Dendrobium Colliery
Area 3A, Longwall 6

END OF PANEL REPORT
FOR LONGWALL 6
AT DENDROBIUM COLLIERY

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Executive Summary

This End of Panel (EOP) report has been prepared to describe the impacts observed following the extraction of Dendrobium Area 3A Longwall 6, in accordance with the approval for the Area 3A SMP for Longwalls 6-8 and 19, granted on 28th June 2010 by NSW Planning and 9th July 2010 by Industry and Investment (I&I) NSW.

The report presents subsidence movements and impacts observed during the extraction of Longwall 6 and compares these impacts with those predicted. Dendrobium Longwall 6 is located within Consolidated Coal Lease No. 768 and is the first longwall to be mined in Area 3A. It was extracted using conventional longwall techniques and equipment during the period from **9th February 2010** to **28th March 2011**.

Economic Impacts

While assisting BHP Billiton to achieve its corporate objectives for the Illawarra Coal business, the Dendrobium project provides benefits at international, national, state and local levels due to the coals premium coking characteristics. Continuing benefits occur through continuity of employment, expendable income, export earnings and government revenue. As of January 2010 there were 260 full time employees at Dendrobium Colliery, with an additional 200 contractors. These jobs are reliant on maintaining longwall coal extraction. Illawarra Coal generates employment for approximately 2,000 direct employees and contractors throughout its operations. In addition, the jobs of 10,000 workers at the Port Kembla Steelworkers are secured by the local supply of coking coal from Illawarra Coal's mines. The company is a major contributor to the economy of the local region and New South Wales. Illawarra Coal paid $37,654,227 to the NSW Government in royalties for the coal extracted from Longwall 6. Illawarra Coal's expenditure on goods and services is in the order of $597 million per annum in Australia with $540M in New South Wales (Illawarra Coal 2009-10 Sustainability Report).

Subsidence

Subsidence movements resulting from the extraction of Longwall 6 were measured using monitoring that included Wongawilli Creek 2D Closure Lines, Area 3A 3D monitoring points, Sandy Creek Waterfall North and South Lines, Sandy Creek Waterfall 3D monitoring points, Sandy Creek Waterfall High Resolution Survey lines, strain gauge and geophone monitoring, tributary cross Lines, TransGrid and Integral Energy 3D monitoring points and airborne laser scans of the area.

Maximum observed closures at the Wongawilli Creek closure lines was either less than predicted (A-Line and B-Line) or within the order of survey tolerance (C-Line). The observed movements at the Tributary Cross Lines were typically in the order of survey tolerance.

Far-field movements measured using 3D monitoring points were within the range of those typical in the Southern Coalfield at similar distances from active longwalls. The movements are generally orientated towards Longwall 6 and include a component of downslope movement.

Sandy Creek Waterfall monitoring showed subsidence and tilts that were either less than or similar to those predicted. Maximum observed incremental horizontal movements were in the order of survey tolerance and closures along the Sandy Creek 3D Lines were less than the predicted maximum closure. Observed closures along the Sandy Creek High Resolution Survey Lines were also less than the predicted maximum closure.

The observed subsidence at the Transgrid 330 kV Transmission Line Towers 15 and 18 was similar to survey tolerance. The observed subsidence at Towers 16 and 17 was less than predicted. The maximum observed changes in the differential horizontal movements between

the tower legs were less than the order of survey tolerance, and less than predicted. The observed total tilts of the earth wire were less than predicted.

Impacts on Man Made Features

The impacts on man made features resulting from the extraction of Dendrobium Longwall 6 are all either less than or in accordance with predicted impacts.

Impacts to infrastructure including fire trails and 4WD tracks, the 330 kV transmission line and 33 kV powerline, survey control marks and the Upper Cordeaux No.2 Dam were within predictions. Some surface cracking and soil displacement was observed along the fire trails though this did not result in risk to traffic in the area. Remediation works were successfully undertaken on a crack in Fire Road 6C.

No impacts to the transmission line or powerline were recorded and small regional horizontal movements occurred to the survey marks. There were no reported impacts to the Upper Cordeaux No.2 Dam wall.

Impacts on Natural Features

The observed impacts on natural features above Longwall 6 are generally consistent with those predicted in the assessments undertaken prior to mining.

Fracturing of the sandstone bedrock was observed and small volume rockfalls occurred in line with predictions. Some surface cracking and soil displacement was observed along tracks and in naturally vegetated areas, as predicted.

While predictions to Wongawilli and Sandy Creek included localised ponding or flooding, and fracturing of the bedrock, no impacts to the creeks were observed, and no water flow diversions occurred. As predicted, there were no significant impacts to water quality in these creeks. On the smaller drainage lines there were no reports of additional flooding, scouring, ponding or water flow diversions. Minor fractures and a small rock fall were observed in the tributary drainage lines (WC17 and WC19). Such impacts were predicted in the initial assessments along drainage lines above or within 250 m of the longwalls. No loss of pool water level was observed in ephemeral pools although it was predicted that this could occur in ephemeral creeks.

It was predicted that fracturing of strata underlying the swamps could occur, resulting in the diversion of surface water. Minor fracturing was observed in WC17 but no loss of surface flow water occurred in the stream or swamp. There was no significant impact on geochemistry or hydrology of the swamps.

Hawkesbury Sandstone groundwater heads were unaffected by the extraction of Longwall 6 or concurrent development headings with one exception at Bore S1889 (DDH97) over Longwall 7 where 25 m drawdown was observed during the passage of Longwall 6, but the head in the upper Hawkesbury Sandstone was unaffected.

The downhole piezometers nearest the Sandy Creek waterfall showed minor depressurisation in the Wongawilli Seam but barely any change in the heads in overlying formations during the extraction of Longwall 6. Apart from the Wongawilli Seam, the heads were maintained at an elevation above the Cordeaux Reservoir water level. Groundwater head reductions in the deeper formations and coal seams were in good general agreement with predictions of spatial pattern and drawdown magnitude, with the exception of the Bulli Seam where drawdowns of about 40-60 m were greater than expected and the decline pushed well into Area 3B.

The Wongawilli Seam showed only minor (5-20 m) reductions in head over Area 3A because most of the depressurisation had already occurred as a result of development headings. As

predicted, the largest Wongawilli Seam drawdowns occurred in Area 3B and to the south of the Area 3A longwalls. This suggests that the initial heads in those areas were close to natural levels and the mining activities in Area 3A are starting to influence Area 3B and farther south in Area 3A.

Recovery of a few metres of head in most formations was evident in Area 2 between February 2010 and March 2011. This is in agreement with predictions.

It was predicted that reductions in the availability of aquatic habitat due to mining impacts were expected to be minor, localised and transient if present. There have been no detectable impacts on aquatic biota resulting from the extraction of Longwall 6. Macquarie Perch is considered highly unlikely to be present in the study area.

Localised impacts to terrestrial flora and fauna habitat were predicted due to cracking and rockfalls, possible scouring and increased ponding. Impacts have been as predicted with rockfalls impacting on individual plants and an area of localised dieback occurring due to soil and rock cracking. While a significant local impact on four threatened fauna species was predicted, no significant impact has been observed. Terrestrial plant communities, fauna habitats, threatened species, populations and ecological communities are not considered to have been significantly affected by subsidence related impacts associated with the mining of Longwall 6.

Predicted potential impacts on archaeological sites included fracturing of sandstone, isolated rock falls, and water seepage through joints with potential to affect artwork. The overall risk of this occurring was considered negligible to moderate. With the exception of the expansion of one vertical joint in one rock art site, which did not impact the art, no impacts have been observed.

Conclusion

Impacts due to the mining of Longwall 6 were generally less than or equal to the predicted impacts. Monitoring and management measures within the SMP are effectively reducing the level of mining impacts to within acceptable levels in line with the approval for mining.

End of Panel Report – Dendrobium Longwall 6

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1. INTRODUCTION

1.1 Background

BHP Billiton Illawarra Coal (IC) has completed the extraction of Longwall 6 at Dendrobium Mine, which is located in the Southern Coalfield of New South Wales. Longwall 6 is located within Consolidated Coal Lease No. 768 and was extracted using conventional longwall techniques and equipment during the period from **9th February 2010** to **28th March 2011**. The location of Longwall 6 is shown in **Figure 1.1** (Drawing No. MSEC488-01).

This End of Panel (EOP) report has been prepared to compare the predicted and observed impacts following the extraction of Dendrobium Area 3A Longwall 6, in accordance with Condition 9 (Schedule 3) of the Modification to the Development Consent which covers the extraction of Longwall 6 in Area 3A.

Longwall 6 is located to the south and west of Lake Cordeaux, within Area 3A. The surface overlying Area 3A is part of the Sydney Catchment Authority's Special Areas as defined in the *Sydney Water Catchment Management Act 1998*. Part of the surface is catchment for Cordeaux Dam. Area 3A consists largely of undisturbed native bush.

Information in this report has been provided by BHP Billiton Illawarra Coal (BHPBIC) and its specialist consultants who have been involved in the monitoring of the area in the vicinity of Dendrobium Longwall 6. This report should be read in conjunction with the environmental impact assessment documents associated with Dendrobium Area 3A that were submitted in support of the Development Consent modification in 2007. The Subsidence Management Plan (and related sub-plans) required in accordance with Schedule 3 of the modified Development Consent was conditionally approved in December 2009. The current version of the SMP was approved in April 2010. The SMP outlines in full the predicted impacts to the natural environment and man-made features due to the mining of Dendrobium Longwall 6.

The impact predictions are primarily described in the following reports:

- Cardno Forbes Rigby, November 2007. *Dendrobium Colliery Area 3A – Longwalls 6 to 10 Subsidence Management Plan Application, Part A – Written Report.*

- BHPB Illawarra Coal, April 2010. *Dendrobium Colliery Area 3A – Part B – Subsidence Management Plan for Areas 1, 2 and 3A – Report 003 Part B Rev 4 – Final Report*.

1.2 Approval History

Consent was granted on 20th November 2001, by the then Minister for Urban Affairs and Planning, to Illawarra Coal to construct and operate the Dendrobium Mine and associated infrastructure at Kemira Valley, West Cliff and Port Kembla Steelworks. This consent was modified on 12th December 2008 (under S75W of the *Environmental Planning and Assessment Act 1979*).

The conditions of the Dendrobium development consent, as modified in December 2008, required the preparation of a Subsidence Management Plan (SMP) and approval of this by NSW Planning and the Department of Industry and Investment (I&I) NSW prior to commencement of the project. The SMP was prepared as required.

First Workings Approval

An SMP Approval for limited first workings for Longwalls 6-10 in Area 3A was granted on the 12th August 2008 by I&I NSW. SMP Approval for the remainder of the first workings for Longwalls 6-10 was granted on the 24th December 2008.

Secondary Workings Approvals

The application for secondary workings and associated subsidence was originally supported by an SMP application made by IC. Conditional approval for the Area 3A SMP was granted for Longwall 6 by I&I NSW and NSW Planning on 24th December 2009.

The proposed mine plan for Area 3A was subsequently modified to include modified Longwalls 6-8 in Area 3A and Longwall 19 (previously Longwall 9), with Longwall 10 removed from the plan. An application for the SMP entitled "Dendrobium Colliery Area 3A – Part B – Subsidence Management Plan for Areas 1, 2 and 3A – Report 003 Part B Rev 4 – Final Report" (April 2010) was submitted.

Approval for the Area 3A SMP for Longwalls 6-8 and Longwall 19 was granted on 28th June 2010 by NSW Planning and 9th July 2010 by I&I NSW.

1.3 Consent Conditions

The original consent was modified on 9th July 2010 and Condition 9 of Schedule 3 of the modified consent contains the EOP reporting requirements relevant to Longwall 6. This states the following:

9 ***End of Panel Report*** *– Within 4 months of the completion of each longwall panel, or as otherwise permitted by the Director-General, the Applicant shall:*

a) 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

b) Submit the report to the Department, DPI, SCA, DECC, DWE and any other relevant agency to the satisfaction of the Director-General.

The Applicant shall include a comprehensive summary, analysis and discussion of the results of the monitoring of subsidence effects, subsidence impacts and environmental consequences in each AEMR.

In accordance with the above conditions, this EOP Report provides:

- reporting of subsidence effects associated with Longwall 6;
- a comparison between the predicted and observed subsidence movements at the monitoring lines and points in Dendrobium Area 3A resulting from the extraction of Longwall 6; and
- a comparison between the predicted and observed impacts on man made and natural features within the SMP Area resulting from the extraction of Longwall 6.

1.4 Management Plans

Management plans prepared for Dendrobium Area 3A include:

- Dendrobium Colliery Area 3A
  Part B – Subsidence Management Plan for Areas 1, 2 and 3A (April 2010);
- Watercourse Impact Monitoring, Management and Contingency Plan (April 2010) (Condition 4 Schedule 3 of modified consent);
- Swamp Impact Monitoring, Management and Contingency Plan (April 2010) (Condition 6 Schedule 3 of modified consent);
- Aboriginal Heritage Plan (April 2010) (Condition 12 Schedule 3 of modified consent);
- Groundwater Monitoring Plan (Condition 13 Schedule 3 of modified consent);
- Sandy Creek Waterfall Management Plan;
- SCA Assets Protection Plan (Condition 7 Schedule 3 of modified consent);
- Dam Safety Committee Closure, Contingency and Monitoring Plans;
- Integral Energy Transmission Infrastructure Monitoring and Management Plan (October 2009);
- TransGrid Management Plan;
- Integral Management Plan;
- Subsidence Monitoring Programmme (Condition 12 of I&I SMP Approval).

These plans have been prepared in consultation with relevant stakeholders and authorities and are used to monitor and manage the various aspects of the project. Regular reporting occurs to authorities in accordance with these plans.

1.5 Report Outline

Observed impacts have been described by BHPBIC field personnel and specialist consultants during and following completion of Longwall 6. Results of the specialist studies are summarised in this report.

Economic implications of the project are provided in Section 2. A summary of predicted and observed subsidence effects is provided in Section 3. Section 4 outlines the predicted and observed subsidence impacts of Longwall 6 on man made features, and Section 5 addresses the environmental consequences including predicated and observed impacts of Longwall 6 on natural features. Section 6 outlines the monitoring program associated with the longwall and the proposed future monitoring in the area. Section 7 summarises remediation measures carried out and proposed in the area.

2. ECONOMIC IMPACTS

The extraction of underground coal reserves from Area 3A is necessary to achieve BHP Billiton's corporate objectives for the Illawarra Coal business. At the same time, it provides benefits at international, national, state and local levels due to the coals premium coking characteristics.

About 50% of the coal produced from IC mines is used in the domestic steel industry, where it is processed to create a high quality coke. The remainder is exported to key customers overseas. Dendrobium is the only IC mine extracting from the Wongawilli Seam. Wongawilli Seam coal is an important component of the coal blend used at the Port Kembla steelworks. The Port Kembla steelworks requires approximately 1 Mtpa of clean Wongawilli Coal to operate and is Illawarra Coal's major domestic customer (OEC, 2001).

The proposed extraction of coal from Area 3A is vital as minimal reserves of such coal exist. It also represents continuing significant capital and operating investments in the Southern Coalfield of New South Wales.

In the 2011 financial year, Illawarra Coal paid $37,654,227 to the NSW Government in royalties for the coal extracted from Longwall 6.

Continuing benefits occur through continuity of employment, expendable income, export earnings and government revenue. As of July 2011 there were 260 full time employees at Dendrobium Colliery, with an additional 200 contractors. These jobs are reliant on maintaining longwall coal extraction.

Illawarra Coal generates employment for approximately 2,000 direct employees and contractors throughout its operations. In addition, the jobs of 10,000 workers at the Port Kembla Steelworkers are secured by the local supply of coking coal from Illawarra Coal's mines. The company is a major contributor to the economy of the local region and New South Wales. Illawarra Coal's expenditure on goods and services is in the order of $597 million per annum in Australia with $540M in New South Wales (Illawarra Coal 2009-10 Sustainability Report).

3. SUBSIDENCE MONITORING LINES AND POINTS

Mine Subsidence Engineering Consultants (MSEC) has previously prepared numerous reports relating to subsidence predictions and impact assessments for Dendrobium Longwall 6 and these are listed in **Attachment A** (MSEC488). The earlier key subsidence reports relevant to mining of Longwall 6 are:

- WKA77 (January 2001) – Dendrobium Mine Project – Report on the Prediction of Mining Subsidence Parameters and the Assessment of Impacts on Surface Infrastructure – Longwalls 1 to 18 (In support of the EIS).

- MSEC311 (October 2007) – The Prediction of Subsidence Parameters and the Assessment of Mine Subsidence Impacts on Natural Features and Surface Infrastructure Resulting from the Extraction of Proposed Longwalls 6 to 10 in Area 3A and Future Longwalls in Areas 3B And 3C at Dendrobium Mine (In Support of the SMP Application and the Modification to the Development Consent).

- MSEC437, February 2010 *The Effects of the Proposed Modifications to the Longwalls in Area 3A at Dendrobium Mine on the Subsidence Predictions and Impact Assessments.* MSEC437 (Revision D).

MSEC was commissioned by IC to summarise subsidence effects associated with Longwall 6 and compare the observed and predicted subsidence movements along the monitoring lines and at the monitoring points resulting from the subsidence. The MSEC report is provided in full in **Attachment A** (MSEC488 Revision A, 2011), which is summarised in the following sections.

3.1 Mining Context

Longwall 6 is the first longwall to be extracted in Area 3A, with an extracted length of 2,575 metres. The void width of Longwall 6 is 250 metres and the extent of the mining is shown in **Figure 1.1**. Longwall 6 was taken off at maingate cut through 9, which is 50 metres short of the approved finishing end, as part of the adaptive management strategy which was developed for the Sandy Creek Waterfall. The depth of cover to the Wongawilli Seam ranged from 290 m above the commencing (western) end of the longwall, to a maximum of 385 metres, towards the middle of the longwall.

The extraction height varied along the length of the longwall, depending on the local roof conditions, with the maximum extraction height being 3.9 metres.

3.2 Subsidence Monitoring

The subsidence movements resulting from the extraction of Longwall 6 were monitored at the following survey points and lines:

- Wongawilli Creek 2D Closure Lines;
- Area 3A 3D monitoring points;
- Sandy Creek Waterfall North and South Lines;
- Sandy Creek Waterfall 3D monitoring points;
- Sandy Creek Waterfall High Resolution Survey lines;
- Tributary Cross Lines;
- TransGrid 3D monitoring points; and
- Airborne laser scans of the area.

The locations of these monitoring lines and points in Dendrobium Area 3A are shown in **Figure 1.1** (from Drawing No. MSEC488-01 in **Attachment A**).

Additional monitoring was also undertaken in the vicinity of Sandy Creek Waterfall as part of the adaptive management strategy for the waterfall, including strain gauge and Geophone monitoring.

A summary of the subsidence and comparisons between the observed and predicted effects are provided in the following sections.

3.3 Wongawilli Creek Closure Lines

The closure movements across Wongawilli Creek were measured using 2D surveys along the Wong X A-Line, Wong X B-Line and the Wong X C-Line as shown in **Figure 1.1**.

The monitoring lines measured the closure between the valley sides using two survey marks located either side of the creek. Due to the difficult terrain, there were no survey marks near the base of the creek so upsidence in the base of the creek could not be measured.

The maximum observed and maximum predicted closure movements for each of the Wongawilli Creek Closure Lines is provided in **Attachment A**. In summary, the maximum observed closures at the Wongawilli Creek A-Line and B-Line of 36 and 34 mm respectively, were less than the maxima predicted in those locations. The maximum closure observed at the Wongawilli Creek C-Line was very small (6 mm) and in the order of survey tolerance, which is ±5mm.

3.4 Dendrobium Area 3A 3D Monitoring Points

Far-field horizontal movements in the vicinity of Longwall 6 were measured using 3D monitoring points across the area as shown in **Figure 1.1**. The observed incremental horizontal movement vectors for the 3D points are shown in **Figure 3.1** (source: **Attachment A** MSEC488-06).

Figure 3.1 shows that far-field movements are generally orientated towards Longwall 6 and include a component of downslope movement. The maximum total horizontal movement, predicted due to the extraction of Longwalls 6-8 & 19, was 300 mm. The maximum observed incremental horizontal movement at the 3D monitoring points was 189 mm (Mark DA3A-7), occurring directly above Longwall 6. The movements were within the range of those typical in the Southern Coalfield at similar distances from active longwalls.

3.5 Sandy Creek Waterfall Monitoring

3.5.1 SCW North and South Lines

Subsidence movements along the Sandy Creek Waterfall (SCW) North and South Lines were measured using 3D surveys at locations shown in **Figure 1.1**. Maximum predicted and observed incremental subsidence parameters along these lines due to Longwall 6, are provided in **Attachment A** (Tables 2.4 and 2.5) and summarised below.

SCW North Line

The maximum observed incremental subsidence was 1220 mm, which was less than the maximum predicted of 1450 mm. The maximum observed incremental tilt was 13 mm/m (i.e. 1.3 %, or a change in grade of 1 in 77), which was similar to but slightly larger than the maximum predicted.

The maximum observed incremental tensile strain of 2.1 mm/m was less than the 3.0 mm/m maxima predicted based on conventional movements. The maximum observed compressive strains was 5.9 mm/m, which was greater than the 2.5 mm/m predicted based on conventional movements. This could be the result of non-conventional downslope

movement, and the horizontal vectors for the North Line indicate that there is a component of downslope movement involved (see **Attachment A** - Fig.2.2).

