



APPIN AREA 7
LONGWALL 706 END OF
PANEL REPORT

March 2016



Executive Summary

This End of Panel (EoP) Report has been prepared in accordance with Condition 18 of the Appin Area 7 Longwalls 705 and 706 Subsidence Management Plan (SMP) Approval, granted on the 28th February 2012. This EoP report outlines the measured and observed impacts during the extraction of Longwall 706 and analyses the monitoring results against relevant impact assessment criteria and predictions made in the SMP.

Longwall 706 is located within Consolidated Coal Lease No. 767 (CCL767) and was extracted using conventional longwall techniques and equipment during the period from 23rd April 2014 to 28th November 2015.

Economic Effects

Continuing benefits occur through continuity of employment, expendable income, export earnings and government revenue. South32 Illawarra Coal (previously BHP Billiton Illawarra Coal) was granted consent for the Bulli Seam Operations Project in 2011, which outlines the Company's plans for its Appin and West Cliff Mines for the next 30 years. The Company provides local jobs for over 1000 direct employees. More than 300 small to medium local businesses provide their goods and services to the company. In terms of the Bulli Seam Operations (Appin and West Cliff Mines), as of 28th November 2015 there were 783 full time employees at the sites. These jobs are reliant on maintaining continuity of longwall coal extraction.

Subsidence

Subsidence movements resulting from the extraction of Longwall 706 were monitored at various lines and points within the SMP area. Monitoring was conducted to measure subsidence associated with the Nepean River, Moreton Park Road, M31 Hume Motorway, Main Southern Railway (ARTC) and Sydney Catchment Authority infrastructure.

Differential movements across the Nepean River valley were measured by South32 along six ground monitoring lines, being the NEPX L-Line through to the NEPX Q-Line, during Longwall 706. The maximum observed incremental and total closures along the Nepean River valley cross lines were all less than predicted.

In general, the observed ground strains along Moreton Park Road during the mining of Longwall 706 were within the range expected based on regular (i.e. conventional) ground movements, i.e. no irregular or anomalous movements developed along this monitoring line during Longwall 706.

Very minor vertical subsidence developed along Menangle Road, as predicted.

The mine subsidence movements along the M31 Hume Motorway and Main Southern Railway were measured by South32 using 3D monitoring lines, being the M31 East and M31 West Lines and ARTC Line. There is reasonable correlation between the shapes of the observed and predicted incremental subsidence profiles on the maingate side, but observed subsidence above the chain pillars is less than predicted, as observed generally in Appin Area 7.



Observed peak compressive strains were localised between Marks E145R to E146R along the East Line and between Marks W138 to W139 along the West Line, and Marks ARTC1122 to ARTC1123, with an associated bump in the observed subsidence profiles, which indicates that non-conventional movements have developed at these locations.

The movements at the Ousedale and Nepean Creek Aqueducts were similar to survey tolerance. The incremental opening at the Mallaty Creek Aqueduct resulted in a reduction of the existing net closure from 10 mm to 6 mm. The observed incremental movements at the remaining aqueducts and bridges were in the order of survey tolerance, i.e. not measureable.

The remaining observed incremental net vertical and horizontal movements at the Concrete Aqueducts C and D, during the extraction of Longwall 706, were less than 3 mm, which are similar to survey tolerance, i.e. not measurable.

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. Observed profiles of subsidence and tilt were reasonably similar to the profiles predicted.

Impacts on Man-made Features

The observed impacts on the surface infrastructure, after the extraction of Longwall 706, are similar to or less than the predicted impacts.

Impacts to man-made features due to Longwall 706 were observed along the M31 Hume Motorway and included humps forming on both carriageways, these were remediated by re-shaping of the pavement surface and installation of additional slots as part of Management Plan responses. Along the Main Southern Railway changes in track geometry were recorded and remediated in accordance with the established Management Plan, there were no adverse impacts to safety and serviceability.

Small levels of signal loss to copper telecommunications cables and optical fibre cables were measured during the extraction of Longwall 706, and were associated with the non-conventional movement which attributed to the impacts along the M31 Hume Motorway and Main Southern Railway.

To date, one claim to the MSB for impacts to building structures due to the mining of Longwall 706 has been made (including an impact to a pool), and one is in the process of being made. One impact to a private borehole was attributed to Longwall 706.

Seven cultural heritage sites are located in proximity to Longwall 706. No historical sites are located above Longwall 706. Cultural Heritage sites included Open Camp Sites, Isolated Artefacts and a Scarred Tree. Detailed assessment of the afore mentioned Aboriginal sites was not required as the subsidence predictions for Open Camp Sites, Isolated Artefacts and Scarred trees considers a negligible impact on cultural heritage values. This assessment is based on the results of subsidence monitoring reported by MSEC (MSEC808) and results of monitoring carried out by the Illawarra Coal Environmental Field Team (ICEFT), in which no impacts were observed outside of predictions and subsidence parameters measured were generally less than or similar to predictions.



Impacts on Natural Features

Impacts observed on natural features from Longwall 706 were within the predictions outlined in the SMP.

Impacts to the Nepean River included one new gas release, which was likely a reactivation of a gas release attributed to previous Longwall 16 from Tower Colliery.

No significant water quality, water levels or flow impacts have been observed or measured within the Nepean River as a result of mining Longwall 706. No significant water level or water quality effects for groundwater were identified (Geoterra, 2016).

The results from the latest survey indicate that there have been no significant changes to the aquatic and riparian habitat in the Nepean River since monitoring commenced (CEL, 2016). The gas releases identified in the Nepean River associated with previous longwalls do not appear to have had any effect on macroinvertebrates, fish or macrophytes in the Nepean River. This is not surprising given that no impacts to water quality, flow and levels, or impacts to physical features have been observed in the Nepean River during extraction of Longwall 706 (MSEC 2016, GeoTerra, 2016, ICEFT, 2016).

With regards to terrestrial ecology, inspections of the Nepean River area show that there has been no change to habitat features within either the Nepean River gorge or its tributaries and no impacts to cliffs or steep slopes as a result of the extraction of Longwall 706. It is therefore concluded that there has been negligible impact on threatened fauna or their habitats in these areas.

Trigger Action Response Plans (TARPs)

Impacts associated with roads and highways were minor, and have been reported, rehabilitated and monitored in accordance with agreed actions of the Management Plan and TARP.

Gas releases observed in Nepean River, which were still active during the extraction of Longwall 706, or reactivated during the extraction of Longwall 706, were within the level 1 TARP trigger level (i.e. <3000L/min).

Conclusion

All impacts to man-made and natural features observed during monitoring associated with the extraction of Longwall 706 have been within prediction. Monitoring of man-made and natural features will continue as part of post-mining monitoring and during mining monitoring (for Longwall 707) in accordance with the SMP, relevant Management Plans and approved modifications.





CONTENTS

Executive Summary.....	2
1. Introduction.....	8
1.1. Background.....	8
1.2. Approval and Legislative Requirements.....	8
1.3. Report and Management Plans.....	10
1.4. Report Outline.....	10
1.5. Economic Effects.....	11
1.6. Stakeholder Consultation.....	11
1.7. Social Impacts Associated with Subsidence.....	11
2. Predicted and Observed Subsidence.....	12
2.1. The Nepean River Cross Lines.....	13
2.2. Moreton Park Road Line.....	13
2.3. Menangle Road.....	13
2.4. M31 Hume Motorway.....	15
2.5. The Main Southern Railway.....	16
2.6. Highway and Railway Cutting Points.....	17
2.7. Partridge VC Rest Area.....	19
2.8. Far-field 3D Marks.....	19
2.9. Douglas Park Twin Bridges over the Nepean River.....	20
2.10. Moreton Park Road Bridge (South).....	21
2.11. Water NSW Infrastructure.....	22
2.12. Telstra Infrastructure.....	23
3. Impacts to Built Features.....	23



4.	Impacts to Natural Features	25
4.1.	Surface Water Quality	28
4.2.	Nepean River Water Level and Flow.....	29
4.3.	Nepean River Appearance	30
4.4.	Groundwater	30
4.5.	Landscape Features.....	34
4.6.	Terrestrial Ecology	34
4.7.	Aquatic Ecology	34
4.8.	Cultural Heritage	36
4.9.	Private Property	36
5.	Longwall 706 Monitoring Program	37
6.	Management of Impacts and Remediation	48
6.1.	Management	48
6.2.	Remediation Associated with Longwall 706	48
6.3.	Trigger Action Response Plans (TARPs)	49
	Appendix 1: Longwall 706 Impact and TARP Summary Table.....	51

TABLES

	Table 1-1: Bulli Seam Operations Project Approval – Subsidence Impact Performance Measures.....	8
	Table 1-2: End of Panel Reporting Condition	10
	Table 1-3: Social Impact Variables Associated with Subsidence	11
	Table 3-1: Summary of the Assessed and Observed Impacts for Built Features Resulting from the Extraction of Longwall 706.....	24
	Table 4-1: Cultural Heritage Sites considered in Longwall 706 Assessment	36
	Table 5-1: Monitoring Commitments for Man-made Features	37
	Table 5-2: Monitoring Commitments for Natural Features.....	41



FIGURES

Figure 2-1: Longwall 706 Subsidence Monitoring Lines (MSEC 808-01).....	14
Figure 2-2: Observed Absolute Incremental Horizontal Movements at the Highway and Railway Cutting Points due to the Extraction of Longwall 706 (8 th December 2015)	18
Figure 2-3: Observed Absolute Incremental Horizontal Movements versus Distance to Nearest Longwall Goaf Edge with Solid Coal between Mark and Extracted Longwall, with Longwall 706 results overlaid.	19
Figure 2-4: Observed Absolute Incremental Horizontal Movements at the Far-field 3D Monitoring Points due to the Extraction of Longwall 706 (15 th December 2015)	20
Figure 4-1: Natural Features associated with Longwall 706 (MSEC808-02).....	26
Figure 4-2: Area 7 Monitoring Sites and Impacts Observed During Longwall 706	27
Figure 4-3: NGW Groundwater levels during Longwall 706 extraction	31
Figure 4-4: EAW7 Water Levels.....	32
Figure 4-5: Aquatic ecology monitoring sites in the Nepean River in relation to Appin Area 7 and 9 Longwalls (CEL, 2016).	35

ATTACHMENTS

Attachment A: Approvals

Attachment B: End of Panel Subsidence Monitoring Report for Appin Longwall 706 (MSEC808)

Attachment C1: Appin Area 7 Longwall 706 End of Panel Landscape Report (ICEFT)

Attachment C2: Longwall 706 Impact Reports

Attachment D: Longwall 706 End of Panel Surface and Groundwater Monitoring Report (GeoTerra)

Attachment E: Appin Areas 7 and 9 Aquatic Ecology Monitoring 2003 to 2015 (Cardno Ecology Lab)

Attachment F: Aboriginal and European Heritage Assessment for Appin Colliery – Longwall 706 End of Panel Report (Niche Environment and Heritage)



1. Introduction

1.1. Background

Appin Area 7 Longwall 706 is located within Consolidated Coal Lease No.767 (CCL767). The extraction of Longwall 706 commenced on the 23rd April 2014 and was completed on the 28th November 2015, using conventional longwall techniques and equipment.

This End of Panel (EoP) Report has been prepared, in accordance with Condition 18 of the Appin Area 7 Longwalls 705 and 706 Subsidence Management Plan (SMP) Approval, granted on the 28th February 2012. The EoP Report outlines the measured and observed impacts of Longwall 706 and analyses the monitoring results against relevant impact assessment criteria and predictions made in the SMP and associated management plans and reports for Longwall 706.

Information in this report is based on monitoring and reports undertaken by South32 Illawarra Coal (Illawarra Coal) and specialist consultants that have been involved with the monitoring and analysis of data relating to the Longwall 705 to 706 SMP Area.

1.2. Approval and Legislative Requirements

The Appin Area 7 SMP for Longwalls 705 to 706 was approved by the Director General of the Department of Trade and Investment, Regional Infrastructure and Services, NSW on the 28th February 2012. The SMP approval is provided as Attachment A.

In September 2009, BHP Billiton 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 22nd 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 (EP&A Act).

The Subsidence Impact Performance Measures for natural features, heritage features and built features are outlined in the BSOP Approval, and reflected in the Longwall 705 and 706 SMP Approval. The performance measures relevant to Appin Area 7 are shown below in Table 1-1.

Table 1-1: 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 4.1 to 4.3 Appendix 1
Other watercourses	No greater subsidence impact or environmental consequences than predicted in the EA and PPR	Section 4.5 Appendix 1
Cliffs of “special significance (i.e. cliffs)	Negligible environmental consequences (that is occasional rockfalls, displacement or dislodgement of	Section 4.5 Appendix 1

longer than 200m and/or higher than 5m that constitute water falls)	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 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 4.6 to 4.7 Appendix 1
Aboriginal heritage		Section 4.8 Appendix 1
Sites determined to hold "special significance"	Negligible impact or environmental consequence.	
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		Section 3
Key public infrastructure: - Main Southern Railway - Hume Highway; and - The SCA Upper Canal	Always safe and serviceable. Damage that does not affect safety or serviceability must be fully repairable, and must be fully repaired.	
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

Condition 18 of the SMP Approval is provided below in Table 1-2.

Table 1-2: End of Panel Reporting Condition

SMP Approval Condition	Relevant Section in EoP Report
Condition 18	
<p>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:</p>	
a) Include a summary of the subsidence and environmental monitoring results for the applicable longwall panel;	<i>Section 2, Section 4 and relevant attachments</i>
b) Include an analysis of these monitoring results against the relevant: <ul style="list-style-type: none"> - impact assessment criteria; - monitoring results from previous panels; - predictions in the SMP; and - performance measures specified in Table 1 and Table 2; 	<i>Section 2, Section 4, Appendix 1 and relevant attachments</i>
c) Identify any trends in the monitoring results over the life of the activity; and	<i>Relevant attachments</i>
d) Describe what actions were taken to ensure adequate management of any potential subsidence impacts due to longwall mining.	<i>Section 6</i>

1.3. Report and Management Plans

The impact predictions associated with Longwall 706 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. Report Outline

Observed impacts have been described by the Illawarra Coal Environmental Field team (ICEFT) and specialist consultants during and following the mining of Longwall 706.

Economic effects associated with the longwall extraction are discussed in Section 1.5. An Overview of the consultation involved with Appin mining operations is provided in Section 1.6. Subsidence movement predictions and measurements are in Section 2. Predicted and observed impacts of Longwall 706 on man-made features and natural features are provided in Sections 3 and 4 respectively. The Longwall 705-706 monitoring program and proposed future monitoring in the SMP

Area is outlined in Section 5. A summary of the Trigger Action Response Plans (TARPs) including any remediation measures is included in Section 6.

1.5. Economic Effects

The extraction of underground coal reserves from Area 7 provides benefits at international, national, state and local levels. Illawarra Coal provides coking coal to BlueScope Steel for its domestic steelmaking production, and for export to overseas customers.

Continuing benefits occur through continuity of employment, expendable income, export earnings and government revenue. Illawarra Coal was granted consent of the Bulli Seam Operations Project in 2011, which outlined the Company's plans for its Appin and West Cliff Mines for the next 30 years. The Company provides local jobs for over 1000 direct employees. More than 300 small to medium local businesses provide their goods and services to the company. In terms of the Bulli Seam Operations (Appin and West Cliff Mines), as of 28th November 2015 there were 783 full time employees at the sites. These jobs are reliant on maintaining continuity of longwall coal extraction.

1.6. 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 information sheets and 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;
- Illawarra Coal Community e-Newsletter – a monthly newsletter distributed to a managed subscription list of residents and key stakeholders;
- 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 and emailed direct to interested stakeholders);
- Landholder relations program;
- Annual review; and
- Information days.

1.7. 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 1-3.

