SOUTH32

Illawarra Coal

End of Panel Report

Appin Area 7

Longwall 707 End of Panel Report

October 2018

Executive Summary

This End of Panel (EoP) Report has been prepared, in accordance with Condition 18 of the Appin Area 7 Longwalls 707 to 710 Subsidence Management Plan (SMP) Approval, granted on the 28th September 2012. The EoP Report outlines the measured and observed impacts of Longwall 707 and analyses the monitoring results against relevant impact assessment criteria and predictions made in the SMP and associated management plans and reports for Longwall 707.

Longwall 707, comprised of Longwalls 707A and 707B, is located within Consolidated Coal Lease No.767 (CCL767). The extraction of Longwall 707 commenced on the 7 January 2016 and was completed on the 19 June 2018, using conventional longwall techniques and equipment.

South32 Illawarra Coal (IC) provides 70% of BlueScope Steel's coking coal requirements. Mining operations at Appin Colliery represents continuing significant capital and operating investments in the Southern Coalfield of New South Wales. From the operations of Appin Mine, IC paid approximately $20.3 Million in government royalties during the 2017/2018 financial year.

Subsidence movements resulting from the extraction of Longwall 707 were monitored along various lines and points within the SMP Area. A comparison of the observed and predicted movements resulting from the extraction of Longwall 707 was prepared by the subsidence engineering firm MSEC (MSEC975 2018). In general, the subsidence movements measured were within prediction.

All impacts to built and natural features observed during monitoring associated with the extraction of Longwall 707 have been within prediction. Infrastructure, such as roads and railways remained in safe and serviceable condition during the extraction of Longwall 707. Monitoring of built and natural features will continue as part of post-mining and during-mining monitoring (for Longwall 708) in accordance with the SMP, relevant Management Plans and approved modifications.

Contents

List of Tables

List of Figures

Attachments

Attachment A – Appin Area 7 Longwall 707 to 710 SMP Approval

Attachment B – Longwall 707 Subsidence Monitoring Report (MSEC)

Attachment C – Longwall 707 Landscape Report (ICEFT)

Attachment D – Longwall 707 Impact and Private Property Reports (ICEFT)

Attachment E – Longwall 707 Surface and Groundwater Assessment (GeoTerra)

Attachment F – Longwall 707 Aquatic Ecology Assessment (Cardno)

Abbreviations

ARTC	Australian Rail and Track Corporation
BFMP	Built Feature Management Plans
BSO	Bulli Seam Operations
DP&E	Department of Planning and Environment
EP	Extraction Plan
EP&A Act 1979	Environmental Planning and Assessment Act 1979
IC	Illawarra Coal
ICEFT	Illawarra Coal Environmental Field Team
IPM	Incremental Profile Method
PAC	Planning and Assessment Commission
SMP	Subsidence Management Plan
WMP	Water Management Plan

1. Introduction

1.1. Background

Appin Area 7 Longwall 707, comprised of Longwalls 707A and 707B, is located within Consolidated Coal Lease No.767 (CCL767). The extraction of Longwall 707 commenced on the 7 January 2016 and was completed on the 19 June 2018, using conventional longwall techniques and equipment.

This EoP Report has been prepared, in accordance with Condition 18 of the Longwalls 707 to 710 SMP Approval, granted on the 28 September 2012. The EoP Report outlines the measured and observed impacts of Longwall 707 and analyses the monitoring results against relevant impact assessment criteria and predictions made in the SMP and associated management plans and reports for Longwall 707.

Information in this report is based on monitoring and reports undertaken by IC and specialist consultants that have been involved with the monitoring and analysis of data relating to the Longwall 707 – 710 SMP Area.

Table 1: Condition 18 of the SMP Approval - End of Panel Reporting Condition.

SMP Approval Condition	Relevant Section in EoP Report
Condition 18 Within 4 months of the completion of each longwall panel, an end of panel report must be prepared to the satisfaction of the Director Environmental Sustainability. The end of panel report must:	
a) Include a summary of the subsidence and environmental monitoring results for the applicable longwall panel;	Section 2, Section 3 to 6 and relevant attachments
b) Include an analysis of these monitoring results against the relevant: – impact assessment criteria; – monitoring results from previous panels; – predictions in the SMP; and – performance measures specified in Table 1 and Table 2;	Section 2, Section 3 to 7, Appendix 1 and relevant attachments
c) Identify any trends in the monitoring results over the life of the activity; and	
d) Describe what actions were taken to ensure adequate management of any potential subsidence impacts due to longwall mining.	

1.2. Approval and Legislative Requirements

In September 2009, Illawarra Coal submitted an Environmental Assessment (EA) for its Bulli Seam Operations Project (BSOP) to the NSW Department of Planning and Infrastructure, now the Department of Planning and Environment (DPE) for the continuation of underground mining operations for both Appin and West Cliff Mines. The BSOP was approved 22 December 2011 by the NSW Planning Assessment Commission (PAC) under delegation of the NSW Minister for Planning under Part 3A of the NSW Environmental Planning and Assessment Act 1979 (EP&A Act 1979).

The SMP for Longwalls 707 to 710 was approved by the Director General of the Department of Trade and Investment, Regional Infrastructure and Services, NSW on the 28 September 2012. The SMP approval is provided as Attachment A.

The Subsidence Impact Performance Measures for natural, heritage and built features are outlined in the BSOP Approval, and reflected in the Longwall 707 to 710 SMP Approval. The performance measures relevant to Appin Area 7 are shown below in Table 2. Condition 18 of the SMP Approval is provided below in Table 1.

Table 2: Bulli Seam Operations Project Approval – Subsidence Impact Performance Measures.

BSOP Approval Condition		Relevant Section in EoP Report
Condition 1, Schedule 3 The Proponent shall ensure that the project does not cause any exceedance of the performance measures in Table 1, to the satisfaction of the Director-General.		
Nepean River	Negligible environmental consequences including: negligible diversion of flows or changes in the natural drainage behaviour of pools; · negligible gas releases and iron staining; and · negligible increase in water cloudiness	Section 5 and Attachments C and E
Other watercourses	No greater subsidence impact or environmental consequences than predicted in the EA and PPR	Section 5
Cliffs of "special significance (i.e. cliffs longer than 200m and/or higher than 5m that constitute water falls)	Negligible environmental consequences (that is occasional rockfalls, displacement or dislodgement of boulders or slabs, or fracturing, that in total do not impact more than 0.5% of the total face area of such cliffs within any longwall mining domain).	Section 5 and Attachment C
Other cliffs flanking the Nepean River	Negligible environmental consequences (that is occasional rockfalls, displacement or dislodgement of boulders or slabs, or fracturing, that in total do not impact more than 0.5% of the total face area of such cliffs within any longwall mining domain).	
Other cliffs	Minor environmental consequences (that is occasional rockfalls, displacement or dislodgement of boulders or slabs, or fracturing, that in total do not impact more than 3% of the total face area of such cliffs within any longwall mining domain).	
Threatened species, threatened populations, or endangered ecological communities	Negligible environmental consequences	Section 5
Aboriginal heritage Sites determined to hold "special significance"	Negligible impact or environmental consequence.	Section 5
Sites determined to hold high or moderate significance	Less than 10% of such sites across the mining area are affected by subsidence impacts (other than negligible impacts or environmental consequence).	
Other Aboriginal heritage sites	Less than 10% of such sites (or 1 such site, whichever is the greater) within any longwall mining domain are/is affected by subsidence impacts (other than minor impacts or environmental consequence).	
Historic heritage St Mary's Tower (Douglas Park)	Negligible impact on structural integrity or external fabric.	
Other buildings or structures of State or National heritage significance	Negligible loss of heritage value. Negligible impact on structural integrity or external fabric unless the owner of the feature agrees otherwise in writing.	
Condition 3, Schedule 3 The Proponent shall ensure that the project does not cause any exceedance of the performance measures in Table 2, to the satisfaction of the Director-General.		
Built Features Key public infrastructure: - Main Southern Railway	Always safe and serviceable. Damage that does not affect safety or serviceability must be fully repairable, and must be fully repaired.	Sections 3 and 4

BSOP Approval Condition		Relevant Section in EoP Report
- Hume Highway; and - The SCA Upper Canal		
Other public infrastructure (including water supply pipelines; high pressure gas pipelines and the gas distribution network; electricity transmission and distribution lines; telecommunications cables and optical fibre networks; roads, trails and associated structures). Houses, industrial premises, swimming pools, farm dams and other built features or improvements	Always safe. Serviceability should be maintained wherever practicable. Loss of serviceability must be fully compensated. Damage must be fully repaired or fully compensated, or else the damaged built feature or damaged infrastructure component replaced.	
Public Safety	Negligible additional risk.	Section 3

1.3. Report and Management Plans

The impact predictions associated with Longwall 707 are described in the following reports:

Cardno Forbes Rigby Pty Ltd, June 2008. Appin Colliery Area 7 Longwalls 705 to 710 Subsidence Management Plan Application. This plan includes specialist reports on subsidence, water quality, aquatic ecology, flora and fauna and cultural heritage predictions as follows:

- Biosis Research (2008). Appin Colliery Area 7 – Longwalls 705-710 Impacts of Subsidence on Terrestrial Flora and Fauna.
- Biosis Research (2008) Archaeological and Cultural Heritage Assessment of Proposed Longwalls 705-710, West Appin, NSW.
- Ecoengineers (2008) Assessment of Water Flow and Quality Effects Appin Colliery Longwalls 705-710.
- Geoterra (2008) Appin Area 7 Longwalls 705-710 Groundwater Assessment Douglas Park NSW.
- MSEC (2007) The Prediction of Subsidence Parameters and the Assessment of Mine Subsidence Impacts on Natural Features and Surface Infrastructure Resulting from the Extraction of Proposed Longwalls 705 to 710 in Area 7 at Appin Colliery, in support of the SMP application, MSEC326.

1.4. Economic Effects

The extraction of underground coal reserves from Appin Mine provides benefits at national, state and local levels. Illawarra Coal provides coking coal to BlueScope Steel for its domestic steelmaking production, and for export to overseas customers.

South32 IC provides 70% of BlueScope Steel's coking coal requirements. Mining operations at Appin Mine represents continuing significant capital and operating investments in the Southern Coalfield of New South Wales. From the operations of Appin Mine, IC paid approximately $20.3 Million in government royalties during the 2017/2018 financial year.

Appin Mine supports approximately 1000 employees and contractors. The mining industry has high employment multiplier effects with around 3.5 additional jobs supported by a mining job and up to 5.5 including consumption-induced effects (Lawrence Consulting 2016).

Longwall 707 is located within Consolidated Coal Lease 767 which amalgamated a number of long standing head leases for mining coal in 1991.

1.5. Stakeholder Consultation

Impact monitoring and provision of ongoing information to the community has been undertaken by Illawarra Coal during the extraction of Appin Area 7.

Information on Illawarra Coal operations is provided to the community through the following mechanisms:

- Community letter box drops;
- Media releases and other media activities;
- General community surveys and reports;
- Illawarra Coal Community Newsletter – a periodical Illawarra Coal publication distributed to the community;
- Internet site - http://www.south32.net/our-operations/australia/illawarra-coal
- Illawarra Coal Community Consultative Committee meetings for BSOP (meeting minutes provided on the South32 website);
- Landholder relations program;
- Annual review; and
- Social media – South32 on Instagram, LinkdIn and Twitter.

1.6. Social Impacts Associated with Subsidence

Illawarra Coal aims to mitigate the potential impacts subsidence may cause to community members through various means outlined in Table 3.

Table 3: Social Impact Variables Associated with Subsidence.

