METROPOLITAN COAL LONGWALLS 308-310

WATER MANAGEMENT PLAN




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METROPOLITAN COAL

LONGWALLS 308-310

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Revision Status Register

Section/Page/ Annexure	Revision Number	Amendment/Addition	Distribution	DPE Approval Date
All	WMP-R01-A	Original	DPE, DPE-Water, BCS, WaterNSW and DSNSW	-
All	WMP-R01-B	To Address Agency Comments on Version A of the Plan	DPE	-
Section 8.10	WMP-R01-C	To Address Recommendations from the IAPUM	DPE	-

November 2022

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1 INTRODUCTION

The Metropolitan Coal Mine is owned and operated by Metropolitan Coal Pty Ltd (Metropolitan Coal), which is a wholly owned subsidiary of Peabody Energy Australia Pty Ltd (Peabody). The Metropolitan Coal Mine is located adjacent to the township of Helensburgh (Figure 1), approximately 30 kilometres (km) north of Wollongong in New South Wales (NSW).

Metropolitan Coal was granted approval for the Metropolitan Coal Project (the Project) under section 75J of the 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. Longwalls 308-310 are situated to the west of Longwalls 301-307 and define the next mining sub-domain within the Project underground mining area (Figure 2). Longwall 311 on will be subject to future Extraction Plans.

1.1 PURPOSE AND SCOPE

In accordance with Condition 6, Schedule 3 of the Project Approval, this Water Management Plan (WMP) has been prepared as a component of the Metropolitan Coal Longwalls 308-310 Extraction Plan to manage the potential environmental consequences of the Extraction Plan on watercourses (including the Woronora Reservoir), aquifers and catchment yield. The relationship of this WMP to the Metropolitan Coal Environmental Management Structure and to the Metropolitan Coal Longwalls 308-310 Extraction Plan is shown on Figure 3.

This WMP includes post-mining monitoring and management of water resources and watercourses for Longwalls 20-22, 23-27, 301-303, 304 and 305-307, subject to the previously approved Metropolitan Coal Longwalls 305-307 WMP. Consistent with the recommended approach in the NSW Department of Planning and Environment (DP&E) (now the NSW Department of Planning and Environment [DPE]) and NSW Division of Resources and Energy (DRE) (2015) *Guidelines for the Preparation of Extraction Plans*, the Longwalls 305-307 WMP will be superseded by this document following the completion of Longwall 307.

In accordance with Condition 6, Schedule 3 of the Project Approval, this WMP has been prepared by Metropolitan Coal, with assistance from SLR Consulting, Hydro Engineering & Consulting, HydroAlgorithmics, Associate Professor Barry Noller (The University of Queensland) and Mine Subsidence Engineering Consultants (MSEC).

1.2 STRUCTURE OF THE WATER MANAGEMENT PLAN

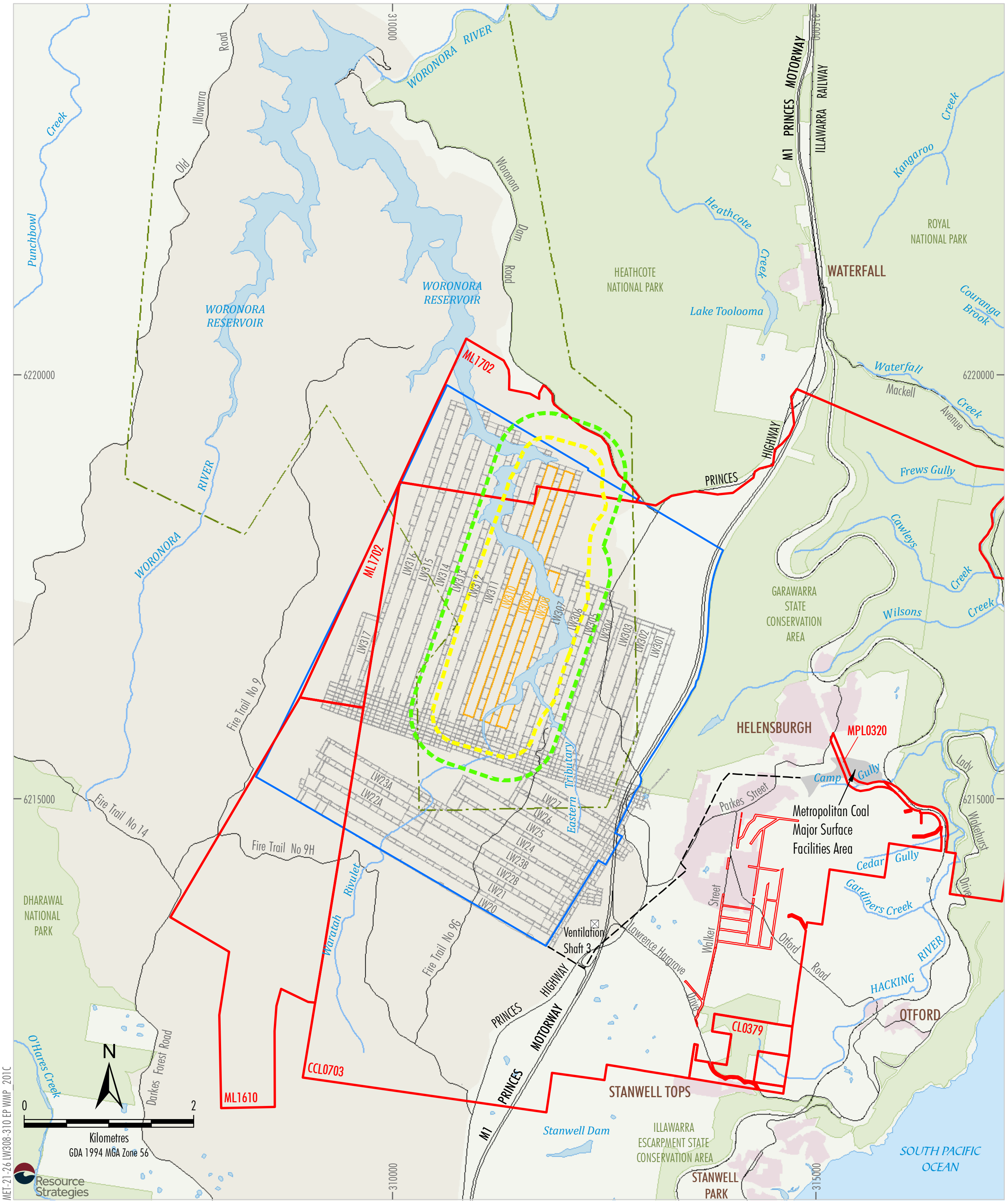
The remainder of the WMP is structured as follows:

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

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

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

Section 5: Provides a revised assessment of the potential subsidence impacts and environmental consequences for Longwalls 308-310.



LEGEND

- Mining Lease Boundary
- Woronora Special Area
- Railway
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Longwalls 308-310 Secondary Extraction
- Longwalls 308-310 35° Angle of Draw and/or Predicted 20 mm Subsidence Contour
- 600 m from Longwalls 308-310 Secondary Extraction
- Woronora Notification Area
- Existing Underground Access Drive (Main Drift)

Source: Land and Property Information (2015); Department of Industry (2015); Metropolitan Coal (2021); MSEC (2021)

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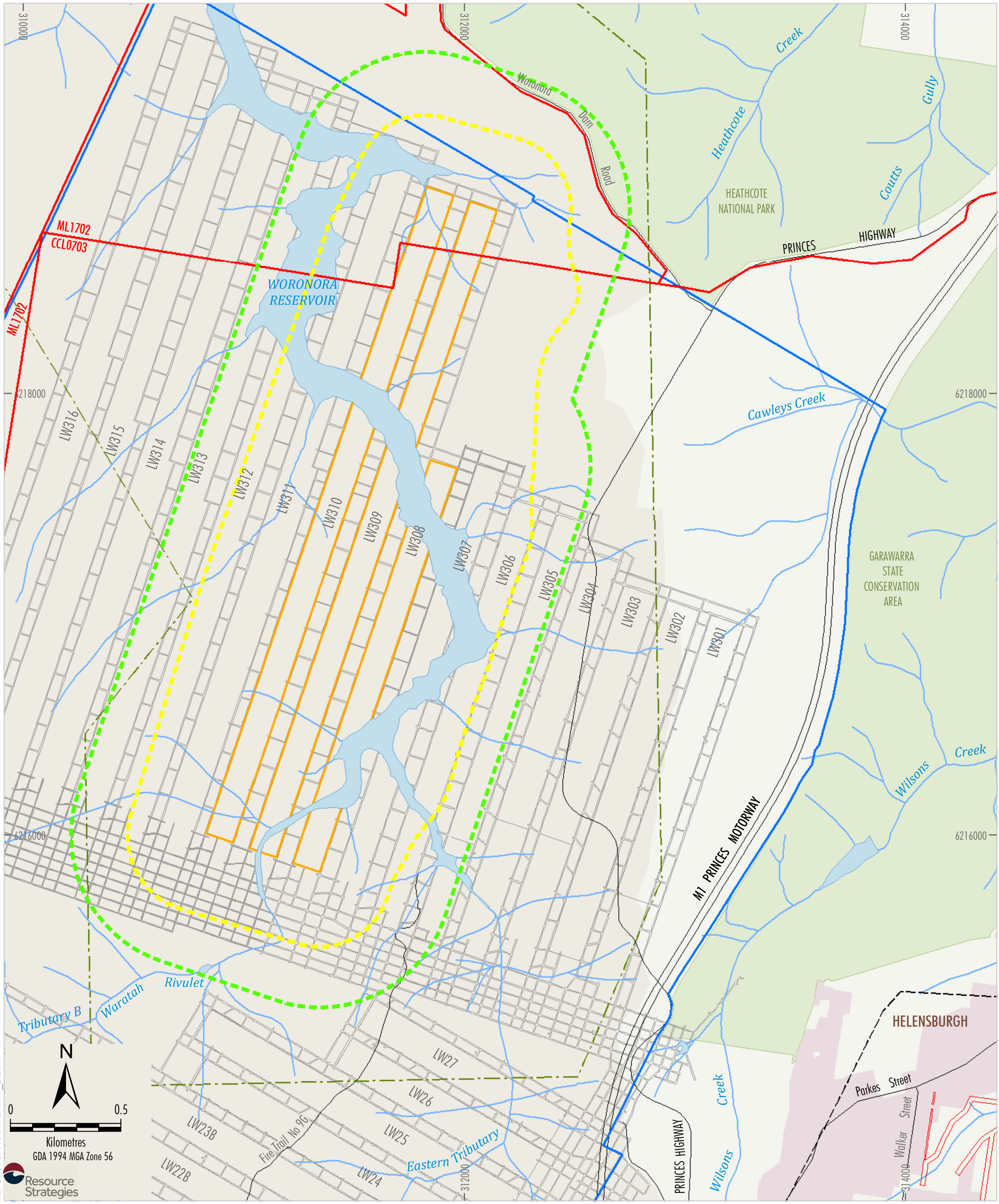
Longwalls 308-310 and Project Underground Mining Area

Figure 1



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Source: Land and Property Information (2015); Department of Industry (2015); Metropolitan Coal (2021); MSEC (2021)

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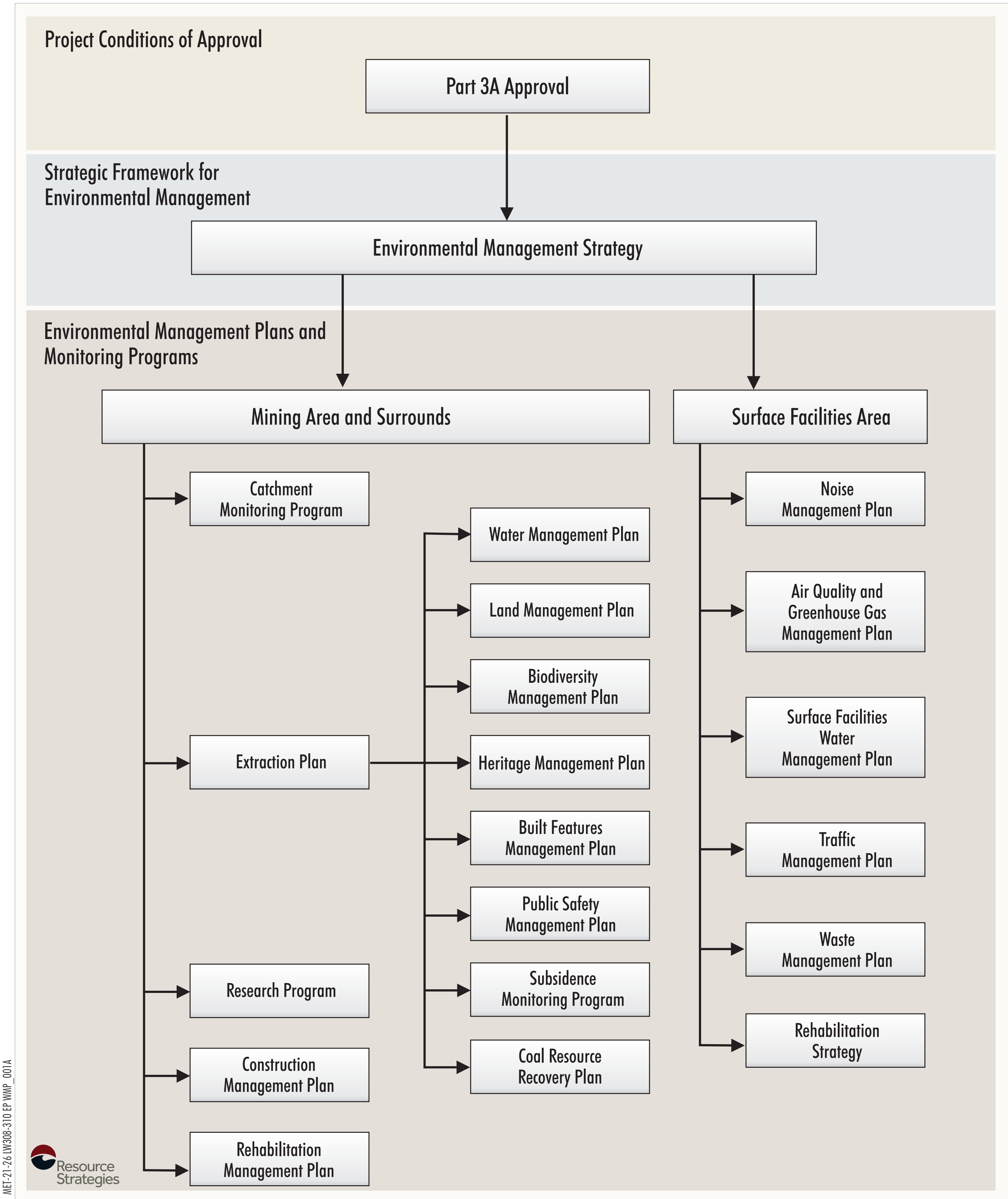
Longwalls 308-310 Layout

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: Details the available 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 WMP.

2 WATER MANAGEMENT PLAN REVIEW AND UPDATE

In accordance with Condition 4, Schedule 7 of the Project Approval, this WMP 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 DPE, to ensure the WMP is updated on a regular basis and to incorporate any recommended measures to improve environmental performance.

The WMP will also be reviewed within three months of approval of any Project modification and if necessary, revised to the satisfaction of the DPE.

The revision status of this WMP is indicated on the title page of each copy. The distribution register for controlled copies of the WMP 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 WMP publicly available on the Peabody website. A hard copy of the WMP 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 WMP, 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 WMP 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 ENVIRONMENTAL PLANNING & ASSESSMENT ACT APPROVAL

Condition 6(f), Schedule 3 of the Project Approval requires the preparation of a WMP 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:*
>
> *…*
>
> - *Water Management Plan, which has been prepared in consultation with OEH[1], SCA[2] and NOW[3], to manage the environmental consequences of the Extraction Plan on watercourses (including the Woronora Reservoir), aquifers and catchment yield;*

1 The Office of Environment and Heritage (OEH) is now the Department of Planning and Environment – Biodiversity, Conservation and Science Directorate (BCS).

2 The Sydney Catchment Authority (SCA) is now WaterNSW.

3 The NSW Office of Water (NOW) is now the Department of Planning and Environment – Water (DPE – Water).

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 WMP. Table 1 indicates where each component of the conditions is addressed within this WMP.

Table 1
Management Plan Requirements

Project Approval Condition	WMP 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 the Metropolitan Coal Mine will be undertaken in accordance with the following licences, permits and leases which have been issued or are pending issue:

- The conditions of mining leases issued by the NSW Division of Resources and Geoscience (DRG) (now Mining, Exploration and Geoscience [MEG]), 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 320).
- The *Metropolitan Coal Mining Operations Plan 1 October 2021 to 30 September 2023* approved by the Resources Regulator.
- 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 Industry – Water (now DPE – 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 Resources Regulator and WorkCover NSW.
- Supplementary approvals obtained from WaterNSW 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)[4]:

- *Biodiversity Conservation Act 2016;*
- *Biosecurity Act 2015;*
- *Contaminated Land Management Act 1997;*
- *Crown Land Management Act 2016;*
- *Dams Safety Act 2015;*
- *Dangerous Goods (Road and Rail Transport) Act 2008;*
- *Energy and Utilities Administration Act 1987;*
- *Fisheries Management Act 1994;*

[4] The list of potentially applicable Acts has been updated to reflect changes to the Acts that were in force at the time of submission of the Metropolitan Coal Project Environmental Assessment (Project EA) (HCPL, 2008).

- *Mining Act 1992;*
- *National Parks and Wildlife Act 1974;*
- *Protection of the Environment Operations Act 1997;*
- *Rail Safety (Adoption of National Law) Act 2012;*
- *Roads Act 1993;*
- *Water Act 1912;*
- *Water Management Act 2000;*
- *Water NSW Act 2014;*
- *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 WATER MANAGEMENT INFORMATION OBTAINED SINCE PROJECT APPROVAL

4.1 SURFACE WATER

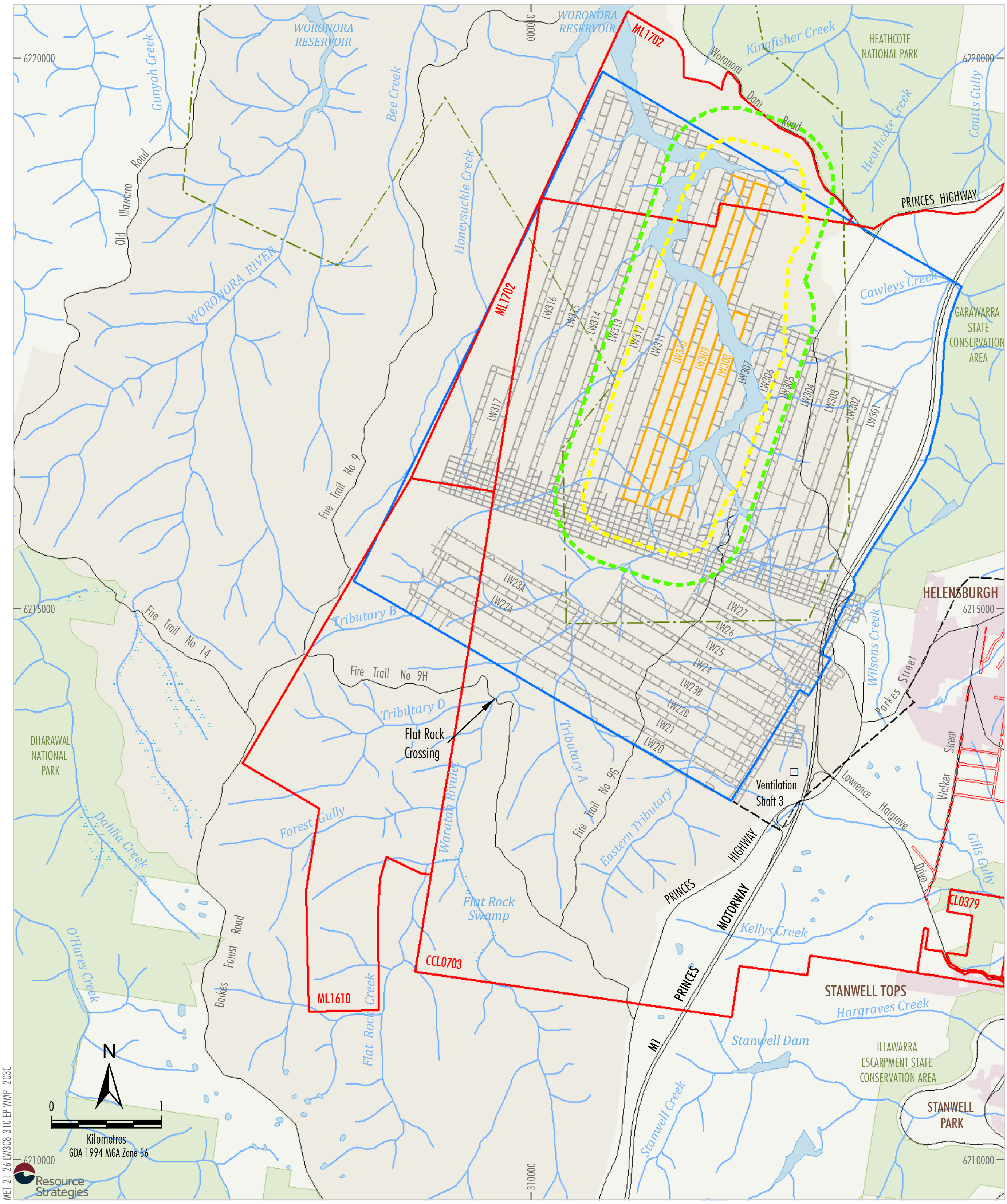
Streams occurring within 600 metres (m) of Longwalls 20-22, 23-27, 301-303, 304 and/or 305-307 secondary extraction include the Waratah Rivulet and its tributaries (such as Tributary A and B), the Eastern Tributary and its tributaries, and small first and second order streams including those that drain into the Woronora Reservoir (Figure 4).

The Waratah Rivulet and Eastern Tributary are the subject of Project performance measures, as described in Section 6. The locations of pools on the Waratah Rivulet and the Eastern Tributary are shown on Figure 5. The Preferred Project Report (HCPL, 2009) indicated that valley closure values of greater than (>) 200 millimetres (mm) were predicted for a number of pools/rock bars on the Waratah Rivulet, Eastern Tributary and other streams. 'Negligible consequence' for a watercourse was considered by the Project Approval to mean, *'no diversion of flows, no change in the natural drainage behaviour of pools, minimal iron staining, and minimal gas releases'*, and was assumed to be achieved in circumstances where predicted valley closure was less than (<) 200 mm.

Subsidence impacts to a number of pools on the Eastern Tributary occurred during the mining of Longwalls 26 and 27 at predicted valley closure values of less than 200 mm.

The Independent Expert Panel for Mining in the Catchment (IEPMC)[5] Initial Report recommended that the concept of restricting predicted valley closure to a maximum of 200 mm to avoid significant environmental consequences be revised for watercourses (IEPMC, 2018). Metropolitan Coal agreed that the 200 mm valley closure concept required revision in relation to the Eastern Tributary, noting that the unexpected impacts are particular to the Eastern Tributary and not the Waratah Rivulet. Restricting predicted valley closure to 200 mm has been a successful design tool for mining in the vicinity of the Waratah Rivulet.

[5] The IEPMC was established in November 2017 by the NSW Government to provide expert advice to the DPE on the impact of mining activities in the Greater Sydney Water Catchment Special Areas, with a particular focus on risks to the quantity of water in the catchment.



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- Woronora Notification Area

Source: Land and Property Information (2015); Department of Industry (2015); Metropolitan Coal (2021); MSEC (2021)

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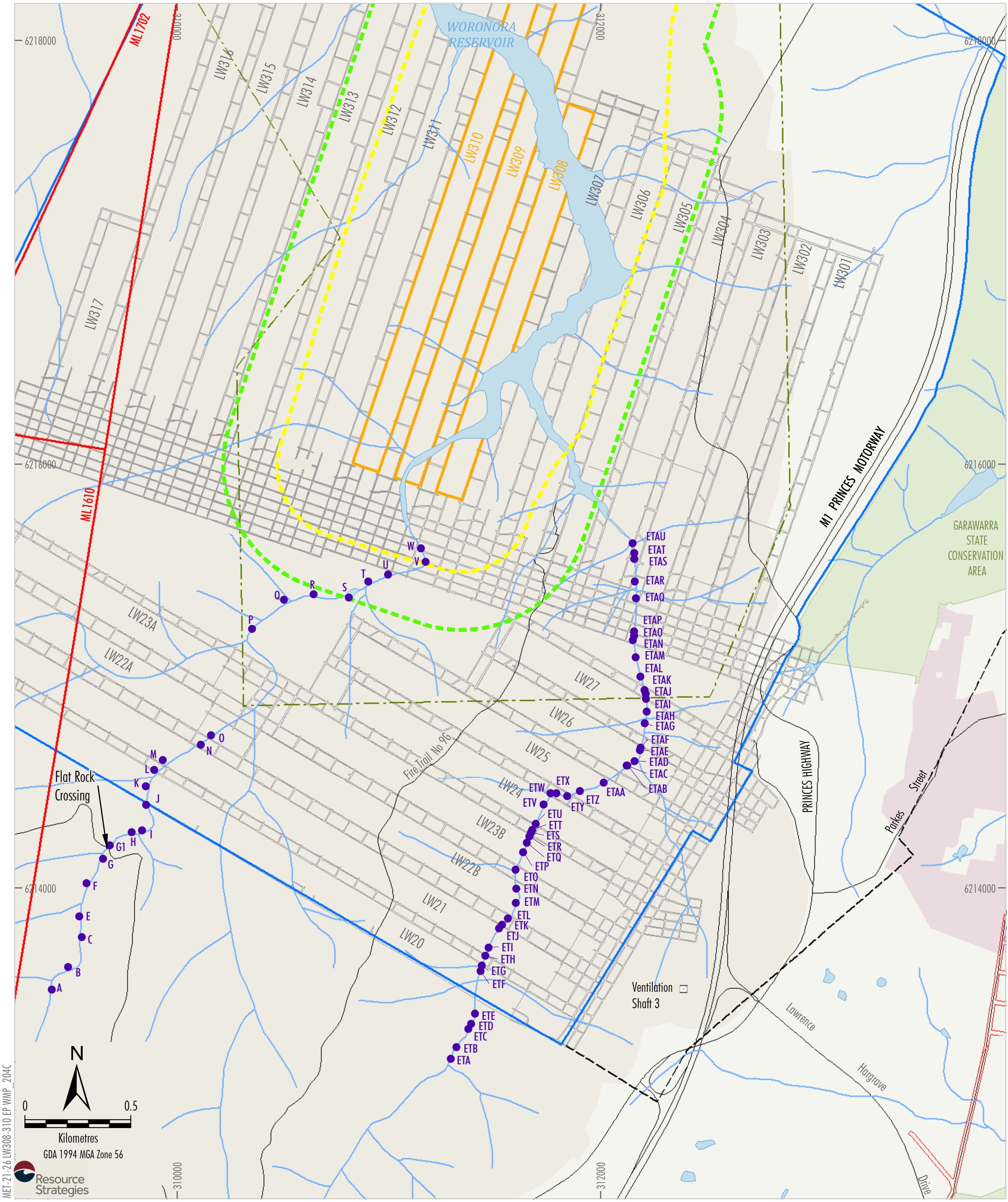
Streams within the Project Underground Mining Area and Surrounds

Figure 4



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- Woronora Notification Area
- Existing Underground Access Drive (Main Drift)
- Pool

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

Source: Land and Property Information (2015); Department of Industry (2015); Metropolitan Coal (2021); MSEC (2021)

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Waratah Rivulet and Eastern Tributary Pools

Figure 5

The negligible environmental consequences performance measure for watercourses as described above applied specifically for the Waratah Rivulet along the portion of the '*Waratah Rivulet between the full supply level of the Woronora Reservoir and the maingate of Longwall 23 (upstream of Pool P)'.* This section of the Waratah Rivulet includes Pool P to Rock Bar W, located to the south of Longwalls 308-310.

The restriction of predicted valley closure to 200 mm has been a successful design tool on the Waratah Rivulet, with no impacts to pools and rock bars along the Waratah Rivulet at predicted total valley closure of less than 200 mm. Pool P to Rock Bar W have not exceeded the negligible environmental consequence performance measure for the Waratah Rivulet. Predicted total valley closure for Pool P to Rock Bar W was less than 200 mm for the extraction of Longwalls 20-27 and Longwalls 301-303 and did not increase for Longwalls 301-306.

Pool A to Pool O4 (a total of 16 pools) are located upstream of Pool P, and are therefore not subject to the Waratah Rivulet negligible environmental impact performance measure. It is noted that the majority of these pools were predicted to experience maximum predicted total closure of greater than 200 mm. However, of these pools, only two (Pools G1 and N) have experienced subsidence impacts that would have resulted in an exceedance of the negligible environmental impact performance measure. Impacts that have occurred at these pools have been the result of mining directly beneath the Waratah Rivulet or in close proximity (< 100 m) to the rock bars, at predicted total valley closure greater than 200 mm.

Although subsidence impacts were observed at a number of pools on the Eastern Tributary at predicted total valley closure values of less than 200 mm during the mining of Longwalls 26 and 27, restricting predicted total valley closure to 200 mm is no longer applied for the Eastern Tributary.

A geotechnical study of the Waratah Rivulet stream bed investigated the geological characteristics of the stream bed, with the aim of identifying any characteristics that would make the Waratah Rivulet more susceptible to subsidence movements (similar to the Eastern Tributary). The study focussed on Pool P to Rock Bar W on the Waratah Rivulet, and compared these sites to Pool ETAM on the Eastern Tributary, which has experienced subsidence movements due to historical mining.

The geotechnical study identified a thick unit (approximately 25 m) of thinly bedded sandstone along the Eastern Tributary at the location of Pool ETAM. The thinly bedded sandstone is considered to be of lower strength, and more weathered than adjoining thickly bedded sandstone units and therefore more prone to impact from valley closure movements. In addition, a higher frequency of seam level faults and surface lineaments have been identified in the vicinity of the Eastern Tributary. The thinly bedded units identified along the along Waratah Rivulet were limited to less than 5 m thickness and the frequency of seam level faults and surface lineaments was considerably less.

Based on the results of the assessment, the geological features identified along the Eastern Tributary are considered to be unique, compared to the Waratah Rivulet. The Eastern Tributary is therefore more likely to be susceptible to subsidence movements. Restricting valley closure to 200 mm therefore continues to be an appropriate design tool for the Waratah Rivulet. Further discussion on the subsidence predictions and 200 mm valley closure design tool for Longwalls 308-310 is provided in Section 5.

Metropolitan Coal developed a monitoring and adaptive management approach to the mining of Longwall 303 towards the Eastern Tributary. As Longwall 303 mined towards the Eastern Tributary, Metropolitan Coal used a TARP designed to monitor valley closure movements on the Eastern Tributary. The Eastern Tributary Valley Closure TARP has been successfully implemented by Metropolitan Coal for Longwalls 303, 304 and 305. The same monitoring and adaptive management approach will be used for extraction of Longwalls 306 and 307 (as described in the Longwalls 305-307 Extraction Plan). For Longwalls 308-310, the Waratah Rivulet will be monitored by the same Global Navigation Satellite System (GNSS) valley closure monitoring methods used for the Eastern Tributary with consideration of the 200 mm valley closure design tool.

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 WMPs.

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) have either been manually monitored on a daily basis or monitored using a continuous water level sensor and logger (Figure 6). A number of pools on the Eastern Tributary (Pools ETG, ETJ, ETM, ETO, ETU, ETW, ETAF, ETAG, ETAH, ETAI/ETAJ/ETAK[6], ETAL, ETAM, ETAN, ETAO, ETAP, ETAQ ETAR, ETAS/ETAT[7] and ETAU), Tributary B (Pools RTP1 and RTP2) and Woronora River (Pools WRP1, WRP2, WRP3 and WRP4) have also been 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 WMPs. These documents identified that the key potential subsidence impacts in relation to pool water levels and surface water flow would include:

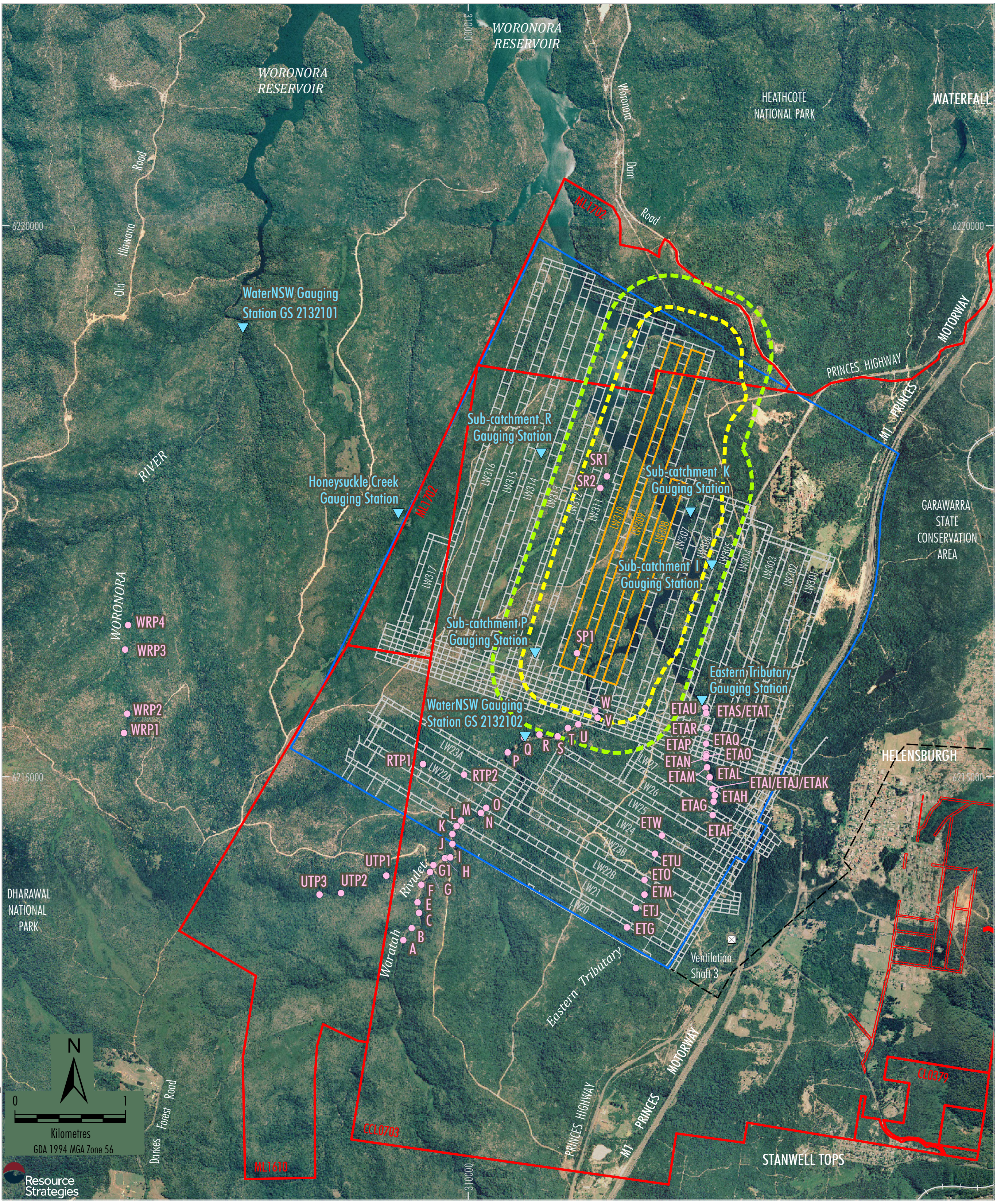
- The magnitudes of the predicted systematic and/or valley related movements are likely to result in some fracturing and dilation of the underlying strata of streams above and immediately adjacent to the longwalls.
- Cracking and dilation of bedrock are likely to result in the localised diversion of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

[6] Only small rock bars separate Pools ETAI, ETAJ and ETAK. Pools join to become the one large pool. Pool ETAK is controlled by a rock bar. The water level meter situated in Pool ETAI is considered to be representative of the water level in Pools ETAJ and ETAK.

[7] Due to the nature of rock bar ETAS, Pool ETAS and Pool ETAT typically sit at the same level. The water level meter situated in Pool ETAT is considered to be representative of the water level in Pool ETAS.



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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 (2021); MSEC (2021)

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Surface Water Quantity Sites

Figure 6

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. 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 and not as a result of climatic conditions, namely, Pool G1 in March 2011 and Pool N in September 2012[8]) (Figure 5). To date, stream remediation activities on the Waratah Rivulet have been conducted at Pools A, F and G. 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).

In 2021, Hydro Engineering & Consulting (2021a) assessed the success of pool remediation measures undertaken by Metropolitan Coal and if subsidence impacts had otherwise diminished in pools on the Waratah Rivulet. Hydro Engineering & Consulting (2021a) found that for Pools G1 and N, water level recession behaviour was consistent with pre-impact behaviour, and that for Pools B, C, E, F and G, water levels during low flow conditions were consistent with the water levels of similar, un-impacted pools. For Pool A, recorded water levels during low flow conditions were not consistent with the water levels of similar, un-impacted pools.

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.

Up until December 2016, the monitoring of water levels/drainage behaviour of pools on the Eastern Tributary between the full supply level of the Woronora Reservoir and the Longwall 26 maingate 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 percent [%]) 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 on the Eastern Tributary 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 (Eastern Tributary Incident). 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). Mining has not resulted in the diversion of flows or change to the natural drainage behaviour of Pools ETAS, ETAT and ETAU (Figure 5).

[8] To date (September 2021), Pool N has overflowed its rock bar since December 2014, with the exception of relatively short periods. Pools on the Woronora River also stopped flowing within the same periods. Monitoring of Pool N will continue to be conducted.

The Longwalls 303, 304 and 305-307 Eastern Tributary Valley Closure TARPs were designed to minimise the risk that mining of Longwalls 303, 304 and 305-307 would result in exceedance of the Eastern Tributary performance measure, being negligible environmental consequences. Consistent with the TARP, the decision to cease mining of Longwalls 303, 304 and 305 was made at a very low magnitude of valley closure. High accuracy closure measurements taken directly on the rock bar or valley floor demonstrated that total rock bar closure was less than 2 mm throughout the mining process and strains on the rock bar were less than 0.5 mm/m, (i.e. in the order of survey accuracy). The Eastern Tributary Valley Closure TARP has been successfully implemented by Metropolitan Coal for Longwalls 303, 304 and 305.

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 has been conducted at the Waratah Rivulet, Woronora River (Figure 6) and O'Hares Creek gauging stations since the commencement of Longwall 20 in 2010. 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 megalitre (ML) per day (ML/day). One (1) ML/day has been used as it is considered to be the limit of effective detection of an impact. 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 continuous and that it has been generally consistent with, or above, model predictions. This indicates that flows reaching the Woronora Reservoir have not been reduced by mining.

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.

The gauging stations installed in sub-catchments I and K as a component of the Woronora Reservoir Impact Strategy are discussed in Section 4.3.

Iron Staining

Hawkesbury Sandstone is the main geological feature of the Woronora River catchment within the Woronora Plateau (The University of Queensland, 2016a). The sandstone is held together by cements, most commonly carbonate, which contains iron (The University of Queensland, 2016a). Iron staining occurs naturally in the Waratah Rivulet and Eastern Tributary and other streams on the Woronora Plateau (examples of which can be found in Appendix 5).

As described in the Southern Coalfield Panel Report (Department of Planning, 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.

In October 2016, Metropolitan Coal reported the exceedance of the *minimal iron staining* component of the Eastern Tributary performance measure (the Eastern Tributary Incident) to the Secretary of the Department of Planning, Industry and Environment (DPIE) and other relevant agencies in accordance with Condition 6, Schedule 7 of the Project Approval and the Metropolitan Coal Longwalls 23-27 WMP Contingency Plan. Inspection results of fresh iron staining/flocculent within the performance measure reach indicates the extent of iron staining/flocculent has varied over time since the exceedance (Metropolitan Coal, 2021).

The iron staining/flocculent is associated with Eastern Tributary water quality impacts, which have occurred in association with the exceedance of the Eastern Tributary watercourse performance measure. Reducing conditions (through water saturation excluding oxygen) has solubilised iron in the groundwater, which has been transferred to surface water through mine-induced cracking. The soluble iron (iron (II) ion, Fe2+), rapidly oxidises to iron (III) Fe3+, and forms insoluble hydrated ferric hydroxide in colloidal (<0.45 micrometres [µm]) and particulate (>0.45 µm) forms (The University of Queensland, 2018a). Iron oxidising bacteria can also create oxidised iron precipitate (National Health and Medical Research Council, 2011). The iron floc is a mixture of precipitated iron oxyhydroxide material >0.45 µm size and colloidal material which is <0.45 µm size. The colloidal material coagulates to give the larger size precipitated material and coats the creek bed rock surfaces (The University of Queensland, 2018a). The iron oxyhydroxide gradually converts to goethite (Yee *et al*., 2006) which has a darker colour and is commonly found in the creek sediment. Goethite is much darker in colour (a dark reddish-brown) and goethite staining occurs both naturally and commonly and can be seen in many similar watercourses throughout the Southern Coalfield (Department of Planning, 2009). It is anticipated that the stream remediation activities being conducted on the Eastern Tributary (Section 9.4.1) will reduce the transfer of iron from the groundwater to the Eastern Tributary.

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 WMP 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, ETAH, ETAI, ETAL and ETAM on the Eastern Tributary (Figure 5). Primarily, the two minor natural gas components that occur in gas releases from mine subsidence are carbon dioxide and methane. 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; 2016b; 2017; 2018b, 2018c, 2019a, 2020a – 2020d, 2021a – 2021e).

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 WMPs included:

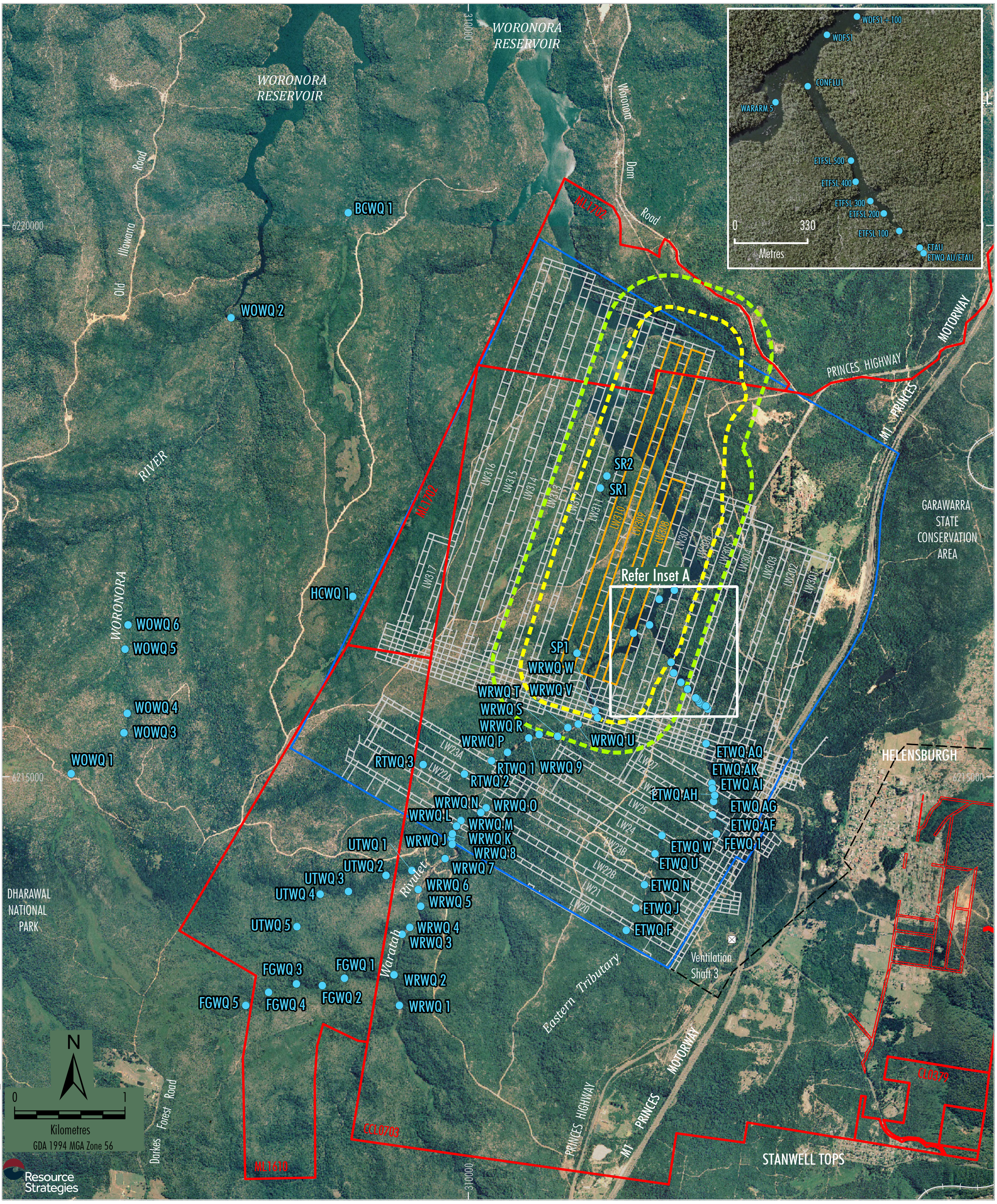
- Potential changes in bed gradients could occur, however, were anticipated to be small relative to the existing grades.
- An increased potential for scouring of the stream bed and banks (at locations where the predicted tilts considerably increase the natural pre-mining stream gradients). The potential 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.

