METROPOLITAN COAL

SIX MONTHLY REPORT




1 JANUARY TO 30 JUNE 2015

Peabody ENERGY

METROPOLITAN COAL

METROPOLITAN COAL

SIX MONTHLY REPORT

1 JANUARY TO 30 JUNE 2015

Project No. MET-08-08
Document No. 00710224

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF APPENDICES

EXECUTIVE SUMMARY

Metropolitan Coal is wholly owned by Peabody Energy Australia Pty Ltd (Peabody), and is located adjacent to the township of Helensburgh and approximately 30 kilometres north of Wollongong in New South Wales (NSW).

Metropolitan Coal was granted approval for the Metropolitan Coal Project (the Project) by the Minister for Planning under Section 75J of the NSW *Environmental Planning and Assessment Act, 1979* on 22 June 2009. A copy of the Project Approval is available on the Peabody website (http://www.peabodyenergy.com.au).

The Project comprises the continuation, upgrade and extension of underground coal mining operations and surface facilities at Metropolitan Coal. The underground mining longwall layout is shown on Figure ES-1.

The Metropolitan Coal Environmental Management Structure is shown on Figure ES-2. Consistent with the Environmental Management Structure and in accordance with Condition 6, Schedule 3 of the Project Approval, Metropolitan Coal prepares Extraction Plans for specific mining domains as mining progresses.

In accordance with Condition 9(c), Schedule 3 of the Metropolitan Coal Longwalls 23-27 Extraction Plan Approval, this Six Monthly Report has been prepared to report on impacts and environmental monitoring results associated with the Longwalls 23-27 Extraction Plan. This Six Monthly Report also includes reporting of impacts and on-going environmental monitoring associated with the Longwalls 20-22 Extraction Plan. Longwall 22 was completed in April 2014. Longwall 23 extraction commenced in May 2014 and was completed in March 2015. Longwall 24 extraction commenced in April 2015. This report presents data for the reporting period 1 January to 30 June 2015.

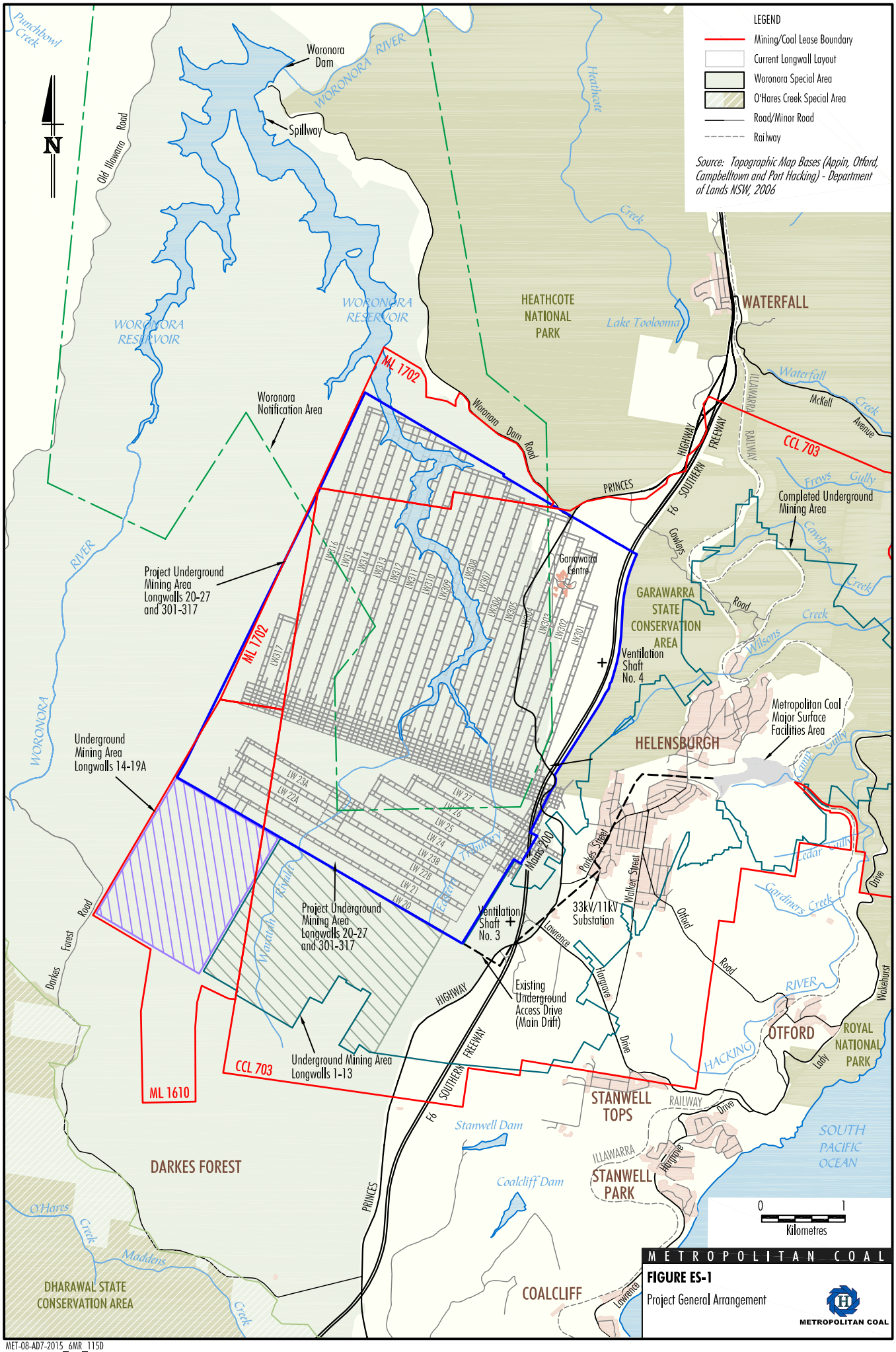
No Project-related exceedances of performance measures associated with underground mining of Longwalls 20-22 or Longwalls 23-27 occurred during the reporting period. During the reporting period, two performance indicators were exceeded, as summarised in Table ES-1.

