

# METROPOLITAN COAL    LONGWALLS 301-303

## SUBSIDENCE MONITORING PROGRAM



## **METROPOLITAN COAL**

### **LONGWALLS 301-303**

## **SUBSIDENCE MONITORING PROGRAM**

#### **Revision Status Register**

<b>Section/Page/ Annexure</b>	<b>Revision Number</b>	<b>Amendment/Addition</b>	<b>Distribution</b>	<b>DRE Satisfaction/ DP&amp;E Approval Date</b>
All	SMP-R01-A	Original	DP&E, DRE	11 May 2017*
All	SMP-R01-B	Revised Longwalls 301-303 Extraction Plan	DP&E, NSW Resources Regulator	-

\* The approval allows for the extraction of Longwalls 301 and 302 only.

**September 2018**

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- Attachment 1 Plan 7 (Subsidence Monitoring Locations) in accordance with the Department of Planning and Environment and Division of Resources and Energy (2015) *Guidelines for the Preparation of Extraction Plans*

## 1 INTRODUCTION

Metropolitan Coal is a wholly owned subsidiary of Peabody Energy Australia Pty Ltd (Peabody). Metropolitan Coal was granted approval for the Metropolitan Coal Project (the Project) under section 75J of the New South Wales (NSW) *Environmental Planning and Assessment Act, 1979* (EP&A Act) on 22 June 2009. A copy of the Project Approval is available on the Peabody website (<http://www.peabodyenergy.com>).

The Project comprises the continuation, upgrade and extension of underground coal mining operations (Longwalls 20-27 and Longwalls 301-317) and surface facilities at Metropolitan Coal (Figure 1). Longwalls 301, 302 and 303 (herein referred to as Longwalls 301-303) are situated to the north of completed Longwalls 20-27 and define the next mining sub-domain within the Project underground mining area (Figures 1 to 3). Longwalls 304 on will be subject to future Extraction Plans.

This Subsidence Monitoring Program (SMP) describes the subsidence monitoring program (subsidence effects and subsidence impacts) that forms part of the overall management of the consequential environmental impacts associated with the extraction of Longwalls 301-303. Where relevant, this SMP includes the post-mining requirements of the two previously approved Subsidence Monitoring Programs at Metropolitan Coal (Longwalls 20-22 and Longwalls 23-27). That is, the Longwalls 20-22 and Longwalls 23-27 Subsidence Monitoring Programs will be superseded by this document following the completion of Longwall 27 consistent with the recommended approach in the NSW Department of Planning & Environment (DP&E) and NSW Division of Resources and Energy (DRE) (2015) *Guidelines for the Preparation of Extraction Plans*.

### 1.1 PURPOSE AND SCOPE

Condition 6, Schedule 3 of the Project Approval requires the preparation of various documents as a component of Extraction Plan(s) for second workings. Condition 6(e), Schedule 3 states:

#### **SECOND WORKINGS**

##### ***Extraction Plan***

6. *The Proponent shall prepare and implement an Extraction Plan for all second workings in the mining area to the satisfaction of the Director-General. This plan must:*

...

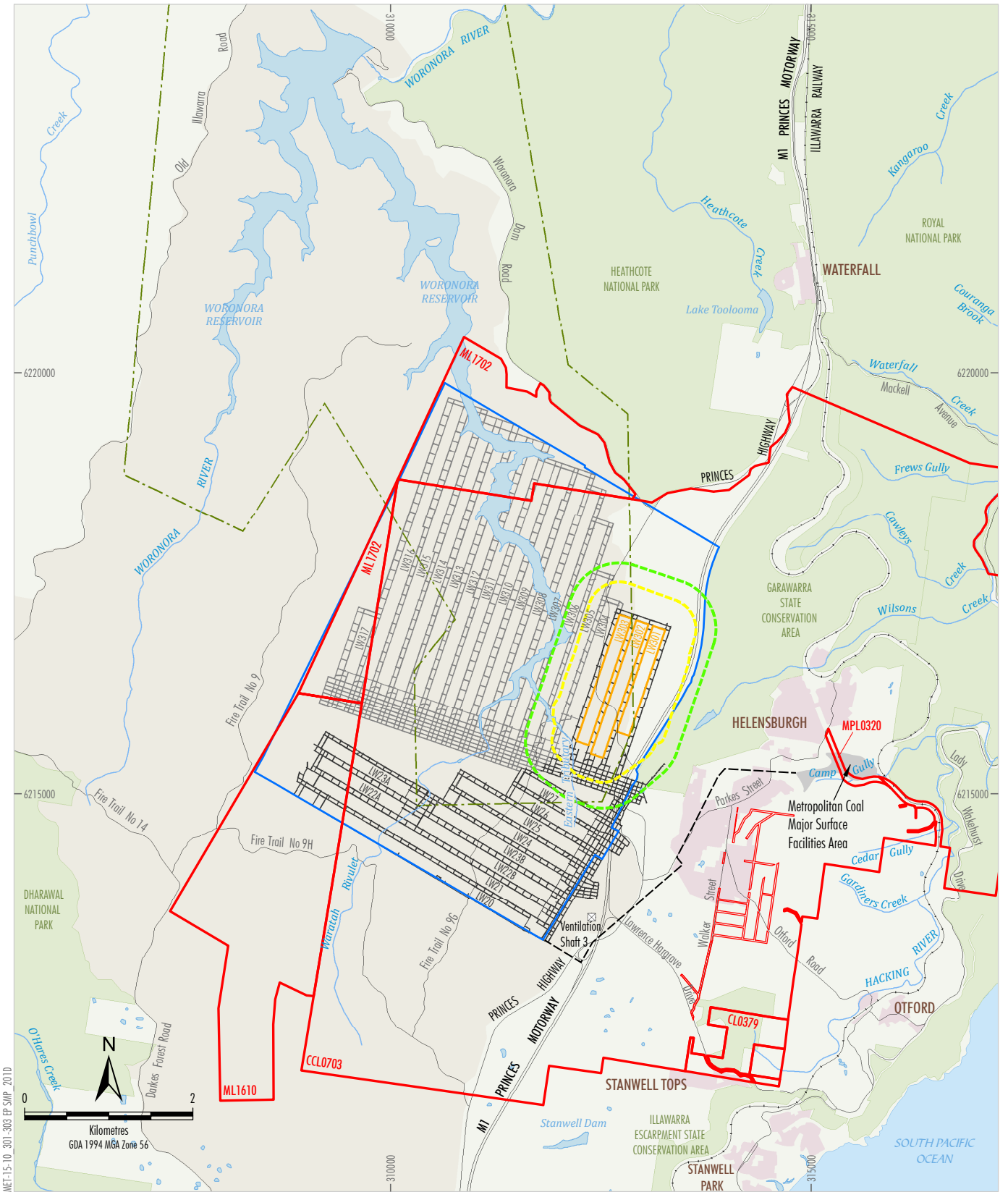
(e) *include the following to the satisfaction of DRE:*

...

- *a Subsidence Monitoring Program to:
 
  - *validate the subsidence predictions; and*
  - *analyse the relationship between the subsidence effects and subsidence impacts of the Extraction Plan and any ensuing environmental consequences;**

...

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**LEGEND**

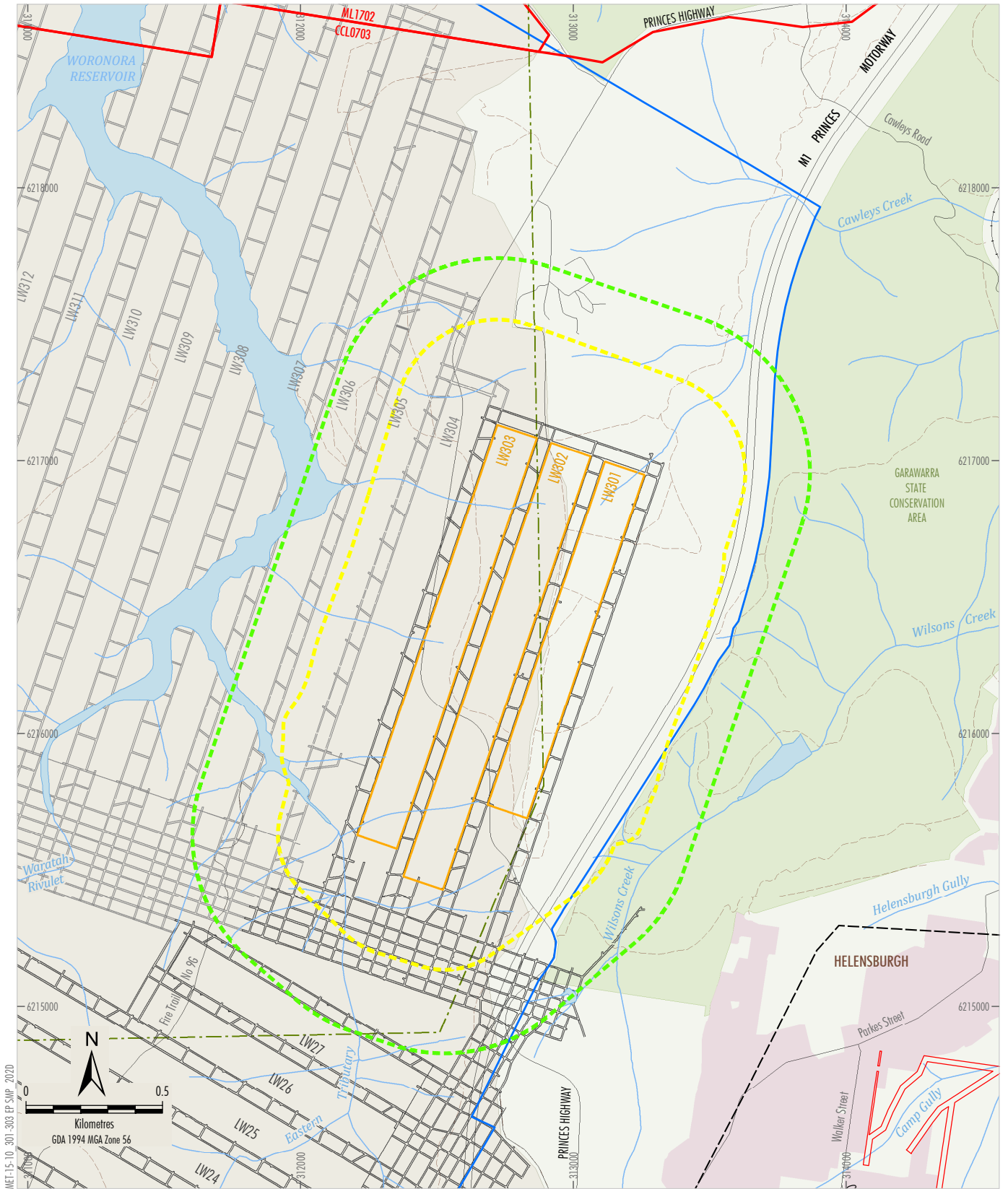
- Mining Lease Boundary
- Woronora Special Area
- Railway
- Project Underground Mining Area  
Longwalls 20-27 and 301-317
- Longwalls 301-303 Secondary Extraction
- 35° Angle of Draw and/or Predicted  
20 mm Subsidence Contour
- 600 m from Secondary Extraction of  
Longwalls 301-303
- Woronora Notification Area
- Existing Underground Access Drive (Main Drift)

Source: Land and Property Information (2015); Department of Industry (2015);  
Metropolitan Coal (2018); MSEC (2018)

**Peabody**

METROPOLITAN COAL  
Longwalls 301 - 303 and  
Project Underground Mining Area

**Figure 1**



MEF-15-10-301-303 EP SMP 2020

**LEGEND**

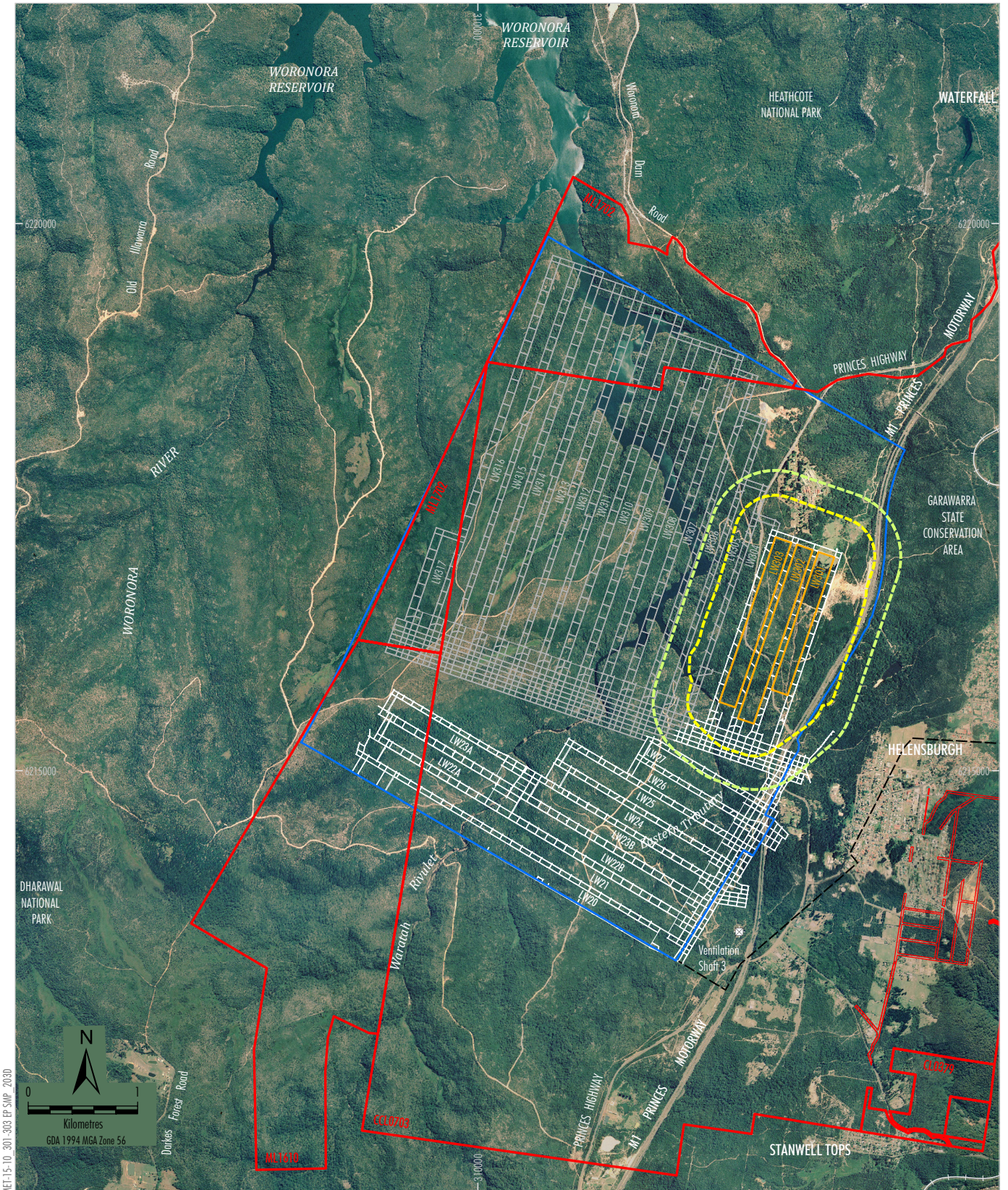
- Mining Lease Boundary
- Woronora Special Area
- Railway
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Longwalls 301-303 Secondary Extraction
- 35° Angle of Draw and/or Predicted 20 mm Subsidence Contour
- 600 m from Secondary Extraction of Longwalls 301-303
- Woronora Notification Area
- Existing Underground Access Drive (Main Drift)
- Road
- Vehicular Track

Source: Land and Property Information (2015); Department of Industry (2015); Metropolitan Coal (2018); MSEC (2018)

**Peabody**  
METROPOLITAN COAL  
Longwalls 301 - 303 Layout

**Figure 2**





MET-15-10-301-303 EP SMP 203D

- LEGEND**
- Mining Lease Boundary
  - Railway
  - Project Underground Mining Area  
Longwalls 20-27 and 301-317
  - Longwalls 301-303 Secondary Extraction
  - 35° Angle of Draw and/or Predicted  
20 mm Subsidence Contour
  - 600 m from Secondary Extraction of  
Longwalls 301-303
  - Existing Underground Access Drive (Main Drift)

Source: Land and Property Information (2015); Date of Aerial Photography 1998;  
Department of Industry (2015); Metropolitan Coal (2018); MSEC (2018)

**Peabody**  
METROPOLITAN COAL  
Longwalls 301 - 303 and  
Project Underground Mining Area  
Aerial Photograph

**Figure 3**

The following graphical plans have been prepared in accordance with DP&E and DRE (2015) *Guidelines for the Preparation of Extraction Plans* and are provided separately in the Longwalls 301-303 Coal Resource Recovery Plan (CRRP, Appendix H of the Longwalls 301-303 Extraction Plan):

- Plan 1: Existing, Proposed and Future Workings.
- Plan 2: Longwalls 301-303 Surface Features.
- Plan 3: Geological and Seam Data.
- Plan 5: Mining Titles and Land Ownership.
- Plan 6: Geological Section and Geotechnical Logs.

Plan 7 (Longwalls 301-303 Subsidence Monitoring Locations) referred to in the DP&E and DRE (2015) *Guidelines for the Preparation of Extraction Plans* is included as Attachment 1 to this SMP.

The document *Metropolitan Mine - Longwalls 301 to 303 Subsidence Predictions and Impact Assessments for the Natural and Built Features in Support of the Extraction Plan* has been prepared by Mine Subsidence Engineering Consultants (MSEC) (2018) (Appendix I of the Longwalls 301-303 Extraction Plan) includes revised predictions of the conventional and non-conventional subsidence effects and subsidence impacts of the Extraction Plan, incorporating any relevant information that has been obtained since Project Approval.

This SMP outlines the subsidence monitoring program prepared to satisfy that component of Condition 6(e), Schedule 3 of the Project Approval relating to subsidence monitoring. The SMP is, among other things, designed to compare and validate the subsidence predictions outlined in MSEC (2018).

The relationship of this SMP to the Metropolitan Coal Environmental Management Structure and to the Metropolitan Coal Longwalls 301-303 Extraction Plan is shown on Figure 4.

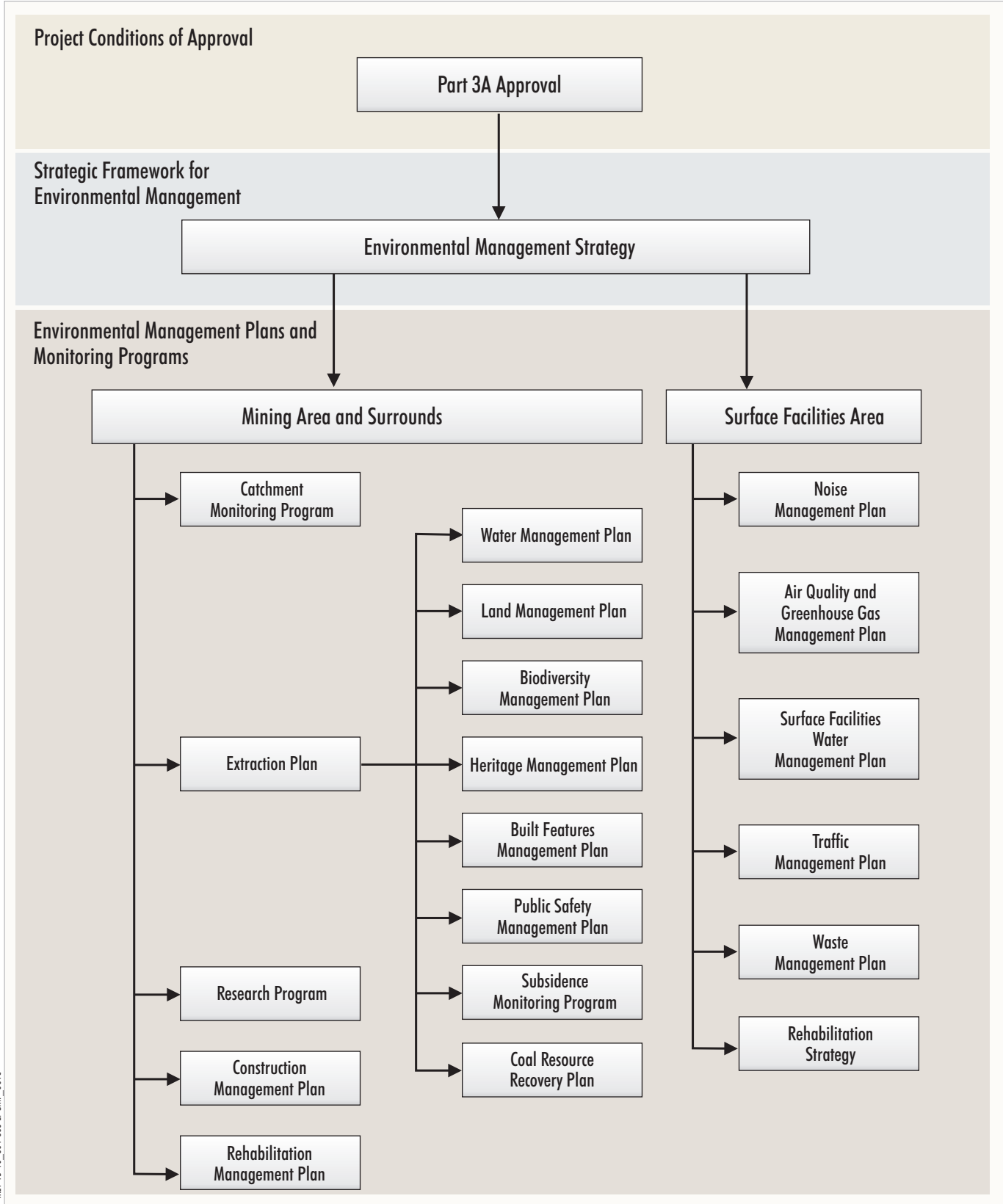
In accordance with Condition 6, Schedule 3 of the Project Approval, this SMP has been prepared by Metropolitan Coal, with assistance from MSEC.

## 1.2 STRUCTURE OF THE SMP

The remainder of the SMP is structured as follows:

- Section 2: Describes the SMP revision status and distribution list.
- Section 3: Describes the Longwalls 301-303 extraction layout.
- Section 4: Describes the natural and built features.
- Section 5: Summarises the revised predicted subsidence parameters and impacts for the longwalls.
- Section 6: Describes the monitoring program.
- Section 7: Describes the program to analyse subsidence effects, subsidence impacts, and environmental consequences.
- Section 8: Lists the references cited.

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Figure 4

## 2 SMP REVIEW AND UPDATE

In accordance with Condition 4, Schedule 7 of the Project Approval, this SMP will be reviewed within three months of the submission of:

- (a) an audit under Condition 8, Schedule 7;
- (b) an incident report under Condition 6, Schedule 7;
- (c) an annual review under Condition 3, Schedule 7; and

if necessary, revised to the satisfaction of the Director-General (now Secretary) of the DP&E, to ensure the SMP is updated on a regular basis and to incorporate any recommended measures to improve environmental performance.

The SMP will also be reviewed within three months of approval of any Project modification and if necessary, revised to the satisfaction of the DP&E.

Certain details of the monitoring program will be reviewed and amended as required in consultation with the NSW Resources Regulator to the satisfaction of the Director-General (now Secretary) of DP&E.

The revision status of this plan is indicated on each copy of the SMP. The distribution register for controlled copies of the SMP is described in Section 2.1.

Revisions to any documents listed within this SMP will not necessarily constitute a revision of this document.