Table 1-3: Social Impact Variables Associated with Subsidence

Potential Impact	Monitoring Variables	Mechanism
Subsidence Impacts	<ul style="list-style-type: none"> - Level of community concern relating to subsidence. - Awareness of subsidence and its effects and management. - Level of perceived community 	<ul style="list-style-type: none"> - Longwall progress maps displayed on local notice board, letters and community newsletters. - Illawarra Coal Community

	<p>risk associated with subsidence effects.</p> <ul style="list-style-type: none"> - 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. 	<p>Consultative Committee meetings for BSOP</p> <ul style="list-style-type: none"> - 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.
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The management of subsidence impacts on private properties is addressed in Built Feature Management Plans (BFMPs). The BFMPs have been prepared in consultation with individual property owners. For any impacts to properties in relation to Longwall 706, landholders have been advised to lodge claims with the MSB. 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 Appin Longwall 706 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 706 has been prepared by MSEC (MSEC808, 2016) and is included as **Attachment B**. The results from MSEC808 are summarised below, for further details on the subsidence results refer to MSEC808.

Monitoring points and lines associated with Longwall 706 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 2-1.

2.1. The Nepean River Cross Lines

Differential movements across the Nepean River valley were measured by South32 along six ground monitoring lines, being the NEPX L-Line through to the NEPX Q-Line, during Longwall 706.

The maximum observed incremental and total closures along the cross lines were all less than predicted. It is noted that the predictions have some conservatism as they are based on the full approved length of Longwall 706 adopted in the SMP Application and Report No. MSEC342.

2.2. Moreton Park Road Line

The mine subsidence movements along Moreton Park Road were measured by South32 using a 3D monitoring line.

Correlation between the shapes of the observed and predicted subsidence profiles on the maingate side of the panel (the maingate is the side of the panel on the leading edge of the longwall series adjacent to solid, unmined coal) was comparable. However, the observed incremental subsidence above the previously extracted longwalls is slightly greater than that predicted, but this exceedance is less than 10 % of the maxima.

In general, the observed ground strains along Moreton Park Road during the mining of Longwall 706 were within the range expected based on regular (i.e. conventional) ground movements, i.e. no irregular or anomalous movements developed along this monitoring line during Longwall 706.

2.3. Menangle Road

The mine subsidence movements along Menangle Road were measured by South32 using a 3D monitoring line.

Very minor vertical subsidence developed along the road, as predicted. Elevated tilts and strains were observed between Pegs MR7012 and MR7014, where Menangle Road crosses a small watercourse. It is considered that the differential movements are associated with valley closure and upsidence. A localised compressive strain of 1.2 mm/m was also measured between Pegs MR7012 and MR7013 which is within the range expected based on regular ground movements. Elsewhere, the strains measured along the Menangle Road monitoring line were similar to the order of survey tolerance.

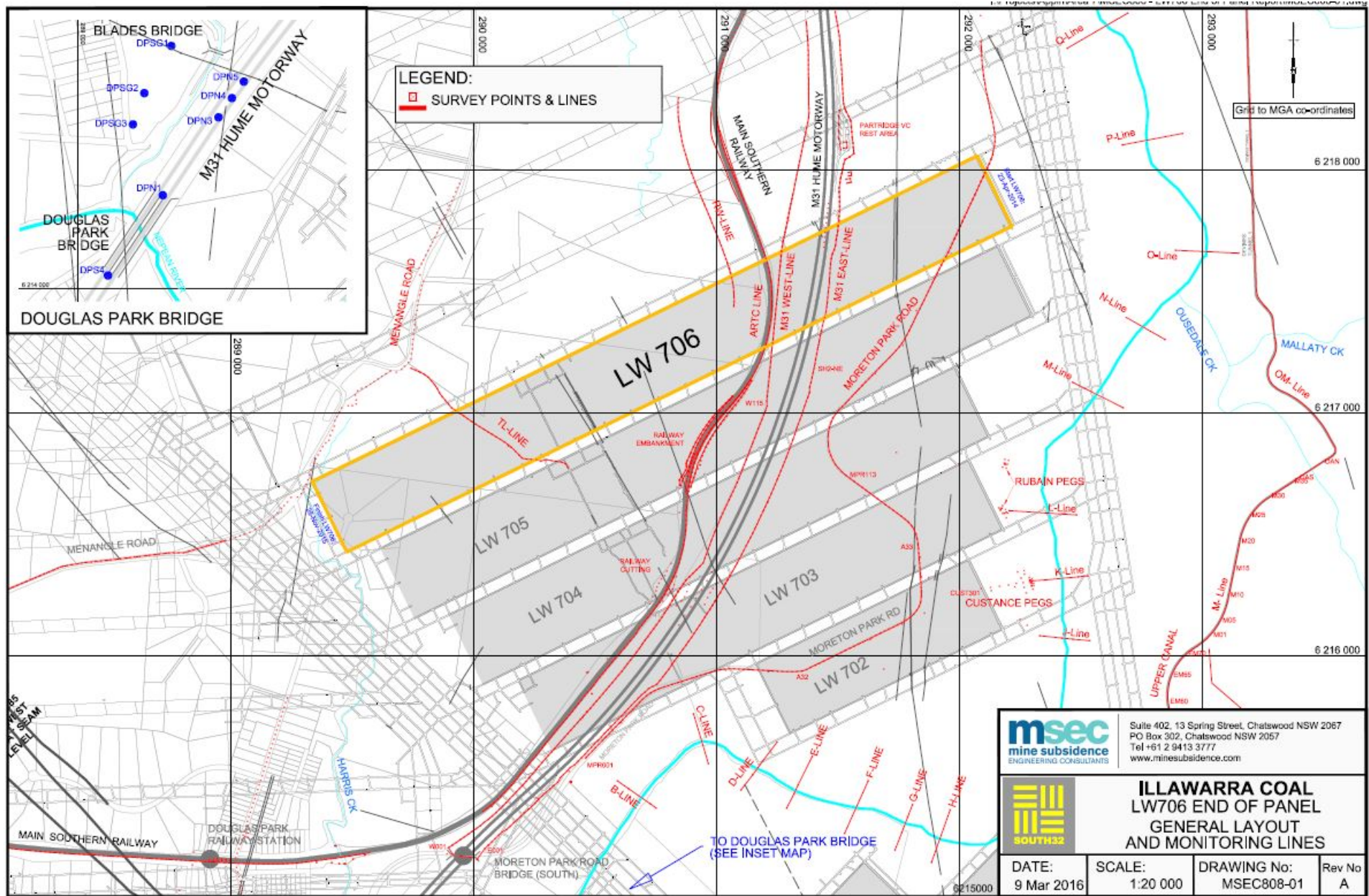


Figure 2-1: Longwall 706 Subsidence Monitoring Lines (MSEC 808-01)

2.4. M31 Hume Motorway

The monitoring associated with the Motorway, during the extraction of Longwall 706, included the following:-

- M31 East and West Lines;
- Highway Cutting Points; and
- FBG and slot closure monitoring.

2.4.1. M31 East and West Lines

The mine subsidence movements along the M31 Hume Motorway were measured by South32 using two 3D monitoring lines, being the M31 East and M31 West Lines.

There is reasonable correlation between the shapes of the observed and predicted incremental subsidence profiles on the maingate side, but observed subsidence above the chain pillars is less than predicted, as observed generally in Appin Area 7.

The maximum observed incremental subsidence along the M31 East and M31 West Lines of 863 mm and 922 mm, respectively, were less than the predicted maximum subsidence of 975 mm. The maximum observed incremental tilt along the M31 East Line of 5.8 mm/m was slightly greater than the maximum predicted tilt of 5.5 mm/m, but this exceedance only represents an additional 5 % above the maxima. The maximum observed tilt along the M31 West Line was less than the maxima predicted.

The maximum observed incremental tensile strains along the M31 East Line and M31 West Line were 2.5 mm/m and 3.0 mm/m, respectively. The maximum predicted incremental and total conventional tensile strain along the monitoring lines, based on applying a factor of 15 to the maximum predicted curvatures, was 0.7 mm/m. The observed maximum tensile strain on the East Line occurred in a localised location and is considered to be likely due to disturbance of the survey peg.

The maximum observed incremental compressive strains along the M31 East Line and M31 West Line were 3.1 mm/m and 3.0 mm/m, respectively. The maximum predicted total conventional compressive strain along the monitoring lines, based on applying a factor of 15 to the maximum predicted curvatures, was 1.2 mm/m. The observed peak compressive strains were localised between Marks E145R to E146R along the East Line and between Marks W138 to W139 along the West Line with an associated bump in the observed subsidence profiles, which indicates that non-conventional movements have developed at these locations.

2.4.2. Highway Cutting Points

Monitoring of the Highway Cutting points is discussed in Section 2.6.

2.4.3. FBG and Slot Displacement Monitoring

FBG Monitoring

A total of 620 temperature and 620 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 metres and the temperature and strain were measured every 15 minutes during the mining of Longwall 706.

The temperature compensated FBG strains exceeded the trigger levels in the Management Plan at two locations during the mining of Longwall 706.

A blue alarm was received on the 15th October 2014 for an exceedance of the average strain at two FBGs 160.1 and 160.2 on the Northbound Carriageway. Upon inspection at the trigger point, a hump, which had been detected in the previous week, was found to have grown. A smaller hump was observed on the Southbound Carriageway opposite the site above Slot SB159. Observed pavement strains were found to correspond with observed increased compressive ground strains on both the East and West monitoring lines in this area.

A blue alarm was received on the 19th October 2014 for an exceedance of the average strain at FBG 154.3 on the Northbound Carriageway. Inspection at the trigger point found no deformation to the pavement. Intensive visual inspections were undertaken as mining continued and these confirmed that no impacts occurred to the pavement.

A number of additional management measures were undertaken in response to the events.

The additional management measures included re-profiling of the pavement. The motorway remained safe and serviceable during the event, though temporary speed restrictions were imposed for short durations during this time. A small number of additional blue alarms were received during this period.

Slot Displacement Monitoring

Displacement sensors were installed in each pavement slot and were measured every 5 minutes during the mining of Longwall 706. The slot displacements did not exceed the management plan trigger levels for closure at any stage during the mining of Longwall 706, though Slot SB157 was very close. The maximum observed closure of the slots located directly above Longwall 706 was less than 1 mm below the trigger level 60 mm at SB157 and 48 mm at NB156.

2.5. The Main Southern Railway

The Main Southern Railway crosses directly above Longwall 706. The monitoring associated with the railway, during the extraction of Longwall 706, included the following:-

- ARTC 3D ground monitoring line;
- ARTC 3D embankment monitoring points;
- Railway cutting points;
- Strain gauges; and
- Tilt sensors.

2.5.1. ARTC Line

The mine subsidence movements along the Main Southern Railway were measured by South32 using a 3D ground monitoring line, referred to as the ARTC Line.

There is reasonable correlation between the shapes of the observed and predicted incremental subsidence profiles on the longwall maingate side, but the observed subsidence above the chain pillar is less than predicted, as observed generally in Appin Area 7.

The maximum observed incremental subsidence along the ARTC Line of 929 mm was less than the maxima predicted of 975 mm. The maximum observed incremental tilt of 6.7 mm/m was slightly more than the maximum predicted of 6.0 mm/m.

The maximum observed incremental tensile and compressive strains along the ARTC Line were 1.3 mm/m and 2.8 mm/m, respectively. The maximum predicted incremental conventional tensile and compressive strains along this monitoring line, based on applying a factor of 15 to the maximum predicted curvatures, were both 0.6 mm/m.

The observed peak compressive strains were localised between Marks ARTC1122 to ARTC1123 with an associated bump in the observed subsidence profile, which indicates that non-conventional movement has developed at this location.

2.5.2. Automated Track Monitoring

Tilt Sensors

Bi-directional tiltmeters are located in the Down (Southbound) track within the railway cutting at 71 km. They measured changes in grade every 15 minutes during the mining of Longwall 706. While the sensors detected changes in tilt as a result of mining, which correlated with ground survey and track geometry measurements, these measurements did not exceed the trigger levels.

Rail Stress Transducers

Rail stress transducers are located along all four rails of the railway track, spaced every 25 metres to 60 metres. They measured changes in rail strain every 5 minutes during the mining of Longwall 706. While some false alarms were triggered during mining due to malfunction or damage to transducers, actual stress readings did not exceed trigger levels.

Expansion Switch Displacement Sensors

Displacement sensors have been installed at each expansion switch. Measurements were recorded every 5 minutes during the mining of Longwall 706. 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 the Embankment were measured by South32 using a 3D ground monitoring line, referred to as the ARTC Embankment.

Comparisons between predicted and observed subsidence movements were similar to findings from the ARTC Line (Section 2.5.1). It is noted, that there were locations of higher tilts and strains, which have generally been measured where bay lengths are short (less than 10 metres).

2.6. Highway and Railway Cutting Points

The Highway and Railway Cutting Points were measured by South32, during the extraction of Longwall 706, which are 3D monitoring points located on the cuttings along the M31 Hume Motorway and the Main Southern Railway.

The final observed absolute incremental horizontal movements at the Highway and Railway Cutting Points, due to the extraction of Longwall 706, are shown in Figure 2-2.

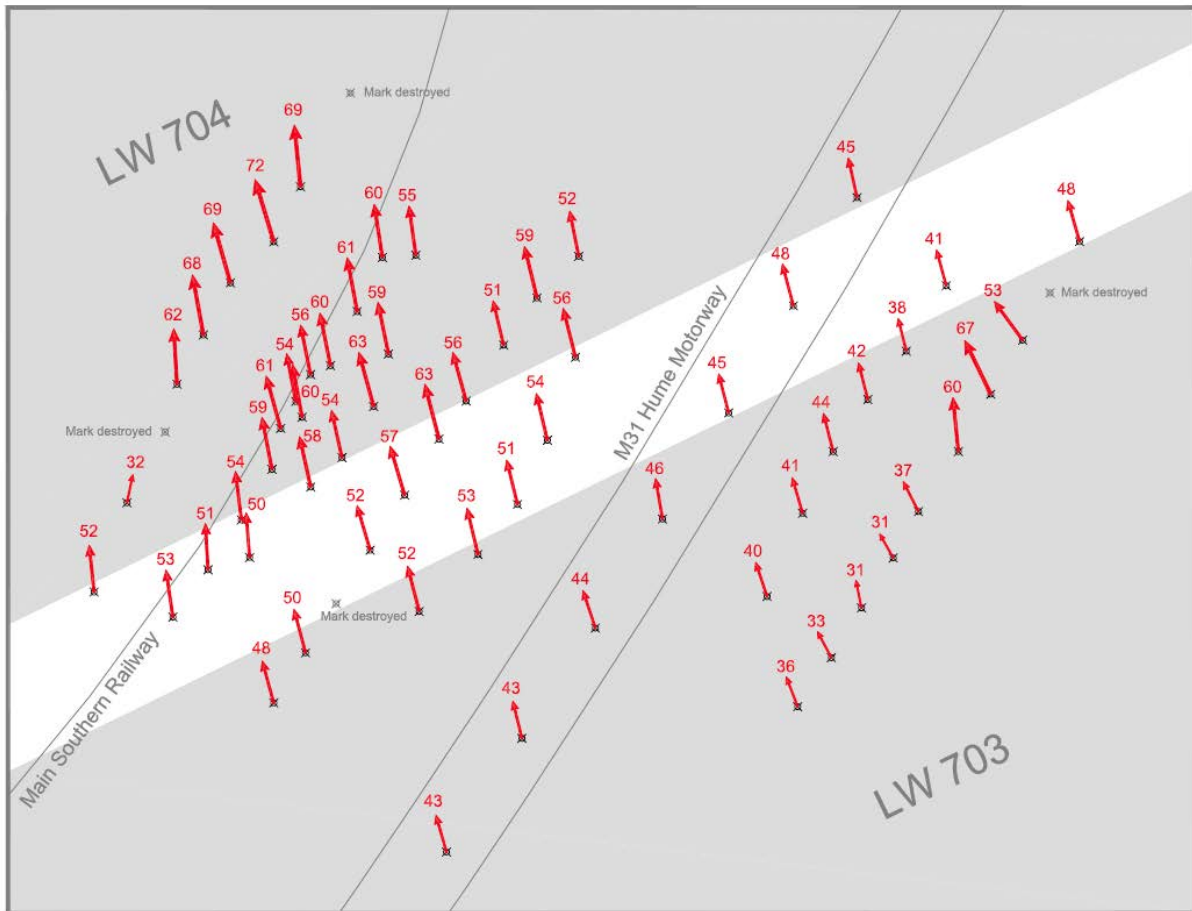


Figure 2-2: Observed Absolute Incremental Horizontal Movements at the Highway and Railway Cutting Points due to the Extraction of Longwall 706 (8th December 2015)

The observed incremental horizontal movements at the highway and railway cutting points versus distance from Longwall 706 are illustrated in Figure 2-3. It can be seen from this figure that the observed movements were within the range of those observed along the highway and railway monitoring lines, and less than those typically observed elsewhere in the Southern Coalfield.

