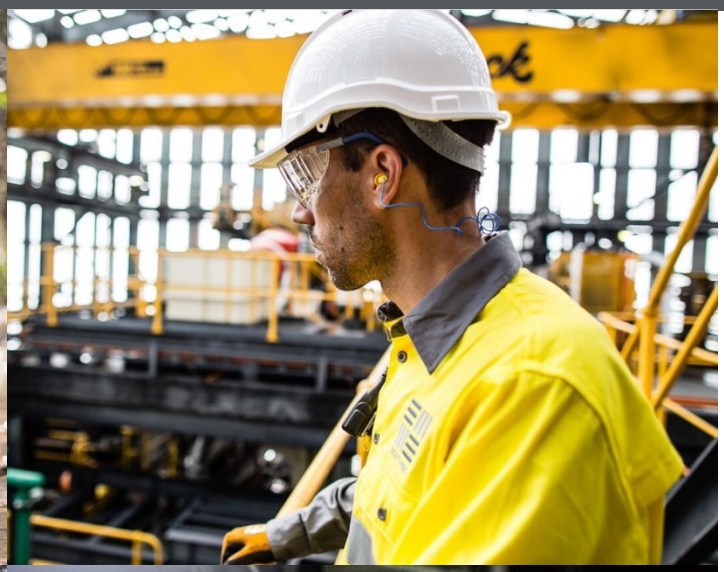
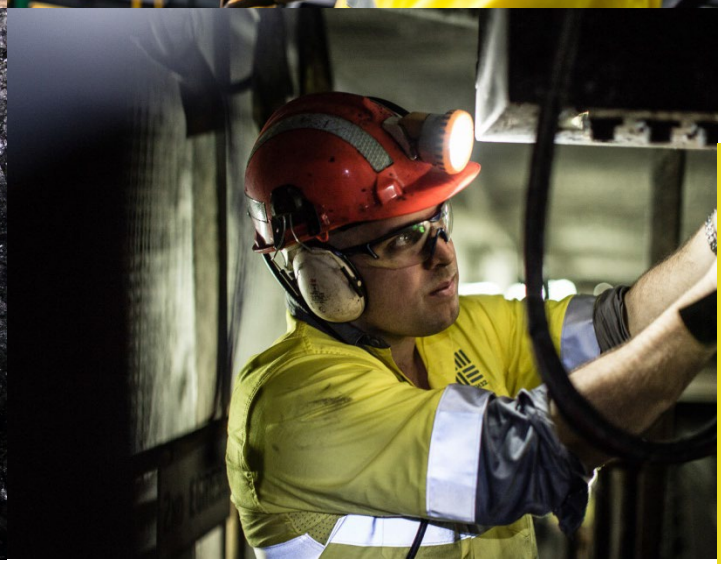
SOUTH32

Illawarra Metallurgical Coal
End of Panel Report





Dendrobium Area 3B Longwall 15 End of Panel Report

May 2020

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 15, and presents monitoring results and analyses compared to relevant impact assessment criteria and predictions in the DA3B Subsidence Management Plan (SMP).

Dendrobium Longwall 15 is located within Consolidated Coal Lease 768 and is the seventh panel to be extracted in DA3B. Extraction of Longwall 15 commenced on 4 April 2019 and was completed on 22 January 2020. The extracted longwall has a length of 1952 metres (m), a void width of 305m (including first workings) and a cutting height up to 3.9m

The extraction of underground coal reserves from DA3B provides benefits at international, national, state and local levels. Illawarra Metallurgical Coal (IMC) provides an essential supply of coking coal to BlueScope Steel for its steelmaking production, and for export to overseas customers. Operations at Dendrobium Mine 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, IMC paid approximately $54.64 Million in government royalties during the 2018/2019 financial year.

Subsidence movements resulting from the extraction of Longwall 15 were monitored along lines and points within the SMP Area. The measured total vertical subsidence and closure at all monitoring lines are less than or similar to the predicted values at the completion of Longwall 15.

During the extraction of Longwall 15, twenty-eight new surface impacts were identified. These impacts are labelled as "*DA3B_LW15_001*" to "*DA3B_LW15_028*". Twenty-two of these impacts were observed on natural features. The remaining six impacts 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)*, a Trigger Action Response Plan (TARP) Level 2 was recorded for Electrical Conductivity (EC) and Dissolved Oxygen (DO). At *Donalds Castle Creek (FR6)*, a TARP Level 3 was recorded for EC.

The effects of mining subsidence on surface water hydrology was assessed using a newly introduced TARP. TARP triggers for surface water hydrology were identified at Donalds Castle Creek (*DCS2; DCU*); DC13 (*DC13S1*); WC21 (*WC21S1*); WC15 (*WC15S1*), LA4 (*LA4S1*) and LA3 (*LA3S1*). Water flow performance measures were met for Longwall 15.

Analysis of surface water flow observation records for Wongawilli Creek triggered a Level 2 TARP in February 2020. Assessment of data indicated that flow reductions due to mining were in the order of 0.008 to 0.015 ML/d.

The average daily inflow to DA3B during Longwall 15 extraction was 4.03 megalitres per day (ML/day) which represents approximately 70 % of total mine inflow for the period. The average groundwater inflow component of the water balance for Area 3B and the total mine was similar during Longwall 15 to that of the previous longwall (4.21 ML/day; Longwall 14).

Seepage losses from Avon Dam have been estimated by regional and local scale numerical models to be in the range 0.39 to 0.47 ML/day following the extraction of Longwall 15. The estimates are within the tolerable loss limit of 1 ML/day prescribed by Dams Safety NSW (DSC).

Soil moisture and/or shallow groundwater triggers were recorded in Swamp 13, 14 and 23 during the extraction of Longwall 15.

The results of the total species richness (TSR) analysis demonstrate the response to mining at individual swamps is complex, with Swamp 15B generally showing a decline in TSR following mining and changes in shallow groundwater. Swamp 15A(2), Swamp 1A, Swamp 1B and Swamp 5 displayed no statistically significant decline in TSR despite observed changes in shallow groundwater availability.

When accounting for yearly effects, a statistically significant change in species composition post-mining was found at Swamp 15B and Swamp 1B. Swamp 1A, Swamp 15A and Swamp 5 displayed no statistically significant decline in species composition.

The analysis of the most recent LiDAR data used to assess the extent of upland swamps and their composite vegetation communities, has identified that the extent of all upland swamps (impact and control swamps) within the study area have decreased substantially from the 2014 baseline.

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 at 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.

Two out of the six Aboriginal cultural heritage sites had observable impacts from subsidence movements related to the extraction of Longwall 15. Impacts reported at *Site 1 -DB1* during Longwall 14 EoP have since been identified as naturally occurring and not caused by mining.

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Attachment C2 – Longwall 15 Impact Reports (IMCEFT)

Attachment D – Surface Water and Shallow Groundwater Assessment (HGEO)

Attachment E – Groundwater Assessment (HGEO)

Attachment F – Terrestrial Ecology Assessment (Biosis)

Attachment G – Aquatic Ecology Assessment (Cardno)

Attachment H – Heritage Assessment (Niche)

1 INTRODUCTION

1.1 Approval and Legislative Requirements

Dendrobium Longwall 15 is located within Consolidated Coal Lease 768 and is the seventh panel to be extracted in DA3B. Extraction of Longwall 15 commenced on 4 April 2019 and was completed on 22 January 2020. The extracted longwall had a length of 1952m, a void width of 305m (including first workings) and a cutting height up to 3.9m.

This EoP report has been prepared in accordance with Schedule 3 Condition 9 of the Development Consent (DA60-03-2001 – MOD 8) (Table 1). The EoP report outlines the measured and observed impacts of Longwall 15 and the analyses of 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 the Department of Trade and Investment, Regional Infrastructure and Services NSW (DTI) on the 5 February 2013 and the Department of Planning and Environment (DP&E) on the 6 February 2013. Subsequent approval for the Longwalls 14 - 15 SMP was granted on the 16 December 2016 by DP&E, which is provided as **Attachment A**.

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

Table 1: Approval conditions excerpt from the Dendrobium Development Consent (DA60-03-2001 – MOD 8).

Development Consent Approval Condition	Relevant Section in EoP Report
Schedule 3 of Development Consent DA60-03-2001 – MOD 8 **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* *The AEMR (July to June) is submitted in August each year*

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 impact predictions for Longwall 15 are described in the following reports:

- South32, December 2016 - DA3B Longwalls 14 – 15 SMP;
- South32, October 2017 – DA3B Watercourse Impact Monitoring Management and Contingency Plan (WIMMCP), Revision 1.6; and
- South32, October 2017 – DA3B Swamp Impact, Monitoring, Management and Contingency Plan, Revision 1.6.

Impacts have been reported by the Illawarra Metallurgical Coal Environmental Field Team (IMCEFT) 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. IMC provides an essential supply of coking coal to BlueScope Steel for its steelmaking production, and for export to overseas customers. Mining operations at Dendrobium Mine 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, IMC paid approximately $54.64 Million in government royalties during the 2018/2019 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.

IMC 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 IMC 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 15 were monitored along lines and points within the SMP Area. A comparison of the observed and predicted movements has been prepared by Mine Subsidence Engineering Consultants (MSEC) and is included as **Attachment B**.

Monitoring points and lines associated with Longwall 15 include (Figure 1):

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

The predicted subsidence parameters have been obtained using the re-calibrated subsidence model presented in Reports Nos. MSEC792 and MSEC865.

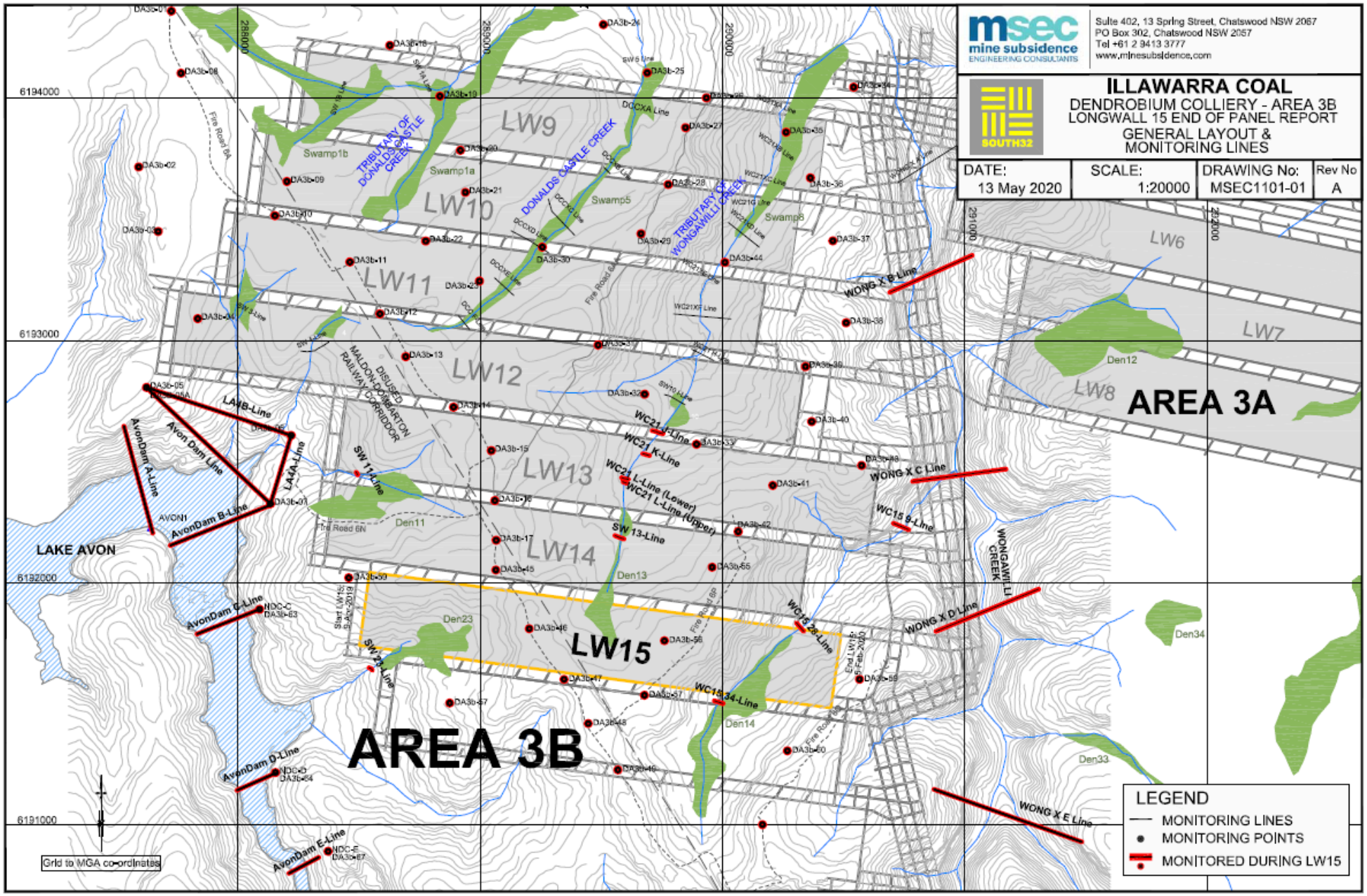

Figure 1: Overview of subsidence monitoring sites, comprised of monitoring lines and monitoring points.

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, Wong X D-Line and the Wong X E-Line. The Wong X A-Line was not required to be measured at the completion of Longwall 15.

The maximum measured total closure at each of the Wongawilli Creek closure lines are similar to or less than the predictions after the completion of Longwall 15 (Figure 2).

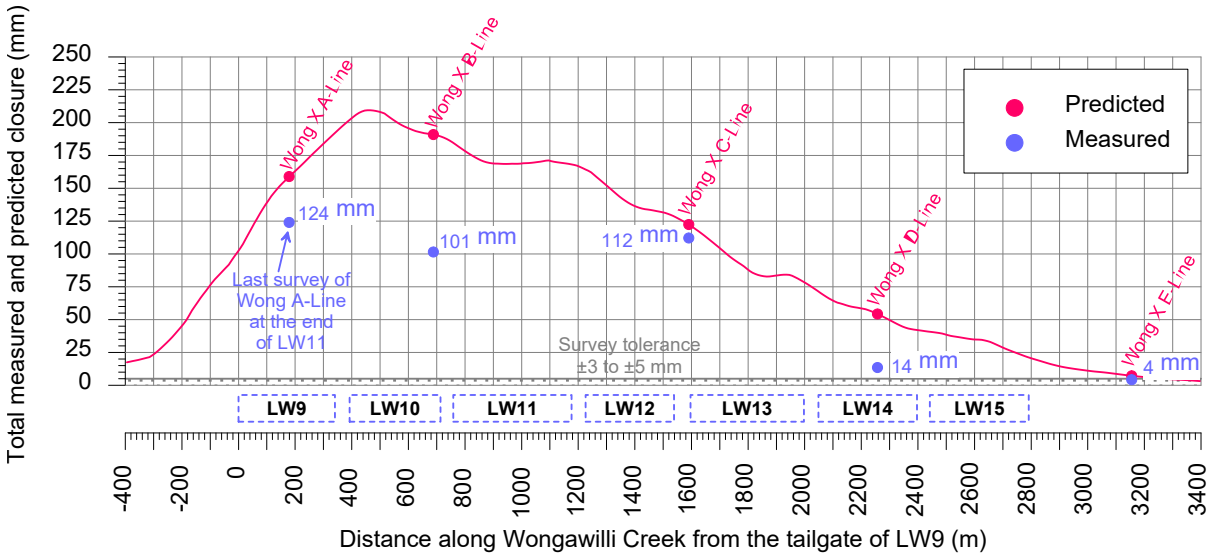

Figure 2: Measured and predicted total closure along Wongawilli Creek after the extraction of Longwall 15. (Source: Attachment B).

2.2 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 through to Longwall 15 only.

The maximum measured total movements at the Avon Dam closure lines are less than the predicted values at the completion of Longwall 15. The extraction of Longwall 15 has only resulted in a small decrease in the closure measured at the A-Line and small increases in the openings measured at each of the other monitoring lines. (Figure 3).

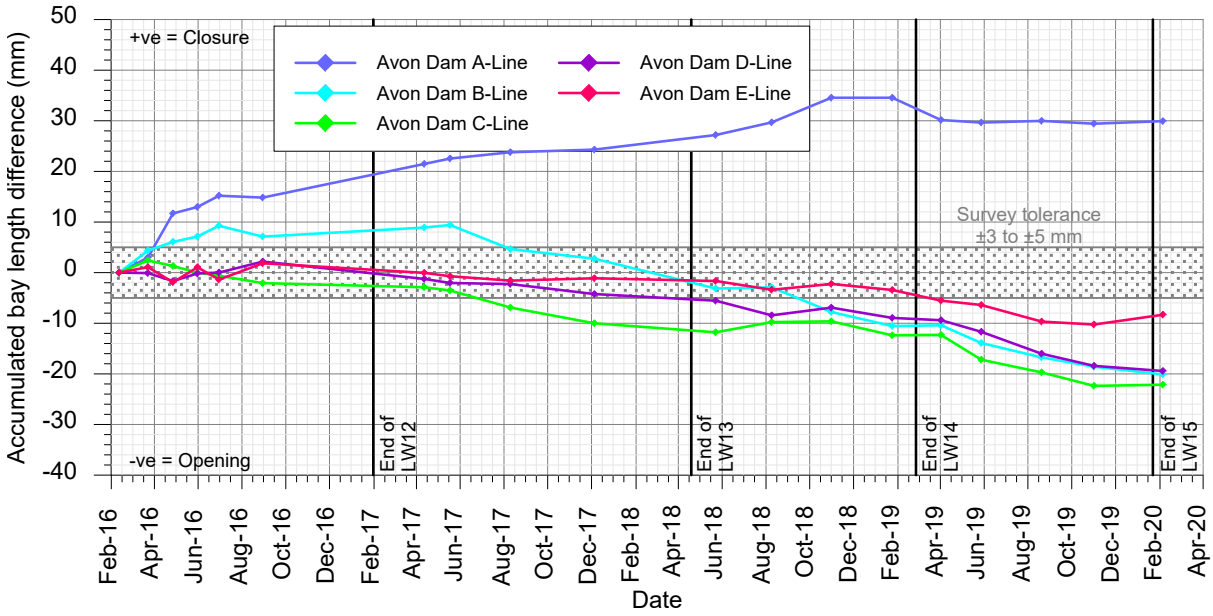

Figure 3: Measured accumulated closure for the Avon Dam closure lines. (Source: Attachment B).

2.3 Wongawilli Creek Tributaries and Avon Dam Tributary Cross Lines

Mine subsidence movements across WC21, a tributary to Wongawilli Creek, have been measured with 2D survey techniques at the WC21 J-Line, WC21 K-Line, WC21 L-Line (lower) and WC21 L-Line (upper). The remaining WC21 cross lines were not measured during Longwall 15.

The measured total vertical subsidence and closure for the WC21 cross lines are less than the predicted values at the completion of Longwall 15 (Figure 4). The measured vertical subsidence movements range is between 58 % and 64 % of the predicted values, with an average of 62 %. The measured closures range is between 17 % and 41 % of the predicted values, with an average of 32 %. It is considered, therefore, that the ground movements measured along WC21 are considerably less than the predictions.

