

Metallurgical Coal



DENDROBIUM AREA 3B

SUBSIDENCE MANAGEMENT PLAN

Volume 2 – Subsidence Management Plan

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13 INTRODUCTION

This Subsidence Management Plan (SMP) presents the proposed monitoring and management for Longwalls 9 to 18 in Dendrobium Area 3B.

This volume of the Plan relies on the subsidence impact characterisation and Risk Assessment which have been undertaken and discussed in **Volume 1**.

The SMP and associated Monitoring and Management Plans are considered adequate for the management of any impacts from the extraction of the proposed longwalls given the nature, magnitude, extent and causes of the expected subsidence impacts arising from the proposed mining. The level of investigation and detail presented reflect the scale of the impact and the sensitivity of the features potentially affected.

13.1 EXISTING APPROVALS AND ENVIRONMENTAL MANAGEMENT

Dendrobium Colliery operates under an Environmental Management System (EMS) certified to the International Standard, ISO 14001. The Dendrobium Environmental Management Strategy (refer **Figure 13.1**) provides a framework for the environmental management of the project and builds upon the information provided in the Environmental Impact Statement (EIS) for the project.

Environmental Management of Dendrobium Colliery is achieved through application of a range of Environmental Management Plans, most of which are required to be prepared under the Area 3 Modification Conditions.

The SMP has been developed in accordance with the following existing documentation:

- Dendrobium Colliery Consent Modification 6 (2008);
- Area 3 Environmental Assessment (2007);
- Dendrobium Area 3A SMP (2007);
- Dendrobium Colliery EMS; and
- DRE (formerly DPIM) SMP Guidelines.

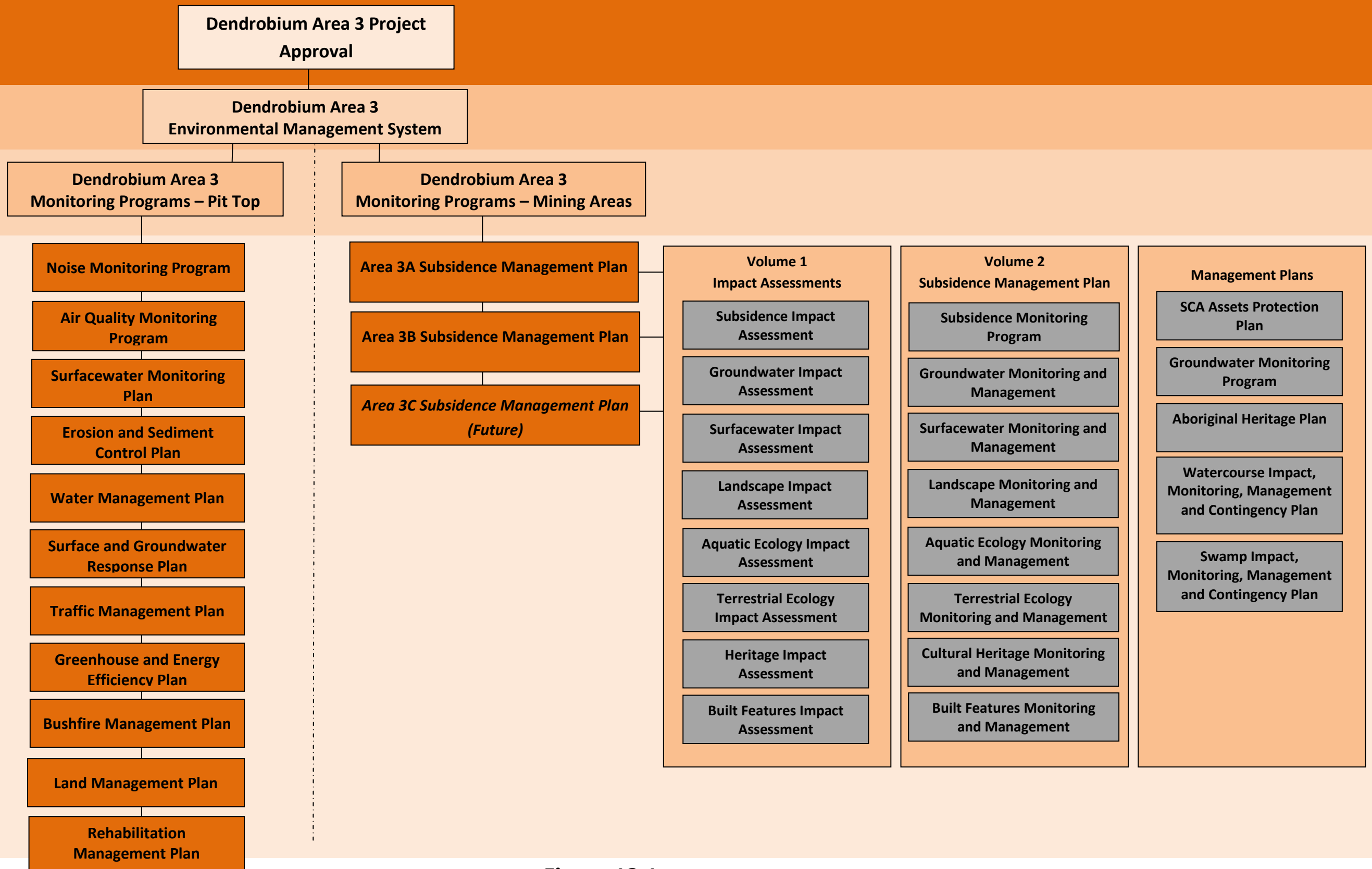


Figure 13.1

13.2 SMP PURPOSE AND OBJECTIVES

13.2.1 Purpose

The purpose of the SMP is to provide for the adequate protection of important natural and built features (NSW Mineral Resources, 2003) which may be affected by the extraction of Longwalls 9 to 18 in Dendrobium Area 3B.

It is a requirement of the Area 3 Modification that the SMP is approved prior to the carrying out of any underground operations that could cause subsidence in Area 3B. The scope of this SMP has been defined in **Volume 1**.

13.2.2 Objectives

The fundamental objective of this SMP and its associated documentation is to:

- Describe a system to adequately manage subsidence risks in a timely manner and to demonstrate BHPBIC's capability to manage subsidence.
- Clearly state the objective of what is to be achieved for both systems and individual plans.
- Outline the systems used to establish monitoring mechanisms.
- Outline the systems to ensure ongoing analysis of monitoring information is used to implement management actions in a timely manner.
- Clearly define the necessary trigger levels and response actions.
- Assess the likelihood and scale of impact and any requirements for statutory approvals.
- Demonstrate preparedness for impacts outside of predictions.
- Carry out remediation works in a manner that protects to the greatest practicable extent the ecological values of the area and re-establishes the ecological values of an area to a similar state to that existing before mining.
- Monitoring and report on the effectiveness of the SMP.

The Mine Plan has been optimised to maximise the extraction of the resource and minimise subsidence impacts to sensitive features.

13.2.3 Performance Indicators

Indicators of appropriate subsidence impact management resulting from the proposed Dendrobium Area 3B Longwalls 9 to 18 include:

- Subsidence impacts and risks will be managed in consultation with key stakeholders.
- Subsidence monitoring mechanisms will provide appropriate data for ongoing analysis and implementation of management actions to the satisfaction of key stakeholders.
- Any impacts are identified and managed appropriately.
- Performance will be monitored and reported in accordance with the requirements of the Development Consent.

13.2.4 Limitations and Assumptions

This SMP addresses the mining of the proposed Dendrobium Area 3B Longwalls 9 to 18 only, and should not be applied to other areas without review.

The assumptions of this SMP are:

- Subsidence will generally be in accordance with the predictions in technical report MSEC459.
- Impacts will be similar to those previously observed in adjacent comparable areas. Where impacts are greater than predicted, contingency measures are based on previous anomalous events and detailed scenario analysis.
- Rigorous monitoring can identify anomalous subsidence movements and can be used to manage impacts through early intervention strategies. This monitoring is targeted at surface features susceptible to impacts from anomalous movements.
- Surface features and land use will remain substantially constant during the mining period.
- The applied impact studies are comprehensive and accurate.
- This SMP focuses on potential subsidence impacts only. Mining operational risks are not considered in detail in this SMP.

This SMP will be reviewed if any of these assumptions become invalid during the SMP's operational life. Any change to these assumptions will become apparent within an adequate timeframe due to the rigorous monitoring proposed in this SMP.

13.2.5 Actions

In addition to the SMP objectives listed above, the following management actions may be required to be implemented in accord with the TARPs described in **Section 22**:

- Reporting of monitoring and management in future SMP Applications and AEMRs.
- Implementation of monitoring program.
- Condition assessment and preparation of photographic records.
- Review of monitoring program and modify if necessary.
- Reporting to key stakeholders as required.
- Development of site management plan to mitigate effects.
- Reporting to key stakeholders.
- Site visit and discussions with DRE and resource managers.

14 MINE PLAN

14.1 THE APPROVED PLAN

The SMP is based on refined mine layouts. The longwall layout within Area 3B has been refined to:

- Minimise risk to the stored water in Lake Avon.
- Reduce impact to Wongawilli Creek.
- Efficiently extract the coal resource from Area 3B.

14.2 REVISIONS TO AREA 3B MINE PLAN

Since the Area 3 Modification was granted in 2008 the following modifications have been made to the Area 3 (and more specifically Area 3B) Mine Plan:

- Longwall 10 (Area 3A) has been omitted (i.e. not extracted).
- Longwall 9 (Area 3A) has been renamed Longwall 19 and will be extracted after Longwalls 9 to 18.
- Extraction height up to 4.6 m for Longwalls 9 to 18.
- Refinement of the setback from Wongawilli Creek.
- Longwall 19 is now 75 m shorter than the approved length.

The modified mine plan for Area 3B results in lower environmental impacts than those identified for the original mine plan for Dendrobium Area 3, whilst maximizing resource recovery.

15 SUBSIDENCE MONITORING AND MANAGEMENT

15.1 IDENTIFIED HAZARDS

In March 2012, AXYS Consulting was commissioned to facilitate a qualitative risk assessment to critically examine BHPBIC's Area 3B mine plan to identify and assess mine subsidence-related risk issues. The Risk Assessment is provided as **Attachment H**; Volume 1 of this SMP Application.

The risk assessment considers potential impacts including effects on BHPBIC's strategic, business and operational objectives as well as third party and environmental aspects.

As well as this formal risk assessment, BHPBIC is required by corporate policy and standard procedures to develop and implement risk management plans in consultation with relevant stakeholders. This risk based approach to subsidence management will continue for all activities undertaken pursuant to this SMP.

The SMP and various sub-consultant studies and programs have taken into consideration the results of the risk assessment undertaken by AXYS Consulting (**Attachment H**; Volume 1 of this SMP Application).

15.2 CONTROL PROCEDURES

Procedures developed to manage subsidence impacts fall into the following five categories.

Baseline Assessment – natural features and infrastructure have been identified within the SMP Area, including Lake Avon and associated infrastructure, steep slopes, swamps, creeks and tributaries, terrestrial and aquatic ecology, roads, and survey marks.

A comprehensive description of the surface and subsurface features within Area 3B is provided in the Written Report in **Volume 1** of this SMP Application and the MSEC459 report which is provided as **Attachment A**.

Baseline Monitoring – monitoring has been undertaken in accordance with the various baseline studies associated with Areas 1, 2, 3A and 3B as summarised in the following sections.

Baseline monitoring programs for water quality, surface water flows, shallow and deep groundwater, water dependent ecosystems and weather conditions as well as a range of ecological parameters have been revised and updated as part of the development of this SMP.

Impact Assessment – an assessment of impacts associated with the development was initially described in the EIS for the project (OEC, 2001). Updated assessments for Area 2 were included in the SMP Application for Area 2. Assessments for Area 3 were first presented in the Area 3 EA and Area 3A SMP (CFR, 2007). Updated Assessments for Area 3B are included in Section 8; **Volume 1** of this SMP Application.

Impact Monitoring – is based on knowledge gained from previous studies and management of subsidence associated with the extraction of Areas 1, 2 and 3A and other longwalls in the district. Techniques used in previous mining areas are equally applicable to the current monitoring program. The proposed monitoring programs are summarised in the following sections.

Subsidence Management – provides a basis for the design and implementation of any mitigation and remediation. Monitoring provides key data when determining any requirement for mitigation or rehabilitation. Baseline data is compared with monitoring results to

determine any remediation that may be required. Descriptions of mitigation and rehabilitation options are detailed in **Section 23** of the SMP Application.

15.3 RESOURCES AVAILABLE

Adequate internal and external resources are available to ensure the implementation of this SMP. This is demonstrated by the input into planning and mining in the area since 2000.

The contractors used for implementation of rehabilitation are readily available in the local area. The BHPBIC Manager - Approvals is responsible for the implementation of mitigation measures required for environmental aspects.

BHPBIC has a successful history of implementing management strategies in relation to infrastructure within its mining areas. Mitigation resources are detailed in the specific Management Plans. The Manager Infrastructure and Rehabilitation is responsible for the implementation (with the owner) of Infrastructure Management Plans.

A tender process is in place for Environmental Contractors used for subsidence management. The acquisition of goods and services required for monitoring and remedial provisions of this SMP will be subject to BHPBIC purchasing requirements that include but are not limited to:

- All tender documents to include detailed specifications and scope of work.
- Tenderers to supply details of products, employee expertise, previous work undertaken and safety records.
- All chemicals used for projects must have MSDS documents supplied.
- All equipment used for projects must have approval documents complete and complied with.
- All persons working on projects must comply with induction requirements.

15.4 MONITORING OF SUBSIDENCE EFFECTS

The objectives of the subsidence monitoring program are to:

- Provide information on the magnitude and extent of subsidence over the longwall panels.
- Enable comparison of actual ground movements with predicted ground movements.
- Monitor ground movements at or near surface infrastructure that are at risk from ground movements.
- Provide an indication of any non-systematic movements within the subsidence zone (however, given the low density of surface infrastructure above the longwalls, the risk of adverse impacts by non-systematic movements, i.e.: anomalies, is very low).
- Satisfy the objectives of the SMP.
- Satisfy the objectives of agreed Management Plans between BHPBIC and infrastructure owners.
- Meet the expectations of the community with regard to monitoring subsidence.
- Contribute to existing knowledge of subsidence effects.

15.4.1 Monitoring Program

The program of monitoring and management established in Area 3A is proposed to be extended into Area 3B. The monitoring program will show if subsidence impacts are greater than predicted. If subsidence effects are greater than predicted, BHPBIC will investigate reasons for the occurrence.

It is noted that the Area 3 Modification Conditions (*Condition 7a, Schedule 3*) requires SMPs to “*integrate ongoing management of Areas 1 and 2*”. If required, details of these Monitoring Programs can be found in the Dendrobium Area 3A SMP.

All data from the subsidence-monitoring program will be available to various technical experts and any relevant research projects. BHPBIC has provided significant quantities of data for the refinement of predictive models and research related to mining induced subsidence. This support will continue.

Subsidence monitoring supports other components of the SMP. This is important for impact assessment, mitigation and rehabilitation. Regular reviews of subsidence data will be undertaken and a final report on subsidence in the area will be undertaken at the completion of all significant subsidence movements.

The locations of the monitoring previously undertaken and currently carried out in Areas 1, 2 and 3A are provided in the Dendrobium Area 3A SMP (Volume 2; Figures 17.1 to 17.3). The recommended monitoring locations in Area 3B will be determined once the proposed monitoring program for Area 3B (as an extension of the subsidence monitoring program in Area 3A) is finalised. Refer **Figure 15.1**.

The discussion below refers to the monitoring indicated in these figures.

15.4.1.1 Airborne Laser Scanning Survey

Due to terrain, vegetation and access restrictions, the primary method of monitoring subsidence over Dendrobium Areas 1, 2, 3A and 3B has previously been, and will continue to be undertaken by Airborne Laser Scanning (ALS). This technique generates a complete topographic model of the terrain as well as subsidence over entire longwalls and mining domains.

Base surveys over Area 1, Area 2, Areas 3A and 3B were completed prior to first workings, yielding nominal accuracies of +/- 0.15m.

A survey is generally completed after the completion of each longwall and 12 months after the completion of longwall extraction in each mining domain. Contours of the complete subsidence bowl from each longwall will be provided, rather than reliance on the traditional data along discrete subsidence lines.

15.4.1.2 3D Survey Points

Selected 3D survey marks are also established and monitored to augment the ALS data. The points will be established in accessible areas as control for the ALS Survey.

For Area 3A the 3D survey points are located around the transmission towers associated with the 330 kV transmission line and around the tension pole associated with the 33 kV transmission line. A number of additional 3D monitoring points were established along Wongawilli and Sandy Creeks (including around the waterfall at the downstream end of Sandy Creek), along fire road No. 6C, along the 330 kV transmission line, and near Swamp 15a and Swamp 15b.

The establishment of 3D survey points will be undertaken in phases prior to mining of the proposed longwalls and will include points that will encompass monitoring of Wongawilli

Creek as well as the fire roads. Survey point establishment phases would be refined prior to commencement of extraction, however, indicative phases would include:

Phase 1 – Longwalls; 9 – 11;

Phase 2 – Longwalls 12 – 15; and

Phase 3 – Longwalls 16 – 18).

Based on this approach not all of the 50 plus points would be established immediately, with only the Phase 1 and potentially Phase 2 points established.

In addition to any specific requirement for Infrastructure Management Plans, the survey frequency of these points will coincide with the ALS flights.

15.4.1.3 2D Survey Lines

Area 3A

ALS is used to provide an indication of the extent of the whole subsidence trough. BHPBIC survey the 2D monitoring lines in Area 3A once every month during the extraction of the first 1000m of Longwalls 6 and 7; and then survey every six months until a reduction is justified to the DSC and other stakeholders.

Visual monitoring (for cracking) along survey lines is undertaken and reported with each set of subsidence data. Visual checking of creek beds is carried out in accordance with the Subsidence Landscape Monitoring and Management Program

Area 3B

Area 3B has similar topographic constraints to Area 2 and 3A with respect to 2D subsidence monitoring. ALS will therefore also be used to provide an indication of the extent of the whole subsidence trough.

Currently there are three (3) 2D closure lines being monitored for Wongawilli Creek. These lines are known as *WONG X A, B, and C lines*. These three lines were originally established during the mining of Dendrobium Area 3A and are evenly distributed along the extent of Wongawilli Creek potentially affected by Dendrobium Area 3A. These existing lines are ideally located for monitoring closure for Area 3B Longwalls 9, 10 and 11. Further closure lines for Longwalls 12 to 18 will be established as mining progresses south. The exact number and location of any additional lines will be determined based on movements observed to date and vegetation and topographic constraints.

Swamps 1a, 1b and 5 will be monitored for relative and absolute horizontal and vertical movements. A line of nominally five (5) to eight (8) points will be established across a narrow rockbar / water course section of each of these three swamps. The location of these cross lines will be in the vicinity of the piezometer monitoring networks. At each of the three swamps a single point will be established as close as practically possible to each of the lines at which GPS measurements can be taken.

Relative movement of points in the cross lines will be measured via total station based EDM measurement whilst the absolute 3D movements will be determined by GPS as part of the overall *Dendrobium Area 3B Regional 3D GPS network*. Depending on the results of the above swamp monitoring during the first two longwalls in Area 3B, additional survey monitoring may be required in swamps further south which may be affected by later longwalls.

Visual monitoring (for cracking) along survey lines is undertaken and reported with each set of subsidence data. Visual checking of creek beds is carried out in accordance with the Subsidence Landscape Monitoring and Management Program **Section 18**.

Area 3B Subsidence Survey Monitoring Locations

DENDROBIUM AREA 3B SMP

Legend

- Nominal Swamp Monitoring Lines
- Regional 3D GPS Points
- Nominal Existing Wongawilli Cross Lines
- 600m Study Boundary - Condition 8(d)
- Creek Centrelines
- SMP Area (MSEC 2012)
- Dendrobium Area 3
- DSC Notification Zone
- +— Maldon to Dombarton Rail
- Proposed Longwall Layout (BHPBIC, 2012)
- 10m Contours (LPI)
- Waterbodies (LPI)
- Stream Mapping (Illawarra Coal 2012)
- Area 3B Swamps (Illawarra Coal, 2011)

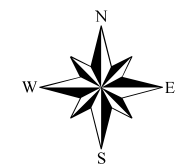
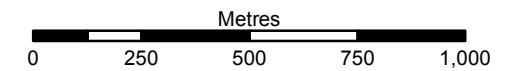


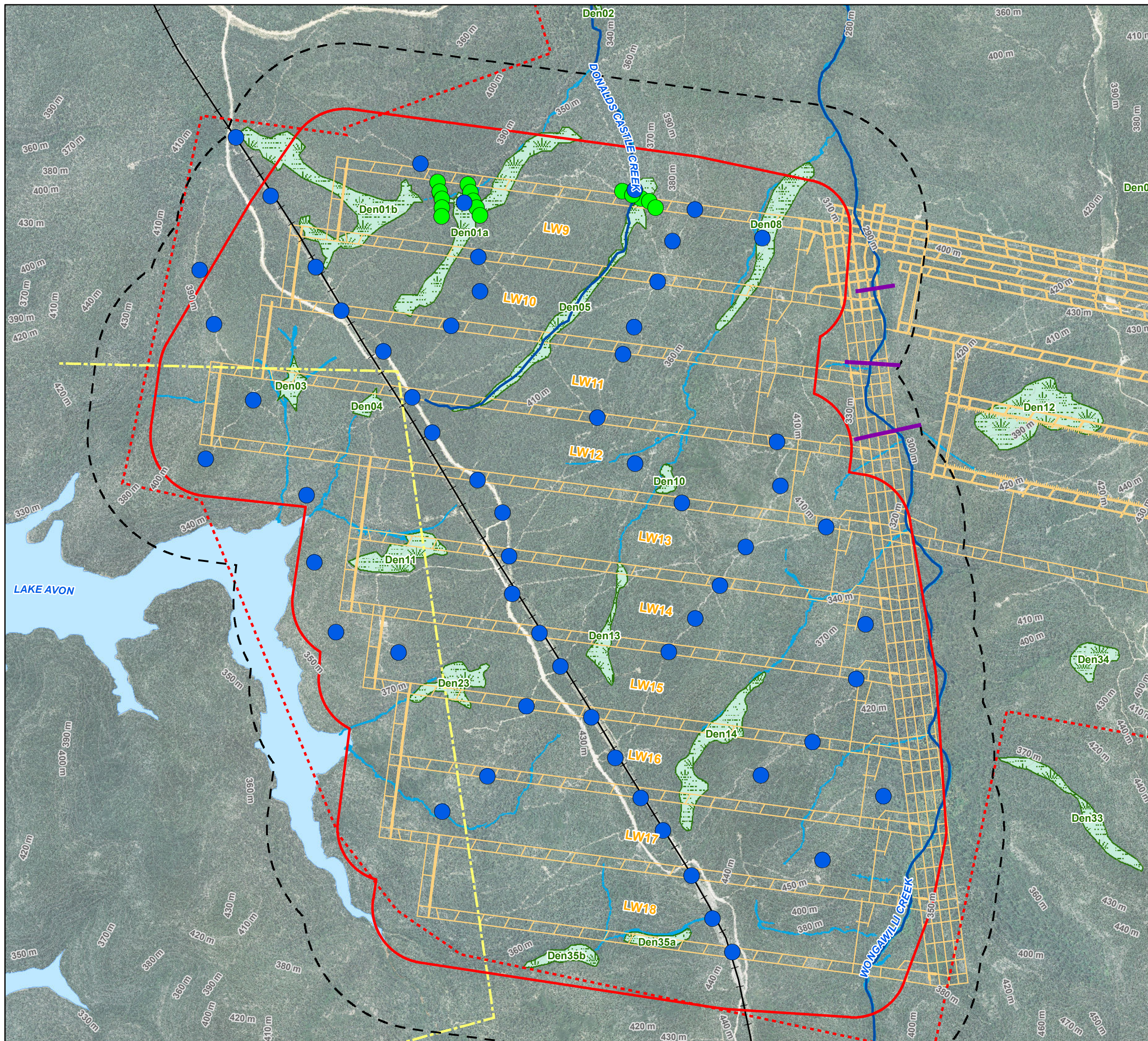
FIGURE 15.1

1:17,500 Scale at A3



Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2012-09-28
Coordinate System: GDA 1994 MGA Zone 56
Project: 112041-01
Map: G1040_NominalMonitoringLocations.mxd 01

Data supplied by MSEC (2012) unless otherwise stated
Aerial imagery supplied by BHPBIC (2009)



15.4.1.4 Infrastructure

Specific monitoring requirements will be agreed with infrastructure owners. Integral Energy, the DSC and SCA have previously indicated specific monitoring requirements for mining within Area 3. The SCA have undertaken to install and maintain monitoring at the Upper Cordeaux No. 2 Dam with the costs borne by BHPBIC.

Table 15.1 - Subsidence Monitoring for Dendrobium Areas 3A and 3B

Item	Description	Survey	Methodology	Accuracy	Frequency
Airborne Laser Scanning	ALS over entire Areas 3A and 3B - including 3D Digital Terrain Model (DTM)	AAM Hatch	Comparison of DTM	+/- 150mm	Base DTM 2000 prior to longwall extraction in Area 1 2005 Prior to longwall extraction in Area 1 and Area 2 (to confirm accuracy of data capture in Area 1) Summer 2007 ALS to be undertaken at conclusion of each longwall and 12 months after extraction is complete in each area
Area 3A and 3B 2D monitoring lines (numerous)	Survey station – capped gal pipe or star picket driven to refusal	BHPBIC	Two-dimensional level and strain survey using Leica TDA5005	Level misclose, to comply with SP1 Class LB +/- 3.5mm	Monthly for first 1000m of extraction then 6 monthly
3D Control Survey	Absolute control survey to coordinate selected monitoring stations throughout Areas 3A and 3B	BHPBIC	Three-dimensional survey using Leica GPS System 500 Reports ground movement to fixed points outside the influence of subsidence	Baseline dependent Nominally +/- 25mm in x and y, +/-35mm in z	Conclusion of each longwall and 12 months after completion of each area
3D Points (Area 3A)	Around Transmission Towers along TransGrid 330kV Transmission Line	BHPBIC	Three-dimensional survey using Leica GPS System 500 Reports ground movement to fixed points outside the influence of subsidence	Baseline dependent Nominally +/- 25mm in x and y, +/-35mm in z	Conclusion of each longwall and 12 months after completion of each area
3D Points (Area 3A)	Along TransGrid 330kV Transmission Line	BHPBIC	Three-dimensional survey using Leica GPS System 500 Reports ground movement to fixed points outside the influence of subsidence	Baseline dependent Nominally +/- 25mm in x and y, +/-35mm in z	Conclusion of each longwall and 12 months after completion of each area
3D Points (Area 3A)	Around Tension Pole along Integral 33kV Power Line	BHPBIC	Three-dimensional survey using Leica GPS System 500 Reports ground movement to fixed points outside the	Baseline dependent Nominally +/- 25mm in x and y, +/-35mm in z	Conclusion of each longwall and 12 months after completion of each area

Item	Description	Survey	Methodology	Accuracy	Frequency
			influence of subsidence		
3D Points (Area 3A)	Along Fire Road No. 6C	BHPBIC	Three-dimensional survey using Leica GPS System 500 Reports ground movement to fixed points outside the influence of subsidence	Baseline dependent Nominally +/- 25mm in x and y, +/-35mm in z	Conclusion of each longwall and 12 months after completion of each area
3D Points (Area 3A)	Along Integral 33kV Power Line	BHPBIC	Three-dimensional survey using Leica GPS System 500 Reports ground movement to fixed points outside the influence of subsidence	Baseline dependent Nominally +/- 25mm in x and y, +/-35mm in z	Conclusion of each longwall and 12 months after completion of each area
3D Points (Area 3A)	Around Swamps 15a and 15b	BHPBIC	Three-dimensional survey using Leica GPS System 500 Reports ground movement to fixed points outside the influence of subsidence	Baseline dependent Nominally +/- 25mm in x and y, +/-35mm in z	Conclusion of each longwall and 12 months after completion of each area
3D Monitoring Points and 2D Monitoring Lines (Area 3A)	Along Wongawilli and Sandy Creeks	BHPBIC	Three-dimensional survey using Leica GPS System 500 Reports ground movement to fixed points outside the influence of subsidence	Baseline dependent Nominally +/- 25mm in x and y, +/-35mm in z	Conclusion of each longwall and 12 months after completion of each area

16 GROUNDWATER MONITORING AND MANAGEMENT

The Area 3 Modification Conditions require the SMP to include a Groundwater Monitoring Program under *Condition 13 Schedule 3*. A groundwater monitoring program is currently implemented at Dendrobium Colliery and is conducted in accordance with the *Dendrobium Colliery Area 3A SMP Groundwater Management Plan* and the Area 3 Modification Conditions. The existing groundwater management plan will be modified to include Area 3B.

