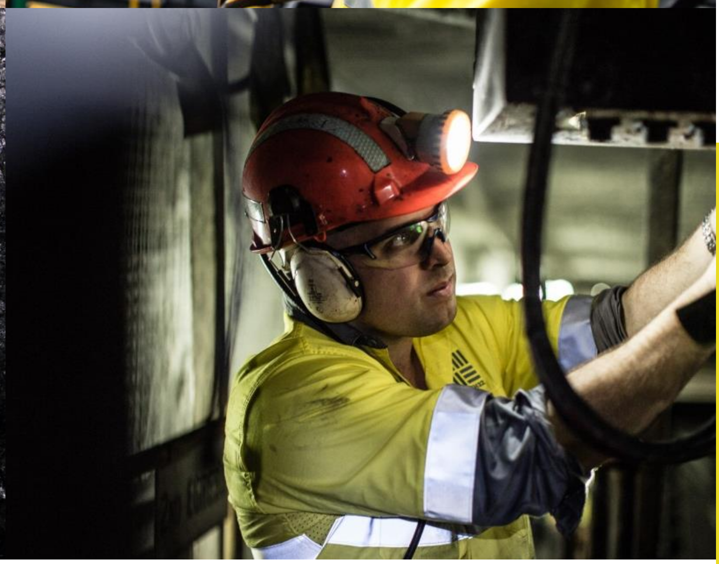
Illawarra Coal
End of Panel Report



Dendrobium Area 3B Longwall 13 End of Panel Report

August 2018

EXECUTIVE SUMMARY

This End of Panel (EoP) report has been prepared in accordance with Schedule 3 Condition 9 of the Dendrobium Development Consent (DA 60-03-2001). The EoP report outlines the measured and observed impacts during the extraction of Dendrobium Area 3B (DA3B) Longwall 13, and presents monitoring results and analyses compared to relevant impact assessment criteria and predictions in the DA3B Subsidence Management Plan (SMP).

Dendrobium Longwall 13 is located within Consolidated Coal Lease 768. Extraction of Longwall 13 commenced on 4th March 2017 and was completed on 19th April 2018, and is the fifth panel to be extracted in DA3B, with an extracted length of 2270 m, a void width of 305 m (including first workings) and a cutting height of between 3.7 and 3.95 m.

The extraction of underground coal reserves from DA3B provides benefits at international, national, state and local levels. Illawarra Coal (IC) provides coking coal to BlueScope Steel for its steelmaking production, and for export to overseas customers.

South32 IC provides 70% of BlueScope Steel's coking coal requirements. Mining operations at Dendrobium Colliery represents continuing significant capital and operating investments in the Southern Coalfield of New South Wales.

Continuing benefits occur through continuity of employment, expendable income, export earnings and government revenue. From the operations of Dendrobium Mine, Illawarra Coal paid approximately $45.2 Million in government royalties during the 2016/2017 financial year, and $37.9 Million during the 2017/2018 financial year.

Subsidence movements resulting from the extraction of Longwall 13 were monitored along lines and points within the SMP Area.

The maximum measured total closures at each of the Wongawilli Creek closure lines are equal to or less than the predictions after the completion of Longwall 13.

The maximum measured total closures at the Avon Dam closure lines are less than predicted after the completion of Longwall 13.

The mine subsidence movements across WC21, a tributary to Wongawilli Creek, have been measured with 2D survey using the WC21 F-Line, WC21 H-Line, WC21 I-Line, WC21 J-Line, WC21 K-Line, WC21 L-Line (lower) and WC21 L-Line (upper). The WC21 A-Line, B-Line, C-Line, D-Line, E-Line and G-Line were not required to be measured during Longwall 13. The measured total vertical subsidence and closure for the WC21 cross lines are less than predictive at the end of Longwall 13. The measured vertical subsidence movements range between 52 % and 72 % of the predicted values, with an average of 61 %. The measured closures range between 19 % and 95 % of the predicted values, with an average of 51 %. It is considered, therefore, that the ground movements measured along WC21 are consistent with the predicted movements.

The mine subsidence movements across LA4, a tributary to Avon Dam, were measured with 2D survey techniques using the LA4-Line. The base survey was carried out on the 26th February 2013, prior to the commencement of Longwall 9. The measured total closure for the LA4-Line was less than the predicted total closure at the completion of Longwall 13.

The maximum measured vertical subsidence for the SW13-Line of 48 mm is greater than the predicted value of less than 20 mm. This monitoring line is located more than 100 m south of the maingate of Longwall 13 and, therefore, only low-level vertical subsidence was predicted. The vertical subsidence could have developed further from Longwall 13 than predicted since SW13-Line is located upslope of the longwall maingate. The measured closure at SW13-Line was 2 mm, less than the predicted value of 150 mm.

The measured vertical subsidence and closure at the SW4-Line, SW10-Line and SW11-Line were all less than the predicted values. The measured vertical subsidence movements range between 66 % and 76 % of the predicted values. The measured closures range from less than 10 % to 45 % of the predicted values.

During the extraction of Longwall 13, forty-three new surface impacts were identified. These impacts are labelled as "*DA3B_LW13_001*" to "*DA3B_LW13_043*". Nineteen of these impacts were observed on natural features. The remaining twenty-nine were observed on built features such as fire roads and other access tracks, which were remediated (or observed as self-remediated) in accordance with Corrective Management Actions (CMAs).

At *Wongawilli Creek (FR6)*, the Trigger Action Response Plan (TARP) level for Electrical Conductivity (EC) was triggered on two occasions and the Dissolved Oxygen (DO) trigger level was exceeded on three occasions. Additionally, the EC of surface water increased at numerous stream monitoring sites across DA3A and DA3B during the extraction of Longwall 13. This trend is considered to reflect the unusually dry conditions during the extraction of Longwall 13 and evaporative concentration of dissolved salts in disconnected pools during low-flow and no-flow conditions.

The effects of mining subsidence on surface water hydrology was assessed by comparing observed stream flow characteristics for each monitored sub-catchment against predictions of streamflow from a calibrated rainfall-runoff model. There were three TARP triggers observed for sub-catchment yield change: Donalds Castle Creek (DCS2; Level 3); DC13 (DC13S1; Level 1); and LA4 (LA4S1; Level 1).

The average daily inflow to DA3B mine workings during Longwall 13 extraction was 4.68 ML/d, which represents approximately 62 % of total mine inflow for the period; the average daily inflow remained below the Level 1 TARP trigger level. The average water balance for DA3B, during the extraction of Longwall 13, was similar to the average water balance during the extraction of Longwall 12 (4.5 ML/day).

The estimated net loss of water from Lake Avon, based on numerical model predictions, at the end of Longwall 13 extraction, was less than 0.4 ML/d and therefore within the tolerable loss limit of 1 ML/day prescribed by the Dams Safety Committee (DSC) (DSC 2014).

Longwall 13 passed within 400 m of shallow groundwater and soil moisture sites within two swamps: Swamps 11 and 13. A level 1 Shallow Groundwater TARP trigger, and a Level 3 Soil Moisture TARP trigger, was observed at monitoring sites within Swamp 11. A level 3 Soil Moisture TARP trigger was observed at monitoring sites within Swamp 13.

The results of the Total Species Richness (TSR) analyses demonstrate the responses to mining at individual swamps are complex. Swamp 15A(2) and Swamp 15B exhibited a decline and subsequent increase in TSR following mining and changes in shallow groundwater. Whereas, Swamp 1A, Swamp 1B and Swamp 5 exhibited no statistically significant decline in TSR despite observed changes in shallow groundwater levels.

When accounting for yearly effects, a statistically significant change in species composition post-mining was detected at Swamp 15B and Swamp 15A(2). As with TSR, these changes were observed immediately following undermining and have continued at Swamp 15B and Swamp 15A(2) for at least four years post-mining.

Swamp extent analyses identified reductions in extent of two vegetation communities: MU43 (Tee-tree Thicket) and MU44c (Cyperoid Heath). Only declines in MU43 have been determined to be of statistical significance. Declines in the extent of MU44c, while triggering a Level 1 TARP, require further investigation to determine why this community is increasing in extent at some swamps and decreasing at others.

A reduction in habitat of the Littlejohn's Tree Frog was observed within streams impacted by subsidence.

Reductions in aquatic habitat for over 2 years in WC21 and Donalds Castle Creek constitute a Level 3 TARP trigger. No TARPs have been triggered with respect to Wongawilli Creek as there has not been a loss in aquatic habitat for longer than 1 year.

No impacts to Aboriginal archaeological sites were observed.

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1 INTRODUCTION

1.1 Approval and Legislative Requirements

Dendrobium Longwall 13 is located within Consolidated Coal Lease 768. Extraction of Longwall 13 commenced on 4th March 2017 and was completed on 19th April 2018, and is the fifth panel to be extracted in DA3B, with an extracted length of 2270 m, a void width of 305 m (including first workings) and a cutting height of between 3.7 and 3.95 m. This EoP report has been prepared in accordance with Condition 18 of the DA3B SMP Approval. The EoP report outlines the measured and observed impacts of Longwall 13 and analyses the monitoring results compared to relevant impact assessment criteria and predictions made in the SMP and associated management plans and reports.

The DA3B SMP was approved by Department of Trade and Investment, Regional Infrastructure and Services NSW (DTI) on the 5th February 2013 and the Department of Planning and Environment (DP&E) on the 6th February 2013. The SMP approval is provided as **Attachment A**.

Schedule 3 Conditions 9 and 10 of the Development Consent is provided in Table 1.

Table 1: Longwalls 9 – 13 SMP Approval Condition for End of Panel Reporting

SMP Approval Condition	Relevant Section in EoP Report
Schedule 3 of Development Consent DA60-03-2001 – MOD 7 **9.** Within 4 months of the completion of each longwall panel, or as otherwise permitted by the Director-General, the Applicant shall: 1. prepare an end-of-panel report – reporting all subsidence effects (both individual and cumulative) for the panel and comparing subsidence effects with predictions; – describing in detail all subsidence impacts (both individual and cumulative) for the panel; – discussing the environmental consequences for watercourses, swamps, water yield, water quality, aquatic ecology, terrestrial ecology, groundwater, cliffs and steep slopes; and – comparing subsidence impacts and environmental consequences with predictions; and 2. Submit the report to the Department, DPI, SCA, DECC, DWE and any other relevant agency to the satisfaction of the Director-General	*Sections 4 to 8, Attachments B to F*
10. The Applicant shall include a comprehensive summary, analysis and discussion of the results of monitoring of subsidence effects, subsidence impacts and environmental consequences in each AEMR	*The AEMR (July to June) is submitted in August each year*

The impact predictions for Longwall 13 are described in the following reports:

- BHPBIC, November 2012 -DA3B SMP;
- South32, October 2015 – DA3B Watercourse Impact Monitoring Management and Contingency Plan (WIMMCP), Revision 1.5;
- South32, October 2015 – DA3B Swamp Impact, Monitoring, Management and Contingency Plan, Revision 1.5.

Impacts have been reported by the Illawarra Coal Environmental Field Team (ICEFT) and specialist consultants during and following mining.

1.2 Economic Benefits

The extraction of underground coal reserves from DA3B provides benefits at international, national, state and local levels. Illawarra Coal provides coking coal to BlueScope Steel for its steelmaking production, and for export to overseas customers.

South32 IC provides 70% of BlueScope Steel's coking coal requirements. Mining operations at Dendrobium Colliery represents continuing significant capital and operating investments in the Southern Coalfield of New South Wales.

Continuing benefits occur through continuity of employment, expendable income, export earnings and government revenue. From the operations of Dendrobium Mine, IC paid approximately $45.2 Million in government royalties during the 2016/2017 financial year, and $37.9 Million during the 2017/2018 financial year.

1.3 Stakeholder Consultation

Provision of monitoring data and ongoing information to the community has been undertaken during the extraction of DA3B. Information on South32 operations is provided to the community through the following mechanisms:

- Community information sheets and letter box drops;
- Media releases and other media activities;
- General community surveys and reports;
- Dendrobium Community Newsletter – distributed to the community;
- Internet site http://www.south32.net/our-operations/australia/illawarra-coal/regulatory-document;
- Dendrobium Community Consultative Committee (DCCC) Meetings;
- Landholder relations program;
- Annual review reports; and
- Information days.

Illawarra Coal aims to mitigate the potential impacts subsidence may cause on individuals through various means outlined in Table 2.

Table 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 • Level of satisfaction with the company's subsidence management practices • The extent to which the community attributes environmental, social and economic change within the community to mining activities	• The DCCC meetings including presentations and explanations of how and why subsidence occurs, and its potential impacts • A biennial telephone survey of residents in the communities in which Illawarra Coal operates. The survey aims to determine the community's perception of the company's overall performance

2 PREDICTED AND OBSERVED SUBSIDENCE

Subsidence movements resulting from the extraction of Longwall 13 were monitored along lines and points within the SMP Area. A comparison of the observed and predicted movements has been prepared by MSEC and is included as Attachment B.

Monitoring points and lines associated with Longwall 13 include (Figure 1):

- Wongawilli Creek Closure Lines;
- Avon Dam Closure Lines;
- DA3B 3D and Avon Dam 3D Monitoring Points;
- Tributary Cross Lines;
- Donalds Castle Creek Cross lines;
- Swamp Cross Lines; and
- Airborne Laser Scans (ALS) of the area.

The predicted subsidence values have been derived from the predicted subsidence contours illustrated in Report No. MSEC865. The predicted closures are based on a combination of the conventional and valley related movements, taking the equivalent heights within half-depths of cover from the valley bases.

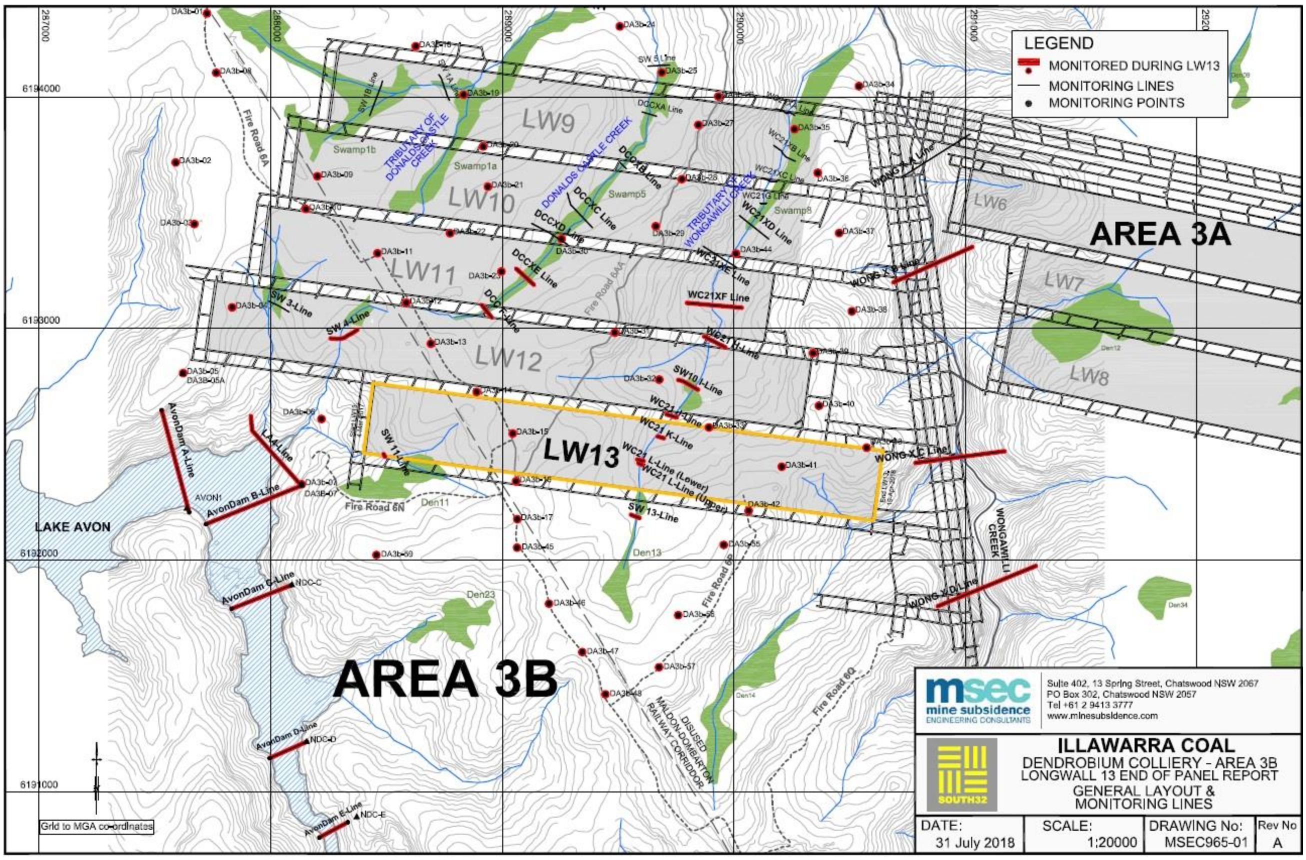

Figure 1: Overview of subsidence monitoring sites, comprised of monitoring lines and monitoring points.

2.1 Wongawilli Creek Closure Lines

The closure movements across Wongawilli Creek have been measured using 2D survey techniques at the Wong X B-Line, Wong X C-Line and Wong X D-Line. The Wong X A-Line was not required to be measured at the completion of Longwall 12 or Longwall 13 due to its distance from these longwalls.

The maximum measured total closures at each of the Wongawilli Creek closure lines are equal to or less than the predictions after the completion of Longwall 13 (Figure 2).

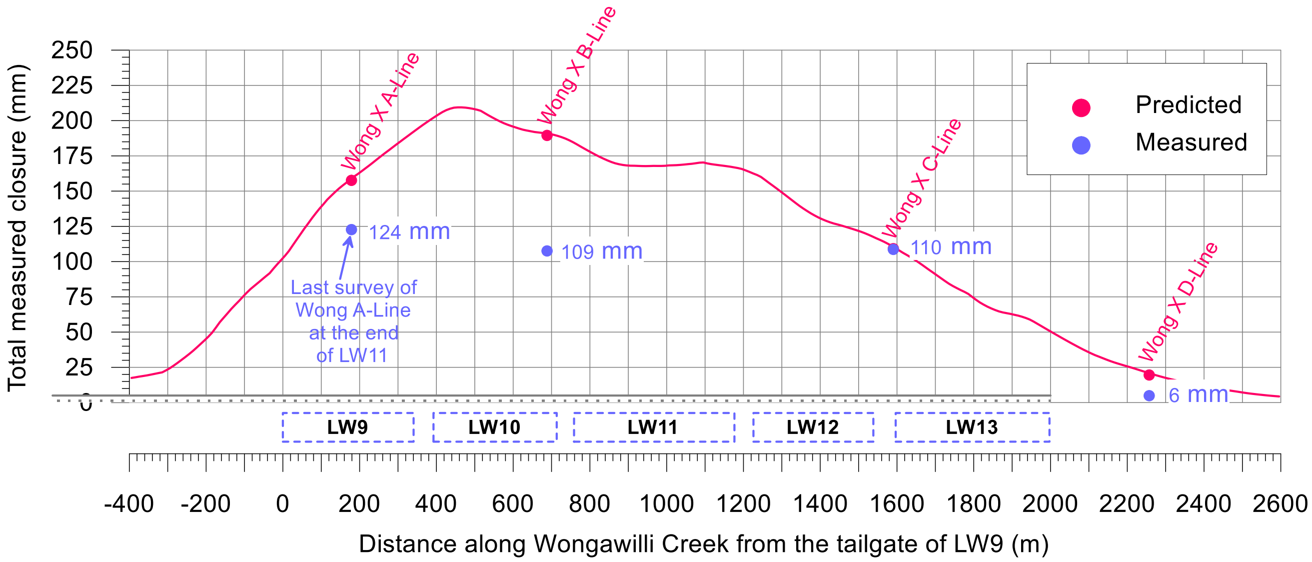

Figure 2: Measured and predicted total closure along Wongawilli Creek after the extraction of LW13. Source: MSEC (2018).

2.2 Donalds Castle Creek Cross Lines

The mine subsidence movements across Donalds Castle Creek were measured using 2D survey techniques using the DCCXE-Line and DCCXF-Line. The DCCXA-Line, DCCXB-Line, DCCXC-Line and DCCXD-Line were not required to be measured during Longwall 13.

2.3 Avon Dam Closure Lines

The baseline surveys of Avon Dam closure lines were carried out prior to the commencement of Longwall 12 (in February 2016) and, therefore, the closure lines have measured the accumulated movements due to the extraction of Longwall 12 and Longwall 13 only.

The maximum measured cumulative closures at the Avon Dam closure lines are less than the predicted closures after the completion of Longwall 13. The extraction of Longwall 13 resulted in additional closure at the A-Line but reduced closure at the other monitoring lines. The final measured movements at the B-Line, D-Line and E-Line are similar to the order of accuracy of the survey measurements.

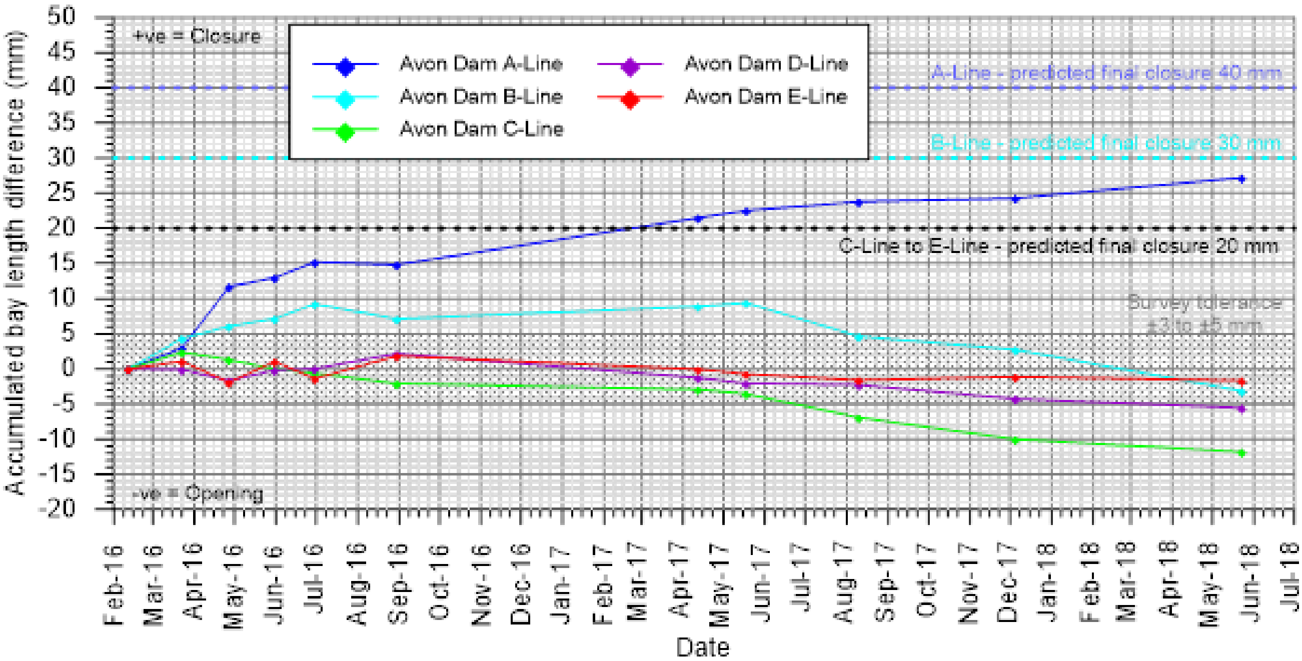

Figure 3: Measured and predicted closure for the Avon Dam closure lines. Source: MSEC (2018).

2.4 Wongawilli Creek Tributary and Lake Avon Tributary Cross Lines

The mine subsidence movements across WC21, a tributary to Wongawilli Creek, have been measured with 2D survey techniques using the WC21 F-Line, WC21 H-Line, WC21 I-Line, WC21 J-Line, WC21 K-Line, WC21 L-Line (lower) and WC21 L-Line (upper). The WC21 A-Line, B-Line, C-Line, D-Line, E-Line and G-Line were not required to be measured during Longwall 13. The measured total vertical subsidence and closure for the WC21 cross lines are less than the predicted values at the end of Longwall 13. The measured vertical subsidence movements range between 52 % and 72 % of the predicted values, with an average of 61 %. The measured closures range between 19 % and 95 % of the predicted values, with an average of 51 %. It is considered, therefore, that the ground movements measured along WC21 are generally consistent with or less than the predicted movements.

The mine subsidence movements across LA4, a tributary to Avon Dam, were measured with 2D survey techniques using the LA4-Line. The base survey was carried out on the 26th February 2013, prior to the commencement of Longwall 9. The measured closure for the LA4-Line was less than the predicted closure at the completion of Longwall 13.

