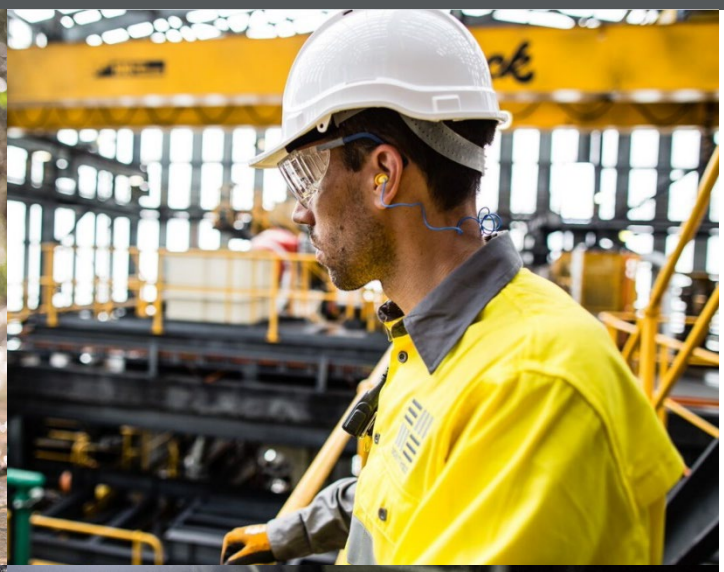
SOUTH32

DENDROBIUM
AREA 3A

MARCH 2021



LONGWALL 19
AREA 3A
SUBSIDENCE MANAGEMENT PLAN

EXECUTIVE SUMMARY

Illawarra Metallurgical Coal (IMC), a wholly owned subsidiary of South32 Pty Ltd (South32), operates underground coal mining operations at Dendrobium Mine, located in the Southern Coalfield of New South Wales. Longwalls from the Wongawilli Seam have been mined previously in Areas 1, 2 and 3A, with current operations in Area 3B.

The socio-economic benefits to the region and the State of New South Wales from underground mining at IMC's Dendrobium and other operations is significant. IMC operations:

- Employ approximately 1,800 people, of which 90% are based locally;
- Spend over $160 million a year with more than 400 locally based businesses;
- Contribute $0.03 per tonne of saleable coal to community trusts supporting community projects; and
- Contribute approximately $95 million in royalties each year (with approximately $54 million from the Dendrobium Mine).

IMC is the most significant metallurgical coal producer in the region, providing local access to a product essential to the BlueScope steelworks.

IMC was granted Development Consent by the NSW Minister for Planning for the Dendrobium Project 20 November 2001.

The Independent Expert Panel for Mining in the Catchment's Report Part 1 (IEP) (2019a) recommended that any Subsidence Management Plan (SMP) application consider the potential implications for water quantity of faulting, basal shear planes and lineaments and that a Risk Assessment be included in applications to extract coal within Catchment Special Areas.

A risk assessment has been completed to identify hazards and existing controls associated with mining operations in the Special Areas and to make recommendations for further controls where appropriate. The Longwall 18 SMP and risk assessment address key catchment values (groundwater, Avon Reservoir, Wongawilli Creek, Native Dog Creek, swamps and tributaries) in relation to the following concerns (where relevant):

- Surface subsidence and sub-surface ground movements;
- Valley closure and basal shear planes;
- Lineaments, faults and dykes including the Elouera Fault; and
- Groundwater drawdown.

The following statements from the IEP Report Part 1 (2019a) identify that there has been no observed material impacts to Sydney's drinking water supplies due to mining in the catchment:

> *"Reservoir leakage rates – there is no measured evidence of significant long-term leakage from reservoirs due to mining in the Special Areas."*
>
> *"Watercourse bed leakage (at catchment scale) – from material presented to the Panel, there remains no strong evidence that cracking of watercourse beds leads to significant losses of water at catchment scales relevant for water supplies."*

While the potential for mining to cause impacts within the Special Areas requires special attention, the localised impacts that have been observed need to be considered objectively and in the context of the broader catchment.

The IEP's estimate of average surface water diversion of 3 ML/day at the Dendrobium Mine equates to 0.2% of the 1.5 billion litres of drinking water provided to customers each day by Sydney Water (IEP 2019a). IEP Report Part 2 (2019b) recommended an inter-agency working group be established with the task of identifying acceptable levels of surface water loss due to mining.

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Attachments

Attachment A – Aquatic Flora and Fauna Review

Attachment B – Groundwater Assessment

Attachment C – Subsidence Predictions and Impact Assessments

Attachment D – Risk Assessment

Attachment E – Surface Water Assessment

Attachment F – Terrestrial Ecology Assessment

Attachment G – Geology of Longwall 19

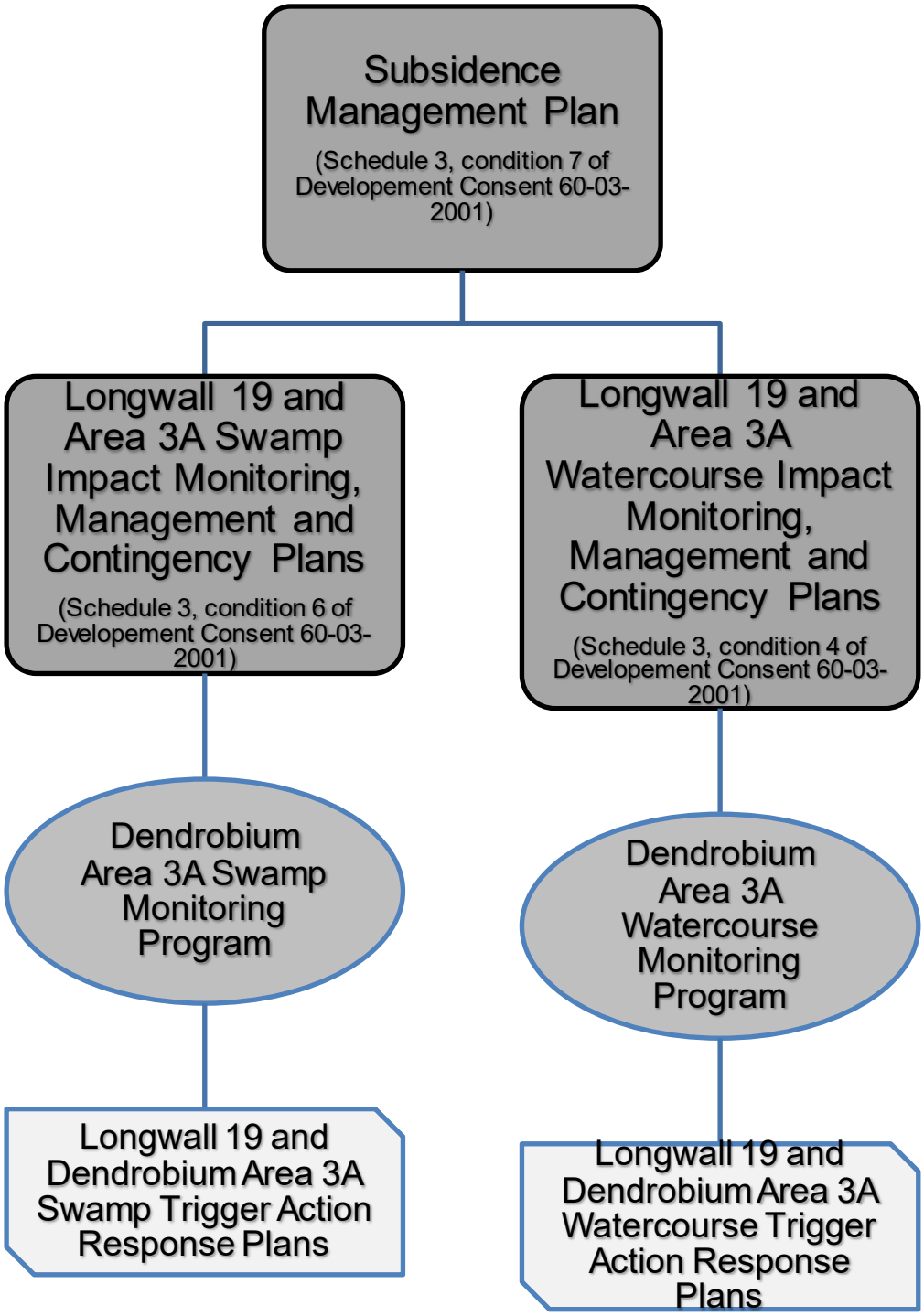
Attachment H – Groundwater Model Peer Review

Attachment I – Aboriginal Cultural Heritage Assessment Report

Review History

Revision	Description of Changes	Date	Approved
1	New Document	March 2020	GB
2	Minor administrative changes and updated for Longwall 19 WIMMCP and SIMMCP	March 2021	GB

Flowchart 1 – SMP, SIMMCP and WIMMCP interactions



1 INTRODUCTION

1.1 Project Background

Illawarra Metallurgical Coal (IMC), a wholly owned subsidiary of South32 Pty Ltd (South32), operates underground coal mining operations at Dendrobium Mine, located in the Southern Coalfield of New South Wales. Longwalls from the Wongawilli Seam have been mined in Areas 1, 2 and 3A with current operations in Area 3B.