The consent condition requirements that are addressed within the SMP are provided in **Table 16.1**.

Table 16.1 - Conditions of Approval Requirements

Project Approval Condition	Relevant SMP Section
<p>Schedule 3 - Condition 13</p> <p>The SMP prepared under condition 7 must include a Groundwater Monitoring Program, which must include:</p> <ul style="list-style-type: none"> (a) proposals to develop a detailed regional and local groundwater model, with special reference to flows to and from nearby water storages; (b) detailed baseline data to benchmark the natural variation in groundwater levels, yield and quality; (c) groundwater impact assessment criteria; (d) a program to monitor the impact of the development on: <ul style="list-style-type: none"> • Groundwater levels, yield and quality (particularly any potential loss of flow to, or flow from; SCA water storages); • Groundwater springs and seeps. (e) consideration of the requirement of the latest version (or subsequent replacement) of SCA's <i>The Design of Hydrological and Hydrogeological Monitoring Program to Assess the Impacts of Longwall Mining in SCA Catchment</i>. 	<p>Section 5.5</p> <p>Attachment C</p> <p>Section 7.8</p> <p>This Section (16)</p> <p>This Section (16)</p>

The Plan also aims to manage the potential impacts and/or environmental consequences of the proposed second workings and to demonstrate how the subsidence impact limits in *Conditions 1 to 3 Schedule 3* (and reiterated below) are to be met. These limits are outlined in **Table 16.2**.

Table 16.2 - Management Plan Requirements

1. *The Applicant shall ensure that, as a result of the development:*
 - (a) *no rock fall occurs at Sandy Creek Water fall from its overhang;*
 - (b) *the structural integrity of the waterfall, its overhang and its pool are not impacted;*
 - (c) *cracking in Sandy Creek within 30 m of the waterfall is of negligible environmental and hydrological consequence; and*
2. *The Applicant shall ensure that underground mining operations do not cause subsidence impacts at Sandy Creek and Wongawilli Creek other than 'minor impacts' (such as minor fracturing, **gas release, iron staining** and minor impacts on water flows, water levels and water quality) to the satisfaction of the Director-General.*
3. *The Applicant shall ensure the development does not result in reduction (other than negligible reduction) in the quality or quantity of surface water or **ground water inflows to Lake Cordeaux or Lake Avon** or surface water inflow to the Cordeaux River at its confluence with Wongawilli Creek, to the satisfaction of the Director-General.*

The Monitoring and Management Plan for shallow groundwater within Dendrobium Area 3B has been developed by Ecoengineers (2012) and is described in **Section 17**.

16.1 EXISTING MANAGEMENT PLANS

The monitoring and management program for Areas 1, 2, 3A and 3B are outlined in the following reports:

- GHD (2006) *Dendrobium Area 2 Predicted Hydrogeologic Performance*. May 2006. Prepared for BHPBIC.
- Ecoengineers (2007a), *Surface Water Quality and Hydrology Assessment to Support SMP Application for Dendrobium Area 3*. Prepared for BHPBIC.
- GHD (2007) *Dendrobium Area 3 Predicted Hydrogeologic Performance*. November 2007. Prepared for BHPBIC.
- Ecoengineers (2012) *Dendrobium Area 3B Subsidence Management Plan Surface and Shallow Groundwater Assessment*. Prepared for BHPBIC.
- Coffey (2012) *Dendrobium Area 3B Groundwater Assessment*. Prepared for BHPBIC.

In addition, development of the groundwater monitoring and management program has taken into consideration the requirements of the latest version (or subsequent replacement) of SCA's '*The Design of Hydrological and Hydrogeological Monitoring Program to access the impacts of longwall mining in the SCA Catchment*'.

Information on the monitoring and management of groundwater presented below is drawn from these documents, which should be consulted for detailed information. The most recent of these, Coffey (2012), is provided in **Attachment C** Volume 1 of this SMP Application.

16.2 BASELINE DATA

Previous groundwater monitoring at the Dendrobium Colliery has occurred in Areas 1, 2 and 3. Data and results of this past monitoring have enabled groundwater models to be calibrated of the Dendrobium mining area.

Groundwater parameters measured in Area 3A have included water level, pH, EC and ORP.

The layout of boreholes for piezometer installation at Dendrobium has been designed to provide coverage of the footprint of longwalls in the entire mining area. The location and type of piezometric monitoring for Areas 1 through to 3A are detailed in Dendrobium Area 3A SMP Volume 2; Table 18.8.

Vibrating wire piezometer strings measure piezometric pressure in each hole in the overburden and target strata of interest in relation to the formation of the goaf, interconnection with the dams and groundwater dependent ecosystems. The multiple piezometers have built in redundancy to ensure robustness of the system.

Significant progress on the modelling of groundwater within Area 3B has been undertaken by Coffey via modification of the Heritage Computing (2010) model developed for Area 3A. This has been done by reassigning the grid (redefining it above Lake Avon) and including additional model layers (as discussed in **Section 16.4**).

16.3 ONGOING MONITORING

Deep Groundwater Monitoring

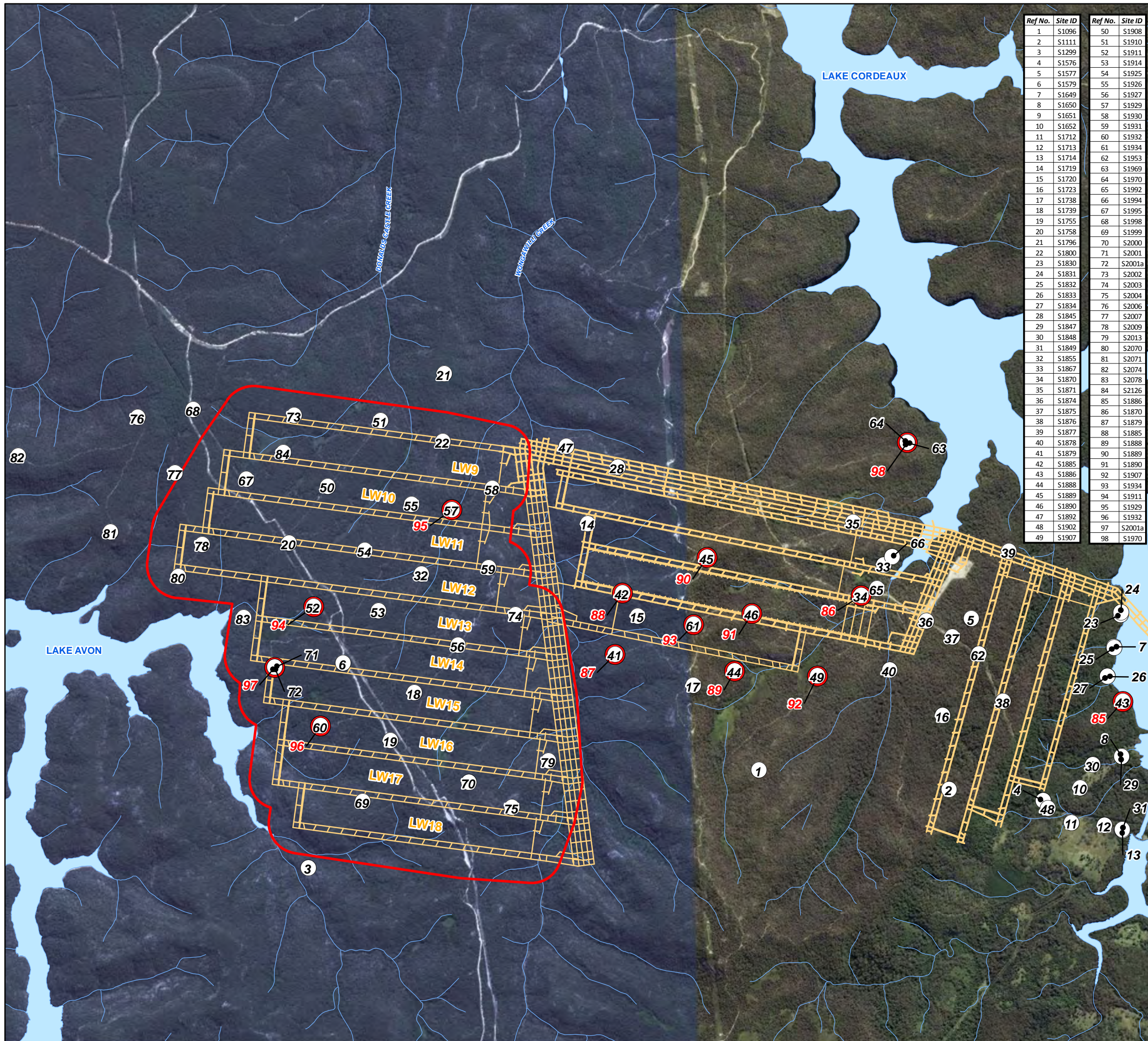
Monitoring consists of a significant number of piezometric pressure transducers within the rockmass coupled with the measurement of a detailed water balance within Dendrobium 1, 2, 3A and 3B. The monitoring within the rockmass consists of arrays of downhole vibrating wire Piezometers (VWPs).

Dendrobium Area 1, 2, 3A and 3B monitoring locations are shown in **Figure 16.1**.

Monitoring of the groundwater within Area 3B will be undertaken pre-mining, during mining and at the completion of mining for a period agreed with key stakeholders (at least two years). Coffey has developed a model for Area 3B by modifying the model developed for Area 3A. Coffey has reassigned the grid (refining it near Lake Avon) and included additional model layers.

Predictive modelling has been undertaken for the 10 longwall panels in Area 3B. Heritage Computing (2010) have developed the local model focussing on the four panels in Area 3A, therefore Coffey (2012) have focused on calibrating a regional model for the 10 new proposed longwalls in Area 3B, Longwalls 8 to 19.

The aim of this modelling is to assess the changes in groundwater conditions, including any leakage from, or baseflow to, Lake Avon. MODFLOW-SURFACT (version 3) will be employed for the regional model.



Ref No.	Site ID	Ref No.	Site ID
1	S1096	50	S1908
2	S1111	51	S1910
3	S1299	52	S1911
4	S1576	53	S1914
5	S1577	54	S1925
6	S1579	55	S1926
7	S1649	56	S1927
8	S1650	57	S1929
9	S1651	58	S1930
10	S1652	59	S1931
11	S1712	60	S1932
12	S1713	61	S1934
13	S1714	62	S1953
14	S1719	63	S1969
15	S1720	64	S1970
16	S1723	65	S1992
17	S1738	66	S1994
18	S1739	67	S1995
19	S1755	68	S1998
20	S1758	69	S1999
21	S1796	70	S2000
22	S1800	71	S2001
23	S1830	72	S2001a
24	S1831	73	S2002
25	S1832	74	S2003
26	S1833	75	S2004
27	S1834	76	S2006
28	S1845	77	S2007
29	S1847	78	S2009
30	S1848	79	S2013
31	S1849	80	S2070
32	S1855	81	S2071
33	S1867	82	S2074
34	S1870	83	S2078
35	S1871	84	S2126
36	S1874	85	S1886
37	S1875	86	S1870
38	S1876	87	S1879
39	S1877	88	S1885
40	S1878	89	S1888
41	S1879	90	S1889
42	S1885	91	S1890
43	S1886	92	S1907
44	S1888	93	S1934
45	S1889	94	S1911
46	S1890	95	S1929
47	S1892	96	S1932
48	S1902	97	S2001a
49	S1907	98	S1970

Deep Groundwater Monitoring Locations

DENDROBIUM AREA 3B SMP

- Legend**
- Deep Groundwater Monitoring Sites (BHPBIC)
 - Groundwater Sample Pump Locations (BHPBIC)
 - SMP Area (1,199 ha)
 - Longwall Layout (BHPBIC, 2012)
 - Watercourses (LPI)
 - Waterbodies (LPI)

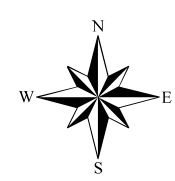
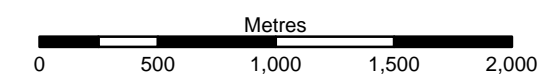


FIGURE 16.1

1:32,000 Scale at A3



Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
 Date: 2012-06-01
 Coordinate System: GDA 1994 MGA Zone 56
 Project: 112041-01
 Map: G1010_DeepGroundwaterMonitoringLocations.mxd 06
 Aerial imagery supplied by Bing Maps and associated third party suppliers

Modelling undertaken by Coffey has been treated using similar methods to those employed by Heritage Computing for Area 3A, including adoption of the same assumptions (Heritage Computing, 2010) to ensure consistency of results. Further development of the model included the Bulgo and Hawkesbury sandstone being divided into two layers each to accommodate significant hydraulic gradients.

Further information regarding groundwater monitoring within Hawkesbury Sandstone is provided in **Section 17.5**.

16.4 MANAGEMENT MEASURES

The Groundwater Trigger Action Response Plan (TARP) is included in Section 4 of the Groundwater Management Plan. The TARP is used in conjunction with a flow chart (refer Figure 4.1 of Groundwater Management Plan) which includes trigger levels based on measured seven day averaged flow rates.

A number of management actions may be implemented in the case that there are variations from predicted subsidence impacts, and in accordance with the TARPs. These actions include:

- Key stakeholders will be informed of any variance to predicted impacts and proposed investigation, mitigation and rehabilitation, if required.
- BHPBIC and its consultants and contractors acting on alerts.
- Investigative, mitigation and rehabilitation actions will be taken in response to alerts after consultation with key stakeholders and appropriate approvals are in place.
- Water quality effects of remediation measures will be taken into account when designing and implementing any program. These issues will be addressed during any approval process.

The effectiveness of remediation will be further discussed with approval agencies for each program but will be based on returning the area to as similar to pre-mining conditions as is practicable or as otherwise negotiated with relevant stakeholders.

In the event the TARPs (refer **Section 22**) are considered to have been exceeded, or are likely to be exceeded, BHPBIC will implement a Contingency Plan to manage any unpredicted impacts and their consequences. The Contingency Plan is outlined in **Section 23**.

17 SURFACEWATER MONITORING AND MANAGEMENT

Surface water monitoring and management programs have previously been developed for Dendrobium Areas 1 and 2 by MHL (2006) for the management of any mining induced subsidence. Similarly, a *Water Monitoring and Management Plan* has been developed for Dendrobium Area 3A by Ecoengineers (2007). Ecoengineers have also developed the *Proposed Dendrobium Area 3B Water Monitoring and Management Plan* for Dendrobium Area 3B (Ecoengineers, 2012). This is included as part of **Attachment B** Volume 1 of this SMP Application.

A summary of the Water Monitoring and Management Program is provided below.

The specific aim of the Plan is to comply with *Condition 4 Schedule 3* of the Area 3 Modification Conditions and adhere to the DRE SMP Guidelines (2003) with respect to water management issues.

The Plan also aims to manage the potential impacts and/or environmental consequences of the proposed second workings and to demonstrate how the subsidence impact limits in *Conditions 1 to 3 Schedule 3* are to be met. These limits are outlined in **Table 16.2**.

17.1 WATER MONITORING OBJECTIVES

In order to comply with the Area 3 Modification Conditions with respect to water management issues the Impact Monitoring, Management and Contingency Plan is required to provide the following information:

- A description on how the subsidence impact limits in Conditions 1 to 3 are to be met.
- A monitoring program and reporting mechanisms to enable close and ongoing review by DRE and DP&I of the subsidence effects and impacts (individual and cumulative) on Wongawilli Creek, Sandy Creek and Sandy Creek Waterfall.
- Include a general monitoring and reporting program addressing surface water levels, water flows, water quality, surface slope and gradient, erodibility, aquatic flora and fauna (including Macquarie Perch, any other threatened aquatic species and their habitats) and ecosystem function in areas that may be affected by mine subsidence.
- Include a management plan for avoiding, minimising, mitigating and remediating impacts on watercourses including a TARPS Table. This is to focus on measures for remediating both predicted and unpredicted impacts.

17.2 EXISTING MANAGEMENT PLANS

The monitoring and management program for Areas 1, 2, 3A and 3B are outlined in the following reports:

- MHL (2006) BHP Billiton Dendrobium Colliery Areas 1 & 2 Subsidence Environmental Management Plan, Water Monitoring and Management Plan. Prepared for BHP Billiton Illawarra Coal.
- Ecoengineers (2007a), *Surface Water Quality and Hydrology Assessment to Support SMP Application for Dendrobium Area 3*. Prepared for BHP Billiton Illawarra Coal.
- Ecoengineers (2012) *Surface Water Quality and Hydrology Assessment Dendrobium Area 3B Subsidence Management Plan Surface and Shallow Groundwater Assessment*. Prepared for BHP Billiton Illawarra Coal.

Information on the monitoring and management of the surface water features presented below is drawn from these documents, which should be consulted for detailed information. The most recent of these is provided in **Attachment B** Volume 1 of this SMP Application.

17.3 BASELINE DATA

A number of natural features have been identified in the vicinity of the proposed longwalls.

These include:

- **Wongawilli Creek** running south to north along the eastern side of Area 3B;
- **Donalds Castle Creek**; the **Native Dog Creek Arm of Lake Avon** on the south east side of Longwalls 13 through to 18; and
- Thirteen **Swamps**.

A detailed description of the geomorphological characteristics of these natural features can be found in **Attachment B**; Volume 1 of this SMP Application.

The Proposed Dendrobium Area 3B Water Monitoring and Management Plan prepared by Ecoengineers (2012) aims to provide a comprehensive baseline hydrographic and water quality database for Area 3B and builds on previous monitoring programs developed for Area 3.

A minimum 2 year baseline study is required to be conducted within the SMP Area with the collection of samples at an appropriate frequency and scale for all significant natural features. The baseline study records the biophysical characteristics of the SMP Area and enables a comparison between pre-mining, during and post-mining conditions.

The proposed programs comprising the Plan for Area 3B are as follows:

1. A pre-mining baseline and post-mining stream hydrographic monitoring, hydrologic modelling and assessment program.
2. Establishment of shallow piezometers in those upland areas where a significant unified hillslope aquifer, potentially susceptible to subsidence effects, is believed to occur and where large aquifer embedded swamps or families of such swamps also occur.
3. A pre-mining baseline and post-mining field water quality monitoring and laboratory analysis program based on extension of the existing long term study of water quality conducted in the Native Dog, Wongawilli and Donald's Castle Creeks since late 2001.

Surface Water Features

Ecoengineers (2012) have also undertaken a Surface Water Quality and Hydrology Assessment investigating water quality, hydrologic and aquatic ecological effects in relation to longwall mining in the Illawarra region and is based on 15 years of past experience of both Ecoengineers and other consultants. In particular, it covers the studies and assessments previously conducted in relation to the closed BHPBIC Elouera Mine immediately south of Dendrobium Area 3B.

Between 2001 and 2006, BHPBIC commissioned Ecoengineers to carry out monthly water quality monitoring campaigns at a significant number of sites in both Wongawilli Creek and Donald's Castle Creeks to detect potential impacts from Longwalls 5 through 10 of BHPBIC's Elouera Colliery and Longwalls 14 and 17 for Delta Colliery. These studies were also carried out to provide baseline water quality data in respect of the proposed future mining of Dendrobium Area 3.

In addition, throughout that period, BHPBIC conducted similar water quality monitoring at a number of sites in Native Dog Creek. Monitoring was undertaken prior and during mining of the Elouera Longwalls 1 to 10.

Reports on these water quality monitoring programs are provided in Ecoengineers Pty Ltd, 2003, 2004a, 2004b, 2005, 2006a, 2007a, and 2007c.

The following is a summary of relevant baseline data assessed:

- Monthly water quality monitoring campaigns and assessments - Wongawilli and Donalds Castle Creeks, Native Dog Creek - 2001 to 2006.
- Installation of ultrasonic Doppler flow meters - Native Dog Creek, Wongawilli Creek and Native Dog Creek - 2002.
- Installation of nine hydrographic gauging stations and pluviometer in Dendrobium Areas 2 and 3 - including Sandy Creek (2007-2008), Wongawilli Creek (designated WWU and WWL) and Upper Donalds Castle creek (designated DCU).

- Installation of Pluviometer at a central location within Area 3A (designated the Centroid Rainfall Station 'CRS').
- Monthly water quality monitoring campaigns for pH, EC, DO and ORP.
- Rainfall data collected from CRS since 1 January 2008 and stream flow data collected from 1 January 2008. Used to determine key hydraulic performance parameters for the Wongawilli Creek Catchment and Sandy Creek Catchment.

Swamp Studies

There is a large body of work and conclusions from numerous studies of upland swamps on the Woronora Plateau (Young, 1986a, b; Keith, 1993; Mooney, 1994; Cary and Morrison, 1995; DLWC, 2002; Tomkins and Humphrey, 2006; Keith et al., 2006 and 2007). A Landscape Impact Assessment including an assessment of swamps within the SMP Area has also been undertaken by Cardno Forbes Rigby (2007) to support the Dendrobium Area 3 Environmental Assessment.

Shallow groundwater piezometers have also been installed in a number of swamps within and around Area 3. These include shallow piezometers in the hillslope aquifers on the eastern side of Sandy Creek and a number of shallow auger holes in Swamp 15b and Swamp 11 with long term piezometer records.

These studies constitute a substantial database of baseline swamp monitoring data and will be used as baseline data for Area 3B.

Existing Hydrographic Study Locations and Durations

Flow gauging in Wongawilli Creek and Upper Donalds Castle Creek has been conducted since 1 January 2008 recording instantaneous flow rates every 15 minutes and computed average flow rates (ML/day) every 6 hours (refer **Table 17.1**).

A continuous rainfall record has also been obtained from the Centroid Rainfall Station (CRS) since 1 January 2008. Long term rainfall records (>20 years) in the vicinity of Area 3B have been obtained from the weather stations located at Browns Road (located in Area 3B), Cordeaux Dam Number 2 (which lies about 6.5 km east of the Browns Road weather stations), and Cordeaux Quarters' located at the modern Cordeaux Dam site about 7 km north-east of Browns Road weather station.

Details on the modelling for Area 1 and 2 are provided in MHL (2006). Detail on the modelling for Area 3 is provided in Ecoengineers (2007a and 2012) (refer **Attachment B**; Volume 1 of this SMP Application).

A centrally located rainfall monitoring gauge is proposed for installation in Area 3B prior to mining in the Area.

Table 17.1 - Flow Gauging at Lower Wongawilli Creek and Upper Donalds Castle Creek

Catchment	Gauging Sites	Area (km ²)	Duration of Flow gauging (days)
Lower Wongawilli Creek	WWL	20.026	1141
Upper Donalds Castle Creek	DCU	6.219	1141

17.4 ONGOING MONITORING

The ongoing water monitoring plan incorporates provisions for hydrographic and water quality monitoring. It is proposed to conduct monitoring before, during and after mining of Area 3B.

Field parameters monitored for water quality analysis include the following:

- pH.
- Electrical Conductivity (EC).
- Oxidation Reduction Potential (ORP; Eh).
- Dissolved Oxygen (DO).
- Turbidity; and
- Laboratory Analytes (Na, K, Ca, Mg, Filt. SO₄, Cl, T. Alk, Total Fe, Mn, Al, Filt. Cu, Ni, Zn, TKN, NH₃-N, NO_x-N, TP)

The monitoring of these parameters provides an extremely sensitive and timely means of detecting and providing quantitative assessment of effects in the very early stages of creek bed fracturing or induction of ferruginous springs.

The RUNOFF2005 model will be used for hydrographic modelling and assessment as it has been successful in its application in the local area during past monitoring campaigns (Ecoengineers 2006b and 2012).

Assessment of water quality data will be supported by geochemical modelling using PHREEQC (Parkhurst and Appelo, 1999).

Initially hydrographic and water quality monitoring would be based around sites located within main channels of the principal creeks being Wongawilli Creek and Donalds Castle Creek and tributary catchments around swamps. A justification for the selection of water quality and hydrographic monitoring sites selected is provided in **Attachment B** Volume 1 of this SMP Application.

Hydrographic and Water Quality Monitoring Sites for Area 3B

Preliminary monitoring sites were selected for watercourses that overlay the location of proposed longwalls in Area 3B and the SMP Area. Areas targeted included upland swamps and stream features permitting monitoring sites to be established (i.e. pools and rockbars). Site access was also considered.

Figure 17.1 shows the location of the monitoring sites.

