West Cliff Colliery Area 5
Longwalls 34 to 36

SUBSIDENCE MANAGEMENT PLAN APPLICATION

WRITTEN REPORT

January 2008

Volume 1/3

Cardno Forbes Rigby Pty Ltd

278 Keira Street

Wollongong NSW 2050

(02) 4228 4133

Prepared for:

bhpbilliton

TABLE OF CONTENTS

List of Plans (A4 size)

LIST OF APPENDICES

LIST OF TABLES

LIST OF FIGURES

Document Compliance with Subsidence Management Plan (SMP) Guidelines

SMP Guideline Section	SMP Application Section Number Reference
6.2 The SMP Area	Volume 1- Section 2
6.3 Mining System and Resource Recovery	Volume 1- Section 3
6.4 Site Conditions of the SMP Area	Volume 1- Section 4
6.5 Stability of Underground Workings	Volume 1- Section 5
6.6 Characterisation of Surface and Sub-Surface Features within the SMP Area	Volume 1- Section 6
6.7 Subsidence Prediction	Volume 1- Section 7
6.8 Community Consultation.	Volume 1- Section 13
6.9 Statutory Requirements	Volume 1- Section 11
6.10 Subsidence Impacts	Volume 1- Sections 8, 9 and 10
6.10.2 Risk Assessment	Volume 1- Section 12
7. Proposed Subsidence Management Plan	Volume 2
9. Plans	Volume 3 (A0 size) and Volume 1 (reduced)
10. SMP Approved Plan	Volume 3 (A0 size) and Volume 1 (reduced)

1. INTRODUCTION

1.1. OVERVIEW

BHP Billiton Illawarra Coal (Illawarra Coal) proposes to continue its underground mining operations at the West Cliff Colliery Area 5, located in the Southern Coalfield of New South Wales, by extracting coal from the Bulli Seam using longwall mining techniques. West Cliff Colliery Area 5 is one of three operating underground mines managed by Illawarra Coal south of Sydney.

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.

This report supports an application for approval of a Subsidence Management Plan (SMP) for the development of longwall roadways by first workings and the secondary extraction of coal from Longwalls 34 to 36, **see Approved Plan.**

The proposed mining method uses continuous miner and longwall equipment to develop and extract the coal from the longwall panel. Illawarra Coal has recently mined longwalls (Longwalls LW29 to LW32) in the vicinity of the proposed workings.

A condition of the mining lease (which is granted under the *Mining Act 1992*) is that the leaseholder shall prepare and have approved a Subsidence Management Plan prior to commencing any underground mining operations which will potentially lead to subsidence of the land surface. This process is administered by the Department of Primary Industries Minerals (DPIM). The specific requirements for gaining approval of an SMP are set out in the *Guideline for Applications for Subsidence Management Approvals (Department of Mineral Resources, 2003).*

Approval is sought for the SMP for Longwalls 34 to 36 as per the subsidence management approval process. In accordance with the relevant DPIM guidelines, this report provides details on the:

- SMP Area;
- Proposed mining system and resource recovery;
- Site conditions within the SMP Area;
- Surface and sub-surface features within the SMP Area;
- Subsidence predictions;
- Government and community consultation;
- Statutory requirements;
- Subsidence impacts associated with the proposed mining.

This assessment (**Volume 1 – Written Report**) and the SMP for the extraction of Longwalls 34 to 36 has been developed using the principals of risk management and the *New Approval Process for Management of Coal Mining Subsidence (NSW Mineral Resources, 2003*). The SMP itself is presented as **Volume 2** of the submission.

Mine Subsidence Engineering Consultants (MSEC) were commissioned by Illawarra Coal to study the mining proposal, to identify natural features and all surface infrastructure, and to prepare subsidence predictions and impact assessments for these features. The MSEC report is included in **Appendix A** and key conclusions are presented in this Written Report. Further impact assessment for terrestrial and aquatic ecology, water quality and flow, Aboriginal and European heritage was undertaken by Biosis Research and the Ecology Lab, Ecoengineers. These reports are provided in **Appendices B to E**.

1.2. THE APPLICANT

The owner and operator of the underground operation at West Cliff Colliery Area 5 is Illawarra Coal, which is a wholly owned subsidiary of BHP Billiton. Illawarra Coal's three operating mines in the Illawarra region produce hard coking coal, approximately 65% of which is consumed at steelworks in Port Kembla and Whyalla, while the remainder is exported.

1.3. APPROVALS SOUGHT

1.3.1. SMP Approval

This SMP application seeks approval for the activity of developing the longwall roadways associated with Longwall panels 34 to 36 and the mining of coal via the Longwall method within West Cliff Colliery Area 5 of Longwall panels 34 to 36 (the **Activity**) (refer **Figure 1.1**). The Activity includes the monitoring, mitigation and remediation measures proposed in this report and the SMP to minimise the impacts from the proposed mining. An aerial photograph of the area to be mined is provided in **Figure 2.1**.

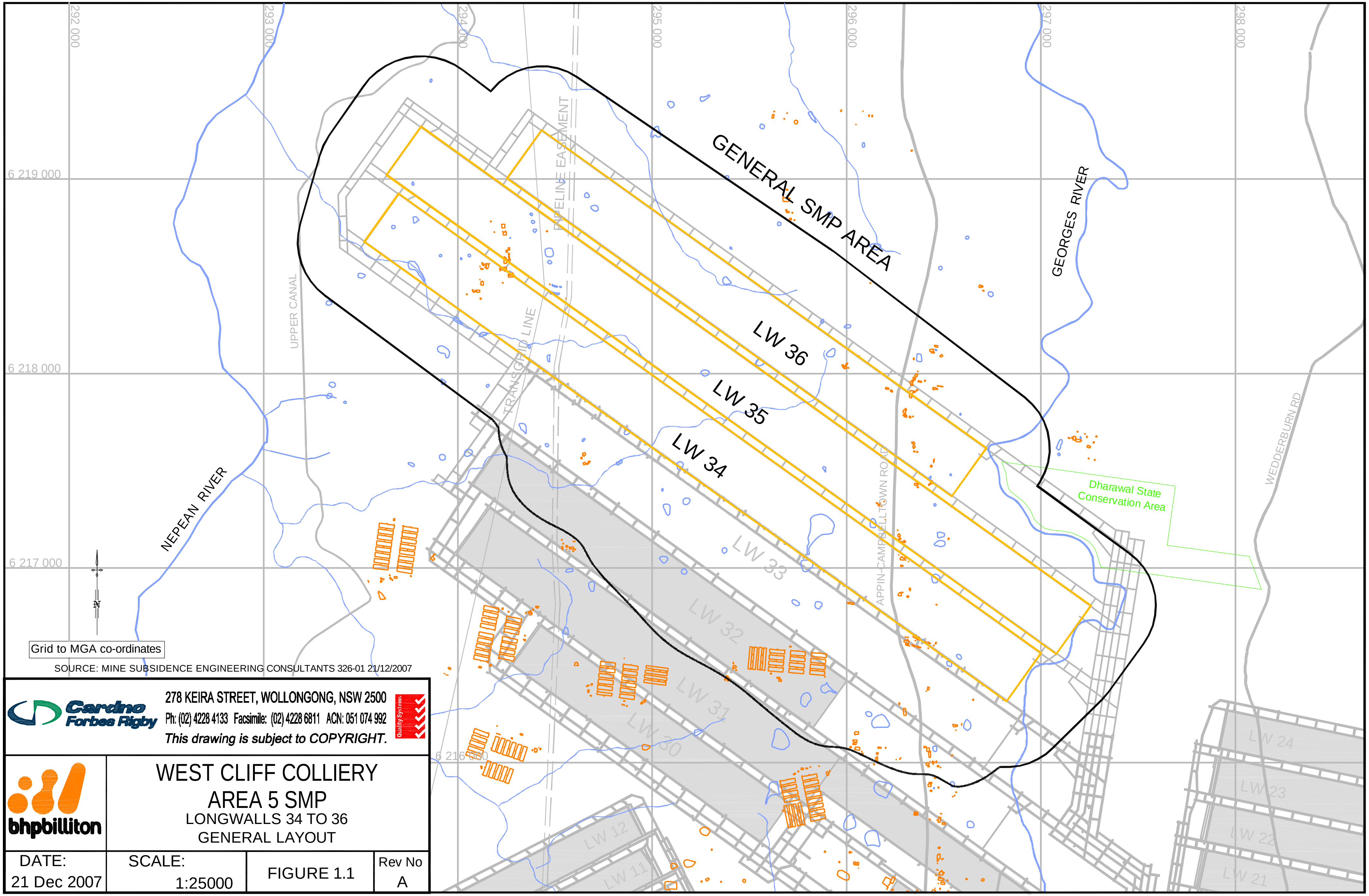
1.3.2. Part 5 Approval under the Environmental Planning and Assessment Act

The DPIM aims to promote the responsible development of the State's resources for the community's benefit and in doing this must administer a range of environmental legislation that is applicable to mining in NSW. The Department is concerned to ensure that any adverse effects of mining are minimised, and that a consistent high standard of environmental protection and rehabilitation is practiced throughout NSW.

Longwalls 34 to 36 are within an existing mining lease, where there is an existing mine. West Cliff Colliery is subject to the Wollondilly Local Environment Plan, which adopts Clauses 35 and Schedule 1(7) of the Environmental Planning and Assessment Model Provisions. Under these provisions the Development Consent is therefore not required for the project. However, the EP&A Act requires that DPIM comply with Part 5 of the EP&A Act when determining the SMP application for Longwalls 34 to 36. This report provides information on the environmental impacts of the Activity (the activity being the proposed mining of Longwalls 34 to 36 and the mitigation and rehabilitation measures that will be implemented to minimise impacts from this mining).

This document:

- provides the DPIM with the information required by the EP&A Act for DPIM to be able to comply with the requirements imposed on DPIM by Part 5 of the EP&A Act in assessing the SMP application for the Activity;



SOURCE: MINE SUBSIDENCE ENGINEERING CONSULTANTS 326-01 21/12/2007

Cardno Forbes Rigby
278 KEIRA STREET, WOLLONGONG, NSW 2500
Ph: (02) 4228 4133 Facsimile: (02) 4228 6811 ACN: 051 074 992

bhpbilliton

WEST CLIFF COLLIERY AREA 5 SMP

LONGWALLS 34 TO 36
GENERAL LAYOUT

DATE:	SCALE:		Rev No
21 Dec 2007	1:25000	FIGURE 1.1	A

- has also been prepared in accordance with the *Guideline for Applications for Subsidence Management Approvals (Department of Mineral Resources, 2003)* to seek approval for the SMP for Longwalls LW34 to LW36.

This report demonstrates that for the purposes of Part 5 of the EP&A Act the proposed Activity does not significantly affect the environment and accordingly an EIS is not required for this Activity.

1.4. LAND OWNERSHIP

The SMP Area encompasses land owned by private landowners, commercial landowners and state government (refer **Plan 5**).

1.5. FIRST WORKINGS APPROVAL

1.5.1. First working application

As stated above this SMP application is for approval of both the mining of Longwalls 34 to 36 by longwalling mining methods and the development of the roadways, by way of first workings, which delineate Longwalls 34 to 36.

1.6. PRIOR APPROVALS

Mining of Longwalls 29 to 33 to the south of Longwalls 34 to 36 has been previously approved. Extraction of Longwalls 29 to 30 and part of Longwalls 31 to 33 is being conducted under a Section 138 Approval dated 24 December 2003. The remainder of Longwalls 31 to 33 are conducted under a SMP Approval dated 1 September 2006.

1.6.1. SMP Study Team

The specialist studies undertaken for the Longwalls 34 to 36 SMP include:

- Subsidence (Mine Subsidence Engineering Consultants - MSEC) – **Appendix A**
- Water Quality Subsidence Impact Assessment (Ecoengineers) – **Appendix B**
- Aquatic Ecology Subsidence Impact Assessment (The Ecology Lab) – **Appendix C**
- Flora and fauna Subsidence Impact Assessment (BIOSIS Research) – **Appendix D**
- Cultural Heritage Subsidence Impact Assessment (BIOSIS Research) – **Appendix E**
- Stakeholder Consultation Documentation – **Appendix F**
- Subsidence Risk Assessment (AXYS Consulting) – **Appendix G**
- Property Subsidence Management Plans (Cardno Forbes Rigby) – The PSMPs contain confidential information relating to properties and will be sent to DPIM separately.

This report refers to a number of different areas relevant to the mining proposal. These are the SMP Area and the Extent of Workings, as shown in the Approved Plan. These are further explained below.

2. APPLICATION AREA

2.1. APPROVED PLAN

The **Approved Plan** for Longwalls 34 to 36 refers to the proposed longwall extraction area and associated roadway development. An A4 copy of the SMP Plans and Approved Plan are attached at the rear of this document prior to the Appendices.

2.2. SMP AREA

(SMP Guideline Section 6.2)

The 'Application Area' is defined as the area that is likely to be potentially impacted by the proposed mining of Longwalls 34 to 36 in the Bulli Seam at West Cliff Colliery Area 5. 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 20mm subsidence contour;
- Features sensitive to far-field ground movements.

The 35 degree angle of draw line is described as the "surface area defined by the cover depths, angle of draw of 35 degrees and the limit of the proposed extraction area in mining leases of the Southern Coalfield", as stated in Section 6.2 of the DPIM SMP Guideline, 2003. Given that the depth of cover above proposed Longwalls 34 to 36 varies between 470 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 around the limit of the proposed extraction area.

The predicted vertical limit of subsidence, taken as the 20mm subsidence contour, has been determined using the Incremental Profile Method (MSEC 2006). The predicted 20 millimetre subsidence contour is generally located within the 35 degree angle of draw line, however, it extends beyond the draw line above adjacent Longwalls LW29 to LW33.

The 'Application Area' is also referred to as the '*SMP Area'*, and is referred to as the *SMP Area* from this point forward. The SMP Area is shown in **Figure 2.1**, and is shown in all figures presented throughout the report.

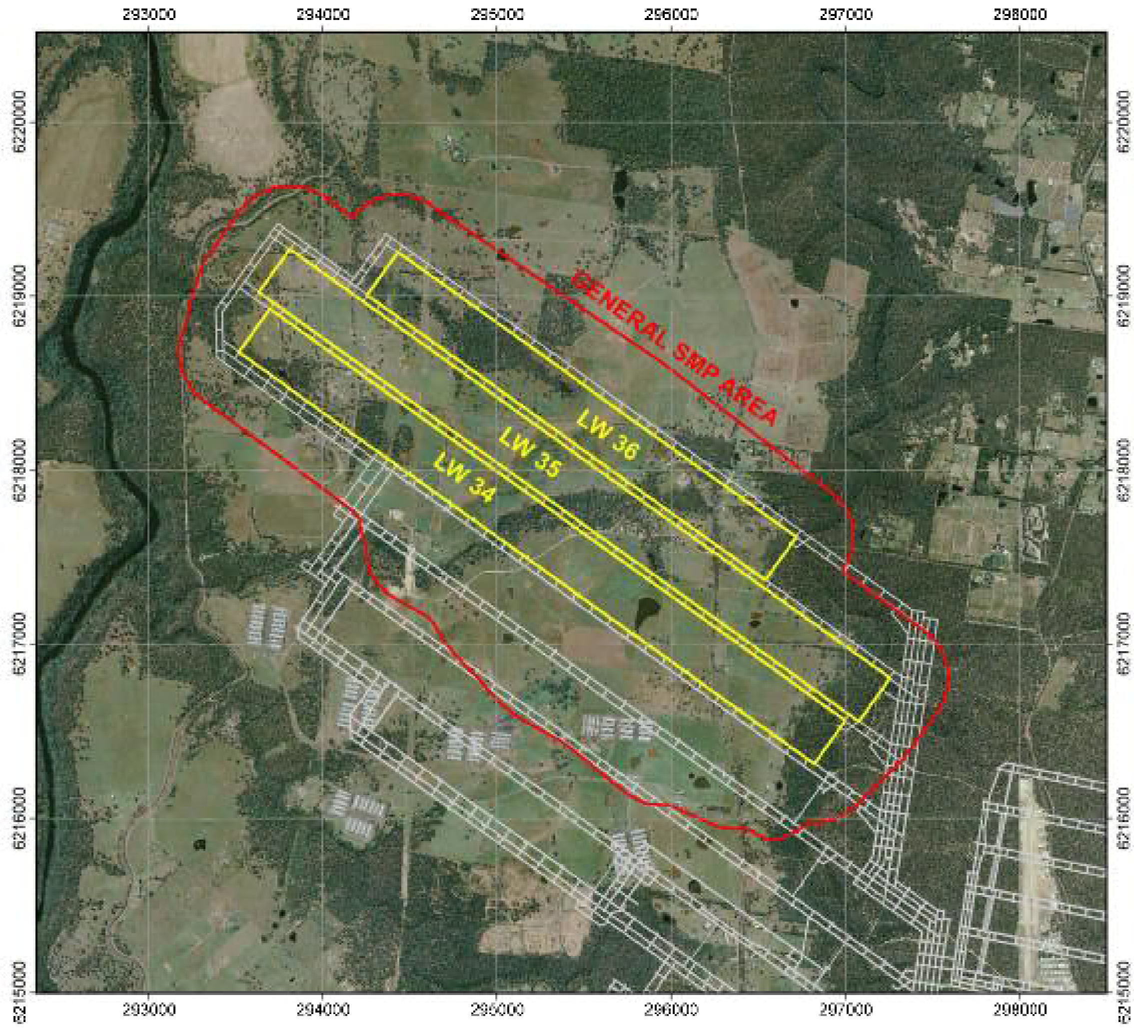


Figure 2.1 Aerial Photograph Showing Longwalls 34 to 36 and the SMP Area

2.3. EXTENT OF WORKINGS

The extent of workings is the polygon that includes the first workings and extraction that will be undertaken as a result of this application being approved (refer to the Approved Plan).

3. MINING SYSTEM AND RESOURCE RECOVERY

(SMP Guideline Section 6.1)

3.1. MINING METHOD

Longwalls 34 to 36 will be extracted using a longwall retreating system of mining, an established method of coal mining widely used in Australia and overseas. This method is described briefly below and in more detail in the subsidence report in **Appendix A**.

Coal is mined from the Bulli Seam using a longwall system supported by continuous miner development units. The longwall is a complex system of mining equipment that incorporates roof support, coal cutting and coal transport equipment to provide a safe working environment.

During the preparation stages of a longwall operation, the roadways are developed to delineate proposed longwall blocks. These roadways define the boundaries of the longwall block and are required to provide employee access, ventilation, coal transport and other services. Roadways are nominally driven 4.8 metres wide and full seam height. The value of coal extracted when roadways are being driven does not meet the high mining costs of driving the roadways in the Southern Coalfield. The economic returns from investing in roadway development come from the subsequent longwall extraction, which require the previously developed roadways.

Longwall mining involves extracting a block of coal with longwall shearer, which travels back and forth across the coalface, totally removing the coal between the developed roadways. This machinery cuts the coal from the coalface on each pass and a face conveyor, running along the full length of the coalface, carries this away to discharge onto a belt conveyor. The belt conveyor carries the coal out of the mine.

The coalface is supported by a series of hydraulic roof supports. The supports temporarily hold up the roof strata and enable enough space for the shearer and face conveyor. After each slice of coal is removed, the face conveyor, hydraulic roof supports and the shearer are moved forward. When coal is extracted using this method, the roof immediately above the seam collapses, behind the supports into the void (goaf) that is left as the face retreats. This method of mining relies on the material goafing as the longwall retreats. If this roof material does not collapse the longwall equipment is unable to hold the increasing weight of the material above the coal seam. As the roof material collapses into the goaf behind the roof supports, the fracturing and settlement of the rocks progresses through the overlying strata and results in sagging and bending of the near surface rocks and subsidence of the ground above. The subsidence effect moves across the ground at approximately the same speed as the mining face, which is typically 50 to 60 metres per week.

The coal is transported to the surface at West Cliff Colliery Area 5 via conveyors and is processed on-site at the West Cliff Washery. The clean coal is then delivered to the Port Kembla steelworks or Port Kembla Coal Terminal by truck. No additional surface facilities or activities are required as part of this proposal.

The majority of underground coal producers in Australia use longwall extraction coal mining methods to achieve production requirements. The high cost of mining necessitates that coal mines produce in excess of 3.0 Mtpa or 15,000 tonne per man output to be competitive. Major impacts on the mine planning process include the geology, mining conditions encountered and inseam and strata gas regime. These all dictate the rate of roadway development and the layout of longwall blocks. Due to the high cost of roadway development, and the speed of retreat of a longwall face to produce more than 3.0 Mtpa, longwall face widths and lengths are increasing in order to achieve high longwall retreat to roadway development ratios. Wider longwall blocks provide the best resource recovery possible while maintaining longwall continuity between blocks.

3.2. MINING GEOMETRY

The proposed layout of Longwalls 34 to 36 within the Bulli Seam is shown in **Figure 2.1 and Plan 1**. A summary of the proposed dimensions of these longwalls is provided in Table 3.1. and **Plan 1**.

Table 3.1 - 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.

Longwalls 34 and 36 have been shortened to ensure that the impacts of mining on the Georges River is minor and temporary. The proposed Longwall 34 and 36 have been shortened by 175m and 674m respectively, so as not to mine under the Georges River.

For figures of surface level contours, depth of cover contours, seam thickness contours and seam floor contours, refer **Plan 2, 3A, 3B and 3C** or **Appendix A**.

3.3. SEAM TO BE MINED

Coal in Longwalls 34 to 36 is to be extracted from the Bulli Seam, of the Illawarra Coal measures, (refer **Plan 6)** located approximately 470 to 540 metres underground. The seam floor generally dips from east to west. The seam thickness within the proposed goaf area varies from a minimum of 2.20 metres at the western end of the proposed longwalls, to a maximum of 2.65 metres at the eastern end of the proposed longwall. It is planned to extract the full seam.

For figures of seam floor contours and seam thickness contours refer **Plan 3B and 3C** or **Appendix A**.

3.4. SCHEDULE OF PROPOSED MINING

First workings for Longwalls 34 to 36 are planned to commence in March 2008. Longwall extraction is planned to commence in October 2009 and be completed by November 2013. Development and longwall mining schedules are subject to continual revision based on changing mining conditions and timing could vary considerably. Ongoing discussions with key stakeholders, including the DPIM, will ensure that any changes to the mining schedule are communicated to key stakeholders as soon as possible.

A summary of the mining schedule for the proposed Longwalls 34 to 36 as described in this application is presented in **Table 3.2**.

Table 3.2 - Mining Schedule

Longwall	Scheduled Start
Longwall 34 development	March 2008
Longwall 34 extraction	October 2009
Longwall 35 extraction	June 2011
Longwall 36 extraction	December 2012

Mine layouts for both West Cliff Area 5 have been developed using Illawarra Coal's Integrated Mine Planning Process (IMPP). This process considers site specific mining and surface impact issues when designing mine layouts. It is an iterative process where mine layouts are modified to take into account additional surface and underground information as it is obtained during the planning and approval process. As a result of the IMPP, Illawarra Coal currently has no mine layouts planned to directly longwall mine beneath rivers.

Illawarra Coal recognises the importance of working closely with Government and communities to address stakeholder issues in the planning and management of mining activities. In response to the issues raised from the community and Government, Illawarra Coal assessed alternative mine layouts which reduced impacts to the Georges River from mining subsidence. The development and implementation of an IMPP was identified as a key strategy to address stakeholder issues such as mining under rivers. In order to build an approach with the ownership of all stakeholders, the development of the IMPP has involved both internal and external consultation. This process was developed in consultation with DPIM and is consistent with the requirements of the DPIM Subsidence Management Plan approvals process. Each of the mining layout options was assessed against the following key criteria:

- Extent, duration and nature of the impact to surface features;
- Community, social and environmental impacts;
- Coal customer requirements;
- Roadway development and longwall continuity;
- Mine services such as ventilation;
- Recovery of the resource for the business and the State;
- Gas drainage, geological and geotechnical issues;
- Previous experience gained in mining in the adjacent areas and the results of that mining coupled with the results of the monitoring and mitigatory measures where applicable.

3.5. BENEFITS OF THE PROPOSED DEVELOPMENT

The extraction of underground coal reserves from Longwalls 34 to 36 is necessary to ensure continuity of coal supply to customers and achieve business objectives for Illawarra Coal. At the same time, it provides financial benefits at international, national, state and local levels.

About 60% of the high quality coal produced is blended with Wongawilli Seam coal to supply a specific coal product to the BlueScope and OneSteel Steelworks, the remainder is exported. The proposed extraction of coal from Longwalls 34 to 36 represents a continuing significant operating investment in the Southern Coalfield of New South Wales. Continuing benefits occur through continuity of employment, expendable income, export earnings and government revenue.

In 2005-06, Illawarra Coal had 997 permanent employees, with a total payroll of $170.2 million, up 15.6 per cent from $154.6 million last year. In addition, the jobs of the workers at the Port Kembla Steelworkers are secured by the local supply of coking coal from Illawarra Coal's mines. Illawarra Coal has a significant commitment to sourcing its goods, materials and services from the Illawarra region and our local expenditure increased on the previous year. In 2005-06, we spent $324.37 on Illawarra regional suppliers and, overall, New South Wales suppliers accounted for 93 per cent (or $552 million) of our total goods, materials and services spend in Australia. Our total spend increased from $468 million to $588 million, predominantly due to investment in development of the Douglas Project and new longwall equipment, all aimed at the long-term sustainability of our business.

In 2005-06, Illawarra Coal contributed $161.4 million to local, state and federal government taxes.

3.6. IMPACT ON RESOURCE RECOVERY

The consequences of not mining Longwalls 34 to 36 include loss of coal production from the colliery and potential closure of operations. Losses from a major supply of Bulli Seam coal from the Illawarra Coal operations has the potential to severely disrupt or prevent the production of the Illawarra Coal blend, which is the basis of Illawarra Coal customer requirements. Illawarra Coal provides 90% of the coal for the Australian Steel Industry

From experience with the Bulli Seam in the West Cliff Mine, the mining method to be used for Longwalls 34 to 36 has been shown to ensure safety of personnel, operating the equipment, economic viability, acceptable environmental impact and maximum resource recovery.

The two other seams in the area, namely the Balgownie and the Wongawilli Seams are considered to be non-economic at this time, **see Plan 6.** These seams are not necessarily sterilized by this development.

3.7. ESTIMATED RECOVERY

Longwalls 34 to 36 contain 11.1 million tonnes of coal, excluding associated development roadways. 0.9 million tonnes of coal will not be mined due to Longwalls 34 and 36 being shortened to avoid impacts to the Georges River.

3.8. POSSIBLE EFFECTS ON OTHER SEAMS

The Bulli Seam is the top seam in the Illawarra Coal Measures and consequently, mining this seam does not preclude future extraction of the seams below. There are currently no workings in other seams in the area.

There are five coal seams below the Bulli Seam ranging in thickness from 0.8m to 9m. The adjacent Balgownie seam is from 5m to 10m below the Bulli seam, but is only, approximately, 1.2m thick and is not considered economically viable to mine. The mining of Longwalls 34 to 36 will not preclude the future mining of the lower seams (see **Plan 6**).

3.9. FURTHER PLANS FOR MINING OTHER SEAMS

Using available technology the Bulli Seam is currently the only economic seam in the area and there are no existing plans for mining other seams in the future.

4. SITE CONDITIONS

(SMP GUIDELINES section 6.4)

4.1. GEOMORPHOLOGY AND SOILS

4.1.1. Geomorphology

The study area is situated south of Sydney and is within the southern part of the Sydney Basin. The surface geology of the Study Area is dominated by Wianamatta Shale, with Hawkesbury Sandstone occurring along the Georges and Nepean Rivers. The general area consists of a broad dissected plateau, largely formed on Hawkesbury Sandstone, capped in places by Wianamatta Shale and dissected by incised streams.

The surface of the land within the SMP Area varies from gently undulating to hilly refer **Figure 4.1**.

4.1.2. Soil landscapes

Near-surface geology of the SMP Area is dominated by weathered Wianamatta Shale outcrop, with Hawkesbury Sandstone occurring as outcropping in gullies and river valleys. The soil landscapes of the area have been mapped by Hazelton and Tille (1990) at a scale of 1:100,000. They identified three main soil types in the area:

- *Blacktown*; described as a residual soil landscape occurring on gently undulating landscape on Wianamatta Group Shale;
- *Hawkesbury*; described as a colluvial soil landscape occurring on rugged, rolling to very steep hills on Hawkesbury Sandstone;
- *Luddenham*; described as an erosional soil landscape occurring on undulating to rolling hills on Wianamatta Shale, often associated with Minchinbury Sandstone.

Refer **Appendix A** for figure of surface geology.

