APPIN LONGWALL 707 END OF PANEL LANDSCAPE REPORT

AUGUST 2018

Contents

Abbreviations

DRE – New South Wales Department of Trade and Investment – Division of Resources and Energy

EMP – Environmental Management Plan

EoP – End of Panel Report

ICEFT – Illawarra Coal Environmental Field Team

Illawarra Coal – South 32 Illawarra Coal

SMP – Subsidence Management Plan

TARP – Trigger Action Response Plan

Executive Summary

This report has been prepared by the South32 Illawarra Coal Environmental Field Team (ICEFT) to summarise the observed and measured subsidence effects on water, landscape features and terrestrial ecology, resulting from the extraction of Longwall 707.

Extraction of Longwall 707 began on the 7th of January 2016 and was completed on the 19th of June 2018.

The ICEFT conducts detailed monitoring and inspections of landscape features including the Nepean River, watercourses, groundwater, cliffs and steep slopes as well as private properties. This monitoring was conducted in accordance with the Appin Longwall 707 to 710 Environmental Management Plan (EMP), dated August 2015.

ICEFT identified two new gas releases during the extraction of Longwall 707, observed in a property dam and a private groundwater borehole. No new gas releases were identified on the Nepean River. Some existing gas releases persisted during Longwall 707 however these have since ceased and there are currently no active gas releases as a result of Appin Area 7 mining operations.

1. Introduction

This report outlines monitoring of landscape features relevant to Longwall 707 and forms part of the Appin Area 7 Longwall 707 End of Panel (EoP) Report. Monitored features include the Nepean River and associated tributaries, cliffs and steep slopes, terrestrial flora, as well as private properties (farm dams, private boreholes and surface area). Monitoring of landscape features relevant to Longwall 707 has been carried out in accordance with the Longwall 707 to 710 Environmental Management Plan (EMP), dated August 2015. The Trigger Action Response Plan (TARP) set out in the EMP provides the actions required for any subsidence impacts identified (Appendix 1).

Extraction of Longwall 707 began on the 7th of January 2016 and was completed on the 19th of June 2018.

Monitoring was conducted for landscape features in the Subsidence Management Plan (SMP) area during the baseline period, active mining (longwall within 400m of a feature) and post-mining periods. This monitoring involved measurement of surface water quality and levels, groundwater quality and levels (from Illawarra Coal and private boreholes) and general observations of the landscape features within the SMP Area. The results of the monitoring are outlined in the relevant sections below.

Detailed analysis of surface and groundwater, subsidence survey results and aquatic ecology will be included in respective specialist assessments which will make up the final End of Panel Report for Longwall 707.