Potential Impact	Monitoring Variables	Mechanism
Subsidence Impacts	Level of community concern relating to subsidence. Awareness of subsidence and its effects and management. Level of perceived community risk associated with subsidence effects. Level of satisfaction with the company's subsidence management practices. The extent to which the community attributes environmental, social and economic change occurring within the community to mining activities.	Longwall progress maps displayed on local notice board, letters and community newsletters. Illawarra Coal Community Consultative Committee meetings for BSOP. Douglas Park Advisory Panel. A biennial survey of residents and stakeholders in the communities in which Illawarra Coal operates. The survey aims to determine the community's perception of the company's overall performance. Development of individual Built Feature Management Plans (BFMPs) in consultation with landowners within the mine subsidence zone. Meetings and on-going consultation with landowners during mining and in accordance with individual BFMPs.

The management of subsidence impacts on private properties is addressed in BFMPs. The BFMPs have been prepared in consultation with property owners. For any impacts to properties in relation to Longwall 707, landholders have been advised to lodge claims with Subsidence Advisory NSW. Illawarra Coal is available to assist landholders throughout the process of making a claim and is continuing to assist in the management of the impacts of the mining operations associated with Appin Area 7.

2. Predicted and Observed Subsidence

Subsidence movements resulting from the extraction of Longwall 707 were monitored along various lines and points within the SMP Area. A comparison of the observed and predicted movements resulting from the extraction of Longwall 707 has been prepared by MSEC (MSEC975 2018) and is included as **Attachment B**. The results from MSEC975 are summarised below, for further details on the subsidence refer to MSEC975.

Monitoring points and lines associated with Longwall 707 include:

- The Nepean River Cross Lines;
- Moreton Park Road Line;
- Menangle Road;
- M31 East and West Lines;
- FBG monitoring along the M31 Hume Motorway;
- Slot closure monitoring along the M31 Hume Motorway;

- ARTC monitoring line, strain gauges and tilt sensors;
- ARTC Embankment Points;
- Highway and Railway Cutting Points;
- Partridge VC Rest Area Points;
- Absolute far-field 3D monitoring points adjacent to the Douglas Park Twin Bridges and Moreton Park Road Bridge (South);
- Relative 3D monitoring points on the Douglas Park Twin Bridges and Moreton Park Road Bridge (South);
- Inclinometer monitoring near the Douglas Park Twin Bridges;
- Bridge joint monitoring on the Douglas Park Twin Bridges;
- Visual monitoring of the M31 Hume Motorway, Moreton Park Road, the Douglas Park Twin Bridges and Moreton Park Road Bridge (South);
- Monitoring lines at Water NSW infrastructure; and
- Monitoring along the Telstra Line.

The locations of these monitoring lines and points are shown in Figure 1.

2.1. The Nepean River Cross Lines

The closure movements across the Nepean River valley were measured by IC using 2D survey techniques along six monitoring lines during the extraction of Longwall 707B. The monitoring lines comprise the Nep X N-Line, Nep X O-Line, Nep X P-Line, Nep X Q-Line and Nep X R-Line.

The measured total closures at the Nep X N-Line, Nep X O-Line and Nep X P-Line were less than the predicted values at the completion of Longwall 707B. The measured total closures at the Nep X Q-Line and Nep X R-Line are greater than the predicted values; however, the exceedances of 15 mm and 6 mm, respectively, are in the order of accuracy of survey tolerance and the prediction method. The closures measured at these two monitoring lines are less than the maximum measured closure anywhere along the Nepean River of 182 mm, at the Nep X C-Line, after the completion of Longwall 704.

2.2. Moreton Park Road Line

The mine subsidence movements along Moreton Park Road were measured by IC using a 3D monitoring line. It is considered that the ground movements measured using the Moreton Park Road monitoring line are consistent with the predictions provided in Reports Nos. MSEC342 and MSEC825.

2.3. Menangle Road

The mine subsidence movements along Menangle Road were measured by IC using a 3D monitoring line. It is considered that the ground movements measured using the Menangle Road monitoring line are consistent with the predictions provided in Reports Nos. MSEC342 and MSEC825.

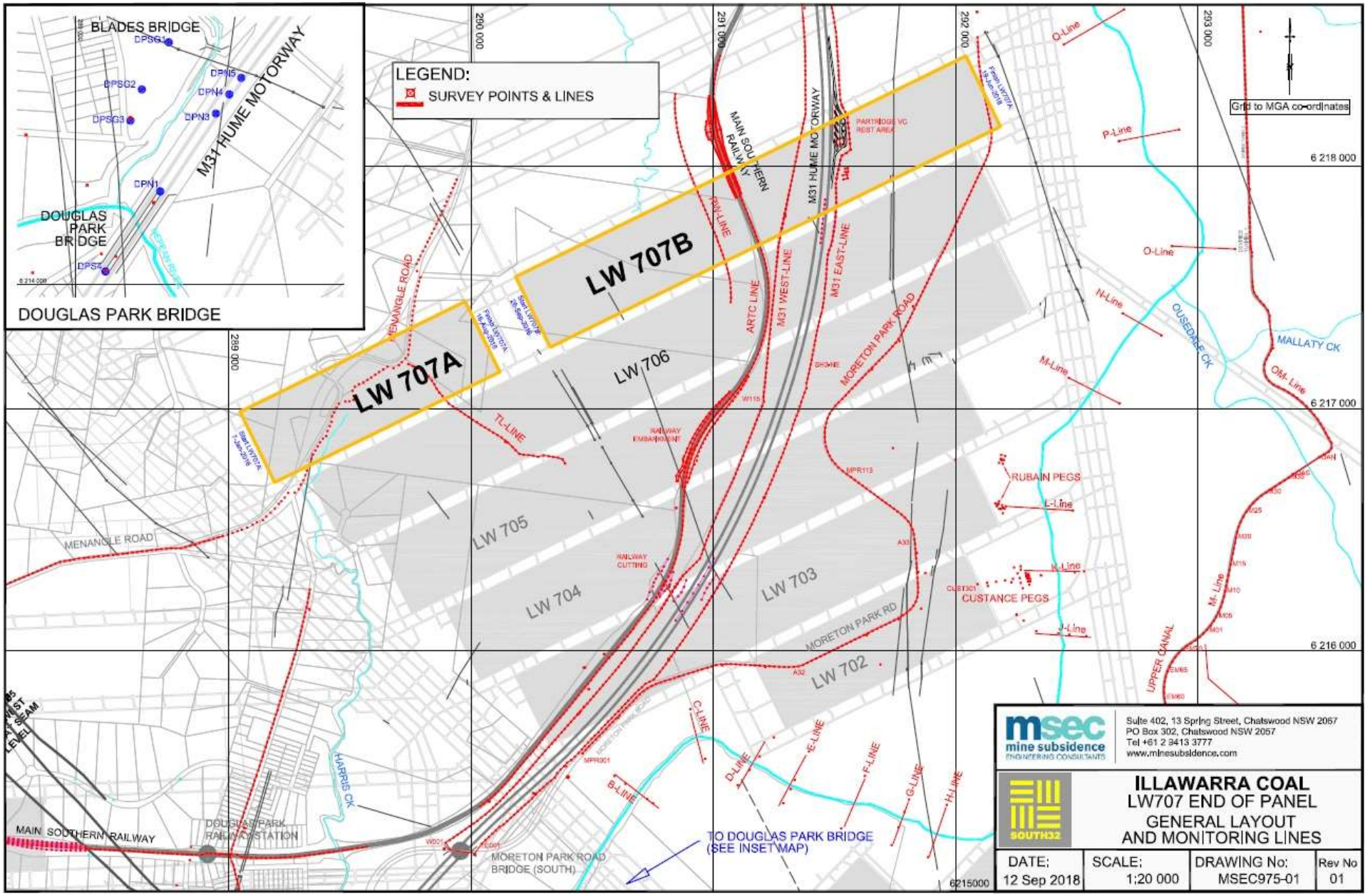

Figure 1: Longwall 707 Subsidence Monitoring Lines (MSEC975).

2.4. M31 Hume Motorway

The monitoring associated with the Hume Motorway, during the extraction of Longwall 707, included the following:

- M31 East and West Lines;
- Highway Cutting Points; and
- FBG (Fibre Bragg Grating) and slot closure monitoring.

2.4.1. *M31 East and West Lines*

The mine subsidence movements along the M31 Hume Motorway were measured by IC using two 3D monitoring lines, being the M31 East and M31 West Lines.

The ground movements measured using the M31 East Line and M31 West Line are consistent with the predictions provided in Reports Nos. MSEC342 and MSEC825.

2.4.2. *FBG and Slot Displacement Monitoring*

FBG Monitoring

A total of 785 temperature and 785 strain FBG sensors were installed in the top 50 mm of asphalt along each carriageway within the outside shoulder. The sensors are spaced every 10 m and temperature and strain were measured every 15 minutes during the mining of LW707B.

The temperature compensated FBG strains exceeded the trigger levels in the management plan at two locations during the mining of LW707B.

A blue alarm was received 27 December 2017 for an exceedance of compressive strain at FBG170.4 on the Northbound Carriageway. A small hump had been previously observed at this location, which had not changed. There were no immediate concerns from the Technical Committee at that stage. Extraction of LW707B temporarily stopped and very little change in pavement strain was observed. The hump continued to gradually increase in size and the pavement was resurfaced 2 February 2018.

The compressive strain at FBG170.4 started to increase upon recommencement of extraction of LW707B in March 2018. The Technical Committee agreed to increase the trigger level to -1.1 mm/m 20 March 2018. A blue alarm was received 19 April 2018 at FBG170.4 and a visual inspection was carried out. There were no immediate concerns noted from the site inspection, though minor bumps had re-emerged since the pavement had been resurfaced.

The Technical Committee agreed to increase the trigger level to -1.3 mm/m on 26 April 2018. The compressive strain at FBG170.4 continued to increase gradually and the pavement deformation gradually increased. The pavement was resurfaced again 24 May 2018, with very minor changes observed since that time.

The M31 Hume Motorway remained safe and serviceable during the above events.

Slot displacement monitoring

Displacement sensors were installed in each pavement slot and were measured every 5 minutes during the mining of LW707B. The slot displacements did not exceed the management plan trigger levels for closure at any stage during the mining of LW707B. As slots SB159, SB171 and SB173 approached the trigger level of 60 mm, the Technical Committee agreed to increase the trigger to 70 mm. The maximum measured closure of the slots located directly above LW707B was 56 mm at SB171 and 51 mm at NB172.

Further investigations identified that slot sensors SB171 and NB172 had reached their monitoring limits and SB173 was very close to its limit. The Technical Committee met on the 2 May 2018 and agreed that an immediate repair was not required as rates of change from the mining of LW707B had reduced to low levels. After considering options, the Technical Committee selected the following actions:

- a check survey of pavement pins was conducted; and
- repair or replace the slot sensors at SB171, SB173 and NB172 prior to the influence of LW708B.

2.5. The Main Southern Railway

The Main Southern Railway crosses directly above LW707B as shown in Drawings Nos. MSEC975-01 and MSEC975-03, in Appendix B. The monitoring associated with the railway for LW707B included the:

- ARTC 3D ground monitoring line;
- ARTC 3D embankment monitoring points;
- railway cutting points; and
- strain gauges.

The monitoring results and discussions were provided in the weekly subsidence monitoring review reports for the railway (MSEC831-01 to MSEC831-60), which were issued during the extraction of LW707B between October 2016 and June 2018.

A summary of the monitoring results for the Main Southern Railway are provided in the following sections.

2.5.1. *ARTC Line*

The mine subsidence movements along the Main Southern Railway were measured by IC using a 3D ground monitoring line, referred to as the ARTC Line.