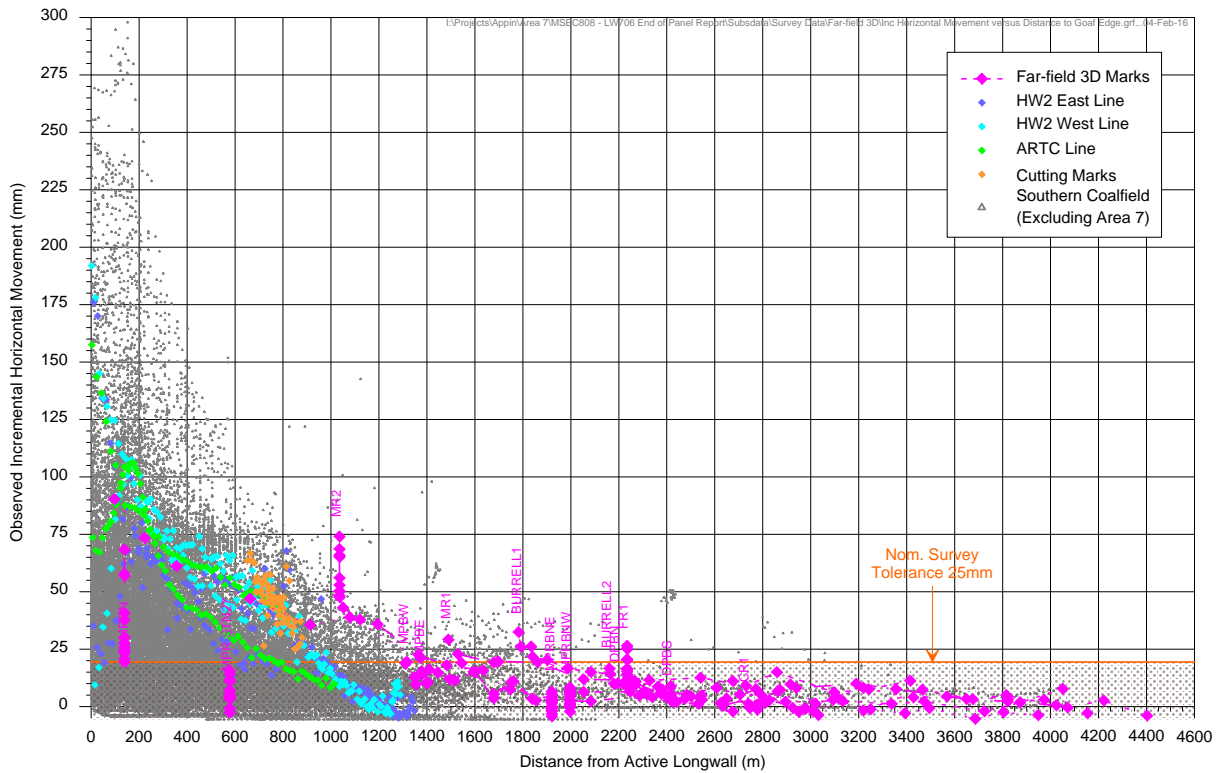


Figure 2-3: Observed Absolute Incremental Horizontal Movements versus Distance to Nearest Longwall Goaf Edge with Solid Coal between Mark and Extracted Longwall, with Longwall 706 results overlaid.

2.7. Partridge VC Rest Area

The Partridge VC Rest Area points were measured by South32 during the extraction of Longwall 706. Minor vertical and horizontal displacements were measured during the mining of Longwall 706. This was expected given that the Rest Area is located above future Longwall 707.

2.8. Far-field 3D Marks

The far-field mine subsidence movements were measured by South32 using a number of 3D points in the vicinity of Longwall 706.

The final observed absolute incremental horizontal movements at the far-field 3D monitoring points, due to the extraction of Longwall 706, are shown in Figure 2-4.

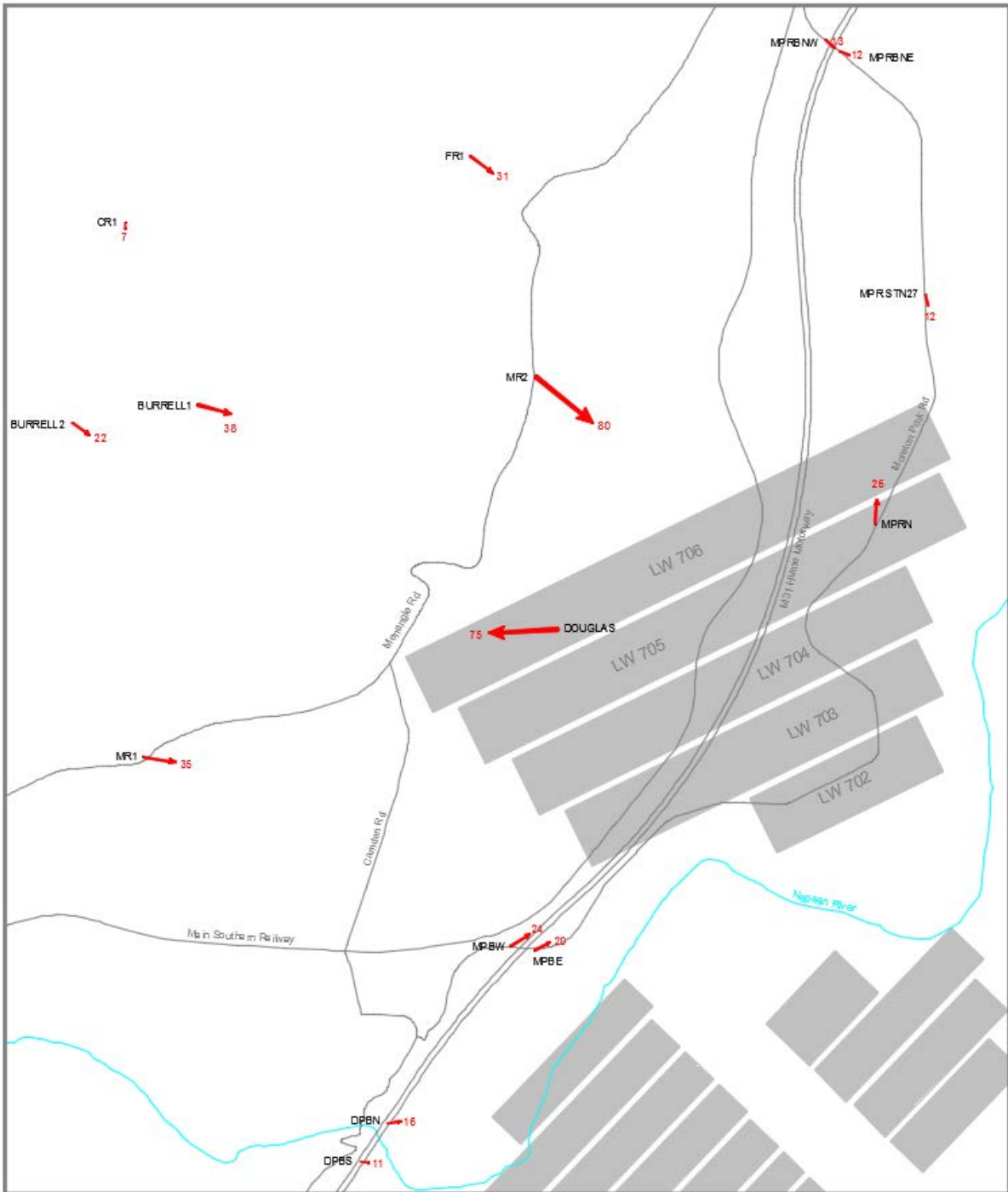


Figure 2-4: Observed Absolute Incremental Horizontal Movements at the Far-field 3D Monitoring Points due to the Extraction of Longwall 706 (15th December 2015)

2.9. Douglas Park Twin Bridges over the Nepean River

The Douglas Park Twin Bridges are located approximately 2.1 kilometres south-west of the finishing (western) end of Longwall 706.

The monitoring associated with the Douglas Park Twin Bridges, during the extraction of Longwall 706, included the following:-

- Absolute 3D bridge monitoring points;
- Relative 3D bridge monitoring points;
- Inclinometer monitoring;
- Bridge joint monitoring; and
- Visual inspections.

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 South32 at Points DPBN and DPBS, which are located adjacent to the northern and southern ends, respectively, of the bridges.

The TARP for the Douglas Park Twin Bridges, which was developed by the RMS chaired Technical Committee, provided triggers for absolute and relative horizontal movements of the far-field 3D Points DPBN and DPBS adjacent to the bridges. The maximum observed absolute and relative horizontal movements at the far-field 3D monitoring Points DPBN and DPBS did not exceed the *Level 1 Triggers*.

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 South32 using relative 3D marks fixed directly to the bridge structure.

Measured differential horizontal movements are very small and close to survey tolerance. The highest accuracy surveys of differential horizontal movements are straight 195 metre long 2D horizontal distance measurements between survey pillars at Pegs DPBN and DPBS, which are situated between the two bridges at abutment level. Measured changes between the pillars are within survey tolerance. The relative 3D surveys are slightly less accurate and while variations exist between surveys, the results are close to survey tolerance but consistently tensile in nature for the last four surveys.

2.9.3. Inclinometers near the Douglas Park Twin Bridges

The differential movements at two inclinometers near the Douglas Park Twin Bridges were monitored during the extraction of Longwall 706, being PSM2 and PSM6. The TARP for the Douglas Park Twin Bridges, which was developed by the RMS chaired Technical Committee, provided a trigger for differential movements at the inclinometers. The Level 1 Trigger was not exceeded during the extraction of Longwall 706.

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 Longwall 706. The TARP for the Douglas Park Twin Bridges, which was developed by the RMS chaired Technical Committee, provided a trigger for the differential movements across the bridge movement joints. The Level 1 Triggers were not exceeded as the result of mining Longwall 706.

2.10. Moreton Park Road Bridge (South)

Moreton Park Road Bridge (South) is located approximately 1,340 metres southeast of the finishing (western) end of Longwall 706. The monitoring associated with Moreton Park Road Bridge (South), during the extraction of Longwall 706, included the following:-

- Absolute 3D bridge monitoring points;
- Relative 3D bridge monitoring points; and
- Visual inspections.

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 South32 at Points MPBE and MPBW, which are located adjacent to the eastern and western ends, respectively, of the bridge. The surveys for Points MPBE and MPBW were carried out as part of the far-field surveys.

The TARP for the Moreton Park Road Bridge (South), which was developed by the RMS chaired 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 Triggers were not exceeded as the result of mining Longwall 706.

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.

The observed total changes in the horizontal distance between the abutments, during the extraction of Longwalls 701 to 706, has shown a small amount of abutment spreading, in the order of 5 mm, which primarily developed during the extraction of the previous Longwalls 703 and 704. The results vary slightly between surveys and the cause is thought to be related to changes in moisture and/or temperature. Relative 3D surveys have also detected a horizontal rotation of the deck. The deck movements are not considered to be due to subsidence during the mining of Longwalls 701 to 706, as the deck is moving independently of the abutment and bases of the column supports.

2.11. WaterNSW Infrastructure

WaterNSW infrastructure in the vicinity of Longwall 706 includes the Upper Canal, Devines Tunnels, wrought iron aqueducts, bridges and concrete aqueducts.

The movements at the Ousedale Creek, Mallaty Creek, Leaf's Gully and Nepean Creek Aqueducts and Bridges were monitored by South32 using local 3D surveys. The incremental changes in the distances between the aqueduct headwalls, during the mining of Longwall 706, were +2 mm (opening) for the Ousedale Creek Aqueduct, +4 mm (opening) for the Mallaty Creek Aqueduct and - 2 mm (closure) for the Nepean Creek Aqueduct. The movements at the Ousedale and Nepean Creek Aqueducts were similar to the order of survey tolerance. The incremental opening at the Mallaty Creek Aqueduct resulted in a reduction of the existing net closure from 10 mm to 6 mm. The observed incremental movements at the remaining aqueducts and bridges were in the order of survey tolerance, i.e. not measurable.

The movements at Concrete Aqueducts C and D were monitored by South32 using local 3D surveys. The incremental movements at Mark 1WB for Concrete Aqueduct C, during the mining of

Longwall 706, were 5 mm in the vertical and 3 mm in the horizontal. The notes from the survey indicate that this mark appears to be compromised. The remaining observed incremental net vertical and horizontal movements at the Concrete Aqueducts C and D, during the extraction of Longwall 706, were less than 3 mm, which are similar to 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. Observed profiles of subsidence and tilt were reasonably similar to the profiles predicted.

3. Impacts to Built Features

The built features in the vicinity of Longwall 706 are shown in Figure 2-1. The features which are located within the predicted 20 mm incremental subsidence contour, due to the extraction of Longwall 706, or which may be sensitive to far-field or valley related movements include:-

- Moreton Park Road and drainage culverts,
- Menangle Road and drainage culverts,
- M31 Hume Motorway and associated infrastructure,
- Main Southern Railway and associated infrastructure,
- The Douglas Park Twin Bridges,
- Moreton Park Road Bridge (South),
- Low voltage powerlines,
- Copper telecommunications cables,
- Optical fibre cables – Telstra (2 off), 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, resulting from the extraction of Appin Longwalls 705 to 710, were provided in the Longwall 705 to 710 SMP (MSEC342). Comparisons between the assessed and observed impacts for the built features located within either the 35 degree angle of draw line from Longwall 706, or within the predicted incremental 20 mm subsidence contour due to Longwall 706, are provided in Table 3-1. The built features in the vicinity of Longwall 706, which have been considered sensitive to far-field or valley related movements, have also been included in this table.

The observed impacts on the built features, resulting from the extraction of Longwall 706, were generally similar to or less than the predicted impacts.

Table 3-1: Summary of the Assessed and Observed Impacts for Built Features Resulting from the Extraction of Longwall 706

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 impacts observed during the mining of LW706
Menangle Road	No impacts expected during LW706	Cracking observed to pavement on steep slope on Menangle Road at a site located more than 400 m from closest edge of LW706. Cracks are not considered to be due to mine subsidence due to offset distance and available monitoring data.
M31 Hume Motorway	No impacts on the safety or serviceability of the motorway after the implementation of the management strategies	No adverse impacts to 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 reported impacts
Copper telecommunications cables	Impacts unlikely	No adverse impacts observed
Optical fibre cables	Impacts unlikely with the implementation of the management strategies including OTDR monitoring and mitigation	Small levels of signal loss measured
Building structures	Category A Tilt Impacts. Typically Category 0 Strain Impacts, with 11 x Category 1 Strain Impacts, 5 x Category 2 Strain Impacts.	<i>Houses and Non-Residential Structures</i> To date, one claim made to MSB for impacts to house and one claim in the process of being made, due to the extraction of Longwall 706. *
Pools	Inground pools could be more susceptible to ground strains	One impact reported (claim included with house impact mentioned above).*
Water tanks	Impacts unlikely	No reported impacts
Farm dams	Potential for minor cracking or leakage	No reported 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	One private bore impact (refer to Section 4.4.5)
Pumps in the Nepean River	Impacts unlikely	No reported impacts

Built Feature	MSEC Assessed Impacts	Observed 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

* Information regarding impacts and claims to MSB became available following submission of MSEC Report (MSEC808).

4. Impacts to Natural Features

The natural features in the vicinity of Longwall 706 are shown in Figure 4-1, which include:-

- The Nepean River;
- Creeks;
- Cliffs and rock outcrops;
- Steep slopes; and
- Archaeological Sites.

The MSEC assessments for the natural features, resulting from the extraction of Appin 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 consultants reports.

Monitoring activities for natural features within the Longwall 705 SMP Area relate to the following categories:

- Water flow, pool water levels and water quality monitoring;
- Photographic and observational monitoring to identify mining-induced fractures, strata gas releases, iron staining and rock falls (cliff line and steep slopes);
- Aquatic ecology monitoring;
- Terrestrial flora and fauna monitoring; and
- Aboriginal and European heritage items.