### 2.1 DISTRIBUTION REGISTER

In accordance with Condition 10, Schedule 7 'Access to Information', Metropolitan Coal will make the SMP publicly available on the Peabody website. A hard copy of the SMP will also be maintained at the Metropolitan Coal site.

Metropolitan Coal recognises that various regulators have different distribution requirements, both in relation to whom documents should be sent and in what format. An Environmental Management Plan and Monitoring Program Distribution Register has been established in consultation with the relevant agencies and infrastructure owners that indicates:

- to whom the Metropolitan Coal plans and programs, such as the SMP, will be distributed;
- the format (i.e. electronic or hard copy) of distribution; and
- the format of revision notification.

Metropolitan Coal will make the Distribution Register publicly available on the Peabody website.

Metropolitan Coal will be responsible for maintaining the Distribution Register and for ensuring that the notification of revisions is sent by email or post as appropriate.

In addition, Metropolitan Coal employees with local computer network access will be able to view the controlled electronic version of this SMP on the Metropolitan Coal local area network. Metropolitan Coal will not be responsible for maintaining uncontrolled copies beyond ensuring the most recent version is maintained on Metropolitan Coal's computer system and the Peabody website.

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### 3 LONGWALLS 301-303 EXTRACTION LAYOUT

Longwalls 301-303 and the area of land within 600 metres (m) of Longwalls 301-303 secondary extraction are shown on Figures 1, 2 and 3. A summary of the longwall dimensions for Longwalls 301-303 is provided in Table 1. The longwall layout includes 163 m panel widths (void) with 45 m pillars (solid).

**Table 1**  
**Summary of Longwall Dimensions for Longwalls 301-303**

Longwall	Longwall Length (m)	Total Void Width (m)	Tailgate Chain Pillar Width (m)
LW301	1,338	163	0
LW302	1,684	163	45
LW303	1,600	163	45

m = metres.

Longwall extraction will occur from north to south. The provisional extraction schedule for Longwalls 301-303 is provided in Table 2.

**Table 2**  
**Provisional Extraction Schedule**

Longwall	Estimated Start Date	Estimated Duration	Estimated Completion Date
LW301	28 June 2017	8 months	4 February 2018
LW302	29 March 2018	8 months	October 2018
LW303	November 2018	8 months	June 2019

The dimensions of the headings would be approximately 5.2 m wide and 3.2 m in height. The headings are connected approximately every 120 m by driving a cut-through from one heading to another which forms pillars of coal along the length of the gate road.

The geology, seam structure, and depth of cover are described in the Longwalls 301-303 CRRP.

The depth of cover above the proposed longwalls varies between a minimum of 395 m in the base of the Eastern Tributary and a maximum of 555 m at the northern commencing end of Longwall 303.

The seam floor within the proposed mining area generally dips from the south-east to the north-west. The seam thickness within the goaf areas of the longwalls varies between a minimum of 2.7 m at the northern end of Longwalls 301-303 and a maximum of 2.9 m at the southern end of Longwalls 301-303.

The proposed longwalls will extract the full height of the seam.

## 4 SURFACE FEATURES INCLUDED IN MONITORING PROGRAM

### 4.1 THE STUDY AREA

The Study Area in MSEC (2018) was defined as the surface area that is likely to be affected by the mining of Longwalls 301-303 in the Bulli Seam at Metropolitan Colliery. The surface features included in the Study Area are those features within areas bounded by the following limits:

- a 35° angle of draw line from the extents of Longwalls 301 to 303; and
- the predicted limit of vertical subsidence, taken as the predicted 20 mm subsidence contour resulting from the extraction of Longwalls 301 to 303.

There are features that lie outside the Study Area that are expected to experience either far-field movements, or valley related movements. The surface features which are sensitive to such movements have been identified and have been included in the assessments provided in MSEC (2018).

Natural features identified within the Longwalls 301-303 Study Area include:

- streams (including Eastern Tributary and other small first and second order tributaries);
- steep slopes and land in general (including ledges and rock outcrops);
- upland swamps; and
- other natural vegetation.

Natural features within 600 m of Longwalls 301-303 are also considered in MSEC (2018). Aboriginal heritage sites have also been identified within the Longwalls 301-303 Study Area and surrounds.

The built features identified within the Longwalls 301-303 Study Area include:

- M1 Princes Motorway;
- M1 Princes Motorway bridge (Bridge 2 – Old Princes Highway Underpass);
- Old Princes Highway;
- 330 kV and 132 kV transmission lines and towers;
- telecommunication towers and compounds;
- optical fibre cables;
- water pipelines and water storage tanks;
- Garrawarra Centre Complex buildings and structures (southern areas);
- Waterfall General (Garrawarra) Cemetery; and
- fire trails and four wheel drive tracks.

MSEC (2018) also considered built features that lay outside the Study Area that may experience far-field movements. The built features included within the assessment beyond the extent of the Study Area included:

- Illawarra Railway;
- M1 Princes Motorway bridge (Cawley Road Overbridge);
- Woronora Dam;
- Garrawarra Centre Complex buildings and structures (northern areas);
- exploration bores; and
- survey control marks.

These are discussed in detail in MSEC (2018) and summarised below.

The surface features are shown on Plan 2 in Attachment 1 of the Longwalls 301-303 CRRP.

#### 4.1.1 Streams

Streams in the Study Area for Longwalls 301-303 include:

- the Eastern Tributary; and
- other small first and second order tributaries.

Many of the other tributaries consist of shallow drainage lines from the topographical high point above Longwalls 301-303. These tributaries drain into the Eastern Tributary and the Woronora Reservoir to the west of the longwalls.

The Waratah Rivulet is located outside the Study Area, approximately 1 km west of Longwall 303 at its closest point to longwalls.

A comprehensive set of pool mapping and photographic survey of pools (pool dimensions, nature of the stream bed, rock bar characteristics etc.) within the Eastern Tributary and the Waratah Rivulet are provided in the Metropolitan Coal Longwalls 301-303 Water Management Plan (WMP).

Gilbert & Associates (now Hydro Engineering & Consulting) conducted a visual inspection and photographic survey of streams in the vicinity of Longwalls 301-303 in July 2015 and is also reported in the Metropolitan Coal Longwalls 301-303 WMP.

#### 4.1.2 Cliffs and Associated Overhangs

A new cliff and overhang site (COH17) was identified below the full supply level of the Eastern Tributary arm of the Woronora Reservoir in August 2018. Detailed baseline recording for this site will be conducted prior to the commencement of Longwall 303 extraction.

The next nearest cliffs and overhang sites are located more than 800 m to the west of Longwalls 301-303. At these distances, the cliffs are not expected to experience any measurable vertical subsidence resulting from the extraction of Longwalls 301-303.

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### 4.1.3 Steep Slopes and Land in General

Steep slopes have been identified to highlight areas where existing ground slopes may be marginally stable. However, no significant slope failures have been observed in the Southern Coalfield as a result of longwall mining. Land in general refers to the general landscape other than cliffs and steep slopes and includes rock ledges/rock outcrops and minor cliffs.

### 4.1.4 Upland Swamps

The mapped extents of the upland swamps are based on field inspection and validation by Eco Logical Australia (2016). There are 14 swamps located within the Study Area. Detailed descriptions of the swamps within the Study Area are provided in the Metropolitan Coal Longwalls 301-303 BMP.

### 4.1.5 Other Natural Vegetation

The vegetation within the Study Area generally consists of native bushland. A summary of the vegetation communities present is provided in the Metropolitan Coal Longwalls 301-303 BMP. An occurrence of the Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion Endangered Ecological Community is situated to the north of Longwall 301 and outside the Study Area.

## 4.2 PUBLIC UTILITIES

### 4.2.1 Railways

There are no railways within the Study Area. The Illawarra Railway is located to the east of the Study Area. The Illawarra Railway (which links Sydney and Wollongong) is located more than 1.4 km from the longwalls.

### 4.2.2 Roads and Culverts

The locations of roads including the M1 Princes Motorway, Old Princes Highway, private roads, access roads, fire trails and four-wheel drive tracks within and adjacent to the Study Area are shown on Plan 2 in the Longwalls 301-303 CRRP.

The M1 Princes Motorway will not be directly mined beneath by Longwalls 301-303. The distance from the M1 Princes Motorway to the longwalls varies from approximately 210 m near the finishing (southern) end of Longwall 301 to 345 m near the commencing (northern) end of Longwall 301. A series of culverts of varying diameters from 375 mm to 1,800 mm cross the M1 Princes Motorway.

The total length of the Old Princes Highway that is located within the Study Area is approximately 2.9 km, of which 800 m is located directly above the longwall panels.

A network of private roads also services the Garrawarra Centre Complex.

All other roads within the Study Area are unsealed fire trails or access roads which are used by WaterNSW and other asset owners and groups for fire fighting and other activities.

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### 4.2.3 Bridges

The features along the M1 Princes Motorway considered to be most sensitive to relative movements arising from far-field effects are Bridge 2 (at the location where the Old Princes Highway passes below the M1 Princes Motorway) and Cawley Road Overbridge.

Bridge 2 (Old Princes Highway Underpass) is located within the Study Area and is approximately 330 m from the finishing end of Longwall 301. A program of high accuracy monitoring has been implemented to date by the Roads and Maritime Services (RMS) Technical Committee at Bridge 2.

The Cawley Road Overbridge is located approximately 1.51 km from the northern end of Longwall 301 at its nearest point.

A summary of the bridge details is provided in Table 3.

**Table 3**  
**Summary of Bridge 2 and Cawley Road Overbridge Details along the M1 Princes Motorway**

Bridge Name	RMS Name	RMS Chainage from Sydney	Nearest Longwall	Approximate Distance to Nearest Longwall (m)
Old Princes Highway Underpass 2 (Bridge 2)	Twin Bridges over Old Princes Highway BN616 on S/B carriageway BN617 on N/B carriageway	30 miles 1,326 feet (48 kilometres 684.5 m)	301	330
Cawley Road Overbridge	BN615	28 miles 1,350 feet (45.47 kilometres south of Sydney)	301	1,510

### 4.2.4 Electrical Services

There are aboveground and buried electrical services within the Study Area, the locations of which are shown on Plan 2 in the Longwalls 301-303 CRRP and on Drawing No. MSEC984-08 in MSEC (2018).

A 330 kilovolt (kV) transmission line, which is owned by TransGrid, and a 132 kV power line, which is owned by Endeavour Energy, are within the 35° angle of draw to the east of Longwalls 301-303. The 330 kV transmission line and 132 kV power line and towers will not be directly undermined by Longwalls 301-303. All 330 kV and 132 kV transmission towers within the Study Area are suspension towers.

Endeavour Energy also own aerial high voltage powerlines which service the Garrawarra Centre Complex to the north of Longwalls 301-303. The feeder aerial powerline that runs between Helensburgh and the Garrawarra Centre Complex is referred as Powerline 1. Underground powerlines are also present within the Garrawarra Centre Complex.

### 4.2.5 Telecommunications Services

There are underground telecommunication lines within the Study Area consisting of both optical fibre and copper cables, the locations of which are shown on Plan 2 in the Longwalls 301-303 CRRP and on Drawing No. MSEC984-08 in MSEC (2018).

There are three main optical fibre cables that cross the southern end of Longwall 301 owned by Telstra, Optus and Vocus (previously Nextgen<sup>1</sup>). A second optical fibre cable owned by Telstra crosses above the northern end of Longwall 303 and a second optical fibre cable owned by Optus crosses above the northern end of Longwall 303 and above Longwalls 301 and 302.

Copper telecommunications cables owned by Telstra are also located to the north of Longwalls 302 and 303 and these cables service the Garrawarra Centre Complex.

There are also a number of telecommunications towers and compounds that are located above and to the north of Longwall 303. These towers and compounds are owned by Telstra, Axicom and Sydney Trains.

#### 4.2.6 Dams, Reservoirs and Associated Works

The closest dam to Longwalls 301-303 is the Woronora Dam. The Woronora Dam wall is located approximately 7.1 km to the commencing end of Longwall 303. The distance from the labyrinth spillway (south of the dam wall) is approximately 6.7 km from the nearest point of Longwall 303. Monitoring of the Woronora Dam wall is not included in this SMP due to the large distance of the Dam wall from extraction.

A portion of Longwalls 301-303 is within the Woronora Notification Area. The full supply level of the Woronora Reservoir is located inside the Study Area and is 100 m west of Longwall 303 at its nearest point.

### 4.3 MINE INFRASTRUCTURE

There are two exploration drill holes (boreholes) within the Study Area, the locations of which are shown on Plan 2 in the Longwalls 301-303 CRRP and on Drawing No. MSEC984-09. One borehole (S225) is located directly above the longwalls and the other (S872) is located outside the extents of mining.

### 4.4 GARRAWARRA CENTRE COMPLEX

The location of the Garrawarra Centre Complex and buildings, structures and other services are shown in Drawings No. MSEC984-08, MSEC984-09 and MSEC984-10 in MSEC (2018). There are a total of 86 building structures on the complex, comprising 57 buildings (hospital/aged care/houses) and 29 ancillary structures.

There are also nine water storage tanks, a gas storage tank, kiln and a number of telecommunication towers located within the complex. A network of bitumen sealed private roads services the complex. NSW Health manages the Garrawarra Centre Complex. Further details are provided in the BFMP-Garrawarra.

<sup>1</sup> Nextgen has been acquired by Vocus Group (Vocus).

## 4.5 ITEMS OF ARCHAEOLOGICAL SIGNIFICANCE

### 4.5.1 Aboriginal Heritage Sites

The locations of known Aboriginal heritage sites within the Study Area are shown in Drawing No. MSEC984-09 in MSEC (2018). Detailed baseline recordings of Aboriginal heritage sites are provided in baseline reports prepared by Niche Environment and Heritage and are described in the Metropolitan Coal Longwalls 301-303 Heritage Management Plan (HMP).

### 4.5.2 Local Heritage Sites

The *Wollongong Local Environmental Plan, 2009* lists items of heritage significance at the Garrawarra Centre Complex including the Garrawarra Hospital Heritage Conservation Area, Gates and Gatehouse, Administration, Kitchen and Store Block, Staff Cafeteria, Nurses Hostel and Residential Houses. Howard Tanner and Associates (1993) also lists additional items of varying significance at the Garrawarra Centre Complex. NSW Health manages the Garrawarra Centre Complex. Further details are provided in the BFMP-Garrawarra.

The Waterfall General [Garrawarra] Cemetery, also referred as the Garrawarra Hospital Cemetery or Waterfall Cemetery, is currently listed as an item of local significance under the *Wollongong Local Environmental Plan, 2009* (item 6505). The Waterfall Cemetery site is under the management of the Wollongong City Council (WCC). Further details are provided in the BFMP-Cemetery.

## 4.6 PERMANENT SURVEY CONTROL MARKS

The locations of survey control marks are shown on Plan 2 in the Longwalls 301-303 CRRP and on Drawing No. MSEC984-09 in MSEC (2018).

## 5 REVISED SUBSIDENCE PARAMETERS AND SUBSIDENCE IMPACTS DUE TO LONGWALLS 301-303 EXTRACTION

MSEC (2018) provides a detailed description of the development of mine subsidence and the method used to predict the mine subsidence movements resulting from the extraction of the longwalls. The report includes the maximum predicted conventional subsidence parameters for the longwalls (Chapter 5 of MSEC [2018]) including:

- Incremental Subsidence Parameters, which are the predicted subsidence parameters due to the extraction of a single Longwall.
- Total Subsidence Parameters, which include the accumulated subsidence parameters after the completion of each longwall within a series of longwalls.

The maximum predicted incremental conventional subsidence parameters from the extraction of Longwalls 301-303 is 900 mm, which represents around 30% of the seam thickness.

A comparison of the maximum predicted conventional total subsidence parameters, for the Extraction Plan Layout and the Preferred Project Layout for Longwalls 301-303, is provided in MSEC (2018). The maximum predicted total subsidence and tilt are slightly less than predicted based on the Preferred Project Layout. The maximum predicted total hogging curvature for the Extraction Plan Layout is similar but slightly greater than the hogging curvature based on the Preferred Project Layout. The maximum predicted total sagging curvature is the same for both layouts.

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While the predicted maxima are generally similar to those for the Preferred Project Layout, the predicted subsidence parameters at the southern ends of Longwalls 302 and 303 are greater than those predicted for the Preferred Project Layout. However, these parameters remain below the maximum predicted subsidence parameters based on the Preferred Project Layout across previous Longwalls 20-27 and future 300 series longwalls (e.g. maximum predicted total conventional hogging curvature of  $0.11 \text{ km}^{-1}$ ).

The predictions of conventional subsidence parameters do not include the valley related upsidence and closure movements, or the effects of faults and other geological structures.

## 5.1 PREDICTED SUBSIDENCE PARAMETERS AND IMPACTS FOR THE NATURAL AND BUILT FEATURES WITHIN THE STUDY AREA

MSEC (2018) provides a comprehensive description of revised (since the Project Environmental Assessment [Helensburgh Coal Pty Ltd, 2008] and Preferred Project Report [Helensburgh Coal Pty Ltd, 2009]) site specific predicted subsidence parameters and impact assessments for each of the natural and built features that are located within the Study Area, due to the extraction of Longwalls 301-303. Additionally, natural and built features that are located outside the Study Area, which may be subjected to far-field movements and may be sensitive to the predicted subsidence parameters, were also included in the revised assessments. In particular, the following surface features were assessed:

- Waratah Rivulet (*located approximately 1 km west of the nearest longwall*).
- Eastern Tributary.
- Other Tributaries.
- Woronora Reservoir and Woronora Dam (*the latter being located approximately 7.1 km away*).
- Cliffs and Associated Overhangs.
- Steep Slopes.
- Upland Swamps.
- Endangered Ecological Communities.
- Illawarra Railway (*located more than 1.4 km away*).
- M1 Princes Motorway.
- Old Princes Highway.
- Fire Trails and Four Wheel Drive Tracks.
- Bridges (Bridge 2 and Cawley Road Overbridge [*located approximately 1.51 km away*]).
- Electrical Services.
- Sydney Water Infrastructure (water mains).
- Optical Fibre Cables.
- Telecommunication Towers and Compounds.
- Copper Telecommunications Cables.
- Garrawarra Centre Complex (including buildings, structures and services).

- Waterfall General (Garrawarra) Cemetery.
- Archaeological Sites (Aboriginal heritage and local heritage).
- Survey Control Marks.

The monitoring program described below was developed in consideration of the predicted subsidence parameters and subsidence impacts outlined in MSEC (2018).

## 6 MONITORING

### 6.1 INTRODUCTION

The objectives of the monitoring program are:

- To monitor the subsidence effects associated with Longwalls 301-303 extraction, and where relevant, previous Longwalls 20-27.
- To summarise and consolidate the various environmental monitoring programs presented in each of the key component plans of the Longwalls 301-303 Extraction Plan which focus on the monitoring of subsidence impacts and environmental consequences of mine subsidence. These include:
  - the Water Management Plan (Longwalls 301-303 WMP);
  - the Biodiversity Management Plan (Longwalls 301-303 BMP);
  - the Land Management Plan (Longwalls 301-303 LMP);
  - the Heritage Management Plan (Longwalls 301-303 HMP);
  - the Built Features Management Plan (Longwalls 301-303 BFMP); and
  - the Public Safety Management Plan (Longwalls 301-303 PSMP).
- To analyse the relationship between the subsidence effects and subsidence impacts of the Extraction Plan and any ensuing environmental consequences.
- To validate subsidence predictions.
- To provide subsidence data to improve the predictive methods and provide a better understanding of the underlying factors contributing to ground movement.

The subsidence monitoring program is composed of subsidence parameter monitoring that is summarised in Table 4 and subsidence impact/environmental consequence monitoring as summarised in Table 5.

**Table 4**  
**Subsidence Parameter Monitoring Components**

Monitoring Component	Description	Frequency	Relevant Management Plan
300 XL Line	Main monitoring line traversing Longwalls 301-303.	<ul style="list-style-type: none"> <li>Prior to Longwall 301.</li> <li>Within 3 months following completion of each of Longwalls 301, 302 and 303.</li> </ul>	General – all plans
[Old] Princes Highway Line	Along the Old Princes Highway from M1 Princes Motorway to Garrawarra Centre Complex entrance road.	<ul style="list-style-type: none"> <li>Prior to Longwall 301.</li> <li>Weekly for area within 400 m of active longwall face passing under highway.</li> <li>Within 3 months following completion of each of Longwalls 301, 302 and 303.</li> </ul>	BFMP-WCC BFMP-Syd Water
Optic/Water Line	Along an unsealed track and Garrawarra Centre Complex internal roads from the Old Princes Highway to beyond the 35° angle of draw line within Garrawarra Centre Complex.	<ul style="list-style-type: none"> <li>Prior to Longwall 301.</li> <li>Weekly when within 400 m of active longwall face passing under Fibre Cables or pipeline.</li> <li>Within 3 months following completion of each of Longwalls 301, 302 and 303.</li> </ul>	BFMP-Optus BFMP-Vocus BFMP-Telstra BFMP-Sydney Water BFMP-Garrawarra BFMP-Axicom BFMP-Sydney Trains
M1 North Bound Line	Along the M1 Princes Motorway from Bridge 2 to Cawley Road Overbridge.	<ul style="list-style-type: none"> <li>Prior to Longwall 301.</li> <li>Within 3 months of the completion of each of Longwalls 301, 302 and 303.</li> </ul>	BFMP-RMS BFMP-Sydney Trains
Transmission Line	Along the transmission lines within the 35° angle of draw. Southern limit of survey extents is Longwall 26 or TL11-101 (Survey Point T87). Northern limit of survey extents is Longwall 301 angle of draw adjacent F913B-T09.	<ul style="list-style-type: none"> <li>Prior to Longwall 301.</li> <li>Weekly for survey points within 400 m of the active longwall face (or at an increased frequency subject to consultation with the asset owner).</li> <li>Within 3 months following the completion of extraction of each of Longwalls 301, 302 and 303.</li> </ul>	BFMP-TransGrid BFMP-Endeavour Energy BFMP-Vocus BFMP-Telstra BFMP-Optus BFMP-RMS BFMP-Sydney Trains BFMP-Cemetery
Transmission Towers	Towers TL11-101 to TL11-108 and F9132B-T7 to F9132B-T13 including: <ul style="list-style-type: none"> <li>Each of the four tower legs.</li> <li>Four ground points adjacent to each tower leg.</li> <li>Top of each tower at fixed point.</li> <li>Real time absolute 3D monitoring at TransGrid Towers, sites #4 through #8 corresponding with TL11-104 to TL11-108.</li> </ul>	<ul style="list-style-type: none"> <li>Prior to Longwall 301.</li> <li>Weekly at each tower within 400 m of the active longwall face (or at an increased frequency subject to consultation with the asset owner).</li> <li>Within 3 months following the completion of extraction of each of Longwalls 301, 302 and 303.</li> <li>Real-time (continuous) absolute 3D monitoring on TransGrid towers.</li> </ul>	BFMP-TransGrid BFMP-Endeavour Energy BFMP-RMS BFMP-Vocus BFMP-Telstra BFMP-Optus
Telecommunication Towers	Lattice (Truss) Towers including: <ul style="list-style-type: none"> <li>Each of the tower legs.</li> <li>Ground points adjacent each tower leg</li> </ul> Pole Tower including: <ul style="list-style-type: none"> <li>Tiltmeters at base of pole.</li> <li>Ground point adjacent to tower on Optic/Water Line.</li> </ul>	<ul style="list-style-type: none"> <li>Prior to Longwall 302, or otherwise agreed with the asset owner.</li> <li>Weekly on commencement of Longwall 302 and 303 until subsidence effects are below survey accuracy.</li> <li>Within 3 months following the completion of extraction of each of Longwalls, 302 and 303.</li> </ul>	BFMP-Telstra BFMP-Axicom BFMP- Sydney Trains BFMP-Garrawarra