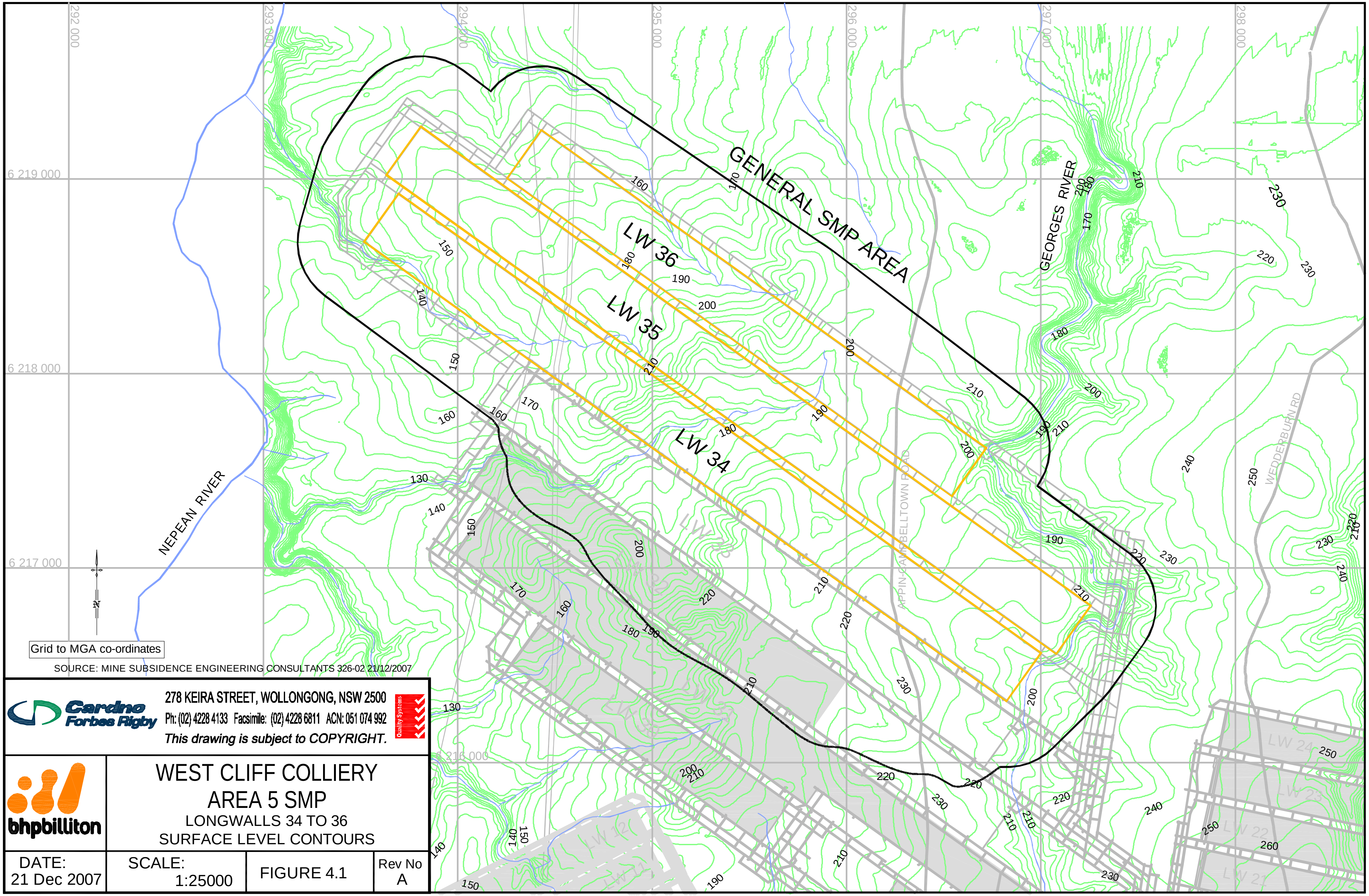
4.2. COVER DEPTHS

The depth of cover to the Bulli Seam within the general SMP area varies from a minimum of 450 metres, in the base of the Georges River Valley, and a maximum of 550 metres above Longwall LW32.

For figures relating to depth of cover refer **Appendix A**.

4.3. OVERBURDEN STRATIGRAPHY

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 a number of workable seams throughout the area, the uppermost of which is the Bulli Seam (refer **Figure 4.2**).



Cardno Forbes Rigby

278 KEIRA STREET, WOLLONGONG, NSW 2500
Ph: (02) 4228 4133 Facsimile: (02) 4228 6811 ACN: 051 074 992

bhpbilliton

WEST CLIFF COLLIERY
AREA 5 SMP
LONGWALLS 34 TO 36
SURFACE LEVEL CONTOURS

DATE:	SCALE:	FIGURE 4.1	Rev No
21 Dec 2007	1:25000		A

The Illawarra Coal Measures are overlain by sandstone, shales and mudstones of the Narrabeen Group, which are in turn, overlain by Hawkesbury Sandstone. In much of the study area, the Hawkesbury Sandstone is overlain by the Wianamatta Shale. The coal measures contain numerous 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 310m. 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 185m. 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 **Plan 6**.

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 alignments belong to the Hawkesbury Sandstone.

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. Significant claystone units exist lower in the overburden, the Stanwell Park Claystone and Wombarra Shale.

The known geological structures at seam level are shown in **Figure 4.3** and **Plan 3B.** There are no significant geological structures known in the Bulli Seam within the proposed longwalls. The longwalls have been planned to avoid a series of faults to the north of the Longwall 36. At the surface In areas of the Wainamatta Shale there is negligible outcrop for geological mapping. There is geological and geomorphological mapping along the Georges River, where the Hawkesbury Sandstone is exposed, however no significant geological features are present. The potential for irregular subsidence profiles due to geological structures are discussed further in **Appendix A**. West Cliff has mined through numerous faults, dykes and sills in over 30 years of mining. None of the geological features encountered in the West Cliff workings have been able to be detected at the surface.

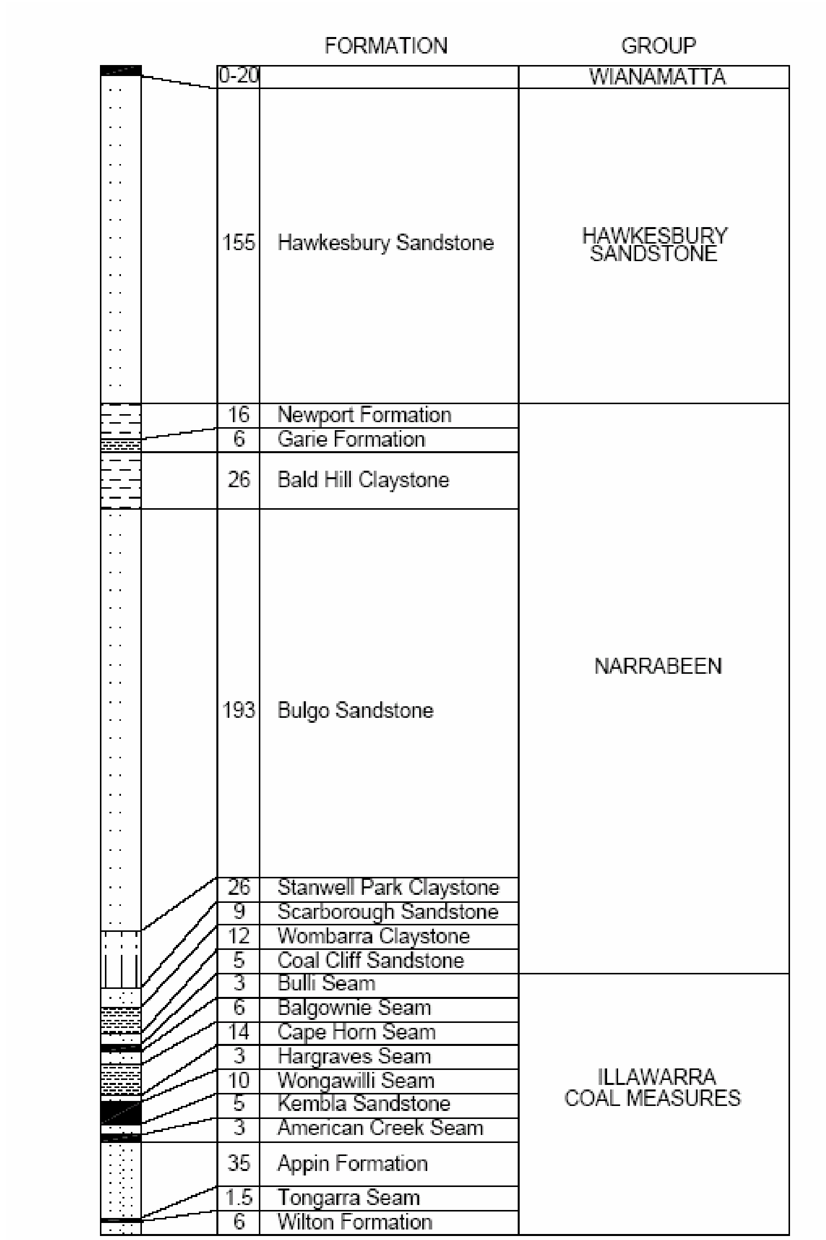
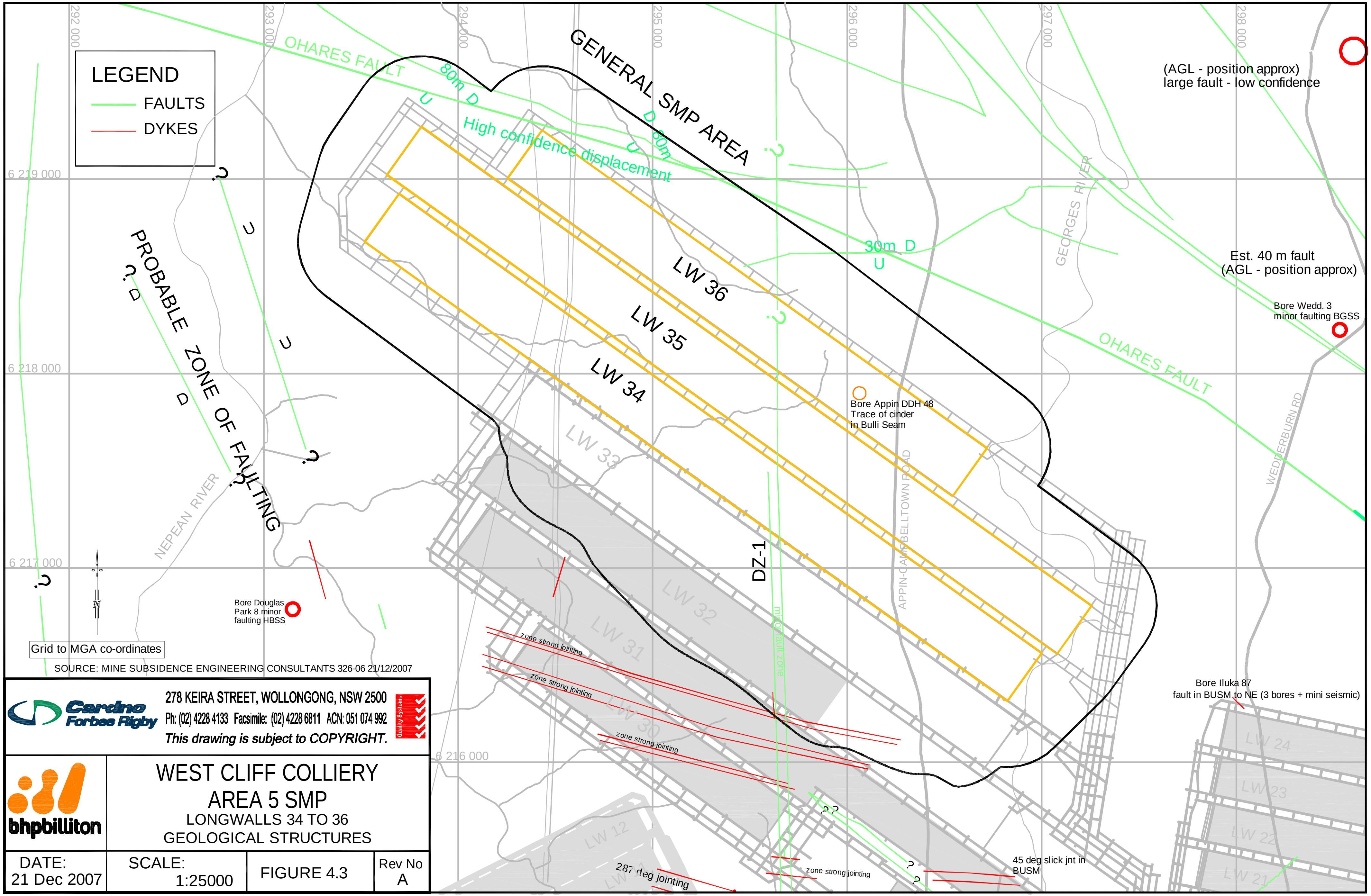


Figure 4.2 Typical Stratigraphic Section – Southern Coalfield

4.4. LOCATION OF EXISTING AND FUTURE WORKINGS

The areas to the south of Longwalls 34 to 36 have been successfully mined over recent years. Longwalls 29 to 31 have been recently completed with mining of Longwall 32 in progress. Mining of Longwall 33 is due to commence in mid 2008.



SOURCE: MINE SUBSIDENCE ENGINEERING CONSULTANTS 326-06 21/12/2007

Cardno Forbes Rigby
278 KEIRA STREET, WOLLONGONG, NSW 2500
Ph: (02) 4228 4133 Facsimile: (02) 4228 6811 ACN: 051 074 992

bhpbilliton

WEST CLIFF COLLIERY AREA 5 SMP

LONGWALLS 34 TO 36 GEOLOGICAL STRUCTURES

DATE:	SCALE:	FIGURE 4.3	Rev No
21 Dec 2007	1:25000		A

4.5. LITHOLOGICAL AND GEOTECHNICAL CHARACTERISTICS OF THE ROOF AND FLOOR

The stratum around the Bulli Seam provides good longwall conditions and in particular the sandstone floor is hard and competent. The immediate roof is a combination of bedded mudstone, interbedded siltstone and sandstone. It caves readily and is strong enough to stand in front of the supports, unless affected by geological features or poor face management.

Support of all development roadways is rigorously applied in accordance with the mine's Strata Management Plan. This provides for both primary support in all roadways (principally using roofbolts and mesh) and secondary support (principally with cable-bolts) in more critical areas such as at intersections, and in some beltroads. Confirmation of stratigraphy and monitoring of rock properties is accomplished by the periodic coring of the immediate 8 metres of roof strata. Roof dilation is routinely monitored with extensometers at defined locations. In addition, the Plan provides for certain actions in response to triggers defined in terms of the measured and observed strata behaviour. The Strata Management Plan is part of West Cliff Colliery's statutory management system, is approved by the DPIM and has provided a formalised and effective means of managing these issues and will be extended to apply to Longwalls 34 to 36.

West Cliffs Area 5 longwalls operate under a face management plan, which aims to maintain strata integrity in and around the operating face. There is provision for the use of specialised bolting, the use of recovery equipment and access to experienced contractors for processes such as polyurethane injection, when required.

4.6. UNCONTROLLED COLLAPSE OF ROOF (FOR SHALLOW WORKINGS)

Given that the depth of cover over the proposed longwalls typically is around 500 metres, the consideration for uncontrolled collapse due to shallow (<30 metres) overburden effects is not applicable and is not considered further for this application.

5. STABILITY OF UNDERGROUND WORKINGS

(SMP GUIDELINES section 6.5)

Illawarra Coal Geotechnical Engineers have designed the underground workings to be stable. The design considers the stability of the roadways for secondary extraction via longwall mining methods. In addition, the West Cliff Colliery Strata Management Plan will be used to manage the ongoing stability of the workings.

6. CHARACTERISATION OF SURFACE AND SUB-SURFACE FEATURES

(SMP GUIDELINES section 6.6)

Studies of the surface and sub-surface features have been completed for the SMP by a team of experts in relevant fields. The information provided below summarises this information and is drawn from the subsidence report (**Appendix A**), other specialist reports and other documentation where relevant.

6.1. MINE SUBSIDENCE DISTRICT

Longwalls 34 to 36 lie within two mine subsidence districts; the Appin Mine Subsidence District, established in 1968, and the South Campbelltown Mine Subsidence District established in 1976 refer to **Plan 2A**. The area to the east of the Georges River does not lie within a Mine Subsidence District

6.2. LAND USE AND GENERAL DESCRIPTION

Land use over the SMP Area includes:

- residential properties;
- horse and cattle grazing (both commercial and non-commercial);
- commercial chicken farming;
- water supply infrastructure including the SCA Upper Canal;
- other infrastructure corridors (gas, telecommunications, electrical transmission lines, roads).

Plan 2 shows all relevant surface features within the SMP Area and **Plan 5** shows the property boundaries.

Much of the land throughout the whole of the SMP Area has been cleared for grazing, residential or similar purposes (refer **Plan 7**). Much of the land is used for light grazing of cattle and horses.

6.3. IDENTIFICATION OF SURFACE AND SUB-SURFACE FEATURES

The following sections identify and describe all major natural features and infrastructure that lie within the SMP Area. A summary of these features is provided in **Table 6.1**, which follows the listing required by the DPIM SMP Guideline, 2003.

Table 6.1 - Natural Features and Surface Improvements

Item	Within SMP Area	Environmentally Sensitive Area	Section Number Reference
NATURAL FEATURES			
Catchment Areas or Declared Special Areas			
Rivers or Creeks	ü	ü	6.5.1
Aquifers or Known Groundwater Resources			
Springs	ü		6.5.3
Sea or Lakes			
Shorelines			
Natural Dams			
Cliffs or Pagodas	ü	ü	6.5.5
Steep Slopes	ü		6.5.6
Escarpments			
Land Prone to Flooding or Inundation			
Swamps, Wetlands or Water Related Ecosystems	ü		6.5.8
Threatened, Protected Species or Critical Habitats	ü	ü	6.5.9
National Parks or Wilderness Areas			
State Recreational or Conservation Areas	ü	ü	6.5.10
State Forests			
Natural Vegetation	ü		6.5.11
Areas of Significant Geological Interest			
Any Other Natural Feature Considered Significant			
PUBLIC UTILITIES			
Railways			
Roads (All Types)	ü		6.9.1
Bridges	ü		6.9.2
Tunnels	ü		6.9.3
Culverts	ü		6.9.4
Water or Gas Pipelines	ü	ü	6.9.7 6.9.8 6.9.10
Liquid Fuel Pipelines			
Electricity Transmission Lines or Associated Plants	ü	ü	6.9.14
Telecommunication Lines or Associated Plants	ü	ü	6.9.17
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			

Item	Within SMP Area	Environmentally Sensitive Area	Section Number Reference
FARM LAND AND FACILITIES			
Agricultural Utilisation, Agricultural Improvements or Agricultural Suitability of Farm Land	ü		6.10.1
Farm Buildings or Sheds	ü		6.10.21
Gas or Fuel Storages			
Poultry Sheds	ü		6.11.1
Glass Houses or Green Houses			
Hydroponic Systems			
Irrigation Systems			
Fences	ü		6.10.4
Farm Dams	ü		6.10.5
Wells or Bores	ü		6.10.6
Any Other Farm Features			
INDUSTRIAL, COMMERCIAL AND BUSINESS ESTABLISHMENTS			
Factories			
Workshops			
Business or Commercial Establishments or Improvements	ü		6.11.1
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	ü	ü	6.12.1 6.12.2
ITEMS OF ARCHITECTURAL SIGNIFICANCE			
PERMANENT SURVEY CONTROL MARKS	ü		6.13
RESIDENTIAL ESTABLISHMENTS			
Houses	ü		6.14.1
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 or Tennis Courts			
Any Other Residential Features	ü		6.14.2
ANY OTHER ITEM OF SIGNIFICANCE			

6.4. AREAS OF ENVIRONMENTAL SENSITIVITY

This section provides a brief summary of features identified as areas of environmental sensitivity within the SMP Area (**Table 6.2**). Areas of environmental sensitivity are defined in *Section 6.6.3 of the DPIM SMP Guideline, 2003*.

Table 6.2 - 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*	ü	Dharawal State Conservation Area	6.5.10
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	ü	The Georges River	6.7
16	Lake foreshores and flood prone areas	None		
17	Cliffs, escarpments and other significant natural features	ü	Two small cliffs adjacent to the Georges River	6.5.5
18	Areas containing significant ecological values	None		

19	Major surface infrastructure	ü	1200mm Water Pipeline The Upper Canal and Aqueducts Devines Tunnel Alinta Natural Gas Pipeline AGL Natural Gas Pipeline Gorodok Ethane Pipeline 330 kV Transmission Line Optical Fibre Cable	6.9.7
20	Surface features of community significance (including cultural, heritage or archaeological significance)	ü	The Georges River Aboriginal and European Heritage sites	6.5.1 6.12
21	Any other land identified by the Department to the titleholder			

6.5. SIGNIFICANT NATURAL FEATURES

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.

6.5.1. Rivers and Creeks

There is one river located within the SMP Area. The Georges River is approximately located on the easterly border of the SMP area and each of the three Longwalls 34 to 36 abut the westerly side of 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.

Mallaty Creek is the largest creek located within the SMP Area. Mallaty Creek is a third order ephemeral creek, which flows in a westerly direction into Ousedale Creek, which in turn flows into the Nepean River. The natural gradient of Mallaty Creek within the SMP Area varies between 10mm/m and 10mm/m, with an average natural gradient of approximately 30mm/m.

Leafs Gully is located within the SMP Area and flows in a north westerly direction directly into the Nepean River. Leafs Gully borders Longwall 34 on the western side and the headwaters start at approximately the middle of Longwall 35. The natural gradient of Leafs Gully within the SMP Area varies between 10 mm/m and 125 mm/m, with an average natural gradient of approximately 50mm/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 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.

The locations of the river and creeks within the SMP Area are shown in **Figure 6.1**.

6.5.2. Aquifers and Known Groundwater Resources

There is no commercial use of groundwater in the SMP Area, grazing activities rely on rural dam water and the Chicken Farms utilise town water. There are no significant, continuous alluvial deposits in the area which contain groundwater. 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, as shown in **Figure 6.2**. The work summary sheets provided by Department of Natural Resources (DNR) indicate that the intended use for these bores is for irrigation, stock or drainage, rather that for the supply of potable water.

The lack of utilisation of local groundwater is a function of the high salinity of water associated with the Wianamatta Shales (refer **Section 6.8**) and the low permeability of the underlying Hawkesbury Sandstone.

6.5.3. Springs

A number of small groundwater seeps have been identified within the SMP Area, the locations of which are shown in **Figure 6.3**.

6.5.4. Natural Dams

There are no natural dams within the SMP Area. There are, however, a number of farm dams within the area, which are described in **Section 10.10.4**.

6.5.5. Cliffs or Pagodas

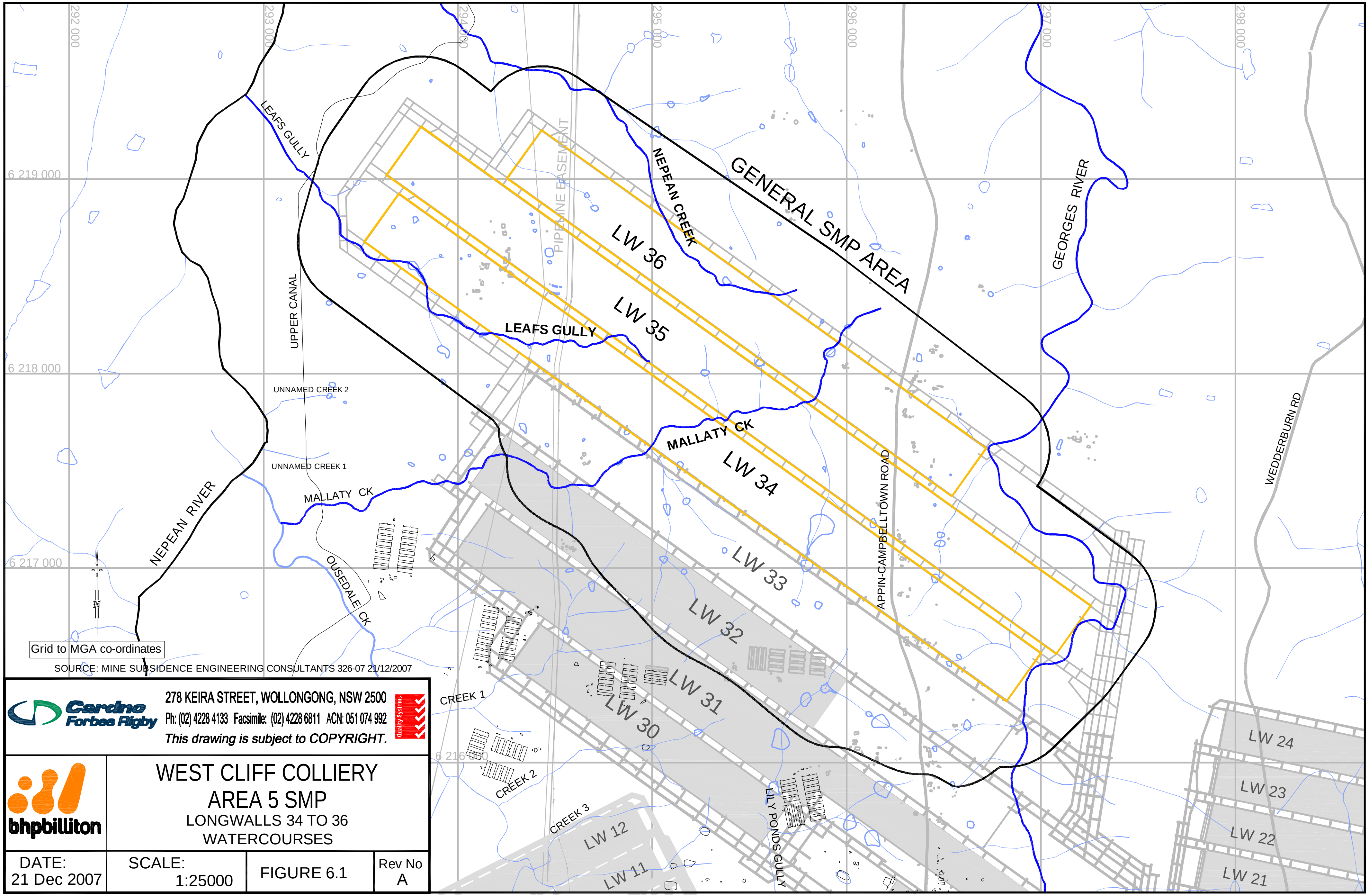
For the purposes of this report, a cliff has been defined as a continuous rockface having a minimum height of 10 metres and a minimum slope of 2 to 1, ie: having a minimum angle to the horizontal of 63°. The locations of cliffs within the SMP Area were determined from site investigations and from the 1 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 **Figure 6.4** and details are provided in **Table 6.3**.

Table 6.3 - 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.



Cardno Forbes Rigby

278 KEIRA STREET, WOLLONGONG, NSW 2500
Ph: (02) 4228 4133 Facsimile: (02) 4228 6811 ACN: 051 074 992
This drawing is subject to COPYRIGHT.

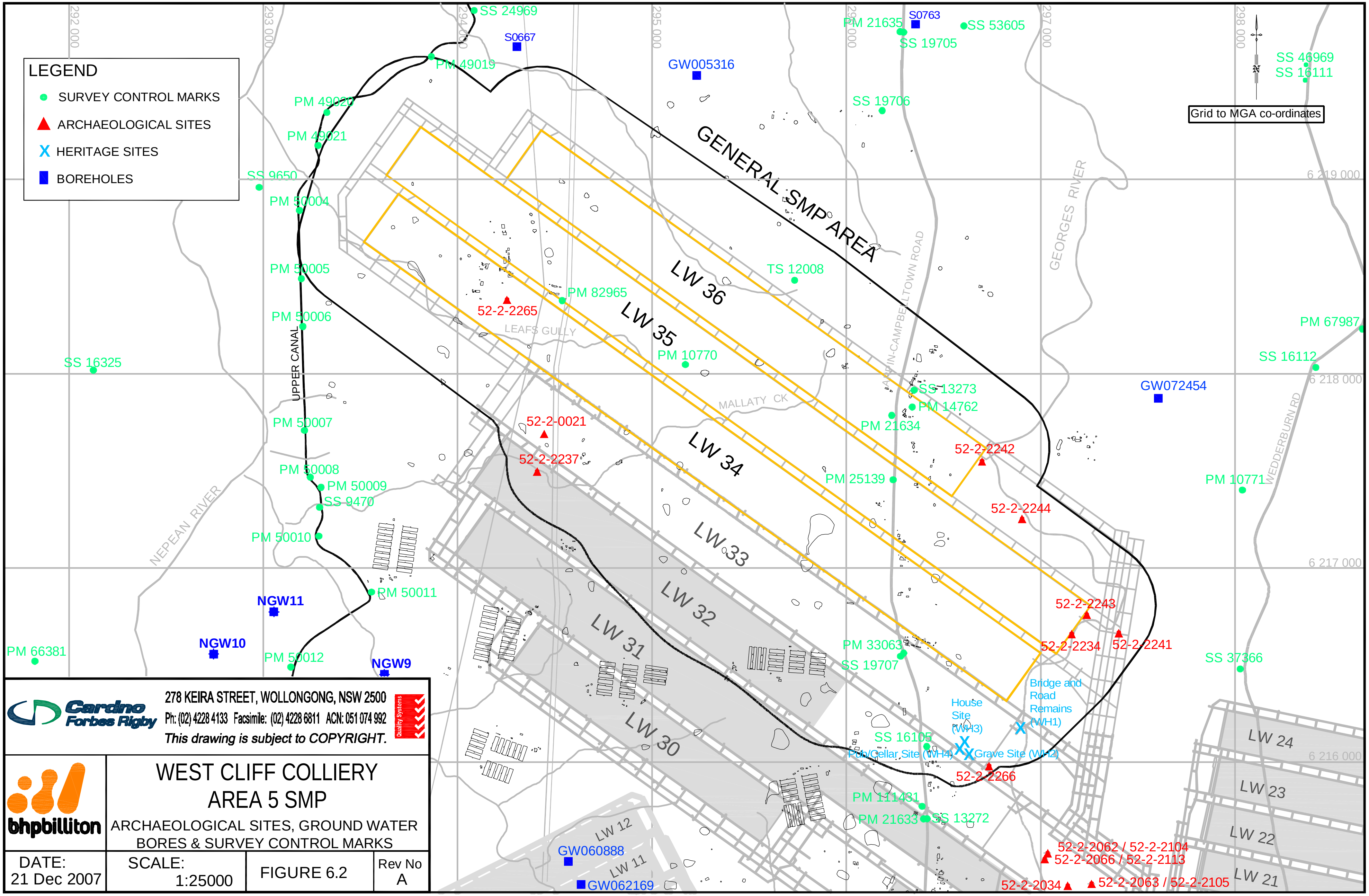
Quality Systems

bhpbilliton

WEST CLIFF COLLIERY AREA 5 SMP

LONGWALLS 34 TO 36
WATERCOURSES

DATE:	SCALE:	FIGURE 6.1	Rev No
21 Dec 2007	1:25000		A



278 KEIRA STREET, WOLLONGONG, NSW 2500
Ph: (02) 4228 4133 Facsimile: (02) 4228 6811 ACN: 051 074 992

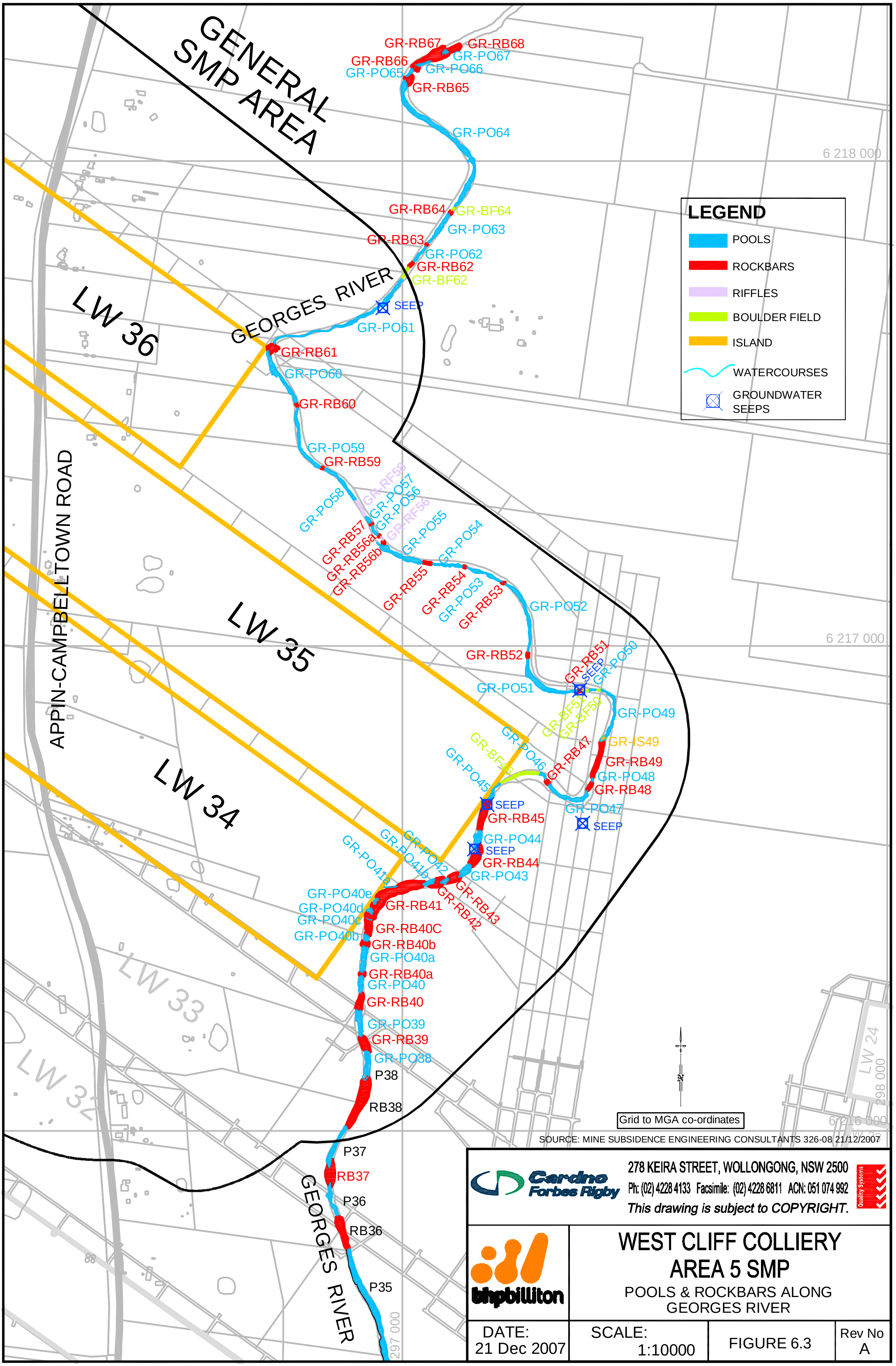
This drawing is subject to COPYRIGHT.

