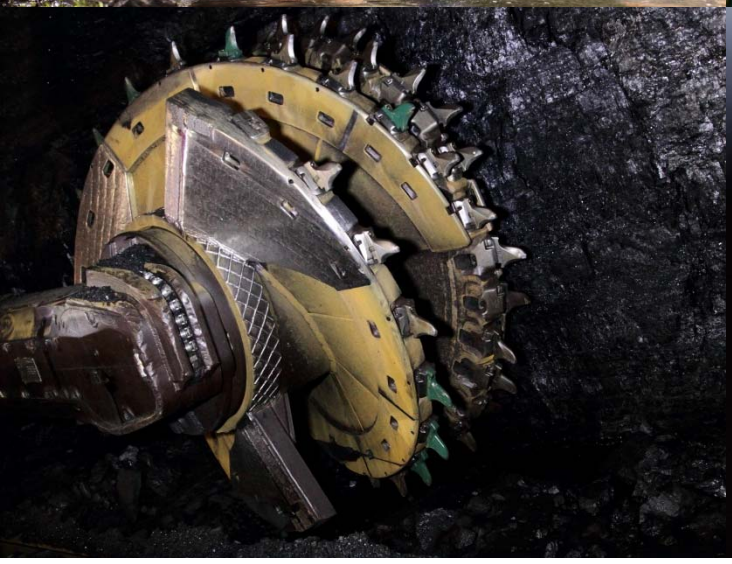
SOUTH32

Illawarra Coal
End of Panel Report



DENDROBIUM AREA 3B LONGWALL 11 END OF PANEL REPORT

25 May 2016

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 11 and analyses the monitoring results against relevant impact assessment criteria and predictions made in the DA3B Subsidence Management Plan (SMP).

Longwall 11 is within Consolidated Coal Lease 768 and was extracted using longwall equipment from the 18th of February 2015 to the 26th of January 2016.

The extraction of DA3B coal reserves provides benefits at international, national, state and local levels due to the coal's unique characteristics. Illawarra Coal provides 70% of BlueScope Steel's coking coal requirements. Continuing benefits occur through continuity of employment, expendable income, export earnings and government revenue.

Illawarra Coal provides local jobs for over 1300 direct employees throughout its operations with an employment flow-on effect in the Illawarra and Wollondilly regions of 2.6 full time equivalent jobs (IRIS, 2011). More than 400 local businesses provide their goods and services to the company. Illawarra Coal is a major contributor to the economy of the region, contributing 4.7% of household income and 5.3% of industry value added. As of January 2016 Dendrobium Mine had 280 direct employees. These jobs are reliant on maintaining continuity of longwall coal extraction.

Monitoring was conducted to measure subsidence at creeks, swamps and other landscape features within the zone of influence of Longwall 11.

The observed incremental horizontal movements at 3D monitoring points, resulting from the extraction of Longwall 11 were within the range of those measured at similar distances from previously extracted longwalls at Dendrobium Mine and elsewhere in the Southern Coalfield.

The maximum observed total closures at each of the Wongawilli Creek cross-lines were less than the predictions after the completion of Longwall 11. The observed total closure at the WC21XF-Line of 669 mm was greater than the maximum predicted total closure of 325 mm. The observed total subsidence and total closure at the remaining Tributary Cross Lines were less than predicted after the completion of Longwall 11.

The total observed closures were greater than predicted along the DCCXC-Line and DCCXE-Line. The observed total closures along the DCCXB-Line, DCCXD-Line and DCCXF-Line were less than predicted.

The observed total subsidence for the Swamp Cross-Lines was between 18 mm and 30 mm. The observed total closures for these monitoring lines were less than those predicted.

The observed impacts on surface infrastructure following the extraction of Longwall 11 were within predictions. There were no observed impacts to the Maldon – Dombarton railway corridor as a result of Longwall 11 extraction. Impacts were observed to Fire Road 6A, tracks and seismic lines. Remediation works were implemented at Fire Road 6A.

There were no observed impacts to Wongawilli or Donalds Castle Creek resulting from Longwall 11. Multiple fractures, uplift and displacement occurred within WC21 (a tributary of Wongawilli Creek), in Rockbar 27 and upstream of Pool 30. There was surface water diversion and loss of flow in the impacted areas. Soil surface cracking was observed on or near fire trails and tracks.

Groundwater levels lower than baseline and recession rates greater than baseline were recorded for Swamps 3 and 5. Soil moisture levels below baseline were also recorded in Swamp 5.

No impact to archaeological sites was observed.

In addition to the impacts described above, a number of TARPs were reached or continued during the reporting period. Dams Safety Committee (DSC) Level 3 groundwater TARPs have been reached in four bores monitoring the Bulgo Sandstone in Area 3A near Sandy Creek and Lake Cordeaux. Level 3 groundwater TARPs have been reached in Swamps 3 and 5 as well as a Level 3 soil moisture TARP in Swamp 5.

The water quality TARP for Dissolved Oxygen (DO) was triggered for Donalds Castle Creek (Level 1) and Wongawilli Creek (Level 2). Water flow TARPs were triggered for the DCS2, DC13S1 and WC21S1 sub-catchments but there were no triggers for the larger Donalds Castle or Wongawilli Creek catchments.

A number of swamp triggers were met as defined by the revised TARPs in the Swamp Impact Monitoring Management and Contingency Plan (SIMMCP). Impacts to the first and second order streams SC10C, WC17, DC13, WC21 and the upper reaches of Donalds Castle Creek has resulted in a reduction of aquatic and stream pool habitat which has resulted in a number of TARP triggers.

Impacts to man-made and natural features observed during monitoring associated with the extraction of Longwall 11 have been within the performance measures for Dendrobium Mine. Monitoring will continue in accordance with the SMP and as outlined in this report.

CONTENTS

Executive Summary 2

1. Introduction 7

2. Economic Effects 8

3. Stakeholder Consultation 9

4. Predicted and Observed Subsidence 10

4.1. Wongawilli Creek Closure Lines 10

4.2. Dendrobium Area 3B 3D Monitoring Points 10

4.3. Wongawilli Creek Tributary Cross Lines 12

4.4. Donalds Castle Creek Cross Lines 12

4.5. Swamp Cross Lines 12

4.6. Airborne Laser Scan 13

5. Impacts to Man-Made Features 14

6. Impacts to Natural Features 16

6.1. Landscape Features 16

6.2. Shallow Groundwater 17

6.3. Soil Moisture 21

6.4. Surface Water Quality 21

6.5. Surface Water Flow 22

6.6. Deep Groundwater 23

6.7. Terrestrial Ecology 24

6.8. Aquatic Ecology 29

6.9. Cultural Heritage 31

6.10. Summary of TARP Triggers 31

7. Longwall 11 Monitoring Program 38

8. Management of Impacts and Remediation 40

TABLES

Table 1: Longwalls 9 – 13 SMP Approval Condition for End of Panel Reporting 7

Table 2: Social Impact Variables Associated with Subsidence 9

Table 3: Summary of the Assessed and Observed Impacts for Surface Infrastructure Resulting from the Extraction of Longwall 11 15

Table 4: Summary of Landscape Impacts 18

Table 5: Summary of Water Quality Triggers 22

Table 6: Summary of Water Flow Triggers 22

Table 7: Aboriginal Archaeological Sites in Relation to Longwall 11 31

Table 8: Summary of TARP Triggers Observed During Longwall 11 Extraction 35

Table 9: Monitoring Associated with Longwall 11 38

Table 10: Dendrobium Area 3B Landscape TARP 41

Table 11: Dendrobium Area 3B Swamp TARP 44

Table 12: Dendrobium Area 3B Watercourse TARP 45

FIGURES

Figure 1: Dendrobium Mine Area 3B Monitoring Points and Lines 11

Figure 2: Observed Incremental Horizontal Movement for DA3B 3D Monitoring Points 11

Figure 3: Observed Changes in Surface Level and Predicted Subsidence along Long-Section 1 13

Figure 4: Location of Longwall 11 Surface Impacts 19

Figure 5: Location of Groundwater Monitoring Sites 25

ATTACHMENTS

Attachment A: Approvals

Attachment B: End of Panel Subsidence Monitoring Report for Longwall 11 (MSEC821)

Attachment C1: Dendrobium Longwall 11 End of Panel Landscape Report (ICEFT)

Attachment C2: Dendrobium Longwall 11 Impact Reports

Attachment D1: Dendrobium Longwall 11 End of Panel Surface Water Monitoring Report (Hydrosimulations)

Attachment D2: Dendrobium Longwall 11 End of Panel Groundwater Monitoring Report (Hydrosimulations)

Attachment E1: Dendrobium Longwall 11 Aquatic Ecology Monitoring 2003 to 2015 (Cardno Ecology Lab)

Attachment E2: Dendrobium Longwall 11 Terrestrial Ecology Monitoring 2003 to 2015 (Biosis)

Attachment E3: Dendrobium Area 3A and 3B TARP Response Littlejohn's Tree Frog Tadpole Surveys

Attachment F: Dendrobium Longwall 11 Cultural Heritage (Biosis)

1. Introduction

Dendrobium Longwall 11 is located within Consolidated Coal Lease 768. Longwall 11 was extracted from the 18th of February 2015 to the 26th of January 2016 using longwall equipment.

This EoP report has been prepared in accordance with Condition 18 of the DA3B SMP Approval. The EoP report outlines the measured and observed impacts of Longwall 11 and analyses the monitoring results against relevant impact assessment criteria and predictions made in the SMP and associated management plans and reports.

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

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

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

SMP Approval Condition	Relevant Section in EoP Report
Schedule 3 of Development Consent DA60-03-2001 – MOD 7 **9.** Within 4 months of the completion of each longwall panel, or as otherwise permitted by the Director-General, the Applicant shall: 1. prepare an end-of-panel report – reporting all subsidence effects (both individual and cumulative) for the panel and comparing subsidence effects with predictions; – describing in detail all subsidence impacts (both individual and cumulative) for the panel; – discussing the environmental consequences for watercourses, swamps, water yield, water quality, aquatic ecology, terrestrial ecology, groundwater, cliffs and steep slopes; and – comparing subsidence impacts and environmental consequences with predictions; and 2. Submit the report to the Department, DPI, SCA, DECC, DWE and any other relevant agency to the satisfaction of the Director-General	*Sections 4 to 8, Attachments B to F* *This report was submitted 26 May 2016*

10. The Applicant shall include a comprehensive summary, analysis and discussion of the results of monitoring of subsidence effects, subsidence impacts and environmental consequences in each AEMR.	*The AEMR (July to June) is submitted in August each year*

The impact predictions for Longwall 11 are described in the following reports:

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

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

Economic effects associated with longwall extraction are discussed in Section 2. An overview of the consultation involved with Dendrobium operations is provided in Section 3. Subsidence movement predictions and measurements are in Section 0. Predicted and observed impacts of Longwall 11 on man-made and natural features are provided in Sections 5 and 6 respectively. The Longwall 11 monitoring program and proposed future monitoring in the SMP Area is provided in Section 7 and a summary of the TARPs including remediation measures are outlined in Section 8.

2. Economic Effects

The extraction of underground coal reserves from DA3B provides benefits at international, national, state and local levels due to the coal's unique characteristics. Illawarra Coal provides 70% of BlueScope Steel's coking coal requirements. Continuing benefits occur through continuity of employment, expendable income, export earnings and government revenue.

Illawarra Coal provides local jobs for over 1300 direct employees throughout its operations with an employment flow-on effect in the Illawarra and Wollondilly regions of 2.6 full time equivalent jobs (IRIS, 2011). More than 400 local businesses provide their goods and services to the company. Illawarra Coal is a major contributor to the economy of the region, contributing 4.7% of household income and 5.3% of industry value added. As of January 2016 Dendrobium Mine had 280 direct employees. These jobs are reliant on maintaining continuity of longwall coal extraction.

3. Stakeholder Consultation

Monitoring and provision of 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, and
- Information days.

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

Table 2: Social Impact Variables Associated with Subsidence

Potential Impact	Monitoring Variables	Mechanism
Subsidence Impacts	- Level of community concern relating to subsidence - Awareness of subsidence, its effects and management - Level of perceived community risk associated with subsidence - Level of satisfaction with the company's subsidence management practices - The extent to which the community attributes environmental, social and economic change within the community to mining activities	- The DCCC meetings including presentations and explanations of how and why subsidence occurs, and its potential impacts - A biennial telephone survey of residents in the communities in which Illawarra Coal operates. The survey aims to determine the community's perception of the company's overall performance

4. Predicted and Observed Subsidence

Subsidence movements resulting from the extraction of Longwall 11 were monitored along various lines and points within the SMP Area. A comparison of the observed and predicted movements has been prepared by MSEC (MSEC821, 2016) and is included as **Attachment B**.