**Table 4 (Continued)**  
**Subsidence Parameter Monitoring Components**

Monitoring Component	Description	Frequency	Relevant Management Plan
Bridge 2 (Old Princes Highway Underpass)	<ul style="list-style-type: none"> <li>Absolute 3D movement of the survey reference pillar.</li> <li>Relative 3D movements of bridge monitoring points</li> <li>Fibre Optic monitoring system.</li> <li>Real time absolute 3D monitoring site #3.</li> </ul>	<ul style="list-style-type: none"> <li>Prior to Longwall 301.</li> <li>Real-time (continuous) absolute 3D monitoring.</li> <li>Weekly Fibre Bragg Grating (FBG) sensor monitoring from the commencement of Longwall 301 extraction for a duration determined in consultation with the RMS Technical Committee.</li> <li>Monthly survey when active longwall mining is within 500 m of the bridge.</li> <li>Greater frequency or commencing earlier if determined in consultation with the RMS Technical Committee.</li> <li>Following the completion of extraction of each of Longwalls 301, 302 and 303.</li> </ul>	BFMP- RMS
Cawley Road Overbridge	<ul style="list-style-type: none"> <li>Absolute 3D movement of the survey reference pillar.</li> <li>Relative 3D movements of bridge monitoring points.</li> <li>Real time absolute 3D monitoring site #9.</li> </ul>	<ul style="list-style-type: none"> <li>Prior to Longwall 301.</li> <li>Real-time (continuous) absolute 3D monitoring.</li> <li>Following the completion of extraction of each of Longwalls 301, 302 and 303.</li> </ul>	BFMP- RMS
Illawarra Railway Line	<ul style="list-style-type: none"> <li>Relative 3D movements of culverts monitoring points.</li> <li>Real time absolute 3D monitoring for Valley Closure.</li> </ul>	<ul style="list-style-type: none"> <li>Prior to Longwall 301.</li> <li>Real-time (continuous) absolute 3D monitoring for valley closure at Wilsons Creek and Cawleys Creek from Longwall 303.</li> <li>Following the completion of extraction of each of Longwalls 301, 302 and 303.</li> </ul>	BFMP-Sydney Trains
Eastern Tributary Cross Line	Cross lines at ETAU (Metropolitan Coal gauging station), ETAT, ETAR and ETAQ.	<ul style="list-style-type: none"> <li>Prior to Longwall 301.</li> <li>Following the completion of extraction of each of Longwalls 301, 302 and 303.</li> </ul>	WMP (Pools ETAU, ETAT, ETAR and ETAQ)
Waratah Rivulet Cross Line	Cross Line Q (WaterNSW gauging station).	<ul style="list-style-type: none"> <li>Annually.</li> </ul>	WMP (Rock Bar Q)
Ridge to Ridge	Eastern Tributary (2 x GPS Monitoring Points). Waratah Rivulet (7 x GPS Monitoring Points).	<ul style="list-style-type: none"> <li>Within 3 months following completion of Longwall 27.</li> </ul>	General
D Line	Existing line traversing previous Longwalls 1-18.	<ul style="list-style-type: none"> <li>Within 3 months following completion of Longwall 27.</li> </ul>	General
G Line	Existing line traversing previous Longwalls 20-27.	<ul style="list-style-type: none"> <li>Within 3 months following completion of Longwall 27.</li> </ul>	General

**Table 5**  
**Subsidence Impact and Environmental Consequences Monitoring Components**

Extraction Plan	Aspect	Sites	Frequency	Parameters / Purpose
LMP	Cliffs and overhangs	<ul style="list-style-type: none"> <li>Cliff site COH17.</li> </ul>	<ul style="list-style-type: none"> <li>Visual observations during catchment visits.</li> <li>Monthly when Longwall 303 extraction is within 400 m of the site.</li> <li>Following the completion of Longwall 303 extraction.</li> </ul>	<ul style="list-style-type: none"> <li>Cliff instabilities – length of cliff/overhang that experiences mining-induced rock fall (i.e. the exposure of a fresh face of rock and debris scattered around the base of the cliff or overhang), compared against the land subsidence impact performance measure.</li> </ul>
	Steep slopes and land in general	<ul style="list-style-type: none"> <li>Steep slopes and other land within 600 m of Longwalls 20-27 and Longwalls 301-303 secondary extraction.</li> </ul>	<ul style="list-style-type: none"> <li>Visual observations during catchment visits.</li> </ul>	<ul style="list-style-type: none"> <li>Sandstone fracturing and rock falls (nature and extent of surface tension cracks and rock ledge collapse, compared against the land subsidence impact performance indicator).</li> </ul>
BMP	Upland Swamps – Vegetation	<p><i>Longwalls 301-303</i></p> <ul style="list-style-type: none"> <li>Swamps 38, 40, 41, 46, 47, 48, 49, 50, 51/52, 53 and 58.</li> <li>Control Swamps 101, 111a, 125, 135, 136, 137a, 137b and 138.</li> </ul> <p><i>Previous Longwalls</i></p> <ul style="list-style-type: none"> <li>Swamps 16, 17, 19, 20, 24, 25, 30, 31, 32, 33, 34, 35, 36 and 95.</li> </ul>	<ul style="list-style-type: none"> <li>Visual inspections bi-annually in spring and autumn.</li> </ul>	<ul style="list-style-type: none"> <li>Cracking of exposed bedrock areas and/or swamp substrate.</li> <li>Areas of increased erosion, particularly along any existing drainage line.</li> <li>Any changes in water colour, particularly evidence of iron precipitation.</li> <li>Changes in vegetation condition, including areas of stressed vegetation (i.e. plants that demonstrate symptoms of stress) and dead/dying plants that appear unusual.</li> <li>Whether the amount of seepage (at the terminal step/over exposed surfaces of the swamp) at the time of inspection appears unusual (relative to recent rainfall).</li> </ul>
		<p><i>Longwalls 301-303</i></p> <ul style="list-style-type: none"> <li>Swamps 40, 41, 46, 51/52 and 53.</li> <li>Control Swamps 101, 135, 136, 137a and 137b.</li> </ul> <p><i>Previous Longwalls</i></p> <ul style="list-style-type: none"> <li>Swamps 16, 17, 18, 20, 24 and 25 (Longwalls 20-22).</li> <li>Swamps 28, 30, 33, 35 and 94 (Longwalls 23-27).</li> <li>Control Swamps 101, 111a, 125, 135, 136, 137a, 137b, 138, Bee Creek Swamp, Woronora River 1, Woronora River south arm and Dahlia Swamp.</li> </ul>	<ul style="list-style-type: none"> <li>Transect and quadrat monitoring bi-annually in spring and autumn.</li> </ul>	<ul style="list-style-type: none"> <li>Vegetation structure.</li> <li>Dominant species.</li> <li>Estimated cover and height for each stratum.</li> <li>Full floristics.</li> <li>Estimated cover abundance for each species using seven point Braun-Blanquet scale.</li> <li>Condition/health rating for each species in the quadrat.</li> </ul>



**Table 5 (Continued)**  
**Subsidence Impact and Environmental Consequences Monitoring Components**

Extraction Plan	Aspect	Sites	Frequency	Parameters / Purpose
BMP (continued)	Upland Swamps - Vegetation (Cont.)	<p><i>Longwalls 301-303</i></p> <ul style="list-style-type: none"> <li>Twenty tagged individuals (<i>Epacris obtusifolia</i> and <i>Sprengelia incarnata</i>) in each of Swamps 40 and 53.</li> <li>Twenty tagged individuals (<i>Epacris obtusifolia</i>) in each of Control Swamps 101, 136 and 137a.</li> <li>Twenty tagged individuals (<i>Sprengelia incarnata</i>) in each of Control Swamps 101, 136 and 137b.</li> </ul>	<ul style="list-style-type: none"> <li>Indicator species monitoring bi-annually in spring and autumn.</li> </ul>	<ul style="list-style-type: none"> <li>Population monitoring data including condition/health rating for each plant and reproductive rating.</li> </ul>
		<p><i>Previous Longwalls</i></p> <ul style="list-style-type: none"> <li>Twenty tagged individuals (<i>Epacris obtusifolia</i>) in each of Swamps 18, 24 and 25 (Longwalls 20-22) and Control Swamps 101, 111a and 125.</li> <li>Twenty tagged individuals (<i>Epacris obtusifolia</i>) in each of Swamps 19, 30, 33, 35 and 94 (Longwalls 23-27) and Control Swamps 135, 136, 137a, 137b and 138.</li> <li>Twenty tagged individuals (<i>Sprengelia incarnata</i>) in each of Swamps 24 (Longwalls 20-22) and Control Swamps 101 and 125.</li> <li>Twenty tagged individuals (<i>Sprengelia incarnata</i>) in each of Swamps 19, 33, 35 and 94 (Longwalls 23-27) and Control Swamps 135, 136, 137a and 138.</li> <li>Twenty tagged individuals (<i>Pultenaea aristata</i>) in each of Swamps 18, 24 and 25 (Longwalls 20-22) and Control Swamps 101 and 111a.</li> </ul>	<ul style="list-style-type: none"> <li>Indicator species monitoring bi-annually in spring and autumn.</li> </ul>	<ul style="list-style-type: none"> <li>Population monitoring data including condition/health rating for each plant and reproductive rating.</li> </ul>

**Table 5 (Continued)**  
**Subsidence Impact and Environmental Consequences Monitoring Components**

Extraction Plan	Aspect	Sites	Frequency	Parameters / Purpose
BMP (continued)	Upland Swamps - Vegetation (Cont.)	<p><i>Previous Longwalls (Cont.)</i></p> <ul style="list-style-type: none"> <li>Twenty tagged individuals (<i>Pultenaea aristata</i>) in each of Swamps 19, 30, 33, 35 and 94 (Longwalls 23-27) and Control Swamps 135, 136, 137a and 138.</li> <li>Twenty tagged individuals (<i>Banksia robur</i>, <i>Callistemon citrinus</i> and <i>Leptospermum juniperinum</i>) in each of Swamps 20 (Longwalls 20-22) and Control Swamps Woronora River 1, Woronora River south arm and Dahlia Swamp.</li> <li>Twenty tagged individuals (<i>Banksia robur</i> and <i>Callistemon citrinus</i>) in each of Swamps 28 (Longwalls 23-27) and Control Swamps Woronora River 1, Woronora River south arm and Dahlia Swamp.</li> </ul>	<ul style="list-style-type: none"> <li>Indicator species monitoring bi-annually in spring and autumn.</li> </ul>	<ul style="list-style-type: none"> <li>Population monitoring data including condition/health rating for each plant and reproductive rating.</li> </ul>
	Upland Swamps - Groundwater	<p><i>Longwalls 301-303</i></p> <ul style="list-style-type: none"> <li>Paired piezometers (i.e. one swamp substrate piezometer to a depth of approximately 1 m and one sandstone piezometer to a depth of approximately 10 m) in Swamps 40, 41, 46, 51, 52 and 53.</li> </ul> <p><i>Previous Longwalls</i></p> <ul style="list-style-type: none"> <li>Swamp substrate monitoring in Swamps 20 and 25 (Longwalls 20-22).</li> <li>Swamp substrate monitoring in Swamps 28, 30, 33 and 35 (Longwalls 23-27).</li> <li>Swamp substrate monitoring in Control Swamps 101, 137a, 137b, Bee Creek Swamp and Woronora River 1.</li> </ul>	<ul style="list-style-type: none"> <li>Datalogger (continuous).</li> </ul>	<ul style="list-style-type: none"> <li>Groundwater levels.</li> </ul>

**Table 5 (Continued)**  
**Subsidence Impact and Environmental Consequences Monitoring Components**

Extraction Plan	Aspect	Sites	Frequency	Parameters / Purpose
BMP (Cont.)	Riparian Vegetation	<ul style="list-style-type: none"> <li>Sites MRIP01 to MRIP12.</li> </ul>	<ul style="list-style-type: none"> <li>Visual inspections bi-annually in spring and autumn.</li> </ul>	<ul style="list-style-type: none"> <li>Areas of new water ponding.</li> <li>Any cracking or rock displacement.</li> <li>Changes in vegetation condition, including areas of stressed vegetation that appear unusual.</li> </ul>
		<ul style="list-style-type: none"> <li>Sites MRIP01 to MRIP08, MRIP11 and MRIP12.</li> </ul>	<ul style="list-style-type: none"> <li>Permanent quadrat (20 m x 2 m) monitoring bi-annually in spring and autumn.</li> </ul>	<ul style="list-style-type: none"> <li>Vegetation structure.</li> <li>Dominant species.</li> <li>Estimated cover and height for each stratum.</li> <li>Full floristics.</li> <li>Estimated cover abundance for each species using seven point Braun-Blanquet scale.</li> <li>Condition/health rating for each species in the quadrat.</li> </ul>
		<ul style="list-style-type: none"> <li>Existing tagged individuals (<i>Prostanthera linearis</i>, <i>Schoenus melanostachys</i> and <i>Lomatia myricoides</i>) at sites MRIP01 to MRIP12.</li> </ul>	<ul style="list-style-type: none"> <li>Indicator species monitoring bi-annually in spring and autumn.</li> </ul>	<ul style="list-style-type: none"> <li>Population monitoring data including condition/health rating for each plant and reproductive rating.</li> </ul>
	Aquatic Biota and their Habitats	<ul style="list-style-type: none"> <li>Surface water resources and watercourses in accordance with the WMP.</li> </ul>	<ul style="list-style-type: none"> <li>In accordance with the WMP.</li> </ul>	<ul style="list-style-type: none"> <li>Monitoring of aquatic habitats in accordance with the WMP.</li> </ul>
		<ul style="list-style-type: none"> <li>Stream monitoring at following Locations (if sufficient aquatic habitat is available for sampling); <ul style="list-style-type: none"> <li>WT3, WT4, WT5, ET1, ET2, ET3, ET4, B1 and B2.</li> <li>Control Locations: WR1; OC; BC; and WOT.</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>Sites WT3, WT4, WT5, ET1, ET2, ET3, ET4, WR1 and OC biannually in spring (15 September to 15 December) and autumn (15 March to 15 June).</li> <li>Sites B1, B2, BC and WOT bi-annually in spring (15 September to 15 December) and autumn (15 March to 15 June) up to and including spring 2018, and thereafter every 3 years in autumn and spring (i.e. next surveys to be conducted in autumn and spring 2021).</li> </ul>	Impacts on aquatic ecology: <ul style="list-style-type: none"> <li>Habitat Characteristics.</li> <li>Water Quality.</li> <li>Aquatic Macroinvertebrates.</li> <li>Aquatic Macrophytes.</li> </ul>

**Table 5 (Continued)**  
**Subsidence Impact and Environmental Consequences Monitoring Components**

Extraction Plan	Aspect	Sites	Frequency	Parameters / Purpose
BMP (Cont.)	Aquatic Biota and their Habitats	<ul style="list-style-type: none"> <li>Pool monitoring at the following Pools: <ul style="list-style-type: none"> <li>Larger pools J, M1, N and ETAH.</li> <li>Larger control pools (Pool WP and Pool OC).</li> <li>Smaller pools K, L, M, ETAG, ETAI and ETAK.</li> <li>Smaller control pools (Pools WP-A, WP-B, WP-C, OC-A, OC-B and OC-C).</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>Biannually in spring (15 September to 15 December) and autumn (15 March to 15 June) if sufficient aquatic habitat is available for sampling).</li> </ul>	<p>The response of aquatic ecosystems to the implementation of potential future stream remediation works:</p> <ul style="list-style-type: none"> <li>Habitat Characteristics.</li> <li>Water Quality.</li> <li>Aquatic Macroinvertebrates.</li> <li>Aquatic Macrophytes.</li> </ul>
	Amphibian Monitoring	<p><i>Longwalls 301-303</i></p> <ul style="list-style-type: none"> <li>Sites 23-28.</li> </ul> <p><i>Previous Longwalls</i></p> <ul style="list-style-type: none"> <li>Sites 1-6 (Longwalls 20-22) and 13-17 (Longwalls 23-27).</li> <li>Control Sites 7, 8, 9, 10, 11, 12, 18, 19, 20, 21 and 22.</li> </ul>	<ul style="list-style-type: none"> <li>Survey annually in spring/ summer (i.e. October to February) during suitable weather conditions.</li> </ul>	<ul style="list-style-type: none"> <li>Species assigned to relative abundance categories for tadpole and adult stages.</li> </ul>
WMP	Stream Features	<ul style="list-style-type: none"> <li>The Eastern Tributary from full supply level of the Woronora Reservoir to the maingate of Longwall 26.</li> <li>The Waratah Rivulet from Pool P to the full supply level of the Woronora Reservoir.</li> </ul>	<ul style="list-style-type: none"> <li>Visual inspection and photographic survey of the Eastern Tributary conducted monthly when mining is within 400 m of the stream.</li> <li>Visual inspection and photographic survey of the Waratah Rivulet within 3 months of the completion of each longwall.</li> <li>Weekly monitoring at pools observed with gas releases on the Eastern Tributary and Waratah Rivulet, until no gas releases have been observed at the pool for three consecutive weeks.</li> </ul>	<ul style="list-style-type: none"> <li>Location, approximate dimensions (length, width and depth), and orientation of surface cracks (specifically whether cracks are developed perpendicular to the stream flow or are controlled by rock joints or other factors, etc.).</li> <li>Nature of iron staining (e.g. whether isolated or across the entire streambed).</li> <li>Extent of iron staining (e.g. the length of stream affected).</li> <li>Description of gas release (e.g. isolated bubbles or continuous stream, and type of gas [methane or carbon dioxide]).</li> <li>Nature of scouring, for example the depth of scouring, type of soil exposed, any obvious vegetation impact, potential for severe erosion, etc.</li> <li>Water discoloration or opacity if present.</li> <li>Rock bar characteristics such as extent of cracking, seepage, underflow.</li> </ul>

**Table 5 (Continued)**  
**Subsidence Impact and Environmental Consequences Monitoring Components**

Extraction Plan	Aspect	Sites	Frequency	Parameters / Purpose
WMP (Cont.)	Surface Water Flow	<ul style="list-style-type: none"> <li>Eastern Tributary (GS 300078).</li> <li>Waratah Rivulet (GS 2132102).</li> <li>Woronora Reservoir Sub-catchment I (GS 300092).</li> <li>Woronora Reservoir Sub-catchment K (GS 300093).</li> </ul> <p><i>Control Sites</i></p> <ul style="list-style-type: none"> <li>Woronora River (GS 2132101).</li> <li>Honeysuckle Creek (GS 300077).</li> <li>O'Hares Creek (GS 213200).</li> </ul>	<ul style="list-style-type: none"> <li>Continuous (downloaded monthly).</li> </ul>	<ul style="list-style-type: none"> <li>Stream flow data.</li> </ul>
	Pool Water Levels and Drainage Behaviour	<ul style="list-style-type: none"> <li>Eastern Tributary Pools ETG, ETJ, ETM, ETU, ETW, ETAF, ETAG, ETAH, ETAI, ETAT, ETAQ and ETAU.</li> <li>Waratah Rivulet Pools A, F, J, K, L, M, N, O, P, Q, R, S, T, U, V and W.</li> </ul> <p><i>Control Sites</i></p> <ul style="list-style-type: none"> <li>Woronora River Control Pools WRP1, WRP2, WRP3 and WRP4.</li> </ul>	<ul style="list-style-type: none"> <li>Continuous water level sensor and logger (downloaded monthly).</li> </ul>	<ul style="list-style-type: none"> <li>Pool water levels.</li> </ul>
		<ul style="list-style-type: none"> <li>Waratah Rivulet Pools B, C, E, G, G1, H and I.</li> </ul>	<ul style="list-style-type: none"> <li>Manually monitored daily, until such time that continuous sensors are installed.</li> </ul>	<ul style="list-style-type: none"> <li>Pool water levels.</li> </ul>
		<ul style="list-style-type: none"> <li>Pools on the Eastern Tributary situated downstream of the maingate of Longwall 26 to the full supply level of the Woronora Reservoir.</li> </ul>	<ul style="list-style-type: none"> <li>Visual inspections conducted weekly when mining is within 400 m of the stream.</li> </ul>	<ul style="list-style-type: none"> <li>Evidence of new cracking within the stream bed or rock bar.</li> <li>Whether the pools continue to flow over, through and/or below the rock bars (where relevant).</li> <li>Whether surface flow is evident along the length of the pools prior to flowing over/through/below the rock bars or boulder fields.</li> </ul>
		<ul style="list-style-type: none"> <li>Pools on the Waratah Rivulet from Pool P to the full supply level of the Woronora Reservoir.</li> </ul>	<ul style="list-style-type: none"> <li>Visual inspections conducted at the time of download (monthly).</li> </ul>	

**Table 5 (Continued)**  
**Subsidence Impact and Environmental Consequences Monitoring Components**

Extraction Plan	Aspect	Sites	Frequency	Parameters / Purpose
WMP (Cont.)	Stream Water Quality	<ul style="list-style-type: none"> <li>Eastern Tributary sites ETWQF, ETWQJ, ETWQN, ETWQU, ETWQW, ETWQAF, ETWQAH, ETWQAQ and ETWQAU.</li> <li>Waratah Rivulet sites WRWQ2, WRWQ6, WRWQ8, WRWQ9, WRWQM, WRWQN, WRWQP, WRWQR, WRWQT, WRWQU, WRWQV, and WRWQW.</li> <li>Tributary B site RTWQ1.</li> <li>Tributary D site UTWQ1.</li> <li>Far Eastern Tributary site FEWQ1.</li> <li>Honeysuckle Creek site HCWQ1.</li> <li>Bee Creek site BCWQ1.</li> </ul> <p><i>Control Sites</i></p> <ul style="list-style-type: none"> <li>Woronora River control sites WOWQ1 and WOWQ 2.</li> </ul>	<ul style="list-style-type: none"> <li>Monthly.</li> </ul>	<ul style="list-style-type: none"> <li>Water quality parameters as described in the WMP (samples collected for metal analysis to be field filtered).</li> </ul>
		<ul style="list-style-type: none"> <li>Eastern Tributary sites ETWQF, ETWQJ, ETWQN, ETWQAF and ETWQAQ.</li> <li>Waratah Rivulet sites WRWQ2, WRWQ6, WRWQ8, WRWQ9, WRWQM, WRWQN and WRWQP.</li> </ul> <p><i>Control Site</i></p> <ul style="list-style-type: none"> <li>Woronora River site WOWQ2.</li> </ul>	<ul style="list-style-type: none"> <li>Monthly.</li> </ul>	<ul style="list-style-type: none"> <li>Unfiltered water quality samples analysed for total iron.</li> </ul>
	Woronora, Nepean and Cataract Reservoir Water Quality	<ul style="list-style-type: none"> <li>Woronora Reservoir (site DW01).</li> <li>Nepean Reservoir.</li> <li>Cataract Reservoir.</li> </ul>	<ul style="list-style-type: none"> <li>As made available by Water NSW.</li> </ul>	<ul style="list-style-type: none"> <li>Total iron, total manganese and total aluminium.</li> </ul>
	Shallow Groundwater Levels Near Streams	<ul style="list-style-type: none"> <li>Eastern Tributary site ETGW1.</li> <li>Waratah Rivulet sites WRGW1, WRGW2 and WRGW7.</li> </ul>	<ul style="list-style-type: none"> <li>Data downloaded monthly; analysis on a six monthly basis.</li> </ul>	<ul style="list-style-type: none"> <li>Groundwater levels.</li> </ul>