Surface Water Quality

Subsidence impacts on water quality were predicted by the Project EA, Preferred Project Report, and Metropolitan Coal WMPs to be similar to that previously observed at Metropolitan Coal, specifically, transient pulses of iron, manganese and to a lesser extent aluminium, which would likely occur following fresh cracking of the stream bed. Aluminium comes from erosion of rock material whereas iron and manganese arise from dissolution of minerals in sandstone via changes in redox conditions.

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. Recent trends in the monitoring data 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 (2021b). The water quality sites are shown on Figure 7.



LEGEND

- Mining Lease Boundary
- Railway
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Longwalls 308-310 Secondary Extraction
- Longwalls 308-310 35° Angle of Draw and/or Predicted 20 mm Subsidence Contour
- 600 m from Longwalls 308-310 Secondary Extraction
- 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 (2021); MSEC (2021)

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Surface Water Quality Sites

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 at times iron. Reducing conditions (through water saturation excluding oxygen) has solubilised iron (and manganese) in the groundwater. The soluble iron and manganese has been transferred to surface water through mine-induced cracking, resulting in increases in iron and manganese concentrations in the Eastern Tributary. The soluble iron (iron (II) ion, Fe^{2+}), rapidly oxidises to iron (III) Fe^{3+}, and forms insoluble hydrated ferric hydroxide in colloidal (<0.45 μm) and particulate (>0.45 μm) forms (The University of Queensland, 2018a). Manganese remains dissolved in the water column as oxidation at near-neutral pH is slow (Raveendran *et al.,* 2001) and soluble manganese (II ion, Mn^{2+}) is the most stable species (Rayner-Canham, 1996) (The University of Queensland, 2018a). Low levels of manganese, e.g. <0.1 milligrams per litre (mg/L) exist in the natural creek water. Dissolved manganese is however readily diluted by freshwater flow to low levels when higher creek flows occur.

Assessment of the water quality monitoring results to date by Associate Professor Barry Noller (The University of Queensland, 2018a, 2018d – 2018l; 2019b – 2019d, 2020e – 2020l, 2021f – 2021n) 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.

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 (sites WRWQ 2 and WRWQ 6) show slightly acidic to near neutral pH values with higher (slightly alkaline) values being recorded at lower to middle and lower reach sites (e.g. at sites WRWQ 8, WRWQ T and WRWQ W). • Electrical conductivity levels have recently been generally consistent with historical values with no historically high electrical conductivity values recorded from January to June 2021. • Dissolved iron concentrations recorded from January to June 2021 were below 0.5 mg/L at upper and middle reach sites and below 0.1 mg/L at lower reach sites, consistent with baseline values. • Dissolved aluminium concentrations have typically been low (<0.01 mg/L). Concentrations increased slightly in March and May 2021, although were consistent with historical levels. • Dissolved manganese concentrations at the upper, middle and lower reach sites recently have been generally consistent with previously recorded levels (0.08 mg/L to 0.30 mg/L).
Woronora River (control sites WOWQ 1[1] and WOWQ 2)	• Sites on Woronora River typically show slight acidity and high variability in pH. • Electrical conductivity values have been similar to values recorded on Waratah Rivulet. • Dissolved iron has been generally low and similar to values recorded in Waratah Rivulet. • Dissolved manganese has been typically low with evidence of increased concentrations occurring in the summer months. • Dissolved aluminium concentrations have been typically low and typically higher upstream.

Table 2 (Continued)
Stream Water Quality Monitoring Results

Stream	Monitoring Results to Date
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 slightly acidic to near neutral pH values. • Electrical conductivity values have historically been low, however have been more variable since mid 2016. Electrical conductivity values recorded during January to June 2021 were below 500 microSiemens per centimetre (µS/cm). • 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. • Dissolved aluminium concentrations are typically low (<0.01 mg/L), with some variable levels recorded from January to June 2021.
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 recent values have been 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). Elevated values have been recorded on Bee Creek and Honeysuckle Creek from early 2020 (in relation to earlier recorded values).

Source: after Hydro Engineering & Consulting (2021b)

Woronora Reservoir Water Quality

The Project EA, Preferred Project Report, and Metropolitan Coal WMPs 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 data has been assessed consistent with the Trigger Action Response Plan in Section 8.9. Since early to mid-2020, a gradual increasing trend in total iron and total manganese has been recorded at sampling location DW01.

While there was a more rapid increase in total aluminium in early 2020, recorded concentrations have remained consistent since then. It is noteworthy that similar intermittent increases in concentrations of iron, aluminium and manganese in the Woronora Reservoir are evident over the period of record, including during the baseline period prior to the start of Longwall 20.

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.

4.2 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) defines a regional water table and is separate from the overlying perched groundwater system.
- 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 elevated sandstone that ultimately discharges to 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.

The only recognised economic aquifer in the area is the Hawkesbury Sandstone. The Hawkesbury Sandstone is a low yield aquifer of generally good quality beneath the Woronora Plateau and the Illawarra Plateau. Review of the WaterNSW 'Real-time Data' database (September 2021) indicates no privately owned registered bores, other than those registered by Metropolitan Coal, are located in the vicinity of the 300 series longwalls.

Groundwater Model

A tabulated list of groundwater models developed and used for the Project by Heritage Computing and SLR Consulting 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.

Table 3 (Continued)
Groundwater Model Tabulation

Date	Groundwater Model	Purpose
2018	MODFLOW-SURFACT [17 layers]	Revised model, which 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. Transient calibration.
2020	MODFLOW-SURFACT [17 layers]	Revised model, including the implementation of 'stacked drains' in the groundwater model. Recalibration of model completed.

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 were 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 was undertaken in 2018 to incorporate Metropolitan Coal updates to the geological model. The previously revised model included 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 on the previously revised model was prepared (HydroSimulations, 2018), which was used for the assessment of the Longwall 304 and Longwalls 305-307 Extraction Plans.

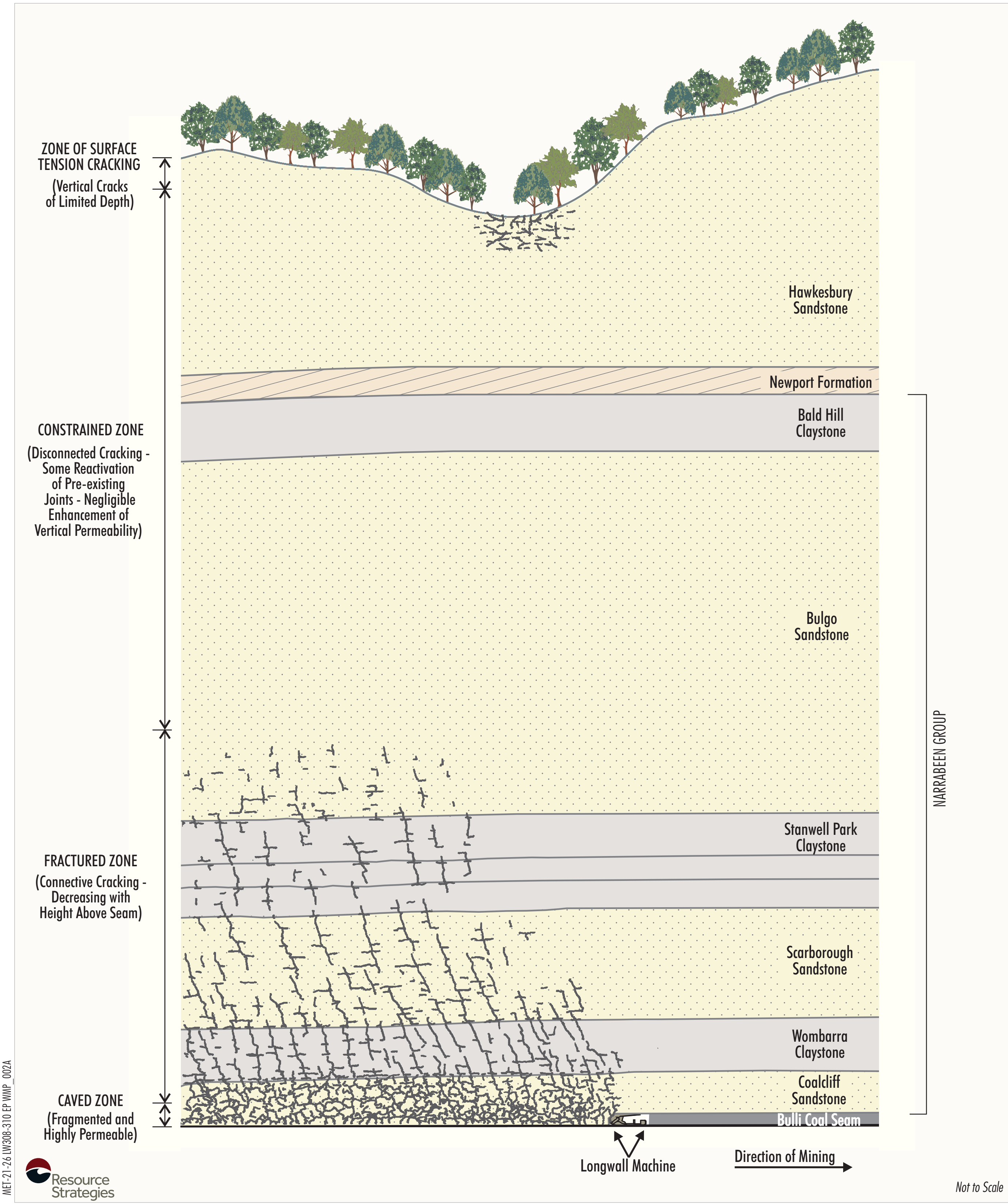
In 2020, and consistent with the recommendations of the Woronora Reservoir Impact Strategy (WRIS) Panel Stage 2 Report (Hebblewhite *et al*., 2019), the groundwater model was updated to include the incorporation of 'stacked drains' to represent the fractured zone instead of using enhanced hydraulic conductivity and storage properties. A calibration report for the updated model was prepared by SLR Consulting (2020), which has been used for the assessment of Longwalls 308-310.

In December 2020, Metropolitan Coal commissioned Dr Justin Bell (JBS&G) to undertake a peer review of the calibration report for the updated model (SLR Consulting, 2020). Although the peer review was focussed around the incorporation of stacked drains, Dr Bell reviewed the complete groundwater model as described in the calibration report. Dr Bell concluded that "*the current approach to the groundwater model is 'fit-for-purpose', as per the definition of the NSW Aquifer Interference Policy"*.

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 WMPs and Biodiversity Management Plans, included:

- Any cracking of the bedrock within upland swamps was 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 was 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.



Source: After Geosensing Solutions (2008);

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Schematic - Longwall Mining and Subsidence Profile

Figure 8

- It was 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 were expected to be unmeasurable 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 were 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 was 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:

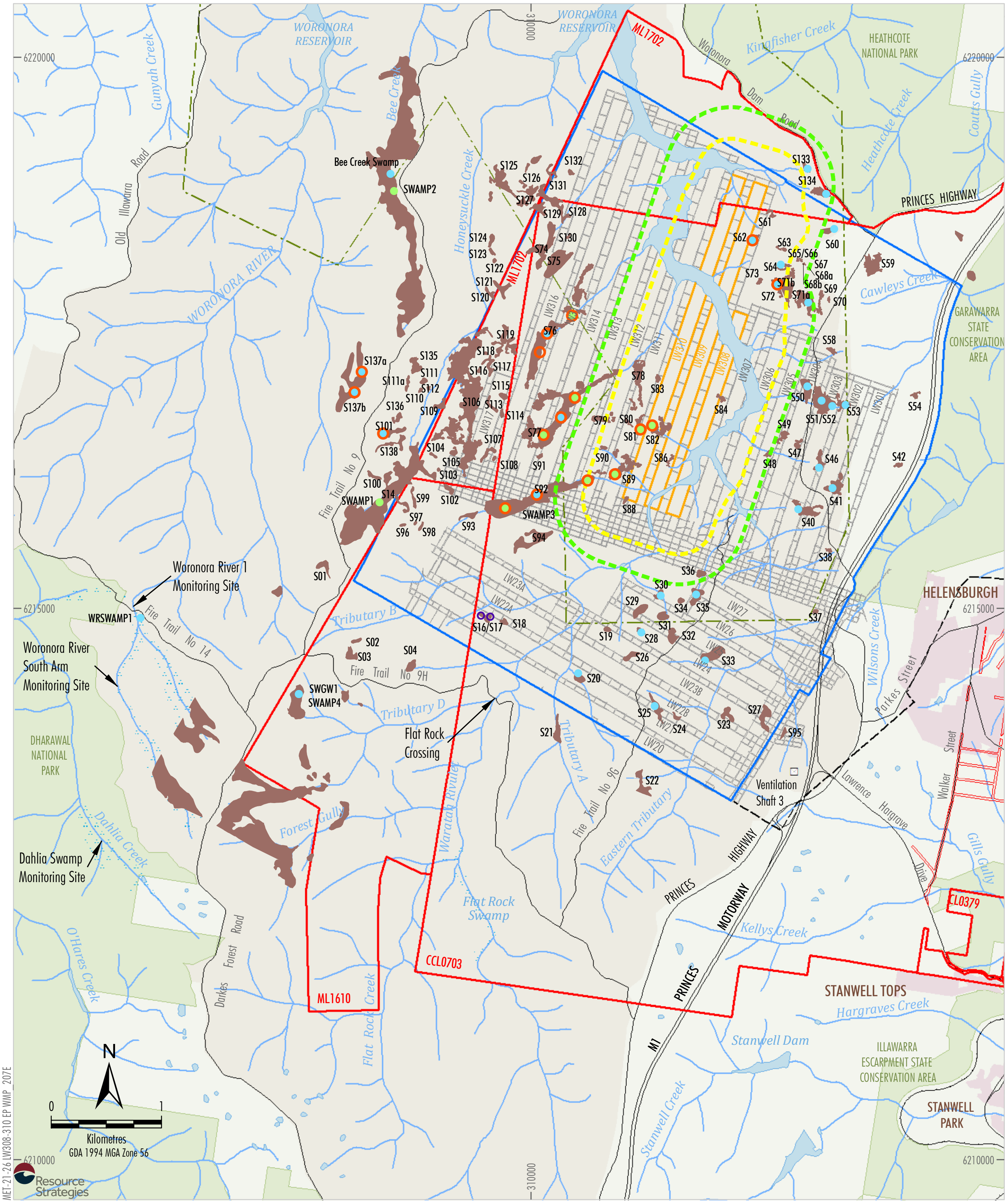
- for most swamps in the Project Area, there was a low risk of negative environmental consequences; and
- that there was a very low risk that a significant number of swamps would suffer such consequences.

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 Swamps 20 and 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, Swamp 50 overlying Longwall 304, Swamps 71a and 72 adjacent to Longwalls 305-307, and in control Swamps 101, 137a, 137b, Woronora River Swamp 1 and Bee Creek Swamp (Figure 9). At Swamp 20 and 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.

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 1) (SLR Consulting, 2021). There is a very strong correlation with rainfall trend at Swamp 20 and control swamp Woronora River Swamp 1 over the period of record. As the rate of decline in the two piezometers is similar from 2013, but different in 2012, it is considered that Longwall 21 caused a mining effect at Swamp 20, but the effects were not exacerbated by Longwalls 22-27 (SLR Consulting, 2021).

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 2) (SLR Consulting, 2021). Swamp 28 is considered to have had 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 (SLR Consulting, 2021).



LEGEND

- Mining Lease Boundary
- Woronora Special Area
- Railway
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Longwalls 308-310 Secondary Extraction
- Longwalls 308-310 35° Angle of Draw and/or Predicted 20 mm Subsidence Contour
- 600 m from Longwalls 308-310 Secondary Extraction
- Existing Underground Access Drive (Main Drift)
- Woronora Notification Area
- Upland Swamp
- Swamp Substrate and Shallow Groundwater Piezometer
- Swamp Substrate Groundwater Piezometer
- Swamp Shallow Groundwater Piezometer
- Swamp Soil Moisture Probe

Source: Land and Property Information (2015); Department of Industry (2015); Metropolitan Coal (2021); MSEC (2021); after NPWS (2003), Bangalay Botanical Surveys (2008); Eco Logical Australia (2015; 2016; 2018)

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Upland Swamps Groundwater Piezometer Locations

Figure 9

Analysis of the swamp substrate water levels of Swamps 25, 30, 33, 35, 40, 41, 46, 50, 51, 52, 53, 71a and 72 including comparisons with control swamps and rainfall records have indicated the drop in swamp water levels (below sensor level) recorded in the swamps that prevailed up to early 2020 were a natural response to reduced rainfall (SLR Consulting, 2021). It should be noted that piezometers measure only free water within swamps substrates and not bound water such as that which occurs within peat.

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 vegetation monitoring results from autumn 2017 to autumn 2019 suggest the changes in vegetation occurring in Swamp 28 are significantly different from changes in the control swamps (Eco Logical Australia, 2018a, 2018b, 2019a, 2019b, 2020a). In spring 2019, the declining trend in the vegetation condition at Swamp 28 stabilised and has remained stable to date (Eco Logical Australia, 2020b, 2021a, 2021b).

No adverse impact has been observed on threatened vertebrate species that potentially could be present in swamps, particularly threatened amphibian species. However, since bound water is not currently being measured at these sites, potential adverse impacts on species using swamp substrates cannot be determined.

Consistent with the recommendations of Hydro Engineering & Consulting (2019) (Appendix 5), flow measuring flumes were installed immediately downstream of Swamps 76 (Sub-catchment R) and 92 (Sub-catchment P) in November 2020.

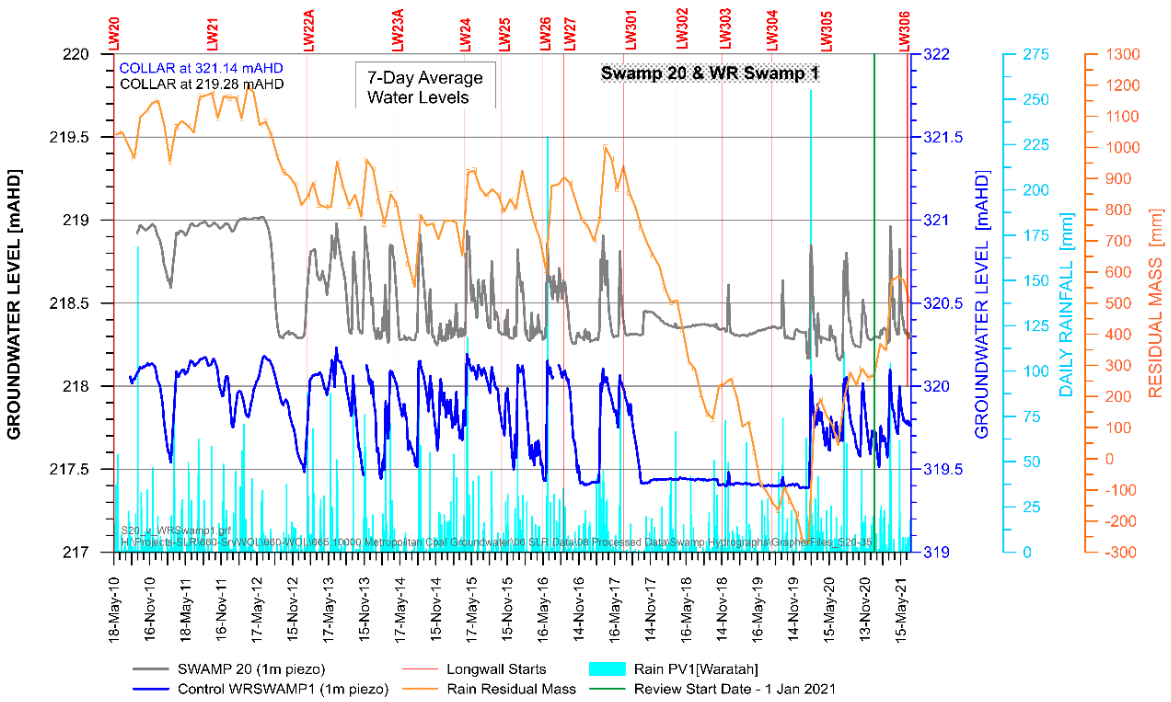


Chart 1 **Comparison of Piezometer Responses at Swamp 20 and Woronora River 1 Control Swamp**

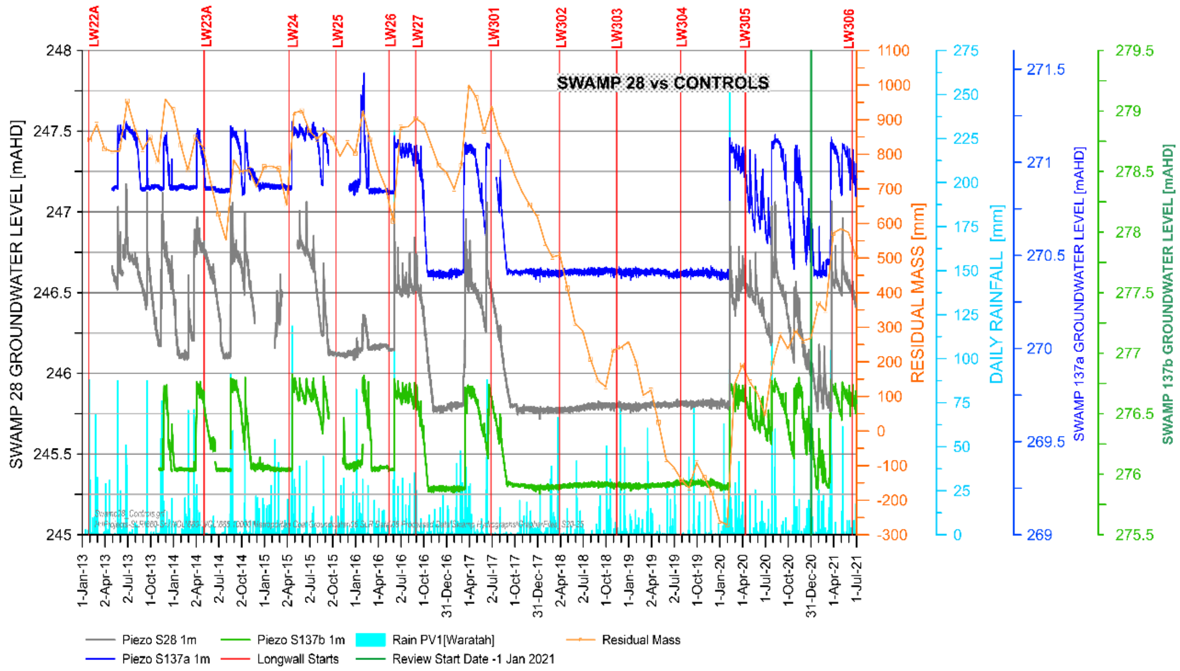


Chart 2 Groundwater Hydrographs at Swamp 28 and Two Control Swamps (137a and 137b)

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 WMPs 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] would not be 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.
- There would be negligible loss of groundwater yield to the Woronora Reservoir since groundwater modelling indicated 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 might provide a direct hydraulic connection between the surface and the mine workings.
- Local surface water quality impacts are expected as a result of enhanced groundwater – surface water interactions (as described for surface water quality above).

The locations of groundwater bores that have been sampled for groundwater levels/pressures and groundwater quality at Metropolitan Coal are shown on Figures 10 and 11, respectively.

The shallow 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 WMPs.

Depressurisation of the Deep Groundwater System

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, with some increase also in horizontal permeability over the dimension of a longwall panel.

The key potential subsidence impacts and environmental consequences on the deep groundwater system described in the Project EA, Preferred Project Report, and Metropolitan Coal WMPs, 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 about 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 less permeable Narrabeen Group sandstones.
- Groundwater discharge to the mined seam would occur from above and below the seam in proportion to local permeabilities. Based on earlier modelling, the water make (i.e. groundwater inflow) was predicted to be in the order of 0.1 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[9]. The 2018 groundwater model predicted that inflow for Longwalls 305-307 would be approximately 0.02 ML/day to approximately 0.24 ML/day at the end of Longwall 307[10].
- 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.

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

[9] Modelling and assessments conducted for Longwalls 20-27 and Longwalls 301-303 were documented in the Metropolitan Coal Longwalls 20-22, 23-27 and 301-303 Extraction Plans.

[10] Modelling and assessments conducted for Longwalls 301-307 were documented in the Metropolitan Coal Longwalls 305-307 Extraction Plan.

Previously, two goaf holes drilled at Metropolitan Coal 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 have both supported the uppermost fractured layer that has been adopted in previous groundwater modelling for Metropolitan Coal (Ditton S. and Merrick N., 2014). 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, would result 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 structures, or strata generally either prior to, or since, the commencement of Longwall 20.

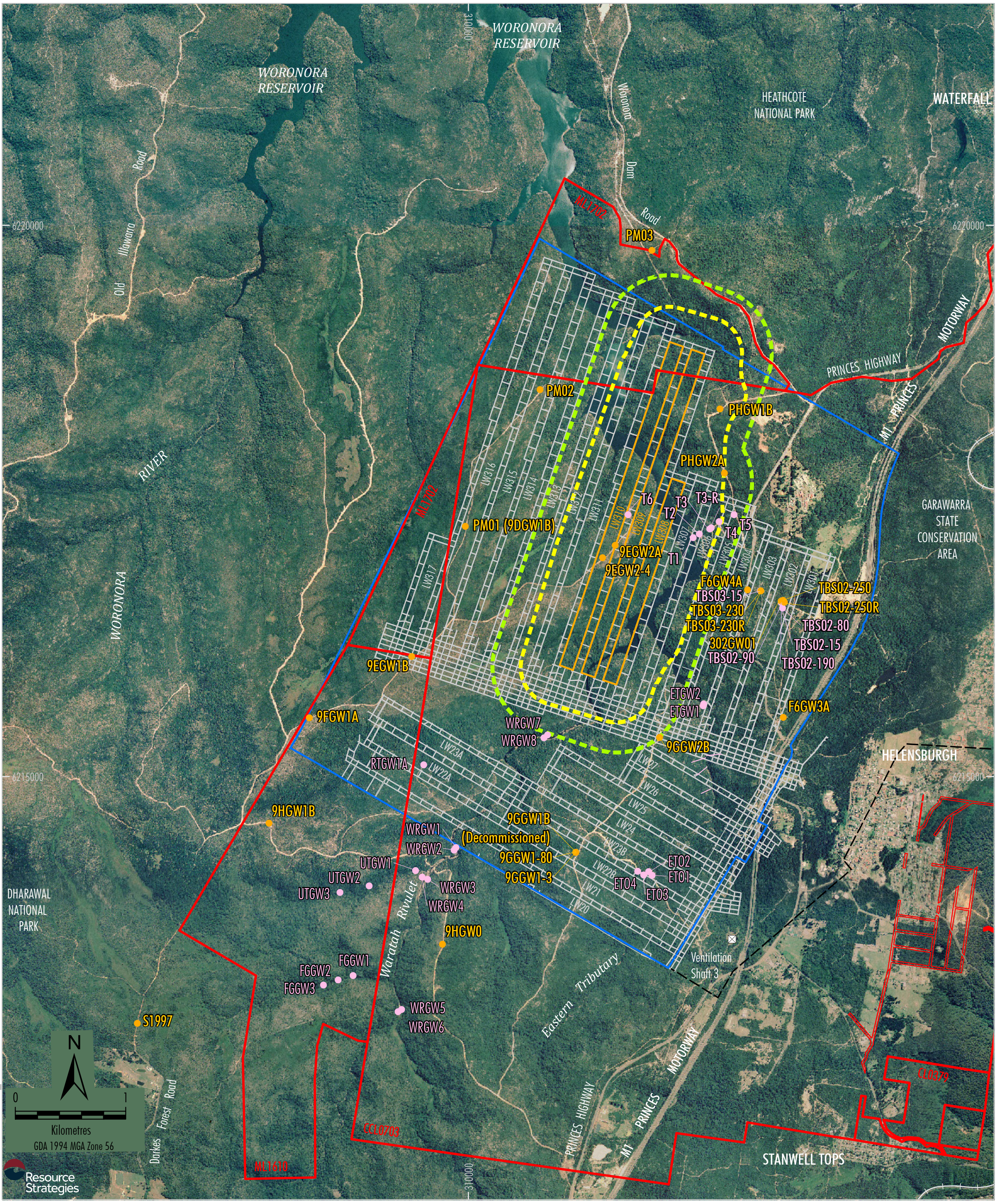
Multiple structures have been intersected by development workings that are coincident with the Woronora Reservoir directly above the maingates of Longwall 305 (F0027, F0030), Longwall 306 (F0036, F0037), and Longwall 307 (F0037). These structures were dry at the time of intersection and have continued to remain dry during regular inspections conducted as part of the underground inspection program. In October 2021, Longwall 306 extracted through F0037 which lies directly beneath the reservoir. Inspections of the structure and development workings found that both continued to remain dry. Similar to previously encountered structures, changes to the hydraulic conductivities of F0008, F0021 and F0027 as a result of mining are considered highly unlikely.

Monitoring of the mine water balance (mine water make) is calculated from the difference between total mine inflows and total mine outflows (refer Section 8.6 for details). Given the large fluctuations in daily water usage and the cycle period for water entering the mine and for assessment of environmental performance of the mine, a 20-day average is used by Metropolitan Coal to provide a more reliable estimate of water make. The 20 day average daily mine water make has been below 0.5 ML/day (Charts 3a and 3b). The increased water make during the period April 2011 to July 2011 (Chart 3a) was a result of dewatering of old workings in advance of the 200 Mains Panel (Metropolitan Coal, 2011). From January 2009 to August 2021, the mine water make has averaged 0.01 ML/day, which is less than that predicted by groundwater modelling for the Project.

Further to a request from the Dams Safety Committee (now Dams Safety NSW), a water balance for the 300 area (i.e. a localised water balance underground in and about the 300 series longwalls) was established using a series of flow meters installed underground. The results of the localised water balance are shown in Chart 3c. Metropolitan Coal provide the results of the localised water balance, with the results of the overall mine water balance (Charts 3a and 3c) to Dams Safety NSW monthly.

Continuous groundwater level/pressure monitoring has been conducted at bores 9HGW0 (Longwall 10 Goaf Hole), 9EGW1B, 9FGW1A, 9GGW1-3, 9GGW1-80, 9GGW2B, 9HGW1B, PM02, PM01 (9DGW1B), 9EGW2A[11], 9EGW2-4, PM03, PHGW1B, PHGW2A, 302GW01, TBS02, TBS03, F6GW3A and F6GW4A (Figure 10) in accordance with the Metropolitan Coal WMPs. 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. The results of the additional groundwater monitoring conducted as a component of the Woronora Reservoir Impact Strategy are discussed in Section 4.3.

[11] Multi-level piezometer site 9EGW2A experienced failure of some lower level instrumentation. An additional hole was drilled adjacent to 9EGW2A (bore 9EGW2-4) to a depth of 557 m to install new piezometers at the same levels as the failed piezometers in December 2017.



LEGEND
- Mining Lease Boundary
- Railway
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Longwalls 308-310 Secondary Extraction
- Longwalls 308-310 35° Angle of Draw and/or Predicted 20 mm Subsidence Contour
- 600 m from Longwalls 308-310 Secondary Extraction
- Existing Underground Access Drive (Main Drift)
- Groundwater Level/Pressure Bore
- Groundwater Level Bore

Source: Land and Property Information (2015); Date of Aerial Photography 1998; Department of Industry (2015); Metropolitan Coal (2021); MSEC (2021)

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Groundwater Level and/or Pressure Bore Locations

Figure 10

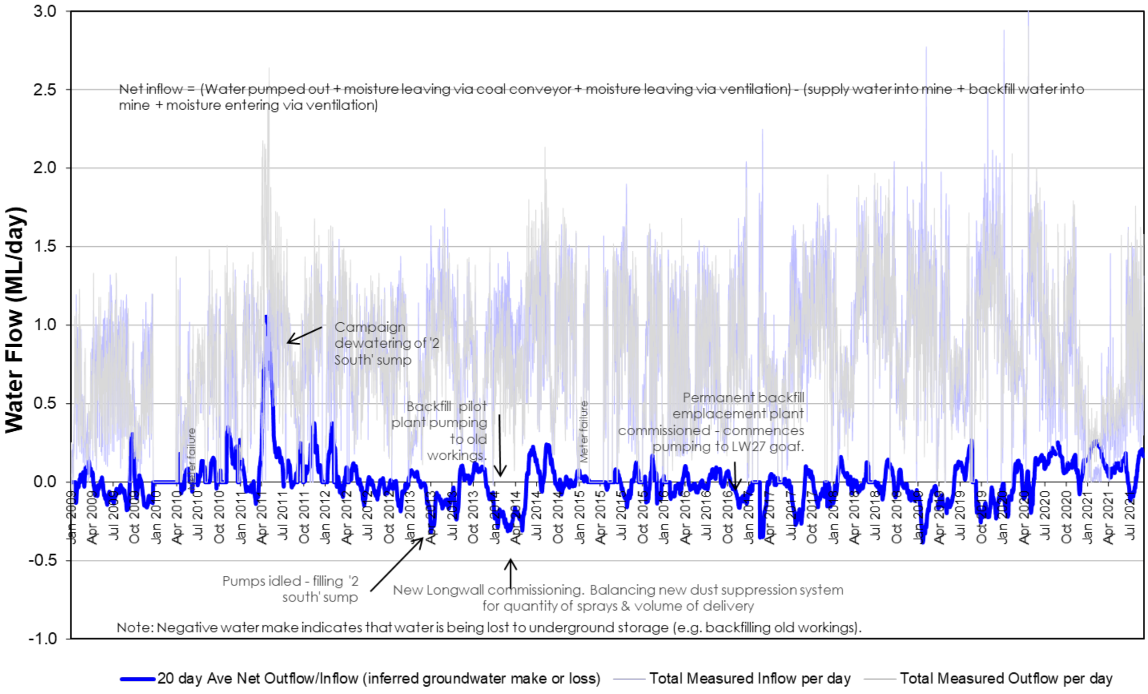


Chart 3a Estimated Daily Mine Water Make, 2009 to August 2021

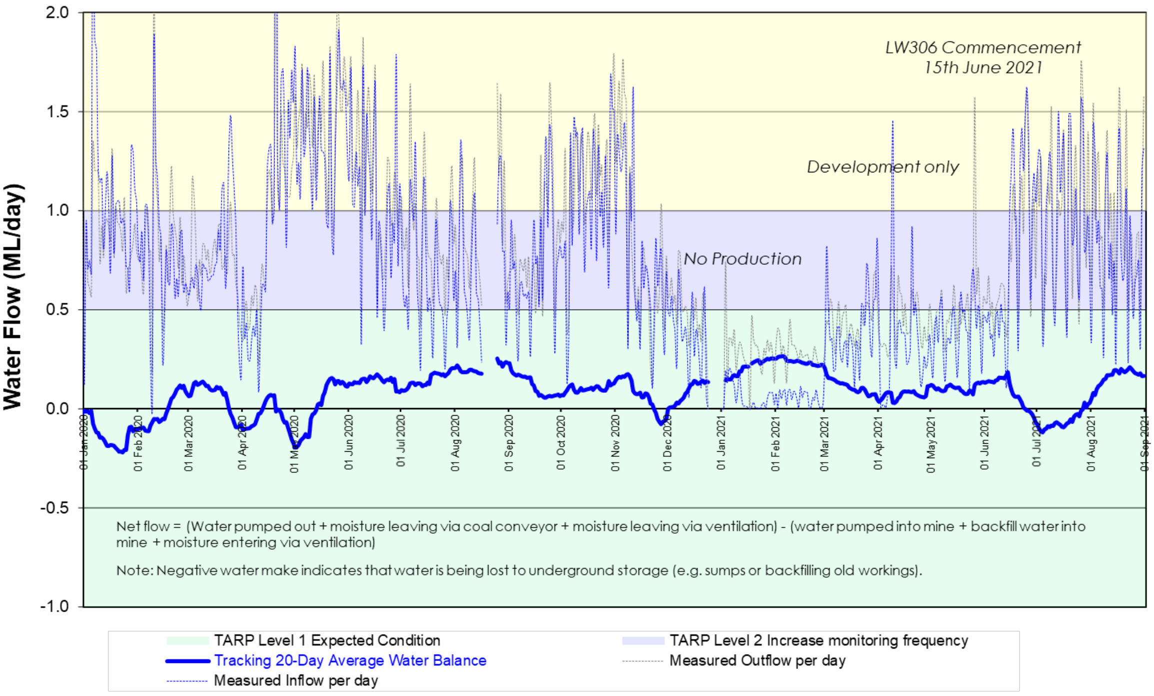


Chart 3b Estimated Daily Mine Water Make, January 2020 to August 2021

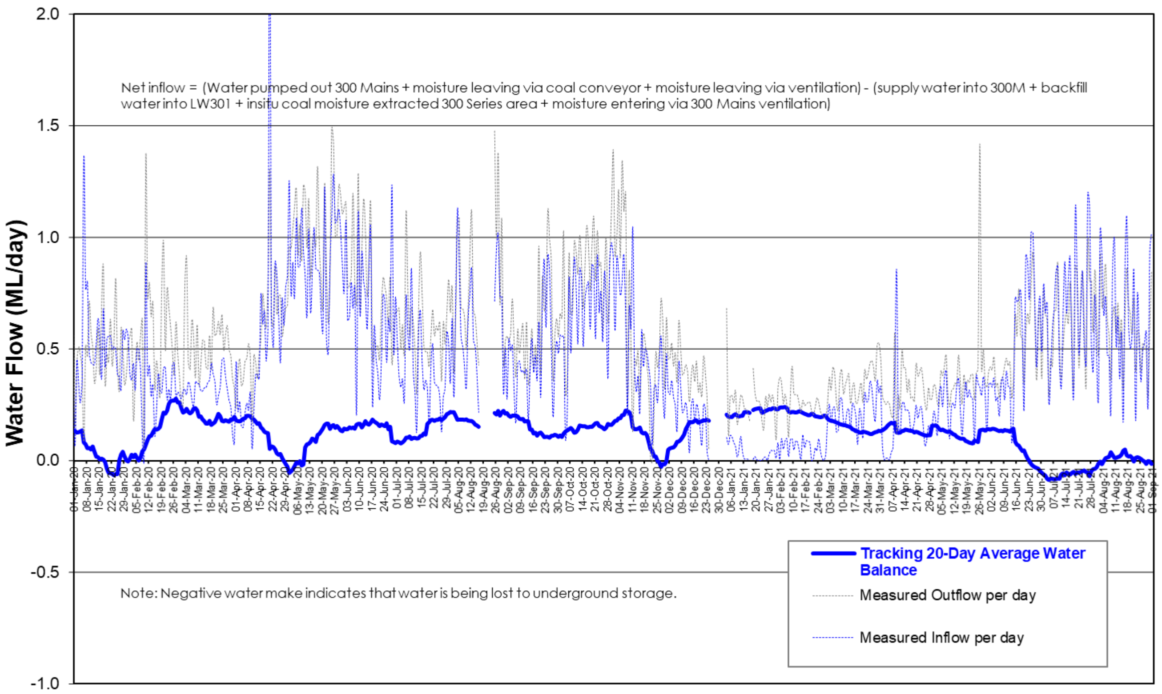


Chart 3c 300 Mains Water Balance, January 2020 to August 2021

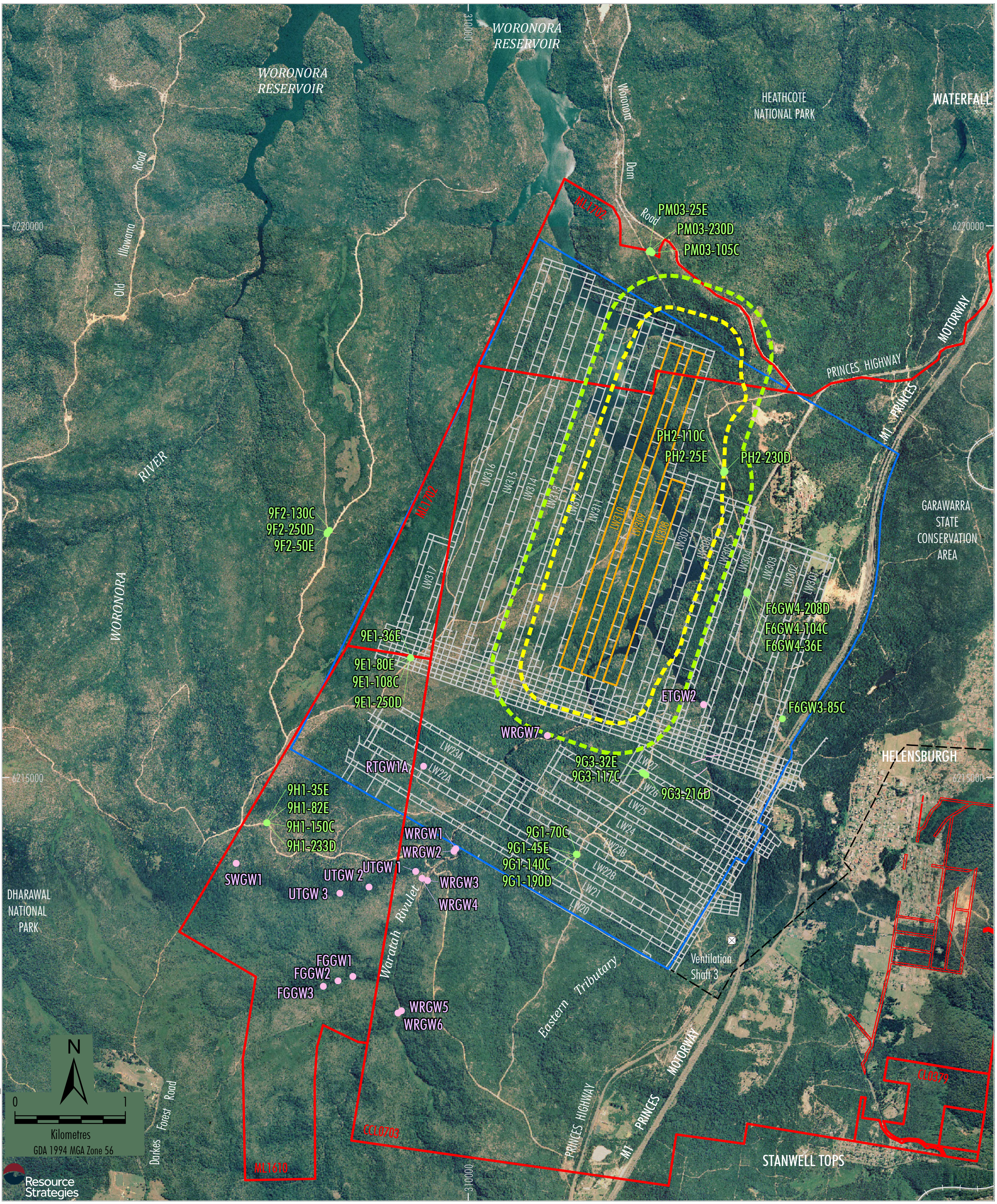
In accordance with the Dams Safety NSW Approvals for mining within the Woronora Reservoir Notification Area, Metropolitan Coal has undertaken sampling programs to investigate the properties of groundwater above and below the Hawkesbury Sandstone and to establish chemical signatures that would indicate mining-induced fracturing through the Bald Hill Claystone, should it occur. The groundwater quality sites monitored in accordance with the Water Fingerprinting Monitoring Program are shown on Figure 11. The data analysis (to June 2021) shows through statistics, trend diagrams (Piper), time-series plots and ratio plots that although a few sampling sites were grout-impacted, there are sufficient reliable data to show a clear distinction between groundwaters in the upper Hawkesbury Sandstone, lower Hawkesbury Sandstone and upper Bulgo Sandstone, and that there is no evidence of mining-induced leakage across the Bald Hill Claystone.