IMC was granted Development Consent by the NSW Minister for Planning for the Dendrobium Project on 20 November 2001. In 2007, IMC proposed to modify its underground coal mining operations and the NSW Department of Planning advised that the application for the modified Area 3 required a modification to the original consent. The application followed the process of s75W of the *Environmental Planning and Assessment Act 1979* (EP&A Act) and required the submission of a comprehensive Environmental Assessment (Cardno 2007). The Environmental Assessment (EA) described the environmental consequences likely from cracking and diversion of surface water as a result of the proposed mining. These impacts included diversion of flow, lowering of aquifers, changes to habitat for threatened species as well as other impacts and environmental consequences.

On 8 December 2008, the Minister for Planning approved a modification to DA_60-03-2001 for Dendrobium Underground Coal Mine and associated surface facilities and infrastructure under Section 75W of the EP&A Act.

Schedule 3, Condition 7 of the Development Consent requires the development of a Subsidence Management Plan (SMP) for approval prior to carrying out mining operations that could cause subsidence.

1.2 Scope

This SMP has been prepared for Dendrobium Area 3A Longwall 19, and complies with the Dendrobium Development Consent Schedule 3, Condition 7 as provided below.

> 7. Prior to carrying out any underground mining operations that could cause subsidence in either Area 3A, 3B or 3C, the Applicant must prepare a Subsidence Management Plan (SMP) to the satisfaction of the Secretary and the DRG. Each such SMP must:
>
> (a) integrate ongoing management of Areas 1 and 2;
>
> (b) integrate the Watercourse and Swamp Impact Monitoring, Management and Contingency Plans required under conditions 4 and 6;
>
> (c) include monitoring of subsidence effects;
>
> (d) include a WaterNSW Assets Protection Plan;
>
> (e) include monitoring, management, and contingency plans for all other significant natural features and all significant man made features which may be impacted by subsidence, including:
>
> - landscape (including cliffs and steep slopes);
> - groundwater (see condition 13);
> - terrestrial flora and fauna and ecology (including all threatened species assessed as being likely to be significantly affected by the development and their habitats);
> - Aboriginal and other cultural heritage (see condition 12); and
> - electrical, communications and other infrastructure;
>
> (f) be prepared in consultation with OEH, WaterNSW and DRG;
>
> (g) be approved prior to the carrying out of any underground mining operations that could cause subsidence in the relevant Area; and
>
> (h) be implemented to the satisfaction of the Secretary and the DRG.

1.3 Study Area

The Study Area is defined as the surface area that could be affected by the mining of Longwall 19 (**Figure 1-1**). The extent of the Study Area has been calculated by combining the areas bounded by the following limits:

- The 35° angle of draw line from the extents of Longwall 19;

- The predicted limit of vertical subsidence, taken as the 20 mm subsidence contour, resulting from the extraction of the longwall; and
- The natural features located within 600 m of the extent of the longwall mining area, in accordance with Schedule 3, Condition 8(d) of the Development Consent.

The depth of cover varies between 295 m and 380 m directly above Longwall 19. The 35° angle of draw line, therefore, has been determined by drawing a line that is a horizontal distance varying between 196 m and 259 m around the extents of the longwall void.

The predicted limit of vertical subsidence, taken as the predicted total 20 mm subsidence contour, has been determined using the calibrated Incremental Profile Method (IPM), which is described in MSEC (2020). The predicted incremental 20 mm subsidence contour extends beyond the 35° angle of draw above the existing Longwalls 6 and 8. Elsewhere, the contour is located inside the angle of draw (**Figure 1-1**).

The features that are located within the 600 m boundary that are predicted to experience valley related movements and could be sensitive to these movements have been included in the assessments provided in this report. These features include the streams, upland swamps and Aboriginal heritage sites.

There are additional features that are located outside the 600 m boundary that could experience either far-field horizontal or valley related effects. The surface features that could be sensitive to such movements have been identified and have also been included in the assessments provided in this report.

1.4 Objectives

The objective of this SMP and associated documents is to:

- Describe a system to adequately manage subsidence risks in a timely manner and to demonstrate IMC'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 the ecological values of the area and re-establishes the ecological values of an area to the greatest practicable extent.
- Monitor 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. This SMP is to comply with the Dendrobium Development Consent conditions.

1.5 Specialist Assessments

The following specialist assessments have been prepared to support the Longwall 19 SMP:

Attachment	Addressed in Document
Attachment A	Aquatic Flora and Fauna Review – March 2020 (Cardno 2020)
Attachment B	Longwall 19 Groundwater Assessment – January 2020 (SLR 2020)
Attachment C	Subsidence Predictions and Impact Assessments – March 2020 (MSEC 2020) including addendum A (MSEC 2021)
Attachment D	Risk Assessment Report – March 2020 (Axys 2020)

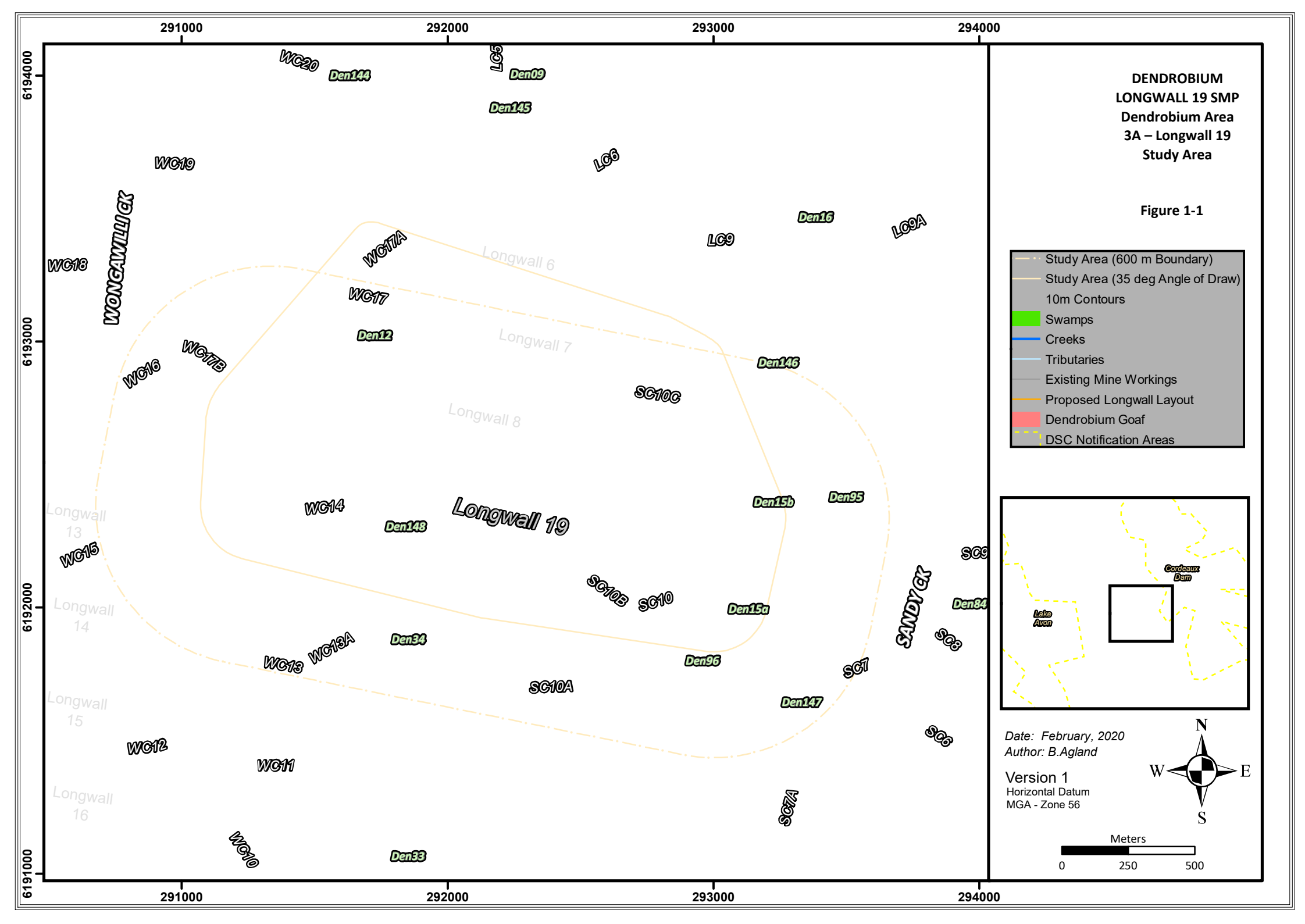
Attachment E	Assessment of Surface Water Flow and Quality Effects of Proposed Dendrobium Longwall 19 – March 2020 (HGEO 2020)
Attachment F	Terrestrial Ecology Assessment – March 2020 (Niche 2020b)
Attachment G	Geology of Longwall 19 – February 2020 (IMC 2020)
Attachment H	Groundwater Model Peer Review – April 2020 (KA 2020)
Attachment I	Aboriginal Cultural Heritage Assessment – October 2020 (Niche 2020a)

1.6 Consultation

The Dendrobium SMPs and other management plans have been developed by IMC in consultation with:

- Department of Planning, Infrastructure and Environment (DPIE);
- Biodiversity, Conservation and Science Directorate (BCS) within DPIE; and
- WaterNSW.