The ground movements measured using the ARTC Line are consistent with the predictions provided in Reports Nos. MSEC342 and MSEC825.

2.5.2. *Automated Track Monitoring*

Rail Stress Transducers

Rail stress transducers are located along all four rails of the railway track, spaced every 25 m to 60 m. They measured the changes in rail strain every 5 minutes during the extraction of LW707B. While some

false alarms were triggered during mining, due to malfunction or damage to transducers, the actual stress readings did not exceed the trigger levels.

Expansion Switch Displacement Sensors

Displacement sensors have been installed at each expansion switch. Measurements were recorded every 5 minutes during the extraction of LW707B. While some low level (Blue) alarms were triggered during mining, responses had already been planned in anticipation of the alarms.

2.5.3. *Embankment Monitoring*

The mine subsidence movements along and across the Embankment at 70.5 km and Embankment at 69.0 km were measured by IC during the mining of LW707B. The findings are similar to those for the ARTC Line, which was previously discussed.

2.5.4. *Culverts*

The mine subsidence movements along the railway culverts at 70.5 km and 69.0 km were measured by IC using two 3D ground monitoring lines, referred to as the ARTC 70.5 km Culvert and ARTC 69.0 km Culvert.

2.6. Highway Cutting 2

The Highway Cutting 2 Points were measured by IC during the extraction of LW707B. The 3D monitoring points are located on the cuttings along the M31 Hume Motorway. A detailed discussion of results can be found in Attachment B; Section 2.7.

2.7. Partridge Visitor Centre Rest Area

The Partridge Visitor Centre (VC) Rest Area points were measured by IC during the extraction of LW707B.

The Partridge VC Rest Area experienced up to 859 mm of total vertical subsidence during the mining of LW707B. The ground strains were generally less than 1 mm/m tension and compression. Mark AM03 was observed to move relative to the adjacent pegs, with a compressive strain of 1.3 mm/m measured between Marks AM03 and E168 and a compressive strain of 1.6 mm/m measured between Marks AM03 and E170. Impacts were observed in this location to the concrete footpath, kerbs and unreinforced concrete mattress forming the spillway at the southern end of the Rest Area.

2.8. Far-field 3D Marks

The far-field mine subsidence movements were measured by IC using a number of 3D marks in the vicinity of LW707A and LW707B.

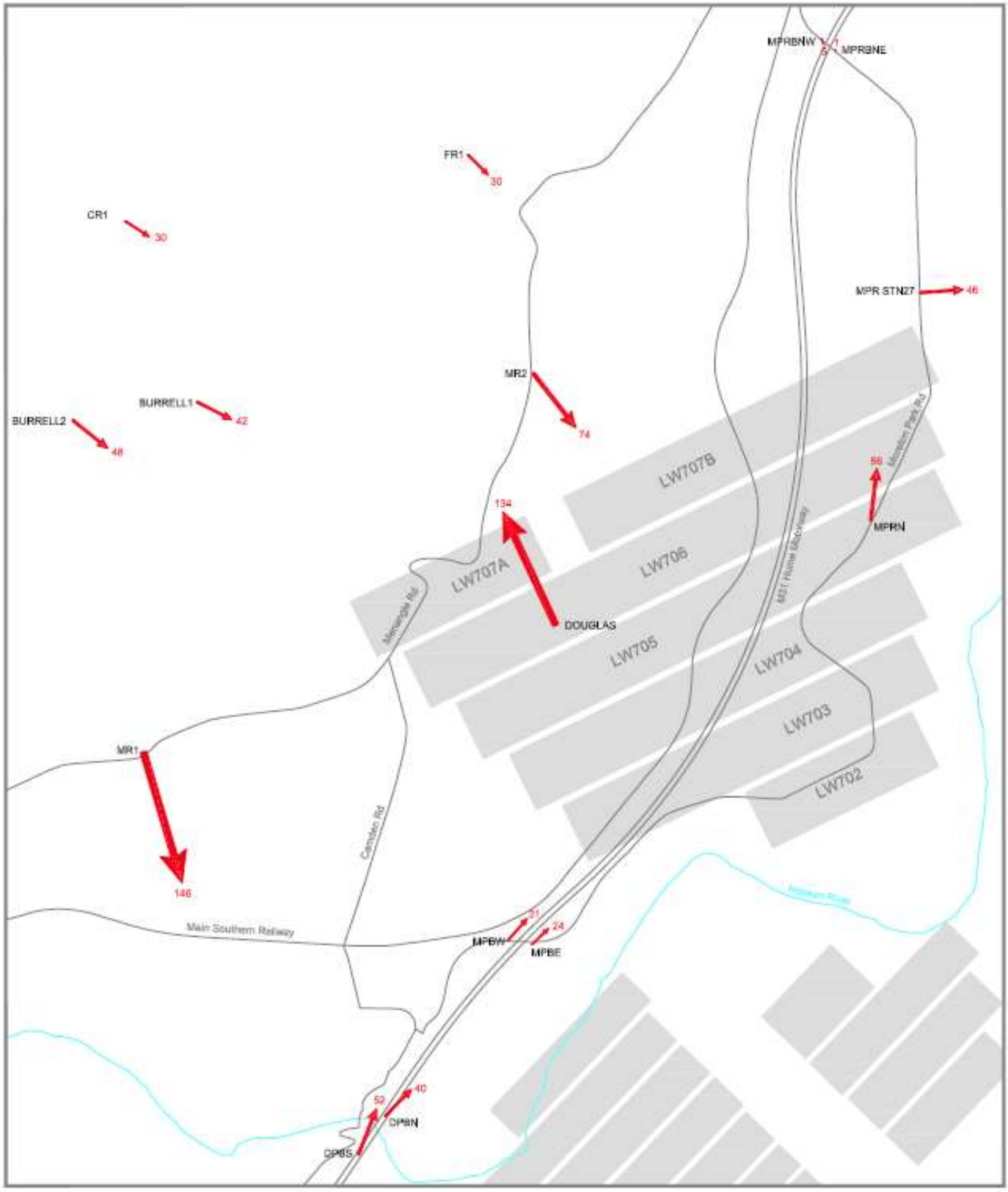

Figure 2: Measured (mm) absolute incremental horizontal movements at the far-field 3D marks due to the extraction of LW707A and LW707B.

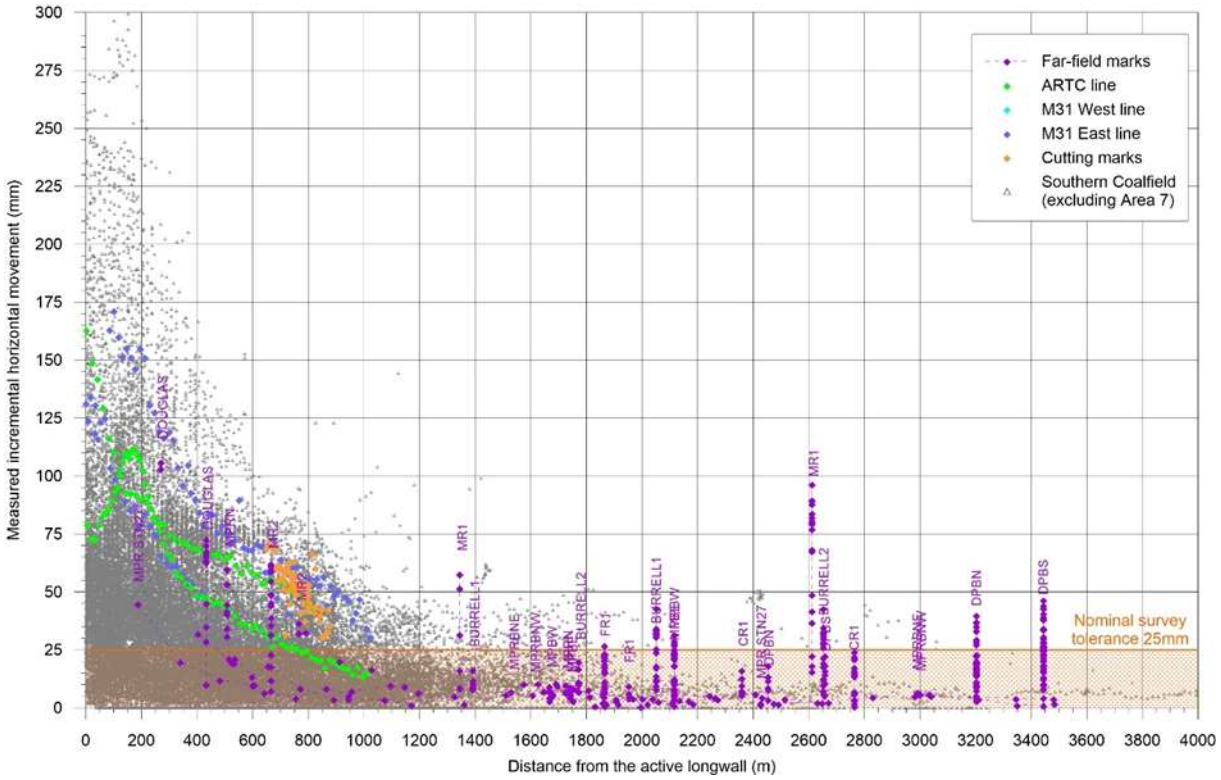

Figure 3: Measured incremental horizontal movements versus distance from the active longwall.

The measured incremental horizontal movements at the far-field 3D marks, due to the extraction of LW707A and LW707B, were typically within the range of those measured elsewhere in the Southern Coalfield at distances up to approximately 2000 m.

The measured horizontal movements at Marks MR1, DPBN and DPBS were greater than those typically measured at similar distances elsewhere in the Southern Coalfield. Mark MR1 is located on an embankment along the Main Southern Railway at a distance of 1.3 km west of LW707A. Marks DPBN and DPBS are located near the Douglas Park Twin Bridges and these marks could have been influenced by valley closure effects. Elsewhere, the measured horizontal movements were typically in the order of survey tolerance at distances greater than 2000 m.

2.9. Douglas Park Twin Bridges over the Nepean River

The Douglas Park Twin Bridges are located approximately 2.4 km south of the commencing (i.e. western) end of LW707A. The locations of these bridges are shown in Drawing No. MSEC975-01, in Appendix B, where the M31 Hume Motorway crosses the Nepean River. The monitoring associated with the Douglas Park Twin Bridges for LW707A and LW707B included the:

- absolute 3D bridge monitoring points;
- relative 3D bridge monitoring points;
- inclinometer monitoring;
- bridge joint monitoring; and
- visual inspections.

The descriptions of the monitoring results are provided in the following sections.

2.9.1. *Absolute 3D Monitoring for the Douglas Park Twin Bridges*

The absolute 3D horizontal movements at the Douglas Park Twin Bridges were monitored by IC at Marks DPBN and DPBS. The Trigger Action Response Plan (TARP) for the Douglas Park Twin Bridges, developed by the RMS chaired Technical Committee, provided triggers for absolute and relative horizontal movements of Marks DPBN and DPBS.

A formal review was undertaken by the Technical Committee 10 May 2017, where it was agreed to increase the Monitoring Review Point trigger level for absolute movement from 75 mm to 100 mm. This decision was based on the surveys of the bridges, monitoring of displacement sensors and FBGs at the bridge joints, which indicated no measurable differential lateral movement.

The maximum measured absolute horizontal movements of Marks DPBN and DPBS were less than the Level 1 trigger during the extraction of LW707A and LW707B. However, the maximum measured relative horizontal movement between these marks of 8 mm exceeded the Level 1 trigger of 5 mm. In response to this trigger, another relative 3D survey of the bridges was carried out and it was found that the measured lateral alignments of the bridges were within the allowable tolerances.