Table ES-1
Performance Indicators Exceeded during the Reporting Period

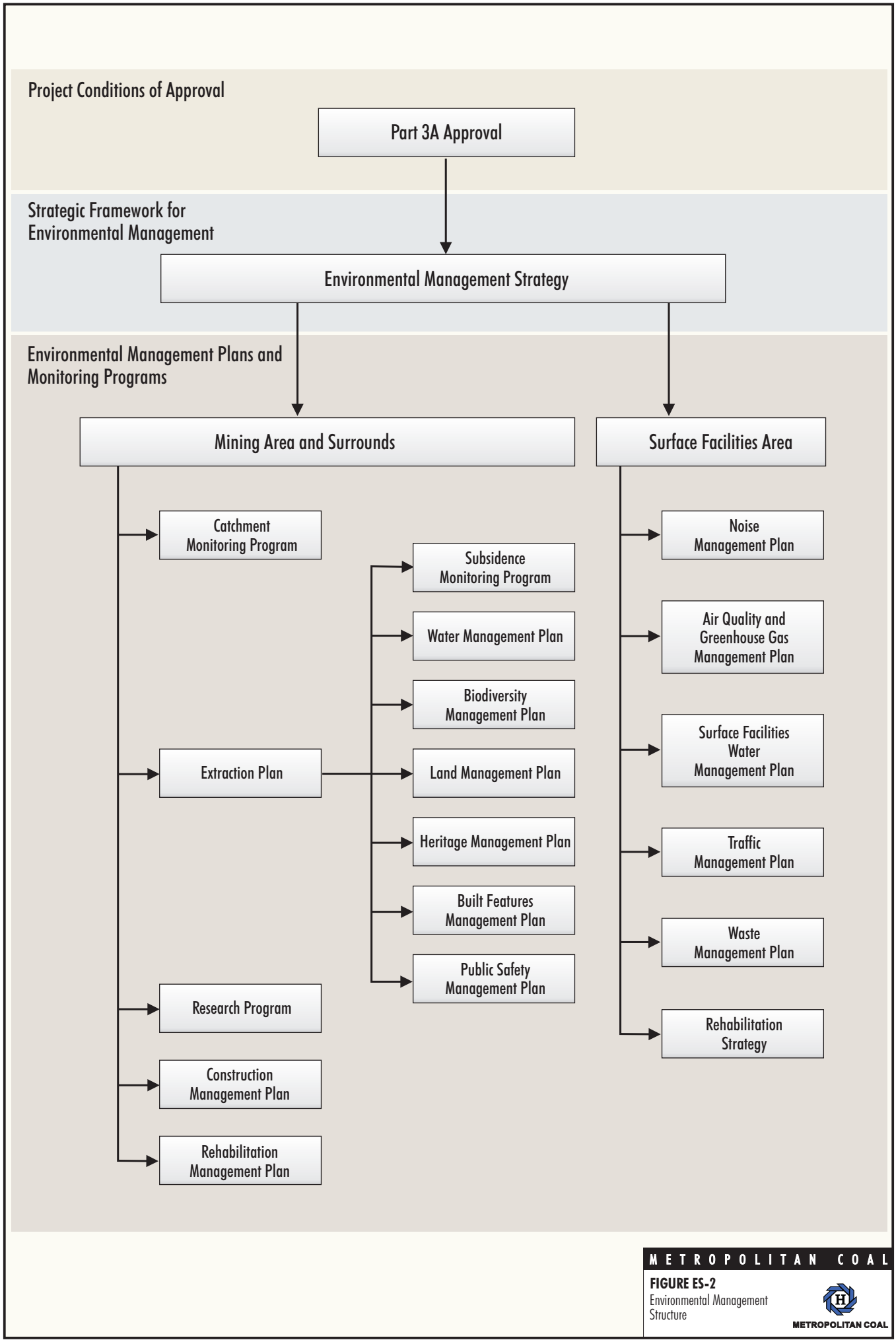
Environmental Aspect	Performance Indicator Exceeded	Comment
Biodiversity	*Surface cracking within upland swamps resulting from mine subsidence is not expected to result in measurable changes to swamp groundwater levels when compared to control swamps or seasonal variations in water levels experienced by upland swamps prior to mining.* (Longwalls 20-22)	Continued exceedance of the performance indicator at Swamp 20 (overlying Longwall 21) triggered an assessment against the performance measure, *Negligible impact on threatened species and populations,* consistent with the Longwalls 20-22 Biodiversity Management Plan. The performance measure was not exceeded.
	Impacts to riparian vegetation are expected to be localised and limited in extent, similar to the impacts previously experienced at Metropolitan Coal. (Longwalls 20-22 and Longwalls 23-27)	Continued exceedance of the performance indicator at site MRIP02 on Waratah Rivulet and between sites MRIP09 and MRIP05 on the Eastern Tributary triggered an assessment against the performance measure, *Negligible impact on threatened species and populations,* consistent with the Longwalls 20-22 and Longwalls 23-27 Biodiversity Management Plans. The performance measure was not exceeded.

The Six Monthly Report includes:

- A description of the environmental performance of water, biodiversity, land, Aboriginal heritage, built features and public safety management during the underground mining of Longwalls 20-22 and Longwalls 23-27.
- A comprehensive review of the monitoring results associated with underground mining during the reporting period.
- Identification of trends in the monitoring data during the reporting period.
- Assessment of environmental performance against the performance indicators and performance measures during the reporting period.
- Revised characterisation of performance indicators and performance measures according to the relevant Trigger Action Response Plans.
- A description of rehabilitation management in the underground mining area and associated monitoring.



MET-08-AD7-2015_6MR_115D



METROPOLITAN COAL

FIGURE ES-2
Environmental Management Structure

METROPOLITAN COAL

MET-08-AD7 2015_6MR_001A

1 INTRODUCTION

Metropolitan Coal is wholly owned by Peabody Energy Australia Pty Ltd (Peabody), and is located adjacent to the township of Helensburgh and approximately 30 kilometres (km) north of Wollongong in New South Wales (NSW) (Figure 1). Metropolitan Coal is located within Consolidated Coal Lease (CCL) 703, Mining Lease (ML) 1610 and ML 1702. Metropolitan Coal is one of the earliest established and longest continually running coal mining operations in Australia, with a history dating back to the 1880s.

Metropolitan Coal was granted approval for the Metropolitan Coal Project (the Project) by the Minister for Planning under Section 75J of the NSW *Environmental Planning and Assessment Act, 1979* (EP&A Act) on 22 June 2009. The Project comprises the continuation, upgrade and extension of underground coal mining operations and surface facilities at Metropolitan Coal. The Project Approval authorises mining for a period of 23 years from its date of issue and sets the regulatory framework therein. The underground mining longwall layout is shown on Figure 2.

The Metropolitan Coal Environmental Management Structure is shown on Figure 3. It includes the Metropolitan Coal Environmental Management Strategy (Metropolitan Coal, 2011), developed to provide the strategic context for environmental management at Metropolitan Coal, and management plans and monitoring programs applicable to the underground mining area or mine's surface facilities area.

Consistent with the Environmental Management Structure and in accordance with Condition 6, Schedule 3 of the Project Approval, Metropolitan Coal prepares Extraction Plans for specific mining domains as mining progresses. Extraction Plans are developed to monitor, manage and remediate the effects of longwall extraction at Metropolitan Coal. Metropolitan Coal was granted approval for the Metropolitan Coal Longwalls 20-22 Extraction Plan (Metropolitan Coal, 2010) on 14 May 2010. Metropolitan Coal commenced mining of Longwall 20 in May 2010 and completed Longwall 22 in April 2014. Metropolitan Coal was granted approval for the Metropolitan Coal Longwalls 23-27 Extraction Plan (Metropolitan Coal, 2014) on 9 April 2014. The extraction of Longwall 23 commenced in May 2014 and was completed in March 2015. Longwall 24 extraction commenced in April 2015.

1.1 PURPOSE AND SCOPE

In accordance with Condition 9(c), Schedule 3 of the Metropolitan Coal Longwalls 23-27 Extraction Plan Approval, this Six Monthly Report has been prepared to report on impacts and environmental monitoring results associated with the Longwalls 23-27 Extraction Plan.

Condition 9(c), Schedule 3 states:

Monitoring and Reporting Requirements

9. The Proponent shall implement a monitoring and reporting procedure that contains the following elements:

...

c) six-monthly reporting of all impacts and environmental monitoring results, including:

- *a comprehensive summary of all impacts, including a revised characterisation according to the relevant TARP(s);*
- *any proposed actions resulting from Triggers being met in the TARP, or other actions;*
- *assessment of compliance with all relevant performance measures and indicators;*
- *a comprehensive summary of all quantitative and qualitative environmental monitoring results, including landscape monitoring, water quality data, water flow and pool level data, piezometer readings, etc;*

...

