant impact on the stability of the dam walls. It is possible, however, that the larger changes in freeboard could result in a reduction in the capacities of the farm dams, where the maximum tilts increase the water levels at the dam walls, which occur at Dams A39d02, C07d01, F03d02, F05d02 and H03d03.

The maximum predicted systematic tensile and compressive strains at the farm dams within the SMP Area, at any time during or after the extraction of the proposed longwalls, are 1.1 mm/m and 2.0 mm/m, respectively. The minimum radii of curvatures associated with the maximum predicted systematic tensile and compressive strains at the farm dams are 14 kilometres and 7.5 kilometres, respectively.

Farm dams, such as those identified within the SMP Area, are typically constructed from cohesive soils with reasonably high clay contents. The walls of the farm dams should be capable of withstanding tensile strains of up to 3 mm/m without impact, because of their inherent elasticity. It is unlikely, therefore, that the maximum predicted systematic strains, resulting from the extraction of the proposed longwalls, would result in a significant impact on the farm dams within the SMP Area.

It is possible, however, that some minor cracking or leakage of water may occur in the farm dam walls which are subjected to the higher strains, though any minor cracking or leakages can be easily identified and remediated as required. It is not expected that any significant loss of water would occur from the farm dams within the SMP Area and that any loss would flow into the tributary in which the dam was formed and not result in a significant impact on the environment.

There is a possibility that high concentrations of strain could occur at faults, fissures and other geological features, or points of weaknesses in the strata, and such occurrences could be coupled with localised stepping at the surface. If this type of phenomenon coincided with a farm dam wall, there is a possibility that an impact on the dam could occur, but the likelihood of this occurring is very small. In the unlikely event that these impacts occur, they can be easily remediated using well established dam construction and maintenance techniques. With the implementation of the appropriate remediation measures, there is unlikely to be a significant impact on the ongoing operations of the farm dams within the SMP Area or on the downstream environment.

5.26.3. Impact Assessments for the Farm Dams Based on Increased Predictions

If the predicted systematic tilts at the farm dams were increased by factors of up to 2 times, the maximum change in freeboard would be 900 mm, which is still relatively small and unlikely, therefore, to affect the stability of the dam walls. The capacities of the farm dams subjected to the greatest tilts would decrease accordingly.

If the predicted systematic strains at the farm dams were increased by factors of up to 2 times, the maximum predicted tensile strain would still be less than 3 mm/m and unlikely, therefore, to result in a significant impact on the farm dams. It is possible that some minor impacts could occur at the farm dams subjected to the larger strains, such as minor cracking or leakages, which are expected to be easily identified and remediated as required. With the implementation of the appropriate remediation measures, there is unlikely to be a significant impact on the ongoing operations of the farm dams within the SMP Area or on the downstream environment.

5.26.4. Recommendations for the Farm Dams

The assessed impacts on the farm dams within the SMP Area, resulting from the predicted systematic subsidence parameters, can be managed with the implementation of suitable management strategies. It is recommended that all water retaining structures be visually monitored during the extraction of the proposed longwalls, to ensure that they remain in a safe and serviceable condition.

5.27. Groundwater Bores

There are no registered groundwater bores within the general SMP Area. There are, however, a number of registered groundwater bores in the vicinity of the proposed longwalls which could be affected by far-field horizontal movements.

The locations of the groundwater bores in the vicinity of the proposed longwalls are shown in Drawing No. MSEC326-27. The closest registered groundwater bore to the proposed longwalls is S0667, which is located 450 metres north-west of Longwall 36.

At the distances of the registered groundwater bores from the proposed longwalls, there are unlikely to be any significant differential horizontal movements at the different strata horizons in the bores. It is unlikely, therefore, that there would be a significant impact on the registered groundwater bores resulting from the extraction of the proposed longwalls, even if the predicted far-field horizontal movements were increased by a factor of up to 2 times.

5.28. Inghams Farm No. 3

Inghams Farm No. 3, which is part of the Inghams Farm Complex, is located within the SMP Area. The predictions and impact assessments for the building structures and associated infrastructure on Inghams Farm No. 3 are provided in the following sections.

5.28.1. Predictions and Impact Assessments for the Building Structures on Inghams Farm No. 3

A total of 45 building structures (Structure Type C) on Inghams Farm No. 3 have been identified within the SMP Area, which include commercial chicken sheds and ancillary structures. The locations of the building structures on Inghams Farm No. 3 (Refs. F03a to F03as) are shown in Drawings Nos. MSEC326-24 and MSEC326-25 and details are provided in Table E.01 in Appendix E.

Predictions of systematic subsidence, tilt and strain have been made at the centroid and at the vertices of each building structure, as well as eight equally spaced points placed radially around the centroid and vertices at a distance of 20 metres. In the case of a rectangular shaped structure, predictions have been made at a minimum of 45 points within and around the structure.

At these points, the maximum predicted values of systematic subsidence, tilt and strain have been determined, during and after the extraction of each proposed longwall, for each building structure. An additional strain of 0.2 mm/m has been added to the magnitude of the predicted strains, where the predicted subsidence is greater than 20 mm, to account for the scatter which is generally observed in strain profiles.

There are 16 chicken sheds (Refs. F03a to F03p) on the farm which are very long and, therefore, an impact assessment based on the peak strain over the full length of these structures would be very conservative. The peak strain at each structure occurs over a short distance and the strains reduce considerably away from this point for long structures. For the sheds greater than 30 metres in length, therefore, the average strains over the full lengths of these structures have been used in the impact assessments.

The assessed impacts on the building structures were determined using the method outline in the background report entitled *Mine Subsidence Damage to Building Structures (Revision A)* which can be obtained from *www.minesubsidence.com*.

The maximum predicted subsidence and the impact assessments for tilt and strain for each building structure on Inghams Farm No. 3 are provided in Table E.01. A summary of the tilt and strain impact assessments for the 16 large chicken sheds on the farm, after the extraction of each proposed longwall, is provided in Table 5.34. A summary of the tilt and strain impact assessments for the 29 ancillary building structures on the farm, after the extraction of each proposed longwall, is provided in Table 5.35.

Table 5.34 Summary of Impact Assessments for Tilt and Strain for the Large Chicken Sheds on Inghams Farm No. 3 after the Extraction of Each Proposed Longwall

Longwall	Tilt Impact Categories				Strain Impact Categories					
	Cat A	Cat B	Cat C	Cat D	Cat 0	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5
After LW34	16	0	0	0	0	0	16	0	0	0
After LW35	16	0	0	0	0	0	16	0	0	0
After LW36	16	0	0	0	0	0	16	0	0	0

It can be seen from the above table, that none of the large chicken sheds are assessed to experience a tilt impact greater than Category A. It can also be seen from the above table that none of the large chicken sheds are assessed to experience a strain impact greater than Category 2.

Table 5.35 Summary of Impact Assessments for Tilt and Strain for the Ancillary Building Structures on Inghams Farm No. 3 after the Extraction of Each Proposed Longwall

Longwall	Tilt Impact Categories				Strain Impact Categories					
	Cat A	Cat B	Cat C	Cat D	Cat 0	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5
After LW34	29	0	0	0	27	2	0	0	0	0
After LW35	29	0	0	0	27	2	0	0	0	0
After LW36	29	0	0	0	27	2	0	0	0	0

It can be seen from the above table, that no ancillary building structures are assessed to experience a tilt impact greater than Category A. It can also be seen from the above table that no ancillary building structures are assessed to experience a strain impact greater than Category 1.

Mitigation measures are generally not recommended for building structures unless the impact assessments are Category C for tilt or Category 3 for strain, or greater. It should also be noted that the additional tilts and strains, resulting from the extraction of Longwalls 34 to 36, are less than 1 mm/m and less than 0.1 mm/m, respectively, for all the building structures on Inghams Farm No 3.

It is expected, therefore, that the building structures on Inghams Farm No. 3 would remain in a safe and serviceable condition throughout the mining period. No mitigation measures are recommended for the building structures on Inghams Farm No. 3.

If the predicted systematic tilts were increased by a factor of 1.5 times, there would be no large chicken sheds or ancillary buildings assessed to experience a Category C tilt impact or greater. If the predicted systematic tilts were increased by a factor of 2 times, there would be 12 large chicken sheds and seven ancillary buildings assessed to experience a Category C tilt impact.

If the predicted systematic strains were increased by a factor of 1.5 times, there would be eight large chicken sheds and no ancillary buildings assessed to experience a Category 3 strain impact. If the predicted systematic strains were increased by a factor of 2 times, all 16 large chicken sheds and no ancillary buildings would be assessed to experience a Category 3 strain impact.

The building structures assessed to experience a Category C tilt impact or a Category 3 strain impact, based on the predictions being increased by a factor of up to 2 times, would experience these after the extraction of Longwall 33, that is, prior to the commencement of Longwalls 34 to 36. Provided that these building structures are in a sound condition at the completion of Longwall 33, therefore, it would be expected that these they would remain in a safe and serviceable condition during and after the extraction of the proposed longwalls, even if the predictions were exceeded by a factor of up to 2 times.

5.28.2. Predictions and Impact Assessments for the Roads and Drainage Culverts on Inghams Farm No. 3

The roads and drainage culverts associated with Inghams Farm No. 3 are located above Longwall 32. The maximum predicted additional systematic tensile strain at these features, resulting from the extraction of Longwalls 34 to 36, is 0.1 mm/m and unlikely, therefore, to result in a significant impact.

5.28.3. Predictions and Impact Assessments for the Water and Gas Infrastructure on Inghams Farm No. 3

The gas infrastructure associated with Inghams Farm No. 3 is located above Longwall 32. The maximum predicted additional systematic tensile strain at this infrastructure, resulting from the extraction of Longwalls 34 to 36, is 0.1 mm/m and unlikely, therefore, to result in a significant impact.

5.28.4. Recommendations for the Building Structures and Infrastructure on Inghams Farm No. 3

A management plan has been established for the building structures and infrastructure on Inghams Farm No. 3 for Longwalls 29 to 33. It is recommended that the existing management plan be reviewed, in consultation with Inghams, and that amendments are made to the plan, where necessary, to include the predicted movements resulting from Longwalls 34 to 36.

5.29. Archaeological Sites

There are nine archaeological sites that have been identified within the SMP Area, the locations of which are shown in Drawing No. MSEC326-27. The predictions and impact assessments for these archaeological sites are provided in the following sections.

5.29.1. Predictions for the Archaeological Sites

A summary of the maximum predicted values of systematic subsidence, tilt and strain at the archaeological sites within the SMP Area, at any time during or after the extraction of the proposed longwalls, is provided in Table 5.36.

Table 5.36 Maximum Predicted Systematic Subsidence, Tilt and Strain at the Archaeological Sites within the SMP Area Resulting from the Extraction of the Proposed Longwalls

Archaeological Site	Maximum Predicted Cumulative Subsidence (mm)	Maximum Predicted Cumulative or Travelling Tilt (mm/m)	Maximum Predicted Cumulative or Travelling Tensile Strain (mm/m)	Maximum Predicted Cumulative or Travelling Compressive Strain (mm/m)
52-2-0021	890	2.8	0.1	0.4
52-2-2234	125	1.4	0.3	0.1
52-2-2237	760	3.1	0.9	0.2
52-2-1682	< 20	0.1	< 0.1	< 0.1
52-2-2242	70	0.8	0.1	< 0.1
52-2-2243	55	0.8	0.1	< 0.1
52-2-2244	40	0.3	0.1	< 0.1
52-2-2265	760	1.7	0.3	0.5
52-2-2266	225	1.6	0.3	< 0.1

The values provided in the above table are the maximum predicted parameters within a 20 metre radius of each site, including the predicted movements resulting from the extraction of Longwalls 29 to 33. The predicted tilts and strains are the maximum values which occur anytime during or after the extraction of the proposed longwalls.

5.29.2. Impact Assessments for the Archaeological Sites

There are three open sites with artefacts within the SMP Area, being Sites 52-2-0021, 52-2-2265 and 52-2-2266, which are located near the finishing (western) end of Longwall 33, at the western end of Longwall 34 and adjacent to the finishing (eastern) end of Longwall 33, respectively. Open sites can potentially be affected by cracking in the surface soils as a result of mine subsidence movements. It is unlikely, however, that the artefacts themselves would be impacted by surface cracking. The potential for surface cracking resulting from the extraction of the proposed longwalls is discussed in Section 5.33.5.

The remaining archaeological sites within the SMP Area are shelters with art, which are located within the valleys of the Georges River and Mallaty Creek. These types of sites can potentially be impacted by mine subsidence movements including the fracturing of sandstone, rock falls, or water seepage through joints which may affect artwork. The main mechanisms which could potentially result in impact on sandstone shelters are the systematic strains and curvatures.

The maximum predicted systematic strains at the shelters with art occur at Site 52-2-2237, which is located above Longwall 32. The maximum predicted systematic tensile and compressive strains at this site are 0.9 mm/m and 0.2 mm/m, respectively, and the associated minimum radii of curvatures are 17 kilometres and 75 kilometres, respectively. The maximum predicted systematic tensile and compressive strains at the remaining shelters with art within the SMP Area are 0.3 mm/m and 0.1 mm/m, respectively, and the associated minimum radii of curvatures are 50 kilometres and 150 kilometres, respectively.

Tensile strains greater than 0.5 mm/m may be of a sufficient magnitude to result in the fracturing of sandstone. Compressive strains greater than 2 mm/m may be of a sufficient magnitude to result in the underlying strata buckling, which could result in the fracturing of the sandstone bedrock.

It is possible, therefore, that the maximum predicted systematic tensile strain at Site 52-2-2237 could be of sufficient magnitude to result in fracturing in the sandstone bedrock and, hence, the possibility of a rock instability. There were no reported impacts at this site resulting from the extraction of Longwall 32. The additional tensile strain at this site, resulting from the extraction of Longwalls 33 to 36, is 0.2 mm/m. It would be expected at this magnitude of predicted additional strain, therefore, that any fracturing which were to occur at Site 52-2-2237, as a result of the extraction of the proposed longwalls, would be of a minor nature and unlikely to result in rock instability.

The maximum predicted systematic tensile and compressive strains at the remaining shelters with art are less than 0.5 mm/m and less than 2 mm/m, respectively. It is unlikely, therefore, that the predicted maximum systematic strains at these sites would be of sufficient magnitude to result in the fracturing of the sandstone bedrock. Sites 52-2-2234 and 52-2-2243 are located along Cliff GR-CF01 and could be impacted by potential cliff instabilities, which is described in Section 5.5.

The shelters with art within the SMP Area are located within the valleys of the Georges River and Mallaty Creek and could, therefore, experience valley related movements as a result of the extraction of the proposed longwalls. The maximum predicted upsidence and the maximum predicted compressive strains due to the closure movements are expected to occur in the bases of the valleys and are not expected to be significant in the locations of the shelters which are located along the valley sides. Sites 52-2-2241 and 52-2-2243 are located on bends in the Georges River and could, therefore, experience elevated strains resulting from differential closure movements around these bends in the river.

The likelihood of impact on shelters with art located outside of extracted longwalls are considerably less than those which are located directly above extracted longwalls. It has been reported that, where longwall mining has previously been carried out in the Southern Coalfield, beneath 52 shelters, that approximately 10 % of the shelters have been affected by fracturing of the strata or shear movements along bedding planes and that none of the shelters have collapsed (Sefton, 2000). This suggests that the likelihood of significant impacts on the shelters with art, resulting from the extraction of the proposed longwalls, is low.

Further assessments of the potential impacts on the archaeological sites are provided in a report by Biosis (2007b).

5.29.3. Impact Assessments for the Archaeological Sites Based on Increased Predictions

If the predicted systematic strains were increased by factors of up to 1.5 times, the likelihood and extent of fracturing and, hence, the likelihood of rock instabilities would increase accordingly at Site 52-2-2237. The likelihood of cliff instabilities at Sites 52-2-2234 and 52-2-2243 would also increase accordingly. The likelihood of fracturing and, hence, the likelihood of rock instabilities at the remaining shelters would not significantly increase, as the predicted systematic tensile and compressive strains would still be less than 0.5 mm/m and 2 mm/m, respectively.

If the predicted systematic strains were increased by factors of up to 2 times, the likelihood and extent of fracturing and, hence, the likelihood of rock instabilities would increase accordingly at all the shelters with art within the SMP Area. It should be noted, however, that the Incremental Profile Method generally provides conservative predictions and that additional conservatism has been provided by taking the maximum predicted systematic subsidence parameters within a 20 metre radius of each archaeological site. It is expected, therefore, that the systematic subsidence parameters at the archaeological sites would not be significantly exceeded.

5.29.4. Recommendations for the Archaeological Sites

It is recommended that a survey of the archaeological sites be undertaken and a monitoring programme established to record the effects of mine subsidence on these sites.

5.30. Heritage Sites

The locations of the heritage sites within the SMP Area are shown in Drawing No. MSEC326-27. The predictions and impact assessments for these sites are provided in the following sections.

5.30.1. Predictions for the Heritage Sites

A summary of the maximum predicted values of systematic subsidence, tilt and strain at the heritage sites within the SMP Area, at any time during or after the extraction of the proposed longwalls, is provided in Table 5.37.

Table 5.37 Maximum Predicted Systematic Subsidence, Tilt and Strain at the Heritage Sites Resulting from the Extraction of the Proposed Longwalls

Heritage Site	Maximum Predicted Cumulative Subsidence (mm)	Maximum Predicted Cumulative or Travelling Tilt (mm/m)	Maximum Predicted Cumulative or Travelling Tensile Strain (mm/m)	Maximum Predicted Cumulative or Travelling Compressive Strain (mm/m)
Bridge and Road Remains Site (WH1)	150	1.0	0.1	< 0.1
Grave Site (WH2)	530	4.4	0.5	0.2
House Site (WH3)	755	4.5	0.1	0.5
Pub/Cellar Site (WH4)	700	3.9	0.3	0.4

The values provided in the above table are the maximum predicted parameters within a 20 metre radius of each site, including the predicted movements resulting from the extraction of Longwalls 29 to 33. The predicted tilts and strains are the maximum values which occur any time during or after the extraction of the proposed longwalls.

5.30.2. Impact Assessments for the Heritage Sites

The maximum predicted systematic tensile and compressive strains at the Bridge and Road Remains Site (WH1) are 0.1 mm/m and less than 0.1 mm/m, respectively. It is unlikely, therefore that this site would be impacted by the predicted systematic subsidence movements resulting from the extraction of the proposed longwalls, even if the predicted movements were increased by a factor of 2 times.

As discussed in Section 5.2.2.3, minor fracturing in the sandstone bedrock of the Georges River could occur adjacent to the proposed longwalls as the result of the valley related upsidence and closure movements. It is very difficult to determine the precise location of any fracturing. The likelihood of fracturing being coincident with the historic road is considered to be relatively low.

The E-Line and F-Line subsidence monitoring lines are located in similar positions to Longwalls 29 and 31, respectively, as the Bridge and Road Remains Site (WH1) is located to Longwall 33. There was no fracturing observed in the rock bars or in the visible river bed after the extractions of Longwalls 29 and 31. Isolated gas releases were observed along the Georges River during the extraction of these longwalls, however, which may indicate some minor fracturing, or the mobilisation of existing joints in the bed rock, which was not visible at the surface.

The Grave Site (WH2) consists only of scatter stones. The maximum predicted systematic tensile and compressive strains at the site are 0.5 mm/m and 0.2 mm/m, respectively. It is possible that the maximum predicted tensile strain could result in minor surface cracking at the site, however, it is unlikely that the scattered stones would be impacted by surface cracking, even if the predictions were increased by a factor of 2 times.

The House Site (WH3) consists of a flagstone, discontinuous lines of sandstone blocks, a concrete slab and a concrete footpath. The maximum predicted systematic tensile and compressive strains at the site are 0.1 mm/m and 0.5 mm/m, respectively. It is unlikely that the predicted systematic strains would have a significant impact on the House Site, as any surface cracking which develops is likely to arch around the sandstone blocks and the concrete slabs, even if the predictions were increased by a factor of 2 times. The concrete footpath is also extensively cracked and it is more likely that the existing cracks would open up very slightly under the tensile ground strains, rather than develop any additional cracks.

The Pub/Cellar Site (WH4) consists of discontinuous lines of sandstone blocks which may continue down below the surface to form the walls of a cellar. For the purposes of this assessment, it has been conservatively assumed that the sandstone walls continue below the surface for a minimum depth of 5 metres and have a maximum plan dimension of 7 metres. Based on these assumptions, the cellar walls are assessed to experience a Category 0 strain impact and are unlikely, therefore, that the site would be impacted, even if the predictions were increased by a factor of 2 times.

5.30.3. Recommendations for the Heritage Sites

It is recommended that a survey of the heritage sites be undertaken and that a monitoring programme be established to record the effects of mine subsidence on these sites.

5.31. Survey Control Marks

There are a number of survey control marks within the vicinity of the proposed longwalls, the locations of which are shown in Drawing No. MSEC326-27. The predictions and impact assessments for the survey control marks are provided in the following sections.

5.31.1. Predictions for the Survey Control Marks

There are ten survey control marks located within the general SMP Area. A summary of the maximum predicted values of systematic subsidence and horizontal movement at these survey control marks, at any time during or after the extraction of the proposed longwalls, is provided in Table 5.38.

Table 5.38 Maximum Predicted Systematic Subsidence and Horizontal Movement at the Survey Control Marks within the General SMP Area Resulting from the Extraction of Longwalls 29 to 36

Survey Mark	Maximum Predicted Total Subsidence (mm)	Maximum Predicted Total Horizontal Movement (mm)
PM 10770	1025	35
PM 14762	325	60
PM 21634	805	90
PM 25139	770	70
PM 33063	925	80
PM 82965	830	30
SS 13273	130	20
SS 16105	850	75
SS 19707	1005	90
TS 12008	50	5

The values provided in the above table are the maximum predicted parameters within a 20 metre radius of each survey control mark, including the predicted movements resulting from the extraction of Longwalls 29 to 33.

There are also a number of other survey control marks that are located in the vicinity of the proposed longwalls which are likely to experience either small amounts of subsidence or small far-field horizontal movements as a result of the extraction of the proposed longwalls. It is possible that other survey control marks outside the immediate area could also be affected by far-field horizontal movements, up to 3 kilometres outside the SMP Area.

5.31.2. Impact Assessments for the Survey Control Marks

It will be necessary on the completion of the proposed longwalls, when the ground has stabilised, to re-establish any survey control marks that are required for future use. Consultation between IC and the Department of Lands will be required to ensure that these survey control marks are reinstated at the appropriate time, as required.

5.31.3. Impact Assessments for the Survey Control Marks Based on Increased Predictions

If the predicted systematic subsidence parameters were increased by factors of up to 2 times, the extent of the remediation measures would not significantly increase. If the predicted far-field horizontal movements were increased by factors up to 2 times, it is likely that additional survey control marks further afield would be affected and, therefore, could require re-establishment. It is anticipated that with the appropriate remediation measures implemented, that it would be unlikely that there would be a significant impact on the survey control marks resulting from the extraction of the proposed longwalls.

5.31.4. Recommendations for the Survey Control Marks

It is recommended that management strategies are developed, in consultation with the Department of Lands, such that the survey control marks can be re-established, as required, at the appropriate time.

5.32. Houses

There are 28 houses located within the SMP Area, of which 24 are single-storey houses with lengths less than 30 metres (Type H1), two are single-storey houses with lengths greater than 30 metres (Type H2) and two are double-storey houses with lengths less than 30 metres (Type H3).

The locations of the houses within the SMP Area are shown in Drawings Nos. MSEC326-15 to MSEC326-26 and details are provided in Tables E.01 in Appendix E. The impact assessments for the houses within the SMP Area are provided in the following sections.

5.32.1. Predictions for the Houses

Predictions of systematic subsidence, tilt and strain have been made at the centroid and at the vertices of each house, as well as eight equally spaced points placed radially around the centroid and vertices at a distance of 20 metres. In the case of a rectangular shaped structure, predictions have been made at a minimum of 45 points within and around the structure.

At these points, the maximum predicted values of systematic subsidence, tilt and strain have been determined, during and after the extraction of each proposed longwall, for each house. An additional strain of 0.2 mm/m has been added to the magnitude of the predicted strains, when the predicted subsidence is greater than 20 mm, to account for the scatter in observed strain profiles.

The assessed impacts on the houses were determined using the method outline in the background report entitled *Mine Subsidence Damage to Building Structures (Revision A)* which can be obtained from *www.minesubsidence.com*.

The maximum predicted subsidence and the impact assessments for tilt and strain for each house within the SMP Area are provided in Table E.01. A summary of the tilt and strain impact assessments for the houses within the SMP Area, after the extraction of each proposed longwall, is provided in Table 5.39.

Table 5.39 Summary of Predicted Tilt and Strain Impact Assessments for the Houses within the SMP Area after the Extraction of Each Proposed Longwall

Longwall	Tilt Impact Categories				Strain Impact Categories					
	Cat A	Cat B	Cat C	Cat D	Cat 0	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5
After LW34	26	2	0	0	18	6	4	0	0	0
After LW35	26	2	0	0	14	9	5	0	0	0
After LW36	25	3	0	0	11	11	6	0	0	0

It can be seen from the above table, that no houses are assessed to experience a tilt impact greater than Category B. It can also be seen from the above table that no houses are assessed to experience a strain impact greater than Category 2.

5.32.2. Impact Assessments for the Houses

Mitigative measures are generally not recommended for houses unless the impact assessments are Category C for tilt or Category 3 for strain, or greater. There are no houses assessed to experience a Category C tilt impact or a Category 3 strain impact, or greater, at any stage of the mining period.

To date, Cardno Forbes Rigby has inspected all but two houses within the SMP Area, being Structures Refs. D01a and D08a, and have found them to be in sound conditions. Details of these inspections are provided in the Property Subsidence Management Plans (PSMPs). The houses, therefore, are expected to remain in a safe and serviceable condition throughout the mining period. No mitigative measures are recommended for the houses prior to the extraction of Longwalls 34 to 36.

The maximum predicted systematic tensile and compressive strains resulting from the extraction of Longwalls 34 to 36 are similar to the maximum predicted systematic tensile and compressive strains resulting from the extraction of Tahmoor Longwalls 22, 23A, 23B and 24B. At the time of writing this report, the longwalls at Tahmoor Colliery had mined directly beneath or adjacent to approximately 800 houses, rural building structures and public amenities. All structures have remained in a safe and serviceable condition throughout the mining period.

Impacts have been reported at approximately 14 % of all houses at Tahmoor Colliery, most of which have occurred directly above the extracted longwalls. The majority of the impacts have been assessed as very slight or slight (ie: Category 1 or 2), which consists of sticky doors and minor impacts to internal walls, ceilings or floor finishes.

Less than 1 % of all structures at Tahmoor Colliery had reported impacts that were assessed as moderate or greater (ie: Category 3 or greater). In all of these cases, however, the impacts were considered to have occurred as the result of non-systematic anomalous movements, due to near surface geological features, the locations of which cannot be predicted prior to mining. In two of these cases (ie: 0.3 % of all structures), the impacts were substantial and the costs to repair these structures were deemed to be greater than the costs to rebuild these structures.

In overall terms, it was found that the number of impacted structures at Tahmoor Colliery was less than half the total number predicted. The observed impacts at some houses, however, exceeded those predicted, particularly where anomalous movements had occurred. It is expected that the likelihood of an anomalous movement being coincident with a structure at West Cliff Colliery is significantly less than that at Tahmoor Colliery, as the density of structures above the proposed longwalls is significantly less.

The observations at Tahmoor Colliery provide a valuable empirical guide to the level of impact that could occur as a result of the extraction of the proposed West Cliff Longwalls 34 to 36. While specific subsidence predictions and impact assessments have been provided for each structure at West Cliff Colliery, these should only be used as a guide to the overall level of impact on the structures. The impact assessments for individual structures do not include, for example, the impacts resulting from non-systematic anomalous movement. Based on the observations at Tahmoor Colliery, the expected incidence of anomalous movements being coincident with structures is less than 1 % of the total number of structures directly mined beneath.

There are 18 houses located directly above or immediately adjacent to the proposed West Cliff Longwalls 34 to 36. Based on the experience at Tahmoor Colliery, it is expected that all houses would remain in a safe and serviceable condition throughout the mining period. It is also expected that approximately 15 % of the houses located directly above the proposed longwalls would experience a very slight or slight impact, and that each house has a probability of less than 1 % that it would experience an impact that would be considered moderate or greater.

Impacts on the houses resulting from the extraction of the proposed Longwalls 34 to 36 are generally predicted to be of a minor nature, which could be easily remediated using well established building techniques. With these remediation measures in place, it is unlikely that there would be a significant impact on the houses resulting from the extraction of the proposed longwalls.

5.32.3. Impact Assessments for Houses Based on the Potential for Non-Systematic Movements

It is possible that some houses may experience adverse impacts from non-systematic subsidence movements. The potential reasons for the non-systematic movements include the influence of geological structures and, where the structures are located close to drainage lines, the influence of valley related movements. In some cases, the reason for an observed irregular movement cannot be explained and these are termed “anomalies”.

The locations of non-systematic or anomalous movements cannot be predicted prior to mining. Based on the experience at Tahmoor Colliery, however, it is expected that all the houses located directly above the proposed Longwalls 34 to 36 have a probability of less than 1 % that it would experience an impact that would be considered moderate or greater as a result of a non-systematic or anomalous movement.

A discussion on the potential for non-systematic movements is provided the background report entitled *General Discussion of Mine Subsidence Ground Movements* which can be obtained from *www.minesubsidence.com*.

5.32.4. Impact Assessments for the Houses Based on Increased Predictions

If the predicted systematic subsidence parameters were to be increased by factors of 1.25 to 5 times, the potential impacts on the houses would increase accordingly. The impact assessments for tilt and strain for the houses based on increased predictions are provided in Table E.01 and are summarised in Table 5.40.

Table 5.40 Summary of Tilt and Strain Impact Assessments for the Houses within the SMP Area Based on Increased Predictions

Increased Prediction	Number of Houses with Tilt Impact Assessment for Increased Predictions				Number of Houses with Strain Impact Assessment for Increased Predictions					
	Cat A	Cat B	Cat C	Cat D	Cat 0	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5
x 1.25	22	5	1	0	8	12	8	0	0	0
x 1.50	22	3	3	0	6	8	13	1	0	0
x 1.75	19	3	5	1	5	9	12	2	0	0
x 2.00	18	4	3	3	3	10	9	6	0	0
x 5.00	5	2	8	13	0	2	8	10	6	2

If the predictions were increased by a factor of 1.5 times, three houses would be assessed to experience a Category C tilt impact and one house would be assessed to experience a Category 3 strain impact. Remediation measures may be required for these structures, after the extraction of the proposed longwalls, if the predictions were exceeded by a factor of up to 1.5 times. With these remediation measures in place, it is unlikely that there would be a significant impact on the houses resulting from the extraction of the proposed longwalls.

5.32.5. Recommendations for the Houses

The assessed impacts on the houses resulting from the predicted systematic subsidence parameters can be managed with the implementation of suitable management strategies. It is recommended that the houses are visually monitored during the extraction of the proposed longwalls.

5.32.6. Non-Residential Building Structures

The predictions and impact assessments for the rural building structures and tanks are provided in Sections 5.23 and 5.24, respectively. The predictions and impact assessments for the swimming pools and on-site waste water systems are provided in the following sections.

5.32.6.1. Swimming Pools

There are three privately owned swimming pools (Structure Type P) which have been identified within the SMP Area, the locations of which are shown in Drawings Nos. MSEC326-17, MSEC326-23 and MSEC326-26.

Predictions of systematic subsidence, tilt and strain have been made at the centroid and at the corners of each pool, as well as eight equally spaced points placed radially around the centroid and corners at a distance of 20 metres.

A summary of the maximum predicted values of cumulative systematic subsidence, tilt and strain at each pool, after the extraction of each proposed longwall, is provided in Table 5.41.

Table 5.41 Maximum Predicted Cumulative Systematic Subsidence, Tilt and Strain at the Private Swimming Pools Resulting from the Extraction of Longwalls 29 to 36

Pool	Longwall	Maximum Predicted Cumulative Subsidence (mm)	Maximum Predicted Cumulative Tilt (mm/m)	Maximum Predicted Cumulative Tensile Strain (mm/m)	Maximum Predicted Cumulative Compressive Strain (mm/m)
A32p01	After LW33	125	1.3	0.2	< 0.1
	After LW34	800	1.0	0.4	0.3
	After LW35	980	1.7	0.4	0.3
	After LW36	980	1.7	0.4	0.3
D08p01	After LW33	< 20	< 0.1	< 0.1	< 0.1
	After LW34	< 20	< 0.1	< 0.1	< 0.1
	After LW35	< 20	< 0.1	< 0.1	< 0.1
	After LW36	20	0.1	< 0.1	< 0.1
G03p01	After LW33	< 20	< 0.1	< 0.1	< 0.1
	After LW34	310	2.3	0.2	0.1
	After LW35	705	0.5	0.3	0.2
	After LW36	760	1.0	0.3	0.2

The values provided in the above table are the maximum predicted systematic subsidence parameters which occur at each pool, including the predicted movements resulting from the extraction of Longwalls 29 to 33.

The maximum predicted systematic cumulative tilt at the pools, at the completion of any or all of the proposed longwalls, is 2.3 mm/m (ie: 0.2 %), or a change in grade of 1 in 435, which occurs at Pool G03p01 after the extraction of Longwall 34. The maximum predicted systematic travelling tilt at the pools, at any time during the extraction of the proposed longwalls, is 2.5 mm/m (ie: 0.3 %) or a change in grade of 1 in 400, which occurs at Pool A32p01 during the extraction of Longwall 34.

The maximum predicted changes in gradient at the pools are less than 1 % and are unlikely, therefore, to result in a significant impact on the serviceability of the pools. While the predicted systematic tilts are not expected to result in a loss of capacity for the pools, it is noted that tilts are more readily noticeable to the property owners, particularly if the walls of the pools are tiled, as the heights of the freeboard will vary along the lengths of the pools.

The maximum predicted systematic tensile and compressive strains at the pools, resulting from the extraction of the proposed longwalls, are 0.4 mm/m and 0.3 mm/m, respectively. The minimum radii of curvatures associated with the maximum predicted tensile and compressive strains are 38 kilometres and 50 kilometres, respectively.

The maximum predicted systematic tensile and compressive strains resulting from the extraction of Longwalls 34 to 36 are similar to the maximum predicted systematic tensile and compressive strains resulting from the extraction of Tahmoor Longwalls 22, 23A, 23B and 24B. At the time of writing this report, the longwalls at Tahmoor Colliery have mined directly beneath 46 pools, of which nine pools (ie: 20 %) have been impacted which includes the cracking of the pool linings, cracking of the coping and impacts on associated infrastructure such as skimmer boxes. Of the nine pools impacted at Tahmoor Colliery, seven pools (ie: 15 %) could be repaired and two pools (ie: 5 %) required replacement. It was also observed, that the in ground fibreglass pools were more susceptible to impact than the in ground concrete pools.

Pools A32p01 and G03p01 are located directly above West Cliff Longwalls 34 to 36. Based on the experience at Tahmoor Colliery, it is expected that each of these pools have a 15 % probability of minor impacts, which would require repairs, and a 5 % probability of major impacts, requiring replacement, as a result of the extraction of the proposed West Cliff Longwalls 34 to 36. Pool D08p01is located 250 metres north of Longwall 36 and is unlikely, therefore, to be impacted as a result of the extraction of the proposed Longwalls 34 to 36.

5.32.6.2. On-Site Waste Water Systems

The residences on the rural properties within the SMP Area have on-site waste water systems. The predicted systematic subsidence parameters at the on-site waste water systems are similar to those at the houses which they serve, which are summarised in Tables E.01 in Appendix E, as these are the maximum values which occur within 20 metres of the houses.

A summary of the maximum predicted systematic subsidence parameters at the on-site waste water systems, at any time during or after the extraction of the proposed longwalls, whichever is the greater, is provided in Table 5.42.

Table 5.42 Maximum Predicted Systematic Subsidence Parameters at the On-Site Waste Water Systems Resulting from the Extraction of the Longwalls 29 to 36

Location	Maximum Predicted Subsidence (mm)	Maximum Predicted Tilt (mm/m)	Maximum Predicted Systematic Tensile Strain (mm/m)	Maximum Predicted Systematic Compressive Strain (mm/m)
On-site Waste Water Systems	1240	6.0	1.1	1.9

The maximum predicted systematic tilt at the on-site waste water systems is 6.0 mm/m (ie: 0.6 %), or a change in grade of 1 in 165, which represents a change in grade of less than 1 % and is unlikely, therefore, to result in a significant impact on the systems. The maximum predicted systematic tilt could, however, be of sufficient magnitude to affect the serviceability of buried pipes between the houses and the on-site waste water systems, if the existing grades of these pipes are very small, say less than 1 %. Any impacts that occurred on the buried pipes in the location of maximum predicted tilt would be expected to be minor and easily repaired.

The maximum predicted systematic tensile and compressive strains at the on-site waste water systems are 1.1 mm/m and 1.9 mm/m, respectively, and the associated minimum radii of curvatures are 14 kilometres and 7.9 kilometres, respectively. The on-site waste water system tanks are generally small, typically less than 3 metres in diameter, are constructed from reinforced concrete, and are usually bedded in sand and backfilled. It is unlikely, therefore, that the maximum predicted systematic strains would be fully transferred into the tank structures themselves.

It is possible, however, that the buried pipelines associated with the on-site waste water tanks could be impacted by the predicted systematic strains if they are anchored by the tanks or other structures in the ground. Any impacts are expected to be of a minor nature, including leaking pipe joints, and could be easily repaired. With the implementation of these remediation measures, it would be unlikely that there would be a significant impact on the pipelines associated with the on-site waste water systems.

If the predicted systematic subsidence parameters at the on-site waste water systems were increased by factors of up to 2 times, it would still be unlikely to result in a significant impact on the tank structures themselves. The likelihood of impact on the buried pipelines would, however, increase accordingly, but the same mitigative measures would be effective in repairing these pipes.

5.32.7. Fences

The predictions and impact assessments for fences are provided in Section 5.25.

5.32.8. Concrete Pavements

A number of the houses within the SMP Area have concrete driveways or footpaths. The predicted subsidence parameters at the concrete pavements are similar to those at the houses, which is summarised in Table E.01, as these predictions are the maximum values within 20 metres of the houses.

The maximum predicted systematic tilt at the houses within the SMP Area, resulting from the extraction of the proposed longwalls, is 6.0 mm/m (ie: 0.6 %), or a change in grade of 1 in 165, which is very small and unlikely to result in a significant impact on the concrete pavements.

The maximum predicted systematic tensile and compressive ground strains at the houses within the SMP Area, resulting from the extraction of the proposed longwalls, are 1.1 mm/m and 1.9 mm/m, respectively. It is expected that the concrete pavements could tolerate tensile strains of up to 2 mm/m without significant impact. It is possible, however, that there could be some minor cracking in the concrete pavements which are subjected to the larger predicted strains, however, any cracking is not expected to be significant and could be easily repaired.

Residential concrete pavements are typically constructed with tooled joints which do not have any compressive capacity. It is possible that some of the smaller footpaths in the locations of the larger predicted compressive strains could buckle upwards if there are insufficient expansion joints in the pavements. It is expected, however, that the buckling of footpaths and pavements would not be common, at these magnitudes of predicted strain, and could be easily repaired.

If the predicted systematic strains were increased by factors of up to 2 times, the likelihood and extent of impacts on the concrete pavements in the locations of the greater predicted strains would increase accordingly. It is expected, however, that any impacts would still be of a minor nature and easily repairable. With these remediation measures in place, it is unlikely that there would be a significant impact on the concrete pavements.

5.33. General Predictions and Other Potential Impacts

The following sections provide general predictions and discuss other potential impacts resulting from the extraction of the proposed longwalls.

5.33.1. Predicted Horizontal Movements

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

The maximum predicted systematic tilt within the SMP Area, at any time during or after the extraction of the proposed longwalls, is 6.0 mm/m, which occurs above the maingate of Longwall 36. This area will experience the greatest predicted systematic horizontal movement towards the centre of the overall goaf area resulting from the extraction of the proposed longwalls. The maximum predicted systematic horizontal movement is, therefore, approximately 90 mm, ie: 6.0 mm/m multiplied by a factor of 15.

Systematic horizontal movements do not directly impact on natural features or items of surface infrastructure, rather impacts occur as the result of differential horizontal movements. Systematic strain is the rate of change of systematic horizontal movement. The impacts of systematic strain on the natural features and items of surface infrastructure are addressed in impact assessments for each feature, which are provided in Sections 5.2 to 5.32.

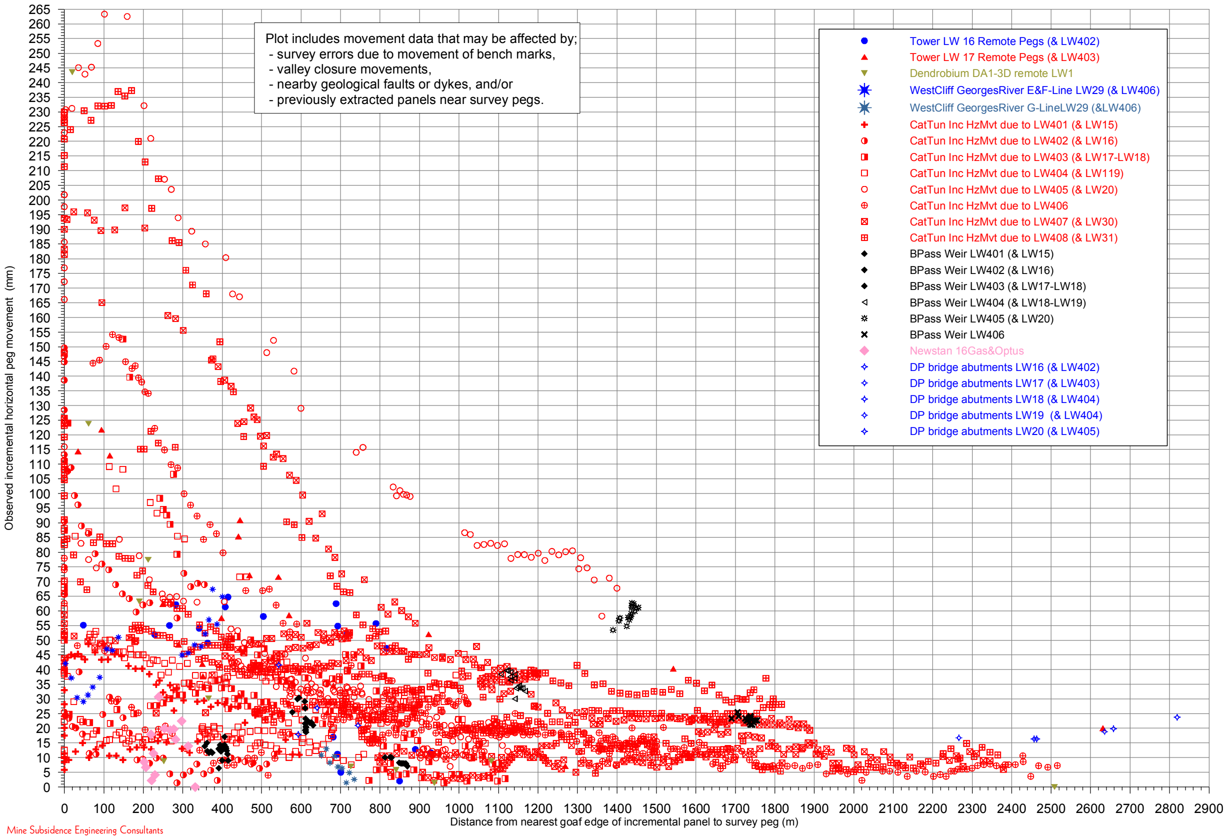
5.33.2. Predicted Far-Field Horizontal Movements

In addition to the systematic movements that have been predicted above and adjacent to the proposed longwalls and the predicted valley related movements along the rivers and drainage lines, it is also likely that some far-field horizontal movements will also be experienced during the extraction of these longwalls.

Far-field horizontal movements result from the redistribution of horizontal in situ stress in the strata around the extracted voids and the collapsed zones above the extracted voids. Such movements are, to some extent, predictable and occur whenever significant excavations occur at the surface or underground.

An empirical database of observed incremental far-field horizontal movements has been compiled using monitoring data primarily from the Southern Coalfield, from Collieries including Appin, Bellambi, Dendrobium, Newstan, Tower and West Cliff. The far-field horizontal movements resulting from longwall mining were generally observed to be orientated towards the extracted longwalls. At very low levels of far-field horizontal movements, however, there was a high scatter in the orientation of the observed movements.

The observed incremental far-field horizontal movements, resulting from the extraction of a single longwall for all monitoring points within the database, is provided in Fig. 5.12. The observed incremental far-field horizontal movements, resulting from the extraction of a single longwall for monitoring points within the database only where there was solid coal between the longwalls and the monitoring points, is provided in Fig. 5.13.



Plot includes movement data that may be affected by;
- survey errors due to movement of bench marks,
- valley closure movements,
- nearby geological faults or dykes, and/or
- previously extracted panels near survey pegs.

Fig. 5.12 Observed Incremental Far-Field Horizontal Movements

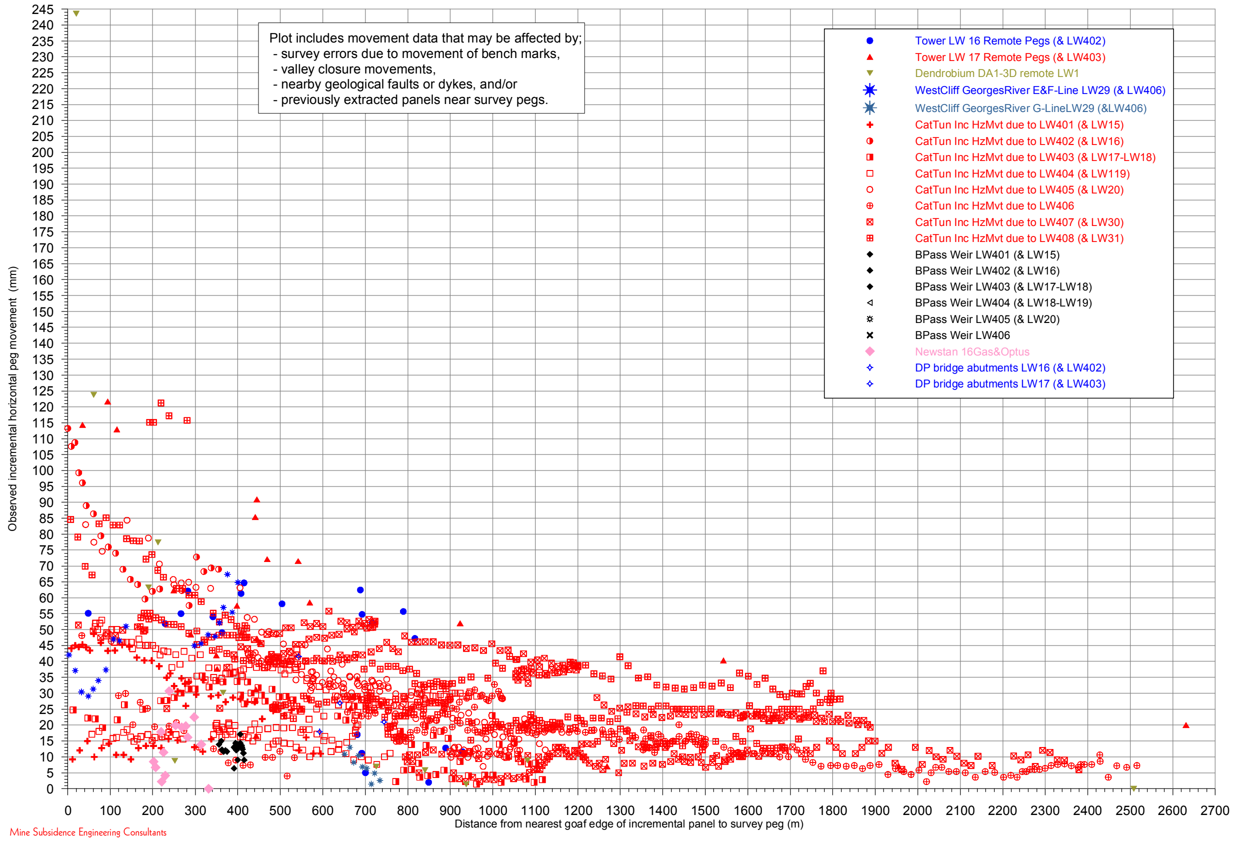


Fig. 5.13 Observed Incremental Far-Field Horizontal Movements with Solid Coal between the Monitoring Points and Mined Longwalls

It can be seen from these figures, that incremental far-field horizontal movements of up to 20 mm have been observed at distances of 2000 metres from extracted longwalls. It should be noted, however, that at the larger distances from the longwall extractions, the measured movements contain larger proportions of survey error, in addition to valley related closure movements and movements along geological anomalies.

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

The predicted far-field horizontal movements resulting from the extraction of the proposed longwalls are very small and could only be detected by precise surveys. Such movements tend to be bodily movements towards the extracted goaf area and are accompanied by very low levels of strain, which are generally less than 0.1 mm/m. The impacts of far-field horizontal movements on the natural features and items of surface infrastructure within the vicinity of the SMP Area are not expected to be significant.

5.33.3. Likely Height of the Fractured Zone above the Proposed Longwalls

The background to sub-surface strata movements is provided in the report entitled *General Discussion on Mine Subsidence Ground Movements* which can be obtained from *www.minesubsidence.com* and the following conclusions should be read in that context.

The height of the fractured zone is dependent upon the angle of break (a), the width of the panel (W) and the spanning capacity of a competent stratum at the top of the fractured zone, span (w). These are illustrated in Fig. 5.14. From the mining geometry it can be shown that the height of the fractured zone equals the panel width (W) minus the span (w) divided by twice the tangent of the angle of break.

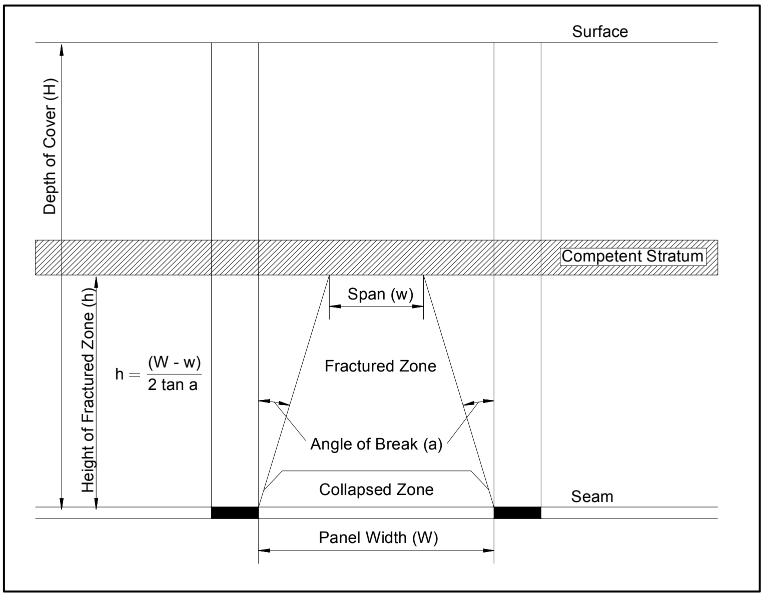


Fig. 5.14 Theoretical Model Illustrating the Development and Limit of the Fractured Zone

Using this relationship, the theoretical height of the fractured zone, as a proportion of the width of the extracted panel, has been determined for a range of panel width-to-depth ratios. These values have been plotted in the graph shown in Fig. 5.15, together with the values that have been reported in literature. The red data points are those which have been reported in literature whilst the theoretical values are shown in green, magenta and blue for angles of break of 17, 20 and 23 degrees, respectively.

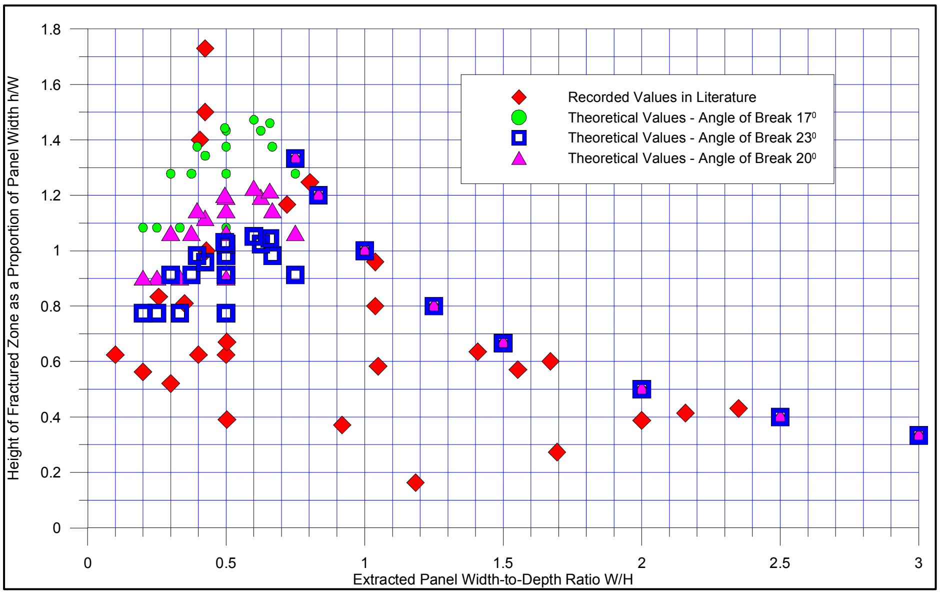


Fig. 5.15 Graph Showing the Height of the Fractured Zone as a Proportion of Panel Width for Different Width-to-Depth Ratios

It can be seen from the above figure that the height of the fractured zone in the database is reasonably represented by the theoretical model using an angle of break of 20 degrees. Only three red data points appear above the magenta data points and these are the heights of the fractured zone over Longwall 2 at Ellalong Colliery and over Longwall 3 at Tahmoor Colliery, which were given by Holla (1986) and Holla and Buizen (1991).

In both of these cases, the apparent heights of the fractured zones were determined from extensometer readings which could have included horizontal shear as well as vertical dilation. The stated heights of the fractured zone at Tahmoor, which are the highest data points in the graph, are not supported by the measured vertical strains, which averaged only 0.6 mm/m in the top 160 metres of the overburden. A more realistic assessment is that the fractured zone extended only to the Bald Hill Claystone.

In some cases, it is likely that the upwards progression of the fractured zone was limited by the levels of vertical strain that could be developed, which is dependent upon the extracted seam thickness, the surface subsidence and the depth of cover.

The proposed Longwalls 34 to 36 have width-to-depth ratios of around 0.6, which are well represented by the theoretical model using an angle of break of 20 degrees. It can be seen from Fig. 5.15, that there are no observed red data points above the predicted magenta data points for width-to-depth ratios greater than 0.6.

The upper limit of the fractured zone will be reached when the strata above that zone are sufficiently strong to span the goaf area without significant bending or shear strains being developed. In the Southern Coalfield, the upper layers of the overburden strata are relatively strong units in the Hawkesbury and Bulgo Sandstones which would be expected to be capable of spanning at least 30 metres.

If an average angle of break of 20 degrees is assumed, with a proposed longwall width of 305 metres, then a height of 380 metres would be required above the seam to reduce the effective span to 30 metres. If an angle of break of 23 degrees is assumed, then a height of 325 metres would be required above the seam to reduce the effective span to 30 metres. The height of the fractured zone above the proposed Longwalls 34 to 36 is, therefore, between 325 and 380 metres above seam level.

The major claystone unit within the SMP Area is the Bald Hill Claystone, which lies above the Bulgo Sandstone at the base of the Hawkesbury Sandstone. This claystone varies in thickness and is, in some places, more than 25 metres thick. Due to the nature of this claystone, which swells when it is wetted, it tends to act as an aquiclude.

It is possible, therefore, that the height of the fractured zone above the proposed longwalls could extend up to the Bald Hill Claystone, which lies approximately 270 metres above the base of the Bulli Seam. Some vertical dilation above the Bald Hill Claystone and below the Hawkesbury Sandstone is possible but this would not necessarily increase the vertical permeability through the Bald Hill Claystone, which is expected to continue to respond as an aquiclude.

The depths of cover directly above the proposed longwalls varies between 470 metres and 540 metres, which are greater than the predicted height of the fractured zone. It is expected, therefore, that a *Constrained Zone*, also called a *Continuous Deformation Zone*, would occur between the fractured zone and the surface, which is illustrated in Fig. 5.16 and Fig. 5.17.

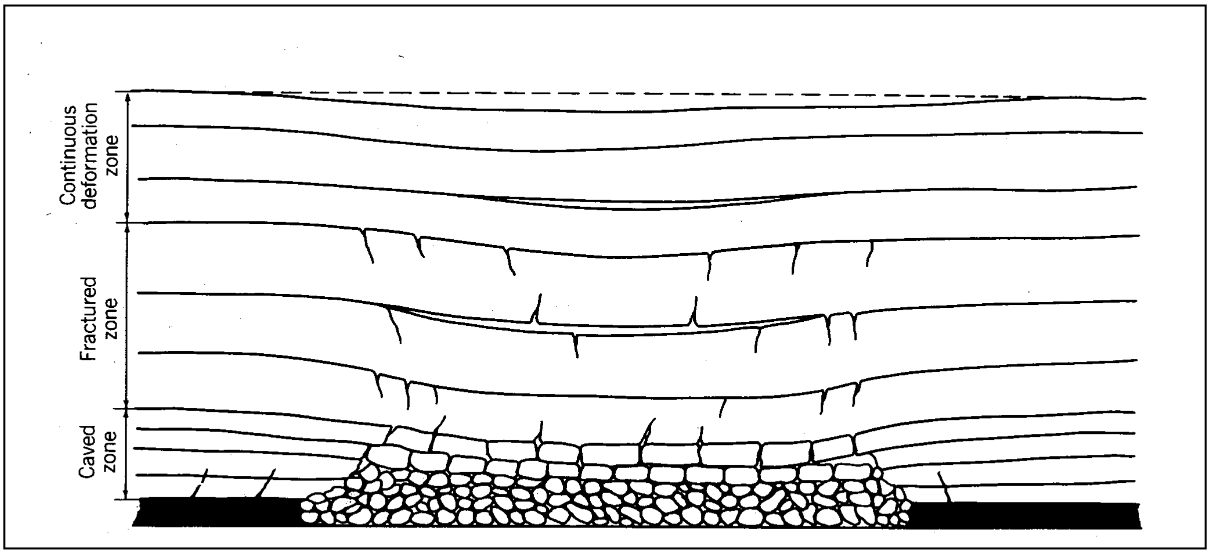


Fig. 5.16 Zones in the Overburden According to Peng and Chiang (1984)

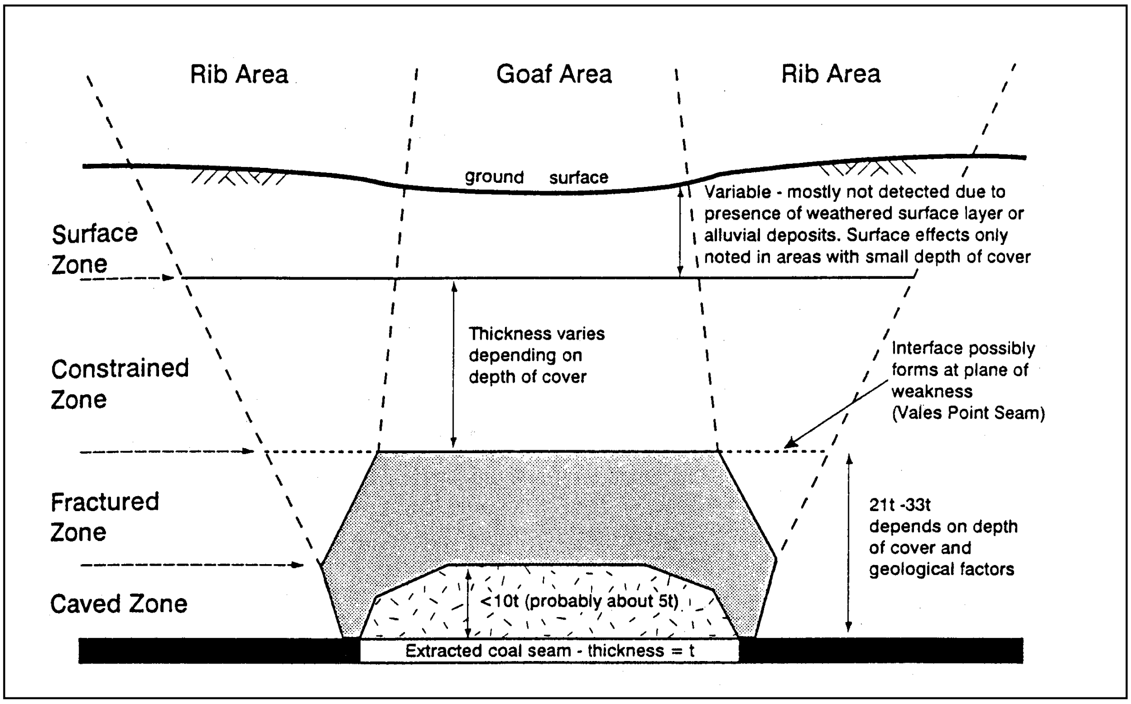


Fig. 5.17 Zones in the Overburden according to Forster (1995)

The constrained zone comprises confined rock strata which have sagged slightly but, because they are constrained, have absorbed most of the strain energy without suffering significant fracturing or alteration to the original physical properties. Some bed separation or slippage can be present, as well as discontinuous vertical cracks, usually on the underside of thick strong beds. Weak or soft beds in this zone may suffer plastic deformation.