2.9.2. *Relative 3D Monitoring for the Douglas Park Twin Bridges*

The mine subsidence movements at the Douglas Park Twin Bridges were measured by IC using relative 3D marks fixed directly to the bridge structure.

The total changes in horizontal distance between the abutments and piers at the completion of LW707B were generally less than ±5 mm and, therefore, were similar to the order of survey tolerance. The total changes between SBNA and SBSA, between SBP2BW and SPB3BW and between NBNA and NBSA were between 6 mm and 8 mm.

2.9.3. *Inclinometers near the Douglas Park Twin Bridges*

The differential movements at the RST and SAA inclinometers at Site PSM6, located near the Douglas Park Twin Bridges, were monitored during the extraction of LW707A and LW707B and the concurrent

mining in Area 9. The inclinometer was installed and maintained by Pells Sullivan and Meynink (PSM), measured by IC and the results interpreted by PSM.

The inclinometers comprise boreholes with plastic casings that allow probes to measure the differential tilt or inclination over the lengths of the boreholes. Further details on the inclinometers and the results were provided in the monitoring Report Nos. PSM883-309L through PSM883-369L.

The TARP for the Douglas Park Twin Bridges, which was developed by the Technical Committee, provided a trigger threshold for differential movements at the inclinometers. The measured differential movements at the inclinometers at Site PSM6 did not exceed the Level 1 trigger during the extraction of LW707A and LW707B.

2.9.4. *Joint Monitoring for the Douglas Park Twin Bridges*

The differential movements across the movement joints in the Douglas Park Twin Bridges were measured by PSM during the extraction of LW707A and LW707B. The bridge movement joints are referred to as Joint 1 (adjacent to Pier 1), Joint 2 (adjacent to Pier 2) and Joint 3 (main expansion joint adjacent to Pier 3).

The bridge joint monitoring readings commenced 29 November 2007 (during the mining of LW701) and measurements have since been taken at 5 or 10 minute intervals. Further details on the bridge joint monitors and the results are provided in the monitoring Report Nos. PSM883-309L through PSM883-369L.

The TARP for the Douglas Park Twin Bridges, which was developed by the Technical Committee, provided a trigger for the differential movements across the bridge movement joints. The measured differential movements at the bridge joints did not exceed the Level 1 triggers during the extraction of LW707A and LW707B.

2.10. Moreton Park Road Bridge (South)

Moreton Park Road Bridge (South) is located approximately 1.7 km southwest of the commencing (i.e. western) end of LW707A. The monitoring associated with Moreton Park Road Bridge (South) for LW707A and LW707B included the:

- absolute 3D bridge monitoring points;
- relative 3D bridge monitoring points; and
- visual inspections.

The descriptions of the monitoring results are provided in the following sections.

2.10.1. *Absolute 3D Monitoring Points for Moreton Park Road Bridge (South)*

The absolute 3D horizontal movements at the Moreton Park Road Bridge (South) were monitored by IC at Marks MPBE and MPBW.

The TARP for the Moreton Park Road Bridge (South), which was developed by the Technical Committee, provided triggers for the absolute horizontal movements of the far-field 3D Points MPBE and MPBW adjacent to the bridge.

The Level 1 trigger for the absolute total horizontal movement was originally 125 mm, as agreed by the Technical Committee 25 August 2015, during the extraction of LW706. During the mining of LW707B, the Level 1 trigger was increased to 150 mm 30 May 2017, as agreed by the Technical Committee following assessment of monitoring results and approval by the RMS Bridge Maintenance Planner. The maximum measured absolute horizontal movements at Marks MPBE and MPBW were less than the Level 1 trigger at the completion of LW707B.

2.10.2. *Relative 3D Monitoring Points for the Moreton Park Road Bridge (South)*

The mine subsidence movements of the Moreton Park Road Bridge (South) were measured by South32 using relative 3D marks fixed directly to the bridge structure.

There was a small amount of abutment spreading, in the order of +5 mm, that developed during the previous extraction of LW703 to LW705. The results vary slightly between surveys and the cause is thought to be related to changes in moisture and/or temperature.

The measured total changes in horizontal distance between the bridge abutments were less than ±2 mm at the completion of LW707B. The total measured movements, therefore, were within the order of survey tolerance at the completion of this longwall.

2.11. WaterNSW Infrastructure

The WaterNSW infrastructure located near Area 7 includes the: Upper Canal, Devines Tunnel, wrought iron aqueducts, bridges and concrete aqueducts.

The movements at the Ousedale Creek, Mallaty Creek, Leafs Gully and Nepean Creek Aqueducts and bridges were monitored by IC using local 3D surveys.

The maximum measured incremental net subsidence and uplift at the aqueducts and bridges, during the extraction of LW707A and LW707B, were in the order of survey tolerance, i.e. not measurable.

The incremental changes in the distances between the aqueduct headwalls, during the extraction of LW707A and LW707B, were -4 mm (closure) at the Mallaty Creek Aqueduct, +2 mm (opening) at the Nepean Creek Aqueduct and +4 mm (opening) at the Nepean Creek Aqueduct. The movements at the Ousedale Creek Aqueduct were similar to the order of survey tolerance. The observed incremental movements at each of the bridges were in the order of survey tolerance, i.e. not measurable.

The movements at Concrete Aqueducts C and D were monitored by IC using local 3D surveys. The maximum measured incremental net vertical and horizontal movements at the Concrete Aqueducts C and D, during the extraction of LW707A and LW707B, were less than 3 mm. The measured movements, therefore, were similar to the order of survey tolerance, i.e. not measurable.

2.12. Telstra Infrastructure

The mine subsidence movements along the Telstra optical fibre line were measured by South32 using a 3D ground monitoring line, referred to as the Telstra Line.

The maximum measured incremental vertical subsidence and tilt along the Telstra Line, due to the extraction of LW707A only, are less than the predicted values. The maximum measured incremental strains are 0.9 mm/m tensile and 1.3 mm/m compressive. No localised or irregular ground movements occurred due to the extraction of LW707A. The measured strains are less than the maximum predicted strains based on regular ground movements of 1 mm/m tensile and 2 mm/m compressive.

There was a reasonable correlation between the high accuracy tiltmeter measurements and the ground surveys at the Telstra Tower. The maximum measured tilts were 3.4 mm/m (i.e. 0.20°) in the north-south direction and 2.5 mm/m (i.e. 0.15°) in the east-west direction. The maximum measured tilts were less than the operating tolerances of the antennae.

3. Impacts to Built Features

3.1. Infrastructure

The built features located near Longwall 707A and Longwall 707B are shown in Figure 1. The features considered in this End of Panel report include those located within either the 35° angle of draw line from Longwall 707A and Longwall 707B and/or the predicted 20 mm incremental subsidence contour due to the extraction of these longwalls. The built features expected to experience far-field or valley related movements that could be sensitive to these movements have also been considered. The built features include:

- Moreton Park Road and drainage culverts;
- Menangle Road and drainage culverts;
- M31 Hume Motorway and associated infrastructure;
- Main Southern Railway and associated infrastructure;
- Douglas Park Twin Bridges;
- Moreton Park Road Bridge (South);
- low voltage powerlines;
- copper telecommunications cables;
- optical fibre cables – Telstra (2 of), Optus, NextGen and Powertel;
- building structures, pools, tanks and farm dams;
- heritage structures (including the Mountbatten Group);
- groundwater bores (including GW101437 and GW104154);
- pumps in the Nepean River;
- the Upper Canal, Cataract Tunnel and associated infrastructure; and
- survey control marks.

The MSEC assessments for the built features, due to the extraction of LW705 to LW710, were provided in Reports Nos. MSEC342 and MSEC825. Comparisons between the assessed and observed impacts for the built features located near LW707A and LW707B, as listed above, are provided in Table 4. The observed impacts are based on those recorded by ICEFT.

Minor cracking and deterioration of the pavement occurred along Menangle Road. Replacement of a 100 m section of the Telstra optical fibre cable was also required during LW707B. There are no long-term adverse impacts on this road or cable. Elsewhere, the observed impacts on the built features, due to the extraction of LW707A and LW707B, were similar to or less than the assessed (i.e. predicted) impacts.

Table 4: Summary of the assessed and observed impacts for built features due to the extraction of LW707A and LW707B.

Built feature	MSEC assessed impacts	Observed impacts
Moreton Park Road	Minor cracking and localised heaving of the road surface may occur in some locations above the longwalls	No adverse impacts observed due to the extraction of LW707B
Menangle Road	Minor cracking and localised heaving of the road surface may occur in some locations above the longwalls	Minor cracking observed in the road in the location of a culvert near the commencing end of LW707A and cracking and deterioration of pavement near the top of a hill above the longwall
M31 Hume Motorway	No impacts on the safety or serviceability of the motorway after the implementation of the management strategies	No adverse impacts on safety or serviceability. Humps formed on both carriageways and these were remediated by re-shaping of the pavement surface as part of Management Plan responses
Main Southern Railway	No impacts on the safety or serviceability of the railway after the implementation of the management strategies	Changes in track geometry recorded and remediated in accordance with the Management Plan. No adverse impacts to safety and serviceability
Douglas Park Twin Bridges	Impacts unlikely after the implementation of the TARP	No adverse impacts observed
Moreton Park Road Bridge (South)	Impacts unlikely after the detailed investigation, analysis and implementation of the TARP	No adverse impacts observed
Low voltage powerlines	Impacts unlikely, but minor mitigation measures may be required	No adverse impacts observed
Copper telecommunications cables	Impacts unlikely	Small levels of signal loss measured
Optical fibre cables	Impacts unlikely with the implementation of the management strategies including OTDR monitoring and mitigation	Loss of signal along the Telstra optical fibre cable adjacent to the Main Southern Railway at 69.3 km. The cable was excavated and replaced with a new 100 m section of cable in conduit
Building structures	Category A or B tilt impacts	Building structures remained in safe and serviceable conditions during the extraction of LW707A and LW707B. Claims that have been lodged are being managed by Subsidence Advisory NSW (SA NSW) through the relevant legislation
Pools	Inground pools could be more susceptible to ground strains	Claims that have been lodged are being managed by Subsidence Advisory NSW (SA NSW) through the relevant legislation
Water tanks	Impacts unlikely	Claims that have been lodged are being managed by SA NSW through the relevant legislation.

Built feature	MSEC assessed impacts	Observed impacts
Farm dams	Potential for minor cracking or leakage	Gas release observed in one private dam (Site AA7_LW707_001) and soil cracking observed around another private dam (no adverse impacts)
Heritage structures	No heritage sites located near LW706	No reported impacts
Groundwater bores	Potential for blockage or reduction in the capacity of the groundwater bores	Gas release and iron staining to water expelled from borehole GW102584. Refer to the accompanying Groundwater Report by Geoterra
Pumps in the Nepean River	Impacts unlikely	No reported impacts
The Upper Canal, Cataract Tunnel and associated infrastructure	Impacts unlikely	No reported impacts
Survey control marks	Small fair-field horizontal movements which could require re-establishment	Small far-field horizontal movements

3.2. Private Properties

Private property inspections were conducted before and during the extraction of Longwall 707 to assess the baseline status and potential subsidence impacts on private bores. These inspections were conducted in consultation with the respective landholders. Other inspections were conducted at the request of landholders in response to potential impacts. The full private property and borehole inspection reports are included in **Attachment D**.