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 WMPs.

Significance of Chain Pillars on Simulated Groundwater Pressures

The Research Program, *Significance of Chain Pillars on Simulated Groundwater Pressures*, funded by Metropolitan Coal has been carried out by Dr. Noel Merrick (HydroSimulations, 2019). The research program has investigated 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 provide an improved understanding of the significance of chain pillars with respect to alteration of the groundwater regime and a quantitative appreciation of critical pillar widths in absolute and relative terms.

The research program has examined spatial scale effects, and differences in spatial scales that are routinely applied in the geotechnical and hydrogeological disciplines. A cross-section model was built with a structured grid using traditional modelling software (MODFLOW-SURFACT), using a range of different scales.



LEGEND

- Mining Lease Boundary
- Railway
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Longwalls 308-310 Secondary Extraction
- Longwalls 308-310 35° Angle of Draw and/or Predicted 20 mm Subsidence Contour
- 600 m from Longwalls 308-310 Secondary Extraction
- Existing Underground Access Drive (Main Drift)
- Deep Groundwater Chemistry Monitoring Site
- Stream Shallow Groundwater Quality Monitoring Site

Source: Land and Property Information (2015); Date of Aerial Photography 1998; Department of Industry (2015); Metropolitan Coal (2021); MSEC (2021)

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Groundwater Quality Sites

Figure 11

The cross-sectional model was developed through three representative longwall panels (Longwalls 21, 22B and 23B) and several different scenarios with different model cell size and pillar width were run. The results of the modelled scenarios with variable model cell size show that the predicted mine inflows *decrease* with increasing cell size. The results of the modelled scenarios with variable chain pillar width show that the predicted mine inflows *decrease* with increasing pillar width. The cross-sectional model was found to be sensitive to reductions in the horizontal hydraulic conductivity above the chain pillars (to represent pillar overburden compression). Reducing the horizontal hydraulic conductivity results in a *decrease* in mine inflows, and an *increase* in pressure head above the pillars, for all model scenarios. The effect on mine inflow was found to be less than ten percent (10%).

The cross-sectional model was not sensitive to the fracture zone shape. Changing the fracture zone from a rectangular to a parabolic shape did not result in a significant change to the mine inflows or groundwater levels. The use of a rectangular fracture zone shape, as is currently implemented in the Metropolitan Coal Mine regional groundwater model, and more generally in simulated mines elsewhere, is considered to be appropriate.

4.3 WORONORA RESERVOIR IMPACT STRATEGY

Condition 2 of the Longwalls 301 and 302 approval required Metropolitan Coal to conduct further investigation into potential impacts on the 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 DPIE for the Woronora Reservoir Impact Strategy in May 2017.

The *Woronora Reservoir Strategy Report – Stage 1* (Hebblewhite *et al.,* 2017) 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 *Woronora Reservoir Strategy Report – Stage 2* (Hebblewhite *et al.,* 2019) was provided by the independent experts to the DPIE in June 2019. The Stage 2 report includes additional recommendations in regard to groundwater and surface water investigations and monitoring, based on further data and analysis arising from the ongoing monitoring programs, including those recommended in the original Stage 1 report.

The Stage 2 report represents the second stage of the Woronora Reservoir Impact Strategy, based on further data and analysis arising from the ongoing monitoring programs, including those recommended in the Stage 1 report.

The surface water and groundwater monitoring locations that have been installed as a component of the Woronora Reservoir Impact Strategy are included in Sections 7 and 8, where appropriate.

The additional monitoring sites and environmental investigations for the Woronora Reservoir Impact Strategy included the installation of two streamflow monitoring stations in sub-catchments I and K to the west of Longwalls 301-303 and the installation of a pluviometer in the vicinity of the northern end of Longwall 307. The Stage 2 report recommended that further analysis of the data obtained from these monitoring sites (that covers at a minimum the initial 12-month period) be conducted. A summary of the outcomes of this assessment is provided below.

Data collected from the flumes on sub-catchments I and K commenced on 31 May 2018 and 3 June 2018, respectively (the flumes were installed on 17 May 2018 and 16 May 2018, respectively). Secondary extraction from Longwall 302 was occurring at the commencement of monitoring and continued through to 6 October 2018. Secondary extraction of Longwall 303 commenced on 13 November 2018 and was completed in May 2019. Longwall 304 commenced in July 2019 and was completed in January 2020. Mining of Longwall 305 commenced on 12 April 2020 and was completed on 21 November 2020. Mining of Longwall 306 commenced on 15 June 2021. Assessments of the dry weather recessions recorded at the flumes on sub-catchments I and K show consistent behaviour with time, although the recorded streamflow recession during low flow periods appears to be more rapid at the gauging station on Sub-Catchment K than on Sub-Catchment I during various periods throughout the duration of monitoring. There is no visual indication of a change in recessionary behaviour (i.e. rate of recession) for Sub-Catchment I and no indication from the recorded stage and streamflow data that mining of Longwall 301 to Longwall 305 has impacted streamflow at the Sub-Catchment I gauging station. Additionally, there is no visual indication of a change in recessionary behaviour (i.e. rate of recession) for Sub-Catchment K and no indication from the recorded data that mining of Longwall 306 has impacted streamflow at the Sub-Catchment K gauging station (to 30 June 2021). This is consistent with the results of monitoring of the quantity of water resources reaching the Woronora Reservoir for the Waratah Rivulet and Eastern Tributary.

A preliminary water balance of the Woronora Reservoir has been developed as a component of the Woronora Reservoir Impact Strategy. The primary purpose of the water balance analysis was to establish whether the inputs to and outputs from the Woronora Reservoir could be measured sufficiently accurately to estimate a loss through the bed of the reservoir because of longwall mining being undertaken in the catchment and/or from other activities that may affect the water balance. The issues identified in the water balance suggest that the magnitude of bias and uncertainty in the data used in the analysis is such that it is doubtful that the water balance values provide a satisfactory baseline for assessing the potential loss of reservoir water through the bed and it was recommended that a Stage 2 water balance study be not undertaken.

A number of groundwater monitoring bores and inclinometer monitoring points have also been installed as a component of the Woronora Reservoir Impact Strategy. The results obtained to date are summarised below.

The Stage 2 report recommended groundwater model-derived cross sections be generated to display the pressure head profiles before and after mining specific panels with the zero pressure heads clearly displayed. Representative north-south and east-west cross sections have been prepared for Longwalls 308-310 using the re-calibrated model with stacked drains (Appendix 6).

In December 2019, the WRIS Panel prepared a letter report which provides a summary of the key conclusions from the Stage 1 and Stage 2 reports and considers the IEPMC *Report on Coal Mining Impacts in the Special Areas of the Greater Sydney Water Catchment* (dated 14 October 2019). It also considers feedback from the WRIS Panel's meeting with the DPIE, Water NSW and Metropolitan Coal on 11 November 2019. The key findings of this report were:

1. *Connective fracturing/depressurisation and depressurisation alone extends up to approximately 195 m above the current 163 m wide longwall extraction zone (Figure 1).*
2. *There is virtually no pressure head propagation (i.e. depressurisation), that is pressure head loss, extending upwards beyond about 80 m from the surface and very little above 150 m from the surface (Figure 1). The depressurisation zone below 150m is recovering due to lateral groundwater flow.*
3. *There is no evidence of surface to longwall panel connectivity at the Metropolitan Mine, with inflows averaging 0.01 ML/day between January 2009 and April 2019.*
4. *There is a clear benefit in using narrower panels and wider chain pillars near and beneath the Woronora Reservoir as it substantially reduces subsidence predictions.*

5. *The ratios of 'width of panel' and 'depth of cover' at the Metropolitan Mine proposed for mining under the Woronora Reservoir (0.32 to 0.35) are similar to those used for the previously successful mining conducted with very low inflow reported at the South Bulli Mine and Bellambi West Colliery below the Cataract Reservoir (0.34 to 0.41).*
6. *Mining in the upper reaches of sub-catchment I has not impacted on flows recorded at the flume further downstream, consistent with the results of monitoring of the quantity of water resources reaching the Woronora Reservoir for the Waratah Rivulet and Eastern Tributary.*
7. *Water balance modelling of inputs to and outputs from the Woronora Reservoir indicates that the combined average loss from groundwater outflow under the dam wall and loss through the bed of the Woronora Reservoir is 2.9 ML/day with a 95% uncertainty band between 0.4 ML/day to 5.4 ML/day, in which ungauged inflows to the reservoir and reservoir evaporation are the major contributors to the uncertainty. The 2.9 ML/day equates to 3.6% of the total outputs modelled from the Woronora Reservoir. Taking into account the facts that groundwater outflow under than dam wall could not be adequately modelled, that there are problems in stream gauging a large proportion of the current ungauged area, and there are difficulties in estimating reservoir evaporation, it is recommended that a Stage 2 water balance study be not undertaken.*
8. *Based on the review of available data, analytical predictions and monitoring bore evidence at LW302, together with the use of narrower panels and wider chain pillars beneath the reservoir, the proposed longwall mining is not expected to result in connective cracking between the longwalls and surface or significant inflows from Woronora Reservoir to the mine extraction zone.*
9. *The existing monitoring regime should be continued, together with the additional monitoring recommended above. All monitoring results should be regularly reviewed against predicted values to provide ongoing confidence in the performance of the mining operation and its impacts.*

Metropolitan Coal understands that the WRIS Panel is no longer required to conduct investigations into potential impacts on the Woronora Reservoir and that these investigations will instead be conducted by a new panel of independent experts to be convened by the DPE.

4.3.1 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 because 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), bracketing the Bald Hill Claystone, survived the crossing and continued to record meaningful data until November 2018 (P192) and January 2019 (P243). The maximum 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 recovered by about 40 m and 50 m respectively (at November 2018), so that the pressure heads (the height of water above the sensor) at that time were about 70 m and 65 m respectively. Due to lost communication at TBS02, a redrill was installed to replicate the pre-mining hole adjacent to the 302GW01 hole (bore 302GW01-R). This hole commenced monitoring on 24 January 2019 with four Vibrating Wire Piezometers (VWPs) at 90 m (Hawkesbury Sandstone), 150 m (Hawkesbury Sandstone), 180 m (Hawkesbury Sandstone) and 243 m (Bulgo Sandstone). Apart from P243 which failed on 20 February 2019, the sensors have remained active. The pressure heads at the end of Longwall 305 were about 1 m, 30 m and 50 m at piezometers P90, P150 and P180 respectively.

At bore TBS03 in the centre of Longwall 303, to the immediate west of TBS02, the corresponding pressure heads were about 90 m and 140 m respectively at November 2018. After that all communication was lost for these VWPs in December 2018. Four replacement piezometers were installed in a replacement hole (bore TBS03-230R) on 12 April 2019. Only the 162 m piezometer was installed in Hawkesbury Sandstone and three other piezometers at 213 m, 245 m and 265 m were installed in the Bulgo Sandstone. All piezometers declined in head in April 2019 due to mining. Pressure heads recorded during the extraction of longwall 304 (15th Sept 2019 – last complete set of data) were about 54 m, 81 m, 67 m and 68 m at P162, P213, P245 and P265, respectively.

Further west, over the pillar between Longwalls 303 and 304, bore F6GW4A 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). In January 2019, F6GW4A was undermined by Longwall 303 causing the depressurisation and disabling of the six lower sensors (139, 201, 278, 362, 440 and 512 metres below ground level [mbgl]). The upper and mid Hawkesbury Sandstone piezometers (50 and 90 mbgl) also displayed a lowering of groundwater head following the passage of Longwall 303; however, they showed no significant decline after the passage of Longwalls 304 and 305. Both piezometers showed a slight increasing trend during January to June 2021.

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 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 3 m. While the 80 m piezometer at 302GW01 continues recording, with no evident sustained mining effect, the standpipe hole became obstructed. Replacement standpipes were installed in December 2018 to depths of 90 m (TBS02-90) and 190 m (TBS02-190). Since monitoring commenced from 20 February 2019, the 90 m hole appears to have run dry (at August 2019).

4.3.2 Inclinometers

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 monitored horizontal shearing locations, measured the magnitude and direction of shearing in the Hawkesbury Sandstone and recorded any basal shearing on the sandstone contact with the Bald Hill Claystone formation. The installation was one of the deepest such inclinometer sites in Australia to date (Hebblewhite *et al*., 2019).

A total of 10 inclinometer surveys were completed pre-mining 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 last depth being at the top of the Bald Hill Claystone. Inclinometer surveys were conducted at TBS02-230 between March and August 2018. The extent of shear movements is less than for site TBS02-250, with shear movements at depths within the 140 m to 190 m depth range, representing the time when Longwall 302 passed adjacent to the site. The inclinometer at TBS03-230 ceased to function after Longwall 303 passed beneath it. Based on this monitoring data, such shear plane activation is restricted to a region of less than 400 m from the edge of the goaf or edge of extraction (Hebblewhite *et.al*., 2019).

4.3.3 Permeability Measurements

In September 2017, pre-mining packer testing was conducted in bore 302GW01 for 15 12-metre sections from 238 m to 490 m depth, finishing in the Scarborough Sandstone. 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.

In December 2018, post-mining packer testing was conducted in replacement hole 302GWR for 10 12-metre sections from 99 m to 243 m depth, with four shorter 6-metre sections at the top of the Bald Hill Claystone (183-207 m). The post-mining horizontal permeabilities were found to be not significantly different from the pre-mining values, except for a narrow highly permeable zone at the top of the Bald Hill Claystone or within the Newport Formation, corresponding to the shear plane identified by the inclinometer at 202 m depth. There is no evidence of any fracturing reaching the packer zone of investigation, which extended down to about 300 m above the Bulli coal seam. An acoustic televiewer downhole survey showed no fracturing to the maximum depth of the hole (300 m), about 250 m above the Bulli seam. Both investigations support the interpretation of the low pressures recorded at 302GW01 in the deeper piezometers as being anomalous (due to shearing) and not due to fracturing. The anticipated fracture heights (120-160 m) remain consistent with field investigations.

In May 2020 an exploratory hole was installed north-east of LW307 face line directly onto a seismic feature identified as a normal fault (FN004) 15 m above the Bulli Seam in the Wombarra Claystone. The purpose of the hole was to define permeability characteristics of the structure and surrounding host rock as well as gas reservoir definition to a total depth of 576 m. The fault was intersected at 479 m dipping at 43 degrees as predicted with drilling stopped immediately for packer testing. FN004 horizontal permeability measured $1.0x10^{-5}$ m/d vs the surrounding Wombarra Claystone at $1.0x10^{-4}$ m/d. Hydraulic conductivities measured across fault FN004 were comparable to those recorded in the unfractured host rock between the Bald Hill Claystone and the Bulli Seam, indicating negligible disturbance in horizontal flow associated with the FN004 fault at this location; i.e. the host claystone unit shares a similar transmissive signature to the intruding fault structure at this location, and the fault will not act as a conduit.

5 REVISED ASSESSMENT OF POTENTIAL ENVIRONMENTAL CONSEQUENCES

5.1 LONGWALLS 308-310 EXTRACTION LAYOUT

Longwalls 308-310 and the area of land within 600 m of Longwalls 308-310 secondary extraction are shown on Figures 1 and 2. Longwall extraction will occur from north to south. The layout of Longwalls 308 and 309 include 138 m panel widths (void) and 70 m pillar widths (solid). The layout of Longwall 310 includes a 138 m panel width (void) and a 70 m tailgate pillar width. Approximately 1,370 m from the commencing end of Longwall 310, the maingate pillar width of Longwall 310 decreases from 70 m to 45 m until the finishing end of Longwall 310 (Figure 2).

The provisional extraction schedule for Longwalls 308-310 is provided in Table 4.

Table 4
Provisional Extraction Schedule

Longwall	Estimated Start Date	Estimated Duration	Estimated Completion Date
Longwall 308	February 2023	7 Months	August 2023
Longwall 309	September 2023	11 Months	July 2024
Longwall 310	August 2024	12 Months	July 2025

The total cumulative predicted subsidence effects, subsidence impacts and/or environmental consequences at the completion of the Project are considered in the Project EA (HCPL, 2008) and the Preferred Project Report (HCPL, 2009), 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 308-310 Extraction Plan[12] *viz.* Biodiversity Management Plan, Land Management Plan, Heritage Management Plan and this WMP 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 DPIE for the preparation of the Metropolitan Coal Longwalls 308-310 Extraction Plan participated in the ERA[13]. The ERA process involved the key steps described below.

[12] Risk assessments have been undertaken separately in relation to the Metropolitan Coal Longwalls 308-310 Built Features Management Plan and the Metropolitan Coal Longwalls 308-310 Public Safety Management Plan, and are reported in their respective documents.

[13] Participants included Mr Peter DeBono (Mine Subsidence Engineering Consultants, Subsidence and Land), Dr Noel Merrick and Ms Ines Epari (SLR Consulting, Groundwater), Mr Anthony Marszalek and Dr Camilla West (Hydro Engineering & Consulting, Surface Water), Associate Professor Barry Noller (The University of Queensland, Surface Water Quality), Dr David Goldney (Cenwest Environmental Services, Fauna), Mr Jamie Reeves and Ms Renee Regal (Niche Environment and Heritage, Heritage), Mr Jon Degotardi (Metropolitan Coal), Mr Stephen Love (Metropolitan Coal), Mr Shane Kornek (Metropolitan Coal), Mr Jamie Warwick (Resource Strategies) and Mr Patric Illingworth (Resource Strategies). Ms Elizabeth Norris (Ecoplanning, Flora) contributed to the risk assessment external to the workshop.

Review of Relevant Documentation and Risk Identification

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 2008 *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 Longwalls 305-307 Environmental Risk Assessment Report (Operational Risk Mentoring, 2019) (which included consideration of the Longwalls 301-303 and Longwall 304 Environmental Risk Assessment Reports).
- Figures showing the Longwalls 308-310 layout in relation to key surface features.
- Subsidence predictions for Longwalls 308-310 (including subsidence contours, Eastern Tributary, Waratah Rivulet, Woronora Reservoir, other streams, cliff sites, upland swamps and Aboriginal heritage sites).

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.

ERA Workshop

The ERA workshop for Longwalls 308-310 was conducted on 23 September 2021, with all participants attending via video conferencing. The ERA workshop was facilitated by an independent specialist, Dr Peter Standish of Risk Mentor and conducted in accordance with AS/NZS ISO 31000: *2009 Risk Management – Principles and Guidelines.*

The general consensus of the workshop participants was the additional (specific) issues/risks identified for Longwalls 308-310 were broadly assessed and ranked as part of the 2008 Environmental Risk Analysis, Longwalls 301-303, Longwall 304 and/or Longwalls 305-307 ERAs. However, additional (specific) issues were identified by the workshop participants relevant to Longwalls 308-310. Each of the issues/risks were explained systematically by the relevant workshop participants and each carefully reviewed.

Loss scenarios for the key potential environmental issues were identified for upland swamps, aquatic biota, threatened amphibians, Waratah Rivulet and the Woronora Reservoir. The risk rankings are within the "low-medium" range and consequently the potential outcomes can be integrated into the existing management systems for effective review and monitoring.

ERA Report Review

All ERA participants were asked to review the draft Longwalls 308-310 ERA report that was prepared to summarise the outcomes of the risk assessment. Participants' comments were incorporated into the final Risk Mentor (2021) report.

This WMP has been prepared to provide for effective management of the identified subsidence risks.

5.3 RISK ASSESSMENT FOR GEOLOGICAL FEATURES AND WATER QUANTITY TO THE WORONORA RESERVOIR AND ABORIGINAL HERITAGE

The IEPMC Initial Report recommended that the potential implications for water quantity of faulting, basal shear planes and lineaments be carefully considered and risk assessed at all mining operations in the Catchment Special Areas (IEPMC, 2018).

In relation to the Metropolitan Coal Mine, the IEPMC Initial Report concluded (pg 127):

> *In the case of Metropolitan Mine:*
>
> - *…..*
> - *the potential for water be diverted out of Woronora Reservoir and into other catchments through valley closure shear planes and geological structures including lineaments will require careful assessment in the future because it is planned that most of the remaining longwall panels in the approved mining area will pass beneath the reservoir.*

A risk assessment workshop was held on 6 October 2021. The workshop participants[14] identified and assessed the potential for mining effects on lineaments, joints, faulting, basal shear planes and dykes to impact on the quantity of water to the Woronora Reservoir, including the potential for water to be diverted out of Woronora Reservoir and into other catchments. Participants also assessed the impacts to Aboriginal heritage sites as a result of mining effects on geological features.

The participants considered the risk control measures and procedures to be reasonable to manage the identified risks.

Further information on the risk assessment is provided in the Longwalls 308-310 Coal Resource Recovery Plan.

5.4 REVISED SUBSIDENCE PREDICTIONS

The subsidence predictions for Longwalls 308-310 in relation to streams have been prepared by MSEC (2021)[15].

Waratah Rivulet

The Waratah Rivulet flows to the north-east and into the full supply level of the Woronora Reservoir, approximately 170 m to the south of Longwalls 308 to 310 (Figures 1 and 2). The predicted profiles of subsidence, upsidence and closure along the Waratah Rivulet (to the full supply level of the Woronora Reservoir), resulting from the extraction of Longwalls 308-310, are shown on Figure 12 (MSEC, 2021).

The maximum predicted values of total subsidence, tilt, curvature, upsidence and closure for the Waratah Rivulet (to the full supply of the Woronora Reservoir), after Longwall 307 and resulting from the extraction of Longwalls 308-310, is provided in Table 5 (MSEC, 2021). The values are the predicted maxima within the Longwalls 308-310 35° angle of draw and/or predicted 20 mm subsidence contour.

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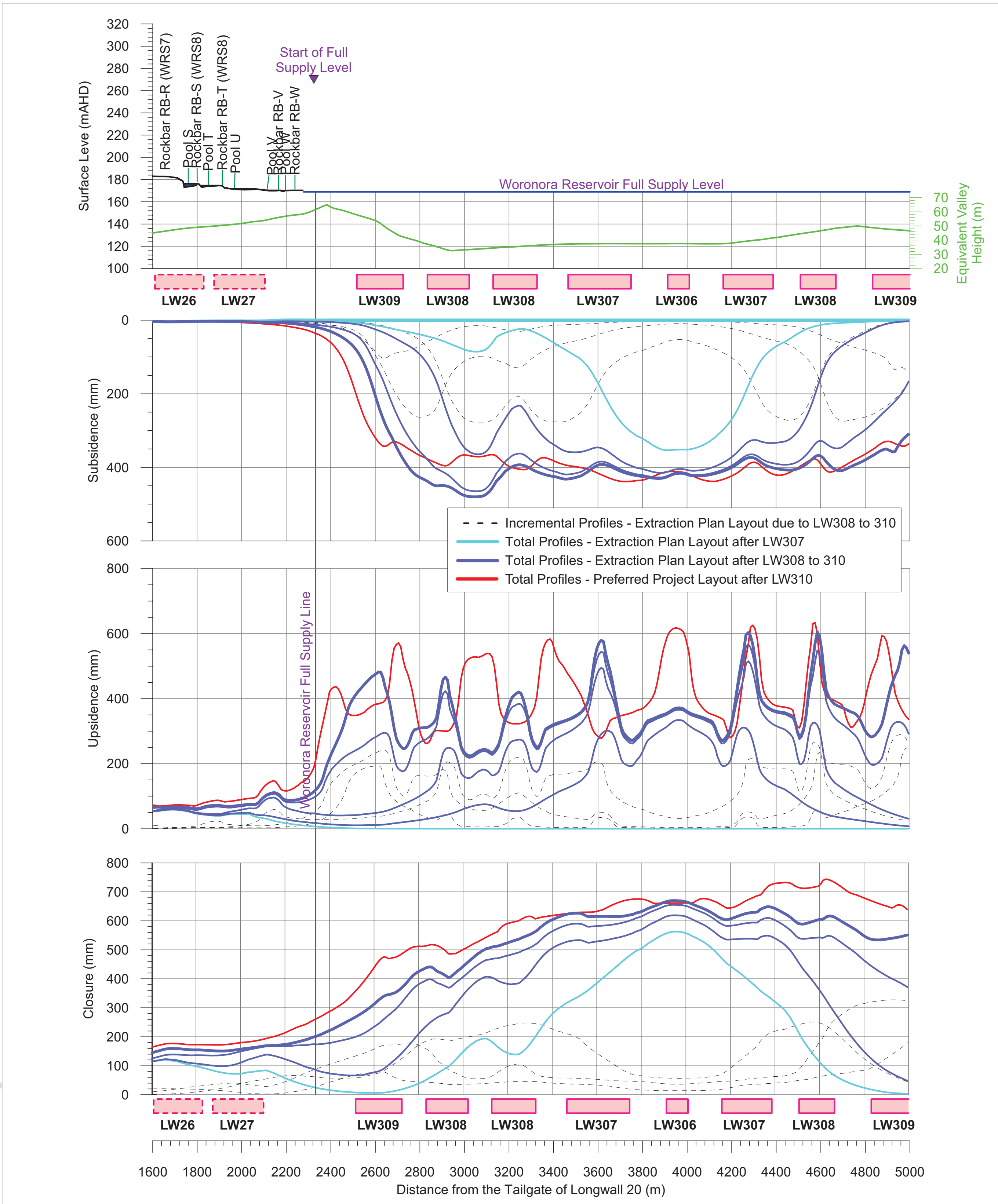
14 Participants included Dr Noel Merrick (HydroAlgorithmics, Groundwater), Ines Epari (SLR Consulting, Principal Hydrology & Hydrogeology) Peter DeBono (Mine Subsidence Engineering Consultants, Subsidence), Shane Kornek (Metropolitan Coal, Senior Geotechnical Engineer), Jon Degotardi (Metropolitan Coal, Technical Services Manager), Christian Mans (Strata Control, Director & Principal Geotechnical Engineer), Roger Byrnes (Byrnes Geotechnical, Principal Geotechnical Engineer) and Stephen Love (Metropolitan Coal, Environment & Community Superintendent). The risk assessment was facilitated by Mr Nate Bain (Peabody Senior Mining Engineer).

15 The revised subsidence effects, subsidence impacts and potential environmental consequences to upland swamps are addressed in the Metropolitan Coal Longwalls 308-310 Biodiversity Management Plan (Figure 3).



Source: MSEC (2021)

MET-21-26 LW308-310 EP WMP_004B

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Predicted Profiles of Subsidence, Upsidence and Closure along the Waratah Rivulet and Woronora Reservoir due to Longwalls 308-310

Figure 12

The maximum predicted conventional tilt for the Waratah Rivulet is less than 0.5 mm/m (i.e. 0.05 %, or 1 in 2,000) (MSEC, 2021). The maximum predicted conventional curvatures are less than 0.01 km^{-1} hogging and sagging, which equate to minimum radii of curvature of greater than 100 km. The predicted conventional strains for the Waratah Rivulet (based on 15 times the curvature) are less than 0.5 mm/m tensile and compressive (MSEC, 2021). The maximum predicted total closure on the Waratah Rivulet resulting from the extraction of Longwalls 308-310 is 200 mm (MSEC, 2021).

Table 5
Maximum Predicted Subsidence, Tilt, Curvature, Upsidence and Closure for the Waratah Rivulet Resulting from Longwalls 308-310 Extraction

Longwall	Maximum Predicted (to the full supply level of the Woronora Reservoir)					
	Subsidence[1] (mm)	Tilt[2] (mm/m)	Hogging Curvature[3] (km^{-1})	Sagging Curvature[3] (km^{-1})	Upsidence[4] (mm)	Closure[5] (mm)
After LW307	< 20	< 0.5	< 0.01	< 0.01	40	80
After LW308	< 20	< 0.5	< 0.01	< 0.01	100	125
After LW309	< 20	< 0.5	< 0.01	< 0.01	100	175
After LW310	< 20	< 0.5	< 0.01	< 0.01	125	200

Source: after MSEC (2021).

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

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 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.

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

The maximum predicted valley closure for the rock bars/boulder field downstream of Pool P, resulting from Longwalls 308-310 is provided in Table 6. The rock bar downstream of Pool P is approximately 790 m from Longwall 310. Rock bars V and W are located within the Longwalls 308-310 35° angle of draw and/or predicted 20 mm subsidence contour.

Table 6
Maximum Predicted Total Closure at Rock Bars/Boulder Field along the Waratah Rivulet

Longwall	Maximum Predicted Total Closure (mm)						
	RB-P	RB-Q	RB-R	RB-S	RB-T	RB-V	RB-W
After LW307	125	100	125	100	80	70	50
After LW308	125	100	125	100	100	125	125
After LW309	125	100	150	125	125	175	175
After LW310	150	125	150	150	150	175	200

Source: after MSEC (2021)

mm = millimetres

Table 6 indicates that there is negligible additional predicted closure at the rock bars upstream of the full supply level of the Woronora Reservoir (MSEC, 2021).

A comparison of the maximum predicted closure for the rock bars, resulting from the Extraction Plan Layout of Longwalls 308-310, with those based on the Preferred Project Layout is provided in Table 7.

Table 7
Comparison of Maximum Predicted Closure for the Waratah Rivulet Rock Bars based on the Preferred Project Layout and the Extraction Plan Layout

Layout	Maximum Predicted Total Closure (mm)						
	RB-P	RB-Q	RB-R	RB-S	RB-T	RB-V	RB-W
Preferred Project Layout (after LW310)	150	150	200	200	200	225	250
Extraction Plan Layout	150	125	150	150	150	175	200

Source: after MSEC (2021)
mm = millimetres

The maximum predicted closure for the rock bars downstream of Pool P, based on the Extraction Plan Layout, are less than the maxima predicted based on the Preferred Project Layout at Rock Bars Q, R, S, T, V and W, and the maximum predicted closure is the same at Rock Bar P (MSEC, 2021).

Eastern Tributary

The Eastern Tributary flows in a northerly direction into the full supply level of the Woronora Reservoir approximately 780 m (at the full supply level) to the east of Longwall 308.

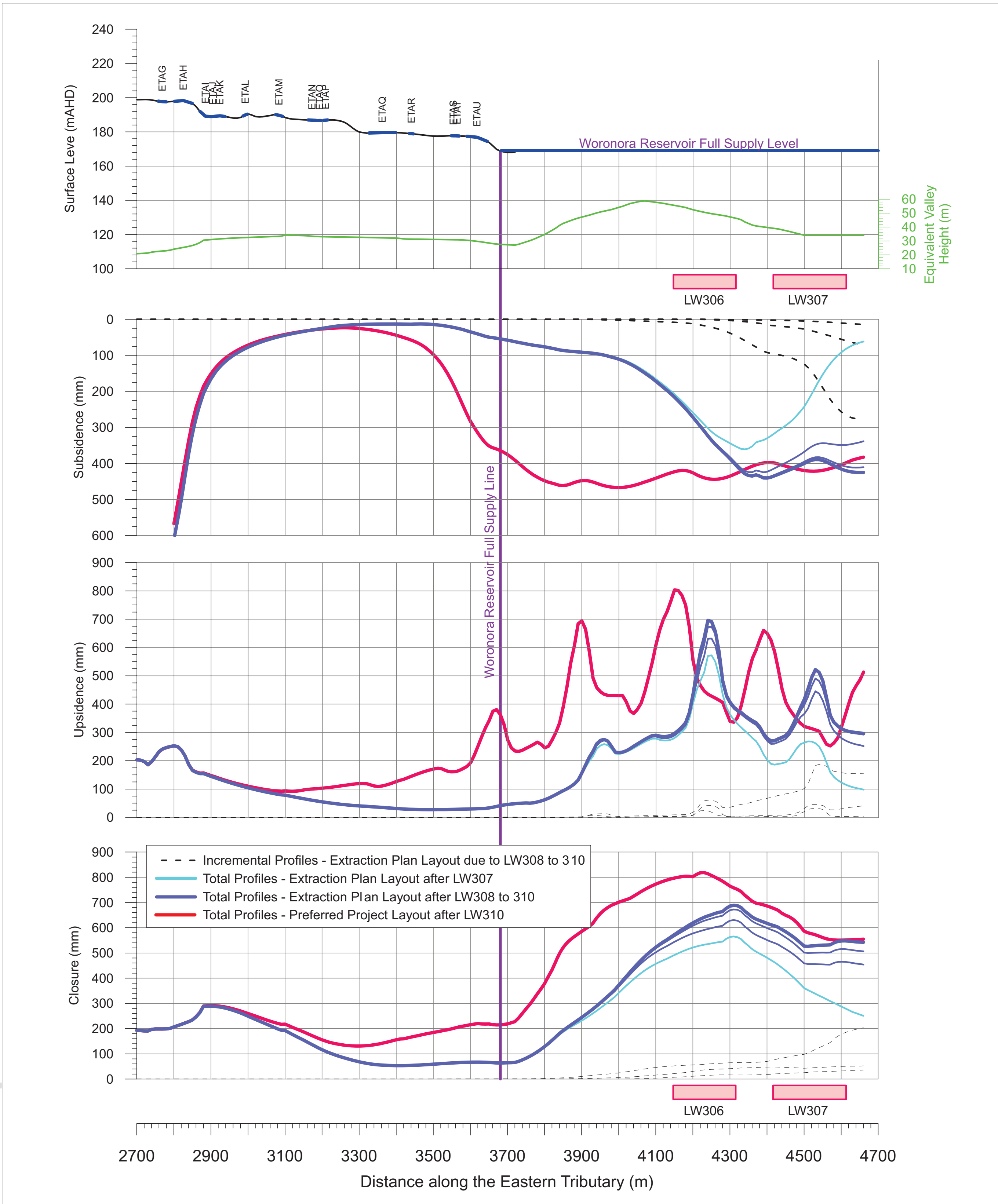
The predicted profiles of subsidence, upsidence and closure along the Eastern Tributary (to the full supply level of the Woronora Reservoir), resulting from the extraction of Longwalls 308-310, are shown on Figure 13.
Being 780 m or more east of Longwall 308, the Eastern Tributary is not predicted to experience measurable valley related movements and conventional subsidence movements during the extraction of Longwalls 308 to 310.

The Eastern Tributary has been managed using an adaptive management approach during the extraction of Longwalls 303 to 305 with a comprehensive monitoring program about Rock Bar ETAU. The monitoring program will continue during the extraction of Longwalls 306 and 307. Following a review of monitoring data after the completion of Longwall 307, the need for further monitoring of Rock Bar ETAU will be determined

Woronora Reservoir

The Woronora Reservoir full supply level is located above Longwalls 308-310. The area of the Woronora Reservoir full supply level immediately downstream of the Waratah Rivulet and Eastern Tributary is referred to as an inundation area. When the Woronora Reservoir is at full capacity, this area is flooded. When the water level is below the full supply level, portions of the inundation area form temporary pools above exposed rock bars.

The predicted profiles of vertical subsidence, upsidence and closure for the Woronora Reservoir full supply level, resulting from the extraction of Longwalls 308-310, are shown on Figure 12 (for the alignment of the Waratah Rivulet) and Figure 13 (for the alignment of the Eastern Tributary).



MET-21-26 LW308-310 EP WMP_003C

Source: MSEC (2021)

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Predicted Profiles of Subsidence, Upsidence and Closure along the Eastern Tributary and Woronora Reservoir due to Longwalls 308-310

Figure 13

A summary of the maximum predicted values of total subsidence, tilt, curvature, upsidence and closure for the Woronora Reservoir full supply level, after Longwall 307 and resulting from the extraction of Longwalls 308-310 is provided in Table 8. The values are the predicted maxima within the 35° angle of draw and/or predicted 20 mm subsidence contour for Longwalls 308-310.

Table 8
Maximum Predicted Subsidence, Tilt, Curvature, Upsidence and Closure for the Woronora Reservoir Resulting from Longwalls 308-310 Extraction

Longwall	Maximum Predicted					
	Subsidence (mm)	Tilt (mm/m)	Hogging Curvature (km^{-1})	Sagging Curvature (km^{-1})	Upsidence (mm)	Closure (mm)
After LW307	350	1	0.02	0.04	575	575
After LW308	425	2	0.05	0.05	625	625
After LW309	475	1.5	0.05	0.05	675	675
After LW310	475	2	0.05	0.05	700	700

Source: after MSEC (2021).
mm = millimetres; mm/m= millimetres per metre; km^{-1} =1/kilometres

The maximum predicted conventional tilt for the Woronora Reservoir full supply level is 2.0 mm/m (i.e. 0.2%, or 1 in 500). The maximum predicted conventional curvatures are 0.05 km^{-1} hogging and sagging, which equate to minimum radii of curvature of 20 km (MSEC, 2021). The predicted conventional strains for the Woronora Reservoir full supply level (based on 15 times the curvature) are < 1 mm/m tensile and compressive (MSEC, 2021).

A comparison of the maximum predicted vertical subsidence, upsidence and closure for the Woronora Reservoir full supply level resulting from the Extraction Plan Layout of Longwalls 308-310, with those based on the Preferred Project Layout after Longwall 310, is provided in Table 9. The revised maximum predicted subsidence, upsidence and closure for the Woronora Reservoir full supply level, are less than the maxima for the Preferred Project Layout (MSEC, 2021). The maximum predicted total closure on the Woronora Reservoir full supply level resulting from the extraction of Longwalls 308-310 is 700 mm (Table 9).

Table 9
Comparison of Maximum Predicted Conventional Subsidence Parameters for the Woronora Reservoir 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 (after LW310)	475	800	825
Extraction Plan Layout	475	700	700

Source: after MSEC (2021)
mm = millimetres

The maximum predicted closure based on the Extraction Plan Layout is less than the maximum predicted based on the Preferred Project Layout.

Other Drainage Lines/Streams

First and second order streams are also located within the Longwalls 308-310 35° angle of draw and/or predicted 20 mm subsidence contour (Figure 2). These streams consist of shallow drainage lines from the topographical high points, forming tributaries where valley heights increase and drain into the Woronora Reservoir. The streams are located above Longwalls 308-310, and could experience the full range of predicted subsidence movements, with maximum predicted closure up to 700 mm (MSEC, 2021).

5.5 REVISED ASSESSMENT OF POTENTIAL SUBSIDENCE IMPACTS AND ENVIRONMENTAL CONSEQUENCES

5.5.1 Surface Water

The maximum predicted subsidence parameters for the Waratah Rivulet, based on the Extraction Plan Layout, are less than the maxima predicted based on the Preferred Project Layout.

Previous assessments of stream impacts at Metropolitan Coal have used a relationship between predicted total closure at rock bars and proportion of impacted pools for streams in the Southern Coalfield. The relationship identified approximately 10% of pools were impacted at a predicted total valley closure of up to 200 mm (MSEC, 2021). Impacts to some pools along the Eastern Tributary resulting from the extraction of Longwall 27, have occurred at predicted values of total valley closure of less than 200 mm resulting in a higher proportion of impacted pools at lower magnitudes of predicted total valley closure. As a result of the observed impacts to the Eastern Tributary, the finishing ends of Longwalls 303, 304 and 305 were set back to minimise predicted valley closure at the Eastern Tributary.

As described in Section 4.1, Metropolitan Coal has established a comprehensive monitoring and adaptive management program to identify subsidence related movements at the Eastern Tributary to minimise the risk of further exceedance of the Eastern Tributary performance measure. The Eastern Tributary Valley Closure TARP has been successfully implemented by Metropolitan Coal for Longwalls 303, 304 and 305. The same monitoring and adaptive management program will be used for the extraction of Longwalls 306 and 307 (as described in the Longwall 305-307 Extraction Plan).

As discussed in Section 4.1, the restriction of predicted total valley closure to 200 mm has been a successful design tool for complying with the negligible environmental consequence performance measure on the Waratah Rivulet. Furthermore, the geotechnical study of the Waratah Rivulet (detailed in Section 4.1) concluded that the geological features identified along the Eastern Tributary are considered to be unique, compared to the Waratah Rivulet. The Eastern Tributary is therefore more likely to be susceptible to subsidence movements. Restricting valley closure to 200 mm therefore continues to be an appropriate design tool for the Waratah Rivulet.

Given that the maximum predicted closure for the rock bars downstream of Pool P, based on the Extraction Plan Layout, are less than or equal to the maxima predicted based on the Preferred Project Layout, and that the maximum predicted total valley closure for the rock bars downstream of Pool P is 200 mm (Table 7), the potential subsidence impacts and environmental consequences described in the Project EA, Preferred Project Report, and Metropolitan Coal Water Management Plans in relation to the Waratah Rivulet continue to be applicable for Longwalls 308-310.

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) and IEPMC (2018) Initial Report contend that areas containing lineaments may experience greater than normal subsidence. The IEPMC (2018) Initial Report indicates that in recent years it has been identified in the Western Coalfield that surface subsidence, groundwater and surface water responses to longwall mining can be significantly modified in the vicinity of lineaments[16]. Further to advice from the IEPMC, and at the request of the DPIE, specific regard was given in the Longwall 304 and Longwalls 305-307 Extraction Plans to the potential impacts of mining near and under lineaments on surface water features, including waterfalls. A similar assessment has been conducted for the Longwalls 308-310 Extraction Plan[17].

Lineaments and faults mapped by Metropolitan Coal in close proximity to streams within 600 m of Longwalls 308-310 are shown on Figure 14.

A lineament that aligns with the Eastern Tributary at the waterfall at the downstream end of Rock Bar ETAU (Figure 14) is aligned with a 20 mm wide minor strike-slip fault, F0021, which has zero vertical displacement. No moisture has been evident at seam level where it crosses the 300 mains or in the Longwalls 303 maingate. WaterNSW representatives were shown this particular strike-slip fault, along with F0008 during an underground inspection on 19 March 2019[18]. WaterNSW representatives concurred that the faults are not readily apparent without the assistance of Metropolitan Coal's geologist.

It is considered likely that Fault F0008 and Fault F0021, would have similar characteristics and behave in a similar manner to that experienced by mine extraction and development to date. Similar to the assessment for Longwall 304 and Longwalls 305-307, hydraulic connectivity via lineaments to the waterfall at Rock Bar ETAU on the Eastern Tributary is considered to be highly unlikely as a result of the extraction of Longwalls 308-310.

A strike slip fault, F0027, with zero vertical displacement, has been mapped in the gate roads leading into Longwalls 304 and 305. The associated surface linear is located approximately 250 m west of the end of the Eastern Tributary arm of Woronora Reservoir full supply level. No moisture has been evident at seam level where F0027 crosses the 300 mains or in the Longwalls 304 or 305 maingate. Similar to the assessment for F0008 and F0021, hydraulic connectivity of F0027 via lineaments on the Eastern Tributary is considered to be highly unlikely as a result of the extraction of Longwalls 308-310.

