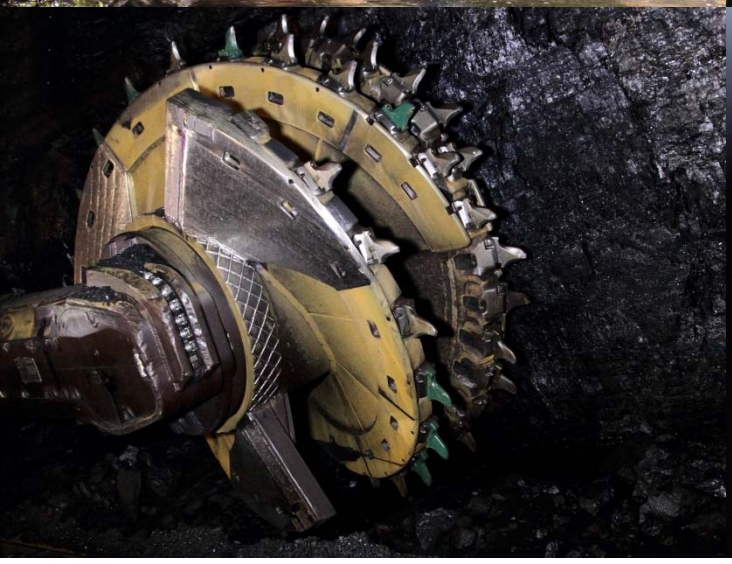
Illawarra Coal
End of Panel Report






West Cliff Area 5 Longwall 38 End of Panel Report

31 May 2016

Executive Summary

This End of Panel (EoP) Report details the findings of the monitoring programs and inspections associated with Longwall 38 extraction. It also analyses the monitoring results against relevant impact assessment criteria and predictions made in the Extraction Plan (EP) and associated management plans and reports.

West Cliff Longwall 38 is located within Consolidated Coal Lease No.767. The extraction of Longwall 38 commenced on the 3rd of February 2015 and was completed on the 1st of February 2016 using longwall equipment.

The extraction of Longwall 38 provides benefits at international, national, state and local levels due to the coal's unique characteristics. Illawarra Coal provides 70% of BlueScope Steel's coking coal requirements. Continuing benefits occur through continuity of employment, expendable income, export earnings and government revenue.

Illawarra Coal provides local jobs for over 1300 direct employees throughout its operations with an employment flow-on effect in the Illawarra and Wollondilly regions of 2.6 full time equivalent jobs (IRIS, 2011). More than 400 local businesses provide their goods and services to the company. Illawarra Coal is a major contributor to the economy of the region, contributing 4.7% of household income and 5.3% of industry value added.

The Appin Mine complex (which includes the West Cliff Longwall 38 operations) had approximately 780 employees during the extraction of Longwall 38.

The observed impacts on the surface infrastructure after the extraction of Longwall 38 are similar or less than the predicted impacts. There were no reported impacts to the Integral Energy low voltage power lines, the Telstra copper cables or water tanks. There were minor impacts to local access tracks, one farm dam and one private swimming pool. Two properties have reported impacts during Longwall 38 (to date).

Impacts to natural features were within the performance measures outlined in the Longwall 37 and 38 EP.

The water level in monitoring bore WC95 dropped by 5m during the longwall extraction. Since then the bore has shown continuous recovery.

Potential impacts were recorded at two privately owned bores, including changes in water appearance and water chemistry.

Iron staining was observed along a 20m section of the Georges River downstream of GR_Pool 49.

Three zones of fracturing and uplift were identified in a tributary to Georges River (GR108). Minor iron staining was noted and no flow was present during the inspections. Fracturing to the base of tributary GR110 with associated loss of flow was identified.

Fracturing and flow diversion was identified in the Georges River at GR_Rockbar_49. During monitoring for Longwall 38, below baseline levels were reported for Georges River pools; GR_Pool 60, GR_Pool 59, GR_Pool 58, GR_Pool 57, GR_Pool 56, GR_Pool 54 and GR_Pool 44. These pools have been reported during the extraction of previous longwalls and the impacts are attributed to Longwall 35. During significant rainfall events or

increased mitigatory flow from Brennans Creek Dam these pools continue to show water levels similar to baseline.

Remediation of impacts within the Georges River as a result of Longwalls 32 to 38 will be addressed in the Georges River Remediation Plan (currently under review).

Aquatic ecology impacts in some sections of the river, resulting from the extraction of Longwall 35, have recovered to some degree. Recovery is almost certainly a result of the restoration of pool water levels and flow in affected areas of the Georges River attributed to the additional releases of water from Brennans Creek Dam. There is no evidence to suggest the extraction of Longwalls 36 to 38 has had any impact on aquatic ecology.

No impacts were observed to vegetation within the study area during inspections undertaken throughout the Longwall 38 extraction period.

There were no new impacts observed during the site inspections of Aboriginal shelter sites Georges River No. 2 (AHIMS # 52-2-2243) or Georges River No. 3 (52-2-2243). Impacts at these sites were a result of subsidence movements from Longwall 35 (Niche 2013) and Longwall 36 (Niche 2014) and have not been further impacted by Longwall 38.

Impacts associated with the extraction of Longwalls 32 to 38 have included gas releases, iron staining, rock fracturing to pools and rock bars and a decline in pool water levels below baseline in some pools along the Georges River. In response to impacts, actions have included increased subsidence surveys and observational monitoring frequencies and increased water releases from Brennans Creek Dam. The Approved Subsidence Management Plan (SMP) and EP requires remediation of the river bed to restore flows to the river and ensure pool water levels respond in a similar way to pre-mining levels.

All impacts to man-made and natural features associated with the extraction of Longwall 38 have been in line with the performance measures provided in the approvals to mine. Monitoring of man-made and natural features will continue in accordance with the Longwall 37 and 38 EP and Longwall 34 to 36 SMP.

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1. Introduction

West Cliff Longwall 38 is located within Consolidated Coal Lease No.767. The extraction of Longwall 38 commenced on the 3rd of February 2015 and was completed on the 1st of February 2016, using longwall equipment.

This End of Panel (EoP) Report details the findings of the Longwall 38 monitoring programs. It also analyses the monitoring results against relevant impact assessment criteria and predictions made in the Extraction Plan (EP) and associated management plans and reports.

Information in this report is based on monitoring by Illawarra Coal and specialist consultants that have been involved with the monitoring and analysis of data relating to West Cliff Area 5.

1.1. Approval and Legislative Requirements

The West Cliff Area 5 EP for Longwalls 37 and 38 was approved by Department of Planning and Infrastructure – DoPI (now the Department of Planning and Environment - DoPE) on the 24th of March 2014. SMP approval was granted by the Department Trade and Investment (T&I) on 28th March 2014. The EP and SMP approval are provided as **Attachment A**. Approvals were granted to shorten Longwall 38 from the commencing end by 59m on the 14th October 2014 (DoPE) and 16th October 2014 (T&I).

In September 2009, Illawarra Coal submitted an Environmental Assessment (EA) for its Bulli Seam Operations Project (BSOP) to the DoPE for the continuation of existing underground mining operations for both Appin and West Cliff Mines. The BSOP was approved 22nd December 2011 by the NSW Planning Assessment Commission under delegation of the NSW Minister for Planning under Part 3A of the NSW Environmental Planning and Assessment Act (EP&A Act). *Condition 5, Schedule 3* of the BSOP Approval requires the preparation and implementation of an EP for the first and second workings within each mining domain to the satisfaction of the Director-General. *Condition 1 and 3, Schedule 3* of the BSOP Approval addresses performance measures for the project.

Subsidence impact performance measures relevant to Longwall 38, under *Condition 1 and 3, Schedule 3 (Table 1 and Table 2)* of the BSOP Approval, are outlined in **Table 1-1**.

Table 1-1: Bulli Seam Operations Project Approval – Environmental Performance Measures.

BSOP Approval Condition		Relevant Section in EoP Report
Watercourses		
Georges 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 over at least 80% of the stream length subject to vertical subsidence >20mm.	*- Sections 4.1, 4.2 and 4.3* *- Attachments C, C1 and D*

	No subsidence impact or environmental consequence greater than minor.	
Other watercourses	No greater subsidence impact or environmental consequences than predicted in the EA and PPR	*- Sections 4.1, 4.2 and 4.3* *- Attachments C, C1 and D*
Land		
Dharawal State Conservation Area	Negligible environmental consequence	*Sections 4.1, 4.2 and 4.3*
Cliffs of "special significance" (i.e. cliffs longer than 200m and/or higher than 40m; and cliff-like rock faces higher than 5m that constitute waterfalls)	Negligible impact (that is occasional rock falls 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.	*N/A*
Other cliffs	Minor impacts (that is occasional rock falls, 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).	*- Section 4.1* *- Attachments C and C1*
Biodiversity		
Threatened species, threatened populations, or endangered ecological communities	Negligible environmental consequences.	*- Sections 4.5 and 4.6*
Aboriginal Heritage		
Sites determined to hold 'special significance' as a result of studies required for Extraction Plans	Negligible impact or environmental consequences.	*- Section 4.7* *- Attachment F*
Sites determined to hold high or moderate significance as a result of studies required for Extraction Plans	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 within any longwall mining area are affected by subsidence impacts (other than minor impacts or environmental consequence).	
Historic Heritage		
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.	*N/A*
Other buildings or structures of identified heritage significance	No loss of heritage value greater than predicted under a Heritage Management Plan prepared under Condition 6 Schedule 3.	*N/A*
Built Features		
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 must be replaced.	*- Section 3* *- Attachment B*

1.2. Management Plans

The impact predictions associated with Longwall 38 are described in Cardno Forbes Rigby, March 2014, West Cliff Area 5 Longwalls 37 and 38 Extraction Plan, which includes:

- Annexure A: MSEC, June 2013, *Subsidence Predictions and Impact Assessments for the Natural Features and Surface Infrastructure in Support of the Extraction Plan*, MSEC533.
- Annexure B: BHP Billiton, August 2013, *Subsidence Monitoring Program*.
- Annexure C: Cardno Forbes Rigby, March 2014, *Water Management Plan*.
- Annexure D: Cardno Forbes Rigby, August 2013, *Biodiversity Management Plan*.
- Annexure E: Cardno Forbes Rigby, August 2013, *Land Management Plan*.
- Annexure F: Cardno Forbes Rigby, August 2013, *Heritage Management Plan*.
- Annexure G: Cardno Forbes Rigby, August 2013, *Public Safety Management Plan*.
- Annexure H: Cardno Forbes Rigby, August 2013, *Built Features Management Plan*.

