METROPOLITAN COAL LONGWALLS 301-303

BIODIVERSITY MANAGEMENT PLAN




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Revision Status Register

Section/Page/ Annexure	Revision Number	Amendment/Addition	Distribution	DP&E Approval Date
All	BMP-R01-A	Original – Draft for Consultation	DP&E, OEH, DPI - Fishing	-
All	BMP-R01-B	Minor amendments to reflect revised Longwalls 302 and 303	DP&E, OEH, DPI - Fishing	-
Sections 4.1 and 4.3, Figure 3	BMP-R01-C	Addition of footnotes in Sections 4.1 and 4.3, and minor amendments to Figure 3	DP&E, OEH, DPI - Fishing	11 May 2017*
All	BMP-R01-D	Revised TARPs and associated management plan amendments	DP&E, OEH, DPI - Fishing	-
8.1.2, Table 12 and Table 13	BMP-R01-E	Minor amendments	DP&E	-
All	BMP-R01-F	Revised Longwalls 301-303 Extraction Plan	DP&E, OEH, DPI - Fishing	-

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

September 2018

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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 and 2). Longwalls 304 on will be subject to future Extraction Plans.

1.1 PURPOSE AND SCOPE

In accordance with Condition 6(f), Schedule 3 of the Project Approval, this Biodiversity Management Plan (BMP) has been prepared as a component of the Metropolitan Coal Longwalls 301-303 Extraction Plan to manage the potential environmental consequences of the Extraction Plan on aquatic and terrestrial flora and fauna, with a specific focus on swamps.

The relationship of this BMP to the Metropolitan Coal Environmental Management Structure and to the Metropolitan Coal Longwalls 301-303 Extraction Plan is shown on Figure 3.

This updated BMP includes descriptions of pre and post-mining monitoring and management of aquatic and terrestrial flora and fauna, also subjects in the two previously approved Metropolitan Coal Biodiversity Management Plans for Longwalls 20-22 and Longwalls 23-27. Thus, the Longwalls 20-22 and Longwalls 23-27 Biodiversity Management Plans will be superseded by this document following the completion of Longwall 27 consistent with the recommended approach in the NSW Department of Planning and Environment (DP&E) and NSW Division of Resources and Energy (DRE) (2015) *Guidelines for the Preparation of Extraction Plans*.

In accordance with Condition 6, Schedule 3 of the Project Approval, this BMP has been prepared by Metropolitan Coal, with assistance from FloraSearch[1], Cenwest Environmental Services, Eco Logical Australia (Eco Logical), Bio-Analysis, HydroSimulations, and Mine Subsidence Engineering Consultants (MSEC).

1.2 STRUCTURE OF THE BIODIVERSITY MANAGEMENT PLAN

The remainder of the BMP is structured as follows:

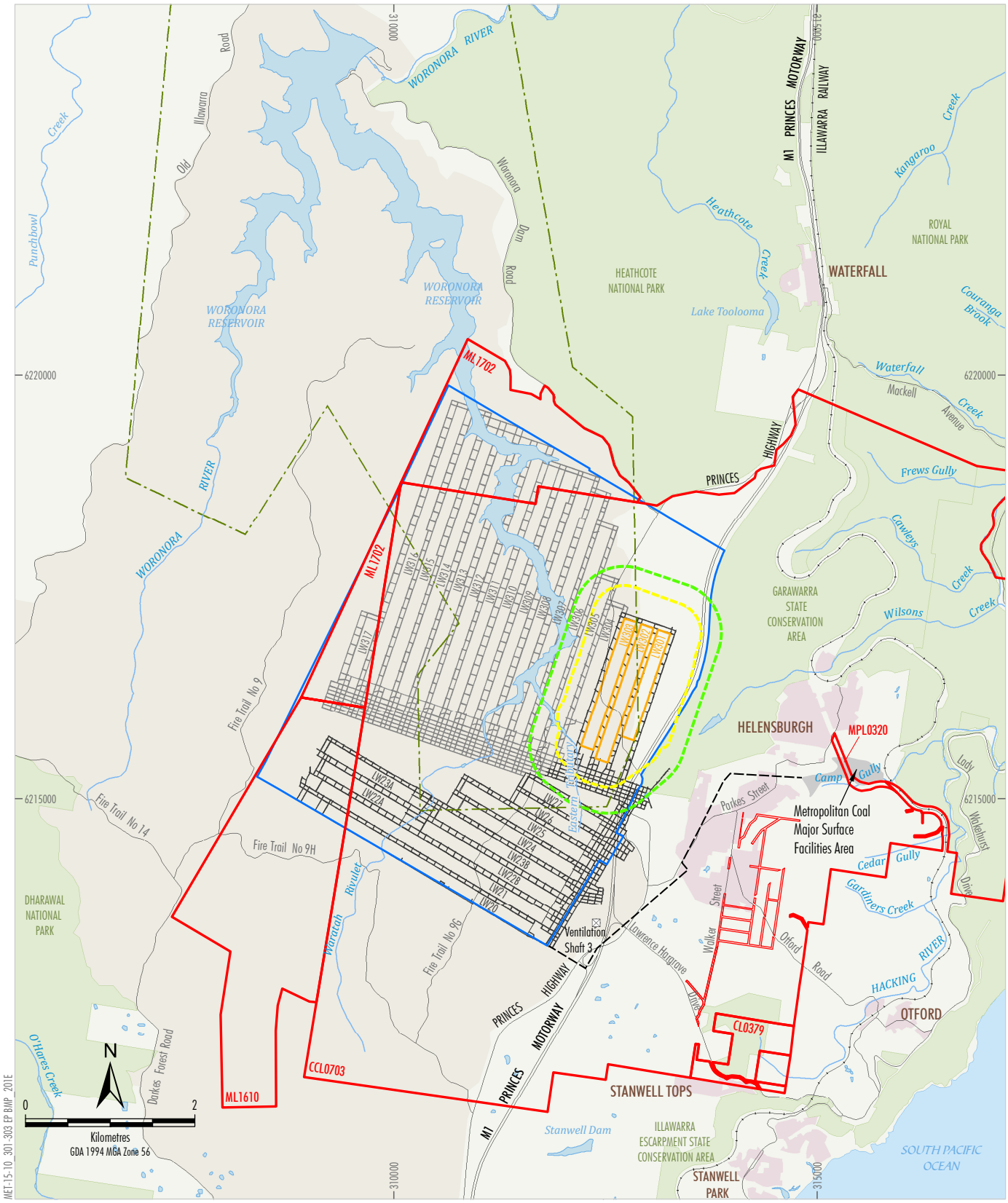
Section 2: Describes the review and update of the BMP.

Section 3: Outlines the statutory requirements applicable to the BMP.

Section 4: Provides a summary of the water, land and biodiversity management information obtained since Project Approval.

Section 5: Provides a revised assessment of the potential subsidence impacts and environmental consequences for Longwalls 301-303.

[1] The terrestrial flora components of the Biodiversity Management Plan have been reviewed and revised with assistance from Eco Logical from Version E.



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)

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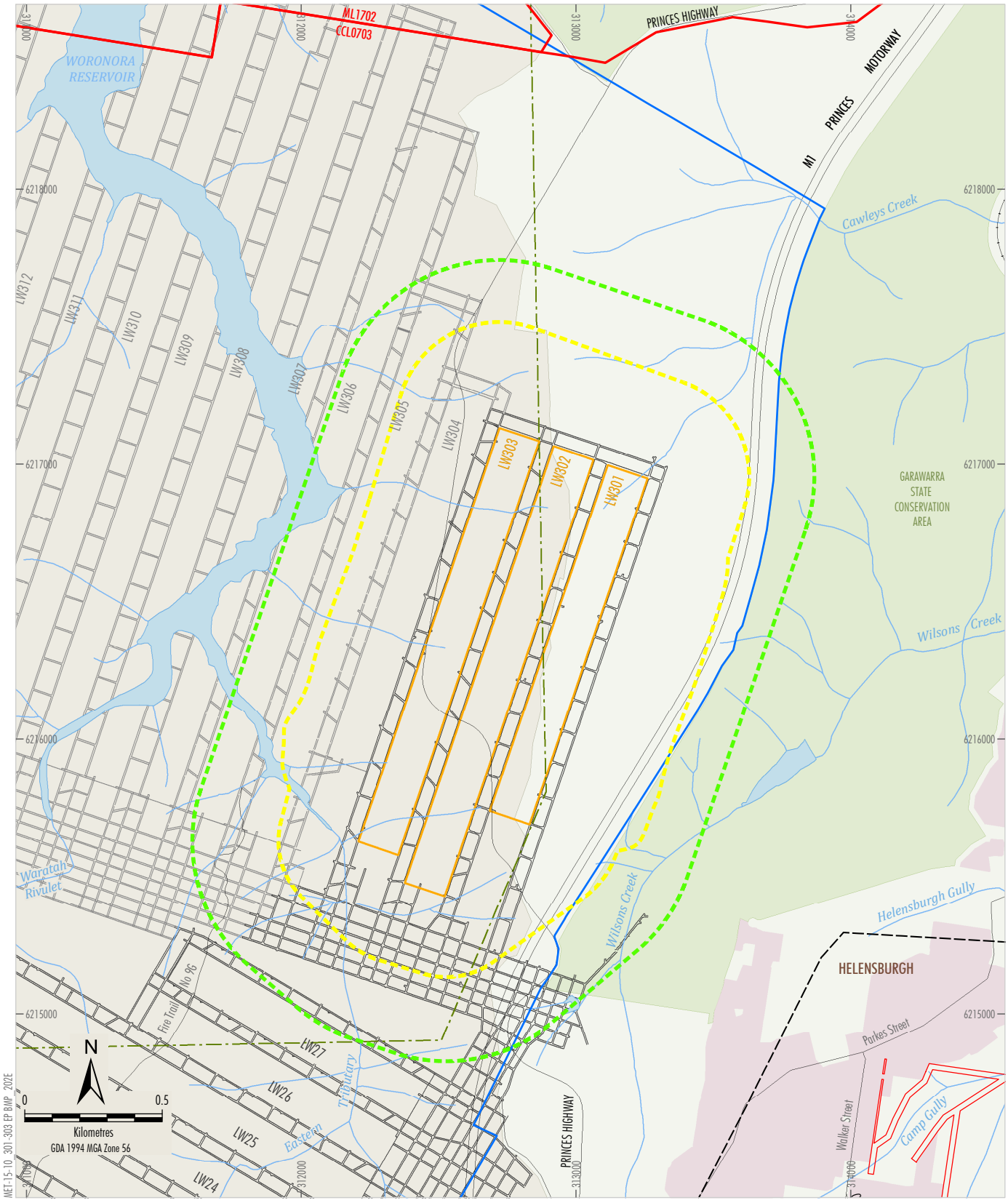
Longwalls 301 - 303 and Project Underground Mining Area

Figure 1



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

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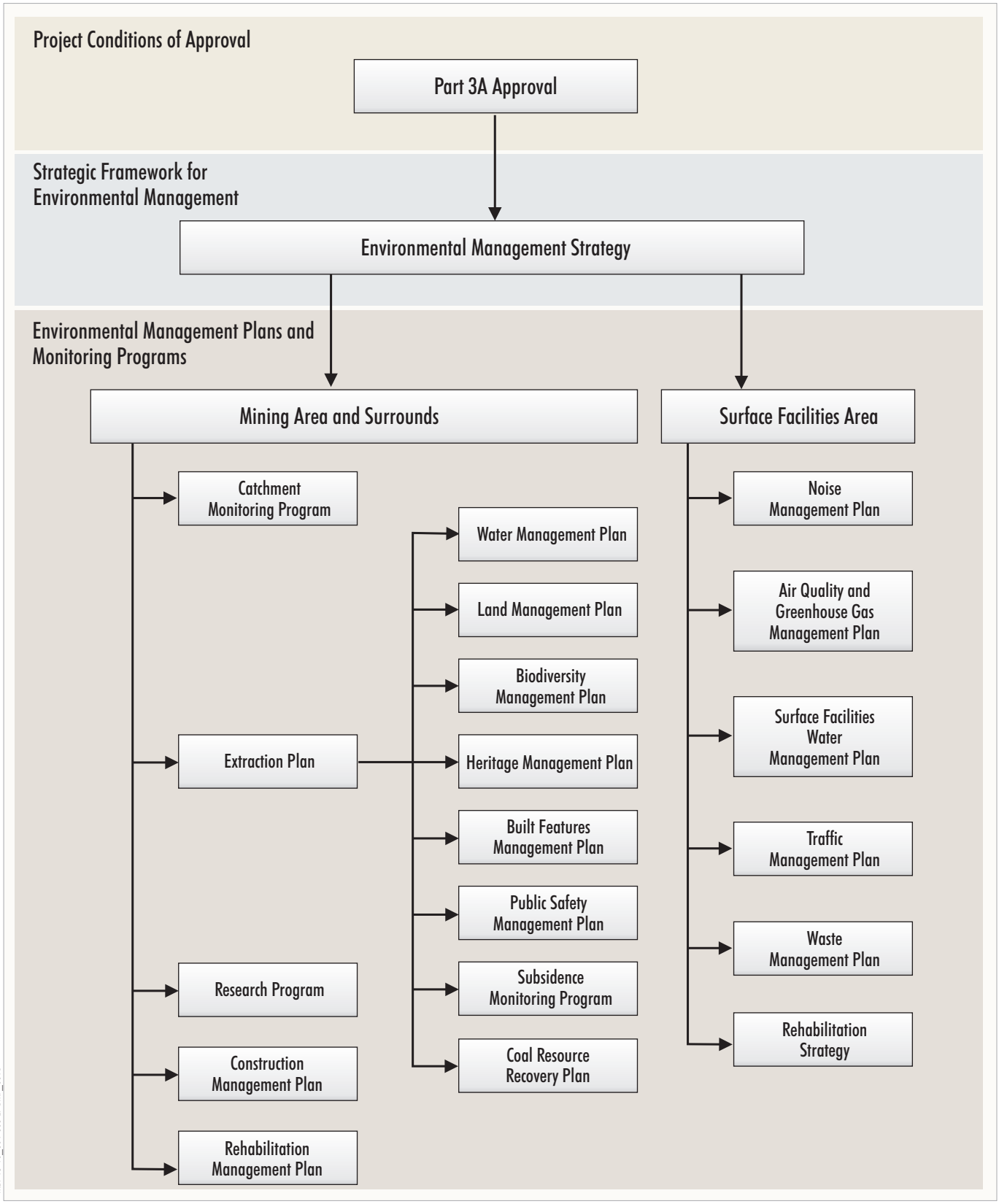
Longwalls 301 - 303 Layout

Figure 2



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Environmental Management Structure

Figure 3

Section 6: Details the performance measures and indicators that will be used to assess the Project.

Section 7: Provides the detailed baseline data.

Section 8: Describes the monitoring programs and provides the detailed Trigger Action Response Plans (TARPs).

Section 9: Describes the management measures that will be implemented.

Section 10: Provides a Contingency Plan to manage any unpredicted impacts and their consequences.

Section 11: Describes the program to collect baseline data for future Extraction Plans.

Section 12: Describes the annual review and improvement of environmental performance.

Section 13: Outlines the management and reporting of incidents.

Section 14: Outlines the management and reporting of complaints.

Section 15: Outlines the management and reporting of non-compliances with statutory requirements.

Section 16: Lists the references cited in this BMP.

2 BIODIVERSITY MANAGEMENT PLAN REVIEW AND UPDATE

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

- an audit under Condition 8, Schedule 7;
- an incident report under Condition 6, Schedule 7;
- 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 BMP is updated on a regular basis and to incorporate any recommended measures to improve environmental performance.

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

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

2.1 DISTRIBUTION REGISTER

In accordance with Condition 10, Schedule 7 of the Project Approval 'Access to Information', Metropolitan Coal will make the BMP publicly available on the Peabody website. A hard copy of the BMP 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 BMP, 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 BMP 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.

3 STATUTORY REQUIREMENTS

Metropolitan Coal's statutory obligations are contained in:

(i) the conditions of the Project Approval;

(ii) relevant licences and permits, including conditions attached to mining leases; and

(iii) other relevant legislation.

These are described below.

3.1 EP&A ACT APPROVAL

Condition 6(f), Schedule 3 of the Project Approval requires the preparation of a BMP as a component of Extraction Plan(s) for second workings. Condition 6(f), 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:*
>
> *…*
>
> *(f) include a:*
>
> *…*
>
> - *Biodiversity Management Plan, which has been prepared in consultation with OEH and DRE (Fisheries)[2], to manage the potential environmental consequences of the Extraction Plan on aquatic and terrestrial flora and fauna, with a specific focus on swamps;*

[2] DRE (Fisheries) is now the Department of Primary Industries (DPI) - Fishing.

In addition, Condition 2, Schedule 7 and Condition 7, Schedule 3 of the Project Approval outline management plan requirements that are applicable to the preparation of the BMP. Table 1 indicates where each component of the conditions is addressed within this BMP.

Table 1
Management Plan Requirements

Project Approval Condition	BMP Section
Condition 2, Schedule 7	
2. The Proponent shall ensure that the management plans required under this approval are prepared in accordance with any relevant guidelines, and include:	
a) detailed baseline data;	Section 7
b) a description of:	
• the relevant statutory requirements (including any relevant approval, licence or lease conditions);	Section 3
• any relevant limits or performance measures/criteria;	Section 6
• the specific performance indicators that are proposed to be used to judge the performance of, or guide the implementation of, the project or any management measures;	Section 6
c) a description of the measures that would be implemented to comply with the relevant statutory requirements, limits, or performance measures/criteria;	Sections 6, 8, 9 and 10
d) a program to monitor and report on the:	Sections 8, 9 and 12
• impacts and environmental performance of the project;	
• effectiveness of any management measures (see c above);	
e) a contingency plan to manage any unpredicted impacts and their consequences;	Section 10
f) a program to investigate and implement ways to improve the environmental performance of the project over time;	Sections 8 and 12
g) a protocol for managing and reporting any;	
• incidents;	Section 13
• complaints;	Section 14
• non-compliances with statutory requirements; and	Section 15
• exceedances of the impact assessment criteria and/or performance criteria; and	Section 10
h) a protocol for periodic review of the plan.	Sections 2 and 12
Condition 7, Schedule 3	
7. In addition to the standard requirements for management plans (see condition 2 of schedule 7), the Proponent shall ensure that the management plans required under condition 6(f) above include:	
a) a program to collect sufficient baseline data for future Extraction Plans;	Section 11
b) a revised assessment of the potential environmental consequences of the Extraction Plan, incorporating any relevant information that has been obtained since this approval;	Sections 4 and 5
c) a detailed description of the measures that would be implemented to remediate predicted impacts; and	Section 9
d) a contingency plan that expressly provides for adaptive management.	Section 10

3.2 LICENCES, PERMITS AND LEASES

In addition to the Project Approval, all activities at or in association with Metropolitan Coal will be undertaken in accordance with the following licences, permits and leases which have been issued or are pending:

- The conditions of mining leases issued by the DRG (Division of Resources and Geoscience, previously Division of Resources and Energy [DRE]), under the NSW *Mining Act, 1992* (e.g. Consolidated Coal Lease [CCL] 703, Mining Lease [ML] 1610, ML 1702, Coal Lease [CL] 379 and Mining Purpose Lease [MPL] 320).
- The *Metropolitan Coal Mining Operations Plan 1 October 2012 to 30 September 2019* approved by the DRG.
- The conditions of Environment Protection Licence (EPL) No. 767 issued by the NSW Environment Protection Authority (EPA) under the NSW *Protection of the Environment Operations Act, 1997*. Revision of the EPL will be required prior to the commencement of Metropolitan Coal activities that differ from those currently licensed.
- The prescribed conditions of specific surface access leases within CCL 703 for the installation of surface facilities as required.
- Water Access Licences (WALs) issued by the NSW Department of Primary Industries – Water (now the Department of Industry – Water) under the NSW *Water Management Act, 2000*, including WAL 36475 under the *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011* and WAL 25410 under the *Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources 2011.*
- Mining and workplace health and safety related approvals granted by the NSW Resources Regulator and WorkCover NSW.
- Supplementary approvals obtained from WaterNSW (previously the Sydney Catchment Authority) for surface activities within the Woronora Special Area (e.g. fire road maintenance activities).

3.3 OTHER LEGISLATION

Metropolitan Coal will conduct the Project consistent with the Project Approval and any other legislation that is applicable to an approved Part 3A Project under the EP&A Act.

The following Acts may be applicable to the conduct of the Project (Helensburgh Coal Pty Ltd [HCPL], 2008):

- *Contaminated Land Management Act, 1997;*
- *Crown Lands Act, 1989;*
- *Dams Safety Act, 1978;*
- *Dangerous Goods (Road and Rail Transport) Act, 2008;*
- *Energy and Utilities Administration Act, 1987;*
- *Fisheries Management Act, 1994;*
- *Mining Act, 1992;*
- *Noxious Weeds Act, 1993;*
- *Protection of the Environment Operations Act, 1997;*
- *Rail Safety (Adoption of National Law) Act, 2012;*

- *Roads Act, 1993;*
- *Biodiversity Conservation Act, 2016;*
- *Water NSW Act, 2014;*
- *Water Act, 1912;*
- *Water Management Act, 2000;*
- *Work Health and Safety Act, 2011;* and
- *Work Health and Safety (Mines and Petroleum Sites) Act, 2013.*

Relevant licences or approvals required under these Acts will be obtained as required.

4 RELEVANT INFORMATION OBTAINED SINCE PROJECT APPROVAL

Sections 4.1 – 4.3 summarise the water, land and biodiversity management information obtained since Project Approval, respectively.

4.1 RELEVANT WATER MANAGEMENT INFORMATION OBTAINED SINCE PROJECT APPROVAL

The Metropolitan Coal Water Management Plans were prepared to manage the potential environmental consequences of the Metropolitan Coal Extraction Plans on water resources and watercourses in accordance with Condition 6, Schedule 3 of the Project Approval.

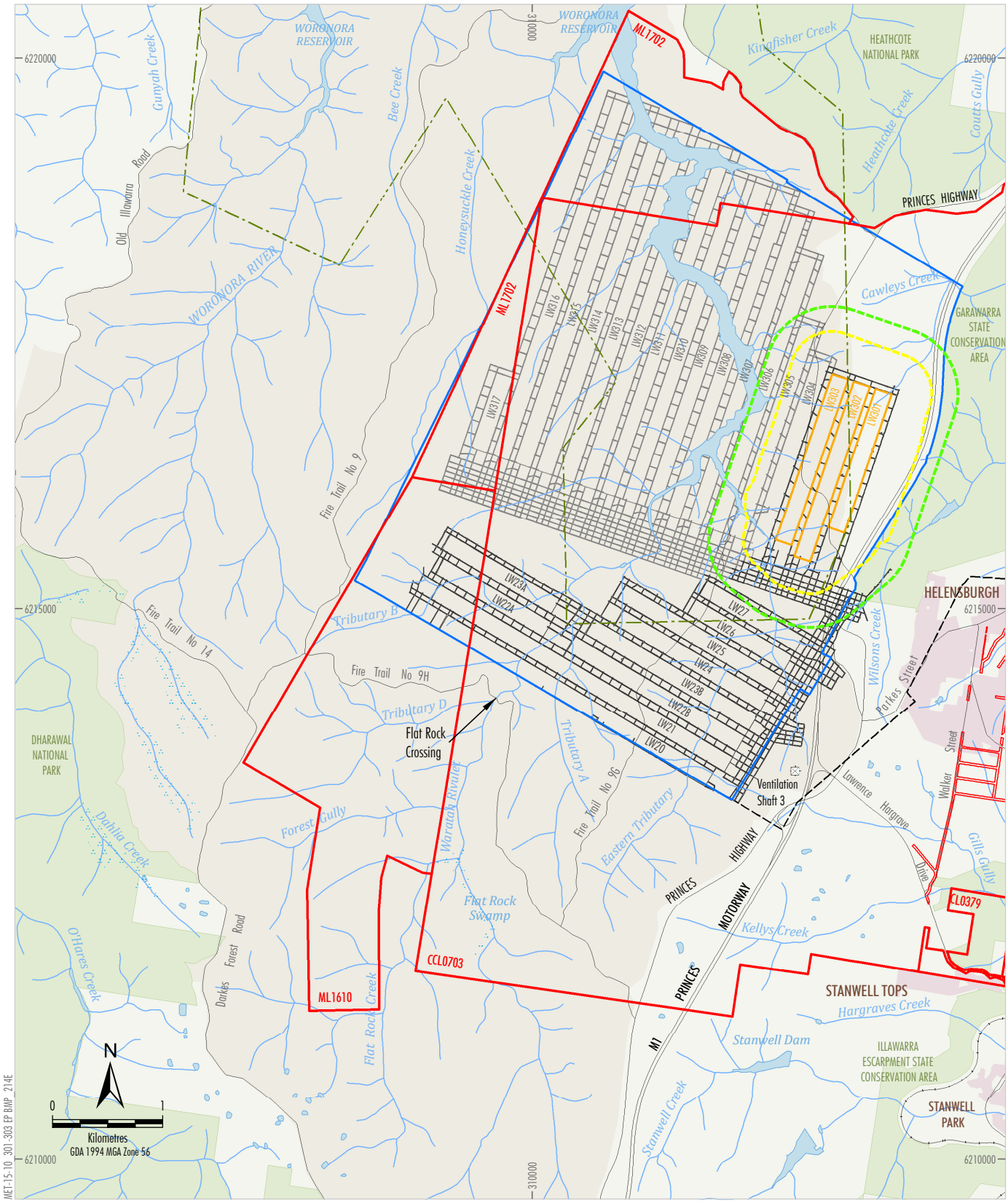
4.1.1 Surface Water

Streams occurring within 600 m of Longwalls 20-22, Longwalls 23-27 and Longwalls 301-303 secondary extraction include the Waratah Rivulet and its tributaries (such as Tributary A and B) and the Eastern Tributary and its tributaries (Figure 4). The locations of pools on the Waratah Rivulet and the Eastern Tributary are shown on Figure 5.

The Preferred Project Report (HCPL, 2009), and Metropolitan Coal Longwalls 20-22 and Longwalls 23-27 Water Management Plans indicated that valley closure values of greater than 200 millimetres (mm) were predicted at pools/rock bars on the Waratah Rivulet upstream of the maingate of Longwall 23 (Figure 5). Pools P to W on the Waratah Rivulet (Figure 5) were predicted to be subject to valley closure values of less than 200 mm.

The Preferred Project Report, and Metropolitan Coal Longwalls 20-22 and Longwalls 23-27 Water Management Plans indicated that valley closure values of greater than 200 mm were predicted at pools/rock bars along the Eastern Tributary (from Pool ETF over Longwall 20 extending to Pool ETAC over Longwall 26, and from Pool ETAH over Longwall 27 extending to Pool ETAL downstream of Longwall 27) (Figure 5). Approximately 244 metres (m) of the Eastern Tributary between the maingate of Longwall 26 and the full supply level of the Woronora Reservoir (i.e. from Pool ETAH to Pool ETAL) was predicted to be subject to valley closure values of greater than 200 mm as a result of Longwalls 23-27.

The Preferred Project Report, and Metropolitan Coal Longwalls 20-22 and Longwalls 23-27 Water Management Plans indicated that valley closure values of greater than 200 mm would also occur on Tributary B (maximum predicted total closure of 718 mm at the completion of Longwall 27).



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- Woronora Notification Area

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

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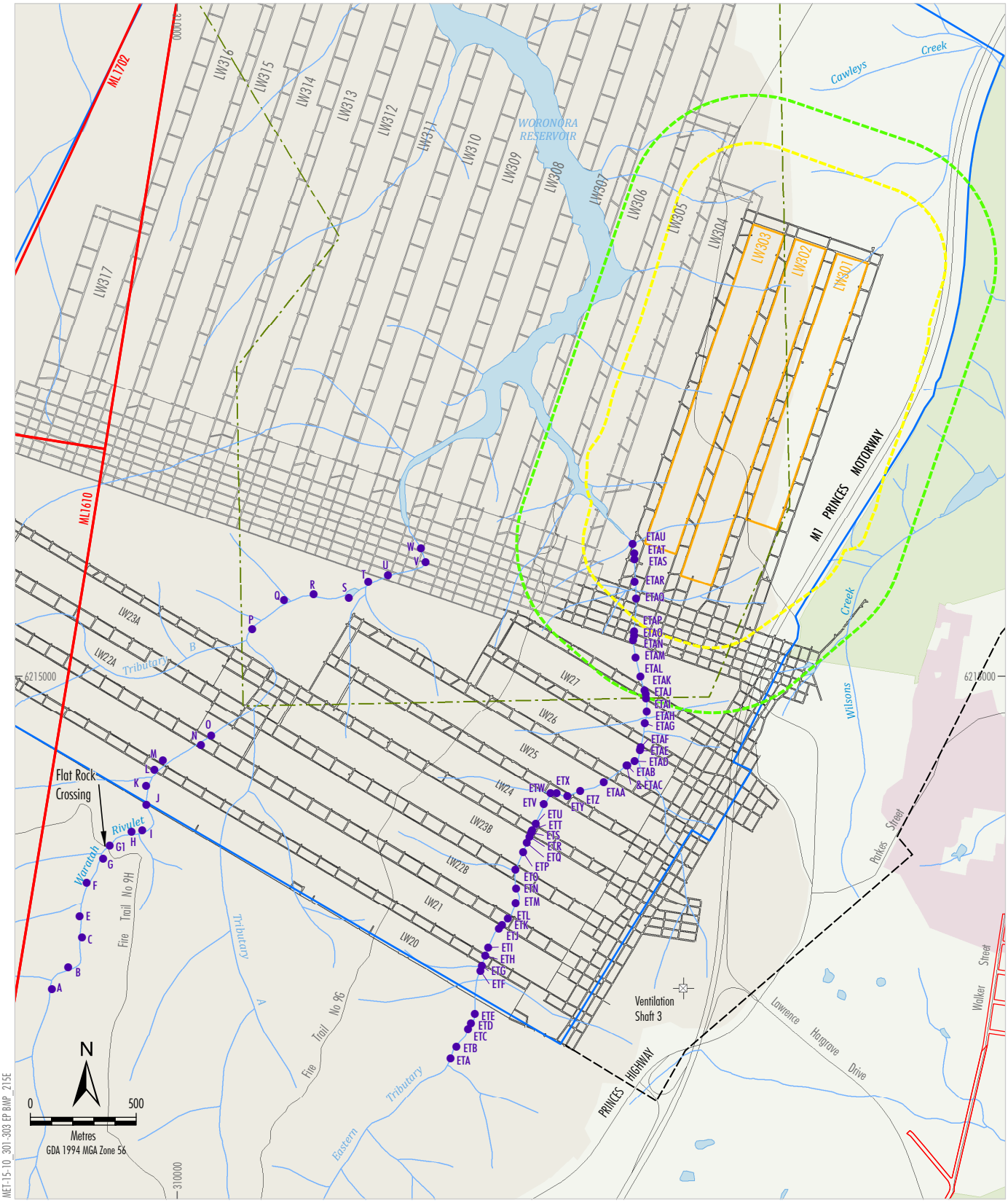
Streams Within the Project Underground Mining Area and Surrounds

Figure 4



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- Existing Underground Access Drive (Main Drift)
- Pool

Notes: 1. The streams are based on mapping by the Lands Department (2006). More detailed and accurate mapping of the streams is provided in WMP Appendices 1 to 4.

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

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Waratah Rivulet and Eastern Tributary Pools

Figure 5

The NSW Planning Assessment Commission's Report for the Metropolitan Coal Project (NSW Planning Assessment Commission, 2009) indicates the Panel considered 'negligible consequence' for a watercourse to mean, *'no diversion of flows, no change in the natural drainage behaviour of pools, minimal iron staining, and minimal gas releases'*, and is assumed to be achieved in circumstances where predicted valley closure is less than 200 mm.

Pool Water Levels and Surface Water Flow

Visual inspections and photographic surveys have been conducted of the Waratah Rivulet, Eastern Tributary, Tributary A and Tributary B in accordance with the Metropolitan Coal Water Management Plans.

Water levels in pools on the Waratah Rivulet (Pools A, B, C, E, F, G, G1, H, I, J, K, L, M, N, O, P, Q, R, S, T, U, V and W) and a number of pools on the Eastern Tributary (Pools ETG, ETJ, ETM, ETU, ETW, ETAF, ETAG, ETAH, ETAI, ETAQ, ETAT[3] and ETAU) and Tributary B (Pools RTP1 and RTP2) have also either been manually monitored on a daily basis or monitored using a continuous water level sensor and logger (Figure 6).

The stream inspections, pool water level monitoring and surface water flow monitoring have identified subsidence impacts and environmental consequences consistent with those described in the Metropolitan Coal Project Environmental Assessment (Project EA) (HCPL, 2008), Preferred Project Report, and Metropolitan Coal Water Management Plans. These documents identified that the key potential subsidence impacts in relation to pool water levels and surface water flow would include:

- The magnitudes of the predicted systematic and/or valley related movements are likely to result in some fracturing and dilation of the underlying strata of streams above and immediately adjacent to the longwalls.

Cracking and dilation of bedrock are likely to result in the localised diversion of a portion of the surface flow through either:

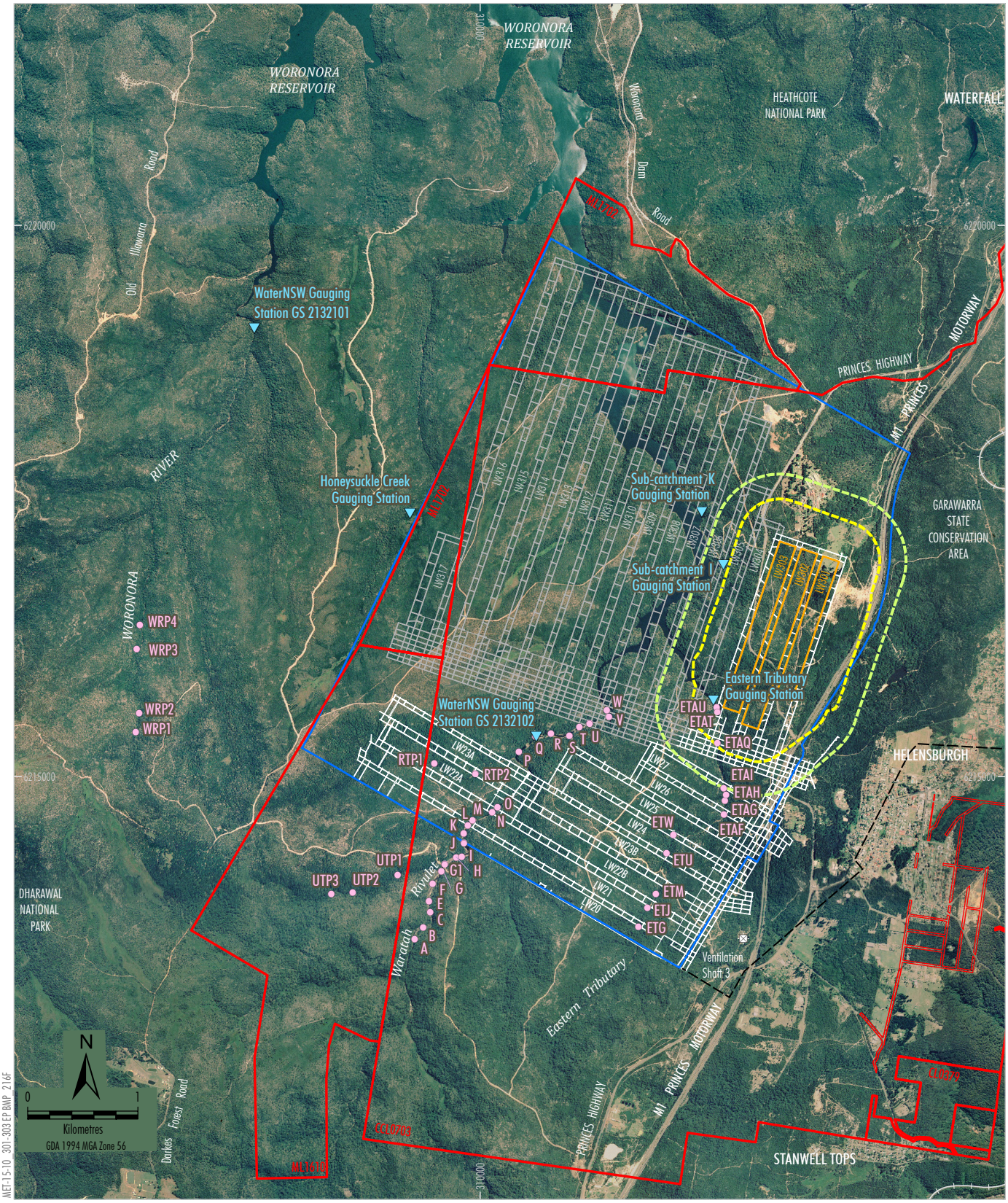
  – **diversion into subterranean flows**, where water travels via new mining induced fractures and opened natural joints in the bedrock into near-surface dilated strata beneath the bedrock, ultimately re-emerging at the surface downstream; or

  – **leakage through rock bars**, where the rate of leakage from pools through rock bars to the downstream reaches of the stream is increased by new mining induced fractures.

The key potential environmental consequences in relation to pool water levels and surface water flow included:

Changes in stream flows as a result of fracturing of bedrock and the consequent diversion of a portion of the total stream flow as underflow. The effects of underflow would be localised to the subsidence affected reaches of streams. Underflows would be most noticeable during periods of low flow and would depend on the frequency of no flow periods, while the effects on the frequency and magnitude of high flows would be negligible.

[3] A water level meter was installed in Pool ETAT in March 2018.



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- Existing Underground Access Drive (Main Drift)
- Gauging Station
- Pool Water Level Site

Source: Land and Property Information (2015); Date of Aerial Photography 1998; Department of Industry (2015); Metropolitan Coal (2018); MSEC (2008; 2018)

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Surface Water Quantity Sites

Figure 6

Changes in pool water levels and in-stream connectivity - underflow has been observed to result in lower water levels in pools as they become hydraulically connected with the fracture network. During prolonged dry periods when flows recede to low levels, the number of instances where loss of flow continuity between pools occurs increases with a greater proportion of the flow being conveyed entirely in the subsurface fracture network.

- Negligible impacts on water quantity to the Woronora Reservoir.

Prior to the commencement of Longwall 20, the water levels in pools upstream of Flat Rock Crossing (i.e. Pools A to G, Figure 5) on the Waratah Rivulet had been impacted by mine subsidence as described in the Metropolitan Coal Rehabilitation Management Plan (i.e. the pool water level had fallen below the cease to flow level). Since the commencement of Longwall 20, two additional pools on the Waratah Rivulet have been impacted by mine subsidence (i.e. fallen below their cease to flow levels, namely, Pool G1 in 2011 and Pool N in September 2012) (Figure 5).

Since the commencement of Longwall 20, stream remediation activities on the Waratah Rivulet have been conducted at Pools A, F and G. To date, mining has not resulted in the diversion of flows or change to the natural drainage behaviour of pools downstream of the maingate of Longwall 23 (i.e. Pools P to W) (Figure 5).

Since 2012 sections of Tributary B have been mostly dry (in the vicinity of site RTP1, Figure 6) with no surface flow. Pool RTP2 on Tributary B regularly falls below its cease to flow level, however generally overflows during and following rainfall events.

Sections of the Eastern Tributary were predicted to be subject to greater than 200 mm of valley closure, which has resulted in the cracking and dilation of bedrock and associated diversion of surface flow and leakage of water through rock bars at pools along the Eastern Tributary.

Up until December 2016 the monitoring of water levels/drainage behaviour of pools on the Eastern Tributary between the maingate of Longwall 26 and the full supply level of the Woronora Reservoir was consistent with predictions. In the Longwalls 20-22 Extraction Plan Subsidence Assessment it was recognised that fracturing resulting in surface flow diversion could be observed at a site where the predicted total closure is less than 200 mm, although none had been observed to date. The report also noted that reference to the 200 mm predicted total closure value should be viewed as an indication of low probability (10%) of impact rather than certainty. In the Longwalls 23-27 Extraction Plan Subsidence Assessment, additional case studies were added to the pool impact model, including cases where loss of pool water levels had occurred at less than 200 mm predicted total closure. Similar to the previous database for Longwalls 20-22, the updated database showed that based on a maximum predicted total closure of 200 mm, the proportion of pools that experienced loss of pool water levels was around 10%.

In December 2016 and January 2017, a number of pools with predicted closure values of less than 200 mm experienced loss of pool water levels. This resulted in the exceedance of the negligible environmental consequences performance measure for the Eastern Tributary in relation to diversion of flows and drainage behaviour. The combined data that is available to MSEC for the Southern Coalfield (including the Waratah Rivulet and Eastern Tributary results) indicated that less than 10% of all pools have experienced the diversion of flow at predicted closure values of less than 200 mm, consistent with previous assessments of potential pool impacts. Downstream of the Longwall 26 maingate, mine subsidence has resulted in the diversion of flows or change to the natural drainage behaviour of Pools ETAG to ETAR (Figure 5).

To date, mining has not resulted in the diversion of flows or change to the natural drainage behaviour of Pools ETAS, ETAT and ETAU (Figure 5).

Woronora Reservoir Inflows

For the Project EA a comprehensive analysis of stream flow data and data on the yield behaviour of Woronora Reservoir indicated that past mining at Metropolitan Coal had no discernible effect on the inflow to, or yield from, the reservoir. Surface water flow monitoring at the Waratah Rivulet, Woronora River (Figure 6) and O'Hares Creek gauging stations since the commencement of Longwall 20 in 2010 indicates there has been a negligible reduction in the quantity of water resources reaching the Woronora Reservoir.

As documented in the original model in the Project Environmental Assessment, the Waratah Rivulet catchment model is capable of reliably identifying a loss of 1 ML/day. One (1) ML/day meets the definition of 'negligible' (being *small and unimportant, such as not to be worth considering*) on the basis that it is a small component of overall inflows – it represents about 1.4% of annual average inflow to the reservoir; and is small compared to changes in inflows caused by changes in climate and catchment conditions. It is also noted that 1 ML/day is well above the reduction in catchment yield that is actually predicted.

The surface water flow monitoring data obtained from the Eastern Tributary gauging station has also been assessed. The results indicate that flow at the Eastern Tributary gauging station has been consistent with model predictions.

Surface water flow monitoring indicates there is no evidence of a loss of flow from the Waratah Rivulet or Eastern Tributary reaching the Woronora Reservoir.

Iron Staining

As described in the Southern Coalfield Panel Report (Department of Planning [DoP], 2008) and the NSW Planning Assessment Commission's Report for the Metropolitan Coal Project (NSW Planning Assessment Commission, 2009), under certain conditions the cracking of stream beds and underlying strata has the potential to result in changes in water quality, particularly ferruginous springs and/or development of iron bacterial mats. Experience at Metropolitan Coal prior to Project Approval indicated that areas of the substratum can be covered by iron flocculent material for several hundred metres downstream of mine subsidence fractures.

Metropolitan Coal has monitored the extent of iron staining through visual and photographic surveys and assessed the extent of iron staining against the subsidence impact performance measures as follows:

- Negligible environmental consequences (that is, no diversion of flows, no change in the natural drainage behaviour of pools, minimal iron staining, and minimal gas releases) on the Waratah Rivulet between the full supply level of the Woronora Reservoir and the maingate of Longwall 23 (upstream of Pool P).
- Negligible environmental consequences over at least 70% of the stream length (that is, no diversion of flows, no change in the natural drainage behaviour of pools, minimal iron staining, and minimal gas releases) on the Eastern Tributary between the full supply level of the Woronora Reservoir and the maingate of Longwall 26.

Monitoring to date indicates the subsidence impact performance measure in relation to iron staining has not been exceeded for the Waratah Rivulet.

On 14 October 2016, Metropolitan Coal reported the exceedance of the *minimal iron staining* component of the Eastern Tributary performance measure to the Secretary of the DP&E and other relevant agencies in accordance with Condition 6, Schedule 7 of the Project Approval and the Metropolitan Coal Longwalls 23-27 Water Management Plan Contingency Plan. Subsequent incident reports were provided to the DP&E and other relevant agencies on 21 October 2016, 25 November 2016, 21 December 2016, 3 February 2017 and 21 February 2017 and provided a concise summary of information relevant to the performance of the mine relative to is Extraction Plans and Approval Conditions for the Eastern Tributary.

Inspections of iron staining/flocculent on the Eastern Tributary between the full supply level and the Longwall 26 maingate in August 2018 recorded residual iron staining (i.e. where previous fresh iron staining has receded and iron flocculent was not present) from boulderfield ETAF to rock bar ETAP (Metropolitan Coal, 2018). Fresh iron staining/flocculent was evident in the reach from Pool ETAQ to boulderfield ETAU (Metropolitan Coal, 2018).

Gas Releases

Prior to approval of the Project in 2009, no gas releases had been observed along the Waratah Rivulet, Eastern Tributary or other tributaries over the Metropolitan Coal lease, either before or during mining. Notwithstanding, the Project EA, Preferred Project Report and Metropolitan Coal Longwalls 20-22 Water Management Plan recognised there was the potential for gas releases to occur. Gas releases (often sporadic) have since been observed on occasions over particular periods in Pools A, J, K, L, O, P, S, U and W on the Waratah Rivulet and Pools ETAG, ETAI, ETAL and ETAM on the Eastern Tributary (Figure 5). Assessments against the subsidence impact performance measure for negligible environmental consequence on the Waratah Rivulet and Eastern Tributary, *minimal gas releases*, to date indicate the performance measure has not been exceeded (Gilbert & Associates, 2014; The University of Queensland, 2014; 2016; 2017; 2018).

Changes in Bed Gradients, Scouring and Stream Alignment

The key potential subsidence impacts and environmental consequences in relation to bed gradients, scouring and stream alignment described in the Project EA, Preferred Project Report, and Metropolitan Coal Water Management Plans included:

- Potential changes in bed gradients could occur, however, were anticipated to be small relative to the existing grades.
- An increased potential for scouring of the stream bed and banks (at locations where the predicted tilts considerably increase the natural pre-mining stream gradients). The potential for scouring is greatest in stream sections with alluvial deposits. Since the streambed of the Waratah Rivulet and the Eastern Tributary is predominantly erosion-resistant Hawkesbury Sandstone, scouring was expected to be very low.
- Subsidence fracturing of bedrock has the potential to cause dislodgement of rock fragments during high flow events.
- The potential for changes to stream alignment as a result of mine subsidence effects was considered to be low.
- Minor stream bank erosion, where changes in channel gradients result in increases in flow energy. It would be expected that bank erosion would be relatively minor and comprise a slow retreat of the bank until a new dynamic equilibrium is reached.

The results of the stream inspections have generally been consistent with these predictions. On the Waratah Rivulet (in a section of the stream over Longwall 21) and Eastern Tributary (in a section of the stream over Longwalls 20 and 21) increased ponding from changes in bed gradients has previously resulted in the prolonged inundation of the adjacent riparian vegetation which has resulted in some vegetation dieback on a local scale as described in Section 4.3.2.

Surface Water Quality

Subsidence impacts on water quality were predicted by the Project EA, Preferred Project Report, and Metropolitan Coal Water Management Plans to be similar to that previously observed at Metropolitan Coal, specifically, transient pulses of iron, manganese and aluminium, which would likely occur following fresh cracking of the stream bed.

Surface water quality has been monitored at a number of sites on Waratah Rivulet, Tributary B, Tributary D, Eastern Tributary, Far Eastern Tributary, Honeysuckle Creek, Bee Creek and Woronora River. Trends in the monitoring data to date for key parameters (pH, electrical conductivity, dissolved iron, dissolved manganese and dissolved aluminium) at the sites listed in Table 2 have been summarised by Hydro Engineering & Consulting (2018). The water quality sites are shown on Figure 7.

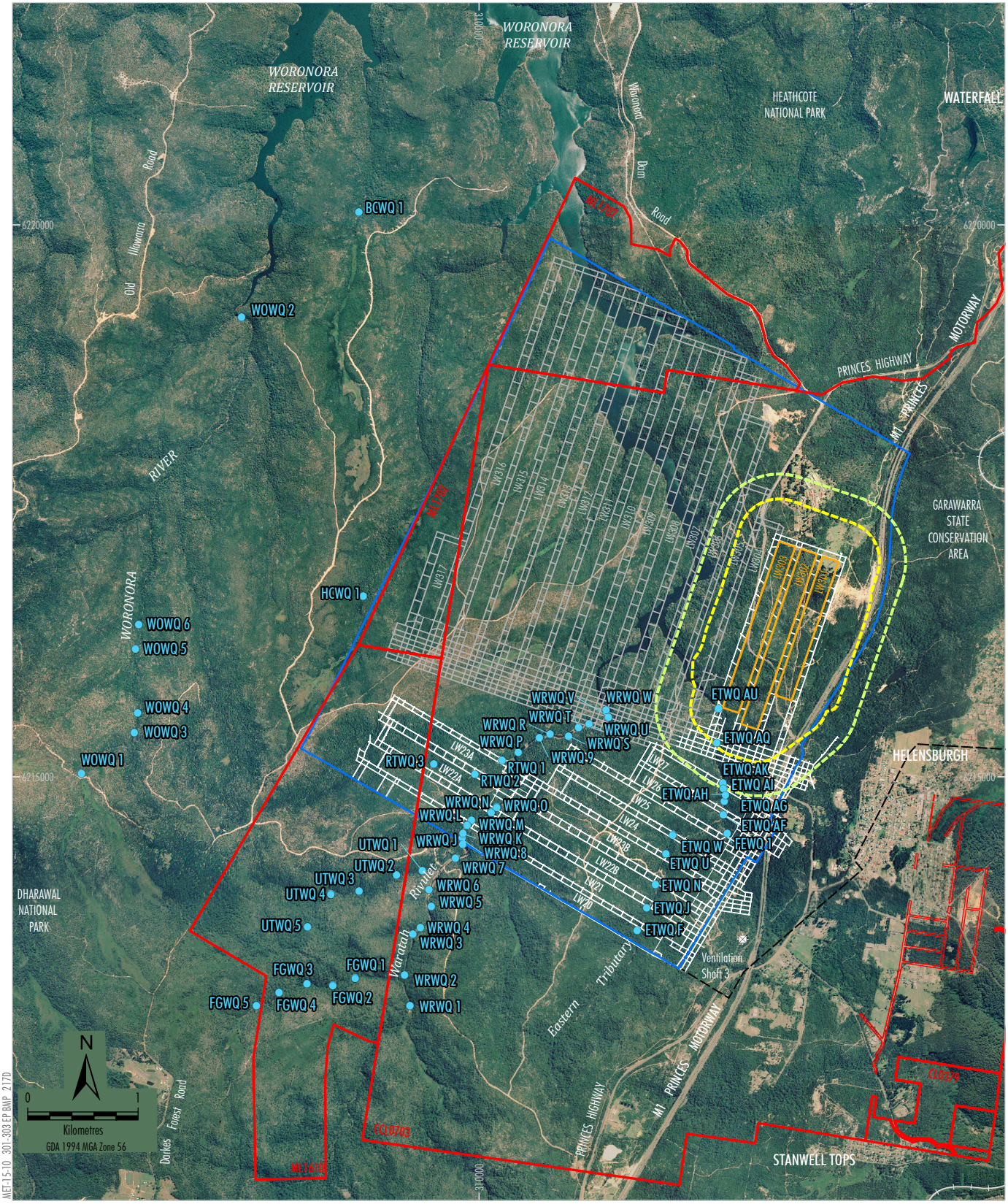
The cracking and dilation of bedrock and associated diversion of surface flow and leakage of water through rock bars at pools which has occurred on the Eastern Tributary (including the reach associated with the exceedance of the Eastern Tributary watercourse performance measure) has resulted in impacts on water quality, in particular increases in dissolved manganese and iron. Assessment of the water quality monitoring results to date by Associate Professor Barry Noller (The University of Queensland) indicate there has been a negligible reduction in the quality of water resources reaching the Woronora Reservoir. Notwithstanding, subsidence impacts on water quality will continue to be monitored. Metropolitan Coal is committed to the remediation of pools on the Eastern Tributary. Metropolitan Coal has shortened the length of Longwall 303 by 98 m to maintain the maximum predicted total closure on the lower reaches of the Eastern Tributary to less than 200 mm.

Woronora Reservoir Water Quality

The Project EA, Preferred Project Report, and Metropolitan Coal Water Management Plans predicted the Project would not impact on the performance of the Woronora Reservoir and would have a neutral effect on water quality. Water quality monitoring results to date are consistent with the predictions.

Metropolitan Coal sources water quality data for the Woronora Reservoir from WaterNSW in accordance with a data exchange agreement and analyses data for total iron, total aluminium and total manganese from 0 m to 9 m below the reservoir surface.

The water quality monitoring results to date are consistent with the predictions and indicate there has been a negligible reduction in the water quality of Woronora Reservoir.



MEI-15-10_301-303 EP BMP_217D

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)
- Surface Water Quality Site

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

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Surface Water Quality Sites

Figure 7

Table 2
Stream Water Quality Monitoring Results

Stream	Monitoring Results to Date
Waratah Rivulet (sites WRWQ 2, WRWQ 6, WRWQ 8, WRWQ 9, WRWQ M, WRWQ N, WRWQ P, WRWQ R, WRWQ T and WRWQ W)	• Water quality patterns have generally been consistent with earlier data. • Upstream sites on Waratah Rivulet show slightly acidic to near neutral pH values with higher (slightly alkaline) values being recorded at downstream sites. • Electrical conductivity has been consistently low. • Dissolved iron and dissolved manganese concentrations have typically been higher at the upper to middle reach sites. • Dissolved aluminium has been consistent from upstream to downstream and low.
Woronora River (control sites WOWQ 1 and WOWQ 2)	• Sites on Woronora River typically show slightly acidic and high variability in pH. • Electrical conductivity values have been consistently low and similar to values recorded on Waratah Rivulet. • Dissolved iron has been generally low and similar to values recorded in Waratah Rivulet. • Dissolved aluminium concentrations have been typically low and typically higher upstream. • Dissolved manganese has been typically low with evidence of more elevated concentrations occurring in the summer months.
Eastern Tributary (sites ETWQ F, ETWQ J, ETWQ N, ETWQ U, ETWQ W, ETWQ AF, ETWQ AH, ETWQ AQ and ETWQ AU)	• Sampling sites on Eastern Tributary show variable but typically near neutral pH values. • Electrical conductivity values have historically been low, however were more variable during 2017, with higher values recorded associated with low water levels. • Dissolved aluminium concentrations are typically low, with some spikes occasionally recorded. • Higher dissolved manganese and dissolved iron concentrations have been recorded since mid 2016, corresponding with an extended period of low flow/rainfall and mine subsidence impacts to a number of pools.
Bee Creek, Honeysuckle Creek, Far Eastern Tributary, Tributary B and Tributary D (sites BCWQ 1, HCWQ 1, FEWQ 1, RTWQ 1, and UTWQ 1)	• Sampling sites in Bee Creek and Honeysuckle Creek have recorded variable to slightly acidic pH levels, while pH levels in Far Eastern Tributary, Tributary B and Tributary D have been near neutral. Since mid-2015, the pH at all sites has generally been less variable. • Electrical conductivity values have been generally low at most of these sites, however, recorded values on Tributary B have been variable and periodically elevated since late 2013. • Dissolved iron concentrations have been generally low at these sites with periodic small spikes in dissolved iron recorded mostly during summer months. • Dissolved manganese concentrations have been generally low and consistent with historical values. • Dissolved aluminium concentrations at Far Eastern Tributary, Tributary B and Tributary D have been low. Dissolved aluminium concentrations at Bee Creek and Honeysuckle Creek have been higher (in relation to other tributary sites) over the period of record and this trend continued throughout 2017.

Source: after Hydro Engineering & Consulting (2018)

4.1.2 Groundwater

The conceptual hydrogeological model supports three distinct groundwater systems, including:

- Perched groundwater system – generally above and independent of the regional groundwater table (typically less than 50 m below the ground surface).

  Excess rainfall produces a permanent perched water table within swamp sediments and outcropping sandstone that is independent of the regional water table in the Hawkesbury Sandstone. As the swamps are essentially rain-fed, water levels within upland swamps fluctuate seasonally with climatic conditions.

- Shallow groundwater system – the shallow groundwater system (extending typically to less than 100 m below the ground surface) is separate from the perched groundwater system and defines a regional water table.

- Deep groundwater system – although the shallow and deep groundwater systems are connected, low permeability of the Bald Hill Claystone provides a degree of isolation between the Hawkesbury Sandstone (Figure 8) that hosts shallow groundwater and the underlying Bulgo Sandstone and deeper formations that host deep groundwater. The deep groundwater system is typically more than 100 m below the ground surface.

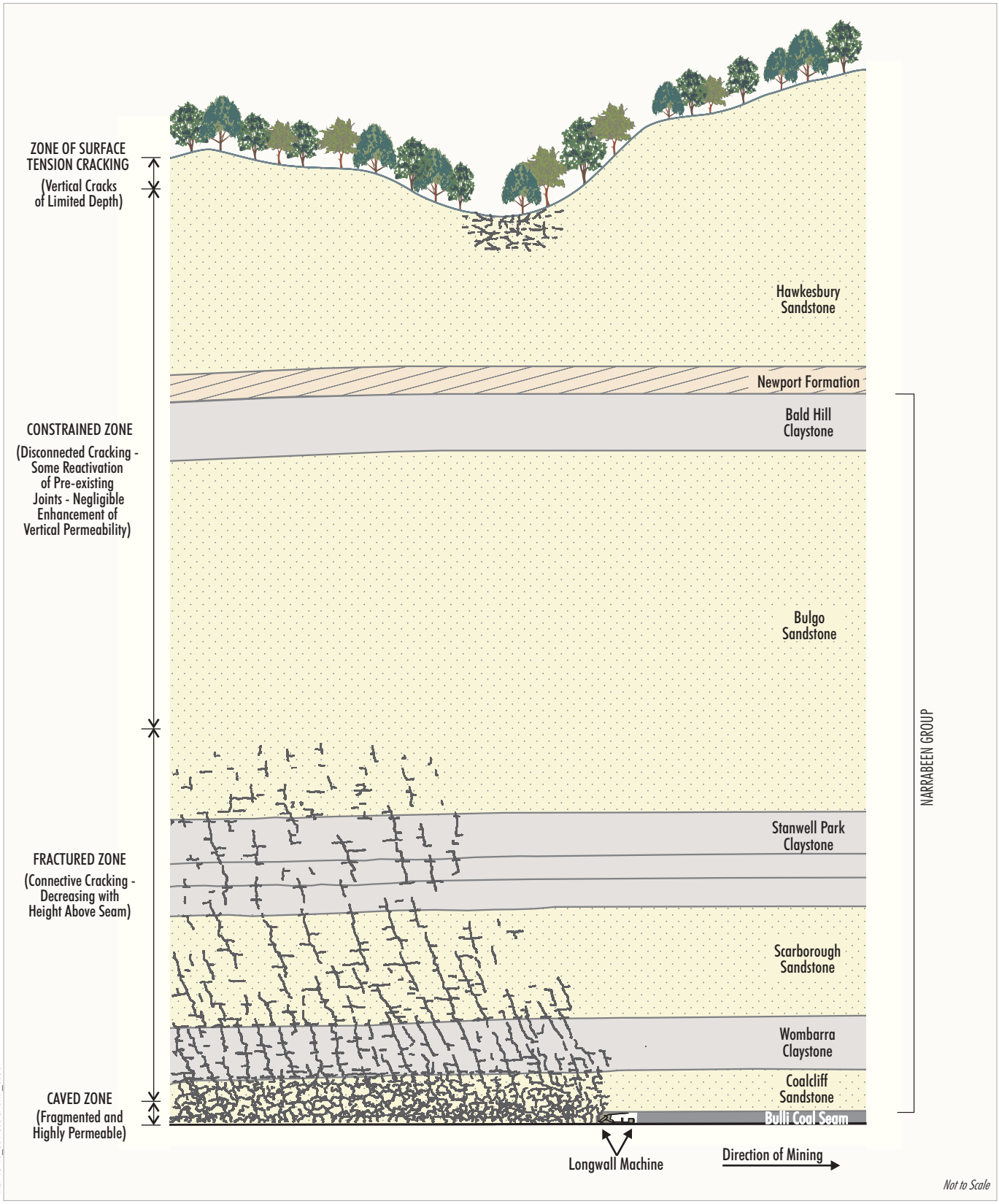
Recharge to the groundwater system is from rainfall and from lateral groundwater flow. Although groundwater levels are sustained by rainfall infiltration, they are controlled by ground surface topography and surface water levels. A local groundwater mound develops beneath the sandstone hills with ultimate discharge to incised creeks and waterbodies. Loss by evapotranspiration through vegetation where the water table is within a few metres of the ground surface occurs within upland swamps and outcropping sandstone.

Groundwater Model

A tabulated list of groundwater models developed and used for the Project by HydroSimulations is provided in Table 3.

Table 3
Groundwater Model Tabulation

Date	Groundwater Model	Purpose
2008	Modflow 3D [13 layers]	Groundwater assessment of Longwalls 20-44 for the Project EA. Steady-state calibration.
2009	Modflow-SURFACT [13 layers]	Recalibration of the regional groundwater model prepared for Longwalls 20 to 44 with advanced software; high-inflow and low-inflow model versions.
2009	Modflow-SURFACT [13 layers]	Post-audit of the 3D groundwater model confirmed model performance at three new deep bores.
2012	Modflow-SURFACT [15 layers]	Recalibration of Hawkesbury Sandstone vertical head gradients and the addition of two extra layers to the Hawkesbury Sandstone section to improve resolution of the vertical hydraulic gradient in the shallow groundwater system.



Source: After Geosensing Solutions (2008); Heritage Consulting (2008)

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Schematic - Longwall Mining and Subsidence Profile

Figure 8

A three-dimensional numerical model of groundwater flow was developed in 2008 for the Project EA. The groundwater model was recalibrated in December 2012 for the Preferred Project Layout by revising the hydraulic conductivities in the Hawkesbury Sandstone and the Bald Hill Claystone. At this time, two extra layers were added to the Hawkesbury Sandstone section to improve resolution of the vertical hydraulic gradient in the shallow groundwater system. The model simulations are based on initial conditions at the end of Longwall 14, consistent with the Project EA assessment (Heritage Computing, 2008). Model outputs have been examined every six months for review of environmental performance.

Transient calibration has been undertaken to incorporate Metropolitan Coal updates to the geological model. The revised model includes an update of the topographical surface and geological interfaces, the addition of two model layers below the Bulli seam and updated estimates of the fractured zone height. A report has been prepared for the updated model (HydroSimulations, 2018a) and the model will be used for the assessment of future longwalls (i.e. for Longwalls 304 on).

Perched Groundwater Systems (Upland Swamps)

The key potential subsidence impacts and environmental consequences on perched groundwater systems described in the Project EA, Preferred Project Report, and Metropolitan Coal Water Management Plans and Biodiversity Management Plans, included:

- Any cracking of the bedrock within upland swamps is expected to be isolated and of a minor nature, due to the relatively low magnitudes of the predicted strains and the relatively high depths of cover.
- Surface cracking resulting from mine subsidence within the upland swamps is not expected to result in an increase in the vertical movement of water from the perched water table into the regional aquifer as the sandstone bedrock is massive in structure and permeability decreases with depth.
- It is expected that any surface cracking that may occur would be superficial in nature (i.e. would be relatively shallow) and would terminate within the unsaturated part of the low permeability sandstone. Any changes in swamp water levels as a result of cracking are expected to be immeasurable when compared to the scale of seasonal and even individual rainfall event based changes in swamp groundwater levels.
- Whilst swamp grades vary naturally, the predicted maximum mining-induced tilts are generally orders of magnitude lower than the existing natural grades within the swamps. The predicted tilts would not have any significant effect on the localised or overall gradient of the swamps or the flow of water. Any minor mining-induced tilting of the scale and nature predicted is not expected to significantly increase lateral surface water movements which are small in relation to the other components in the swamp water balance.

No changes to the fundamental surface hydrological processes and upland swamp vegetation were expected within upland swamps.

In relation to impacts of the Project on upland swamps, the NSW Planning Assessment Commission (2009) concluded that the mining parameters were such that:

- for most swamps in the Project Area, there was a low risk of negative environmental consequences; and
- that there was a very low risk that a significant number of swamps would suffer such consequences.

Groundwater monitoring of upland swamps has involved the use, where practicable, of paired piezometers, one swamp substrate piezometer (at approximately 1 m depth) and one sandstone piezometer (at a depth of approximately 10 m) (Figure 9). Specifically, paired piezometers have been monitored in Swamp 25 overlying Longwalls 20-22, Swamps 28, 30, 33 and 35 overlying Longwalls 23-27, Swamps 40, 41, 46, 51, 52 and 53 overlying Longwalls 301-303, and in control swamps 101, 137a and 137b (Figure 9). At Swamp 20 and at control swamp Woronora River Swamp 1, multiple piezometers have been monitored (i.e. one swamp substrate piezometer to a depth of approximately 1 m and two sandstone piezometers to depths of approximately 4 and 10 m) (Figure 9).

The swamp substrate piezometer represents water levels within the swamp sediments, and the piezometer at approximate depths of 4 m and 10 m allows comparison with the shallow water table in the Hawkesbury Sandstone. Data shows that water levels within the swamps over longwalls are typically perched above those of the local Hawkesbury sandstone groundwater levels and indicates a separate control on swamp water levels. That is, the swamps are primarily surface water fed systems and generally water infiltrates downwards from the swamps to the groundwater.

Analyses to date indicate the swamp substrate water levels of all swamps have remained perched, with the exception of Swamp 20 and Swamp 28 (HydroSimulations, 2018b). The substrate water levels in Swamp 20 changed from being permanently saturated to being periodically saturated as a result of the passing of Longwall 21 (Chart 1a) (HydroSimulations, 2018b). This trend has continued to be observed (HydroSimulations, 2018b). It is considered that Longwall 21 caused a mining effect at Swamp 20, but the effects have not been exacerbated by Longwalls 22-27 or Longwall 301.

A mining effect to the substrate water levels of Swamp 28 (overlying Longwall 24) was identified in 2016 based on the incomplete recovery of substrate water levels following rainfall events (Chart 1b). Swamp 28 is considered to have an impact from mining of Longwall 25, although no effect on swamp substrate water levels occurred when Longwall 24 passed directly beneath the monitoring site.