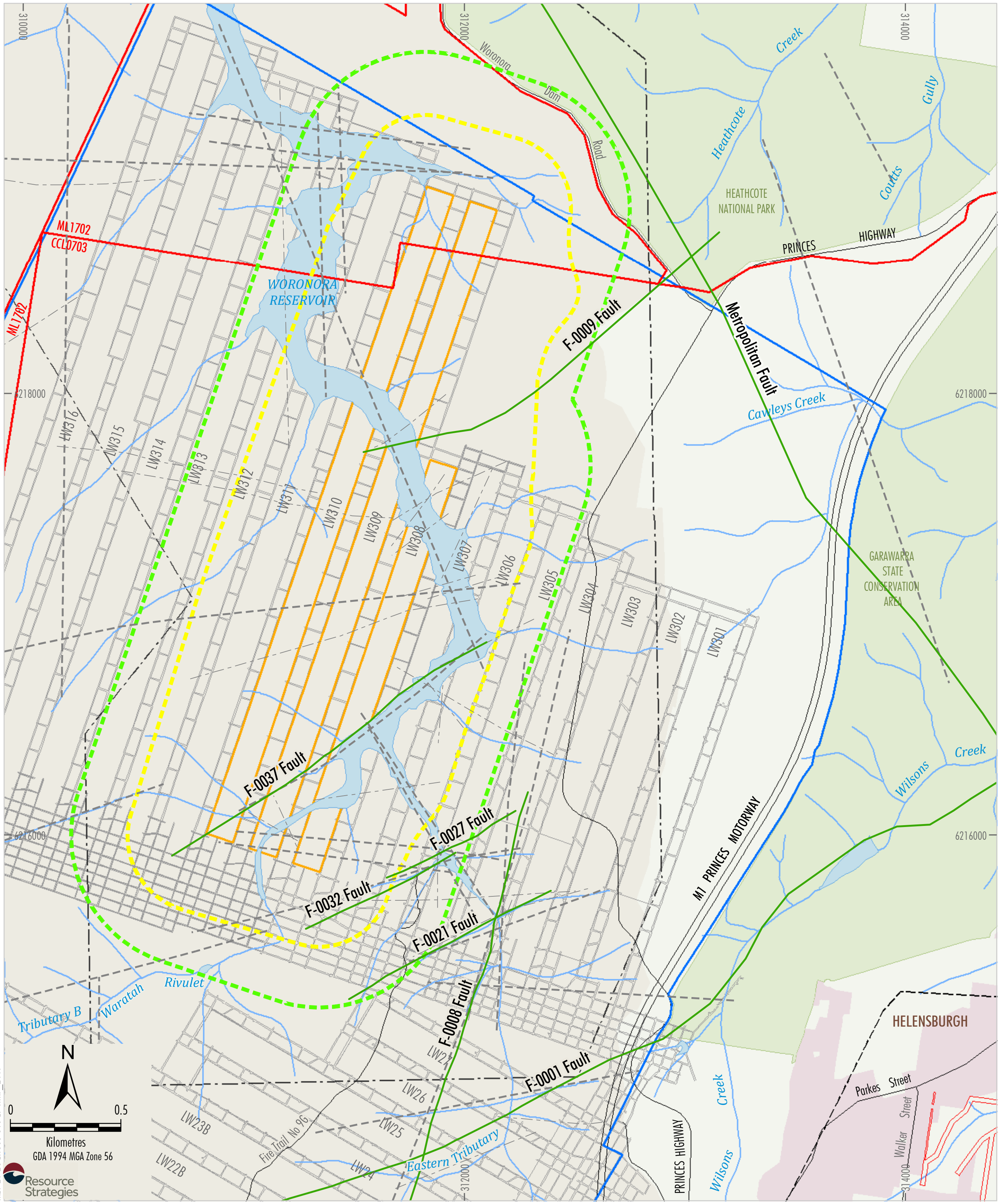
A strike slip fault, F0037, with zero vertical displacement, has been mapped in the gate roads leading into Longwalls 306 and 307. The associated surface linear is aligned with the Waratah Rivulet arm of Woronora Reservoir. Similar to previous experience of mining through these features no moisture has been evident from F0037 structure in the seam. The Longwalls 308-310 Geological Features Risk Assessment participants were shown images of F0037 during longwall extraction with the structure displaying dry and dusty conditions.

F0009 is a normal fault with a displacement of 10-15 m located north of Longwall 308 and with a south-west strike bisecting Longwall 309. The displacement of F0009 combined with poorer coal quality north of the structure led to an economic decision to reposition the Longwall 308 face line from the Preferred Project Layout to the Extraction Plan Layout. Longwall 309 and Longwall 310 are anticipated to be able to ramp through the structure.

[16] Drawing comparisons of lineament behaviour between two geographically separated regions is problematic, given the degree of variables potentially present. Depth to the basement rock is a variable with likely substantive influence on behaviour of lineaments and markedly different between the Western and Southern Coalfields. Many features of the NSW Coalfields surface topography are directly correlated to the basement structure, the depth of the basement from the surface through many sedimentary epochs and the deformational episodes of the basement rock.

[17] The risk assessment conducted for potential impacts of mining effects on geological features on the quantity of water resources to the reservoir is discussed in Section 5.3. The risk assessment conducted for potential impacts of mining effects on geological features on surface water resources, including waterfalls is discussed in Section 5.2.

[18] WaterNSW representatives on the underground visit included Ms Fiona Smith (Executive Manager, Water and Catchment Protection) and Mr Peter Dupen (Manager, Mining).



LEGEND

- Mining Lease Boundary
- Woronora Special Area
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Longwalls 308-310 Secondary Extraction
- Longwalls 308-310 35° Angle of Draw and/or Predicted 20 mm Subsidence Contour
- 600 m from Longwalls 308-310 Secondary Extraction
- Woronora Notification Area
- Existing Underground Access Drive (Main Drift)
- Lineament (prominent)
- Lineament (minor)
- Faults and Dykes (lateral extent >1 km)

Source: Land and Property Information (2015); Department of Industry (2015); Metropolitan Coal (2021); MSEC (2021);

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Lineaments, Faults and Streams over Longwalls 308-310 and Surrounds

Figure 14

A detailed seismic assessment of F0009 was commissioned to determine the vertical extent of the structure with multiple dedicated seismic lines installed to provide a suitable resolution throughout the stratigraphy. The Velseis (2018) report concluded:

> *The large normal fault F0009 can be seen to impact the Bulli Seam only, and there is no evidence from available seismic data that this normal fault extends to the shallower Bald Hill Claystone level in the stratigraphy*

From the detailed seismic report, the fault is not vertically extensive, residing at depth about the Illawarra Coal Measures. Whilst not vertically extensive, horizontally the structure extends north-west away from the extraction area towards the Metropolitan Fault. From the point where F0009 bisects Longwall 309 to the Metropolitan fault, the horizontal distance is approximately 1.5 km.

To demonstrate the structure poses negligible effects to the groundwater systems, a surface to seam borehole (2020EX02) was approved and installed in 2020. This hole, located along strike, approximately 500 m north-west of the intercept with Longwall 309, was designed to measure the horizontal permeability characteristics of F0009 by coring through the structure at depth. An assessment of the permeability characteristics found (Golder Associates Pty Ltd, 2020):

> *Hydraulic conductivities measured across the fault were comparable to those recorded for the unfractured host rock… there is negligible variance in horizontal flow characteristics associated with the fault measured at this location.*

Detailed surface mapping has not identified any associated surface linear with this feature. Given the available data, it is highly unlikely that this feature would provide hydraulic connectivity either vertically or horizontally as a result of the extraction of Longwalls 308-310, similar to previous experiences of mining through other structures such as F0008, F0021, F0027 and F0037. The risk posed by F0009 was carefully considered and reviewed during the Longwalls 308-310 Geological Features Risk Assessment, with an additional control being specified to undertake water make monitoring specifically for F0009 with further delineation to occur on roadway advancement (similar to controls previously used for structures passed through by mining).

The maximum predicted subsidence parameters for the Woronora Reservoir full supply level, based on the Extraction Plan Layout, are less than or equal to the maxima predicted based on the Preferred Project Layout. The potential impacts on the Woronora Reservoir, based on the Extraction Plan Layout, therefore, are predicted to be consistent with or less than those assessed based on the Preferred Project Layout (including cracking at the base of valleys and fracturing and dilation of the underlying strata when the reservoir level is lower than the full supply level). Further, it is noted that Longwall 306 commenced mining beneath the Woronora Reservoir (vertically) from September 2021, and Metropolitan Coal has not identified abnormal water flow from the goaf, geological structure, or the strata generally.

The first and second order streams located above Longwalls 308-310 (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 and 5.4.

5.5.2 Groundwater

The revised subsidence predictions for the Extraction Plan Layout do not change the subsidence impact assessment or assessment of environmental consequences provided in the Project EA and Preferred Project Report for groundwater that are described in Section 4.

Potential environmental consequences of Longwalls 308-310 extraction on aquifers and baseflow to watercourses have been predicted using the latest calibrated model (SLR Consulting, 2020). The model provides predictions of impacts and mine inflow that can be used to assess the performance of the Project, as described in Section 8. As mining and data collection proceed, confidence levels in the model parameters will increase.

***Catchment Yield*[19]**

Based on the period of record available for the Woronora Reservoir (1977 to 2008) at the time of the Project EA, the model predictions indicate a negligible reduction in catchment yield due to Longwalls 308-310 extraction (i.e. 0.2% of the annual average yield to the reservoir)[20].

Mine Groundwater Inflows

The simulated groundwater inflow to Longwalls 301-310 is presented on Chart 4 for the groundwater model, from the start of the 300-series mains to the end of Longwall 310 (assuming no subsequent mining). The groundwater inflow is expected to be approximately 0.02 ML/day at the start of Longwall 301 to approximately 0.12 ML/day at the end of Longwall 310. As these rates are consistent with the predictions made in the Project EA, the Project EA estimates of mine groundwater inflow at the end of mining remain valid.

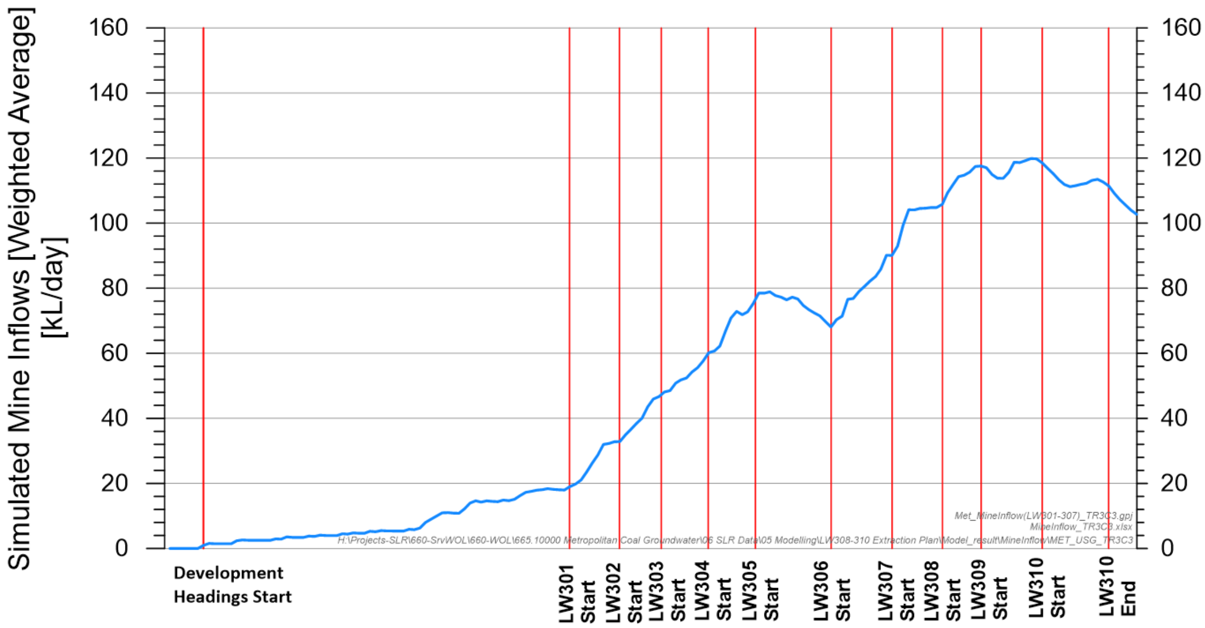


Chart 4 Predicted Groundwater Inflows to Longwalls 301-310 as Mining Proceeds

[19] Total water flow from the catchment including surface and sub-surface contributions.

[20] Gilbert & Associates (2008) prepared a water balance for Woronora Reservoir using Sydney Catchment Authority (now WaterNSW) reservoir data and calculated a total yield to Woronora Reservoir over 31 years of approximately 800,000 ML, which equates to an annual average yield of 25,806 ML. The updated groundwater model predicts 0.15 ML/day (54 ML/annum) reduction in catchment yield for Longwalls 308-310 extraction.

Vertical Head Profiles

Vertical profiles of potentiometric head are effective monitors of the capacity of an aquifer system to maintain pressure during the formation of deformation zones caused by caving and subsidence. Head profiles show a characteristic reduction in head with depth due to mining. That is, as mining moves closer, groundwater pressures are expected to fall.

The predicted head profiles for multi-piezometer bores are presented on Charts 5 to 13 at the end of Longwalls 308 and 310. The locations of these bores are shown on Figure 10.

Every bore shows some effect from past and/or present mining. The least affected bore is PM02, which is the furthest from active mining. Using the range in heads from the uppermost piezometer to the lowest head predicted at depth as a guide, to the end of Longwall 310, the order of total predicted mining effect (from most to least) is: 9EGW2A (485 m head range), F6GW4A (450 m head range), 9GGW2B (405 m head range), F6GW3A (365 m head range), 9EGW1B (335 m head range), PHGW2A (325 m head range), PHGW1B (315 m head range), PM01 (9DGW1B) (295 m head range), and PM02 (215 m head range) (Figure 10). As the responses at bores F6GW3A, F6GW4A and 9GGW2B on Charts 5 to 7 show no predicted changes as mining progresses away from those sites to the west, there is no need for ongoing reporting at these sites.

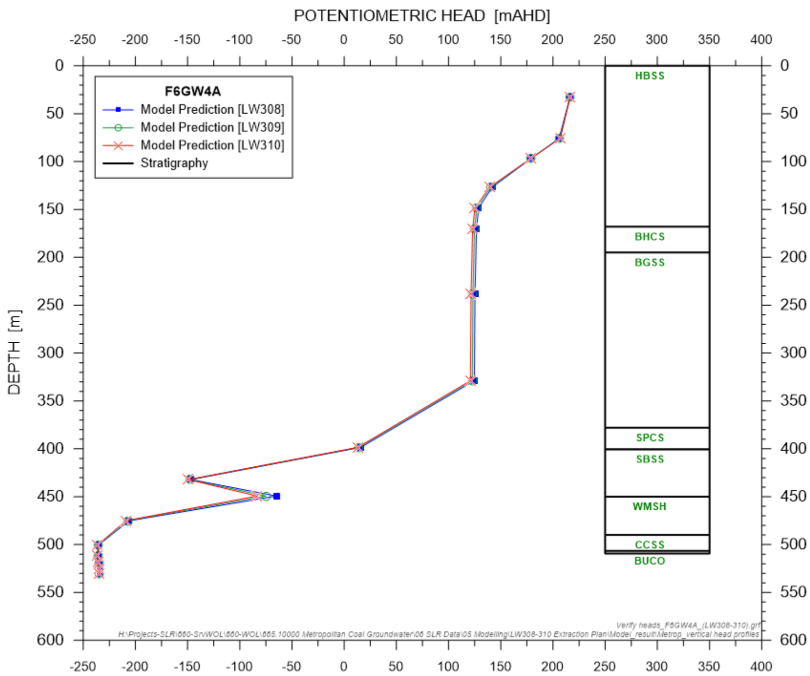


Chart 5 Predicted Vertical Head Profile at Bore F6GW4A at the end of Longwalls 308 to 310

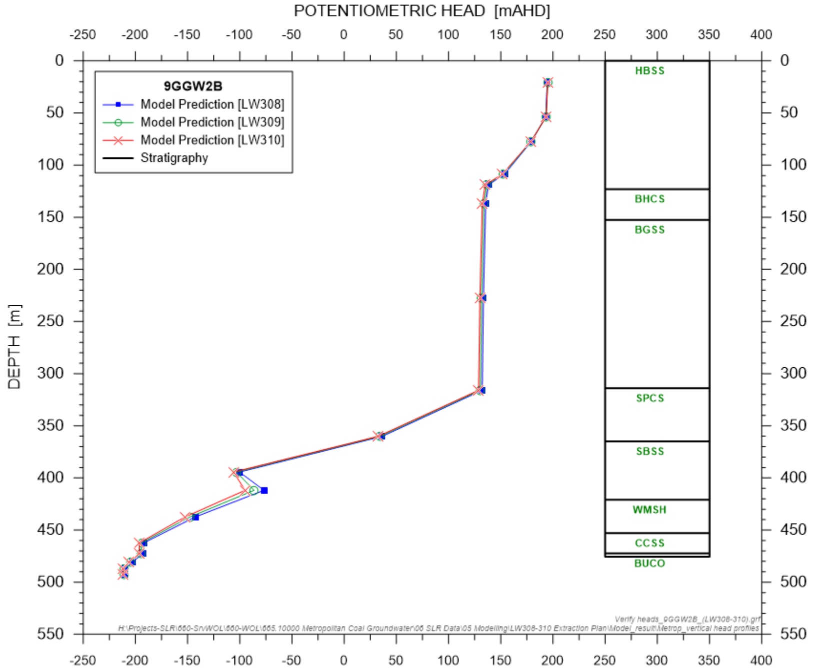


Chart 6 Predicted Vertical Head Profile at Bore 9GGW2B at the end of Longwalls 308 to 310

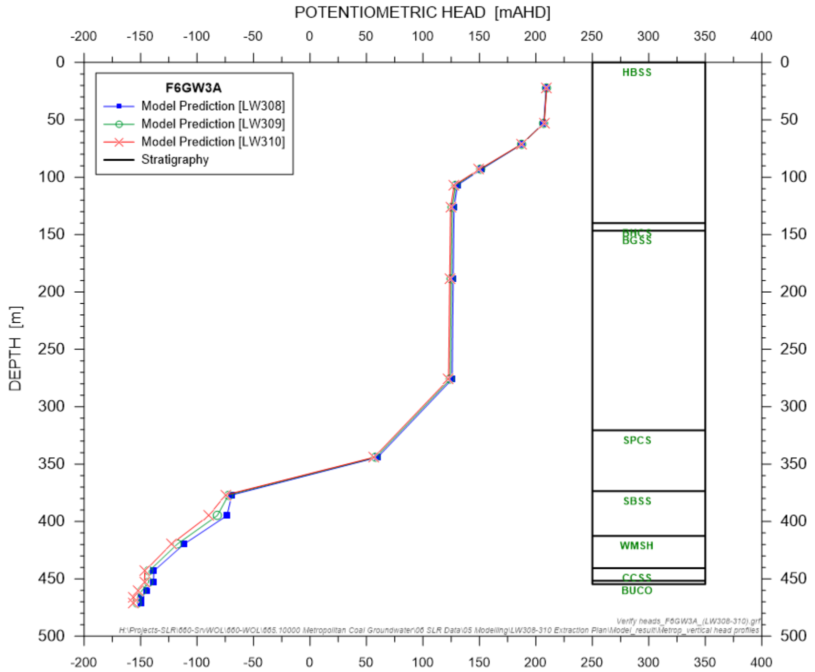


Chart 7 Predicted Vertical Head Profile at Bore F6GW3A at the end of Longwalls 308 to 310

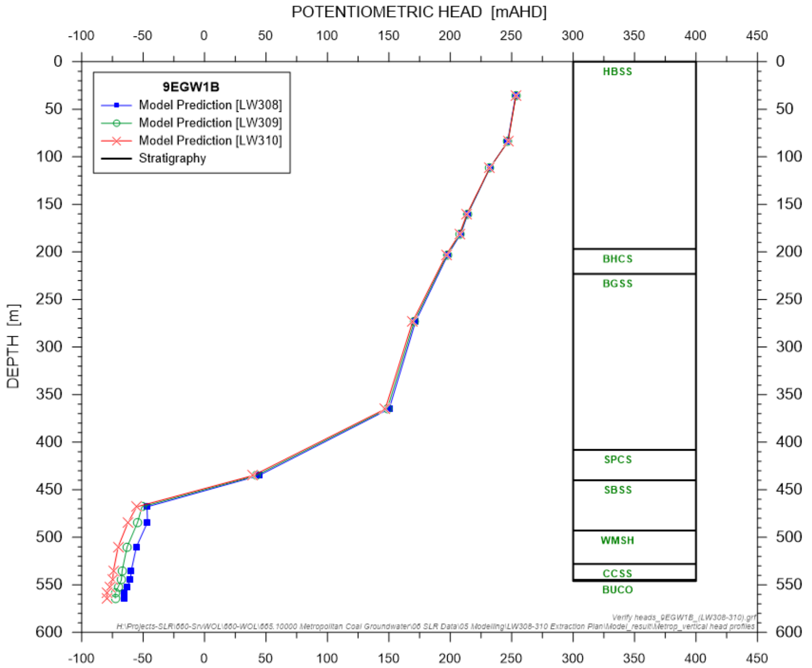


Chart 8 Predicted Vertical Head Profile at Bore 9EGW1B at the end of Longwalls 308 to 310

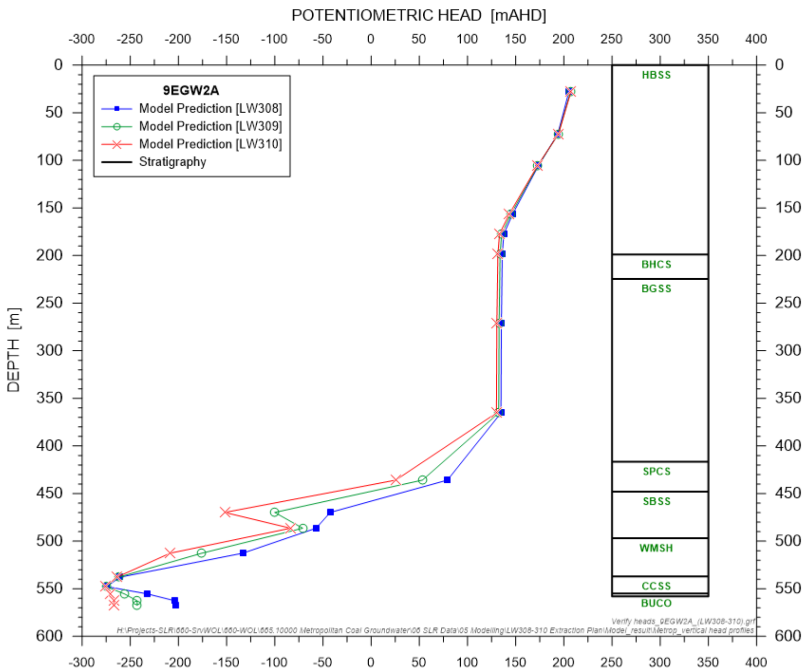


Chart 9 Predicted Vertical Head Profile at Bore 9EGW2A at the end of Longwalls 308 to 310

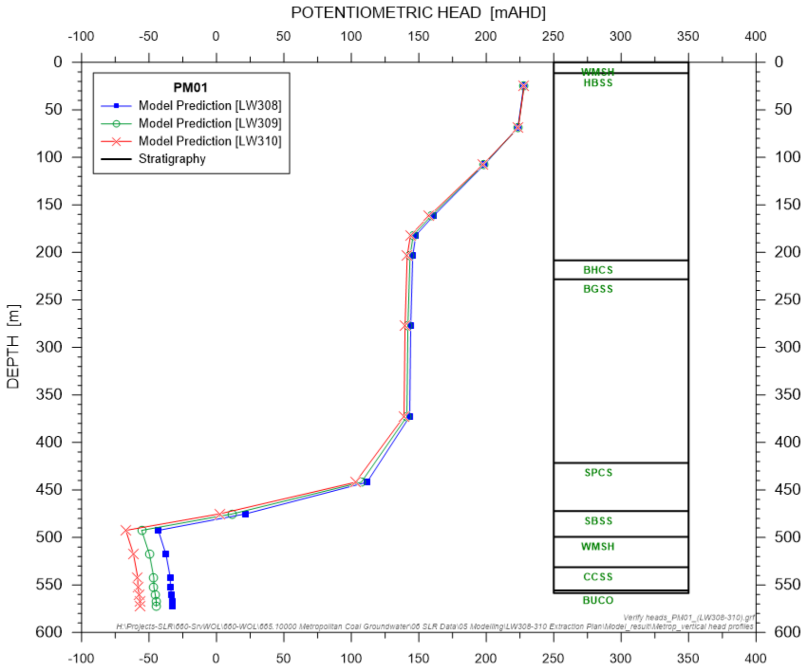


Chart 10 Predicted Vertical Head Profile at Bore PM01 (9DGW1B) at the end of Longwalls 308 to 310

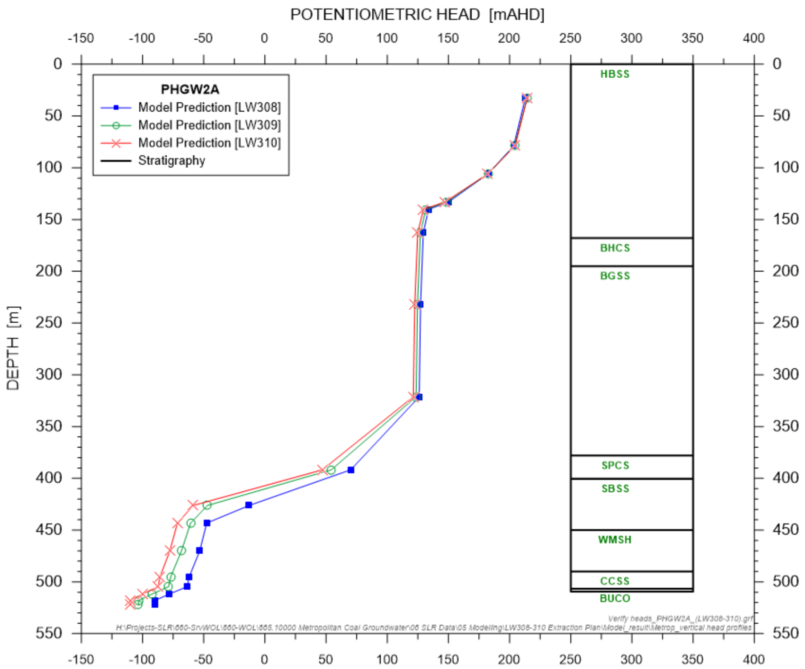


Chart 11 Predicted Vertical Head Profile at Bore PHGW2A at the end of Longwalls 308 to 310

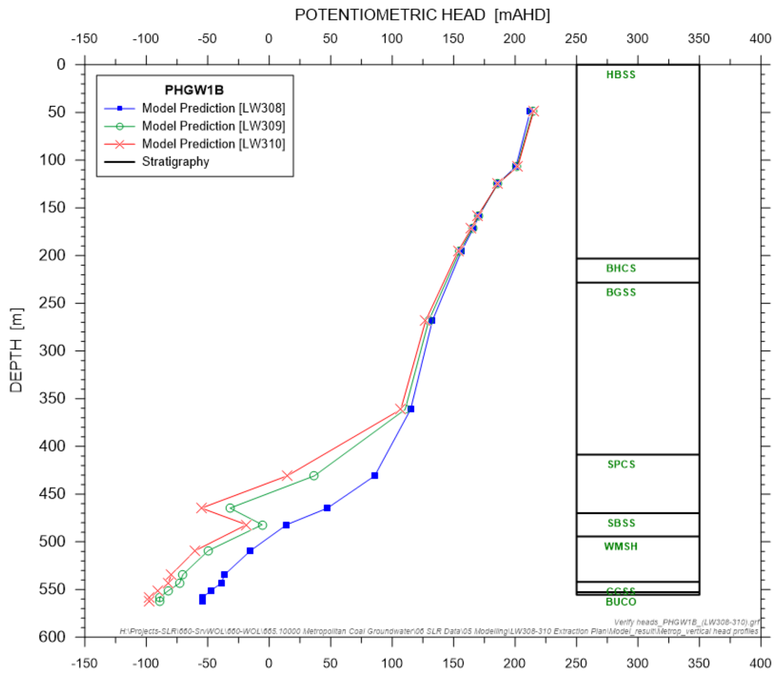


Chart 12 Predicted Vertical Head Profile at Bore PHGW1B at the end of Longwalls 308 to 310

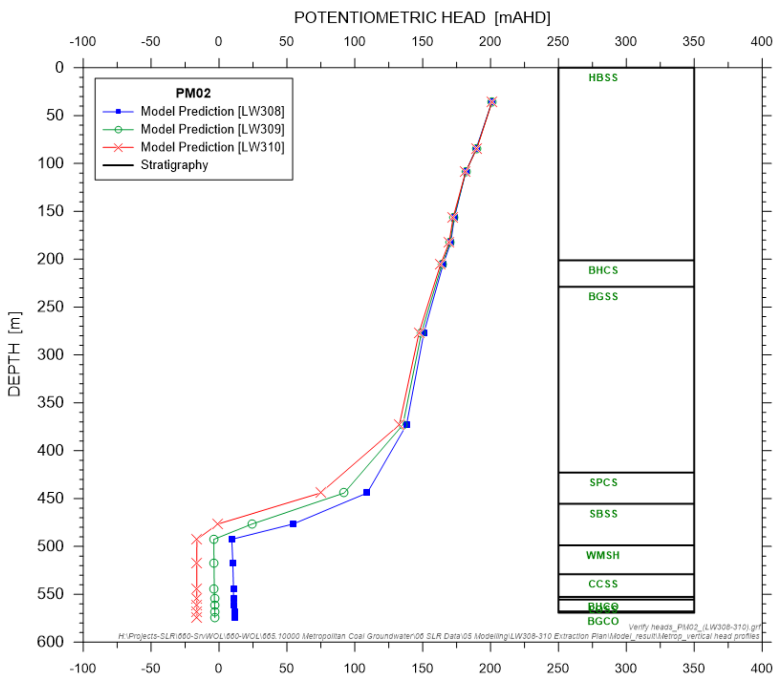


Chart 13 Predicted Vertical Head Profile at Bore PM02 at the end of Longwalls 308 to 310

The performance measures, *No connective cracking between the surface and the mine* and *Negligible leakage from the Woronora Reservoir* are predicted to not be exceeded by the mining of Longwalls 308-310.

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.

The subsidence impact performance measures specified in Table 1 of Condition 1, Schedule 3 in relation to water resources and watercourses are:

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)*

The term '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 water resource and watercourse performance indicators outlined in Table 10.

Table 10
Summary of Water Resource and Watercourse Performance Indicators and Measures

Performance Measure	Performance Indicator(s)
Negligible reduction to the quantity of water resources reaching the Woronora Reservoir.	*Changes in the quantity of water entering Woronora Reservoir are not significantly different post-mining compared to pre-mining, that are not also occurring in the control catchment.*
Negligible reduction to the quality of water resources reaching the Woronora Reservoir.	*Changes in the quality of water entering Woronora Reservoir are not significantly different post-mining compared to pre-mining concentrations that are not also occurring at control site WOWQ2.*
No connective cracking between the surface and the mine.	*Visual inspection does not identify abnormal water flow from the goaf, geological structure, or the strata generally.*
	The 20-day average mine water make does not exceed 1 ML/day.
	Significant departure from the predicted envelope of the vertical potentiometric head profile at Bore PM02 does not occur.
	Significant departure from the predicted envelope of the vertical potentiometric head profile at Bore PHGW2A does not occur.

Table 10 (Continued)
Summary of Water Resource and Watercourse Performance Indicators and Measures

Performance Measure	Performance Indicator(s)
No connective cracking between the surface and the mine. Negligible leakage from the Woronora Reservoir.	*The hydraulic gradient to the Woronora Reservoir at full supply level from Bore PHGW2A is reduced by no more than 40% from that measured to 30 June 2017.*
Negligible leakage from the Woronora Reservoir.	*The hydraulic gradient to the Woronora Reservoir at full supply level from Bore 9EGW2A is reduced by no more than 40% from that measured to 30 June 2017.*
	The hydraulic gradient to the Woronora Reservoir at full supply level from Bore PM02 is reduced by no more than 40% from that measured to 30 June 2017.
	The hydraulic gradient from transect bore T5 to bore T3-R is reduced by no more than 10% from that measured on 30 June 2017.
Negligible reduction in the water quality of Woronora Reservoir.	*Changes in the quality of water in the Woronora Reservoir are not significantly different post-mining compared to pre-mining concentrations.*
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).	*No change to the natural drainage behaviour of Pools P, Q, R, S, T, U, V and W.*
	Analysis of water level data for Pools P, T, U, V and W indicates the water level is at or above the pool's previous minimum.
	Analysis of water level data for Pools Q, R and S indicates the water levels are above that required to maintain water over the downstream rock bar.
	Visual inspection of the Waratah Rivulet from Pool P to the full supply level of the Woronora Reservoir does not show significant changes in the extent or nature of iron staining that isn't also occurring in the Woronora River (control site).
	Gas releases in Waratah Rivulet from Pool P to the full supply level of the Woronora Reservoir have not increased beyond those observed up to the commencement of Longwall 301 extraction.
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) of the Eastern Tributary between the full supply level of the Woronora Reservoir and the maingate of Longwall 26.	*No change to the natural drainage behaviour of Pools ETAS, ETAT and ETAU.*
	Analysis of water level data for Pools ETAS/ETAT and ETAU indicates the water levels are above that required to maintain water over the downstream rock bars.
	Gas releases in Eastern Tributary between the full supply level of the Woronora Reservoir and the maingate of Longwall 26 have not increased beyond those observed up to the commencement of Longwall 301 extraction.

Section 8 describes the monitoring that will be conducted to inform the assessment of the Project against the subsidence impact performance indicators and measures for water resources and watercourses. The monitoring program includes the monitoring of:

- meteorology (Section 8.1);
- stream features (Section 8.2);
- surface water quantity (Section 8.3);
- surface water quality (Section 8.4);
- Woronora Reservoir water quality (Section 8.5);
- groundwater levels/pressures (Section 8.6);
- mine inflows (Section 8.7); and
- groundwater quality (Section 8.8).

Section 8.9 provides detailed TARPs to assess the water resource and watercourse subsidence impact performance indicators and measures.

7 BASELINE DATA

Sections 7.1 to 7.3 describe the baseline data available of relevance to water resources and watercourses.

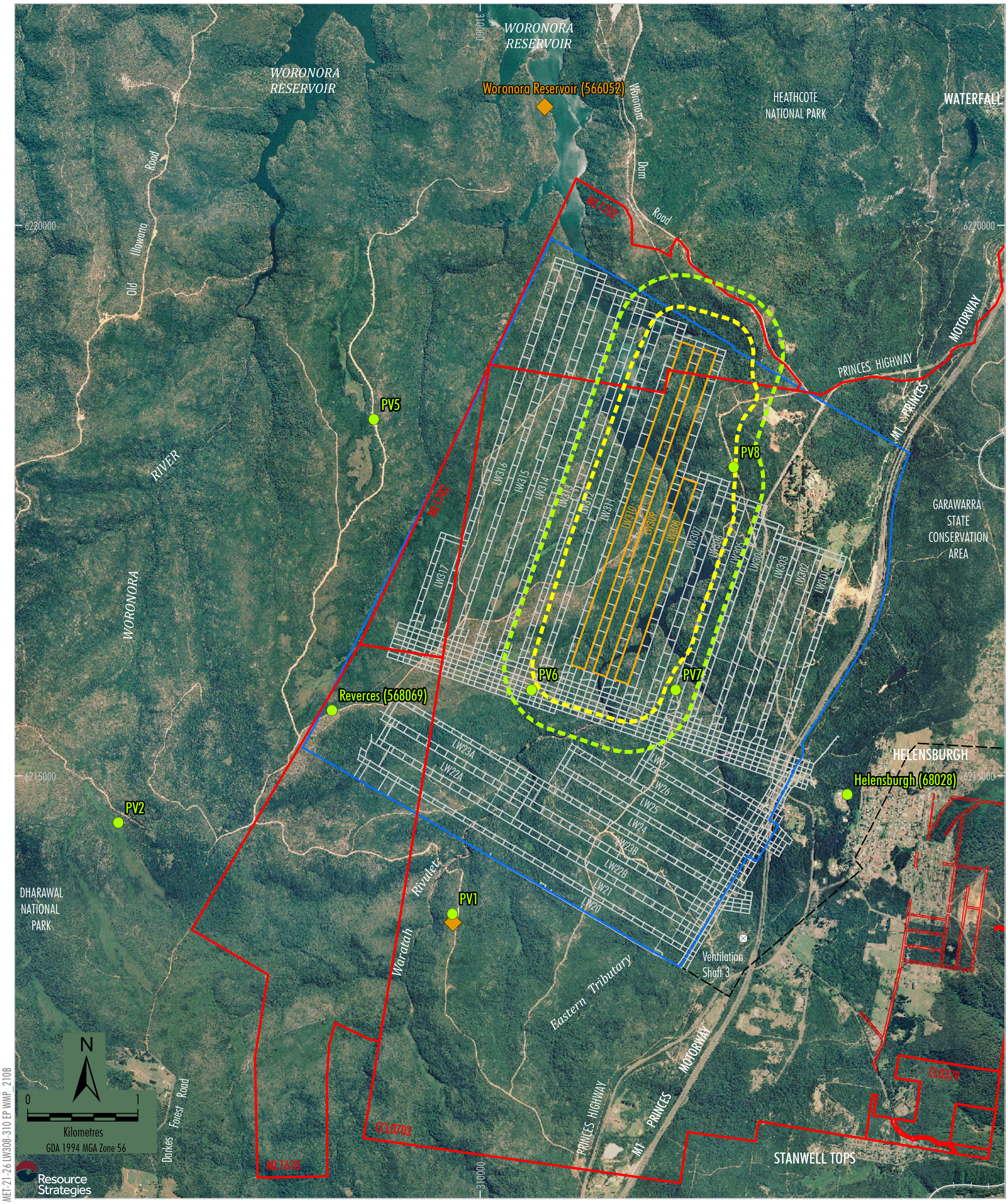
Metropolitan Coal will maintain a register of water sites that includes: the location; date the site was established; and relevant comments. The water sites register will be made publicly available on the Peabody website and updated as required.

Baseline data will be made available to relevant regulatory agencies upon request.

7.1 METEOROLOGY

Regional and local meteorological data is available from the Bureau of Meteorology (BoM) weather stations at Lucas Heights (Station Number 66078), Woronora Dam (Station Number 68070), Darkes Forest (Station Number 68024), and ‘Reverces’ (Station Number 568069) (Table 11). Rainfall data is also available from Metropolitan Coal pluviometers situated in the Waratah Rivulet catchment (site PV1), Woronora River catchment (site PV2), Honeysuckle Creek catchment (site PV5), Waratah Rivulet catchment (site PV6), Eastern Tributary catchment (site PV7) and Woronora Reservoir catchment (site PV8) (Figure 15).

Evaporation data is available from the WaterNSW station at the Woronora Dam (Table 11) and the Metropolitan Coal evaporimeter within the Waratah Rivulet catchment, at site PV1 (Table 11 and Figure 15).



LEGEND

- Mining Lease Boundary
- Railway
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Longwalls 308-310 Secondary Extraction
- Longwalls 308-310 35° Angle of Draw and/or Predicted 20 mm Subsidence Contour
- 600 m from Longwalls 308-310 Secondary Extraction
- Existing Underground Access Drive (Main Drift)
- Evaporimeter
- Pluviometer

Notes:
1. The Bureau of Meteorology pluviometer at Darkes Forest (68024) is not shown. It is located approximately 3.75 km south of the Metropolitan Coal pluviometer (PV2).
2. The Bureau of Meteorology pluviometer at Lucas Heights (66078) is not shown. It is located approximately 12.5 km north of the Metropolitan Coal pluviometer (PV8).

Source: Land and Property Information (2015); Date of Aerial Photography 1998; Department of Industry (2015); Metropolitan Coal (2021); MSEC (2021)

Peabody

METROPOLITAN COAL

Meteorological Sites

Figure 15

Table 11
Meteorological Monitoring Station Locations and Recording Periods

Station Number	Data Type	Period of Record
Lucas Heights (BoM Station Number 66078)	Rainfall (daily read prior to pluviometer installation)	1958 to present
	Rainfall intensity	1958 to 1982, 1997 to present
	Evaporation	1979 to 1982
	Air temperature, wet bulb temperature, barometric pressure, humidity, cloud cover, wind speed, wind direction	1962 to 1982
Darkes Forest (BoM Station Number 68024)	Rainfall (BoM daily read converted to pluviometer)	1894 to present
Woronora Dam (BoM Station Number 68070, WaterNSW Station 566052)	Rainfall (BoM and WaterNSW daily read)	1927 to present
'Reverces' (BoM Station Number 568069)	Rainfall (pluviometer)	2000 to present
Waratah Rivulet (site PV1)	Rainfall (Metropolitan Coal pluviometer)	2006 to present
	Evaporation data (Metropolitan Coal evaporimeter)	2010 to present
Woronora River (site PV2)	Rainfall (Metropolitan Coal pluviometer)	2007 to present
Woronora Reservoir (WaterNSW station 566052)	Evaporation data	1976 to present
Honeysuckle Creek (site PV5)	Rainfall (Metropolitan Coal pluviometer)	2010 to present
Waratah Rivulet (site PV6)	Rainfall (Metropolitan Coal pluviometer)	2010 to present
Eastern Tributary (site PV7)	Rainfall (Metropolitan Coal pluviometer)	2010 to present
Woronora Reservoir catchment (site PV8)	Rainfall (Metropolitan Coal pluviometer)	January 2018 to present

7.2 SURFACE WATER

7.2.1 Stream Features

Prior to the commencement of Longwall 20, MSEC compiled a comprehensive survey and photographic record of Waratah Rivulet (from Flat Rock Crossing to the Woronora Reservoir full supply level), Eastern Tributary (from the east-west headings to the Woronora Reservoir full supply level), Tributary A (from its headwaters to its confluence with Waratah Rivulet) and Tributary B (from its headwaters to its confluence with Waratah Rivulet). The detailed mapping and photographic record of the Waratah Rivulet, Eastern Tributary, Tributary A and Tributary B is provided in Appendices 1 to 4, respectively.

Visual and photographic surveys conducted in accordance with the Metropolitan Coal WMPs have recorded:

- the location, approximate dimensions (length, width and depth), and orientation of surface cracks (specifically whether cracks are developed perpendicular to the stream flow or are controlled by rock joints or other factors, etc.);
- the nature of iron staining (e.g. whether isolated or across the entire streambed);
- the extent of iron staining (e.g. the length of stream affected);

- a description of gas release (e.g. isolated bubbles or continuous stream, and type of gas [methane or carbon dioxide]);
- the nature of scouring, for example the depth of scouring, type of soil exposed, any obvious vegetation impact, potential for severe erosion, etc.;
- water discoloration or opacity if present;
- natural underflow if evident (i.e. evidence of surface flows either entering or exiting the sub-surface domain via surface cracks in the streambed);
- rock bar characteristics such as extent of cracking, seepage, underflow;
- whether any actions are required (e.g. implementation of management measures, incident notification, implementation of appropriate safety controls, review of public safety, etc.); and
- any other relevant information.

The monthly visual surveys have recorded the stream visual parameters by exception (i.e. where they have differed to the baseline record).

Hydro Engineering & Consulting conducted a visual inspection and photographic survey of streams in the vicinity of Longwalls 304-310 (not previously inspected for Longwalls 301-303) in April 2018 (Hydro Engineering & Consulting, 2019). The visual inspection and photographic survey report is provided in Appendix 5.

7.2.2 Surface Water Flow

Surface water flow data is available for the gauging stations listed in Table 12. The locations of the Waratah Rivulet (GS 2132102), Woronora River (GS 2132101), Eastern Tributary (GS 300078), Honeysuckle Creek (GS 300077), Sub-catchment I (GS 300092), Sub-catchment K (GS 300093), Sub-catchment P (GS 300142), Sub-catchment R (GS 300143) gauging stations are shown on Figure 6. Surface water flow data is available from WaterNSW for the gauging stations on O'Hares Creek: an upstream gauging station at Darkes Forest (GS 212002) and a downstream gauging station near the town of Wedderburn (GS 213200). The O'Hares Creek catchment is located immediately south and west of the Woronora Dam catchment. Longwall mining occurred in the catchment of the Wedderburn gauging station (GS 213200) in 1986 to 1987 and 1990 to 1999.

As described in the Longwalls 305-307 WMP, Metropolitan Coal investigated the potential to install a small flow measuring flume immediately downstream of Swamps 76, 77 and 92 (Figure 9). Based on the initial site investigations, it was identified that there was potential to install flow measuring flumes immediately downstream of Swamps 76 and 92. Further investigations determined that it was not feasible to install a flow measuring flume downstream of Swamp 77.

Consistent with the recommendations of Hydro Engineering & Consulting (2019) (Appendix 5), flow measuring flumes were subsequently installed immediately downstream of Swamps 76 (Sub-catchment R) and 92 (Sub-catchment P) in November 2020 (Table 12) (Figure 6).

Table 12
Gauging Station Locations and Recording Periods

Station Number	Watercourse	Catchment Area (km^2)	Period of Record
WaterNSW (GS 2132102)	Waratah Rivulet, upstream of the Woronora Reservoir full supply level	20.2	February 2007 to present
WaterNSW (GS 2132101)[1]	Woronora River, upstream of the Woronora Reservoir full supply level	12.4	February 2007 to present
WaterNSW (GS 213002)	O'Hares Creek at Darkes Forest	16	1924 to 1930
WaterNSW (GS 213200)	O'Hares Creek at Wedderburn	73	1978 to present
Metropolitan Coal (GS 300078)	Eastern Tributary, upstream of the Woronora Reservoir full supply level	6.7	January 2013 to present
Metropolitan Coal (GS 300077)	Honeysuckle Creek (control site)	4.6	January 2013 to present
Sub-catchment I (GS 300092)	A tributary of the Woronora Reservoir	0.33	May 2018 to present
Sub-catchment K (GS 300093)	A tributary of the Woronora Reservoir	0.27	May 2018 to present
Sub-catchment P (GS 300142)	A tributary of the Woronora Reservoir	0.86	November 2020 to present
Sub-catchment R (GS 300143)	A tributary of the Woronora Reservoir	1.4	November 2020 to present

1 Note, the Woronora River gauging station (GS 2132101) contains periods of missing data.

Numerical catchment models for the Waratah Rivulet, and the Woronora River and O'Hares Creek control catchments, have been developed based on the nationally recognised Australian Water Balance Model (AWBM) (Boughton, 2004). The AWBM is a catchment-scale water balance model that estimates streamflow from rainfall and evaporation. The calibrated catchment model is used to assess potential subsidence impacts on the quantity of water resources reaching the Woronora Reservoir.