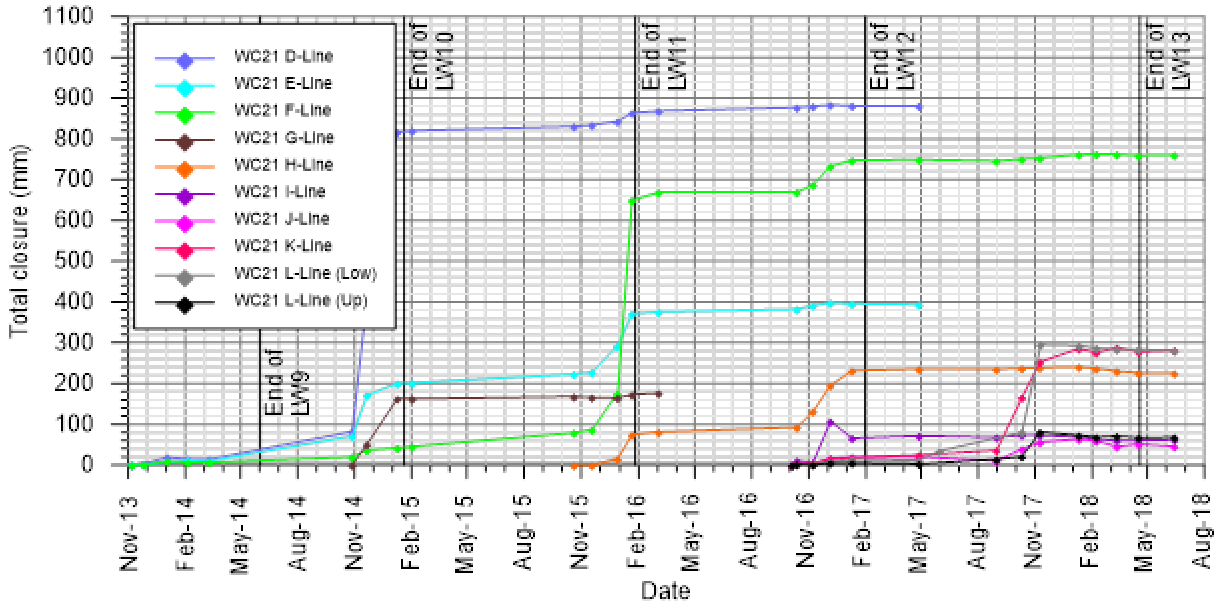

Figure 4: Measured and predicted closure for WC21 cross lines. Source: MSEC (2018).

2.5 Swamp Cross Lines

The mine subsidence movements across the swamps have been measured using 2D survey techniques at the SW4-Line, SW10-Line, SW11-Line and SW13-Line.

The maximum measured vertical subsidence for the SW13-Line of 48 mm is greater than the predicted value of less than 20 mm. This monitoring line is located more than 100 m south of the maingate of Longwall 13 and, therefore, only low-level vertical subsidence was predicted. The vertical subsidence could have developed further from Longwall 13 than predicted since SW13-Line is located upslope of the longwall maingate. The measured closure at SW13-Line was 2 mm, less than the predicted value of 150 mm.

Elsewhere, the measured vertical subsidence and closure at the SW4-Line, SW10-Line and SW11-Line were all less than the predicted values. The measured vertical subsidence movements range between 66 % and 76 % of the predicted values. The measured closures range from less than 10 % to 45 % of the predicted values.

Thus, the subsidence movements measured using Swamp cross lines are considered to be generally consistent with or less than the predicted subsidence movements.

2.6 Dendrobium Area 3B 3D and the Avon Dam 3D monitoring points

The far-field horizontal movements near Longwall 13 have been measured using DA3B 3D monitoring points and the Avon Dam 3D monitoring points (Figure 1). The accuracies of the measured absolute positions (i.e. Eastings and Northings) are in the order of ±20 mm.

Following the extraction of Longwall 13, the vectors of incremental horizontal movement were typically orientated towards Longwall 13 and were skewed towards the east, i.e. towards the longwall finishing end (Figure 6). The greatest movements have been measured directly above Longwall 13 and, to lesser extents, above the previously extracted Longwall 12. Only low-level incremental horizontal movements have been measured outside the extents of the mining area.

The comparison between the maximum measured incremental horizontal movements at the DA3B 3D and Avon Dam 3D monitoring points with those previously measured in Dendrobium Area 1 (DA1 3D) and Dendrobium Area 2 (DA2 3D), Dendrobium Area 3A (DA3A 3D), as well as other collieries in the Southern Coalfield, is provided in Fig. 2.4. The mean and the 95 % confidence level for the 3D monitoring data at Dendrobium Mine are also shown in this figure. The measured incremental horizontal movements resulting from the extraction of Longwall 13 (i.e. purple diamonds and circles) are typically within the range of those measured at similar distances from previously extracted longwalls at Dendrobium Mine (i.e. blue, cyan, green, brown, orange, red and magenta diamonds) and elsewhere in the Southern Coalfield (i.e. grey triangles).

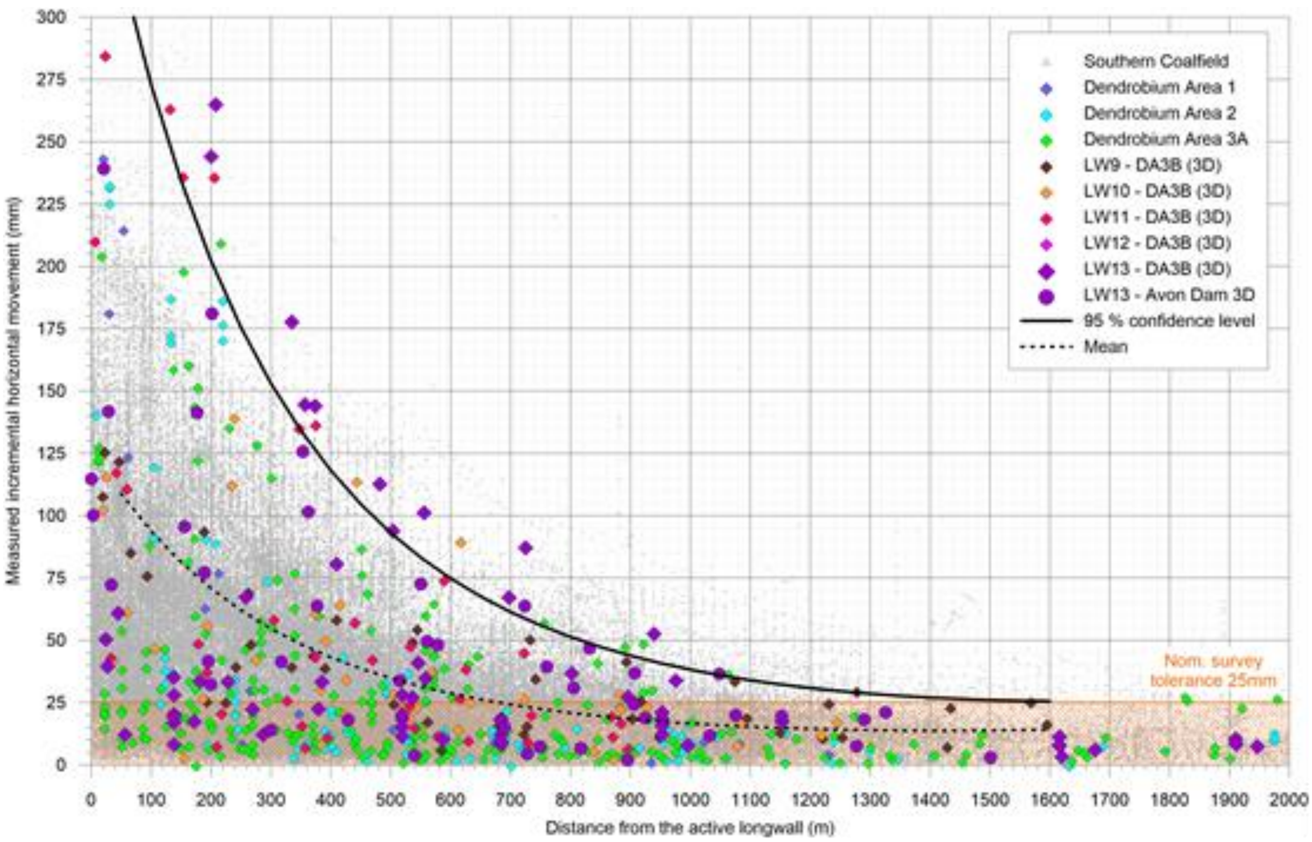

Figure 5: Measured incremental horizontal movements at Dendrobium Mine. Source: MSEC (2018).

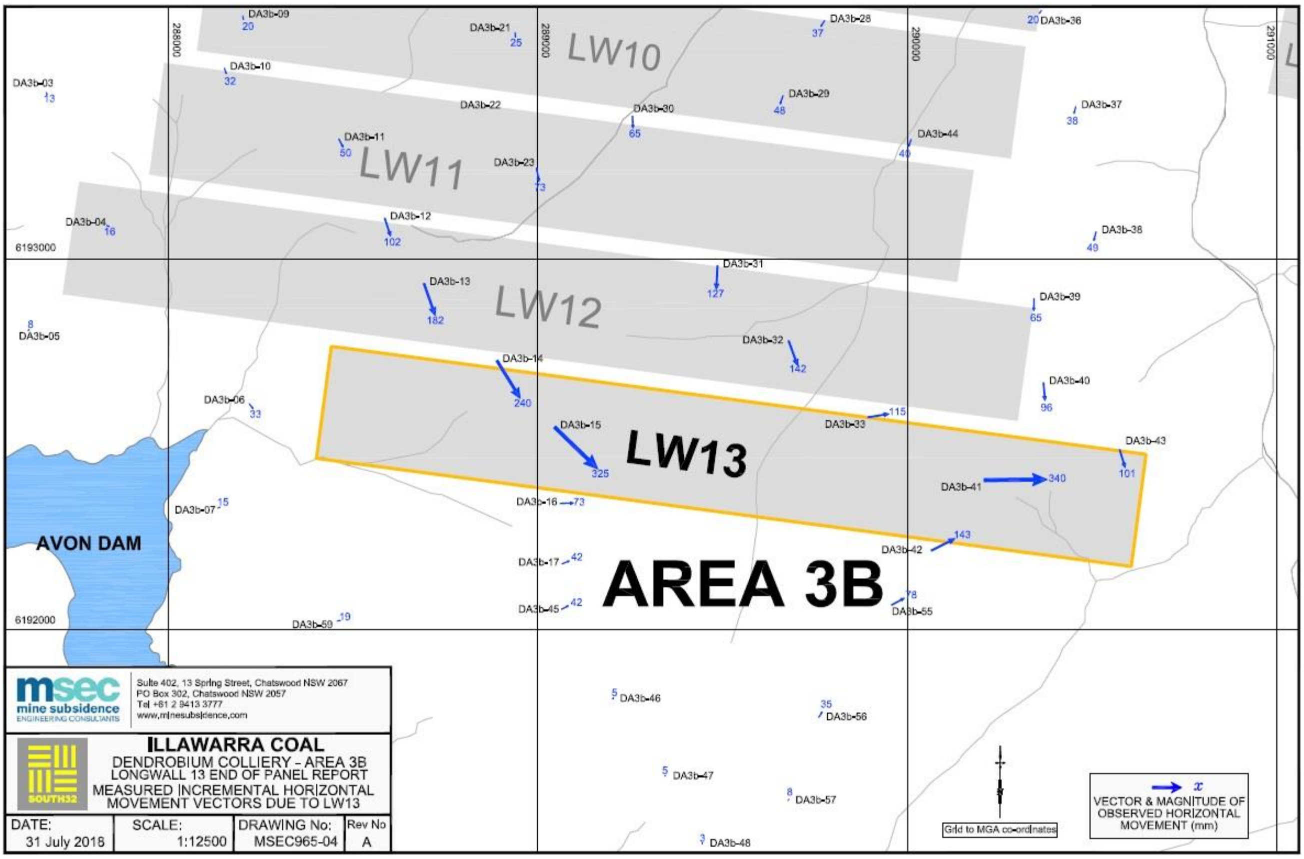

Figure 6: Incremental horizontal movement vectors following the extraction of Longwall 13.

2.7 ALS / LiDAR Surveys

The changes in surface level due to the extraction of Longwalls 9 to 13 have been measured using Airborne Laser Scan (ALS) / Light Detection and Ranging (LiDAR) surveys. The initial surface level contours have been determined from the base survey carried out in January 2013, prior to the extraction of Longwall 9. The post-mining surface level contours have been determined from the subsequent surveys carried out in February 2014 after Longwall 9, in January 2015 after Longwall 10, in April 2016 after Longwall 11, in March 2017 after Longwall 12 and in May 2018 after Longwall 13.

The changes in surface level were determined by calculating the differences between pre-mining surface levels and post-mining surface levels, incrementally (Figure 7), and cumulatively (Figure 8).

The profiles of the measured changes in surface-level reasonably match the predicted profiles of vertical subsidence along each of the cross-sections and long-section (Figure 9, Figure 10, Figure 11 and Figure 12). The maximum measured changes in surface level above each of the longwalls are less than the maximum predicted values. Also, the measured changes in surface level above each of the chain pillars are similar to, but slightly less, than the predicted values in these locations.

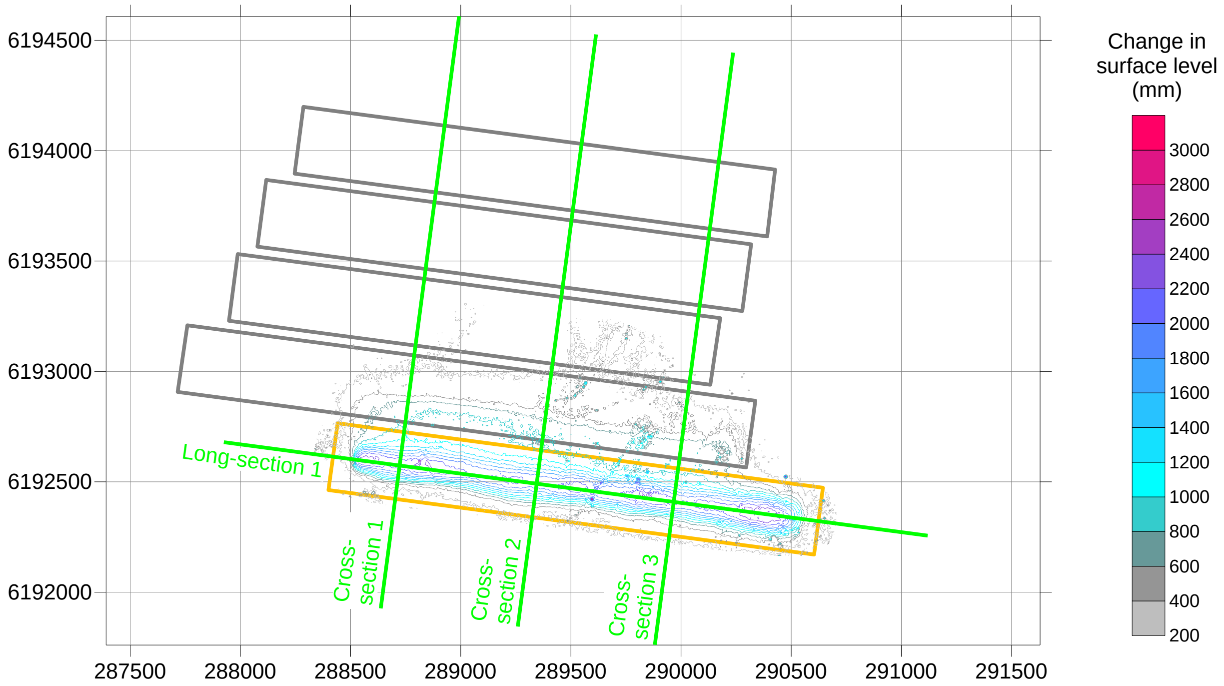

Figure 7: Measured incremental changes in surface level due to the extraction of Longwall 13. Source: MSEC (2018).

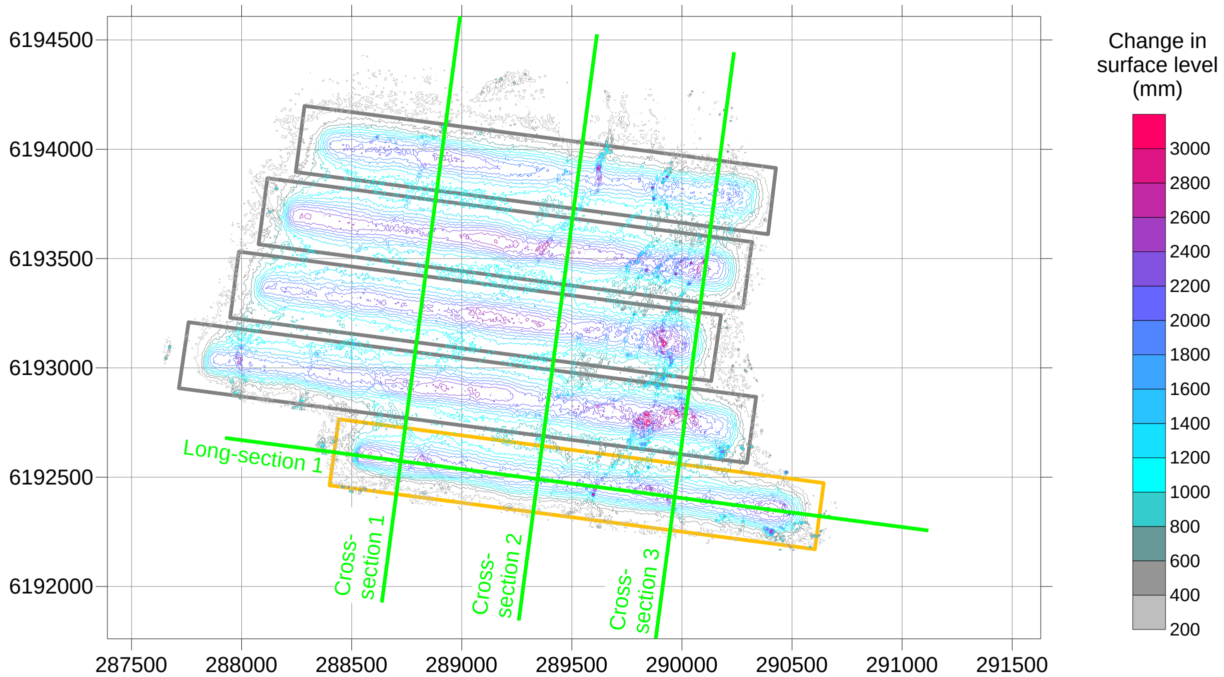

Figure 8: Measured cumulative changes in surface level due to the extraction of Longwalls 9 to 13.

The measured change in surface level along Long-section 1 (refer to Fig. 2.11) is greater than the predicted vertical subsidence above the commencing end of Longwall 13 (i.e. left side of figure). However, this may be partly due to the effects of the horizontal movements detected by the LiDAR surveys. The ground directly above the commencing end of Longwall 13 has moved towards the ends (i.e. following the extraction face) as illustrated in the horizontal movement vectors in Figure 6. The natural surface dips towards the west in this location (i.e. towards the thalweg of LA4B). The mining-induced horizontal movement, therefore, results in the measured changes in level at a fixed position to be greater than the true vertical subsidence above the commencing end of Longwall 13.

There are localised areas outside of the longwalls where the measured changes in surface level exceed the predicted vertical subsidence. However, these are artefacts of the LiDAR surveys and are not real movements. It is considered that the subsidence movements measured using the LiDAR surveys are consistent with the predicted subsidence movements.

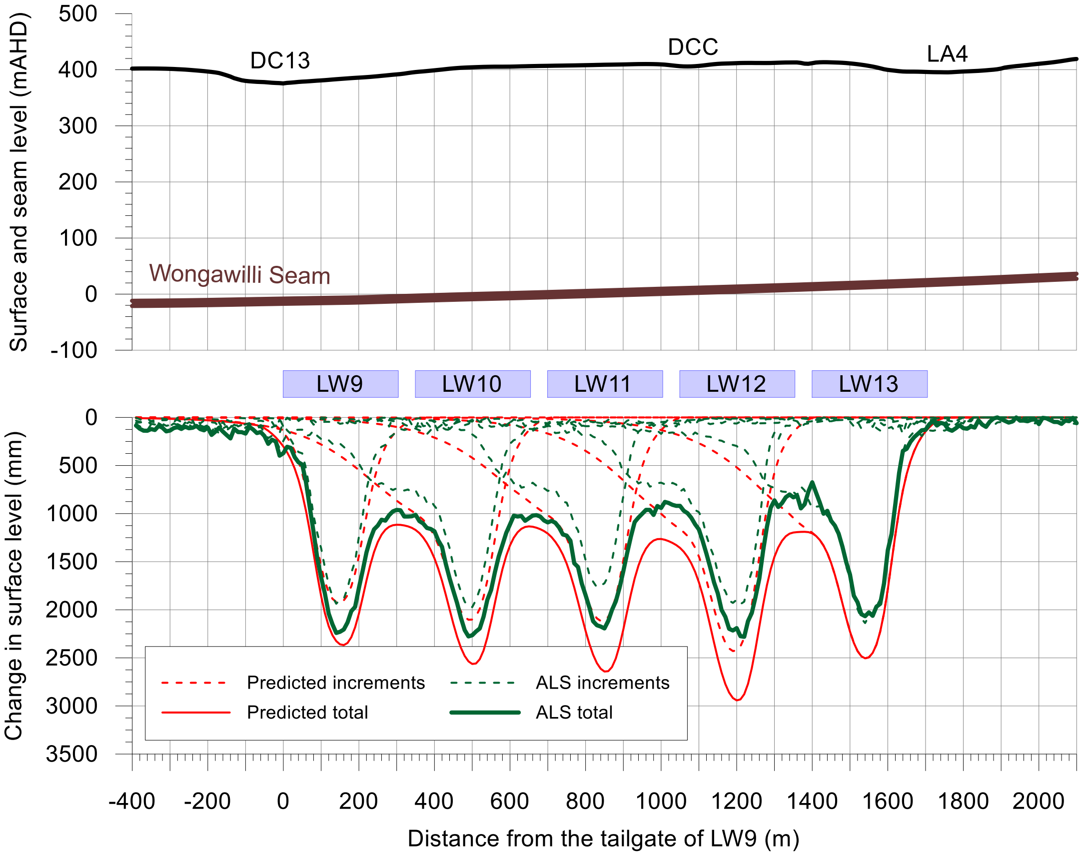

Figure 9: Measured changes in surface level and predicted vertical subsidence along Cross-section 1.

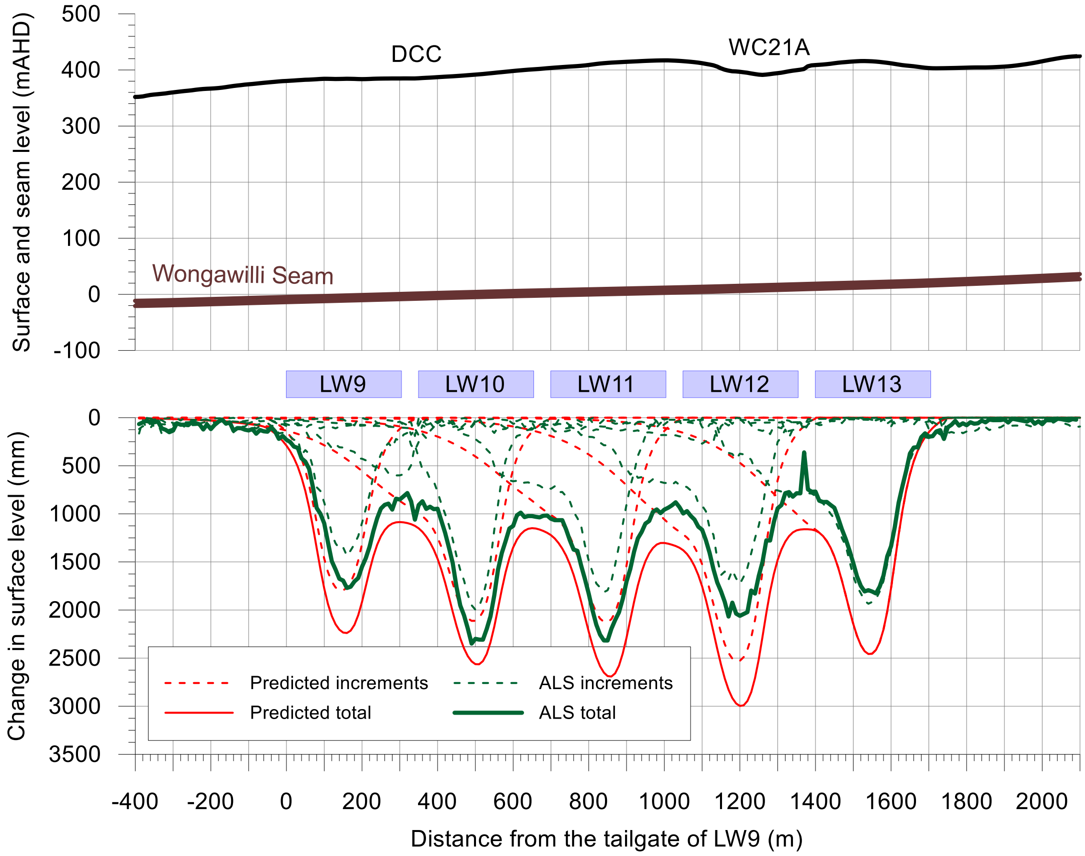

Figure 10: Measured changes in surface level and predicted vertical subsidence along Cross-section 2

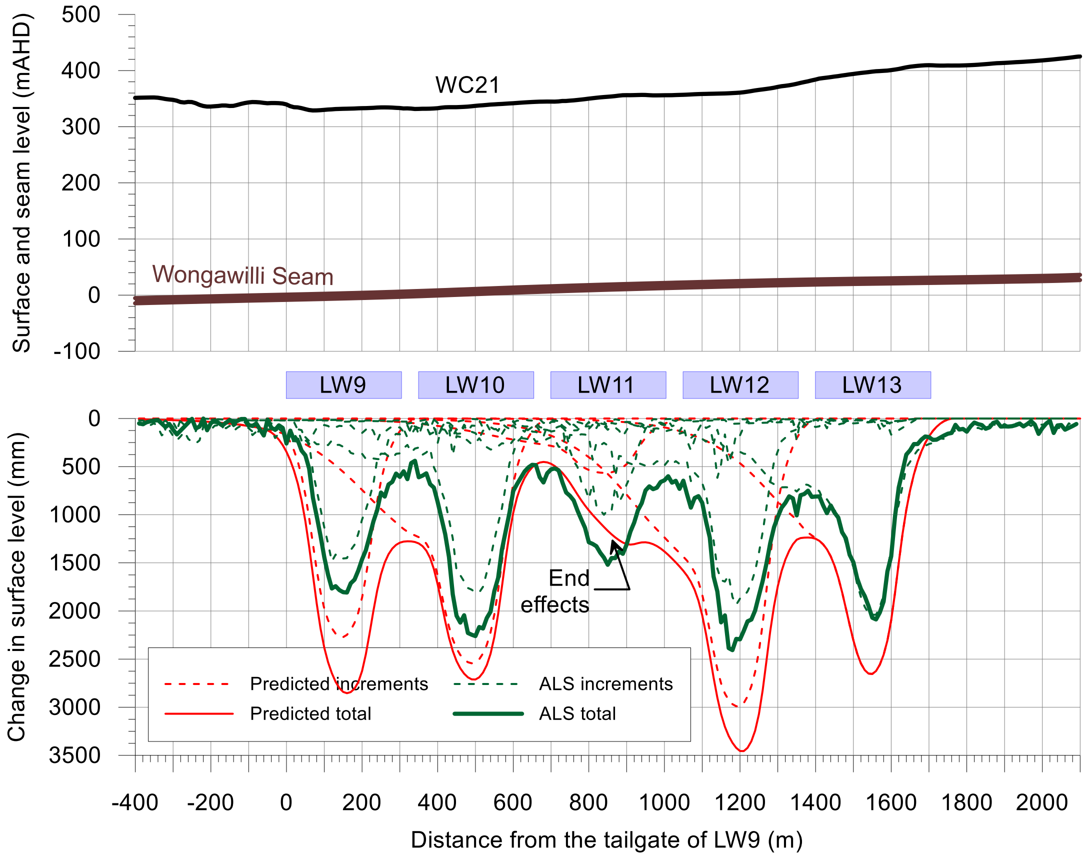

Figure 11: Measured changes in surface level and predicted vertical subsidence along Cross-section 3.