Further details on sub-surface strata movements are provided in the background report entitled *General Discussion on Mine Subsidence Ground Movements* which can be obtained at *www.minesubsidence.com*.

5.33.4. The Likelihood of Irregular Profiles

Wherever faults, dykes and abrupt changes in geology are present at the surface, it is possible that irregularities in the subsidence profiles could occur. Similarly, where surface rocks are thinly bedded, and where cross-bedded strata exist close to the surface, it is possible for surface buckling to occur, leading to irregular movements. By far the greatest number of irregularities in subsidence profiles, however, can be explained by the presence of surface incisions such as gorges, river valleys and creeks.

The geological structures which have been identified at seam level are shown in Drawing No. MSEC326-06. The geological features within the SMP Area include the minor faulting zone, which crosses near the mid-lengths of Longwalls 34 to 36, and the series of faults located to the north of Longwall 36. It is not expected that any significant irregular subsidence movements would occur as a result of these features.

It is possible that anomalous movements could occur as a result of the extraction of the proposed longwalls, as these have occurred in the past in the Southern Coalfield. Given the relatively low density of surface features within the SMP Area, the probability of an anomalous movement coinciding with a surface feature sensitive to these movements is assessed as low. Further details on anomalous movements are provided in the background report entitled *General Discussion on Mine Subsidence Ground Movements* which can be obtained from *www.minesubsidence.com*.

Irregularities also occur in shallow mining situations, where the collapsed zone, above the extracted seam, extends all the way to the surface. This type of irregularity is generally only seen where the depth of cover is less than 100 metres, which does not occur above the proposed longwalls.

Irregular profiles can also occur where longwall mining is carried out beneath previous workings such as bord and pillar extractions. In such situations, the stooks left in the upper seam can collapse, when mining occurs beneath them, leading to localised subsidence and irregular subsidence profiles. There are no earlier workings above the proposed longwalls and this kind of irregularity will not occur in this case.

5.33.5. The Likelihood of Surface Cracking in Soils and Fracturing of Bedrock

As subsidence occurs, surface cracks will generally appear in the tensile zone, ie: within 0.1 to 0.4 times the depth of cover from the longwall perimeters. Most of the cracks will occur within a radius of approximately 0.1 times the depth of cover from the longwall perimeters. The cracks will generally be parallel to the longitudinal edges of the longwalls.

It is also possible that surface cracks could occur above and parallel to the moving longwall extraction faces, ie: at right angles to the longitudinal edges of the longwalls, as the subsidence trough develops. This cracking is, however, likely to be transient, since the tensile phase, which causes the cracks to open up, is generally followed by a compressive phase, that partially closes them.

Fracturing of exposed sandstone or near surface bedrock is likely to occur coincident with the maximum tensile strains, but open fractures could also occur due to buckling of surface beds that are subject to compressive strains. Fracture widths tend to increase as the depth of cover reduces and only minor fracturing is expected above the proposed longwalls, where the depths of cover vary between 470 and 540 metres.

Fractures are less likely to be observed in exposed bedrock where tensile strain levels are low, typically less than 2 mm/m, as has been predicted within the SMP Area. A joint spacing of ten metres is not unusual for Hawkesbury Sandstone and, therefore, fractures at the existing joints could be as wide as 10 mm, based the maximum predicted systematic tensile strain of 1.1 mm/m resulting from the extraction of the proposed longwalls.

The incidence of cracks on the surface due to mine subsidence is additionally dependent on the thickness and inherent plasticity of the soils that overlie the bedrock. Surface soils above the proposed longwalls have been derived from the Hawkesbury Sandstone and from the Wianamatta Group, which can be inferred from Fig. 1.3, and are weathered to some degree.

The widths and frequencies of any cracks at the surface are also dependent upon the pre-existing jointing patterns in the bedrock. Large joint spacing can lead to concentrations of strain and possibly the development of fissures at the rockhead, which are not necessarily coincident with the joints.

The relationship between the depth of cover and the width of surface cracking in relatively flat terrain, based upon measured data from the NSW Coalfields and observations over mines in the United Kingdom, is shown in Fig. 5.18. The line on the graph represents the conservative limit of the data in relatively flat terrain.

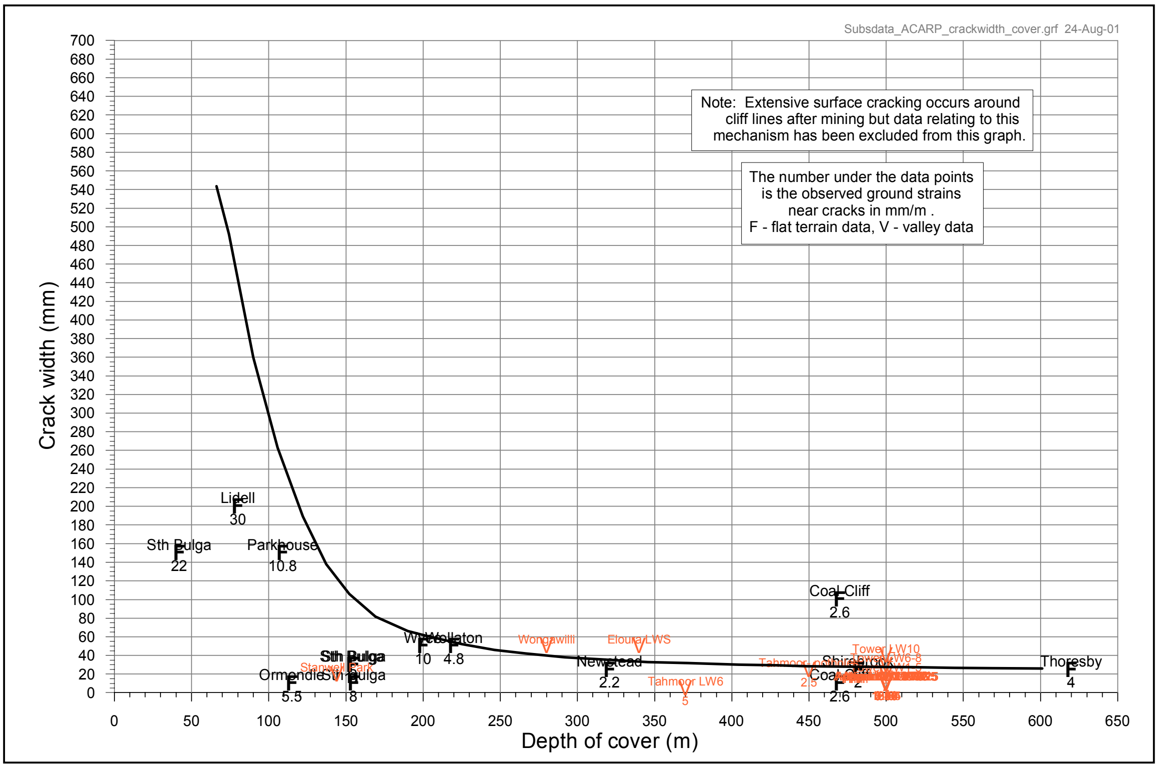


Fig. 5.18 Relationship between Crack Width and Depth of Cover

It can be seen from the above figure, that at a depth of cover of 500 metres in relatively flat terrain, the maximum crack width in the surface soils, resulting from normal systematic subsidence movements, would generally be expected to be in the order of 25 mm. If a reasonable thickness of surface soil exists, it is more likely that the surface soil would exhibit a number of narrower cracks, rather than a single larger crack.

Surface cracking in soils as the result of systematic subsidence movements is not commonly seen at depths of cover greater than 500 metres, such as at West Cliff Colliery, and any cracking that has been observed has generally been isolated and of a minor nature. Any significant cracking in the surface soils could be easily remediated, where required, by infilling with soil or other suitable materials, or by locally regrading and recompacting the surface.

It is also likely that some cracking would also occur along the alignments of the watercourses as a result of valley related upsidence and closure movements. Discussions on the likelihood and extent of cracking along the river and drainage lines within the SMP Area are provided in Sections 5.2 to 5.4.

Further discussion on surface cracking is provided in the background report entitled *General Discussion on Mine Subsidence Ground Movements* which can be obtained at *www.minesubsidence.com*.

5.33.6. The Likelihood of Gas Emissions at the Surface

It is known that the mining of coal causes fracturing of the strata above the coal seam and this may result in the liberation of methane and other gases. Methane, being a lighter gas, would tend to move upwards to fill the voids in the rock mass and diffuse towards the surface through any continuous cracks or fissures.

Some strata, however, have lower permeability and are able to act as barriers to water and gas movements. One such barrier is the Bald Hill Claystone, which separates the Hawkesbury and Bulgo Sandstones and inhibits the movement of water and gas.

If the claystone were to be fractured by subsidence of the strata it is possible that some gas and/or water could move upwards through the cracks. It is also possible that water could move downwards through the cracks, but an increase in moisture content of the claystone would cause it to swell and seal off the cracks, thus inhibiting further gas or water movements.

Gas emissions at the surface have typically occurred within river valleys such as the Georges, Nepean and Cataract Rivers, although some gas emissions have also been observed in smaller creeks and in water bores. Analyses of gas compositions indicate that the coal seam is not the direct and major source of the gas and that the most likely source is the Hawkesbury Sandstone (APCRC, 1997).

Gas emissions from the beds of rivers and drainage lines will not have time to dissolve in surface water which is present. In addition to this, gas emissions as the result of mining comprises mainly of methane which is not significantly soluble in water. The gas emissions, therefore, are released into the atmosphere and are unlikely to have significant impacts on water quality.

It is possible, however, that substantial gas emissions at the surface could result in localised vegetation die back. This occurred at Tower Colliery over small areas in the base of the Cataract River Gorge, as a result of gas emissions directly above Longwalls 10 and 14. These impacts were limited to small areas of vegetation, local to the points of emission where composting occurred. The gas emissions have declined and the affected areas have successfully revegetated.

It should also be noted that the emission of gases at the surface tends to be short-lived temporary events and result in minor impacts that are readily managed. Further discussions on the potential impact of gas emissions of flora and fauna are provided in the report by Biosis (2007a).

5.33.7. The Potential Impacts of Ground Vibration on Structures due to Mining

The settlement of the ground resulting from systematic subsidence is generally a gradual and progressive movement, the effect of which is not apparent to an observer at the surface. The major breakage and collapse of strata into the voids left by the extraction of the seam occur in the layer immediately above the seam. Above that level, the breakage and collapse of the strata reduces to become a bending and sagging of the upper layers of rock with less sudden and much smaller movements occurring. In some instances, the movements can be concentrated at faults or other points of weakness in the strata with minor stepping at the surface.

Any major collapse below ground would result in some vibration in the layers of rock above it, which might be felt as a minor effect at the surface. This effect is generally only noticeable where the depth of cover is less than 100 metres, which does not occur above the proposed longwalls.

It is possible, therefore, as the proposed longwalls are mined and the strata subsides, for some vibrations to be felt at the surface, though these are more likely to occur directly above or close to the longwalls. The levels of vibration would, however, generally be very low and would not be of sufficient amplitude to result in a significant impact on the natural features or items of infrastructure. The impact due to vibration resulting from the extraction of the proposed longwalls is not expected to be significant.

5.33.8. The Potential for Noise at the Surface due to Mining

It would be very unusual for noise to be noticed at the surface due to longwall mining at depths greater than 100 metres. As systematic subsidence occurs and the near surface rocks are affected by tensile and compressive strains, the rocks open up at joints and planes of weakness and displace due to rotation and shear.

Generally the movements are gradual and cannot be noticed by an observer at the surface. These movements are also generally shielded by the more plastic surface soils which tend to distribute the strains more evenly and insulate against any sounds from below.

In some cases, the stresses in the rock can build up to the point that the rock suddenly shears to form a new fracture and if the rock is exposed or has only a thin covering of surface soil, the noise resulting from the fracturing can be heard at the surface. Normally the background level of noise in the countryside is high enough to ensure that the sound is not noticed, although in the stillness of night, it might occasionally be noticed when it occurs in close proximity. The impact of noise at the surface resulting from the extraction of the proposed longwalls is not expected to be significant.

5.34. Comparison of Predicted Subsidence Parameters Obtained using the Holla Series and Department's Handbook Methods

The maximum predicted systematic subsidence parameters along Prediction Line 1, obtained using the Incremental Profile Method, were compared with the maximum predicted subsidence parameters obtained using the Holla Series Method (Holla, 1988) and the Department's Handbook Method (Holla, 1985).

The Holla Series and the Department's Handbook Methods only allow the prediction of the maximum values of subsidence, tilt, curvature and strain, and do not precisely indicate where these maxima will occur. The comparisons were limited to, therefore, the maximum predicted values of each parameter over the proposed longwalls.

The overall void widths of Longwalls 34 to 36 are 305 metres and the solid chain pillar widths between each of the proposed longwalls are 42 metres. Along Prediction Line 1, the depth of cover varies between 490 and 525 metres, with an average depth of cover of 500 metres. The average seam thickness along Prediction Line 1 is 2.45 metres.

The maximum predicted systematic subsidence obtained using the Holla Series Method is determined from Figure 4 of a published paper which has been reproduced in Fig. 5.19. This figure provides the maximum predicted subsidence, as a ratio of the extracted seam thickness, for varying panel width-to-depth ratios and varying pillar width-to-depth ratios, based on critical extraction conditions.

Strictly speaking, the Department's Handbook Method is only applicable for the range of width-to-depth ratios between 0.23 and 0.45 and, therefore, does not apply to longwalls having a width-to-depth ratio of 0.6, such as for the proposed longwalls.

Based on an individual panel width-to-depth ratio of 0.6 (ie: 305 metres / 500 metres) and pillar width-to-depth ratios of 0.08 (ie: 42 metres / 500 metres), the maximum predicted subsidence obtained using Fig. 5.19 is 0.46 times the extracted seam thickness, giving a total maximum subsidence of 1125 mm. It should be noted that the maximum predicted total subsidence obtained using the Holla Series Method is based on achieving critical extraction conditions.

The maximum predicted systematic tilts and strains can be obtained using the Department's Handbook Method and are determined by multiplying various factors by the maximum predicted subsidence in millimetres and dividing the result by the depth of cover in metres. The factors for tensile strain, compressive strain and tilt are given in Figures 14, 15 and 17, respectively, of the handbook. The curvatures are determined from the strains using Figure 18 of the handbook.

In the Department's Handbook Method, the tilt and strain factors are only applicable for single panels, but, based upon the definition of width, W, in the new handbook, it appears that the factors can be used to determine the tilts and strains over a series of longwall panels, using the overall width of the series to determine the width-to-depth ratio. For a series of panels having an overall width-to-depth ratio above 1.4, ie: for critical extraction conditions, the tilt factor is 3.0, the tensile strain factor is 0.4 and the compressive strain factor is 0.9.

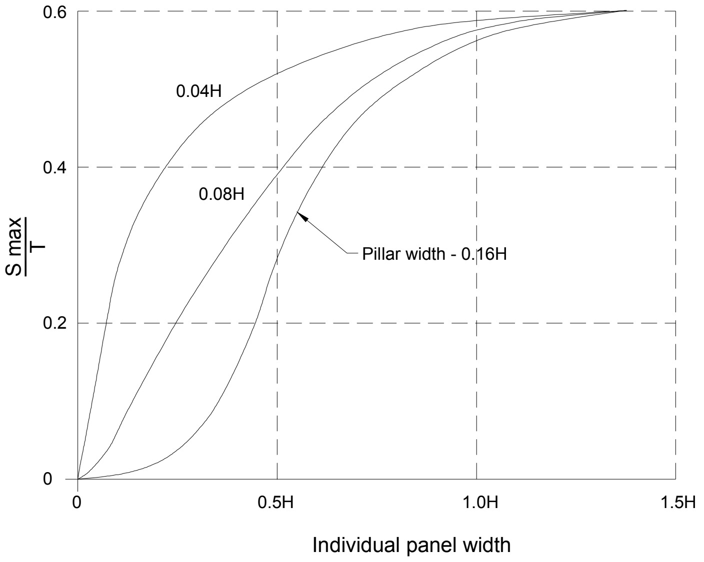


Fig. 5.19 Graph for the Prediction of Maximum Subsidence Over a Series of Panels for Critical Extraction Conditions (after Holla 1988)

The maximum predicted values of systematic subsidence, tilt, curvature and strain along Prediction Line 1 obtained using the Incremental Profile Method are compared to those obtained using the Holla Series and Department's Handbook Methods in Table 5.43.

Table 5.43 Comparison of Maximum Predicted Parameters Obtained using Alternative Methods

Predicted Parameter	Incremental Profile Method	Holla Series and the Departments Handbook Methods
Vertical Subsidence (mm)	1215	1125
Tilt (mm/m)	5.9	6.7
Hogging Curvature (1/km)	0.073	0.076
Sagging Curvature (1/km)	0.113	0.148
Tensile Strain (mm/m)	1.1	0.9
Compressive Strain (mm/m)	1.7	2.0

It can be seen from Table 5.43, that the maximum predicted systematic subsidence and tensile strain obtained using the Incremental Profile Method are similar to, but slightly greater than those obtained using the Holla Series and Department's Handbook Methods.

It can also be seen from this table, that the maximum predicted systematic tilt and compressive strain obtained using the Incremental Profile Method are similar to, but slightly less than those obtained using the Holla Series and Department's Handbook Methods.

5.35. Testing of the Incremental Profile Method against West Cliff Colliery Surveys

Using the Incremental Profile Method, subsidence predictions were made along Survey Line J, which follows the pipeline easement across the western ends of Longwalls 30 to 33 at West Cliff Colliery. The measured and predicted profiles of subsidence, strain and horizontal movement along the J-Line, after Longwall 32 had mined well beyond the pipeline easement, are shown in Fig. 5.20.

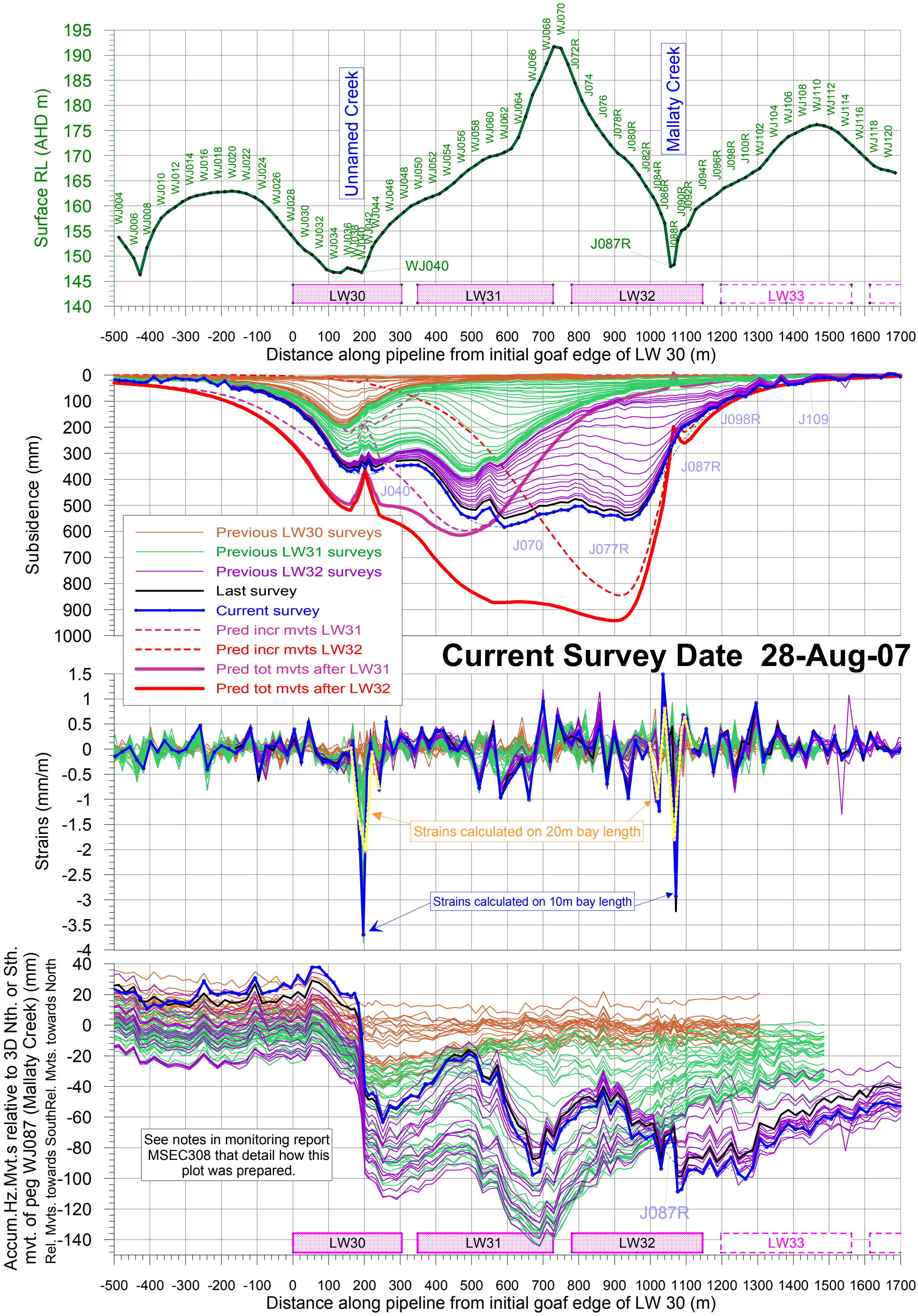


Fig. 5.20 West Cliff Colliery – J Line – Measured & Predicted Profiles

It can be seen from Fig. 5.20, that the Incremental Profile Method provided conservative predictions of subsidence along the J-Line. It can also be seen from this figure, that the ACARP method provided conservative predictions of upsidence at the Mallaty and Unnamed Creek crossings.

The maximum predicted systematic tensile and compressive strains along the pipeline easement, obtained using the Incremental Profile Method, were 0.6 mm/m and 1.2 mm/m, respectively, after the extraction of Longwall 32. The peak observed compressive strains at the Mallaty and Unnamed Creek crossings were the result of valley closure movements which were predicted. Elsewhere, the maximum observed strains along the J-Line were generally less than the maximum predicted strains.

5.36. Testing of the Incremental Profile Method against Appin and Tower Colliery Surveys

Using the Incremental Profile Method, subsidence predictions were made along Survey Line A, which crosses transversely over the previously mined Longwalls 21B to 28 at Appin Colliery. The measured and predicted incremental and total subsidence profiles along Line A are plotted in Fig. 5.21. It can be seen that a good correlation between the final predicted and final measured subsidence profiles was achieved.

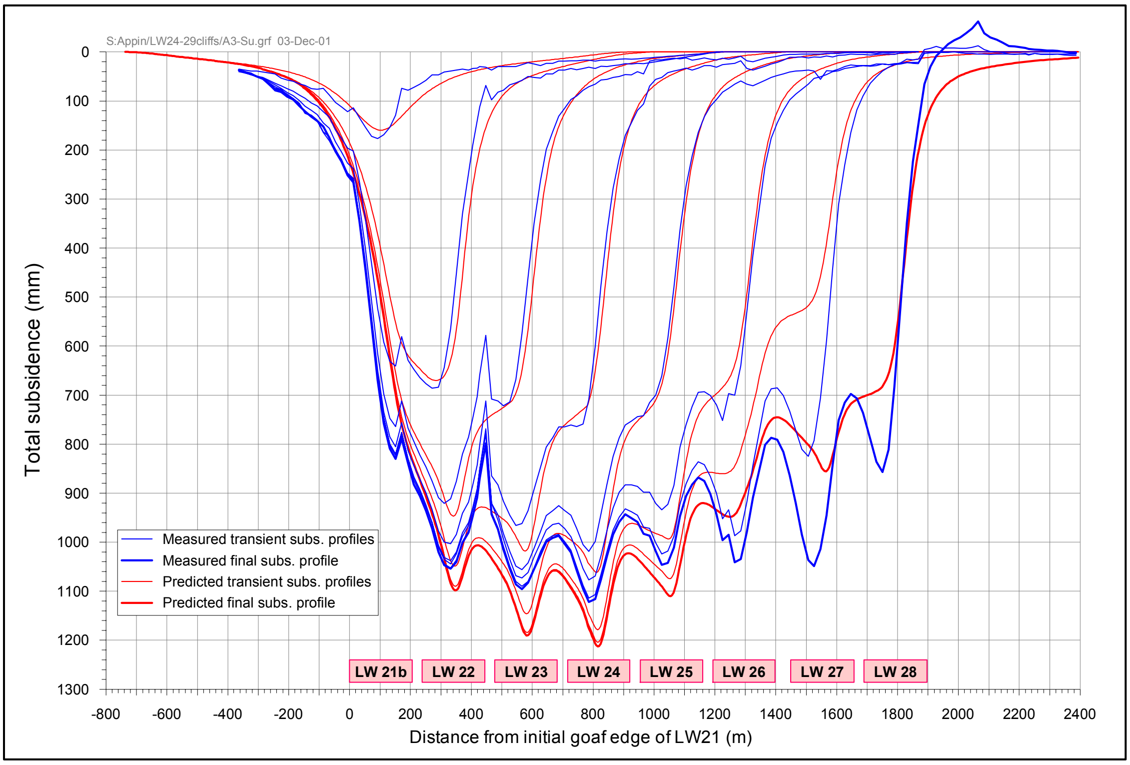


Fig. 5.21 Appin Colliery – A Line – Measured & Predicted Profiles

It is noticeable that the measured incremental subsidence over Longwall 28 was much greater than over previous longwalls in the series and higher than predicted. This increase in subsidence is apparently due to the presence of significant faulting in the strata above this longwall. The upsidence in the final subsidence profile over the advancing edge of Longwall 28 is due to the presence of a local creek, which runs alongside the survey line, at right angles to the longwall centreline.

Subsidence predictions were also made along the irregular TG Line at Tower Colliery. The measured and predicted subsidence profiles after mining Longwall 16 at Tower Colliery are plotted in Fig. 5.22. In both cases, the predicted and observed subsidence and tilt profiles were in reasonably close agreement, though the predicted and observed curvatures showed greater divergence due to scatter in the measured data, which was caused by buckling of near-surface strata.

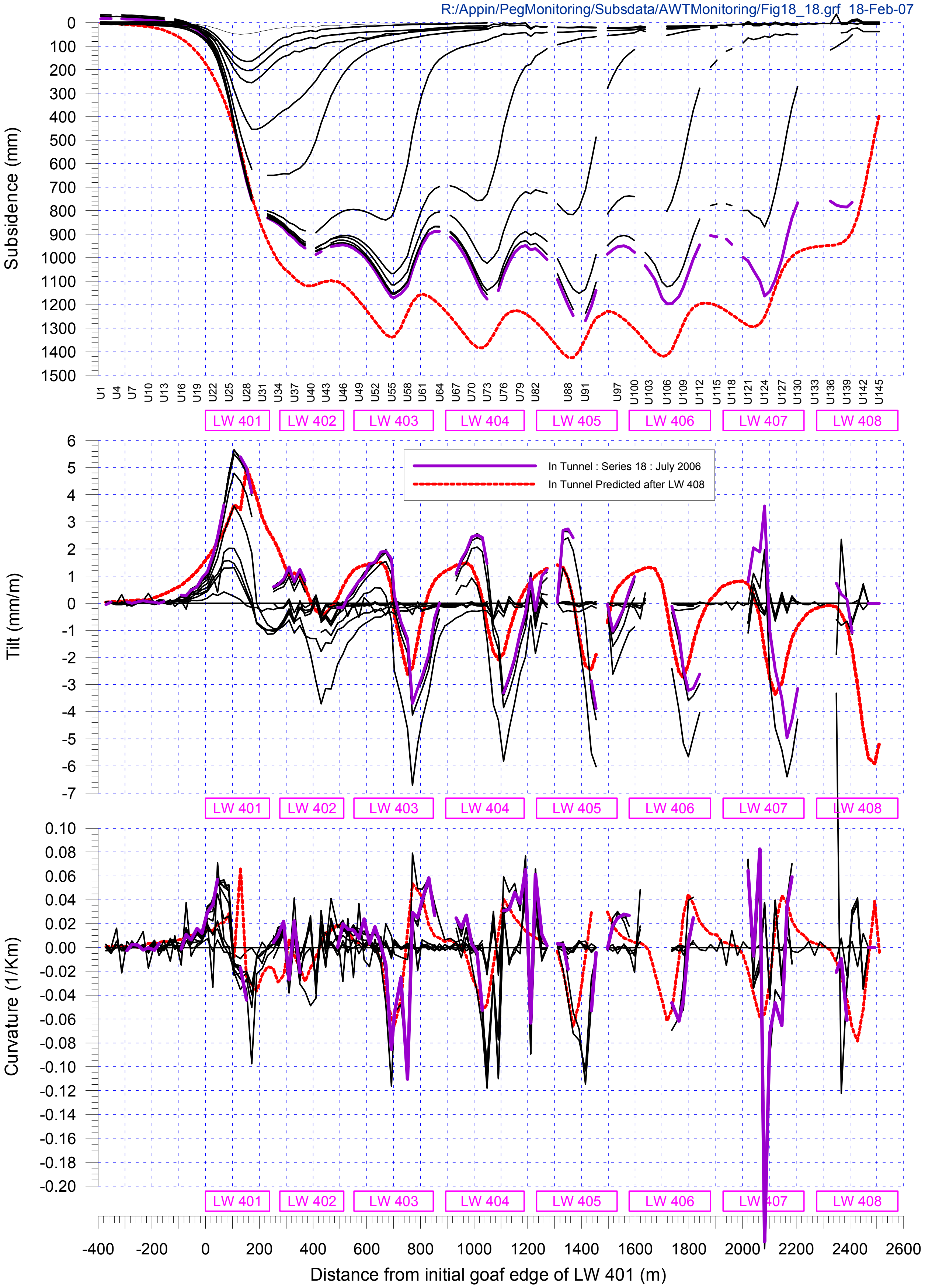


Fig. 5.22 Tower Colliery – TG curved line – Predicted & Observed Profiles

It can be seen that the Incremental Profile Method compares reasonably well with observed subsidence profiles at Appin and Tower Collieries, and it is anticipated that it will also provide reasonable results for the proposed longwalls at the West Cliff Colliery.

5.37. Estimation of the Reliability of the Subsidence Predictions

The Incremental Profile Method is based upon a large database of observed subsidence movements in the Southern Coalfield and has been found to give good, if rather conservative results in most cases. An additional factor of safety has been added to the predictions at isolated features as discussed in Section 5.1.

As indicated in Sections 5.35 and 5.36, the predicted subsidence movements obtained using the Incremental Profile Method for Longwalls 30 to 32 at West Cliff Colliery and for the nearby longwalls at Appin and Tower Collieries, have shown a reasonable correlation with the measured movements over those longwalls. It should also be noted, as discussed in Section 5.34, that the maximum predicted subsidence parameters obtained using the Incremental Profile Method are similar to those obtained using the Holla Series and Department's Handbook Methods.

The Incremental Profile Method should, therefore, provide realistic and possibly conservative predictions of subsidence, tilt, curvature and strain for the proposed longwalls. The predicted profiles obtained using this method also reflect the way in which each parameter varies over the mined area and indicate the movements that are likely to occur at any point on the surface.

It is likely, however, that the predicted systematic tilts, curvatures and strains will be exceeded at the watercourses, as a result of valley related movements, which is discussed in Sections 5.2 to 5.4. The predicted net vertical movements, due to the addition of subsidence plus upsidence movements, and the compressive strains due to valley closure movements along the alignments of the watercourses are provided and discussed in these sections.

It is also possible that localised irregularities could occur elsewhere in the subsidence profiles, which is discussed in Section 5.33.4. Elsewhere, it is reasonable to assume that any significant irregularities or anomalies in the subsidence profiles would be relatively infrequent occurrences.

Empirical methods of subsidence prediction are generally accepted as providing predictions of maximum subsidence to an accuracy of ±10 % to ±15 %. It was indicated by Dr Lax Holla (1991), in his paper entitled, "Reliability of Subsidence Prediction Methods for use in Mining Decisions in New South Wales", that the accuracy of predictions of maximum subsidence, made using the Department's Empirical Method, generally ranged from +8 % to -11 %. Of the 14 examples, referred to in the paper, from longwalls at seven different collieries in the Southern and Newcastle Coalfields, the predicted maximum subsidence was less than the measured maximum subsidence in only four cases. Where empirical models have been calibrated to local data, even greater accuracies have been found to be possible in predicting the maximum values of the subsidence parameters.

The prediction of systematic subsidence parameters at a specific point is more difficult, but, based upon a large number of comparative analyses, it has been concluded that the vertical subsidence predictions for single seam extractions, obtained using the Incremental Profile Method, should generally be conservative where the geology is consistent and the model has been calibrated to local data. Where subsidence is predicted at points beyond the goaf edge, which are likely to experience very low values of subsidence, the predictions should generally be accurate to within 50 mm of subsidence.

The systematic tilts can be predicted to the same level of accuracy as subsidence, but the measured curvatures and strains can vary considerably from the predicted systematic values for the following reasons:-

- Variations in local geology can affect the way in which the near surface rocks are displaced as subsidence occurs. In the compression zone, the surface strata can buckle upwards or can fail by shearing and sliding over their neighbours. If localised cross bedding exists, this shearing can occur at relatively low values of stress. This can result in fluctuations in the local strains, which can range from tensile to compressive. In the tensile zone, existing joints can be opened up and new fractures can be formed at random, leading to localised concentrations of tensile strain.
- Where a thick surface layer of soil, clay or rock exists, the underlying movements in the bedrock are often transferred to the surface at reduced levels and the measured strains are, therefore, more evenly distributed and hence more systematic in nature than they would be if they were measured at rockhead.
- Strain measurements can sometimes give a false impression of the state of stress in the ground. For example:
  - buckling of the near-surface strata can result in localised cracking and apparent tensile strain in areas where overall, the ground is in fact being compressed, because the actual values of the measured strains are dependent on the locations of the survey pegs.
  - where joints open up or cracks develop in the tensile phase and fail to close in the compressive phase, as they sometimes do if they are subsequently filled, the ground can appear to be in tension when it is actually in compression.
- Sometimes, survey errors can also affect the measured strain values and these can result from movement in the benchmarks, inaccurate instrument readings, or disturbed survey pegs. In these circumstances it is not surprising that the predicted systematic strain at a point does not match the measured strain.
- In sandstone dominated environments, much of the earlier ground movements can be concentrated at the existing natural joints, which have been found to be at an average spacing of 7 to 15 metres.

It is also recognised that the ground movements above a longwall panel can be affected by the gradient of the coal seam, the direction of mining and the presence of faults and dykes within the panel, which can cause a lateral shift in the subsidence profile. The assessments at isolated features have, therefore, been based upon the highest predicted values of subsidence, tilt, curvature and strain within a radius of 20 metres of each feature, rather than the predicted values at the points.

A comparative analysis along the line of the Cataract Tunnel over Longwalls 401 to 403 at Appin Colliery revealed that the predicted strains at points along the surface over a length of 1.1 kilometres were exceeded in only eight locations. At six of these locations, the measured strain in a particular bay was immediately preceded or followed by a strain of equal amplitude, but of opposite sign, in the adjoining bay.

The two highest values of measured strain were 1.9 mm/m, tensile, and 2.1 mm/m, compressive, but all other strains were within the range 1.2 mm/m, tensile, to 1.4 mm/m, compressive. In five out of the eight locations, the measured strains exceeded the maximum predicted values. In many locations, the measured strains at particular points were less than predicted.

The prediction of strain at a point must be considered within an appropriate confidence interval, but the Incremental Profile Method approach does allow a more realistic assessment of the subsidence impacts to be made. An assessment based upon applying the maximum predicted strains at every point would be overly conservative and would yield an excessively overstated assessment of the potential subsidence impacts.

5.38. Estimation of the Reliability of Upsidence and Closure Predictions

It should be noted that the development of the predictive methods for upsidence and closure are the result of recent research and the methods do not, at this stage, have the same confidence level as systematic subsidence prediction techniques. As further case histories are studied, the methods will be improved, but it can be used in the meantime, so long as suitable factors of safety are applied. This is particularly important where the predicted levels of movement are small and the potential errors, expressed as percentages, can be higher.

Whilst the major factors that determine the levels of upsidence and closure movements have been identified, there are some factors that are difficult to isolate. One factor that is thought to influence the upsidence and closure movements is the level of in-situ horizontal stress that exists within the strata. In-situ stresses are difficult to obtain and not regularly measured and the limited availability of data makes it difficult to be definitive about the influence of the in-situ stress on the upsidence and closure values. The methods are, however, based predominantly upon the measured data from Tower Colliery, where the in-situ stresses are high. It is expected, therefore, that the method will tend to over-predict the movements in areas of lower stress.

It should be noted, that the method used to predict the upsidence and closure movements for the proposed longwalls was not adjusted for any local changes in the geology within the beds of the watercourses. The database for upsidence and closure is mainly based on rivers and creeks which predominantly have sandstone beds. It has been observed where rivers and creeks are founded on thinly bedded shales, the observed closure is higher and the observed upsidence is smaller than what would be predicted using the upsidence and closure model.

A review has been undertaken on the available observed upsidence and closure movements at locations within the Georges River, Cataract River, Nepean River and the Bargo River against the predictions made using the revised upsidence and closure prediction curves. Details are provided in the background report entitled *Estimation of the Reliability of Upsidence and Closure Predictions* which can be obtained from *www.minesubsidence.com*.

CHAPTER 6. RECOMMENDED GROUND MONITORING

6.1. Objectives of Ground Monitoring

The objectives of a ground monitoring program are envisaged as follows:-

- Provide general information on the magnitude and extent of subsidence over the longwall panels,
- Compare actual ground movements with predicted ground movements,
- Monitor ground movements at or near surface infrastructure at greater risk,
- Provide an indication of any non-systematic movements within the subsidence zone, however, given the low density of surface features above the longwalls, the risk of adverse impacts from non-systematic movements (ie: anomalies) is very low. If the density was high, the purpose would be to provide early detection,
- Satisfy the objectives of the Subsidence Management Plan,
- Satisfy the objectives of agreed management plans between IC and infrastructure owners, and
- Meet the expectations of the community with regard to monitoring subsidence.

It should be noted that ground monitoring is only one part of an overall management strategy. Other forms of monitoring include visual monitoring and specific monitoring related to items of infrastructure. It has often been found that these other forms of monitoring are more effective in identifying impacts than traditional ground movement monitoring.

6.2. Recommended Ground Movement Monitoring for the Proposed Longwalls

The locations of recommended ground monitoring lines are shown in Drawing No. MSEC326-32. These are described briefly below:-

- **1200 mm Diameter Water Main**
  It is recommended that the existing survey line along the 1200 mm diameter water main be extended over Longwalls 34 to 36 and is monitored during the extraction of these longwalls. The timing and frequency of ground monitoring should be determined in consultation with United Utilities.
- **Gas Pipelines**
  It is recommended that the existing survey lines along the Alinta EGP and AGN Natural Gas Pipelines and along the Gorodok Ethane Pipeline be extended over Longwalls 34 to 36 and are monitored during the extraction of these longwalls. The timing and frequency of ground monitoring should be determined in consultation with Alinta and Gorodok.
- **330 kV Transmission Line**
  It is recommended that the existing monitoring points at towers along the 330 kV transmission line be extended to the towers above Longwalls 34 to 36 and are monitored during the extraction of these longwalls. The timing and frequency of ground monitoring should be determined in consultation with TransGrid.
- **Optical Fibre Cable**
  It is recommended that the existing monitoring line along Appin Road be extended over Longwalls 34 to 36 and is monitored during the extraction of these longwalls. The timing and frequency of ground monitoring should be determined in consultation with Telstra.
- **The Georges River**
  It is recommended that ground movements are monitored along the Georges River. In addition to the existing E-Line, F-Line and G-Line, it is proposed that four additional monitoring lines are provided across the river, adjacent to the finishing ends of Longwalls 34 and 35, north of the maingate of Longwall 35 and at the north-eastern corner of Longwall 36.

The locations of the existing and proposed monitoring lines are shown in Drawing No. MSEC326-32.

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.
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.
Extracted seam thickness	The thickness of coal that is extracted. The extracted seam thickness is normally given as an average over the area of the panel.
Effective extracted seam thickness (T)	The extracted seam thickness modified to account for the percentage of coal left as pillars within the panel.
Face length	The width of the coalface measured across the longwall panel.
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.
Overlap adjustment factor	A factor that defines the ratio between the maximum incremental subsidence of a panel and the maximum incremental subsidence of that panel if it were the first panel in a series.
Panel	The plan area of coal extraction.
Panel length (L)	The longitudinal distance along a panel measured in the direction of (mining from the commencing rib to the finishing rib.
Panel width (Wv)	The transverse distance across a panel, usually equal to the face length plus the widths of the roadways on each side.
Panel centre line	An imaginary line drawn down the middle of the panel.
Pillar	A block of coal left unmined.
Pillar width (Wpi)	The shortest dimension of a pillar measured from the vertical edges of the coal pillar, ie: from rib to rib.

Strain	The change in the horizontal distance between two points divided by the original horizontal distance between the points.
Sub-critical area	An area of panel smaller than the critical area.
Subsidence	The vertical movement of a point on the surface of the ground as it settles above an extracted panel.
Super-critical area	An area of panel greater than the critical area.
Tilt	The difference in subsidence between two points divided by the horizontal distance between the points.
Uplift	An increase in the level of a point relative to its original position.
Upsidence	A reduction in the expected subsidence at a point, being the difference between the predicted subsidence and the subsidence actually measured.

The structure classifications used in this report are defined below:

C	Commercial
D	Dams
H1	Single storey houses with a maximum plan dimension less than 30 metres
H2	Single storey houses with a maximum plan dimension greater than 30 metres
H3	Double storey houses with a maximum plan dimension less than 30 metres
H4	Double storey houses with a maximum plan dimension greater than 30 metres
P	Pools
PA	Public amenities
PU	Public utilities
R	Other non-residential structures
T	Tanks

APPENDIX B - REFERENCES

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APPENDIX C. DEVELOPMENT OF THE LONGWALL LAYOUT

C.1. Development of the Longwall Layout

A number of variations in the layout of Longwalls 34 to 36 were considered as part of the process to develop the final mining geometry. These included variations in the locations of the ends of the longwalls relative to the Georges River. The following sections provide two examples of the longwall layouts which were considered.

C.1.1. Example 1 – Predicted Movements along the Georges River Based on Varying Offsets of All Proposed Longwalls

The first example provides the predicted systematic subsidence, valley related movements and tonnage of sterilised coal for a range of longwall offsets from the Georges River. The predicted movements along the Georges River were determined based on the river being directly mined beneath and based on longwall offsets of 0, 100, 200, 300, and 400 metres from the river. The layout of the longwalls adopted in this option is shown in Fig. C. 1.

Fig. C. 1 Longwall Layout Option Mining Directly Beneath the River and with Offsets Varying between Zero and 400 metres from the River for Longwalls 34 to 36

The predicted profiles of subsidence, upsidence and closure along the Georges River, based on each offset from the river, are shown in Fig. C. 2. A summary of the maximum predicted upsidence and closure movements anywhere along the river and the tonnage of sterilised coal for each offset are provided in Fig. C. 3.

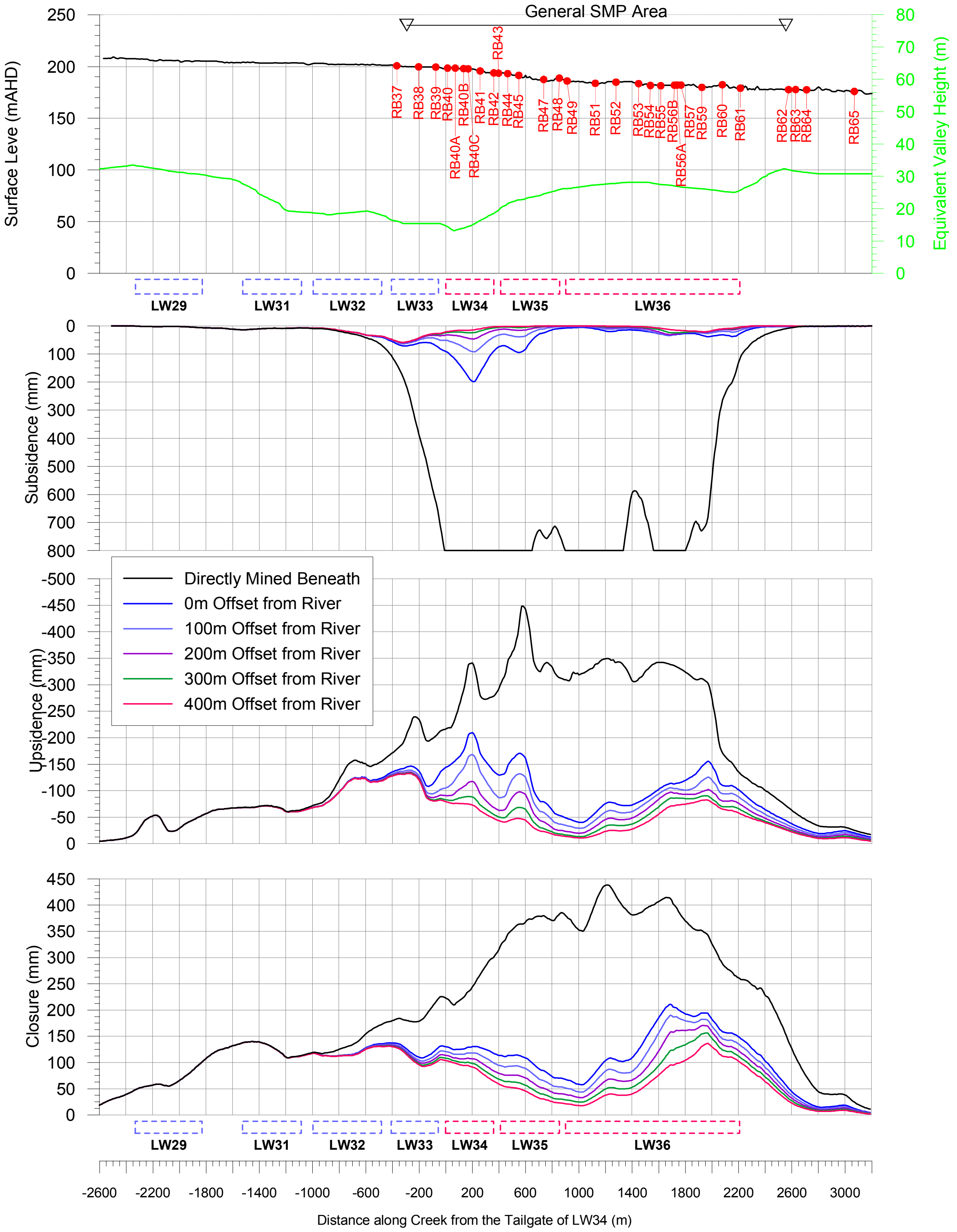


Fig. C. 2 Predicted Subsidence, Upsidence and Closure along the Georges River Based on Varying Offsets from the Georges River for Longwalls 34 to 36

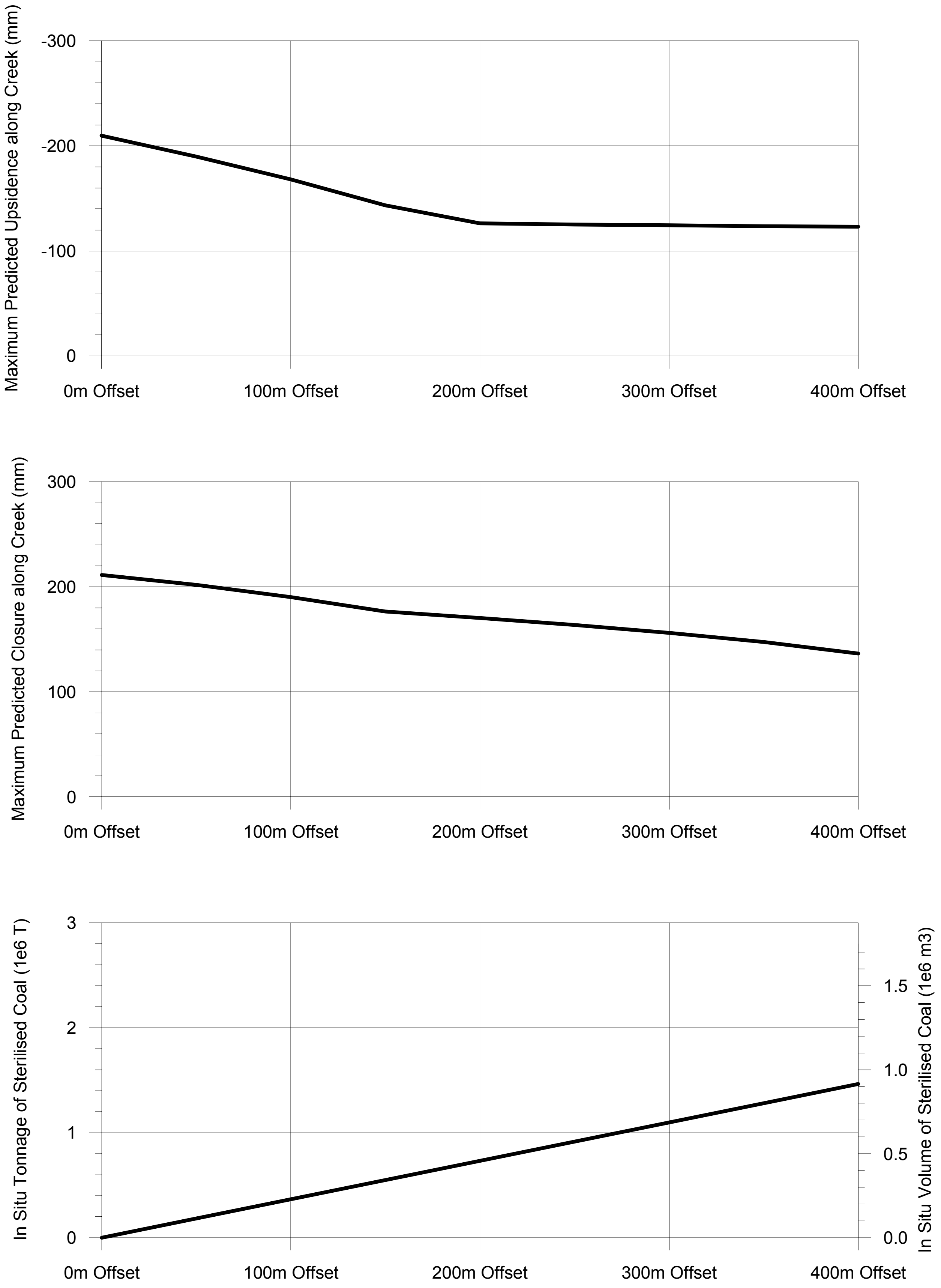


Fig. C. 3 Summary of Maximum Predicted Subsidence, Upsidence and Closure along the Georges Rivers and Tonnage of Sterilised Coal Based on Varying Offsets from the River for Longwalls 34 to 36

C.1.2. *Example 2 – Predicted Movements along the Georges River Based on Varying Offsets of Longwall 35 Only*

In the previous example, the component of closure from Longwall 35 at the location of maximum predicted closure was significantly greater the components of closure from the remaining longwalls. It was deemed more effective, therefore, to offset Longwall 35 only in order to reduce the maximum predicted closure whilst minimising the tonnage of sterilised coal.

The second example provides the predicted movements along the Georges River based on the river being directly mined beneath and based on offsets of 0, 100, 200, 300, and 400 metres from the river for Longwall 35 only. The layout of the longwalls adopted in this option is shown in Fig. C. 4.

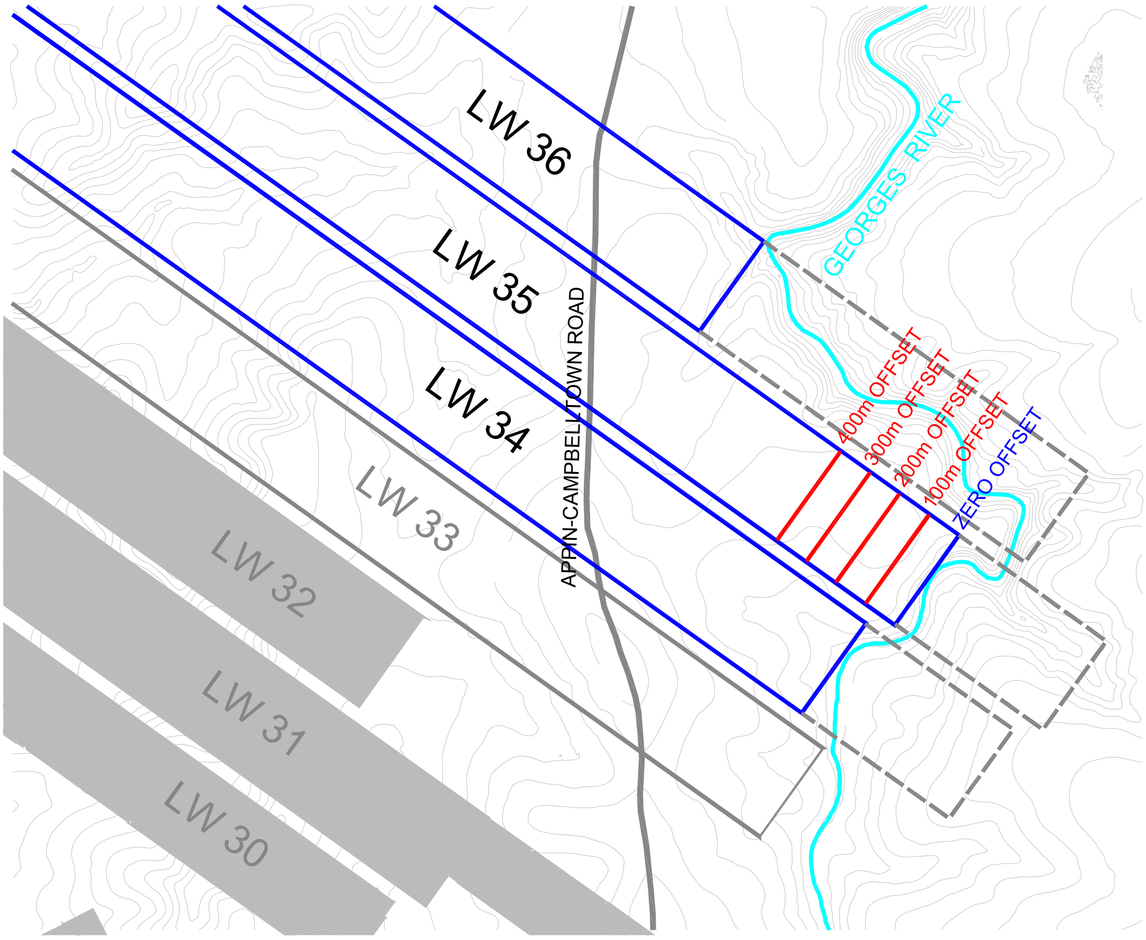


Fig. C. 4 Longwall Layout Option Mining Directly Beneath the River and with Offsets Varying between Zero and 400 metres from the River for Longwall 35 Only

The predicted profiles of subsidence, upsidence and closure along the Georges River, based on each offset from the river, are shown in Fig. C. 5. A summary of the maximum predicted upsidence and closure movements anywhere along the river and the tonnage of sterilised coal for each offset are provided in Fig. C. 6.