WEST CLIFF COLLIERY AREA 5 SMP

ARCHAEOLOGICAL SITES, GROUND WATER BORES & SURVEY CONTROL MARKS

DATE:	SCALE:	FIGURE 6.2	Rev No
21 Dec 2007	1:25000		A

SOURCE: MINE SUBSIDENCE ENGINEERING CONSULTANTS 326-27 21/12/2007



Cardno Forbes Rigby

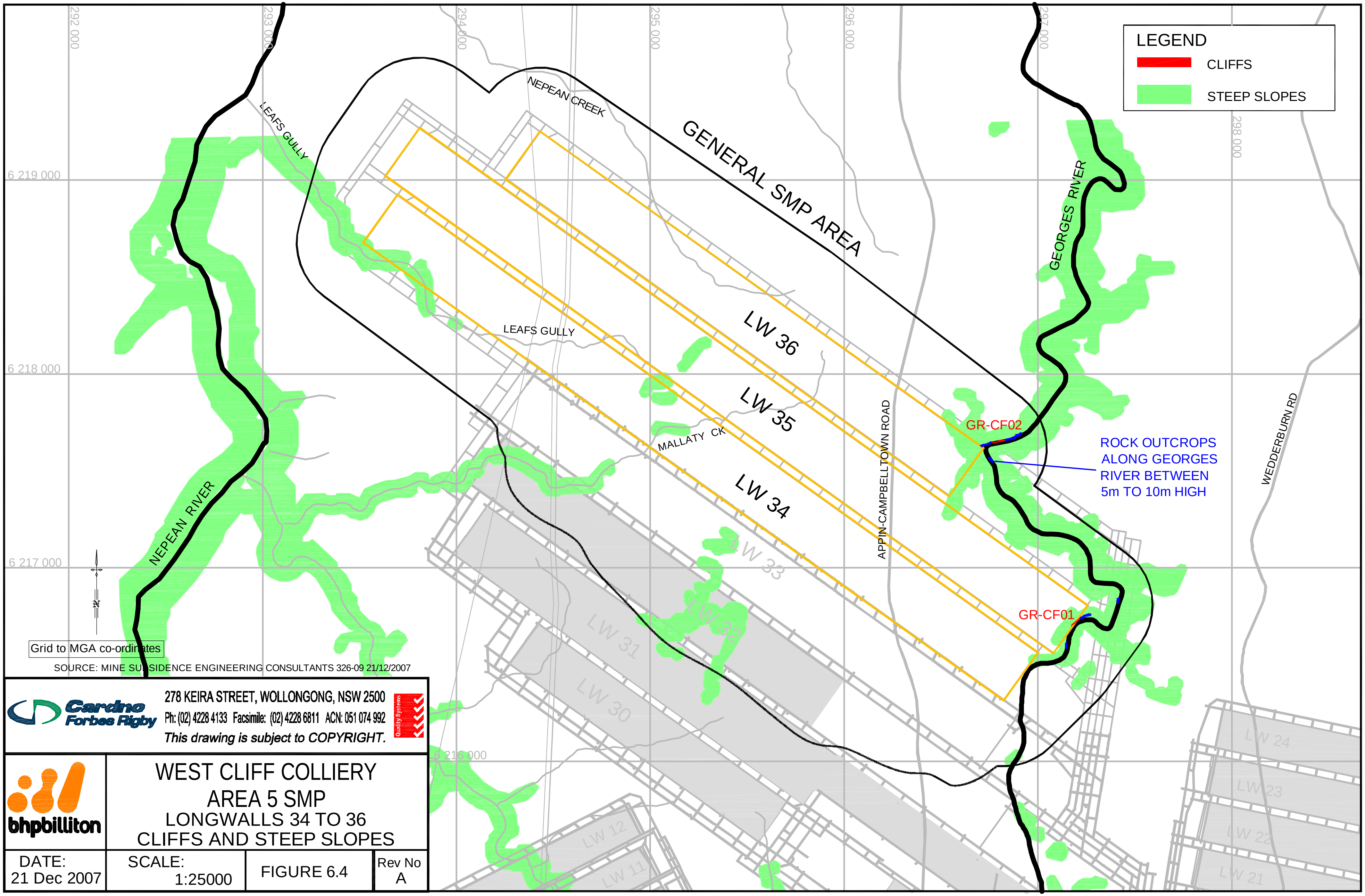
278 KEIRA STREET, WOLLONGONG, NSW 2500
Ph: (02) 4228 4133 Facsimile: (02) 4228 6811 ACN: 051 074 992

bhpbilliton

WEST CLIFF COLLIERY AREA 5 SMP

POOLS & ROCKBARS ALONG GEORGES RIVER

DATE:	SCALE:	FIGURE 6.3	Rev No
21 Dec 2007	1:10000		A



SOURCE: MINE SUBSIDENCE ENGINEERING CONSULTANTS 326-09 21/12/2007

Cardno Forbes Rigby
278 KEIRA STREET, WOLLONGONG, NSW 2500
Ph: (02) 4228 4133 Facsimile: (02) 4228 6811 ACN: 051 074 992

bhpbilliton

WEST CLIFF COLLIERY
AREA 5 SMP
LONGWALLS 34 TO 36
CLIFFS AND STEEP SLOPES

DATE:	SCALE:	FIGURE 6.4	Rev No
21 Dec 2007	1:25000		A

6.5.6. 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 areas of steep slopes were identified from the 1 metre surface level contours which were generated from an aerial laser scan of the area, and the locations have been shown in **Figure 6.4**. 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°).

Refer **Appendix A** for further details on steep slopes.

6.5.7. 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.

6.5.8. Swamps, Wetlands and Water Related Ecosystems

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 report by **Ecoengineers (2007)** refer **Appendix B, The Ecology Lab (2007)** refer **Appendix C, and Biosis (2007)** refer **Appendix D**.

6.5.9. 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 (2007) refer **Appendix D**.

6.5.10. State Recreation Areas or 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 **Plan 2**. There are no other State Recreation Areas or State Conservation Areas within the SMP Area.

6.5.11. 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 drainage lines. A detailed survey of the natural vegetation has been undertaken and is described in the report by Biosis in **Appendix D**.

6.6. FLORA AND FAUNA

Biosis Research Pty. Ltd. was commissioned by BHP Billiton Illawarra Coal (BHPBIC) to undertake a terrestrial flora and fauna impact assessment for subsidence impacts associated with Longwalls 34 to 36.

The area considered in this flora and fauna assessment (Study Area) is the SMP Area described in Section 2 of this report. The report assesses the ecological values of the Study Area and the potential impacts of mining in this area in terms of threatened species, populations or ecological communities that occur, or have the potential to occur in the Study Area (refer **Appendix D**).

6.6.1. Vegetation Communities

Six vegetation communities were recorded in the Study Area: Sandstone Ridgetop Woodland, Cumberland Plain Woodland, Shale Sandstone Transition Forest, Moist Shale Wooland, Upper Georges River Sandstone Woodland, and the Western Sandstone Gully Forest.

These vegetation communities are described in detail in **Appendix D**.

Cleared land with little or no flora habitat value was also present within the Study Area. It should be noted that this vegetation is highly modified and does not constitute a native vegetation community. This was mostly improved pasture, which reflects the previous disturbances of vegetation clearing, over-grazing and the addition of fertilisers to the paddocks.

6.6.2. Flora

One hundred and seventy-five (175) vascular plant species were recorded within the Study Area, comprising 147 (84%) native species and 28 (16%) exotic species.

During the field survey a population of *Grevillea parviflora* ssp. *parviflora* was found within the Study Area. This was the only threatened plant species detected during the field survey.

A further nine threatened plant species are considered to have potential habitat within the Study Area. These include *Acacia bynoeana, Callistemon linearifolius, Leucopogon exolasius, Persoonia bargoensis, Persoonia hirsuta, Pimelea spicata, Pomaderris brunnea, Pterostylis saxicola* and *Pultenaea pedunculata*. It should be noted that *Pultenaea pedunculata* has been previously recorded within the Study Area, whilst *Acacia bynoeana, Callistemon linearifolius*, *Persoonia hirsuta* and *Pomaderris brunnea* have been previously recorded near or adjacent to the Study Area.

None of the threatened plant species listed above, or their potential habitats, are dependent on water availability or riparian vegetation. All are found away from potentially impacted riparian areas, and are generally found on relatively unaffected plateau and ridgelines.

As such it is unlikely that any of these species would be significantly impacted by subsidence. None of these species are aquatic plants and they would generally be confined in distribution to the drier sclerophyll vegetation of the Sandstone Ridgetop Woodland, Upper Georges River Sandstone Woodland and Western Sandstone Gully Forest communities. Seven Part Tests and Significant Impact Criteria have not been conducted for any threatened flora as no significant impacts are predicted to occur.

Flora is described in detail in **Appendix D**.

6.6.3. Fauna

The fauna survey within the Study Area consisted of a habitat-based assessment. Incidental observations of fauna species in the Study Area from this and other recent studies include, 41 species of birds (two introduced), two reptiles, two amphibians, two native mammals and seven introduced mammals.

A total of 44 threatened or migratory animal species, as listed on the TSC and/or EPBC Acts, are considered in the Biosis report (refer **Appendix D**).

Of the 44 threatened or migratory animal species, 36 species have limited known or potential habitat within the Study Area.

One threatened animal species, the Koala, was recorded in the Study Area during a previous study. A single koala was recorded (calling) from the Shale Sandstone Transition Forest on the western bank of the Georges River. Although not recorded during this or previous assessments, the Eastern Pygmy Possum *Cercartetus nanus* is reported to occur on a property within the Study Area (Steve McMahon, Appin Resident, *pers. comm.*). However, neither of these species is likely to be significantly impacted by the subsidence resulting from the extraction of the proposed longwalls and as such they have not been assessed further.

Only those species for which the proposed development is considered likely to have an impact in one or more of the above ways will be considered further in the impact assessment. As the only possible impact from subsidence is surface flow diversions in the Georges River or other creeks, only animal species with potential habitat in the Study Area that rely on surface water for their survival are considered further. Four of the 36 threatened or migratory animal species with potential habitat in the Study Area (Giant Burrowing Frog, Littlejohn's Tree Frog, Red-crowned Toadlet and Large-footed Myotis), are likely to be dependent on the Georges River for breeding or foraging.

Fauna is described in detail in **Appendix D**.

6.7. SURFACE HYDROLOGY OF THE GEORGES RIVER

A detailed assessment of water quality by Ecoengineers is provided in **Appendix B**, and is summarised below.

Ecoengineers were engaged to prepare an assessment of water quality effects that may arise in Georges River or any other watercourse from the proposed extraction of Longwalls 34 to 36.

The water flows in the Georges River within the SMP Area are derived from two main sources:

- flows sourced from the catchment areas; and
- flows sourced from Dept. of Environment and Climate Change (DECC) Licensed Discharges from Appin and West Cliff Collieries.

Between 2000 and 2006, the area was in drought and experienced significantly lower than average rainfalls than occurred over the previous decade. Annual rainfall in the upper river catchment as measured at West Cliff Colliery averaged about 789 mm over those 7 years.

This is more than 20% lower than the long term median annual rainfall at nearby Cataract Dam which, over the 100 years since recording commenced in 1904 has been about 1000 mm, a value that is similar to the mean rainfall for the previous 10 years (ie pre 2000) at West Cliff which was at least 946 mm.

As actual ET in the Upper Georges River Catchment (which drains a mix of Hawkesbury Sandstone and Wianamatta Shale outcropping terrain) averages around 500 to 600 mm/year. As such, there would have been little excess water available to sustain a baseflow in the Upper Georges River over the drought period 2000 to 2006.

6.8. WATER CHEMISTRY OF THE GEORGES RIVER AND CREEKS

Table 6.4 lists the mean values from the laboratory data that has been accumulated at the GRQ17, GRQ17A and GRQ18 sites for the Georges River since August 2004. For locations of the monitoring sites for the Georges River and creeks refer **Appendix B**.

(Note DO = Dissolved Oxygen, EC = Electrical Conductivity, Na = sodium, Ca = calcium, Mg = magnesium, Cl = chloride, TDS = Total Dissolved Solids, T. Alk. = Total Alkalinity and SO4 = sulfate, T. Fe = Total Iron, T. Mn = Total Manganese and Filt. Ni = Filterable Nickel).

Table 6.4 - Laboratory Data for the Georges River Sites August 2004 to October 2007

Site	N field /N lab.	Field pH	Field EC µS/cm	DO % Sat.	Ca mg/L	Mg mg/L	Na mg/L	T. Alk. mg/L as $CaCO_3$	SO_4	Cl	T. Fe mg/L	T. Mn mg/L	Filt. Ni mg/L
GRQ17 (upstream)	128 /27	8.53 ±0.39	1586 ±652	113 ±25	5 ±2	5 ±2	364 ±185	592 ±311	29 ±11	162 ±72	0.99 ±0.55	0.050 ±0.044	0.083 ±0.049
GRQ17A (adjacent)	81 /18	8.51 ±0.38	1568 ±694	102 ±27	5 ±2	4 ±2	374 ±192	593 ±320	28 ±11	160 ±74	0.86 ±0.58	0.066 ±0.076	0.080 ±0.052
GRQ18 (downstream)	29 /27	8.15 ±0.38	1247 ±548	89 ±35	6 ±2	5 ±2	316 ±142	508 ±228	22 ±13	152 ±61	1.24 ±0.81	0.074 ±0.075	0.069 ±0.037

As can be seen from **Table 6.4** there is very little difference in mean river baseline water quality immediately upriver, adjacent to and immediately downriver of the SMP Area.

Baseline water quality is clearly dominated by flows from the West Cliff licensed discharge, albeit diluted by further runoff into the River north of Brennans Creek confluence, especially over the very wet (approximately 95 percentile) year of 2007.

Table 6.5 shows the major mean (not median) characteristics of baseline water quality at the MC05 site since December 2005. We have also inserted some field data obtained for site MC30 by The Ecology Lab (2007) in August 2007. Errors are expressed at the ± standard deviation level. N = number of field and laboratory measurements (generally monthly for lab.).

Table 6.5 - Average Baseline Water Qualities in some Mallaty Creek Sites after December 2005

Site	N field /N lab.	Field pH	Field EC µS/cm	DO % Sat.	Ca mg/L	Mg mg/L	Na mg/L	T. Alk. mg/L as $CaCO_3$	SO_4	Cl	T. Fe mg/L	T. Mn mg/L	Filt. Ni mg/L
MC130	2	7.54 ±0.06	285.5 ±4.5	60 ±2									
MC05	84 /20	7.04 ±0.55	4836 ±1732	54 ±26	58 ±21	176 ±74	676 ±280	349 ±135	53 ±23	1462 ±629	1.92 ±1.35	0.604 ±0.873	<0.005

The issue of salinity is highly relevant to the assessment of potential impact(s) on aquatic ecology for Longwalls 34 to 36 because mine subsidence-related effects deriving from their mining can potentially affects two chemically very different classes of aquatic ecosystem namely the following:

- The lower salinity (lowland river) context of Georges River where runoff into the River is dominated by a mix of Hawkesbury Sandstone Woronora Plateau landscape (on the eastern side of the River) and Cumberland Plain (Lowlands) landscape (on the western side of the River and on the eastern side from Wedderburn north), salinity of the river water expressed in Electrical Conductivity (EC) units, even taking into account the West Cliff Colliery environmental discharge from BCD is unlikely to ever exceed about 4000 µS/cm and chloride and sulfate concentrations are unlikely to frequently exceed about 250 and 25 mg/L respectively.
- The water quality context of Mallaty, Leafs Gully and Nepean Creeks which arise exclusively in Cumberland Plain (Lowlands) landscape dominated by Wianamatta Shale outcrop and Shale-derived soils are such that salinities in the middle and lower sections of these creeks frequently exceed 10,000 µS/cm and chloride and sulfate concentrations are likely to frequently exceed 1500 mg/L and 50 mg/L respectively.

Water chemistry of the Georges River and associated creeks is discussed in detail in **Appendix B**.

6.9. UTILITIES

6.9.1. Roads

The locations of the roads within the SMP Area are shown in **Figure 6.5**. The main 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. The western end of Blackburn Road Wedderburn lies within the SMP area. Blackburn Road is a sealed road that supports acces to the local properties, there is no through traffic.

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.

Refer **Plan 2** or **Figure 6.5** for further detail.

6.9.2. Bridges

There are a number of bridges within the SMP Area associated with the Upper Canal, which are described in **Section 6.9.6**.

6.9.3. Tunnels

Devines Tunnels Nos. 1 and 2 are located to the west and partially within the general SMP Area. The tunnels are part of the SCA Upper Canal System, which are described in **Section 6.9.6 and shown in Plan 2**. There are no other tunnels within the SMP Area.

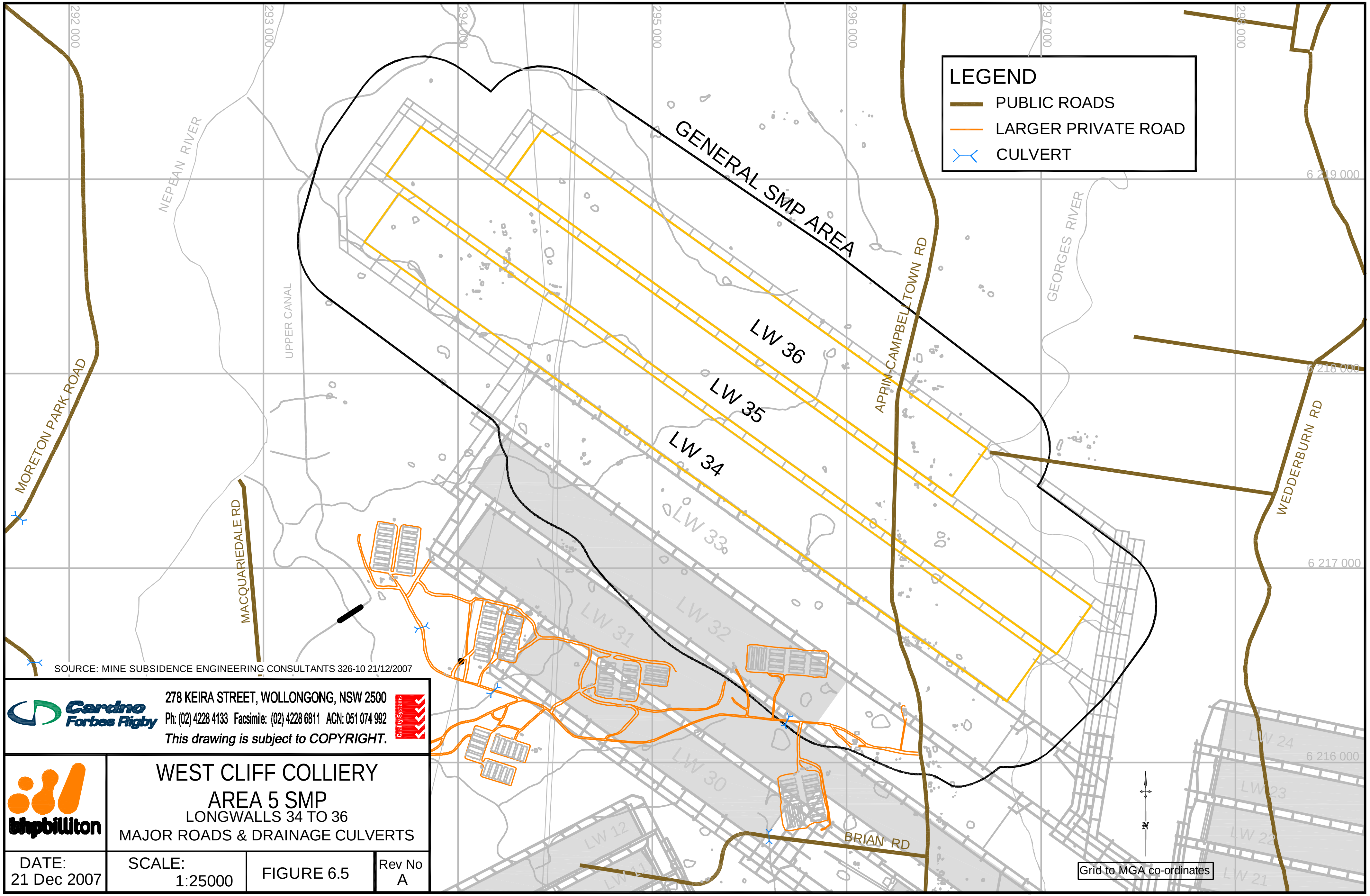
6.9.4. Drainage Culverts

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, and on the Inghams Farm Complex.

Refer **Figure 6.5 and Plan 2** for locations of drainage culverts.

6.9.5. Water Services

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 **Figure 6.6 and Plan 2** and are described in the following sections.



Cardno Forbes Rigby

278 KEIRA STREET, WOLLONGONG, NSW 2500

Ph: (02) 4228 4133 Facsimile: (02) 4228 6811 ACN: 051 074 992

This drawing is subject to COPYRIGHT.

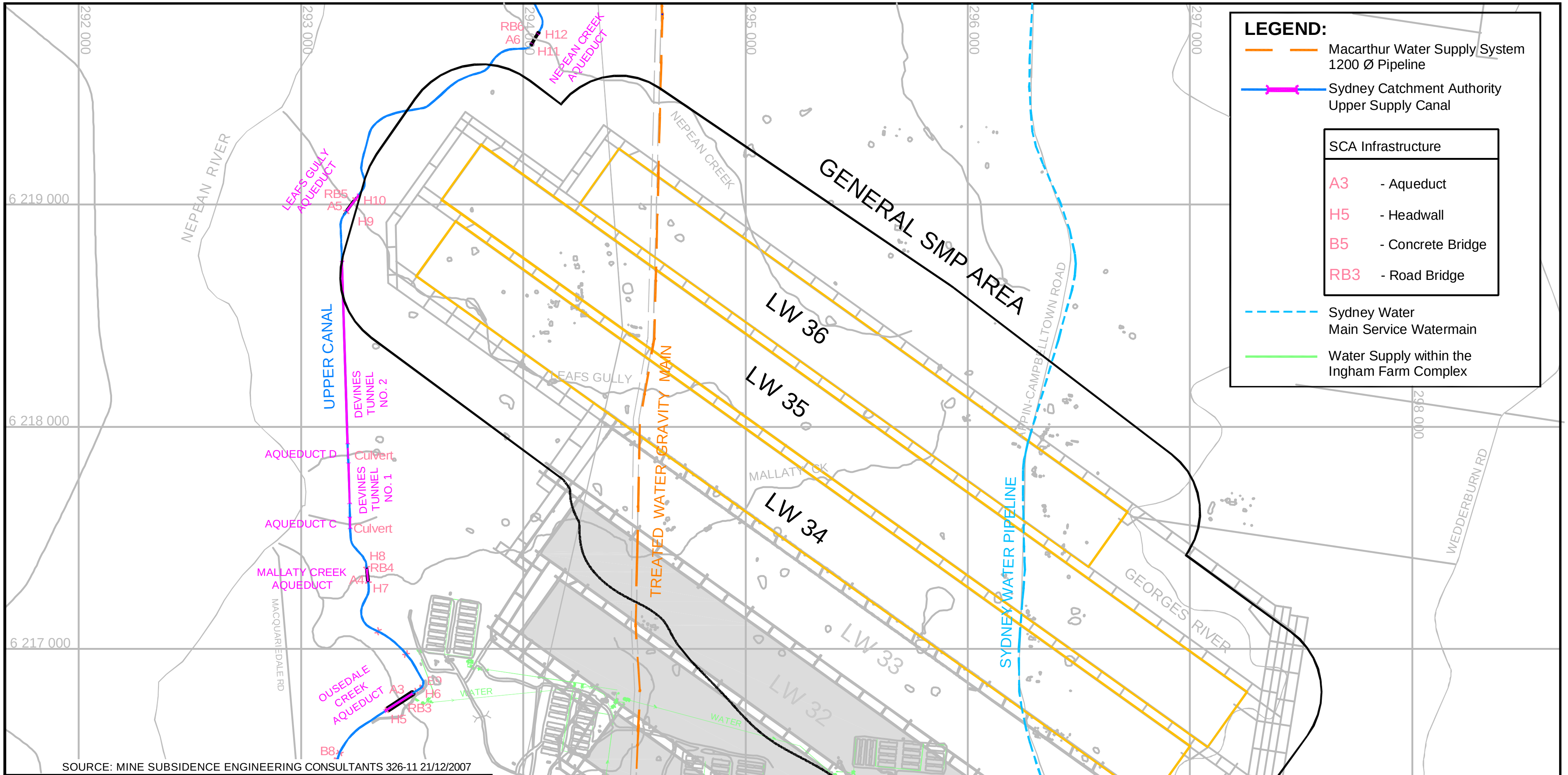
bhpbilliton

WEST CLIFF COLLIERY
AREA 5 SMP

LONGWALLS 34 TO 36

MAJOR ROADS & DRAINAGE CULVERTS

DATE:	SCALE:	FIGURE 6.5	Rev No
21 Dec 2007	1:25000		A



Cardno Forbes Rigby

278 KEIRA STREET, WOLLONGONG, NSW 2500
Ph: (02) 4228 4133 Facsimile: (02) 4228 6811 ACN: 051 074 992

This drawing is subject to COPYRIGHT.

bhpbilliton

WEST CLIFF COLLIERY AREA 5 SMP

LONGWALLS 34 TO 36 WATER INFRASTRUCTURE

DATE:	SCALE:	FIGURE 6.6	Rev No
21 Dec 2007	1:25000		A

6.9.6. The Upper Canal and Associated Infrastructure

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 millimetres.

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.

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.

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.

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 have been defined as *areas of environmental sensitivity* for the purposes of the SMP Application.

Refer to **Appendix A** for further details on the upper canal and associated infrastructure.

6.9.7. 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.

6.9.8. Water Supply Pipelines

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. The pipeline is shown on Plan 2.

6.9.9. 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 on-site septic tanks or package treatment plants.

6.9.10. 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 **Figure 6.7 and Plan 2**. 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.

6.9.11. Alinta EGP Natural Gas Pipelines

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.

As discussed in **Section 10**, it is predicted that there will be no significant impact on the Alinta EGP Natural Gas Pipeline from the proposed Activity.