Water Quality Monitoring Locations

DENDROBIUM AREA 3B

Legend

- Weather Station
- Water Quality
- Water Quality/ Flow
- Area 3A Existing Monitoring Sites
- Preliminary Monitoring Sites
- SMP Area (MSEC, 2012)
- Longwall Layout (BHPBIC)
- Watercourses (LPI)
- Swamps
- Waterbodies (LPI)

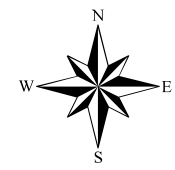
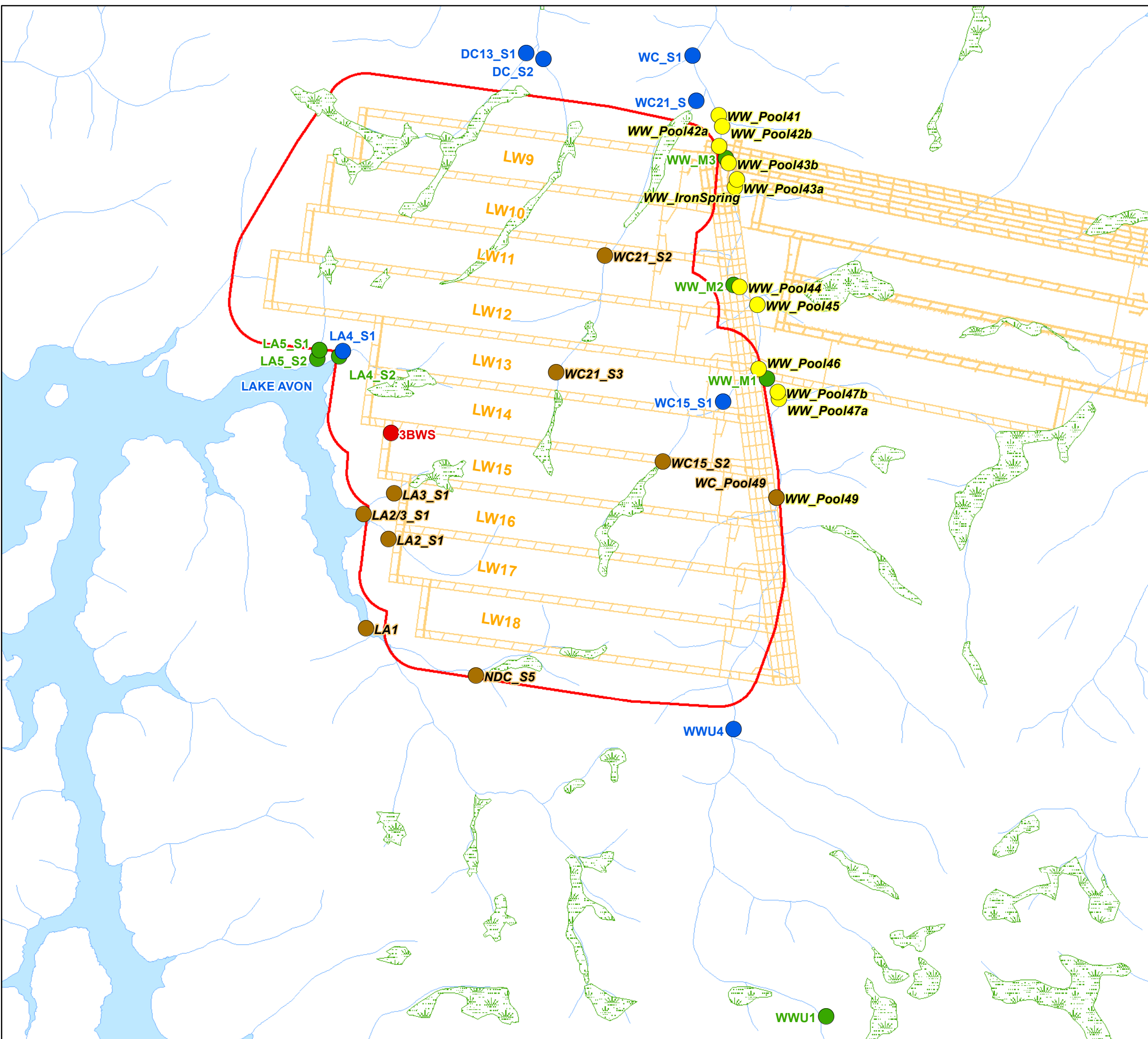
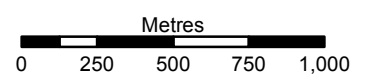


FIGURE 17.1

1:25,000 Scale at A3



Hydrographic Monitoring Program

Approximately five additional flow monitoring stations will be installed within Wongawilli and Donalds Castle Creeks (and some of their tributaries) for the Area 3B monitoring program.

These will be used in association with the existing stations to more accurately measure stream flow as well as encompass an adequate number of storm events through rising peak and recessional stages of the storm hydrographs.

The locations of the existing and proposed hydrographic and rainfall monitoring sites (including new pluviometer) are listed in **Table 17.2** and shown in **Figure 17.2**.

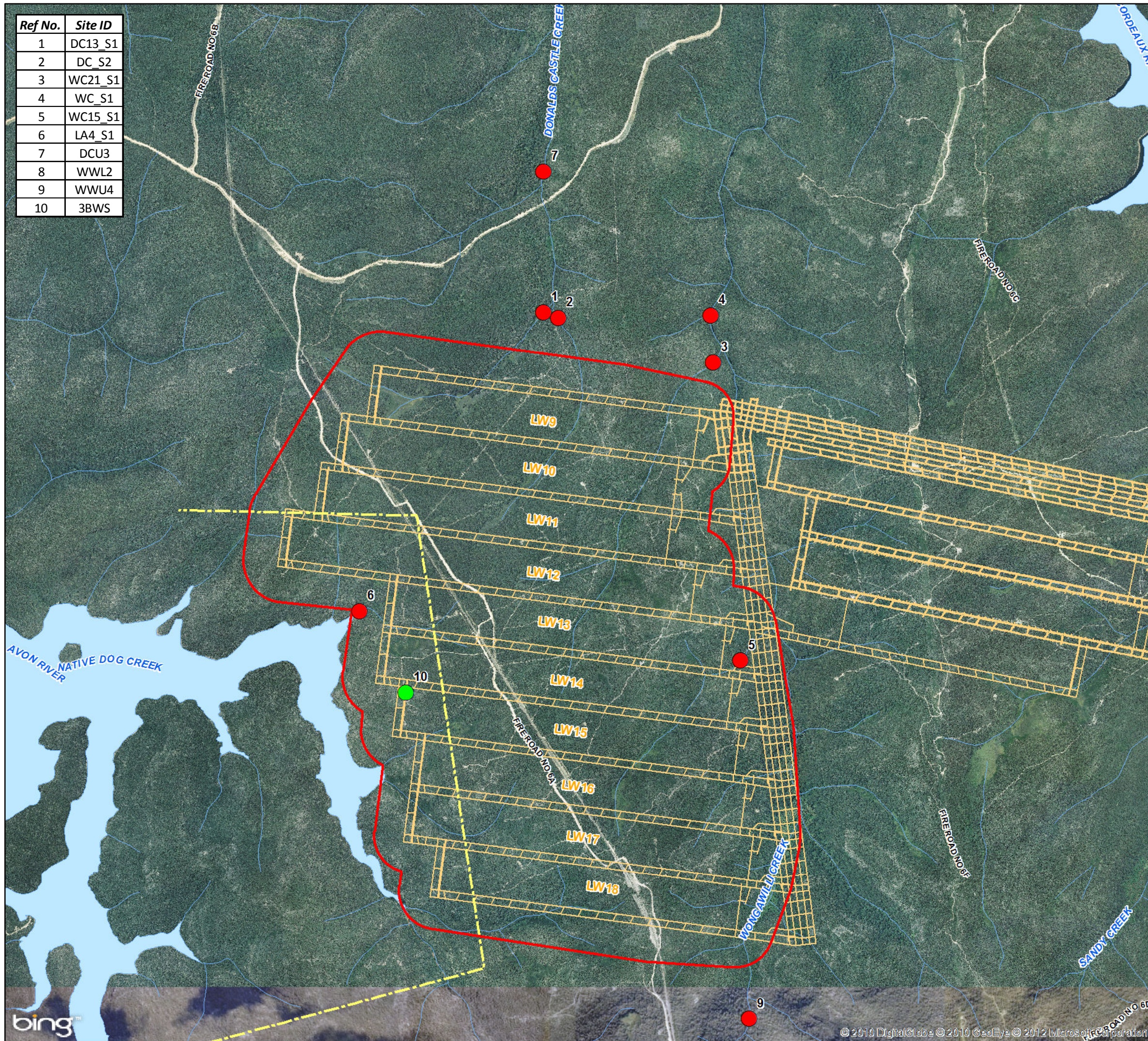
Where possible, rockbars will be used as flow control structures and where this is not possible flow control structures will be installed.

Flow monitoring stations will aim to accurately characterise flows within the streams at low flows i.e. base flows where the potential for mining induced impacts are most likely to be apparent and most necessary to quantify.

Table 17.2 - Hydrographic and Rainfall Monitoring Sites

Monitoring Location	Proposed Site Identifier	Easting (MGA)	Northing (MGA)	Catchment
Upper Donalds Castle Creek	DC13_S1	289397	6194613	Donalds Castle Creek
Upper Donalds Castle Creek upstream of DC_S1	DC_S2	289496	6194574	Donalds Castle Creek
Wongawilli Creek	WC21_S1	290555	6194270	Wongawilli Creek
Wongawilli Creek	WC_S1	290539	6194591	Wongawilli Creek
Wongawilli Creek Middle	WC15_S1	290743	6192232	Wongawilli Creek
Unnamed Creek LA4	LA4_S1	288138	6192567	Lake Avon
Upper Donalds Castle Creek	DCU3	289398	6195573	Donalds Castle Creek
Lower Wongawilli Creek	WWL2	290977	6197548	Wongawilli Creek
Upper Wongawilli Creek	WWU4	290803	6189783	Wongawilli Creek
Area 3B Weather Station	3BWS	288458	6192012	Full Area 3B Weather Station

Ref No.	Site ID
1	DC13_S1
2	DC_S2
3	WC21_S1
4	WC_S1
5	WC15_S1
6	LA4_S1
7	DCU3
8	WWL2
9	WWU4
10	3BWS



Hydrographic Weather Station and Flow Gauging Locations

DENDROBIUM AREA 3B SMP

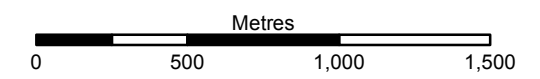
Legend

- Hydrometric Monitoring Sites**
- Flow Gauging Site
 - Weather Station Site
 - SMP Area (1,199 ha)
 - DSC Notification Zone
 - Longwall Layout (BHPBIC, 2012)
 - Watercourses (LPI)
 - Waterbodies (LPI)



FIGURE 17.2

1:25,000 Scale at A3



Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
 Date: 2012-10-02
 Coordinate System: GDA 1994 MGA Zone 56
 Project: 112041-01
 Map: G1009_HydrographicWeatherStation_and_FlowGaugingLocations.mxd 04
 Data supplied by MSEC (2012) unless otherwise stated
 Aerial imagery supplied by BHPBIC (2009) and Bing Maps

An initial rating and measurement program will be implemented in response to a number of rainfall events in order to develop a robust understanding of the stream flow dynamics, particularly during the recession period of a flow event. Repeated manual stream flow measurements will be made at each new site, which in combination with cross sections will enable the derivation of rating tables. Dependant on weather, these tables are likely to be available within six months of installation.

Flow monitoring at these sites will be by water levels measured using an enclosed pressure inducer-type water level gauge with onboard data logging. Level data will then be converted to flow using the aforementioned derived rating tables.

Monitoring stations will be serviced and data downloaded on a monthly basis. This will include routine clearing of the controls and obtaining flow measurements to verify and modify the flow rating tables.

Data will be reviewed, archived and disseminated using the software HYDSTRA, the preferred software for the hydrometric industry including the SCA. Level and rainfall data will be available within seven days for download and will be presented as both level and flow.

After collection of sufficient stream flow for the pre-mining phase the equipment will remain in place for monitoring during mining, as well as the post-mining phase.

Hydrographic campaigns will continue to be undertaken after mining ceases in Area 3B to characterise the responses of the catchment after significant rainfall events (with an influence on low flow event conditions).

At the conclusion of the monitoring program all equipment and structures will be removed and the sites rehabilitated, in consultation with key stakeholders.

Groundwater Monitoring Program

The shallow groundwater program currently operating in Area 3A will be extended into Area 3B. Water levels and water quality will be logged with routine downloads made to a central database for analysis. New piezometers have been installed progressively in identified tributary sub-catchments as illustrated in **Figure 17.3**. The method of piezometer installation is described in **Attachment B** Volume 1 of this SMP Application.

Status reports and maintenance of the sites is conducted at regular intervals to rectify any identified issues. Data recovery, storage and reporting comply with NATA-accredited procedures.

Hawkesbury Sandstone Groundwater Monitoring Program

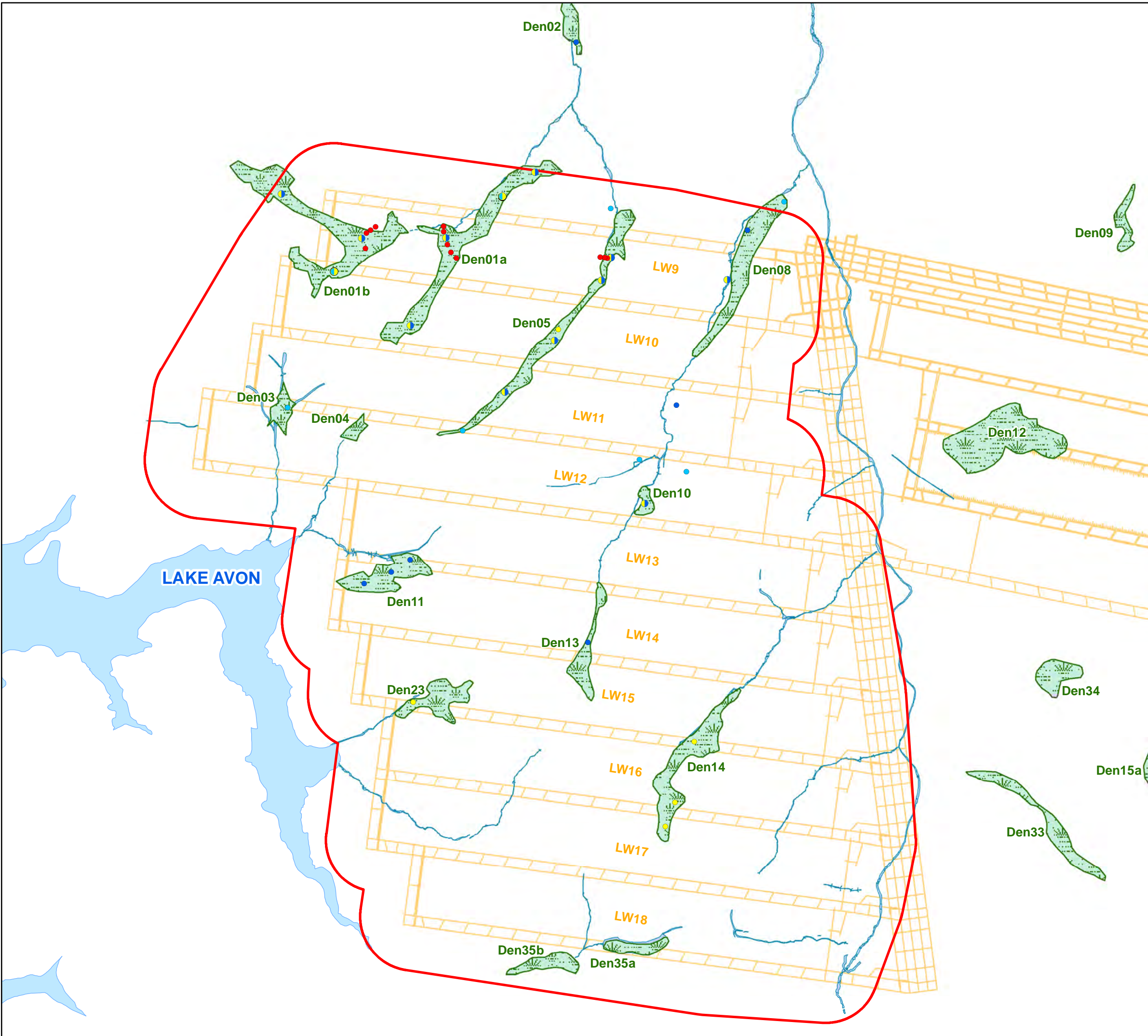
As in previous mining areas, a program has already been put into place by Geosensing Pty Ltd on behalf of BHPBIC for the installation of shallow to deep multi-level groundwater piezometers in Area 3B. The locations of Hawkesbury Sandstone groundwater piezometers are provided in **Figure 17.4**.

Since the development of Area 2, these programs have also included the installation of separate boreholes situated a few metres away from some piezometers which are fitted with low flow bladder pumps located within packed-off intervals of various strata which had been shown, during drilling, to have significant water-bearing capacity.

The sampling pumps provide for periodic sampling of in situ groundwater from various strata above any longwall. It is noted that groundwater sampling with such pumps provides samples collected in accord with best practice low flow sampling guidelines (USEPA, 1996.)

Shallow Groundwater Monitoring Sites

DENDROBIUM AREA 3B



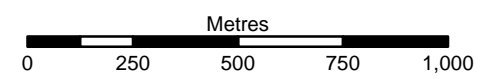
Legend

- Proposed Borehole/Piezometer Sites (12)
- Installed Borehole Site - Manual Dip (6)
- Installed Borehole Site - Piezometer (7)
- Gopher Sites (5)
- Gopher Sites / Installed Borehole Site - Manual Dip (2)
- Gopher Sites / Installed Borehole Site - Piezometer (11)
- Longwall Layout
- SMP Area (MSEC, 2012)
- Area 3B Swamps
- Streams
- Waterbodies (LPI)



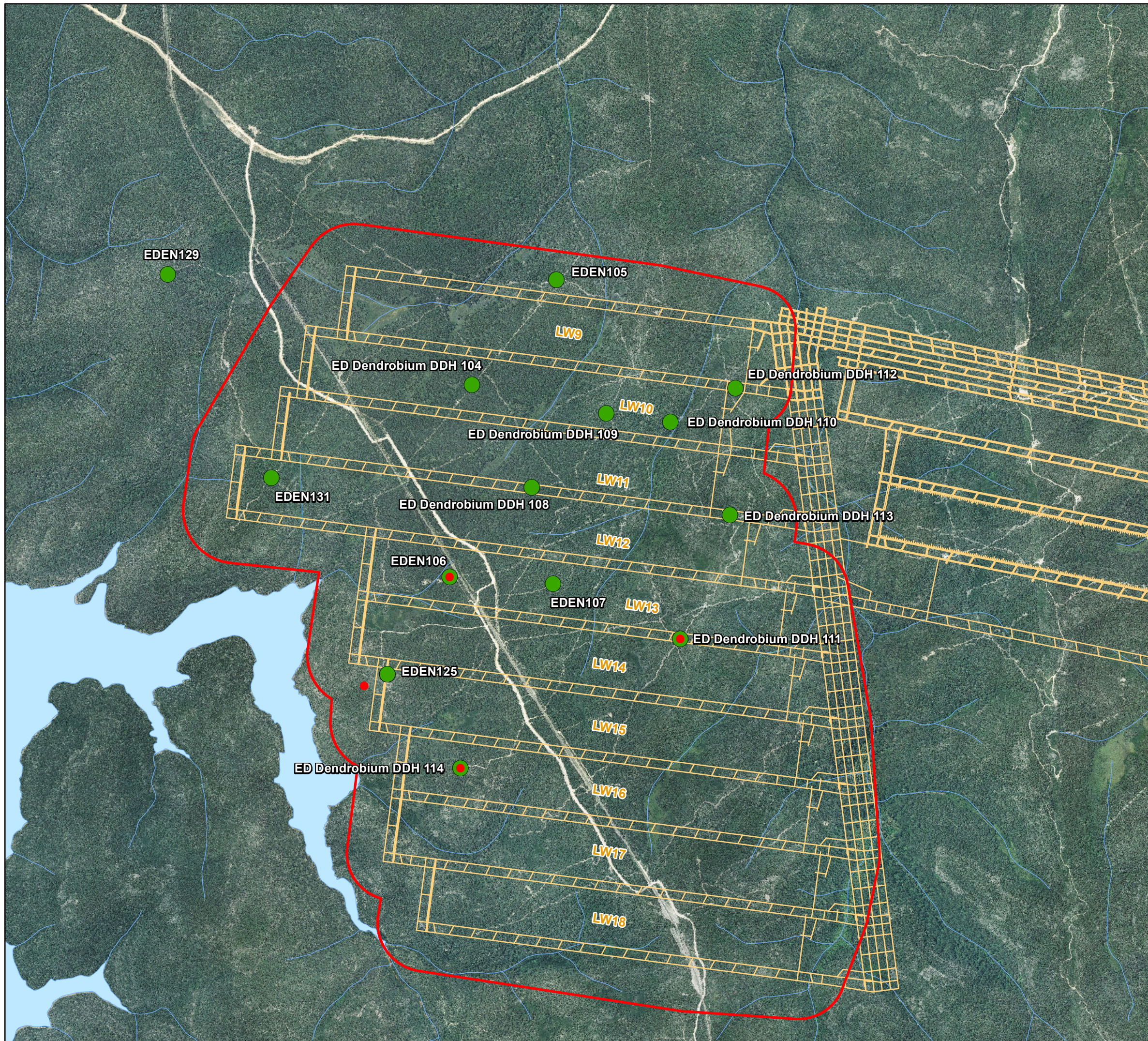
FIGURE 17.3

1:18,000 Scale at A3



Groundwater Monitoring Plan (Strata)

DENDROBIUM AREA 3B SMP



Legend

- Monitoring bore with sample pump in HBSS
- Monitoring bore with piezometer in HBSS
- SMP Area (MSEC)
- Longwall Layout (BHPBIC, 2012)
- Watercourses (LPI)
- Waterbodies (LPI)

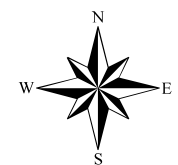
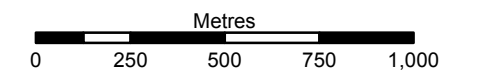


FIGURE 17.4

1:20,000 Scale at A3



A total of thirteen monitoring bores with multi-level groundwater sampling pumps have been installed in Hawkesbury Sandstone (HBSS). HBSS groundwater levels and quality will be assessed at the End of Panel reporting stages. These assessments will include those bores close to Lake Avon.

Proposed Water Quality Monitoring Program

Proposed locations of the water quality monitoring sites are provided in **Figure 17.1**. Proposed field and laboratory parameters and monitoring frequencies for both Ecoengineers and the BHPBIC Environmental Field Team are provided in **Attachment B** Volume 1 of this SMP Application (refer Tables A6.2 and A6.4).

Three-tiered water quality TARPs proposed for Area 3B will be established from baseline data obtained prior to mining. The proposed triggers for action are provided in **Section 17.6**.

17.5 MANAGEMENT MEASURES

The Longwalls 8 to 19 SMP surface water TARP is provided in **Section 22**. A three tiered water quality TARP is proposed for Area 3B. This approach is tailored specifically for surface water management within Area 3B and is explained below in **Section 17.6**.

A number of management actions may be implemented in the event that there are subsidence impacts, and in accordance with the TARPs as discussed in **Section 22**. These actions include:

- Key stakeholders will be informed of any impacts and proposed investigation, mitigation and rehabilitation, if required.
- BHPBIC and its consultants and contractors are responsible for acting on alerts.
- Investigative, mitigation and rehabilitation actions will be taken in response to alerts after consultation with key stakeholders and appropriate approvals are in place.
- The potential for environmental impacts of remediation will be taken into account when designing and implementing any program. These issues will be addressed during any approval process.

The effectiveness of remediation will be further discussed with approval agencies for each program but will be based on returning the area to as similar to pre-mining conditions as is practicable or as otherwise agreed with relevant stakeholders.

If any future monitoring indicates that there has been significant hydrologic or aquatic ecotoxic effects within any Area 3B catchments then it is possible that some management and mitigation measures will need to be implemented.

Management measures for remediation of excessive acid and metal levels resulting from mine induced subsidence may be treated through liming. This technique would use a granular agricultural grade limestone (calcium carbonate; CaCO₃) to treat any proven point of chronic emergence of acidic, Fe and Mn-rich upsidence-induced sub-bed diversion flows, especially if such pools were located within 250 m of Lake Cordeaux. Further details regarding the use of this technique at Area 3B is provided in **Attachment B** Volume 1 of this SMP Application.

Whilst unlikely, precipitation of hydrous iron and manganese oxides and the consequent generation of local acidity from an incident such as the induction of ferruginous springs may occur. Where the precipitation/acid generation effect occurs too far down slope from the spring and hence impacts on a pool or inshore ecosystem in Lake Avon, the location of the zone of maximal oxygen can be moved upslope closer to the spring source.

This may be achieved by placing heavy rocks and boulders closer to the spring. This would increase turbulence and oxygenation and precipitation of hydrous iron and manganese oxides to occur further upstream allowing natural amelioration effects to occur before reaching Lake Avon.

If the impacts cannot be mitigated to an acceptable level using these established techniques, management measures may involve alterations to the longwall layout and dimensions for a particular longwall or succeeding longwalls.

In the event that the TARPs parameters **Section 22** are considered to have been exceeded, or are likely to be exceeded, BHPBIC will implement a Contingency Plan to manage any unpredicted impacts and their consequences. The Contingency Plan is outlined in **Section 23**.

17.6 TARPS

Three-tiered Water Quality TARPs proposed for Area 3B (**Section 22**) will be established from baseline data obtained prior to the commencement of mining of any longwall in Area 3B. A decline in water quality as a result of mining will be measured as a statistically significant change in water quality parameters during/after mining compared to pre-mining water quality, or a statistically significant change in water quality adjacent to or downstream of mining when compared to upstream water quality.

The proposed triggers for action are as follows:

Level 1

- A temporary (two to four months) change in water quality following the onset of mining at any site in which any field water quality parameter (i.e. pH, EC, ORP or DO) changes by more than two standard deviations from the mean established for the baseline monitoring period.

Level 2

- An ongoing (more than four month duration) change in water quality following the onset of mining at any site where any single field water quality parameter (i.e. pH, EC, ORP or DO) deviates by more than two standard deviations from the mean established for the baseline monitoring period.
- The simultaneous shift by more than two standard deviations from the means established for the baseline monitoring period of any two or more field water quality parameters (i.e. pH, EC, ORP or DO) immediately after the onset of mining at any site.
- The simultaneous increase by more than two standard deviations from the mean established for the baseline monitoring period of any two or more key monthly monitored laboratory parameters (i.e. sulfate, filterable Fe, filterable Zn, filterable Ni or filterable Mn) as determined from any targeted investigation or during an End of Panel reporting stage.

Level 3

- A change of more than two standard deviations from the mean established for the baseline monitoring period in the inshore water quality of Lake Avon i.e. at the 4 designated Lake monitoring sites (LA1, LA2/3_S1, LA4_S2 and LA5_S2) or at the downstream Wongawilli Creek

The Longwalls 8 to 19 SMP Surfacewater TARP is discussed in **Section 22**.

18 LANDSCAPE MONITORING AND MANAGEMENT

A Subsidence Landscape Management and Monitoring Plan (SLMMP) has been prepared for Dendrobium Colliery.

An SLMMP for the landscape elements of Dendrobium Area 1 was prepared by GSS in November 2004. This Plan has been subsequently modified to include Area 2 (GSS, 2006) and the revised document was incorporated into the Subsidence Management Plan (SMP) prepared for Area 2 in accordance with the DRE guidelines.

The landscape monitoring and management nominated for Area 3A will be extended for Dendrobium Area 3B.

18.1 EXISTING MANAGEMENT PLANS

The SLMMP for Dendrobium Area 3B will be based on the management plans developed for Areas 1, 2 and 3A and will be developed as a modification to the existing Area 3A SLMMP. The monitoring and management objectives within the SLMMP plan for Area 3B will therefore be contiguous with all existing SLMMP's for Dendrobium. Requirements of the SLMMP includes pre-mining baseline monitoring of all Area 3B sites, six monthly monitoring of sites above the panel currently being mined and previously mined under sites, and monthly monitoring of the active subsidence area.

18.2 BASELINE DATA

The aim of the monitoring is to record any cracking, rock falls, erosion and/or sedimentation impacts resulting from subsidence. To achieve this, two baseline surveys are undertaken (some months apart) to establish the existing condition of the monitoring sites prior to mining. This data is then used as a reference when measuring impacts before, during and after mining.

The monitoring program will be implemented throughout the entire period of mining, and for a two year period after mining is complete, or other period agreed with relevant stakeholders. The monitoring measures subsidence impacts so that CMAs can be implemented as required.

18.3 ONGOING MONITORING

The criteria for monitoring site selection is described in detail in Appendix A of GSS (2006) for Area 1, Appendix B of GSS (2006) for Area 2, and CFR (2007) for Area 3A.

Where observation of erosion and/or sedimentation is reported, additional monitoring sites may be added to the list of ongoing monitoring sites for prescriptive monitoring if warranted.

In addition to general observational monitoring conducted across large portions of the area potentially affected by subsidence, the location of specific risk based monitoring sites selected in Area 3B (to be monitored in more detail) is shown in **Figure 18.1** and discussed below. The proposed monitoring schedule is summarised in **Table 18.1**.