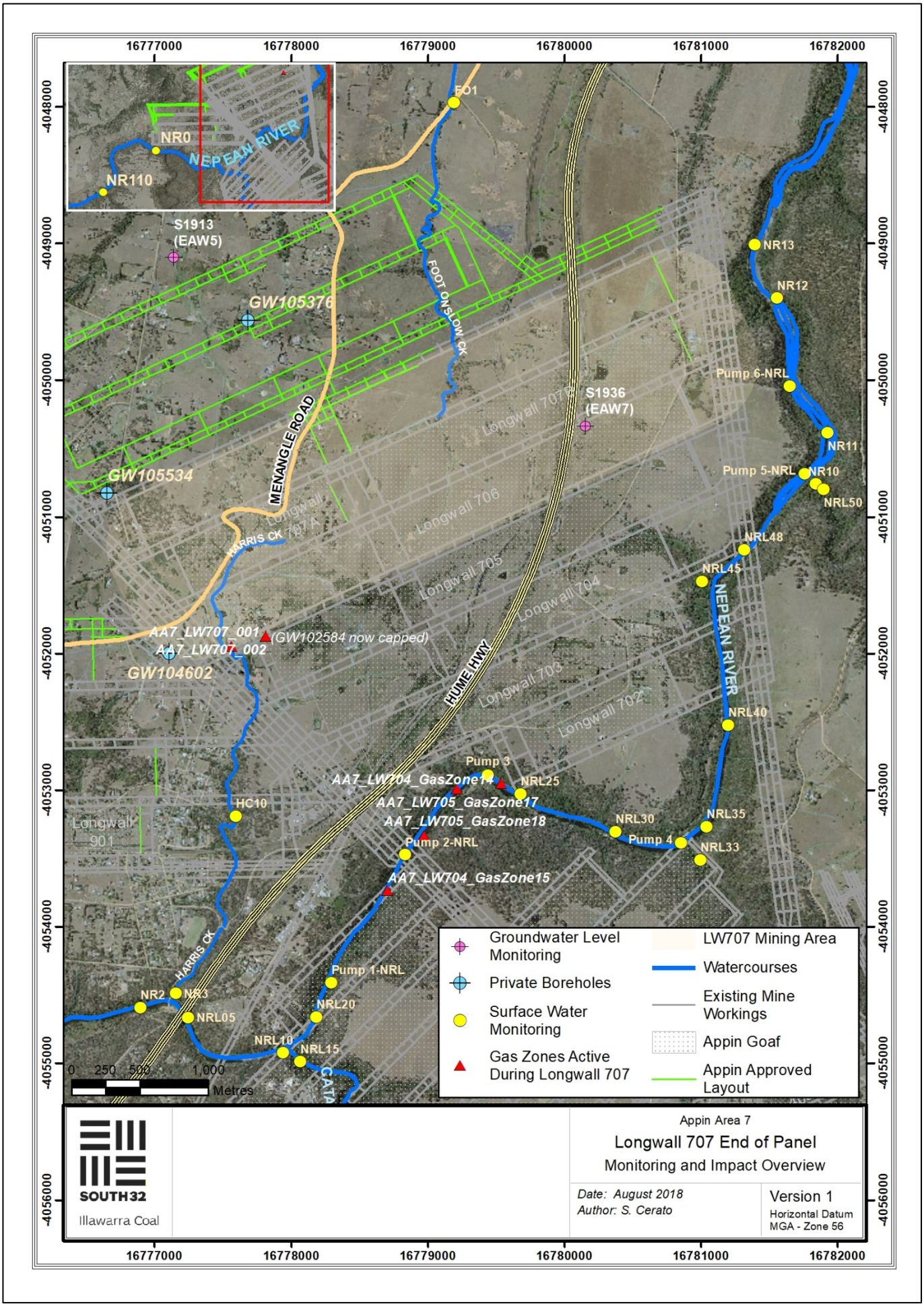

Figure 1: Location of Area 7 monitoring sites and impacts. Inset shows upstream reference site NR110.

2. Summary of Monitoring Program and Results

Monitoring of landscape features has been conducted in accordance with the EMP for Longwall 707 to 710 dated August 2015. The EMP for Longwall 707 is included as Appendix 1, this includes the monitoring program, TARP Table and monitoring locations.

2.1. Water Quality

In-situ water quality parameters measured include temperature, specific conductivity (SpC), oxidation-reduction potential (ORP), pH and dissolved oxygen (DO). These parameters were measured by the ICEFT on a monthly basis (where access was safe and granted), with fortnightly inspections for active Nepean River gas zones as required. Water samples are collected on a monthly basis for laboratory analysis. Detailed analysis of water quality will be included in the specialist Surface and Groundwater Assessment of the Longwall 707 EoP Report.

2.2. Gas Releases

Two new gas releases were observed during extraction of Longwall 707. Impact *AA7_LW707_001* consisted of four small gas releases observed in a private property dam (Photo 1 and Photo 2). Details of the impact are included in *160408 AA7 Property Impact Report*. The gas release has since ceased. Impact *AA7_LW707_002* was recorded at a private property borehole which exhibited iron staining and gas release (Photo 3). Details of the impact are included in *Property Impact Report_AA7_160422*.

Now new gas releases were identified on the Nepean River resulting of Longwall 707. Existing releases- Gas Zone 14, 15, 17, 18 and *AA7_LW706_001* were active during this period, however they were activated by previous longwalls (Longwalls 704, 705 and 706). Gas Zone 14 was last observed to be active on the 6th July 2016; Gas Zone 15 was last observed to be active on the 3rd December 2016; Gas Zone 17 was last observed to be active on the 29th August 2016; Gas Zone 18 was last observed to be active on the 17th July 2017 and *AA7_LW706_001* was last observed to be active on the 18th of January 2018. No gas releases have been observed on the Nepean River as a result of Appin Area 7 since January 2018.

Photo 1: Impact *AA7_LW707_001*, gas release observed in property dam. Photo taken 6/04/2016.

Photo 2: Impact *AA7_LW707_001*, close-up of gas release observed in property dam. Photo taken 6/04/2016.

Photo 3: Impact *AA7_LW707_002*, iron staining to water expelled from borehole GW102584. Photo taken 22/04/2016.