Notes:

- *The Director-General may agree to a lesser frequency for the bi-monthly and six-monthly reporting set out above, if subsidence impacts and environmental consequences at the mine are relatively rare and benign in character.*
- *There is no need to include results of the monitoring of subsidence effects within bi-monthly and six-monthly reports to P&I. However, a summary of subsidence effects monitoring results should be included in the Annual Review.*
- *Other regular reports may be required by other agencies for their own purposes, such as reports to the Dams Safety Committee and regular reports assessing impacts of mining close to sensitive built features. P&I expects to receive copies of reports of these types.*

As Condition 9(c), Schedule 3 of the Project Approval is specific to the Metropolitan Coal Longwalls 23-27 Extraction Plan (Metropolitan Coal, 2014), impacts on environmental monitoring results associated with other Metropolitan Coal activities (such as those at the major surface facilities area) are not included in this Six Monthly Report.

While Condition 9(c), Schedule 3 of the Project Approval is specific to the Metropolitan Coal Longwalls 23-27 Extraction Plan (Metropolitan Coal, 2014), Metropolitan Coal has also included reporting of impacts and environmental monitoring results associated with Longwalls 20-22 in this Six Monthly Report.

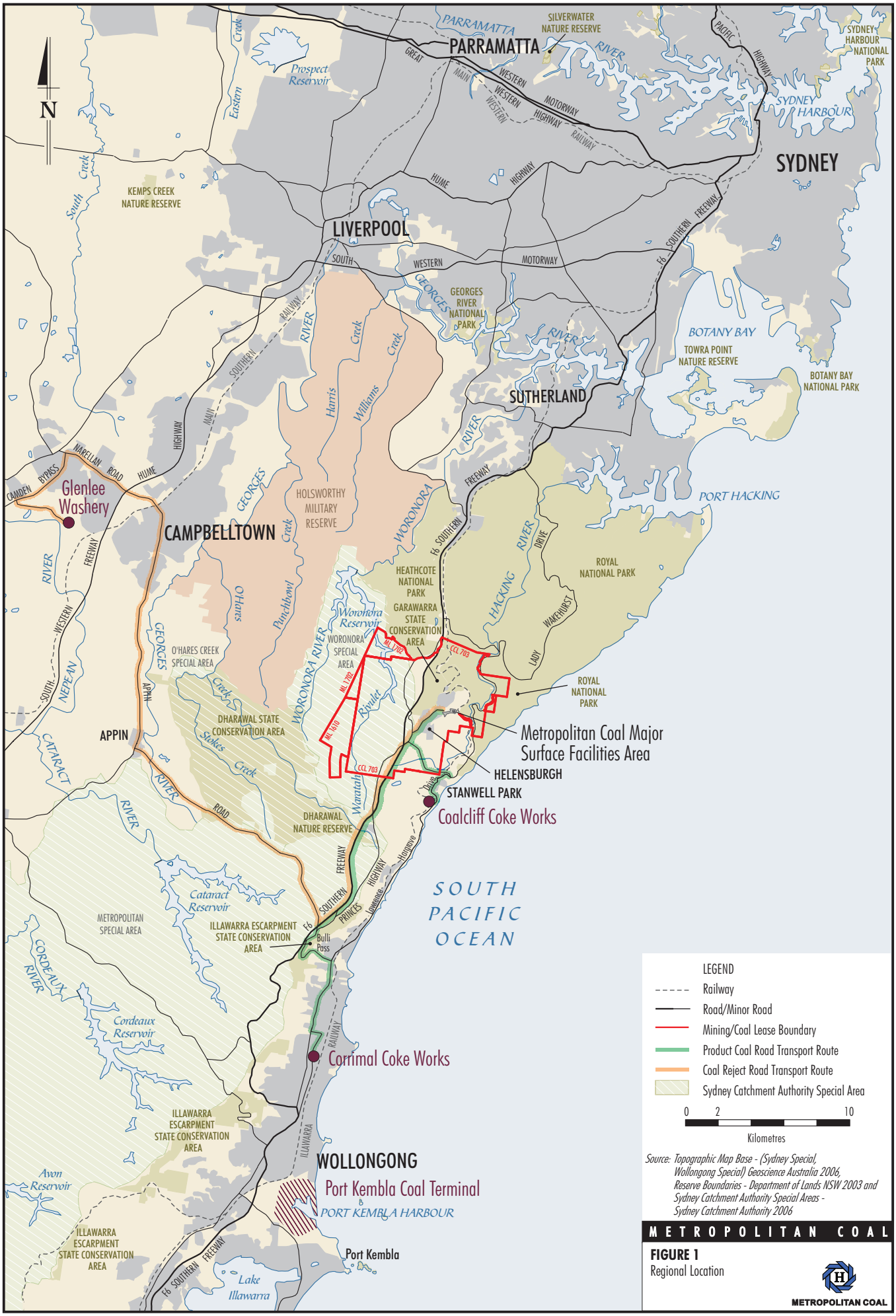
This report presents data for the period 1 January to 30 June 2015. The status of longwall development at the end of the reporting period is shown on Figure 4. During the reporting period Longwall 23B was completed in March 2015 and Longwall 24 commenced in April 2015.

1.2 STRUCTURE OF THE REPORT

The remainder of this report is structured as follows:

- Section 2 describes the environmental performance of water management during the mining of Longwalls 20-22 and Longwalls 23-27.
- Section 3 describes the environmental performance of biodiversity management during the mining of Longwalls 20-22 and Longwalls 23-27.
- Section 4 describes the environmental performance of land management during the mining of Longwalls 20-22 and Longwalls 23-27.
- Section 5 describes the environmental performance of heritage management during the mining of Longwalls 20-22 and Longwalls 23-27.
- Section 6 describes the environmental performance of built features management during the mining of Longwalls 20-22 and Longwalls 23-27.
- Section 7 describes the management of public safety during the mining of Longwalls 20-22 and Longwalls 23-27.
- Section 8 summarises rehabilitation management in the underground mining area and associated monitoring.
- Section 9 lists the references cited.

Sections 2 to 7 include a comprehensive review of monitoring results, identification of trends in the monitoring data, assessment of environmental performance (against the performance indicators and measures) and a revised characterisation according to the relevant Trigger Action Response Plans (TARPs).