6.9.12. Alinta AGN Natural Gas Pipeline

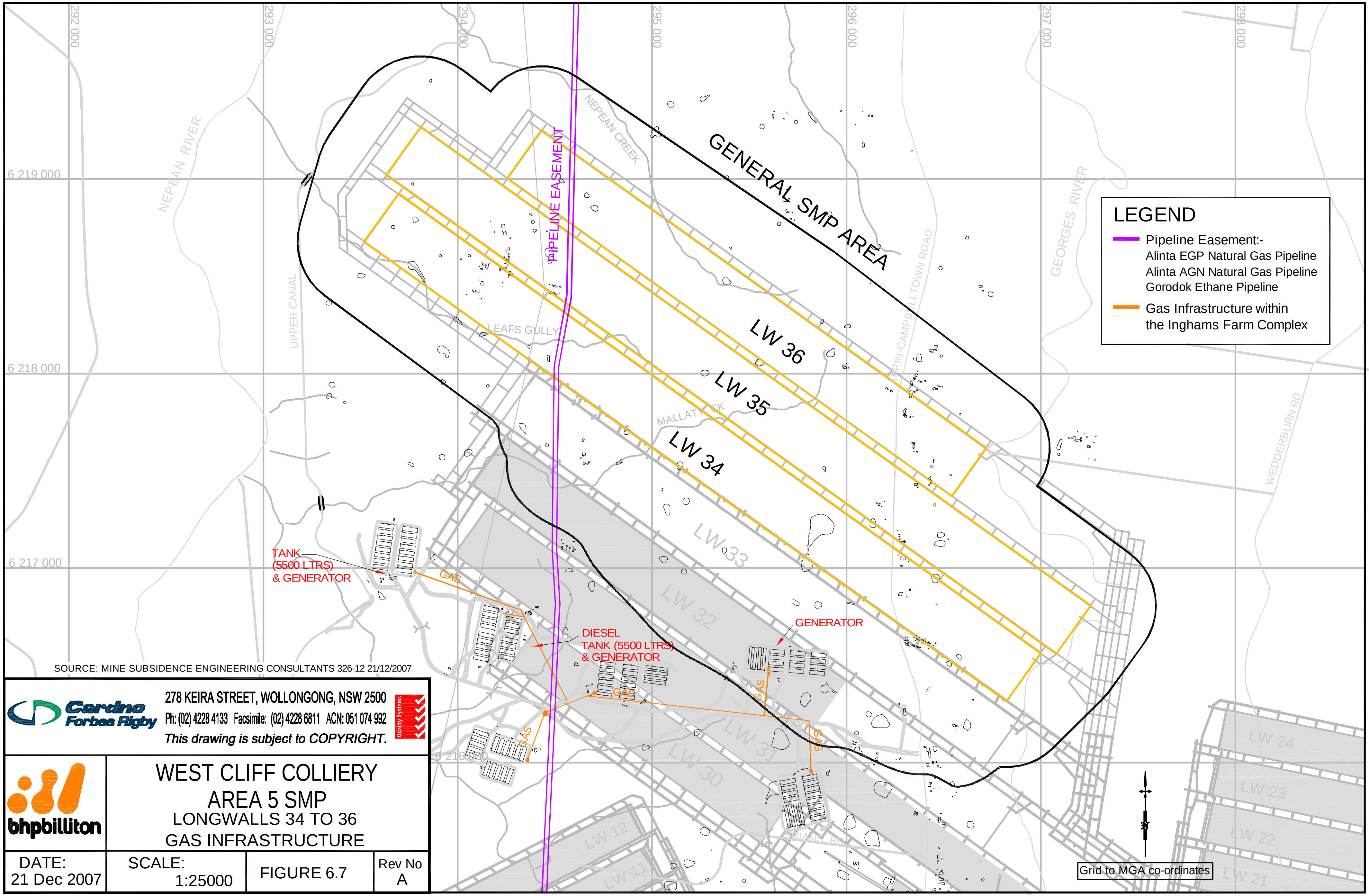
The Alinta AGN Natural Gas Pipeline, previously known as the AGL High Pressure Natural Gas Pipeline, was completed prior to 1976 and forms part of the Sydney Region Trunk Distribution System. The pipeline is a fully welded steel pipeline, 864 mm in diameter, which is laid below ground with a minimum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

The 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.

As discussed in **Section 10**, it is predicted that there will be no significant impact on the Alinta AGN Natural Gas Pipeline from the proposed Activity.

6.9.13. Gorodok Ethane Pipeline

The Gorodok Ethane Pipeline is a fully welded steel pipeline with a 203 mm diameter. It 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 15MPa.



SOURCE: MINE SUBSIDENCE ENGINEERING CONSULTANTS 326-12 21/12/2007

Cardno Forbes Rigby
278 KEIRA STREET, WOLLONGONG, NSW 2500
Ph: (02) 4228 4133 Facsimile: (02) 4228 6811 ACN: 051 074 992

bhpbilliton

WEST CLIFF COLLIERY AREA 5 SMP

LONGWALLS 34 TO 36 GAS INFRASTRUCTURE

DATE:	SCALE:	FIGURE 6.7	Rev No
21 Dec 2007	1:25000		A

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

As discussed in **Section 10**, it is predicted that there will be no significant impact on the Gorodok Ethane Pipeline from the proposed Activity.

6.9.14. Electricity Transmission Lines and Associated Plants

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 locations of the electrical services are shown in **Figure 6.8 and Plan 2** and are described below.

6.9.15. TransGrid Infrastructure

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 **Figure 6.8**. 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.

As discussed in **Section 10,** it is predicted that there will be no significant impact on the TransGrid infrastructure from the proposed Activity.

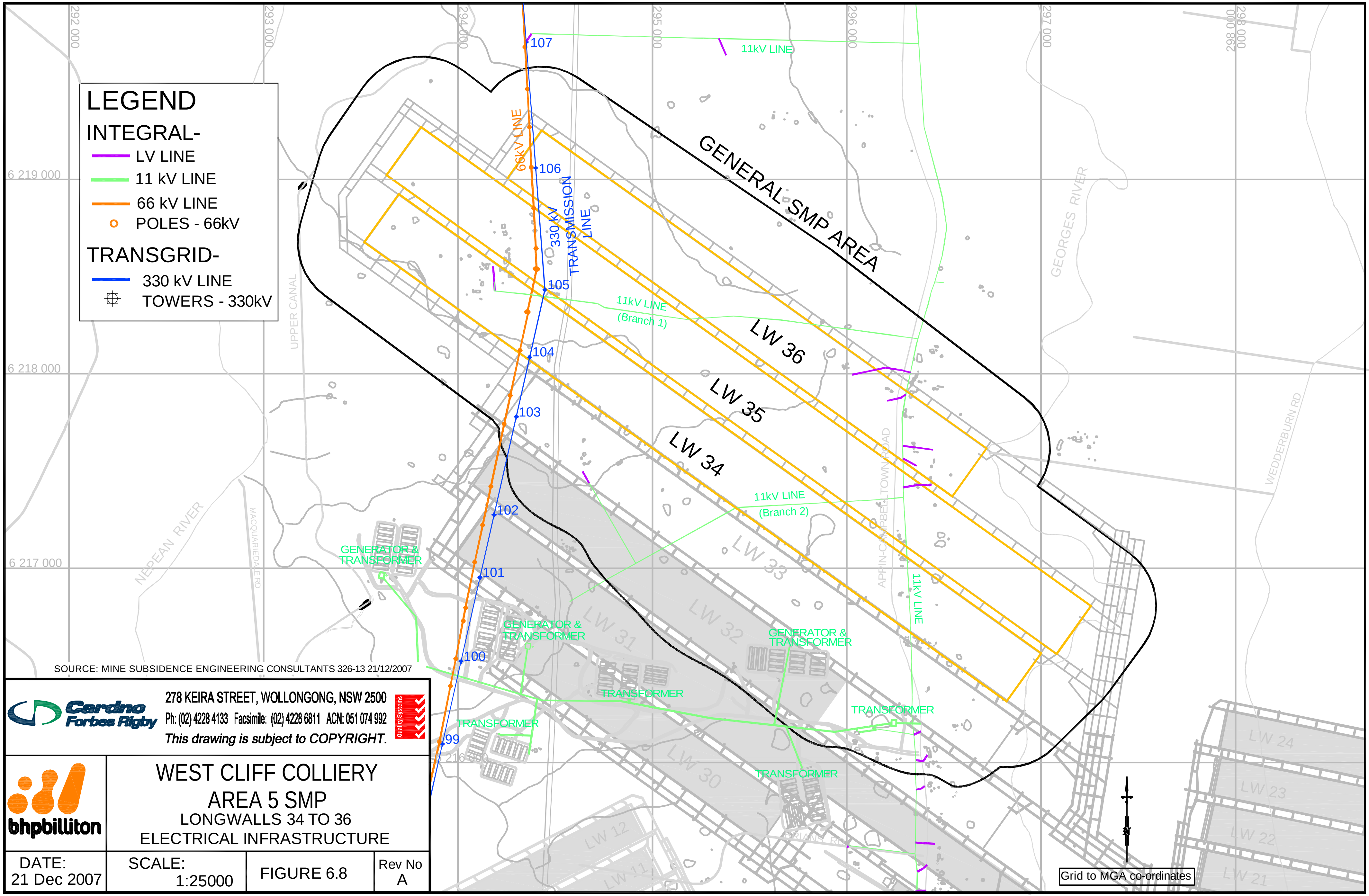
6.9.16. Integral Energy Infrastructure

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.

As discussed in **Section 10**, it is predicted that there will be no significant impact on the Integral Energy infrastructure from the proposed Activity.



SOURCE: MINE SUBSIDENCE ENGINEERING CONSULTANTS 326-13 21/12/2007

Cardno Forbes Rigby

278 KEIRA STREET, WOLLONGONG, NSW 2500
Ph: (02) 4228 4133 Facsimile: (02) 4228 6811 ACN: 051 074 992

This drawing is subject to COPYRIGHT.

bhpbilliton

WEST CLIFF COLLIERY
AREA 5 SMP
LONGWALLS 34 TO 36
ELECTRICAL INFRASTRUCTURE

DATE:	SCALE:	FIGURE 6.8	Rev No
21 Dec 2007	1:25000		A

6.9.17. Telecommunications Lines and Associated Plants

The locations of the telecommunication services within the SMP Area are shown in **Figure 6.9 and Plan 2**. The telecommunication services include a direct buried optical fibre cable and direct buried copper telecommunications cables, all of which are owned by Telstra.

As discussed in **Section 10**, it is predicted that there will be no significant impact on telecommunication lines and associated plant from the proposed Activity.

Refer **Figure 6.9** for further details on telecommunications lines and associated plants.

6.9.18. 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. The rural properties within the SMP Area also have on-site waste systems.

6.9.19. Dams, Reservoirs and Associated Plants

There are no public dams, reservoirs or associated works within the SMP Area. There are, however, a number of farm dams within the SMP Area. They are discussed in **Section 6.11.5**.

6.10. FARM LAND AND FACILITIES

6.10.1. 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 6.12.1**.

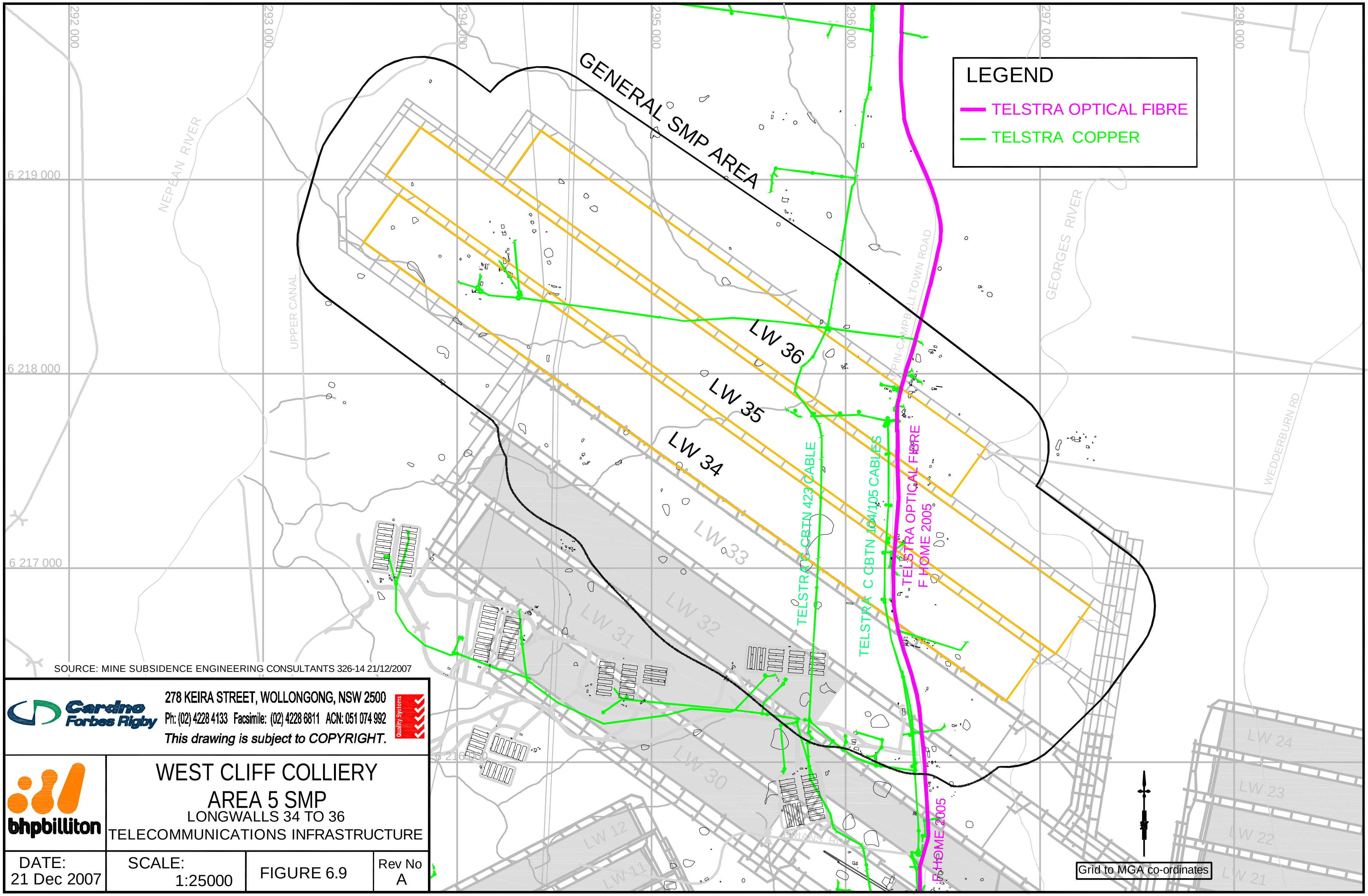
Features on the rural properties are discussed in the following sections.

6.10.2. 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 and details provided in **Appendix A and Plan 2**.

6.10.3. Tanks

There are 90 tanks (Structure Type T) that have been identified within the SMP Area which tanks generally serve as water storages for properties within the SMP Area. The locations of the tanks within the SMP Area are shown in **Appendix A**.



SOURCE: MINE SUBSIDENCE ENGINEERING CONSULTANTS 326-14 21/12/2007

Cardno Forbes Rigby
278 KEIRA STREET, WOLLONGONG, NSW 2500
Ph: (02) 4228 4133 Facsimile: (02) 4228 6811 ACN: 051 074 992

bhpbilliton

WEST CLIFF COLLIERY
AREA 5 SMP
LONGWALLS 34 TO 36
TELECOMMUNICATIONS INFRASTRUCTURE

DATE:	SCALE:	FIGURE 6.9	Rev No
21 Dec 2007	1:25000		A

6.10.4. 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.

6.10.5. 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 **Plan 2** and **Appendix A**.

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.

6.10.6. 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 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. The locations of these bores are shown in **Figure 6.2** and details are provided in **Table 6.6**.

Table 6.6 - 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

6.11. INDUSTRIAL, COMMERCIAL AND BUSINESS ESTABLISHMENTS

6.11.1. 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 **Plan 2** and **Appendix A**.

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 **Figure 6.4**.

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

6.12. AREAS OF ARCHAEOLOGICAL OR HERITAGE SIGNIFICANCE

6.12.1. 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 **Figure 6.2, Plan 2** and details are provided in **Table 6.7**.

Table 6.7 - Archaeological Sites within the SMP Area

AHIMS 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 in **Appendix C**.

6.12.2. Items of 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 6.9.6**. 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 **Figure 6.2**. 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 **Appendix E**.

6.13. 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 **Figure 6.2**. Ten survey control marks have been identified within the general SMP Area refer **Figure 6.2**.

6.14. RESIDENTIAL ESTABLISHMENTS

6.14.1. 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. Details of each of the houses are provided in the Property Subsidence Management Plans (PSMPs).

The locations of the houses within the SMP Area are shown in **Appendix A**.

6.14.2. Any Other Residential Feature

There are seven swimming pools within the SMP Area, the locations of which are shown in **Appendix A**. The houses within the SMP Area also have on-site waste water systems.

7. SUBSIDENCE PREDICTIONS AND IMPACTS

(SMP Guidelines Section 6.7)

7.1. BACKGROUND

Coal extracted through longwall mining methods results in subsidence of the surface. Mining Subsidence Engineering Consultants prepared detailed subsidence predictions for Longwalls 34 to 36 and these are fully described in the report, provided as **Appendix A**.

Using these predictions, specialist consultants identified the likely impacts of the proposed mining on features including the landscape and ecology. Full reports are provided in the appendices to this document. The following sections outline the results of these detailed predictions and impact assessments.

7.2. PREDICTION METHOD AND RELIABILITY

Subsidence predictions are one of the essential input parameters for the assessment of risk and the severity of the consequences associated with the potential impacts on natural and cultural features.

In the context of management, the importance of accurate subsidence predictions relates to the quality and effectiveness of the managed solutions.

The *Incremental Profile Method* used by MSEC makes its predictions based on extensive databases of historical monitoring data in the Southern Coalfield. This ensures high confidence in the subsidence profiles predicted.

7.3. METHODS EMPLOYED

The predicted parameters were obtained using the Incremental Profile Model for the Southern Coalfield based on monitoring data from the Bulli Seam. This method is described in detail in **Appendix A**.

The method is an empirical model that is used to predict subsidence, tilts, curvatures and strains likely to be experienced as longwall mining proceeds and assess the likely effects on surface features. The model uses the surface level contours, seam floor contours and seam thickness contours (extraction height) to make the predictions.

The Incremental Profile Method is based on predicting the incremental subsidence profile for each longwall in a series and adding the respective incremental profile to show the cumulative subsidence profile at any stage of extraction.

The method predicts profiles in both the transverse and longitudinal directions, allowing the subsidence, tilts, systematic curvatures and systematic strains to be predicted at any point on the surface. It also allows the magnitude of both transient and residual tilts and curvatures within the subsidence trough to be determined.

The Incremental Profile Method provides a greater understanding of the mechanism of subsidence over a series of panels and allows a detailed prediction of subsidence parameters to be made for any point in the subsidence profile.

Due to the inherent advantages of the Incremental Profile Method, it has been used to make the detailed subsidence predictions for this project. Further details of the Incremental Profile Method are provided in MSEC's report presented as **Appendix A** and the information presented below has been drawn from this report (MSEC326, December 2007).

7.3.1. Development of Subsidence

The development of subsidence is complex and is a function of geology (e.g. stratigraphy, rock strength, spacing of joints), topography (including location of creeks and rivers) and mining parameters' (e.g. depth and method of mining). In the subsidence report prepared by MSEC, further details of the factors that may affect the development of subsidence over the SMP Area are provided.

7.3.2. Assumptions Used

The Incremental Profile Method of subsidence prediction is based on the following assumptions:

- impacts will be similar to those previously observed in comparable areas;
- there may be anomalous cases where subsidence will not occur as predicted;
- surface features and land use at the time of the assessment remains similar;
- effects on infrastructure include ground strains being fully transferred to the feature.

7.3.3. Reliability of Subsidence Predictions

A summary of the reliability of the predictions is provided below and detailed discussion is provided in the **Appendix A**.

For the proposed longwalls, the predicted maximum values of the subsidence and tilt, obtained using the Incremental Profile Method, are greater than those obtained using the DMR Handbook Method.

The predicted levels of strain obtained using the Incremental Profile Method, are greater than those obtained using the DMR Handbook Method.

The predictions obtained using the DMR Handbook Method are located on the steepest part of the curves. Therefore a small increase in width-to-depth ratio results in a large decrease in strains and curvatures.

Therefore, the Incremental Profile Method should provide realistic, if not conservative predictions of subsidence, tilt and systematic curvature and strain over the proposed Longwalls 34 to 36.

The tilts and systematic curvatures can be predicted to the same level of accuracy, but the measured curvatures and strains can vary considerably from the predicted systematic values due to variations in geology, thick soils masking bedrock movements, strain measurement giving false impressions of the state of strain in the ground and survey errors.

It is also recognized that the ground movements above a longwall can be affected by the gradient of the coal seam, the direction of mining and the presence of dykes, which can result in a lateral shift in the subsidence profile.

The predicted maximum tilts and strains within the SMP Area are, generally, those which are aligned in the transverse direction to the longwall. However, at the ends of the longwall, the maximum tilts and strains are at right angles to the subsidence contours and these values have been calculated where appropriate.

In some cases, the transient or travelling longitudinal tilts and strains can be greater than the transverse values, in which cases the travelling longitudinal values have been adopted for the impact assessments.

7.3.4. Reliability of Closure and Upsidence Predictions

The development of predictive methods for closure and subsidence are the result of relatively 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 method will be improved, but it can be used confidently 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.

While the major factors that determine the levels of movement have been identified, there are some factors that are difficult to isolate. One factor is thought to influence the closure and subsidence movements, is the level of an in-situ horizontal stress that exists within the strata.

In-situ stresses are not regularly measured and the limited availability of data makes it impossible to be definitive about the influence of the in-situ stress on the closure and subsidence values.

7.4. PREDICTED REGIONAL HORIZONTAL MOVEMENTS

MSEC notes that in addition to the systematic movements that have been predicted above and around the proposed Longwalls 34 to 36, and the closure and subsidence movements that have been predicted within the creeks, it is probable that some regional horizontal movements will also be experienced as mining occurs.

The predicted subsidence parameters vary considerably over the proposed Longwalls 34 to 36 due to the variations in the depths of cover and seam thickness, which are illustrated in the depth of cover contours, surface contours, seam floor contours and seam thickness contours in **Appendix A**.

7.5. 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. 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.

Several dykes and fault zones have been identified in the vicinity of proposed longwalls and it is possible that some irregularity could occur in the subsidence profiles due to those geological structures. The likelihood of irregular profiles is discussed further in **Appendix A**.

7.6. SUMMARY RESULTS OF SUBSIDENCE PREDICTIONS

Table 7.1 - 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 7.2 - 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

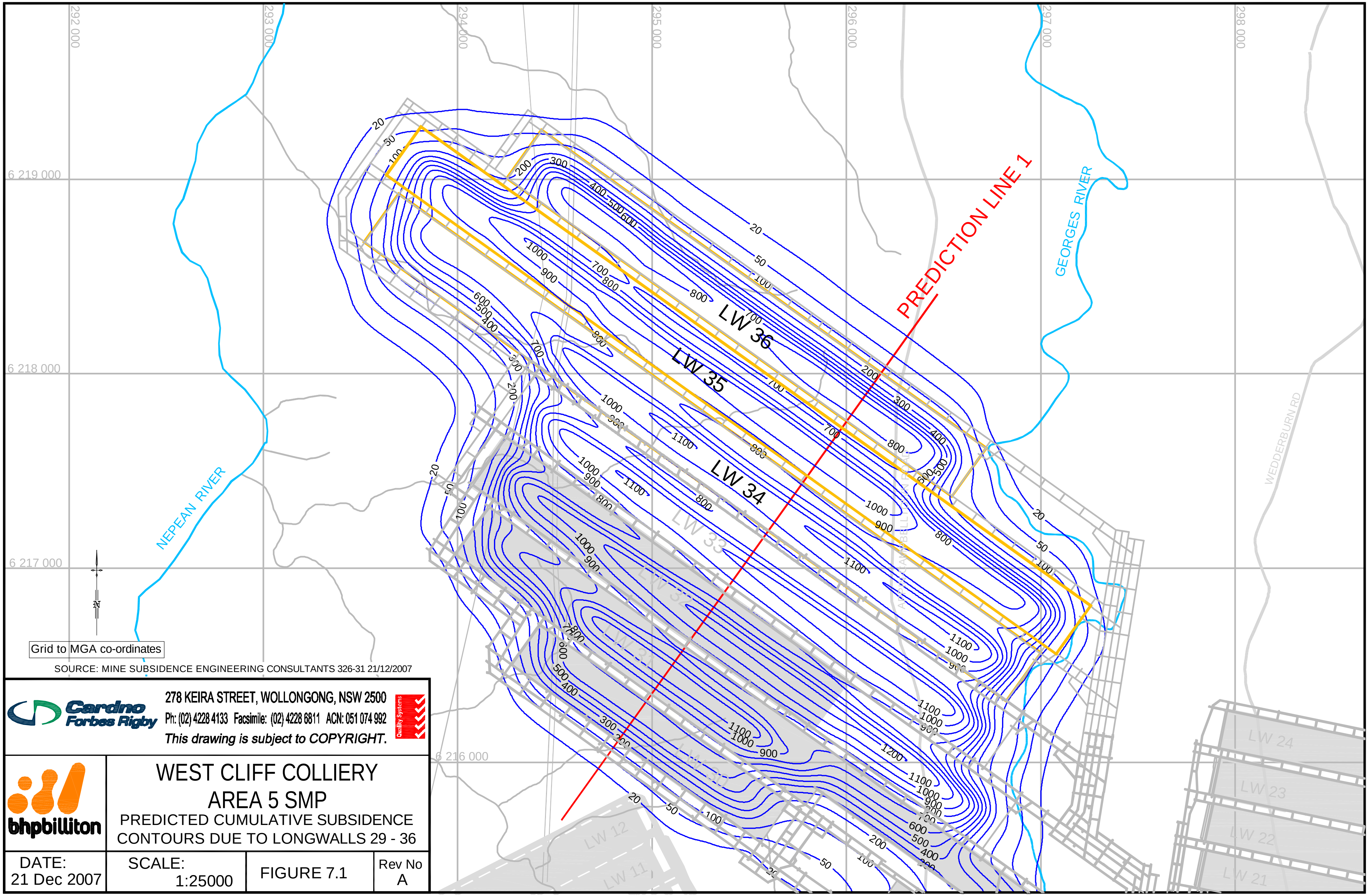
Table 7.3 - Maximum Predicted Travelling Subsidence Parameters during the Extraction of Each Proposed Longwall 34 to 36

Longwall	Maximum Predicted Travelling Tilt (mm)	Maximum Predicted Travelling Tensile Strain Tilt (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 predicted systematic subsidence parameters have been determined along Prediction Line 1, the location of which is shown in **Figure 7.1**. Details are provided in **Table 7.4**.

Table 7.4 - Maximum Predicted Cumulative Systematic Subsidence Parameters along Prediction Line 1 Resulting from the Extraction of Longwalls 33 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



SOURCE: MINE SUBSIDENCE ENGINEERING CONSULTANTS 326-31 21/12/2007

Cardno Forbes Rigby

278 KEIRA STREET, WOLLONGONG, NSW 2500

Ph: (02) 4228 4133 Facsimile: (02) 4228 6811 ACN: 051 074 992

This drawing is subject to COPYRIGHT.

bhpbilliton

WEST CLIFF COLLIERY AREA 5 SMP

PREDICTED CUMULATIVE SUBSIDENCE CONTOURS DUE TO LONGWALLS 29 - 36

DATE:	SCALE:	FIGURE 7.1	Rev No
21 Dec 2007	1:25000		A

8. SUBSIDENCE PREDICTIONS AND IMPACTS ON NATURAL FEATURES

8.1. THE GEORGES RIVER

8.1.1. Predictions along 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 **Appendix A**. 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 8.**1.

Table 8.1 - Maximum Predicted Cumulative Subsidence, Upsidence and Closure at the Georges River Resulting from the Extraction of Longwalls 33 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 36. 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 **Appendix A**. 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 **Appendix A**, 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 8.**2.

Table 8.2 - Maximum Predicted Cumulative Net Vertical Movements Resulting from the Extraction of Longwalls 33 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 8.3. 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 8.**3.

Table 8.3 - Maximum Predicted Cumulative Systematic Tilts and Strains at the Georges River Resulting from the Extraction of Longwalls 33 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 **Figure 6.3**. 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 8.4**.

Table 8.4 - 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

8.1.2. The Increased Likelihood 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 **Figure 6.3**, 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.

Refer **Appendix A** for the maximum predicted systematic increasing and decreasing tilts along the Georges River

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.

8.1.3. 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.

Refer **Appendix A** for the maximum predicted systematic tilt and maximum predicted total upsidence along the river.

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.

8.1.4. 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.

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. Refer **Appendix A** for the locations and details of these impacts.

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.

Refer **Appendix A** for details of the selected case studies.

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 **Figure 8.1**. 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.

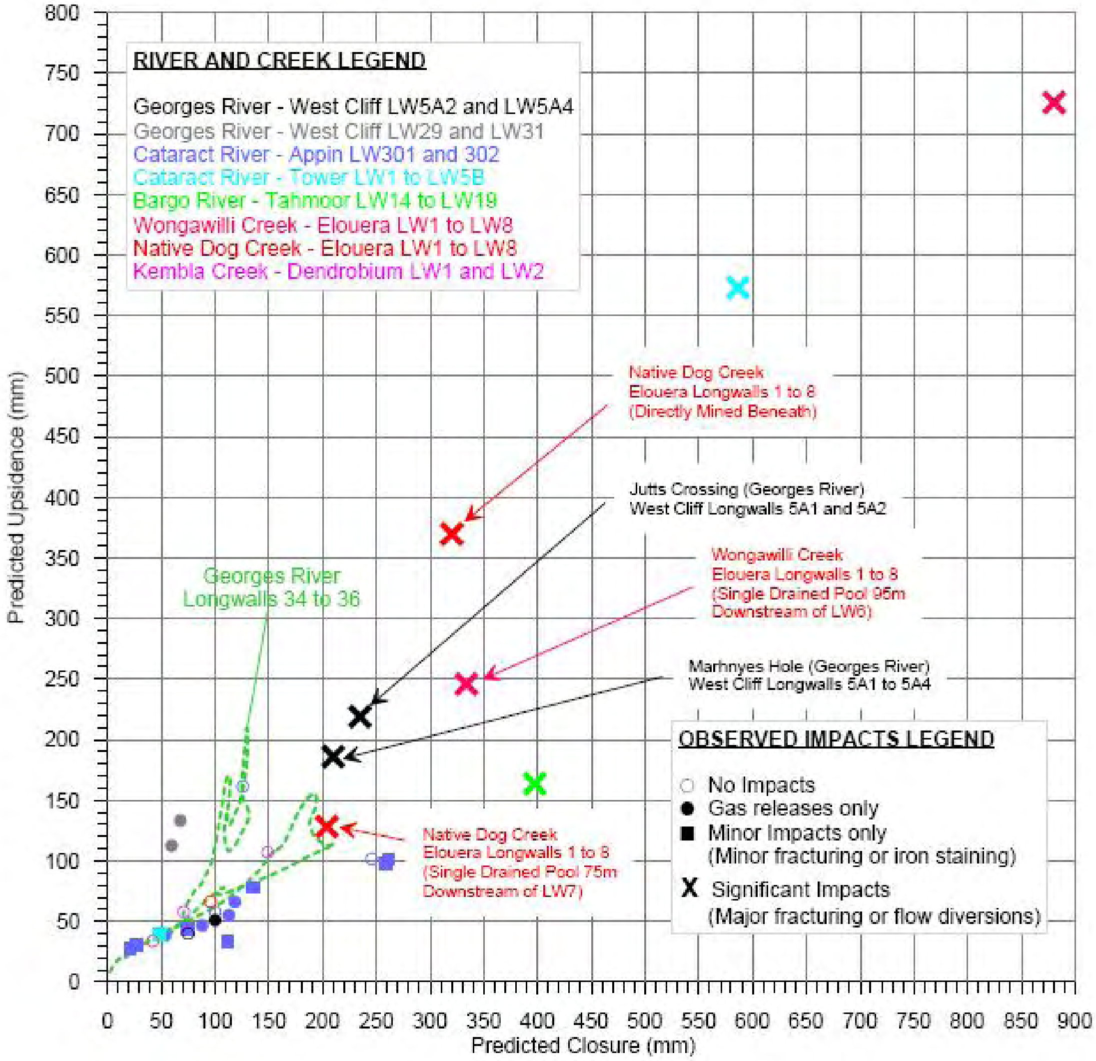


Figure 8.1 Back-Predicted Upsidence and Closure and the Observed Impacts for the Case Studies

The natural pools along the Georges River are controlled by the rock bars and riffles, the locations of which are shown in **Appendix A**. 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 **Figure 8.2**.