During 2015 the flow records from the Waratah Rivulet (GS 2132102) and Woronora River (GS 2132101) gauging stations were regenerated using amended rating relationships developed by Hydro Engineering & Consulting (formerly Gilbert & Associates Pty Ltd) on behalf of Metropolitan Coal (Gilbert & Associates, 2015a). A revised rating curve was also developed for O'Hares Creek at Wedderburn (GS 213200) based on the NSW Department of Industry – Water (now the DPE – Water) gaugings conducted over the period 1978 to 2003, as well as the known geometry of the V-notch and concrete weir control at this gauging station.

Revised and re-calibrated catchment models have also been developed for the Waratah Rivulet, Woronora River and O'Hares Creek gauging stations using the regenerated flow data (Gilbert & Associates, 2015b). The models were revised to include a variable baseflow index. The baseflow index (BFI) is defined as the ratio of baseflow to total flow. It is used as a constant parameter in the AWBM. As part of the model re-calibration, the BFI, as a constant parameter, was replaced by a function where its value was allowed to vary as a function of daily rainfall excess and the depth of water in baseflow storage. The revised rating curves and associated recalibration of the catchment models were peer reviewed by Emeritus Professor Tom McMahon (School of Engineering, The University of Melbourne).

Catchment models have also been developed for the Eastern Tributary and Honeysuckle Creek gauging stations with the same model structure as for Waratah Rivulet, Woronora River and O'Hares Creek.

7.2.3 Pool Water Levels

Pool water level data is available for a number of sites on the Waratah Rivulet, Eastern Tributary, Tributary B, Tributary D, Woronora River, and tributaries of the Woronora Reservoir (Table 13).

The locations of the pools are shown on Figure 6. Pools and rock bars along the Waratah Rivulet, Eastern Tributary, Tributary A and Tributary B are shown on the detailed mapping and photographs provided in Appendices 1 to 4, respectively.

Table 13
Pool Water Level Sites (Manual and/or Continuous Water Level Data)

Site Number	Watercourse	Commencement Date[1]
Pool A	Waratah Rivulet	20/9/2005
Pool B	Waratah Rivulet	20/9/2005
Pool C	Waratah Rivulet	20/9/2005
Pool E	Waratah Rivulet	20/9/2005
Pool F	Waratah Rivulet	20/9/2005
Pool G	Waratah Rivulet	20/9/2005
Pool G1	Waratah Rivulet	13/10/2005
Pool H	Waratah Rivulet	11/10/2005
Pool I	Waratah Rivulet	11/10/2005
Pool J	Waratah Rivulet	3/4/2007
Pool K	Waratah Rivulet	13/5/2010
Pool L	Waratah Rivulet	11/12/2008
Pool M	Waratah Rivulet	11/12/2008
Pool N	Waratah Rivulet	11/12/2008[2]
Pool O	Waratah Rivulet	11/12/2008
Pool P	Waratah Rivulet	11/12/2008
Pool Q	Waratah Rivulet	20/2/2007
Pool R	Waratah Rivulet	11/12/2008
Pool S	Waratah Rivulet	11/12/2008
Pool T	Waratah Rivulet	20/1/2010
Pool U	Waratah Rivulet	20/1/2010
Pool V	Waratah Rivulet	20/1/2010
Pool W	Waratah Rivulet	20/1/2010
Pool ETG	Eastern Tributary	16/2/2011
Pool ETJ	Eastern Tributary	29/3/2011
Pool ETM	Eastern Tributary	11/12/2008
Pool ETO	Eastern Tributary	30/5/2019
Pool ETU	Eastern Tributary	18/5/2010
Pool ETW	Eastern Tributary	18/5/2010
Pool ETAF	Eastern Tributary	12/11/2010
Pool ETAG	Eastern Tributary	12/11/2010
Pool ETAH	Eastern Tributary	19/1/2011
Pool ETAI[3]	Eastern Tributary	19/1/2011
Pool ETAL	Eastern Tributary	3/10/2018

Table 13 (Continued)
Pool Water Level Sites (Manual and/or Continuous Water Level Data)

Site Number	Watercourse	Commencement Date[1]
Pool ETAM	Eastern Tributary	3/10/2018
Pool ETAN	Eastern Tributary	3/10/2018
Pool ETAO	Eastern Tributary	3/10/2018
Pool ETAP	Eastern Tributary	3/10/2018
Pool ETAQ	Eastern Tributary	17/1/2011
Pool ETAR	Eastern Tributary	3/10/2018
Pool ETAT[4]	Eastern Tributary	24/5/2018
Pool ETAU	Eastern Tributary	23/9/2012
Pool RTP1	Tributary B	7/3/2007
Pool RTP2	Tributary B	7/3/2007
Pool UTP1	Tributary D	7/3/2007
Pool UTP2	Tributary D	7/3/2007
Pool UTP3	Tributary D	7/3/2007
Pool SR1	Tributary of Woronora Reservoir	23/5/2019
Pool SR2	Tributary of Woronora Reservoir	23/5/2019
Pool SP1	Tributary of Woronora Reservoir	3/6/2019
Pool WRP1[5]	Woronora River (Control Site)	1/1/2016
Pool WRP2[5]	Woronora River (Control Site)	1/1/2016
Pool WRP3[5]	Woronora River (Control Site)	1/1/2016
Pool WRP4[5]	Woronora River (Control Site)	1/1/2016

1 The dates provided represent the dates from which pool water level monitoring commenced, however, some of the data is known to be unreliable and could not be used for the assessment of pre-impact behaviour.

2 Data from 11 December 2008 contains periods of missing data and periods where data is considered to be largely unreliable due to sensor error/instability.

3 Only small rock bars separate Pools ETAI, ETAJ and ETAK. Pools join to become the one large pool. Pool ETAK is controlled by a rock bar. The water level meter situated in Pool ETAI is therefore considered to be representative of the water level in Pools ETAJ and ETAK.

4 Due to the nature of Rock Bar ETAS, Pool ETAS and Pool ETAT typically sit at the same level.

5 Pool water level data for the Woronora River pools prior to January 2016 is considered to be largely unreliable as a result of water level sensor issues.

7.2.4 Surface Water Quality

Water quality data has been collected at a large number of sites including sites on the Waratah Rivulet, Eastern Tributary, Far Eastern Tributary, Woronora River, Bee Creek, Honeysuckle Creek, Tributary B, Tributary D and Forest Gully. The water quality sites are summarised in Table 14 and shown on Figure 7.

Table 14
Stream Water Quality Sites

Site Number	Watercourse	Commencement Date
WRWQ 1	Waratah Rivulet	27/9/2006
WRWQ 2	Waratah Rivulet	27/9/2006
WRWQ 3	Waratah Rivulet	27/9/2006
WRWQ 4 (Pool B)	Waratah Rivulet	27/9/2006
WRWQ 5	Waratah Rivulet	27/9/2006
WRWQ 6 (Pool F)	Waratah Rivulet	27/9/2006
WRWQ 7 (Pool H)	Waratah Rivulet	27/9/2006
WRWQ 8	Waratah Rivulet	27/9/2006
WRWQ 9 (Pool Q)	Waratah Rivulet	27/9/2006
WRWQ J	Waratah Rivulet	27/1/2010
WRWQ K	Waratah Rivulet	27/1/2010
WRWQ L	Waratah Rivulet	11/12/2008
WRWQ M	Waratah Rivulet	11/12/2008
WRWQ N	Waratah Rivulet	11/12/2008
WRWQ O	Waratah Rivulet	11/12/2008
WRWQ P	Waratah Rivulet	11/12/2008
WRWQ R	Waratah Rivulet	11/12/2008
WRWQ S	Waratah Rivulet	11/12/2008
WRWQ T	Waratah Rivulet	10/2/2010
WRWQ U	Waratah Rivulet	10/2/2010
WRWQ V	Waratah Rivulet	10/2/2010
WRWQ W	Waratah Rivulet	10/2/2010
UTWQ 1	Waratah Rivulet	3/8/2006
UTWQ 2	Tributary D	3/8/2006
UTWQ 3	Tributary D	3/8/2006
UTWQ 4	Tributary D	3/8/2006
UTWQ 5	Tributary D	3/8/2006
FGWQ 1	Forest Gully	1/8/2006
FGWQ 2	Forest Gully	1/8/2006
FGWQ 3	Forest Gully	1/8/2006
FGWQ 4	Forest Gully	1/8/2006
FGWQ 5	Forest Gully	1/8/2006
RTWQ 1	Tributary B	3/8/2006
RTWQ 2	Tributary B	3/8/2006
RTWQ 3	Tributary B	3/8/2006
ETWQ F	Eastern Tributary	17/2/2010
ETWQ J	Eastern Tributary	17/2/2010
ETWQ N	Eastern Tributary	7/9/2007
ETWQ U	Eastern Tributary	28/1/2010
ETWQ W	Eastern Tributary	28/1/2010
ETWQ AF	Eastern Tributary	28/1/2010
ETWQ AG	Eastern Tributary	28/1/2010

Table 14 (Continued)
Stream Water Quality Sites

Site Number	Watercourse	Commencement Date
ETWQ AH	Eastern Tributary	28/1/2010
ETWQ AI	Eastern Tributary	28/1/2010
ETWQ AK	Eastern Tributary	28/1/2010
ETWQ AQ	Eastern Tributary	28/1/2010
ETWQ AU	Eastern Tributary	28/1/2010
FEWQ 1	Far Eastern Tributary	7/9/2007
BCWQ 1	Bee Creek	7/9/2007
HCWQ 1	Honeysuckle Creek	7/9/2007
WOWQ 1	Woronora River (Control Site)	7/9/2007
WOWQ 2	Woronora River (Control Site)	17/1/2008
WOWQ 3	Woronora River (Control Site)	11/12/2008
WOWQ 4	Woronora River (Control Site)	28/1/2010
WOWQ 5	Woronora River (Control Site)	28/1/2010
WOWQ 6	Woronora River (Control Site)	28/1/2010
Pool SR1	Tributary of Woronora Reservoir	24/11/2021
Pool SR2	Tributary of Woronora Reservoir	24/11/2021
Pool SP1	Tributary of Woronora Reservoir	23/11/2021

Note: Water quality sampling sites WRWQ J to WRWQ W have been taken from Pools J to W on the Waratah Rivulet and water quality sampling sites ETWQ F to ETWQ AU have been taken from Pools ETF to ETAU on the Eastern Tributary, respectively.

In October 2016, Metropolitan Coal increased the frequency of water quality sampling at select sites on the Eastern Tributary (sites ETWQF, ETWQN, ETWQAF, ETWQAG, ETWQAH, ETWQAI, ETWQAK, ETWQAQ and ETWQAU) and at site WOWQ2 on the Woronora Reservoir from monthly to weekly in response to the Eastern Tributary Incident, which is described in Section 4.1.

Additional water quality data has also been collected at site ETAU[21] and at a number of sites downstream of site ETAU to inform assessments against the water quality performance measure for catchment yield to the Woronora Reservoir. Sampling has been conducted at site ETAU, ETFSL 0, ETFSL 20, ETFSL 40, ETFSL 60, ETFSL 80, ETFSL 100, ETFSL 200, ETFSL 300, ETFSL 400 and ETFSL 500 (Figure 7). Site ETAU has sampled the pool at the Eastern Tributary gauging station and site ETFSL 0 has sampled the pool at the top of the waterfall. Sites ETFSL 20 to 500 m have been sampled at the designated distances when the water level of the reservoir is reduced enough such that the Eastern Tributary extends downstream of ETFSL 0 (without inundation) (Figure 7). The additional sampling commenced in August 2017 and continues to date[22].
In response to reducing water levels in the Woronora Reservoir, sampling from 22 November 2018 has been conducted at site ETWQ AU (November)/site ETAU (from 12 December 2018), site ETFSL 200, site ETFSL 500, site CONFLU1, site WARARM5, site WDFS1 and site WDFS1+100 (Figure 7)[23].

[21] Site ETAU is the same as site ETWQ AU (i.e. samples are taken at the same location). The difference between the sites relates to the time of sampling. Site ETWQ AU monitoring is conducted on the same day as sites upstream of ETWQ AU/ETAU, while site ETAU monitoring is conducted on the same day as the sites downstream of ETWQ AU/ETAU.

[22] Sampling was suspended in November 2018 at sites ETFSL 100, ETFSL 300 and ETFSL 400. Monitoring at these recommenced in February 2020 .

[23] Due to the increasing water level in the Woronora Reservoir throughout February and March 2020, sampling at sites WARARM5, WDFS1 and WDFS1+100 has not been undertaken since March 2020, and site CONFLU1 has not been sampled from July 2020.

7.2.5 Woronora, Nepean and Cataract Reservoir Water Quality

WaterNSW has an extensive water quality database for the Woronora Reservoir, Nepean Reservoir and Cataract Reservoir. Metropolitan Coal obtains surface water quality data for the Woronora Reservoir (site DW01, from 0 m to 9 m below the reservoir surface), Nepean Reservoir and Cataract Reservoir (including total iron, total manganese and total aluminium concentrations) from WaterNSW in accordance with a data exchange agreement.

7.3 GROUNDWATER

7.3.1 Swamp Groundwater Levels

Groundwater level data is available for a number of upland swamps including from piezometers in the swamp substrate and/or piezometers in the shallow sandstone, as summarised in Table 15. The piezometer locations are shown on Figure 9.

Table 15
Swamp Substrate and Shallow Groundwater Level Sites

Site Number	Swamp	Easting (m)	Northing (m)	RL (m AHD)	Depth (m)	Lithology	Commencement Date
SWAMP1	S14	308625	6215963	295.6	3.1	Hawkesbury Sandstone	7 February 2007
SWAMP2	Bee Creek Swamp	308755	6218787	245.3	1.5	Hawkesbury Sandstone	4 April 2007
SWAMP3	S92	310063	6216007	294.7	4.3	Hawkesbury Sandstone	7 February 2007
SWAMP4	S06	307891	6214219	344.1	1.0	Hawkesbury Sandstone	12 March 2009
SWGW1	S06	307893	6214226	343.7	~20	Hawkesbury Sandstone	12 March 2009
S25	S25	311125	6214115	273.1	~0.9	Hawkesbury Sandstone	31 August 2010
		311126	6214117	272.9	~10		
S101 (control)	S101	308658	6216585	293.4	~0.9	Hawkesbury Sandstone	31 August 2010
		308659	6216585	293.4	~10		
S16[1]	S16	309702	6214791	251.2	~10	Hawkesbury Sandstone	30 August 2010
S17	S17	309599	6214931	240.6	~10	Hawkesbury Sandstone	1 September 2010
S20	S20	310431	6214413	219.3	~0.9	Hawkesbury Sandstone	1 September 2010
		310429	6214403	219.1	~4		
		310428	6214401	219.1	~10		
WRSWAMP1 (control)	Woronora River 1	306454	6214914	321.1	~0.9	Hawkesbury Sandstone	2 September 2010
		306452	6214913	321.1	~4		
		306451	6214912	321.0	~10		
S28	S28	311003	6214783	247.9	~1	Hawkesbury Sandstone	8 March 2013
		311002	6214782	247.8	~10		
S30	S30	311180	6215115	236.2	~1	Hawkesbury Sandstone	8 March 2013
		311176	6215115	236.0	~10		

Table 15 (Continued)
Swamp Substrate and Shallow Groundwater Level Sites

Site Number	Swamp	Easting (m)	Northing (m)	RL (m AHD)	Depth (m)	Lithology	Commencement Date
S33	S33	311582	6214529	241.3	~1	Hawkesbury Sandstone	8 March 2013
		311585	6214528	241.2	~10		
S35	S35	311501	6215126	256.0	~1	Hawkesbury Sandstone	8 March 2013
		311500	6215156	256.1	~10		
S137a (control)	S137a	308466	6217145	271.3	~1	Hawkesbury Sandstone	8 March 2013
		308463	6217148	271.1	~10		
S137b (control)	S137b	308399	6216962	276.6	~1	Hawkesbury Sandstone	8 March 2013
		308396	6216961	276.7	~10		
Bee Creek Swamp (control)	Bee Creek Swamp	308724	6218941	241.1	~1	Hawkesbury Sandstone	8 March 2013
		308723	6218939	241.3	~10		
S40	S40	312428	6215898	231.9	1.0	Hawkesbury Sandstone	28 June 2016
		312429	6215897	232.1	9.9		
S41	S41	312740	6216093	279.6	0.8	Hawkesbury Sandstone	28 June 2016
		312739	6216093	279.4	9.9		
S46	S46	312615	6216277	282.6	0.7	Hawkesbury Sandstone	28 June 2016
		312616	6216278	282.8	10.1		
S50	S50	312510	6217013	266.8	0.4	Hawkesbury Sandstone	27 June 2016
		312509	6217012	266.9	9.9		
S51	S51	312639	6216883	274.9	0.6	Hawkesbury Sandstone	28 June 2016
		312638	6216884	274.9	9.9		
S52	S52	312739	6216836	283.8	1.1	Hawkesbury Sandstone	30 June 2016
		312738	6216835	283.7	9.8		
S53	S53	312859	6216845	295.6	1.7	Hawkesbury Sandstone	28 June 2016
		312858	6216845	295.5	9.9		
S60	S60	312754	6218443	282.9	1.6	Hawkesbury Sandstone	4 February 2019
		312754	6218443	273.6	10.9		
S62	S62	312011	6218339	263.7	1.3	Hawkesbury Sandstone	4 February 2019
		312011	6218339	254.1	10.8		
S64	S64	312269	6218118	266.4	1.0	Hawkesbury Sandstone	4 February 2019
		312269	6218118	256.5	10.9		
S71a	S71a	312519	6217774	276.6	0.3	Hawkesbury Sandstone	27 June 2016
		312519	6217772	276.6	9.9		
S72	S72	312239	6217938	263.1	1.4	Hawkesbury Sandstone	4 February 2019
		312239	6217938	253.6	10.9		
S76-1	S76	310371	6217651	266.7	0.9	Hawkesbury Sandstone	15 November 2020
S76-2	S76	310142	6217474	280.1	0.9	Hawkesbury Sandstone	15 November 2020
		310142	6217474	272.6	~10		
S76-3	S76	310059	6207350	282.4	0.9	Hawkesbury Sandstone	15 November 2020

Table 15 (Continued)
Swamp Substrate and Shallow Groundwater Level Sites

Site Number	Swamp	Easting (m)	Northing (m)	RL (m AHD)	Depth (m)	Lithology	Commencement Date
S77-1	S77	310397	6216915	273.1	0.9	Hawkesbury Sandstone	15 November 2020
S77-2	S77	310269	6216732	281.8	0.9	Hawkesbury Sandstone	15 November 2020
		310269	6216732	272.5	~10		
S77-3	S77	310114	6216572	296.2	0.9	Hawkesbury Sandstone	15 November 2020
S81	S81	310993	6216619	264.6	0.3	Hawkesbury Sandstone	15 November 2020
S82	S82	311104	6216658	256.1	0.6	Hawkesbury Sandstone	15 November 2020
S89	S89	310769	6216216	262.3	0.6	Hawkesbury Sandstone	15 November 2020
S92-1	S92	310515	6216166	278.1	0.9	Hawkesbury Sandstone	15 November 2020
S92-2	S92	310054	6216033	292.9	0.9	Hawkesbury Sandstone	15 November 2020
		310054	6216033	283.2	~10		
S92-3	S92	309763	6215908	302.8	0.9	Hawkesbury Sandstone	15 November 2020
S133	S133	312513	6218988	248.6	1.3	Hawkesbury Sandstone	4 February 2019
		312513	6218988	239.1	10.9		
S134	S134	312682	6218760	260.6	1.5	Hawkesbury Sandstone	4 February 2019
		312682	6218760	251.3	10.8		

1 As discussed in the *Metropolitan Coal 2013 Annual Review and Annual Environmental Management Report* (Metropolitan Coal, 2014), the sensor in the Swamp 16 piezometer became unreliable.

Metropolitan Coal completed Surface Works Assessment Forms for the proposed installation of upland swamp piezometers in Swamps 60, 62, 64, 72, 133 and 134 (Figure 9) which were approved and installed in February 2019 (Table 15).

Further, Metropolitan Coal completed Surface Works Assessment Forms for the proposed installation of upland swamp piezometers in Swamps 76, 77, 81, 82, 89 and 92 (Figure 9), which were submitted to the DPIE in early 2020. DPIE subsequently approved these works and piezometers were installed in all of these upland swamps in November 2020 (Figure 9).

7.3.2 Swamp Moisture Probes

Metropolitan Coal installed soil moisture probes (linked to a datalogger) at various depth intervals to monitor the vertical profile of soil moisture in the swamp substrate of Swamps 62, 72, 76, 77, 81, 82, 89, 92, 101, 137a and 137b (Table 16). The location of these soil moisture probes is shown on Figure 9.

Table 16
Swamp Soil Moisture Monitoring Sites

Site Number	Swamp	Easting (m)	Northing (m)	RL (m AHD)	Depth (m)	Commencement Date
S62	S62	312011	6218341	264.41	0.6	15 November 2020
S72	S72	312238	6217939	263.80	0.6	15 November 2020
S76-1	S76	310372	6217655	267.94	1.2	15 November 2020
S76-2	S76	310146	6217492	281.03	0.9	15 November 2020
S76-3	S76	310081	6217323	283.20	0.9	15 November 2020
S77-1	S77	310399	6216911	274.39	1.2	15 November 2020
S77-2	S77	310273	6216732	283.10	1.2	15 November 2020
S77-3	S77	310114	6216573	296.72	0.3	15 November 2020
S81	S81	310514	6216161	265.20	0.3	15 November 2020
S82	S82	310053	6216032	256.65	0.6	15 November 2020
S89	S89	309763	6215909	263.25	0.9	15 November 2020
S92-1	S92	310995	6216622	179.10	1.2	15 November 2020
S92-2	S92	311102	6216659	294.01	1.2	15 November 2020
S92-3	S92	310763	6216217	303.71	1.2	15 November 2020
S101	S101	308657	6216586	292.09	0.9	15 November 2020
S137a	S137a	308461	6217145	270.90	0.9	15 November 2020
S137b	S137b	308395	6216960	276.83	0.9	15 November 2020

7.3.3 Shallow Groundwater Levels Near Streams

Shallow groundwater level data is available for a number of sites near streams, as summarised in Table 17. The piezometer locations are shown on Figure 10.

Table 17
Shallow Groundwater Level Sites Near Streams

Site Number	Location	Easting (m)	Northing (m)	RL (m AHD)	Depth (m)	Lithology	Commencement Date
WRGW1	Waratah Rivulet	309886	6214360	207.8	~20	Hawkesbury Sandstone	16 February 2007
WRGW2	Waratah Rivulet	309868	6214335	207.9	~20	Hawkesbury Sandstone	16 February 2007
WRGW3	Waratah Rivulet	309629	6214072	215.0	~20	Hawkesbury Sandstone	16 February 2007
WRGW4[1]	Waratah Rivulet	309579	6214090	217.8	~20	Hawkesbury Sandstone	16 February 2007
WRGW5	Waratah Rivulet	309393	6212890	225.4	~20	Hawkesbury Sandstone	4 April 2007
WRGW6	Waratah Rivulet	309361	6212871	226.1	~20	Hawkesbury Sandstone	4 April 2007
WRGW7	Waratah Rivulet	310717	6215382	184.2	~20	Hawkesbury Sandstone	September 2010

Table 17 (Continued)
Shallow Groundwater Level Sites Near Streams

Site Number	Location	Easting (m)	Northing (m)	RL (m AHD)	Depth (m)	Lithology	Commencement Date
WRGW8[2]	Waratah Rivulet	310685	6215353	184.3	~20	Hawkesbury Sandstone	September 2010
RTGW1A[3]	Tributary B	309593	6215109	222.0	~19.5	Hawkesbury Sandstone	23 August 2007
FGGW1	Forest Gully	308951	6213200	232.4	~20	Hawkesbury Sandstone	8 March 2007
FGGW2	Forest Gully	308816	6213158	240.5	~20	Hawkesbury Sandstone	4 April 2007
FGGW3	Forest Gully	308682	6213113	250.4	~20	Hawkesbury Sandstone	4 April 2007
UTGW1	Tributary D	309520	6214151	218.2	~20	Hawkesbury Sandstone	16 February 2007
UTGW2	Tributary D	309097	6214012	237.6	~20	Hawkesbury Sandstone	7 March 2007
UTGW3	Tributary D	308833	6213951	247.2	~20	Hawkesbury Sandstone	7 March 2007
ETGW1	Eastern Tributary	312129	6215644	172.6	~20	Hawkesbury Sandstone	September 2010
ETGW2	Eastern Tributary	312134	6215664	172.1	~20	Hawkesbury Sandstone	September 2010
ETO1	Eastern Tributary	311665	6214107	228.0	~39	Hawkesbury Sandstone	30 May 2019
ETO2	Eastern Tributary	311634	6214141	217.3	~20	Hawkesbury Sandstone	30 May 2019
ETO3	Eastern Tributary	311589	6214112	221.0	~26.5	Hawkesbury Sandstone	30 May 2019
ETO4	Eastern Tributary	311534	6214143	216.2	~38.5	Hawkesbury Sandstone	30 May 2019

1 Site WRGW4 was sheared in 2011 and has subsequently not been sampled.

2 As reported in the *Metropolitan Coal 2014 Annual Review and Annual Environmental Management Report/Rehabilitation Report* (Metropolitan Coal, 2015), site WRGW8 is faulty and is no longer recording reliable data.

3 Due to bore failure as a result of subsidence, bore RTGW1A on Tributary B has not been able to be dipped since December 2013. The diver was able to be downloaded up until May 2014.

7.3.4 Groundwater Levels/Pressures

Metropolitan Coal installed groundwater transect bores T1 to T5 in June 2016 (data loggers installed in September 2016) and groundwater transect bore T6 to the west of the Woronora Reservoir in December 2017 (Table 18 and Figure 10).

Table 18
Groundwater Transect

Site Number	Easting (m)	Northing (m)	Top of Collar (m AHD)	Sensor[1] (m AHD)	Hole Depth (m)	Lithology	Commencement Date
T1	312048	6217168	174.106	154.96	21	Hawkesbury Sandstone	7 September 2016
T2	312092	6217209	195.118	161.04	35	Hawkesbury Sandstone	7 September 2016
T3[2]	312201	6217246	225.450	166.49	61	Hawkesbury Sandstone	7 September 2016
T3-R	312203	6217256	226.826	145.83	82	Hawkesbury Sandstone	20 May 2021
T4[3]	312280	6217296	236.306	170.16	67	Hawkesbury Sandstone	7 September 2016
T5	312423	6217379	258.041	166.80	94	Hawkesbury Sandstone	7 September 2016
T6	311447	6217375	255.87	165.90	130	Hawkesbury Sandstone	18 December 2017

1 Sensor depth may vary over time if a diver is replaced, i.e. a new cable length.

2 Bore T3 ceased recording in December 2020. The bore was replaced by a redrilled bore T3-R, approximately 10 m to the north of the original T3 location.

3 The water level data obtained at bore T4 is anomalous and unreliable as its head is higher than the head at upgradient site T5. This is considered unlikely to be a groundwater divide as it is not related to the topographic ridge well upgradient (SLR Consulting, 2021).

Metropolitan Coal groundwater level and/or pressure data is also available from the multi-level piezometers and single-level piezometers listed in Table 19 and shown on Figure 10. Groundwater level/pressure data is also available at site S1997, courtesy of Illawarra Metallurgical Coal (Table 19 and Figure 10).

Table 19
Groundwater Level and Groundwater Level/Pressure Sites

Site Number	Location	Easting (m)	Northing (m)	Collar (m AHD)	Depth (m)	Elevation (m AHD)	Lithology	Commencement Date
9HGW0	Longwall 10 Goaf Hole on Fire Trail 9H	309762	6213480	274.5	35.0	239.5	Hawkesbury Sandstone	12 April 2007
					70.0	204.5	Hawkesbury Sandstone	
					110.0	164.5	Hawkesbury Sandstone	
					135.0	139.5	Bald Hill Claystone	
					165.0	109.5	Bulgo Sandstone	
					205.0	69.5	Bulgo Sandstone	
					250.0	24.5	Bulgo Sandstone	
					300.0	-25.5	Bulgo Sandstone	
9HGW1B	Fire Trail 9H west of Longwall 18	308189	6214580	351.2	52.0	299.2	Hawkesbury Sandstone	12 November 2008
					81.5	269.7	Hawkesbury Sandstone	
					158.0	193.2	Hawkesbury Sandstone	
					174.6	176.6	Newport Formation	
					205.4	145.8	Bald Hill Claystone	
					225.4	125.8	Bulgo Sandstone	
					303.0	48.2	Bulgo Sandstone	
					385.6	-34.4	Bulgo Sandstone	
9GGW1B[1]	Fire Trail 9G	310974	6214317	287.9	45.0	242.9	Hawkesbury Sandstone	14 March 2009
					59.5	228.4	Hawkesbury Sandstone	
					124.0	163.9	Hawkesbury Sandstone	
					159.0	128.9	Bald Hill Claystone	
					179.0	108.9	Bulgo Sandstone	
					345.1	-57.2	Bulgo Sandstone	
					385.1	-97.2	Bulgo Sandstone	
					404.1	-116.2	Stanwell Park Claystone	
					416.0	-128.2	Scarborough Sandstone	
					476.7	-188.8	Coal Cliff Sandstone	

Table 19 (Continued)
Groundwater Level and Groundwater Level/Pressure Sites

Site Number	Location	Easting (m)	Northing (m)	Collar (m AHD)	Depth (m)	Elevation (m AHD)	Lithology	Commencement Date
9GGW1-3	Longwall 22B Goaf Hole on Fire Trail 9G	310974	6214317	286.61	60.0	226.6	Hawkesbury Sandstone	31 August 2016
					124.0	162.6	Hawkesbury Sandstone	
					159.0	127.6	Hawkesbury Sandstone	
					200.0	86.6	Shale	
					250.0	36.6	Bulgo Sandstone	
9GGW1-80	Fire Trail 9G	310974	6214317	287.0	80.0	206.9	Hawkesbury Sandstone	21 November 2013
9GGW2B	Fire Trail 9G at western end of Longwall 27	311734	6215359	240.8	55.0	185.8	Hawkesbury Sandstone	20 April 2010
					80.3	160.5	Hawkesbury Sandstone	
					105.5	135.3	Hawkesbury Sandstone	
					137.8	103.0	Bald Hill Claystone	
					162.5	78.3	Bulgo Sandstone	
					304.0	-63.2	Bulgo Sandstone	
					339.5	-98.7	Stanwell Park Claystone	
					393.0	-152.2	Scarborough Sandstone	
					437.0	-196.2	Wombarra Claystone	
					474.1	-233.3	Bulli Coal Seam	
9FGW1A	Fire Trail 9F west of Longwall 22A	308556	6215537	310.2	55.0	255.2	Hawkesbury Sandstone	19 February 2010
					73.5	236.7	Hawkesbury Sandstone	
					137.0	173.2	Hawkesbury Sandstone	
					184.5	125.7	Bald Hill Claystone	
					209.5	100.7	Bulgo Sandstone	
					369.0	-58.8	Bulgo Sandstone	
					404.5	-94.3	Stanwell Park Claystone	
					455.0	-144.8	Scarborough Sandstone	
					490.5	-180.3	Wombarra Claystone	
					513.3	-203.1	Bulli Coal Seam	

Table 19 (Continued)
Groundwater Level and Groundwater Level/Pressure Sites

Site Number	Location	Easting (m)	Northing (m)	Collar (m AHD)	Depth (m)	Elevation (m AHD)	Lithology	Commencement Date
9EGW1B	Fire Trail 9E	309483	6216091	309.0	52.0	257.0	Hawkesbury Sandstone	1 November 2009
					91.0	218.0	Hawkesbury Sandstone	
					170.0	139.0	Hawkesbury Sandstone	
					213.0	96.0	Bald Hill Claystone	
					233.0	76.0	Bulgo Sandstone	
					403.0	-94.0	Bulgo Sandstone	
					424.0	-115.0	Stanwell Park Claystone	
					450.0	-141.0	Scarborough Sandstone	
					488.0	-179.0	Scarborough Sandstone	
					541.5	-232.5	Coal Cliff Sandstone	
9EGW2A	Fire Trail 9E	311331	6217099	276.9	60.0	216.9	Hawkesbury Sandstone	28 May 2011
					107.5	169.4	Hawkesbury Sandstone	
					155.0	121.9	Hawkesbury Sandstone	
					211.8	65.1	Bald Hill Claystone	
					234.5	42.4	Bulgo Sandstone	
					406.5	-129.6	Bulgo Sandstone	
					432.5	-155.6	Stanwell Park Claystone	
					454.0	-177.1	Scarborough Sandstone	
					483.5	-206.6	Scarborough Sandstone	
					517.0	-240.1	Wombarra Claystone	
					556.5	-279.6	Bulli Coal Seam	
9EGW2-4[2]	Fire Trail 9E	311216	6216986	276.3	407.0	-131	Bulgo Sandstone	18 December 2017
					454.0	-178	Scarborough Sandstone	
					484.0	-208	Scarborough Sandstone	
					517.0	-241	Wombarra Shale	
					557.0	-281	Bulli Coal Seam	

Table 19 (Continued)
Groundwater Level and Groundwater Level/Pressure Sites

Site Number	Location	Easting (m)	Northing (m)	Collar (m AHD)	Depth (m)	Elevation (m AHD)	Lithology	Commencement Date
F6GW3A	Old Princes Hwy east of LW 301	312855	6215539	242.6	50.0	192.6	Hawkesbury Sandstone	17 June 2013
					70.0	172.6	Hawkesbury Sandstone	
					100.0	142.6	Hawkesbury Sandstone	
					135.0	107.6	Newport Formation	
					220.0	22.6	Bulgo Sandstone	
					308.0	-65.4	Bulgo Sandstone	
					380.0	-137.4	Bulgo Sandstone	
					450.0	-207.4	Bulli Seam	
F6GW4A	Old Princes Hwy between LW303 and LW304	312531	6216694	265.0	50.0	215.0	Hawkesbury Sandstone	17 June 2013
					90.0	175.0	Hawkesbury Sandstone	
					139.0	126.0	Hawkesbury Sandstone	
					201.0	64.0	Bulgo Sandstone	
					278.0	-13.0	Bulgo Sandstone	
					362.0	-97.0	Bulgo Sandstone	
					440.0	-175.0	Scarborough Sandstone	
					512.0	-247.0	Bulli Seam	
PHGW2A	Fire Trail west of Princes Highway	312322	6217752	263.0	60.0	203.0	Hawkesbury Sandstone	16 March 2011
					97.5	165.5	Hawkesbury Sandstone	
					135.0	128.0	Hawkesbury Sandstone	
					181.5	81.5	Bald Hill Claystone	
					201.0	62.0	Bulgo Sandstone	
					365.0	-102.0	Bulgo Sandstone	
					389.0	-126.0	Stanwell Park Claystone	
					411.0	-148.0	Scarborough Sandstone	
					437.0	-174.0	Scarborough Sandstone	
					470.0	-207.0	Wombarra Claystone	
					508.0	-245.0	Bulli Coal Seam	

Table 19 (Continued)
Groundwater Level and Groundwater Level/Pressure Sites

Site Number	Location	Easting (m)	Northing (m)	Collar (m AHD)	Depth (m)	Elevation (m AHD)	Lithology	Commencement Date
PHGW1B	Fire Trail west of Princes Highway	312281	6218335	289.8	65.0	224.8	Hawkesbury Sandstone	28 June 2010
					115.5	174.3	Hawkesbury Sandstone	
					166.0	123.8	Hawkesbury Sandstone	
					215.5	74.3	Bald Hill Claystone	
					238.0	51.8	Bulgo Sandstone	
					396.0	-106.3	Bulgo Sandstone	
					432.0	-142.3	Stanwell Park Claystone	
					482.3	-192.6	Scarborough Sandstone	
					518.3	-228.6	Wombarra Claystone	
					554.1	-264.4	Bulli Coal Seam	
PM01 (9DGW1B)	Fire Trail 9D	309971	6217271	283.6	52.0	231.7	Hawkesbury Sandstone	5 February 2010
					90.0	193.7	Hawkesbury Sandstone	
					170.0	113.7	Hawkesbury Sandstone	
					218.0	65.7	Bald Hill Claystone	
					238.0	45.7	Bulgo Sandstone	
					415.0	-131.3	Bulgo Sandstone	
					440.0	-156.3	Stanwell Park Claystone	
					482.0	-198.3	Scarborough Sandstone	
					494.0	-210.3	Scarborough Sandstone	
					547.5	-263.8	Coal Cliff Sandstone	
PM02	Fire Trail 9D	310650	6218509	267.4	35.0	232.4	Hawkesbury Sandstone	23 December 2007
					100.0	167.4	Hawkesbury Sandstone	
					220.0	47.4	Bald Hill Claystone	
					250.0	17.4	Bulgo Sandstone	
					400.0	-132.7	Bulgo Sandstone	
					435.0	-167.7	Stanwell Park Claystone	
					475.0	-207.7	Scarborough Sandstone	
					495.0	-227.7	Scarborough Sandstone	

Table 19 (Continued)
Groundwater Level and Groundwater Level/Pressure Sites

Site Number	Location	Easting (m)	Northing (m)	Collar (m AHD)	Depth (m)	Elevation (m AHD)	Lithology	Commencement Date
PM03	Woronora Dam Road	311664	6219773	265.0	64.0	201.0	Hawkesbury Sandstone	14 February 2011
					106.5	158.5	Hawkesbury Sandstone	
					149.0	116.0	Hawkesbury Sandstone	
					189.3	75.7	Bald Hill Claystone	
					214.0	51.0	Bulgo Sandstone	
					385.0	-120.0	Bulgo Sandstone	
					408.0	-143.0	Stanwell Park Claystone	
					430.2	-165.2	Scarborough Sandstone	
					462.0	-197.0	Scarborough Sandstone	
					492.0	-227.0	Wombarra Claystone	
					526.0	-261.0	Coal Cliff Sandstone	
S1997*	North Cliff	306997	6212765	370.2	24.0	346.2	Hawkesbury Sandstone	10 June 2009
					68.5	301.7	Hawkesbury Sandstone	
					132.0	238.2	Hawkesbury Sandstone	
					218.0	152.2	Bulgo Sandstone	
					292.5	77.7	Bulgo Sandstone	
					372.0	-1.8	Bulgo Sandstone	
					429.0	-58.8	Scarborough Sandstone	
					441.5	-71.3	Scarborough Sandstone	
					454.0	-83.3	Scarborough Sandstone	
					504.5	-134.3	Coal Cliff Sandstone	
					511.6	-141.4	Bulli Coal Seam	

Table 19 (Continued)
Groundwater Level and Groundwater Level/Pressure Sites

Site Number	Location	Easting (m)	Northing (m)	Collar (m AHD)	Depth (m)	Elevation (m AHD)	Lithology	Commencement Date
302GW01[3]	Overlying Longwall 302	312952	6216553	305.1	80.0	225.1	Hawkesbury Sandstone	Commenced 23 November 2017 End Date: 25 May 2018
					150.0	155.1	Hawkesbury Sandstone	
					200.0	105.1	Newport Formation	
					245.0	60.1	Interbedded Shale and Sandstone	
					340.0	-34.9	Bulgo Sandstone	
					380.0	-74.9	Bulgo Sandstone	
					400.0	-94.9	Bulgo Sandstone	
					410.0	-104.9	Bulgo Sandstone	
					440.0	-134.9	Scarborough Sandstone	
TBS02-80[4] (pre-mining standpipe)	Overlying Longwall 302	312849	6216579	305.1	82.5	222.6	Hawkesbury Sandstone	1 October 2017 End Date 12 January 2018
TBS02-90 (post-mining standpipe)	Overlying Longwall 302	312843	6216580	306.5	90.0	216.5	Hawkesbury Sandstone	13 February 2019
TBS02-190 (post-mining standpipe)	Overlying Longwall 302	312837	6216583	305.7	190.0	115.7	Hawkesbury Sandstone	8 February 2019
TBS02-250[5] (pre-mining hole)	Overlying Longwall 302	312852	6216598	306.1	192.0	114.1	Newport Formation	27 October 2017 End Date 22 October 2018
					243.0	63.1	Shale/ Sandstone	27 October 2017 End Date 22 October 2018

Table 19 (Continued)
Groundwater Level and Groundwater Level/Pressure Sites

Site Number	Location	Easting (m)	Northing (m)	Collar (m AHD)	Depth (m)	Elevation (m AHD)	Lithology	Commencement Date
TBS02-250R (post-mining hole)	Overlying Longwall 302	312865	6216583	307.4	90.0	217.4	Hawkesbury Sandstone	24 January 2019 VWP 245 failed during grouting
					150.0	157.4	Hawkesbury Sandstone	
					180.0	127.4	Hawkesbury Sandstone	
					245.0	62.4	Upper Bulgo/ Sandstone	
TBS02A-15	Overlying Longwall 302	312837	6216577	304.2	15.5	288.7	Hawkesbury Sandstone	31 October 2017
TBS03-230[6] Pre-Mining	Overlying Longwall 303	312652	6216685	281.9	162.0	119.9	Newport Formation	22 February 2018 End Date 13 December 2018
					213.0	68.9	Shale/ Sandstone	
TBS03-230R (post-mining hole)	Overlying Longwall 303	312648	6216686	281.5	162.0	119.5	Newport Formation	12 April 2019
					213.0	68.5	Shale/ Sandstone	
					245.0	36.5	Bulgo Sandstone	
					265.0	16.5	Bulgo Sandstone	
TBS03-15	Overlying Longwall 303	312647	6216684	281.9	15.5	266.4	Hawkesbury Sandstone	23 February 2018

1 Multi-level piezometer site 9GGW1B was installed above Longwall 22 to monitor deep groundwater levels/pressure as part of the Longwalls 20-22 monitoring program, however this site was decommissioned due to safety risks in late 2013 prior to Longwall 22 passing the site. Metropolitan Coal replaced this site with a new bore (9GGW1-80) which monitors the groundwater level with a single piezometer at 70 m depth.

2 Multi-level piezometer site 9EGW2A experienced failure of certain lower level instrumentation. An additional hole was drilled adjacent to 9EGW2A (bore 9EGW2-4) to a depth of 557 m to install new piezometers at the same RL as the failed piezometers in December 2017.

3 302GW01 piezometer site intended to be first site to safely monitor throughout the longwall extraction process with new optical fibre piezometers. Optical fibres unfortunately were severed by ground movement as Longwall 302 passed under the site.

4 TBS02-80 m hole found obstructed 12 Dec 2018, unable to clear obstruction or dip water level. Hole remediated, and replacement hole installed 13 Feb 2019 at 90 m depth.

5 TBS02-250 (pre-mining) VWP communications lost 22 Oct 2018. Hole remediated, and replacement hole installed 24 Jan 2019.

6 TBS03-230 (pre-mining) VWP communication lost as Longwall 303 passed underneath. Post mining hole (TBS03-230R) reinstated 12 April 2019.

* Data courtesy of Illawarra Metallurgical Coal.

Measured Vertical Head Profiles

The measured vertical hydraulic head profiles for installed multi-piezometer bores will be monitored as a component of this WMP. The measured vertical hydraulic head profiles for multi-piezometer bores PHGW2A, PHGW1B, 9EGW1B, 9EGW2A/9EGW2-4, PM01 (9DGW1B) and PM02 will be compared against their predicted vertical head profiles as described in Section 8.6.3. Their measured vertical hydraulic head profiles are illustrated on Charts 14 to 19 on stratigraphic sections with piezometer offtakes, average potentiometric head levels and pressure heads. It should be noted that the heads at these bores have potentially been affected to some degree by previous mining at Metropolitan Coal and/or other nearby mines (e.g. North Cliff and Darkes Forest).

Bore PHGW2A

Bore PHGW2A is located approximately 400 m north of the T1-T5 transect and about 350 m north-east of Longwalls 308-310. The profiles in Chart 14 show a mild downwards hydraulic gradient over the past decade.

In comparison to other bores, the head in the Lower Hawkesbury Sandstone is about 178 metres Australian Height Datum (m AHD) and the head in the Lower Bulgo Sandstone is about 160 m AHD. The profiles at various times in Chart 14 show that the heads were not varying with time as mining proceeded, until commencement of Longwall 305 when the deeper piezometers showed a sudden increase. This increase could be due to compressive effects but anomalous behaviour cannot be ruled out until further data is acquired.