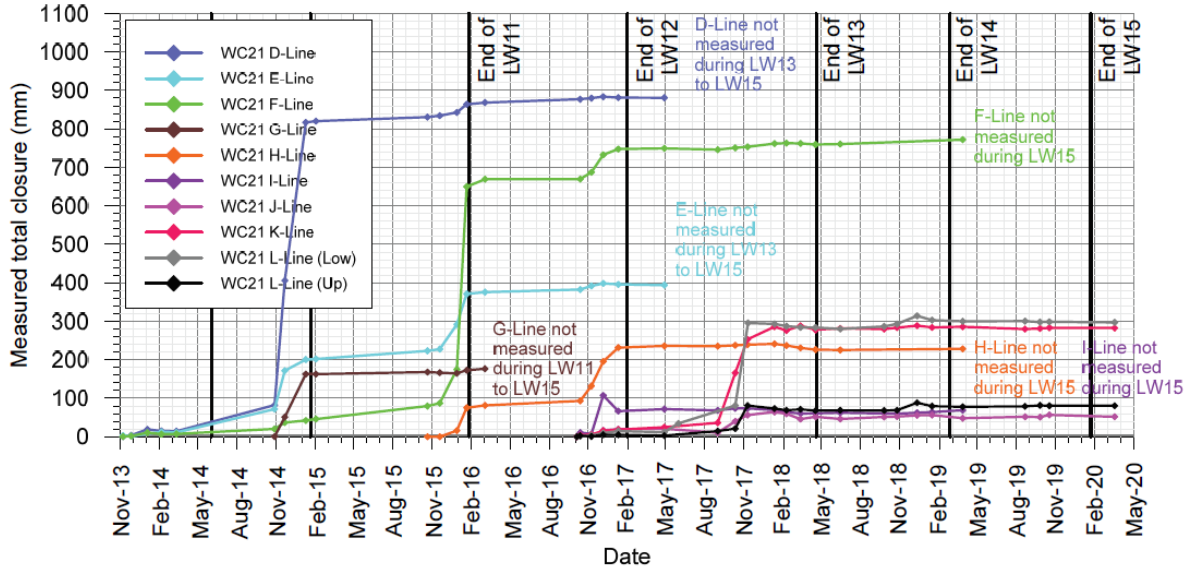

Figure 4: Measured total closure for WC21 cross lines. (Source: Attachment B).

The mine subsidence movements across WC15, a tributary to Wongawilli Creek, have been measured using 2D survey techniques at the WC15 RB9-Line, WC15 RB28-Line and WC15 RB34-Line (Figure 5). These monitoring lines were established in December 2018 during the mining of Longwall 14.

The subsidence measured at WC15 RB28-Line of 89mm is less than the predicted value of 400 mm. Low level net uplift was measured at WC15 RB9-Line and WC15 RB34-Line, which are in the order of the survey tolerance for absolute height. The closure measured at the WC15 RB28-Line of 262mm is similar to but slightly greater than the predicted value of 260 mm. The exceedance of 2mm (i.e. 0.7 %) is less than the accuracy of the prediction method for valley closure effects. The closures measured at the WC15 RB9-Line and WC15 RB34-Line are less than their predicted values.

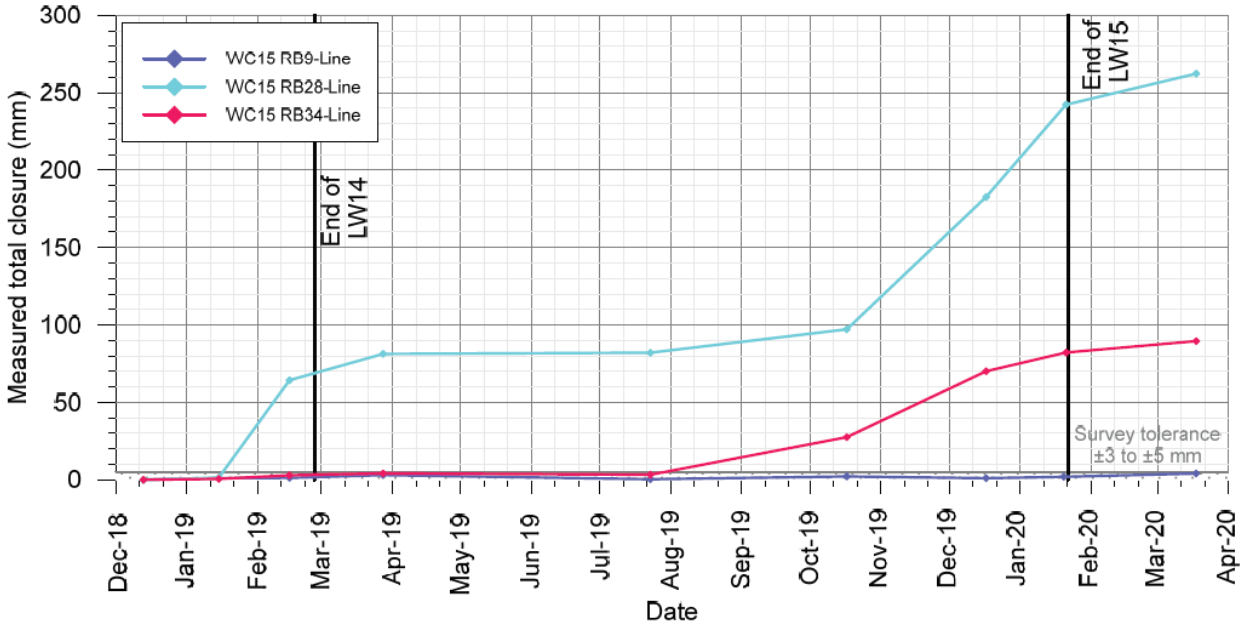

Figure 5: Measured incremental closure for the WC15 cross lines. (Source: Attachment B).

The closure across Avon Dam and two tributaries to Avon Dam (LA4A and LA4B), were measured using the Avon Dam GPS (Figure 6). The base survey was carried out on 26 February 2013, prior to the commencement of Longwall 9. The maximum measured total movements across LA4A, LA4B and the Avon Dam are less than the predicted values at the completion of Longwall 15. It is considered that the ground movements measured using these monitoring lines are considerably less than the predictions.

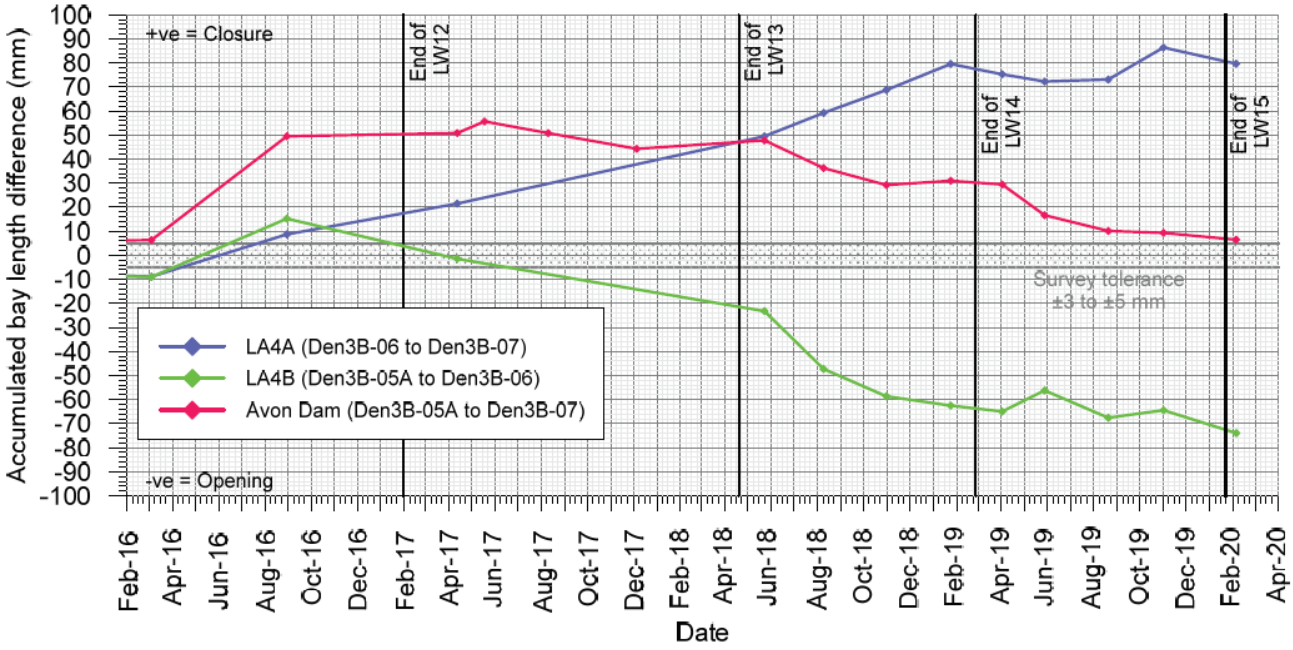

Figure 6: Measured accumulated closure for Tributaries LA4A, LA4B and the Avon Dam. (Source: Attachment B).

2.4 Swamp Cross Lines

The mine subsidence movements across swamps and their associated drainage lines have been measured using 2D survey techniques at the SW11-Line, SW13-Line and SW23-Line. The remaining swamp cross lines were not measured during Longwall 15. The maximum measured total vertical subsidence and closure at the SW11-Line, SW13-Line and SW23-Line are all less than the predicted values. Measured vertical subsidence at the SW13-Line is 74 % of the predicted value. Opening was measured along the SW11-Line. The measured closures at the SW13-Line and SW23-Line are 13 % and 7 %, respectively, of the predicted values. It is noted that marks have been disturbed along each of the monitoring lines and, therefore, the actual closures could be greater that those measured. In any case, it is expected that the actual closure for these monitoring lines would be considerably less than the predicted values.

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

The far-field horizontal movements near Longwall 15 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.

The vectors of incremental horizontal movement are typically orientated towards Longwall 15 and skewed towards the east, i.e. towards the longwall finishing end, or in the downslope direction (Figure 7). The greatest movements have been measured directly above Longwall 15 and, to lesser extents, above the previously extracted Longwall 14. 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 Figure 8. The mean and the 95 % confidence level for the 3D monitoring data at Dendrobium Mine are also shown in Figure 8.

The measured incremental horizontal movements resulting from the extraction of Longwall 15 (i.e. black 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, magenta, purple and grey diamonds) and elsewhere in the Southern Coalfield (i.e. grey triangles).

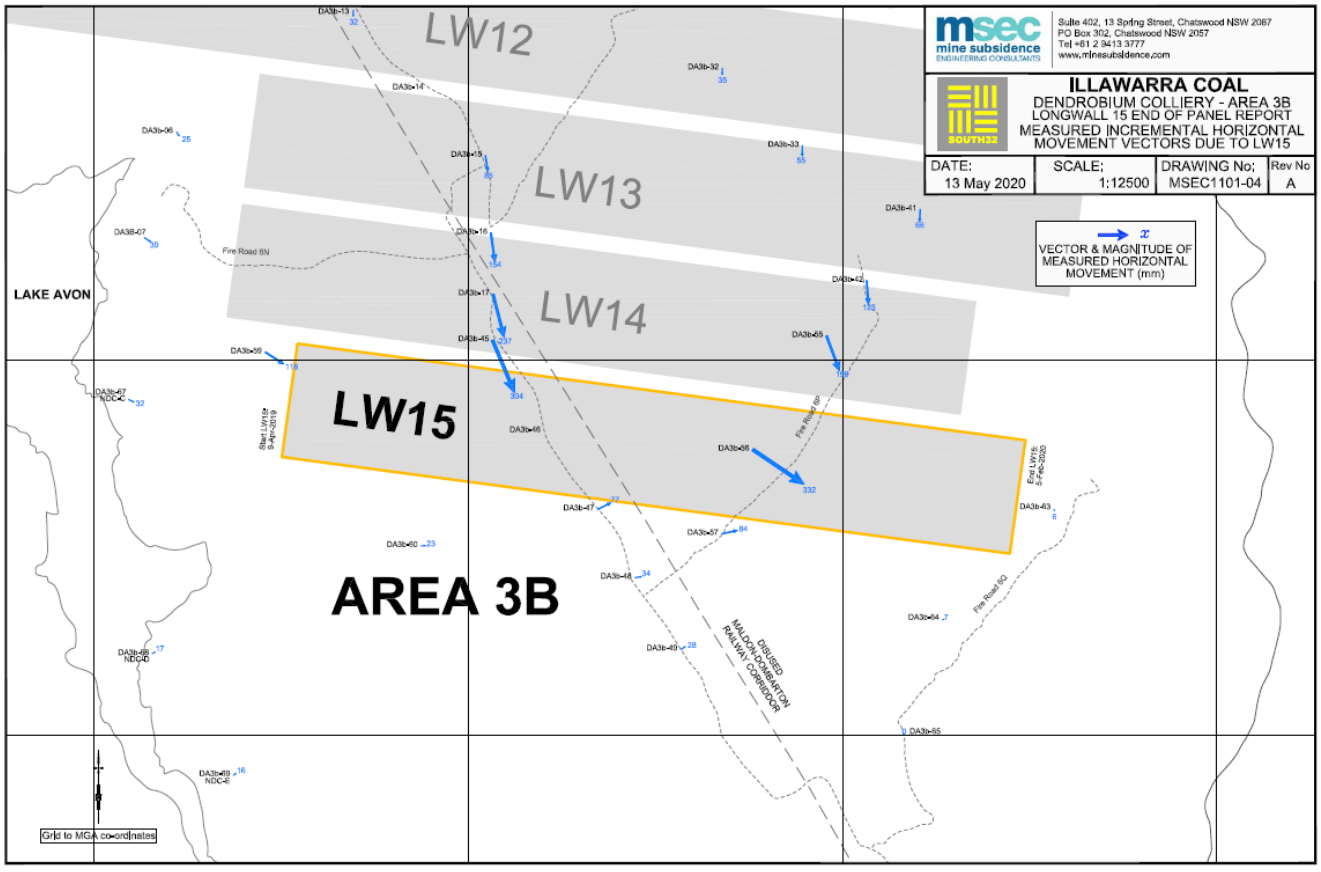

Figure 7: Incremental horizontal movement vectors following the extraction of Longwall 15. (Source: Attachment B).

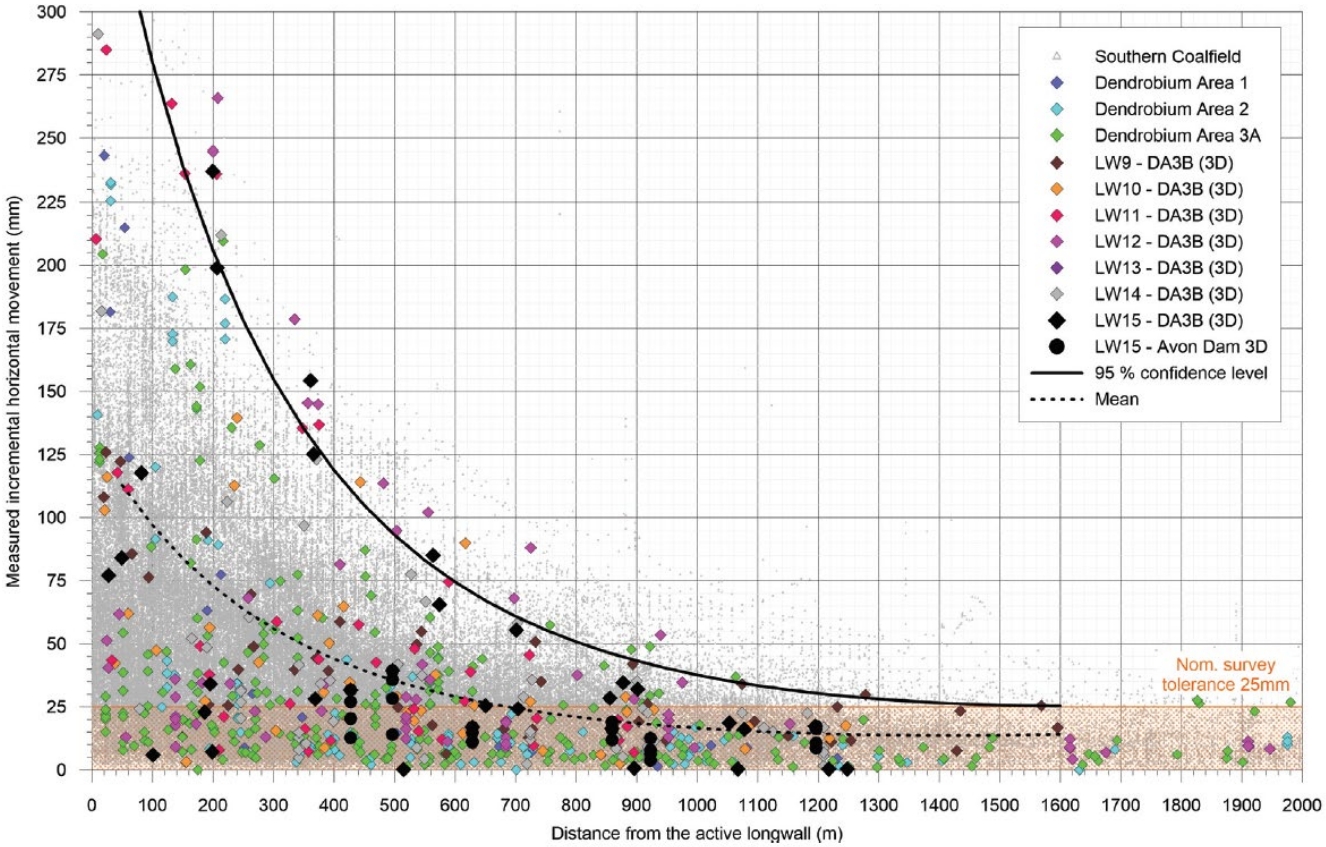

Figure 8: Measured incremental horizontal movements at Dendrobium Mine. (Source: Attachment B).

2.6 Airborne Laser Scanner (ALS) / LiDAR Surveys

The changes in surface level due to the extraction of Longwall 9 to Longwall 15 have been measured using Airborne Laser Scanning (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 after the completion of each longwall. The changes in surface level were determined by calculating the differences between pre-mining surface levels and post-mining surface levels, incrementally (Figure 9), and cumulatively (Figure 10).

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 11, Figure 12, Figure 13 and Figure 14). The maximum measured changes in surface level above each of the longwalls are similar to or less than the maximum predicted values. Also, the measured changes in surface level above each of the chain pillars are similar to or less than the predicted values in these locations.