**Table 5 (Continued)**  
**Subsidence Impact and Environmental Consequences Monitoring Components**

Extraction Plan	Aspect	Sites	Frequency	Parameters / Purpose
WMP (Cont.)	Groundwater Levels/Pressures	<ul style="list-style-type: none"> <li>Transect sites T1, T2, T3, T4, T5 and T6.</li> <li>Survey of water level from benchmark at end of Fire trail 1.</li> <li>Groundwater standpipes TBS02-80, TBS02-15 and bore TBS03-15.</li> </ul>	<ul style="list-style-type: none"> <li>Data downloaded/reading monthly.</li> <li>Analysis at the frequency described in the Longwalls 301-303 WMP.</li> </ul>	<ul style="list-style-type: none"> <li>Groundwater levels.</li> <li>Woronora Reservoir level.</li> </ul>
		<ul style="list-style-type: none"> <li>Site 9HGW0 (Longwall 10 Goaf Hole).</li> <li>Site 9EGW1B.</li> <li>Site 9FGW1A.</li> <li>Site 9GGW2B.</li> <li>Site 9HGW1B.</li> <li>Site PM02.</li> <li>Site 9GGW1-80.</li> <li>Site PM01 (9DGW1B).</li> <li>Site 9EGW2A.</li> <li>Site 9EGW2-4.</li> <li>Site PM03.</li> <li>Site PHGW1B.</li> <li>Site PHGW2A.</li> <li>Site F6GW3A.</li> <li>Site F6GW4A.</li> <li>Site 302GW01.</li> <li>Site TBS02-80.</li> <li>Site TBS02-250.</li> <li>Site TBS02-15.</li> <li>Site TBS03-230.</li> <li>Site TBS03-15.</li> </ul>	<ul style="list-style-type: none"> <li>Data downloaded monthly; analysis on a six monthly basis.</li> <li>Analysis at the frequency described in the Longwalls 301-303 WMP.</li> </ul>	<ul style="list-style-type: none"> <li>Groundwater levels.</li> <li>Groundwater levels/pressures.</li> </ul>
	Groundwater Quality	<ul style="list-style-type: none"> <li>Eastern Tributary site ETGW2.</li> <li>Waratah Rivulet sites WRGW1, WRGW2 and WRGW7.</li> </ul>	<ul style="list-style-type: none"> <li>Monthly.</li> </ul>	<ul style="list-style-type: none"> <li>Water quality parameters as described in the WMP (samples collected for metal analysis to be field filtered).</li> </ul>
	Mine Water Make	Underground	<ul style="list-style-type: none"> <li>Mine water balance inputs (as described in the WMP).</li> <li>Weekly statutory inspections.</li> </ul>	<ul style="list-style-type: none"> <li>Groundwater inflow to the mine (20 day average).</li> </ul>

**Table 5 (Continued)**  
**Subsidence Impact and Environmental Consequences Monitoring Components**

Extraction Plan	Aspect	Sites	Frequency	Parameters / Purpose
HMP	Aboriginal Heritage	<p><i>Longwalls 301-303</i></p> <ul style="list-style-type: none"> <li>Sites FRC 76 and FRC 117</li> </ul> <p><i>Previous Longwalls</i></p> <ul style="list-style-type: none"> <li>Sites MET 1, FRC 176, FRC 28, FRC 29, FRC 34 and FRC 60</li> </ul>	<ul style="list-style-type: none"> <li>Within three months of the completion of Longwall 303.</li> </ul>	<ul style="list-style-type: none"> <li>Inspections of rock surfaces for cracking and/or exfoliation and/or blockfall.</li> <li>Inspection of art motifs for damage or deterioration.</li> <li>Identification of any natural weathering processes that may result in deterioration (e.g. fire, vegetation growth and water seepage).</li> <li>Comparison of the physical characteristics of the site at the time of monitoring against the previous monitoring and the baseline record.</li> </ul>
BFMP-RMS	M1 Princes Motorway - Pavement	<p>Visual inspection for impacts on:</p> <ul style="list-style-type: none"> <li>Asphaltic concrete surface.</li> <li>Kerbs, gutters and pits.</li> <li>Signs or other road infrastructure.</li> </ul>	<p><i>Baseline:</i></p> <ul style="list-style-type: none"> <li>Prior to the commencement of Longwall 301 extraction.</li> </ul> <p><i>During mining:</i></p> <ul style="list-style-type: none"> <li>Following the completion of extraction of each Longwall 301, 302 and 303.</li> <li>Greater frequency if determined in consultation with the Technical Committee</li> <li>Network Safety Inspection twice weekly during the extraction of Longwalls 301-303.</li> <li>RoadCrack, Gipsicam and Laser Profilometer surveys in accordance with RMS inspection program.</li> </ul>	<p>To identify development of, or changes in existing:</p> <ul style="list-style-type: none"> <li>Asphaltic concrete surface including cracks, buckling and stepping.</li> <li>Kerbs and gutters including cracking, buckling and joint movement.</li> </ul>



**Table 5 (Continued)**  
**Subsidence Impact and Environmental Consequences Monitoring Components**

Extraction Plan	Aspect	Sites	Frequency	Parameters / Purpose
BFMP-RMS	M1 Princes Motorway - Cuttings	Visual inspection for impacts on: <ul style="list-style-type: none"> <li>Cuttings along the M1 Princes Motorway as described in the BFMP-RMS.</li> </ul>	<i>Baseline:</i> <ul style="list-style-type: none"> <li>Prior to the commencement of Longwall 301 extraction.</li> </ul> <i>During mining:</i> <ul style="list-style-type: none"> <li>Following the completion of extraction of each Longwall 301, 302 and 303.</li> <li>Greater frequency if determined in consultation with the Technical Committee</li> <li>Network Safety Inspection twice weekly during the extraction of each Longwalls 301-303.</li> </ul>	To identify: <ul style="list-style-type: none"> <li>Changes in cutting condition, including opening of cracks, spalling.</li> <li>Changes in groundwater seepage or surface water flows.</li> <li>Rockfalls.</li> <li>Changes in RMS risk ranking.</li> </ul>
	M1 Princes Motorway - Culverts	<ul style="list-style-type: none"> <li>CCTV inspection for impacts on internal surfaces.</li> </ul>	<i>Baseline:</i> <ul style="list-style-type: none"> <li>Prior to the commencement of Longwall 301 extraction.</li> </ul> <i>During mining:</i> <ul style="list-style-type: none"> <li>Following the completion of extraction of each Longwall 301, 302 and 303 or more frequent if determined in consultation with the RMS Technical Committee.</li> </ul>	<ul style="list-style-type: none"> <li>To identify changes to the visible surfaces of the culverts including cracking, buckling, shearing, and collapse.</li> </ul>
	Bridge 2 (Old Princes Highway Underpass)	Visual inspection for impacts on: <ul style="list-style-type: none"> <li>Abutments.</li> <li>Pier frames.</li> <li>Elastomeric bearings.</li> <li>Soffits of girders.</li> <li>Deck expansion joints.</li> <li>Steel traffic barrier joints.</li> <li>Other areas of substructure and adjoining areas including concrete paths, stairs, and slope protection.</li> </ul>	<ul style="list-style-type: none"> <li>Following the completion of each Longwall 301, 302 and 303.</li> <li>Greater frequency if determined in consultation with the Technical Committee.</li> </ul>	To identify development of, or changes in existing: <ul style="list-style-type: none"> <li>Surface cracks.</li> <li>Closing or opening of joints.</li> <li>Distortion or damage to elastomeric bearings.</li> </ul>

**Table 5 (Continued)**  
**Subsidence Impact and Environmental Consequences Monitoring Components**

Extraction Plan	Aspect	Sites	Frequency	Parameters / Purpose
BFMP-RMS (Cont.)	Cawley Road Overbridge	Visual inspection for impacts on: <ul style="list-style-type: none"> <li>• Abutments.</li> <li>• Pier blade wall.</li> <li>• Tetron bearings.</li> <li>• Deck expansion joints.</li> <li>• Steel traffic barrier and safety screen joints.</li> </ul>	<ul style="list-style-type: none"> <li>• Following completion of each Longwall 301, 302 and 303.</li> <li>• Greater frequency if determined in consultation with the RMS Technical Committee.</li> </ul>	To identify development of, or changes in existing: <ul style="list-style-type: none"> <li>• Surface cracks.</li> <li>• Closing or opening of joints.</li> <li>• Distortion or damage to Tetron bearings.</li> </ul>
BFMP-WCC	Old Princes Highway - Pavement	From the Old Princes Highway Underpass (Bridge 2) to the entrance to the Garrawarra Centre Complex.	<p><i>Baseline</i></p> <ul style="list-style-type: none"> <li>• Prior to the commencement of Longwall 302 extraction, as otherwise agreed with WCC.</li> </ul> <p><i>During Mining</i></p> <ul style="list-style-type: none"> <li>• Progress monitoring (visual inspections) to occur as longwall face within 400 m passing under asset.</li> <li>• Within 3 months following the completion of extraction of each Longwall 302 and 303.</li> <li>• Routinely as per WCC inspections (quarterly).</li> </ul>	<ul style="list-style-type: none"> <li>• Impacts to the surface including cracks, buckling and stepping.</li> </ul>
	Old Princes Highway – Drainage Structures (Pipe/Culverts) and Other Furniture	Drainage structures and other furniture within the Study Area.	<p><i>Baseline</i></p> <ul style="list-style-type: none"> <li>• Prior to the commencement of Longwall 302 extraction, as agreed with WCC.</li> </ul> <p><i>During Mining</i></p> <ul style="list-style-type: none"> <li>• Progress monitoring (visual inspections) to occur as longwall face within 400 m of passing under asset.</li> <li>• Within 3 months following the completion of extraction of each Longwall 302 and 303.</li> <li>• Routinely as per WCC inspections.</li> </ul>	<ul style="list-style-type: none"> <li>• Impacts to the visible surfaces of pipes/culverts including cracking, buckling, shearing, and collapse.</li> <li>• Visible impacts to furniture.</li> </ul>

**Table 5 (Continued)**  
**Subsidence Impact and Environmental Consequences Monitoring Components**

Extraction Plan	Aspect	Sites	Frequency	Parameters / Purpose
BFMP- Endeavour Energy	132 kV Towers	<ul style="list-style-type: none"> <li>Towers T7 to T13.</li> </ul>	<p><i>Baseline</i></p> <ul style="list-style-type: none"> <li>Prior to the commencement of Longwall 301 extraction.</li> </ul> <p><i>During mining</i></p> <ul style="list-style-type: none"> <li>Within 3 months following the completion of extraction of each Longwall 301, 302 and 303.</li> <li>More frequently (e.g. weekly) at each tower within 400 m of the active longwall face.</li> <li>Routinely as per Endeavour Energy inspections (annual ground inspection, six yearly climbing inspection).</li> <li>At any time in case of fault or emergency.</li> </ul>	<ul style="list-style-type: none"> <li>Degradation of tower structure.</li> <li>Degradation of tower foundations/footings.</li> <li>Movement of insulator strings.</li> </ul>
	132 kV Transmission Lines	<ul style="list-style-type: none"> <li>Lines from Towers T7 to T13.</li> <li>Ground survey.</li> <li>Climbing inspection.</li> </ul>	<p><i>Baseline</i></p> <ul style="list-style-type: none"> <li>Prior to the commencement of Longwall 301 extraction.</li> </ul> <p><i>During mining</i></p> <ul style="list-style-type: none"> <li>Within 3 months following the completion of extraction of each Longwall 301, 302 and 303.</li> <li>Routinely as per Endeavour Energy inspections (annual ground inspection, six yearly climbing inspection).</li> <li>At any time in case of fault or emergency.</li> </ul>	<ul style="list-style-type: none"> <li>Vegetation clearance.</li> <li>Land clearance.</li> <li>Road clearance.</li> <li>Integrity and function of support clamps or other items.</li> </ul>
	Poles	<ul style="list-style-type: none"> <li>Timber poles within the Study Area.</li> </ul>	<ul style="list-style-type: none"> <li>Prior to the commencement of Longwall 301 extraction.</li> <li>Within 3 months following the completion of extraction of Longwalls 301-303.</li> <li>Routinely as per Endeavour Energy inspections.</li> <li>At any time in case of fault or emergency.</li> </ul>	<ul style="list-style-type: none"> <li>Degradation of structure.</li> <li>Movement of conductors.</li> </ul>

**Table 5 (Continued)**  
**Subsidence Impact and Environmental Consequences Monitoring Components**

Extraction Plan	Aspect	Sites	Frequency	Parameters / Purpose
BFMP- Endeavour Energy (Cont.)	High Voltage Powerlines	<ul style="list-style-type: none"> <li>Powerlines within Study Area.</li> <li>Ground survey.</li> </ul>	<ul style="list-style-type: none"> <li>Prior to the commencement of Longwall 301 extraction.</li> <li>Within 3 months following the completion of extraction of Longwalls 301-303.</li> <li>Routinely as per Endeavour Energy inspections.</li> <li>At any time in case of fault or emergency.</li> </ul>	<ul style="list-style-type: none"> <li>Vegetation clearance.</li> <li>Land clearance.</li> <li>Road clearance.</li> <li>Integrity and function of support clamps or other items.</li> </ul>
	Access Roads/Tracks	<ul style="list-style-type: none"> <li>Within 600 m of Longwalls 301-303 extraction.</li> </ul>	<ul style="list-style-type: none"> <li>Prior to the commencement of Longwall 301 extraction.</li> <li>Within 3 months following the completion of extraction of Longwalls 301-303.</li> <li>Visual observations during catchment visits as per the Longwalls 301-303 LMP.</li> <li>Routinely as per Endeavour Energy inspections.</li> </ul>	<ul style="list-style-type: none"> <li>Surface cracks, buckling and general safety.</li> </ul>
BFMP- TransGrid	330 kV Towers	<ul style="list-style-type: none"> <li>Towers TL11-103 to TL11-108.</li> </ul>	<ul style="list-style-type: none"> <li>Prior to the commencement of Longwall 301 extraction.</li> <li>Weekly at each tower within 400 m of the active longwall face (or at an increased frequency for TL11-107 and TL11-108 as determined in consultation with TransGrid during the first month of mining Longwalls 301, 302 and 303).</li> <li>Within 3 months following the completion of extraction of Longwalls 301-303.</li> <li>Routinely as per TransGrid inspections (annual ground inspection, six yearly climbing inspection).</li> <li>At any time in case of fault or emergency.</li> </ul>	<ul style="list-style-type: none"> <li>Degradation of tower structure.</li> <li>Degradation of tower foundations/footings.</li> <li>Movement of insulator strings.</li> <li>Visual check by TransGrid of earthwire/OPGW and conductor movement.</li> <li>Calculation of differential leg movement (TransGrid to be notified if total differential movement exceeds 4 mm).</li> </ul>
	330 kV Transmission Lines	<ul style="list-style-type: none"> <li>Line from Towers TL11-103 to TL11-108.</li> <li>Ground survey.</li> <li>Climbing inspection.</li> </ul>	<ul style="list-style-type: none"> <li>Routinely as per TransGrid inspections (annual ground inspection, six yearly climbing inspection).</li> <li>At any time in case of fault or emergency.</li> </ul>	<ul style="list-style-type: none"> <li>Vegetation clearance.</li> <li>Land clearance.</li> <li>Road clearance.</li> <li>Integrity and function of support clamps or other items.</li> </ul>

**Table 5 (Continued)**  
**Subsidence Impact and Environmental Consequences Monitoring Components**

Extraction Plan	Aspect	Sites	Frequency	Parameters / Purpose
BFMP-TransGrid (Cont.)	Access Roads/Tracks	<ul style="list-style-type: none"> <li>Within 600 m of Longwalls 301-303 extraction.</li> </ul>	<ul style="list-style-type: none"> <li>Prior to the commencement of Longwall 301 extraction.</li> <li>Within 3 months following the completion of extraction of Longwalls 301-303.</li> <li>Visual observations during catchment visits as per the Longwalls 301-303 LMP.</li> <li>Routinely as per TransGrid inspections.</li> </ul>	<ul style="list-style-type: none"> <li>Surface cracks, buckling and general safety.</li> </ul>
BFMP-Telstra	Fibre Optic Cable line 1 and associated pits	<ul style="list-style-type: none"> <li>Within 600 m of Longwalls 301-303 extraction.</li> </ul>	<ul style="list-style-type: none"> <li>Weekly physical inspection for the period covering 100 m prior to undermining the cable to 400 m past the cable line.</li> </ul>	<ul style="list-style-type: none"> <li>Movement of conduit, degree of freedom of cable in conduit, ground compression / tension.</li> </ul>
		<ul style="list-style-type: none"> <li>Point loss or area of loss within 600 m of Longwalls 301-303 extraction.</li> </ul>	<ul style="list-style-type: none"> <li>If Remote Fibre Monitoring System (RFMS) records loss event <math>\pm 0.3</math> dB; or exceeds <math>\pm 1.0</math> dB.</li> </ul>	<ul style="list-style-type: none"> <li>Movement of conduit, degree of freedom of cable in conduit, ground compression / tension.</li> </ul>
	Fibre Optic Cable line 2 and associated pits	<ul style="list-style-type: none"> <li>Within 600 m of Longwalls 301-303 extraction.</li> </ul>	<ul style="list-style-type: none"> <li>Weekly physical inspection (during commencing 400 m of extraction from Longwalls 302 and 303).</li> </ul>	<ul style="list-style-type: none"> <li>Movement of conduit, degree of freedom of cable in conduit, ground compression / tension.</li> </ul>
		<ul style="list-style-type: none"> <li>Point loss or area of loss within 600 m of Longwalls 301-303 extraction.</li> </ul>	<ul style="list-style-type: none"> <li>If RFMS records loss event <math>\pm 0.3</math> dB; or exceeds <math>\pm 1.0</math> dB.</li> </ul>	<ul style="list-style-type: none"> <li>Movement of conduit, degree of freedom of cable in conduit, ground compression / tension.</li> </ul>
	Telecommunications Tower (and compound)	<ul style="list-style-type: none"> <li>Tower.</li> </ul>	<p><i>Baseline</i></p> <ul style="list-style-type: none"> <li>Prior to the commencement of Longwall 302 extraction.</li> </ul> <p><i>During Mining</i></p> <ul style="list-style-type: none"> <li>Weekly on commencement of mining Longwalls 302 and 303.</li> <li>Within 3 months following the completion of extraction of Longwalls 301-303.</li> </ul>	<ul style="list-style-type: none"> <li>Structural integrity of the telecommunications tower and compound.</li> </ul>
Access Roads/Tracks	<ul style="list-style-type: none"> <li>Within 600 m of Longwalls 301-303 extraction.</li> </ul>	<p><i>Baseline</i></p> <ul style="list-style-type: none"> <li>Prior to the commencement of Longwall 301 extraction.</li> </ul> <p><i>During Mining</i></p> <ul style="list-style-type: none"> <li>Following the completion of extraction of Longwalls 301-303.</li> <li>Visual observations during catchment visits as per the Longwalls 301-303 LMP.</li> </ul>	<ul style="list-style-type: none"> <li>Surface cracks, buckling and general safety.</li> </ul>	

**Table 5 (Continued)**  
**Subsidence Impact and Environmental Consequences Monitoring Components**

Extraction Plan	Aspect	Sites	Frequency	Parameters / Purpose
BFMP-Axicom	Telecommunications Towers (and compounds)	<ul style="list-style-type: none"> <li>Towers and compounds.</li> </ul>	<p><i>Baseline</i></p> <ul style="list-style-type: none"> <li>Prior to the commencement of Longwall 302 extraction</li> </ul> <p><i>During Mining</i></p> <ul style="list-style-type: none"> <li>Weekly on commencement of Longwalls 302 and 303 until subsidence reduces below level of survey accuracy</li> </ul>	<ul style="list-style-type: none"> <li>Structural integrity of the telecommunications tower and compound.</li> </ul>
	Access Roads/Tracks	<ul style="list-style-type: none"> <li>Within 600 m of Longwalls 301-303 extraction.</li> </ul>	<p><i>Baseline</i></p> <ul style="list-style-type: none"> <li>Prior to the commencement of Longwall 301 extraction</li> </ul> <p><i>During Mining</i></p> <ul style="list-style-type: none"> <li>Following the completion of extraction of Longwalls 301-303.</li> <li>Visual observations during catchment visits as per the Longwalls 301-303 LMP.</li> </ul>	<ul style="list-style-type: none"> <li>Surface cracks, buckling and general safety.</li> </ul>
BFMP-Sydney Trains	Telecommunications Tower (and compound)	<ul style="list-style-type: none"> <li>Tower and compound.</li> </ul>	<p><i>Baseline</i></p> <ul style="list-style-type: none"> <li>Prior to the commencement of Longwall 302 extraction (or as otherwise agreed with Sydney Trains).</li> </ul> <p><i>During Mining</i></p> <ul style="list-style-type: none"> <li>Weekly on commencement of Longwall 302 and 303 until subsidence reduces below level of survey accuracy.</li> <li>Within 3 months following the completion of extraction of Longwalls 301, 302 and 303.</li> </ul>	<ul style="list-style-type: none"> <li>Structural integrity of the telecommunications tower and compound.</li> </ul>
	Illawarra Railway	<ul style="list-style-type: none"> <li>Wilsons Creek</li> <li>Cawley Creek</li> </ul>	<p><i>Baseline</i></p> <ul style="list-style-type: none"> <li>Prior to Longwall 301 extraction.</li> </ul> <p><i>During Mining</i></p> <ul style="list-style-type: none"> <li>Commencing prior to Longwall 303.</li> </ul>	<ul style="list-style-type: none"> <li>Signs of any far field subsidence during mining (valley closure monitoring), using continuous remote survey with GNSS telemetry during mining.</li> </ul>
	Railway Culverts	<ul style="list-style-type: none"> <li>Wilsons Creek</li> <li>Cawley Creek</li> </ul>	<p><i>Baseline</i></p> <ul style="list-style-type: none"> <li>Prior to Longwall 301 extraction.</li> </ul> <p><i>During Mining</i></p> <ul style="list-style-type: none"> <li>Mid panel and end of panel surveys.</li> </ul>	<ul style="list-style-type: none"> <li>Survey monitoring and visual inspection to record signs of change.</li> </ul>
	Access roads/tracks	<ul style="list-style-type: none"> <li>Access roads/tracks</li> </ul>	<p><i>Baseline</i></p> <ul style="list-style-type: none"> <li>Prior to Longwall 302 extraction.</li> </ul> <p><i>During Mining</i></p> <ul style="list-style-type: none"> <li>On commencement of LW302 and LW303.</li> </ul>	<ul style="list-style-type: none"> <li>Surface cracks, buckling and general safety.</li> </ul>