An inspection by ICEFT of the private borehole GW112441 on 15 July 2015, during Longwall 707 extraction, identified water cloudiness and a gaseous smell in the extracted bore water. Laboratory analysis confirmed the presence of methane, along with other hydrocarbons. The analysis indicated no post-Longwall 707 change to pH, salinity or metals. The landowner ceased to use the bore, the area around the wellhead was fenced off and a 10,000 Litre tank was provided by IC for livestock watering, which is topped up as required by IC. At this stage, a replacement bore is planned to be drilled after completion of Longwall 708 unless an alternative arrangement is agreed to by the landowner.

Private borehole GW105388, which is located approximately 500 m from Longwall 707, was reported to have reduced pumping times on 14 December 2016. No adverse effect on bore yield was reported. IC have been supplying trucked tank water to the landholder since March 2017.

One gas release impact was observed within a private dam during extraction of Longwall 707. Impact *AA7_LW707_001* consisted of four small gas releases observed in dam E13d01 on the 6 April 2016. The gas release has since ceased.

A gas release and increased iron staining (impact *AA7_LW707_002)*, was observed in the private borehole GW102584 on 22/04/2016. The bore was subsequently capped, by means of grouting the hole, on the 22 June 2016.

4. Impacts to Natural Features

The natural features located near Longwall 707 include:

- Nepean River;
- creeks;
- cliffs and rock outcrops;
- steep slopes; and
- archaeological sites.

The MSEC assessments for the natural features, resulting from the extraction of Longwalls 705 to 710 were provided in the Longwall 705 to 710 SMP (MSEC342). More detailed assessments for some natural features were also provided in other consultant's reports.

The MSEC assessments for the natural features, due to the extraction of LW705 to LW710 were provided in Reports Nos. MSEC342 and MSEC825. More detailed assessments for some natural features were also provided in other consultant's reports. Comparisons between the MSEC assessments and the observed impacts for the natural features, as listed above, are provided in Table 5. The observed impacts are based on those recorded by ICEFT and are described in **Attachment C**.

Table 5: Summary of the MSEC assessments and the observed impacts for the natural features due to the extraction of Longwall 707.

Natural feature	MSEC assessed impacts	Observed impacts
The Nepean River	**Minor fracturing** could occur in the bed of the river	No fracturing observed; however, the flooded valley and sediment profile limits observations of the river bed
	The potential for **surface water flow diversion** assessed as very low	No observable loss or diversion of water from the Nepean River – refer to the accompanying Surface Water Report by Geoterra
	The **surface water level** is expected to remain essentially unchanged. Uplift of the banks could result in some desiccation of the banks	No observed change in water level apart from the normal fluctuations associated with rainfall and WaterNSW discharges
	Possible that mining-induced **springs** could occur	No additional iron staining or iron seeps were observed in the Nepean River during LW707A and LW707B
	Possible that isolated **gas emissions** could occur	No new gas release zones were identified during the extraction of LW707A and LW707B. Existing gas release zones 14, 15, 17 and 18 were active during this period. However, these gas release zones have since ceased as of January 2018. For further details, refer to the accompanying Landscape Report by IC
	Water quality – Refer to the accompanying Surface Water Report by Geoterra **Terrestrial ecology** – Refer to the accompanying Landscape Report by IC	
Creeks	Potential for some **ponding**, **flooding** and **desiccation** above the longwalls	No observed adverse impacts in the monitored streams
	Fracturing could occur in the beds of the smaller creeks above the longwalls	No observed adverse impacts in the monitored streams
Cliffs and rock outcrops	Potential for **cliff instabilities** assessed as very low	No observed adverse impacts
Steep slopes	Potential for **soil slippage**	No observed adverse impacts
Archaeological sites	Low likelihood of impacts on open sites, scarred tree and shelters.	No observed adverse impacts. Refer to the accompanying Cultural Heritage Report by Niche

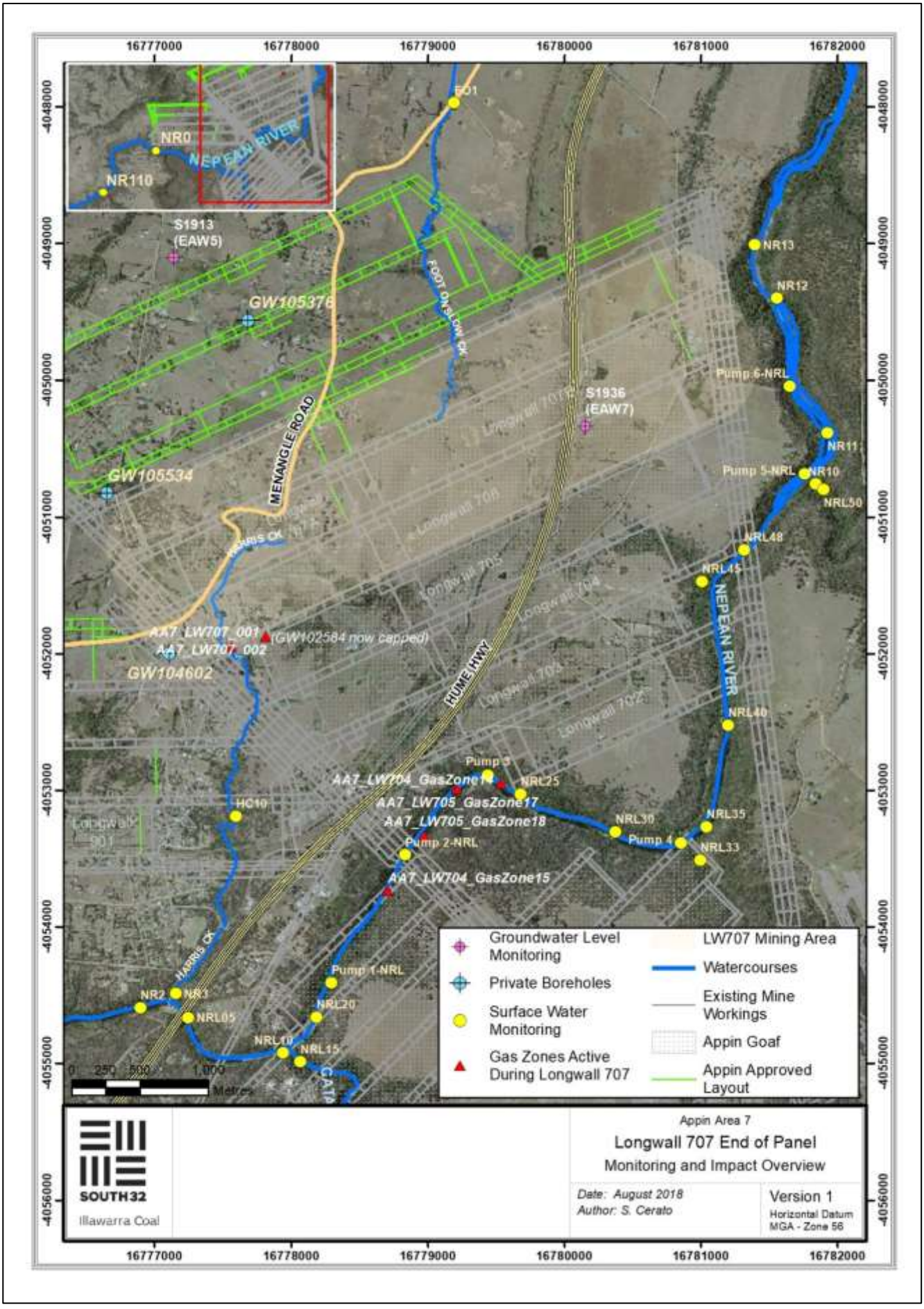

Figure 4: Natural features and monitoring sites within the AA7 study area.

4.1. Surface Water Assessment

In-situ water quality parameters measured for the Nepean River and tributaries include temperature, specific conductivity (SpC), Oxidation-Reduction Potential (ORP), pH and dissolved oxygen (DO). These parameters were measured by the ICEFT on a weekly and monthly basis, and have been undertaken since July 2002. The assessment of surface water during the extraction of Longwall 707 has been undertaken by GeoTerra. The key points are included in this report, the full report by GeoTerra is provided as **Attachment D**.

Water flows in the Nepean River are derived from a number of sources, including (Ecoengineers, 2014);

- flows from catchment areas,
- flows from licensed discharges, including Appin Mine and Tahmoor Colliery (the latter located adjacent to Bargo River), and
- stormwater runoff from agricultural and urban areas.

Stream water level as well as field chemistry and laboratory analysis of river water samples has been conducted by ICEFT in the Nepean River since July 2002.

4.1.1. *Nepean River Water Level and Flow*

In accordance with the Longwall 707 to 710 TARP monitoring requirements, and focussing on the relevant sites for the extraction of Longwall 707, this report outlines the Nepean River monitoring sites Pump 5 – NRL, which is downstream of Longwall 707, and Pump 6 – NRL, which is upstream of Longwall 707.

Water levels in the Nepean River and its tributaries were monitored by the ICEFT using observations and benchmarks on a weekly and monthly basis (where access was safe and granted).

Based on the monitoring conducted by the ICEFT and, supported by **Figure 4,** there have been no periods in the Nepean River where dry and / or flooded areas of riverbed were observed during the extraction of Longwall 707.

4.1.2. *Nepean River Water Quality*

pH and Salinity

During the extraction of Longwall 707, no TARP trigger levels were observed for pH or salinity, as the two standard deviation value reduction in pH, or exceedance in EC, at NR13 did not persist for longer than two months.

Dissolved Oxygen

During the extraction of Longwall 707, no significant change in trend, extended adverse changes or TARP trigger levels were observed for dissolved oxygen.

Iron and Manganese

During the extraction of Longwall 707, no TARP trigger levels were observed for iron and manganese, as the exceedances in levels that occurred at NR13 did not persist for more than two months.

4.1.3. *Gas Releases into the Nepean River*

No new gas release zones were observed during the extraction of Longwall 707.

Previously observed Gas Zones 14, 15, 17, 18 and AA7_LW706_001 were active during the Longwall 707 extraction period; however, they were activated by previous longwalls (704, 705 and 706).

The following gas release zones were last observed to be active:

- Gas Zone 14 – 6 July 2016;
- Gas Zone 15 – 3 December 2016;
- Gas Zone 17 – 29 August 2016;
- Gas Zone 18 – 17 July 2017, and;
- AA7_LW706_001 – 18 January 2018.

No gas release zones have been observed on the Nepean River within the AA7 study area since January 2018.

4.2. Nepean River Appearance

The Nepean River and its tributaries was monitored by the ICEFT on a weekly basis (where access was safe and permission granted). Following the approval to modify the monitoring program (4 June 2015), monitoring was conducted monthly or as required due to any potential mining impacts. Photographs are taken of monitoring sites, and any other potential impact site. No impacts to the appearance of the Nepean River or tributaries were observed during the extraction of Longwall 707.

4.3. Groundwater Assessment

GeoTerra was commissioned by IC to report on the predicted and any observed groundwater changes resulting from extraction of Longwall 707. The information in this section has been drawn from the GeoTerra report, which is provided as **Attachment D**.

Fully cemented, sealed vibrating wire piezometer arrays were installed by IC in bores EAW5 (S1913) and EAW7 (S1936) (Figure 4).

The following private boreholes within the Longwall 702 to 707 subsidence area were inspected during the extraction of Longwall 707, or have previously been inspected:

- GW102584, 104602, 104661, 105339, 105376, 105388, 105534, 106574, 108312 and GW112441

4.3.1. *Groundwater Levels*

Groundwater levels are logged hourly using vibrating wire piezometers in the EAW series piezometers and are downloaded at the completion of longwall panels (or as required). The discussion of results from EAW5 and EAW7 are detailed in **Attachment E**. No groundwater level reduction TARP triggers were exceeded during the extraction of Longwall 707.

4.3.2. *Groundwater Quality*

A summary of the sampled private bore water chemistry is contained in **Attachment E; Appendix A**.