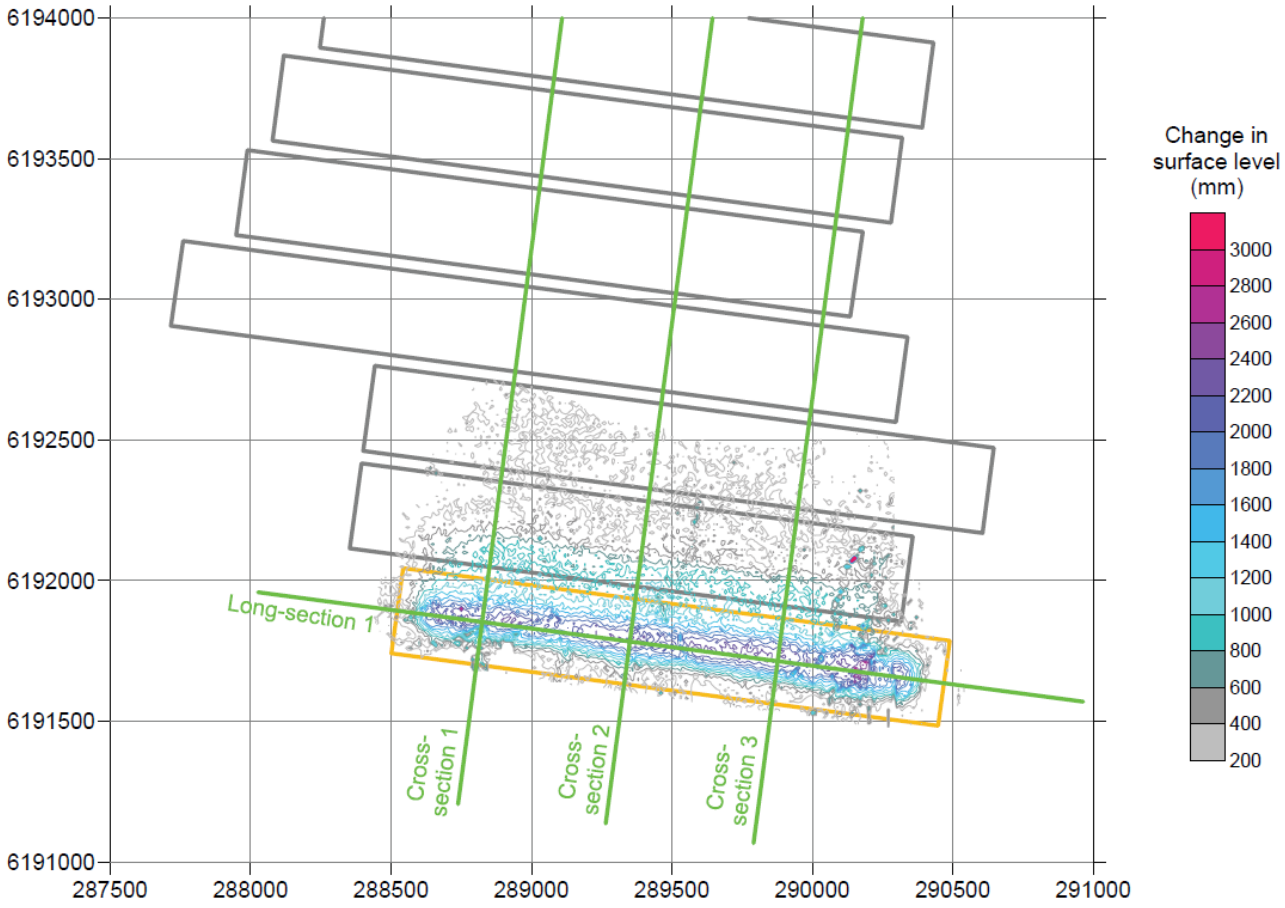

Figure 9: Measured incremental changes in surface level due to the extraction of Longwall 15. (Source: Attachment B).

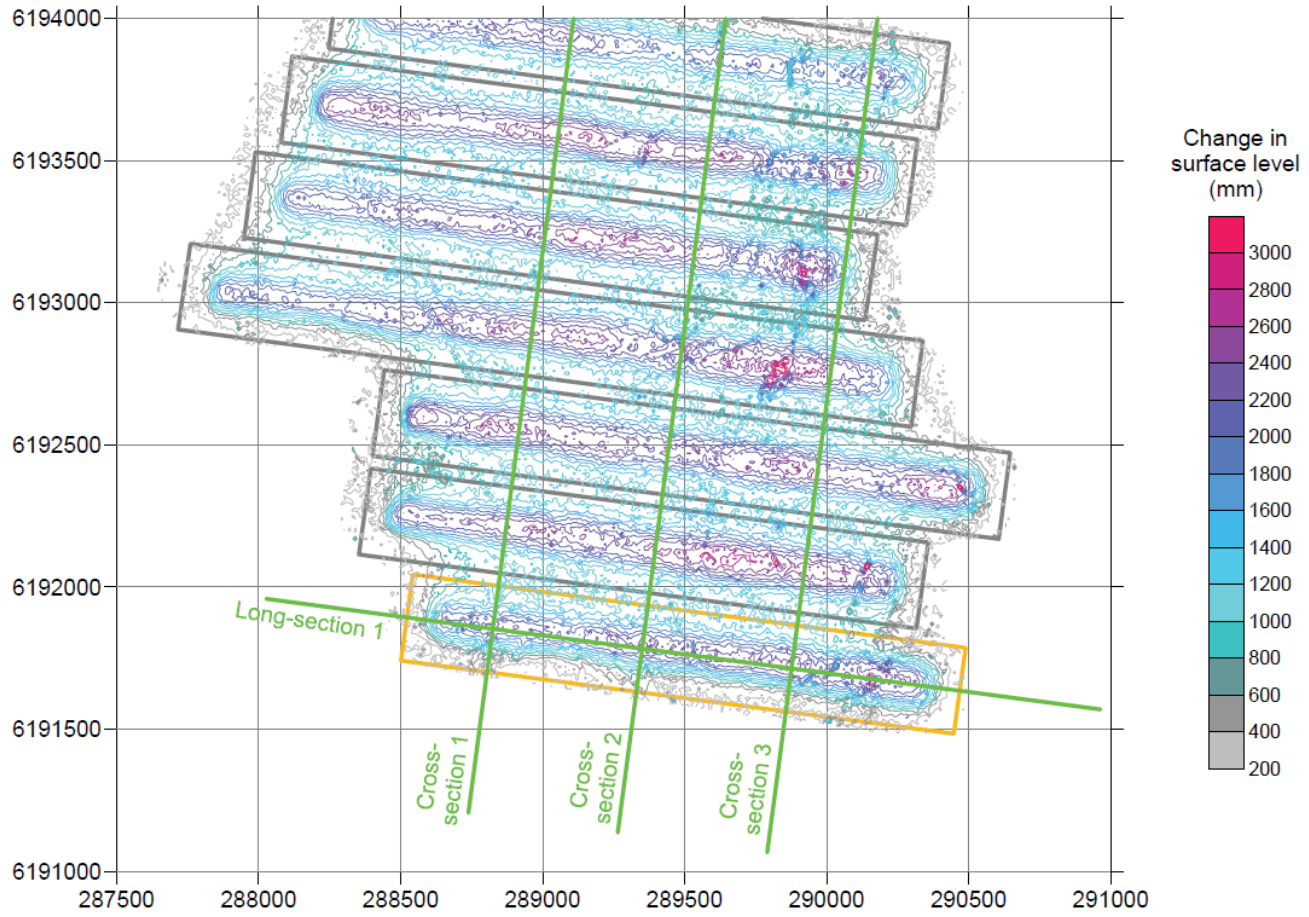

Figure 10: Measured cumulative changes in surface level due to the extraction of Longwalls 9 to 15. (Source: Attachment B).

The measured change in surface level along Long-section 1 (Figure 14) is greater than the predicted vertical subsidence above the commencing end of Longwall 15 (i.e. left side of figure). However, this may be partly due to the surveying tolerance and the effects of the horizontal movements and sloping terrain on the ALS surveys. The ground directly above the commencing end of Longwall 15 has moved towards the longwall (i.e. following the extraction face). The natural surface dips towards the west in this location (i.e. towards Avon Dam). 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 15. 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 ALS surveys and are not real movements. It is considered that the subsidence movements measured using the ALS surveys are consistent with the predicted subsidence movements.

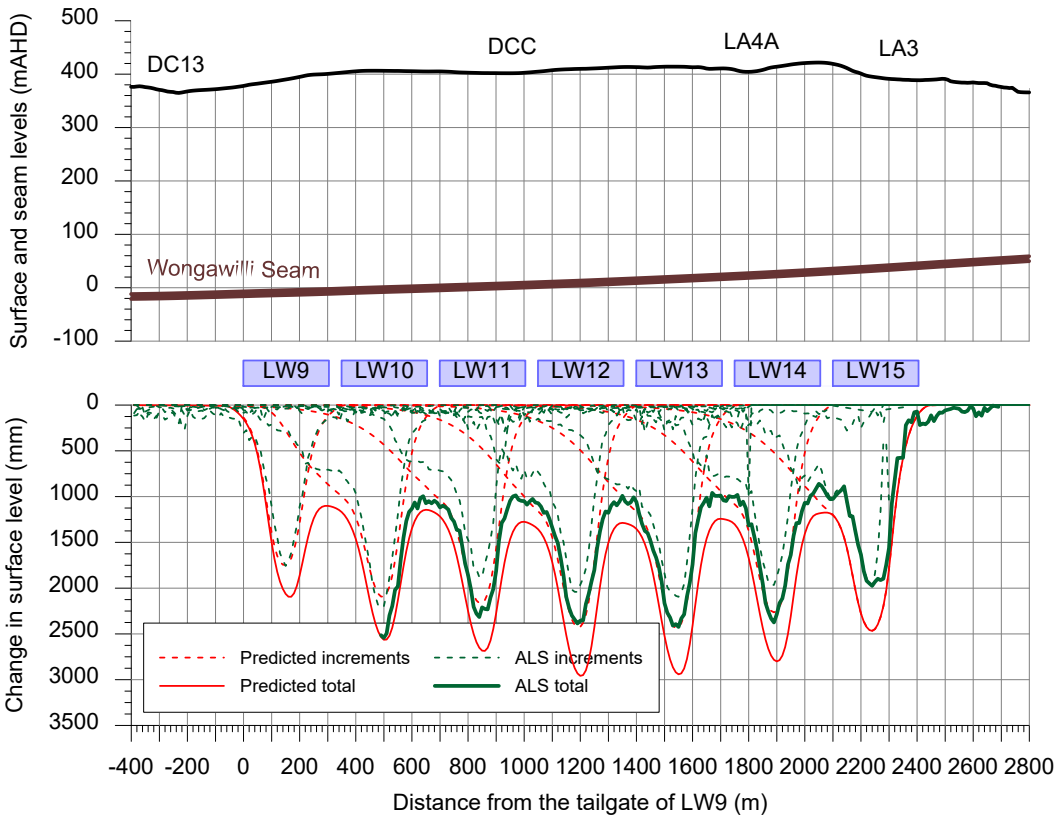

Figure 11: Measured changes in surface level and predicted vertical subsidence along Cross-section 1. (Source: Attachment B).

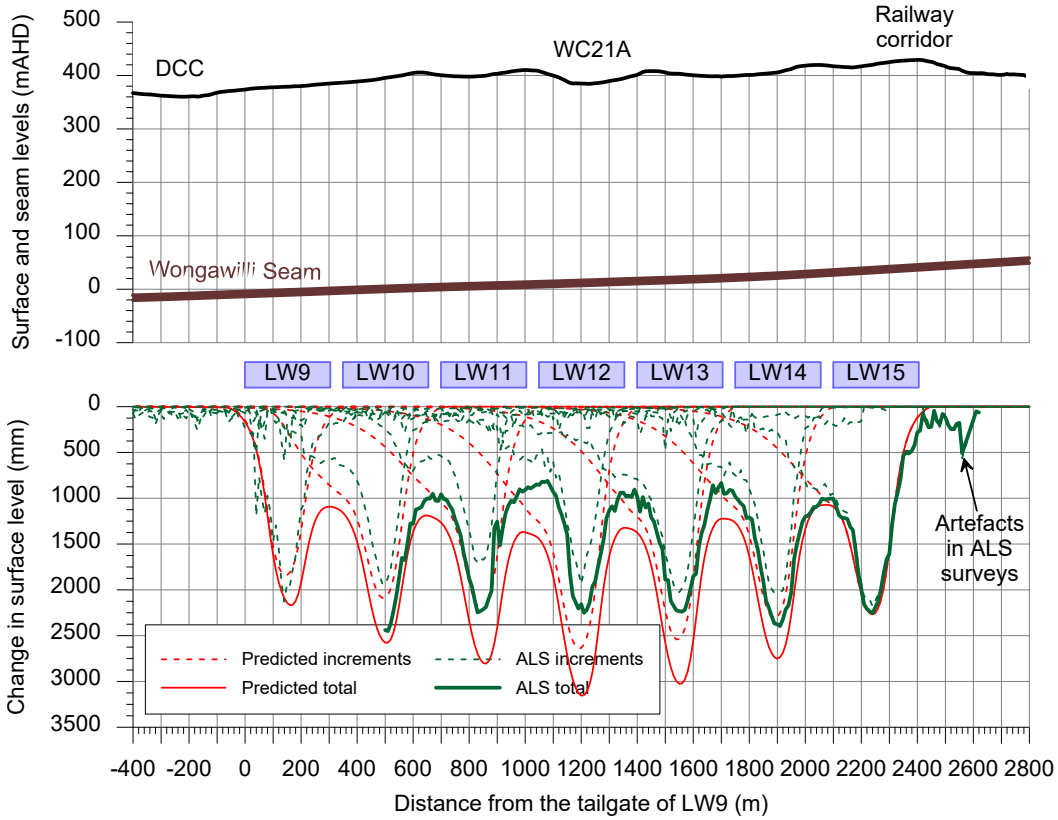

Figure 12: Measured changes in surface level and predicted vertical subsidence along Cross-section 2. (Source: Attachment B).

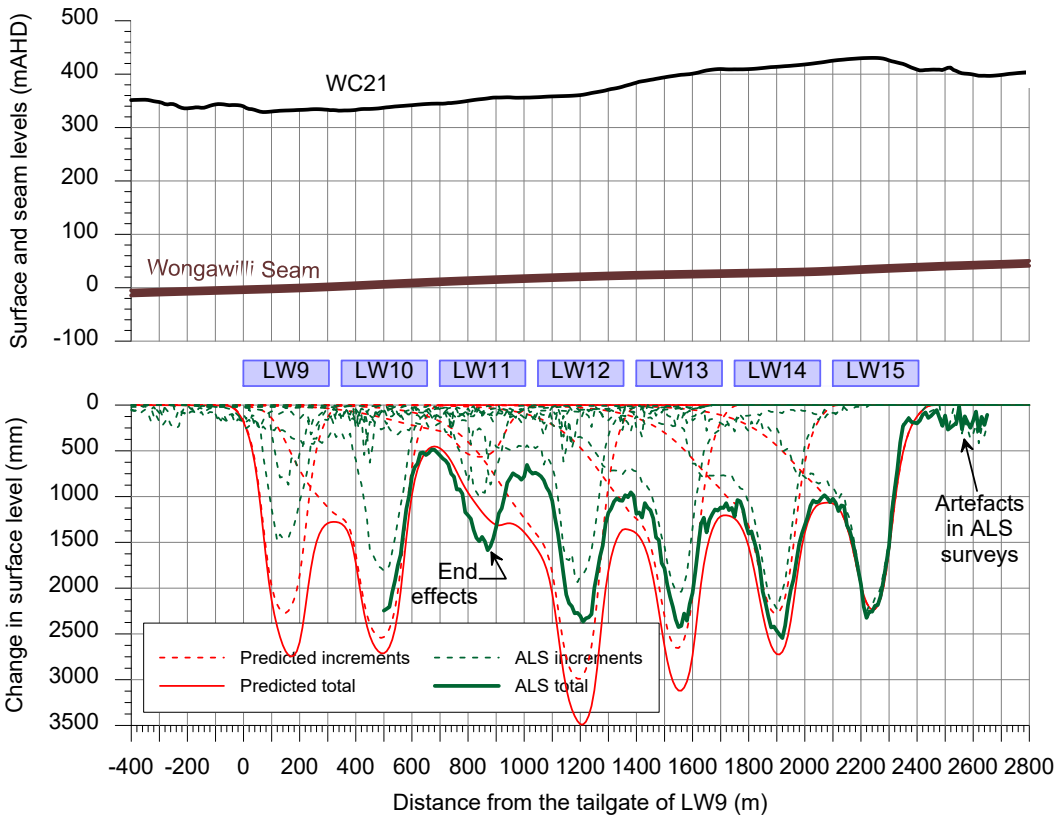

Figure 13: Measured changes in surface level and predicted vertical subsidence along Cross-section 3. (Source: Attachment B).

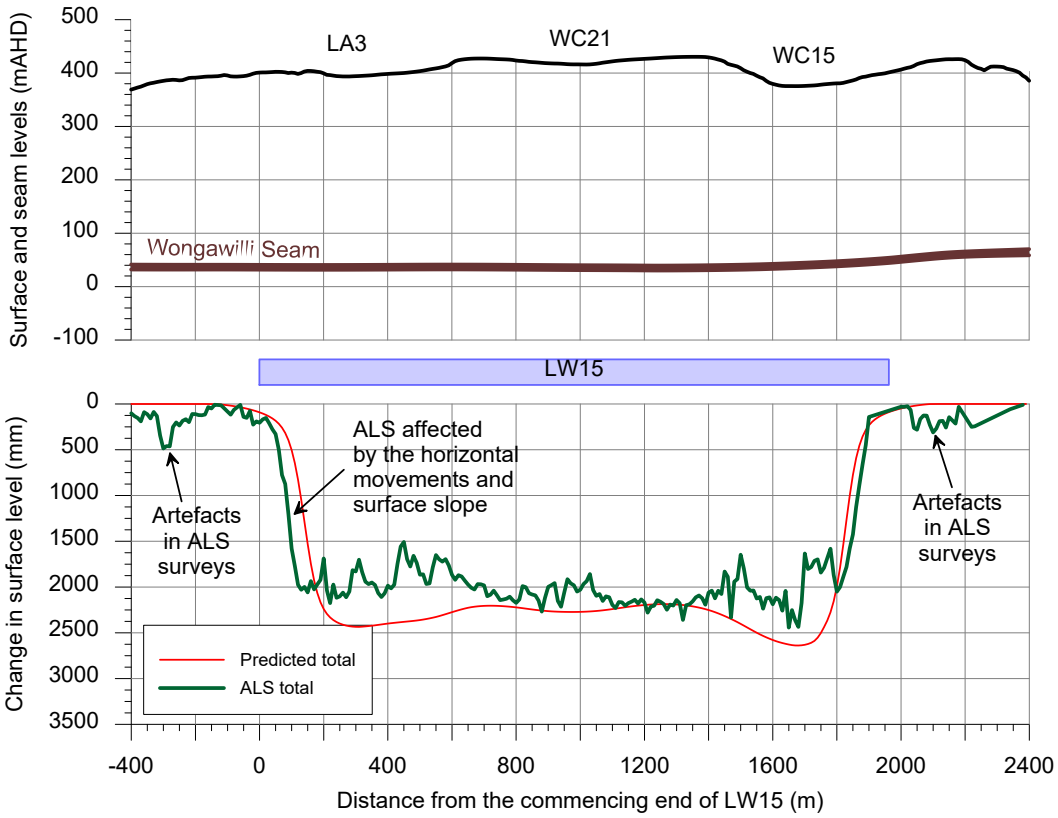

Figure 14: Measured changes in surface level and predicted vertical subsidence along Long section 1. (Source: Attachment B).

3 IMPACTS TO NATURAL FEATURES

During the extraction of Longwall 15, Twenty-eight new surface impacts were identified. These impacts are labelled as *DA3B_LW15_001* to *DA3B_LW15_028*. Updates are provided for three existing Longwall 13 impacts; these impacts are labelled as *DA3B_LW13_010 (Update), DA3B_LW13_035 (Update)* and *DA3B_LW13_046 (Update)*. Updates are provided for two existing Longwall 14 impacts; these impacts are labelled as *DA3B_LW14_015 (Update)* and *DA3B_LW14_016 (Update)*. Other triggers are addressed in their respective sections, with further detail in the attached specialist assessments.