2.3. Water Level and Flow

Water levels in the Nepean River and its tributaries were monitored by the ICEFT on a monthly basis, or as required due to mining impacts (where access was safe and granted). No subsidence-induced flooding of river banks was observed. Likewise, no areas of dry river bed were observed outside low rainfall periods. For assessment of water level and flow refer to the specialist Surface and Groundwater Assessment of the Longwall 707 EoP Report.

2.4. Appearance

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

2.5. Groundwater

Boreholes relevant to Longwall 707 are S1913 (EAW5) and S1936 (EAW7). Assessment of groundwater data will be included in the Surface and Groundwater Assessment of the Longwall 707 EoP

2.6. Landscape Features

Observations of clifflines and steep slopes along the Nepean Gorge and associated tributaries were conducted by the ICEFT on a monthly basis. No impacts to cliffs were identified during the extraction of Longwall 707. No reports of surface impacts to landscape above Longwall 707 have been reported by landholders. Detailed analysis of surface movement survey results will be included in the Subsidence Review of the Longwall 707 EoP Report.

2.7. Terrestrial Ecology

Terrestrial ecology in Appin Area 7 is monitored by the ICEFT in conjunction with general observational monitoring. Aspects include changes in vegetation condition and vegetation that may have been impacted by rockfalls, soil slippage or gas emissions. No impacts or changes to terrestrial ecology were observed during monitoring for Longwalls 707.

2.8. Private Property Inspections

Post-mining inspections of dams, boreholes and landscape features on private properties are conducted by the ICEFT where access is available. These inspections include:

- field observations for any surface impacts,
- measurement of in-situ water quality parameters (of any dams and private boreholes where applicable),
- collection of water samples for laboratory analysis (of any dams and private boreholes where applicable).

Lot 8_DP804133

Impact *AA7_LW707_001* consisted of a small gas release zone to dam E13d01 on Lot 8 DP804133. Details of the impact are included in *160408 AA7 Property Impact Report.* A Longwall 707 post-mining inspection was undertaken where the gas release was observed to have ceased. Details are included in report *Lot 8_DP804133_LW707 Post Mining Report_180516.*

Lot 5 DP804133

Impact *AA7_LW707_002* consisted of gas release from borehole GW102584 on Lot 5 DP804133. Iron staining was also observed to water extracted from the bore. Refer to '*Property Impact Report_AA7_160422'* for further details. Following identification of the impact, a decision was made to cap the borehole which was completed on the 22nd June 2016 (Figure 1).

Post-mining inspections were also undertaken for properties with groundwater bores, where access was available. No impacts were observed from field observations. Analysis of water quality results from samples taken from the boreholes will be included in the Surface and Groundwater Assessment of the Longwall 707 EoP Report.

2.9. Summary of Impacts

A summary of the impacts observed during the extraction of Longwall 707 is included in Table 1; refer to Figure 1 for locations. A detailed description of the impacts identified during Longwall 707 can be found in abovementioned impact reports. A summary of the Performance Measures (as defined in the Bulli Seam Operations Development Consent Approval and the Longwall 707 to 710 EMP Approval), TARPs and impacts observed is provided in Appendix 2.

Table 1: Summary of observed impacts activated by Longwall 707.

Site ID	Impact Type	Identification Date	Initial Description	Feature Affected	TARP Level Triggered	Refer to Impact Report Dated
AA7_LW 707_001	Gas Release	*6/04/2016*	Four small gas releases over a 4m^2 area.	Property Dam (E13d01)	Level 1	8/04/2016
AA7_LW 707_002	Gas Release and iron staining	*22/04/2016*	Gas release and iron staining from borehole	Private Borehole (GW102584)	Level 3	22/04/2016

3. Future Monitoring

Post-mining monitoring will continue monthly for two years or as otherwise required/approved, as stated in the Longwall 707 to710 EMP (Appendix 1). Monitoring of future longwalls in Appin Area 7 (Longwall 708 to 710) will follow the monitoring schedule and TARPs set out in the Longwall 707-710 EMP. The Longwall 707 to 710 EMP was approved on 2nd September 2015 by DRE.