**Table 5 (Continued)**  
**Subsidence Impact and Environmental Consequences Monitoring Components**

Extraction Plan	Aspect	Sites	Frequency	Parameters / Purpose
BFMP-Sydney Water	Water pipelines	<ul style="list-style-type: none"> <li>Water Main 1</li> <li>Water Main 2</li> </ul>	<ul style="list-style-type: none"> <li>Prior to the commencement of Longwall 301 extraction.</li> <li>Routinely as per Sydney Water inspections.</li> <li>Weekly when active longwall face within 400m of pipeline for Longwall 302 and 303</li> <li>Following the completion of extraction of Longwalls 301, 302 and 303.</li> </ul>	<ul style="list-style-type: none"> <li>Surface ground cracks.</li> <li>Cracks or leaks in the pipelines.</li> <li>Fittings can be accessed beneath surface covers and are operable.</li> </ul>
BFMP-Vocus	Fibre Optic Cable line and/or joint housing pit	<ul style="list-style-type: none"> <li>Point loss or area of loss within 600 m of Longwalls 301-303 extraction.</li> </ul>	<ul style="list-style-type: none"> <li>If RFMS records loss event <math>\pm 0.3</math> dB; <math>\pm 0.5</math> dB; or exceeds <math>\pm 1.0</math> dB.</li> </ul>	<ul style="list-style-type: none"> <li>Movement of conduit, degree of freedom of cable in conduit, ground compression / tension.</li> </ul>
	Access Roads/Tracks	<ul style="list-style-type: none"> <li>Within 600 m of Longwalls 301-303 extraction.</li> </ul>	<p><i>Baseline</i></p> <ul style="list-style-type: none"> <li>Prior to the commencement of Longwall 301 extraction.</li> </ul> <p><i>During Mining</i></p> <ul style="list-style-type: none"> <li>Following the completion of extraction of Longwalls 301-303.</li> </ul>	<ul style="list-style-type: none"> <li>Surface cracks, buckling and general safety.</li> </ul>
BFMP-Optus	Fibre Optic Cables	<ul style="list-style-type: none"> <li>Within 600 m of Longwalls 301-303 extraction.</li> </ul>	<ul style="list-style-type: none"> <li>Prior to commencement of Longwall 302</li> <li>Weekly when within 400m of active longwall face</li> <li></li> </ul>	
	Cable lines and associated pits	<ul style="list-style-type: none"> <li>Point loss or area of loss within 600 m of Longwalls 301-303 extraction.</li> </ul>	<ul style="list-style-type: none"> <li>If RFMS records loss event exceeds greater than 4.5 dB.</li> </ul>	<ul style="list-style-type: none"> <li>Signal integrity.</li> <li>Movement of conduit, degree of freedom of cable in conduit, ground compression / tension.</li> </ul>
	Access Roads/Tracks	<ul style="list-style-type: none"> <li>Within 600 m of Longwalls 301-303 extraction.</li> </ul>	<ul style="list-style-type: none"> <li>Prior to the commencement of Longwall 301 extraction.</li> <li>Visual observations as part of routine works and inspections.</li> <li>Following the completion of extraction of Longwalls 301-303.</li> </ul>	<ul style="list-style-type: none"> <li>Surface cracks, buckling and general safety.</li> </ul>
BFMP-Garrawarra	Garrawarra Centre Complex - Derelict Buildings	<ul style="list-style-type: none"> <li>Former Male Wards (Building A01a-i and A01a-v).</li> <li>Laundry / Boilerhouse, (Building B03a).</li> <li>Seamstress (Building B03d).</li> <li>Houses (B04a-B09a).</li> <li>Former Female Wards (Building B02c).</li> </ul>	<ul style="list-style-type: none"> <li>External inspection only due to degraded state of derelict buildings</li> <li>Prior to the commencement of Longwall 302 extraction.</li> <li>Within 3 months following the completion of extraction of Longwalls 302-303.</li> </ul>	<ul style="list-style-type: none"> <li>Structural integrity changes.</li> <li>Cracking.</li> </ul>

**Table 5 (Continued)**  
**Subsidence Impact and Environmental Consequences Monitoring Components**

Extraction Plan	Aspect	Sites	Frequency	Parameters / Purpose
BFMP-Garrawarra (Cont.)	Garrawarra Centre Complex – Occupied Buildings	<ul style="list-style-type: none"> <li>Palmer House (A09a).</li> <li>Building structures (B01a-B01e).</li> <li>Administration / Kitchen Group (Buildings B02a and B02b).</li> </ul>	<ul style="list-style-type: none"> <li>Prior to the commencement of Longwall 302 extraction, as agreed with NSW Health.</li> <li>Within 3 months following the completion of extraction of Longwalls 302-303.</li> </ul>	<ul style="list-style-type: none"> <li>Structural integrity.</li> <li>Cracking at pre-existing rock joints.</li> </ul>
	Garrawarra Centre Complex – Water Storage Tanks	<ul style="list-style-type: none"> <li>Water storage tanks (B14t01, B14t02, B16t01-B16t03, B17t01 and B18t01) and trickle filter tank (B15t01).</li> </ul>	<ul style="list-style-type: none"> <li>Prior to the commencement of Longwall 302 extraction</li> <li>Weekly visual inspection for B14t02 on commencement of Longwall 303 until wall has retreated away 400 m from tank.</li> <li>Within 3 months following the completion of extraction of Longwalls 301-303.</li> </ul>	<ul style="list-style-type: none"> <li>Structural integrity.</li> <li>New Leaks.</li> <li>Cracking in columns, elevated ring beam or central access shaft (B14t02). B14t02 is derelict structure and does not hold water.</li> </ul>
	Garrawarra Centre Complex – Gas Storage Tank	<ul style="list-style-type: none"> <li>Gas storage tank (B01t03).</li> </ul>	<ul style="list-style-type: none"> <li>Prior to the commencement of Longwall 302 extraction</li> <li>Within 3 months following the completion of extraction of Longwalls 302-303.</li> </ul>	<ul style="list-style-type: none"> <li>Structural integrity.</li> <li>Leaks.</li> </ul>
	Garrawarra Centre Complex – Kiln	<ul style="list-style-type: none"> <li>Kiln (F01b).</li> </ul>	<ul style="list-style-type: none"> <li>Prior to the commencement of Longwall 302 extraction.</li> <li>Weekly visual inspection on commencement of Longwall 302 and 303 until wall has retreated 400 m away from kiln chimney.</li> <li>Within 3 months following the completion of extraction of Longwalls 302-303.</li> </ul>	<ul style="list-style-type: none"> <li>Structural integrity of the kiln chimney.</li> </ul>
	Garrawarra Centre Complex – Other Services (Powerlines and Poles)	<ul style="list-style-type: none"> <li>Timber poles and powerlines.</li> </ul>	<ul style="list-style-type: none"> <li>Prior to the commencement of Longwall 302 extraction.</li> <li>Within 3 months following the completion of extraction of Longwalls 302-303.</li> <li>At any time in case of fault or emergency.</li> </ul>	<ul style="list-style-type: none"> <li>Degradation of structure.</li> <li>Movement of conductors.</li> <li>Vegetation clearance.</li> <li>Land clearance.</li> <li>Road clearance.</li> <li>Integrity and function of support clamps or other items.</li> </ul>
	Garrawarra Centre Complex – Other Services (Water Pipelines)	<ul style="list-style-type: none"> <li>Water pipelines within the Study Area.</li> </ul>	<ul style="list-style-type: none"> <li>Prior to the commencement of Longwall 302 extraction.</li> <li>Following the completion of extraction of Longwalls 302 and 303.</li> </ul>	<ul style="list-style-type: none"> <li>Surface ground cracks.</li> <li>Cracks or leaks in the pipelines.</li> <li>Fittings can be accessed beneath surface fittings and are operable.</li> </ul>



**Table 5 (Continued)**  
**Subsidence Impact and Environmental Consequences Monitoring Components**

Extraction Plan	Aspect	Sites	Frequency	Parameters / Purpose
BFMP-Garrawarra (Cont.)	Garrawarra Centre Complex – Private Roads and Access Roads/Tracks	<ul style="list-style-type: none"> <li>Within 600 m of Longwalls 301-303 extraction.</li> </ul>	<ul style="list-style-type: none"> <li>Prior to the commencement of Longwall 302 extraction.</li> <li>Within 3 months following the completion of extraction of Longwalls 302-303.</li> <li>Visual observations during catchment visits as per the Longwalls 301-303 LMP.</li> </ul>	<ul style="list-style-type: none"> <li>Surface cracks, buckling and general safety.</li> </ul>
BFMP-Cemetery	Waterfall General (Garrawarra) Cemetery site	<ul style="list-style-type: none"> <li>Within 600 m of Longwalls 301-303 extraction.</li> </ul>	<p><i>Baseline</i></p> <ul style="list-style-type: none"> <li>Prior to the commencement of Longwall 301 extraction.</li> </ul> <p><i>During Mining</i></p> <ul style="list-style-type: none"> <li>Following the completion of extraction of Longwalls 301-303.</li> </ul>	<ul style="list-style-type: none"> <li>Pre and post mining audits (photographic record and commentary).</li> <li>Surface cracks, buckling and general safety.</li> </ul>
	Access Roads/Tracks	<ul style="list-style-type: none"> <li>Within 600 m of Longwalls 301-303 extraction.</li> </ul>	<p><i>Baseline</i></p> <ul style="list-style-type: none"> <li>Prior to the commencement of Longwall 301 extraction.</li> </ul> <p><i>During Mining</i></p> <ul style="list-style-type: none"> <li>Following the completion of extraction of Longwalls 301-303.</li> <li>Visual observations during catchment visits as per the Longwalls 301-303 LMP.</li> </ul>	<ul style="list-style-type: none"> <li>Surface cracks, buckling and general safety.</li> </ul>

## 6.2 SUBSIDENCE PARAMETER MONITORING COMPONENTS

The components of the program to monitor subsidence parameters are illustrated in the Subsidence Monitoring Locations (Plan 7 prepared in accordance with the DP&E and DRE (2015) *Guidelines for the Preparation of Extraction Plans*) provided in Attachment 1 and described below.

### 6.2.1 '300 XL Line'

The location of '300 XL Line' is shown in Attachment 1. The line is located across and perpendicular to Longwalls 301 to 303 extending from the M1 Princes Motorway to the Woronora Reservoir full supply level.

The '300 XL Line' will be composed of survey marks established at a spacing of approximately 20 m (being less than 1/20<sup>th</sup> the mining depth). Survey marks will be comprised of either:

- concrete nails set in rock; or
- galvanised iron pipes, capped and punched.

Due to the practicalities of following existing tracks and steep terrain, bends in the survey line will have to be incorporated.

Prior to installation of the survey marks, consideration will be given to the presence of Aboriginal heritage sites and if detected the survey marks will be located so as to avoid these heritage sites.

The purpose of the '300 XL Line' is to measure the subsidence parameters (subsidence, tilt, strain) associated with extraction of each longwall panel and the cumulative subsidence parameters associated with overall extraction.

The frequency of monitoring the '300 XL Line' will be:

- within 3 months of the completion of each longwall panel (Longwalls 301, 302 and 303); and
- more frequently if directed by the Principal Subsidence Engineer NSW Resources Regulator.

Monitoring of the '300 XL Line' will provide information of relevance to each of the management plans listed in Section 6.1.

### 6.2.2 'Princes Highway Line'

The location of 'Princes Highway Line' is shown in Attachment 1. The line follows the alignment of the Old Princes Highway from the M1 Princes Motorway to the Garrawarra Centre Complex entrance road.

The 'Princes Highway Line' will be composed of survey marks established at a spacing of approximately 20 m which will be comprised of either:

- concrete nails set in rock or asphaltic concrete; or
- galvanised iron pipes, capped and punched.

Due to the practicalities of following the road, bends in the survey line will have to be incorporated.

The purpose of 'Princes Highway Line' is to:

- provide monitoring of ground movements about the Old Princes Highway; and
- obtain subsidence information ahead of longwall panels to validate, and if necessary better calibrate, the MSEC subsidence prediction methods.

The frequency of monitoring 'Princes Highway Line' will be:

- within 3 months of the completion of each longwall panel (Longwalls 301, 302 and 303); and
- more frequently if directed by the Principal Subsidence Engineer NSW Resources Regulator.

The 'Princes Highway Line' is a monitoring component of BFMP-WCC.

### 6.2.3 'Optic / Water Line'

The location of 'Optic/Water Line' is shown in Attachment 1. The line follows the alignment of an unsealed track and the Garrawarra Centre Complex internal roads, extending from the Old Princes Highway to beyond the 35 degree angle of draw line within the Garrawarra Centre Complex.

The 'Optic/Water Line' will be composed of survey marks established at a spacing of approximately 20 m which will be comprised of either:

- concrete nails set in rock or asphaltic concrete; or
- galvanised iron pipes, capped and punched.

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Due to the practicalities of following the unsealed track and road, bends in the survey line will have to be incorporated.

The purpose of the ‘Optic/Water Line’ is to:

- provide monitoring of ground movements about the Sydney Water pipelines, fibre optic cable lines (Optus, Telstra and Vocus), telecommunication towers and compounds (Telstra, Axicom and Sydney Trains) and other buildings, structures and roads at the Garrawarra Centre Complex; and
- obtain subsidence information ahead of longwall panels to validate, and if necessary better calibrate, the MSEC subsidence prediction methods.

The frequency of monitoring ‘Optic/Water Line’ will be:

- weekly at commencement of Longwall 302 and 302 when within 400m of the active longwall face;
- within 3 months of the completion of each longwall panel; and
- more frequently if directed by the Principal Subsidence Engineer NSW Resources Regulator.

The ‘Optic/Water Line’ is a monitoring component of BFMP-Sydney Water, BFMP-Optus, BFMP-Telstra, BFMP-Vocus, BFMP-Axicom, BFMP-Sydney Trains and BFMP-Garrawarra.

#### **6.2.4 ‘Transmission (Subsidence) Line’**

The location of ‘Transmission (Subsidence) Line’ is shown in Attachment 1. The line is located along the easement containing the 330 kV TransGrid and 132 kV Endeavour Energy transmission lines and also runs generally parallel to the fibre optic cables, M1 Princes Motorway and the eastern boundary of the Waterfall General (Garrawarra) Cemetery. The line extends between the intersection with the 35 degree angle of draw line to the north and south of the Longwalls 301 to 303.

The ‘Transmission (Subsidence) Line’ will be composed of survey marks established at a spacing of approximately 20 m which will be comprised of either:

- concrete nails set in rock; or
- galvanised iron pipes, capped and punched.

Due to the practicalities of following the terrain and access tracks, bends in the survey line will have to be incorporated.

Prior to installation of the survey marks, consideration will be given to the presence of Aboriginal heritage sites and if detected the survey marks will be located so as to avoid these heritage sites.

The purpose of ‘Transmission (Subsidence) Line’ is to:

- provide monitoring of ground movements about the transmission lines, towers, fibre optic cables, M1 Princes Motorway and Waterfall General (Garrawarra) Cemetery; and
- obtain subsidence information ahead of longwall panels to validate, and if necessary better calibrate, the MSEC subsidence prediction methods.

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The frequency of monitoring ‘Transmission (Subsidence) Line’ will be:

- weekly within 400 m of the active longwall face;
- within 3 months of the completion of each longwall panel (Longwalls 301, 302 and 303); and
- more frequently if directed by the Principal Subsidence Engineer NSW Resources Regulator.

The ‘Transmission (Subsidence) Line’ monitoring is a component of BFMP-TransGrid, BFMP-Endeavour Energy; BFMP-Vocus; BFMP-Telstra; BFMP-Optus; BFMP-RMS and BFMP-Cemetery.

The ‘Transmission (Subsidence) Line’ monitoring would also inform any future review of monitoring and/or action for the Illawarra Railway as a component of the BFMP-Sydney Trains.

### 6.2.5 ‘M1 North Bound Line’

The location of ‘M1 North Bound Line’ is shown in Attachment 1. The line extends from south<sup>2</sup> of M1 Princes Motorway Bridge 2 (Old Princes Highway Underpass) to Cawley Road Overbridge along the verge of the M1 Princes Motorway.

The ‘M1 North Bound Line’ will be composed of survey marks established at a spacing of approximately 20 m which will be comprised of either:

- concrete nails set in rock, asphaltic concrete or concrete kerb; or
- galvanised iron pipes, capped and punched.

Due to the practicalities of following the road, bends in the survey line will have to be incorporated.

The purpose of ‘M1 North Bound Line’ is to:

- provide monitoring of ground movements about the M1 Princes Motorway; and
- obtain subsidence information ahead of longwall panels to validate, and if necessary better calibrate, the MSEC subsidence prediction methods.

The frequency of monitoring ‘M1 North Bound Line’ will be:

- within 3 months of the completion of each longwall panel; and
- more frequently if directed by the RMS Technical Committee or the Principal Subsidence Engineer NSW Resources Regulator.

The ‘M1 North Bound Line’ is a monitoring component of BFMP-RMS.

The ‘M1 North Bound Line’ monitoring would also inform any future review of monitoring and/or action for the Illawarra Railway as a component of the BFMP-Sydney Trains.

<sup>2</sup> A distance determined in consultation with the RMS Technical Committee.

### 6.2.6 ‘Transmission Towers Monitoring’

The locations of ‘Transmission Towers Monitoring’ are shown in Attachment 1.

Monitoring for Longwalls 301-303 will include towers TL11-103 to TL11-108 of the 330 kV TransGrid transmission line and towers F9132B-T7 to F9132B-T13 of the 132 kV Endeavour Energy transmission line.

While outside the Study Area, monitoring of TL11-101 to TL11-102 of the 330 kV TransGrid transmission line will continue to be conducted.

The ‘Transmission Towers Monitoring’ will be composed of:

- survey marks (prisms) established at each of the four tower legs;
- ground survey marks established adjacent to each of the four tower legs; and
- a fixed point identified at the top of each tower.

The ground survey marks will be comprised of either:

- concrete nails set in rock; or
- galvanised iron pipes, capped and punched.

Due to the practicalities of survey mark installation, prisms cannot be used at the tops of the towers.

The purpose of the ‘Transmission Towers Monitoring’ is to:

- provide monitoring of ground movements and tower movements for the transmission towers; and
- obtain subsidence information ahead of longwall panels to validate, and if necessary better calibrate the MSEC subsidence prediction methods.

The frequency of ‘Transmission Towers Monitoring’ will be:

- weekly at each tower within 400 m of the active longwall face (or at an increased frequency for TL11-107 and TL11-108 as determined in consultation with the TransGrid during the first month of mining Longwalls 301, 302 and 303);
- within 3 months of the completion of each longwall panel (Longwalls 301, 302 and 303);
- real-time (continuous) absolute 3D monitoring of TransGrid Towers subject to review of current trial; and
- more frequently if directed by the asset owner or the Principal Subsidence Engineer NSW Resources Regulator.

The ‘Transmission Towers Monitoring’ is a monitoring component of BFMP-TransGrid; BFMP-Endeavour Energy; BFMP-RMS; BFMP-Vocus; BFMP-Telstra and BFMP-Optus.

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### 6.2.7 ‘Telecommunication Towers Monitoring’

The locations of ‘Telecommunication Towers Monitoring’ are shown in Attachment 1. Monitoring will include towers located near the commencing end of Longwalls 302 and 303.

The ‘Telecommunication Towers Monitoring’ will be composed of survey marks (prisms) established at each of the tower legs, and corresponding ground based prisms outside each leg. Due to the practicalities of survey mark installation, prisms cannot be used at the tops of the towers.

Tower monitoring of the single pole tower will be composed of tilt meters at the base of the tower and fixed ground points.

The purpose of the ‘Telecommunication Towers Monitoring’ is to:

- provide monitoring of ground movements and tower movements for the telecommunication towers; and
- obtain subsidence information ahead of longwall panels to validate, and if necessary better calibrate the MSEC subsidence prediction methods.

The frequency of ‘Telecommunication Towers Monitoring’ will be:

- weekly on commencement of Longwall 302 and 303 until subsidence reduces below level of survey accuracy.
- within 3 months of the completion of each longwall panel (Longwalls 301, 302 and 303); and
- more frequently if directed by the asset owner or the Principal Subsidence Engineer NSW Resources Regulator.

The ‘Transmission Towers Monitoring’ is a monitoring component of BFMP-Telstra; BFMP-Axicom; BFMP-Sydney Trains; and BFMP-Garrawarra.

### 6.2.8 ‘Bridge 2 Monitoring’

The location of Bridge 2 (Old Princes Highway Underpass) is shown in Attachment 1. Monitoring will include the structural elements of the bridge as described in detail in the BFMP-RMS.

The ‘Bridge 2 Monitoring’ will be composed of a survey reference pillar, survey marks (prisms) established at structural elements of the bridge, a fixed absolute 3D real time monitor and a fibre optic monitoring system.

The purpose of the ‘Bridge 2 Monitoring’ is to:

- provide monitoring of ground movements and bridge structural element movements for the bridge; and
- obtain subsidence information ahead of longwall panels to validate, and if necessary better calibrate the MSEC subsidence prediction methods.

The frequency of ‘Bridge 2 Monitoring’ will be:

- prior to Longwall 301;
- real-time (continuous) absolute 3D monitoring;

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- weekly Fibre Bragg Grating sensor monitoring from the commencement of Longwall 301 extraction for a duration determined in consultation with the Technical Committee;
- monthly survey when active longwall mining is within 500 m of the bridge;
- greater frequency or commencing earlier if determined in consultation with the RMS Technical Committee or the Principal Subsidence Engineer NSW Resources Regulator; and
- following the completion of extraction of each of Longwalls 301, 302 and 303.

The 'Bridge 2 Monitoring' is a monitoring component of the BFMP-RMS.

### 6.2.9 'Cawley Road Overbridge Monitoring'

The location of the Cawley Road Overbridge is shown in Attachment 1. Monitoring will include the structural elements of the bridge.

The 'Cawley Road Overbridge Monitoring' will be composed of a survey reference pillar, a fixed absolute 3D real time monitor and survey marks (prisms) established at structural elements of the bridge.

The purpose of the 'Cawley Road Overbridge Monitoring' is to:

- provide monitoring of ground movements and bridge structural element movements for the bridge; and
- obtain subsidence information ahead of longwall panels to validate, and if necessary better calibrate the MSEC subsidence prediction methods.

The frequency of 'Cawley Road Overbridge Monitoring' will be:

- prior to Longwall 301;
- real-time (continuous) absolute 3D monitoring; and
- following the completion of extraction of each of Longwalls 301, 302 and 303.

The 'Cawley Road Overbridge Monitoring' is a monitoring component of the BFMP-RMS.

### 6.2.10 'Illawarra Railway Monitoring'

The location of the Illawarra Railway is shown in Attachment 1. Monitoring will include the relative structural elements of the culverts at Wilsons Creek and Cawley Creek and absolute ground movements at each creek valley.

The 'Culvert Monitoring' is composed of 5 rings of 3 survey marks established at intervals inside each culvert.

The purpose of the Culvert Monitoring is to:

- provide monitoring of ground movements and culvert structural element movements;

The frequency of 'Culvert Monitoring' will be:

- prior to Longwall 301; and
- following the completion of extraction of each of Longwalls 301, 302 and 303.

The Railway Valley Closure Monitoring will be composed of 2 real time (continuous) absolute 3D monitors at each valley, being Wilsons Creek and Cawley Creek.

The frequency of Railway Valley Closure Monitoring will be:

- Commenced during extraction of Longwall 303;
- real-time (continuous) absolute 3D monitoring.

The 'Illawarra Railway Monitoring' is a monitoring component of the BFMP-SYD TRAINS.

#### **6.2.11 Eastern Tributary Cross Lines**

Cross lines established across the Eastern Tributary at the ETAU (Metropolitan Coal gauging station), ETAT, ETAR and ETAQ will be monitored for subsidence movement.

The frequency of monitoring of the cross line will be:

- prior to Longwall 301; and
- following the completion of extraction of each of Longwalls 301, 302 and 303.

#### **6.2.12 Waratah Rivulet Cross Line**

Although Waratah Rivulet is approximately 1 km from Longwalls 301-303, monitoring for any subsidence movements during and following the extraction of Longwalls 301-303 will include the cross line downstream of the maingate of Longwall 23 at Pool Q (WaterNSW Gauging Station).

The frequency of monitoring of the cross line will be annually.

#### **6.2.13 Ridge to Ridge**

Two existing GPS monitoring points have been established at ridge top locations across the Eastern Tributary. GPS monitoring points have also been established at ridge top locations across the Waratah Rivulet.

The purpose of the ridge to ridge survey points was to measure total valley closure and compare predicted values with measured to assist in providing a better understanding of the mechanism of valley closure and/or better inform the prediction methods.