SCW South Line

The maximum observed incremental subsidence was 34 mm, which is similar to but slightly greater than the maximum 30 mm predicted. As stated in Report No. MSEC311, that where "*subsidence is predicted at points beyond the goaf edge, which are likely to experience very low values of subsidence, the predictions should generally be accurate to within 50 mm of subsidence*".

The maximum observed incremental tilt (0.4 mm/m) was similar to but slightly less than the maxima predicted (<0.5 mm/m).

The maximum observed incremental tensile and compressive strains were both 0.4 mm/m, which are similar to but slightly greater than the order of survey tolerance. The maximum predicted conventional tensile and compressive strains along the monitoring line were both less than 0.3 mm/m. The maximum observed strains along this monitoring line were therefore, similar to the maxima predicted based on conventional movements.

The horizontal movement vectors along the SCW South Line indicate that the horizontal movements consisted of both conventional movements towards the extracted goaf and potentially some very low level downslope movements.

3.5.2 Sandy Creek 3D Monitoring Points

Far-field horizontal movements and closure at the Sandy Creek Waterfall were measured using four monitoring lines referred to as the Sandy Creek 3D Monitoring Lines: A-Line, B-Line, C-Line and D-Line as shown in **Figure 1.1**. Once the more accurate high resolution survey lines were installed in October 2010, the survey frequency of these 3D lines was reduced.

The maximum observed incremental horizontal movements at the Sandy Creek Waterfall 3D monitoring points were in the order of survey tolerance. The observed incremental closures measured along the Sandy Creek Waterfall 3D Monitoring Lines were very small, and generally in the order of survey tolerance of ±5 mm. In the latest survey, the observed closure along the B-Line was 7 mm, which was slightly greater than survey tolerance however it was noted in the results that survey mark stability may have compromised this result.

The maximum predicted closure at the Sandy Creek Waterfall was 35 mm based on the actual finishing end of Longwall 6. The observed closures along the Sandy Creek 3D Lines were less than the predicted maximum closure.

3.5.3 SCW High Resolution Closure Lines

As part of the adaptive management strategy for the Sandy Creek Waterfall, six additional high resolution 2D monitoring lines were installed across the waterfall. The locations of the Sandy Creek Waterfall High Resolution Survey (SCW HRS) lines are shown in **Figure 1.1**. The accuracies of the measured closures at these monitoring lines are in the order ±1 mm.

Measureable closure (i.e. greater than survey tolerance) developed first along the H1-Line around the 28th January 2011, when the longwall had 196 metres of extraction remaining. Measurable closure developed along the H2-Line and H3-Line in early to the middle of February 2011 and developed along the G1-Line, G2-Line and AA-Line in middle to late March 2011.

The maximum predicted closure at the Sandy Creek Waterfall was 35 mm based on the actual finishing end of Longwall 6 (i.e. 50 metres short of the approved finishing end). The

observed closures along the Sandy Creek HRC Lines were less than the predicted maximum closure.

3.6 Tributary Cross Lines

The mine subsidence movements across drainage lines were measured using 2D survey techniques along the SC E-Line, SC F-Line, SC G-Line, SC H-Line, SW 15A-Line and SW 15B-Line, as shown in **Figure 1.1**.

The Tributary Cross Lines are located at distances greater than 230 metres from Longwall 6. The predicted incremental subsidence, strain and closure along these monitoring lines were in the order of survey tolerance.

The observed movements at the Tributary Cross Lines were also typically in the order of survey tolerance. An opening of 8 mm was measured across the SW 15B-Line, which is likely to have developed as the result of the horizontal movements towards the extracted longwall.

3.7 Closure Across the Arm of Lake Cordeaux

The closure movements across the arm of Lake Cordeaux were measured between SCW North Line Points SCW-N39 and SCW-N40. The maximum observed incremental closure, due to the extraction of Longwall 6, was approximately 7 mm, which is similar to that measured at Sandy Creek Waterfall and less than predicted.

3.8 Transgrid 3D Monitoring Points

Four TransGrid towers were monitored during the extraction of Longwall 6, being Towers Nos. 15, 16, 17 and 18, the locations of which are shown in **Figure 1.1**. Tower 17 is a tension tower and the remaining are suspension towers.

The mine subsidence movements of the TransGrid 330 kV transmission line towers were measured using 3D monitoring techniques. The predicted subsidence and the predicted changes for the 330 kV Transmission Line towers, resulting from the extraction of Longwalls 6 to 19, were provided in Report No. MSEC437. The maximum predicted and observed subsidence parameters at the transmission line towers are provided in **Attachment A** (Table 2.14) and summarised below.

The predicted tilts at the earth wire were calculated based on the maximum predicted tilts and horizontal movements at each of the towers. The observed subsidence at the Towers 15 and 18 was similar to the order of survey tolerance. The observed subsidence at Towers 16 and 17 was less than predicted. The maximum observed changes in the differential horizontal movements between the tower legs were less than the order of survey tolerance, and less than predicted. The observed total tilts of the earth wire (i.e. horizontal movement at the level of the earth wire) were less than predicted.

3.9 Integral Energy Pole

The 33 kV powerline has a tension pole located above the northern edge of Longwall 6. Illawarra Coal measured the mine subsidence movements at this tension pole. The maximum horizontal movement at Mark DA3a-15 was 21 mm. The tension pole was replaced during the mining of Longwall 6. The tilt of the new pole was monitored and there was little to no measurable change during mining.

3.10 Airborne Laser Scan

The initial surface levels in Dendrobium Area 3A were determined using an airborne laser scan (ALS) prior to and following Longwall 6. The changes in surface level were determined

by IC by taking the differences between the surface levels measured before and after the extraction of Longwall 6. The observed incremental changes in surface level, due to the extraction of Longwall 6, are shown in **Attachment A**.

The profiles of the observed changes in surface level along one long-section and three cross-sections have been determined from the results of the ALS, the locations of which are shown in **Attachment A** (Drawing No. MSEC438-07). The profile of the predicted and observed incremental changes in surface level along Long-section 1, due to the extraction of Longwall 6, is provided in **Figure 3.2**.

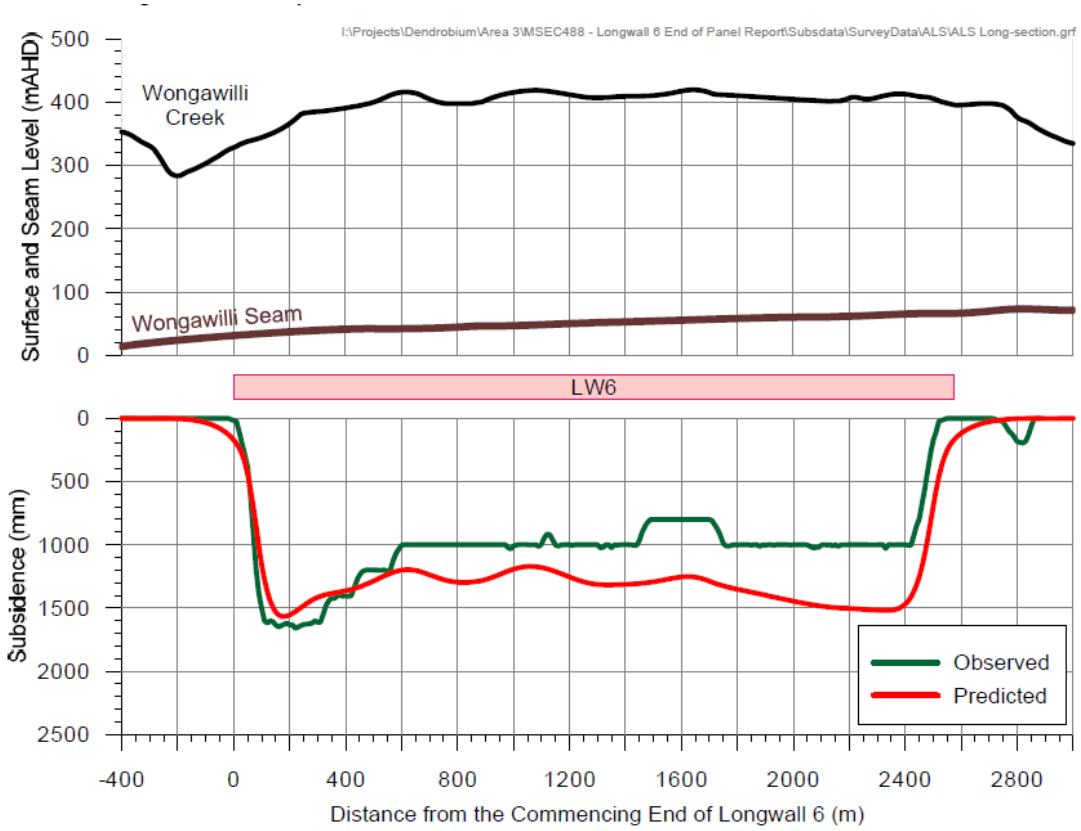

Figure 3.2 - Observed Changes in Surface Level and Predicted Subsidence along Long-section 1

It can be seen from the above figure, that the observed changes in surface level along Long-section 1 are generally similar to or slightly less than those predicted above Longwall 6. The observed changes in surface level are slightly greater than those predicted, in some locations, however, these differences are generally within the order of accuracy of the ALS results.

The maximum observed incremental changes in surface level at Cross-sections 1, 2 and 3 were less than the maximum predicted total subsidence movements. The locations of the maximum observed changes in surface level and the maximum predicted subsidence were in similar locations, near the longwall centreline, which is expected for a first panel in a series.

The profiles of the observed total changes in surface level are more localised above the extracted longwall, whereas the predicted subsidence profiles extend further outside the edges of the longwall. It can be inferred from the steepness of the profiles in the above figure, that the maximum observed tilts at these cross-sections are reasonably similar to the maximum predicted tilts in these locations.

4. IMPACTS TO MAN MADE SURFACE FEATURES

4.1 Surface Infrastructure

The surface infrastructure that is in the vicinity of Longwall 6 is shown in **Figure 4.1** (**Attachment A**: Drawing No. MSEC488-05) and includes:

- ❒ Fire trails and four wheel drive tracks,
- ❒ 330 kV transmission line,
- ❒ 33 kV powerline, and
- ❒ Survey control marks.

The Upper Cordeaux No. 2 Dam is also located in the vicinity of Longwall 3 and it was predicted that the dam could experience far-field horizontal movements resulting from the extraction of this longwall. For this reason, the dam wall was also included in the assessment.

The predicted impacts for the surface infrastructure, resulting from the extraction of Dendrobium Longwalls 6-8 and 19, were provided in MSEC Report Nos. MSEC311 and MSEC437. Comparisons between the MSEC assessments and the observed impacts for the surface infrastructure are summarised in **Table 4.1** and discussed further below.

Table 4-1: Summary of Predicted and Observed Impacts of Dendrobium Longwall 6 on Surface Infrastructure

Surface Infrastructure	Predicted Impacts	Observed Impacts
Fire Trails and Four Wheel Drive Tracks	Cracking of unsealed road surfaces	Some surface cracking and soil displacement observed along the tracks.
330 kV Transmission Line	Impacts unlikely after the implementation of necessary management strategies (i.e. installation of cruciform bases)	No reported impacts
33 kV Powerline	Impacts unlikely	No reported impacts
Survey Control Marks	Vertical and horizontal movements which could require re-establishment	Vertical and horizontal movements
Upper Cordeaux No. 2 Dam Wall	Impacts unlikely	No reported impacts
Cordeaux Reservoir Stored Waters & Mine Inflow	Negligible loss of water is expected from the Cordeaux Reservoir to the Area 3A voids	Negligible loss of water. Measured inflows much less than predicted.
	The expected magnitude of mine inflow from aquifer storage for the current preferred model is about 3-4 ML/day	Measured inflows much less than predicted. Actual inflows range up to 3.6 ML/day but average 1.3 ML/day (standard deviation 0.6 ML/day).

The observed impacts on surface infrastructure are generally similar to or less than the predicted impacts. Where impacts have been observed to the infrastructure, these are discussed below.

4.1.1 Fire Trails and 4WD Tracks

Some roads are located directly above the proposed longwalls including Fire Road No.6C and Fire Road No.6F as shown in **Figure 4.1**. These are monitored weekly by the IC Field Team and their reports are provided in **Attachment B**.

Predicted Impacts on Fire Trails and 4WD Tracks

It was predicted that the fire trails could experience cracking or buckling due to subsidence effects in the underlying strata, which could induce cracking in the unsealed surfaces of the trails.

Observed Impacts on Firetrails and Other 4WD Tracks

Minor fracturing and soil cracking occurred along some of the fire roads in the vicinity of Longwall 6. Discontinuous hairline and small cracks were identified on Fire Road 6C, 6F and 6K at eight locations.

Given that Fire Road 6C is a major road within the catchment area, approval to carry out remediation work on surface cracking was obtained from the Sydney Catchment Authority. Remediation works were undertaken successfully on surface crack DA3Longwall 6_62 as discussed in **Section 7**.

At the end of the longwall panel, cracks in the fire roads had either been totally filled or partially filled though active remediation or natural infilling processes, as outlined in **Attachment B**.

No moderate or severe impacts to the fire roads occurred.

The observed impacts were in line with those predicted.

4.1.2 Survey Control Marks

It was predicted that survey control marks located in the area would experience horizontal and vertical movements. Vertical and horizontal movements have occurred as predicted and the survey control marks will need to be re-established once mining associated movement has ceased.

4.2 Cordeaux Reservoir Stored Waters and Mine Inflow Events

The mine water monitoring system at Dendrobium is comprehensive and measures the water pumped in and out of the mine, water taken out of the mine with the coal and moisture brought in and out of the mine in the ventilation air. During Longwall 6 the groundwater make into the whole mine averaged 3.3 ML per day with a maximum daily value of 7.3 ML.

Table 4.2 shows the Total Mine Water Balance condition during the extraction of Longwall 6.

Table 4-2: Total Mine Water Balance During Longwall 6

Period		Principal Response Flowchart Condition
From	To	
9/02/2010	11/04/2010	Normal
12/04/2010	13/04/2010	Level 1
14/04/2010	26/04/2010	Normal
27/04/2010	28/06/2010	Level 1
29/06/2010	12/07/2010	Level 2
13/07/2010	15/08/2010	Level 1
16/08/2010	20/10/2010	Normal
21/10/2010	26/10/2010	Level 1
27/10/2010	11/11/2010	Normal
12/11/2010	15/12/2010	Level 1
16/12/2010	13/1/2011	Level 2
14/01/2011	13/02/2011	Level 1
14/02/2011	28/03/2011	Normal

* Alarm Levels based on 0% Dam Water

In addition to the Principal Response Flowchart the DSC Double Flow Alarm was triggered on 18 and 25 September, and 28 October 2010. The '3 Standard Deviation' Alarm was triggered on 15 and 16 February, 7 April and 29 June 2010. The alarms were primarily caused by changes in the Area 2 water balance.

Monitoring for a discrete Area 3A water balance was established on 26 June 2010. The Area 3A water balance determines the groundwater inflow into Area 3A from all operational panels (longwall & development). **Figure 4.2** shows the Area 2 and 3A Balance in relation to the Total Mine Balance.

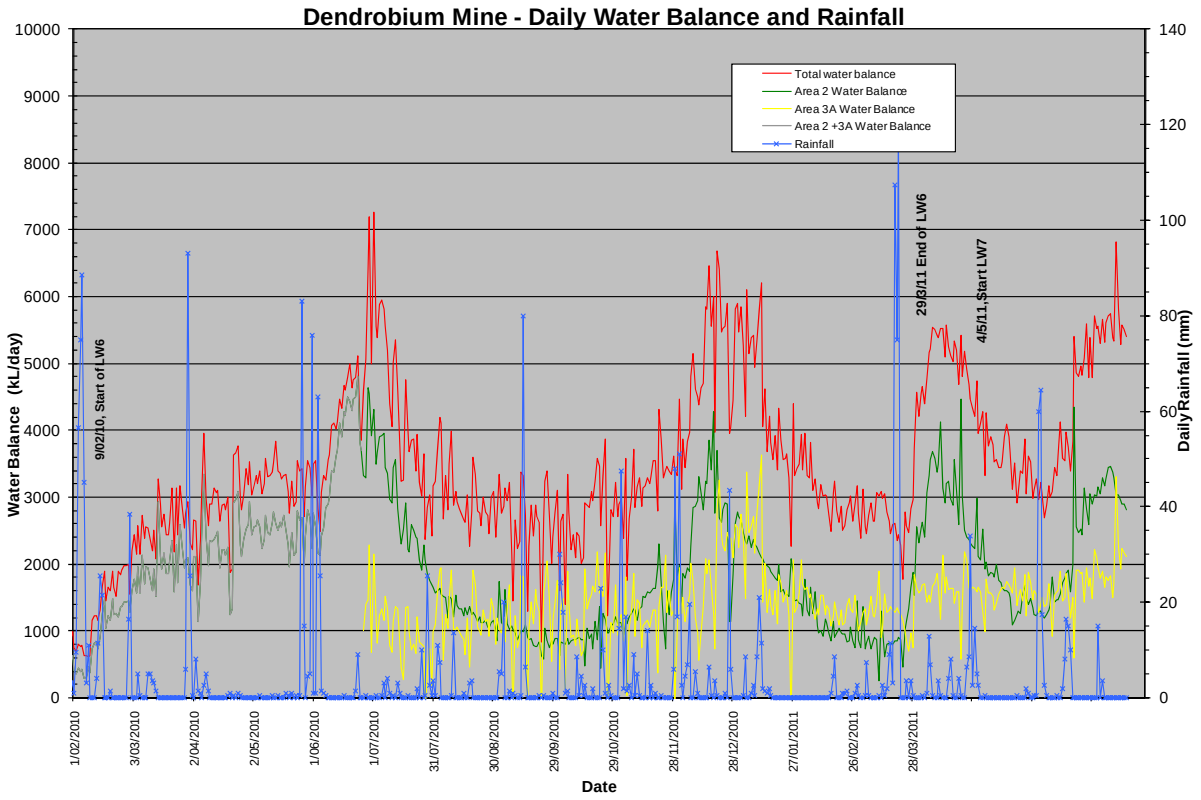

Figure 4.2 – Dendrobium Mine Daily Water Balance and Rainfall

Mine inflow to Area 3A during Longwall 6 extraction averaged 1.3 ML/day with standard deviation 0.6 ML/day. Although this was much lower than the predicted rate of 3-4 ML/day, the maximum Area 3A inflow of 3.6 ML/day (on 11 January 2011) fell within the predicted range. The low inflow rates support the model-based contention that there will be negligible loss of water from the Cordeaux Reservoir to Area 3A.

Two high inflow events for the entire mine occurred during Longwall 6 excavation with peak inflows of 7.2 ML/day (29 June – 1 July 2010) and 6.7 ML/day (16-21 December 2010). The corresponding Area 3A rates were 2.3 ML/day and 3.3 ML/day. The December high inflow event occurred in both Area 2 and Area 3A, with the Area 3A peak response following about 6 days later.

It is expected that the Principal Response Flowchart will be revised in 2011 to accommodate the additional groundwater make from Area 3A.

5. IMPACTS TO NATURAL SURFACE FEATURES

Natural features in the vicinity of Dendrobium Longwall 6 are shown in **Figure 5.1** (Source: MSEC488-04 in **Attachment A**). These features include the following:

- ❒ Wongawilli Creek,
- ❒ Sandy Creek,
- ❒ Sandy Creek Waterfall,
- ❒ Drainage lines,
- ❒ Cliffs and rock outcrops,
- ❒ Steep slopes,
- ❒ Swamps, and
- ❒ Archaeological sites.

Monitoring activities for natural surface features within Dendrobium Area 3A relate to the following major categories. These are:

- ❒ Cordeaux catchment landscape features including cliffs and steep slopes;
- ❒ Water flow and quality monitoring;
- ❒ Hydrogeology;
- ❒ Aquatic ecology monitoring;
- ❒ Terrestrial flora and fauna monitoring.

Assessments of the condition of the area pre and post mining have been provided by IC and relevant specialist consultants, and are summarised in the sections below. Landscape features have been monitored by the Illawarra Coal Environmental Field Team and GSSE; water flows and quality have been assessed by Ecoengineers and IC Field Team. Biosis Research has undertaken monitoring of the terrestrial vegetation and archaeological sites and Cardno Ecology Lab (CEL) has assessed aquatic ecology.

The observed impacts on natural features in the vicinity of Longwall 6 were similar to or less than the predicted impacts.