APPENDIX 1 – Longwall 707 to 710 Environmental Management Plan

Table 2: Appin Longwalls 707-710 Environmental Monitoring

MONITORING SITE	SITE TYPE	MONITORING FREQUENCY	PARAMETER
WATER QUALITY			
Nepean River Baseline upriver sites for cross-checking for upriver perturbations: • NR110 Impact monitoring sites adjacent to each longwall: • NR12 • NR13 Downstream site: • NR50 *Other sites:* • NR0 • NR7 • NR2 • NR9 • NR4 • NR11 • NR6 *Refer Figure 1*	Grab Sample and field measurements	• Monthly baseline prior to mining • Monthly observations and field analysis during mining[1] • Monthly detailed laboratory analysis during mining • Monthly monitoring for 2 years post mining (or as otherwise required/approved) • If required as a result of assessment of mining impacts	• Field measurements of: – Temperature – pH – ORP – Dissolved Oxygen (DO) – Electrical Conductivity (EC) – Time – General Comments • Laboratory analysis of: – pH – EC – SO4 filtered – Fe Total – Na filtered – K filtered – Ca filtered – Cl filtered – DOC – Pb filtered – Ni filtered – Zn filtered – Fe filtered – Mn filtered – As filtered – Br filtered – Cu filtered – I filtered – Se filtered – NOx-N – NH3-N – TKN – TP – TRP – TDS – CH_4[2] – Trace Phenols[2] – Sulfide[2]
1st and 2nd Order Watercourses • Lower Harris Creek (NR3) • Cataract River (NR5) • Elladale Creek (NR8) • Ousedale Creek (NR10) • Menangle Creek (NR40) • Upper Harris Creek (HC10) • Foot Onslow Creek (FO1) • Navigation Creek (NAV1) *Refer Figure 1*	Grab sample and field measurements	• 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	

MONITORING SITE	SITE TYPE	MONITORING FREQUENCY	PARAMETER
WATER LEVEL AND FLOW			
Nepean River At benchmark sites and water pump sites: • NR110 • NR0 • NRL05 • NRL10 • NRL15 • NR12 • NR13 • NRL20 • Pump 1-NRL • Pump 2-NRL • NRL25 • NRL30 • NRL33 • NRL35 • NRL40 • NRL45 • NRL48 • Pump 5-NRL • Pump 6-NRL SCA flow monitoring sites: • Maldon Weir • Broughtons Pass Weir • Menangle Weir *Refer Figure 1*	Water Level Water flow (measured at SCA weirs)	• 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 SCA) • Ongoing monthly monitoring for 2 years post mining (or as otherwise required/approved)	• Areas of dry riverbed compared with baseline • Areas of flooded riverbed compared with baseline • Measurement of water level compared with baseline (where benchmark is available) • Photo points
1st and 2nd Order Watercourses • Lower Harris Creek (NR3) • Cataract River (NRL15) • Elladale Creek (NRL33) • Ousedale Creek (NRL50) • Menangle Creek (NR40) • Upper Harris Creek (HC10) • Foot Onslow Creek (F01) • Navigation Creek (NAV1) *Refer Figure 1*	Water Level	• 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	• As above

MONITORING SITE	SITE TYPE	MONITORING FREQUENCY	PARAMETER
APPEARANCE			
Nepean River • Observations along the length of the Nepean River within the active mining area	Observational and photographic monitoring	• Monthly baseline prior to mining (data has been recorded for most sites since 2003) • 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	• Iron or salinity staining (e.g. orange or white staining in water or on banks/seeps) • Water cloudiness • Evidence of springs in Nepean River • Visual signs of impacts (e.g. cracking, vegetation changes, increased erosion, changes in water colour etc.) • Impacts determined from comparing photo points taken prior to, during and post mining • Erosion and/or sedimentation compared with baseline
1st and 2nd Order Watercourses • Lower Harris Creek (NR3) • Cataract River (NR5) • Elladale Creek (NR8) • Ousedale Creek (NR10) • Menangle Creek (NR40) • Upper Harris Creek (HC10) • Foot Onslow Creek (FO1) • Navigation Creek (NAV1)	Observational and photographic monitoring	• Prior to mining of longwall underlying watercourse or mining of any immediately adjacent longwall • Following the development of incremental subsidence for each longwall that will impact on the feature	• As above
Water Pumps • Pump 1 NRL • Pump 2 NRL • Pump 3 • Pump 4 • Pump 5 NRL • Pump 6 NRL	Observational and photographic monitoring	• Pre mining photographs • Monthly visual inspection during mining • If required as a result of assessment of mining impacts	• Pump submergence and disturbance
AQUATIC ECOLOGY			

Nepean River
• Sites 1 and 2
• Sites 5 and 6
• Sites 7 and 8
• Sites X3 and X4 (AA9 Monitoring)
• Sites X5 and X6
 	