4.3.3. *Private Bore Inspections*

Five private property inspections were conducted during and before extraction of Longwall 707 to assess the baseline status and potential subsidence impacts on private bores, where requested by landowners.

Three properties have no observed impact (GW101986, 105376 and 105534), one property had a confirmed impact of increased iron staining and gas discharge in the bore water (GW102584) and one possible impact of decreased bore pressure and yield was reported by a landowner (GW104602).

A summary of property inspections is provided in Table 6**.** The full private property reports are provided in **Attachment D,** along with their assessment in **Attachment E.**

Table 6: Private Bore Inspections

Borehole ID	Observation	Subsidence Impact Status
GW101986	No observed changes	No Impact
GW102584	Iron staining, gas odour and bubbling reported by landowner	Confirmed Impact
GW104602	Decrease in flow pressure and yield reported by landowner	Possible Impact
GW105376	No observed changes	No Impact
GW105534	No observed changes	No Impact

4.3.4. *Mine Water Balance*

Daily mine groundwater inflow data for the Area 7 workings was available between 31 July 2017 and 30 May 2018. During the extraction of Longwall 707, with the available data, the estimated mine water balance did not reach or exceed any TARP trigger levels (Figure 5).

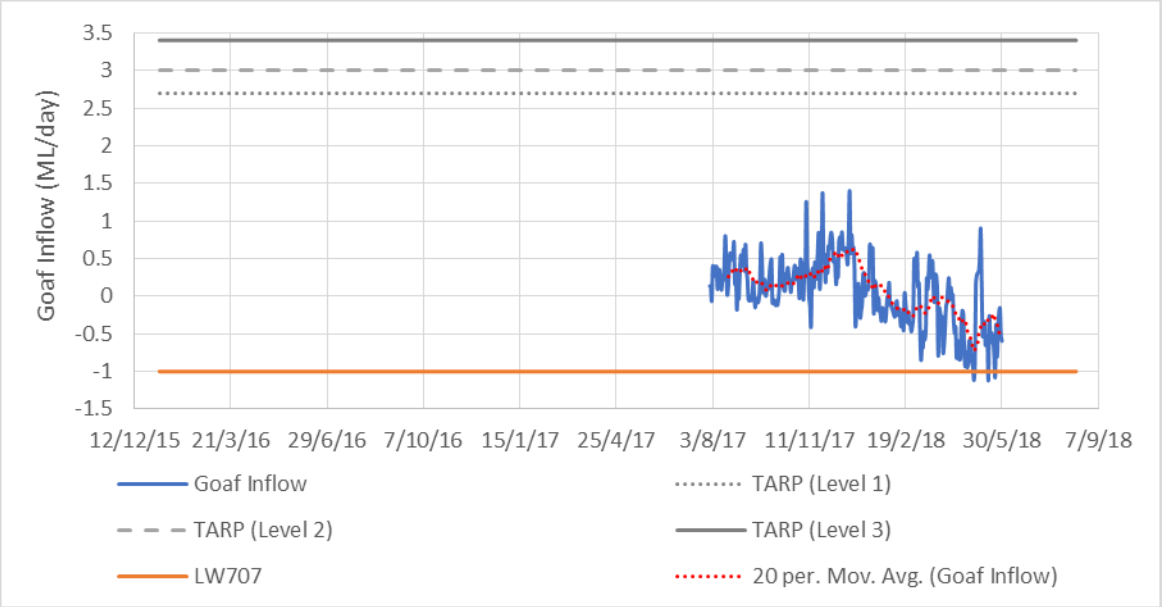

Figure 5: Daily goaf inflow for AA7, which is determined by subtracting the estimated water supply volume (to AA7) from the total volume of water pumped to storage.

4.4. Terrestrial Ecology Assessment

Terrestrial ecology in Area 7 is monitored by the ICEFT in conjunction with general observational monitoring. Monitoring identifies any changes in vegetation condition and vegetation that may have been impacted by rockfalls, soil slippage or gas emissions.

There have been no reported impacts to vegetation as a result of Longwall 707 (ICEFT 2018). Mechanisms of subsidence that could potentially result in impacts to native vegetation, such as vegetation die-off due to surface cracking or gas releases, were not observed by the ICEFT within vegetation communities in the mining area during monitoring inspections. It is therefore concluded that the extraction of Longwall 707 has had negligible impact on terrestrial ecology.

4.5. Aquatic Ecology Assessment

Cardno was commissioned by IC to assess the potential impact of mine subsidence on ecological indicators of the Nepean River within the Area 7 and 9 mine areas through the implementation of an aquatic ecological monitoring program (Figure 5). The aims of the monitoring program are to:

- Determine the occurrence of fish and macroinvertebrates and asses the condition of aquatic habitat that may be affected by subsidence-related impacts; and
- Determine whether any changes observed in aquatic habitat or biota may be linked to subsidence-related impacts.

No changes to aquatic ecology indicators that could be associated with extraction of Longwall 707 were detected in data collected following the commencement of extraction of this longwall. This is as expected, given that no water quality or physical mining impacts (other than isolated gas releases) have been identified. The gas releases identified in the Nepean River during extraction of previous longwalls do not appear to have had any measurable effect on macroinvertebrates, fish or macrophytes in the Nepean River.

There is also no evidence that mining of Longwall 707 has had any impact on fish populations. The relatively large changes in the extent and distribution of aquatic macrophytes observed since the commencement of monitoring represent natural variation relating to high flow periods, and are unrelated to mining.

4.6. Cultural Heritage Assessment

There are no known cultural heritage sites within the study area of Longwall 707.

5. Longwall 707 Monitoring Program

Table 7: Longwall 707 Monitoring Program

Monitoring Site	Monitoring Type	Monitoring Frequency	Parameters	Observations from Longwall 707	Future Monitoring (Longwall 708)
WATER QUALITY					
Nepean River Baseline upriver sites for cross- checking for upriver perturbations: • NR110 Impact monitoring sites adjacent to each longwall: • NR12 • NR13 Downstream site: • NR50 *Other sites:* • NR0 • NR2 • NR4 • NR6 • NR7 • NR9 • NR11 **1st and 2nd Order Watercourses** • Lower Harris Creek (NR3) • Cataract River (NR5) • Elladale Creek (NR8) • Ousedale Creek (NR10) • Menangle Creek (NR40) • Upper Harris Creek (HC10) • Foot Onslow Creek (FO1) • Navigation Creek (NAV1)	Grab Sample and field measurements	• Monthly baseline prior to mining • Monthly observations and field analysis during mining(1) • Monthly detailed laboratory analysis during mining • Monthly monitoring for 2 years post mining (or as otherwise required/approved) If required as a result of assessment of mining impacts	**Field Parameters:** •Temperature •Dissolved Oxygen (DO) •Specific Conductivity •pH •ORP **Standard Lab Sample:** pH and EC Filtered, Na, K, Ca, Mg, Cl, Ni, Zn, Fe, Mn, Al, SO4 Total Fe, Mn, Al Total Alkalinity TKN, TP, NH3-N, NOx-N (TON), FRP, TSS, DOC **Lab Sample for Gas Releases:** •CH4 •C2H6 •Trace Phenols •Sulphide	• No new gas releases observed. • Five previously observed gas releases were active during the extraction of Longwall 707; however, they ceased as of January 2018. • Deviations in water quality were observed; however, they were not attributed to mining impacts	• Continue monitoring as required
WATER LEVEL AND FLOW					
Nepean River At benchmark sites and water pump sites:	Water Level	• Monthly baseline prior to mining (data has been recorded for most sites since	• Areas of dry riverbed compared with baseline • Areas of flooded riverbed	• Flow monitoring discontinued by WaterNSW.	• Continue monitoring as required

Monitoring Site	Monitoring Type	Monitoring Frequency	Parameters	Observations from Longwall 707	Future Monitoring (Longwall 708)
• NR110 • NR0 • NRL05 • NRL10 • NRL15 • NR12 • NR13 • NRL20 • Pump 1-NRL • Pump 2-NRL • NRL25 • NRL30 • NRL33 • NRL35 • NRL40 • NRL45 • NRL48 • Pump 5-NRL • Pump 6-NRL SCA flow monitoring sites: • Maldon Weir • Broughtons Pass Weir • Menangle Weir **1st and 2nd Order Watercourses** • Lower Harris Creek (NR3) • Cataract River (NRL15) • Elladale Creek (NRL33) • Ousedale Creek (NRL50) • Menangle Creek (NR40) • Upper Harris Creek (HC10) • Foot Onslow Creek (F01) • Navigation Creek (NAV1)		2007) • Monthly manual monitoring at benchmarks during mining(1) • Flow monitoring at weirs (data supplied by SCA) • Ongoing monthly monitoring for 2 years post mining (or as otherwise required/approved)	compared with baseline • Measurement of water level compared with baseline (where benchmark is available) • Photo points		
APPEARANCE					
Nepean River • Observations along the length of the Nepean River within the active mining area **1st and 2nd Order Watercourses** • Lower Harris Creek (NR3) • Cataract River (NR5) • Elladale Creek (NR8) • Ousedale Creek (NR10) • Menangle Creek (NR40) • Upper Harris Creek	Observational and photographic monitoring	• Prior to mining of longwall underlying watercourse or mining of any immediately adjacent longwall Following the development of incremental subsidence for each longwall that will impact on the feature • Pre mining photographs • Monthly visual inspection during mining If required as a result of assessment of mining impacts	• Iron or salinity staining (e.g. orange or white staining in water or on banks/seeps) • Water cloudiness • Evidence of springs in Nepean River • Visual signs of impacts (e.g. cracking, vegetation changes, increased erosion, changes in water colour etc.) • Impacts determined from comparing photo points taken prior to, during and post mining	• No observed impacts	• Continue monitoring as required

Monitoring Site	Monitoring Type	Monitoring Frequency	Parameters	Observations from Longwall 707	Future Monitoring (Longwall 708)
(HC10) • Foot Onslow Creek (FO1) • Navigation Creek (NAV1) **Water Pumps** • Pump 1 NRL • Pump 2 NRL • Pump 3 • Pump 4 • Pump 5 NRL • Pump 6 NRL •			• Erosion and/or sedimentation compared with baseline • Pump submergence and disturbance		
AQUATIC ECOLOGY					
Nepean River • Sites 1 and 2 • Sites 5 and 6 • Sites 7 and 8 • Sites X3 and X4 (AA9 Monitoring) • Sites X5 and X6	Quantitative and observational monitoring	• Two Baseline monitoring campaigns • prior to mining • Annual monitoring campaigns (spring) during mining • Two monitoring campaigns post mining	• Photographic records • Macro-invertebrate Assessment • Fish sampling • Water Quality • Monitored in conjunction with: Flow River Morphology	• No observed impacts	• Continue monitoring as required
GROUNDWATER					
Water Level IC Monitoring Bores • S1913 (EAW5) • S1936 (EAW7) *Additional Bulli Seam piezometers located throughout the mining area (Refer Figure 1)* Private Bores (10 registered bores): • GW104602 • GW105376 • GW105574 • GW105339 • GW072874 • GW104661 • GW105388 • GW101986 • GW106574 • GW105534	Groundwater level	IC Bores • Pre-mining • Water level logged hourly • Post-mining – following the development of incremental subsidence for each longwall that will potentially impact on the borehole • Monitoring to continue for at least 12 months post mining depending on borehole functionality Private Bores • Prior to mining of longwall underlying bore or mining of any immediately adjacent longwall (if in agreement with landholder) • Post-mining – following the development of incremental subsidence for each longwall that will impact on the borehole (if in agreement with landholder) • As requested by landholder or if physical impacts to bore identified (landholder to observe during use of bore)	Grouted monitoring holes: • Piezometric head in various strata Private bores • Water level measured with dip meter (where access to property is available and in agreement with landholder)	• Reduction in groundwater level of Hawkesburry and Bulgo Sandstones; further detail in **Attachment E.** • One property had a confirmed impact of increased iron staining and gas discharge in the bore water (GW102584) and one possible impact of decreased bore pressure and yield was reported by a landowner (GW104602).	• Continue monitoring as required