Monitoring of the ridge to ridge survey points will occur within three months of the completion of Longwall 27. On the basis that extraction of Longwalls 301-303 is below a topographic high point, no ridge to ridge subsidence monitoring is proposed for Longwalls 301-303, however the survey points would be reviewed during the future Extraction Plan (i.e. Longwall 304 onwards).

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#### 6.2.14 'D Line'

The D-Line over the previous Longwalls 1-18 extraction block will be monitored within three months of the completion of Longwall 27. Subject to the review of longer term time dependent subsidence movement, where subsidence has effectively ceased at this location, no further subsidence monitoring is proposed.

#### 6.2.15 'G Line'

The G-Line over the previous Longwalls 20-27 extraction block will be monitored within three months of the completion of Longwall 27. Subject to the review of longer term time dependent subsidence movement, where subsidence has effectively ceased at this location, no further subsidence monitoring is proposed.

#### 6.2.16 Parameters to be Measured

Surveys will measure subsidence movements in three dimensions using a total station survey instrument.

#### 6.2.17 Monitoring Methods and Accuracy

Longwall subsidence measurements will be surveyed in accordance with the relevant specifications and legislation as applied in NSW. These include:

- Survey and Drafting Directions For Mine Surveyors 2015 (NSW – Mines); and
- Inter-government Committee on Surveying and Mapping Standards and Practices for Control Surveys (SP1) Version 1.7 Sept 2007 ICSM Publication No.1 (ICSM SP1).

The Survey and Drafting Directions for Mine Surveyors 2015 *Section 3.4 Correlation of Surface and Underground Surveys* will be consistent with Class 'D' survey as prescribed in ICSM SP1. It is intended that all Control Surveys for mine subsidence of the central areas of Longwalls 301-303 to be surveyed to Class 'D' using prescribed methods as described in ICSM SP1. In 2000, ICSM adopted POSITIONAL UNCERTAINTY and LOCAL UNCERTAINTY as new, easily understood methods of classifying the accuracy of coordinates.

POSITIONAL UNCERTAINTY is a new concept which caters for positions obtained independent of the survey network (e.g. GPS results from Wide Area Differential GPS (WADGPS) or Geoscience Australia's on-line positioning service). POSITIONAL UNCERTAINTY is the uncertainty of the coordinates or height of a point, in metres at the 95% confidence level, with respect to the defined reference frame. LOCAL UNCERTAINTY is the average measure, in metres at the 95% confidence level, of the relative uncertainty of the coordinates, or height, of a point(s), with respect to the survey connections to adjacent points in the defined frame.

CLASS is a function of the precision of a survey network, reflecting the precision of observations as well as suitability of network design, survey methods, instruments and reduction techniques used in that survey. Preferably the CLASS is verified by an analysis of the minimally constrained least squares adjustment of the network.

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### Survey Accuracy

Each control survey and subsidiary survey must be planned and surveyed to satisfy the conditions to achieve a standard of accuracy of Class 'D' or better as prescribed in ICSM SP1. The allocation of CLASS to a survey on the basis of the results of a successful minimally constrained least squares adjustment may generally be achieved by assessing whether the semi-major axis of each relative standard error ellipse or ellipsoid (i.e. one sigma), is less than or equal to the length of the maximum allowable semi-major axis (r) using the following formula:

$$r = c ( d + 0.2 )$$

Where;

- r = length of maximum allowable semi-major axis in mm.
- c = an empirically derived factor represented by historically accepted precision for a particular standard of survey.
- d = distance to any station in km.

The values of 'c' assigned to various CLASSES of survey are shown in Table 6.

**Table 6**  
**Classification of Horizontal Control Survey**

Class	C (for one sigma)	Typical Applications
3A	1	Special high precision surveys
2A	3	High precision National geodetic surveys
A	7.5	National and State geodetic surveys
B	15	Densification of geodetic survey
C	30	Survey coordination projects
D	50	Lower CLASS projects
E	100	Lower CLASS projects

The radius of a 95% circle of uncertainty is readily calculated from the standard (1  $\sigma$ ) error ellipse produced by most least squares adjustment software. However, as the Positional Uncertainty is in terms of the national geodetic datum (not just the local control for a particular survey) the error ellipse used also must be in terms of the national geodetic datum. In Australia the national geodetic datum is the Geocentric Datum of Australia 1994 (GDA94).

In Australia, this means that the Positional Uncertainty must be calculated from a standard error ellipse that refers to the Australian Fiducial Network (AFN) or the Australian National Network (ANN) that were held fixed in the original national GDA94 adjustment.

In essence the subsidence accuracy for POSITIONAL UNCERTAINTY is related to the Positional uncertainty of the controlling survey stations used to co-ordinate the subsidence survey. Controlling survey stations used to co-ordinate the subsidence survey will be of a higher class and survey techniques used will reflect recommended methods of achieving higher class survey.

LOCAL UNCERTAINTY is basically the relationship of the accuracy between the survey subsidence monitoring points. It is expected that the results will be far superior to Class 'D', with monitoring points having a 95% confidence major error ellipse in order of 17 mm.

A total station survey instrument will be used to achieve a survey target accuracy of  $\pm 5$  mm between marks and  $\pm 20$  mm relative to external survey reference.

### 6.3 SUBSIDENCE IMPACTS/ENVIRONMENTAL CONSEQUENCES MONITORING COMPONENTS

The subsidence impact/environmental consequences monitoring components are summarised in Table 5. All subsidence impact/environmental consequence monitoring is included in a relevant management plan within the Longwalls 301-303 Extraction Plan as summarised in Table 5. Each management plan within the Extraction Plan includes:

- detailed baseline data;
- a description of:
  - the relevant statutory requirements (including any relevant approval, licence or lease conditions);
  - any relevant limits or performance measures/criteria; and
  - the specific performance indicators that are to be used to judge the performance of, or guide the implementation of, the Project or any management measures;
- a description of the measures that would be implemented to comply with the relevant statutory requirements, limits, or performance measures/criteria;
- a program to monitor and report on the:
  - impacts and environmental performance of the project; and
  - effectiveness of any management measures;
- a contingency plan to manage any unpredicted impacts and their consequences;
- a program to investigate and implement ways to improve the environmental performance of the Project over time;
- a protocol for managing and reporting any:
  - incidents;
  - complaints;
  - non-compliances with statutory requirements;
  - exceedances of the impact assessment criteria and/or performance criteria; and
- a protocol for periodic review of the plan.

The subsidence impacts/environmental consequences monitored as part of each management plan are summarised in the following sections.

### 6.4 LAND MANAGEMENT PLAN

The Longwalls 301-303 LMP has been prepared to manage the potential environmental consequences of the Longwalls 301-303 Extraction Plan on cliffs and overhangs, steep slopes and land in general.

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### 6.4.1 Cliffs and Overhangs

One cliff and overhang site (COH17) has recently (August 2018) been identified within 600 m of Longwalls 301-303 secondary extraction. As detailed in the Longwalls 301-303 LMP, detailed baseline recording of this newly identified cliff and overhang site will be undertaken prior to the commencement of Longwall 303 extraction.

Following the completion of Longwall 27 extraction, cliff sites COH1, COH2, COH3, COH4, COH5, COH6, COH6A, COH7, COH8, COH9, COH10, COH14, COH15 and COH16 were inspected for any change in the previously recorded subsidence impact (e.g. cliff instabilities and cracking). The visual inspections did not record any additional subsidence impacts.

Visual inspections for subsidence impacts on cliff site COH17 will be conducted to record subsidence impacts on a monthly basis when Longwall 303 extraction is within 400 m of the site. Additional opportunistic observations of subsidence impacts will be conducted during routine works and sampling by Metropolitan Coal and its contractors. Following completion of Longwall 303 extraction, cliff site COH17 will also be inspected to record any additional subsidence impacts to those previously recorded.

In the event subsidence impacts are identified on cliff and overhang site COH17, the following details will be noted and/or photographed:

- the date of the inspection;
- the location of longwall extraction (i.e. the longwall chainage);
- the location of the cliff instability (i.e. freshly exposed rock face and debris scattered around the base of the cliff or overhang) relative to the cliff face or overhang;
- the nature and extent of the cliff instability (including an estimate of volume);
- the length of the cliff instability;
- other relevant aspects such as water seepage (which can indicate weaknesses in the rock);
- whether any actions are required (for example – implementation of management measures, initiation of the Contingency Plan, incident notification, implementation of appropriate safety controls, review of public safety etc); and
- any other relevant information.

### 6.4.2 Step Slopes and Land in General

Visual inspections for subsidence impacts on steep slopes and land in general within 600 m of Longwalls 20-27 and Longwalls 301-303 extraction will be conducted by Metropolitan Coal and its contractors during catchment visits, sampling and routine works conducted in the catchment.

In the event subsidence impacts are identified within 600 m of Longwalls 20-27 (that were not previously recorded during the mining of Longwalls 20-27), or within 600 m of Longwalls 301-303, the following details will be noted and/or photographed:

- the location, approximate dimensions (length, width and depth), and orientation of surface tension cracks;
- the location of the surface tension crack in relation to fire trails or vehicular tracks;
- the location and approximate dimensions of rock falls (e.g. rock ledges);

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- whether any actions are required (for example – implementation of management measures, initiation of the Contingency Plan, incident notification, implementation of appropriate safety controls, review of public safety etc.); and
- any other relevant information.

## 6.5 BIODIVERSITY MANAGEMENT PLAN

The Longwalls 301-303 BMP has been prepared to manage the potential environmental consequences of the Longwalls 301-303 Extraction Plan on aquatic and terrestrial flora and fauna, with a specific focus on swamps.

### 6.5.1 Upland Swamps - Vegetation

#### *Longwalls 301-303*

Upland swamp vegetation monitoring for Longwalls 301-303 will include visual, quadrat/transect and indicator species monitoring consistent with the methods used for the monitoring of Longwalls 20-22 and Longwalls 23-27 upland swamp vegetation.

#### *Visual Inspections*

Visual inspections will be conducted of Swamps 38, 40, 41, 46, 47, 48, 49, 50, 51/52, 53 and 58 and in control Swamps 101, 111a, 125, 135, 136, 137a, 137b and 138 to record evidence of potential subsidence impacts.

Traverses over the swamp will be conducted biannually in autumn and spring, to record:

- cracking of exposed bedrock areas and/or swamp substrate;
- areas of increased erosion, particularly along any existing drainage line;
- any changes in water colour, particularly evidence of iron precipitation;
- changes in vegetation condition, including areas of stressed vegetation (i.e. plants that demonstrate symptoms of stress) and dead/dying plants that appear unusual; and
- whether the amount of seepage (at the terminal step/over exposed surfaces of the swamp) at the time of inspection appears unusual (relative to recent rainfall).

#### *Transect/Quadrat Monitoring*

Transect and quadrat monitoring will be conducted in Swamps 40, 41, 46, 51/52 and 53 over Longwalls 301-303. Each swamp will be monitored with three transects running downslope perpendicular to the horizontal long axis and approximately evenly distributed along the long axis.

The data collected for each quadrat will include:

- vegetation structure;
- dominant species;
- estimated cover and height for each stratum;
- full floristics;
- estimated cover abundance for each species using seven point Braun-Blanquet scale; and

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- condition/health rating for each species in the quadrat.

Surveys will be conducted biannually in autumn and spring.

Existing control Swamps 101, 135, 136, 137a and 137b have been selected for comparison with the swamps over Longwalls 301-303.

*Indicator Species Monitoring*

Twenty tagged individuals of:

- *Epacris obtusifolia* will be monitored in each of Swamps 40 and 53 (longwall swamps) and control Swamps 101, 136 and 137a; and
- *Sprengelia incarnata* will be monitored in each of Swamps 40 and 53 (longwall swamps) and control Swamps 101, 136 and 137b.

Population monitoring data collected will include:

- condition/health rating for each plant; and
- reproductive rating.

Surveys will be conducted biannually in autumn and spring.

**Previous Longwalls 20-22 and Longwalls 23-27**

*Visual Inspections*

Visual inspections of Swamps 16, 17, 19, 20, 24, 25, 30, 31, 32, 33, 34, 35, 36 and 95 will continue to be conducted biannually during the extraction of Longwalls 301-303. These swamps are also subject to biannual transect/quadrat and/or indicator species monitoring as described below.

*Transect/Quadrat Monitoring*

Transect and quadrat monitoring will continue to be conducted biannually in Swamps 16, 17, 18, 20, 24 and 25 overlying Longwalls 20-22, Swamps 28, 30, 33, 35 and 94 overlying or adjacent to Longwalls 23-27 and in control Swamps 101, 111a, 125, 135, 136, 137a, 137b, 138, Bee Creek Swamp, Woronora River 1, Woronora River south arm and Dahlia Swamp for Longwalls 20-27.

*Indicator Species Monitoring*

Population monitoring will continue to be conducted for Longwalls 20-22 during the extraction of Longwalls 301-303, specifically, 20 tagged individuals of:

- *Epacris obtusifolia* in each of Swamps 18, 24 and 25 (longwall swamps) and control Swamps 101, 111a and 125;
- *Sprengelia incarnata* in each of Swamp 24 (longwall swamp) and control swamps 101 and 125; and
- *Pultenaea aristata* in each of Swamps 18, 24 and 25 (longwall swamps) and control swamps 101 and 111a.

Three indicator species characteristic of the Tea Tree Thicket vegetation namely, *Banksia robur*, *Callistemon citrinus* and *Leptospermum juniperinum* will also continue to be monitored in Swamp 20 and at associated control sites (Woronora River 1, Woronora River south arm and Dahlia Swamp). The twenty tagged individuals will continue to be monitored in each swamp.

Population monitoring will also continue to be conducted for Longwalls 23-27 during the extraction of Longwalls 301-303, specifically, 20 tagged individuals of:

- *Epacris obtusifolia* in each of Swamps 19, 30, 33, 35 and 94 (longwall swamps) and control Swamps 135, 136, 137a, 137b and 138;
- *Sprengelia incarnata* in each of Swamps 19, 33, 35 and 94 (longwall swamps) and control Swamps 135, 136, 137a and 138;
- *Pultenaea aristata* in each of Swamps 19, 30, 33, 35 and 94 (longwall swamps) and control Swamps 135, 136, 137a and 138; and
- *Banksia robur* and *Callistemon citrinus* in Swamp 28 (longwall swamp) and control Swamps Woronora River 1, Woronora River south arm and Dahlia Swamp.

Population monitoring for Longwalls 20-22 and Longwalls 23-27 will continue to be conducted in the abovementioned swamps using the methods described in the Longwalls 301-303 BMP.

## 6.5.2 Upland Swamps - Groundwater

### **Longwalls 301-303**

Groundwater monitoring of upland swamps will include the monitoring of paired piezometers (i.e. one swamp substrate piezometer to a depth of approximately 1 m and one sandstone piezometer to a depth of approximately 10 m) in Swamps 40, 41, 46, 51, 52 and 53 overlying Longwalls 301-303. Each piezometer has been equipped with a data logger for continuous water level monitoring.

### **Previous Longwalls 20-22 and Longwalls 23-27**

Swamp substrate groundwater monitoring will continue to be conducted in Swamps 20 and 25 for Longwalls 20-22, Swamps 28, 30, 33 and 35 for Longwalls 23-27 and in control Swamps 101, 137a, 137b, Bee Creek Swamp and Woronora River 1 (WRSWAMP 1) for Longwalls 20-27.

## 6.5.3 Riparian Vegetation

No additional riparian vegetation monitoring sites have been established for Longwalls 301-303. Riparian areas along Waratah Rivulet and the Eastern Tributary monitored for Longwalls 20-22 and Longwalls 23-27 will continue to be monitored at sites MRIP01 to MRIP12 during the mining of Longwalls 301-303.

### **Visual Inspections**

Visual inspections of riparian areas will continue to be conducted in locations adjacent to riparian vegetation monitoring sites (sites MRIP01 to MRIP12), and areas traversed whilst accessing the monitoring sites during the extraction of Longwalls 301-303 to record evidence of subsidence impacts including:

- areas of new water ponding;
- any cracking or rock displacement; and
- changes in vegetation condition, including areas of stressed vegetation that appear unusual.

### **Quadrat Monitoring**

The existing permanent quadrat (20 m x 2 m) will continue to be used to monitor riparian vegetation at:

- sites MRIP07 and MRIP08 downstream of Longwalls 23-27 and within the 35° angle of draw and/or predicted 20 mm subsidence contour for Longwalls 301-303;
- sites MRIP01, MRIP02, MRIP05 and MRIP06 overlying Longwalls 20-22;
- sites MRIP11 and MRIP12 overlying Longwalls 23-27; and
- sites MRIP03 and MRIP04 downstream of Longwall 23A.

The data collected for each quadrat will include:

- vegetation structure;
- dominant species;
- estimated cover and height for each stratum;
- full floristics;
- estimated cover abundance for each species using seven point Braun-Blanquet scale; and
- condition/health rating for each species in the quadrat.

Surveys of the quadrats will be conducted biannually in autumn and spring.

### **Indicator Species Monitoring**

The three indicator species will continue to be monitored within the riparian vegetation of the Eastern Tributary and Waratah Rivulet, namely, *Prostanthera linearis*, *Schoenus melanostachys* and *Lomatia myricoides*. The existing tagged individuals will continue to be monitored at:

- sites MRIP07 and MRIP08 downstream of Longwalls 23-27 and within the 35° angle of draw and/or predicted 20 mm subsidence contour for Longwalls 301-303;
- sites MRIP01, MRIP02, MRIP05, MRIP06 and MRIP09 overlying Longwalls 20-22;
- sites MRIP11 and MRIP12 overlying Longwalls 23-27; and
- sites MRIP03, MRIP04 and MRIP10 downstream of Longwall 23A.

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Population monitoring data collected includes:

- condition/health rating for each plant; and
- reproductive rating.

Surveys will be conducted biannually in autumn and spring.

#### **6.5.4 Aquatic Biota and Habitat**

Metropolitan Coal will assess the subsidence impacts and environmental consequences on surface water resources and watercourses (aquatic habitats) in accordance with the Metropolitan Coal Longwalls 301-303 WMP.

The aquatic ecology monitoring programs include the monitoring of aquatic habitat characteristics, water quality, macroinvertebrates and aquatic macrophytes. Observations of surface cracking, iron staining and gas releases will also be made during the conduct of the aquatic ecology surveys.

##### ***Stream Monitoring***

Monitoring of aquatic biota (macroinvertebrates and macrophytes) will continue to be conducted (if sufficient habitat is available for sampling) at two sampling sites (approximately 100 m long) at the following stream sampling locations:

- Location ET2 on the Eastern Tributary, downstream of Longwalls 20-27 and within the Longwalls 301-303 35° angle of draw and/or predicted 20 mm subsidence contour.
- Locations WT3 and WT4 on Waratah Rivulet, Locations ET1, ET3 and ET4 on the Eastern Tributary and Locations B1 and B2 on Tributary B overlying Longwalls 20-27.
- Location WT5 on Waratah Rivulet, downstream of Longwalls 20-27.
- Control Locations: WR1 on Woronora River; OC on O'Hares Creek; BC on Bee Creek; and WOT on Woronora Tributary.

Monitoring of the sampling sites on the Waratah Rivulet, Eastern Tributary, Woronora River and O'Hares Creek will be conducted biannually in spring (15 September to 15 December) and autumn (15 March to 15 June), consistent with the timing required by the Australian River Assessment System (AUSRIVAS) protocol.

Monitoring of sample sites on Tributary B, Bee Creek and Woronora Tributary will be conducted biannually up to and including spring 2018, and thereafter every three years in autumn and spring (i.e. next surveys to be conducted in autumn 2021 and spring 2021) consistent with the revised monitoring schedule for Location B1 for previous Longwalls 18-19A. Given the distance from Longwall 301-303, Tributary B will not experience any measurable subsidence or valley related movements resulting from the extraction of Longwalls 301-303.

##### ***Pool Monitoring***

A number of pools will continue to be monitored to assess the response of aquatic ecosystems to the implementation of potential future stream remediation works, namely:

- Larger pools (i.e. >40 m in length) J, M1 and N on Waratah Rivulet and ETAH on the Eastern Tributary, overlying Longwalls 20-27.

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- Smaller pools (i.e. <40 m in length) K, L and M on Waratah Rivulet and ETAG, ETAI and ETAK on the Eastern Tributary, overlying Longwalls 20-27.
- One larger control pool on Woronora River (Pool WP) and one larger control pool on O'Hares Creek (Pool OC).
- Three smaller control pools on Woronora River (Pools WP-A, WP-B and WP-C) and three smaller control pools on O'Hares Creek (Pools OC-A, OC-B and OC-C).

Monitoring of the sampling sites will be conducted biannually in spring (15 September to 15 December) and autumn (15 March to 15 June) if sufficient aquatic habitat is available for sampling.

### 6.5.5 Terrestrial Fauna and their Habitats

Terrestrial fauna habitats (upland swamps, riparian vegetation, slopes and ridgetops, and aquatic habitats) will be monitored as described in the Longwalls 301-303 BMP. Observations of any surface cracking and loss of flow in streams will also be noted at amphibian monitoring sites during the conduct of the amphibian surveys.

Amphibians were selected as the appropriate representative of terrestrial vertebrate fauna because they are widespread across the Study Area, include two threatened species that are sensitive to changes in surface hydrology, and because this group is represented by 14 species that appear to have viable populations.

#### **Longwalls 301-303**

Six amphibian monitoring sites (sites 23-28) have been established for Longwalls 301-303. The eleven control sites for Longwalls 20-22 (namely, sites 7, 8, 9, 10, 11 and 12) and Longwalls 23-27 (namely, sites 18, 19, 20, 21 and 22) will also serve as control sites for Longwalls 301-303.

The amphibian monitoring sites will be surveyed annually in spring/summer (i.e. October to February) during suitable weather conditions.

Species will be assigned to relative abundance categories for tadpole and adult stages.

#### **Previous Longwalls 20-22 and Longwalls 23-27**

The Longwalls 20-22 amphibian monitoring program includes six test sites (sites 1-6) and six control sites (sites 7-12).

The Longwalls 23-27 amphibian monitoring program includes five test sites (sites 13-17) and five control sites (sites 18-22).

The amphibian monitoring sites will be surveyed annually in spring/summer (i.e. October to February) during suitable weather conditions.

Species will be assigned to relative abundance categories for tadpole and adult stages.

## 6.6 WATER MANAGEMENT PLAN

The Longwalls 301-303 WMP has been prepared to manage the potential environmental consequences of the Longwalls 301-303 Extraction Plan on water resources (including the Woronora Reservoir) and watercourses.

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### 6.6.1 Stream Features

Visual and photographic surveys of the Eastern Tributary from the full supply level of the Woronora Reservoir to the maingate of Longwall 26 will be conducted monthly when mining is within 400 m of the stream and within three months of the completion of each longwall.

The Waratah Rivulet is located approximately 1 km west of Longwall 303, at its closest point to Longwalls 301-303 secondary extraction. At this distance, the Waratah Rivulet is not predicted to experience any measurable subsidence or valley related movements resulting from the extraction of Longwalls 301-303.

Notwithstanding, visual inspections and photographic surveys will also be conducted along the Waratah Rivulet from Pool P to the full supply level of the Woronora Reservoir within three months of the completion of each longwall to provide a record of the Waratah Rivulet stream features post the mining of Longwall 27.

The visual and photographic surveys will record:

- the location, approximate dimensions (length, width and depth), and orientation of surface cracks (specifically whether cracks are developed perpendicular to the stream flow or are controlled by rock joints or other factors, etc.);
- the nature of iron staining (e.g. whether isolated or across the entire streambed);
- the extent of iron staining (e.g. the length of stream affected);
- a description of gas release (e.g. isolated bubbles or continuous stream, and type of gas [methane or carbon dioxide]);
- the nature of scouring, for example the depth of scouring, type of soil exposed, any obvious vegetation impact, potential for severe erosion, etc.;
- water discoloration or opacity if present;
- rock bar characteristics such as extent of cracking, seepage, underflow;
- whether any actions are required (e.g. implementation of management measures, incident notification, implementation of appropriate safety controls, review of public safety, etc.); and
- any other relevant information.