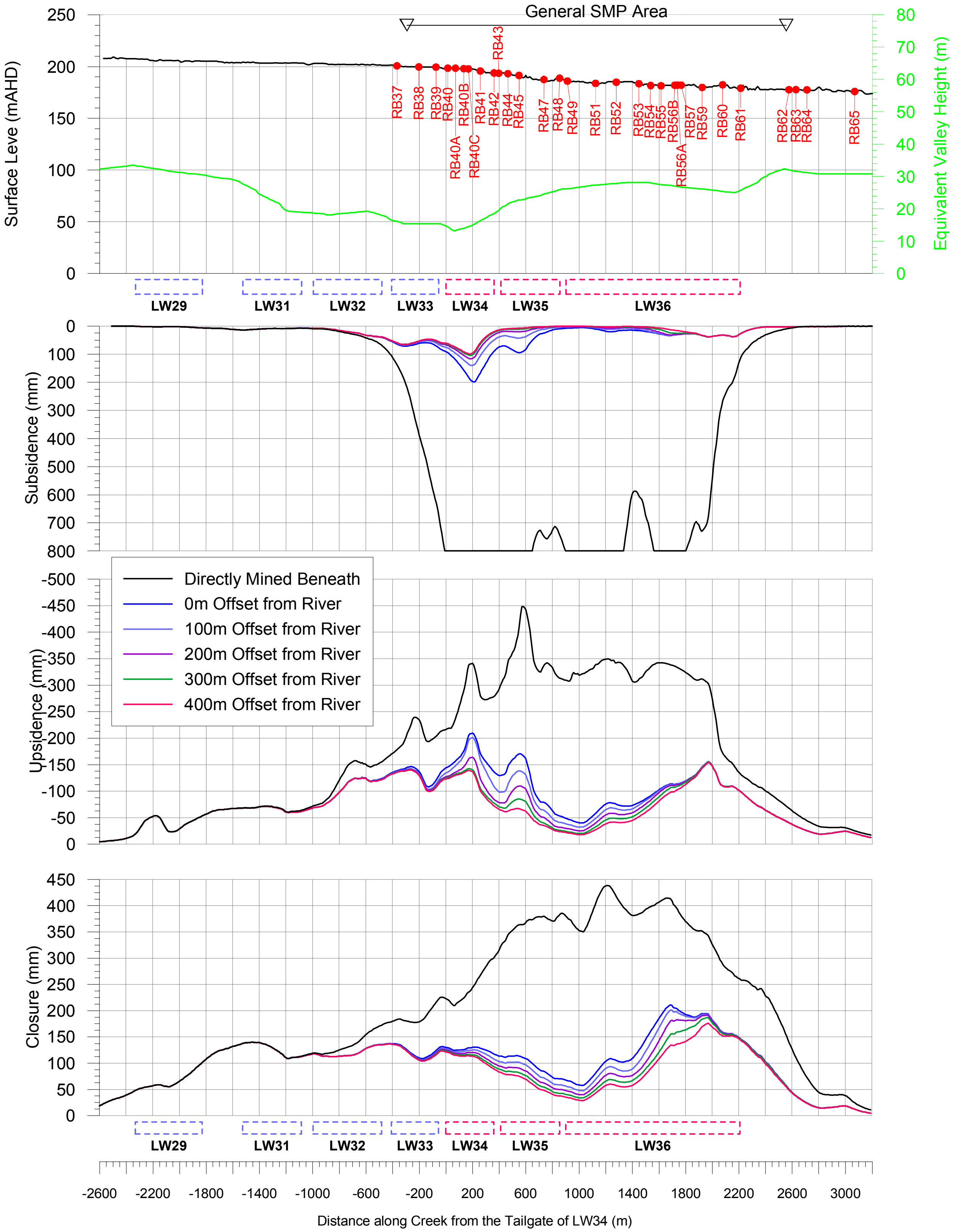


Fig. C. 5 Predicted Subsidence, Upsidence and Closure along the Georges River Based on Varying Offsets from the River for Longwall 35 Only

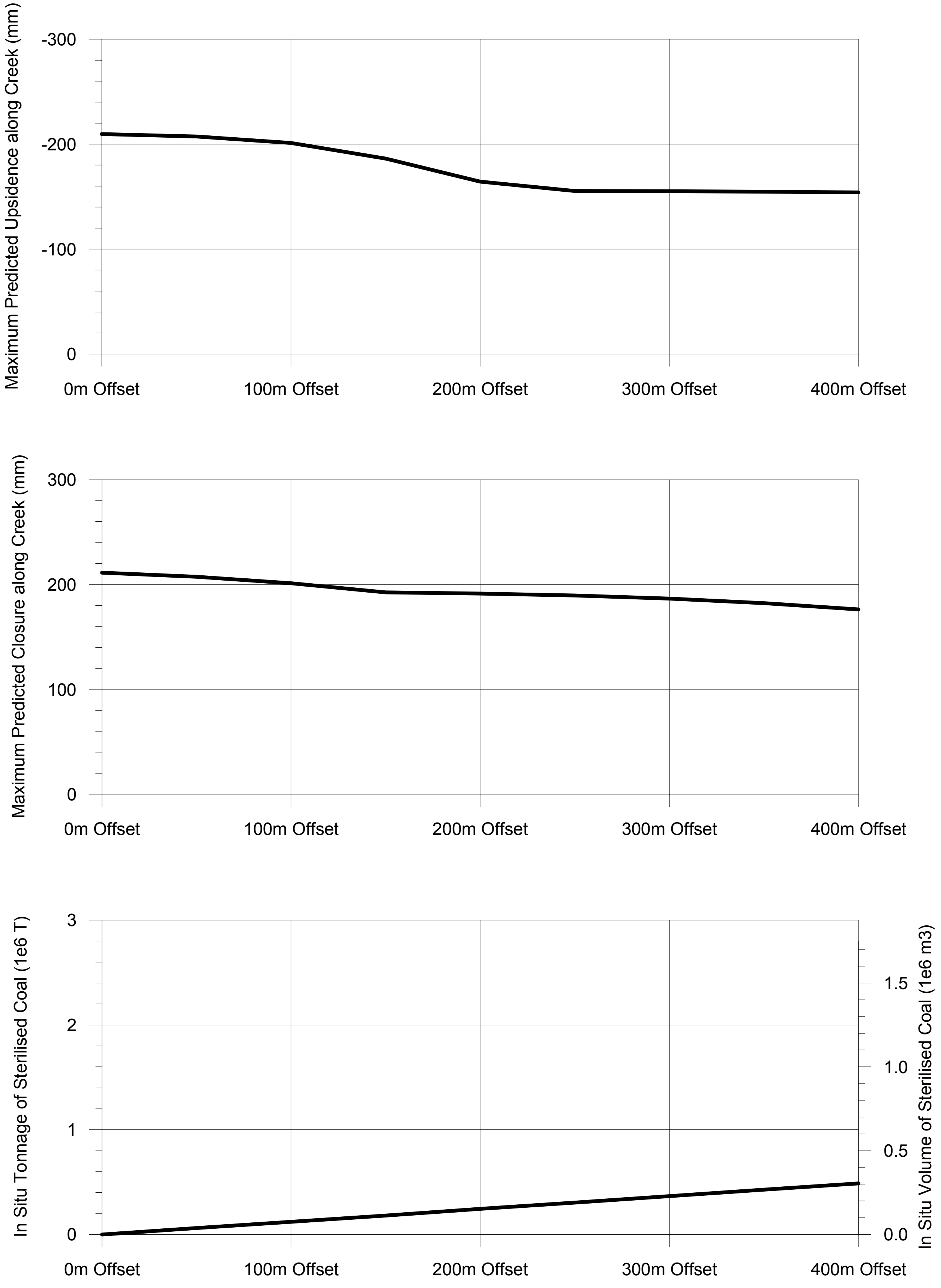


Fig. C. 6 Summary of Maximum Predicted Subsidence, Upsidence and Closure along the Georges Rivers and Tonnage of Sterilised Coal Based on Varying Offsets from the River for Longwall 35 Only

APPENDIX D. CASE STUDIES OF MINING NEAR RIVERS AND CREEKS IN THE SOUTHERN COALFIELD

D.1. Case Studies for Mining Near Rivers and Creeks in the Southern Coalfield

This appendix provides the background details for the selected case studies where longwalls have mined immediately adjacent to or directly beneath rivers and creeks within the Southern Coalfield. The case studies include:-

- West Cliff Longwalls 5A1 to 5A4 which mined adjacent to and directly beneath the Georges River,
- West Cliff Longwalls 29 and 31 which mined adjacent to the Georges River,
- Appin Longwalls 301 and 302 which mined adjacent to the Cataract River,
- Tahmoor Longwalls 14 to 19 which mined adjacent to and directly beneath the Bargo River,
- Elouera Longwalls 1 to 10 which mined adjacent to and directly beneath Wongawilli Creek,
- Elouera Longwalls 1 to 10 which mined adjacent to and directly beneath Native Dog Creek, and
- Dendrobium Longwalls 1 and 2 which mined adjacent to Kembla Creek.

The extraction dates of these longwalls are provided in Table D. 1.

Table D. 1 Longwall Extraction Dates

Colliery	Longwall	Start Date	End Date	Details
West Cliff	LW5A1	May 1999	Jan 2000	LW5A1 to LW5A4 mined directly beneath the George River
	LW5A2	Feb 2000	Nov 2000	
	LW5A3	Jan 2001	Jan 2002	
	LW5A4	Mar 2002	Jan 2003	
	LW29	Apr 2003	Aug 2004	LW29 and LW31 mined adjacent to the Georges River
	LW31	Jul 2005	Jan 2007	
Appin	LW301	Oct 2006	Apr 2007	LW301 and LW302 mined adjacent to the Cataract River
	LW302	Apr 2007	Sep 2007	
Tahmoor	LW14B	Jun 1995	May 1996	LW14 to LW19 mined directly beneath the Bargo River
	LW15	Jun 1996	Aug 1997	
	LW16	Sep 1997	Dec 1998	
	LW17	Feb 1999	May 2000	
	LW18	Jun 2000	Sep 2001	
	LW19	Oct 2001	Jul 2002	
Elouera	LW1	Feb 1993	Jun 1994	LW1 to LW6 mined directly beneath Wongawilli Creek LW1 to LW7, LW9 and LW10 mined directly beneath Native Dog Creek
	LW2	Jul 1994	Nov 1995	
	LW3	Dec 1995	Nov 1996	
	LW4	Jan 1997	Mar 1998	
	LW5	Apr 1998	Feb 2000	
	LW6	Mar 2000	Oct 2001	
	LW7	Nov 2001	Mar 2003	
	LW8	Apr 2003	Sep 2003	
	LW9	Oct 2003	Jul 2004	
	LW10	Aug 2004	Jun 2005	

D.2. West Cliff Longwalls 5A1 to 5A4 – Georges River

Longwall Geometry: West Cliff Longwalls 5A1 to 5A4
205 ~ 255 metre void widths
35 metre chain pillar widths

Seam Information: Bulli Seam
450 ~ 500 metre depth of cover
3 metre seam height

Creek Information: Georges River
Perennial
Sandstone base rock bar controlled
1 ~ 5 mm/m natural gradient upstream of Marhnyes Hole and
50 mm/m natural gradient immediately downstream of Marhnyes Hole
10 ~ 20 metre effective valley height

Back-predictions:

Location	Back-Predicted Subsidence (mm)	Back-Predicted Upsidence (mm)	Back-Predicted Closure (mm)
Jutts Crossing	600	220	235
Marhnyes Hole	400	185	210

Observed movements:

Longwall	Observed Subsidence (mm)	Observed Upsidence (mm)	Observed Closure (mm)
Jutts Crossing	550	410	230
Marhnyes Hole	450	70	145

Observed Impacts: -

- Release of strata gas from the river bed at some locations, including Jutts Crossing and Marhnyes Hole,
- Fractures at rock bars and in the river bed at Pools 8, 9, 14, 15, 16B and 17,
- Reduced water levels in pools with fracturing, including complete draining of Pools 8, 9 and 16B, for short periods of time during low flow conditions, and
- Formation of a spring at Pool 11.

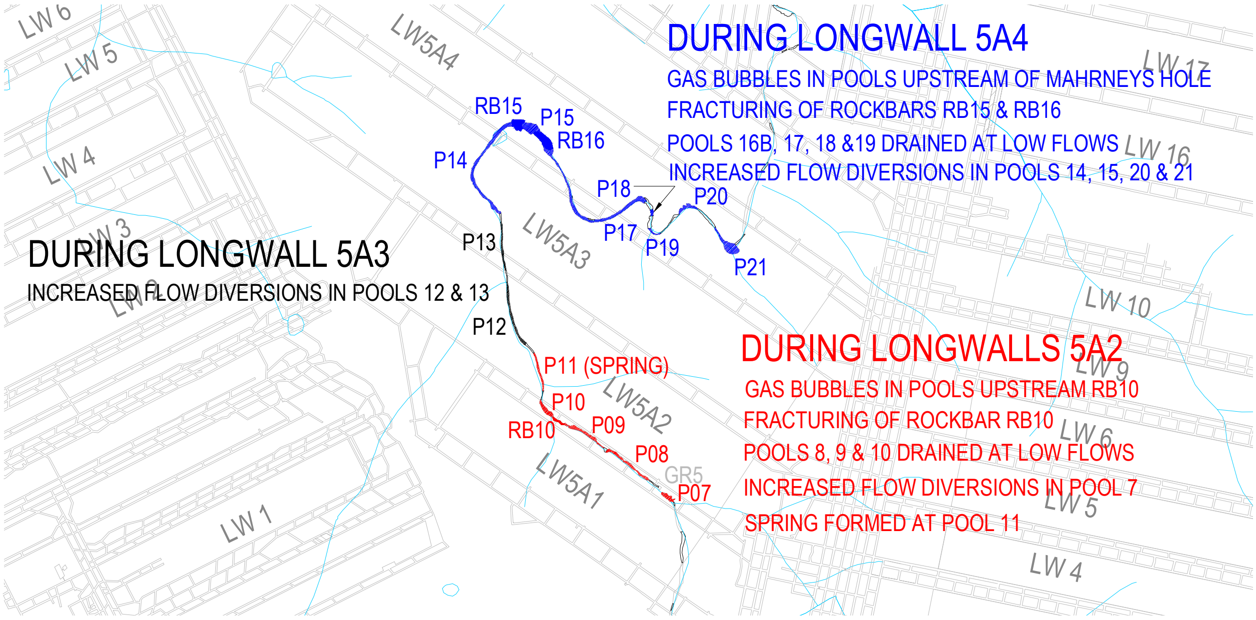


Fig. D. 1 Observed Impacts along the Georges River Resulting from the Extraction of West Cliff Longwalls 5A1 to 5A4

D.2.1. Observed Impacts at Jutts Crossing

Jutts Crossing is located where an unsealed road crosses the Georges River at Rock Bar 10. It is located directly above the chain pillar between Longwalls 5A1 and 5A2. No adverse impacts were observed at Jutts Crossing during the extraction of Longwall 5A1. In August 2000, during the extraction of Longwall 5A2, fractures were observed in the bedrock at Jutts Crossing. In November 2000, Pools 8, 9 and 10 upstream of Jutts Crossing were observed to lose water and then to completely drain during times of low flow. Increased flow diversions were also observed at Pool 7.

During the extraction of Longwall 5A2, a spring was identified at Pool 11 which is believed to be a result of strata dilation and subsurface flows to the side of the Georges River valley. The subsurface flows which pass through the Wianamatta Shales gave the spring an increased iron content.

The earliest flow monitoring data at Jutts Crossing was collected in late 2002. The recorded flow rates at the Georges River V-Notch Weir (GR05) and at Jutts Crossing between October 2002 and December 2002 are shown in Fig. D. 2.

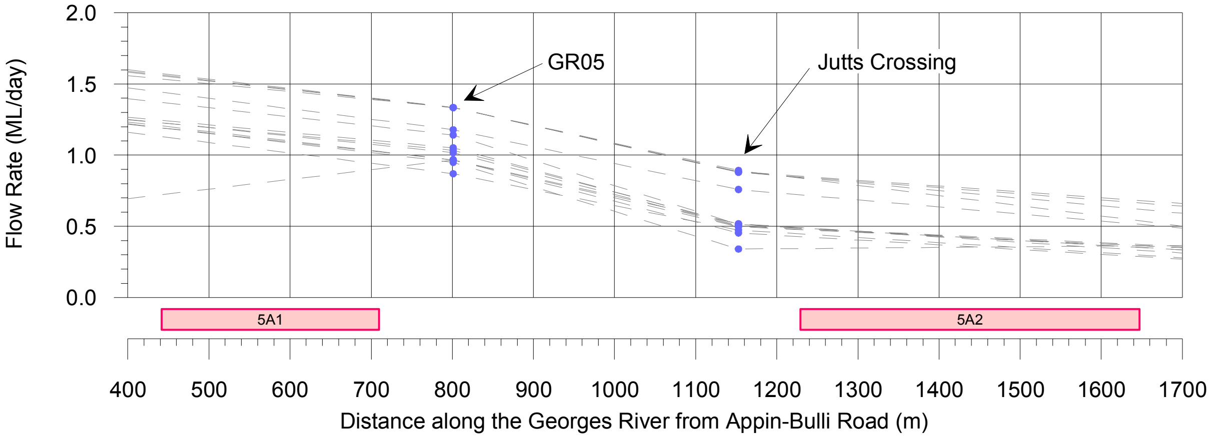


Fig. D. 2 Recorded Water Flows across Jutts Crossing between October and December 2002

The surface flow rates at GR05 in late 2002 varied between 0.9 ML/day and 1.3 ML/day. The difference in surface flow rates at Jutts Crossing varied between 0.4 ML/day and 0.6 ML/day during this period. This infers an average of approximately 45 % of the surface water between GR05 and Jutts Crossing was being diverted into subsurface flows in late 2002.

The proportion of surface flow diversion between GR05 and Jutts Crossing has been observed to reduce since 2002. Flow monitoring infers that an average diversion of approximately 22 % and 20 % occurred during 2003 and 2004, respectively. This reduction in flow diversion beneath Jutts Crossing is considered to have occurred as the result of remediation works and the natural sealing of fractures at the crossing.

A grout curtain was installed at Jutts Crossing to reduce the volume of subsurface flow and, hence, increase the surface flow. Additional grouting was applied to fill fractures near the surface and at a number of sections below the surface where fracturing had been identified. Monitoring indicates that the grout curtain has increased the proportion of surface flow across the rock bar, but some subsurface flow under or around the grout curtain remains (IC, 2004a).

A proportion of the reduction in the diversion of surface water into subsurface flow may also be the result of natural sealing of fractures in the bedrock and rock bars, which occurs during times of high flow. Some natural sealing of fractures in the rock bar and bedrock at Jutts Crossing may have occurred during floods in May and June 2003.

The water levels in the Pools 8 and 9 upstream of Jutts Crossing have been periodically monitored by IC. The water levels in these pools, the total licensed discharge and the rainfall, between January 2005 and September 2005 are shown in Fig. D. 3.

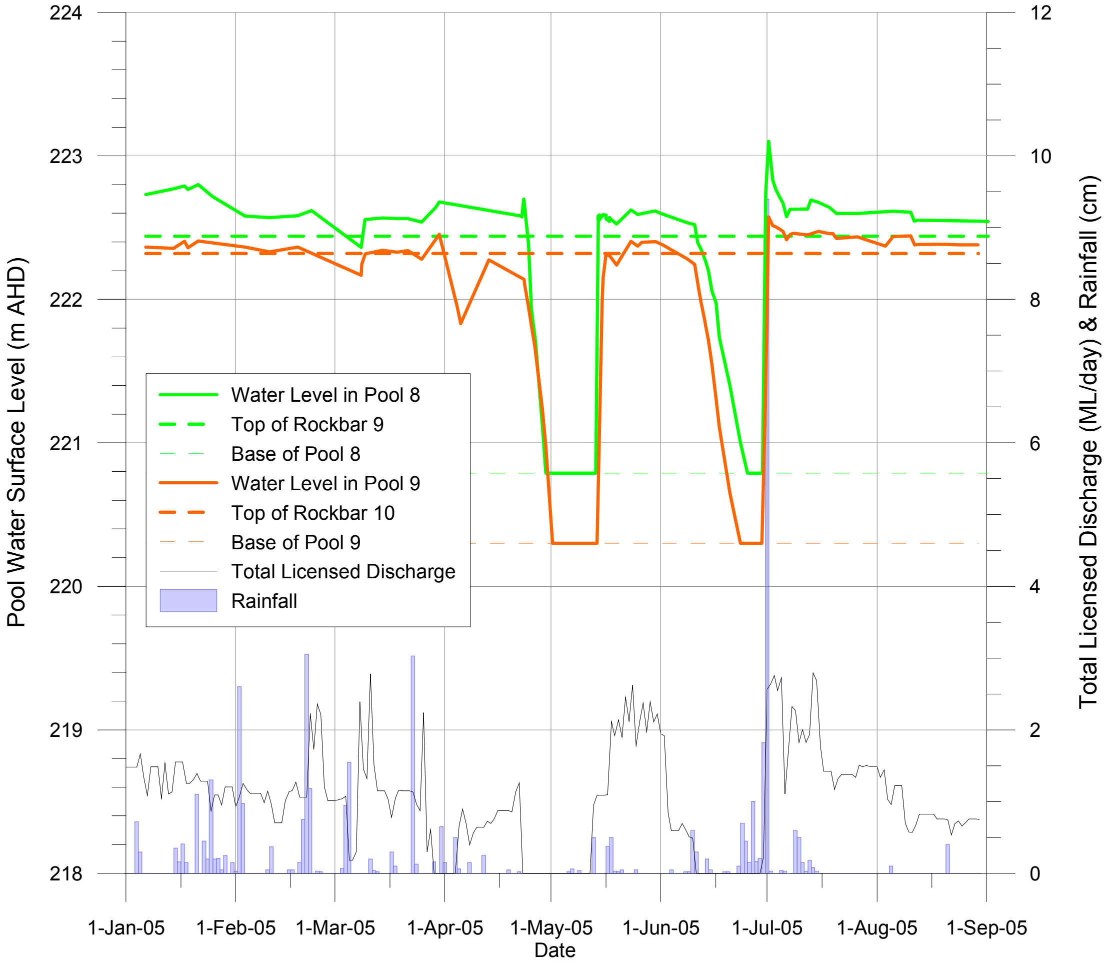


Fig. D. 3 Pool Water Levels, Licensed Discharge and Rainfall at Jutts Crossing between January 2005 and September 2005

It can be seen from the above figure that Pools 8 and 9 drained on two occasions between January 2005 and September 2005. On the 23rd April 2005, the licensed discharge ceased and Pool 8 fully drained in 6 days and Pool 9 fully drained in 8 days. During this period there was no recorded rainfall. Both pools were fully recharged overnight on the 13th May 2005 when the total licensed discharge was approximately 1 ML/day. There was no mine discharge between 23rd April and 12th May 2005.

Again on the 11th June 2005, the licensed discharge ceased and Pool 8 fully drained in 14 days and Pool 9 fully drained in 12 days. In this time approximately 18 mm of rain fell during the 14 days in which Pool 8 drained and approximately 7 mm of rain fell during the 12 days in which Pool 9 drained. Both pools were fully recharged on the 30th June 2005. Pool 8 completely recharged in 5 days as the result of 34 mm of rain and a combined licensed discharge of 0.2 ML/day. Pool 9 completely recharged in 7 days as the result of 45 mm of rain and a combined licensed discharge of 0.2 ML/day. There was no mine discharge between 11th June and 29th June 2005.

The conclusion that can be inferred from these results is that Pools 8 and 9 maintained their water levels while the total licensed discharge was greater than approximately 1 ML/day.

D.2.2. Observed Impacts at Marhnyes Hole

The Marhnyes Hole area consists of two pools along the Georges River, designated Pools 14 and 15, which are separated by Rock Bar 15. The downstream pool, being Pool 15, is contained by Rock Bar 16. Marhnyes Hole is located above Longwall 5A4. It has been observed that water is naturally diverted around Marhnyes Hole, from the pools downstream of Jutts Crossing, through the ridgeline above Longwall 5A3, into the pools downstream of Marhnyes Hole (IC, 2004a).

No major impacts were observed at Marhnyes Hole during the extraction of Longwalls 5A1 to 5A3 which were extracted between May 1999 and January 2002. Gas bubbles were observed at Marhnyes Hole during the extraction of Longwall 5A3. This indicates that there may have been minor fracturing, bed separation or joint mobilisation in the underlying strata.

A stress-relieving slot was installed adjacent to Marhnyes Hole prior to the extraction of Longwall 5A4. The slot reduced the horizontal stress across the valley and allowed some of the closure movements to occur with reduced strain in the underlying strata.

Longwall 5A4 mined directly beneath Marhnyes Hole in September 2002. Initially, a reduction in the ground water level was observed in a nearby borehole in August, when the longwall extraction face was approximately 227 metres before Marhnyes Hole. Minor fracturing of the rock bars was observed when the extraction face was directly beneath Marhnyes Hole, and further fracturing was observed when the extraction face was approximately 100 metres past.

The water level in the upstream pool, being Pool 14, began to fall in late September 2002, when the longwall face was approximately 140 metres past the rock bar. The level of in-situ stress within the strata was reduced due to the installation of a stress-relieving slot. The water level in the downstream pool, being Pool 15, started to fall shortly after, when the longwall face was approximately 180 metres past. The timing of the impacts indicates that the diversion of surface water into subsurface flows occurred after the longwall extraction face passed beneath the rock bars (IC, 2004a).

Shallow pattern grouting was initiated in March and April 2003 to seal voids in the bedrock. The result was that Pool 14 retained water, even at low flows. Grouting with directionally drilled holes was initiated in November and December 2003 to seal the voids in the dilated strata under Pool 15.

Flow monitoring has been conducted at Rock Bars 16 and 16B and the results between March 2004 and April 2005 are shown in Fig. D. 4.

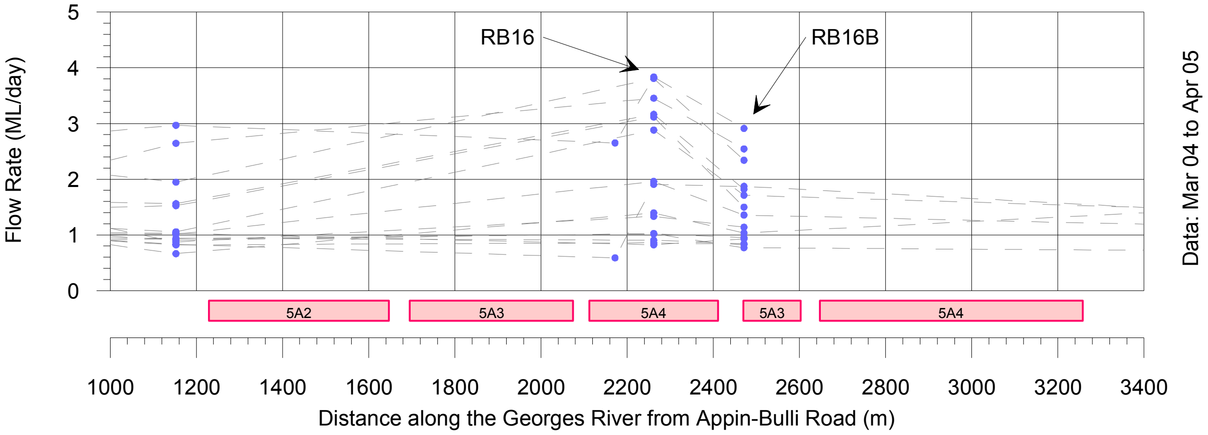


Fig. D. 4 Recorded Water Flows at Marhnyes Hole between March 2004 and April 2005

It can be seen from the above figure, that there was a consistent diversion of surface water to subsurface water between the recording stations at Rock Bar 16 and Rock Bar 16B. The surface flow rates at Rock Bar 16 varied between 0.8 ML/day and 3.8 ML/day during this period. The difference in surface flow rates at Marhnyes Hole varied between 0.1 ML/day and 1.6 ML/day during this period. This infers an average of approximately 26 % of the surface water between RB16 and RB16B was being diverted into subsurface flows during this period. It was also observed that the rate of diversion increased as the upstream flow rates increased, and visa versa.

The water levels in the pools at Marhnyes Hole have been periodically monitored by IC. The water levels in Pools 15 and 16, the total licensed discharge and the rainfall, between January 2005 and September 2005 are shown in Fig. D. 5.

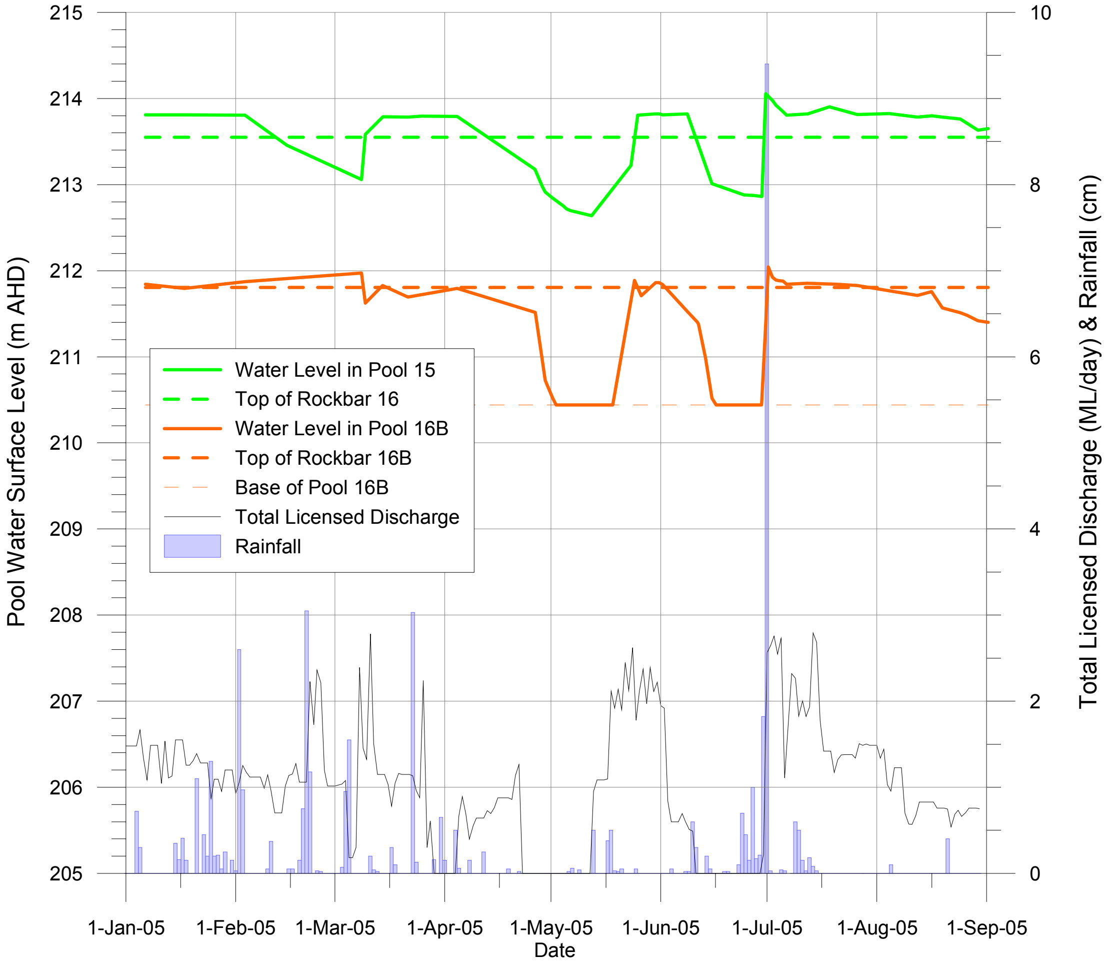


Fig. D. 5 Pool Water Levels, Licensed Discharge and Rainfall at Marhnyes Hole between January 2005 and September 2005

It can be seen from the above figure that Pool 16B drained on two occasions between January 2005 and September 2005. The water level in Pool 15 but did not fully drain during this period. On the 23rd April 2005, the licensed discharge ceased and Pool 16B fully drained in 9 days. There was no recorded rainfall during this period. Pool 16B was fully recharged on the 24th May 2005, 11 days after the licensed discharge recommenced with flows that initial began at 1 ML/day and steadily increased to approximately 2.6 ML/day by 24th May 2005. The total rainfall during this period was 15 mm.

The licensed discharge ceased again on 11th June 2005 and Pool 16B completely drained in 6 days. During this period approximately 6 mm of rain had fallen. Pool 16B was fully recharged on 1st July 2005 in response to a large rainfall event.

The conclusion that can be inferred from these results is that Pools 15 and 16 were able to maintain their water levels while the total licensed discharge was greater than approximately 1.5 ML/day.

D.3. West Cliff Longwalls 29 and 31 – Georges River

Longwall Geometry:	West Cliff Longwalls 29 and 31 255 metre (LW29) and 200 metre (LW31) void widths 95 metre (LW29) and 140 metre (LW31) chain pillar widths
Seam Information:	Bulli Seam 475 ~ 525 metre depth of cover 2.7 metre seam height
Creek Information:	Georges River Perennial Sandstone base rock bar controlled 5 ~ 10 mm/m natural gradient 20 ~ 35 metre effective valley height

Back-predictions:

Longwall	Back-Predicted Subsidence (mm)	Back-Predicted Upsidence (mm)	Back-Predicted Closure (mm)
LW29	< 20	60	115
LW31	< 20	70	135

Observed movements:

Longwall	Observed Subsidence (mm)	Observed Upsidence* (mm)	Observed Closure (mm)
LW29	110	-	25
LW31	170	-	35

Note: No upsidence spike observed and lines too short to measure gaussian component.

Observed Impacts: Only minor gas releases observed after the extraction of Longwalls 29 and 31.

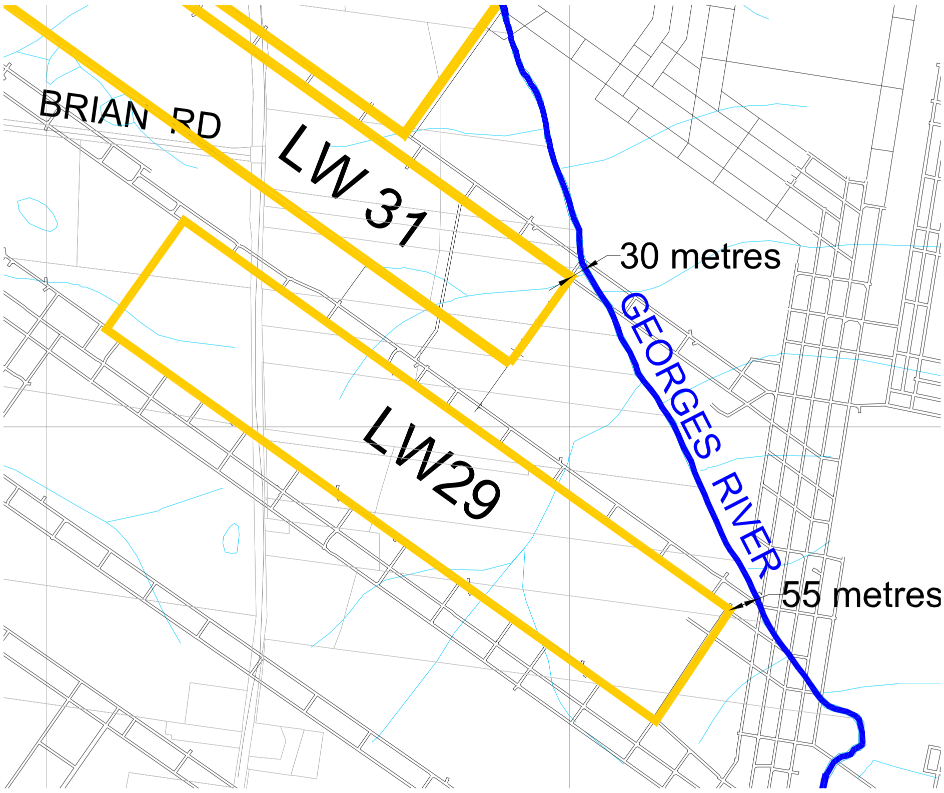
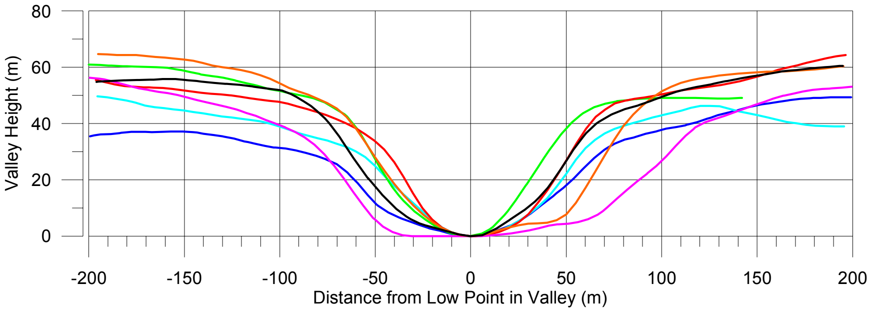


Fig. D. 6 Layout of West Cliff Longwalls 29 and 31 and the Georges River

D.4. Appin Longwalls 301 and 302 – Cataract River

Longwall Geometry:	Appin Longwalls 301 and 302 260 metre void widths 40 metre chain pillar width
Seam Information:	Bulli Seam 500 metre depth of cover 2.8 ~ 3.0 metre seam height
Creek Information:	Cataract River Water flow controlled by the Cataract Dam (typically 0.5 ~ 100 ML/day) Sandstone base rock bar controlled 10 ~ 150 mm/m natural gradient 50 ~ 70 metre effective valley height



Predictions:

Longwall	Location	Predicted Subsidence (mm)	Predicted Upsidence (mm)	Predicted Closure (mm)
After LW301	Above longwall	420	-	-
	Along river	25	165	260
After LW302	Above longwalls	815	-	-
	Along river	40	350	410

Observed movements: 250 mm maximum upsidence along river after Longwall 301
165 mm maximum closure along river after Longwall 301

430 mm maximum upsidence along river after Longwall 302
275 mm maximum closure along river after Longwall 302

Observed Impacts: No mining-induced surface water flow diversions were observed during or after the extraction of Longwalls 301 and 302.

All pools that were observed to hold water at low flows prior to mining have continued to hold water.

Refer to Table D. 2 for a summary of observed impacts.

Table D. 2 Observed Impacts along the Cataract River Resulting from the Extraction of Appin Longwalls 301 and 302

Impact	Locations
Fractures	Observed in 15 locations, most of which have occurred to the side of Longwall 301, where the movements were the greatest. Fracture widths varied between 3 and 34 mm. Fracture lengths varied between 0.4 and 10 metres. Following the extraction of Longwall 301, the furthest fracture was 375 metres from this longwall. This fracture was 150 metres from Longwall 302. The further fracture from both longwalls was 255 metres from Longwall 301.
Gas Release	Observed in 30 locations. The furthest gas release site was observed at a distance of 620 metres from the longwalls. 14 of these sites have ceased to release gas as of November 2007.
Iron Staining	Observed to source from seven locations. The furthest iron stain site was observed at a distance of 540 metres from the longwalls. Four sites have ceased to release iron staining as of November 2007.

It should be noted that there were no surface water flow diversions observed along the river during the mining period. Surface water flow rates did not fall below 3 ML/day during the mining period.

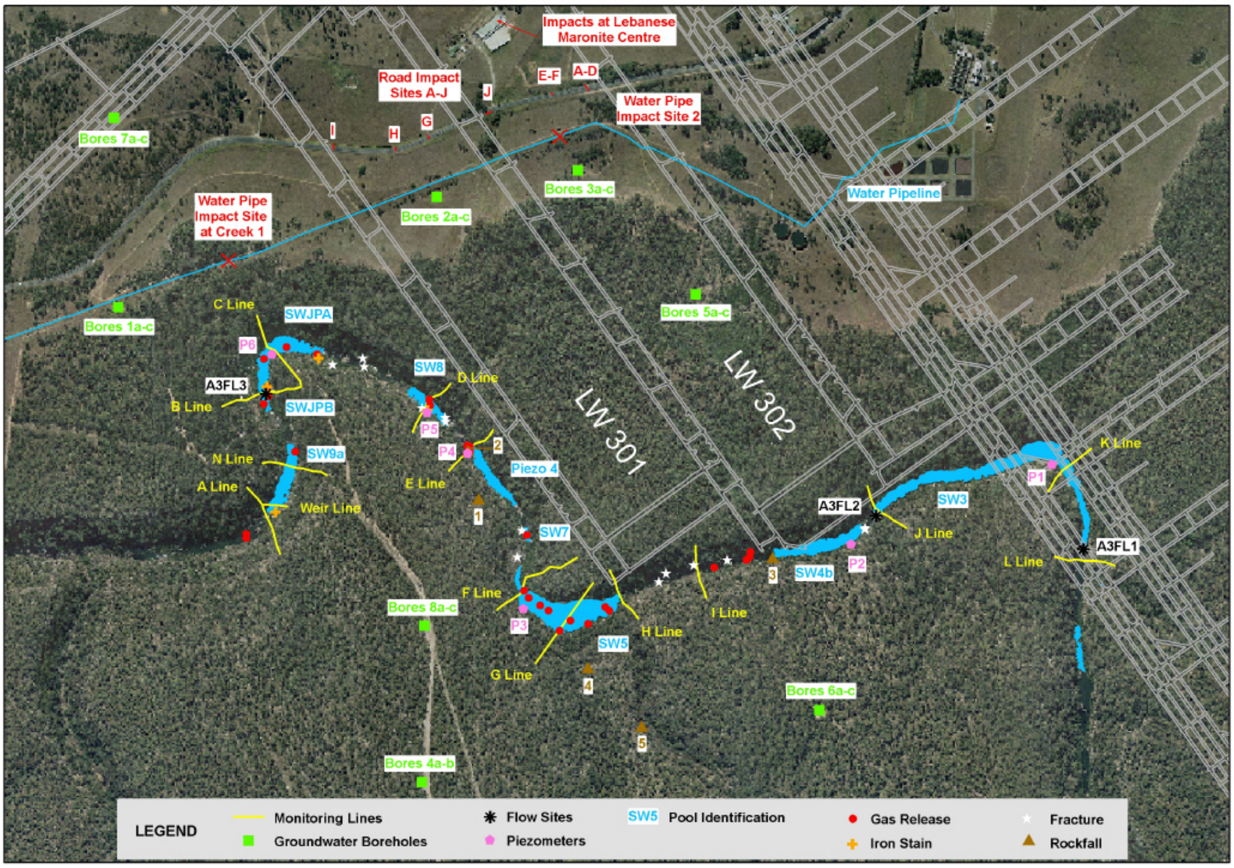
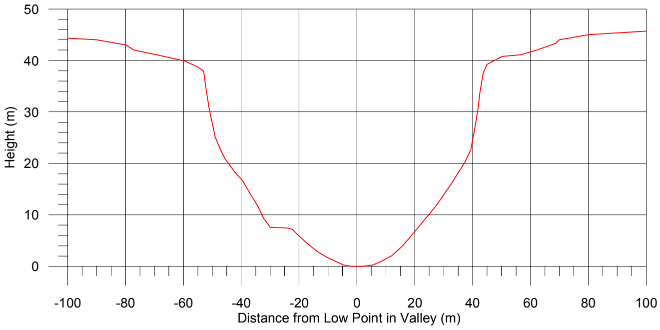


Fig. D. 7 Observed Impacts along the Cataract River Resulting from the Extraction of Appin Longwalls 301 and 302

D.5. Tahmoor Longwalls 14 to 19 - Bargo River



Longwall Geometry:	Tahmoor Longwalls 14 to 19 340 metre void widths 40 metre chain pillar widths
Seam Information:	Bulli Seam 400 metre depth of cover 2 metre seam height
River Information:	Bargo River Water flow controlled by the Picton Weir (typically 0 ~ 4 ML/day) Sandstone base rock bar controlled 45 to 65 metre effective valley height

Back-predictions:

Location	Back-Predicted Subsidence (mm)	Back-Predicted Upsidence (mm)	Back-Predicted Closure (mm)
Directly above Longwalls	860	1000	1100
Flow Diversion 125 metres from Longwall 19	35	165	400

Observed movements:

Longwall	Observed Subsidence (mm)	Observed Upsidence (mm)	Observed Closure (mm)
Directly above Longwalls	830	400	610

Observed Impacts: Majority of standing ponds drained directly above extracted longwalls.

No surface water flow 125 metres upstream of the maingate of Longwall 19, where the back- predicted upsidence is 165 mm and back-predicted closure is 400 mm, observed after the completion of Longwall 19.

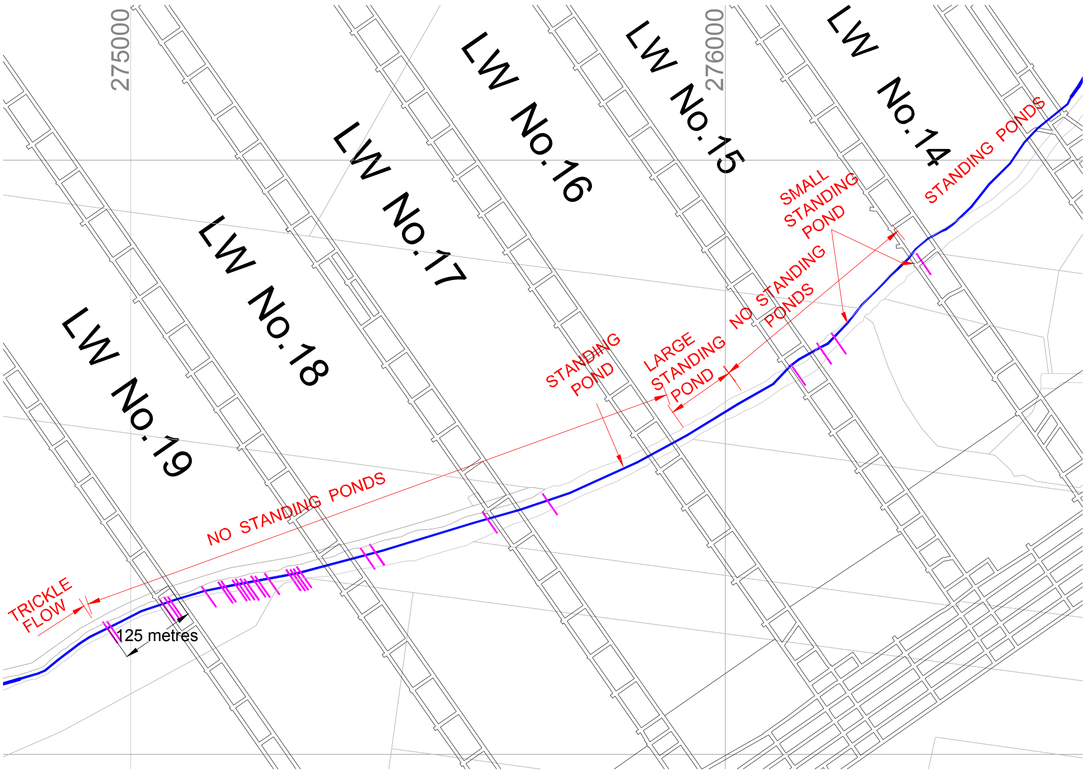


Fig. D. 8 Observed Impacts along the Bargo River Resulting from the Extraction of Tahmoor Longwalls 14 to 19

D.6. Elouera Longwalls 1 to 10 – Wongawilli Creek

Longwall Geometry: Elouera Longwalls 1 to 10
150 ~ 185 metre void widths
40 metre chain pillar widths

Seam Information: Wongawilli Seam
280 ~ 350 metre depth of cover
3 ~ 3.7 metre seam height

Creek Information: Wongawilli Creek
Permanent stream with small base flow
Sandstone base rock bar controlled
10 ~ 100 mm/m (35 mm/m average) natural gradient
30 metre effective valley height

Back-predictions:

Location	Back-Predicted Subsidence (mm)	Back-Predicted Upsidence (mm)	Back-Predicted Closure (mm)
Directly above Longwalls	1400	725	880
Last Drained Pool	75	245	335
First Full Pool	< 20	35	40

Observed movements: No ground monitoring data along creek

Observed Impacts: Majority of standing pools drained directly above longwalls.

Last drained pool 95 metres (to rock bar) downstream of Longwall 6, observed after the completion of Longwall 6.

First full pool 275 metres (to rock bar) from edge of Longwall 7.

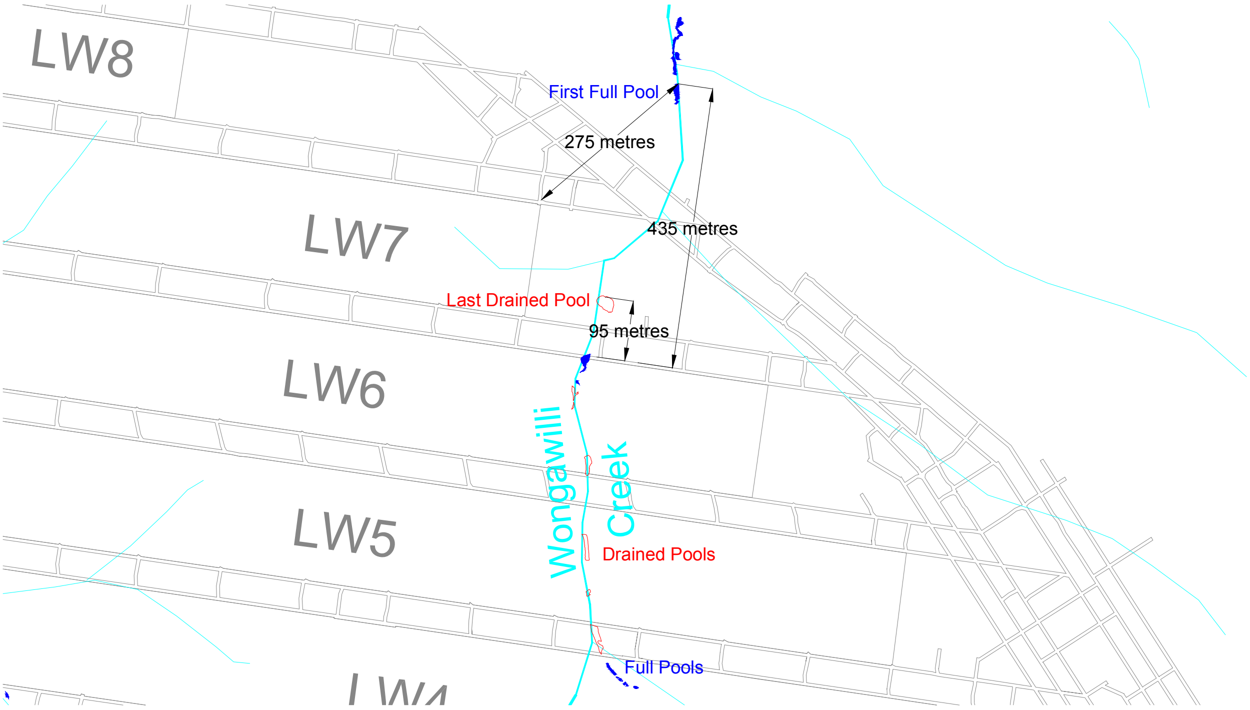


Fig. D.9 **Observed Impacts along Wongawilli Creek Resulting from the Extraction of Elouera Longwalls 1 to 10**

D.7. Elouera Longwalls 1 to 10 – Native Dog Creek

Longwall Geometry:	Elouera Longwalls 1 to 10 150 ~ 185 metre void widths 40 metre chain pillars widths
Seam Information:	Wongawilli Seam 280 ~ 350 metre depth of cover 3 ~ 3.7 metre seam height
Creek Information:	Native Dog Creek Ephemeral Sandstone base rock bar controlled 10 ~ 90 mm/m (35 mm/m average) natural gradient 15 ~ 20 metre effective valley height

Back-predictions:

Location	Back-Predicted Subsidence (mm)	Back-Predicted Upsidence (mm)	Back-Predicted Closure (mm)
Directly above Longwalls	1400	725	880
Last Drained Pool	75	130	205
First Full Pool	50	65	95

Observed movements: No ground monitoring data along creek.

Observed Impacts: Majority of standing pools drained directly above longwalls.

Last drained pool 75 metres (to rock bar) downstream of Longwall 7, observed during the extraction of Longwall 7.

First full pool 105 metres (to rock bar) downstream of Longwall 7.

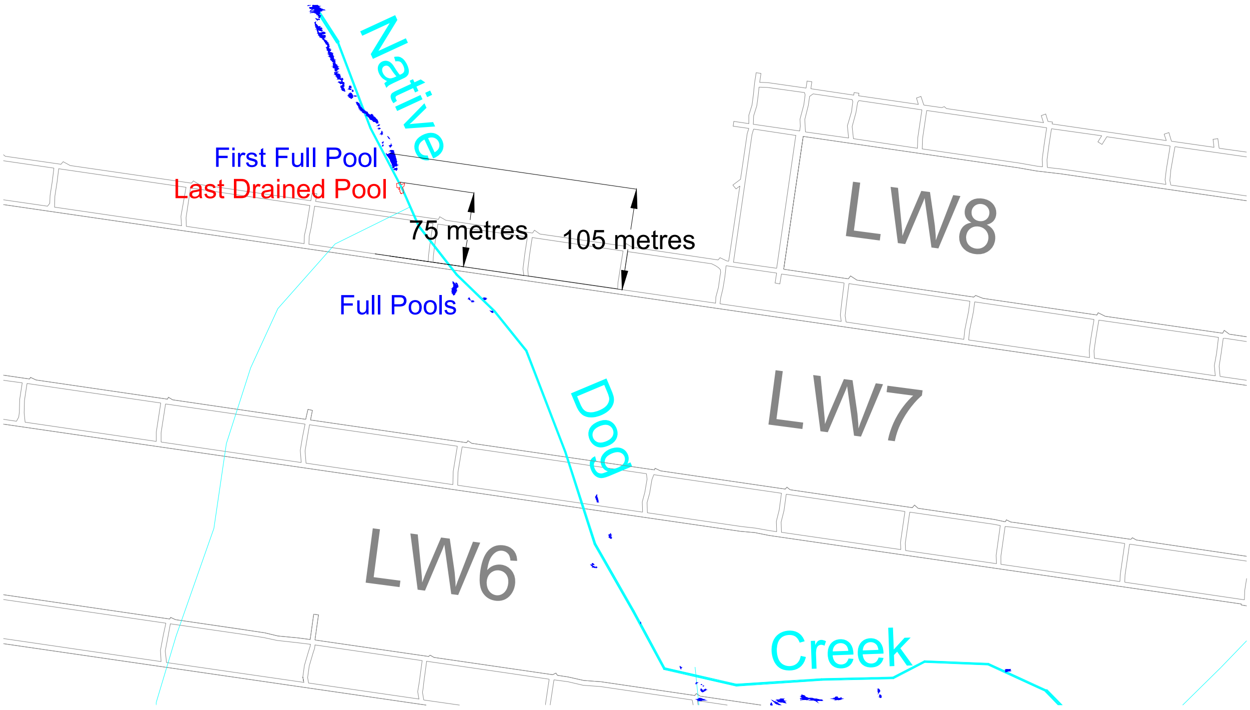


Fig. D.10 Observed Impacts along Native Dog Creek Resulting from the Extraction of Elouera Longwalls 1 to 10

D.8. Dendrobium Area 1 – Longwalls 1 and 2 – Kembla Creek

Longwall Geometry:	Dendrobium Longwalls 1 and 2 250 metre void widths 50 metre chain pillar width
Seam Information:	Wongawilli Seam 170 ~ 320 metre depth of cover 3.2 ~ 3.4 metre seam height
Creek Information:	Kembla Creek Ephemeral upstream of Lake Cordeaux Sandstone base rock bar controlled 10 ~ 75 mm/m natural gradient 40 metre effective valley height

Back-predictions:

Location	Back-Predicted Subsidence (mm)	Back-Predicted Upsidence (mm)	Back-Predicted Closure (mm)
Directly above Longwalls	2850	-	-
Along creek	< 20	110	150

Observed movements:	No ground monitoring data along creek
Observed Impacts:	No observed fracturing or loss of water in pools after the completion of Longwalls 1 and 2.