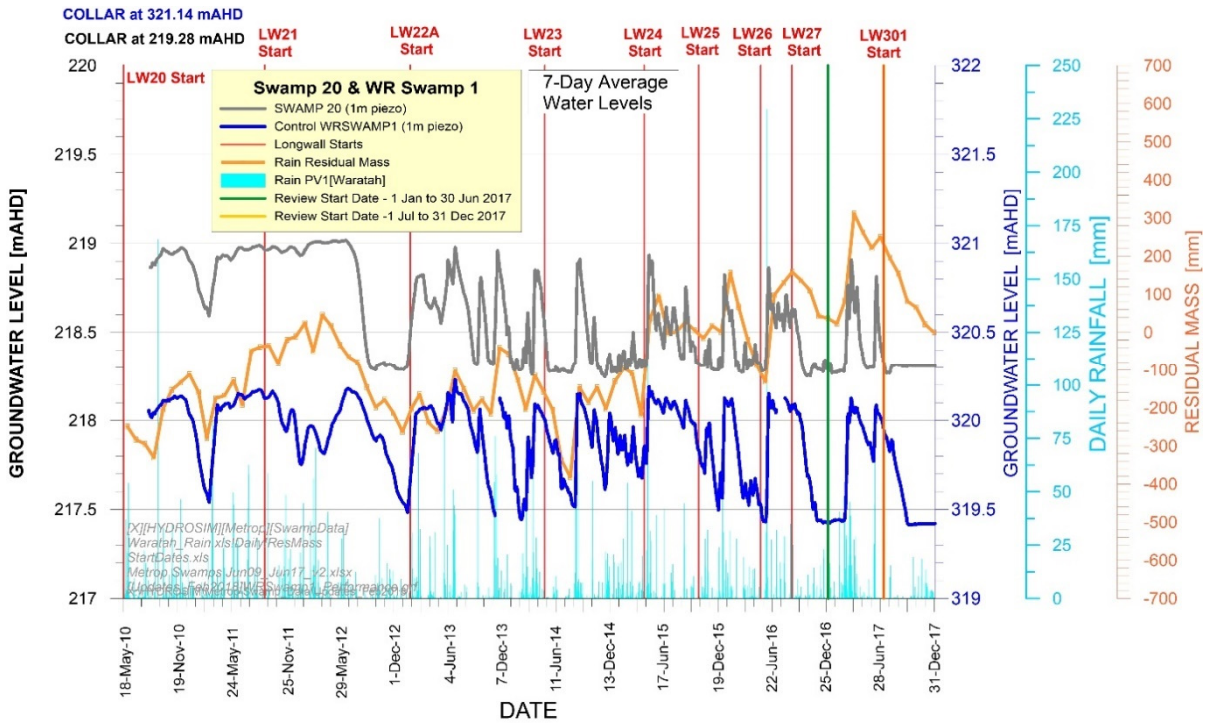
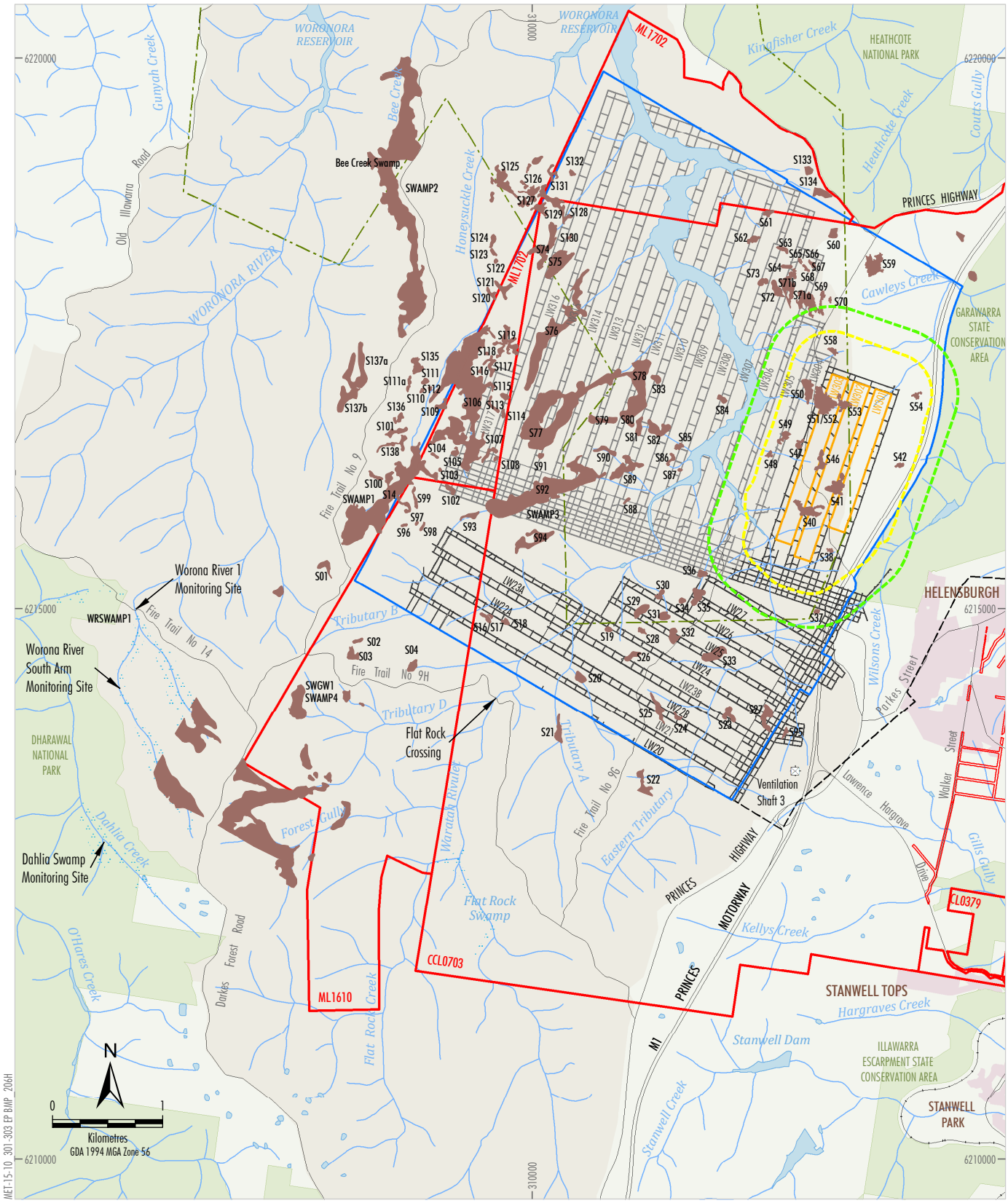


Chart 1a: Comparison of Piezometer Responses at Swamp 20 and Woronora River 1 Control Swamp



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)
- Upland Swamp
- Swamp Substrate and Shallow Groundwater Piezometer
- Swamp Substrate Groundwater Piezometer
- Swamp Shallow Groundwater Piezometer

Source: Land and Property Information (2015); Department of Industry (2015); Metropolitan Coal (2018); MSEC (2018); after NPWS (2003), Bangalay Botanical Surveys (2008) and Eco Logical Australia (2015; 2016)

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Upland Swamps Mapped over Longwalls 20-27, Longwalls 301-317 and Surrounds

Figure 9

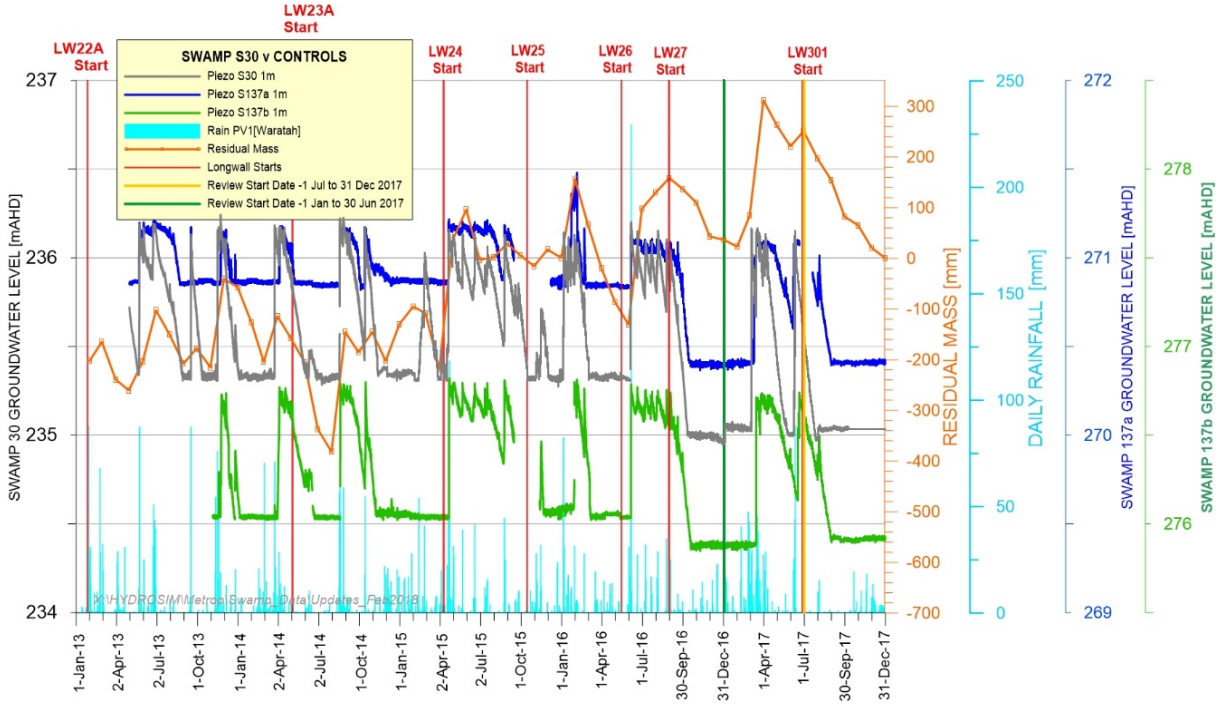


Chart 1b: Groundwater Hydrographs at Swamp 28 and Two Control Swamps (137a and 137b)

While the water lost from Swamp 20 and Swamp 28 was retained in the unsaturated sandstone above the regional water table, the changes in swamp water levels as a result of cracking are measurable when compared to seasonal individual rainfall event based changes in swamp groundwater levels. There is currently no sign that the vegetation in Swamp 20 is being impacted by the changed hydrological conditions. The autumn 2017 vegetation monitoring results suggest that the changes in vegetation occurring in Swamp 28 are significantly different to changes in the control swamps (refer Section 4.3.1.4).

Shallow Groundwater Systems and Inflows to the Woronora Reservoir

The key potential subsidence impacts and environmental consequences on shallow groundwater systems and inflows to the Woronora Reservoir described in the Project EA, Preferred Project Report, and Metropolitan Coal Water Management Plans included:

- Permanent mining-induced changes in the groundwater levels of shallow aquifers in connection with streams and ecosystems at Metropolitan Coal would not occur to any significant degree (i.e. the direction of shallow groundwater system flow [i.e. in the Hawkesbury Sandstone] has not been altered by mining).
- As there is an alternation of thick sandstone/claystone lithologies, there is a constrained zone in the overburden that remains rigid and acts as a barrier which isolates shallow and deep aquifers. At the substantial depths of cover of the Project, there would not be connective cracking from the mined seam to the surface.
- The depressurisation effects described below for the deep groundwater system would not propagate to the Hawkesbury Sandstone where the shallow groundwater system is located. As a result, no measurable impacts on registered bores in the wider Project area and surrounds would be expected.

- Based on the analysis of the conceptual groundwater system, there would be negligible loss of groundwater yield to the Woronora Reservoir. This is reinforced by the groundwater modelling which indicates negligible reduction in cumulative average inflows to the Woronora Reservoir. In relation to the potential loss of catchment yield, the NSW Planning Assessment Commission (2009) was of the view that the risk of any significant loss is very low unless a major geological discontinuity is encountered during mining that provides a direct hydraulic connection between the surface and the mine workings.
- Local surface water quality impacts as a result of enhanced groundwater – surface water interactions (as described for surface water quality above).

The groundwater monitoring results are considered to be consistent with the potential subsidence impacts and environmental consequences described in the Project EA, Preferred Project Report, and Metropolitan Coal Water Management Plans.

Depressurisation of the Deep Groundwater System[4]

Immediately above a mined coal seam, rocks collapse into the void created by the removal of coal to form a caved zone and a fractured zone develops above the caved zone (Figure 8). This causes aquifer properties to change (e.g. permeability and porosity) and results in a higher vertical permeability as a result of mining.

The key potential subsidence impacts and environmental consequences on the deep groundwater system described in the Project EA, Preferred Project Report, and Metropolitan Coal Water Management Plans, included:

- Based on experience at Metropolitan Coal, substantial depressurisation of the deep aquifers in the fractured zone above the goaf is restricted to a height of less than 130 m from the top of the goaf, while transient pressure effects have been observed to propagate to a height of about 300 m above the goaf. That is, there is a pronounced increase in vertical hydraulic gradient in the deep groundwater system over the Metropolitan Coal longwalls.
- Above goaf zones there would be substantial changes in fracture porosity and permeability, due to opening up of existing joints, new fractures and bed separation. Permeability increases would have accompanying reductions in lateral hydraulic gradients, with associated changes in groundwater levels and pressures. Pronounced changes in groundwater levels can occur without any significant drainage into a mine, particularly from the Narrabeen Group sandstones.
- Groundwater discharge to the mined seam would occur from above and below the seam in proportion to local permeabilities. The water make (i.e. groundwater inflow) is expected to be in the order of 0.1 megalitres per day (ML/day) for Longwalls 20-27 and from 0.045 to 0.6 ML/day for Longwalls 301-303. Modelling indicated that the inflow could be up to 0.5 ML/day from the deep groundwater system during mining of Longwall 24 and up to 0.6 ML/day during the mining of Longwall 302.
- Due to the substantial depths of cover at the Project, there would not be connective fracturing from the mined seam to the surface. Groundwater modelling for the Project indicates that there is expected to be eventual recovery of deep groundwater system pressures over many decades following the cessation of mining.

[4] The Research Program, *Significance of Chain Pillars on Simulated Groundwater Pressures*, funded by Metropolitan Coal has been implemented and progressed by Dr. Noel Merrick. The research program is investigating the role played by chain pillars in isolating groundwater pressure reductions above mined longwall panels, and whether they might limit the outwards propagation of pressure reductions and environmental effects. The outcomes of this research will be an improved understanding of the significance of chain pillars with respect to alteration of the groundwater regime, a quantitative appreciation of critical pillar widths in absolute and relative terms and a rationale for considering geotechnical model outputs in terms of groundwater model inputs (permeability fields).

The NSW Planning Assessment Commission (2009) concluded that given the considerable depth of mining and the restricted panel width in the Project area, that, in the absence of geological structures such as faults and igneous intrusions (sills, dykes and diatremes), there is a very high probability that a constrained zone will be associated with the mine layout proposed over the Project area, thereby preventing direct hydraulic connections between mine workings and surface water bodies.

Previously, two goaf holes drilled at Metropolitan Coal have informed the height of connective fracturing (both holes indicating the height is less than 130 m from the top of the goaf). Comparisons of calculated fracture heights using the Ditton model and the Tammetta model both support the uppermost fractured layer that has been adopted in previous groundwater modelling for Metropolitan Coal.

The Metropolitan Coal longwall widths (narrower than typical Southern Coalfield longwalls), substantial depths of cover (compared to other Southern Coalfield mines) and the alternation of thick sandstone/claystone lithologies, results in a constrained zone in the overburden that remains rigid and acts as a bridge which isolates shallow and deep aquifers.

Metropolitan Coal conducts weekly inspections of development workings for water accumulation. The mine inspections have not identified any abnormal water flows from the goaf, geological structure, or strata generally either prior to, or since the commencement of Longwall 20.

Monitoring of the mine water balance (mine water make) is calculated from the difference between total mine inflows and total mine outflows. The 20 day average daily mine water make has consistently been less than 0.5 ML/day since 2009 (Charts 2a and 2b). The increased water make during the period April 2011 to July 2011 (Chart 2a) was a result of dewatering of old workings in advance of the 200 Mains Panel (Metropolitan Coal, 2011). The monitoring results are consistent with the predictions for mine water make.

Further to a request from the Dams Safety Committee, a water balance for the 300 area (i.e. a localised water balance underground in and about the 300 series longwalls) has been established using a series of water meters installed underground. The results of the localised water balance are shown in Chart 2c. Metropolitan Coal will provide the results of the localised water balance, with the results of the overall mine water balance (Charts 2a and 2c) to the Dams Safety Committee monthly.

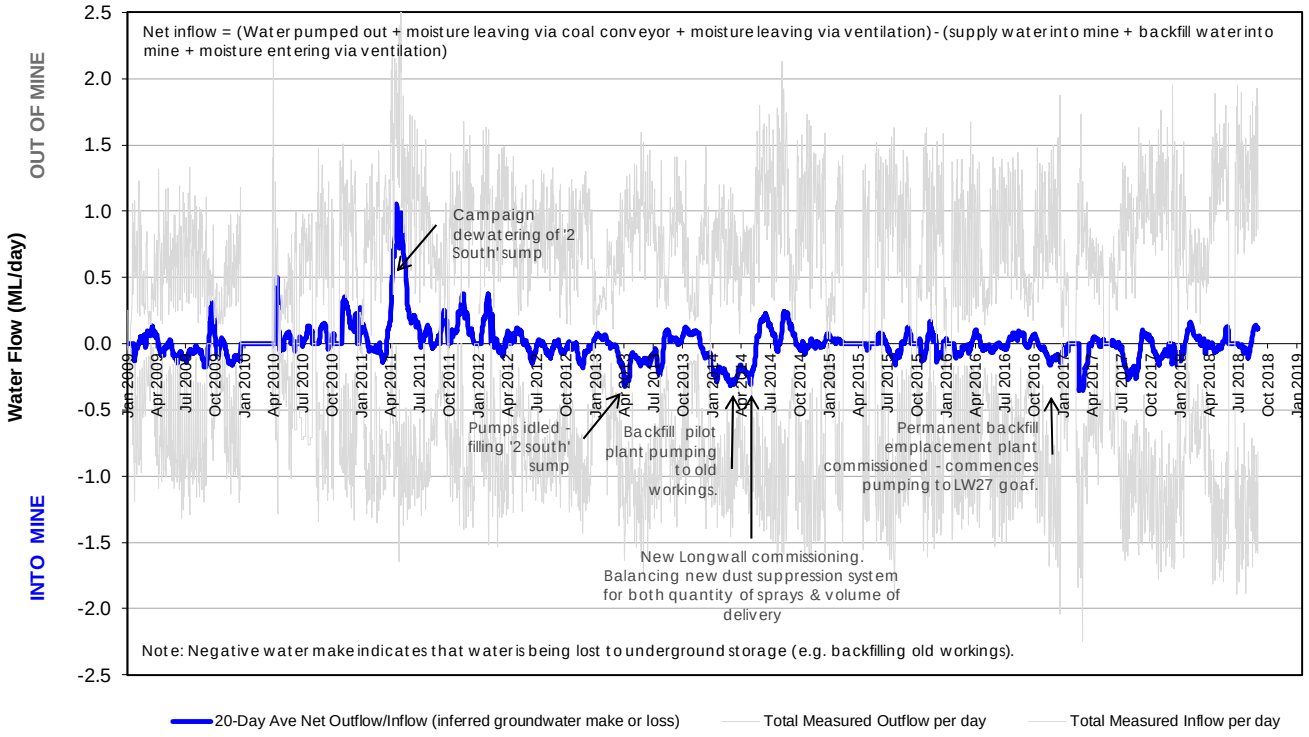


Chart 2a Estimated Daily Mine Water Make, 2009 to August 2018

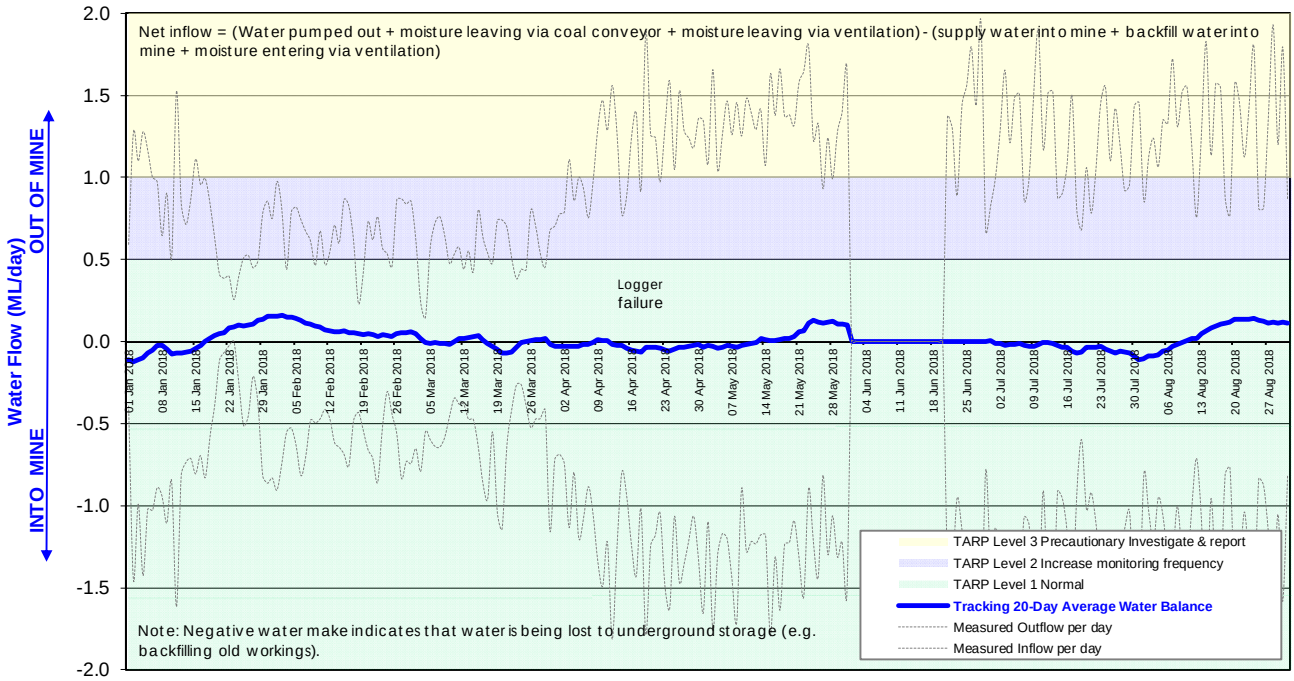


Chart 2b Estimated Daily Mine Water Make, January to August 2018

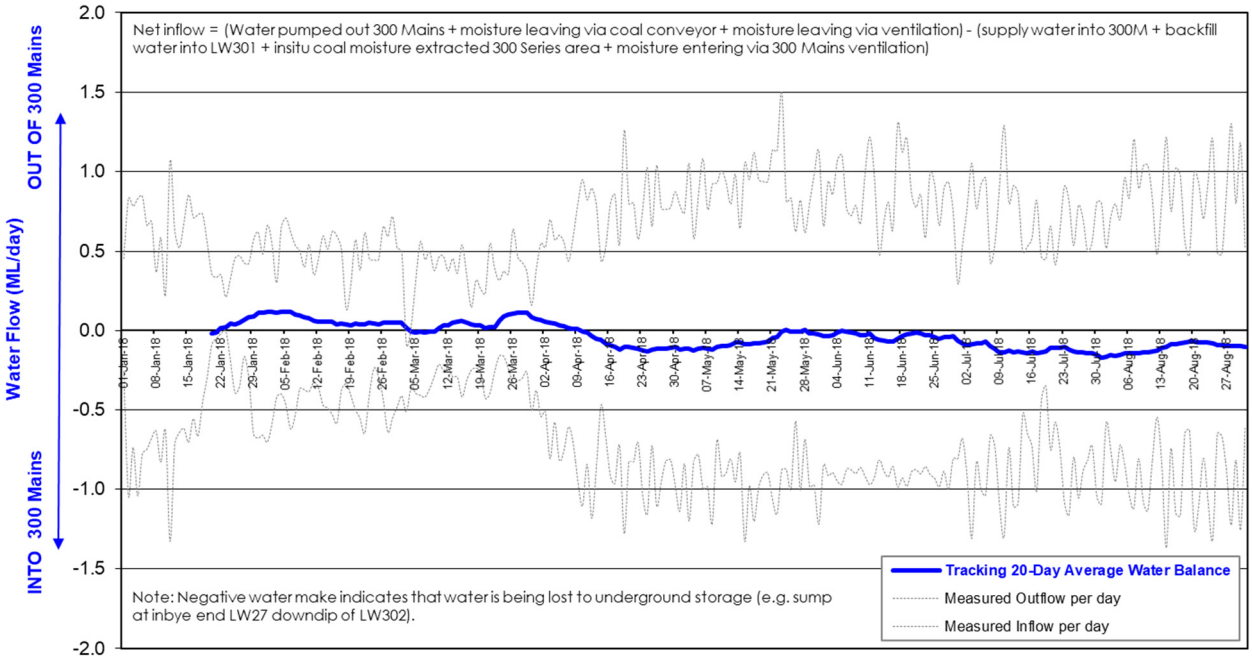


Chart 2c 300 Mains Water Balance, January to August 2018

Continuous groundwater level/pressure monitoring has been conducted at bores 9HGW0 (Longwall 10 Goaf Hole), 9EGW1B, 9FGW1A, 9GGW1-80, 9GGW2B, 9HGW1B, PM02, PM01 (9DGW1B), 9EGW2A, PM03, PHGW1B, PHGW2A, F6GW3A and F6GW4A in accordance with the Metropolitan Coal Water Management Plans. The monitoring results indicate that a hydraulic gradient has been maintained between bores and the floor levels of the nearest streams and a hydraulic gradient exists from bores to the Woronora Reservoir at the level of the regional water table. The monitoring results also support the assessment of no connective cracking between the surface and the mine.

In accordance with the Dams Safety Committee Approval (26 April 2012), for mining within the Woronora Reservoir Notification Area, Metropolitan Coal has undertaken sampling programs to investigate the properties of groundwater above and below the Hawkesbury Sandstone and to establish chemical signatures that would indicate mining-induced fracturing through the Bald Hill Claystone, should it occur. The data are analysed through statistics, trend diagrams (Stiff, Schoeller and Piper), time-series plots, spatial maps, and ratio plots. Although a few sampling sites are grout-impacted, there is sufficient reliable data to show a clear distinction between groundwaters in the upper Hawkesbury Sandstone, lower Hawkesbury Sandstone and upper Bulgo Sandstone. To date, there is no evidence of mining-induced leakage across the Bald Hill Claystone.

The groundwater monitoring results to date are considered to be consistent with the potential subsidence impacts and environmental consequences described in the Project EA, Preferred Project Report, and Metropolitan Coal Water Management Plans.

4.1.3 Woronora Reservoir Impact Strategy

Condition 2 of the Longwalls 301 and 302 approval requires Metropolitan Coal to conduct further investigation into potential impacts on Woronora Reservoir. Metropolitan Coal engaged independent experts to prepare a Woronora Reservoir Impact Strategy to provide a staged plan of action for further investigations and a report into the impacts of mining near the reservoir. Professor Bruce Hebblewhite (B. K. Hebblewhite Consulting), Dr Frans Kalf (Kalf and Associates Pty Ltd) and Emeritus Professor Thomas McMahon (University of Melbourne) were endorsed by the DP&E for the Woronora Reservoir Impact Strategy in May 2017.

The *Woronora Reservoir Strategy Report - Stage 1* was provided by the independent experts to the DP&E in September 2017. The Stage 1 report included recommendations for further groundwater and surface water investigations and monitoring and was approved by the Secretary for Planning in December 2017.

The surface water and groundwater monitoring locations that have been installed as a component of the Woronora Reservoir Impact Strategy are described in the Longwalls 301-303 Water Management Plan.

The additional monitoring sites and environmental investigations included the installation of two streamflow monitoring stations in sub-catchments K and I and the installation of a pluviometer in the vicinity of the northern end of Longwall 307.

A number of groundwater monitoring bores have also been installed as a component of the Woronora Reservoir Impact Strategy including a goaf hole over Longwall 302 (302GW01). Metropolitan Coal installed five copper wire and four optical fibre piezometers in hole 302GW01 to monitor groundwater as longwall extraction progressed. Unfortunately, most of the sensor cables were severed by ground movement as Longwall 302 passed under the site. Follow-up piezometer installation to monitor post-mining groundwater pressures similar to the previous goaf hole sites with traditional copper cabling is scheduled for late 2018.

Metropolitan Coal also installed additional bores over Longwall 302 (TBS02-80, TBS02-250 and TBS02-15) and Longwall 303 (TBS03 – 230 and TBS03-15). The two deep holes have vibrating wire piezometers installed 15 m above and below the Bald Hill Claystone. A summary of the groundwater monitoring results analysed to date is provided further below.

At the time the mining face crossed the position of bore 302GW01, the pressure head profile suggests that the top of the connected fracture zone would have been between the sensors at 340 m and 380 m depth. This would correspond to a fracture height range of 166-206 m. The Ditton calculation of fracture height (using the geology model and t' of 20 m) gives a range of 168-192 m (A to A95), whereas the Tammetta method gives 152-189 m (C to C95). Both algorithms are in good agreement with observation. Due to the observation of very low pressure heads to greater height than expected shortly after the day on which the mining face passed the bore, and uncertainty over whether the VWP sensors are recording valid data from that time, Metropolitan Coal will install a post-mining open bore hole to obtain a direct measurement of post-mining water pressures over time on the recommendation of the Woronora Reservoir Impact Strategy independent experts.

Two deep inclinometer monitoring points (TBS02-250 and TBS03-230) were established on the centreline axis of Longwall 302 and Longwall 303 to establish trends of horizontal shearing as the extraction of the respective longwalls progress towards the instruments. The inclinometers monitor horizontal shearing locations, measure the magnitude and direction of shearing in the Hawkesbury Sandstone and record any basal shearing on the sandstone contact with the Bald Hill Claystone formation. A total of 10 inclinometer surveys have been completed at TBS02-250 between January and June 2018. The data suggests lateral movement associated with the extraction of Longwall 302 has resulted in a north-east trending displacement across multiple shear planes identifiable at depths 74 m, 105 m, 114 m, 162 m and 202 m. The follow up piezometer hole planned for 302GW01 in late 2018 will test for any permeability changes associated with the identified shear planes.

Groundwater Monitoring Results

Groundwater pressures were first recorded at bore 302GW01 in November 2017 when the mining face was approximately 450 m to the south in the adjacent Longwall 301, heading away from 302GW01. During the extraction of Longwall 302, the heads in 302GW01 commenced rising in all but the shallowest piezometer when the mining face was about 300 m from the bore. The rises of 10-60 m are expected to be due to dynamic compression of the rock matrix as the mining face approached the bore. About a week before the mining face passed beneath the bore on 25 May 2018, the groundwater heads declined substantially, except for the shallowest piezometer at 80 m depth. About a week after the crossing, eight of the nine sensors ceased to function. It is probable that the sensor cables sheared off at the shear planes identified by the TBS02 inclinometer surveys. However, the two corresponding sensors in bore TBS02, 20 m away, survived the crossing and have continued to record meaningful data. The observed drawdowns were about 80 m at the base of the Hawkesbury Sandstone and about 140 m at the top of the Bulgo Sandstone. Since then, the water levels have recovered by about 20 m and 10 m respectively (at September 2018), so that the pressure heads (the height of water above the sensor) are currently about 50 m and 25 m respectively. At bore TBS03 in the centre of Longwall 303, to the immediate west of TBS02, the corresponding pressure heads are currently about 90 m and 140 m respectively.

Further west, over the pillar between Longwalls 303 and 304, bore F6GW4 has been recording groundwater heads at eight depths since August 2013. The sensors at this bore responded to the passing of the mining face (450 m away) during Longwall 301 with mild rises in head at most depths followed by mild drawdown. During the extraction of Longwall 302 (250 m away), larger rises in head occurred prior to the date of crossing (25 May 2018) followed by substantial declines in the lowest three piezometers (from the lower Bulgo Sandstone to Bulli Coal). The heads at TBS03 are consistent with those measured at F6GW4, and the responses at F6GW4 are consistent with those at 302GW01.

The two shallow 15 m standpipes have recorded stable depths to water of about 7 m at TBS02-15 and about 9 m at TBS03-15 over the past six months since measurements commenced. The deeper standpipe at TBS02-80 has recorded heads consistent with those at the 80 m piezometer at 302GW01, with a difference of about 3m. While the 80 m piezometer at 302GW01 continues recording, with no evident sustained mining effect, the standpipe hole has become obstructed.

Pre-Mining Permeability Measurements

Pre-mining packer testing was conducted in bore 302GW01 for 15 12-metre sections from 238 m to 490 m depth below the Bald Hill Claystone. The interpreted hydraulic conductivities ranged from $8x10^{-7}$ m/d in the Scarborough Sandstone to $5x10^{-4}$ m/d in the lower Bulgo Sandstone, with a median of $8x10^{-5}$ m/d. Across these lithologies, the groundwater model has a median horizontal value of $3x10^{-3}$ m/d and a median vertical value of $1x10^{-5}$ m/d.

Laboratory measurements of horizontal and vertical permeability were made on core taken from the Hawkesbury Sandstone, Bald Hill Claystone and Bulgo Sandstone. Typical results for horizontal hydraulic conductivity were $4x10^{-5}$, $4x10^{-6}$ and $2x10^{-6}$ m/d respectively. Corresponding typical values in the groundwater model are, respectively, $2x10^{-3}$, $7x10^{-5}$ and $6x10^{-3}$ m/d. The higher values in the model are consistent with the upscaling required when measurements are made at different scales.

At bore TBS02, pre-mining packer testing was conducted from 99 m in Hawkesbury Sandstone to 243 m total depth, beneath the Bald Hill Claystone. The Hawkesbury Sandstone hydraulic conductivities ranged from $2x10^{-6}$ m/d to $1x10^{-3}$ m/d with a median of $6x10^{-4}$ m/d. The Bald Hill Claystone measurements were $6x10^{-5}$ and $3x10^{-4}$ m/d (average $4x10^{-4}$ m/d), and the upper Bulgo Sandstone had a single value of $1x10^{-4}$ m/d. For these lithologies, the groundwater model has consistent horizontal hydraulic conductivities of $2x10^{-3}$ (median), $7x10^{-5}$ and $7x10^{-4}$ m/d.

4.2 RELEVANT LAND MANAGEMENT INFORMATION OBTAINED SINCE PROJECT APPROVAL

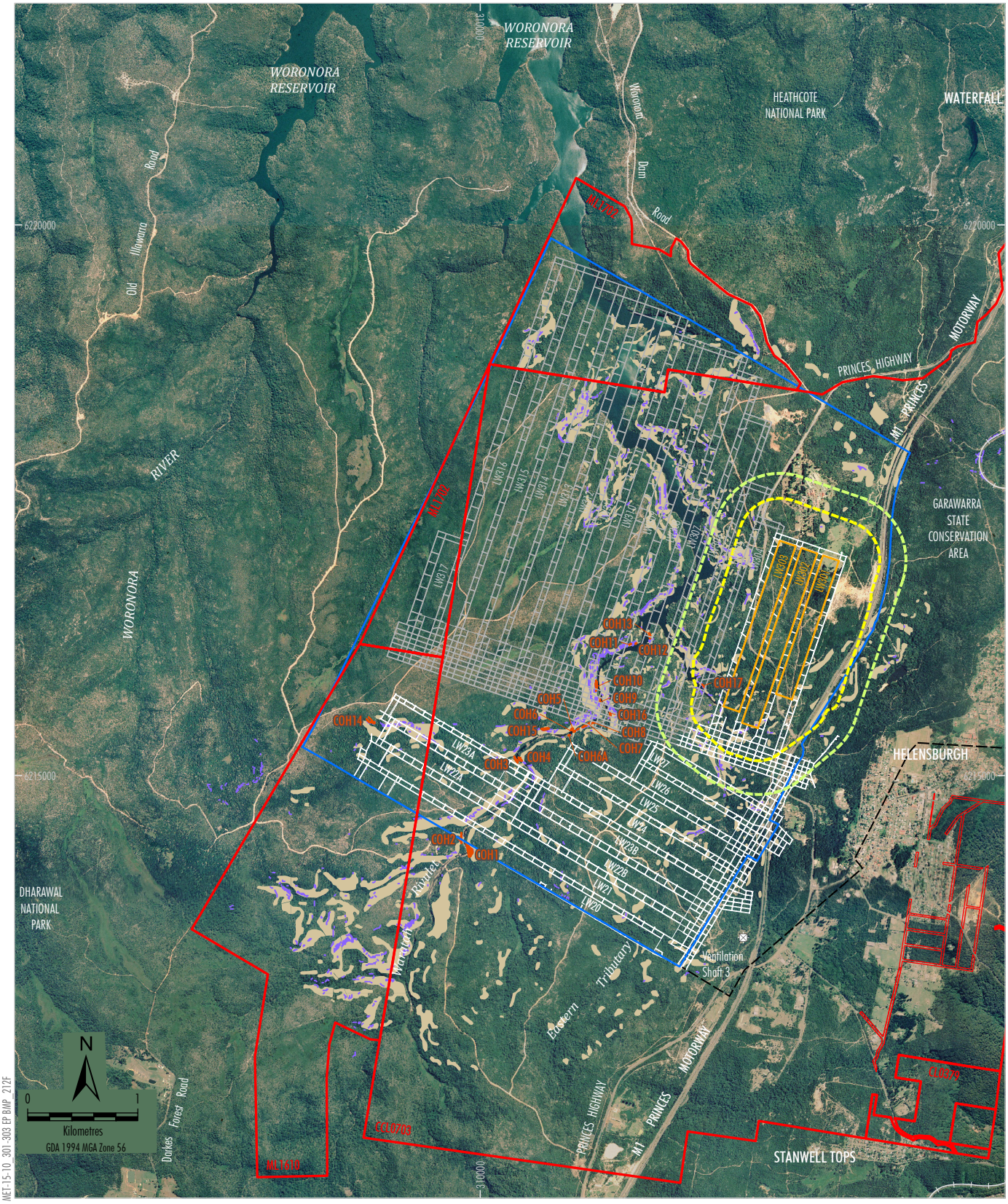
The Metropolitan Coal Land Management Plans were prepared to manage the potential environmental consequences of the Metropolitan Coal Extraction Plans on cliffs, overhangs, steep slopes and land in general, in accordance with Condition 6, Schedule 3 of the Project Approval.

Visual inspections of cliffs and overhangs were conducted monthly when mining of Longwalls 20-22 and/or Longwalls 23-27 was within 400 m of sites COH1, COH2, COH3, COH4, COH5, COH6, COH6A, COH7, COH8, COH9, COH10, COH14, COH15 and COH16 (Figure 10) and following the completion of each longwall to record evidence of subsidence impacts. A vertical tension crack (approximately 50 mm wide and 15 m long) on the cliff face and a small rock fall (approximately 1.5 m long, 0.5 m wide and 0.5 m^3) were recorded at site COH2 (Figure 10) in December 2013 during the mining of Longwall 22 (Metropolitan Coal, 2014).

No additional subsidence impacts at the cliff or overhang sites were recorded following the completion of Longwall 27 (Metropolitan Coal, 2017). A new cliff and overhang site (COH17) was identified below the full supply level on 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.

Observations of steep slopes and land in general have been conducted by Metropolitan Coal and its contractors as part of routine works conducted in the catchment. In February 2012 during the mining of Longwall 21, a surface tension crack was recorded on Fire Trail 9C adjacent to Longwall 20, approximately 10 m long with a maximum width of 20 mm (Metropolitan Coal, 2011). In February 2017 a surface tension crack was recorded on a rock platform located over Longwall 25 in the vicinity of Aboriginal heritage site FRC 301 approximately 10 mm wide and 25 m long (Metropolitan Coal, 2017).

In September 2011 during the mining of Longwall 21, a rock ledge was recorded to have collapsed on the Unnamed Tributary/Tributary D, located to the south of Longwalls 20-22 (Metropolitan Coal, 2011). In July 2015 during the mining of Longwall 24, a rock ledge collapse was recorded on Tributary B (Metropolitan Coal, 2016a). In February 2017, rock fall from the underside of a sandstone boulder overhang, approximately 60 cm wide and 80 cm in length, was recorded in the vicinity of Aboriginal heritage site FRC 285 located over Longwall 22B (Metropolitan Coal, 2017). The potential for impacts on public safety, as well as the potential environmental consequences of the observed subsidence impacts were assessed. None of the recorded subsidence impacts were considered to represent a safety or environmental hazard and no management measures were considered necessary. The recorded subsidence impacts are consistent with the potential subsidence impacts described in the Project EA, Preferred Project Report and Metropolitan Coal Land Management Plans.



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)
- Cliffs and Overhangs
- Steep Slopes (Project Approval)
- Steep Slopes (Project Environmental Assessment)

Source: Land and Property Information (2015); Date of Aerial Photography 1998; Department of Industry (2015); Metropolitan Coal (2018); MSEC (2008; 2018)

Peabody

METROPOLITAN COAL

Cliffs and Overhangs, Steep Slopes and Land in General within the Project Underground Mining Area and Surrounds

Figure 10

4.3 RELEVANT BIODIVERSITY MANAGEMENT INFORMATION OBTAINED SINCE PROJECT APPROVAL

The Metropolitan Coal Biodiversity Management Plans were prepared to manage the potential environmental consequences of the Metropolitan Coal Extraction Plans on aquatic and terrestrial flora and fauna, with a specific focus on swamps, in accordance with Condition 6, Schedule 3 of the Project Approval.

4.3.1 Upland Swamps

4.3.1.1 Swamp Types

Several types of upland swamps have been defined in the Metropolitan Coal Project underground mining area and surrounds according to the geomorphological settings in which they occur by the Metropolitan Coal Biodiversity Management Plans, as follows:

1. Headwater swamps. These are the largest swamp type. They occupy broad, shallow, trough-shaped valleys, usually on first order watercourses at the head of valleys on broad plateaux. They sit on a relatively impermeable, low gradient sandstone base with dispersed seepage flows that encourage the growth of hygrophilic vegetation that in turn traps sediment, thereby increasing the water holding capacity. These swamps usually terminate at points where the watercourse suddenly steepens or drops away at a 'terminal step'. Terminal steps often occur at constrictions in the landscape where two ridges converge, causing a narrowing of the swamp and a concentration of water flows into a central channel.

2. Valley side swamps. Valley side swamps occur on steeper terrain than headwater swamps and are sustained by small horizontal aquifers that seep from the sandstone strata and flow over unbroken outcropping rock masses. These 'swamps' have shallow soils because the gradient usually limits sediment accumulation. They tend to terminate either on a horizontal step in the bedrock, or where broken rock, scree or deeper soil occurs at the base of the outcropping rock.

3. In-valley swamps. In-valley swamps are uncommon and occur on relatively flat sections of more deeply incised second and third order watercourses. Some are thought to develop behind obstructions in the watercourse, such as fallen rocks or log jams that result in a slowing of the water flow and deposition of sediments. Flat Rock Swamp is considered to represent a 'classic' in-valley swamp. Because of their relatively large catchment areas these swamps tend to be wetter than many headwater and valley side swamps.

Although these swamp types may occur discretely in the landscape, they can also occur in the same connected swamp system. For example, large headwater swamps may transition into in-valley swamps at the downstream end. Similarly, valley side swamps may occur around the steeper margins of some headwater swamps.

The terrain over Longwalls 20-27 is highly dissected with narrow ridges. All the swamps mapped in the Longwalls 20-22 and Longwalls 23-27 mining areas are valley side swamps, with the exception of Swamp 20 which is a small in-valley swamp on a second order stream over Longwall 21 (Figure 9). Swamp 20 (situated in a gently inclined valley over solid bedrock) appears to have developed behind a terminal step, at a geological constriction in a valley, in much the same way as headwater swamps develop.

All of the swamps mapped in the Longwalls 301-303 mining area are also valley side swamps.

4.3.1.2 Swamp Characterisation

Swamp characterisation studies were conducted by Cenwest Environmental Services (2010) for the Longwalls 20-22 Biodiversity Management Plan and Cenwest Environmental Services (2011; 2013a) for the Longwalls 23-27 Biodiversity Management Plan. These studies have contributed to Metropolitan Coal's understanding of the ecological, hydrological and geomorphic processes of the upland swamps over Longwalls 20-27.

4.3.1.3 Swamp Vegetation Mapping

Bangalay Botanical Surveys (2008) conducted a baseline flora survey and mapped vegetation communities within the Project underground mining area for Longwalls 20-27 and Longwalls 301-317 for the Project EA (HCPL, 2008). Swamps were mapped by Bangalay Botanical Surveys (2008) consistent with vegetation mapping by the NSW National Parks and Wildlife Service (NPWS) (2003) as either vegetation community 3a (Banksia Thicket), 3b (Tea Tree Thicket), 3c (Sedgeland-heath Complex), 3d (Fringing Eucalypt Woodland), or a combination of these communities.

Swamps mapped by Bangalay Botanical Surveys (2008) located above or immediately adjacent to Longwalls 20-27 include Swamps 16, 17, 18, 19, 20, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35 and 36 (Figure 9).

While Swamp 29 is illustrated on Figure 9 (for consistency with the previous Longwalls 23-27 Biodiversity Management Plan), field inspections by Eco Logical for the Longwalls 23-27 vegetation monitoring program indicated that it is not a swamp. The vegetation was found to be similar to sandstone heath woodland, being dominated by *Angophora costata, Corymbia gummifera* and *Eucalyptus oblonga,* with an understorey of *Banksia ericifolia, Acacia ulicifolia, Leptospermum trinervium, Kunzea ambigua, Dillwynia retorta* and *Schoenus ericetorum*. Accordingly, Swamp 29 was not considered further in the Metropolitan Coal Longwalls 23-27 Biodiversity Management Plan.

The vegetation in the remaining swamps (with the exception of Swamp 33) was classified by Bangalay Botanical Surveys (2008) as 'Sedgeland-heath Complex' consistent with vegetation mapping by NPWS (2003). Sedgeland-heath Complex is a mapping unit that amalgamates the Sedgeland, Restioid Heath and Cyperoid Heath vegetation associations identified by Keith and Myerscough (1993). The three communities were condensed by NPWS (2003) because they could not be reliably distinguished by Air Photo Interpretation for community mapping. Swamp 33, was mapped by Bangalay Botanical Surveys as 'Banksia Thicket' consistent with vegetation mapping by NPWS (2003).

Field inspections for the previous Longwalls 20-22 and Longwalls 23-27 Biodiversity Management Plans by Eco Logical indicated that all the swamps over Longwalls 20-27 comprised either Banksia Thicket or Restioid Heath (or a combination of the two), with the exception of Swamp 20 and Swamp 28. Swamp 20 supports Tea Tree Thicket, while Swamp 28 is a Banksia Thicket swamp with the lower portion supporting Tea Tree Thicket.

Three of the vegetation patches mapped as swamps (Swamps 16, 17 and 23), although showing seepage, do not appear to be upland swamps, being more akin to Sandstone Heath Woodland with low tree densities. The vegetation on these patches have species found in upland swamps, mixed with a range of non-swamp species, including *Banksia serrata, Eucalyptus sieberi* and *E. racemosa* in Swamps 16 and 17, and *Angophora hispida* and *Allocasuarina littoralis* in the case of Swamp 23. However, Swamp 23 also has a number of characteristic swamp species, including *Sprengelia incarnata, Epacris obtusifolia* and *Pultenaea aristata,* indicating at least some parts of it are quite moist. However, despite this, Swamp 23 is considered to be transitional between swamp and wet heath and somewhat atypical.

Similarly, Swamp 32 and Swamp 34 included elements of the Sandstone-Heath Woodland consistent with descriptions of this community by NPWS (2003).

During the conduct of the Longwalls 20-27 upland swamp vegetation monitoring, the swamp boundary of control swamps 101, 111a, 135, 136, 137a, 137b, 138 and Bee Creek Swamp were updated by Eco Logical (as shown on Figure 11).

4.3.1.4 Upland Swamp Vegetation Monitoring

Upland swamp vegetation monitoring for Longwalls 20-22 and Longwalls 23-27 has included visual, quadrat/transect and indicator species monitoring, as described below.

The upland swamp vegetation monitoring program was designed to comprehensively assess potential vegetation changes at three scales; overall gross changes across the whole swamp, changes at the community level and changes at the level of individual plants. Visual inspections aim to appraise the overall condition of the swamp and to detect any localised changes, described below, that may not be detected by detailed transect, quadrat and individual plant monitoring. The visual inspections provide qualitative information that may lead to further investigation and/or actions.

The fixed vegetation transects and associated quadrats aim to precisely measure changes in vegetation community composition over time in undermined and control swamps, including a two year pre-mining baseline data period. This sampling design follows that of Keith and Myerscough (1993) which is specifically tailored for upland swamp monitoring. The design includes sufficient replication for robust statistical analysis.

Monitoring of individual plants provides species level data on the health and survival of individual plants in undermined and control swamps. Monitoring is targeted to swamp specialist species that may be prone to any mining-induced changes to swamp hydrology.

<u>Visual Inspections</u>

Visual inspections have been conducted in Swamps 16, 17, 18, 19, 20, 23, 24, 25, 26 27, 28, 30, 31, 32, 33, 34, 35, 36, 93, 94, 95, 96, 97 and 98 overlying or adjacent to Longwalls 20-27 when mining has been within 400 m of the swamp and at the time of the vegetation surveys (i.e. biannually in autumn and spring) to record evidence of potential subsidence impacts.

Traverses covering the majority of the extent of the swamp have been conducted to record:

- cracking of exposed bedrock areas and/or swamp sediments;
- areas of increased erosion, particularly along any existing drainage lines;
- any changes in water colour;
- changes in vegetation condition, including areas of stressed[5] or senescent vegetation that appear unusual; and
- the amount of seepage at the time of inspection, relative to recent rainfall events.

[5] Note, the Longwalls 20-22 and Longwalls 23-27 Biodiversity Management Plans refer to 'senescing' vegetation. The text has been changed to differentiate vegetation that is 'stressed' and vegetation that is dying or has died (senescent). Senescence is the process of ageing including the period leading up to death. It is sometimes difficult to differentiate between the two under field conditions.

Transect and Quadrat Monitoring

Transect and quadrat monitoring is conducted of:

- Banksia Thicket/Restioid Heath vegetation – in Swamps 16, 17, 18, 24 and 25 overlying Longwalls 20-22, Swamps 28 (upper portion), 30, 33, 35 and 94 overlying or adjacent to Longwalls 23-27, and in control Swamps 101, 111a, 125, 135, 136, 137a, 137b, 138 and Bee Creek Swamp (Figure 9); and
- Tea Tree Thicket vegetation – in Swamp 20 overlying Longwalls 20-22, in the lower portion of Swamp 28 overlying Longwalls 23-27, and in control swamps Woronora River 1, Woronora River south arm and Dahlia Swamp (Figure 9).

Baseline upland swamp vegetation surveys were conducted for Longwalls 20-22 in spring 2009 and autumn 2010[6] and for Longwalls 23-27 from spring 2010 to spring 2013[7].

The Banksia Thicket/Restioid Heath swamps and Swamp 20 (Tea Tree Thicket) have been monitored with three transects, with the exception of Swamp 28. Swamp 28 is a small valley-side swamp which supports Banksia Thicket in the upper portion of the swamp and Tea Tree Thicket in the lower portion of the swamp. Vegetation within Swamp 28 has been monitored along two transects, one within the Banksia Thicket and one within Tea Tree Thicket vegetation. Tea Tree Thicket control swamps Woronora River 1, Woronora River south arm and Dahlia Swamp have been monitored with a single transect owing to the much larger size of these control swamps.

For the Banksia Thicket/Restioid Heath swamps, assessments have been made on 1 square metre (m^2) quadrats centred on the transect line every 5 m starting from 0 m. For the Tea Tree Thicket swamps, assessments have been made on 1 m^2 quadrats located upslope of the transect line with one quadrat edge located on the line as a means of avoiding the impacts of vegetation trampling as a result of access into these thickly vegetated swamps. As for Banksia Thicket/Restioid Heath swamps, assessments are made every 5 m starting from 0 m.

The data collected for each quadrat includes:

- 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

  Modified Braun-Blanquet Scale

  1 = cover less than 5% of site and rare

  2 = cover less than 5% of site and uncommon

  3 = cover of less than 5% and common

  4 = cover of 5-20% of site

  5 = cover of 21-50% of site

  6 = cover of 51-75% of site

  7 = cover of greater than 75%

[6] Longwall Swamps 16 and 17 (Restioid Heath/Sandstone Heath Woodland) were added to the vegetation monitoring program in autumn 2010.

[7] Monitoring of transects/quadrats in control Swamps 101, 111a, 125, Woronora River 1, Woronora River south arm and Dahlia Swamp commenced in spring 2009 and in control Swamps 135, 136, 137a, 137b, 138 and Bee Creek Swamp in spring 2010.

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

  Condition Scale

  1 severe damage/dieback
  2 many dead stems
  3 some dead branches
  4 minor damage
  5 healthy

Permanent photo points were established along each transect.

Indicator Species Monitoring

Indicator species monitoring has been conducted in Banksia Thicket/Restioid Heath swamps, as follows:

- *Epacris obtusifolia* in Swamps 18, 24 and 25 overlying Longwalls 20-22, in Swamps 19, 30, 33, 35 and 94 overlying or adjacent to Longwalls 23-27, and in control Swamps 101, 111a, 125, 135, 136, 137a, 137b and 138.
- *Sprengelia incarnata* in Swamp 24 overlying Longwalls 20-22, in Swamps 19, 33, 35 and 94 overlying or adjacent to Longwalls 23-27 and in control Swamps 101, 125, 135, 136, 137a and 138.
- *Pultenaea aristata* in Swamps 18, 24 and 25 overlying Longwalls 20-22, in Swamps 19, 30, 33, 35 and 94 overlying or adjacent to Longwalls 23-27 and in control Swamps 101, 111a, 135, 136, 137a and 138.

Indicator species monitoring of *Banksia robur, Callistemon citrinus* and *Leptospermum juniperinum* has been conducted in the Tea Tree Thicket vegetation of Swamp 20 overlying Longwalls 20-22, of *Banksia robur* and *Callistemon citrinus* in the Tea Tree Thicket vegetation of Swamp 28 overlying Longwalls 23-27, and at the associated control sites (Woronora River 1, Woronora River south arm and Dahlia Swamp).

Baseline indicator species monitoring was conducted in spring 2009 and autumn 2010 for Longwalls 20-22[8], and from spring 2010 to spring 2013 for Longwalls 23-27[9].

Twenty tagged individuals of each species have been monitored in the swamps indicated above. Population monitoring data collected includes a condition/health rating (1 - severe damage/dieback, 2 - many dead stems, 3 - some dead branches, 4 -minor damage, 5 – healthy) and a reproductive rating (1 – nil, 2 - sparse [occasional flowers only], 3 - low [under 25 percent of potential], 4 - moderate [25 to 75 percent], 5 - high [over 75 percent of potential flowering]) for each plant.

8 Monitoring of *Pultenaea aristata* in Swamp 24 commenced in autumn 2010.

9 Monitoring of indicator species in control Swamps 101, 111a, 125, Woronora River 1, Woronora River south arm and Dahlia Swamp commenced in spring 2009 and monitoring of indicator species in control Swamps 135, 136, 137a, 137b and 138 commenced in spring 2010.

Monitoring Results to Date

The results of the Longwalls 20-22 and Longwalls 23-27 upland swamp vegetation monitoring programs (up to and including the autumn 2017 survey) can be summarised as follows:

- No cracking of exposed bedrock areas or swamp sediments has been observed, other than those recorded during the baseline surveys. Areas in which active erosion was observed were all minor and limited to access tracks, drainage lines and areas of bare earth without vegetation cover. At Swamp 20, iron-stained groundwater seepage has been observed since spring 2012 on the terminal rocky step and a small rocky step. In autumn 2017 iron staining was confined to the terminal rocky step and continues to be reduced in area compared to previous seasons.
- The vegetation structure, dominant species and estimated cover abundance for each stratum has been variable across all seasons with variations recorded between sites, seasons and strata. No notable changes in vegetation structure, dominant species or estimated cover/abundance which could be attributed to impacts associated with the mining of Longwalls 20-22 or Longwalls 23-27 have been recorded.
- Fluctuations in species cover/abundance and condition have been recorded across all sites. No patterns of increasing or decreasing cover/abundance, or declines in vegetation condition have been identified in relation to individual species across sites or groups of species (i.e. swamp indicator species, generalist species, shrubs, ground covers) within sites.
- Analysis of species richness within Restioid Heath/Banksia Thicket sites using analysis of variance (ANOVA) did not detect significant differences between longwall and control sites in any season including autumn 2017.
- Species richness within individual Tea Tree Thicket sites in autumn 2017 was within the range of previous seasons at all control sites and at longwall Swamp 20 over Longwalls 20-22.
- Species richness within the longwall swamp supporting Tea Tree Thicket (Swamp 28 - Transect 2) over Longwalls 23-27 has declined over time and in autumn 2017 was below previous records (Chart 3). Analysis of changes in species richness over time indicate the decrease in species richness has predominantly occurred prior to subsidence impacts occurring to Swamp 28 substrate groundwater levels in 2016. Rainfall during autumn and spring 2016 was well below average, although heavy rains fell in June 2016. Similarly, rainfall leading up to the autumn 2017 survey was well below average. Swamp 28 is very small, does not contain any internal drainage lines and free surface water has never been observed at this site since the inception of monitoring.
- Monitoring of indicator species (*Epacris obtusifolia, Sprengelia incarnata, Pultenaea aristata, Banksia robur, Callistemon citrinus* and *Leptospermum juniperinum*) indicates the results for longwall swamps are similar to the results for control swamps or the baseline monitoring data and the observed mortality is considered to be attributable to natural factors including predation, competition with other vegetation and abiotic factors. The increased mortality of *Banksia robur* at the single Tea Tree Thicket longwall site (Swamp 28) over Longwalls 23-27 has been observed since spring 2012 prior to the commencement of mining Longwalls 23-27. This suggests that it is attributable to natural factors, however its rate of decline since autumn 2015 and in particular since spring 2016 to autumn 2017 may also be indicative of the drying out of the swamp sediments as a result of the mine subsidence impacts as indicated by piezometer data.

- The upland swamp vegetation performance indicator, *The vegetation in upland swamps is not expected to experience changes significantly different to changes in control swamps*, has not been exceeded for any of the Restioid Heath/Banksia Thicket Swamps or Swamp 20 (Tea Tree Thicket vegetation). However, for longwall Tea Tree Thicket Swamp 28, based on the autumn 2017 continual decline in condition of the understorey and species richness, and the high mortality rate of *Banksia robur* in comparison to the control sites the upland swamp vegetation performance indicator is considered to have been exceeded at this site. Assessments against the biodiversity subsidence impact performance measure, *negligible impact on the species, populations or ecological communities* have been completed and the performance measure has been met

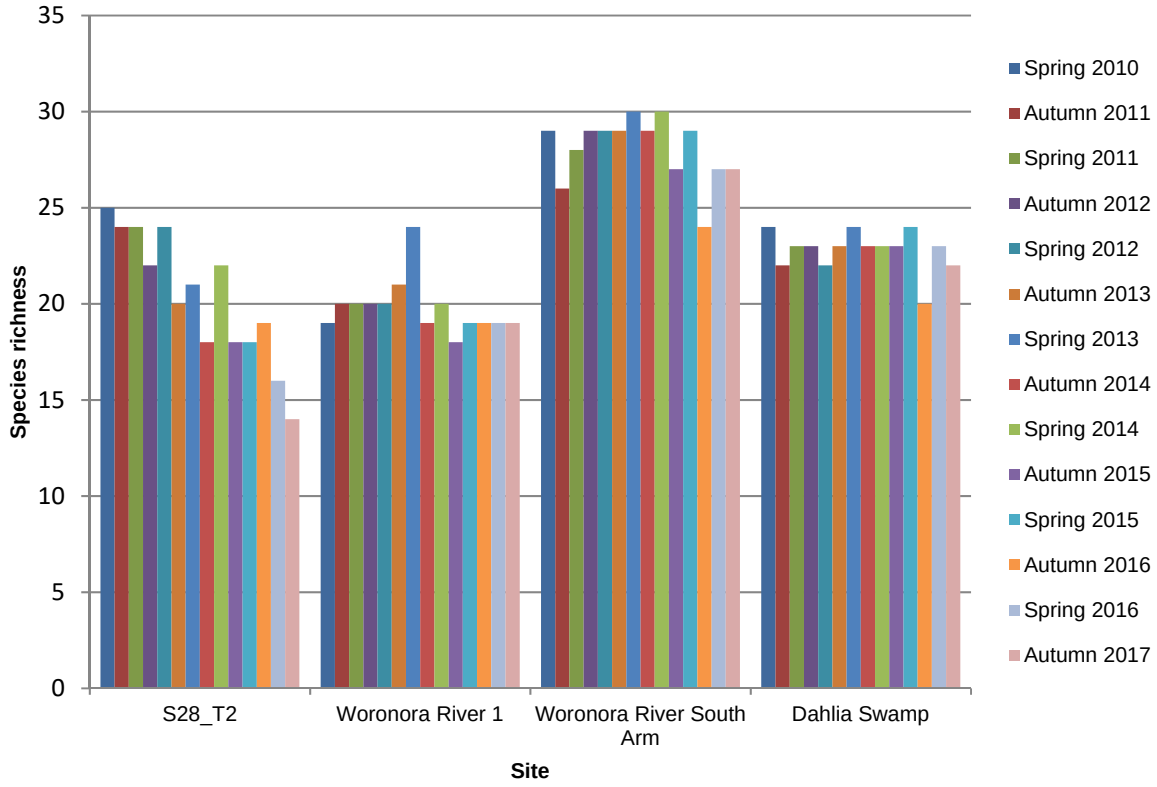


Chart 3: Native Species and Richness within Longwalls 23-27 Upland Swamp Sites Supporting Tea Tree Thicket, Spring 2010 – Autumn 2017

4.3.1.5 Upland Swamp Groundwater Monitoring

Groundwater monitoring of upland swamps is described in Section 4.1.2 above.

4.3.1.6 Assessment of Monitoring Results against Predicted Subsidence Impacts and Environmental Consequences

The key potential subsidence impacts and environmental consequences on perched groundwater systems and upland swamp vegetation described in the Project EA, Preferred Project Report and Metropolitan Coal Water Management Plans and Biodiversity Management Plans are described in Section 4.1.2.

In summary, no change to the fundamental surface hydrological processes and upland swamp vegetation were expected within upland swamps, however, Swamp 20 was identified as being most at risk of subsidence impacts as a result of Longwalls 20-27.

Analyses to date indicate the swamp substrate water levels of all swamps have remained perched, with the exception of Swamp 20 and Swamp 28 (HydroSimulations, 2018b). The substrate water levels in Swamp 20 changed from being permanently saturated to being periodically saturated (HydroSimulations, 2016). A mining effect to the substrate water levels of Swamp 28 was identified based on the incomplete recovery of substrate water levels following rainfall events.

While the water lost from Swamp 20 and Swamp 28 was retained in the unsaturated sandstone above the regional water table, the changes in swamp water levels as a result of cracking are measurable when compared to seasonal individual rainfall event based changes in swamp groundwater levels.

To date, the upland swamp vegetation monitoring results indicate that the vegetation in Swamp 20 has not experienced changes significantly different to changes in control swamps. However, it is not possible to predict the long term impacts on the vegetation of Swamp 20 owing to uncertainty about the altered hydrological regime, particularly the extent of cracking, and the potential for natural remediation. The effects on vegetation of reductions in water levels in Swamp 20, if any, may take some years to be expressed in the absence of a catastrophic event such as extreme drought and/or a wildfire. Continued biannual quantitative monitoring is required to reliably determine the impact of subsidence on Swamp 20 vegetation.

Based on the decline in condition of the understorey and species richness, and the high mortality rate of *Banksia robur*, compared to the control swamps, Swamp 28 is considered to have experienced changes significantly different to the control sites.

Assessments against the biodiversity subsidence impact performance measure, *Negligible impact on threatened species and populations* have been conducted for Swamp 20 and Swamp 28 by FloraSearch (2012, 2013, 2014, 2015, 2016a), Cenwest Environmental Services (2012, 2013b, 2014a, 2015, 2016, 2017) and Eco Logical (2017) and concluded the subsidence impact performance measure had been met.

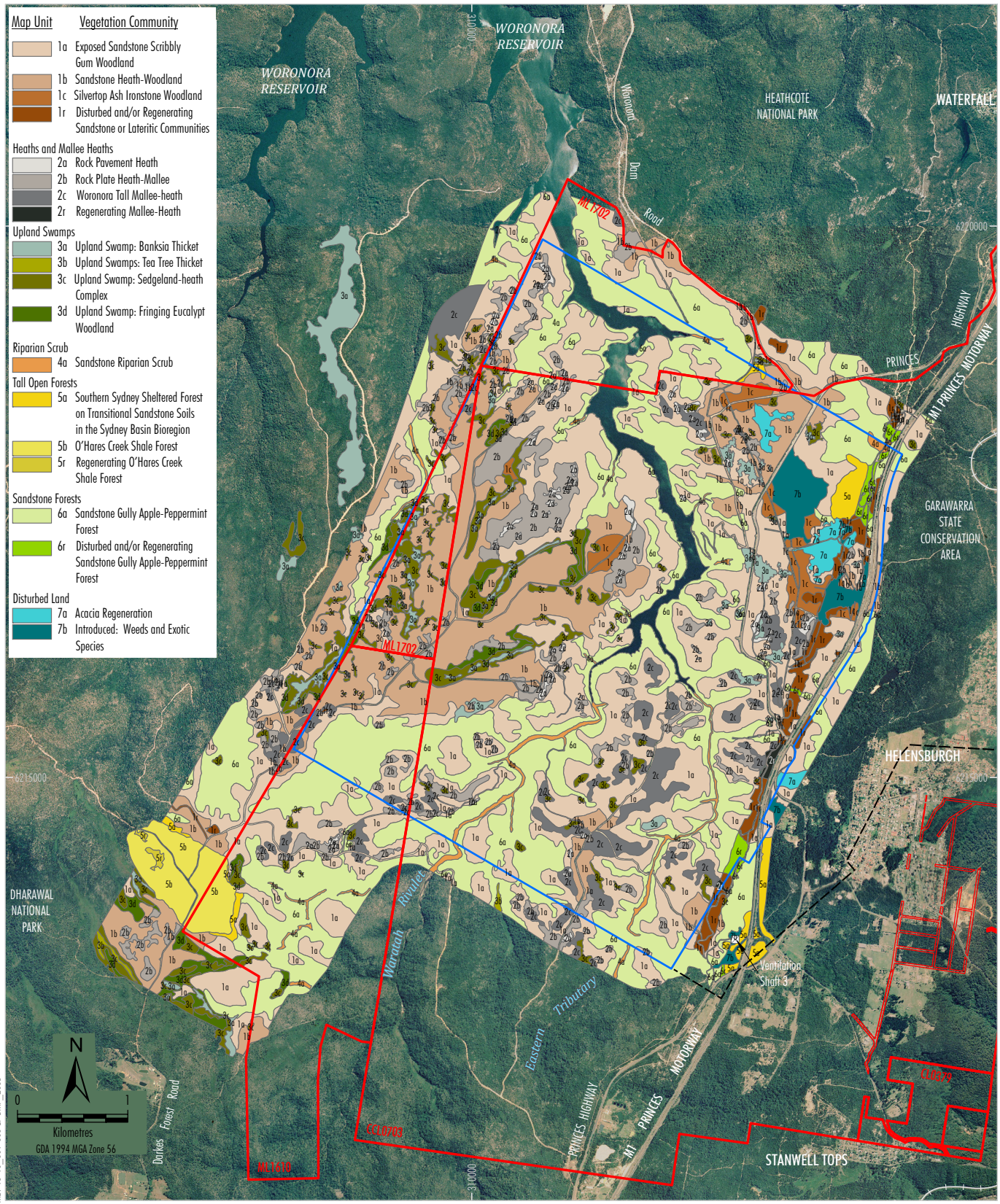
4.3.2 Riparian Vegetation

Riparian vegetation within the Project underground mining area occurs along streams which flow to the Woronora Reservoir, including Waratah Rivulet and the Eastern Tributary, and some of their tributaries. Vegetation mapping within the Project underground mining area is shown on Figure 11. Riparian vegetation includes vegetation mapped as community 4a (Sandstone Riparian Scrub).