1.3. Report Outline

Economic effects associated with the longwall extraction are discussed in **Section 1.4**. An overview of the consultation involved with West Cliff mining operations is provided in **Section 1.5**. Subsidence movement predictions and measurements are in **Section 2**. Impacts associated with Longwall 38 on man-made and natural features are provided in **Sections 3 and 4** respectively. Management of impacts, Trigger Action Response Plans (TARPs) and remediation measures are discussed in **Section 5**. The Longwall 38 monitoring program and proposed future monitoring in the EP Area are outlined in **Section 6**.

1.4. Economic Effects

The extraction of coal reserves from West Cliff provides benefits at international, national, state and local levels due to the coal's unique characteristics. Illawarra Coal provides 70% of BlueScope Steel's coking coal requirements. Continuing benefits occur through continuity of employment, expendable income, export earnings and government revenue.

Illawarra Coal provides local jobs for over 1300 direct employees throughout its operations with an employment flow-on effect in the Illawarra and Wollondilly regions of 2.6 full time equivalent jobs (IRIS, 2011). More than 400 local businesses provide their goods and services to the company. Illawarra Coal is a major contributor to the economy of the region, contributing 4.7% of household income and 5.3% of industry value added.

The Appin Mine complex (which includes the West Cliff Longwall 38 operations) had approximately 780 employees during the extraction of Longwall 38.

1.5. Stakeholder Consultation

Provision of ongoing information to the community has been undertaken during the extraction of Longwall 38. Information on South32 operations is provided to the community through the following:

- Community information sheets and letter box drops,
- Media releases and other media activities,
- General community surveys and reports,
- Internet site http://www.south32.net/our-operations/australia/illawarra-coal/regulatory-document
- Community Consultative Committee meetings,
- Landholder relations program, and
- Information days.

Illawarra Coal aims to monitor and mitigate the impacts subsidence on individuals as outlined in **Table 1-2**.

Table 1-2: Social Impact Variables Associated with Subsidence

Potential Impact	Monitoring Variables	Mechanism
Subsidence Impacts	- Level of community concern relating to subsidence - Awareness of subsidence, its effects and management - Level of perceived community risk associated with subsidence effects - Level of satisfaction with subsidence management practices - The extent that community attributes environmental, social and economic change to mining	- Noticeboards and newsletter where longwall progress is displayed - Community Consultative Committee meetings - Survey of residents and stakeholders - Development of individual Built Feature Management Plans (BFMPs) in consultation with landowners - Meetings and on-going consultation with landowners during mining

The management of subsidence impacts on private properties is addressed in BFMPs which are prepared in consultation with property owners. Where impacts to properties have occurred the landholders have been encouraged to make claims with the Mine Subsidence Board (MSB). Illawarra Coal is available to assist landholders throughout the process of making a claim to the MSB and is continuing to assist in the management of the social impacts of the mining operations associated with West Cliff Area 5.

2. Predicted and Observed Subsidence

Subsidence movements resulting from the extraction of Longwall 38 were monitored along various lines and points within the EP Area. A comparison of the observed and predicted movements resulting from the extraction of Longwall 38 has been prepared by MSEC, 2016 (**Attachment B)**.

Longwall 38 monitoring points and lines include:

- The Georges River cross lines;
- Exley Road monitoring line;
- Blackburn Road monitoring line;
- Wedderburn Airfield Line; and
- Harland's Dam monitoring points.

2.1. Georges River Cross Lines

The observed incremental upsidence for the L-Line and M-Line of 65 mm and 26 mm were slightly greater than the predicted incremental upsidence of 50 mm and 20 mm, respectively. The observed incremental closure along the H-Line of 29 mm was also slightly greater than the predicted incremental closure of less than 20 mm. These three exceedances were small (i.e. 6 to 15 mm) and within the order of accuracy of the prediction method. The observed incremental upsidence and closure for the remaining monitoring lines were all less than the incremental predictions.

The observed total upsidence and closure exceeded the predictions at the G-Line, H-Line (closure only) L-Line, M-Line and N-Line. In each of these cases, the observed movements had exceeded the predictions prior to the extraction of Longwall 38.

The observed total closures exceeded the predictions by 9% to 18% for the G-Line, L-Line, M-Line and N-Line and by 29% for the H-Line. There is more uncertainty in the prediction of valley related movements when compared with the prediction of vertical subsidence. The accuracy of empirical prediction methods are generally in the order of ±15% to ±25% for maximum vertical subsidence. The exceedances for the valley related closure along the Georges River are similar to the order of accuracy normally considered acceptable for empirical methods.

The observed total closure for the remaining monitoring lines were between 4% and 61% of the predicted total closure (i.e. observed less than predicted). The average ratio of the observed to predicted total closure for all the Georges River cross lines was 67%.

2.2. Exley Road Monitoring Line

Exley Road crosses Longwall 38 near the commencing end. The mine subsidence movements were measured along this road using 2D and 3D monitoring techniques.

The maximum observed subsidence of 922mm was greater than the maximum predicted value of 360mm. The exceedance is partly due to the proximity of the monitoring line to the longwall commencing end, with the end effects reducing the predicted subsidence. If the end effects are excluded, then the maximum predicted subsidence for the monitoring line would be 560mm.

The maximum observed subsidence therefore exceeded the maximum predicted by a factor of 2.5 when the longwall end effects are included and by a factor of 1.6 when the longwall end effects are excluded. The maximum observed tilt of 7.9mm/m was greater than the maximum predicted value of 2.5mm/m based on the modified commencing end position and 3.5mm/m when the longwall end effects are excluded.

The vertical subsidence and tilt along this monitoring line could have exceeded the predictions due to the presence of both O'Hares Fault and the Georges River valley. The proximities of these features could have made this longwall subside more like a series panel rather than a single isolated longwall.

The maximum observed strains were 0.5mm/m tensile and 2.7mm/m compressive. The maximum predicted strains based on regular (i.e. conventional) ground movements were 1.2mm/m tensile and 1.8mm/m

compressive. The maximum predicted strains including the potential for irregular movements were: 0.9mm/m tensile and 1.6mm/m compressive based on the 95% confidence level; and 1.6mm/m tensile and 3.2mm/m compressive based on the 99% confidence level.

The tensile strains therefore were within the range of those predicted based on regular ground movements. The maximum observed compressive strain of 2.8mm/m appears to be a localised irregular movement, with its magnitude less than that predicted based on the 99% confidence level. Elsewhere, the compressive strains were 1.5mm/m or less and, therefore, within the range of those predicted based on regular ground movements.

2.3. Blackburn Road Monitoring Line

Blackburn Road crosses near the middle of Longwall 38. The mine subsidence movements were measured along this road using 2D monitoring techniques.

The maximum observed subsidence of 840mm was greater than the maximum predicted value of 540mm, representing an exceedance of 1.6 times. The maximum observed tilt of 8.4mm/m was greater than the maximum predicted value of 3.5mm/m, representing an exceedance of 2.4 times.

The vertical subsidence and tilt along this monitoring line could have exceeded the predictions due to the presence of both O'Hares Fault and the Georges River valley. The proximities of these features could have made this longwall subside more like a series panel rather than a single isolated longwall.

The maximum observed strains were 0.5mm/m tensile and 1.9mm/m compressive. The maximum predicted strains based on regular (i.e. conventional) ground movements were 1.2mm/m tensile and 1.8mm/m compressive. The strains measured along the Blackburn Road monitoring line therefore were similar to the range predicted based on regular ground movements.

2.4. Wedderburn Airfield Monitoring Line

The Wedderburn Airfield is located outside and to the east of Longwall 38. The mine subsidence movements were measured in this location using 3D monitoring techniques.

The maximum observed subsidence of 37mm was similar to the maximum predicted subsidence of less than 50mm. The maximum observed tilt of 0.8mm/m was slightly greater than the maximum predicted tilt of less than 0.5mm/m. However, the maximum tilt appears to be the result of a disturbed survey mark (AF25) due to the locally higher subsidence in this location. Elsewhere, the observed tilts were up to 0.4mm/m and therefore were less than the maximum predicted tilt.

The maximum observed strains were 0.3mm/m tensile and 0.5mm/m compressive. The maximum predicted strains based on regular (i.e. conventional) ground movements outside of the longwall were less than 0.5mm/m tensile and compressive. The strains measured along the Wedderburn Airfield monitoring line were therefore within the range of those predicted based on regular ground movements.

2.5. Harland's Dam Monitoring Points

Harland's Dam is located above Longwall 38 on the southern side of Blackburn Road. The dam wall was monitored using 3D monitoring points.