Refer Figure 1
	Quantitative and observational monitoring	• Two Baseline monitoring campaigns prior to mining
		• Annual monitoring campaigns (spring) during mining
		• Two monitoring campaigns post mining
			• Photographic records
			• Macro-invertebrate Assessment
			• Fish sampling
			• Water Quality
			• Monitored in conjunction with:
			  – Flow
			  – River Morphology

MONITORING SITE	SITE TYPE	MONITORING FREQUENCY	PARAMETER
GROUNDWATER			
Water Level IC Monitoring Bores • S1913 (EAW5) • S1936 (EAW7) *Additional Bulli Seam piezometers located throughout the mining area (Refer Figure 1)* Private Bores (10 registered bores): • GW104602 • GW104661 • GW105376 • GW105388 • GW105574 • GW101986 • GW105339 • GW106574 • GW072874 • GW105534 *Refer Figure 1*	Groundwater level	IC Bores • Pre-mining • Water level logged hourly • Post-mining – following the development of incremental subsidence for each longwall that will potentially impact on the borehole • Monitoring to continue for at least 12 months post mining depending on borehole functionality Private Bores • Prior to mining of longwall underlying bore or mining of any immediately adjacent longwall (if in agreement with landholder) • Post-mining – following the development of incremental subsidence for each longwall that will impact on the borehole (if in agreement with landholder) • As requested by landholder or if physical impacts to bore identified (landholder to observe during use of bore)	Grouted monitoring holes • Piezometric head in various strata Private bores • Water level measured with dip meter (where access to property is available and in agreement with landholder)
LANDSCAPE FEATURES			
Cliffs • Along Nepean Gorge **Steep Slopes** • Along Nepean Gorge, associated tributaries and above western end of the proposed longwalls *Refer Figure 19.1 in LW705-710 SMP*		• Once prior to mining. Photographic records taken • Monthly visual inspections • Monitoring to continue 6 monthly for 2 years following the completion of mining (or as otherwise required/approved) • As required when specific impacts are identified or when concern is raised by a landowner • As required, in accordance with Built Feature Management Plans and landholder agreement	• Cliff and steep slopes will be observed for any instability (e.g. rock falls, mass movement) and seeps

MONITORING SITE	SITE TYPE	MONITORING FREQUENCY	PARAMETER
TERRESTRIAL ECOLOGY			
Monitored in conjunction with general observational monitoring for the Nepean River, watercourses and landscape		• If required as a result of assessment of mining impacts • General observation of active mining areas during all other monitoring	• Vegetation communities • Vegetation condition • Changes in vegetation • Tree health • Threatened species
ABORIGINAL ARCHAEOLOGY			
There are no aboriginal archaeology sites on the AIHMS database within the Appin LW707-710 mining area. No sites have been identified during the SMP studies			Any sites identified during the mining period would be monitored as required by the Bulli Seam Operations Heritage Management Plan
HISTORIC HERITAGE			
• Gilbulla (Anglican Conference Centre) *Refer Figure 1*	Observational, photographic monitoring and structural inspections	Property Management Plan to be developed prior to influence of mining	• Building/structure condition • Heritage value