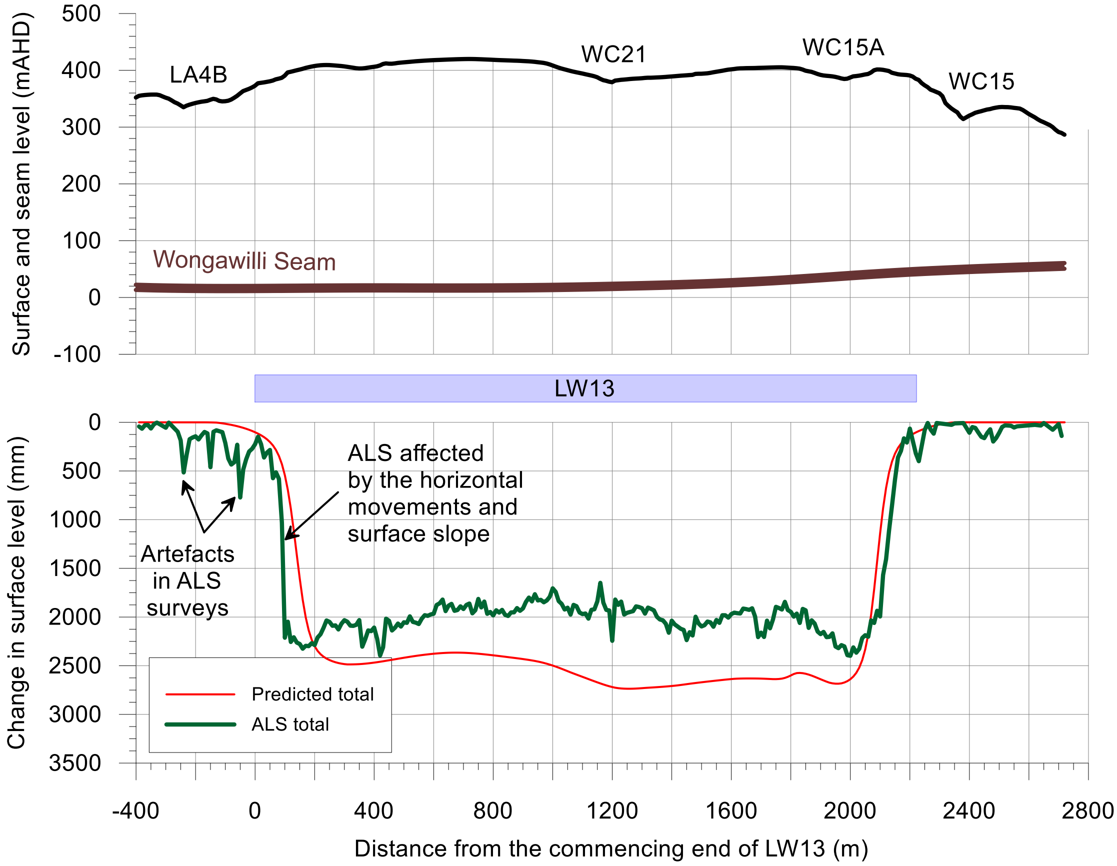

Figure 12: Measured changes in surface level and predicted vertical subsidence along Long section 1.

3 IMPACTS TO NATURAL FEATURES

During the extraction of Longwall 13, forty-three new surface impacts were identified. These impacts are labelled as "*DA3B_LW13_001*" to "*DA3B_LW13_043*". Other triggers are addressed in their respective sections, with further detail in the attached specialist assessments.

The monitoring program for Longwall 13 was conducted in accordance with the SMP, WIMMCP and SIMMCP. The monitoring program is outlined in Section 6. The results of the ICEFT monitoring are provided in Attachment C1; the Impact Reports submitted during the extraction of Longwall 13 are provided as Attachment C2. The results of monitoring undertaken by specialist consultants are provided as Attachments D to H. Figure 17 illustrates the location of surface impacts identified during the extraction of Longwall 13.

3.1 Landscape Features

Subsidence includes vertical and horizontal movement of the land surface, which can result in surface and subsurface cracking, uplifting, buckling, dilation and tilting. These impacts can affect watercourse hydrology and morphology, swamp hydrology and ecological function, and other landscape features by means of surface cracking, which can lead to erosion and rock falls. Potential mine subsidence impacts within DA3B are discussed in the DA3B SMP, WIMMCP and SIMMCP.

An overview of impacts observed during the extraction of Longwall 13 is provided in the following sections. For specific details on the impacts, refer to the relevant impact reports (**Attachment C2**).

3.1.1 Impacts to First and Second Order Streams

Ten first and second order streams were monitored as part of the Longwall 13 monitoring program; *LA4, LA4B, LA4A, LA4A1, WC21, WC21A, WC16, WC15, WC15A* and *WC15A1*. Impacts observed at these streams during Longwall 13 are described below.

3.1.1.1 LA4

Impact DA3B_LW13_001

Rock fracturing to the downstream end of tributary *LA4* was initially reported on the 4th May 2016. Following the impact, high discharge flow events have likely caused the dislocation and downstream transport of large rock fragments. An inspection on the 19th April 2017 revealed fracturing to the base of the pool at monitoring site *LA4S1* (Photo 1 and Photo 2). Flow diversion was observed through the fracturing, directly upstream from the installed concrete weir, which forms part of the flow monitoring installation at the site (Photo 3 and Photo 4).

Level 2: Crack or fracture between 100 and 300 mm width at its widest point or any fracture which results in observable loss of surface water or erosion.

Photo 1: Fracturing downstream from concrete weir, looking upstream. Taken on 19th April 2017.

Photo 2: Fracturing downstream from concrete weir, looking downstream. Taken on 19th April 2017.

Photo 3: Flow diversion adjacent to monitoring equipment at *LA4S1*. Taken on 3rd May 2017.

Photo 4: Flow diversion through fracturing in base of pool. Taken on 3rd May 2017.

Impact DA3B_LW13_043

Impact *DA3B_LW13_043* is located on *LA4*, a tributary to *Lake Avon*, 300m from the commencing end of Longwall 13, and 300m from the southern edge of Longwall 12. The impact was identified on the 18th May 2018. The impact is comprised of rock fracturing, associated rock fragmentation and iron staining to *LA4_Step 0* (Photo 9), which is the most downstream feature before entering Lake Avon. The fracturing is 2 m in length and 0.02 m in width; the rock fragment is 1.5 m in length, 0.5 m in width and 0.3 m in height (Photo 9). These impacts are not evident in baseline photos from 2011 (Photo 6). There was no surface flow at the site during the inspection; however, diversion of flow is likely to occur to some degree. Given the proximity of the site to the commencing end of Longwall 13 and previously recorded impacts (i.e. *DA3B_LW13_001*), it is probable that the impact originated approximately one year before it was first identified. Previously, the site has been inundated by reservoir water, which would have obscured identification of the impact.

<u>Level 2:</u> Crack or fracture that results in observable loss of surface water or erosion and/or observable increase in iron staining within the mining area continues to outside the mining area.

Photo 5: *LA4_Step 0*, looking across stream; the pooling to the left of the image is *Lake Avon reservoir* water. Taken 18th May 2018.

Photo 6: *LA4_Step 0*, looking across stream; the pooling to the left of the image is *Lake Avon reservoir* water. Taken during baseline mapping of the area 14th November 2011.

3.1.1.2 WC15

Impact DA3B_LW13_021

DA3B_LW13_021 is located towards the upstream extent of *WC15_Rockbar 18*. The site was passed by Longwall 13 at an approximate distance of 185 m on the 29th March 2018. The impact consists of a rock fracture, which extends across the extent of the rockbar (Photo 7 to Photo 10). The fracture is approximately 5.7 m in length, with widths ranging from hairline to a maximum of 0.015 m. The maximum measurable depth is 0.06 m. Additionally, there is a small section of plating, which measures approximately 0.3 m by 0.15 m.

<u>Level 2:</u> Crack or fracture between 100 and 300 mm width at its widest point or any fracture which results in observable loss of surface water or erosion.

Photo 7: *DA3B_LW13_021*, looking at the widest section of fracturing. Taken 29th March 2018.

Photo 8: *DA3B_LW13_021*, looking at the widest section of fracturing. Taken 29th March 2018.

Photo 9: *DA3B_LW13_021*, looking at the small section plating. Taken 29th March 2018.

Photo 10: *DA3B_LW13_021*, looking at the narrowest section of fracturing. Taken 29th March 2018.

Impact DA3B_LW13_022

DA3B_LW13_022 is located on *WC15_Rockbar 18*, approximately 35 m downstream of *DA3B_LW13_021*. The site was passed by Longwall 13 at an approximate distance of 157 m on the 29th March 2018. The impact is a rock fracture zone, which is comprised of approximately 10 fractures, with associated uplift (Photo 11 to Photo 14) and rock fragmentation (Photo 13), within an area of approximately 7.2 m by 6 m. Each fracture within the zone is greater than 0.5 m in length, the longest of which, is approximately 3 m. The fractures range from hairline to a maximum of 0.015 m in width; the maximum measurable depth is approximately 0.04 m. Additionally, there are lateral fractures to the face of a 0.3 m high step (Photo 14).

<u>Level 2:</u> Crack or fracture between 100 and 300 mm width at its widest point or any fracture which results in observable loss of surface water or erosion.

Photo 11: DA3B_LW13_022, looking across stream towards section of uplift. Taken 29th March 2018.

Photo 12: *DA3B_LW13_022*, looking downstream towards longest fracture. Taken 29th March 2018.

Photo 13: *DA3B_LW13_022*, looking upstream towards a small rock fragment. Taken 29th March 2018.

Photo 14: *DA3B_LW13_022*, looking upstream towards lateral fracturing on face of step. Taken 29th March 2018.

Impact DA3B_LW13_023

DA3B_LW13_023 is located on *WC15_Rockbar 18*, approximately 7 m downstream of *DA3B_LW13_022*. The site was passed by Longwall 13 at an approximate distance of 150 m on the 29th March 2018. The impact is comprised of a rock fracture approximately 5.6 m in length and 0.03 m at its widest point (Photo 15 to Photo 18); the maximum measurable depth of the fracture is 0.16 m (Photo 18). There was no observable surface flow at *WC15_Rockbar 18* during the inspection, however, surface flow has previously been observed at the feature. Given the extent and nature of the fractures, it is likely that these impacts would cause some degree of flow diversion if surface flow was present at *WC15_Rockbar 18.*

Level 2: Crack or fracture between 100 and 300 mm width at its widest point or any fracture, which results in observable loss of surface water or erosion.

Photo 15: *DA3B_LW13_023*, widest section of fracturing. Taken 29th March 2018.

Photo 16: *DA3B_LW13_023*, widest section of fracturing. Taken 29th March 2018.

Photo 17: *DA3B_LW13_023*, closeup of the widest section of fracturing. Taken 29th March 2018.

Photo 18: *DA3B_LW13_023*, closeup of the deepest section of fracturing. Taken 29th March 2018.

Impact DA3B_LW13_028

DA3B_LW13_028 was identified on the 5th April 2018 and is located on the tributary *WC15*; the site was passed by Longwall 13 on the 29th March 2018 at an approximate distance of 124 m. The impact is comprised of lateral fractures, with associated uplift and plating, to the rockbar shelf on the northern extent of *WC15_Pool 18*. The largest fracture is 1.4 m in length and 0.018 m in width (Photo 19 and Photo 20). There was no evidence of flow diversion at the site.

Level 1: Crack or fracture up to 100mm at its widest point with no observable loss of surface water or erosion; Crack or fracture up to 10m length with no observable loss of surface water or erosion

Photo 19: *DA3B_LW13_028*, looking upstream at the extent of the impact. Taken 5th April 2018.

Photo 20: *DA3B_LW13_028*, looking upstream at largest section of fracturing. Taken 5th April 2018.

Impact DA3B_LW13_035

DA3B_LW13_035 was identified on the 23rd April 2018 and is located on the tributary *WC15*; the site was passed by Longwall 13 on the 18th March 2018 at an approximate distance of 280 m. The impact is comprised of multiple small fractures near the upstream extent of *WC15_Rockbar 21* (Photo 21 and Photo 22). The largest fracture is 1.6 m in length and 0.002 m in width. Additionally, there is a small section of plating and uplift (approximately 0.1 m by 0.05 m) at the site. There was no evidence of flow diversion at the site.

<u>Level 1:</u> *Crack or fracture up to 100mm at its widest point with no observable loss of surface water or erosion;*

Crack or fracture up to 10m length with no observable loss of surface water or erosion.

Photo 21: *DA3B_LW13_035*, looking across stream at the largest fracture. Taken 23rd April 2018.

Photo 22: *DA3B_LW13_035*, looking across stream at the section of plating and uplift. Taken 23rd April 2018.

Impact DA3B_LW13_040

DA3B_LW13_040 is situated on Wongawilli Creek tributary *WC15*. The impact zone extends 20 m from the top of *WC15_Step 0* to *WC15_Pool 2* which is approximately 80 m from the confluence with Wongawilli Creek. The site is approximately 262 m from the end of Longwall 13. The impact is comprised of rock fracturing and uplift, which has a maximum measurable length of 5.5 m, a maximum width of 0.05 m and a maximum measurable depth of 0.24 m (Photo 23 to Photo 26). While not evident during the inspection, flow diversion would occur if surface flow was present.

<u>Level 2:</u> Crack or fracture between 100 and 300mm width at its widest point or any fracture which results in observable loss of surface water or erosion.

Photo 23: *DA3B_LW13_040*, looking at a section of rock fracturing and uplift. Taken 7th May 2018.

Photo 24: *DA3B_LW13_040*, looking at a section of rock uplift. Taken 7th May 2018.

Photo 25: *DA3B_LW13_040*, looking at a section of rock fracturing and uplift. Taken 7th May 2018.

Photo 26: *DA3B_LW13_040*, looking at the maximum measurable depth of the rock fracturing. Taken 7th May 2018.

Impact DA3B_LW13_041

DA3B_LW13_041 is situated on Wongawilli Creek tributary *WC15*, specifically across *WC15_Step 0*, which is approximately 75 m from the confluence with Wongawilli Creek. The site is situated approximately 267 m from the end of Longwall 13. The impact is comprised of rock fracturing which has resulted in a rockfall. The rock fracturing has a maximum length of 12 m, a maximum width of 0.05 m and the maximum depth is unknown due to access difficulties (Photo 27 to Photo 30).

Level 2: Crack or fracture between 100 and 300mm width at its widest point or any fracture which results in observable loss of surface water or erosion. Crack or fracture between 10m and 50m length.

Photo 27: *DA3B_LW13_041*, an overview of the area impacted by the rockfall. Taken 7th May 2018.

Photo 28: *DA3B_LW13_041*, looking at the extent of the rockfall. Taken 7th May 2018.

Photo 29: *DA3B_LW13_041*, looking at the rock fracturing from the top of the step. Taken 7th May 2018.

Photo 30: DA3B_LW13_041, looking the accumulation of rock that resulted from the rockfall. Taken 7th May 2018.

Impact DA3B_LW13_042

Impact *DA3B_LW13_042* is situated on *WC15*, approximately 150 m from the end of Longwall 13. The impact is comprised of multiple rock fractures, with associated rock fragmentation and iron staining to *WC15_Rockbar 7*, an undercut rockbar (Photo 31), approximately 295 m from the *WC15* confluence with Wongawilli Creek. The impact zone extends 15 m across the upper extent of *WC15_Rockbar 7* (Photo 32 and Photo 33), below *WC15_Step 7B*. The rock fracturing has a maximum length of 4.5 m, a maximum width of 0.01 m and a maximum measurable depth of 0.19 m. Two large rock fragments have been displaced from the underside of the rockbar, the largest of which is approximately 1 m in length, 1 m width and 0.30 m height. Flow diversion through the fractures was observed at the site. Iron staining was observed downstream of the flow diversion in the pool below *WC15_Rockbar 7* (Photo 34 and Photo 35).

<u>Level 2:</u> *Crack or fracture between 100 and 300 mm width at its widest point or any fracture which results in observable loss of surface water or erosion.*

Photo 31: *WC15_Rockbar 7*, looking upstream, highlighting the undercut nature of the rockbar.

Photo 32: *DA3B_LW13_042*, looking at a section of rock fracturing and uplift. Taken 16th May 2018.

Photo 33: *DA3B_LW13_042*, looking at a section of rock fracturing. Taken 16th May 2018.

Photo 34: *DA3B_LW13_042*, looking at largest rock fragment and iron staining. Taken 16th May 2018.

Photo 35: *DA3B_LW13_042*, looking at a section of iron staining. Taken 16th May 2018.

3.1.1.3 WC21

Impact DA3B_LW13_006

Impact *DA3B_LW13_006* is comprised of fracturing to the upstream extent of *WC21_Pool 48*. The fracturing is up to 5 m long and 0.03 m wide with some dislodged fragments (Photo 36 and Photo 37). The fracturing has resulted in an observable loss of surface water within the pool (Photo 36). The absence of surface water extends downstream before reappearing at the base of *WC21_Step 38*, which is directly downstream from *WC21_Pool 38* (see *Impact DA3B_LW13_007*).

<u>Level 2:</u> Crack or fracture between 100 and 300 mm width at its widest point or any fracture which results in observable loss of surface water or erosion.

Photo 36*:* Impact *DA3B_LW13_006*, looking upstream. Taken on 3/10/2017.

Photo 37: Impact *DA3B_LW13_006*, looking across pool at fracturing. Taken on 3/10/2017.

Impact DA3B_LW13_007

Re-emergence of surface flow is evident at the base of *WC21_Step 38,* directly downstream from *WC21_Pool 38*. Surface flow is associated with iron staining at this location (Photo 38 and Photo 39). The surface flow continues for approximately 2 m, which is where the iron staining ceases, before shifting to subsurface flow. (Photo 39).

<u>Level 1</u>: Observable increase in iron staining within the mining area.

Photo 38: Impact *DA3B_LW13_007*, looking upstream. Taken on 3/10/2017.

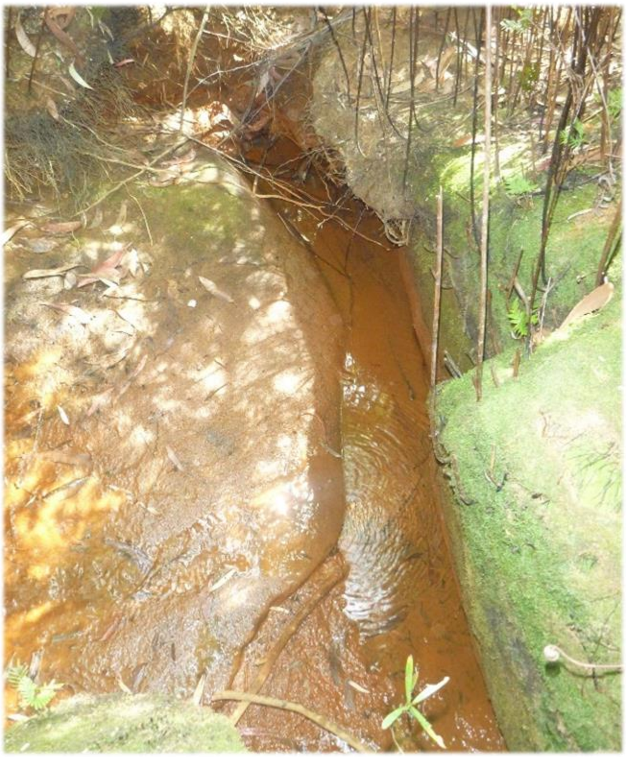

Photo 39: Impact *DA3B_LW13_007*, looking downstream. Taken on 3/10/2017.

Impact DA3B_LW13_009

Impact *DA3B_LW13_009* was identified on the 27th October 2017. This impact consists of fracturing and fragmentation to the rockbar at the downstream extent of *WC21_Pool 54*, which was mined beneath by Longwall 13 on the 24th September 2017. The largest fracture is 0.22 m wide, 0.37 m deep and 0.38 m long (Photo 40 and Photo 41). Surface water was not present at the site during the inspection.

<u>Level 1:</u> *Crack or fracture up to 100 mm at its widest point with no observable loss of surface water or erosion.*

Photo 40: Impact *DA3B_LW13_009*, looking across stream, taken on 23/10/2017.

Photo 41: Impact *DA3B_LW13_009*, looking upstream, taken on 23/10/2017.

Impact DA3B_LW13_010

Impact *DA3B_LW13_010* was identified on the 27th October 2017. The impact consists of lateral fracturing to the step at the upstream extent of *WC21_ Pool 53*, which was mined beneath by Longwall 13 on the 24th September 2017. The largest fracture is approximately 2.5 m long, 0.01 m wide, and 0.03 m at its deepest measurable point (Photo 42). The portion of sandstone below the fracture has been displaced laterally by approximately 0.03 m (Photo 43). A smaller, approximately 1 m long, hairline fracture is present adjacent to the largest fracture (Photo 48). No flow diversion was observed at the site; however, the water level at *WC21_Pool 53* has lowered considerably following being mined beneath by Longwall 13 (Photo 45 to Photo 47). It is likely there is an unobservable fracture at the base of the pool diverting water.

<u>*Level 2:*</u> *Crack or fracture between 100 and 300 mm width at its widest point or any fracture which results in observable loss of surface water or erosion.*

Photo 42: Impact *DA3B_LW13_010* looking upstream, taken 27/10/2017.

Photo 43: Impact *DA3B_LW13_010* looking top-down at the displaced rock, taken 27/10/2017.

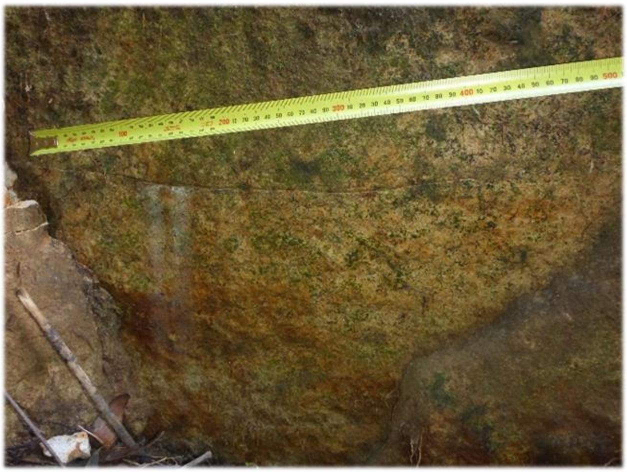

Photo 44: Impact *DA3B_LW13_010* looking across stream, taken 27/10/2017.

Photo 45: *WC21_Pool 53*, looking upstream, taken 11/09/2017.

Photo 46: *WC21_Pool 53*, looking upstream, taken 10/10/2017.

Photo 47: *WC21_Pool 53* looking upstream, taken 27/10/2017.