The SMP and other relevant documentation are available on the IMC website (Schedule 8, Condition 11).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WC17B
WC16
Den146
SC10C
Longwall 8
WC14
Longwall 19
Den15b
Den95
Longwall 13
Den148
WC15
SC9
SC10B
SC10
Den15a
SANDY CK
Den84
Longwall 14
SC8
WC13A
Den34
WC13
Den96
SC7
SC10A
Longwall 15
Den147
WC12
SC6
WC11
Longwall 16
SC7A
WC10
Den33
DENDROBIUM
LONGWALL 19 SMP
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3A – Longwall 19
Study Area
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Swamps
Creeks
Tributaries
Existing Mine Workings
Proposed Longwall Layout
Dendrobium Goaf
DSC Notification Areas
Cordeaux Dam
Lake Avon
Date: February, 2020
Author: B.Agland
Version 1
Horizontal Datum
MGA - Zone 56
N
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Meters
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500

2 PLAN REQUIREMENTS

Extraction of coal from Longwall 19 will be in accordance with the conditions set out in the Dendrobium Development Consent and conditions attached to relevant mining leases.

Baseline studies have been completed within the Study Area and surrounds to record biophysical characteristics. Monitoring is conducted in the area potentially affected by subsidence from the extraction of Longwall 19. The monitoring in these areas will be based on the Before After Control Impact (BACI) design criteria.

The Area 3A monitoring and assessment programs will provide ongoing data for the areas and features potentially affected by the mining of Longwall 19 and previous longwalls.

2.1 Dendrobium Development Consent DA60-03-2001

The Dendrobium Underground Coal Mine (DA 60-03-2001) modification was approved under Section 75W of the EP&A Act 1979 on 8 December 2008 (Modification 8). **Table 2-1** lists the Conditions of Consent relevant to the Longwall 19 SMP.

Table 2-1 Dendrobium Development Consent (DA-60-03-2001) Conditions relevant to Area 3A

Development Consent Condition
Schedule 3 - Condition 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 Secretary.
Schedule 3 - Condition 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 groundwater 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 Secretary.
Schedule 3 - Condition 4 (a) to (i) Prior to carrying out any underground mining operations that could cause subsidence in either Area 3A, Area 3B or Area 3C, the Applicant shall prepare a Watercourse Impact Monitoring, Management and Contingency Plan to the satisfaction of the Secretary.
Schedule 3 – Condition 6 (a) to (i) Prior to carrying out any underground mining operations that could cause subsidence in either Area 3A, Area 3B or Area 3C, the Applicant shall prepare a Swamp Impact Monitoring, Management and Contingency Plan to the satisfaction of the Director-General. Swamp Impact, Monitoring, Management and Contingency Plan
Schedule 3 - Condition 7 Prior to carrying out any underground mining operations that could cause subsidence in either Area 3A, 3B or 3C, the Applicant shall prepare a Subsidence Management Plan (SMP) to the satisfaction of the Secretary and the DRE. Each such SMP must: (a) integrate ongoing management of Areas 1 and 2; (b) integrate the Watercourse Impact, Monitoring, Management, and Contingency Plan (WIMMCP) and Swamp Impact, Monitoring, Management, and Contingency Plan (SIMMCP) required under conditions 4 and 6; (c) include monitoring of subsidence effects; (d) include a SCA Assets Protection Plan; (e) include monitoring, management, and contingency plans for all other significant natural features and all significant man-made features which may be impacted by subsidence, including: (f) landscape (including cliffs and steep slopes); (g) groundwater (see condition 13);

(h) terrestrial flora and fauna and ecology (including all threatened species assessed as being likely to be significantly affected by the development and their habitats);

(i) Aboriginal and other cultural heritage (see condition 12); and

(j) electrical, communications and other infrastructure;

(k) be prepared in consultation with OEH, SCA and DRE;

(l) be approved prior to the carrying out of any underground mining operations that could cause subsidence in the relevant Area; and

(m) be implemented to the satisfaction of the Secretary and the DRE.

2.2 Dendrobium Area 3A SMP

The Dendrobium Mine Area 3A SMP Approval was granted by the Director-General on 18 November 2010.

2.3 Leases and Licences

The following licences and permits may be applicable to IMC's operations in Dendrobium Area 3A:

- Dendrobium Mining Lease CCL 768;
- Environmental Protection Licence 3241 which applies to the Dendrobium Mine. A copy of the licence can be accessed at the EPA website via the following link http://www.environment.nsw.gov.au/poeo;
- Dendrobium Mining Operations Plan FY 2016 to FY 2022;
- Relevant Occupational Health and Safety approvals; and
- Any additional leases, licences or approvals resulting from the Dendrobium Development Consent.

3 MONITORING

3.1 Surface Water Quality

Monitoring undertaken by IMC since 2003 (see Longwall 19 Watercourse Impact Monitoring, Management and Contingency Plan [WIMMCP] and Swamp Impact Monitoring, Management and Contingency Plan [SIMMCP]) includes water quality monitoring of parameters such as pH, Electrical Conductivity (EC), Dissolved Oxygen (DO), Oxygen Reduction Potential (ORP) and laboratory tested analytes (DOC, Na, K, Ca, Mg, Filt. SO_4, Cl, T. Alk., Total Fe, Mn, Al, Filt. Cu, Ni, Zn, Si).

The key field parameters of DO, pH, EC and ORP for monitoring sites within Dendrobium Area 3A will be analysed to identify any changes in water quality resulting from the mining. Pools and streams away from mining are monitored to allow for a comparison against sites not influenced by mining.

Pools within streams will be measured monthly before and following mining, weekly during active subsidence and in response to any observed impacts.

The water chemistry in Avon Reservoir will be monitored as a basis for comparison to the mine water. The locations of the samples and the testing procedure have been developed in consultation with Dams Safety NSW and WaterNSW.

3.2 Surface Water Level and Flow

Pool water levels in swamps and streams are measured using installed benchmarks in impact sites and reference sites (see Longwall 19 WIMMCP and SIMMCP). Water level/flow gauges and data loggers are installed at key stream flow monitoring sites; sites will be installed 2 years prior to the extraction of Longwall 19. Data has been collected since 2003 and has been compiled within monitoring and field inspection reports, End of Panel (EoP) Reports and Annual Reviews (AR).

Pool water levels are measured monthly before and after mining, on a weekly basis during active subsidence and in response to any identified impacts. Water level measurements will be undertaken relative to benchmarks installed on rocks or other stable features on the edge of the pools.

This data is used to compare differences in pool water level within swamps and streams before and after mining. Sites that will not be mined under are also monitored to provide a comparison of mined and not mined under sites during different climatic conditions.

3.3 Upland Swamp Near-Surface Groundwater and Soil Moisture

Near-surface groundwater piezometers have been installed within and around several swamps and associated watercourses in Area 3 (see Longwall 19 SIMMCP and WIMMCP). This data is used to compare differences in shallow groundwater levels within swamps, streams and hill-slope aquifers before and after mining. Sites that will not be mined under are also monitored to provide a comparison of sites mined under and not mined under during different climatic conditions.

The piezometric monitoring directed at near-surface groundwater levels is supplemented with monitoring of soil moisture profiles.

The shallow groundwater piezometers and soil moisture probe data is compared with the Cumulative Monthly Rainfall Residuals (a key parameter for interpreting temporal soil and shallow groundwater data). Comparisons of the Cumulative Monthly Rainfall Residuals against mean monthly water heads in shallow groundwater piezometers and soil moisture profiles will take into account the known distribution of rainfall isohyets (contours of equal annual precipitation) in the local region (these being denser and less smooth closer to the Illawarra Escarpment and much wider proceeding northwest).

3.4 Groundwater

A specialist Groundwater Assessment (Watershed Hydrogeo 2020) is provided in **Attachment B**. A peer review of this assessment was undertaken by Dr Franz Kalf and is provided in **Attachment H**. An existing groundwater monitoring program is in place for Dendrobium which includes Area 3A. This is detailed in the Area Longwall 19 WIMMCP.

Groundwater monitoring is undertaken in:

- Surficial and shallow systems associated with upland swamps and the weathered near-surface bedrock.

- Consolidated rock strata comprising the deeper Hawkesbury Sandstone, the underlying Narrabeen Group and Illawarra Coal Measures.

Pre-mining and post-mining monitoring holes have been installed within Area 3 to investigate and monitor the connected fracture network above the goaf and the upwards migration of the phreatic surface.

Monitoring pore pressures at Dendrobium Mine uses vibrating wire piezometers installed at different depths within the same borehole, thereby creating a vertical array which can be used for 3D mapping and analysis of the pore pressure regime (IEP 2019a). Before and after mining piezometers are routinely installed along the centreline of longwall panels to identify the maximum groundwater effects and the height of depressurisation within the subsidence zone.

3.5 Pools and Controlling Rockbars

Dendrobium Mine lies in the southern part of the Permo-Triassic Sydney Basin. The geology mainly comprises sedimentary sandstones, shales and claystones, which have been intruded by igneous sills.

The sandstone units vary in thickness from a few metres to as much as 120 m. The major sandstone units are interbedded with other rocks and, though shales and claystones are quite extensive in places, the sandstone predominates.

The major sedimentary units at Dendrobium are, from the top down:

- The Hawkesbury Sandstone;
- The Narrabeen Group; and
- The Eckersley Formation.

Extensive geomorphological mapping has been completed for Dendrobium Area 3, including the location of pools and rockbars (Longwall 19 WIMMCP and SIMMCP).