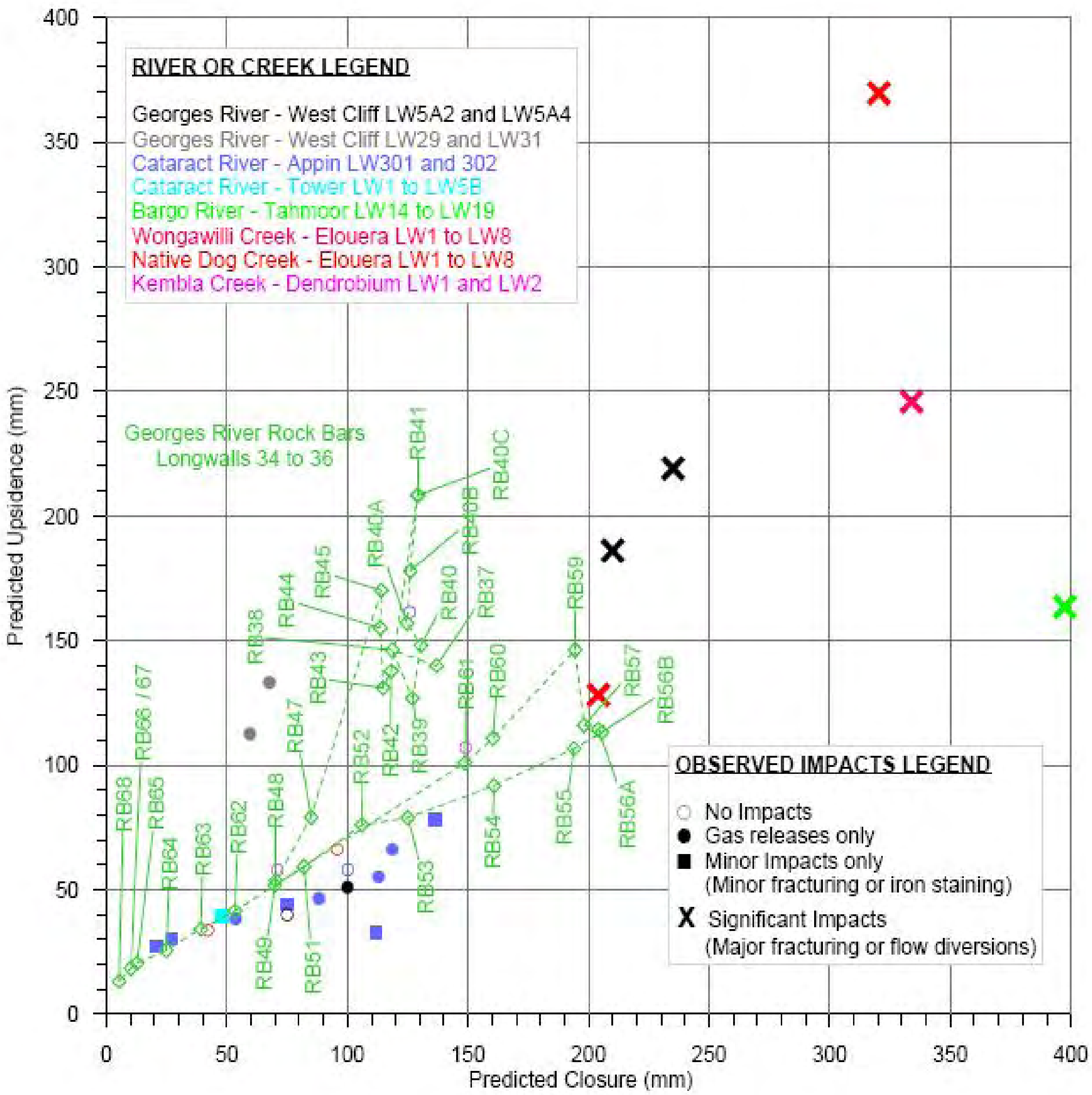


Figure 8.2 Comparison of Predicted Upsidence and Closure at the Rock Bars along the Georges River with Back-Predicted Movements and Observed Impacts for the Case Studies

It can be seen from **Figure 8.2** 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 **Figure 8.3** and **Figure 8.4**, 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.

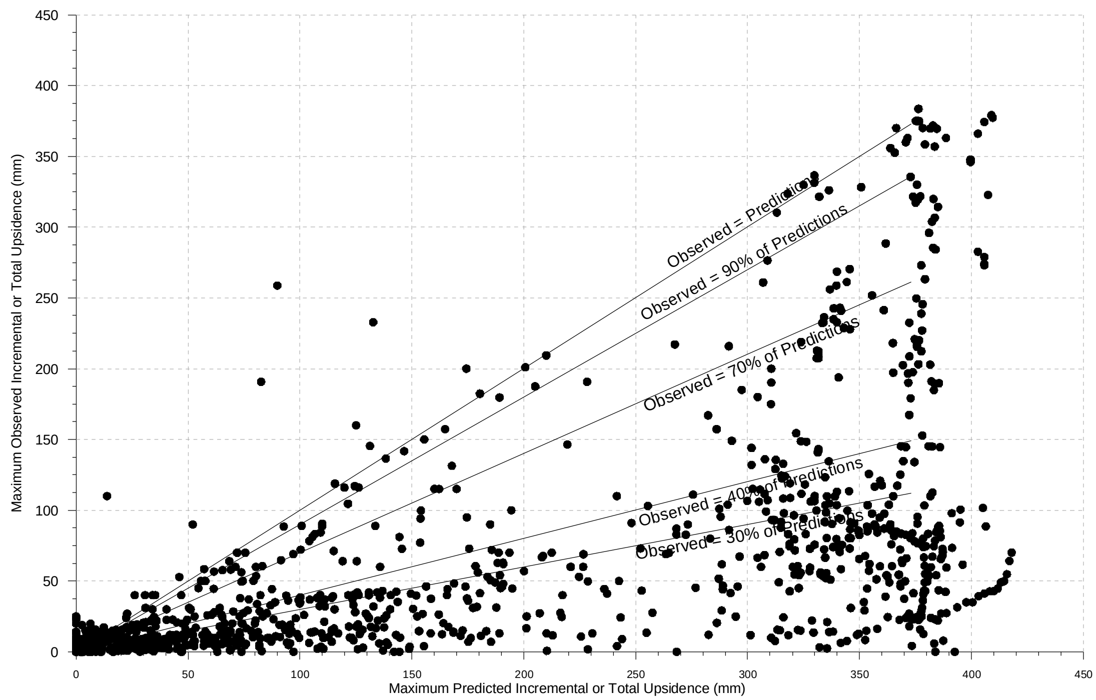


Figure 8.3 Comparison of Predicted and Observed Upsidence Movements in Database

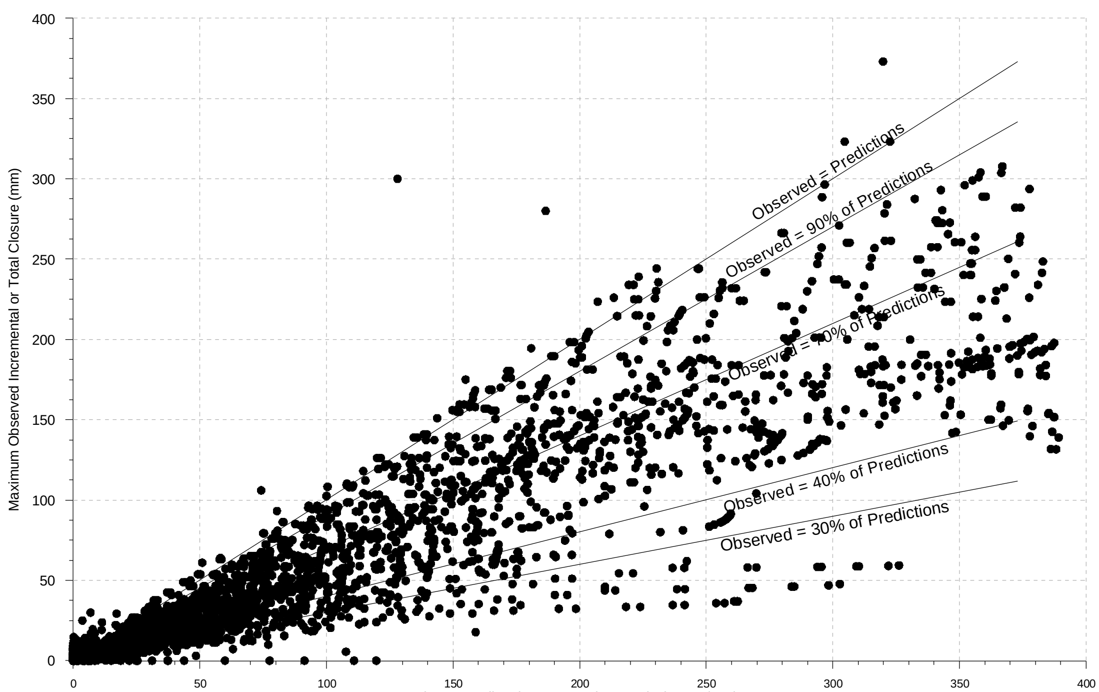


Figure 8.4 Comparison of Predicted and Observed Closure Movements in Database

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 **Figure 8.4**.
- 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 **Figure 8.3**.
- 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 **Figure 8.1** and **Figure 8.2**, allows us to use the predicted closure movements to assess the potential for these impacts.

It can be seen from **Figure 8.1**, 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 slightly 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 **Figure 8.4**, 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. Refer **Appendix A** for details on the case studies.

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. 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.

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.

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 based on extensometer monitoring of rockbars.

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. Refer **Appendix A** for details on previous field investigations.

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 **Appendix A**).

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.

8.1.5. Impacts due to Increased Subsidence 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 %.

8.2. CLIFFS

8.2.1 Predictions for the Cliffs

The locations of the cliffs within the SMP Area are shown in **Figure 6.4**. The predictions and impact assessments for the cliffs are provided in the following sections.

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 8.5**.

Table 8.5 - 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.

8.2.2 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 by MSEC 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. Refer **Appendix A** for details on the case studies.

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 or death to people. 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 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. Refer **Section 8.4** for impacts on water quality.

8.2.2 Impacts due to Increased Subsidence 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.

8.3. STEEP SLOPES

The locations of the steep slopes within the SMP Area are shown in **Figure 6.4**. The predictions and impact assessments for the steep slopes are provided in the following sections.

8.3.1. 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 8.6**.

Table 8.6 - 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

8.3.2. 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.

8.3.3. 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

8.4. POTENTIAL SUBSIDENCE IMPACTS ON SURFACE WATER QUALITY

Ecoengineers have completed an assessment of potential water effects in the SMP Area including the Georges River and associated creeks, refer **Appendix E**. The impacts on water quality for the Georges River and the associated creeks are discussed below.

While it is possible for fracturing to occur anywhere along the River within close proximity to the proposed longwalls, the most likely areas would be where the predicted mine subsidence related movements are the greatest, or where the rock bars are the largest. On the basis of the predictions of mine subsidence effects in the Georges River (refer Section 5.2.1 in **Appendix A**) it is believed that:

1. The rock bars most likely to fracture are Rock Bars 56A and 56B, which are located adjacent to the maingate of proposed Longwall 35 (refer **Figure 6.3**). This is because this is where the predicted closures exceed the back-predicted closure for the Elouera Colliery Native Dog Creek case study. It is noted that the back-predicted closure at bracketing Rock Bars 55, 57 and 59 are also of a similar magnitude to that back-predicted for the Native Dog Creek case study.

2. The pools most likely to drain (due to proximity to proposed Longwall 35) are Pools 45, 51, 55, 56, 57 and 60.

At the present time we simply do not know enough about the geotechnical factors that trigger the formation of such springs as no piezometric studies have been conducted in the vicinity of recognized, subsidence-induced springs and no systematic back analysis has been conducted of subsidence parameters in their vicinity.

Nevertheless, on the basis of field arguments, is considered that such springs would be more prone to arise, or of pre-existing be enhanced in westward draining catchments in the SMP Area i.e. Upper Mallaty Creek, Upper Leafs Gully Creek and Upper Nepean Creek than in Georges River. Refer **Appendix E** for field observations.

The acid generation rate of the fractured rock bar NDC2A in upper Native Dog Creek over Elouera Colliery longwalls occurred in mid May 2003 and the acid generation rate of the rock bar declined strongly over several years thereafter. Similar effects have been observed on Wongawilli Creek, a headwater catchment of Cordeaux River (below Cordeaux Dam) where acid generation has declined sharply over about five years despite persistence of sub-bed flow diversions over sections of that Creek (e.g. Ecoengineers Pty Ltd., 2003, 2004).

The principal reasons for the observed decline in acid generation after an initial peak within one year of mining impacts are believed to be:

- the depletion of readily available siderite/rhodocrosite and marcasite in the accessible fractured Sandstone; and
- the build up of armouring over residual siderite/rhodocrosite and marcasite by precipitated hydrous Fe and Mn oxides.

The Pool 11 spring in Georges River, which was first observed in November 2000 after it had contributed substantial ferruginous staining to the water and bed of the upper Georges River declined over a period of just under 4 years.

The relatively large spring recently identified in Cataract Gorge just upriver of the Appin Longwalls 301 to 302 would appear to have arisen between early 1991 and mid 1992 during the mining of Appin Longwalls 21B, 22B and possibly part of Longwall 23. The appearance of the spring, which has mature under canopy type rainforest tree species growing amidst deposited iron oxides around and below the spring's emergence point suggests that it has been a relatively stable feature since around that time i.e. a period of about 14 years. It is therefore concluded that if they do occur such springs may have a lifetime of at least 10 years without significant diminution in intensity and may in fact be relatively permanent once established.

With respect to possible sub-bed flow diversions due to actual river bed fracturing (exposing siderite/rhodocrosite and possibly also significant marcasite in unweathered sandstone), such diversions arising from development of Longwalls 34 to 36 are considered unlikely for the reasons given above.

However, if they should occur, a considerable 'mitigative effect' against ecotoxicity attributable to acidity, Ni and Zn is provided by the moderately saline waters released from Brennans Creek Dam, which contain a significant concentration (1000 – 1500 mg/L typically) of bicarbonate/carbonate alkalinity which not only serves to:

- 'buffer out' any acidity generated by any dissolution of marcasite in mining-induced freshly fractured sandstone bedrock; but also
- complexes dissolved Ni and Zn, greatly reducing the net concentration of the ecotoxic, cationic forms of these metals.

The following effects have been inferred, using geochemical modelling, to be the maximum short term 'worst case' effects at the peak of the rate of dissolution of marcasite in the Hawkesbury Sandstone bedrock of the river:

- Only in the case where 0.5 ML/day is diverted through freshly fractured bedrock, and there is no diluting surface flow, would emerging waters be highly reduced (Oxidation Reduction Potential; ORP <0 mV) and largely devoid of DO but they would have extremely low levels of the ecotoxic species of Ni and Zn.
- Where sub-bed diversion flows are less than one third of the total flow there would be no exceedance of the national water quality guidelines at the emergence point for pH and DO and dissolved ecotoxic cationic Ni but considerable exceedances of the default national water quality guidelines (for protection of 95% of all aquatic species) for dissolved cationic Zn would remain.

- For Rivers flows up to at least 2.5 ML/day only if there were at least one third diversion through the fractured riverbed, would there be considerable exceedances of the default national water quality guidelines at the emergence point for dissolved oxygen, dissolved, ecotoxic cationic zinc and minor exceedances for ecotoxic cationic nickel but no exceedances for pH.

It is concluded that sub-bed diversions through fractured river bedrock in the Georges River would generally maintain and may slightly increase ecotoxic concentrations of Zn down river partly because of the pre-existing concentrations of zinc in the moderately saline waters released from Brennans Creek Dam and partly through the further release of Zn contained within dissolving marcasite in the fractured bedrock.

The national water quality guidelines explicitly allow for the consideration of site or region specific factors (ANZECC/ARMCANZ, 2000) and, in our view pHs in the Georges River between 8.0 and 9.5 are demonstrably still within the 'natural range' for lowland rivers with good access of light to the river surface and many pools that can support significant algal populations. This is because when flows in the river under 'steady state' conditions i.e. when pool depths remain constant due to controlled release from BCD then pHs in the river already able to be found lying in the 8.0 – 9.5 range 'naturally' especially under warm, sunny conditions. Algal primary productivity in river pools maximizes under those circumstances and algae absorb dissolved CO_2 and bicarbonate from water and respire oxygen – thereby driving pH up. It is therefore common to observe pHs in pools in the river rising to levels as high as 9.5 during warm, sunny conditions. This suggests that; to expect the pH of water in the river to lie below 8.5 at all times is unwarranted and it is very likely that local aquatic biota is acclimatized to pHs at least as high as 9.5. This in turn suggest there is no deleterious effect arising *per se* from the fact that the BCD discharge typically has a pH in the 8.0 – 8.6 range.

It is therefore predicted that there will be no significant effect on pH from any effect resulting from the extraction of proposed longwalls.

On the basis of the information presented in previous sections of this report and above we conclude that:

- the Likelihood of one or more sub-bed diversions arising within Georges River as a consequence of the mining of proposed Longwalls 34 - 36 is Minor; but
- the Consequences of such a diversion on Aesthetics of the River from iron floc would be Major; however
- the Consequences of such a diversion or diversions to Property would be Insignificant to None; and
- the Consequences of such a diversion to the Ecological Health of immediate downstream pool(s) in the River would be Major but only under low flow conditions (<0.3 ML/day) which have occurred no more than 15% of the time since the introduction of the controlled discharge to the River from West Cliff Colliery BCD; but
- the Consequences of such a diversion to the Ecological Health of immediate downstream pool(s) would be Insignificant provided the River continued to receive an environmental flow e.g. from West Cliff Colliery in excess of 0.5 ML/day with an Total Alkalinity in excess of 500 mg/L expressed as $CaCO_3$ (calcium carbonate).

With respect to the possible induction of a ferruginous spring while such an occurrence is considered unlikely, if it should occur, then the following effects are inferred by us, on the basis of geochemical modelling, to be the maximum 'worst case' long term effects in Georges River:

- for all discrete spring flows into the river above 0.1 ML/day and river flows below about 0.3 ML/day i.e. below 15 percentile the default lower limit for DO in the national water quality guidelines would not be met at the spring emergence point.
- for all discrete spring flows into the river below 0.2 ML/day and river flows below about 0.5 ML/day i.e. below 50 percentile flows the 95% default limit for Ni in the national water quality guidelines would not be exceeded by the concentration of cationic ecotoxic NI species at the spring emergence point.
- for all discrete spring flows into the river below about 0.2 ML/day and river flows below about 0.5 ML/day i.e. below 50 percentile flows the 95% default limit for zinc in the national water quality guidelines would not be exceeded by the concentration of cationic ecotoxic Zn species at the spring emergence point.
- or all discrete spring flows into the river above 0.15 ML/day and river flows below about 1.0 ML/day i.e. below 50 percentile flows the default lower limit for dissolved oxygen in the national water quality guidelines would be marginally not met at the spring emergence point

Again, the principal reason why concentrations of ecotoxic Ni and Zn species in the Georges River deriving from any such springs would not exceed the default national water quality guidelines limits for nickel and zinc of 0.011 and 0.008 mg/L respectively for river flows of 1.0 ML/day and above is due to the considerable carbonate alkalinity in the water discharged from Brennans Creek Dam which constitutes the major part of the flows in the river (i.e. up to at least the 50 percentile flows).

Given the nature of the Georges River bed, it is believed that typical re-aeration coefficients applying in the river would be such that, for discrete spring flows into the river above 0.15 ML/day, and river flows above 0.5 ML/day, the minor deficit in DO at the spring emergence point would not have a significant impact. This is because geomorphological considerations suggest the river water should be quickly re-aerated over very short distances – likely only a few metres (USEPA, 1985).

It is concluded that such springs would only cause a considerable river DO deficiency at their emergence points if their flow rate exceeded 0.1 ML/day and if flows in the river were concurrently <0.3 ML/day (i.e. <15% probability). The likelihood of this occurring is extremely low.

It is noted that such springs do not contain sufficient dissolved Fe and Mn to cause a significant depression of river pHs through the oxidation and precipitation of hydrous Fe and Mn oxides because the River water contains significant bicarbonate/carbonate alkalinity deriving from the BCD discharge from West Cliff Colliery.

On the basis of the information summarised above, it is concluded that:

- the Likelihood of one or more springs arising within Georges River as a consequence of the mining of proposed Longwalls 34 - 36 is Minor; and
- the Consequences of such springs to Property would be Insignificant to None; and

- the Consequences of such a spring or springs to the Ecological Health of immediate downstream pool(s) in the River would be Major under low flow conditions (<0.3 ML/day); but
- the Consequences of such a spring or springs to the Ecological Health of immediate downstream pool(s) would be Insignificant provided the River continued to receive an environmental flow e.g. from West Cliff Colliery in excess of 0.5 ML/day with an Total Alkalinity in excess of 500 mg/L expressed as $CaCO_3$ (calcium carbonate); but that
- the Consequences of such a diversion on Aesthetics of the Georges River would be Major.

It is possible ferruginous saline springs may be more prone to be induced or if pre-existing enhanced in flow rates westward draining catchments overlying Longwalls 34 to 36 that ultimately flow to the Nepean River e.g. Mallaty Creek, Leafs Gully Creek and Upper Nepean Creek. Given that the gradients in Ingham's Tributary are similar to those in Upper Mallaty and Leafs Gully Creek, but significantly less than those in Upper Nepean Creek (within the SMP Area), and that maximum predicted systematic tilts along the alignments of Mallaty Creek are similar to those back-predicted for Longwalls 30 and 31 (MSEC, 2005), there would appear to be a low but finite probability of induction of, or enhancement of existing ferruginous springs in the Upper Mallaty and Leafs Gully Creek catchments as a consequence of the mining of Longwalls 34 to 36.

Notwithstanding, the westward draining streams are clearly strongly ephemeral in nature with ongoing agricultural land use and it is unlikely there would be any significant impact to water quality resulting from the formation of springs in these streams over and above current anthropological effects (The Ecology Lab, 2007).

On the basis of the information summarised above it is concluded that:

- the Likelihood of one or more ferruginous springs arising within Upper Mallaty Creek catchment from subsidence-related effects within that catchment as a consequence of the mining of proposed Longwalls (33), 34 or 35 is Minor as the mining of Longwalls 31 and 32 (mined from the west) has possibly not led to induction of such springs although Longwall 30 appears to have created a spring in Ingham's Tributary of Ousedale Creek to the south; and
- the Consequences of such a spring or springs to Property would be Minor and we base this on a minor risk of potential contamination to a farm or commercial water storage dam; and
- the Consequences of such a spring or springs to the Ecological Health of immediate downstream pool(s) in the Creek would be Insignificant under high flow conditions but Minor under low flow conditions and we principally base this conclusion on the existing effects of local agricultural land uses on stream water quality; and
- the Consequences of such a spring or springs on Aesthetics in Nepean River would be Minor given that Mallaty Creek discharges to Ousedale Creek and the confluence receives additional flows from Upper Ousedale Creek.

On the basis of the information summarised above it is concluded that:

- the Likelihood of one or more ferruginous springs arising within Leafs Gully Creek or Upper Nepean Creek catchment from subsidence-related effects within that catchment as a consequence of the mining of proposed Longwalls 25 and 26 is Minor; and

- the Consequences of such a spring or springs to the Ecological Health of immediate downstream pool(s) in the Creek would be Insignificant under high flow conditions but Minor under low flow conditions and we principally base this conclusion on the existing effects of local agricultural land uses on stream water quality; and
- the Consequences of such a spring or springs to Property would be Minor and we again base this on a minor risk of potential contamination to a farm or commercial water storage dam; and
- the Consequences of such a spring or springs on Aesthetics in Nepean River would be Major.

8.5. GROUNDWATER

- West Cliff mine has been operating since 1976 and longwall extraction commenced in 1981.
- No reported inflows to the mine have occurred along geological structures.
- No significant inflow into the mine has occurred.

The mine has mined under BCD reservoir without connection between reservoir and workings. There is negligible risk of any significant impacts on the groundwater in the mining area.

Regular statutory inspections are undertaken that would identify any significant groundwater ingress.

Mining generally avoids known geological structures as longwall techniques are not flexible.

9. SUBSIDENCE PREDICTIONS AND IMPACTS ON ECOLOGY

Biosis Research Pty. Ltd. undertook an assessment of the potential subsidence impacts of proposed mining of Longwalls 34 to 36 on terrestrial and aquatic flora and fauna and the following summary is taken from the report attached as **Appendix D**.

9.1. PREDICTED IMPACTS OF MINING INDUCED SUBSIDENCE

The greatest potential for impacts on flora and fauna 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 flora and fauna habitats are reliant on these surface waters, some impacts are possible, which are discussed below.

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.

9.2. VEGETATION COMMUNITIES

There are six vegetation communities present within the SMP area. These include:

Sandstone Ridgetop Woodland

Sandstone Ridgetop Woodland is structurally variable and may lack a tree stratum. Shrub density is highly variable, with the density of obligate seeders varying as a function of fire frequency. This community occurs predominantly on sandstone ridgetops and plateaux, but may extend to the floor of shallow gullies to steeper gullies, woodland grades into one of two forms of Sandstone Gully Forest, depending on rainfall. In poorly drained areas Woodland abruptly changes to sedgeland.

Approximately 10 hectares of this vegetation type was present as four small patches on the eastern edges of the Study Area. Whilst not all these patches were sampled during the field survey, those that were are considered to be in good condition. Sandstone Ridgetop Woodland does not constitute an Endangered Ecological Community and, due to its position in the landscape, is not likely to be impacted by the proposal.

Cumberland Plain Woodland

Approximately 64 hectares of Cumberland Plain Woodland is present within the Study Area as isolated and fragmented patches on the western side of Appin Road. These patches are, however, linked by the adjacent Shale Sandstone Transition Forest which is relatively un-fragmented. The bulk of this community was assessed as being in a poor to moderate condition with substantial impacts from land clearance and grazing.

Shale Sandstone Transition Forest

Approximately 273 hectares of Shale Sandstone Transition Forest is present within the Study Area and forms contiguous patches of vegetation along the plateau above the western bank of the Georges River. It is also present along Mallaty Creek and Leafs Gully on the western side of Appin Road. This community was assessed as being in a moderate condition within the Study Area due to its inherent resilience and un-fragmented state. This assessment was made despite impacts from land clearance, grazing and weed invasion.

Moist Shale Woodland

Approximately 0.6 hectares of Moist Shale Woodland is present on the edge of the SMP area, approximately 450 metres to the south of Longwall 34. This community was not sampled during the field assessment, however from aerial photography it is likely to be highly disturbed and in poor condition. It is unlikely that this patch of vegetation will be impacted by subsidence as it is not ecologically dependent on water flows and is located on the edge of the SMP area.

Upper Georges River Sandstone Woodland,

Approximately 63 hectares of Upper Georges River Sandstone Woodland is present within the Study Area and, in conjunction with Sandstone Ridgetop Woodland and Western Sandstone Gully Forest, forms a band of contiguous vegetation along the sandstone slopes and scarps above the eastern and western banks of the Georges River. This community was assessed as being in a good condition within the Study Area due to its inherent resilience and un-fragmented state. Upper Georges River Sandstone Woodland does not constitute an Endangered Ecological Community and, due to its position in the landscape, is not likely to be impacted by the proposal.

Western Sandstone Gully Forest

Approximately 74 hectares of Western Sandstone Gully Forest is present within the Study Area and forms a band of contiguous vegetation along the banks of Georges River. A narrow band of Riparian Scrub usually occupies the creekline, however in this case no Riparian Scrub is present in the Study Area.

Western Sandstone Gully Forest was assessed as being in a good condition within the Study Area due to its inherent resilience and un-fragmented state, despite localised areas of weed infestation. This vegetation community does not constitute an Endangered Ecological Community.

Cleared land with little or no flora habitat value was also present within the Study Area. It should be noted that this vegetation is highly modified and does not constitute a native vegetation community. This was mostly improved pasture, which reflects the previous disturbances of vegetation clearing, over-grazing and the addition of fertilisers to the paddocks.

Three Endangered Ecological Communities (EECs) were recorded in the Study Area (Figure 3). They include Cumberland Plain Woodland and Shale Sandstone Transition Forest which are both listed as EECs on the TSC Act and the EPBC Act, and Moist Shale Woodland which is listed on the TSC Act only.

Each of these EECs occur on the undulating topography on shale derived and shale influenced sandy soils respectively. While creeks and or drainage lines may cut thorough these EECs, they are entirely terrestrial in nature. Unlike wetlands or other flow-dependent vegetation communities, they are not dependent on the flow of water from creeks or streams. Surface cracking, as predicted by MSEC, is likely to be the only subsidence related impact to occur within these EECs, and cracking alone is unlikely to alter the species composition or distribution of these communities. For these reasons it is considered unlikely that subsidence impacts would have a significant impact on these EECs within the Study Area.