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

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

Table 3: Appin Longwalls 707-710 Environmental Monitoring - TARP

MONITORING	TRIGGER	ACTION
WATER QUALITY		
Nepean River Impact monitoring sites adjacent to longwalls: • NR12 • NR13 *Refer to Figure 1* ***Notes:*** *Baseline upriver site NR110 will be used for cross-checking upriver perturbations*[3] *Impact Sites* **NR12** *pH* 7.54 (Mean) 0.34 (1 STDEV) 0.68 (2 STDEV) *DO (%)* 88.03 10.62 21.23 *SpC (µS/cm)* 180 50 100 *Tot Fe (mg/L)* 0.421 0.135 0.270 *Tot Mn (mg/L)* 0.034 0.012 0.023 **NR13** *pH* 7.43 0.35 0.70 *DO (%)* 86.99 12.82 25.63 *SpC (µS/cm)* 180 49 98 *Tot Fe (mg/L)* 0.407 0.129 0.259 *Tot Mn (mg/L)* 0.034 0.013 0.026 *Control Site* **NR110** *pH* 7.90 0.42 0.84 *DO (%)* 84.19 15.22 30.44 *SpC (µS/cm)* 240 92 184 *Tot Fe (mg/L)* 0.328 0.131 0.262 *Tot Mn (mg/L)* 0.025 0.015 0.031	***Level 1***[1] Impact monitoring sites: • pH reduction greater than 1 standard deviation but less than 2 standard deviation from pre-mining mean resulting from the mining for two consecutive months • DO reduction greater than 1 standard deviation but less than 2 standard deviation from pre-mining mean resulting from the mining for two consecutive months • Identification of strata gas plume of flow rate < 3000 L/min [2]	• Continue monitoring program • Report impacts to key stakeholders • Summarise impacts and record
	Level 2[1] Impact monitoring sites: • pH reduction greater than 2 standard deviation from pre-mining mean resulting from the mining for two consecutive months • DO reduction greater than 2 standard deviation from pre-mining mean resulting from the mining for two consecutive months • EC, total Fe and total Mn increases greater than 2 standard deviation from pre-mining mean resulting from the mining for two consecutive months • Identification of strata gas plume of flow rate >3000 L/min[2]	• *Actions as stated for Level 1 plus*: • Review monitoring program • Notify relevant specialists (South32 IC) and develop and implement remedial action if necessary Strata Gas Emission Plume: • Estimate gas emission flow rates. Re-estimate should significant change be observed • Take sample of plume (if possible) for: – chemical composition – dissolved methane from exactly above gas plume and at established downriver monitoring sites – dissolved sulfide and total phenols from exactly above gas plume and at nearest downriver monitoring site(s)
	Level 3[1] Impact monitoring sites: • Level 2-type reduction in water quality resulting from the mining observed for six consecutive months	• *Actions as stated for Level 2* • Notify OEH, D&PI, NoW & DRE and any other relevant specialist. • Consultation with stakeholders. • Collect laboratory samples and analyse for: – pH, EC, Total Fe and Mn – Suite of Filterable metals. – Dissolved methane, sulfide and total phenols (if relevant). • Develop any site management measures as soon as practically possible (pending stakeholder availability) and seek any approvals required to implement • Review the relevant TARP and Management Plan in consultation with key stakeholders
	Exceeding Prediction • More than negligible gas releases	• *Actions as stated for Level 3* • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation

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

MONITORING	TRIGGER	ACTION
1st and 2nd Order Watercourses • Upper Harris Creek (HC10) • Foot Onslow Creek (FO1) • Navigation Creek (NAV1)	***Level 1***[1] • Fracturing with no observable loss of surface water flow • Fracturing with no reduction in pool water level when compared to baseline period • Increase in turbidity, iron staining, algal growth, or other visible water quality parameters resulting from the mining for two consecutive months determined by comparing baseline photos with photos during the mining period	• Continue monitoring program • Report impacts to key stakeholders • Summarise impacts and record
	Level 2[1] • Fracturing resulting in loss of surface flow in some creeks or tributary • Fracturing resulting in water loss from some permanent pools • Reduced water retention time in pools • Increase in turbidity, iron staining, algal growth, or other visible water quality parameters resulting from the mining for two consecutive months determined by comparing baseline photos with photos during the mining period	• *Actions as stated for Level 1* • Review monitoring program • Notify relevant specialists (South32 IC) and develop and implement remedial action if necessary
	Level 3[1] • 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	• *Actions as stated for Level 2* • Notify relevant government agencies, other resource managers and relevant technical specialists and seek advice on any CMA required. • Site visits with stakeholders if required • Develop any site management measures as soon as practically possible (pending stakeholder availability) and seek any approvals required to implement • Review the relevant TARP and Management Plan in consultation with key stakeholders
Water Pumps • Pump 1 • Pump 2 • Pump 3 • Pump 4 • Pump 5 • Pump 6	• Pump not functioning due to water level changes or physical disturbance from subsidence	• Continue monitoring program • Report impacts to key stakeholders • Summarise impacts and record • Develop and implement CMA (if required) in consultation with key stakeholders
AQUATIC ECOLOGY		
Nepean River • Sites 5 and 6 • Sites 7 and 8 *Refer Figure 1*	***Level 1***[1] • Reduction in aquatic habitat resulting from mining (when comparing to baseline conditions) for 1 year	• Continue monitoring program • Report impacts to key stakeholders • Summarise impacts and record
	Level 2[1] • Reduction in aquatic habitat resulting from mining (when comparing to baseline conditions) for 2 consecutive years	• *Actions as stated for Level 1* • Review monitoring program • Notify relevant specialists (South32 IC) and develop and implement remedial action if necessary