Monitoring points and lines associated with Longwall 11 include:

- Wongawilli Creek Closure Lines,
- Area 3B 3D Monitoring Points,
- Tributary Cross Lines,
- Donalds Castle Creek Cross Lines,
- Swamp Cross Lines, and
- Airborne Laser Scans (ALS) of the area.

The locations of these monitoring lines and points are shown in **Figure 1** (MSEC821, 2016).

4.1. Wongawilli Creek Closure Lines

Closure movements across Wongawilli Creek were measured using 2D surveys at the Wong X A-Line, Wong X B-Line and Wong X C-Line. The maximum observed closures at each of the Wongawilli cross lines were less than predicted.

4.2. Dendrobium Area 3B 3D Monitoring Points

Vertical and horizontal movements above and in the vicinity of Longwall 11 were measured using 3D monitoring points. The location of these monitoring points is shown in **Figure 1**.

The horizontal movement vectors for the marks located outside the extents of Longwall 11 were generally orientated towards the extracted goaf and the longwall finishing end. The horizontal movement vectors for the marks located above the longwall were also generally oriented towards the finishing end.

The observed incremental horizontal movements at the 3D monitoring points, resulting from the extraction of Longwall 11 were within the range measured at similar distances from previously extracted longwalls at Dendrobium Mine and elsewhere in the Southern Coalfield (**Figure 2**).

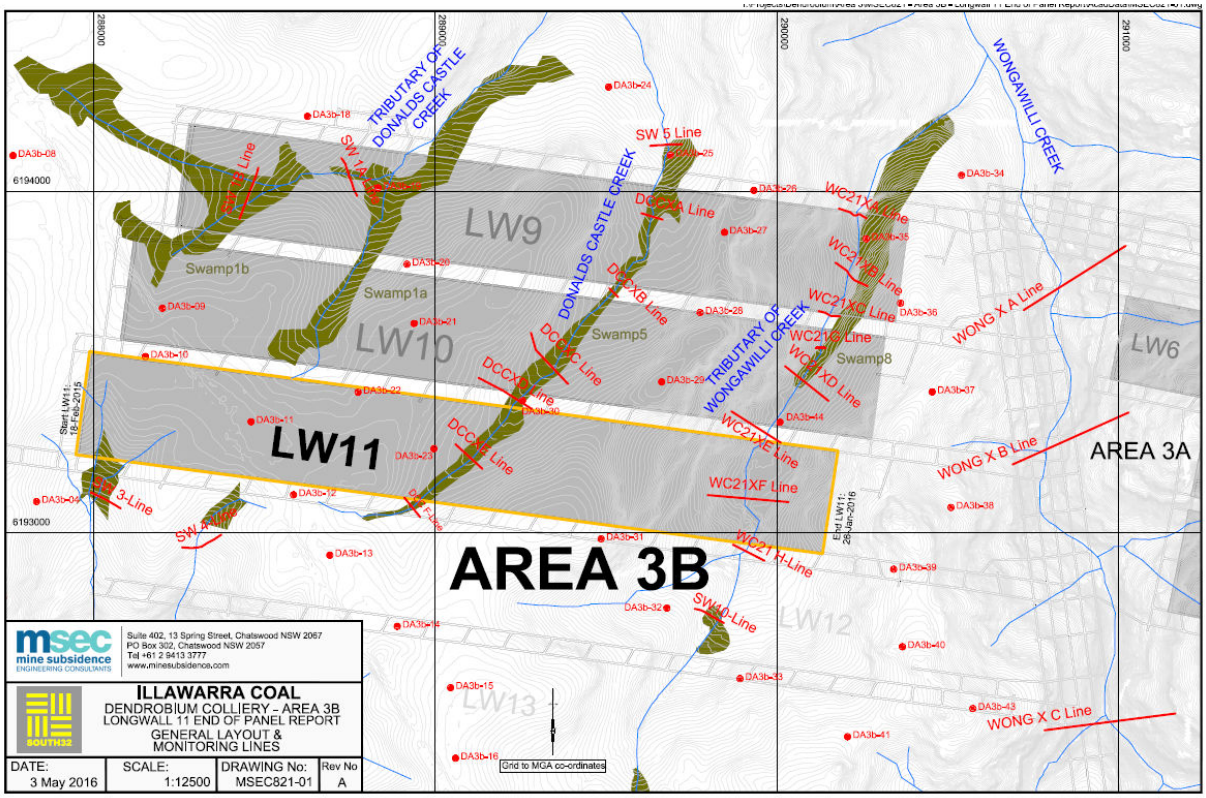


Figure 1: Dendrobium Mine Area 3B Monitoring Points and Lines

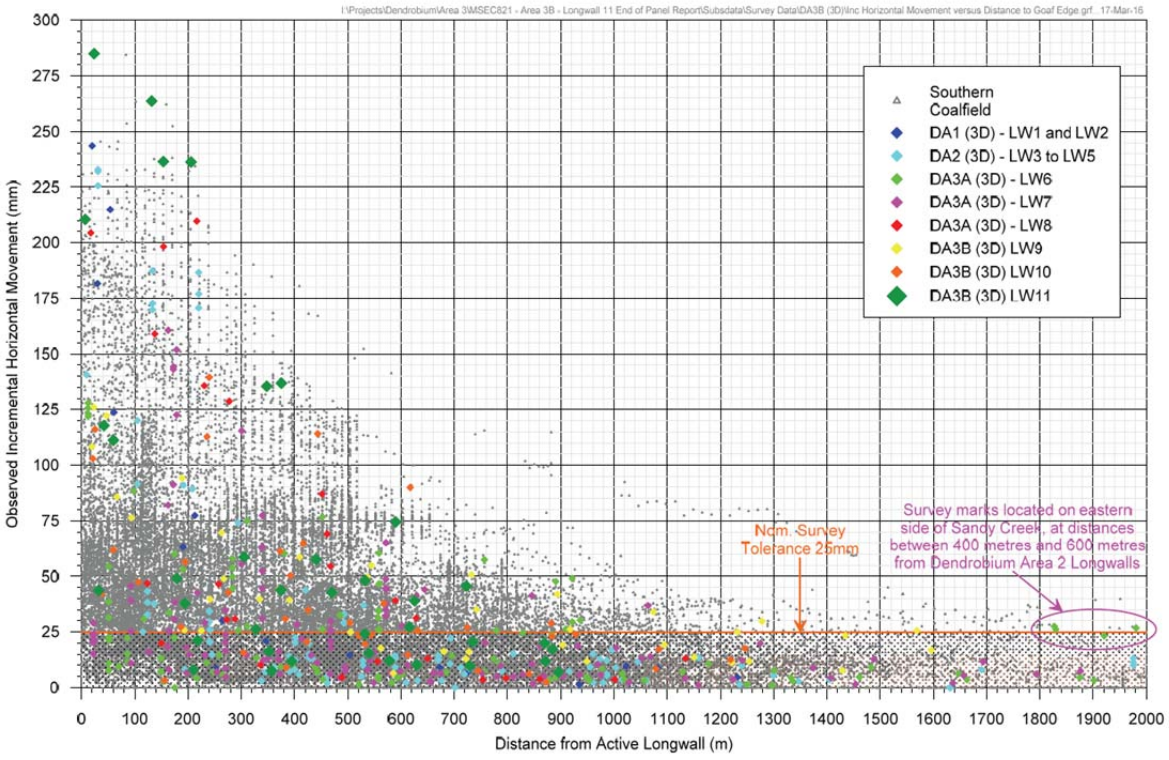


Figure 2: Observed Incremental Horizontal Movement for DA3B 3D Monitoring Points

4.3. Wongawilli Creek Tributary Cross Lines

The mine subsidence movements across drainage lines were measured with 2D survey techniques using the WC21XB Line, WC21XC Line, WC21XD Line, WC21XE Line, WC21XF Line, WC21XG Line and WC21XH Line.

The observed total closure at the WC21XF-Line of 669 mm was greater than the maximum predicted total closure of 325 mm. As this monitoring line is orientated along the main axis of Longwall 11 the predicted conventional closure is less than other monitoring lines which are oblique to the longwalls.

The observed total closure for WC21XF-Line is less than that observed and predicted along the WC21XD-Line, which is located in a similar position above Longwall 10, but orientated obliquely to the longwall.

The observed total subsidence and total closure at the remaining Tributary Cross Lines were less than predicted after the completion of Longwall 11. The observed total closures for these monitoring lines were between 40% and 97% of the predicted total closures.

4.4. Donalds Castle Creek Cross Lines

The mine subsidence movements across Donalds Castle Creek lines were measured with 2D survey techniques using the DCCXB-Line, DCCXC-Line, DCCXD-Line, DCCXE-Line and DCCXF-Line.

The total observed subsidence was greater than predicted along the DCCXB-Line, DCCXC-Line, DCCXD-Line and DCCXE-Line. The DCCXB-Line and DCCXD-Line are located above the chain pillars, away from the locations of the maximum vertical subsidence. The DCCXC-Line and DCCXE-Line are located closer to the longwall centrelines and the observed vertical subsidence exceeded those predicted by 32% and 17%, respectively.

The total observed closure was greater than predicted along the DCCXC-Line and DCCXE-Line. These exceedances are partly due to under-predicting the vertical subsidence and, therefore, under-predicting the conventional component of closure. The DCCXE-Line is orientated along the main axis of Longwall 11 and the DCCXC-Line is oblique to Longwall 10 and, therefore, the predicted conventional closures are less than for other lines orientated more transverse to the longwalls.

The observed total closures along the DCCXB-Line and DCCXD-Line were less than predicted. A net opening of 4mm was measured along the DCCXB-Line. The observed total subsidence along the DCCXF-Line was less than predicted.

4.5. Swamp Cross Lines

The mine subsidence movements across the Swamp Cross Lines were measured with 2D survey techniques using the SW3 Line, SW 4 Line and SW 10 Line.

The observed total subsidence for the Swamp Cross-Lines was between 18 mm and 30 mm. These low level vertical movements are similar to the accuracy of the prediction method outside of the active longwall, i.e. in the order of 20 mm vertical subsidence. The observed total closures for these monitoring lines were less than predicted.

4.6. Airborne Laser Scan

The results from the Airborne Laser Scan / Light Distance and Ranging surveys were not available at the time of this report. The change in surface level measured before and after the extraction of Longwalls 9 and 10 is provided as **Figure 3**.

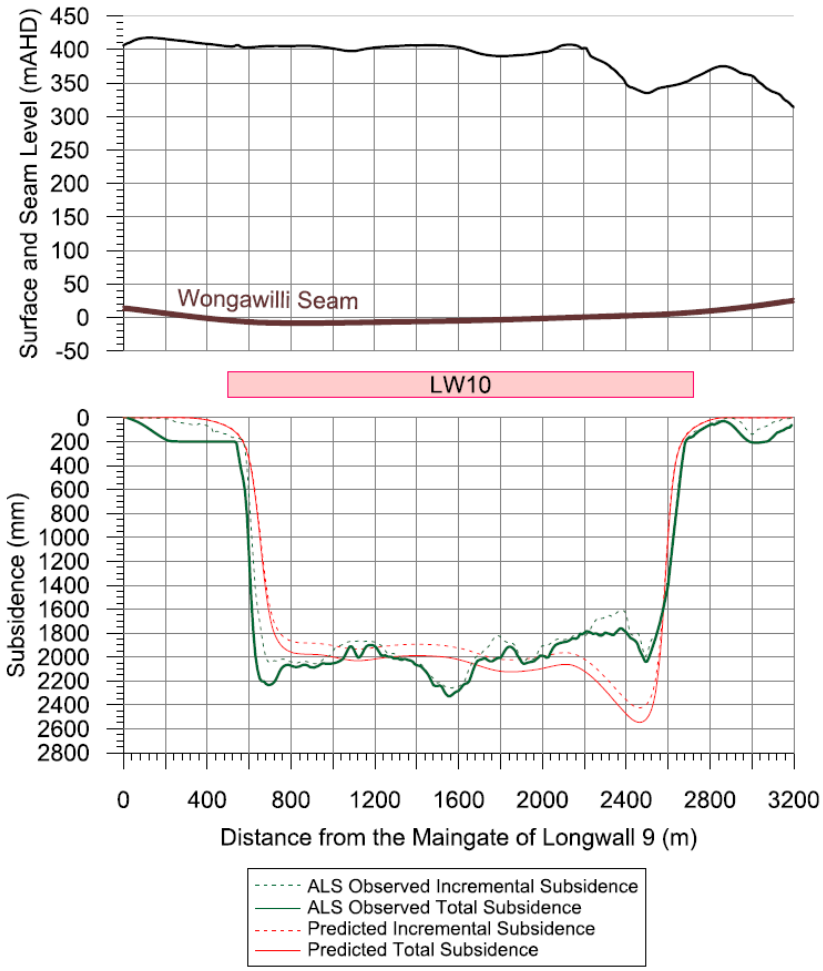


Figure 3: Observed Changes in Surface Level and Predicted Subsidence along Long-Section 1

During the extraction of Longwall 11 the subsidence model was reviewed, based on the updated monitoring data from Longwalls 7 and 8 in Area 3A and Longwalls 9 and 10 in Area 3B, which was summarised in MSEC792. The review found that the subsidence prediction model provides reasonable predictions of vertical subsidence for the longwalls in Areas 1, 2 and 3A. However, the maximum observed vertical subsidence in Area 3B is around 30% greater than the maxima predicted for Longwalls 9 and 10 in Area 3B. The higher magnitudes of vertical subsidence is the result of the

higher depth of cover and wider longwall widths in Area 3B, resulting in pillar compression greater than predicted by the subsidence model.