Landscape Monitoring Plan

DENDROBIUM AREA 3B SMP

Legend

- DA3-CF19 Cliff Monitoring Site (BHPBIC)
 - Fire Roads Monitoring Site (BHPBIC)
 - Area 3A Steep Slope Monitoring Site (BHPBIC)
 - Rail Cutting (MSEC 2012)
 - Rail Embankment (MSEC 2012)
 - SMP Area (1,199 ha) (MSEC 2012)
 - Maldon to Dombarton Rail (MSEC 2012)
 - Longwall Layout (BHPBIC, 2012)
 - Fire Roads (BHPBIC and LPI)
 - Watercourses (LPI and BHPBIC)
- Watercourse Monitoring Site (BHPBIC)**
- Area 2
 - Area 3A
 - Area 3B
 - Steep Slopes to be monitored (BHPBIC)
 - Waterbodies (LPI)
 - Swamps to be monitored (Illawarra Coal, 2011)

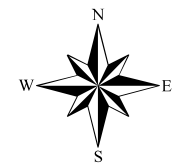
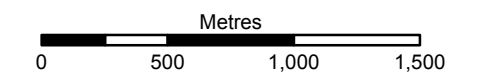


FIGURE 18.1

1:30,000 Scale at A3



Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2012-10-02
Coordinate System: GDA 1994 MGA Zone 56
Project: 112041-01
Map: G1012_LandscapeMonitoringPlan.mxd 08

Aerial imagery supplied by Bing Maps and associated third party suppliers

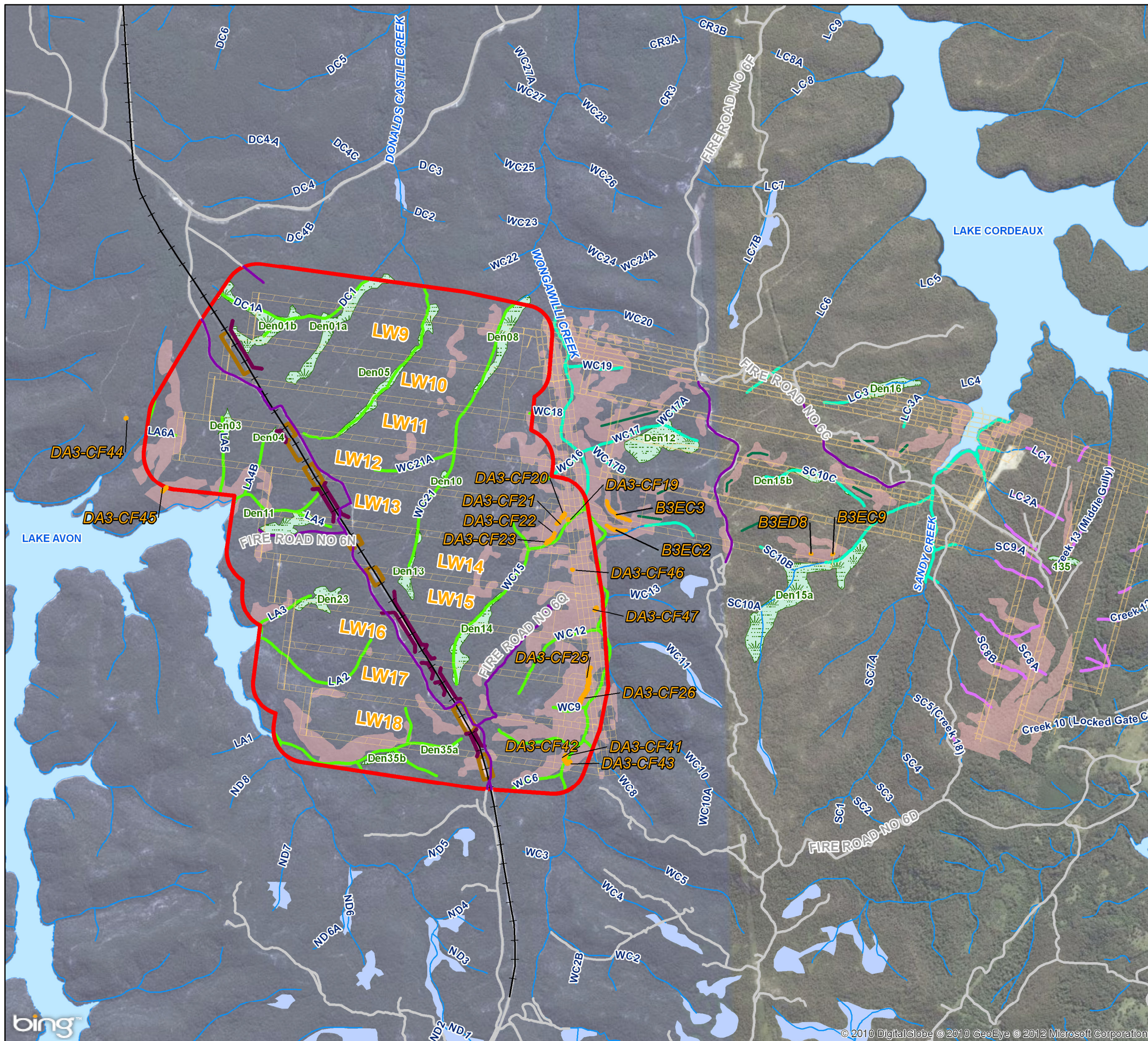


Table 18.1 - Summary of Landscape Monitoring Schedule

Environmental Aspect	Pre-Mining Baseline Survey Frequency	Monitoring Frequency During Mining	Monitoring Frequency Post-Mining	Persons Responsible
<i>Cliffs</i>	Twice	All Sites 6 Monthly &	6 Monthly for two years after mining	Environmental Consultant
<i>Steep Slopes</i>	(Months apart)	Individual Sites Monthly During Active Subsidence		
<i>Watercourses</i>	And in response to third party observations, where necessary			
<i>Firetrail</i>				
<i>Land Capability</i>	Once	None	Once, two years after mining	Environmental Consultant

A risk based approach is adopted to identify landscape features at greatest risk of impacts, including erosion and/or sedimentation resulting from mining induced subsidence. Monitoring sites were selected to represent each landscape feature based on the area having the highest risk of experiencing impacts as a result of subsidence.

Cliffs

MSEC defines cliffs as ‘a continuous rock face with a minimum height of ten metres and a minimum slope of 2 in 1. **Figure 18.1** shows the clifflines DA3-CF 19, DA3-CF20, DA3-CF21, DA3-CF22, DA3-CF23, DA3-CF 25, DA3-CF 26, DA3-CF 41, DA3-CF 42 and DA3-CF 43 located within Area 3B.

The majority of these clifflines are located along the alignment of Wongawilli Creek. The longwalls in Area 3B are offset from those cliffs by 30 m to 280 m at their closest points and are outside of goaf areas. It is therefore likely that there would only be isolated rock falls associated with the cliffs.

Steep Slopes

While in most cases, impacts on steep slopes are likely to be restricted to surface cracks, there remains a low probability of large scale downslope movements. Steep slopes will therefore be monitored throughout the mining period and until any necessary rehabilitation measures are complete.

The steepest slopes within the SMP Area are located within the valley of Wongawilli Creek. Steep slopes are also located directly above the proposed longwalls, along Donalds Castle Creek and other major drainage lines. The locations of steep slopes in the SMP Area proposed for monitoring are illustrated in **Figure 18.1**.

Watercourses/Swamps

The potential mining induced subsidence impacts to swamps and watercourses will be monitored as described in **Section 17.5** (Surface Water Features) and **Section 17.6**).

Fire Trails

- **Fire Road No.6A** - The full length of the Fire Trail above Longwall panels 10, 11, 12, 13, 14, 15, 16, 17 and 18.
- **Fire Road No.6N** - The full length of the Fire Trail above Longwall 14.

- **Fire Road No.6Q** - The full length of the Fire Trail above Longwall 15, 16 and 17.

All sites will be subject to inspections to confirm suitable access to and establish comparative photo points.

18.4 MANAGEMENT MEASURES

Details of the Longwall 8 to 19 SMP Landscape TARP is provided in **Section 22**.

A number of management actions may be implemented in the event of subsidence impacts, and in accordance with the TARPs as discussed in **Section 22**. These actions include:

- Key stakeholders will be informed of any impacts and proposed investigation, mitigation and rehabilitation, if required.
- BHPBIC and its consultants and contractors are responsible for acting on alerts.
- Investigative, mitigative and rehabilitation actions will be taken in response to alerts after consultation with key stakeholders and appropriate approvals are in place.

The results of the monitoring program will be used to determine whether CMAs are required. If established trigger levels are reached, CMAs are to be implemented. Options for CMAs consist of a number of different tools such as basic erosion controls outlined in the 'blue book', to detailed and specialist investigation of specific impacts. The nature of the CMA will be determined by the trigger levels set in **Section 22**.

The Longwalls 8 to 19 SMP Landscape Contingency Plan is outlined in **Section 23**.

19 AQUATIC ECOLOGY MONITORING AND MANAGEMENT

The aquatic ecological values within Dendrobium Area 3 are detailed in the SIS (Biosis, 2007a). Cardno Ecology Lab (CEL) has undertaken a revised assessment of the aquatic ecology and predicted mining induced subsidence in the SMP Area provided as **Attachment E** Volume 1 of this SMP Application.

Previous assessments of aquatic ecology in Dendrobium are provided in the COI, and the environmental effects of subsidence for Area 3 were originally investigated in '*Environmental Effects of Subsidence Associated with the Dendrobium Project*' (NECS, 2001).

Extensive monitoring of aquatic ecology has occurred within Dendrobium Area 3, CEL was previously commissioned by BHPBIC to prepare a number of reports on Dendrobium Area 3. These include:

- The description of aquatic habitats for the EIS (CEL, 2001a);
- The primary submission for the Col (CEL, 2001b);
- Two additional surveys of creeks within Areas 1 and 3 (CEL, 2001c, d);
- Dendrobium Colliery Area 2 Aquatic Ecology Baseline Survey report (CEL, 2006c);
- Assessment of the potential impacts on aquatic habitats and biota arising from mining of Dendrobium Area 3 (CEL, 2007a);
- Baseline aquatic ecology monitoring for Dendrobium Areas 3A (2009 - ongoing) (CEL, 2009 and 2011a); and
- End of panel reports describing effects, if any, on extraction of Longwalls 9 and 10 on aquatic habitats and biota (CEL, 2007b).

The Area 3 Modification Conditions and the SMP guidelines require BHPBIC to monitor and report on the impacts of longwall mining on water quality, aquatic habitats and biota (including threatened species and their habitats) and ecosystem functions, before, during and after mining.

The Aquatic ecology monitoring and management plan focuses on the sections of Wongawilli Creek, Donalds Castle Creek and the drainage lines that flow through the proposed SMP Area and the streams, drainage lines and part of Lake Avon outside the SMP Area that may experience either far-field or valley-related movements.

19.1 EXISTING MANAGEMENT PLANS

The monitoring and management program for Areas 1, 2, 3A and 3B are outlined in the following reports:

- The Ecology Lab (CEL) (Mar 2003), *Dendrobium Coal Mine - Subsidence Environmental Management Plan for Aquatic Ecology in Area 1*
- The Ecology Lab (CEL) (Feb 2006a), *Dendrobium Area 2 Aquatic Habitat Survey and Recommendations for Monitoring. (Report No.22/0405A Version 2).*
- The Ecology Lab (CEL) (Sep 2007), *Dendrobium Area 3 Assessment of Mine Subsidence Impacts on Aquatic Habitat and Biota.*
- CEL (Jan 2012a), *Dendrobium Area 3B Subsidence Management Plan, Aquatic Flora and Fauna Assessment.*
- CEL (April 2012b), *Dendrobium Area 3 Aquatic Monitoring 2008 – 2011.*

Information on the monitoring and management of the aquatic ecology presented below is drawn from these documents, which should be consulted for detailed information. The most recent of these, CEL (2012a), is provided in **Attachment E** Volume 1 of this SMP Application.

A comprehensive monitoring plan was outlined in The Ecology Lab (2007). This monitoring plan has been modified for Area 3B to include the recommendations made in the Southern Coalfields Inquiry regarding sufficient baseline data collection periods and intensity. The baseline data monitoring is discussed below, and includes the recommendation from the Southern Coalfields Inquiry, comprehensive details regarding the monitoring undertaken within Dendrobium Area 3 from 2008 to 2012 is provided in CEL (2012b).

19.2 BASELINE DATA

Baseline data has been collected by CEL as part of the monitoring programs for Area 1, Area 2, Area 3A and Area 3B. Details for previous data collection in Area 1, 2 and 3A can be found in the Dendrobium Area 3A SMP (CFR, 2007). Details for data collected for 3B can be found in (CEL, 2012b).

Aquatic ecology data collection for Area 3B can be found in **Attachment E** Volume 1 of this SMP Application and a summary is provided below. Monitoring includes indicators such as aquatic habitat, *In situ* water quality, Aquatic macrophytes, Aquatic macroinvertebrates and fish. To date, two years of baseline data, and one year of during-extraction data have been collected for Area 3A and two years of baseline data have been collected for Area 3B.

Ongoing data collection and monitoring is discussed in **Section 19.3** below.

19.3 ONGOING MONITORING

An aquatic ecology monitoring program for Area 3B has been implemented to:

- Determine the nature and extent of any subsidence induced impacts on aquatic ecology; and
- Assess the response of aquatic ecosystems to any stream remediation and management works implemented.

Monitoring will include direct measures of aquatic flora and fauna as well as biophysical measures. Aquatic ecology monitoring sites for Area 3B are shown in **Figure 19.1**. These sites are located in watercourses that contain 'significant' or 'moderate' aquatic habitat and are suitable for AUSRIVAS assessment (i.e. are at least 100 m long).

The monitoring conforms to the BACI design with two types of monitoring sites included in the program:

- *Potential impact sites* - these may be subject to mine subsidence impacts during and after longwall extraction; and
- *Control sites* - these will provide a measure of the background environmental variability within the catchments as distinct from any mine subsidence impacts.

The "potential impact" sites are as follows:

- Wongawilli Creek - Sites 2, 3 and 4 situated adjacent to the eastern ends of Longwall 13, 11 and 9, respectively and Sites X4, X5 and X6, distributed adjacent to the eastern ends of Longwalls 17 to 20.
- Donalds Castle Creek – Site X1 situated adjacent to Longwall 11 (where the creek emerges from an upland swamp).

Aquatic Ecology Monitoring Locations

DENDROBIUM AREA 3B SMP

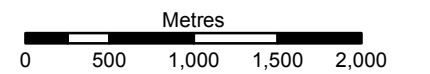
Legend

- Monitoring Sites (Cardno Ecology Lab)
- Watercourses (LPI)
- SMP Area (1,199 ha)
- - - Maximum Footprint Area 3
- - - Restricted Zone
- - - DSC Notification Zone
- Maldon to Dombarton Rail
- Longwall Layout (BHPBIC, 2012)
- Waterbodies (LPI)



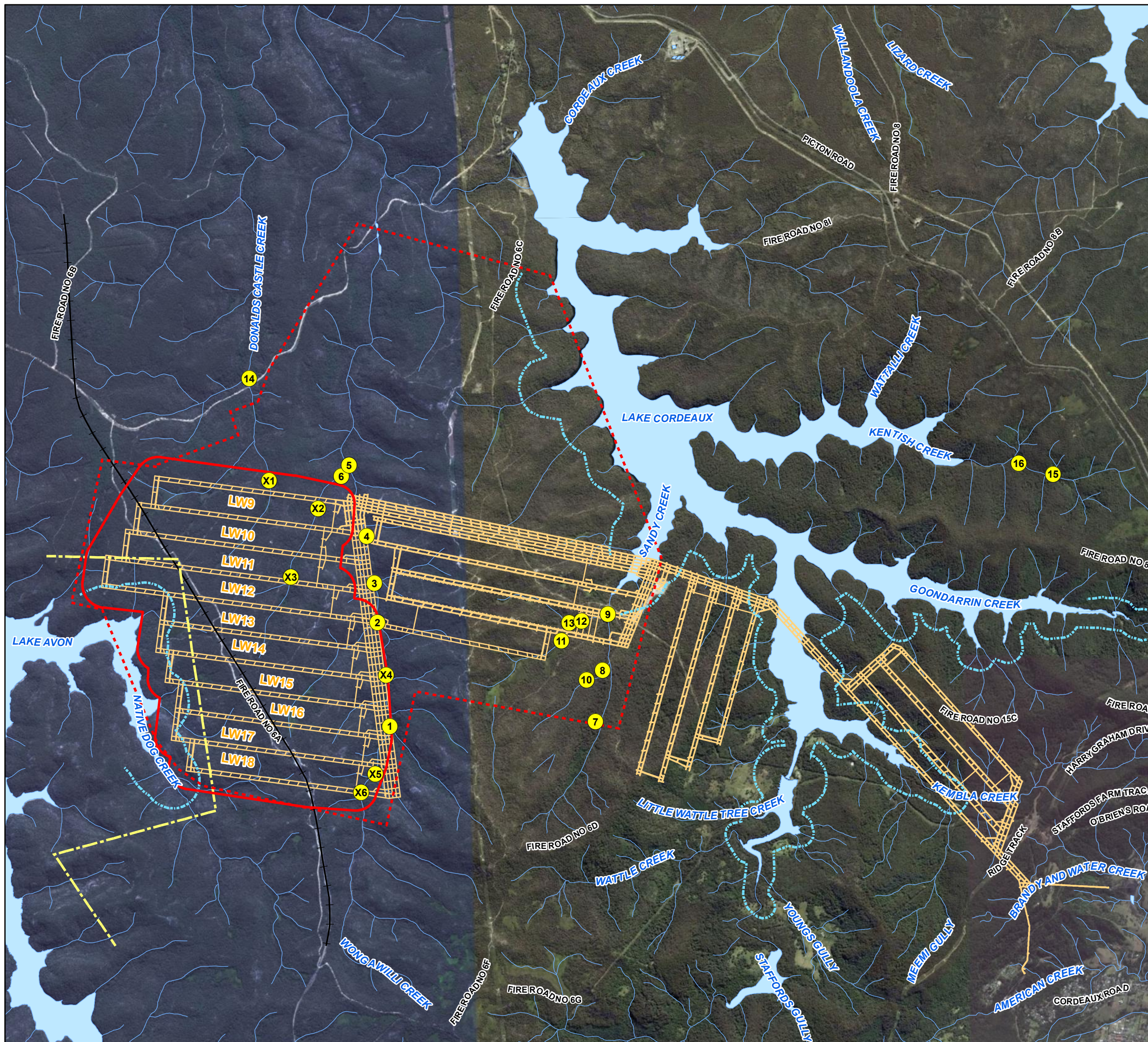
FIGURE 19.1

1:45,000 Scale at A3



Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2012-05-22
Coordinate System: GDA 1994 MGA Zone 56
Project: 112041-01
Map: G1007_WaterQualityMonitoring_CEL.mxd 04

Data supplied by MSEC (2012) unless otherwise stated
Aerial imagery supplied by Bing Maps and associated third party suppliers



- WC21 - Sites X2 and X3 which are located above Longwalls 11-14 where there is suitable aquatic habitat.

Sites 2, 3 and 4 are also 'potential' impact sites for Dendrobium Area 3A.

The control sites for Area 3B are the same as those for Area 3A and are as follows:

- Wongawilli Creek – Sites 1 and 5 situated well upstream and downstream of the potential impact zone.
- Donalds Castle Creek - Site 14.
- WC21 - Site 6 situated near the confluence of WC21 and Wongawilli Creek.
- Sandy Creek - Site 7 situated well upstream of the potential impact zone for Dendrobium Area 3A.
- Kentish Creek - Sites 15 and 16.

19.3.1 Monitoring Methods

The monitoring methodology outlined below is consistent with that recommended for assessment of aquatic impacts within Area 3. All monitoring methods will be employed at each site. As two years extraction data is now available, it is recommended that monitoring associated with Area 3B resume once extraction commences, or autumn 2014, whichever is earlier.

Aquatic Habitats

During the baseline study the condition of the aquatic habitat at each site was assessed using a modified version of the Riparian, Channel and Environmental Inventory method (RCE) (Chessman et al. 1997). This assessment involved evaluation and scoring of the characteristics of the adjacent land, the condition of riverbanks, channel and bed of the watercourse, and degree of disturbance evident at each site. Any changes in the condition of the aquatic habitat would be recorded during the subsequent surveys.

A photographic record will be captured at each survey. This will be done by taking standardised photos, using a 2m tall x 1m wide T-bar, from the top of the site looking downstream, the middle of the site looking upstream, the middle of the site looking downstream, and the bottom of the site looking upstream.

Water Quality Monitoring

Water quality will be measured at each site at the time of fish sampling and macrophyte mapping to give an indication of the conditions at the time of sampling. This will be in addition to the monitoring described in **Section 17.6** which includes a more comprehensive assessment of the changes in surfacewater quality at selected sites undertaken by Ecoengineers.

Two replicate measurements will be taken using a Yeo-Kal 611 probe and the variables to be measured are: pH, dissolved oxygen, oxidation-reduction potential, temperature, turbidity and conductivity. Where applicable, the results will be compared to ANZECC (2000) water quality guidelines for the protection of aquatic ecosystems.

Aquatic Macrophytes

At each site where instream aquatic macrophytes are present, their species composition and total area of coverage would be recorded. Features such as the presence of algae or flocculent on the surface of macrophytes would also be noted.

Aquatic Macroinvertebrates

Two methods would be used to sample aquatic macroinvertebrates: the AUSRIVAS protocol for NSW streams (Turak *et al.* 2004) and artificial aquatic macroinvertebrate collectors, a quantitative method developed by CEL for freshwater environmental impact assessment.

Macroinvertebrate Collector Sampling

CEL has developed a quantitative method to sample macroinvertebrates within stream habitats using collectors composed of a standardised artificial substratum deployed for a specified period of time. This methodology is described in **Attachment E** Volume 1 of this SMP Application.

AusRivAS

At each site macroinvertebrates will also be sampled using the AusRivAS protocol developed under the National River Health Program. Where available, riffle and edge habitats will be sampled using a dip net along a 10 m stretch of habitat. These samples will be sorted in the field, preserved in alcohol and transported to the lab for identification.

The AusRivAS methodology and predictive model requires that sampling be done in autumn (April to June) and/or spring (Oct to Dec).

Threatened Species

In consideration of the possible but unlikely presence of two threatened macroinvertebrate species (Adams Emerald Dragonfly and Sydney Hawk Dragonfly) within the SMP Area, all dragonfly larvae collected in invertebrate sampling will be identified to the taxonomic level of family. Any individuals of the genus *Austrocorduliidae* or *Gomphomacromiidae* will be further identified to genus and species level if possible, and if there is any confusion, specimens will be referred to a specialist taxonomist. The confirmed presence of a threatened species will trigger further investigation into this species and its habitats in relation to potential subsidence impacts.

Fish Sampling

Fish will be sampled using a back-pack electrofisher (model LR-24 Smith-Root) and baited traps. At each site, eight baited traps are to be deployed in a variety of habitats such as amongst aquatic plants and snags, in deep holes and over bare substratum. The back-pack electrofisher will be operated around the edge of pools and in riffles. At each site, four, two minute shots will be performed. Fish stunned by the current will be collected in a scoop net, identified and measured. Native species will be released unharmed while exotics will not be returned to the water.

19.4 MANAGEMENT MEASURES

Trigger values for aquatic ecology monitoring parameters are outlined in **Section 22**. These values may be revised in consultation with relevant stakeholders following analysis of natural variability within the pre-mining baseline data. Each trigger value corresponds to either a negligible or significant impact on the aquatic habitat and/or biota within the SMP Area and management actions are presented if thresholds are exceeded.

Four approaches would be used to manage potential impacts on aquatic ecology within the Dendrobium Area 3B SMP Area:

- Impact minimisation;
- Aquatic ecology monitoring;

- Additional aquatic ecology studies that would be triggered by specific impacts on physico-chemical characteristics of the watercourses; and
- Contingent measures should impacts exceed predictions.

The potential impacts of the extraction of Longwalls 9 to 18 on aquatic ecology in the watercourses within the SMP Area would be minimised by:

- Adopting a mine layout that does not involve undermining of Wongawilli Creek or Lake Avon and setting the nearest longwall 75 m back from the centreline of the creek and 230 m away from the full supply level of Lake Avon; and
- Identifying triggers that would prompt surveys to assess any impacts on aquatic habitats and their biota identified during and after extraction of the longwalls.

Additional ecological studies may be undertaken in the case of events such as significant changes in water quality and availability of aquatic habitats.

The following contingent measures would be implemented in the unlikely event that there are mining induced subsidence impacts due to the extraction of Longwalls 9 to 18 in the SMP Area:

- Review of the mine layout and appropriate offset distances from Wongawilli Creek and Lake Avon;
- Implementing stream remediation measures, such as backfilling or grouting, in areas where fracturing of controlling rock bars and/or the stream bed leads to diversion of stream flow and drainage of pools; and
- Implementing appropriate control measures, such as installation of sediment fences down slope of areas where subsidence has led to erosion and stabilisation of areas prone to erosion and soil slumping using rock, brush matting or vegetation, to limit the potential for deposition or eroded sediment into the watercourses.

If these management strategies prove ineffectual, appropriate offset and compensatory measures would be implemented.

Further contingency management measures are described in **Section 25**.

20 TERRESTRIAL ECOLOGY MONITORING AND MANAGEMENT

The terrestrial ecological values within Area 3 of the Dendrobium Colliery have been assessed in the EA and SIS (Biosis, 2007a). A revised assessment of the ecological values within Area 3B was undertaken by Niche (2012) and is provided in **Attachment D** Volume 1 of this SMP Application. The terrestrial flora and fauna monitoring sites identified in relation to Areas 1, 2, 3A and 3B are shown in **Figure 20.1**.

Sites located in western areas of Area 3 including Area 3B were previously reference sites for creek and swamp habitat monitoring in Areas 2 and 3A. Existing reference sites in Area 3B will become impact sites once mined under by Area 3B. Additional reference sites will be established outside Area 3B to replace these sites closer to the time of mining and the locations of these additional reference sites will be subject to further field work.

Other assessments and recommendations concerning terrestrial ecology have also been undertaken in the past including long term monitoring and contemporary assessments for a range of exploration activities and other non-mining related infrastructure projects.

Ecological assessments were also detailed during the Commission of Inquiry where the environmental effects of subsidence were detailed in the report *Environmental Effects of Subsidence Associated with the Dendrobium Project* (NECS, 2001).

20.1 EXISTING MANAGEMENT PLANS

The monitoring and management program for Areas 1, 2, 3A and 3B are outlined in the following reports:

- Biosis (2006a) *Dendrobium Coal Mine, Subsidence Monitoring Program Terrestrial Ecology*.
- Biosis (2002). *Terrestrial Flora and Fauna Habitat Assessment of Dendrobium Colliery – Area 1 and 2*. Biosis Research Pty Ltd, November 2002.
- Niche (2012) *Dendrobium Area 3B Subsidence Management Plan Aquatic Flora and Fauna Assessment*.

Information on the monitoring and management of the terrestrial ecology presented below is drawn from these documents, which should be consulted for detailed information. The most recent of these, Niche (2012), is provided in **Attachment E** Volume 1 of this SMP Application.

20.2 BASELINE DATA

The Area 3 Modification Conditions requires a baseline study in areas above the longwall panels in order to characterise the biophysical characteristics in these areas. Specifically, the consent identifies upland swamps and steep slopes as areas that require particular attention.