The maximum observed tilt of 4.1mm/m was similar to but slightly greater than the maximum predicted value of 3.5mm/m. The exceedance represents around 17% which is within the range considered acceptable for subsidence prediction methodologies of ±15% to ±25% for maximum tilt.

The maximum observed strains were 1.8mm/m tensile and 1.2mm/m compressive. The maximum predicted strains based on regular (i.e. conventional) ground movements were 1.2mm/m tensile and 1.8mm/m compressive. The maximum observed tensile strain is greater than the prediction based on regular movements. The strain in this location reduced to 1.2mm/m tensile in the final survey and, therefore, was similar to that predicted based on regular movements. The observed compressive strains were within the range of those predicted based on regular ground movements.

The horizontal movements at the survey marks were all orientated towards the centreline of Longwall 38. The magnitudes of these movements varied between 100mm and 121mm. The maximum predicted horizontal movement based on applying a factor of 15 to the predicted tilt of 4mm/m is 60mm. The maximum predicted horizontal movement based on applying this factor to the maximum observed tilt of 8mm/m is 120mm.

3. Impacts to Man-Made Features

The buildings and infrastructure (**Appendix 8-2**) located above or immediately adjacent to Longwall 38 include:

- Exley, Blackburn and Lysaght Roads and unsealed tracks;
- Low voltage aerial powerlines;
- Copper telecommunications cables;
- Farm dams and rural building structures;
- Houses and private swimming pools;
- Wedderburn Airfield and associated infrastructure; and
- Survey control marks.

Comparisons between the assessed and observed impacts for infrastructure resulting from the extraction of Longwall 38 are provided in **Table 3-1**.

Table 3-1: Assessed and Observed Impacts for Infrastructure Resulting from Longwall 37.

Surface Infrastructure	Predicted Impacts	Observed Impacts
Public roads and tracks	Minor impacts that could be managed using normal road maintenance techniques	Soil cracking in two access tracks to Georges River
Low voltage powerlines	Minor impacts possible requiring adjustment of cable catenaries, pole tilts or consumer cables	No reported impacts
Copper telecommunications cables	Impacts unlikely	No reported impacts

Farm dams	Potential for cracking or leakage in farm dams	Leaking in one dam reported
Rural Building Structures	Minor impacts that could be remediated using normal building techniques. Structures would remain safe and serviceable	One impact reported where the concrete slab in a shed had dropped
Tanks	Impacts unlikely	No reported impacts
Endeavour Energy 66 kV, 11 kV and low voltage powerlines	Impacts unlikely	No reported impacts
Telstra Optical Fibre Cable along Appin Road	Impacts unlikely	No reported impacts
Telstra Copper Cables	Impacts unlikely	No reported impacts
Houses	Generally slight to minor impacts anticipated, but possible major impacts due to irregular movements	Cracking to one house reported
Pools	Tilt could be visible along waterline and in-ground pools could be more susceptible to strain impacts	Cracking in one pool reported
Fences	Possible that some fences could experience impacts	No reported impacts
Survey control marks	Small far-field horizontal movements which could require re-establishment	Small far-field horizontal movements

4. Impacts to Natural Features

The natural features (**Appendix 8-1**) above or adjacent to Longwall 38 include:

- The Georges River and tributaries;
- Cliffs, rock outcrops and steep slopes;
- Ecological communities; and
- Archaeological sites.

Monitoring for natural features relates to the following:

- Landscape features (steep slopes, vegetation and watercourses);
- Surface water quality, water flow and pool water levels;
- Shallow groundwater level and quality;
- Aquatic ecology monitoring;
- Terrestrial flora and fauna monitoring; and
- Aboriginal and European heritage items.

The ICEFT undertakes landscape and detailed watercourse and rockbar monitoring of features potentially impacted by Longwall 38, before, during and after mining. The monitoring program is in accordance with EP requirements for West Cliff Longwalls 37 and 38. The monitoring program is outlined in **Table 6-1**.

The observed and assessed impacts, TARPs and approved performance measures are summarised in **Appendix 8-6**.

4.1. Landscape Features

The ICEFT undertakes observations and monitoring of landscape features such as steep slopes, Georges River, first and second order streams. Stream features along the Georges River and its tributaries are monitored for mining impacts such as gas releases, iron staining, rock fracturing and pool water levels as outlined in **Table 6-1**.

Three surface impacts, WCA5_LW38_006, WCA5_LW38_010 and WCA5_LW38_011, were identified to landscape features during or following extraction of Longwall 38.

WCA5_LW38_006 is a soil crack which occurred to an access track adjacent to Georges River. The crack is approximately 3m long, 0.08m deep and has a maximum width of 0.01m. It does not impact access and is likely to naturally remediate.

WCA5_LW38_010 is a zone of fracturing to a rock outcrop adjacent to GR110. The largest fracture is approximately 2.1m long, 0.03m wide and has a measurable depth of 0.414m.

WCA5_LW38_011 is a soil cracking on an access track up to 3m long and 0.004m wide. There was no impact to track access.

4.2. Surface Water Level and Flow

Pool water levels and flow conditions in the Georges River are monitored by the ICEFT using observations, photo comparisons and measured benchmarks. Inspections of water level were conducted weekly during mining (when the longwall is within 400m) and twice weekly when water levels fell below baseline in impacted pools.

Fracturing was identified in the Georges River at GR_Rockbar_49. The largest fracture at this site is 10m long and 0.04m wide. Flow diversion was observed and the impact is a Level 2 Trigger under the TARPs.

During monitoring for Longwall 38, below baseline levels were reported for Georges River pools; GR_Pool 60, GR_Pool 59, GR_Pool 58, GR_Pool 57, GR_Pool 56, GR_Pool 54 and GR_Pool 44. These pools have been reported during the extraction of previous longwalls and have been attributed to Longwall 35 impacts. During significant rainfall events and increased mitigatory flow from Brennans Creek Dam these pools continue to show water levels similar to baseline. However, these water levels decrease during periods of low rainfall and reduced releases from Brennans Creek Dam.

As these water level impacts are a result of Longwall 35 they are addressed by the West Cliff Area 5 Longwalls 34 to 36 Subsidence Management Plan and Georges River Management Plan (2014).

Remediation options for impacted sections of the Georges River as a result of Longwalls 32 to 38 will be addressed in the Georges River Remediation Plan (in draft).

4.3. Surface Water Quality

Water quality is measured by the ICEFT on a weekly basis when mining is within 400m of the area and when access to the monitoring sites is safe and available. Parameters measured include temperature, electrical

conductivity (EC), Oxidation-Reduction Potential (ORP), pH and dissolved oxygen (DO). Water samples are collected on a monthly basis to test for a range of laboratory parameters. In-situ and sampled water quality results are assessed in **Attachment D**.

The Longwall 37 and 38 TARP (BHPBIC, 2014) focusses on the following stream sites:

- Pool 34 - upstream of Longwall 38.
- Pool 54 - mid stream reach adjacent to Longwall 38.
- Pool 64 – north stream reach adjacent to Longwall 38 (downstream of Longwall 37).

Longwall 38 trigger levels for pH in the Georges River are:

- Level 1 0.5 – 1.0 unit drop for 2 consecutive months.
- Level 2 1.0 – 1.5 unit drop for 2 consecutive months.
- Level 3 1.5 unit drop for more than 2 consecutive months.

The pH, DO, ORP and salinity in the selected Georges River and tributary sites maintained a similar variability, with no significant change to the baseline range, along with no significant change in trend or extended adverse changes being observed as a result of extraction of Longwall 38. No TARP trigger levels were attained for pH due to extraction of Longwall 38.

During the extraction of Longwall 38, a 20m section of iron staining was observed in the Georges River downstream of GR_Pool 49. Minor iron staining was noted at impacts WCA5_LW38_002, as well as WCA5_LW38_005 in tributary GR108.

The levels of Mn, Ni and Zn in Georges River maintained similar pre Longwall 38 variability, with no significant change to the observed ranges as a result of extraction of Longwall 38.

4.4. Shallow Groundwater

Shallow groundwater in the Georges River catchment is monitored at six bores: GR27, GR28, GR70, WC54, WC95 and S2087 (**Appendix 8-3**).

No adverse interconnection of aquifers and aquitards has been observed within 20m of the plateau surface and no increased rate of groundwater recharge into the plateau has been observed as a result of Longwall 38.

No TARP trigger levels related to aquifer or aquitard interconnection or changes in recharge have been observed as a result of Longwall 38.

Piezometers GR29 and WC95 as well as the Private Bore GW72454 overly Longwall 38. Piezometer GR27 lies within the Longwall 38 (20mm) subsidence zone to the southwest, between Longwall 38 and the Georges River, whilst GR28 lies on the western side of the Georges River.

Piezometers WC54 and GR70 are located within the Longwall 37 (20mm) subsidence zone. Water levels in GR27, GR28, GR70 and WC54 have not been affected by subsidence up to the end of extraction of Longwall 38,

although GR28 was affected by an approximately 6m drop associated with subsidence in August 2011.

The water level in WC95 fell by approximately 9m between the end of March and late May 2015 and then recovered by approximately 4m up to mid-January 2016.

A Level 1 TARP was triggered by the 9m reduction in water level in piezometer WC95 as the fall was between 5 and 7.5 m greater than the predicted reduction in Hawkesbury Sandstone related depressurisation over a minimum two month period.

The landowner at Lot 10, DP3221 reported an adverse effect on groundwater pumping supply and iron levels from bore GW72454 in mid-November 2015.

The landowner at Lot 81, DP622780 reported an adverse effect on groundwater supply from bore K10bh01 in March 2016 in that it had not been performing as usual for several months.