Table 5-1: Summary of Predicted and Observed Impacts on Natural Features Resulting from Dendrobium Longwall 6

Natural Feature	Predicted Impacts	Observed Impacts
Landscape Features		
Cliffs and Rock Outcrops	Fracturing of bedrock which could result in cliff instabilities or rockfalls along the exposed rockfaces	Fracturing and rockfalls observed
Steep Slopes	Potential for soil slippage resulting in tension cracks and compression ridges	Some surface cracking and soil displacement observed along the tracks and in vegetated areas.
Wongawilli and Sandy Creeks	Possible for some very localised additional ponding or flooding developing in the locations of existing pools, steps or cascades	No reported impacts
	Some minor fracturing of the bedrock within 400 metres of the longwalls	No reported impacts
	Unlikely that surface water flow diversions would occur	No reported impacts
Sandy Creek Waterfall	Rockfalls unlikely with the implementation of monitoring and management strategies including a trigger action response plan	No reported impacts
Drainage Lines	Some localised additional ponding, flooding or scouring	No reported impacts
	Some buckling and fracturing of the bedrock	Minor fractures and a small rock fall

Table 5-1: Summary of Predicted and Observed Impacts on Natural Features Resulting from Dendrobium Longwall 6

Natural Feature	Predicted Impacts	Observed Impacts
	along the drainage lines above or within 250 metres of the longwalls	observed in WC17 and WC19. No impacts to pools or flows.
	Some surface water flow diversions into the dilated strata beneath the drainage lines which are directly mined beneath	No reported impacts
Swamps	Potential for fracturing of the underlying strata which could result in the diversion of surface water. Possible localised ponding.	Minor cracking observed in WC17, but no loss of surface water flow.
Surface waters		
Wongawilli & Sandy Creeks (3rd order permanently flowing creeks)	Minor fracturing possible No water loss from pools No significant flow or water quality from outflows	No fracturing observed in either creek. No water loss observed No significant impacts to outflows or water quality
Other permanently flowing creeks (1st & 2nd order)	Fracturing resulting in water loss from some permanent pools	Minor fractures observed but no associated water loss
Ephemeral creeks (1st order creeks)	Fracturing resulting in reduced water retention time in some ephemeral pools	No ephemeral pools were fractured
Swamps		
Swamps 12 and 16	Fracturing of rockbars resulting in loss of some pool water or permanent surface flow	No loss of surface flow through rockbar fractures has been observed in Swamp 12 or 16
	Fracturing of some outcropping bedrock	No outcropping bedrock fractures observed
	Soil cracking due to subsidence strain	No soil cracking observed
	No significant impact on geochemistry or hydrology	No significant impact on geochemistry or hydrology observed
Bulk Drinking Water		
Lake Cordeaux	Negligible impact on bulk drinking water quality in Lake Cordeaux	Negligible impact on drinking water quality in Lake Cordeaux.
Groundwater		
	Only minor reductions in head expected in the Wongawilli Seam due to the extraction of Longwall 6, as substantial depressurisation has already occurred due to development headings.	Minor reductions in head of 5-20 m have been observed over Area 3A.
	Large reductions in Wongawilli Seam head expected in Area 3B as Area 3A mining activities erode the natural pre-mining levels in Area 3B.	Drawdowns in excess of 30 m are observed in the eastern half of Area 3B and the southern part of Area 3A.
	No further drawdown in deeper formations in Area 2, as heads there should have stabilised. Minor drawdown (about 2 m) could occur in the Bulgo Sandstone over LW5.	No more than 5 m drawdown has been recorded in any deeper formation in Area 2 (Scarborough Sandstone and below). In most cases recovery of several metres has been observed. In the Bulgo Sandstone, two measurements of 4 m and 6 m have been recorded to the west of LW5.
	Fairly uniform drawdowns of 10-20 m expected in the Bulli Seam over Area 3A when LW6 is mined, with larger focussed drawdown over the mined panel.	Drawdown in the Bulli Seam is fairly uniform over all of Area 3A and the eastern half of Area 3B. The drawdown magnitude of about 40-

Table 5-1: Summary of Predicted and Observed Impacts on Natural Features Resulting from Dendrobium Longwall 6

Natural Feature	Predicted Impacts	Observed Impacts
		60 m is greater than expected.
	Fairly uniform drawdowns of 5-20 m expected in the Scarborough Sandstone over all of Area 3A when LW6 is mined. Mild recovery of 2-5 m is expected over LW5 in Area 2.	Over Area 3A the drawdown is fairly uniform at about 10-20 m in agreement with expectations. There is one isolated drawdown of 40 m which is a probable anomaly. There is one measurement of 2 m recovery to the immediate west of LW5 in Area 2, in agreement with the prediction. The highest drawdowns (generally 30 m) occur in the western half of Area 3B (beyond the model domain).
	Fairly uniform drawdowns of 5-10 m expected in the Bulgo Sandstone over all of Area 3A when LW6 is mined.	Drawdown in the Bulgo Sandstone is typically 5-10 m in Area 3A, in agreement with the prediction, and in Area 3B (beyond the model domain). There is one isolated drawdown over LW7 of 50 m.
	No head reduction expected in the Hawkesbury Sandstone due to mining.	In general, the Hawkesbury Sandstone heads are unaffected by the excavation of LW6 or the concurrent development headings. An exception occurred in the Lower Hawkesbury Sandstone at Bore S1889 (DDH97) over LW7 where 25 m drawdown was observed during the passage of LW6; the head in the Upper Hawkesbury Sandstone was unaffected. The piezometer depths are 10 m for the Upper Hawkesbury Sandstone and 123 m for the Lower Hawkesbury Sandstone.
	Extraction of LW7, LW8 and LW19 will cause the regions of lowest head to broaden and extend to the south and the west. At the level of the Wongawilli Seam, the low heads are likely to link with those in the Elouera workings to give one large groundwater sink.	For the future.
Aquatic Ecology	Impacts on water quality due to mining induced erosion and fracturing expected to be minor. Unlikely to be major fracturing or pool drainage in Sandy and Wongawilli Creeks. Fracturing could lead to small localised reductions in the availability of aquatic habitat.	No fracturing, gas releases or impacts on water levels in Sandy or Wongawilli Creeks. Minor fracturing observed. Minor impacts identified in ephemeral water course WC19 though none of these were in ephemeral pools. No significant water quality impacts observed.
	Potential subsidence induced ponding, flooding or scouring of banks, and any flow-on effects on aquatic ecology, are unlikely to occur in stretches of Wongawilli and Sandy Creek in the SMP area.	No impacts observed

Table 5-1: Summary of Predicted and Observed Impacts on Natural Features Resulting from Dendrobium Longwall 6

Natural Feature	Predicted Impacts	Observed Impacts
	Any potential impacts on the aquatic biota (including threatened macroinvertebrates) in Wongawilli and Sandy Creeks and their drainage lines are expected to be minor, localised and transient, if at all present. Potential impacts on the aquatic biota in drainage lines would be further limited due to the absence of significant aquatic habitat.	No impacts observed
	Potential impacts on populations of Macquarie Perch	Highly unlikely that this species is in the study area due to it not being observed during targeted surveys and the presence of significant barriers to fish passage. No additional targeted surveys are considered necessary.
Terrestrial Ecology Vegetation Communities and Fauna Habitat	Impacts to Sandy and Wongawilli Creeks; localised increased ponding and flooding. Impacts to tributaries; minor fracturing of creek beds water diversions, possible increased ponding and scouring.	Minor impacts to tributaries. No significant impacts to plant communities or fauna habitat were observed.
	Cracking of surface rock and soils on slopes. Possible compressive ridges at the bottom of slopes. Localised impacts to flora and fauna habitat.	Cracking of both soil and surface rock resulting in an area of localised dieback of native vegetation. Larger cracks forming pitfalls for small fauna species.
	Possible cliff instability or rockfalls due to fracturing of bedrock with localised impacts on flora	Rock falls with localised impacts on flora located beneath the falls
	Upland Swamps unlikely to be affected by changes in water levels and therefore no significant impacts on associated flora and fauna habitat	No impact to upland swamps observed.
Threatened Fauna	A significant local impact upon four species: Giant Burrowing Frog, Littlejohn's Tree Frog, Red-crowned Toadlet and the Giant Dragonfly.	No significant impacts observed.
Threatened Flora	None	None
Archaeological Heritage		
Archaeological Sites	Potential impacts on overhang sites included fracturing of sandstone, isolated rock falls, and water seepage through joints which may affect artwork. The overall risk of this occurring was considered negligible to moderate.	Expansion of vertical joint in one rock art site (SCR25).

The results of each of the monitoring programs and impact assessment are discussed further below.

5.1 Landscape Monitoring

The IC Field Team and GSS Environmental have undertaken monitoring of the landscape features before, during and after mining as set out in the SMP Part B and associated management plans.

Details of the monitoring undertaken are contained in the Field Team's End of Panel report, provided as **Attachment B**. Regular inspections of the surface features above the extracted portions of Longwall 6 were conducted including the ridgelines, drainage lines and slopes in the vicinity. Surface features monitored included water levels in Wongawilli and Sandy Creek and other minor watercourses (WC17, LC3), rock steps and steep slopes, swamps and fire roads. Swamps 12, 15b, 16, have been monitored in accordance with the *Dendrobium Area 3A Swamp Impact, Monitoring, Management and Contingency Plan*, April 2010.

As each impact is identified during monitoring, the impact is numbered and impact reports are prepared providing photographs, location maps and details of each impact. A table summarising each of the impacts identified during the mining of Longwall 6 is included in the Field Team's EOP Report (Table 1.5 in **Attachment B**) and each impact report is also included in **Attachment B**. The location of each site is shown in **Figure 5.2** and details of the location of each site (including numbers) are provided in **Attachment B**.

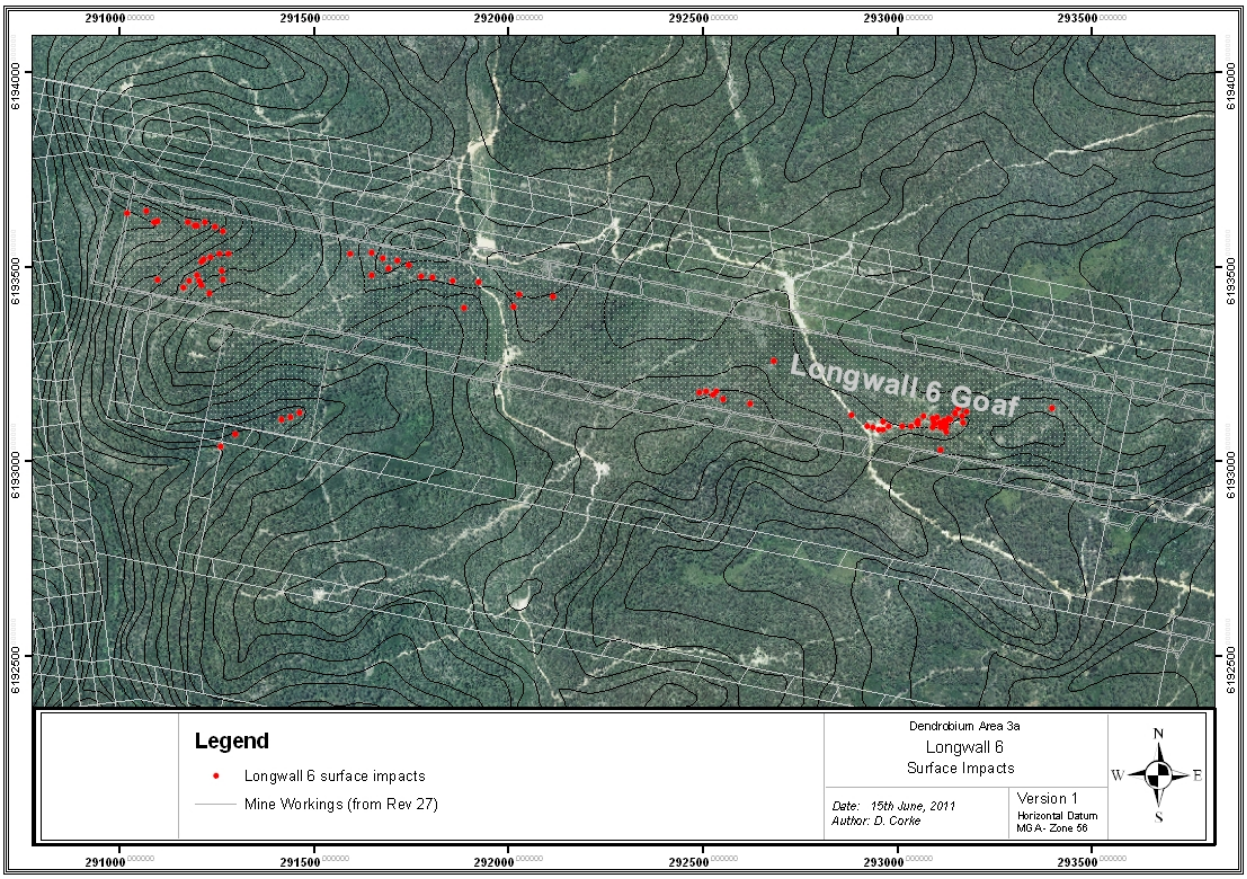

Figure 5.2 – Surface Impact locations above Longwall 6

During the mining of Longwall 6, 89 minor impacts were observed by the IC Field Crew and GSS Environmental. These include soil cracking, fracturing in watercourses, rock fracturing and displacement, and small rockfalls. The nature of the impacts are discussed in the sections below, and specific descriptions of impacts are found in the Field Team's EOP Report and individual impact reports in **Attachment B**.

5.1.1 Rock Outcrops and Steep Slopes

Predicted Impacts

The subsidence strains were considered to be sufficient to result in fracturing of sandstone and therefore result in cliff instabilities or rockfalls along rockfaces. The predicted rockfalls were assessed as most likely to occur where rock outcrops are continuous, massive,

overhanging and marginally stable. Rockfalls were predicted to be unlikely to impact on fire roads or public safety and appropriate management measures were recommended to ensure the safety of personnel in the area during the mining period. With such measures in place, it was regarded as unlikely that there would be significant impacts associated with rock outcrops due to the extraction of Longwall 6.

The predicted subsidence strains at the steep slopes were considered likely to be of sufficient magnitude to result in surface cracking, due both to tensile strains and buckling of bedrock associated with compressive strains. Downhill slumping was also considered possible though large-scale slope failure was regarded as unlikely. Appropriate monitoring and remediation measures were recommended to prevent erosion developing and with such mitigation measures in place it was considered unlikely that there would be any significant impact on the environment due to surface cracking.

Observed Impacts on Rock Outcrops and Steep Slopes

There have been multiple minor impacts identified by the IC Field Team, the majority of which are soil cracks and rock fractures over Longwall 6 (see **Figure 5.2**). The Field Team's report provides information on representative impacts while the individual impact reports provide details on all the impacts (**Attachment B**).

There are 67 locations where rock displacement and/or rock fractures have been observed on the edge of rock shelves, outcrops and within rock platforms in the area above and adjacent to Longwall 6. Some of these fractures are visible as fractures on vertical rock faces (eg. DA3Longwall 6_027) while others are evident at the surfaces of flat rock shelves or platforms or in creeks (eg. DA3Longwall 6_038). They vary considerably in nature, from short hairline fractures (eg. DA3Longwall 6_044) to large cracks that may be 300 mm wide, 85 m long and some 4 m deep (eg. DA3Longwall 6_002). Natural processes have already completely filled some of the smaller cracks and larger cracks are being monitored and remediation options identified should they be required.

Eight rock falls have been identified in the area. These falls vary from small rocks of approximately 0.5 m^3 falling from a rock step, to slabs that have fallen from overhangs in creeks (eg DA3Longwall 6_14 in WC19), to a slab of approximately 75 m^3 that fell away from a rock edge (DA3Longwall 6_004).

Fourteen impact sites have been identified involving soil cracking on fire roads, in vegetated areas and adjacent to rock fracturing. The most minor of these consist of hairline cracks that have naturally filled with sediment and closed over time (eg. Impact DA3Longwall 6_0046). Larger soil cracks have also occurred, including a 400 mm wide crack that extended for 50 m and included part of Fire Road 6C (DA3Longwall 6_062). Given the potential safety issues associated with this soil crack active remediation measures were conducted successfully as discussed further in **Section 7**.

Follow-up inspections have revealed some infilling of cracks and fractures with local sedimentary material. Nine surface impacts have totally filled with sediment since they were first observed. A further four impacts are moderately filled and three impacts filled partially.

At the end of mining all impacts were considered stable with no signs of significant erosion and no significant adverse consequences from the impacts.

The impacts observed associated with Longwall 6 are within the predictions for subsidence impacts for Dendrobium Area 3 and are similar to previous impacts in Dendrobium Areas 1 and 2. With mitigation measures implemented, the impacts identified within Area 3A have had minor consequences as predicted in the Subsidence Management Plan, consisting of ground disturbances that will stabilise naturally and do not impede traffic or pose a significant safety risk.

5.1.2 Watercourses

Four watercourses of the Cordeaux catchment were monitored for impacts by the IC Environmental Field Crew as required by the Dendrobium SMP. These were the 3rd Order permanently flowing creeks, Wongawilli Creek and Sandy Creek; the 1st/2nd Order creek, WC17; and the ephemeral 1st Order creek WC19.

Predicted Impacts on Watercourses

In Wongawilli and Sandy Creeks it was considered possible for some very localised additional ponding or flooding developing in the locations of existing pools, steps or cascades. Minor fracturing within 400 m of the longwalls was also considered possible though no significant loss of water from pools or flow was predicted in these creeks. While regarded as unlikely, it was considered as possible for some localised ponding, flooding or scouring to occur in the watercourses. Possible buckling and fracturing of the bedrock resulting in some pool water loss was considered possible in other permanently flowing un-named creeks and ephemeral creeks.

Observed Impacts on Watercourses

Minor impacts were identified in WC17 and WC19. These impacts were within predictions and no triggers were reached, thus no corrective management actions were implemented. No impacts were observed in Sandy and Wongawilli Creeks or ephemeral drainage lines. In addition, no changes in water flows or ponding were observed in any drainage lines.

Minor cracking and a small rock collapse were observed in WC17, an un-named permanently flowing creek, and WC19, an ephemeral creek, during the mining of Longwall 6. Impact sites consisted of small fractures, buckling on the rockbar and a small rock collapse in an overhang (DA3Longwall 6_41, DA3Longwall 6_42 and DA3Longwall 6_88, DS3Longwall 6_38 and DA3Longwall 6_43). Further details are provided in **Attachment B**. No changes to water flows or pool holding capacities have been observed.

An iron staining plume was evident prior to mining in Wongawilli Creek and this plume became less pronounced during the extraction period. An iron spring was observed on the 25th of June 2010 between Pool 43b and Pool 43a. There was no visible iron leaching from this spring on the latest inspection and the presence of iron leaching in Wongawilli Creek is unlikely to have been increased by mining.

5.1.3 Sandy Creek Waterfall

Sandy Creek Waterfall is located at the point where Sandy Creek flows into Cordeaux Reservoir. A Technical Committee has been established to guide the development and implementation of the Sandy Creek Waterfall Management Plan (SCWMP, IC, 2010). The SCWMP outlined the investigations undertaken to understand the waterfall structure, geology, geomechanics, predicted mining impacts and identify the monitoring and management process to ensure outcomes consistent with the Development Consent.

The Development Consent (Condition 1 of Schedule 3) required that no rockfalls occur at Sandy Creek Waterfall as a result of mining, that the structure integrity of the waterfall not be impacted, that any cracking in Sandy Creek within 30 m of the waterfall is of negligible environmental and hydrological consequence, and that negligible diversion of water occurs from the lip of the waterfall. Further requirement for a Sandy Creek Waterfall Management Plan was issued in an interim approval (24 December 2009 approval, Condition 13).

In order to achieve these requirements, prior to the commencement of mining within Dendrobium Area 3A, Illawarra Coal:

- established a "technical committee" that included BHPB, DPI, MSEC, and independent subsidence and geotechnical experts to advise on Sandy Creek Waterfall,
- prepared a Sandy Creek Waterfall Management Plan, and
- developed and implemented detailed management outcomes such as a Trigger, Action, Response Plan (TARP) triggers and detailed monitoring where Longwalls 6-8 approach the Sandy Creek Waterfall.

The TARP and relevant management and/or mitigation plans were finalised and agreed by the Technical Committee before the longwall retreat was within 700m of the Sandy Creek Waterfall, and addressed triggers to initiate early longwall take off at either of the pre-installed points, should monitoring have indicated this was necessary.

Sandy Creek Waterfall Predicted Impacts

It was predicted that rockfalls would be unlikely at Sandy Creek Waterfall with the implementation of the monitoring and management strategies developed by the Technical Committee.

Sandy Creek Waterfall Observed Impacts

No impacts to Sandy Creek Waterfall were observed. In line with the requirements of the consent, no rockfalls have occurred from the waterfall or its overhang and no cracking of the rock mass has been recorded at or near the waterfall.

5.1.4 Swamps

Swamps 12, 15a, 15b and 16 are located within or partially within valleys of drainage lines that could be affected by the Longwalls 6-8 and 19 and Swamps 12 and 16 are closest to Longwall 6 though neither lie directly over it (see **Figure 5.1**).

Predicted Impacts on Swamps

Predicted subsidence and tilt in these areas could result in increased water levels above the centrelines of the longwalls and decreased water levels above the chain pillars and longwall goaf edges though Swamps 12 and 16 are both outside the Longwall 6 footprint. Changes in water levels could impact vegetation however no significant changes in water levels were predicted as a result of subsidence or tilt.

Fracturing, buckling and dilation of the topmost bedrock and associated soil cracking was expected at joints and bedding planes. Loss of some pool water or permanent surface flow could have occurred. This was considered unlikely to have a significant impact on the sediments or aquifers and hence the swamps.

Observed Impacts on Swamps

Sites within Dendrobium Swamps 12 and 16 and the downstream watercourses, WC17 and LC3, were monitored by the IC Field Team to characterise swamp morphology and encapsulate changes due to natural processes and possible mining impacts.

Swamp 12: Observational and photographic data and soil parameters were recorded on a routine basis at four sites within Dendrobium Swamp 12. Water quality, water level, observational and photographic data were recorded at eighteen sites in WC17. No surface water loss was observed through fractures, and no soil cracking was recorded.

Swamp 16: Observational and photographic data and soil parameters were recorded on a routine basis at five sites within Dendrobium Swamp 16. Water quality, water level,

observational and photographic data were recorded at seven sites in LC3. No surface water loss was observed and no soil cracking was recorded.

5.1.5 Gas Releases

It was considered unlikely that gas emissions would be a significant issue for Dendrobium Area 3A. No gas emissions have been identified in any of the monitored creeks as a result of Longwall 6.