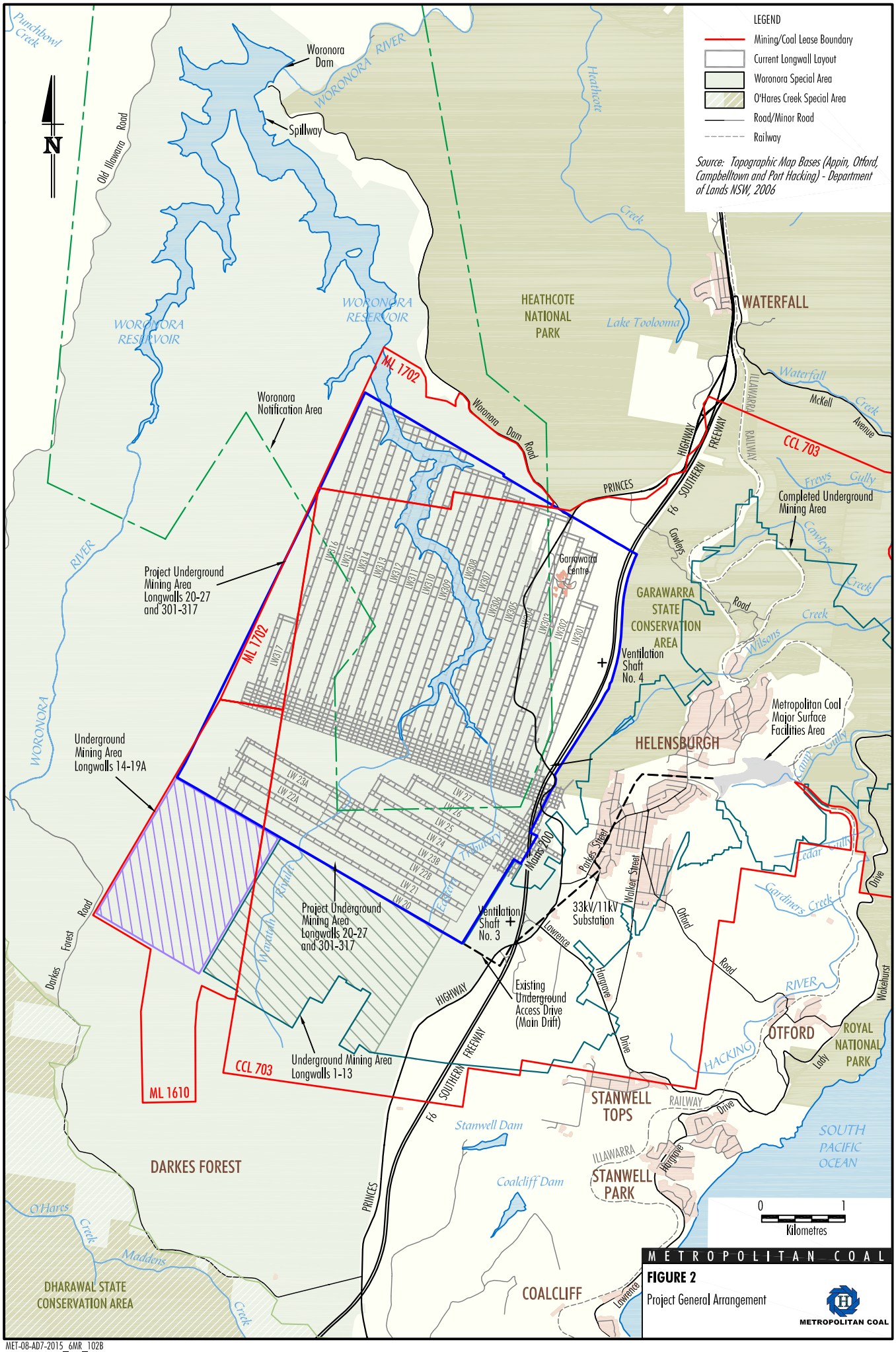
Source: Topographic Map Base - (Sydney Special, Wollongong Special) Geoscience Australia 2006, Reserve Boundaries - Department of Lands NSW 2003 and Sydney Catchment Authority Special Areas - Sydney Catchment Authority 2006