Bore PHGW1B

Bore PHGW1B is about 500 m due north of PHGW2A and about 700 m north of Longwalls 308-310. It would be expected to have a similar vertical hydraulic profile to PHGW2A, but in fact it has a stronger gradient (Chart 15). This seems to be due to the naturally higher lateral hydraulic gradient towards the north-east in deeper strata, but could be due to the influence of the Metropolitan Fault.

For comparison with other bores, the head in the Lower Hawkesbury Sandstone is about 190 m AHD and the head in the Lower Bulgo Sandstone is about 108 m AHD. The profiles at various times in Chart 15 show that the heads are not varying with time as mining proceeds. The observed variations are stabilisation effects.

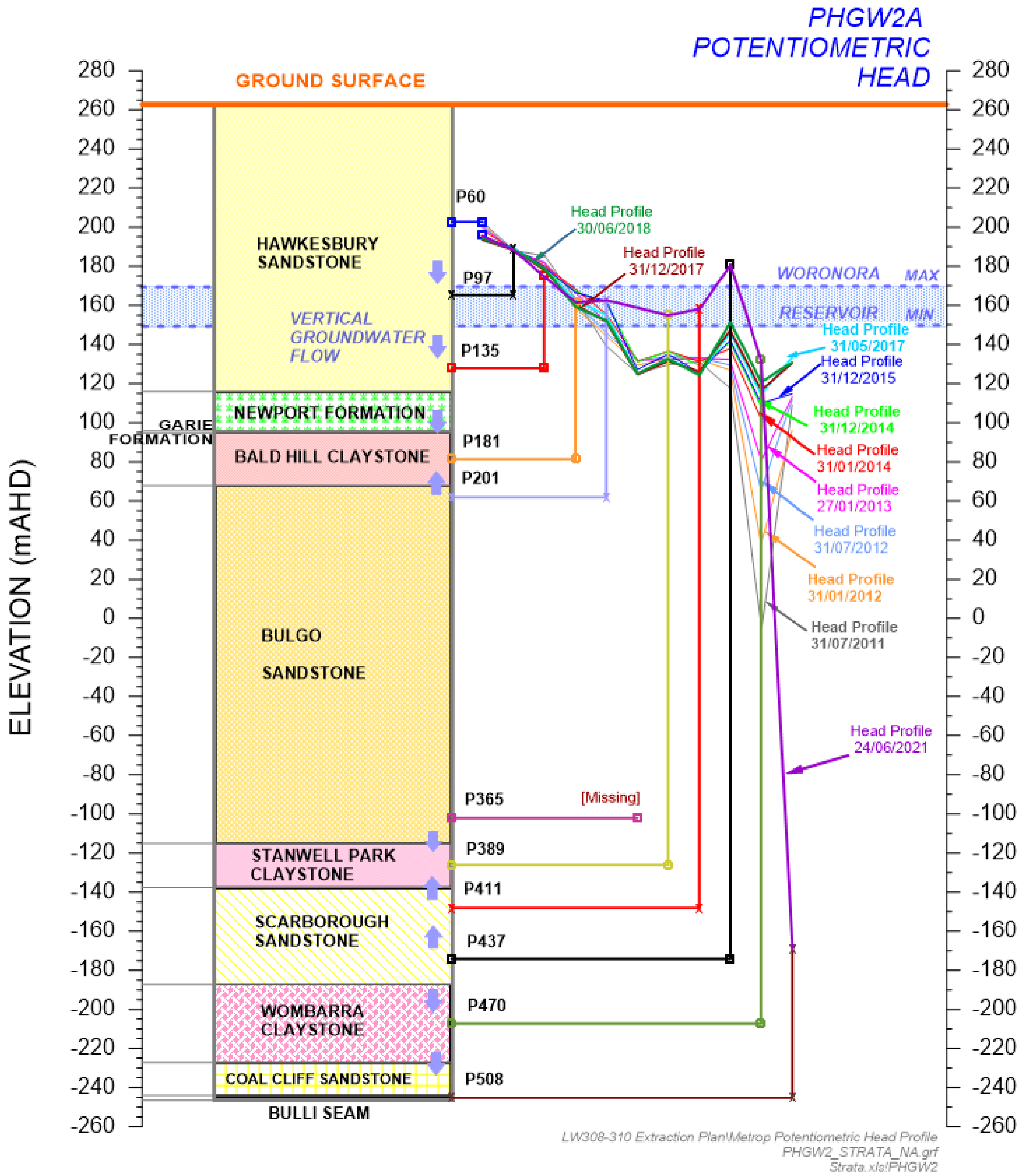


Chart 14 Vertical Groundwater Flow Directions, Relative Piezometer Elevations and Potentiometric Heads at Bore PHGW2A

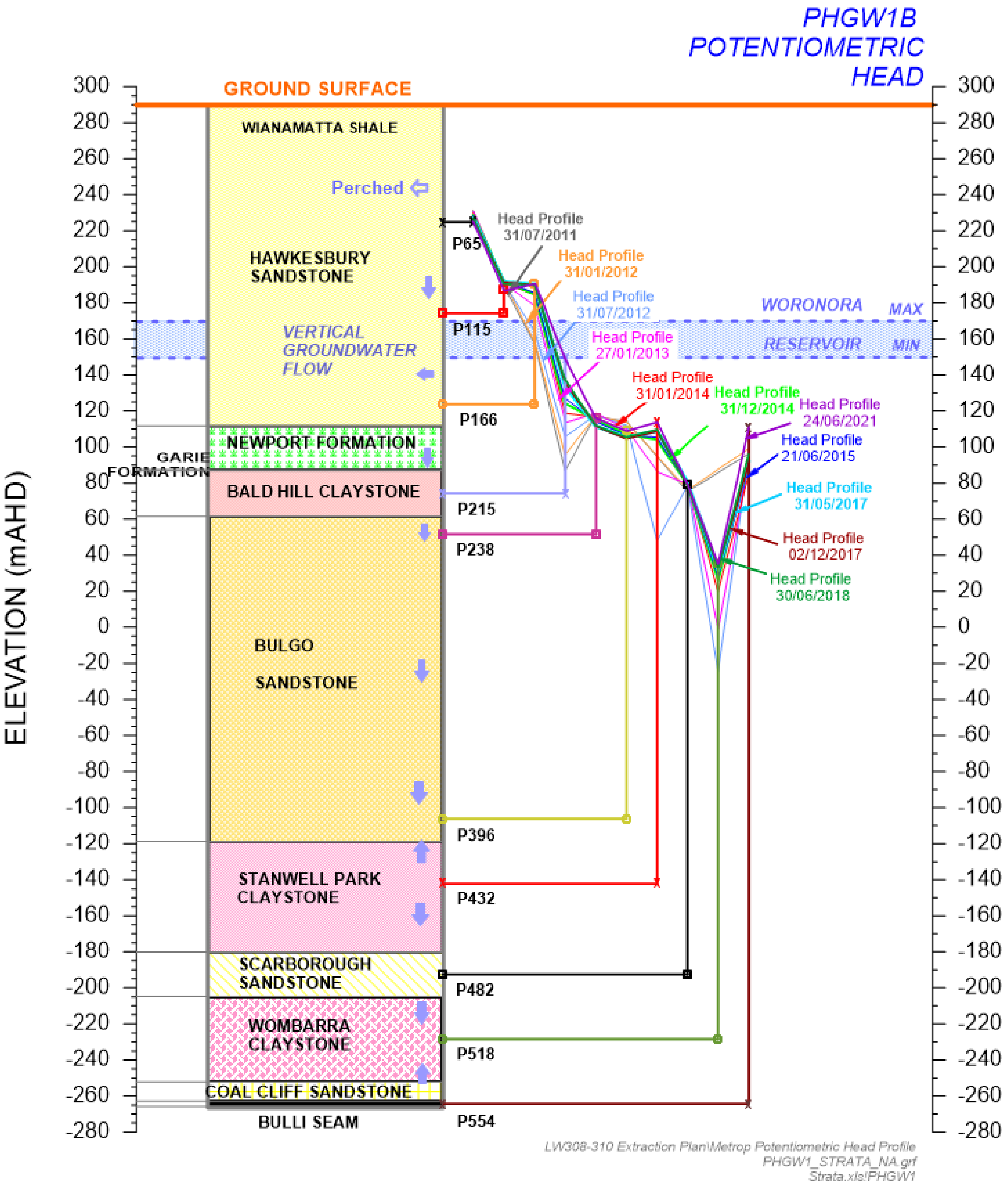


Chart 15 **Vertical Groundwater Flow Directions, Relative Piezometer Elevations and Potentiometric Heads at Bore PHGW1B**

Bore 9EGW1B

Bore 9EGW1B is located approximately 500 m north of the western end of Longwall 23A and some 1.3 km west of Longwall 310. Some depressurisation appears to have occurred in the Lower Bulgo Sandstone and lower formations due to mining to the south (Chart 16).

For comparison with other bores, the head in the Lower Hawkesbury Sandstone is about 240 m AHD and the head in the Lower Bulgo Sandstone is about 170 m AHD. The profiles at various times in Chart 16 show that the heads are not varying significantly with time as mining proceeds, but several piezometers have taken time to stabilise.

Bore 9EGW2A and 9EGW2-4

Bore 9EGW2A is located above Longwall 310. The vibrating wire piezometers indicate substantial depressurisation at depth, but the records are erratic and not internally consistent (Chart 17). The vibrating wire piezometers at the lower Bulgo Sandstone and from the Scarborough Sandstone downwards had unreliable data from 14 October 2014.

An additional hole (9EGW2-4) with five piezometers (P407, P454, P484, P517 and P557) was installed in close proximity to 9EGW2A (also above Longwall 310) on 18 December 2017 at Lower Bulgo Sandstone and from the Scarborough Sandstone downwards.

For comparison with other bores, the head in the Lower Hawkesbury Sandstone is about 165 m AHD and the head in the Lower Bulgo Sandstone is about 153 m AHD. The profiles at various times in Chart 17 show that there is no definitive reduction in heads with time as mining proceeds, but several piezometers have taken time to stabilise.

Bore PM01 (9DGW1B)

Bore PM01 (9DGW1B) is located approximately 1.2 km west of Longwall 310. This site has a similar vertical head gradient to that observed at PHGW1B, apparently due to the naturally higher lateral hydraulic gradient towards the north-east in deeper strata, but also due to mining effects from the south.

For comparison with other bores, the head in the Lower Hawkesbury Sandstone is about 240 m AHD and the head in the Lower Bulgo Sandstone is about 140 m AHD. The profiles at various times in Chart 18 show that the heads are not varying significantly with time as mining proceeds, but the Scarborough Sandstone piezometer (P482) has been unstable.

Bore PM02

Bore PM02 is located approximately 1 km west of Longwall 310. Chart 19 indicates that all potentiometric heads are high and within 40 m of the maximum level of the Woronora Reservoir. As there is no difference in head between the Lower Bulgo Sandstone and the Lower Scarborough Sandstone, it is inferred that there is no substantial change in vertical hydraulic gradient (at depth) due to mining.

For comparison with other bores, the head in the Lower Hawkesbury Sandstone is about 185 m AHD and the head in the Lower Bulgo Sandstone is about 125 m AHD. The profiles at various times in Chart 19 show that the heads are not varying significantly with time as mining proceeds.

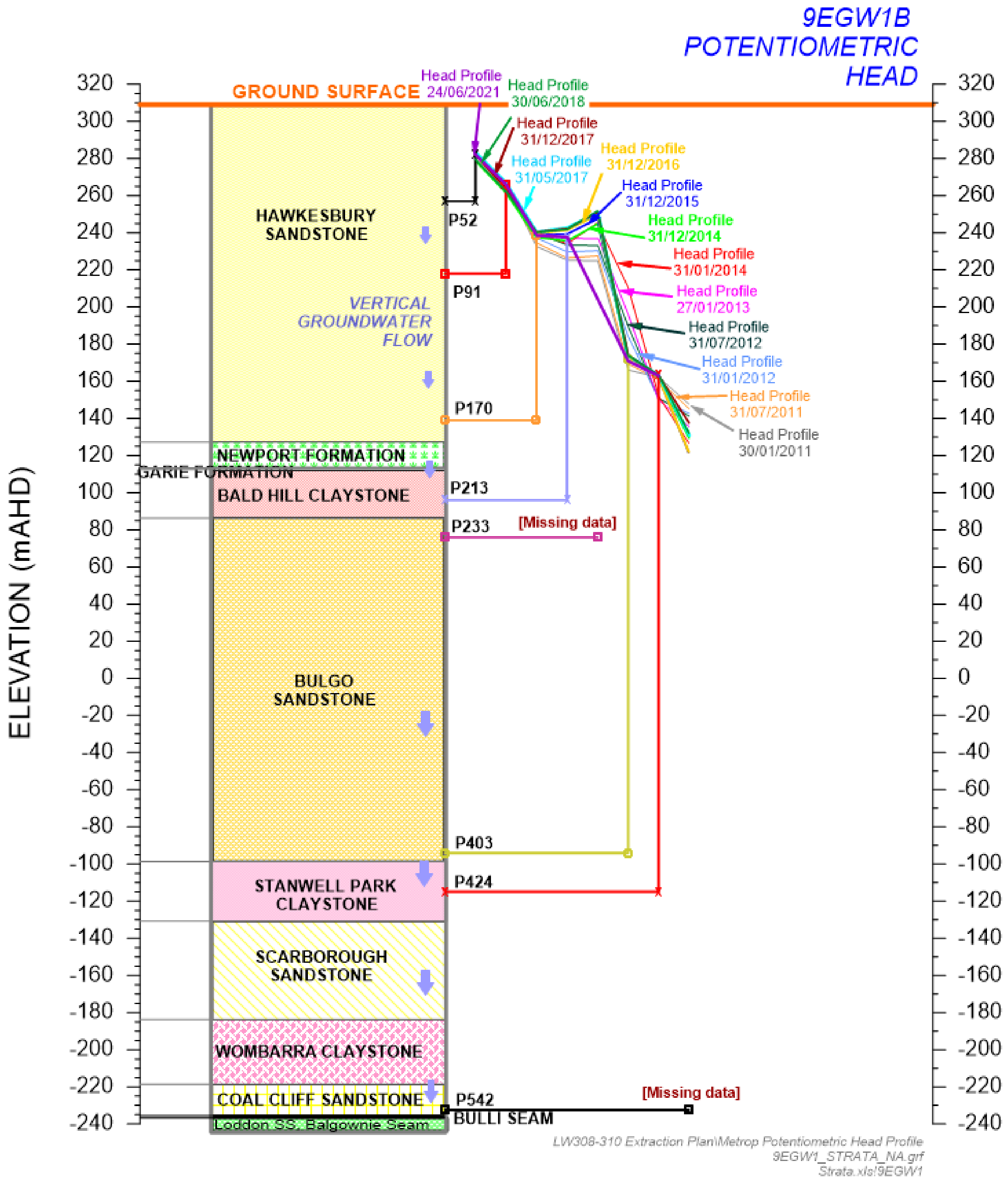


Chart 16 **Vertical Groundwater Flow Directions, Relative Piezometer Elevations and Potentiometric Heads at Bore 9EGW1B**

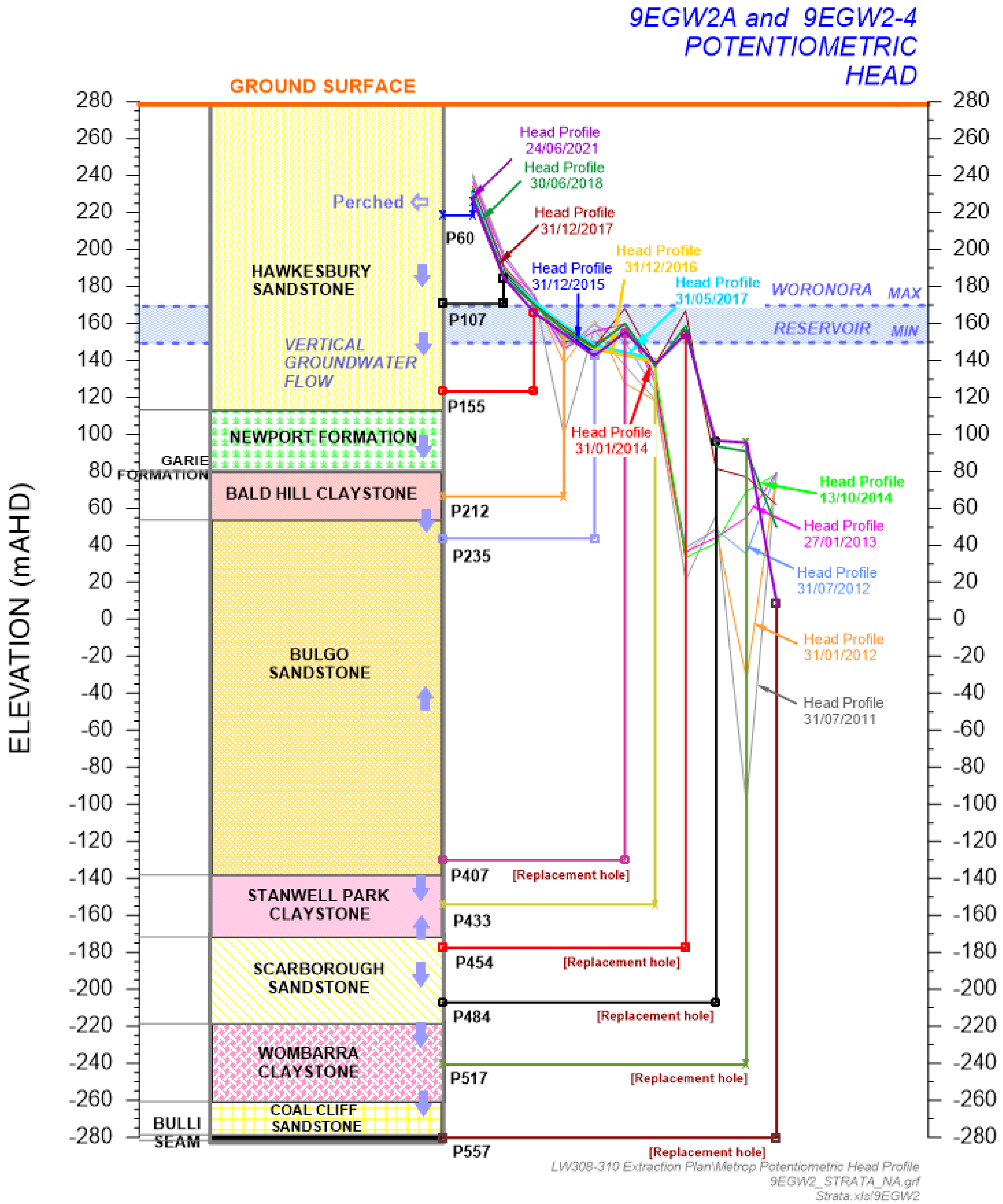


Chart 17 **Vertical Groundwater Flow Directions, Relative Piezometer Elevations and Potentiometric Heads at Bores 9EGW2A and 9EGW2-4**

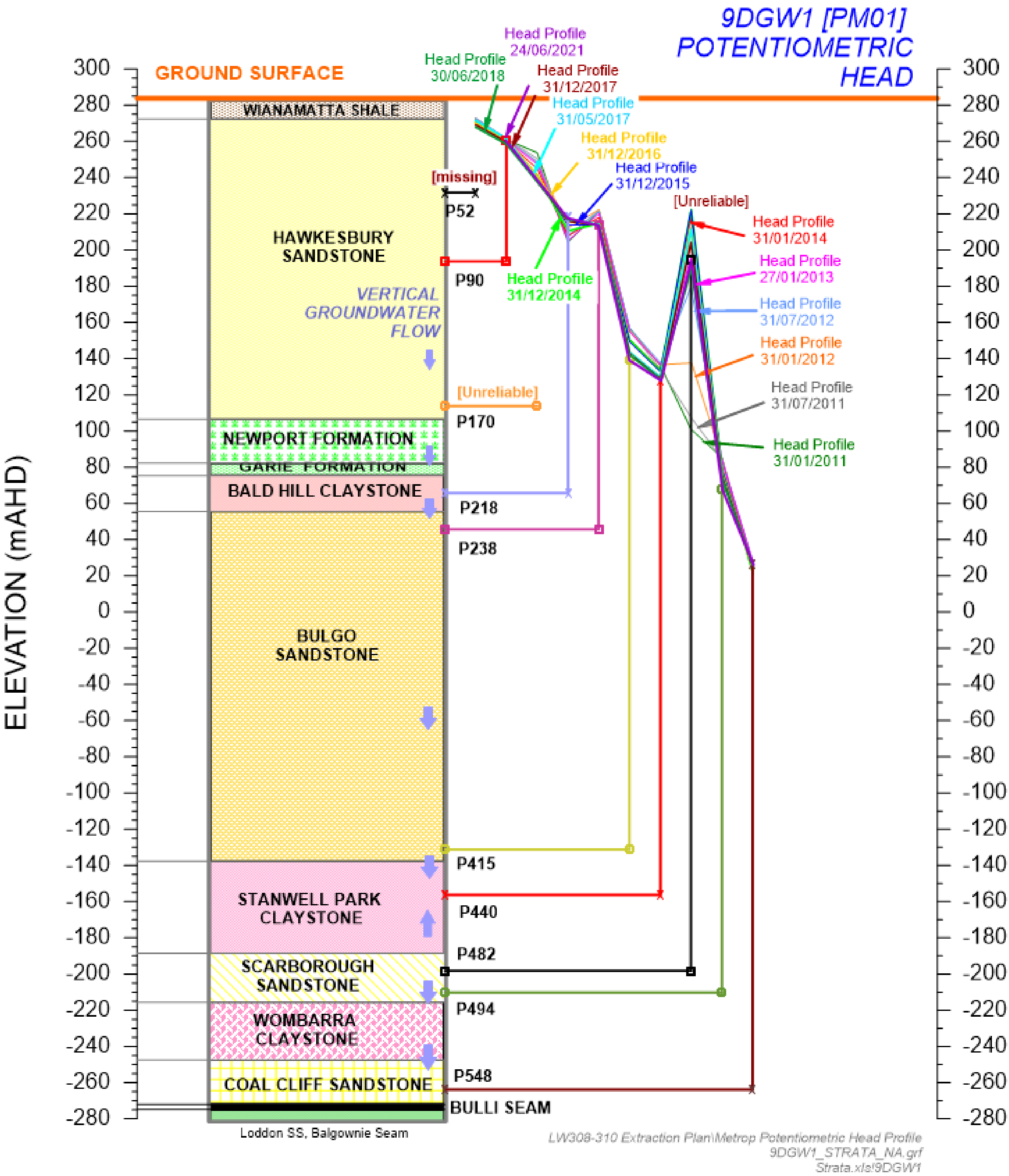


Chart 18 **Vertical Groundwater Flow Directions, Relative Piezometer Elevations and Potentiometric Heads at Bore PM01 (9DGW1B)**

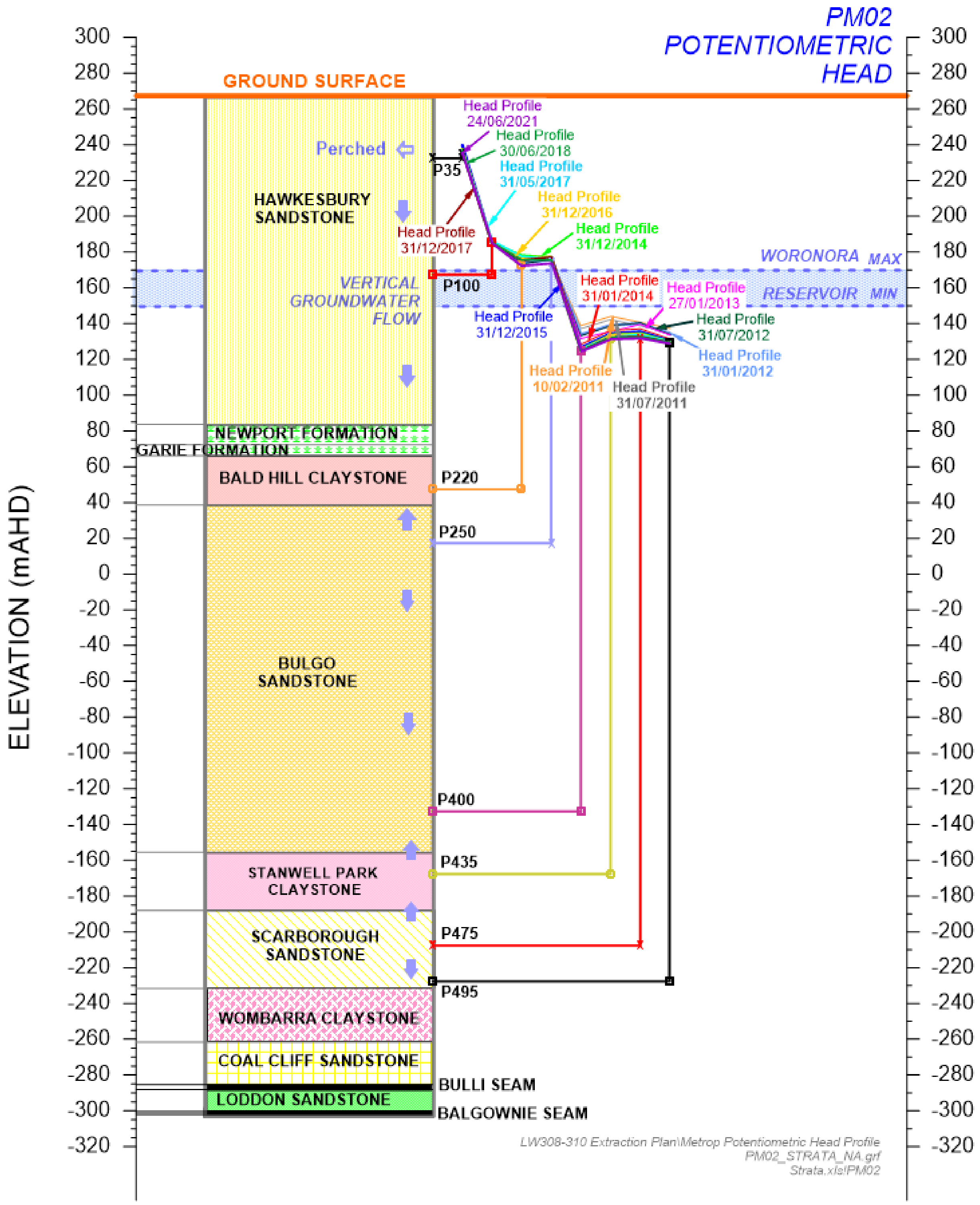


Chart 19 **Vertical Groundwater Flow Directions, Relative Piezometer Elevations and Potentiometric Heads at Bore PM02**

7.3.5 Mine Water Make

Mine water make (i.e. groundwater that has seeped into the mine through the strata) is calculated from the difference between total mine inflows (reticulated water into the mine, moisture in the downcast ventilation, moisture in backfill delivery pipe and the Run-of-Mine (ROM) coal *in-situ* moisture content) and mine outflows (reticulated water out of the mine, moisture in the exhaust ventilation, and moisture in the ROM coal).

Charts 3a and 3b in Section 4.2 show the mine water make results to August 2021. The 20-day average daily mine water make has consistently been less than 0.5 ML/day (Chart 3a). From January 2009 to August 2021, the mine water make has averaged 0.01 ML/day, which is less than that predicted by groundwater modelling for the Project.

The predicted groundwater take from the Sydney Basin Central Groundwater Source of the Water Sharing Plan for the *Greater Metropolitan Region Groundwater Sources 2011* for each year from 2023 to 2026 is presented in Table 20.

Table 20
Predicted Groundwater Take Volume

Year	Water Take Volume (ML)
2023	57.2
2024	57.9
2025	55.1
2026	52.4

Metropolitan Coal holds WAL 36475 with sufficient entitlements to account for the maximum predicted take associated with inflows to the underground workings.

7.3.6 Groundwater Quality

Groundwater quality data is available from a number of sites with installed piezometers, as summarised in Table 21. The locations of the groundwater quality sites are shown on Figure 11.

Table 21
Shallow Groundwater Quality Sites

Site Number	Location	Easting (m)	Northing (m)	RL (m AHD)	Commencement Date
SWGW1	Swamp S06	307893	6214226	343.7	12 March 2009
WRGW1	Waratah Rivulet	309886	6214360	207.8	16 February 2007
WRGW2	Waratah Rivulet	309868	6214335	207.9	16 February 2007
WRGW3	Waratah Rivulet	309629	6214072	215.0	16 February 2007
WRGW4	Waratah Rivulet	309579	6214090	217.8	16 February 2007
WRGW5	Waratah Rivulet	309393	6212890	225.4	4 April 2007
WRGW6	Waratah Rivulet	309361	6212871	226.1	4 April 2007

Table 21 (Continued)
Shallow Groundwater Quality Sites

Site Number	Location	Easting (m)	Northing (m)	RL (m AHD)	Commencement Date
WRGW7	Waratah Rivulet	310717	6215382	184.2	1 September 2010
RTGW1A[1]	Tributary B	309593	6215109	222.0	23 August 2007
UTGW 1	Tributary D	309520	6214151	218.2	16 February 2007
UTGW 2	Tributary D	309097	6214012	237.6	7 March 2007
UTGW 3	Tributary D	308833	6213951	247.2	7 March 2007
FGGW1	Forest Gully	308951	6213200	232.4	8 March 2007
FGGW2	Forest Gully	308816	6213158	240.5	4 April 2007
FGGW3	Forest Gully	308682	6213113	250.4	4 April 2007
ETGW1[2]	Eastern Tributary	312129	6215644	172.6	1 September 2010
ETGW2	Eastern Tributary	312134	6215664	172.1	1 September 2010

1 Due to bore failure as a result of subsidence, groundwater quality at RTGW1A has not been sampled since December 2013.

2 Site ETGW1 was unable to be sampled from January to March 2017, and since August 2017.

Groundwater quality is also sampled by Metropolitan Coal to meet its Dams Safety NSW Approval requirements. The groundwater quality sampling sites are detailed in Table 22 and shown on Figure 11.

Table 22
Deep Groundwater Chemistry Sites

EES (2014) Bore Name	Metropolitan Coal Site Number	Easting (m)	Northing (m)	Collar (m AHD)	Depth (m)	Elevation (m AHD)	Lithology	Sampling Type	Status
9F2-50E	9FGW2	308717.4	6217210.3	289.8	50	239.8	Upper Hawkesbury Sandstone	Chemical and Static Water Level	Operational
9F2-130C		308740.7	6217240.7	289.8	130	139.8	Lower Hawkesbury Sandstone	Chemical and Static Water Level	Operational (recovered from initial grout impact)
9F2-250D		308720.5	6217223.8	289.8	250	39.8	Bulgo Sandstone	Chemical and Static Water Level	Operational (recovered from initial grout impact)
PH2-25E	PHGW2	312316.1	6217761.1	263.0	25	238	Upper Hawkesbury Sandstone	Chemical and Static Water Level	Operational
PH2-110C		312322.3	6217782.3	263.1	110	153	Lower Hawkesbury Sandstone	Chemical and Static Water Level	Operational (recovered from initial grout impact)
PH2-230D		312327.1	6217772.3	262.2	230	33	Bulgo Sandstone	Chemical and Static Water Level	Operational
PM03-25E	PM03	311640.8	6219766.2	265.7	25	242.7	Upper Hawkesbury Sandstone	Chemical and Static Water Level	Operational
PM03-105C		311665.2	6219754.9	265.7	105	160.7	Lower Hawkesbury Sandstone	Chemical and Static Water Level	Operational
PM03-230D		311647.6	6219776.1	265.7	230	35.7	Bulgo Sandstone	Chemical and Static Water Level	Operational (recovered from initial grout impact)

Table 22 (Continued)
Deep Groundwater Chemistry Sites

EES (2014) Bore Name	Metropolitan Coal Site Number	Easting (m)	Northing (m)	Collar (m AHD)	Depth (m)	Elevation (m AHD)	Lithology	Sampling Type	Status
9E1-36E	9EGW1	309474.7	6216083.5	309.2	36	273.2	Upper Hawkesbury Sandstone	Chemical	Operational (field measurement only)
9E1-80E					80	229.2	Upper Hawkesbury Sandstone	Chemical	Operational (field measurement only)
9E1-108C					108	201.2	Lower Hawkesbury Sandstone	Chemical	Operational (field measurement only)
9E1-250D					250	59.2	Bulgo Sandstone	Chemical	No longer operational (drilling fluid but no water recovered)
9H1-35E	9HGW1	308171.8	6214592.5	350.3	35	315.3	Upper Hawkesbury Sandstone	Chemical	Operational (field measurement only)
9H1-82E					82	268.3	Upper Hawkesbury Sandstone	Chemical	No longer operational (no recovery)
9H1-150C					150	200.3	Lower Hawkesbury Sandstone	Chemical	No longer operational (no recovery)
9H1-233D					233	117.3	Bulgo Sandstone	Chemical	No longer operational (no recovery)
9G1-70C	9GGW1	310980.5	6214309.1	286.0	70	216.0	Lower Hawkesbury Sandstone	Chemical and Static Water Level	Operational (field measurement only)
9G1-45E		310986.2	6214305.4	287.0	45	242.0	Upper Hawkesbury Sandstone	Chemical	No longer operational (no recovery)
9G1-140C				287.0	140	147.0	Lower Hawkesbury Sandstone	Chemical	No longer operational (no recovery)
9G1-190D				287.0	190	97.0	Bulgo Sandstone	Chemical	No longer operational (no recovery)

Table 22 (Continued)
Deep Groundwater Chemistry Sites

EES (2014) Bore Name	Metropolitan Coal Site Number	Easting (m)	Northing (m)	Collar (m AHD)	Depth (m)	Elevation (m AHD)	Lithology	Sampling Type	Status
9G3-32E	9GGW3	311581.3	6215044.6	260.0	32	228.0	Upper Hawkesbury Sandstone	Chemical and Static Water Level	Operational (recovered from initial grout impact)
9G3-117C		311588.0	6215040.3	260.0	117	143.0	Lower Hawkesbury Sandstone	Chemical and Static Water Level	Operational (recovered from initial grout impact) (field measurement only)
9G3-216D		311609.7	6215024.9	260.0	216	44.0	Bulgo Sandstone	Chemical and Static Water Level	Operational (still grout impacted) (field measurement only)
F6GW3-85C	F6GW3	312849.0	6215533.9	243.5	85	158.5	Lower Hawkesbury Sandstone	Chemical and Static Water Level	Operational (recovered from initial grout impact)
F6GW4-36E	F6GW4	312524.1	6216670.7	265.0	36	229.0	Upper Hawkesbury Sandstone	Chemical and Static Water Level	Operational
F6GW4-104C		312527.7	6216681.3	265.0	104	161.0	Lower Hawkesbury Sandstone	Chemical and Static Water Level	Operational
F6GW4-208D		312528.4	6216686.0	265.0	208	57.0	Bulgo Sandstone	Chemical and Static Water Level	Operational

Source: after Environmental Earth Sciences (EES) (2014) *Assessment and Interpretation of Deep Groundwater Sampling Program – June 2009 to February 2014 – Woronora Catchment Area, Helensburgh, NSW* and Brienen Environment & Safety (BES) (2019) *Deep Groundwater Sampling Program – January – March 2019 – Woronora Catchment Area, Helensburgh, NSW.*

8 MONITORING PROGRAM

Subsidence parameters will be measured in accordance with the Metropolitan Coal Longwalls 308-310 Subsidence Monitoring Program (Figure 3). In summary, surveys will be conducted to measure subsidence movements in three dimensions using a total station survey instrument and real time GNSS monitoring stations. 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 water resources and watercourses during the mining of Longwalls 308-310. The monitoring program is described in Sections 8.1 to 8.8.

Section 8.9 provides detailed TARPs to assess the water resource and watercourse subsidence impact performance indicators and measures.

8.1 METEOROLOGY

Rainfall data will be monitored using pluviometers at the following locations (Figure 15):

- Waratah Rivulet catchment (sites PV1 and PV6);
- Woronora River catchment (site PV2);
- Honeysuckle Creek catchment (site PV5);
- Eastern Tributary catchment (site PV7); and
- Woronora Reservoir catchment (site PV8).

A pan evaporimeter at site PV1 (Figure 15) will monitor evaporation in the Waratah Rivulet catchment.

This data will be supplemented by rainfall and/or climate data from nearby Bureau of Meteorology stations or WaterNSW owned monitoring equipment, as required.

The meteorology data will input to the catchment models described in Section 8.3.1.

8.2 STREAM FEATURES

Visual inspections and photographic surveys of the Waratah Rivulet from the full supply level of the Woronora Reservoir to Pool P will be conducted monthly when longwall extraction is within 450 m of the stream and within three months of the completion of Longwalls 308, 309 and 310.

Visual inspections and photographic surveys of the Eastern Tributary from the full supply level of the Woronora Reservoir to the maingate of Longwall 26 will be conducted at annual intervals.

The visual and photographic surveys will record:

- the location, approximate dimensions (length, width and depth), and orientation of surface cracks (specifically whether cracks are developed perpendicular to the stream flow or are controlled by rock joints or other factors, etc.);
- the nature of iron staining (e.g. whether isolated or across the entire streambed);
- the extent of iron staining (e.g. the length of stream affected);
- a description of gas release (e.g. isolated bubbles or continuous stream, and type of gas [methane or carbon dioxide]);

- the nature of scouring, for example the depth of scouring, type of soil exposed, any obvious vegetation impact, potential for severe erosion, etc.;
- water discoloration or opacity if present;
- rock bar characteristics such as extent of cracking, seepage, underflow;
- whether any actions are required (e.g. implementation of management measures, incident notification, implementation of appropriate safety controls, review of public safety, etc.); and
- any other relevant information.

Global Positioning System (GPS) coordinates will be recorded where appropriate (e.g. of particular observations and associated photographs).

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

Any gas releases identified as occurring on the Waratah Rivulet and Eastern Tributary to the Woronora Reservoir full supply level by the visual inspections during the mining of Longwalls 308-310 (either during the visual and photographic surveys or other catchment monitoring) will be monitored weekly to determine the nature of the gas releases, gas concentration (samples taken for the analysis for carbon dioxide and methane content) and any observable environmental effects (e.g. impacts to riparian vegetation or fish kills). Weekly monitoring will be conducted at pools observed with gas releases, until no gas releases have been observed at the pool for three consecutive weeks.

8.3 SURFACE WATER QUANTITY

8.3.1 Surface Water Flow

Surface water flow monitoring will include continuous flow monitoring at (Figure 6):

- the WaterNSW owned gauging station on the Waratah Rivulet, close to the inundation limits of the Woronora Reservoir (GS 2132102);
- the Metropolitan Coal owned gauging station on the Eastern Tributary, close to the inundation limits of the Woronora Reservoir (GS 300078);
- the WaterNSW owned gauging station on the Woronora River, close to the inundation limits of the Woronora Reservoir (GS 2132101) (control site);
- the Metropolitan Coal owned gauging station on Honeysuckle Creek (GS 300077) (control site);
- the WaterNSW gauging station on O’Hares Creek at Wedderburn (GS 213200) (control site);
- the Metropolitan Coal owned gauging station on a tributary of the Woronora Reservoir (Sub-catchment I [GS 300092]);
- the Metropolitan Coal owned gauging station on a tributary of the Woronora Reservoir (Sub-catchment K [GS 300093]);
- the Metropolitan Coal owned gauging station on a tributary of the Woronora Reservoir (Sub-catchment P [GS 300142]); and
- the Metropolitan Coal owned gauging station on a tributary of the Woronora Reservoir (Sub-catchment R [GS 300143]).

Data from the WaterNSW owned gauging stations will continue to be downloaded monthly by WaterNSW and provided to Metropolitan Coal in accordance with a data exchange agreement.

Metropolitan Coal will source flow data for the O'Hares Creek gauging station at Wedderburn from WaterNSW.

A modified catchment model (Gilbert & Associates, 2015b) will be used to assess the quantity of water resources reaching the Woronora Reservoir from the Waratah Rivulet and Eastern Tributary. Details of the modified catchment models are provided in the Metropolitan Coal Catchment Monitoring Program.

Metropolitan Coal will monitor the sub-catchment I, K, P and R streamflow monitoring stations during the extraction of Longwalls 308-310.

8.3.2 Pool Water Levels and Drainage Behaviour

The water level in Pools B, C, E, G, G1, H and I on Waratah Rivulet will be manually monitored daily (Figure 6).

Pool water levels and drainage behaviour will be monitored using a continuous water level sensor and logger in (Figure 6):

- Pools A, F, J, K, L, M, N, O, P, Q, R, S, T, U, V and W on Waratah Rivulet;
- Pools ETG, ETJ, ETM, ETO, ETU, ETW, ETAF, ETAG, ETAH, ETAI/ETAJ/ETAK[24], ETAL, ETAM, ETAN, ETAO, ETAP, ETAQ, ETAR, ETAS/ETAT[25] and ETAU on the Eastern Tributary;
- Pools SR1, SR2 and SP1 on tributaries of the Woronora Reservoir; and
- control Pools WRP1, WRP2, WRP3 and WRP4 on the Woronora River.

Data from these water level meters will be downloaded monthly.

Pools situated on the Waratah Rivulet from Pool P to the full supply level of the Woronora Reservoir will be visually inspected at the time of download of the pool water level data (i.e. monthly) when longwall extraction is within 450 m of the stream and again at the completion of Longwalls 308, 309 and 310 to observe whether the pool water level has fallen below the cease to flow level or whether any changes to the natural drainage behaviour have occurred. Pools P and T on the Waratah Rivulet terminate by flowing through and below their respective rock bars. Pools U and W on the Waratah Rivulet terminate in boulder fields and are not characterised by flow over rock bars. Pool V on the Waratah Rivulet terminates in a rock bar characterised by partial flow over the rock bar and partial flow through and below the rock bar. Pools Q, R and S on the Waratah Rivulet terminate at rock bars.

Pools ETAS, ETAT and ETAU on the Eastern Tributary will be visually inspected at the completion of Longwalls 308, 309 and 310 to observe whether any changes to the natural drainage behaviour have occurred. Pool ETAS is a rock bar controlled pool. Water enters the pool as surface flow from boulder field ETAR. The downstream rock bar is permeable (allowing both underflow and surface flow), and appears to be mainly detached blocks and boulders. Due to the nature of Rock Bar ETAS, Pool ETAS and Pool ETAT typically sit at the same level. Pool ETAT is a rock bar controlled pool. Water enters the pool as surface flow or underflow through Rock Bar ETAS. The downstream rock bar is effectively impermeable. Pool ETAU flows through Eastern Tributary gauging station, over a rock bar/waterfall, into ETAU boulder field.

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[24] Only small rock bars separate Pools ETAI, ETAJ and ETAK. Pools join to become the one large pool. Pool ETAK is controlled by a rock bar. The water level meter situated in Pool ETAI and is considered to be representative of the water level in Pools ETAJ and ETAK.

[25] Due to the nature of rock bar ETAS, Pool ETAS and Pool ETAT typically sit at the same level. The water level meter situated in Pool ETAT is considered to be representative of the water level in Pool ETAS.

Observations will include:

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

8.4 SURFACE WATER QUALITY

Surface water quality will be sampled monthly at the following sites (Figure 7):

- sites WRWQ 2, WRWQ 6, WRWQ 8, WRWQ 9, WRWQ M, WRWQ N, WRWQ P, WRWQ R, WRWQ T, WRWQ U, WRWQ V, and WRWQ W on the Waratah Rivulet;
- site RTWQ 1 on Tributary B;
- site UTWQ 1 on Tributary D;
- sites ETWQ F, ETWQ J, ETWQ N, ETWQ U, ETWQ W, ETWQ AF, ETWQ AH, ETWQ AQ and ETWQ AU on the Eastern Tributary;
- site FEWQ 1 on the Far Eastern Tributary;
- site HCWQ 1 on Honeysuckle Creek;
- site BCWQ 1 along Bee Creek;
- sites SR1, SR2 and SP1 on Woronora Reservoir tributaries; and
- control sites WOWQ 1 and WOWQ 2 on the Woronora River.

Water quality parameters will include electrical conductivity (EC), pH, redox potential (Eh), dissolved oxygen (DO), turbidity, calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), chloride (Cl), sulphate (SO_4), bicarbonate (HCO_3), total nitrogen (Ntot), total phosphorous (Ptot), nitrate (NO_3), barium (Ba), strontium (Sr), manganese (Mn), iron (Fe), zinc (Zn), cobalt (Co) and aluminium (Al). Samples collected for metal analysis will be field filtered.