The subsidence model was recalibrated by increasing the predicted vertical subsidence by 30%. The impact assessments were reviewed, based on the revised predictions of vertical subsidence, and is provided in MSEC792. It was found that "whilst it would be expected that the rates of potential impacts would increase, given the greater predicted subsidence, the nature of these impacts are unlikely to change, i.e. a greater number of fractures with increased widths in the exposed bedrock resulting in a slightly increased potential for surface water flow diversions". Therefore, "the management strategies for the natural and built features for the future Longwalls 12 to 18 are the same as provided in MSEC459 and the SMP Application".

5. Impacts to Man-Made Features

The built features in the vicinity of Longwall 11 are shown in Drawing MSEC821-03 (**Attachment B**); and include:

- Fire trails and four wheel drive tracks,
- Disused Maldon – Dombarton Railway Corridor, and
- Survey control marks.

Cordeaux Dam Wall is located in excess of 5km north of Longwall 11. The Upper Cordeaux No. 2 Dam Wall is located in excess of 6km south-east of Longwall 11. It is unlikely these dam walls would experience any measurable far-field horizontal movements resulting from Longwall 11.

Eight impacts have been identified on access tracks within the Longwall 11 mining area (**Table 4**). These impacts consist of multiple soil cracks on seismic trails, Fire Road 6A and Access Track 6000.

Impact DA3B_LW11_003 was identified to the west of Swamp 5 and consists of a zone of soil cracking approximately 5m long by 3m wide, the largest crack is 1.9m with a depth of approximately 0.015m to 0.03m. Three soil cracking impacts; DA3B_LW11_004, 005 and 006, were identified on an access track between Swamp 5 and Access Track 6000. The largest crack measured 4.0m long, with a maximum width of 0.03m and depth of 0.08m. Impact DA3B_LW11_009 was identified as a zone of soil cracking across a seismic track that runs alongside WC21, the largest crack is 2.7m long and 0.01m wide. Additional soil cracking (DA3B_LW11_011) was identified on a seismic track above the eastern edge of Longwall 11, east of WC21, consisting of surface cracks totalling a length of 2.5m with a maximum width of 0.04m and depth of 0.30m.

These cracks are a Level 1 impact according to the Dendrobium Landscape Impacts, Triggers and Response Plan, 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.

Three surface cracks on access tracks were identified as TARP Level 2 impacts. These cracks on Fire Road 6A (DA3B_LW11_001 and 002) were up to 25m long and continued beneath vegetation on either side of the Fire Road with up to 0.050m of uplift and small associated cracks up to 0.020m wide. Impact DA3B_LW11_007 on Access Track 6000, initially reported as a Level 1 Impact on the 11th of December 2015, was found to have additional cracking and slumping of soil on an inspection on the 3rd of February 2016 and updated to a Level 2 impact. The longest continual soil crack in the zone is 8m long, 0.1m wide and 0.25m deep. Two soil holes were identified along a discontinuous soil crack, the largest being 0.45m wide, 1m long and approximately 1m deep.

These cracks are a Level 2 impact according to the Dendrobium Landscape Impacts, Triggers and Response Plan (Appendix A. Table 2), specifically:

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

MSEC predicted impacts for surface infrastructure, resulting from the extraction of Longwalls 9 to 18, and these are provided in MSEC459. Comparisons between the MSEC assessments and the observed impacts resulting from the extraction of Longwall 11 are provided in **Table 3**.

Table 3: Summary of the Assessed and Observed Impacts for Surface Infrastructure Resulting from the Extraction of Longwall 11

Surface Infrastructure	MSEC Assessed Impacts	Observed Impacts
Fire Trails and Tracks	Cracking of unsealed road surfaces	Localised surface cracking observed at tracks, Fire Road 6A and seismic lines
Survey Control Marks	Vertical and horizontal movements which could require re-establishment	No reported impacts Survey Control Marks to be re-established after completion of mining
Disused Maldon-Dombarton Railway	Possible fracturing of rock cuttings, spalling, and/or mobilisation of rock joints	No reported impacts

It can be seen from **Table 3** that the observed impacts on surface infrastructure, resulting from the extraction of Longwall 11, were generally similar to or less than predicted.

6. Impacts to Natural Features

The monitoring program for Longwall 11 was conducted in accordance with the SMP, WIMMCP and SIMMCP. During the period of extraction updated TARPs were developed in consultation with relevant government agencies. The monitoring program is outlined in Section 7. The results of the ICEFT monitoring are provided in **Attachment C1** and the Impact Reports submitted during Longwall 11 extraction are provided as **Attachment C2**. The results of monitoring undertaken by specialist consultants are provided as **Attachments D to F**. **Figure 4** illustrates the location of surface impacts identified during Longwall 11 extraction.

6.1. Landscape Features

The ICEFT have conducted detailed monitoring of landscape features including swamps, watercourses, rock outcrops and the general area within DA3B. Impacts to landscape features were incorporated into the monitoring program as they were identified.

A total of eleven surface impacts were identified by the ICEFT. Nine of these impacts were observed on fire roads or access tracks, and two were observed within a watercourse (WC21). These impacts have been labelled as "DA3B_LW11_001" to "DA3B_LW11_011" (**Table 4**). The impacts are described in the DA3B Longwall 11 Landscape Report (**Attachment C**).

Impacts were assessed against the relevant TARP (for watercourse, swamp or landscape) which results in assigning a trigger level to each impact (Level 1, Level 2, Level 3). Trigger levels for fractures were determined based on characteristics such as:

- The width and length of the fracture,
- Whether the fracture contributed to any observable loss or diversion of surface water, and
- Any erosion or potential for erosion caused by the fracture.

Wongawilli and Donalds Castle Creeks

No change to the existing impact in Wongawilli Creek (DA3B_LW9_017) was recorded during Longwall 11 extraction. No additional surface impacts were identified in Donalds Castle Creek during Longwall 11 extraction.

First and Second Order Streams

Four first and second order streams were monitored during Longwall 11 extraction; LA5, LA4B, DC13 and WC21. Surface cracking and rock fracturing was observed in WC21 within the zone of influence for Longwall 11. These impacts were assessed under the TARP's in the WIMMCP and SMP.

Two TARP Level 1 rock fractures have been observed in WC21- DA3B_LW11_008 and DA3B_LW11_010 (**Photo 1** and **Photo 2 and Figure 4)**. No flow diversion was observed at the fractures.

In accordance with the TARPs these fractures are consistent with a Level 1 impact:

- 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 in length with no observable loss of surface water or erosion.

Photo 1: DA3B_LW11_008- Rock fracture, looking upstream along WC21. Taken on 14/01/2016.

Photo 2: DA3B_LW11_008- Rock fracture, looking along WC21. Taken on 14/01/2016.

Rockfalls

There were no impacts involving fracturing and rock fall during the extraction of Longwall 11. Inspections of the landscape will continue in order to identify impacts from future longwalls.

6.2. Shallow Groundwater

Shallow groundwater in swamps is monitored in accordance with the SIMMCP. Changes to groundwater are reported when measurements of water level drop below baseline levels or when rates of recession exceed those recorded during baseline periods. For further details refer to the relevant impact reports (**Attachment C2**).

Table 4: Summary of Landscape Impacts

Site ID	Easting	Northing	Description	Features Affected	Identification Date	Impact Level	TARP's Used	Refer to Impact Report/s Dated
DA3B_LW11_001	288499	6193268	A soil crack with uplift across Fire Road 6A with associated smaller cracking.	FR6A	1/06/2015	Level 2	Dendrobium Area 3B SMP Volume 2 – Table 2, TARP dated 12/11/2012	2/06/2015
DA3B_LW11_002	288353	6193334	A single soil crack with some uplift across Fire Road 6A.	FR6A	1/06/2015	Level 2	Dendrobium Area 3B SMP Volume 2 – Table 2, TARP dated 12/11/2012	2/06/2015
DA3B_LW11_003	288632	6193249	A zone of soil cracking approx 5m x 3m identified on a seismic track to the east of Fire Road 6A.	Seismic Track	24/06/2015	Level 1	Dendrobium Area 3B SMP Volume 2 – Table 2, TARP dated 12/11/2012	25/06/2015
DA3B_LW11_004	289224	6193221	A soil crack on a seismic track adjacent Swamp 5 next to Access Track 6000.	Seismic Track	21/08/2015	Level 1	Dendrobium Area 3B SMP Volume 2 – Table 2, TARP dated 12/11/2012	24/08/2015
DA3B_LW11_005	289353	6193130	A soil crack on a seismic track adjacent Swamp 5 next to Access Track 6000.	Seismic Track	19/09/2015	Level 1	Dendrobium Area 3B SMP Volume 2 – Table 2, TARP dated 12/11/2012	21/09/2015
DA3B_LW11_006	289383	6193112	A soil crack on a seismic track adjacent Swamp 5 next to Access Track 6000.	Seismic Track	24/09/2015	Level 1	Dendrobium Area 3B SMP Volume 2 – Table 2, TARP dated 12/11/2012	24/09/2015
DA3B_LW11_007	289502	6193103	A zone of soil cracking along a 50m section of Access Track 6000.	FR6000	**Initial**: 10/12/2015 **Update**: 4/02/2016	Level 2	Dendrobium Area 3B SMP Volume 2 – Table 2, TARP dated 12/11/2012	11/12/2015, 5/02/2016
DA3B_LW11_008	289918	6193219	Multiple fractures on a rockbar across a 30m section of WC21.	WC21	14/01/2016	Level 2	WIMMCP TARP dated 12/10/2015	15/01/2016
DA3B_LW11_009	289830	6192993	A zone of soil cracking along a section of sesmic track adjacent to WC21.	Seismic Track	14/01/2016	Level 1	Dendrobium Area 3B SMP Volume 2 – Table 2, TARP dated 12/11/2012	15/01/2016
DA3B_LW11_010	289965	6193303	Rock fracture on WC21_RB27.	WC21	11/02/2016	Level 1	WIMMCP TARP dated 12/10/2015	12/02/2016
DA3B_LW11_011	290147	6193066	A soil crack on a seismic line east of WC21.	Seismic Track	26/02/1016	Level 1	Dendrobium Area 3B SMP Volume 2 – Table 2, TARP dated 12/11/2012	26/02/2016