Impact DA3B_LW13_011

Impact *DA3B_LW13_011* was identified on the 27th October 2017. This impact consists of fracturing to the rockbar base of *WC21_Pool 47*, which was mined beneath by Longwall 13 on the 8th October 2017. The fracturing is 1.1 m long, 0.01 m wide and 0.3 m at its deepest measurable point (Photo 48 and Photo 49). Flow diversion has likely occurred at the site given the change in pool level over a relatively short period. Observations show surface water at *WC21_Pool 47* as of the 25th September 2017 (Photo 50. *Note: photo shows 20th September 2017*). The following observation, on the 3rd of October 2017, shows no surface water within the pool (Photo 51).

<u>Level 2:</u> Crack or fracture between 100 and 300 mm width at its widest point or any fracture which results in observable loss of surface water or erosion.

Photo 48: *DA3B_LW13_011*, looking top-down, taken 23/10/2017.

Photo 49: *DA3B_LW13_011*, looking upstream, taken 23/10/2017.

Photo 50: *WC21_Pool 47*, looking downstream, taken 20/09/2017

Photo 51: *WC21_Pool 47*, looking across stream, taken 3/10/2017.

Impact DA3B_LW13_017

Impact *DA3B_LW13_017* was identified during an inspection on the 8th January 2018. The impact consists of rock fracturing across tributary *WC21*. The crack is approximately 2 m long, 0.03 m wide and 0.22 m at its deepest measurable point (Photo 52 and Photo 53). Whilst there was no surface flow during the inspection, it is likely that the fracture would result in diversion of flow. Longwall 12 passed adjacent to the site in November 2016 with Longwall 13 passing the site in October 2017.

<u>Level 2:</u> *Crack or fracture between 100 and 300 mm width at its widest point or any fracture which results in observable loss of surface water or erosion.*

Photo 52: Impact *DA3B_LW13_017*, overall extent. Taken on 8/01/2018.

Photo 53: Impact *DA3B_LW13_017*, overall extent. Taken on 8/01/2018.

Impact DA3B_LW13_018

The impact consists of rock fracturing across *WC21_Pool 46*. The largest fracture is approximately 0.5 m long, 0.01 m wide and 0.05 m at its deepest measurable point (Photo 54 and Photo 55). Whilst there was no surface flow at the site during the inspection, it is possible that the fracture would result in flow diversion. The site was mined beneath by Longwall 13 on the 15th October 2017.

Level 2: Crack or fracture between 100 and 300 mm width at its widest point or any fracture which results in observable loss of surface water or erosion.

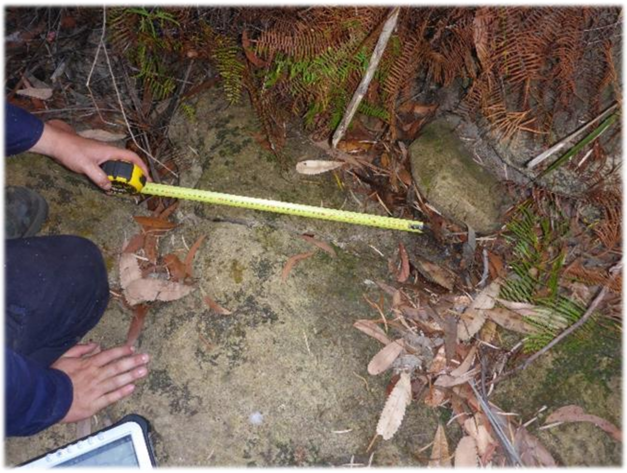

Photo 54: *DA3B_LW13_018*, looking across stream at the largest fracture. Taken on 12/02/2018.

Photo 55: *DA3B_LW13_018*, looking top-down at the largest fracture. Taken on 12/02/2018.

3.1.2 Wongawilli and Donalds Castle Creeks

No surface impacts were observed in Donalds Castle Creek during the extraction of Longwall 13. One surface impact (*DA3B_LW13_015*) was observed in Wongawilli Creek.

Wongawilli Creek - Impact DA3B_LW13_015

Fracturing was observed in *WC_Pool 43a,* on the 18th December 2013, as Longwall 9 approached it's finishing end towards Wongawilli Creek. No observed change in pool level was associated with the fracturing at the time.

In November 2017, pool-water levels in *WC_Pool 43a* were observed as the lowest for the monitoring period (Figure 13, Photo 56 and Photo 57). Following these observations, *DA3B_LW13_015* was reported as a Level 3 trigger (on the 28th November 2017) in accordance with the DA 3B Watercourse TARP, specifically: Fracturing resulting in diversion of flow such that <10% of the pools have water levels lower than baseline period.

In accordance with the CMAs, additional monitoring was implemented; two water-level loggers (*WCS1* in pool *WC_Pool 32* and *WCS2* in *WC_Pool 43a*) were installed on the 27th December 2017. Furthermore, pool water level and flow observations in Wongawilli Creek were detailed in an update report 14th February 2018.

An extension to the previously reported fracturing was observed at the site during an inspection on the 4th January 2018. The fracture exhibited weathered characteristics and most likely originated closer to the initially observed fracture.

An additional report, published on the 31st May 2018, provided an update on Wongawilli Creek following inspections on the 21st and 28th May 2018. During these inspections, discontinuous surface flows were observed along an approximately 1.4 km portion of Wongawilli Creek (including *WC_Pool 44* to downstream of *WC_Pool 41*), which was greater than previously observed. The conditions within this portion of Wongawilli Creek range from essentially no surface water to large pools with discontinuous surface flow. Surface flow recommences at *WCS1*, just downstream of the Wongawilli Creek – WC21 confluence. No fracturing additional to *DA3B_LW13_015* has been observed within this section of the creek.

Assessment of the declining water levels in Pool 43, conducted by HGEO (2018), is complicated by the unusually dry conditions during the extraction of Longwall 13, which has also reduced stream flow and pool water levels outside the influence of mining. However, the steady decline in water levels at Pool 43a since 2012, appears independent of the rainfall trends and, combined with observations of drawdown in groundwater pressures in the sandstone substrate, suggests that water level trends at Pool 43a may be due to induced baseflow reduction. Rainfall-runoff modelling of flows at the downstream gauge (WWL) indicates that baseflow reduction for the Wongawilli Creek catchment at that point is less than predicted by numerical modelling. Further monitoring and assessment of these trends is recommended.

Photo 56: *WC_Pool 43a*, looking upstream. Taken on 12/12/2017.

Photo 57: *WC_Pool 43a*, looking upstream. Taken on 10/01/2018.

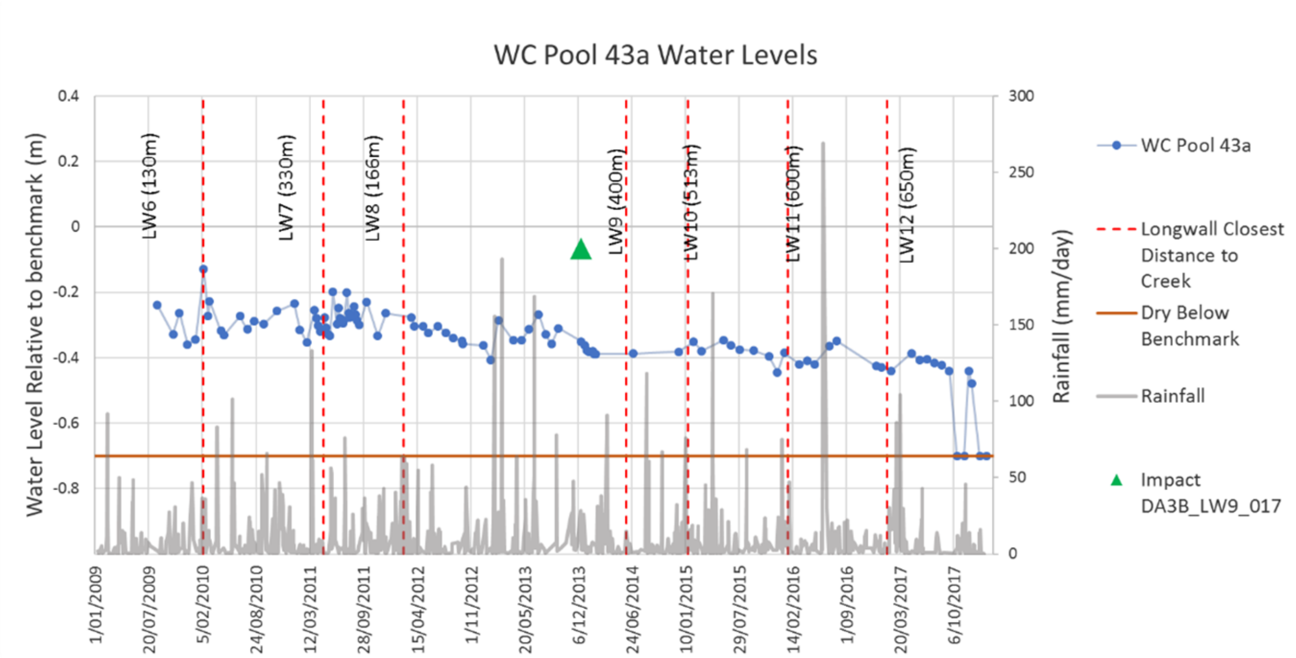

Figure 13: Pool water levels recorded in WC_Pool 43a. Initial observation date of impact DA3B_LW9_017 is also displayed.

Further analysis on Wongawilli Creek is presented in **Attachment D.**

3.1.3 Impacts to Other Landscape Features

DA3B_LW13_036

DA3B_LW13_036 was identified on the 23rd April 2018; the site was mined beneath by Longwall 13 on the 24th March 2018. The impact is comprised of fracturing to a sandstone outcrop, measuring 5.5 m in length, 0.05m in width and 1.64 m at its deepest measurable point (Photo 58).

Level 1: Crack or fracture up to 100 mm in width and/or crack or fracture up to 10 m in length.

Photo 58: Photo *DA3B_LW13_036*, looking at the extent of the fracture. Taken 23rd April 2018.

3.2 Surface Water Quality

The monitoring of water quality parameters provides a means of detecting and assessing the effects of streambed fracturing or induction of ferruginous springs. Monitoring includes measurement of field parameters such as pH, EC, DO, Oxygen Reduction Potential (ORP) and laboratory tested analytes (DOC, Na, K, Ca, Mg, Filt. SO4, Cl, T. Alk., Total Fe, Mn, Al, Filt. Cu, Ni, Zn, Si).

Table 3: Summary of water quality TARP triggers during the extraction of Longwall 13.

DATE	CATCHMENT / LOCATION	PARAMETER	VALUE	TARP	TRIGGER LEVEL
23/01/2018	Wongawilli Ck (FR6)	SpC	169	154.1	Level 3
12/02/2018	Wongawilli Ck (FR6)	SpC	174	154.1	
02/01/2018	Wongawilli Ck (FR6)	DO	43.3	50.5	Level 3
23/01/2018	Wongawilli Ck (FR6)	DO	34.7	50.5	
12/02/2018	Wongawilli Ck (FR6)	DO	30.4	50.5	

At *Wongawilli Creek (FR6)*, the TARP level for EC was triggered on two occasions and the DO trigger level was exceeded on three occasions (Table 3). As with the *Donalds Castle Creek (FR6)* site, elevated and apparently increasing EC values from mid-2017 to early 2018 are likely due to evaporation during low rainfall conditions. Nearly all monitored pools along Wongawilli Creek, including those up-stream of Longwall 13 show a trend of increasing EC during the extraction of Longwall 13. The same period is characterised by low pool water levels and low-flow or no-flow conditions at gauging stations. Similar responses are noted for previous periods with low rainfall and high evapotranspiration, and EC levels were observed as decreasing following rainfall in early 2018. Nevertheless, it is recommended that stream water quality be monitored to determine if the stream EC mean and range has shifted as a response to mining.

The EC of surface water increased at numerous stream monitoring sites across DA3A and DA3B during the extraction of Longwall 13. This trend is considered to reflect the unusually dry conditions during the extraction of Longwall 13 and evaporative concentration of dissolved salts in disconnected pools during low-flow and no-flow conditions. EC increased to levels significantly higher than baseline ranges at several pool-monitoring sites across DA3B during the extraction of Longwall 13, most notably at *DC_Pool 19* and *DC_Pool 20* on the main first-order tributary of Donalds Castle Creek. Some of the high-EC pools are not near active mining and are unlikely to be related to mining. However, it is likely that subsidence has affected stream runoff in the upper Donalds Castle Creek tributaries and therefore may have contributed to the water quality effects at those sites (*DC_Pool 19 and 20*). The effect does not extend to the downstream monitoring sites.

Further details are presented in **Attachment D1.**

3.3 Surface Water Hydrology

The effects of mining subsidence on surface water hydrology is assessed by comparing observed stream flow characteristics for each monitored sub-catchment against predictions of streamflow from a calibrated rainfall-runoff model, specifically, the industry-standard Australian Water Balance Model (AWBM; Walter Boughton, 2009). The assessment consists of calibrating the rainfall-runoff model to observed pre-mining flows and then reviewing whether flows have diverged from the model in the post-mining period. Differences in the pre- and -

post-mining conditions are then highlighted and used to infer and quantify any effects that mining has had on the catchment. Furthermore, the most recent iteration of the model, used for the Longwall 13 assessment, has been modified to include the added functionality of allowing for evaporative losses from the shallow water table.

The assessment approach and TARP are defined in Attachment 1 of the WIMMP (South32 2015a). The Catchment Water Balance TARP is described in the WIMMCP as:

- **Level 1:** a change in measured discharge (between pre- and post-mining) **6-12 %** less than average annual precipitation;
- **Level 2:** a change in measured discharge (between pre- and post-mining) **12-18 %** less than average annual precipitation;
- **Level 3:** a change in measured discharge (between pre- and post-mining) **>18 %** less than average annual precipitation.

Table 4: Summary of surface water flow yield changes from baseline following the extraction of Longwall 13.

Catchment	Site	TARP Trigger	Yield Change Following the Extraction of Longwall 13	Comments
Donalds Castle Creek	DCS2	Level 3	-21%	Evidence that undermining by Longwall 9 affected the sub-catchment yield, and this continues through Longwalls 10-12; as well as during Longwall 13. During Longwall 13 the effects have occurred across the full range of flows.
	DC13S1	Level 1	-7 %	Stream flow characteristics and sub-catchment yield as measured at DC13S1 appear to have been affected as a result of undermining of the watercourse midway through Longwall 9. The effect continues through Longwalls 10-13. Cease-to-flow conditions have occurred about 14% of the time since undermining, while the model suggested that under the pre-mining case this would have been about 2% of the time.
	DCU	No Trigger	-2 %	Evidence that undermining by recent longwalls affected the pattern of flow and the magnitude of recession flows at DCU through Longwalls 11-12; as well as during Longwall 13. Cease to flow conditions increased by about 6%.
Wongawilli Creek	WWL	No Trigger	-3 %	There is no evidence that undermining has affected recession behaviour or reduced sub-catchment flow / yield.

Catchment	Site	TARP Trigger	Yield Change Following the Extraction of Longwall 13	Comments
	WC21S1	No Trigger	-2 %	The evidence is that recent undermining by Longwalls 10-12, and now Longwall 13 has modified the patterns of flow in this tributary. Mean flow has declined, but on average is less affected in Longwall 13 (-9%) than in previous longwalls (e.g. -20-40%). This is supported by field observation of the creek being dry upstream of the gauge. Since undermining occurred, cease-to-flow conditions at the gauging station have occurred approximately 20% of the time, but during Longwall 13 the cease-to-flow period is similar to the model.
	WC15S1	No Trigger	+1 %	No evidence that mining has affected flows in this sub-catchment, including during Longwall 13, noting that the period from mid-2017 is marked by dry conditions. Recent low flows and recession periods are consistent with the model.
Lake Avon	LA4S1	Level 1	-6 %	Flows in LA4 were affected by Longwall 13. During Longwall 13 average flow is approximately 5% lower than modelled but the hydrograph above shows periods when observed flows were significantly lower than and significantly higher than modelled. These variances were in the range of one order of magnitude higher and lower.

Further details are presented in **Attachment D1.**

3.4 Deep Groundwater Hydrology

Groundwater monitoring at Dendrobium Mine is conducted in accordance with the DA3B SMP Groundwater Management Plan (South32 2012) and the DA3B Subsidence Management Plan (South32 2015).

The aims of the Groundwater Management Plan are to:

- Monitor groundwater levels and quality, commencing at least one year prior to mining affecting the system;
- Project potential groundwater changes during mining (short term) and post-mining (long term) with particular attention to the effect of changes to groundwater regime, impact on the catchment yield and interaction with the stored waters;
- Identify hydraulic characteristics of overlying and intercepted groundwater systems, and determine changes to groundwater systems due to coal extraction and dewatering operations;

- Report any pumping tests and groundwater/surface water simulation studies; and
- Collect water level data from all agreed groundwater-monitoring locations.

Further details are presented in **Attachment E.**

3.4.1 Mine Water Balance

The System Control and Data Acquisition (SCADA) system calculates a daily mine Water Balance. The Water Balance is an accurate measure of all water that enters, circulates and leaves the mine, including via air moisture and coal moisture content. Mine water seepage (groundwater inflow), which cannot be directly measured, is determined by mass balance for each goaf and is therefore known to a reasonable accuracy. Key metrics of the Mine Water Balance are reported against TARP levels to the DSC fortnightly.

The average daily inflow to Area 3B during Longwall 13 extraction was 4.68 ML/d which represents approximately 62 % of total mine inflow for the period. The average water balance for DA3B was similar for Longwall 13 to that during Longwall 12 (4.5 ML/day).

Groundwater ingress to DA3B has increased steadily since the start of mining (2013), and correlates approximately with the total area mined. However, the overall rate of increase appears to have slowed during the mining of Longwalls 12 and 13, representing a possible departure from the area-inflow relationship, as was seen at DA3A after Longwall 7. As of Longwall 12, there is an apparent correlation between periods of high inflow to DA3B and periods of high rainfall with a lag time of between two and three months. Peak inflow rates to DA3B following high rainfall events is one to two ML/day higher than during low rainfall periods. The inflow peak that followed the high rainfall event of early 2017 accounts for approximately 20 % of the total inflow for the 2017 year. The peak component in 2016 was approximately 12 %.

The presence of modern water in mine inflow is monitored by analysing tritium. Samples are collected from goaf inflow and the roadway development stage seepage water samples. The results are reported monthly to the DSC. Tritium is an isotope of hydrogen (3H), which decays exponentially according to its half-life (12.32 years) and is typically only detectable in surface water samples and in groundwater that recharged within 4 to 5 half-lives (50 to 70 years). Detection of tritium above deep groundwater baseline levels in mine inflow samples would indicate a component of modern water in the sample (as it does for samples from Area 2). As of June 2018, tritium in samples from the Area 3B goaf are not statistically different from deep groundwater baseline data (represented by the shaded area below 0.2 TU in Figure 8, from HGEO 2018). The laboratory processing time for high precision tritium analysis can be more than 6 months and therefore results for samples collected in the latter part of Longwall 13 are pending.

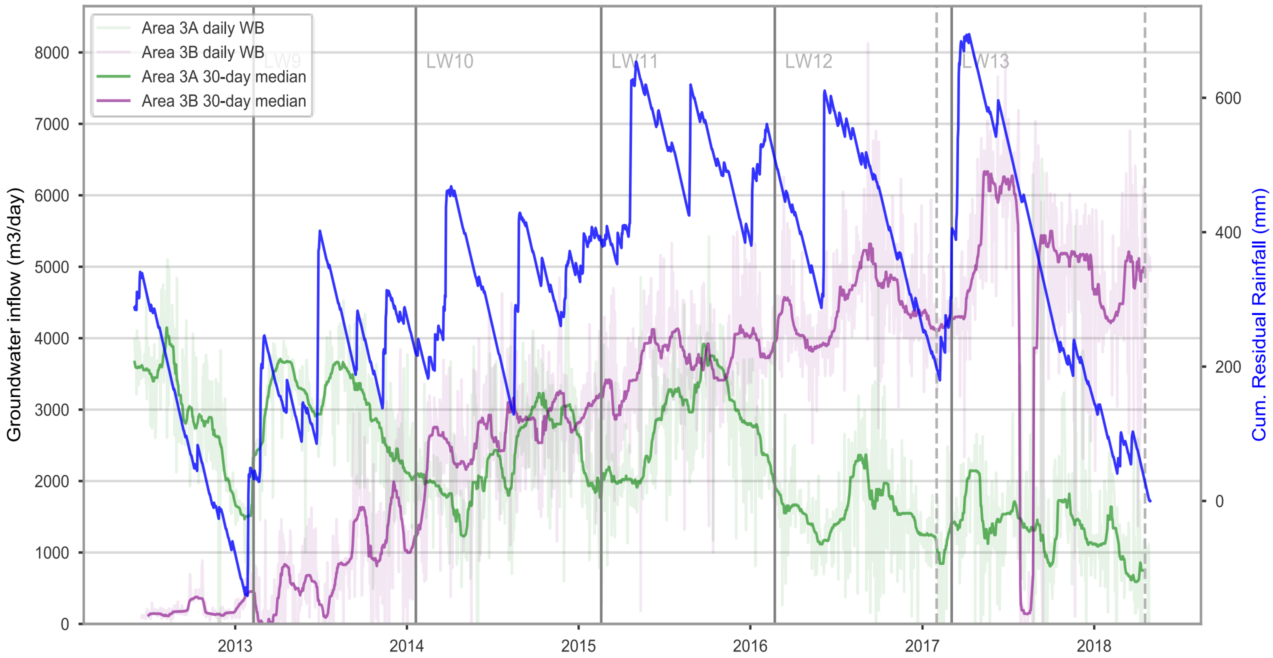

Figure 14: Groundwater inflow in to DA3A and DA3B.

3.4.2 Deep Groundwater Levels

Mining of Longwall 13 resulted in continued depressurisation of the target coal seam and overlying strata. The observed changes in groundwater levels are in line with numerical model predictions that support mining approvals.

As expected, the greatest depressurisation is within the Wongawilli Coal Seam, and decreases with height above the seam. Incremental drawdown in the Scarborough and Bulgo Sandstones is apparent in the areas immediately to the south-west of Longwall 13 and extending to S2194, located 1.4 km to the south of Longwall 13.

Drawdown in the Hawkesbury Sandstone is greatest above and immediately adjacent to Longwall 13, with some drawdown also evident at S2001, located 435 m to the south. Elsewhere drawdown is negligible or negative (an increase in groundwater level).

These results indicate that fracture networks result in depressurisation of adjacent strata above mined longwalls over much of Area 3B. However, there is evidence that drainage of the Hawkesbury Sandstone above goafs is not complete in all areas and some perched groundwater horizons remain in shallow sandstone strata. In the case of S2220, perched horizons appear to respond to groundwater recharge events. Perching at S2338 is not clear, since piezometers at a similar depth in the immediately adjacent S2337 record near-zero pressure head suggesting full depressurisation of monitored strata (Hawkesbury Sandstone).

Observations at monitoring bores installed above mined longwalls indicate that the Hawkesbury Sandstone undergoes fracturing throughout its full thickness, accompanied by depressurisation of most strata. There is evidence that drainage of the Hawkesbury Sandstone above goafs is not complete in all areas and some perched groundwater horizons remain.

3.4.3 DSC Monitoring – Loss of baseflow to Lake Avon

Starting in 2015, a series of monitoring bores was installed along the barrier zone between Lake Avon reservoir and Area 3B. Observations at those bores indicate depressurisation of the upper Colo Vale Sandstone in response to longwall extraction, but variable drawdown in the Hawkesbury Sandstone. A hydraulic gradient towards the lake is preserved in the Hawkesbury Sandstone at S2313, whereas at S2314 and S2376 the hydraulic gradient is locally reversed towards the mine, implying movement of groundwater from the lake to the mine. It is estimated that seepage loss between Lake Avon and Longwalls 12 to 16 would be less than 0.28 ML/day (or 0.17 ML/day/km of shoreline adjacent to extracted longwalls). This estimate is consistent with numerical modelling predictions.

Numerical model predictions of the net loss (seepage) from Lake Avon as of the end of Longwall 13 are shown in Figure 15. This reduction comprises induced leakage from, and reduced seepage to, the Lake, relative to pre-mining conditions.

The estimated net loss from the reservoir at the end of Longwall 13 is less than 0.4 ML/d and therefore within the tolerable loss limit of 1 ML/day prescribed by the DSC (DSC 2014).

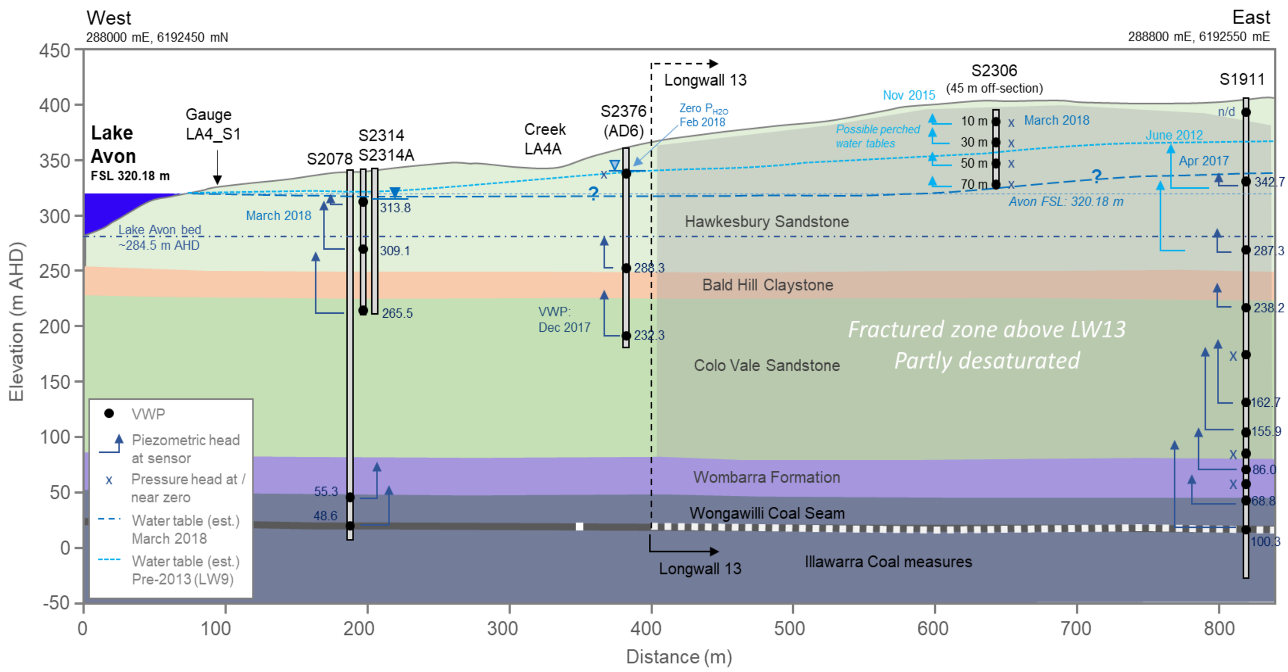

Figure 15: Hydrogeological cross-section of Lake Avon and relevant monitoring bores.