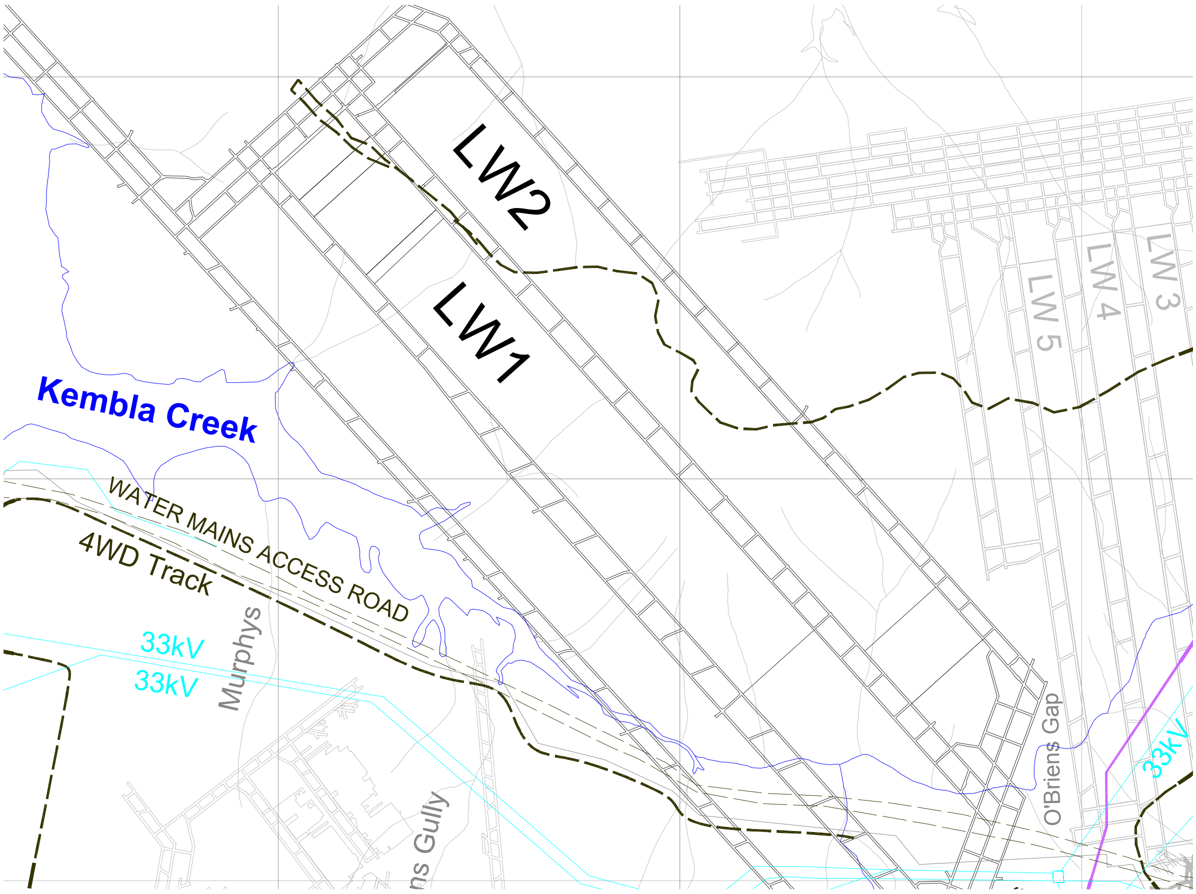


Fig. D. 11 Kembla Creek – Dendrobium Longwalls 1 and 2

APPENDIX E. TABLES

Table E.01 - West Cliff Colliery - Longwalls 34 to 36
Predictions and Impact Assessments for the Building Structures within the SMP Area

Structure Name	Structure Type	Structure Centroid MGA Easting (m)	Structure Centroid MGA Northing (m)	Maximum Structure Plan Dimension (m)	Structure Height (m)	Maximum Predicted Subsidence due to LW29 to LW34 (mm)	Maximum Predicted Subsidence due to LW29 to LW35 (mm)	Maximum Predicted Subsidence due to LW29 to LW36 (mm)	Maximum Predicted Tilt due to LW29 to LW34 (mm/m)	Maximum Predicted Tilt due to LW29 to LW35 (mm/m)	Maximum Predicted Tilt due to LW29 to LW36 (mm/m)	Maximum Predicted Travelling or Cumuatlive Tilt during LW34 to LW36 (mm/m)	Tilt Impact Assessment at the Completion of Longwall 34	Tilt Impact Assessment at the Completion of Longwall 35	Tilt Impact Assessment at the Completion of Longwall 36
A27a	H1	296416	6215991	14.0	3.75	1160	1160	1160	5.4	5.3	5.3	5.5	Category B	Category B	Category B
A27b	R	296422	6215980	7.0	2.50	1160	1160	1160	5.4	5.4	5.4	5.5	Category B	Category B	Category B
A27c	R	296429	6216003	4.0	2.50	1065	1065	1065	5.4	5.3	5.3	5.4	Category B	Category B	Category B
A28a	H1	296428	6216040	27.0	3.75	985	990	990	5.2	5.1	5.1	5.3	Category B	Category B	Category B
A28b	R	296446	6216001	11.0	2.50	1035	1040	1040	5.5	5.4	5.4	5.5	Category B	Category B	Category B
A28c	R	296471	6215980	9.3	2.50	1020	1020	1020	5.7	5.7	5.7	5.7	Category B	Category B	Category B
A28d	R	296539	6216035	2.0	2.50	675	685	685	2.7	2.8	2.8	2.8	Category A	Category A	Category A
A28e	R	296545	6216038	2.0	2.50	670	680	680	2.8	2.9	2.9	2.9	Category A	Category A	Category A
A28f	R	296461	6216003	7.0	2.50	955	960	960	5.4	5.4	5.4	5.5	Category B	Category B	Category B
A28g	R	296483	6215975	3.0	2.50	975	980	980	5.8	5.8	5.8	5.8	Category B	Category B	Category B
A28h	R	296446	6215991	2.0	2.50	1045	1050	1050	5.5	5.5	5.5	5.5	Category B	Category B	Category B
A28i	H3	296420	6216066	18.0	6.75	910	915	915	4.3	4.2	4.2	4.4	Category A	Category A	Category A
A28j	R	296405	6216078	13.0	2.50	890	895	895	3.7	3.7	3.7	3.9	Category A	Category A	Category A
A28k	R	296400	6216081	5.0	2.50	880	890	890	3.5	3.5	3.5	3.7	Category A	Category A	Category A
A28l	O	296442	6216001	12.0	2.50	1045	1050	1050	5.4	5.4	5.4	5.5	Category B	Category B	Category B
A29a	H1	296554	6216189	13.8	3.75	995	1030	1030	2.8	3.0	3.0	3.0	Category A	Category A	Category A
A29b	R	296568	6216190	7.0	2.50	980	1015	1015	2.9	3.1	3.1	3.1	Category A	Category A	Category A
A29c	R	296592	6216193	3.0	2.50	960	995	995	3.3	3.5	3.5	3.5	Category A	Category A	Category A
A29d	R	296592	6216199	3.0	2.50	970	1005	1005	3.3	3.5	3.5	3.5	Category A	Category A	Category A
A29e	R	296562	6216166	4.0	2.50	930	960	960	3.0	3.2	3.2	3.2	Category A	Category A	Category A
A30a	H1	296421	6216380	14.0	3.75	1100	1155	1155	4.5	4.1	4.1	5.4	Category A	Category A	Category A
A30b	R	296411	6216366	2.0	2.50	1100	1155	1155	3.2	2.9	2.9	4.1	Category A	Category A	Category A
A30c	R	296651	6216323	6.0	2.50	665	735	735	4.5	4.3	4.3	4.6	Category A	Category A	Category A
A31a	H1	296308	6216621	25.3	3.75	770	915	915	1.0	1.7	1.7	2.4	Category A	Category A	Category A
A31b	R	296339	6216603	8.0	2.50	760	905	905	1.1	1.7	1.7	2.2	Category A	Category A	Category A
A31c	R	296349	6216599	8.0	2.50	765	905	905	1.1	1.7	1.7	2.2	Category A	Category A	Category A
A31d	R	296368	6216594	8.0	2.50	770	915	920	1.1	1.8	1.8	2.3	Category A	Category A	Category A
A31e	R	296354	6216626	3.0	2.50	785	945	945	1.0	1.7	1.7	2.4	Category A	Category A	Category A
A31f	R	296449	6216601	4.0	2.50	810	995	995	1.0	1.7	1.7	2.6	Category A	Category A	Category A
A31g	R	296315	6216629	6.0	2.50	775	920	920	1.0	1.6	1.7	2.3	Category A	Category A	Category A
A31h	R	296308	6216608	10.0	2.50	755	885	890	1.1	1.6	1.6	2.7	Category A	Category A	Category A
A31i	R	296315	6216603	8.0	2.50	750	880	885	1.0	1.6	1.6	2.6	Category A	Category A	Category A
A31j	R	296316	6216643	4.0	2.50	785	935	940	1.0	1.6	1.6	2.3	Category A	Category A	Category A
A31k	R	296304	6216644	5.0	2.50	780	930	930	1.0	1.6	1.6	2.3	Category A	Category A	Category A
A31l	R	296420	6216587	3.0	2.50	785	950	950	1.1	1.8	1.8	2.4	Category A	Category A	Category A
A31m	R	296344	6216601	5.0	2.50	760	905	905	1.1	1.7	1.7	2.2	Category A	Category A	Category A
A31n	R	296316	6216609	9.0	2.50	760	895	895	1.0	1.6	1.6	2.5	Category A	Category A	Category A
A32a	H2	296358	6216643	32.0	3.75	800	980	980	1.0	1.7	1.7	2.5	Category A	Category A	Category A
A32b	R	296419	6216617	5.0	2.50	805	985	990	1.0	1.7	1.7	2.5	Category A	Category A	Category A
A32c	R	296459	6216614	9.0	2.50	825	1025	1025	0.9	1.6	1.6	2.7	Category A	Category A	Category A
A32d	R	296358	6216654	4.0	2.50	805	980	985	0.9	1.6	1.6	2.5	Category A	Category A	Category A
A32e	R	296428	6216614	8.0	2.50	810	990	995	1.0	1.7	1.7	2.5	Category A	Category A	Category A
A33a	H1	296274	6216865	16.0	3.75	825	1090	1105	4.3	3.1	3.0	3.9	Category A	Category A	Category A
A33b	R	296284	6216874	6.0	2.50	820	1090	1105	4.9	3.6	3.5	4.4	Category A	Category A	Category A
A33c	R	296315	6216853	12.0	2.50	825	1095	1105	5.2	3.9	3.8	4.7	Category B	Category A	Category A
A33d	R	296463	6216811	6.0	2.50	685	1020	1025	5.9	4.6	4.6	5.4	Category B	Category A	Category A
A34a	R	296326	6216891	12.4	2.50	750	1060	1070	5.9	4.5	4.5	5.3	Category B	Category A	Category A
A35a	H1	296285	6217048	21.0	3.75	255	730	770	3.1	1.3	1.4	2.7	Category A	Category A	Category A
A35b	R	296284	6217011	12.0	2.50	350	760	790	4.3	2.9	2.8	3.9	Category A	Category A	Category A
A35c	R	296319	6217033	3.0	2.50	210	730	760	2.5	1.1	1.3	2.2	Category A	Category A	Category A
A36a	H1	296270	6217167	12.8	3.75	95	795	900	0.9	0.8	1.5	2.6	Category A	Category A	Category A
A36b	R	296272	6217150	7.0	2.50	105	785	875	1.0	0.9	1.5	2.6	Category A	Category A	Category A
A36c	R	296297	6217141	4.7	2.50	95	790	865	0.9	0.9	1.4	2.6	Category A	Category A	Category A
A36d	R	296301	6217134	6.0	2.50	100	790	860	0.9	0.9	1.4	2.6	Category A	Category A	Category A
A36e	R	296279	6217135	5.0	2.50	110	780	855	1.1	0.9	1.5	2.5	Category A	Category A	Category A
A36f	R	296283	6217134	2.0	2.50	105	780	855	1.0	0.9	1.5	2.5	Category A	Category A	Category A
A36g	R	296274	6217136	2.0	2.50	110	775	855	1.1	1.0	1.5	2.5	Category A	Category A	Category A
A36h	R	296279	6217152	2.0	2.50	95	790	875	0.9	0.8	1.5	2.6	Category A	Category A	Category A
A36i	R	296263	6217194	4.0	2.50	75	800	925	0.7	0.7	1.5	2.6	Category A	Category A	Category A
A36j	R	296270	6217175	2.0	2.50	85	795	900	0.8	0.8	1.5	2.6	Category A	Category A	Category A
A36k	R	296293	6217134	10.0	2.50	105	785	855	1.0	0.9	1.4	2.6	Category A	Category A	Category A
A38i	R	296524	6217150	7.0	2.50	30	805	830	0.2	5.9	5.8	5.8	Category A	Category B	Category B

Table E.01 - West Cliff Colliery - Longwalls 34 to 36
Predictions and Impact Assessments for the Building Structures within the SMP Area

Structure Name	Structure Type	Structure Centroid MGA Easting (m)	Structure Centroid MGA Northing (m)	Maximum Structure Plan Dimension (m)	Structure Height (m)	Maximum Predicted Subsidence due to LW29 to LW34 (mm)	Maximum Predicted Subsidence due to LW29 to LW35 (mm)	Maximum Predicted Subsidence due to LW29 to LW36 (mm)	Maximum Predicted Tilt due to LW29 to LW34 (mm/m)	Maximum Predicted Tilt due to LW29 to LW35 (mm/m)	Maximum Predicted Tilt due to LW29 to LW36 (mm/m)	Maximum Predicted Travelling or Cumuatlive Tilt during LW34 to LW36 (mm/m)	Tilt Impact Assessment at the Completion of Longwall 34	Tilt Impact Assessment at the Completion of Longwall 35	Tilt Impact Assessment at the Completion of Longwall 36
A39a	H1	296169	6217327	11.0	3.75	50	805	1060	0.4	0.8	1.3	2.8	Category A	Category A	Category A
A39b	R	296163	6217322	2.0	2.50	50	805	1050	0.4	0.4	1.4	2.7	Category A	Category A	Category A
A39c	O	296154	6217334	4.0	2.50	50	805	1055	0.4	0.4	1.4	2.7	Category A	Category A	Category A
A39d	O	296157	6217332	5.0	2.50	50	805	1055	0.4	0.4	1.3	2.7	Category A	Category A	Category A
A39e	R	296173	6217334	2.0	2.50	45	805	1060	0.4	0.9	1.3	2.8	Category A	Category A	Category A
A39f	R	296170	6217335	1.0	2.50	45	805	1060	0.4	0.8	1.3	2.8	Category A	Category A	Category A
A39g	R	296165	6217321	1.0	2.50	50	805	1050	0.4	0.4	1.4	2.7	Category A	Category A	Category A
A39h	R	296199	6217249	3.0	2.50	70	800	985	0.6	0.7	1.4	2.6	Category A	Category A	Category A
A39i	R	296193	6217342	4.0	2.50	40	805	1060	0.3	2.8	1.7	3.0	Category A	Category A	Category A
A39j	R	296179	6217316	2.0	2.50	50	805	1050	0.4	0.4	1.3	2.7	Category A	Category A	Category A
C01a	R	294651	6217537	12.0	2.50	985	1035	1040	1.7	1.9	2.0	1.9	Category A	Category A	Category A
C01b	R	294668	6217537	12.0	2.50	1000	1050	1055	1.6	1.9	1.9	1.9	Category A	Category A	Category A
C01c	R	294636	6217566	10.0	2.50	995	1045	1050	1.6	1.8	1.8	1.8	Category A	Category A	Category A
C01d	H1	294649	6217586	16.0	3.75	1005	1065	1070	1.4	1.6	1.6	1.6	Category A	Category A	Category A
C01e	R	294678	6217547	9.0	2.50	1010	1065	1070	1.5	1.7	1.8	1.7	Category A	Category A	Category A
C01f	R	294672	6217545	5.0	2.50	1000	1055	1060	1.5	1.8	1.8	1.8	Category A	Category A	Category A
C05a	R	296022	6216819	33.0	2.50	770	905	915	0.8	1.4	1.5	2.5	Category A	Category A	Category A
C07a	R	296001	6218050	11.8	2.50	< 20	< 20	440	< 0.1	0.1	5.4	3.0	Category A	Category A	Category B
C07b	R	295985	6218038	18.0	2.50	< 20	< 20	555	< 0.1	0.1	6.0	3.5	Category A	Category A	Category B
C07c	R	295992	6218031	15.0	2.50	< 20	< 20	570	< 0.1	0.1	6.0	3.5	Category A	Category A	Category B
C07d	R	295998	6218028	6.0	2.50	< 20	< 20	525	< 0.1	0.1	5.9	3.4	Category A	Category A	Category B
C07e	R	296063	6218088	9.0	2.50	< 20	< 20	185	< 0.1	< 0.1	2.2	1.2	Category A	Category A	Category A
C08a	H1	296231	6217910	11.8	3.75	< 20	< 20	330	< 0.1	0.1	4.2	2.3	Category A	Category A	Category A
C08b	R	296214	6217922	7.0	2.50	< 20	< 20	325	< 0.1	0.1	4.1	2.3	Category A	Category A	Category A
C08c	R	296205	6217924	10.0	2.50	< 20	< 20	345	< 0.1	0.1	4.4	2.4	Category A	Category A	Category A
C13a	R	296122	6218465	4.0	2.50	< 20	< 20	< 20	< 0.1	< 0.1	< 0.1	< 0.1	Category A	Category A	Category A
D01a	H1	296357	6217430	14.0	3.75	< 20	230	640	< 0.1	2.8	2.2	2.4	Category A	Category A	Category A
D01b	R	296367	6217434	6.0	2.50	< 20	195	635	< 0.1	2.3	2.3	1.9	Category A	Category A	Category A
D01c	R	296366	6217428	5.0	2.50	< 20	205	625	< 0.1	2.5	2.3	2.1	Category A	Category A	Category A
D01d	R	296364	6217416	3.0	2.50	< 20	235	610	< 0.1	2.8	2.2	2.5	Category A	Category A	Category A
D01e	R	296367	6217415	6.0	2.50	< 20	235	605	< 0.1	2.9	2.4	2.5	Category A	Category A	Category A
D01f	R	296426	6217428	6.0	2.50	< 20	140	555	< 0.1	1.5	3.5	1.6	Category A	Category A	Category A
D01g	R	296435	6217441	15.0	2.50	< 20	125	570	< 0.1	1.3	3.7	1.7	Category A	Category A	Category A
D02a	H1	296436	6217524	10.0	3.75	< 20	65	705	< 0.1	0.6	3.2	2.2	Category A	Category A	Category A
D02b	R	296448	6217544	4.0	2.50	< 20	50	705	< 0.1	0.4	3.1	2.3	Category A	Category A	Category A
D02c	R	296449	6217552	4.0	2.50	< 20	45	715	< 0.1	0.4	3.0	2.3	Category A	Category A	Category A
D02d	R	296450	6217557	5.0	2.50	< 20	45	720	< 0.1	0.4	3.0	2.3	Category A	Category A	Category A
D02e	R	296451	6217561	2.0	2.50	< 20	45	720	< 0.1	0.4	2.9	2.3	Category A	Category A	Category A
D03a	H1	296346	6217623	11.0	3.75	< 20	50	825	< 0.1	0.4	0.7	2.7	Category A	Category A	Category A
D03b	R	296343	6217643	12.0	2.50	< 20	45	830	< 0.1	0.4	1.7	2.8	Category A	Category A	Category A
D03c	R	296351	6217640	3.0	2.50	< 20	40	830	< 0.1	0.3	1.4	2.8	Category A	Category A	Category A
D03d	R	296345	6217634	2.0	2.50	< 20	45	830	< 0.1	0.4	0.7	2.7	Category A	Category A	Category A
D03e	R	296348	6217634	2.0	2.50	< 20	45	830	< 0.1	0.4	0.9	2.7	Category A	Category A	Category A
D03f	R	296348	6217599	7.0	2.50	< 20	55	815	< 0.1	0.5	0.9	2.7	Category A	Category A	Category A
D03g	R	296363	6217597	7.0	2.50	< 20	55	810	< 0.1	0.5	1.0	2.7	Category A	Category A	Category A
D04a	H1	296298	6217805	17.1	3.75	< 20	< 20	600	< 0.1	0.1	6.0	3.5	Category A	Category A	Category B
D04b	R	296300	6217793	7.0	2.50	< 20	20	625	< 0.1	0.2	6.0	3.6	Category A	Category A	Category B
D04c	R	296294	6217789	3.0	2.50	< 20	20	650	< 0.1	0.2	6.0	3.6	Category A	Category A	Category B
D04d	R	296301	6217786	11.0	2.50	< 20	20	660	< 0.1	0.2	6.0	3.6	Category A	Category A	Category B
D04e	R	296305	6217779	8.0	2.50	< 20	20	675	< 0.1	0.2	6.0	3.6	Category A	Category A	Category B
D04f	R	296326	6217777	9.0	2.50	< 20	20	620	< 0.1	0.2	6.0	3.6	Category A	Category A	Category B
D04g	R	296304	6217816	8.0	2.50	< 20	< 20	495	< 0.1	0.1	5.8	3.3	Category A	Category A	Category B
D04h	R	296341	6217779	3.0	2.50	< 20	< 20	535	< 0.1	0.1	6.0	3.4	Category A	Category A	Category B
D04i	R	296343	6217779	3.0	2.50	< 20	< 20	530	< 0.1	0.1	6.0	3.4	Category A	Category A	Category B
D04j	R	296299	6217780	6.0	2.50	< 20	20	685	< 0.1	0.2	6.0	3.6	Category A	Category A	Category B
D05a	H2	296331	6217896	36.2	3.75	< 20	< 20	225	< 0.1	< 0.1	2.7	1.5	Category A	Category A	Category A
D06a	H1	296333	6217952	15.0	3.75	< 20	< 20	115	< 0.1	< 0.1	1.2	0.7	Category A	Category A	Category A
D06b	R	296335	6217942	4.0	2.50	< 20	< 20	115	< 0.1	< 0.1	1.2	0.7	Category A	Category A	Category A
D06c	R	296341	6217965	10.0	2.50	< 20	< 20	95	< 0.1	< 0.1	0.9	0.6	Category A	Category A	Category A
D06d	R	296371	6217960	7.0	2.50	< 20	< 20	85	< 0.1	< 0.1	0.8	0.5	Category A	Category A	Category A
D06e	R	296379	6217958	5.0	2.50	< 20	< 20	80	< 0.1	< 0.1	0.8	0.5	Category A	Category A	Category A
D06f	R	296384	6217961	4.0	2.50	< 20	< 20	75	< 0.1	< 0.1	0.7	0.4	Category A	Category A	Category A

Table E.01 - West Cliff Colliery - Longwalls 34 to 36
Predictions and Impact Assessments for the Building Structures within the SMP Area

Structure Name	Structure Type	Structure Centroid MGA Easting (m)	Structure Centroid MGA Northing (m)	Maximum Structure Plan Dimension (m)	Structure Height (m)	Maximum Predicted Subsidence due to LW29 to LW34 (mm)	Maximum Predicted Subsidence due to LW29 to LW35 (mm)	Maximum Predicted Subsidence due to LW29 to LW36 (mm)	Maximum Predicted Tilt due to LW29 to LW34 (mm/m)	Maximum Predicted Tilt due to LW29 to LW35 (mm/m)	Maximum Predicted Tilt due to LW29 to LW36 (mm/m)	Maximum Predicted Travelling or Cumuatlive Tilt during LW34 to LW36 (mm/m)	Tilt Impact Assessment at the Completion of Longwall 34	Tilt Impact Assessment at the Completion of Longwall 35	Tilt Impact Assessment at the Completion of Longwall 36
D06g	R	296450	6217924	14.0	2.50	< 20	< 20	75	< 0.1	< 0.1	0.7	0.4	Category A	Category A	Category A
D06h	O	296459	6217922	6.0	2.50	< 20	< 20	65	< 0.1	< 0.1	0.6	0.4	Category A	Category A	Category A
D06i	O	296463	6217922	7.0	2.50	< 20	< 20	65	< 0.1	< 0.1	0.6	0.4	Category A	Category A	Category A
D06j	O	296468	6217921	6.0	2.50	< 20	< 20	65	< 0.1	< 0.1	0.6	0.4	Category A	Category A	Category A
D06k	R	296481	6217934	31.0	2.50	< 20	< 20	60	< 0.1	< 0.1	0.5	0.3	Category A	Category A	Category A
D06l	R	296363	6217915	8.0	2.50	< 20	< 20	125	< 0.1	< 0.1	1.3	0.8	Category A	Category A	Category A
D07a	H1	296358	6217991	14.0	3.75	< 20	< 20	75	< 0.1	< 0.1	0.7	0.4	Category A	Category A	Category A
D07b	R	296345	6217977	7.0	2.50	< 20	< 20	85	< 0.1	< 0.1	0.8	0.5	Category A	Category A	Category A
D07c	R	296350	6217972	6.0	2.50	< 20	< 20	85	< 0.1	< 0.1	0.8	0.5	Category A	Category A	Category A
D07d	R	296403	6217963	6.0	2.50	< 20	< 20	70	< 0.1	< 0.1	0.6	0.4	Category A	Category A	Category A
D07e	R	296352	6217976	6.0	2.50	< 20	< 20	80	< 0.1	< 0.1	0.8	0.5	Category A	Category A	Category A
D08a	H3	296437	6218119	18.3	6.75	< 20	< 20	20	< 0.1	< 0.1	0.2	0.1	Category A	Category A	Category A
D08b	R	296448	6218109	7.0	2.50	< 20	< 20	20	< 0.1	< 0.1	0.2	0.1	Category A	Category A	Category A
D08c	R	296463	6218140	14.0	2.50	< 20	< 20	< 20	< 0.1	< 0.1	0.1	< 0.1	Category A	Category A	Category A
D08d	R	296487	6218091	13.0	2.50	< 20	< 20	20	< 0.1	< 0.1	0.2	0.1	Category A	Category A	Category A
F03a	C	295504	6216538	114.8	5.00	1235	1235	1235	4.1	4.0	4.0	4.3	Category A	Category A	Category A
F03aa	C	295513	6216481	3.0	3.00	1185	1185	1185	1.9	1.9	1.9	1.9	Category A	Category A	Category A
F03ab	C	295557	6216478	3.0	3.00	1215	1220	1220	1.8	1.8	1.8	1.8	Category A	Category A	Category A
F03ac	C	295562	6216477	3.0	3.00	1220	1220	1220	1.7	1.8	1.8	1.8	Category A	Category A	Category A
F03ad	C	295682	6216578	3.0	3.00	970	975	975	3.4	3.4	3.4	3.7	Category A	Category A	Category A
F03ae	C	295679	6216548	2.0	3.00	1075	1085	1085	4.4	4.4	4.4	4.7	Category A	Category A	Category A
F03af	C	295675	6216517	3.0	3.00	1190	1195	1195	4.4	4.4	4.4	4.7	Category A	Category A	Category A
F03ag	C	295673	6216487	4.0	3.00	1240	1245	1245	4.3	4.3	4.3	4.5	Category A	Category A	Category A
F03ah	C	295705	6216484	3.0	3.00	1220	1225	1225	4.5	4.4	4.4	4.7	Category A	Category A	Category A
F03ai	C	295709	6216515	3.0	3.00	1125	1130	1130	4.5	4.4	4.4	4.7	Category A	Category A	Category A
F03aj	C	295712	6216545	2.0	3.00	1005	1010	1010	3.9	3.9	3.9	4.2	Category A	Category A	Category A
F03ak	C	295714	6216576	3.0	3.00	920	930	930	2.3	2.2	2.2	2.6	Category A	Category A	Category A
F03al	C	295821	6216567	3.0	3.00	940	960	960	1.4	1.5	1.5	1.5	Category A	Category A	Category A
F03am	C	295818	6216536	2.0	3.00	905	920	920	1.1	1.3	1.3	1.3	Category A	Category A	Category A
F03an	C	295816	6216506	4.0	3.00	925	935	935	2.2	2.1	2.1	2.5	Category A	Category A	Category A
F03ao	C	295813	6216476	4.0	3.00	1005	1015	1015	3.9	3.8	3.8	4.1	Category A	Category A	Category A
F03ap	C	295713	6216595	5.0	3.00	895	905	905	1.4	1.3	1.3	1.7	Category A	Category A	Category A
F03aq	C	295708	6216597	4.0	3.00	895	905	905	1.5	1.4	1.4	1.8	Category A	Category A	Category A
F03ar	C	295708	6216593	3.0	3.00	900	910	910	1.6	1.5	1.5	1.9	Category A	Category A	Category A
F03as	C	295888	6216439	4.0	3.00	960	970	970	3.0	2.9	2.9	3.3	Category A	Category A	Category A
F03b	C	295528	6216536	114.5	5.00	1235	1235	1235	4.4	4.3	4.3	4.6	Category A	Category A	Category A
F03c	C	295553	6216535	114.4	5.00	1235	1240	1240	4.4	4.4	4.4	4.6	Category A	Category A	Category A
F03d	C	295576	6216532	114.3	5.00	1235	1240	1240	4.4	4.4	4.4	4.6	Category A	Category A	Category A
F03e	C	295644	6216570	78.0	5.00	1190	1195	1195	4.4	4.4	4.4	4.6	Category A	Category A	Category A
F03f	C	295640	6216540	77.0	5.00	1235	1240	1240	4.5	4.4	4.4	4.7	Category A	Category A	Category A
F03g	C	295637	6216509	76.0	5.00	1240	1240	1240	4.4	4.4	4.4	4.7	Category A	Category A	Category A
F03h	C	295635	6216479	77.0	5.00	1245	1245	1245	4.2	4.2	4.2	4.4	Category A	Category A	Category A
F03i	C	295750	6216562	77.0	5.00	975	985	985	3.5	3.4	3.4	3.7	Category A	Category A	Category A
F03j	C	295747	6216531	76.0	5.00	1085	1090	1090	4.5	4.4	4.4	4.7	Category A	Category A	Category A
F03k	C	295744	6216500	77.0	5.00	1190	1195	1195	4.5	4.4	4.4	4.7	Category A	Category A	Category A
F03l	C	295742	6216470	76.0	5.00	1245	1245	1245	4.5	4.4	4.4	4.7	Category A	Category A	Category A
F03m	C	295857	6216552	77.0	5.00	990	1020	1020	1.4	1.6	1.6	1.6	Category A	Category A	Category A
F03n	C	295854	6216522	76.0	5.00	955	980	980	1.7	1.6	1.6	2.0	Category A	Category A	Category A
F03o	C	295852	6216491	78.0	5.00	975	985	985	3.4	3.3	3.3	3.6	Category A	Category A	Category A
F03p	C	295849	6216461	77.0	5.00	1080	1090	1090	4.5	4.4	4.4	4.7	Category A	Category A	Category A
F03q	C	295424	6216492	18.0	3.00	1115	1115	1115	1.9	1.9	1.9	1.9	Category A	Category A	Category A
F03r	C	295417	6216511	7.0	3.00	1130	1130	1130	1.9	1.9	1.9	1.9	Category A	Category A	Category A
F03s	C	295432	6216476	5.0	3.00	1095	1095	1095	1.9	1.9	1.9	1.9	Category A	Category A	Category A
F03t	C	295416	6216482	6.0	3.00	1085	1085	1085	1.9	1.9	1.9	1.9	Category A	Category A	Category A
F03u	C	295436	6216473	1.0	3.00	1090	1090	1090	1.9	1.9	1.9	1.9	Category A	Category A	Category A
F03v	C	295436	6216471	1.0	3.00	1085	1085	1085	1.9	1.9	1.9	1.9	Category A	Category A	Category A
F03w	C	295611	6216457	6.0	3.00	1235	1240	1240	1.7	1.7	1.7	1.7	Category A	Category A	Category A
F03x	C	295650	6216435	16.0	3.00	1245	1245	1245	1.7	1.7	1.7	1.7	Category A	Category A	Category A
F03y	C	295658	6216421	14.0	3.00	1240	1245	1245	1.8	1.8	1.8	1.8	Category A	Category A	Category A
F03z	C	295507	6216482	3.0	3.00	1180	1180	1180	1.9	1.9	1.9	1.9	Category A	Category A	Category A
F06a	R	296299	6216260	35.0	2.50	965	995	995	1.8	2.0	2.0	2.0	Category A	Category A	Category A
F07a	H1	296155	6216019	19.0	3.75	1155	1160	1160	2.1	2.2	2.2	2.2	Category A	Category A	Category A

Table E.01 - West Cliff Colliery - Longwalls 34 to 36
Predictions and Impact Assessments for the Building Structures within the SMP Area

Structure Name	Structure Type	Structure Centroid MGA Easting (m)	Structure Centroid MGA Northing (m)	Maximum Structure Plan Dimension (m)	Structure Height (m)	Maximum Predicted Subsidence due to LW29 to LW34 (mm)	Maximum Predicted Subsidence due to LW29 to LW35 (mm)	Maximum Predicted Subsidence due to LW29 to LW36 (mm)	Maximum Predicted Tilt due to LW29 to LW34 (mm/m)	Maximum Predicted Tilt due to LW29 to LW35 (mm/m)	Maximum Predicted Tilt due to LW29 to LW36 (mm/m)	Maximum Predicted Travelling or Cumuatlive Tilt during LW34 to LW36 (mm/m)	Tilt Impact Assessment at the Completion of Longwall 34	Tilt Impact Assessment at the Completion of Longwall 35	Tilt Impact Assessment at the Completion of Longwall 36
F08a	R	296170	6216076	18.0	2.50	1220	1225	1225	1.9	1.9	1.9	1.9	Category A	Category A	Category A
F08b	R	296203	6216076	5.0	2.50	1220	1225	1225	1.9	1.9	1.9	2.1	Category A	Category A	Category A
F08c	R	296275	6216019	9.0	2.50	1215	1220	1220	1.8	1.8	1.8	1.8	Category A	Category A	Category A
F08d	R	296255	6216015	4.0	2.50	1215	1220	1220	1.9	2.0	2.0	2.0	Category A	Category A	Category A
F10a	H1	296158	6216047	11.0	3.75	1195	1195	1195	2.1	2.1	2.1	2.1	Category A	Category A	Category A
F11a	H1	296052	6216151	21.5	3.75	1235	1240	1240	1.9	1.9	1.9	1.9	Category A	Category A	Category A
F11b	R	296044	6216110	22.0	2.50	1190	1190	1190	2.0	2.1	2.1	2.1	Category A	Category A	Category A
F11c	R	296041	6216097	17.0	2.50	1165	1165	1165	2.0	2.1	2.1	2.1	Category A	Category A	Category A
F11d	R	296020	6216078	8.0	2.50	1105	1105	1105	2.0	2.0	2.0	2.0	Category A	Category A	Category A
F11e	R	296055	6216071	26.0	2.50	1140	1145	1145	2.1	2.1	2.1	2.1	Category A	Category A	Category A
F11f	R	296077	6216056	5.0	2.50	1120	1125	1125	2.1	2.1	2.1	2.1	Category A	Category A	Category A
G01a	R	294104	6218424	19.0	2.50	530	680	690	1.4	2.3	2.3	2.3	Category A	Category A	Category A
G01b	R	294077	6218429	7.0	2.50	525	650	660	1.6	2.4	2.4	2.4	Category A	Category A	Category A
G01c	R	294082	6218421	4.0	2.50	525	645	650	1.6	2.4	2.4	2.4	Category A	Category A	Category A
G01d	R	294118	6218385	9.0	2.50	525	635	640	1.9	2.5	2.6	2.5	Category A	Category A	Category A
G01e	R	294046	6218408	5.0	2.50	500	580	585	2.3	2.7	2.8	2.8	Category A	Category A	Category A
G01f	R	294079	6218422	3.0	2.50	525	640	645	1.6	2.4	2.4	2.4	Category A	Category A	Category A
G01g	R	294079	6218419	2.0	2.50	525	635	640	1.7	2.4	2.5	2.4	Category A	Category A	Category A
G01h	R	294113	6218482	3.0	2.50	525	725	740	1.7	1.5	1.6	1.9	Category A	Category A	Category A
G01i	H1	294125	6218464	19.0	3.75	525	725	740	1.7	1.7	1.8	1.9	Category A	Category A	Category A
G01j	R	294126	6218474	2.0	2.50	525	725	740	1.7	1.5	1.6	1.9	Category A	Category A	Category A
G02a	R	294132	6218560	10.0	2.50	425	725	740	2.4	0.5	0.4	1.9	Category A	Category A	Category A
G02b	R	294126	6218563	7.0	2.50	425	725	740	2.4	0.5	0.4	1.9	Category A	Category A	Category A
G02c	H1	294151	6218553	25.9	3.75	430	725	740	2.4	0.5	0.3	1.9	Category A	Category A	Category A
G02d	R	294123	6218538	13.0	2.50	470	725	740	2.4	0.5	0.3	1.9	Category A	Category A	Category A
G03a	H1	294273	6218505	25.2	3.75	365	715	760	2.4	0.5	1.0	1.9	Category A	Category A	Category A
G03b	R	294231	6218467	5.0	2.50	465	730	755	2.4	0.6	0.3	1.9	Category A	Category A	Category A
G03c	R	294289	6218502	8.0	2.50	325	705	760	2.4	0.4	0.9	1.9	Category A	Category A	Category A
G04a	R	294235	6218541	30.0	2.50	345	710	760	2.4	0.6	1.1	1.9	Category A	Category A	Category A
G04b	R	294242	6218527	5.0	2.50	335	705	745	2.4	0.4	0.7	1.9	Category A	Category A	Category A
G04c	R	294253	6218580	11.0	2.50	235	740	805	1.9	1.1	1.6	2.1	Category A	Category A	Category A
G04d	R	294263	6218576	6.0	2.50	225	740	810	1.8	1.1	1.6	2.1	Category A	Category A	Category A
G04e	R	294265	6218585	10.0	2.50	215	755	830	1.7	1.1	1.8	2.2	Category A	Category A	Category A
G04f	O	294264	6218596	6.0	2.50	195	760	835	1.6	1.1	1.8	2.2	Category A	Category A	Category A
G04g	R	294263	6218604	5.0	2.50	185	765	845	1.5	1.1	1.8	2.2	Category A	Category A	Category A
G04h	R	294263	6218615	10.0	2.50	175	780	865	1.4	1.2	1.9	2.3	Category A	Category A	Category A
G04i	R	294251	6218629	11.0	2.50	170	785	875	1.4	1.2	1.9	2.4	Category A	Category A	Category A
G04j	R	294263	6218641	12.0	2.50	150	800	905	1.2	1.2	1.9	2.5	Category A	Category A	Category A
G04k	R	294243	6218581	28.0	2.50	260	745	815	2.1	1.1	1.7	2.1	Category A	Category A	Category A
G04l	O	294263	6218570	5.0	2.50	230	735	800	1.9	1.0	1.6	2.0	Category A	Category A	Category A
G04m	R	294239	6218598	6.0	2.50	215	745	810	1.8	1.1	1.7	2.1	Category A	Category A	Category A
G05a	H1	294242	6218721	17.0	3.75	105	825	965	0.7	1.0	1.7	2.7	Category A	Category A	Category A
G05b	R	294234	6218758	19.0	2.50	85	830	960	0.6	3.9	3.1	3.4	Category A	Category A	Category A
G05c	R	294188	6218727	6.0	2.50	120	825	905	0.9	1.1	1.7	2.6	Category A	Category A	Category A
G05d	R	294245	6218732	5.0	2.50	90	830	965	0.6	1.3	1.6	2.8	Category A	Category A	Category A
G06a	R	294459	6218732	6.0	2.50	40	455	785	0.3	5.3	3.9	4.8	Category A	Category B	Category A
G07a	R	294557	6218385	3.0	2.50	190	760	865	1.6	1.0	1.7	2.1	Category A	Category A	Category A
H06a	R	294169	6218783	5.0	2.50	90	835	915	0.7	1.1	1.4	2.8	Category A	Category A	Category A

Table E.01 - West Cliff Colliery - Longwalls 34 to 36

Predictions and Impact Assessments for the Building Structures within the SMP Area

Structure Name	Structure Type	Impact Assessment Strain due to LW29 to LW34 (mm/m)	Strain Impact Assessment due to LW29 to LW34	Impact Assessment Strain due to LW29 to LW35 (mm/m)	Strain Impact Assessment due to LW29 to LW35	Impact Assessment Strain due to LW29 to LW36 (mm/m)	Strain Impact Assessment due to LW29 to LW36	Tilt Impact Assessment at the Completion of LW29 to LW36 with an Increased Prediction x1.25	Tilt Impact Assessment at the Completion of LW29 to LW36 with an Increased Prediction x1.5	Tilt Impact Assessment at the Completion of LW29 to LW36 with an Increased Prediction x1.75	Tilt Impact Assessment at the Completion of LW29 to LW36 with an Increased Prediction x2.0	Tilt Impact Assessment at the Completion of LW29 to LW36 with an Increased Prediction x5.0	Strain Impact Assessment due to the Extraction of LW29 to LW36 with an Increased Prediction x1.25	Strain Impact Assessment due to the Extraction of LW29 to LW36 with an Increased Prediction x1.5	Strain Impact Assessment due to the Extraction of LW29 to LW36 with an Increased Prediction x1.75	Strain Impact Assessment due to the Extraction of LW29 to LW36 with an Increased Prediction x2.0	Strain Impact Assessment due to the Extraction of LW29 to LW36 with an Increased Prediction x5.0
A27a	H1	-1.8	Category 1	-1.8	Category 1	-1.8	Category 1	Category B	Category C	Category C	Category D	Category D	Category 2	Category 2	Category 2	Category 2	Category 4
A27b	R	-1.9	Category 1	-1.9	Category 1	-1.9	Category 1	Category B	Category C	Category C	Category D	Category D	Category 1	Category 1	Category 1	Category 1	Category 3
A27c	R	1.4	Category 0	1.4	Category 0	1.4	Category 0	Category B	Category C	Category C	Category D	Category D	Category 0	Category 0	Category 0	Category 0	Category 1
A28a	H1	1.6	Category 2	1.6	Category 2	1.6	Category 2	Category B	Category C	Category C	Category D	Category D	Category 2	Category 3	Category 3	Category 3	Category 5
A28b	R	1.5	Category 1	1.5	Category 1	1.5	Category 1	Category B	Category C	Category C	Category D	Category D	Category 1	Category 1	Category 1	Category 2	Category 3
A28c	R	1.5	Category 1	1.5	Category 1	1.5	Category 1	Category C	Category C	Category C	Category D	Category D	Category 1	Category 1	Category 1	Category 1	Category 3
A28d	R	1.1	Category 0	1.1	Category 0	1.1	Category 0	Category A	Category A	Category A	Category B	Category D	Category 0	Category 0	Category 0	Category 0	Category 0
A28e	R	1.0	Category 0	1.0	Category 0	1.0	Category 0	Category A	Category A	Category B	Category B	Category D	Category 0	Category 0	Category 0	Category 0	Category 0
A28f	R	1.5	Category 0	1.5	Category 0	1.5	Category 0	Category B	Category C	Category C	Category D	Category D	Category 1	Category 1	Category 1	Category 1	Category 2
A28g	R	1.5	Category 0	1.5	Category 0	1.5	Category 0	Category C	Category C	Category D	Category D	Category D	Category 0	Category 0	Category 0	Category 0	Category 1
A28h	R	1.4	Category 0	1.4	Category 0	1.4	Category 0	Category B	Category C	Category C	Category D	Category D	Category 0	Category 0	Category 0	Category 0	Category 1
A28i	H3	1.9	Category 2	1.9	Category 2	1.9	Category 2	Category B	Category B	Category C	Category C	Category D	Category 2	Category 2	Category 2	Category 3	Category 4
A28j	R	1.5	Category 1	1.5	Category 1	1.5	Category 1	Category A	Category B	Category B	Category C	Category D	Category 1	Category 2	Category 2	Category 2	Category 3
A28k	R	1.5	Category 0	1.6	Category 0	1.6	Category 0	Category A	Category B	Category B	Category B	Category D	Category 0	Category 0	Category 1	Category 1	Category 2
A28l	O	1.5	Category 1	1.5	Category 1	1.5	Category 1	Category B	Category C	Category C	Category D	Category D	Category 1	Category 1	Category 2	Category 2	Category 3
A29a	H1	-0.5	Category 0	-0.5	Category 0	-0.5	Category 0	Category A	Category A	Category B	Category B	Category D	Category 0	Category 0	Category 1	Category 1	Category 2
A29b	R	-0.7	Category 0	-0.7	Category 0	-0.7	Category 0	Category A	Category A	Category B	Category B	Category D	Category 0	Category 0	Category 0	Category 0	Category 1
A29c	R	-1.2	Category 0	-1.2	Category 0	-1.2	Category 0	Category A	Category B	Category B	Category C	Category D	Category 0	Category 0	Category 0	Category 0	Category 1
A29d	R	-1.4	Category 0	-1.4	Category 0	-1.4	Category 0	Category A	Category B	Category B	Category B	Category D	Category 0	Category 0	Category 0	Category 0	Category 1
A29e	R	-0.5	Category 0	-0.5	Category 0	-0.5	Category 0	Category A	Category A	Category B	Category B	Category D	Category 0	Category 0	Category 0	Category 0	Category 0
A30a	H1	-1.7	Category 1	-1.7	Category 1	-1.7	Category 1	Category B	Category B	Category C	Category C	Category D	Category 1	Category 2	Category 2	Category 2	Category 3
A30b	R	-1.7	Category 0	-1.7	Category 0	-1.7	Category 0	Category A	Category A	Category B	Category B	Category D	Category 0	Category 0	Category 0	Category 0	Category 1
A30c	R	1.4	Category 0	1.5	Category 0	1.5	Category 0	Category B	Category B	Category C	Category C	Category D	Category 0	Category 1	Category 1	Category 1	Category 2
A31a	H1	1.4	Category 2	1.4	Category 2	1.4	Category 2	Category A	Category A	Category A	Category A	Category C	Category 2	Category 2	Category 3	Category 3	Category 5
A31b	R	1.2	Category 0	1.2	Category 0	1.2	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 1	Category 1	Category 1	Category 2
A31c	R	1.2	Category 0	1.2	Category 0	1.2	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 1	Category 1	Category 1	Category 2
A31d	R	1.1	Category 0	1.1	Category 0	1.1	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 1	Category 1	Category 1	Category 2
A31e	R	0.6	Category 0	0.6	Category 0	0.6	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 0
A31f	R	0.6	Category 0	0.6	Category 0	0.6	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 0
A31g	R	1.0	Category 0	1.0	Category 0	1.0	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 2
A31h	R	1.3	Category 1	1.4	Category 1	1.4	Category 1	Category A	Category A	Category A	Category A	Category C	Category 1	Category 1	Category 1	Category 1	Category 3
A31i	R	1.3	Category 0	1.4	Category 0	1.4	Category 0	Category A	Category A	Category A	Category A	Category C	Category 1	Category 1	Category 1	Category 1	Category 2
A31j	R	0.7	Category 0	0.7	Category 0	0.7	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 1
A31k	R	0.7	Category 0	0.8	Category 0	0.8	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 1
A31l	R	0.6	Category 0	0.6	Category 0	0.6	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 0
A31m	R	1.1	Category 0	1.2	Category 0	1.2	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 1
A31n	R	1.3	Category 0	1.3	Category 0	1.3	Category 0	Category A	Category A	Category A	Category A	Category C	Category 1	Category 1	Category 1	Category 1	Category 2
A32a	H2	0.6	Category 1	0.6	Category 1	0.6	Category 1	Category A	Category A	Category A	Category A	Category C	Category 1	Category 2	Category 2	Category 2	Category 3
A32b	R	0.6	Category 0	0.6	Category 0	0.6	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 1
A32c	R	0.6	Category 0	0.6	Category 0	0.6	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 1
A32d	R	0.6	Category 0	0.6	Category 0	0.6	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 0
A32e	R	0.6	Category 0	0.6	Category 0	0.6	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 1
A33a	H1	-1.6	Category 1	-1.6	Category 1	-1.6	Category 1	Category A	Category A	Category B	Category B	Category D	Category 2	Category 2	Category 2	Category 2	Category 4
A33b	R	-1.7	Category 0	-1.7	Category 0	-1.7	Category 0	Category A	Category B	Category B	Category C	Category D	Category 0	Category 1	Category 1	Category 1	Category 2
A33c	R	-1.7	Category 1	-1.7	Category 1	-1.7	Category 1	Category A	Category B	Category B	Category C	Category D	Category 1	Category 2	Category 2	Category 2	Category 3
A33d	R	-1.1	Category 0	-1.1	Category 0	-1.1	Category 0	Category B	Category B	Category C	Category C	Category D	Category 0	Category 0	Category 0	Category 1	Category 2
A34a	R	-1.6	Category 1	-1.6	Category 1	-1.6	Category 1	Category B	Category B	Category C	Category C	Category D	Category 1	Category 1	Category 2	Category 2	Category 3
A35a	H1	1.0	Category 1	1.5	Category 2	1.5	Category 2	Category A	Category A	Category A	Category A	Category C	Category 2	Category 2	Category 2	Category 3	Category 4
A35b	R	1.1	Category 1	1.5	Category 1	1.5	Category 1	Category A	Category A	Category A	Category B	Category D	Category 1	Category 1	Category 2	Category 2	Category 3
A35c	R	0.8	Category 0	1.4	Category 0	1.4	Category 0	Category A	Category A	Category A	Category A	Category B	Category 0	Category 0	Category 0	Category 0	Category 1
A36a	H1	0.4	Category 0	0.7	Category 0	0.7	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 1	Category 1	Category 1	Category 2
A36b	R	0.4	Category 0	0.6	Category 0	0.6	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 1
A36c	R	0.4	Category 0	0.6	Category 0	0.6	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 1
A36d	R	0.4	Category 0	0.6	Category 0	0.6	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 1
A36e	R	0.4	Category 0	0.6	Category 0	0.6	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 1
A36f	R	0.4	Category 0	0.6	Category 0	0.6	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 0
A36g	R	0.4	Category 0	0.6	Category 0	0.6	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 0
A36h	R	0.4	Category 0	0.6	Category 0	0.6	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 0
A36i	R	0.3	Category 0	0.7	Category 0	0.7	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 1
A36j	R	0.4	Category 0	0.6	Category 0	0.6	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 0
A36k	R	0.4	Category 0	0.6	Category 0	0.6	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 2
A38i	R	0.2	Category 0	-1.7	Category 0	-1.7	Category 0	Category C	Category C	Category D	Category D	Category D	Category 1	Category 1	Category 1	Category 1	Category 3

Table E.01 - West Cliff Colliery - Longwalls 34 to 36
Predictions and Impact Assessments for the Building Structures within the SMP Area

Structure Name	Structure Type	Impact Assessment Strain due to LW29 to LW34 (mm/m)	Strain Impact Assessment due to LW29 to LW34	Impact Assessment Strain due to LW29 to LW35 (mm/m)	Strain Impact Assessment due to LW29 to LW35	Impact Assessment Strain due to LW29 to LW36 (mm/m)	Strain Impact Assessment due to LW29 to LW36	Tilt Impact Assessment at the Completion of LW29 to LW36 with an Increased Prediction x1.25	Tilt Impact Assessment at the Completion of LW29 to LW36 with an Increased Prediction x1.5	Tilt Impact Assessment at the Completion of LW29 to LW36 with an Increased Prediction x1.75	Tilt Impact Assessment at the Completion of LW29 to LW36 with an Increased Prediction x2.0	Tilt Impact Assessment at the Completion of LW29 to LW36 with an Increased Prediction x5.0	Strain Impact Assessment due to the Extraction of LW29 to LW36 with an Increased Prediction x1.25	Strain Impact Assessment due to the Extraction of LW29 to LW36 with an Increased Prediction x1.5	Strain Impact Assessment due to the Extraction of LW29 to LW36 with an Increased Prediction x1.75	Strain Impact Assessment due to the Extraction of LW29 to LW36 with an Increased Prediction x2.0	Strain Impact Assessment due to the Extraction of LW29 to LW36 with an Increased Prediction x5.0
A39a	H1	0.3	Category 0	-1.1	Category 0	-1.1	Category 0	Category A	Category A	Category A	Category A	Category B	Category 1	Category 1	Category 1	Category 1	Category 3
A39b	R	0.3	Category 0	0.7	Category 0	0.7	Category 0	Category A	Category A	Category A	Category A	Category B	Category 0	Category 0	Category 0	Category 0	Category 0
A39c	O	0.3	Category 0	-0.8	Category 0	-0.8	Category 0	Category A	Category A	Category A	Category A	Category B	Category 0	Category 0	Category 0	Category 0	Category 1
A39d	O	0.3	Category 0	-0.9	Category 0	-0.9	Category 0	Category A	Category A	Category A	Category A	Category B	Category 0	Category 0	Category 0	Category 0	Category 1
A39e	R	0.3	Category 0	-1.3	Category 0	-1.3	Category 0	Category A	Category A	Category A	Category A	Category B	Category 0	Category 0	Category 0	Category 0	Category 0
A39f	R	0.3	Category 0	-1.2	Category 0	-1.2	Category 0	Category A	Category A	Category A	Category A	Category B	Category 0	Category 0	Category 0	Category 0	Category 0
A39g	R	0.3	Category 0	0.7	Category 0	0.7	Category 0	Category A	Category A	Category A	Category A	Category B	Category 0	Category 0	Category 0	Category 0	Category 0
A39h	R	0.3	Category 0	0.7	Category 0	0.7	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 0
A39i	R	0.3	Category 0	-1.7	Category 0	-1.7	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 1	Category 2
A39j	R	0.3	Category 0	-0.8	Category 0	-0.8	Category 0	Category A	Category A	Category A	Category A	Category B	Category 0	Category 0	Category 0	Category 0	Category 0
C01a	R	-0.4	Category 0	-0.4	Category 0	-0.4	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 1
C01b	R	-0.5	Category 0	-0.5	Category 0	-0.5	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 2
C01c	R	-0.6	Category 0	-0.6	Category 0	-0.6	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 1
C01d	H1	-1.5	Category 1	-1.5	Category 1	-1.5	Category 1	Category A	Category A	Category A	Category A	Category C	Category 1	Category 2	Category 2	Category 2	Category 3
C01e	R	-0.9	Category 0	-0.9	Category 0	-0.9	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 1	Category 1	Category 2
C01f	R	-0.6	Category 0	-0.6	Category 0	-0.6	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 1
C05a	R	1.4	Category 2	1.4	Category 2	1.4	Category 2	Category A	Category A	Category A	Category A	Category C	Category 2	Category 3	Category 3	Category 3	Category 5
C07a	R	0.1	Category 0	0.1	Category 0	1.2	Category 1	Category B	Category C	Category C	Category D	Category D	Category 1	Category 1	Category 1	Category 1	Category 3
C07b	R	0.1	Category 0	0.1	Category 0	1.2	Category 1	Category C	Category C	Category D	Category D	Category D	Category 1	Category 2	Category 2	Category 2	Category 3
C07c	R	0.1	Category 0	0.1	Category 0	1.2	Category 1	Category C	Category C	Category D	Category D	Category D	Category 1	Category 1	Category 2	Category 2	Category 3
C07d	R	0.1	Category 0	0.1	Category 0	1.1	Category 0	Category C	Category C	Category D	Category D	Category D	Category 0	Category 0	Category 0	Category 1	Category 2
C07e	R	0.1	Category 0	0.1	Category 0	0.7	Category 0	Category A	Category A	Category A	Category A	Category D	Category 0	Category 0	Category 0	Category 1	Category 2
C08a	H1	0.1	Category 0	0.1	Category 0	1.2	Category 1	Category B	Category B	Category C	Category C	Category D	Category 1	Category 1	Category 1	Category 1	Category 3
C08b	R	0.1	Category 0	0.1	Category 0	1.1	Category 0	Category B	Category B	Category C	Category C	Category D	Category 0	Category 0	Category 1	Category 1	Category 2
C08c	R	0.1	Category 0	0.1	Category 0	1.1	Category 0	Category B	Category B	Category C	Category C	Category D	Category 1	Category 1	Category 1	Category 1	Category 2
C13a	R	0.1	Category 0	0.1	Category 0	0.1	Category 0	Category A	Category A	Category A	Category A	Category A	Category 0	Category 0	Category 0	Category 0	Category 0
D01a	H1	0.1	Category 0	1.0	Category 1	1.5	Category 1	Category A	Category A	Category A	Category A	Category D	Category 1	Category 2	Category 2	Category 2	Category 3
D01b	R	0.1	Category 0	0.8	Category 0	1.3	Category 0	Category A	Category A	Category A	Category A	Category D	Category 0	Category 0	Category 1	Category 1	Category 2
D01c	R	0.1	Category 0	0.8	Category 0	1.3	Category 0	Category A	Category A	Category A	Category A	Category D	Category 0	Category 0	Category 0	Category 1	Category 2
D01d	R	0.1	Category 0	0.9	Category 0	1.3	Category 0	Category A	Category A	Category A	Category A	Category D	Category 0	Category 0	Category 0	Category 0	Category 1
D01e	R	0.1	Category 0	0.9	Category 0	1.3	Category 0	Category A	Category A	Category A	Category A	Category D	Category 0	Category 0	Category 1	Category 1	Category 2
D01f	R	0.1	Category 0	0.6	Category 0	0.6	Category 0	Category A	Category B	Category B	Category C	Category D	Category 0	Category 0	Category 0	Category 0	Category 1
D01g	R	0.1	Category 0	0.5	Category 0	-0.6	Category 0	Category A	Category B	Category B	Category C	Category D	Category 0	Category 0	Category 1	Category 1	Category 2
D02a	H1	0.1	Category 0	0.3	Category 0	0.6	Category 0	Category A	Category A	Category B	Category B	Category D	Category 0	Category 0	Category 0	Category 0	Category 2
D02b	R	0.1	Category 0	0.3	Category 0	-0.6	Category 0	Category A	Category A	Category B	Category B	Category D	Category 0	Category 0	Category 0	Category 0	Category 0
D02c	R	0.1	Category 0	0.3	Category 0	-0.8	Category 0	Category A	Category A	Category B	Category B	Category D	Category 0	Category 0	Category 0	Category 0	Category 1
D02d	R	0.1	Category 0	0.3	Category 0	-1.0	Category 0	Category A	Category A	Category B	Category B	Category D	Category 0	Category 0	Category 0	Category 0	Category 1
D02e	R	0.1	Category 0	0.3	Category 0	-1.0	Category 0	Category A	Category A	Category B	Category B	Category D	Category 0	Category 0	Category 0	Category 0	Category 0
D03a	H1	0.1	Category 0	0.3	Category 0	-1.0	Category 0	Category A	Category A	Category A	Category A	Category A	Category 1	Category 1	Category 1	Category 1	Category 2
D03b	R	0.1	Category 0	0.3	Category 0	-1.6	Category 1	Category A	Category A	Category A	Category A	Category C	Category 1	Category 1	Category 2	Category 2	Category 3
D03c	R	0.1	Category 0	0.3	Category 0	-1.5	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 1
D03d	R	0.1	Category 0	0.3	Category 0	-1.2	Category 0	Category A	Category A	Category A	Category A	Category A	Category 0	Category 0	Category 0	Category 0	Category 0
D03e	R	0.1	Category 0	0.3	Category 0	-1.2	Category 0	Category A	Category A	Category A	Category A	Category A	Category 0	Category 0	Category 0	Category 0	Category 0
D03f	R	0.1	Category 0	0.3	Category 0	0.7	Category 0	Category A	Category A	Category A	Category A	Category A	Category 0	Category 0	Category 0	Category 0	Category 1
D03g	R	0.1	Category 0	0.3	Category 0	0.7	Category 0	Category A	Category A	Category A	Category A	Category B	Category 0	Category 0	Category 0	Category 0	Category 1
D04a	H1	0.1	Category 0	0.1	Category 0	1.2	Category 1	Category C	Category C	Category D	Category D	Category D	Category 1	Category 2	Category 2	Category 2	Category 3
D04b	R	0.1	Category 0	0.2	Category 0	1.2	Category 0	Category C	Category C	Category D	Category D	Category D	Category 0	Category 0	Category 1	Category 1	Category 2
D04c	R	0.1	Category 0	0.2	Category 0	1.1	Category 0	Category C	Category C	Category D	Category D	Category D	Category 0	Category 0	Category 0	Category 0	Category 1
D04d	R	-0.1	Category 0	0.2	Category 0	1.1	Category 0	Category C	Category C	Category D	Category D	Category D	Category 1	Category 1	Category 1	Category 1	Category 3
D04e	R	0.1	Category 0	0.2	Category 0	1.1	Category 0	Category C	Category C	Category D	Category D	Category D	Category 0	Category 1	Category 1	Category 1	Category 2
D04f	R	0.1	Category 0	0.2	Category 0	1.2	Category 0	Category C	Category C	Category D	Category D	Category D	Category 1	Category 1	Category 1	Category 1	Category 2
D04g	R	0.1	Category 0	0.1	Category 0	1.2	Category 0	Category C	Category C	Category D	Category D	Category D	Category 0	Category 1	Category 1	Category 1	Category 2
D04h	R	0.1	Category 0	0.1	Category 0	1.2	Category 0	Category C	Category C	Category D	Category D	Category D	Category 0	Category 0	Category 0	Category 0	Category 1
D04i	R	0.1	Category 0	0.1	Category 0	1.2	Category 0	Category C	Category C	Category D	Category D	Category D	Category 0	Category 0	Category 0	Category 0	Category 1
D04j	R	0.1	Category 0	0.2	Category 0	-1.1	Category 0	Category C	Category C	Category D	Category D	Category D	Category 0	Category 0	Category 0	Category 1	Category 2
D05a	H2	0.1	Category 0	0.1	Category 0	0.9	Category 2	Category A	Category A	Category A	Category B	Category D	Category 2	Category 2	Category 2	Category 3	Category 4
D06a	H1	0.1	Category 0	0.1	Category 0	0.5	Category 0	Category A	Category A	Category A	Category A	Category B	Category 0	Category 0	Category 0	Category 1	Category 2
D06b	R	0.1	Category 0	0.1	Category 0	0.5	Category 0	Category A	Category A	Category A	Category A	Category B	Category 0	Category 0	Category 0	Category 0	Category 0
D06c	R	0.1	Category 0	0.1	Category 0	0.4	Category 0	Category A	Category A	Category A	Category A	Category A	Category 0	Category 0	Category 0	Category 0	Category 1
D06d	R	0.1	Category 0	0.1	Category 0	0.4	Category 0	Category A	Category A	Category A	Category A	Category A	Category 0	Category 0	Category 0	Category 0	Category 0
D06e	R	0.1	Category 0	0.1	Category 0	0.4	Category 0	Category A	Category A	Category A	Category A	Category A	Category 0	Category 0	Category 0	Category 0	Category 0
D06f	R	0.1	Category 0	0.1	Category 0	0.3	Category 0	Category A	Category A	Category A	Category A	Category A	Category 0	Category 0	Category 0	Category 0	Category 0

Table E.01 - West Cliff Colliery - Longwalls 34 to 36
Predictions and Impact Assessments for the Building Structures within the SMP Area