Unfiltered water quality samples will also be collected monthly at the following sites and analysed for total iron, total aluminium and total manganese, in addition to the filtered concentrations (Figure 7):

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

Monitoring of water quality in areas subject to mining indicates that the effects of subsidence on water quality have been most noticeable in iron, manganese and, to a lesser extent, aluminium (Gilbert & Associates, 2008). These parameters will be used to trigger further assessment of subsidence impacts on water quality as outlined in the TARP provided in Table 24 (Section 8.9).

Metropolitan Coal will continue to monitor site ETAU and a minimum of three downstream sites (site ETFSL 0, site ETFSL 100, ETFSL 200, site ETFSL 300, site ETFSL 400, site ETFSL 500, site CONFLU1, site WDFS1 and/or site WDFS1+100) (Figure 7) weekly until the site ETWQ AU monitoring results are at Level 1 or Level 2 of the TARP for the quality of water resources reaching the Woronora Reservoir (Table 24, Section 8.9) for four consecutive assessment periods.

The downstream sites will be selected in consideration of the Woronora Reservoir water level and safe access to the sites. Sampling of site ETAU and three downstream sites will continue monthly once the site ETWQ AU monitoring results have returned to Level 1 or Level 2 TARP levels for four consecutive assessment periods, unless the TARP level returns to Level 3.

Metropolitan Coal will monitor WARARM5 at the same frequency described above when the sites downstream of site CONFLU1 can be accessed for sampling (i.e. when the Woronora Reservoir water levels are suitably low).

8.5 WORONORA RESERVOIR WATER QUALITY

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

Consistent with the monitoring described in Section 8.4, the water quality data will comprise key water quality parameters of relevance to water supply and effects of subsidence, namely: total iron; total manganese; and total aluminium. These parameters will be used to trigger further assessment of subsidence impacts on reservoir water quality as outlined in the TARP provided in Table 26 (Section 8.9).

8.6 GROUNDWATER LEVELS

Metropolitan Coal will provide a groundwater impact verification in the Annual Review including an interpretation of multi-aquifer drawdown for the relevant monitoring piezometers.

8.6.1 Swamp Groundwater Levels

Monitoring of upland swamp groundwater levels will be conducted in accordance with the Metropolitan Coal Longwalls 308-310 Biodiversity Management Plan. In summary, 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). Each piezometer has been equipped with a data logger for continuous water level monitoring.

Upland swamp 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, Swamps 40, 41, 46, 51, 52 and 53 for Longwalls 301-303, Swamp 50 for Longwall 304, Swamps 71a and 72 for Longwalls 305-307 and in control Swamps 101, 137a, 137b, Bee Creek Swamp and Woronora River 1 (WRSWAMP 1) (Figure 9).

Upland swamp groundwater monitoring will be conducted in Swamps 62 and 64 for Longwalls 308-310 (Figure 9).

8.6.2 Shallow Groundwater Levels Near Streams

Continuous water level monitoring of shallow groundwater will be conducted along streams at (Figure 10):

- sites WRGW1, WRGW2 and WRGW7 along Waratah Rivulet; and
- sites ETO1, ETO2, ETO3 and ETO4 adjacent to Pool ETO on the Eastern Tributary.

These shallow boreholes contain a piezometer at the base of each hole. Data will be downloaded monthly.

8.6.3 Groundwater Levels/Pressures

Continuous groundwater level monitoring will also be conducted at an approximately east-west transect of bores (sites T1, T2, T3-R, T5 and T6)[26] located to the east of Longwalls 308-310 (Figure 10). Bore T3 ceased recording in December 2020 and was replaced by a redrilled bore T3-R, approximately 10 m north of the original T3 location. Data from the divers in the standpipes will be downloaded monthly and the measured water levels at these bores will be compared against the water level in the Woronora Reservoir.

Additional groundwater standpipes have been installed as a component of the Woronora Reservoir Impact Strategy, namely bores TBS02-15 (pre-mining Longwall 302), bore TBS03-15 (pre-mining Longwall 303), bore TBS02-90 (post-mining Longwall 302), and bore TBS02-190 (post-mining Longwall 302) (Figure 10).

Continuous groundwater level/pressure monitoring will be conducted at (Figure 10):

- site 9HGW0 (Longwall 10 Goaf Hole);
- site 9EGW1B;
- site 9FGW1A;
- site 9GGW2B;
- site 9HGW1B;
- site PM02;
- site 9GGW1-3;
- site 9GGW1-80;
- site PM01 (9DGW1B);
- site 9EGW2A;
- site 9EGW2-4;
- site PM03;
- site PHGW1B;
- site PHGW2A;
- site F6GW3A;
- site F6GW4A;
- site TBS02-90;
- site TBS02-190;
- site TBS02-250R;
- site TBS02-15; and
- site TBS03-15.

Data from the piezometers will be downloaded monthly.

[26] The water level data obtained at bore T4 is anomalous and unreliable as its head is higher than the head at upgradient site T5. This is considered unlikely to be a groundwater divide as it is not related to the topographic ridge well upgradient (SLR Consulting, 2021).

Vertical profiles of potentiometric head are effective monitors of the capacity of an aquifer system to maintain pressure during the formation of deformation zones caused by caving and subsidence. Head profiles show a characteristic reduction in head with depth due to mining. That is, as mining moves closer, groundwater pressures can fall. Vertical groundwater head profiles will be used to assess the potential for connective cracking between the surface and the mine. The measured vertical hydraulic head profiles for six bores[27] (those most relevant to Longwalls 308-310, as listed in Section 7.3.3 and shown in Charts 14 to 19) will be compared against the predicted vertical hydraulic head profiles for each bore as outlined in the TARPs provided in Section 8.9.

Metropolitan Coal will review VWPs that are performing poorly and assess whether sufficient groundwater data is being collected by the remaining VWPs. In the event mine subsidence results in the loss of a deep monitoring bore, Metropolitan Coal will assess whether sufficient groundwater data is being collected by the remaining deep monitoring bores.

8.6.4 Woronora Reservoir Leakage

Continuous groundwater level/pressure monitoring will be conducted at bores PM02, 9GGW2B, PHGW2A, 9EGW2A and F6GW4A and data from the piezometers will be downloaded monthly (Figure 10). The water levels in Hawkesbury Sandstone at depths similar to reservoir level, measured at Bores PM02, PHGW2A and 9EGW2A, will be compared against the full supply level of Woronora Reservoir to assess reductions in hydraulic gradient from the bores to the Woronora Reservoir as detailed in the TARPs in Section 8.9.

As described in Section 8.6.3, continuous groundwater level monitoring will also be conducted at an approximately east-west transect of bores (sites T1, T2, T3-R, T5 and T6) overlying Longwalls 305-307 (Figure 10). Data from the water level sensors in the standpipes will be downloaded monthly. The water tables measured at transect bores T3-R and T5 will be used to assess the hydraulic gradient to the reservoir as detailed in the TARP in Section 8.9.

8.7 MINE WATER MAKE

Metropolitan Coal has an In-rush Hazard Management Plan to manage the potential risk of in-rush from:

- water lodgement in external (from adjacent mines) workings;
- water stored in existing Metropolitan workings;
- mining under surface water bodies; and
- intersection with boreholes or gas drainage holes.

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

In the event the statutory inspection identifies the potential for in-rush, an investigation is conducted by the Senior Mine Supervisor on that shift and reported to the Mining Engineering Manager.

Monitoring of the mine water balance will comprise monitoring of water flows into and out of the mine.

[27] This includes bore site 9EGW2A; not site 9EGW2-4.

Water flows into the mine:

- Clean water reticulated into the mine (recorded continuously and downloaded monthly).
- Backfill water used to assist pumping into the mine (recorded continuously and downloaded monthly).
- Ventilation moisture content entering the mine at the intake points by manual measurement using a digital psychrometer. The frequency of readings will be as follows:
  - every hour over a 9 hour period on two occasions during a 12 month period;
  - daily (week day) except public holidays or other circumstances (access) that prevent readings to be taken; and
  - once per week as a minimum.
- Measurement of the in-situ moisture content of the coal during channel sampling for coal quality.

Water flows out of the mine:

- Return water reticulated out of the mine (recorded continuously and downloaded monthly).
- Moisture content of the raw coal conveyed out of the mine at the drift portal using an automated moisture scanner. Recorded continuously and downloaded monthly.
- Moisture content of gas stream reticulated out of the mine to the gas drainage plant (recorded continuously and downloaded monthly).
- Ventilation moisture content exiting the mine at the upcast shaft by manual measurement using a digital psychrometer. The frequency of readings will be as follows:
  - every hour over a 9 hour period on two occasions during a 12 month period;
  - daily (weekday) except public holidays or other circumstances (access, fan maintenance) that prevent readings to be taken; and
  - once per week as a minimum.

The inferred water make (i.e. groundwater that has seeped into the mine through the strata) will be calculated from the difference between total mine inflows (reticulated water into the mine, moisture in the downcast ventilation, moisture in the backfill process and the *in-situ* coal moisture content) and total mine outflows (reticulated water out of the mine, moisture in the exhaust ventilation, reticulated gas moisture out of the mine and moisture in the ROM coal). Given the large fluctuations in daily water usage and the cycle period for water entering the mine, being used by machinery, and draining to sumps for return pumping to the surface, a 20-day average will be used to provide a more reliable estimate of water make.

Metropolitan Coal will also monitor the water balance for the 300 area (i.e. a localised water balance underground in and about the 300 series longwalls) using a series of underground water flow meters. Metropolitan Coal will provide the results of the localised water balance, with the results of the overall mine water balance to Dams Safety NSW monthly.

Metropolitan Coal will report in the Annual Review on the total volume of groundwater taken as inflows to the underground mine as a component of the underground water balance. In addition, the following volumes of surface water will be measured: water taken by means of the weir on Camp Gully, water discharged into Camp Gully and Sydney Water usage. Other meters will measure usage on site (e.g. stockpile sprays and recycled water).

8.8 GROUNDWATER QUALITY

Shallow groundwater quality sampling will be conducted monthly at the following sites (Figure 11):

- sites WRGW1, WRGW2 and WRGW7 along the Waratah Rivulet.

Water quality parameters will include EC, pH, Eh, Ca, Mg, Na, K, Cl, SO_4, HCO_3, Ba, Sr, Mn, Fe, Zn, Co and Al. The samples collected for the analysis of metals will be field filtered.

To identify trends in water quality parameters (i.e. Fe, Mn and pH) over the length of the Waratah Rivulet, groundwater quality sampling will also be conducted at sites WRGW1, WRGW2, WRGW3, WRGW5[28], WRGW6 and WRGW7.

Unfiltered water quality samples will also be collected monthly at site WRGW7 on the Waratah Rivulet and analysed for total iron.

8.9 TRIGGER ACTION RESPONSE PLANS AND ASSESSMENT OF PERFORMANCE INDICATORS AND MEASURES

The monitoring results will be used to assess the Project against the performance indicators and performance measures using the TARPs detailed in Tables 23 to 27.

[28] Site WRGW4 was sheared in 2011 and subsequently has not been sampled.

Table 23
Trigger Action Response Plan – Negligible Reduction to the Quantity of Water Resources Reaching the Woronora Reservoir

Performance Measure	Performance Indicator	Monitoring Site(s)	Parameters	Frequency/ Sample Size	Analysis Methodology	Error Types	Baseline	Significance Levels/ Triggers		Action/Response
Negligible reduction to the quantity of water resources reaching the Woronora Reservoir	*Changes in the quantity of water entering Woronora Reservoir are not significantly different post-mining compared to pre-mining, that are not also occurring in the control catchment.*	WaterNSW gauging station on Waratah Rivulet (GS 2132102) WaterNSW gauging station on O'Hares Creek at Wedderburn (GS 213200) (control site)	Surface water flow.	Monthly download of continuous data-logger.	Analysis of measured flow versus modelled flows in Waratah Rivulet using catchment model, specifically: - Monitored flows will be filtered in order to assess low flows (i.e. flows of 1 mm/day or less)[1]. - The filtered monitored flows on Waratah Rivulet will be integrated over successive 14 day periods to produce a smoothed set of data for comparison with the corresponding integrated flows (14 day totals) predicted by the modified AWBM model for the Waratah Rivulet. - The ratio of filtered monitored flows divided by the modified AWBM predicted flows will be calculated at 14 day intervals commencing at the beginning of the baseline period and advancing beyond the commencement of Longwall 20 secondary extraction. The median of the ratios will be analysed over a sliding window of 1 year. Analysis of measured flow versus modelled flows in Waratah Rivulet, six monthly, within one month of download.	Accuracy of flow measurements which depend on measuring water level and conversion of water level (stage) to flow using a flow versus stage (rating curve). Accuracy of catchment flow modelling.	Baseline data (prior to commencement of Longwall 20) is available from the gauging station on Waratah Rivulet from March 2007 to May 2010. Estimated minimum daily flow recorded during baseline period was 0.048 ML/day. Baseline data for O'Hares Creek is available over the same period. Estimated minimum daily flow during adopted baseline period was 0.0063 ML/day.	Level 1	The median of the ratios does not fall below the 35th percentile of the baseline data	Continue monitoring. Six monthly reporting.
								Level 2	The median of the ratios falls below the 35th percentile but does not fall below the 20th percentile of the baseline data	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	The median of the ratios falls below the 20th percentile of the baseline data	Conduct the same analysis of measured flow versus modelled flows for the control catchment, specifically: - The filtered monitored flow rates on O'Hares Creek and Woronora River will be integrated over successive 14 day periods to produce a smoothed set of data for comparison with the corresponding integrated flows (14 day totals) predicted by the modified AWBM models of the same catchments. - The ratio of the filtered monitored flow divided by the modified AWBM predicted flow will be calculated at 14 day intervals commencing at the beginning of the baseline period and advancing beyond the commencement of Longwall 20 secondary extraction. The median of the ratios will be analysed over a sliding window of 1 year. If the same has occurred in the control catchment, continue monitoring and six monthly reporting. If the same has not occurred in the control catchment: • Increase the frequency of data analysis to quarterly (until such time that data analysis indicates a return to Level 1). • Undertake investigation and assess against the performance measure. Report to DPE, WaterNSW, DPE – Water and BCS within one month of assessment completion. • Consider the need for management measures, in accordance with Sections 8 and 9.

[1] Monitored flows will be filtered numerically (in order to remove the effect of high flows) by setting monitored flows that are greater than 1mm/day to equal modelled flows.

Table 24-A
Trigger Action Response Plan – Negligible Reduction to the Quality of Water Resources Reaching the Woronora Reservoir

Performance Measure	Performance Indicator	Monitoring Site(s)	Parameters	Frequency/ Sample Size	Analysis Methodology	Error Types	Baseline	Significance Levels/Triggers		Action/Response
Negligible reduction to the quality of water resources reaching the Woronora Reservoir.	*Changes in the quality of water entering Woronora Reservoir are not significantly different post-mining compared to pre-mining concentrations that are not also occurring at control site WOWQ2.*	Site WRWQ9 on the Waratah Rivulet. Site ETWQ AU on the Eastern Tributary. Control site WOWQ2 on the Woronora River.	Iron (Fe). Manganese (Mn). Aluminium (Al). [Field filtered].	Monthly.	Water quality data analysed quarterly, following the receipt of laboratory data[1]: • Adjusted baseline mean plus two standard deviations[2, 3] have been calculated for each water quality parameter and are provided in Table 24-B. • Adjusted baseline mean plus one standard deviation[4, 5] has been calculated for each water quality parameter and are provided in Table 24-B. The six month mean metal concentration will also be calculated at the end of each six month review period.	Potential for sampling, laboratory and data management errors.	<u>WRWQ9</u> • Fe (0.03 to 0.39 mg/L). • Mn (0.01[6] to 0.069 mg/L). • Al (0.001[6] to 0.15 mg/L). <u>ETWQ AU</u> • Fe (0.1 to 0.5 mg/L). • Mn (0.005[6] to 0.033 mg/L). • Al (0.03 to 0.11 mg/L). <u>WOWQ2</u> • Fe (0.05[6] to 1.3 mg/L). • Mn (0.01[6] to 0.1 mg/L). • Al (0.0005[6] to 0.11 mg/L).	Level 1	Data analysis indicates no water quality parameter exceeds the adjusted baseline mean plus two standard deviations.	Continue monitoring. Six monthly reporting.
								Level 2	Data analysis indicates any water quality parameter exceeds the adjusted baseline mean plus two standard deviations for one month.	Increase the frequency of data analysis to monthly (until such time that data analysis indicates a return to Level 1). Six monthly reporting.
								Level 3	Data analysis indicates: • any water quality parameter exceeds the adjusted baseline mean plus two standard deviations for two consecutive months; or • over a three month period the water quality parameter exceeds the adjusted mean plus two standard deviations in the first month, the adjusted mean plus one standard deviation in the next month and the adjusted mean plus two standard deviations in the third month; or • the six month mean exceeds the adjusted baseline mean plus one standard deviation for two consecutive assessment periods (i.e. over two six monthly reports); and • there was not a similar exceedance of the trigger at the control site.	Increase the frequency of data analysis to monthly (until such time that data analysis indicates a return to Level 1). If the water quality parameter is greater than the historical maximum, then undertake an investigation and assess against the performance measure. If the water quality parameter is less than the historical maximum, then undertake an investigation and assess against the performance measure at the end of the quarter[7]. Report to DPE, WaterNSW, DPE – Water and BCS within one month of assessment completion. Consider the need for management measures, in accordance with Sections 8 and 9.

[1] Log transformations (i.e. base 10 logs of the water quality concentrations) will be used to calculate the arithmetic means and standard deviations. Log transformations are commonly applied to concentrations as part of statistical analyses in water resources studies as is evidenced by the following statement from a US Geological Survey publication regarding such analyses: "In order to make an asymmetric distribution become more symmetric, the data can be transformed or re-expressed into new units. These new units alter the distances between observations on a line plot. The effect is to either expand or contract the distances to extreme observations on one side of the median, making it look more like the other side. The most commonly-used transformation in water resources is the logarithm. Logs of water discharge, hydraulic conductivity, or concentration are often taken before statistical analyses are performed." Techniques of Water-Resources Investigations of the United States Geological Survey Book 4, Hydrologic Analysis and Interpretation Chapter A3 Statistical Methods By D.R. Helsel and R.M. Hirsch in Water Resources (September 2002), section 1.7.1, page 12.

[2] Baseline is considered to be prior to subsidence effects occurring from Longwall 20 on the relevant environmental feature. In this case, baseline data at site WRWQ9 includes data from September 2006 to 18 May 2010 (i.e. prior to the commencement of Longwall 20). The baseline period for site ETWQ AU includes data from January 2010 to 25 May 2011 on the basis of negligible subsidence effects. Comparable means plus two standard deviations have been calculated at control site WOWQ2 using concurrent monitoring data i.e. a comparable mean plus two standard deviations has been calculated for the control site WOWQ2 using monitoring data over the same period of time used to calculate the baseline mean plus two standard deviations at WRWQ9. Similarly, a comparable mean plus two standard deviations has been calculated for the control site WOWQ2 using monitoring data over the same period of time used to calculate the baseline mean plus two standard deviations at ETWQ AU.

[3] The maximum percentage increase in the mean plus two standard deviations at the control site (WOWQ2) since the end of the baseline period to December 2014 has been calculated as described in 2. Above. The maximum percentage increase at the control site has been used to factor up the baseline mean plus two standard deviations values for WRWQ9 and ETWQ AU to account for increasing trends in water quality at the control site. This has resulted in adjusted mean plus two standard deviation values for each site (where appropriate).

[4] Baseline is considered to be prior to subsidence effects occurring from Longwall 20 on the relevant environmental feature. In this case, baseline data at site WRWQ9 includes data from September 2006 to 18 May 2010 (i.e. prior to the commencement of Longwall 20). The baseline period for site ETWQ AU includes data from January 2010 to 25 May 2011 on the basis of negligible subsidence effects. Comparable mean plus one standard deviation values have been calculated at control site WOWQ2 using concurrent monitoring data i.e. a comparable mean plus one standard deviation has been calculated for the control site WOWQ2 using monitoring data over the same period of time used to calculate the baseline mean plus one standard deviations at WRWQ9. Similarly, a comparable mean plus one standard deviation has been calculated for the control site WOWQ2 using monitoring data over the same period of time used to calculate the baseline mean plus one standard deviation at ETWQ AU.

[5] The maximum percentage increase in the mean plus one standard deviation at the control site (WOWQ2) since the end of the baseline period to December 2014 has been calculated as described in 4. Above. The maximum percentage increase at the control site has been used to factor up the baseline mean plus one standard deviation values for WRWQ9 and ETWQ AU to account for increasing trends in water quality at the control site. This has resulted in adjusted mean plus one standard deviation values for each site (where appropriate).

[6] Results reported as < (detection limit) have been set equal to nominated detection limit.

[7] Based on historical assessments of the performance measure, Professor Barry Noller (The University of Queensland) has recommended (February 2021) that the assessment against the performance measure be undertaken quarterly where the measured concentrations are less than the historical maximum (The University of Queensland, 2021j – 2021n).

Table 24-B
Adjusted Baseline Mean plus Standard Deviations for Sites WRWQ9, ETWQ AU and WOWQ2

Assessment	Site	Water Quality Indicator	Baseline Mean Plus Two Standard Deviations (mg/L)	Adjusted Baseline Mean Plus Two Standard Deviations (mg/L)	Baseline Mean Plus One Standard Deviation (mg/L)	Adjusted Baseline Mean Plus One Standard Deviation (mg/L)
Waratah Rivulet water quality post-mining versus baseline, and compared to control site WOWQ2	**WRWQ9**	Filtered Iron	0.544	0.706	0.284	0.337
		Filtered Aluminium	0.097	0.100	0.041	0.047
		Filtered Manganese	0.092	0.117	0.055	0.066
	WOWQ2 (using same baseline period as WRWQ9 to allow comparison)	Filtered Iron	0.741	0.961	0.324	0.385
		Filtered Aluminium	0.244	0.250	0.094	0.109
		Filtered Manganese	0.064	0.082	0.042	0.051
Eastern Tributary water quality post-mining versus baseline, and compared to control site WOWQ2	**ETWQ AU**	Filtered Iron	0.543	0.543	0.336	0.336
		Filtered Aluminium	0.094	0.188	0.065	0.106
		Filtered Manganese	0.029	0.030	0.017	0.020
	WOWQ2 (using same baseline period as ETWQ AU to allow comparison)	Filtered Iron	1.657	1.657	0.555	0.555
		Filtered Aluminium	0.075	0.151	0.061	0.100
		Filtered Manganese	0.090	0.094	0.052	0.058

Table 25
Trigger Action Response Plan – No Connective Cracking Between the Surface and the Mine and Negligible Leakage from Woronora Reservoir

Performance Measure	Performance Indicator	Monitoring Site(s)	Parameters	Frequency/ Sample Size	Analysis Methodology	Error Types	Baseline	Significance Levels/ Triggers		Action/Response
No connective cracking between the surface and the mine	*Visual inspection does not identify abnormal water flow from the goaf, geological structure, or the strata generally.*	Underground.	Inspections of development workings for water accumulation.	Weekly.	Identification of abnormal water flow from the goaf, geological structure, or the strata generally.	N/A	No abnormal water flow from the goaf, geological structure, or the strata generally	Level 1	Normal water flow identified from the goaf, geological structure, or the strata generally.	Continue monitoring. Six monthly reporting.
								Level 2	Abnormal water flow identified from the goaf, geological structure, or the strata generally, however consistent with expected operational conditions.	Increase the frequency of data analysis to daily (until such time that data analysis indicates a return to Level 1). Six monthly reporting.
								Level 3	Abnormal water flow identified from the goaf, geological structure, or the strata generally, inconsistent with expected operational conditions.	Increase the frequency of data analysis to daily (until such time that data analysis indicates a return to Level 1). Undertake investigation and assess against the performance measure. Report to DPE, WaterNSW, DPE – Water and BCS within one month of assessment completion. Consider the need for management measures, in accordance with Sections 8 and 9.
	The 20-day average mine water make does not exceed 1 ML/day.	Underground	• Backfill water used to assist pumping into the mine. • Metered water reticulated out of the mine (mine outflow). • Moisture content into and out of the mine through the mine ventilation system (mine inflow and outflow). • *In-situ* moisture content of the coal (mine inflow). • Moisture content of ROM coal conveyed out of the mine at the drift portal (mine outflow). • Moisture content of gas stream reticulated out of the mine to the gas drainage plant (mine outflow).	• Continuous monitoring, downloaded monthly. • Moisture content will be monitored using a digital psychrometer: - every hour over a 9 hour period on two occasions during a 12 month period; - daily (weekday) when possible; and - minimum once per week. • Measured during routine channel sampling for coal quality. • Continuous monitoring using an automated moisture scanner, downloaded monthly.	Water make[1] calculated from the difference between total mine inflows and total mine outflows, within one month of download.	Instrumentation precision.	The modelled daily mine inflow to Longwalls 308-310 is predicted to be less than 0.2 ML/day on average.	Level 1	20-day average mine water make is less than or equal to 0.5 ML/day.	Continue monitoring. Six monthly reporting.
								Level 2	20-day average mine water make is between 0.5 ML/day and 1 ML/day.	Increase the frequency of data analysis to fortnightly (until such time that data analysis indicates a return to Level 1). Six monthly reporting.
								Level 3	20-day average mine water make is greater than or equal to 1 ML/day.	Increase the frequency of data analysis to fortnightly (until such time that data analysis indicates a return to Level 1). Undertake investigation and assess against the performance measure. Report to DPE, WaterNSW, DPE – Water and BCS within one month of assessment completion. Consider the need for management measures, in accordance with Sections 8 and 9.

Table 25 (Continued)
Trigger Action Response Plan – No Connective Cracking Between the Surface and the Mine and Negligible Leakage from Woronora Reservoir

Performance Measure	Performance Indicator	Monitoring Site(s)	Parameters	Frequency/ Sample Size	Analysis Methodology	Error Types	Baseline	Significance Levels/ Triggers		Action/Response
No connective cracking between the surface and the mine	*Significant departure from the predicted envelope of the vertical potentiometric head profile at Bore PM02 does not occur.*	Bore PM02	Groundwater pressures/levels	Monthly download of continuous datalogging.	Analysis of vertical head profiles, six-monthly, within one month of download	Datalogger instrumentation precision to 1 mm; error is +/- 0.5 mm	Predicted profile for longwall panel relevant to longwall status	Level 1	PM02 Head Profile is consistent with the shape and magnitude of the predicted Model Curve[2]	Continue monitoring. Six monthly reporting.
								Level 2	PM02 Head Profile is consistent with the shape of, and does not lie significantly to the left of the predicted Model Curve[2]	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	PM02 Head Profile is inconsistent with the shape of, or lies significantly to the left of the predicted Model Curve[2]	Increase the frequency of data analysis to quarterly (until such time that data analysis indicates a return to Level 1). Undertake investigation and assess against the performance measure. Report to DPE, WaterNSW, DPE - Water and BCS within one month of assessment completion. Consider the need for management measures, in accordance with Sections 8 and 9.
	Significant departure from the predicted envelope of the vertical potentiometric head profile at Bore PHGW2A does not occur.	Bore PHGW2A	Groundwater pressures/levels	Monthly download of continuous datalogging.	Analysis of vertical head profiles, six-monthly, within one month of download	Datalogger instrumentation precision to 1 mm; error is +/- 0.5 mm	Predicted profile for longwall panel relevant to longwall status	Level 1	PHGW2A Head Profile is consistent with the shape and magnitude of the predicted Model Curve[2]	Continue monitoring. Six monthly reporting.
								Level 2	PHGW2A Head Profile is consistent with the shape of, and does not lie significantly to the left of the predicted Model Curve[2]	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	PHGW2A Head Profile is inconsistent with the shape of, or lies significantly to the left of the predicted Model Curve[2]	Increase the frequency of data analysis to quarterly (until such time that data analysis indicates a return to Level 1). Undertake investigation and assess against the performance measure. Report to DPE, WaterNSW, DPE - Water and BCS within one month of assessment completion. Consider the need for management measures, in accordance with Sections 8 and 9.
No connective cracking between the surface and the mine. **Negligible leakage from the Woronora Reservoir.**	*The hydraulic gradient to the Woronora Reservoir at full supply level from Bore PHGW2A is reduced by no more than 40% from that measured to 30 June 2017[5].*	Bore PHGW2A (97.5 m)	Groundwater pressures/levels.	Monthly download of continuous datalogging.	Analysis of water tables quarterly, within one month of download.	Datalogger instrumentation precision to 1 mm; error is +/- 0.5 mm.	PHGW2A > 186.92 m AHD[2]	Level 1	PHGW2A[4] >= 186.92 m AHD	Continue monitoring. Six monthly reporting.
								Level 2	PHGW2A[4] < 186.92 m AHD and > 179.71 m AHD	Increase the frequency of data analysis to monthly (until such time that data analysis indicates a return to Level 1). Six monthly reporting.
								Level 3	PHGW2A[4] =< 179.71 m AHD	Increase the frequency of data analysis to monthly (until such time that data analysis indicates a return to Level 1). Undertake investigation and assess against the performance measures. Report to DPE, WaterNSW, DPE - Water and BCS within one month of assessment completion. Consider the need for management measures, in accordance with Sections 8 and 9.

Table 25 (Continued)
Trigger Action Response Plan – No Connective Cracking Between the Surface and the Mine and Negligible Leakage from Woronora Reservoir

Performance Measure	Performance Indicator	Monitoring Site(s)	Parameters	Frequency/ Sample Size	Analysis Methodology	Error Types	Baseline	Significance Levels/ Triggers		Action/Response
Negligible leakage from the Woronora Reservoir.	*The hydraulic gradient to the Woronora Reservoir at full supply level from Bore 9EGW2A is reduced by no more than 40% from that measured to 30 June 2017[5].*	Bore 9EGW2A (107.5 m)	Groundwater pressures/levels.	Monthly download of continuous datalogging.	Analysis of water tables quarterly, within one month of download.	Datalogger instrumentation precision to 1 mm; error is +/- 0.5 mm.	9EGW2A > 186.32 m AHD[3]	Level 1	9EGW2A[4] >= 186.32 m AHD	Continue monitoring. Six monthly reporting.
								Level 2	9EGW2A[4] < 186.32 m AHD and > 179.35 m AHD	Increase the frequency of data analysis to monthly (until such time that data analysis indicates a return to Level 1). Six monthly reporting.
								Level 3	9EGW2A[4] =< 179.35 m AHD	Increase the frequency of data analysis to monthly (until such time that data analysis indicates a return to Level 1). Undertake investigation and assess against the performance measure. Report to DPE, WaterNSW, DPE – Water and BCS within one month of assessment completion. Consider the need for management measures, in accordance with Sections 8 and 9.
	The hydraulic gradient to the Woronora Reservoir at full supply level from Bore PM02 is reduced by no more than 40% from that measured to 30 June 2017[5].	Bore PM02 (100 m)	Groundwater pressures/levels.	Monthly download of continuous datalogging.	Analysis of water tables, quarterly, within one month of download.	Datalogger instrumentation precision to 1 mm; error is +/- 0.5 mm.	PM02 > 183.86 m AHD[3]	Level 1	PM02[4] >= 183.86 m AHD	Continue monitoring. Six monthly reporting.
								Level 2	PM02[4] < 183.86 m AHD and > 177.88 m AHD	Increase the frequency of data analysis to monthly (until such time that data analysis indicates a return to Level 1). Six monthly reporting.
								Level 3	PM02[4] =< 177.88 m AHD	Increase the frequency of data analysis to monthly (until such time that data analysis indicates a return to Level 1). Undertake investigation and assess against the performance measure. Report to DPE, WaterNSW, DPE – Water and BCS within one month of assessment completion. Consider the need for management measures, in accordance with Sections 8 and 9.
	The hydraulic gradient from transect bore T5 to bore T3-R is reduced by no more than 10% from that measured on 30 June 2017.	Bores T3-R and T5	Groundwater levels	Monthly download of continuous datalogging.	Analysis of water tables quarterly, within one month of download.	Datalogger instrumentation precision to 1 mm; error is +/- 0.5 mm	T5-T3-R = 17.92 m[7]	Level 1	T5-T3-R >= 17.92 m	Continue monitoring. Six monthly reporting.
								Level 2	T5-T3-R < 17.92 m and > 16.13 m	Increase the frequency of data analysis to monthly (until such time that data analysis indicates a return to Level 1). Six monthly reporting.
								Level 3	T5-T3-R =< 16.13 m	Increase the frequency of data analysis to monthly (until such time that data analysis indicates a return to Level 1). Undertake investigation and assess against the performance measure. Report to DPE, WaterNSW, DPE – Water and BCS within one month of assessment completion. Consider the need for management measures, in accordance with Sections 8 and 9.

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

2 Based on the measured potentiometric head profile (averaged over the preceding month). In forming the vertical head profile from vibrating-wire piezometer measurements, unreliable data points are to be excised. A data point will be considered unreliable for any of the following reasons: the piezometer response has not yet stabilised (common in claystones); a piezometer head is inconsistent with overlying and underlying measurements; or the piezometer head has an unreasonably low pressure head component (to be recognised by proximity to the line of unsaturation).

3 Minimum measurement to 30 June 2017.

4 7-Day Average Potentiometric Head at the mid Hawkesbury Sandstone Piezometer

5 As mining approaches bores they will be subject to localised subsidence effects (i.e. due to tilts and strains), which may result in compromised VWP pressure measurements. These will be considered during the implementation of the TARP. The purpose of the TARP is not to monitor for localised subsidence effects; rather it is to measure the hydraulic gradient in the groundwater to the Woronora Reservoir.

6 As at 31 March 2019, the water level in the Woronora Reservoir was 155.9 mAHD, some 13 m below the Woronora Reservoir full supply level, and some 23 m below the Level 3 trigger of 178.9 mAHD.

7 30 June 2017 measurement.

Table 26
Trigger Action Response Plan – Negligible Reduction to the Quality of Water Resources in the Woronora Reservoir

Performance Measure	Performance Indicator	Monitoring Site(s)	Parameters	Frequency/ Sample Size	Analysis Methodology	Error Types	Baseline	Significance Levels/ Triggers		Action/Response
Negligible reduction in the water quality of Woronora Reservoir.	*Changes in the quality of water in the Woronora Reservoir are not significantly different post-mining compared to pre-mining concentrations.*	Woronora Reservoir (site DW01) (subject to data availability from WaterNSW) Nepean Reservoir (subject to data availability from WaterNSW) Cataract Reservoir (subject to data availability from WaterNSW)	Total Iron (Fe). Total Manganese (Mn). Total Aluminium (Al).	Sampling frequency is variable.	Water quality data analysed annually, following the receipt of data from WaterNSW. Water quality parameters, measured in the same location on the same day will be geometrically averaged. The parameter records will be interpolated to provide daily records. Concentration exceedance duration curves will be calculated for each parameter by determining the concentration exceeded at each location by percentages of days of the year covering the full range from 0% to 100%, at 5% intervals. Baseline data[1] will be analysed in an annual format to determine concentration exceeded with an estimated average recurrence interval (ARI[2]) curve of 20 years by percentages of days in the year from 0% to 100%. For each percentage of time selected from this range, an ARI curve will be calculated by fitting a log Generalised Extreme Value distribution to the concentration exceeded each year of the baseline record by that percentage of days. For each water quality parameter, the concentration exceedance curve for the current year of monitoring and the 20 year ARI exceedance curve calculated from the baseline records will be plotted on a graph.	Potential for sampling, laboratory and data management errors.	Baseline 10 and 20 year ARI exceedance curve	Level 1	The current year's duration exceedance curve for a water quality parameter in Woronora Reservoir (total iron, total manganese and total aluminium) is below the baseline 10 year ARI exceedance curve for any range of the duration percentages from 0% to 75%.	Continue monitoring. Annual reporting.
								Level 2	The current year's duration exceedance curve for a water quality parameter in Woronora Reservoir (total iron, total manganese and total aluminium) is above the baseline 10 year ARI but below the baseline 20 year ARI exceedance curve for any range of the duration percentages from 0% to 75%.	Plot and qualitatively assess the Woronora Reservoir, Nepean Reservoir and Cataract Reservoir water quality data every six months (until such time that data analysis indicates a return to Level 1). Annual reporting.
								Level 3	The current year's duration exceedance curve for a water quality parameter in Woronora Reservoir (total iron, total manganese and total aluminium) is above the baseline 20 year ARI exceedance curve for any range of the duration percentages from 0% to 75%.	Plot and qualitatively assess the data from the Nepean Reservoir and Cataract Reservoir. Undertake investigation and assess against the performance measure. Report to DPE, WaterNSW, DPE – Water and BCS within one month of assessment completion. Consider the need for management measures, in accordance with Sections 8 and 9.

1 Baseline data includes data prior to 19 May 2010 (i.e. prior to the commencement of Longwall 20).

2 Average Recurrence Interval. This term has been used here for consistency with previous Annual Reviews and Water Management Plans. Based on recommendations by the Institution of Engineers Australia, the preferred terminology now involves the term Annual Exceedance Probability (AEP) expressed as a percentage probability. This is to avoid confusion that the term ARI has caused within the industry, community and other stakeholders. A 20 year ARI is equivalent to a 5% AEP.

Table 27
Trigger Action Response Plan – Negligible Environmental Consequences on Waratah Rivulet

Performance Measure	Performance Indicator	Monitoring Site(s)	Parameters	Frequency/ Sample Size	Analysis Methodology	Error Types	Baseline	Significance Levels/ Triggers		Action/Response
No Diversion of Flows, No Change in the Natural Drainage Behaviour										
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).	*No change to the natural drainage behaviour of Pools P, Q, R, S, T, U, V and W.*	Pools P to W on Waratah Rivulet. Control pools on the Woronora River.	Streambed cracking and drainage behaviour.	Monthly, during download of pool water level data.	Visual inspections of Pools P to W for streambed cracking and changes to the natural drainage behaviour.	Limitations of visual observations.	No mine-induced surface cracking present at Pools P, Q, R, S, T, U, V or W within the stream bed or rock bar. Pools P and T flow through and below rock bars. Pools Q, R and S terminate at rock bars. Pools U and W terminate in a boulder field (i.e. no flow over a rock bar). Pool V terminates in a rock bar characterised by partial flow over the rock bar and partial flow through and below the rock bar.	Level 1	No mine-induced surface cracking or impacts to natural drainage behaviour observed	Continue monitoring. Six monthly reporting.
								Level 2	Mine-induced surface cracking observed. No impacts to natural drainage behaviour observed.	Initiate survey of the relevant subsidence cross line. Assess pool water level data. Six monthly reporting.
								Level 3	There appear to be impacts to natural drainage behaviour such that: - a pool does not continue to flow over, through and/or below the rock bars (where relevant); or - surface flow is not evident along the length of Pools P or T prior to flowing through/below the rock bars; - surface flow is not evident along the length of Pools Q, R or S prior to flowing over the rock bars; - surface flow is not evident along the length of Pool V prior to flowing over/through/below the rock bar; and - surface flow is not evident along the length of Pools U or W prior to flowing through the downstream boulder field.	Initiate survey of the relevant subsidence cross line. Assess pool water level data. Undertake investigation and assess against the performance measure. Report to DPE, WaterNSW, DPE – Water and BCS within one month of assessment completion. Consider the need for management measures, in accordance with Sections 8 and 9.
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).	*Analysis of water level data for Pools P, T, U, V and W indicates the water level is at or above the pool's previous minimum.*	Pools P, T, U, V and W on Waratah Rivulet. Control pools on the Woronora River.	Pool water level.	Monitored continuously, with a data logger and downloaded monthly.	Analysis of Pools P, T, U, V and W water level data against the pool's previous minimum, quarterly, within one month of download. Analysis of Pools U, V and W water level data against the pool's previous minimum within one month of download when Longwall 307 extraction is within 450 m of the Waratah Rivulet.	Water level sensor precision, data logger malfunction and download error.	Pool water level hydrographs to 31 December 2018[1]	Level 1	The water level in Pools P, T, U, V or W has not been below the pool's previous minimum.	Continue monitoring. Six monthly reporting.
								Level 2	The water level in Pools P, T, U, V or W has been below the pool's previous minimum, however, is considered to be due to an error type.	Increase the frequency of data analysis to monthly (until such time that data analysis indicates a return to Level 1). Six monthly reporting.
								Level 3	The water level in Pools P, T, U, V or W has been below the pool's previous minimum and does not appear to be due to an error type; and the same is not occurring in control pool(s).	Increase the frequency of data analysis to monthly (until such time that data analysis indicates a return to Level 1). Initiate survey of the relevant subsidence cross line. Undertake investigation (including assessment of control pools) and assess against the performance measure. Report to DPE, WaterNSW, DPE – Water and BCS within one month of assessment completion. Consider the need for management measures, in accordance with Sections 8 and 9.

Table 27 (Continued)
Trigger Action Response Plan – Negligible Environmental Consequences on Waratah Rivulet

Performance Measure	Performance Indicator	Monitoring Site(s)	Parameters	Frequency/ Sample Size	Analysis Methodology	Error Types	Baseline	Significance Levels/ Triggers		Action/Response
No Diversion of Flows, No Change in the Natural Drainage Behaviour (Continued)										
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)	*Analysis of water level data for Pools Q, R and S indicates the water levels are above that required to maintain water over the downstream rock bar.*	Pools Q, R and S on Waratah Rivulet. Control pools on the Woronora River.	Pool water level.	Monitored continuously, with a data logger and downloaded monthly.	Analysis of Pools Q, R and S water level data against the level required to maintain water over the downstream rock bar, quarterly, within one month of download.	Water level sensor precision, data logger malfunction and download error.	Pool water level hydrographs to 31 December 2018[1]	Level 1	The water level in Pools Q, R or S has been above that required to maintain water over the downstream rock bar.	Continue monitoring. Six monthly reporting.
								Level 2	The water level in Pools Q, R or S has been below that required to maintain water over the downstream rock bar, however, appears to be due to an error type.	Increase the frequency of data analysis to monthly (until such time that data analysis indicates a return to Level 1). Six monthly reporting.
								Level 3	The water level in Pools Q, R or S has been below that required to maintain water over the downstream rock bar and does not appear to be due to an error type and the same is not occurring in control pool(s).	Increase the frequency of data analysis to monthly (until such time that data analysis indicates a return to Level 1). Initiate survey of the relevant subsidence cross line. Undertake investigation (including assessment of control pools) and assess against the performance measure. Report to DPE, WaterNSW, DPE – Water and OEH within one month of assessment completion. Consider the need for management measures, in accordance with Sections 8 and 9.
Minimal Iron Staining										
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)	*Visual inspection of the Waratah Rivulet from Pool P to the full supply level of the Woronora Reservoir does not show significant changes in the extent or nature of iron staining that isn't also occurring in the Woronora River (control site).*	Waratah Rivulet, from Pool P to the full supply level of the Woronora Reservoir.	Nature and extent of iron staining	Monthly	Visual inspections of Waratah Rivulet	Subjective nature of visual observations.	Iron staining present (dark in colour [crystalline goethite]), apparent in the baseline stream mapping photographs. Natural seeps and associated iron staining also occur (as recorded by baseline mapping).	Level 1	The extent or nature of iron staining in the Waratah Rivulet from Pool P to the full supply level of the Woronora Reservoir has not changed.	Continue monitoring. Six monthly reporting.
								Level 2	The extent or nature of iron staining in the Waratah Rivulet from Pool P to the full supply level of the Woronora Reservoir has changed significantly, as a result of climatic conditions.	Record the nature and extent of the changes in the Waratah Rivulet. Inspect the nature and extent of iron staining on the Woronora River (control site). Increase the frequency of visual inspections on the Waratah Rivulet and Woronora River to weekly (until such time that data analysis indicates a return to Level 1). Six monthly reporting.
								Level 3	The extent or nature of iron staining in the Waratah Rivulet from Pool P to the full supply level of the Woronora Reservoir has changed significantly, not as a result of climatic conditions (i.e. a similar change has not occurred in the Woronora River [control site]).	Record the nature and extent of the changes in the Waratah Rivulet. Inspect the nature and extent of iron staining on the Woronora River (control site). Increase the frequency of visual inspections on the Waratah Rivulet and Woronora River to weekly (until such time that data analysis indicates a return to Level 1). Undertake investigation and assess against the performance measure. Report to DPE, WaterNSW, DPE - Water and BCS within one month of assessment completion. Consider the need for management measures, in accordance with Sections 8 and 9.