4.3.2.1 Riparian Vegetation Monitoring

The riparian vegetation monitoring program includes visual, quadrat/transect and indicator species monitoring of riparian vegetation on the Waratah Rivulet and Eastern Tributary, as described below.

The riparian vegetation monitoring program was designed to comprehensively assess potential vegetation changes at three scales; overall gross changes across the observed streamside section, changes at the community level and changes at the level of individual plants. Visual inspections aim to appraise the overall condition of the riparian zone and to detect any localised changes, described below, that may not be detected by detailed transect, quadrat and individual plant monitoring. The visual inspections provide qualitative information that may lead to further investigation and/or actions.



MET-15-10_301-303 EP BMP_203D

LEGEND

- Mining Lease Boundary
- Railway
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Existing Underground Access Drive (Main Drift)

Source: Land and Property Information (2015); Date of Aerial Photography 1998; Department of Industry (2015); Metropolitan Coal (2016); MSEC (2016); after NPWS (2003), Bangalay Botanical Surveys (2008) and Eco Logical Australia (2015; 2016)

Peabody

METROPOLITAN COAL

Mapped Vegetation Communities Within the Project Underground Mining Area and Surrounds

Figure 11

The fixed vegetation transects and associated quadrats aim to precisely measure changes in vegetation community composition over time, including a two year pre-mining baseline data period. The design allows statistical comparison of pre and post mining data.

Monitoring of individual plants provides species level data on the health and survival of individual within riparian zone species. Monitoring is targeted to specialist species that depend on the habitats of the riparian zone and may be prone to any mining-induced changes to stream geomorphology.

Visual Inspections

Visual inspections of riparian areas are conducted biannually in locations adjacent to riparian vegetation monitoring sites (sites MRIP01 to MRIP12) (Figure 12), and areas traversed whilst accessing the monitoring sites, 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.

Transect/Quadrat Monitoring

A permanent quadrat (20 m x 2 m) and permanent transect (50 m x 2 m, i.e. a 30 m extension of each quadrat) have been used to monitor riparian vegetation on the Waratah Rivulet and Eastern Tributary at (Figure 12)[10]:

- sites MRIP01, MRIP02, MRIP05 and MRIP06 overlying Longwalls 20-22;
- sites MRIP11 and MRIP12 overlying Longwalls 23-27; and
- sites MRIP03, MRIP04, MRIP07 and MRIP08 downstream of Longwalls 23-27[11].

The data collected for each quadrat includes:

- 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

  Modified Braun-Blanquet Scale

  1 = cover less than 5% of site and rare
  2 = cover less than 5% of site and uncommon
  3 = cover of less than 5% and common
  4 = cover of 5-20% of site
  5 = cover of 21-50% of site
  6 = cover of 51-75% of site
  7 = cover of greater than 75%

[10] Note that no quadrat or transect monitoring is conducted at sites MRIP09 and MRIP10. These sites were established for the purpose of visual inspections and indicator species monitoring only.

[11] Prior to the autumn 2017 vegetation monitoring survey, mine subsidence impacts to pool drainage behaviour were recorded by Metropolitan Coal at sites MRIP07 and MRIP08.

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

  Condition Scale

  1 severe damage/dieback
  2 many dead stems
  3 some dead branches
  4 minor damage
  5 healthy

The data collected along each transect includes the occurrence of weed species (species and location) and a condition/health rating for each plant along the transect.

Permanent photo points have been established for each quadrat and along each transect.

Baseline riparian transect/quadrat surveys were conducted biannually from spring 2008 to autumn 2010 at sites MRIP01 to MRIP08 and from spring 2010 to spring 2013 (i.e. prior to the commencement of Longwall 23) at sites MRIP11 and MRIP12.

Indicator Species

Three riparian vegetation indicator species have been monitored along Waratah Rivulet and the Eastern Tributary, namely, *Prostanthera linearis*, *Schoenus melanostachys* and *Lomatia myricoides*. Twenty tagged individuals of each species have been monitored at the following sites (Figure 12):

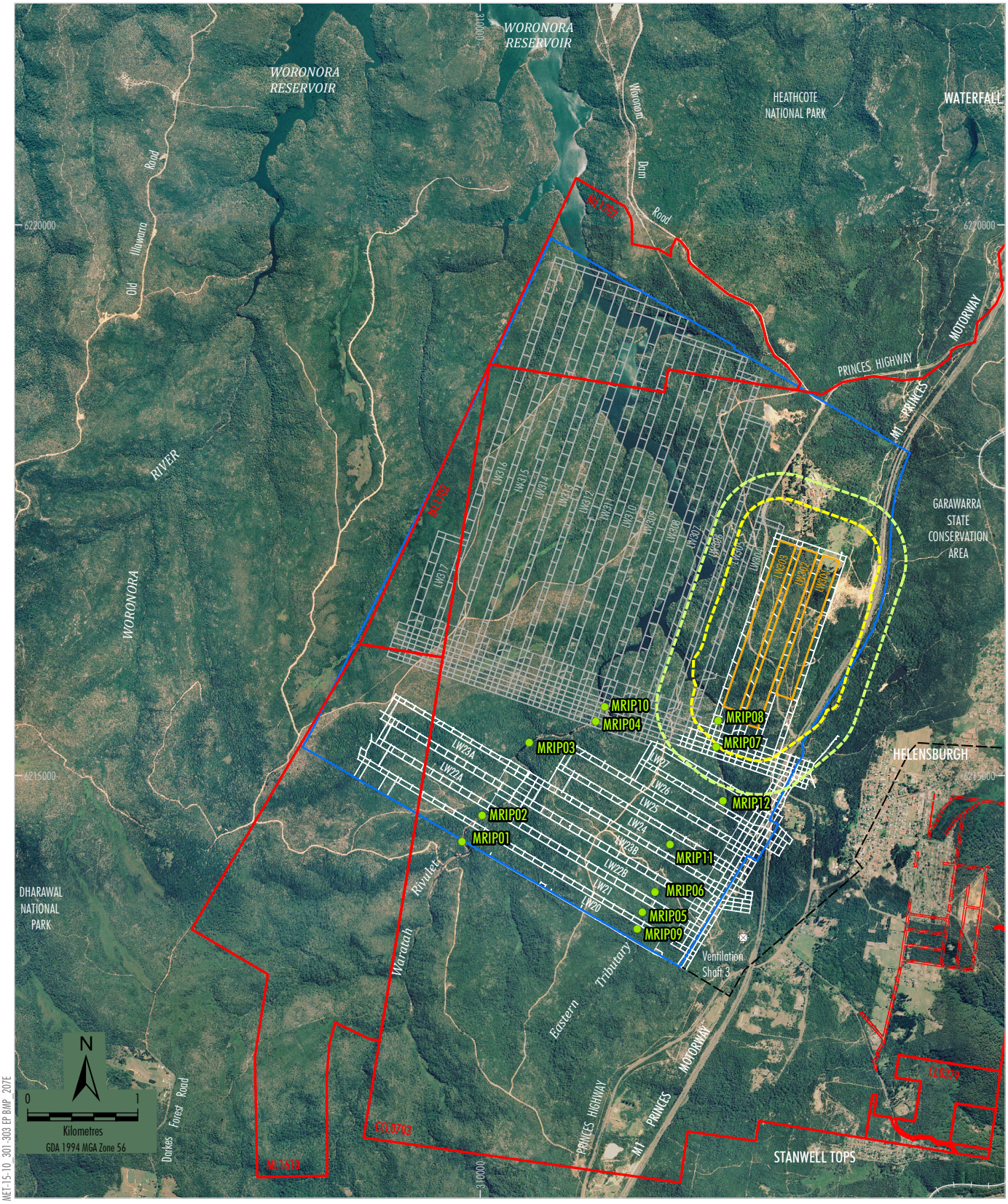
- sites MRIP01, MRIP02, MRIP05, MRIP06 and MRIP09 overlying Longwalls 20-22;
- sites MRIP11 and MRIP12 overlying Longwalls 23-27; and
- sites MRIP03, MRIP04, MRIP07, MRIP08[12] and MRIP10 downstream of Longwalls 23-27.

Population monitoring data collected includes a condition/health rating (1 - severe damage/dieback, 2 - many dead stems, 3 - some dead branches, 4 - minor damage, 5 – healthy) and a reproductive rating (1 – nil, 2 - sparse [occasional flowers only], 3 - low [under 25 percent of potential], 4 - moderate [25 to 75 percent], 5 - high [over 75 percent of potential flowering]) for each plant.

Surveys have been conducted bi-annually in autumn and spring.

Baseline indicator species monitoring was conducted in spring 2009 and autumn 2010 at sites MRIP01 to MRIP10 and from spring 2010 to spring 2013 (i.e. prior to the commencement of Longwall 23) at sites MRIP11 and MRIP12.

[12] Note: Twenty individuals of *Prostanthera linearis* were not available for tagging at site MRIP08.



MET-15-10_301-303 EP BMP_207E

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)

Monitoring Site

- Riparian Vegetation Monitoring Site

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

Peabody

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Riparian Vegetation Monitoring Locations

Figure 12

Monitoring Results to Date

The results of the riparian vegetation monitoring programs (up to and including the autumn 2017 survey) are summarised below.

Vegetation has generally been observed in good condition, with the exception of site MRIP02 on Waratah Rivulet and between sites MRIP05 and MRIP09 on the Eastern Tributary (Figure 12). Increased depth and breadth of ponding from subsidence at these sites has resulted in submersion of streamside vegetation causing vegetation dieback. Vegetation dieback was first observed at site MRIP02 in spring 2012 and between sites MRIP09 and MRIP05 in spring 2013.

The vegetation dieback at site MRIP02 on the Waratah Rivulet and between sites MRIP05 and MRIP09 on the Eastern Tributary (greater than 50 cm from the Waratah Rivulet/Eastern Tributary) continues to be monitored. It was considered that the most appropriate action was to continue monitoring to determine whether the vegetation recovers in these areas or whether management measures are required, consistent with management measures outlined in the Biodiversity Management Plans.

The amount of dieback has not changed at these sites over time (i.e. the same dead vegetation has been re-recorded on each survey visit and there has been no recovery). These results indicate the dieback has been a once only response to subsidence, resulting in both cases in submersion of a narrow strip of streamside vegetation. It is anticipated that a new stream bank will be established that will be colonised in due course with ecologically adapted vegetation.

Assessments against the biodiversity subsidence impact performance measure, *Negligible impact on threatened species and populations* by FloraSearch (2012-2013, 2014, 2015, 2016b), Cenwest Environmental Services (2012-2013, 2014b, 2015, 2016, 2017) and Eco Logical (2017) have been conducted for the riparian vegetation dieback at Site MRIP02, and between Sites MRIP05 and MRIP09, and concluded the subsidence impact performance measure had been met.

4.3.2.2 Assessment of Monitoring Results against Predicted Subsidence Impacts and Environmental Consequences

The key potential subsidence impacts and environmental consequences on streams described in the Project EA, Preferred Project Report and Metropolitan Coal Water Management Plans and Biodiversity Management Plans are described in Section 4.1.1.

The Project EA, Preferred Project Report and Metropolitan Coal Biodiversity Management Plans predicted potential impacts on riparian vegetation, primarily as a result of changes in stream water levels. As described above and in Section 4.1.1, increased ponding from changes in bed gradients has resulted in the prolonged inundation of the adjacent riparian vegetation which has resulted in vegetation dieback.

4.3.3 Aquatic Biota and their Habitats

4.3.3.1 Aquatic Ecology Monitoring

The richness and abundance of assemblages of fish recorded by the Project EA aquatic ecology surveys was low. Only two native species were recorded, *viz.* the Long-finned Eel (*Anguilla reinhardtii*) in the Waratah Rivulet and Woronora River, and Australian Smelt (*Retropinna semoni*) in the Woronora Reservoir. The introduced Mosquito Fish (*Gambusia holbrooki*) was recorded in the Woronora Reservoir, Waratah Rivulet and Woronora River.

No threatened fish have been recorded in the Woronora Reservoir, Waratah Rivulet or Woronora River and the dam wall of the Woronora Reservoir is likely to be a major barrier to migration of fish. Further to discussions with the Department of Primary Industries (DPI) – Fisheries during development of the Metropolitan Coal Longwalls 20-22 Biodiversity Management Plan, fish were not included in the aquatic ecology monitoring programs.

Metropolitan Coal has assessed subsidence impacts and environmental consequences on aquatic habitats in accordance with the Metropolitan Coal Water Management Plans (Section 4.1.1). Surface water monitoring includes monitoring of stream features, surface water flow, pool water levels, surface water quality, iron staining and gas releases. Observations of surface cracking, iron staining and gas releases are also made during the conduct of the aquatic ecology surveys.

The Longwalls 20-22 and Longwalls 23-27 aquatic ecology monitoring programs include the monitoring of aquatic habitat characteristics, water quality, macroinvertebrates and aquatic macrophytes. Consistent with the Project EA, the Longwalls 20-22 and Longwalls 23-27 aquatic ecology monitoring programs were designed to:

- monitor subsidence-induced impacts on aquatic ecology (stream monitoring); and
- monitor the response of aquatic ecosystems to the implementation of future potential stream remediation works (pool monitoring).

The design of the monitoring programs uses a “Beyond BACI” experimental design and focuses on representative sampling within streams and pools in mining areas and in suitable control streams and pools (i.e. not subject to mine subsidence).

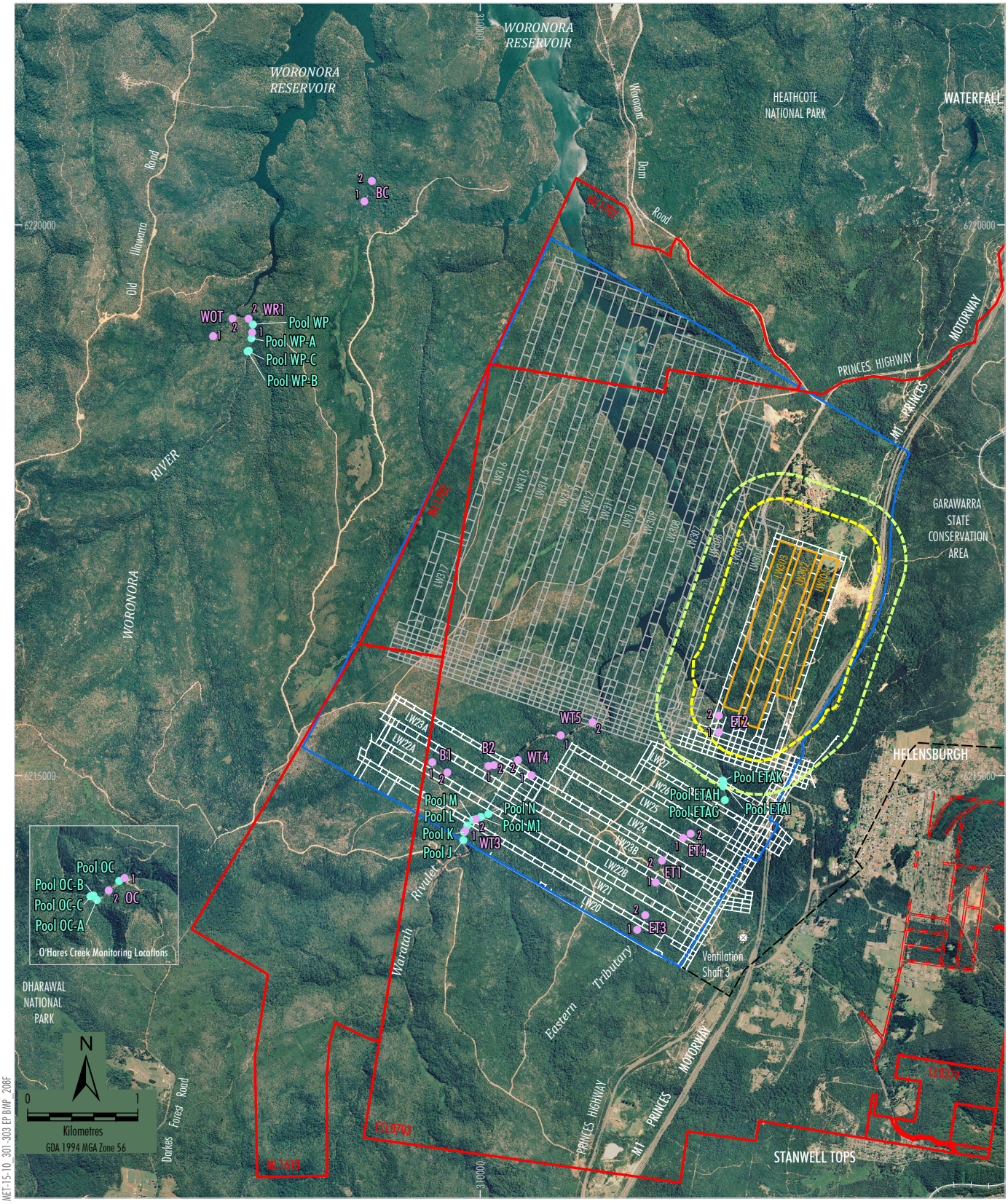
Stream Monitoring

Monitoring of aquatic biota has been conducted at two sampling sites (approximately 100 m long) at the following stream sampling locations (Figure 13):

- 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 and Location ET2 on the Eastern Tributary, 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.

The approximate locations of the sampling sites are shown on Figure 13.

Monitoring of the sampling sites has been 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.



MET-15-10_301-303 EP BMP_208F

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)

Monitoring

- Pool Aquatic Ecology Sampling Site
- Stream Aquatic Ecology Sampling Site

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

Peabody

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Aquatic Ecology Monitoring Locations

Figure 13

The monitoring parameters and methods are described in Table 4.

Table 4
Stream Monitoring Parameters and Methods

Monitoring Parameter	Monitoring Methods
• Habitat Characteristics	Information on stream characteristics is recorded at each site in accordance with the AUSRIVAS protocol (Turak *et al.*, 2004). Characteristics recorded include a visual assessment of stream width and depth, riparian conditions, signs of disturbance, water quality and percentage cover of the substratum by algae.
• Water Quality	A number of water quality variables are measured at each of the sampling sites prior to undertaking the biological sampling. Measurements of physico-chemical water quality will be determined using a submersible data logger. Water quality measurements include electrical conductivity (microSiemens per centimetre [µS/cm]), dissolved oxygen (% Saturation and milligrams per litre [mg/L]), pH, temperature (degrees Celsius [ºC]), turbidity (Neophlemetric Turbidity Units [NTU]) and oxygen reduction potential (millivolts [mV]). Alkalinity is determined in the field using a total alkalinity field kit. The water quality measurements provide information relevant to water quality at the time of sampling.
• Aquatic Macroinvertebrates	Two methods are used to sample aquatic macroinvertebrates at each site: sampling using the AUSRIVAS protocol and quantitative sampling, as described below.
AUSRIVAS Sampling	To sample assemblages of macroinvertebrates in accordance with the AUSRIVAS protocol (Turak *et al.*, 2004), samples of stream edge habitats are collected using a 250 micrometre (µm) dip net. Edge habitat is defined as areas along stream banks with little or no flow, including alcoves and backwaters, with abundant leaf litter, fine sediment deposits, beds of macrophytes, overhanging banks and areas with trailing vegetation (Turak *et al.*, 2004). At each site (approximately 100 m long), samples are collected over a total length of 10 m, usually in 1 to 2 m sections, ensuring all significant edge sub-habitats within a site (i.e. macrophytes, over-hanging bank and vegetation, leaf-litter, pool rocks, logs) are included in the sample (Turak *et al.*, 2004). The contents of each net sample are placed into a white sorting tray and animals will be collected for a minimum period of 30 minutes. Thereafter, removals are carried out in 10 minute periods, up to a total of one hour (Turak *et al.*, 2004). If no new taxa are found within a 10 minute period, removals cease (Turak *et al.*, 2004). The animals collected are placed inside a labelled container and preserved with 70% alcohol. Samples are identified using a stereomicroscope. Taxa are identified to family level with the exception of Acarina (to order), Chironomidae (to sub-family), Nematoda (to phylum), Nemertea (to phylum), Oligochaeta (to class), Ostracoda (to subclass) and Polychaeta (to class). Some families of Anisoptera (dragonfly larvae) are identified to species, as they could potentially include threatened aquatic species.
Quantitative Sampling	Within each site, three replicate macroinvertebrate samples are collected using timed one minute sweeps of all habitats (edge, riffle, pools, etc.), using a 250 x 250 cm (250 µm) dip net. For each replicate sample, the contents of the net are placed into white plastic trays filled with fresh water and then placed into pre-labelled plastic sample containers filled with 70% alcohol. In the laboratory, animals are identified to family level with the exception of some families of Anisoptera (dragonfly larvae), which are identified to species, as they could potentially include threatened aquatic species.
• Aquatic Macrophytes	The distribution of submerged and emergent (occurring in-stream and in the riparian zone) macrophytes is estimated along each sampling location by assigning a cover class to each species. The cover classes are: (1) one plant or small patch (i.e. few), (2) not common, growing in a few places (i.e. scattered), and (3) widespread (i.e. common). Within each site, an assessment of the in-stream (i.e. submerged and emergent) aquatic vegetation is made by estimating the relative abundance (i.e. percentage cover) of aquatic macrophytes within five haphazardly placed 0.25 m^2 quadrats, using a stratified sampling technique.

Baseline aquatic ecology surveys of macroinvertebrates and macrophytes were conducted biannually from spring 2008 or spring 2009[13] to autumn 2010 for Longwalls 20-22 stream monitoring at Locations WT3, WT4 and WT5 on Waratah Rivulet, Locations ET1, ET2 and ET3 on the Eastern Tributary, Location B1 on Tributary B, Location WR1 on Woronora River, Location OC on O'Hares Creek, Location BC on Bee Creek and Location WOT on Woronora Tributary (Figure 13). Baseline surveys of macroinvertebrates and macrophytes were conducted prior to the commencement of Longwall 23 (biannually from spring 2009 to spring 2013) for the additional Longwalls 23-27 stream monitoring sites at Location ET4 on the Eastern Tributary and Location B2 on Tributary B (Figure 13).

Pool Monitoring

A number of pools are monitored to assess the response of aquatic ecosystems to the implementation of potential future stream remediation works, namely (Figure 13):

- 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.
- 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 is conducted biannually in spring (15 September to 15 December) and autumn (15 March to 15 June).

Sampling is conducted at two random sites within the larger pools and at one site within the smaller pools. Within each site in each pool, aquatic macroinvertebrates and macrophytes are sampled using the same quantitative techniques described in Table 4 for stream monitoring. Quantitative estimates of aquatic macrophytes (i.e. emergent, floating attached and/or submerged species of aquatic plants) are collected at one site at each small pool and at two sites at each large pool. In addition, the spatial distribution of floating attached and/or submerged macrophytes (i.e. *Myriophyllum penduculatum* and *Triglochin procerum*) are also mapped in each pool on each sampling occasion to provide a visual comparison of their distribution through time. AUSRIVAS sampling techniques is not used for pool monitoring.

Baseline aquatic ecology surveys of macroinvertebrates and macrophytes were conducted biannually from spring 2008 or spring 2009[14] to autumn 2010 for Longwalls 20-22 pool monitoring at Pools J, K, L, M, M1 and N on Waratah Rivulet, Pools WP, WP-A, WP-B and WP-C on the Woronora River and Pools OC, OC-A, OC-B and OC-C on O'Hares Creek (Figure 13). Baseline surveys were also conducted prior to the commencement of Longwall 23 (biannually from spring 2009 to spring 2013) for Longwalls 23-27 pool monitoring at Pools ETAG, ETAH, ETAI and ETAK on the Eastern Tributary for comparison with Pools WP, WP-A, WP-B and WP-C on the Woronora River and Pools OC, OC-A, OC-B and OC-C on O'Hares Creek (Figure 13).

[13] The sampling of Location ET3 on the Eastern Tributary commenced in spring 2009.

[14] The sampling of larger pools N on Waratah Rivulet, WP on Woronora River and OC on O'Hares Creek commenced in spring 2008. The sampling of larger pools J and M1 on Waratah Rivulet, and smaller pools K, L and M on Waratah Rivulet, WP-A to WP-C on Woronora River and OC-A to OC-C on O'Hares Creek commenced in spring 2009.

Monitoring Results to Date

The results of the Longwalls 20-22 and Longwalls 23-27 aquatic ecology monitoring programs (up to and including the autumn 2017 survey) are summarised below.

Multivariate and univariate statistical procedures (Permutational Multivariate Analyses of Variance [PERMANOVA] and Plymouth Routines in Multivariate Ecological research [PRIMER] software packages) are used to examine temporal and spatial patterns in macroinvertebrates and macrophytes sampled within the study area. Specifically, PERMANOVA's are used to test hypotheses related to differential changes (e.g. before vs after commencement of mining) in multivariate and univariate (e.g. total number of taxa, total abundance and abundances of the most important taxonomic groups identified from the samples) estimates occurring in streams or pools subject to mining (i.e. potential 'impact' streams) in comparison to independent streams or pools that are not subject to mine subsidence (i.e. control places).

Multivariate statistical techniques (Bray Curtis dissimilarities) are also used to examine patterns in assemblages of macroinvertebrates and macrophytes among locations or pools. Multivariate methods allow comparisons of two (or more) samples based on the degree to which these samples share particular species, at comparable levels of abundance (Clarke and Warwick, 1994). Principal Coordinates Analyses are used to present a graphical representation of relationships among samples. Similarity of percentages (SIMPER) are used to determine those taxa primarily responsible for the observed similarities (or dissimilarities) (Clarke, 1993).

Stream Monitoring

As indicated in Section 4.1.1, Metropolitan Coal reported the exceedance of the Eastern Tributary watercourse performance measure in relation to iron staining to the DP&E and other relevant agencies in October 2016 and exceedance of the performance measure in relation to the natural drainage behaviour of pools in February 2017.

Multivariate analyses (PERMANOVA) of the Longwalls 20-22 and Longwalls 23-27 stream monitoring data compared before versus after mining indicates that any effect of longwall mining on assemblages of aquatic macroinvertebrates at Locations ET1[15], ET2, ET3 and ET4 on the Eastern Tributary and at Locations WT3, WT4 and WT5 on the Waratah Rivulet to date (to autumn 2017) are within the range of natural variability in these assemblages as measured by the control locations.

Multivariate and univariate analyses of monitoring data before versus after commencement of mining (of Longwall 20 and Longwall 23[16]) indicates that any effect of longwall mining on assemblages of aquatic macrophytes at Locations ET1, ET2, ET3 and ET4 on the Eastern Tributary and Locations WT3[17], WT4 and WT5 on the Waratah Rivulet are within the range of natural variability in these assemblages in relation to the control locations.

A considerable drop in water level was noted in a large pool at Location B1 in spring 2012. By autumn 2013, the pool had almost completely emptied and there was no surface flow along the study reach due to subsidence associated with mining of the Longwalls 20-22 underground mining area. Quantitative sampling of aquatic macroinvertebrates has not been carried out at Location B1 on Tributary B in spring 2013, or from spring 2014 to autumn 2017 due to insufficient habitat available for sampling.

[15] Since sampling commenced, multivariate analyses have detected a significant before to after change in the structure of the assemblage of aquatic macroinvertebrates at Location ET1 in spring 2016 (Longwalls 23-27 program only), but not in autumn 2017.

[16] Univariate analyses for Longwalls 23-27 have found significant differences in some parameters in particular surveys, however the same statistical difference has not been found by the longer running Longwalls 20-22 program.

[17] Univariate analyses for spring 2016 detected a significant increase in mean diversity at Location WT3 in relation to the control locations, however no significant changes were detected by the autumn 2017 survey.

The structure of assemblages of aquatic macroinvertebrates at Location B2 on Tributary B have differed significantly from before-to-after the commencement of Longwalls 23-27 in comparison to the control locations from autumn 2014 to autumn 2017. However, there were no differences in aquatic macrophytes at Location B2 on Tributary B related to the commencement of mining of Longwalls 23-27.

The aquatic ecology subsidence impact performance indicator: *The aquatic macroinvertebrate and macrophyte assemblages in streams are not expected to experience long-term impacts as a result of mine subsidence* has been exceeded at Location B1 since the autumn 2016 survey and at Location B2 on Tributary B since the spring 2016 survey.

Assessments have been made against the biodiversity subsidence impact performance measure, *Negligible impact on threatened species, populations, or ecological communities.* The assessment against the biodiversity performance measure has been conducted in relation to threatened terrestrial flora and fauna; there are no threatened aquatic fauna or flora known, or considered likely to occur. Assessments conducted by Eco Logical (2017) and Cenwest Environmental Services (2017) for threatened flora and threatened fauna, respectively, concluded that the subsidence impact performance measure has been met.

Pool Monitoring

Monitoring of large and small pools on Waratah Rivulet (large pools J, M1 and N; small pools K, L and M) and Eastern Tributary (large pool ETAH; small pools ETAG, ETAI and ETAK) (i.e. the pool monitoring) has been established to monitor the response of aquatic ecosystems to the implementation of future potential stream remediation works.

In December 2016 and January 2017 a number of pools on the Eastern Tributary downstream of the Longwall 26 maingate (including Pools ETAG, ETAH, ETAI and ETAK) experienced loss of pool water levels as a result of mine subsidence. This resulted in the negligible environmental consequences performance measure for the Eastern Tributary watercourse being exceeded in relation to the diversion of flows and drainage behaviour component. Stream remediation has been triggered for the Eastern Tributary. Water levels in Pool N fell below the cease to flow level in September 2012, however has overflowed its rock bar since December 2014 until the relatively short periods where it ceased to flow in January and February 2017.

4.3.3.2 Assessment of Monitoring Results against Predicted Subsidence Impacts and Environmental Consequences

The key potential subsidence impacts and environmental consequences for streams described in the Project EA, Preferred Project Report and Metropolitan Coal Biodiversity Management Plans are described in Section 4.1.1.

Potential environmental consequences include impacts on aquatic habitats (e.g. alteration of hydrology, pool habitat, in-stream connectivity and water quality), and on biodiversity (e.g. aquatic macrophytes, macroinvertebrates, fish and riparian vegetation).

In summary, the key potential environmental consequences described in the Project EA, Preferred Project Report, and Metropolitan Coal Biodiversity Management Plans include:

- Changes in stream flows as a result of fracturing of bedrock and the consequent diversion of a portion of the total stream flow as underflow. The effects of underflow would be most noticeable during periods of low flow and on the frequency of no flow, while the effects on the frequency and magnitude of high flows would be negligible.

- Changes in pool water levels and in-stream connectivity - underflow has been observed to result in lower water levels in pools as they become hydraulically connected with the fracture network. During prolonged dry periods when flows recede to low levels, the number of instances where loss of flow continuity between pools occurs increases with a greater proportion of these lower flows being conveyed entirely in the subsurface fracture network.
- Impacts on water quality following cracking of the stream bed that can reduce the quality of habitat for aquatic biota (e.g. generation of iron flocculent material).
- Minor stream bank erosion, where changes in channel gradients result in increases in flow energy.
- Impacts on aquatic macrophyte plants (e.g. as a result of changes in hydrology described above) resulting in exposure and desiccation or smothering of plants by iron flocculent material. Aquatic macrophytes have evolved reproductive strategies to cope with the variable nature of flow in streams and wetlands within Australia. Obligate water plants generally require permanent water, however they can recolonise once water becomes available again.
- Localised impacts on aquatic macroinvertebrates (as a result of the changes in aquatic habitat/hydrology described above). The Project is unlikely to have any significant long-term impacts on assemblages of macroinvertebrates.
- The conveyance of surface water flows to sub-surface fractures in the area affected by subsidence has the potential to reduce available habitat for fish (e.g. aquatic macrophytes, pools) and connectivity among sections of the stream channel, impeding fish passage.

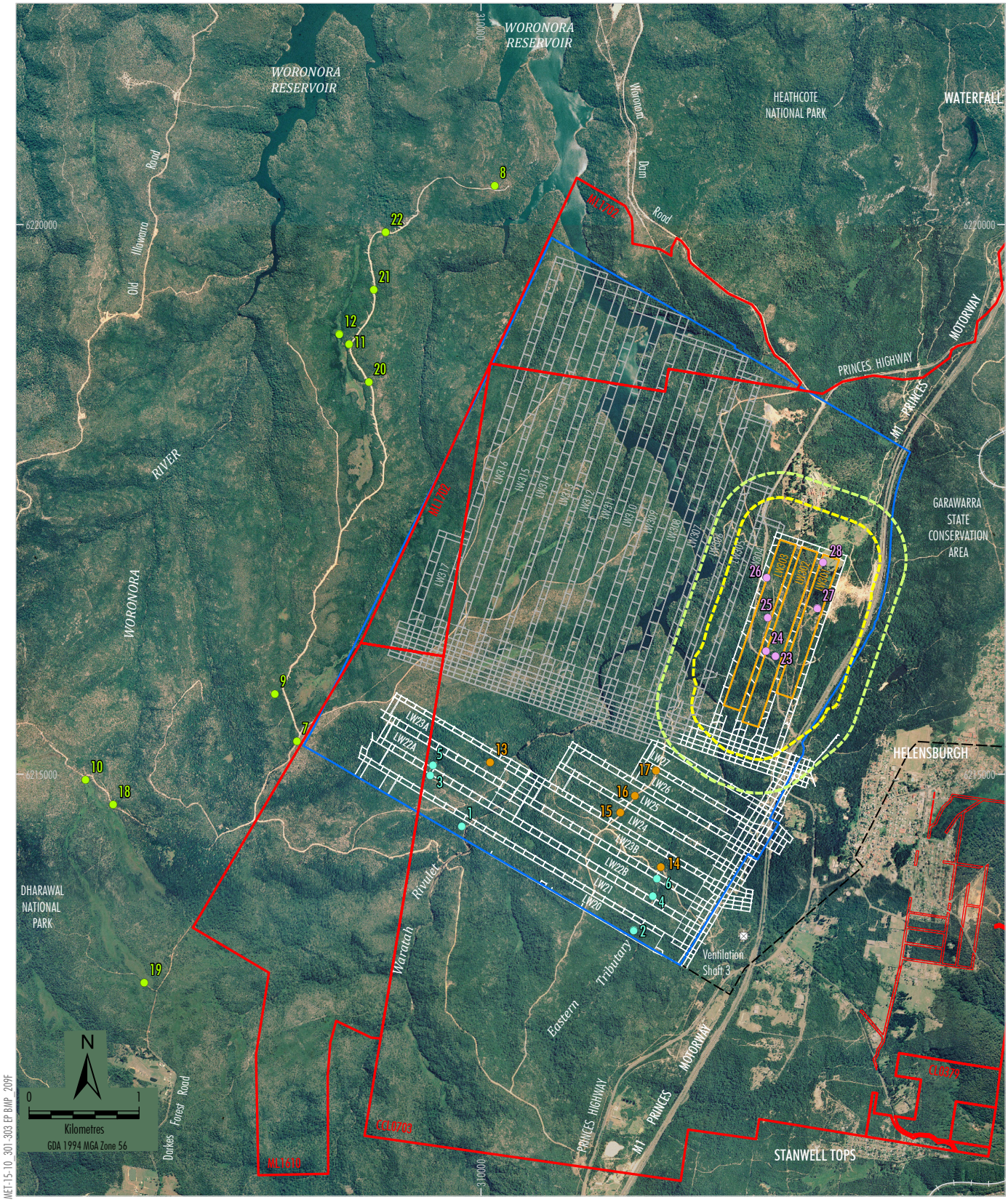
The results of aquatic ecology monitoring for Longwalls 20-22 and Longwalls 23-27 are considered to be consistent with the potential subsidence impacts and environmental consequences described in the Project EA, Preferred Project Report and the Metropolitan Coal Water Management Plans and Biodiversity Management Plans. However, subsidence impacts on Tributary B have resulted in no surface flow along the stream in the vicinity of Location B1 for an extended period of time. This change in aquatic habitat/hydrology has resulted in impacts to the aquatic macroinvertebrate assemblage at this location (Location B1) and downstream at Location B2. Assessments have been made against the biodiversity subsidence impact performance measure, *Negligible impact on threatened species, populations or ecological communities*, by Eco Logical (2017) and Cenwest Environmental Services (2017) and concluded the subsidence impact performance measure has been met.

4.3.4 Terrestrial Fauna and their Habitats

4.3.4.1 Amphibian Monitoring

Amphibian monitoring programs have been implemented annually in spring/summer for Longwalls 20-22 (2009 – 2016), Longwalls 23-27 (2010 – 2016) and Longwalls 301-303 (2015 - 2016). Fifteen amphibian species have been monitored including three threatened species: the Giant Burrowing Frog (*Heleiporus australiacus*), Red-crowned Toadlet (*Pseudophryne australis*) and Littlejohn's Tree Frog (*Litoria littlejohni*).

Six test sites overlying Longwalls 20-22 (sites 1-6), five test sites overlying Longwalls 23-27 (sites 13-17), six test sites overlying Longwalls 301-303 (sites 23-28) and eleven control sites (sites 7-12 and 18-22) are surveyed annually in spring/summer (i.e. October to February) during suitable weather conditions. The control sites for Longwalls 301-303 consist of the eleven existing sites associated with Longwalls 20-22 and Longwalls 23-27. The approximate locations of the monitoring sites are shown on Figure 14. Site selection was biased towards optimising the detection of the two threatened species.



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)

Monitoring Sites

- Longwalls 20-22 Amphibian Monitoring
- Longwalls 23-27 Amphibian Monitoring
- Longwalls 301-303 Amphibian Monitoring
- Control Site

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

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Amphibian Monitoring Locations

Figure 14

Each site is surveyed once during a standard one hour general area day search (early morning and late afternoon) supplemented by an evening 60 minute search/playback session using hand held spotlights and head lamps.

Species are assigned to the following relative abundance categories for tadpole and adult stages:

- 0 = no sightings;
- 1 = one sighting of adult or tadpole stage;
- UC = uncommon (i.e. 2 to 10 individuals), adult or tadpole stage;
- MC = moderately common (i.e. 11 to 20 individuals), adult or tadpole stage;
- C = common (i.e. 21 to 40 individuals), adult or tadpole stage; and
- A = abundant (>40 individuals), adult or tadpole stage.

Baseline monitoring was conducted in spring/summer 2009 and 2010 for Longwalls 20-22, in spring/summer 2010 to 2013 for Longwalls 23-27, and in spring/summer 2015 to 2016 for Longwalls 301-303.

The Littlejohn's Tree Frog was recorded for the first time during the spring/summer 2016 survey at site 24 during baseline monitoring for Longwalls 301-303. No evidence of breeding was observed for this species. Metropolitan Coal commissioned a targeted survey for the Littlejohn's Tree Frog to be carried out in August or September 2017 when adult calling was likely to be at its peak under wet conditions to determine the status of the species within the Project area. However, the dry weather conditions experienced in August and September 2017 did not provide suitable weather conditions for the conduct of the targeted survey. The survey was postponed until 2018, and the dry weather conditions to date have not allowed a 2018 survey to be conducted.

Subsidence impacts have been observed at a number of test sites including stream flow diversion to subterranean flows under low flow conditions, in-stream rock cracking, loss of pool numbers and/or persistence under low flow conditions, and iron staining/bacterial mats.

The data gathered since 2009 is non-normally distributed and characterised by significant occurrences of zero data. Such data require non-normal analysis to determine if potential adverse impacts are significant at the 95% confidence level. Poisson regression analysis has been used to analyse the amphibian survey results.

The performance indicator (null hypothesis) for the monitoring program is:

> *The amphibian assemblage is not expected to experience changes significantly different to the amphibian assemblage at control sites.*

To date (2009 – 2016), no adverse impact from mining can be detected for any frog species, including the Giant Burrowing Frog, Red-crowned Toadlet and Littlejohn's Tree Frog at the 95% confidence level. However, it cannot be discounted that a delayed adverse impact might be detected at some future date. Such potential future impacts might be due to either a lag phase in the expression of any potential impact or a more immediate future adverse impact.

4.3.4.2 Assessment of Monitoring Results against Predicted Subsidence Impacts and Environmental Consequences

A Poisson regression analysis has been used to analyse the amphibian survey results obtained to date (to spring/summer 2016). No adverse impact from mining has been detected for any frog species including the Giant Burrowing Frog and Red-crowned Toadlet, at the 95% confidence level. The monitoring results are consistent with the predictions described in the Project EA, Preferred Project Report, and Metropolitan Coal Biodiversity Management Plans, specifically, that it is unlikely that any vertebrate population would be put at risk by the Project.

4.3.5 Threatened Flora and Fauna

A number of threatened flora and fauna species listed under the NSW *Biodiversity Conservation Act, 2016* (BC Act) or Commonwealth *Environment Protection and Biodiversity Conservation Act, 1999* (EPBC Act) are known to occur, or have the potential to occur within the Project underground mining area or surrounds.

Figure 1-1 in Appendix 1 shows the location of threatened flora recorded by Bangalay Botanical Surveys (2008), FloraSearch (2008; 2009) and Eco Logical (2010 – 2015) in the Project underground mining area and surrounds. Figure 1-2 in Appendix 1 shows the location of threatened fauna recorded by Western Research Institute and Biosphere Environmental Consultants (2008) and Cenwest Environmental Services (2008 – 2017) in the Project underground mining area and surrounds. No threatened aquatic biota listed under the *Fisheries Management Act, 1994*, BC Act or EPBC Act has been recorded within the Project underground mining area or in the Woronora Reservoir.

In relation to threatened flora and fauna, the Project was considered unlikely to have a significant effect on threatened flora or fauna (Appendix G of the Project EA). No endangered flora or fauna populations that were listed under the BC Act at the time of Project Approval occur within the Project underground mining area or surrounds. Endangered Ecological Communities (EECs) listed under the BC Act at the time of Project Approval and identified as occurring in the Project underground mining area or surrounds includes the Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion EEC (Map Unit 5a) and the O'Hares Creek Shale Forest EEC (Map Units 5b and 5r) (Figure 11).

Coastal Upland Swamp in the Sydney Basin Bioregion was listed as an EEC under the BC Act in March 2012 which post-dates the Project Approval. The predicted impacts to this community were assessed in the Project EA and subsequently approved by the Project Approval in 2009.

The research program, *Conservation of the Eastern Ground Parrot on the Woronora Plateau*, funded by Metropolitan Coal has been completed by the OEH. The research program involved a targeted survey for the Eastern Ground Parrot (*Pezoporus wallicus wallicus)* (classified as Vulnerable under the BC Act) and the establishment of a network of bio-acoustic monitoring stations (35 sites) in 2013. A total of 588 days and approximately 3,000 hours of data were recorded from the stations, however, no Eastern Ground Parrots were detected. Spot checks of recordings from a range of sites, confirmed the recogniser was performing accurately (i.e. no Eastern Ground Parrot calls).

The results of the research program were considered by OEH to indicate that Eastern Ground Parrots are not likely to be resident on the Woronora Plateau. The occasional records of single parrots on the Woronora Plateau in the past ten years suggest isolated birds are dispersing through the area and are not part of a larger resident population[18].

[18] This description is based on OEH's reporting to Metropolitan Coal on the status of the research program for inclusion in the *Metropolitan Coal 2014 Annual Review and Annual Environmental Management Report/Rehabilitation Report* (Metropolitan Coal, 2015).

Assessments against the biodiversity subsidence impact performance measure, *Negligible impact on threatened species, populations or ecological communities*, to date indicate the performance measure has been met.

5 REVISED ASSESSMENT OF POTENTIAL ENVIRONMENTAL CONSEQUENCES

5.1 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 and 2. Longwall extraction will occur from north to south. The longwall layout includes 163 m panel widths (void) with 45 m pillars (solid).

The provisional extraction schedule for Longwalls 301-303 is provided in Table 5.

Table 5
Provisional Extraction Schedule

Longwall	Estimated Start Date	Estimated Duration	Estimated Completion Date
Longwall 301	28 June 2017	8 months	4 February 2018
Longwall 302	29 March 2018	8 months	October 2018
Longwall 303	November 2018	8 months	June 2019

Note the total cumulative predicted subsidence effects, subsidence impacts and/or environmental consequences at the completion of the Project are considered in the Project EA and Preferred Project Report, and the cumulative subsidence effects, subsidence impacts and environmental consequences will be assessed in future Extraction Plans.

5.2 ENVIRONMENTAL RISK ASSESSMENT

An Environmental Risk Assessment (ERA) was conducted for four of the key component plans of the Metropolitan Coal Longwalls 301-303 Extraction Plan[19] *viz.* Water Management Plan, Land Management Plan, Heritage Management Plan and this BMP to give appropriate consideration to risk assessment and risk management in accordance with the DP&E and DRE (2015) *Guidelines for the Preparation of Extraction Plans*.

The suitably qualified and experienced experts endorsed by the Secretary of the DP&E for the preparation of the Metropolitan Coal Longwalls 301-303 Extraction Plan participated in the ERA[20]. The ERA process involved the key steps described below.

[19] Individual risk assessments have been undertaken separately for the Metropolitan Coal Longwalls 301-303 Built Features Management Plan and the Metropolitan Coal Longwalls 301-303 Public Safety Management Plan, and are reported in their respective documents.

[20] Participants included Mr Peter DeBono (Mine Subsidence Engineering Consultants, Subsidence), Dr Noel Merrick (HydroSimulations, Groundwater), Mr Lindsay Gilbert (Hydro Engineering & Consulting, Surface Water), Dr David Goldney (Cenwest Environmental Services, Fauna), Dr Colin Bower (FloraSearch, Flora), Mr Jamie Reeves (Niche Environment and Heritage, Heritage), Mr Joshua Hunt (Resource Strategies, Land), Mr Jon Degotardi (Metropolitan Coal) and Mr Ryan Pascoe (Metropolitan Coal).

Review of Relevant Documentation

In preparation for the ERA workshop, the ERA participants reviewed a number of documents relevant to the risk assessment. This included (but was not limited to):

- The *Environmental Risk Analysis* (SP Solutions, 2008) conducted for the Project EA (Appendix O of the Project EA).
- The Preferred Project Report (HCPL, 2009). During the NSW Government's assessment phase of the Project EA, and in recognition of concerns raised by key stakeholders during the formal Planning Assessment Commission (PAC) assessment process, HCPL considered it appropriate to reduce the proposed extent of the original Project longwall mining area (i.e. Longwalls 20-44). This reduction in the extent of longwall mining resulted in a significant reduction to the extent of potential subsidence effects to the Waratah Rivulet and the Eastern Tributary and a reduction in the consequential potential environmental impacts.
- The revised subsidence predictions and assessments for the approved changes to the first workings layout for Longwalls 301-303 (Metropolitan Coal, 2016b).
  - Following further mine planning investigations, Metropolitan Coal identified that significant operational efficiencies and consequently a significant economic benefit would be achieved by rotating the first workings of Longwalls 301-317 to be square with the 300 Mains (a rotation of approximately six degrees). The Secretary of the DP&E approved the revised first workings in accordance with Condition 5, Schedule 3 of the Project Approval on 20 April 2015.
  - On 5 May 2016, Metropolitan Coal requested the approval of the Secretary of the DP&E to further amend the first workings layout for Longwalls 301-303. The proposed changes to the first workings layout for Longwalls 301-303 were as follows:
    - Longwall 301 – reduce the panel void length from 1,680 metres (m) to 1,428 m, with no change to the tailgate pillar dimensions.
    - Longwall 302 – reduce the panel void length from 2,637 m to 1,954 m, with a reduction in the tailgate pillar width by 25 m for approximately 608 m of the panel length.
    - Longwall 303 – reduce the panel void length from 2,760 m to 2,122 m, with a reduction in the tailgate pillar width by 25 m for approximately 728 m of the panel length.

  The changes to the first workings layout for Longwalls 301-303 described above were approved by the Secretary of the DP&E on 16 June 2016.[21]

Risk Identification

The participants were asked to identify any additional (specific) issues/risks and/or changes to previously assessed levels of risk in preparation for the ERA workshop.

[21] Note that subsequent to the completion of the Environmental Risk Assessment, Metropolitan Coal has made further revisions to the lengths of Longwalls -301-303. The updated longwall layout is shown on the BMP figures.

ERA Workshop

The ERA workshop for Longwalls 301-303 was conducted on 21 June 2016 via a teleconference. The ERA workshop was facilitated by an independent specialist, Operational Risk Mentoring.

While the general consensus of the workshop participants was the additional (specific) issues/risks were broadly assessed and ranked as part of the previous *Environmental Risk Analysis* (SP Solutions, 2008), it was considered necessary to assess some specific potential environmental issues (upland swamps and the Eastern Tributary) in further detail for Longwalls 301-303, considering experience to date from Longwalls 20-27 and other local mines. These were assessed using the same probability, consequence and risk rankings tables as used in the original *Environmental Risk Analysis* (SP Solutions, 2008). The re-assessed risk rankings for Longwalls 301-303 were within the "low" range and consequently the potential outcomes can still be integrated into the existing management systems for effective review and monitoring (Metropolitan Coal, 2016c).

ERA Report Review

All ERA participants were asked to review the draft report that was prepared to summarise the outcomes of the risk assessment workshop. Participants' comments were incorporated into the final Metropolitan Coal (2016c) report.

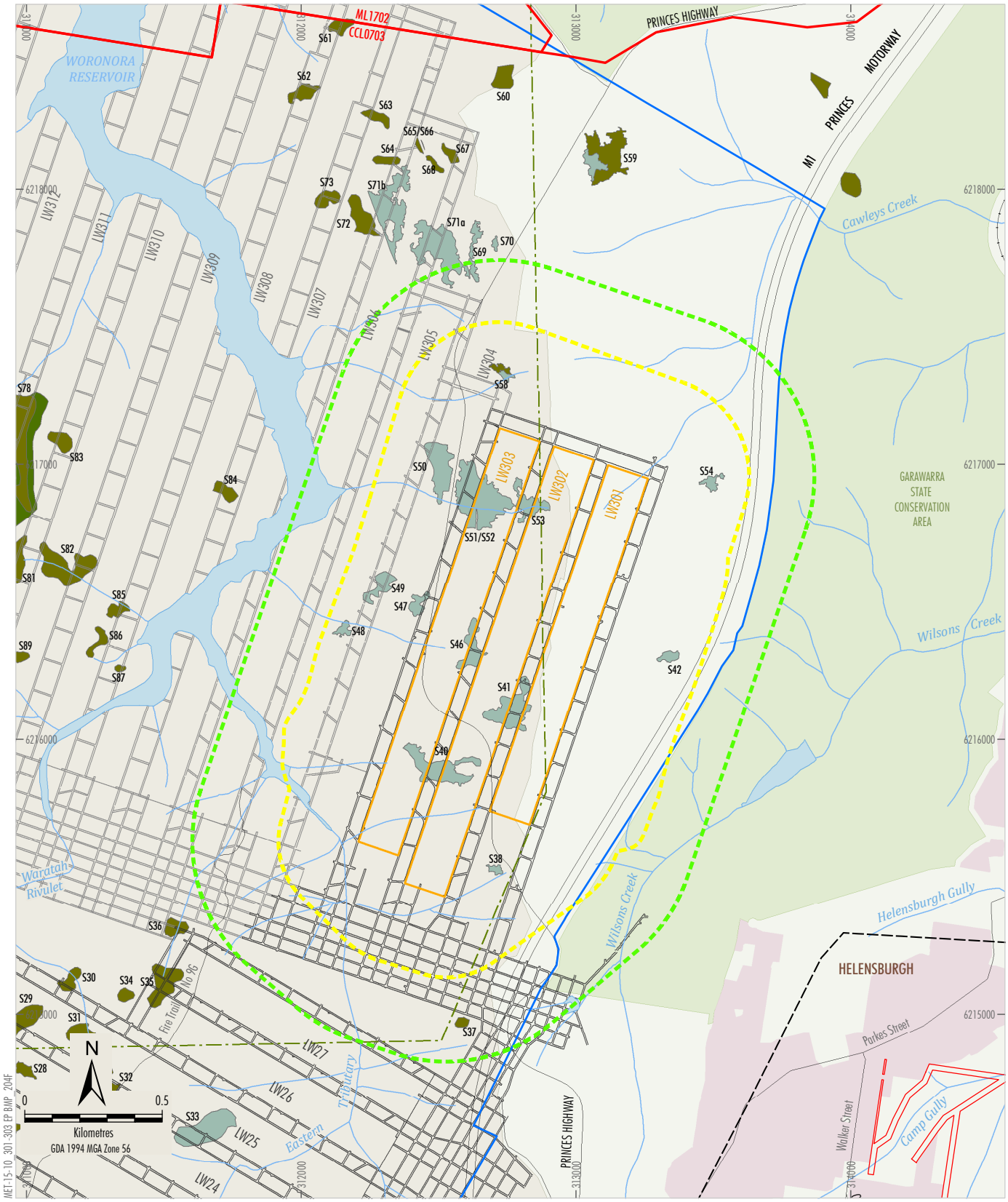
5.3 UPLAND SWAMPS

Upland swamp vegetation mapping by Eco Logical (2016) within 600 m of Longwalls 301-303 secondary extraction is shown on Figure 15. Fourteen upland swamps are located within the 35 degree (°) angle of draw and/or predicted 20 mm subsidence contour, namely, Swamps 38, 40, 41, 42, 46, 47, 48, 49, 50, 51/52, 53, 54 and 58 (Figure 15).

5.3.1 Revised Subsidence Predictions

The maximum predicted subsidence parameters for swamps located within the 35° angle of draw and/or predicted 20 mm subsidence contour have been prepared by MSEC (2018). Table 6 compares the revised subsidence predictions for the Longwalls 301-303 Extraction Plan layout with the subsidence predictions for the Preferred Project Layout at the completion of Longwall 303.

The predicted subsidence parameters for some swamps increase and for other swamps decrease as a result of shifts in locations of maxima and minima above each longwall from the change in longwall orientation. Increases in the predicted subsidence parameters in the south of the Longwalls 301-303 Extraction Plan layout also occur as a result of narrowing the pillar widths. While there is an increase in the predicted subsidence parameters for some swamps, the magnitudes of the maximum predicted subsidence parameters are similar to or less than the maxima predicted elsewhere above the approved Project underground mining area (MSEC, 2018).



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)

Map Unit	Vegetation Community
3a	Upland Swamp: Banksia Thicket
3b	Upland Swamps: Tea Tree Thicket
3c	Upland Swamp: Sedgeland-heath Complex
3d	Upland Swamp: Fringing Eucalypt Woodland

Source: Land and Property Information (2015); Department of Industry (2015); Metropolitan Coal (2018); MSEC (2018); after NPWS (2003), Bangalay Botanical Surveys (2008) and Eco Logical Australia (2015; 2016)

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Upland Swamps over Longwalls 301 - 303 and Surrounds

Figure 15

The maximum subsidence predictions for swamps for the Longwalls 301-303 Extraction Plan layout indicate (Tables 6 and 7):

- Maximum predicted average tilts[22] of 5 mm/m in Swamps 40 and 41 (the remaining 12 swamps have predicted tilts of 4 mm/m or less). A maximum predicted average tilt of 5 mm/m was also predicted for the Preferred Project Layout for Longwalls 301-303.
- Maximum predicted hogging curvature[23] for the 14 swamps ranges from <0.01 to 0.06 km^{-1} (corresponding conventional tensile strains range from <0.5 to 1.0 mm/m). A maximum predicted hogging curvature of 0.06 km^{-1} and maximum predicted conventional tensile strain of 1.0 mm/m were also predicted for the Preferred Project Layout for Longwalls 301-303.
- Maximum predicted sagging curvature[20] for the swamps ranges from <0.01 to 0.13 km^{-1} (corresponding conventional compressive strains range from <0.5 to 2.0 mm/m). A maximum predicted sagging curvature of 0.10 km^{-1} and maximum predicted conventional compressive strain of 1.50 mm/m were predicted for the Preferred Project Layout for Longwalls 301-303. The maximum predicted conventional compressive strains for 13 of the 14 swamps are less than 2 mm/m.
- A few swamps could experience valley closure[24] movements as a result of their position in the landscape (i.e. those near to drainage lines). Valley closure movements at all swamps are well below 200 mm, and the associated valley closure strains are all less than 7 mm/m.

5.3.2 Revised Assessment of Potential Subsidence Impacts and Environmental Consequences

The potential subsidence impacts and environmental consequences to upland swamps described in the Project EA and Preferred Project Report (as described in Section 4.1.2) have been reviewed in consideration of the information obtained since Project approval and the revised subsidence predictions. The predictions for the Longwalls 301-303 Extraction Plan layout do not change the subsidence impact assessment provided in the Project EA and Preferred Project Report for upland swamps[25].

22 Tilt is the change in the slope of the ground as a result of differential subsidence, and is calculated as the change in subsidence between two points divided by the distance between those points.

23 Curvature is the second derivative of subsidence, the rate of change of tilt and is calculated as the change in tilt between two adjacent sections of the tilt profile divided by average length of those sections.

24 Closure is the reduction in the horizontal distance between the valley sides.

25 The Independent Expert Scientific Committee's (IESC's) *Advice to decision maker on coal mining – Further advice on impacts to swamps* (24 July 2015) (IESC advice) contends that areas containing lineaments may experience greater than normal subsidence. HydroSimulations advises that the potential is highly unlikely for hydraulic connectivity via lineaments to impact adversely on upland swamps as a result of the mining of Longwalls 301-303.

Table 6
Revised Maximum Subsidence Predictions for Upland Swamps – Subsidence, Tilt and Curvature

Swamp[1]	Maximum Predicted											
	Subsidence[2] (mm)			Tilt[3] (mm/m)			Hogging Curvature[4] (km^{-1})			Sagging Curvature[4] (km^{-1})		
	PPL (LW301-317)[5]	PPL (LW301-303)[6]	Extraction Plan Layout (LW301-303)[7]	PPL (LW301-317)[5]	PPL (LW301-303)[6]	Extraction Plan Layout (LW301-303)[7]	PPL (LW301-317)[5]	PPL (LW301-303)[6]	Extraction Plan Layout (LW301-303)[7]	PPL (LW301-317)[5]	PPL (LW301-303)[6]	Extraction Plan Layout (LW301-303)[7]
S38	60	60	70	< 0.5	<0.5	0.5	< 0.01	<0.01	<0.01	< 0.01	<0.01	<0.01
S40	550	550	900	3.0	3.0	5.0	0.04	0.04	0.06	0.09	0.09	0.07
S41	825	800	900	5.0	5.0	5.0	0.04	0.04	0.03	0.10	0.10	0.13
S42	50	50	60	< 0.5	<0.5	<0.5	< 0.01	<0.01	<0.01	< 0.01	<0.01	<0.01
S46	775	725	850	2.5	2.5	3.0	0.06	0.06	0.05	0.07	0.07	0.05
S47	575	250	200	1.0	2.5	1.5	0.03	0.03	0.03	0.04	<0.01	<0.01
S48	500	50	40	0.5	<0.5	<0.5	0.03	<0.01	<0.01	0.03	<0.01	<0.01
S49	500	80	80	0.5	<0.5	<0.5	0.04	<0.01	<0.01	0.04	<0.01	<0.01
S50	550	100	125	1.0	0.5	1.0	0.04	<0.01	<0.01	0.04	<0.01	<0.01
S51	600	350	425	1.0	2.5	4.0	0.03	0.03	0.05	0.04	0.01	<0.01
S52	650	525	700	1.0	3.0	4.0	0.04	0.04	0.04	0.07	0.07	0.03
S53	750	700	800	1.5	2.5	3.0	0.06	0.06	0.05	0.07	0.07	0.05
S54	80	80	<20	< 0.5	<0.5	<0.5	< 0.01	<0.01	<0.01	< 0.01	<0.01	<0.01
S58	975	225	<20	2.0	2.0	<0.5	0.05	0.03	<0.01	0.05	<0.01	<0.01

Source: after MSEC (2018).

Swamps overlying Longwalls 301-303.

mm = millimetres; mm/m= millimetres per metre; km^{-1} =1/kilometres

1 Swamps within the Longwalls 301-303 35° angle of draw and/or predicted 20 mm subsidence contour.

2 Subsidence refers to vertical displacements of the ground.

3 Tilt is the change in the slope of the ground as a result of differential subsidence, and is calculated as the change in subsidence between two points divided by the distance between those points.

4 Curvature is the second derivative of subsidence, the rate of change of tilt and is calculated as the change in tilt between two adjacent sections of the tilt profile divided by average length of those sections.

5 PPL (LW301-317) – after completion of Longwall 317 of the Preferred Project Layout.

6 PPL (LW301-303) – after completion of Longwall 303 of the Preferred Project Layout.

7 Extraction Plan Layout (LW301-303) – after completion of Longwall 303 of the Extraction Plan Layout (i.e. Longwalls 301-303 subject of this BMP).

Table 7
Revised Maximum Subsidence Predictions for Upland Swamps – Tensile and Compressive Strain, Upsidence and Closure

Swamp[1]	Maximum Predicted											
	Conventional Tensile Strain[2] (mm/m)			Conventional Compressive Strain[2] (mm/m)			Upsidence[3] (mm)			Closure[4] (mm)		
	PPL (LW301-317)[5]	PPL (LW301-303)[6]	Extraction Plan Layout (LW301-303)[7]	PPL (LW301-317)[5]	PPL (LW301-303)[6]	Extraction Plan Layout (LW301-303)[7]	PPL (LW301-317)[5]	PPL (LW301-303)[6]	Extraction Plan Layout (LW301-303)[7]	PPL (LW301-317)[5]	PPL (LW301-303)[6]	Extraction Plan Layout (LW301-303)[7]
S38	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 20	< 20	20	< 20	< 20	< 20
S40	0.5	0.5	1.0	1.5	1.5	1.0	-	-	-	-	-	-
S41	0.5	0.5	0.5	1.5	1.5	2.0	-	-	-	-	-	-
S42	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	-	-	-	-	-	-
S46	1.0	1.0	1.0	1.0	1.0	1.0	-	-	-	-	-	-
S47	0.5	0.5	< 0.5	0.5	< 0.5	< 0.5	-	-	-	-	-	-
S48	< 0.5	< 0.5	< 0.5	0.5	< 0.5	< 0.5	-	-	-	-	-	-
S49	0.5	< 0.5	< 0.5	0.5	< 0.5	< 0.5	-	-	-	-	-	-
S50	0.5	< 0.5	< 0.5	0.5	< 0.5	< 0.5	-	-	-	-	-	-
S51	0.5	0.5	0.5	0.5	< 0.5	< 0.5	-	-	-	-	-	-
S52	0.5	0.5	0.5	1.0	1.0	< 0.5	80	50	50	40	30	30
S53	1.0	1.0	1.0	1.0	1.0	1.0	100	80	80	40	40	30
S54	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	-	-	-	-	-	-
S58	0.5	0.5	< 0.5	1.0	< 0.5	< 0.5	40	< 20	< 20	30	< 20	< 20

Source: after MSEC (2018).

Swamps overlying Longwalls 301-303.

mm = millimetres; mm/m= millimetres per metre; km^{-1} =1/kilometres

1 Swamps within the Longwalls 301-303 35° angle of draw and/or predicted 20 mm subsidence contour.

2 Conventional strain based on 15 times curvature. Strain is the relative differential horizontal movements of the ground. Tensile strains occur where the distance between two points increases and compressive strains occur when the distance between two points decreases.

3 Upsidence is the reduced subsidence, or the relative uplift within a valley which results from the dilation or buckling of near surface strata at or near the base of the valley.

4 Closure is the reduction in the horizontal distance between the valley sides.

5 PPL (LW301-317) – after completion of Longwall 317 of the Preferred Project Layout.

6 PPL (LW301-303) – after completion of Longwall 303 of the Preferred Project Layout.

7 Extraction Plan Layout (LW301-303) – after completion of Longwall 303 of the Extraction Plan Layout (i.e. Longwalls 301-303 subject of this BMP).

5.4 RIPARIAN ZONE AND AQUATIC BIOTA AND THEIR HABITATS

Riparian vegetation and habitats for aquatic biota occur along streams which flow to the Woronora Reservoir (including the Waratah Rivulet and Eastern Tributary), and some of their tributaries (Figures 1 and 2).

Vegetation mapping within 600 m of Longwalls 301-303 secondary extraction is shown on Figure 16. Riparian vegetation includes vegetation mapped as community 4a (Sandstone Riparian Scrub).

5.4.1 Revised Subsidence Predictions

The subsidence predictions for Longwalls 301-303 in relation to streams have been prepared by MSEC (2018).

Waratah Rivulet

The Waratah Rivulet is located approximately 1 km west of Longwall 303, at its closest point to Longwalls 301-303 secondary extraction (Figure 1). 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 (MSEC, 2018).