The monthly visual inspections on the Eastern Tributary will record the above parameters by exception (i.e. where they differ to the baseline visual and photographic record).

Any gas releases identified as occurring on the Waratah Rivulet and Eastern Tributary to the full supply level by the visual inspections during the mining of Longwalls 301-303 (either during the visual and photographic surveys or other catchment monitoring) will be monitored weekly to determine the nature of the gas releases, gas concentration (samples taken for the analysis for carbon dioxide and methane content) and any observable environmental effects (e.g. impacts to riparian vegetation or fish kills).

Weekly monitoring will be conducted at pools observed with gas releases, until no gas releases have been observed at the pool for three consecutive weeks.

### 6.6.2 Surface Water Flow

Surface water flow monitoring will include continuous flow monitoring at:

- the Metropolitan Coal owned gauging station on the Eastern Tributary, close to the inundation limits of the Woronora Reservoir (GS 300078);
- the WaterNSW owned gauging station on the Waratah Rivulet, close to the inundation limits of the Woronora Reservoir (GS 2132102);
- the WaterNSW owned gauging station on the Woronora River, close to the inundation limits of the Woronora Reservoir (GS 2132101) (control site);
- the Metropolitan Coal owned gauging station on Honeysuckle Creek (GS 300077) (control site);
- the Department of Industry – Water gauging station on O’Hares Creek at Wedderburn (GS 213200) (control site);
- the Metropolitan Coal owned gauging station on a tributary of the Woronora Reservoir (Sub-catchment I (GS 300092);
- the Metropolitan Coal owned gauging station on a tributary of the Woronora Reservoir (Sub-catchment K (GS 300093).

### 6.6.3 Pool Water Levels and Drainage Behaviour

Pool water levels and drainage behaviour will be monitored using a continuous water level sensor and logger in:

- Pools ETG, ETJ, ETM, ETU, ETW, ETAF, ETAG, ETAH, ETAI, ETAQ, ETAT and ETAU on the Eastern Tributary;
- Pools A, F, J, K, L, M, N, O, P, Q, R, S, T, U, V and W on Waratah Rivulet; and
- control Pools WRP1, WRP2, WRP3 and WRP4 on the Woronora River.

Data from these devices will be downloaded monthly.

The water level in Pools B, C, E, G, G1, H and I on Waratah Rivulet will be manually monitored daily until such time that continuous water level sensors are installed and operating.

Pools situated downstream of the maingate of Longwall 26 on the Eastern Tributary will be visually inspected weekly when mining of Longwalls 301-303 is within 400 m of the Eastern Tributary.

Pools situated on the Waratah Rivulet from Pool P to the full supply level of the Woronora Reservoir will be visually inspected at the time of download of the pool water level data (i.e. monthly) to observe whether the pool water level has fallen below the cease to flow level or whether any changes to the natural drainage behaviour have occurred.

Observations will include:

- evidence of new cracking within the stream bed or rock bar;
- whether the pools continue to flow over, through and/or below the rock bars (where relevant); and
- whether surface flow is evident along the length of the pools prior to flowing over/through/below the rock bars or boulder fields.

#### 6.6.4 Surface Water Quality

Surface water quality will be sampled monthly at the following sites:

- sites ETWQ F, ETWQ J, ETWQ N, ETWQ U, ETWQ W, ETWQ AF, ETWQ AH, ETWQ AQ and ETWQ AU on the Eastern Tributary;
- sites WRWQ 2, WRWQ 6, WRWQ 8, WRWQ 9, WRWQ M, WRWQ N, WRWQ P, WRWQ R, WRWQ T, WRWQ U, WRWQ V, and WRWQ W on the Waratah Rivulet;
- site RTWQ 1 on Tributary B;
- site UTWQ 1 on Tributary D;
- site FEWQ 1 on the Far Eastern Tributary;
- site HCWQ 1 on Honeysuckle Creek;
- site BCWQ 1 along Bee Creek; and
- control sites WOWQ 1 and WOWQ 2 on the Woronora River.

Water quality parameters will include electrical conductivity (EC), pH, redox potential (Eh), dissolved oxygen (DO), turbidity, calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), chloride (Cl), sulphate (SO<sub>4</sub>), bicarbonate (HCO<sub>3</sub>), total nitrogen (N<sub>tot</sub>), total phosphorous (P<sub>tot</sub>), nitrate (NO<sub>3</sub>), barium (Ba), strontium (Sr), manganese (Mn), iron (Fe), zinc (Zn), cobalt (Co) and aluminium (Al). Samples collected for metal analysis will be field filtered.

Unfiltered water quality samples will also be collected monthly at the following sites and analysed for total iron:

- sites ETWQ F, ETWQ J, ETWQ N, ETWQ AF and ETWQ AQ on the Eastern Tributary;
- sites WRWQ 2, WRWQ 6, WRWQ 8, WRWQ 9, WRWQ M, WRWQ N and WRWQ P on the Waratah Rivulet; and
- control site WOWQ 2 on the Woronora River.

#### 6.6.5 Woronora, Nepean and Cataract Reservoir Water Quality

Metropolitan Coal will source water quality data for the Woronora Reservoir (site DW01, measurements taken from 0 to 9 m below the water surface level), the Nepean Reservoir and the Cataract Reservoir from WaterNSW in accordance with a data exchange agreement.

#### 6.6.6 Shallow Groundwater Levels near Streams

Continuous water level monitoring of shallow groundwater will be conducted at:

- site ETGW2 along the Eastern Tributary; and
- sites WRGW1, WRGW2 and WRGW7 along Waratah Rivulet.

Data will be downloaded monthly and analysis will be conducted on a six monthly basis.

### 6.6.7 Groundwater Levels/Pressures

Continuous groundwater level monitoring will be conducted at an approximately east-west transect of bores (sites T1, T2, T3, T4, T5 and T6) located to the west of Longwalls 301-303. Data from the divers in the standpipes will be downloaded monthly and the measured water levels at these bores will be compared against the water level at the Woronora Reservoir on a six monthly basis.

Additional groundwater standpipes have been installed as a component of the Woronora Reservoir Impact Strategy, namely bores TBS02-80, TBS02-15 and bore TBS03-15.

Continuous groundwater level/pressure monitoring will be conducted at:

- site 9HGW0 (Longwall 10 Goaf Hole);
- site 9EGW1B;
- site 9FGW1A;
- site 9GGW2B;
- site 9HGW1B;
- site PM02;
- site 9GGW1-80;
- site PM01 (9DGW1B);
- site 9EGW2A;
- site PM03;
- site PHGW1B;
- site PHGW2A;
- site F6GW3A;
- site F6GW4A;
- site 9EGW2-4;
- site 302GW01;
- site TBS02-250; and
- site TBS03-230.

Data from the piezometers will be downloaded monthly and assessed in accordance with the Longwalls 301-303 Water Management Plan.

### 6.6.8 Groundwater Quality

Shallow groundwater quality sampling will be conducted monthly at the following sites:

- site ETGW2 along the Eastern Tributary; and
- sites WRGW1, WRGW2 and WRGW7 along the Waratah Rivulet.

Water quality parameters will include EC, pH, Eh, Ca, Mg, Na, K, Cl, SO<sub>4</sub>, HCO<sub>3</sub>, Ba, Sr, Mn, Fe, Zn, Co and Al. The samples collected for the analysis of metals will be field filtered.

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### 6.6.9 Mine Water Make

Monitoring of the mine water balance will comprise:

- Metered water reticulated into the mine (recorded continuously and downloaded monthly).
- Backfill water used to assist pumping into the mine (recorded continuously and downloaded monthly).
- Metered water reticulated out of the mine (recorded continuously and downloaded monthly).
- Manual measurement of moisture content into and out of the mine through the mine ventilation system using a digital psychrometer. The frequency of readings will be as follows:
  - every hour over a 9 hour period on two occasions during a 12 month period;
  - daily (week day) except public holidays or other circumstances (access, fan maintenance, etc.) that prevent readings to be taken; and
  - once per week as a minimum.
- Measurement of the in-situ moisture content of the coal during channel sampling for coal quality.
- Measurement of the moisture content of run-of-mine (ROM) coal conveyed out of the mine at the drift portal using an automated moisture scanner. A fully automated data acquisition system records and stores the data.

The inferred water make (i.e. groundwater that has seeped into the mine through the strata) will be calculated from the difference between total mine inflows (reticulated water into the mine, moisture in the downcast ventilation, and the *in-situ* coal moisture content) and total mine outflows (reticulated water out of the mine, moisture in the exhaust ventilation, and moisture in the ROM coal).

Given the large fluctuations in daily water usage and the cycle period for water entering the mine, being used by machinery, and draining to sumps for return pumping to the surface, a 20 day average will be used to provide a more reliable estimate of water make.

In addition to shift inspections conducted by statutory officials that report on any abnormal conditions at the working face and in outbye areas, Metropolitan Coal conducts statutory weekly inspections of development workings to identify water accumulations. A weekly audit of the statutory inspections is conducted by the shift undermanager.

## 6.7 HERITAGE MANAGEMENT PLAN

The Longwalls 301-303 HMP has been prepared to manage the potential environmental consequences of the Longwalls 301-303 Extraction Plan on Aboriginal heritage sites or values.

### **Longwalls 301-303**

Monitoring of the following Aboriginal heritage sites will be undertaken for Longwalls 301-303, within three months of the completion of Longwall 303:

- FRC 76 (sandstone overhang with art only).
- FRC 117 (sandstone overhang with art and PAD).

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The monitoring team will include a suitably qualified archaeologist (with experience in rock art recording and management) and representatives of the Aboriginal stakeholders (where available). Specific details that will be recorded during the monitoring program include (but are not limited to):

- the date of monitoring;
- the location of longwall extraction (i.e. the longwall chainage) at the time of monitoring;
- comparison of the physical characteristics of the site at the time of monitoring against the previous monitoring and the baseline record (detail/quantify any changes observed);
- inspections of rock surfaces for cracking and/or exfoliation and/or blockfall since the previous monitoring and against the baseline record;
- inspection of art motifs for damage or deterioration since the previous monitoring and against the baseline record;
- identification of any natural weathering processes that may result in deterioration (e.g. fire, vegetation growth and water seepage);
- detailed description and quantification of any changes noted during the completion of the above tasks;
- a photographic record of any changes noted during monitoring (taken at the same position and distance as baseline record to allow comparison over time);
- whether any follow-up actions are required to be considered (e.g. implementation of management or initiation of the Contingency Plan, etc.); and
- any other relevant information.

#### ***Previous Longwalls 20-22 and Longwalls 23-27***

The Longwalls 20-27 Aboriginal heritage sites at which previous monitoring indicates continued change due to mining induced subsidence, will be monitored as a component of the Longwalls 301-303 HMP. The sites that show continued change due to mining induced subsidence have been determined by the Round 5 monitoring survey for Longwalls 23-27. The Aboriginal heritage sites that show continued change (MET 1 and FRC 176) will be monitored within three months of the completion of Longwall 303. Sites FRC 28, FRC 29, FRC 34 and FRC 60 were observed to have shown change for the first time during the Round 5 survey. These sites will be monitored within three months of the completion of Longwall 303.

## **6.8 BUILT FEATURES MANAGEMENT PLAN**

A number of component plans have been prepared to manage the potential environmental consequences of the Longwalls 301-303 Extraction Plan on built features including:

- Garrawarra Centre Complex buildings and services (BFMP-Garrawarra [BFMP-GAR]).
- M1 Princes Motorway including bridges (BFMP-Roads and Maritime Services [BFMP-RMS]).
- Old Princes Highway (BFMP-Wollongong City Council [BFMP-WCC]).
- Waterfall General [Garrawarra] Cemetery (BFMP-Cemetery [BFMP-CEM]).
- Water mains (BFMP-Sydney Water [BFMP-SYDWATER]).
- Transmission lines and towers (BFMP-Endeavour Energy [BFMP-END] and BFMP-TransGrid [BFMP-TRA]).

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- Telecommunication cables (BFMP-Telstra [BFMP-TELSTRA], BFMP-Vocus [BFMP-VOCUS] and BFMP-Optus [BFMP-OPTUS]).
- Telecommunication towers and compounds (BFMP-TELSTRA, BFMP-Axicom [BFMP-AXICOM] and BFMP-Sydney Trains [BFMP-SYDTRAINS]).
- Illawarra Railway (BFMP-SYDTRAINS).

Each plan has been developed in consultation with the relevant asset owner in accordance with Project Approval Condition 6(f), Schedule 3.

Any subsidence impacts will be recorded in the relevant BFMP - Subsidence Impact Register.

### 6.8.1 Garrawarra Centre Complex (BFMP-GAR)

Visual inspections will be conducted at the Garrawarra Centre Complex at the buildings and structures, and private roads as described in the BFMP-GAR or as otherwise determined in consultation with NSW Health.

Specific details that will be noted and/or photographed include:

- the date of the inspection;
- the location of longwall extraction (i.e. the longwall chainage);
- assessment against the performance indicators and performance measure;
- whether any actions are required (e.g. initiation of the Contingency Plan, incident notification, implementation of appropriate safety controls, review of public safety, etc.); and
- any other relevant information.

It is important to note that subsidence effects predicted for the Garrawarra Centre Complex buildings and structures during mining of Longwall 301 alone are minimal to nil as the total subsidence profile does not develop until after commencement of Longwall 302 and Longwall 303.

#### ***Garrawarra Centre Buildings***

External inspections of derelict buildings will be conducted prior to the commencement of Longwall 302 extraction (as agreed with NSW Health internal inspection is not possible with safety hazards presented by the particularly degraded state of buildings) and within 3 months following the completion of extraction of Longwalls 302 and 303 to identify any subsidence impacts to the structural integrity:

- Former Male Wards (Building A01a-i and A01a-v); and
- Laundry / Boilerhouse, (Building B03a).
- Former Female Wards (Building B02c).
- Houses (B04a-B09a);

**Dementia Care Buildings**

Inspections of occupied buildings will be conducted prior to the commencement of Longwall 302 extraction (as agreed with NSW Health) and within 3 months following the completion of extraction of Longwalls 302 and 303 to identify any subsidence impacts to the structural integrity, and more specifically if any cracking at pre-existing rock joints:

- Building structures (B01a-B01e);
- Administration / Kitchen Group (Buildings B02a and B02b); and
- Palmer House (A09a).

**Water Storage Tanks**

Inspections of the water storage tanks (B14t01, B14t02, B16t01-B16t03, B17t01 and B18t01) and trickle filter tank (B15t01) will be conducted prior to the commencement of Longwall 302 extraction and within 3 months following the completion of extraction of Longwalls 302 and 303 to identify any subsidence impacts to the structural integrity and leaks.

In addition, weekly visual inspections will be conducted for B14t01 and B14t02 on commencement of Longwall 303 until the longwall face has retreated away 400 m from the tanks. Recording of any cracking in columns, elevated ring beam or central access shaft of the elevated water storage tank (B14t01) would also occur at these times.

**Gas Storage Tank**

Inspections of the gas storage tank (B01t03) will be conducted prior to the commencement of Longwall 301 extraction (or as otherwise agreed with NSW Health) and within 3 months following the completion of extraction of each of Longwalls 301, 302 and 303 to identify any subsidence impacts to the structural integrity and leaks.

**Kiln**

Inspections of the kiln will be conducted prior to the commencement of Longwall 302 extraction (as agreed with NSW Health) and within 3 months following the completion of extraction of each of Longwalls 302 and 303 to identify any subsidence impacts to the structural integrity of the kiln chimney. In addition, weekly visual inspections will be conducted for the kiln on commencement of Longwall 302 and Longwall 303 until the longwall face has retreated away 400 m from the kiln chimney.

**Telecommunication Towers**

As described in Section 6.8.8.

**Other Services (Powerlines and Poles, Water Pipelines)**

Inspections of the powerlines and timber poles will be conducted prior to the commencement of Longwall 301 extraction (or as otherwise agreed with NSW Health) and within 3 months following the completion of extraction of each of Longwalls 301, 302 and 303, or at any time in case of fault or emergency, to identify any degradation of structures, movement of conductors, vegetation clearance, land clearance, road clearance and integrity and function of support clamps or other items.

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Inspections of the water pipelines will be conducted prior to the commencement of Longwall 301 extraction (or as otherwise agreed with NSW Health) and within 3 months following the completion of extraction of each of Longwalls 301, 302 and 303 to identify any surface ground cracks, cracks or leaks in the pipelines, and to confirm that fittings can be accessed beneath surface fittings and are operable.

### ***Private Roads and Access Roads/Tracks***

As described in Section 6.9.

## **6.8.2 M1 Princes Motorway including Bridges (BFMP-RMS)**

### ***Pavement and Roadside Furniture of M1 Princes Motorway***

The condition of the M1 Princes Motorway pavement will be monitored by 'Roadcrack', an optical system that detects and records pavement cracks. The system will be operated by RMS personnel. The frequency of monitoring will be in accordance with the RMS inspection program (generally twice/week). Gipsicam and Laser Profilometer surveys will also be used where available in accordance with RMS inspection program.

Visual inspections for impacts on the asphaltic concrete surface, kerbs, gutters and pits, and signs or other road infrastructure will be carried out by the RMS prior to the commencement of Longwall 301 extraction and following the completion of each longwall, or more frequently if determined in consultation with the RMS Technical Committee.

Regular visual inspections will be conducted during mining by representatives of the RMS as part of the RMS Network Safety Inspections. These inspections are carried out by a dedicated inspector twice weekly and any observed defects that represent a safety hazard will be reported to the RMS Technical Committee.

### ***Culverts***

A site inspection of the culverts will occur (using CCTV) prior to the commencement of Longwall 301 extraction and following the completion of each longwall, or more frequently if determined in consultation with the Technical Committee.

The inspections will be used to identify changes to the visible surfaces of the culverts including cracking, buckling, shearing, and collapse and include:

- recording of existing cracks;
- recording of other defects and general condition;
- two dimensional image records of the affected structures; and
- condition of the access roads with specific attention to surface cracks.

The site inspection will be conducted by representative(s) from the RMS.

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## **Cuttings**

Visual monitoring will be undertaken to assess potential movement and or impacts to the cuttings, including:

- changes in cutting condition, including opening of cracks or spalling;
- changes in groundwater seepage or surface water flows;
- rockfalls; and
- changes in RMS risk ranking.

A site inspection of the cuttings will be conducted following the completion of each longwall, or more frequently if determined in consultation with the Technical Committee. The site inspection will be conducted by representative(s) from the RMS. A report will be prepared by the RMS following each inspection noting the observed changes to the condition of the cuttings and any changes to the ARL ranking for the cuttings.

Regular visual inspections will be conducted during mining by representatives of the RMS as part of the RMS Network Safety Inspections. These inspections are carried out by a dedicated inspector twice weekly and any observed defects that represent a safety hazard will be reported to the RMS Technical Committee.

## **Bridges**

### *Bridge 2 (Old Princes Highway Underpass)*

The existing system for high accuracy measurement of the Bridge 2 structure distortions using FBG sensors will be retained for Longwalls 301-303 to allow early detection of small relative ground movements which could then be monitored more closely using all available methods. Prior to and during the early stages of mining of Longwall 301 (for a duration determined in consultation with the Technical Committee), the FBG readings will be taken on one day of each week. The FBG monitoring frequency will be increased if determined in consultation with the RMS Technical Committee although weekly readings should be sufficient, even if significant relative ground movements are occurring.

The existing system established for relative 3D survey of Bridge 2 using conventional survey equipment will also be retained for Longwalls 301-303. Re-survey of Bridge 2 targets will occur:

- prior to extraction of Longwall 301; and
- within 3 months of the completion of each longwall (Longwalls 301, 302 and 303).

Monitoring frequency of Bridge 2 will be reviewed if:

- absolute horizontal movement of survey lines (e.g. Transmission Line and M1 Princes Motorway Northbound Line) indicate more than 30 mm of horizontal movement;
- FBG sensor monitoring detects significant distortion of the structure;
- visual inspection indicates cracking; or
- if otherwise determined in consultation with the RMS Technical Committee.

It is envisaged by the RMS Technical Committee that the frequency of conventional survey monitoring, after 30 mm of absolute movement is measured or significant structure distortion is detected by the FBG sensor system, will be weekly. The frequency may be reduced if the FBG sensor system readings indicate that relative ground movements are developing slowly.

Visual inspection of Bridge 2 will be conducted at the completion of Longwalls 301, 302 and 303 or otherwise if determined in consultation with the RMS Technical Committee.

#### *Cawley Road Overbridge*

A visual inspection of the Cawley Road Overbridge will be conducted prior to the extraction of Longwall 301. Visual inspections of Cawley Road Overbridge will be conducted at the completion of Longwalls 301, 302 and 303 or otherwise if determined in consultation with the RMS Technical Committee.

A system for relative 3D survey of Cawley Road Overbridge using conventional survey equipment will be installed prior to the commencement of Longwall 301. Survey of Cawley Road Overbridge targets will occur:

- prior to extraction of Longwall 301 (baseline survey); and
- within 3 months of the completion of each longwall (Longwalls 301, 302 and 303).

Monitoring frequency of Cawley Road Overbridge will be reviewed if:

- absolute horizontal movement of survey lines (e.g. Transmission Line and M1 Princes Motorway Northbound Line) indicate more than 30 mm of horizontal movement;
- visual inspection indicates cracking; or
- if otherwise determined in consultation with the RMS Technical Committee.

It is envisaged by the RMS Technical Committee that the frequency of conventional survey monitoring, after 30 mm of absolute movement is measured, will be weekly.

### **6.8.3 Old Princes Highway (BFMP-WCC)**

#### ***Pavement***

Subsidence impacts will be monitored extending from the Old Princes Highway Underpass (Bridge 2) to the entrance to the Garrawarra Centre Complex.

An inspection of the pavement will occur prior to commencement of Longwall 302 (as agreed with Wollongong City Council) and within three months of the completion of Longwalls 302 and 303. Progress monitoring (visual inspections) will occur weekly when the longwall face is within 400 m of passing underneath the Old Princes Highway. Additional observations of subsidence impacts will be conducted during routine works and WCC's routine (quarterly) road condition inspections.

Specific details that will be noted and/or photographed include:

- the date of the inspection;
- the location of longwall extraction (i.e. the longwall chainage);
- assessment against the performance indicators and performance measure;

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- whether any actions are required (e.g. initiation of the Contingency Plan, incident notification, implementation of appropriate safety controls, review of public safety, etc.); and
- any other relevant information.

Wollongong City Council utilises video photography (i.e. recording of existing defects i.e. one photograph every 2 m), this technique can assist identifying road pavement subsidence impacts Other road pavement baseline records (e.g. deflectograph survey, video) would also be provided to Metropolitan Coal.

**Guard Rails, Marker Posts and Signage**

An inspection of guard rails, marker posts and signage will occur prior to commencement of Longwall 302 (as agreed with Wollongong City Council) and within three months of the completion of Longwalls 302-303. Progress monitoring (visual inspections) will occur weekly when the longwall face is within 400 m of passing underneath the Old Princes Highway.

**6.8.4 Waterfall General [Garrawarra] Cemetery (BFMP-CEM)**

A post mining audit will be conducted following completion of Longwalls 301-303 for comparison with the pre-mining audit records.

Visual inspections will be conducted by Metropolitan Coal at the Waterfall Cemetery in consultation with Wollongong City Council.