The largest watercourse within the Study Area is Wongawilli Creek, which is located between Areas 3A and 3B. The headwaters of Wongawilli Creek are located along a drainage divide separating surface runoff and shallow groundwater outflow runoff from Native Dog Creek and Lake Avon to the west.

3.6 Landscape and Photo Point Monitoring

IMC has conducted ongoing observational and photo point monitoring in the Dendrobium area since 2001 (Longwall 19 WIMMCP and SIMMCP).

The IMC Environmental Field Team undertakes a structured monitoring assessment, including:

- Water: location, volume and flow characteristics;
- Significant features: swamps, rockbars, pools and flow channels;
- Vegetation: location, species, height and observed health; and
- Sediment: composition, depth and moisture.

Observations of any surface water and vegetation health changes for prominent species are conducted. Where surface water is present within a swamp or a watercourse the data collected includes water quality parameters (using a monitoring probe) and water levels from installed benchmarks established at the pool. Observations of any surface flow are also made during monitoring.

This data is used to compare differences in site conditions of swamps and watercourses before and after mining. Sites that will not be mined under are also monitored to provide a comparison of sites mined under and sites not mined under during different climatic conditions.

3.7 Slopes and Gradients

Slopes within Area 3A have been mapped and are identified on Drawing 8 in MSEC (2020) (**Attachment C**). Monitoring of landscape features such as cliffs, slopes and rock outcrop is undertaken in Area 3A.

Monitoring of these sites allows for the measurement of any changes to the surface including soil cracking, erosion and/or sedimentation impacts resulting from subsidence.

The inspection and monitoring include:

- Monitoring sites based on an assessment of risk of impact where pre-mining measurements have been undertaken and reported;
- Areas of steep slopes that are en route or near monitoring sites;
- Rock outcrops that are en route or near monitoring sites;
- Any other sites where impacts have been previously observed that warrant follow-up inspection (i.e. rockfalls and soil cracking); and
- The general areas above the current mining location at the time of inspection.

Steep slopes are monitored throughout the mining period and until any necessary rehabilitation is complete. Slopes and gradients are monitored prior to mining as well as monthly during active subsidence. The monitoring is undertaken at six monthly intervals for two years following completion of mining.

3.8 Erodibility

Most of the surface of Area 3A has been identified as highly weathered Hawkesbury Sandstone outcrops and Sandstone derived-soils. This soil landscape has been identified to have high to extreme erosion susceptibilities to concentrated flows. This results in potential flow on effects to slope stability and erosion from any cracking resulting from subsidence. Monitoring of slopes is undertaken in Area 3A to identify any erosion of the surface.

An extensive survey network has been implemented which includes relative and absolute horizontal and vertical movements. Additional sites will be added to the monitoring program prior to subsidence movements impacting the sites.

Due to terrain, vegetation and access restrictions, the primary method of identifying any erosion over Area 3A will be Airborne Laser Scanning (ALS). This technique has proven to be successful in generating topographic models of subsidence over entire longwall and mining domains and will also provide identification of any erosion. The maximum areas, length and depth of erosion will be measured by standard survey methods.

Base surveys using ALS will be carried out prior to the extraction of the proposed longwall. Subsidence landscape models using the same methodology after the completion of subsidence at each longwall will provide a new (subsided) baseline surface dataset. For a period of up to ten years after mining repeat ALS datasets and surface modelling will be completed to identify new or increases in existing erosion. Erosion will be quantified by comparison of the immediate post subsidence landscape model with the long-term monitoring model. Targeted ALS scans will be completed where erosion is observed via the observational and landscape monitoring programs or after significant events such as bushfire and flooding.

Inspections of the mining area will be undertaken at regular intervals, during active subsidence. In addition to erosion, these observations aim to identify any surface cracking, surface water loss, soil moisture changes, vegetation condition changes, and slope and gradient changes.

3.9 Flora, Fauna and Ecosystem Function

Terrestrial flora and vegetation communities in the Study Area are described in the Longwall 19 Terrestrial Ecology Assessment (**Attachment F**) (Niche 2020b). Aquatic flora and fauna in the Study Area are described in the Aquatic Flora and Fauna Review (**Attachment A**) (Cardno 2020).

A monitoring program designed to detect potential impacts to ecology and ecosystem function from subsidence will be implemented for Longwall 19. The monitoring program is based on a BACI design with sampling undertaken at impact and control locations prior to the commencement of extraction, during extraction and after extraction.

Sufficient baseline data will be collected for Area 3A to enable the detection of changes to ecology associated with mining related impacts.

The study focuses on flora, fauna and ecosystem function of swamps and watercourses and is measured via the following attributes:

- The size of the swamps and the groundwater dependent communities contributing to the swamps;
- The composition and distribution of species within the swamps;
- RCE including a photographic record of each stream assessment site;
- Water quality, including pH, DO, ORP, temperature, turbidity and EC;
- Aquatic macrophytes, including presence, species composition and total area of coverage;

- Aquatic macroinvertebrates using the Australian River Assessment System (AUSRIVAS) sampling protocol and artificial aquatic macroinvertebrate collectors;
- Fish presence and numbers using backpack electro fisher and/or baited traps; and
- Presence of threatened species (including Macquarie Perch, Littlejohn's Tree Frog, Giant Burrowing Frog, Adams Emerald Dragonfly, Giant Dragonfly and Sydney Hawk Dragonfly).

Observation data will also be collected as part of the monitoring program. Locations where significant changes have been observed (e.g. drainage of pools) will be mapped, documented and reported.

3.10 Cultural Heritage

A total of eight (8) Aboriginal cultural heritage sites fall within the Longwall 19 Study Area. The majority of the sites (5 of 8) have a low scientific (archaeological) significance. One site is of moderate scientific (archaeological) significance and two (2) are of high scientific (archaeological) significance. The RAPs have advised that all sites have a high cultural significance.

Subsidence predictions detailed by MSEC (2020) suggest that four Aboriginal cultural heritage sites located above the proposed Longwall 19 have the potential to experience direct impacts from the extraction of Longwall 19. These sites include:

- DM 13 (AHIMS ID#48-2-0056);
- DM 15 (AHIMS ID#52-2-3639);
- DM 20 (AHIMS ID# 52-2-3644); and
- Sandy Creek Road 21 (AHIMS ID#52-5-0273).

Four Aboriginal cultural heritage sites within the Subject Area are not predicted to experience subsidence related effects (MSEC 2020). These Aboriginal cultural heritage sites include:

- Browns Road Site 31 (AHIMS ID#52-2-1645);
- Browns Road Site 32 (AHIMS ID#52-2-1646);
- DM 16 (AHIMS ID#52-2-3640); and
- DM 17 (AHIMS ID #52-2-3641).

In addition to the comprehensive reassessment of the Aboriginal Heritage Information Management System (AHIMS) registered sites that fall within the Subject Area, the Longwall 19 ACHA has included a review of the previous surveys and assessments from within the Dendrobium 3A Area and surrounds. Biosis Research's previous assessment Dendrobium Area 3 Archaeological and Cultural Heritage Assessment (Biosis Research 2007) was sourced as a foundation for this assessment as a previous AHIP (ID# 1098243) had been approved within the existing Study Area. This AHIP expired on 27 March 2017. IMC has sought a new AHIP with HeritageNSW and are awaiting a determination at the time of writing.

A total of 11 separate Aboriginal stakeholders (including groups and individuals) have identified themselves as Registered Aboriginal Parties (RAPs) through the consultation process following the *Aboriginal cultural heritage consultation requirements for proponents 2010*. Consultation with RAPs was ongoing through the development of the ACHA and the subsequent AHIP application.

The Dendrobium Area 3A Aboriginal Heritage Management Plan (AHMP) (Biosis 2009) was developed in accordance with Condition 6, Schedule 3 of the Dendrobium Development Consent, the AHMP has been prepared to manage the potential environmental consequences of extracting Longwall 19 on Aboriginal cultural heritage sites or values.

3.11 Built Features

3.11.1 Disused Rail Corridor

Unsealed roads and tracks are located across the Study Area. It is likely that cracking and heaving of the unsealed road surfaces would occur where they are located directly above the proposed longwall. Routine monitoring will be conducted along roads and tracks, during periods of active subsidence, to identify any potential impacts. Based on experience in Areas 1, 2, 3A and 3B, it is expected that these features can be maintained in safe and serviceable conditions using normal road maintenance techniques.

The Avon and Cordeaux Reservoirs are located at minimum distances of 3.1 km and 0.9 km, respectively, from the proposed Longwall 19. The Avon Dam Wall and Cordeaux Dam Wall are located at distances of more than 3 km from the proposed longwall.

The predicted vertical and horizontal movements at the Avon and Cordeaux Reservoirs and their associated dam walls are very small and are unlikely to be measurable. Previous experience of mining in Areas 1, 2, 3A and 3B has not resulted in adverse impacts on these structures. It is unlikely, therefore, that the reservoirs and dam walls would experience adverse impacts due to the extraction of the proposed Longwall 19.

Further detail on built features within the study area is located in Attachment C (MSEC 2020).

3.11.2 Unsealed Roads and Tracks

Unsealed roads and tracks are located across the Study Area. It is likely that cracking and heaving of the unsealed road surfaces would occur where they are located directly above the proposed longwall. Routine monitoring will be conducted along roads and tracks, during periods of active subsidence, to identify any potential impacts. Based on experience in Areas 1, 2, 3A and 3B, it is expected that these features can be maintained in safe and serviceable conditions using normal road maintenance techniques.