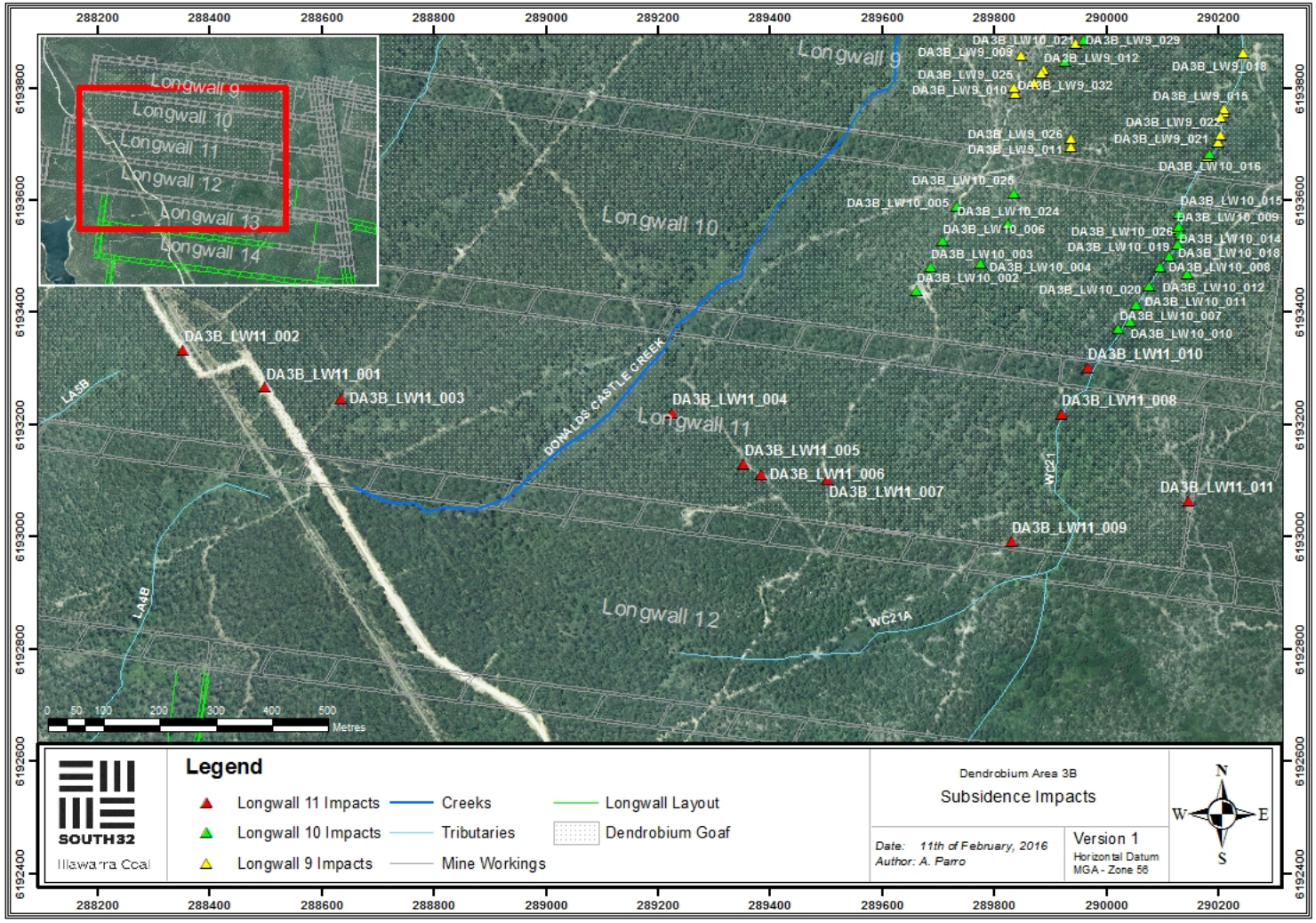


Figure 4: Location of Longwall 11 Surface Impacts

Swamps 1a and 1b

Fourteen groundwater monitoring sites have been installed in Swamps 1a and 1b. Eleven have been undermined by Longwall 9 and one by Longwall 10. No sites were undermined by Longwall 11. Eight of the bores have recorded post-mining water levels lower than baseline and six cases where post-mining water level recession exceeded baseline. No further shallow groundwater effects attributed to the extraction of Longwall 11 have been recorded at these swamps.

Swamp 3

Due to the relatively small size of Swamp 3, one groundwater monitoring site has been installed. Since Longwall 11 passed under the site, the post-mining rate of water level recession has exceeded the fastest rate recorded before mining at the equivalent horizon. Water level has not dropped below the lowest level recorded during the baseline period. A more detailed analysis is provided in **Attachment C**.

Swamp 3 is a Level 3 Trigger according to the SIMMCP TARP: 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.

Swamp 5

Eight groundwater monitoring sites have been installed in and around Swamp 5, six of which are located with the upland swamp vegetation community. Three sites have been undermined by Longwall 9, one by Longwall 10, and two (05_05 and 05_01) by Longwall 11.

During extraction of Longwall 11 groundwater levels at bore 05_01 dropped below the lowest level recorded during the baseline period, and the post-mining rate of water recession has exceeded the rate during the baseline period. At bore 05_05 the post-mining rate of water recession has exceeded the rate before mining.

Two out of the six shallow bores within Swamp 5 have recorded a trigger for water level. Six out of six shallow bores within Swamp 5 have recorded a trigger for rate of recession. Swamp 5 is at a Level 3 Trigger (see **Attachment C** report dated 19/08/2015): 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.

Swamp 8

Bore 08_01 is located adjacent to Swamp 8 and was undermined by Longwall 11 on the 6th of January 2016. Since being undermined groundwater level has been recorded as dry, below the

lowest level recorded during the baseline period. Bore 08_01 recorded a rate of recession exceeding the rate before mining of Longwall 10.

6.3. Soil Moisture

Soil moisture sensors have been installed in swamps and monitor to a depth of 1m. Swamps 5 and 11 and Reference Swamps 14 and 87 have been installed with loggers, measuring soil moisture half-hourly or hourly at 200mm increments (to 1m). Soil moisture is recorded in units of millimetres of H20 around the 100mm radius of the sensor using a raw count calibrated to obtain absolute volumetric soil water content, with the results averaged through the soil profile.

Swamp 5

Four soil moisture profiles are monitored in Swamp 5. Sites S05_S02 and S05_S08 were undermined by Longwall 10 and during extraction of Longwall 11 soil moisture levels dropped below baseline levels. Following extraction of Longwall 11 soil moisture at sites S05_S01 and S05_S05 also dropped to a level lower than recorded during the baseline period (**Attachment C1**). Soil moisture at all four sites has responded to rainfall and has fluctuated between baseline and below baseline levels since being undermined. Swamp 5 is at a Level 3 Trigger according to the SIMMCP TARP: Soil moisture level lower than baseline level at >80% of monitoring sites (within 400m of mining) within a swamp (in comparison to reference swamps).

Swamp 8

One soil moisture profile is monitored adjacent to Wongawilli tributary WC21. S08_S05 has not been undermined by Longwall 11 but is within 400m and the total soil moisture level has dropped below those recorded in the baseline period (**Attachment C1**). Soil moisture levels fluctuate in response to rainfall.

6.4. Surface Water Quality

TARPs have been defined in the WIMMCP for three locations downstream of the mining area (Wongawilli Creek (FR6) and Donalds Castle Creek (FR6) and Lake Avon (LA4_S1). The TARPs are based on pH, Electrical Conductivity (EC) and DO and defined by the value three standard deviations (SD) from the baseline mean (mean plus 3SD for EC and mean minus 3SD for pH and DO).

During the reporting period monitoring was carried out at 57 sites. Sites were monitored on an approximately weekly basis for Wongawilli Creek (FR6) and Donald's Castle Creek (FR6) and approximately monthly for other sites.

TARP triggers for the monitoring period are detailed in **Attachment D1** and summarised in **Table 5**.

Table 5: Summary of Water Quality Triggers

DATE	CATCHMENT / LOCATION	PARAMETER	VALUE	TARP	TRIGGER LEVEL
23/02/2016	Donalds Castle Creek (FR6)	DO	37.5	40.1	1
13/01/2016	Wongawilli Creek (FR6)	DO	44	50.5	2
23/02/2016	Wongawilli Creek (FR6)	DO	31	50.5	

6.5. Surface Water Flow

Flow gauges have been installed on Sandy Creek (Area 3A); Wongawilli Creek (Area 3B and 3A); Donalds Castle Creek and a tributary (LA4) of Lake Avon (Area 3B). The historical flow record has been plotted alongside the record from a nearby 'control' gauge (i.e. a gauge that was not undermined, either at all or not undermined during the period of interest). The hydrographs are shown in **Attachment D1**.

An Australian Water Balance Model (AWBM) was constructed and calibrated for each of the sites, focussing on 'history-matching' of observed and modelled flows during the pre-mining period at each monitoring site. The flow during the 'post-mining' period plus specific sub-periods covering the extraction of Longwall 11 was predicted while holding all parameters constant.

The predicted post-mining flows were compared against observed flows. Differences in the pre and post-mining period are then highlighted and used to infer and quantify any effects of mining.

The Catchment Water Balance TARP is described in the WIMMCP as:

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

Table 6: Summary of Water Flow Triggers

CATCHMENT	SITE	TARP TRIGGER	YIELD CHANGE	COMMENTS
Donalds Castle	DCS2	Level 3	-20%	Sub-catchment of Donalds Castle Creek
	DC13S1	Level 2	-15%	Sub-catchment of Donalds Castle Creek
	DCU	Not Triggered	-	Donalds Castle Creek Catchment
Wongawilli Creek	WC15S1	Not Triggered		Sub-catchment of Wongawilli Creek (not mined under)

	WC21S1	Level 1	-11%	Sub-catchment of Wongawilli Creek
	WWL	Not Triggered	-	Wongawilli Creek Catchment
Lake Avon Tributary	LA4S1	Not Triggered	-	Tributary to Lake Avon

6.6. Deep Groundwater

Groundwater at Dendrobium Mine was assessed by examining spatial and temporal responses measured in downhole vibrating wire piezometers, and comparison of observed groundwater head drawdowns with those anticipated by numerical groundwater modelling. Groundwater inflow to the mine has also been compared to the flows anticipated by the numerical model. Variations in groundwater salinity have been examined in several geological formations. These groundwater assessments are provided in **Attachment D2**.

Mine Inflow

At the completion of Longwall 11, the total mine inflow was approximately 8ML/d after averaging 6.2ML/d during Longwall 11 extraction. Mine inflow to DA3B during the extraction of Longwall 11 averaged 3.6ML/d with standard deviation 0.7 ML/d. Modelled mine inflows agree well with those observed over the assessment period. Periods of high total mine inflow compared with the long-term trend tend to correlate with high rainfall events associated increased inflows to Area 3A and Area 2.

Groundwater Quality

Groundwater salinity (as indicated by EC) shows no significant spatial variation in either Bulgo Sandstone or Hawkesbury Sandstone bores. There is a general increase in salinity with depth from the Hawkesbury Sandstone to the Bulgo Sandstone and down to the coal measures. Groundwater in the Hawkesbury Sandstone is variable but typically has an EC of between 80 and 500µS/cm, whereas inflow to the mine typically has an EC in the range of 1000 to 3000µS/cm. This is a natural phenomenon and indicates that groundwater inflow to the mine is dominated by groundwater from the deep geological strata. There is no evidence for adverse change to groundwater quality as a result of mining.

Groundwater Levels

Groundwater levels are monitored by an extensive network of vibrating wire piezometers that extend vertically from near the surface to within the coal measures. In the Wongawilli and Bulli coal seams, the lowest groundwater pressures occurred in the vicinity of Longwall 11 (as expected), although partial depressurisation above the longwall is evident prior to the start of Longwall 11 as a result of previous mining at Areas 3B and 3A, and at neighbouring mines.

The largest change in groundwater level (groundwater drawdown) during the extraction of Longwall 11 occurred within the Scarborough Sandstone and Bulgo Sandstone in Area 3B. This is attributed to

subsidence induced fracturing above the extracted longwalls in Area 3B and resulting depressurisation of the fracture network. Incremental drawdown in the Bulgo Sandstone and Scarborough Sandstone was in the order of 40 to 50m, based on piezometers not damaged by mining induced movements. Drawdown decreases with distance from the panel to approximately 5m at a distance of 1km from Longwall 11. The observed incremental drawdown is consistent with numerical model predictions.

In the lower Hawkesbury Sandstone, incremental drawdown of approximately 16m was observed in a piezometer immediately adjacent to Longwall 11. Drawdown of approximately 10m was observed in piezometers within the Hawkesbury Sandstone that overlie Longwalls 9 and 10. Depressurisation is largely restricted to the longwall footprint, decreasing to zero (no identifiable drawdown during the period) at a distance of 1.2km from the goaf. Piezometers in the Sandy Creek area (Area 2) show slight recovery of groundwater levels by up to 2m during the reporting period. The observed drawdown in the lower Hawkesbury Sandstone in Area 3B due to the extraction of Longwall 11 is less than the modelled drawdown in the vicinity of the longwall, and of a similar magnitude elsewhere.

The numerical model predictions of groundwater inflow to the mine continue to match well with observed inflows, particularly in Area 3B. The model tends to slightly over-estimate groundwater drawdown in overlying strata, particularly in the deeper strata.

DSC Monitoring

The Secondary DSC TARP 4 (Area 3A Groundwater monitoring – Bores S1867, S1870, S1992, S1994) is at Level 3. Piezometric head measured in all Bulgo piezometers (within a borehole) have dropped below the Cordeaux Dam water level.

6.7. Terrestrial Ecology

Attachment E2 reports on the Dendrobium Terrestrial Ecology Monitoring Program for Dendrobium Areas 2, 3A and 3B. The report incorporates the previous 10.5 years of monitoring in Area 2, 6.5 years in Area 3A and 3.5 years in Area 3B. Monitoring of reference sites has been up to a maximum of 11 years.

The following ecological features are monitored as part of the program:

- Vegetation within upland swamps in Area 2, Area 3A and Area 3B.
- Vegetation along one stream in Area 3A.
- Littlejohn's Tree Frog monitoring along streams in Area 3A and Area 3B.