METROPOLITAN COAL

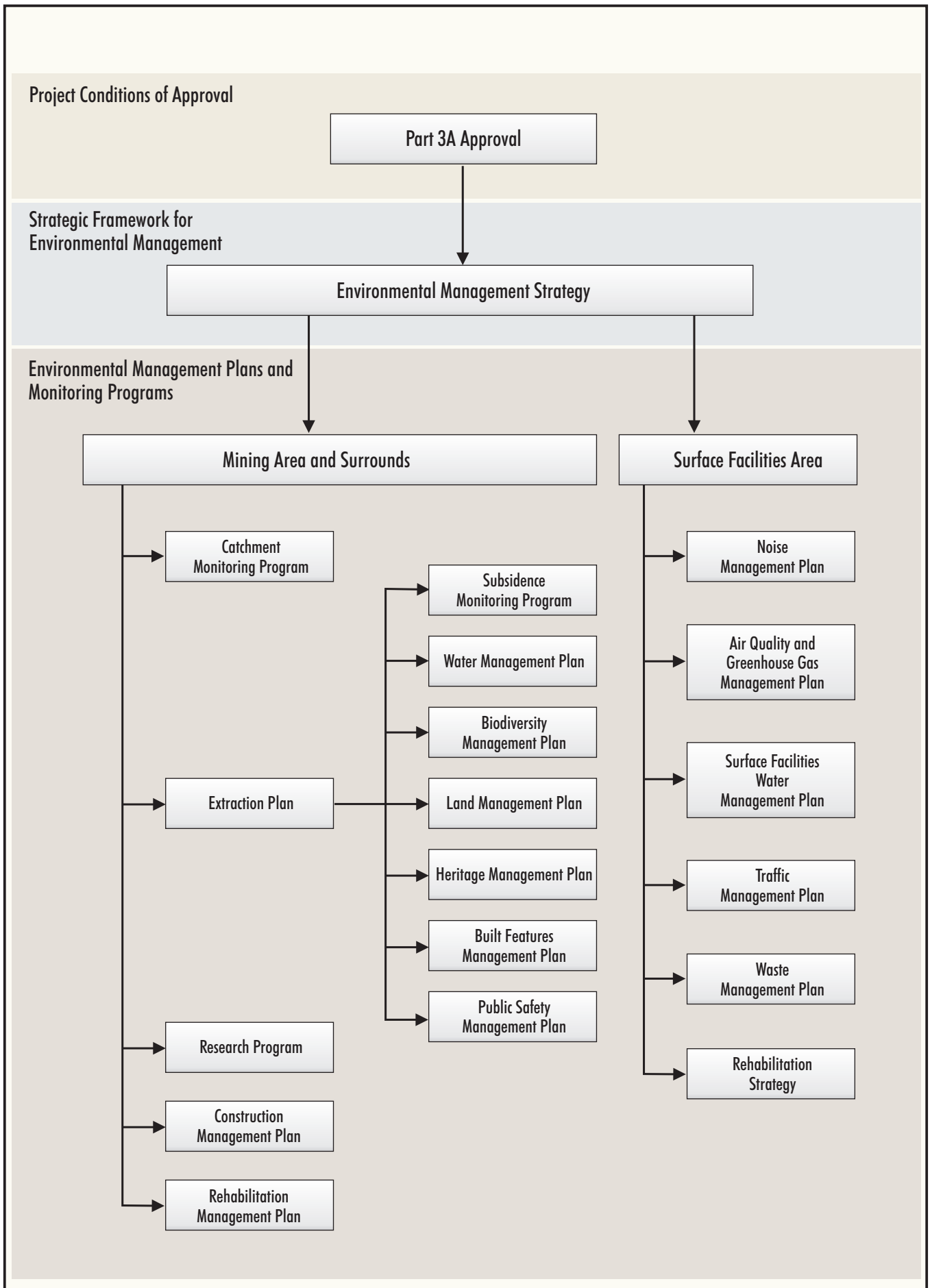
FIGURE 1
Regional Location

METROPOLITAN COAL

MET-08-AD7 2015_6MR_002A



MET-08-AD7-2015_6MR_102B

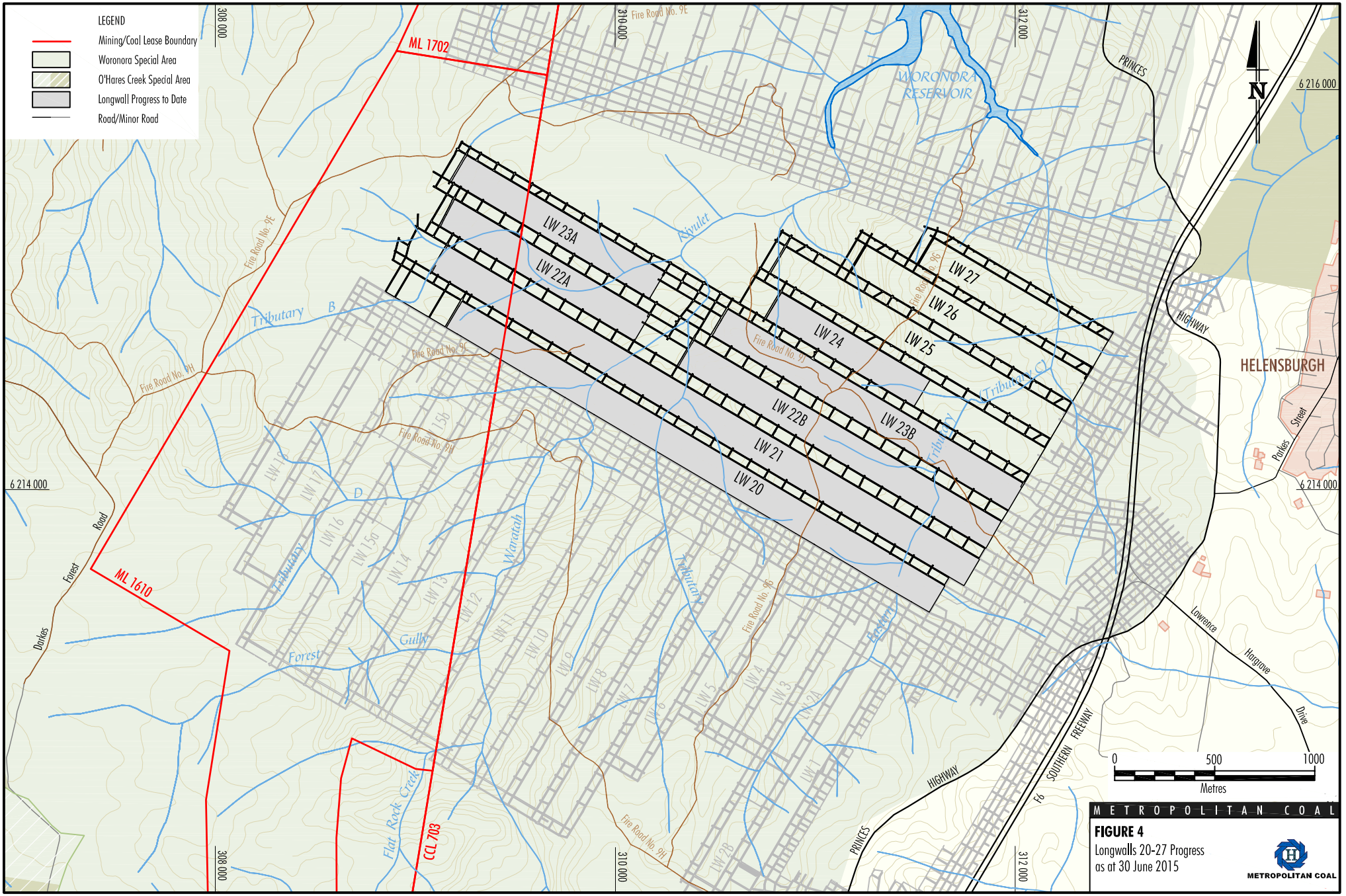


METROPOLITAN COAL

FIGURE 3
Environmental Management Structure

METROPOLITAN COAL

MET-08-AD7 2015_6MR_003B



METROPOLITAN COAL

FIGURE 4

Longwalls 20-27 Progress as at 30 June 2015

METROPOLITAN COAL

MET-08-AD7-2015_6MR_110F

2 WATER MANAGEMENT

2.1 BACKGROUND

The Metropolitan Coal Longwalls 20-22 Water Management Plan and Metropolitan Coal Longwalls 23-27 Water Management Plan were prepared to manage the potential environmental consequences of the Metropolitan Coal Longwalls 20-22 Extraction Plan and Metropolitan Coal Longwalls 23-27 Extraction Plan on watercourses (including the Woronora Reservoir), aquifers and catchment yield in accordance with Condition 6, Schedule 3 of the Project Approval.

2.2 MONITORING

Where the surface water and groundwater monitoring programs are entirely consistent between the Longwalls 20-22 and Longwalls 23-27 Water Management Plans, the monitoring results for the reporting period are described holistically in Section 2.2.2. Where there are differences in the monitoring programs between the Longwalls 20-22 and Longwalls 23-27 Water Management Plans, the results are described in Section 2.2.1 for monitoring applicable to Longwalls 20-22 and Section 2.2.2 for monitoring applicable to Longwalls 23-27.

2.2.1 Longwalls 20-22

2.2.1.1 Stream Features

Visual and photographic surveys of the Waratah Rivulet (from Flat Rock Crossing to the full supply level) and Eastern Tributary (from within the 35° angle of draw of Longwalls 20-22 to the full supply level) were conducted monthly when Longwalls 20-22 were within 400 m of the relevant stream and within three months of the completion of each longwall. Longwall 22 extraction was completed in April 2014.

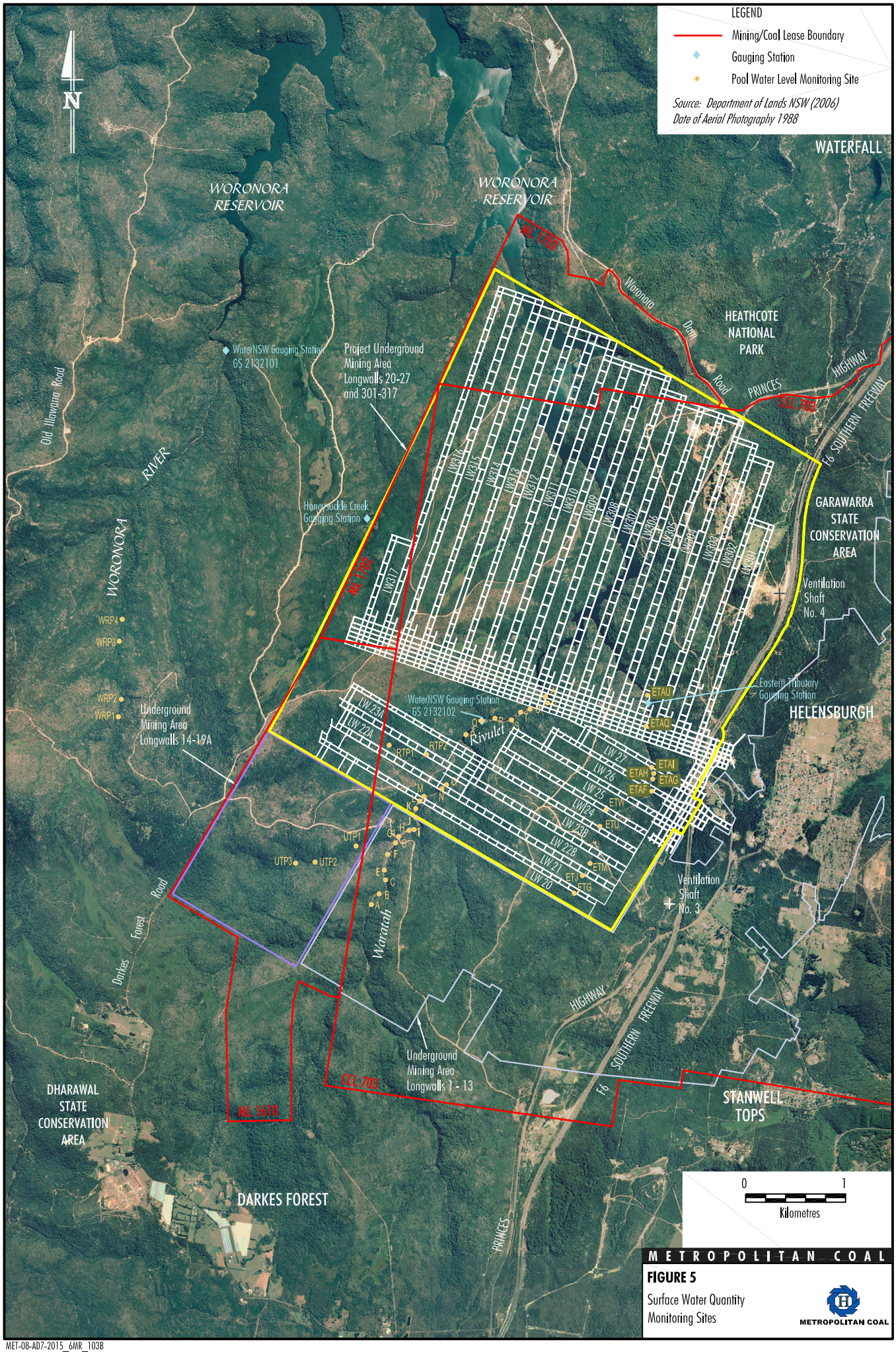
The Metropolitan Coal 2014 Annual Review and AEMR/Rehabilitation Report included the visual and photographic survey results for the Waratah Rivulet, Eastern Tributary, Tributary A and Tributary B conducted within three months of the completion of Longwall 22.