Structure Name	Structure Type	Impact Assessment Strain due to LW29 to LW34 (mm/m)	Strain Impact Assessment due to LW29 to LW34	Impact Assessment Strain due to LW29 to LW35 (mm/m)	Strain Impact Assessment due to LW29 to LW35	Impact Assessment Strain due to LW29 to LW36 (mm/m)	Strain Impact Assessment due to LW29 to LW36	Tilt Impact Assessment at the Completion of LW29 to LW36 with an Increased Prediction x1.25	Tilt Impact Assessment at the Completion of LW29 to LW36 with an Increased Prediction x1.5	Tilt Impact Assessment at the Completion of LW29 to LW36 with an Increased Prediction x1.75	Tilt Impact Assessment at the Completion of LW29 to LW36 with an Increased Prediction x2.0	Tilt Impact Assessment at the Completion of LW29 to LW36 with an Increased Prediction x5.0	Strain Impact Assessment due to the Extraction of LW29 to LW36 with an Increased Prediction x1.25	Strain Impact Assessment due to the Extraction of LW29 to LW36 with an Increased Prediction x1.5	Strain Impact Assessment due to the Extraction of LW29 to LW36 with an Increased Prediction x1.75	Strain Impact Assessment due to the Extraction of LW29 to LW36 with an Increased Prediction x2.0	Strain Impact Assessment due to the Extraction of LW29 to LW36 with an Increased Prediction x5.0
D06g	R	0.1	Category 0	0.1	Category 0	0.3	Category 0	Category A	Category A	Category A	Category A	Category A	Category 0	Category 0	Category 0	Category 0	Category 1
D06h	O	0.1	Category 0	0.1	Category 0	0.3	Category 0	Category A	Category A	Category A	Category A	Category A	Category 0	Category 0	Category 0	Category 0	Category 0
D06i	O	0.1	Category 0	0.1	Category 0	0.3	Category 0	Category A	Category A	Category A	Category A	Category A	Category 0	Category 0	Category 0	Category 0	Category 0
D06j	O	0.1	Category 0	0.1	Category 0	0.3	Category 0	Category A	Category A	Category A	Category A	Category A	Category 0	Category 0	Category 0	Category 0	Category 0
D06k	R	0.1	Category 0	0.1	Category 0	0.3	Category 0	Category A	Category A	Category A	Category A	Category A	Category 0	Category 1	Category 1	Category 1	Category 2
D06l	R	0.1	Category 0	0.1	Category 0	0.5	Category 0	Category A	Category A	Category A	Category A	Category B	Category 0	Category 0	Category 0	Category 0	Category 1
D07a	H1	0.1	Category 0	0.1	Category 0	0.3	Category 0	Category A	Category A	Category A	Category A	Category A	Category 0	Category 0	Category 0	Category 0	Category 1
D07b	R	0.1	Category 0	0.1	Category 0	0.4	Category 0	Category A	Category A	Category A	Category A	Category A	Category 0	Category 0	Category 0	Category 0	Category 0
D07c	R	0.1	Category 0	0.1	Category 0	0.4	Category 0	Category A	Category A	Category A	Category A	Category A	Category 0	Category 0	Category 0	Category 0	Category 0
D07d	R	0.1	Category 0	0.1	Category 0	0.3	Category 0	Category A	Category A	Category A	Category A	Category A	Category 0	Category 0	Category 0	Category 0	Category 0
D07e	R	0.1	Category 0	0.1	Category 0	0.4	Category 0	Category A	Category A	Category A	Category A	Category A	Category 0	Category 0	Category 0	Category 0	Category 0
D08a	H3	0.1	Category 0	0.1	Category 0	0.2	Category 0	Category A	Category A	Category A	Category A	Category A	Category 0	Category 0	Category 0	Category 0	Category 1
D08b	R	0.1	Category 0	0.1	Category 0	0.2	Category 0	Category A	Category A	Category A	Category A	Category A	Category 0	Category 0	Category 0	Category 0	Category 0
D08c	R	0.1	Category 0	0.1	Category 0	0.1	Category 0	Category A	Category A	Category A	Category A	Category A	Category 0	Category 0	Category 0	Category 0	Category 0
D08d	R	0.1	Category 0	0.1	Category 0	0.2	Category 0	Category A	Category A	Category A	Category A	Category A	Category 0	Category 0	Category 0	Category 0	Category 1
F03a	C	-1.6	Category 2	-1.6	Category 2	-1.6	Category 2	Category B	Category B	Category C	Category C	Category D	Category 3	Category 3	Category 3	Category 3	Category 5
F03aa	C	-0.4	Category 0	-0.4	Category 0	-0.4	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 0
F03ab	C	-0.5	Category 0	-0.5	Category 0	-0.5	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 0
F03ac	C	-0.6	Category 0	-0.6	Category 0	-0.6	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 0
F03ad	C	1.4	Category 0	1.4	Category 0	1.4	Category 0	Category A	Category B	Category B	Category B	Category D	Category 0	Category 0	Category 0	Category 0	Category 1
F03ae	C	1.4	Category 0	1.4	Category 0	1.4	Category 0	Category B	Category B	Category C	Category C	Category D	Category 0	Category 0	Category 0	Category 0	Category 1
F03af	C	-1.5	Category 0	-1.5	Category 0	-1.5	Category 0	Category B	Category B	Category C	Category C	Category D	Category 0	Category 0	Category 0	Category 0	Category 1
F03ag	C	-1.8	Category 0	-1.8	Category 0	-1.8	Category 0	Category B	Category B	Category C	Category C	Category D	Category 0	Category 0	Category 0	Category 1	Category 2
F03ah	C	-1.7	Category 0	-1.7	Category 0	-1.7	Category 0	Category B	Category B	Category C	Category C	Category D	Category 0	Category 0	Category 0	Category 0	Category 1
F03ai	C	1.4	Category 0	1.4	Category 0	1.4	Category 0	Category B	Category B	Category C	Category C	Category D	Category 0	Category 0	Category 0	Category 0	Category 1
F03aj	C	1.4	Category 0	1.4	Category 0	1.4	Category 0	Category A	Category B	Category B	Category C	Category D	Category 0	Category 0	Category 0	Category 0	Category 1
F03ak	C	1.4	Category 0	1.4	Category 0	1.4	Category 0	Category A	Category A	Category A	Category A	Category D	Category 0	Category 0	Category 0	Category 0	Category 1
F03al	C	0.9	Category 0	0.9	Category 0	0.9	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 1
F03am	C	1.2	Category 0	1.2	Category 0	1.2	Category 0	Category A	Category A	Category A	Category A	Category B	Category 0	Category 0	Category 0	Category 0	Category 0
F03an	C	1.4	Category 0	1.4	Category 0	1.4	Category 0	Category A	Category A	Category A	Category A	Category D	Category 0	Category 0	Category 0	Category 0	Category 1
F03ao	C	1.4	Category 0	1.4	Category 0	1.4	Category 0	Category A	Category B	Category B	Category C	Category D	Category 0	Category 0	Category 0	Category 0	Category 1
F03ap	C	1.3	Category 0	1.3	Category 0	1.3	Category 0	Category A	Category A	Category A	Category A	Category B	Category 0	Category 0	Category 0	Category 1	Category 2
F03aq	C	1.3	Category 0	1.3	Category 0	1.3	Category 0	Category A	Category A	Category A	Category A	Category B	Category 0	Category 0	Category 0	Category 0	Category 1
F03ar	C	1.3	Category 0	1.3	Category 0	1.3	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 1
F03as	C	1.4	Category 0	1.4	Category 0	1.4	Category 0	Category A	Category A	Category B	Category B	Category D	Category 0	Category 0	Category 0	Category 0	Category 1
F03b	C	-1.6	Category 2	-1.6	Category 2	-1.6	Category 2	Category B	Category B	Category C	Category C	Category D	Category 3	Category 3	Category 3	Category 3	Category 5
F03c	C	-1.6	Category 2	-1.6	Category 2	-1.6	Category 2	Category B	Category B	Category C	Category C	Category D	Category 3	Category 3	Category 3	Category 3	Category 5
F03d	C	-1.6	Category 2	-1.6	Category 2	-1.6	Category 2	Category B	Category B	Category C	Category C	Category D	Category 3	Category 3	Category 3	Category 3	Category 5
F03e	C	1.5	Category 2	1.5	Category 2	1.5	Category 2	Category B	Category B	Category C	Category C	Category D	Category 2	Category 2	Category 3	Category 3	Category 5
F03f	C	-1.6	Category 2	-1.6	Category 2	-1.6	Category 2	Category B	Category B	Category C	Category C	Category D	Category 2	Category 3	Category 3	Category 3	Category 5
F03g	C	-1.7	Category 2	-1.7	Category 2	-1.7	Category 2	Category B	Category B	Category C	Category C	Category D	Category 2	Category 3	Category 3	Category 3	Category 5
F03h	C	-1.7	Category 2	-1.7	Category 2	-1.7	Category 2	Category B	Category B	Category C	Category C	Category D	Category 2	Category 3	Category 3	Category 3	Category 5
F03i	C	1.5	Category 2	1.5	Category 2	1.5	Category 2	Category A	Category B	Category B	Category B	Category D	Category 2	Category 2	Category 3	Category 3	Category 5
F03j	C	1.5	Category 2	1.5	Category 2	1.5	Category 2	Category B	Category B	Category C	Category C	Category D	Category 2	Category 2	Category 3	Category 3	Category 5
F03k	C	1.5	Category 2	1.5	Category 2	1.5	Category 2	Category B	Category B	Category C	Category C	Category D	Category 2	Category 2	Category 3	Category 3	Category 5
F03l	C	-1.7	Category 2	-1.7	Category 2	-1.7	Category 2	Category B	Category B	Category C	Category C	Category D	Category 2	Category 3	Category 3	Category 3	Category 5
F03m	C	1.2	Category 2	1.2	Category 2	1.2	Category 2	Category A	Category A	Category A	Category A	Category C	Category 2	Category 2	Category 2	Category 3	Category 4
F03n	C	1.5	Category 2	1.5	Category 2	1.5	Category 2	Category A	Category A	Category A	Category A	Category C	Category 2	Category 2	Category 3	Category 3	Category 5
F03o	C	1.5	Category 2	1.5	Category 2	1.5	Category 2	Category A	Category A	Category B	Category B	Category D	Category 2	Category 2	Category 3	Category 3	Category 5
F03p	C	1.5	Category 2	1.6	Category 2	1.6	Category 2	Category B	Category B	Category C	Category C	Category D	Category 2	Category 2	Category 3	Category 3	Category 5
F03q	C	0.5	Category 0	0.5	Category 0	0.5	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 1	Category 1	Category 1	Category 2
F03r	C	0.4	Category 0	0.4	Category 0	0.4	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 1
F03s	C	0.5	Category 0	0.5	Category 0	0.5	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 0
F03t	C	0.5	Category 0	0.5	Category 0	0.5	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 1
F03u	C	0.5	Category 0	0.5	Category 0	0.5	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 0
F03v	C	0.5	Category 0	0.5	Category 0	0.5	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 0
F03w	C	-1.1	Category 0	-1.1	Category 0	-1.1	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 1	Category 2
F03x	C	-1.4	Category 1	-1.4	Category 1	-1.4	Category 1	Category A	Category A	Category A	Category A	Category C	Category 1	Category 2	Category 2	Category 2	Category 3
F03y	C	-1.2	Category 1	-1.2	Category 1	-1.2	Category 1	Category A	Category A	Category A	Category A	Category C	Category 1	Category 1	Category 1	Category 2	Category 3
F03z	C	-0.4	Category 0	-0.4	Category 0	-0.4	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 0
F06a	R	0.8	Category 1	0.8	Category 1	0.8	Category 1	Category A	Category A	Category A	Category A	Category C	Category 1	Category 2	Category 2	Category 2	Category 3
F07a	H1	-0.5	Category 0	-0.5	Category 0	-0.5	Category 0	Category A	Category A	Category A	Category A	Category D	Category 0	Category 1	Category 1	Category 1	Category 2

Table E.01 - West Cliff Colliery - Longwalls 34 to 36
Predictions and Impact Assessments for the Building Structures within the SMP Area

Structure Name	Structure Type	Impact Assessment Strain due to LW29 to LW34 (mm/m)	Strain Impact Assessment due to LW29 to LW34	Impact Assessment Strain due to LW29 to LW35 (mm/m)	Strain Impact Assessment due to LW29 to LW35	Impact Assessment Strain due to LW29 to LW36 (mm/m)	Strain Impact Assessment due to LW29 to LW36	Tilt Impact Assessment at the Completion of LW29 to LW36 with an Increased Prediction x1.25	Tilt Impact Assessment at the Completion of LW29 to LW36 with an Increased Prediction x1.5	Tilt Impact Assessment at the Completion of LW29 to LW36 with an Increased Prediction x1.75	Tilt Impact Assessment at the Completion of LW29 to LW36 with an Increased Prediction x2.0	Tilt Impact Assessment at the Completion of LW29 to LW36 with an Increased Prediction x5.0	Strain Impact Assessment due to the Extraction of LW29 to LW36 with an Increased Prediction x1.25	Strain Impact Assessment due to the Extraction of LW29 to LW36 with an Increased Prediction x1.5	Strain Impact Assessment due to the Extraction of LW29 to LW36 with an Increased Prediction x1.75	Strain Impact Assessment due to the Extraction of LW29 to LW36 with an Increased Prediction x2.0	Strain Impact Assessment due to the Extraction of LW29 to LW36 with an Increased Prediction x5.0
F08a	R	-1.7	Category 2	-1.7	Category 2	-1.7	Category 2	Category A	Category A	Category A	Category A	Category C	Category 2	Category 2	Category 2	Category 3	Category 4
F08b	R	-1.9	Category 0	-1.9	Category 0	-1.9	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 1	Category 1	Category 1	Category 2
F08c	R	-1.9	Category 1	-1.9	Category 1	-1.9	Category 1	Category A	Category A	Category A	Category A	Category C	Category 1	Category 1	Category 2	Category 2	Category 3
F08d	R	-1.6	Category 0	-1.6	Category 0	-1.6	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 2
F10a	H1	-0.6	Category 0	-0.6	Category 0	-0.6	Category 0	Category A	Category A	Category A	Category A	Category D	Category 0	Category 0	Category 0	Category 1	Category 2
F11a	H1	-1.6	Category 2	-1.6	Category 2	-1.6	Category 2	Category A	Category A	Category A	Category A	Category C	Category 2	Category 2	Category 2	Category 3	Category 4
F11b	R	-0.5	Category 0	-0.5	Category 0	-0.5	Category 0	Category A	Category A	Category A	Category A	Category D	Category 1	Category 1	Category 1	Category 1	Category 2
F11c	R	-0.5	Category 0	-0.5	Category 0	-0.5	Category 0	Category A	Category A	Category A	Category A	Category D	Category 0	Category 0	Category 1	Category 1	Category 2
F11d	R	0.5	Category 0	0.5	Category 0	0.5	Category 0	Category A	Category A	Category A	Category A	Category D	Category 0	Category 0	Category 0	Category 0	Category 1
F11e	R	0.5	Category 0	0.5	Category 0	0.5	Category 0	Category A	Category A	Category A	Category A	Category D	Category 1	Category 1	Category 1	Category 1	Category 3
F11f	R	0.4	Category 0	0.4	Category 0	0.4	Category 0	Category A	Category A	Category A	Category A	Category D	Category 0	Category 0	Category 0	Category 0	Category 0
G01a	R	-0.6	Category 0	-0.6	Category 0	-0.6	Category 0	Category A	Category A	Category A	Category A	Category D	Category 1	Category 1	Category 1	Category 1	Category 2
G01b	R	-0.6	Category 0	-0.6	Category 0	-0.6	Category 0	Category A	Category A	Category A	Category A	Category D	Category 0	Category 0	Category 0	Category 0	Category 1
G01c	R	-0.6	Category 0	-0.6	Category 0	-0.6	Category 0	Category A	Category A	Category A	Category A	Category D	Category 0	Category 0	Category 0	Category 0	Category 0
G01d	R	-0.6	Category 0	-0.6	Category 0	-0.6	Category 0	Category A	Category A	Category A	Category B	Category D	Category 0	Category 0	Category 0	Category 0	Category 1
G01e	R	-0.6	Category 0	-0.6	Category 0	-0.6	Category 0	Category A	Category A	Category A	Category B	Category D	Category 0	Category 0	Category 0	Category 0	Category 1
G01f	R	-0.6	Category 0	-0.6	Category 0	-0.6	Category 0	Category A	Category A	Category A	Category A	Category D	Category 0	Category 0	Category 0	Category 0	Category 0
G01g	R	-0.6	Category 0	-0.6	Category 0	-0.6	Category 0	Category A	Category A	Category A	Category A	Category D	Category 0	Category 0	Category 0	Category 0	Category 0
G01h	R	-0.6	Category 0	-0.6	Category 0	-0.6	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 0
G01i	H1	-0.6	Category 0	-0.6	Category 0	-0.6	Category 0	Category A	Category A	Category A	Category A	Category C	Category 1	Category 1	Category 1	Category 1	Category 2
G01j	R	-0.6	Category 0	-0.6	Category 0	-0.6	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 0
G02a	R	0.5	Category 0	0.5	Category 0	0.5	Category 0	Category A	Category A	Category A	Category A	Category A	Category 0	Category 0	Category 0	Category 0	Category 1
G02b	R	0.4	Category 0	0.4	Category 0	0.4	Category 0	Category A	Category A	Category A	Category A	Category A	Category 0	Category 0	Category 0	Category 0	Category 1
G02c	H1	0.5	Category 0	0.5	Category 1	0.6	Category 1	Category A	Category A	Category A	Category A	Category A	Category 1	Category 1	Category 1	Category 1	Category 3
G02d	R	-0.5	Category 0	-0.6	Category 0	-0.6	Category 0	Category A	Category A	Category A	Category A	Category A	Category 0	Category 0	Category 1	Category 1	Category 2
G03a	H1	0.5	Category 0	0.6	Category 1	0.6	Category 1	Category A	Category A	Category A	Category A	Category A	Category 1	Category 1	Category 1	Category 2	Category 3
G03b	R	-0.5	Category 0	-0.5	Category 0	-0.5	Category 0	Category A	Category A	Category A	Category A	Category A	Category 0	Category 0	Category 0	Category 0	Category 1
G03c	R	0.4	Category 0	0.5	Category 0	0.6	Category 0	Category A	Category A	Category A	Category A	Category A	Category 0	Category 0	Category 0	Category 0	Category 1
G04a	R	0.4	Category 1	0.5	Category 1	0.6	Category 1	Category A	Category A	Category A	Category A	Category B	Category 1	Category 1	Category 2	Category 2	Category 3
G04b	R	0.4	Category 0	0.5	Category 0	0.6	Category 0	Category A	Category A	Category A	Category A	Category A	Category 0	Category 0	Category 0	Category 0	Category 1
G04c	R	0.4	Category 0	0.6	Category 0	0.6	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 2
G04d	R	0.4	Category 0	0.6	Category 0	0.6	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 1
G04e	R	0.4	Category 0	0.6	Category 0	0.6	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 1
G04f	O	0.4	Category 0	0.6	Category 0	0.6	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 1
G04g	R	0.4	Category 0	0.6	Category 0	0.6	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 1
G04h	R	0.4	Category 0	0.6	Category 0	0.6	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 1
G04i	R	0.4	Category 0	0.6	Category 0	0.6	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 1	Category 2
G04j	R	0.4	Category 0	0.6	Category 0	0.6	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 1	Category 1	Category 2
G04k	R	0.4	Category 0	0.6	Category 1	0.6	Category 1	Category A	Category A	Category A	Category A	Category C	Category 1	Category 1	Category 1	Category 2	Category 3
G04l	O	0.4	Category 0	0.5	Category 0	0.6	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 1
G04m	R	0.4	Category 0	0.6	Category 0	0.6	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 1
G05a	H1	0.3	Category 0	-1.3	Category 1	-1.3	Category 1	Category A	Category A	Category A	Category A	Category C	Category 1	Category 2	Category 2	Category 2	Category 3
G05b	R	0.3	Category 0	-1.7	Category 2	-1.8	Category 2	Category A	Category A	Category B	Category B	Category D	Category 2	Category 2	Category 2	Category 3	Category 4
G05c	R	0.4	Category 0	0.6	Category 0	0.6	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 1
G05d	R	0.3	Category 0	-1.5	Category 0	-1.5	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 1	Category 2
G06a	R	0.2	Category 0	1.1	Category 0	1.3	Category 0	Category A	Category B	Category B	Category C	Category D	Category 0	Category 0	Category 1	Category 1	Category 2
G07a	R	0.5	Category 0	0.6	Category 0	0.6	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 0	Category 0
H06a	R	0.3	Category 0	-1.4	Category 0	-1.4	Category 0	Category A	Category A	Category A	Category A	Category C	Category 0	Category 0	Category 0	Category 1	Category 2

Table E.02 - West Cliff Colliery - Longwalls 34 to 36
Predicted Systematic Subsidence Parameters for the Tanks within the SMP Area

Structure Name	Structure Type	Easting	Northing	Diameter (m)	Height (m)	Maximum Predicted Subsidence due to LW29 to LW33 (mm)	Maximum Predicted Subsidence due to LW29 to LW34 (mm)	Maximum Predicted Subsidence due to LW29 to LW35 (mm)	Maximum Predicted Subsidence due to LW29 to LW36 (mm)	Maximum Predicted Tilt due to LW29 to LW33 (mm/m)	Maximum Predicted Tilt due to LW29 to LW34 (mm/m)	Maximum Predicted Tilt due to LW29 to LW35 (mm/m)	Maximum Predicted Tilt due to LW29 to LW36 (mm/m)	Maximum Predicted Tensile Strain due to LW29 to LW33 (mm/m)	Maximum Predicted Tensile Strain due to LW29 to LW34 (mm/m)	Maximum Predicted Tensile Strain due to LW29 to LW35 (mm/m)	Maximum Predicted Tensile Strain due to LW29 to LW36 (mm/m)	Maximum Predicted Comp. Strain due to LW29 to LW33 (mm/m)	Maximum Predicted Comp. Strain due to LW29 to LW34 (mm/m)	Maximum Predicted Comp. Strain due to LW29 to LW35 (mm/m)	Maximum Predicted Comp. Strain due to LW29 to LW36 (mm/m)
A28t1	T	296430	6216058	3.5	TBC	818	865	871	871	4.0	3.7	3.6	3.6	1.1	1.1	1.1	1.1	-0.1	-0.2	-0.2	-0.2
A29t1	T	296563	6216188	3.3	TBC	822	975	1011	1011	1.6	2.8	3.0	3.0	0.1	0.1	0.1	0.1	-0.4	-0.4	-0.4	-0.4
A30t1	T	296418	6216372	2.0	TBC	833	1101	1156	1156	5.5	3.9	3.6	3.6	0.1	0.2	0.2	0.2	-1.7	-1.7	-1.7	-1.7
A30t2	T	296523	6216482	2.1	TBC	196	751	891	891	2.3	1.1	1.8	1.8	0.5	0.7	0.8	0.8	0.0	-0.2	-0.2	-0.2
A31t1	T	296381	6216591	3.9	TBC	183	771	920	921	2.1	1.1	1.8	1.8	0.4	0.7	0.7	0.7	0.0	-0.2	-0.2	-0.2
A31t2	T	296374	6216592	3.9	TBC	189	768	915	917	2.1	1.1	1.8	1.8	0.5	0.7	0.7	0.7	0.0	-0.2	-0.2	-0.2
A31t3	T	296363	6216595	3.2	TBC	197	765	909	911	2.2	1.1	1.8	1.8	0.5	0.7	0.8	0.8	0.0	-0.2	-0.2	-0.2
A31t4	T	296359	6216597	3.3	TBC	199	764	908	909	2.3	1.1	1.7	1.8	0.5	0.7	0.8	0.8	0.0	-0.2	-0.2	-0.2
A31t5	T	296324	6216598	2.3	TBC	245	748	880	882	2.9	1.0	1.6	1.6	0.6	0.9	1.0	1.0	0.0	-0.2	-0.2	-0.2
A31t6	T	296317	6216645	1.3	TBC	166	784	938	940	1.8	1.0	1.6	1.6	0.4	0.4	0.4	0.4	0.0	-0.3	-0.3	-0.3
A31t7	T	296448	6216601	1.1	TBC	111	807	991	992	1.1	1.0	1.7	1.7	0.2	0.4	0.4	0.4	0.0	-0.3	-0.3	-0.3
A32t1	T	296361	6216635	3.8	TBC	140	794	961	963	1.4	1.0	1.7	1.7	0.3	0.3	0.3	0.3	0.0	-0.3	-0.3	-0.3
A32t2	T	296407	6216621	4.8	TBC	120	803	982	983	1.2	1.0	1.7	1.7	0.2	0.4	0.4	0.4	0.0	-0.3	-0.3	-0.3
A32t3	T	296376	6216629	1.4	TBC	133	795	965	966	1.4	1.0	1.7	1.7	0.3	0.4	0.4	0.4	0.0	-0.3	-0.3	-0.3
A32t4	T	296421	6216619	1.1	TBC	111	807	991	992	1.1	0.9	1.6	1.6	0.2	0.4	0.4	0.4	0.0	-0.3	-0.3	-0.3
A33t1	T	296289	6216874	3.2	TBC	37	816	1092	1104	0.3	5.0	3.7	3.7	0.0	0.4	0.4	0.4	0.0	-1.6	-1.6	-1.6
A35t1	T	296306	6217055	7.8	TBC	12	190	743	781	0.1	2.2	1.1	1.4	0.0	0.5	0.9	0.9	0.0	-0.1	-0.3	-0.3
A35t2	T	296269	6217066	2.6	TBC	13	212	726	771	0.1	2.5	1.1	1.5	0.0	0.5	1.0	1.1	0.0	-0.1	-0.2	-0.2
A35t3	T	296302	6217041	2.0	TBC	13	217	725	759	0.1	2.6	1.1	1.3	0.0	0.6	1.1	1.1	0.0	-0.1	-0.2	-0.2
A35t4	T	296304	6217041	2.0	TBC	13	214	726	761	0.1	2.5	1.1	1.3	0.0	0.5	1.1	1.1	0.0	-0.1	-0.2	-0.2
A36t1	T	296274	6217162	2.7	TBC	7	91	791	887	0.1	0.8	0.8	1.5	0.0	0.2	0.4	0.4	0.0	0.0	-0.3	-0.3
A36t2	T	296276	6217149	3.3	TBC	7	99	786	871	0.1	1.0	0.9	1.5	0.0	0.2	0.4	0.4	0.0	0.0	-0.3	-0.3
A39t1	T	296170	6217320	2.0	TBC	2	50	803	1050	0.0	0.4	0.4	1.3	0.0	0.1	0.4	0.4	0.0	0.0	-0.5	-0.5
C01t1	T	294648	6217576	2.3	TBC	779	1002	1060	1064	0.6	1.4	1.6	1.6	0.1	0.1	0.1	0.1	-0.8	-0.8	-0.8	-0.8
C01t2	T	294648	6217579	2.0	TBC	779	1003	1061	1066	0.7	1.3	1.6	1.6	0.1	0.1	0.1	0.1	-0.9	-0.9	-0.9	-0.9
C01t3	T	294645	6217579	1.8	TBC	779	1002	1059	1064	0.6	1.3	1.6	1.6	0.1	0.1	0.1	0.1	-0.9	-0.9	-0.9	-0.9
C07t1	T	296009	6218030	3.9	TBC	0	0	16	474	0.0	0.0	0.1	5.6	0.0	0.0	0.0	0.8	0.0	0.0	0.0	-0.2
C08t1	T	296225	6217909	1.9	TBC	0	0	13	331	0.0	0.0	0.1	4.2	0.0	0.0	0.0	0.8	0.0	0.0	0.0	-0.1
D03t1	T	296345	6217615	2.6	TBC	0	1	50	822	0.0	0.0	0.4	0.7	0.0	0.0	0.1	0.4	0.0	0.0	0.0	-0.3
D03t2	T	296335	6217646	1.6	TBC	0	0	42	831	0.0	0.0	0.3	0.9	0.0	0.0	0.1	0.4	0.0	0.0	0.0	-1.2
D04t1	T	296305	6217806	2.7	TBC	0	0	18	531	0.0	0.0	0.1	6.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	-0.2
D04t2	T	296292	6217786	3.5	TBC	0	0	22	673	0.0	0.0	0.2	6.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	-0.9
D04t3	T	296309	6217784	2.1	TBC	0	0	21	621	0.0	0.0	0.2	6.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	-0.4
D04t4	T	296292	6217810	0.7	TBC	0	0	19	546	0.0	0.0	0.1	6.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	-0.2
D05t1	T	296348	6217906	7.0	TBC	0	0	7	148	0.0	0.0	0.1	1.6	0.0	0.0	0.0	0.3	0.0	0.0	0.0	-0.1
D05t2	T	296354	6217907	1.7	TBC	0	0	7	138	0.0	0.0	0.1	1.5	0.0	0.0	0.0	0.3	0.0	0.0	0.0	-0.1
D05t3	T	296356	6217907	1.8	TBC	0	0	7	137	0.0	0.0	0.1	1.5	0.0	0.0	0.0	0.3	0.0	0.0	0.0	-0.1
D05t4	T	296335	6217882	2.6	TBC	0	0	9	198	0.0	0.0	0.1	2.4	0.0	0.0	0.0	0.5	0.0	0.0	0.0	-0.1
D06t1	T	296331	6217941	3.2	TBC	0	0	6	119	0.0	0.0	0.1	1.2	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0
D06t2	T	296339	6217940	3.3	TBC	0	0	6	115	0.0	0.0	0.1	1.2	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0
D06t3	T	296384	6217957	3.6	TBC	0	0	3	77	0.0	0.0	0.1	0.7	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
D06t4	T	296447	6217917	1.8	TBC	0	0	3	74	0.0	0.0	0.1	0.7	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
D06t5	T	296340	6217945	1.7	TBC	0	0	5	108	0.0	0.0	0.1	1.1	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0
D07t1	T	296365	6217994	2.0	TBC	0	0	2	64	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
D07t2	T	296362	6217984	2.0	TBC	0	0	2	70	0.0	0.0	0.1	0.7	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
D07t3	T	296353	6217968	1.9	TBC	0	0	3	84	0.0	0.0	0.1	0.8	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
D07t4	T	296367	6218011	3.4	TBC	0	0	1	57	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
D08t1	T	296438	6218107	3.5	TBC	0	0	0	22	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
D08t2	T	296453	6218143	3.2	TBC	0	0	0	17	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
D08t3	T	296346	6218078	4.2	TBC	0	0	0	40	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
D08t4	T	296346	6218073	4.2	TBC	0	0	0	41	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
F03t1	T	295387	6216442	2.0	TBC	969	994	994	994	1.5	1.7	1.7	1.7	0.7	0.7	0.7	0.7	0.0	0.0	0.0	0.0
F03t10	T	295781	6216547	1.7	TBC	786	897	909	909	1.8	1.3	1.2	1.2	0.9	0.9	0.9	0.9	0.0	0.0	0.0	0.0
F03t11	T	295782	6216539	1.7	TBC	799	906	917	917	2.2	1.7	1.6	1.6	0.9	1.0	1.0	1.0	0.0	0.0	0.0	0.0
F03t12	T	295777	6216486	1.7	TBC	966	1053	1060	1060	4.8	4.3	4.3	4.3	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0
F03t13	T	295776	6216478	1.7	TBC	999	1083	1090	1090	4.9	4.5	4.4	4.4	1.0	1.0	1.0	1.0	-0.1	-0.1	-0.1	-0.1
F03t14	T	295602	6216493	1.7	TBC	1178	1240	1242	1242	1.5	1.4	1.4	1.4	0.0	0.0	0.0	0.0	-1.7	-1.7	-1.7	-1.7
F03t15	T	295603	6216501	1.7	TBC	1180	1239	1241	1241	2.3	2.0	1.9	1.9	0.0	0.0	0.0	0.0	-1.7	-1.7	-1.7	-1.7
F03t16	T	295607	6216531	1.7	TBC	1175	1236	1239	1239	4.6	4.2	4.1	4.1	0.0	0.0	0.0	0.0	-1.7	-1.7	-1.7	-1.7
F03t17	T	295608	6216561	1.7	TBC	1121	1191	1194	1194	4.8	4.4	4.3	4.3	0.5	0.6	0.6	0.6	-1.5	-1.5	-1.5	-1.5
F03t18	T	295572	6216586	1.7	TBC	1121	1190	1193	1193	4.8	4.4	4.3	4.3	0.5	0.5	0.6	0.6	-1.5	-1.5	-1.5	-1.5
F03t19	T	295565	6216587	1.7	TBC	1133	1200	1204	1204	4.8	4.4	4.4	4.4	0.4	0.4	0.4	0.4	-1.6	-1.6	-1.6	-1.6
F03t2	T	295381	6216435	1.5	TBC	956	979	979	979	1.3	1.5	1.5	1.5	0.8	0.8	0.8	0.8	0.0	0.0	0.0	0.0
F03t20	T	295524	6216591	1.7	TBC	1170	1231	1234	1234	4.6	4.2	4.1	4.1	0.0	0.0	0.0	0.0	-1.7	-1.7	-1.7	-1.7

Table E.02 - West Cliff Colliery - Longwalls 34 to 36
Predicted Systematic Subsidence Parameters for the Tanks within the SMP Area

Structure Name	Structure Type	Easting	Northing	Diameter (m)	Height (m)	Maximum Predicted Subsidence due to LW29 to LW33 (mm)	Maximum Predicted Subsidence due to LW29 to LW34 (mm)	Maximum Predicted Subsidence due to LW29 to LW35 (mm)	Maximum Predicted Subsidence due to LW29 to LW36 (mm)	Maximum Predicted Tilt due to LW29 to LW33 (mm/m)	Maximum Predicted Tilt due to LW29 to LW34 (mm/m)	Maximum Predicted Tilt due to LW29 to LW35 (mm/m)	Maximum Predicted Tilt due to LW29 to LW36 (mm/m)	Maximum Predicted Tensile Strain due to LW29 to LW33 (mm/m)	Maximum Predicted Tensile Strain due to LW29 to LW34 (mm/m)	Maximum Predicted Tensile Strain due to LW29 to LW35 (mm/m)	Maximum Predicted Tensile Strain due to LW29 to LW36 (mm/m)	Maximum Predicted Comp. Strain due to LW29 to LW33 (mm/m)	Maximum Predicted Comp. Strain due to LW29 to LW34 (mm/m)	Maximum Predicted Comp. Strain due to LW29 to LW35 (mm/m)	Maximum Predicted Comp. Strain due to LW29 to LW36 (mm/m)
F03t21	T	295516	6216591	1.7	TBC	1173	1232	1234	1234	4.4	4.0	3.9	3.9	0.0	0.0	0.0	0.0	-1.7	-1.7	-1.7	-1.7
F03t4	T	295393	6216430	1.7	TBC	960	984	984	984	1.4	1.6	1.6	1.6	0.8	0.8	0.8	0.8	0.0	0.0	0.0	0.0
F03t6	T	295884	6216469	1.7	TBC	797	908	919	921	2.0	1.5	1.4	1.4	0.9	1.0	1.0	1.0	0.0	0.0	0.0	0.0
F03t7	T	295884	6216477	1.7	TBC	785	899	914	916	1.7	1.1	1.0	1.0	0.9	0.9	0.9	0.9	0.0	-0.1	-0.1	-0.1
F03t8	T	295885	6216507	1.7	TBC	771	925	947	948	0.7	1.4	1.5	1.5	0.7	0.7	0.7	0.7	0.0	-0.1	-0.1	-0.1
F03t9	T	295888	6216538	1.7	TBC	789	962	987	989	0.7	1.4	1.6	1.6	0.4	0.4	0.4	0.4	-0.1	-0.1	-0.1	-0.1
F06t1	T	296271	6216305	5.0	TBC	809	976	1007	1008	1.0	1.8	1.9	1.9	0.2	0.2	0.2	0.2	-0.1	-0.1	-0.1	-0.1
F06t2	T	296271	6216300	4.5	TBC	805	968	999	999	1.0	1.8	1.9	1.9	0.2	0.2	0.2	0.2	-0.1	-0.1	-0.1	-0.1
F11t1	T	296081	6216045	7.3	TBC	1083	1107	1108	1108	1.9	2.1	2.1	2.1	0.2	0.2	0.2	0.2	-0.1	-0.1	-0.1	-0.1
G01t1	T	294117	6218461	2.7	TBC	0	526	716	730	0.0	1.2	1.7	1.8	0.0	0.3	0.3	0.3	0.0	-0.5	-0.5	-0.5
G01t2	T	294091	6218427	3.4	TBC	0	526	658	667	0.0	1.3	2.2	2.3	0.0	0.3	0.3	0.3	0.0	-0.5	-0.5	-0.5
G01t3	T	294090	6218422	3.5	TBC	0	526	650	659	0.0	1.5	2.3	2.4	0.0	0.3	0.3	0.3	0.0	-0.5	-0.5	-0.5
G02t1	T	294126	6218570	3.8	TBC	0	408	722	739	0.0	2.4	0.5	0.4	0.0	0.2	0.2	0.2	0.0	-0.2	-0.2	-0.2
G02t2	T	294113	6218550	1.9	TBC	0	455	727	742	0.0	2.4	0.5	0.4	0.0	0.2	0.2	0.2	0.0	-0.3	-0.4	-0.4
G02t3	T	294142	6218546	1.1	TBC	0	427	723	741	0.0	2.4	0.5	0.3	0.0	0.2	0.2	0.2	0.0	-0.2	-0.2	-0.2
G02t4	T	294140	6218545	1.1	TBC	0	431	724	742	0.0	2.4	0.5	0.3	0.0	0.2	0.2	0.2	0.0	-0.2	-0.3	-0.3
G02t5	T	294163	6218565	2.0	TBC	0	364	711	734	0.0	2.4	0.5	0.3	0.0	0.2	0.3	0.3	0.0	-0.1	-0.2	-0.2
G03t1	T	294267	6218507	1.4	TBC	0	336	706	747	0.0	2.4	0.4	0.6	0.0	0.2	0.3	0.3	0.0	-0.1	-0.2	-0.2
G03t2	T	294265	6218526	1.9	TBC	0	301	706	757	0.0	2.3	0.5	0.9	0.0	0.2	0.3	0.3	0.0	-0.1	-0.2	-0.2
G04t1	T	294217	6218541	3.5	TBC	0	339	705	742	0.0	2.4	0.4	0.6	0.0	0.2	0.3	0.3	0.0	-0.1	-0.2	-0.2
G04t2	T	294217	6218537	3.5	TBC	0	347	707	740	0.0	2.4	0.5	0.5	0.0	0.2	0.3	0.3	0.0	-0.1	-0.2	-0.2
G04t3	T	294263	6218601	3.7	TBC	0	187	761	839	0.0	1.5	1.1	1.8	0.0	0.2	0.3	0.3	0.0	-0.1	-0.2	-0.2
G04t4	T	294217	6218530	4.0	TBC	0	360	709	738	0.0	2.4	0.5	0.4	0.0	0.2	0.3	0.3	0.0	-0.1	-0.2	-0.2
G05t1	T	294231	6218729	3.0	TBC	0	96	828	949	0.0	0.7	0.8	1.7	0.0	0.1	0.4	0.4	0.0	0.0	-0.9	-0.9
G05t2	T	294231	6218732	2.0	TBC	0	94	828	950	0.0	0.7	0.7	1.6	0.0	0.1	0.4	0.4	0.0	0.0	-1.0	-1.0
G07t1	T	294473	6218459	3.7	TBC	1	182	771	872	0.0	1.5	1.0	1.8	0.0	0.2	0.3	0.3	0.0	-0.1	-0.2	-0.2
						1180	1240	1242	1242	5.5	5.0	4.4	6.0	1.1	1.1	1.1	1.1	-1.7	-1.7	-1.7	-1.7

Table E.03 - West Cliff Colliery - Longwalls 34 to 36
Predictions and Impact Assessments for the Farm Dams within the SMP Area

Label	Easting	Northing	Type	Longest Side (m)	Maximum Predicted Cumulative Subsidence after LW29 to LW34 (mm)	Maximum Predicted Cumulative Subsidence after LW29 to LW35 (mm)	Maximum Predicted Cumulative Subsidence after LW29 to LW36 (mm)	Maximum Predicted Cumualtive Tilt due to LW29 to LW34 (mm/m)	Maximum Predicted Cumualtive Tilt due to LW29 to LW35 (mm/m)	Maximum Predicted Cumualtive Tilt due to LW29 to LW36 (mm/m)	Maximum Predicted Travelling or Cumulative Tilt due to LW29 to LW36 (mm/m)	Maximum Predicted Change in Freeboard (mm)	Maximum Predicted Cumualtive Tensile Strain due to LW29 to LW34 (mm/m)	Maximum Predicted Cumualtive Tensile Strain due to LW29 to LW35 (mm/m)	Maximum Predicted Cumualtive Tensile Strain due to LW29 to LW36 (mm/m)	Maximum Predicted Cumualtive Comp. Strain due to LW29 to LW34 (mm/m)	Maximum Predicted Cumualtive Comp. Strain due to LW29 to LW35 (mm/m)	Maximum Predicted Cumualtive Comp. Strain due to LW29 to LW36 (mm/m)
A26d1	296545	6215888	Dam	27.9	1045	1050	1050	6.0	6.0	6.0	6.0	170	0.7	0.7	0.7	-2.0	-2.0	-2.0
A28d1	296455	6216070	Dam	29.0	815	820	820	2.9	2.8	2.8	3.0	90	1.1	1.1	1.1	-0.2	-0.2	-0.2
A29d1	296621	6216191	Dam	55.9	950	995	995	5.0	5.0	5.0	5.0	280	< 0.1	< 0.1	< 0.1	-1.7	-1.7	-1.7
A30d1	296528	6216507	Dam	32.3	790	955	955	1.1	1.8	1.8	2.5	80	0.6	0.6	0.6	-0.3	-0.3	-0.3
A31d1	296578	6216543	Dam	30.8	835	1050	1050	1.1	1.9	1.9	2.8	90	0.4	0.4	0.4	-0.3	-0.3	-0.3
A34d1	296458	6216947	Dam	45.8	250	765	775	3.1	1.1	1.2	3.1	140	0.7	1.1	1.1	< -0.1	-0.3	-0.3
A38d1	296482	6217125	Dam	55.7	50	825	860	0.4	4.0	3.9	4.0	220	< 0.1	0.4	0.4	< -0.1	-1.7	-1.7
A38d2	296484	6217170	Dam	38.8	35	820	855	0.3	5.9	5.8	5.9	230	< 0.1	0.4	0.4	< -0.1	-1.7	-1.7
A39d1	296137	6217229	Dam	47.2	140	780	955	1.5	1.1	1.7	2.5	120	0.3	0.4	0.4	< -0.1	-0.3	-0.3
A39d2	295861	6217206	Dam	214.5	800	1060	1105	5.7	4.3	4.0	5.7	1220	0.8	1.0	1.1	-1.6	-1.6	-1.6
C01d1	294646	6217658	Dam	19.0	995	1060	1065	4.0	3.6	3.5	4.8	90	0.3	0.3	0.3	-1.5	-1.5	-1.5
C01d2	294871	6217699	Dam	34.6	740	915	945	1.1	1.7	1.9	2.3	80	0.5	0.6	0.6	-0.3	-0.3	-0.3
C01d3	294831	6217543	Dam	35.2	1035	1090	1100	4.4	4.0	3.9	5.2	180	0.8	0.8	0.8	-1.7	-1.7	-1.7
C03d1	295164	6216982	Dam	29.1	885	890	890	2.4	2.3	2.3	2.6	80	1.0	1.0	1.0	< -0.1	< -0.1	< -0.1
C03d2	295059	6217045	Dam	43.4	900	905	905	3.3	3.2	3.2	3.5	150	1.0	1.0	1.0	< -0.1	< -0.1	< -0.1
C04d1	295077	6217303	Dam	59.8	1050	1090	1095	3.8	3.5	3.4	4.6	280	0.2	0.2	0.2	-1.6	-1.6	-1.6
C04d2	295176	6217344	Dam	41.8	925	980	980	4.2	3.8	3.8	5.0	210	1.1	1.1	1.1	-0.4	-0.4	-0.4
C04d3	295053	6217402	Dam	14.3	975	1030	1035	4.3	3.9	3.9	5.1	70	0.8	0.8	0.8	-1.0	-1.0	-1.0
C04d4	295143	6217527	Dam	40.4	785	960	985	1.0	1.6	1.8	2.6	100	0.4	0.4	0.4	-0.3	-0.3	-0.3
C05d1	295855	6216809	Dam	40.2	1080	1140	1140	4.3	4.0	3.9	5.2	210	0.9	0.9	0.9	-1.6	-1.6	-1.6
C05d2	295738	6216822	Dam	42.8	1090	1140	1145	2.6	2.3	2.2	3.4	150	0.2	0.2	0.2	-1.6	-1.6	-1.6
C05d3	295794	6217014	Dam	64.2	780	945	970	0.9	1.5	1.6	2.4	160	1.1	1.1	1.1	-0.3	-0.3	-0.3
C05d4	295372	6217091	Dam	31.2	1055	1105	1105	3.2	2.9	2.9	4.0	130	0.2	0.2	0.2	-1.5	-1.5	-1.5
C06d1	295887	6217510	Dam	29.6	55	805	1060	0.5	0.6	1.6	2.8	80	< 0.1	0.4	0.4	< -0.1	-0.5	-0.5
C07d1	295921	6218105	Dam	52.1	< 20	< 20	550	< 0.1	0.1	6.0	6.0	310	< 0.1	< 0.1	0.8	< -0.1	< -0.1	-0.2
C07d2	295552	6218056	Dam	42.5	< 20	160	775	< 0.1	1.8	1.2	2.3	100	< 0.1	0.4	0.4	< -0.1	< -0.1	-0.3
C07d3	295272	6218003	Dam	41.6	45	775	1045	0.4	4.4	3.1	4.4	180	< 0.1	0.4	0.4	< -0.1	-1.5	-1.5
C09d1	295382	6218476	Dam	47.3	< 20	20	555	< 0.1	0.1	5.7	5.7	270	< 0.1	< 0.1	0.8	< -0.1	< -0.1	-0.2
C09d2	295405	6218646	Dam	14.5	< 20	< 20	85	< 0.1	< 0.1	0.8	0.8	< 50	< 0.1	< 0.1	0.2	< -0.1	< -0.1	< -0.1
C10d1	295019	6219240	Dam	66.4	< 20	< 20	< 20	< 0.1	< 0.1	0.1	0.1	< 50	< 0.1	< 0.1	< 0.1	< -0.1	< -0.1	< -0.1
C12d3	295653	6218770	Dam	19.1	< 20	< 20	< 20	< 0.1	< 0.1	0.1	0.1	< 50	< 0.1	< 0.1	< 0.1	< -0.1	< -0.1	< -0.1
C12d4	295384	6219008	Dam	21.5	< 20	< 20	< 20	< 0.1	< 0.1	< 0.1	< 0.1	< 50	< 0.1	< 0.1	< 0.1	< -0.1	< -0.1	< -0.1
C12d5	295875	6218268	Dam	21.3	< 20	< 20	130	< 0.1	< 0.1	1.4	1.4	< 50	< 0.1	< 0.1	0.3	< -0.1	< -0.1	< -0.1
C13d1	296006	6218242	Dam	33.5	< 20	< 20	80	< 0.1	< 0.1	0.7	0.7	< 50	< 0.1	< 0.1	0.1	< -0.1	< -0.1	< -0.1
D01d1	296454	6217325	Dam	13.1	< 20	325	445	0.1	4.2	4.0	4.2	50	< 0.1	0.8	0.9	< -0.1	-0.1	-0.1
D02d1	296429	6217463	Dam	17.3	< 20	105	615	< 0.1	1.1	3.6	3.6	60	< 0.1	0.2	0.3	< -0.1	< -0.1	-0.4
D02d2	296535	6217479	Dam	9.2	< 20	50	360	< 0.1	0.5	3.9	3.9	< 50	< 0.1	< 0.1	0.6	< -0.1	< -0.1	-0.1
D08d1	296374	6218080	Dam	44.3	< 20	< 20	40	< 0.1	< 0.1	0.3	0.3	< 50	< 0.1	< 0.1	< 0.1	< -0.1	< -0.1	< -0.1
D10d1	296585	6217791	Dam	9.5	< 20	< 20	80	< 0.1	< 0.1	0.9	0.9	< 50	< 0.1	< 0.1	0.2	< -0.1	< -0.1	< -0.1
F03d1	295790	6216324	Dam	72.2	1250	1255	1255	2.1	2.2	2.2	2.2	160	0.1	0.1	0.1	-1.8	-1.8	-1.8
F03d2	295897	6216378	Dam	85.4	1225	1230	1230	4.5	4.4	4.4	4.7	400	1.0	1.0	1.0	-1.7	-1.7	-1.7
F05d1	296115	6216248	Dam	34.0	1095	1100	1105	4.6	4.6	4.6	4.8	160	1.1	1.1	1.1	-0.3	-0.3	-0.3
F05d2	296174	6216208	Dam	92.4	1200	1205	1205	4.7	4.6	4.6	4.9	450	1.1	1.1	1.1	-1.8	-1.8	-1.8
G02d1	294017	6218591	Dam	9.9	505	740	755	2.3	0.8	0.9	2.3	< 50	0.3	0.3	0.3	-0.5	-0.5	-0.5
G04d1	294270	6218698	Dam	5.4	100	825	970	0.7	0.9	1.8	2.7	< 50	0.1	0.4	0.4	< -0.1	-0.8	-0.8
G06d1	294470	6218622	Dam	50.6	80	815	1010	0.5	5.8	4.3	5.8	290	< 0.1	0.4	0.4	< -0.1	-1.6	-1.7
G06d2	294473	6218573	Dam	22.3	95	815	1010	0.7	2.2	1.8	2.8	60	0.1	0.4	0.4	< -0.1	-1.6	-1.6
G06d3	294704	6218851	Dam	40.2	< 20	40	830	< 0.1	0.4	4.9	4.9	190	< 0.1	< 0.1	0.4	< -0.1	< -0.1	-1.8
G06d4	294664	6218916	Dam	27.0	< 20	30	825	< 0.1	0.3	6.1	6.1	160	< 0.1	< 0.1	0.4	< -0.1	< -0.1	-1.8
G06d5	294535	6218990	Dam	33.6	< 20	35	795	< 0.1	0.3	5.2	5.2	180	< 0.1	< 0.1	0.4	< -0.1	< -0.1	-1.8
G06d6	294378	6218820	Dam	15.3	35	350	670	0.3	4.3	3.0	4.3	70	< 0.1	0.8	0.9	< -0.1	-0.1	-0.2
G06d7	294387	6218780	Dam	17.2	45	495	790	0.3	5.6	4.4	5.6	100	< 0.1	0.8	0.9	< -0.1	-0.2	-0.2
G06d8	294396	6218736	Dam	18.6	55	675	940	0.3	5.8	4.5	5.8	110	< 0.1	0.8	0.9	< -0.1	-1.0	-1.2
G07d1	294513	6218410	Dam	19.1	215	760	860	1.8	1.0	1.7	2.1	< 50	0.2	0.3	0.3	< -0.1	-0.2	-0.2
G07d2	294494	6218413	Dam	12.6	230	750	840	2.0	1.0	1.6	2.0	< 50	0.2	0.3	0.3	< -0.1	-0.2	-0.2
G07d3	294528	6218446	Dam	12.0	155	790	915	1.3	1.0	1.8	2.3	< 50	0.2	0.4	0.4	< -0.1	-0.3	-0.3
G07d4	294498	6218450	Dam	30.5	180	785	900	1.5	1.0	1.8	2.3	70	0.2	0.4	0.4	< -0.1	-0.3	-0.3
G07d5	294479	6218415	Dam	15.6	245	745	830	2.1	0.9	1.6	2.1	< 50	0.2	0.3	0.4	-0.1	-0.2	-0.2
G08d1	294367	6218138	Dam	17.3	570	650	660	2.6	3.1	3.2	3.2	60	0.3	0.3	0.3	-0.3	-0.3	-0.3

Table E.03 - West Cliff Colliery - Longwalls 34 to 36
Predictions and Impact Assessments for the Farm Dams within the SMP Area

Label	Easting	Northing	Type	Longest Side (m)	Maximum Predicted Cumulative Subsidence after LW29 to LW34 (mm)	Maximum Predicted Cumualtive Subsidence after LW29 to LW35 (mm)	Maximum Predicted Cumualtive Subsidence after LW29 to LW36 (mm)	Maximum Predicted Cumualtive Tilt due to LW29 to LW34 (mm/m)	Maximum Predicted Cumualtive Tilt due to LW29 to LW35 (mm/m)	Maximum Predicted Cumualtive Tilt due to LW29 to LW36 (mm/m)	Maximum Predicted Travelling or Cumualtive Tilt due to LW29 to LW36 (mm/m)	Maximum Predicted Change in Freeboard (mm)	Maximum Predicted Cumualtive Tensile Strain due to LW29 to LW34 (mm/m)	Maximum Predicted Cumualtive Tensile Strain due to LW29 to LW35 (mm/m)	Maximum Predicted Cumualtive Tensile Strain due to LW29 to LW36 (mm/m)	Maximum Predicted Cumualtive Comp. Strain due to LW29 to LW34 (mm/m)	Maximum Predicted Cumualtive Comp. Strain due to LW29 to LW35 (mm/m)	Maximum Predicted Cumualtive Comp. Strain due to LW29 to LW36 (mm/m)
G08d2	294467	6218080	Dam	34.8	735	880	905	2.4	3.1	3.2	3.2	110	0.4	0.4	0.4	-0.4	-0.4	-0.4
G08d3	294154	6217938	Dam	17.0	100	100	100	0.6	0.7	0.7	0.7	< 50	< 0.1	< 0.1	< 0.1	< -0.1	< -0.1	< -0.1
G08d4	294336	6217723	Dam	59.4	575	590	595	4.0	4.1	4.1	4.1	240	0.6	0.6	0.6	-0.3	-0.3	-0.3
G08d5	294459	6217632	Dam	20.1	860	895	895	2.3	2.5	2.5	2.5	50	0.1	0.1	0.1	-0.3	-0.3	-0.3
H02d1	293928	6218116	Dam	75.5	70	70	70	0.5	0.5	0.5	0.5	< 50	< 0.1	< 0.1	< 0.1	< -0.1	< -0.1	< -0.1
H02d2	293925	6217957	Dam	31.4	30	30	30	0.3	0.3	0.3	0.3	< 50	< 0.1	< 0.1	< 0.1	< -0.1	< -0.1	< -0.1
H03d1	294130	6218201	Dam	45.3	300	330	330	2.3	2.6	2.6	2.6	120	0.2	0.3	0.3	-0.1	-0.1	-0.1
H03d2	293999	6218272	Dam	52.3	230	255	255	1.9	2.1	2.1	2.1	110	0.2	0.2	0.2	< -0.1	< -0.1	< -0.1
H03d3	293783	6218538	Dam	133.2	465	535	535	2.6	3.0	3.0	3.0	400	0.3	0.3	0.3	-0.4	-0.4	-0.4
H03d4	293911	6218606	Dam	14.7	545	745	755	1.4	1.9	1.9	2.0	< 50	0.3	0.3	0.3	-0.5	-0.5	-0.5
H04d1	293503	6218504	Dam	38.7	55	65	65	0.7	0.8	0.8	0.8	< 50	0.1	0.1	0.1	< -0.1	< -0.1	< -0.1
H05d1	293668	6218754	Dam	19.8	265	400	400	2.8	3.5	3.5	3.5	70	0.4	0.5	0.5	-0.2	-0.2	-0.2
H06d1	293782	6218791	Dam	34.3	370	665	670	2.6	3.0	3.0	3.0	100	0.2	0.2	0.2	-0.3	-0.4	-0.4
H06d2	294059	6218607	Dam	15.1	440	735	745	2.4	0.5	0.5	2.4	< 50	0.2	0.2	0.2	-0.3	-0.3	-0.3
H08d1	293769	6218976	Dam	17.2	55	525	525	0.8	3.8	3.9	3.9	70	0.2	0.4	0.4	< -0.1	-0.2	-0.2
H09d1	293861	6219506	Dam	15.9	< 20	< 20	< 20	< 0.1	< 0.1	< 0.1	< 0.1	< 50	< 0.1	< 0.1	< 0.1	< -0.1	< -0.1	< -0.1

APPENDIX F. FIGURES

Predicted Profiles of Systematic Subsidence, Tilt and Strain along Prediction Line 1 Resulting from the Extraction of Longwalls 29 to 36

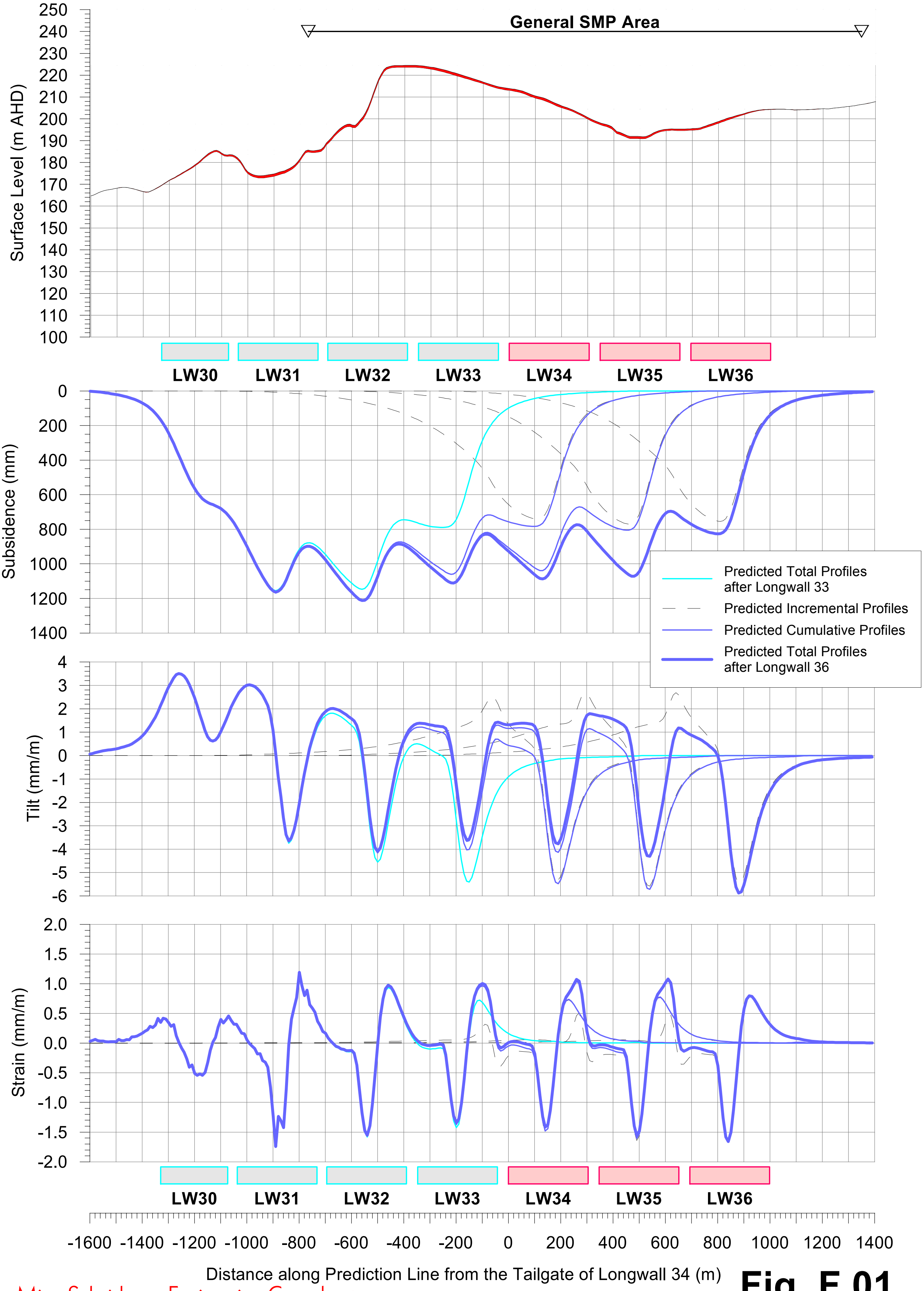


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Fig. F.01

Predicted Profiles of Subsidence, Upsidence and Closure along the Georges River Resulting from the Extraction of Longwalls 29 to 36

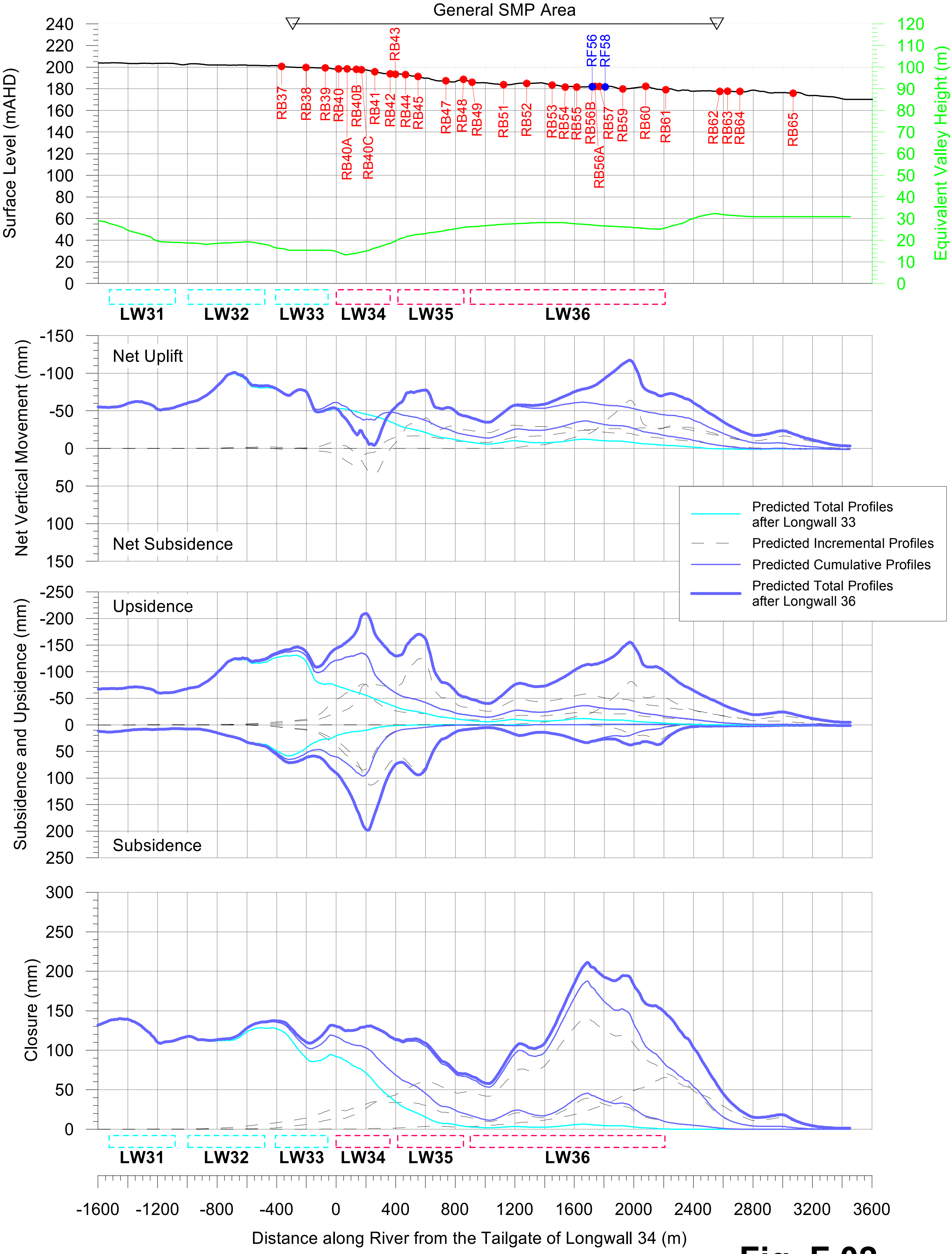

Fig. F.02

Predicted Profiles of Subsidence, Upsidence and Closure along Mallaty Creek Resulting from the Extraction of Longwalls 29 to 36