3.4.4 Groundwater Chemistry

Previous reviews have shown that there is no clear spatial pattern in the distribution of groundwater quality in Hawkesbury Sandstone and Bulgo Sandstone bores. Groundwater salinity (EC) for samples collected from monitoring bores in DA3A and DA3B. The groundwater salinity tends to increase with depth.

A notable change is seen in the most recent sampling from S1886 (DEN94) where samples from all three depths (at 22 m, 30 m, and 38 m) show EC field measurements that are up to 200 µS/cm higher than last sampling round. Laboratory measured EC for all three samples are within the historical range suggesting that the field EC measurements are in error.

The average EC for all samples collected are: 163 µS/cm for the Hawkesbury Sandstone (n = 298), 579 µS/cm for the Bulgo Sandstone (n = 75) and 559 µS/cm for the Scarborough Sandstone (n = 112). The Scarborough Sandstone outcrops at monitoring bore S1886 and therefore represents shallow groundwater. The data provide no evidence for adverse changes to groundwater quality as a result of mining.

3.5 Impacts to Upland Swamps

3.5.1 Shallow Groundwater and Soil Moisture

TARP values for subsidence-induced decreases in groundwater levels and soil moisture, at surface and near-surface monitoring sites within Area 3B swamps, are provided in the SIMMCP (South32 2015a). Reductions in shallow groundwater and soil moisture have been identified as an indicator of potential changes in ecosystem functionality within Upland Swamps.

Changes to groundwater are reported when measurements of water level drop below baseline levels or when rates of recession exceed those recorded during baseline monitoring. Groundwater level hydrographs for each shallow piezometer are presented in **Attachment D**. Each hydrograph is plotted together with ground elevation and the elevation of the piezometer base, longwall timing, rainfall trend ("rainfall CRM"), and the dates that longwalls pass under (if relevant) a piezometer. Assessment of mining effects is based on these hydrographs.

Longwall 13 passed within 400 m of shallow groundwater and soil moisture sites within two swamps: Swamps 11 and 13.

Table 5: Summary table of Upland Swamp TARP trigger levels relevant to Longwall 13.

Swamp Name	Comments	Shallow Groundwater TARP Level	Soil Moisture TARP Level
Swamp 11	A sharp decline in shallow groundwater levels and increase recession rate in H1 after closest pass of LW13 in mid-April 2017. No clear change at H2, H3. Soil moisture at all sensors dropped below baseline after LW12 and LW13 passed within 400 m. Likely a mining effect at S01.	Level 1	Level 3
Swamp 13	Soil moisture at all sensors dropped below baseline after LW13 passed within 400 m. Possible mining effect, noting unusually dry conditions prevailing at the time of reporting.	NA	Level 3

Swamp 11

The hydrograph for Swamp 11 piezometer H1 shows both a decline in shallow groundwater levels (dropping below the piezometer base for the first time) and a steepening of the groundwater recession curve following the closest passage of Longwall 13 in April 2017 (<10 m from H1). The hydrograph shows a clear change in groundwater level characteristics from mid-2017, compared with similar dry conditions during the extraction of Longwall 12. The change is almost certainly related to the subsidence effects of Longwall 13 and represents a Level 1 TARP trigger. Groundwater hydrographs for the other two Swamp 11 piezometers (S02 and S03) are not clearly different from previous dry periods.

At all soil moisture sensors within Swamp 11, soil moisture dipped below baseline levels during Longwall 12 and Longwall 13, triggering a Level 3 TARP during Longwall 12. The decline in average soil moisture content is notable after Longwall 13 passed within 400 m of the sites, particularly at sensor S01. Given the proximity of the sensor site to Longwall 13, and the magnitude of the decline compared with the baseline period, it is likely to be partly related to mining subsidence impacts. The decline in soil moisture at S01 is also matched by the decline in shallow groundwater level at the proximate H1 piezometer site. In addition, soil moisture readings become erratic in the months following the closest pass of Longwall 13 (April 2017 at <10 m), prior to the sharp decline in levels in July 2017.

Swamp 13

Swamp 13 piezometer S01 was passed by Longwall 13 at a distance of 296 m on the 20th September 2017. The hydrograph for S01 shows no clear change in groundwater characteristics following the passage of Longwall 13; the groundwater recession during the extraction of Longwall 13 has a similar slope and depth to previous dry periods. Further monitoring during and after heavy rainfall events is required to determine whether shallow groundwater at S13_S01 has been affected by mining.

At Swamp 13, soil moisture at all sensors dropped below baseline after Longwall 13 passed within 400 m, which triggers a TARP Level 3 and is possibly related to mine subsidence effects. However, soil moisture levels at sensors in Swamps 23 and 14, that are more distant from Longwall 13 (>500 m), have also declined to their lowest levels since the start of monitoring. Therefore, it is likely that the anomalous dry conditions during the extraction of Longwall 13, both prior to and during the summer months, have contributed to the decline in moisture levels in all swamps.

Further monitoring during and after heavy rainfall events is required to determine whether, and to what extent, soil moisture levels at Swamps 11 and 13 have been affected by mining.

3.5.2 Erosion in Upland Swamps

The SIMMCP describes the monitoring and assessment to determine any areas of erosion in swamps resulting from mining. Tilting, cracking, desiccation and/or changes in vegetation health could result in the concentration of runoff and erosion, which intern could alter water distribution in the swamp. TARPs have been established within the SIMMCP (See Appendix A: Table 16).

Impact assessment of Upland Swamp erosion includes analyses of LiDAR results, combined with infield observations. No notable areas of erosion were identified following completion of Longwall 13. Any erosion observed was found to be present during the baseline period or was less than 2% of the length or area of the swamp.

Erosion monitoring in conjunction with analysis of LiDAR results will continue.

3.6 Terrestrial Ecology

Biosis Pty Ltd was commissioned by Illawarra Coal to undertake terrestrial ecology monitoring for the Dendrobium Coal Mine in accordance with the Flora and Fauna Environmental Management Program (Subsidence) (Biosis 2003) and as required by the Dendrobium Mine Development Consent. The Dendrobium Terrestrial Ecology Monitoring Program commenced in 2003 and is expected to continue throughout the duration of mining activities and for a period after the completion of mining within each area.

The aim of the program is to determine whether subsidence effects associated with longwall mining result in impacts to terrestrial ecology. A Before-After Control-Impact (BACI) experimental design has been established and implemented. The BACI design investigates the temporal changes at sites that have been mined beneath (Before-After) compared with change at control sites that have not been mined beneath (Control-Impact).

The terrestrial ecology monitoring program focuses on ecological features considered to be at risk of impact from subsidence effects, namely those values reliant on shallow groundwater or surface water. The following ecological features are monitored as part of the program:

- Vegetation communities (species and diversity) within Upland Swamps in DA3A and DA3B.
- Littlejohn's Tree Frog *Litoria littlejohni* along selected streams that provide suitable habitat in DA3A and DA3B.

Further details of the methodology used by Biosis for the Terrestrial Ecology Assessment can be found in **Attachment F**.

3.6.1 Terrestrial Flora

The latest terrestrial ecology (flora) assessment report includes the 2017 monitoring period, and includes monitoring and analysis of seven Upland Swamp sites as post-mining sites (Swamp 15B (S15B), Swamp 15A(2) (S15A(2)), Swamp 1A (S1A), Swamp 1B (S1B), Swamp 5 (S5), Swamp 11 (S11) and Swamp 13 (S13)). The remaining swamps were monitored and analysed as controls or pre-mining sites, including baseline monitoring for Swamp 23 and Swamp 14, commencing in autumn 2017. Parameters analysed include TSR, species composition and swamp extent (i.e. the extent of groundwater dependent swamp sub-communities).

3.6.1.1 Upland Swamp total species richness

An overall decline in TSR has been observed at all sites (both impact and control) and is likely indicative of landscape scale factors, such as changes in climatic conditions, natural succession of swamp vegetation and/or changes on Upland Swamp vegetation following bushfire. The most recent recorded fire within DA3A and DA3B occurred in 2001/02 and burnt across both control and impact sites. Whilst vegetation dynamics associated with fire may explain observed declines in richness and diversity at all sites, it is unlikely to have been the only factor contributing to the changes observed at post-mining sites.

The results of the TSR analyses demonstrate the responses to mining at individual swamps are complex. Swamp 15A(2) and Swamp 15B exhibited a decline and subsequent increase in TSR following mining and changes in shallow groundwater. Whereas, Swamp 1A, Swamp 1B and Swamp 5 exhibited no statistically significant decline in TSR despite observed changes in shallow groundwater levels.

3.6.1.2 Upland Swamp species composition

Statistically significant yearly and, occasionally, seasonal trends in species composition were detected at most sites, regardless of mining area or treatment. Such trends are indicative of natural turnover of species within Upland Swamps in response to seasonal and annual variability in climate, competition, disturbance and edaphic factors including nutrient availability.

When accounting for yearly effects, a significant change in species composition post-mining was detected at Swamp 15B and Swamp 15A(2). As with TSR, these changes were observed immediately following mining and have continued at Swamp 15B and Swamp 15A(2) for at least four years post-mining.

3.6.1.1 Upland Swamp Extent

The analyses of 2017 LiDAR data, collected by AAM Hatch used to assess the extent of Upland Swamps and their composite vegetation communities, have detected that while all Upland Swamps within the study area have decreased from the baseline, minimal change was identified between 2016 and 2017. The analyses also detected continual declines in the extent of vegetation communities that comprise Upland Swamps within the study area. The two vegetation communities identified as being reduced in extent are MU43 (Tee-tree Thicket) and MU44c (Cyperoid Heath). Only declines in MU43 have been determined to be of statistical significance. Declines in the extent of MU44c, while triggering a Level 1 TARP, require further investigation to determine why this community is increasing in extent at some swamps and decreasing at others.

During the 2017 monitoring period, the area of Upland Swamps decreased relative to the 2014 baseline across all impact and control swamps assessed, with the exception of Swamp 8, which recorded a marginal increase. The overall extent of the smaller control swamps (Swamps 89, 91, 92 and 93) remained stable over the four-year period. Between 2016 and 2017 the extent of each Upland Swamp, inclusive of control and impact swamps, remained relatively stable with only minor increases and decreases in extent observed across all treatments. To decrease the occurrence of false detection of changes in swamp extent, LiDAR data was assessed based on a differential canopy height of 8 metres, as canopy height of swamp species often exceeded the previous 5 metre threshold.

Table 6: DA3A and DA3B Swamp Monitoring – Terrestrial Flora: RS and Species Composition TARP summary.

Swamp Name	Predicted Impact	TARP Trigger Level	Results and TARP Justification	Recommendations
DA3A Landscape Monitoring - Terrestrial Flora and Fauna TARP (12 November 2012)				
Swamp 15B	Level 1, 2 or 3 TARP	Level 2 triggered	A statistically significant difference in TSR between BACI sites. No CMAs have been initiated, therefore a Level 3 trigger cannot be assessed.	Continue monitoring S15B in spring and autumn each year. Consult with technical specialists to identify need and type of CMA required and implement any agreed CMA.
Swamp 15A(2)	Level 1, 2 or 3 TARP	Level 2 triggered	No statistically significant decline in TSR was detected at S15A(2)) at the p=0.05 level. However, data analysis indicates that change in TSR is becoming increasingly significant (Section 3.2.1). A statistically significant change in species composition was detected at S15A(2) during the 4 year post-mining period (p-value = 0.003) indicating a Level 2 TARP has been triggered (Table 9). No CMAs have been initiated, therefore a Level 3 trigger cannot be assessed.	Continue monitoring S15A(2) in spring and autumn each year and investigate reasons for the TARP trigger. Consult with technical specialists to identify need and type of CMA required and implement any agreed CMA.
DA3B Swamp Monitoring – Terrestrial Flora: Composition and Distribution of Species (dated 12 October 2015)				
Swamp 1A	Level 1, 2 or 3 TARP	No TARP trigger	TSR within S1A showed no statistically significant decline when compared with control sites. Additionally, no statistically significant decline in species composition was found post-mining at S1A.	Due to the detection of decreased groundwater and incidental observations of Needlebush yellowing, continued monitoring of S1A is recommended.

Swamp Name	Predicted Impact	TARP Trigger Level	Results and TARP Justification	Recommendations
Swamp 1B	Level 1, 2 or 3 TARP	No TARP trigger	TSR within S1B showed no statistically significant decline when compared with control sites. Additionally, no statistically significant decline in species composition was found post-mining at S1B.	Due to the detection of decreased groundwater, continued monitoring of S1B is recommended.
Swamp 5	Level 1, 2 or 3 TARP	No TARP trigger	TSR within S5 showed no statistically significant decline when compared with control sites. Additionally, no statistically significant decline in species composition was found post-mining at S5.	Due to the detection of decreased groundwater and soil moisture along with the yellowing of Needlebush, continued monitoring of S5 is recommended.

Table 7: DA3B Swamp Monitoring – Terrestrial Flora: Swamp Size and Ecosystem Functionality (Illawarra Coal 2015c)

Swamp Name	Predicted Impact	TARP Trigger Level	Results and TARP Justification	Recommendations
Swamp 15B (not included in DA3B TARP)	No prediction made in EIS.	None	N/A	Continue monitoring in 2018 using the expanded ALS capture footprint.
Swamp 1A	Level 1, 2 or 3 TARP.	Swamp Size: No TARP triggered. Ecosystem Function: Level 1 TARP triggered.	One year of decline in total swamp extent greater than the mean (±SE) decline of the control group. Trending decline in the extent of subcommunity MU43 for two consecutive monitoring periods greater than the mean (±SE) decline of MU43 in the control group.	Continue monitoring in 2018 using the expanded ALS capture footprint. Investigate practical remediation measures, or offset if remediation deemed to be ineffective after 5 years.
Swamp 1B	Level 1, 2 or 3 TARP.	Swamp Size: No TARP triggered.	One year of decline in total swamp extent greater than the mean (±SE) decline of the control group.	Continue monitoring in 2018 using the expanded ALS capture footprint.

Swamp Name	Predicted Impact	TARP Trigger Level	Results and TARP Justification	Recommendations
		Ecosystem Function: Level 1 TARP triggered	Trending decline in the extent of subcommunity MU44c for two consecutive monitoring periods greater than the mean (±SE) decline in the control group.	Ground-truth and assess MU44c at S1B compared with S15B (control) to determine drivers of change, to determine adequacy of practical remediation measures.
Swamp 5	Level 1, 2 or 3 TARP.	Swamp Size: No TARP triggered. Ecosystem Function: Level 2 TARP triggered.	One year of decline in total swamp extent not greater than the mean (±SE) decline of the control group. Trending decline in the extent of subcommunity MU43 for three consecutive monitoring periods greater than the mean (±SE) decline in the control group.	Continue monitoring in 2018 using the expanded ALS capture footprint. Ground-truth decline in MU43 to determine requirement of practical remediation measures.
Swamp 8	Level 1, 2 or 3 TARP.	Swamp Size: No TARP triggered. Ecosystem Function: No TARP triggered.	One year of decline in total swamp extent not greater than the mean (±SE) decline of the control group. No trending decline in the extent of any sub-communities over the monitoring period.	Continue monitoring in 2018 and investigate increases in extent.

3.6.2 Terrestrial Fauna – Littlejohn’s Tree Frog Assessment

Monitoring of Littlejohn's Tree Frog transects was undertaken at five locations within DA3A during winter; 6CDL, SC10 (two sections), SC10C and WC17 (Figure 2). As a result of impacts to SC10C and WC17, monitoring of streams within DA3A continued in 2017. During 2017 a total of six creeks were monitored for threatened species as part of the DA3B program; continued monitoring at DC(1), DC13, LA4A, WC15, WC21 as well as the addition of LA2 to the program to commence two years of pre-mine baseline monitoring (Figure 3).

It was predicted that mining within DA3A and DA3B would have a significant impact to one or more local populations of Littlejohn’s Tree Frog (Biosis 2007b; Niche 2012). Analysis of adult Littlejohn's Tree Frog standardised abundance for the combined DA3A and DA3B programs indicates that the abundance of adult frogs is lower at impact sites than control sites. Subsidence related impacts appear to be the most likely agent causing declines in Littlejohn's Tree Frog populations at DA3A and DA3B post-mining sites.

Across all monitoring sites, there was a decrease in detection of adult Littlejohn’s Tree Frog during the 2017 monitoring period compared to 2016 by approximately 32 %, and tadpoles by 84 %. However, 2016 was an excellent year for breeding due to high levels of rainfall; observed frog numbers in 2016 were also much higher than previous years. Detection of Littlejohn’s Tree Frog in 2017 was comparable to detection in 2015.

Since commencement of threatened frog monitoring in DA3A and DA3B, the abundance of all life stages detected has varied substantially year to year, at both impact and control sites. This is most likely due to movement of individuals amongst sites, as well as differences in environmental conditions (e.g. rainfall frequency, rainfall intensity, temperature) at the time of survey. Environmental conditions such as rainfall can influence both detectability of individuals (adults may not be active if conditions are not suitable), as well as the timing of breeding events relative to survey. The amphibian surveys conducted during the breeding season only provide an indication of frog abundance at that particular time, which contributes to variation between surveys. However, there is no visually discernible trend in either year or mining status (pre/post mining) in both mining areas (DA3A and DA3B).

Further monitoring of breeding pools conducted in summer 2016/2017 confirmed that, at several of these sites, identified breeding pools contained sufficient water to support the laying of egg clutches in winter. However, these pools did not retain water long enough into summer for individuals to successfully reach metamorphosis. This represents a reduction in the available Littlejohn's Tree Frog breeding habitat within both DA3A and DA3B.

In response to the impacts to DC(1), DC13 and WC21 (Table 8), water level monitoring and tadpole surveys were undertaken during summer 2016/2017 to determine if metamorphosis was occurring along streams where reductions in habitat were detected (Biosis 2017b). Continuing tadpole development at DC13, WC21 and DC(1) varied based on the availability of sustained water levels within potholes and pools throughout the key development stages following the 2016 winter breeding season. Due to a limited number of breeding pools that contain water long enough to allow for full development to metamorphosis and adults, the risk of losing a generation of a local population of Littlejohn’s Tree Frogs at these sites has increased as a result of mining impacts. Continued monitoring and corrective management actions are recommended in Biosis (2017b) (Table 8).

Table 8: Assessment of Littlejohn's Tree Frog monitoring results at impact sites, within DA3A and DA3B, against DA3A and DA3B TARPs.

Stream	Predicted Impact	TARP Trigger Level	Results and TARP Justification	Recommendations
DA3A Landscape Monitoring TARP (dated 12 November 2012)				
SC10C	Significant impacts to local populations of Littlejohn's Tree Frog.	Level 1 TARP triggered.	Due to the level of variation in the dataset and lack of replication of monitoring events each year, a statistical analysis of the data could not be completed. However, a decline in the abundance of adult frogs was observed following subsidence impacts detected at SC10C following extraction of Longwall 7 and Longwall 8 during 2011 and 2012 (2 years after the initial mining within the RMZ), and numbers have not recovered.	Continue monitoring to investigate whether CMAs for related watercourse TARPs may address some impacts to threatened frog habitats.
SC10(1 & 2)	Significant impacts to local populations of Littlejohn's Tree Frog.	No TARP levels triggered.	There has been no significant decline in Littlejohn's Tree Frogs at SC10(1) since mining began in 2011 (Figure 17). Although tadpole and egg mass numbers were low in 2017, this is consistent with pre-mining records, and does not appear associated with mining impacts. There has been no significant decline in Littlejohn's Tree Frogs at SC10(2) since mining in 2011.	Continue monitoring.
WC17	Significant impacts to local populations of Littlejohn's Tree Frog.	Level 1 TARP no longer triggered.	Due to the level of variation in the dataset and lack of replication of monitoring events each year, a statistical analysis of the data could not be completed. However, in 2017, detection of Littlejohn's Tree Frog continued to increase from previous years, with abundance records consistent with pre-mining numbers (Figure 20). In particular, 120 tadpoles were observed during the 2017 transect, indicating appropriate recruitment conditions within the site, and the presence of breeding adult pairs.	Continue monitoring.

Stream	Predicted Impact	TARP Trigger Level	Results and TARP Justification	Recommendations
DA3B Watercourse Monitoring TARP (dated 12 October 2015)				
DC(1)	Significant impacts to local populations of Littlejohn's Tree Frog.	Level 1 TARP triggered.	Following the 2016 survey at DC(1), breeding pools (Pools 32 and 33) had a reduced water level below the benchmark. In order to confirm whether water remained present in pools long enough for Littlejohn's Tree Frog tadpoles and eggs to develop and metamorphose, follow up surveys were undertaken in summer 2016/2017 by Biosis. These surveys confirmed that pool water had dried up before recorded tadpoles and eggs had a chance to metamorphose, resulting in zero survival, and indicating a loss of Littlejohn's Tree Frog breeding habitat within DC1 (Biosis 2017).	Continue monitoring as a part of the terrestrial monitoring program. Submit an Impact Report to OEH, DoPE, T&I, Water NSW and other relevant resource managers. Due to the reduction in water levels, additional tadpole surveys should be conducted in summer 2018/2019 and additional pool water level monitoring should be conducted by Illawarra Coal.
DC13	Significant impacts to local populations of Littlejohn's Tree Frog.	Level 3 TARP triggered.	Subsidence impacts following mining has resulted in the loss of water in pools located above Longwall 9. In 2016, subsidence impacts extended along approximately 30% of the monitoring transect. Pools located within this stretch (Pools 18A through to the transect end) provided known habitat for Littlejohn's Tree Frog during the baseline monitoring period. Pools along approximately 40% of the total length of the transects had experienced a reduction in water in 2016. Follow up monitoring in summer 2016/2017 confirmed that many of the identified breeding pools that had water in winter 2016 had experienced a significant reduction in water by summer, and were considered no longer appropriate habitat for Littlejohn's Tree Frogs to survive to metamorphosis.	Continue monitoring as a part of the terrestrial monitoring program. Submit an Impact Report to OEH, DoPE, T&I, Water NSW and other relevant resource managers. Additional tadpole surveys should be conducted by Biosis in summer 2018/2019 and additional pool water level monitoring should be conducted by Illawarra Coal. Illawarra Coal are to develop site CMA (subject to stakeholder feedback).

Stream	Predicted Impact	TARP Trigger Level	Results and TARP Justification	Recommendations
WC21	Significant impacts to local populations of Littlejohn's Tree Frog.	Level 3 TARP triggered.	A reduction in habitat for five monitoring periods (four years) has been recorded at WC21 following the extraction of Longwall 9, Longwall 10, Longwall 11 and Longwall 12. Approximately 57% of the potential breeding habitat along this stream is experiencing a reduction in water levels (between Pool 11 and Pool 30) including three confirmed breeding pools (observations by Biosis during monitoring in 2015).	Continue monitoring as a part of the terrestrial monitoring program. Submit an Impact Report to OEH, DoPE, T&I, Water NSW and other relevant resource managers. Additional tadpole surveys should be conducted by Biosis in summer 2018/2019 and additional pool water level monitoring should be conducted by Illawarra Coal. Illawarra Coal are to develop site CMA (subject to stakeholder feedback).
LA4A	Significant impacts to local populations of Littlejohn's Tree Frog.	No TARP levels triggered.	No observed impacts have been detected at the one breeding pool, LA4A-P1 along this stream. Some fracturing and flow diversion has been detected at the lower end of the transect where it becomes LA4; however. this has not resulted in a reduction of breeding habitat for the species.	Continue monitoring as a part of the terrestrial monitoring program.

3.7 Aquatic Ecology

Cardno was commissioned by South32 to undertake a review of aquatic flora and fauna in relation to the extraction of Longwall 13. Cardno has been undertaking ongoing monitoring of watercourses within the DA3B mining area including Wongawilli Creek, Donalds Castle Creek and several associated tributaries. The overall objective of the monitoring is to determine whether the extent and nature of observed impacts, primarily subsidence-induced fracturing of bedrock, diversion and loss of aquatic habitat, are consistent with the predictions made in the aquatic flora and fauna review (AFFA) (Cardno Ecology Lab 2012) and DA3B SMP (BHPBIC 2012).