The monitoring program for Longwall 15 was conducted in accordance with the SMP, WIMMCP and SIMMCP. The monitoring program is outlined in Section 6. The results of the IMCEFT monitoring are provided in **Attachment C1**; the impact reports submitted during the extraction of Longwall 15 are provided in **Attachment C2**. The results of monitoring undertaken by specialist consultants are provided in **Attachments D to H**. Figure 17 illustrates the location of surface impacts identified during the extraction of Longwall 15.

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 rockfalls. 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 15 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

Eight first and second order streams were monitored as part of the Longwall 15 monitoring program; LA2, LA3, LA4A, LA4A1, WC21, WC15, WC15A and WC12. Impacts observed at watercourses during Longwall 15 are described in Table 3, with Photos Photo **1**Photo 8 showing the impacts recorded.

Table 3: Summary of impacts to first and second order streams.

Site ID	Easting	Northing	Impact Type	Feature Affected	Identification Date	Trigger Level	Description	Refer to Impact Report/s Dated
DA3B_LW15_003 Photo 1	288351	6192457	Rock Fracturing and Fragmentation	LA4A	17/06/2019	1	Rock fracturing and associated rock fragmentation at *LA4A_Step 3A*. The rock fracturing has a length of 0.5m and a width of 0.02m. The largest rock fragment has a length of 0.30m, a width of 0.03m and a height of 0.19m.	19/06/2019
DA3B_LW15_014 Photo 2	288376	6192452	Rockfall, Rock Fracturing and Fragmentation	LA4A	11/10/2019	2	Rockfall, rock fracturing and fragmentation to *LA4A_Step 3B* and *LA4A_Channel 3A*. The rock fracturing has a length of 4.3m, a width of 0.015m and a maximum measurable depth of 0.25m. Approximately 10 rock fragments were dislodged from the step. The largest rock fragment has a length of 1.3m, width of 0.8m and height of 0.4m.	15/10/2019
DA3B_LW15_015 Photo 3	288344	6192464	Rock Fracturing	LA4A	11/10/2019	2	Rock fracturing to *LA4A_Rockbar 2*. The rock fracturing has a maximum length of 1m and a maximum width of 0.002m.	15/10/2019
DA3B_LW15_027 Photo 4	290467	6192043	Rock Fracturing	WC15	21/01/2020	1	Rock fracturing to *WC15_Rockbar 18*. The rock fracture has a length of 6m, a width of 0.04m and a depth of approximately 2.5m.	23/01/2020
DA3B_LW13_010 (Update) Photo 5	289591	6192424	Rockfall	WC21	21/08/2019	2	Rockfall to a step at *WC21_Pool 53*. Additional rock fragments were dislodged from the step. The largest fragment was approximately 0.4m^2.	23/08/2019
DA3B_LW13_035 (Update) Photo 6	290408	6191915	Rock Fracturing	WC15	21/01/2020	2	Additional rock fracturing to *WC15_Rockbar 21*. The rock fracture has a length of 1m and a width of 0.02m. Uplifted sections are associated with the fracturing.	23/01/2020
DA3B_LW13_046 (Update) Photo 7	290887	6192408	Rock Fracturing and Displacement	WC15	1/04/2020	1	Additional rock fracturing and displacement to *WC15_Pool 2*. Following a heavy rainfall event, a section of sandstone bedrock with a length of 1.42m, width of 1.05m and depth of 0.21m, had been displaced 3.2m downstream.	3/04/2019
DA3B_LW14_016 (Update) Photo 8	290345	6191835	Rock Fracturing	WC15	21/01/2020	2	Additional rock fracturing to *WC15_Rockbar 25.* The fracturing has resulted in a 4m by 2m by 0.15m area of overhanging rock to be displaced approximately 0.1m onto underlying bedrock. Following a heavy rainfall event, the section of rockbar previously displaced has been further fractured into approximately 6 large pieces. The largest fragment has a length of 1.5m, width of 1.5m and depth of 0.2m.	23/01/2020

Photo 1: *DA3B_LW15_003*, looking at fracturing and dislodged rock segments. Taken on 17/06/2019.

Photo 2: *DA3B_LW15_014,* an overview of the rockfall. Taken on 11/10/2019.

Photo 3: *DA3B_LW15_015,* looking at a section of rock fracturing. Taken on 11/10/2019.

Photo 4: *DA3B_LW15_027,* looking at the rock fracture. Taken on 21/01/2020.

Photo 5: *DA3B_LW13_010,* rockfall at the inflow step to WC21_*Pool 53*.Taken on 26/02/2020.

Photo 6: *DA3B_LW13_035*, looking at the rock fragmentation. Taken on 28/02/2020.

Photo 7: *DA3B_LW13_046*, looking at the section of rock displacement. Taken on 10/03/2020.

Photo 8: *DA3B_LW14_016,* looking at the rock fracture and displacement. Taken on 28/02/2020.

3.1.2 Impacts to Other Landscape Features

Impacts recorded on steep slopes, steps and general landscape features are presented below (Table 4).

Table 4: Summary of Impacts to other landscape features

Site ID	Easting	Northing	Impact Type	Feature Affected	Identification Date	Trigger Level	Description	Refer to Impact Report/s Dated
DA3B_LW15_001 Photo 9	288679	6191767	Rock Fracturing and Rockfall	Steep Slope	29/05/2019	1	Rock fracturing and rockfall at a step adjacent to Swamp 23. The rock fracturing has a length of 1m and a width of 0.01m. The largest rock fragment resulting from the rockfall has a length of 0.40m, width of 0.15m and height of 0.15m.	31/05/2019
DA3B_LW15_002 Photo 10	288651	6191771	Rockfall	Steep Slope	29/05/2019	1	Rockfall at a step adjacent to Swamp 23. The impact is comprised of a rockfall with a length of 3m, width of 2m and height of 1m.	31/05/2019
DA3B_LW15_006 Photo 11	288876	6191945	Soil Cracking and Rock Fracturing	Access Track & Sandstone Outcrop	09/07/219	1	Soil cracking to a closed access track and fracturing to adjacent rock outcrop. The soil cracking has a length of 2.9m, width of 0.01m and maximum measurable depth of 0.3m. The rock fracturing has a length of 0.7m, width of 0.01m wide and depth of 0.3m.	11/07/2019
DA3B_LW15_007 Photo 12	288696	6191767	Rock Fracturing	Steep Slope	09/07/219	1	Fracturing to sandstone step, north of Swamp 23. The fracturing has a length of 2.3m and width of 0.05m.	11/07/2019
DA3B_LW15_009 Photo 13	288744	6191771	Rockfall	Steep Slope	29/07/2019	1	Small rockfall to ledge adjacent to Swamp 23. The fragment of rock fallen from the ledge is approximately 0.2m$^{3.}$	30/07/2019
DA3B_LW15_013 Photo 14	288673	6191855	Rock Fracturing and Fragmentation	Steep Slope	05/09/2019	1	Rock fracturing and fragmentation near SLMMP site *A3b-SS11*. The rock fracturing has a length of 4m, a maximum width of 0.06m and a maximum measurable depth of 1.7m. The largest rock fragment resulting from the rock fracturing has an approximate volume of 0.2m^3.	06/09/2019
DA3B_LW15_016 Photo 15	290011	6191602	Rock Displacement	Steep Slope	25/10/2019	1	Rock displacement at a steep slope between Fire Road 6P and Swamp 14. The displacement has a maximum measurable length of 2.5m, a maximum width of 0.02m and a depth of 0.6m.	28/10/2019
DA3B_LW15_017 Photo 16	289939	6191673	Rockfall	Steep Slope	25/10/2019	1	Small rockfall at a steep slope between Fire Road 6P and Swamp 14. The rock fragment resulting from the rockfall has a length of 0.5m, a width of 0.17m and a height of 0.1m.	28/10/2019

Site ID	Easting	Northing	Impact Type	Feature Affected	Identification Date	Trigger Level	Description	Refer to Impact Report/s Dated
DA3B_LW15_018 Photo 17	290090	6191892	Rock Fracturing	Steep Slope	25/10/2019	1	Rock fracturing at a steep slope between Fire Road 6P and WC15. The impact is comprised of a rock fracture with a length of 0.9m, width of 0.03m and horizontal depth of 0.25m.	28/10/2019
DA3B_LW15_019 Photo 18	290125	6191990	Rock Fracturing	Steep Slope	25/10/2019	1	Rock fracturing at a steep slope between Fire Road 6P and WC15. The impact is comprised of a rock fracture with a length of 1m, a width of 0.02m and a horizontal depth of 0.22m.	28/10/2019
DA3B_LW15_020 Photo 19	290140	6192074	Rockfall	Steep Slope	25/10/2019	1	Small rockfall at a steep slope between Fire Road 6P and WC15. The rock fragment resulting from the rockfall has a length of 0.4m, a width of 0.2m and a height of 0.09m.	28/10/2019
DA3B_LW15_021 Photo 20	290151	6192085	Rockfall	Steep Slope	25/10/2019	1	Small rockfall at SLMMP site *A3b-SS9-Pt1*. The area of exposed rock has a length of 0.4m, width of 0.27m and height of 0.2m.	28/10/2019
DA3B_LW15_022 Photo 21	290172	6192102	Rock Fracturing	Steep Slope	25/10/2019	1	Rock fracturing at a steep slope between Fire Road 6P and WC15. The rock fracture has a length of 4m and a width of 0.01m. The rock fragment resulting from the displacement has a length of 0.2m and a height of 0.08m.	28/10/2019
DA3B_LW15_023 Photo 22	290174	6192128	Rock Fracturing	Steep Slope	25/10/2019	2	Rock fracturing at a steep slope between Fire Road 6P and WC15. The rock fracture has a length of 25m, a maximum width of 0.08m and a depth greater than 5m.	28/10/2019
DA3B_LW15_024 Photo 23	290033	6191605	Rock Fracturing and Soil Uplift	Steep Slope	21/01/2020	1	Rock fracturing and uplift at a steep slope between Swamp 14 and WC15. The rock fracture has a length of 1.8m, a width of 0.005m and a depth of approximately 0.02m.	23/01/2020
DA3B_LW15_025 Photo 24	290057	6191622	Rockfall	Steep Slope	21/01/2020	1	Rockfall at a steep slope between Swamp 14 and WC15. The largest rock fragment resulting from the rockfall has a length of 1.7m, width of 0.5m and height of 1.7m.	23/01/2020
DA3B_LW15_026 Photo 25	290056	6191749	Soil Cracking and Displacement	Steep Slope	21/01/2020	1	Soil cracking and displacement at SLMMP site *A3B-SS13*. The displacement has a length of 1.05m, a width of 0.03m and a depth of approximately 0.2m.	23/01/2020
DA3B_LW15_028 Photo 26	290142	6192091	Rock Fracturing	Rock Outcrop	30/01/2020	1	Rock fracturing to sandstone outcrop between Fire Road 6P and WC15. The rock fracturing has a length of 5.2m, width of 0.07m and maximum measurable depth of 1.3m.	07/02/2020

Site ID	Easting	Northing	Impact Type	Feature Affected	Identification Date	Trigger Level	Description	Refer to Impact Report/s Dated
DA3B_LW14_015 (Update) Photo 27	288070	6192528	Rockfall	Cliff line	5/12/2019 and 11/06/2019	2	Rockfall on Avon Dam cliff edge. The impacted length of the cliff line increased to approximately 20m, with eight large boulders, multiple smaller boulders and a tree observed at the base of the cliff. The largest boulder has an approximate length of 5m, width of 3m and height of 1.5m.	06/12/2018 and 12/06/2019

Photo 9: *DA3B_LW15_001,* looking at a section of the rockfall. Taken on 29/05/2019.

Photo 10: *DA3B_LW15_002*, looking at the rockfall. Taken on 29/05/2019.

Photo 11: *DA3B_LW15_006,* looking at the rock fracture. Taken on 09/07/2019.

Photo 12: *DA3B_LW15_007*, looking at fracturing on the step. Taken on 26/02/2020

Photo 13: *DA3B_LW15_009,* looking at a section of rockfall. Taken on 26/02/2020.

Photo 14: *DA3B_LW15_013*, looking at a section of rock fracturing. Taken on 26/02/2020

Photo 15: *DA3B_LW15_016,* looking at the width of displacement. Taken on 25/10/2019.

Photo 16: *DA3B_LW15_017,* looking at the area of rockfall. Taken on 27/02/2020.

Photo 17: *DA3B_LW15_018,* looking at the rock fracture. Taken on 27/02/2020.

Photo 18: *DA3B_LW15_019,* looking at width of rock fracture. Taken on 27/02/2020.

Photo 19: *DA3B_LW15_020,* looking at area of rockfall. Taken on 27/02/2020.

Photo 20: *DA3B_LW15_021,* looking at the area of rockfall. Taken on 27/02/2020.

Photo 21: *DA3B_LW15_022,* looking at the rock fracture. Taken on 27/02/2020.

Photo 22: *DA3B_LW15_023,* looking at a section of rock fracturing. Taken on 25/10/2019.

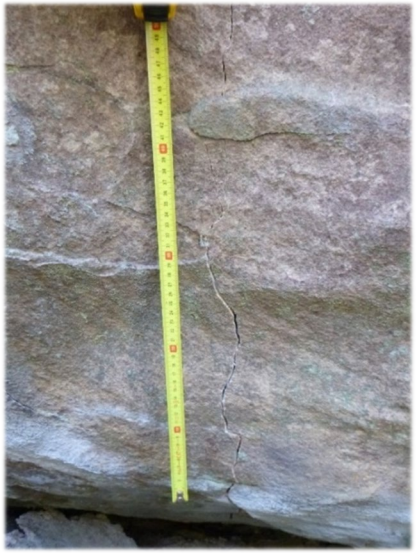

Photo 23: *DA3B_LW15_024,* looking at the rock fracturing. Taken on 21/01/2020.

Photo 24: *DA3B_LW15_025,* overview of the rockfall. Taken on 21/01/2020

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Photo 25: *DA3B_LW15_026,* looking at the soil cracking. Taken on 27/02/2020.

Photo 26: *DA3B_LW15_028,* overview of the impact site. Taken on 26/02/2020.

Photo 27: *DA3B_LW14_015,* an overview of the impact site. Taken on 11/6/2019**.**

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 a suite of laboratory-tested analytes. At *Wongawilli Creek (FR6)*, a Level 2 TARP trigger was recorded for EC and DO (Table 5). At *Donalds Castle Creek (FR6)* a Level 3 TARP trigger was recorded for EC (Table 5).

All TARP triggers occurred from April 2019 to January 2020 during which time 366mm fell at Dendrobium, only 42% of the average for the same period.

Table 5: Summary of water quality TARP triggers during the extraction of DA3B Longwalls.

Monitoring Site	Observation	LW9	LW10	LW11	LW12	LW13	LW14	LW15
Rainfall rate, (Average = 1032mm/year.)		1352	1293	1287	805	1015	864	452
Wongawilli Creek (FR6)	EC				1	3	1	2
	DO			2	1	2	2	2
Donalds Castle Creek (FR6)	EC						3	3
	DO	1	1	1	2			

At many stream monitoring sites including reference sites, water EC became elevated during 2018 and 2019 relative to the baseline mean. The increase in EC and accompanying decrease in DO is related to the low rainfall conditions which resulted in evaporative concentration of salts in residual pools combined with a greater proportion of groundwater discharge in total stream flow. The large rainfall event in early 2020 resulted in EC and DO returning to within the baseline range at most sites.

Elevated EC conditions were observed in the upper sub-catchments of Donalds Castle Creek during 2018 and 2019. The high EC was accompanied by low DO and elevated sulfate, Zn and Mn compared with baseline concentrations. A longitudinal survey of pools along Donalds Castle Creek first carried out during Longwall 14 was repeated quarterly during Longwall 15. The latest survey following the heavy February rain showed that the EC in all pools had returned to within the baseline range.

At the *Wongawilli Creek (FR6)* monitoring site, triggering of the EC and DO TARPs is likely related to the dry conditions during 2019. EC at other monitoring sites along Wongawilli Creek also returned to baseline levels following rainfall in early 2020.

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

3.3 Surface Water Hydrology

The surface water flow assessment and relevant TARPs have been modified from those used previously for Area 3B End of Panel reports. Consultation with agencies during 2018-2019 led to final agreement in early 2020 of new TARPs, as outlined in the Watercourse Impact Monitoring Management and Contingency plan (WIMMCP) (South32, 2020). This assessment of surface water flow in this EoP report relies on comparison against flows at Reference Sites, as recommended by the IEPMC (IEPMC, 2019, 2018).

The four surface water hydrology assessment methods are as follows:

(A) General hydrological behaviour compared to Reference Sites,

(B) The frequency and duration of ecologically-significant cease-to-flow events compared with Reference Sites;

(C) Changes to median flow compared with Reference Sites which is now the agreed measure of the water resource availability in each sub-catchment; and

(D) Comparison of qualitative flow data from gauging stations and semi-quantitative field observations by IMCEFT along the “middle reach” of Wongawilli Creek.

Table 6 summarises these surface water hydrology assessments at monitoring sites against the TARPs.

The assessments indicate that sub-catchments in the upper part of the Donalds Castle Creek catchment (i.e. *DC13S1* and *DCS2*) have been and continue to be affected by mining, as is tributary LA4 of Avon Dam (at *LA4S1*) and probably in the neighbouring tributary LA3 (although analysis is hampered by a very short baseline flow record). The findings for DC13, *DCS2* and LA4 are similar to those for the EoP report for Longwall 14. LA3 has been affected by mining for the first time by Longwall 15.

Similarly, the flow characteristics at *WC21S1* and *WC15S1* within the Wongawilli Creek catchment have altered as a result of mining. WC21 and WC15 are similar to those for the previous longwall.

As in recent EoP reports, analysis indicates that mining effects are probable at the Donalds Castle Creek downstream monitoring site (*DCU*). Specifically, the newly designed TARP assessments indicate that the general pattern of flow and the median flows do not trigger, which suggest that any mining effects or impacts on those indicators are of similar magnitude or less than natural variability. However, the new Assessment B, which examines cease-to-flow duration and frequency, indicates that the watercourse at *DCU* has been experiencing a mild increase in the number of cease-to-flow days compared to the Reference Sites.

Changes to stream flow characteristics are not evident at the downstream gauge on Wongawilli Creek Lower (*WWL*), despite mining-related effects being clear and significant at upstream tributaries (e.g. WC21, WC15). This suggests that some or all flow lost in headwater catchments is returned downgradient, or that upstream diversions or losses are not significant in relation to the larger catchment water balance given the natural variability and the accuracy of flow measurements.

Analysis of available surface water flow observation records for Wongawilli Creek triggered a Level 2 TARP in February 2020. Assessment D was carried out, and indicated that flow reductions due to mining were in the order of 0.008 to 0.015 ML/d.

Water flow performance measures were met for Longwall 15 (Table 7).

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

Table 6 : Summary of Surface Water TARPS for Longwall 15.