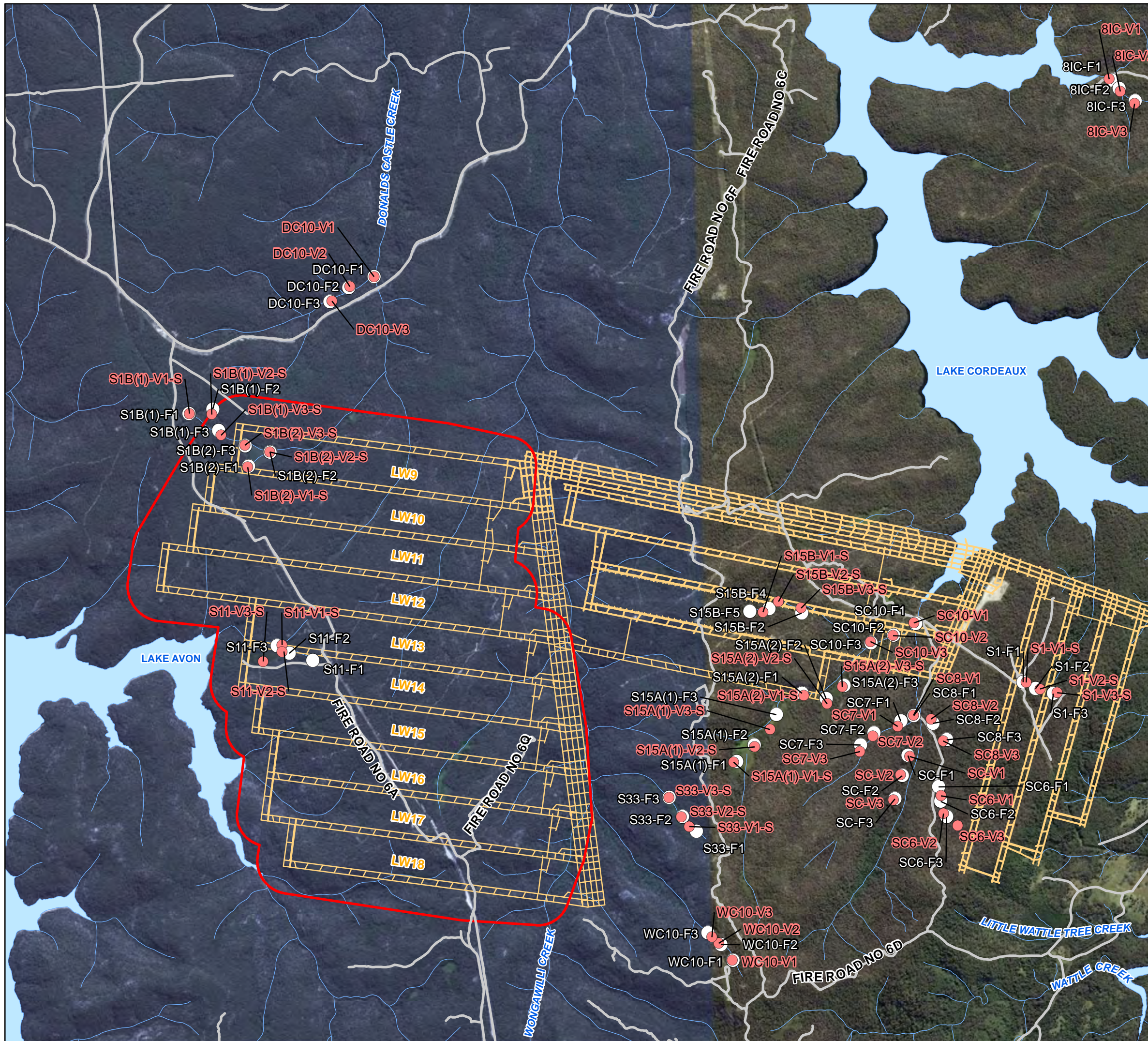
Long-term monitoring of vegetation and fauna populations has been undertaken in Dendrobium Area 3 since 2003. Monitoring has targeted both flora and fauna, and has involved vegetation quadrats and transects, and bird, frog, and reptile surveys.

Previous survey of the SMP Area and Locality (10 km radius of the SMP Area) include:

- Dendrobium Coal Project SIS (Biosis Research 2001a);
- Dendrobium Coal Project: Terrestrial and Aquatic Habitat Assessment (Biosis Research 2001b);

Terrestrial Ecology Monitoring Plan

DENDROBIUM AREA 3B SMP



- Legend**
- SC10-V1 Flora Monitoring Sites (Biosis Research)
 - SC10-V1 Fauna Monitoring Sites (Biosis Research)
 - Fire Roads (BHPBIC and LPI)
 - SMP Area (1,199 ha, MSEC 2012)
 - Longwall Layout (BHPBIC, 2012)
 - Watercourses (LPI)
 - Waterbodies (LPI)

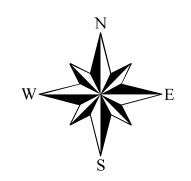
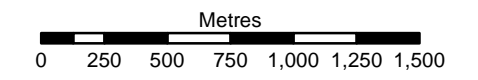


FIGURE 20.1

1:30,000 Scale at A3



Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2012-05-29
Coordinate System: GDA 1994 MGA Zone 56
Project: 112041-01
Map: G1013_TerrestrialEcologyPlan.mxd 04

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- Dendrobium Coal Project: Likely Impacts of Subsidence on Terrestrial Ecology (Biosis Research 2001c);
- Terrestrial Flora and Fauna Habitat Assessments accompanying coal exploration activities within DA3B (various companies approximately 1996 – 2011);
- Dendrobium Coal Mine and Elouera Colliery Flora and Fauna Environmental Management Program, Annual Monitoring Report – Spring 2003 to Winter 2006 (Biosis Research 2007b);
- Dendrobium Area 2 Longwalls 3 to 5a Impacts of Subsidence on Terrestrial Flora and Fauna (Biosis Research 2006b).

The monitoring design incorporates the SMP Area (i.e. potential impact area) and several reference areas. The baseline assessments broadly follow the process described in the Dendrobium Area 3A SMP (CFR, 2007).

20.3 ONGOING MONITORING

Methodologies for ongoing monitoring in Area 3B will be finalised prior to mining in consultation with key stakeholders. The monitoring program methodology is expected to be similar to current monitoring programs within Dendrobium Areas 1, 2 and 3A.

On-going terrestrial ecology monitoring within Area 3B currently includes transects within Upland Swamps DEN01a and DEN11, threatened amphibian searches (for Littlejohn's Tree Frog, Red-crowned Toadlet) along Donalds Castle Creek and Sandy Creek, and Upland Swamps DEN1a and DEN11. Other related monitoring programs include ecological values and abiotic conditions including soil moisture, depth to water table, rainfall and temperature variation. Further details of the current monitoring program for Dendrobium Area 3 are provided in Biosis Research (2009).

It is proposed that terrestrial monitoring at Dendrobium Area 3B will likely include the following:

- Monitoring of Upland Swamps will continue to follow the methodology outlined in Biosis Research (2009) which is consistent with Keith et al. (2006).
- Visual comparison of photopoint monitoring undertaken at each Upland Swamp site to continue from marked monitoring points.
- Transects conducted in Upland Swamp 35a will be incorporated into the monitoring program. The large population of *Pultenaea aristata* is located within this swamp. Photopoint monitoring will also occur.
- Mapping of Upland Swamp boundaries, using aerial imagery will be used to compare changes over monitoring years.
- Amphibian monitoring to continue along Donalds Castle Creek and Sandy Creek and Upland Swamps DEN1a and DEN11 using the current methodology.
- Monitoring should be conducted for as long as impacts could occur, or where applicable, until a decision can be made about recovery.
- In the event that monitoring does reveal impacts greater than authorised under the Dendrobium Consent, mitigation measures as outlined in **Section 22** would be considered.
- The implementation of any mitigation measures would also be monitored to confirm success.

Current access restrictions to the SMP Area during appropriate survey conditions limits the effectiveness of targeted surveys for two animal species (Giant Burrowing Frog and Stuttering Frog) which are considered likely to be significantly impacted at a local level by the Proposal.

Should the SCA allow increased access to the proposed monitoring area during appropriate survey conditions, i.e. during and immediately following significant rainfall events, targeted surveys and monitoring would also be recommended for these two species.

Targeted surveys are expected to involve diurnal habitat assessments to locate potential habitat within the SMP Area, followed by targeted searches of potential habitat to locate populations. Any Impacts of the Proposal on known populations would then be monitored and if trigger points are reached, as defined by the TARPs (refer **Section 22**), management strategies would be undertaken.

The aim of the ongoing monitoring program is to monitor selected known threatened or significant species to detect any changes in distribution and abundance. The monitoring program will follow the methodology of the baseline study subject to consultation with key stakeholders. At the completion of the baseline study all methodology, including the number or replicates, will be reviewed and the monitoring program finalised.

Prior to the underground mining operation, a Swamp Impact Monitoring, Management and Contingency Plan will be prepared and implemented to the satisfaction of the Director-General as per *Schedule 3 Condition 6* of the Area 3 Modification Conditions.

20.4 MANAGEMENT MEASURES

The monitoring program will monitor longer term trends in terrestrial ecological values that may or may not be attributable to subsidence impacts. It is possible however that there may be some relatively immediate changes associated with mining that may result in impacts to terrestrial ecological values. Such impacts, or triggers, would require a level of response appropriate to the impacts. Details of the Longwall 8 to 19 SMP Terrestrial Ecology TARP is provided in **Section 22**.

A number of management actions may be implemented in the case that there are subsidence impacts, and in accordance with the TARPs. These actions include:

- Key stakeholders will be informed of the variance and proposed investigation, mitigation and rehabilitation, if required.
- BHPBIC and its consultants and contractors are responsible for acting on alerts.
- Investigative, mitigative and rehabilitation actions will be taken in response to alerts after consultation with key stakeholders and appropriate approvals are in place.

Furthermore the following mitigation measures are in place for the protection of terrestrial flora and fauna in the SMP Area.

- Maximum vehicle speed limits will be applied to fire trail 6A that is used by the monitoring and survey teams. If an animal is injured veterinary assistance will be sought.
- It is the responsibility of all employees and contractors to ensure damage and harm to flora and fauna is minimised during the life of the Dendrobium Project.
- All remediation works must take appropriate measures to minimise environmental impacts. This includes avoiding the spread of Chytrid Fungus following the NPWS guidelines.

The Longwalls 8 to 19 SMP Terrestrial Ecology Contingency Plan is outlined in **Section 23**.

21 CULTURAL HERITAGE MONITORING AND MANAGEMENT

The Subsidence Archaeological Monitoring and Management Programs for Dendrobium Areas 1, 2, 3A and 3B were developed by Biosis Research in consultation with relevant Aboriginal groups. The cultural heritage monitoring and management requirements for Areas 1 and 2 are provided in Biosis (2006c) for Area 3A in Biosis (2007c) and Area 3B in Biosis (2012) and in **Attachment F** Volume 1 of this SMP Application.

There are 23 sites in Area 3B that require management in accordance with the Dendrobium Consent and the DRE Guidelines (2003). All of these sites are Aboriginal cultural heritage sites, located within Area 3B and are listed in Volume 1 of this SMP Application.

All of these sites are either sandstone shelters with art or sandstone shelters with deposit. The sites are required to be monitored before, during and after longwall mining. Refer to **Figure 21.1** for the location of these sites.

The management plans (Biosis 2006c, Biosis 2007c and Biosis 2012) describe the methodology of the monitoring program for Areas 1, 2, 3A and 3B. A summary of these plans is provided below.

21.1 EXISTING MANAGEMENT PLANS

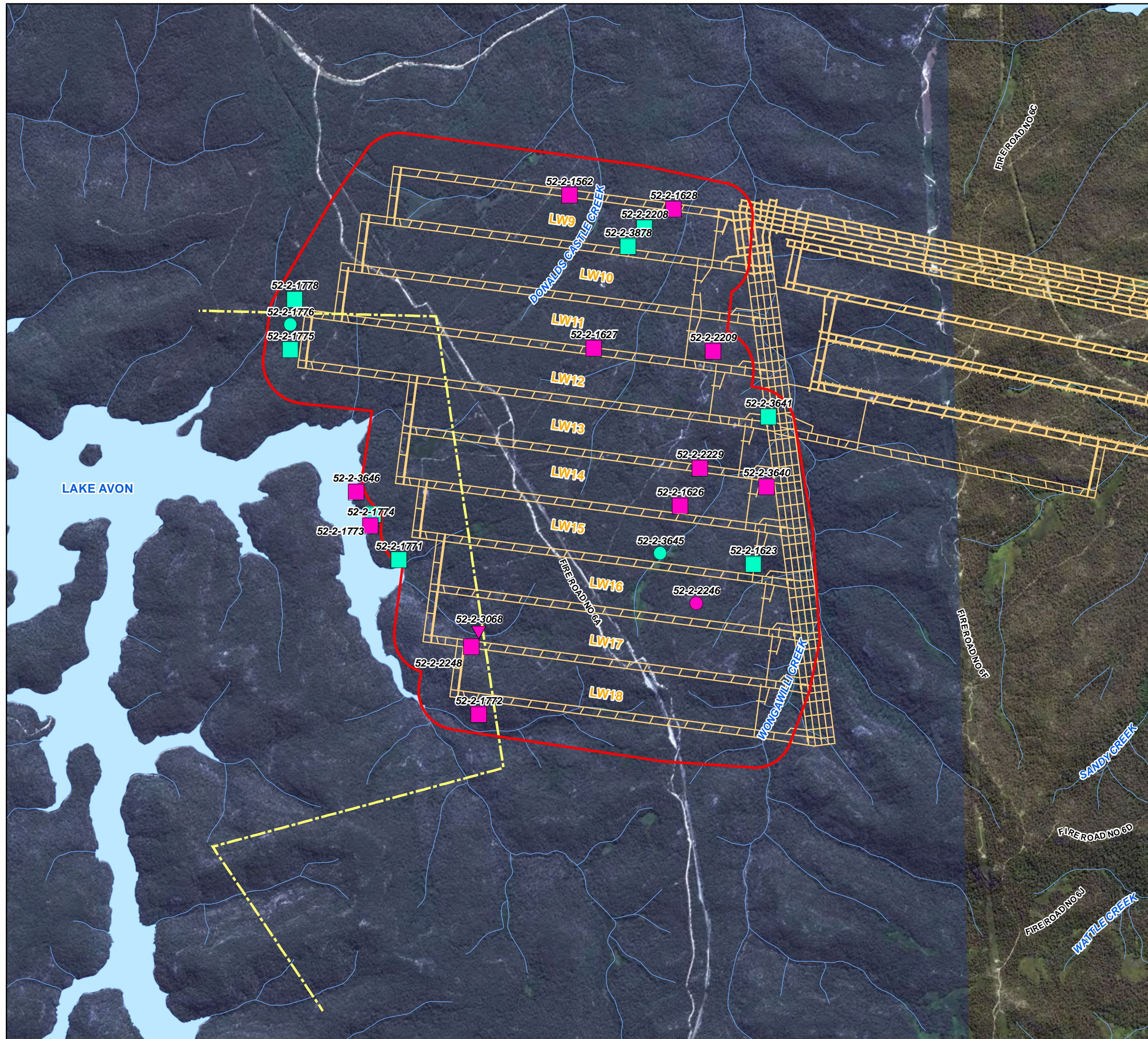
The monitoring and management program for Areas 1, 2, 3A and 3B are outlined in the following reports:

- Biosis (2006c) *Dendrobium Coal Mine, Subsidence Monitoring Program Cultural Heritage*.
- Biosis (2007c). *Dendrobium Coal Mine – Area 3A: Cultural Heritage Management Program (Subsidence)*.
- Biosis (2012) *Dendrobium Area 3B Heritage Impact Assessment* Report prepared for BHPBIC.

Information on the monitoring and management of the Aboriginal heritage presented below is drawn from these documents, which should be consulted for detailed information. The most recent of these, Biosis (2012), is provided in **Attachment F**; Volume 1 of the SMP application.

Archaeological Monitoring Sites

DENDROBIUM AREA 3B SMP



- Legend**
- Archaeological Sites (Biosis 2012)**
- Isolated Artefact
 - Shelter with Art
 - ▼ Shelter with Art; Grinding Grooves
 - Shelter with Art; Shelter with Deposit
 - Shelter with Deposit
 - SMP Area (1,199 ha, MSEC 2012)
 - DSC Notification Zone (MSEC 2012)
 - Longwall Layout (BHPBIC, 2012)
 - Watercourses (LPI)
 - Waterbodies (LPI)

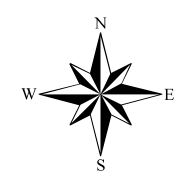
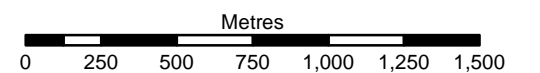


FIGURE 21.1

1:25,000 Scale at A3



Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2012-05-23
Coordinate System: GDA 1994 MGA Zone 56
Project: 112041-01
Map: G1011_ArchaeologicalMonitoringSites.mxd 03

Aerial imagery supplied by Bing Maps and associated third party suppliers

21.2 BASELINE DATA

All known archaeological sites within Dendrobium Area 3B have been subject to recording at a level appropriate for registration on the Aboriginal Heritage Information Management System (AHIMS). The aim of the baseline recording is to:

- Mitigate the risk of potential impact through more detailed archival recording of all shelter sites; and
- Provide a set of baseline records for the monitoring program.

The archival monitoring of sandstone shelter sites within Dendrobium Area 3B will continue the methodology outlined in Dendrobium Area 3A SMP Volume 2 (Section 22.4) and is briefly summarised below.

The archival recording of sandstone shelter sites within the Area 3B SMP will consist of:

- Re-recording of the principal components 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, graffiti, joints, bedding planes, exfoliation scars, cracks, mineral and micro-organism growth, drip lines and water seepage locations.

The results of the archival recording procedures will be stored in a purpose built database for information storage and ongoing comparisons to determine any actual impact from mining. The general schedule proposed for monitoring will continue that used for Dendrobium Area 3A as outlined in Dendrobium Area 3A SMP **Volume 2 (Section 22.5)** and is summarised below:

- *Baseline archival recording:* Prior to longwall mining beginning in the SMP Area.
- *First impact assessment recording:* Following initial subsidence movement of the site.
- *Further impact assessment recording:* Six months after undermining or final predicted subsidence movement at the site.
- *Final impact assessment recording:* Twelve months after undermining or final subsidence movement at the site.

Any impacts will be assessed by comparing results of the impact recording stages with the baseline data. Movement at and within the site will be monitored by comparing survey results with the elevations and drawings, photographic records, and multiple layer imaging methods for isolating and comparing components/agents on the art panel will also be used. This data will be used in conjunction with Sefton's (2000) principal components to build and continually add to a reference database for monitoring subsidence effects.

A review of the methodology and monitoring regime will be undertaken during the course of this program.

A review of the archival recording procedure will be conducted at the end of the collection of the baseline data. This review will assess the collection process and the amount of data that is collected and its relevance to the project. An additional review of the archival recording procedure will take place at the conclusion of archival recording.

A review of the monitoring methodology will also be undertaken. This will be completed at the conclusion of each of the scheduled monitoring periods. The review will assess the time period between monitoring events and the effectiveness for gathering the required data.

21.3 ONGOING MONITORING

The sandstone shelter Aboriginal sites will be monitored at least four times after the baseline data is collected. For each monitoring period, key aspects of the rock shelter will be recorded and compared to the baseline data. Any significant changes to the condition of the rock shelter will be noted and reported to key stakeholders, including:

- BHPBIC;
- Registered Aboriginal Parties (RAPs);
- OEH;
- SCA; and
- DRE.

Reports will be prepared subsequent to the completion of each work segment. The following reports will be produced in consultation with the RAPs and submitted to OEH:

- Report of findings of the comprehensive survey works;
- Report documenting baseline and archival records;
- Impact assessment reports subsequent to each monitoring activity; and
- The reports will include site and impact specific recommendations for management.

21.4 MANAGEMENT MEASURES AND CONTINGENCY PLAN

The Longwalls 8 to 19 SMP Heritage TARP is illustrated in **Section 22**.

In the event that there are subsidence impacts to any site being monitored, management strategies specific to the impact will be developed. The management strategies will be implemented in accordance with current conservation practice and the conservation principles contained within the Australia International Council on Monuments and Sites (ICOMOS) *Burra Charter*, and the NSW DECC *Guidelines for Aboriginal Heritage Impact Assessment* (Draft) and the *Aboriginal Cultural Heritage Standards and Guidelines Kit*. The advice of the identified Aboriginal communities regarding appropriate management methodologies will form an integral part of the development of the management strategies.

All contingent management strategies will be developed in consultation with the RAPs, BHPBIC, the SCA and OEH.

In the event the TARP parameters **Section 22** are considered to have been exceeded, or are likely to be exceeded, BHPBIC will implement a Contingency Plan to manage any unpredicted impacts and their consequences. The Contingency Plan is outlined in **Section 25**.

21.5 NON- ABORIGNIAL HERITAGE

Non-Aboriginal Heritage items have been identified within Area 1 only. There are no heritage items identified within Areas 2, 3A or 3B (MSEC 2006, MSEC, 2007 and MSEC 2012). Subsidence impacts on the heritage items within Area 1 were negligible.

If, during longwall extraction or other mining-related activities, BHPBIC becomes aware of heritage sites not previously identified, all work likely to affect the site would cease and relevant bodies consulted. Necessary permits or consents will be obtained and complied with prior to commencement of work.

22 TRIGGER ACTION RESPONSE PLAN (TARP)

The TARPs relate to identifying, assessing and responding to subsidence impacts. The TARPs provided in this SMP include:

- Watercourses and groundwater;
- Swamps;
- Landscape;
- Terrestrial Ecology; and
- Aquatic Ecology.

The TARPs represent actions to be taken as each defined trigger level is reached. A CMA on the other hand is an action developed in consultation with stakeholders in order to manage an observed impact in accordance with the relevant approvals. The management programme provides a basis for the design and implementation of any mitigation and remediation.

The TARPs presented in **Appendix A** have been developed in consideration with previously approved areas of mining and can be reviewed when necessary. Dendrobium Area 3A is the most recent approved area of mining and the TARPs being utilised for this area, are currently under review. Following approval, the TARPs for Area 3B will be reviewed and/or revised for consistency.

Monitoring of environmental aspects of the area will provide key data when determining any requirement for mitigation or rehabilitation. The triggers are based on comparison of baseline with monitoring results and the proposed triggers are presented in **Appendix A**; Volume 2 of this SMP Application. Specific triggers will continue to develop as the impact monitoring phase of the SMP matures. Refinement of triggers will be in consultation with key stakeholders and subject to approval by DP&I and DRE.

The TARPs employs a three tiered approach where trigger levels determine the likelihood that CMAs will be required.

23 CONTINGENCY AND RESPONSE PLAN

In the event the TARP parameters are considered to have been exceeded, or are likely to be exceeded, BHPBIC will implement a Contingency Plan to manage any unpredicted impacts and their consequences.

This would involve the following actions:

- Capture record immediately.
- Notify relevant stakeholders soon as practicable.
- Notify relevant agencies and specialists soon as practicable.
- Conduct site visits with stakeholders as required.
- Contract specialists to investigate and report on changes identified.
- Provide incident report to relevant agencies within seven days.
- Undertake a condition assessment to record impacts completed within 14 days.
- Establish weekly monitoring frequency until stabilised.
- Monthly updates from specialists on investigation process.
- Inform relevant agencies and stakeholders of results of investigation within 1 week of completion.
- Develop site CMA in consultation with key stakeholders if required within 1 month, (pending stakeholder availability) and seek approvals.
- Implement CMA as agreed with stakeholders following approvals.
- Conduct initial follow up monitoring and reporting within two months of CMA completion.
- Review Management Plan within three months.
- Report in regular reporting and AEMR.

24 REHABILITATION AND MANAGEMENT

Natural features that may be impacted by subsidence have been described in the EIS, other specialist reports and the SMP application. BHPBIC has developed a strategy that sets out the history, objectives, key technical constraints and opportunities, and options available to manage subsidence impacts to natural features (BHP Billiton 2005). This strategy has been utilised in the assessment of the need for specific preventative or mitigative measures for the potential mining induced subsidence in Area 3B.

Remedial measures will be assessed through the results of the monitoring programs outlined in the SMP as well as any additional assessments as required. The focus of the SMP is on the natural environment and the subsequent sections deal primarily with these aspects.

Given the predictions of subsidence impacts for mining in Area 3B (refer Volume 1 of this SMP Application) it is not anticipated that substantial rehabilitation works will be required. If predicted subsidence levels and subsidence effects are exceeded, *contingent* remedial measures may be implemented; these potential measures are outlined in **Section 24.2**.

Section 14 Schedule 2 of the Area 3 Modification Conditions (Costs of Management Measures) requires BHPBIC to take responsibility for the cost of all management measures. This includes measures to minimise, mitigate, offset or remediate impacts of the development which are not recoverable by a third party through the *Mine Subsidence Compensation Act 1961* or the *Mining Act 1992* including but not limited to remediation of natural features, rehabilitation of ecological systems, the provision of supplementary waters and monitoring of the effectiveness of the works, as determined by the Director-General.

24.1 REMEDIATION MEASURES

Subsidence levels and potential impacts for key natural features in Area 3B are provided below, together with a summary of the avoidance, mitigation and contingent measures proposed to manage impacts where predicted impacts are exceeded. Comparative information for Areas 1, 2 and 3A can be found in the Dendrobium Area 3A SMP Volume 2.

Specific details on contingent remediation measures are provided in **Section 25**.

Specific rehabilitation measures for subsidence impacts on natural features within the SMP Area are briefly summarised below.

A complete description of these methods are provided in the Dendrobium Area 3A SMP Volume 2.

Natural Remediation

Surface cracks from mining induced subsidence will tend to infill and seal through natural processes of erosion and deposition. The rate of infill will depend on the physical characteristics of the surrounding lithology as well as system dynamics.

In some instances the level of disturbance may be too great for natural processes to re-establish the site to an acceptable level of protection from further impacts.

In other cases, although there may be minimal impact, an area may have a low ability to naturally seal in this case pro-active rehabilitation may be necessary.

Cracks occurring in drainage paths are more likely to be able to naturally seal, however it is possible that at times either erosion or deposition could dominate which would lead to additional surface impacts. It is recognised that natural processes may not provide sufficient mitigation in some situations and that active sealing of streams may be required in some locations.

Hand Mortaring

Where water transfer is observed through well-defined joints or fractures, the joints and fractures will be sealed using a variety of products. Should large fractures occur in the base of the pools they will be sealed over with hand placed cement grout and natural oxides.

Injection Grouting

Where creeks are fractured as a result of subsidence and there is limited ability for them to naturally seal it would be necessary to carry out remedial measures. This may include grouting to return ground water to the surface or reduce pool water loss.

The choice of grout will be determined based on the nature and extent of the fracturing, the surface/ground water interaction and the objectives of the rehabilitation program.

These rehabilitation operations have the potential to cause adverse environmental impacts through the materials used and the disturbance associated with access and will be carefully planned to avoid contamination of watercourses.

Pattern Grouting

Large surfaces of a stream bed may be sealed using pattern grouting. This involves drilling holes in a grid pattern in areas that stream bed fracturing is identified. A number of passes of grouting are generally required to seal the subsurface layers. This involves injection into the voids of the fractured strata with grouts and filler materials. The intention of this grouting is to achieve a low permeability 'layer' approximately 1 to 2 metres thick below the riverbed over the impacted area.

The choice of grout is dependent upon the permeability of the rock from site to site. A range of specialist grouts and techniques can be used including cement, bentonite, mixes, micro fine cements and sodium silicate-based grouts. The selection of a particular grout includes an analysis of potential aquatic ecosystem toxicity.

Deep Angled Hole Grouting

Where access difficulties make pattern grouting inappropriate (for example where a pool has not totally drained), directionally drilled holes may be installed from some distance away to allow grouting to be delivered from a remote location.