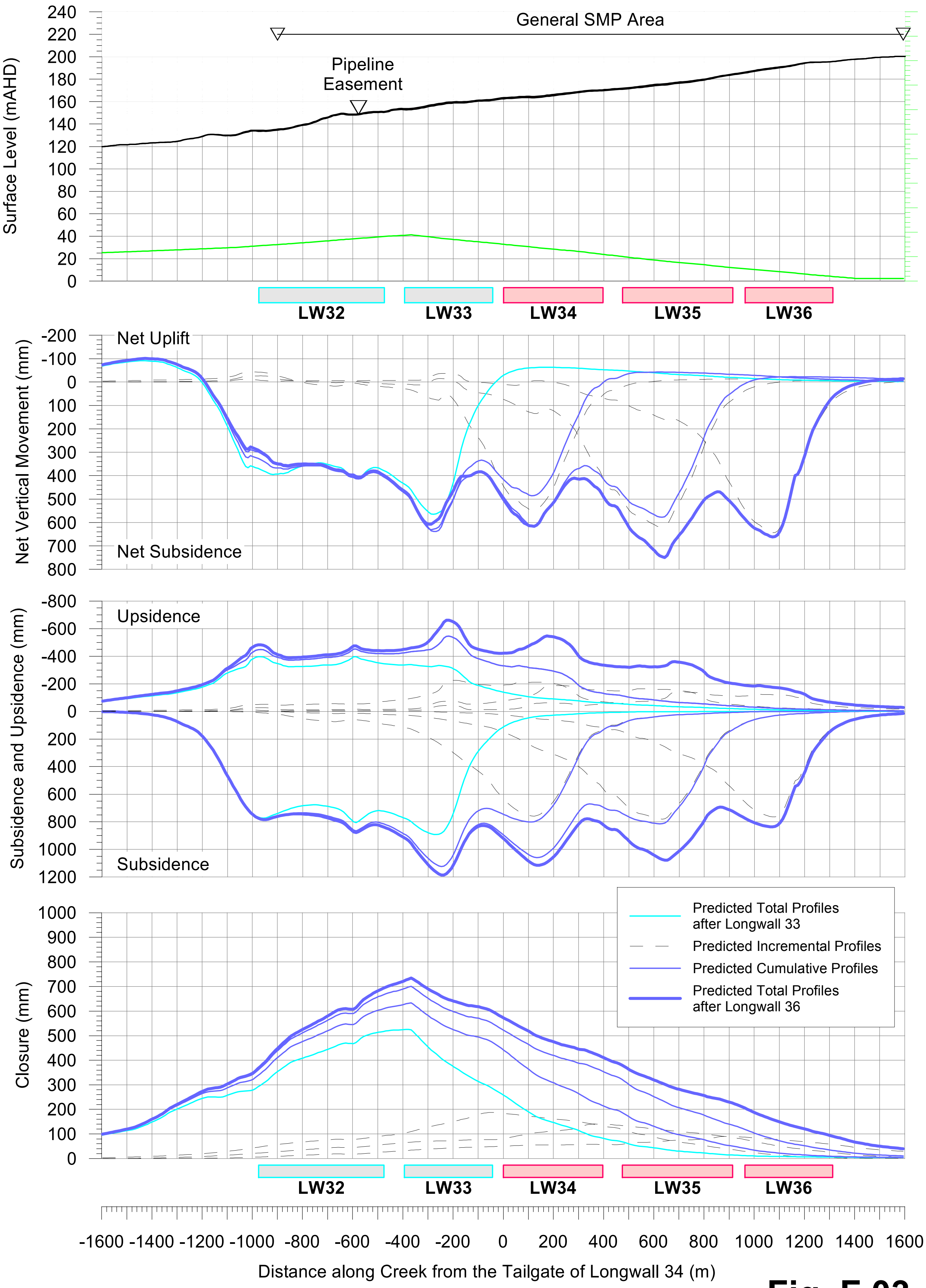

Fig. F.03

Predicted Profiles of Subsidence, Upsidence and Closure along Leafs Gully Resulting from the Extraction of Longwalls 29 to 36

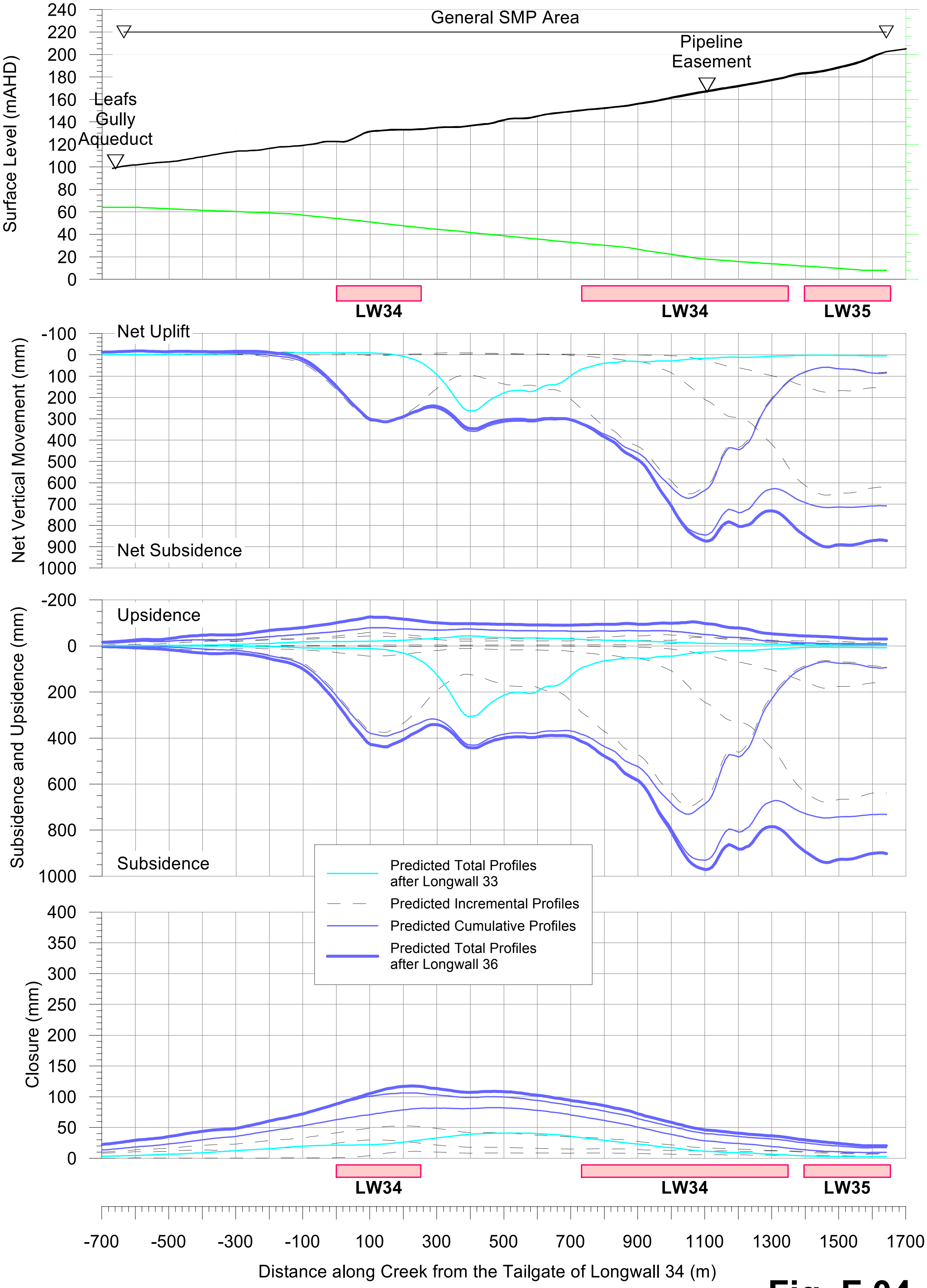

Fig. F.04

Predicted Profiles of Subsidence, Upsidence and Closure along Nepean Creek Resulting from the Extraction of Longwalls 29 to 36

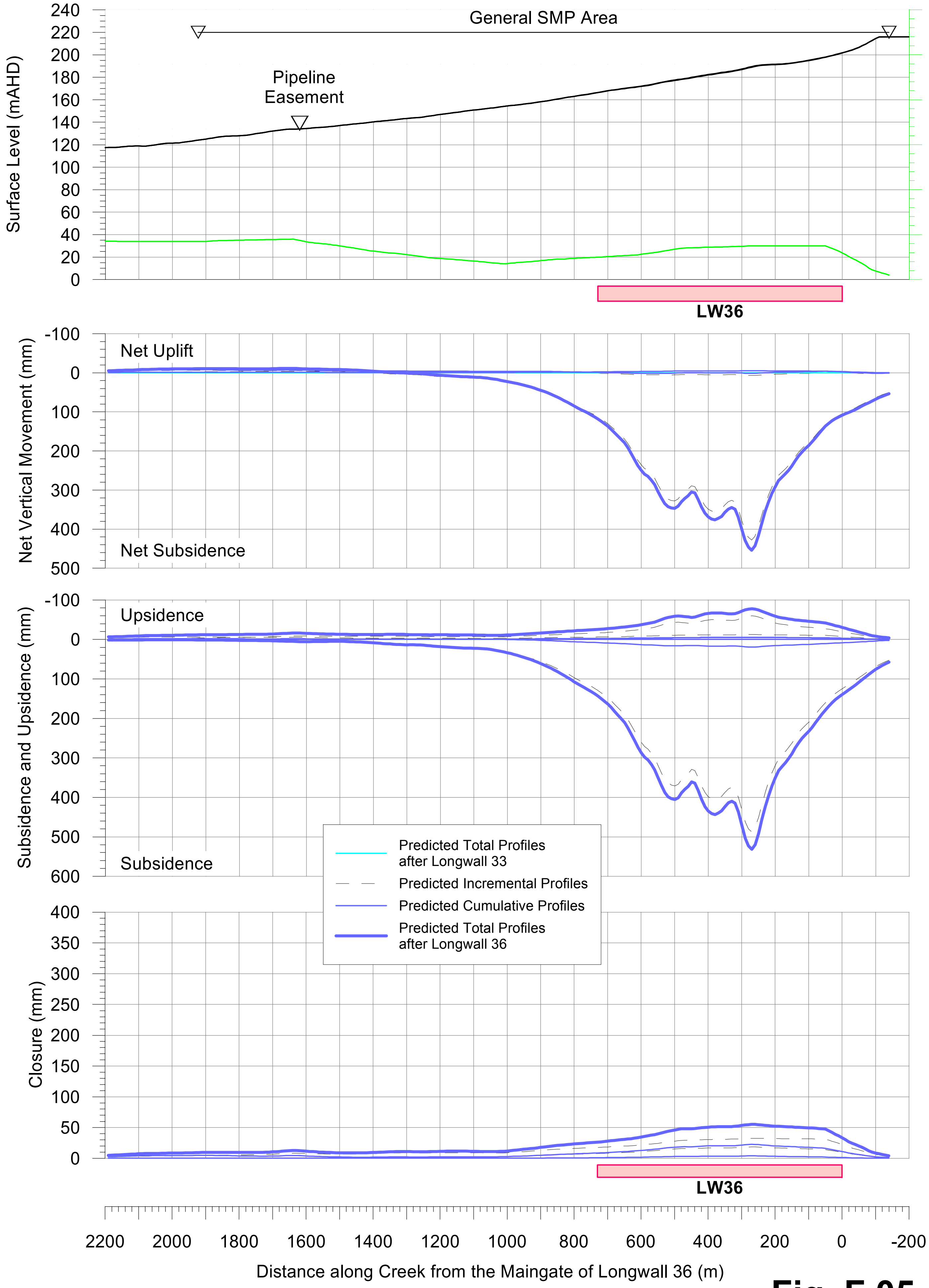

Fig. F.05

Predicted Profiles of Systematic Subsidence, Tilt and Strain along Appin Road Resulting from the Extraction of Longwalls 29 to 36

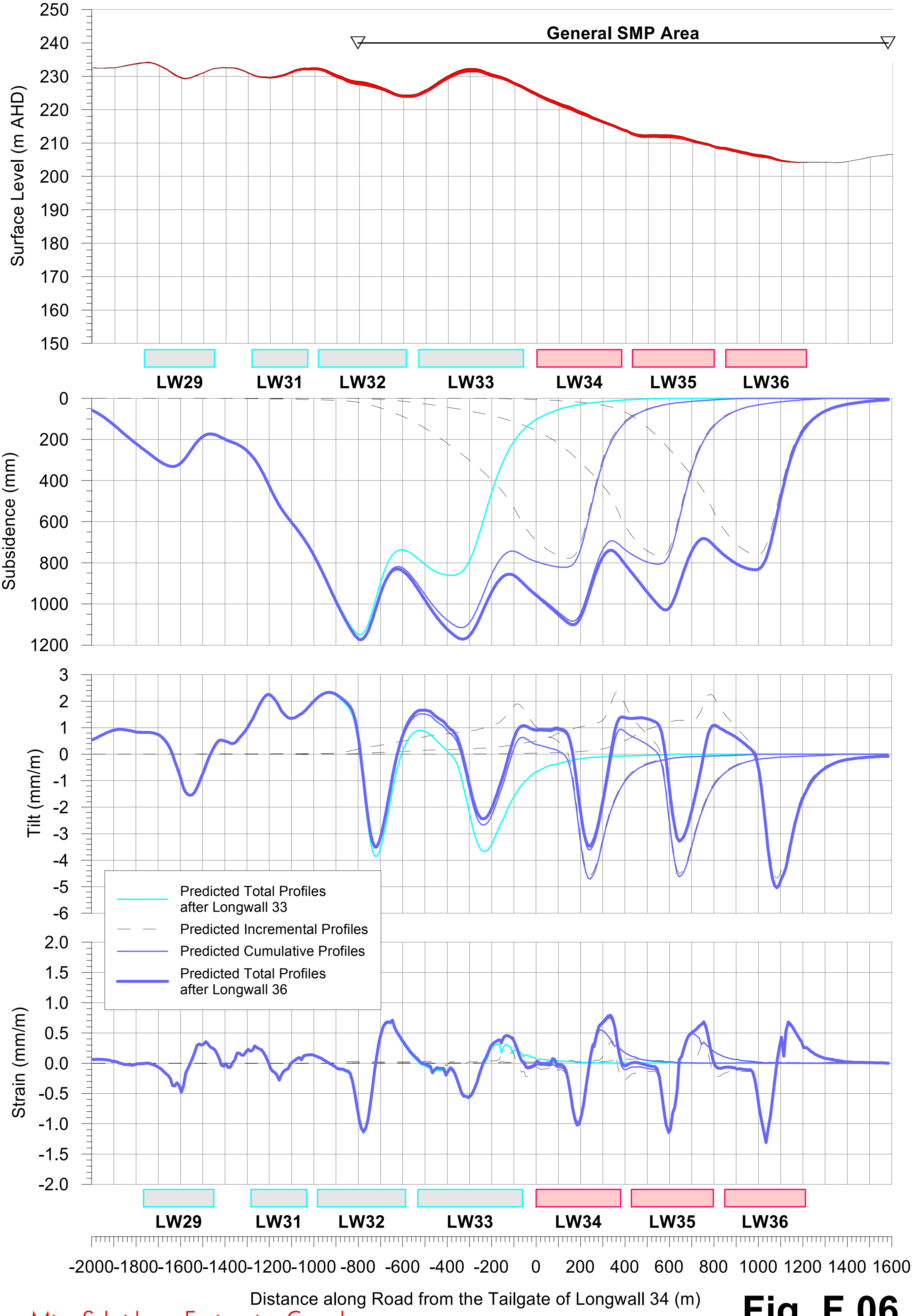

Fig. F.06

Predicted Profiles of Systematic Subsidence, Tilt and Strain along the 1200mm Water Pipeline Resulting from the Extraction of Longwalls 29 to 36

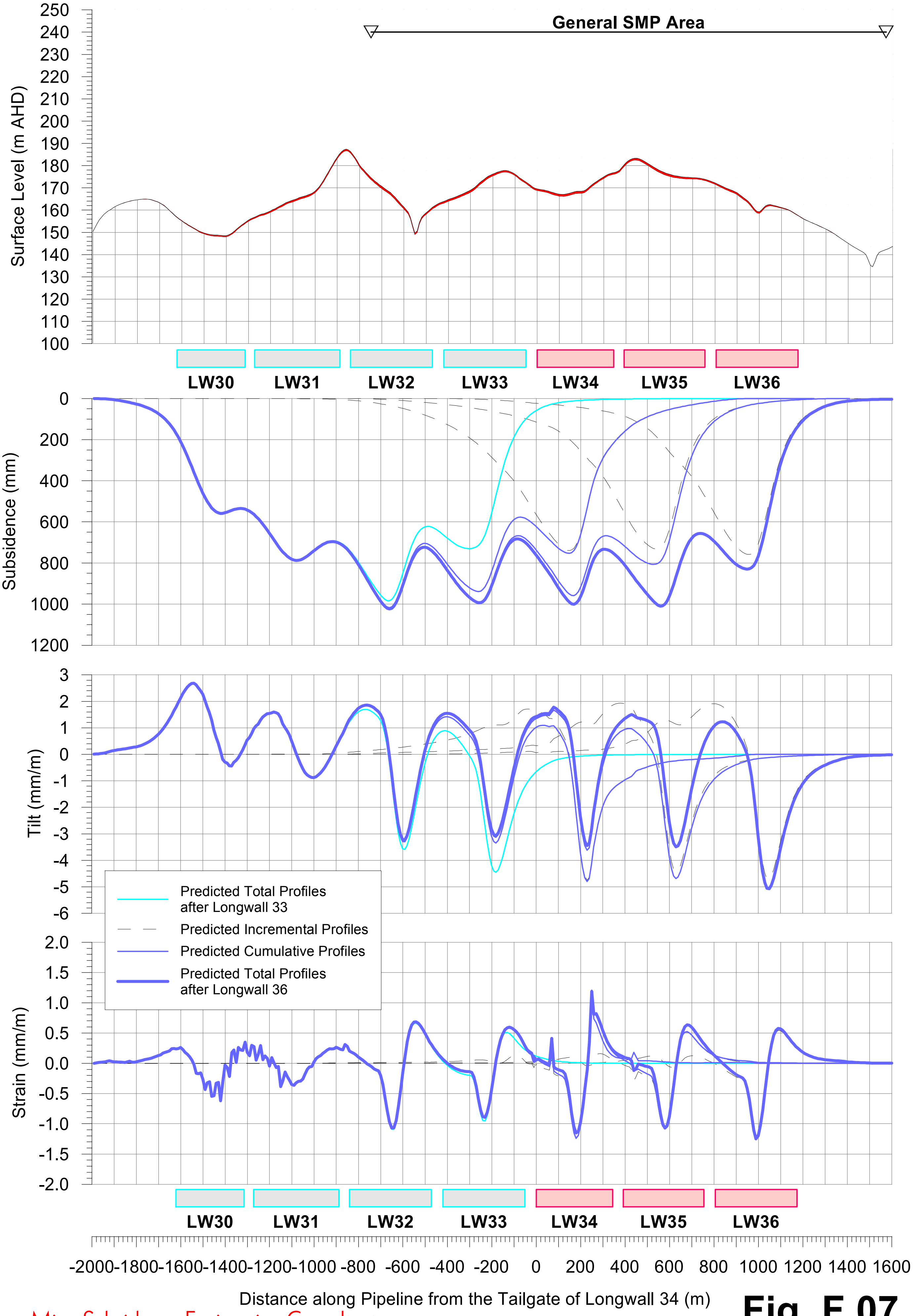

Fig. F.07

Predicted Profiles of Systematic Subsidence, Tilt and Strain along the Alinta EGP Natural Gas Pipeline Resulting from the Extraction of Longwalls 29 to 36

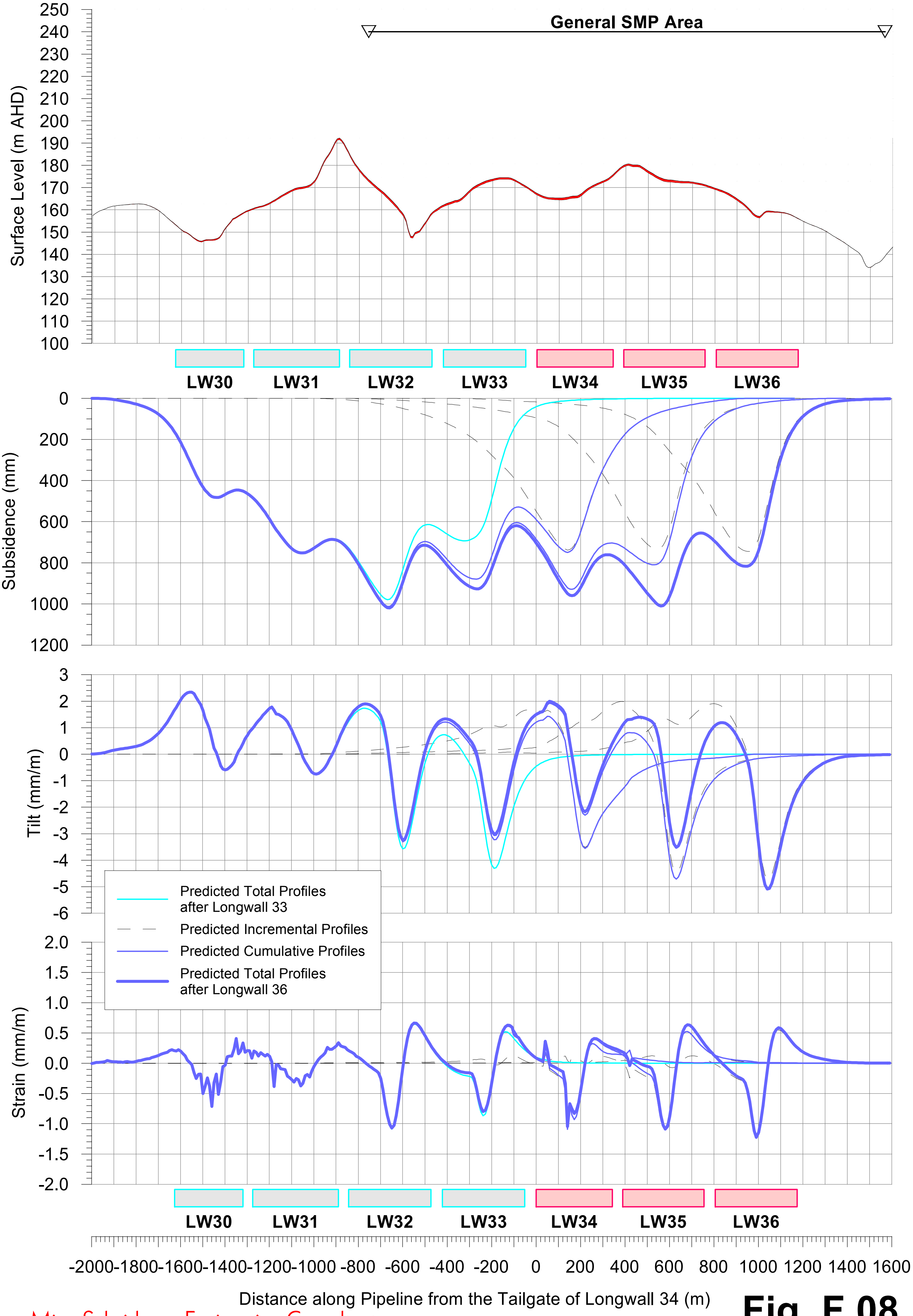

Fig. F.08

Predicted Profiles of Systematic Subsidence, Tilt and Strain along the Alinta AGN Natural Gas Pipeline Resulting from the Extraction of Longwalls 29 to 36

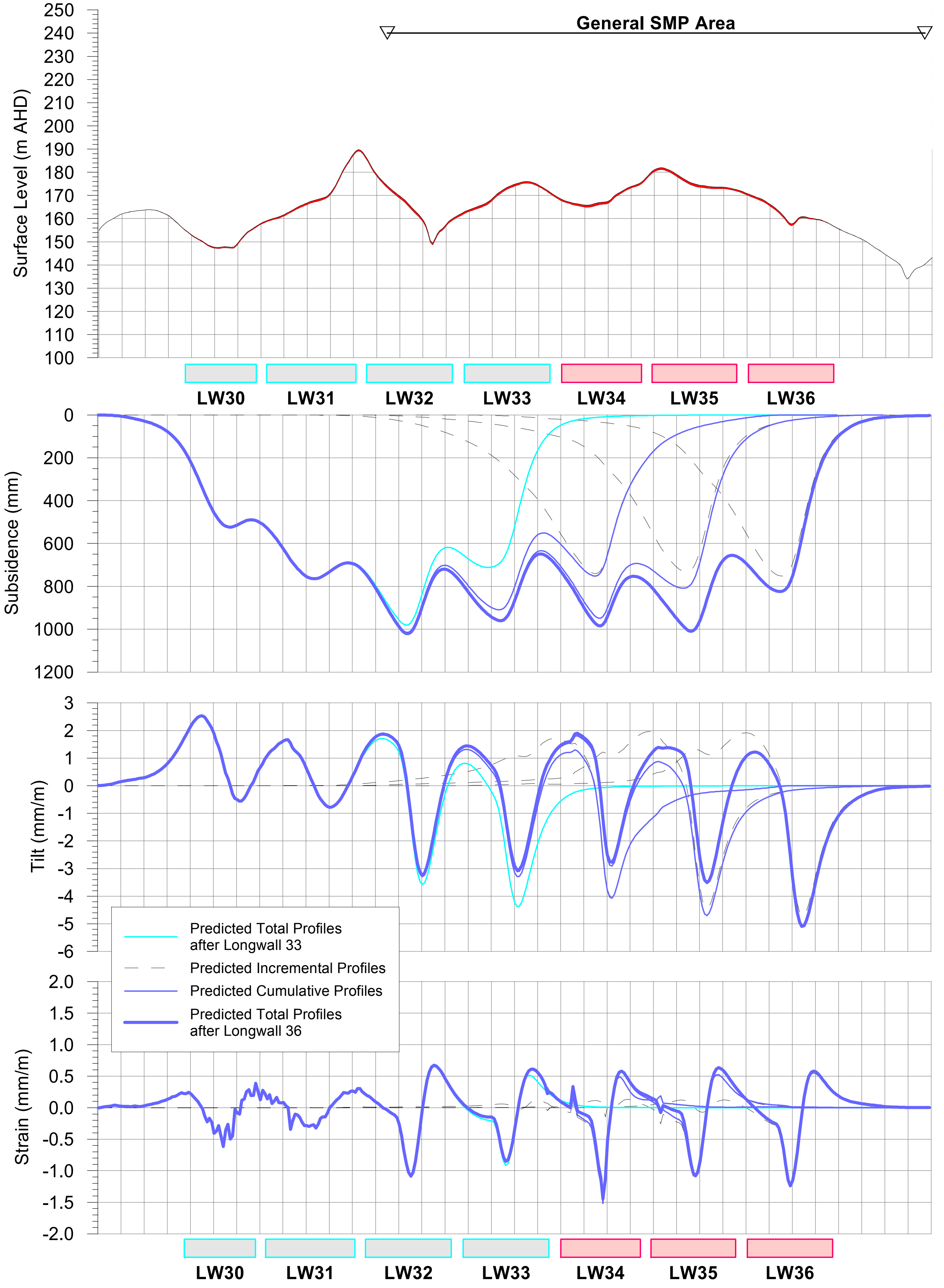

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Fig. F.09

Predicted Profiles of Systematic Subsidence, Tilt and Strain along the Gorodok Gas Pipeline Resulting from the Extraction of Longwalls 29 to 36

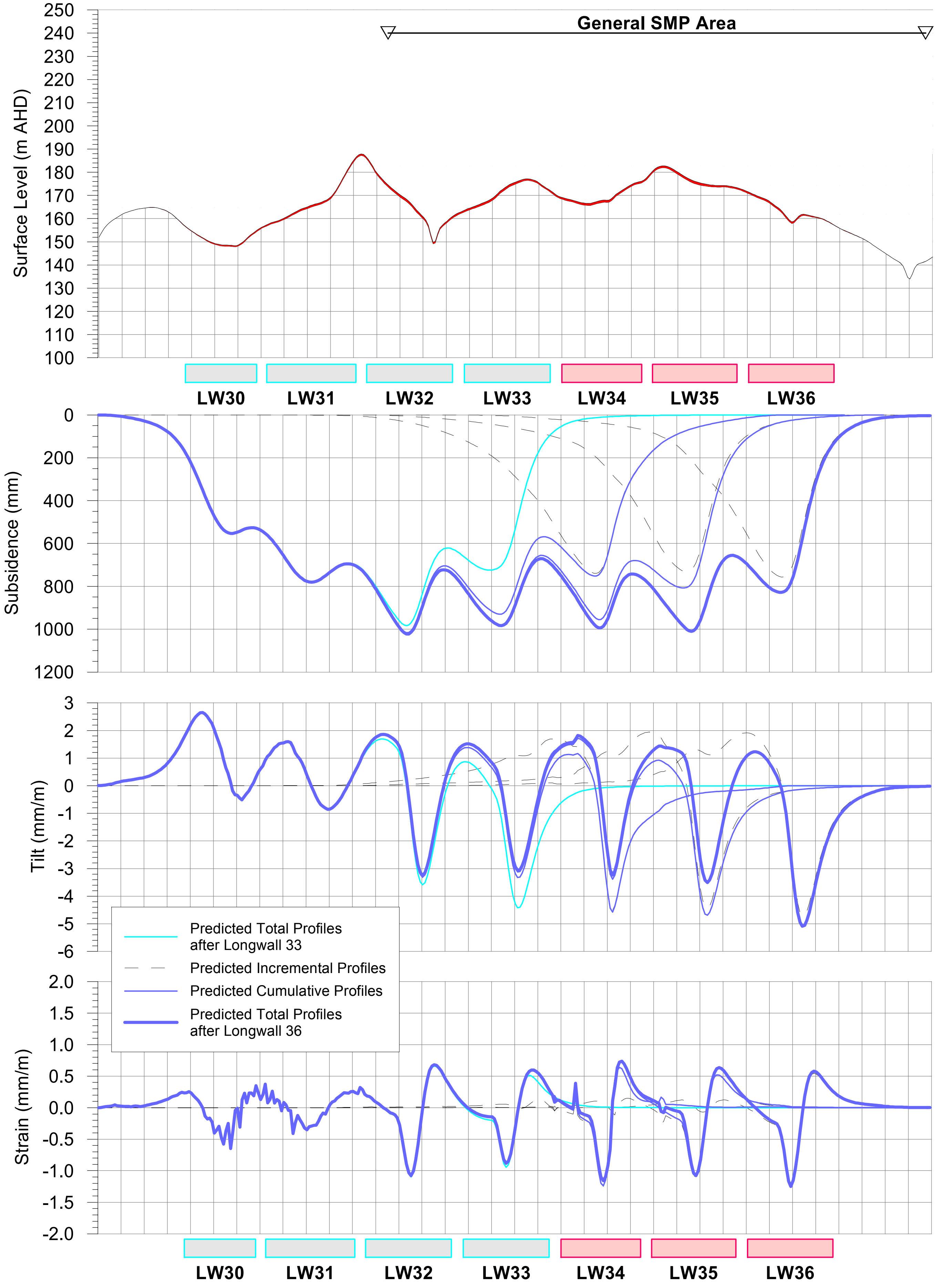

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Fig. F.10

I:\Projects\West Cliff\Area 5\MSEC326 - Longwalls 34 to 36\Subsdata\Impacts\Gas\Fig. F.11 - Pipeline Easement.grf.....21-Dec-07

Predicted Profiles of Net Vertical and Horizontal Movements along the Alignment of the Pipeline Easement Resulting from the Extraction of Longwalls 29 to 36

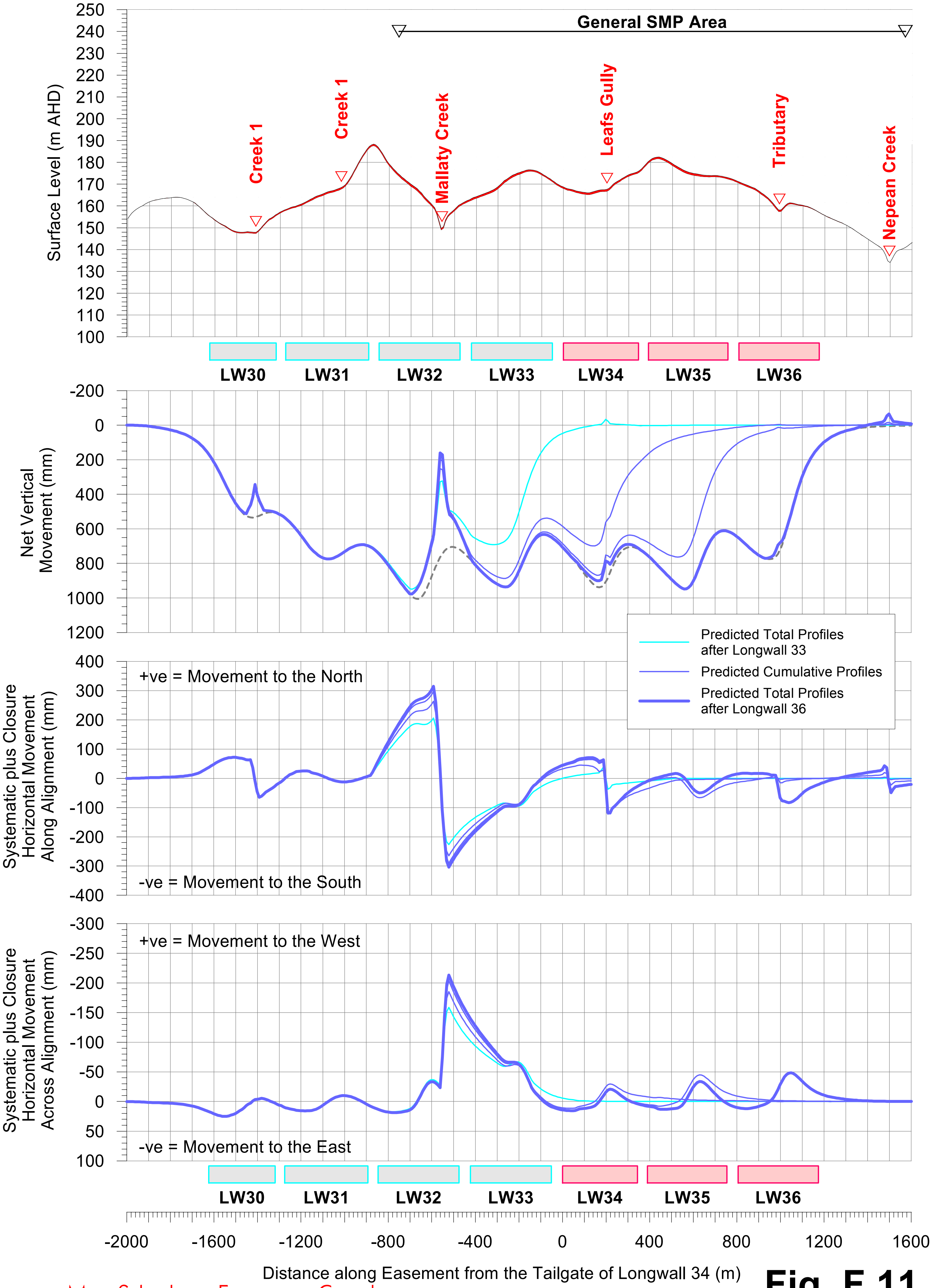
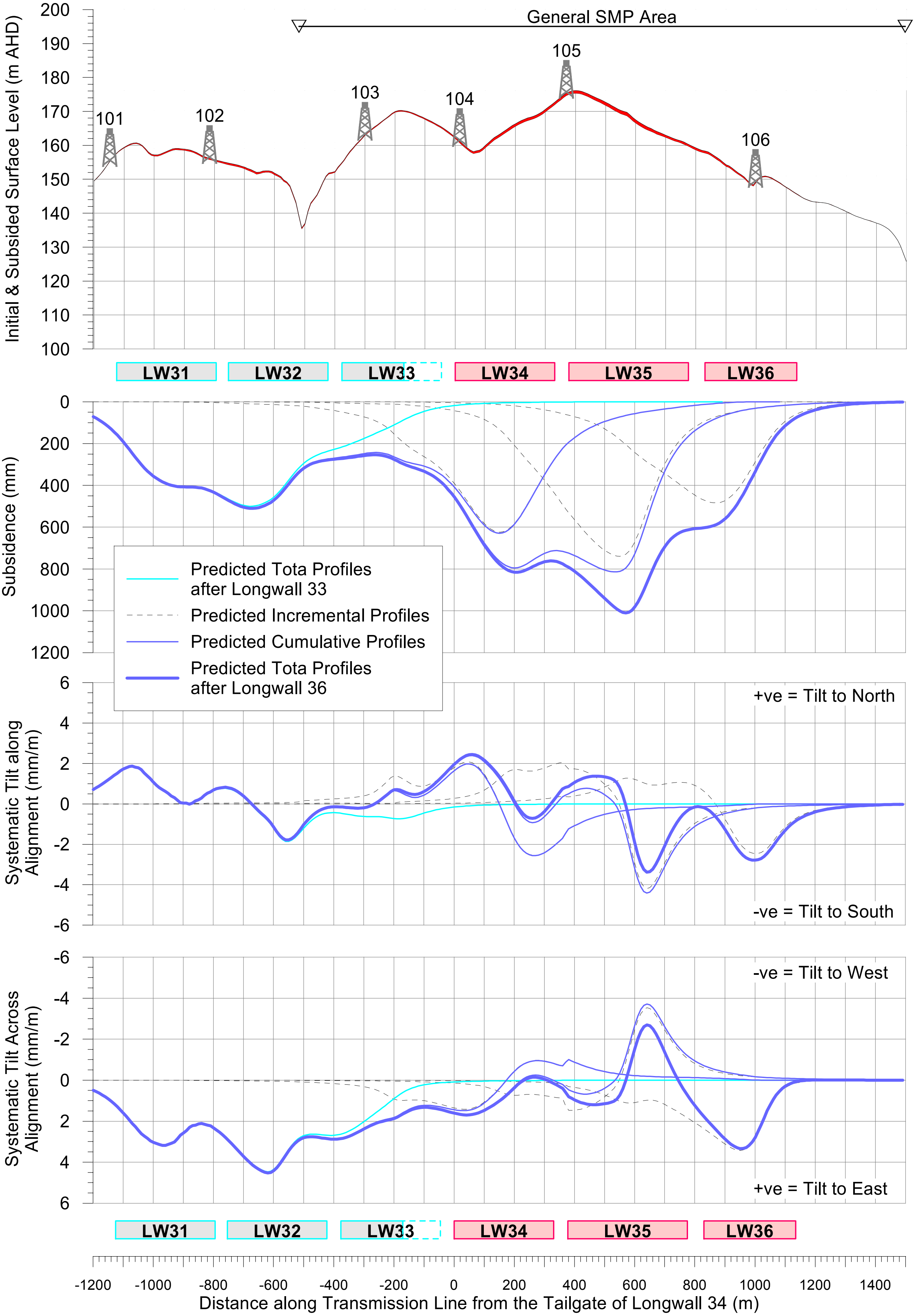


Fig. F.11

Predicted Profiles of Systematic Subsidence, Tilt Along and Tilt Across the Alignment of the 330 kV Transmission Line due to LW29 to LW36



I:\Projects\West Cliff\Area 5\MSEC326 - Longwalls 34 to 36\Subsdata\Impacts\Electrical\Fig. F.13 - 66kV Powerline.grf.....21-Dec-07

Predicted Profiles of Systematic Subsidence, Tilt and Strain along the 66kV Powerline due to Longwalls 29 to 36

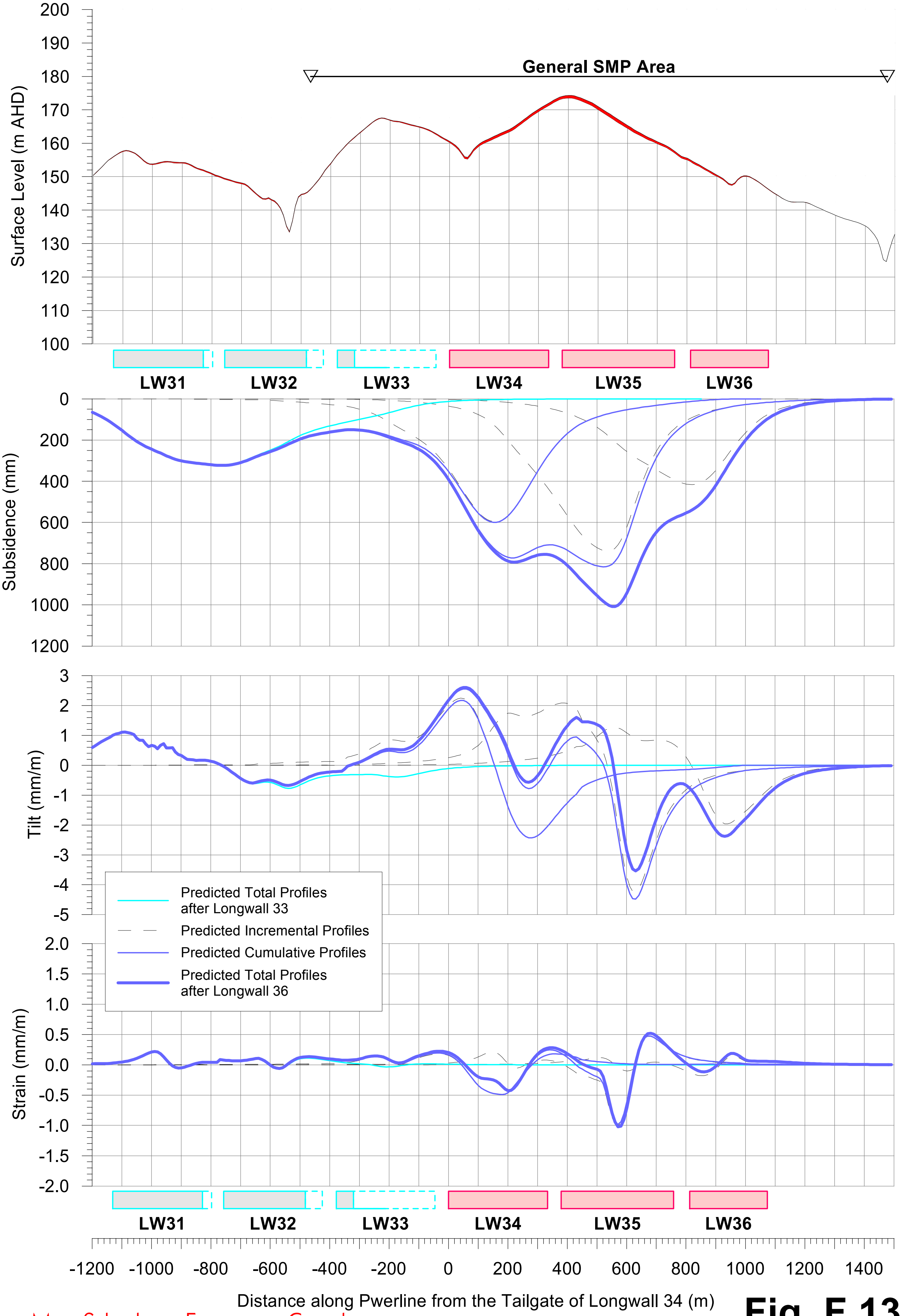


Fig. F.13

Predicted Profiles of Systematic Subsidence, Tilt and Strain along the 11kV Powerline Branch 1 due to Longwalls 29 to 36

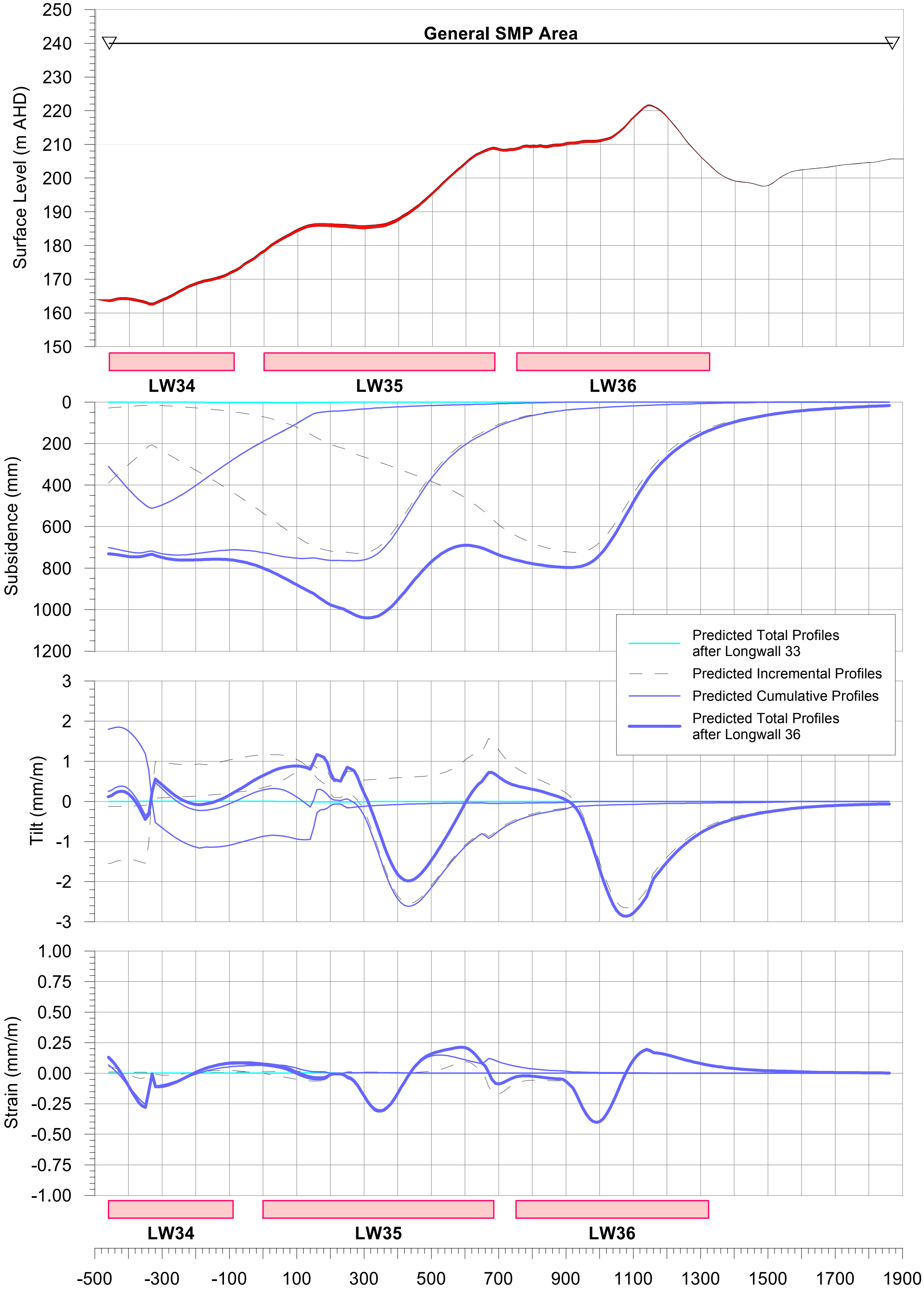


Fig. F.14

Predicted Profiles of Systematic Subsidence, Tilt and Strain along the 11kV Powerline Branch 2 due to Longwalls 29 to 36

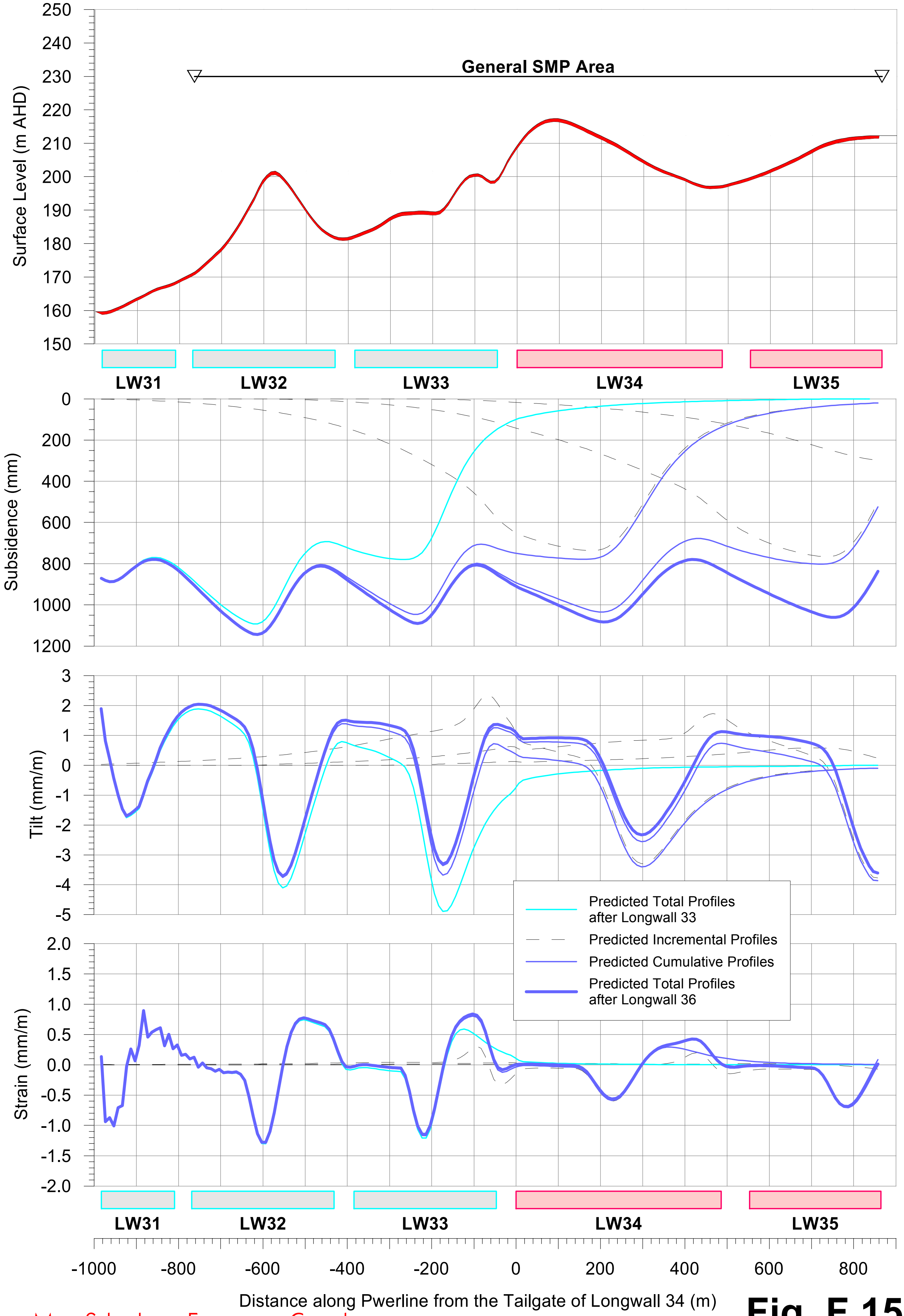


Fig. F.15

Predicted Profiles of Systematic Subsidence, Tilt and Strain along CBTN 423 Copper Cables due to Longwalls 29 to 36

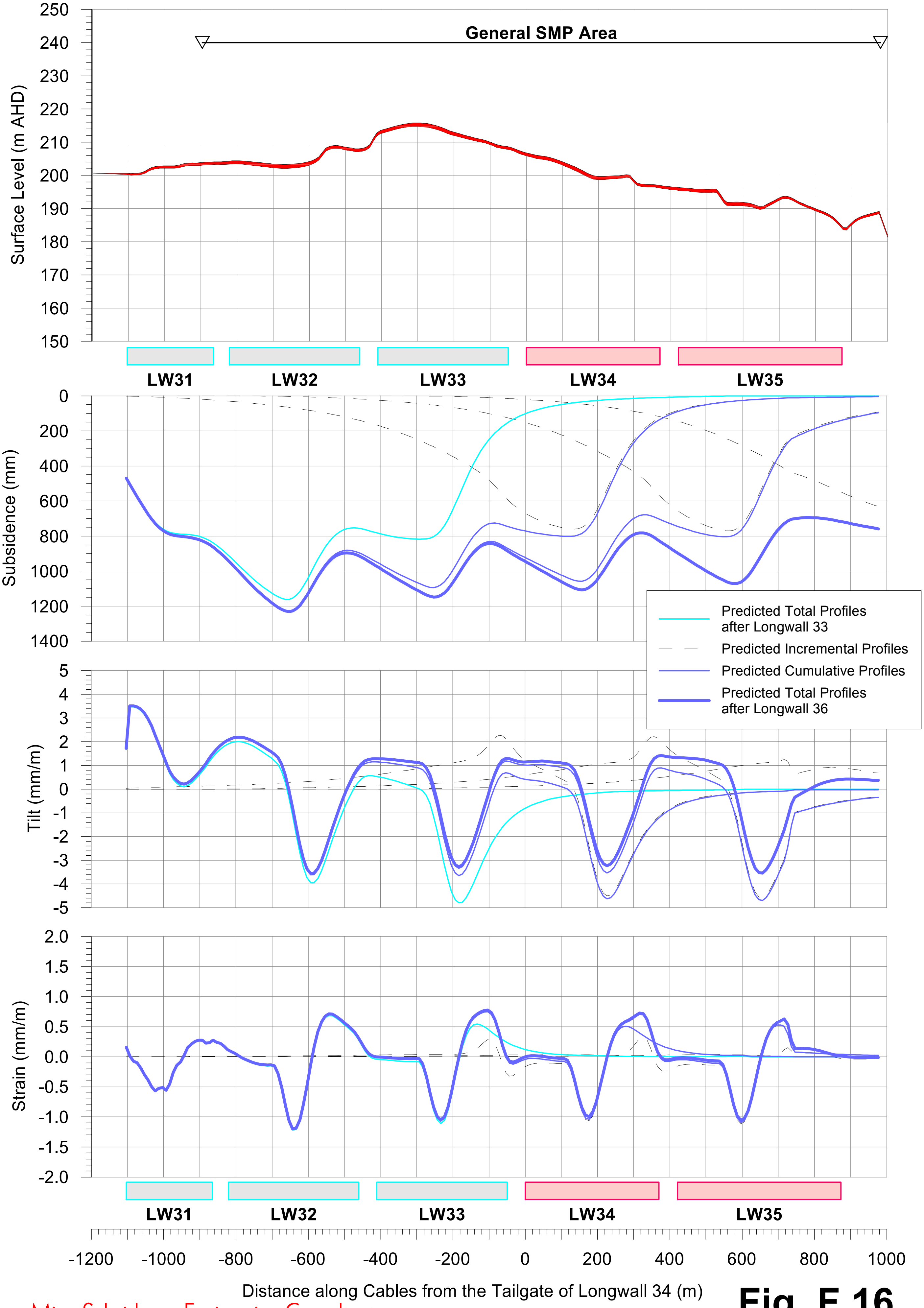


Fig. F.16

APPENDIX G. DRAWINGS

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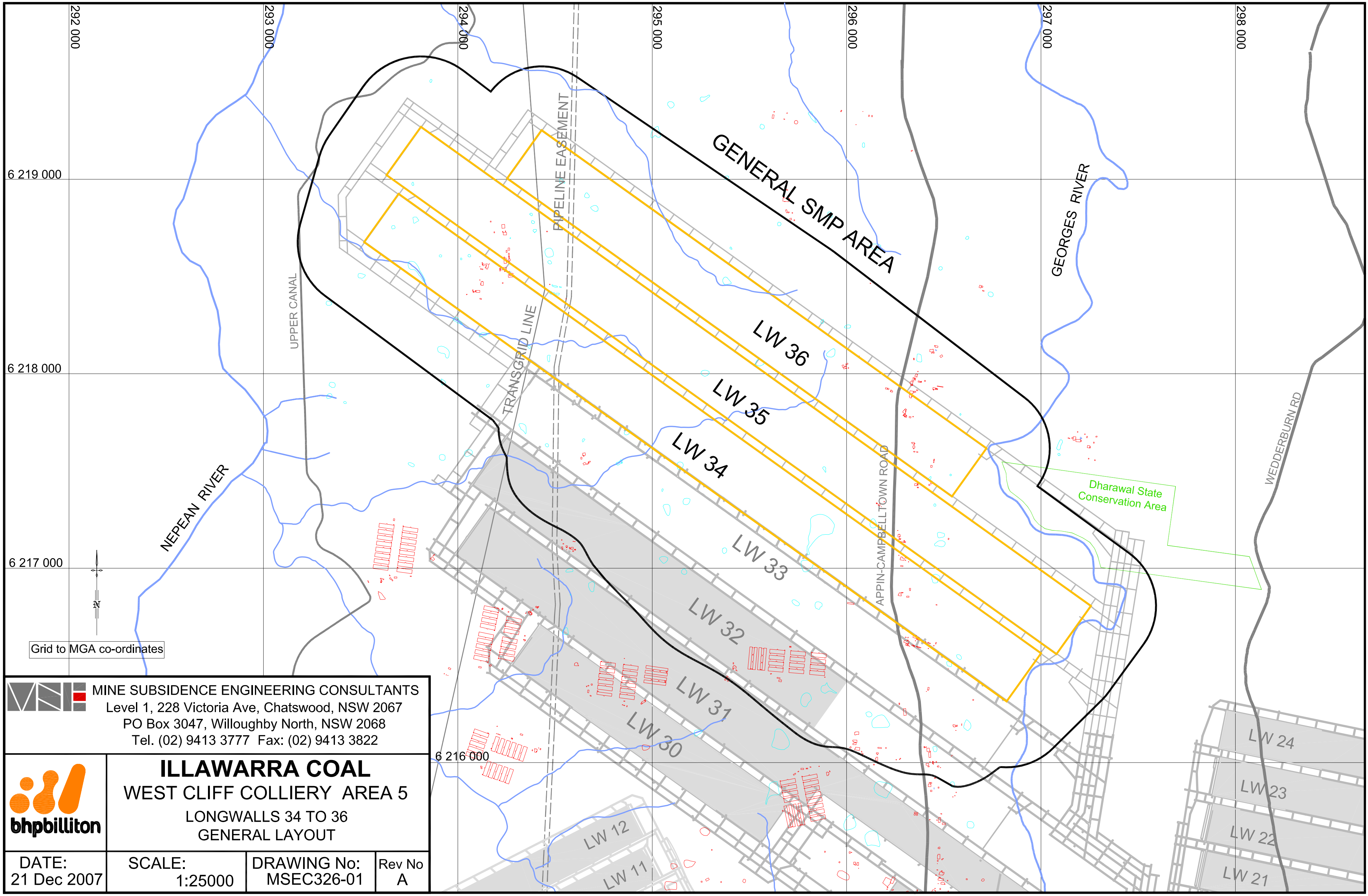