The ICEFT undertook monitoring of landscape features in the vicinity of Longwall 706. Their findings are provided in **Attachment C1 and C2** and summarised below. The key watercourse in the SMP Area is the Nepean River, as shown in Figure 4-1. Monitoring sites along the Nepean River are shown in Figure 4-2.

There are no significant tributaries of the Nepean River in the vicinity of Longwall 706. The water level within the River is predominantly regulated by the downstream weir at Menangle, which acts as a dam.

The monitoring program for Longwall 706 is undertaken in accordance with Environmental Management Plan (EMP) requirements for Appin Longwalls 705 to 706. The monitoring program is outlined in Section 5.

The information below has been provided by the ICEFT and relevant specialist consultants. The ICEFT undertook detailed monitoring of watercourses potentially impacted by Longwall 706, before, during and after mining. Water quality and flow data have been reviewed by GeoTerra. Groundwater data has been reviewed by GeoTerra. Niche has undertaken a review of Cultural Heritage. Cardno Ecology Lab (CEL) was responsible for the aquatic ecology monitoring and assessment. The results of these monitoring programs and assessments are discussed below.

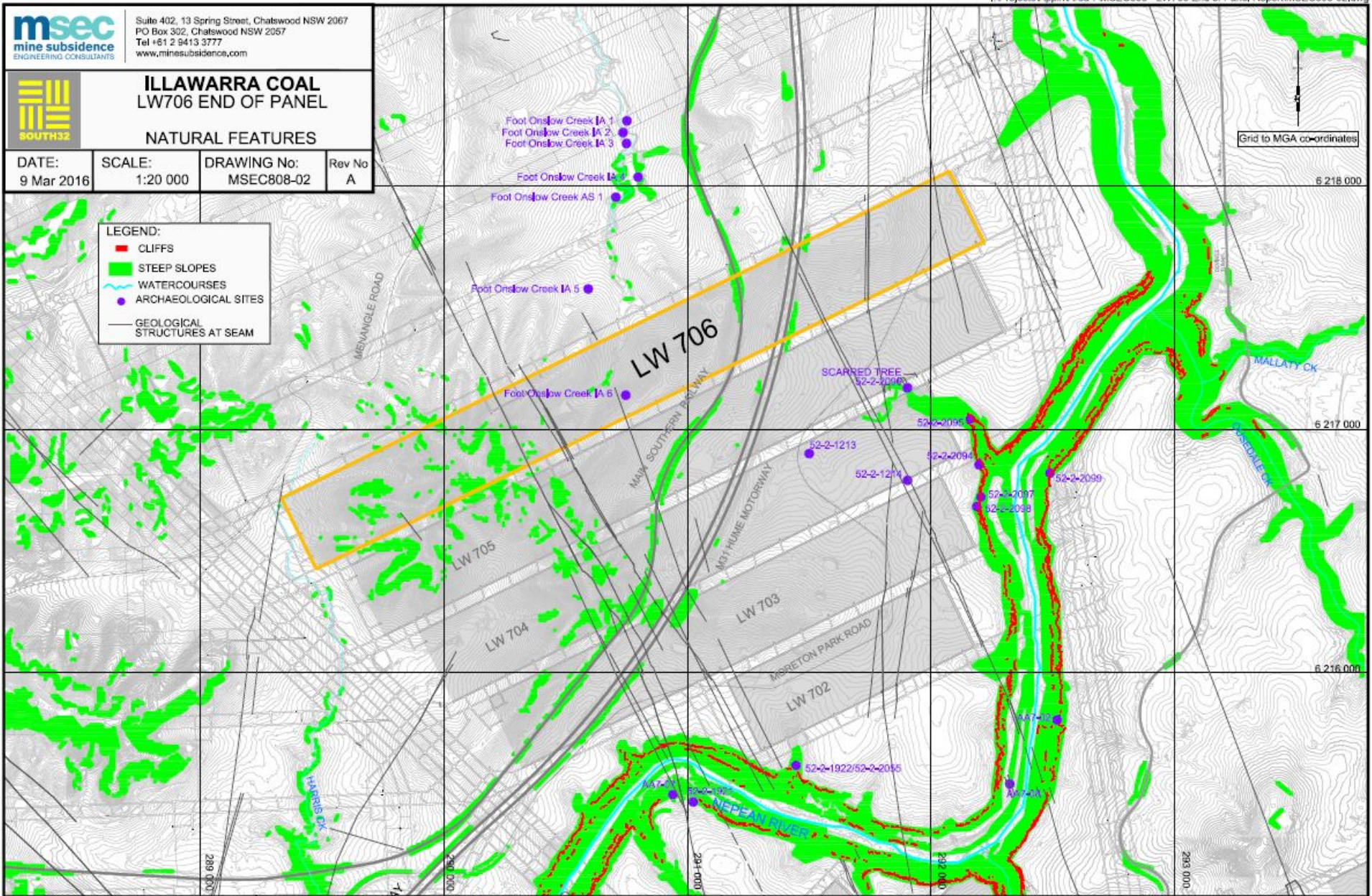


Figure 4-1: Natural Features associated with Longwall 706 (MSEC808-02)

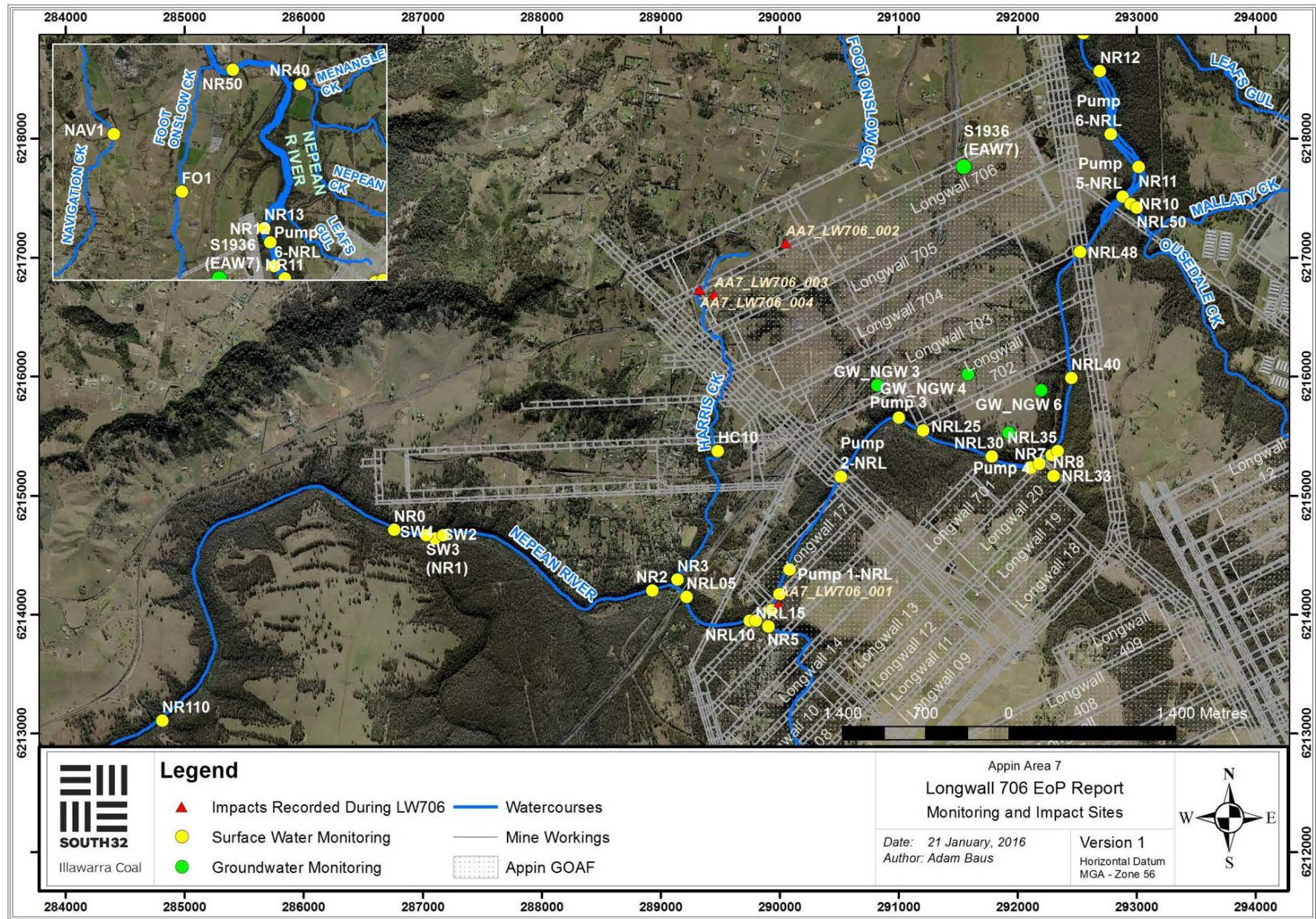


Figure 4-2: Area 7 Monitoring Sites and Impacts Observed During Longwall 706

4.1. Surface Water Quality

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 706 has been undertaken by GeoTerra. The key points are included in this report, the full report by GeoTerra is provided as **Attachment D**.

Baseline water qualities in the Nepean River, especially under the ecologically more critical low flow conditions (<50 percentile), are clearly dominated by the following processes (Ecoengineers, 2014):

- *inputs of more acidic water from Cataract River;*
- *low flow inputs of more saline water from Harris, Elladale and Ousedale Creeks which have negligible to minor bulk effect on overall river salinity;*
- *consistent inputs of low DO water from Cataract River (and Elladale Creek) which is the primary driver of DO in the Nepean River immediately downstream of the Cataract River confluence;*
- *a relatively low rate of re-aeration downriver of the Cataract River confluence (the flooded geomorphology of the River is such that it has a low re-aeration coefficient adjacent to Area 7; and*
- *consistent inputs of Fe and Mn to the river from Cataract River and Elladale Creek.*

In line with the TARP monitoring requirements for surface water quality, results are focussed on Sites NR2 (background), Sites NR11, NR12 and NR13. Sites NR20 and NR30 (downstream) were approved to be removed from the monitoring program by the DTI in June 2015.

During the Longwall 706 extraction period, the Nepean River pH, salinity and DO maintained similar pre Longwall 706 variability, with no significant change to the observed ranges as a result of extraction of Longwall 706. No significant change in trend or extended adverse changes occurred for pH, salinity or DO. No TARP trigger levels were reached for pH, salinity or DO.

During the Longwall 706 extraction period, the levels of iron and manganese within the water of the Nepean River maintained similar pre Longwall 706 variability, with no significant change to the observed ranges as a result of extraction of Longwall 706. No significant change in trend or extended adverse changes occurred for iron and manganese. No TARP trigger levels were reached for iron and manganese.

4.1.1. Gas Releases into the Nepean River

One zone of gas release, AA7_LW706_001, was activated during the extraction of Longwall 706. It was first observed on the 13th August 2014 and consisted of four releases in two 2m x 1m areas (Photo 1). When initially observed it was located approximately 3800m south-west of the nearest point of Longwall 706. Due to this distance it is most likely that it is a reactivation of a gas release from previously mined Longwall 16 which was extracted between October 1998 and August 1999 and is the closest longwall to this impact. AA7_LW706_001 was last observed to be active on the 7th January 2016. As the flow rate of this gas release is less than 3000L/min it falls within a Level 1 trigger according to the Longwall 705-706 TARPs. For further information refer to the Impact Report attached (dated 14th August 2014).

Gas Zones 5, 14 and 18 were active during this period however they were activated by previous longwalls (Longwalls 704 and 705). Gas Zone 5 was last observed on the 13th August 2014, Gas Zone 14 on the 11th December 2015 and Gas Zone 18 on the 26th October 2015.



Photo 1: AA7_LW706_001 Gas release (13/08/14)

4.2. Nepean River Water Level and Flow

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).

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 Colliery and Tahmoor Colliery (the latter located adjacent to Bargo River), and*
- *stormwater runoff from agricultural and urban areas.*

Excess flows from the Lake Nepean and Lake Avon catchment areas released over Pheasants Nest Weir contribute the majority of flows into the River. Minor amounts of water are directly drawn from the river by licensed water pumps and there are several of these close to Area 7.

Flow varies greatly and is largely dependent on rainfall within the catchment. Regular monitoring is not conducted within the SMP area as it is difficult to measure flow in deep, wide channels. The closest flow gauging station upstream of Appin Area 7 is at Maldon Weir, located approximately 14 km upriver from Longwall 706. The closest flow gauging station downstream of the SMP Area is Menangle Weir, located approximately 5 km downriver of Longwall 706.

Water flows in the Nepean River:

- vary greatly and are highly responsive to rain events due to the significant areas of upriver catchment involved;
- reach very high levels during sustained storm events, while minimum flow is rarely likely to be less than 13 ML/day (approx. a 5 percentile flow at Menangle Weir);
- cease on a small number of occasions, usually only when the rate of pumping out of the river exceeds the rate of inflow under low flow/drought conditions; and

- are characterised by median flow rates in the Nepean River adjacent to Area 7 that are likely to be much higher than the median flow rate at Maldon Weir (33.01ML/day), and about 15% less than the median flow rate at Menangle Weir (105.4ML/day).

No subsidence induced flooding of river banks was observed. Likewise, no areas of dry river bed were observed.

4.3. Nepean River Appearance

The appearance of the Nepean River and its tributaries was monitored by the ICEFT on a weekly basis (where access was safe and granted). Following the approval to modify the monitoring regime (on the 4th June 2015), monitoring is 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 706.

4.4. Groundwater

GeoTerra was commissioned by Illawarra Coal to report on the predicted and any observed groundwater changes resulting from extraction of Longwall 706. The information in this section has been drawn from the GeoTerra report which is provided as **Attachment D**.

Eight open standpipe piezometers (NGW3, 4, 5, 6, 7, 9, 10 and 11) were installed by Illawarra Coal over, or in the vicinity of Longwalls 701 – 706 in 2004. Groundwater level and water quality monitoring within the Hawkesbury Sandstone to 10m below the base of the Nepean River gorge began in June 2004 from locations shown in Figure 4-2.

Due to the advancement of mining to the west, and the age of the installed equipment, not all sites have recent data. Illawarra Coal downloads water level data from the following functional piezometers;

- NGW3 (up to 3/10/2015)
- NGW4
- NGW5
- NGW6

Fully cemented, sealed vibrating wire piezometer arrays were also installed by Illawarra Coal in bores EAW5 (S1913) and EAW7 (S1936), location shown in Figure 4-2.

Five NOW registered private bores are located within the Longwall 706 20mm subsidence area (GW102584, 104602, 104661, 105339 and GW108312). All NOW registered private bores in the region are located on the western plateau of the Nepean River gorge. They were drilled between 70 - 294m below surface, with water obtained primarily from sandstone aquifers, however some thin, perched horizons encountered water in the Wianamatta Shale (GW103161 at 17-18m and GW104602 at 30m). The majority of aquifer intersections over the Longwall 701 to 706 mining area lie at or below the relative height of the Nepean River, even though the bore water levels may rise under pressure to higher elevations in a bore.

The piezometer and bore monitoring data has been used to determine the pre Longwall 706 baseline status and groundwater level and water quality variations within the regional Hawkesbury Sandstone

aquifer to a maximum depth of 10m below the relative level of the Nepean River bed. Groundwater levels are logged hourly using vibrating wire piezometers in the NGW and EAW series piezometers and are downloaded at the completion of longwall panels (or as required).

4.4.1. Groundwater Levels

NGW6 was not undermined by Longwall 704, 705 or 706, however a definitive response comprising an up to 2.21m fall in groundwater level occurred after Longwall 704 was completed and before Longwall 705 extraction occurred.

The Nepean River water surface averages 61.10mAHD at Douglas Park weir and 60.84mAHD at Menangle, and as a result, the NGW6 water level varied from 2.33 – 4.75m higher in elevation than the river during the Longwall 704 and Longwall 705 monitoring.

The decline in water level occurred just after Longwall 704 was completed and then erratically rose, fell, then continued to rise until the logger trace cut out on 03/09/12. Prior to re-establishment of the logger in a rising limb of the water level trace, the water level had previously fallen by 1.02m.