3.12 Reporting

EoP Reports are prepared in accordance with Schedule 3, Condition 9 of the Dendrobium Development Consent. Results from the monitoring program are included in the EoP Report and in the AR. These reports detail the outcomes of monitoring undertaken; provide results of inspections and determine whether performance indicators have been exceeded.

Monitoring results will be reviewed monthly by the IMC Subsidence Management Committee. However, if the findings of monitoring are deemed to warrant an immediate response, the Principal Approvals will initiate that response.

Monitoring results are included in the Annual Reporting requirement under Schedule 8, Condition 5 in accordance with the Dendrobium Development Consent and are made publicly available in accordance with Schedule 8, Condition 11.

4 PERFORMANCE MEASURES AND INDICATORS

Performance measures and indicators have been derived from the modified Dendrobium Development Consent. These performance measures are presented in **Table 4-1** and will be applied to the Dendrobium Area 3A mining area.

Table 4-1 Subsidence Impact Performance Measures

Dendrobium Development Consent
Condition 1 – Schedule 3 • The Applicant must ensure that, as a result of the development: - no rock fall occurs at Sandy Creek Waterfall or from its overhang; - the structural integrity of the waterfall, its overhang and its pool are not impacted; - cracking in Sandy Creek within 30 m of the waterfall is of negligible environmental and - hydrological consequence; and - negligible diversion of water occurs from the lip of the waterfall to the satisfaction of the Secretary. Condition 2 – Schedule 3 • The Applicant must 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 Secretary. Condition 3 – Schedule 3 • Operations will not result in reduction (other than negligible reduction) in the quality or quantity of surface water or groundwater inflows to Lake Cordeaux or Lake Avon or surface water inflow to the Cordeaux River at its confluence with Wongawilli Creek. Condition 5 – Schedule 3 • Operations shall not cause erosion of the surface or changes in ecosystem functionality of Swamp 15a and that the structural integrity of its controlling rockbar is maintained or restored, to the satisfaction of the Secretary.

A detailed list of performance measures and triggers is included in the Trigger Action Response Plans (TARP) (see attached Longwall 19 WIMMCP and SIMMCP).

4.1 Impact Mechanisms

Subsidence is an unavoidable consequence of longwall mining and includes vertical and horizontal movement of the land surface. Subsidence effects include surface and sub-surface cracking, buckling, dilation and tilting. These effects can result in changes to the hydrology of watercourses.

Changes to watercourse hydrology and water quality can result in environmental consequences. The likelihood and timing of these consequences relate to the size and duration of the effect. The potential consequences of mining on groundwater and surface water in the Special Areas are (IEP 2019a):

- Groundwater depressurisation
  - The creation of an excavation below the water table can affect groundwater in a number of basic ways. In all cases, because the fluid pressure in an excavation is much lower than that of the fluid that originally occupied the space, a flow system is established with the excavation acting as a sink into which surrounding groundwater flows. The rate of flow and observed extent of depressurisation depend on the hydrogeological properties of the rock mass. If the excavated area is sufficiently large, the spatial extent and rate of flow into the sink can be enhanced by the formation of fractures.
- Surface water diversions

  - Diversions into a shallow, localised fracture network, where loss of flow from a surface water is likely to return to the system at some point downstream, which based on observations of the SCI (2008) may vary from 20 m for specific rockbars to more than 200 m.

- Surface water permanent losses
  - Diversions into deeper, dilated shear surfaces on bedding planes, where these form a conduit for lateral water flow, which may or may not report to the same catchment (i.e. it may become a permanent loss).
- Groundwater depressurisation
  - Groundwater within the Hawkesbury Sandstone and Narrabeen Group as well as the Permian coal measures is recharged from rainfall and water bodies where the lithologies occur at outcrop, as well as potential downward leakage from overlying strata (Hydrosimulations 2018).
- Water quality
  - Water quality within watercourses is affected by numerous factors including runoff from swamps and interactions between bedrock and water, with fracturing of bedrock due to mining causing local water quality impacts.

The environmental consequences which could relate to changes in hydrology and water quality include:

- Species composition change and/or changes in vegetation communities.
- Loss of aquatic ecology and/or changes in aquatic habitat resulting from a reduction of surface water quality and/or flows and standing pools.
- Water-borne inputs to Lake Avon and Cordeaux River such as erosive export of fine sands and clays and/or ferruginous precipitates.
- Reduced inflows into Lake Avon and Cordeaux River.

An overview of the potential impacts and consequences of mining on swamps, surface flows and storages is presented in **Table 4-2**.

Table 4-2 Summary of subsidence effects, impacts and consequences for surface flows, storages and swamp hydrology (IEP 2019b)

Subsidence effects	Impacts	Consequences
• Cracking (tensile and compressive) or shear movement of joints and bedding planes • Fracturing of sandstone blocks • Buckling and localised upsidence in the stream bed below the swamp • Tilting of bedrock	• Cracking of rock bars • Lowered water tables and soil moisture • Potential erosion and scouring • Altered water chemistry e.g. enhanced release of iron • Change to the size of swamps	• Loss of surface flow and storage through leakage • Loss of baseflow generation including from swamps • Vulnerability of swamps to fire and further erosion and reduction in baseflow generation capacity • Increased loads of contaminants to water storages

The impact mechanisms and environmental consequences relevant to the performance measures are detailed in the Longwall 19 WIMMCP and SIMMCP.

4.2 Risk Assessment

The IEP (2019a) recommended that any SMP application consider the potential implications for water quantity of faulting, basal shear planes and lineaments and that a Risk Assessment be included in applications to extract coal within Catchment Special Areas. The Longwall 19 Risk Assessment has been peer review by an independent consultant, Professor Bruce Hebblewhite. As per the IEP recommendations, the Longwall 19 Risk Assessment is included as **Attachment D**.

5 MANAGEMENT AND CONTINGENCY PLAN

This section describes the potential impacts of mine subsidence in Area 3A, together with a summary of the avoidance, minimising, mitigation and remediation measures proposed.

5.1 Objectives

The aims and objectives of the Plan include:

- Avoiding and minimising impacts to significant environmental values where possible;
- Implementing TARPs to identify, assess and responding to impacts;
- Carrying out mitigation and remediation works in a manner that protects to the greatest practicable extent the environmental values of the area;
- Achieving the Performance Measures outlined in the Development Consent, to the satisfaction of the Secretary; and
- Monitoring and reporting effectiveness of the Plan.

To achieve these aims, monitoring, management, mitigation and remediation has been incorporated into the mining activity proposed by IMC.

5.2 Trigger Action Response Plan

The TARPs relate to identifying, assessing and responding to potential impacts to watercourses (including impacts greater than predicted) from subsidence in the Longwall 19 Study Area and Dendrobium Area 3A. These TARPs have been prepared using knowledge gained from previous mining in other areas of Dendrobium. The TARPs for Longwall 19 are included in the appendices of the SIMMCP and WIMMCP.

The TARPs represent reporting and/or other actions to be taken upon reaching each defined trigger level. A Corrective Management Action (CMA) is developed in consultation with stakeholders in order to manage an observed impact in accordance with relevant approvals. The SIMMCP and WIMMCP provide a basis for the design and implementation of any mitigation and remediation.

Monitoring of environmental aspects provides key data when determining any requirement for mitigation or rehabilitation. The triggers are based on comparison of baseline and impact monitoring results. Specific triggers will continue to be reviewed and developed in consultation with key stakeholders as the impact monitoring phase matures. Where required the triggers will be reviewed and changes proposed in impact assessment reports provided to government agencies or in EoP Reports. Any changes to the triggers would require approval of DPIE.

Level 2 and 3 TARPs result in further investigations and reporting by appropriately qualified people. Impact assessment reports will include:

Study scope and objectives;

- Consideration of relevant aspect from this Plan;
- Analysis of trends and assessment of any impacts compared to prediction;
- Root cause analysis of any change or impact;
- Assessment of the need for contingent measures and management options;
- Any recommended changes to this Plan; and
- Appropriate consultation.

The Level 2 and 3 TARPs may require the development of site-specific CMAs which include:

- A description of the impact to be managed;
- Results of specific investigations;
- Aims and objectives for any corrective actions;
- Specific actions required to mitigate/manage and timeframes for implementation;
- Roles and responsibilities;
- Gaining appropriate approvals from landholders and government agencies; and

- Reporting, consultation and communication.

5.3 Avoiding and Minimising

Mine layouts for Dendrobium Area 3A have been developed using IMC's Integrated Mine Planning Process (IMPP). This process considers mining and surface impacts when designing mine layouts.

IMC has assessed mining layout options for Dendrobium Area 3A against the following criteria:

- • Extent, duration and nature of any community, social and environmental impacts;
- • Coal customer requirements;
- • Roadway development and longwall continuity;
- • Mine services such as ventilation;
- • Recovery of the resource for the business and the State; and
- • Gas drainage, geological and geotechnical issues.

Several layout alternatives for Area 3A were assessed by IMC using a multi-disciplinary team including environment, community, mining and exploration expertise. These included variations in the number of longwalls and orientations, lengths, and setbacks of the longwall from key surface features. These options were reviewed, analysed and modified until an optimised longwall layout in Area 3A was achieved.