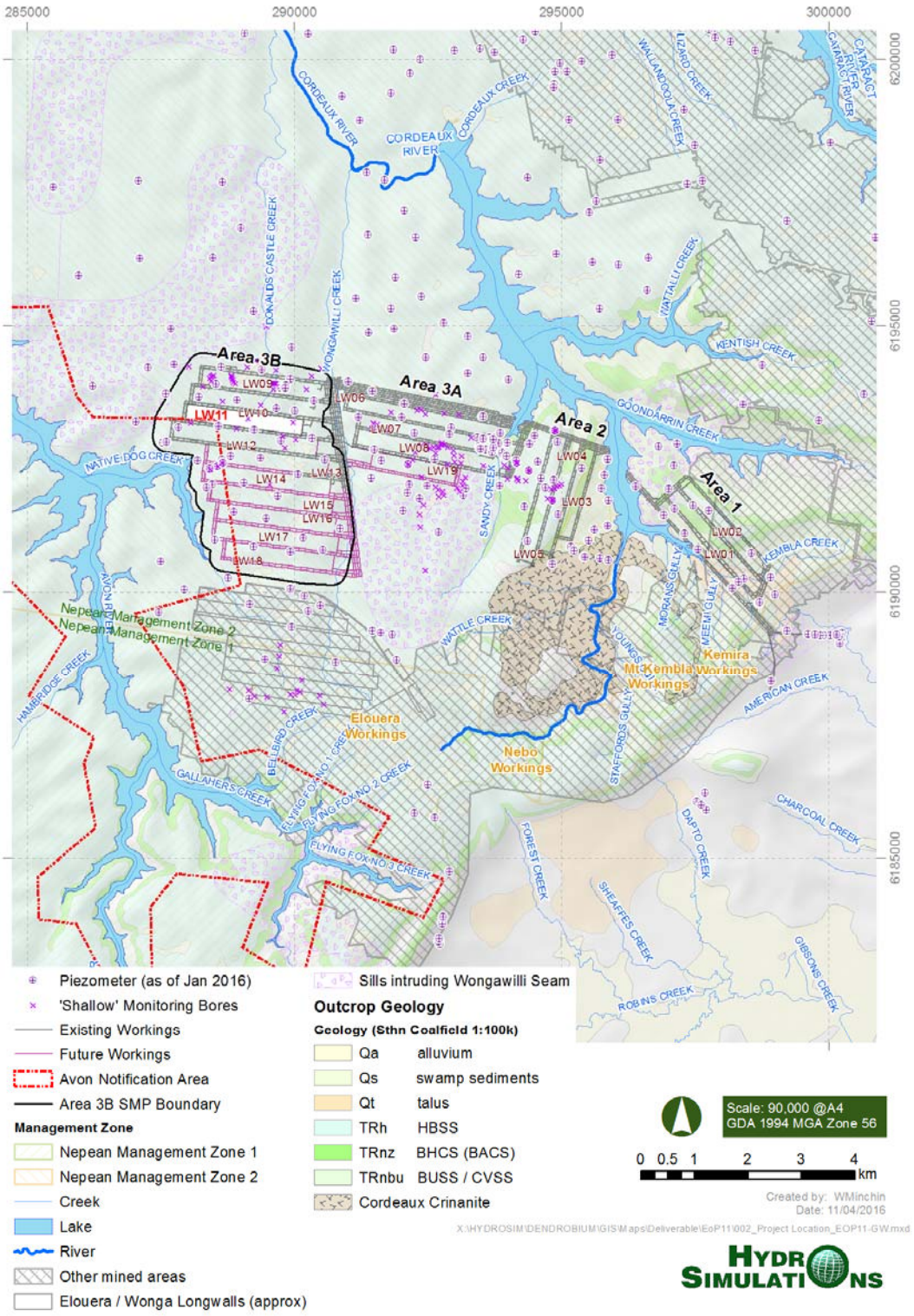


Figure 5: Location of Groundwater Monitoring Sites

The program includes monitoring and analysis of five post-mining sites (Swamps 1, 15B, 1A, 1B and 5). The remaining swamps were monitored and analysed as controls or pre-mining sites. Parameters include Total Species Richness (TSR) and species composition as well as swamp size and the extent of groundwater dependent swamp sub-communities.

Swamp Size

Swamp size and the extent of groundwater dependent sub-communities, mapped using LiDAR data captured in 2012, 2014 and 2015, showed a global decrease across control and impacted swamps in 2014 and 2015 when compared to 2012 data. The decrease was found to be greater at impacted sites when compared to control sites suggesting some effect of mining-related impacts.

Swamps 1A, 1B, 5 and 8 have reached a Level 1 Swamp Size Trigger. This is defined as two monitoring periods of decline in swamp size relative to baseline in which the decline is greater than the observed decline in the control group and exceeds the standard error of the control group.

Swamps 1A, 1B, 5 and 8 have reached a Level 1 Ecosystem Function Trigger. This is defined as two monitoring periods of decline in groundwater dependent swamp sub-communities relative to baseline in which the decline is greater than the observed decline in the control group and exceeds the standard error of the control group.

Ground-truthing of model results in March 2016 found that, in many cases, the modelled contraction in swamp size was not an accurate reflection of swamp vegetation on the ground and the model over-estimated the reduction in swamp size and extent of groundwater dependent sub-communities.

Potential causes of this observed difference in modelled and actual swamp extent include:

- Natural growth and expansion of fringing eucalypt tree crowns at the perimeter of swamps.
- Inherent inaccuracies of the LiDAR data (e.g. interpolation between LiDAR strikes).
- Movement of vegetation during LiDAR capture.

Caution is urged when interpreting the results of the swamp size and ecosystem functionality monitoring given that a number of factors unrelated to mining may drive some of the modelled decrease in swamp size and extent of groundwater dependent sub-communities. Moreover, changes in swamp size and extent of groundwater dependent communities observed at each swamp may be the result of responses to natural phenomena such as recent and long-term climate conditions, fire patterns and stochastic events (e.g. storm damage).

Ongoing monitoring and improvements to the LiDAR swamp modelling approach are recommended in order to improve the confidence with which modelled decreases in swamp size and ecosystem functionality can be said to represent real change attributable to mining-related impacts.

TSR

All upland swamps continue to show a trending decline in TSR, indicating broader landscape scale driven changes. The declines observed each year are small but statistically significant (p-value = 0.002). In addition to the background trending decline across all sites, Swamps 15B and 1A show a small, but statistically significant decline in TSR following mining, where TSR is declining post-mining.

A statistically significant change in Species Composition was detected at Swamp 15A(2) during the 3 year post-mining period (p-value = 0.004) indicating a Level 2 TARP had been triggered.

A decline in TSR has occurred for 4 years (2012 – 2015) so a Level 2 TARP has been triggered for Swamp 15B.

A statistically significant change in Species Composition has been detected at Swamp 1A post-mining (p-value = 0.092) which, given post-mining for 3 years, corresponding with the change in species composition, a Level 2 TARP has been triggered for Swamp 1A. The decrease in TSR and change in species composition was observed over a 3 year post-mining period (2013 – 2015) indicating a Level 2 TARP has been triggered.

Regardless of treatment (impact and control), species composition is changing every year and this change is statistically significant at most sites. This change is within expected range, as some natural turnover of species occurs at sites each season and across years. When species composition is analysed at impact sites located within the vicinity of mining (the risk management zone), a statistically significant change between pre- and post-mining species composition is detected at two sites, Swamp 15A(2) (p-value = 0.004) and Swamp 1A (p-value = 0.092). This change was not detected at other sites located within a risk management zone. Further assessment of sites that had been mined beneath revealed that there was no change in species composition, other than the natural background change.

One post-mining creek site (SC10) within Area 3A is monitored. A graphical representation, in conjunction with formal statistical tests, identifies no significant change in the TSR when comparing pre-mining data and post-mining data. Additionally, no significant trends were detected for control sites within this area. Based on TARPs for Area 3A, Biosis recommended ceasing biannual monitoring at SC10 until six months prior to the extraction of Longwall 19 (Biosis 2015b).

Littlejohn's Tree Frog

Monitoring of five streams in 2015 (SC10C, DC(1), DC13, WC17 and WC21) as part of the Littlejohn's Tree Frog program were analysed as post-mining sites. Within Area 3A, adult Littlejohn's Tree Frogs have not been recorded at WC17 for two consecutive years following subsidence related impacts. An assessment of WC17 against the WIMMCP TARPs indicates that a Level 3 TARP has been triggered.

Following heavy rains during the breeding season Littlejohn's Tree Frog was recorded at SC10C for the first time since 2012. When assessing the presence of Littlejohn's Tree Frog at SC10C over the course of time, it is clear that despite detecting the species in 2015, a local reduction in the available breeding habitat has occurred where mining impacts have occurred. This reduction in habitat has been evident for three consecutive winter monitoring surveys and documented in stream monitoring data collected by the ICEFT (January 2016). An assessment of SC10C against the WIMMCP TARPs indicates a Level 3 TARP had been triggered.

Littlejohn's Tree Frogs were recorded at DC13 for the first time since 2012 following subsidence related impacts in 2013 following the extraction of Longwall 9 (Illawarra Coal 2014). Adult frog abundance was very low (one frog) and following an assessment against the WIMMCP TARPs it was determined that a Level 2 TARP had been triggered. A reduction in habitat for two monitoring periods has been recorded at WC21 following the extraction of Longwall 9 and Longwall 10. Approximately 35% of the potential breeding habitat along this stream was experiencing a reduction in water levels (between Pool 11 and Pool 24) including three confirmed breeding pools (observations by Biosis during monitoring in 2015). Therefore, a level 1 TARP has been triggered for WC21.

As a result of the Triggers for Littlejohn's Tree Frog additional monitoring was undertaken and this is provided as **Attachment E3**.

Monitoring of upland swamps and Littlejohn's Tree Frog sites will continue throughout 2016. It is also recommended that Swamp 1 be monitored in autumn 2016 as a biennial program for this site following observed changes in vegetation succession within upland swamp sub-communities.

The monitoring program will continue to achieve the four key outcomes:

- Ongoing monitoring of biophysical characteristics within Areas 2 and 3.
- Determine if mining results in changes to the biological integrity of the mining area through comparison of baseline and control data with that collected through ongoing monitoring.
- Provide input to the design of any rehabilitation programs that may be necessary.
- Monitor the success of any remedial works.

Following the 2015 terrestrial monitoring it was found that an ecological response had been detected at impact sites within Dendrobium Areas 2, 3A and 3B where physical impacts have occurred. The impacts remain within predicted impact levels identified within relevant Environmental Impact Statements for Dendrobium Areas 2, 3A and 3B. However, observed ecological responses of upland swamps and threatened frogs at some monitoring locations do trigger WIMMCP and SIMMCP TARPs (**Attachment E2**).

6.8. Aquatic Ecology

Cardno Ecology Lab undertakes a monitoring program designed to detect mining-related subsidence impacts to indicators of the condition of aquatic ecology. The monitoring program is based on a Before, After, Control, Impact (BACI) design that provides a measure of natural spatial and temporal variability in key aquatic ecology indicators at potential impact and control sites before, during and after mining. This enables changes in the mining area to be distinguished from changes due to natural variability.

The monitoring program focuses on four key indicators:

- Habitat condition, assessed using the Riparian, Channel and Environmental (RCE) Inventory method and by establishing a photographic record through time;
- Aquatic macroinvertebrates sampled in accordance with the Australian River Assessment System (AUSRIVAS);
- Aquatic macroinvertebrates sampled quantitatively using artificial collectors;
- Sampling of fish using bait traps and backpack electrofishing; and
- Limited in situ water quality sampling is undertaken to assist with interpretation of trends in the above indicators.

Monitoring is undertaken within Wongawilli Creek, WC21 (a tributary of Wongawilli Creek) and Donalds Castle Creek, and at comparable Control sites established on Wongawilli, Sandy, Donalds Castle and Kentish creeks. Univariate and multivariate statistical analyses of data obtained from the AUSRIVAS sampling and artificial collectors were used to examine changes to aquatic ecology that may have occurred and to assess whether such changes are associated with mining. Surveys were undertaken in 2010, 2011, 2013 and 2015. **Attachment E1** presents data from all of these years.

Fracturing of bedrock and reductions in pool water levels and flow associated with the extraction of Longwalls 9 and 10 were observed in WC21 from December 2013. This represents a direct loss of aquatic habitat and biota. During field visits for the aquatic ecology study the only water present at the WC21 monitoring sites was at Site X2 which consisted of a few small, shallow, disconnected pools. In Donalds Castle Creek similar, but less extensive physical mining impacts and loss of aquatic habitat were observed at Site X1 in September 2013 and in 2015.