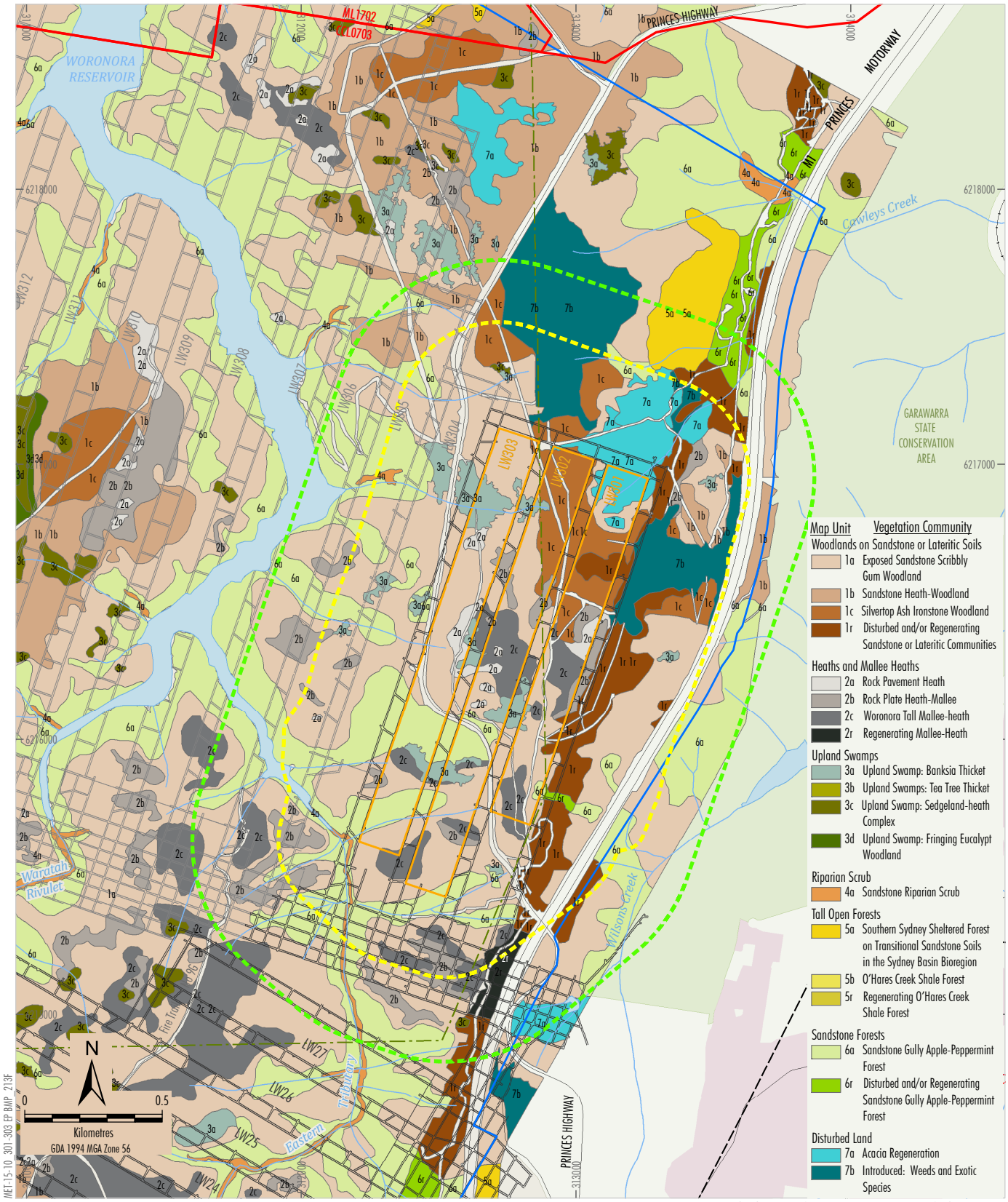
Eastern Tributary

The Eastern Tributary flows in a northerly direction into the Woronora Reservoir. Within the Longwalls 301-303 35° angle of draw and/or predicted 20 mm subsidence contour, the Eastern Tributary flows into the full supply level of the Woronora Reservoir (Figure 2). Longwalls 301-303 do not directly mine beneath the Eastern Tributary (Figure 2).

When the Woronora Reservoir is at full capacity water backs up and covers an area referred to as the inundation area. The inundation area includes parts of the Eastern Tributary in the 301 to 303 area. When the water level is below the full supply level, portions of the Eastern Tributary inundation area form temporary pools above exposed rock bars.

The maximum predicted values of total conventional subsidence, tilt, curvature, upsidence and closure[26] for the Eastern Tributary, resulting from the extraction of Longwalls 301-303, is provided in Table 8(MSEC, 2018).

[26] The valley closure modelling has been updated to reflect the shortening of Longwall 301 by 346 m (not previously reflected in the closure modelling) as described in the Subsidence Report (Appendix I of the Longwalls 301-303 Extraction Plan).



Source: Land and Property Information (2015); Department of Industry (2015); Metropolitan Coal (2018); MSEC (2018); after NPWS (2003), Bangalay Botanical Surveys (2008) and Eco Logical Australia (2015; 2016)

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)

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Longwalls 301 - 303
Vegetation Mapping

Figure 16

Table 8
Maximum Predicted Subsidence, Tilt, Curvature, Upsidence and Closure for the Eastern Tributary Resulting from Extraction of Longwalls 301, 302 and 303

Longwall	Maximum Predicted					
	Subsidence (mm)	Tilt (mm/m)	Hogging Curvature (km^{-1})	Sagging Curvature (km^{-1})	Upsidence (mm)	Closure (mm/m)
LW 301	<20	<0.5	<0.01	<0.01	30	50
LW 302	<20	<0.5	0.01	<0.01	40	60
LW 303	30	<0.5	0.01	<0.01	80	100

Source: after MSEC (2018).

mm = millimetres; mm/m= millimetres per metre; km^{-1} =1/kilometres

A comparison of the maximum predicted subsidence, upsidence and closure for the Eastern Tributary resulting from the Extraction Plan Layout of Longwalls 301-303, with those based on the Preferred Project Layout for Longwalls 301-303, is provided in Table 9. The revised maximum predicted subsidence, upsidence and closure for the Eastern Tributary, are less than the maxima for the Preferred Project Layout (MSEC, 2018). The maximum predicted total closure on the Eastern Tributary within the Longwalls 301-303 35° angle of draw and/or predicted 20 mm subsidence contour is 100 mm (Table 9).

Table 9
Comparison of Maximum Predicted Conventional Subsidence Parameters for the Eastern Tributary based on the Preferred Project Layout and the Extraction Plan Layout

Layout	Maximum Predicted Total Conventional		
	Subsidence (mm)	Upsidence (mm)	Closure (mm)
Preferred Project Layout (LW301-303)	200	175	150
Extraction Plan Layout	30	80	100

Source: after MSEC (2018)

mm = millimetres

The predicted profiles of subsidence, upsidence and closure along the Eastern Tributary, resulting from the extraction of Longwalls 301-303, are shown on Figure 17 (MSEC, 2018). Figure 17 indicates the maximum predicted total closure along the lower reach of the Eastern Tributary (i.e. outside of the 35° angle of draw and/or predicted 20 mm subsidence contour) is less than 200 mm.

Other Drainage Lines/Streams

Small first and second order streams are located within the Longwalls 301-303 35° angle of draw and/or predicted 20 mm subsidence contour (Figure 2). Many of the streams consist of shallow drainage lines from the topographical high point above Longwalls 301-303. Shallow drainage lines have small valley heights of generally less than 10 m and are predicted to experience small magnitudes of predicted upsidence and closure (MSEC, 2018). Valley heights increase at the lower reaches of these streams.

The stream with the largest valley height above Longwalls 301-303 is located near the southern end of Longwalls 302 and 303 (Figure 2). The stream has a maximum valley height of approximately 20 m and is predicted to experience maximum total closure of 120 mm.

There are two streams with slightly greater valley heights to the west of Longwalls 301-303, however since they are outside the longwall layouts, the predicted closure is lower.

5.4.2 Revised Assessment of Potential Subsidence Impacts and Environmental Consequences

The revised subsidence predictions for the Extraction Plan Layout do not change the subsidence impact assessment provided in the Project EA and Preferred Project Report for streams.

Fracturing could develop in the bedrock along the section of the Eastern Tributary located closest to the proposed longwalls (MSEC, 2018). Minor and isolated fracturing could occur up to approximately 400 m from the longwalls, as has been observed along other streams in the Southern Coalfield (*ibid*.). The sizes and extents of fracturing are expected to be considerably less than those observed along other streams that were located directly above the previously extracted longwalls.

The small first and second order streams located within the Longwalls 301-303 35° angle of draw and/or predicted 20 mm subsidence contour (Figure 2) could experience the full range of predicted subsidence movements.

The potential subsidence impacts and environmental consequences for these streams, based on the Extraction Plan Layout, are consistent with those assessed for the Preferred Project Layout that are described in Sections 4.1.1, 4.3.2 and 4.3.3.

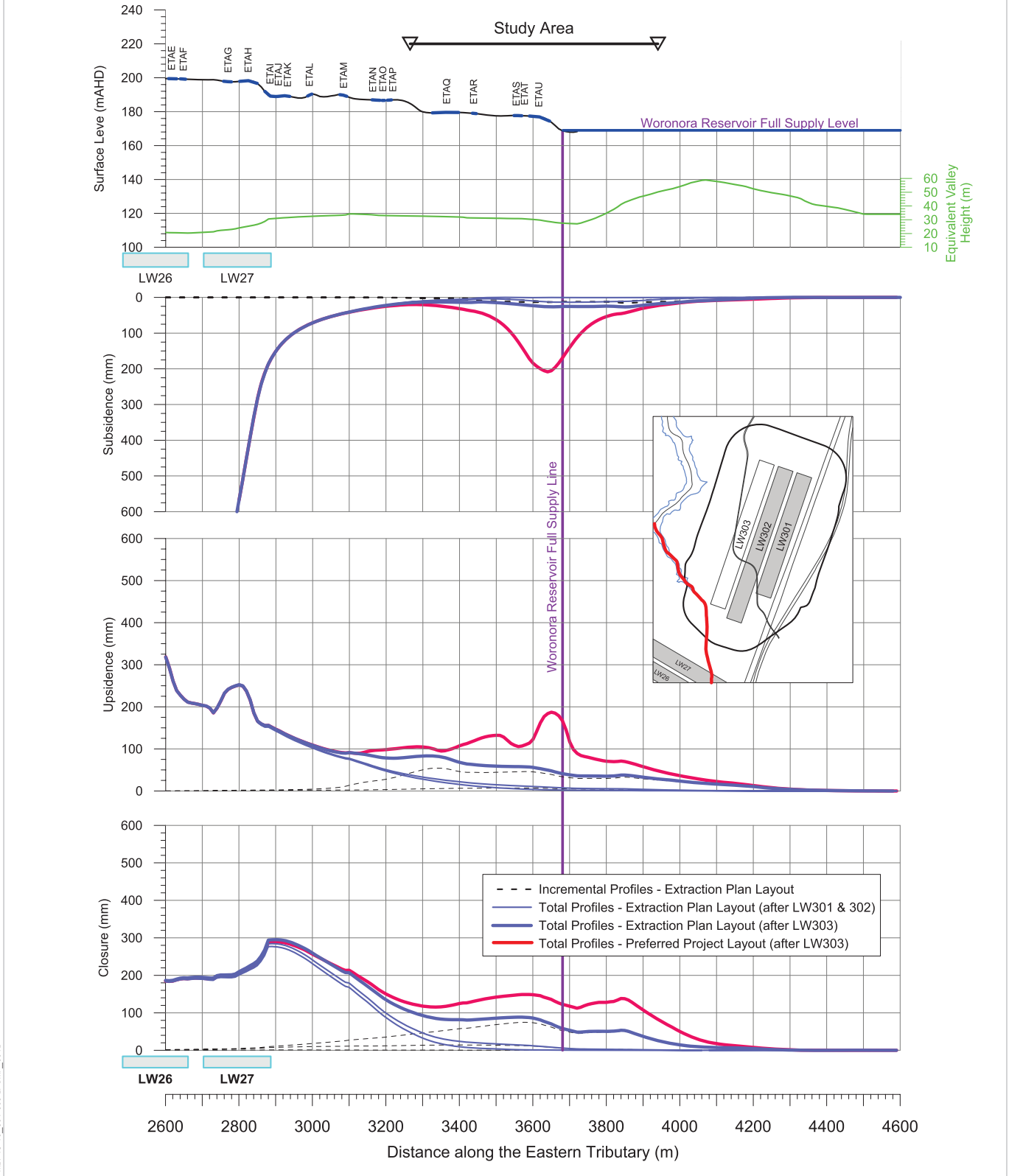
The maximum predicted total closure on the Eastern Tributary within the Longwalls 301-303 35° angle of draw and/or predicted 20 mm subsidence contour is 100 mm. The maximum predicted total closure on the lower reaches of the Eastern Tributary (i.e. outside of the 35° angle of draw and/or predicted 20 mm subsidence contour) as a result of the Extraction Plan Layout is less than 200 mm.

5.5 SLOPES AND RIDGETOPS

Vegetation communities mapped on slopes and ridgetops within 600 m of Longwalls 301-303 secondary extraction include woodlands on sandstone or lateritic soils (vegetation communities 1a, 1b 1c and 1r), heaths and mallee heaths (vegetation communities 2a, 2b, 2c and 2r), tall open forests (vegetation community 5a), sandstone forests (vegetation communities 6a and 6r) and disturbed land (vegetation community 7a and 7b) (Figure 16).

An occurrence of the Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion EEC listed under the BC Act is situated to the north of Longwall 301, outside of the Longwalls 301-303 35° angle of draw and/or predicted 20 mm subsidence contour (Figure 16).

Figure 10 shows the location of the cliffs and associated overhangs, steep slopes, and land in general that occur within 600 m of Longwalls 301-303 secondary extraction and wider Project underground mining area in accordance with the Metropolitan Coal Longwalls 301-303 Land Management Plan.



MET-15-10_301-303 EP BMP_004E

Source: MSEC (2018)

Peabody
METROPOLITAN COAL

Predicted Profiles of Subsidence, Upsidence and Closure along the Eastern Tributary and Woronora Reservoir due to Longwalls 301 - 303

Figure 17

5.5.1 Revised Subsidence Predictions

The subsidence predictions for slopes and ridgetops have been revised by MSEC (2018) for the Longwalls 301-303 Extraction Plan layout.

One cliff and overhang site (COH17) has been identified within 600 m of Longwalls 301-303 (Figure 10). The revised subsidence predictions for Longwalls 301-303 in relation to cliff sites within the 35° and/or predicted 20 mm subsidence contour (i.e. COH17) have been prepared by MSEC (2018). Table 10 compares the subsidence impacts for the Longwalls 301-303 Extraction Plan with the subsidence predictions for the Preferred Project Layout (at the completion of Longwall 303). As described 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.

The maximum predicted vertical subsidence and tilt for COH17 based on the Extraction Plan layout are less than the maxima predicted based on the Preferred Project Layout (Table 10). The maximum predicted curvature for COH17 based on the Extraction Plan layout are the same as the maxima predicted based on the Preferred Project Layout.

The next nearest cliff and overhang sites are located more than 800 m to the west of Longwalls 301-303 (Figure 10). At these distances, the cliffs are not expected to experience any measurable vertical subsidence resulting from the extraction of Longwalls 301-303. The predicted valley related movements in these locations are less than 20 mm upsidence and less than 20 mm closure. The strains due to these valley related effects are not expected to be measurable (MSEC, 2018).

Table 10
Revised Subsidence Predictions for Cliffs and Overhangs

Longwall	Maximum Predicted Conventional Subsidence for Cliff COH17			
	Subsidence[1] (mm)	**Tilt[2] (mm/m)**	**Hogging Curvature[3] (km^{-1})**	**Sagging Curvature[3] (km^{-1})**
Preferred Project Layout[4]	70	0.6	< 0.01	< 0.01
Longwalls 301-303 Extraction Plan Layout[5]	35	< 0.5	< 0.01	< 0.01

Source: after MSEC (2018).

1 Subsidence refers to vertical displacements of the ground.

2 Tilt is the change in the slope of the ground as a result of differential subsidence, and is calculated as the change in subsidence between two points divided by the distance between those points.

3 Curvature is the second derivative of subsidence, the rate of change of tilt, and is calculated as the change in tilt between two adjacent sections of the tilt profile divided by average length of those sections.

4 After completion of Longwall 303 of the Preferred Project Layout.

5 After completion of Longwall 303 of the Extraction Plan layout (Longwalls 301-303).

mm = millimetres

mm/m= millimetres per metre

km^{-1} =1/kilometres

The revised maximum predicted subsidence parameters for the steep slopes and land in general are similar to the maxima for the Preferred Project Layout (MSEC, 2018).

The reduction in the length of Longwalls 301-303 for the Extraction Plan layout results in a significant reduction in the predicted subsidence parameters associated with the occurrence of the Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion EEC. This vegetation community is situated to the north of Longwall 301. Predicted total subsidence for the Extraction Plan Layout is less than 20 mm, and predicted total tilt and curvature are less than 0.5 mm/m and 0.01 km^{-1} respectively (MSEC, 2018).

5.5.2 Revised Assessment of Potential Subsidence Impacts and Environmental Consequences

As described in Section 5.5.1, the maximum predicted vertical subsidence, tilt and curvatures for cliff COH17, based on the Extraction Plan layout, are less than or the same as the maxima predicted based on the Preferred Project Layout.

Cliff COH17 is located outside the extent of Longwalls 301-303 and the predicted subsidence parameters are small and much less than the maxima predicted for the cliffs located above the approved Longwalls 20-27. Although isolated rock falls have been observed over solid coal outside the extracted goaf areas of longwall mining in the Southern Coalfield, there have been no recorded cliff instabilities outside the extracted goaf areas of longwall mining in the Southern Coalfield. It is possible that isolated rock falls could occur as a result of the extraction of the proposed longwalls. It is not expected, however, that any large cliff instabilities would occur as a result of the extraction of the longwalls, as the longwalls are not proposed to be extracted directly beneath the cliff.

As described above, the next nearest cliffs are located approximately 800 m to the west of Longwalls 301-303 (Figure 10). At this distance, it is unlikely the cliffs would experience adverse impacts resulting from the extraction of Longwalls 301-303 (MSEC, 2018).

The potential impacts on steep slopes and land in general, for the Extraction Plan Layout, are the same as those assessed for the Preferred Project Layout, specifically, surface tension cracking of sandstone and rock falls, particularly where rock ledges are marginally stable.

The subsidence predictions and impact assessment for the Extraction Plan Layout do not change the assessment of environmental consequences on slope and ridgetop vegetation and terrestrial fauna habitats provided in the Project EA and Preferred Project Report:

- The magnitude of expected surface cracking is considered too small to influence the hydrological processes in the slope and ridgetop areas and is unlikely to have any biologically significant effect on the soil moisture regime that sustains the existing vegetation.
- Rock falls occur naturally in the slope and ridgetop areas, however subsidence has the potential to further reduce the stability of features and thereby increase the incidence of rock fall. Impacts to vegetation from rock falls are expected to be isolated and small. The potential impacts on terrestrial fauna are described in Section 5.6.
- Given the magnitude of predicted subsidence movements at the occurrence of the Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion EEC situated to the north of Longwall 301, it is unlikely that the EEC would be adversely affected by mine subsidence.

5.6 TERRESTRIAL FAUNA AND THEIR HABITATS

Terrestrial fauna habitats include the habitat types discussed in Section 5.3 (upland swamps), Section 5.4 (riparian zone and aquatic biota and their habitats) and Section 5.5 (slopes and ridgetops).

5.6.1 Revised Subsidence Predictions

The revised subsidence predictions for the Extraction Plan Layout for upland swamps, riparian vegetation and aquatic habitats, and slopes/ridgetops are discussed in Sections 5.3 to 5.5, respectively.

5.6.2 Revised Assessment of Potential Subsidence Impacts and Environmental Consequences

As described in Sections 5.3 to 5.5, the revised subsidence predictions for the Extraction Plan Layout for terrestrial fauna habitats (i.e. upland swamps, riparian vegetation and aquatic habitats, and slopes/ridgetops) do not change the subsidence impact assessment provided in the Project EA and Preferred Project Report.

Further, the subsidence impact assessment for the Extraction Plan Layout does not change the assessment of environmental consequences on terrestrial fauna and their habitats provided in the Project EA and Preferred Project Report. In summary, the key potential environmental consequences include:

- No change to the fundamental surface hydrological processes and upland swamp vegetation are expected within upland swamps. Given the above, it is unlikely that vertebrate fauna species or their habitats would be impacted and that any vertebrate population would be put at risk.
- Localised and limited impacts on riparian vegetation, which may reduce the habitat resources available to terrestrial fauna in the riparian zone. However, the nature of the impacts on riparian habitat is unlikely to significantly impact this habitat type or any terrestrial fauna species.
- The potential for surface cracking to form areas capable of 'trapping' some ground dwelling fauna (e.g. frogs and reptiles) in the same way that pitfall traps operate. The size and extent of surface cracking is expected to be minor. Any impacts on vertebrate fauna due to surface cracking are likely to be relatively minor and very unlikely to result in an impact that would threaten the viability of any vertebrate species population.
- The potential for a reduction in terrestrial fauna habitat resources (e.g. roost sites for bats, nest sites for birds, and shelter for reptiles and some amphibian species) as a result of rock falls, or the loss of individuals in a few cases, either by entrapment or direct fatal rock fall. It is predicted that the incidence of rock falls would be low.
- The potential for a reduction in water level in pools as they become hydraulically connected with the fracture network, reduced continuity of flow between affected pools during dry weather and changes in water quality leading to changes in fauna habitats.

6 PERFORMANCE MEASURES AND INDICATORS

The Project Approval requires Metropolitan Coal not to exceed the subsidence impact performance measures outlined in Table 1 of Condition 1, Schedule 3.

Two subsidence impact performance measures are specified in Table 1 of Condition 1, Schedule 3 in relation to biodiversity:

Table 1: Subsidence Impact Performance Measures

Biodiversity	
Threatened species, populations, or ecological communities	*Negligible impact*
Swamps 76, 77 and 92	*Set through condition 4 below*

In relation to the subsidence impact performance measure for Swamps 76, 77 and 92, these swamps will not be undermined by Longwalls 301-303. Swamps 76, 77 and 92 will be subject to assessment in future Extraction Plan(s) and revisions of this BMP.

In relation to the subsidence impact performance measure for threatened species, populations or ecological communities, *negligible* is defined in the Project Approval as *small and unimportant, such as to be not worth considering.*

Metropolitan Coal will also assess the Project against the following biodiversity performance indicators to monitor environmental performance consistent with the Trigger Action Response Plans (TARPs) detailed in Section 8.7:

The vegetation in upland swamps is not expected to experience changes significantly different to vegetation in control swamps.

Surface cracking within upland swamps resulting from mine subsidence is not expected to result in measurable changes to swamp groundwater levels when compared to control swamps or seasonal variations in water levels experienced by upland swamps prior to mining.

Impacts to riparian vegetation are expected to be localised and limited in extent, similar to the impacts previously experienced at Metropolitan Coal.

The aquatic macroinvertebrate and macrophyte assemblages in streams are not expected to experience long-term impacts as a result of mine subsidence.

The aquatic macroinvertebrate and macrophyte assemblages in pools are not expected to experience long-term impacts as a result of mine subsidence.

The amphibian assemblage is not expected to experience changes significantly different to the amphibian assemblage at control sites.

If data analysis indicates a biodiversity performance indicator has been exceeded, Metropolitan Coal will initiate an assessment against the performance measure and consider the need for management measures (Section 9).

Other subsidence impact performance measures (Table 1 of Condition 1, Schedule 3) of relevance to the BMP include:

Table 1: Subsidence Impact Performance Measures

Water Resources	
Catchment yield to the Woronora Reservoir	*Negligible reduction to the quality or quantity of water resources reaching the Woronora Reservoir* *No connective cracking between the surface and the mine*
Woronora Reservoir	*Negligible leakage from the Woronora Reservoir* *Negligible reduction in the water quality of Woronora Reservoir*
Watercourses	
Waratah Rivulet between the full supply level of the Woronora Reservoir and the maingate of Longwall 23 (upstream of Pool P)	*Negligible environmental consequences (that is, no diversion of flows, no change in the natural drainage behaviour of pools, minimal iron staining, and minimal gas releases)*
Eastern Tributary between the full supply level of the Woronora Reservoir and the maingate of Longwall 26	*Negligible environmental consequences over at least 70% of the stream length (that is no diversion of flows, no change in the natural drainage behaviour of pools, minimal iron staining and minimal gas releases)*
Land	
Cliffs	*Less than 3% of the total length of cliffs (and associated overhangs) within the mining area experience mining-induced rock fall*

Other performance indicators of relevance to the BMP include those detailed in the Metropolitan Coal Longwalls 301-303 Water Management Plan and Metropolitan Coal Longwalls 301-303 Land Management Plan.

If data analysis indicates a water resource, watercourse or land performance indicator has been exceeded, Metropolitan Coal will initiate an assessment against the relevant water resource, watercourse or land performance measure and consider the need for management measures. If a water resource, watercourse or land performance measure is considered to have been exceeded, the relevant Contingency Plan will be implemented and Metropolitan Coal will initiate an assessment against the biodiversity performance measure.

Section 8 describes the monitoring that will be conducted to assess the Project against the biodiversity performance indicators and subsidence impact performance measure for threatened species, populations and ecological communities. The monitoring program includes monitoring of:

- upland swamps (Sections 8.1 and 8.2);
- riparian vegetation (Section 8.3);
- slopes and ridgetops (Section 8.4);
- aquatic biota and their habitats (Section 8.5); and
- terrestrial fauna and their habitats (Section 8.6).

Section 8.7 provides the detailed TARPs to assess the biodiversity subsidence impact performance indicators and measures.

7 BASELINE DATA

In accordance with Condition 2, Schedule 7 of the Project Approval, this section outlines the biodiversity baseline information and data available for Longwalls 301-303.

The Longwalls 301-303 biodiversity monitoring program is described in Section 8.

7.1 UPLAND SWAMPS

7.1.1 Swamp Types

As described in Section 4.3.1, several types of upland swamps have been defined within the Metropolitan Coal Project underground mining area and surrounds according to the geomorphological settings in which they occur, namely, headwater swamps, valley side swamps and in-valley swamps.

Similar to the Longwalls 20-27 mining area, the terrain over Longwalls 301-303 is highly dissected with narrow ridges. All the swamps mapped in the Longwalls 301-303 mining area are valley side swamps (Figure 15).

7.1.2 Swamp Vegetation Mapping

Field inspections of upland swamp vegetation mapped by Bangalay Botanical Surveys (2008) proximal to[27] Longwalls 301-303 secondary extraction were conducted by Eco Logical in 2015 to confirm the upland swamp vegetation communities present and to check the swamp boundaries. For each upland swamp a description of the vegetation was recorded including the different strata present, the dominant species and an estimation of percent foliage cover for each stratum to assign vegetation communities described by NPWS (2003) and Bangalay Botanical Surveys (2008). Final delineation of vegetation community boundaries was undertaken by interpretation of recent aerial photographs. Patterns identified on aerial photographs were related to the field observations and used to delineate the boundaries of vegetation communities. The revision of the upland swamp vegetation mapping is detailed in Eco Logical (2016), which is provided in Appendix 2.

The revised upland swamp and associated vegetation community mapping by Eco Logical is shown on Figures 9 and 15. A total of 18 upland swamps are situated within 600 m of Longwalls 301-303, namely; 37, 38, 40, 41, 42, 46, 47, 48, 49, 50, 51/52, 53, 54, 58, 69, 70 and 71a. Of these swamps, 14 are located within the 35° angle of draw and/or predicted 20 mm subsidence contour (all except Swamps 37, 69, 70 and 71a). All upland swamps within 600 m of Longwalls 301-303 secondary extraction were classified as Banksia Thicket, except for Swamp 58, which was mapped as a combination of Sedgeland-heath Complex and Banksia Thicket (Figure 15 and Appendix 2).

7.1.3 Swamp Vegetation Data

Baseline upland swamp vegetation surveys for Longwalls 301-303 have been conducted in spring 2015, autumn 2016, spring 2016 and autumn 2017. The survey methods used for the Longwalls 301-303 baseline surveys (visual, transect/quadrat and indicator species monitoring) are consistent with those used for the Longwalls 20-22 and Longwalls 23-27 upland swamp vegetation monitoring programs.

[27] Note, subsequent to the completion of the Eco Logical (2016) report, Metropolitan Coal revised the layout of Longwalls 301-303. The updated longwall layout is shown on the BMP figures.

Baseline transect and quadrat data has been obtained for Swamps 40, 41, 46, 51/52 and 53 overlying Longwalls 301-303 and for control Swamps 101, 135, 136, 137a and 137b (Figures 9 and 15).

Baseline data for the indicator species *Epacris obtusifolia* has been obtained in Swamps 40, 51/52 and 53 overlying Longwalls 301-303 and in control Swamps 101, 136 and 137a. Baseline data for the indicator species *Sprengelia incarnata* has been obtained in Swamps 40, 51/52 and 53 overlying Longwalls 301-303 and in control Swamps 101, 136 and 137b.

The detailed baseline data are provided in Appendix 3[28].

7.1.4 Swamp Groundwater Data

The NSW Government's *Draft Policy Framework for Biodiversity Offsets for Upland Swamps and Associated Threatened Species* (May 2015) (Draft Upland Swamp Offsets Policy) and the Independent Expert Scientific Committee's (IESC's) *Advice to decision maker on coal mining – Further advice on impacts to swamps* (24 July 2015) (IESC advice) were reviewed and considered in detail in developing the Longwalls 301-303 groundwater monitoring program for the Metropolitan Coal Longwalls 301-303 Biodiversity Management Plan.

The Draft Upland Swamp Offsets Policy proposes shallow groundwater monitoring in every swamp within 400 m of longwall mining. The IESC's advice recommends that each swamp potentially impacted by mining have two transects of piezometers, installed perpendicular to each other, with a minimum of five piezometers along the two transects. Within the transects, the IESC advice also recommends a piezometer be installed at the deepest point in the swamp's sediments and not be placed such that they are all overlying pillars between longwalls. The IESC's advice also recommends at least three control swamps be matched with each potentially impacted swamp (individual sites may serve as controls for multiple potentially impacted swamps). To reduce baseline variance between control and impact locations, control sites need to be as similar as practicable to the impact sites in terms of vegetation, geomorphology and hydrology, and size.

Field inspections were conducted by Metropolitan Coal[29] to determine suitable locations for the installation of groundwater piezometers in upland swamps overlying and in the vicinity of Longwalls 301-303. The objective of the field inspections was to select piezometer locations consistent with the Draft Upland Swamp Offsets Policy and the IESC's advice.

Consistent with the Draft Upland Swamp Offsets Policy Metropolitan Coal proposed monitoring of each swamp within 400 m of Longwalls 301-303 with the exception of Swamps 42 and 54 on the basis of predicted subsidence (Figures 9 and 15, Tables 6 and 7).

Given the majority of the swamps are small in size and the vegetation disturbance that would be required for piezometer installation, the IESC recommendation of two transects was not considered necessary or appropriate to assess the impacts on swamp groundwater. That is, the majority of swamps were not considered large enough to support or warrant a transect of three plus bores within each individual swamp.

[28] Baseline data for upland swamps has been obtained up to, and including, autumn 2017 prior to the commencement of mining and is reported in Eco Logical (2018).

[29] The field inspection team included a hydrogeologist (HydroSimulations) and a botanist (Eco Logical Australia) to inform the positioning of the swamp piezometers.

Based on the results of the field inspections, a monitoring design was proposed which retained the same general principle of the Longwalls 20-27 monitoring design: that is, a piezometer in the swamp substrate be installed (to refusal) and one in the shallow groundwater (at a depth of 10 m). In consideration of the IESC's advice regarding the use of transects, monitoring locations that create larger transects which span multiple swamps, across multiple longwalls (from upgradient to downgradient) were proposed. The piezometers, where practicable, were also proposed to be positioned to avoid chain pillars. Where a terminal step occurs within a swamp (and where cracking of the terminal step has the potential to result in impacts to swamp substrate water levels), the paired piezometers are located close to the terminal step. Other factors which guided the proposed piezometer locations included the depth to sediment and proximity to existing access (where possible) in order to minimise disturbance.

In accordance with the Metropolitan Coal Construction Management Plan, Metropolitan Coal completed Surface Works Assessment Forms for the proposed installation of upland swamp piezometers in Swamps 38, 40, 41, 46, 47, 48, 49, 50, 51, 52, 53, 58, 69, 70 and 71a, which were submitted to WaterNSW and the DP&E. WaterNSW subsequently raised concerns regarding the amount of disturbance associated with the installation of the upland swamp piezometers. Following further consultation with WaterNSW and the DP&E, paired piezometers were proposed and approved to be installed in Swamps 40, 41, 46, 50, 51, 52, 53 and 71a on the basis of vegetation characteristics, landform features, swamp sediment profile and predicted subsidence. Piezometer sites 50, 51, 52 and 53 provide an extended transect which allows for monitoring of the Swamp 50 to 53 complex along the gradient and over consecutive longwalls. The locations of the groundwater piezometers are shown on Figure 9.

7.2 RIPARIAN VEGETATION

7.2.1 Riparian Vegetation Mapping

Field inspections of Sandstone Riparian Scrub vegetation mapped by Bangalay Botanical Surveys (2008) on a tributary of the Woronora Reservoir within 600 m of Longwalls 301-303 secondary extraction were conducted by Eco Logical in 2015. The area mapped by Bangalay Botanical Surveys (2008) as Sandstone Riparian Scrub was found to support Sandstone Gully Apple-Peppermint Forest in the eastern upper portion and Sandstone Riparian Scrub in the western lower portion. The revised vegetation community mapping of this riparian vegetation by Eco Logical is shown on Figure 16.

The area of Sandstone Riparian Scrub occurs along a steep and deeply incised drainage line with extensive stream boulders[30]. The vegetation of this area was consistent with the description of Sandstone Riparian Scrub by NPWS (2003) including the following features: a variable canopy commonly including overhanging *Angophora costata* and *Eucalyptus piperita;* a dense shrub layer commonly including *Ceratopetalum apetalum, Callicoma serratifolia, Lomatia myricoides* and *Tristania neriifolia;* and a ground layer dominated by mesic ferns such *as Sticherus flabellatus* var. *flabellatus* and *Gleichenia microphylla*. While the vegetation was closely aligned with the description of Sandstone Riparian Scrub by NPWS (2003), a number of abiotic features typical of the community (and observed along the Waratah Rivulet and Eastern Tributary) were absent including rock pools, rock platforms, sandy banks and sandy alluvial deposits.

[30] At the time of inspection by Eco Logical, standing water was largely absent from the drainage line. Due to the steep slope it is expected that standing water would generally be absent and only be present for a short period after rainfall events.

7.2.2 Riparian Vegetation Data

Visual, transect/quadrat and indicator species monitoring has been conducted of Eastern Tributary riparian vegetation for Longwalls 20-22 and Longwalls 23-27 as described in Section 4.3.2. Sites MRIP07 and MRIP08, are situated downstream of Longwalls 23-27 and within the 35° angle of draw and/or predicted 20 mm subsidence contour for Longwalls 301-303 (Figure 12).
No additional monitoring sites have been established in relation to Longwalls 301-303.

7.3 SLOPES AND RIDGETOPS

A cliff and overhang site (COH17) has recently been identified within 600 m of Longwalls 301-303 secondary extraction (Figure 10). In accordance with the Metropolitan Coal Longwalls 301-303 Land Management Plan, detailed baseline recording of this cliff and overhang site will be undertaken prior to the commencement of Longwall 303 extraction.

No surface tension cracks as a result of previous mining had been observed within the 35º angle of draw and/or predicted 20 mm subsidence contour of Longwalls 301-303 prior to the commencement of Longwall 301.

7.4 AQUATIC BIOTA AND THEIR HABITATS

The Eastern Tributary flows in a northerly direction into the Woronora Reservoir. Within the Longwalls 301-303 35° angle of draw and/or predicted 20 mm subsidence contour, the Eastern Tributary flows into the full supply level of the Woronora Reservoir (Figure 2). Longwalls 301-303 do not directly mine beneath the Eastern Tributary (Figure 2).

Prior to the commencement of Longwall 20 MSEC compiled a comprehensive survey and photographic record of the Eastern Tributary from the east-west headings to the Woronora Reservoir full supply level. The detailed mapping and photographic record of the Eastern Tributary is provided in the Metropolitan Coal Longwalls 301-303 Water Management Plan.

Baseline surface water data (e.g. surface water flow, pool water levels and water quality) are also available for the Eastern Tributary at the sites shown on Figures 6 and 7 and as described in the Metropolitan Coal Longwalls 301-303 Water Management Plan.

As described in Section 5.4.1, small first and second order streams are located within the Longwalls 301-303 35°angle of draw and/or predicted 20 mm subsidence contour (Figures 2 and 4). Many of the streams consist of shallow drainage lines from the topographical high point above Longwalls 301-303. Gilbert & Associates (now Hydro Engineering & Consulting) conducted a visual inspection and photographic survey of streams in the vicinity of[31] Longwalls 301-303 in July 2015. Hydro Engineering & Consulting's (2016) report is provided in Appendix 4.

Monitoring of macroinvertebrates and macrophytes has been conducted at sites on the Eastern Tributary for Longwalls 20-22 and Longwalls 23-27 as described in Section 4.3.3. Aquatic ecology monitoring Location ET2 is situated within the Longwalls 301-303 35° angle of draw and/or predicted 20 mm subsidence contour (Figure 13).

No additional monitoring sites have been established in relation to Longwalls 301-303.

[31] Note, subsequent to the completion of the Hydro Engineering & Consulting (2016b) report, Metropolitan Coal revised the layout of Longwalls 301-303. The updated longwall layout is shown on the BMP Figures.

7.5 TERRESTRIAL FAUNA AND THEIR HABITATS

Baseline data are available for terrestrial fauna habitats, i.e. upland swamps, riparian vegetation, slopes and ridgetops, and aquatic habitats, as described in Sections 7.1 to 7.4, respectively.

Amphibians were selected as the appropriate representative of terrestrial vertebrate fauna because they are widespread across the study area at the time of monitoring program design, included two threatened species that are sensitive to changes in surface hydrology, and because this group is represented by at least 14 species that appear to have viable populations. Baseline amphibian surveys for Longwalls 301-303 have been conducted in spring/summer 2015 and spring/summer 2016 at sites 23, 24, 25, 26, 27 and 28 shown on Figure 14. The baseline data are provided in Appendix 5.

8 MONITORING PROGRAM

Subsidence parameters will be measured in accordance with the Longwalls 301-303 Subsidence Monitoring Program (Figure 3). In summary, surveys will be conducted to measure subsidence movements in three dimensions using a total station survey instrument. Subsidence movements will be measured along subsidence lines that have been positioned across the general landscape.

A monitoring program will be implemented to monitor the impacts and environmental performance of the Project on aquatic and terrestrial flora and fauna during the mining of Longwalls 301-303. The monitoring program is described in Sections 8.1 to 8.6 and will be implemented at the commencement of Longwall 301 extraction. The monitoring program includes monitoring for Longwalls 301-303, as well as the post-mining monitoring to be implemented for Longwalls 20-22 and Longwalls 23-27. As described in Section 1.1, the Metropolitan Coal Longwalls 20-22 and Longwalls 23-27 Biodiversity Management Plans will be superseded by this document following the completion of Longwall 27 consistent with the recommended approach in the DP&E and DRE (2015) *Guidelines for the Preparation of Extraction Plans*.

Section 8.7 provides detailed TARPs to assess the biodiversity subsidence impact performance indicators and measures.

As described in Section 2, this BMP will be reviewed within three months of the submission of an Annual Review, and revised where appropriate, to the satisfaction of the Secretary of the DP&E.

8.1 UPLAND SWAMPS VEGETATION MONITORING

8.1.1 Longwalls 301-303 Upland Swamp Vegetation Monitoring

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. The rationale for the upland swamp vegetation monitoring methods is described in Section 4.3.1.4 and remains applicable to Longwalls 301-303.

Details of the Longwalls 301-303 vegetation monitoring are provided below.

Visual Inspections

Visual inspections will be conducted of Swamps 38, 40, 41, 46, 47, 48, 49, 50, 51/52, 53 and 58[32] and in control Swamps 101, 111a, 125, 135, 136, 137a, 137b and 138 (Figure 9 and Figure 15) to record evidence of potential subsidence impacts.

Traverses[33] 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).

Photographs of any cracking, erosion, water colour changes and stressed vegetation will be taken, concurrently with a description of the nature and extent of the observations, and appropriate global positioning system (GPS) readings. If changes in vegetation condition are observed in a swamp that are not similar to that in control swamp(s), the extent of change will be noted, and where practicable, mapped. Seepage will be documented by photographs of flow over exposed surfaces, e.g. terminal step.

The visual inspections will assess the changes in the observed physical condition of the swamps over time (Table 14 in Section 8.7).

Transect/Quadrat Monitoring

Upland swamp sites overlying Longwalls 301-303 were selected for transect/quadrat monitoring in consideration of the baseline characteristics described in Section 7.1 and Appendix 2. Transect and quadrat monitoring will be conducted in Swamps 40, 41, 46, 51/52 and 53[34] over Longwalls 301-303.

Similar to the valley side swamps over Longwalls 20-27, the swamps above Longwalls 301-303 tend to have their longest axis running horizontally along the contour perpendicular to the gradient and are often rather narrow. 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 line of each transect has been marked at regular intervals (flagging tape every 5 m, metal stakes approximately every 20 m) to ensure that the same line is used each time. Assessments will be made on 1 m^2 quadrats placed immediately adjacent to the transect line with one quadrat edge located on the line (southern side of transect line for Swamps 40, 46, 51/52 and 53 and eastern side for Swamp 41) every 5 m starting from 0 m. The transect length varies for each swamp, however the statistical analyses performed on the quadrat data do not require the transect lengths to be the same between swamps.

[32] This includes all swamps within the Longwalls 301-303 35° angle of draw and/or predicted 20 mm subsidence contour (Figure 15), with the exception of Swamp 42 and Swamp 54 which are predicted to experience minimal subsidence movements (MSEC, 2016).

[33] Many of the Longwalls 301-303 upland swamps comprise dense Banksia Thicket. It is anticipated that such traverses will be difficult to impractical at some locations.

[34] Portions of Swamp 46 and Swamp 51/52 were subject to WaterNSW hazard reduction burns in 2017. Specifically, Swamp 46 (Transect 1) and Swamp 51/52 (Transects 1 and 3) have been affected by the hazard reduction burns.

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

  Modified Braun-Blanquet Scale

  1 = cover less than 5% of site and rare
  2 = cover less than 5% of site and uncommon
  3 = cover of less than 5% and common
  4 = cover of 5-20% of site
  5 = cover of 21-50% of site
  6 = cover of 51-75% of site
  7 = cover of greater than 75%
- condition/health rating for each species in the quadrat:

  Condition Scale

  1 severe damage/dieback
  2 many dead stems
  3 some dead branches
  4 minor damage
  5 healthy

Permanent photo points have been established along each transect. 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. It is noted that some of these control swamps have previously been identified as supporting Sedgeland-heath Complex (Bangalay Botanical Surveys, 2008; Metropolitan Coal, 2014), however, the height and density of the shrub layer of these swamps (in particular *Banksia ericifolia* subsp*. ericifolia*) has increased with time since fire, and these control swamps now support vegetation comparable to Banksia Thicket as described in NPWS (2003) and Bangalay Botanical Surveys (2008) and similar to that observed in swamps overlying Longwalls 301-303 (Appendix 2)[35].

Table 14 in Section 8.7 details the analysis of the quadrat/transect data that will be conducted to assess the vegetation monitoring results against the upland swamp vegetation performance indicator, *The vegetation in upland swamps is not expected to experience changes significantly different to vegetation in control swamps*.

Indicator Species Monitoring

Consistent with the Longwalls 20-22 and Longwalls 23-27 upland swamp vegetation monitoring programs the indicator species for monitoring were *Epacris obtusifolia, Sprengelia incarnata* and *Pultenaea aristata.* However, insufficient individuals of *Pultenaea aristata* were available in the swamps over Longwalls 301-303 for monitoring. The swamps selected for the monitoring of *Epacris obtusifolia* and *Sprengelia incarnata* is based on the availability of the indicator species in the swamps as described in detail in Appendix 2.

[35] Swamp 46 and Swamps 51/52 over Longwalls 301-303 were subject to WaterNSW hazard reduction burns in 2017, resulting in vegetation along some transects in these swamps no longer being comparable to the control swamps.

Twenty tagged individuals[36] 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

  Condition Scale

  1 severe damage/dieback
  2 many dead stems
  3 some dead branches
  4 minor damage
  5 healthy

- reproductive rating:

  Reproductive Rating

  1 nil
  2 sparse (occasional flowers only)
  3 low (under 25 percent of potential)
  4 moderate (25 to 75 percent)
  5 high (over 75 percent of potential flowering)

Surveys will be conducted biannually in autumn and spring.

Table 14 in Section 8.7 details the analysis of the indicator species data that will be conducted to assess the vegetation monitoring results against the upland swamp vegetation performance indicator, *The vegetation in upland swamps is not expected to experience changes significantly different to vegetation in control swamps*.

8.1.2 Longwalls 20-22 and Longwalls 23-27 Upland Swamp Vegetation Monitoring

Visual Inspections

Visual inspections were previously conducted in Swamps 16, 17, 18, 19, 20, 23, 24, 25, 26, 27, 28, 30, 31, 32, 33, 34, 35, 36, 93, 94, 95, 96, 97 and 98 overlying or adjacent to Longwalls 20-27 when mining of Longwalls 20-22 and/or Longwalls 23-27 was within 400 m of the swamp and at the time of the vegetation surveys (i.e. biannually in autumn and spring) as described in Section 4.3.1.4. None of these swamps are located within 600 m of Longwalls 301-303 secondary extraction.

Visual inspections of Swamps 16, 17, 19, 20, 24, 25, 28, 30, 31, 32, 33, 34, 35, 36 and 94 during the extraction of Longwalls 301-303 will be conducted biannually. These swamps are also subject to biannual transect/quadrat and/or indicator species monitoring as described below.

[36] Individuals of indicator species being monitored within these control swamps for Longwalls 23-27 will not be used for Longwalls 301-303 as a proportion of these individuals within control swamps have already been recorded with severe dieback or are dead. Additional individuals have been tagged as a component of the monitoring program.

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 (Figure 9) for Longwalls 20-27. None of these swamps are located within 600 m of Longwalls 301-303 secondary extraction.

Table 14 in Section 8.7 details the analysis of the transect/quadrat data that will be conducted to assess the vegetation monitoring results against the upland swamp vegetation performance indicator, *The vegetation in upland swamps is not expected to experience changes significantly different to vegetation in control swamps,* consistent with the approved Longwalls 20-22 and Longwalls 23-27 vegetation monitoring programs.

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 (from autumn 2010) 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 Section 4.3.1.4.

Table 14 in Section 8.7 details the analysis of the indicator species data that will be conducted to assess the vegetation monitoring results against the upland swamp vegetation performance indicator, *The vegetation in upland swamps is not expected to experience changes significantly different to vegetation in control swamps*, consistent with the approved Longwalls 20-22 and Longwalls 23-27 vegetation monitoring programs.

8.2 UPLAND SWAMPS GROUNDWATER MONITORING

8.2.1 Longwalls 301-303 Upland Swamp Groundwater Monitoring

The approach taken to the development of the upland swamp groundwater monitoring program is described in Section 7.1.4 in relation to the collection of baseline data. 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 (Figure 9). Each piezometer has been equipped with a data logger for continuous water level monitoring.

Table 15 in Section 8.7 details the data analysis that will be conducted to assess the monitoring results against the upland swamp groundwater performance indicator, *Surface cracking within upland swamps resulting from mine subsidence is not expected to result in measurable changes to swamp groundwater levels when compared to control swamps or seasonal variations in water levels experienced by upland swamps prior to mining*, during the mining of Longwalls 301-303.

8.2.2 Longwalls 20-22 and Longwalls 23-27 Upland Swamp Groundwater Monitoring

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) (Figure 9) for Longwalls 20-27. None of these swamp groundwater monitoring sites are located within 600 m of Longwalls 301-303 secondary extraction. Swamp groundwater monitoring will continue to be conducted in the abovementioned swamps as described in Section 4.3.1.5.

Table 15 in Section 8.7 details the data analysis that will be conducted to assess the monitoring results against the upland swamp groundwater performance indicator, *Surface cracking within upland swamps resulting from mine subsidence is not expected to result in measurable changes to swamp groundwater levels when compared to control swamps or seasonal variations in water levels experienced by upland swamps prior to mining*, consistent with the approved Longwalls 20-22 and Longwalls 23-27 vegetation monitoring programs.

8.3 RIPARIAN VEGETATION

8.3.1 Longwalls 301-303 Riparian Vegetation Monitoring

As indicated in Section 7.2.2, no additional riparian vegetation monitoring sites have been established for Longwalls 301-303. Existing sites MRIP07 and MRIP08 on the Eastern Tributary are situated downstream of Longwalls 23-27 and within the 35° angle of draw and/or predicted 20 mm subsidence contour for Longwalls 301-303 (Figure 12). Monitoring of sites MRIP07 and MRIP08 will continue to be conducted during the mining of Longwalls 301-303 as described in Section 8.3.2 below.

8.3.2 Longwalls 20-22 and Longwalls 23-27 Riparian Vegetation Monitoring

Riparian areas along Waratah Rivulet and the Eastern Tributary will continue to be monitored at sites MRIP01 to MRIP12[37] for Longwalls 20-22 and/or Longwalls 23-27 (Figure 12). Sites MRIP01, MRIP02, MRIP05, MRIP06 and MRIP09 are situated over Longwalls 20-22 and sites MRIP11 and MRIP12 are situated over Longwalls 23-27. Sites MRIP03, MRIP04 and MRIP10 are situated downstream of Longwall 23A on the Waratah Rivulet. Sites MRIP07 and MRIP08 are situated on the Eastern Tributary downstream of Longwalls 23-27 and within the 35° angle of draw and/or predicted 20 mm subsidence contour for 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 mining 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.

Photographs of any new water ponding, cracking/rock displacement and stressed vegetation will be taken, concurrently with a description of the nature and extent of the observations, and appropriate GPS readings. Flora species that have been subject to vegetation dieback will be noted. The visual inspections will be conducted biannually in autumn and spring.

The visual inspections will assess the changes in the observed physical condition of the riparian zone over time (Table 16 in Section 8.7).

Quadrat Monitoring

The existing permanent quadrat (20 m x 2 m) will continue to be used to monitor riparian vegetation at (Figure 12):

- sites MRIP01, MRIP02, MRIP05 and MRIP06 overlying Longwalls 20-22;
- sites MRIP11 and MRIP12 overlying Longwalls 23-27;
- sites MRIP03 and MRIP04 downstream of Longwall 23A; and
- 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.

[37] Sites MRIP01, MRIP02, MRIP03, MRIP04 and MRIP10 are situated in the vicinity of pools J, N, Q, U and W, respectively on the Waratah Rivulet. Sites MRIP05, MRIP06, MRIP07, MRIP08, MRIP09, MRIP11 and MRIP12 are situated in the vicinity of pools ETJ, ETM, ETAQ, ETAS, ETF, ETV and ETAG, respectively, on the Eastern Tributary.

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

  Modified Braun-Blanquet Scale

  1 = cover less than 5% of site and rare
  2 = cover less than 5% of site and uncommon
  3 = cover of less than 5% and common
  4 = cover of 5-20% of site
  5 = cover of 21-50% of site
  6 = cover of 51-75% of site
  7 = cover of greater than 75%

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

  Condition Scale

  1 severe damage/dieback
  2 many dead stems
  3 some dead branches
  4 minor damage
  5 healthy

Permanent photo points have been established for each quadrat.

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

The permanent transect (50 m x 2 m, i.e. a 30 m extension of each quadrat) which was used to monitor riparian vegetation at the following sites for Longwalls 20-27 will be discontinued following the commencement of Longwall 301:

- sites MRIP01, MRIP02, MRIP05 and MRIP06 overlying Longwalls 20-22;
- sites MRIP11 and MRIP12 overlying Longwalls 23-27;
- sites MRIP03 and MRIP04 downstream of Longwall 23A; and
- 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.

Analysis of the transect data indicated the data is highly variable between seasons, which is attributed to the dynamic nature of riparian vegetation associated with variable flooding impacts. This variability has been found to reduce the ability of this monitoring technique to detect changes to riparian vegetation associated with potential mining impacts. The riparian vegetation visual, quadrat, and indicator species monitoring techniques are considered to be more effective in detecting differences in riparian vegetation between selected longwall sites and control sites.

The quadrat data that will be used to inform the assessment of vegetation dieback for the assessment against the riparian vegetation performance indicator, *Impacts to riparian vegetation are expected to be localised and limited in extent, similar to the impacts previously experienced at Metropolitan Coal*.

Indicator Species Monitoring

The three indicator species will continue to be monitored within the riparian vegetation of Waratah Rivulet and the Eastern Tributary, namely, *Prostanthera linearis*, *Schoenus melanostachys* and *Lomatia myricoides*. The existing tagged individuals[38] will continue to be monitored at:

- sites MRIP01, MRIP02, MRIP05, MRIP06 and MRIP09 overlying Longwalls 20-22;
- sites MRIP11 and MRIP12 overlying Longwalls 23-27;
- sites MRIP03, MRIP04 and MRIP10 downstream of Longwall 23A; and
- sites MRIP07 and MRIP08[39] downstream of Longwalls 23-27 and within the 35° angle of draw and/or predicted 20 mm subsidence contour for Longwalls 301-303.

Population monitoring data collected includes:

- condition/health rating for each plant; and

  Condition Scale
  1 severe damage/dieback
  2 many dead stems
  3 some dead branches
  4 minor damage
  5 healthy

- reproductive rating:

  Reproductive Rating
  1 nil
  2 sparse (occasional flowers only)
  3 low (under 25 percent of potential)
  4 moderate (25 to 75 percent)
  5 high (over 75 percent of potential flowering)

Surveys will be conducted biannually in autumn and spring.

The indicator species data will be used to inform the assessment of vegetation dieback for the assessment against the riparian vegetation performance indicator, *Impacts to riparian vegetation are expected to be localised and limited in extent, similar to the impacts previously experienced at Metropolitan Coal*.

8.4 SLOPES AND RIDGETOPS

8.4.1 Cliffs and Overhangs, Steep Slopes and Land in General

Potential subsidence impacts and environmental consequences on cliffs and overhangs, steep slopes, and land in general will be monitored in accordance with the Metropolitan Coal Longwalls 301-303 Land Management Plan, a summary of which is provided below. As described in Section 4.2 and Section 5, subsidence impacts on cliffs and overhangs, steep slopes, and land in general have the potential to result in environmental consequences to aquatic and terrestrial biota and their habitats.

[38] Twenty individuals were selected and tagged for monitoring at the commencement of the Longwalls 20-22 and Longwalls 23-27 programs.

[39] Note: Twenty individuals of *Prostanthera linearis* were not available for tagging at site MRIP08.

8.4.1.1 Longwalls 301-303 Cliffs and Overhangs, Steep Slopes and Land in General

As described in Section 4.2, a newly identified cliff and overhang site (COH17) was recorded within 600 m of Longwalls 301-303 secondary extraction. Visual inspections for subsidence impacts on cliff site COH17 will be conducted monthly when Longwall 303 extraction is within 400 m of the site. Additional visual observations of subsidence impacts will be conducted during routine works and sampling by Metropolitan Coal and its contractors. Following the completion of Longwall 303 extraction, 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 appropriate safety controls, review of public safety etc.); and
- any other relevant information.

The information obtained will be recorded in the Land Management Plan – Subsidence Impact Register and reported in accordance with the Project Approval conditions.

The information obtained will be used to assess the potential environmental consequences of the subsidence impact. Specific details that will be noted and/or photographed to assess the potential environmental consequences of the subsidence impact include:

- the nature and extent of impacts on the aesthetic values of the land feature;
- any areas of erosion or sedimentation arising from mining activities;
- the co-ordinates of the subsidence impact to assess impacts on known Aboriginal heritage sites;
- nature and extent of impacts on potential flora and fauna habitats;
- evidence of impacts on terrestrial fauna (e.g. observed fauna mortality); and
- any impacts on the serviceabilty of fire trails/vehicular tracks and/or stream crossings.

Metropolitan Coal will document the assessment of potential environmental consequences in the Land Management Plan – Subsidence Impact Register Assessment

Form.In accordance with the Metropolitan Coal Longwalls 301-303 Land Management Plan, visual inspections for subsidence impacts on steep slopes and land in general within 600 m of 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 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);
- 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.

The date of the observation, details of the observer and the location of longwall extraction will also be documented. The information obtained will be recorded in the Land Management Plan – Subsidence Impact Register and reported in accordance with the Project Approval conditions.

Metropolitan Coal will use the subsidence impact monitoring results for cliffs and overhangs, steep slopes, and land in general, to assess the potential environmental consequences of the subsidence impact on flora, fauna and/or their habitats. Specific details that will be noted and/or photographed include:

- any areas of erosion or sedimentation that have the potential to impact on surface water quality;
- nature and extent of impacts on potential flora and fauna habitats; and
- evidence of impacts on terrestrial fauna (e.g. observed fauna mortality).

Metropolitan Coal will document the assessment of potential environmental consequences in the Land Management Plan – Subsidence Impact Register Assessment Form.

8.4.1.2 Longwalls 20-22 and Longwalls 23-27 Cliffs and Overhangs, Steep Slopes and Land in General

Following the completion of Longwall 27 extraction, cliff sites COH1, COH2, COH3, COH4, COH5, COH6, COH6A, COH7, COH8, COH9, COH10, COH14, COH15 and COH16 (Figure 10) were inspected to record any additional subsidence impacts (e.g. cliff instabilities and cracking) to those previously recorded. The visual inspections did not record any additional subsidence impacts.

Visual inspections for subsidence impacts on steep slopes and land in general within 600 m of Longwalls 20-27 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), 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);

- whether any actions are required (for example, implementation of appropriate safety controls, review of public safety etc.); and
- any other relevant information.

The date of the observation, details of the observer and the location of longwall extraction will also be documented. The information obtained will be recorded in the Land Management Plan – Subsidence Impact Register and Land Management Plan – Subsidence Impact Register Assessment Form and reported in accordance with the Project Approval conditions.

Metropolitan Coal will use the subsidence impact monitoring results for cliffs and overhangs, steep slopes, and land in general, to assess the potential environmental consequences of the subsidence impact on flora, fauna and/or their habitats. Specific details that will be noted and/or photographed include:

- any areas of erosion or sedimentation that have the potential to impact on surface water quality;
- nature and extent of impacts on potential flora and fauna habitats; and
- evidence of impacts on terrestrial fauna (e.g. observed fauna mortality).

Metropolitan Coal will document the assessment of potential environmental consequences in the Land Management Plan – Subsidence Impact Register Assessment Form.

8.4.2 Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion EEC

As described in Section 5.5, an occurrence of the Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion EEC listed under the BC Act is situated to the north of Longwall 301 and outside the Longwalls 301-303 35° angle of draw and/or predicted 20 mm subsidence contour (Figure 16).

8.5 AQUATIC BIOTA AND THEIR HABITATS

8.5.1 Longwalls 301-303 Aquatic Ecology Monitoring

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 Water Management Plan (Figure 3 and Section 6).

As indicated in Section 7.4, no additional aquatic ecology monitoring sites have been established in relation to Longwalls 301-303. Existing monitoring Location ET2 on the Eastern Tributary is situated downstream of Longwalls 23-27 and within the 35° angle of draw and/or predicted 20 mm subsidence contour for Longwalls 301-303 (Figure 13). Monitoring of Location ET2 will continue to be conducted during the mining of Longwalls 301-303 as described in Section 8.5.2 below.

8.5.2 Longwalls 20-22 and Longwalls 23-27 Aquatic Ecology Monitoring

Consistent with the Project EA, the aquatic ecology monitoring programs for Longwalls 20-22 and Longwalls 23-27 were designed to:

- monitor subsidence-induced impacts on aquatic ecology (stream monitoring); and
- monitor the response of aquatic ecosystems to the implementation of future potential stream remediation works (pool monitoring).

The design of the monitoring programs uses a "Beyond BACI" experimental design and focuses on representative sampling within streams and pools in mining areas and in suitable control streams and pools (i.e. not subject to mine subsidence).

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

- 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.
- 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.
- Control Locations: WR1 on Woronora River; OC on O'Hares Creek; BC on Bee Creek; and WOT on Woronora Tributary.

The approximate locations of the sampling sites are shown on Figure 13.

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 sampling 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.

The monitoring parameters and methods are described in Table 4 (in Section 4.3.3).

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 (Figure 13):

- 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.
- 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[40].
Sampling of pools will continue to be conducted as described in Section 4.3.3.

Tables 18 and 19 in Section 8.7 detail the data analysis that will be conducted to assess the monitoring results against the aquatic ecology performance indicators:

> *The aquatic macroinvertebrate and macrophyte assemblages in streams are not expected to experience long-term impacts as a result of mine subsidence.*
>
> *The aquatic macroinvertebrate and macrophyte assemblages in pools are not expected to experience long-term impacts as a result of mine subsidence.*

8.6 TERRESTRIAL FAUNA AND THEIR HABITATS

Terrestrial fauna habitats (upland swamps, riparian vegetation, slopes and ridgetops, and aquatic habitats/streams) will be monitored as described in Sections 8.1 to 8.5, respectively. 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 three threatened species that are sensitive to changes in surface hydrology, and because this group is represented by at least 14 species[41] that appear to have viable populations.

[40] As a result of mine subsidence impacts in late 2016, large Pool ETAH and small Pools ETAG, ETAI and ETAK on the Eastern Tributary were dry at the time of the spring 2017 aquatic ecology survey (Bio-Analysis Pty Ltd, 2018).

[41] One adult of the Littlejohn's Tree Frog was recorded at site 24 over Longwalls 301-303 by the spring/summer 2016 amphibian survey. A targeted survey for the Littlejohn's Tree Frog was proposed to be conducted in August or September 2017 under suitable wet weather conditions when adult calling was likely to be at its peak to seek to determine the status of the species within the underground mining area. It is very likely that the species will be found to be uncommon. The dry weather conditions experienced in August and September 2017 and in August 2018 have not provided suitable weather conditions for the conduct of the targeted survey.

The objective of the monitoring programs is to determine if longwall mining adversely impacts amphibian species as expressed in the null hypothesis:

> *The amphibian assemblage is not expected to experience changes significantly different to the amphibian assemblage at control sites.*

8.6.1 Longwalls 301-303 Amphibian Monitoring

As described in Section 7.5, additional amphibian monitoring sites have been established for Longwalls 301-303. The six test sites located over Longwalls 301-303 are described in Table 11. 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) (refer to Section 8.6.2 below) will also serve as control sites for Longwalls 301-303. The approximate locations of the sampling sites are shown on Figure 14.

Table 11
Attributes of Amphibian Monitoring Sites for Longwalls 301-303

Site	Northing	Easting	Approximate Elevation (m)	Description of Site Location	Location in Relation to Longwall Mining
23	6216060	312678	270	Potential for pool formation within Swamp 41, beside a firetrail.	Longwall 302
24	6216105	312594	270	Potential for large pool formation beside firetrail.	Longwall 302
25	6216409	312609	265	Potential for large pool formation beside roadside soak on Swamp 46, beside a firetrail.	Longwall 303
26	6216780	312650	265	Potential for pool formation within Swamp 51/52, beside a firetrail.	Longwall 303
27	6216492	313061	300	Potential for shallow pool formation beside a firetrail.	Longwall 301
28	6216915	313111	290	Potential for pool formation, draining to a first order stream.	Longwall 301

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

Each site will be surveyed once during a standard one hour general area day search (early morning and late afternoon) supplemented by an evening 60 minute search/playback session using hand held spotlights and head lamps.

The location of threatened amphibian species will be recorded using a GPS.

Species will be assigned to the following relative abundance categories for tadpole and adult stages:

- 0 = no sightings;
- 1 = one sighting of adult or tadpole stage;
- U = uncommon (i.e. 2 to 10 individuals), adult or tadpole stage;
- MC = moderately common (i.e. 11 to 20 individuals), adult or tadpole stage;
- C = common (i.e. 21 to 40 individuals), adult or tadpole stage; and
- A = abundant (>40 individuals), adult or tadpole stage.

Poisson regression analysis will be used to analyse the amphibian survey results. Table 19 in Section 8.7 details the data analysis that will be conducted to assess the monitoring results against the amphibian performance indicator, *The amphibian assemblage is not expected to experience changes significantly different to the amphibian assemblage at control sites.*

8.6.2 Longwalls 20-22 and Longwalls 23-27 Amphibian Monitoring

The Longwalls 20-22 and Longwalls 23-27 amphibian monitoring programs described in Section 4.3.4.1 will continue during the mining of Longwalls 301-303 to monitor amphibian species, with a focus on the habitats of the Giant Burrowing Frog (*Heleiporus australiacus*) and Red-crowned Toadlet (*Pseudophryne australis*) associated with tributaries.

The Longwalls 20-22 amphibian monitoring program includes six test sites and six control sites, which are described in Table 11. The approximate locations of the sampling sites are shown on Figure 14.

The Longwalls 23-27 amphibian monitoring program includes five test sites and five control sites, which are described in Table 12. The approximate locations of the sampling sites are shown on Figure 14.

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

Each site will be surveyed once during a standard one hour general area day search (early morning and late afternoon) supplemented by an evening 60 minute search/playback session using hand held spotlights and head lamps.

Species will be assigned to the following relative abundance categories for tadpole and adult stages:

- 0 = no sightings;
- 1 = one sighting of adult or tadpole stage;
- UC = uncommon (i.e. 2 to 10 individuals), adult or tadpole stage;
- MC = moderately common (i.e. 11 to 20 individuals), adult or tadpole stage;
- C = common (i.e. 21 to 40 individuals), adult or tadpole stage; and
- A = abundant (>40 individuals), adult or tadpole stage.

Table 12
Attributes of Amphibian Monitoring Sites for Longwalls 20-22

Site	Northing	Easting	Approximate Elevation (m)	Description of Site Location	Location in Relation to Longwall Mining
1	6214525	309825	200	Downstream from trail 9H, tributary off Waratah Rivulet.	Longwall 20
2	6213575	311388	220	Confluence of two first order streams with the Eastern Tributary, approximately 50 m upstream of eastern first order tributary.	Longwall 20
3	6214990	309538	240	1st order tributary with road depression, along an ephemeral stream, ponds water.	Longwall 21
4	6213888	311563	235	On the Eastern Tributary (near Pool ETL), valley bedrock platform south of track intersection.	Longwall 21
5	6215081	309562	220	1st order tributary north of fire trail 9C.	Longwall 22A
6	6214050	311601	220	1st order tributary of the Eastern Tributary, approximately 50 m upstream of confluence.	Longwall 22B

Table 12 (Continued)
Attributes of Amphibian Monitoring Sites for Longwalls 20-22

Site	Northing	Easting	Approximate Elevation (m)	Description of Site Location	Location in Relation to Longwall Mining
7	6215298	308325	300	Fire trail 9E, roadside culvert site draining to first order stream, ponds water.	Control site
8	6220353	310125	260	Fire trail 9, depression-soak along track fed from seepage off a series of rock ledges.	Control site
9	6215726	308124	300	Upland swamp, off fire trail 9, upper Honeysuckle Creek.	Control site
10	621495	306402	310	Upland swamp immediately upstream of intersection of Darkes Forest Road and Woronora River.	Control site
11	6218912	308800	260	Fire trail 9, roadside culvert that ponds water and drains to Bee Creek Swamp to the west.	Control site
12	6219000	308711	230	Bee Creek Swamp north, due west of site 11.	Control site

Table 13
Attributes of Amphibian Monitoring Sites for Longwalls 23-27

Site	Northing	Easting	Approximate Elevation (m)	Description of Site Location	Location in Relation to Longwall Mining
13	6215108	310084	265	Located on Tributary B, beyond extent of Fire Road 9C. First order soak.	Longwall 23
14	6214152	311635	272	Located on Tributary downstream of Fire Road 9J crossing. Riffle-pool.	Longwall 23
15	6214650	311267	283	Soak adjacent to Fire Road 9G draining to a first order stream.	Longwall 24
16	6214800	311400	275	Soak adjacent to Fire Road 9G draining to a first order stream.	Longwall 25
17	6215031	311593	263	Headwaters of an upland swamp off Fire Road 9G draining to a first order stream.	Longwall 26
18	6214721	306653	281	Darkes Forest Road, road side culvert which crosses road to form a series of small pools.	Control
19	6213105	306937	359	Soak feeding a first order stream located on a disused track approximately 150 m off Darkes Forest Road.	Control
20	6218565	308980	227	Extensive roadside soak on Fire Road 9 along a distance of 75 m parallel with Bee Creek.	Control
21	6219407	309023	239	Extensive roadside soak on Fire Road 9 along a distance of 100 m.	Control
22	6219927	309133	222	Source reach of a first order stream flowing to Bee Creek.	Control

Poisson regression analysis will be used to analyse the amphibian survey results. Table 19 in Section 8.7 details the data analysis that will be conducted to assess the monitoring results against the amphibian performance indicator, *The amphibian assemblage is not expected to experience changes significantly different to the amphibian assemblage at control sites.*

8.7 TRIGGER ACTION RESPONSE PLANS AND ASSESSMENT AGAINST PERFORMANCE INDICATORS AND MEASURES

The monitoring results will be used to assess the Project against the performance indicators and performance measures using the Trigger Action Response Plans (TARPs) detailed in Tables 14 to 19.