SMP Approval for the area of Longwall 19 was granted 9 July 2010, along with Longwalls 6 – 8. The width of the proposed Longwall 19 was set at 305 m in April of 2014 when the mains headings were established to allow for the gateroads of the longwall. Subsequent Area 3B Approval conditions required that Longwall 19 be further considered by DPIE. Due to these circumstances, consideration of a reduction in longwall width cannot be assessed as part of this SMP application.

Area 3A is part of the overall mining schedule for Dendrobium Mine and has previously been mined, with Longwall 8 the most recently extracted in December 2012. A return to Area 3A to extract Longwall 19 has been designed to flow on from Areas 3B and 3C to provide a continuous mining operation.

There are a number of surface and subsurface constraints within the vicinity of Area 3A including major surface water features such as Cordeaux Reservoir, Sandy Creek, Wongawilli Creek; and a number of geological constraints such as dykes, faults, and particularly the Dendrobium Nepheline Syenite Intrusion, which has intruded into the Wongawilli Seam to the east of the Longwall 19. The process of developing the layout for Area 3A has considered predicted impacts on natural features and aimed to minimise these impacts within geological and other mining constraints.

No contingent mining areas containing Wongawilli Seam Coal resources with the possibility for extraction are available to IMC.

The layouts at Dendrobium Mine have been modified to reduce the potential for impacts to surface features. Changes to a mine layout have significant flow-on impacts to mine planning and scheduling as well as economic viability. These issues need to be taken into account when optimising mine layouts. The process adopted in designing the Dendrobium Area 3A mine layout incorporated the hierarchy of avoid/minimise/mitigate as requested by the DPIE and BCD. Mine plan changes result in significant business and economic impact, including:

- Reduction in coal extracted;
- Reduction in royalties to the State;
- Additional costs to the business;
- Risks to longwall production due to additional roadway development requirements; and
- Constraints on blending which can disrupt the supply of coal to meet customer requirements.

Restricting mine layout flexibility can also have the following consequences:

- Additional energy used to ventilate the mine;
- Increased safety risks such as risk of frictional ignition on the longwall due to less than optimal ventilation;
- Increased power usage, reduced fan lifespan and a requirement to install booster fans;
- Requirement for heavy secondary support density;

- Potential for horizontal stress and vertical abutment concentrations;
- The risk of strata control associated with increased roadway development and longwall install and take-off faces;
- Exposes the workforce to higher risk environments more frequently;
- Results in a large number of equipment movements and interaction with workers and infrastructure; and
- Requires specialised equipment and skilled personnel with limited availability.

The mining layout of the proposed longwall is designed to avoid Wongawilli Creek and the Nepheline Syenite Intrusion. A summary of the geology of Longwall 19 is available in **Attachment G**.

Wongawilli Creek is located to the east of the proposed Longwall 19. The thalweg (i.e. base or centreline) of Wongawilli Creek is located at a minimum distance of 175 m south-west of the finishing end of Longwall 19, at its closest point. The minimum distances between the thalweg of the creek and the completed longwalls are 110 m for Longwall 6 in Area 3A and 290 m for Longwall 9 in Area 3B.

5.4 Mitigation and Rehabilitation

If the performance measures in the Development Consent are not met, then following consultation with BCS, WaterNSW and Mining, Exploration and Geosciences (MEG), the Secretary of DPIE may issue a direction in writing to undertake actions or measures to mitigate or remediate subsidence impacts and/or associated environmental consequences. The direction must be implemented in accordance with its terms and requirements, in consultation with the Secretary and affected agencies.

As indicated in Schedule 2, Conditions 1 and 14 of the Development Consent, the mitigation and rehabilitation described in this Plan is required for the development and an integral component of the proposed mining activity. To the extent these activities are required for the development approved under the Dendrobium Mine Development Consent no other licence under the then *Threatened Species Conservation Act 1995* (TSC Act) (repealed by the *Biodiversity Conservation Act 2016*) is required in respect of those activities.

At the time of grant of the Dendrobium Development Consent there was no requirement for concurrence in respect of threatened species or ecological communities. The requirement for concurrence was, at that time, governed by section 79B of the EPA Act. At the time of grant of the Dendrobium Consent there was a requirement for consultation with the Minister administering the then TSC Act and this consultation was undertaken.

5.4.1 Sealing of Rock Fractures

Where the bedrock base of any significant permanent pool or controlling rockbar within Wongawilli Creek or Sandy Creeks are impacted from subsidence and where there is limited ability for these fractures to seal naturally they will be sealed with an appropriate and approved cementitious (or alternative) grout. Grouting will be focused where fractures result in diversion of flow from pools or through the controlling rockbar. Significant success has been achieved in the remediation of the Georges River where four West Cliff longwalls directly mined under the river and pool water level loss was observed (BHP Billiton Illawarra Coal, 2006).

A number of grouts are available for use including cement with various additives. These grouts can be used with or without fillers such as clean sand. Grouts can be mixed on-site and injected into a fracture network or placed by hand. Hand-placed and injection grouting of large fractures were successfully implemented in the Georges River near Appin.

Such operations do have the potential to result in additional environmental impacts and are carefully planned to avoid contamination. Mixing areas will be restricted to cleared seismic lines or other open areas wherever possible. Bunds are used to contain any local spillage at mixing points. Temporary cofferdams can be built downstream of the grouting operations to collect any spillage or excess grouting materials for disposal off-site. The selection of grouting materials is based on demonstrated effectiveness and ensuring that there is no significant impact to water quality or ecology.

5.4.2 Injection Grouting

Injection grouting involves the delivery of grout through holes drilled into the bedrock targeted for rehabilitation. A variety of grouts and filler materials can be injected to fill the voids in the fractured strata intercepted by the drill holes. The intention of this grouting is to achieve a low permeability 'layer' below any affected pool as well as the full depth of any controlling rockbar.

Where alluvial materials overlie sandstone, grouts may be injected through grout rods to seal voids in or under the soil profile. This technique was successfully used at Pool 16 in the Georges River to rehabilitate surface flow by-pass to Pool 17. In this case 1-2 m of loose sediment was grouted through using purpose built grouting pipes.

Grouting holes are drilled in a pattern, usually commencing at a grid spacing of 1 m by 1 m to 2 m by 2 m. The most efficient way to drill the holes in consideration of potential environmental impacts is by using handheld drills. The drills are powered by compressed air which is distributed to the work area from a compressor. The necessary equipment will be sited on cleared seismic lines or other clear areas wherever possible with hoses run out to target areas.

Grout is delivered from a small tank into the ground via mechanical packers installed at the surface. All equipment can be transported with vehicles capable of travelling on tracks similar to seismic lines. If necessary, equipment or materials can be flown to nearby tracks or open spaces by helicopter. Helicopter staging has previously occurred from Cordeaux Mine where there is appropriate logistical support.

Grouting volumes and locations are recorded and high volume areas identified. Once the grout take in the area is reduced and the material has set, the grouted section of the pool is isolated and tested with local or imported clean water. The rate at which the water drains is measured and compared to pre-grouting results. The grouting process is iterative; relying on monitoring of grout injection quantities, grout backpressures and measurements of water holding capacity. In the Georges River pools were sealed with two to three grout passes.

If flow diversion through a large rockbar occurs it may be more appropriate to implement alternative grouting techniques such as a deeper grout curtain which can be delivered via traditional or directional drilling technologies. Grouting should preferentially be undertaken at the completion of subsidence movements in the area to reduce the risk of the area being re-impacted. **Figure 5-1** shows grouting operations in progress within the Georges River.

(a) Drilling into the bedrock

(b) Grout pump station setup

(c) Injecting grout into bedrock via a specially designed packer system

Figure 5-1 Rockbar Grouting in the Georges River

5.4.3 Erosion Control

Erosion can occur along preferred flow paths where subsidence induced tilts increase a catchment area. To arrest this type of erosion, 'coir log dams' are installed at knick points in the channelised flow paths or at the inception of tunnel/void spaces (**Figure 5-2**).

Figure 5-2 Square Coir Logs for Knick Point Control

As the coir log dams silt up they are regularly added to by the placement of additional layers of logs until the pooled water behind the 'dams' is at or above the level of the bank of the eroded channel. The coir logs are held in place by 50 mm x 50 mm wooden stakes and bound together with wire (**Figure 5-3**). The coir log dam slows the flows in the eroding drainage line such that the drainage line will silt up.

Figure 5-3 Installation of Square Coir Logs

The most important aspect of these coir dams is the positioning of the first layer of coir logs. A trench is cut into the soil so the first layer sits on the underlying substrate or so the top of the first coir log is at ground level (**Figure 5-4**).

Figure 5-4 Trenching and Positioning of the First Layer of Coir Logs and Construction of a Small Dam in a Channel

The coir log dams are constructed at intervals down the eroding flow line, the intervals being calculated on the depth of erosion and predicted peak flows and added to until the pooled water behind the 'dams' is at or above the level of the bank of the erosion. Where increased filtering of flows is required the coir logs are wrapped in fibre matting (**Figure 5-5**).