In accordance with the Metropolitan Coal Longwalls 20-22 Water Management Plan, the following actions are undertaken once a gas release is identified:

- monitoring conducted weekly to determine the extent of the gas releases;
- gas concentration monitoring; and
- identification of any observable environmental effects (e.g. impacts to riparian vegetation or fish).

During the reporting period, gas releases in the Waratah Rivulet continued to be observed in Pools L, O and P (Figure 5). Gas releases previously observed at Pool K were not observed during the reporting period. Gas releases in Pool L were previously observed in March 2012 and from July 2013 to December 2014. Gas releases continued to be observed in Pool L throughout the reporting period (i.e. from January to June 2015). Gas releases in Pool O were previously observed from April 2012 to February 2014, from mid April to mid May 2014, and from September to December 2014. Gas releases continued to be observed from January to June 2015. Gas releases in Pool P were identified for the first time in February 2014 and continued to the end of the reporting period.

Monitoring indicates that the gas releases were predominantly comprised of methane. No environmental effects resulting from the gas releases (such as riparian vegetation dieback or dead fish) have been observed.



MET-08-AD7-2015_6MR_103B

2.2.1.2 Surface Water Flow

Surface water flow monitoring for Longwalls 20-22 has included continuous flow monitoring at the WaterNSW (previously Sydney Catchment Authority [SCA])-owned gauging stations on the Waratah Rivulet (GS2132102) and Woronora River (GS2132101) and at the OEH gauging station on O'Hares Creek at Wedderburn (GS213200).

The results of stream flow monitoring are discussed in Section 2.2.2.2.

2.2.1.3 Pool Water Levels

Water levels in a number of 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), Eastern Tributary (Pools ETG, ETJ, ETM, ETU, ETW, ETAF, ETAG, ETAH, ETAI, ETAQ and ETAU), Tributary B (Pools RTP1 and RTP2) and Woronora River (Pools WRP1, WRP2, WRP3 and WRP4) have been either manually monitored on a daily basis or monitored using a continuous water level sensor and logger for Longwalls 20-22 (Figure 5).

The pool water level monitoring results for Waratah Rivulet are discussed in Section 8.2.2 in relation to the initiation of stream remediation.

The pool water level monitoring results for Pools RTP1 and RTP2 on Tributary B and Pools ETG, ETJ, ETM, ETU and ETW on the Eastern Tributary are discussed in Section 2.2.2.3 for the reporting period.

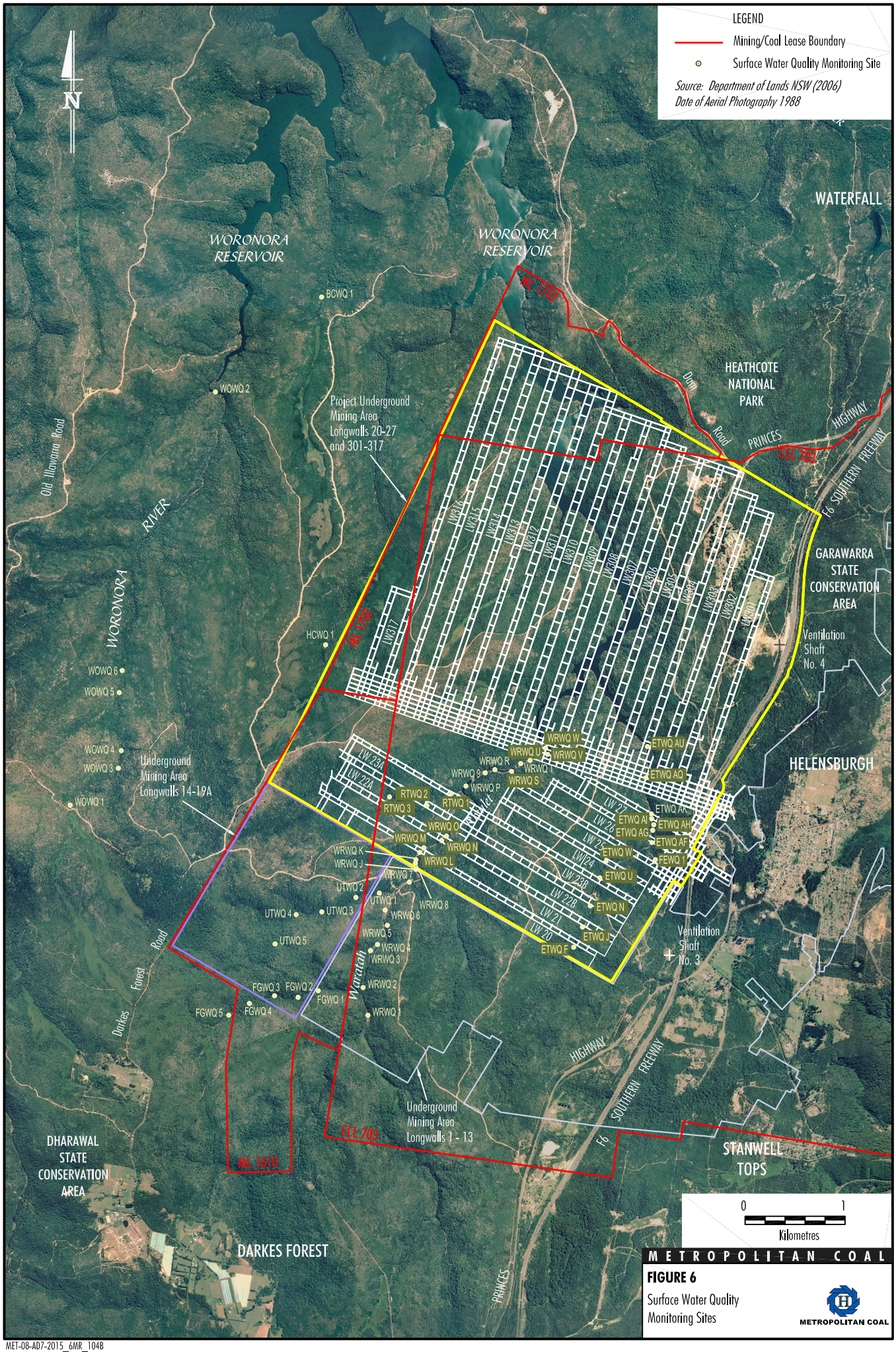
The pool water level monitoring results for Pools ETAF, ETAG, ETAH, ETAI, ETAQ and ETAU on the Eastern Tributary are discussed in Section 2.3.2.7 in relation to Longwalls 23-27.