Site	Watercourse	Under-mined	Position of sub-catchment relative to mining	A) Low flow Q%ile outside Reference Site Q%ile	B) Change in cease-to-flow frequency (beyond natural)	C) Change in median flow, Q50 (beyond natural)	Comment
DC13S1	DC13	Yes	Above Longwalls	Level 3	Level 3	Level 3	Similar to Longwall 14.
DCS2	Donalds Castle Creek	Yes	Above Longwalls	Level 3	Level 3	Level 3	Similar to Longwall 14.
DCU	Donalds Castle Creek	Yes	Downstream	Not triggered	Level 1	Not triggered	Similar to Longwall 14.
WC21S1	WC21	Yes	Above Longwalls	Level 3	Level 2	Level 3	Similar to Longwall 14.
WC15S1	WC15	Yes	Above Longwalls	Level 3	Level 2	Level 3	Effects increased since Longwall 14
WC12S1	WC12	No	Headwater				To be assessed in future EoP report.
WWL	Wongawilli Creek	Yes	Downstream	Not triggered	Not triggered	Not triggered	Similar to Longwall 14
WWLA	Wongawilli Creek	Yes	Downstream				To be used in future EoP report.
LA4S1	LA4	Yes	Above Longwalls	Level 1	Not triggered* (Level 3)	Level 3	Effects appear to have reduced slightly since Longwall 14 * However, changes to low flow accuracy means that Method B assessment not completely reliable. Level 3 is more likely for this.
LA3S1	LA3	Yes	Above Longwalls	Level 1	Level 2	Level 3	New site. Very short baseline period (2 months), so statistics are unreliable.
LA2S1	LA2	No	Headwater				To be assessed in future EoP report.
NDTS1	NDT1	No	Headwater				To be assessed in future EoP report.

Site Watercourse	Position of sub-catchment relative to mining	D) Surface flow observations		Comment
Wongawilli Creek	Between A3A andA3B	February 2020	Level 2	Refer to Performance Measures

Table 7: Summary of surface water Performance Measures for Longwall 15.

Wongawilli Creek – minor environmental consequences	**This Performance Measure is met.**
Donalds Castle Creek – minor environmental consequences	**This Performance Measure is met.**
Avon Dam – negligible reduction in the quantity of surface water inflows to Avon Dam	**This Performance Measure is met.**
Cordeaux River – negligible reduction in the quantity if surface water inflow to the Cordeaux River at its confluence with Wongawilli Creek.	**This Performance Measure is met.**

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

3.4 Deep Groundwater Hydrology

Groundwater monitoring at Dendrobium Mine is conducted in accordance with the "Dendrobium Mine Area 3B SMP Groundwater Management Plan" (South32 2012) and the DA3B Subsidence Management Plan. 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.

The average daily inflow to DA3B during Longwall 15 extraction was 4.03 ML/day which represents approximately 70 % of total mine inflow for the period. The average groundwater inflow component of the water balance for Area 3B and the total mine was similar during Longwall 15 to that of the previous longwall (4.21 ML/day; Longwall 14).

Groundwater ingress to DA3B has increased steadily since the start of mining (2013), initially correlating with the total area mined. However, the rate of increase has declined (flattened) during the mining of Longwalls 12 and 13 and the water balance decreased during the extraction of Longwall 14 and Longwall 15 (Figure 15). This overall trend reflects a declining groundwater inflow per unit area mined due to progressive depressurisation of the surrounding strata by previous mining (a decline in driving head). The decline in groundwater inflow to Area 3B during Longwall 14 and Longwall 15 is likely to be partly due to the unusually dry conditions during 2018-2019. As of longwall 12, peaks in inflow to Area 3B appear to correlate with periods of high rainfall with a lag time of between two and three months. Prior to Longwall 12, the influence of rainfall on the water balance was less distinct.

The presence of modern water in mine inflow is monitored by analysing tritium. Samples are collected from goaf inflow and development seepage. 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 23 of September 2019, there is no detectable component of modern water in DA3B inflow. The laboratory processing time for high precision tritium analysis can be more than 6 months and therefore results for some samples collected in the latter part of Longwall 15 are pending.

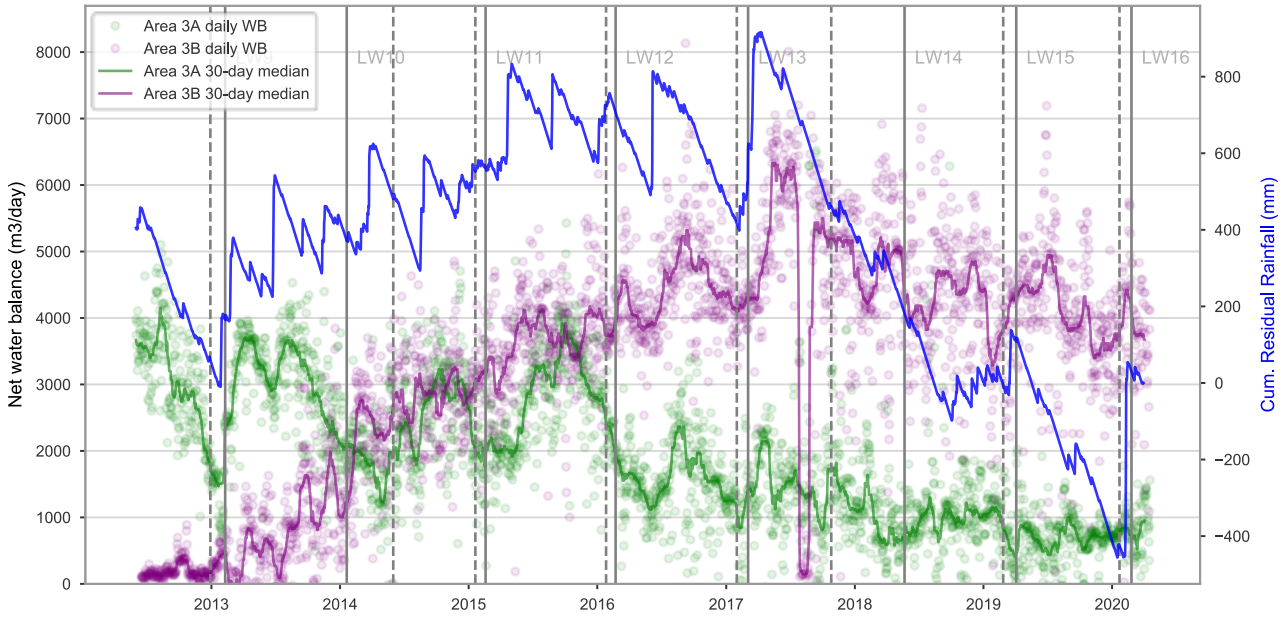

Figure 15: Groundwater inflow to the mine for DA3A and DA3B (kL/d).

3.4.2 Deep Groundwater Levels

Mining of Longwall 15 resulted in continued depressurisation of the target coal seam and overlying strata. The observed changes in groundwater levels are in line with, or less then 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.

During 2018 and 2019, IMC carried out investigation drilling above extracted longwalls (Longwall 6, Longwall 7, Longwall 12, Longwall 13, Longwall 14 and Longwall 15) to characterise the height of fracturing and assess groundwater conditions in strata above the longwall goaf. The investigation found that mining-induced fracturing, including high-angle fracturing is highly variable but appears to extend to the surface in both Dendrobium Area 3A and 3B. Piezometers installed after longwall extraction indicate significant depressurisation throughout all strata, with complete depressurisation throughout the Hawkesbury Sandstone (HBSS) in most holes. Drawdown

in the HBSS reduces with distance and is typically negligible at distances greater than 1 km from the goaf footprint.

Piezometers located to the north and west, and within 1km of the longwall footprint show a gradual decline in groundwater pressures in most strata with the rate of decline increasing with depth and proximity to the longwall. Those observations are consistent with the gradual expansion of a drawdown cone away from the mine and are in line with numerical modelling predictions. Piezometers located to the south of the active longwalls in DA3B show more pronounced depressurisation in the mid to deep stratigraphic levels with some strata pressures dropping to zero well in advance of the longwall. It is likely that those piezometers are affected by depressurisation from the Elouera mine to the south, as well as drawdown from Dendrobium, an effect that is predicted from numerical groundwater modelling.

3.4.3 DSC Monitoring – Loss of baseflow to Avon Dam

Piezometers installed along the barrier zone between Avon Dam and extracted longwalls in Area 3B show declines in piezometric heads to levels below contemporaneous water levels in Avon Dam. The observed levels imply hydraulic gradients away from the lake and towards the mine adjacent to extracted longwalls. Testing of strata permeability before and after mining of adjacent longwalls indicates that permeability increases by at least an order of magnitude at some locations as a result of strata movement, but with little or no apparent change in strata permeability at other locations.

Seepage losses from Avon Dam have been estimated by regional and local scale numerical models to be in the range 0.39 to 0.47 ML/day following the extraction of Longwall 15. The estimates are within the tolerable loss limit of 1 ML/day prescribed by Dams Safety NSW and supported by the declining mine inflow rates to Area 3B during the extraction of Longwall 13-15 adjacent to Avon Dam.

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 tends to increase with depth.

Samples collected from bore S2377 at depth 113m reported lower EC during Longwall 15 than the previous longwall. This monitoring bore is located in the barrier zone between Area 3B and Avon Dam (adjacent to Longwall 14). Given the location of the bore relative to the reservoir, it is recommended that the bore is resampled as soon as practical. All of the bores that were sampled twice or more during the last three longwalls returned sample EC values within 20% of the previous samples.

3.5 Impacts to Upland Swamps

3.5.1 Shallow Groundwater and Soil Moisture

Trigger levels for changes to groundwater and soil moisture at surface and near-surface monitoring sites at DA3B swamps have been established within the SIMMCP for DA3B (South32 2015a). Shallow groundwater level and soil moisture characteristics have been identified as an indicator of potential changes in ecosystem functionality of 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.

The soil moisture TARP has been assessed by comparing the moisture content of the soil profile during the longwall assessment period against that of the baseline period. If the average soil moisture level drops below the minimum level recorded during the baseline period, a TARP is triggered.

Both shallow groundwater levels and soil moisture levels in reference swamps were anomalously low during the assessment period in response to drought conditions. Rapid recovery in both shallow groundwater and soil moisture occurred in response to rain in early 2020.

Longwall 15 mined under and/or passed within 400m of shallow groundwater and soil moisture sites within four swamps: Swamps 11, 13, 14 and 23. It was predicted that these swamps would be affected by mine subsidence due to mining in DA3B (South32 2015a). Soil moisture and shallow groundwater assessments for these swamps are summarised in Table 8 and Table 9.

Trigger levels are assessed differently by the IMCEFT and HGEO. The IMCEFT report triggers when groundwater or moisture decrease below the baseline level during the mining period whilst the HGEO assessment is conducted following the completion of Longwall 15 and considers other factors such as longer-term climatic conditions and reference swamp comparisons.

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

Table 8: Summary of soil moisture level TARP status at Longwall 15 impact sites.

Swamp	Longwall	Sensors and TARP triggers			Comment	IMCEFT TARP Level	HGEO TARP Level
		Not Triggered	Triggered	Not within mine influence			
11	LW13 LW14 LW15		S11_S01 S11_S02 S11_S05		Soil moisture at all sensors dropped to lowest levels following Longwall 13 and 14. Likely mining effect exacerbated by dry conditions.	Level 3 (LW12/13)	Level 3 (LW14)
13	LW14 LW15		S13_S01 S13_S02 S13_S03		Soil moisture at all sensors dropped to lowest levels during Longwall 15 following low levels during Longwall 13 and 14. Likely mining effect.	Level 3 (LW14)	Level 3 (LW14)
14	LW15		S14_S02 S14_S01		Soil moisture at dropped below baseline at both sites in late 2019. Likely mining effect at *14_S02*; possible mining effect at *14_S01*.	Level 3	Level 3
23	LW15	S23_S01	S23_S02		Partially mined under by Longwall 15; soil moisture dropped below baseline in *23_S02* Longwall 14 passed the site but recovered during Longwall 15.	Level 1 (LW14)	Level 2

Table 9: Summary of shallow groundwater level TARP status at Longwall 15 impact sites.

SWAMP	TARP SITES	RELEVANT LONGWALLS	PIEZOMETERS WITH AN OBSERVED RESPONSE			OBSERVED BEHAVIOUR	COMMENT	IMCEFT TARP LEVEL	HGEO TARP LEVEL
			YES	UNCLEAR	NO				
11	3	LW13, LW14, LW15	11_H1 11_H2 11_H3			All three piezometers show mostly desaturated conditions following the passage of Longwall 14 with only brief periods of saturation following rainfall events.	Partially mined under by Longwall 13 and by Longwall 15. Passed by Longwall 15 (<400m)	Level 2 (LW14)	Level 3 (LW14)
13	1	LW14, LW15	13_01			Groundwater level below the piezometer base since early 2018; Impact apparent as of Longwall 15.	Partially mined under by Longwall 13, Longwall 14 and Longwall 15.	Level 3 (LW14)	Level 3
14	2	LW15, LW16	14_02	14_01		Evidence for impact to swamp groundwater levels at *14_02* following Longwall 15	Partially mined under by Longwall 15.	Level 2	Level 2
23	2	LW15, LW16	23_01	23_02		Evidence for impact to swamp groundwater levels at *23_01* following Longwall 15; Possible effects at *23_02* but unclear.	Partially mined under by Longwall 15.	Level 2	Level 2

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 that 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 23).

Impact assessment of Upland Swamp erosion includes analyses of ALS results, combined with infield observations. ALS results detected no erosion in swamps. Other apparent localised movements were inspected infield with no erosion or subsidence related impacts identified. These apparent localised movements are likely to be due to the effects of the horizontal movements and sloping terrain on the ALS surveys.

3.6 Terrestrial Ecology

Biosis Pty Ltd was commissioned by IMC to undertake terrestrial ecology monitoring for the Dendrobium Mine in accordance with the Flora and Fauna Environmental Management Program (Biosis 2003) and as required by the Dendrobium Development Consent, granted in 2001, and as modified in 2008 and 2010. 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 monitor and determine whether subsidence effects associated with longwall mining result in impacts to terrestrial ecological values located above the longwalls. A Before-After Control-Impact (BACI) experimental design has been established and implemented. The BACI design investigates how sites that have been mined beneath change over time (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. Ecological values which are currently being monitored include vegetation communities (species and diversity) of upland swamps, and threatened frog species Littlejohn's Tree Frog (Vulnerable EPBC Act and BC Act), within suitable habitats (second and third order streams) throughout the three domains.

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 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), Swamp 13 (S13)). Swamp 14 and Swamp 23 were added to the program in 2017 to commence pre-mine baseline monitoring. Parameters analysed include total species richness (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

The results of the TSR analysis demonstrate the response to mining at individual swamps is complex, with Swamp 15B generally showing a decline in TSR following mining and changes in shallow groundwater. Swamp 15A(2), Swamp 1A, Swamp 1B and Swamp 5 displayed no statistically significant decline in TSR despite observed changes in shallow groundwater availability. Table 10 summarises the swamp TSR assessment against the TARP and outlines future monitoring recommendations.

3.6.1.2 Upland Swamp Species Composition

Statistically significant yearly background 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.

When accounting for yearly effects, a statistically significant change in species composition post-mining was detected at Swamp 15B, triggering a Level 3 TARP. These changes were observed immediately following undermining and have continued at Swamp 15B for at least four years post-mining. Observed reduction in woodland species recorded at Swamp 15B is likely linked to vegetation changes following a significant period since fire and subsequent increased shading by shrub.

A statistically significant change in species composition post-mining was detected at Swamp 1B. No statistically significant change was recorded at Swamp 1A, Swamp 15A or Swamp 5 despite the observed changes in shallow groundwater availability. Table 10 summarises the swamp species composition assessment against the TARP and outlines future monitoring recommendations.

3.6.1.1 Upland Swamp Extent

The analysis of the most recent LiDAR data used to assess the extent of upland swamps and their composite vegetation communities, has identified that the extent of all upland swamps (impact and control swamps) within the study area have decreased substantially from the 2014 baseline. Table 11 summarises the Swamp size and ecosystem functionality assessment against the TARPS and outlines future monitoring recommendations.

The results of the 2019 LiDAR data analysis have identified continued declines in the extent of vegetation communities that comprise upland swamps, recorded in 2017. These are MU43 (Tee-tree Thicket) and MU44c (Sedgeland). 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. MU44b (Sedgeland-Heath Complex) was also identified as being reduced in extent at a number of impact sites in 2019.

The overall extent of the smaller control swamps (S89, S91, S92 and S93) remained relatively stable during the 2014 to 2017 period but show small but more marked decreases in the 2019 data relative to the other years. The changes observed in impact swamp total areas appear to be comparable to those observed at the control swamps, indicating that catchment scale conditions, rather than mining impacts are driving the reduction in total swamp area.

Table 10: DA3A and DA3B Swamp Monitoring – Terrestrial Flora: TSR 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 3 triggered	A statistically significant difference in TSR at Swamp 15B was detected (following being mined beneath) from 2013 through to 2019 at the α=0.1 level. This difference was detected during a period of stability at control swamps over three consecutive years (2013 to 2015), which was followed by an increase in TSR between 2015 and 2016 at these control swamps. A statistically significant (p-values < = 0.05) change in species composition was detected at S15B during four of the most recent monitoring periods, indicating a Level 2 TARP has been triggered.	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 offsetting has been provided for as per Schedule 2 Condition 15 of the Consent.
Swamp 15A(2)	Level 1, 2 or 3 TARP.	No TARP trigger	No statistically significant decline in TSR was detected at S15A(2) at the p=0.05 level. Additionally, no statistically significant decline in species composition was found post-mining at S15A(2).	Due to the detection of decreased groundwater and soil moisture, continued monitoring S15A(2) in spring and autumn each year is recommended.

Swamp Name	Predicted Impact	TARP Trigger Level	Results and TARP Justification	Recommendations
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 to 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 1B	Level 1, 2 or 3 TARP.	Level 1 triggered	TSR within S1B showed no statistically significant decline when compared to control sites. However, a statistically significant decline in species composition was found post-mining at S1B.	Due to the Level 1 trigger and 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 to 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 11: DA3B Swamp Monitoring – Terrestrial Flora: Swamp Size and Ecosystem Functionality (Illawarra Coal 2015b).

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	TARPS relating to swamp size and extent of groundwater dependent sub-communities do not currently apply to swamps within Dendrobium Area 3A.	Continue on-ground and UAV imagery monitoring in 2020.
Swamp 1A	Level 1, 2 or 3 TARP.	Swamp Size: Level 1 TARP triggered. Ecosystem Function: Level 2 TARP triggered.	Two years of decline in total swamp extent greater than the mean (±SE) decline of the control group. Trending decline in the extent of sub-community MU43 for three consecutive monitoring periods greater than the mean (±SE) decline of MU43 in the control group. Trending decline in the extent of sub-community MU42 and MU44b for three consecutive monitoring periods greater than the mean (±SE) decline of MU42 and MU44b in the control group.	Continue on-ground and UAV imagery monitoring in 2020. Ground truth swamp extent and swamp vegetation community extent in 2020. Investigate practical remediation measures. Swamp offsetting has been provided for as per Schedule 2 Condition 15 of the Consent.
Swamp 1B	Level 1, 2 or 3 TARP.	Swamp Size: Level 1 TARP triggered. Ecosystem Function: Level 1 TARP triggered.	Two years of decline in total swamp extent greater than the mean (±SE) decline of the control group. Trending decline in the extent of sub-community MU43 and MU44b for two consecutive monitoring periods greater than the mean (±SE) decline in the MU42 and MU43 control group.	Continue on-ground and UAV imagery monitoring in 2020. Ground truth swamp extent and swamp vegetation community extent in 2020. Investigate practical remediation measures.
Swamp 5	Level 1, 2 or 3 TARP.	Swamp Size: No TARP triggered.	One year of decline in total swamp greater than the mean (±SE) decline of the control group.	Continue monitoring in 2020. Capture UAV imagery for this swamp in 2020.