Specific details that will be noted and/or photographed include:

- the date of the inspection;
- the location of longwall extraction (i.e. the longwall chainage);
- assessment against the performance indicators and performance measure;
- whether any actions are required (e.g. initiation of the Contingency Plan, incident notification, implementation of appropriate safety controls, review of public safety, etc.); and
- any other relevant information.

**6.8.5 Water Mains (BFMP-SYDWATER)**

Routine visual inspections by Sydney Water will also be conducted of the pipelines in accordance with the Sydney Water inspection program. For pipelines, this generally includes:

- assessment of the condition of water mains and associated fittings;
- inspection on fittings (valves and hydrants); and
- detection of leaks, breaks or water pressure drops in the pipeline reported by Sydney Water customers.

A visual inspection of the pipeline route will occur prior to commencement of Longwall 301 and following completion of each of Longwalls 301, 302 and 303 to identify surface ground cracks, cracks or leaks in the pipelines, and to confirm that fittings can be accessed beneath surface fittings and are operable.

Weekly observations of subsidence impacts along the pipeline route will be conducted when Longwall 302 and Longwall 303 is within 400m of passing directly underneath the pipeline. Specific details that will be noted and/or photographed include:

- the date of the inspection;
- the location of longwall extraction (i.e. the longwall chainage);
- evidence of wet ground where the pipe is buried
- assessment against the performance indicators and performance measure;
- whether any actions are required (e.g. initiation of the Contingency Plan, incident notification, implementation of appropriate safety controls, review of public safety, etc.); and
- any other relevant information.

#### **6.8.6 Transmission Lines and Towers (BFMP-TRA, BFMP-END)**

##### ***TransGrid***

##### *330 kV Transmission Line and Towers*

An audit / baseline inspection will occur prior to commencement of Longwall 301. Documentation of pre-mining conditions would include results of:

- survey of monitoring lines/points;
- survey of tower legs (TL11-103 to TL11-108); and
- earth peaks monitoring.

Weekly survey inspections will be conducted at each tower when the active longwall face is within 400 m of the tower and following survey monitoring carried out:

- survey 4 x ground monitoring points outside each leg;
- survey 4 x tower leg mounted prisms;
- survey the earth wire peak point; and
- survey transmission line  $\pm$  10 points either side of the tower being monitored.

For each survey event the surveyors will record on their field notes and provide in the weekly report the following:

- Any observable surface deformations or other subsidence related effects at the tower being surveyed.
- Any observable subsidence effects on the road accessing each tower.
- Any observable effects will be noted quantitatively in regards width, length, orientation.

During the first month of mining Longwalls 301, 302 and 303, monitoring of TL11-107 and TL11-108 would be undertaken at a weekly frequency as determined in consultation with TransGrid.

If, during mining, the measured separation between tower legs is more than 4 mm; and/or surface deformations at a tower are observed, Metropolitan Coal would consult with TransGrid about increasing monitoring frequency.

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In addition to the above monitoring, Metropolitan Coal has installed real-time survey monitoring at the towers as an additional management tool.

Inspections to identify any degradation of tower structure, tower foundations/footings, and movement of insulator strings as well as the transmission lines (e.g. vegetation clearance, land clearance, road clearance, and integrity and function of support clamps or other items) will occur within 3 months following the completion of extraction of each of Longwalls 301, 302 and 303, or at any time in case of a fault or emergency.

Visual inspections will be conducted of the towers and transmission line between TransGrid Tower TL11-103 to TL11-108 inclusive in accordance with the TransGrid inspection program. This generally includes:

- annual inspection of the structure integrity sites from the ground;
- annual inspection of vegetation growth and electrical clearances from the air;
- six yearly climbing inspection; and
- fault and emergency patrols from either the air or ground at any time.

Additional observations of subsidence impacts will be conducted during routine works and recorded by surveyors during tower monitoring survey.

Specific details that will be noted and/or photographed include:

- the date of the inspection;
- the location of longwall extraction (i.e. the longwall chainage);
- assessment against the performance indicators and performance measure;
- whether any actions are required (e.g. initiation of the Contingency Plan, incident notification, implementation of appropriate safety controls, review of public safety, etc.); and
- any other relevant information.

### ***Endeavour Energy***

#### *132 kV Transmission Line and Towers*

A visual inspection will be conducted prior to commencement of Longwall 301. More frequent (e.g. weekly) inspections will be conducted by Metropolitan Coal at each tower within 400 m of the active longwall face.

Inspections to identify any degradation of tower structure, tower foundations/footings, and movement of insulator strings as well as the transmission lines (e.g. vegetation clearance, land clearance, road clearance, and integrity and function of support clamps or other items) will occur within 3 months following the completion of extraction of each of Longwalls 301, 302 and 303, or at any time in case of a fault or emergency.

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Visual inspections will be conducted of the 132 kV transmission line and towers between Tower T7 and T13 inclusive in accordance with the Endeavour Energy inspection program. This generally includes:

- annual inspection of the structural integrity of sites from the ground;
- annual inspection of vegetation growth and electrical clearances from the air;
- six yearly climbing inspections; and
- fault and emergency patrols from either the air or ground at any time.

Additional observations of subsidence impacts will be conducted during routine works and recorded by surveyors during tower monitoring survey.

Specific details that will be noted and/or photographed include:

- the date of the inspection;
- the location of longwall extraction (i.e. the longwall chainage);
- assessment against the performance indicators and performance measure;
- whether any actions are required (e.g. initiation of the Contingency Plan, incident notification, implementation of appropriate safety controls, review of public safety, etc.); and
- any other relevant information.

*Timber Poles and High Voltage Powerlines*

A visual inspection of the timber poles<sup>3</sup> and powerlines will be conducted prior to commencement of Longwall 301.

Inspections to identify any degradation of the structure and movement of conductors as well as the high voltage power lines (e.g. vegetation clearance, land clearance, road clearance, and integrity and function of support clamps or other items) will occur within 3 months following the completion of extraction of each of Longwalls 301, 302 and 303, or at any time in case of a fault or emergency.

Additional observations of subsidence impacts will be conducted during routine works and sampling by Metropolitan Coal and its contractors.

Specific details that will be noted and/or photographed include:

- the date of the inspection;
- the location of longwall extraction (i.e. the longwall chainage);
- assessment against the performance indicators and performance measure;
- whether any actions are required (e.g. initiation of the Contingency Plan, incident notification, implementation of appropriate safety controls, review of public safety, etc.); and
- any other relevant information.

<sup>3</sup> For example, where a timber pole lean of greater than 15 degrees from vertical is identified.

### 6.8.7 Telecommunication Cables (BFMP-TELSTRA, BFMP-VOCUS, BFMP-OPTUS)

#### *Fibre Optic Cables*

Fibre cables installed by each of the three communication companies are in separate conduits but follow the same route as each other.

Weekly survey inspections will be conducted along each cable route when the active longwall face is within 400 m of passing under the cable. The following survey monitoring will be carried out:

- survey of optical / water line and/or transmission line

For each survey event the surveyors will record on their field notes and provide in the weekly report the following:

- Any observable surface deformations or other subsidence related effects along the track being surveyed.
- Any observable effects will be noted quantitatively in regards width, length, orientation.

#### *Telstra Fibre Optic Cable 1*

Continuous RFMS monitoring using the 1,625 nanometres Optical Time Domain Reflectometer (OTDR) monitoring on a Telstra spare fibre will be used to measure the signal integrity (i.e. dB change) during mining of Longwalls 301-303.

Visual inspections will be conducted of the cable line and associated pits in accordance with the Telstra inspection system (e.g. weekly physical inspection for the period covering 100 m prior to undermining the cable to 400 m past the cable line) or if triggered by a transmission fault (e.g. RFMS records loss event  $\pm 0.3$  dB; or exceeds  $\pm 1.0$  dB) detected by the Telstra monitoring system (BFMP-Telstra). The visual inspections would be used to identify any movement of conduit, degree of freedom of cable in conduit and ground compression / tension.

Specific details that will be noted and/or photographed include:

- the date of the inspection;
- the location of longwall extraction (i.e. the longwall chainage);
- assessment against the performance indicators and performance measure;
- whether any actions are required (e.g. initiation of the Contingency Plan, incident notification, implementation of appropriate safety controls, review of public safety, etc.); and
- any other relevant information.

#### *Telstra Fibre Optic Cable 2*

Continuous RFMS monitoring using the 1,625 nanometres Optical Time Domain Reflectometer (OTDR) monitoring a Telstra spare fibre will be used to measure the signal integrity (i.e. dB change) during the commencing 400 m of extraction from Longwalls 302 and 303.

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Visual inspections will be conducted of the cable line and associated pits in accordance with the Telstra inspection system (e.g. weekly physical inspection for the period during commencing 400 m of extraction from Longwalls 302 and 303) or if triggered by a transmission fault (e.g. RFMS records loss event  $\pm 0.3$  dB; or exceeds  $\pm 1.0$  dB) detected by the Telstra monitoring system (BFMP-Telstra). The visual inspections would be used to identify any movement of conduit, degree of freedom of cable in conduit and ground compression / tension.

#### *Vocus Fibre Optic Cable*

The continuous RFMS monitoring on the Telstra spare fibre will also be used to measure the signal integrity (i.e. dB change) for the Vocus fibre optic cable during mining of Longwalls 301-303.

Visual inspections will be conducted on the cable line and joint house pit in accordance with the Vocus inspection system (e.g. weekly if the ground strain exceeds 1 mm/m between adjacent survey marks until movement stabilises, or more frequently if subsidence exceeds 225 mm) or if triggered by a transmission fault (RFMS records loss event  $\pm 0.3$  dB;  $\pm 0.5$  dB; or exceeds  $\pm 1.0$  dB) detected by the Vocus monitoring system (utilising the continuous RFMS monitoring using the 1,625 nanometres Optical Time Domain Reflectometer (OTDR) monitoring the Telstra spare fibre). The visual inspections would be used to identify any movement of conduit, degree of freedom of cable in conduit and ground compression / tension.

Specific details that will be noted and/or photographed include:

- the date of the inspection;
- the location of longwall extraction (i.e. the longwall chainage);
- assessment against the performance indicators and performance measure;
- whether any actions are required (e.g. initiation of the Contingency Plan, incident notification, implementation of appropriate safety controls, review of public safety, etc.); and
- any other relevant information.

#### *Optus Fibre Optic Cables*

Visual inspections will be conducted of the cable lines by Optus as required, in accordance with the Optus inspection system or if triggered by a transmission fault detected by Optus.

Specific details that will be noted and/or photographed include:

- the date of the inspection;
- the location of longwall extraction (i.e. the longwall chainage);
- assessment against the performance indicators and performance measure;
- whether any actions are required (e.g. initiation of the Contingency Plan, incident notification, implementation of appropriate safety controls, review of public safety, etc.); and
- any other relevant information.

#### **Copper Telecommunication Cables**

Visual inspections of the aerial and buried copper telecommunication cables (at the Garrawarra Centre Complex) will be conducted as required in accordance with the Telstra Management Plan Agreement (2016) for the area.

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### 6.8.8 Telecommunication Towers and Compounds (BFMP-TELSTRA, BFMP-AXICOM, BFMP-SYDTRAINS)

Monitoring of subsidence parameters at the telecommunication towers and compounds will be undertaken as described in the BFMPs. Survey will be established for subsidence, tilt and ground strain at the towers prior to subsidence occurring.

It is important to note that subsidence effects predicted for the telecommunications towers and compounds during mining of Longwall 301 alone are minimal to nil as the total subsidence profile does not develop until after commencement of Longwall 302 and Longwall 303

#### ***Telstra Telecommunication Tower and Compound***

A pre and post-mining inspection of the Telstra hut and fencing at the compound will be undertaken. Visual inspections will be conducted as required in accordance with the Telstra Management Plan Agreement (2016) for the area included in the BFMP-Telstra.

During mining, monitoring of the structural integrity of the telecommunications tower and compound and the tower tilt (i.e. to determine if greater than 1 degree) will occur:

- within 3 months following the completion of extraction of Longwall 301;
- weekly during the commencing 400 m of extraction from each of Longwalls 302 and 303; and
- within 3 months following the completion of extraction of each of Longwalls 302 and 303.

#### ***Axicom Telecommunication Towers and Compounds***

A pre and post-mining inspection of the Axicom towers and huts (including fencing) at the compounds will be undertaken. Visual inspections will be conducted of the telecommunications towers and compounds. An audit and site inspection of the entries and cable lines to the hut and condition of the cable will also be conducted prior to extraction of Longwall 301 (or as otherwise agreed with Axicom).

During mining, monitoring of the tower structures as described in the BFMP will occur:

- within 3 months following the of extraction of Longwall 301;
- weekly during the commencing 400 m of extraction from each of Longwalls 302 and 303; and
- within 3 months following the completion of extraction of each of Longwalls 302 and 303.

#### ***Sydney Trains Telecommunication Tower and Compound***

Visual inspections of the telecommunications tower and compound will be conducted in consultation with the Sydney Trains.

Monitoring of the Sydney Trains tower and compound will be conducted by Metropolitan Coal as described in the BFMP:

- within 3 months following the completion of extraction of Longwall 301;
- weekly during the commencing 400 m of extraction from each of Longwalls 302 and 303; and
- within 3 months following the completion of extraction of each of Longwalls 302 and 303.

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### 6.8.9 Illawarra Railway (BFMP-SYDTRAINS)

Sydney Trains Illawarra Railway is located more than 1.4 km from the Longwalls 301-303 and at that distance, no measurable conventional or non-conventional subsidence movements are anticipated. Notwithstanding the separation distance, survey monitoring is installed at the Wilsons Creek and Cawley Creek culverts to confirm negligible relative movement of these structures. In addition, for Longwall 303 real time (continuous) absolute 3D monitoring will monitor for any far field valley closure mechanism that may be detectable at Wilsons Creek and Cawley Creek.

It is noted that the TransGrid (weekly) monitoring program results (Section 6.8.6), TransGrid towers real time 3D monitoring and RMS monitoring (Section 6.8.2) informs monitoring and/or action for the Illawarra Railway.

While not a component of the monitoring program, visual inspections of the Illawarra Railway are also conducted in accordance with the Sydney Trains inspection plans for the area. This generally includes:

- track condition;
- structures condition;
- drainage changes; and
- culvert condition.

### 6.9 ACCESS ROADS/TRACKS

Visual inspection of the access roads/tracks will be conducted prior to the commencement of Longwall 301, and following extraction of each longwall panel.

Visual observations of access roads/tracks would occur as part of routine works and inspections as well as during catchment visits within 600 m of Longwalls 301-303 secondary extraction as described in the Metropolitan Coal Longwalls 301-303 LMP.

Specific details that will be noted and/or photographed that are relevant to the access roads/tracks include:

- the location, approximate dimensions (length, width and depth), and orientation of surface tension cracks;
- the location of the surface tension crack in relation to the access road/track;
- whether any actions are required (e.g. implementation of management measures as outlined in the Longwalls 301-303 LMP, initiation of the Contingency Plan as outlined in the Longwalls 301-303 LMP, incident notification, implementation of appropriate safety controls, review of public safety, etc.); and
- any other relevant information.

## 7 ANALYSIS OF SUBSIDENCE EFFECTS, SUBSIDENCE IMPACTS AND ENVIRONMENTAL CONSEQUENCES

Analysis of the relationship between subsidence effects, subsidence impacts and environmental consequences will be reported annually in the Annual Review. The analysis will include:

- comparison of predicted subsidence effects and measured parameters;
- comparison of predicted subsidence impacts and measured impacts;
- analysis of any variations between predicted and measured conventional subsidence effects and impacts (e.g. consideration of underlying parameters such as distance functions, etc. used to determine the predicted subsidence profile);
- analysis of variations between predicted and measured far-field movements and non-conventional subsidence effects (e.g. effects of geological structures and valley closure) and impacts; and
- analysis of the 3D movement about longwall extraction with particular reference to the transverse and longitudinal movements versus distance in advance of the longwall panel.

The analyses will be used to assess the validity of the subsidence predictions and to refine the predictive methods where appropriate.

The relationship between subsidence effects, impacts and environmental consequences will be determined through review and reporting of each environmental management plan (e.g. Longwalls 301-303 LMP, Longwalls 301-303 WMP, Longwalls 301-303 BMP) in accordance with Condition 3, Schedule 7 of the Project Approval.

## 8 REFERENCES

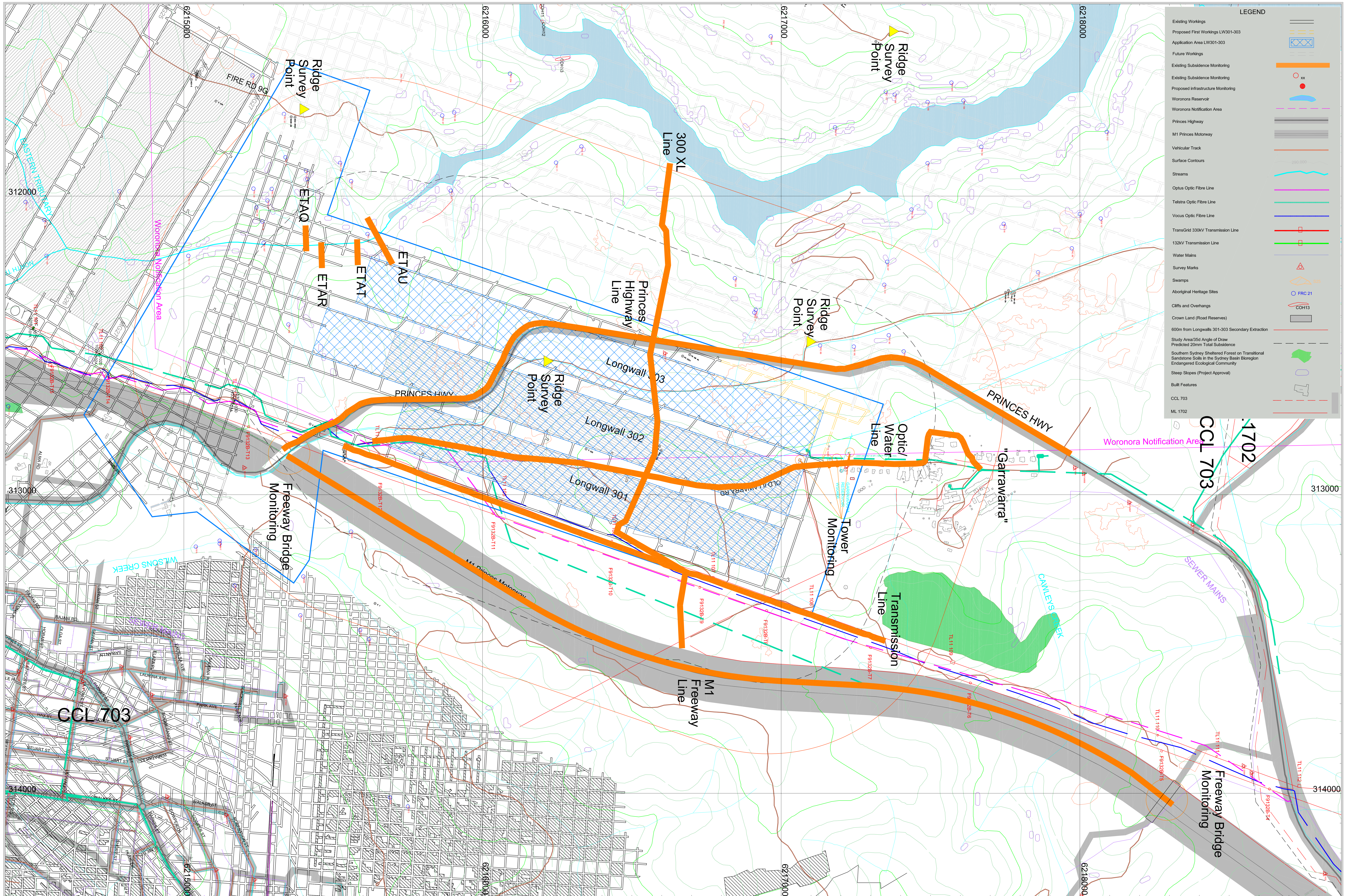
- Department of Planning and Environment and NSW Trade & Investment – Division of Resources and Energy (2015) *Guidelines for the Preparation of Extraction Plans Required under Conditions of Development Consents, Project Approvals and Mining Lease Conditions for Underground Coal Mining*. Version 5. Draft.
- Eco Logical Australia (2016) *Longwalls 301-303 Upland Swamp Vegetation Mapping and Proposed Monitoring Program*. Report prepared for Metropolitan Coal. August 2016.
- Helensburgh Coal Pty Ltd (2008) *Metropolitan Coal Project Environmental Assessment*.
- Helensburgh Coal Pty Ltd (2009) *Metropolitan Coal Project Preferred Project Report*.
- Howard Tanner & Associates (1993) *Conservation Plan for the Garrawarra Centre for Aged Care*.
- Mine Subsidence Engineering Consultants (2008) Metropolitan Colliery Longwalls 20-44 Subsidence Assessment Report (MSEC Report MSEC285 Revision C, August 2008) in *Metropolitan Coal Project Environmental Assessment (Appendix A)*.
- Mine Subsidence Engineering Consultants (2018) *Metropolitan Mine – Longwalls 301 to 303 Subsidence Predictions and Impact Assessments for the Natural and Built Features in Support of the Extraction Plan (MSEC Report MSEC984)*.

ATTACHMENT 1

PLAN 7 (SUBSIDENCE MONITORING LOCATIONS)  
IN ACCORDANCE WITH THE  
DEPARTMENT OF PLANNING AND ENVIRONMENT AND  
DIVISION OF RESOURCES AND ENERGY (2015)  
*GUIDELINES FOR THE PREPARATION OF EXTRACTION PLANS*

Metropolitan Coal – Subsidence Monitoring Program		
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LEGEND	
Existing Workings	[Symbol]
Proposed First Workings LW301-303	[Symbol]
Application Area LW301-303	[Symbol]
Futura Workings	[Symbol]
Existing Subsidence Monitoring	[Symbol]
Existing Subsidence Monitoring	[Symbol]
Proposed Infrastructure Monitoring	[Symbol]
Woronora Reservoir	[Symbol]
Woronora Notification Area	[Symbol]
Princes Highway	[Symbol]
M1 Princes Motorway	[Symbol]
Vehicular Track	[Symbol]
Surface Contours	[Symbol]
Streams	[Symbol]
Optus Optic Fibre Line	[Symbol]
Telstra Optic Fibre Line	[Symbol]
Vocus Optic Fibre Line	[Symbol]
TransGrid 330kV Transmission Line	[Symbol]
132kV Transmission Line	[Symbol]
Water Mains	[Symbol]
Survey Marks	[Symbol]
Swamps	[Symbol]
Aboriginal Heritage Sites	[Symbol]
Cliffs and Overhangs	[Symbol]
Crown Land (Road Reserves)	[Symbol]
600m from Longwalls 301-303 Secondary Extraction	[Symbol]
Study Area 35d Angle of Draw	[Symbol]
Predicted 20mm Total Subsidence	[Symbol]
Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion	[Symbol]
Endangered Ecological Community	[Symbol]
Steep Slopes (Project Approval)	[Symbol]
Built Features	[Symbol]
CCL 703	[Symbol]
ML 1702	[Symbol]

Mining Engineering Manager Date Registered Mine Surveyor Date

CLIENT/PROJECT

**Peabody**

**METROPOLITAN COAL PTY LTD**  
METROPOLITAN MINE

PO BOX 402  
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SURV'D/DESC'D CHECKED AUTHORISED

DRAWING No **M180929 P7 Rev4**

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Longwalls 301-303 Extraction Plan:  
Plan 7 - Longwalls 301-303 Subsidence Monitoring Locations