Figure 5-5 Small Coir Log Dams with Fibre Matting

5.4.4 Surface Treatments and Water Spreading

Where cracking develops in significant areas and natural infilling is not occurring, the cracks may require forking over and compacting to prevent erosion. Larger cracks may require more work to repair them, for example, mulch or other protection to prevent the development of erosion channels. Surface protection will remain in place until revegetation covers the disturbed area. In some cases, if the cracks are wider they may require gravel or sand filling up to surface level and revegetation using brush matting. Maintenance of moisture in rehabilitation areas can be enhanced by additional water spreading techniques, involving long lengths of coir logs and hessian 'sausages' linked together across the contour such that water flow builds up behind them and slowly seeps through the water spreaders (**Figure 5-6**).

Where sheet and rill erosion forms, these processes can reduce vegetation on the surface and/or be a precursor to the formation of gully and stream channel erosion. Treatment of these areas can prevent the formation of channels and maintain swamp moisture. The treatment proposed includes water spreading techniques, involving long lengths of coir logs and hessian 'sausages' linked together across the contour such that water flow builds up behind them and slowly seeps through the water spreaders

Figure 5-6 Round Coir Logs Installed to Spread Water

Erosion control and water spreading involves soft-engineering materials that are biodegradable and become integrated into the soil profile. This approach is ecologically sustainable in that all the materials used can breakdown and become part of the organic component of the soil.

This also removes the requirement for any post-rehabilitation removal of structures or materials. However, rehabilitation measures have the potential to cause impact through the materials used and the disturbance associated with access. Relevant approvals will be obtained to ensure the protection of the environment as works are implemented.

5.4.5 Gas Release

A typical driver of gas release at the surface is pressure changes, dilation and/or fracturing of the rock mass and associated release to the surface, with or without groundwater flows. Grouting techniques discussed above can reduce these associated gas flows at specific sites. In all identified circumstances in the Southern Coalfield the gas releases have diminished over time. Typically this time is a number of months but it can be a number of years. Long running gas releases significantly reduce in quantity over time. Where vegetation is impacted by gas releases the areas affected will be revegetated once monitoring determines the gas releases have ceased or reduced to an extent that vegetation is no longer affected.

Very few gas releases have been observed within the Dendrobium mining area.

5.4.6 Water Quality

Ecoengineers (2012) outline mitigation measures that would be considered if unpredicted water quality impacts were detected. Any works on WaterNSW land requires approval from WaterNSW to access the land and there is a requirement for compliance with the Access Agreement between WaterNSW and IMC. These requirements ensure strict limits are placed on any impacts associated with undertaking rehabilitation works on WaterNSW land.

5.4.7 Alternative Remediation Approaches

IMC has successfully implemented a subsidence rehabilitation program in the Georges River where there were impacts associated with mining directly under streams. This rehabilitation focused on grouting of mining induced fractures and strata dilation to reinstate the structural integrity and water holding capacity of the bedrock. Metropolitan Colliery is currently undertaking work aimed at rehabilitating areas impacted by subsidence using Polyurethane Resin (PUR) and other grouting materials. IMC is consulting with Metropolitan Colliery in relation to these new and emerging technologies. Should rehabilitation be necessary in Dendrobium Area 3A, the best option available at the time of the rehabilitation work will be identified and with appropriate approval, implemented by IMC.

Cracking due to subsidence will tend to seal as the natural processes of erosion and deposition act on them. The characteristics of the surface materials and the prevailing erosion and depositional processes of a specific area will determine the rate of infill of cracks and sealing of any fracture network.

5.4.8 Monitoring Remediation Success

Baseline studies have been completed within the Study Area in order to record biophysical characteristics of the mining area. Monitoring is conducted in the area potentially affected by subsidence from the Area 3A extraction as well as areas away from mining to act as control sites.

The monitoring program would remain in place prior to, during and following the implementation of any remediation measures in the Longwall 19 Study Area. The monitoring program is based on the BACI design with sampling undertaken at impact and control locations prior to the commencement of remediation, during remediation and after the completion of the remediation actions. The monitoring locations/points for watercourses within Dendrobium Area 3A will be reviewed as required and can be modified (with agreement) accordingly.

Statistical analyses between control, impact and remediation sites will be used to determine whether there are statistically significant differences between these sites. This analysis will assist in determining the success of any remediation or natural reduction of mining impacts over time.

Observation data will be collected as part of the monitoring program and be used to provide contextual information to the above assessment approach. Monitoring data and observations will be mapped, documented and reported.

5.5 Biodiversity Offset Strategy

Where impacts are greater than predicted or not within approved levels, compensatory measures will be considered. Any compensatory measure will consider the level of impact requiring compensation, the compensatory measures available and the practicality and cost of implementing the measure.

Subject to Condition 14 of Schedule 3 of the Development Consent:

- The Applicant shall provide suitable offsets for loss of water quality or loss of water flows to WaterNSW storages, clearing and other ground disturbance (including cliff falls) caused by its mining operations and/or surface activities within the mining area, unless otherwise addressed by the conditions of this consent, to the satisfaction of the Secretary. These offsets must:

  (a) be submitted to the Secretary for approval by 30 April 2009;

  (b) be prepared in consultation with WaterNSW;

  (c) provide measures that result in a beneficial effect on water quality, water quantity, aquatic ecosystems and/or ecological integrity of WaterNSW's Special Areas or water catchments.

IMC transferred 33 ha of land adjacent to the Cataract River to WaterNSW to meet the above condition.

A biodiversity offset strategy has been developed in consultation with BCS and WaterNSW for the approval of the Secretary of DPIE. The Secretary DPIE approved the Strategic Biodiversity Offset in accordance with Condition 15 of Schedule 2 of the Development Consent for the Dendrobium Coal Mine 16 December 2016. The Secretary also expressed satisfaction that the Strategy fulfils the requirements of the SMP for Area 3B and 3C.

5.6 Research

To assist in further understanding the impacts of subsidence and rehabilitation of swamps, IMC will undertake research to the satisfaction of the Secretary. The research will be directed to improving the prediction, assessment, remediation and/or avoidance of subsidence impacts and environmental consequences to swamps. The Swamp Rehabilitation Research Program (SRRP) is currently being undertaken in Swamp 1B and 14.

5.7 Contingency and Response Plan

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

This would involve the following actions:

- Identify and record the event.
- Notify government agencies and specialists as 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.
- Review the monitoring frequency.
- Updates from specialists on investigation process.
- Inform relevant government agencies of investigation results.
- Develop site CMA in consultation with key stakeholders and seek approvals.
- Implement CMA as agreed with stakeholders following approvals.
- Conduct initial follow up monitoring and reporting following CMA completion.
- Provide any environmental offset required by the Consent.
- Review the WIMMCP and/or SIMMCP in consultation with key government agencies and seek approval for any modifications.
- Report in EoP Report and AR.

A site-specific rehabilitation action plan detailing the location and specific works to be implemented will be prepared following the identification of mining induced degradation that exceeds the trigger levels specified in the TARPs.

The site-specific rehabilitation action plan will be developed in consultation with relevant stakeholders. Authority to access the land to conduct works and implement environmental controls will be approved by WaterNSW.

The WIMMCP and SIMMCP describes the avoidance, mitigation and contingency measures proposed to manage impacts where predicted impacts are exceeded.

6 INCIDENTS, COMPLAINTS, EXCEEDANCES AND NON-CONFORMANCES

6.1 Incidents

IMC will notify DPIE and any other relevant agencies of any incident associated with Area 3A operations as soon as practicable after IMC becomes aware of the incident. IMC will provide DPIE and any relevant agencies with a report on the incident within seven days of confirmation of any event.

6.2 Complaints Handling

IMC will:

- Provide a readily accessible contact point through a 24-hour toll-free Community Call Line (1800 102 210). The number will be displayed prominently on IMC sites in a position visible by the public as well as on publications provided to the local community.
- Respond to complaints in accordance with the IMC Community Complaints and Enquiry Procedure.
- Maintain good communication lines between the community and IMC.
- Keep a register of any complaints, including the details of the complaint with information such as:
    - Time and date.
    - Person receiving the complaint.
    - Complainant's name and phone number.
    - Description of the complaint.
    - Area where complaint relates to.
    - Details of any response where appropriate.
    - Details of any corrective actions.

6.3 Non-Conformance Protocol

The requirement to comply with all approvals, plans and procedures is the responsibility of all personnel (staff and contractors) employed on or in association with Dendrobium Mine operations. Regular inspections, internal audits and initiation of any remediation/rectification work in relation to this Plan will be undertaken by the Principal Approvals.

Non-conformities, corrective actions and preventative actions are managed in accordance with the following process:

- Identification and recording of non-conformance and/or non-compliance;
- Evaluation of the non-conformance and/or non-compliance to determine specific corrective and preventative actions;
- Corrective and preventative actions to be assigned to the responsible person;
- Management review of corrective actions to ensure the status and effectiveness of the actions;
- An Annual Review will be undertaken to assess IMC's compliance with all conditions of the Dendrobium Development Consent, Mining Leases and other approvals and licenses.

An independent environmental audit will be undertaken in accordance with Schedule 8, Condition 6 to review the adequacy of strategies, plans or programs under these approvals and if appropriate, recommend actions to improve environmental performance. The independent environmental audit will be undertaken by a suitably qualified, experienced and independent team of experts whose appointment has been endorsed by the Secretary of DPIE.

7 PLAN ADMINISTRATION

This SMP will be administered in accordance with the requirements of the Dendrobium Environmental Management System (EMS) and the Dendrobium Development Consent. A summary of the administrative requirements is provided below.