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

MONITORING	TRIGGER	ACTION
	Level 3[1] • Abnormal rise in water flow from the goaf >3.4ML/day (over 20 day average)	• *Actions as stated for Level 2* • Notify relevant government agencies, other resource managers and relevant technical specialists and seek advice on any CMA required. • Site visits with stakeholders if required • Develop any site management measures as soon as practically possible (pending stakeholder availability) and seek any approvals required to implement • Review the relevant TARP and Management Plan in consultation with key stakeholders
LANDSCAPE FEATURES		
Cliffs • Along Nepean Gorge **Steep Slopes** • Along Nepean Gorge, associated tributaries and above western end of the proposed Longwalls *Refer Figure 19.1 in LW705-710 SMP*	***Level 1***[1] • Any rock fall, displacement, dislodgement of boulders or slabs or fracturing of a cliff line flanking the Nepean River resulting from mining • Erosion resulting from mining localised to a small area that should naturally stabilise within the monitoring period • Surface movement resulting from mining with no more than negligible soil surface exposed	• Continue monitoring program • Report impacts to key stakeholders • Summarise impacts and record
	Level 2[1] • Any rock falls, displacements, dislodgements of boulders or slabs or fracturing of a cliff line(s) flanking the Nepean River resulting from mining that in total impacts 0.3% of the total cliff line face area of the mining domain. • Erosion resulting from mining likely to naturally stabilise within the monitoring period. • Surface movement or rock displacement resulting from mining with no more than minor soil surface exposed	• *Actions as stated for Level 1* • Review monitoring program • Notify relevant specialists (South32 IC) and develop and implement remedial action if necessary
	Level 3[1] • Any rock falls, displacements, dislodgements of boulders or slabs or fracturing of a cliff line(s) flanking the Nepean River resulting from mining that in total impacts up to 0.5% of the total cliffline face area of the mining domain. • Any rock falls, displacements, dislodgements of boulders or slabs or fracturing of a cliffline(s) flanking the Nepean River resulting from mining that in total impacts 0.4% of the total cliffline face area of the mining domain after 1 longwall. • Mass movement of a slope causing large areas of exposed soil • Any form of rockfall or erosion that poses a threat to public safety	• *Actions as stated for Level 2* • Notify relevant government agencies, other resource managers and relevant technical specialists and seek advice on any CMA required. • Site visits with stakeholders if required • Develop any site management measures as soon as practically possible (pending stakeholder availability) and seek any approvals required to implement • Review the relevant TARP and Management Plan in consultation with key stakeholders
Cliffs flanking the Nepean River	***Exceeding Prediction*** • More than negligible environmental consequences (that is occasional rockfalls, displacement or dislodgement of boulders or slabs, or fracturing, that in total impacts more than 0.5% of the total face area of such cliffs within the Longwall mining domain)	• *Actions as stated for Level 3* • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation

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

MONITORING	TRIGGER	ACTION
		seek any approvals required to implement • Review the relevant TARP and Management Plan in consultation with key stakeholders
• Sites determined to hold high or moderate significance as a result of studies required for Extraction Plans	***Exceeding Prediction*** • More than 10% of such sites across the mining area are affected by subsidence impacts (other than negligible impacts or environmental consequence)	• *Actions as stated for Level 3* • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation
• Other Aboriginal heritage sites	• Less than 10% of such sites (or 1 such site, whichever is the greater) within any longwall mining domain are/is affected by subsidence impacts (other than minor impacts or environmental consequence)	
HISTORIC HERITAGE		
Gilbulla (Anglican Conference Centre) ***Note:*** Property Management Plan to be developed prior to influence of mining	***Exceeding Prediction*** • Loss of heritage value greater than predicted under the Heritage Management Plan	• Continue monitoring program • Report impacts to key stakeholders • Summarise impacts and record • Notify relevant government agencies, other resource managers and relevant technical specialists and seek advice on any CMA required. • Site visits with stakeholders if required • Develop any site management measures as soon as practically possible (pending stakeholder availability) and seek any approvals required to implement • Review the relevant TARP and Management Plan in consultation with key stakeholders • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation

(1) These may be revised in consultation with DPE and other key stakeholders

(2) If strata gas emission plumes are detected – particularly coinciding with low river flow and significant gas evolution

(3) Baseline upriver sites for cross-checking for upriver perturbations impacting Area 7 monitoring sites:

- NR110 - possible upstream perturbations (>2 standard deviations)
- Checks at Upriver sites NR4, NR5 and NR6 for possible Cataract River-based perturbations (>2 standard deviation)