2.2.1.4 Stream Water Quality

Surface water quality sampling for Longwalls 20-22 has been conducted monthly at the following sites on Waratah Rivulet, Tributary B, Tributary D, Eastern Tributary, Far Eastern Tributary, Honeysuckle Creek, Bee Creek and the Woronora River (Figure 6) in accordance with the Longwalls 20-22 Water Management Plan.

- sites WRWQ 2, WRWQ 6, WRWQ 8, WRWQ 9, WRWQ M, WRWQ N, WRWQ P, WRWQ R, WRWQ T 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 on Bee Creek; and
- control sites WOWQ 1 and WOWQ 2 on the Woronora River.

Water quality parameters sampled 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 phosphorus (Ptot), nitrate (NO_3), barium (Ba), strontium (Sr), manganese (Mn), iron (Fe), zinc (Zn), cobalt (Co) and aluminium (Al). Samples collected for metal analysis have been field filtered.



MET-08-AD7-2015_6MR_104B

Unfiltered water quality samples were also collected at a select number of sites on the Waratah Rivulet, Eastern Tributary and Woronora River and analysed for total iron in accordance with the Longwalls 20-22 Water Management Plan.

The results of the stream water quality monitoring for the reporting period are described in Section 2.2.2.4.

2.2.1.5 Woronora, Nepean and Cataract Reservoir Water Quality

Metropolitan Coal has sourced water quality data for the Woronora Reservoir, Nepean Reservoir and Cataract Reservoir from WaterNSW in accordance with a data exchange agreement.

Results of the analysis of this data are presented in Section 2.2.2.5.

2.2.1.6 Swamp Groundwater Levels

Upland swamp groundwater monitoring for Longwalls 20-22 is described in Section 3.2.1.2.

2.2.1.7 Shallow Groundwater Levels

Continuous water level monitoring of shallow groundwater levels has been conducted at sites WRGW1, WRGW2 and WRGW7 along Waratah Rivulet and sites ETGW1 and ETGW2 on the Eastern Tributary (Figure 7)[1].

The results of shallow groundwater level monitoring for the reporting period are described in Section 2.2.2.7.

2.2.1.8 Deep Groundwater Levels/Pressures

Continuous groundwater level/pressure monitoring has been conducted at bores 9HGW0 (Longwall 10 Goaf Hole), 9EGW1B, 9FGW1A, 9GGW1-80, 9GGW2B, 9HGW1B and PM02 (Figure 7) in accordance with the Metropolitan Coal Longwalls 20-22 Water Management Plan.

The results of deep groundwater level monitoring for the reporting period are described in Section 2.2.2.8.

2.2.1.9 Groundwater Quality

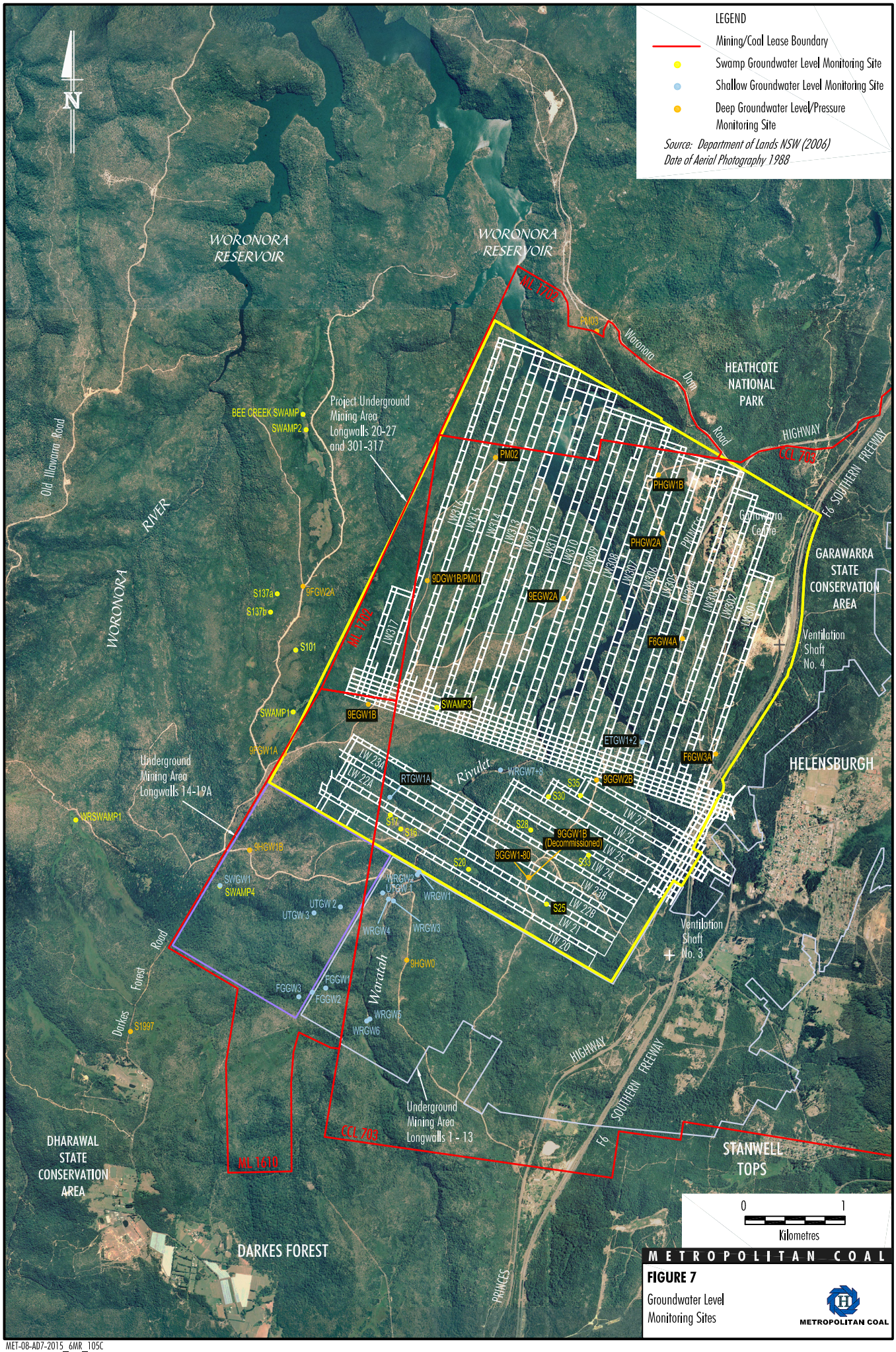
Shallow groundwater quality has been sampled monthly at sites WRGW1, WRGW2 and WRGW7 along the Waratah Rivulet and sites ETGW1 and ETGW2 on the Eastern Tributary (Figure 8)[2]. Water quality parameters sampled include EC, pH, Eh, Ca, Mg, Na, K, Cl, SO_4, HCO_3, Ba, Sr, Mn, Fe, Zn, Co and Al. The samples collected for the analysis of metals have been field filtered.