If data analysis indicates a biodiversity performance indicator has been exceeded, an assessment will be made against the biodiversity performance measure and the need for management measures will be considered (Section 9).

The key assessment considerations that will be taken into account when assessing the biodiversity performance measure are outlined in Table 20. Threatened species, populations and ecological communities include those listed under the BC Act, EPBC Act or Fisheries Management Act at the time of Project Approval (i.e. the lists current as at 22 June 2009).

If the biodiversity performance measure is considered likely to have been exceeded, the Contingency Plan will be implemented (Section 10). Metropolitan Coal will implement suitable contingency measures (Section 10) and continue to monitor (Section 8).

8.8 MONITORING PROGRAM REVIEW

Each of the ongoing monitoring programs described in this BMP will be reviewed at the completion of Longwall 303, and thereafter at the completion of each future longwall. The review will include consideration of changes to the monitoring programs, including site locations, parameters measured and the frequency of measurement based on the data obtained to date and the planned future mining activities. Any proposed changes to the monitoring programs will be undertaken in consultation with the OEH and DPI - Fishing, and to the satisfaction of the DP&E.

Table 14
Trigger Action Response Plan – Upland Swamp Vegetation Monitoring

Performance Measure	Performance Indicator	Monitoring Sites	Parameters	Frequency/ Sample Size	Analysis Methodology	Error Types	Baseline	Significance Levels/ Triggers		Action/Response
Negligible impact on Threatened Species, Populations, or Ecological Communities	*The vegetation in upland swamps is not expected to experience changes significantly different to vegetation in control swamps*	• Swamps 16, 17, 18, 20, 24 and 25 overlying or adjacent to Longwalls 20-22. • Swamps 19, 28, 30, 31, 32, 33, 34, 35, 36 and 94 overlying or adjacent to Longwalls 23-27. • Swamps 38, 40, 41, 46, 47, 48, 49, 50, 51/52, 53 and 58 overlying or adjacent to Longwalls 301-303. • Control Swamps 101, 111a, 125, 135, 136, 137a, 137b, 138, Bee Creek Swamp, Woronora River 1, Woronora River south arm and Dahlia Swamp.	• Visual inspections. • Transect/ quadrat data. • Population monitoring of indicator species.	Biannually, in autumn and spring.	• Visual assessment of changes in the condition of the swamps over time. • Qualitative analysis of collected vegetation data. • Statistical analysis of species diversity[6] (e.g. ANOVA[1] or cluster analysis[2]). • Qualitative analysis of proportions of plants surviving, and differences in health and reproduction ratings over time and relative to control swamps.	• Subjective nature of visual observations and qualitative analysis. • Statistical significance levels. Significant = $P < 0.05$	• Longwalls (LW) 20-22 swamps, as detailed in the LW20-22 vegetation monitoring report for the spring 2008 to autumn 2010 surveys[3]. • LW23-27 swamps, as detailed in the LW23-27 vegetation monitoring report for the spring 2010 to spring 2013 surveys[4]. • LW301-303 swamps, as detailed in the LW301-303 vegetation monitoring report for the spring 2015 to autumn 2017 surveys[5].	Level 1	Data analysis indicates[6]: - there is not a declining trend in the condition of longwall swamp vegetation; and - there are no significant changes in vegetation between the mined and control swamps.	Continue monitoring. Six monthly reporting.
								Level 2	Data analysis indicates[6]: - there is a declining trend in the condition of longwall swamp vegetation over time, however a similar trend is occurring in control swamp vegetation; or - there are significant differences in vegetation between the mined and control swamps, however, the data indicates longwall swamp vegetation is consistent with the baseline monitoring results.	Consider swamp groundwater monitoring data. Six monthly reporting.
								Level 3	Data analysis indicates[6]: - there is a declining trend in the condition of longwall swamp vegetation over time that is not occurring in control swamp vegetation; or - there are significant differences in vegetation between the mined and control swamps, and the data indicates longwall swamp vegetation is not consistent with the baseline monitoring results.	Consider swamp groundwater monitoring data. Initiate assessment against the performance measure[7]. Consider the need for management measures, in accordance with Sections 8 and 9.

1 In general, the purpose of ANOVA is to test for significant differences between means.

2 The term cluster analysis encompasses a number of different algorithms and methods for grouping objects of similar kind into respective categories.

3 Eco Logical Australia (2010) *Metropolitan Coal Vegetation Monitoring Longwalls 20-22 - Baseline Data.* Report prepared for Metropolitan Coal.

4 Eco Logical Australia (2013) *Metropolitan Coal Vegetation Monitoring Longwalls 23-27 - Baseline data*. Report prepared for Metropolitan Coal.

5 Eco Logical Australia (2018) *Metropolitan Coal Vegetation Monitoring Longwalls 301-303 - Baseline data*. Report prepared for Metropolitan Coal.

6 Not applicable to vegetation subject to the hazard reduction burns conducted by WaterNSW in 2017.

7 Threatened species, populations and ecological communities include those listed under the BC Act, EPBC Act or Fisheries Management Act at the time of Project Approval (i.e. the lists current as at 22 June 2009).

Table 15
Trigger Action Response Plan – Upland Swamp Groundwater Monitoring

Performance Measure	Performance Indicator	Monitoring Sites	Parameters	Frequency/ Sample Size	Analysis Methodology	Error Types	Baseline	Significance Levels/ Triggers[2, 3]		Action/Response
Negligible impact on Threatened Species, Populations, or Ecological Communities	*Surface cracking within upland swamps resulting from mine subsidence is not expected to result in measurable changes to swamp groundwater levels when compared to control swamps or seasonal variations in water levels experienced by upland swamps prior to mining*[1]	• Swamp 25 overlying Longwalls 20-22. • Swamps 30, 33 and 35 overlying Longwalls 23-27. • Swamps 40, 41, 46, 51, 52 and 53 overlying Longwalls 301-303. • Control Swamps 101, 137a, 137b and Bee Creek Swamp.	Groundwater levels.	Continuous water level monitoring with data logger, downloaded monthly.	Analysis of swamp substrate groundwater levels, six monthly, within one month of download.	Data logger precision and download error.	<u>Longwalls 20-27 Swamps</u> • Swamp 25, 5th percentile of substrate water levels = 270.7 m AHD • Swamp 30, 5th percentile of substrate water levels = 235.3 m AHD • Swamp 33, 5th percentile of substrate water levels = 240.5 m AHD • Swamp 35 substrate water levels two standard deviations below the mean = 255.0 m AHD <u>Longwalls 301-303 Swamps</u> • Swamp 40, baseline minimum substrate water level = 230.2 m AHD • Swamp 41, baseline minimum substrate water level = 278.2 m AHD • Swamp 46, baseline minimum substrate water level = 281.2 m AHD • Swamp 51, baseline minimum substrate water level = 273.5 m AHD • Swamp 52, baseline minimum substrate water level = 282.3 m AHD • Swamp 53, baseline minimum substrate water level = 293.1 m AHD	Level 1	Data analysis for Longwalls 20-27 swamps indicates: - the seven day moving average for Swamps 25, 30 and 33 is within the 5th percentile established for the swamp's full length of record; and - the seven day moving average for Swamp 35 is within two standard deviations below the mean established for the swamp's full length of record. Data analysis for Longwalls 301-303 swamps indicates: - the seven day moving average for Swamps 40, 41, 46, 51, 52 and 53 is at or above the minimum established for the swamp's full length of record.	Continue monitoring. Six monthly reporting.
								Level 2	Data analysis for Longwalls 20-27 swamps indicates: - the seven day moving average for Swamps 25, 30 and 33 is below the 5th percentile established for the swamp's full length of record; - the seven day moving average for Swamp 35 lie outside two standard deviations below the mean established for the swamp's full length of record; and - semi-quantitative comparisons with control swamps and rainfall record indicates that dry swamp conditions are natural. Data analysis for Longwalls 301-303 swamps indicates[2]: - the seven day moving average for Swamps 40, 41, 46, 51, 52 and 53 is below the minimum established for the swamp's full length of record; and - semi-quantitative comparisons with control swamps and rainfall record indicates that dry swamp conditions are natural.	Increase the frequency of data analysis to quarterly (until such time that data analysis indicates a return to Level 1). Six monthly reporting.
								Level 3	Data analysis for Longwalls 20-27 swamps indicates: - the seven day moving average for Swamps 25, 30 and 33 is below the 5th percentile established for the swamp's full length of record; - the seven day moving average for Swamp 35 lie outside two standard deviations below the mean established for the swamp's full length of record; and - semi-quantitative comparisons with control swamps and rainfall record indicates that dry swamp conditions are not natural. Data analysis for Longwalls 301-303 swamps indicates: - the seven day moving average for Swamps 40, 41, 46, 51, 52 and 53 is below the minimum established for the swamp's full length of record; and - semi-quantitative comparisons with control swamps and rainfall record indicates that dry swamp conditions are not natural.	Increase the frequency of data analysis to quarterly (until such time that data analysis indicates a return to Level 1). Initiate assessment against the performance measure for threatened species. Consider the need for management measures, in accordance with Sections 8 and 9.

1 This performance indicator has been exceeded at Swamp 20 since 2012 and at Swamp 28 since 2016. Swamp water levels at Swamp 20 and Swamp 28 will continue to be analysed on a six monthly basis and assessments against the performance measure will be conducted annually.

2 The 'full length of record' relates to the groundwater swamp substrate dataset for Longwalls 20-22 swamps to 31 May 2012, for Longwalls 23-27 swamps to 30 June 2014 and for Longwalls 301-303 swamps to 30 June 2017.

3 Consistent with the OEH (2016) *Addendum to NSW Biodiversity Offsets Policy for Major Projects: Upland swamps impacted by longwall mining subsidence*, the Level 2 and 3 triggers include semi-quantitative analysis of swamp substrate groundwater levels in comparison to control swamps. The semi-quantitative analysis includes analysis of the rate of recession from high to low water levels and analysis of rates of recovery from low to high water levels, compared to control swamps. The TARP method complies with the tenor of the OEH (2016) proposed analysis of recession rates.

Table 16
Trigger Action Response Plan – Riparian Vegetation Monitoring

Performance Measure	Performance Indicator	Monitoring Sites	Parameters	Frequency/ Sample Size	Analysis Methodology	Error Types	Baseline	Significance Levels/ Triggers		Action/Response
Negligible impact on Threatened Species, Populations, or Ecological Communities	*Impacts to riparian vegetation are expected to be localised and limited in extent, similar to the impacts previously experienced at Metropolitan Coal*	Locations adjacent to riparian vegetation monitoring sites (MRIP01 to MRIP12) and areas traversed whilst accessing the monitoring sites: • sites MRIP01, MRIP02, MRIP05, MRIP06 and MRIP09 overlying Longwalls 20-22; • sites MRIP11 and MRIP12 overlying Longwalls 23-27; • sites MRIP03, MRIP04 and MRIP10 downstream of Longwall 23A; and • 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.	The extent of vegetation subject to vegetation dieback.	Biannually, in autumn and spring.	Assessment of the extent of riparian vegetation dieback.	Subjective nature of visual observations.	No dieback of riparian vegetation prior to the commencement of Longwall 20 as a result of mining. Dieback of riparian vegetation greater than 50 cm from the stream identified at site MRIP02 on the Waratah Rivulet and between sites MRIP05 and MRIP09 on the Eastern Tributary during the mining of Longwalls 20-27.	Level 1	No dieback of riparian vegetation greater than 50 cm from the stream as a result of mine subsidence.	Continue monitoring. Six monthly reporting. For sites that were previously observed with riparian vegetation dieback greater than 50 cm record the reasons for the reduction in dieback (e.g. vegetation recovery, new stream bank resulting from erosion, other).
								Level 2	Vegetation monitoring: - does not identify an increase in the extent of vegetation dieback compared to that observed at site MRIP02 on the Waratah Rivulet and between sites MRIP05 and MRIP09 on the Eastern Tributary; and - does not identify vegetation dieback greater than 50 cm from the stream at sites MRIP01, MRIP03, MRIP04, MRIP06, MRIP07, MRIP08, MRIP10, MRIP11 or MRIP12, as a result of mine subsidence.	Consider recent stream features mapping results and pool water level monitoring data. Consider extent of erosion associated with areas of vegetation dieback and whether management measures are required. Six monthly reporting.
								Level 3	Vegetation monitoring: - identifies an increase in the extent of vegetation dieback compared to that observed at site MRIP02 on the Waratah Rivulet and between sites MRIP05 and MRIP09 on the Eastern Tributary; and - identifies vegetation dieback greater than 50 cm from the stream at sites MRIP01, MRIP03, MRIP04, MRIP06, MRIP07, MRIP08, MRIP10, MRIP11 or MRIP12, as a result of mine subsidence.	Consider recent stream features mapping results and pool water level monitoring data. Initiate assessment against the performance measure[1]. Consider the need for management measures, in accordance with Sections 8 and 9.

[1] Threatened species, populations and ecological communities include those listed under the BC Act, EPBC Act or Fisheries Management Act at the time of Project Approval (i.e. the lists current as at 22 June 2009).

Table 17
Trigger Action Response Plan – Monitoring of Aquatic Biota, Stream Monitoring

Performance Measure	Performance Indicator	Monitoring Sites	Parameters	Frequency/ Sample Size	Analysis Methodology	Error Types	Baseline	Significance Levels/ Triggers		Action/Response
Negligible impact on Threatened Species, Populations, or Ecological Communities	*The aquatic macroinvertebrate and macrophyte assemblages in streams are not expected to experience long-term impacts as a result of mine subsidence*[1].	Two sampling sites (approximately 100 m in length) at the following locations: • Location WT3 on Waratah Rivulet, Locations ET1, ET3 and ET4 on the Eastern Tributary overlying Longwalls (LW) 20-27. • Locations WT4 and WT5 on the Waratah Rivulet, downstream of LW20-27. • Location ET2 on the Eastern Tributary, downstream of LW20-27 and within the LW301-303 35° angle of draw and/or predicted 20 mm subsidence contour. • Control Locations: WR1 on Woronora River; and OC on O'Hares Creek.	• Aquatic macroinvertebrates. • Aquatic macrophytes.	Biannually, in autumn and spring.	• Analysis of macroinvertebrate and macrophyte multivariate[2] and univariate[3] data using PERMANOVA to test the null hypothesis of no significant change in relation to control places, bi-annually following completion of survey.	Statistical significance levels. Significant = $P < 0.05$	• LW20-22 stream sites, as detailed in the LW20-22 aquatic ecology monitoring reports for the spring 2008 to autumn 2010 surveys[4]. • LW23-27 stream sites, as detailed in the LW23-27 aquatic ecology monitoring reports for the spring 2009 to spring 2013 surveys[5].	Level 1	Data analysis indicates no significant changes in relation to control places pre-mining[7] compared to post-extraction[8]: - occur in the aquatic macroinvertebrate and macrophyte assemblages in Waratah Rivulet or the Eastern Tributary at Locations WT3, ET1, ET3 or ET4, located within the LW20-22 and LW23-27 mining areas during the mining of LW301-303; or - occur in the aquatic macroinvertebrate and macrophyte assemblages in the Eastern Tributary at Location ET2 during the mining of LW301-303[9].	Continue monitoring. Six monthly reporting.
								Level 2	Data analysis indicates significant (not long-term[6]), changes[6] in relation to control places pre-mining[7] compared to post-extraction[8]: - occur in the aquatic macroinvertebrate and macrophyte assemblages in Waratah Rivulet or the Eastern Tributary at Locations WT3, ET1, ET3 or ET4, located within the LW20-22 and LW23-27 mining areas during the mining of LW301-303; or - occur in the aquatic macroinvertebrate and macrophyte assemblages in the Eastern Tributary at Location ET2 within the LW301-303 mining area after the completion of Longwall 306[9].	Consider recent stream features mapping results and pool water level monitoring data. Consider status/progress of stream remediation activities. Six monthly reporting.
								Level 3	Data analysis indicates significant long-term changes[6] in relation to control places pre-mining[7] compared to post-extraction[8]: - occur in the aquatic macroinvertebrate and macrophyte assemblages in Waratah Rivulet or the Eastern Tributary at Locations WT3, ET1, ET3 or ET4, located within the LW20-22 and LW23-27 mining areas during the mining of LW301-303; or - occur in the aquatic macroinvertebrate and macrophyte assemblages in the Eastern Tributary at Location ET2 within the LW301-303 mining area after the completion of Longwall 306[9].	Initiate assessment against the performance measure[10]. Consider the need for management measures, in accordance with Sections 8 and 9.

1 This performance indicator has been exceeded at Location B1 since the autumn 2016 survey and at Location B2 since the spring 2016 survey and assessments have been made against the performance measure. Aquatic macroinvertebrate (if sufficient aquatic habitat is available for sampling) and macrophyte sampling at these locations will be conducted every three years after spring 2018, 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 Longwalls18-19A . 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.

2 Multivariate Analysis: comparisons of two (or more) samples based on the degree to which these samples share particular species, at comparable levels of abundance.

3 Univariate Analysis: comparison of individual variables (e.g. total number of taxa, total abundance, abundances of individual taxa).

4 Cummins, S. P., Roberts, D. E. (2009a; 2009b; 2010a; 2010b). Aquatic Ecology Monitoring: Metropolitan Coal Longwalls 20-22 Spring 2008 to Autumn 2010 Survey Reports. Prepared for Metropolitan Coal Pty Ltd. BIO-ANALYSIS: Marine, Estuarine & Freshwater Ecology.

5 Cummins, S. P., Roberts, D. E. (2010a; 2010b; 2011; 2012a; 2012b; 2012c; 2013a; 2013b, 2014). Aquatic Ecology Monitoring: Metropolitan Coal Longwalls 23-27 Spring 2009 to Spring 2013 Survey Reports. Prepared for Metropolitan Coal Pty Ltd. BIO-ANALYSIS: Marine, Estuarine & Freshwater Ecology.

6 Long-term changes to the macroinvertebrate and macrophyte assemblages are considered to be significant changes resulting from mining that are persistent (i.e. occurring at the monitoring locations within a mining area up to 3 years after extraction of that mining area).

7 Pre-mining data is as follows: sites WT3 and ET1 (spring 2008 to autumn 2010); site ET3 (spring 2009 to autumn 2010); site ET4 (spring 2009 to spring 2013); site ET2 (will be assessed for two periods: spring 2008 to autumn 2010 [i.e. pre-mining of Longwalls 20-22] and spring 2009 to spring 2013 [i.e. pre-mining of Longwalls 23-27]).

8 Post-extraction data is represented as follows: sites WT3 and ET1 (from spring 2010 on); site ET3 (from spring 2010 on); site ET4 (from autumn 2014 on); site ET2 (will be assessed for two periods: spring 2010 on [Longwalls 20-22] and autumn 2014 on [Longwalls 23-27]).

9 Relevantly, the *minimal iron staining* and *no diversion of flows, no change in the natural drainage behaviour of pools* components of the Eastern Tributary watercourse subsidence impact performance measure (*Negligible environmental consequences over at least 70% of the stream length (that is, no diversion of flows, no change in the natural drainage behaviour of pools, minimal iron staining, and minimal gas releases) on the Eastern Tributary between the full supply level of the Woronora Reservoir and the maingate of Longwall 26)* was exceeded during the mining of Longwalls 23-27, triggering contingency measures for the impacted pools.

10 Threatened species, populations and ecological communities include those listed under the BC Act, EPBC Act or Fisheries Management Act at the time of Project Approval (i.e. the lists current as at 22 June 2009).

Table 18
Trigger Action Response Plan – Monitoring of Aquatic Biota, Pool Monitoring

Performance Measure	Performance Indicator	Monitoring Sites	Parameters	Frequency/ Sample Size	Analysis Methodology	Error Types	Baseline	Significance Levels/ Triggers		Action/Response
Negligible impact on Threatened Species, Populations, or Ecological Communities	*The aquatic macroinvertebrate and macrophyte assemblages in pools are not expected to experience long-term impacts as a result of mine subsidence.*	• Larger pools J, M1 and N on Waratah Rivulet and ETAH on the Eastern Tributary, overlying Longwalls (LW) 20-27. • Smaller pools K, L and M on Waratah Rivulet and ETAG, ETAK and ETAI on the Eastern Tributary, overlying LW20-27. • 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).	• Aquatic macroinvertebrates. • Aquatic macrophytes.	Biannually, in autumn and spring.	• Analysis of macroinvertebrate and macrophyte multivariate[1] and univariate[2] data using PERMANOVA to test the null hypothesis of no significant change in relation to control places, bi-annually following completion of survey. • Analysis of changes in distribution and abundance of aquatic macrophytes in pools, bi-annually following completion of survey.	Statistical significance levels. Significant = $P < 0.05$	• LW20-22 pool sites, as detailed in the LW20-22 aquatic ecology monitoring reports for the spring 2008 (Pool N) or spring 2009 (Pools J, M1, K, L and M) to autumn 2010 surveys[3]. • LW23-27 pool sites (ETAG, ETAH, ETAI and ETAK) as detailed in the LW23-27 aquatic ecology monitoring reports for the spring 2009 to spring 2013 surveys[4].	Level 1	Data analysis indicates no significant changes or significant (not long term[5]) changes in relation to control places pre-mining[7] compared to post-extraction[8]: - occur in the aquatic macroinvertebrate and macrophyte assemblages at pools J, K, L, M1, M or N; or - occur in the aquatic macroinvertebrate and macrophyte assemblages at pools ETAG, ETAH, ETAI or ETAK[8].	Continue monitoring. Six monthly reporting.
								Level 2	Data analysis indicates significant long-term changes[5] in relation to control places pre-mining[6] compared to post-extraction[7]: - occur in the aquatic macroinvertebrate and macrophyte assemblages at pools J, K, L, M1, M or N; or - occur in the aquatic macroinvertebrate and macrophyte assemblages at pools ETAG, ETAH, ETAI or ETAK[8].	Consider recent stream features mapping results and pool water level monitoring data. Consider status/progress of stream remediation activities. Six monthly reporting.
								Level 3	Data analysis indicates significant long-term changes[5] in relation to control places pre-mining[6] compared to post-extraction[7]: - occur in the aquatic macroinvertebrate and macrophyte assemblages in pools J, K, L, M1, M or N after one year of the completion of stream remediation on Waratah Rivulet; or - occur in the aquatic macroinvertebrate and macrophyte assemblages in pools ETAG, ETAH, ETAI or ETAK after one year of the completion of stream remediation on the Eastern Tributary[8].	Initiate assessment against the performance measure[9]. Consider the need for management measures, in accordance with Sections 8 and 9.

1 Multivariate Analysis: comparisons of two (or more) samples based on the degree to which these samples share particular species, at comparable levels of abundance.

2 Univariate Analysis: comparison of individual variables (e.g. total number of taxa, total abundance, abundances of individual taxa).

3 Cummins, S. P., Roberts, D. E. (2009a; 2009b; 2010a; 2010b). Aquatic Ecology Monitoring: Metropolitan Coal Longwalls 20-22 Spring 2008 to Autumn 2010 Survey Reports. Prepared for Metropolitan Coal Pty Ltd. BIO-ANALYSIS: Marine, Estuarine & Freshwater Ecology.

4 Cummins, S. P., Roberts, D. E. (2010a; 2010b; 2011; 2012a; 2012b; 2012c; 2013a; 2013b, 2014). Aquatic Ecology Monitoring: Metropolitan Coal Longwalls 23-27 Spring 2009 to Spring 2013 Survey Reports. Prepared for Metropolitan Coal Pty Ltd. BIO-ANALYSIS: Marine, Estuarine & Freshwater Ecology.

5 Long-term changes to the macroinvertebrate and macrophyte assemblages are considered to be significant changes resulting from mining that are persistent (i.e. occurring at the monitoring locations within a mining area up to 3 years after extraction of that mining area).

6 Pre-mining data is as follows: Pool N on Waratah Rivulet (spring 2008 to autumn 2010); Pools J, K, L, M and M1 on Waratah Rivulet (spring 2009 to autumn 2010); Pools ETAG, ETAH, ETAI and ETAK (spring 2009 to spring 2013).

7 Post-extraction data is represented as follows: Pool N on Waratah Rivulet (from spring 2010 on); Pools J, K, L, M and M1 on Waratah Rivulet (from spring 2010 on); Pools ETAG, ETAH, ETAI and ETAK (from autumn 2014).

8 Relevantly, the *minimal iron staining* and *no diversion of flows, no change in the natural drainage behaviour of pools* components of the Eastern Tributary watercourse subsidence impact performance measure (*Negligible environmental consequences over at least 70% of the stream length (that is, no diversion of flows, no change in the natural drainage behaviour of pools, minimal iron staining, and minimal gas releases) on the Eastern Tributary between the full supply level of the Woronora Reservoir and the maingate of Longwall 26)* was exceeded during the mining of Longwalls 23-27, triggering contingency measures and stream remediation for the impacted pools.

9 Threatened species, populations and ecological communities include those listed under the BC Act, EPBC Act or Fisheries Management Act at the time of Project Approval (i.e. the lists current as at 22 June 2009).

Table 19
Trigger Action Response Plan – Amphibian Monitoring

Performance Measure	Performance Indicator	Monitoring Sites	Parameters	Frequency/ Sample Size	Analysis Methodology	Error Types	Baseline	Significance Levels/ Triggers		Action/Response
Negligible impact on Threatened Species, Populations, or Ecological Communities	*The amphibian assemblage is not expected to experience changes significantly different to the amphibian assemblage at control sites.*	• Test sites 1 to 6 overlying Longwalls (LW) 20-22. • Test sites 13 to 17 overlying LW23-27. • Test sites 23 to 28 overlying LW301-303. • Control sites 7 to 12 and 18 to 22.	• Amphibian species diversity and relative abundance.	Annually in spring/summer	Analysis using Poisson regression[1] analysis to determine if the null hypothesis remains intact, following completion of survey.	The Poisson analysis can determine impacts on the amphibian assemblage at the 95% confidence level.	• LW20-22 amphibian sites, as detailed in the spring/summer 2009 LW20-22 amphibian monitoring report[2]. • LW23-27 amphibian sites, as detailed in the spring/summer 2010, 2011, 2012 and 2013 LW23-27 amphibian monitoring reports[3]. • LW301-303 amphibian sites, as detailed in the LW301-303 amphibian monitoring reports for the spring/summer 2015 and spring/summer 2016 surveys[4].	Level 1	Data analysis does not identify a significant change in the amphibian population.	Continue monitoring. Six monthly reporting.
								Level 2	Data analysis identifies a significant change in the amphibian population for one survey period.	Investigate whether additional analyses can be conducted in relation to the threatened amphibian species. Six monthly reporting.
								Level 3	Data analysis identifies a significant change in the amphibian population for more than one survey period.	Investigate whether additional analyses can be conducted in relation to the threatened amphibian species. Initiate assessment against the performance measure[5]. Consider the need for management measures, in accordance with Sections 8 and 9.

1 Poisson regression is a generalized linear model form of regression analysis used to model count data and contingency tables.

2 Cenwest Environmental Services (2010) *Metropolitan Coal Longwalls 20-22 Spring/Summer 2009 Amphibian Survey.* Report prepared for Metropolitan Coal.

3 Cenwest Environmental Services (2010; 2011; 2012; 2013) Metropolitan Coal Longwalls 23-27 Spring/Summer 2010 to 2013 Amphibian Survey Reports. Reports prepared for Metropolitan Coal.

4 Cenwest Environmental Services (2015; 2016) Metropolitan Coal Longwalls 301-303 Spring/Summer 2015 to 2016 Amphibian Survey Reports. Reports prepared for Metropolitan Coal.

5 Threatened species, populations and ecological communities include those listed under the BC Act, EPBC Act or Fisheries Management Act at the time of Project Approval (i.e. the lists current as at 22 June 2009).

Table 20

Key Assessment Considerations for Assessing Negligible Impact on Threatened Species, Populations and Ecological Communities

Negligible Impact on:	Key Assessment Considerations
Threatened species	1. What is the nature of the environmental consequence (e.g. the potential for adverse impacts on upland swamps, riparian vegetation, slopes and ridgetops or aquatic habitats)? 2. What are the potential factors that may have contributed to the environmental consequence (e.g. the degree of subsidence effects, ineffective management measures or prevailing climatic conditions)? 3. Which threatened species have the potential to be impacted? 4. What are the potential impacts on the lifecycle of the potential threatened species (e.g. foraging, breeding/reproduction, nesting, shelter and movement/dispersal)? 5. What are the potential impacts on the habitat of the potential threatened species (e.g. area affected)? 6. Has the habitat connectivity of the threatened species been affected? 7. What actions, if any, are most appropriate to mitigate the impacts and/or to minimise future impacts?
Threatened populations	1. What is the nature of the environmental consequence (e.g. the potential for adverse impacts on upland swamps, riparian vegetation, slopes and ridgetops or aquatic habitats)? 2. What are the potential factors that may have contributed to the environmental consequence (e.g. the degree of subsidence effects, ineffective management measures or prevailing climatic conditions)? 3. Are there any threatened populations that have the potential to be impacted? 4. What are the potential impacts on the lifecycle of the threatened population? 5. What are the potential impacts on the habitat of the threatened population (e.g. area affected)? 6. Has the habitat connectivity of the threatened population been affected? 7. What actions, if any, are most appropriate to mitigate the impacts and/or to minimise future impacts?
Threatened Ecological Communities	1. Can any subsidence impacts (e.g. surface cracking, subsidence-induced erosion) be observed within the occurrence of the Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion EEC situated to the north of Longwall 301? 2. If yes, over what area has been affected? 3. What are the potential environmental consequences of the change in subsidence effects? 4. What actions, if any, are most appropriate to mitigate the impacts and/or to minimise future impacts?

9 MANAGEMENT MEASURES

This section describes the management measures that will be implemented to remediate impacts, including subsidence impacts and impacts associated with surface activities in the underground mining area and surrounds. Management measures will be implemented, as appropriate, to comply with the relevant statutory requirements and the subsidence impact performance measure.

Systematic and/or valley related movements associated with the Project have the potential to result in fracturing and dilation of the underlying strata of streams above and immediately adjacent to the longwalls. Cracking and dilation of bedrock may result in the localised diversion of a portion of the surface flow into subterranean flows or leakage from pools. Stream remediation measures required to be implemented on the Waratah Rivulet and Eastern Tributary are described in Section 9.1.

Other potential subsidence impacts and associated management measures such as stream bank erosion, ponding of stream bank vegetation, cliff falls and surface tension cracks, and swamp remediation measures are described in Section 9.2.

Vegetation clearance management measures are described in Section 9.3.1.

Metropolitan Coal personnel and contractors will be required to access the underground mining area and surrounds to conduct a range of surface activities including various monitoring, exploration, construction and remediation/rehabilitation activities. Management measures will be implemented to minimise the potential for impacts of such activities on flora and fauna, and their habitats. These measures are described in Section 9.4.

Follow-up inspections will be conducted to assess the effectiveness of implemented management measures and the requirement for any additional management measures.

Management measures will be reported in the Annual Review (Section 12).

9.1 STREAM REMEDIATION

In accordance with Condition 1, Schedule 6 of the Project Approval, Metropolitan Coal is required to achieve the rehabilitation objective: *Restore surface flow and pool holding capacity as soon as reasonably practicable* for (Figure 4):

- Waratah Rivulet, between the downstream edge of Flat Rock Swamp and the full supply level of the Woronora Reservoir; and
- Eastern Tributary, between the maingate of Longwall 26 and the full supply level of the Woronora Reservoir.

Metropolitan Coal will conduct stream remediation works in accordance with the Metropolitan Coal Longwalls 301-303 Water Management Plan and Metropolitan Coal Rehabilitation Management Plan.

As described in Section 4.1.1, since the commencement of Longwall 20 stream remediation activities on the Waratah Rivulet have been conducted at Pools A, F and G (Figure 5). In 2015, all pools on the Waratah Rivulet remained above their cease to flow levels or exhibited natural behaviour (i.e. those pools that do not have a 'solid' rock bar control), with the exception of Pool G (where stream remediation is being undertaken). In 2016, all pools on the Waratah Rivulet remained above their cease to flow levels or exhibited natural behaviour, except Pool A (pool water levels fell to or below the pool's cease to flow level during the period 24 November to 31 December 2016).

In 2017, all pools except Pools A, B and N remained above their cease to flow levels or exhibited natural behaviour. Pool water levels in control pool WRP2 on the Woronora River also stopped flowing in the same or similar period.

In December 2016 and January 2017 a number of pools on the Eastern Tributary downstream of the Longwall 26 maingate experienced loss of pool water levels as a result of mine subsidence. This resulted in the negligible environmental consequences performance measure for the Eastern Tributary watercourse being exceeded in relation to diversion of flows and drainage behaviour. As a result, stream remediation has been triggered for the Eastern Tributary.

Pools ETAG to ETAU on the Eastern Tributary are situated downstream of the maingate of Longwall 26.

Stream remediation activities will be conducted in accordance with the Metropolitan Coal Longwalls 301-303 Water Management Plan and Metropolitan Coal Rehabilitation Management Plan.

Section 8.5 describes the monitoring that will be conducted to monitor the response of aquatic biota to the implementation of stream remediation works.

9.2 OTHER SUBSIDENCE IMPACT MANAGEMENT MEASURES

9.2.1 Stream Bank Erosion

Visual inspections (particularly along Waratah Rivulet and the Eastern Tributary) will be conducted to identify any areas subject to excessive erosion and sedimentation. Where visual observations indicate the potential for excessive erosion or sediment migration, specific mitigation measures will be employed. Potential management measures include:

- filling of cracks and minor erosion holes in the bed or banks of watercourses;
- installation of sediment fences downslope of subsidence-induced erosion areas;
- stabilisation of erosion areas using rock or other appropriate materials;
- stabilisation of banks subject to soil slumping; and
- implementation of vegetation management measures.

These management measures will be implemented in accordance with the Metropolitan Coal Longwalls 301-303 Water Management Plan.

To date, limited erosion and sedimentation has been identified. Sediment controls (coir logs and sandbags) have been used at previous stream remediation sites Pools A and F for erosion control.

There is potential for the riparian areas that have been subject to increased ponding as a result of subsidence to result in stream bank erosion. The potential for excessive erosion and sedimentation will be monitored at these locations. However, it is anticipated that a new stream bank would be established that would be colonised in due course by native vegetation adapted to the new conditions.

9.2.2 Vegetation

Potential management measures for impacts on vegetation include the implementation of weed control measures (e.g. mechanical removal or the application of approved herbicides), the planting of endemic plant species and brush matting, should monitoring indicate the need.

Weed management measures in the Woronora Special Area will be conducted in consultation with WaterNSW.

Any active planting program will utilise flora species characteristic of the particular vegetation community in that area and will utilise seed collected from the Woronora Special Area. Consultation will be undertaken with the DP&E and OEH for any proposed revegetation works associated with subsidence impacts (e.g. impacts to riparian vegetation).

To date, brush matting has been used at stream remediation sites in conjunction with locally collected vegetative material to encourage the regeneration of native vegetation.

9.2.3 Cliff Falls

Cliff and overhang site COH17 will be monitored to record evidence of potential subsidence impacts in accordance with the Metropolitan Coal Longwalls 301-303 Land Management Plan. The monitoring results will be used to assess the potential environmental consequences of the recorded subsidence impact and identify management measures, where appropriate.

In relation to impacts on aquatic or terrestrial flora, fauna, or their habitats, potential management measures include:

- the implementation of erosion and sediment control measures (e.g. the installation of sediment fences downslope of erosion areas, the stabilisation of erosion areas using rock or other appropriate materials); and
- stabilisation techniques (e.g. installation of artificial rock support, installation of standing supports, or scaling/dislodgement/removal of remaining loose rock).

The implementation of management measures will be considered with regard to the specific circumstances of the subsidence impact (e.g. the location, nature and extent of the impact) and the assessment of the environmental consequences in accordance with the Metropolitan Coal Longwalls 301-303 Land Management Plan.

9.2.4 Surface Tension Cracks

As described in Section 8.4, visual inspections for surface tension cracks will be conducted by Metropolitan Coal and its contractors as part of routine works conducted in the catchment in accordance with the Metropolitan Coal Longwalls 301-303 Land Management Plan.

Metropolitan Coal will use the subsidence impact monitoring results to assess the potential environmental consequences of the recorded subsidence impact, including the nature and extent of impacts on flora and fauna habitats and evidence of impacts on terrestrial fauna (e.g. observed fauna mortality). The implementation of management measures will be considered with regard to the specific circumstances of the subsidence impact (e.g. the location, nature and extent of the impact) and the assessment of the environmental consequence.

Potential management measures include the permanent filling of the surface tension crack. Consistent with the Metropolitan Coal Longwalls 301-303 Land Management Plan, WaterNSW will be consulted in the event Metropolitan Coal propose to in-fill any surface tension cracks in the Woronora Special Area.

9.2.5 Swamp Remediation Measures

In the event remediation measures are proposed to be implemented in an upland swamp, Metropolitan Coal will prepare a swamp remediation plan for the swamp in consultation with the DP&E, OEH, WaterNSW, DPI - Fishing and DRG.

Potential remediation measures for impacts on upland swamps that could be used or are being investigated, include:

- installation of coir log dams (i.e. erosion control structures) at any knick points in a swamp;
- use of surface water spreading techniques, involving long lengths of coir logs and hessian 'sausages' linked together across a swamp contour such that water flow builds up behind them and slowly seeps through the water spreaders to maintain swamp moisture; and
- injection grouting of rock substrate where fracturing has occurred.

A summary of these techniques is provided below. Installation of the erosion control works can be undertaken promptly as the need arises and installed within a few weeks.

Knick Point Control

Coir log dams can be installed at knick points (e.g. areas of erosion or scour) if detected during monitoring. Coir logs trap sediment by slowing water and allowing particulate matter to settle and for slow repair to occur. A shallow, narrow trench is cut into the swamp soils such that the first layer of coir logs sits on the underlying substrate or the top of the first coir log is at ground level. The coir logs are held in place by wooden stakes and bound together with wire (Good *et al*., unpublished in BHPIC, 2009). The small coir log dams are constructed at intervals down the erosion channel.

Where increased filtering of flows is required, the coir logs can be wrapped in jute fibre matting. Coir log dams have been successfully used during a number of swamp rehabilitation programs in recent years in the Blue Mountains and Snowy Mountains. The soft-engineering materials used eventually degrade (totally biodegradable) and become integrated into the soil/organic matter complex of the swamps (Good *et al*., unpublished in BHPIC, 2009).

Water Spreading

The maintenance of the swamp moisture regime can also be enhanced by additional water spreading techniques, involving long lengths of coir logs and hessian 'sausages' linked together across the contour such that water flow builds up behind them then slowly seeps through the water spreaders (Good *et al*., unpublished in BHPIC, 2009). The logs can be positioned as required within shallow trenches within a swamp. The soft-engineering materials eventually degrades (totally biodegradable) and becomes integrated into the soil/organic matter complex of the swamps (*ibid*.).

Injection Grouting

Where piezometer data indicate that a fracture has developed under a swamp leading to the potential/actual drying of a swamp substrate, then injection grouting to repair the fracture may be a possibility. If the rock fractures are very narrow, then self-healing may occur via transport of sediments. In cases where self-healing cannot occur because of fracture characteristics, then the use of grouting may be a possibility. The major issues are: (1) identifying the location and scale of the rock fracture, (2) injecting grout to seal the fracture network, and (3) implementing (1) and (2) with minimal impacts on the swamp in question. A variety of inert grouts and filler materials can be injected to fill the voids in the fractured strata intercepted by the drill holes, thereby preventing water loss from an impacted swamp.

9.2.6 Additional Monitoring

Where a performance indicator and/or measure has been exceeded, it may be appropriate to conduct additional monitoring (e.g. increase the frequency of monitoring or the parameters monitored) or conduct additional test work.

9.3 SURFACE DISTURBANCE

The Metropolitan Coal Construction Management Plan describes the management measures that will be implemented for surface construction works (excluding remediation or rehabilitation works) in the Woronora Special Area. The Metropolitan Coal Longwalls 301-303 Water Management Plan and Metropolitan Coal Rehabilitation Management Plan describes the management measures that will be implemented for remediation and rehabilitation works. Management measures include those described in Sections 9.3.1 and 9.3.2 below.

9.3.1 Vegetation Clearance/Habitat Disturbance

Vegetation clearance activities may be required for ongoing surface exploration activities, the upgrade and extension of surface infrastructure, access tracks, environmental monitoring and management activities, stream restoration activities and other mine-related surface activities.

The environmental management of vegetation clearance sites will include:

- Detailed site inspections to identify the specific flora characteristics of the areas proposed to be disturbed.
- Identification of areas in which specific surface works involving vegetation clearance will be avoided or limited (e.g. within swamps, EECs and areas where threatened flora species are present).
- Final site selection and works design so as to minimise the amount of vegetation clearance required.
- Identification of management measures to minimise impacts on flora, prior to, during and/or following the completion of the surface works including natural regeneration and/or rehabilitation measures.

9.3.2 Weed Management

Weed management will be implemented to limit the spread and colonisation of noxious and environmental weeds, where weeds are found to occur in areas subject to mine-related surface activities.
Weed management will include:

- Limiting activities that cause soil disturbance.
- The inspection of vehicles and mechanical equipment brought to the site to avoid importation of foreign material and organic matter.
- Inspections of mine-related surface disturbance areas to identify areas requiring weed management measures to be implemented.

- Implementation of weed management measures (e.g. mechanical removal and application of approved herbicides in authorised areas). Prior to the use of any chemical controls, the chemicals will be approved by the relevant landholder and the Material Safety Data Sheet for the chemical obtained prior to spraying. The implementation of measures that favour the restoration of native vegetation (where appropriate) is also considered an effective method of weed management.
- Follow-up inspections to assess the effectiveness of the weed management measures implemented and the requirement for any additional management measures.
- Consultation with WaterNSW and other relevant land holders in relation to weed management activities.

The weed management activities will be reported in the Annual Review (Section 12).

9.4 OTHER MANAGEMENT MEASURES

9.4.1 Bushfire Hazard

Fire awareness and fire safety training will be included in the induction of all Metropolitan Coal personnel and contractors required to access the Woronora Special Area to reduce the risk of bushfire.

9.4.2 Introduced Pests

Vegetation clearance associated with the Project (e.g. for access tracks) has the potential to increase the occurrence of vertebrate pest species. In accordance with the Metropolitan Coal Construction Management Plan, surface construction works will occupy only small areas of the surface, will involve minimal clearance and disturbed areas will be allowed to naturally regenerate from the soil seed bank when no longer needed. Active planting may be undertaken in areas where natural regeneration is not considered to be progressing.

Management measures for introduced pests will include:

- Maintenance of a clean, rubbish-free environment in order to discourage scavenging and reduce the potential for colonisation of these areas by non-endemic fauna. Employees and contractors will not be permitted to take domestic pets into the Woronora Special Area.
- Reporting sightings of vertebrate pest species to WaterNSW, and the OEH for inclusion in the Atlas of NSW Wildlife in order for the distribution and abundance of the vertebrate pests to be better understood. This is particularly relevant to Feral Deer.
- Subject to consultation with WaterNSW, implementation of pest control measures where observations indicate the need (e.g. the control of Feral Cats and Foxes, or the destruction of rabbit burrows).
- The inclusion of general vertebrate pest awareness in Metropolitan Coal inductions, particularly for staff and contractors accessing the Woronora Special Area.
- Ongoing consultation with WaterNSW and the OEH in relation to the management of vertebrate pest species.

Pest management activities will be reported in the Annual Review (Section 12).

9.4.3 Infection of Native Plants by *Phytophthora cinnamomi*

Measures for the management of *P. cinnamomi* have been developed in consideration of *Management of Phytophthora cinnamomi for Biodiversity Conservation in Australia* (Commonwealth Department of the Environment and Heritage, 2006). Management measures that will be implemented to minimise the potential for the introduction or spread of *P. cinnamomi* include:

- restricting the movement of vehicles to formed tracks and pre-existing roads, where practicable;
- limiting activities that cause soil disturbance; and
- encouraging natural regeneration in areas requiring revegetation.

Measures that will be implemented in the event infestation areas are identified include:

- limiting access to infestation areas;
- limiting access to un-infested areas following entry to infested sites;
- development of hygiene protocols (e.g. clean footwear, equipment, vehicles and/or hygiene stations) to access known infestation areas; and
- the inclusion of *P. cinnamomi* general awareness and procedure information in Metropolitan Coal personnel and contractor inductions, particularly for those requiring access to identified infestation areas.

9.4.4 Amphibian Chytrid Fungus

Personnel conducting amphibian surveys in the Waratah Rivulet and Woronora River catchments, including movement between these two catchments, will be required to observe the following hygiene protocols in accordance with the *Hygiene Protocols for the Control of Disease in Frogs* (NPWS, 2001):

- The thorough cleaning and disinfecting of footwear.
- The thorough cleaning and disinfecting of equipment (such as nets, callipers, headlamps and waders).
- Restricting the movement of vehicles to formed tracks and pre-existing roads, where practicable.
- In the event the amphibian *Chytrid* fungus is known to be present at a site, that site would be the last site surveyed/sampled, where practicable.

10 CONTINGENCY PLAN

In the event the subsidence impact biodiversity performance measure for threatened species, populations or ecological communities detailed in Section 6 is considered to have been exceeded, Metropolitan Coal will implement the following Contingency Plan:

- the exceedance will be reported to the Manager – Technical Services and/or the Environment & Community Superintendent within 24 hours.
- The Manager – Technical Services and/or the Environment & Community Superintendent will report the likely exceedance to the General Manager as soon as practicable after becoming aware of the exceedance.

- Metropolitan Coal will report the likely exceedance of the biodiversity performance measure to the DP&E, OEH and DPI – Fishing as soon as practicable after Metropolitan Coal becomes aware of the exceedance.
- Metropolitan Coal will identify an appropriate course of action with respect to the identified impact(s), in consultation with specialists and relevant agencies, as necessary. For example:
  - proposed contingency measures;
  - a program to review the effectiveness of the contingency measures; and
  - consideration of adaptive management under circumstances where a water resource or watercourse performance measure detailed in Table 1 of the Project Approval has been exceeded.

  Contingency measures will be developed in consideration of the specific circumstances of the exceedance and the assessment of environmental consequences. Potential contingency measures include management measures described in this BMP, the Metropolitan Coal Longwalls 301-303 Land Management Plan and Metropolitan Coal Longwalls 301-303 Water Management Plan.
- Metropolitan Coal will submit the proposed course of action to the DP&E for approval.
- Metropolitan Coal will implement the approved course of action to the satisfaction of the DP&E.

In accordance with Condition 6, Schedule 6 of the Project Approval, Metropolitan Coal will provide a suitable offset to compensate for the impact to the satisfaction of the Secretary of the DP&E if either the contingency measures implemented by Metropolitan Coal have failed to remediate the impact or the Secretary of the DP&E determines that it is not reasonable or feasible to remediate the impact.

11 FUTURE EXTRACTION PLANS

In accordance with Condition 7, Schedule 3 of the Project Approval, Metropolitan Coal will collect baseline data for the next Extraction Plan (i.e. Longwalls 304-306). The collection of baseline data for upland swamps, riparian vegetation, slopes and ridgetops, aquatic biota and their habitats, and terrestrial fauna and their habitats is described below.

A workshop was held in December 2017 with Cenwest Environmental Services and Eco Logical to further discuss the monitoring design and collection of baseline ecological data for Longwalls 304-306 as well as potential ecological investigations to inform future extraction plans. Where relevant, the outcomes of the workshop have been incorporated into Sections 11.1 to 11.5.

11.1 UPLAND SWAMPS

The upland swamps situated to the north-west of Longwalls 301-303 were inspected in July/August 2016 to confirm the extent of the upland swamps and the vegetation communities present to inform the next Extraction Plan. To date, baseline transect and quadrat vegetation surveys for the next Extraction Plan have been conducted in spring 2015, autumn 2016, spring 2016, autumn 2017, spring 2017 and autumn 2018 in Swamps 48, 50 and 71a overlying Longwalls 304 and 305 (Figure 15) consistent with the methods used for Longwalls 20-22, Longwalls 23-27 and Longwalls 301-303 upland swamp vegetation monitoring programs. Baseline data will continue to be collected in Swamps 48, 50 and 71a upland swamp transect/quadrat monitoring sites prior to the next Extraction Plan.

In October 2016, a number of swamps situated over or in the vicinity of Longwalls 304-306 were subject to a hazard reduction burn conducted by WaterNSW, including Swamps 63, 64, 65/66, 67, 68a, 68b, 69, 70, 71a and 71b. As Swamp 71a, which has been subject to baseline vegetation monitoring for Longwalls 304-306 has been affected by the hazard reduction burn, this will have implications for the data analyses that can be conducted for Longwalls 304-306.

Paired swamp piezometers were installed in Swamps 50 and 71a in June 2016. Additional swamps have been inspected to determine appropriate locations for proposed additional swamp groundwater piezometers in consideration of the Draft Upland Swamps Policy and IESC advice. A Construction Management Plan Surface Works Assessment Form will be submitted shortly to the DP&E and WaterNSW in this regard.

11.2 RIPARIAN VEGETATION

No significant streams are located to the immediate west of Longwalls 301-303 with the exception of the Eastern Tributary. As such no riparian vegetation monitoring will be required in this area.

The baseline riparian vegetation monitoring data that has already been obtained for the Eastern Tributary (as described in Section 7) will be applicable to the next Extraction Plan.

11.3 SLOPES AND RIDGETOPS

Cliffs COH11, COH12 and COH13 adjacent to the Woronora Reservoir (over Longwalls 307 and 308) were identified during the Project EA (MSEC, 2008). In accordance with the Metropolitan Coal Longwalls 301-303 Land Management Plan, if Cliffs COH11, COH12 and COH13 are located within 600 m of the next Extraction Plan longwall layout, the following baseline data will be obtained for these cliffs and included in the Extraction Plan:

- photographic records of each cliff and overhang;
- sketches of overhangs; and
- mapping of the approximate location of the cliff/overhang face and the rear extent of the overhang/undercut.

In accordance with the Metropolitan Coal Longwalls 301-303 Land Management Plan, baseline data collection for the next Extraction Plan will also include a description of steep slopes and land in general and a description of the recorded subsidence impacts within 600 m of the next Extraction Plan longwall layout (i.e. where mining of Longwalls 301-303 has resulted in subsidence impacts overlying the next Extraction Plan longwall layout [if any] at the time of Extraction Plan preparation).

11.4 AQUATIC BIOTA AND THEIR HABITATS

As described in Section 11.2, no significant streams are located to the immediate west of Longwalls 301-303 with the exception of the Eastern Tributary and as such no baseline data for aquatic habitats (e.g. pool water levels and water quality) will be required to be collected in this area.

The baseline aquatic macroinvertebrate and macrophyte monitoring data that has already been obtained for the Eastern Tributary will be applicable to the next Extraction Plan mining domain.

11.5 TERRESTRIAL FAUNA AND THEIR HABITATS

Baseline data will be collected for terrestrial fauna habitats (i.e. upland swamps, riparian vegetation, slopes and ridgetops, and aquatic habitats), as described in Sections 11.1 to 11.4.

A total of 28 amphibian survey sites have been established for Longwalls 20-22, Longwalls 23-27 and Longwalls 301-303, including 17 test sites overlying or adjacent to longwalls to monitor amphibian species, with a focus on the habitats of the Giant Burrowing Frog and Red-crowned Toadlet. No additional control sites are required to ensure a continuing robust experimental design with the addition of test sites for Longwalls 301-303.

Two additional amphibian survey sites situated over Longwalls 305-306 (test sites) and two additional control amphibian survey sites will be established and surveyed in spring/summer 2018.

Baseline data will be collected for terrestrial fauna habitats (i.e. upland swamps, riparian vegetation, slopes and ridgetops, and aquatic habitats), as described in Sections 11.1 to 11.4.

12 ANNUAL REVIEW AND IMPROVEMENT OF ENVIRONMENTAL PERFORMANCE

In accordance with Condition 3, Schedule 7 of the Project Approval, Metropolitan Coal will conduct an Annual Review of the environmental performance of the Project by the end of March each year.

The Annual Review will specifically address the environmental performance of the BMP and will:

- describe the works that were carried out in the past calendar year, and the works that are proposed to be carried out over the current calendar year;
- include a comprehensive review of the monitoring results and complaints records of the Project over the past year, including a comparison of these results against the:
  - relevant statutory requirements, limits or performance measures/criteria;
  - monitoring results of previous years; and
  - relevant predictions in the Project EA, Preferred Project Report and Extraction Plan;
- identify any non-compliance over the last year, and describe what actions were (or are being) taken to ensure compliance;
- identify any trends in the monitoring data over the life of the Project;
- identify any discrepancies between the predicted and actual impacts of the Project, and analyse the potential cause of any significant discrepancies; and
- describe what measures will be implemented over the next year to improve the environmental performance of the Project.

The Annual Review will also review the current monitoring programs, including if and when cessation of some monitoring activities is appropriate.

As described in Section 2, this BMP will be reviewed within three months of the submission of an Annual Review, and revised where appropriate.

13 INCIDENTS

An incident is defined as a set of circumstances that causes or threatens to cause material harm to the environment, and/or breaches or exceeds the limits or performance measures/criteria in the Project Approval.

The reporting of incidents will be conducted in accordance with Condition 6, Schedule 7 of the Project Approval. Metropolitan Coal will notify the Secretary of the DP&E and any other relevant agencies of any incident associated with the Project as soon as practicable after Metropolitan Coal becomes aware of the incident. Within seven days of the date of the incident, Metropolitan Coal will provide the Secretary and any relevant agencies with a detailed report on the incident.

14 COMPLAINTS

A protocol for the managing and reporting of complaints has been developed as a component of Metropolitan Coal's Environmental Management Strategy and is described below.

The Environment & Community Superintendent is responsible for maintaining a system for recording complaints.

Metropolitan Coal will maintain public signage advertising the telephone number on which environmental complaints can be made. The Environment & Community Superintendent is responsible for ensuring that the currency and effectiveness of the service is maintained. Notifications of complaints received are to be provided as quickly as practicable to the Environment & Community Superintendent.

Complaints and enquiries do not have to be received via the telephone line and may be received in any other form. Any complaint or enquiry relating to environmental management or performance is to be relayed to the Environment & Community Superintendent as soon as practicable. All employees are responsible for ensuring the prompt relaying of complaints. All complaints will be recorded in a complaints register.

For each complaint, the following information will be recorded in the complaints register:

- date and time of complaint;
- method by which the complaint was made;
- personal details of the complainant which were provided by the complainant or, if no such details were provided, a note to that effect;
- nature of the complaint;
- the action(s) taken by Metropolitan Coal in relation to the complaint, including any follow-up contact with the complainant; and
- if no action was taken by Metropolitan Coal, the reason why no action was taken.

The Environment & Community Superintendent is responsible for ensuring that all complaints are appropriately investigated, actioned and that information is fed back to the complainant, unless requested to the contrary.

In accordance with Condition 10, Schedule 7 of the Project Approval, the complaints register will be made publicly available on the Peabody website and updated on a monthly basis. A summary of complaints received and actions taken will be presented to the Community Consultative Committee as part of the operational performance review.

15 NON-COMPLIANCES WITH STATUTORY REQUIREMENTS

A protocol for the managing and reporting of non-compliances with statutory requirements has been developed as a component of Metropolitan Coal's Environmental Management Strategy and is described below.

Compliance with all approvals, plans and procedures will be the responsibility of all personnel (staff and contractors) employed on or in association with Metropolitan Coal, and will be developed through promotion of Metropolitan Coal ownership under the direction of the General Manager.

The Manager – Technical Services and/or Environment & Community Superintendent will undertake regular inspections, internal audits and initiate directions identifying any remediation/rectification work required, and areas of actual or potential non-compliance.

As described in Section 13, Metropolitan Coal will notify the Secretary of the DP&E and any other relevant agencies of any incident associated with Metropolitan Coal as soon as practicable after Metropolitan Coal becomes aware of the incident. Within seven days of the date of the incident, Metropolitan Coal will provide the Secretary of the DP&E and any relevant agencies with a detailed report on the incident.

A review of Metropolitan Coal's compliance with all conditions of the Project Approval, mining leases and all other approvals and licences will be undertaken prior to (and included within) each Annual Review. The Annual Review will be made publicly available on the Peabody website.

Additionally, in accordance with Condition 8, Schedule 7 of the Project Approval, an independent environmental audit was undertaken by the end of December 2011, and is undertaken a minimum of once every three years thereafter. A copy of the audit report will be submitted to the Secretary of the DP&E and made publicly available on the Peabody website. The independent audit will be undertaken by an appropriately qualified, experienced and independent team of experts whose appointment has been endorsed by the Secretary of the DP&E.

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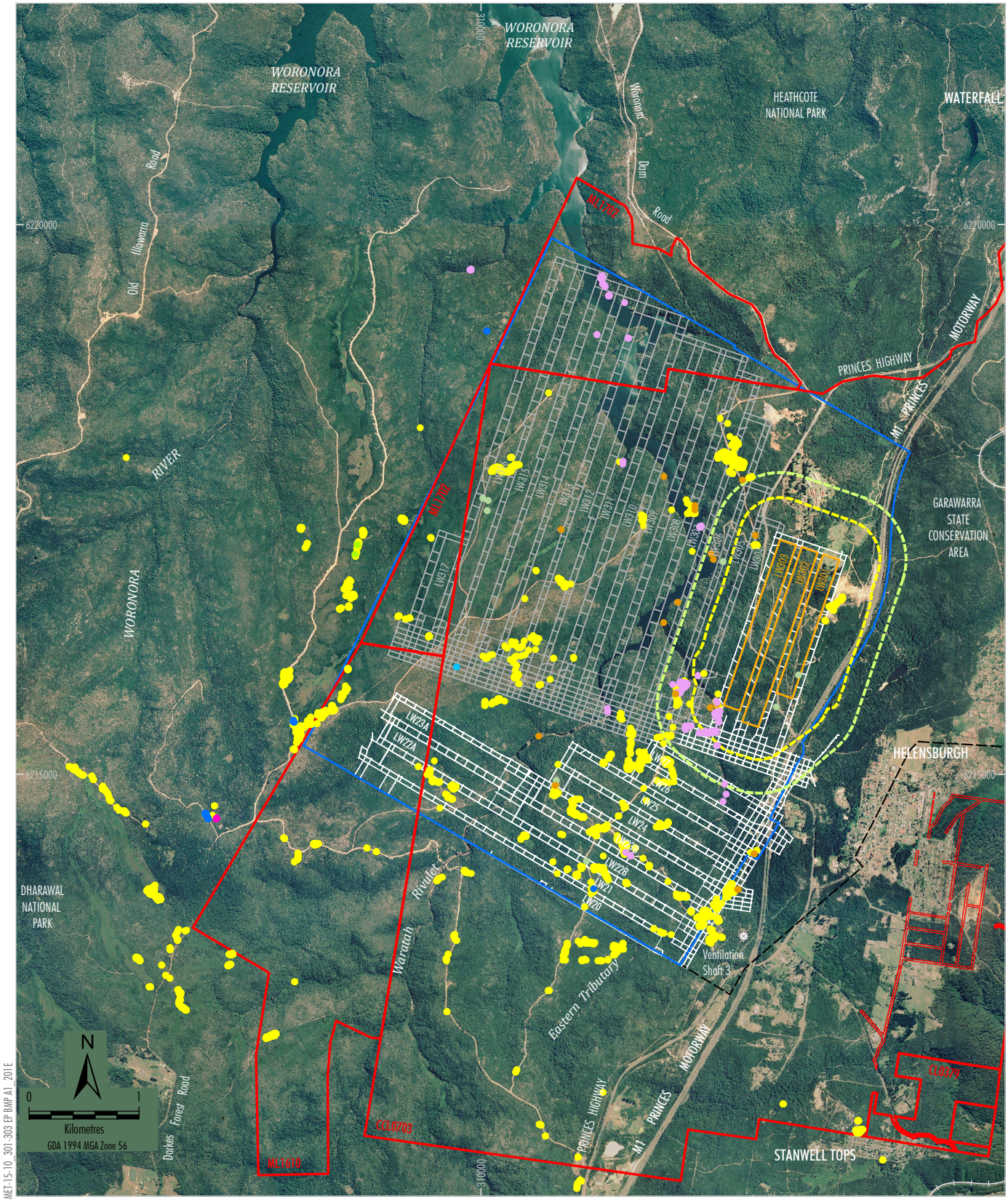
APPENDIX 1

THREATENED FLORA AND FAUNA SPECIES RECORDS



MET-15-10_301-303 EP BMP A1_201E

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)

Confirmed Threatened Species

- *Astrotricha crassifolia*
- *Acacia bynoeana*
- *Acacia baueri* subsp. *aspera*
- *Melaleuca deanei*
- *Pultenaea aristata*
- *Cryptostylis hunteriana*

Potential (Unconfirmed) Threatened Species

- *Epacris purpurascens* var. *purpurascens*
- *Leucopogon exolasius*

Notes 1. Includes threatened species records up to and including the Autumn 2015 surveys.
2. Each symbol is indicative of a specific location rather than the number of individuals of each species.

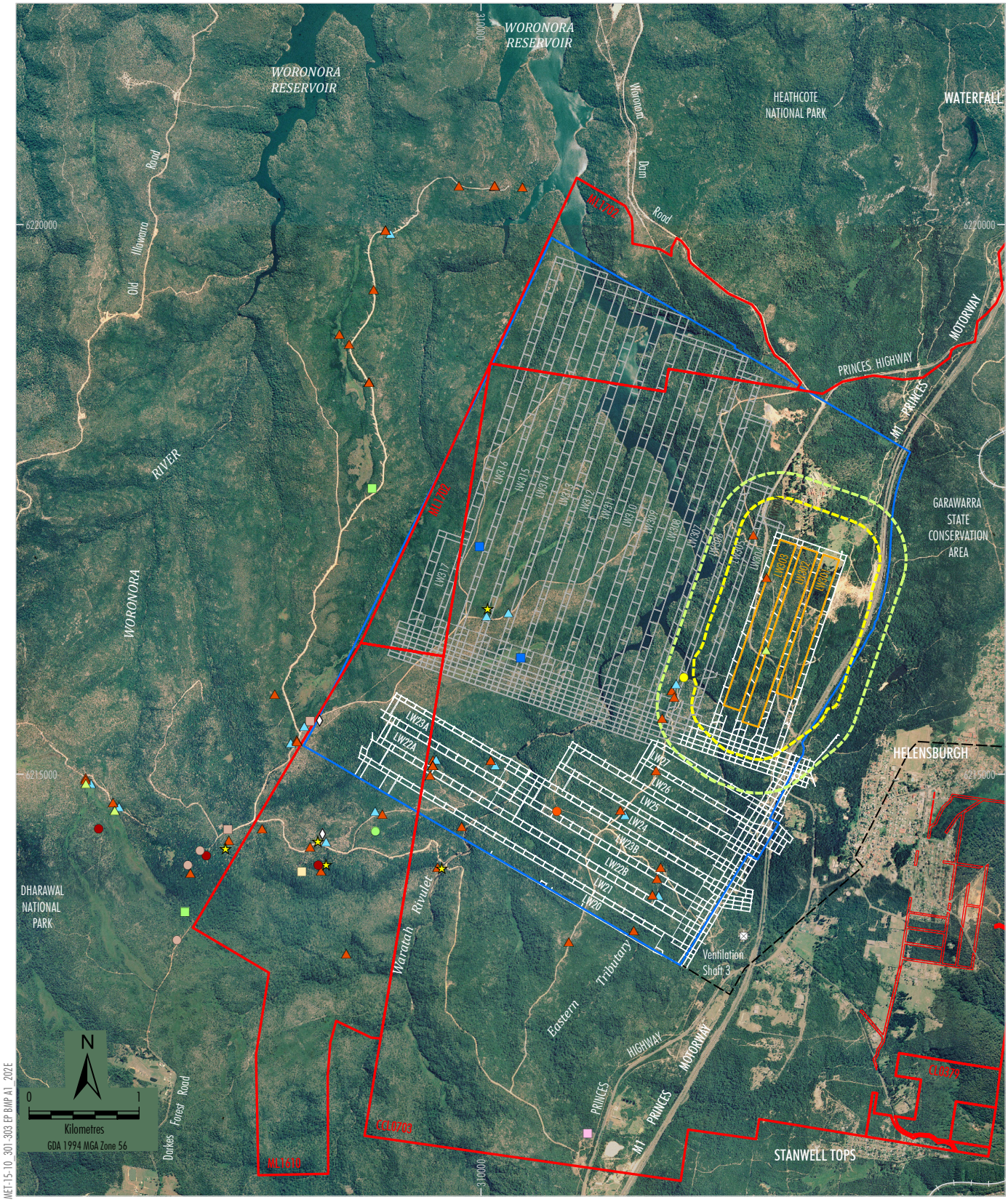
Source: Land and Property Information (2015); Date of Aerial Photography 1998; Department of Industry (2015); Metropolitan Coal (2018); MSEC (2018); Threatened species recorded by Bangalay Botanical Surveys (2008); FloraSearch (2008, 2009); Eco Logical (2010-2015)

Peabody

METROPOLITAN COAL

Threatened Flora Recorded During Metropolitan Coal Surveys

Figure 1-1



MET-15-10_301-303 EP BMP A1_202E

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)

Threatened Fauna

- Giant Burrowing Frog
- Littlejohn's Tree Frog
- Red-crowned Toadlet
- Grey Falcon
- Square-tailed Kite
- Black-necked Stork
- Eastern Ground Parrot
- Turquoise Parrot
- Grey-headed Flying Fox
- Large-footed Myotis
- Squirrel Glider
- Eastern Pygmy-possum
- Eastern Bentwing Bat
- Broad-headed Snake
- Diggings that could potentially belong to the threatened Southern Brown Bandicoot or Long-nosed Potoroo, or the Protected Long-nosed Bandicoot

Notes: 1. Includes threatened species records up to March 2016.
2. Each symbol is indicative of a specific location rather than the number of individuals of each species.