The water level rise significantly flattened out around mid-October 2012, then continued to fall at a lower rate after that time until early October 2013, then rose and fell a minor amount after that time to the end of the monitoring period.

No significant water level reduction occurred during extraction of Longwall 706 in NGW3, NGW4, NGW5 and NGW6 as shown in Figure 4-3.

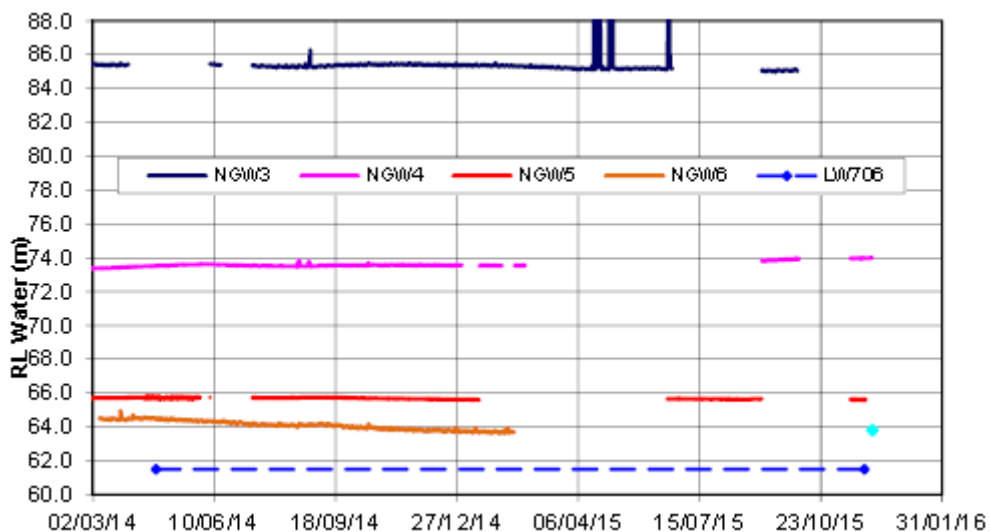


Figure 4-3: NGW Groundwater levels during Longwall 706 extraction

4.4.2. Vibrating Wire Piezometers

Bore EAW5 [S1913] is located approximately 2.2 km north to northwest of Longwall 706. Head declines linearly at EAW5 in the Hawkesbury Sandstone and there is a clear difference in the behaviour of groundwater pressures above and below the Bald Hill Claystone.

This is evidence of the contiguous nature of the claystone across the general Appin Area 7 mining area and evidence of the pre-mining separation between shallow and deep aquifer heads.

Within the upper Bulgo Sandstone the heads become artesian (at or above ground level), except for a slightly lower head in the Bulli Seam. The vertical profiles between the 2008-09 and June 2012 data are consistent, although the Bulli Seam water level rose from 2008-09 to June 2012 to an artesian level, unlike the 2008-09 data which is sub-artesian (HydroSimulations, 2013).

The EAW5 water levels were essentially unaffected by Longwall 706 extraction, outside of a gradual water level decline in the Bulli Seam, Scarborough Sandstone (505mbgl), Bulgo Sandstone (274mbgl) and a rise in the Hawkesbury Sandstone at 65mbgl.

EAW7 (S1936) is located over Longwall 706. The deeper heads are sub-artesian at EAW7, although were generally higher than the Hawkesbury Sandstone levels at June 2012 and lower at June 2013. The head profile patterns at June 2012 and June 2013 are similar, although there is clearly more variation between 2009, 2012 and 2013 in the deeper water levels than in the Hawkesbury Sandstone. For example, within the Bulgo Sandstone, there was a decline in levels of about 6 - 17m between June 2012 and June 2013 in the middle and lower Bulgo Sandstone respectively as shown in Figure 4-4.

The decline was greater at around 30m in the Scarborough Sandstone, which is a clear mining effect due to Longwall 705. There is minimal difference in the lower Hawkesbury Sandstone water levels between 2012 and 2013 and no change was observed in the upper Hawkesbury Sandstone (HydroSimulations, 2013). A definitive sharp fall in water levels occurred around late April 2014 in the Scarborough Sandstone at 456.2, 462.1 and 468mbgl, along with a continued enhanced reduction in water levels in the Bulgo Sandstone at 347.8 and 422.5mbgl and a distinctive pressure reduction in the Bulli Seam since the start of monitoring.

No groundwater level reduction TARP triggers were exceeded during extraction of Longwall 706 in any private bores and no changes outside of predictions for the VWP monitoring bores occurred.

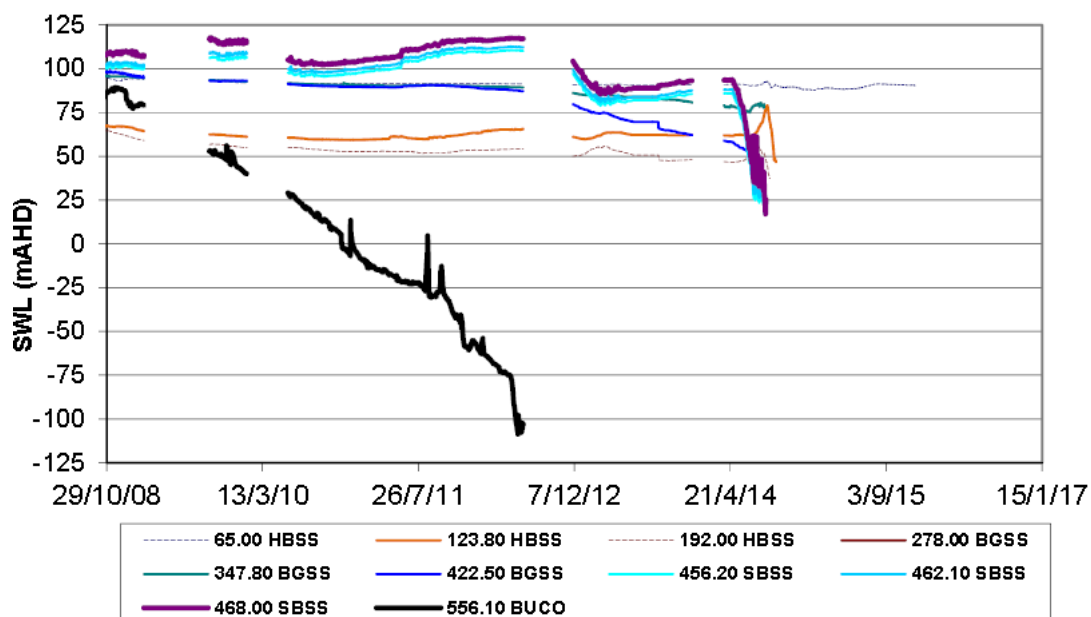


Figure 4-4: EAW7 Water Levels

4.4.3. Well Yield and Bore Serviceability

No adverse effects on groundwater supply, well yield or bore serviceability have been monitored or reported during and following extraction of Longwalls 702 to 706.

No well yield TARP triggers were exceeded during or following the extraction of Longwall 706. Gas seepage has occurred in one private borehole and is discussed in Section 4.4.5. This has adversely impacted supply from the bore as a result of mining and is a Level 3 trigger.

4.4.4. Groundwater Quality

The groundwater quality in NGW3 is generally fresh (344 - 434 mg/L) with circum-neutral to slightly alkaline pH (7.1 – 7.7), however as the piezometer is regularly inundated with rainwater recharge down the bore annulus, the data does not represent the actual formation water quality and is not further considered.

NGW4 may also be affected by rainwater recharge, although it does not show in the water level trace after significant storms as it also has a low salinity (434 – 458mg/L) and circumneutral to slightly alkaline pH (7.5 – 8.0).

NGW 5, 6 and 10 generally exceed the ANZECC 2000 irrigation water quality for chloride and sodium, whilst NGW7, 9 and 11 are relatively fresh with a circum-neutral to slightly acidic pH.

Since December 2007, on-going monitoring indicates that:

- NGW5 salinity has remained essentially unchanged, and its pH has reduced from 7.9 to 6.3, whilst;
- NGW6 salinity has reduced from 5,180 to 729 μ S/cm, and its pH has reduced from 7.5 to 7.0.

No additional monitoring of the NGW 3, NGW 4 and NGW 5 piezometers groundwater quality occurred during extraction of Longwall 706.

No groundwater quality TARP triggers were exceeded during or following the extraction of Longwall 706.

4.4.5. Gas Seepage

Monitoring by ICEFT during Longwall 706 extraction on 15th July 2015 identified water cloudiness and a gaseous smell in the bore water, with laboratory analysis confirming the presence of methane, along with other hydrocarbons in GW112441. Laboratory analysis indicated no pre and post Longwall 706 change to pH, salinity or metals.

The landowner was advised to cease use of the bore and the area around the wellhead was fenced off. A 10,000 Litre tank was provided by Illawarra Coal for livestock watering and is topped up as required by Illawarra Coal. At this stage, a replacement bore is planned to be drilled after completion of Longwall 707 unless an alternative arrangement is agreed with the landowner and approved by the Secretary.

4.4.6. Potential Inflow to Mine Workings

There was no increases in groundwater inflow to the Appin Mine workings following extraction of Longwall 706, compared to the previous longwall periods. No TARP trigger levels have been reached based on statutory inspections underground.

4.5. Landscape Features

Observations of clifflines and steep slopes along the Nepean Gorge and associated tributaries were conducted by the ICEFT on a weekly and monthly basis. Cliff A7_129 is the closest to Longwall 706 (approximately 900m from the Longwall). No impacts to cliffs were identified during the extraction of Longwall 706. Observations above the active longwall were conducted where access was available. Some minor impacts were identified on private properties as discussed in Section 4.9 below.

4.6. Terrestrial Ecology

Terrestrial ecology in Appin 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 706 (ICEFT, 2016). 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 706 has had negligible impact on terrestrial ecology, including Threatened Species and potential habitat for threatened plants and fauna.

4.7. Aquatic Ecology

Cardno Ecology Lab (CEL) was commissioned by Illawarra Coal to assess the potential impact of longwall mining-related subsidence on the aquatic ecology of the Nepean River and other nearby watercourses within the Appin Area 7 SMP Area through the implementation of an aquatic ecology monitoring programme. The latest round of aquatic ecology monitoring was undertaken in November 2015, as part of the ongoing aquatic ecology monitoring programme. The assessment focussed on the effects of extraction of Longwalls 701 to 706 on aquatic habitats and biota in nearby sections of the Nepean River, comparing results from surveys undertaken since 2002 (CEL, 2013). The findings of their investigation are summarised below and provided as **Attachment E**. The monitoring sites associated with the aquatic ecology programme are shown in Figure 4-5.

The assessment of impacts on aquatic ecology in relation to the Longwall 706 EoP Report draws on findings from the report provided by The Ecology Lab (2004), the assessment undertaken by CEL (in November 2015), the EoP assessment on surface and shallow groundwater impacts from Longwall 706 and the landscape report summarising the observed impacts from Longwall 706.

Monitoring undertaken by South32 during extraction of Longwalls 705 and 706 identified isolated gas releases in the Nepean River. No fracturing, changes in water levels and flow or changes in water quality have been attributed to mining.

There were no observed impacts to indicators of aquatic ecology (number of taxa and biotic indices derived from macroinvertebrate sampling) that could be attributed to extraction of Longwalls 705 and 706. Differences in the number of taxa between Impact and Control Reaches prior to extraction, and

between Control Reaches after extraction of Longwall 706, were not related to mining. Likewise, an increase in the OE50 Taxa Score (a biotic index of aquatic habitat and water quality) at the Impact Reach and a decrease at a Control Reach following the commencement of extraction of Longwall 706 was also unrelated to mining.

Rather, such changes, and other statistically significant differences in various indicators were attributed to natural variation, rather than mining.

Similarly, there was no evidence of any changes to fish and aquatic macrophytes attributable to mining. The fish assemblage sampled in the Nepean River following the commencement of extraction of these longwalls was comparable with that sampled prior to extraction and no fish kills or any other observations that may suggest an impact due to mining have been observed. Over the course of the monitoring program large changes in the distribution of aquatic macrophytes have occurred. Despite this, the species composition of macrophytes has been relatively consistent and the number and type of species identified in December 2015 were very similar to those identified in December 2013 and 2014. Given the absence of any observed macrophyte desiccation and die-back, there is no evidence to suggest that changes in macrophyte diversity and distributions are outside what would be expected due to natural variation.

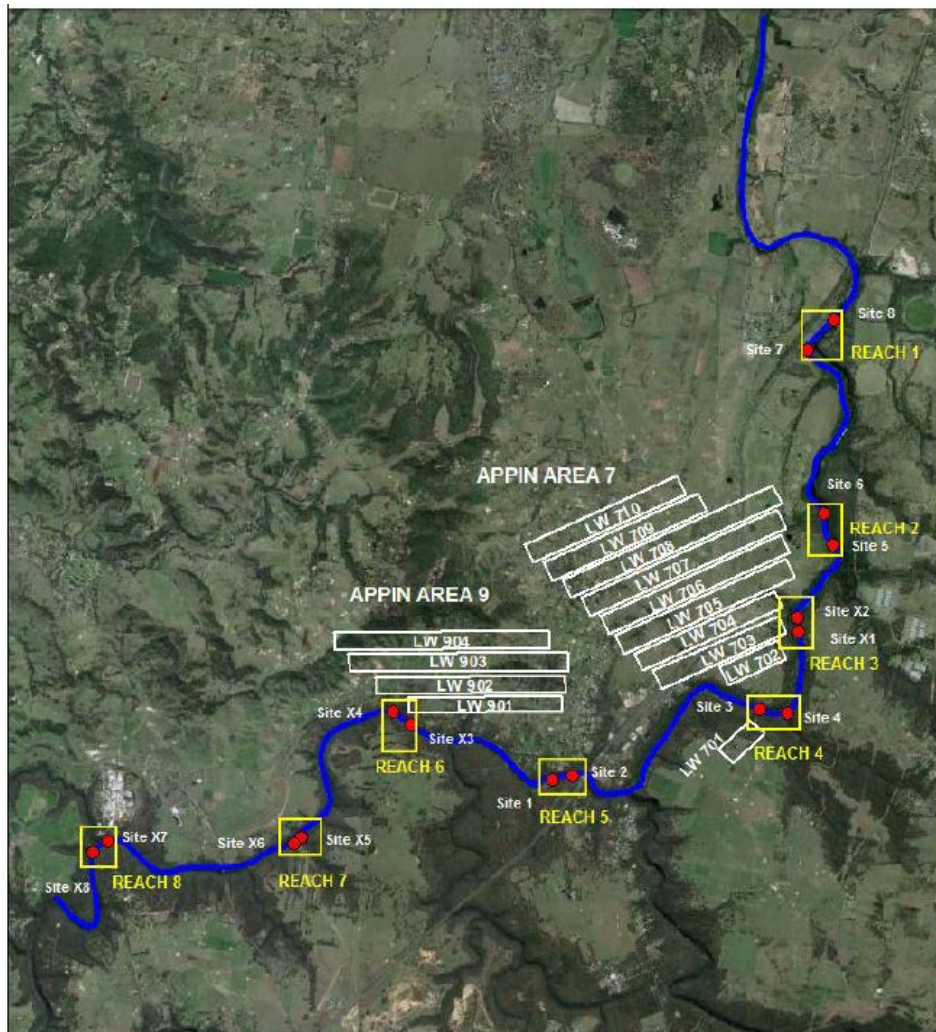


Figure 4-5: Aquatic ecology monitoring sites in the Nepean River in relation to Appin Area 7 and 9 Longwalls (CEL, 2016).

4.8. Cultural Heritage

Niche was commissioned by Illawarra Coal to conduct an assessment of the European and Aboriginal cultural heritage and archaeological sites within the limit of subsidence of Longwall 706.

Archaeological surveys were initially conducted by Biosis Research in 2008; as part of the *Archaeological and Cultural Heritage Impact Assessment of Proposed Longwalls 705 to 710, West Appin, NSW*.

Nineteen registered Aboriginal archaeological sites are located within the Longwalls 705 to 710 SMP Area. Seven of these sites are located in proximity to Longwall 706. The remaining twelve Aboriginal archaeological sites within the SMP Area were assessed as having negligible potential to be impacted by subsidence caused by the extraction of Longwall 706.