5.2 Surface Waters

Since 2004 Ecoengineers has been engaged by BHPBIC to study, review and report on the results of water quality testing undertaken on water bodies above and adjacent to Dendrobium Mine and to assess the chemical and ecological impacts of longwall mining on surface water catchment areas, including tributaries of Lake Cordeaux, and upland swamps in the Wongawilli Creek and Sandy Creek catchments.

The report prepared by Ecoengineers reviews all available hydrological and water quality data obtained for the Wongawilli Creek Catchment and the Sandy Creek Catchment (situated over and adjacent to Dendrobium Longwall 6) up to the completion of Longwall 6. The material below summarises the assessment of pre and post mining conditions, and the full report prepared by Ecoengineers is provided in **Attachment C**.

To assess the surface hydrology of the area the following components were used by Ecoengineers:

- surface water quality;
- rainfall data;
- hydrologic modelling using flow rate monitoring & the Dutch RUNOFF2005 hydrologic model;
- groundwater piezometers

Prior to, during and after the mining of Longwall 6, field assessments of landscape condition (including cracking of soils and outcropping rock and slope movement) have been carried out by the IC Field Team and surface water quality has been collected by Ecoengineers, IC Field Team and Manly Hydraulics Laboratory (MHL). This data was used by Ecoengineers in the preparation of its report.

Surface Water Monitoring Sites: The surface water monitoring sites associated with Dendrobium Area 3A are shown in **Figure 5.3** and include:

- Lower Wongawilli Creek (WWL2)
- Upper Donald's Castle Creek (DCU3)
- Middle Wongawilli Creek at three locations (WWM1, WWM2 and WWM3)
- Upper Wongawilli Creek at two locations (WWU1 and WWU4)
- Lower Sandy Creek (SCL), also visited bi-monthly by MHL
- Creek SC10 also known colloquially as Banksia Creek (B1)
- Creek SC10C Pool 0 also known colloquially Banksia Creek Tributary (BCT)
- Creek SC7 also known colloquially as Cascade Creek (C1) and
- Upper Sandy Creek (SCU) monitored by Manly Hydraulics Laboratory (MHL).

The closest water quality sites to Longwall 6 are Wongawilli Creek Middle 3 site (WWM3) to the west, and Lower Sandy Creek site (SCL), Creek SC10 site and Creek SC10C Pool 0 to the south.

Swamps: Four upland swamps were recognised as having the potential to be affected by the mining operations in Dendrobium Area 3A (including Longwall 6). These swamps were

identified in the Dendrobium Area 3A Swamp Impact, Monitoring, Management and Contingency Plan (Good *et al.* 2010 in **Attachment C**) as;

- Swamp 12, Pool 3.
- Swamp 15a, Pool 10A (also referred to as SC10 Pool 10A).
- Swamp 15b, Pool 0 (also referred to as SC10C Pool 0).
- Swamp 16, Pool 2.

Ecoengineers has analysed the field and laboratory water data from the pool furthest downstream in each swamp. The location of the swamps is shown in **Figure 5.4**.

Rainfall: Rainfall data for Dendrobium Area 3A as recorded by Hydrometric Consulting Services (HCS) at the Dendrobium Area 3 Centroid Rainfall Station and the SCA's Browns Road Rainfall Station is presented in **Attachment C**.

Flow Monitoring: Nine hydrographic gauging stations were installed by Hydrometric Consulting Services ('HCS') to monitor flow rates within the waterways of the Sandy Creek and Wongawilli Catchment areas and their associated sub-catchments (for maps see Section 4 of **Attachment C**). The hydrographic gauging stations are comprised of a water level logging pressure transducer located behind a natural control such as a rock bar or in some cases a small constructed weir. The logging transducer records instantaneous flow rates every 15 minutes and computes average flow rates (ML/day) every six hours. Ecoengineers have used the Dutch RUNOFF2005 hydrologic model for the hydrologic assessment of the above catchments, and details are provided in **Attachment C**.

Shallow Groundwaters: For assessing impacts on shallow groundwater levels in and around upland swamps, BHPBIC Field Team maintains a number of shallow piezometers and several deeper boreholes installed into the outcropping Hawkesbury Sandstone. The piezometers used in the assessment include:

- Piezometers 12_01, 12_02, 12_03 and 12_04 situated in upland Swamp 12 which drains west into Wongawilli Creek.
- Piezometers 15a_03 and 15a_17 are situated in Swamp 15a which drains north- east into Creek SC10.
- Piezometers 15b_21, 15b_27, and 15b_32 are situated in Swamp 15b which drains east into Creek SC10C which is a tributary of Creek SC10.
- Piezometer LC3_02 is situated in the uphill end of Swamp 16 which is associated with drainage line LC3 and drains east into the Sandy Creek Arm of Lake Cordeaux.

Further details of the monitoring undertaken for the assessment are provided in **Attachment C**.

5.2.1 Predicted Surface Water Impacts

The water quality impact assessment for Dendrobium Area 3A, prepared by Ecoengineers was summarised in the *Environmental Assessment for Modification to Dendrobium Area 3* (Cardno Forbes Rigby 2007). The assessment noted that the mine plan included longwall set-back distances designed to avoid significant cracking and surface water loss in major creeks including Sandy and Wongawill Creeks.

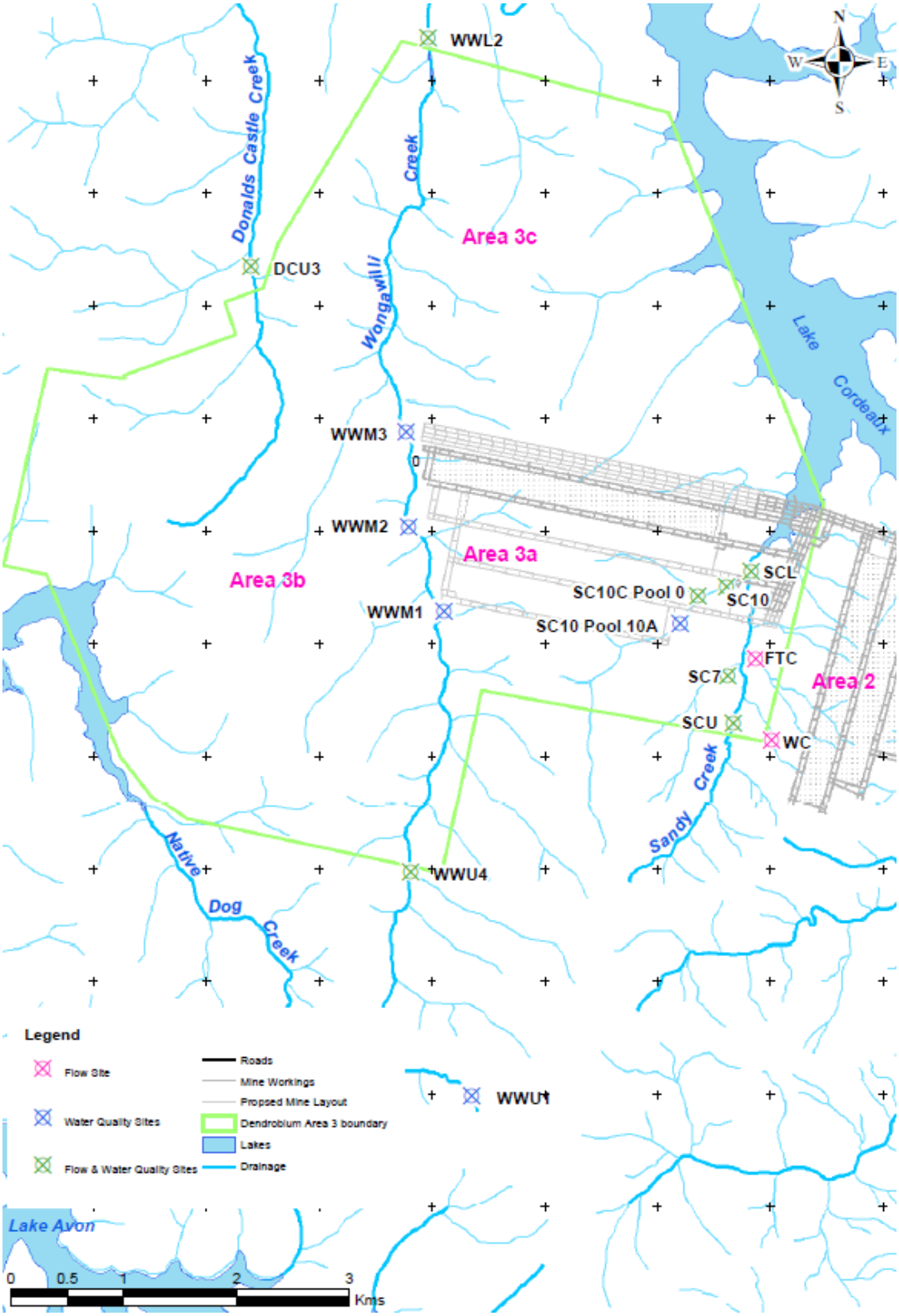

Figure 5.3- Surface Water Monitoring Sites.
(Note Wongawilli Middle 3 = WWM3; Lower Sandy Creek = SCL; Creek SC10 = 'Banksia Creek'; and Creek SC10C = 'Banksia Creek Tributary').

Figure 5.4 - Upland Swamps associated with Dendrobium Area 3A.

The assessment concluded that the predicted subsidence effects on surface waters were:

- ❒ unlikely to cause any significant increases in levels of ponding, flooding, or scouring of creek banks. While it was considered possible there could be some very localised increased levels of ponding or flooding (where maximum tilts coincided with existing pools, steps or cascades along the creeks) any changes were not expected to result in significant impacts;
- ❒ unlikley to cause significant channel bed fracturing or subsequent sub-bed diversions, hydrologic and geochemical effects or loss of pool water in Sandy and Wongawilli Creeks. Minor fracturing, while considered possible, was not predicted to result in significant water flow diversions;
- ❒ unlikely to result in detectable losses of flows or significant impacts on water quality from outflows from Sandy and Wongawilli Creek catchments;
- ❒ unlikely to result in significant erosive effects that would impact water quality;
- ❒ unlikely to significantly affect swamp geochemistry or hydrology; and
- ❒ unlikely to adversely affect bulk drinking water quality in Lake Cordeaux.

5.2.2 Observed Surface Water Impacts

Data for pH, EC and ORP at all monitoring sites within Dendrobium Area 3A were analysed to identify any significant changes in water quality resulting from the mining of Longwall 6. TARP trigger values were established by the Dendrobium Colliery Area 3A Subsidence Management Plan (SMP) for each parameter. There were three levels of TARP trigger values (increasing in severity) for pH, EC and ORP:

- ❒ Level 1 (Predicted). Temporary reduction in water quality (observed for less than two months) when comparing the baseline period to the mining period. Specifically, a pH decrease of 1.5 pH units, EC increase of 50 µS/cm and/or ORP decrease of 150 mV.

- ❒ Level 2 (Predicted). Temporary reduction in water quality (observed for less than two months) when comparing the baseline period to the mining period. Specifically, a pH decrease of 2.0 pH units, EC increase of 100µS/cm and/or ORP decrease of 200 mV.
- ❒ Exceedance of predicted impacts and a major reduction in water quality (observed for more than 2 months) when comparing the baseline period to the mining period. Specifically, this was a pH decrease of 2.0 pH units, EC increase of 100 µS/cm and/or ORP decrease of 200 mV.

Water Quality

During the period 9 February 2010 to 12 July 2010, Longwall 6 mined beneath the Wongawilli Creek catchment. Data obtained from environmental monitoring shows that key water quality parameters measured immediately downstream of Longwall 6 (site WWM3) and for the Greater Wongawilli catchment area (site WWL2 approximately 4.5 km to the north) did not exceed the TARP limits. Water quality monitoring just downstream of Swamp 12 at Pool 3, in the tributary designated WC17 also indicated that water quality there was not impacted by the mining of Longwall 6.

From 12 July 2010 to the completion of Longwall 6 on 28 March 2011, the longwall mined beneath the catchment of Sandy Creek. Water quality assessments carried out throughout this catchment also showed no exceedances of TARP limits or any other geochemical effects of aquatic ecological concern. This was found to be the case for monitoring sites in close proximity to the longwall (sites SC10 and SC10C) as well as for the Greater Sandy Creek catchment monitoring station (SCL) near the Creeks discharge point into the Sandy Creek Arm of Lake Cordeaux. Water quality monitoring of Swamps 15a and 15b (at sites SC10 Pool 10A and SC10C Pool 0, respectively) within the Sandy Creek catchment area also indicated no degradation of pre-mining water quality as a result of the mining of Longwall 6.

There were no discernable impacts on the water quality of the Wongawilli Creek or Sandy Creek catchments, their local sub-catchments or the swamps within those sub-catchments as a consequence of the mining of Longwall 6.

In Swamp 16 there were three Level 1, ORP TARP exceedances at Pool 2 during the mining period however, it is unclear whether these ORP TARP exceedances are mining related. The ORP TARP exceedances were on the 30 August (229.0 mV), 21 September (206.0 mV) and 18 November 2010 (235.0 mV). There were minor increases in sulfate (SO_4) concentrations and sharp increases in filterable iron and manganese respectively during the mining of Longwall 6 which tends to support the conclusion that the ORP TARP exceedances may be associated with impacts of the mining of Longwall 6. On the other hand, there were no visual subsidence-related impacts to Swamp 16 observed by the IC Environmental Field Team, and there have been no further ORP TARP triggers since November 2010 (i.e. from before the completion of Longwall 6). There was also nothing unusual about shallow groundwater levels in piezometer LC3_02 located near Swamp 16. These were the only possible water quality impacts identified in the area.

Hydrology

Rainfall data obtained at the Dendrobium Area 3 Centroid Rainfall Station established on 1 January 2008 and stream flow data collected from that date was used to determine key hydrologic performance parameters for the Greater and Lesser Wongawilli Creek catchment areas, the Greater Sandy Creek catchment area and the relevant Sandy Creek sub-catchments (SC10 and SC101A) under baseline pre-mining conditions.

Ecoengineers concluded that there is no evidence that the mining of Longwall 6 has had any discernible impact on the hydrologic performance of Wongawilli or Sandy Creek catchments or important local sub-catchments of Sandy Creek.

Shallow Groundwater

Shallow groundwater level records for ten local shallow piezometers were compared with the local daily rainfall as measured at the Dendrobium Area 3 Centroid Rainfall Station during and after the Longwall 6 mining period. These comparisons showed that the mining of Longwall 6 did not appear to have any noticeable adverse effect on local groundwater levels in and around Swamps 15a, 15b, 12 and 16. Fluctuations in the groundwater levels occurred in response to rainfall events in the catchment.

While the rainfall and shallow groundwater plots demonstrate that the fluctuating groundwater levels are responding to local precipitation, it was observed that many of the piezometers either show regular occurrences of 'drying up' or appear to maintain a consistent water level during the mining and post-mining period. Comparison of the shallow groundwater levels record with the cumulative monthly rainfall mass residual showed that the general decline in water levels and the drying out ('flat lining') of most piezometers after the end of the Longwall 6 mining period (see **Attachment C**) was a consequence of the general drying of the Dendrobium Area 3A area over the June 2008 to March 2010 period.

Ecoengineers concluded that the observed impacts on surface water quality of the mining of Longwall 6 were fully consistent with the nature of predicted impacts.

Drinking Water

Given that the impacts on the water quality and hydrology of Sandy Creek and its sub-catchments has been insignificant, the impacts on the bulk water supply in Lake Cordeaux has been negligible, which is in line with predictions. This is confirmed by the lack of changes to the hydrology and water chemistry at the Lower Sandy Creek monitoring site.

5.3 Groundwater

Heritage Computing (HC) was been engaged by IC to prepare an assessment of environmental consequences of Longwall 6 extraction on groundwater conditions. The full report is provided in **Attachment D** and summarised below.

A regional approach has been adopted for the groundwater monitoring in Area 3, supplemented by focused monitoring between Longwall 6/Longwall 7 and the Sandy Creek arm of the Cordeaux Reservoir. A map of the monitoring sites in Area 3A is shown in **Figure 5.5** and maps of the sites in Area 1 and Area 2 are provided in **Attachment D**. Groundwater monitoring at Dendrobium Mine is conducted in accordance with the "Dendrobium Colliery Area 3A SMP Groundwater Management Plan" (April 2010).

Heritage Computing report HC2009/2 (Merrick, 2009) provides an assessment of groundwater conditions and local geology. A local 3D numerical groundwater model has been deployed recently to give more quantitative groundwater predictions than has been possible in the past. Due to the local scale of this model, the predictions are of an interim nature and will be improved by a more robust regional model that is currently being developed. Predicted groundwater responses are documented in Heritage Computing reports HC2010/15 (Merrick & Akhter, September 2010) and HC2010/16 (Merrick & Akhter, October 2010) as outlined in **Attachment D**.

5.3.1 Predicted vs Observed Hydrogeologic Impacts

Based on field electrical conductivity measurements, there is no clear spatial pattern in the distribution of groundwater quality in Hawkesbury Sandstone and Bulgo Sandstone bores, but there is a clear increase in salinity with depth from the Hawkesbury Sandstone to the Bulgo Sandstone and down to the goaf waters. During the extraction of Longwall 6, Area 3A goaf waters were roughly half the salinity of Area 2 goaf waters but they followed a very similar temporal pattern. Elevated values from November 2010 to January 2011 in both areas were in good agreement with the timing of enhanced mine inflows in both areas.

Hawkesbury Sandstone heads were unaffected by the extraction of Longwall 6 or concurrent development headings. There was one exception at Bore S1889 (DDH97) over Longwall 7 where 25 m drawdown in the lower Hawkesbury Sandstone was observed during the passage of Longwall 6, but the head in the upper Hawkesbury Sandstone was unaffected.

The downhole piezometers nearest the Sandy Creek waterfall showed minor depressurisation in the Wongawilli Seam but barely any change in the heads in overlying formations during the extraction of Longwall 6. The depressurisation was expected due to the extensive workings in the Wongawilli Seam. Apart from the Wongawilli Seam, the heads were maintained at an elevation above the Cordeaux Reservoir water level. In addition, an elevated pressure saddle in the Bulgo Sandstone and the Scarborough Sandstone has established between Longwall 6 and the Sandy Creek arm.

Groundwater head reductions in the deeper formations and coal seams were in good general agreement with predictions of spatial pattern and drawdown magnitude, with the exception of the Bulli Seam where drawdowns of about 40-60 m were greater than expected and the decline pushed well into Area 3B.

In agreement with predictions, the Wongawilli Seam showed only minor (5-20 m) reductions in head over Area 3A because most of the depressurisation had already occurred as a result of development headings. As predicted, the largest Wongawilli Seam drawdowns occurred in Area 3B and to the south of the Area 3A longwalls. This suggests that the initial heads in those areas were close to natural levels and the mining activities in Area 3A were impacting Area 3B and farther south in Area 3A.

Recovery of a few metres of head in most formations was evident in Area 2 between February 2010 and March 2011. This is in agreement with predictions.

5.4 Aquatic Ecology

Cardno Ecology Lab (previously The Ecology Lab) has undertaken baseline, during and post-extraction mining surveys of the aquatic ecology in accordance with the SMP for Dendrobium Area 3A and the report is provided in full in **Attachment E** and the key findings are summarised below. Cardno Ecology Lab (2006) prepared baseline reports for Dendrobium Area 3 (see **Attachment E**) and the main findings are as follows.

- Aquatic habitat within the reach of Wongawilli Creek in the SMP area consists of a series of long pools separated by small sandstone rockbars, sandbars, debris accumulations and small boulder fields. The channel contains numerous in-stream habitat features and a diverse range of aquatic habitats and is considered significant aquatic habitat. The mid to lower reaches of Sandy Creek within the SMP area have extensive and diverse habitat and are also considered significant aquatic habitat. The upper reaches of Sandy Creek and the entire catchment of Banksia Creek (within the Sandy Creek catchment) are considered moderate aquatic habitat;
- Habitat assessment undertaken in the catchments of Wongawilli and Sandy Creek based on the Riparian, Channel and Environmental Inventory (RCE) indicated that water courses in these catchments were natural, undisturbed systems. Similar scores were recorded at potential impact and control sites and scores did not change over the course of baseline monitoring.
- Macroinvertebrate species sampled within the mine area indicated that potential impact and control sites were generally in good condition, although some sites were assessed as impaired relative to reference conditions on some sampling occasions. No threatened species of invertebrates were found, however, there is suitable habitat for the Sydney hawk dragonfly (Austrocordulia leonardi) and Adams emerald dragonfly (Archaephya adamsi) and it is possible that they may occur in the study area;

- Four species of native fish: Australian smelt (Retropinna semoni), climbing galaxias (Galaxias brevipinnis), longfinned eel (Anguilla reinhardtii), shortfinned eel (Angilla australis) and the native freshwater crayfish (Euastacus sp.) were identified in Dendrobium Area 3A.
- No listed threatened species of fish were found. It is considered highly unlikely that Macquarie perch (Macquaria austrakasica), a species listed as vulnerable under the Fisheries Management Act, 1996 occurs within the area, because of the presence of significant barriers to their upstream passage;
- Aquatic macrophytes were limited to Wongawilli Creek, with only milfoil (Myriophyllum sp.) found within the SMP area for DA3A. Spike rush (Eleocharis sp.) was present downstream of the Dendrobium Area 3A footprint.

Monitoring undertaken involves a comparison of data collected from two potentially impacted creeks, Wongawilli Creek, and Sandy Creek, and their tributaries, with that obtained from baseline surveys at control sites on Wongawilli, Sandy, Donalds Castle and Kentish Creek. Monitoring includes direct measures of aquatic biota as well as biophysical measures. Further details of the monitoring carried out are provided in **Attachment E**.