Gas emissions may result from sandstone fracturing above areas where coal is being extracted from longwalls. The liberation of gas emissions has been observed within the Cataract River above the workings of Tower Colliery. The impact of the gas emissions above these workings was localised and resulted in the loss of some plants in a very small area and that the vegetation recovered after gas emissions ceased. Gas emissions are unlikely to result in the alteration of species distribution or composition within the three EECs and, as such, it is considered that the proposed longwall activities would be unlikely to have a significant impact on these EECs. Seven Part Tests (TSC Act) and Significant Impact Criteria (EPBC Act) have not been carried out for these EECs in this case as no significant impacts are predicted to occur.

9.3. FLORA

Potential habitat within the Study Area exists for nine threatened plant species: *Acacia bynoeana, Callistemon linearifolius, Leucopogon exolasius, Persoonia bargoensis, Persoonia hirsuta, Pimelea spicata, Pomaderris brunnea, Pterostylis saxicola* and *Pultenaea pedunculata*. It should be noted that *Pultenaea pedunculata* has been previously recorded within the western part of the Study Area but was not recorded during the field survey for this assessment. *Acacia bynoeana, Callistemon linearifolius*, *Persoonia hirsuta* and *Pomaderris brunnea* have been previously recorded adjacent to the Study Area. *Grevillea parviflora* ssp. *parviflora* was the only threatened plant species recorded within the Study Area during the field survey.

The volume of water available for plant use within the Study Area is unlikely to be significantly altered. It is therefore considered unlikely that subsidence impacts would result in a broad change in the floristic composition of the riparian zone. However, subsidence may affect the way in which water is made available to plants within the area, leading to small changes in riparian vegetation.

Potential changes in the riparian vegetation may include:

- loss of aquatic plants (e.g. *Eleocharis sphacelata* and *Potamogeton crispus*); and
- loss of individuals, changes in species distribution and abundance for those species requiring moist conditions (e.g. *Drosera* spp.)

None of the threatened plant species listed above, or their potential habitats, are dependent on water availability or riparian vegetation. All are found away from potentially impacted riparian areas, and generally on relatively unaffected plateau and ridgelines. As such it is unlikely that any of these species would be significantly impacted by subsidence. None of these species are aquatic plants and they would generally be confined in distribution to the drier sclerophyll vegetation of the Sandstone Ridgetop Woodland, Upper Georges River Sandstone Woodland and Western Sandstone Gully Forest communities. Seven Part Tests and Significant Impact Criteria have not been conducted for any threatened flora as no significant impacts are predicted to occur.

9.4. FAUNA

Potential impacts on fauna and their habitats will occur where the disturbance to the soils and near surface strata are the greatest, resulting in changes to surface water conditions.

Where fauna and their habitats are reliant on these surface waters, some impacts are possible. It is possible that fracturing of the Georges River bed will occur, but it is unlikely to result in any noticeable loss of surface water flows or quality (Ecoengineers 2007). Any fractures that do occur may result in surface flows being redirected into the dilated strata below to re-surface downstream and/or reduced overflow and increased leakage at rockbars. However, observations indicate that surface flow diversions are generally limited to sections of river located directly above the longwalls, which is not the case here (i.e. none of the longwalls extend completely under the Georges River). It is therefore unlikely that native fauna that rely on these areas will be significantly impacted by the proposed longwall extraction.

Where the creeks have an alluvial bed above the strata, it is unlikely that cracking in the strata will continue up to the surface (MSEC 2007). In the unlikely event that it does, the cracks are likely to be filled with alluvial material during subsequent flow events. Where the creek beds are exposed rock, there may be some loss of water from the creek beds into the dilated strata beneath them and the draining of some of the pools that exist within the creek alignments (MSEC 2007). However, the creek lines generally occur on gentle, undulating land and are unlikely to be significantly altered by mining induced subsidence. Furthermore, the creek lines and associated pools are ephemeral and it is likely that fauna reliant on them would be adapted to using a non-perennial water source. It is therefore unlikely that native fauna that rely on these areas will be significantly impacted by the proposed longwall extraction.

Small areas of two cliff lines in the Georges River valley have been identified as potentially being subject to alteration by mining. As discussed above, the predicted extent of possible alteration equates to a maximum of 21 and 16 m of the cliff lines respectively. Cliff lines are unlikely to be impacted in the western end of the Study Area (i.e. Nepean River valley and associated tributaries). Consequently, it is unlikely that native fauna that live in such areas will be significantly impacted by the proposed longwall extraction.

Gas emission through alluvial or rocky substrate within a watercourse are unlikely to result in adverse water quality impacts Gas emissions are expected to be very low and it is unlikely that any significant negative impacts on fauna or their habitats will occur.

Water quality has been discussed in detail in **Section 8.4** of this report. Water quality in both the Georges River in the east and the Nepean River and associated tributaries in the west of the Study Area is not likely to be significantly altered by the proposal and therefore is unlikely to alter habitats of terrestrial ecological values.

Given the nature of the likely subsidence impacts and that significant fauna habitats will not be directly mined beneath by the proposal, it is considered that the proposed longwall extraction would not have a significant impact on any important fauna habitats.

10. SUBSIDENCE PREDICTIONS AND IMPACTS ON MAN-MADE FEATURES

Details of the predicted subsidence parameters for each of the items of infrastructure are provided in **Appendix A**. The following sections provide a summary of predictions and the impact assessments for the SMP Area, due to the extraction of proposed Longwalls 34 to 36. The infrastructure is shown on **Plan 2** and in the Figures referred to in separate figures in the report.

10.1 ROADS

The locations of Appin Road within the SMP Area are presented in **Figure 6.3**.

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 **Appendix A**. 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 10.1**.

Table 10.1 - Maximum Predicted Cumulative Systematic Subsidence, Tilt and Strain along the Alignment of Appin Road Resulting from the Extraction of Longwalls 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 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 10.2**.

Table 10.2 - 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

Impact Assessments for Appin Road

It is unlikely 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 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.

Refer **Appendix A** for predicted tilts and strains at Appin Road.

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.

10.2 CULVERTS

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.

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

10.3 SYDNEY CATCHMENT AUTHORITY INFRASTRUCTURE

10.3.1 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.

10.3.2 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 **Figure 6.6**. 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 10.3**.

Table 10.3 - 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 **Figure 6.6**. 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.

10.3.3 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 **Figure 6.6**.

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.

10.3.4 Predictions and Impact Assessments on 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.

10.3.5 Predictions and Impact Assessment 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. 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 10.4**.

Table 10.4 - 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.

10.3.6 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.

10.4 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 **Figure 6.6**. The predictions and impact assessments for the pipeline are provided in the following sections.

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 **Appendix A**. 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 10.5**.

Table 10.5 - 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 10.6**.

Table 10.6 - 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 **Figure 6.5**. 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 10.7**.

Table 10.7 - 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	Mallaty Creek	455	645
Water	Leafs Gully	95	45
Pipeline	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 **Appendix A**.

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 10.8**.

Table 10.8 - 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 10.5** and **Table 10.6**, are less than the MSB minimum design requirements, which are summarised in **Table 10.8**. However, the maximum predicted valley related movements at the drainage line crossings, which are summarised in **Table 10.7**, are greater than the MSB minimum design requirements, which are summarised in **Table 10.8**.

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.

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.

10.5 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 **Figure 6.6**. The predictions and impact assessments for the pipeline are provided in the following sections.

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 Appendix A. 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 10.9**.

Table 10.9 - 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 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 10.10**.

Table 10.10 - 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.

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.

Refer **Appendix A** for details of previously mined longwalls under the Sydney Water Pipeline.

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.

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.

10.6 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 **Figure 6.7**. The predictions and impact assessments for the pipelines are provided in the following sections.

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 **Appendix A**. 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 10.11**.

Table 10.11 - 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 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 10.12**.

Table 10.12 - 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 **Figure 6.5**. 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 10.13**.

Table 10.13 - Maximum Predicted Total Upsidence and Closure Movements at the Drainage Line Crossings Resulting from the Extraction of Longwalls 34 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 AGL 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

10.6.1 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 10.14**.

Table 10.14 - 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 10.12** and **Table 10.13**, are less than the MSB minimum design requirements, which are summarised in **Table 10.14**. However, the maximum predicted valley related movements at the drainage line crossings, which are summarised in **Table 10.13**, are greater than the MSB minimum design requirements, which are summarised in **Table 10.14.**

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. 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.

10.6.2 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. 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.

10.6.3 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. 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.

10.7 ELECTRICAL SERVICES

The major electrical services within the SMP Area include the 330kV transmission line, which is owned by TransGrid, and the 66kV, 11kV and low voltage powerlines, which are owned by Integral Energy. The locations of the electrical services within the SMP Area are shown in **Figure 6.8**. The following sections provide the predictions and impact assessments for these electrical services.

10.7.1 330kV Transmission Lines

The 330 kV transmission line crosses the western ends of the proposed Longwalls 34 to 36, the location of which is shown in **Figure 6.8**. The predictions and impact assessments for the transmission line are provided in the following sections.

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 **Appendix A**. 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 **Appendix A**.

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 10.15**.

Table 10.15 - 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 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 10.16**.

Table 10.16 - 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 10.17**.

Table 10.17 - 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.

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.

Refer **Appendix A** for predicted tilts and strains at 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 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.

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.

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.

10.7.2 66 kV and 11 kV Powerlines

The locations of the powerlines within the SMP Area are shown in **Figure 6.8**. The predictions and impact assessments for the powerlines are provided in the following sections.

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 **Appendix** A.

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 **Appendix A**.

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 **Appendix A**.

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 10.18**.

Table 10.18 - 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 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 10.19**.

Table 10.19 - 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

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.

Refer **Appendix A** for predicted subsidence and tilt at the power lines.

It is unlikely 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.

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.

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.

10.8 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 **Figure 6.8**. The predictions and impact assessments for the optical fibre cable are provided in the following sections.

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 **Appendix A**. 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 10.20**.

Table 10.20 - 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 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 10.21**.

Table 10.21 - 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.

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.

Refer **Appendix A** for predicted strains at the optical fibre cable.

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.

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.

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.

10.9 TELECOMMUNICATIONS SERVICES

The locations of the copper telecommunications cables within the SMP Area are shown in **Figure 6.9**. The predictions and impact assessments for the copper telecommunications cables are provided in the following sections.

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 **Appendix A**.

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 **Appendix A**.

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 10.22**.

Table 10.22 - 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 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 10.23**.

Table 10.23 - 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.

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.

Refer **Appendix A** for predicted strains at the cables.

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.

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.

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.

10.10 FARM LAND AND FACILITIES

The following sections provide the subsidence predictions and impact assessments for the farm land and facilities within the SMP Area, due to the extraction of the proposed Longwalls 34 to 36.

10.10.1 Farm Buildings and Sheds

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 locations of the rural building structures are shown in **Appendix A**. The impact assessments for the rural building structures within the SMP Area are provided in the following sections.

Predictions for the Rural Building Structures

The maximum predicted subsidence and the impact assessments for tilt and strain for each rural building structure within the SMP Area are provided in **Appendix A**. 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 10.24**.

Table 10.24 - 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.

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.

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 summarised in **Table 10.25**.

Table 10.25 - 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.

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.

10.10.2 Tanks

There are 90 tanks (Structure Type T) that have been identified within the SMP Area. The locations of the tanks are provided in **Appendix A**. The impact assessments for the tanks within the SMP Area are provided in the following sections.

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 **Appendix A**. 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.

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.

Refer **Appendix A** for predicted strains at the tanks.

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.

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.

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

10.10.3 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.

Refer **Appendix A** for predicted tilts within the SMP Area

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.

10.10.4 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 **Appendix A**. The predictions and impact assessments for the farm dams are provided in the following sections.

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 **Appendix A**.

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.

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 **Appendix A**.

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.

Refer **Appendix A** for maximum predicted strains at the farm dams.

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.

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.

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 as part of the PSMP for each property.

10.10.5 Wells and 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 **Figure 6.2**. 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.

10.10.6 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.

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 are provided in Appendix A.

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 maximum predicted subsidence and the impact assessments for tilt and strain for each building structure on Inghams Farm No. 3 are provided in **Appendix A**. 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 10.26**. 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 10.27**.

Table 10.26 - 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 10.27 - 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.

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.

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.

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.

10.11 ARCHAEOLOGICAL SITES

There are nine archaeological sites that have been identified within the SMP Area, the locations of which are shown in **Figure 6.2**. The predictions and impact assessments for these archaeological sites are provided in the following sections.

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 10.28**.

Table 10.28 - 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

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 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.

Further assessments of the potential impacts on the archaeological sites are provided in a report by Biosis (2007b) in **Appendix E**.

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.

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.

10.12 HERITAGE SITES

The locations of the heritage sites within the SMP Area are shown in **Figure 6.2**. The predictions and impact assessments for these sites are provided in the following sections.

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 10.29**.

Table 10.29 - 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

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.

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.

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.

10.13 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 **Figure 6.2**. The predictions and impact assessments for the survey control marks are provided in the following sections.

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 10.30**.

Table 10.30 - 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

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.

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.

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.

10.14 RESIDENTIAL ESTABLISHMENTS

10.14.1 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).

The locations of the houses within the SMP Area are shown in **Appendix A**. The impact assessments for the houses within the SMP Area are provided in the following sections.

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 maximum predicted subsidence and the impact assessments for tilt and strain for each house within the SMP Area are provided in **Appendix A**. 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 10.31**.

Table 10.31 - 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.

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.

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.

Refer **Appendix A** for details on impacts on houses at Tahmoor Colliery.

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.

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.

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 **Appendix A** and are summarised in **Table 10.32**.

Table 10.32 - 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.

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.

10.14.2 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 **Appendix A**.

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 **10.33**.

Table 10.33 - 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 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.

10.14.3 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 Appendix A, 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 10.34**.

Table 10.34 - 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.

Refer **Appendix A** for predicted strains at the on-site waste water systems.

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

10.14.4 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 Appendix A, as these predictions are the maximum values within 20 metres of the houses.

Refer **Appendix A** for predicted tilt and strains at the houses.

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.

10.15 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 **Figure 4.3**. 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 (refer **Appendix A**).

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.

10.16 PREDICTED REGIONAL 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

10.17 OTHER POTENTIAL IMPACTS

10.17.6 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.

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.

10.17.7 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.

10.17.8 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.

10.17.9 The Potential of 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 400m. 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.

Subsidence movements are gradual and cannot be detected 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, stresses in surface rocks 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 soil, the noise resulting from the fracturing can be heard at the surface. Background noise in the countryside is generally such that any sound is not significant. In the stillness of night these sounds might occasionally be noticed when it occurs in close proximity. The impact due to noise at the surface resulting from the extraction of the proposed longwall is predicted to be insignificant.

11 STATUTORY REQUIREMENTS

(SMP GUIDELINES SECTION 6.9)

This section identifies the statutory requirements that apply to the SMP Area and the proposed mining operation in relation to any potential subsidence impacts. A range of environmental legislation is applicable to mining in NSW and the DPIM aims to promote the responsible development of the State's resources for the community's benefit. The Department is therefore concerned to ensure that any adverse effects of mining are minimised, and that a consistent high standard of environmental protection and rehabilitation is practiced throughout NSW.

11.1 STATUTORY PROCESS FOR APPROVALS

Under current legislation, the major approvals required for mining Longwalls 34 to 36 using longwall extraction methods include:

- a mining lease granted under the *Mining Act 1992*;
- various approvals required under the mining lease associated with land use and environmental impacts. To obtain this a Subsidence Management Plan (SMP) must be prepared and approved by the DPIM;
- Compliance by DPIM with Part 5 of the EP&A Act 1979 for approval of the Subsidence Management Plan;
- Section 88 Approval under the *Coal Mines Health and Safety Act 2006.*

11.1.1 Mining Leases

The key mining leases covering West Cliff Colliery include:

- Consolidated Coal Lease No. 767 (renewal date 3 September 2010) covering the majority of the West Cliff Colliery lease area;
- Coal Lease No. 388 (renewal date 22 January 2012). This lease covers the Upper Canal.

11.1.2 Mining Lease Conditions

The SMP approval process was introduced by DPIM by insertion of a new mining lease condition as detailed below. This lease condition requires the approval of an SMP prior to coal extraction that may result in subsidence of the surface.

Mining leases (CCL767 and CL388) contains the following SMP condition:

- The leaseholder shall prepare a Subsidence Management Plan prior to commencing any underground mining operations which will potentially lead to subsidence of the land surface;
- Underground mining operations which will potentially lead to subsidence include secondary extraction panels such as longwalls or miniwalls, associated first workings

(gateroads, installation roads and associated main headings, etc), and pillar extractions, and are otherwise defined by the *Guideline for Applications for Subsidence Management Approvals*;

- The leaseholder must not commence or undertake underground mining operations that will potentially lead to subsidence other than in accordance with a Subsidence Management Plan approved by the Director-General, an approval under the *Coal Mines Regulation Act 1982*, or the document *New Subsidence Management Plan Approval Process - Transitional Provisions*;
- Subsidence Management Plans are to be prepared in accordance with the *Guideline for Applications for Subsidence Management Approvals*;
- Subsidence Management Plans as approved shall form part of the Mining Operations Plan required under Condition 2 and will be subject to the Annual Environmental Management Report process as set out under Condition 3. The SMP is also subject to the requirements for subsidence monitoring and reporting set out in the document *New Approval Process for Management of Coal Mining Subsidence – Policy*.

Consequently, as a lease condition, an SMP must be approved by the DPIM to allow the proposed longwall mining of Longwalls 34 to 36 to occur.

11.1.3 SMP

The main areas to be addressed by an SMP application include:

- The proposed mining system(s) and resource recovery;
- Community consultation;
- Statutory requirements that apply to the SMP Area;
- Expected subsidence and its potential impacts on public safety, the environment, community, land use, surface improvements and infrastructure;
- The proposed Subsidence Management Plan for the expected subsidence impacts.

The SMP approval requires an outcome-based systems approach. The SMP must be capable of managing potential subsidence impacts to produce outcomes that are consistent with government policies and which take into account community expectations. The emphasis of the approach is on the quality and effectiveness of the proposed management solutions and their outcomes. An SMP approval is restricted to a maximum period of seven years.

The SMP application is assessed by a DPIM SMP Review Committee comprising the Director Environment (Chair), Assistant Director Environment, Chief Inspector of Coal Mines, Principal Subsidence Engineer, Manager Policy and Legislative Review and Chief Geologist Coal and Petroleum.

A Subsidence Management Plan Review Committee has been established to:

- advise the Director-General on the environmental implications of predicted subsidence as detailed in Mine Subsidence Management Plans and to recommend an appropriate and effective suite of conditions to be attached to any approval;

- review annually the results of monitoring supplied by mining companies in compliance with their approvals and to make recommendations on any amendments to subsidence management or to rehabilitation methods;
- advise on the management of subsidence controlled under section 138 approvals, particularly in relation to sensitive areas and where those approvals are granted after 31 December 2003.

The DPIM is represented by the Director Strategic Planning and Policy, Director Environment and the Assistant Director Safety Operations. The Committee also includes representatives nominated by the CEO of each of the following agencies:

- Department of Planning;
- Department of Natural Resources;
- Department of Environment and Conservation;
- NSW Fisheries;
- Dams Safety Committee;
- Sydney Catchment Authority;
- Mine Subsidence Board;
- Other agencies where their interest is recognised by the Committee.

The Committee is chaired by the Director Environment or Assistant Director Environment DPIM. The approach taken in assessing SMP applications is one of openness and consultation with all parties affected by the proposal. A consensus solution is always sought. However, where consensus is not possible, the Deputy Director-General (or delegate) will make a decision on the basis of all the available information.

11.1.4 Development Consent

Longwalls 34 to 36 are within an existing mining lease, where there is an existing mine, and is subject to the Wollondilly Local Environment Plan which adopts Clauses 35 and Schedule 1(7) of the Environmental Planning and Assessment Model Provisions. Under these provisions the Development Consent is therefore not required for the project. However, the EP&A Act requires that DPIM comply with Part 5 of the EP&A Act when determining the SMP application for Longwalls 34 to 36. This report provides information on the environmental impacts of the Activity (the activity being the proposed mining of Longwalls 34 to 36 and the mitigation and rehabilitation measures that will be implemented to minimise impacts from this mining).

11.2 OTHER RELEVANT LEGISLATION

11.2.1 Mining Act 1992

Primary regulatory control is exercised over mining by the DPIM through the provisions of the *Mining Act 1992* and the conditions attached to mining leases granted under the provisions of that Act. The preparation of an SMP is required where underground mining is likely to lead to subsidence. This SMP has been prepared as part of the application for submission to the DPIM, seeking approval to mine Longwalls 34 to 36.

11.2.2 Environmental Planning and Assessment Act 1979

The *Environmental Planning and Assessment Act* 1979 is administered by the Department of Planning. It institutes a system of environmental planning and assessment for NSW. The objectives of the EP&A Act are to encourage:

- the proper management, development and conservation of natural and constructed resources;
- public involvement;
- promotion and co-ordination of the orderly and economic use and development of land;
- ecologically sustainable development;
- the protection of the environment.

11.2.3 Coal Mines Health and Safety Regulation 2006

The *Coal Mines Health and Safety Regulation 2006* (CMH&S Reg) is administered by DPIM. Under Section 88 of the Regulation, a mining company must submit and have approved an application for approval to the DPIM prior to commencement of secondary extraction

An application for the extraction of coal under Section 88 of the CMH&S Reg for Longwalls 34 to 36 will be submitted for approval prior to the extraction of Longwall 34.

11.2.4 Environmental Protection and Biodiversity Conservation Act 1999

The Commonwealth's mechanism for national environmental protection is the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act). Under the EPBC Act, any action which has, will have, or is likely to have a significant impact on a matter of national environmental significance, or is undertaken on Commonwealth land is defined as a controlled action and requires approval by the Minister for the Environment.

11.2.5 Protection of the Environment Operations Act 1997

The *Protection of the Environment Operations Act* 1997 (POEO Act) is administered by the DECC. The Act establishes the procedures for issuance of licences for environmental protection including waste, air, water and noise pollution control. The owner or operator of a premise that is engaged in scheduled activities is required to hold an Environment Protection Licence and comply with the conditions of the licence.

West Cliff Colliery holds Environment Protection Licence No. 2504 granted by the EPA. No variance to this licence is required for the proposed longwall extraction.

11.2.6 Fisheries Management Act 1994

The *Fisheries Management Act* 1994 was amended by the inclusion of provisions (listed in the *Fisheries Management Amendment Act* 1997) to declare and list threatened species of fish and marine vegetation, endangered populations and ecological communities and key threatening processes. One of the major features of the legislation is the integration of threatened aquatic species into the development control processes under the EP&A Act.

EP&A 1979 Act sets out the factors to be considered in a preliminary assessment of whether there is likely to be a significant effect on threatened species arising from a development. Eight factors are considered in a process referred to as the Eight-Part Test. The test is a series of questions, the answers to which assist in determining whether a planned action will significantly affect threatened species, populations, ecological communities or their habitats. For the Eight-Part Test to have relevance there must be the likelihood that one or more threatened species occur in an area which could be affected by the proposal.

If it is determined by the Government Regulator that, on the basis of the Eight-Part Test, that the proposal is likely to significantly affect threatened species, populations, ecological communities or their habitats, the preparation of a Species Impact Statement (SIS) is required as part of the environmental assessment process for approval of the development under Part 5 of the EP&A Act. In making such a determination, it is important that the proposal be considered in its entirety, including mitigative measures designed to remove or minimise impacts to the aquatic environment.

11.2.7 Dam Safety Act 1978

The proposed mining is not under any dams (including stored waters and reservoirs) and/or under structures or designated areas referred to by the Dams Safety Act 1978.

11.2.8 Sydney Water Catchment Management Act 1998

The *Sydney Water Catchment Management Act* establishes arrangements for the supply of bulk water, the management of water quality and the improvement of catchment health. It outlines the role, objectives and functions of the SCA including the management and protection of catchment areas, catchment infrastructure and water quality in the catchments.

11.2.9 National Parks and Wildlife Act 1974

The National Parks and Wildlife Act provides for the protection of Aboriginal sites and places. It is an offence to damage, deface or destroy any Aboriginal site or place without consent. Illawarra Coal will seek s90 consents prior to mining Longwalls 34-36, although the risk of damage to shelter sites is low. The Act also prescribes the protections and values of State Conservation Areas.

11.3 OTHER APPROVALS AND PROVISIONS

Any necessary approvals, consents, licenses or permits will be in place prior to any impact resulting from subsidence.

Agreement with infrastructure owners is required prior to mining in relation to the proposed mitigation and remediation works associated with the longwall extraction.

Following mining and prior to any identified remediation measures being carried out, additional approvals may be required. Such approvals cannot be obtained until the areas requiring remediation are identified and site specific plans developed.

11.3.1 Threatening Processes

On the 26 June 2005 the NSW Scientific Committee established by the NSW *Threatened Species Conservation Act* made a Final Determination to list Alteration of Habitat Following Subsidence due to Longwall Mining as a Key Threatening Process in Schedule 3 of the Act.

While longwall mining has been listed as a key threatening process the normal processes of assessment still apply to it. Meetings between the DEC and the DPIM to discuss the implications of the listing, it was decided that a threat abatement plan would not be prepared because SMP and other approval processes already satisfactorily addressed subsidence impacts on the environment, including impacts on threatened species and their habitats.

11.3.2 Mining under Heritage Items

One previously identified historic heritage item, the Upper Canal, is situated within close proximity to the SMP Area. The Upper Canal system is listed on the Register of the National Estate, the State Heritage Register, the Campbelltown LEP 2002 – District 8, Heritage Schedule 1 and the Sydney Catchment Authority S170 Heritage and Conservation Register. The Upper Canal comprises several identified components (such as the Cataract Tunnel, the canal, and numerous flumes, culverts and aqueducts) and has been identified as a heritage item of state-level heritage significance.

Four other historic features have been identified within the SMP Study Area, including the remains of an early pub site, grave site, former house site and a former crossing and related roadway over the Georges River.

The existing CMP for the Upper Canal should be followed at all times. The potential for far-field subsidence movements identified by MSEC (2007) should be taken into consideration, and if required, the management plan (CMP) amended accordingly.

Consultation between BHP Billiton Illawarra Coal, MSEC, the Sydney Catchment Authority heritage officer and the NSW Heritage Council / NSW Heritage Office should be an integral component of this process.

Although it is unlikely that these sites will be impacted as a result of mining associated within Longwalls 34-36, it is recommended that monitoring of historic road site (WH1) on the Georges River, should occur prior, during and after longwall extraction.

11.3.3 Mining under Areas of Potential Archaeological Significance

Aboriginal heritage management in NSW is provided for by two pieces of legislation: the *National Parks and Wildlife Act* 1974 and the *Environmental Planning and Assessment Act* 1979. These acts provide protection for all material relating to the past Aboriginal occupation of Australia.

Nine previously recorded Aboriginal archaeological sites are situated within the Subsidence Management Plan (SMP) Area surrounding Longwalls 34 to 36. These include three stone artefact scatter sites, and six shelters with art and / or deposit sites. All of these sites have been registered on the Aboriginal Heritage Information Management System at DECC. All six of the shelters with art and / or deposit sites are situated within the SMP Area.

Based on the subsidence predictions provided by MSEC (2007), it is unlikely that there will be significant impacts to the archaeological sites resulting from the proposed longwall mining.

However, as six of the Aboriginal archaeological shelter with art sites (52-2-2234, 52-2-2237, 52-2-2241, 52-2-2242, 52-2-2243, and 52-2-2244) are located within the SMP Area, a monitoring program will be implemented.

The monitoring program would involve site visits prior to the commencement of extraction of Longwalls 34 to 36, during extraction and 3, 6 and 12 months following the completion of extraction adjacent to the sites.

Notwithstanding the low probability of damage to these sites, BHP Billiton Illawarra Coal will apply for consents under s90 of the National Parks and Wildlife Act 1974 for sites:

- 52-2-2234
- 52-2-2241
- 52-2-2242
- 52-2-2243
- 52-2-2244

An application for a Section 90 consent for site 52-2-2237 has been submitted to the DECC in light of the low probability of damage that may arise from mining Longwall 33. Ongoing consultation will continue between BHP Billiton Illawarra Coal, the Tharawal Local Aboriginal Land Council, Cubbitch Barta Native Title Claimants, and DECC as required.

12 RISK ASSESSMENT

In January 2008, AXYS Consulting was engaged to facilitate a qualitative risk assessment to critically examine West Cliff Colliery's Longwalls 34 to 36 mining plan to identify and assess mine subsidence-related risk issues. The Risk Assessment is attached as **Appendix G**.

The assessment considers potential loss impacts including effects on West Cliff Colliery's strategic, business and operational objectives as well as third party and environmental aspects. Risk ranking was undertaken in accordance with the BHP Billiton Enterprise Wide Risk Management (EWRM) Standard Risk Matrix shown in *Appendix A – EWRM Risk Matrix*.

The objectives of the risk assessment were to:

- Assist West Cliff Colliery in identification and control of subsidence risks associated with mining of Longwalls 34 to 36 in accordance with:
  - BHP Billiton Standards;
  - Australian Standards;
  - Planning, Environmental, OH&S, Mining and other Legislation.
- Facilitate and record the risk assessment for the identification of hazards and assessment of risk in accordance with AS4360:2004, BHP Billiton EWRM Standard and MDG1010;
- Provide a report detailing the outcomes of the risk assessment, including:
  - Risk issues, causes and impacts;
  - Identification of existing risk mitigation controls;
  - EWRM risk rating;
  - Risk reduction strategy/actions.

In accordance with the scope, high level risk issues were considered and recorded by the risk assessment team. The reader should refer to the sections regarding the Objectives, Scope and Assumption and Limitations of this risk assessment.

Attachment 2 (Analysis Worksheets) of **Appendix G** identifies all of the hazards, existing controls, risk rankings and any new treatment options and the people responsible for their implementation.

Attachment 5 (Risk Treatment Schedule) of **Appendix G** provides a format of all the new treatment options and the people responsible for their implementation. In addition a required date and sign off is also provided.

Attachment 3 and 4 (Risk Rank Order and Consequence Order) of **Appendix G** provides all of the identified hazards and treatment options in order of highest risk to lowest risk and from highest consequence to lowest consequence. The BHPB EWRM standard does not require these reports, however to provide compliance to the Department of Primary Industries MDG1010 and MDG1014 standards they are included.

13 COMMUNITY AND STAKEHOLDER CONSULTATION

(*SMP GUIDELINES SECTION 6.8)*

The SMP Guidelines outlines a process of community consultation regarding persons or organisations that may be impacted by predicted subsidence following extraction of Longwalls 34 to 36.