Those sites within close proximity to Longwall 706 are identified in Table 4-1 and have been considered further in the assessment undertaken.

No historical sites are located above Longwall 706. The Mountbatten group of historical sites is located to the southwest of Longwall 706 within the SMP Area. The MSEC predication for this group was for negligible subsidence to occur and therefore they are not referred to further.

Table 4-1: Cultural Heritage Sites considered in Longwall 706 Assessment

AHIMS Site Number	Site Name	Site Description
52-2-3845	Morton Park Rd 5	Open Camp Site
52-2-2096	Nepean River 7	Scarred Tree
52-2-3842	Morton Park Rd 2	Open Camp Site
52-2-1214	Unit D ground axe Paddock; Didicoolum	Open Camp Site
52-2-3844	Morton Park Rd 4	Isolated Artefact
52-2-3846	Mountbatten 2	Isolated Artefact
52-2-3674	Mountbatten 1	Isolated Artefact

Impacts associated with Longwall 706 have been within predictions of the initial impact assessment (Biosis Research 2008).

The Open Camp Sites, Isolated Artefacts and Scarred Tree do not require further inspection as impacts from longwall mining on these types of sites were predicted to be negligible.

Detailed assessment of the afore mentioned Aboriginal sites was not required as the subsidence predictions for Open Camp Sites, Isolated Artefacts and Scarred trees considers a negligible impact on cultural heritage values. This assessment is based on the results of subsidence monitoring reported by MSEC (MSEC808) and results of monitoring carried out by the ICEFT, in which no impacts were observed outside of predictions and subsidence parameters measured were generally less than or similar to predictions.

4.9. Private Property

Pre-mining and post-mining inspections of dams, boreholes and landscape features on private properties are conducted by the ICEFT.

Impact AA7_LW706_002 was a period of strata gas emissions from a private borehole (discussed in Section 4.4.5).

AA7_LW706_003 and AA7_LW706_004 are areas of soil cracking on a private property. AA7_LW706_003 consists of multiple soil cracks within a 30m x 35m area. Discontinuous cracking along a fence with a total length of approximately 65m was also identified at the property. AA7_LW706_004 consisted of a single soil crack at the base of a dam wall. It was approximately 1.3m long, with a maximum width and depth of 0.02m and 0.03m respectively. Both of these soil cracks are expected to self-remediate.

For further information on the above impacts, refer to the relevant Impact Reports attached (dated 21st July 2015 and 4th January 2016).

5. Longwall 706 Monitoring Program

Monitoring of landscape features has been conducted in accordance with the EMP for Longwall 705 and 706 dated 23rd July 2012. During the extraction of Longwall 706, approval was granted by DRE (on the 4th June 2015) to modify the monitoring program for the Nepean River. This modification involved:

- reduction from the routine weekly inspections of the Nepean River to monthly;
- fortnightly inspections of impact sites;
- removal of monitoring sites NR20 and NR30;
- reduction in data download frequency for NGW groundwater bores.

The monitoring commitments for man-made features and natural features are outlined in Table 5-1 and 5-2 respectively.

Table 5-1: Monitoring Commitments for Man-made Features

Monitoring Commitment	Monitoring to Date Associated with LW706	Future Monitoring	Undertaken By
Nepean River Cross Lines - Five valley closure lines. Nep X M to Q inclusive.	- Prior to start of LW706 - Monthly during extraction of LW706, until PSE satisfied bulk of movement has finished. - After completion of LW706	Five valley closure lines. Nep X N to R inclusive. - Prior to start of LW707 - Monthly for the last 500m extraction of LW707. - After completion of LW707	Illawarra Coal
Endeavour Energy Power Poles All critical poles identified by Endeavour Energy as requiring monitoring. Survey marks established at each Pole to determine, Subsidence, and Tilt of the Top relative to the Base.	- Prior to start of LW706 - monthly for all poles within 500m of longwall face - After completion of LW706	-Prior to start of LW707 -monthly for all poles within 500m of longwall face - After completion of LW707	Illawarra Coal
Telecommunications FOC and co-axial cables	Monitoring as per RMS and ARTC Monitoring Plans referenced below.	Monitoring as per RMS and ARTC Monitoring Plans referenced below.	Illawarra Coal
Moreton Park Rd 3D survey	Prior to the Start of LW706, monthly for the first 1000m of extraction, at 1500m of	Prior to the Start of LW707, monthly for the last 500m of extraction, and after the	Illawarra Coal

	extraction, and after the completion of LW706.	completion of LW707.	
Telstra Telecommunications Tower and Line.	Surveys performed at start of LW706 then monthly once longwall face is within 100m of tower until 500m past tower then end of LW706.	Surveys performed at start of LW707 then monthly once longwall face is within 100m of the TL line until 500m past TL line then end of LW707.	Illawarra Coal
RMS Infrastructure			Illawarra Coal
Appin Area 7 Far Field *	<ul style="list-style-type: none"> - Prior to start of LW706 - Monthly once LW706 extraction reaches 300m - After completion of LW706 	<ul style="list-style-type: none"> - Prior to start of LW707 - Monthly once LW706 extraction reaches 700m - After completion of LW707 	
Douglas Park Twin Bridges <i>Absolute 3D Survey</i>	<ul style="list-style-type: none"> - Prior to start of LW706 - Monthly once LW706 extraction reaches 300m - After completion of LW706 	<ul style="list-style-type: none"> - Prior to start of LW707 - Monthly once LW706 extraction reaches 700m - After completion of LW707 	
<i>Relative 3D Survey</i>	<ul style="list-style-type: none"> - Prior to start of LW706 - By exception if levels 1 trigger values reached for Absolute 3D surveys above or inclinometer readings. Frequency defined by Technical Committee. - After completion of LW706 	<ul style="list-style-type: none"> - Prior to start of LW707 - By exception if levels 1 trigger values reached for Absolute 3D surveys above or inclinometer readings. Frequency defined by Technical Committee. - After completion of LW707 	
Moreton Park Road Bridge (South) <i>Absolute 3D Survey</i>	<ul style="list-style-type: none"> - Prior to start of LW706 - Monthly once LW706 extraction reaches 300m - After completion of LW706 	<ul style="list-style-type: none"> - Prior to start of LW707 - Monthly once LW706 extraction reaches 700m - After completion of LW707 	
<i>Relative 3D Survey / Closure monitoring / 2D survey</i>	<ul style="list-style-type: none"> - Prior to start of LW706 - By exception if levels 1 trigger values reached for Absolute 3D surveys above or inclinometer readings. Frequency defined by Technical Committee. - After completion of LW706 	<ul style="list-style-type: none"> - Prior to start of LW707 - By exception if levels 1 trigger values reached for Absolute 3D surveys. Frequency defined by Technical Committee. - After completion of LW707 	
M31 Pavement <i>2 X Absolute 3D/2D Survey lines which start at Moreton Park Road Bridge South (MPRBS) and extends for over 4km to the North. The 2 lines run parallel, one on the western side of the</i>	<ul style="list-style-type: none"> - Full line in 3D / 2D prior to start of LW706 - Monthly 3D surveys over focused extent of both lines once LW706 reaches 500m of extraction - 2D surveys over focused extents of both lines (E059 to E179 and W058 to W180) once LW706 reaches 600m of extraction, then weekly 	<ul style="list-style-type: none"> - Full line in 3D / 2D prior to start of LW707 - Monthly 3D surveys over focused extent of both lines once LW707 reaches 2000m of extraction - 2D surveys over focused extents of both lines (E059 to E179 and W058 to W180) once LW707 reaches 2300m of 	

<p><i>northbound carriageway with the other on the eastern side of the southbound carriageway. Point spacing along the lines is nominally 20m.</i></p>	<p>through to the end of mining. - Full line in 3D / 2D after completion of each LW706</p>	<p>extraction, then weekly through to the end of mining. - Full line in 3D / 2D after completion of each LW707</p>	
<p>Partridge VC Rest Area</p>	<p>- Prior to start of LW706 - Monthly once LW706 reaches 500m of extraction - After completion of LW706</p>	<p>- Prior to start of LW707 - Monthly once LW707 reaches 2000m of extraction - Weekly local 3D from 2300m extraction - After completion of LW707</p>	
<p>Moreton Park Road * <i>Absolute 3D/2D survey line</i></p>	<p>- Prior to start of LW706 - Monthly after 300m extraction until 1000m of extraction - Survey at 1500m extraction - After completion of LW706</p>	<p>- Prior to start of LW707 - Monthly for last 500m of extraction - After completion of LW707</p>	
<p>M31 Cutting No. 2</p>	<p>- Prior to start of LW706 - After completion of LW706</p>	<p>- Prior to start of LW707 - Monthly once LW707 reaches 2000m of extraction - Weekly local 3D from 2300m extraction - After completion of LW707</p>	
<p>ARTC Rail Assets</p>			<p>Illawarra Coal</p>
<p>ATRC Rail Corridor Line</p>	<p>- Full line in 3D / 2D before 200 m of extraction of LW706 - Monthly 3D / 2D surveys over focused extent of ARTC line commencing from 700m of LW706 extraction - Weekly 2D surveys over the focused extent of the ARTC line from 850m of extraction through to the end of mining - Full line in 3D / 2D after completion of LW706.</p>	<p>- Monthly 3D / 2D surveys over focused extent of ARTC line commencing from 1700m of LW707 extraction - Weekly 2D surveys over the focused extent of the ARTC line from 2000m of extraction through to the end of mining - Full line in 3D / 2D after completion of LW707.</p>	
<p>ARTC Cutting @ 71.000Km <i>Absolute 3D survey of the network of points</i></p>	<p>- Prior to start of LW706 - After completion of LW706</p>	<p>- Prior to start of LW707 - After completion of LW707</p>	
<p>Longitudinal Rail Creep & Long Bays</p>	<p>- Prior to start of LW706 - Monthly surveys after 700m of LW706 extraction. - Weekly surveys once LW706 reaches 850m extraction through to end of LW - After completion of each LW706</p>	<p>- Prior to start of LW707 - Monthly surveys after 1700m of LW707 extraction. - Weekly surveys once LW707 reaches 2000m extraction through to end of LW - After completion of each LW707</p>	

Railway Embankment 1 (70.5km)	<ul style="list-style-type: none"> - Prior to start of LW706 - Monthly surveys once LW706 reaches 1000m of extraction - Weekly surveys once LW706 reaches 1250m extraction through to end of LW - After completion of each LW706 	<ul style="list-style-type: none"> - Prior to start of LW707 - Monthly surveys once LW707 reaches 1700m of extraction - After completion of each LW707 	
Railway Embankment 1 Culvert Pipe / Liner (70.5km)	<ul style="list-style-type: none"> - Prior to start of LW706 - By exception at request of RMG if changes in brick arch culvert are detected in complimentary monitoring. - After completion of each LW706 	<ul style="list-style-type: none"> - Prior to start of LW707 - By exception at request of RMG if changes in brick arch culvert are detected in complimentary monitoring. - After completion of each LW707 	
SCA Infrastructure	<ul style="list-style-type: none"> - Baseline Survey prior to start of Longwall. - Survey at 350m and 700m extraction** - End of Longwall. 	<ul style="list-style-type: none"> - Baseline Survey prior to start of Longwall. - Survey at 700m and 350m remaining extraction** - End of Longwall. 	Illawarra Coal & WaterNSW

* RMS and ARTC Assets ** not applicable for all items

Table 5-2: Monitoring Commitments for Natural Features

Monitoring Site	Site Type	Monitoring Frequency	Future Monitoring (LW707-710 EMP)
WATER QUALITY			
<p>Nepean River</p> <p>Baseline upriver sites for cross-checking for upriver perturbations:</p> <ul style="list-style-type: none"> ▪ NR0 ▪ NR2 (pre Area 9 mining) ▪ NR110 (New site - post Area 9 mining) ▪ NR4 ▪ NR5 ▪ NR6 <p>Impact monitoring sites adjacent to each longwall:</p> <ul style="list-style-type: none"> ▪ NR11 ▪ NR12 ▪ NR13 ▪ NR20* ▪ NR30* <p>Other sites</p> <ul style="list-style-type: none"> ▪ NR7 ▪ NR9 ▪ NR50 <p><i>*approved to be removed June 2015.</i></p>	<p>Grab Sample and field measurements</p>	<ul style="list-style-type: none"> ▪ Monthly baseline prior to mining (data has been recorded for most sites since 2003). ▪ Weekly observations and field analysis during mining. ▪ 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. 	<p>Nepean River</p> <p>Baseline upriver sites for cross- checking for upriver perturbations:</p> <ul style="list-style-type: none"> • NR110 <p>Impact monitoring sites adjacent to each longwall:</p> <ul style="list-style-type: none"> • NR12 • NR13 <p>Downstream site:</p> <ul style="list-style-type: none"> • NR50 <p><i>Other sites:</i></p> <ul style="list-style-type: none"> • NR0 • NR2 • NR4 • NR6 • NR7 • NR9 • NR11 <p>Frequency</p> <ul style="list-style-type: none"> • 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
<p>Ephemeral Watercourses</p> <ul style="list-style-type: none"> ▪ Lower Harris Creek (NR3) ▪ Elladale Creek (NR8) ▪ Ousedale Creek (NR10) ▪ Menangle Creek (NR40) ▪ Upper Harris Creek (HC10) ▪ Foot Onslow Creek (FO1) ▪ Navigation Creek (NAV1) 	<p>Grab sample and field measurements</p>	<ul style="list-style-type: none"> ▪ Prior to mining of longwall underlying watercourse or mining of any immediately adjacent longwall. ▪ Monthly detailed laboratory analysis during mining. ▪ Following the development of incremental subsidence for each longwall that will impact on the feature. 	<p>1st and 2nd Order Watercourses</p> <ul style="list-style-type: none"> • 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)

Monitoring Site	Site Type	Monitoring Frequency	Future Monitoring (LW707-710 EMP)
LEVEL AND FLOW			
Nepean River <ul style="list-style-type: none"> ▪ At benchmark sites and water pump sites: <ul style="list-style-type: none"> – NRL05 – NRL10 – NRL12 – NRL13 – NRL15 – NRL20 – Pump 1 NRL – Pump 2 NRL – NRL25 – NRL30 – NRL33 – NRL35 – NRL40 – NRL45 – NRL48 – NRL50 – Pump 5 NRL – Pump 6 NRL 	Water Level Water flow (measured at SCA weirs)	<ul style="list-style-type: none"> ▪ Monthly baseline prior to mining (data has been recorded for most sites since 2007). ▪ Weekly manual monitoring at nails during mining. ▪ Flow monitoring at weirs (data supplied by WaterNSW). ▪ Ongoing monthly monitoring for 2 years post mining (or as otherwise required/approved). 	Nepean River At benchmark sites and water pump sites: <ul style="list-style-type: none"> • 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 WaterNSW flow monitoring sites (WaterNSW data): <ul style="list-style-type: none"> • Maldon Weir • Broughtons Pass Weir • Menangle Weir Frequency: <ul style="list-style-type: none"> • Monthly baseline prior to mining (data has been recorded for most sites since 2007) • Monthly manual monitoring at benchmarks during mining⁽¹⁾ • Flow monitoring at weirs (data supplied by WaterNSW) • Ongoing monthly monitoring for 2 years post mining (or as otherwise required/approved)
Ephemeral Watercourses <ul style="list-style-type: none"> ▪ Lower Harris Creek (NR3) ▪ Elladale Creek (NR8) ▪ Ousedale Creek (NR10) ▪ Menangle Creek (NR40) ▪ Upper Harris Creek (HC10) ▪ Foot Onslow Creek (F01) ▪ Navigation Creek (NAV1) 	Water Level	<ul style="list-style-type: none"> ▪ 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. 	No change
APPEARANCE			
Nepean River <ul style="list-style-type: none"> ▪ Visual observations along the length of the Nepean River 	Observational and photographic monitoring	<ul style="list-style-type: none"> ▪ Monthly baseline prior to mining (data has been recorded for most sites since 2003). ▪ Weekly observations and field analysis 	Frequency: <ul style="list-style-type: none"> • Monthly baseline prior to mining (data has been recorded for most sites since 2003)