7.1 Roles and Responsibilities

Statutory obligations applicable to Dendrobium operations are identified and managed via an online compliance management system. The online system can be accessed by the responsible IMC managers from the link below.

https://illaw.arracoal.tod.net.au/login.

The overall responsibility for the implementation of the SMP resides with the Approvals Manager who shall be the SMP's authorising officer.

Responsibilities for environmental management in Dendrobium Area 3 and the implementation of the SMP include:

Manager Approvals

- Ensure that the requisite personnel and equipment are provided to enable this SMP to be implemented effectively.
- Authorise the SMP.

Principal Approvals

- Develop the SMP and any amendments thereto.
- To document any approved changes to the SMP.
- Provide regular updates to IMC on the results of the SMP.
- Arrange information forums for key stakeholders as required.
- Prepare any report and maintain records required by the SMP.
- Organise and participate in assessment meetings called to review mining impacts.
- 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 and implement if appropriate.
- Arrange 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.

Coordinator Environment

- 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 assessment meetings to review subsidence impacts.
- Bring to the attention of the Principal Approvals any findings indicating an immediate response may be warranted.
- Bring to the attention of the Principal Approvals any non-conformances identified with the Plan provisions or ideas aimed at improving the SMP.

Survey Team Coordinator

- Collate survey data and present in an acceptable form for review at assessment meetings.
- Bring to the attention of the Principal Approvals any findings indicating an immediate response may be warranted.

- Bring to the attention of the Principal 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 Principal Approvals and provide expert opinion.

Person(s) Performing Inspections

- Inform the Environmental Field Team Lead of any non-conformances identified with the Plan, or ideas aimed at improving the SMP.
- Conduct inspections in a safe manner.

7.2 Resources Required

The Manager Approvals provides resources sufficient to implement this SMP.

Equipment will be needed for the TARP provisions of the SIMMCP and WIMMCP. Where this equipment is of a specialised nature, it will be provided by the supplier of the relevant service. All equipment is to be appropriately maintained, calibrated and serviced as required in operations manuals.

The Approvals Manager shall ensure personnel and equipment are provided as required to allow the provisions of this Plan to be implemented.

7.3 Training

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

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

It is the responsibility of the Principal 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 Coordinator Environment and be trained in observation, measurement and reporting. The Coordinator Environment shall be satisfied that the person(s) performing the inspections are capable of meeting and maintaining this standard.

7.4 Record Keeping and Control

Environmental Records are maintained in accordance with IMC document control requirements.

IMC document control requirements include:

- 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; and
- The SMP and other relevant documentation will be made available on the IMC website.

7.5 Management Plan Review

A comprehensive review of the objectives and targets associated with the Dendrobium Area 3 operations is undertaken on an annual basis via the IMC planning process. These reviews, which include involvement from senior management and other key site personnel, assess the performance of the mine over the previous year and develop goals and targets for the following period.

An annual review of the environmental performance of Dendrobium Area 3 operations will also be undertaken in accordance with Condition 5, Schedule 8 of the Dendrobium Development Consent. More specifically this SMP will be subject to review (and revision if necessary, to the satisfaction of the Secretary) following:

- The submission of an annual review under Condition 5, Schedule 8;

- The submission of an incident report under Condition 3, Schedule 8;
- The submission of an audit report under Condition 6, Schedule 8; and
- Any modification to the conditions of the Dendrobium Development Consent or SMP approval.

If deficiencies in the EMS and/or SMP are identified in the interim period, the plans will be modified as required. This process has been designed to ensure that all environmental documentation continues to meet current environmental requirements, including changes in technology and operational practice, and the expectations of stakeholders.

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Appendix 1 – Longwall 19 - Approved Mine Plan DEN-01-7753

LEGEND

- EXISTING WORKINGS
- PROPOSED WORKINGS FOR THIS APPLICATION
- PROPOSED EXTRACTION
- APPLICATION AREA
- CORDEAUX DAM NOTIFICATION AREA
- PREVIOUS EXTRACTION APPROVALS
- DEVELOPMENT CONSENT BOUNDARY

	MGA E	MGA N
A	291687.723	6193463.326
B	292820.000	6193098.567
C	293020.086	6192995.713
D	293281.128	6192352.852
E	293156.450	6191808.424
F	292136.943	6191959.724
G	291059.566	6192225.783
H	291094.659	6192782.218

I hereby certify the accuracy of the plan.

20/2/20

Registered Mining Surveyor Date

I hereby accept the information on the plan.

20-2-2020

Manager of Mining Engineering

SCALE IN METRES

0 100 200 300 400 500

N

A B C D E F G H

LONGWALL 6

LONGWALL 7

LONGWALL 8

LONGWALL 19
VOID 1760m x 305m

Extraction Direction

Industry & Investment Extraction SMP Approval Date 24/12/09 and NSW Government Planning conditional approval dated 24/12/09

Industry & Investment Extraction SMP Approval Date 09/07/10 and NSW Government Planning Approval date 28/06/10

Industry & Investment Extraction SMP Approval Date 09/07/10 & NSW Government Planning Approval date 28/06/10

Resources & Energy Extraction SMP Approval Date 29/08/11 File OUT11/15910 Section File NO. 11/3940

Cordeaux Notification Area

MG19

ved Plan DEN-91-6151 Rev 6

ning From Approved Plan DEN-91-6151 Rev 6

rtening From Approved Plan DEN-01-6151 Rev 6

E 291000 E 291500 E 292000 E 292500 E 293000 E 293500

N 6193500 N 6193000 N 6192500 N 6192000 N 6191500

Dendrobium Mine
Illawarra Metallurgical Coal
Cordeaux Rd, Mt Kembla, NSW, 2526, Australia
ABN 85 098 744 088

SOUTH32

	Name	Date
DRN	P.Naughton	18/02/2020
REV		
APP		
SCALE	1:3000 @ A0	

Title: Dendrobium Mine - Area 3A - Longwall 19 Subsidence Management Plan Plan 1 - Approved Plan

DRAWING NUMBER: DEN-01-7753

REV: 1

Appendix 2 – Longwall 19 - Surface Features DEN-01-7783

LEGEND

- EXISTING WORKINGS
- PROPOSED WORKINGS FOR THIS APPLICATION
- PROPOSED EXTRACTION
- SMP AREA
- TRIG STATION
- SURVEY MARK
- ARCHAEOLOGICAL SITE
- DA3-CF1 CLIFF
- FIRE TRAIL
- SURFACE CONTOURS (AHD) - Based on 2003 airborne data
- CREEK/RIVER - FROM LPI DATA

STEAM FEATURES:

- BOULDER FIELD
- CHANNEL
- ISLAND
- POOL
- RIFFLE
- ROCK BAR
- ROCK SHELF
- SANDBAR
- SEDIMENT
- SPRING
- SWAMP
- STEP
- TRIBUTARY
- LOG JAM
- 330kV POWERLINE AND TOWER
- 33kV POWERLINE AND TOWER
- DEVELOPMENT CONSENT BOUNDARY

SCALE IN METRES

0 100 200 300 400 500

DA3-CF13 WC19 LC6 44-TC59 LC9 33T1 LC9A

TG6 DA3-CF14 SMP AREA LONGWALL 6 2578m 33kv Transmission Line

WONGA MAINS WC17A WC17 MG7 43-SC78 LONGWALL 7 2225m

DA3-CF15 DEN 12 DEN 146 Cordeaux Notification Area

WC16 WC17B WONGAWILLI CREEK MG8 LONGWALL 8 2224m SC10C

DA3-CF16 42-SD89 DEN 15B DEN 95

52-2-3641 DA3-CF17

LONGWALL 19 VOID 1760m x 305m

WC14 DEN 148 Extraction Direction

DA3-CF22 WC15A DA3-CF19 DA3-CF18 SC10B DA3-CF7 DA3-CF8 SC10

DA3-CF23 MG13 52-2-1646 DEN 15A

52-2-1626 52-2-3640 41-SD104

52-2-2229 SMP AREA DEN 15A

WC15 WONGA MAINS DA3-CF24 WC13A 330kv Transmission Line DEN 96 SC7

MG14 WC13 DEN 34 SC10A DEN 147

DEN 15A

MG15 52-2-1623 WONGA 2 SC10 SC7A

DEN 14 40-SC101

WONGA 3 DEN 33 WC11

52-2-2246 WC12

SOUTH32

Dendrobium Mine

Illawarra Metallurgical Coal
Cordeaux Rd, Mt Kembla, NSW, 2526, Australia
ABN 85 098 744 088

	Name	Date
DRN	P.Naughton	18/02/2020
REV		
APP		
SCALE	1:3000 @ A0	

Title: Dendrobium Mine - Area 3A - Longwall 19
Subsidence Management Plan
Plan 2 - Surface Features

DRAWING NUMBER: DEN-01-7783

REV: 0

Appendix 3 – Longwall 19 Swamp Impact Monitoring, Management and Contingency Plan

Appendix 4 – Longwall 19 Watercourse Impact Monitoring, Management and Contingency Plan

Attachment A – Aquatic Flora and Fauna Review

Attachment B – Groundwater Assessment

Attachment C – Subsidence Predictions and Impact Assessments

Attachment D – Risk Assessment

Attachment E – Surface Water Assessment

Attachment F – Terrestrial Ecology Assessment

Attachment G – Geology of Longwall 18

Attachment H – Groundwater Assessment Peer Review

Attachment I - Aboriginal Cultural Heritage Assessment Report