5.4.1 Predicted Impacts on Aquatic Ecology

Small localised reductions in the availability of aquatic habitat were predicted in the event that flow diversions or fracturing occurred. Potential subsidence induced ponding, flooding or scouring of banks, and any flow-on effects on aquatic ecology, were considered unlikely to occur in stretches of Wongawilli and Sandy Creek in the SMP area and therefore unlikely to impact aquatic ecology. Subsidence induced impacts on the aquatic ecology of smaller drainage lines was predicted to be minor, localised and transient, if present at all.

Threatened Species Habitat

The impact assessments undertaken by The Ecology Lab (2007) indicated that the proposed longwall mining in Dendrobium Area 3A did not pose a significant threat to any potential population of Macquarie perch, or the potential populations of Sydney hawk dragonfly and Adams emerald dragonfly.

5.4.2 Observed impacts on Aquatic Ecology

No evidence of subsidence, upsidence, fracturing or any impacts on water depth, flow or connectivity were observed by Cardno Ecology Lab during the 2010 surveys, and this was supported by photographic records taken in the field. Water quality data collected by Cardno Ecology Lab provided no evidence of any decline in water quality between baseline and during-extraction monitoring. Thus no evidence of impacts on aquatic ecology was observed by Cardno Ecology Lab.

No changes were observed to quatic habitat present in Sandy and Wongawilli Creek catchments in the SMP area. Water levels in Sandy and Wongawilli Creeks have been consistent throughout the extraction of Longwall 6 and no water level changes were observed in the photographic records. Similarly, no gas releases or fracturing were observed. No significant water quality impacts occurred and no impacts on any aspect of aquatic ecology monitored by Cardno Ecology Lab were identified.

Cardno Ecology Lab found no observable reduction in the availability of aquatic habitat and no evidence of any impairment in the macroinvertebrate fauna or any other aquatic biota that could be linked with extraction of Longwall 6.

Threatened Species Habitat

No evidence of impacts on threatened macroinvertebrates was observed.

Intensive fish surveys targeting Macquarie perch in Wongawilli Creek in 2008 and 2009 failed to locate any populations that could potentially be affected by mining activity in DA3A (Cardno Ecology Lab 2009). On the basis of this finding and the presence of significant barriers to fish passage directly upstream of the crossing at Fire Road 6, it was recommended that no further targeted sampling of this threatened species within the proposed Area 3A footprint was necessary .

5.4.3 TARPs and Conclusion

Two aspects of Principal Trigger-Action-Response-Plans (TARPS) were considered by Cardno Ecology Lab (2011). The aspect incorporating pool water level, interconnectivity, connectivity, noticeable alteration of habitat and fish kills was not triggered as all relevant observations were within predictions. The quantitative sampling for Macquarie Perch was not triggered because following targeted surveys this species it was considered highly unlikely for this species to be present within the SMP area. As such, this trigger is no longer considered applicable.

On the basis of the above results, there is no evidence of impacts on aquatic ecology resulting from habitat reduction or loss, or from change in water quality due to mine subsidence following the extraction of Longwall 6. This conclusion is consistent with predictions of impacts for aquatic ecology.

5.5 Terrestrial Flora and Fauna

Biosis Research compared the findings of the pre-mining ecological assessment and predicted impacts with those observed during a post-mining ecological survey conducted by Biosis Research on 18th March 2011 for Longwall 6. The results of their investigation are summarised below and provided in detail in **Attachment F**.

The study area for Longwall 6 supports six broad vegetation communities as determined by NPWS (NPWS 2003):

- ❒ Exposed Sandstone Scribbly Gum Woodland;
- ❒ Sandstone Gully Peppermint Forest;
- ❒ Upland Swamps Sedgeland Heath Complex;
- ❒ Rock Plate Heath Mallee;
- ❒ Moist Gully Gum Forest;
- ❒ Tall Open Peppermint-Blue Gum Forest;
- ❒ Tall Open Gully Gum Forest.

None of these plant communities are listed as Endangered Ecological Communities on the *Threatened Species Conservation Act 1995* and/or the *Environment Protection and Biodiversity Conservation Act 1999.*

A comprehensive monitoring program is being undertaken to monitor the impacts of longwall mining on the native vegetation within Dendrobium Area 3A.

5.5.1 Predicted impacts on Terrestrial Flora and Fauna

Plant Communities

Predicted impacts on flora and fauna species included potential effects to vegetation adjacent to tributary streams associated with diversion of surface flows. Flows were predicted to re-emerge a short distance downstream of impact areas and this impact was therefore predicted to be localised and not significant to vegetation communities.

Rock cracking and rock falls were predicted to occur, which were expected to have localised impacts on vegetation communities. Similarly, cracks on steep slopes had the potential to displace vegetation and cause roots to become exposed and dry out. Large scale slope failures were considered to be unlikely. Any erosion associated with soil cracking had potential to affect vegetation communities and contribute to siltation in aquatic habitats.

Die-back due to gas emissions were not expected to impact on the local flora.

With mitigation measures proposed it was predicted that significant impacts on flora species were unlikely.

Fauna and Fauna Habitats

Fracturing of bedrock within tributaries was predicted by Biosis to pose a threat of entrapment to fauna species. These fractures were predicted to be minor and therefore did not pose a significant threat of impact to fauna species. Similarly, impacts associated with steep slopes and soil cracking were not predicted to have significant effects on fauna in the area.

With implementation of mitigation measures, no significant impacts on fauna species were predicted.

Swamps

It was considered unlikely that subsidence impacts would have a significant impact on upland swamps in Area 3 and therefore, no significant impact on the flora and fauna of swamps was predicted in the area. It was also noted however, that vegetation communities dependant on groundwater, such as upland swamps, were more likely to be impacted by subsidence than those occurring on ridgetops and on slopes.

Threatened Flora, Fauna and Fauna Habitat

Biosis reported that there were 11 threatened flora species possibly occurring in the study area and that four of these, had potential to be impacted by mining. These species were the Leafless Tongue Orchid (*Cryptostylis hunterianaI*), Bearded Bush-pea (*Pultenaea aristata*), *Epacris purpurascens var purpurascens* and *Leucopagon exolasius*. This assessment was based on the habitat for these species being within groundwater dependent ecosystems that are most likely to be affected by subsidence.

Assessments of Significance (Biosis 2007 in **Attachment G**) for each of these flora species found the impacts of mining were unlikely to have a significant effect on them.

The Species Impact Statement undertaken prior to mining reported 32 threatened fauna species with potential to be impacted by mining in Area 3A. Seven Part Tests (Assessments of Significance) were conducted for these species and it was concluded that mining impacts were likely to be significant on local populations of Littlejohn's Tree Frog (*Litoria littlejohni*), Giant Burrowing Frog (*Heleioporus australiacus*), Red-crowned Toadlet (*Pseudophryne australis*), Stuttering Frog (*Mixophyes balbus*) and the Giant Dragonfly (*Petalura gigantea*).

Fauna habitats are composed mostly of woodland and open forest with smaller components of rainforest and heath. Finer scale habitat features include rock outcrops, caves, overhangs, tree hollows, hollow logs, riparian habitats including creeks, ephemeral drainage lines, dams and temporary ponds and soaks. Biosis Research (2007) reported that the habitats at most risk to subsidence related impacts included creeks, steep slopes and cliffs.

5.5.2 Observed Impacts on Terrestrial Flora and Fauna

Plant Communities

The vegetation communities observed throughout the area following mining of Longwall 6 are generally in good condition. No significant impacts occurred to vegetation communities as a result of mining though localised impacts were recorded as outlined below.

Dieback and drying of native plants over an area of approximately 30m square including Tick Bush *(Kunzea ambigua)* and *Lepidospema limicola* due to root exposure was recorded along the edge of a rock fall to the east of Fire Road 6C. Cracking of sandstone above the rock fall has caused a depression within this slab to drain and individual plants as listed above have died as a result.

Soil cracking, approximately 100mm wide at the widest point, was observed on a seismic track west of Fire Road 6F. A large root of a mature Sydney Peppermint *(Eucalyptus piperita)* was exposed as a result of the crack. The tree appeared to be unaffected at the time of the inspection. Much of the understorey vegetation along the edges of soil cracks appeared unaffected at the time of the inspection despite the roots being exposed.

A rock fall in the western end of the longwall has disturbed vegetation including one mature and three small Silver Top Ash (*Eucalyptus seiberi*) and one mature Old Man Banksia (*Banksia serrata)*(shown in Plate 4).

Fauna and Fauna Habitats

Post mining, fauna habitats were generally in a similar condition to those observed during pre-mining assessments. No significant impacts to fauna or fauna habitat were recorded during the post mining inspections.

Threatened Flora, Fauna and Fauna Habitats

No impacts or changes to potential habitat for threatened plant species were observed in the current surveys. Potential habitat for threatened plant species is unlikely to have been affected by subsidence related impacts associated with the mining of Longwall 6. Subsidence has resulted in surface cracks and rock falls with some modification of habitat, however the impact of this on habitat for the threatened Broad-headed snake is not considered to be significant.

There is no evidence that a local population of any threatened animal species which is known to occur or for which potential habitat exists within the Study Area has been significantly impacted by subsidence related impacts associated with the mining of Longwall 6. Monitoring of frog populations to date has not resulted in significant changes to frog populations within the Study Area (Biosis Research 2011). Monitoring of sensitive habitats and threatened species will continue for a number of years post mining.

Damage to rock outcrops with exfoliating rock crevices that are considered potential habitat for the endangered Broad-headed Snake *Hoplocephalus bungaroides* has been observed in the end of panel inspections to the east of Fire Road 6C, at the eastern extent of Longwall 6 and at the western extent of the longwall. Subsidence has resulted in surface cracks and rock falls with some modification of habitat, however the impact of this on habitat for the threatened snake species is not considered to be significant.

Surface cracking of the base rock of Creek WC19, at the western extent of Longwall 6, could cause localised impact on the Red-crowned Toadlet *Pseudophryne australis* should pools be impacted. To date observed impacts have been minimal and have not had any significant impact on pool levels or this species.

5.6 Aboriginal Heritage Sites

Biosis Research assessed and determined the impacts due to Longwall 6 on recorded archaeological sites located within the Dendrobium SMP area. The findings of this assessment are summarised below and are provided in full in **Attachment G**. **Figure 5.6** shows the location of archaeological sites in Area 3A.

Initial archaeological surveys were conducted as part of the Environmental Assessment for the Dendrobium Coal Project (Navin Officer 2000 in **Attachment G**. Six recorded Aboriginal archaeological sites (BRS33, BRS32, SCR22, SCR25, SCR26 and SCA-6C) were identified as having potential to be impacted by subsidence from Longwall 6. Four of the sites consist of shelters with art, one shelter with deposits and one of stone artefacts. Two of the shelters with art are located above Longwall 6 (SCR25 and SCR36).

The archaeological sites satisfied a number of risk categories identified by Caryll Sefton as part of her study of subsidence impacts to Aboriginal archaeological sandstone overhang sites (Sefton 2000). Due to the potential risk of impacts to the sites from subsidence movements an Aboriginal Heritage Impact Permit for the sites was obtained from DECC 27 March 2009 (AHIP No. 1098243).

Predicted Impacts on Aboriginal Heritage Sites

As outlined in **Attachment G** the open artefact scatter site SCA-6C was considered unlikely to be directly impacted from subsidence movements. It was predicted that at the shelter sites there was potential for rock fracturing due to tensile and compressive strains and possibly associated isolated rock falls. The overall risk of impacts was varied between moderate (SCR262, SCR26), low (SCR25), very low (BRS33 & BRS20) and negligible (SCA-6c). Further details of the predicted impacts at each site are provided in **Table 5-2**.

Observed Impacts on Indigenous Heritage Sites

Biosis Research assessed the impacts of Longwall 6 on the Aboriginal sites as outlined in **Attachment G**. Of the Aboriginal archaeological sites monitored, only SCR25 had identified subsidence impacts, consisting of rock fracturing (see **Table 5-2**).

Monitoring undertaken 2 February 2011 at rock shelter SCR25 identified the slight expansion of jointing near the main art panel as shown in **Figure 5.7**. This is considered to be very minor in nature and unlikely to lead to secondary impacts such as water seepage or rock falls. The art at the site has not been impacted, though there is potential for the cracking to speed up natural exfoliation processes. These impacts were in line with predictions.

Baseline record - Vertical joint plane prior to longwall mining, located below the main art panel

Post Longwall 6 record (2 February) - Vertical joint plane has begun to separate

Figure 5.7 - Photographs of vertical joint prior to and post Longwall 6 mining in SCR26

Table 5-2: Summary of Predicted and Observed Impacts Resulting from Dendrobium Longwall 6 on Heritage Items

Surface Infrastructure	Predicted Impacts	Observed Impacts
BRS33	Possible impacts were rock fracturing and associated follow on effects such as isolated rock falls and water seepage. Overall risk of impact was assessed as **Very Low.**	No observed impacts
BRS20	Possible impacts were rock fracturing and associated follow on effects such as isolated rock falls and water seepage Overall risk of impact was assessed as **Very Low.**	No observed impacts
SCR22	Possible impacts were rock fracturing and associated follow on effects such as isolated rock falls and water seepage Overall risk of impact was assessed as **Moderate.**	No observed impacts
SCA-6C	Possible impacts were cracking of surface soils Overall risk of impact was assessed as **Negligible.**	No observed impacts
SCR25	Possible impacts were rock fracturing and associated follow on effects such as isolated rock falls and water seepage Overall risk of impact was assessed as **Low.**	Expansion of vertical joint

Table 5-2: Summary of Predicted and Observed Impacts Resulting from Dendrobium Longwall 6 on Heritage Items

Surface Infrastructure	Predicted Impacts	Observed Impacts
SCR26	Possible impacts were rock fracturing and associated follow on effects such as isolated rock falls and water seepage Overall risk of impact was assessed as **Moderate.**	No observed impacts

6. LONGWALL 6 MONITORING PROGRAM AND TARPS

Table 6-1 and Table 6-2 outline the monitoring commitments approved for Dendrobium Area 3A Longwall 6-8 and 19, the monitoring undertaken to date and the ongoing monitoring proposed following the completion of Longwall 6.

6.1 Monitoring of Man Made Features

Table 6-1: Man Made Features Monitoring Program for Dendrobium Longwall 6

Monitoring Commitments[1]	Monitoring to Date:	Future Monitoring
Subsidence Monitoring		
Baseline	***Baseline***	
❒ Airborne Laser scanning	❒ Airborne Laser scanning	
❒ 3D Control Survey to cover general area, Transgrid towers and Integral Energy poles, Swamps 15a and 15b,	❒ 3D Control Survey	
During Active Mining		
❒ Airborne Laser scanning at conclusion of each longwall & 12 months after completion of Area.	❒ Airborne Laser Scanning completed at conclusion of longwall.	❒ Airborne Laser scanning following each longwall and 12 months after completion of Area.
❒ 3D GPS Network of over 30 survey marks - at conclusion of each longwall & 12 months after completion of Area.	❒ 3D GPS Network of over 30 survey marks - at conclusion of Longwall 6	❒ 3D GPS Network of over 30 survey marks - at conclusion of each longwall and 12 months after completion of area
❒ 3D Points re TransGrid 330 kV transmission line towers: at conclusion of each longwall & 12 months after completion of Area.	❒ TransGrid 330 kV transmission line towers: - 100 m before reaching pole - 100 m, 200m, 300m, 400m, 500m past each pole - at conclusion of Longwall	❒ TransGrid 330 kV transmission line towers during Longwall 7 mining: - 100 m before reaching pole - 100 m, 200m, 300m, 400m, 500m past each pole - at conclusion of Longwall and 12 months after completion of area
❒ 3D points re Integral Energy 33 kV transmission line poles: at conclusion of each longwall & 12 months after completion of Area.	❒ Integral Energy 33 kV transmission line poles: - 100 m before reaching pole - 100 m, 200m, 300m, 400m, 500m past each pole - at conclusion of Longwall	❒ Integral Energy 33 kV transmission line poles over Longwall 7: - 100 m before reaching pole - 100 m, 200m, 300m, 400m, 500m past each pole - at conclusion of Longwall and 12 months after completion of area
❒ 3D Points along Fire Road No.6C - at conclusion of Longwall and 12 months after completion of Area	❒ 3D Points along Fire Road No.6 - at conclusion of Longwall 6	❒ 3D Points along Fire Road No.6 - at conclusion of Longwall and 12 months after completion of area
Cultural Heritage Site – D4		
Baseline:		
❒ Monitoring commitments were identified for cultural heritage sites in close proximity to Longwall 6. These sites are Browns Road Site 33 (52-2-0458]), Browns Road Site 32 (52-2-1647), Sandy Creek Road 22 (52-2-0274), Sandy	❒ Baseline recording was completed for Browns Road Site 33 (52-2-0458]), Browns Road Site 32 (52-2-1647), Sandy Creek Road 22 (52-2-0274), Sandy Creek Road 25 (52-2-0277), Sandy Creek Road 26 (52-2-0278) and SCA Special	

Table 6-1: Man Made Features Monitoring Program for Dendrobium Longwall 6

Monitoring Commitments[1]	Monitoring to Date:	Future Monitoring
Creek Road 25 (52-2-0277), Sandy Creek Road 26 (52-2-0278) and SCA Special Area Fire Trail 6c (52-2-3052).	Area Fire Trail 6c (52-2-3052).	
During Active Mining		
❒ Monitoring commitments were identified for cultural heritage sites in close proximity to Longwall 6. These sites are Browns Road Site 33 (52-2-0458]), Browns Road Site 32 (52-2-1647), Sandy Creek Road 22 (52-2-0274), Sandy Creek Road 25 (52-2-0277), Sandy Creek Road 26 (52-2-0278) and SCA Special Area Fire Trail 6c (52-2-3052).	❒ Monitoring of Browns Road Site 33 (52-2-0458]), Browns Road Site 32 (52-2-1647), Sandy Creek Road 22 (52-2-0274), Sandy Creek Road 25 (52-2-0277), Sandy Creek Road 26 (52-2-0278) and SCA Special Area Fire Trail 6c (52-2-3052).	❒ Future monitoring will be undertaken for cultural heritage sites following Longwall 7. Will include monitoring of Browns Road Site 33 (52-2-0458]), Browns Road Site 32 (52-2-1647), Sandy Creek Road 22 (52-2-0274), Sandy Creek Road 25 (52-2-0277), Sandy Creek Road 26 (52-2-0278) and SCA Special Area Fire Trail 6c (52-2-3052).

1 – SMP commitments as modified by monitoring plans prepared in consultation with government and stakeholders subsequent to the SMP

Monitoring in Dendrobium Area 3A will continue as outlined in **Table 6.1** and monitoring results will be reported in annual reporting and as required by the Dendrobium Area 3A SMP.

6.2 Monitoring of Natural Features

Natural features will continue to be monitored as mining continues in Area 3. Results will be reported in the AEMR and EOP Reports for current and future longwalls. Details of the monitoring program are provided in the table below.

Table 6-2: Natural Features Monitoring Program for Dendrobium Longwall 6

SMP Commitments[1]	Monitoring to Date:	Future Monitoring[2]
Subsidence Monitoring of Natural Features		
❒ 3D points around Swamps 15a and 15b - at conclusion of Longwall - 12 months after completion of Area 3A	❒ Swamps 15a and 15b closure lines 2 x 2D cross lines & 3D GPS survey. - at conclusion of Longwall	❒ Swamps 15a and 15b closure lines 2 x 2D cross lines & 3D GPS survey. - at conclusion of Longwall each longwall - 12 months after completion of Area 3A
	❒ Wongawilli Creek Closure Lines - 3 x 2D lines (Wong X A, Wong X B, Wong X C lines): - end of Longwall 6	❒ Wongawilli Creek Closure Lines - 3 x 2D lines - at end of each longwall
	❒ Sandy Creek & tributary cross lines – 4 x 2D lines (SCE, SCF, SCG, SCF) - 4 x 3D lines (A, B, C, D Lines): - prior to mining influence - end of Longwall 6	❒ Sandy Creek & tributary cross lines: - end of each longwall

Table 6-2: Natural Features Monitoring Program for Dendrobium Longwall 6

SMP Commitments[1]	Monitoring to Date:	Future Monitoring[2]
Sandy Creek Waterfall:		
Ground Survey		
❒ 3D Movement and closure across creek and waterfall - monthly during the extraction of the last 500 m of Longwall 6	❒ 3D Closure Lines: 4 cross lines (SCWA, SCWB,SCWC, SCWD): - prior to mining influence - monthly from ref mark 1500 m to 500 m - weekly from ref 500 m to end of Longwall 6 - end of Longwall 6	
	❒ Absolute 3D GPS network of 10 survey marks around waterfall: - prior to mining influence - weekly for last 500 m of Longwall 6 - end of Longwall 6	❒ Absolute 3D GPS network of 10 survey marks around waterfall: - weekly for last 500 m of Longwall 7 (TBC) - monthly for last 500 m of LW8, 9 & 19 (TBC) - end of each longwall
	❒ Waterfall North and Waterfall South Lines – 3D subsidence lines along the centrelines of Longwall 6 & Longwall 7: - prior to mining influence - monthly from ref mark 1500 to 600 m - weekly for last 600 m of Longwall 6 - end of each Longwall 6	❒ Waterfall North and Waterfall South Lines – 3D subsidence lines: - monthly from ref mark 1500 to 600 m - weekly for last 600 m of Longwall 7 (TBC) - end of each longwall
Strain Monitoring	❒ High resolution closure lines - 6 x high res 2D monitoring lines across waterfall.	❒ High resolution closure lines - 8 x 2D monitoring lines across waterfall.
	❒ Strain monitoring of an array of stress change monitoring cells	❒ Strain monitoring of an array of stress change monitoring cells
Micro-seismic Monitoring	❒ Micro-seismic monitoring using an array of 8 triaxial geophones	❒ Micro-seismic monitoring using an array of 8 triaxial geophones
Subsidence Landscape Monitoring and Management		
Baseline Observation of surface features on 2 occasions (months apart): ❒ Watercourses (WWM1, WWM2, WWM3, SCU1, SCL, BC1, BCC1, CC1) ❒ General observation of active mining areas for SC10, SC7, WC17, Sandy and Wongawilli Creeks.	***Baseline*** Observation of surface features on 2 occasions: ❒ Watercourses (WWM1, WWM2, WWM3, SCU1, SCL, BC1, BCC1, CC1) ❒ General observation of active mining areas for SC10, SC7, WC17, Sandy and Wongawilli Creeks.	
During Active Mining 6 monthly monitoring and monthly during active subsidence: ❒ Watercourses (WWM1, WWM2, WWM3, SCU1, SCL, BC1, BCC1, CC1) ❒ General observation of active mining areas for SC10, SC7, WC17, Sandy and Wongawilli Creeks. ❒ General inspection of all ❒ active subsidence areas.	***During Active Mining*** 6 monthly monitoring and monthly during active subsidence: ❒ Watercourses (WWM1, WWM2, WWM3, SCU1, SCL, BC1, BCC1, CC1) ❒ General observation of active mining areas for SC10, SC7, WC17, Sandy and Wongawilli Creeks. ❒ General inspection of all	***Following Mining*** 6 monthly monitoring for 2 years following completion of mining for: ❒ Watercourses (WWM1, WWM2, WWM3, SCU1, SCL, BC1, BCC1, CC1) ❒ General observation of active mining areas for SC10, SC7, WC17, Sandy ❒ and Wongawilli Creeks. ❒ Identified impact sites.