The groundwater quality monitoring of piezometers GR27, 28 and 70 indicates that there was no adverse effects on their salinity or pH as a result of Longwall 38 extraction.

Monitoring of the GW72454 bore indicates no change in salinity, a minor alkalisation in pH from 4.78 to 5.27 along with an increase in iron from 0.42 mg/L before undermining to 6.96mg/L after undermining.

Bore K10bh01 had a minor increase in salinity of 104uS/cm before undermining to 331uS/cm after undermining, as well as a change in pH from 5.89 to 4.46.

There were no bore water quality TARP triggers during or after the extraction of Longwall 38.

No increased groundwater inflow to the West Cliff mine workings following extraction of Longwall 38 has occurred and no TARP trigger levels have been reached or exceeded. For further detail on the assessment of groundwater, refer to **Attachment D**.

4.5. Aquatic Ecology

Cardno Ecology Lab (CEL) was commissioned by Illawarra Coal to assess the potential impacts of subsidence on the aquatic ecology of the Georges River and other nearby watercourses. The assessments focus on aquatic habitats and biota in sections of the Georges River, comparing results from surveys undertaken since 2002 (CEL, 2016). The assessment report is provided as **Attachment E1**. The monitoring sites associated with the aquatic ecology programme are shown in **Appendix 8-4**. The latest round of aquatic ecology monitoring was undertaken in November 2015.

The monitoring program focuses on three main indicators:

- Aquatic habitat, including fish habitat, aquatic macrophytes and riparian vegetation;
- Aquatic macroinvertebrates sampled in accordance with the Australian River Assessment System (AUSRIVAS); and
- Fish sampled using backpack electrofishing.

The results of the November 2015 survey were compared with those obtained in May 2002, March 2005, November 2007, September 2008, May 2010, May 2012, December 2012, November 2013 and December 2014.

Data collected during December 2014 and November 2015 suggested that impacts to indicators of aquatic ecology in some sections of the river, previously observed in November 2013 following mining impacts in the Georges River due to extraction of Longwall 35, have recovered to some degree. Recovery is almost certainly a result of the restoration (at least temporarily) of pool water levels and flow in affected areas of the Georges River attributed to the additional releases of water from Brennans Creek Dam which were implemented as an ameliorative measure following extraction of Longwall 35.

There is no evidence to suggest the extraction of Longwalls 36 to 38 has had any impact on aquatic ecology. This finding is not surprising considering that minor physical impacts and no significant impacts to water quality have resulted from extraction of these longwalls.

The physical impacts of mining associated with extraction of Longwall 35 were first identified in February 2013, and included fracturing of bedrock, loss of water flow and reductions in pool water levels. In November 2013, corresponding reductions in the number of macroinvertebrate taxa and the numbers of fish and large mobile invertebrates were observed at one of the two sites on the Georges River affected by subsidence and there was also evidence of a reduction in the OE50 Taxa Score (an AUSRIVAS biotic measure of aquatic habitat and water quality) at the other site. Aquatic macrophytes became desiccated at both sites. These changes were attributed to subsidence caused by mining. As no changes to ecological indicators were evident at sites further downstream in November 2013, impacts due to extraction of Longwall 35 appear to have been localised to the areas affected by subsidence caused by mining.

The re-establishment of pool water levels and flow following releases of water from Brennans Creek Dam in the second half of 2014 likely explains the observed increase (recovery) in the number of macroinvertebrate taxa and fish generally, and improvement in habitat quality, at the sites in December 2014. The observation, however, of some persistent reductions in pool water level and flow at one of these sites in November 2015 suggests that aquatic ecology remains affected by physical impacts associated with longwall extraction.

It is recommended that increased discharges from Brennans Creek Dam are maintained for as long as practicable whenever low pool water levels and flow are experienced in the Georges River. This will reduce any potential further impacts to aquatic biota associated with loss of habitat, flow and connectivity. Rehabilitation of the mining impacts such as grouting and recovery of surface flow is also recommended.

4.6. Terrestrial Ecology

A baseline Terrestrial Flora and Fauna Assessment (Flora Search, 2009; Biosphere, 2009) was undertaken in support of the Bulli Seam Operations Environmental Assessment, the Study Area for these assessments included the Longwalls 37 and 38 Study Area. Supplementary field surveys for terrestrial biodiversity were undertaken by Niche (2013), for the purposes of the Longwall 37 and 38 EP.

Subsidence effects are unlikely to have a significant impact on any threatened flora or fauna species (Niche, 2013). However, impacts may lead to the alteration of habitat and the alteration of the natural flow regimes of rivers, stream, floodplains and wetlands following longwall mining (Niche, 2013).

Visual inspections of vegetation communities were undertaken as a part of landscape and water monitoring programs. Monitoring focused on detecting significant changes to vegetation communities and fauna habitat.

Inspections of vegetation condition assessed the following:

- Vegetation health.
- Observation of impacts (e.g. canopy thinning, thinning of shrub layer, loss of ground cover, dead branches present).

No impacts were observed to the vegetation within the study area during inspections undertaken throughout the Longwall 38 extraction period.

A field assessment was conducted by Niche Environment and Heritage 17th of February 2016 (**Attachment E2**). The field survey targeted areas along Georges River within the limits of subsidence. The field assessment involved traversing the creek habitat, general observation of habitat and vegetation health, threatened flora searches, and any potential impacts as a result of subsidence.

The impacts which have occurred within the limit of subsidence for Longwall 38 are within the parameters of the predicted impacts outlined in the terrestrial ecological assessment for Longwalls 37 to 38 (Niche 2013). These levels of impact were assessed as not being significant by Niche (2013). The extraction of Longwall 38 is not likely to have led to a significant impact on threatened terrestrial ecological values.

4.7. Cultural Heritage

Niche Environment and Heritage has undertaken a site assessment and review of the predicted and observed impacts on Aboriginal heritage sites and their associated values resulting from the extraction of Longwall 38 (**Attachment F**).

There were no new impacts noted during the site inspections. Impacts have previously been noted to Aboriginal shelter sites Georges River No. 2 (AHIMS # 52-2-2243) and Georges River No. 3 (52-2-2243). These impacts were a result of subsidence movements from Longwall 35 (Niche 2013) and Longwall 36 (Niche 2014) and have not been further impacted by the extraction of Longwall 38 (**Table 4-1**).

Table 4-1: Site Visits to the Aboriginal Heritage Sites in Proximity to Longwall 38

AHIMS Site Number	Site Name	Results of Inspection
52-2-2243	Georges River 2	Impacts to this shelter had been noted in Niche (2014). Observations found that impacts had not worsened and remained in the same condition as described by Niche 2015. The art panel remains in the same condition as described in Biosis Research 2007 and Niche 2013b, 2014 and 2015 and has not been affected by the observed changes.
52-2-2244	Georges River 3	This shelter was in the same condition as described by Niche 2015. There has been no further movement of the horizontal bedding plane joints of the shelter and the cracking and exfoliation observed in relation to LW35. The site remains the same as previously described. The art panel remains in the same condition as described in Biosis

		Research 2007 and Niche 2013b.
52-2-2242	Georges River 4	Shelter and Art are in the same condition as described by Biosis Research 2007 and Niche Environment and Heritage 2011, 2013, 2014 and 2015.
52-2-2234	Georges River 1	This shelter is in the same condition as previously described in both Biosis Research 2007 and Niche Environment and Heritage 2011, 2013, 2013b and 2014. Natural weathering of the art panel has caused further granular loss, and a white leeching process has occurred over the infill kangaroo.
52-2-2241	Georges River 5	Shelter and art are in the same condition as described by Biosis Research 2007 and Niche Environment and Heritage 2011, 2013 and 2014.The previously reported charcoal drawings were in the same condition as described previously by Biosis 2007. The single quartz artefact was not observed in the shelters drip line during this assessment.
52-2-2235	Georges River 6	The site could not be accessed due to landholder restrictions.

The TARPs, Performance Measures and Corrective Management Actions for Aboriginal heritage sites are outlined in the Longwalls 37 and 38 Heritage Management Plan (Cardno, 2013), are included in **Appendix 8-6**.

4.8. Summary of Impacts

Eleven impacts were identified by the ICEFT during Longwall 38 extraction. One of these impacts is attributed to Longwalls 36 and 37, due to timing of the observation and distance from Longwall 38.

Pool water level triggers from Longwall 35 were also reported during the extraction of Longwall 38. New impacts and ongoing pool water level triggers are outlined in **Table 4-2** and **Appendix 8-6**.

The locations of the impacts during extraction of Longwall 38 are provided in **Figure 5-1**. A detailed description of these impacts is provided as **Attachment C-1**.