Monitoring Site	Site Type	Monitoring Frequency	Future Monitoring (LW707-710 EMP)
within the active mining area.		<ul style="list-style-type: none"> during mining. ▪ Monthly monitoring for 2 years post mining (or as otherwise required/approved). ▪ If required as a result of assessment of mining impacts. 	<ul style="list-style-type: none"> • Monthly observations and field analysis during mining ⁽¹⁾ • Monthly monitoring for 2 years post mining (or as otherwise required/approved) • If required as a result of assessment of mining impacts
Ephemeral Watercourses <ul style="list-style-type: none"> ▪ Lower Harris Creek (NR3) ▪ Elladale Creek (NR8) ▪ Ousedale Creek (NR10) ▪ Menangle Creek (NR40) ▪ Upper Harris Creek ▪ Foot Onslow Creek ▪ Navigation Creek 	Observational and photographic monitoring	<ul style="list-style-type: none"> ▪ 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. 	No change
Water Pumps <ul style="list-style-type: none"> ▪ Pump 1 NRL ▪ Pump 2 NRL ▪ Pump 3 ▪ Pump 4 ▪ Pump 5 NRL ▪ Pump 6 NRL 	Observational and photographic monitoring	<ul style="list-style-type: none"> ▪ Pre mining photographs ▪ Weekly visual inspection during mining ▪ If required as a result of assessment of mining impacts. 	Frequency: <ul style="list-style-type: none"> • Pre mining photographs • Monthly visual inspection during mining • If required as a result of assessment of mining impacts
AQUATIC ECOLOGY			
Nepean River <ul style="list-style-type: none"> ▪ Sites 1 and 2 (located upstream of Longwall 701 near Douglas Park Weir). ▪ Sites 3 and 4 (located adjacent to Longwalls 701 and 702 near confluence of the Nepean River and Elladale Creek). ▪ Sites X1 and X2 (located adjacent to Longwalls 703 and 704). ▪ Sites 5 and 6 (located adjacent to Longwalls 705 and 706 downstream of the confluences with Mallaty and Ousedale Creeks) ▪ Sites 7 and 8 (located 	Quantitative and observational monitoring	<ul style="list-style-type: none"> ▪ Two Baseline monitoring campaigns (autumn/spring) prior to mining ▪ Annual monitoring campaigns (autumn and spring) during mining (i.e. longwall within 400m of monitoring site) ▪ Two monitoring campaigns (autumn/spring) post mining ▪ General observation of all streams in the active mining areas during all other monitoring 	Nepean River <ul style="list-style-type: none"> • Sites 1 and 2 • Sites 5 and 6 • Sites 7 and 8 • Sites X3 and X4 (AA9 Monitoring) • Sites X5 and X6 Frequency: <ul style="list-style-type: none"> • Two Baseline monitoring campaigns prior to mining • Annual monitoring campaigns (spring) during mining • Two monitoring campaigns post mining

Monitoring Site	Site Type	Monitoring Frequency	Future Monitoring (LW707-710 EMP)
downstream of all proposed Longwalls 701-710)			
Ephemeral Watercourses <ul style="list-style-type: none"> ▪ Sites F1 and F2 (located on Foot Onslow Creek, over Longwalls 708 and 710) ▪ Site N1 (located on Navigator Creek northeast of Longwall 710) ▪ General observation of all other watercourses in active mining areas. 			

GROUNDWATER													
Water Level IC monitoring bores <ul style="list-style-type: none"> ▪ NGW3 ▪ NGW4 ▪ NGW6 ▪ NGW5 ▪ NGW7 ▪ NGW9 ▪ NGW10 ▪ NGW11 ▪ EAW5 ▪ EAW7 (S1936) ▪ S1584 	Groundwater level	IC Bores <ul style="list-style-type: none"> ▪ Pre-mining (data has been recorded since September 2004 for some sites) ▪ 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. Private Bores <ul style="list-style-type: none"> ▪ Prior to mining of longwall underlying 	Water Level IC Monitoring Bores <ul style="list-style-type: none"> • S1913 (EAW5) • S1936 (EAW7) Private Bores (10 registered bores): <table style="width: 100%; border: none;"> <tr> <td style="width: 50%;">• GW104602</td> <td style="width: 50%;">• GW104661</td> </tr> <tr> <td>• GW105376</td> <td>• GW105388</td> </tr> <tr> <td>• GW105574</td> <td>• GW101986</td> </tr> <tr> <td>• GW105339</td> <td>• GW106574</td> </tr> <tr> <td>• GW072874</td> <td>• GW105534</td> </tr> </table>	• GW104602	• GW104661	• GW105376	• GW105388	• GW105574	• GW101986	• GW105339	• GW106574	• GW072874	• GW105534
• GW104602	• GW104661												
• GW105376	• GW105388												
• GW105574	• GW101986												
• GW105339	• GW106574												
• GW072874	• GW105534												

Monitoring Site	Site Type	Monitoring Frequency	Future Monitoring (LW707-710 EMP)
<ul style="list-style-type: none"> ▪ S1809 ▪ S1853 ▪ S1854 <p>Private bores</p> <ul style="list-style-type: none"> ▪ 10 registered bores within the SMP area (refer to Built Feature Management Plans for monitoring/management) 		<p>bore or mining of any immediately adjacent longwall (if in agreement with landholder).</p> <ul style="list-style-type: none"> ▪ 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). 	<p>Frequency:</p> <p>IC Bores</p> <ul style="list-style-type: none"> • 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 <p>Private Bores</p> <ul style="list-style-type: none"> • 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)
<p>Water Quality</p> <p>IC monitoring bores</p> <ul style="list-style-type: none"> ▪ NGW6 ▪ NGW5 <p>Private bores</p> <ul style="list-style-type: none"> ▪ 10 registered bores within the SMP area (refer to Built Feature Management Plans for monitoring/management) 	<p>Grab Sample</p>	<p>IC Bores</p> <ul style="list-style-type: none"> ▪ Pre-mining – prior to mining of longwall underlying bore or mining of any immediately adjacent longwall. ▪ Post-mining – following the development of incremental subsidence for each longwall that will impact on the feature (i.e. each longwall). ▪ As required to provide additional data for any bore impact investigation or if physical impacts to bore identified. <p>Private Bores</p> <ul style="list-style-type: none"> ▪ 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 	<p>No water quality testing (unless requested by landholder for private borehole).</p>

Monitoring Site	Site Type	Monitoring Frequency	Future Monitoring (LW707-710 EMP)
		(landholder to observe during use of bore).	
Mine Water Inflows Active mining areas – longwall face and roadway development. Mined goaf areas – 705 and 706	<ul style="list-style-type: none"> ▪ Visual ▪ Flow Meter 	<ul style="list-style-type: none"> ▪ Daily statutory mine inspections ▪ Mine dewatering monitored throughout the mining process by flow meter of water pumped into and discharged from workings. 	No change
LANDSCAPE FEATURES			
Cliffs <ul style="list-style-type: none"> ▪ Along Nepean Gorge Steep Slopes <ul style="list-style-type: none"> ▪ Along Nepean Gorge, associated tributaries and above western end of the proposed longwalls. Refer Figure 19.1 in LW705-710 SMP		<ul style="list-style-type: none"> ▪ Once prior to mining. Photographic records taken. ▪ During mining, monthly visual inspections, increased to weekly inspections during critical periods (for cliffs and steep slopes along the Nepean Gorge and associated tributaries). ▪ 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. 	Frequency: <ul style="list-style-type: none"> • 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
TERRESTRIAL ECOLOGY			
Monitored in conjunction with general observational monitoring for the Nepean River, ephemeral watercourses and landscape.		<ul style="list-style-type: none"> ▪ If required as a result of assessment of mining impacts. ▪ General observation of active mining areas during all other monitoring. 	
ABORIGINAL ARCHAEOLOGY			
<ul style="list-style-type: none"> ▪ Nepean River 4 (52-2-2098) ▪ Nepean River 5 (52-2-2097) ▪ Nepean River 6 (52-2-2095) ▪ Nepean River 7 (52-2-2096) ▪ Nepean River 8 (52-2-2239) ▪ Upper Nepean Hand Stencils ▪ Bulli Site 40 (BS 40) 	Observational and photographic monitoring	<ul style="list-style-type: none"> ▪ Baseline archival recording prior to longwall mining. ▪ Final impact assessment recording 12 months after undermining or final subsidence movement at the site. 	Any sites identified during the mining period would be monitored as required by the Bulli Seam Operations Heritage Management Plan

Monitoring Site	Site Type	Monitoring Frequency	Future Monitoring (LW707-710 EMP)
Refer to Figure 5-22 of Bulli Seam Operations EA and Figure 3 Bulli Seam Operations Appendix G (Aboriginal Cultural Heritage Assessment)			
HISTORIC HERITAGE			
<ul style="list-style-type: none"> ▪ Buildings or structures of identified heritage significance <p><i>Note: Detailed Heritage Management Plans to be developed prior to any heritage item being influence by mining</i></p>	Observational, photographic monitoring and structural inspections.	<ul style="list-style-type: none"> ▪ Baseline assessment recording prior to longwall mining. ▪ Monitoring during subsidence (if in agreement with landholder) ▪ Final assessment recording 12 months after undermining or final subsidence movement at the site. 	

6. Management of Impacts and Remediation

6.1. Management

Management Plans have been prepared to ensure the mining area is adequately monitored and managed, and in accordance with the assessment of impacts involved with the SMP Applications and subsequent SMP Approval conditions. Management Plans applicable to Longwall 706 extraction and required by the SMP Approval are as follows:

- Subsidence Monitoring Program (Condition 12);
- Environmental Management Plan (Condition 13);
- Infrastructure Management Plans (Condition 14.1);
 - Appin Colliery - Longwalls 706 to 710. Management Plan for Longwall Mining beneath the M31 Hume Motorway (MSEC641);
 - Appin Colliery - Longwalls 706 to 710. Management Plan for Longwall Mining beneath the Main Southern Railway (MSEC642);
 - Longwall Mining Appin Area 7, LW707 to LW710 Beneath Telstra Telecommuincations Network;
 - Optus Access Network Mine Subsidence Management Plan for Appin Area No 7;
 - AAPT Telecommunications Network Management Plan, Mining Longwalls 705 to 706 beneath AAPT Telecommunications Network;
 - Longwall Mining Appin Area 7, LW707 to LW710 Beneath NextGen; Telecommuincations Network;
 - Endeavour Energy Distribution and Transmission Infrastructure Monitoring and Management Plan;
 - Public Road Management Plan for Mining West Cliff Longwalls 37 to 38, Appin Longwalls 706 to 710;
 - SCA Upper Canal Management Plan for Area 7 Longwalls 705 and 706;
- Infrastructure Management Plans (Condition 14.2);
 - Safety and Serviceability of Buildings and Man-Made Structures - Summary of Inspections, Recommendations and Consultation for Houses within the 20mm Subsidence Contour of Appin Longwall 706, v2, April 2014;
- Longwalls 705 and 706 Public Safety Management Plan (Condition 15); and
- Nepean River Cliff Safety Management Plan, Appin Area 7 Longwalls 707-710 (Condition 22).

6.2. Remediation Associated with Longwall 706

As outlined in the relevant sections above, impacts associated with Longwall 706 occurred to the M31 Hume Motorway, Main Southern Railway and private properties. The remediation associated with these impacts is outlined in Table 6-1.

Table 6-1: Remediation of impacts associated with Longwall 706

FEATURE	IMPACT	REMEDIATION
M31 Hume Motorway	No adverse impacts to safety or serviceability. Humps and associated cracking formed on both carriageways.	Remediated by re-shaping of the pavement surface as part of Management Plan responses
Main Southern Railway	Changes in track geometry recorded. No adverse impacts to safety and serviceability.	Remediated by expansion switch adjustments in accordance with the Management Plan.
Private Property –	Water cloudiness and gas seepage.	Borehole sealed and area fenced off. IC

Groundwater bore		providing adequate water supply. Replacement borehole anticipated to be drilled following active subsidence period for Longwall 707.
Private Property – surface cracking		No remediation required.
Private Property - other	To date one claim has been made with the MSB for impacts to property.	Remediation managed by the MSB.

6.3. Trigger Action Response Plans (TARPs)

TARPs are developed for all features potentially impacted by subsidence where required. These are included in Management Plans outlined in Section 6.1 above. Appendix 1 of this report provides a summary of all impacts observed for Longwall 706, alongside the relevant trigger level and performance measure (outlined in the BSO and SMP Approvals).

7. References

Appin Area 7 Longwalls 705 to 706 Subsidence Management Plan Approval

Biosis, 2012. *Bulli Seam Operations Project Heritage Management Plan*, October 2012. Prepared for BHP Billiton Illawarra Coal.

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.

Cardno Ecology Lab (2016) Appin Areas 7 and 9 Aquatic Ecology Monitoring, 2003 – 2015.

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

Ecoengineers (2014) End of Panel Assessment of Water Flow and Quality Effects, Appin Colliery Longwall 705, Revision 1.

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

Geoterra (2016) Appin Colliery Longwall 706 End of Panel Surface and Groundwater Monitoring Report.

Illawarra Coal Environmental Field Team (2016) Longwall 706 End of Panel Landscape Monitoring Report.

Illawarra Coal Environmental Field Team (2016). Longwall 706 Impact Reports.

Minister for Planning and Infrastructure, *Bulli Seam Operations Project Approval*, 22 December 2011.

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.

MSEC (2016) End of Panel Subsidence Monitoring Report for Appin Colliery Longwall 706, Revision A (MSEC808).

Niche Environment and Heritage (2016) Aboriginal and European Heritage Assessment for Appin Colliery – Longwall 706 End of Panel Report.

Appendix 1: Longwall 706 Impact and TARP Summary Table

Feature	Performance Measure*	Potential Impacts	Exceeding Prediction	TARP Trigger Level	Observed Impacts	Additional Comments / Recommendations
Water Quality						
<p>Nepean River Impact Monitoring Sites adjacent to each Longwall:</p> <ul style="list-style-type: none"> - NR11 - NR12 - NR13 - NR20* - NR30* <p>Notes: Baseline upriver sites will be used for cross-checking for upriver perturbations⁽¹⁾ Baseline upriver site NR2 data to be updated at end of panel following completion of each longwall, subject to checks-for, and discard-of upriver perturbed data</p> <p><i>* Monitoring sites were removed (following approval) from program 4/06/2015.</i></p>	<p>Negligible environmental consequences including:</p> <ul style="list-style-type: none"> • Negligible gas releases and iron staining; and • Negligible increase in water cloudiness 	<ul style="list-style-type: none"> - Mining induced gas emissions. - Reduction in dissolved oxygen (DO) (in association with gas releases) at very low flows due to the microbiological consumption of methane. - Minor iron flocs in association with gas release sites. 	<ul style="list-style-type: none"> • More than negligible gas release 	<p>Level 1 Impact monitoring sites:</p> <ul style="list-style-type: none"> • 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 	<p>No pH reduction >1 but < 2 standard deviations from the pre LW706 mean for 2 months.</p> <p>No DO reduction >1 but < 2 standard deviations from the pre LW706 mean for 2 months.</p> <p>No gas plumes identified >3000L/min</p>	<p>Continue monitoring Small new gas plume at AA7_LW706_001 & continued low level gas release at Gas Zone 5, 14.</p>
				<p>Level 2 Impact monitoring sites:</p> <ul style="list-style-type: none"> • 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- 	<p>No pH reduction >2 standard deviations from the pre LW706 mean for 2 months</p> <p>No DO reduction > 2 standard deviations from the pre LW706 mean for 2 months</p> <p>No EC, Total Fe or Mn increase >2 standard</p>	

Feature	Performance Measure*	Potential Impacts	Exceeding Prediction	TARP Trigger Level	Observed Impacts	Additional Comments / Recommendations
				mining mean resulting from the mining for two consecutive months <ul style="list-style-type: none"> • Identification of strata gas plume of flow rate >3000 L/min 	deviations from pre LW706 means for 2 months No gas plumes identified >3000L/min	
				Level 3 Impact monitoring sites: <ul style="list-style-type: none"> • Level 2-type reduction in water quality resulting from the mining observed for six consecutive months 	No Level 3 impacts identified	
Water Level and Flow						
Nepean River Visual observations along the length of the Nepean River within the active mining area	Negligible environmental consequences including: <ul style="list-style-type: none"> • Negligible diversion of flows or changes in the natural drainage behaviour of pools 	<ul style="list-style-type: none"> - Unlikely that predicted systemic subsidence would cause significant change in water level along the Nepean River. - Potential for surface water flow diversion is very low. - Fracturing may occur, but expected to be minor in nature. - Where upsidence exceeds subsidence, areas may experience a reduction in the frequency of water inundation. 	More than negligible diversion of flows or changes in the natural drainage behaviour of pools.	Level 1 <ul style="list-style-type: none"> • Observation of areas of dry and/or flooded riverbed in comparison to baseline observations and flows, for less than two consecutive months. 	No dry or flooded areas observed compared to pre LW706 for <2 months	Continue monitoring
				Level 2 <ul style="list-style-type: none"> • Observation of areas of dry and/or flooded riverbed in comparison to baseline observations and flows, for more than two consecutive months. 	No dry or flooded areas observed compared to pre LW706 for >2 months	
				Level 3 <ul style="list-style-type: none"> • Observation of areas of dry and/or flooded riverbed in comparison to baseline observations and flows, for six consecutive months. 	No dry or flooded areas observed compared to pre LW706 for >6 months	
Appearance						
Nepean River Visual observations along the length of the Nepean River within the active mining area	Negligible environmental consequences including: <ul style="list-style-type: none"> • Negligible gas releases and iron staining; and • Negligible increase in water cloudiness 	<ul style="list-style-type: none"> - Minor iron flocs in association with gas releases. 	<ul style="list-style-type: none"> • More than negligible iron staining resulting from the mining • More than negligible increase in water cloudiness resulting 	Level 1 <ul style="list-style-type: none"> • Iron staining resulting from the mining for two consecutive months • Water cloudiness resulting from the 	One gas release observed (Impact Ref AA7_LW706_001)	This impact was located approximately 3800m from the nearest point of Longwall 706 at the time of initial observation.