The monitoring requirements recommended in the AFFA and included in the SMP incorporates a BACI sampling design to monitor mine subsidence impacts on the aquatic environment with collection of at least two years of baseline data followed by monitoring during extraction, and at least two years of post-extraction monitoring. The following indicators were monitored at impact and control sites (total of 16) within and outside the SMP area as a measure of aquatic health:

- Aquatic habitat condition - using a modified version of the Riparian, Channel and Environmental Inventory method (RCE) (Chessman et al. 1997);
- Macroinvertebrates, including threatened species of dragonfly (Adams emerald dragonfly and Sydney hawk dragonfly), using AUSRIVAS and standardised artificial collectors;
- Limited in-situ water quality – using a portable probe; and
- Fish abundance using backpack electrofishing and bait traps.

Further details of the Aquatic Ecology Assessment methodology can be found in **Attachment G.**

Table 9: Summary of predicted and observed impacts to aquatic ecology.

Attribute	Predicted Physical Impacts	Predicted Impacts on Aquatic Ecology	Observed Impacts to Aquatic Ecology
Wongawilli Creek			
Ponding, flooding and scouring of stream banks due to tilt	No significant change predicted.	No measurable effects due to tilt.	None identified during observations at aquatic ecology monitoring sites on Wongawilli Creek.
Fracturing of bedrock and diversion of surface flows	No significant fracturing resulting in surface water flow diversions. Minor, isolated fractures of the streambed may occur within 400 metres from the proposed Longwalls. Minor fracturing of the creek bed and subsequent diversion of flows would not have significant geochemical effects. Formation of ferruginous springs is unlikely, but could occur at the margins or upslope of swamps (Ecoengineers 2011).	No significant changes in the quantity or quality of permanent aquatic habitat.	Reduction in pool water levels and flow have resulted in a reduction in aquatic habitat (full or partial loss of pool water) in approximately 1.4 km of Wongawilli Creek. This represents around 10 % of the 12 km long creek. Loss of some aquatic biota (fish and macroinvertebrates) would likely also have occurred here. Indirect impacts to aquatic biota would include a loss of longitudinal habitat connectivity.

Attribute	Predicted Physical Impacts	Predicted Impacts on Aquatic Ecology	Observed Impacts to Aquatic Ecology
Donalds Castle Creek and drainage lines (WC21, WC15 and LA4)			
Ponding, flooding and scouring of stream banks due to tilt	Reversals in grade may occur along Tributary WC21, adjacent to the tailgates of Longwalls 10 and 11. These could result in small increases in the levels of ponding, flooding and scouring of stream banks in highly localised areas along the tributaries. The impacts resulting from such changes are expected to be small relative to those that occur naturally during floods.	Localised changes in habitat availability and connectivity may occur along the tributaries due to tilt, but will be difficult to detect because of the large variability in natural flows within these ephemeral systems.	No impacts observed due to tilt.
Fracturing of bedrock and diversion of surface flows	Fracturing of the bedrock is likely to occur. In ephemeral creeks with alluvial deposits, fractures are likely to be in-filled by deposits during flow events. In areas with exposed bedrock, some diversion of surface flows into underlying strata and drainage of pools may occur, particularly during low flows. It is unlikely, that this would result in a significant impact on the overall quantity or quality of water flowing from the catchment.	There is unlikely to be any significant long-term changes in the quantity, quality or connectivity of aquatic habitats.	Rock fracturing observed in WC21 during extraction of Longwall 13 has potentially exacerbated impacts (fracturing and associated reduction in the water level of pools and reductions in the quantity and connectivity of aquatic habitat) identified during extraction of previous DA3B longwalls. These impacts were first observed in 2013, have persisted since and have been observed in 1.7 km (over 50 %) of the total length of the watercourse. This is a relatively severe impact at the scale of the individual watercourse. Fracturing of bedrock and diversion of flows in Lake Avon tributaries is likely to have resulted in some minor reduction in quantity and connectivity of aquatic habitat.

Table 10: Summary of Aquatic Ecology TARP sites and their respective trigger levels.

TARP	Wongawilli Creek	Donalds Castle Creek	WC21
Level 1 – Reduction in aquatic habitat for 1 year	Not triggered	Triggered September 2014	Triggered December 2014
Level 2 – Reduction in aquatic habitat for 2 years following the active subsidence period (i.e. when a longwall within 400 m of a feature, such as a creek, is completed)	Not triggered	Triggered 24 October 2015	Triggered 20 January 2017
Level 3 – Reduction in aquatic habitat for >2 years or complete loss of habitat following the active subsidence period	Not triggered	Triggered During 2017 Aquatic Ecology Surveys (Cardno 2018)	Triggered During 2017 Aquatic Ecology Surveys (Cardno 2018)

3.8 Cultural Heritage

Following the extraction of Longwall 13, an inspection of Aboriginal archaeological sites within the Longwall 13 study area was conducted by Niche on the 4th July 2018 (Figure 16). There were no observable impacts identified during the site inspections (Table 11). There have been no European heritage sites identified within the Longwall 13 study area.

Further details of the methodology used by Niche for the Cultural Heritage Assessment can be found in **Attachment H**.

Table 11: Summary table of Aboriginal archaeological sites within the Longwall 13 study area.

AHIMS Number	Site Name	Site Description	Observed Changes
2-2-1628	Browns Road Site 12	Shelter with art	None
52-2-1626	Browns Road Site 11	Shelter with art	None
52-2-2229	Site 1-DB1	Shelter with art	None
52-2-3640	DM16	Shelter with art	None
52-2-3641	DM17	Shelter with deposit	None

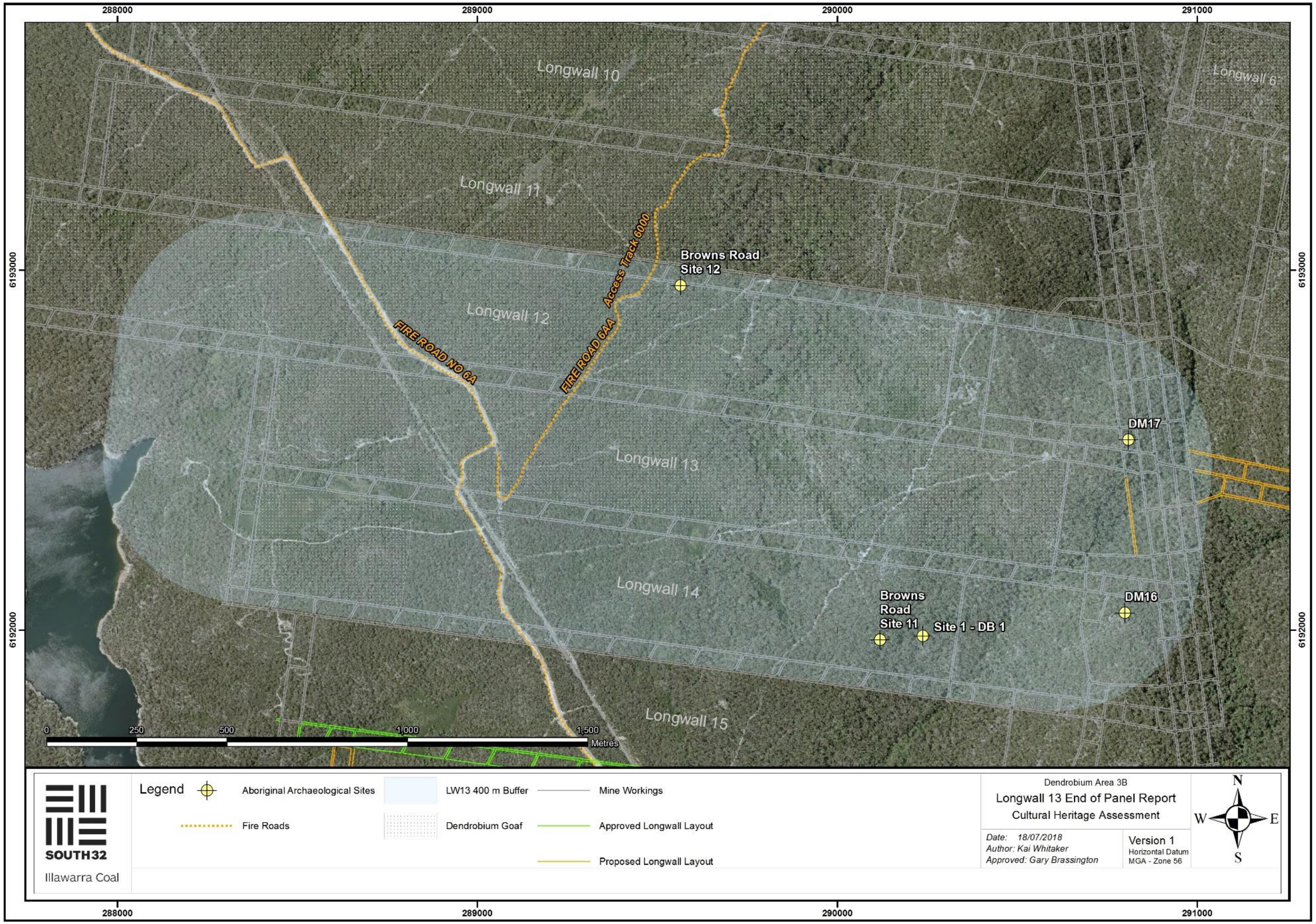

Figure 16: Aboriginal archaeological sites within the Longwall 13 study area.

4 IMPACTS TO BUILT FEATURES

The built features in proximity to Longwall 13 are shown in (**Attachment B**); and include:

- Fire trails and four-wheel drive tracks;
- disused Maldon – Dombarton Railway Corridor;
- survey control marks; and
- exploration and monitoring boreholes.

Cordeaux Dam Wall is in excess of 5 km north of Longwall 13. The Upper Cordeaux No. 2 Dam Wall is in excess of 5 km south-east of Longwall 13. It is unlikely these dam walls would experience any measurable far-field horizontal movements resulting from Longwall 13.

Twenty-four impacts associated with built features were identified during the extraction of Longwall 13 (Table 13). These impacts consist of soil cracks and uplift on seismic trails, Fire Road 6A, Access Track 6AA (also known as Access Track 6000) and the disused Maldon – Dombarton Railway Corridor. All twenty-four impacts were either remediated (by means of in-filling) or were observed as self-remediating.

Table 12: Summary of predicted impacts in comparison to observed impacts relevant to Longwall 13.

Built feature	MSEC assessed impacts	Reported impacts
Fire trails and four-wheel drive tracks	Cracking of unsealed road surfaces	Soil / surface cracking observed on or near the fire trails, seismic tracks and railway corridor, with widths ranging between approximately 20 mm and 450 mm. Refer to the IC landscape report for further details
Disused Maldon-Dombarton Railway	Possible fracturing of rock cuttings, spalling, and/or mobilisation of rock joints	Surface cracking above LW13 near the alignment of the railway corridor
Avon Dam	Adverse impacts not anticipated	No reported impacts to Avon Dam. Refer to associated groundwater report for further details
Survey control marks	Vertical and horizontal movements which could require re-establishment	No reported damage to the survey control marks. The marks to be re-established after completion of mining, as required

4.1 Level 1 Surface Cracking

Eighteen impacts (Photo 59 to Photo 62) to built features were reported as Level 1 impacts in accordance with the DA3B SMP; specifically:

- crack at the surface, which should not result in any significant erosion or further ground movement;
- crack in a fire trail, which should not result in erosion or impede access;
- crack or fracture up to 100 mm width;
- crack or fracture up to 10 m length; and

- erosion in a localised area, which would be expected to naturally stabilise without CMA and within the period of monitoring.

Photo 59: DA3B_LW13_032, soil cracking across Fire Road 6P. Taken 9th April 2018.

Photo 60: *DA3B_LW13_012*, largest section of surface cracking. Taken 30th October 2017.

Photo 61: *DA3B_LW13_034*, close up of the widest section of the soil cracking impact. Taken 9th April 2018.

Photo 62: *DA3B_LW13_020*, looking across the access track. Taken on 16th March 2018.

4.2 Level 2 Surface Cracking

Six impacts (Photo 63 to Photo 66) to built features were reported as Level 2 impacts in accordance with the DA3B SMP; specifically:

- Crack or fracture between 100 mm and 300 mm width;
- crack in the fire trail, which could result in significant erosion or impede vehicle access;
- crack or fracture between 10 m and 50 m length.

Photo 63: *DA3B_LW13_003*, showing the longest continuous section of cracking on *FR6A*, taken 26th June 2017.

Photo 64: *DA3B_LW13_029*, close up of the widest section of cracking. Taken 9th April 2018.

Photo 65: *DA3B_LW13_024*, looking across track. Taken 4th March 2018.

Photo 66: *DA3B_LW13_019*, looking inside soil crack. Taken on 2/03/2018.

5 SUMMARY OF TARP TRIGGERS

A summary of TARP triggers reached during the extraction of Longwall 13 is presented below in Table 13; additionally, an overview of Longwall 13 surface impacts is presented in Figure 17.

Table 13: Summary of TARP Triggers during the extraction of Longwall 13.

Site ID	Identification Date	Feature Affected	Impact Type	Description	Impact Level	TARPs Used	Refer to Report/s Dated
DA3B_LW13_001	19/04/2017	*LA4S1*	Rock Fracturing	Rock fracturing and uplift to base of *LA4S1*. approx. 0.5m length, 0.01m width.	2	Area 3B: SMP Volume 2, Table 2	3/05/2017
DA3B_LW13_002	22/05/2017	Access Track	Surface Cracking	Soil Cracking on access track, approx. 5m length, 0.02m width, 0.1m depth.	1	Area 3B: SMP Volume 2, Table 2	30/05/2017
DA3B_LW13_003	26/06/2017	*FR6A*	Surface Cracking	Discontinuous surface cracking on *FR6A*, 70m in length, 0.03m wide, 0.45m depth.	2	Area 3B: SMP Volume 2, Table 2	27/06/2017
DA3B_LW13_004	14/07/2017	*FR6A*	Surface Cracking	Discontinuous surface cracking on *FR6A*, 3m length, 0.01m width, uplift of 0.2m.	1	Area 3B: SMP Volume 2, Table 2	17/7/2017
DA3B_LW13_005	19/07/2017	*AT6AA*	Surface Cracking	Surface cracking on *Access Track 6AA*, 2.3m long, average width 0.05m, 0.2m max width, 2.34m depth.	2	Area 3B: SMP Volume 2, Table 2	20/07/2017
DA3B_LW13_006	25/09/2017	*WC21*	Rock Fracturing	Rock fracture to the base of *WC21_Pool 48*. 5m length, 0.03m width. Also associated with an absence of water in pool.	2	Area 3B: SMP Volume 2, Table 2	05/10/2017
DA3B_LW13_007	03/10/2018	*WC21*	Iron Staining	Iron staining at subsurface outflow, downstream from *WC21_Pool 38*, at BF37.	1	Area 3B: SMP Volume 2, Table 2	05/10/2017
DA3B_LW13_008	10/10/2017	Access Track	Surface Cracking	Consists of two small zones of surface cracking and uplift on access track adjacent to *WC21*. Max length 1.4m, width 0.06m, depth 0.1m.	1	Area 3B: SMP Volume 2, Table 2	24/10/2017

Site ID	Identification Date	Feature Affected	Impact Type	Description	Impact Level	TARPs Used	Refer to Report/s Dated
DA3B_LW13_009	23/10/2017	*WC21*	Rock Fracturing	Rock fracturing to the downstream extent of *WC21_Pool 54*. 0.38m long, 0.22m wide, 0.37m deep.	1	Area 3B: SMP Volume 2, Table 2	24/10/2017
DA3B_LW13_010	23/10/2017	*WC21*	Rock Fracturing	Rock fracturing to the step at the upstream extent of *WC21_Pool 53*. 2.5m long, 0.01m wide, and 0.03m deep.	2	Area 3B: SMP Volume 2, Table 2	24/10/2017
DA3B_LW13_011	23/10/2017	*WC21*	Rock Fracturing	Rock fracturing to the base of *WC21_Pool 47*.	2	Area 3B: SMP Volume 2, Table 2	24/10/2017
DA3B_LW13_012	30/10/2017	Access Track	Surface Cracking	Surface cracking on access track adjacent to *WC21*. Max 1m long, 0.05m wide and 0.12m wide.	1	Area 3B: SMP Volume 2, Table 2	14/11/2017
DA3B_LW13_013	30/10/2017	Access Track	Surface Cracking	Surface cracking on access track adjacent to *WC21*. Max 2m long, 0.02m wide and 0.1m wide.	1	Area 3B: SMP Volume 2, Table 2	14/11/2017
DA3B_LW13_014	13/11/2017	Access Track	Surface Cracking	Surface cracking on access track adjacent to *WC21*. Max 0.64m long, 0.1m wide and 0.16m deep.	1	Area 3B: SMP Volume 2, Table 2	14/11/2017
DA3B_LW13_015	20/11/2017	*Wongawilli Creek*	Pool Level	*WC_Pool 43a* water level below baseline. Fracture was identified in the pool during LW9.	3	Area 3B: SMP Volume 2, Table 2	28/11/2017 24/02/2018 31/05/2018
DA3B_LW13_016	20/11/2017	Access Track	Surface Cracking	Surface cracking and minor slumping on access track adjacent to *WC21*. Max 2m long, 0.03m wide and 0.1m deep.	1	Area 3B: SMP Volume 2, Table 2	09/01/2018
DA3B_LW13_017	08/01/2018	*WC21*	Rock Fracturing	Rock fracturing across Pool 45 in tributary *WC21*. 2m long, 0.03m wide and 0.22m at its deepest measurable point.	2	Area 3B: SMP Volume 2, Table 2	09/01/2018
DA3B_LW13_018	12/02/2018	*WC21*	Rock Fracturing	Rock fracturing across Pool 46 in tributary *WC21*. Max, 0.5m long, 0.01m wide and 0.05m.	2	Area 3B: SMP Volume 2, Table 2	23/02/2018
DA3B_LW13_019	02/03/2018	*FR6P*	Surface Cracking	Surface cracking on *FR6P*. 8.5m long, 0.45m max depth 0.45m, max width 0.15m.	2	Area 3B: SMP Volume 2, Table 2	05/03/2018

Site ID	Identification Date	Feature Affected	Impact Type	Description	Impact Level	TARPs Used	Refer to Report/s Dated
DA3B_LW13_020	16/03/2018	Access Track	Surface Cracking	Soil cracking on seismic track adjacent to *FR6P*. 0.35m long, 0.12m max depth, 0.07m width.	1	Area 3B: SMP Volume 2, Table 2	19/03/2018
DA3B_LW13_021	29/03/2018	*WC15*	Rock Fracturing	Rock fracturing to the upstream extent of *WC15_Rockbar 18*. 5.7m long, up to 0.015m wide, depth 0.06m.	2	Area 3B: SMP Volume 2, Table 2	03/04/2018
DA3B_LW13_022	29/03/2018	*WC15*	Rock Fracturing	Rock fracturing to *WC15_Rockbar 18*. Comprised of approx. 10 fractures. Max 3m long, up to 0.015m wide, depth 0.04m.	2	Area 3B: SMP Volume 2, Table 2	03/04/2018
DA3B_LW13_023	29/03/2018	*WC15*	Rock Fracturing	Rock fracturing to *WC15_Rockbar 18*. Max 5.6m long, up to 0.03m wide, depth 0.16m.	2	Area 3B: SMP Volume 2, Table 2	03/04/2018
DA3B_LW13_024	04/04/2018	Access Track	Surface Cracking	Soil cracking on access track adjacent to *FR6P*. 40m length, 0.2m wide, 0.85m depth.	2	Area 3B: SMP Volume 2, Table 2	06/04/2018
DA3B_LW13_025	04/04/2018	Access Track	Surface Cracking	Soil cracking on access track adjacent to *FR6P*. 5.7m length, 0.08m wide, 0.16m depth.	1	Area 3B: SMP Volume 2, Table 2	06/04/2018
DA3B_LW13_026	04/04/2018	Access Track	Surface Cracking	Soil cracking on access track adjacent to *FR6P*. 0.95m length, 0.01m wide, 0.01m depth.	1	Area 3B: SMP Volume 2, Table 2	06/04/2018
DA3B_LW13_027	04/04/2018	Access Track	Surface Cracking	Soil cracking on access track adjacent to *FR6P*. 2.1m length, 0.02m wide, 0.01m depth.	1	Area 3B: SMP Volume 2, Table 2	06/04/2018
DA3B_LW13_028	05/04/2018	*WC15*	Rock Fracturing	Rock fracturing to *WC15_Pool 18*. Max 1.4m long, up to 0.018m wide. No evidence of flow diversion.	1	Area 3B: SMP Volume 2, Table 2	06/04/2018
DA3B_LW13_029	09/04/2018	Access Track	Surface Cracking	Surface cracking on access track adjacent to *FR6P*. 9m length, 0.15m wide, 5m depth.	2	Area 3B: SMP Volume 2, Table 2	10/04/2018
DA3B_LW13_030	09/04/2018	Access Track	Surface Cracking	Surface cracking on access track adjacent to *FR6P*. 10m length, 0.15m wide, 0.25m depth.	2	Area 3B: SMP Volume 2, Table 2	10/04/2018

Site ID	Identification Date	Feature Affected	Impact Type	Description	Impact Level	TARPs Used	Refer to Report/s Dated
DA3B_LW13_031	09/04/2018	*FR6P*	Surface Cracking & Rock Fracturing	Surface cracking and rock fracturing on *FR6P*. 4.8m length, 0.06m width, 2.2m depth.	1	Area 3B: SMP Volume 2, Table 2	10/04/2018
DA3B_LW13_032	09/04/2018	*FR6P*	Surface Cracking	Surface cracking on *FR6P*. 3.2m length, 0.1m width, 0.4m depth.	1	Area 3B: SMP Volume 2, Table 2	10/04/2018
DA3B_LW13_033	09/04/2018	*FR6P*	Surface Cracking	Surface cracking on *FR6P*. 4.1m length, 0.1m width, 0.4m depth.	1	Area 3B: SMP Volume 2, Table 2	10/04/2018
DA3B_LW13_034	09/04/2018	*FR6P*	Surface Cracking	Surface cracking on *FR6P*. 1.5m length, 0.04m width, 0.8m depth.	1	Area 3B: SMP Volume 2, Table 2	10/04/2018
DA3B_LW13_035	23/04/2018	*WC15*	Rock Fracturing	Rock fracturing to *WC15_Rockbar 21*. Max 1.6m long, up to 0.002m wide. Small section of uplift and plating. No evidence of flow diversion.	1	Area 3B: SMP Volume 2, Table 2	27/04/2018
DA3B_LW13_036	23/04/2018	Sandstone Outcrop	Rock Fracturing	Rock fracturing to sandstone outcrop. Max 5.5m long, 0.05m width. 1.64m depth.	1	Area 3B: SMP Volume 2, Table 2	27/04/2018
DA3B_LW13_037	23/04/2018	Access Track	Surface Cracking	Soil cracking on access track adjacent to *FR6P*. 2.1m length, 0.09m width, 0.34m depth.	1	Area 3B: SMP Volume 2, Table 2	27/04/2018
DA3B_LW13_038	23/04/2018	Access Track	Surface Cracking	Soil cracking on access track adjacent to *FR6P*. 1.96m length, 0.03m width, 0.11m depth.	1	Area 3B: SMP Volume 2, Table 2	27/04/2018
DA3B_LW13_039	23/04/2018	Access Track	Surface Cracking	Soil cracking on access track adjacent to *FR6P*. 2.12m length, 0.025m width, 0.46m depth.	1	Area 3B: SMP Volume 2, Table 2	27/04/2018
DA3B_LW13_040	07/05/2018	*WC15*	Rock Fracturing	Rock fracturing and uplift zone of 20m. Longest continuous fracture is 5.5m, 0.05m width, 0.24m depth.	2	Area 3B: SMP Volume 2, Table 2	08/05/2018
DA3B_LW13_041	07/05/2018	*WC15*	Rock Fracturing & Rock Fall	Rock fracturing across step on *WC15*. 12m length, 0.05m width. Rockfall 3m x 3m x 0.2m. Ironing staining present	2	Area 3B: SMP Volume 2, Table 2	08/05/2018

Site ID	Identification Date	Feature Affected	Impact Type	Description	Impact Level	TARPs Used	Refer to Report/s Dated
DA3B_LW13_042	16/05/2018	*WC15*	Rock Fracturing & Rock Fall & Iron Staining	Impacts to *WC15_Rockbar 7*. Combination of rock fracturing, iron staining and a rock fall. Max length of fracturing is 4.5, depth 0.19m and width 0.01m. Multiple rock fractures under rockbar. Estimated to be 1m x1 mx 0.3m.	2	Area 3B: SMP Volume 2, Table 2	17/05/2018
DA3B_LW13_043	16/05/2018	*LA4*	Rock Fracturing & Rock Fall & Iron Staining	Rock fracturing, rockfall and iron staining evident to the base of *LA4_Step 0* on *LA4*. Fracture is 2m length, 0.02m width. rock fragment is 1.5m in length, 0.5m in width and 0.3m in height.	2	Area 3B: SMP Volume 2, Table 2	17/05/2018
Swamp 11	01/06/2017; 16/07/2018	*Swamp 11*	Shallow Groundwater	Rate of recession below baseline and water level below baseline at *S11_H1*. Reported separately.	1	SIMMCP TARP	27/06/2017; 20/07/2018
Swamp 11		*Swamp 11*	Soil Moisture	Soil moisture at all three sensors dropped below baseline after LW13 passed within 400 m. Probable mining effect.	3	SIMMCP TARP	HGEO (August 2018)
Swamp 13		*Swamp 13*	Soil Moisture	Soil moisture at all three sensors dropped below baseline after LW13 passed within 400 m. Possible mining effect, noting unusually dry conditions.	3	SIMMCP TARP	HGEO (August 2018)
Wongawilli Creek (FR6)	23/01/2018, 12/02/2018	*Wongawilli Creek*	Water Quality	Dissolved oxygen trigger.	2	WIMMCP TARP	3/01/2018 15/02/2018
Wongawilli Creek (FR6)	23/01/2018, 12/02/2018	*Wongawilli Creek*	Water Quality	Electrical conductivity trigger.	3	WIMMCP TARP	15/02/2018
DCS2	NA	*Donalds Castle Creek*	Catchment Yield	-21 % yield change during the extraction of Longwall 13.	3	WIMMCP TARP	HGEO (August 2018)
DC13S1	NA	*DC13 (Donalds Castle Creek Tributary)*	Catchment Yield	-7 % yield change during the extraction of Longwall 13.	1	WIMMCP TARP	HGEO (August 2018)
LA4	NA	*LA4 (Lake Avon Tributary)*	Catchment Yield	-6 % yield change during the extraction of Longwall 13.	1	WIMMCP TARP	HGEO (August 2018)