Source: Land and Property Information (2015); Date of Aerial Photography 1998; Department of Industry (2015); Metropolitan Coal (2018); MSEC (2018); Threatened Species recorded by Western Research Institute and Biosphere Environmental Consultants (2008); Cenwest Environmental Services (2008-2017)

Peabody

METROPOLITAN COAL

Threatened Fauna Recorded During Metropolitan Coal Surveys

Figure 1-2

APPENDIX 2

LONGWALLS 301-303 UPLAND SWAMP VEGETATION MAPPING AND PROPOSED MONITORING PROGRAM

.

Longwalls 301-303 Upland Swamp Vegetation Mapping and Proposed Monitoring Program

Prepared for
Metropolitan Coal




DOCUMENT TRACKING

Item	Detail
Project Name	Longwalls 301-303 Upland Swamp Vegetation Mapping and Proposed Monitoring Program
Project Number	2544
Project Manager	Elizabeth Norris (02) 8536 8600 Level 3, Suite 2 668 – 672 Old Princes Highway Sutherland NSW 2232
Prepared by	Brian Towle & Elizabeth Norris
Reviewed by	Bruce Mullins
Approved by	Bruce Mullins
Status	Final
Version Number	3
Last saved on	6 August 2016
Cover photo	Upland swamps overlying Longwalls 301-303, Elizabeth Norris, August 2015

This report should be cited as 'Eco Logical Australia 2016. *Longwalls 301-303 Upland Swamp Vegetation Mapping and Proposed Monitoring Program*. Prepared for Metropolitan Coal.'

ACKNOWLEDGEMENTS

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1 Introduction

Metropolitan Coal was granted approval (08_0149) for the Metropolitan Coal Project in accordance with Section 75J of the *Environmental Planning and Assessment Act, 1979* on 22 June 2009. In accordance with Project Approval Condition 6, Schedule 3, an Extraction Plan must be prepared for all second workings which must include a Biodiversity Management Plan to manage the potential environmental consequences of the Extraction Plan on aquatic and terrestrial flora and fauna, with a specific focus on swamps. The term 'swamps' in this report is used to refer to all vegetation communities identified as forming the Upland Swamps Complex, as described by NSW National Parks and Wildlife Services (NPWS 2003).

This report has been prepared to update previous vegetation mapping of upland swamps within 600 metres (m) of Longwalls 301-303 secondary extraction, and to inform the Longwalls 301-303 Biodiversity Management Plan. Specifically, the aims of this report are to:

- Validate existing mapping of upland swamp vegetation within 600 m of Longwalls 301-303 secondary extraction, and where appropriate update vegetation mapping.
- Document any revisions to the existing vegetation mapping.
- Document the vegetation characteristics of each swamp.
- Conduct searches for indicator species within the swamps to inform the vegetation monitoring program design for Longwalls 301-303.
- Provide a detailed design of the proposed vegetation monitoring program for Longwalls 301-303 consistent with the Longwalls 20-22 and 23-27 Biodiversity Management Plans (Metropolitan Coal 2014; Metropolitan Coal 2015).

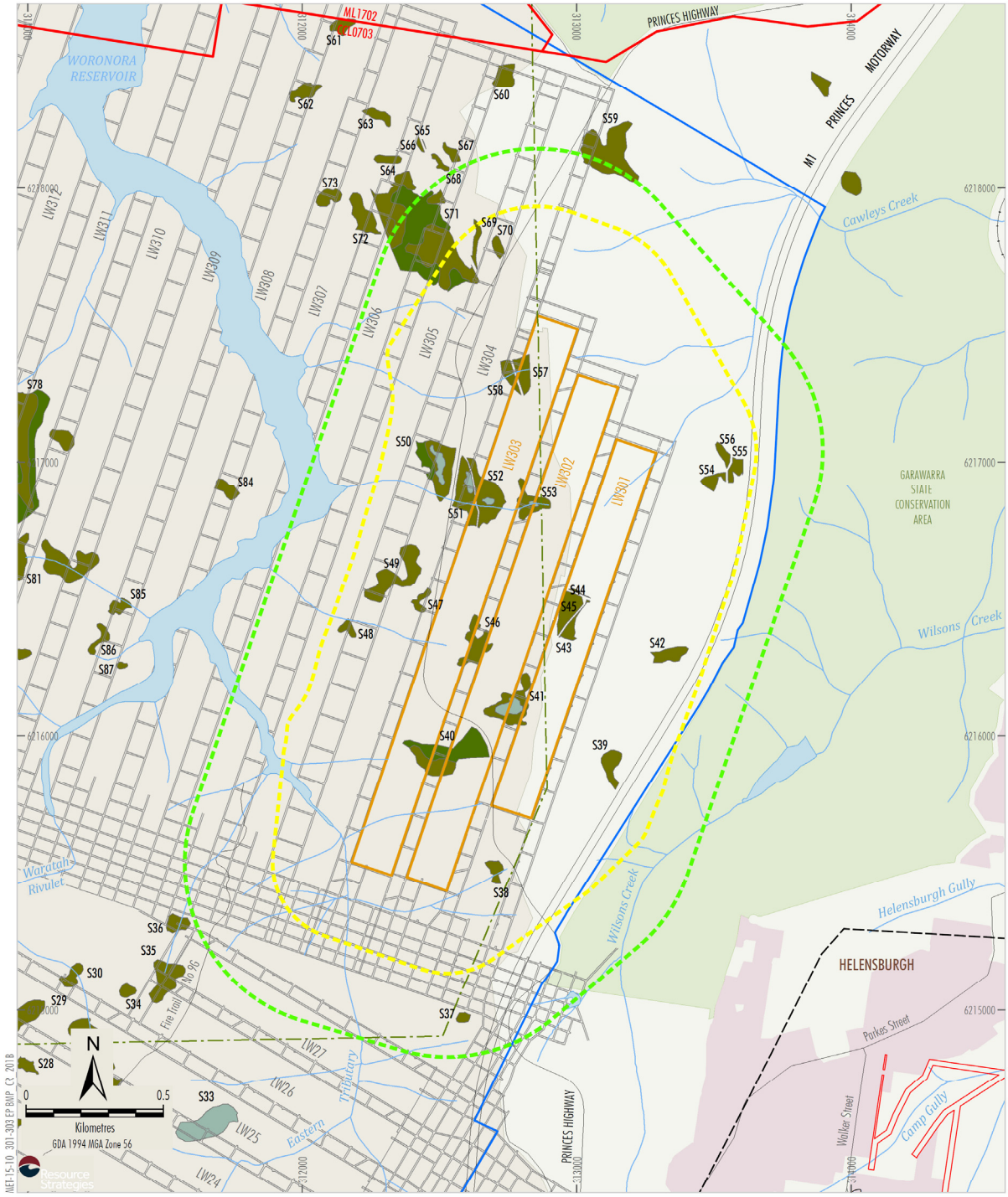
2 Bangalay Botanical Surveys (2008) Vegetation Mapping

A baseline flora survey of the Metropolitan Coal longwall mining area was undertaken by Bangalay Botanical Surveys (2008) for the Metropolitan Coal Project Environmental Assessment (Helensburgh Coal Pty Ltd, 2008). This baseline flora survey identified and mapped vegetation communities for a large area of the Metropolitan Coal lease boundary including the area overlying Longwalls 301-303 and surrounds. The identification of vegetation communities in the baseline flora survey (Bangalay Botanical Surveys 2008) largely followed the vegetation mapping of the Woronora, O'Hares and Metropolitan Catchments by NSW National Parks and Wildlife Services (NPWS 2003).

A number of distinct vegetation communities have been identified as comprising the Upland Swamps Complex within the Woronora, O'Hares and Metropolitan Catchments (NPWS 2003), with four distinct upland swamp vegetation communities identified by Bangalay Botanical Surveys (2008) namely:

- Tea Tree Thicket;
- Banksia Thicket;
- Sedgeland–heath Complex (an amalgamation of the Sedgeland, Restioid Heath and Cyperoid Heath vegetation associations identified by Keith & Myerscough [1993] consistent with NPWS [2003]); and
- Fringing Eucalypt Woodland.

A total of 25 Upland Swamps were identified by Bangalay Botanical Surveys (2008) within 600 m of Longwalls 301-303 secondary extraction. The Bangalay Botanical Surveys (2008) mapping of upland swamps is shown on **Figure 1**. A summary of the vegetation mapping and location relative to Longwalls 301-303 for each of these swamps is provided in **Table 1**.



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)

Map Unit	Vegetation Community
3a	Upland Swamp: Banksia Thicket
3b	Upland Swamps: Tea Tree Thicket
3c	Upland Swamp: Sedgeland-heath Complex
3d	Upland Swamp: Fringing Eucalypt Woodland

Source: Land and Property Information (2015); Department of Industry (2015); Metropolitan Coal (2016); MSEC (2016); Bangalay Botanical Surveys (2008)

Peabody ENERGY

METROPOLITAN COAL

Upland Swamp Vegetation Mapping by Bangalay Botanical Surveys (2008)

Figure 1

Table 1: Upland Swamps within 600 m of Longwalls 301-303 Secondary Extraction (Bangalay Botanical Surveys 2008)

Swamp Number	Over Longwalls 301-303 or Pillars	Within 600 m from Secondary Extraction	Vegetation Community (Bangalay Botanical Surveys 2008)
S37		X	Sedgeland-heath Complex
S38		X	Sedgeland-heath Complex
S39		X	Sedgeland-heath Complex
S40	X		Sedgeland-heath Complex/Fringing Eucalypt Woodland
S41	X		Sedgeland-heath Complex/Banksia Thicket
S42		X	Sedgeland-heath Complex
S43/S44/S45	X		Sedgeland-heath Complex
S46	X		Sedgeland-heath Complex
S47	X		Sedgeland-heath Complex
S48		X	Sedgeland-heath Complex
S49		X	Sedgeland-heath Complex
S50		X	Sedgeland-heath Complex/Banksia Thicket/Fringing Eucalypt Woodland
S51/S52	X		Sedgeland-heath Complex/Banksia Thicket
S53	X		Sedgeland-heath Complex/Banksia Thicket
S54/S55/S56		X	Sedgeland-heath Complex
S57/S58	X		Sedgeland-heath Complex
S59		X	Sedgeland-heath Complex
S69		X	Sedgeland-heath Complex
S70		X	Sedgeland-heath Complex
S71		X	Sedgeland-heath Complex/Fringing Eucalypt Woodland

3 Methods

3.1 Eco Logical Australia (2015) Upland Swamp Vegetation Mapping

Field inspections of Upland Swamp vegetation were undertaken by two ecologists, Elizabeth Norris and Brian Towle, on three days, the 8th and 9th of July and the 19th of August 2015. At each Upland Swamp mapped by Bangalay Botanical Surveys (2008), the extent of the mapped polygon was traversed to confirm the presence of Upland Swamp vegetation communities, confirm the boundaries and extent of these vegetation communities and identify the specific vegetation community present (i.e. Banksia Thicket, Sedgeland-heath Complex, Tea Tree Thicket or Fringing Eucalypt Woodland).

For each area confirmed as an Upland Swamp a description of the vegetation was recorded including the different stratum present, the dominant species and an estimation of percent foliage cover for each stratum. These descriptions formed the basis for assigning vegetation communities described by NPWS (2003) and Bangalay Botanical Surveys (2008). Final delineation of vegetation community boundaries was undertaken by interpretation of aerial photographs. Patterns identified on aerial photographs were related to the field observations and used to delineate the boundaries of vegetation communities.

3.2 Indicator Species

The presence of indicator species for each vegetation type (as identified and monitored within the vegetation communities as part of the Longwalls 20-22 and Longwalls 23-27 vegetation monitoring programs) was noted, including a rapid assessment of the number of individuals for each indicator species. The indicator species targeted by the field survey and inspections were *Epacris obtusifolia, Sprengelia incarnata* and *Pultenaea aristata.*

4 Results

4.1 Upland Swamp Vegetation Mapping

All swamps within 600 m of Longwalls 301-303 secondary extraction were identified as 'valley side swamps'. The highly dissected landscape, with narrow ridges overlying Longwalls 301-303 does not contain broad plateaux capable of supporting the larger 'headwater swamps'. While 'in-valley swamps' which occur on incised second and third order watercourses, have previously been identified within highly dissected landscapes, none were identified within this area.

The field inspections indicated that several of the upland swamps identified by Bangalay Botanical Surveys (2008) (which was based on NPWS [2003] mapping) did not comprise Upland Swamp vegetation. Specifically, the following swamps mapped by Bangalay Botanical Surveys (2008) (as shown on **Figure 1**) were identified as supporting non-swamp vegetation communities:

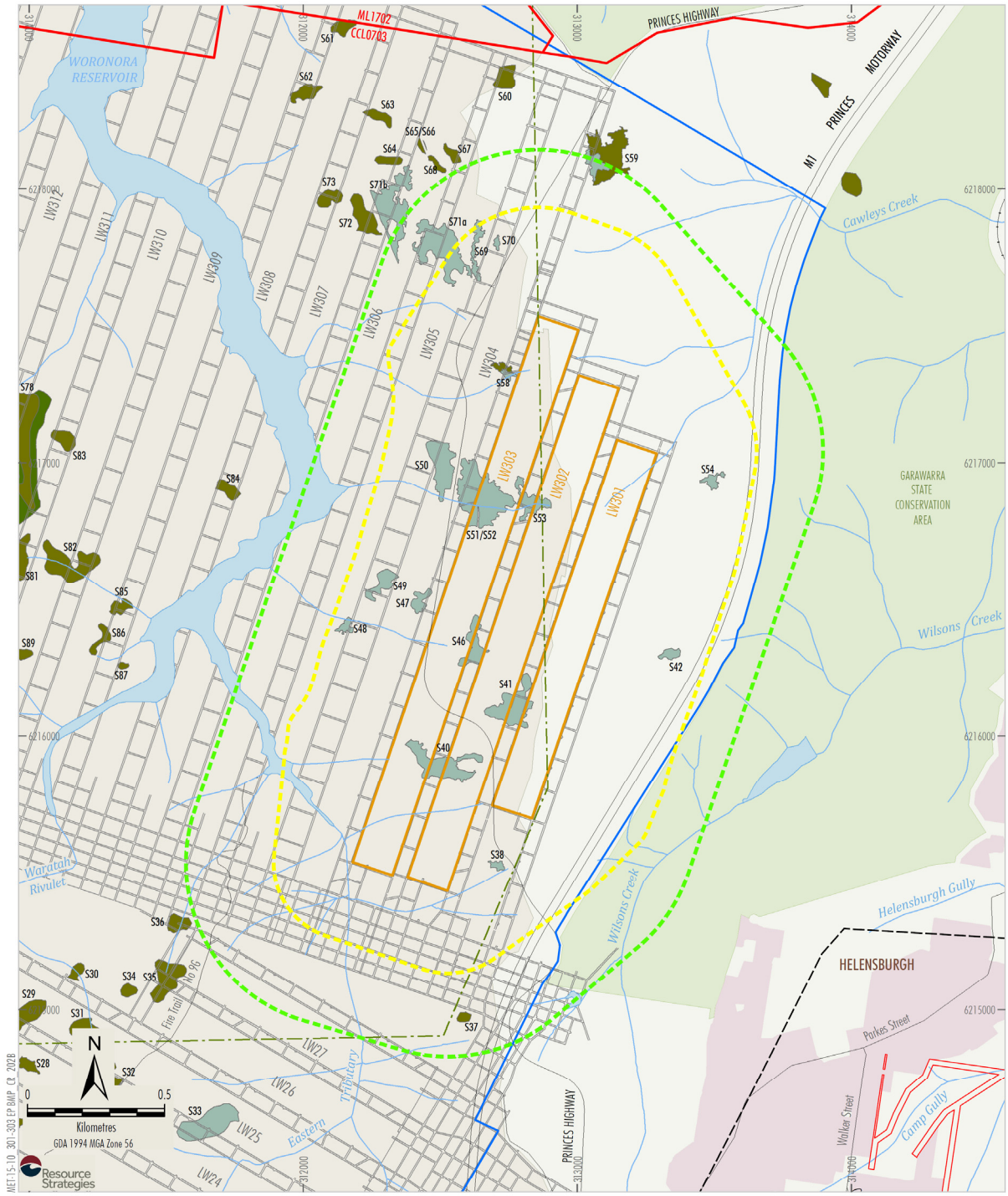
- S39 – The previously mapped extent of this swamp (Bangalay Botanical Surveys 2008) was found to support Sandstone Gully Apple-Peppermint Forest occurring along a drainage line.
- S43/44/45 – The previously mapped extent of these swamps (Bangalay Botanical Surveys 2008) consisted of a single stand of Disturbed and/or Regenerating Sandstone or Lateritic Communities as described by Bangalay Botanical Surveys (2008).

- S55/S56 – Consists of Disturbed and/or Regenerating Sandstone or Lateritic Communities (S55) following previous disturbance following transmission line maintenance and Sandstone Heath-Woodland (S56).
- S57 – The mapped extent of this swamp supports an area of Exposed Sandstone Scribbly Gum Woodland.

In addition to the areas of remapped vegetation above, a large portion of three swamps identified by Bangalay Botanical Surveys (2008) were identified as supporting a woodland/forest vegetation community (i.e. not a swamp). Namely, Swamps 38, 49 and 58 were identified as having a much reduced extent with large portions mapped by Bangalay Botanical Surveys (2008) identified by Eco Logical Australia as supporting Sandstone Gully Apple-Peppermint Forest (Swamps 38 and 49) and Exposed Sandstone Scribbly Gum Woodland (Swamp 58).

The upland swamps within 600 m of Longwalls 301-303 secondary extraction were all identified as supporting the Banksia Thicket vegetation community, with the exception of Swamps 58 and 59 (**Figure 2**), which were identified as supporting both Banksia Thicket and Sedgeland-heath Complex. The occurrence of Sedgeland-heath Complex was limited to these two swamps (Swamps 58 and 59) and only in the portions of these swamps with evidence of recent fire disturbance (following hazard reductions burns undertaken in this area during the last two years). Much of the Banksia Thicket identified within 600 m of Longwalls 301-303 secondary extraction was mapped by Bangalay Botanical Surveys (2008) as Sedgeland-heath Complex. The mapping of Bangalay Botanical Surveys (2008) was based upon field surveys undertaken between late 2006 and early 2008, approximately five years post the fire of December 2001 and January 2002, which extensively burnt the catchments of Woronora, O'Hares, Nepean and Avon. The identification of the Banksia Thicket vegetation community in areas previously mapped as Sedgeland-heath Complex (**Figures 1 and 2**) may relate to the finer scale of vegetation mapping undertaken as part of the Longwalls 301-303 surveys, or may be related to the timing of surveys since recent fire events.

The revised swamp boundaries are shown on Figure 2 and in **Appendix A**. Profiles for each of the swamps including the specific vegetation community confirmed as occurring, updated boundaries, photos and key vegetation characteristics of each swamp are also provided in **Appendix A.** The revised vegetation community mapping (as a result of the revised upland swamp boundaries and vegetation community classification within 600 m of Longwalls 301-303 secondary extraction) by Eco Logical Australia is shown on **Figure 3**.



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)

Map Unit	Vegetation Community
3a	Upland Swamp: Banksia Thicket
3b	Upland Swamps: Tea Tree Thicket
3c	Upland Swamp: Sedgeland-heath Complex
3d	Upland Swamp: Fringing Eucalypt Woodland

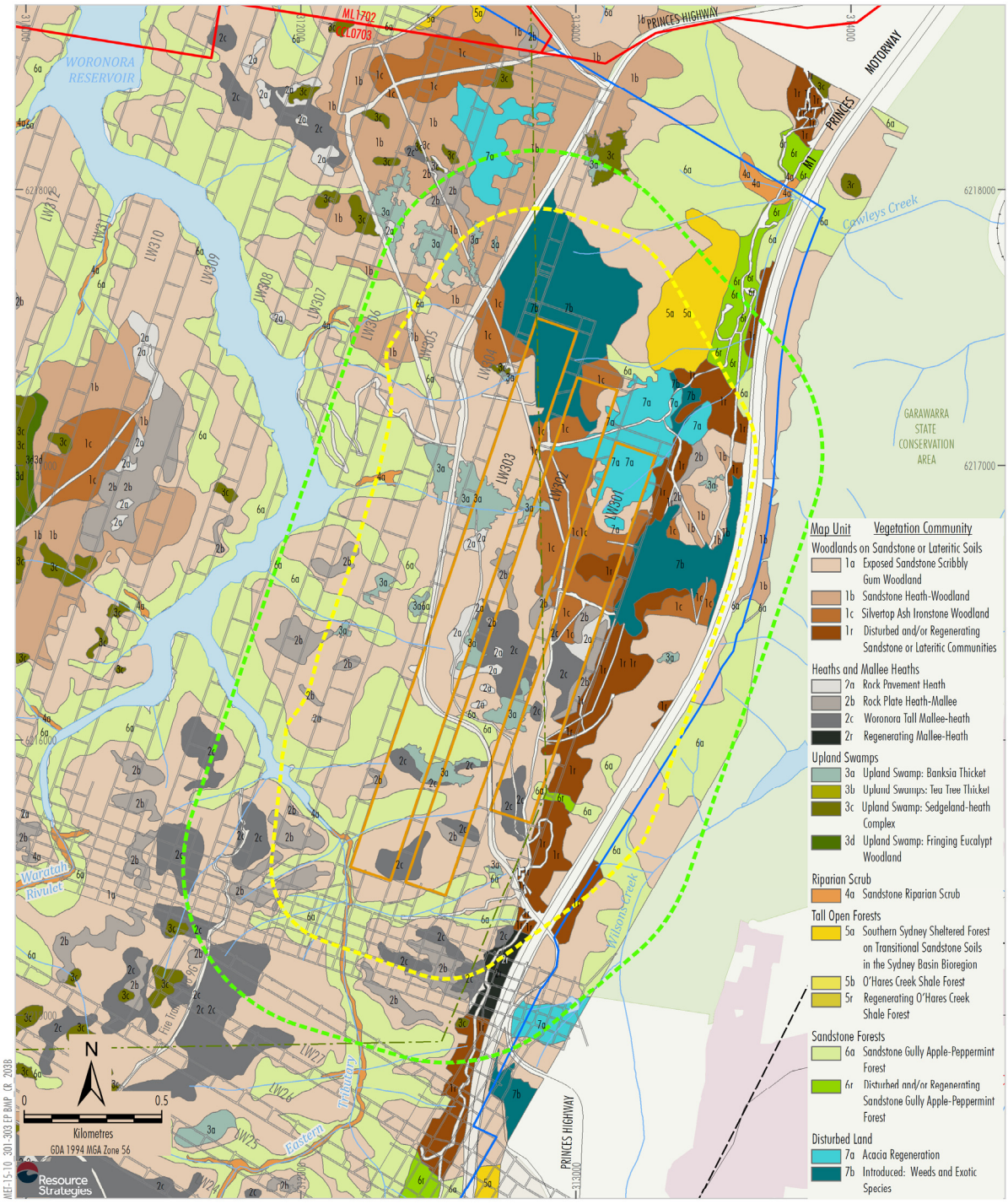
Source: Land and Property Information (2015); Department of Industry (2015); Metropolitan Coal (2016); MSEC (2016); after Bangalay Botanical Surveys (2008); Eco Logical Australia (2015)

Peabody ENERGY

METROPOLITAN COAL

Longwalls 301 - 303
Upland Swamps

Figure 2



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 (2016); MSEC (2016); after Bangalay Botanical Surveys (2008); Eco Logical Australia (2015)

Peabody ENERGY

METROPOLITAN COAL

Longwalls 301 - 303 Vegetation Mapping

Figure 3

The field surveys undertaken for this report were undertaken some 12 years post fire compared to five years for the Bangalay Botanical Surveys (2008). Much of the Upland Swamp vegetation mapped as Banksia Thicket in this report is likely to have had more affinity to the Sedgeland-heath Complex in the years immediately following the fires in 2001/2002. Keith & Myerscough (1993) observed that the boundaries delineating Banksia Thicket may shift after fire and speculated that fires influence the relative occurrence of Upland Swamp communities that occur in drier habitats, including Banksia Thicket, Restioid Heath & Sedgeland.

Bangalay Botanical Surveys (2008) identified relatively large stands of Fringing Eucalypt Woodland as occurring within portions of Swamps 40, 50 and 71 (**Figure 1**). Fringing Eucalypt Woodland was described by NPWS (2003) as occurring at the ecotone between the Upland Swamps communities and the surrounding Sandstone Woodland and as consisting of widely spaced eucalypts marking the transition between sandstone woodland and treeless heath and sedgelands (NPWS 2003). Field investigations undertaken as part of this report identified sharp boundaries between stands of Banksia Thicket and adjacent woodland vegetation communities with respect to the presence or absence of a eucalypt canopy. As such, these areas have been classified by Eco Logical Australia as forming components of adjacent sandstone woodland or forest communities and not as part of Upland Swamp vegetation mapping (**Figure 2** and **Appendix A**). Swamp 71 has been revised in this report to Swamps 71a and 71b (**Figure 2** and **Appendix A**).

4.2 Indicator Species

Indicator species were identified in the swamps as follows:

- In Swamp 37, no swamp indicator species were observed.
- In Swamp 38, no swamp indicator species were observed.
- In Swamp 40, indicator species were present including *Epacris obtusifolia* (>20 individuals) and *Sprengelia incarnata* (>20 individuals). *Pultenaea aristata* was not recorded.
- In Swamp 41, only one swamp indicator species was identified in sufficient numbers to allow for monitoring, *Epacris obtusifolia*.
- In Swamp 42, only five individuals of *Epacris obtusifolia* were recorded.
- In Swamp 46, indicator species were sparse within the swamp and limited to a few individuals of *Epacris obtusifolia* (4 recorded) and *Pultenaea aristata* (2 recorded). No *Sprengelia incarnata* was recorded within this swamp.
- In Swamp 47, no swamp indicator species were observed.
- In Swamp 48, indicator species were observed, although they were limited to *Epacris obtusifolia* (>20 individuals) and a single individual of *Pultenaea aristata* (more individuals may subsequently be located). No individuals of *Sprengelia incarnata* were recorded within this swamp.
- In Swamp 49, indicator species within the swamp were limited to a small number of *Epacris obtusifolia* individuals (only 12 recorded). No individuals of *Sprengelia incarnata or Pultenaea aristata* were recorded.
- In Swamp 50, indicator species were present within this swamp, although they were limited to *Epacris obtusifolia* (> 20 individuals) and *Sprengelia incarnata* (> 20 individuals) with only scattered individuals of *Pultenaea aristata* present (only 3 recorded).

- In Swamp 51/52, indicator species were present within this swamp, although they were limited to *Epacris obtusifolia* (> 20 individuals) and *Sprengelia incarnata* (> 20 individuals). No *Pultenaea aristata* individuals were recorded.
- In Swamp 53, indicator species were observed along the lower western section of this swamp including *Epacris obtusifolia* (>20 individuals) and *Sprengelia incarnata* (>20 individuals) with only scattered individuals of *Pultenaea aristata* present along the southern edge of the swamp (approx. 5 recorded).
- In Swamp 54, no swamp indicator species were observed.
- In Swamp 58, indicator species were observed within the area of Sedgeland-heath Complex within Swamp 58, although they were limited to a few young *Pultenaea aristata* individuals (3 individuals approximately 5 cm in height were recorded).
- In Swamp 59, indicator species present included *Epacris obtusifolia* (>20 individuals) and *Sprengelia incarnata* (12 individuals). *Pultenaea aristata* was not recorded.
- In Swamp 69, indicator species were limited to *Epacris obtusifolia* (>20 individuals). No individuals of *Sprengelia incarnata* or *Pultenaea aristata* were recorded.
- In Swamp 70, indicator species recorded included *Epacris obtusifolia* (>20 individuals) and *Sprengelia incarnata* (16 individuals recorded). No *Pultenaea aristata* were recorded.
- In Swamp 71a, *Epacris obtusifolia* (>20 individuals) were present. No individuals of *Sprengelia incarnata* or *Pultenaea aristata* were recorded.
- In Swamp 71b, *Epacris obtusifolia* (>20 individuals) and *Pultenaea aristata* (>20 individuals) were observed. No individuals of *Sprengelia incarnata* were recorded.

5 Proposed Vegetation Monitoring Program

This section presents the proposed vegetation monitoring locations based upon the results of field inspections and vegetation mapping described in **Section 3**, shown on **Figures 2** and **3**, and detailed in **Appendix A**. It is proposed that the upland swamp vegetation survey methodology be consistent with that undertaken as part of the Longwalls 20-22 and Longwalls 23-27 Biodiversity Management Plans including survey timing (i.e. bi-annually in autumn and spring), data collection and data analysis.

The upland swamp vegetation monitoring programs for Longwalls 20-22 and Longwalls 23-27 involve the following three monitoring techniques, as described in the Longwalls 20-22 Biodiversity Management Plan (Metropolitan Coal 2014) and Longwalls 23-27 Biodiversity Management Plan (Metropolitan Coal 2015):

- Visual inspections.
- Transect/quadrat monitoring.
- Indicator species monitoring.

The upland swamps where these monitoring techniques are proposed are outlined in **Table 2**. A description of the proposed vegetation monitoring program is provided below. The proposed Longwalls 301-303 vegetation monitoring program is summarised in Table 3.

5.1 Visual Inspections

Visual observations are proposed to be conducted in all swamps which have been confirmed to support Upland Swamp vegetation, namely; Swamps 38, 40, 41, 46, 47, 48, 49, 50, 51/52, 53, 58, 69, 70 and 71a overlying or adjacent to Longwalls 301-303[1] and in selected control swamps (detailed in **Section 5.4**).

Where swamps are small in size or considered marginal (i.e. swamps contain species from a combination of vegetation types including species characteristic of swamps and species not characteristic of swamps) visual inspections alone are proposed. This includes Swamps 38, 47, 49, 58, 69 and 70 (**Table 2**). In other swamps, transect/quadrat monitoring or indicator species monitoring may be proposed.

[1] This includes all swamps within the Longwalls 301-303 35° angle of draw and/or predicted 20 mm subsidence contour, with the exception of Swamp 42 and Swamp 54 which are predicted to experience minimal subsidence movements (MSEC, 2016).

Table 2: Proposed Vegetation Monitoring Program –Swamps

Swamp Number	Revised Vegetation Community	Comments	Proposed Survey Techniques	Indicator Species Monitoring
S37	Upland Swamp: Banksia Thicket	Outside 35° angle of draw and/or predicted 20 mm subsidence contour.	None	No
S38	Upland Swamp: Banksia Thicket	Marginal swamp. Drainage impacted by adjacent Princes Highway. Extent of swamp reduced.	Visual inspections	No
S39	Sandstone Gully Apple Peppermint Forest	Not a swamp.	None	No
S40	Upland Swamp: Banksia Thicket	Typical Banksia Thicket. Large swamp with well-defined boundaries.	Visual inspections Transect/quadrat monitoring Indicator species monitoring	*Epacris obtusifolia* *Sprengelia incarnata*
S41	Upland Swamp: Banksia Thicket	Typical Banksia Thicket. Swamp with well-defined boundaries.	Visual inspections Transect/quadrat monitoring	No
S42	Upland Swamp: Banksia Thicket	Small swamp with woodland influence including emergent eucalypt species.	None	No
S43/S44/S45	Disturbed and/or regenerating sandstone or lateritic communities	Not a swamp. A single stand of vegetation separated by tracks (some overgrown).	None	No
S46	Upland Swamp: Banksia Thicket	Typical Banksia Thicket. Swamp with well-defined boundaries.	Visual inspections Transect/quadrat monitoring	No
S47	Upland Swamp: Banksia Thicket	Boundary of this swamp is not clearly defined and swamp forms a mosaic with the adjacent woodland/forest (Sandstone Gully Apple-Peppermint Forest).	Visual inspections	No
S48	Upland Swamp: Banksia Thicket	Typical Banksia Thicket. Well defined boundaries.	Visual inspections (Transect/quadrat monitoring for next Extraction Plan)	No

Swamp Number	Revised Vegetation Community	Comments	Proposed Survey Techniques	Indicator Species Monitoring
S49	Upland Swamp: Banksia Thicket	Revised extent of swamp. Marginal swamp with Sandstone Gully Apple-Peppermint Forest influence.	Visual inspections	No
S50	Upland Swamp: Banksia Thicket	Typical Banksia Thicket. Well defined boundaries.	Visual inspections (Transect/quadrat for next Extraction Plan)	No
S51/S52	Upland Swamp: Banksia Thicket	Mapped extent of S51 and S52 separated by narrow track with S51 occurring to the west and S52 occurring to the east. Propose monitoring as a single swamp. Typical Banksia Thicket. Well defined boundaries. Central drainage line present throughout these swamps.	Visual inspections Transect/quadrat monitoring Indicator species monitoring	*Epacris obtusifolia* *Sprengelia incarnata*
S53	Upland Swamp: Banksia Thicket	Occurs immediately upslope of S51/52 and separated by a narrow band of Exposed Sandstone Scribbly Gum Woodland with Woronora Tall Mallee-heath influence.	Visual inspections Transect/quadrat monitoring Indicator species monitoring	*Epacris obtusifolia* *Sprengelia incarnata*
S54	Upland Swamp: Banksia Thicket	Small marginal swamp with influence from dry heath vegetation types (i.e. Woronora Tall Mallee Heath).	None	No
S55/S56	Disturbed and/or Regenerating Sandstone or Lateritic Communities (S55)/ Sandstone Heath-Woodland (S56)	Not swamps.	None	No
S57	Exposed Sandstone Scribbly Gum Woodland	Not a swamp.	None	No

Swamp Number	Revised Vegetation Community	Comments	Proposed Survey Techniques	Indicator Species Monitoring
S58	Upland Swamp: Banksia Thicket and Upland Swamp: Sedgeland-heath Complex	Small swamp with poorly defined boundary at present (due to recent hazard reduction burn). Mapped extent of S58 includes mixture of burnt and unburnt vegetation. Where vegetation was not recently burnt, **Banksia Thicket** was identified with burnt areas supporting **Sedgeland-heath Complex**.	Visual inspections	No
S59	Upland Swamp: Banksia Thicket and Upland Swamp: Sedgeland-heath Complex	Swamp with poorly defined boundary at present (due to recent hazard reduction burn). Mapped extent of S59 includes mixture of burnt and unburnt vegetation. Where vegetation was not recently burnt, **Banksia Thicket** was identified with burnt areas supporting **Sedgeland-heath Complex**. Swamp impacted by mountain bike tracks traversing the swamp. Weed species present. Outside 35° angle of draw and/or predicted 20 mm subsidence contour.	None	No
S69	Upland Swamp: Banksia Thicket	Small narrow swamp. Separated from larger S71a by narrow track.	Visual inspections (to commence following the commencement of Longwall 303 secondary extraction[1, 2])	No
S70	Upland Swamp: Banksia Thicket	Very small swamp. Swamp influenced by proximity to highway with weed species recorded.	Visual inspections (to commence following the commencement of Longwall 303 secondary extraction[1, 2])	No

Swamp Number	Revised Vegetation Community	Comments	Proposed Survey Techniques	Indicator Species Monitoring
S71a	Upland Swamp: Banksia Thicket	Large swamp with well-defined boundaries. Typical Banksia Thicket vegetation. Separated from smaller S69 by narrow track.	Visual inspections (to commence following the commencement of Longwall 303 secondary extraction[1, 2]) (Transect/quadrat for next Extraction Plan)	No
S71b	Upland Swamp: Banksia Thicket	Large swamp with well-defined boundaries. Typical Banksia Thicket vegetation. Outside 35° angle of draw and/or predicted 20 mm subsidence contour.	None	No

[1] Timing is based on Swamps 69, 70 and 71a not being within the 35° angle of draw and/or predicted 20 mm subsidence contour until after Longwall 302.

[2] Given the distance of Swamps 69, 70 and 71a from Longwalls 301-303 it is proposed that visual inspections commence following the commencement of secondary extraction of Longwall 303.

5.2 Transect/Quadrat Monitoring

Transect/quadrat monitoring is proposed to be conducted in swamps which are of sufficient size and for which species composition does not show a strong influence from non-swamp vegetation communities. Transect/quadrat monitoring is proposed to be conducted in Swamps 40, 41, 46, 51/52 and 53[2] overlying Longwalls 301-303 and in a selection of control swamps (detailed in **Section 5.4**).

5.3 Indicator Species Monitoring

Population monitoring of indicator species is proposed to be conducted in a selection of upland swamps overlying Longwalls 301-303 and a selection of control sites (detailed in **Section 5.4**). Based on the availability of sufficient numbers of individuals of each indicator species, 20 tagged individuals are proposed to be monitored of:

- *Epacris obtusifolia* in Swamps 40, 51/52 and 53; and
- *Sprengelia incarnata* in Swamps 40, 51/52 and 53.

Insufficient numbers of *Pultenaea aristata* were identified in upland swamps overlying Longwalls 301-303.

5.4 Control Sites

Control sites monitored as part of the Longwalls 20-22 and/or Longwalls 23-27 Biodiversity Management Plans are considered appropriate control sites for swamps overlying and adjacent to Longwalls 301-303. It is noted that some of the control swamps have previously been identified as supporting Sedgeland-heath Complex (Bangalay Botanical Surveys 2008; Metropolitan Coal 2014), however, the height and density of the shrub layer of these swamps (in particular *Banksia ericifolia* subsp. *ericifolia*) has increased with time since fire, and these control swamps now support vegetation comparable to Banksia Thicket as described in NPWS (2003) and Bangalay Botanical Surveys (2008) and similar to that observed in swamps and adjacent to Longwalls 301-303. Table 3 outlines the control swamps that are proposed to be used in comparison to the longwall swamps.

[2] Given the proximity of Swamps 48, 50 and 71a to Longwalls 301-303 it is proposed that baseline transect/quadrat monitoring also commence at these swamps (at the same time as the Longwalls 301-303 upland swamp monitoring program) to obtain appropriate baseline data collection for the next Extraction Plan (i.e. Longwall 304 onwards).

For control swamps, it is proposed that an equal number of individuals of indicator species from an equal number of the control swamps are selected for indicator species monitoring (Table 3). It is not proposed to use individuals of indicator species currently monitored within these control swamps (as part of Longwalls 23-27 Biodiversity Management Plan) as a proportion of these individuals within control swamps have already been recorded with severe dieback or are dead. It is proposed that *Epacris obtusifolia* in Swamps 40, 51/52 and 53 be monitored in comparison with *Epacris obtusifolia* in control Swamps 101, 136 and 137a (Table 3). *Sprengelia incarnata* in Swamps 40, 51/52 and 53 are proposed to be monitored in comparison with *Sprengelia incarnata* in control Swamps 101, 136 and 137b (Table 3).

Table 3: Upland Swamp Vegetation Monitoring Methods for Relevant Longwall and Control Swamps

Vegetation Monitoring Method	Relevant Longwall Swamp	Relevant Control Swamp
Visual Inspections	Swamps 38, 40, 41, 46, 47, 48, 49, 50, 51/52, 53, 58, 69, 70 and 71a.	Swamps 101, 111a, 125, 135, 136, 137a, and 137b and 138.
Transect/Quadrat	Swamps 40, 41, 46, 51/52 and 53.	Swamps 101, 135, 136, 137a and 137b.
Indicator Species		
Epacris obtusifolia	Swamps 40, 51/52 and 53.	Swamps 101, 136 and 137a.
Sprengelia incarnata	Swamps 40, 51/52 and 53.	Swamps 101, 136 and 137b.

6 References

Bangalay Botanical Surveys. 2008. Me*tropolitan Coal Project Baseline Flora Survey – Proposed Longwall Mining Area*. Report prepared for Helensburgh Coal Pty Ltd.

Helensburgh Coal Pty Ltd. 2008. *Metropolitan Coal Project Environmental Assessment*.

Keith, D.A. and Myerscough, P.J. 1993. Floristics and soils relations of Upland Swamp vegetation near Sydney. *Australian Journal of Ecology* 18 (3), 325-344.

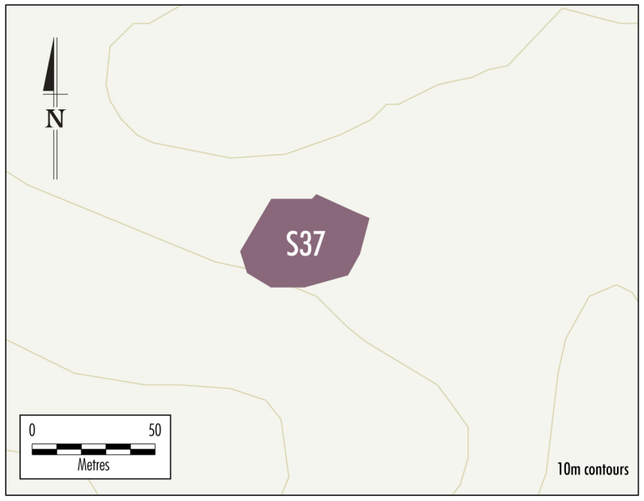
Metropolitan Coal. 2014. *Longwalls 20-22 Biodiversity Management Plan (BMP– R01-G)*.

Metropolitan Coal. 2015. *Longwalls 23-27 Biodiversity Management Plan (BMP– R01-D).*

National Parks and Wildlife Service. 2003. *The native vegetation of the Woronora, O'Hares and Metropolitan catchments*. NSW National Parks and Wildlife Service, Hurstville.

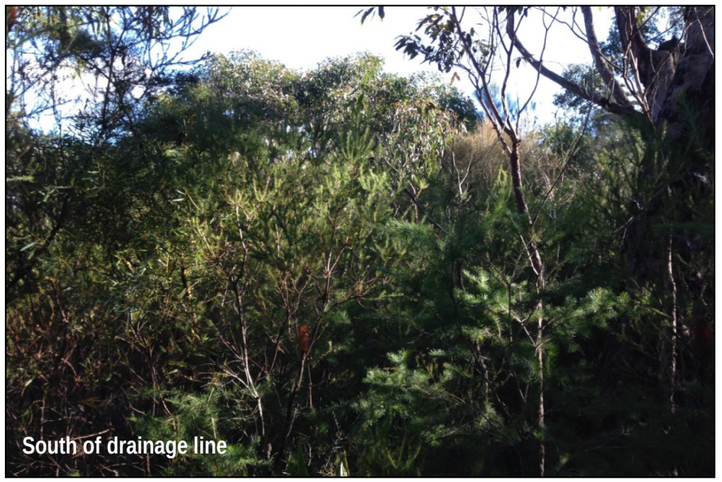
Appendix A Upland Swamp Vegetation Mapping

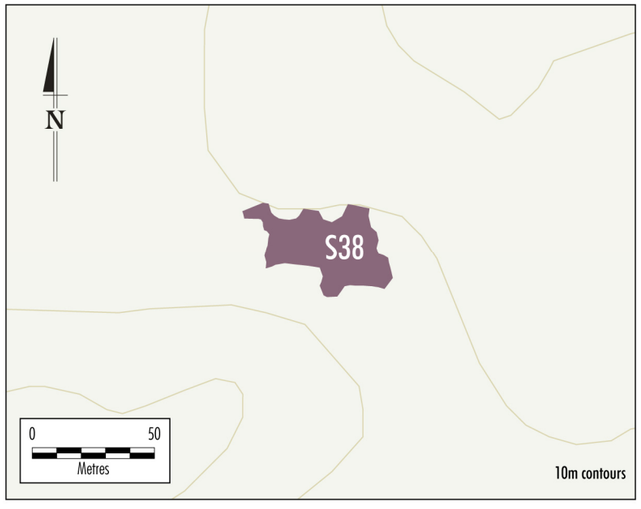
Swamp 37



- Swamp 37 is a valley side swamp located within 600 m of Longwall 301-303 secondary extraction.
- This swamp was previously mapped as Sedgeland-heath Complex by Bangalay Botanical Surveys (2008).
- Field inspections undertaken as part of this report confirmed Banksia Thicket as occurring across the extent of this swamp, with no revisions made to existing swamp boundaries.
- Swamp 37 is approximately 0.1 hectares in area.
- This swamp may represent an artefact of previous clearing/slashing as part of transmission line maintenance.
- A tell dense shrub layer is present within this swamp generally up to 4 m in height and with estimated percent foliage cover of 65-70%. This layer is dominated by *Banksia ericifolia* var. *ericifolia* and *Allocasuarina distyla* with scattered *Hakea teretifolia.*
- The ground layer within this swamp is sparse with estimated percent foliage cover of up to 20% and generally up to 1.1 m in height. This layer is dominated by the sedge *Lepidosperma filiforme.*
- Outcropping sandstone is present upslope (to the north) and downslope (to the south) of the mapped swamp.
- No seepage was observed across areas of exposed sandstone at the time of survey.

Swamp 38



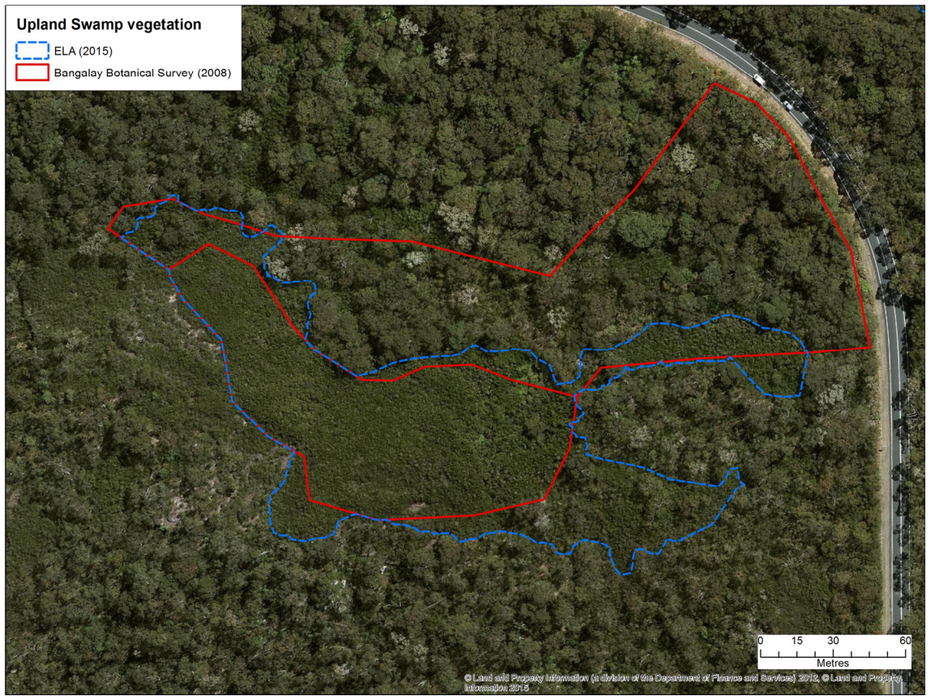


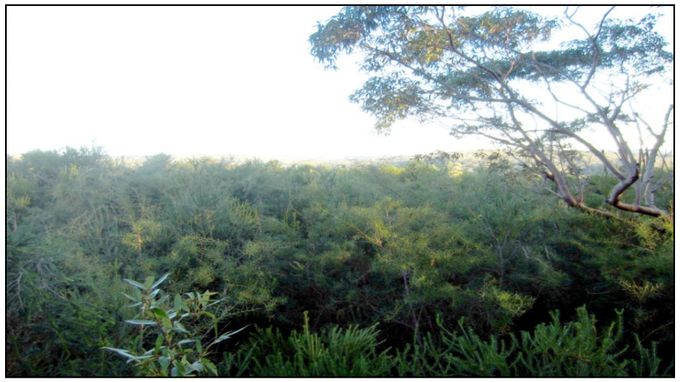
- Swamp 38 is a valley side swamp located to the south of Longwall 301 secondary extraction.
- This swamp was previously mapped as Sedgeland-heath Complex (Bangalay Botanical Surveys 2008).
- Inspections undertaken as part of this report identified a reduced area of Banksia Thicket with Sandstone Gully Apple-Peppermint Forest identified across southern portions of the previously mapped swamp extent.
- The revised area identified as Banksia Thicket (approximately 0.1 hectares) was considered a marginal swamp with emergent eucalypt species.
- A drainage line is present in the southern area of the revised swamp which receives run-off from adjacent Princes Highway, enhancing the growth of wet heath vegetation.
- A dense mid layer is present within the revised swamp extent with an estimated percent foliage cover of 65-70% and generally 4-6 m in height. This layer is dominated by *Banksia ericifolia* var. *ericifolia, Allocasuarina distyla* and *Leptospermum squarrosum.*
- The understorey is sparse and shaded.
- No terminal step or areas of exposed sandstone outcropping were observed within the revised swamp area.

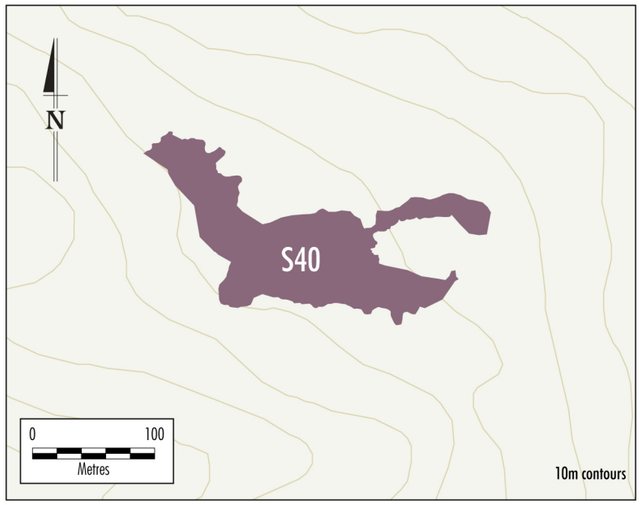
Swamp 39

- Swamp 39 is a narrow south-facing gully located within the 35º angle of draw and/or predicted 20 mm subsidence contour.
- This area was previously mapped as Sedgeland-heath Complex (Bangalay Botanical Surveys 2008).
- Field inspections undertaken as part of this report identified Sandstone Gully Apple-Peppermint Forest occurring across the previously mapped swamp extent, with no swamp vegetation community present at this location.
- Some characteristic swamp species were observed occurring with non-swamp species such as *Doryanthes excelsa, Callicoma serratifolia, Lomatia silaifolia*, *Acacia longifolia* subsp*. longifolia* and *Melaleuca hypericifolia*.
- No terminal step was observed and the area converges into a drainage line flowing adjacent to the M1 Princes Motorway.
- No swamp indicator species were observed.
- Not a swamp.

Swamp 40

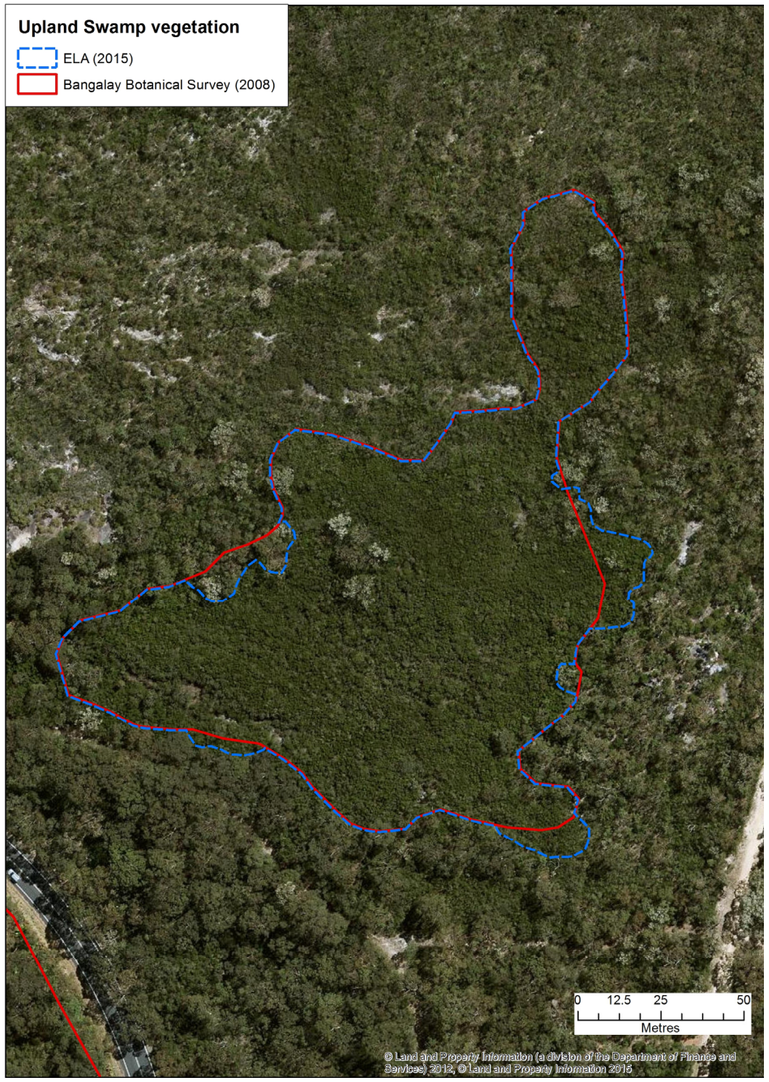






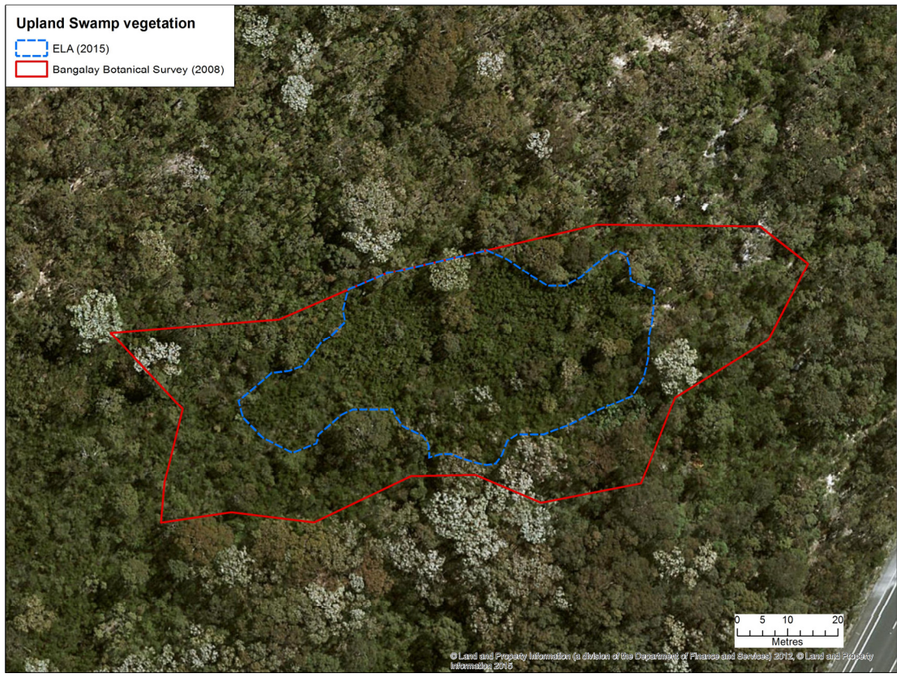
- Swamp 40 is a valley side swamp located over Longwalls 302 and 303 and the associated chain pillar.
- This swamp was previously mapped as Sedgeland-heath Complex and Fringing Eucalypt Woodland (Bangalay Botanical Surveys 2008).
- A revised area of Banksia Thicket was identified as part of this study with the area previously mapped as Fringing Eucalypt Woodland (Bangalay Botanical Surveys 2008) identified as Sandstone Gully Apple-Peppermint Forest. Additionally some minor revisions to the swamp boundary were made from field inspections and aerial photography interpretation. The revised Banksia Thicket is approximately 1.5 hectares in area.
- A small drainage line flows towards the swamp at its northern boundary with a small area of vegetation resembling Tea Tree Thicket present within the swamp adjacent to this drainage line. Species present in this area included *Banksia robur, Melaleuca squarrosa, Callistemon citrinus*, and *Gleichenia microphylla*. The small patch of vegetation similar to Tea Tree Ticket is too small to map (or to be quantitatively monitored).
- Across the swamp more generally, the shrub layer grades from 6 m in height upslope to 3.5 m downslope with a percent foliage cover of approximately 75%. The shrub layer vegetation is dominated by *Banksia ericifolia* subsp. *ericifolia, Hakea teretifolia, Leptospermum squarrosum* and *Dillwynia floribunda*.
- The ground layer is up to 1.3 m in height with estimated percent foliage cover of approximately 30%, although foliage cover of the ground layer is highly variable depending on shading from the shrub layer. Ground layer vegetation is dominated by *Empodisma minus, Chordifex fastigiatus, Lepidosperma filiforme, Schoenus brevifolius* and *Lepyrodia scariosa.*
- A terminal sandstone step is present at the lower, western edge of the swamp with areas of Woronora Tall Mallee-Heath present across some areas of the terminal step.
- Seepage was observed across areas of exposed sandstone at the time of survey.

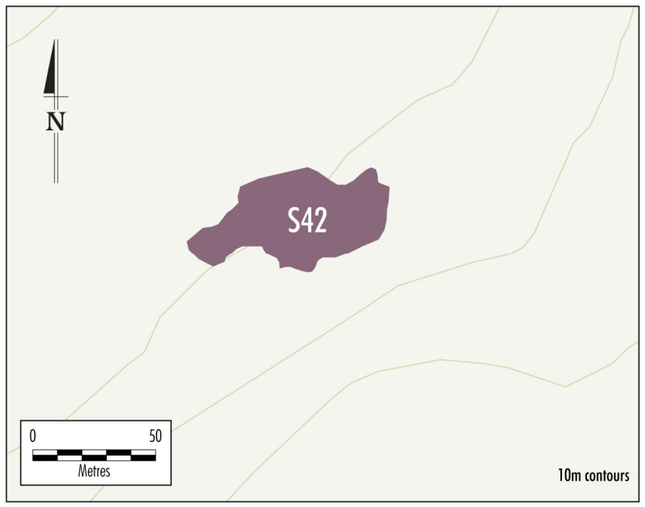
Swamp 41



- Swamp 41 is a valley side swamp located over Longwalls 301 and 302 and the associated chain pillar.
- This swamp was previously mapped as Sedgeland-heath Complex surrounding a small central and area of Banksia Thicket (Bangalay Botanical Surveys 2008).
- Field inspections undertaken as part of this report identified Banksia Thicket as occurring across the entire extent of the swamp. Additionally some minor revisions to the swamp boundary were also identified from field inspections and aerial photography interpretation. The revised area of Banksia Thicket is approximately 1.5 hectares in area.
- A tall dense shrub layer is present within this swamp generally up to 4-6 m in height with an estimated percent foliage cover of 60-80%. This layer is dominated by *Banksia ericifolia* var. *ericifolia* and *Hakea teretifolia*.
- The ground layer is dominated by *Empodisma minus* with *Lepidosperma limicola* occurring in wetter areas.
- A terminal step was recorded along the south-western edge with seepage present across this area at the time of inspection.

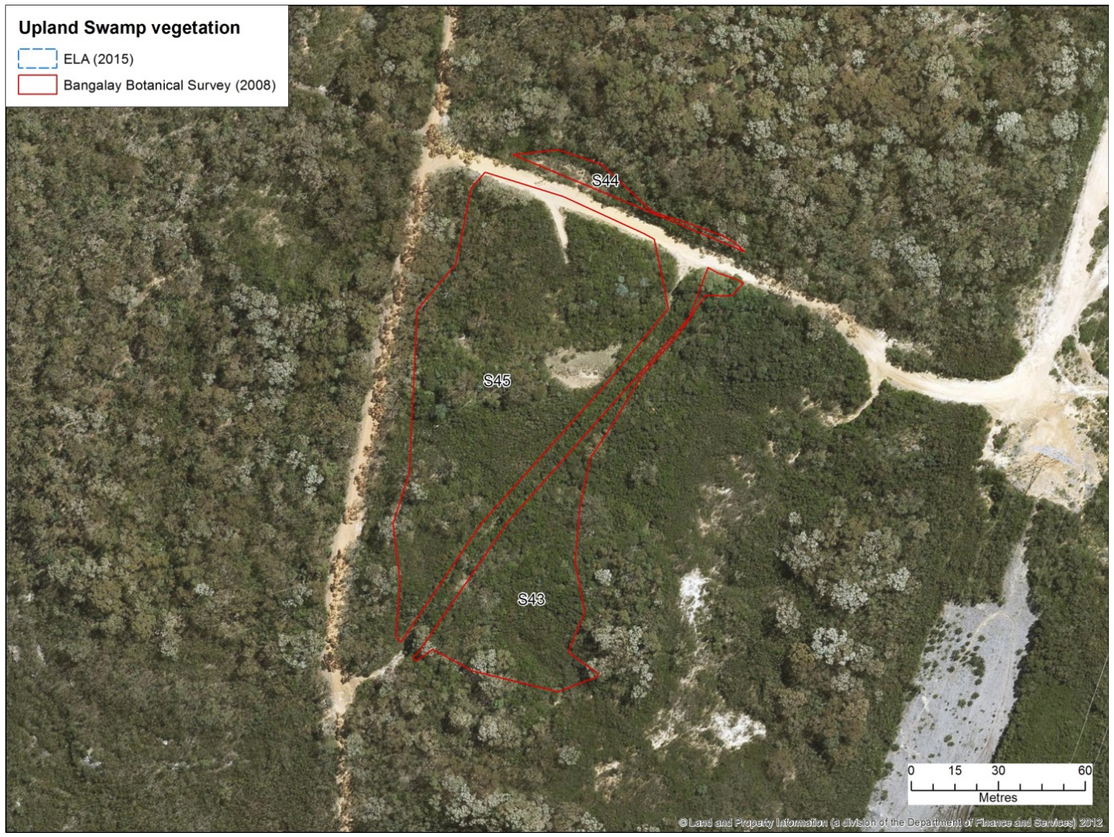
Swamp 42





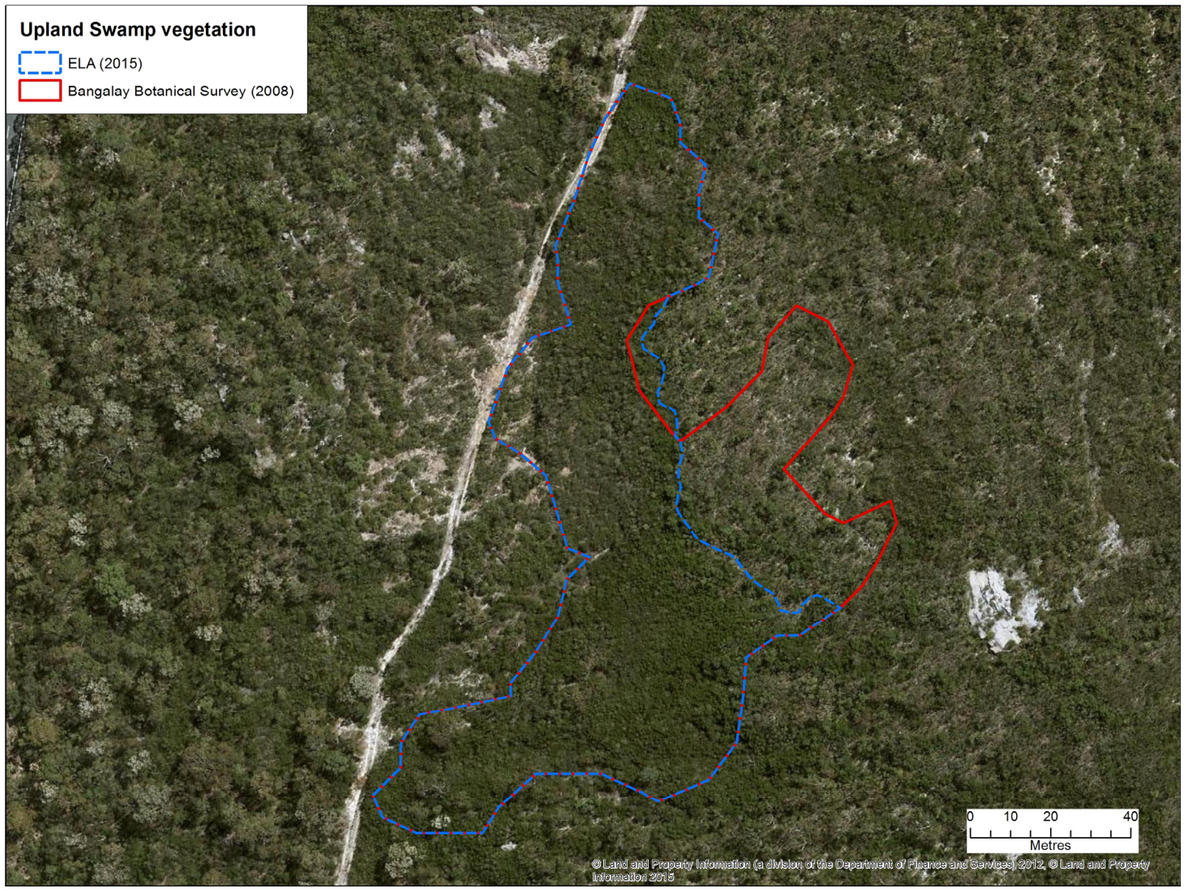
- Swamp 42 is a valley side swamp located within the 35º angle of draw and/or predicted 20 mm subsidence contour.
- This swamp was previously mapped as Sedgeland-heath Complex (Bangalay Botanical Surveys 2008).
- Field inspections undertaken as part of this report identified Banksia Thicket as occurring across the swamp. Additionally some revisions to the swamp boundary were made based upon field inspections and aerial photography interpretation (Swamp 42 is approximately 0.2 hectares in area).
- The boundaries of Swamp 42 are not well defined and influence from surrounding Exposed Sandstone Scribbly Gum Woodland is present across the swamp including emergent eucalypt species, *Corymbia gummifera* and *Eucalyptus racemosa*.
- Within this swamp the shrub layer is dominated by *Banksia ericifolia* subsp. *ericifolia* and the ground layer is dominated by *Entolasia stricta,* with *Empodisma minus, Gahnia sieberiana* and woody debris also common.
- No terminal step or areas of exposed sandstone were observed within the swamp.
- No seepage was recorded at the time of survey.