Table 6-2: Natural Features Monitoring Program for Dendrobium Longwall 6

SMP Commitments[1]	Monitoring to Date:	Future Monitoring[2]
Re-visits to identified impact sites.	❒ active subsidence areas. Re-visits to identified impact sites.	
Rainfall		
Baseline	***Baseline***	
❒ Rainfall using gauges at Centroid Rainfall Station and Browns Road Rainfall Station.	❒ Rainfall using gauges at Centroid Rainfall Station and Browns Road Rainfall Station.	
During & Following Mining	***During & Following Mining***	***Following Mining***
❒ Rainfall using gauges at Centroid Rainfall Station and Browns Road Rainfall Station.	❒ Rainfall using gauges at Centroid Rainfall Station and Browns Road Rainfall Station.	❒ Rainfall using gauges at Centroid Rainfall Station and Browns Road Rainfall Station.
Surface Water Quality Monitoring (MHL & Ecoengineers)		
Baseline	***Baseline***	
Two time series water quality probes (MHL)[1,3]	Two time series water quality probes (MHL)[1,3]	
❒ Upper Sandy Creek (SCU) (bi-monthly)	❒ Upper Sandy Creek (SCU) (bi-monthly)	
❒ Lower Sandy Creek (SCL) (bi-monthly)	❒ Lower Sandy Creek (SCL) (bi-monthly)	
❒ Lower Wongawilli Creek (WWL2) (monthly)	❒ Lower Wongawilli Creek (WWL2) (monthly)	
❒ Middle Wongawilli Creek 1 (WWM1) (monthly)	❒ Middle Wongawilli Creek 1 (WWM1) (monthly)	
❒ Middle Wongawilli Creek 2 (WWM2) (monthly)	❒ Middle Wongawilli Creek 2 (WWM2) (monthly)	
❒ Middle Wongawilli Creek 3 (WWM3) (monthly)	❒ Middle Wongawilli Creek 3 (WWM3) (monthly)	
❒ Upper Donald's Castle Creek (DCU3) (monthly)	❒ Upper Donald's Castle Creek (DCU3) (monthly)	
❒ Upper Wongawilli Creek 1 (WWU1) (monthly)	❒ Upper Wongawilli Creek 1 (WWU1) (monthly)	
❒ Upper Wongawilli Creek 4 (WWU4) (monthly)	❒ Upper Wongawilli Creek 4 (WWU4) (monthly)	
❒ Lower Sandy Creek[3 4 5] (SCL) (monthly)	❒ Lower Sandy Creek[3 4 5] (SCL) (monthly)	
❒ Creek SC10 (Banksia Creek) (monthly)	❒ Creek SC10 (Banksia Creek) (monthly)	
❒ Creek SC10C Pool 0 (Banksia Creek Tributary) (monthly)	❒ Creek SC10C Pool 0 (Banksia Creek Tributary) (monthly)	
❒ Creek SC7 (Cascade Creek) (monthly)	❒ Creek SC7 (Cascade Creek) (monthly)	
❒ Upper Sandy Creek (SCU) [3 4 5] (bi-monthly)	❒ Upper Sandy Creek (SCU) [3 4 5] (bi-monthly)	
During Active Mining	***During Active Mining***	***During Active Mining***
Two time series water quality probes[1,3]:	Two time series water quality probes[1,3]:	Two time series water quality probes[1,3]:
❒ Upper Sandy Creek (SCU) (bi-monthly)	❒ Upper Sandy Creek (SCU) (bi-monthly)	❒ Upper Sandy Creek (SCU) (bi-monthly)
❒ Lower Sandy Creek (SCL) (bi-monthly)	❒ Lower Sandy Creek (SCL) (bi-monthly)	❒ Lower Sandy Creek (SCL) (bi-monthly)
Twelve water quality spot & grab sampling sites[2]:	Twelve water quality spot & grab sampling sites[2]:	Twelve water quality spot & grab sampling sites[2]:
❒ Lower Wongawilli Creek (WWL2) (monthly)	❒ Lower Wongawilli Creek (WWL2) (monthly)	❒ Lower Wongawilli Creek (WWL2) (monthly)
❒ Middle Wongawilli Creek 1 (WWM1) (monthly)	❒ Middle Wongawilli Creek 1 (WWM1) (monthly)	❒ Middle Wongawilli Creek 1 (WWM1) (monthly)
❒ Middle Wongawilli Creek 2	❒ Middle Wongawilli Creek 2	❒ Middle Wongawilli Creek 2

Table 6-2: Natural Features Monitoring Program for Dendrobium Longwall 6

SMP Commitments[1]	Monitoring to Date:	Future Monitoring[2]
(WWM2) (monthly) ❒ Middle Wongawilli Creek 3 (WWM3) (monthly) ❒ Upper Donald's Castle Creek (DCU3) (monthly) ❒ Upper Wongawilli Creek 1 (WWU1) (monthly) ❒ Upper Wongawilli Creek 4 (WWU4) (monthly) ❒ Lower Sandy Creek[3 4 5] (SCL) (monthly) ❒ Creek SC10 (Banksia Creek) (monthly) ❒ Creek SC10C Pool 0 (Banksia Creek Tributary) (monthly) ❒ Creek SC7 (Cascade Creek) (monthly) ❒ Upper Sandy Creek (SCU) [3 4 5] (bi-monthly)	(WWM2) (monthly) ❒ Middle Wongawilli Creek 3 (WWM3) (monthly) ❒ Upper Donald's Castle Creek (DCU3) (monthly) ❒ Upper Wongawilli Creek 1 (WWU1) (monthly) ❒ Upper Wongawilli Creek 4 (WWU4) (monthly) ❒ Lower Sandy Creek[3 4 5] (SCL) (monthly) ❒ Creek SC10 (Banksia Creek) (monthly) ❒ Creek SC10C Pool 0 (Banksia Creek Tributary) (monthly) ❒ Creek SC7 (Cascade Creek) (monthly) ❒ Upper Sandy Creek (SCU) [3 4 5] (bi-monthly)	(WWM2) (monthly) ❒ Middle Wongawilli Creek 3 (WWM3) (monthly) ❒ Upper Donald's Castle Creek (DCU3) (monthly) ❒ Upper Wongawilli Creek 1 (WWU1) (monthly) ❒ Upper Wongawilli Creek 4 (WWU4) (monthly) ❒ Lower Sandy Creek[3 4 5] (SCL) (monthly) ❒ Creek SC10 (Banksia Creek) (monthly) ❒ Creek SC10C Pool 0 (Banksia Creek Tributary) (monthly) ❒ Creek SC7 (Cascade Creek) (monthly) ❒ Upper Sandy Creek (SCU) [3 4 5] (bi-monthly)
Swamp Monitoring (BHPBIC Field Crew)		
Baseline Field monitoring & grab samples taken at pools in swamps in Area 3A SMP Area[1 2]: ❒ Swamp 12 (monthly) ❒ Swamp 15a (monthly) ❒ Swamp 15b (monthly) ❒ Swamp 16 (monthly)	***Baseline*** Field monitoring & grab samples taken at pools in swamps in Area 3A SMP Area[1 2]: ❒ Swamp 12 (monthly) ❒ Swamp 15a (monthly) ❒ Swamp 15b (monthly) ❒ Swamp 16 (monthly)	
During Active Mining Field monitoring & grab samples taken at pools in swamps in Area 3A SMP Area[1 2]: ❒ Swamp 12 (monthly) ❒ Swamp 15a (monthly) ❒ Swamp 15b (monthly) ❒ Swamp 16 (monthly)	***During Active Mining*** Field monitoring & grab samples taken at pools in swamps in Area 3A SMP Area[1 2]: ❒ Swamp 12 (monthly) ❒ Swamp 15a (monthly) ❒ Swamp 15b (monthly) ❒ Swamp 16 (monthly)	***Following Mining*** Field monitoring & grab samples taken at pools in swamps in Area 3A SMP Area[1 2]: ❒ Swamp 12 (monthly) ❒ Swamp 15a (monthly) ❒ Swamp 15b (monthly) ❒ Swamp 16 (monthly)
1. Hydrolab probe: water level, temperature, pH, conductivity, dissolved oxygen, oxidation reduction potential 2. Grab samples: pH. conductivity, total and filterable metals (Fe, Al, Mn), filterable elements (Cu, Ni, Se, Zn,), major cations (Na, K, Ca, Mg), major anions (Cl, Si, SO4, alkalinity), nutrients (TKN, NH3-N, NOx-N, TP, RP), and DOC. Field measurements: Temperature, pH, conductivity, dissolved oxygen, turbidity, oxidation-reduction potential. 3. Additional parameters measured in grab samples: TDS, TSS, true colour , hardness, turbidity, and chlorophyll-a 4. Filterable Li analysed. 5. Nutrients (NH3-N, NOx-N, TKN, TP and RP) not analysed.		
Surface Water Level Monitoring		
Baseline ❒ 75% of the major pools in the watercourses will have pool level nail benchmarks installed (WWM1, WWM2, WWM3, SCU1, SCL, BC1, BCC1, CC1, and WC17).	***Baseline*** ❒ 75% of the major pools in the watercourses have pool level nail benchmarks installed (WWM1, WWM2, WWM3, SCU1, SCL, BC1, BCC1, CC1, and WC17).	
During Active Mining ❒ Pool level nail benchmarks measured monthly (WWM1, WWM2, WWM3, SCU1, SCL, BC1, BCC1, CC1, WC17).	***During Active Mining*** ❒ Pool level nail benchmarks measured monthly (WWM1, WWM2, WWM3, SCU1, SCL, BC1, BCC1, CC1, WC17).	❒ Pool level nail benchmarks measured six monthly (WWM1, WWM2, WWM3, SCU1, SCL, BC1, BCC1, WC17). ❒ CC1 (SC7) monitoring no longer required as LW10 plans have been revised.

Table 6-2: Natural Features Monitoring Program for Dendrobium Longwall 6

SMP Commitments[1]	Monitoring to Date:	Future Monitoring[2]
Deep Ground Water Monitoring		
Baseline		
Groundwater levels and quality at least one year prior to mining affecting the system ❒ A significant data base of groundwater pressures to be established and updated routinely.	Groundwater levels and quality at least one year prior to mining affecting the system ❒ A significant data base of groundwater pressures has been established and is updated routinely. The numbers of installed piezometers are: - 66 in Area 1 - 126 in Area 2 - 142 in Area 3A - 112 in Area 3B	
During Active Mining		
❒ Water levels & pressure – Designated monitoring bores fitted with single or multi-level vibrating wire piezometers (VWPs) that record groundwater pressures hourly. - Area 1: 4 sites - Area 2:11 sites - Area 3:regional approach supplemented by focused monitoring between LWs6&7 and the Sandy Creek arm of the Cordeaux Reservoir ❒ Groundwater chemistry – monthly analysis of ions, algae and hydrogen isotopes measured in Area 3: - 12 sites in Hawkesbury Sandstone & - 5 sites in Bulgo Sandstone	❒ Water levels & pressure – Designated monitoring bores fitted with single or multi-level vibrating wire piezometers (VWPs) that record groundwater pressures hourly. - Area 1: 4 sites - Area 2:11 sites - Area 3:regional approach supplemented by focused monitoring between LWs6&7 and the Sandy Creek arm of the Cordeaux Reservoir ❒ Groundwater chemistry – monthly analysis of ions, algae and hydrogen isotopes measured in Area 3: - 12 sites in Hawkesbury Sandstone & - 5 sites in Bulgo Sandstone	❒ Water levels & pressure – Designated monitoring bores fitted with single or multi-level vibrating wire piezometers (VWPs) that record groundwater pressures hourly. - Area 1: 4 sites - Area 2:11 sites - Area 3:regional approach supplemented by focused monitoring between LWs6&7 and the Sandy Creek arm of the Cordeaux Reservoir ❒ Groundwater chemistry – monthly analysis of ions, algae and hydrogen isotopes measured in Area 3: - 12 sites in Hawkesbury Sandstone & - 5 sites in Bulgo Sandstone
Aquatic Ecology		
Baseline	***Baseline***	
❒ Habitat assessment (including photographic record) ❒ Fish ❒ Macrointertebrates (AusRivAS, artificial collectors, including threatened species) ❒ Targeted Macquarie perch surveys ❒ Water quality	❒ Habitat assessment (including photographic record) ❒ Fish ❒ Macrointertebrates (AusRivAS, artificial collectors, including threatened species) ❒ Targeted Macquarie perch surveys ❒ Water quality	

Table 6-2: Natural Features Monitoring Program for Dendrobium Longwall 6

SMP Commitments[1]	Monitoring to Date:	Future Monitoring[2]
During Active Mining ❒ Habitat assessment (including photographic record) ❒ Fish ❒ Macrointertebrates (AusRivAS, artificial collectors, including threatened species) ❒ Targeted Macquarie perch surveys ❒ Water quality	***During Active Mining*** ❒ Habitat assessment (including photographic record) ❒ Fish ❒ Macrointertebrates (AusRivAS, artificial collectors, including threatened species) ❒ Water quality Note: Macquarie perch surveys no longer relevant	***During Active Mining*** ❒ Habitat assessment (including photographic record) ❒ Fish ❒ Macrointertebrates (AusRivAS, artificial collectors, including threatened species) ❒ Water quality Note: Macquarie perch surveys no longer relevant
Following Mining ❒ Habitat assessment (including photographic record) ❒ Fish ❒ Macrointertebrates (AusRivAS, artificial collectors, including threatened species) ❒ Targeted Macquarie perch surveys ❒ Water quality		***Following Mining*** ❒ Habitat assessment (including photographic record) ❒ Fish ❒ Macrointertebrates (AusRivAS, artificial collectors, including threatened species) ❒ Water quality Note: Macquarie perch surveys no longer relevant
Terrestrial Ecology		
Baseline ❒ Habitat assessment of entire study area prior to mining Seasonal (autumn & spring) surveys of vegetation and frogs at potentially impacted sites in Area 3A including: ❒ 3 creeks SC10, SC7 and Sandy Creek; ❒ 2 upland swamps (15A and 15B); and ❒ 1 ridgeline (not determined) Seasonal (autumn & spring) surveys of vegetation and frogs at control sites in Areas 2 and 3 including: ❒ 3 creeks (DC4 as well as 2 new creekline sites); ❒ 3 upland swamps (Den 01B, Swamp 11 and one other); ❒ 3 ridges. Targeted surveys for Littlejohns tree frog every winter. ❒	***Baseline*** ❒ Habitat assessment of entire study area prior to mining Seasonal (autumn & spring) surveys of vegetation and frogs at potentially impacted sites in Area 3A including: ❒ 3 creeks SC10, SC7 and Sandy Creek; ❒ 2 upland swamps (15A and 15B); and ❒ 1 ridgeline (not determined) Seasonal (autumn & spring) surveys of vegetation and frogs at control sites in Areas 2 and 3 including: ❒ 3 creeks (DC4, 8I Creek and WC10); ❒ 3 upland swamps (Den 01B, Swamp 11 and DC1A); ❒ Ridges monitored by IC Field Team and any impacts reported to ecological specialists Targeted surveys for Littlejohns tree frog every winter. Sites included: ❒ Creek S10, SC7, SC6, SC8 ❒ Reference sites include DC4 and WC11	***Baseline*** Continuation of monitoring program to date to collect baseline data for potential impact sites for longwalls within Area 3A yet to be mined.

Table 6-2: Natural Features Monitoring Program for Dendrobium Longwall 6

SMP Commitments[1]	Monitoring to Date:	Future Monitoring[2]
During Active Mining	***During Active Mining***	
❒ Habitat assessment of entire study area prior to mining	❒ Habitat assessment of entire study area prior to mining	
Seasonal (autumn & spring) surveys of vegetation, and frogs at potentially impacted sites within Area 3. ❒ 3 creeks (SC10, SC7 & Sandy Creek); ❒ 2 upland swamp sites (Den 15A & 15B); ❒ 1 ridgeline (not determined).	Seasonal (autumn & spring) surveys of vegetation, and frogs at potentially impacted sites within Area 3. ❒ 3 creeks (SC10, SC7 & Sandy Creek); ❒ 2 upland swamp sites (Den 15A & 15B).	
Seasonal (autumn & spring) surveys of vegetation, and frogs at control sites within Areas 2 & 3 including: ❒ 3 creeks (DC4 and 2 new sites); ❒ 3 upland swamps (Den 01B, Swamp 11 & one other); ❒ 3 ridges.	Seasonal (autumn & spring) surveys of vegetation, and frogs at control sites within Areas 2 & 3 including: ❒ 3 creeks (DC4, 8I & WC10) ❒ 3 upland swamps (Den 01B, Swamp 11 & DC1A) ❒ Ridges monitored by IC Field Team and any impacts reported to ecological specialists	
Targeted surveys for Littlejohn's tree frog every winter	Targeted surveys for Littlejohn's tree frog every winter at potential impacted sites within Area 3A included ❒ Creek S10, SC7, SC8 Reference Littlejohn's sites include ❒ DC4 & WC11	
Following Mining	***Following Mining***	***Following Mining***
❒ Post mining monitoring of vegetation fauna habitat and frogs at potentially impacted sites and control sites as undertaken in the baseline assessment. ❒ Habitat based surveys at completion of each longwall to inspect potentially impacted habitats and survey areas where surface impacts are reported from BHPBIC Environmental Field Team and other specialist consultants. ❒ Continuation of seasonal (Autumn and Spring) monitoring program. ❒ Targeted surveys for Littlejohn's tree frog in winter	❒ Habitat based surveys at completion of Longwall 6 to inspect potentially impacted habitats and survey areas completed. ❒ Continuation of seasonal flora and fauna monitoring program as conducted during active mining. ❒ Continuation of Littlejohn's tree frog targeted winter surveys.	❒ Post mining monitoring at the end of each longwall. ❒ Continuation of seasonal flora and fauna monitoring program as conducted during active mining. ❒ Continuation of targeted surveys for Littlejohn's tree frog in winter.

6.3 Trigger Action Response Plans

The Trigger Action Response Plan for Dendrobium Area 3A, Longwalls 6-8 and 19 has been used throughout the mining of Longwall 6 to identify and address any issues as they have arisen. To date, the plans have been followed in all areas and have proven successful. The TARPs are shown in **Table 6.3**. Illawarra Coal is currently reviewing the Area 3A TARP to take account of the monitoring data from Longwall 6 extraction. Key stakeholders will be consulted as part of this review.