Under the aquatic ecology TARP for DA3B, a reduction in aquatic habitat for 1 year constitutes a Level 1 Trigger, a reduction for 2 years following the active subsidence period (i.e. when a Longwall is within 400 m of a feature) is a Level 2 Trigger and a reduction for more than 2 years or a complete loss of habitat following the active subsidence period is a Level 3 Trigger. For Site X1, the active subsidence period ended October 2013 when Longwall 9 was more than 400 m away from this site. Longwall 10 did not come within 400 m of Site X1. For X2, the active subsidence period ended when Longwalls 9 and 10 (which finish within 400m of this site) were completed; June 2014 and January

2015, respectively. Thus, at this stage, the reduction in aquatic habitat observed at Site X1 on Donalds Castle Creek constitutes a Level 2 Trigger, and Site X2 on WC21 constitutes a Level 1 Trigger (less than 2 years has passed since extraction of Longwalls 9 and 10 were completed).

In addition to direct habitat loss, there was some evidence of changes in the abundance of chironomins (a pollution tolerant sub-family of non-biting midge) and leptophlebiids (a pollution sensitive family of mayfly) in the artificial collectors deployed at Sites X1 and X2. These included an apparent increase in the number of chironomins at Site X2 and reduction in the numbers of leptophlebiids at Site X1 during 2015. No ecological impacts were identified at any of the sites monitored within Wongawilli Creek.

This is similar to SC10C (a tributary of Sandy Creek) with impacts to flow, pool water levels and water quality due to mining related subsidence in Area 3A. Potential changes were evident during individual surveys only and were usually only apparent relative to one of the Controls. Subsequent changes in these indicators (i.e. apparent reductions and increases in numbers of chironomins and leptophlebiids, respectively) further suggested that impacts, if any, were short term. Also, no significant changes to water quality associated with these physical mining impacts have been observed in these creeks. Further monitoring will assist determine whether the apparent reduction in the number of leptophlebiids at Site X2 observed between June and November 2015 persists.

Similar changes occurring at Impact sites on Wongawilli Creek, and those occurring in WC21 during 2013, are less likely to be due to mining in the absence of observed changes in water quality and anything more than minor fracturing that did not result in flow diversions and pool water level reductions in Wongawilli Creek. Thus, these changes are likely due to natural variation, rather than mining. Overall, patterns in data from the collectors are complex and hence difficult to interpret due to large variability in these data, particularly assemblage data.

There was no evidence in AUSRIVAS and fish data of any changes due to mining. While OE50 Taxa Scores (a biotic index of habitat and water quality), Band Scores (derived from OE50 Taxa Scores) and SIGNAL2 Indices (a biotic index of water pollution) derived from the AUSRIVAS samples suggest that some sections of the watercourses may experience environmental stress, this is more likely due to ephemeral flows and to naturally low pH of the water, unrelated to mining. Fish data were similar before and after commencement of extraction. There were no observations of dead of stressed fish at any of the sites during the study.

The observed loss of aquatic habitat and inferred loss of biota in WC21, and Donalds Castle Creek associated with the physical effects of mining following extraction of Longwalls 9 and 10 are relatively severe at the local level (within each individual watercourse). In the context of the Sydney Catchment Area, the loss of 1km (WC21) and 10m (Donalds Castle Creek) of creek habitat is small compared with the large amount of creek habitat in the local area. Ongoing monitoring will determine if changes observed during the 2015 survey persist.

It is recommended that biennial monitoring of aquatic ecology in Area 3B should continue, with the next round of sampling undertaken in 2017, in line with the requirements of the SMP. Monitoring of the general condition of creeks will continue to be undertaken as required by the SMP.

6.9. Cultural Heritage

The assessment of cultural heritage and archaeological sites potentially impacted by Longwall 11 was conducted by Biosis (**Attachment F**). Aboriginal archaeological sites within 400m of Longwall 11 were inspected three to six months (March and May 2016) after the subsidence movement at the site.

No impacts to Browns Road Site 12 (52-2-1627) or Dendrobium 2 (52-2-2209) were observed (**Table 7**). There are no European heritage sites identified near Longwall 11.

Table 7: Aboriginal Archaeological Sites in Relation to Longwall 11

AHIMS Number	Site Name	Site Type	Changes observed
52-2-1627	Browns Road Site 12	Shelter with art	None
52-2-2209	Dendrobium 2	Shelter with art	None

6.10. Summary of TARP Triggers

Man Made Features

Eight impacts have been identified on access tracks within the Longwall 11 mining area (**Table 4**). These impacts consist of multiple soil cracks on seismic trails, Fire Road 6A and Access Track 6000.

Impacts DA3B_LW11_003, 004, 005, 006, 009 and 11 are Level 1 impacts according to the Dendrobium Landscape Impacts, Triggers and Response Plan.

Three surface cracks on access tracks were TARP Level 2 impacts (DA3B_LW11_001, 002 and 007). Impact DA3B_LW11_007 on Access Track 6000 was initially reported as a Level 1 Impact on the 11th of December 2015. Level 2 impacts were remediated using standard road maintenance techniques.

Landscape Features

A total of eleven surface impacts were identified by the ICEFT. Nine of these impacts were observed on fire roads or access tracks, and two were observed within WC21. These impacts have been labelled as “DA3B_LW11_001” to “DA3B_LW11_011” (**Table 4**).

Two TARP Level 1 rock fractures (WC21- DA3B_LW11_008 and DA3B_LW11_010) with no flow diversion were observed within WC21.

Shallow Groundwater

Due to the relatively small size of Swamp 3, one groundwater monitoring site has been installed. Since Longwall 11 passed under the site, the post-mining rate of water level recession has exceeded the fastest rate recorded before mining at the equivalent horizon. This is a Level 3 Trigger according to the SIMMCP.

Eight groundwater monitoring sites have been installed in and around Swamp 5. Three sites have been undermined by Longwall 9, one by Longwall 10, and two (05_05 and 05_01) by Longwall 11. During extraction of Longwall 11 groundwater levels at bore 05_01 dropped below the lowest levels recorded during the baseline period, and the post-mining rate of water recession has exceeded the rate recorded during the baseline period. At bore 05_05 the post-mining rate of water recession has exceeded the rate recorded before mining. Two out of the six shallow bores within Swamp 5 have recorded a trigger for water level. Six out of the six shallow bores within Swamp 5 have recorded a trigger for rate of recession. Swamp 5 is at a Level 3 Trigger.

Soil Moisture

Four soil moisture profiles are monitored in Swamp 5. Sites S05_S02 and S05_S08 were undermined by Longwall 10 and during extraction of Longwall 11 soil moisture levels dropped below baseline levels. Following extraction of Longwall 11 soil moisture at sites S05_S01 and S05_S05 also dropped to a level lower than recorded during the baseline period (**Attachment C1**). Soil moisture at all four sites has responded to rainfall and has fluctuated between baseline and below baseline levels since being undermined. Swamp 5 is at a Level 3 Trigger according to the SIMMCP TARP.

Surface Water Quality

Trigger values for water quality are defined in the WIMMCP. TARPs have been defined for three locations downstream of the mining area (Wongawilli Creek (FR6) and Donalds Castle Creek (FR6) and Lake Avon (LA4_S1). The TARPs are based on the field parameters pH, EC and DO and defined by the value three standard deviations (SD) from the baseline mean (mean plus 3SD for EC and mean minus 3SD for pH and DO).

Donalds Castle Creek at Fire Road 6 met a Level 1 DO Trigger and Wongawilli Creek at Fire Road 6 met a Level 2 DO Trigger (**Table 5**).

Surface Water Flow

Data from flow gauges installed on Sandy Creek (Area 3A); Wongawilli Creek (Areas 3B and 3A); Donalds Castle Creek and a tributary (LA4) of Lake Avon (Area 3B) has been used to construct an AWBM and compare observed and modelled flows during the pre-mining and post-mining periods.

Differences in the pre and post-mining period are used to infer and quantify any effects that mining has had on the catchment and to determine TARP levels within the WIMMCP.

The DCS2 and DC13S1 sub-catchments of Donalds Castle Creek have triggered Level 3 and 2 TARPs respectively. The overall catchment of Donalds Castle Creek has not triggered a TARP.

The WC21S1 sub-catchment of Wongawilli Creek has triggered a Level 2 TARP. The overall catchment of Wongawilli Creek has not triggered a TARP.

Deep Groundwater

The Secondary DSC TARP 4 (Area 3A Groundwater monitoring – Bores S1867, S1870, S1992, S1994) is at Level 3. Piezometric head measured in all Bulgo piezometers (within a borehole) have dropped below the Cordeaux Dam water level.

Terrestrial Ecology

Swamps 1A, 1B, 5 and 8 have reached a Level 1 Swamp Size Trigger. This is defined as two monitoring periods of decline in swamp size relative to baseline in which the decline is greater than the observed decline in the control group and exceeds the standard error of the control group.

Swamps 1A, 1B, 5 and 8 have reached a Level 1 Ecosystem Function Trigger. This is defined as two monitoring periods of decline in groundwater dependent swamp sub-communities relative to baseline in which the decline is greater than the observed decline in the control group and exceeds the standard error of the control group.

A statistically significant change in Species Composition was detected at Swamp 15A(2) during the 3 year post-mining period (p-value = 0.004) indicating a Level 2 TARP had been triggered.

A decline in TSR has occurred for 4 years (2012 – 2015) so a Level 2 TARP has been triggered for Swamp 15B.

A statistically significant change in Species Composition has been detected at Swamp 1A post-mining (p-value = 0.092) which, given post-mining for 3 years, corresponding with the change in species composition. Therefore a Level 2 TARP has been triggered for Swamp 1A. The significant decrease in TSR and change in species composition was observed over a 3 year post-mining period (2013 – 2015) indicating a Level 2 TARP has been triggered.

Within Area 3A, adult Littlejohn's Tree Frogs have not been recorded at WC17 for two consecutive years following subsidence related impacts. An assessment of WC17 against the WIMMCP TARPs indicates that a Level 3 TARP has been triggered. Following an assessment of SC10C against the WIMMCP TARPs it is determined that a Level 3 TARP had been triggered.

Littlejohn's Tree Frogs were recorded at DC13 for the first time since 2012 following subsidence related impacts in 2013 following the extraction of Longwall 9. Adult frog abundance was very low and following an assessment against the WIMMCP TARPs it was determined that a Level 2 TARP has been triggered.

A reduction in habitat for two monitoring periods has been recorded at WC21 following the extraction of Longwall 9 and Longwall 10. Approximately 35% of the potential breeding habitat along this stream was experiencing a reduction in water levels (between Pool 11 and Pool 24) including three confirmed breeding pools (observations by Biosis during monitoring in 2015). Therefore, a level 1 TARP has been triggered for WC21.

As a result of the Triggers for Littlejohn's Tree Frog additional monitoring was undertaken and this is provided as **Attachment E3**.

Aquatic Ecology

Under the aquatic ecology TARP for DA3B, a reduction in aquatic habitat at a monitoring site for 1 year constitutes a Level 1 Trigger, a reduction for 2 years following the active subsidence period (i.e. when a Longwall is within 400 m of a feature) is a Level 2 Trigger and a reduction for more than 2 years or a complete loss of habitat following the active subsidence period is a Level 3 Trigger. For Site X1, the active subsidence period ended October 2013 when Longwall 9 was more than 400 m away from this site. Longwall 10 did not come within 400 m of Site X1. For Site X2, the active subsidence periods ended when Longwalls 9 and 10 (which finish within 400m of this site) were completed; June 2014 and January 2015, respectively. Thus, the reduction in aquatic habitat observed at Site X1 on Donalds Castle Creek constitutes a Level 2 Trigger, and Site X2 on WC21 constitutes a Level 1 Trigger (less than 2 years has passed since extraction of Longwalls 9 and 10 were completed).

Cultural Heritage

No impacts to Browns Road Site 12 (52-2-1627) or Dendrobium 2 (52-2-2209) were observed (**Table 7**). There are no European heritage sites identified near Longwall 11.