The grout used is likely to be a standard 2% Bentonite and General Purpose Cement mix with a specific gravity of 1.57 delivered to the directionally drilled holes through a packer system. Pumping continues until the grout material returns to the top of the delivery holes. Regular inspections are undertaken throughout and following the operation to reduce releases of grout into the river.

Joint Sealing

Where water is leaking from a creek or riverbed through well-defined joints or fractures, the joints and fractures can be sealed using a variety of products, some of which can be applied in wet conditions and under water.

Surface Treatment

Surface impacts may display as cracks of varying depths and widths, erosion scars or deposition areas. The treatment of these areas will take into account specific site conditions and impacts.

If cracking develops in significant areas and natural sealing is not progressing, the cracks may require forking over and compaction to prevent further subsequent erosion. Larger cracks may require mulch to prevent development of erosion channels. Where cracks are

wider they may require gravel or sand filling up to surface level and revegetation using local plants.

Considerable care and relevant approvals will be obtained to ensure the protection of the environment as such works are implemented.

Land Stability

Landslips and slides are to be monitored and reported in the AEMR. The Steep Slopes and Cliff Monitoring and Management Program (SSCMMP) and any remedial actions carried out are to be to the satisfaction of the SCA and in consultation with DP&I. Small rock falls from clifflines may be brought on by the levels of movement that have been predicted, particularly where rocks and slopes are marginally stable.

Any remediation measures would be undertaken accordance with DP&I Guidelines and to the satisfaction of DP&I and SCA. Measures considered are outlined in the SSCMMP and may include:

- Surface water management measures to minimise sediment mobilisation.
- Erosion and sedimentation control measures to minimise downstream effects.
- Revegetation of disturbed areas.
- Preventive measures i.e. removal or stabilisation of loose boulders and scaling of loose rocks from cliff faces.
- Filling and mulching over large cracks to prevent the development of erosion channels.

Gas Release

A typical driver of gas release at the surface is pressure changes, dilation and/or fracturing of the rock mass and associated changes in groundwater levels. Grouting techniques as discussed above can reduce these associated gas flows at specific sites.

Within the Southern Coalfield where there have been gas releases identified in the past all of these gas releases have diminished over time. This typically occurs over a number of months, or it can occur over a number of years.

Where vegetation is impacted by gas releases they will be revegetated once monitoring has indicated that the gas releases have ceased or reduced to an extent that vegetation is no longer affected.

24.2 OFFSETS

The specific measures included within this SMP and the various management programs attached have been developed to restore the ecological and other values of the Special Areas. Should impacts remain following rehabilitation, compensation to ecological value, rehabilitation of aquatic habitats or water flow and quality in nearby (or distant) streams will be implemented as compensation. These measures are to be implemented when and if adverse subsidence impacts reach specific triggers:

These measures may include:

- Assisting DPI Fisheries to conduct surveys to determine the status of the various populations of Macquarie Perch.
- Fair and reasonable contribution towards the funding of the construction of fishways to rehabilitate fish habitats and ameliorate impacts on Macquarie Perch populations.
- Assisting SCA to maintain or improve values within the Special Areas relating to water quality and quantity.

25 CONTINGENCY AND EMERGENCY RESPONSE

The monitoring programs outlined in this SMP will identify subsidence impacts. Predicted impacts will be managed as outlined in this SMP. Contingency and emergency response options are available and will be implemented if it is demonstrated that environmental and public safety impacts are greater than predictions. This SMP details the actions that will be undertaken to respond to adverse subsidence impacts as summarised in **Section 22**.

The subsidence management framework involves the following components:

- Identifying features/values of significance and impact prediction – to determine the range of possible events and impacts.
- Risk assessment – in terms of determining the probability and consequence of an event occurring.
- Defining triggers and trigger levels for features/values affected and/or the identified events/impacts.
- Defining and implementing environmental monitoring.
- Identifying responses/actions to be taken when different triggers and trigger levels are reached. These include response measures and actions relating to avoidance, minimization, mitigation, compensation, contingency plans and emergency responses.
- Identifying roles and responsibilities of various stakeholders.
- Assessing measured with predicted impacts as mining progresses for features/values affected and implement responses/actions identified based on triggers and various pre-defined trigger levels being exceeded. Impacts need to be assessed based on the significance, extent, scale or longevity of impact and practical aspects of mitigation/rehabilitation.

Public Safety

BHPBIC will make all reasonable efforts to ensure that any member of the public entering mine subsidence effected locations are aware of any dangers they may be exposed to as a result of these subsidence effects.

Dissemination of this information will be through a structured campaign using a variety of methods. The program is likely to include:

- Signs at critical areas.
- Newsletters.
- Regular updates at CCC, SCA and other scheduled meetings.
- Provision of information to interested groups.
- Specific information in the AEMR.

BHPBIC will ensure that any impact due to surface subsidence of roads is restored and safeguarded so that access is not restricted.

Environment

The impacts resulting from subsidence occur gradually and affect a relatively small area of the surface above the longwall. It is possible that a longwall could affect only a small area and that the remainder, being unaffected, will continue to provide unaffected habitats for terrestrial and aquatic species immediately adjacent to impacted areas.

The Areas 1, 2, 3A and 3B have been and will continue to be mined in sequence and consequently subsidence will occur in successive episodes. It may be impractical to carry out final remedial measures (if required) until adjacent longwalls in an area have been mined. In such cases it may be necessary to temporarily support ecological systems until rehabilitation can be completed where it is appropriate to do so and in consultation with relevant stakeholders.

To minimise the impacts associated with subsidence and rehabilitation works a number of measures can be implemented. These are outlined in **Section 24** and detailed in the Dendrobium Area 3A SMP Volume 2.

25.1 SMP ADMINISTRATION

25.1.1 Roles and Responsibilities

The various roles and responsibilities under this SMP are described in the following sections.

Role of the Regulator DRE (formerly DPIM)

DRE is the Government statutory body that is responsible for regulating mining in NSW.

Although mining in Area 3 has received approval under the EP&A Act, it is a requirement of the Area 3 Modification that BHPBIC prepares a SMP to the Satisfaction of the Director General of DPI (now DRE).

As such this SMP has been prepared in accordance with the Development Consent and the DRE Guidelines for Subsidence Management Plan Approvals.

Management and mitigation measures will be developed in consultation with DRE. This SMP provides for the DRE to receive regular updates of the status of this plan so that it is readily able to fulfil its regulatory role. Furthermore, the Principal TARP controlling subsidence impacts provides for the DRE to be notified and closely involved at 'trigger points'.

BHPBIC

All statutory obligations applicable to Dendrobium Area 3B operations are identified and managed via an online compliance management system (TICKIT). The online system can be accessed by appropriate BHPBIC managers at the link below.

<https://illawarracoal.tod.net.au/login>.

The overall responsibility for the implementation of this SMP resides with the Manager Approvals, who shall be the SMP's authorising officer. BHPBIC has a nominated Review Team responsible for ongoing management in Dendrobium Area 3B, and the implementation of the SMP.

The Review Team will:

- Review all monitoring data generated as a result of the provisions of this SMP.
- Determine the need for any additional monitoring, inspections, tests, expert opinion or advice or otherwise to improve their knowledge and understanding of the situation at any time.
- Ensure the implementation of an appropriate remedial response should any monitoring trigger level occur.
- Ensure the immediate implementation of the responses specified within the relevant TARP and any other action that the team considers to be necessary.

- Ensure that all actions required as a result of this SMP are clearly communicated to those responsible for their implementation.
- Maintain records of each Review Team meeting.

Members of the Review Team are nominated below, along with all other parties responsible for the environmental management of Area 3B.

These include:

Head of External Affairs

- Receives reports and briefings from the Review Team
- Ensure that the requisite personnel and equipment are provided to enable this SMP to be implemented effectively.

Manager Approvals

- Authorise the SMP and any amendments thereto.
- Take the specific actions defined within TARPs as trigger levels are reached.
- Delegate to an appropriately qualified person the responsibility to document any changes to the SMP, recognising the potential for those changes to affect other aspects of the SMP.
- Provide regular updates to BHPBIC on the results of the SMP.
- Arrange information forums for key stakeholders as required.
- Prepare any report in accordance with the SMP. Maintain records required by the SMP.
- Organise and participate in assessment meetings called to review mining impacts.
- As soon as practicable, respond to any queries or complaints made by members of the public in relation to aspects of the SMP.
- Organise audits and reviews of the SMP.
- Address any identified non-conformances, assess improvement ideas submitted and implement if considered appropriate.
- Arrange for the implementation of any agreed actions. Responses or remedial measures.
- Ensure surveys required by this SMP are conducted and record details of instances where circumstances prevent these from taking place.

Mine Operations Manager

- Represent the Colliery as required.
- Inform mine personnel of any requirements under this Plan.

Manager Infrastructure and Rehabilitation

- Act as a member of the Review Team
- Ensure that monitoring data related to, and triggers generated by, the SMP are made available for assessment by the Review Team at its meetings.

- Take the specific actions defined within the TARPs as trigger levels are reached.
- Ensure that the standards and frequencies related to the Monitoring Controls are adhered to.

Environmental Field Team Coordinator

- Act as a member of the Review Team
- Take the specific actions defined within the TARPs as trigger levels are reached.
- Ensure that the standards and frequencies related to the Monitoring Controls are adhered to.
- Instruct suitable person(s) in the required standards for inspections, recording and reporting and be satisfied that these standards are maintained.
- Investigate significant subsidence impacts.
- Identify and report any non-conformances with the SMP.
- Participate in any other assessment meetings called to review subsidence impacts in the area affected by mining.

Survey Manager

- Collate survey data and present in an acceptable form for review at assessment meetings.
- Bring to the attention of the Manager Approvals any findings indicating an immediate response may be warranted.
- Ensure that all testing is undertaken by appropriately trained and qualified personnel.
- Bring to the attention of the Manager Approvals any non-conformances identified with the Plan provisions or ideas aimed at improving the SMP.

Technical Experts

- Conduct the roles assigned to them in a competent and timely manner to the satisfaction of the Manager Approvals and formally provide expert opinion as requested.

Person(s) Performing Inspections

- Expedite the assessment of any sampling and analyses required.
- Formally bring to the attention of the Environment Field Team Coordinator any non-conformances identified with the Plan, or ideas aimed at improving the Plan.
- Ensure that all testing is undertaken by appropriately trained and qualified personnel.
- Conduct inspections in a safe manner.
- At all times, all samples are to be collected and prepared using the correct methodology (in which they received training) obtaining, labelling and transporting samples for the analysis used.

The team can request the attendance of additional personnel, stakeholders (e.g. DRE) and technical specialists as it deems necessary.

Specialist Consultants

There are a significant number of expert consultants that support BHPBIC including:

- MSEC – Subsidence predictions and review.
- Cardno– Environmental Assessment and Civil Design.
- Coffey – Hydrogeology.
- Ecoengineers – Water Chemistry and Surface Water Hydrology.
- Biosis Research – Terrestrial Ecology and Cultural Heritage.
- Cardno Ecology Lab – Aquatic Ecology.
- NATA accredited testing laboratories.

Government Agencies

The SMP is assessed through a whole of Government approach, which comprises consultation with a number of government agencies including:

- DP&I;
- DRE;
- NoW;
- OEH;
- DPI – Fisheries;
- DSC;
- SCA;
- MSB; and
- Other agencies where their interest is recognised by the Committee.

Infrastructure Owners

Contact details for each of the infrastructure owners are available from BHPBIC should rapid access to their services be required. Management plans for infrastructure are developed in consultation with owners and where appropriate other regulators (e.g. DSC).

25.2 TRAINING

All staff and contractors working on BHPBIC sites are required to complete the BHPBIC training program which includes:

- An initial site induction (incl. all relevant aspects of environment, safety and community).
- Safe Work Methods Statements and Job Safety Analyses, Toolbox Talks and Pre-shift communications.
- On-going job specific training and re-training (where required).

All training records are maintained by the BHPBIC Safety and Training Department (STAX database system), which can be accessed by BHPBIC staff via the online information system iPick.

It shall be the responsibility of the Manager Approvals to ensure that all persons and organisations having responsibilities under this SMP are trained and understand their responsibilities.

The person(s) performing regular inspections shall be under the supervision of the Environment Field Team Coordinator and be trained in observation and reporting. The Environment Field Team Coordinator shall be satisfied that the person(s) performing the inspections are capable of meeting and maintaining this standard.

25.3 COMMUNICATION AND REPORTING

The AEMR is the principle reporting tool for the SMP. The AEMR will also provide a summary, analysis and discussion of the results of monitoring of subsidence effects, subsidence impacts and environmental consequences on an annual basis. As required by *Schedule 3 Condition 10* of the Area 3 Modification.

During the implementation of this SMP the Manager Approvals will ensure that all personnel are advised of their responsibilities under this Plan and will ensure that each understands the nature and requirements of the role.

BHPBIC maintains a comprehensive system of forums for communication that will be used, among other things, to regularly review monitoring results, assess subsidence impacts as they arise and maintain up to date knowledge of the system status. These forums are outlined below.

Regular Meetings with Field Monitoring Personnel and Surveyors are held as a regular form of general communication on a weekly basis and include any issues relating to monitoring. Where any situation involving subsidence outside predictions or of a serious nature is identified, the Field Monitoring Personnel or Surveyor will contact the relevant Manager immediately. Regular meetings are held between the Consultant Project Manager and the appropriate BHPBIC Manager. Reporting requirements are clearly stated in each contract with the Consultant.

The SMP Review Team will meet regularly to discuss the status of the SMP. Periodic reporting of the results of the monitoring programs to Government will be undertaken in accordance with the commitment in the Monitoring and Triggers sections.

Within four months of the completion of each longwall panel BHPBIC will prepare an end-of-panel report as required in *Schedule 3 Condition 9* of the Area 3 Modification.

25.4 AUDIT AND REVIEW

A risk review of subsidence impacts, based on the latest data has been conducted for the extraction of Dendrobium Area 3B, and this is detailed in **Attachment G** Volume 1 of this SMP Application. Should any significant unpredicted event occur, which is capable of impacting on the ability of this Plan to achieve its fundamental objective i.e. to monitor, assess and control impacts in accordance with the established TARPs, a review will be conducted.

Such events include subsidence impacts outside of predictions or a significant change in the mine plan. The Manager Approvals will discuss the nature of any such event with the DRE to determine if a review of risk is warranted and if the DRE wishes to be involved in that assessment.

Besides determining the degree of operational compliance with SMP provisions, audits will determine the ongoing ability of this Plan to most effectively meet its objectives by considering changes to technology, legislation or equipment and make appropriate recommendations.

Any non-conformances identified by an audit will be rectified as soon as practically possible.

Audits and reviews of this plan will include personnel with appropriate skills, knowledge or experience to contribute effectively to the conduct of each.

A summary of the monitoring data review process is provided in **Figure 25.1**.

25.5 RECORD KEEPING

Environmental records are maintained in order to assess the effectiveness of the SMP. These records include a history of normal conditions and triggers reached, as well as the effectiveness of any corrective actions.

Environmental Records are maintained in accordance with the BHPBIC procedure *Records Management (ICHP0108)*.

25.6 DOCUMENT CONTROL

The BHPBIC *Document Control procedure (ICHP0103)* outlines the method for control of 'business critical' documentation for all BHPBIC operations. The system has been designed in such a manner to ensure that:

- Documents are approved for adequacy by authorised personnel prior to use.
- Obsolete documents are promptly removed from circulation.
- Documents are reissued, or made available, to relevant persons in a timely fashion after changes have been made and the authorisation process is complete.

The SMP and other relevant documentation will be made available on the BHPBIC website.

Any amendments to the SMP will be completed in consultation with and the approval of DP&I and DRE. Appropriate measures to update stakeholders of any amendments to the SMP will be completed as required by the Approval Conditions.

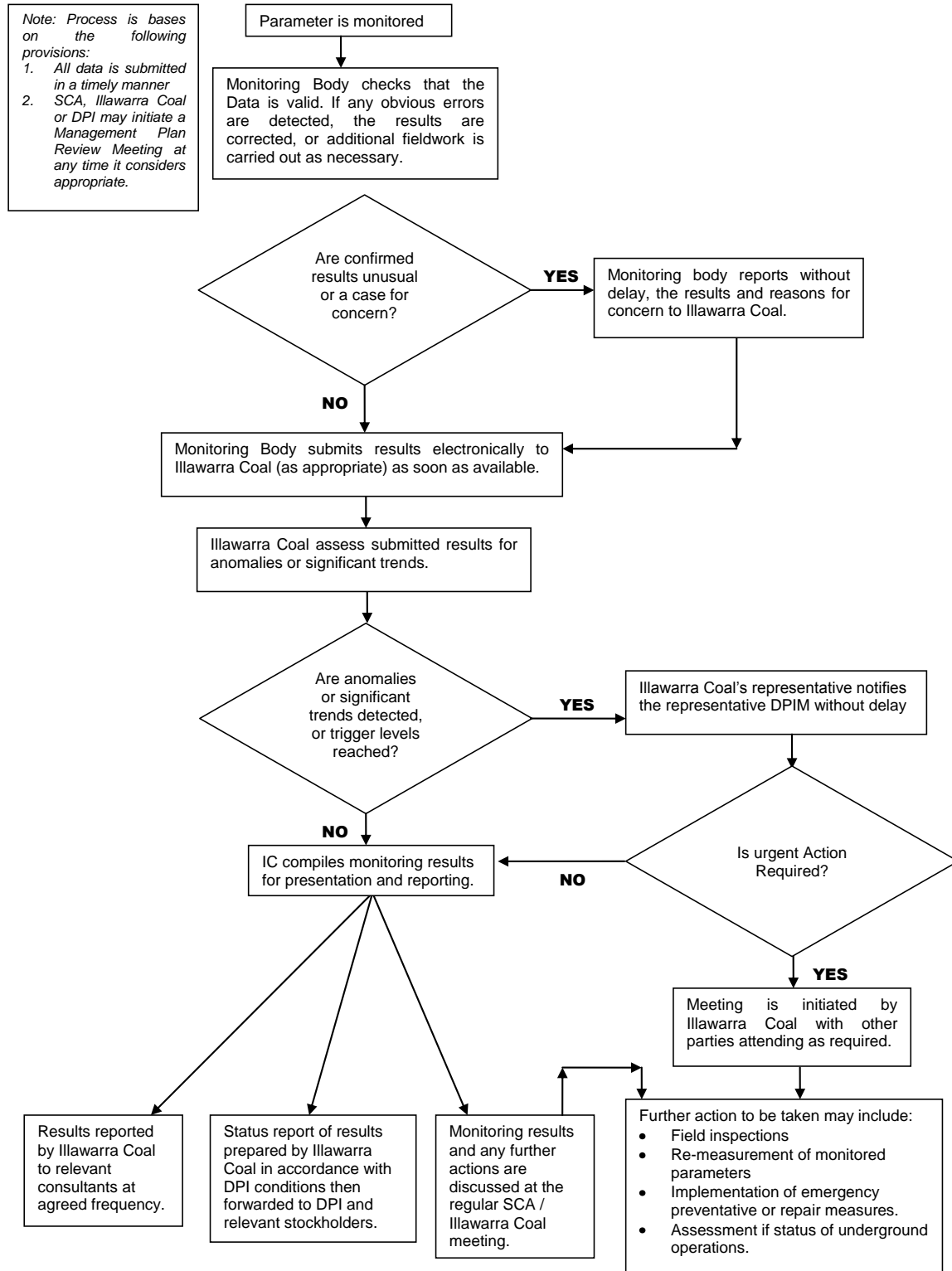


Figure 25.1 - Monitoring Data Review Process

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A. Trigger Action Response Plan

Table 1.1 – Dendrobium Landscape Key Monitoring Sites

Monitoring Site	Monitoring Type	Monitoring Frequency	Monitoring Parameters
LANDSCAPE FEATURES – TARGETED SITES (Refer to Dendrobium Area 3A SMP Figures 19.2 and 19.3 and Dendrobium Area 3B Figure 18.1 for location of sites)			
<p style="text-align: center;">AREA 2</p> <p>Cliffs A2-CL1 (above LW4)</p> <p>Steep Slopes A2-SL1 and A2-SL2 (above LWs 4 & 5)</p> <p>Watercourses A2-WC13 (above LWs 4 & 5)</p> <p>Swamp A2-SW1 (above LWs 4 & 5)</p> <p>4WD Track A2-FT1 (above LWs 4 & 5)</p> <p>Crinanite Surface Extent A2-CN1 & A2-CN2 (above LWs 3 & 4)</p>	<p>The categories of site inspection include:</p> <ol style="list-style-type: none"> Specific targeted monitoring sites based on potential risk Re-visits to identified impact sites 	<ul style="list-style-type: none"> Two 6 monthly baseline monitoring campaigns 1 year prior to mining 6 monthly monitoring during mining and monthly during any substantial subsidence period Monitoring to continue 6 monthly for 2 years following the completion of mining 	<p>Baseline recording includes landform elements from the Australian Soil and Land Survey Field Handbook including:</p> <ul style="list-style-type: none"> Slope Morphological type Dimensions Mode of geomorphological activity and geomorphological agent <p>During mining recording includes impacts to landform elements, e.g.</p> <ul style="list-style-type: none"> Drainage Disturbance of site Erosion Aggradations Inundation Rock Fracturing Changes in runoff Changes in vegetation Rockfalls Soil cracking Slumping
<p style="text-align: center;">AREA 3A</p> <p>Cliffs A3-CL1 & A3-CL2 (above LW10) A3-CL3 & A3-CL4 (W end of LW10) A3-CL5 (SW end of LW9)</p> <p>Steep Slopes A3-SL1 (above LW6) A3-SL2 (SE corner of LW6) A3-SL3 (W end of LW7) A3-SL4 & A3-SL5 (above LWs 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)</p> <p>Watercourses / Swamps A3-WC1 (above LW7 in Swamp 12) A3-WC2 & A3-WC3 (above LWs 8, 9 and 10 in Swamps 15a and 15b)</p> <p>Fire Trails A3-FR1 (across LWs 6-10) A3-FR2 (above LWs 6 & 7)</p>			

AREA 3B	<p>Cliffs</p> <p>DA3-CF19 (E LW13) DA3-CF20 (E LW13) DA3-CF21 (E LW13) DA3-CF22 (E LW13) DA3-CF23 (E LW13) DA3-CF25 (E LW17) DA3-CF26 (E LW17) DA3-CF41 (E LW18) DA3-CF42 (E LW18) DA3-CF43 (E LW 18)</p>	<p>The categories of site inspection include:</p> <ol style="list-style-type: none"> 1. General inspection of all active subsidence areas 2. Re-visits to identified impact sites 	<ul style="list-style-type: none"> • Baseline monitoring campaign prior to mining • monthly monitoring during any subsidence period • Monitoring to continue 6 monthly for 2 years following the completion of mining 	<p>Baseline recording includes landform elements from the Australian Soil and Land Survey Field Handbook including:</p> <ul style="list-style-type: none"> • Slope • Morphological type • Dimensions • Mode of geomorphological activity and geomorphological agent <p>During mining recording includes impacts to landform elements, e.g.</p> <ul style="list-style-type: none"> • Drainage • Disturbance of site • Erosion • Aggradations • Inundation • Rock Fracturing • Changes in runoff • Changes in vegetation • Rockfalls • Soil cracking • Slumping
	<p>Watercourses / Swamps</p> <p><i>Refer to DA3 Watercourse and Swamp Monitoring TARPs</i></p>			
	<p>Fire Trails</p> <p>Fire Road No.6A (across LWs 10-18) Fire Road No.6N (across LW14) Fire Road No.6Q (across LW 15, 16 and 17)</p>			

INSPECTION OF ACTIVE MINING AREA - LANDSCAPE FEATURES, VEGETATION, WATERCOURSES

AREA 3A	<p>All mapped cliff, steep slopes, watercourse, swamp and fire trail sites in subsidence area <i>Refer to Dendrobium Area 3A SMP Figure 19.3 for location of sites</i> General observation of active mining areas</p>	<p>The categories of site inspection include:</p> <ol style="list-style-type: none"> 1. General inspection of all active subsidence areas 2. Re-visits to identified impact sites 	<ul style="list-style-type: none"> • Weekly monitoring when longwall extraction is within 400m of feature 	<p>During mining recording includes impacts to:</p> <ul style="list-style-type: none"> • Drainage • Disturbance of site • Erosion • Aggradations • Inundation • Rock Fracturing • Changes in runoff • Changes in vegetation • Impacts to fauna/fish • Rockfalls • Soil cracking • Slumping
	<p>All mapped cliff, steep slopes, watercourse, swamp and fire trail sites in subsidence area <i>Refer to Dendrobium Area 3B SMP Figure 5.3, 15.1 and 18.1 for location of sites</i> General observation of active mining areas</p>			
AREA 3B				

TERRESTRIAL FLORA				
AREA 2	<p>A number of sites located across and around Areas 2, 3A and 3B <i>Refer Dendrobium Area 3A SMP Figure 21.1, 21.2 and 21.3 and 3B Figure 20.1</i></p>	<p>Observational and quantitative (transect) monitoring to identify 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</p>	<ul style="list-style-type: none"> • Two baseline monitoring campaigns 1 year prior to mining during autumn and spring • 6 monthly monitoring during mining in autumn and spring each year • 6 monthly monitoring post mining for two years or as otherwise required 	<ul style="list-style-type: none"> • Vegetation communities • Vegetation condition • Changes in vegetation • Tree health • Swamp vegetation • Threatened species • Control sites
AREA 3A				
AREA 3B				
TERRESTRIAL FAUNA				
AREA 2	<p>A number of sites located across and around Areas 2, 3A and 3B <i>Refer Dendrobium Area 3A SMP Figure 21.1, 21.2 and 21.3 and 3B Figure 20.1</i></p>	<p>Observational and quantitative (population counts) monitoring to identify alteration or loss of fauna habitat, fauna habitat assessed to be degraded without a natural cause readily apparent</p>	<ul style="list-style-type: none"> • Two baseline monitoring campaigns 1 year prior to mining • 6 monthly monitoring during mining • 6 monthly monitoring post mining for two years or as otherwise required 	<ul style="list-style-type: none"> • Species and habitat characteristics • Targeted surveys and monitoring of known populations of threatened frog species
AREA 3A				
AREA 3B				

ABORIGINAL ARCHAEOLOGY (Refer Dendrobium Area 3A SMP Figure 22.1 and Dendrobium Area 3B Figure 21.1 for location of sites)

AREA 2	<ul style="list-style-type: none"> • Dendrobium 4 	Observational and photographic monitoring in consultation with stakeholders	<ul style="list-style-type: none"> • Baseline archival recording: prior to longwall mining • First impact assessment recording: Following initial subsidence movement of the site • Sandstone shelter Aboriginal sites will be monitored during mining • Further impact assessment recording: twelve months after undermining or final subsidence movement of the site 	<ul style="list-style-type: none"> • Re-recording of the principal components 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
AREA 3A	<ul style="list-style-type: none"> • 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 52-5-0274) • 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) • DM15 (New recording) • DM20 (New recording) • DM23 (New recording) 			