From SMP Part B Table 24.2 – Potential Impacts, Key Monitoring, Triggers, Response & Responsibilities with Longwall 6 Outcomes and Actions

MONITORING		MANAGEMENT		
SITES	**PARAMETERS**	**TRIGGER**	**ACTION**	**Longwall 6 Outcomes & Actions**
CREEKS AND DRAINAGE LINES				
Water Quality				
Area 3A (11 total): **Wongawilli Creek** • WWU1 (headwaters of Wongawilli Ck) • WWU4 (U/S Wongawilli Ck) • WWM1 (mid Wongawilli Ck adjacent to LW 10) • WWM2 (mid Wongawilli Ck adjacent to LW 8) • WWM3 (mid Wongawilli Ck D/S of LW 6) • WWL2 (D/S Wongawilli Ck) **Sandy Creek** • SCU1 (U/S Sandy Ck) • SCL (D/S Sandy Ck adjacent to LW 7) • BC1 (Sandy Ck trib. SC10 over LW 8) • BCC1 (Sandy Ck trib. SC10C over LW 8) • CC1 (Sandy Ck trib. SC7 adjacent to LW10) Refer to Area 3A SMP **Figures 18.1, 18.2, and 18.4** for location of these sites.	**Manual Field Testing:** • Field pH • Temp • EC • DO • ORP • Lab. analytes (incl. lab check of pH, lab. check of EC, Na, K, Ca, Mg, Cl, Total. Alk.) • Total Fe, Mn, Al, • Filt. Fe, Mn, Al, Ni, Zn SO4, Si • DOC • TKN, NH3-N, NOx-N, TP)	***Normal*** No change in water quality when comparing baseline to mining period and considering environmental conditions.	• Continue monitoring program. • Report in the End of Panel Report • Summarise all actions and monitoring in AEMR by end of February (Annually).	No change in water quality at any site other than Swamp 16 (see below)
		Within Prediction (Level 1) Temporary reduction in water quality (observed for less than 2 months) at any site when comparing baseline period to mining period, ie: – pH drop of 1.5 units – EC increase of 50 uS/cm – ORP* drop 150 mV These may be revised in consultation with DoP and DPI and other key stakeholders following analysis of natural variability within the pre-mining baseline data.	• Continue monitoring program. • Report in the End of Panel Report • Summarise all actions and monitoring in AEMR by end of February (Annually).	Three Level 1 Low ORP TARPs Triggered at Swamp 16 on 30/08/2010, 21/09/2010 and 18/11/2010. Observed increases in filterable iron and manganese over same time period. Possible impact of mining though not definitive. Reporting undertaken as required. No further action at this stage. Monitoring to continue. Monitoring of Swamp 12 will continue weekly during Longwall 7 extraction until the active face has progressed a sufficient distance away.
		Within Prediction (Level 2) Temporary reduction in water quality (observed for less than 2 months) at any site when comparing baseline period to mining period, ie: – pH drop of 2 units – EC increase of 100 uS/cm – ORP* drop 200 mV These may be revised in consultation with DoP and DPI and other key stakeholders following analysis of natural variability within the pre-mining baseline data.	• Continue monitoring program (review monitoring frequency). • Submit an Impact Report. • Notify relevant technical specialists. • Report in the End of Panel Report • Summarise all actions and monitoring in AEMR by end of February (Annually).	No such water quality reduction recoded. No management action required
		Exceeding Predicted Impact Criteria Major reduction in water quality (observed for more than 2 months) when comparing baseline period to mining period, ie: – pH drop of >2 – EC increase >100 uS/cm – ORP* drop >200 mV • A > 2 standard deviation reduction in water quality apparent at downstream monitoring site or within Lake Cordeaux when comparing pre-mining to baseline data. These may be revised in consultation with DoP and DPI and other key stakeholders following analysis of natural variability within the pre-mining baseline data.	• Notification to DPIM, SCA and resource manager/s immediately. • Notification to DPIM, SCA and resource manager/s immediately. • Notify Ecological Specialists and other relevant Specialists immediately. • Site visits with stakeholders within 1month. • Capture photographic record immediately. • Collect laboratory samples within 2 weeks and analyse for: – pH, EC, major cations, major anions, Total Fe, Mn & Al. – Analyse filterable suite of metals. • Review sampling program within 1 month and modify if necessary. • Notify other relevant specialists (IC). • Develop and implement site CMA in consultation with key stakeholders within 1 month, (pending stakeholder availability) and seek approvals. These may include: Grouting and repair of surface water controlling features and the beds of streams where fracturing is evident where it is appropriate to do so in consultation with DoP, SCA, DPIM, DECC and other stakeholders. Limestone emplacement to raise pH where it is appropriate to do so in consultation with DoP, SCA, DPIM, DECC and other stakeholders. Emplacement of sandstone rocks in constricted stream flow areas to increase the aeration capacity where ORD drop is evident where it is appropriate to do so in consultation with DoP, SCA, DPIM, DECC and other stakeholders. • Completion of works following approvals. • Additional follow up monitoring and reporting within 2 weeks if required. • Report in the End of Panel Report submitted annually with AEMR. • Summarise all actions and monitoring in AEMR by end of February (Annually).	No impacts exceeding predictions. No management action required

From SMP Part B Table 24.2 – Potential Impacts, Key Monitoring, Triggers, Response & Responsibilities with Longwall 6 Outcomes and Actions

MONITORING		MANAGEMENT		
SITES	**PARAMETERS**	**TRIGGER**	**ACTION**	**Longwall 6 Outcomes & Actions**
Water Level Flow				
Area 3A Water Level Logger Sites (7 total): **Wongawilli Creek** • WWU4 (U/S Wongawilli Ck) • WWL2 (D/S Wongawilli Ck)	Water level / flow Automatic pool water level measurements (in various flows) which are converted to flows by calculation of rating curves using measured creek cross sections at the monitoring point.	***Normal*** No reduction in pool water levels when considering baseline data and environmental conditions.	• Continue monitoring program • Report in the End of Panel Report • Summarise all actions and monitoring in AEMR by end of February (Annually).	No pool water level changes observed.
Area 3A Pool level Benchmarks (i.e. nails) • WWM1 (mid Wongawilli Ck adjacent to LW 10) • WWM2 (mid Wongawilli Ck adjacent to LW 8) • WWM3 (mid Wongawilli Ck D/S of LW 6) Multiple nails will be installed in all pools adjacent to Longwalls 6-10 to provide redundancy in case high flows damage sites. **Sandy Creek** • SCU1 (U/S Sandy Ck) • SCL (D/S Sandy Ck adjacent to LW 7) Multiple nails will be installed in all pools adjacent to Longwalls 6-10 to provide redundancy in case high flows damage sites.	Monthly Manual Water level measurements using pre-established benchmarks (i.e. nails) in major pools. (Excluding Area 1)	***Within Prediction*** • Temporary reduction in pool water levels (observed for less than 2 months) declining < 20% during mining in any of the pools being monitored when compared with similar flows before mining. These may be revised in consultation with DoP and DPI and other key stakeholders following analysis of natural variability within the pre-mining baseline data.	• Continue monitoring program • Report in the End of Panel Report • Summarise all actions and monitoring in AEMR by end of February (Annually).	No pool water level changes observed No management action required
		Exceeding Predicted Impact Criteria Permanent reduction (observed for more than 2 months) in pool water level (>20% decline in any pools monitored) or complete loss of pool water when compared with similar flows before mining. This may be revised in consultation with DPI and other key stakeholders following analysis of natural variability within the pre-mining baseline data.	• Notification to DoP, DPIM, SCA and resource manager/s immediately. • Notify Ecological Specialists and other relevant Specialists immediately. • Site visits with stakeholders. • Capture photographic record immediately. • Review monitoring program within 2 weeks and Implement additional monitoring or increase frequency if required. • Notify other relevant specialists (IC) immediately. • Develop and implement site CMA in consultation with key stakeholders within 2 months. These may include: Grouting and repair of surface water controlling features and the beds of streams where fracturing is evident where it is appropriate to do so in consultation with DoP, SCA, DPIM, DECC and other stakeholders. • Completion of works following approvals. • Conduct initial follow up and additional monitoring & reporting within 2 months of CMA completion if required. • Report in the End of Panel Report submitted annually with AEMR. • Summarise all actions and monitoring in AEMR by end of February (Annually).	No impacts exceeding predictions. No management action required
Ephemeral watercourse in Area 3A • BC1 (Sandy Ck trib. SC10 over LW 8) • BCC1 (Sandy Ck trib. SC10C over LW 8) • CC1 (Sandy Ck trib. SC7 adjacent to LW10) 75% of the major pools in SC10and SC7 will also have Pool level nail benchmarks installed. Refer to Area 3A SMP **Figures 18.1, 18.2, and 18.4** for location of these sites.	Water level / flow Automatic pool water level measurements (in various flows) which are converted to flows by calculation of rating curves using measured creek cross sections at the monitoring point. Monthly Manual Water level measurements using pre-established benchmarks (i.e. nails) in major pools.	***Normal*** No observable drainage of pools when compared with baseline conditions and considering environmental conditions.	• Continue monitoring program • Report in the End of Panel Report • Summarise all actions and monitoring in AEMR by end of February (Annually).	No ephemeral pools fractured and no drainage of pools observed
		Within Prediction (Level 1) • Fracturing of bedrock in the ephemeral drainage lines that are directly mined beneath. • Minor fracturing causes short term (< 6 months) lowering of some mapped pool water levels under similar flows when comparing baseline and considering environmental conditions. This may be revised in consultation with DPI and other key stakeholders following analysis of natural variability within the pre-mining baseline data.	• Continue monitoring program • Submit an Impact Report • Capture photographic record as each impact is observed • Notification to agencies within 24 hours upon confirmation that any pool has drained • Report in the End of Panel Report • Summarise all actions and monitoring in AEMR by end of February (Annually).	No ephemeral pools fractured. No management action required
		Within Prediction (Level 2) • Fracturing of bedrock in the ephemeral drainage lines that are directly mined beneath. • Minor fracturing causes ongoing (> 6 months) lowering of mapped pool water levels under similar flows when comparing baseline and environmental conditions This may be revised in consultation with DPI and other key stakeholders following analysis of natural variability within the pre-mining baseline data.	• Continue monitoring program (review monitoring frequency). • Submit an Impact Report. • Notify relevant technical specialists. • Capture photographic record as each impact is observed • Notification to agencies within 24 hours upon confirmation that any pool has drained. • Review need for CMA. • Report in the End of Panel Report. • Summarise all actions and monitoring in AEMR by end of February (Annually).	No ephemeral pools fractured. No management action required

From SMP Part B Table 24.2 – Potential Impacts, Key Monitoring, Triggers, Response & Responsibilities with Longwall 6 Outcomes and Actions

MONITORING		MANAGEMENT		
SITES	**PARAMETERS**	**TRIGGER**	**ACTION**	**Longwall 6 Outcomes & Actions**
			•	
		Exceeding Predicted Impact Criteria • Fracturing of bedrock in the ephemeral drainage lines that are directly mined beneath. • Fracturing results in re-direction of surface flows fully draining all pools over the longwalls. This may be revised in consultation with DPI and other key stakeholders following analysis of natural variability within the pre-mining baseline data.	• .Notification to agencies within 24 hours upon confirmation that any pool has drained. Notify that all pools within an ephemeral waterway have drained. • Notify Ecological Specialists and other relevant Specialists immediately. • Site visits with stakeholders. • Capture photographic record as each impact is observed. • Review monitoring program within 2 weeks and Implement additional monitoring or increase frequency if required. • Notify other relevant specialists (IC) immediately. • Develop and implement site CMA in consultation with key stakeholders at the completion of subsidence movements in Area 3A or after subsidence movement from future extraction will not adversely affect the effectiveness of rehabilitation works. These may include: Grouting and repair of swamp surface water controlling features where fracturing is evident where it is appropriate to do so in consultation with DoP, SCA, DPIM, DECC and other stakeholders. • Completion of works following approvals. • Conduct initial follow up and additional monitoring & reporting within 2 months of CMA completion if required. • Report in the End of Panel Report submitted annually with AEMR. Summarise all actions and monitoring in AEMR by end of February (Annually).	No impacts exceeding predictions. No management action required
Appearance				
All flow and quality monitoring sites as listed above. General observation of active mining areas for SC10, SC7, WC17, Sandy and Wongawilli Creeks. Particular focus on rockbars in Swamps 15a and 15b	Visual signs of impacts on creeks and drainage lines (i.e., cracking, vegetation changes, increased erosion, changes in water colour etc.) determined by comparing baseline photos with photos during the mining period	***Normal*** No visual signs of impacts when comparing baseline and considering environmental conditions.	• Continue monitoring program • Report in the End of Panel Report • Summarise all actions and monitoring in AEMR by end of February (Annually)	Baseline iron staining observed in Wongawilli Creek. No major increases in iron levels during or following mining.
		Within Prediction • Small crack/s with no observable loss of surface water flow. • Slight increase in turbidity, iron staining, algal growth, or other visible water quality parameters determined by comparing baseline photos with photos during the mining period. This may be revised in consultation with DPI and other key stakeholders following analysis of natural variability within the pre-mining baseline data.	• Continue monitoring program (review frequency of monitoring). • Submit an Impact Report. • Notify relevant technical specialists. • Report in the End of Panel Report • Summarise all actions and monitoring in AEMR by end of February (Annually)	Two fractures observed in WC17 but no associated pool water level loss. Monitoring to continue weekly during Longwall 7 extraction until the active face has progressed a sufficient distance away. No visible loss of surface water or erosion. No major increases in turbidity, iron staining, algal growth or other visible effects. No management action required
		Exceeding Predicted Impact Criteria • Crack in a watercourse that is resulting in visible loss of surface water or erosion. • Major increase in turbidity, iron staining, algal growth, or other visible water quality parameters. • Vegetation changes. • Increased erosion. This may be revised in consultation with DPI and other key stakeholders following analysis of natural variability within the pre-mining baseline data.	• Notification to DPIM, SCA and resource manager/s immediately • Notify Ecological Specialists and other relevant Specialists immediately. • Site visits with stakeholders within one month. • Capture photographic record immediately. • Review sampling program and modify if necessary within 2 weeks. • Implement additional monitoring or increase frequency if required within 2 weeks. • Notify other relevant specialists (IC) immediately. • Develop site CMA in consultation with key stakeholders within 1 month, (pending stakeholder availability) and seek approvals. These may include: Surface sealing of cracks, grouting and repair of surface water controlling features and the beds of streams where fracturing is evident where it is appropriate to do so in consultation with DoP, SCA, DPIM, DECC and other stakeholders. • Completion of works following approvals. • Conduct initial follow up monitoring & reporting within 2 months of CMA completion. • Issue CMA report within 1 month of works completion. • Report in the End of Panel Report submitted annually with AEMR. • Summarise all actions and monitoring in AEMR by end of February	No impacts exceeding predictions. No management action required

From SMP Part B Table 24.2 – Potential Impacts, Key Monitoring, Triggers, Response & Responsibilities with Longwall 6 Outcomes and Actions

MONITORING		MANAGEMENT		
SITES	**PARAMETERS**	**TRIGGER**	**ACTION**	**Longwall 6 Outcomes & Actions**
			(Annually).	
LAKE CORDEAUX				
Water Quality				
Sandy Creek arm of Lake Cordeaux nearest Areas 2 and 3A. • SC (Sandy Ck D/S) Refer to Area 3A SMP Figure **18.2**.	Manual Field Testing: • Field pH • EC • DO • ORP* Lab. analytes (incl. lab check of pH, lab. check of EC, Na, K, Ca, Mg, Filt. SO_4, Cl, T. Alk., Total Fe, Mn, Al, Filt. Cu, Ni, Zn, TKN, NH_3-N, NO_x-N, TP) • Filterable metals (Mn, Ni, Zn).	***Normal*** No change in water quality when comparing with baseline period and considering environmental and operational factors	• Continue monitoring program • Report in the End of Panel Report • Summarise all actions and monitoring in AEMR by end of February (Annually).	No change in water quality observed
		Within Prediction • Regular samples of filterable metals (Mn, Ni, Zn) exceeding 95% ecosystem protection trigger level in the National Water Quality Guidelines.. This may be revised in consultation with DoP and DPI and other key stakeholders following analysis of natural variability within the pre-mining baseline data.	• Continue monitoring program • Report in the End of Panel Report • Summarise all actions and monitoring in AEMR by end of February (Annually).	No observable water quality impacts. No management action required.
		Exceeding Predicted Impact Criteria • Statistical assessment shows mean value of key metals over 12 mth period post initial detection, significantly (>1 SD) in excess of 95% ecosystem protection trigger level. This may be revised in consultation with DPI and other key stakeholders following analysis of natural variability within the pre-mining baseline data.	• Notify DoP, DPIM, SCA & resource manager/s immediately. • Nearest arms of lake monitored for As, Cu, Pb, Ni, Se, Zn, Al, Fe, Mn within 1 week. • Look for Mn, Ni, Zn (major stressors). • Consider mitigation measures in consultation with resource managers within 2 weeks. • Develop and implement site CMA if required in consultation with key stakeholders within 1 month, (pending stakeholder availability) and seek approvals. These may include: Grouting and repair of surface water controlling features and the beds of streams that flow into lake Cordeaux where fracturing is evident where it is appropriate to do so in consultation with DoP, SCA, DPIM, DECC and other stakeholders. Limestone emplacement to raise pH where it is appropriate to do so in consultation with DoP, SCA, DPIM, DECC and other stakeholders. Emplacement of sandstone rocks in constricted stream flow areas to increase the aeration capacity where ORD drop is evident where it is appropriate to do so in consultation with DoP, SCA, DPIM, DECC and other stakeholders. • Issue CMA report within 1 month of works completion. • Completion of works following approvals. • Conduct additional monitoring and reporting if required within 2 weeks. • Report in the End of Panel Report submitted annually with AEMR. • Summarise all actions and monitoring in AEMR by end of February (Annually).	No impacts exceeding predictions. No management action required
Catchment Yield				
Area 3A Catchment yields for SC10, SC7, Upper and Lower Sandy Creek, and Upper and Lower Wongawilli Creek	Jd quick runoff coefficient from Runoff 2005 model Using input data from hydrological monitoring	***Normal*** No change in catchment yield when comparing with baseline period and considering environmental conditions	• Implement analysis of Runoff 2005 for EoP • Report in the End of Panel Report • Summarise all actions and monitoring in AEMR by end of February (Annually).	No reduction in catchment yield observed.
		Within Prediction • Minor reduction (less than 1 standard deviation change from pre-mining) for < 6 months in observed catchment yield in any of the major creeks being monitored indicated by - Jd quick runoff coefficient from Runoff 2005 model. This may be revised in consultation with DoP, DPI and other key stakeholders following analysis of natural variability within the pre-mining baseline data.	• Implement analysis of Runoff 2005 for EoP • Report in the End of Panel Report • Summarise all actions and monitoring in AEMR by end of February (Annually).	Period of anomalous data (1/11-14/12/10) due to malfunctioning of SCA Lower Sandy Creek gauging station. No observed reduction in catchment yield detected by RUNOFF2005 catchment model. Continue regular modelling of catchment hydrologic performance throughout the remainder of Dendrobium Area 3A mining.
		Exceeding Predicted Impact Criteria • Significant reduction (greater than 1 standard deviation change from pre-mining) for > 6 months in observed catchment yield in any of the major creeks being monitored indicated by - Jd quick runoff coefficient from Runoff 2005 model	• Implement analysis of Runoff 2005 for EoP • Develop site CMA in consultation with key stakeholders if required within 1 month (pending stakeholder availability) and seek approvals. • Implement CMA if required as agreed with stakeholders.	No observable water quality impacts. No management action required.

From SMP Part B Table 24.2 – Potential Impacts, Key Monitoring, Triggers, Response & Responsibilities with Longwall 6 Outcomes and Actions

MONITORING		MANAGEMENT		
SITES	**PARAMETERS**	**TRIGGER**	**ACTION**	**Longwall 6 Outcomes & Actions**
		This may be revised in consultation with DPI and other key stakeholders following analysis of natural variability within the pre-mining baseline data.	• Conduct initial follow up and additional monitoring & reporting within 2 months of CMA completion if required. • Report in the End of Panel Report • Summarise all actions and monitoring in AEMR by end of February (Annually).	
Structure and Impoundment Integrity				
Refer to DSC Management Plan for further details relating to structure and impoundment integrity				
SHALLOW GROUNDWATER				
Shallow groundwater level				
Area 3A (Approx. 60 piezometers in total): • S15BH1, S15BH2, and S15BH3 (Swamp 15b above edge of LW 8) • Approximately 50 piezometers in hillslope aquifers around swamps in Area 3A. Refer to Area 3A SMP **Figures 18.1, and 18.2** and the Swamp Monitoring and Management Plan for the location of these sites.	• Shallow Groundwater level.	***Normal*** No signs of impact when comparing baseline to mining period and considering environmental conditions.	• Continue monitoring program. • Report in the End of Panel Report • Summarise all actions and monitoring in AEMR by end of February (Annually). •	
		Within Prediction • Temporary (i.e. effect not persisting after significant groundwater recharge rainfall events) reduction in groundwater level at more than one site (beyond variability determined in baseline monitoring due to rainfall). This may be revised in consultation with DoP & DPI and other key stakeholders following analysis of natural variability within the pre-mining baseline data.	• Continue monitoring program. • Report in the End of Panel Report • Summarise all actions and monitoring in AEMR by end of February (Annually).	No detected anomalous declines in shallow groundwater levels. No management action required
		Exceeding Predicted Impact Criteria • Major reduction (monitoring bore dry where it has not been prior to mining or reference sites) in groundwater level at the majority of bores within any particular aquifer or swamp system or complete loss of groundwater. These may be revised in consultation with DoP & DPI and other key stakeholders following analysis of natural variability within the pre-mining baseline data.	• Notification to DoP & DPIM and resource manager/s immediately. • Site visits with stakeholders within one month. • Review monitoring program and modify if necessary within 1 month. • Develop and implement site CMA if required in consultation with key stakeholders within 1 month, (pending stakeholder availability) and seek approvals. These may include: Grouting and repair of surface water controlling features and the beds of streams that flow where fracturing is evident where it is appropriate to do so in consultation with DoP, SCA, DPIM, DECC and other stakeholders. Also see remedial actions described in Swamp Management Plan. • Completion of works following approvals. • Conduct initial follow up and additional monitoring and reporting within 2 months of CMA completion. • Notify other relevant specialists (IC) immediately. • Report in the End of Panel Report submitted annually with AEMR. • Summarise all actions and monitoring in AEMR by end of February (Annually).	No impacts exceeding predictions. No management action required.
DEEP GROUNDWATER				
Refer to Groundwater Monitoring Plan. The DSC regulate the requirements for deep groundwaters and mine waters and the TARP associated with these is outlined in **Table 23.3**.				
AQUATIC ECOLOGY				
Pool water level, interconnectivity between pools and loss of connectivity, noticeable alteration of habitat, fish kill, frog kill				
Area 3A (15 total): • Wongawilli Ck – 8 sites • WC15 – 1 site • WC21 – 1 site • Sandy Ck – 2 sites • SC10 – 1 site • SC7 – 1 site • Donalds Castle Ck – 1 site Refer to Area 3A SMP **Figures 20.1, 20.2, and**	Physical aspects of watercourses, including: – Wetted perimeter. – Pool depth and presence of large pools. – Riffle/run/pool sequences. – Heights of any barriers as well as their structure and composition. – Presence and position of gravel beds likely to be used for spawning by Macquarie Perch. Water flow characteristics, including:	***Normal*** No signs of impact when comparing baseline to mining period and considering environmental conditions.	• Continue monitoring program. • Report in the End of Panel Report • Summarise all actions and monitoring in AEMR by end of February (Annually).	No pool water level changes identified and no alteration in habitat
		Within Prediction • Temporary pool water levels decline < 20% occurs during mining in any of the pools being monitored when compared with similar flows before mining.. • Temporary (1-2 seasons) reduction in aquatic habitat.	• Continue monitoring program. • Report in the End of Panel Report • Summarise all actions and monitoring in AEMR by end of February (Annually).	No pool water level changes identified and no alteration in habitat. Monitoring to continue. No management action required.