13.1 IDENTIFICATION OF RELEVANT STAKEHOLDERS

Stakeholders who have an interest in or concern about subsidence issues related to the mining project include:

- Private Landowners;
- The Appin Area Community Working Group;
- The Wider Community
- SCA;
- DECC;
- DPIM;
- Alinta;
- AGL;
- Gorodok;
- Telstra;
- Transgrid;
- Integral Energy;
- Wollondilly Shire Council;
- NSW Heritage Council;
- Mines Subsidence Board;
- The Cubbitch Barta Native Title Claimants Group;
- Tharawal Local Aboriginal Land Council.

13.2 CONSULTATION PROCESS

Consultation undertaken has involved:

- Advertising in Local and State newspapers;
- Meetings with individual landowners;
- Specific meetings with infrastructure owners;
- A Risk Assessment process involving infrastructure owners and relevant agencies;
- Community consultation via the Appin Area Community Working Group;

- Aboriginal consultation during the baseline archaeological survey.

13.3 ADVERTISING THE SMP

Pre-lodgement advertisements have been placed in both state and local newspapers advising that a Subsidence Management Plan covering the extraction of Longwalls 34 to 36 at West Cliff Colliery will be submitted. The advertisements included a map which clearly showed the planned extraction area in relation to existing workings and information about where submissions could be sent. The dates for the advertisements were:

- Macarthur Chronicle (Local) – January 2008;
- Wollondilly Advertiser (Local) – January 2008;
- The Land (State) – January 2008.

Post-lodgement advertisements will also be placed in both state and local newspapers advising that a Subsidence Management Plan covering the extraction of Longwalls 34 to 36 at West Cliff Colliery has been submitted. This advertisement will detail a month long exhibition period including where the SMP can be viewed and details of where submissions can be sent.

A copy of the pre-lodgement advertisement is included in **Appendix F**.

13.3.1 Responses from the Community

The Appin Area Community Working Group has requested that digital copies of the SMP Application be made available to each member as soon as they are available, to maximise the time for review.

13.4 INFRASTRUCTURE OWNERS CONSULTATION

Due to the previous and current mining of Longwalls 29 to 32 in the area there have been consultation meetings with the various infrastructure owners over the past few years. As a result of this there are monitoring and management measures currently in place for infrastructure within the SMP area including:

- Gas pipelines (Alinta AGL and EGP and Gorodok);
- Sydney Water and Macarthur Water;
- SCA;
- Inghams;
- Electrical infrastructure (Integral Energy and Transgrid).

Significant pipeline mitigation work has been undertaken at Mallaty Creek for the approved Longwalls 29 to 33. The mitigation work was based on earlier assessment of future mining up to Longwall 38.

13.5 COMMUNITY CONSULTATION

Meetings regarding community consulation in relation to the mining of Longwalls 34 to 36 have been held at the Appin Community Office in Appin on the 16 October and 20 November 2007. Members of the Appin community, representatives from Wollondilly Shire Council and BHPIC were present.

13.6 LAND OWNER CONSULTATION

All landowners and occupiers within the SMP Area have been personally contacted by Illawarra Coal to discuss plans for the proposed Longwalls 34 to 36 and an inspection of the rural properties and dams has been conducted. Property Subsidence Management Plans are being prepared with the latest subsidence predictions and relevant structural observations from the recent consultation. The plans will be finalised and provided to the landowners/occupiers prior to mining. Copies are provided to the DPI and the Mine Subsidence Board.

13.7 ABORIGINAL COMMUNITIES CONSULTATION

Consultation for this project has been undertaken with the stakeholders including the identified Local Aboriginal Land Councils, registered Elders Corporations and Registered Native Title claimants that were involved in the original cultural heritage surveys for West Cliff Area 5. Consultation has been undertaken with representatives from the following Aboriginal stakeholder groups:

- Tharawal Local Aboriginal Land Council (Leanne Hestalow and Donna Whillock)
- Cubbitch Barta Native Title Claimants Aboriginal Corporation (Glenda Chalker and Jacara Clark)

A copy of the Biosis report in **Appendix E** has been forwarded to all the above listed Aboriginal communities for comment. The Aboriginal communities will provide advice regarding the cultural significance of the heritage sites.

Further consultation with the Aboriginal community will be conducted as per the DECC's *National Parks and Wildlife Act 1974: Part 6 Approvals Interim Community Consultation Requirements for Applicants* when Consent to Damage permits are sought from DECC.

13.8 AGENCY CONSULTATION

The Southern Coalfields Rivers Remediation Committees consist of senior management representatives of DPIM, DPI Fisheries, DECC, Illawarra Coal and other mining companies. These groups meet to review the strategy for managing rivers and creeks and provide direction for rehabilitation work. The group aims to provide a forum to allow senior management within industry and government to be aware of activities in relation to mining impacts to natural features.

Discussions have been undertaken with the Principal Subsidence Engineer DPIM over an extended period prior to submission of the SMP Application.

13.9 SUMMARY OF STAKEHOLDER CONSULTATION RESULTS

13.9.1 Summary of Issues and Concerns Raised

In general, potential impacts to natural features were not identified as a major concern. Concerns expressed by most stakeholders focused on the risk of structural damage to houses or public infrastructure, although most stakeholders recognised that processes of mitigation, planning, management and (compensation by the MSB) were in place if required.

DPIM raised the assessment and management measures for the tension tower on the Transgrid 330Kv transmission line in particular, in addition to the normal assessment of infrastructure.

13.9.2 Management Priorities Identified

Management priorities identified were to continue the development of monitoring, mitigation and management actions with infrastructure owners, particularly the SCA and gas pipeline owners.

13.9.3 Areas where Subsidence Management is to be Undertaken Jointly

Subsidence management is to be undertaken jointly with the relevant infrastructure owners via meetings, updating management plans, deciding on mitigation options and monitoring programs.

14 SUMMARY AND ASSESSMENT OF ENVIRONMENTAL FACTORS

(SMP Guidelines Section 6.10.4)

14.1 IMPACT ASSESSMENT ON NATURAL FEATURES

Although the Georges 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.

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 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 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.

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.

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.

14.2 ASSESSMENT OF IMPACTS ON FLORA AND FAUNA

Biosis Research Pty Ltd was commissioned by Illawarra Coal to undertake an assessment of the potential subsidence impacts of proposed mining of Longwalls 34 to 36 on terrestrial and aquatic flora and fauna. The report (**Appendix D**) assesses the ecological values of the Study Area and the potential impacts of mining in this area in terms of threatened species, populations or ecological communities that occur, or have the potential to occur in the Study Area.

14.2.1 Assessment of Impact on Flora

Potential habitat within the Study Area exists for nine threatened plant species: *Acacia bynoeana, Callistemon linearifolius, Leucopogon exolasius, Persoonia bargoensis, Persoonia hirsuta, Pimelea spicata, Pomaderris brunnea, Pterostylis saxicola* and *Pultenaea pedunculata*. It should be noted that *Pultenaea pedunculata* has been previously recorded within the western part of the Study Area but was not recorded during the field survey for this assessment. *Acacia bynoeana, Callistemon linearifolius*, *Persoonia hirsuta* and *Pomaderris brunnea* have been previously recorded adjacent to the Study Area. *Grevillea parviflora* ssp. *parviflora* was the only threatened plant species recorded within the Study Area during the field survey.

The volume of water available for plant use within the Study Area is unlikely to be significantly altered. It is therefore considered unlikely that subsidence impacts would result in a broad change in the floristic composition of the riparian zone. However, subsidence may affect the way in which water is made available to plants within the area, leading to small changes in riparian vegetation.

Potential changes in the riparian vegetation may include:

- loss of aquatic plants (e.g. *Eleocharis sphacelata* and *Potamogeton crispus*); and
- loss of individuals, changes in species distribution and abundance for those species requiring moist conditions (e.g. *Drosera* spp.)

None of the threatened plant species listed above, or their potential habitats, are dependent on water availability or riparian vegetation. All are found away from potentially impacted riparian areas, if not on relatively unaffected plateau and ridgelines. As such it is unlikely that any of these species would be significantly impacted by subsidence. None of these species are aquatic plants and they would generally be confined in distribution to the drier sclerophyll vegetation of the Sandstone Ridgetop Woodland, Upper Georges River Sandstone Woodland and Western Sandstone Gully Forest communities. Seven Part Tests and Significant Impact Criteria have not been conducted for any threatened flora as no significant impacts are predicted to occur.

14.2.2 Assessment of Impact on Fauna

Potential impacts on fauna and their habitats will occur where the disturbance to the soils and near surface strata are the greatest, resulting in changes to surface water conditions. Where fauna and their habitats are reliant on these surface waters, some impacts are possible. It is possible that fracturing of the Georges River bed will occur, but it is unlikely to result in any noticeable loss of surface water flows or quality (Ecoengineers 2007). Any fractures that do occur may result in surface flows being redirected into the dilated strata below to re-surface downstream and/or reduced overflow and increased leakage at rockbars. However, observations indicate that surface flow diversions are generally limited to sections of river located directly above the longwalls, which is not the case here (i.e. none of the longwalls extend completely under the Georges River). It is therefore unlikely that native fauna that rely on these areas will be significantly impacted by the proposed longwall extraction.

Where the creeks have an alluvial bed above the strata, it is unlikely that cracking in the strata will continue up to the surface (MSEC 2007). In the unlikely event that it does, the cracks are likely to be filled with alluvial material during subsequent flow events. Where the creek beds are exposed rock, there may be some loss of water from the creek beds into the dilated strata beneath them and the draining of some of the pools that exist within the creek alignments (MSEC 2007). However, the creek lines generally occur on gentle, undulating land and are unlikely to be significantly altered by mining induced subsidence. Furthermore, the creek lines and associated pools are ephemeral and it is likely that fauna reliant on them would be adapted to using a non-perennial water source. It is therefore unlikely that native fauna that rely on these areas will be significantly impacted by the proposed longwall extraction.

Small areas of two cliff lines in the Georges River valley have been identified as potentially being subject to alteration by mining. As discussed above, the predicted extent of possible alteration equates to a maximum of 21 and 16 m of the cliff lines respectively. Cliff lines are unlikely to be impacted in the western end of the Study Area (i.e. Nepean River valley and associated tributaries). Consequently, it is unlikely that native fauna that live in such areas will be significantly impacted by the proposed longwall extraction.

Gas emission through alluvial or rocky substrate within a watercourse are unlikely to result in adverse water quality impacts Gas emissions are expected to be very low and it is unlikely that any significant negative impacts on fauna or their habitats will occur.

Water quality in both the Georges River in the east and the Nepean River and associated tributaries in the west of the Study Area is not likely to be significantly altered by the proposal and therefore is unlikely to alter habitats of terrestrial ecological values.

Given the nature of the likely subsidence impacts and that significant fauna habitats will not be directly mined beneath by the proposal, it is considered that the proposed longwall extraction would not have a significant impact on any important fauna habitats.

14.3 ASSESSMENT OF IMPACT ON WATER QUALITY

On the basis of the information discussed in **Section 8.4**, it is summarised that:

- the Likelihood of one or more springs arising within Georges River as a consequence of the mining of proposed Longwalls 34 - 36 is Minor; and
- the Consequences of such springs to Property would be Insignificant to None; and
- the Consequences of such a spring or springs to the Ecological Health of immediate downstream pool(s) in the River would be Major under low flow conditions (<0.3 ML/day); but
- the Consequences of such a spring or springs to the Ecological Health of immediate downstream pool(s) would be Insignificant provided the River continued to receive an environmental flow e.g. from West Cliff Colliery in excess of 0.5 ML/day with an Total Alkalinity in excess of 500 mg/L expressed as $CaCO_3$ (calcium carbonate); but that
- the Consequences of such a diversion on Aesthetics of the Georges River would be Major.
- the Likelihood of one or more ferruginous springs arising within Upper Mallaty Creek catchment from subsidence-related effects within that catchment as a consequence of the mining of proposed Longwalls (33), 34 or 35 is Minor as the mining of Longwalls 31 and 32 (mined from the west) has possibly not led to induction of such springs although Longwall 30 appears to have created a spring in Ingham's Tributary of Ousedale Creek to the south; and

- the Consequences of such a spring or springs to Property would be Minor and we base this on a minor risk of potential contamination to a farm or commercial water storage dam; and
- the Consequences of such a spring or springs to the Ecological Health of immediate downstream pool(s) in the Creek would be Insignificant under high flow conditions but Minor under low flow conditions and we principally base this conclusion on the existing effects of local agricultural land uses on stream water quality; and
- the Consequences of such a spring or springs on Aesthetics in Nepean River would be Minor given that Mallaty Creek discharges to Ousedale Creek and the confluence receives additional flows from Upper Ousedale Creek.
- the Likelihood of one or more ferruginous springs arising within Leafs Gully Creek or Upper Nepean Creek catchment from subsidence-related effects within that catchment as a consequence of the mining of proposed Longwalls 25 and 26 is Minor; and
- the Consequences of such a spring or springs to the Ecological Health of immediate downstream pool(s) in the Creek would be Insignificant under high flow conditions but Minor under low flow conditions and we principally base this conclusion on the existing effects of local agricultural land uses on stream water quality; and
- the Consequences of such a spring or springs to Property would be Minor and we again base this on a minor risk of potential contamination to a farm or commercial water storage dam; and
- the Consequences of such a spring or springs on Aesthetics in Nepean River would be Major.

It is possible ferruginous saline springs may be more prone to be induced or if pre-existing enhanced in flow rates westward draining catchments overlying Longwalls 34 to 36 that ultimately flow to the Nepean River e.g. Mallaty Creek, Leafs Gully Creek and Upper Nepean Creek.

Given that the gradients in Ingham's Tributary are similar to those in Upper Mallaty and Leafs Gully Creek, but significantly less than those in Upper Nepean Creek (within the SMP Area), and that maximum predicted systematic tilts along the alignments of Mallaty Creek are similar to those back-predicted for Longwalls 30 and 31 (MSEC, 2005), there would appear to be a low but finite probability of induction of, or enhancement of existing ferruginous springs in the Upper Mallaty and Leafs Gully Creek catchments as a consequence of the mining of Longwalls 34 – 36.

Notwithstanding, the westward draining streams are clearly strongly ephemeral in nature with ongoing agricultural land use and it is unlikely there would be any significant impact to water quality resulting from the formation of springs in these streams over and above current anthropological effects (The Ecology Lab, 2007).

14.4 ASSESSMENT OF OTHER POTENTIAL IMPACTS

The proposal to extract Longwalls 34 to 36:

- does not include any plans to use groundwater or surface water from a natural water body. There are no plans to store water in a dam or artificial water body;

- is not expected to significantly affect flooding and will not affect tidal waters;
- does not use, store, dispose or transport hazardous substances, use or generate pesticides, herbicides, fertilisers or other chemicals, which may build up as residues in the environment. It is noted that fertilisers and herbicides may be required to assist revegetation of small areas of surface disturbance. Appropriate approvals will be sought if required and the most appropriate methods of usage will ensure minimal impact;
- does not emit significant amounts of dust, odours, noise, vibrations, blasts, electromagnetic fields or radiation from the longwall area, in the proximity of residential areas or land uses likely to be affected;
- involves appropriate disposal of waste generated;
- does not introduce noxious weeds, vermin, feral species or disease or release genetically modified organisms. It is noted that potential to introduce weeds can result from vehicles accessing the area for monitoring or inspection activities. Bare areas that may result from vegetation removal or die back could encourage the germination and establishment of weed species that may already be present. This effect is not expected to be significant;
- does not result in the creation of barriers to movement or the removal of remnant vegetation or wildlife corridors;
- does not involve any activity that affects revegetation or replenishment of native species following disturbance;
- does not introduce unmanageable fire risks.

The proposal to extract Longwalls 34 to 36 does not significantly effect:

- wetlands or flood prone areas;
- groundwater recharge areas or areas with a high water table,
- significant areas of acid sulphate or sodic soils;
- areas with degraded air quality;
- known areas with degraded or contaminated soils or water;
- fishing grounds and commercial fish breeding or nursery areas; or
- any other sensitive areas or areas allocated for Conservation Purposes.

There are no other issues identified likely to affect the biological aspects of the environment and accordingly there will not be a significant impact on the environment.

Therefore, providing the proposed mitigatory measures are in place, there will be no significant adverse environmental effects on any areas that are sensitive because of biological factors.

14.5 EVALUATION OF POTENTIAL IMPACT SIGNIFICANCE

This section evaluates the likely significance of any potential impacts. Likely environmental significance is evaluated using DoP criteria and criteria based on Land and Environment Court decisions and findings. The final determination regarding significance is made by the determining authority.

The DoP Document, "Is an EIS Required?" recommends the following criteria for evaluating the likely environmental significance of impacts:

- How extensive are the impacts? Extensive impacts are likely to be significant.
- How adverse are the impacts on environmentally sensitive areas? Impacts which adversely impact on environmentally sensitive areas are likely to be significant.
- How acceptable are the impacts considering the nature of the impacts? Impacts with a low level of acceptability because of the nature of the impacts are likely to be significant.

Particular emphasis has been placed on determining whether the proposal is likely to significantly affect the environment. After considering the relatively localised extent of the potential impacts, together with the acceptable nature of the impacts, it is considered that the application to extract Longwalls 34 to 36, is not likely to significantly affect the environment, providing that the proposed management measures, which are part of the Activity, are implemented.

REFERENCES

ANZECC&ARMCANZ (2000a) *National Water Quality Management Strategy. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Volume 1: The Guidelines (Chapters 1 – 7).* Australia and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.

ANZECC&ARMCANZ (2000b) *National Water Quality Management Strategy. Paper No. 4. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Volume 2: Aquatic ecosystems – rationale and background information.* Australia and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.

ANZECC&ARMCANZ (2000c) *National Water Quality Management Strategy. Australian Guidelines for Water Quality Monitoring and Reporting. Australia and New Zealand* Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.

Biosis Research (2007). *West Cliff Colliery Area 5 - Longwalls 34-36 Impacts of Subsidence on Terrestrial Flora and Fauna.*

Biosis Research (2007). *Archaeological and Cultural Heritage Assessment: Review of West Cliff Area 5 – Longwalls 34-36, Appin, NSW.*

Ecoengineers (2007). *Assessment of Water Quality Effects West Cliff Colliery Longwalls 34 to 36.*

Guideline of Applications for Subsidence Management Approvals, September 2003, NSW Department of Primary Industries – Minerals.

Landcom (2004). The Soils and Construction (Blue Book) Volume 1, 4th Edition.

Mine Subsidence Engineering Consultants (2007). *West Cliff Colliery Area 5 The Prediction of Subsidence Parameters and the assessment of Mine Susbidence 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, MSEC326.*

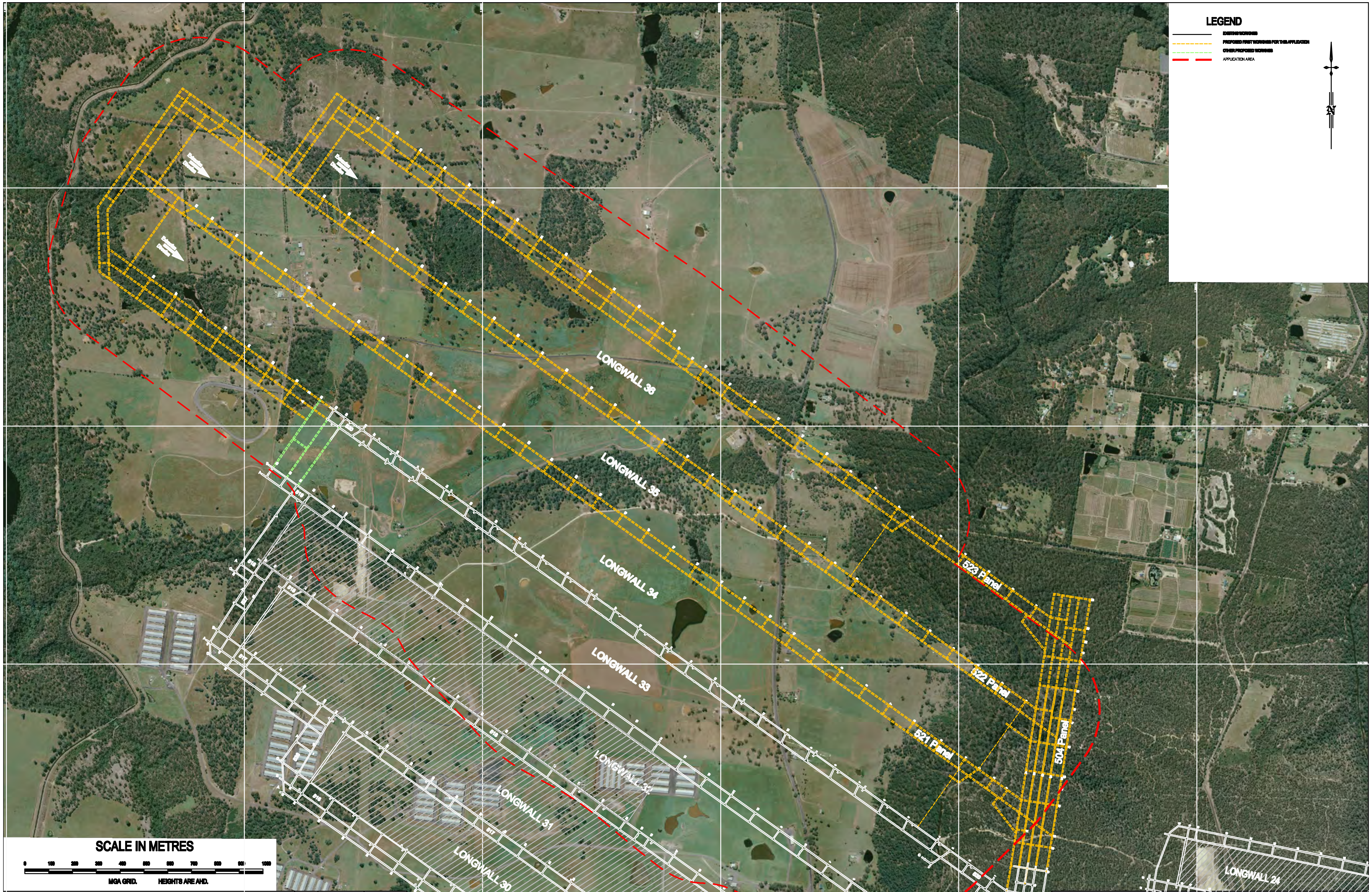
NSW Department of Mineral Resources, 2003. Draft Guidelines for Applications for Subsidence Management Approvals. December 2003.

NSW Department of Mineral Resources, 2003. *New Approval Process for Managing Subsidence*.

Prediction of Subsidence Parameters and the Assessment of Subsidence Impacts on Natural Features and Surface Infrastructure due to Mining Longwall 17", Report MSEC249, Mine Subsidence Engineering Consultants Pty Ltd.

The Ecology Lab (2008). *West Cliff Colliery Area 5 Longwalls 34 to 36 Assessment of Mine Subsidence Impacts on Aquatic Habitat and Biota.*

REDUCED PLANS



West Cliff Colliery

BHPBilliton Endeavour Coal Pty Ltd

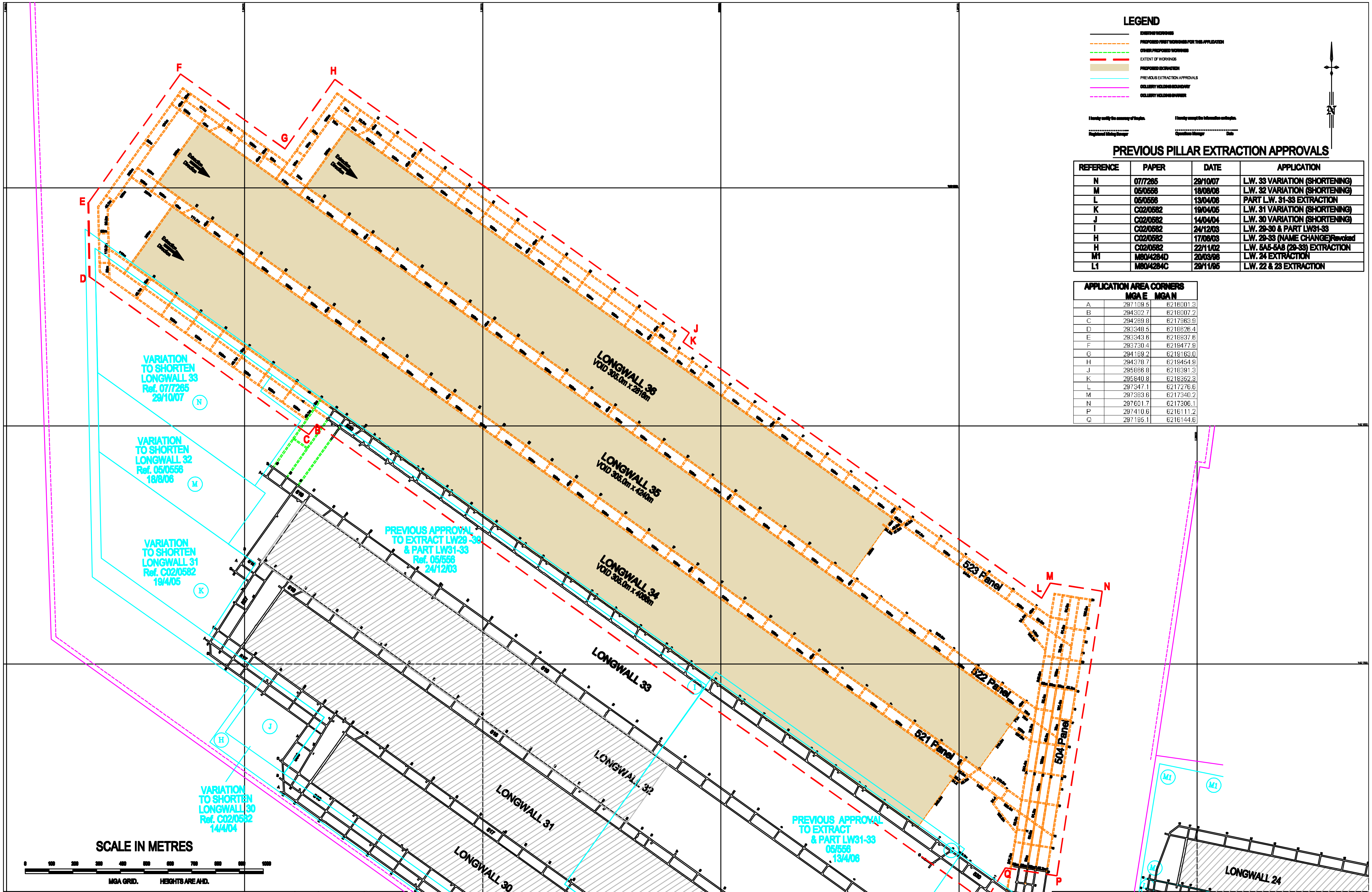
PO Box 514 Unanderra NSW 2526 Australia

ABN 38 099 830 476

	Name	Date
DRN	BRWalker	221107
REV		
APP		
SCALE	A0	1 : 5 000

Title **Subsidence Management Plan**
Part Longwall 34 to Longwall 36
Plan 7 - Orthophoto Plan

DRAWING NUMBER	REV
AS-2210	0



PREVIOUS PILLAR EXTRACTION APPROVALS

REFERENCE	PAPER	DATE	APPLICATION
N	07/7265	29/10/07	L.W. 33 VARIATION (SHORTENING)
M	05/0556	18/08/06	L.W. 32 VARIATION (SHORTENING)
L	05/0556	13/04/06	PART L.W. 31-33 EXTRACTION
K	C02/0582	19/04/05	L.W. 31 VARIATION (SHORTENING)
J	C02/0582	14/04/04	L.W. 30 VARIATION (SHORTENING)
I	C02/0582	24/12/03	L.W. 29-30 & PART LW31-33
H	C02/0582	17/06/03	L.W. 29-33 (NAME CHANGE)Revoked
H	C02/0582	22/11/02	L.W. 5A5-5A8 (29-33) EXTRACTION
M1	M80/4284D	20/03/98	L.W. 24 EXTRACTION
L1	M80/4284C	29/11/95	L.W. 22 & 23 EXTRACTION

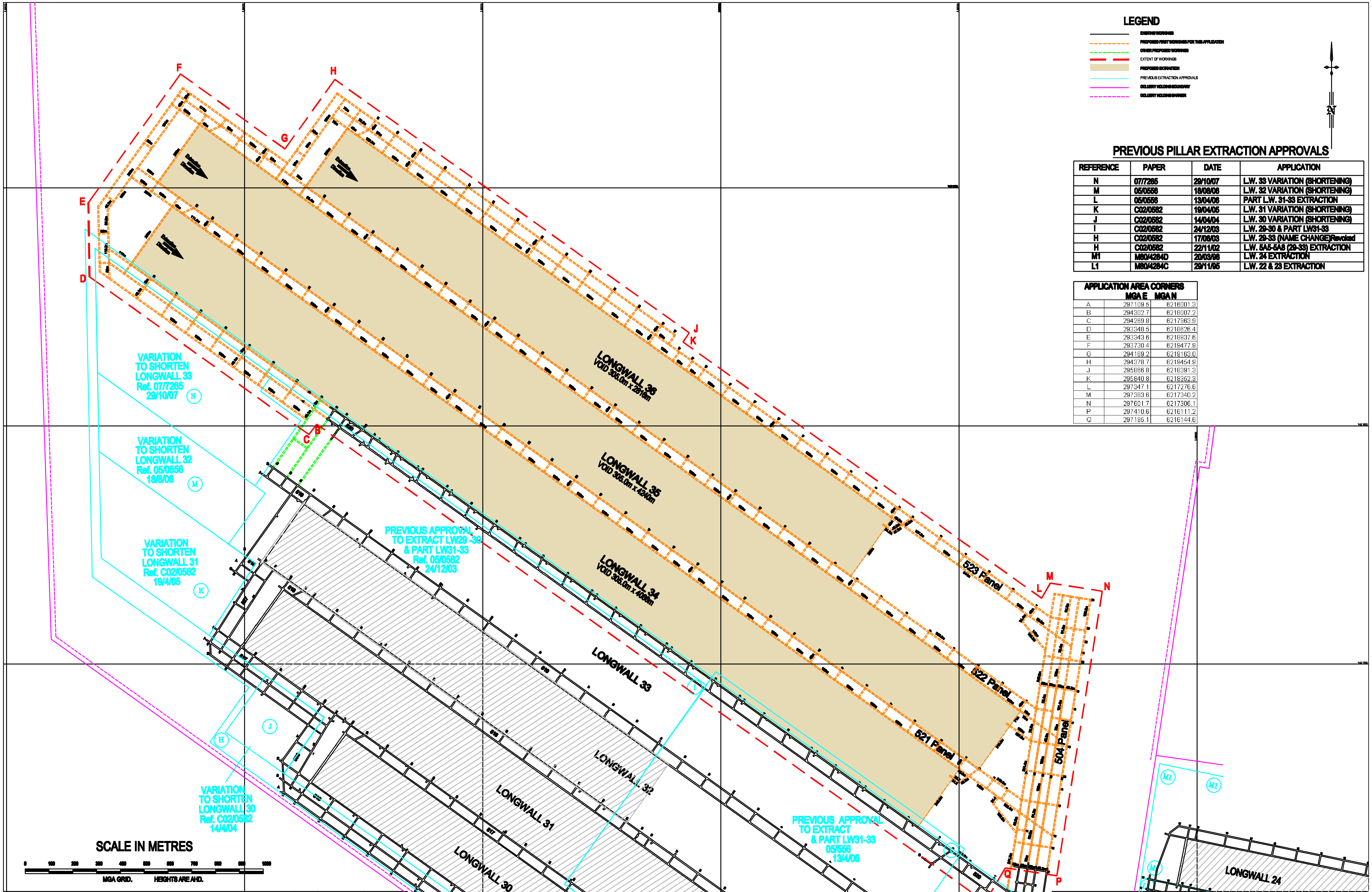
APPLICATION AREA CORNERS	MGA E	MGA N
A	297109.5	6216001.3
B	294302.7	6218007.2
C	294269.8	6217963.9
D	293348.5	6218626.4
E	293343.6	6218937.6
F	293730.4	6219477.9
G	294169.2	6219163.0
H	294378.7	6219454.9
J	295866.8	6218391.3
K	295840.8	6218352.3
L	297347.1	6217276.6
M	297383.6	6217340.2
N	297601.7	6217306.1
P	297410.6	6216111.2
Q	297195.1	6216144.6