Monitoring Site	Monitoring Type	Monitoring Frequency	Parameters	Observations from Longwall 707	Future Monitoring (Longwall 708)
LANDSCAPE FEATURES					
Cliffs • Along Nepean Gorge **Steep Slopes** • Along Nepean Gorge, associated tributaries and above western end of the proposed longwalls	• Once prior to mining. Photographic records taken • Monthly visual inspections • Monitoring to continue 6 monthly for • 2 years following the completion of mining (or as otherwise required/approved) • As required when specific impacts are identified or when concern is raised by a landowner • As required, in accordance with Built Feature Management Plans and landholder agreement	• Cliff and steep slopes will be observed for any instability (e.g. rock falls, mass movement) and seeps		• No observed impacts	
TERRESTRIAL ECOLOGY					
Monitored in conjunction with general observational monitoring for the Nepean River, watercourses and landscape	• Vegetation communities • Vegetation condition • Changes in vegetation • Tree health • Threatened species	• If required as a result of assessment of mining impacts • General observation of active mining areas during all other monitoring	• Vegetation communities • Vegetation condition • Changes in vegetation • Tree health • Threatened species	• No observed impacts	
ABORIGINAL ARCHAEOLOGY					
There are no aboriginal archaeology sites on the AIHMS database within the Appin LW707-710 mining area. No sites have been identified during the SMP studies					
HISTORIC HERITAGE					
• Gilbulla (Anglican Conference Centre)	Observational, photographic monitoring and structural inspections	Property Management Plan to be developed prior to influence of mining	• Building/structure condition • Heritage value	• No observed impacts (not within the zone of influence of Longwall 707).	

(1) Fortnightly targeted monitoring of relevant sites when impacts are observed

(2) Analytes tested at closest downstream sample site following Level 2 and above trigger for gas release

6. References

Ecoengineers (2008) Assessment of Water Flow and Quality Effects Appin Colliery Longwalls 705-710.

Geoterra (2008) Appin Area 7 Longwalls 705-710 Groundwater Assessment Douglas Park NSW.

MSEC (2007) The Prediction of Subsidence Parameters and the Assessment of Mine Subsidence Impacts on Natural Features and Surface Infrastructure Resulting from the Extraction of Proposed Longwalls 705 to 710 in Area 7 at Appin Colliery, in support of the SMP application, MSEC326.

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7. Appendix 1: Longwall 707 TARP Summary Table

<table>
<tr><th>MONITORING</th><th>TRIGGER</th><th>ACTION</th></tr>
<tr><td colspan="3">WATER QUALITY</td></tr>
<tr><td rowspan="3">Nepean River
Impact monitoring sites adjacent to longwalls:

• NR12
• NR13

Refer to Figure 1

Notes:
Baseline upriver site NR110 will be used for cross-checking upriver perturbations(3)

<table>
<tr><th></th><th>Mean</th><th>1 STDEV</th><th>2 STDEV</th></tr>
<tr><td>Impact Sites</td><td></td><td></td><td></td></tr>
<tr><td>NR12</td><td></td><td></td><td></td></tr>
<tr><td>pH</td><td>7.54</td><td>0.34</td><td>0.68</td></tr>
<tr><td>DO (%)</td><td>88.03</td><td>10.62</td><td>21.23</td></tr>
<tr><td>SpC (µS/cm)</td><td>180</td><td>50</td><td>100</td></tr>
<tr><td>Tot Fe (mg/L)</td><td>0.421</td><td>0.135</td><td>0.270</td></tr>
<tr><td>Tot Mn (mg/L)</td><td>0.034</td><td>0.012</td><td>0.023</td></tr>
<tr><td>NR13</td><td></td><td></td><td></td></tr>
<tr><td>pH</td><td>7.43</td><td>0.35</td><td>0.70</td></tr>
<tr><td>DO (%)</td><td>86.99</td><td>12.82</td><td>25.63</td></tr>
<tr><td>SpC (µS/cm)</td><td>180</td><td>49</td><td>98</td></tr>
<tr><td>Tot Fe (mg/L)</td><td>0.407</td><td>0.129</td><td>0.259</td></tr>
<tr><td>Tot Mn (mg/L)</td><td>0.034</td><td>0.013</td><td>0.026</td></tr>
<tr><td>Control Site</td><td></td><td></td><td></td></tr>
<tr><td>NR110</td><td></td><td></td><td></td></tr>
<tr><td>pH</td><td>7.90</td><td>0.42</td><td>0.84</td></tr>
<tr><td>DO (%)</td><td>84.19</td><td>15.22</td><td>30.44</td></tr>
<tr><td>SpC (µS/cm)</td><td>240</td><td>92</td><td>184</td></tr>
<tr><td>Tot Fe (mg/L)</td><td>0.328</td><td>0.131</td><td>0.262</td></tr>
<tr><td>Tot Mn (mg/L)</td><td>0.025</td><td>0.015</td><td>0.031</td></tr>
</table>
</td><td>Level 1(1)
Impact monitoring sites:

• pH reduction greater than 1 standard deviation but less than 2 standard deviation from pre-mining mean resulting from the mining for two consecutive months
• DO reduction greater than 1 standard deviation but less than 2 standard deviation from pre-mining mean resulting from the mining for two consecutive months
• Identification of strata gas plume of flow rate < 3000 L/min (2)</td><td>• Continue monitoring program
• Report impacts to key stakeholders
• Summarise impacts and record</td></tr>
<tr><td>Level 2(1)
Impact monitoring sites:

• pH reduction greater than 2 standard deviation from pre-mining mean resulting from the mining for two consecutive months
• DO reduction greater than 2 standard deviation from pre-mining mean resulting from the mining for two consecutive months
• EC, total Fe and total Mn increases greater than 2 standard deviation from pre-mining mean resulting from the mining for two consecutive months
• Identification of strata gas plume of flow rate >3000 L/min(2)</td><td>• Actions as stated for Level 1 plus:
• Review monitoring program
• Notify relevant specialists (South32 IC) and develop and implement remedial action if necessary

Strata Gas Emission Plume:

• Estimate gas emission flow rates. Re-estimate should significant change be observed
• Take sample of plume (if possible) for:
– chemical composition
– dissolved methane from exactly above gas plume and at established downriver monitoring sites
– dissolved sulfide and total phenols from exactly above gas plume and at nearest downriver monitoring site(s)</td></tr>
<tr><td>Level 3(1)
Impact monitoring sites:

• Level 2-type reduction in water quality resulting from the mining observed for six consecutive months</td><td>• Actions as stated for Level 2
• Notify OEH, D&PI, NoW & DRE and any other relevant specialist.
• Consultation with stakeholders.
• Collect laboratory samples and analyse for:
– pH, EC, Total Fe and Mn
– Suite of Filterable metals.
– Dissolved methane, sulfide and total phenols (if relevant).
• Develop any site management measures as soon as practically possible (pending stakeholder availability) and seek any approvals required to implement
• Review the relevant TARP and Management Plan in</td></tr>
</table>

MONITORING	TRIGGER	ACTION
		consultation with key stakeholders
	Exceeding Prediction • More than negligible gas releases	• *Actions as stated for Level 3* • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation • •
WATER LEVEL AND FLOW		
Nepean River Visual observations along the Nepean River within the active mining area	***Level 1***(1) • Observation of areas of dry and/or flooded riverbed in comparison to baseline observations and flows, for less than two consecutive months.	• Continue monitoring program • Report impacts to key stakeholders • Summarise impacts and record
	Level 2(1) • Observation of areas of dry and/or flooded riverbed in comparison to baseline observations and flows, for more than two consecutive months.	• *Actions as stated for Level 1* • Review monitoring program • Notify relevant specialists (South32 IC) and develop and implement remedial action if necessary
	Level 3(1) • Observation of areas of dry and/or flooded riverbed in comparison to baseline observations and flows, for six consecutive months.	• *Actions as stated for Level 2* • Notify relevant government agencies, other resource managers and relevant technical specialists and seek advice on any CMA required. • Site visits with stakeholders if required • Develop any site management measures as soon as practically possible (pending stakeholder availability) and seek any approvals required to implement • Review the relevant TARP and Management Plan in consultation with key stakeholders •
APPEARANCE		
Nepean River Observations along the Nepean River within the active mining area	***Level 1***(1) • Iron staining resulting from the mining for two consecutive months • Water cloudiness resulting from the mining for two consecutive months	• Continue monitoring program • Report impacts to key stakeholders • Summarise impacts and record

MONITORING	TRIGGER	ACTION
	Level 2[(1)] • Iron staining greater than baseline monitoring resulting from the mining for two consecutive months • Water cloudiness greater than baseline monitoring resulting from the mining for two consecutive months	• *Actions as stated for Level 1* • Review monitoring program • Notify relevant specialists (South32 IC) and develop and implement remedial action if necessary
	Level 3[(1)] • Iron staining greater than baseline monitoring resulting from the mining for six consecutive months • Water cloudiness greater than baseline monitoring resulting from the mining for six consecutive months	• *Actions as stated for Level 2* • Notify relevant government agencies, other resource managers and relevant technical specialists and seek advice on any CMA required. • Site visits with stakeholders if required • Develop any site management measures as soon as practically possible (pending stakeholder availability) and seek any approvals required to implement • Review the relevant TARP and Management Plan in consultation with key stakeholders
	Exceeding Prediction • More than negligible iron staining resulting from the mining • More than negligible increase in water cloudiness resulting from the mining	• *Actions as stated for Level 3* • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation
1st and 2nd Order Watercourses • Upper Harris Creek (HC10) • Foot Onslow Creek (FO1) • Navigation Creek (NAV1)	***Level 1***[(1)] • Fracturing with no observable loss of surface water flow • Fracturing with no reduction in pool water level when compared to baseline period • Increase in turbidity, iron staining, algal growth, or other visible water quality parameters resulting from the mining for two consecutive months determined by comparing baseline photos with photos during the mining period	• Continue monitoring program • Report impacts to key stakeholders • Summarise impacts and record
	Level 2[(1)] • Fracturing resulting in loss of surface flow in some creeks or tributary • Fracturing resulting in water loss from some permanent pools • Reduced water retention time in pools • Increase in turbidity, iron staining, algal growth, or other visible water quality parameters resulting from the mining for two consecutive months determined by comparing baseline photos with photos during the mining period	• *Actions as stated for Level 1* • Review monitoring program • Notify relevant specialists (South32 IC) and develop and implement remedial action if necessary
	Level 3[(1)]	• *Actions as stated for Level 2* • Notify relevant government agencies, other resource