Feature	Performance Measure*	Potential Impacts	Exceeding Prediction	TARP Trigger Level	Observed Impacts	Additional Comments / Recommendations
			from the mining	mining for two consecutive months		
				Level 2 <ul style="list-style-type: none"> 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 	No Level 2 impacts observed.	
				Level 3 <ul style="list-style-type: none"> 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 	No Level 3 impacts observed.	
Ephemeral Watercourses <ul style="list-style-type: none"> Upper Harris Creek (HC10) Foot Onslow Creek (FO1) Navigation Creek (NAV1) Visual observations at water quality monitoring sites and along the length of the stream within the active mining area where landholder access is granted	No greater subsidence impact or environmental consequences than predicted in the EA or SMP.	- fracturing in the uppermost bedrock - localised increase in ponding and flooding.	- Fracturing of controlling rockbars and/or stream bed, resulting in the diversion of all stream flow in the mining area - Increased leakage from all pools in the mining area	Level 1 <ul style="list-style-type: none"> 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 	No Level 1 impacts observed.	
				Level 2	No Level 2 impacts	

Feature	Performance Measure*	Potential Impacts	Exceeding Prediction	TARP Trigger Level	Observed Impacts	Additional Comments / Recommendations
				<ul style="list-style-type: none"> • 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 	observed.	
				<p>Level 3</p> <ul style="list-style-type: none"> • 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 	No Level 3 impacts observed.	
<p>Water Pumps</p> <ul style="list-style-type: none"> • 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.	No such impacts observed or reported.	
Aquatic Ecology						
<p>Nepean River</p> <ul style="list-style-type: none"> • Sites 5 and 6 	Negligible environmental consequences	- loss and/or alteration of aquatic habitat;	More than negligible environmental	<p>Level 1</p> <ul style="list-style-type: none"> • 1 season reduction in 	No reduction in aquatic	Monitoring program to

Feature	Performance Measure*	Potential Impacts	Exceeding Prediction	TARP Trigger Level	Observed Impacts	Additional Comments / Recommendations	
(located adjacent to Longwalls 705 and 706) <ul style="list-style-type: none"> Sites 7 and 8 (located downstream of Longwall 710) Ephemeral Watercourses <ul style="list-style-type: none"> Sites F1 and F2 (Foot Onslow Creek, over Longwalls 708 and 710) Site N1 (Navigator Creek, Longwall 710) 		<ul style="list-style-type: none"> - impacts on fish passage (connectivity between up and downstream habitat); - changes in water quality; and - impacts on species of conservation significance. 	consequences for a threatened species, threatened population or endangered ecological community	aquatic habitat resulting from the mining when comparing to baseline condition	habitat resulting from mining	continue	
				Level 2 <ul style="list-style-type: none"> 2 consecutive season reduction in aquatic habitat resulting from the mining when comparing to baseline condition 			
				Level 3 <ul style="list-style-type: none"> Reduction in aquatic habitat resulting from the mining for > 2 consecutive seasons or complete loss of habitat 			
Groundwater							
Water Level IC monitoring bores: <ul style="list-style-type: none"> NGW3 NGW4 NGW6 NGW5 EAW5 EAW7 (S1936) Private Bores Registered bores and any new bores within the SMP area Notes: <i>Impact monitoring data during longwall mining is compared to predicted groundwater levels from the BSOP (or later updates)</i>		<ul style="list-style-type: none"> - Temporary lowering of the piezometric surface over the subsidence area due to horizontal dilation of strata and resultant increase in secondary porosity. - Groundwater levels may reduce by up to 10m, and may stay at that reduced level until maximum subsidence develops at a specific location. - Groundwater levels should recover over a few months as the newly developed secondary porosity is recharged by rainfall sourced water. - No permanent post mining reduction in water level in bores on the plateau unless a new outflow path develops. 		Level 1 <ul style="list-style-type: none"> Up to an additional 2.5m reduction from the predicted standing water level or pressure (outside of pumping influences) over 2 consecutive months 	No reduction in groundwater level or pressure greater than 2.5m over predicted effects (over 2 months)		
				Level 2 <ul style="list-style-type: none"> Between 2.5m and 5m additional reduction from the predicted standing water level or pressure (outside of pumping influences) over 2 consecutive months 			No reduction in groundwater level or pressure greater than 2.5 - 5m over predicted effects (over 2 months)
				Level 3 <ul style="list-style-type: none"> Greater than 5m of additional reduction from the predicted standing water level or pressure (outside of pumping influences) 			

Feature	Performance Measure*	Potential Impacts	Exceeding Prediction	TARP Trigger Level	Observed Impacts	Additional Comments / Recommendations
<p><i>groundwater model, during preparation of the End of Panel Report</i></p> <p><i>Privately owned water supplies are monitored as agreed with landowners</i></p>				<p>over 2 consecutive months</p> <ul style="list-style-type: none"> Privately owned water supply adversely impacted from the mining (other than impact that is negligible) 	<p>GW112441 adversely affected by hydrocarbon gas seep</p>	<p>Bore to be replaced after completion of LW707, or, if an alternative arrangement is agreed with the landowner</p>
<p>Water Quality</p> <p>IC monitoring bores</p> <ul style="list-style-type: none"> NGW6 NGW5 <p>Private Bores</p> <ul style="list-style-type: none"> Registered bores and any new bores within the SMP area (where water quality samples can be taken) 		<p>- Potential increased iron and manganese hydroxide precipitation in discharged bore water</p> <p>- Potential lowering of pH in discharged bore water</p>		<p>Level 1</p> <ul style="list-style-type: none"> Groundwater quality reduction greater than 1 standard deviation but less than 2 standard deviation from pre-mining mean resulting from the mining for two consecutive months 	<p>No reduction in water quality >1 but <2 standard deviations from the pre LW706 mining mean for 2 months</p>	
				<p>Level 2</p> <ul style="list-style-type: none"> Groundwater quality reduction greater than 2 standard deviation from pre-mining mean resulting from the mining for two consecutive months 	<p>No reduction in water quality >2 standard deviations from the pre LW706 mining mean for 2 months</p>	
				<p>Level 3</p> <ul style="list-style-type: none"> Level 2-type reduction in water quality resulting from the mining observed for more than 6 consecutive months 	<p>No reduction in water quality >2 standard deviations from the pre LW706 mining mean for 6 months</p>	
<p>Mine Water Inflows</p>				<p>Level 1</p> <ul style="list-style-type: none"> Abnormal rise in water flow from the goaf between 2.7 and 3ML/day (over 20 day average) 	<p>No abnormal rise in water flow >2.7ML/Day</p>	
				<p>Level 2</p> <ul style="list-style-type: none"> Abnormal rise in water flow from the goaf between 3 and 3.4ML/day (over 20 		

Feature	Performance Measure*	Potential Impacts	Exceeding Prediction	TARP Trigger Level	Observed Impacts	Additional Comments / Recommendations
				day average) Level 3 • Abnormal rise in water flow from the goaf >3.4ML/day (over 20 day average)		
Landscape Features						
Cliffs <ul style="list-style-type: none"> Along Nepean Gorge Steep Slopes <ul style="list-style-type: none"> Along Nepean Gorge, associated tributaries and above western end of the proposed Longwalls 	<i>Cliffs flanking the Nepean River</i> <ul style="list-style-type: none"> 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 the Longwall mining domain) <i>Cliffs of 'special significance' (i.e. cliffs longer than 200m and/or higher than 40m; and cliff-like rock faces higher than 5m constitute waterfalls)</i> <ul style="list-style-type: none"> 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 the longwall mining domain). <i>Other cliffs</i> <ul style="list-style-type: none"> Minor environmental consequences (that is 	<ul style="list-style-type: none"> minor isolated rock falls could occur any impacts on the cliffs is expected to represent in the order of 1% to 3% of the total length of the cliffs in the SMP Area. surface cracking may occur on steep slopes, however only minor in nature. 	<i>Cliffs flanking the Nepean River</i> <ul style="list-style-type: none"> 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 Longwall mining domain) Rockfall or erosion that poses more than a negligible increased risk to public safety 	Level 1 <ul style="list-style-type: none"> 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 	No Level 1 impacts observed.	
				Level 2 <ul style="list-style-type: none"> 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 	No Level 2 impacts observed.	

Feature	Performance Measure*	Potential Impacts	Exceeding Prediction	TARP Trigger Level	Observed Impacts	Additional Comments / Recommendations
	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).			<p>resulting from mining with no more than minor soil surface exposed</p> <p>Level 3</p> <ul style="list-style-type: none"> 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 	No Level 3 impacts observed.	
Terrestrial Ecology						
Monitored in conjunction with general observational monitoring for the Nepean River, ephemeral watercourses and active mining area	Negligible environmental consequences	<i>Endangered Ecological Communities (and other vegetation)</i> - Potential gas emissions may result in small, isolated areas of vegetation dieback in the Nepean River gorge. Potential surface	More than negligible environmental consequences on threatened species, threatened populations, or endangered ecological communities	<p>Level 1</p> <ul style="list-style-type: none"> Vegetation impacted by mining (by rockfalls, soil slippage, gas emissions) that is likely to naturally regenerate within the monitoring period <p>Level 2</p>	No Level 1 impacts observed.	
					No Level 2 impacts	

Feature	Performance Measure*	Potential Impacts	Exceeding Prediction	TARP Trigger Level	Observed Impacts	Additional Comments / Recommendations
		<p>fracturing and gas emissions considered unlikely to result in alteration of species composition or distribution. Unlikely to have a significant impact on any plant communities.</p> <p><i>Threatened flora</i> Volume of water available for plant use is unlikely to be significantly impacted. It is considered unlikely that subsidence impacts would result in a broad change in the floristic composition of the riparian zone. No significant impact to threatened flora.</p> <p><i>Threatened fauna and flora habitat</i> Changed surface water conditions, such as effects to pools and streams. Impacts to steep slopes and cliffs. Impacts of gas emissions on water quality and riparian vegetation. Unlikely to result in a significant impact to threatened fauna.</p>		<ul style="list-style-type: none"> Vegetation impacted by mining (by rockfalls, soil slippage, gas emissions) that is unlikely to naturally regenerate within the monitoring period 	observed.	
				<p>Level 3</p> <ul style="list-style-type: none"> Vegetation impacted by mining that is not responding to CMAs 	No Level 3 impacts observed.	
Aboriginal Archaeology						
<ul style="list-style-type: none"> Nepean River 4 (52-2-2098) Nepean River 5 (52-2-2097) Nepean River 6 (52-2-2095) Nepean River 7 (52-2-2096) 	<p>Sites determined to hold 'special significance' - Negligible impact or environmental consequence.</p> <p>Sites determined to hold high or moderate significance</p>		<p><i>Sites determined to hold high or moderate significance as a result of studies required for Extraction Plans</i></p> <ul style="list-style-type: none"> More than 10% of such sites across the mining area are affected by subsidence impacts 	<p>Level 1</p> <ul style="list-style-type: none"> Change in shelter conditions not attributable to natural weathering or preservation – mineral growth or micro-organism growth (as observed by comparing 	No shelter sites within proximity to Longwall 706	Sites located within proximity to Longwall 706 were three Open Camp Sites, three Isolated Artefact Sites and one Scarred Tree.

Feature	Performance Measure*	Potential Impacts	Exceeding Prediction	TARP Trigger Level	Observed Impacts	Additional Comments / Recommendations
<ul style="list-style-type: none"> • Nepean River 8 (52-2-2239) • Upper Nepean Hand Stencils • Bulli Site 40 (BS 40) Any other newly identified Aboriginal Archaeology sites	<p>- Less than 10% of such sites across the mining area are affected by subsidence impacts (other than negligible impacts or environmental consequence).</p> <p>Other Aboriginal heritage sites</p> <p>- 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).</p>		<p>(other than negligible impacts or environmental consequence)</p> <p><i>Other Aboriginal heritage sites</i></p> <ul style="list-style-type: none"> • More 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) 	<p>pre-mining photographs with post-subsidence/mining photographs)</p> <ul style="list-style-type: none"> • Changes external to the shelter that affect the site context – ground cracking, boulder slumping, rock and/or tree falls <p>Level 2</p> <ul style="list-style-type: none"> • 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 opening of existing planes and joints at panel, block fall within shelter or overhang <p>Level 3</p> <ul style="list-style-type: none"> • 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 		
Historic Heritage						
Buildings or structures of identified heritage significance	Negligible loss of heritage value. Negligible impact on structural integrity or external fabric unless the		Loss of heritage value greater than predicted under the Heritage Management Plan		No historical sites located above Longwall 706.	The Mountbatten group of historical sites is located to the southwest of Longwall 706. The MSEC

Feature	Performance Measure*	Potential Impacts	Exceeding Prediction	TARP Trigger Level	Observed Impacts	Additional Comments / Recommendations
	owner of the feature agrees otherwise in writing.					<i>predication for this group was for negligible subsidence to occur.</i>
Built Features						
Key public infrastructure: - Main Southern Railway - Hume Highway; and - The SCA Upper Canal	Always safe and serviceable. Damage that does not affect safety or serviceability must be fully repairable, and must be fully repaired.	- No impacts on the safety or serviceability of the motorway after the implementation of the management strategies. - No impacts on the safety or serviceability of the railway after the implementation of the management strategies. - Impacts unlikely to SCA Upper Canal.		<i>Refer to specific management plans for TARPs/management actions</i>	<i>Main Southern Railway</i> - Changes in track geometry recorded and remediated in accordance with the Management Plan. No adverse impacts to safety and serviceability. <i>M31 Hume Motorway</i> - No adverse impacts to 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. <i>The SCA Upper Canal</i> - No reported impacts	
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	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.	<i>Refer to Table 3-1 for specific impacts assessed by MSEC.</i>			<i>Menangle Road</i> Cracking observed to pavement on steep slope on Menangle Road at a site located more than 400 m from closest edge of LW706. Cracks are not considered to be due to mine subsidence due to offset distance and available monitoring data <i>Copper telecommunications cables and OFC</i> Small levels of signal loss measured <i>Building structures</i> Houses and Non-Residential Structures	

Feature	Performance Measure*	Potential Impacts	Exceeding Prediction	TARP Trigger Level	Observed Impacts	Additional Comments / Recommendations
improvements					To date, one claim made to MSB for impacts to house and one claim in the process of being made, due to the extraction of Longwall 706 <i>Pools</i> One impact reported <i>Groundwater bores</i> One private bore impact	

* Performance Measure as defined in BSO Development Consent Approval and Longwall 705 to 706 SMP Approval (Table 1).