Table 4-2: Summary of Impacts

Site ID	Impact Type	Date	Activating Longwall	Feature Affected	Impact Description	Trigger Level	Report/s Date
WCA5_LW38_001	Rock Fracturing	24/04/2015	LW36/7	Tributary GR104	Rock fracture up to 4m long in GR104	n/a	27th April 2015
WCA5_LW38_002	Rock Fracturing	03/08/2015	LW38	Tributary GR108	Fracturing and extension of bedding plane in Rockbar 6A of GR108 approx. 1.4m long. Minor iron staining	n/a	4th August 2015
WCA5_LW38_003	Rock Fracturing	03/08/2015	LW38	Tributary GR108	Fracturing and uplift in Channel 2 of GR108. Maximum fracture approx. 10m long	n/a	4th August 2015
WCA5_LW38_004	Iron Staining	19/08/2015	Area 5	Mallaty Creek	Iron staining along a 400m section between MC107 and MC120	n/a	21st August 2015
WCA5_LW38_005	Rock Fracturing	20/08/2015	LW38	Tributary GR108	Fracturing and uplift downstream of GR108_Pool. Largest	n/a	21st August 2015

Site ID	Impact Type	Date	Activating Longwall	Feature Affected	Impact Description	Trigger Level	Report/s Date
					fracture approx. 1.2m long. No flow diversion. Minor iron staining.		
WCA5_LW38_006	Soil Crack	25/09/2015	LW38	Access Track	Soil cracking across fire trail. Approx. 3m long. No impact to access.	n/a	28th September 2015
WCA5_LW38_007	Rock Fracturing	02/10/2015 *(update: 16/11/2015)*	LW38	Tributary GR110	Fracturing to boulders and base of GR110. Fractures up 2.1m long. Loss of surface flow.	n/a	6th October 2015 17th November 2015
WCA5_LW38_008	Rock Fracturing	10/12/2015	LW38	Georges River	Multiple fractures and dislodgment of rocks on GR_Rockbar 49. Fractures range from 1.3m to 10m long. Flow diversion evident.	Level 2	11th December 2015
WCA5_LW38_009	Iron Staining	10/12/2015	LW38	Georges River	20m section of iron staining downstream of GR_Pool 49.	Level 1	11th December 2015
WCA5_LW38_010	Rock Fracturing	17/02/2016	LW38	Rock Outcrop adjacent to GR110	Fractures to rock. Largest fracture is approx. 2.1m long.	n/a	18th December 2015
WCA5_LW38_011	Soil Cracking	16/03/2016	LW38	Access Track	Soil cracking up to 3m long. No impact to access.	n/a	17th March 2016

5. Management of Impacts and Remediation

Reporting of impacts has been carried out as required under the SMPs, EP and GRMP for mining of West Cliff Area 5. Inspections have identified gas releases, iron staining and rock fracturing to pools and rockbars along the Georges River, adjacent to West Cliff Area 5, associated with the extraction of Longwalls 32 to 38. A decline in water level below baseline in some pools has also occurred. Some of these impacts have remediated naturally while others require Corrective Management Actions (CMAs).

5.1. Trigger Action Response Plans (TARPs)

The TARPs relate to identifying, assessing and responding to impacts to landscape features (including impacts greater than predicted) from subsidence. These TARPs have been prepared using knowledge gained from previous mining in West Cliff Area 5. The TARPs for Longwalls 37 and 38 are included in **Appendix 8-6**: TARPs and Impact Summary.

The TARPs represent actions to be taken upon reaching each defined trigger level. A CMA is developed in consultation with stakeholders in order to manage an observed impact in accordance with relevant approvals.

Monitoring of environmental aspects provides key data when determining any requirement for mitigation or rehabilitation. The triggers are based on comparison of baseline and impact monitoring results.

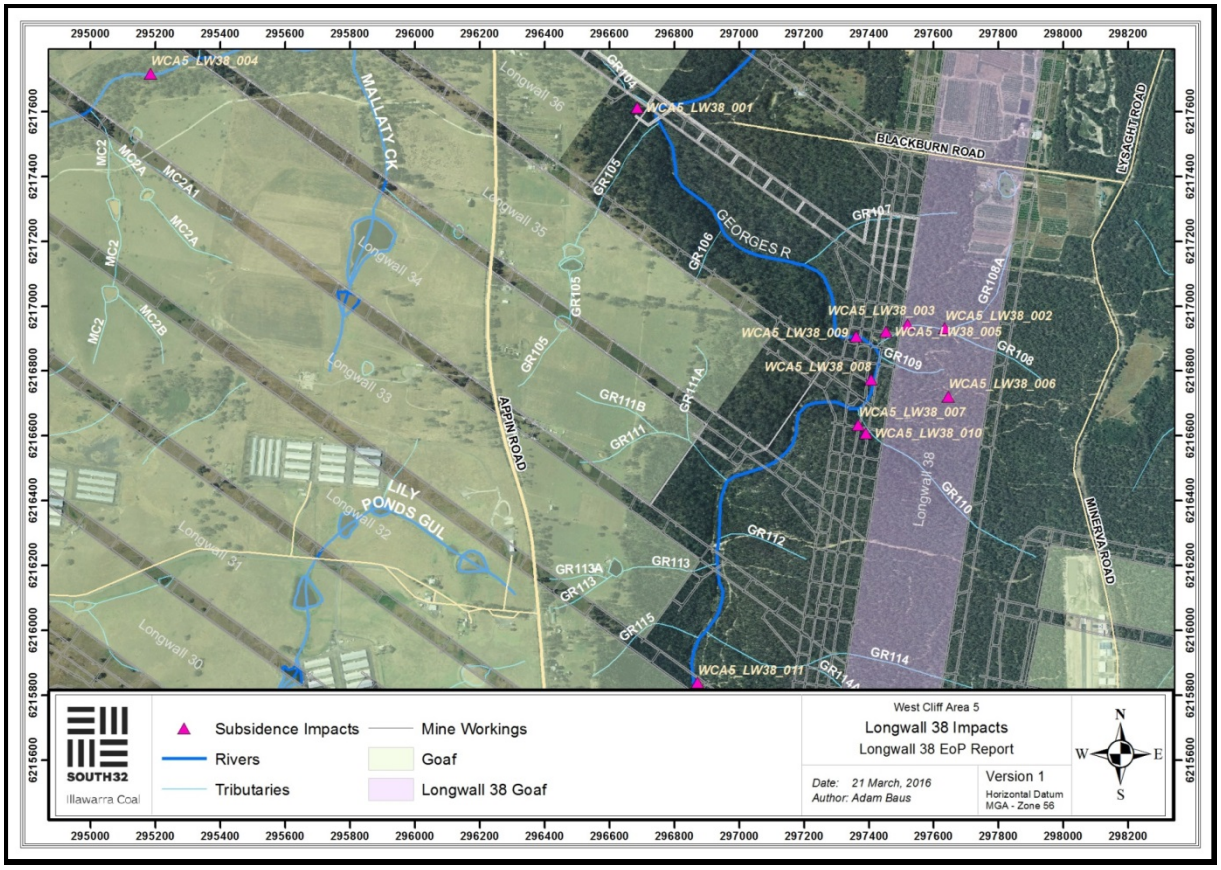


Figure 5-1: Georges River Impacts reported during Longwall 38 Extraction

5.2. Georges River Remediation Plan

The Approved SMP and EP requires remediation of the river bed and rockbars to restore flows to the surface of the river and ensure pool levels respond in a similar way to pre-mining levels. The rehabilitation is aimed at improving water flows in the river to support the ecology of the area following mining.

Impacts associated with Longwalls 32 to 36 have previously been addressed in the West Cliff Colliery Longwall 33 Georges River Impacts Rehabilitation Options, October 2010 and the Georges River Remediation Plan, 2014. These plans were submitted to relevant Government agencies for review. An updated report which addresses impacts from Longwall 38 will be provided to relevant Government agencies in the near term. The extraction of Longwall 38 completes mining activities within West Cliff Area 5.

Objectives of rehabilitation are outlined in the BSOP Approval Condition 31 Schedule 4: Restore pre-mining surface flow and pool holding capacity as soon as reasonably practicable, hydraulically and geomorphologically stable, with riparian vegetation that is the same or better than prior to mining.

The Rehabilitation Plan is to be to the satisfaction of the Executive Director Mineral Resources and must:

- be prepared in consultation with the Department, OEH, NOW, Council and the CCC;
- be prepared in accordance with any relevant DRE (DT&I) guideline and be consistent with the rehabilitation objectives in the BSOP Environmental Assessment and in Table 11 of the Consent; and

- build, to the maximum extent practicable, on the other management plans required under this approval.

5.3. Previous Mitigation/Rehabilitation of the Georges River

Remediation work has been carried out on the Georges River upstream of Longwall 36, associated with West Cliff Longwalls 5A1-4, which were mined from 1999 till 2003. This work is detailed in the report 'Georges River Report; Assessment of Georges River Remediation Longwalls 5A1-4', dated November 2006.

During this period, mining occurred directly beneath the Georges River, resulting in greater impacts than have been observed for subsequent longwalls that have not mined directly under the River.

Impacts observed from Longwalls 5A1-4 included an increased level of interaction between surface and ground waters, as well as reduced pool levels during low and no flow conditions. Localised water quality changes were also observed due to surface and groundwater interactions.

Several techniques were applied during the remediation of the Georges River. These included:

- The release of supplementary flow to the river during low and no flow conditions;
- Grouting of fractures within the riverbed to increase surface flows and water holding capacity in impacted areas. Three main types of grouting were applied:
    - Shallow pattern grouting
    - Grouting of deep angled drilled holes targeting specific fractures
    - Grout curtains

The mitigation and rehabilitation work completed on the Georges River has allowed for a significant reduction in the impacts resulting from subsidence.

5.4. Infrastructure

Properties impacted during Longwall 38 are being managed by the MSB. Where required the survey control marks will be re-established following the completion of all movement in the area in consultation with the Department of Lands.

6. Longwall 38 Monitoring Program

A comprehensive monitoring program for Longwall 38 is undertaken as required by the Longwalls 37 and 38 EP Approval. The monitoring commitments undertaken for Longwall 38 are outlined in **Table 6-1**.