Table 8: Summary of TARP Triggers Observed During Longwall 11 Extraction

Site	Identification Date	Activating Longwall(s)	Feature Affected	Type	Description	Trigger Level	TARPs Used	Impact Report/s
DA3B_LW11_001	1/06/2015	LW11	FR6A	Crack	A soil crack with uplift across Fire Road 6A with associated smaller cracking	Level 2	Area 3B SMP Volume 2 Table 2	2/06/2015
DA3B_LW11_002	1/06/2015	LW11	FR6A	Crack	A single soil crack with some uplift across Fire Road 6A	Level 2	Area 3B SMP Volume 2 Table 2	2/06/2015
DA3B_LW11_003	24/06/2015	LW11	Seismic Track	Crack	A zone of soil cracking approx 5m x 3m identified on a seismic track to the east of Fire Road 6A	Level 1	Area 3B SMP Volume 2 Table 2	25/06/2015
DA3B_LW11_004	21/08/2015	LW11	Seismic Track	Crack	A soil crack on a seismic track adjacent Swamp 5 next to Access Track 6000	Level 1	Area 3B SMP Volume 2 Table 2	24/08/2015
DA3B_LW11_005	19/09/2015	LW11	Seismic Track	Crack	A soil crack on a seismic track adjacent Swamp 5 next to Access Track 6000	Level 1	Area 3B SMP Volume 2 Table 2	21/09/2015
DA3B_LW11_006	24/09/2015	LW11	Seismic Track	Crack	A soil crack on a seismic track adjacent Swamp 5 next to Access Track 6000	Level 1	Area 3B SMP Volume 2 Table 2	24/09/2015
DA3B_LW11_007	Initial: 10/12/2015 Update: 4/02/2016	LW11	FR6000	Crack	A zone of soil cracking along a 50m section of Access Track 6000	Level 2	Area 3B SMP Volume 2 Table 2	11/12/2015, 5/02/2016
DA3B_LW11_008	14/01/2016	LW11	WC21	Fracture	Multiple fractures on a rockbar across a 30m section of WC21	Level 2	WIMMCP TARP	15/01/2016
DA3B_LW11_009	14/01/2016	LW11	Seismic Track	Crack	A zone of soil cracking along a section of sesmic track adjacent to WC21	Level 1	Area 3B SMP Volume 2 Table 2	15/01/2016
DA3B_LW11_010	11/02/2016	LW11	WC21	Fracture	Rock fracture on WC21_RB27	Level 1	WIMMCP TARP	12/02/2016

DA3B_LW11_011	26/02/1016	LW11	Seismic Track	Crack	A soil crack on a seismic line east of WC21	Level 1	Area 3B SMP Volume 2 Table 2	26/02/2016
SWAMP 3	14/05/2015	LW11	Swamp	Groundwater	Post-mining rate of water level recession exceeded baseline	Level 3	SIMMCP TARP	28/05/2015
SWAMP 5	10/08/2015	LWs 9 - 11	Swamp	Groundwater	Post-mining rate of water level recession exceeded baseline	Level 3	SIMMCP TARP	19/08/2015
SWAMP 5	26/11/2015	LWs 10 -11	Swamp	Soil Moisture	Soil moisture levels dropped below baseline levels	Level 3	SIMMCP TARP	12/10/2015, 19/02/2016
Donalds Castle Creek (FR6)	23/02/2016	LW11	Stream	Water Quality	Mean minus 3SD for DO	Level 1	WIMMCP TARP	25/05/2016
Wongawilli Creek (FR6)	13/01/2016, 23/02/2016	LW11	Stream	Water Quality	Mean minus 3SD for DO	Level 2	WIMMCP TARP	25/05/2016
DCS2	N/A	LWs 9 - 11	Stream	Water Flow	-20% yield	Level 3	WIMMCP TARP	25/05/2016
DC13S1	N/A	LWs 9 - 11	Stream	Water Flow	-15% yield	Level 2	WIMMCP TARP	25/05/2016
WC21S1	N/A	LWs 9 – 11	Stream	Water Flow	-11% yield	Level 1	WIMMCP TARP	25/05/2016
DSC Bores S1867, S1870, S1992, S1994	18/6/2015	Area 3A	Groundwater	Bulgo Groundwater Level	Below Cordeaux level	Level 3	DSC Management Plan	N/A
Swamp 1A	N/A	Area 3B	Swamp	Vegetation	Two monitoring periods of decline in swamp size and groundwater dependent swamp sub-communities	Level 1	SIMMCP TARP	25/05/2016
Swamp 1A	N/A	Area 3B	Swamp	Vegetation	A change in species composition and decrease in TSR over a three year post-mining period	Level 2	SIMMCP TARP	25/05/2016
Swamp 1B	N/A	Area 3B	Swamp	Vegetation	Two monitoring periods of decline in swamp size and groundwater dependent	Level 1	SIMMCP TARP	25/05/2016

					swamp sub-communities			
Swamp 5	N/A	Area 3B	Swamp	Vegetation	Two monitoring periods of decline in swamp size and groundwater dependent swamp sub-communities	Level 1	SIMMCP TARP	25/05/2016
Swamp 8	N/A	Area 3B	Swamp	Vegetation	Two monitoring periods of decline in swamp size and groundwater dependent swamp sub-communities	Level 1	SIMMCP TARP	25/05/2016
Swamp 15A (2)	N/A	Area 3A	Swamp	Vegetation	A statistically significant change in Species Composition during the 3 year post-mining period	Level 2	SIMMCP TARP	25/05/2016
Swamp 15B	N/A	Area 3A	Swamp	Vegetation	A decline in TSR has occurred for 4 years	Level 2	SIMMCP TARP	25/05/2016
DC13	N/A	Area 3B	Stream	Habitat	Low numbers of adult Littlejohn's Tree Frogs have been recorded	Level 2	WIMMCP TARP	25/05/2016
WC21	N/A	Area 3B	Stream	Habitat	Reduction in Littlejohn's Tree Frogs habitat for one year	Level 1	WIMMCP TARP	25/05/2016
WC21	N/A	Area 3B	Stream	Habitat	Reduction in aquatic habitat at Site X2	Level 1	WIMMCP TARP	25/05/2016
Donalds Castle Creek	N/A	Area 3B	Stream	Habitat	Reduction in aquatic habitat at Site X1	Level 2	WIMMCP TARP	25/05/2016
WC17	N/A	Area 3A	Stream	Habitat	Adult Littlejohn's Tree Frogs have not been recorded for two consecutive years	Level 3	WIMMCP TARP	25/05/2016
SC10C	N/A	Area 3A	Stream	Habitat	Adult Littlejohn's Tree Frogs have not been recorded for two consecutive years	Level 3	WIMMCP TARP	25/05/2016

7. Longwall 11 Monitoring Program

A Comprehensive monitoring program for Longwall 11 is in place as required by the DA3B SMP Approval. The monitoring commitments outlined in the SMP (and as amended by applicable management plan) is shown in **Table 9**.

Table 9: Monitoring Associated with Longwall 11

ASPECT	MONITORING SITES ASSOCIATED WITH LONGWALL 11	MONITORING REQUENCY	RECOMMENDED FUTURE MONITORING
Watercourses	**Observational, Photo Point and Water Monitoring**		
	• Wongawilli Creek • Donalds Castle Creeks • WC21 • DC13 • LA5 • Swamps 1a, 1b, 3, 5 and 8	• SLMMP Sites: pre and post mining, monthly when longwall is within 400m of monitoring site • Monthly 2 years pre and post mining, weekly when longwall is within 400m of monitoring site	• Wongawilli Creek – Continue as required • Donalds Castle Creek – Continue as required • WC21 – Continue as required with additional upstream sites • DC13 – Continue as required • Swamps 5, 1a, 1b, 8, and 13 – Continue as required • LA5 – Continue as required • Swamp 3, 4 and 11 – Target sites within the subsidence zone of Longwall 12.
	Water Quality		
	• WWU1 (Wongawilli Creek headwaters) • WWU4 (Wongawilli Creek upstream) • WC Pool 49 (Wongawilli Creek adjacent to LW15) • WWM1 (Wongawilli Creek adjacent to LW12) • WWM2 (Wongawilli Creek adjacent to LW11) • WWM3 (Wongawilli Creek downstream of LW9) • WWL2 (Wongawilli Creek downstream) • WC21S1 (Wongawilli Creek tributary downstream of mining) • WC21 Pool 30 (Wongawilli Creek tributaries over mining) • WC15S1 (Wongawilli Creek tributary downstream of mining) **Lake Avon** • LA4_S1, LA4_S2, LA5_S1, LA5_S2 **Donalds Castle Creek:** • DCU3 (Donalds Castle Creek lower) • DCL3 (Donalds Castle Creek @ Cordeaux River) • DCS2 (Donalds Castle Creek downstream of mining) • DC13S1 (Donalds Castle Creek tributary downstream of mining)	• Monthly monitoring during and post mining for two years until required	• Continue water quality sample sites as required by the SMP

Swamps	Observational, Photo Point and Water Monitoring		
	• Swamps 01a, 01b, 03, 04, 05, 08, and 13	• Pre and post mining for two years, monthly when longwall is within 400m of monitoring site	• Swamps 1a, 3, 4, 5, 8, 10, 11 and 13- Continue as required by the SMP
	Shallow Groundwater Level		
	• Swamp 01A: 01a_01, 01a_02, 01a_03, 01a_04, 01a_04i, 01a_04ii, 01a_04iii, 01a_04iv, 01a_04v • Swamp 01B: 01b_01, 01b_02, 01b_02i, 01b_02ii, 01b_02iii, 01b_02iv, 01b_03 • Swamp 3: 03_01. • Swamp 05: 05_01, 05_02, 05_03, 05_03i, 05_03ii, 05_03iii, 05_04, 05_05, 05_06 • Swamp 08: 08_01, 08_02, 08_03, 08_04, 08_05, 08_06 • Swamp 10: 10_01	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 01A: 01a_01, 01a_02, 01a_03, 01a_04, 01a_04i, 01a_04ii, 01a_04iii, 01a_04iv, 01a_04v • Swamp 01B: 01b_01, 01b_02, 01b_02i, 01b_02ii, 01b_02iii, 01b_02iv, 01b_03 • Swamp 3: 03_01. • Swamp 05: 05_01, 05_02, 05_03, 05_03i, 05_03ii, 05_03iii, 05_04, 05_05, 05_06 • Swamp 08: 08_01, 08_02, 08_03, 08_04, 08_05, 08_06 • Swamp 10: 10_01 •Swamp 11: S11-HI, S11-H2, S11-H3 – continue as required •Swamp 13: 13_01 – continue as required
	Soil Moisture		
	• Swamp 05: S05_S01, S05_S02, S05_S03, S05_S03i, S05_S03ii, S05_S03iii, S05_S04, S05_S05, S05_S08 • Swamp 08: S08_S01, S08_S02, S08_S03, S08_S04, S08_S05, S08_S06	• 6 monthly baseline and reference site monitoring • Weekly monitoring when longwall is within 400m of swamp •6 monthly monitoring for 2 years post mining	• Swamp 05: S05_S01, S05_S02, S05_S03, S05_S03i, S05_S03ii, S05_S03iii, S05_S04, S05_S05, S05_S08 • Swamp 08: S08_S01, S08_S02, S08_S03, S08_S04, S08_S05, S08_S06 • Swamp 11: S11_S01, S11_S02, S11_S05 • Swamp 13: S13_S01, S13_S02, S13_S03 •Swamp 14: 14_01, 14_02 •Swamp 23: 23_01, 23_02 •Swamp 35A: 35a_01 •Swamp 35B: 35b_01 Reference Sites: •Swamp 2: S02_S01 •Swamp 7: S07_S05, S07_S06 •Swamp 15A: S15a_S01, S15a_Piezo, S15a_S04, •S15a_S06 •Swamp 22: 22_01, 22_02 •Swamp 24: S24_S01 Swamp 25: S25_S01 •Swamp 33: S033_S01, S033_S03 •Swamp 84: S84_S02 •Swamp 85: S85_S01, S85_S02 •Swamp 86: S86_S01, S86_S02 •Swamp 87: S87_S01, S87_S02 • Swamp 88: S88_S01, S88_S02

Landscape	Targeted Sites		
	Cliffs No clifflines associated with Longwall 10 **Fire Trails** Fire road N.6A (Across Longwalls 10-18)	• Baseline monitoring campaign prior to monitoring • Monthly monitoring during any subsidence period • Monitoring to continue 6 monthly for 2 years following the completion of mining	**Cliffs** No clifflines associated with Longwall 12 **Fire Trails** Fire Road No.6A (across LWs 10-18) - Continue as required by the SMP
	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

8. Management of Impacts and Remediation

The DA3B SMP outlines features that may require preventative, mitigative, and/or remedial measures. Management and rehabilitation of these features are considered in the SMP, SIMMCP and WIMMCP.

Table 10 provides the TARP for landscape features, including cultural heritage. **Table 11** and **Table 12** provide SIMMCP and WIMMCP TARPs respectively.

No remedial measures have been undertaken to date as a result of Longwall 11 extraction. Impacts have occurred as a result of Longwall 11 and these have been within the performance measures for Dendrobium Mine. Ongoing monitoring, assessments and consultation will determine the requirements for remediation works.

The Secretary wrote to Illawarra Coal 28th of August 2015 to request, under Condition 4 of Schedule 3 (DA_60-03-2001), that Illawarra Coal prepare a remediation program for the impacts to WC21. This Plan is to comply with the Area 3B SMP Approval Conditions including Condition 9 Performance Measures for Area 3B. The Plan was submitted to the Secretary 4th of March 2016.