Swamp Name	Predicted Impact	TARP Trigger Level	Results and TARP Justification	Recommendations
		Ecosystem Function: Level 2 TARP triggered.	Trending decline in the extent of sub-community MU42, MU43 for three consecutive monitoring periods greater than the mean (±SE) decline in the control group.	Ground truth swamp extent and swamp vegetation community extent in 2020. Investigate 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 greater than the mean (±SE) decline of the control group. One year of trending decline in the extent of MU42 over the monitoring period.	Continue monitoring in 2020. Capture UAV imagery for this swamp in 2020. Ground truth swamp extent and swamp vegetation community extent in 2020.

3.6.2 Terrestrial Fauna – Littlejohn's Tree Frog Assessment

Monitoring of Littlejohn's Tree Frog transects is undertaken at five locations in four watercourses located within Dendrobium Area 3A during winter; 6CDL, SC10 (two sections), SC10C and WC17. As a result of impacts to SC10C and WC17 observed for consecutive years in 2015 and 2016, monitoring of streams within Dendrobium Area 3A continued in 2017 through 2019. During 2019, a total of six watercourses were monitored for Littlejohn's Tree Frog as part of the DA3B program; continued monitoring at DC(1), DC13, LA4A, WC15, WC21 and LA2.

It was predicted that mining within Dendrobium Area 3A and 3B 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 Dendrobium Area 3A and Area 3B programs over all monitoring periods indicates that broadly the abundance of adult frogs is lower at impact sites than control sites. Due to the catchment wide dry conditions experienced in 2018 and 2019, the continuation of this trend is more difficult to determine for this year and the ability to confidently identify any new impacts may also be limited due to the decreased detection numbers across control sites.

The detection of Littlejohn's Tree Frog was low in 2019 in comparison to the high reproduction rate in the breeding year of 2016 and was comparable to that recorded in 2018, also part of the extended drought experienced in 2019. Variation between the years 2018 and 2019 was observed in terms of the relative abundance of different life stages. Variation was observed among sites generally, including paired control sites, during 2019. A combination of environment driven factors, such as survey timing coinciding or not coinciding with rainfall and habitat differentiation of sites based on landscape position in response to such stimuli, are likely contributors to the variation observed.

The results of the 2019 monitoring period are consistent with those recorded in 2017, as such the recommended monitoring and CMAs in Biosis (2017b) remain relevant. Table 12.summarises the Littlejohn's Tree Frog assessment against the TARPS and outlines future monitoring recommendations.

Table 12: 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 the Littlejohn's Tree Frog.	Level 1 TARP triggered.	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. The following Level 1 triggers relating to terrestrial fauna have been observed: • No significant statistical difference between BACI sites. The following triggers relating to watercourse monitoring have been observed: • Stream appearance at *SC10C*.	Continue monitoring to investigate whether CMAs for related watercourse TARPs may address some impacts to threatened frog habitats.
SC10(1)	Significant impacts to the 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. 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. The 2019 results for Littlejohn's Tree Frogs at this site were considered nominal in comparison to the previous results and control sites during this year. The following trigger relating to watercourse monitoring has been observed: • Iron flocculent covering all stream surfaces This represents a reduction in breeding habitat for Littlejohn's Tree Frogs.	Continue approved monitoring program.

Stream	Predicted Impact	TARP Trigger Level	Results and TARP Justification	Recommendations
SC10(2)	Significant impacts to the Littlejohn's Tree Frog.	No TARP levels triggered.	There has been no significant decline in Littlejohn's Tree Frogs at *SC10(2)* since mining began in 2011.	Continue approved monitoring program.
WC17	Significant impacts to the Littlejohn's Tree Frog.	Level 1 TARP no longer triggered. No TARP levels 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. In 2017, detection of Littlejohn's Tree Frog continued to increase from previous years, with abundance records consistent with pre-mining numbers. Due to a lack of water at this site and associated control sites, and on the basis that comparable abundances of each life stage were recorded for at least one of the paired control sites in 2019, it is determined that the Level 1 TARP continues not to be triggered. However future monitoring results should be closely examined at this site.	Continue approved monitoring program.

Stream	Predicted Impact	TARP Trigger Level	Results and TARP Justification	Recommendations
DA3B Watercourse Monitoring TARP (dated 12 October 2015)				
DC(1)	Significant impacts to the Littlejohn's Tree Frog.	Level 2 TARP triggered.	Following the 2016 survey at *DC(1),* breeding pools (Pools 32 and 33) had a reduced water level below the pool monitoring 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 sufficient time to metamorphose, resulting in zero survival, and indicating a loss of Littlejohn's Tree Frog breeding habitat within DC(1) (Biosis 2017). The Level 1 TARP was triggered in 2017. While also reflecting the impacts of dry conditions, the 2018 and 2019 data is consistent with that of the 2017 findings. As such a reduction in habitat for 2 years following the active subsidence period has occurred and Level 2 TARP has been triggered.	Review monitoring frequency Notify relevant technical specialists and seek advice on any CMA required Implement agreed CMAs as approved (subject to stakeholder feedback) Continue monitoring as a part of the approved terrestrial monitoring program.
DC13	Significant impacts to the Littlejohn's Tree Frog.	Level 3 TARP triggered in 2017. Level 3 TARP is considered to remain triggered in 2019.	Subsidence impacts following mining has resulted in the loss of water in pools located above this longwall. 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	Recommendations for reporting to the relevant authorities were made following the triggering of the Level 3 TARP in Biosis (2017). Continue monitoring as a part of the approved terrestrial monitoring program.

Stream	Predicted Impact	TARP Trigger Level	Results and TARP Justification	Recommendations
			appropriate habitat for Littlejohn's Tree Frogs to survive to metamorphosis. While also reflecting the impacts of dry conditions, the 2019 data is consistent with the 2017 and 2018 findings The Level 3 TARP is considered to remain triggered and should be reviewed in 2020.	
WC21	Significant impacts to the Littlejohn's Tree Frog.	Level 3 TARP triggered. Level 3 TARP is considered to remain.	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). While also reflecting the impacts of dry conditions, the 2019 data is consistent with the 2017 and 2018 findings. The Level 3 TARP is considered to remain triggered and should be reviewed in 2020.	Recommendations for reporting to the relevant authorities were made following the triggering of the Level 3 TARP in Biosis (2017). Continue monitoring as a part of the approved terrestrial monitoring program.
LA4A	Significant impacts to the 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 have 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 approved 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 15. 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 Before, After, Control, Impact (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 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 (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.

Table 13 compares the predicted impacts against the observed impacts and

Table **14**.summarises the aquatic ecology assessment against the TARPS.

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

Table 13: Summary of predicted and observed impacts to aquatic ecology associated with Longwall 15.

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 by IMCEFT during extraction of Longwall 15 or by Cardno at aquatic ecology monitoring sites on Wongawilli Creek in 2019 (Cardno 2020).
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 400m 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 due to fracturing of bedrock and diversion of surface flows.	No reductions in pool water levels and flow observed by South32 or Cardno during extraction of Longwall 15. The relatively minor changes in water quality that have been observed at Wongawilli Creek *(FR6)* are not expected to have significant impacts on aquatic biota. No evidence of impacts occurring to aquatic macroinvertebrates and fish in data collected in 2019. (Cardno 2020).

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. Any losses of habitat and connectivity that do occur would be minor, localised and transient.	None observed in Wongawilli Creek or Donalds Castle Creek during extraction of Longwall 15. Fracturing of bedrock and potential diversion of flows in Avon Dam drainage line LA4A and Wongawilli Creek drainage lines WC15 and WC21 is likely to have resulted in some further minor reduction in quantity and connectivity of aquatic habitat in these drainage lines. Given the abundance of comparable first and second order stream habitat in the upper Avon and Cordeaux Catchments, associated impacts to aquatic biota would also be expected to be minor. The relatively minor changes in water quality that have been observed in *Donalds Castle Creek (FR6)* are not expected to have significant impacts on aquatic biota.

Table 14: 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 400m 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 15, an inspection of Aboriginal cultural heritage sites within the Longwall 15 study area (as defined in Niche 2020; **Attachment H**) was conducted by on the 15th and 16th March 2020 (Figure 16). Two out of the six Aboriginal cultural heritage sites had observable impacts from subsidence movements related to the extraction of Longwall 15 (Table 15) (Photo 28 to Photo 33). *Browns Road Site 11* has experienced diagonal and vertical cracking with minor block fall. These impacts have not affected the art directly, however flaking of the southern Art Panel and change of seepage patterns may occur after large rain events (>142mm rainfall in one day). *DM 21* has experienced diagonal and vertical cracking at the northern exterior end of the shelter. While the Art Panels have not been directly impacted by subsidence impacts.

The Aboriginal Heritage Impact Permit (AHIP) granted to impact Aboriginal objects located within DA3B, states that *Browns Road Site 11* and *DM 21* are identified in Schedule C as sites that can be harmed by mining related activity under section 90 of the *National Parks and Wildlife Act 1974.*

As per the TARPS performance measures, *Browns Road Site 11* and *DM21* are considered to act on Level 1 performance measures. *Browns Road Site 8*, *Dendrobium 6*, *Upper Avon 35* and *Site 1 – DB1* do not trigger CMA's. Future monitoring recommendations for Longwall 15 Aboriginal archaeological sites are outlined in Table 16.

Impacts reported at *Site 1 -DB1* during Longwall 14 EoP (Niche 2019) have since been identified as naturally occurring and not caused by mining.

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

Table 15: Aboriginal cultural heritage sites status following the extraction of Longwall 15.

AHIMS Number	Site Name/ AHIMS Number	Observed Subsidence Related Changes
52-2-1623	Browns Road Site 8	None
52-2-1626	Browns Road Site 11	This Shelter with Art site was previously monitored as part of the Longwall 14 EoP reporting (Niche 2019). The main area of cracking caused by subsidence related effects due the extraction of Longwall 14 was observed in the southern floor area of the shelter. The diagonal cracking measured to an approximate length of 70 cm and a width of 3 cm. The Art Panels located at the northern extent if the shelter were not impacted. The latest inspection identified new subsidence related impacts due to the extraction of Longwall 15. Impacts to the south of the shelter consist of seven vertical and diagonal cracks to the floor of the shelter and two instances of minor block fall. New areas of joint opening and fissuring were observed in areas surrounding the two Art Panels to the north of the shelter. The Art Panels were in moderate condition and have not been directly affected by joint opening or fissuring, although change of seepage patters may further erode opened joints which may lead to direct impacts to Art Panels after large rain events.
52-2-1771	Upper Avon 35	None
52-2-2229	Site 1-DB1	None This Shelter with Art site was identified to have been impacted from the extraction of Longwall 14 resulting in subsidence related vertical cracking located at the backwall of the shelter. It has since been resolved that this site was not impacted by longwall mining. The observable crack in the backwall of the shelter was observed prior to longwall mining (Biosis 2012).The cracking at the backwall of the shelter has occurred due to natural processes.
52-2-2246	Dendrobium 6	None

AHIMS Number	Site Name/ AHIMS Number	Observed Subsidence Related Changes
52-2-3645	DM21	The landscape surrounding the shelter site has experienced a range of subsidence impacts from the extraction of Longwall 15 such as localised rockfalls to the upper ridgelines (South32, 2020). The northern exterior of the shelter has experienced fracturing as result of subsidence from the extraction of Longwall 15. Four main instances of vertical and diagonal cracking were observed. The largest crack at the base of the ridgeline measures 3.7 cm in width. The interior cavern of the shelter did not have any direct impacts from subsidence. The monitoring point of natural fissuring did not have any further separation in comparison to previous monitoring. It was observed that Art Panels have substantially faded in comparison to baseline recording. Vegetation surrounding the shelter is notably reduced from archaeological observations of shelter. The reduction of vegetation may have resulted in the interior of the shelter being increasingly exposed to natural erosive elements.

Table 16: Recommendations for Aboriginal archaeology sites within the study area.

Recommendations	
#	**Browns Road Site 11 (AHIMS ID# 52-2-1626) and DM21 (AHIMS ID #52-3645)**
1.	Notify relevant specialists, key agency stakeholders and Registered Aboriginal Parties of impacts to *Browns Road Site 11* and *DM 21* of Level 1 Action in accordance with the Trigger Action Response Plan.
2.	Ongoing monitoring of *Browns Road Site 11* after large rain events (>142mm rainfall in one day) to observe and record a change in seepage patterns in areas of fissuring and opening of joints as a result of indirect mining impacts to the Art Panels.
3.	Include *DM 21* in the Longwall 16 End of Panel monitoring program and continue to monitor for further impacts as a result of subsidence at the site.
4.	Continue monitoring program for remaining longwalls with condition assessment and photographic records as per the TARPS.

Photo 28: *Browns Road Site 11*, Looking at a section of fracturing. Taken: 15th March 2020.

Photo 29: *Browns Road Site 11,* subsidence related fracturing and exfoliation. Taken: 15th March 2020.

Photo 30: Browns Road Site *11,* **o**pening of bedding plane adjacent to Art Panel to the south of the shelter. Taken: 15th March 2020.

Photo 31: *DM 21,* Image of fading ochre hand stencils located on the roof shelter. Taken: 15th March 2020.

Photo 32: *DM 21*, Two vertical fractures located at the northern exterior of the shelter cavern area. Taken: 15th March 2020.

Photo 33: *DM 21*, Close up of vertical fracturing located at the base of the northern exterior of the shelter cavern area. Taken: 15th March 2020.

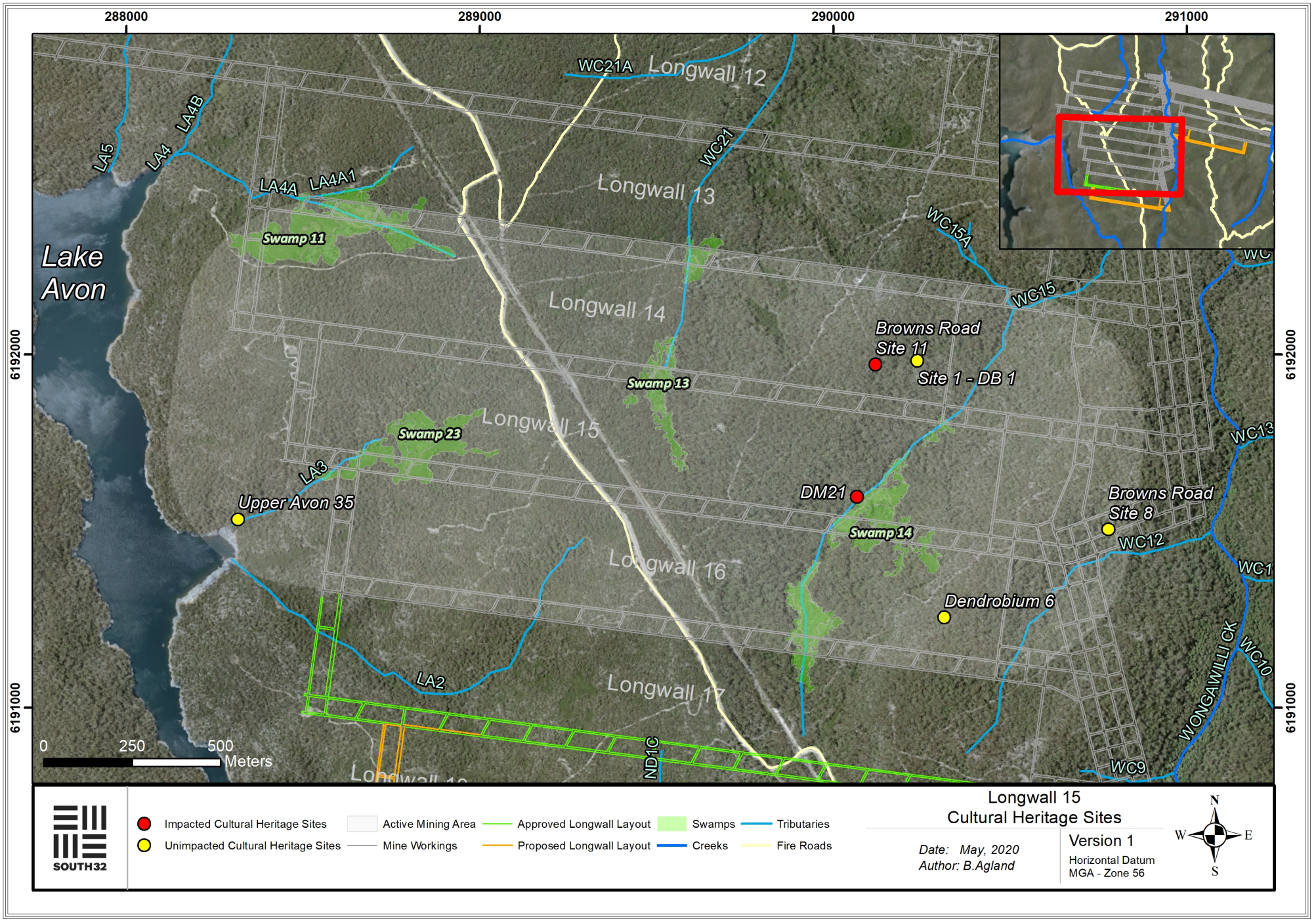

Figure 16: Aboriginal Cultural Heritage sites within the Longwall 15 study area.

4 IMPACTS TO BUILT FEATURES

The built features in proximity to Longwall 15 are shown in (**Attachment B**); and include:

- Fire trails and other access tracks;
- Maldon-Dombarton Railway Corridor;
- Survey control marks; and
- Avon Dam.

Cordeaux Dam Wall is located more than 5 km north of Longwall 15, at its closest point. The Upper Cordeaux No.2 Dam Wall is located more than 6 km south-east of Longwall 15, at its closest point. It is unlikely these dam walls would experience any measurable far-field horizontal movements resulting from Longwall 15 and, therefore, they have not been assessed further.

Six impacts associated with built features were identified during the extraction of Longwall 15 (Table 18 and Table 19). These impacts consist of soil cracks and uplift on seismic trails, Fire Road 6A (FR6A), Fire Road 6P (FR6P) and the disused Maldon Dombarton Railway Corridor. All six impacts were either remediated (by means of in-filling) or were observed as self-remediating.

Table 17: Summary of predicted impacts in comparison to observed impacts relevant to Longwall 15.

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 2mm and 80mm.
Disused Maldon-Dombarton Railway	Possible fracturing of rock cuttings, spalling, and/or mobilisation of rock joints	Surface cracking and rock fracturing above LW15 along the alignment of the railway corridor.
Avon Dam	Adverse impacts not anticipated	No reported impacts to the dam walls. 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

Four impacts (Photo 34 to Photo 36) 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 100mm width;
- crack or fracture up to 10m length; and
- erosion in a localised area, which would be expected to naturally stabilise without CMA and within the period of monitoring.

Table 18: Summary of Level 1 impacts to built features.

Site ID	Easting	Northing	Impact Type	Feature Affected	Identification Date	Trigger Level	Description	Refer to Impact Report/s Dated
DA3B_LW15_005	289151	6191960	Soil Cracking	Fire Road 6A	09/07/219	1	Soil cracking and uplift across Fire Road 6A. The cracking is up to 5m long and 0.01m wide, with up to 0.02m of uplift.	11/07/2019
DA3B_LW15_008	289221	6191783	Soil Cracking and Uplift	Fire Road 6A	29/07/2019	1	Soil cracking and uplift across Fire Road 6A. The largest soil crack is 9.5m in length, 0.02m wide, and has a maximum measurable depth of 0.08m.	30/07/2019
DA3B_LW15_010	289323	6191824	Soil Cracking and Uplift	Closed Access Track	13/08/2019	1	Soil cracking and uplift to a closed access track adjacent to Swamp 23. Discontinuous cracking and uplift occurred over a length of approximately 3.5m, with a width of 0.002m and uplift of 0.01m.	23/08/2019
DA3B_LW15_012	289249	6191777	Soil Cracking	Access Track	28/08/219	1	Soil cracking to access track connecting Fire Road 6A and railway ballast, near Swamp 23. The largest soil crack is 4.1m in length, 0.002m wide.	30/08/2019

Photo 34: *DA3B_LW15_005*. Taken: 09/07/2019.