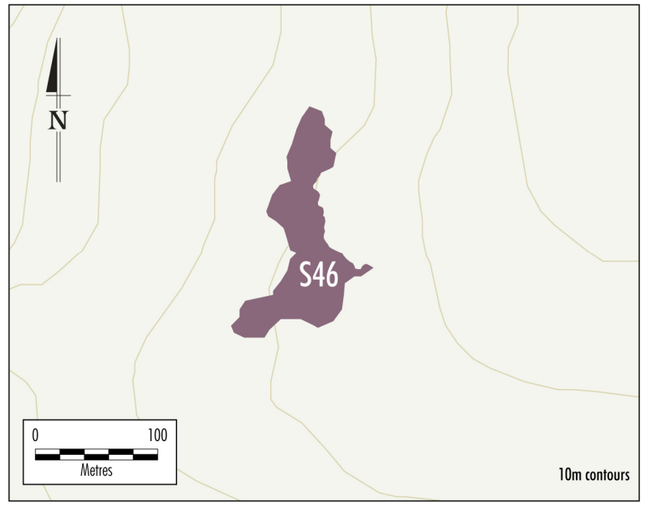
Swamps 43, 44 and 45



- Swamps 43, 44 and 45 are located on the top of a broad ridge overlying Longwall 301 with ironstone outcropping common.
- These swamps were all previously mapped as Sedgeland-heath Complex (Bangalay Botanical Surveys 2008).
- Field inspections undertaken as part of this report identified dense regrowth of previously cleared Silvertop Ash Ironstone Woodland (consistent with the 'Disturbed and/or Regenerating Sandstone or Lateritic Communities' vegetation community of Bangalay Botanical Surveys [2008]) across the mapped extent of these swamps.
- The areas previously mapped as Swamps 43 and 45 (Bangalay Botanical Surveys 2008) were characterised as regrowth dominated by *Banksia ericifolia var. ericifolia, Allocasuarina distyla, Kunzea ambigua* and *Acacia longifolia* subsp*. longifolia* with scattered *Eucalyptus sieberi* also present. The understorey within this area is sparse and without the many sedge species which occur within swamp vegetation communities. Amongst the regrowth, spoil mounds containing rubbish including timber, bricks and concrete were observed.
- The mapped area of Swamp 44 consists of a narrow strip (<5 m wide) located on the northern side of an access trail. This area is a small roadside depression which appears to have been created during trail construction. Vegetation within this area commonly included *Eucalyptus sieberi*, *Banksia ericifolia* subsp. *ericifolia* and *Leptospermum squarrosum* with the sedge *Schoenus brevifolius* occurring in standing water.
- A number of weeds and non-indigenous species are present within the area mapped as Swamps 43, 44 and 45 including *Acacia baileyana* (Cootamundra Wattle), *Ageratina adenophora* (Crofton Weed), *Agapanthus praecox* (African Lily), *Senna pendula* var. *glabrata* and several grass species.
- Neither 43, 44 or 45 are swamps.

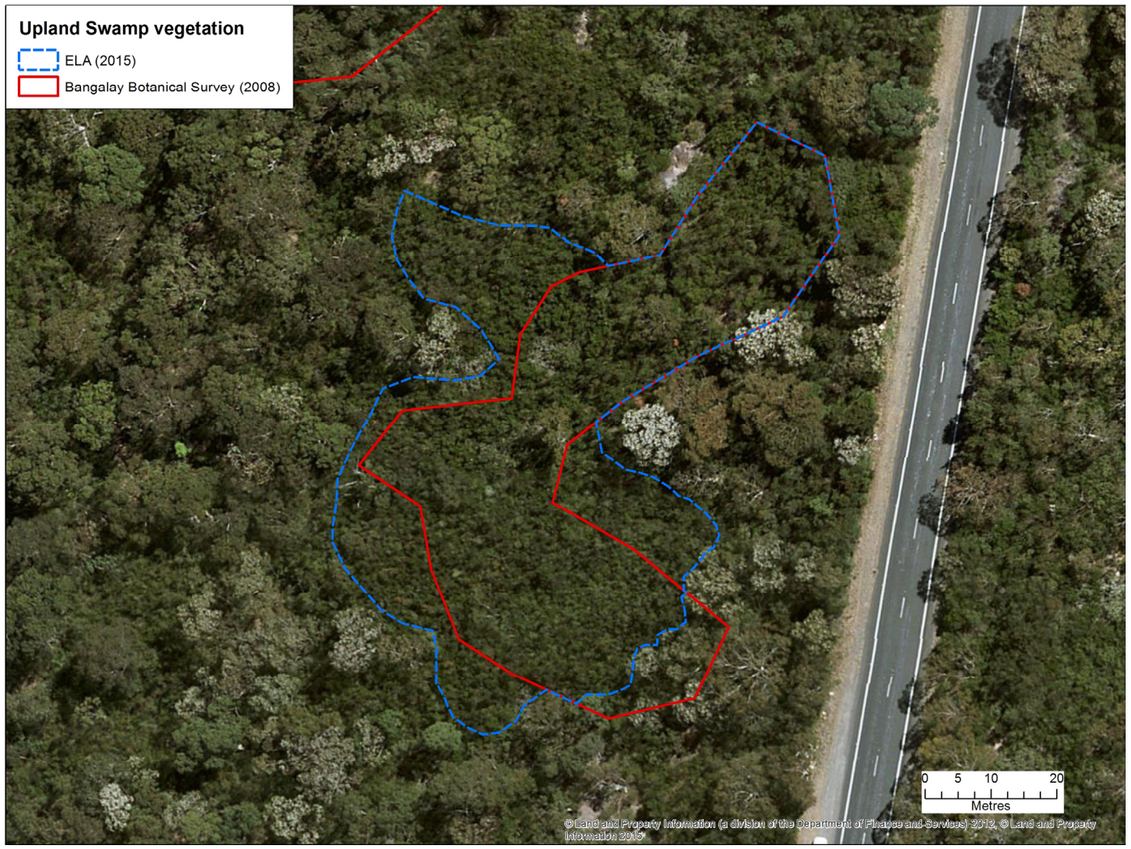
Swamp 46

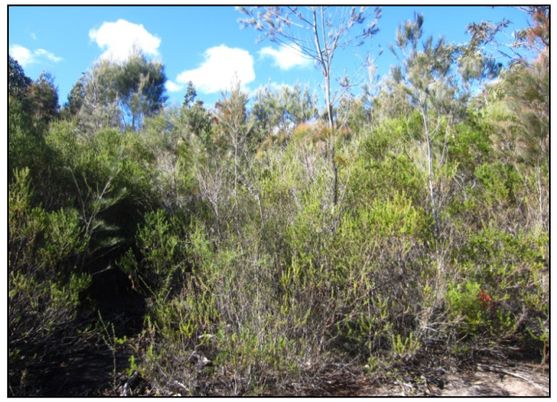


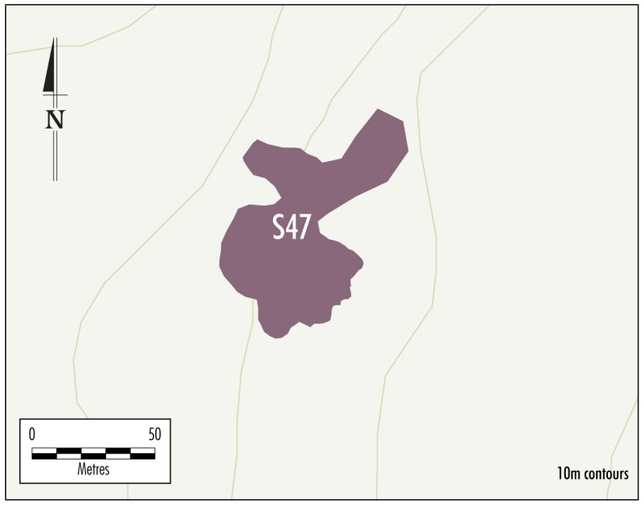


- Swamp 46 is a linear valley side swamp located over the chain pillar separating Longwalls 302 and 303.
- This swamp was previously mapped as Sedgeland-heath Complex (Bangalay Botanical Surveys 2008).
- Field inspections undertaken as part of this report identified Banksia Thicket across the extent of the swamp. Additionally some small revisions were made to the mapping of the boundary of the swamp based upon field inspections and aerial photography interpretation (Swamp 46 is approximately 0.7 hectares in area).
- The shrub layer within this swamp is very dense with an estimated percent foliage cover of 60-80%. This stratum is generally 2-3 m in height and is dominated by *Banksia ericifolia* subsp. *ericifolia, Allocasuarina distyla, Petrophile pulchella, Leptospermum squarrosum* and *Hakea teretifolia*.
- The ground layer is dominated by *Leptocarpus tenax, Chordifex fastigiatus* and *Lepidosperma filiforme.*
- A terminal rocky step is present along the lower, western edge of the swamp with seepage observed across this area during inspections.

Swamp 47

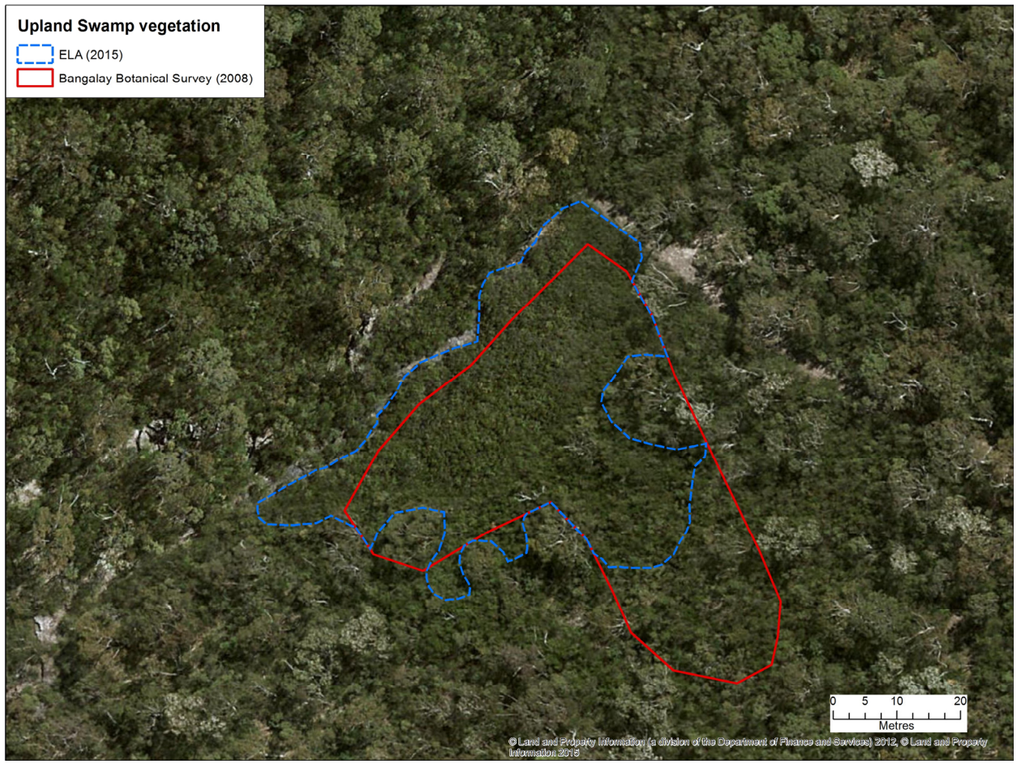


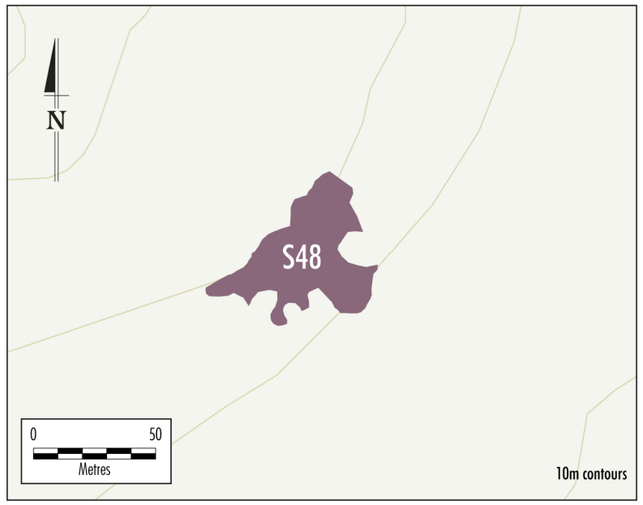




- Swamp 47 is a valley side swamp located over the chain pillar between Longwalls 303 and 304 and within the 35º angle of draw and/or predicted 20 mm subsidence contour of Longwalls 301-303.
- This swamp was previously mapped as Sedgeland-heath Complex (Bangalay Botanical Surveys 2008).
- Field inspections undertaken as part of this report identified Banksia Thicket across the swamp. Additionally some minor revisions to the mapping of the swamp boundary were made based upon field inspections and aerial photography interpretation (Swamp 47 is approximately 0.3 hectares in area).
- Swamp 47 is identified as a marginal swamp in that it forms a mosaic with the adjacent Sandstone Gully Apple-Peppermint Woodland and includes emergent *Angophora costata*. The swamp boundary is not clearly defined.
- The mid layer within this swamp is dominated by *Banksia ericifolia* subsp. *ericifolia* with taller emergent *Allocasuarina littoralis* also present.
- The ground layer was dry at the time of inspection and dominated by *Lepyrodia scariosa* and *Cyathochaeta diandra.*
- A sandstone scarp is present at the northern end of the swamp.
- No seepage was recorded at the time of survey.

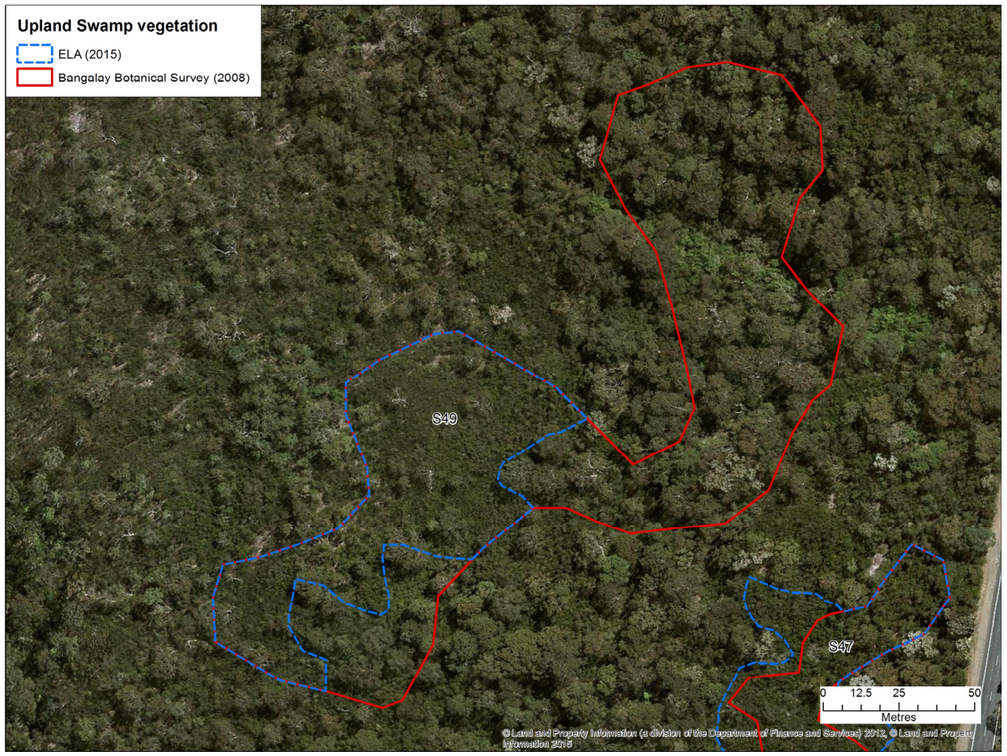
Swamp 48

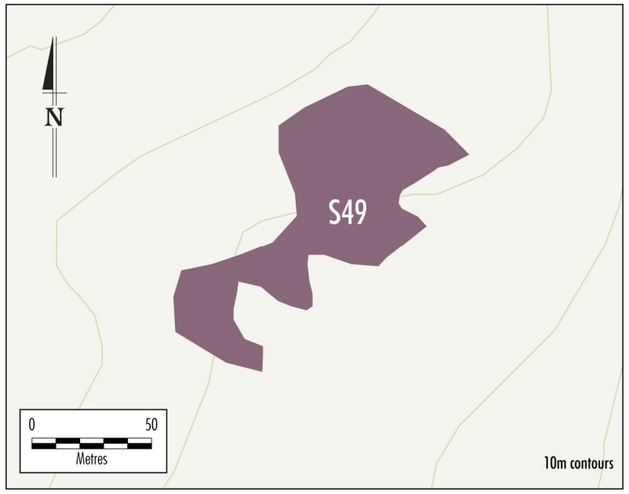




- Swamp 48 is a valley side swamp with well-defined boundaries. It is located within the 35º angle of draw and/or predicted 20 mm subsidence contour of Longwalls 301-303 primarily over Longwall 305.
- This swamp was previously mapped as Sedgeland-heath Complex (Bangalay Botanical Surveys 2008).
- Field inspections undertaken as part of this report identified Banksia Thicket as occurring across the swamp. Additionally some minor revisions to the mapping of the swamp boundary were made based upon field inspections and aerial photography interpretation (Swamp 48 is approximately 0.1 hectares in area.
- The shrub layer is very dense with an estimated percent foliage cover of 65-70%. This stratum is generally 3-5 m in height and is dominated by *Banksia ericifolia* var. *ericifolia, Leptospermum squarrosum* and *Hakea teretifolia.*
- The ground layer is generally 0-1 m in height with an estimated percent foliage cover of up to 25% and is dominated *by Empodisma minus, Lepidosperma filiforme, Lepyrodia scariosa,* and *Schoenus brevifolius*.
- A terminal rocky step is present along the north-western boundary of the swamp. Seepage was observed across this area at the time of survey.

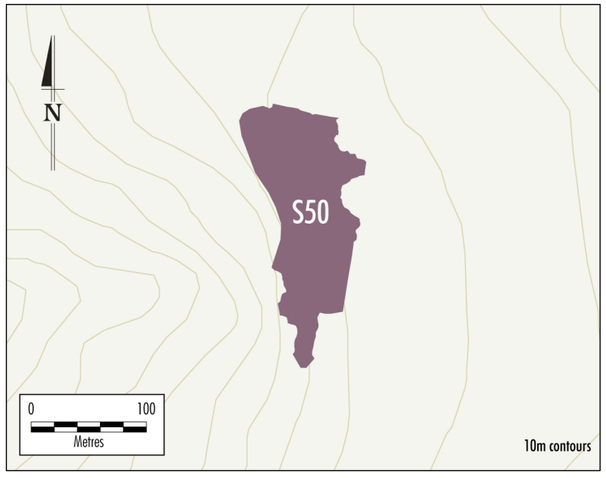
Swamp 49





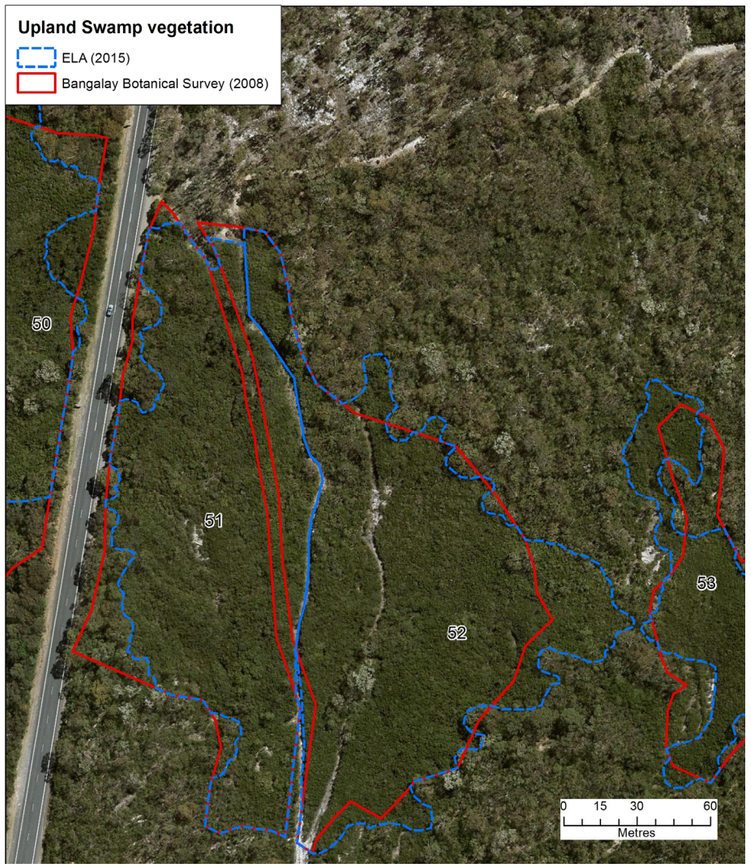
- Swamp 49 is a valley side swamp located within the 35º degree angle of draw and/or predicted 20 mm subsidence contour of Longwalls 301-303 and over the chain pillar between Longwalls 304 and 305.
- This swamp was previously mapped as Sedgeland-heath Complex (Bangalay Botanical Surveys 2008).
- Field inspections undertaken as part of this report identified Banksia Thicket occurring across a small portion of the previously mapped extent of this swamp. The northern portion of the previously mapped extent of this swamp was identified as Sandstone Gully Apple-Peppermint Forest (Swamp 49 is approximately 0.5 hectares in area).
- The revised area of Banksia Thicket was considered to be a marginal form of this community which was a strongly influenced by the adjacent Sandstone Gully Apple-Peppermint forest including a sparse/emergent canopy of *Angophora costata, Eucalyptus piperita* and *Corymbia gummifera*.
- The shrub layer is generally 4-6 m in height with an estimated percent foliage cover of 55%. This layer is dominated by *Banksia ericifolia* subsp. *ericifolia*, *Allocasuarina littoralis* and *Hakea dactyloides.* Smaller shrubs including *Epacris pulchella, Banksia oblongifolia, Platysace linearifolia* and *Leptospermum polygalifolium* were also common.
- The ground layer is generally up to 0.9 m in height with an estimated percent foliage cover of 25%. This layer is dominated by *Empodisma minus, Lepyrodia scariosa, Entolasia stricta* and *Lomandra longifolia*.
- Areas of exposed sandstone outcropping were observed near the northern boundary, though no terminal step was observed.
- No seepage was recorded during the survey.

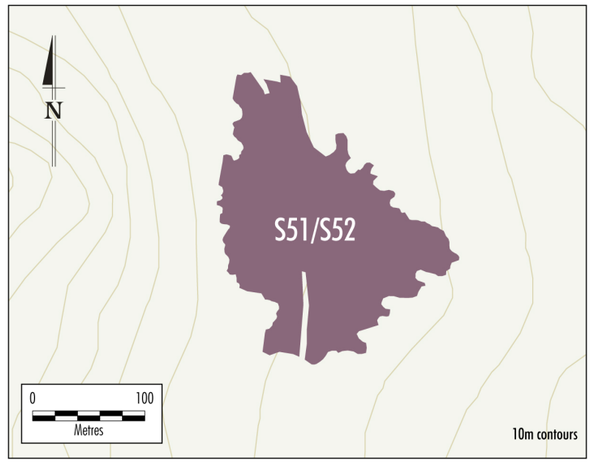
Swamp 50



- Swamp 50 is a valley side swamp located within the 35^{o} angle of draw and/or predicted 20 mm subsidence contour for Longwalls 301-303, over Longwall 304, and the chain pillar between Longwalls 304 and 305.
- This swamp was previously mapped as Sedgeland-heath Complex with a small area of Banksia Thicket in the central portions of the swamp and Fringing Eucalypt Woodland along the western edge of the swamp (Bangalay Botanical Surveys 2008).
- Field inspections undertaken as part of this report identified Banksia Thicket occurring across the entire revised extent of the swamp. The area previously mapped as Fringing Eucalypt Woodland was identified as Sandstone Gully Apple-Peppermint Forest. Additionally some minor revisions to the swamp boundary were made based upon field inspections and aerial photography interpretation (Swamp 50 is approximately 1.3 hectares in area).
- This swamp has well defined boundaries and forms the western limit of a larger swamp complex formed by a series of smaller swamps located down slope of one another (includes Swamps 51, 52 and 53). Swamp 50 is separated from these other swamps by the Princes Highway.
- Within Swamp 50 a tall shrub layer is present, generally 1-4 m in height with an estimated percent foliage cover of 65-75%. This layer is dominated by *Banksia ericifolia, Leptospermum squarrosum* and *Hakea teretifolia.*
- The ground layer is generally up to 1 m in height with a variable percent foliage cover estimated as ranging from 10-20%. This layer is dominated by *Empodisma minus, Schoenus brevifolius, Leptocarpus tenax* and *Chorizandra cymbaria.*
- Areas of sandstone outcropping are present within the swamp with a terminal step also present. Abundant seepage was observed across these rocky areas at the time of survey.

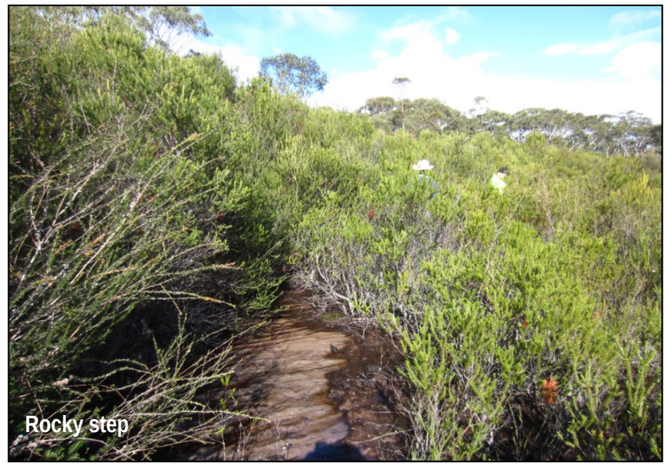
Swamps 51/52





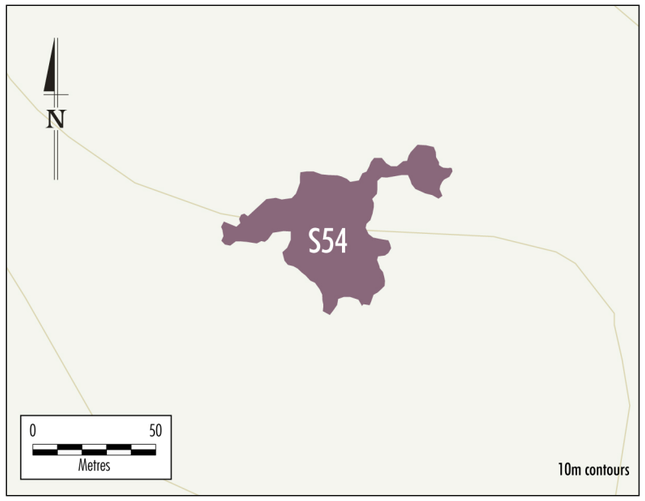
- Swamps 51 and 52 are two valley side swamps located over Longwall 303, the chain pillar between Longwalls 303 and 304 and over Longwall 304 (within the 35º angle of draw and/or predicted 20 mm subsidence contour for Longwalls 301-303).
- Swamps 51 and 52 were previously mapped as Sedgeland-heath Complex, each with a small central area of Banksia Thicket (Bangalay Botanical Surveys 2008). Previous mapping of Swamps 51 and 52 showed these two swamps as being separated by a large track.
- Inspections undertaken as part of this report identified Banksia Thicket as occurring across the entire extent of both of these swamps. Additionally some minor revisions were made to the mapping of the swamp boundaries for these two swamps based upon field inspections and aerial photography interpretation. Inspections undertaken also identified that the previously identified gap between these two swamps was no longer present and that the separation of these two swamps was reduced to a very narrow track. Swamp 51 is approximately 1.3 hectares in area and Swamp 52 is approximately 1.5 hectares in area (approximately 2.8 hectares in total).Swamps 51 and 52 form a larger swamp complex comprising a series of individual swamps (also including Swamps 50 and 53) occurring in a linear band with each swamp located a short distance down slope of the next.
- A tall and dense shrub layer is present within these swamps with an estimated percent foliage cover of 75% and generally 4-5 m in height. This layer is dominated by *Banksia ericifolia* var. *ericifolia, Leptospermum squarrosum* and scattered *Hakea teretifolia.*
- The ground layer is generally up to 1.5 m in height with an estimated percent foliage cover of 10-20%. This layer is dominated by *Empodisma minus, Lepyrodia scariosa, Lepidosperma filiforme* and *Schoenus brevifolius.*
- Areas of outcropping sandstone were observed within these swamps with seepage recorded across these areas at the time of survey.
- Swamps 51 and 52 are essentially the one swamp divided by a 4WD access track underlain by a water main. Several areas of slow water leakage from the water pipe (Swamp 51) are present. Swamp 52 piezometer is more representative of the swamp (upstream from the water pipe).

Swamp 53



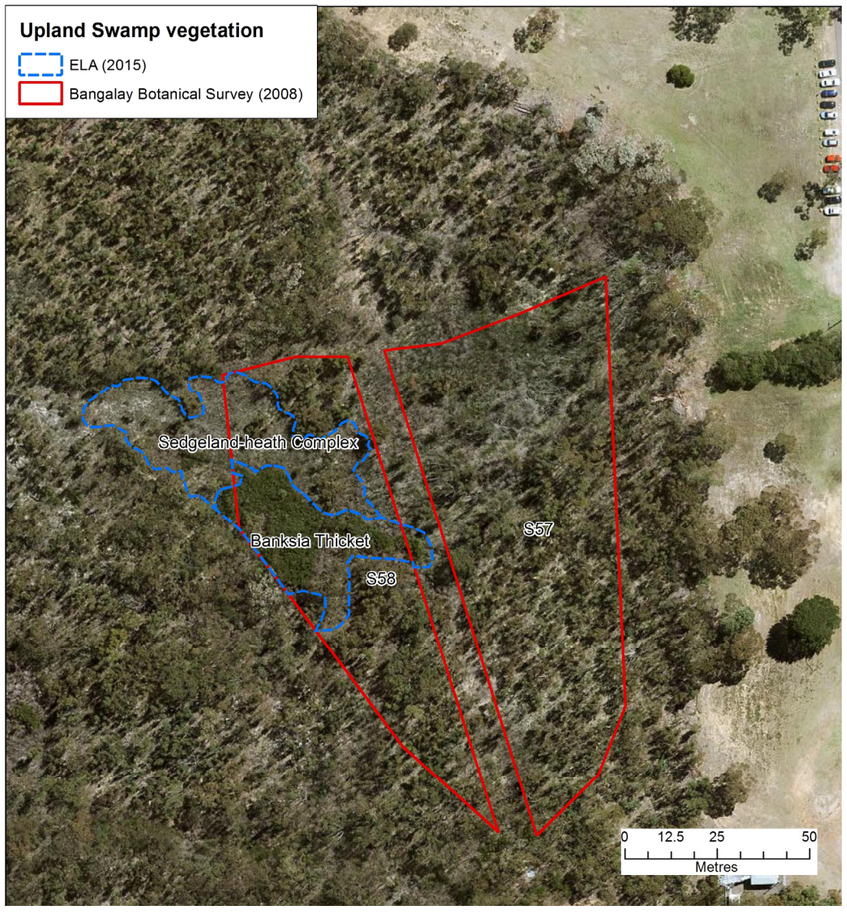
- Swamp 53 is a valley side swamp located over Longwalls 302 and 303, and over the chain pillar between Longwalls 302-303.
- This swamp was previously mapped as Sedgeland-heath Complex with a small area of Banksia Thicket in the centre of the swamp (Bangalay Botanical Surveys 2008).
- Inspections undertaken as part of this report identified Banksia Thicket as occurring across the entire extent of the swamp. Additionally some minor revisions were made to the mapping of the swamp boundary based upon field inspections and aerial photography interpretation (Swamp 53 is approximately 0.7 hectares in area).
- A tall shrub layer is present within this swamp and is generally 3-4 m in height with an estimated percent foliage cover of 60-80%. This layer is dominated by *Banksia ericifolia* subsp*. ericifolia, Leptospermum squarrosum* and occasional *Hakea teretifolia*.
- The ground layer is generally 0-1.3 m in height with an estimated percent foliage cover of 10-15%. This layer is dominated by *Empodisma minus, Leptocarpus tenax, Lepyrodia scariosa* and *Schoenus brevifolia*.
- A terminal sandstone step was observed at the lower end of the swamp with seepage observed across this area at the time of inspections.

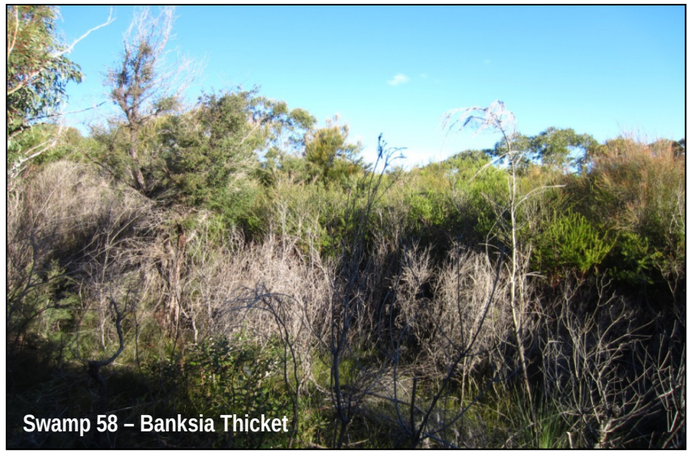
Swamps 54, 55 and 56

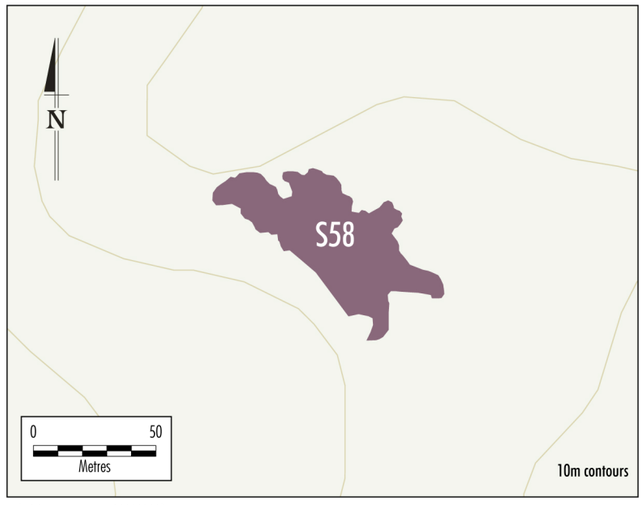


- Swamps 54, 55 and 56 are located on the upper slopes of a broad ridge in proximity to the M1 Princes Motorway and an existing transmission line. They are located to the east of Longwall 301 and within the 35º angle of draw and/or predicted 20 mm subsidence contour for Longwalls 301-303.
- These three swamps were previously mapped as Sedgeland-heath Complex (Bangalay Botanical Surveys 2008).
- Field inspections undertaken as part of this report identified Banksia Thicket (S54), previously slashed vegetation below the transmission line comparable to 'Disturbed and/or Regenerating Sandstone or Lateritic Communities' (S55) of Bangalay Botanical Surveys (2008) and Sandstone Heath-Woodland (S56) occurring across these swamps. That is Swamps 55 and 56 are not swamps. Additionally some minor revisions to the mapping of the boundary of Swamp 54 were made based upon field inspections and aerial photography interpretation. Swamp 54 is approximately 0.2 hectares in area.
- The small area of Banksia Thicket identified within Swamp 54 is considered marginal as it includes both species which typically occur within swamp vegetation communities and species which are more typical of adjacent woodland/heath communities.
- Within Swamp 54 a tall shrub layer is present, generally 2-3 m in height with an estimated percent foliage cover of 55%. This layer is dominated by *Banksia ericifolia, Persoonia pinifolia, Angophora hispida, Allocasuarina distyla* and *Kunzea ambigua.*
- A sparse ground layer was present within Swamp 54 with an estimated percent foliage cover of 10-15% and ranging from 0–1.1 m in height. This layer is dominated by *Entolasia stricta, Cyathochaeta diandra*, and *Lepyrodia scariosa.*
- No terminal or rocky step was found within any of these areas.

Swamps 57 and 58

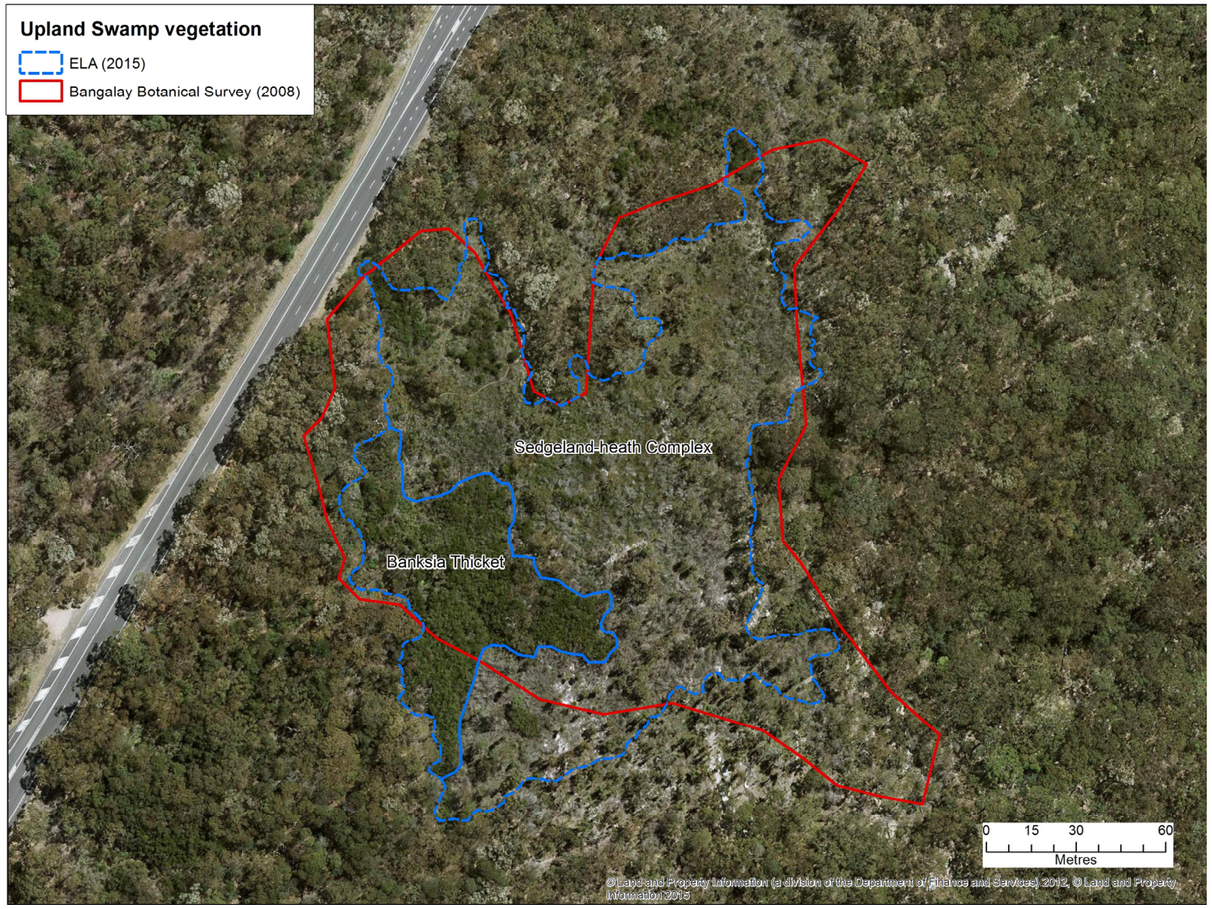


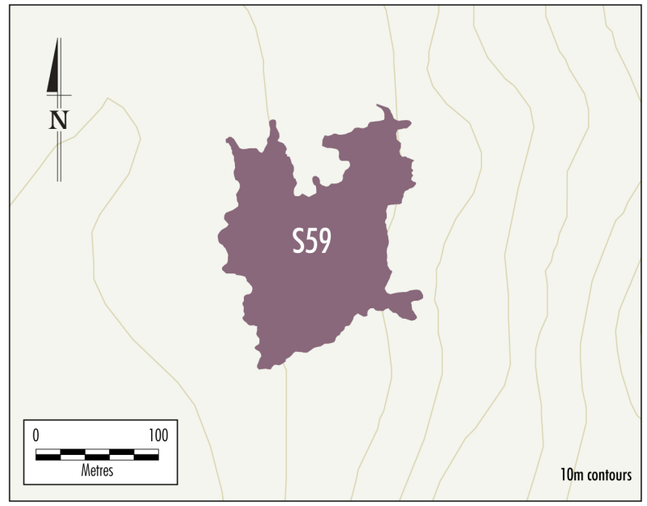




- Swamps 57 and 58 were mapped as two swamps overlying the chain pillar between Longwalls 303 and 304 (Bangalay Botanical Surveys 2008).
- These areas were previously mapped as Sedgeland-heath Complex (Bangalay Botanical Surveys 2008).
- Inspections undertaken as part of this report identified Exposed Sandstone Scribbly Gum Woodland (as described by Bangalay Botanical Surveys 2008) occurring across the mapped extent of Swamp 57 and portions of Swamp 58. The extent of Swamp 58 was revised and it supports a combination of Sedgeland-heath Complex and Banksia Thicket. Some minor revisions were made to the mapped boundary of Swamp 58 based upon field inspections and aerial photography interpretation. Swamp 57 is not a swamp.
- Within the revised extent of Swamp 58 (approximately 0.2 hectares), Sedgeland-heath Complex occur in areas which have been subjected to a hazard reduction burn within the last two years with Banksia Thicket occurring within areas of unburnt vegetation.
- The area of Banksia Thicket within Swamp 58 contained a tall dense shrub layer generally 6-8 m in height with an estimated percent foliage of 40%. This layer is dominated by *Banksia ericifolia* var*. ericifolia* and *Allocasuarina littoralis*.
- The area of Sedgeland-heath Complex within Swamp 58 supports a sparse shrub layer, commonly including regenerating *Leptospermum polygalifolium Entolasia stricta, Ptilothrix deusta, Cyathochaeta diandra, Baeckea imbricata* and *Petrophile pulchella*. Dead standing woody debris was common across this area.

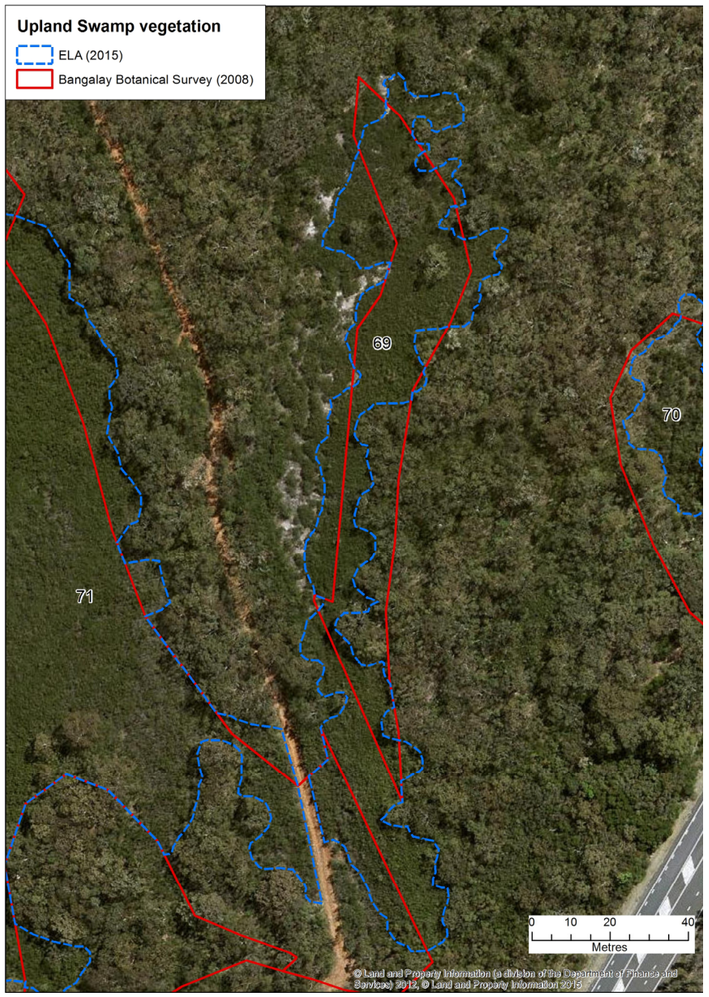
Swamp 59

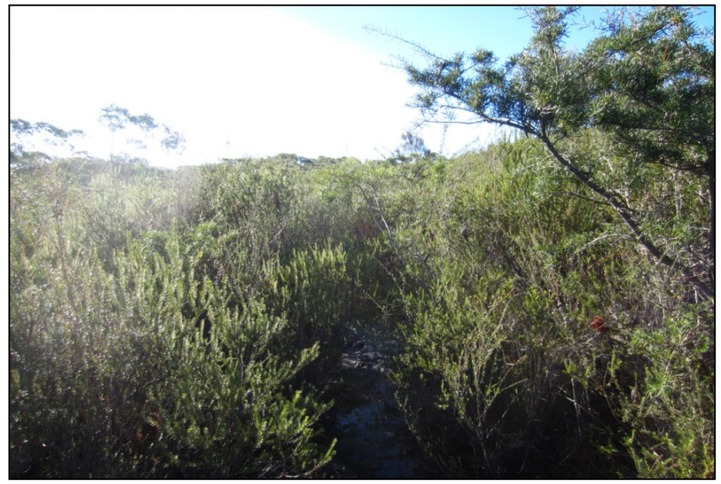


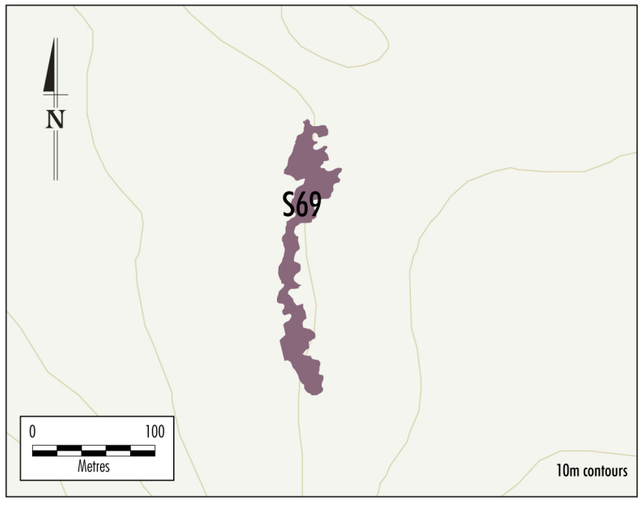


- Swamp 59 is just located within 600 m from Longwalls 301-303 secondary extraction, with portions of the swamp overlying the chain pillar of Longwall 304.
- This swamp was previously mapped as Sedgeland-heath Complex (Bangalay Botanical Surveys 2008).
- Field inspections undertaken as part of this report identified a combination of Banksia Thicket and Sedgeland-heath Complex within this swamp corresponding to areas subjected to a hazard reduction burn within the last two years (Sedgeland-heath Complex) and unburnt areas (Banksia Thicket).
- A poorly defined swamp boundary was noted at time of field surveys (due to recent hazard reduction burn).
- Areas of Banksia Thicket (approximately 2 hectares) include a dense tall shrub layer dominated by dominated by *Banksia ericifolia* subsp. *ericifolia*.
- Areas of Sedgeland-heath Complex within Swamp 59 support a sparse shrub layer (where present) commonly including *Banksia oblongifolia* over a ground layer dominated by sedge species including *Leptocarpus tenax, Lepyrodia scariosa, Ptilothrix deusta, Schoenus brevifolius* and the grass *Entolasia stricta*.
- Within Swamp 59 disturbances associated with mountain bike and feral animal access were observed including bike tracks and ramps, rubbish, weeds (*Andropogon* virginicus), grazed vegetation and ground disturbance by feral deer.
- Areas of exposed sandstone outcropping were present at the lower eastern end of this swamp.
- Abundant seepage was observed across areas of sandstone outcropping at the time of survey.

Swamp 69

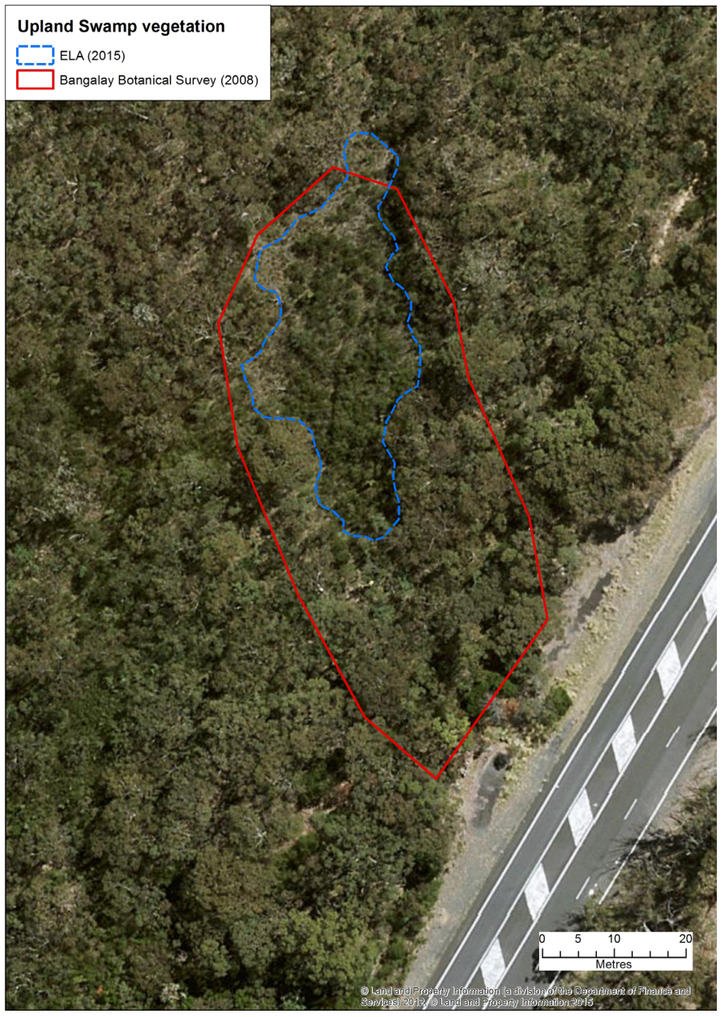


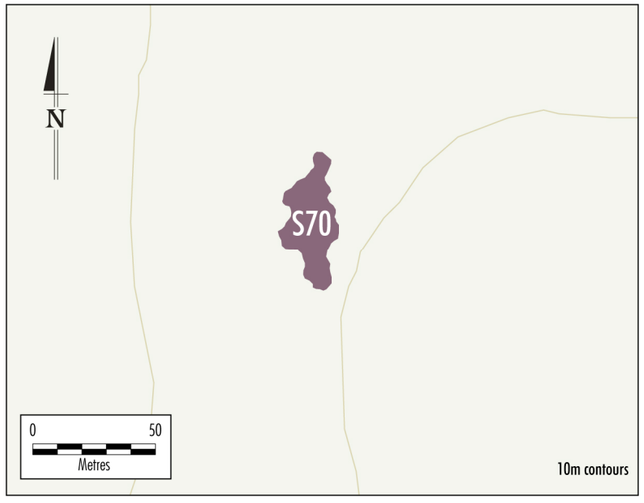




- Swamp 69 is a long narrow side valley swamp located over Longwall 305 and within the 35º angle of draw and/or predicted 20 mm subsidence contour of Longwalls 301-303 secondary extraction.
- This swamp was previously mapped as Sedgeland-heath Complex (Bangalay Botanical Surveys 2008).
- Inspections undertaken as part of this report identified Banksia Thicket across the extent of the swamp. Additionally some minor revisions to the mapping of the swamp boundary were made based upon field inspections and aerial photography interpretation (Swamp 69 is approximately 0.4 hectares in area).
- A tall dense shrub layer is present within this swamp generally 1-3.5 m in height and with an estimated percent foliage cover of 65%. This layer is dominated by *Banksia ericifolia* var. *ericifolia, Leptospermum squarrosum* and *Hakea teretifolia.*
- The ground layer is generally up to 0.9 m in height and is dominated by *Chordifex fastigiatus* and *Lepyrodia scariosa.*
- A terminal step of exposed sandstone was observed along the lower western end of this swamp with some Rock Plate Heath-Mallee vegetation occurring across portions of the exposed sandstone outcropping.
- Abundant seepage was observed across areas of exposed sandstone at the time of survey.

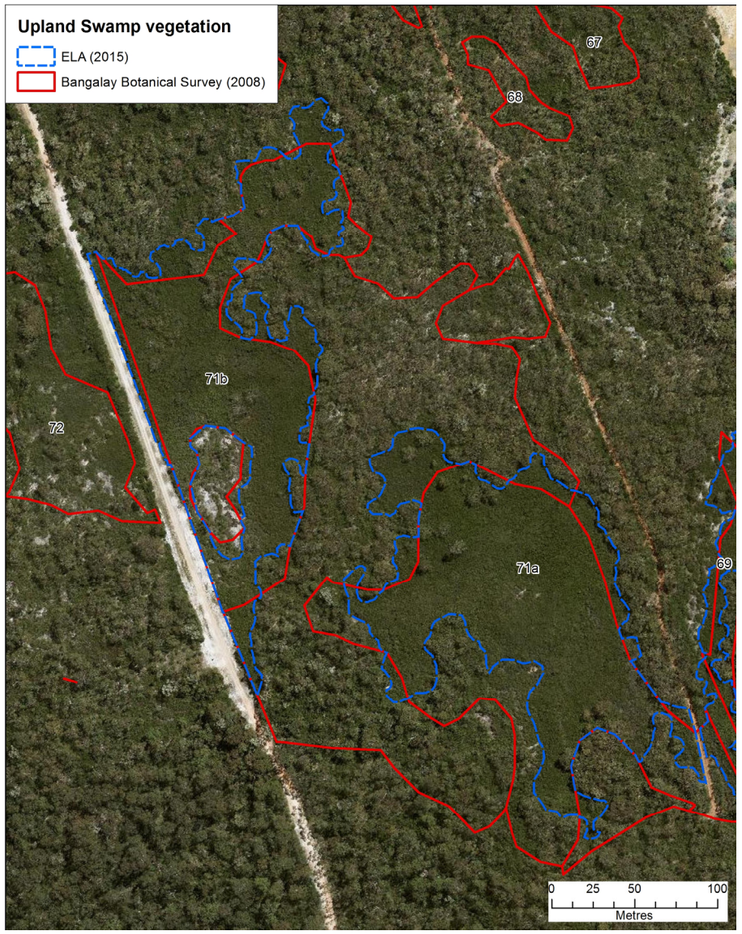
Swamp 70

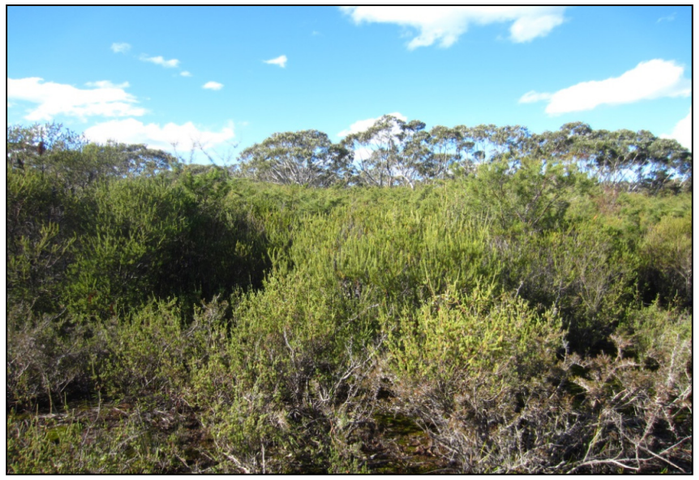


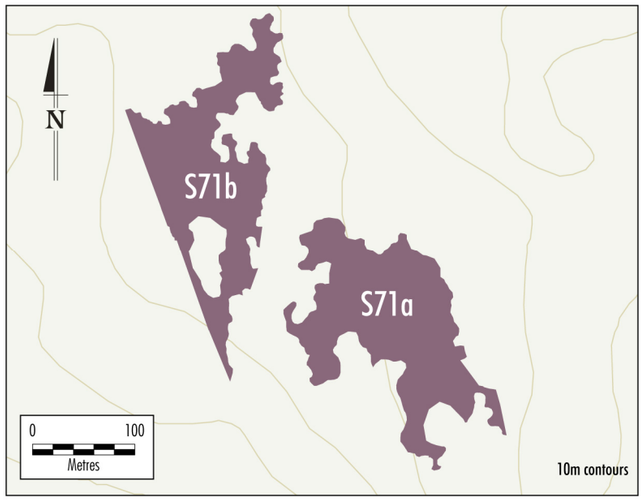


- Swamp 70 is a valley side swamp located over the chain pillar between Longwalls 304 and 305 and within the 35º angle of draw and/or predicted 20 mm subsidence contour of Longwalls 301-303 secondary extraction.
- This swamp was previously mapped as Sedgeland-heath Complex (Bangalay Botanical Surveys 2008).
- Inspections undertaken as part of this report identified a reduced extent of swamp vegetation and identified the Banksia Thicket vegetation community as occurring across the revised extent of this swamp (Swamp 70 is approximately 0.1 hectares in area).
- A tall shrub layer is present within the revised extent of this swamp generally 1–4 m in height with variable foliage cover. This layer is dominated by *Banksia ericifolia* subsp. *ericifolia* and *Hakea teretifolia.* Other common shrub species included *Leptospermum squarrosum, Grevillea oleoides* and *Banksia oblongifolia*.
- The ground layer is generally 0-0.6 m in height with an estimated percent foliage cover of 40-50%. This layer is dominated by *Entolasia stricta, Lepyrodia scariosa, Cyathochaeta diandra* and *Leptocarpus tenax.*
- No terminal step was recorded within this swamp and no seepage was observed during surveys.
- One weed species was recorded within this swamp, possibly *Watsonia* sp., occurring within the upper eastern margin of the swamp.

Swamps 71a and 71b







- Swamp 71 is just located within the 35º angle of draw and/or predicted 20 mm subsidence contour of Longwalls 301-303 secondary extraction, with the majority of Swamp 71 being located within 600 m of Longwalls 301-303 or beyond the 600 m.
- This swamp was previously mapped as Sedgeland-heath Complex with areas of Fringing Eucalypt Woodland through the centre of the swamp (Bangalay Botanical Surveys 2008).
- Inspections undertaken as part of this swamp identified Exposed Sandstone Scribbly Gum Woodland across the area previously mapped as Fringing Eucalypt Woodland and Banksia Thicket across areas previously mapped as Sedgeland-heath Complex (Bangalay Botanical Surveys 2008), resulting in revised mapping of Swamps 71a and 71b. Additionally the boundary of Swamps 71a and 71b have been revised based upon field inspections and aerial photography interpretation (2.1 hectares and 1.9 hectares, respectively).
- Within areas mapped as Banksia Thicket a tall dense shrub layer is present generally 2-4 m in height with an estimated percent foliage cover of 45-65%. This layer is dominated by *Banksia ericifolia* subsp. *ericifolia, Hakea teretifolia* and *Leptospermum squarrosum,* with *Dillwynia floribunda* and *Kunzea capitata* also common.
- The ground layer is up to 0.8 m in height with variable foliage cover. This layer is dominated by *Lepidosperma neesii, Lepyrodia scariosa* and *Ptilothrix deusta.*
- Exposed sandstone outcropping is present within the lower portions of both swamps and seepage was observed across these areas at the time of survey.
- Swamp 71a is separated from the smaller Swamp 69 to the east by a narrow track.

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APPENDIX 3

TERRESTRIAL FLORA BASELINE DATA

UPLAND SWAMP VEGETATION SURVEYS – RAW DATA

Not included in this version.

Available on Request.

APPENDIX 4

VISUAL INSPECTION AND PHOTOGRAPHIC SURVEY OF STREAMS IN THE VICINITY OF LONGWALLS 301 TO 303

Visual Inspection and Photographic Survey of Streams in the Vicinity of Longwalls 301 to 303

1. INTRODUCTION

A visual inspection and photographic survey of streams in the vicinity of Longwalls 301-303 was conducted by Gilbert & Associates (now Hydro Engineering & Consulting) in July 2015 to characterise the baseline characteristics/condition of the streams and to investigate whether any surface water quantity, pool water level, or water quality monitoring of the streams would be required.

2. DESKTOP ASSESSMENT

2.1 Catchments and Streams

An east-west divide runs approximately north to south through the Longwalls 301 to 303 study area, dividing drainages which flow into the Eastern Tributary and the Woronora Reservoir (on the western side) from areas which flow into Wilsons Creek and Cawleys Creek (on the eastern side) (Figure 1). Twelve small sub-catchments within 600 metres (m) of Longwalls 301-303 have been identified on the western side of the study area and two on the eastern side of the study area (Figure 1). A summary of the sub-catchments is provided in Table 1.

Table 1 Sub-catchments and Streams in the Vicinity of Longwalls 301 to 303

Sub-catchment Designation	Sub-catchment Area (km^2)	Stream Order[1]
A	0.24	2
B	0.15	2
C	0.28	2
D	0.04	1
E	0.19	2
F	0.14	2
G	0.04	1
H	0.22	2
I	0.22	2
J	0.38	2
K	0.21	2
L	0.19	2
M	0.79	2
N	0.79	3

[1] Based on mapping of streams using 1 m contours.

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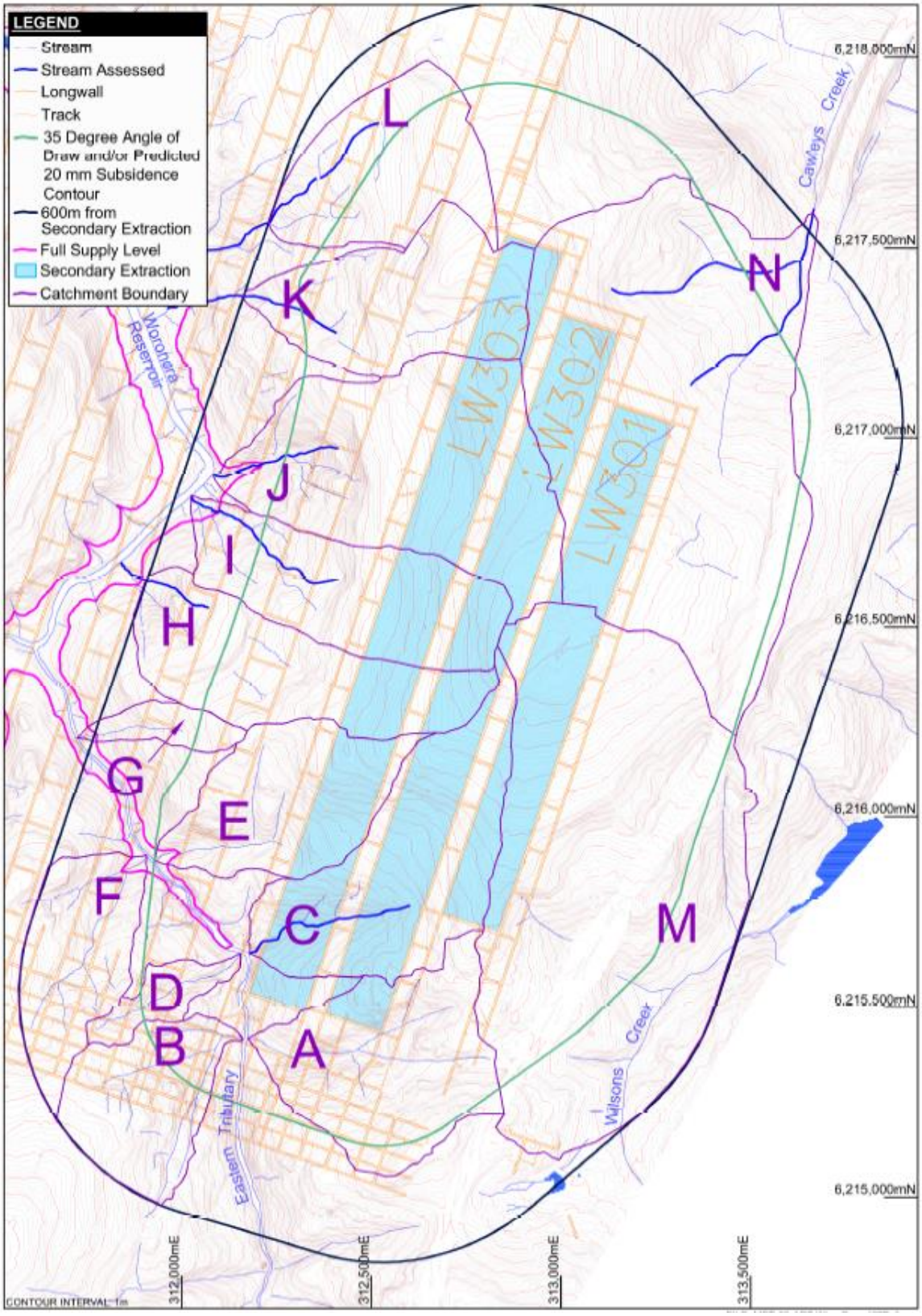

Figure 1 Sub-catchments in the vicinity of Longwalls 301 to 303

One metre contours were used to refine the mapping available from the Department of Lands in the vicinity of Longwalls 301-303. The one metre contour mapping generated by

Geo-Spectrum (Australia) Pty Limited[1] was the most detailed mapping available and provided greater accuracy in terms of stream location, alignment and stream network for the field survey. Figure 1 and Figure 2 show the streams mapped by Geo-Spectrum using one metre contours in the vicinity of Longwalls 301-303.

2.2 Selection of Streams for Visual Inspection and Photographic Survey

Figure 2 was used to inform the selection of streams for visual inspection, mapping and photographic survey.

The streams in the study area (excluding the Eastern Tributary) comprise relatively shallow drainage lines, generally within valleys which are less than 10 m high[2]. The streams are predicted to experience relatively small magnitudes of upsidence and closure[2] particularly in their headwater reaches. The valley heights increase at the lower reaches of these streams. Of the streams above Longwalls 301-303, the stream with the largest valley height is located near the (southern) end of Longwalls 302 and 303 (i.e. stream 3 within sub-catchment C). This stream has a maximum valley height of approximately 20 m. Of the minor tributaries, this stream is predicted to experience the greatest closure due to Longwalls 301-303 (predicted total closure of 190 millimetres [mm])[2]. Streams 1 and 2 (within sub-catchments A and B) are predicted to experience maximum predicted total closures of 130 mm and 30 mm respectively after the extraction of Longwall 303[2]. As a result, there is a reduced likelihood of valley related impacts to Stream 1 . Valley related impacts to Stream 2 due to the extraction of Longwalls 301 to 303 are considered to be unlikely based on the low value of predicted closure for this stream[2].

The streams selected for inspection (i.e. streams 3, 8, 9, 10 11, 12, 14 and 15 in sub-catchments C, H, I, J, K, L and N respectively) were considered the most significant (based on sub-catchment area, and stream length) and to be representative of the other small tributary streams in the study area.

The streams within sub-catchments A and B were not selected as they are primarily located over the main headings and are considered to be less likely to experience subsidence impacts. Wilsons Creek (sub-catchment M) was not selected for visual inspection and photographic survey as it is located outside of the surface area likely to be affected by Longwalls 301-303 (i.e. outside the 35 degree angle of draw and/or predicted 20 mm subsidence contour).