Table 6-1: Longwall 37 Monitoring Program for Natural Features

	Monitoring Site	Monitoring Type	Monitoring Frequency	Monitoring to Date	Future Monitoring
SURFACE WATER QUALITY					
AREA 5	***Longwall 37***			• Monthly monitoring before mining • Weekly monitoring during mining • Monthly monitoring after mining	• Monthly monitoring after mining. • Additional monitoring associated with agreed recommendations in the revised Georges River Remediation Plan.
	Georges River Upstream monitoring site: • Pool 54 Downstream monitoring site: • Pool 64	• Field testing of water quality parameters • Grab sample for testing of specific analytes at an accredited laboratory • Water level measurements (using benchmarks where they can be installed and/or photos) • Observational and photographic monitoring	• Monthly before and after mining • Weekly during mining (when the longwall is within 400 m)		
	Mallaty Creek Downstream monitoring sites: • MC100, MC106 and MC110				
	Nepean Creek Downstream monitoring site: • NC10				
	Tributary of Georges River Downstream monitoring site: • GR104 and 105				
	Longwall 38				
	Georges River Upstream monitoring site: • Pool 34 Adjacent monitoring site: • Pool 54 Downstream monitoring site: • GR100	• Field testing of water quality parameters • Grab sample for testing of specific analytes at an accredited laboratory • Water level measurements (using benchmarks where they can be installed and/or photos • Observational and photographic monitoring	• Monthly before and after mining • Weekly during mining (when the longwall is within 400 m)		
	Tributaries of Georges River Upstream monitoring site: • GR119 Adjacent monitoring sites: • GR107, GR108, GR110 Downstream monitoring sites: • GR102, GR103, GR114 and GR117				

7. References

BHP Billiton Illawarra Coal, 2013. *West Cliff Area 5 Longwalls 34 to 36: Georges River Management Plan*. Revised February 2013.

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

Biosis Research, 2007. Archaeological Cultural Heritage Assessment: Review of West Cliff Area 5, Appin NSW. An unpublished report for BHP Billiton Illawarra Coal.

Cardno Forbes Rigby Pty Ltd, March 2014, West Cliff Area 5 Longwalls 37 and 38 Extraction Plan.

- Annexure A: MSEC, June 2013, *Subsidence Predictions and Impact Assessments for the Natural Features and Surface Infrastructure in Support of the Extraction Plan*, Revision B, MSEC533.
- Annexure B: BHP Billiton, August 2013, *Subsidence Monitoring Program*, Revision A.
- Annexure C: Cardno Forbes Rigby Pty Ltd, March 2014, *Water Management Plan*, Revision B.
- Annexure D: Cardno Forbes Rigby Pty Ltd, August 2013, *Biodiversity Management Plan*, Revision A.
- Annexure E: Cardno Forbes Rigby Pty Ltd, August 2013, *Land Management Plan*, Revision A.
- Annexure F: Cardno Forbes Rigby Pty Ltd, August 2013, *Heritage Management Plan*, Revision A.
- Annexure G: Cardno Forbes Rigby Pty Ltd, August 2013, *Public Safety Management Plan*, Revision A.
- Annexure H: Cardno Forbes Rigby Pty Ltd, August 2013, *Built Features Management Plan*, Revision A.

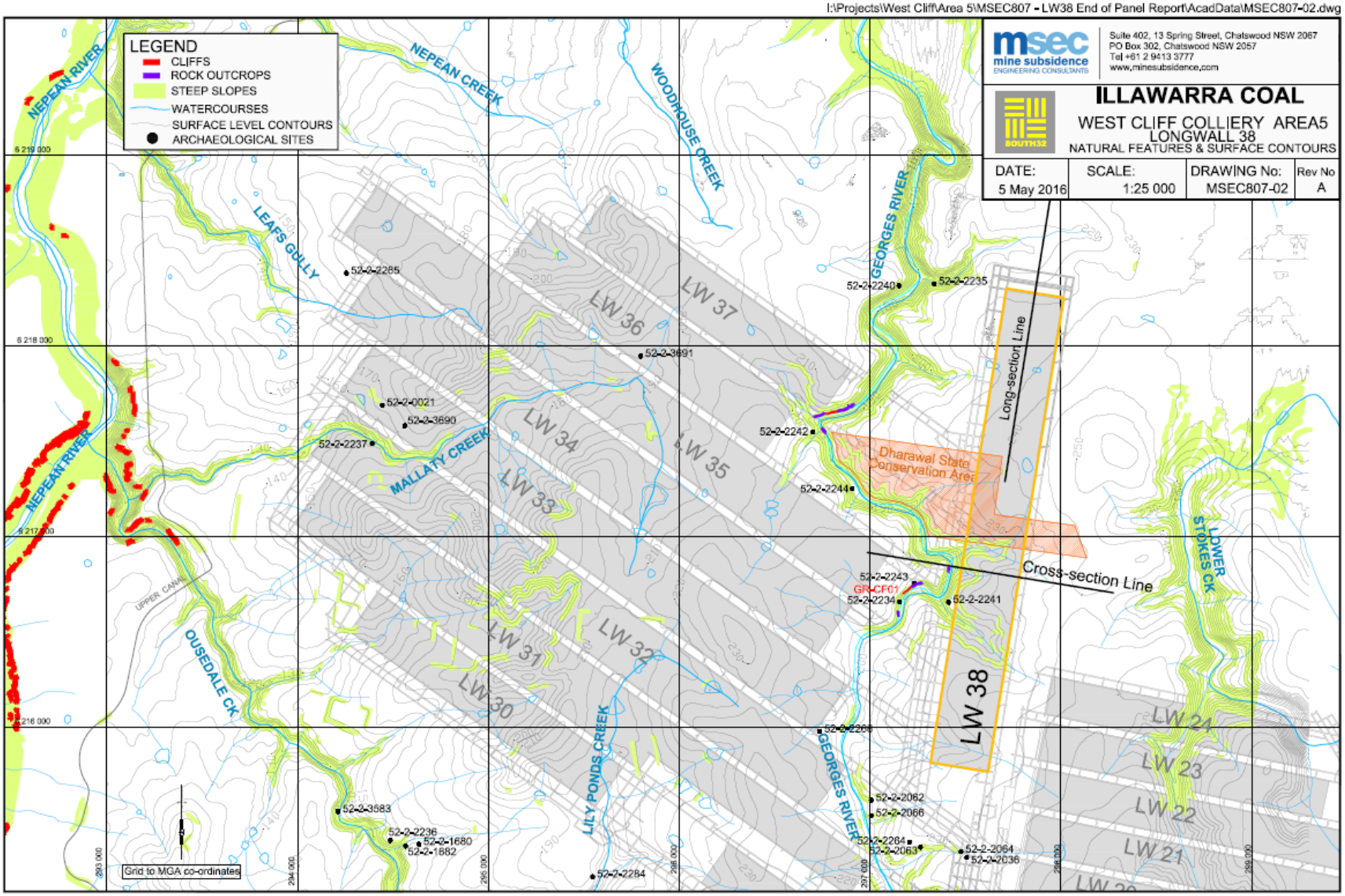
IRIS Research, 2011. The Economic Impact of Illawarra Coal, on the Illawarra/Wollondilly Region and New South Wales. April 2011. Prepared for BHP Billiton Illawarra Coal.

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

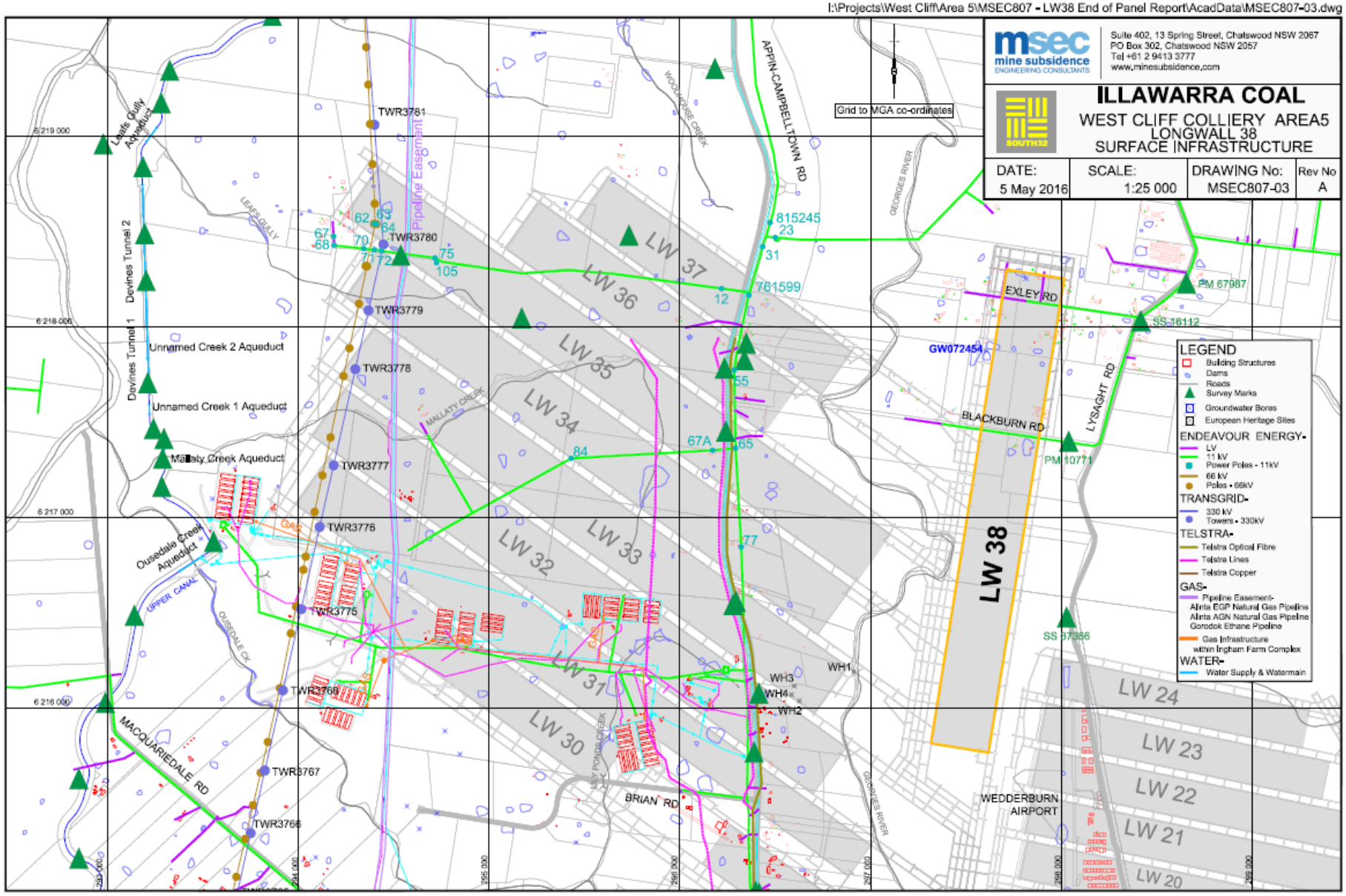
Niche, 2013. *West Cliff Longwalls 37 and 38 Terrestrial Flora and Fauna Assessment*.