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ILLAWARRA COAL
WEST CLIFF COLLIERY AREA 5
LONGWALLS 34 TO 36
GENERAL LAYOUT

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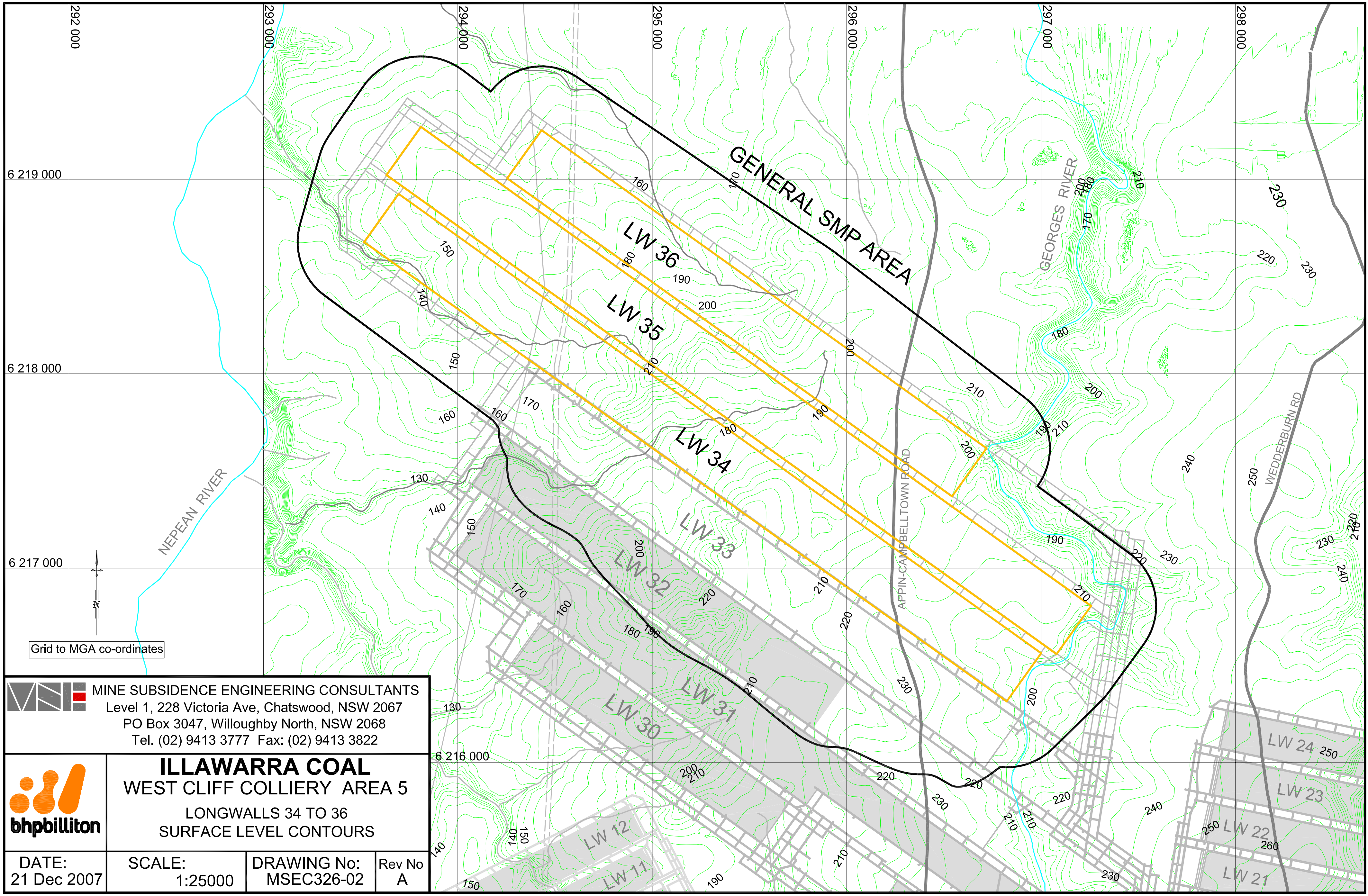

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ILLAWARRA COAL
WEST CLIFF COLLIERY AREA 5
LONGWALLS 34 TO 36
SURFACE LEVEL CONTOURS

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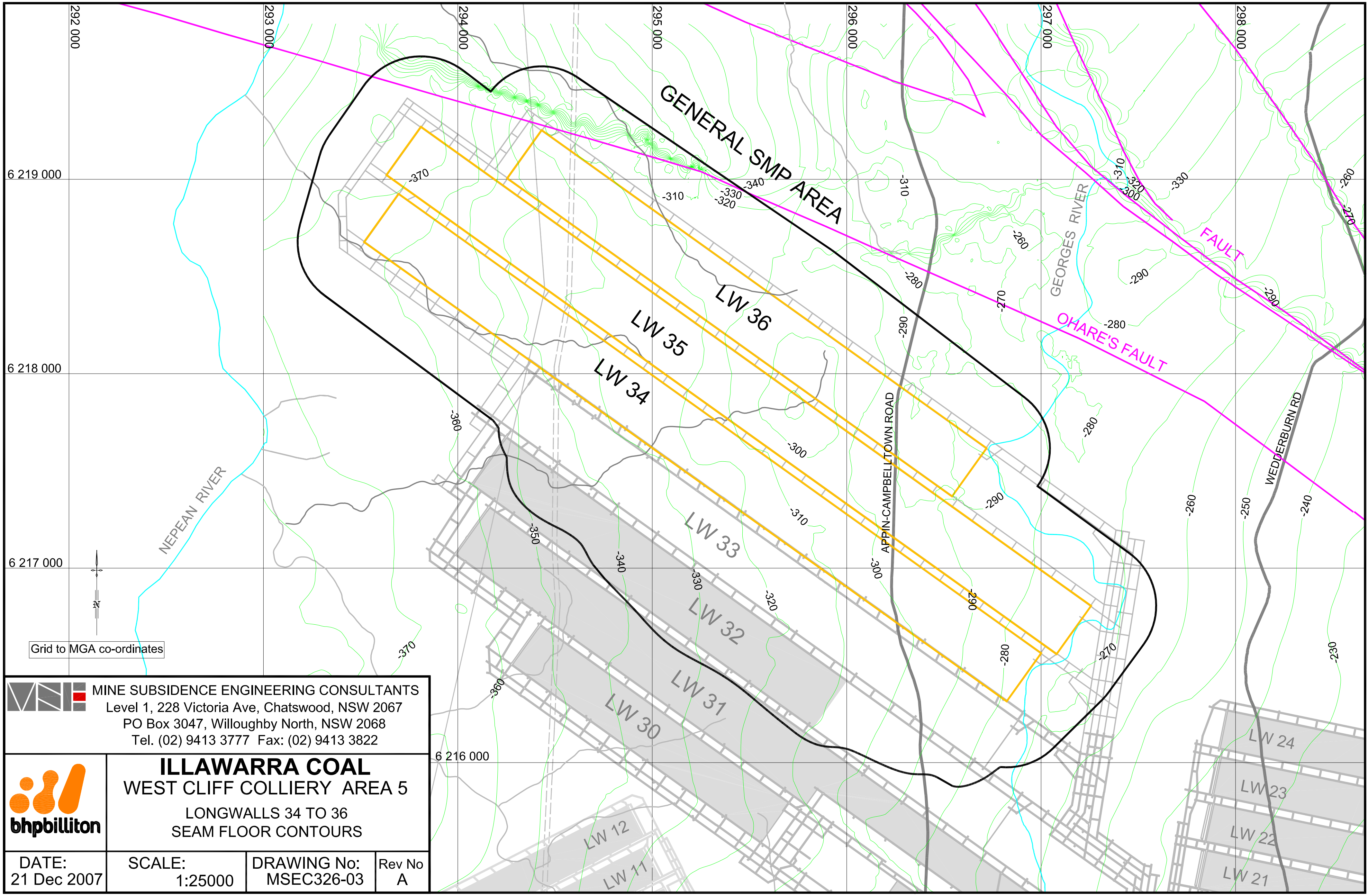

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ILLAWARRA COAL
WEST CLIFF COLLIERY AREA 5

LONGWALLS 34 TO 36
SEAM FLOOR CONTOURS

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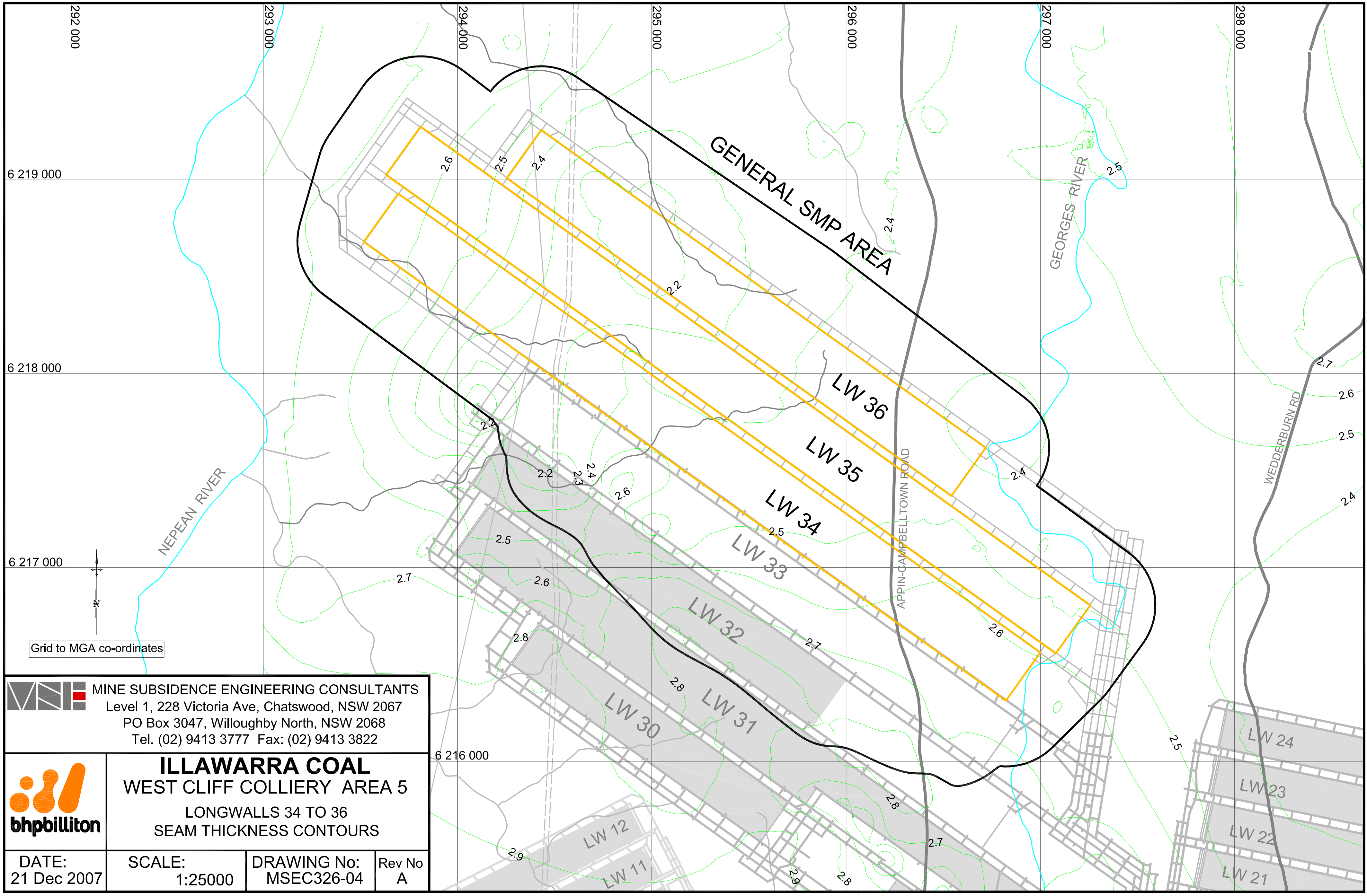

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ILLAWARRA COAL
WEST CLIFF COLLIERY AREA 5
LONGWALLS 34 TO 36
SEAM THICKNESS CONTOURS

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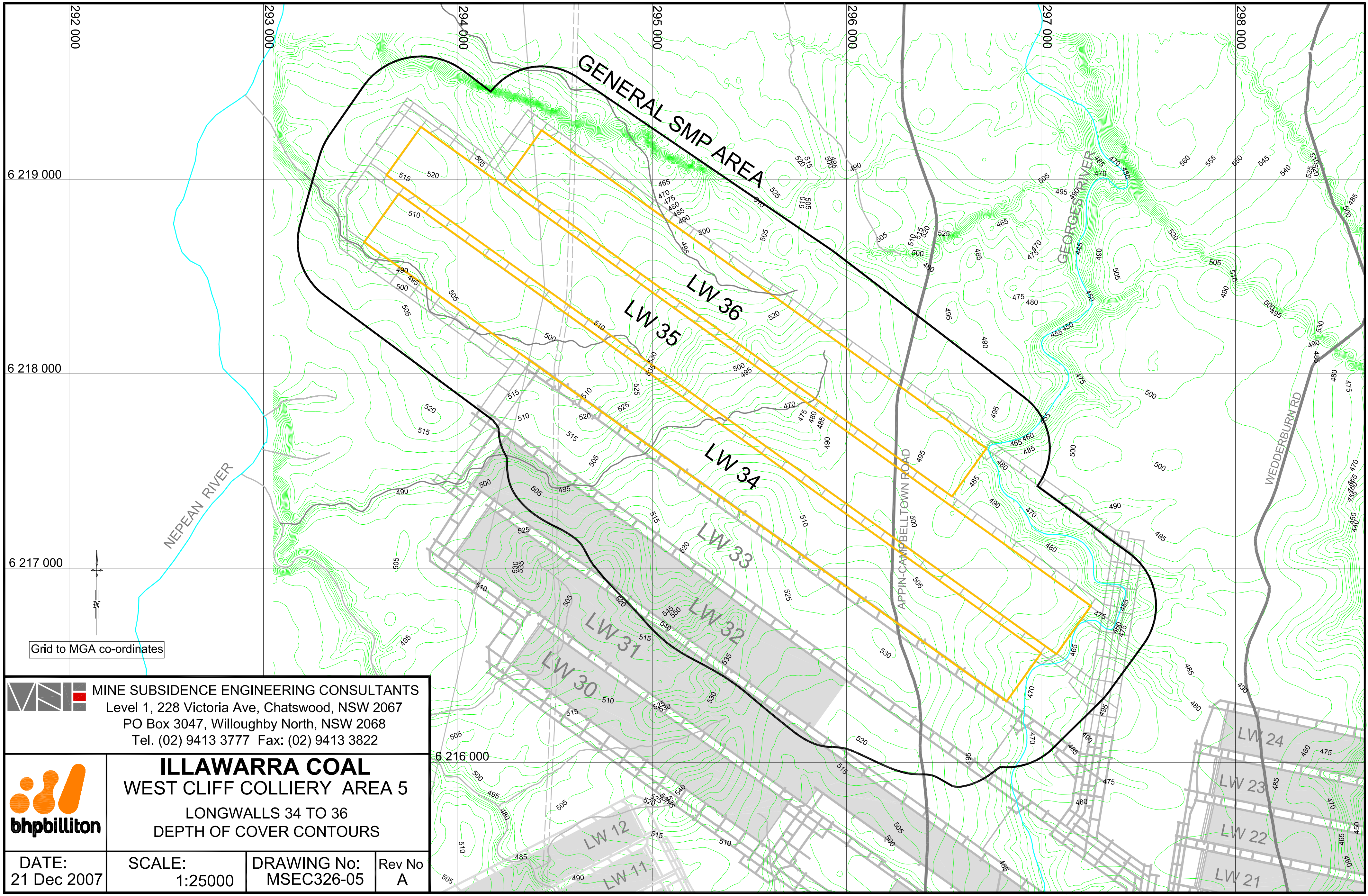

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ILLAWARRA COAL
WEST CLIFF COLLIERY AREA 5
LONGWALLS 34 TO 36
DEPTH OF COVER CONTOURS

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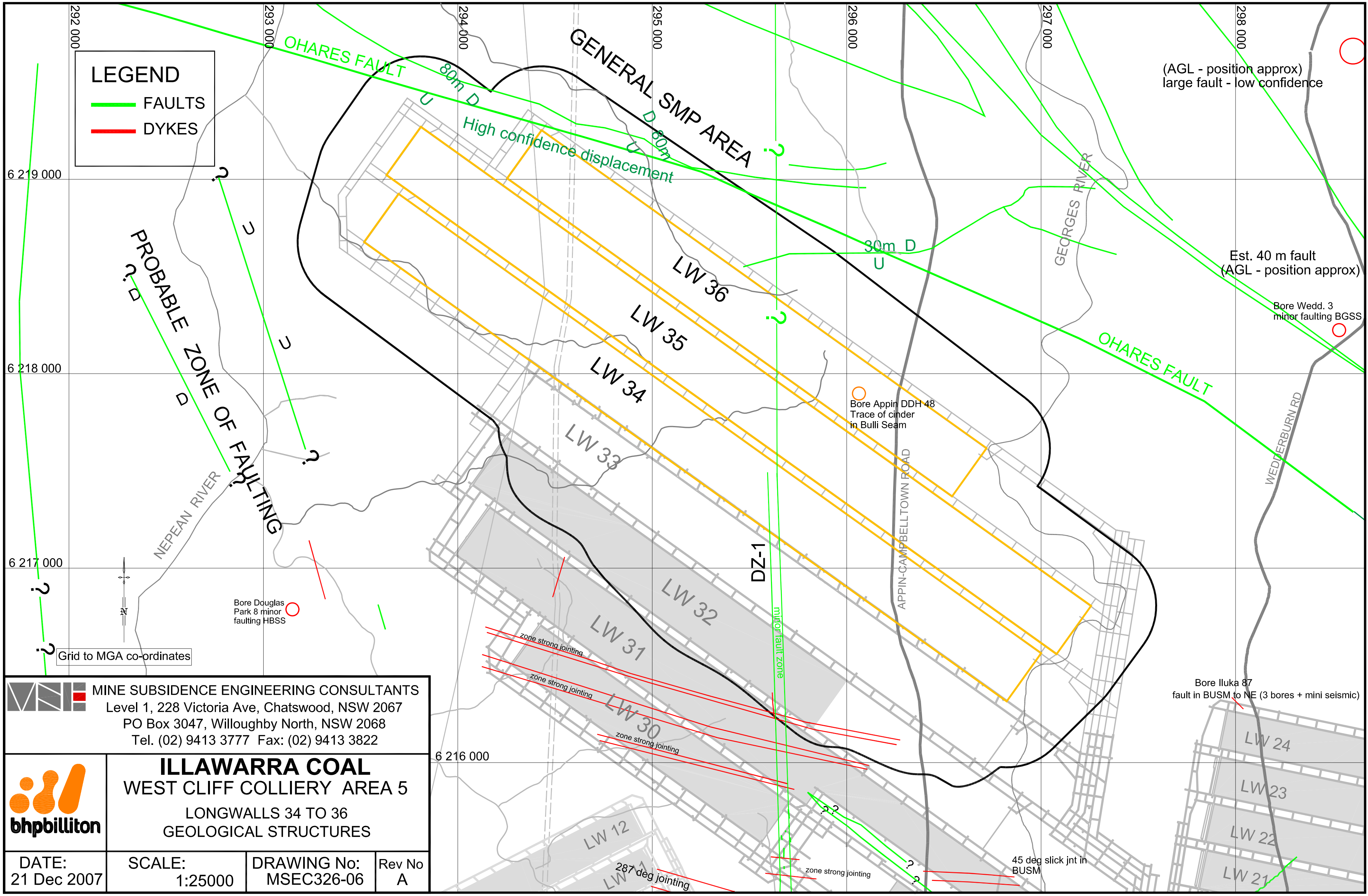

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ILLAWARRA COAL
WEST CLIFF COLLIERY AREA 5
LONGWALLS 34 TO 36
GEOLOGICAL STRUCTURES

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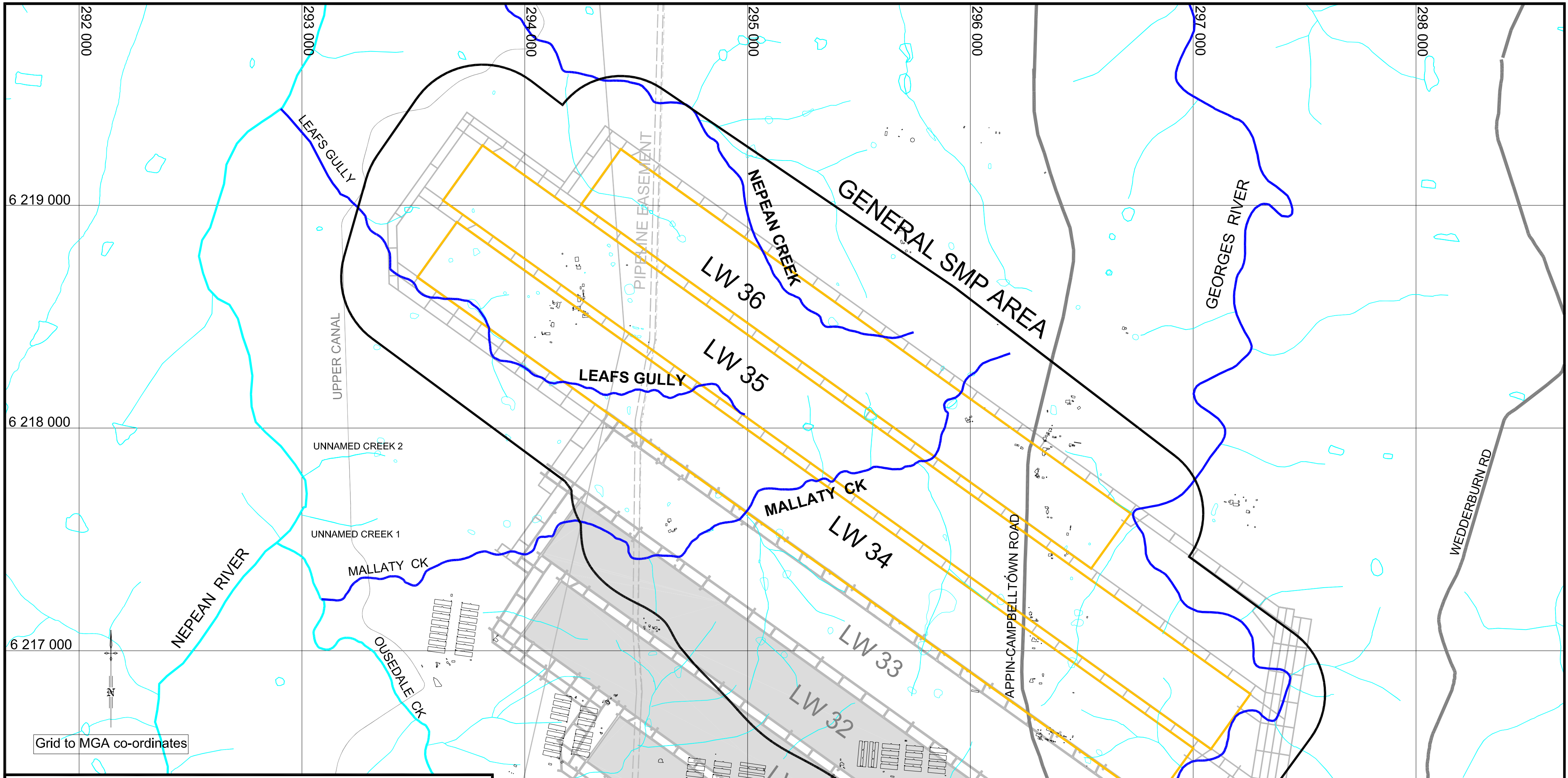

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ILLAWARRA COAL
WEST CLIFF COLLIERY AREA 5
LONGWALLS 34 TO 36
WATERCOURSES

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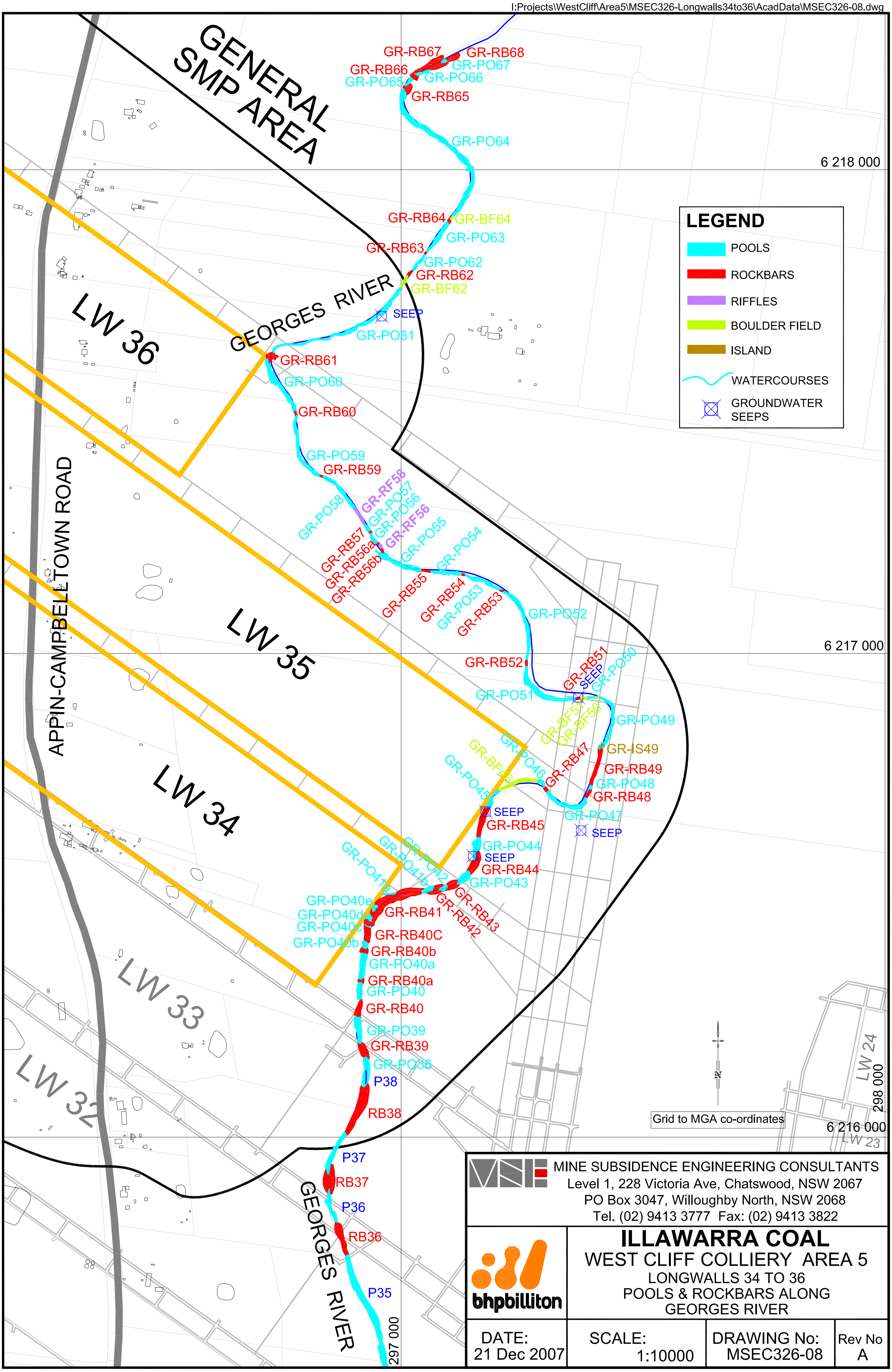

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ILLAWARRA COAL
WEST CLIFF COLLIERY AREA 5
LONGWALLS 34 TO 36
POOLS & ROCKBARS ALONG
GEORGES RIVER

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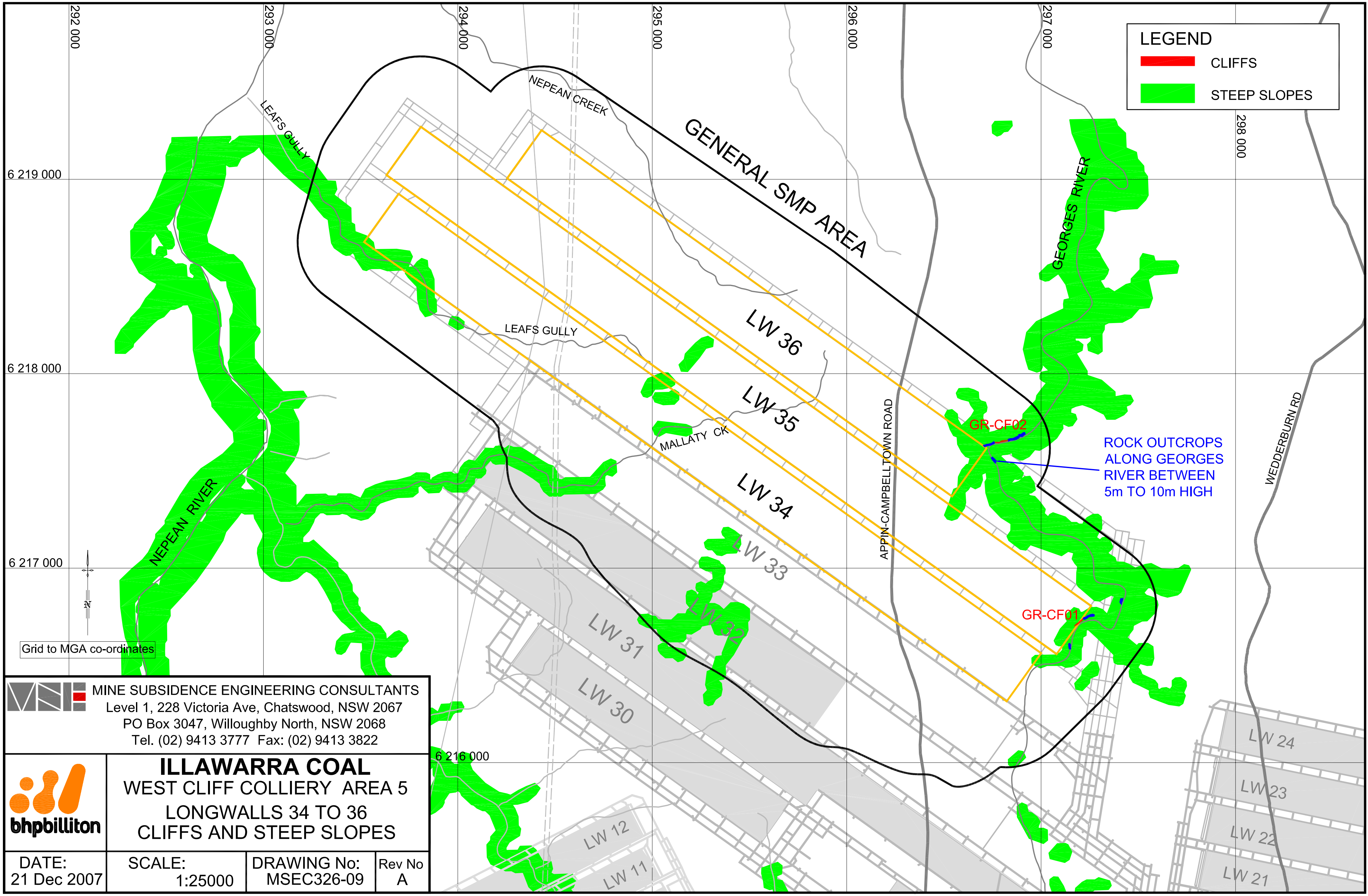

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ILLAWARRA COAL
WEST CLIFF COLLIERY AREA 5
LONGWALLS 34 TO 36
CLIFFS AND STEEP SLOPES

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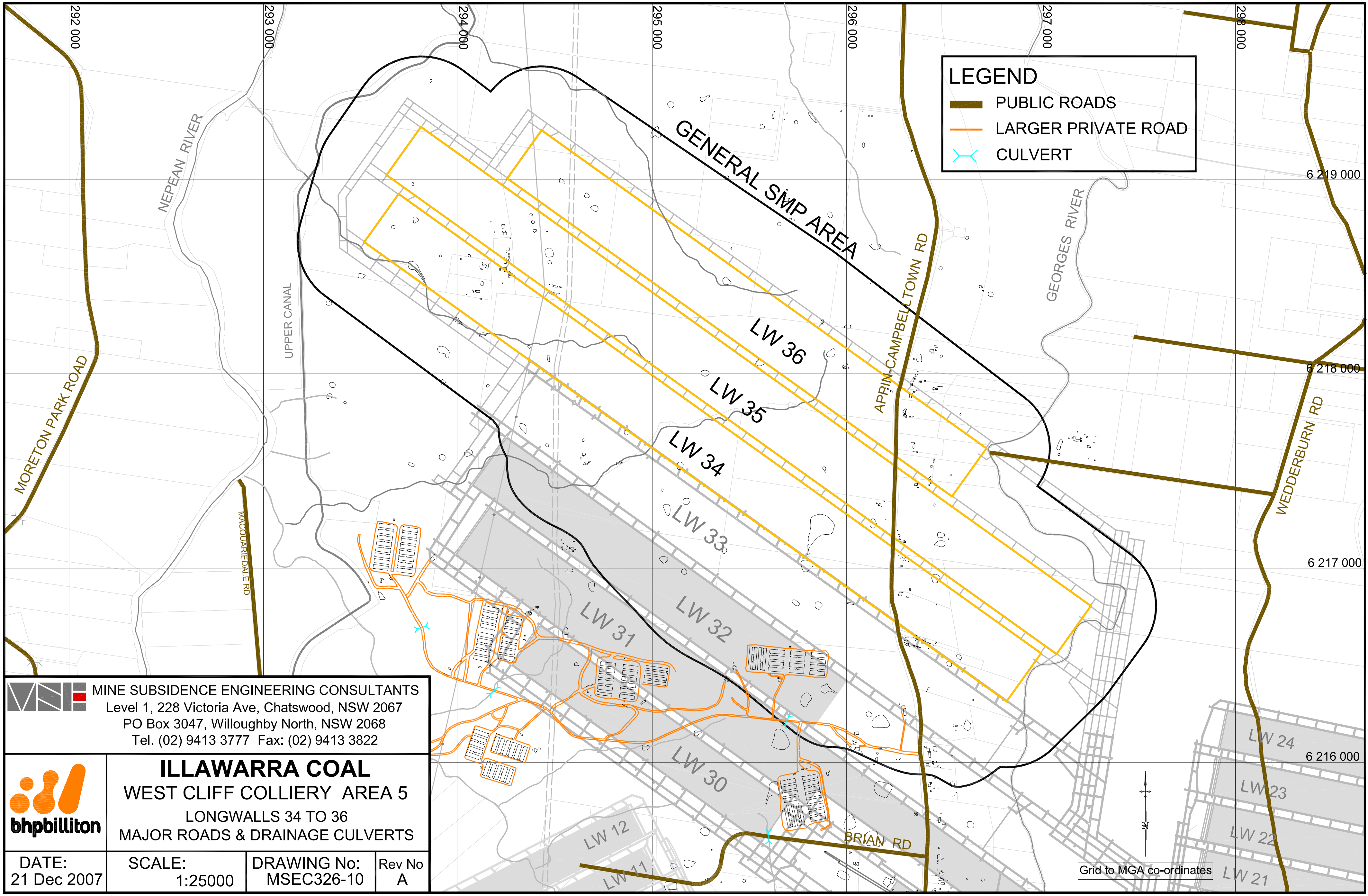

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ILLAWARRA COAL
WEST CLIFF COLLIERY AREA 5
LONGWALLS 34 TO 36
MAJOR ROADS & DRAINAGE CULVERTS

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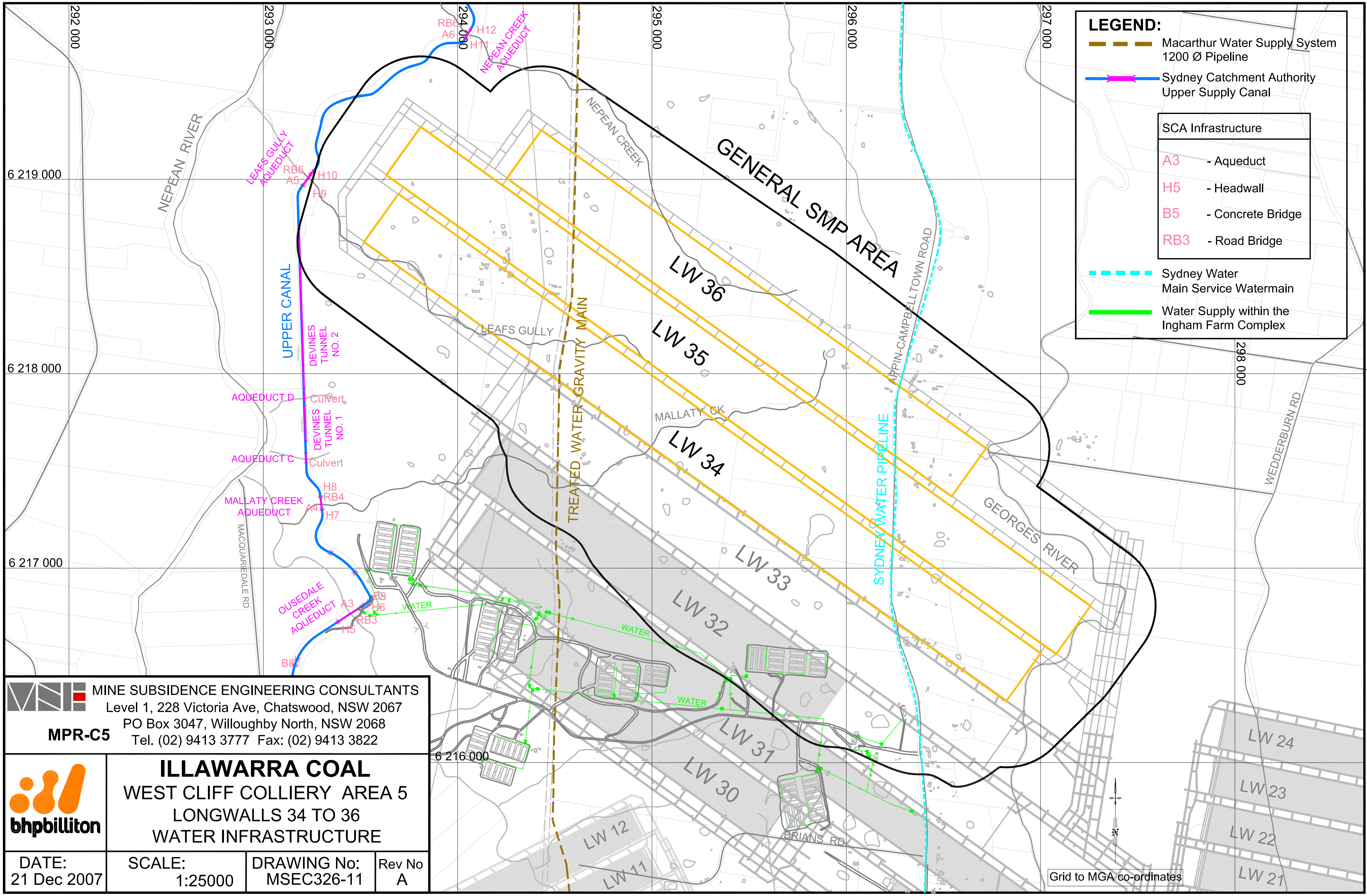

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ILLAWARRA COAL
WEST CLIFF COLLIERY AREA 5
LONGWALLS 34 TO 36
WATER INFRASTRUCTURE

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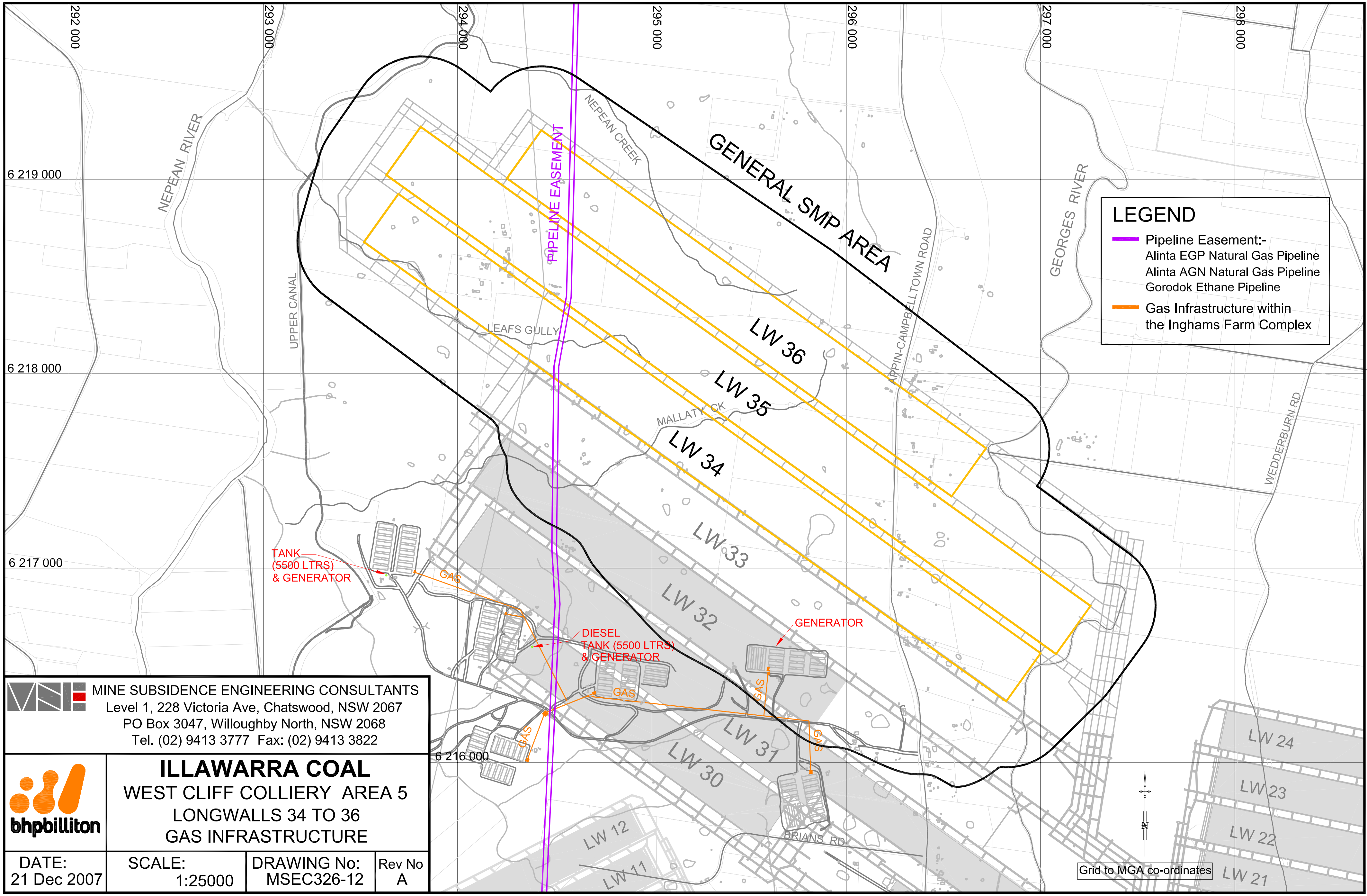

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ILLAWARRA COAL
WEST CLIFF COLLIERY AREA 5
LONGWALLS 34 TO 36
GAS INFRASTRUCTURE

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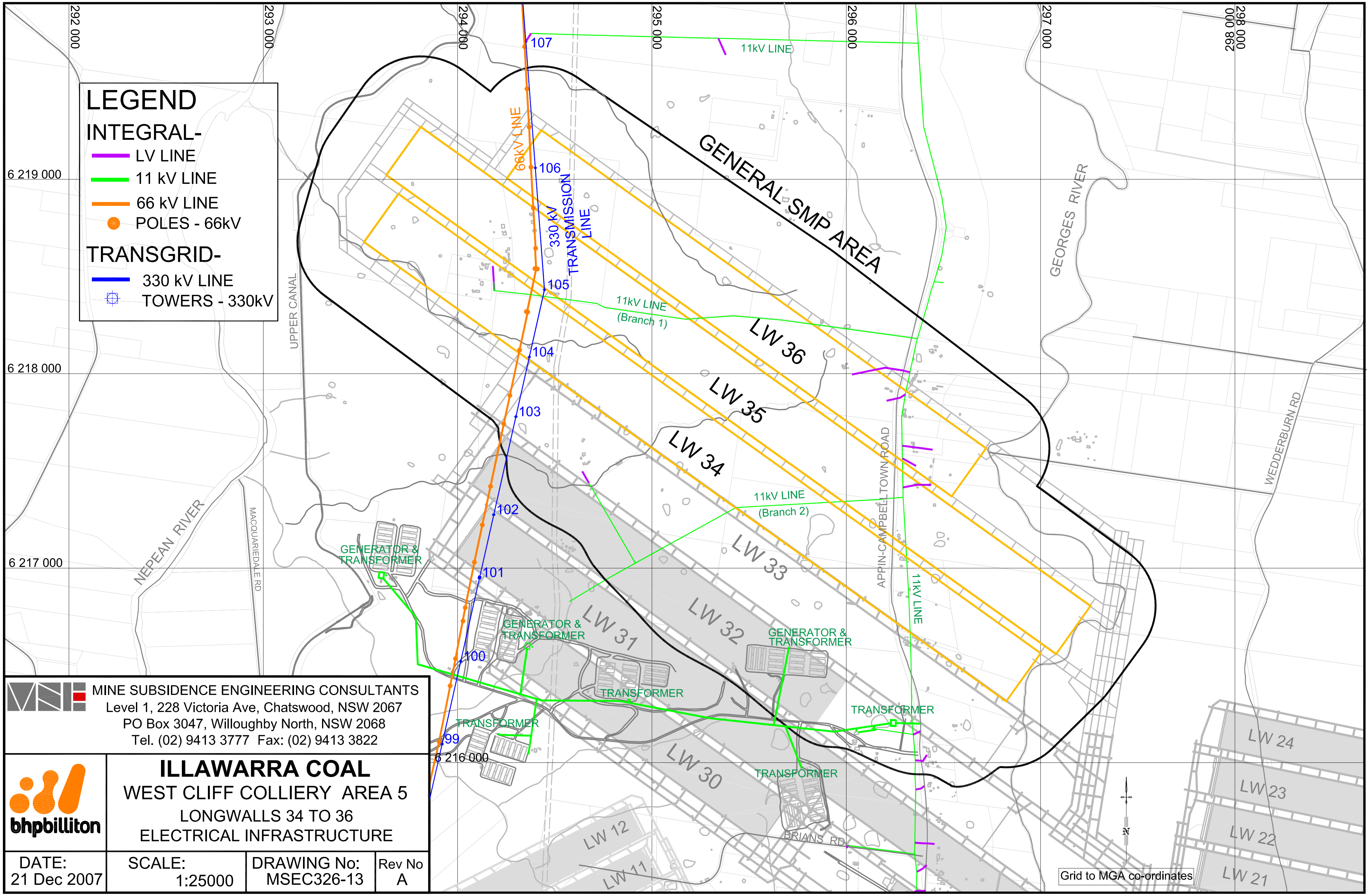

LEGEND

INTEGRAL-

- LV LINE
- 11 kV LINE
- 66 kV LINE
- ● POLES - 66kV

TRANSGRID-

- 330 kV LINE
- ⌖ TOWERS - 330kV

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WEST CLIFF COLLIERY AREA 5
LONGWALLS 34 TO 36
ELECTRICAL INFRASTRUCTURE

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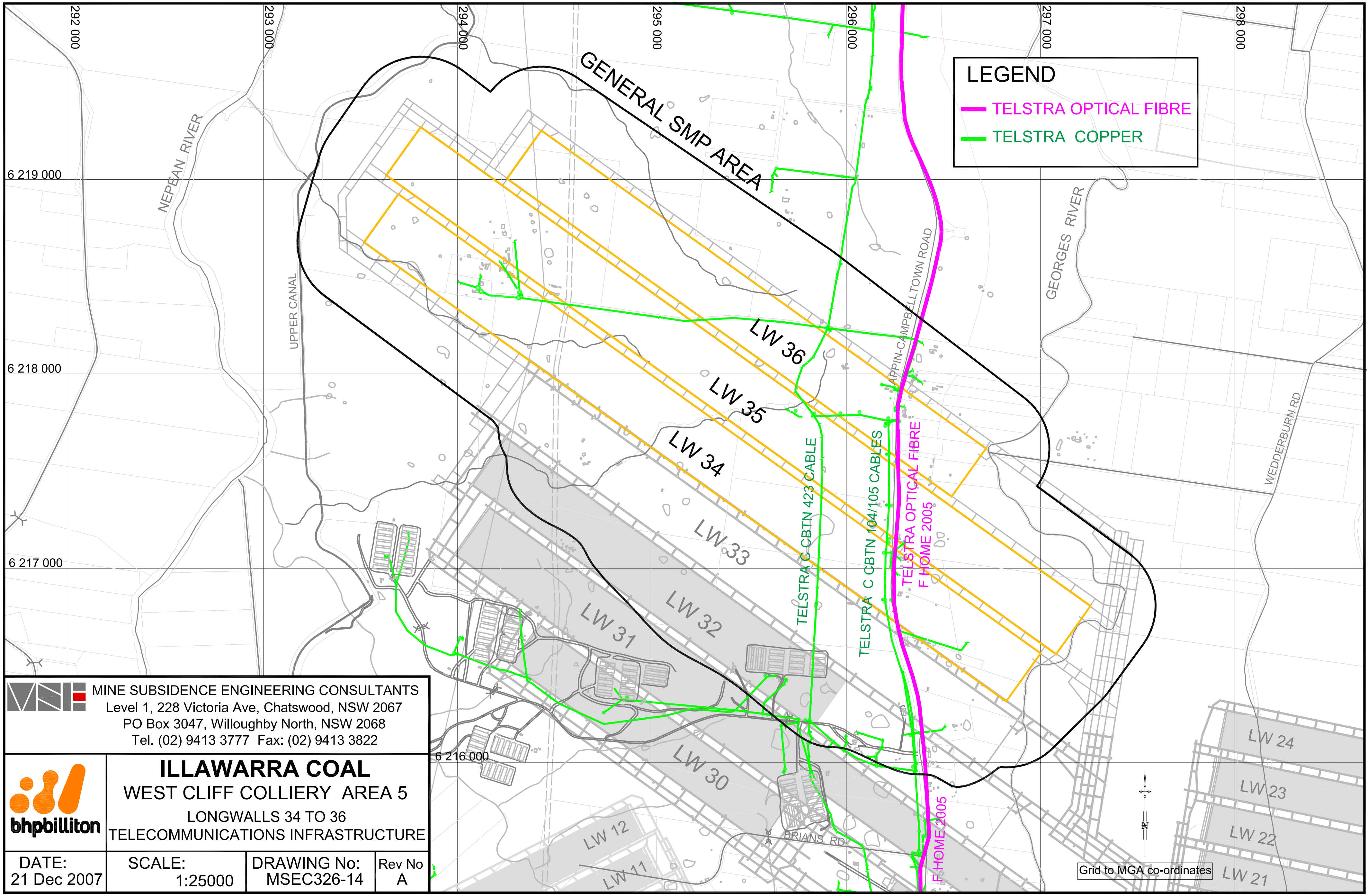

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ILLAWARRA COAL
WEST CLIFF COLLIERY AREA 5
LONGWALLS 34 TO 36
TELECOMMUNICATIONS INFRASTRUCTURE

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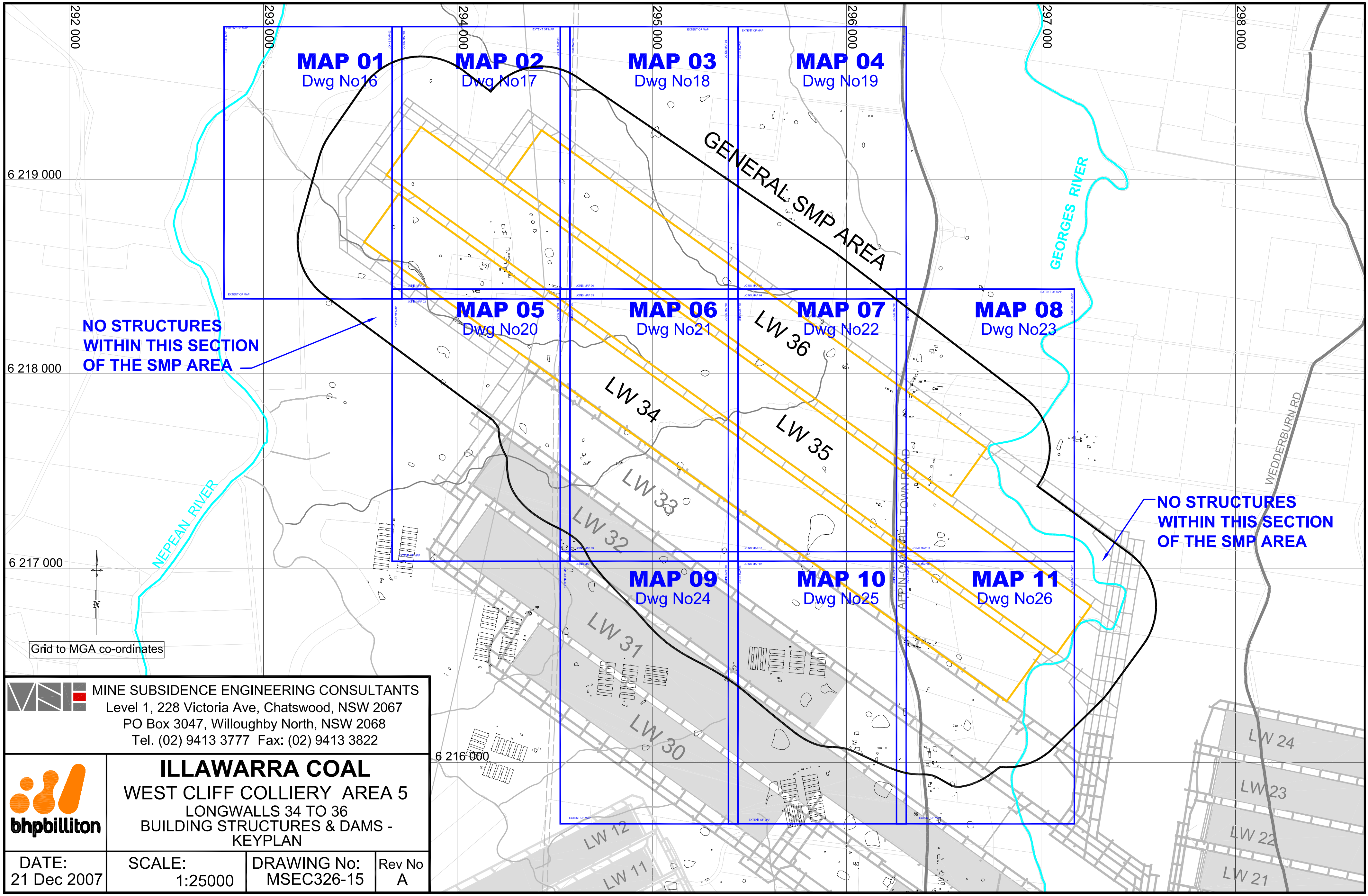

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ILLAWARRA COAL

WEST CLIFF COLLIERY AREA 5
LONGWALLS 34 TO 36
BUILDING STRUCTURES & DAMS - KEYPLAN

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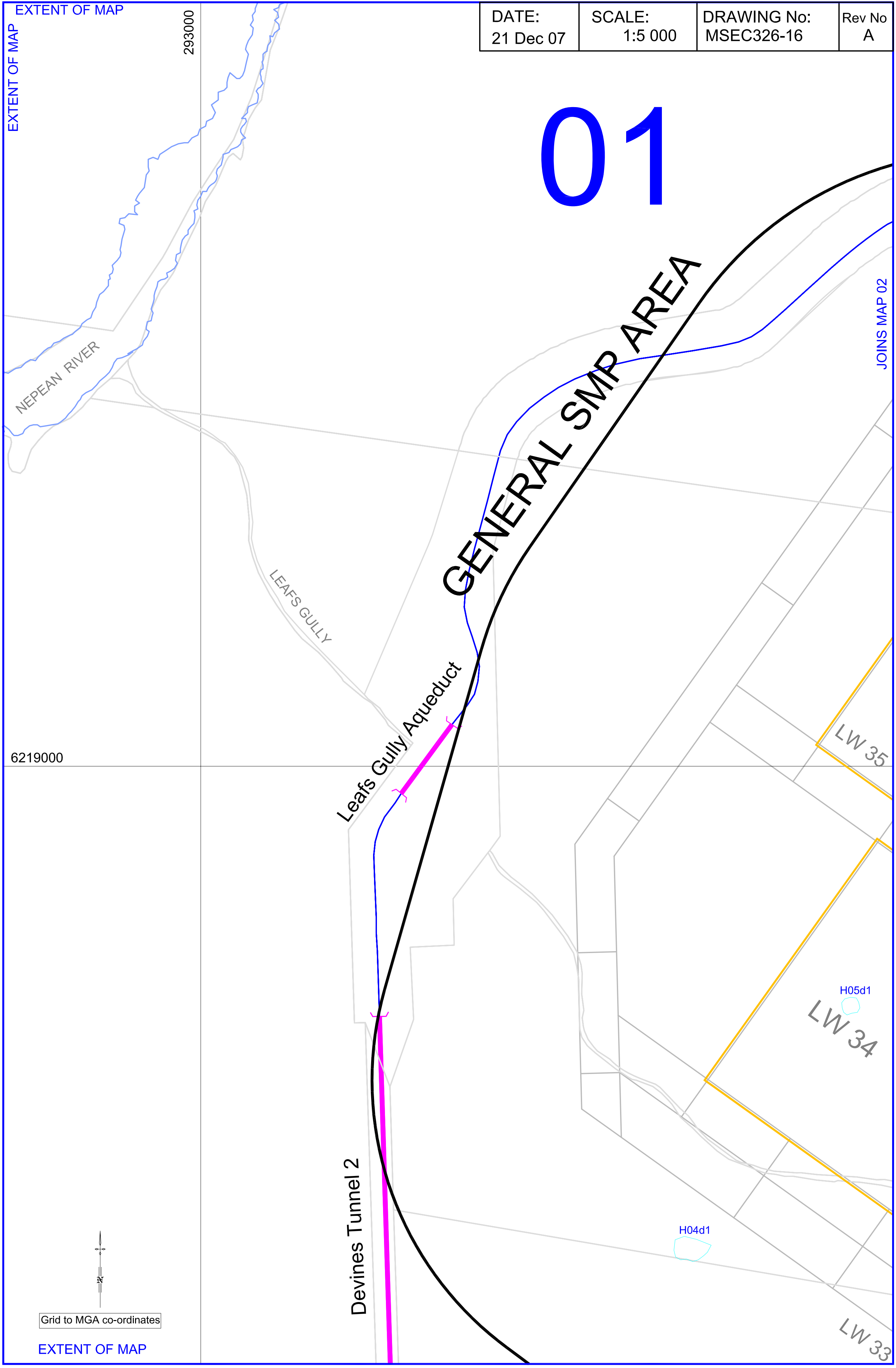