AREA 3B	<ul style="list-style-type: none"> • Donalds Castle Creek Site 1; Cordeaux Catchment Area (recording code 52-2-1562) • Browns Road Site 8 (recording code 52-2-1623) • Browns Road Site 11 (recording code 52-2-1626) • Browns Road Site 12 (recording code 52-2-1627) • Browns Road Site 13 (recording code 52-2-1628) • Upper Avon 35 (recording code 52-2-1771) • Upper Avon 36 (recording code 52-2-1772) • Upper Avon 37 (recording code 52-2-1773) • Upper Avon 38 (recording code 52-2-1774) • Upper Avon 39 (recording code 52-2-1775) • Upper Avon 40 (recording code 52-2-1776) • Upper Avon 41 (recording code 52-2-1777) • DENDROBIUM 1 (recording code 52-2-2208) • DENDROBIUM 2 (recording code 52-2-2209) • SITE 1 – DB1 (recording code 52-2-2229) • DENDROBIUM 6 (recording code 52-2-2246) • DENDROBIUM 7 (recording code 52-2-2248) • DENDROBIUM 8 (recording code 52-2-3088) • DM16 (recording code 52-2-3640) • DM17 (recording code 52-2-3641) • DM21 (recording code 52-2-3645) • DM22 (recording code 52-2-3878) 	<p>Observational and photographic monitoring in consultation with stakeholders</p>	<ul style="list-style-type: none"> • Baseline archival recording: prior to longwall mining • First impact assessment recording: Following initial subsidence movement of the site • Sandstone shelter Aboriginal sites will be monitored during mining • Further impact assessment recording: twelve months after undermining or final subsidence movement of the site 	<ul style="list-style-type: none"> • Re-recording of the principal components 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
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Table 1.2 – Dendrobium Landscape Impacts, Triggers and Response

Monitoring	Trigger	Action
LANDSCAPE FEATURES		
<p>AREA 2</p> <p>Cliffs A2-CL1 (above LW4)</p> <p>Steep Slopes A2-SL1 and A2-SL2 (above LWs 4 & 5)</p> <p>Watercourses A2-WC10 and A2-WC11 (above LW3) A2-WC13 & A2-WC16 (above LWs 4 & 5)</p> <p>Swamp A2-SW1 (above LWs 4 & 5)</p> <p>4WD Track A2-FT1 (above LWs 4 & 5)</p> <p>Crinanite Surface Extent A2-CN1 & A2-CN2 (above LWs 3 & 4)</p>	<p>Level 1 *</p> <ul style="list-style-type: none"> Rock fall from a cliff which is left mostly intact (<10% length), resulting in insignificant ground disturbance Surface movement or rock displacement with negligible soil surface exposed Crack at the surface, which should not result in any significant erosion or further ground movement Crack in a fire trail which should not result in erosion or impede access Crack or fracture up to 100mm width Crack or fracture up to 10m length Erosion in a localised area which would be expected to naturally stabilise without CMA and within the period of monitoring 	<ul style="list-style-type: none"> Continue monitoring program Report impacts to key stakeholders Summarise impacts and Report in the End of Panel Report and AEMR
<p>AREA 3A</p> <p>Cliffs All mapped cliff sites in subsidence area (Refer to Dendrobium Area 3A SMP Figures 19.3 for location of sites)</p> <p>Steep Slopes All mapped steep slopes in subsidence area <i>Refer to Dendrobium Area 3A SMP Figures 19.3 for location of sites</i></p> <p>Watercourses/ Swamps All mapped watercourse and swamps in subsidence area <i>Refer to Dendrobium Area 3A SMP Figure 19.3</i></p> <p>Fire Trails All mapped fire trails in subsidence area <i>Refer to Dendrobium Area 3A SMP Figure 19.3</i></p>	<p>Level 2 *</p> <ul style="list-style-type: none"> Rock fall or overhang collapse at a cliff site, where characteristics of the cliff have changed, and there has been significant ground disturbance Surface movement or rock displacement that has exposed significant areas of soil A crack at the surface, which could result in significant erosion or movement at the surface A crack at the surface with potential risk to safety and/or fauna entrapment A crack in the fire trail, which could result in significant erosion or impede vehicle access Crack or fracture between 100 and 300mm width Crack or fracture between 10 and 50m length Significant erosion at any location, which is not likely to naturally stabilise within the period of monitoring, or is located in a sensitive area e.g. swamps, creek, lake shore, and may result in increased sediment transport to Cordeaux Dam, or has been previously identified as Level 1, but is not likely to naturally stabilise within the monitoring period 	<ul style="list-style-type: none"> Actions as stated for Level 1 Review monitoring frequency Notify relevant technical specialists and seek advice on any CMA required Provide safety signage and barricades as appropriate Implement approved repairs to ensure safety and serviceability on fire trails Implement agreed CMAs as approved <p><i>Note: CMAs are to be proposed based on appropriate management of environmental and other consequences of impacts i.e. cracking at the surface with insignificant consequences may not require specific CMAs other than ongoing monitoring to confirm there are no ongoing impacts</i></p>
<p>AREA 3B</p> <p>Cliffs All mapped cliff sites in subsidence area <i>Refer to Dendrobium Area 3B SMP Figures 18.1 for location of sites</i></p>	<p>Level 3 *</p> <ul style="list-style-type: none"> Major cliff collapse where the characteristics of the cliff change significantly and there is significant ground disturbance that is unlikely to naturally stabilise within the monitoring period 	<ul style="list-style-type: none"> Actions as stated for Level 2 Immediately notify DoPI, DPIM, SCA, resource managers and relevant technical specialists and seek advice on any CMA required Site visits with stakeholders if required

Table 1.2 – Dendrobium Landscape Impacts, Triggers and Response

Monitoring	Trigger	Action
	<ul style="list-style-type: none"> • Crack or fracture over 300mm width • Crack or fracture over 50m length • Mass movement of a slope causing large areas of exposed soil with potential for further movement 	<ul style="list-style-type: none"> • Review monitoring program and modify if necessary within 1 month • Implement increased monitoring if required within 2 weeks • Develop site CMA in consultation with key stakeholders within 1 month, (pending stakeholder availability) and seek approvals • Completion of works following approvals • Issue CMA report within 1 month of works completion • Conduct initial follow up monitoring & reporting within 2 months of CMA completion • Review the relevant TARP and Management Plan in consultation with key stakeholders <p><i>Note: CMAs are to be proposed based on appropriate management of environmental and other consequences of impacts i.e. cracking at the surface with insignificant consequences may not require specific CMAs other than ongoing monitoring to confirm there are no ongoing impacts</i></p>
Sandy Creek Waterfall	<p>Exceeding Prediction</p> <ul style="list-style-type: none"> • Rock fall at Sandy Creek Waterfall or from its overhang • Structural integrity of the waterfall, its overhang and its pool are impacted • More than negligible cracking within 30 m of the waterfall • More than negligible diversion of water from the lip of the waterfall 	<ul style="list-style-type: none"> • Actions as stated for Level 3 • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation
TERRESTRIAL FLORA AND FAUNA		
<p>A number of sites located across and around Areas 2, 3A and 3B <i>Refer Dendrobium Area 3A SMP Figure 21.1, 21.2 and 21.3 and Dendrobium Area 3B Figure 20.1 for location of sites</i></p>	<p>Level 1 *</p> <ul style="list-style-type: none"> • Vegetation impacted by mining (by rockfalls, soil slippage, gas emissions) that is likely to naturally regenerate within the monitoring period 	<ul style="list-style-type: none"> • Continue monitoring program • Report impacts to key stakeholders • Summarise impacts and Report in the End of Panel Report and AEMR
General observation of active mining areas	<p>Level 2 *</p> <ul style="list-style-type: none"> • Vegetation impacted by mining (by rockfalls, soil slippage, gas emissions) that is unlikely to naturally regenerate within the monitoring period • Statistically significant difference between Before After Control Impact sites as a result of mining 	<ul style="list-style-type: none"> • Actions as stated for Level 1 • Review monitoring frequency • Notify relevant technical specialists and seek advice on any CMA required • Implement agreed CMAs as approved

Table 1.2 – Dendrobium Landscape Impacts, Triggers and Response

Monitoring	Trigger	Action
	<p>Level 3 *</p> <ul style="list-style-type: none"> Vegetation impacted by mining that is not responding to CMAs 	<ul style="list-style-type: none"> Actions as stated for Level 2 Immediately notify OEH, DoPI, DPI, SCA, other resource managers and relevant technical specialists and seek advice on any CMA required Site visits with stakeholders if required Review monitoring program and modify if necessary within 1 month Implement increased monitoring if required within 2 weeks Develop site CMA in consultation with key stakeholders within 1 month, (pending stakeholder availability) and seek approvals Completion of works following approvals Issue CMA report within 1 month of works completion Conduct initial follow up monitoring & reporting within 2 months of CMA completion Review the relevant TARP and Management Plan in consultation with key stakeholders
ABORIGINAL ARCHAEOLOGY		
<p>Area 2 (1 site): Dendrobium 4</p> <p>Area 3A (11 total):</p> <ul style="list-style-type: none"> 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) 	<p>Level 1 *</p> <ul style="list-style-type: none"> 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) Changes external to the shelter that affect the site context (e.g. ground cracking, boulder slumping, rock and/or tree falls) <p>Level 2 *</p> <ul style="list-style-type: none"> Change in shelter conditions not attributable to natural weathering or preservation – change in drip line or seepage, cracking or exfoliation of overhang or shelter, movement or opening of existing planes and joints at panel, block fall within shelter or overhang, shelter or overhang collapse <p>Level 3 *</p> <ul style="list-style-type: none"> Level 2 impacts at greater frequency than predicted Level 2 impacts attributable to mining remote from the mining area 	<ul style="list-style-type: none"> Continue monitoring program Condition assessment and photographic record Notify relevant specialists and key stakeholders (e.g. Aboriginal community groups) Summarise impacts and Report in the End of Panel Report and AEMR <p>• Actions as stated for Level 1</p> <ul style="list-style-type: none"> Modify monitoring program if necessary Consider development of site management plan to mitigate effects in consultation with Registered Aboriginal Groups and the Landowner (SCA) <p>• Actions as stated for Level 2</p> <ul style="list-style-type: none"> Immediately notify OEH, DoPI, DPI, SCA, other resource managers and relevant technical specialists and seek advice on any CMA required Site visits with stakeholders if required Review monitoring program and modify if necessary within 1 month Implement increased monitoring if required within 2 weeks Develop site CMA in consultation with key stakeholders within 1 month, (pending stakeholder availability) and seek approvals Completion of works following approvals

Area3B (25 total):

- Donalds Castle Creek Site 1; Cordeaux Catchment Area (recording code 52-2-1562)
- Browns Road Site 8 (recording code 52-2-1623)
- Browns Road Site 11 (recording code 52-2-1626)
- Browns Road Site 12 (recording code 52-2-1627)
- Browns Road Site 13 (recording code 52-2-1628)
- Upper Avon 35 (recording code 52-2-1771)
- Upper Avon 36 (recording code 52-2-1772)
- Upper Avon 37 (recording code 52-2-1773)
- Upper Avon 38 (recording code 52-2-1774)
- Upper Avon 39 (recording code 52-2-1775)
- Upper Avon 40 (recording code 52-2-1776)
- Upper Avon 41 (recording code 52-2-1777)
- DENDROBIUM 1 (recording code 52-2-2208)
- DENDROBIUM 2 (recording code 52-2-2209)
- SITE 1 – DB1 (recording code 52-2-2229)
- DENDROBIUM 6 (recording code 52-2-2246)
- DENDROBIUM 7 (recording code 52-2-2248)
- DENDROBIUM 8 (recording code 52-2-3088)
- DM16 (recording code 52-2-3640)
- DM17 (recording code 52-2-3641)
- DM21 (recording code 52-2-3645)
- DM22 (recording code 52-2-3878)

- Issue CMA report within 1 month of works completion
- Conduct initial follow up monitoring & reporting within 2 months of CMA completion
- Review the relevant TARP and Management Plan in consultation with key stakeholders

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

Office of Environment and Heritage (OEH)

Department of Planning and Infrastructure (DoPI)

Department of Primary Industries: including Division of Resources and Energy, Office of Water, Fisheries (DPI)

Sydney Catchment Authority (SCA)

Table 2.1 – Dendrobium Swamp Key Monitoring

All monitoring sites directly or indirectly related to swamps within Dendrobium Area 3B will be installed ahead of mining to ensure collection of at least 2 years baseline data. The location of some monitoring sites indicated on Figure 27 is “indicative” and will be reviewed and confirmed prior to installation.

Monitoring Site		Site Type	Monitoring Frequency	Parameters
LANDSCAPE FEATURES				
AREA 3A	Swamps 15A, 15B, 12 and 16 General observation of swamps in active mining areas when longwall is within 400m of swamp <i>Refer to Figure 1 of Swamp Impact, Monitoring, Management and Contingency Plan</i>	Landscape observational monitoring	<ul style="list-style-type: none"> • Baseline monitoring in the year prior to mining • Weekly monitoring during mining • 6 monthly monitoring for 2 years post mining 	Visual signs of impacts on swamps and drainage lines (i.e. cracking, vegetation changes, increased erosion, changes in water colour, soil moisture etc.) determined by comparing baseline photos with photos during the mining period Particular focus on rockbars in Swamps 15a and 15b
AREA 3B	Swamps 01A, 01B, 03, 04, 05, 08, 10, 11, 13, 14, 23, 35A and 35B General observation of swamps in active mining areas when longwall is within 400m of swamp			
SHALLOW GROUNDWATER LEVEL				
AREA 2	D2-1, D2-2, D2-3, D2-4, and D2-5 (located at the margin and/or upstream of Dendrobium Swamp 1) D4-1 and 89C (SC9 catchment, above LWs 4 and 5) D3-1, D3-2, D3-3, D3-4, and D3-5 (Swamp 134) D5-1 and D5-2 (approx. 200 m N of Swamp 134)	Piezometric and dip meter monitoring	<p>For open hole sites:</p> <ul style="list-style-type: none"> - Monthly baseline monitoring - Weekly monitoring during active subsidence - Monthly monitoring post mining for two years to be reviewed annually <p>For instrumented sites:</p> <ul style="list-style-type: none"> - Automatic groundwater level monitoring, at least every 4 hours 	Shallow Groundwater level
AREA 3A	S15BH1, S15BH2, and S15BH3 (Swamp 15b) Approximately 50 piezometers in and around swamps in Area 3A (Swamp 15A, 15B, 12 and 16)			
AREA 3B	<p><u>Area 3B:</u></p> <ul style="list-style-type: none"> • 01a_01, 01a_02, 01a_03, 01a_04; • 01b_01, 01b_02, 01b_03; • 02_01; 03_01; 04_01; • 05_01, 05_02, 05_03, 05_04, 05_05, 05_06, 05_07; • 08_01, 08_02, 08_03, 08_04, 08_05, 08_06 • 10_01; 11_h1, h2 and h3; 13_01 • Additional installations during mining <p>Approximately 30 piezometers in and around swamps in Area 3B (Swamps 01A, 01B, 03, 04, 05, 08, 10, 11, 13, 14, 23, 35A and 35B) <i>Refer to Figure 27 in Swamp Impact, Monitoring, Management and Contingency Plan</i></p>			

TERRESTRIAL FLORA AND FAUNA

AREA 3A	Swamp vegetation transects General observation of active mining areas	Flora monitoring	<ul style="list-style-type: none"> • Two baseline monitoring campaigns 1 year prior to mining during autumn and spring (Autumn - Photo points; spring - Photo points & transects/quadrat) • Quarterly monitoring during mining • 6 monthly monitoring post mining for two years or as otherwise required • General observation of active mining areas during all other monitoring 	<ul style="list-style-type: none"> • Vegetation communities • Vegetation condition • Changes in vegetation • Swamp vegetation • Threatened species • Control sites
	A number of sites located across and around swamps in Area 3A. General observation of active mining areas	Fauna Monitoring	<ul style="list-style-type: none"> • Two baseline monitoring campaigns 1 year prior to mining • Bi-annual monitoring during mining • Bi-annual monitoring post mining for 2 years or as otherwise required • Targeted Winter Surveys – Threatened frog species (once per year in winter) prior to mining, during mining and for 2 years post mining or as otherwise required • General observation of active mining areas during all other monitoring 	<p>Species and habitat characteristics</p> <p>Variation in the species or fauna groups</p> <p>Targeted surveys and monitoring (as required) of known populations in Area 3A specifically for Littlejohn’s Tree Frog, Red Crowned Toadlet</p>
AREA 3B	Swamps 01A, 01B, 03, 04, 05, 08, 10, 11, 13, 14, 23, 35A and 35B Swamp vegetation transects General observation of active mining areas	Flora monitoring	<ul style="list-style-type: none"> • Two baseline monitoring campaigns 1 year prior to mining during autumn and spring (Autumn - Photo points; spring - Photo points & transects/quadrat) • Quarterly monitoring during mining • 6 monthly monitoring post mining for two years or as otherwise required • General observation of active mining areas during all other monitoring 	<ul style="list-style-type: none"> • Vegetation communities • Vegetation condition • Changes in vegetation • Swamp vegetation • Threatened species • Control sites
	Swamps 01A, 01B, 03, 04, 05, 08, 10, 11, 13, 14, 23, 35A and 35B A number of sites located across and around swamps in Area 3B. General observation of active mining areas	Fauna Monitoring	<ul style="list-style-type: none"> • Two baseline monitoring campaigns 1 year prior to mining • Bi-annual monitoring during mining • Bi-annual monitoring post mining for 2 years or as otherwise required • Targeted Winter Surveys – Threatened frog species (once per year in winter) prior to mining, during mining and for 2 years post mining or as otherwise required • General observation of active mining areas during all other monitoring 	<p>Species and habitat characteristics</p> <p>Variation in the species or fauna groups</p> <p>Targeted surveys and monitoring (as required) of known populations in Area 3A specifically for Littlejohn’s Tree Frog, Red Crowned Toadlet</p>

Table 2.2 – Dendrobium Swamp Impacts, Triggers and Response

Monitoring	Trigger	Action
SWAMP LANDSCAPE OBSERVATIONAL MONITORING		
<p>Swamps 15A, 15B, 12 and 16 Swamps 01A, 01B, 03, 04, 05, 08, 10, 11, 13, 14, 23, 35A and 35B</p> <p>General observation of swamps in active mining areas when longwall is within 400m of swamp</p> <p><i>Refer to Figure 27 of Swamp Impact, Monitoring, Management and Contingency Plan</i></p>	<p>Level 1 *</p> <ul style="list-style-type: none"> • Fracturing in a swamp, drainage line or rockbar which does not appear to result in visible loss of surface water or cause erosion • Soil surface crack that does not cause erosion 	<ul style="list-style-type: none"> • Continue monitoring program • Submit an Impact Report • Report in the End of Panel Report • Summarise all actions and monitoring in AEMR by due date
	<p>Level 2 *</p> <ul style="list-style-type: none"> • Fracturing in a swamp, drainage line or rockbar which results in visible loss of surface water in some sections of the swamp, drainage line or rockbar or causes erosion which is likely to stabilise within the monitoring period • Soil Surface crack that causes erosion that is likely to stabilise within the monitoring period 	<ul style="list-style-type: none"> • <i>Actions as stated for Level 1</i> • Review monitoring frequency • Notify relevant technical specialists and seek advice on any CMA required • Implement agreed CMAs as approved
	<p>Level 3 *</p> <ul style="list-style-type: none"> • Fracturing in a swamp and/or drainage line and/or rockbar that has resulted in loss of surface water from all sections of the swamp and/ or major erosion caused by loss of water • The structural integrity of the controlling rockbar of a Swamp is impacted 	<ul style="list-style-type: none"> • <i>Actions as stated for Level 2</i> • Notification to OEH, DoPI, DPI, SCA and other resource manager/s immediately • Notify Ecological Specialists and other relevant Specialists immediately • Site visits with stakeholders within one month • Capture photographic record immediately • Implement additional monitoring or increase frequency if required within 2 weeks • Develop site CMA in consultation with key stakeholders within 1 month, (pending stakeholder availability) and seek approvals. These may include: <ul style="list-style-type: none"> – 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 OEH, DoPI, DPI, SCA and other stakeholders • Completion of works following approvals • Conduct initial follow up monitoring & reporting within 2 months of CMA completion • Review relevant TARP and Management Plan in consultation with key stakeholders
<p>Swamp 15A</p>	<p>Exceeding Prediction</p> <ul style="list-style-type: none"> • Subsidence causes erosion of the surface • The structural integrity of the controlling rockbar is impacted and cannot be restored 	<ul style="list-style-type: none"> • <i>Actions as stated for Level 3</i> • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation

SHALLOW GROUNDWATER		
<p>Area 2:</p> <ul style="list-style-type: none"> D2-1, D2-2, D2-3, D2-4, and D2-5 (Swamp 1) D4-1 and 89C (SC9 catchment, above LWs 4 and 5) D3-1, D3-2, D3-3, D3-4, and D3-5 (Swamp 134) D5-1 and D5-2 (approx. 200 m N of Swamp 134) <p>Area 3A:</p> <ul style="list-style-type: none"> S15BH1, S15BH2, and S15BH3 (Swamp 15b above edge of LW 8) <p>Approx. 50 piezometers in hillslope aquifers around swamps (Swamps 15A, 15B, 12 and 16) in Area 3A</p> <p>Approx. 50 piezometers in total installed and instrumented on a priority basis.</p> <p>Area 3B:</p> <ul style="list-style-type: none"> Swamps 01A, 01B, 03, 04, 05, 08, 10, 11, 13, 14, 23, 35A and 35B <p>Approximately 30 piezometers in and around swamps</p> <p><i>Refer to Figure 27 of Swamp, Impact, Monitoring, Management and Contingency Plan</i></p> <p>Piezometers that are not instrumented will be manually measured on a monthly and weekly basis during mining</p>	<p>Level 1 *</p> <ul style="list-style-type: none"> Groundwater level lower than baseline level at any monitoring site within a swamp Rate of groundwater level reduction exceeds rate of groundwater level reduction during baseline period at any monitoring site (measured as average mm/day during the recession curve) 	<ul style="list-style-type: none"> Continue monitoring program Report impacts to key stakeholders Summarise impacts and report in the End of Panel Report and AEMR
	<p>Level 2 *</p> <ul style="list-style-type: none"> Groundwater level lower than baseline level at majority of monitoring sites within a swamp Rate of groundwater level reduction exceeds rate of groundwater level reduction during baseline period at a majority of monitoring sites within the swamp (measured as average mm/day during the recession curve) 	<ul style="list-style-type: none"> <i>Actions as stated for Level 1</i> Review monitoring program Notify relevant technical specialists and seek advice on any CMA required Implement agreed CMAs as approved
	<p>Level 3 *</p> <ul style="list-style-type: none"> Groundwater level lower than baseline level at all monitoring sites within a swamp Rate of groundwater level reduction exceeds rate of groundwater level reduction during baseline period at all monitoring sites within the swamp (measured as average mm/day during the recession curve) 	<ul style="list-style-type: none"> <i>Actions as stated for Level 2</i> Immediately notify OEH, DoPI, DPI, SCA, and resource manager/s and relevant technical specialists and seek advice on any CMA required Site visits with stakeholders within one month Develop site CMA if required in consultation with key stakeholders within 1 month, (pending stakeholder availability) and seek approvals. These may include: <ul style="list-style-type: none"> 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 OEH, DoPI, DPI, SCA, 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 Conduct initial follow up and additional monitoring and reporting within 2 months of CMA completion Review the relevant TARP and Management Plan in consultation with key stakeholders
TERRESTRIAL FLORA AND FAUNA		
<p>The below applies to Swamps 01A, 01B, 03, 04, 05, 08, 10, 11, 13, 14, 23, 35A and 35B</p> <p>FLORA</p> <p>Stressed or dead vegetation not readily explained by natural processes</p> <p>Swamp vegetation transects</p> <p>General observation of active mining areas</p>	<p>Level 1 *</p> <ul style="list-style-type: none"> Vegetation impacted by mining (by rockfalls, soil slippage, gas emissions) that is likely to naturally regenerate within the monitoring period 	<ul style="list-style-type: none"> Continue monitoring program Report in the End of Panel Report Summarise all actions and monitoring in AEMR by due date
	<p>Level 2 *</p> <ul style="list-style-type: none"> Vegetation impacted by mining (by rockfalls, soil slippage, gas emissions) that is unlikely to naturally 	<ul style="list-style-type: none"> <i>Actions as stated for Level 1</i> Review monitoring frequency Notify relevant technical specialists and seek advice on any CMA required

<p>FAUNA Alteration or loss of fauna habitat assessed to be degraded without a natural cause readily apparent</p> <p>Sites located across and around swamps in Area 3A and 3B. General observation of active mining areas</p> <p><i>Refer to: Dendrobium Eco Monitoring Annual Report 2009-2010 08042011 – Figure 5</i></p>	<p>regenerate within the monitoring period</p> <ul style="list-style-type: none"> Statistically significant difference of species richness and species diversity between Before After Control Impact sites as a result of mining 	<ul style="list-style-type: none"> Implement agreed CMAs as approved
	<p>Level 3 *</p> <ul style="list-style-type: none"> Subsidence causes erosion of the surface or significant changes in ecosystem functionality of a swamp Vegetation impacted by mining that is not responding to CMAs 	<ul style="list-style-type: none"> <i>Actions as stated for Level 2</i> Immediately notify OEH, DoPI, DPI, SCA, other resource managers and relevant technical specialists and seek advice on any CMA required Site visits with stakeholders if required Review monitoring program and modify if necessary within 1 month Implement increased monitoring if required within 2 weeks Develop site CMA in consultation with key stakeholders within 1 month, (pending stakeholder availability) and seek approvals Completion of works following approvals Issue CMA report within 1 month of works completion Conduct initial follow up monitoring & reporting within 2 months of CMA completion Review the relevant TARP and Management Plan in consultation with key stakeholders
<p>Swamp 15A</p>	<p>Exceeding Prediction</p> <ul style="list-style-type: none"> Subsidence causes changes in the ecosystem function of the swamp 	<ul style="list-style-type: none"> <i>Actions as stated for Level 3</i> Investigate reasons for the exceedance Update future predictions based on the outcomes of the investigation

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

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Sydney Catchment Authority (SCA)

Table 3.1 – Dendrobium Watercourse Key Monitoring

MONITORING SITE	SITE TYPE	MONITORING FREQUENCY	PARAMETERS	
WATER QUALITY (Refer to the Area 3B Watercourse Impact Monitoring, Management and Contingency Plan Figure 2, the Area 3A Watercourse Impact Monitoring, Management and Contingency Plan Figure 3.1 and Area 2 SMP Figure 18.2)				
AREA 2	GFC (Green Fields Ck Waterfall Pool)	<ul style="list-style-type: none"> - Grab Sample - Field water quality 	<ul style="list-style-type: none"> - Monthly 	Manual Field Testing: <ul style="list-style-type: none"> ▪ 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, Ba, Sr, DOC, TKN, NH3-N, NOx-N, TP Automatic Data Logging: <ul style="list-style-type: none"> ▪ Temperature ▪ Dissolved oxygen ▪ Conductivity ▪ pH ▪ Turbidity
	WC (Waratah Ck)	<ul style="list-style-type: none"> - Grab Sample - Field water quality - Automatic data logger 	<ul style="list-style-type: none"> - Bi-monthly - 5 minute logging intervals 	
	FTC (Fern Tree Ck)	<ul style="list-style-type: none"> - Grab Sample 	<ul style="list-style-type: none"> - Bi-Monthly 	
	SC (Sandy Ck D/S)	<ul style="list-style-type: none"> - Grab Sample - Field water quality - Automatic data logger 	<ul style="list-style-type: none"> - Bi-monthly - 5 minute logging intervals 	
	P3 (Sandy Ck U/S trib. Pool 3)	<ul style="list-style-type: none"> - Grab sample - Field water quality 	<ul style="list-style-type: none"> - Bi-monthly 	
	C12 (Creek 12)	<ul style="list-style-type: none"> - Grab sample - Field water quality 	<ul style="list-style-type: none"> - Bi-monthly 	
AREA 3A	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)	<ul style="list-style-type: none"> - Grab sample - Field water quality 	<ul style="list-style-type: none"> - Monthly manual monitoring during and post mining for two years or until required 	Manual Field Testing: <ul style="list-style-type: none"> ▪ 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, Ba, Sr, DOC, TKN, NH3-N, NOx-N, TP
	Sandy Creek SCU1 (U/S Sandy Ck) SCL (D/S Sandy Ck adjacent to LW 7)			
	Ephemeral watercourses BC1 (Sandy Ck trib. SC10 over LW 8) – Swamp 15a BCC1 (Sandy Ck trib. SC10C over LW 8) – Swamp 15b			
	Swamp Hydrolab Monitoring Sites <i>Refer to Swamp Impact Monitoring, Management and Contingency Plan Figures 22 to 26</i>	<ul style="list-style-type: none"> - Field Water Quality 	<ul style="list-style-type: none"> - Weekly manual monitoring during active subsidence - Monthly manual monitoring post mining for two years or otherwise required 	