Visual inspection, mapping and photographic survey of the Eastern Tributary was conducted by Mine Subsidence Engineering Consultants (MSEC) prior to the commencement of Longwall 20 as a component of the Longwalls 20-22 Water Management Plan.

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1 Geo-Spectrum (Australia) Pty Limited (2007) *Orthophotomap (1:7,500) of Helensburgh Coal Metropolitan Colliery*. October 2007 from 1:20,000 Scale. Aerial photography from 27 August 2007. Ground survey by Monaghan Surveyors Pty Ltd.

2 Mine Subsidence Engineering Consultants (2016) *Metropolitan Coal – Report on Subsidence Predictions and Impact Assessments in support of a Request for a Revised Longwall 301 to 303 Layout*, April.

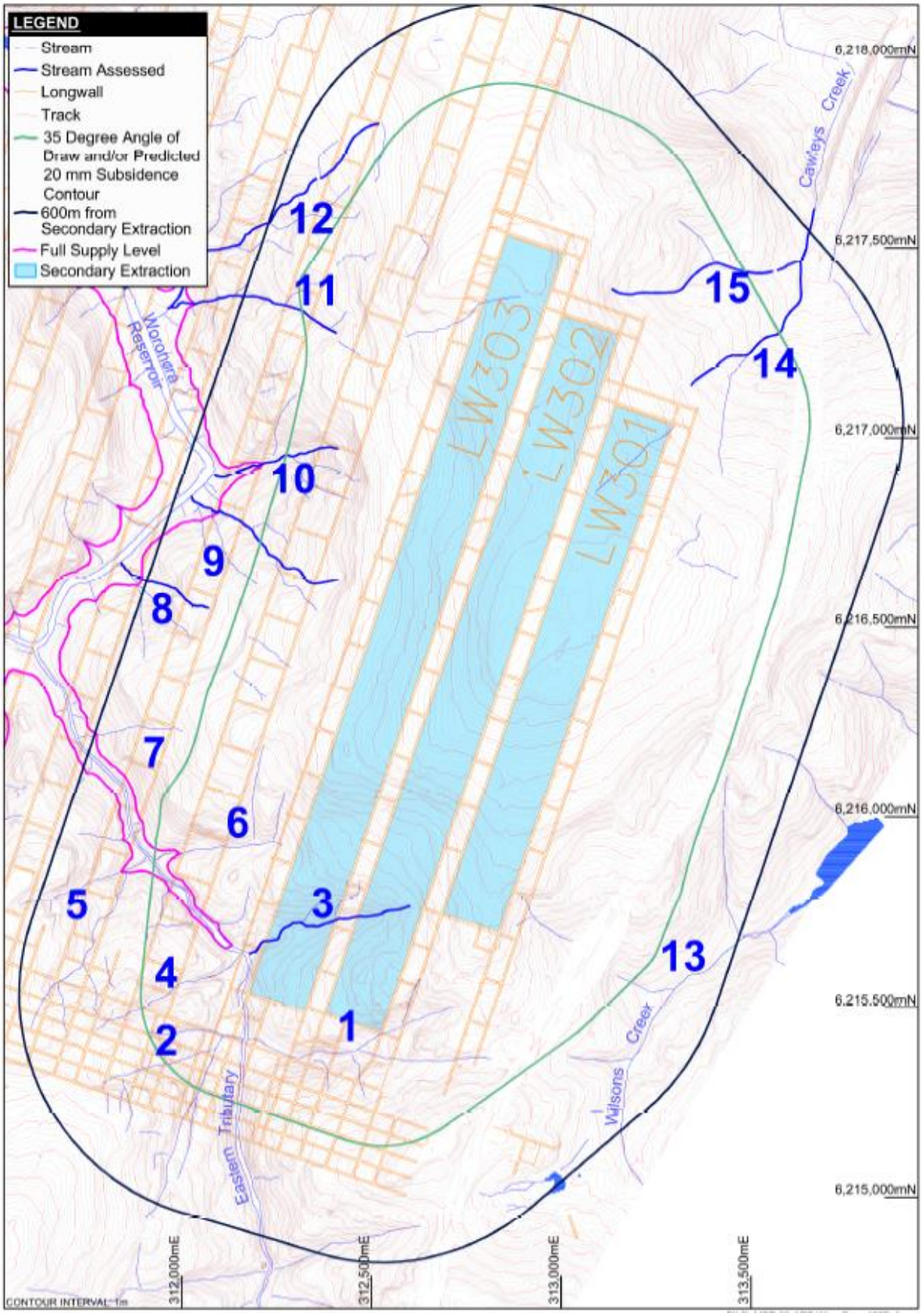

Figure 2 Streams in the vicinity of Longwalls 301 to 303

3. VISUAL INSPECTION AND PHOTOGRAPHIC SURVEY

3.1 Inspection and Survey Timing

Visual inspection and photographic survey of the eight streams was undertaken on the 2nd and 3rd of July 2015. Streams 3, 8, 9, 10, 11 and 12 flow into the Eastern Tributary or Woronora Reservoir on the western side of the study area while streams 14 and 15 flow into Cawleys Creek on the eastern side of the study area (Figure 2).

The significance of the rainfall in the period preceding the survey on stream baseflow can be seen on the residual rainfall curve derived from the historical daily rainfall record at the Darkes Forest rainfall station (68024) from 1 January 1900 to 31 December 2015) Chart 1 shows the rainfall residual for the period 1 January 2000 to 31 December 2015. Periods where the residual rainfall curve increases (i.e. has a positive upward sloping gradient), reflect higher than average rainfall and periods where the residual rainfall line decreases (slopes downward), reflect below average rainfall - drying conditions in the catchment. Periods of decreasing rainfall residual tend to be caused by prolonged periods of low or no rainfall and are seen as slow downward sloping trends. In contrast, periods of upward (above average) rainfall are much steeper and occur over shorter time periods because they tend to be caused by isolated high rainfall events.

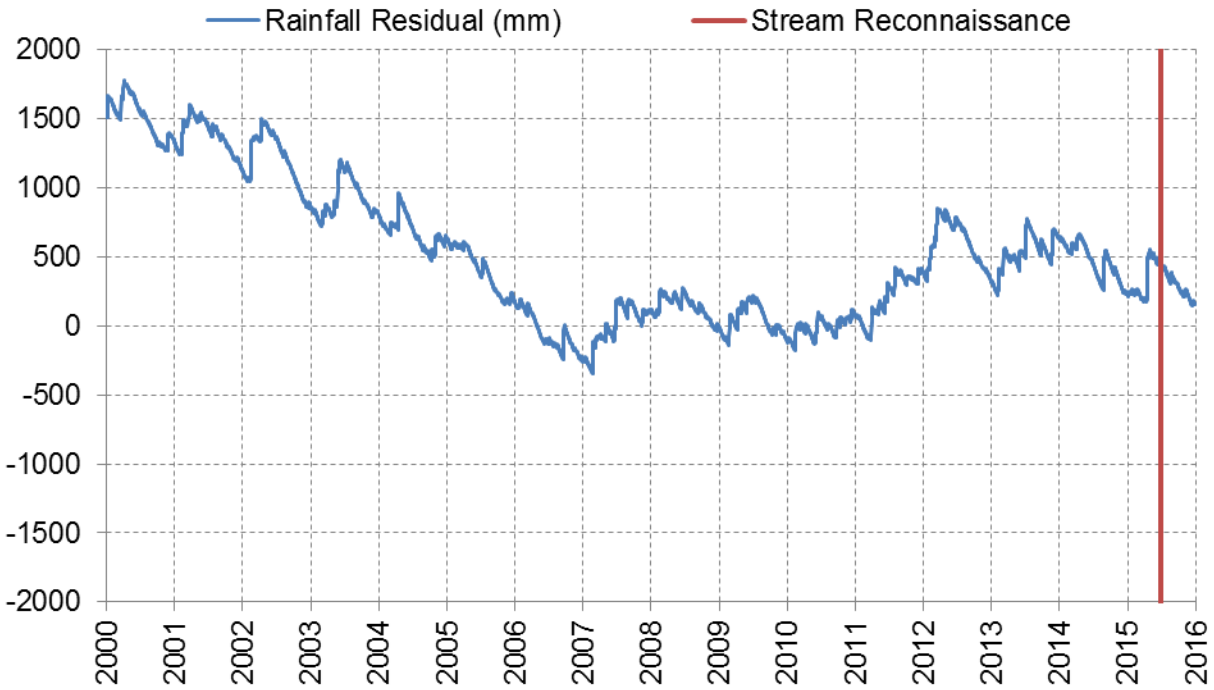

Chart 1 Darkes Forest Rainfall Residual Plot, January 2000 to 31 December 2015 (Showing Period of Significantly High Rainfall in April 2015)

Chart 1 shows the overall trend in rainfall from 2000 to 2007 was downward (below average). However this period was also characterised by a series of short significant rainfall events followed by prolonged drying periods. From 2007 to 2011 rainfall trends were near average. There was a significant wet period in early 2012 followed by a dry period into early 2013. Rainfall 2013 and 2014 tended to be near average. The rainfall trend in 2015 prior to the survey was also generally near average but with a significant steep increase in rainfall trend in late April 2015 caused by an intense event which produced over 285 mm of rain in three days in late April. This event would likely have resulted in significant recharge of shallow groundwater. The wetness of the surveyed stream catchments and persistent baseflow observed during the survey reflect these rainfall trends and can be seen to be abnormally wet with comparable conditions being limited to periods in early 2002, 2003, and 2012 since 2000.

3.2 Methods and Results

The inspection and survey involved walking along the accessible length of the streams, mapping the geomorphic characteristics and features of the stream, and compiling a photographic record. The mapping provided in Figure 3 to Figure 10 shows the locations where photographs were taken and the location of particular stream features observed along the stream.

Stream features were mapped using the following alphabetic symbols:

(WF) Waterfall of at least 2 m near vertical drop.

(BC) Boulder cascade comprising a very steep chute of boulders. Water would be highly aerated by rapid flow over and through spaces between the boulders.

(RS) Rock shelf comprising a hard and relatively smooth rock outcrop often containing shallow depression(s).

(P_s) Small pool between 1 m and 3 m long and less than 0.3 m deep. These features would likely be transient but persist for some time following cessation of flow.

(P_m) Medium sized pool larger than a small pool and typically 3 m to 5 m long and around 0.5 m deep. The largest pool observed was estimated to be less than 5 m long and less than 1 m deep at its deepest. These pools would be expected to retain ponded water under most climatic conditions.

The streams on the western side (i.e. those flowing into the Eastern Tributary and Woronora Reservoir), were steep, single channel flow paths with sections of very steep boulder cascades and waterfalls. The steeper sections were separated by relatively flatter sections. The distribution and location of flatter and steep sections are apparent on the stream long-sections included in Figure 3 to Figure 8. The photographs taken at the points shown in Figure 3 to Figure 8 are provided in Attachment 1.

Small flows were observed in all western side streams as a result of persistent seepage from the adjacent valley sides and residual baseflow from the recent significant rainfalls experienced in the Woronora Reservoir catchment. Small pools (between 1 m and 3 m long and less than 0.3 m deep) were observed along a 45 m reach on stream 3 and two small pools were observed on stream 12 (Figure 3 and Figure 8). No small pools (between 1 m and 3 m long and less than 0.3 m deep) were observed along streams 8, 9, 10 and 11 (Figure 4 to Figure 7). One medium pool (between 3 m and 5 m long and approximately 0.5 m deep) was recorded on stream 3 and one medium pool (between 3 m and 5 m long and approximately 0.5 m deep) was recorded on stream 9 (Figure 3 and Figure 5). No medium pools were observed along streams 8, 10, 11 and 12 (Figure 4, Figure 6, Figure 7, and Figure 8). The stream beds comprised predominantly rock and boulders with some limited sections of shallow sediment accumulations. There was no iron colouration observed along the stream bed although there were some small iron rich seepages observed emanating from fractures in rock outcrops near the sides of streams and at the sides of waterfalls.

The streams on the eastern side of the study area (streams 14 and 15, Figure 9 and Figure 10) which flow into Cawleys Creek were significantly different in condition and character to those on the western side. They comprise shallow ill-defined channels in an open valley setting. Substantial clearing and weed invasion was observed in parts. The streams followed a moderate grade with predominantly alluvial bed material comprising silts and sand. There were no pools observed. Conditions observed in the streams are shown on the stream condition maps included as Figure 9 and Figure 10). The photographs taken at the points shown on Figure 9 and Figure 10 are provided in Attachment 1.

4. CONSIDERATION OF SURFACE WATER MONITORING REQUIREMENTS

The streams which flow to Eastern Tributary and the Woronora Reservoir comprise small (between 0.04 km^2 and 0.38 km^2) first and second order streams.

Based on the nature and characteristics of the streams and their small and negligible contribution to the Woronora Reservoir (compared to the contributions of Waratah Rivulet and Eastern Tributary which will continue to be monitored), establishment of monitoring sites (for surface water flow, pool water level, or surface water quality) is not, in our opinion, warranted.

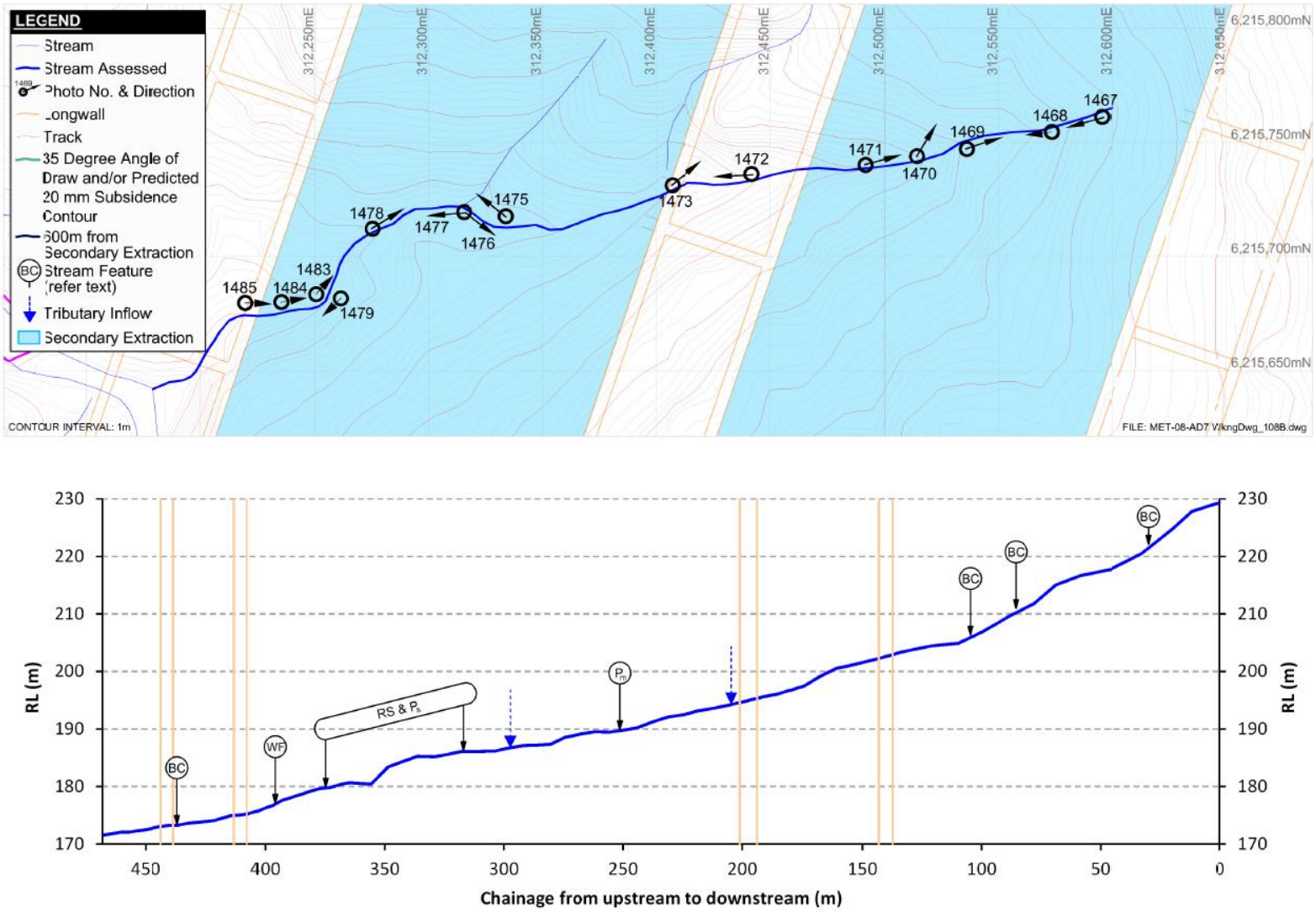

Figure 3 Stream 3 Photo Locations and Stream Features

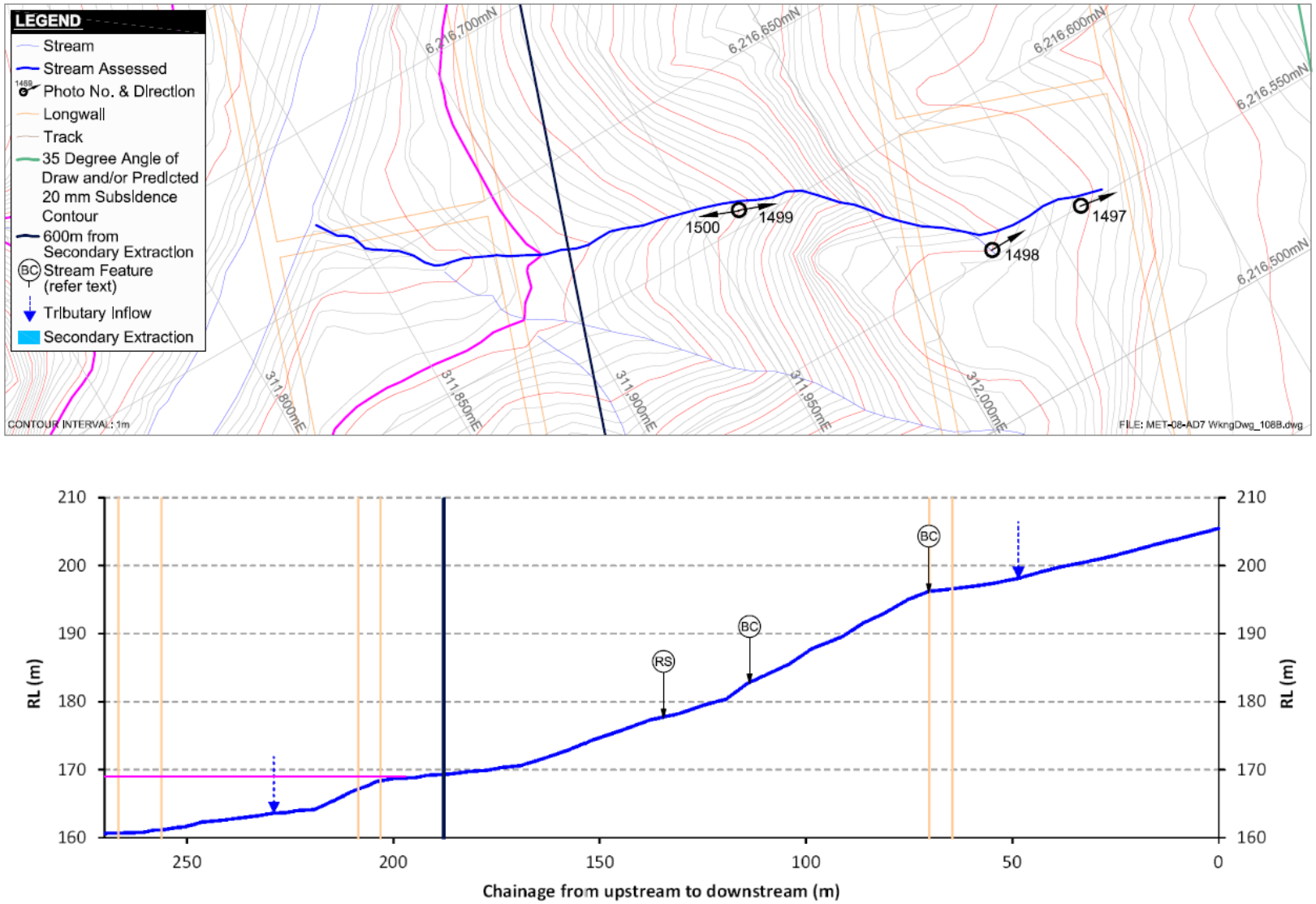

Figure 4 Stream 8 Photo Locations and Stream Features

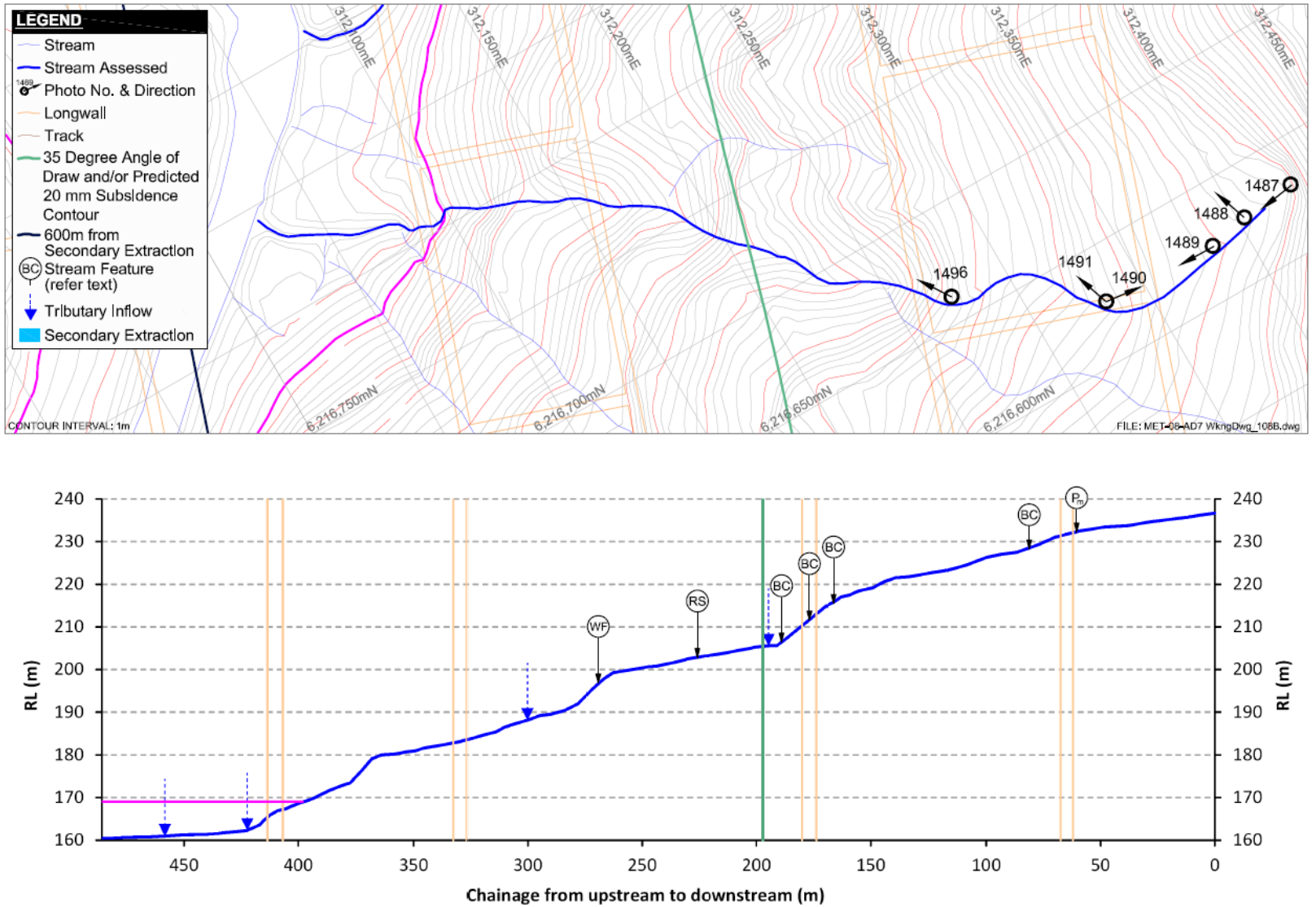

Figure 5 Stream 9 Photo Locations and Stream Features

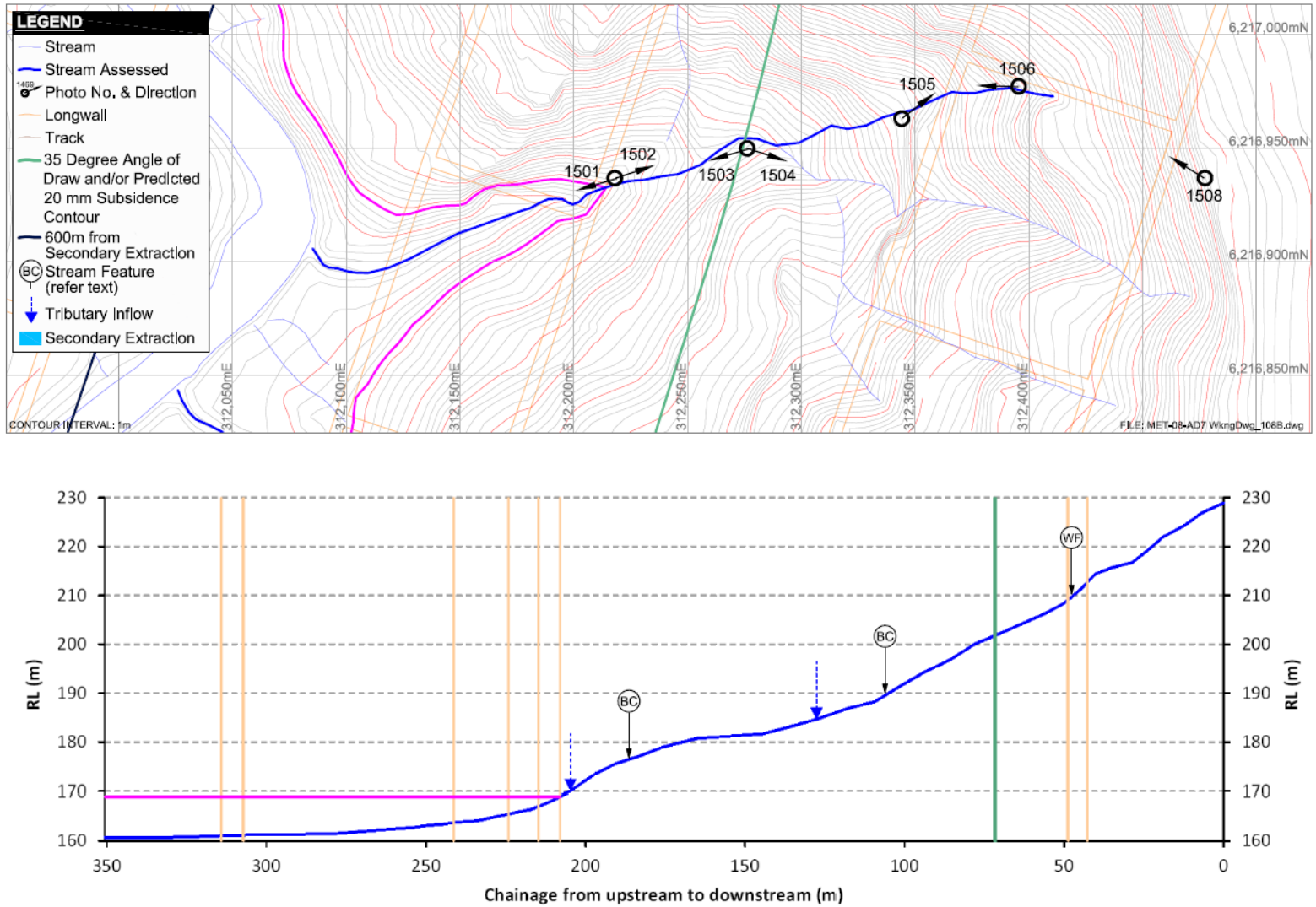

Figure 6 Stream 10 Photo Locations and Stream Features

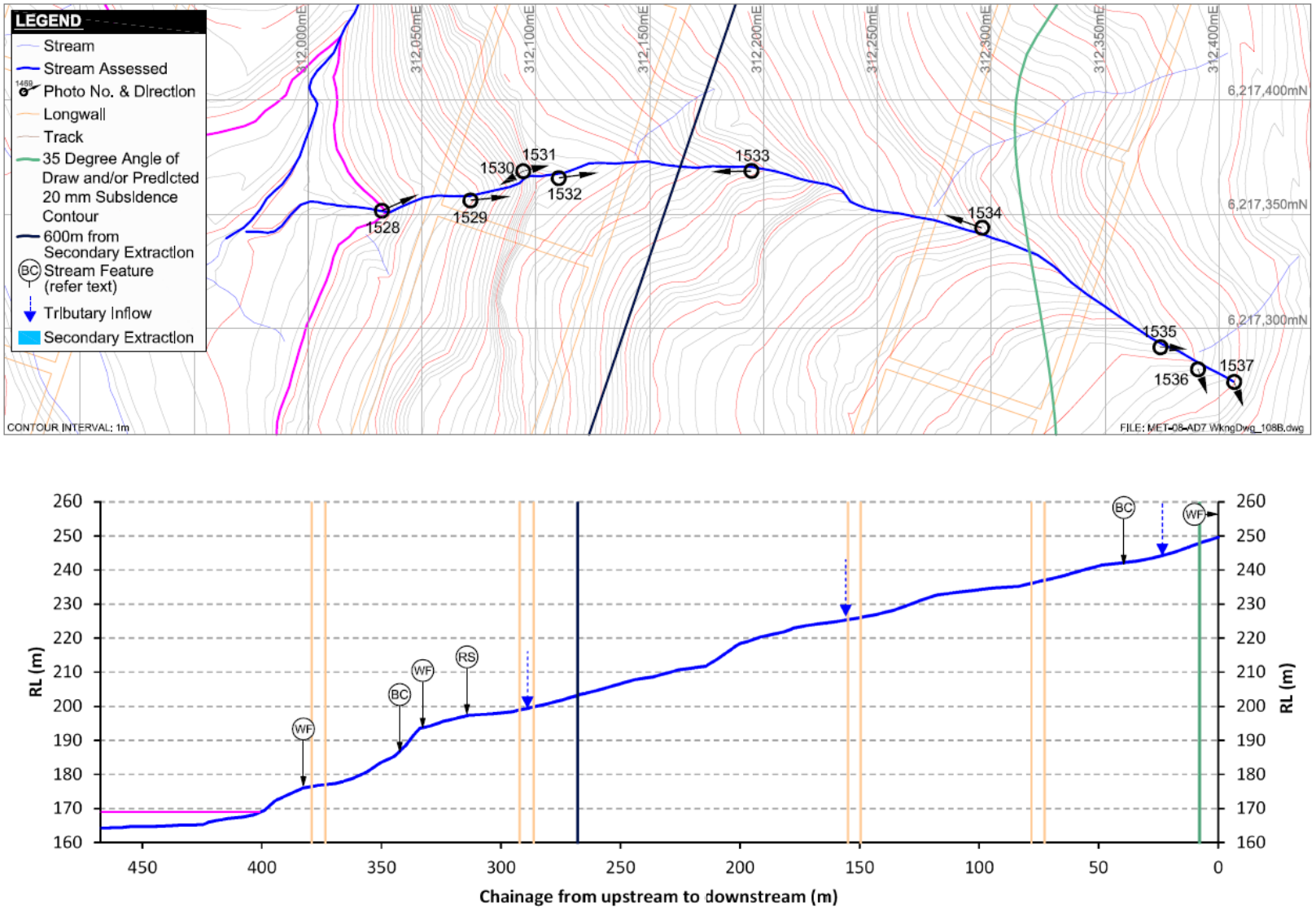

Figure 7 Stream 11 Photo Locations and Stream Features

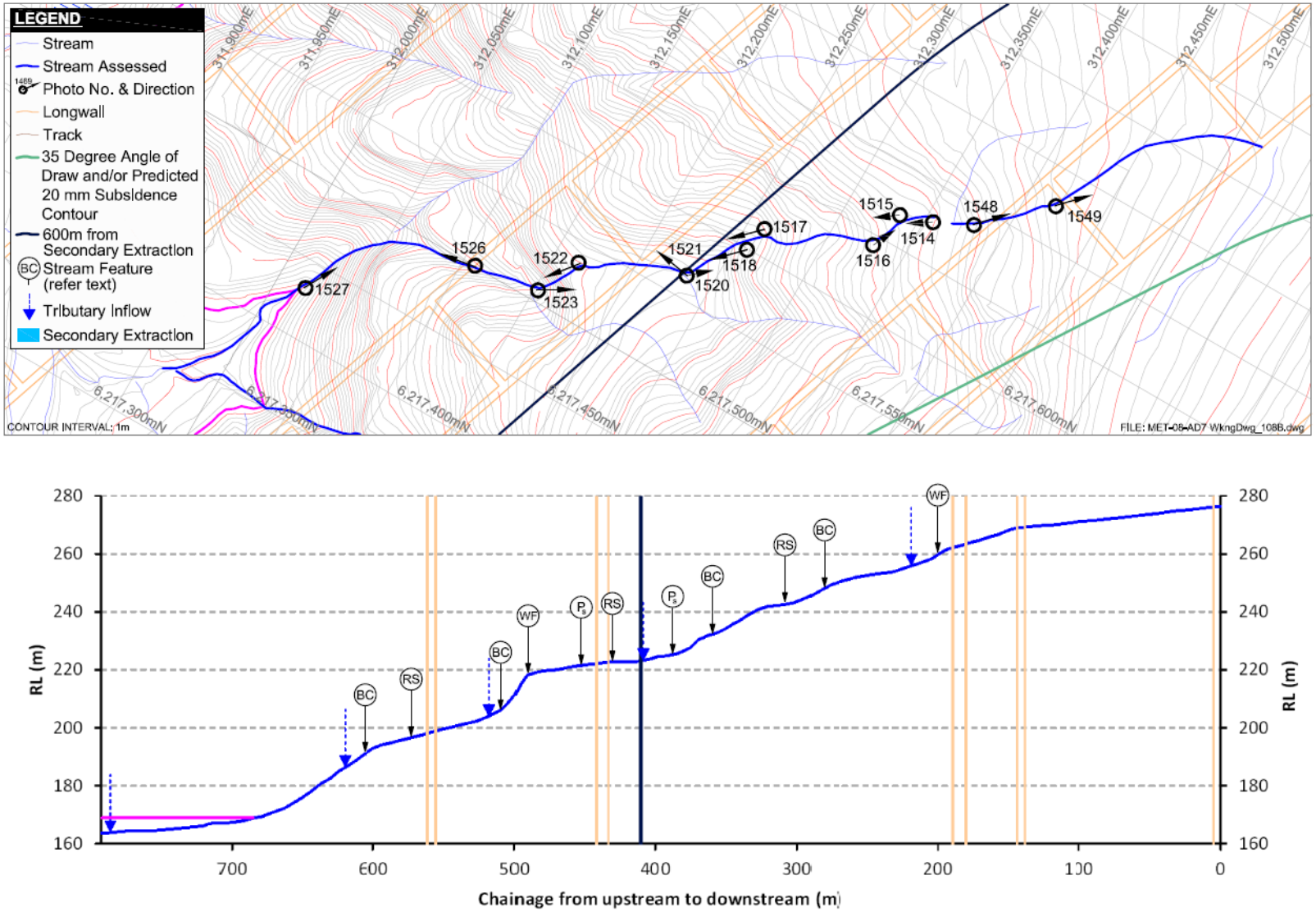

Figure 8 Stream 12 Photo Locations and Stream Features

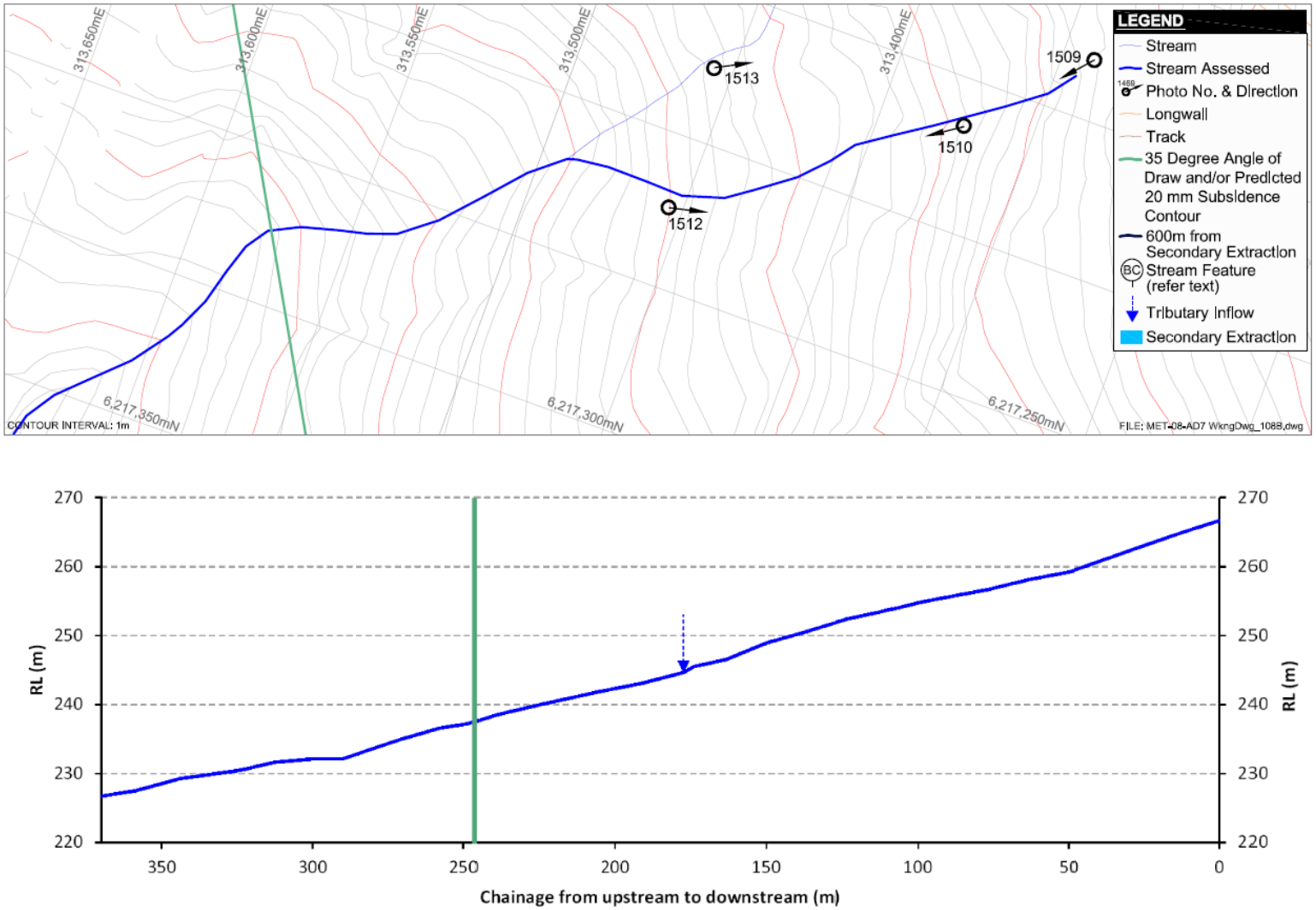

Figure 9 Stream 14 Photo Locations and Stream Features

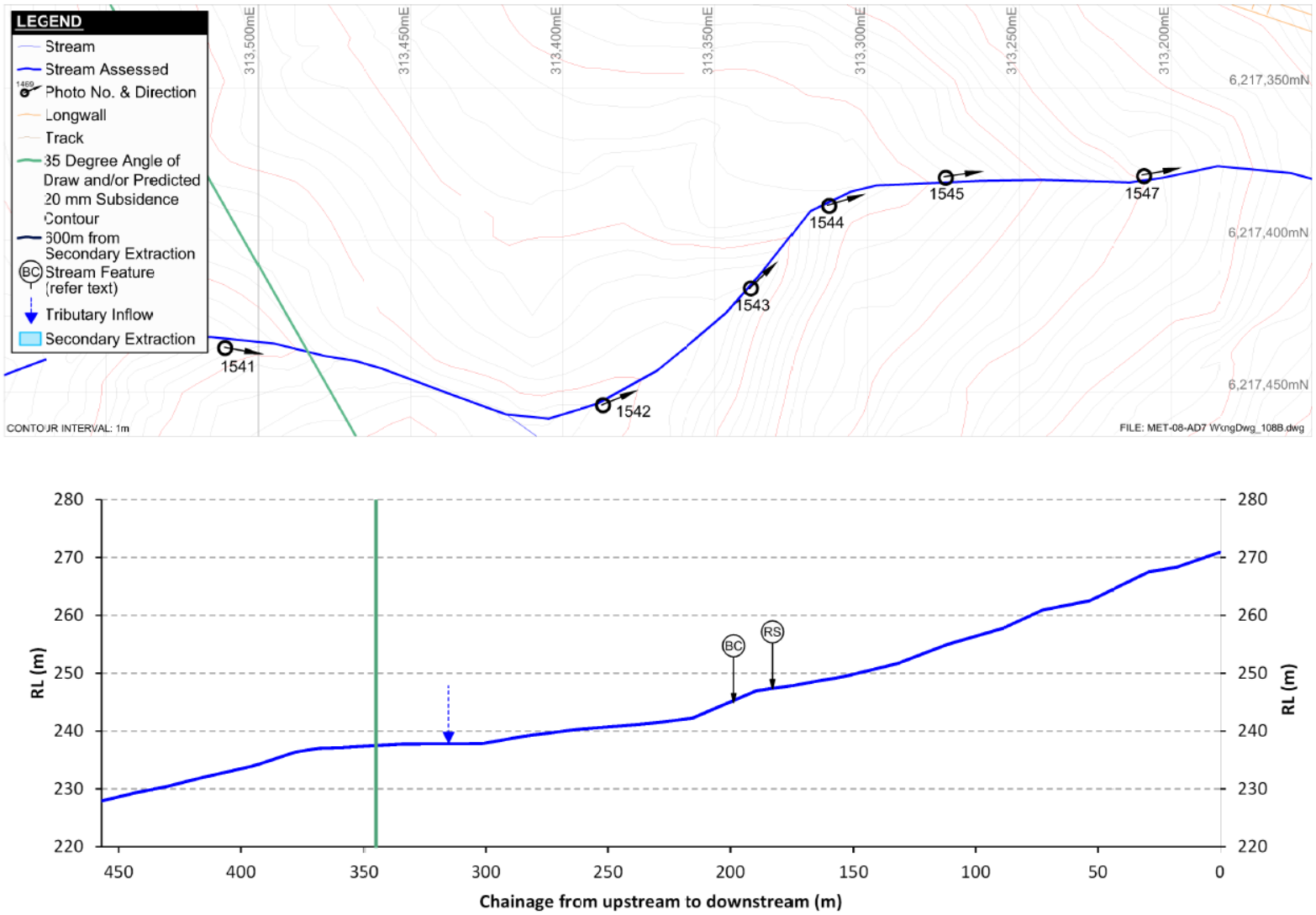

Figure 10 Stream 15 Photo Locations and Stream Features

Attachment 1

Stream Reconnaissance Photographs

Plate 1467

Plate 1468

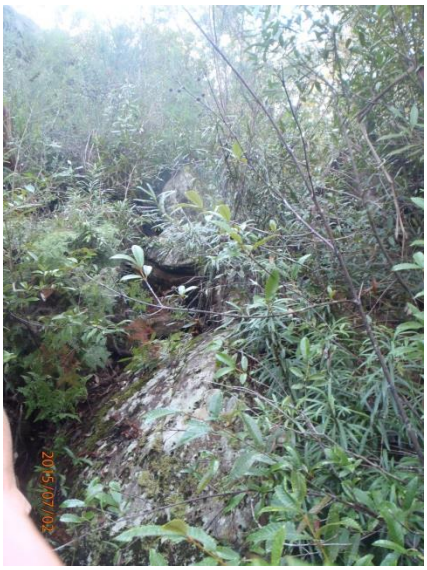

Plate 1469

Plate 1470

Plate 1471

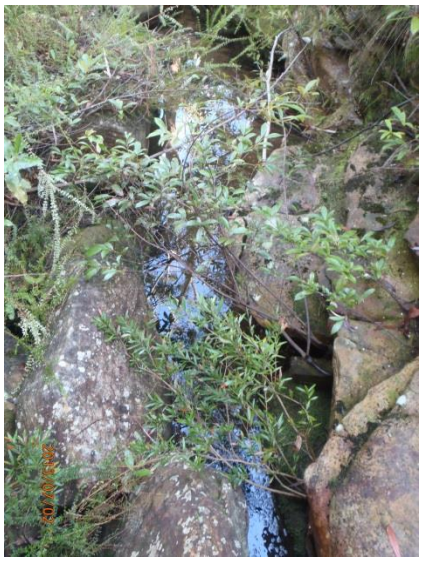

Plate 1472

Stream 1 Plates 1467 to 1472

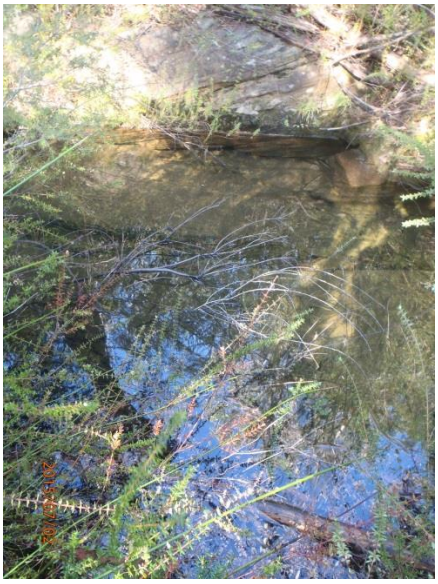

Plate 1473

Plate 1474

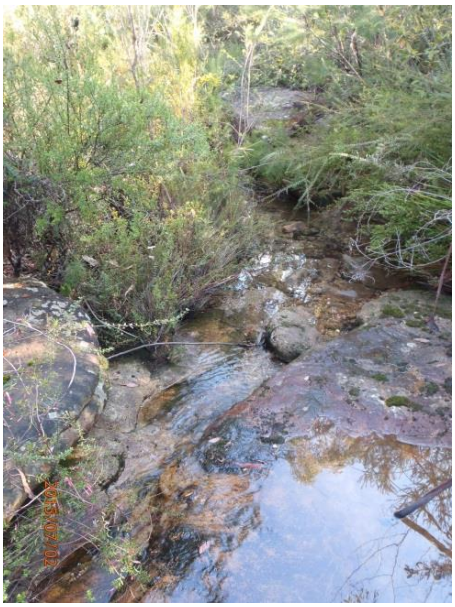

Plate 1475

Plate 1476

Plate 1477

Plate 1478

Stream 1 Plates 1473 to 1478

Plate 1479

Plate 1483

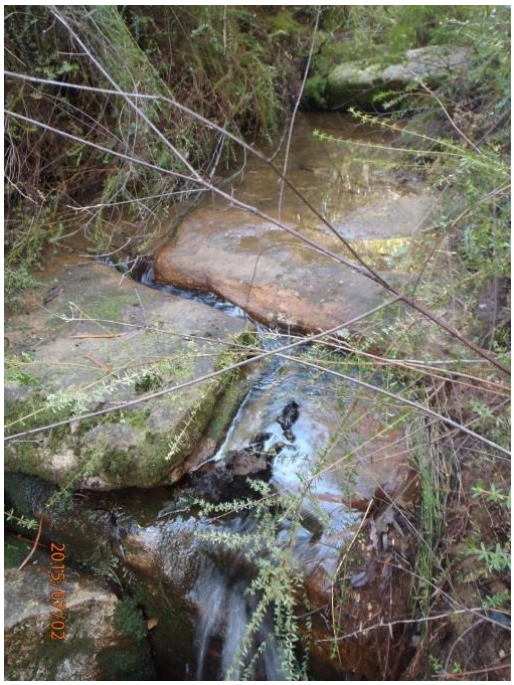

Plate 1484

Plate 1485

Stream 1 Plates 1479 to 1485

Plate 1497

Plate 1498

Plate 1499

Plate 1500

Stream 2 Plates 1497 to 1500

Plate 1487

Plate 1488

Plate 1489

Plate 1490

Stream 2a Plates 1487 to 1490

Plate 1491

Plate 1494

Plate 1495

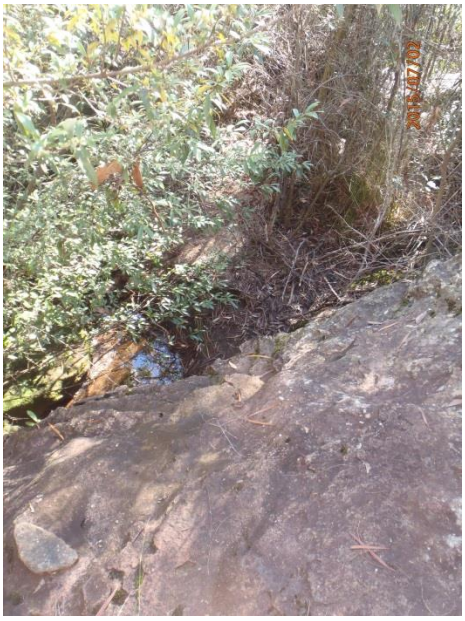

Plate 1496

Stream 2A Plates 1491 to 1496

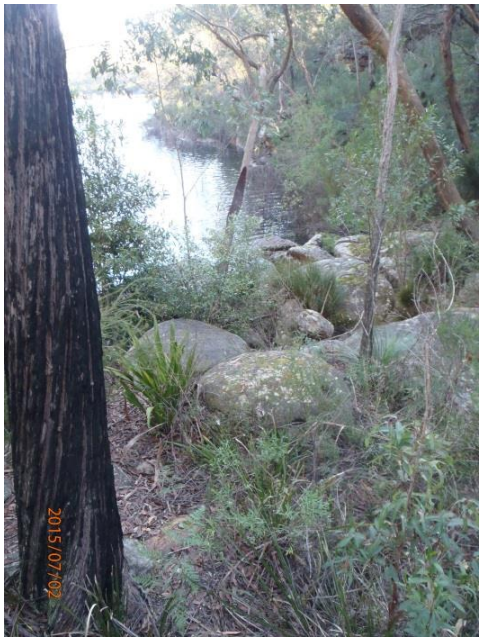

Plate 1501

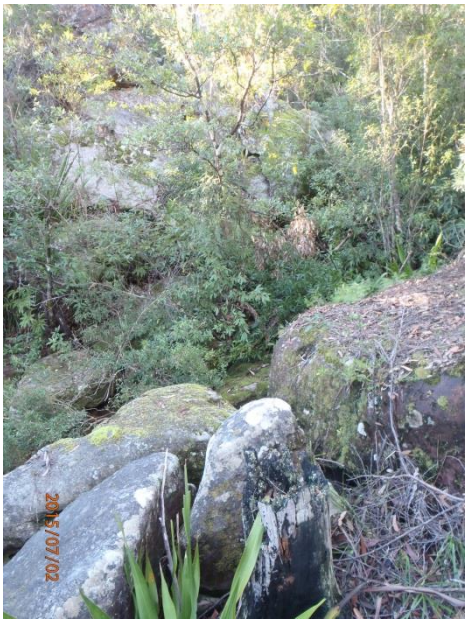

Plate 1502

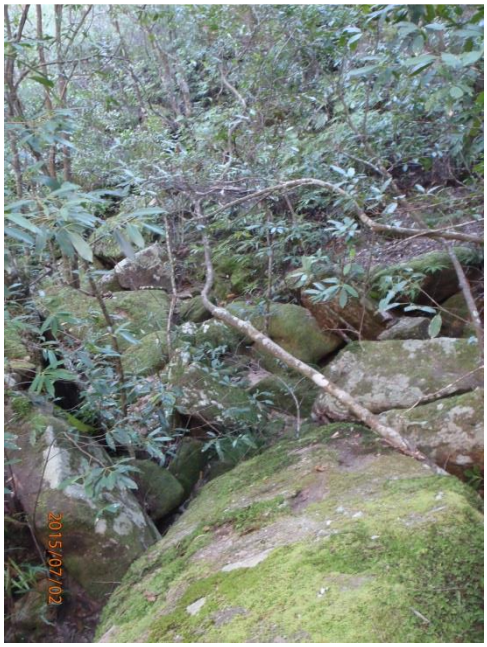

Plate 1503

Plate 1504

Stream 3 Plates 1501 to 1504

Plate 1505

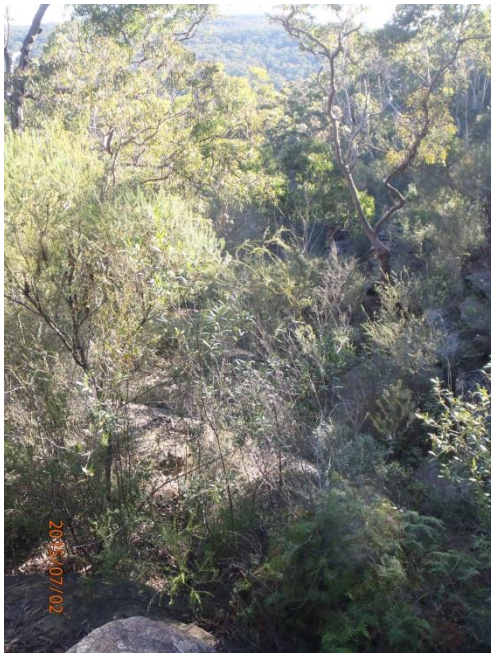

Plate 1506

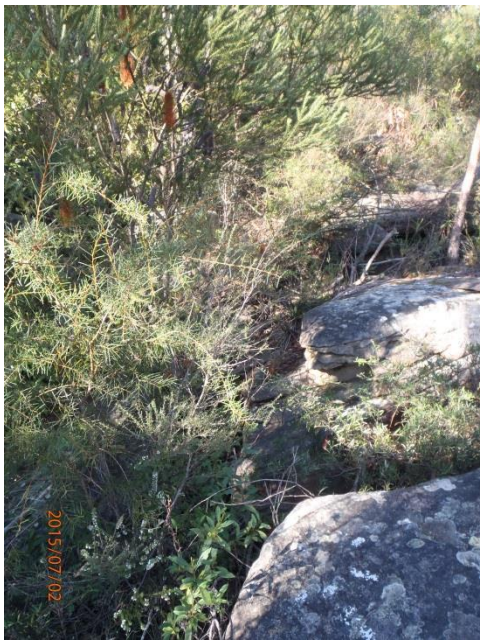

Plate 1508

Stream 3 Plates 1505 to 1508

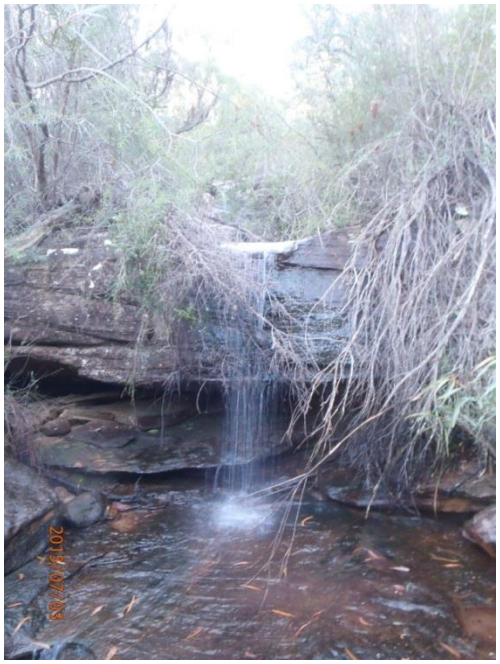

Plate 1528

Plate 1529

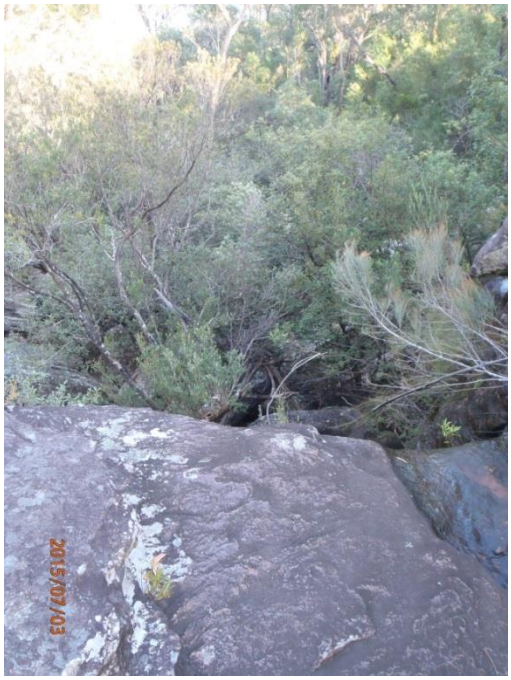

Plate 1530

Plate 1531

Stream 4 Plates 1528 to 1531

Plate 1532

Plate 1533

Plate 1534

Plate 1535

Plate 1536

Plate 1537

Stream 4 Plates 1528 to 1538

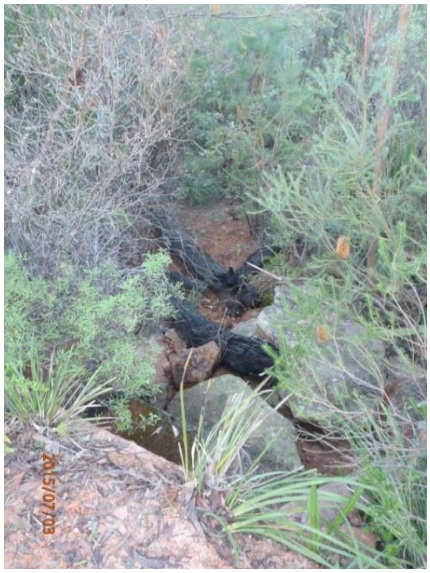

Plate 1514

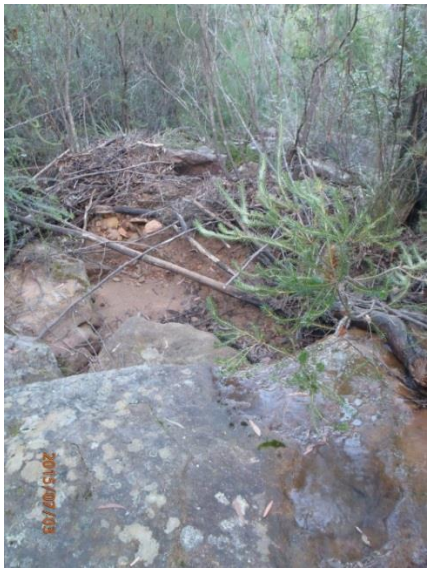

Plate 1515

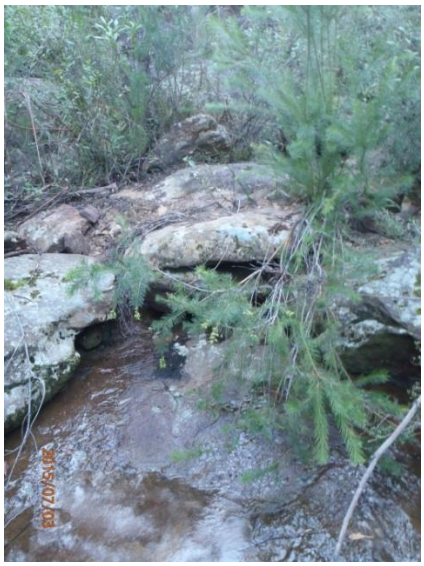

Plate 1516

Plate 1517

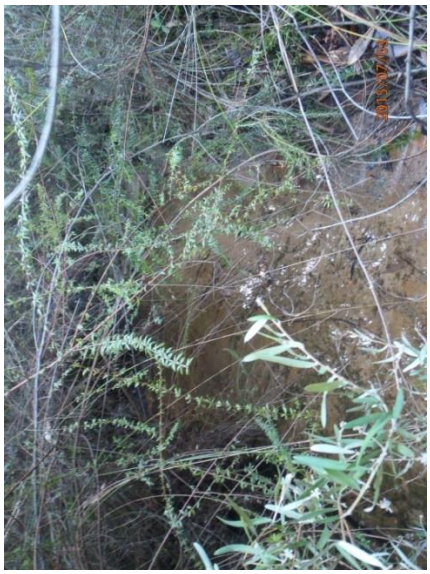

Plate 1518

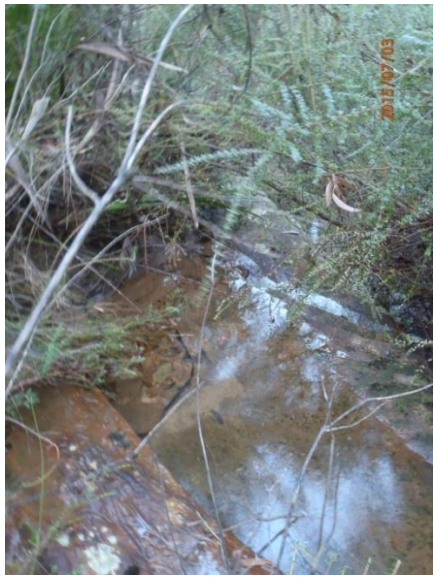

Plate 1519

Stream 5 Plates 1514 to 1519

Plate 1520

Plate 1521

Plate 1522

Plate 1523

Plate 1526

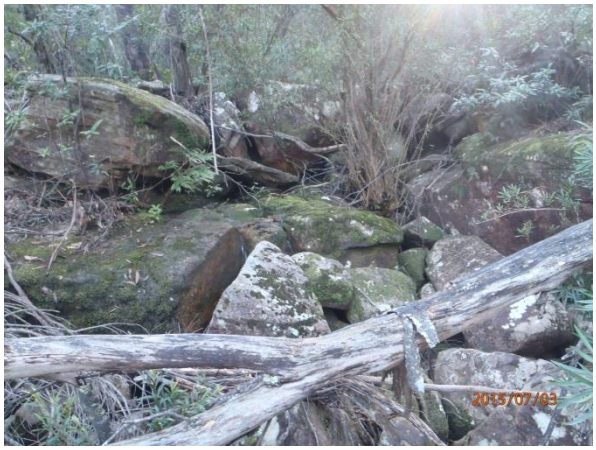

Plate 1527

Stream 5 Plates 1523 to 1527

Plate 1509

Plate 1510

Plate 1512

Plate 1513

Stream 6 Plates 1509 to 1513

Plate 1540

Plate 1541

Plate 1542

Plate 1543

Plate 1544

Plate 1545

Stream 7 Plates 1540 to 1545

Plate 1547

Stream 7 Plate 1547

APPENDIX 5

LONGWALLS 301-303 TERRESTRIAL FAUNA (AMPHIBIAN) BASELINE DATA SPRING/SUMMER 2015 AND SPRING/SUMMER 2016

Table A5-1
Longwalls 301-303 Spring/Summer 2015-2016 Amphibian Species Diversity and Abundance

Scientific Name	Common Name	Year	Site Above Longwalls 301 – 303[1]						Total	Relative Abundance [2]
			23	24	25	26	27	28		
Myobatrachidae										
Crinia signifera	Common Eastern Froglet	2015	4	3	0	1	3	3	14	MC
			0	0	0	0	0	0	0	0
		2016	0	1	3	2	8	4	18	MC
			0	0	40	0	400[a]	0	440	A
Heleiporus australiacus	Giant Burrowing Frog [V, V+]	2015	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0
		2016	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0
Limnodynastes peronii	Brown-striped Frog*	2015	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0
		2016	0	0	0	0	0	0	0	0
			0	0	0	0	30	0	30	C
Limnodynastes tasmaniensis	Spotted Grass Frog+	2015	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0
		2016	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0
Pseudophryne australis	Red-crowned Toadlet [V]	2015	0	0	1	0	0	0	1	1
			0	0	0	0	0	0	0	0
		2016	0	0	1	1	0	0	2	UC
			0	0	0	0	0	0	0	0
Uperoleia laevigata	Smooth Toadlet+	2015	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0
		2016	0	0	0	0	0	1	0	1
			0	0	0	0	0	0	0	0
Hylidae										
Litoria citropa	Blue Mountains Tree Frog*	2015	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0
		2016	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0
Litoria dentata	Bleating Tree Frog+	2015	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0
		2016	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0
Litoria freycineti	Southern Rocket Frog*	2015	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0
		2016	0	0	0	0	0	0	0	0
			0	0	10	0	0	0	10	UC

Table A5-1 (Continued)
Longwalls 301-303 Spring/Summer 2015-2016 Amphibian Species Diversity and Abundance

Scientific Name	Common Name	Year	Site Above Longwalls 301 – 303[1]						Total	Relative Abundance [2]
			23	24	25	26	27	28		
Hylidae (Cont.)										
Litoria latopalmata	Broad-palmed Frog	2015	0 0	0 0	0 0	1 0	0 0	0 0	1 0	1 0
		2016	0 0	1 0	0 0	0 0	0 0	0 0	1 0	1 0
Litoria lesueurii	Lesueur's Frog*	2015	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2016	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
Litoria littlejohni	Littlejohn's Tree Frog[v,v]	*2015*	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2016	0 0	1 0	0 0	0 0	0 0	0 0	1 0	1 0
Litoria wilcoxii	Stony Creek Frog+	2015	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2016	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
Litoria peronii	Peron's Tree Frog*	2015	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2016	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
Litoria phyllochroa	Green Stream Frog+	2015	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2016	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
Species Diversity at Each Site		2015	**1**	**1**	**1**	**2**	**1**	**1**		
		2016	**0**	**3**	**3**	**2**	**2**	**2**		
Species Diversity across the Survey Area		2015							**3**	
		2016							**7**	

[1] First line of data refers to the presence or absence of adults, while the second line of data refers to absence or presence of tadpoles.

[2] Relative Abundance of adult and tadpole stage assessed independently: 0 – No sightings, 1 – One sighting, UC – Uncommon, 2 to 10 individuals, MC – Moderately common, 11 to 20 individuals, C – Common, 21 to 40 individuals, A – Abundant, > 40 individuals.

[v, v] Listed as Vulnerable under the BC Act and EPBC Act. [v] Listed as vulnerable under the BC Act.

* Species not recorded at the Longwalls 301-303 monitoring sites, however it was recorded at either the Longwalls 20-22 or Longwalls 23-27 monitoring sites (as at spring/summer 2015) and is included for ease of future comparison to the Longwalls 20-27 monitoring results.

+ Species not recorded at the Longwalls 301-303 monitoring sites or Longwalls 20-22 or Longwalls 23-27 monitoring sites (as at spring/summer 2015), but included for ease of future comparison to previous Project EA survey results.

[a] Remains of dead tadpoles in pool that had recently dried out.