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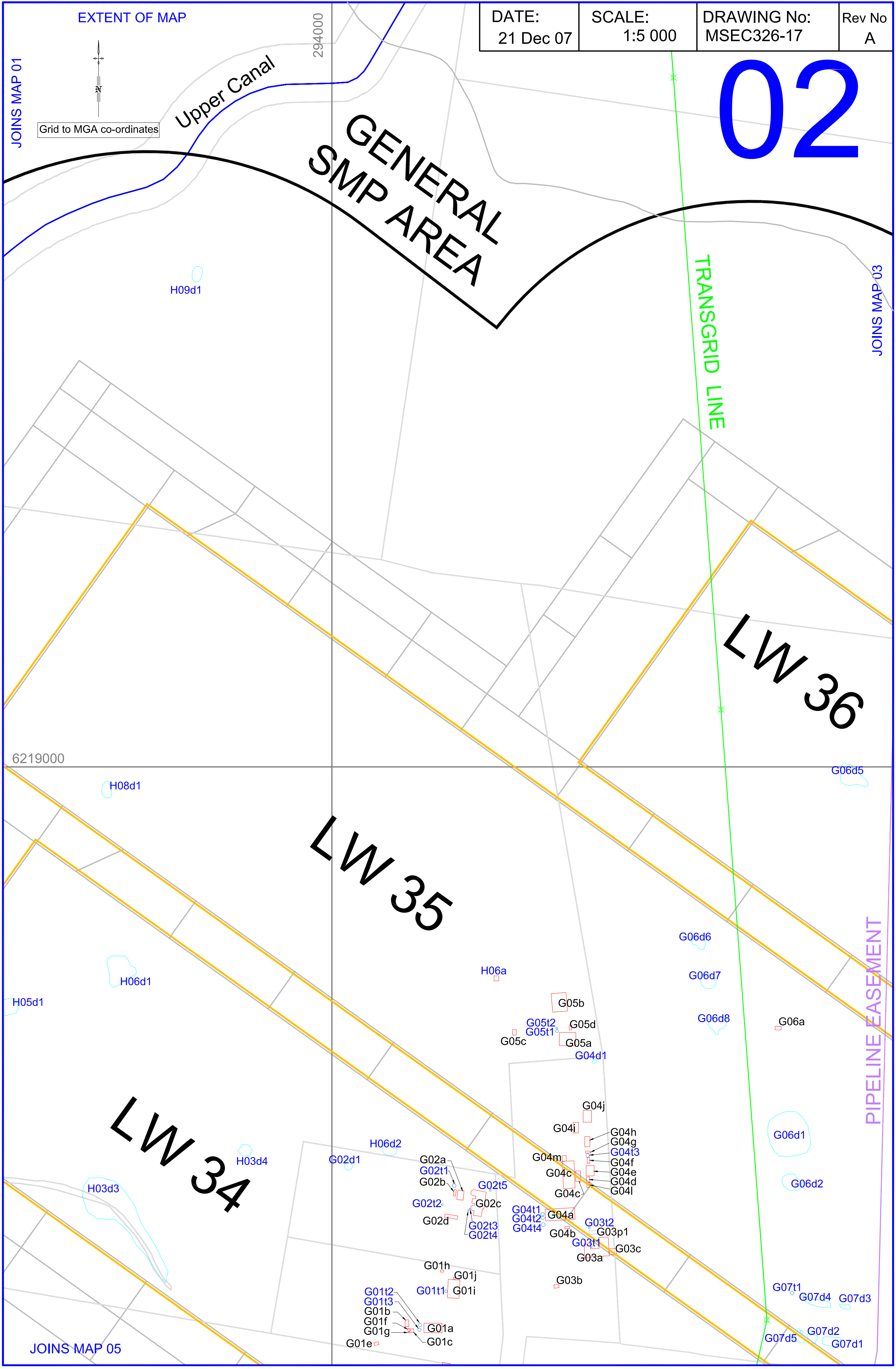

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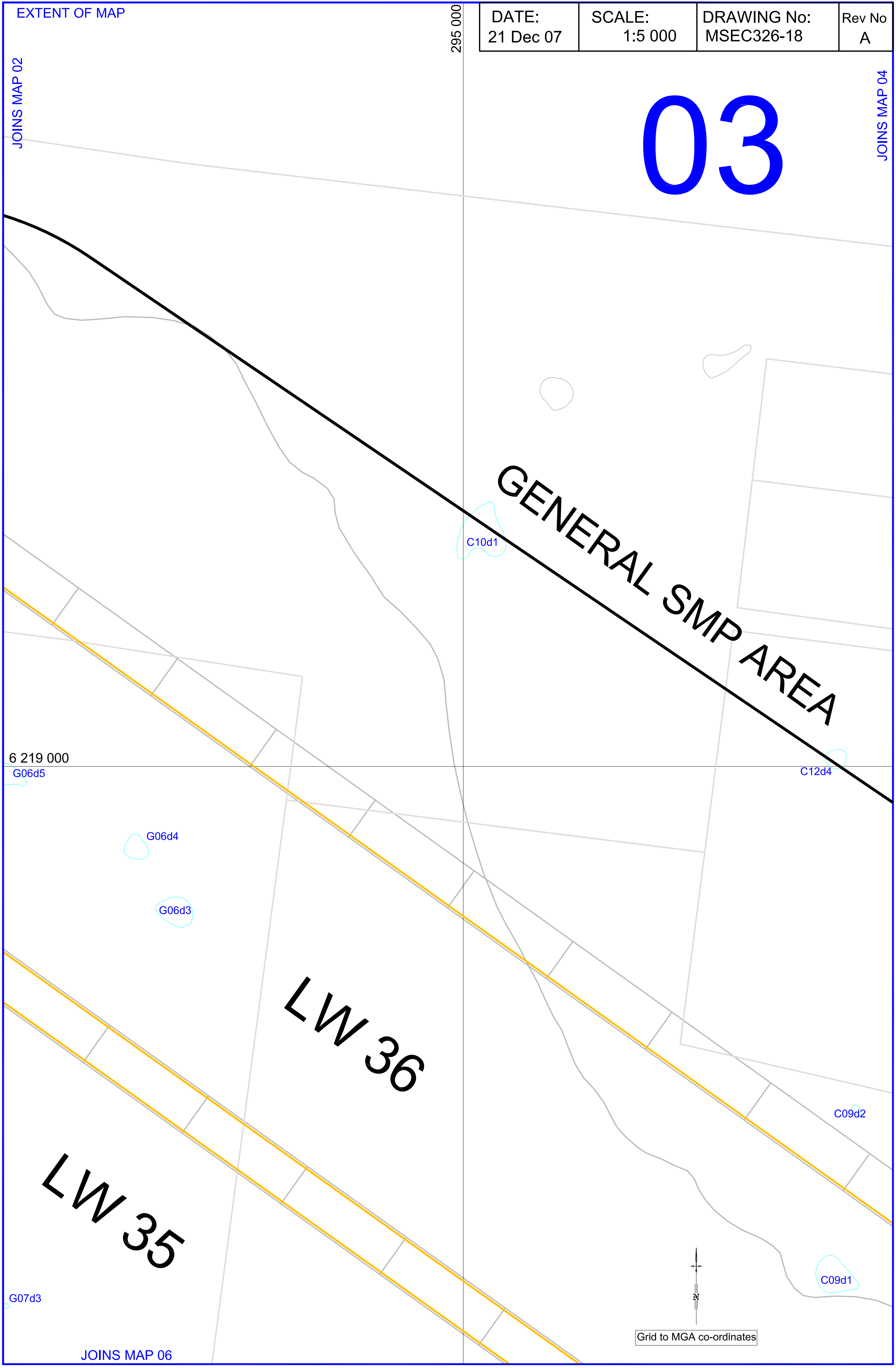

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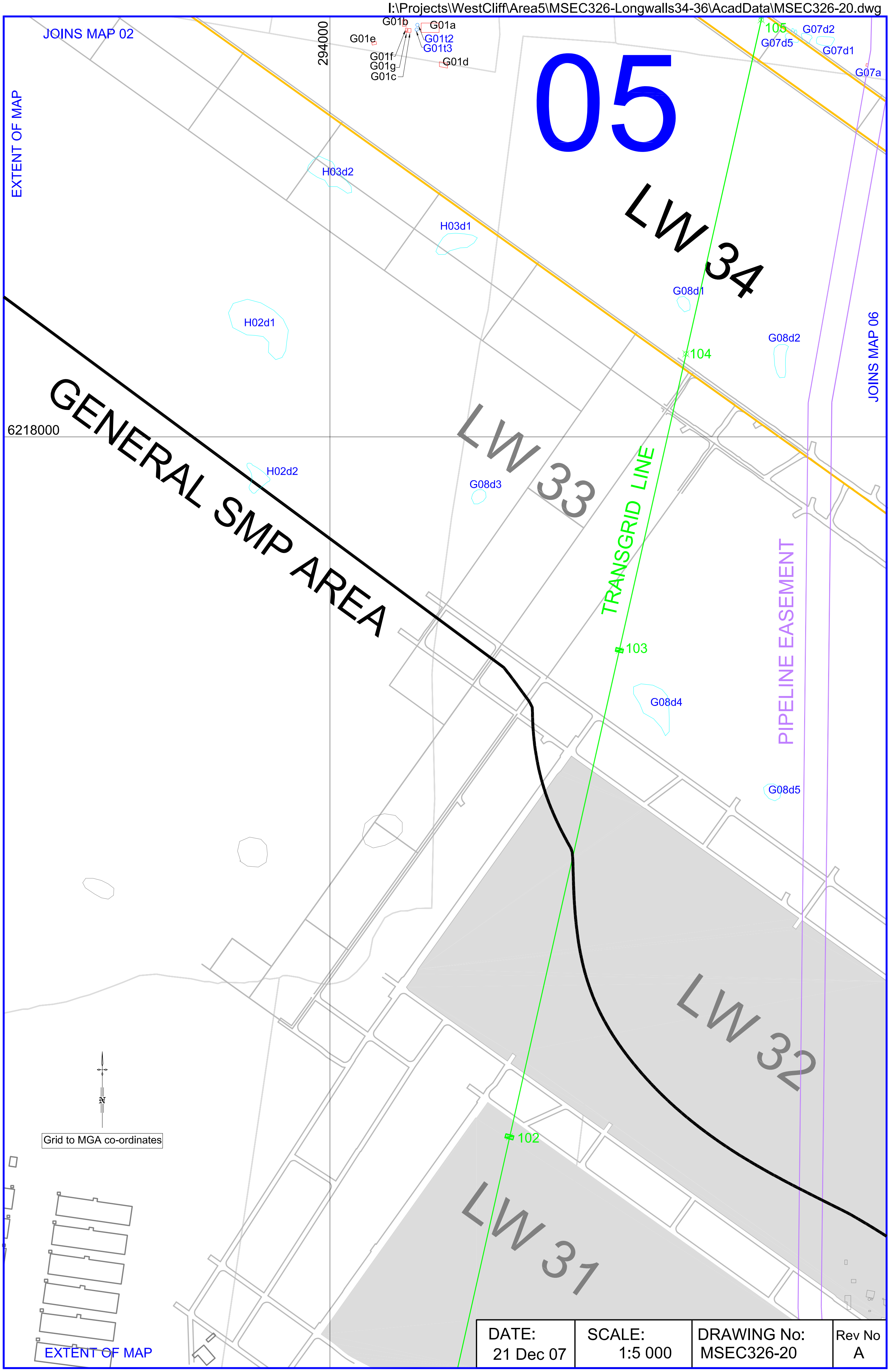

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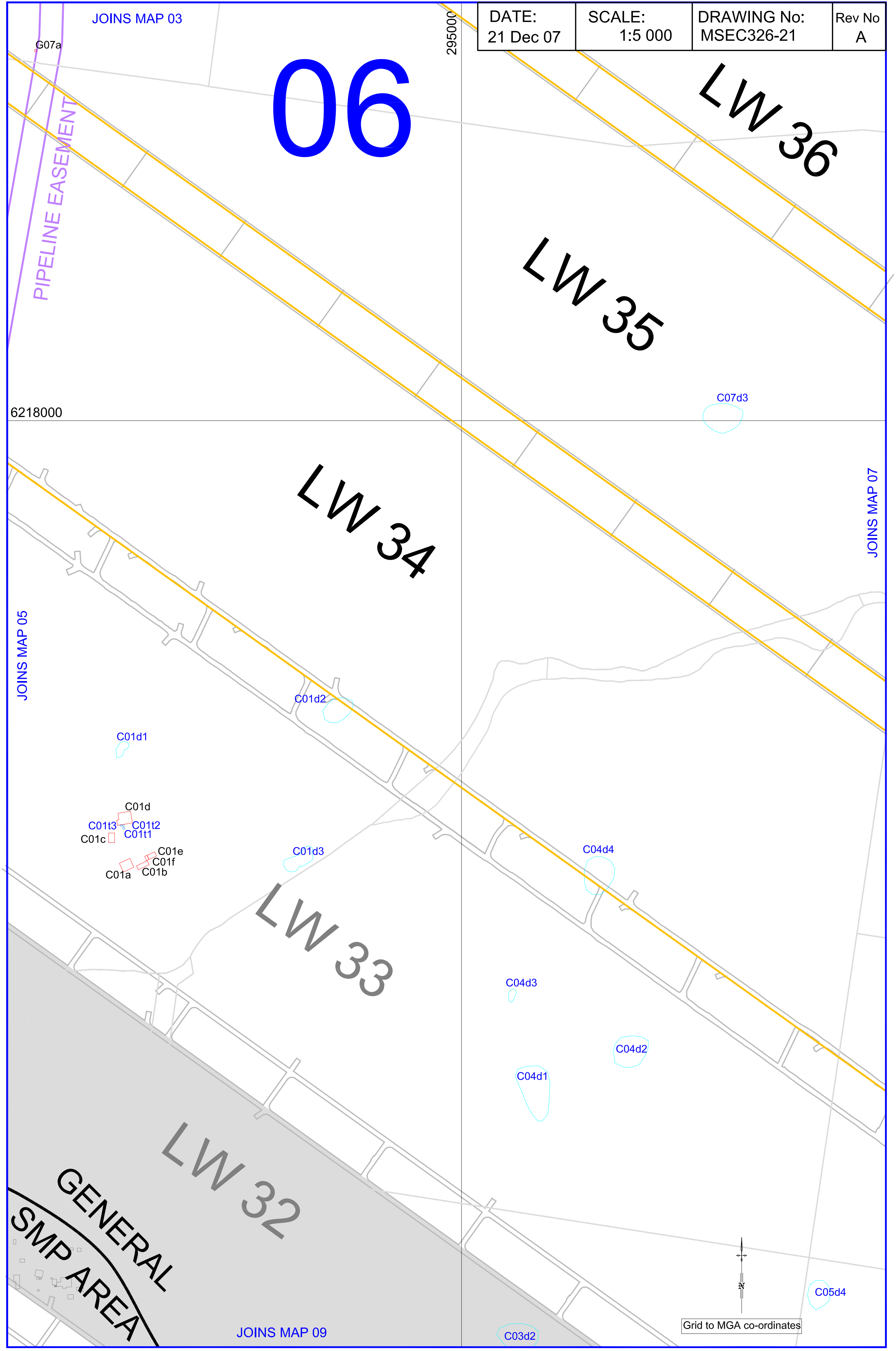

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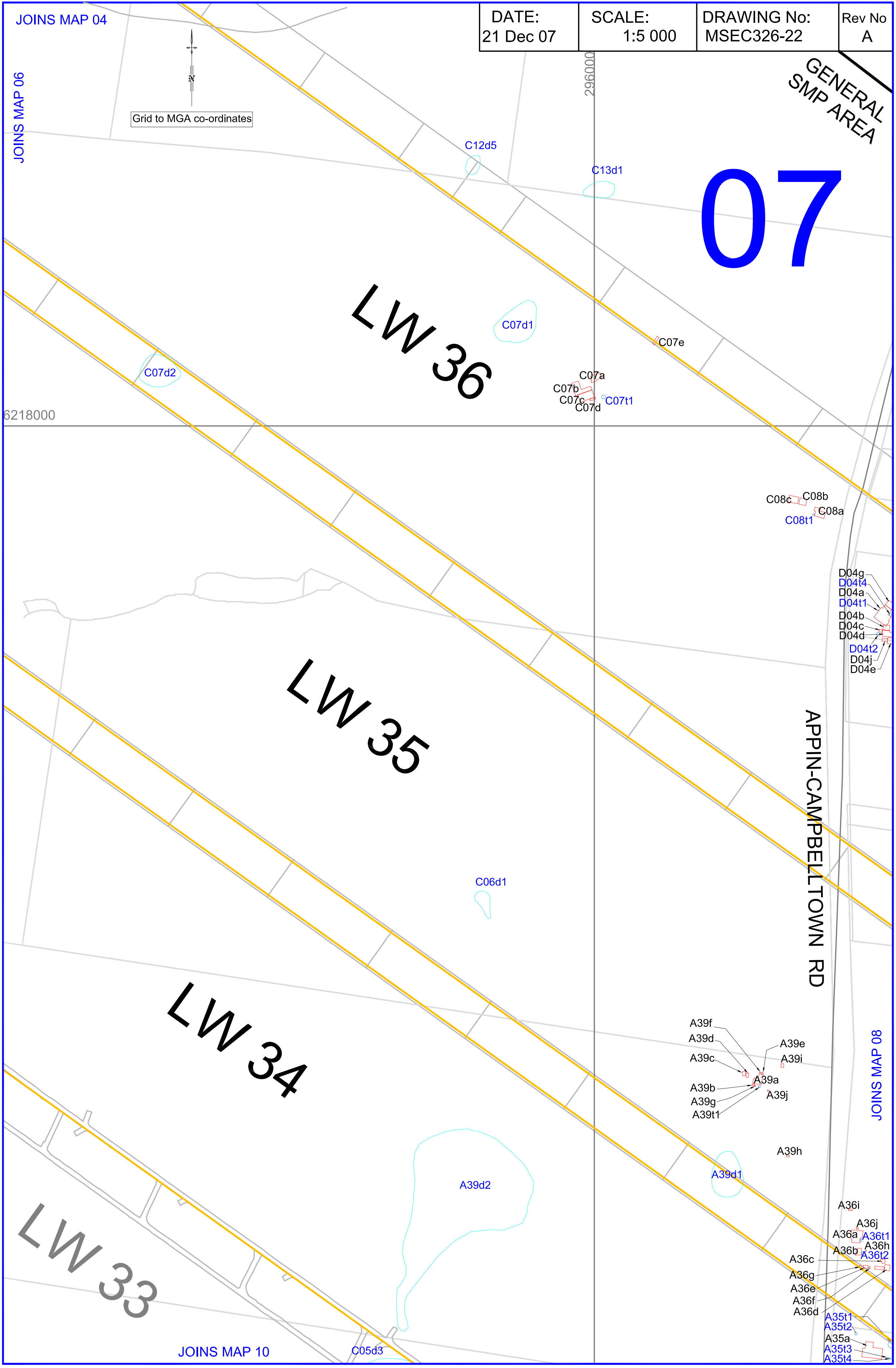

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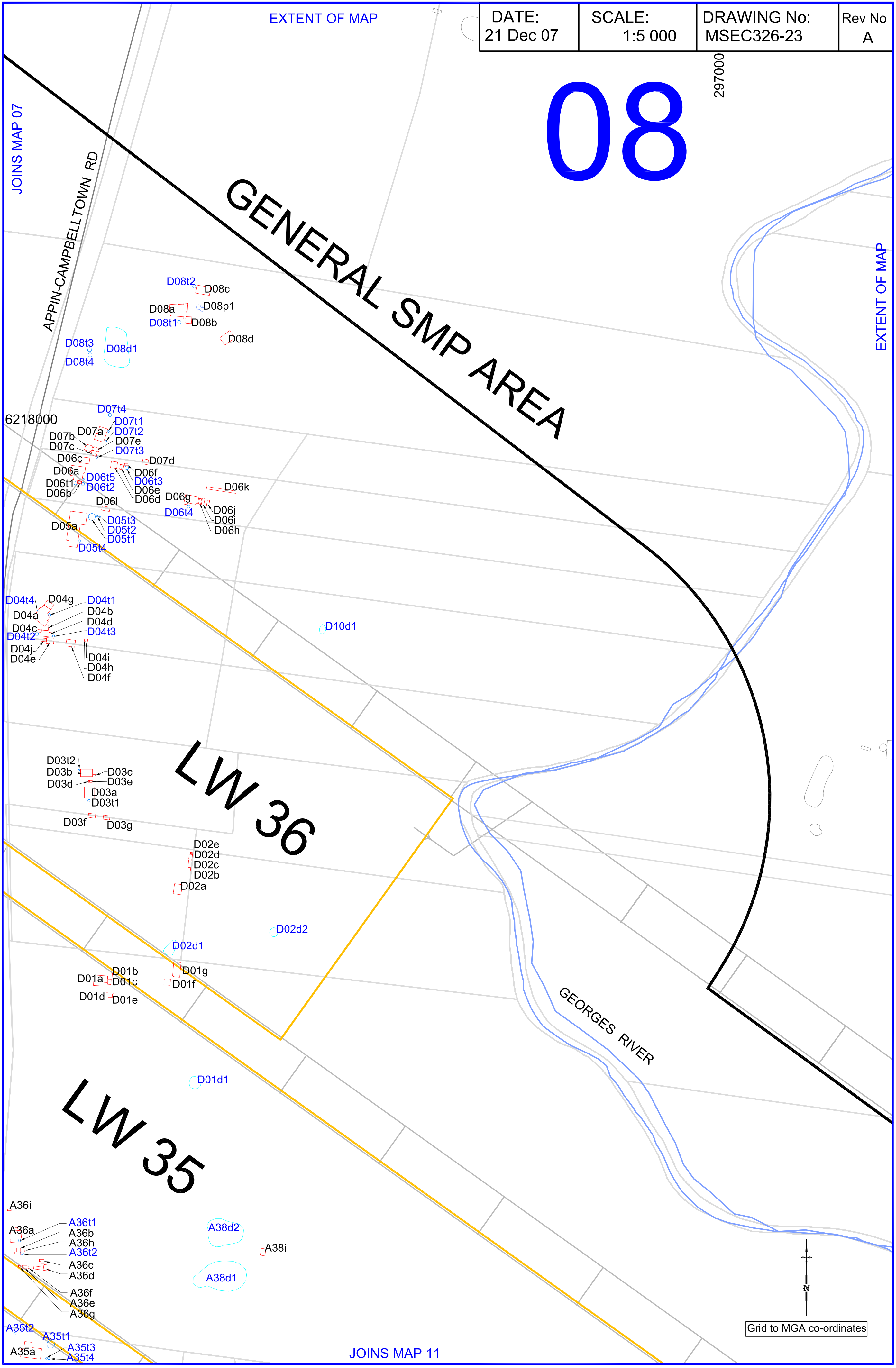

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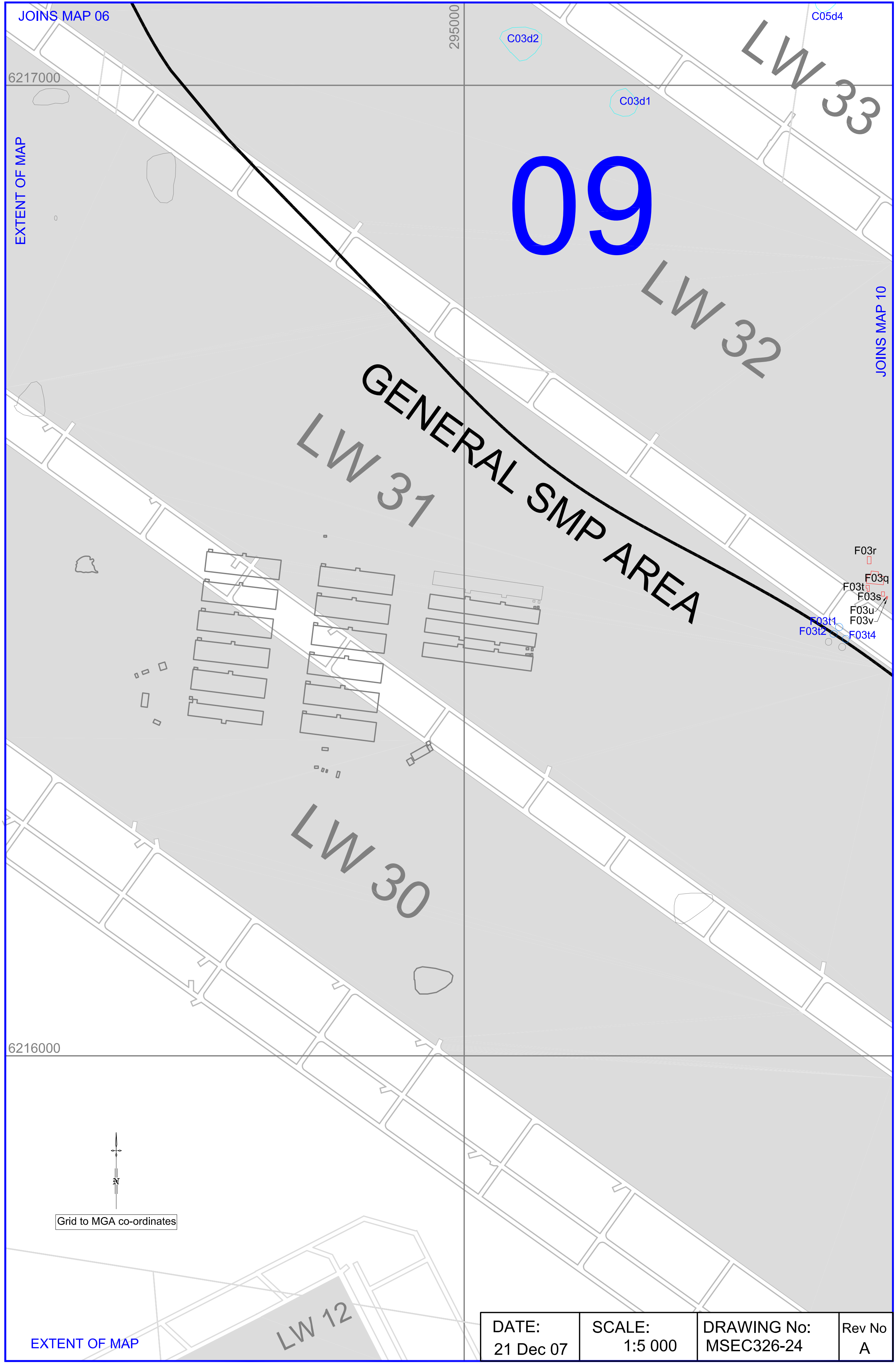

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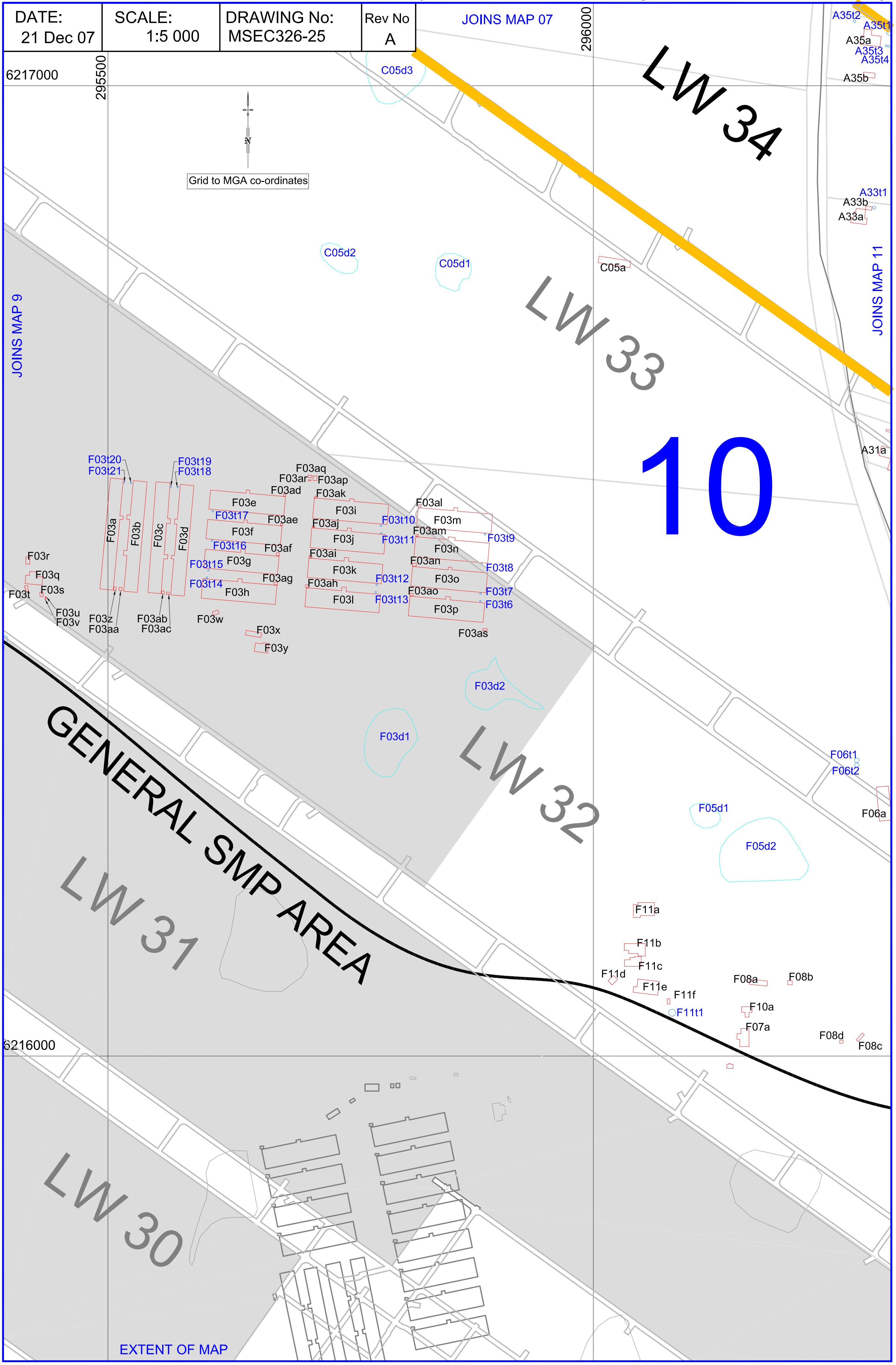

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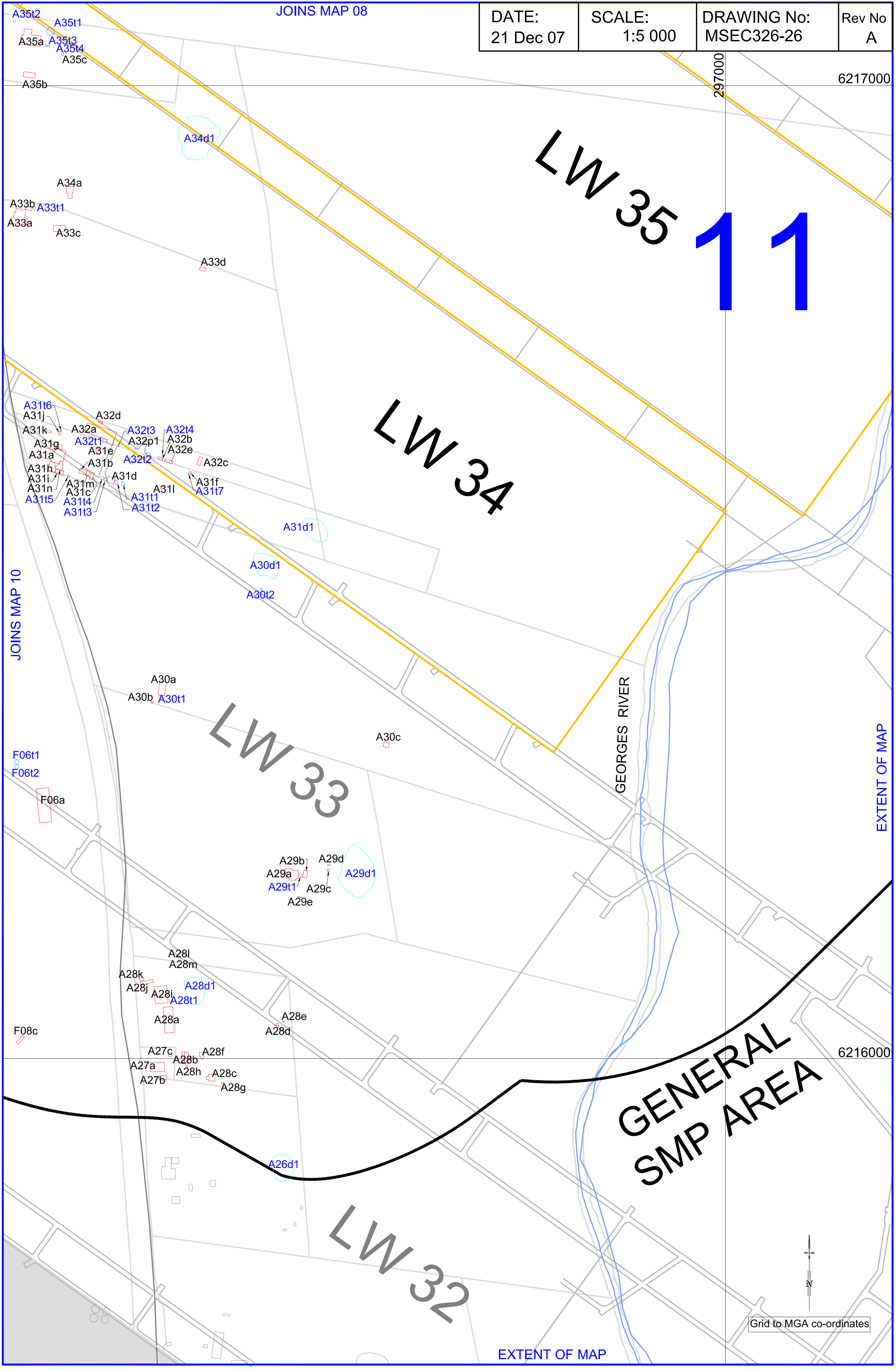

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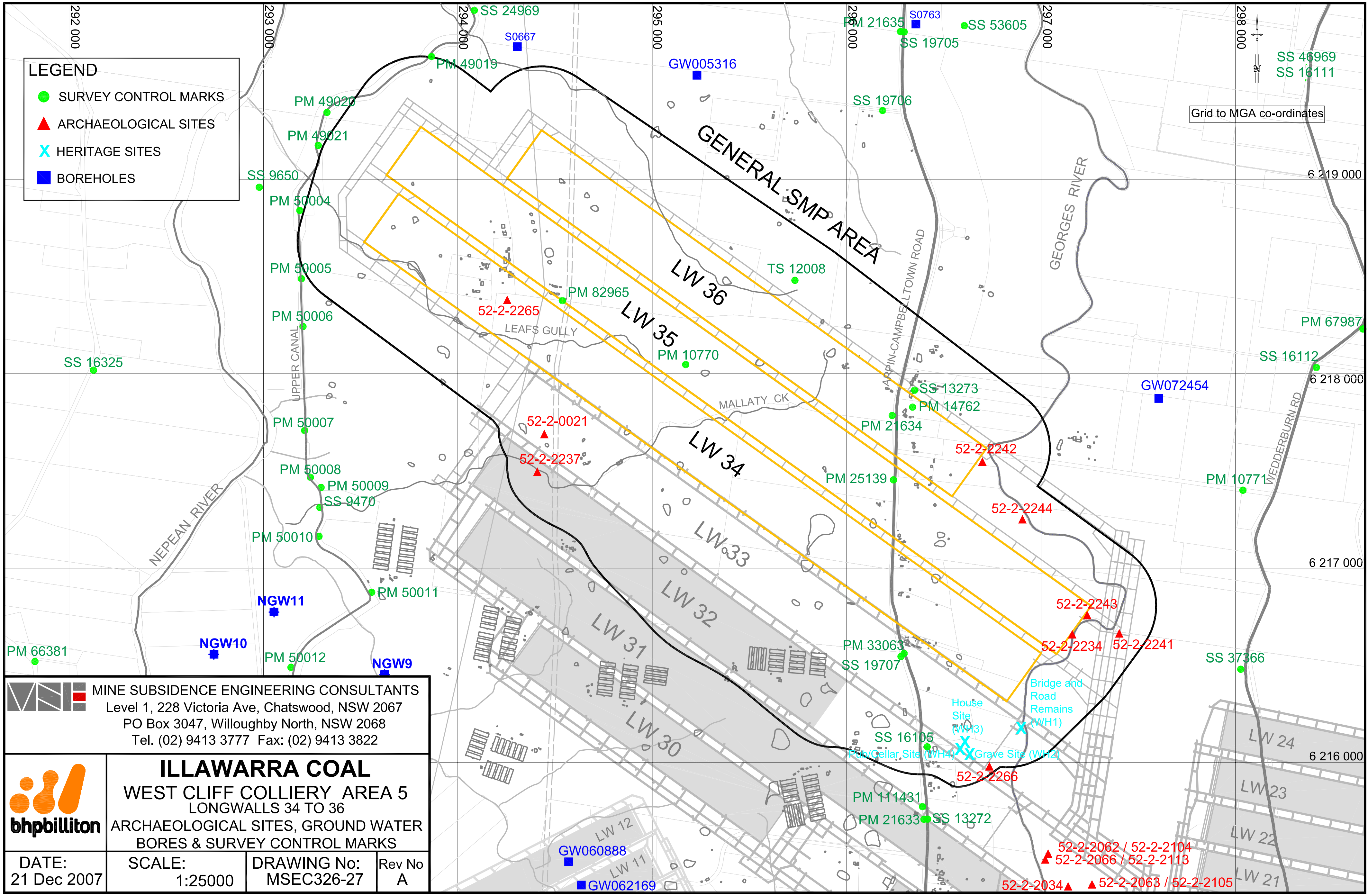

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ILLAWARRA COAL
WEST CLIFF COLLIERY AREA 5
LONGWALLS 34 TO 36
ARCHAEOLOGICAL SITES, GROUND WATER
BORES & SURVEY CONTROL MARKS

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21 Dec 2007	1:25000	MSEC326-27	A

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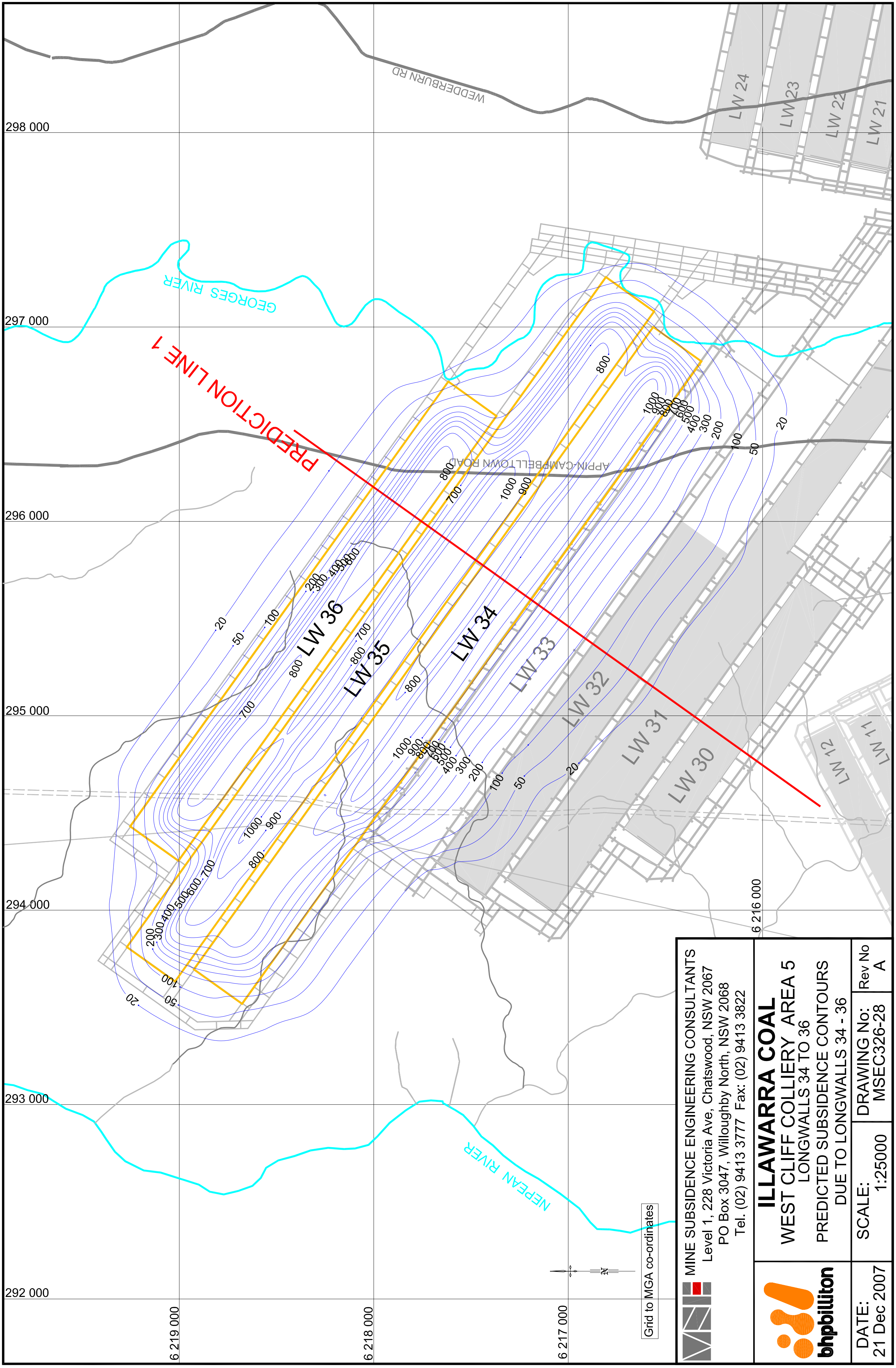

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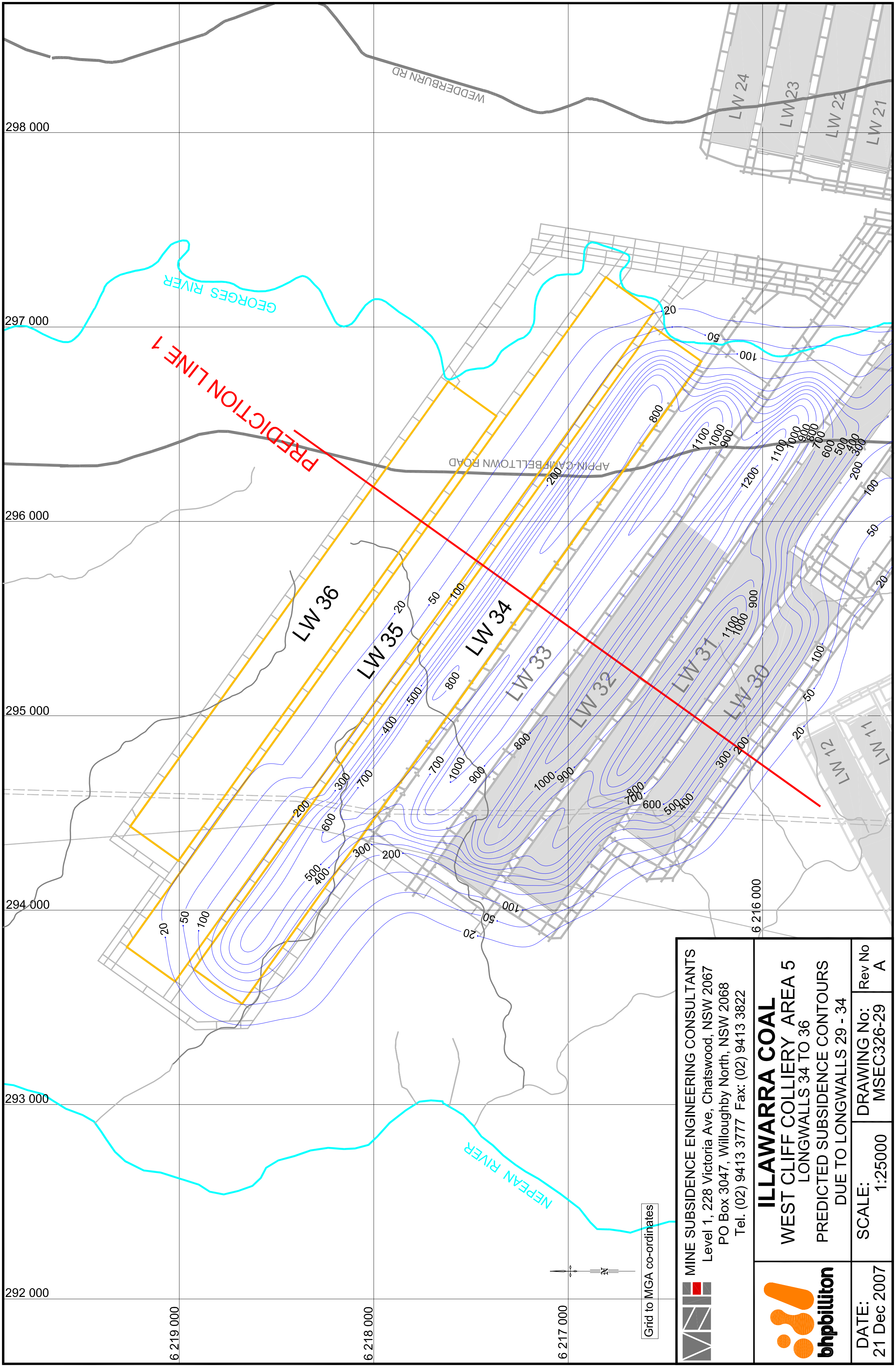
Level 1, 228 Victoria Ave, Chatswood, NSW 2067
PO Box 3047, Willoughby North, NSW 2068
Tel. (02) 9413 3777 Fax: (02) 9413 3822

ILLAWARRA COAL
WEST CLIFF COLLIERY AREA 5
LONGWALLS 34 TO 36
PREDICTED SUBSIDENCE CONTOURS
DUE TO LONGWALLS 34 - 36

DATE: 21 Dec 2007	SCALE: 1:25000
DRAWING No: MSEC326-28	Rev No A



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PO Box 3047, Willoughby North, NSW 2068
Tel. (02) 9413 3777 Fax: (02) 9413 3822

ILLAWARRA COAL
WEST CLIFF COLLIERY AREA 5
LONGWALLS 34 TO 36
PREDICTED SUBSIDENCE CONTOURS
DUE TO LONGWALLS 29 - 34

DATE: 21 Dec 2007
SCALE: 1:25000
DRAWING No: MSEC326-29
Rev No A

Grid to MGA co-ordinates

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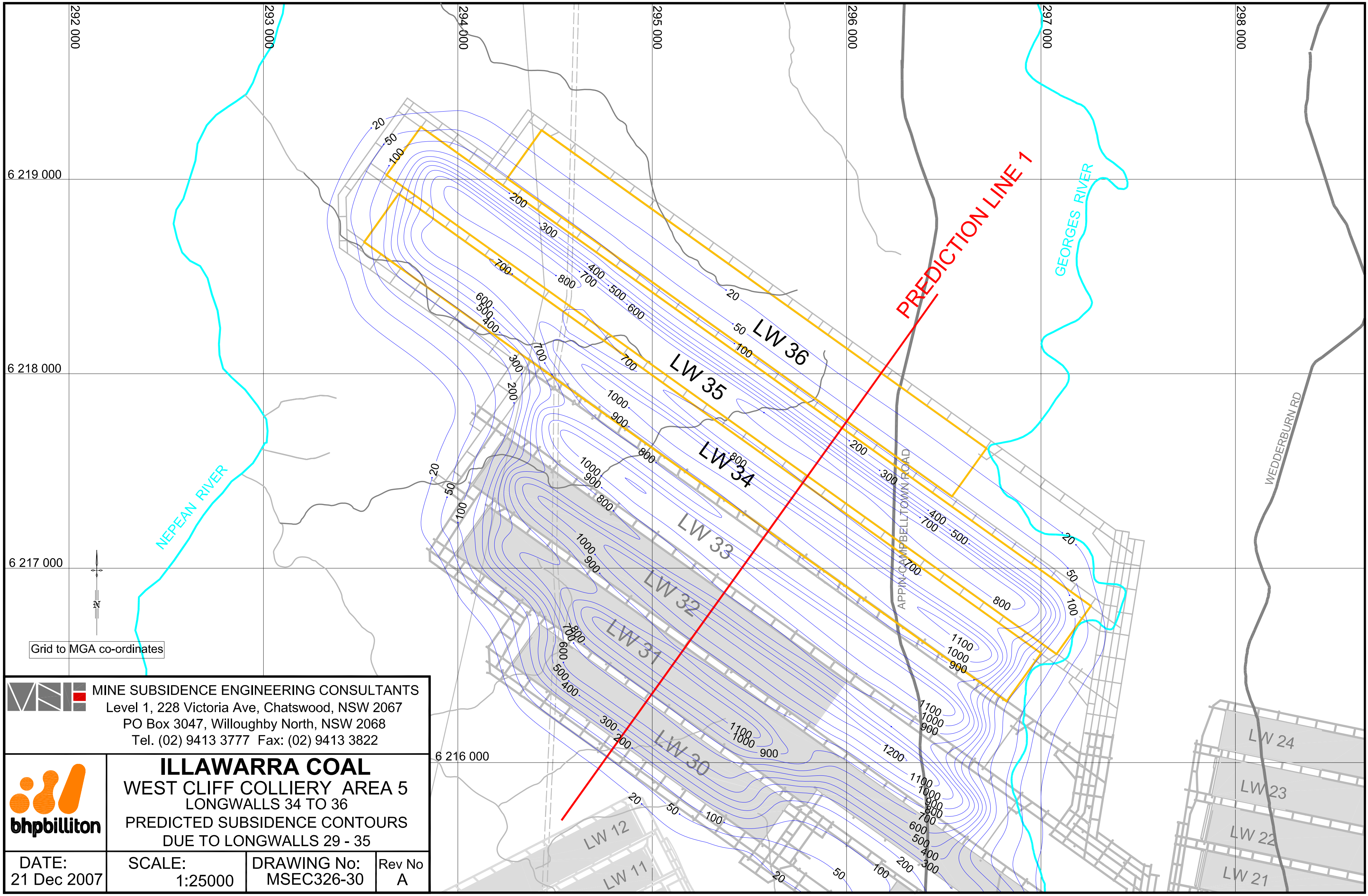

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PO Box 3047, Willoughby North, NSW 2068
Tel. (02) 9413 3777 Fax: (02) 9413 3822

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ILLAWARRA COAL
WEST CLIFF COLLIERY AREA 5
LONGWALLS 34 TO 36
PREDICTED SUBSIDENCE CONTOURS
DUE TO LONGWALLS 29 - 35

DATE:	SCALE:	DRAWING No:	Rev No
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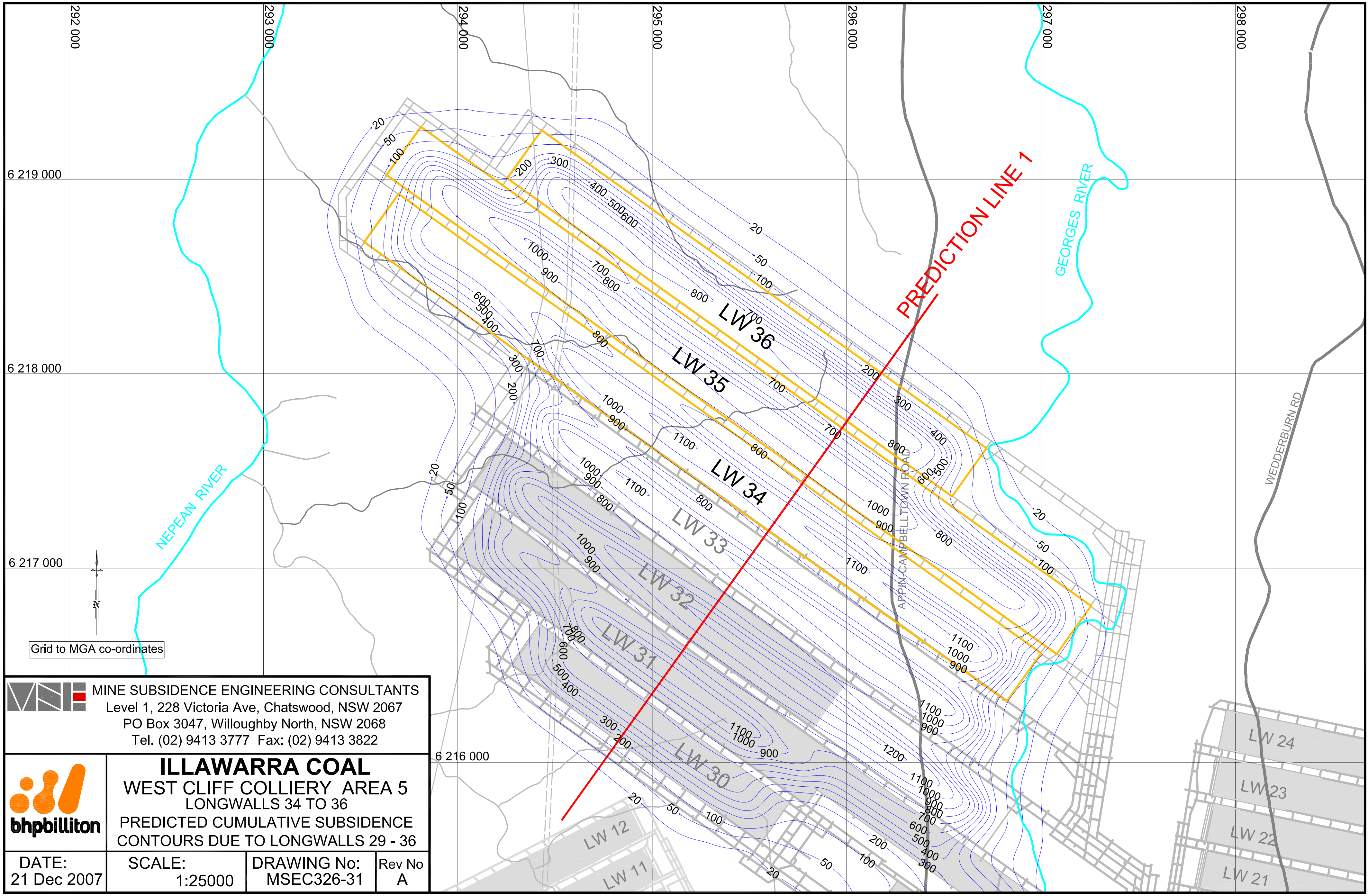

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Level 1, 228 Victoria Ave, Chatswood, NSW 2067
PO Box 3047, Willoughby North, NSW 2068
Tel. (02) 9413 3777 Fax: (02) 9413 3822

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ILLAWARRA COAL
WEST CLIFF COLLIERY AREA 5
LONGWALLS 34 TO 36
PREDICTED CUMULATIVE SUBSIDENCE
CONTOURS DUE TO LONGWALLS 29 - 36

DATE:	SCALE:	DRAWING No:	Rev No
21 Dec 2007	1:25000	MSEC326-31	A

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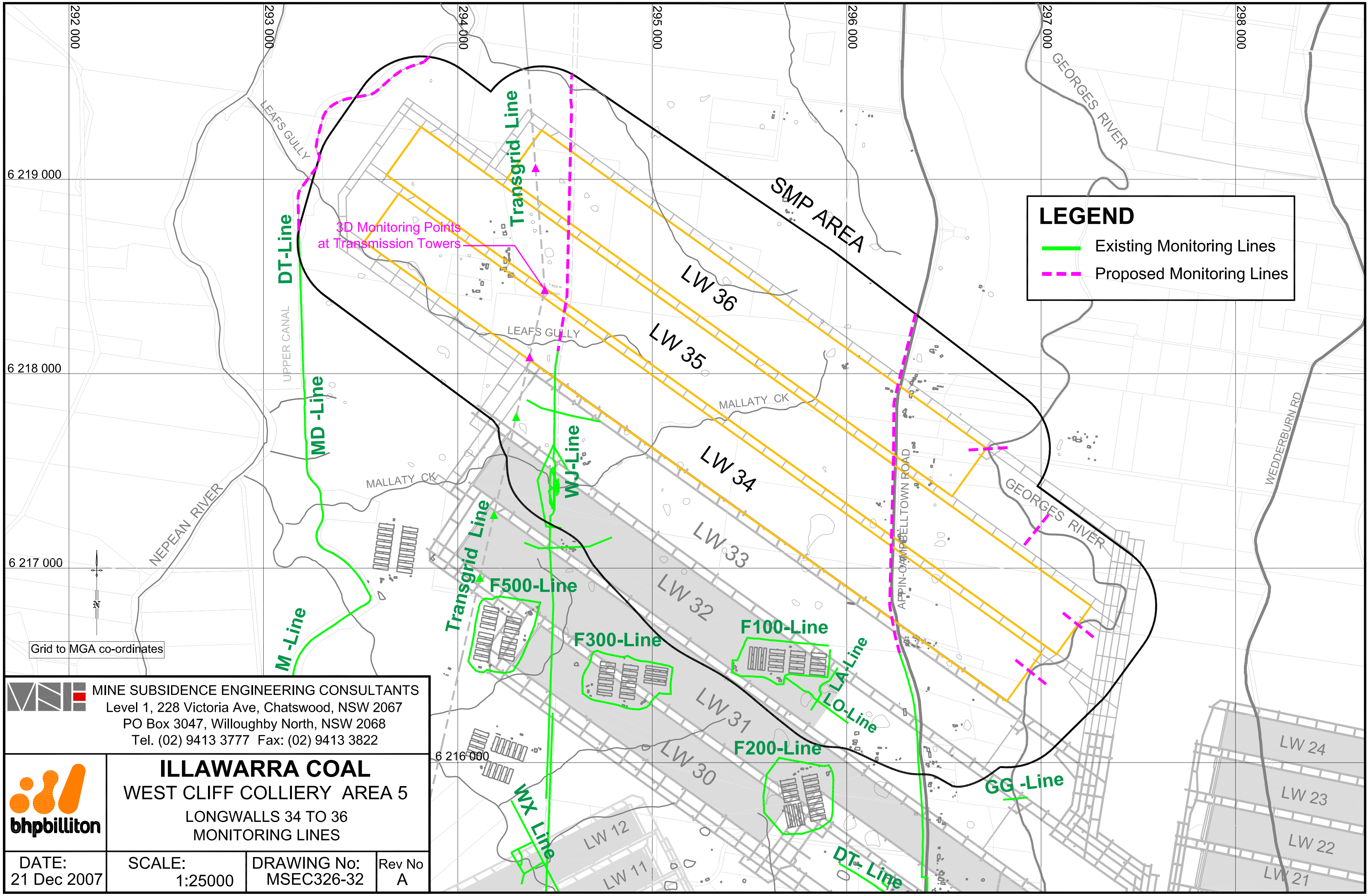

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Level 1, 228 Victoria Ave, Chatswood, NSW 2067
PO Box 3047, Willoughby North, NSW 2068
Tel. (02) 9413 3777 Fax: (02) 9413 3822

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ILLAWARRA COAL
WEST CLIFF COLLIERY AREA 5
LONGWALLS 34 TO 36
MONITORING LINES

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