8. Appendices

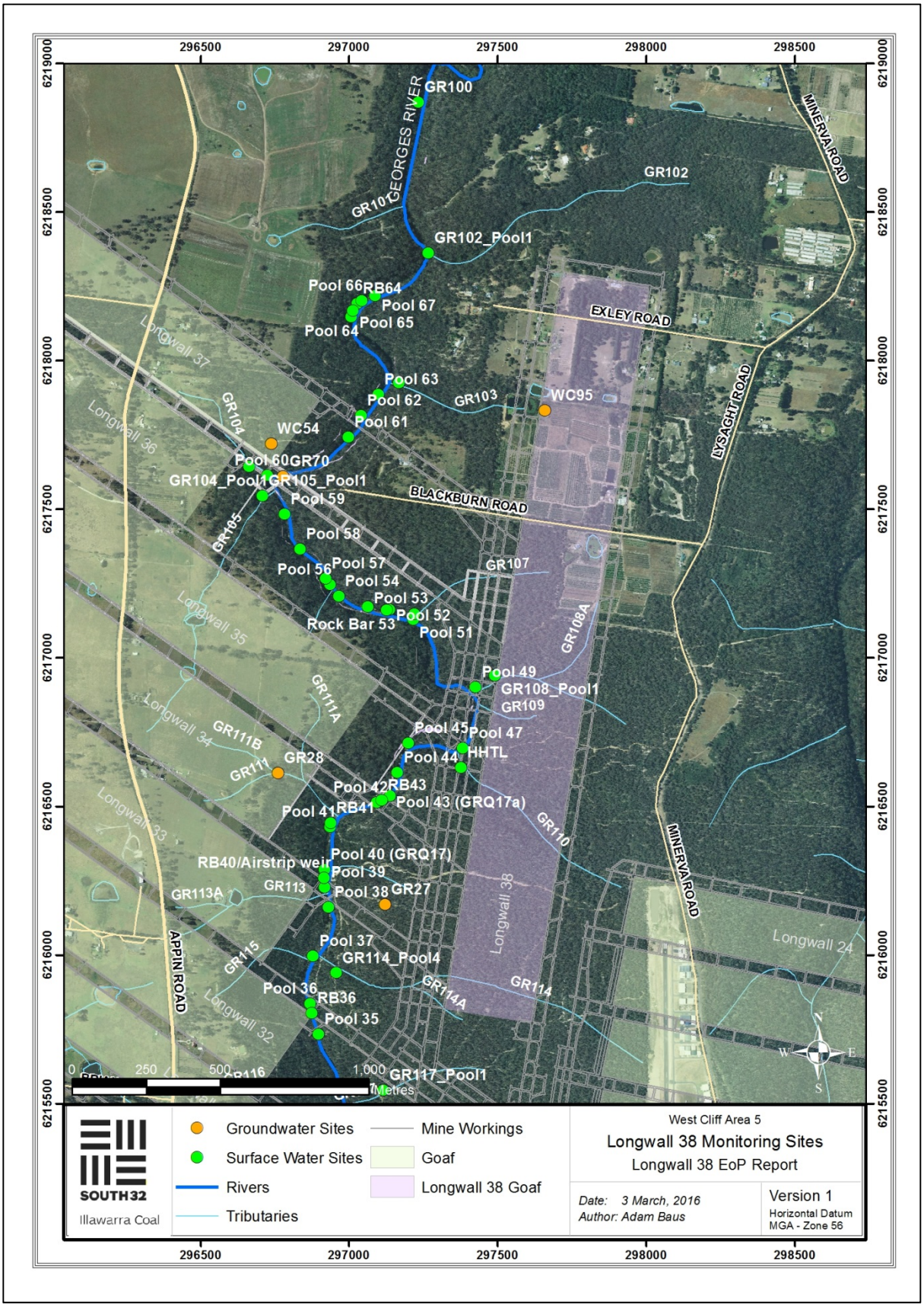
Appendix 8-1: West Cliff Colliery Area 5 Longwall 38 General Layout (MSEC 2016).



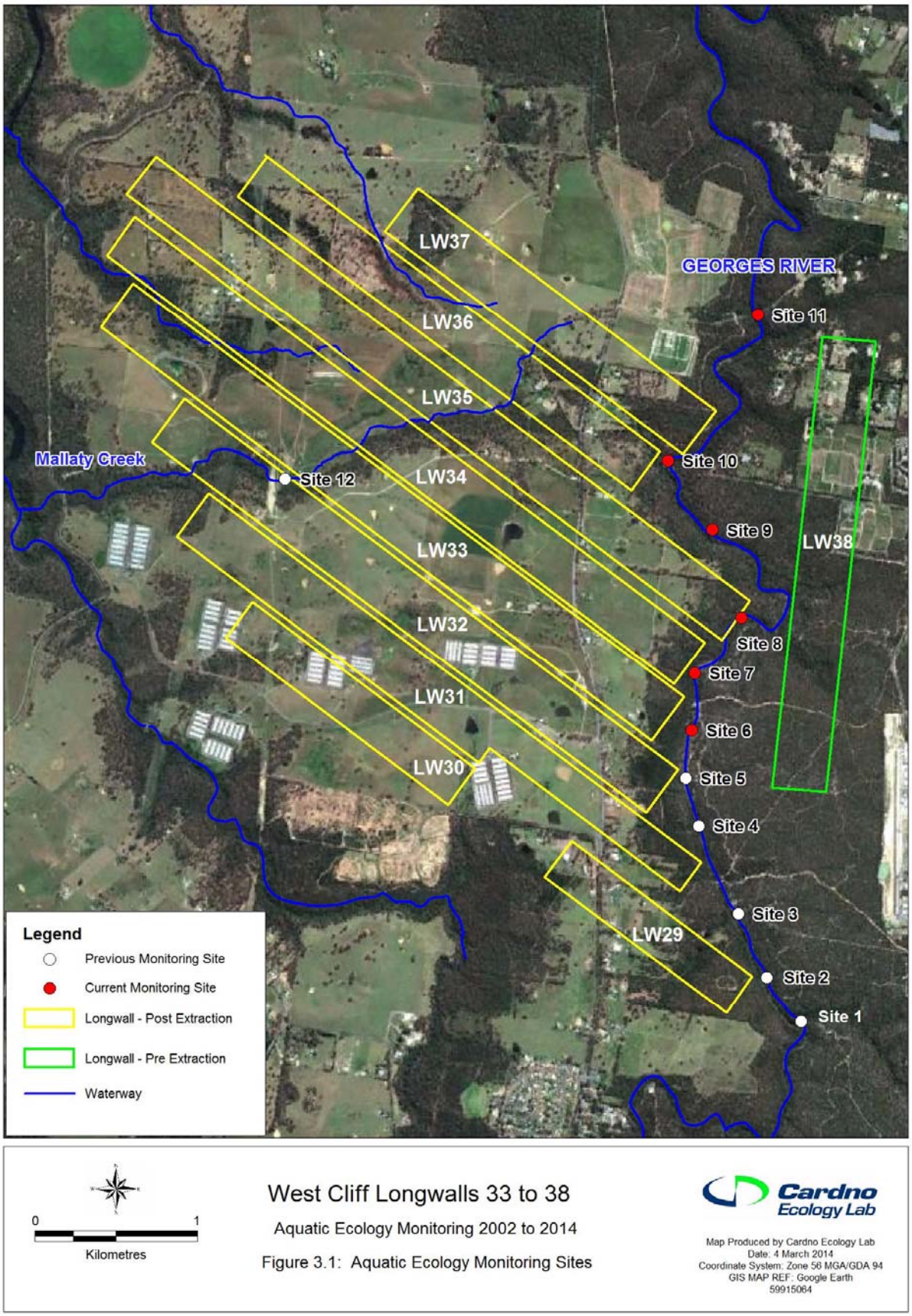
Appendix 8-2: West Cliff Colliery Area 5 Longwall 38 Surface Infrastructure (MSEC 2016).