Photo 35: *DA3B_LW15_010*. Taken: 12/08/2019.

Photo 36: *DA3B_LW15_012*. Taken: 28/08/2019.

4.2 Level 2 Surface Cracking

Two impacts (Photo 37 and Photo 38) to built features were reported as Level 2 impacts in accordance with the DA3B SMP; specifically:

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

Table 19: Summary of Level 2 impacts to built features.

Site ID	Easting	Northing	Impact Type	Feature Affected	Identification Date	Trigger Level	Description	Refer to Impact Report/s Dated
DA3B_LW15_004	289196	6191848	Soil Cracking	Fire Road 6A	09/07/2019	2	Soil cracking along Fire Road 6A. Discontinuous cracking runs for approximately 80m and is up to 0.05m wide and 0.09m deep. The longest continuous section of cracking is approximately 12m long.	11/07/2019
DA3B_LW15_011	289399	6191703	Soil Cracking	Fire Road 6P and railway ballast	28/08/2019	2	Soil cracking to railway ballast and entrance of Fire Road 6P. Multiple cracks are located across an area of approximately 25m^2, with the largest continuous crack having a length of 12m, width of 0.06m and maximum measurable depth of 0.5m.	30/08/2019

Photo 37: *DA3B_LW15_004*. Taken: 09/07/2019.

Photo 38: *DA3B_LW15_004*. Taken: 09/07/2019.

5 SUMMARY OF TARP TRIGGERS

A summary of TARP triggers during the extraction of Longwall 15 is presented below in Table 20; additionally, an overview of Longwall 15 surface impacts and triggers is presented in Figure 17.

Table 20: Summary of TARP Triggers during the extraction of Longwall 15.

Site ID	Impact Type	Feature Affected	Identification Date	Trigger Level	Description	Refer to Impact Report/s Dated
DA3B_LW15_001	Rock Fracturing and Rockfall	Steep Slope	29/05/2019	1	Rock fracturing and rockfall at a step adjacent to Swamp 23.	31/05/2019
DA3B_LW15_002	Rockfall	Steep Slope	29/05/2019	1	Rockfall at a step adjacent to Swamp 23.	31/05/2019
DA3B_LW15_003	Rock Fracturing	LA4A	17/06/2019	1	Rock fracturing and associated rock fragmentation at *LA4A_Step 3A*.	19/06/2019
DA3B_LW15_004	Soil Cracking	Fire Road 6A	09/07/2019	2	Soil cracking along Fire Road 6A.	11/07/2019
DA3B_LW15_005	Soil Cracking	Fire Road 6A	09/07/219	1	Soil cracking and uplift across Fire Road 6A.	11/07/2019
DA3B_LW15_006	Soil Cracking and Rock Fracturing	Access Track & Sandstone Outcrop	09/07/219	1	Soil cracking to a closed access track and fracturing to adjacent rock outcrop.	11/07/2019
DA3B_LW15_007	Rock Fracturing	Steep Slope	09/07/219	1	Fracturing to sandstone step, north of Swamp 23.	11/07/2019
DA3B_LW15_008	Soil Cracking and Uplift	Fire Road 6A	29/07/2019	1	Soil cracking and uplift across Fire Road 6A.	30/07/2019
DA3B_LW15_009	Rockfall	Steep Slope	29/07/2019	1	Small rockfall to ledge adjacent to Swamp 23.	30/07/2019
DA3B_LW15_010	Soil Cracking and Uplift	Closed Access Track	13/08/2019	1	Soil cracking and uplift to a closed access track adjacent to Swamp 23.	23/08/2019
DA3B_LW15_011	Soil Cracking	Fire Road 6P and Ballast	28/08/2019	2	Soil cracking to railway ballast and entrance to Fire Road 6P.	30/08/2019

Site ID	Impact Type	Feature Affected	Identification Date	Trigger Level	Description	Refer to Impact Report/s Dated
DA3B_LW15_012	Soil Cracking	Access Track	28/08/219	1	Soil cracking to access track connecting Fire Road 6A and railway ballast, near Swamp 23.	30/08/2019
DA3B_LW15_013	Rock Fracturing and Fragmentation	Steep Slope	05/09/2019	1	Rock fracturing and fragmentation near SLMMP site *A3b-SS11*.	06/09/2019
DA3B_LW15_014	Rockfall, Rock Fracturing and Fragmentation	LA4A	11/10/2019	2	Rockfall, rock fracturing and fragmentation to *LA4A_Step 3B* and *LA4A_Channel 3A*.	15/10/2019
DA3B_LW15_015	Rock Fracturing	LA4A	11/10/2019	2	Rock fracturing to *LA4A_Rockbar 2*.	15/10/2019
DA3B_LW15_016	Rock Displacement	Steep Slope	25/10/2019	1	Rock displacement at a steep slope between Fire Road 6P and Swamp 14.	28/10/2019
DA3B_LW15_017	Rockfall	Steep Slope	25/10/2019	1	Small rockfall at a steep slope between Fire Road 6P and Swamp 14.	28/10/2019
DA3B_LW15_018	Rock Fracturing	Steep Slope	25/10/2019	1	Rock fracturing at a steep slope between Fire Road 6P and WC15.	28/10/2019
DA3B_LW15_019	Rock Fracturing	Steep Slope	25/10/2019	1	Rock fracturing at a steep slope between Fire Road 6P and WC15.	28/10/2019
DA3B_LW15_020	Rockfall	Steep Slope	25/10/2019	1	Small rockfall at a steep slope between Fire Road 6P and WC15.	28/10/2019
DA3B_LW15_021	Rockfall	Steep Slope	25/10/2019	1	Small rockfall at SLMMP site *A3b-SS9-Pt1*.	28/10/2019
DA3B_LW15_022	Rock Fracturing	Steep Slope	25/10/2019	1	Rock fracturing at a steep slope between Fire Road 6P and WC15.	28/10/2019
DA3B_LW15_023	Rock Fracturing	Steep Slope	25/10/2019	2	Rock fracturing at a steep slope between Fire Road 6P and WC15.	28/10/2019
DA3B_LW15_024	Rock Fracturing and Soil Uplift	Steep Slope	21/01/2020	1	Rock fracturing and soil uplift at a steep slope between Swamp 14 and WC15.	23/01/2020
DA3B_LW15_025	Rockfall	Steep Slope	21/01/2020	1	Rockfall at a steep slope between Swamp 14 and WC15.	23/01/2020

Site ID	Impact Type	Feature Affected	Identification Date	Trigger Level	Description	Refer to Impact Report/s Dated
DA3B_LW15_026	Soil Cracking and Displacement	Steep Slope	21/01/2020	1	Soil cracking and displacement at SLMMP site *A3B-SS13*.	23/01/2020
DA3B_LW15_027	Rock Fracturing	WC15	21/01/2020	1	Rock fracturing to *WC15_Rockbar 18*.	23/01/2020
DA3B_LW15_028	Rock Fracturing	Rock Outcrop	30/01/2020	1	Rock fracturing to sandstone outcrop between Fire Road 6P and WC15.	07/02/2020
DA3B_LW13_010 (Update)	Rockfall	WC21	21/08/2019	2	Rockfall to a step at WC21_*Pool 53*.	23/08/2019
DA3B_LW13_035 (Update)	Rock Fracturing	WC15	21/01/2020	2	Additional rock fracturing to *WC15_Rockbar 21*.	23/01/2020
DA3B_LW13_046 (Update)	Rock Fracturing and Displacement	WC15	1/04/2020	1	Additional rock fracturing and displacement to *WC15_Pool 2*.	3/04/2019
DA3B_LW14_015 (Update)	Rockfall	Cliff line	5/12/2019 and 11/06/2019	2	Rockfall on Avon Reservoir cliff edge.	06/12/2018 and 12/06/2019
DA3B_LW14_016 (Update)	Rock Fracturing	WC15	21/01/2020	2	Additional rock fracturing to *WC15_Rockbar 25*.	23/01/2020
23_01 (IMCEFT)	Shallow Groundwater Trigger	Swamp 23	01/05/2019	2	Rate of recession greater than baseline.	03/05/2019
14_02 (IMCEFT)	Shallow Groundwater Trigger	Swamp 14	01/11/2019	2	Rate of recession greater than baseline.	08/11/2019
S14_02 (IMCEFT)	Soil Moisture Trigger	Swamp 14	13/12/2019	3	Soil moisture level lower than baseline.	17/12/2019
14_01 (IMCEFT)	Shallow Groundwater Trigger	Swamp 14	15/01/2020	2	Groundwater level lower than baseline.	16/01/2020
S14_01 (IMCEFT)	Soil Moisture Trigger	Swamp 14	15/01/2020	3	Soil Moisture level lower than baseline.	16/01/2020

Site ID	Impact Type	Feature Affected	Identification Date	Trigger Level	Description	Refer to Impact Report/s Dated
Swamp 13 (HGEO)	Groundwater	Swamp 13	N/A	3	Evidence for impact to swamp groundwater levels at *13_01*.	HGEO (May 2020)
Swamp 14 (HGEO)	Groundwater	Swamp 14	N/A	2	Evidence for impact to swamp groundwater levels at *14_02*.	HGEO (May 2020)
Swamp 23 (HGEO)	Groundwater	Swamp 23	N/A	2	Evidence for impact to swamp groundwater levels at *23_01*.	HGEO (May 2020)
Swamp 14 (HGEO)	Soil Moisture	Swamp 14	N/A	3	Soil moisture level lower than baseline at *14_S01* and *14_S02*.	HGEO (May 2020)
Swamp 23 (HGEO)	Soil Moisture	Swamp 23	N/A	2	Soil moisture level lower than baseline at *23_S02*	HGEO (May 2020)
Wongawilli Creek (FR6)	Water Quality	Wongawilli Creek	29/01/2020	2	Dissolved oxygen trigger	7/02/2020
Wongawilli Creek (FR6)	Water Quality	Wongawilli Creek	29/01/2020	2	Electrical conductivity trigger	7/02/2020
Donalds Castle Creek (FR6)	Water Quality	Donalds Castle Creek	25/03/2019	3	Electrical conductivity trigger	28/3/2019 & 31/05/2019
DCS2	Surface Water Hydrology	Donalds Castle Creek	N/A	3	General hydrological behaviour.	HGEO (May 2020)
				3	The frequency and duration of ecologically-significant cease-to-flow events.	
				3	Changes to median flow.	
DCU	Surface Water Hydrology	Donalds Castle Creek	N/A	1	Frequency and duration of ecologically-significant cease-to-flow events.	HGEO (May 2020)
DC13S1	Surface Water Hydrology	DC13	N/A	3	General hydrological behaviour.	HGEO (May 2020)
				3	Frequency and duration of ecologically-significant cease-to-flow events.	
				3	Changes to median flow.	

Site ID	Impact Type	Feature Affected	Identification Date	Trigger Level	Description	Refer to Impact Report/s Dated
WC21S1	Surface Water Hydrology	WC21	N/A	3	General hydrological behaviour.	HGEO (May 2020)
				3	Frequency and duration of ecologically-significant cease-to-flow events.	
				3	Changes to median flow.	
WC15S1	Surface Water Hydrology	WC15	N/A	3	General hydrological behaviour.	HGEO (May 2020)
				2	Frequency and duration of ecologically-significant cease-to-flow events.	
				3	Changes to median flow.	
LA4S1	Surface Water Hydrology	LA4	N/A	1	General hydrological behaviour.	HGEO (May 2020)
				3	Changes to median flow.	
LA3S1	Surface Water Hydrology	LA3	N/A	1	General hydrological behaviour.	HGEO (May 2020)
				2	Frequency and duration of ecologically-significant cease-to-flow events.	
				3	Changes to median flow.	
Swamp 15B	Terrestrial Ecology (Flora)	Swamp 15B	N/A	3	A statistically significant difference in Total species richness and species composition.	Biosis (May 2020)
Swamp 1A	Swamp Size	Swamp 1A	N/A	1	Two years of decline in total swamp extent greater than the mean (±SE) decline of the control group.	Biosis (May 2020)
Swamp 1A	Ecosystem Function	Swamp 1A	N/A	2	Trending decline in the extent of subcommunities for three consecutive monitoring periods greater than the mean (±SE) decline in the control group.	Biosis (May 2020)
Swamp 1B	Terrestrial Ecology (Flora)	Swamp 1B	N/A	1	A statistically significant change in and species composition.	Biosis (May 2020)
Swamp 1B	Swamp Size	Swamp 1B	N/A	1	Two years of decline in total swamp extent greater than the mean (±SE) decline of the control group.	Biosis (May 2020)
Swamp 1B	Ecosystem Function	Swamp 1B	N/A	1	Trending decline in the extent of subcommunities for two consecutive monitoring periods greater than the mean (±SE) decline in the control group.	Biosis (May 2020)

Site ID	Impact Type	Feature Affected	Identification Date	Trigger Level	Description	Refer to Impact Report/s Dated
Swamp 5	Ecosystem Function	Swamp 5	N/A	2	Trending decline in the extent of subcommunity MU43 for three consecutive monitoring periods greater than the mean (±SE) decline in the control group.	Biosis (May 2020)
SC10C	Terrestrial Ecology (Fauna)	SC10C	N/A	1	Significant impacts to local populations of Littlejohn's Tree Frog.	Biosis (May 2020)
DC(1)	Terrestrial Ecology (Fauna)	Donalds Castle Creek	N/A	2	Reduction in habitat for 2 years following the active subsidence period.	Biosis (May 2020)
DC13	Terrestrial Ecology (Fauna)	DC13	N/A	3	Reduction in habitat for >2 years or complete loss of habitat following the active subsidence period.	Biosis (May 2020)
WC21	Terrestrial Ecology (Fauna)	WC21	N/A	3	Reduction in habitat for >2 years or complete loss of habitat following the active subsidence period.	Biosis (May 2020)
Donalds Castle Creek	Aquatic Ecology	Donalds Castle Creek	N/A	3	Reduction in aquatic habitat for >2 years or complete loss of habitat following the active subsidence period.	Cardno (May 2020)
WC21	Aquatic Ecology	WC21	N/A	3	Reduction in aquatic habitat for >2 years or complete loss of habitat following the active subsidence period.	Cardno (May 2020)
Browns Road Site 11.	Cultural Heritage	Sandstone Shelter	10/05/2019 & 15/03/2020	1	Additional fracturing, block fall, joint opening and fissuring. Art Panels have not been impacted.	Niche (June 2019 & May 2020)
DM21	Cultural Heritage	Sandstone Shelter	15/03/2020	1	The northern exterior of the shelter has experienced fracturing. Art Panels have not been impacted.	Niche (May 2020)

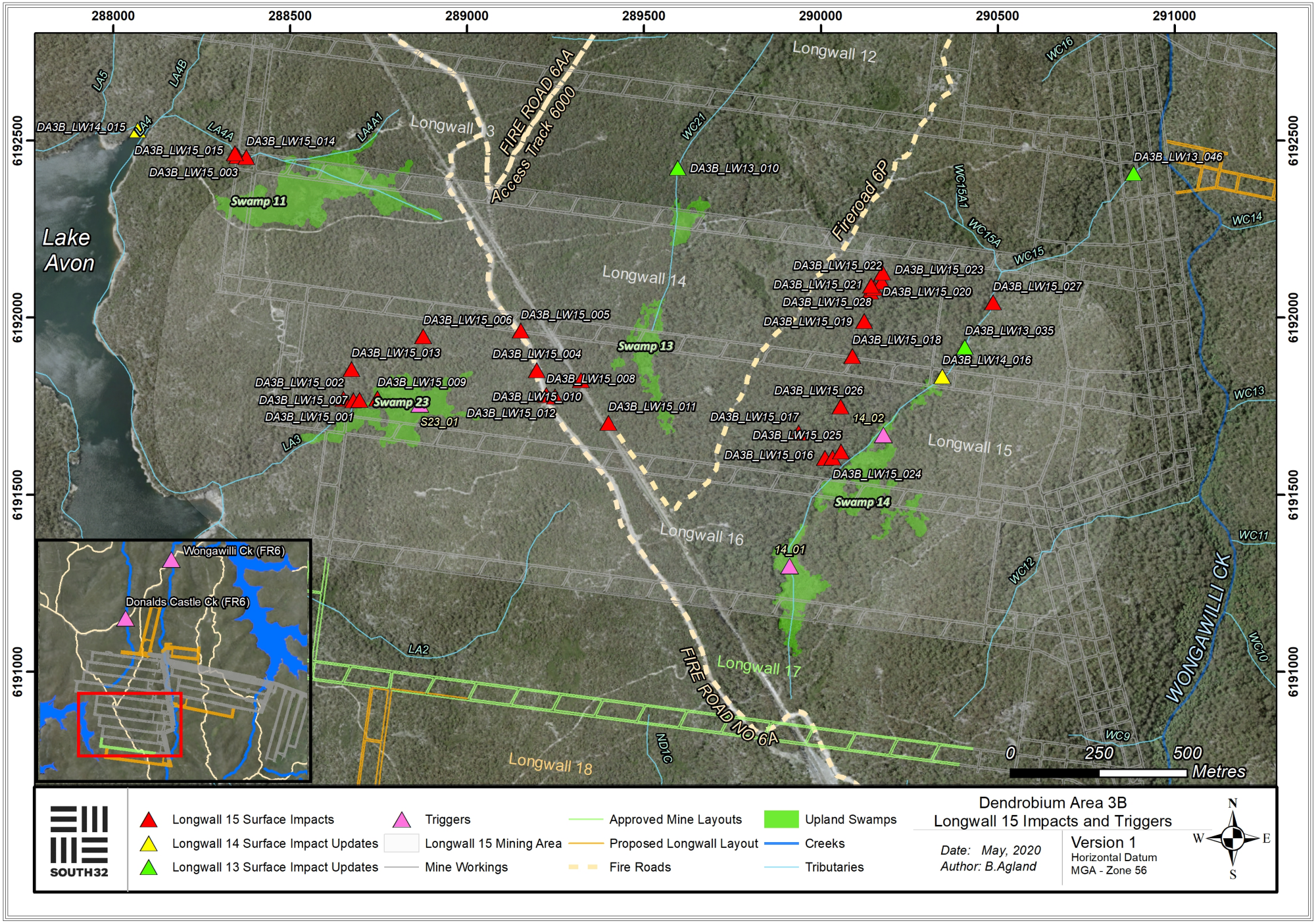

Figure 17: Overview of surface impacts observed during the extraction of Longwall 15.

6 LONGWALL 15 MONITORING PROGRAM

Table 21: Summary of monitoring sites associated with the extraction of Longwall 15. Recommended monitoring sites associated with the extraction of Longwall 16 are also included.