West Cliff Colliery
BHPBilliton Endeavour Coal Pty Ltd
PO Box 514 Unanderra NSW 2526 Australia
ABN 38 099 830 476

	Name	Date
DRN	BRWalker	151107
REV		
APP		
SCALE	A0	1 : 5 000

Title: Subsidence Management Plan
Part Longwall 34 to Longwall 36
Approved Plan

DRAWING NUMBER: AS-2201 REV 0



LEGEND

- EXISTING WORKINGS
- PROPOSED FIRST WORKINGS FOR THIS APPLICATION
- OTHER PROPOSED WORKINGS
- EXTENT OF WORKINGS
- PROPOSED EXTRACTION
- PREVIOUS EXTRACTION APPROVALS
- COLLIERY HOLDING BOUNDARY
- COLLIERY HOLDING BARRIER

PREVIOUS PILLAR EXTRACTION APPROVALS

REFERENCE	PAPER	DATE	APPLICATION
N	07/7265	29/10/07	L.W. 33 VARIATION (SHORTENING)
M	05/0556	18/08/06	L.W. 32 VARIATION (SHORTENING)
L	05/0556	13/04/06	PART L.W. 31-33 EXTRACTION
K	C02/0582	19/04/05	L.W. 31 VARIATION (SHORTENING)
J	C02/0582	14/04/04	L.W. 30 VARIATION (SHORTENING)
I	C02/0582	24/12/03	L.W. 29-30 & PART LW31-33
H	C02/0582	17/06/03	L.W. 29-33 (NAME CHANGE)Revoked
H	C02/0582	22/11/02	L.W. 5A5-5A8 (29-33) EXTRACTION
M1	M80/4284D	20/03/98	L.W. 24 EXTRACTION
L1	M80/4284C	29/11/95	L.W. 22 & 23 EXTRACTION

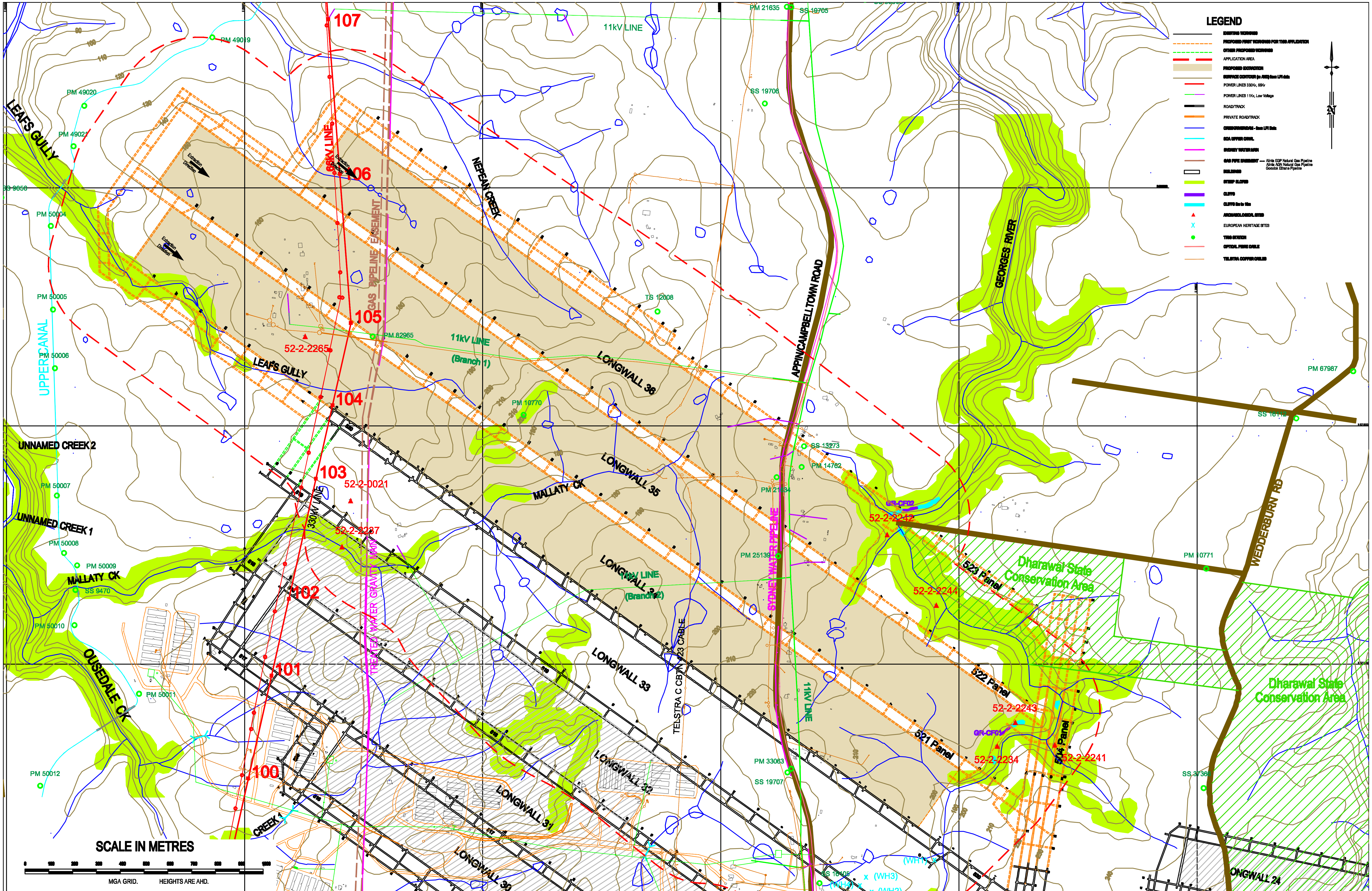
APPLICATION AREA CORNERS	MGA E	MGA N
A	297109.5	6216001.3
B	294302.7	6218007.2
C	294269.8	6217963.9
D	293348.5	6218626.4
E	293343.6	6218937.6
F	293730.4	6219477.9
G	294169.2	6219163.0
H	294378.7	6219454.9
J	295866.8	6218391.3
K	295840.8	6218352.3
L	297347.1	6217276.6
M	297383.6	6217340.2
N	297601.7	6217306.1
P	297410.6	6216111.2
Q	297195.1	6216144.6

West Cliff Colliery
BHPBilliton Endeavour Coal Pty Ltd
PO Box 514 Unanderra NSW 2526 Australia
ABN 38 099 830 476

	Name	Date
DRN	BRWalker	151107
REV		
APP		
SCALE	A0	1 : 5 000

Title: **Subsidence Management Plan Part Longwall 34 to Longwall 36 Plan 1**

DRAWING NUMBER: AS-2202 | REV 0



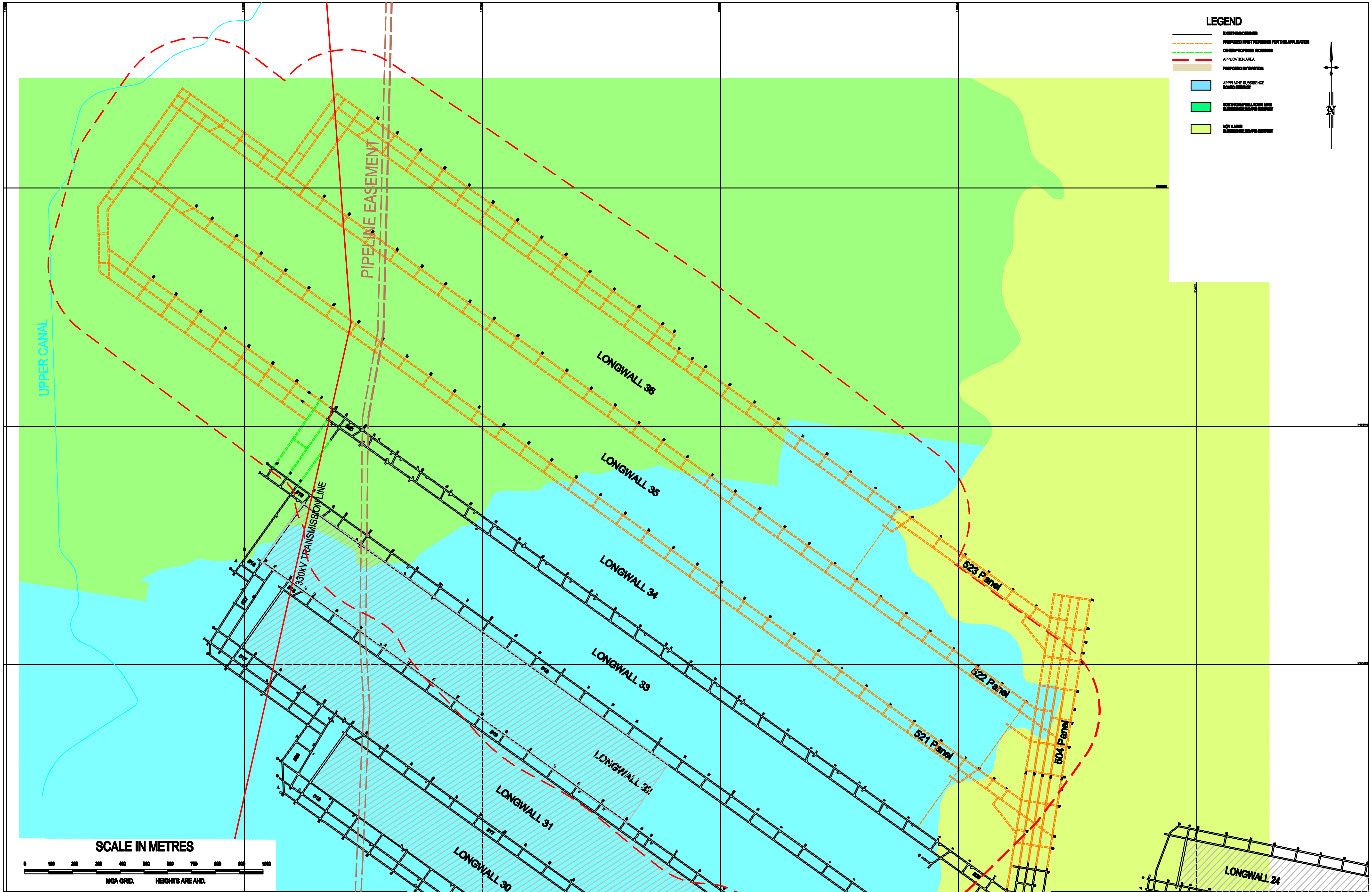
West Cliff Colliery

BHPBilliton Endeavour Coal Pty Ltd
PO Box 514 Unanderra NSW 2526 Australia
ABN 38 099 830 476

	Name	Date
DRN	BRWalker	080108
REV		
APP		
SCALE	A0	1 : 5 000

Title
Subsidence Management Plan
Part Longwall 34 to Longwall 36
Plan 2 - Surface Features

DRAWING NUMBER **AS-2203** REV **0**



West Cliff Colliery

BHPBilliton Endeavour Coal Pty Ltd

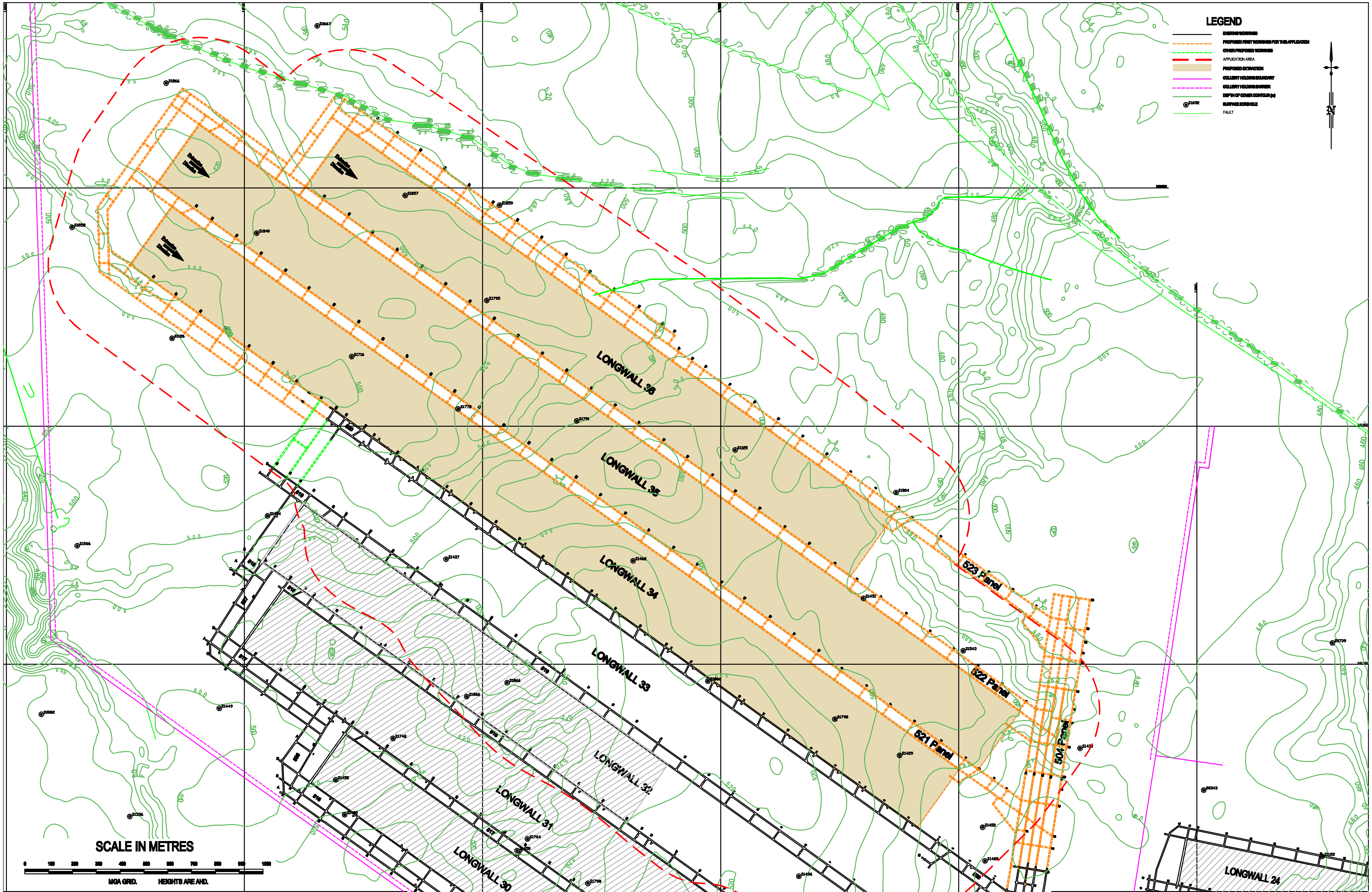
PO Box 514 Unanderra NSW 2526 Australia

ABN 38 099 830 476

	Name	Date
DRN	BRWalker	080108
REV		
APP		
SCALE	A0	1 : 5 000

Title **Subsidence Management Plan**
Part Longwall 34 to Longwall 36
Plan 2A - Mine Subsidence Districts

DRAWING NUMBER **AS-2204** REV **0**



West Cliff Colliery

BHPBilliton Endeavour Coal Pty Ltd

PO Box 514 Unanderra NSW 2526 Australia

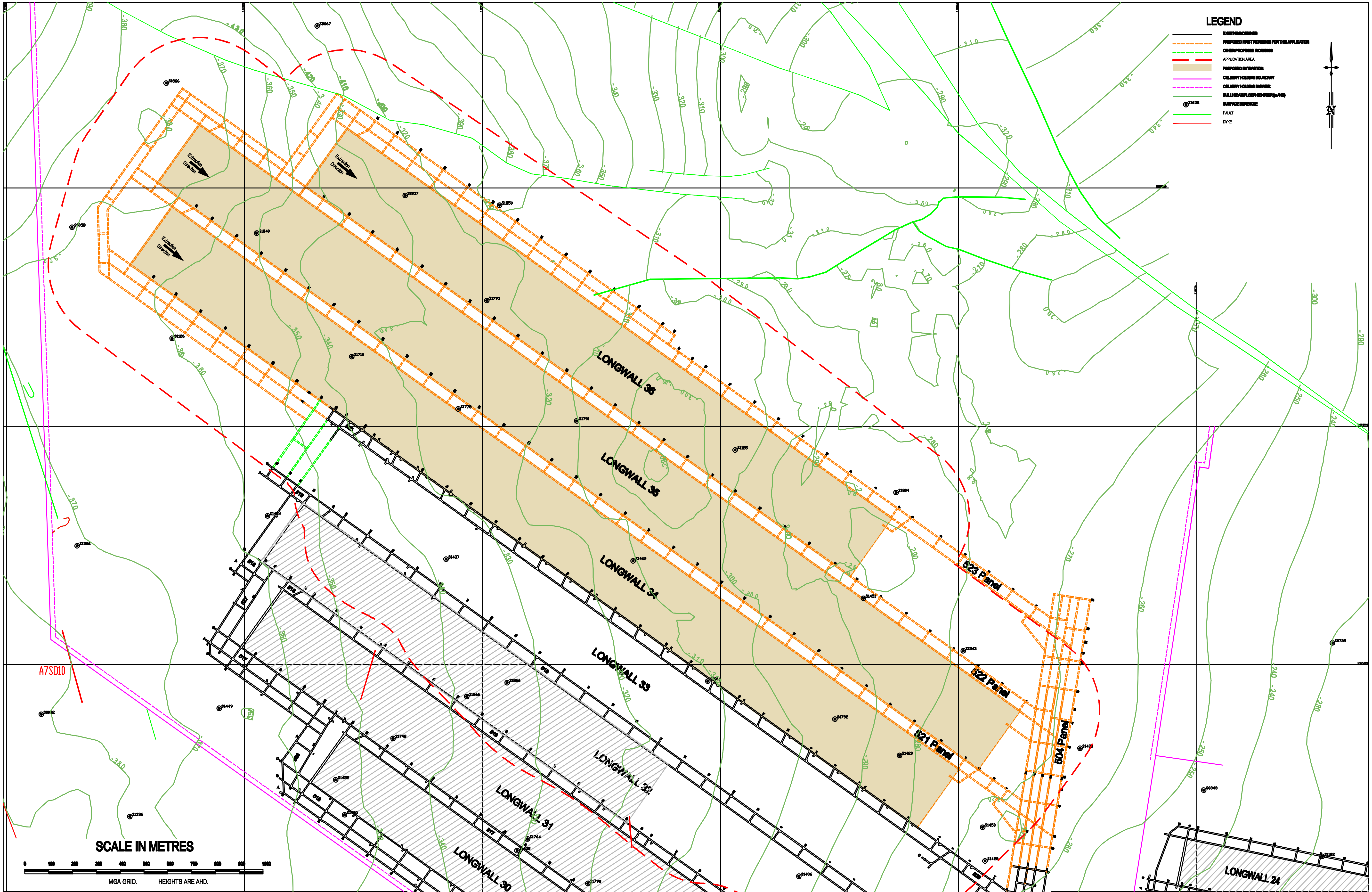
ABN 38 099 830 476

	Name	Date
DRN	BRWalker	151107
REV		
APP		
SCALE	A0	1 : 5 000

Title

Subsidence Management Plan
Part Longwall 34 to Longwall 36
Plan 3A - Surface Boreholes and Depth of Cover Contours

DRAWING NUMBER **AS-2205** REV **0**



West Cliff Colliery

BHPBilliton Endeavour Coal Pty Ltd

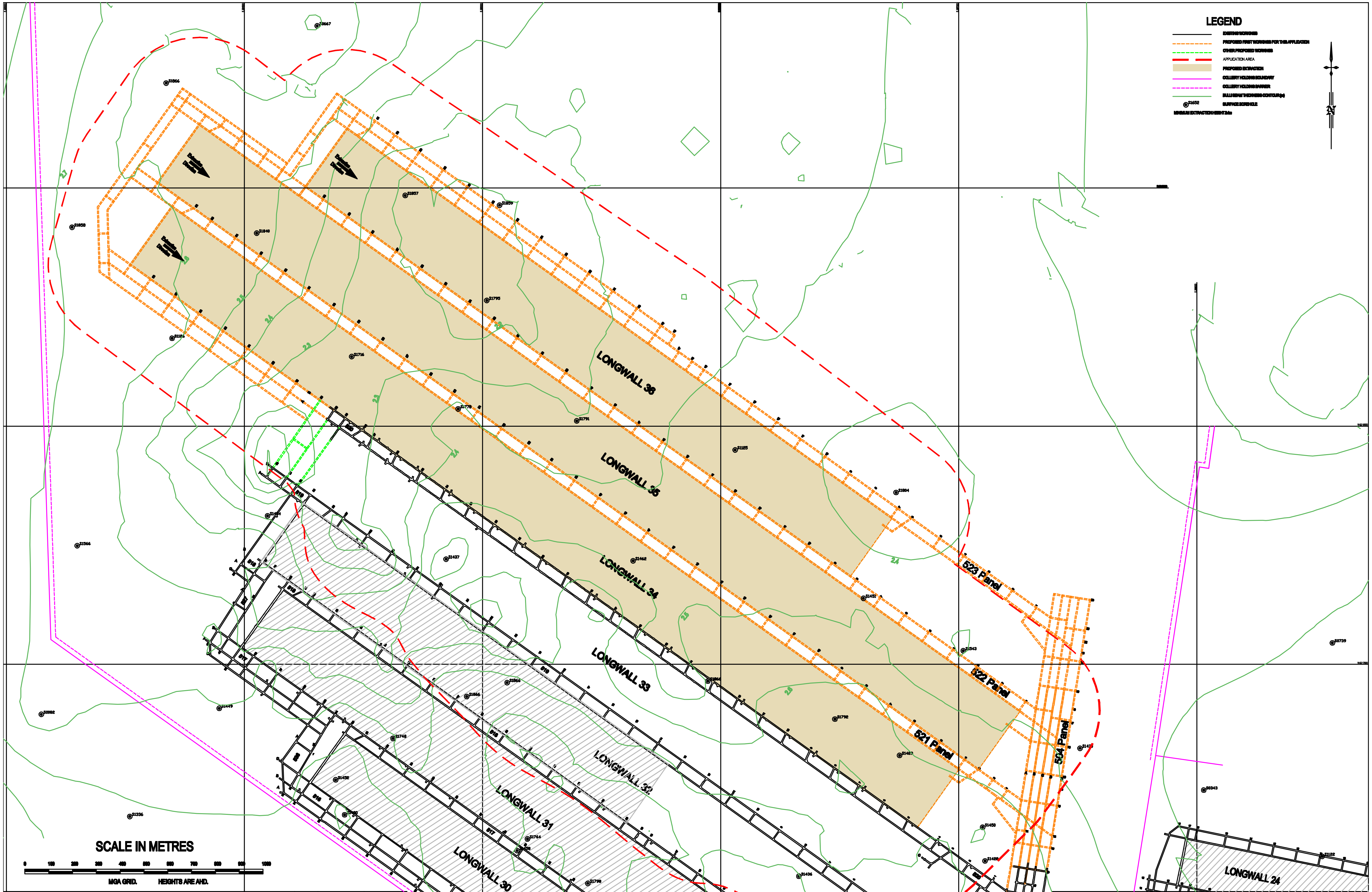
PO Box 514 Unanderra NSW 2526 Australia

ABN 38 099 830 476

	Name	Date
DRN	BRWalker	161107
REV		
APP		
SCALE	A0	1 : 5 000

Title: **Subsidence Management Plan**
Part Longwall 34 to Longwall 36
Plan 3B - Bulli Seam Geology and Seam Floor Contours

DRAWING NUMBER: **AS-2206** REV **0**



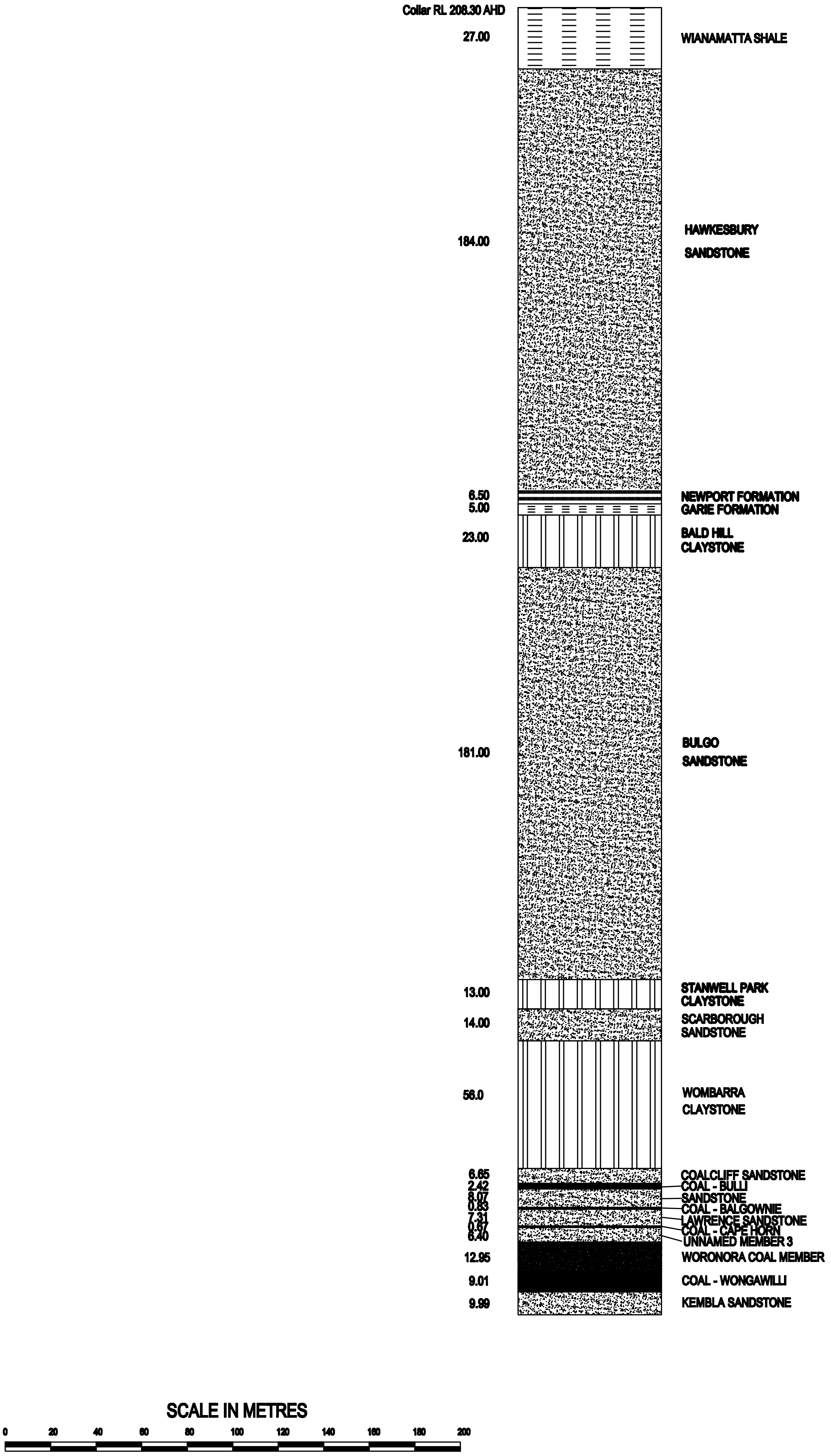
West Cliff Colliery
BHPBilliton Endeavour Coal Pty Ltd
PO Box 514 Unanderra NSW 2526 Australia
ABN 38 099 830 476

	Name	Date
DRN	BRWalker	161107
REV		
APP		
SCALE	A0	1 : 5 000

Title
Subsidence Management Plan
Part Longwall 34 to Longwall 36
Plan 3C - Bulli Seam Thickness Contours

DRAWING NUMBER AS-2207
REV 0

SECTION OF BOREHOLE WEST CLIFF DDH19 S1462
AT MGA E 295632.00 N 6217436.57
REFER PLAN 3A FOR LOCATION



West Cliff Colliery BHPBilliton Endeavour Coal Pty Ltd PO Box 514 Unanderra NSW 2526 Australia ABN 38 099 830 476		Name	Date	Title	Subsidence Management Plan Part Longwall 34 to Longwall 36 Plan 6 - Geological Section S1462
	DRN	BRWalker	221107		
	REV				
	APP			DRAWING NUMBER	AS-2209
	SCALE	A3	1 : 2000	REV	0