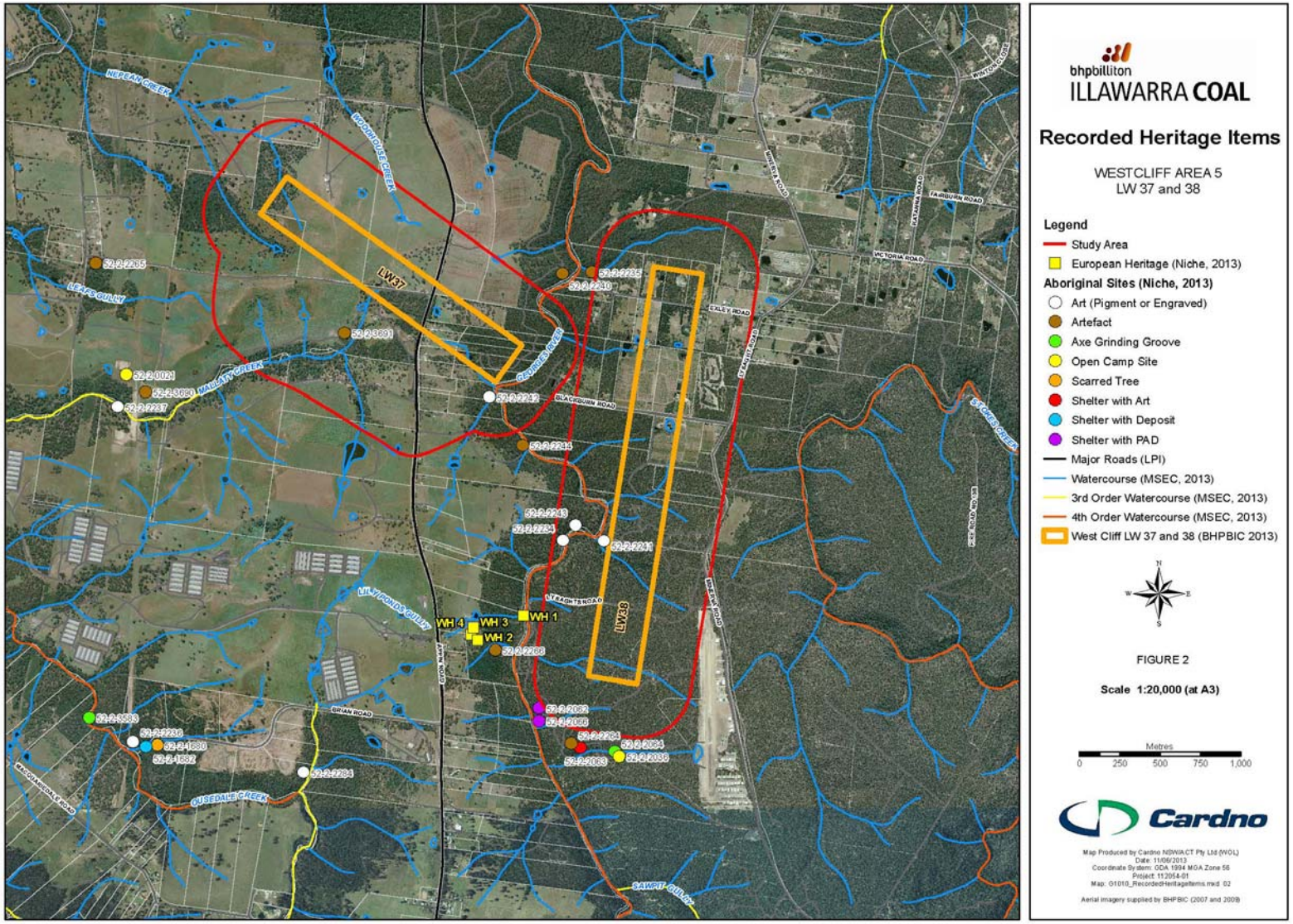
Appendix 8-3: Monitoring Sites along the Georges River (ICEFT sites)



Appendix 8-4: Aquatic Ecology Monitoring Sites (CEL, 2015)



Appendix 8-5: Cultural Heritage Monitoring Sites



Feature	Performance Measure*	Potential Impacts	*Exceeding* Prediction	TARP Trigger Level	Observed Impacts	Additional Comments / Recommendations
Appearance and Pool Water Level						
Georges River All mapped pools within the mining area	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, over at least 80% of the stream length subject to vertical subsidence >20 mm. No subsidence impact or environmental consequence greater than minor	• Fracturing and pool water level loss • Subsidence induced springs • Gas releases • Fracturing of rockbars and the stream bed where the subsidence movements are predicted to be highest • Changes in grade of drainage lines are considered small in comparison to natural grades. This is unlikely to result in significant increases in ponding or flooding, although some very localised impacts may occur • Diversion of surface water flows where fracturing coincides with a water controlling feature e.g. rock bar.	• More than negligible diversion of flows or changes in the natural drainage behaviour of pools over more than 20% of the stream length subject to vertical subsidence >20mm • More than negligible increase in water cloudiness over more than 20% of the stream length subject to vertical subsidence >20mm • More than negligible increase in iron staining over more than 20% of the stream length subject to vertical subsidence >20mm • Subsidence impacts or environmental consequences greater than minor	***Level 1*** • Fracturing with no observable surface water diversion • Pool water level lower than baseline in any mapped pool located in the mining area (within 400m of the longwall) • Increase in turbidity, iron staining, algal growth, or other visible water quality parameters determined by comparing baseline photos with photos during the mining period.	• **WCA5_LW38_009** Iron Staining downstream of Georges River GR_Pool 49	
				Level 2 • Pool water level lower than baseline in the majority of mapped pools located in the mining area (within 400m of the longwall) • Fracturing with observable surface water diversion.	• **WCA5_LW38_008** Rock Fracturing in Georges River GR_Rockbar 49	To be addressed in the Gorges River Rehabilitation Plan
				Level 3 • Pool water level lower than baseline in all mapped pools		

Feature	Performance Measure*	Potential Impacts	*Exceeding* Prediction	TARP Trigger Level	Observed Impacts	Additional Comments / Recommendations
				in the mining area (within 400m of the longwall) • Fracturing with observable water diversion results in any mapped pool becoming dry during a mitigation flow in the River.		
Tributaries of the Georges River ***Longwall 38*** Upstream monitoring site: • GR119 Adjacent monitoring sites: • GR107, GR108, GR110 Downstream monitoring sites: • GR102, GR103, GR114 and GR117	No greater subsidence impact or environmental consequences than predicted in the EA and PPR.	• Changes in grade of drainage lines are considered small in comparison to natural grades. This is unlikely to result in significant increases in ponding or flooding, although some very localised impacts may occur • Some compressive buckling and dilation of the uppermost bedrock could occur. However, the natural surface soil beds would limit exposure of fracturing at the surface and any minor occurrences are likely to be filled with the natural soils during subsequent flow events.			• **WCA5_LW38_001** Rock Fracturing in GR104 • **WCA5_LW38_002** Rock Fracturing in GR108 • **WCA5_LW38_003** Rock Fracturing in GR108 • **WCA5_LW38_004** Iron Staining in Mallaty Creek • **WCA5_LW38_005** Rock Fracturing in GR108 • **WCA5_LW38_007** Rock Fracturing in GR110	To be addressed in the Gorges River Rehabilitation Plan

Feature	Performance Measure*	Potential Impacts	*Exceeding* Prediction	TARP Trigger Level	Observed Impacts	Additional Comments / Recommendations
Landscape Features						
Cliffs GR-CL01 and GR-CL02 **Steep Slopes** **Georges River – including pools and rockbars** • GR-RB42 • GR-RB43 • GR-RB44 • GR-RB45 • GR-RB47 • GR-RB48 • GR-RB49 • GR-RB51 • GR-RB52 • GR-RB53 • GR-RB54 • GR-RB55 • GR-RB56a • GR-RB56b • GR-RB57 • GR-RB59 • GR-RB60 • GR-RB61 • GR-RB62 • GR-RB63 • GR-RB64 • GR-RB65 • GR-RB66 • GR-RB67	*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, 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).	• Minor cracking at the tops of steep slopes where the longwall mines directly beneath steep slopes. • Fracturing is possible to a small percentage of rock outcrops where located directly above Longwalls. • Possible for rock falls from cliffs • Low risk of cliff failures as there is no longwall mining directly beneath cliffs.	• For cliffs of 'special significance' - more than negligible environmental consequences (i.e. more than occasional rockfalls, displacement or dislodgement of boulders or slabs, or fracturing, that in total impact more than 0.5% of the total face area of such cliffs within any longwall mining domain) • Other cliffs - more than minor environmental consequences (that is occasional rockfalls, displacement or dislodgment of boulders or slabs or fracturing, that in total impact more than 3% of the total face area of such cliffs within any longwall mining domain)	***Level 1*** • Rock fall from a cliff where the cliff is left mostly intact (<10% length of the cliff) • Surface movement or rock displacement where any exposed soil surface is stable • Crack at the surface which does not result in ongoing erosion or ground movement • Erosion which stabilises within the period of monitoring without CMA • Crack or fracture up to 100mm width • Crack or fracture up to 10m length	• **WCA5_LW38_006** soil crack along a access track adjacent to Georges River • **WCA5_LW38_010** zone of fracturing to a rock outcrop adjacent to GR110 • **WCA5_LW38_011** soil crack along a access track adjacent to Georges River	
				Level 2 • Rock fall from cliff where the characteristics of the cliff change (>10% length of the cliff) • Ground disturbance that is unlikely to stabilise within the period of monitoring without CMA • Mass movement of a slope causing		

Feature	Performance Measure*	Potential Impacts	*Exceeding* Prediction	TARP Trigger Level	Observed Impacts	Additional Comments / Recommendations
				areas of exposed soil • Crack or fracture between 100 and 300mm width • Crack or fracture between 10 and 50m length		