AREA 3B	Wongawilli Creek and Tributaries WWL2 (Wongawilli Creek lower) WC_S1 (Mid-Wongawilli Creek) WC21_S1 (Tributary) WW_M3 WW_M2 WW_M1 WC15_S1 (Tributary) WWU4	- Grab sample - Field water quality	- Monthly manual monitoring before and during mining - Monthly manual monitoring post mining for two years or otherwise required	Manual Field Testing: <ul style="list-style-type: none"> ▪ Field pH ▪ Temp ▪ EC ▪ DO ▪ ORP ▪ Turbidity 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, Ba, Sr, DOC, TKN, NH3-N, NOx-N, TP
	Donalds Castle Creek and Drainage Lines DCU3 (Donalds Castle Creek lower) DC_S2 (Upper Donalds Castle Creek) DC13_S1 (Tributary)			
	Lake Avon and Tributaries LA4_S1 (Unnamed Creek) LA4_S2 (Lake Avon off Creek LA4) LA5_S1 (Unnamed Creek) LA5_S2 (Lake Avon off Creek LA5)			
	Lake Cordeaux Sandy Creek arm of Lake Cordeaux nearest Areas 2 and 3A SC (Sandy Creek D/S)	- Grab sample	- 6 monthly Baseline monitoring 1 year prior to mining - Monthly manual monitoring during and post mining - Monthly manual monitoring post mining for two years or otherwise required	Manual Field Testing: <ul style="list-style-type: none"> ▪ Field pH ▪ Temp ▪ EC ▪ DO ▪ ORP Lab. analytes (incl. lab check of pH, lab. check of EC, Na, K, Ca, Mg, Filt. SO4, Cl, T. Alk., Total Fe, Mn, Al, Filt. Cu, Ni, Zn, Ba, Sr, TKN, NH3-N, NOx-N, TP) Filterable metals (Mn, Ni, Zn)
WATER LEVEL/FLOW (Refer to the Area 3B Watercourse Impact Monitoring, Management and Contingency Plan Figure 2 and the Area 3A Watercourse Impact Monitoring, Management and Contingency Plan Figure 3.1)				
AREA 1	KS1 (Kembla Ck Pool 3)	- Piezometer with automatic Data logger	- Continuous 1 hour logging intervals	Automatic pool water level measurements
	KS2 (trib. of Kembla Ck, Un-named Ck)			
AREA 2	GFC (Green Fields Ck Waterfall Pool)			
	FTC (Fern Tree Ck)			

AREA 3A	<p>Wongawilli Creek WWU4 (U/S Wongawilli Ck) WWL2 (D/S Wongawilli Ck)</p> <p><i>Pool level benchmarks (i.e. nails)</i> WWM1 (WC Pool 46) (mid Wongawilli Ck adjacent to LW 10) WWM2 (WC Pool 44) (mid Wongawilli Ck adjacent to LW 8) WWM3 (WC Pool 43b) (mid Wongawilli Ck D/S of LW 6) WC Pools 41, 42b, 43a, Pool 45, 47b and 49</p>	<ul style="list-style-type: none"> - Automatic Data logger 	<ul style="list-style-type: none"> - Continuous 1 hour logging intervals 	<p>Automatic pool water level measurements which are converted to flows by calculation of rating curves using measured creek cross sections/measured flows at the monitoring point</p>
	<p><i>Pool level benchmarks (i.e. nails)</i> WWM1 (WC Pool 46) (mid Wongawilli Ck adjacent to LW 10) WWM2 (WC Pool 44) (mid Wongawilli Ck adjacent to LW 8) WWM3 (WC Pool 43b) (mid Wongawilli Ck D/S of LW 6) WC Pools 41, 42b, 43a, Pool 45, 47b and 49</p>	<ul style="list-style-type: none"> - Manual water level measurement 	<ul style="list-style-type: none"> - Monthly - Weekly when Longwall is within 400m of site 	<p>Monthly Manual Water level measurements using pre-established benchmarks (i.e. nails) in major pools</p>
	<p>Sandy Creek SCU1 (U/S Sandy Ck) SCL (Sandy Creek at Dendrobium) (D/S Sandy Ck adjacent to LW 7)</p> <p>SCK Pools 3a, 4, 5, 7, 10, 15, 20, 21 and 23</p>	<ul style="list-style-type: none"> - Automatic Data logger 	<ul style="list-style-type: none"> - Continuous 1 hour logging intervals 	<p>Automatic pool water level measurements which are converted to flows by calculation of rating curves using measured creek cross sections/measured flows at the monitoring point</p>
	<p><i>Pool level benchmarks (i.e. nails)</i> SCK Pools 3a, 4, 5, 7, 10, 15, 20, 21 and 23</p>	<ul style="list-style-type: none"> - Manual water level measurement 	<ul style="list-style-type: none"> - Monthly - Weekly when Longwall is within 400m of site 	<p>Monthly Manual Water level measurements using pre-established benchmarks (i.e. nails) in major pools</p>
AREA 3A	<p>First and Second Order watercourses BC1 (Sandy Ck trib. SC10 over LW 8) – Swamp 15a trib BCC1 (Sandy Ck trib. SC10C over LW 8) – Swamp 15b trib</p> <p>75% of the major pools in SC10, SC10c and WC17 have Pool level nail benchmarks installed</p>	<ul style="list-style-type: none"> - Automatic Data logger 	<ul style="list-style-type: none"> - Continuous 1 hour logging intervals 	<p>Automatic pool water level measurements which are converted to flows by calculation of rating curves using measured creek cross sections/measured flows at the monitoring point</p>
	<p><i>Pool level benchmarks (i.e. nails)</i> 75% of the major pools in SC10, SC10c and WC17 have Pool level nail benchmarks installed</p>	<ul style="list-style-type: none"> - Manual water level measurement 	<ul style="list-style-type: none"> - Monthly - Weekly when Longwall is within 400m of site 	<p>Monthly Manual Water level measurements using pre-established benchmarks (i.e. nails) in major pools</p>
	<p>Catchment Yield Catchment yields for SC10, SC7, Upper and Lower Sandy Creek, and Upper and Lower Wongawilli Creek</p>		<ul style="list-style-type: none"> - After each Longwall during mining - For a period of two years post mining 	<p>Jd quick runoff coefficient from Runoff 2005 model using input data from hydrological monitoring</p>
AREA 3B	<p>Wongawilli Creek WC21_S1, WC15_S1 (Wongawilli Creek Middle), WWL2 (Lower Wongawilli Creek), WWU4 (Upper Wongawilli Ck)</p> <p><i>Pool level benchmarks (i.e. nails)</i></p>	<ul style="list-style-type: none"> - Automatic Data logger 	<ul style="list-style-type: none"> - Continuous 1 hour logging intervals 	<p>Automatic pool water level measurements which are converted to flows by calculation of rating curves using measured creek cross sections/measured flows at the monitoring point</p>
	<p><i>Pool level benchmarks (i.e. nails)</i></p>	<ul style="list-style-type: none"> - Manual water level measurement 	<ul style="list-style-type: none"> - Monthly - Weekly when Longwall is within 400m of site 	<p>Monthly Manual Water level measurements using pre-established benchmarks (i.e. nails) in major pools</p>

	Donalds Castle Creek and tributaries DC13_S1 (Upper Donalds Castle Creek) DC_S2 (Upper Donalds Castle Creek – Upstream of DC_S1)	- Automatic Data logger	- Continuous 1 hour logging intervals	Automatic pool water level measurements which are converted to flows by calculation of rating curves using measured creek cross sections/measured flows at the monitoring point
	Lake Avon LA4_S1 (Unnamed Creek LA4) <i>Pool level benchmarks (i.e. nails)</i>	- Manual water level measurement	- Monthly - Weekly when Longwall is within 400m of site	Monthly Manual Water level measurements using pre-established benchmarks (i.e. nails) in major pools
	Catchment Yield Upper and Lower Wongawilli Creek Donalds Castle Creek		- After each Longwall during mining - For a period of two years post mining	Jd quick runoff coefficient from Runoff 2005 model using input data from hydrological monitoring
APPEARANCE				
AREA 3A	All flow and quality monitoring sites listed above General observation of active mining areas for SC10, SC10c, WC17, Sandy and Wongawilli Creeks	- Observational and photographic monitoring	- Monthly monitoring during mining - 6 Monthly monitoring for 2 yrs post mining - Weekly when Longwall is within 400m of site	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
AREA 3B	All flow and quality monitoring sites listed above General observation of active mining areas for Wongawilli Creek and tributaries, Lake Avon and tributaries	- Observational and photographic monitoring	- Monthly monitoring during mining - 6 Monthly monitoring for 2 yrs post mining - Weekly when Longwall is within 400m of site	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
AQUATIC ECOLOGY (Refer to Area 3A SMP Figures 20.1, 20.2, and 20.3 and Dendrobium Area 3B Figure 19.1)				
AREA 2	Sandy Ck - 4 sites • SC7 –1 replicate • SC10 – 2 replicates Middle Gully Ck (Creek 13) – 2 replicates Green Fields Ck (Creek 11) – 2 replicates	- Quantitative and observational monitoring	- Two Baseline monitoring campaigns 1 year prior to mining during autumn and spring - 6 monthly monitoring during mining in autumn and spring of each year - 6 monthly monitoring post mining for two years or as otherwise required - General observation of active mining areas during all other monitoring	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: – Rainfall – Surface and near surface water flows Water Quality (refer above water quality section)
AREA 3A	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			

AREA 3B	<p>Wongawilli Creek sites (as above) Wongawilli Creek sites X2, X3, X4, X5, X6 Donalds Castle Creek Sites 14, X1</p> <p>Sites 1 – 14 <i>Ref. Figure 19.1</i> Reference sites 15 and 16</p>			<p>Ecological Investigations, including:</p> <ul style="list-style-type: none"> – Catalogue of aquatic habitats, flora and fauna of watercourses – Photographic records – Measurement of aquatic plants using transects (where applicable) – Sampling of Macroinvertebrates – Sampling fish and large invertebrates (e.g. yabbies)
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Table 3.2 – Dendrobium Watercourse Impacts, Triggers and Response

Monitoring	Trigger	Action
MONITORED CREEKS AND TRIBUTORIES		
WATER QUALITY		
<p><u>Area1:</u></p> <ul style="list-style-type: none"> • KS1 (Kembla Ck Pool 3) • KS2 (trib. of Kembla Ck, Un-named Ck) 		<ul style="list-style-type: none"> • Continue to monitor and report in AEMRs
<p><u>Area 2:</u></p> <ul style="list-style-type: none"> • GFC (Green Fields Ck Waterfall Pool) • WC (Waratah Ck) • FTC (Fern Tree Ck) • SC (Sandy Ck D/S) • P3 (Sandy Ck U/S trib. Pool 3) • C12 (Creek 12) <p><u>Area 3A:</u></p> <p>Wongawilli Creek</p> <ul style="list-style-type: none"> • 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) 	<p>Level 1 *</p> <ul style="list-style-type: none"> • Temporary reduction in water quality (observed for 2 consecutive months) at any site when comparing to the baseline period to mining period for that site, i.e. : <ul style="list-style-type: none"> – pH drop between 1 and 1.5 units from the minimum baseline value – EC increase between 50 and 100us/cm from the maximum baseline value – ORP drop between 50 and 100mV from the minimum baseline value 	<ul style="list-style-type: none"> • Continue monitoring program • Report impacts to key stakeholders • Summarise impacts and Report in the End of Panel Report and AEMR
<p>Sandy Creek</p> <ul style="list-style-type: none"> • SCL (D/S Sandy Ck adjacent to LW 7) <p>First and Second Order watercourses</p> <ul style="list-style-type: none"> • BC1 (Sandy Ck trib. SC10 over LW 8) • BCC1 (Sandy Ck trib. SC10C over LW 8) <p><i>Refer to the Area 3A Watercourse Impact Monitoring, Management and Contingency Plan Figure 3.1</i></p>	<p>Level 2 *</p> <ul style="list-style-type: none"> • Temporary reduction in water quality (observed for 2 consecutive months) at any site when comparing to the baseline period to mining period for that site, ie: <ul style="list-style-type: none"> – pH drop between 1.5 and 2 units from the minimum baseline value – EC increase between 100 and 150us/cm from the maximum baseline value – ORP drop between 100 and 175mV from the minimum baseline value 	<ul style="list-style-type: none"> • <i>Actions as stated for Level 1</i> • Review monitoring program • Notify relevant technical specialists and seek advice on any CMA required
<p><u>Area 3B:</u></p> <p>Wongawilli Creek</p> <p>Area 3A sites (above)</p> <p>WC21_S1 (Tributary)</p> <p>WC_S1 (Mid-Wongawilli Creek)</p> <p>WC15_S1 (Tributary)</p> <p>Donalds Castle Creek and Drainage Lines</p> <p>DC U3 Donalds Castle Creek downstream)</p> <p>DC_S2 (Upper Donalds Castle Creek)</p> <p>DC13_S1 (Tributary)</p>	<p>Level 3 *</p> <ul style="list-style-type: none"> • Reduction in water quality (observed for more than 2 consecutive months) when comparing to the baseline period to mining period for that site, ie: <ul style="list-style-type: none"> – pH drop of >2 units from the minimum baseline value – EC increase >150us/cm from the maximum baseline value – ORP drop >175mV from the minimum baseline value 	<ul style="list-style-type: none"> • <i>Actions as stated for Level 2</i> • Immediately notify OEH, DoPI, DPI, SCA, other resource managers and relevant technical specialists and seek advice on any CMA required. • Site visits with stakeholders if required. • Collect laboratory samples within 2 weeks and analyse for: <ul style="list-style-type: none"> – pH, EC, major cations, major anions, Total Fe, Mn & Al – Filterable suite of metals • Develop site CMA in consultation with key stakeholders within 1 month,

Table 3.2 – Dendrobium Watercourse Impacts, Triggers and Response

Monitoring	Trigger	Action
<p>Lake Avon and Tributaries LA4_S1 (Unnamed Creek) LA4_S2 (Lake Avon off Creek LA4) LA5_S1 (Unnamed Creek) LA5_S2 (Lake Avon off Creek LA5)</p> <p><i>(Refer to Watercourse Impact Monitoring Management and Contingency Plan Figure 2)</i></p> <p>Swamp Water Quality Monitoring Sites <i>(Refer to Swamp Impact Monitoring Management and Contingency Plan Figure 27)</i></p>		<p>(pending stakeholder availability) and seek approvals. These may include:</p> <ul style="list-style-type: none"> - 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 OEH, DoPI, DPI, SCA, and other stakeholders - Limestone emplacement to raise pH where it is appropriate to do so in consultation with OEH, DoPI, DPI, SCA, 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 OEH, DoPI, DPI, SCA, and other stakeholders <ul style="list-style-type: none"> • Completion of works following approvals • Issue CMA report within 1 month of works completion • Conduct initial follow up monitoring & reporting within 2 months of CMA completion • Review the relevant TARP and Management Plan in consultation with key stakeholders
<p>Sandy and Wongawilli Creeks</p>	<p>Exceeding Prediction</p> <ul style="list-style-type: none"> • More than minor gas release, iron staining and reduction in water quality 	<ul style="list-style-type: none"> • <i>Actions as stated for Level 3</i> • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation
POOL WATER LEVEL/FLOW		
<p><u>Area 1:</u></p> <ul style="list-style-type: none"> • KS1 (Kembla Ck Pool 3) • KS2 (trib. of Kembla Ck, Un-named Ck) 		<ul style="list-style-type: none"> • Continue to monitor and report in AEMRs
<p><u>Area 2:</u> <u>Instrumented Pools:</u></p> <ul style="list-style-type: none"> • GFC (Green Fields Ck Waterfall Pool) • FTC (Fern Tree Ck) 	<p>Level 1 *</p> <ul style="list-style-type: none"> • Temporary reduction in pool water levels (observed for less than 2 consecutive months) declining 15-20% during mining in any of the pools being monitored when compared with similar flows before mining 	<ul style="list-style-type: none"> • Continue monitoring program • Report impacts to key stakeholders • Summarise impacts and Report in the End of Panel Report and AEMR
<p><u>Area 3A:</u> Instrumented Pools: Wongawilli Creek</p> <ul style="list-style-type: none"> • WWU4 (U/S Wongawilli Ck) • WWL2 (D/S Wongawilli Ck) 	<p>Level 2 *</p> <ul style="list-style-type: none"> • Temporary reduction in pool water levels (observed for 2 consecutive months) declining 15-20% during mining in any of the pools being monitored when compared with similar flows before mining 	<ul style="list-style-type: none"> • <i>Actions as stated for Level 1</i> • Review monitoring program • Notify relevant technical specialists and seek advice on any CMA required • Implement agreed CMAs as approved
<p>Sandy Creek</p> <ul style="list-style-type: none"> • SCU1 (U/S Sandy Ck) • SCL (Sandy Creek at Dendrobium) (D/S Sandy Ck adjacent to LW 7) 	<p>Level 3 *</p> <ul style="list-style-type: none"> • 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 	<ul style="list-style-type: none"> • <i>Actions as stated for Level 2</i> • Immediately notify OEH, DoPI, DPI, SCA,, resource managers and relevant technical specialists and seek advice on any CMA required • Site visits with stakeholders if required

Table 3.2 – Dendrobium Watercourse Impacts, Triggers and Response

Monitoring	Trigger	Action
<p>Nail Pools:</p> <p>Wongawilli Creek</p> <ul style="list-style-type: none"> • 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) • WC Pools 41, 42b, 43a, Pool 45, 47b and 49 • SCK Pools 3a, 4, 5, 7, 10, 15, 20, 21 and 23 <p><u>Area 3B:</u></p> <p>Instrumented Pools:</p> <p>Wongawilli Creek and Tributaries</p> <ul style="list-style-type: none"> • Area 3A sites (above) • WC_S1 • WC21_S • WC15_S1 <p>Donalds Castle Creek</p> <ul style="list-style-type: none"> • DCU (Donalds Castle Creek lower) • DC13_S1 (Upper Donalds Castle Creek) • DC_S2 (Upper Donalds Castle Creek – Upstream of DC_S1) <p>Lake Avon Tributaries</p> <ul style="list-style-type: none"> • LA4_S1 		<ul style="list-style-type: none"> • Develop site CMA in consultation with key stakeholders within 1 month These may include: <ul style="list-style-type: none"> – 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 OEH, DoPI, DPI, SCA, and other stakeholders • 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 if required • Review the relevant TARP and Management Plan in consultation with key stakeholders
<p>Sandy and Wongawilli Creeks</p>	<p>Exceeding Prediction</p> <ul style="list-style-type: none"> • More than minor fracturing and water flow/water level impacts • More than negligible reduction in the quality of surface or groundwater inflows to Lake Cordeaux, Lake Avon or Cordeaux River 	<ul style="list-style-type: none"> • <i>Actions as stated for Level 3</i> • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation
<p>APPEARANCE</p>		
<p>Wongawilli Creek and Sandy Creek</p>	<p>Level 1 *</p> <ul style="list-style-type: none"> • Increase in iron staining, algal growth, or other observed changes, for no more than 2 consecutive months, determined by comparing baseline photos with photos during the mining period • Isolated (at less than 10% of mapped pools) fracturing resulting in no pool water level loss 	<ul style="list-style-type: none"> • Continue monitoring program. • Report impacts to key stakeholders • Summarise impacts and Report in the End of Panel Report and AEMR
	<p>Level 2 *</p> <ul style="list-style-type: none"> • Increase in iron staining, algal growth, or other observed changes, for > 2 consecutive months, determined by comparing baseline photos with photos during the mining period 	<ul style="list-style-type: none"> • <i>Actions as stated for Level 1</i> • Review monitoring program • Notify relevant technical specialists and seek advice on any CMA required

Table 3.2 – Dendrobium Watercourse Impacts, Triggers and Response

Monitoring	Trigger	Action
	<ul style="list-style-type: none"> Fracturing (at greater than 10% of mapped pools) resulting in no pool water level loss <p>Level 3 *</p> <ul style="list-style-type: none"> Fracturing in Wongawilli or Sandy Creeks resulting in pool water level loss 	<ul style="list-style-type: none"> Implement agreed CMAs as approved <p><i>Actions as stated for Level 2</i></p> <ul style="list-style-type: none"> Immediately notify OEH, DoPI, DPI, SCA, other resource managers and relevant technical specialists and seek advice on any CMA required. Site visits with stakeholders if required Develop site CMA in consultation with key stakeholders within 2 1 months. These may include: <ul style="list-style-type: none"> 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 OEH, DoPI, DPI, SCA, and other stakeholders 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 if required Review the relevant TARP and Management Plan in consultation with key stakeholders
<p>First and Second Order Streams</p> <p>General observation of active mining areas for SC10, SC10c, WC17, and other mapped 1st or 2nd order creeks and tributaries</p>	<p>Level 1 *</p> <ul style="list-style-type: none"> Fracturing with no observable loss of surface water flow or pool water reduction Pool water level or pool retention time lower than baseline in any mapped first or second order stream which is located in the mining area Increase in turbidity, iron staining, algal growth, or other visible water quality parameters determined by comparing baseline photos with photos during the mining period <p>Level 2 *</p> <ul style="list-style-type: none"> Pool water level or pool retention time lower than baseline in the majority of mapped pools in any in any first or second order stream which is located in the mining area <p>Level 3 *</p> <ul style="list-style-type: none"> Pool water level or pool retention time lower than baseline in all mapped pools in any first or second order stream which is located in the mining area 	<ul style="list-style-type: none"> Continue monitoring program Report impacts to key stakeholders Summarise impacts and Report in the End of Panel Report and AEMR <p><i>Actions as stated for Level 1</i></p> <ul style="list-style-type: none"> Review monitoring program Notify relevant technical specialists and seek advice on any CMA required Notification to agencies within 24 hours upon confirmation that any pool has drained Implement agreed CMAs as approved <p><i>Actions as stated for Level 2</i></p> <ul style="list-style-type: none"> Immediately notify OEH, DoPI, DPI, SCA, resource managers and relevant technical specialists and seek advice on any CMA required Site visits with stakeholders if required Develop site CMA in consultation with key stakeholders within 1 month,

Table 3.2 – Dendrobium Watercourse Impacts, Triggers and Response

Monitoring	Trigger	Action
		<p>(pending stakeholder availability) and seek approvals. These may include:</p> <ul style="list-style-type: none"> – 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 DoPI, SCA, DPI, DECC and other stakeholders <ul style="list-style-type: none"> • Completion of works following approvals • Conduct initial follow up monitoring & reporting within 2 months of CMA completion • Review relevant TARP and Management Plan in consultation with key stakeholders
CATCHMENT YIELD		
<p><u>Area 3A</u> Inflows to Lake Cordeaux and Cordeaux River**</p> <p><u>Area 3B</u> Inflows to Lake Avon and Cordeaux River **</p>	<p>Level 1 *</p> <ul style="list-style-type: none"> • Yields 6% less than average annual precipitation *** <p>Level 2 *</p> <ul style="list-style-type: none"> • Yields 6 - 12% less than average annual precipitation *** <p>Level 3 *</p> <ul style="list-style-type: none"> • Yields 12 - 24% less than average annual precipitation *** <p>Exceeding Prediction</p> <ul style="list-style-type: none"> • More than negligible reduction in the quantity of surface or groundwater inflows to Lake Cordeaux, Lake Avon or Cordeaux River 	<ul style="list-style-type: none"> • Implement analysis of Runoff 2005 • Report in the End of Panel Report • Summarise all actions and monitoring in EoP Report and AEMR <p><i>Actions as stated for Level 1</i></p> <ul style="list-style-type: none"> • Review monitoring program • Notify relevant technical specialists and seek advice on any CMA required • Implement agreed CMAs as approved <p><i>Actions as stated for Level 2</i></p> <ul style="list-style-type: none"> • Develop site CMA in consultation with key stakeholders if required within 1 month (pending stakeholder availability) and seek approvals • Conduct initial follow up and additional monitoring & reporting within 2 months of CMA completion if required <p><i>Actions as stated for Level 3</i></p> <ul style="list-style-type: none"> • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation
AQUATIC ECOLOGY		
<p>Pool water level, interconnectivity between pools and loss of connectivity, noticeable alteration of habitat</p> <p><u>Area 2:</u></p> <ul style="list-style-type: none"> • Sandy Ck - 4 sites <ul style="list-style-type: none"> • SC7 –1 replicate • SC10 – 2 replicates • Middle Gully Ck (Creek 13) – 2 sites • Green Fields Ck (Creek 11) – 2 sites 	<p>Level 1 *</p> <ul style="list-style-type: none"> • Temporary (1 season) reduction in aquatic habitat <p>Level 2 *</p> <ul style="list-style-type: none"> • Temporary (2 seasons) reduction in aquatic habitat <p>Level 3 *</p>	<ul style="list-style-type: none"> • Continue monitoring program • Report impacts to key stakeholders • Summarise impacts and report in the End of Panel Report and AEMR <p><i>Actions as stated for Level 1</i></p> <ul style="list-style-type: none"> • Review monitoring program • Notify relevant technical specialists and seek advice on any CMA required • Implement agreed CMAs as approved <p><i>Actions as stated for Level 2</i></p>

Table 3.2 – Dendrobium Watercourse Impacts, Triggers and Response

Monitoring	Trigger	Action
<p><u>Area 3A and B:</u></p> <ul style="list-style-type: none"> • 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 <p>General observation of active mining areas (Refer to Dendrobium 3A SMP Figures 20.1, 20.2, and 20.3; and Area 3B SMP Figure 19.1 for the location of these sites)</p>	<ul style="list-style-type: none"> • Reduction in aquatic habitat for an extended timeframe (> 2 seasons) or complete loss of habitat 	<ul style="list-style-type: none"> • Immediately notify DoPI, DPI, SCA, resource manager/s and relevant technical specialists and seek advice on any CMA • Site visits with stakeholders if required • Develop site CMA if required in consultation with key stakeholders within 1 month, (pending stakeholder availability) and seek approvals. These may include: <ul style="list-style-type: none"> – 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 OEH, DoPI, DPI, SCA, 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 • Conduct initial follow up monitoring and reporting within 2 months of CMA completion • Review the relevant TARP and Management Plan in consultation with key stakeholders

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

** Catchment yields would be determined by hydrologic modelling of pre- and post-mining hydrographic data using the Free University of Amsterdam RUNOFF2005 model and validation of model-determined ETs against those estimated by the independent CSIRO Land and Water Division (Zhang et al.) method. These TARPs would apply only to the whole of catchment water delivered to Lake Cordeaux, Lake Avon and Cordeaux River. Model reliability is maintained only for catchments in excess of 1 km² in area. Average annual precipitation is modelled using the most recent 4 – 5 years of local record.

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

Office of Environment and Heritage (OEH)

Department of Planning and Infrastructure (DoPI)

Department of Primary Industries: including Division of Resources and Energy, Office of Water, Fisheries (DPI)

Sydney Catchment Authority (SCA)