Site ID	Identification Date	Feature Affected	Impact Type	Description	Impact Level	TARPs Used	Refer to Report/s Dated
SC10C	NA	*SC10C (Sandy Creek Tributary)*	Terrestrial Ecology (Fauna)	Significant impacts to local populations of Littlejohn's Tree Frog.	1	WIMMCP TARP	Biosis (July 2018)
DC(1)	NA	*Donalds Castle Creek*	Terrestrial Ecology (Fauna)	Significant impacts to local populations of Littlejohn's Tree Frog.	1	WIMMCP TARP	Biosis (July 2018)
DC13	NA	*DC13 (Donalds Castle Creek Tributary)*	Terrestrial Ecology (Fauna)	Significant impacts to local populations of Littlejohn's Tree Frog.	3	WIMMCP TARP	Biosis (July 2018)
WC21	NA	*WC21 (Wongawilli Creek Tributary)*	Terrestrial Ecology (Fauna)	Significant impacts to local populations of Littlejohn's Tree Frog.	3	WIMMCP TARP	Biosis (July 2018)
Swamp 15B	NA	*Swamp 15B*	Terrestrial Ecology (Flora)	A statistically significant difference in TSR between BACI sites.	2	DA3A Terrestrial Flora and Fauna TARP	Biosis (July 2018)
Swamp 15A(2)	NA	*Swamp 15A*	Terrestrial Ecology (Flora)	A statistically significant change in species composition was detected at S15A(2) during the 4 year post-mining period (p-value = 0.003) indicating a Level 2 TARP has been triggered.	2	DA3A Terrestrial Flora and Fauna TARP	Biosis (July 2018)
Swamp 1A	NA	*Swamp 1A*	Terrestrial Ecology (Flora)	Trending decline in the extent of subcommunity MU43 for two consecutive monitoring periods greater than the mean (±SE) decline of MU43 in the control group.	1	SIMMCP TARP	Biosis (July 2018)
Swamp 1B	NA	*Swamp 1B*	Terrestrial Ecology (Flora)	Trending decline in the extent of subcommunity MU44c for two consecutive monitoring periods greater than the mean (±SE) decline in the control group.	1	SIMMCP TARP	Biosis (July 2018)
Swamp 5	NA	*Swamp 5*	Terrestrial Ecology (Flora)	Trending decline in the extent of subcommunity MU43 for three consecutive monitoring periods greater than the mean (±SE) decline in the control group.	2	SIMMCP TARP	Biosis (July 2018)

Site ID	Identification Date	Feature Affected	Impact Type	Description	Impact Level	TARPs Used	Refer to Report/s Dated
Donalds Castle Creek	NA	*Donalds Castle Creek*	Aquatic Ecology	Reduction in aquatic habitat for >2 years or complete loss of habitat following the active subsidence period.	3	WIMMCP TARP	Cardno (August 2018)
WC21	NA	*WC21 (Wongawilli Creek Tributary)*	Aquatic Ecology	Reduction in aquatic habitat for >2 years or complete loss of habitat following the active subsidence period.	3	WIMMCP TARP	Cardno (August 2018)

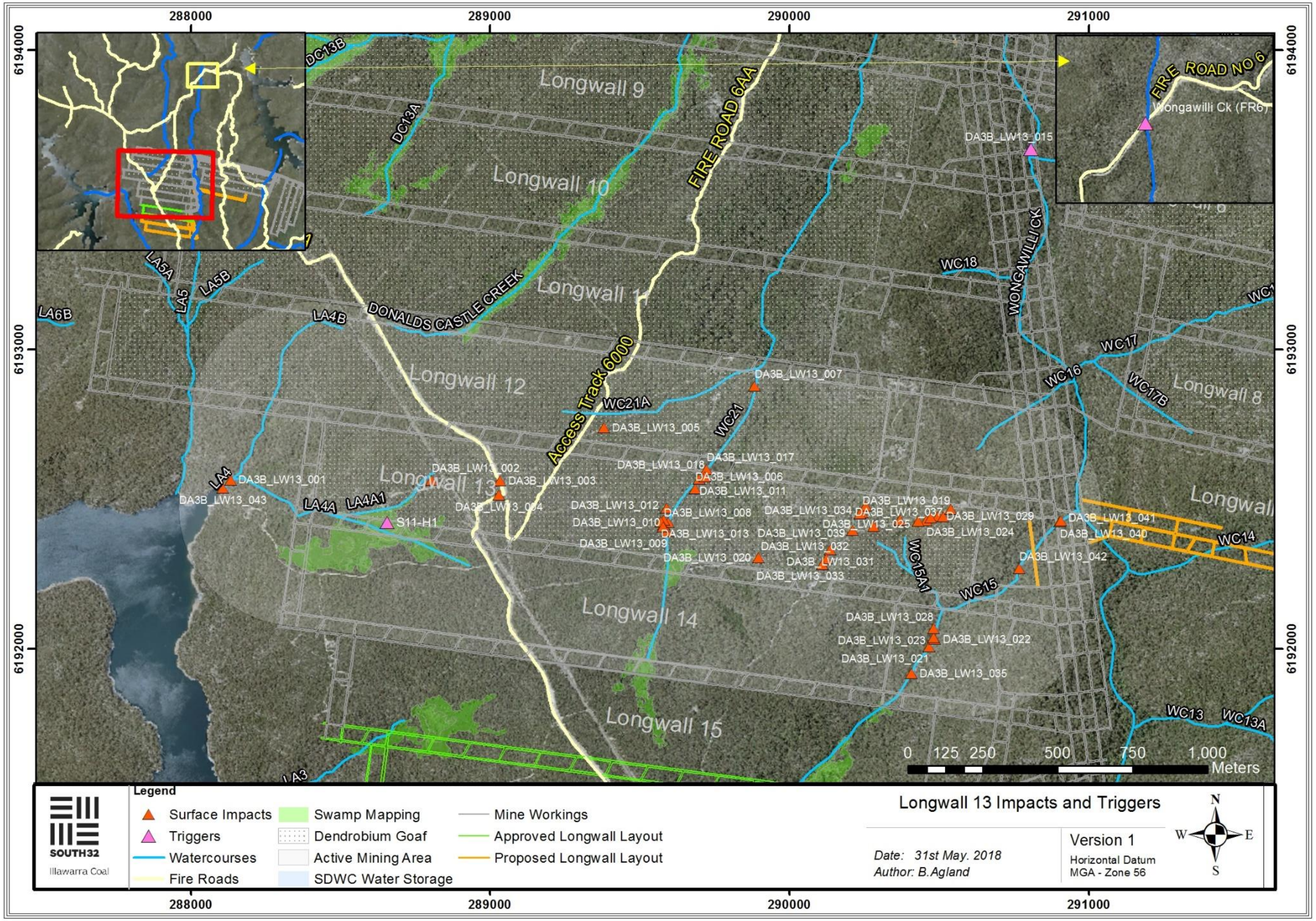

Figure 17: Overview of surface impacts observed during the extraction of Longwall 13.

6 LONGWALL 13 MONITORING PROGRAM

Table 14: Summary of monitoring sites associated with the extraction of Longwall 13. Recommended monitoring sites associated with the extraction of Longwall 14 are also included.

ASPECT	MONITORING SITES ASSOCIATED WITH LONGWALL 13	MONITORING FREQUENCY	RECOMMENDED FUTURE MONITORING FOR LONGWALL 14
Watercourses	**Observational, Photo Point and Water Monitoring**		
	• Wongawilli Creek • Donalds Castle Creek • WC21 • WC15 • WC16 • LA4 • LA4A • LA4B • Swamps 4, 5, 8, 10,11,13 and 14	Monthly 2 years pre and post mining, weekly when longwall is within 400m of monitoring site SLMMP Sites: pre and post mining, monthly when longwall is within 400m of monitoring site	• WC15 • LA3 • Swamp 23 • Wongawilli Creek – continue as required • Donalds Castle Creek – continue as required • WC21, WC16 and WC18 – continue as required • LA4, LA4A, LA4B - continue as required • Swamps 4, 5, 8, 10, 11,13 and 14 – continue as required
	Water Quality		
	• WWU1 (Wongawilli Creek headwaters) • WWU4 (Wongawilli Creek upstream) • WC Pool 49 (Wongawilli Creek adjacent to LW15) • WC_Pool 46 [*Previously named WWM1*] (Wongawilli Creek adjacent to LW12) • WWM2 (Wongawilli Creek adjacent to LW11) • WC_Pool 43b [*Previously named WWM3*] (Wongawilli Creek downstream of LW9) • Wongawilli Ck (FR6) [*Previously named WWL2*] (Wongawilli Creek downstream) • WC21_Pool 5 [*Previously named WC21S1*] (Wongawilli Creek tributary downstream of mining) • WC21 Pool 30 (Wongawilli Creek tributaries over mining) • WC21 Pool 53 (Wongawilli Creek tributaries over mining) • WC15_Pool 9 [*Previously named WC15S1*] (Wongawilli Creek tributary downstream of mining) **Lake Avon**	Monthly monitoring during and post mining for two years until required	Continue water quality sample sites as required by the SMP

	• LA4_S1, LA4_S2, LA5_S1, LA5_S2, LA_1, LA1, LA2_Pool 5, LA3_Pool 4 **Donalds Castle Creek:** • Donalds Castle Ck (FR6) [*Previously named DCU3*] (Donalds Castle Creek lower) • DCL3 (Donalds Castle Creek @ Cordeaux River) • DC_Pool 22 [*Previously named DCS2*] (Donalds Castle Creek downstream of mining) • DC13_Pool 2b [*Previously named DC13S1*] (Donalds Castle Creek tributary downstream of mining)		
Swamps	**Observational, Photo Point and Water Monitoring**		
	• Swamps 4, 5, 8, 10, 11, 13 and 14	Pre- and post-mining for two years, monthly when longwall is within 400m of monitoring site	• Swamp 23 • Swamps 3, 4, 5, 8, 10, 11 13 and 14 - continue as required by the SMP
	Shallow Groundwater Level		
	• Swamp 05: 05_01, 05_02, 05_03, 05_03i, 05_03ii, 05_03iii, 05_04, 05_05, 05_06 • Swamp 08: 08_01, 08_02, 08_03, 08_04, 08_05, 08_06 • Swamp 10: 10_01 • Swamp 11: S11-H1, S11-H2, S11-H3 • Swamp 13: 13_01 • Swamp 14: 14_01, 14_02	For open hole sites: • Monthly monitoring pre, during and post mining for two years to be removed annually • Reference sites 6 monthly For instrumented sites: • Automatic groundwater level monitoring, during and post mining (4-hour interval or similar) • Monitoring post mining for five years to be reviewed annually	• Swamp 05: 05_01, 05_02, 05_03, 05_03i, 05_03ii, 05_03iii, 05_04, 05_05, 05_06 • Swamp 08: 08_01, 08_02, 08_03, 08_04, 08_05, 08_06 • Swamp 10: 10_01 • Swamp 11: S11-H1, S11-H2, S11-H3 • Swamp 13: 13_01 • Swamp 14: 14_01, 14_02 • Swamp 23: 23_01, 23_02
	Soil Moisture		
	• Swamp 05: S05_S01, S05_S02, S05_S03, S05_S03i, S05_S03ii, S05_S03iii, S05_S04, S05_S05, S05_S08 • Swamp 08: S08_S01, S08_S02, S08_S03, S08_S04, S08_S05, S08_S06 • Swamp 11: S11_S01, S11_S02, S11_S05 • Swamp 13: S13_S01, S13_S02, S13_S03	• 6 monthly baseline and reference site monitoring • Weekly monitoring when longwall is within 400m of swamp • 6 monthly monitoring for 2 years post mining	• Swamp 05: S05_S01, S05_S02, S05_S03, S05_S03i, S05_S03ii, S05_S03iii, S05_S04, S05_S05, S05_S08 • Swamp 08: S08_S01, S08_S02, S08_S03, S08_S04, S08_S05, S08_S06 • Swamp 11: S11_S01, S11_S02, S11_S05 • Swamp 13: S13_S01, S13_S02, S13_S03

	Reference Sites: • Swamp 2: S02_S01 • Swamp 7: S07_S05, S07_S06 • Swamp 15A: S15a_S01, S15a_Piezo, S15a_S04, S15a_S06 • Swamp 22: 22_01, 22_02 • Swamp 24: S24_S01 • Swamp 25: S25_S01 • Swamp 33: S033_S01, S033_S03 • Swamp 84: S84_S02 • Swamp 85: S85_S01, S85_S02 • Swamp 86: S86_S01, S86_S02 • Swamp 87: S87_S01, S87_S02 • Swamp 88: S88_S01, S88_S02		• Swamp 14: 14_01, 14_02 • Swamp 23: 23_01, Reference Sites: • Swamp 2: S02_S01 • Swamp 7: S07_S05, S07_S06 • Swamp 15A: S15a_S01, S15a_Piezo, S15a_S04, S15a_S06 • Swamp 22: 22_01, 22_02 • Swamp 24: S24_S01 • Swamp 25: S25_S01 • Swamp 33: S033_S01, S033_S03 • Swamp 84: S84_S02 • Swamp 85: S85_S01, S85_S02 • Swamp 86: S86_S01, S86_S02 • Swamp 87: S87_S01, S87_S02 • Swamp 88: S88_S01, S88_S02
Landscape	**Targeted Sites**		
	Cliffs • DA3-CF19 • DA3-CF20 • DA3-CF21 • DA3-CF22 • DA3-CF23 **Fire Trails** Fire road 6A (Across Longwalls 10-18)	• Baseline monitoring campaign prior to monitoring • Monthly monitoring during any subsidence period • Monitoring to continue 6 monthly for 2 years following the completion of mining	**Cliffs** • DA3-CF19 • DA3-CF20 • DA3-CF21 • DA3-CF22 • DA3-CF23 **Fire Trails** Fire Road 6A (across LWs 10-18) - continue as required by the SMP Fire Road 6N

Inspection of Active Mining Area – Landscape Features, Vegetation, Watercourses		
All mapped cliff, steep slopes, watercourse, swamp and fire trail sites in subsidence area	• Weekly monitoring when longwall extraction is within 400m of feature	Continue monitoring of all mapped cliffs, steep slopes, watercourse, swamp and fire trail sites in subsidence area
General observation of active mining areas		Continue general observation of active mining areas

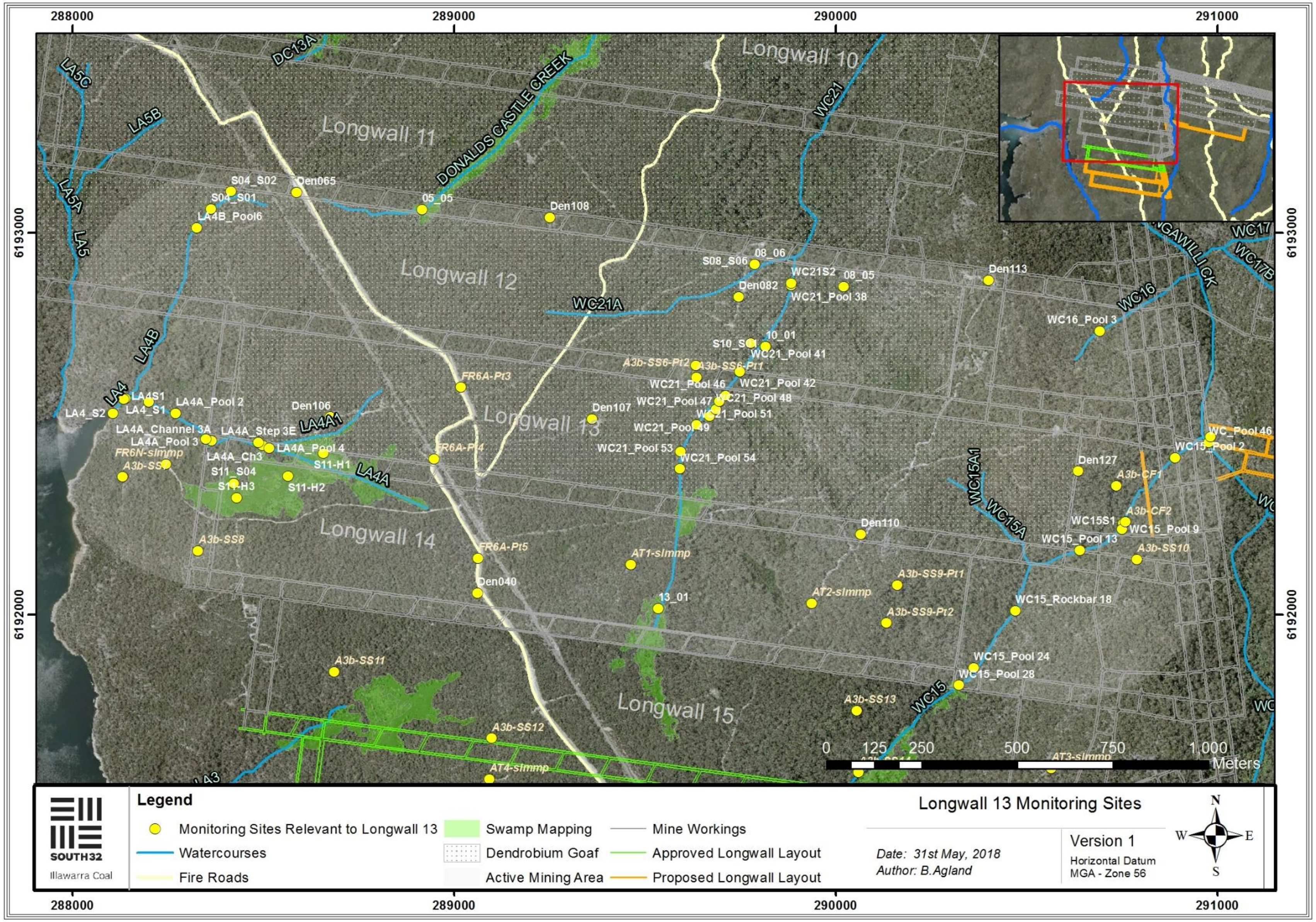

Figure 18: Overview of monitoring sites relevant to Longwall 13.

7 APPENDIX A – IMPACTS, TRIGGERS AND RESPONSE

Table 15: Dendrobium Area 3B Landscape TARPs

Monitoring	Trigger	Action
LANDSCAPE FEATURES		
AREA 2 **Cliffs** • A2-CL1 (above LW4) **Steep Slopes** • A2-SL1 and A2-SL2 (above LWs 4 & 5) **Watercourses** • A2-WC10 and A2-WC11 (above LW3) • A2-WC13 & A2-WC16 (above LWs 4 & 5) **Swamp** • A2-SW1 (above LWs 4 & 5) **4WD Track** • A2-FT1 (above LWs 4 & 5) **Crinanite Surface Extent** • A2-CN1 & A2-CN2 (above LWs 3 & 4) **AREA 3A**	***Level 1 **** • Rock fall from a cliff which is left mostly intact (<10% length), resulting in insignificant ground disturbance • Surface movement or rock displacement with negligible soil surface exposed • Crack at the surface, which should not result in any significant erosion or further ground movement • Crack in a fire trail which should not result in erosion or impede access • Crack or fracture up to 100mm width • Crack or fracture up to 10m length • Erosion in a localised area which would be expected to naturally stabilise without CMA and within the period of monitoring	• Continue monitoring program • Report impacts to key stakeholders • Summarise impacts and Report in the End of Panel Report and AEMR
	Level 2 * • Rock fall or overhang collapse at a cliff site, where characteristics of the cliff have changed, and there has been significant ground disturbance • Surface movement or rock displacement that has exposed significant areas of soil • A crack at the surface, which could result in significant erosion or movement at the surface • A crack at the surface with potential risk to safety and/or fauna entrapment • A crack in the fire trail, which could result in significant erosion or impede vehicle access • Crack or fracture between 100 and 300mm width • Crack or fracture between 10 and 50m length • Significant erosion at any location, which is not likely to naturally stabilise within the period of monitoring, or is located in a sensitive area e.g. swamps, creek, lake shore,	• *Actions as stated for Level 1* • Review monitoring frequency • Notify relevant technical specialists and seek advice on any CMA required • Provide safety signage and barricades as appropriate • Implement approved repairs to ensure safety and serviceability on fire trails • Implement agreed CMAs as approved *Note: CMAs are to be proposed based on appropriate management of environmental and other consequences of impacts i.e. cracking at the surface with insignificant consequences may not require specific CMAs other than ongoing monitoring to confirm there are no ongoing impacts*

Monitoring	Trigger	Action
Cliffs All mapped cliff sites in subsidence area (Refer to Dendrobium Area 3A SMP Figures 19.3 for location of sites) **Steep Slopes** All mapped steep slopes in subsidence area *Refer to Dendrobium Area 3A SMP Figures 19.3 for location of sites* **Watercourses/ Swamps** All mapped watercourse and swamps in subsidence area *Refer to Dendrobium Area 3A SMP Figure 19.3* **Fire Trails** All mapped fire trails in subsidence area *Refer to Dendrobium Area 3A SMP Figure 19.3* **<u>AREA 3B</u>** **Cliffs** All mapped cliff sites in subsidence area *Refer to Dendrobium Area 3B SMP Figures 18.1 for location of sites*	and may result in increased sediment transport to Cordeaux Dam, or has been previously identified as Level 1, but is not likely to naturally stabilise within the monitoring period	
	Level 3 * • Major cliff collapse where the characteristics of the cliff change significantly and there is significant ground disturbance that is unlikely to naturally stabilise within the monitoring period • Crack or fracture over 300mm width • Crack or fracture over 50m length • Mass movement of a slope causing large areas of exposed soil with potential for further movement	• *Actions as stated for Level 2* • Immediately notify DoPI, DPIM, SCA, resource managers and relevant technical specialists and seek advice on any CMA required • Site visits with stakeholders if required • Review monitoring program and modify if necessary within 1 month • Implement increased monitoring if required within 2 weeks • Develop site CMA in consultation with key stakeholders within 1 month, (pending stakeholder availability) and seek approvals • Completion of works following approvals • Issue CMA report within 1 month of works completion • Conduct initial follow up monitoring & reporting within 2 months of CMA completion • Review the relevant TARP and Management Plan in consultation with key stakeholders *Note: CMAs are to be proposed based on appropriate management of environmental and other consequences of impacts i.e. cracking at the surface with insignificant consequences may not require specific CMAs other than ongoing monitoring to confirm there are no ongoing impacts*
Sandy Creek Waterfall	***Exceeding Prediction*** • Rock fall at Sandy Creek Waterfall or from its overhang • Structural integrity of the waterfall, its overhang and its pool are impacted • More than negligible cracking within 30 m of the waterfall • More than negligible diversion of water from the lip of the waterfall	• Actions as stated for Level 3 • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation

Table 16: Dendrobium Area 3B Swamp TARP.