Sites within Areas 3A and 3B have been identified for research into swamp rehabilitation; these proposed sites and techniques have been submitted to DP&E in a Swamp Rehabilitation Research Plan.

Table 10: Dendrobium Area 3B Landscape TARP

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)	***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
AREA 3A **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	***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
subsidence area *Refer to Dendrobium Area 3A SMP Figure 19.3*	Dam, or has been previously identified as Level 1, but is not likely to naturally stabilise within the monitoring period	
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*	***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

TERRESTRIAL FLORA AND FAUNA		
A number of sites located across and around Areas 2, 3A and 3B *Refer Dendrobium Area 3A SMP Figure 21.1, 21.2 and 21.3 and Dendrobium Area 3B Figure 20.1 for location of sites* General observation of active mining areas	***Level 1 **** • Vegetation impacted by mining (by rockfalls, soil slippage, gas emissions) that is likely to naturally regenerate within the monitoring period	• Continue monitoring program • Report impacts to key stakeholders • Summarise impacts and Report in the End of Panel Report and AEMR
	Level 2 * • Vegetation impacted by mining (by rockfalls, soil slippage, gas emissions) that is unlikely to naturally regenerate within the monitoring period • Statistically significant difference between Before After Control Impact sites as a result of mining	• 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
	Level 3 * • Vegetation impacted by mining that is not responding to CMAs	• Actions as stated for Level 2 • Immediately notify OEH, DoPI, DPI, SCA, other 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

Table 11: 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	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	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	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	Monitoring period for swamp size is related to capture of Lidar data at the end of each longwall ~ 1 year Triggers for groundwater decline result in increased intensity and

species within the swamps		exceeding the SE of the Control Group. *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.	rockbars and bedrock base and/or use of other remediation techniques i) reporting j) investigation and review k) update future predictions	the agreement of the Secretary.	frequency of vegetation monitoring

		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.			
Maintenance or restoration of the structural integrity of the bedrock base of any significant permanent pool or controlling rockbar within the swamps	Subsidence impacts (ie cracking) on bedrock base or controlling rockbar	*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). *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.	a) upfront mine planning b) subsidence monitoring c) surface water monitoring d) groundwater monitoring e) grouting of controlling of controlling rockbars and bedrock base and/or use of other remediation techniques f) CMAs g) reporting h) investigation and review i) update future predictions	Offset required **immediately**, if no remediation considered practicable. Offset required **2 years** following remediation, if it is ineffective. This period can be extended to **5 years**, with the agreement of the Secretary.	
Minor changes in the ecosystem functionality of the swamps	Falls in surface or near-surface groundwater levels in swamps *NB. Not linked specifically to a PM and would not be considered a breach if predictions were exceeded.*	*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.	a) upfront mine planning b) groundwater monitoring c) implementation of swamp research program d) weeding e) fire management f) reporting g) update future predictions		Triggers for groundwater decline result in increased intensity and frequency of vegetation monitoring and/or further investigations of subsidence impacts on bedrock base and rockbars

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

Table 12: Dendrobium Area 3B Watercourse TARP

Table 1.2 – Dendrobium Watercourse Impacts, Triggers and Response

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 • 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	• *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

Table 1.2 – Dendrobium Watercourse Impacts, Triggers and Response

Monitoring	Trigger	Action
	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	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 – EC 154.1 uS/cm – DO 50.5%	• *Actions as stated for Level 2* • Site visit with OEH, DoPE, T&I, Water NSW and other resource manager/s (if requested) • Implement additional monitoring or increase frequency if required • Review relevant TARP and Management Plan in consultation with key stakeholders • Develop site CMA (subject to stakeholder feedback). This may include: – Limestone emplacement to raise pH where it is appropriate to do so – Grouting of fractures in rockbar and bedrock base of any significant pool where flow diversion results in pool water level lower than

Table 1.2 – Dendrobium Watercourse Impacts, Triggers and Response

Monitoring	Trigger	Action
		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 – EC 185.8 uS/cm – DO 40.1%	• *Actions as stated for Level 2* • Site visit with OEH, DoPE, T&I, Water NSW and other resource manager/s (if requested) • Implement additional monitoring or increase frequency if required • Review relevant TARP and Management Plan in consultation with key stakeholders • Collect laboratory samples and analyse for: – pH, EC, major cations, major anions, Total Fe, Mn & Al – Filterable suite of metals • Develop site CMA (subject to stakeholder feedback). This may include:

Table 1.2 – Dendrobium Watercourse Impacts, Triggers and Response

Monitoring	Trigger	Action
		– Limestone emplacement to raise pH where it is appropriate to do so – Grouting of fractures in rockbar and bedrock base of any significant pool where flow diversion results in pool water level lower than baseline period • Completion of works following approvals and at a time agreed between BHPBIC, DoPE, T&I and Water NSW (i.e. may be after mining induced movements and impacts are complete), including monitoring and reporting on success
	Exceeding Prediction • Mining results in two conecutive exceedances of the ±3 standard deviation level (positive for EC, negative for pH and DO) from the baseline mean during the monitoring period: – pH 3.60 – EC 185.8 uS/cm – DO 40.1%	• *Actions as stated for Level 3* • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation • Provide residual environmental offset for any mining impact where CMAs are unsuccessful as required by Condition 14 Schedule 3 of the Development Consent
Lake Avon Lake Avon tributary (LA4_S1) Baseline means: • pH 5.38 • EC 90.8 uS/cm • DO 89.9% (24 months of baseline data available - to be updated with additional baseline data) Relevant Performance Measure(s): • Lake Avon - negligible reduction in the quality of surface water inflows to Lake Avon	***Level 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 * • Three exceedances of the ±3 standard deviation level (positive for EC, negative for pH and DO) from the baseline mean during the monitoring period: – pH 4.90 – EC 129.8 uS/cm – DO 69.5%	• *Actions as stated for Level 2* • Site visit with OEH, DoPE, T&I, Water NSW and other resource manager/s (if requested) • Implement additional monitoring or increase frequency if required • Review relevant TARP and Management Plan in consultation with key stakeholders • Collect laboratory samples and analyse for: – pH, EC, major cations, major anions, Total Fe, Mn & Al

Table 1.2 – Dendrobium Watercourse Impacts, Triggers and Response

Monitoring	Trigger	Action
		– Filterable suite of metals • Develop site CMA (subject to stakeholder feedback). This may include: – Limestone emplacement to raise pH where it is appropriate to do so – Grouting of fractures in rockbar and bedrock base of any significant pool where flow diversion results in pool water level lower than baseline period • Completion of works following approvals and at a time agreed between BHPBIC, DoPE, T&I and Water NSW (i.e. may be after mining induced movements and impacts are complete), including monitoring and reporting on success
	Exceeding Prediction • Mining results in two conecutive exceedances of the ±3 standard deviation level (positive for EC, negative for pH and DO) from the baseline mean of the Lake Avon inflows during the monitoring period: – pH 4.90 – EC 129.8 uS/cm – DO 69.5%	• *Actions as stated for Level 3* • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation • Provide residual environmental offset for any mining impact where CMAs are unsuccessful as required by Condition 14 Schedule 3 of the Development Consent
POOL WATER LEVEL		
Mapped pools in the mining area: • Wongawilli Creek • Donalds Castle Creek Relevant Performance Measure(s): • Wongawilli Creek - minor environmental consequences • Donalds Castle Creek - minor environmental consequences	***Level 1*** * • Fracturing not resulting in diversion of flow	• Continue monitoring program • Submit an Impact Report to OEH, DoPE, T&I, Water NSW and other relevant resource managers • Report in the End of Panel Report • Summarise actions and monitoring in AEMR
	Level 2 * • Fracturing resulting in diversion of flow	• *Actions as stated for Level 1* • Review monitoring frequency • Notify relevant technical specialists and seek advice on any CMA required • Implement agreed CMAs as approved (subject to stakeholder feedback)
	Level 3 * • Fracturing resulting in diversion of flow such that <10% of the pools have water levels lower than baseline period	• *Actions as stated for Level 2* • Site visit with OEH, DoPE, T&I, Water NSW and other resource manager/s (if requested) • Implement additional monitoring or increase frequency if required • Review relevant TARP and Management Plan in consultation with key stakeholders • Develop site CMA (subject to stakeholder feedback). This may include: grouting of rockbar and bedrock base of any significant pool where it is appropriate to do so in consultation with OEH, DoPE, T&I, Water NSW and other stakeholders

Table 1.2 – Dendrobium Watercourse Impacts, Triggers and Response

Monitoring	Trigger	Action
		• 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
MODELLED PERIODS OF RECESSIONAL, BASEFLOW AND SMALL STORM UNIT HYDROGRAPH PERIODS		
Subcatchments of Wongawilli and Donalds Castle Creeks and Lake Avon tributaries **	***Level 1 **** • Change 6-12% less than average annual precipitation ***	• Continue monitoring program • Submit an Impact Report to OEH, DoPE, T&I, Water NSW and other relevant resource managers • Report in the End of Panel Report • Summarise actions and monitoring in AEMR
	Level 2 * • Change 12-18% less than average annual precipitation ***	• *Actions as stated for Level 1* • Review monitoring frequency • Notify relevant technical specialists and seek advice on any CMA required • Implement agreed CMAs as approved (subject to stakeholder feedback)
	Level 3 * • Change >18% less than average annual precipitation ***	• *Actions as stated for Level 2* • Site visit with OEH, DoPE, T&I, Water NSW and other resource manager/s (if requested) • Implement additional monitoring or increase frequency if required • Develop site CMA (subject to stakeholder feedback). This may include: grouting of rockbar and bedrock base of any significant pool where it is appropriate to do so in consultation with OEH, DoPE, T&I, Water NSW and other stakeholders • Completion of works following approvals and at a time agreed between BHPBIC, DoPE, T&I and Water NSW (i.e. may be after mining induced movements and impacts are complete), including monitoring and reporting on success

Table 1.2 – Dendrobium Watercourse Impacts, Triggers and Response

Monitoring	Trigger	Action
		• Review relevant TARP and Management Plan in consultation with key stakeholders
Inflows to Lake Avon and Cordeaux River ** Relevant Performance Measure(s): • Lake Avon - negligible reduction in the quantity of surface water inflows to Lake Avon • Cordeaux River - negligible reduction in the quantity of surface water flows from Wongawilli Creek to Cordeaux River	***Exceeding Prediction*** • Measured surface water flow reduction in Wongawilli Creek at its confluence with Cordeaux River that is greater than predicted by the groundwater model (to the satisfaction of the Director General - Condition 13 of the SMP) that cannot be attributed to natural variation • Surface water flow reduction into Lake Avon is greater than predicted by the groundwater model (to the satisfaction of the Director General - Condition 13 of the SMP) that cannot be attributed to natural variation	• *Actions as stated for Level 3* • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation • Provide residual environmental offset for any mining impact where CMAs are unsuccessful as required by Condition 14 Schedule 3 of the Development Consent
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	***Level 1 **** • Reduction in habitat for 1 year	• Continue monitoring program • Submit an Impact Report to OEH, DoPE, T&I, Water NSW and other

Table 1.2 – Dendrobium Watercourse Impacts, Triggers and Response

Monitoring	Trigger	Action
habitat • Wongawilli Creek catchment – 2 sites • Donalds Castle Creek catchment – 2 sites • Lake Avon tributary – 1 site • Native Dog tributary – 1 site		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

* These may be revised in consultation with DoPE and T&I and other key stakeholders following analysis of natural variability within the pre-mining baseline data. These TARPs relate to Dendrobium Area 3B and impacts resulting from mining in Areas 1, 2 and 3A were managed under previous TARPs.

** Water budgets during recessional, baseflow and small storm unit hydrograph periods would be determined by hydrologic modelling of pre- and post-mining hydrographic data using the Free University of Amsterdam RUNOFF2005 model and validation of model-determined ETs against those estimated by the independent CSIRO Land and Water Division (Zhang et al.) method. These TARPs would apply only to the whole of catchment water delivered to Lake Cordeaux, Lake Avon and Cordeaux River. Model reliability is maintained only for catchments in excess of 1 km^2 in area. Average annual precipitation is modelled using the most recent 5 years of local record.

*** Hydrologic modelling conducted in the manner described above for the baseline period routinely produces mean estimated water budgets lying within about ±6% of average annual precipitation at the one standard deviation level and within about ±12% at the two standard deviation level.

Office of Environment and Heritage (OEH)

Department of Planning and Environment (DoPE)

Trade and Investment: including Division of Resources and Energy, Office of Water, Fisheries (T&I)

Water NSW (formally SCA)