Aspect	Monitoring Sites Associated with Longwall 15	Monitoring Frequency	Recommended Future Monitoring for Longwall 16
Watercourses	**Observational, photo point and water monitoring**		
	• Donalds Castle Creek • Avon Dam • LA2 • LA3 • LA4, LA4A, LA4B, LA5 • Swamp 23 • Swamps 3, 4, 5, 10, 11, 13 and 14 • WC12, WC15, WC16, WC18 and WC21 • Wongawilli Creek • WC6, WC7, WC8, WC9, • ND1 • Swamps 35a and 35b	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	• Donalds Castle Creek • Avon Dam • LA2 • LA3 • LA4A • Swamp 23 • Swamps 5, 10, 11, 13 and 14 • WC12 • WC15, WC16 and WC21 • Wongawilli Creek • WC6, WC7, WC8, WC9, ND1 • Swamp 35a/b • Native Dog Creek
	Water Quality		
	Wongawilli Creek • WWU1 (Wongawilli Creek headwaters) • WWU4 (Wongawilli Creek upstream) • WC_Pool 49 (Wongawilli Creek adjacent to LW15) • WC_Pool 46 (Wongawilli Creek adjacent to LW12) • WWM2 (Wongawilli Creek adjacent to LW11) • WC_Pool 43b (Wongawilli Creek downstream of LW9) • Wongawilli Ck (FR6) (Wongawilli Creek downstream) • WC21_Pool 5 (Wongawilli Creek tributary downstream of mining) • WC21_Pool 30 (Wongawilli Creek tributaries over mining) • WC21_Pool 53 (Wongawilli Creek tributary over mining) • WC12_Pool 1 (Wongawilli Creek tributary downstream of mining) • WC15_Pool 9 (Wongawilli Creek tributary downstream of mining) **Avon Dam** • LA4_S1, LA4_S2, LA5_S1, LA5_S2, LA_1, LA1, LA2_Pool 5, LA3_Pool 4 **Donalds Castle Creek:** • Donalds Castle Ck (FR6) (Donalds Castle Creek lower) • DC13_Pool 2b (downstream from mining) • DC_Pool 22 (Donalds Castle Creek downstream of mining)	Monthly monitoring during and post mining for two years until required	**Wongawilli Creek** • WWU1 (Wongawilli Creek headwaters) • WWU4 (Wongawilli Creek upstream) • WC_Pool 49 (Wongawilli Creek adjacent to LW15) • WC_Pool 46 (Wongawilli Creek adjacent to LW12) • WWM2 (Wongawilli Creek adjacent to LW11) • WC_Pool 43b (Wongawilli Creek downstream of LW9) • Wongawilli Ck (FR6) (Wongawilli Creek downstream) • WC21_Pool 5 (Wongawilli Creek tributary downstream of mining) • WC21_Pool 30 (Wongawilli Creek tributaries over mining) • WC21_Pool 53 (Wongawilli Creek tributary over mining) • WC12_Pool 1 (Wongawilli Creek tributary downstream of mining) • WC15_Pool 9 (Wongawilli Creek tributary downstream of mining) **Avon Dam** • LA_1, LA1, LA2_Pool 5, LA3_Pool 4 **Donalds Castle Creek:** • Donalds Castle Ck (FR6) (Donalds Castle Creek lower)

Aspect	Monitoring Sites Associated with Longwall 15	Monitoring Frequency	Recommended Future Monitoring for Longwall 16
	• DCL3 (Donalds Castle Creek further downstream site)		• DC_Pool 22 (Donalds Castle Creek downstream of mining) • DCL3 (Donalds Castle Creek further downstream site) **Reference Site** • LC5_S1
Swamps	**Observational, Photo Point and Water Monitoring**		
	• Swamps 3, 4, 5, 10, 11 13, 14 and 23	Pre and post mining for two years, monthly when longwall is within 400m of monitoring site.	• Swamps 5, 10, 11, 13, 14, 23 and 35a/b
	Shallow Groundwater Level		
	• Swamp 05: 05_01, 05_02, 05_03, 05_03i, 05_03ii, 05_03iii, 05_04, 05_05, 05_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 **Reference Sites** • Swamp 2: 02_S01 • Swamp 7: 07_S05, 07_S06 • Swamp 15A: S15a_S01, S15a_Piezo, S15a_S04, S15a_S06 • Swamp 22: 22_01, 22_02 • Swamp 25: S25_S01 • Swamp 33: S33_S01, S33_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	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 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 **Reference Sites** • Swamp 2: 02_S01 • Swamp 7: 07_S05, 07_S06 • Swamp 15A: S15a_S01, S15a_Piezo, S15a_S04, S15a_S06 • Swamp 22: 22_01, 22_02 • Swamp 25: S25_S01 • Swamp 33: S33_S01, S33_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
	Soil Moisture		
	• Swamp 05: S05_S01, S05_S02, S05_S03, S05_S03i, S05_S03ii, S05_S03iii, S05_S04, S05_S05, S05_S08 • Swamp 11: S11_S01, S11_S02, S11_S05 • Swamp 13: S13_S01, S13_S02, S13_S03 • Swamp 14: 14_01, 14_02 • Swamp 23: 23_01, 23_02 **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	• 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 11: S11_S01, S11_S02, S11_S05 • Swamp 13: S13_S01, S13_S02, S13_S03 • Swamp 14: 14_01, 14_02 • Swamp 23: 23_01, 23_02 **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

Aspect	Monitoring Sites Associated with Longwall 15	Monitoring Frequency	Recommended Future Monitoring for Longwall 16
	• 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 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 No targeted cliff lines associated with Longwall 15 **Fire Trails** Fire Road 6A (across active mining area) Fire Road 6N Fire Road 6P	• Monthly monitoring during any subsidence period • Monitoring to continue 6 monthly for 2 years following the completion of mining	**Cliffs** No targeted cliff lines associated with Longwall 15 **Fire Trails** Fire Road 6A (across active mining area) Fire Road 6N Fire Road 6P
	Inspection of Active Mining Area – Landscape Features, Vegetation, Watercourses		
	All mapped cliff, steep slopes, watercourse, swamp and fire trail sites in subsidence area. General observation of active mining areas.	• 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. Continue general observation of active mining areas.

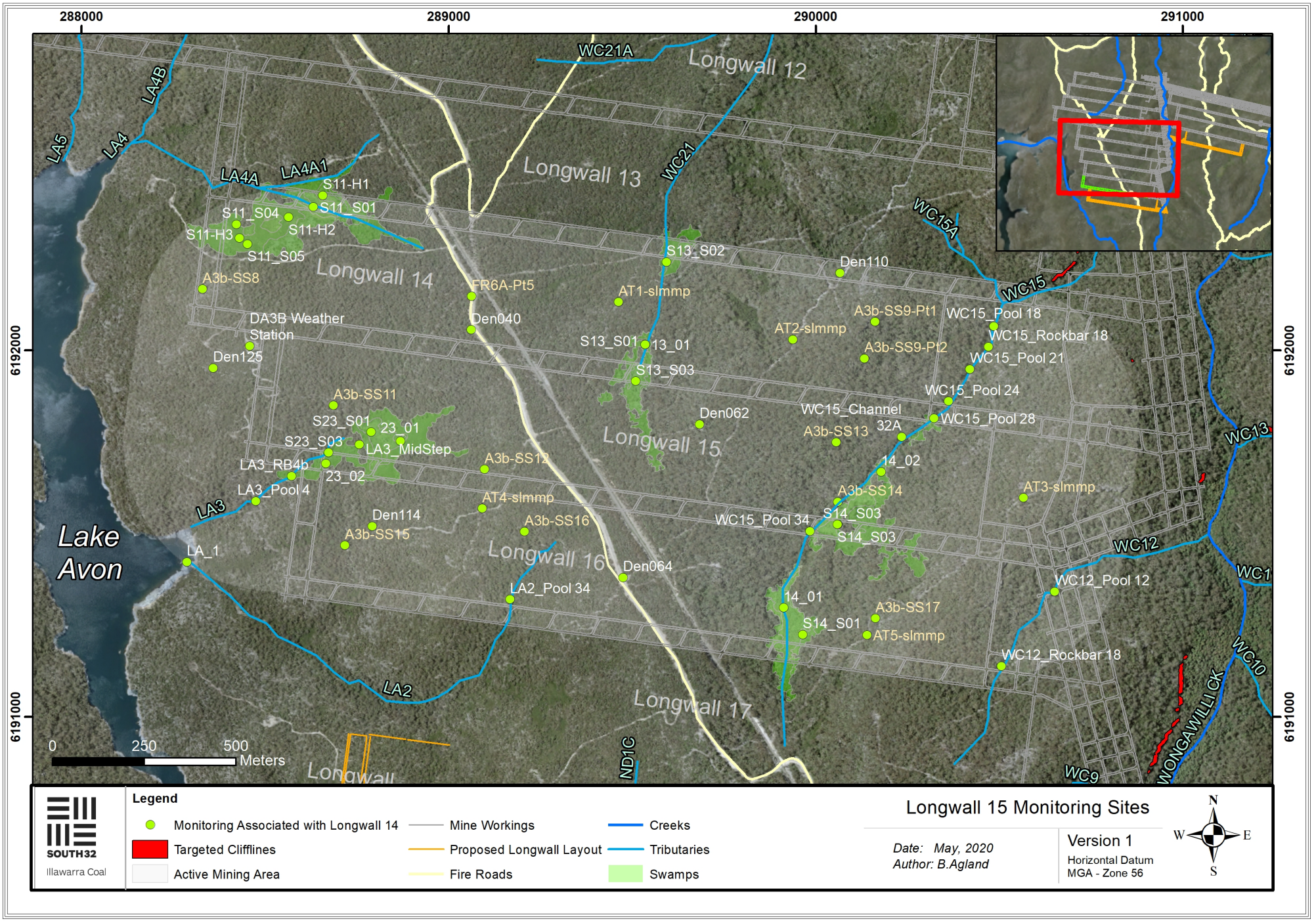

Figure 18: Overview of monitoring sites relevant to Longwall 15.

7 REFERENCES

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8 APPENDIX A – IMPACTS, TRIGGERS AND RESPONSE

Table 22: 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, and may result in increased sediment transport to Cordeaux	• *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* **AREA 3B** **Cliffs** All mapped cliff sites in subsidence area *Refer to Dendrobium Area 3B SMP Figures 18.1 for location of sites*	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 23: 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	<u>*Level 1:*</u> 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. <u>*Level 2*</u>: 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. <u>*Level 3:*</u> 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. <u>*Exceeding Prediction*</u> 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 distribution of species within the swamps	Swamp vegetation changes: - Swamp size - Species richness, distribution, composition and diversity - Vegetation sub-communities	**Swamp Size** <u>*Level 1:*</u> 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 <u>*Level 2:*</u> 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. <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.	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 bedrock base and/or use of other	Offset required **immediately**, if no remediation considered practicable. Offset required **5 years** following remediation, if it is ineffective. This period can be extended to **10 years**, with the	Monitoring period for swamp size is related to capture of LiDAR (ALS) data at the end of each longwall ~ 1 year Triggers for groundwater decline result in increased intensity and frequency of vegetation monitoring

		Exceeding Prediction: 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** *Level 1:* 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. *Level 2:* 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. *Level 3:* 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. *Exceeding Prediction:* 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** *Level 1:* 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 *Level 2:* 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. *Level 3:* 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. *Exceeding Prediction:* 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.	remediation techniques i) reporting j) investigation and review k) update future predictions	agreement of the Secretary.	
Maintenance or restoration of the structural integrity	Subsidence impacts (ie cracking) on	*Level 1:* 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).	a) upfront mine planning b) subsidence monitoring	Offset required **immediately**, if no remediation	

of the bedrock base of any significant permanent pool or controlling rockbar within the swamps	bedrock base or controlling rockbar	*Level 2:* 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). *Level 3:* 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). *Exceeding Prediction* 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.	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	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.*	*Level 1:* 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). *Level 2:* 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. *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.	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
Minor changes in the ecosystem functionality of the swamps	Falls in soil moisture levels in swamps *NB. Not linked specifically to a PM*	*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).	a) upfront mine planning b) soil moisture monitoring c) water spreading d) weeding e) fire management		Triggers of soil moisture decline result in increased intensity and frequency of vegetation

	and would not be considered a breach if predictions were exceeded.	<u>*Level 3:*</u> Soil moisture level lower than baseline level at **>80%** of monitoring sites (within 400m of mining) within a swamp (in comparison to reference swamps).	f) reporting g) update future predictions		monitoring and/or further investigations of subsidence impacts on bedrock base and rockbars

Table 24: 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 •Relevant Performance Measure(s): • Wongawilli Creek - minor environmental consequences • Donalds Castle Creek - minor environmental consequences • Waterfall WC-WF54 – negligible environmental consequences	***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
	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 • Review relevant TARP and Management Plan in consultation with key stakeholders
	Exceeding Prediction	• *Actions as stated for Level 3*

Monitoring	Trigger	Action
	• 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	• 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% •Relevant Performance Measure(s): • Wongawilli Creek - minor environmental consequences	***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
	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)
	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	• *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

Monitoring	Trigger	Action
	– EC 154.1 uS/cm – DO 50.5%	• 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% •Relevant Performance Measure(s): • Donalds Castle Creek - minor environmental consequences	***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
	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 – EC 185.8 uS/cm – DO 40.1%	• *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 3.60	• *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

Monitoring	Trigger	Action
	– EC 185.8 uS/cm – DO 40.1%	• 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
Avon Dam Avon Dam tributary (LA4_S1) Baseline means: • pH 5.38 • EC 90.8 uS/cm • DO 89.9% (24 months of baseline data available - to be updated with additional baseline data) •Relevant Performance Measure(s): • Avon Dam - negligible reduction in the quality of surface water inflows to Avon Dam	***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
	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 *	• *Actions as stated for Level 2* • Site visit with OEH, DoPE, T&I, Water NSW and other resource manager/s (if requested)

Monitoring	Trigger	Action
	• 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%	• 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 Avon Dam 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		
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 *	• *Actions as stated for Level 2*

Monitoring	Trigger	Action
	• Fracturing resulting in diversion of flow such that <10% of the pools have water levels lower than baseline period	• 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
SURFACE WATER FLOW		
Wongawilli Creek and Donalds Castle Creek Avon Dam and Cordeaux River **Relevant Performance Measure(s):**	***Level 1*** • A) Lower flow than expected (additional 10-15% of days where Q% lower than Reference Q%) • B) 5-10% increase in cease-to-flow frequency beyond natural) • C) Reduction in Q50 (10-15% beyond natural)	• Continue monitoring program. • Submit an Impact Report to BCD, DPIE, DRG, WaterNSW. • Report in the End of Panel Report. • Summarise actions and monitoring in AEMR.

• Wongawilli Creek - minor environmental consequences • Donalds Castle Creek - minor environmental consequences • Avon Dam - negligible reduction in the quantity of surface water inflows to Avon Dam[1] • Cordeaux River - negligible reduction in the quantity of surface water inflow to the Cordeaux River at its confluence with Wongawilli Creek[2] **Surface water flow Reference sites** (as in Table 1.1)**:** • Wongawilli Creek - WWU (Wongawilli Creek upstream); • O'Hares Creek at Wedderburn (213200); • (other such sites, if necessary, include Woronora River 2132101 and Bomaderry Creek 215016) NB. This section of the TARP contains four Water Flow Assessment Methods, labelled A, B, C and D, which are specified in detail in Watershed HydroGeo (2019). Hydrological changes are assessed by comparing pre- and post-mining observed flows from impact or assessment sites to flow data from the reference sites. *Natural variability ('NV') will be defined as the 'average' change at the selected reference sites. Triggers may occur when the apparent impact at a site (NV + x% change) could be less than maximum observed variability at one of the reference sites.*	***Level 2*** • A) Lower flow than expected (additional 15-20% of days where Q% lower than Reference Q%). • B) 10-20% increase in cease-to-flow frequency (beyond natural) • C) 15-20% reduction in Q50 (beyond natural) • D) Observation that the subject Creek has ceased to flow at spatially consecutive monitoring sites.	• *Actions as stated for Level 1* • Review monitoring frequency. • D) → carry out Water Flow Assessment Method D. • Submit letter report to DPIE, DRG and WaterNSW and seek advice on any CMA required. • Implement agreed CMAs as approved (subject to agency feedback).
	Level 3 • A) Lower flow than expected (additional >20% of days where Q% lower than Reference Q%) • B) >20% increase in cease-to-flow frequency (beyond natural) • C) >20% reduction in Q50 (beyond natural)	• *Actions as stated for Level 2* • Offer site visit with BCD, DPIE, DRG, WaterNSW. • Implement additional monitoring or increase frequency if required. • Develop site CMA (subject to agency feedback). This may include: grouting of rockbar and bedrock base of any significant pool where it is appropriate to do so in consultation with BCD, DPIE, DRG, WaterNSW. • Completion of works following approvals and at a time agreed between S32, DPIE, DRG and WaterNSW (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 agencies.
	Exceeding Prediction Measured surface water flow reduction, based on Assessment Methods C, D, to be compared against predictions made in contemporary groundwater modelling conducted to the satisfaction of the Secretary to assess whether effects that cannot be explained by natural variability "exceed prediction".	• *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.

[1] Surface water inflows calculation = [Impacts at gauged catchments (LA1 + LA2 + LA3 + LA4 + LA6+ NDT1 + ND2) + estimated impacts at ungauged but undermined catchments (e.g. LA5)] / [total inflow to LA].
[2] Flow reduction as determined from measured at flow gauging station WWL_A.

Tributaries of Wongawilli Creek and Donalds Castle Creek and other affected watercourses not subject to performance measures **Surface water flow Reference sites** (as in Table 1.1)**:** • Wongawilli Creek - WWU (Wongawilli Creek upstream); • O'Hares Creek and Wedderburn (213200); • (other such sites, if necessary, include Woronora River 2132101 and Bomaderry Creek 215016) NB. This section of the TARP contains four Water Flow Assessment Methods, labelled A, B, C and D, which are specified in detail in Watershed HydroGeo (2019). Hydrological changes are assessed by comparing pre- and post-mining observed flows from impact or assessment sites to flow data from the reference sites. *Natural variability ('NV') will be defined as the 'average' change at the selected reference sites. Triggers may occur when the apparent impact at a site (NV + x% change) could be less than maximum observed variability at one of the reference sites.*	***Level 1*** • A) Lower flow than expected (additional 10-20% of days where Q% lower than Reference Q%) • B) 5-10% increase in cease-to-flow frequency (beyond natural) • C) 10-20% reduction in Q50 (beyond natural)	• Continue monitoring program. • Submit an Impact Report to BCD, DPIE, DRG, WaterNSW. • Report in the End of Panel Report. • Summarise actions and monitoring in AEMR.
	Level 2 • A) Lower flow than expected (additional 20-30% of days where Q% lower than Reference Q%) • B) 10-20% increase in cease-to-flow frequency (beyond natural) • C) 20-30% reduction in Q50 (beyond natural)	• *Actions as stated for Level 1* • Review monitoring frequency. • Submit letter report to DPIE, DRG and WaterNSW and seek advice on any CMA required. • Implement agreed CMAs as approved (subject to agency feedback).
	Level 3 • A) Lower flow than expected (additional >30% of days where Q% lower than Reference Q%) • B) >20% increase in cease-to-flow frequency (beyond natural) • C) >30% reduction in Q50 (beyond natural)	• *Actions as stated for Level 2* • Offer site visit with BCD, DPIE, DRG, WaterNSW. • Implement additional monitoring or increase frequency if required • Develop site CMA (subject to agency feedback). This may include: grouting of rockbar and bedrock base of any significant pool where it is appropriate to do so in consultation with BCD, DPIE, DRG, WaterNSW. • Completion of works following approvals and at a time agreed between S32, DPIE, DRG and WaterNSW (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 agencies.
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 • Avon Dam tributary – 1 site • Native Dog 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 * • Reduction in 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 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