Table 27 (Continued)
Trigger Action Response Plan – Negligible Environmental Consequences on Waratah Rivulet

Performance Measure	Performance Indicator	Monitoring Site(s)	Parameters	Frequency/ Sample Size	Analysis Methodology	Error Types	Baseline	Significance Levels/ Triggers		Action/Response
Minimal Gas Releases										
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)	*Gas releases in Waratah Rivulet from Pool P to the full supply level of the Woronora Reservoir have not increased beyond those observed up to the commencement of Longwall 301 extraction.*	Waratah Rivulet, from Pool P to the full supply level of the Woronora Reservoir.	Free Carbon Dioxide as CO_2 (mg/L) Methane (mg/L)	Visual inspections for gas releases monthly. Weekly at pools that have been observed with gas releases, until no gas releases have been observed at the pool for three consecutive weeks.	Visual inspections, and where gas releases occur, water quality sampling. Analysis of water quality results, quarterly, within one month of the receipt of laboratory results.	<u>Free Carbon Dioxide as CO_2 (mg/L)</u> ALS Method APHA 4500 CO_2-D Detection limit is 1 mg/L[4]. <u>Methane (mg/L)</u> ALS Method EPO33: Methane Detection limit is 0.01 mg/L[5].	No gas releases observed in Waratah Rivulet from Pool P to the full supply level of the Woronora Reservoir prior to the mining of Longwall 20. Pool P – gas releases observed in February 2014; May 2014 to February 2015; May and June 2015; September 2015 to June 2017. Pool U – gas releases observed in August 2016 to June 2017. Pool W – gas releases observed in January to May 2016; October 2016. Assessment of gas releases in pools to 30 June 2017 indicates the performance measure has been met.	Level 1	Free carbon dioxide concentrations are equal to or less than 4 mg/L[2] in Waratah Rivulet pools from Pool P to the full supply level of the Woronora Reservoir. Methane concentrations are equal to or less than 0.159 mg/L[2] in Waratah Rivulet pools from Pool P to the full supply level of the Woronora Reservoir.	Continue monitoring. Six monthly reporting.
								Level 2	Free carbon dioxide concentrations are above 4 mg/L and equal to or less than 13 mg/L[3] in Waratah Rivulet pools from Pool P to the full supply level of the Woronora Reservoir. Methane concentrations are above 0.159 mg/L and equal to or less than 0.478 mg/L[3] in Waratah Rivulet pools from Pool P to the full supply level of the Woronora Reservoir.	Increase the frequency of data analysis to monthly in pools subject to gas releases (until such time that data analysis indicates a return to Level 1). Six monthly reporting.
								Level 3	Free carbon dioxide concentrations are above 13 mg/L in Waratah Rivulet pools from Pool P to the full supply level of the Woronora Reservoir. Methane concentrations are above 0.478 mg/L in Waratah Rivulet pools from Pool P to the full supply level of the Woronora Reservoir.	If the gas concentration parameter is greater than the historical maximum, then undertake an investigation and assess against the performance measure. If the gas concentration parameter is less than historical maximum, then undertake an investigation report and assess against the performance measure at the end of the quarter[6], Report to DPE, WaterNSW, DPE – Water and BCS within one month of assessment completion. Consider the need for management measures, in accordance with Sections 8 and 9.

1 Hydro Engineering & Consulting (2021b) Metropolitan Coal Surface Water Review 1 January to 30 June 2021.

2 This value is the 80th percentile of the free carbon dioxide or methane results for gas releases recorded in Waratah Rivulet pools from Pool P to the full supply level of the Woronora Reservoir and in Eastern Tributary pools downstream of the Longwall 26 maingate to 30 June 2017. For the calculation of the 80th percentile, values less than the detection limit (<1 mg/L for free carbon dioxide and <0.01 mg/L for methane) have been taken as the value of the detection limit (i.e. as 1 mg/L or 0.01 mg/L).

3 This value is the 99th percentile of the free carbon dioxide or methane results for gas releases recorded in Waratah Rivulet pools from Pool P to the full supply level of the Woronora Reservoir and in Eastern Tributary pools downstream of the Longwall 26 maingate to 30 June 2017. For the calculation of the 99th percentile, values less than the detection limit (<1 mg/L for free carbon dioxide and <0.01 mg/L for methane) have been taken as the value of the detection limit (i.e. as 1 mg/L or 0.01 mg/L).

4 For 4 mg/L and 13 mg/L in Waratah Rivulet pools from Pool P to the full supply level of the Woronora Reservoir, the error for 2X the Detection Limit (DL) is 50% and 15.4%, respectively.

5 For 0.159 mg/L and 0.478 mg/L in Waratah Rivulet pools from Pool P to the full supply level of the Woronora Reservoir, the error for 2X the Detection Limit (DL) is 11.2% and 4.2%, respectively.

6 Based on historical assessments of the performance measure, Professor Barry Noller (The University of Queensland) has recommended (February 2021) that the assessment against the performance measure be undertaken quarterly where the measured concentrations are less than the historical maximum (The University of Queensland, 2021b – 2021e).

Table 28
Trigger Action Response Plan – Negligible Environmental Consequences on Eastern Tributary

Performance Measure	Performance Indicator	Monitoring Site(s)	Parameters	Frequency/ Sample Size	Analysis Methodology	Error Types	Baseline	Significance Levels/ Triggers		Action/Response
No Diversion of Flows, No Change in the Natural Drainage Behaviour										
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[1]	*No change to the natural drainage behaviour of Pools ETAS, ETAT and ETAU.*	Pools/rock bars ETAS, ETAT and ETAU on the Eastern Tributary.	Stream cracking and drainage behaviour.	Monthly.	Visual inspections of pools/rock bars ETAS, ETAT and ETAU on the Eastern Tributary for stream cracking and changes to natural drainage behaviour.	Limitations of visual observations	No mine-induced surface cracking observed to date at Pools ETAS or ETAT. Two separate cracks at downstream end of rock bar ETAU. Crack 1; approximately 2m in length and 1-7 mm wide, Crack 2; approximately 3m in length and 1-7 mm wide (with a 150 mm x 80 mm section sheared). Pool ETAS is a rock bar controlled pool. Water enters the pool as surface flow from boulder field ETAR. The downstream rock bar is permeable (allowing both underflow and surface flow), and appears to be mainly detached blocks and boulders. Due to the nature of rock bar ETAS, Pool ETAS and Pool ETAT typically sit at the same level. Pool ETAT is a rock bar controlled pool. Water enters the pool as surface flow or underflow through rock bar ETAS. The downstream rock bar is effectively impermeable. Pool ETAU flows through Eastern Tributary gauging station, over a rock bar/waterfall	Level 1	No mine-induced surface cracking at Pool ETAS or Pool ETAT; no increase in previous cracking at Pool ETAU. No impacts to natural drainage behaviour observed.	Continue monitoring. Six monthly reporting.
								Level 2	Mine-induced surface cracking observed at Pool ETAS or Pool ETAT, or increase observed in previous cracking at Pool ETAU. No impacts to natural drainage behaviour observed.	Assess the monitoring results from the relevant subsidence cross lines (ETAT and ETAU). Six monthly reporting.
								Level 3	There appear to be impacts to natural drainage behaviour such that there is not continual surface flow along the length of Pools ETAS, ETAT or ETAU.	Assess the monitoring results from the relevant subsidence cross lines. Assess pool water level data for ETAU. Undertake investigation and assess against the performance measure. Report to DPE, WaterNSW, DPE – Water and BCS within one month of assessment completion. Consider the need for management measures, in accordance with Sections 8 and 9.
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[1]	*Analysis of water level data for Pool ETAS/ETAT and Pool ETAU indicates the water levels are above that required to maintain water over the downstream rock bar.*	Pool ETAS/ETAT[2] and ETAU on the Eastern Tributary.	Pool water level.	Monitored continuously, with a data logger and downloaded monthly.	Analysis of Pool ETAS/ ETAT and Pool ETAU water level data, quarterly (within one month of download).	Water level sensor precision, Data logger malfunction and download error.	Pool water level hydrographs to 31 December 2018[3]	Level 1	The water levels in Pool ETAS/ETAT and Pool ETAU have been above that required to maintain water over the downstream rock bar[4].	Continue monitoring. Six monthly reporting.
								Level 2	The water levels in Pool ETAS/ETAT and Pool ETAU has been below that required to maintain water over the downstream rock bar, however, appears to be due to an error type [4].	Increase the frequency of data analysis to monthly (until such time that data analysis indicates a return to Level 1). Six monthly reporting.
								Level 3	The water levels in Pool ETAS/ETAT and Pool ETAU has been below that required to maintain water over the downstream rock bar and does not appear to be due to an error type [4].	Increase the frequency of data analysis to monthly (until such time that data analysis indicates a return to Level 1). Assess the monitoring results from the Pool ETAS/ETAT and Pool ETAU subsidence cross lines. Initiate Incident Reporting and Contingency Plan in the event the performance measure has been exceeded.

Table 28 (Continued)
Trigger Action Response Plan – Negligible Environmental Consequences on Eastern Tributary

Performance Measure	Performance Indicator	Monitoring Site(s)	Parameters	Frequency/ Sample Size	Analysis Methodology	Error Types	Baseline	Significance Levels/ Triggers		Action/Response
Minimal Iron Staining										
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[5]	N/A	Eastern Tributary between the full supply level of the Woronora Reservoir and the maingate of Longwall 26	Nature and extent of iron staining	Within three months of the completion of Longwall 308, Longwall 309 and Longwall 310.	Visual inspections of Eastern Tributary.	Subjective nature of visual observations.	On 14 October 2016, Metropolitan Coal reported the exceedance of the Eastern Tributary performance measure in relation to iron staining to the DPE and other relevant agencies. Iron staining/flocculent is present at a number of stream features between the maingate of Longwall 26 and the full supply level of the Woronora Reservoir.	N/A	N/A	Metropolitan Coal to monitor the nature and extent of iron staining on the Eastern Tributary during the mining of Longwalls 308-310. Metropolitan Coal to implement stream remediation in accordance with the Metropolitan Coal Stream Remediation Plan.

1 The *no diversion of flows, no change in natural drainage behaviour* component of this performance measure was exceeded during the mining of Longwalls 23-37, triggering contingency measures for the impacted pools. This TARP monitors pools not impacted during the mining of Longwalls 23-27.

2 Due to the nature of rock bar ETAS, Pool ETAS and Pool ETAT typically sit at the same level.

3 Hydro Engineering & Consulting (2021b) Metropolitan Coal Surface Water Review 1 January to 30 June 2021.

4 The performance indicator will be considered to have been exceeded if the water level in Pool ETAS/ETAT and/or Pool ETAU has been below that required to maintain water over the downstream rock bar, except where subsidence causes a local change in stream bed profile that affects the level of the pool, but not the natural behaviour of the pool.

5 The minimal iron staining component of this performance measure was exceeded during the mining of Longwalls 23-37, triggering contingency measures for the impacted pools. The nature and extent of iron staining on the Eastern Tributary will continue to be monitored during the mining of Longwalls 308-310.

Table 28 (Continued)
Trigger Action Response Plan – Negligible Environmental Consequences on Eastern Tributary

Performance Measure	Performance Indicator	Monitoring Site(s)	Parameters	Frequency/ Sample Size	Analysis Methodology	Error Types	Baseline[1]	Significance Levels/ Triggers		Action/Response
Minimal Gas Releases										
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	*Gas releases in Eastern Tributary between the full supply level of the Woronora Reservoir and the maingate of Longwall 26 have not increased beyond those observed up to the commencement of Longwall 301 extraction.*	Eastern Tributary between the full supply level of the Woronora Reservoir and the maingate of Longwall 26	Free Carbon Dioxide as CO_2 (mg/L) Methane (mg/L)	Visual inspections for gas releases monthly. Weekly at pools that have been observed with gas releases, until no gas releases have been observed at the pool for three consecutive weeks.	Visual inspections, and where gas releases occur, water quality sampling. Analysis of water quality results, quarterly, within one month of the receipt of laboratory results.	Free Carbon Dioxide as CO_2 (mg/L) ALS Method APHA 4500 CO_2-D Detection limit is 1 mg/L[4]. Methane (mg/L) ALS Method EPO33: Methane Detection limit is 0.01 mg/L[5].	No gas releases observed in Eastern Tributary prior to the mining of Longwall 20. Pool ETAG – gas releases observed in February 2017. Pool ETAI – gas releases observed in March 2017. Pool ETAL – gas releases observed from January to March 2016. Pool ETAM – gas releases observed from January to June 2016. Assessment of gas releases in pools to 30 June 2017 indicates the performance measure has been met.	Level 1	Free carbon dioxide concentrations are equal to or less than 4 mg/L[2] in Eastern Tributary pools between the full supply level of the Woronora Reservoir and the maingate of Longwall 26. Methane concentrations are equal to or less than 0.159 mg/L[2] in Eastern Tributary pools between the full supply level of the Woronora Reservoir and the maingate of Longwall 26.	Continue monitoring. Six monthly reporting.
								Level 2	Free carbon dioxide concentrations are above 4 mg/L and equal to or less than 13 mg/L[3] in Eastern Tributary pools between the full supply level of the Woronora Reservoir and the maingate of Longwall 26. Methane concentrations are above 0.159 mg/L and equal to or less than 0.478 mg/L[3] in Eastern Tributary pools between the full supply level of the Woronora Reservoir and the maingate of Longwall 26.	Increase the frequency of data analysis to monthly in pools subject to gas releases (until such time that data analysis indicates a return to Level 1). Six monthly reporting.
								Level 3	Free carbon dioxide concentrations are above 13 mg/L[3] in Eastern Tributary pools between the full supply level of the Woronora Reservoir and the maingate of Longwall 26. Methane concentrations are above 0.478 mg/L[3] in Eastern Tributary pools between the full supply level of the Woronora Reservoir and the maingate of Longwall 26.	If the gas concentration parameter is greater than the historical maximum, then undertake an investigation and assess against the performance measure. If the gas concentration parameter is less than historical maximum, then undertake an investigation report and assess against the performance measure at the end of the quarter[6], Report to DPE, WaterNSW, DPE – Water and BCS within one month of assessment completion. Consider the need for management measures, in accordance with Sections 8 and 9.

[1] Consistent with the previously approved Longwalls 301-303 WMP, 'baseline' includes gas releases in pools to 30 June 2017.

[2] This value is the 80th percentile of the free carbon dioxide or methane results for gas releases recorded in Waratah Rivulet pools from Pool P to the full supply level of the Woronora Reservoir and in Eastern Tributary pools downstream of the Longwall 26 maingate to 30 June 2017. For the calculation of the 80th percentile, values less than the detection limit (<1 mg/L for free carbon dioxide and <0.01mg/L for methane) have been taken as the value of the detection limit (i.e. as 1 mg/L or 0.01 mg/L).

[3] This value is the 99th percentile of the free carbon dioxide or methane results for gas releases recorded in Waratah Rivulet pools from Pool P to the full supply level of the Woronora Reservoir and in Eastern Tributary pools downstream of the Longwall 26 maingate to 30 June 2017. For the calculation of the 99th percentile, values less than the detection limit (<1 mg/L for free carbon dioxide and <0.01mg/L for methane) have been taken as the value of the detection limit (i.e. as 1 mg/L or 0.01 mg/L).

[4] For 4 mg/L and 13 mg/L in Eastern Tributary pools between the full supply level of the Woronora Reservoir and the maingate of Longwall 26, the error for 2X the Detection Limit (DL) is 50% and 15.4%, respectively.

[5] For 0.159 mg/L and 0.478 mg/L in Eastern Tributary pools between the full supply level of the Woronora Reservoir and the maingate of Longwall 26, the error for 2X the Detection Limit (DL) is 11.2% and 4.2%, respectively.

[6] Based on historical assessments of the performance measure, Professor Barry Noller (The University of Queensland) has recommended (February 2021) that the assessment against the performance measure be undertaken quarterly where the measured concentrations are less than the historical maximum (The University of Queensland, 2021b – 2021e).

8.10 WARATAH RIVULET MONITORING AND ADAPTIVE MANGEMENT

As described in Section 4.1, Metropolitan Coal has established a comprehensive monitoring and adaptive management program to identify subsidence related movements at the Waratah Rivulet to minimise the risk of exceedance of the Waratah Rivulet performance measure. A similar Valley Closure TARP has been successfully implemented by Metropolitan Coal at the Eastern Tributary for Longwalls 303 to 306.

As Longwalls 308, 309 and 310 mine towards the Waratah Rivulet, Metropolitan Coal will implement the Longwalls 308-310 Waratah Rivulet Valley Closure TARP (Table 29) designed to monitor the development of subsidence effects on the Waratah Rivulet. The longwall layouts have been designed for a low likelihood of impacts based on a predicted total valley closure of 200 mm or less. With the conservative nature of valley closure predictions, observed valley closure is typically lower than predicted valley closure. The Waratah Rivulet Valley Closure TARP has therefore been designed to suit observed valley closure movements. The TARP defines four status levels. Level 1 and 2 status represent observed movement at reduced percentages (50% and 75% respectively) of the design criteria for the Waratah Rivulet, which is based on a predicted valley closure of 200 mm. Level 3 status represents a significant level of observed valley movement but with no observed pool impacts. Level 4 represents a confirmed pool impact.

A Technical Committee, comprising industry and technical representatives, will review the monitoring data in accordance with the TARP. The key outcomes of the Technical Committee review will be reported to DPE, WaterNSW and the Metropolitan Coal General Manager monthly if the results are at TARP Level 1 or Level 2 status.

In the event the results are at TARP Level 3 status, monitoring, review and reporting to DPE, WaterNSW and the Metropolitan Coal General Manager will be conducted weekly. A Level 4 status will initiate procedures to cease extraction of the current longwall and notification to DPE and WaterNSW will be within 24 hours.

Table 29
Longwalls 308-310 Waratah Rivulet Valley Closure Trigger Action Response Plan
TARP Zone – extraction within 450 m of Waratah Rivulet

Valley Closure[1] (*Total Closure*)	Monitoring Method and Measure	TARP LEVEL				
			Level 1	**Level 2**	**Level 3**	**Level 4**
Longwalls 308-310	Telemetered real time data GNSS *# 43,44* Absolute 3D movement and closure	***Trigger***	Baseline to no greater than **40 mm**[2]	Greater than Level 1 (**40 mm**) and no greater than **125 mm**[3]. Measurements over three consecutive epochs (days)	Greater than Level 2 (**125 mm**) and no type 3 impact[4] (loss of pool water level). Measurements over three consecutive epochs (days).	Type 3 impact confirmed, being a diversion of flows or change in natural drainage behaviour of pools in performance measure zone.
		Action	Monthly monitoring[5]: • GNSS data[6] • Pool level data[7] • Visual inspections End of Panel: • Rock bar closure survey[8]	Monthly monitoring: • As per Level 1, and • rock bar closure surveys	Weekly monitoring: • All data gathering increased to weekly frequency • Weekly review of GNSS and rock bar closure line data[9]	Immediate action: • Metropolitan Coal to initiate procedures to cease extraction of current longwall panel at next available cut through
		Response and Reporting	Reporting: • Monthly to Technical Committee Technical Committee: • End of panel meeting • Key outcomes reported to DPE and WaterNSW following the end of panel meeting	Reporting: • Monthly to Technical Committee Technical Committee: • Monthly meeting • Key outcomes reported to DPE and WaterNSW following each meeting	Reporting: • Weekly to Technical Committee Technical Committee: • Weekly meeting • Metropolitan Coal to determine need to cease longwall mining operations at Level 3 in consultation with Technical Committee • Key outcomes of Technical Committee reported to DPE and WaterNSW following each meeting • Notify DPE and WaterNSW of Level 3 status and associated actions	Response: • Immediate Technical Committee meeting and reporting to review all relevant data (within 24hrs) • Immediate reporting (24hrs) to Metropolitan Coal General Manager • Immediate notification (24hrs) of the Level 4 status and associated actions to DPE and WaterNSW • Commence Stream Remediation Plan.

1 Waratah Rivulet will be monitored for total closure (cumulative value) as measured from the commencement of Longwall 307 (i.e. the "baseline" period) to the completion of Longwall 310.

2 Observed closure no greater than 40 mm. No previous Type 3 impacts have been recorded on Waratah Rivulet for measured closure of less than 40 mm.

3 Observed closure no greater than predicted closure of 125 mm at the completion of Longwall 308.

4 Type 3 impacts (loss of pool water level) are not recorded on Waratah Rivulet, where rock bars are more than 170 m distance from a longwall void. All longwalls in this extraction plan are greater than 220 m, with the closest approach by Longwall 308 and 309 being 220 m, and Longwall 310 is 320 m.

5 Monitoring and review frequency can be increased at any time as determined by the Technical Committee.

6 GNSS valley closure monitoring is representative of closure at Rock Bars U, V and W that are within 450 m of extraction of Longwalls 308-310.

7 Pool water level monitoring equipment and loggers are installed at Pools P, Q, R, S, T, U, V and W.

8 Rock bars to be monitored (located within 450 m of extraction) are T, U, V and W for Longwall 308, and U, V and W for Longwalls 309 and 310. Each rock bar has a terrestrial survey closure line.

9 Weekly review to include observations of closure, strain, vertical subsidence, horizontal movement.

8.11 WARATAH RIVULET GAUGING STATION TRIGGER ACTION RESPONSE PLAN

WaterNSW owns a gauging station (GS 2132102) on the Waratah Rivulet at Pool Q, close to the inundation limits of the Woronora Reservoir (Figure 6). Table 30 describes the TARP used to identify and manage subsidence related movements at GS 2132102.

Table 30
Trigger Action Response Plan – Waratah Rivulet Gauging Station

Level	Monitoring frequency	Trigger	Action
Level 1	Quarterly Review (Recorded daily)	Absolute horizontal movement at GNSS monitoring site Q Line is less than or equal to 50 mm.	Continue Monitoring. End of panel survey and inspection of rock bar.
Level 2	Monthly	Absolute horizontal movement at GNSS monitoring site Q Line is greater than 50 mm. There is no visible damage to the gauging station observed.	Survey and visual inspection of rock bar Q at monthly frequency until the longwall panel being mined is completed.
Level 3	Weekly	Visible damage to the gauging station is observed.	Report to WaterNSW within one week of inspection. Weekly survey and inspections until movement stabilised. Liaise with WaterNSW to agree long-term solution for Gauging Station (e.g. recalibration of flows, repairs or replacement). Review and update the 2016 Contingency Plan for Monitoring Waratah Rivulet Stream Flows, as necessary.

9 MANAGEMENT MEASURES

9.1 SUBSIDENCE MANAGEMENT APPROACH

Potential environmental consequences during the mining of Longwalls 308-310 will be managed in accordance with the relevant requirements of the Project Approval and other approvals, through:

- **Mine Planning and Design** – The design of the mine, including avoidance and subsidence mitigation measures (Section 9.2).
- **Subsidence Monitoring** – Monitoring to confirm predictions of subsidence effects and potential subsidence impacts and environmental consequences (Sections 8 and 9.3).
- **Management Measures and Remediation** – Implementation of management measures and/or remediation, as required, to address subsidence impacts and/or environmental consequences (Section 9.4).
- **Adaptive Management** – The implementation of adaptive management where appropriate (Section 9.5).
- **Contingency Plans** – Implementation of Contingency Plans in the event an exceedance of a subsidence impact performance measure or an unexpected impact is detected (Section 10), including consideration of identified potential contingency measures (Sections 10.1).

9.2 MINE PLANNING AND DESIGN

Mine planning and design considerations have included mining geometry, geology and stratigraphy and avoidance and subsidence mitigation measures, as described below.

Since the commencement of longwall mining methods at the Metropolitan Colliery in 1995, Metropolitan Coal has adopted a conservative mining geometry with significantly narrower longwall panels than the industry norm to minimise potential impacts on the environmental values of the area. As a result of the narrower longwall panels, the extracted seam thickness, substantial depths of cover and alteration of thick sandstone/claystone lithologies, there is a constrained zone in the overburden at Metropolitan Coal. The risk of connective cracking between the mine and the surface is very low.

As described in Section 5, a number of risk assessments have been conducted including a risk assessment to assess the potential for Longwalls 308-310 mining effects on lineaments, joints, faulting, basal shear planes and dykes to impact on the quantity of water to the Woronora Reservoir, including the potential for water to be diverted out of Woronora Reservoir and into other catchments. Metropolitan Coal considers all risk control measures and procedures to be reasonable to manage all identified risks.

Longwalls 301 to 308 were shortened at the northern commencing ends as a result of the thinning of the coal seam and/or prohibitive carbon dioxide gas content. Avoidance and subsidence mitigation measures that have been incorporated into the longwall layouts have included:

- The finishing end of Longwall 301 was shortened to reduce potential subsidence effects at Bridge 2 (M1 Princes Motorway).
- The commencing ends of Longwalls 302, 303, 304 and 305 were shortened to reduce potential subsidence effects at the Garrawarra Centre Complex.
- The finishing ends of Longwalls 303, 304 and 305 were shortened to reduce predicted valley closure on the Eastern Tributary.

Metropolitan Coal has developed a monitoring and adaptive management approach for the Waratah Rivulet as described in Sections 8.10 and 9.5.

9.3 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.

9.4 MANAGEMENT MEASURES AND REMEDIATION

This section describes the implementation of management measures and/or remediation for water resources and watercourses. Management measures will be implemented, as appropriate, to comply with the relevant statutory requirements and the subsidence impact performance measure.

As described in Section 4.1, the magnitudes of the systematic and/or valley related movements predicted for the Project were considered likely to result in the fracturing and dilation of the underlying strata of streams above and immediately adjacent to the longwalls. Cracking and dilation of bedrock would likely result in the localised diversion of a portion of the surface flow into subterranean flows or leakage from pools. Stream remediation measures will be implemented as described in Section 9.4.1.

Other potential subsidence impacts such as impacts on aesthetic values, stream bank erosion, cliff falls and swamps and the associated management measures are described in Section 9.4.2.

Management and rehabilitation measures for surface disturbance areas are described in Section 9.4.3.

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).

9.4.1 Stream Remediation

Metropolitan Coal is required to achieve the rehabilitation objective specified in Table 11 of Condition 1, Schedule 6 of the Project Approval for the Waratah Rivulet and the Eastern Tributary watercourses.

Table 11: Rehabilitation Objectives

Domain	***Rehabilitation Objective***
Waratah Rivulet, between the downstream edge of Flat Rock Swamp and the full supply level of the Woronora Reservoir *Eastern Tributary, between the maingate of Longwall 26 and the full supply level of the Woronora Reservoir*	*Restore surface flow and pool holding capacity as soon as reasonably practicable*

Metropolitan Coal is also required to achieve the subsidence impact performance measures specified in Table 1 of Condition 1, Schedule 3 of the Project Approval in relation to the Waratah Rivulet and Eastern Tributary watercourses.

Table 1: Subsidence Impact Performance Measures

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)*

9.4.1.1 Waratah Rivulet Stream Remediation

The location of pools/rock bars along the Waratah Rivulet are shown on Figure 5 and on the detailed mapping in Appendix 1.

As described in Section 9.4.1, Metropolitan Coal is required to restore surface flow and pool holding capacity on the Waratah Rivulet between the downstream edge of Flat Rock Swamp and the full supply level of the Woronora Reservoir (i.e. Pools A to W). Metropolitan Coal is also required not to exceed the Waratah Rivulet watercourse subsidence impact performance measure, which is applicable to Pools P to W.

Stream remediation on the Waratah Rivulet at pools/rock bars overlying the Longwalls 1-13 mining area, at pools/rock bars downstream of the Longwalls 1-13 mining area to the Longwall 23 maingate, and pools/rock bars downstream of the Longwall 23 maingate to the full supply level of the Woronora Reservoir, is described below.

Longwalls 1-13 Mining Area (Downstream of Flat Rock Swamp to Longwall 20 Tailgate)

As described in Section 8.3.3, Pools B, C, E, G, G1, H and I will be manually monitored on a daily basis, while Pools A and F will be monitored continuously with water level sensors and data loggers.

As a result of previous mining, the water levels in pools upstream of Flat Rock Crossing (i.e. Pools A to G) and immediately downstream of Flat Rock Crossing (Pools G1) have been impacted by mine subsidence.

Stream remediation activities have been conducted at Pools A, F and G. The rock bars at Pools A and F are considered to largely control the pools located upstream of these rock bars. As a result, Metropolitan Coal anticipates that the restoration of surface flow and pool holding capacity at Pools A and F will restore the surface flow and pool holding capacity of pools between Flat Rock Swamp and Pool F. Metropolitan Coal considers the pool remediation efforts to have largely been successful but continues to monitor the performance of these works.

In 2021, Hydro Engineering & Consulting (2021a) assessed the success of pool remediation measures undertaken by Metropolitan Coal and if subsidence impacts had otherwise diminished in pools on the Waratah Rivulet. Hydro Engineering & Consulting (2021a) found that for Pools G1 and N, water level recession behaviour was consistent with pre-impact behaviour, and the for Pools B, C, E, F and G, water levels during low flow conditions were consistent with the water levels of similar, un-impacted pools. For Pool A, recorded water levels during low flow conditions were not consistent with the water levels of similar, un-impacted pools.

In the event stream remediation activities are required at any additional pools/rock bars, Metropolitan Coal will prepare stream remediation plans in consultation with the DPE, Resources Regulator and WaterNSW and include the plans in the Metropolitan Coal Stream Remediation Plan (Metropolitan Coal, 2019) (Appendix 7). Metropolitan Coal will also provide the DPE, Resources Regulator and WaterNSW with 14 days' notice of their intention to commence stream remediation activities at each pool/rock bar.

Stream remediation will be triggered at Pools H or I on the Waratah Rivulet if the water level in a pool falls below the water level required for continuous flow over the corresponding downstream rock bar (i.e. stops overflowing), except if as a result of climatic conditions. The control pools on Woronora River will be inspected (for a similar response).

Metropolitan Coal will advise the DPE, Resources Regulator, WaterNSW, BCS, DPE – Water and Department of Primary Industries – Fisheries (DPI – Fisheries) if the stream remediation process has been triggered.

Downstream of Longwalls 1-13 Mining Area (Longwall 20 Tailgate to Longwall 23 Maingate)

Pools J, K, L, M, M1, N and O on the Waratah Rivulet are situated downstream of the completed Longwalls 1-13 mining area, between the Longwall 20 tailgate and Longwall 23 maingate (Figure 5). Pools J to O will be monitored continuously with water level sensors and data loggers (Section 8.3.3).

As a result of mining, the water levels in Pool N were impacted by mine subsidence in early September 2012. A stream remediation plan for Pool N is provided in the Metropolitan Coal Stream Remediation Plan (Appendix 7). To date (September 2021), Pool N has overflowed its rock bar since December 2014, with the exception of relatively short periods when pools on the Woronora River also stopped flowing. Monitoring of Pool N will continue to be conducted.

Stream remediation will be triggered at Pools J, K, L or M on the Waratah Rivulet if the water depth in a pool falls below the water depth required for continuous flow over the corresponding downstream rock bar (i.e. stops overflowing), except if as a result of climatic conditions. The control pools on Woronora River will be inspected (for a similar response). Stream remediation will be triggered at Pool O on the Waratah Rivulet (boulderfield control) if the pool water levels are considered to be inconsistent with natural behaviour.

Metropolitan Coal will advise the DPE, Resources Regulator, WaterNSW, BCS, DPE – Water and DPI – Fisheries if the stream remediation process has been triggered.

Downstream of the Maingate of Longwall 23

Pools P, Q, R, S, T, U, V and W on the Waratah Rivulet are situated between the Longwall 23 maingate and the full supply level of the Woronora Reservoir (Figure 5). Pools P to W will be monitored continuously with water level sensors and data loggers (Section 8.3.3).

Although not anticipated to be required, stream remediation will be triggered at Pools P, Q, R, S, T, U, V or W if the assessment of monitoring results indicates the performance measure:

> *negligible environmental consequences (that is, no diversion of flows, no change in the natural drainage behaviour of pools, …….) on the Waratah Rivulet between the full supply level of the Woronora Reservoir and the maingate of Longwall 23 (upstream of Pool P)*

has been exceeded.

9.4.1.2 Eastern Tributary Stream Remediation

The location of pools/rock bars along the Eastern Tributary are shown on Figure 5 and on the detailed mapping in Appendix 2.

As described in Section 9.1, the Project Approval required Metropolitan Coal to have negligible environmental consequences over at least 70% of the stream length on the Eastern Tributary between the full supply level of the Woronora Reservoir and the maingate of Longwall 26 (which includes Pools ETAG to ETAU).

Monitoring conducted in accordance with the Metropolitan Coal Longwalls 23-27 Water Management Plan identified that the Eastern Tributary watercourse performance measure was exceeded in relation to *minimal iron staining* and *no diversion of flows, no change in the natural drainage behaviour of pools*. The exceedance of the Eastern Tributary watercourse performance measure (referred to as the Eastern Tributary Incident) was reported to the DPE and other relevant agencies in October 2016.

Metropolitan Coal provided the DPE with a proposed course of action in relation to the exceedance of the Eastern Tributary subsidence impact performance measure, focused on the implementation of stream remediation measures.

In accordance with Condition 1, Schedule 6 of the Project Approval, Metropolitan Coal is required to restore surface flow and pool holding capacity on the Eastern Tributary between the full supply level of the Woronora Reservoir and the maingate of Longwall 26.

Between the Woronora Reservoir Full Supply Level and the Maingate of Longwall 26

Pools ETAG to ETAU on the Eastern Tributary are situated between the full supply level of the Woronora Reservoir and the maingate of Longwall 26 (Figure 5).

The drainage behaviour of 12 pools on the Eastern Tributary (Pools ETAG to ETAR) were impacted by mine subsidence during the mining of Longwalls 23-27. The drainage behaviour of Pools ETAS, ETAT and ETAU on the Eastern Tributary have not been impacted.

Within the performance measure reach of the Eastern Tributary, Metropolitan Coal have conducted stream remediation activities at pools ETAH, ETAI, ETAJ and ETAK following the approval of the Stream Remediation Plan.

These stream remediation works have been conducted in accordance with the Metropolitan Coal Stream Remediation Plan (Appendix 7).

Upstream of the Reach Subject to the Eastern Tributary Performance Measure

From July to September 2019, Metropolitan Coal conducted stream remediation on the Eastern Tributary at Pool ETO (immediately upstream of the Fire Road 9J crossing and upstream of the Longwall 26 maingate) (Figure 5). Permeability testing has confirmed a significant reduction in hydraulic conductivity of rock bar ETO and both pool level data and visual observations have confirmed that pool holding capacity has been restored and water is flowing over the rock bar for significantly longer periods post remediation.

9.4.1.3 Stream Remediation Activities

Metropolitan Coal is committed to stream remediation at the earliest opportunity. The specific timing of stream remediation activities will be influenced by practical considerations. For example, the catchment may be closed due to rainfall, bushfire risk or stream remediation activities are unable to be conducted as a result of high stream flows. It is anticipated that remediation activities would generally follow mining in a downstream direction however additional remediation efforts may be required for some pools.

Metropolitan Coal will provide the DPE, Resources Regulator and WaterNSW with 14 days' notice of its intention to commence stream remediation activities at each pool/rock bar.

The Metropolitan Coal Stream Remediation Plan describes the implementation and management of stream restoration works. Stream remediation activities typically include fracture characterisation, stream grouting, environmental management and monitoring.

9.4.2 Other Subsidence Impact Management Measures

9.4.2.1 Aesthetic Values

Potential aesthetic restoration measures include:

- Manual application of coloured cement to the stream bed to reduce the appearance of subsidence-induced cracking. A colour that will blend in with the local stream bed colouration will be selected. A range of potentially suitable products are available from landscape suppliers and/or businesses. The product and landscaper proposed to be used will be selected in consultation with WaterNSW.
- The injection of polyurethane at key iron seep locations to reduce the extent of iron staining.

9.4.2.2 Stream Bank Erosion

Visual monitoring (particularly along Waratah Rivulet and the Eastern Tributary) will be conducted to identify areas subject to excessive erosion and sedimentation. Where monitoring indicates 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.

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 experience 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 will be established that will be colonised in due course by native vegetation adapted to the new conditions.

9.4.2.3 Cliff Falls

Cliff and overhang sites COH7, COH8, COH9, COH10, COH11, COH12, COH13, COH16 and COH17 will be monitored to record evidence of potential subsidence impacts in accordance with the Metropolitan Coal Longwalls 308-310 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 water resources, 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 308-310 Land Management Plan (Figure 3).

9.4.2.4 Swamp Remediation Measures

In accordance with the Metropolitan Coal Longwalls 308-310 Biodiversity Management Plan (Figure 3), 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 DPE, BCS, WaterNSW, DPI – Fisheries and Resources Regulator.

Potential remediation measures for impacts on upland swamps include:

- installation of coir log dams (i.e. erosion control structures) at any knick points in a swamp;
- use of 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.

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 308-310 Biodiversity Management Plan (Figure 3).

9.4.3 Surface Disturbance

The Metropolitan Coal Construction Management Plan (Figure 3) will describe the management measures that will be implemented for surface construction works (excluding remediation or rehabilitation works) in the Woronora Special Area. The management measures will include measures to minimise impacts on water resources and watercourses (e.g. implementation of fuel management measures and erosion and sediment control measures).

The Metropolitan Coal Rehabilitation Management Plan (Figure 3) details the rehabilitation of surface disturbance areas (including those associated with surface exploration activities, vehicular access tracks, environmental monitoring activities and other minor Project-related surface activities).

9.5 ADAPTIVE MANAGEMENT

Metropolitan Coal will implement an adaptive management approach for the Project. Adaptive management involves:

- Planning – developing management strategies to meet performance measures; identifying performance indicators to assess performance; and establishing monitoring programs to monitor against the performance measures.
- Implementation – implementing management strategies and monitoring impacts against performance indicators.
- Review – reviewing and evaluating the effectiveness of management strategies by analysis of monitoring data against predicted impacts, performance indicators and performance measures.
- Contingency Response – implementing the contingency plan in the event a subsidence impact water resource or watercourse performance measure has been exceeded (Section 10).
- Adjustment – adjusting management strategies to improve performance.

Examples of adaptive management measures include the potential to step-around a longwall, stand-offs (environmental pillar) from a particular location, or increasing the setback of the longwalls already subject to stand-off.

10 CONTINGENCY PLAN

In the event a subsidence impact water resource or watercourse performance measure detailed in Section 6 is considered to have been exceeded Metropolitan Coal will implement the following Contingency Plan:

- The likely exceedance will be reported to the Technical Services Manager and/or the Environment & Community Superintendent within 24 hours of assessment completion.
- The Technical Services Manager 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 water resource or watercourse performance measure to the DPE, DPE – Water, WaterNSW and BCS 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 are described in Section 10.1 below.
- Metropolitan Coal will submit the proposed course of action and a program to review the effectiveness of the contingency measures to the DPE for approval.
- Metropolitan Coal will implement the approved course of action to the satisfaction of the DPE.

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 DPE if either the contingency measures implemented by Metropolitan Coal have failed to remediate the impact or the Secretary of the DPE determines that it is not reasonable or feasible to remediate the impact.

10.1 POTENTIAL CONTINGENCY MEASURES

Potential contingency measures for an exceedance of the water resource or watercourse performance measures include:

- The conduct of additional monitoring (e.g. increase in monitoring frequency or additional sampling) to inform the proposed contingency measures.
- The implementation of stream remediation measures to restore surface water flow/pool holding capacity.
- The implementation of revegetation measures to remediate impacts of gas releases on riparian vegetation.
- The purchase of water from Sydney Water in accordance with a license agreement established to the satisfaction of WaterNSW and the DPE.
- The provision of a suitable offset(s) to compensate for the reduction in the quantity of water resources reaching the Woronora Reservoir. Examples of potential offsets include improvement works in the Woronora Reservoir water supply catchment.
- The implementation of adaptive management measures. Examples of adaptive management measures include stepping-around a longwall, the use of stand-offs (environmental pillar) from a particular location, or increasing the setback of the longwalls already subject to stand-off.

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 (Longwall 311 on). The collection of baseline data for water resources and watercourses is described below.

11.1 SURFACE WATER

Meteorological data for the next Extraction Plan is available from the existing pluviometers, pan evaporimeter and climate stations described in Section 8.1.

Streams relevant to the next Extraction Plan include the Waratah Rivulet, Eastern Tributary and the first and second order streams that flow into the Woronora Reservoir.

The results of visual and photographic surveys of the Waratah Rivulet and Eastern Tributary prior to the commencement of Longwall 20 (provided in Appendices 1 and 2 of this WMP) and during the mining of Longwalls 20-27 and Longwalls 301-303 provide information on these streams.

Gilbert & Associates (now Hydro Engineering & Consulting) conducted a visual inspection and photographic survey of streams in the vicinity of Longwalls 301-303 in July 2015 (Hydro Engineering & Consulting, 2016) (Appendix 5 of the Longwalls 301-303 Water Management Plan).

Hydro Engineering & Consulting (2019) conducted a visual inspection and photographic survey of the first and second order streams in the vicinity of Longwalls 304-310 (not previously inspected for Longwalls 301-303) in April 2018. Hydro Engineering & Consulting's (2019) visual inspection and photographic survey report is provided in Appendix 5 of this WMP. Visual inspection and photographic survey of the larger first and second order streams located further to the west of the Woronora Reservoir (over Longwalls 311-316) will be conducted prior to the commencement of Longwall 309.

As noted in the IEPMC Initial Report, it has been proposed that swamps provide an ecologically important component of base flow to watercourses during dry periods (IESC, 2015b; Advisian, 2016).

To monitor predicted impacts on pools/aquatic habitat in advance of future mining, Metropolitan Coal investigated the installation of pool water level sensors in:

- the large pool mapped on the lower reaches of the stream that overlies Longwalls 309 to 311, downstream of Swamp 92 (Appendix 5); and
- two of the large pools mapped on the lower reaches of the stream that overlies Longwall 311, downstream of Swamp 77 (Appendix 5).

Subsequent to the investigation, pool water level sensors were installed in the stream downstream of Swamp 77 on 23 May 2019 (i.e. at Pool SR1 and Pool SR2), and in the stream downstream of Swamp 92 on 3 June 2019 (i.e. at Pool SP1) (Figure 6).

Metropolitan Coal investigated the potential to install flow measuring flumes immediately downstream of Swamps 76, 77 and 92. Based on initial site investigations, it was identified that there was potential to install flow measuring flumes immediately downstream of Swamps 76 and 92. Further investigations determined that it was not feasible to install a flow measuring flume downstream of Swamp 77. In November 2020, Metropolitan Coal installed flow measuring flumes (i.e. established gauging stations) immediately downstream of Swamps 76 and 92 consistent with the recommendations of Hydro Engineering & Consulting (2019) (Figure 6).

The gauging station downstream of Swamp 76 is located outside the predicted 20 mm subsidence contour and/or the 35° angle of draw line from Longwalls 308-310. Therefore this gauging station will provide baseline information against which comparisons can be made of the impacts of future longwalls on Swamp 76 and of the impacts to Swamp 92. The gauging station downstream of Swamp 92 is located within the predicted 35° angle of draw line from Longwalls 308-310 but outside the predicted 20 mm subsidence contour. As such, limited impact is expected to Swamp 92 as a result of mining of Longwalls 308-310 and then likely not until late in the period of mining of Longwall 310 (in 2025). Therefore there is a significant period available for obtaining baseline information on flow from Swamp 92 ahead of any potential impacts from longwall mining.

Consideration of the environmental performance and management of this WMP will also inform the appropriate type and frequency of monitoring of water resources and watercourses relevant to the next Extraction Plan.

Surface water quality data for the Woronora Reservoir (site DW01, measurements taken from 0 to 9 m below the water surface level), Nepean Reservoir and Cataract Reservoir will continue to be sourced from WaterNSW.

11.2 GROUNDWATER

Metropolitan Coal installed paired piezometers in Swamps 60, 62, 64, 133 and 134 overlying or proximal to the commencing ends of Longwalls 308 and 309 in October 2018.

Metropolitan Coal completed Surface Works Assessment Forms for the proposed installation of upland swamp piezometers in Swamps 76, 77, 81, 82, 89 and 92 (Figure 9), which were submitted to the DPIE in early 2020. DPIE subsequently approved these works and piezometers were installed in all of these upland swamps in November 2020

Metropolitan Coal installed soil moisture probes (linked to a datalogger) at various depth intervals to monitor the vertical profile of soil moisture in the swamp substrate of Swamps 62, 72, 76, 77, 81, 82, 89, 92, 101, 137a and 137b (Figure 9).

Metropolitan Coal does not anticipate that any additional groundwater monitoring sites will be required for the next Extraction Plan; however, consideration of the environmental performance and management of this WMP will inform the appropriate type and frequency of groundwater monitoring relevant to the next Extraction Plan, and additional groundwater bores may be installed on the basis of the monitoring and modelling results.

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 WMP 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.

As described in Section 2, this WMP 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 DPE 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 Technical Services Manager 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 DPE 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 DPE 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 DPE 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 DPE.

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