MONITORING	TRIGGER	ACTION
	• Fracturing resulting in total loss of surface flow in all sections of a creek or tributary • Fracturing resulting in total water loss from all permanent pools in the mining area • Reduced water retention time in all pools in the mining area	managers and relevant technical specialists and seek advice on any CMA required. • Site visits with stakeholders if required • Develop any site management measures as soon as practically possible (pending stakeholder availability) and seek any approvals required to implement • Review the relevant TARP and Management Plan in consultation with key stakeholders •
Water Pumps • Pump 1 • Pump 2 • Pump 3 • Pump 4 • Pump 5 • Pump 6 •	• Pump not functioning due to water level changes or physical disturbance from subsidence	• Continue monitoring program • Report impacts to key stakeholders • Summarise impacts and record • Develop and implement CMA (if required) in consultation with key stakeholders
AQUATIC ECOLOGY		
Nepean River • Sites 5 and 6 • Sites 7 and 8 *Refer Figure 1*	***Level 1***(1) • Reduction in aquatic habitat resulting from mining (when comparing to baseline conditions) for 1 year	• Continue monitoring program • Report impacts to key stakeholders • Summarise impacts and record
	Level 2(1) • Reduction in aquatic habitat resulting from mining (when comparing to baseline conditions) for 2 consecutive years	• *Actions as stated for Level 1* • Review monitoring program • Notify relevant specialists (South32 IC) and develop and implement remedial action if necessary •
	Level 3(1) • Reduction in aquatic habitat resulting from the mining (when comparing to baseline conditions) for > 2 consecutive years or complete loss of habitat	• Actions as stated for Level 2 • Notify relevant government agencies, other resource managers and relevant technical specialists and seek advice on any CMA required. • Site visits with stakeholders if required • Develop any site management measures as soon as practically possible (pending stakeholder availability) and seek any approvals required to implement • Review the relevant TARP and Management Plan in consultation with key stakeholders
	Exceeding Prediction • More than negligible environmental consequences for a	• *Actions as stated for Level 3* • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation

MONITORING	TRIGGER	ACTION
	threatened species, threatened population or endangered ecological community	
GROUNDWATER		
Water Level IC monitoring bores: • EAW5 • EAW7 Private Bores (10 registered bores- where accessible) ***Notes:*** *Impact monitoring data during longwall mining is compared to predicted groundwater levels from the BSOP (or later updates) groundwater model, during preparation of the End of Panel Report* *Privately owned water supplies are monitored as agreed with landowners in the Built Feature Management Plans* *Refer Figure 1*	***Level 1***[(1)] • 5.0 – 7.5m reduction greater than predicted standing water level or pressure in the Hawkesbury Sandstone (outside of pumping influences in private bores) over a minimum 2 month period.	• Continue monitoring program • Report impacts to key stakeholders • Summarise impacts and record
	Level 2[(1)] • Between 7.5m and 10m additional reduction from the predicted standing water level or pressure in Hawkesbury Sandstone (outside of pumping influences) over 2 consecutive months	• *Actions as stated for Level 1* • Review monitoring program • Notify relevant specialists (South32 IC) and develop and implement remedial action if necessary
	Level 3[(1)] • Greater than 10m of additional reduction from the predicted standing water level or pressure in the Hawkesbury Sandstone (outside of pumping influences) over 2 consecutive months • Mining results in private groundwater bores unsafe, unserviceable or damaged.	• *Actions as stated for Level 2* • Notify relevant government agencies, other resource managers and relevant technical specialists and seek advice on any CMA required. • Site visits with stakeholders if required • Develop any site management measures as soon as practically possible (pending stakeholder availability) and seek any approvals required to implement • Review the relevant TARP and Management Plan in consultation with key stakeholders • Compensatory water supply measures must be provided as an alternative long-term supply that is equivalent to the loss attributed to the mining impact, and be provided (if required) within 24 hours of the loss being identified.
Mine Water Inflows	***Level 1***[(1)] • Abnormal rise in water flow from the goaf between 2.7 and 3ML/day (over 20 day average)	• Continue monitoring program • Report impacts to key stakeholders • Summarise impacts and record
	Level 2[(1)] • Abnormal rise in water flow from the goaf between 3 and 3.4ML/day (over 20 day average)	• *Actions as stated for Level 1* • Review monitoring program • Notify relevant specialists (South32 IC) and develop and implement remedial action if necessary
	Level 3[(1)] • Abnormal rise in water flow from the goaf >3.4ML/day (over 20 day average)	• *Actions as stated for Level 2* • Notify relevant government agencies, other resource managers and relevant technical specialists and seek advice on any CMA required. • Site visits with stakeholders if required • Develop any site management measures as soon as

MONITORING	TRIGGER	ACTION
		practically possible (pending stakeholder availability) and seek any approvals required to implement • Review the relevant TARP and Management Plan in consultation with key stakeholders
LANDSCAPE FEATURES		
Cliffs • Along Nepean Gorge **Steep Slopes** • Along Nepean Gorge, associated • tributaries and above western end of the proposed Longwalls *Refer Figure 19.1 in LW705-710 SMP*	***Level 1***[(1)] • Any rock fall, displacement, dislodgement of boulders or slabs or fracturing of a cliff line flanking the Nepean River resulting from mining • Erosion resulting from mining localised to a small area that should naturally stabilise within the monitoring period • Surface movement resulting from mining with no more than negligible soil surface exposed	• Continue monitoring program • Report impacts to key stakeholders • Summarise impacts and record
	Level 2[(1)] • Any rock falls, displacements, dislodgements of boulders or slabs or fracturing of a cliff line(s) flanking the Nepean River resulting from mining that in total impacts 0.3% of the total cliff line face area of the mining domain. • Erosion resulting from mining likely to naturally stabilise within the monitoring period. • Surface movement or rock displacement resulting from mining with no more than minor soil surface exposed	• *Actions as stated for Level 1* • Review monitoring program • Notify relevant specialists (South32 IC) and develop and implement remedial action if necessary
	Level 3[(1)] • Any rock falls, displacements, dislodgements of boulders or slabs or fracturing of a cliff line(s) flanking the Nepean River resulting from mining that in total impacts up to 0.5% of the total cliffline face area of the mining domain. • Any rock falls, displacements, dislodgements of boulders or slabs or fracturing of a cliffline(s) flanking the Nepean River resulting from mining that in total impacts 0.4% of the total cliffline face area of the mining domain after 1 longwall. • Mass movement of a slope causing large areas of exposed soil • Any form of rockfall or erosion that poses a threat to public safety	• *Actions as stated for Level 2* • Notify relevant government agencies, other resource managers and relevant technical specialists and seek advice on any CMA required. • Site visits with stakeholders if required • Develop any site management measures as soon as practically possible (pending stakeholder availability) and seek any approvals required to implement • Review the relevant TARP and Management Plan in consultation with key stakeholders
Cliffs flanking the Nepean River	***Exceeding Prediction*** • More than negligible environmental consequences (that is occasional rockfalls, displacement or dislodgement of boulders or slabs, or fracturing, that in total impacts more than 0.5% of the total face area of such cliffs within the	• *Actions as stated for Level 3* • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation

MONITORING	TRIGGER	ACTION
	Longwall mining domain) • Rockfall or erosion that poses more than a negligible increased risk to public safety	
TERRESTRIAL ECOLOGY		
Monitored in conjunction with observational monitoring for the Nepean River, 1st and 2nd Order watercourses and active mining area	***Level 1***(1) • Vegetation impacted by mining (by rockfalls, soil slippage, gas emissions) that is likely to naturally regenerate within the monitoring period	• Continue monitoring program • Report impacts to key stakeholders • Summarise impacts and record
	Level 2(1) • Vegetation impacted by mining (by rockfalls, soil slippage, gas emissions) that is unlikely to naturally regenerate within the monitoring period	• *Actions as stated for Level 1* • Review monitoring program • Notify relevant specialists (South32 IC) and develop and implement remedial action if necessary
	Level 3(1) • Vegetation impacted by mining that is not responding to CMAs	• *Actions as stated for Level 2* • Notify relevant government agencies, other resource managers and relevant technical specialists and seek advice on any CMA required. • Site visits with stakeholders if required • Develop any site management measures as soon as practically possible (pending stakeholder availability) and seek any approvals required to implement • Review the relevant TARP and Management Plan in consultation with key stakeholders
	Exceeding Prediction • More than negligible environmental consequences on threatened species, threatened populations, or endangered ecological communities	• *Actions as stated for Level 3* • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation
ABORIGINAL ARCHAEOLOGY		
No sites currently applicable Any other newly identified Aboriginal Archaeology sites *Refer to Figure 5-22 of Bulli Seam Operations EA and Figure 3 Bulli Seam Operations Appendix G (Aboriginal Cultural Heritage Assessment)*	***Level 1***(1) • Change in shelter conditions not attributable to natural weathering or preservation – mineral growth or micro-organism growth (as observed by comparing pre-mining photographs with post-subsidence/mining photographs) • Changes external to the shelter that affect the site context – ground cracking, boulder slumping, rock and/or tree falls	• Continue monitoring program • Report impacts to key stakeholders • Summarise impacts and record
	Level 2(1) • Change in shelter conditions not attributable to natural weathering or preservation – change in drip line or seepage, cracking or exfoliation of overhang or shelter, movement or	• *Actions as stated for Level 1* • Review monitoring program • Notify relevant specialists (South32 IC) and develop and implement remedial action if necessary

MONITORING	TRIGGER	ACTION
	opening of existing planes and joints at panel, block fall within shelter or overhang	
	Level 3(1) • Shelter or overhang collapse not attributable to natural weathering • Level 2 impacts at greater frequency than predicted • Level 2 impacts attributable to mining remote from the mining area	• *Actions as stated for Level 2* • Notify relevant government agencies, other resource managers and relevant technical specialists and seek advice on any CMA required. • Site visits with stakeholders if required • Develop any site management measures as soon as practically possible (pending stakeholder availability) and seek any approvals required to implement • Review the relevant TARP and Management Plan in consultation with key stakeholders
• Sites determined to hold high or moderate significance as a result of studies required for Extraction Plans	***Exceeding Prediction*** • More than 10% of such sites across the mining area are affected by subsidence impacts (other than negligible impacts or environmental consequence)	• *Actions as stated for Level 3* • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation
• Other Aboriginal heritage sites	• Less than 10% of such sites (or 1 such site, whichever is the greater) within any longwall mining domain are/is affected by subsidence impacts (other than minor impacts or environmental consequence)	
HISTORIC HERITAGE		
• Gilbulla (Anglican Conference Centre) ***Note:*** Property Management Plan to be developed prior to influence of mining	***Exceeding Prediction*** • Loss of heritage value greater than predicted under the Heritage Management Plan	• Continue monitoring program • Report impacts to key stakeholders • Summarise impacts and record • Notify relevant government agencies, other resource managers and relevant technical specialists and seek advice on any CMA required. • Site visits with stakeholders if required • Develop any site management measures as soon as practically possible (pending stakeholder availability) and seek any approvals required to implement • Review the relevant TARP and Management Plan in consultation with key stakeholders • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation

(1) These may be revised in consultation with DPE and other key stakeholders
(2) If strata gas emission plumes are detected – particularly coinciding with low river flow and significant gas evolution
(3) Baseline upriver sites for cross-checking for upriver perturbations impacting Area 7 monitoring sites:
- NR110 - possible upstream perturbations (>2 standard deviations)
- Checks at Upriver sites NR4, NR5 and NR6 for possible Cataract River-based perturbations (>2 standard deviation)

Current Values

Level 1		***Upstream check***
NR12	**NR13**	***NR110***
pH>6.86;<7.2	pH>6.73;<7.08	pH>7.07
DO>66.8%;<77.42%	DO>61.35%;<74.17%	DO>53.75%

Level 2 and 3		***Upstream check***
NR12	**NR13**	***NR110***
pH<6.86	pH<6.73	pH>7.07
DO<66.8%	DO<61.35%	DO>53.75%
EC>280 µS/cm	EC>279 µS/cm	EC<424 µS/cm
Total Fe >0.691 mg/L	Total Fe>0.666 mg/L	Total Fe<0.590 mg/L
Total Mn>0.057 mg/L	Total Mn>0.060 mg/L	Total Mn<0.056 mg/L