From SMP Part B Table 24.2 – Potential Impacts, Key Monitoring, Triggers, Response & Responsibilities with Longwall 6 Outcomes and Actions

MONITORING		MANAGEMENT		
SITES	**PARAMETERS**	**TRIGGER**	**ACTION**	**Longwall 6 Outcomes & Actions**
20.3 for the location of these sites. General observation of active mining areas.	– Rainfall. – Surface and near surface water flows. Water Quality (refer above water quality section). Ecological Investigations, including: – Catalogue of aquatic habitats, flora and fauna of watercourses. – Photographic records. – Measurement of aquatic plants using transects. – Sampling of Macroinvertebrates. – Sampling fish and large invertebrates (e.g. yabbies).	These may be revised in consultation with DoP, DPI and other key stakeholders following analysis of natural variability within the pre-mining baseline data.		
		Exceeding Predicted Impact Criteria • Major reduction in pool water level (>20% decline in any pools monitored) or complete loss of pool water during reduced surface flows.. • Major reduction in aquatic habitat for an extended timeframe (> 2 seasons) or complete loss of habitat. These may be revised in consultation with DoP, DPI and other key stakeholders following analysis of natural variability within the pre-mining baseline data.	• Notification to DoP, DPIM and resource manager/s immediately. • Notify Ecological Specialists and other relevant Specialists immediately. • Site visits with stakeholders within one month. • Capture photographic record immediately. • Review monitoring program and modify if necessary within 1 month. • Implement and conduct additional monitoring or increase frequency if required within 2 weeks. • Notify other relevant specialists (IC) immediately. • Develop and implement site CMA if required in consultation with key stakeholders within 1 month, (pending stakeholder availability) and seek approvals. These may include: Grouting and repair of surface water controlling features and the beds of streams that flow where fracturing is evident where it is appropriate to do so in consultation with DoP, SCA, DPIM, DECC and other stakeholders. Also see remedial actions described in Swamp Management Plan. • Completion of works following approvals. • Issue CMA report within 1 month of works completion. • Report in the End of Panel Report • Summarise all actions and monitoring in AEMR by end of February (Annually).	No impacts exceeding predictions. No management action required
ECOLOGY – THREATENED SPECIES INCLUDING MACQUARIE PERCH				
Quantitative sampling				
Wongawilli, and Sandy Creeks and associated tributaries where moderate or significant Macquarie Perch habitat has been identified. General observation of active mining areas.	Targeted surveys for Macquarie Perch.	***Normal*** No signs of impact to TS when comparing baseline to mining period and considering environmental conditions.	• Continue monitoring program. • Report in the End of Panel Report • Summarise all actions and monitoring in AEMR by end of February (Annually).	No longer applicable. No Macquarie Perch identified in Area 3A during targeted surveys in 2008 and 2009. Quantitative sampling no longer applicable.
		Within Prediction • TS identified as using Kembla, Wongawilli, or Sandy Creeks and impacts from mining occur to the creek (as above in Aquatic Habitat – General section).	• Continue monitoring program. • Report in the End of Panel Report • Summarise all actions and monitoring in AEMR by end of February (Annually)	n/a see above
		Exceeding Predicted Impact Criteria • Identified mortality of TS in proximity to identified mining impact.	• Notification to DoP, DPIM, SCA and resource manager/s immediately. • Notify Specialists immediately. • Condition assessment to record impacts completed within 2 weeks. • Site visits with stakeholders if required. • Capture photographic record immediately. • 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. • Report in the End of Panel Report • Summarise all actions and monitoring in AEMR by end of February (Annually).	n/a see above
TERRESTRIAL FLORA				
Stressed or dead vegetation including riparian and upland swamp vegetation not readily explained by natural processes. Causes may include rock / cliff falls or mass movement, gas emissions, changes in ponding and interconnectivity, and iron staining from ferruginous spring releases.				
A number of sites located across and around Areas 2, and 3A. Refer Area 3A SMP **Figure**	• Vegetation communities.	***Normal***	• Continue monitoring program.	No significant mining impacts to flora identified.

From SMP Part B Table 24.2 – Potential Impacts, Key Monitoring, Triggers, Response & Responsibilities with Longwall 6 Outcomes and Actions

MONITORING		MANAGEMENT		
SITES	**PARAMETERS**	**TRIGGER**	**ACTION**	**Longwall 6 Outcomes & Actions**
21.1. General observation of active mining areas.	• Vegetation condition. • Changes in vegetation. • Tree health. • Swamp Vegetation. • Threatened species. • Control sites.	No signs of impact to terrestrial flora when comparing baseline to mining period and considering environmental conditions.	• Report in the End of Panel Report • Summarise all actions and monitoring in AEMR by end of February (Annually).	
		Within Prediction • Small areas (<100m^2) of impacted vegetation (by rockfalls, soil slippage) that would commence natural regeneration within 6 months. • Minor gas emissions with minor vegetation die off and evidence of natural regeneration • No significant statistical difference between Before After Control Impact sites.	• Continue monitoring program. • Report in the End of Panel Report • Summarise all actions and monitoring in AEMR by end of February (Annually).	No significant mining impacts to flora identified. No management action required.
		Exceeding Predicted Impact Criteria • Large areas (>100m^2) of impacted vegetation (by rockfalls, soil slippage) that is unlikely to commence natural regeneration within 6 months. • Gas emissions with extensive vegetation die off and no evidence of self regeneration. • Significant statistical difference between Before After Control Impact sites.	• Notification to DoP, DPIM and resource manager/s immediately. • Notify Specialists immediately. • Condition assessment to record impacts completed within 2 weeks. • Site visits with stakeholders if required. • Capture photographic record immediately. • 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. • Report in the End of Panel Report • Summarise all actions and monitoring in AEMR by end of February (Annually).	No impacts exceeding predictions. No management action required
TERRESTRIAL FAUNA				
Alteration or loss of fauna habitat, fauna habitat assessed to be degraded without a natural cause readily apparent.				
A number of sites located across and around Areas 2, and 3A. Refer Area 3A SMP Figure 21.1. General observation of active mining areas.	• Species and habitat Characteristics. • Variation in the species or fauna groups. • Monitoring of birds, reptiles and invertebrates. • Targeted surveys and monitoring (as required) of known populations in Area 3A specifically for three animal species (Littlejohn's Tree Frog, Red-crowned Toadlet and Giant Dragonfly)	***Normal*** No signs of impact to terrestrial fauna or potential habitat when comparing baseline to mining period and considering environmental conditions.	• Continue monitoring program. • Report in the End of Panel Report • Summarise all actions and monitoring in AEMR by end of February (Annually).	No significant mining impacts to fauna identified.
		Within Prediction • Small areas (<100m^2) of impacted vegetation (by rockfalls, soil slippage) that would commence natural regeneration within 6 months. • Minor surface soil cracking or rock bar fracturing not resulting in loss of standing water in creeks or swamps. • Minor gas emissions with no vegetation die off. • No significant statistical difference between Before After Control Impact sites. These may be revised in consultation with DPI and other key stakeholders following analysis of natural variability within the pre-mining baseline data.	• Continue monitoring program. • Report in the End of Panel Report • Summarise all actions and monitoring in AEMR by end of February (Annually).	No significant mining impacts to fauna identified. No management action required.
		Exceeding Predicted Impact Criteria • Large areas (>100m^2) of impacted vegetation (by rockfalls, soil slippage) that is unlikely to commence natural regeneration within 6 months. • Significant surface soil cracking or rock bar fracturing resulting in loss of standing water and or erosion in creeks or swamps. • Gas emissions with extensive vegetation die off and no evidence of self regeneration. • Significant statistical difference between Before After Control Impact sites. These may be revised in consultation with DPI and other key stakeholders following analysis of natural variability within the pre-	• Notification to DoP, DPIM and resource manager/s immediately. • Notify Specialists immediately. • Condition assessment to record impacts completed within 2 weeks. • Site visits with stakeholders if required. • Capture photographic record immediately. • 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.	No impacts exceeding predictions. No management action required

From SMP Part B Table 24.2 – Potential Impacts, Key Monitoring, Triggers, Response & Responsibilities with Longwall 6 Outcomes and Actions

MONITORING		MANAGEMENT		
SITES	**PARAMETERS**	**TRIGGER**	**ACTION**	**Longwall 6 Outcomes & Actions**
		mining baseline data.	• Conduct initial follow up monitoring & reporting within 2 months of CMA completion. • Report in the End of Panel Report • Summarise all actions and monitoring in AEMR by end of February (Annually).	
LANDSCAPE FEATURES				
Visual inspection and photographic record of cliffs, steep slopes, water courses, upland swamps and fire trails.				
The three categories of site *inspection* include: 1. General inspection of all active subsidence areas. 2. Specific targeted monitoring sites based on potential risk. 3. Re-visits to identified impact sites). **Area 2 Targeted Monitoring Sites (11 total):** ***Cliffs*** A2-CL1 (above LW4) *Steep Slopes* A2-SL1 and A2-SL2 (above LW 's 4 & 5) **Watercourses** A2-WC10 and A2-WC11 (above LW3). A2-WC13 & A2-WC16 (above LW 's 4 & 5) **Swamp** A2-SW1 (above LW's 4 & 5). *4WD Track* A2-FT1 (above LW's 4 & 5) *Crinanite Surface Extent* A2-CN1 & A2-CN2 (above LW's 3 & 4). **Area 3A Targeted Monitoring Sites (19 total):** ***Cliffs*** • A3-CL1 & A3CL2 (above LW10) • A3-CL3 & A3CL4 (W end of LW10) • A3-CL5 (SW end of LW9) ***Steep Slopes*** • A3-SL1 (above LW6) • A3-SL2 (SE corner of LW 6) • A3-SL3 (W end of LW7) • A3-SL4 & A3-SL5 (above LW's 7 and 8) • A3-SL6 (E end of LW8) • A3-SL7 (W end of LW9) • A3-SL8 (above LW9) • A3-SL9 (W end of LW9) ***Watercourses/* Swamps** • A3-WC1 (above LW7 in Swamp 12) • A3-WC2 & A3-WC3 (above LW's 8, 9, and 10 in Swamps 15a and 15b) ***Fire Trails*** • A3-FR1 (across LW's 6-10) • A3-FR2 (above LW's 6 & 7) Refer to Area 3A SMP **Figures 19.1, 19.2, and 19.3** for the location of these sites.	Landform elements, including: – Slope. – Morphological type. – Dimensions. – Mode of geomorphological activity and geomorphological agent. , including aspect: – Elevation. – Drainage height. – Disturbance of site. – Microrelief. – Erosion. – Aggradations. – Inundation. – Coarse fragments. – Rock outcrop. – Depth to free water. – Runoff. • Land capability.	***Normal*** • Natural landscape impacts which are in line with levels experienced during baseline period, dependent on environmental conditions.	• Continue monitoring program. • Report in the End of Panel Report • Summarise all actions and monitoring in AEMR by end of February (Annually).	Majority of area experienced no change to landscape features
		Within Prediction • Rock fall from a cliff which is left mostly intact (<10% length), resulting in insignificant ground disturbance. • Minor surface movement with negligible soil surface exposed. • Small crack or increased ponding in a watercourse which is not observed to result in surface water loss, be causing erosion or impeding flow. • Small crack in a fire trail which does not appear to be causing erosion or impeding access or that can be readily filled. • Insignificant erosion at any location localised to a small area and should naturally stabilise in the future.	• Continue monitoring program. • Report in the End of Panel Report • Summarise all actions and monitoring in AEMR by end of February (Annually).	No cliffs over longwall 6 Some surface cracking in vegetated areas No increased ponding or cracking. Some surface cracking observed on access tracks and adjacent to infrastructure. No observed erosion of cliffs, steep slopes, water courses, upland swamps or fire trails. No management action required Monitoring to continue
		Exceeding Predicted Impact Criteria • Major cliff collapse or rock fall where the characteristics of the cliff change significantly and there is significant ground disturbance that is unlikely to stabilise in the medium to long term. • Mass movement of a slope causing large areas of exposed soil. • Crack or increased ponding in a watercourse which is causing significant erosion and/or impeding flow. • Crack in a fire trail which is causing significant erosion and/or impeding access.	• Notification to DoP, DPIM, SCA and resource manager/s immediately. • Notify Specialists immediately. • Condition assessment to record impacts completed within 2 weeks. • Site visits with stakeholders if required. • Capture photographic record immediately. • 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. • Report in the End of Panel Report • Summarise all actions and monitoring in AEMR by end of February (Annually).	No major impacts were observed. No management action required
ABORIGINAL ARCHAEOLOGY				
Subsidence and impact monitoring				
Area 2 (1 site):	• Re-recording of the principal components	***Normal***	• Continue monitoring program.	No impacts identified in 5 of the 6 sites monitored.

From SMP Part B Table 24.2 – Potential Impacts, Key Monitoring, Triggers, Response & Responsibilities with Longwall 6 Outcomes and Actions

MONITORING		MANAGEMENT		
SITES	**PARAMETERS**	**TRIGGER**	**ACTION**	**Longwall 6 Outcomes & Actions**
Dendrobium 4. **Area 3A (11 total):** • *Browns Road Site 33* (recording code 52-2-0458). • *Browns Road Site 32* (recording code 52-2-1646). • *Browns Road Site 20* (recording code 52-2-1647). • *Sandy Creek Road 21* (recording code 52-5-0273). • *Sandy Creek Road 22* (recording code 52-5-0274). • *Sandy Creek Road 25* (recording code 52-5-0277). • *Sandy Creek Road 26* (recording code 52-5-0278). • *DM13* (New Recording) • The site *DM15* (New Recording). • The site *DM20* (New Recording). • The site *DM23* (New Recording). Refer Area 3A SMP **Figure 22.1**.	identified by Sefton (Sefton 2000); • Macro and micro recording using digital photography (Navin Officer 2003); • Detailed elevation plans of shelter walls recording structural and surface features including but not limited to the art itself, graffiti, joints, bedding planes, exfoliation scars, cracks, mineral and micro-organism growth, drip line and water seepage locations.	Only change in shelter conditions attributable to natural weathering or preservation – mineral growth or micro-organism growth.	• Report in the End of Panel Report • Summarise all actions and monitoring in AEMR by end of February (Annually).	
		Within Prediction • Change in shelter conditions not attributable to natural weathering or preservation – mineral growth or micro-organism growth (as observed by comparing pre-mining photographs with post-subsidence/mining photographs).	• Continue monitoring program. • Report in the End of Panel Report • Summarise all actions and monitoring in AEMR by end of February (Annually).	Expansion of rock joint inside one shelter. No impacts to art. Monitoring to continue. No management action required.
		Exceeding Predicted Impact Criteria • Change in shelter conditions not attributable to natural weathering or preservation – cracking or exfoliation of art panel, movement of existing planes and joints at panel, block fall within shelter or overhang, shelter or overhang collapse. Observed by comparing pre-mining photographs with post-subsidence/mining photographs.	• Notification to DoP, DECC and resource manager/s immediately. • Notify Specialists immediately. • Condition assessment to record impacts completed within 2 weeks. • Site visits with stakeholders in accordance with approvals and management plans. • Capture photographic record immediately. • Review monitoring program and modify if necessary within 1 month. • Implement increased monitoring 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 additional monitoring and reporting within 2 weeks. • Conduct initial follow up monitoring & reporting within 2 months of CMA completion. • Report in the End of Panel Report. • Summarise all actions and monitoring in AEMR by end of February (Annually).	No impacts exceeding predictions No management action required

If impacts are identified, monitoring and mitigation will continue until determined unwarranted in consultation with SMP Stakeholders

***NOTE: ORP =** Oxidation Reduction Potential.

NOTE: CMA is a *corrective management action* developed in consultation with stakeholders in order to manage an observed impact in accordance with the relevant approvals.

Table 24.3 – Extract from Principal TARP: Total Underground Water Balance coupled with Sampling and Analysis with Longwall 6 Outcomes and Actions

Flow rates averaged over 7 day period

AT 1.9ML/DAY DAM WATER– THE OPERATIONS MANAGER WILL STOP LW AND DEVELOPMENT OPERATIONS FOLLOWING CONFIRMATION OF THIS LEVEL. WHEN REMEDIAL MEASURES BRING WATER INFLOWS BACK BELOW THIS LEVEL, LW AND/OR DEVELOPMENT OPERATIONS MAY RESUME. IF UNABLE TO STEM FLOWS USING OTHER REMEDIAL MEASURES, THE OPERATIONS MANAGER WILL IMPLEMENT RECOVERY OF THE LW AND DEVELOPMENT DISTRICT AND SEALING OF THE AREAS ACCORDING TO THE MINE CLOSURE PLAN PROVISIONS.

Flow rates averaged over 7 day period	CHARACTERISTICS OF LEVEL	ACTIONS	LONGWALL 6 OUTCOMES & ACTIONS
NORMAL	≤ 0.5 ML/day dam water and ≤3ML/day total water imbalance	▪ No remedial action necessary ▪ Monthly review meeting	
Level 1	> 0.5 to ≤1.5 ML/day dam water or >3 to ≤5ML total water imbalance and/or Unacceptable secondary monitoring alarm	▪ Advise DSC and SCA. ▪ Increase sampling frequency to weekly. ▪ Inspection of likely inflow points. ▪ Review all other monitoring inputs for anomalies, likely source and 'conduit' path. ▪ Activate additional pumping capacity as required. ▪ Seek expert advice re appropriate remedial solution or other water reduction strategy. ▪ Monthly review meeting	▪ Level 1 triggered. Actions implemented as required.
Level 2	>1.5 to ≤1.9ML dam water or >5 to ≤9 ML/day total water imbalance	▪ Advise DSC and SCA. ▪ Daily sampling and reporting frequency ▪ Incident Management Team (IMT) notification ▪ Review Production Strategy ▪ Finalise and implement water reduction strategy as per Level 1 ▪ Apply pumping strategy & review ongoing capability	▪ Level 2 trigger exceeded on a number of occasions associated with additional water pumped from Area 2. Investigations and notifications to govt authorities were made as required by the TARP.
Unacceptable	>9ML/day total water imbalance	▪ Advise DSC and SCA. ▪ Activate IMT ▪ Modify Production Strategy to suit ▪ Adopt contingency measures from Level 2 ▪ Execute mitigation and sealing strategies as appropriate ▪ Increase review meeting frequency to daily – seek DSC input	▪ no unacceptable total water imbalance occurred. No management actions required.
Unacceptable Dam Water	>1.9ML/day dam water	▪ Advise DSC and SCA. ▪ Activate IMT ▪ Stop Longwall and Development production ▪ Adopt contingency measures from Level 2 ▪ Mobilise mitigation and sealing strategies ▪ Increase review meeting frequency to daily – seek DSC input	▪ no unacceptable dam water observed. No management actions required.

7. REMEDIATION ACTIVITIES

The following sections discuss the remediation works considered and undertaken in relation to Longwall 6. With the exception of the cracks discussed below, no other features have been identified that need specific remediation following subsidence associated with Longwall 6.

Fire Road 6C Surface Crack DA3Longwall 6_62

Given that Fire Road 6C is a major road within the catchment area, approval to carry out remediation work on surface cracking was obtained from the Sydney Catchment Authority. Remediation works were undertaken successfully on surface crack DA3Longwall 6_62 and consisted of:

- placement of temporary sediment control and safety precautions;
- removal of the temporary barricade tape and sandbags;
- infilling the soil crack by hand with locally sourced sandstone and sediment from a nearby stockpile;
- packing and compacting fill into the crack in small quantities;
- continuing this process until the crack was filled.

Photographs of the crack prior to and following remediation are below.

Left: Soil Crack DA3_62 looking north with sediment control and safety precautions.

Below: DA3_62 looking north following rehabilitation

Figure 7.1 Results of rehabilitation of soil cracking in Fire Road 6C

Rock Fracture DA3Longwall 6_002

Surface Impact DA3Longwall 6_002 is a rock fracture in an outcrop on a steep slope facing northwest towards Wongawilli Creek. The fracture is up to 300mm wide and 85m long, including minor soil displacement. Following an inspection of this fracture and surrounding impacts, a report entitled *Dendrobium Colliery Area 3 Longwall 6 Soil Crack and Rock Fracture Rehabilitation Options* (Comur Consulting, June 2010) was prepared outlining options for remediation to identified areas should remediation be required. Impacts associated with remediation actions themselves were included in the assessments and led to a recommendation to allow remediation to occur naturally or to intervene with techniques that have a minimal impact on the landscape. To date, government authorities have not indicated that active remediation works are required.