Performance Measures	***Potential Impacts***	***Performance Triggers***	***Management Strategies***	***Offsets***	***Other Actions***
Negligible erosion of the surface of the swamp	Gully erosion or similar	*Level 1:* The increase in length of erosion within a swamp (compared to its pre-mining length) is **2%** of the swamp length or area; and/or Erosion in a localised area (not associated with cracking or fracturing) which would be expected to naturally stabilise without CMA and within the period of monitoring. *Level 2*: The increase in length of erosion within a swamp (compared to its pre-mining length) is **3%** of the swamp length or area; and/or Soil surface crack that causes erosion that is likely to stabilise within the monitoring period without intervention; and/or Gully knickpoint forms or an existing gully knickpoint becomes active. *Level 3:* The increase in length of erosion within a swamp (compared to its pre-mining length) is **4%** of the swamp length or area; and/or Soil surface crack that causes erosion that is unlikely to stabilise within the monitoring period without intervention. *Exceeding Prediction* Mining results in the total length of erosion within a swamp (compared to its pre-mining length) to increase **>5%** of the length or area of the swamp compared to any increase in total erosion length in a reference swamp (ie increase in length or area of erosion in an impact swamp less any increase in length or area in erosion in a reference swamp is **>5%**).	a) upfront mine planning b) erosion monitoring (ie ALS, observation) c) coir logs d) knickpoint control e) water spreading f) weeding g) fire management h) reporting i) investigation and review j) update future predictions	Offset required **immediately**, if no remediation considered practicable. Offset required **2 years** following remediation, if it is ineffective. This period can be extended to **5 years**, with the agreement of the Secretary.	
Minor changes in the size of the swamps **Minor changes** in the ecosystem functionality of the swamps **No significant change** to the composition or	Swamp vegetation changes: - Swamp size - Species richness, distribution, composition and diversity - Vegetation sub-communities	**Swamp Size** *Level 1:* A trending decline in the extent of an upland swamp (combined area of groundwater dependent communities) for two consecutive monitoring periods, greater than observed in the Control Group, and exceeding the standard error (SE) of the Control Group *Level 2:* A trending decline in the extent of an upland swamp (combined area of groundwater dependent communities) for three consecutive monitoring periods, greater than observed in the Control Group, and exceeding the SE of the Control Group.	a) upfront mine planning b) vegetation monitoring c) water spreading d) seeding/planting e) weeding f) fauna monitoring g) fire management h) grouting of controlling of controlling rockbars and	Offset required **immediately**, if no remediation considered practicable. Offset required **5 years** following remediation, if it is ineffective.	Monitoring period for swamp size is related to capture of Lidar data at the end of each longwall ~ 1 year Triggers for groundwater decline result in increased intensity and frequency of

distribution of species within the swamps	<u>*Level 3:*</u> A trending decline in the extent of an upland swamp (combined area of groundwater dependent communities) for four consecutive monitoring periods, greater than observed in the Control Group, and exceeding the SE of the Control Group. <u>*Exceeding Prediction:*</u> Mining results in a trending decline in the extent of an upland swamp (combined area of groundwater dependent communities) for five consecutive monitoring periods, greater than observed in the Control Group, and exceeding the SE of the Control Group. **Ecosystem Functionality** <u>*Level 1:*</u> A trending decline in the extent of any individual groundwater dependent community within a swamp for two consecutive monitoring periods, greater than observed in the Control Group, and exceeding the SE of the Control Group. <u>*Level 2:*</u> A trending decline in the extent of any groundwater dependent community within a swamp for three consecutive monitoring periods, greater than observed in the Control Group, and exceeding the SE of the Control Group.. <u>*Level 3:*</u> A trending decline in the extent of any groundwater dependent community within a swamp for four consecutive monitoring periods, greater than observed in the Control Group, and exceeding the SE of the Control Group.. <u>*Exceeding Prediction:*</u> Mining results in a trending decline in the extent of a groundwater dependent community within a swamp for five consecutive monitoring periods, greater than observed in the Control Group, and exceeding the SE of the Control Group. **Species Composition and Distribution** <u>*Level 1:*</u> A **2%** (or otherwise statistically significant) decline in species richness or diversity during a period of stability or increase in species richness/diversity in reference swamps for **two** consecutive years; and/or <u>*Level 2:*</u> A **5%** (or otherwise statistically significant) decline in species richness or diversity during a period of stability or increase in species richness/diversity in reference swamps for **three** consecutive years. <u>*Level 3:*</u> An **8%** (or otherwise statistically significant) decline in species richness or diversity during a period of stability or increase in species richness/diversity in reference swamps for **four** consecutive years.	bedrock base and/or use of other remediation techniques i) reporting j) investigation and review k) update future predictions	This period can be extended to **10 years**, with the agreement of the Secretary.	vegetation monitoring

		<u>Exceeding Prediction:</u> Mining results in a **>10%** (or otherwise statistically significant) decline in species richness or diversity during a period of stability or increase in species richness/diversity in reference swamps for **five** consecutive years.			
Maintenance or restoration of the structural integrity of the bedrock base of any significant permanent pool or controlling rockbar within the swamps	Subsidence impacts (ie cracking) on bedrock base or controlling rockbar	*<u>Level 1:</u>* Fracturing observed in the bedrock base of any significant permanent pool which results in observable loss of surface water of **10%** compared to baseline for the pool (in addition to any decrease in reference pools). *<u>Level 2:</u>* Fracturing observed in the bedrock base of any significant permanent pool which results in observable loss of surface water of **20%** compared to baseline for the pool (in addition to any decrease in reference pools). *<u>Level 3:</u>* Fracturing observed in the bedrock base of any significant permanent pool which results in observable loss of surface water of **20%** compared to baseline for the pool for **>20%** of the time over a period of **1** year (in addition to any decrease in reference pools). *<u>Exceeding Prediction</u>* Structural integrity of the bedrock base of any significant permanent pool or controlling rockbar cannot be restored, ie pool water level within the swamp after CMAs continues to be **>20%** lower than baseline for **>20%** of the time over a period of **1** year.	a) upfront mine planning b) subsidence monitoring c) surface water monitoring d) groundwater monitoring e) grouting of controlling of controlling rockbars and bedrock base and/or use of other remediation techniques f) CMAs g) reporting h) investigation and review i) update future predictions	Offset required **immediately**, if no remediation considered practicable. Offset required **2 years** following remediation, if it is ineffective. This period can be extended to **5 years**, with the agreement of the Secretary.	
Minor changes in the ecosystem functionality of the swamps	Falls in surface or near-surface groundwater levels in swamps *NB. Not linked specifically to a PM and would not be considered a breach if predictions were exceeded.*	*<u>Level 1:</u>* Groundwater level lower than baseline level at any monitoring site within a swamp (in comparison to reference swamps); and/or Rate of groundwater level reduction exceeds rate of groundwater level reduction during baseline period at any monitoring site (measured as average mm/day during the recession curve). *<u>Level 2:</u>* Groundwater level lower than baseline level at **50%** of monitoring sites (within 400 m of mining) within a swamp (in comparison to reference swamps); and/or Rate of groundwater level reduction exceeds rate of groundwater level reduction during baseline period at a **50%** of monitoring sites (within 400m of mining) within the swamp.	a) upfront mine planning b) groundwater monitoring c) implementation of swamp research program d) weeding e) fire management f) reporting g) update future predictions		Triggers for groundwater decline result in increased intensity and frequency of vegetation monitoring and/or further investigations of subsidence impacts on bedrock base and rockbars

		Level 3: Groundwater level lower than baseline level at **>80%** of monitoring sites (within 400m of mining) within a swamp (in comparison to reference swamps); and/or Rate of groundwater level reduction exceeds rate of groundwater level reduction during baseline period at **>80%** of monitoring sites (within 400 m of mining) within the swamp.			
Minor changes in the ecosystem functionality of the swamps	Falls in soil moisture levels in swamps *NB. Not linked specifically to a PM and would not be considered a breach if predictions were exceeded.*	*Level 1:* Soil moisture level lower than baseline level at **any** monitoring sites (within 400 m of mining) within a swamp (in comparison to reference swamps). *Level 2:* Soil moisture level lower than baseline level at **50%** of monitoring sites (within 400m of mining) within a swamp (in comparison to reference swamps). *Level 3:* Soil moisture level lower than baseline level at **>80%** of monitoring sites (within 400m of mining) within a swamp (in comparison to reference swamps).	a) upfront mine planning b) soil moisture monitoring c) water spreading d) weeding e) fire management f) reporting g) update future predictions		Triggers of soil moisture decline result in increased intensity and frequency of vegetation monitoring and/or further investigations of subsidence impacts on bedrock base and rockbars

Table 17: Dendrobium Area 3B Watercourse TARP

Monitoring	Trigger	Action
OBSERVATIONAL, PHOTO POINT AND WATER MONITORING		
Native Dog, Wongawilli and Donalds Castle Creeks, WC21, WC15, LA4, DC13, LA5, ND1, WC6, WC7, WC8, WC9, WC12, WC16 and WC18 General observation of streams in active mining areas when longwall is within 400m	***Level 1*** * • Crack or fracture up to 100mm width at its widest point with no observable loss of surface water or erosion • Crack or fracture up to 10m length with no observable loss of surface water or erosion • Erosion in a localised area (not associated with cracking or fracturing) which would be expected to naturally stabilise without CMA and within the period of monitoring • Observable release of strata gas at the surface • Observable increase in iron staining within the mining area	• Continue monitoring program • Submit an Impact Report to OEH, DoPE, T&I, Water NSW and other relevant resource managers • Report in the End of Panel Report • Summarise actions and monitoring in AEMR
•Relevant Performance Measure(s): • Wongawilli Creek - minor environmental consequences • Donalds Castle Creek - minor environmental consequences • Waterfall WC-WF54 – negligible environmental consequences	***Level 2 **** • Crack or fracture between 100 and 300mm width at its widest point or any fracture which results in observable loss of surface water or erosion • Crack or fracture between 10 and 50m length • Soil surface crack that causes erosion that is likely to stabilise within the monitoring period without intervention • Observable increase in iron staining within the mining area continues to outside the mining area i.e. 400m from the longwall	• *Actions as stated for Level 1* • Review monitoring frequency • Notify relevant technical specialists and seek advice on any CMA required • Implement agreed CMAs as approved (subject to stakeholder feedback) •
	Level 3 * • Crack or fracture over 300mm width at its widest point • Crack or fracture over 50m length • Fracturing observed in the bedrock base of any significant permanent pool which results in observable loss of surface water • Soil surface crack that causes erosion that is unlikely to stabilise within the monitoring period without intervention • Gas release results in vegetation dieback, mortality or loss of aquatic habitat • Observable increase in iron staining within the mining area continues more than 600m from the longwall •	• *Actions as stated for Level 2* • Site visit with OEH, DoPE, T&I, Water NSW and other resource manager/s (if requested) • Implement additional monitoring or increase frequency if required • Develop site CMA (subject to stakeholder feedback). This may include: grouting of rockbar and bedrock base of any significant pool where it is appropriate to do so in consultation with OEH, DoPE, T&I, Water NSW and other stakeholders • Completion of works following approvals and at a time agreed between BHPBIC, DoPE, T&I and Water NSW (i.e. may be after mining induced movements and impacts are complete), including monitoring and reporting on success

Monitoring	Trigger	Action
		• Review relevant TARP and Management Plan in consultation with key stakeholders
	Exceeding Prediction • Structural integrity of the bedrock base of any significant pool or controlling rockbar cannot be restored i.e. pool water level within the pool after CMAs continues to be lower than baseline period • Gas release results in vegetation dieback that does not revegetate • Gas release results in mortality of threatened species or ongoing loss of aquatic habitat • Iron staining and associated increases in dissolved iron resulting from the mining is observed in water at Wongawilli Creek downstream monitoring site WONGAWILLI CK (FR6) • Iron staining and associated increases in dissolved iron resulting from the mining is observed in water at the Donalds Castle Creek downstream monitoring site Donalds Castle Ck (FR6) • Rock fall at WC-WF54 or its overhang • Impacts on the structural integrity of WC-WF54, its overhang or its pool	• *Actions as stated for Level 3* • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation • Provide residual environmental offset for any mining impact where CMAs are unsuccessful as required by Condition 14 Schedule 3 of the Development Consent
• WATER QUALITY		
Wongawilli Creek Wongawilli Ck (FR6) Baseline means: • pH 5.98 • EC 98.8 uS/cm • DO 89.5%	***Level 1*** * • One exceedance of the ±3 standard deviation level (positive for EC, negative for pH and DO) from the baseline mean during the monitoring period: – pH 4.45 – EC 154.1 uS/cm – DO 50.5%	• Continue monitoring program • Submit an Impact Report to OEH, DoPE, T&I, Water NSW and other relevant resource managers • Report in the End of Panel Report • Summarise actions and monitoring in AEMR
• Relevant Performance Measure(s): • Wongawilli Creek - minor environmental consequences •	***Level 2*** * • Two exceedances of the ±3 standard deviation level (positive for EC, negative for pH and DO) from the baseline mean during the monitoring period: – pH 4.45 – EC 154.1 uS/cm – DO 50.5%	• *Actions as stated for Level 1* • Review monitoring frequency • Notify relevant technical specialists and seek advice on any CMA required • Implement agreed CMAs as approved (subject to stakeholder feedback) •

Monitoring	Trigger	Action
	Level 3 * • Three exceedances of the ±3 standard deviation level (positive for EC, negative for pH and DO) from the baseline mean during the monitoring period: – pH 4.45 – EC 154.1 uS/cm – DO 50.5%	• *Actions as stated for Level 2* • Site visit with OEH, DoPE, T&I, Water NSW and other resource manager/s (if requested) • Implement additional monitoring or increase frequency if required • Review relevant TARP and Management Plan in consultation with key stakeholders • Develop site CMA (subject to stakeholder feedback). This may include: – Limestone emplacement to raise pH where it is appropriate to do so – Grouting of fractures in rockbar and bedrock base of any significant pool where flow diversion results in pool water level lower than baseline period • Completion of works following approvals and at a time agreed between BHPBIC, DoPE, T&I and Water NSW (i.e. may be after mining induced movements and impacts are complete), including monitoring and reporting on success
	Exceeding Prediction • Mining results in two conecutive exceedances of the ±3 standard deviation level (positive for EC, negative for pH and DO) from the baseline mean during the monitoring period: – pH 4.45 – EC 154.1 uS/cm – DO 50.5%	• *Actions as stated for Level 3* • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation • Provide residual environmental offset for any mining impact where CMAs are unsuccessful as required by Condition 14 Schedule 3 of the Development Consent
Donalds Castle Creek Donalds Castle Ck (FR6) Baseline means: • pH 5.41 • EC 116.0 uS/cm • DO 85.6%	***Level 1*** * • One exceedance of the ±3 standard deviation level (positive for EC, negative for pH and DO) from the baseline mean during the monitoring period: – pH 3.60 – EC 185.8 uS/cm – DO 40.1%	• Continue monitoring program • Submit an Impact Report to OEH, DoPE, T&I, Water NSW and other relevant resource managers • Report in the End of Panel Report • Summarise actions and monitoring in AEMR
•Relevant Performance Measure(s): • Donalds Castle Creek - minor environmental consequences	***Level 2*** * • Two exceedances of the ±3 standard deviation level (positive for EC, negative for pH and DO) from the baseline mean during the monitoring period: – pH 3.60	• *Actions as stated for Level 1* • Review monitoring frequency • Notify relevant technical specialists and seek advice on any CMA required • Implement agreed CMAs as approved (subject to stakeholder feedback) •

Monitoring	Trigger	Action
	– EC 185.8 uS/cm – DO 40.1%	
	Level 3 * • Three exceedances of the ±3 standard deviation level (positive for EC, negative for pH and DO) from the baseline mean during the monitoring period: – pH 3.60 – EC 185.8 uS/cm – DO 40.1%	• *Actions as stated for Level 2* • Site visit with OEH, DoPE, T&I, Water NSW and other resource manager/s (if requested) • Implement additional monitoring or increase frequency if required • Review relevant TARP and Management Plan in consultation with key stakeholders • Collect laboratory samples and analyse for: – pH, EC, major cations, major anions, Total Fe, Mn & Al – Filterable suite of metals • Develop site CMA (subject to stakeholder feedback). This may include: – Limestone emplacement to raise pH where it is appropriate to do so – Grouting of fractures in rockbar and bedrock base of any significant pool where flow diversion results in pool water level lower than baseline period • Completion of works following approvals and at a time agreed between BHPBIC, DoPE, T&I and Water NSW (i.e. may be after mining induced movements and impacts are complete), including monitoring and reporting on success
	Exceeding Prediction • Mining results in two conecutive exceedances of the ±3 standard deviation level (positive for EC, negative for pH and DO) from the baseline mean during the monitoring period: – pH 3.60 – EC 185.8 uS/cm – DO 40.1%	• *Actions as stated for Level 3* • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation • Provide residual environmental offset for any mining impact where CMAs are unsuccessful as required by Condition 14 Schedule 3 of the Development Consent
Lake Avon Lake Avon tributary (LA4_S1) Baseline means: • pH 5.38 • EC 90.8 uS/cm • DO 89.9%	***Level 1*** * • One exceedance of the ±3 standard deviation level (positive for EC, negative for pH and DO) from the baseline mean during the monitoring period: – pH 4.90 – EC 129.8 uS/cm – DO 69.5%	• Continue monitoring program • Submit an Impact Report to OEH, DoPE, T&I, Water NSW and other relevant resource managers • Report in the End of Panel Report • Summarise actions and monitoring in AEMR

Monitoring	Trigger	Action
(24 months of baseline data available - to be updated with additional baseline data) •Relevant Performance Measure(s): • Lake Avon - negligible reduction in the quality of surface water inflows to Lake Avon	***Level 2*** * • Two exceedances of the ±3 standard deviation level (positive for EC, negative for pH and DO) from the baseline mean during the monitoring period: – pH 4.90 – EC 129.8 uS/cm – DO 69.5%	• *Actions as stated for Level 1* • Review monitoring frequency • Notify relevant technical specialists and seek advice on any CMA required • Implement agreed CMAs as approved (subject to stakeholder feedback) •
	Level 3 * • Three exceedances of the ±3 standard deviation level (positive for EC, negative for pH and DO) from the baseline mean during the monitoring period: – pH 4.90 – EC 129.8 uS/cm – DO 69.5%	• *Actions as stated for Level 2* • Site visit with OEH, DoPE, T&I, Water NSW and other resource manager/s (if requested) • Implement additional monitoring or increase frequency if required • Review relevant TARP and Management Plan in consultation with key stakeholders • Collect laboratory samples and analyse for: – pH, EC, major cations, major anions, Total Fe, Mn & Al – Filterable suite of metals • Develop site CMA (subject to stakeholder feedback). This may include: – Limestone emplacement to raise pH where it is appropriate to do so – Grouting of fractures in rockbar and bedrock base of any significant pool where flow diversion results in pool water level lower than baseline period • Completion of works following approvals and at a time agreed between BHPBIC, DoPE, T&I and Water NSW (i.e. may be after mining induced movements and impacts are complete), including monitoring and reporting on success
	Exceeding Prediction • Mining results in two conecutive exceedances of the ±3 standard deviation level (positive for EC, negative for pH and DO) from the baseline mean of the Lake Avon inflows during the monitoring period: – pH 4.90 – EC 129.8 uS/cm – DO 69.5%	• *Actions as stated for Level 3* • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation • Provide residual environmental offset for any mining impact where CMAs are unsuccessful as required by Condition 14 Schedule 3 of the Development Consent
•POOL WATER LEVEL		

Monitoring	Trigger	Action
Mapped pools in the mining area: • Wongawilli Creek • Donalds Castle Creek • Relevant Performance Measure(s): • Wongawilli Creek - minor environmental consequences • Donalds Castle Creek - minor environmental consequences	***Level 1*** * • Fracturing not resulting in diversion of flow	• Continue monitoring program • Submit an Impact Report to OEH, DoPE, T&I, Water NSW and other relevant resource managers • Report in the End of Panel Report • Summarise actions and monitoring in AEMR
	Level 2 * • Fracturing resulting in diversion of flow	• *Actions as stated for Level 1* • Review monitoring frequency • Notify relevant technical specialists and seek advice on any CMA required • Implement agreed CMAs as approved (subject to stakeholder feedback)
	Level 3 * • Fracturing resulting in diversion of flow such that <10% of the pools have water levels lower than baseline period	• *Actions as stated for Level 2* • Site visit with OEH, DoPE, T&I, Water NSW and other resource manager/s (if requested) • Implement additional monitoring or increase frequency if required • Review relevant TARP and Management Plan in consultation with key stakeholders • Develop site CMA (subject to stakeholder feedback). This may include: grouting of rockbar and bedrock base of any significant pool where it is appropriate to do so in consultation with OEH, DoPE, T&I, Water NSW and other stakeholders • Completion of works following approvals and at a time agreed between BHPBIC, DoPE, T&I and Water NSW (i.e. may be after mining induced movements and impacts are complete), including monitoring and reporting on success
	Exceeding Prediction • Fracturing resulting in diversion of flow such that >10% of the pools have water levels lower than baseline period	• *Actions as stated for Level 3* • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation • Provide residual environmental offset for any mining impact where CMAs are unsuccessful as required by Condition 14 Schedule 3 of the Development Consent
• **Waterfall WC-WF54** • Relevant Performance Measure(s): • Waterfall WC-WF54 – negligible environmental consequences	***Exceeding Prediction*** • Fracturing in Wongawilli Creek within 30m of the waterfall which results in observable flow diversion • Fracturing in Wongawilli Creek which results in observable flow diversion from the lip of the waterfall	• *Actions as stated for Level 3* • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation • Provide residual environmental offset for any mining impact where CMAs are unsuccessful as required by Condition 14 Schedule 3 of the Development Consent

Monitoring	Trigger	Action
MODELLED PERIODS OF RECESSIONAL, BASEFLOW AND SMALL STORM UNIT HYDROGRAPH PERIODS		
Subcatchments of Wongawilli and Donalds Castle Creeks and Lake Avon tributaries **	***Level 1 **** • Change 6-12% less than average annual precipitation ***	• Continue monitoring program • Submit an Impact Report to OEH, DoPE, T&I, Water NSW and other relevant resource managers • Report in the End of Panel Report • Summarise actions and monitoring in AEMR
•	***Level 2 **** • Change 12-18% less than average annual precipitation ***	• *Actions as stated for Level 1* • Review monitoring frequency • Notify relevant technical specialists and seek advice on any CMA required • Implement agreed CMAs as approved (subject to stakeholder feedback)
	Level 3 * • Change >18% less than average annual precipitation ***	• *Actions as stated for Level 2* • Site visit with OEH, DoPE, T&I, Water NSW and other resource manager/s (if requested) • Implement additional monitoring or increase frequency if required • Develop site CMA (subject to stakeholder feedback). This may include: grouting of rockbar and bedrock base of any significant pool where it is appropriate to do so in consultation with OEH, DoPE, T&I, Water NSW and other stakeholders • Completion of works following approvals and at a time agreed between BHPBIC, DoPE, T&I and Water NSW (i.e. may be after mining induced movements and impacts are complete), including monitoring and reporting on success • Review relevant TARP and Management Plan in consultation with key stakeholders
Inflows to Lake Avon and Cordeaux River ** •Relevant Performance Measure(s): • Lake Avon - negligible reduction in the quantity of surface water inflows to Lake Avon • Cordeaux River - negligible reduction in the quantity of surface water flows from Wongawilli Creek to Cordeaux River	***Exceeding Prediction*** • Measured surface water flow reduction in Wongawilli Creek at its confluence with Cordeaux River that is greater than predicted by the groundwater model (to the satisfaction of the Director General - Condition 13 of the SMP) that cannot be attributed to natural variation • Surface water flow reduction into Lake Avon is greater than predicted by the groundwater model (to the satisfaction of the Director General - Condition 13 of the SMP) that cannot be attributed to natural variation	• *Actions as stated for Level 3* • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation • Provide residual environmental offset for any mining impact where CMAs are unsuccessful as required by Condition 14 Schedule 3 of the Development Consent

Monitoring	Trigger	Action
AQUATIC ECOLOGY		
Pool water level, interconnectivity between pools and loss of connectivity, noticeable alteration of habitat • Wongawilli Creek catchment – 8 sites • Donalds Castle Creek catchment – 1 site	***Level 1 **** • Reduction in aquatic habitat for 1 year •	• Continue monitoring program • Submit an Impact Report to OEH, DoPE, T&I, Water NSW and other relevant resource managers • Report in the End of Panel Report • Summarise actions and monitoring in AEMR
	Level 2 * • Reduction in aquatic habitat for 2 years following the active subsidence period	• *Actions as stated for Level 1* • Review monitoring frequency • Notify relevant technical specialists and seek advice on any CMA required • Implement agreed CMAs as approved (subject to stakeholder feedback)
	Level 3 * • Reduction in aquatic habitat for >2 years or complete loss of habitat following the active subsidence period	• *Actions as stated for Level 2* • Site visit with OEH, DoPE, T&I, Water NSW and other resource manager/s (if requested) • Implement additional monitoring or increase frequency if required • Review relevant TARP and Management Plan in consultation with key stakeholders • Develop site CMA (subject to stakeholder feedback). This may include: grouting of rockbar and bedrock base of any significant pool where it is appropriate to do so in consultation with OEH, DoPE, T&I, Water NSW and other stakeholders • Completion of works following approvals and at a time agreed between BHPBIC, DoPE, T&I and Water NSW (i.e. may be after mining induced movements and impacts are complete), including monitoring and reporting on success
TERRESTRIAL FAUNA – THREATENED FROG SPECIES		
Pool water level, interconnectivity between pools and loss of connectivity, noticeable alteration of habitat • Wongawilli Creek catchment – 2 sites • Donalds Castle Creek catchment – 2 sites • Lake Avon tributary – 1 site	***Level 1 **** • Reduction in habitat for 1 year •	• Continue monitoring program • Submit an Impact Report to OEH, DoPE, T&I, Water NSW and other relevant resource managers • Report in the End of Panel Report • Summarise actions and monitoring in AEMR
	Level 2 *	• *Actions as stated for Level 1* • Review monitoring frequency

Monitoring	Trigger	Action
• Native Dog tributary – 1 site	• Reduction in habitat for 2 years following the active subsidence period	• Notify relevant technical specialists and seek advice on any CMA required • Implement agreed CMAs as approved (subject to stakeholder feedback)
	Level 3 * • Reduction in habitat for > 2 years or complete loss of habitat following the active subsidence period	• *Actions as stated for Level 2* • Site visit with OEH, DoPE, T&I, Water NSW and other resource manager/s (if requested) • Implement additional monitoring or increase frequency if required • Review relevant TARP and Management Plan in consultation with key stakeholders • Develop site CMA (subject to stakeholder feedback). This may include: grouting of rockbar and bedrock base of any significant pool where it is appropriate to do so in consultation with OEH, DoPE, T&I, Water NSW and other stakeholders • Completion of works following approvals and at a time agreed between BHPBIC, DoPE, T&I and Water NSW (i.e. may be after mining induced movements and impacts are complete), including monitoring and reporting on success