Current Values

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

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

APPENDIX 2 – Longwall 707 Impact Summary, TARPs and Performance Measures

Feature	Performance Measure*	Potential Impacts	*Exceeding* Prediction	TARP Trigger Level	Observed Impacts	Additional Comments
Appearance						
<u>Nepean River</u> Visual observations along the length of the Nepean River within the active mining area	Negligible environmental consequences including: • Negligible gas releases and iron staining; and • Negligible increase in water cloudiness	- Minor iron flocs in association with gas releases.	• More than negligible iron staining resulting from the mining • More than negligible increase in water cloudiness resulting from the mining	***Level 1*** • Iron staining resulting from the mining for two consecutive months • Water cloudiness resulting from the mining for two consecutive months	No Level 1 impacts observed.	
				Level 2 • 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 • Iron staining greater than baseline monitoring resulting from the mining for six consecutive	No Level 3 impacts observed.	

Feature	Performance Measure*	Potential Impacts	*Exceeding* Prediction	TARP Trigger Level	Observed Impacts	Additional Comments
				months • Water cloudiness greater than baseline monitoring resulting from the mining for six consecutive months		
Ephemeral Watercourses • 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*** • 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 • Fracturing resulting in loss of surface flow in	No Level 2 impacts observed.	

Feature	Performance Measure*	Potential Impacts	*Exceeding* Prediction	TARP Trigger Level	Observed Impacts	Additional Comments
				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		
				Level 3 • 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	No Level 3 impacts observed.	

Feature	Performance Measure*	Potential Impacts	*Exceeding* Prediction	TARP Trigger Level	Observed Impacts	Additional Comments
				time in all pools in the mining area		
<u>Water Pumps</u> • 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.	
Landscape Features						
Cliffs • Along Nepean Gorge **Steep Slopes** • Along Nepean Gorge, associated tributaries and above western end of the	*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	- 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.	*Cliffs flanking the Nepean River* • 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	***Level 1*** • Any rock fall, displacement, dislodgement of boulders or slabs or fracturing of a cliff line flanking the Nepean River resulting from mining • Erosion resulting from mining localised to a small area that should naturally stabilise within	No Level 1 impacts observed.	

Feature	Performance Measure*	Potential Impacts	*Exceeding* Prediction	TARP Trigger Level	Observed Impacts	Additional Comments
proposed Longwalls	cliffs within the Longwall mining domain) *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)* - 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). *Other cliffs* - Minor environmental consequences (that is occasional rockfalls,		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	the monitoring period • Surface movement resulting from mining with no more than negligible soil surface exposed		
				Level 2 • Any rock falls, displacements, dislodgements of boulders or slabs or fracturing of a cliff line(s) flanking the Nepean River resulting from mining that in total impacts 0.3% of the total cliff line face area of the mining domain. • Erosion resulting from mining likely to naturally stabilise within the monitoring period. • Surface movement or rock displacement resulting from mining with no more than minor	No Level 2 impacts observed.	

Feature	Performance Measure*	Potential Impacts	*Exceeding* Prediction	TARP Trigger Level	Observed Impacts	Additional Comments
	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).			soil surface exposed		
				Level 3 • 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	No Level 3 impacts observed.	

Feature	Performance Measure*	Potential Impacts	*Exceeding* Prediction	TARP Trigger Level	Observed Impacts	Additional Comments
				slope causing large areas of exposed soil • Any form of rockfall or erosion that poses a threat to public safety		
Terrestrial Ecology						
Monitored in conjunction with general observational monitoring for the Nepean River, ephemeral watercourses and active mining area	Negligible environmental consequences	*Endangered Ecological Communities (and other vegetation)* - Potential gas emissions may result in small, isolated areas of vegetation dieback in the Nepean River gorge. Potential surface 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. *Threatened flora*	More than negligible environmental consequences on threatened species, threatened populations, or endangered ecological communities	***Level 1*** • Vegetation impacted by mining (by rockfalls, soil slippage, gas emissions) that is likely to naturally regenerate within the monitoring period	No Level 1 impacts observed.	
				Level 2 • Vegetation impacted by mining (by rockfalls, soil slippage, gas emissions) that is unlikely to naturally regenerate within the monitoring period	No Level 2 impacts observed.	
				Level 3 • Vegetation impacted by mining that is not responding to CMAs	No Level 3 impacts observed.	

Feature	Performance Measure*	Potential Impacts	*Exceeding* Prediction	TARP Trigger Level	Observed Impacts	Additional Comments
		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. *Threatened fauna and flora habitat* 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.				

* Performance Measure as defined in BSO Development Consent Approval and Longwall 707 to 710 SMP Approval (Table 1).