---

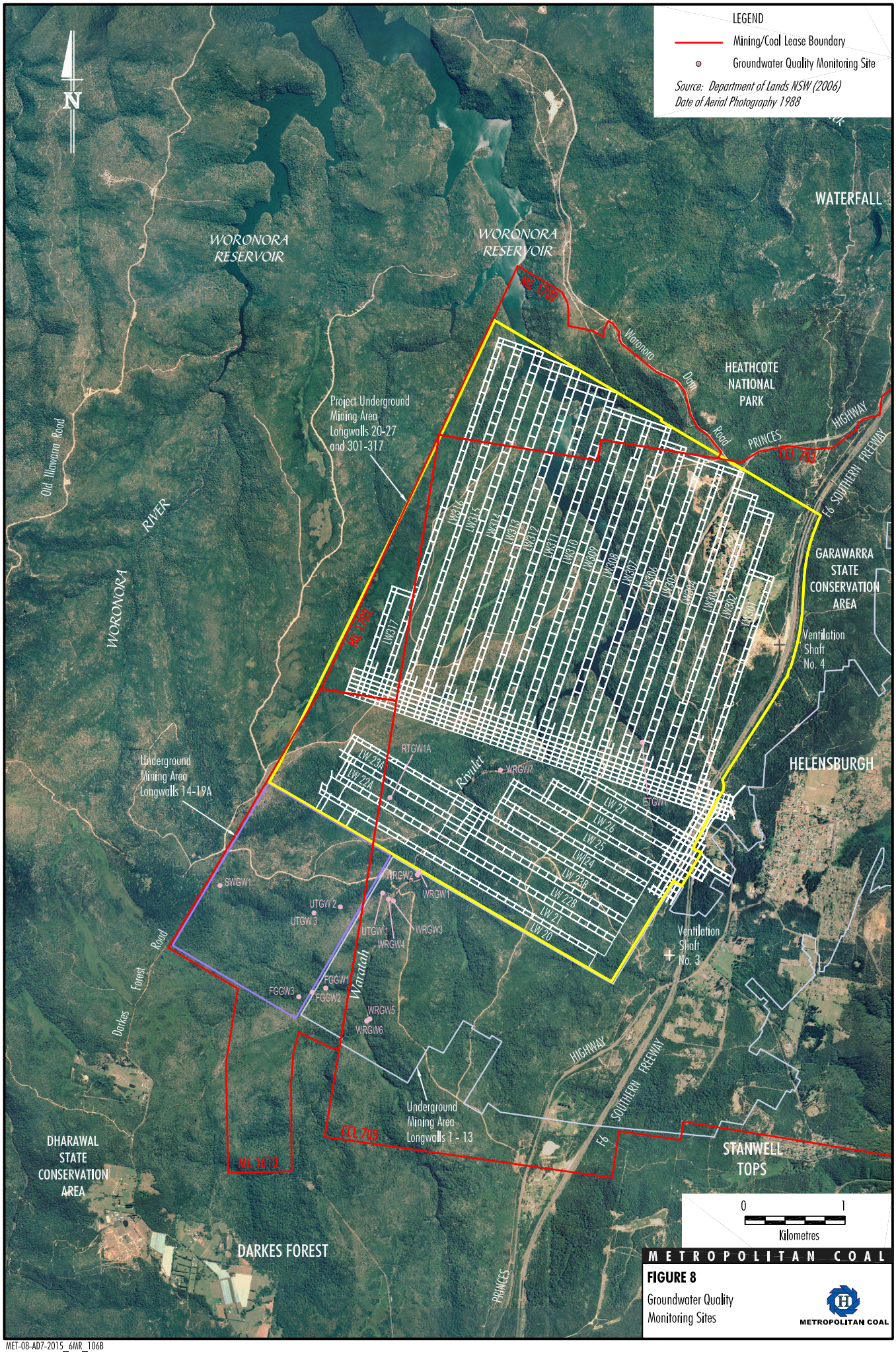
1 As previously reported, site WRGW8 is faulty and is not recording reliable data. Metropolitan Coal does not propose to replace the shallow groundwater bore at site WRGW8 given data is available at site WRGW7 on the opposite bank of the Waratah Rivulet.

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. Metropolitan Coal does not propose to install a new bore at site RTGW1A. It is considered that sufficient data has been obtained from this and previous bores on tributaries to understand the impacts of mine subsidence on the shallow groundwater.

2 Bore WRGW8 is considered faulty and is not recording reliable data. Due to bore failure, groundwater quality at RTGW1A has not been able to be sampled since December 2013.



MET-08-AD7-2015_6MR_105C



MET-08-AD7-2015_6MR_106B

The results of groundwater quality monitoring for the reporting period are described in Section 2.2.2.9.

2.2.1.10 Inspections of Mine Workings

The mine inspections conducted to identify any abnormal water flows from the goaf, geological structure, or strata generally during the reporting period are described in Section 2.2.2.10.

2.2.1.11 Mine Water Make

In accordance with the Metropolitan Coal Longwalls 20-22 Water Management Plan, Metropolitan Coal has monitored the mine water balance.

The results of mine water make monitoring are described in Section 2.2.2.11.

2.2.2 Longwalls 23-27

2.2.2.1 Stream Features

Visual and photographic surveys along Waratah Rivulet and Eastern Tributary (from within the 35° angle of draw of Longwalls 23-27 to the Woronora Reservoir full supply level) are conducted monthly when Longwalls 23-27 are within 400 m of the relevant stream and within three months of the completion of each longwall.

Visual inspections and photographic surveys along Tributary A and Tributary B (within the 35° angle of draw of Longwalls 23-27) are also conducted within three months of the completion of each longwall.

The visual and photographic surveys 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. length of stream affected);
- 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 existing 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.

Global positioning system (GPS) coordinates are recorded where appropriate (e.g. of particular observations and associated photographs).

The monthly visual and photographic surveys record the above parameters by exception (i.e. where they differ to the baseline visual and photographic record). During the reporting period monthly surveys of the Waratah Rivulet were conducted in May 2015 (at the commencement of Longwall 24[3]) and of the Eastern Tributary in January, February, March and June 2015 (near the completion of Longwalls 23 and 24).

No new surface cracking was observed at pools on the Waratah Rivulet during the reporting period, with the exception of between Pools H and I and between Pools N and O. Iron staining and discolouration was noted at a number of rockbars and/or pools on the Waratah Rivulet. There was no evidence of changes in the extent or nature of iron staining observed between Pools P to W.

No new surface cracking and no gas releases were noted on the Eastern Tributary by the monthly inspections.

Iron staining and water discolouration was noted at a number of rockbars and/or pools. At the Fire Road 9J Crossing a high level of iron floculent was observed between Pools ETO and ETP and in some localities thick mats of algae/bacteria had formed. The occurence of iron staining reduced from Pools ETX to ETAQ. There was no indication of elevated levels of flocculent compared to previous at Pools ETAA to ETAU.

The visual and photographic surveys conducted within three months of the completion of each longwall provide a detailed photographic record of stream features. A detailed photographic record of Waratah Rivulet, Eastern Tributary, Tributary A and Tributary B was conducted within three months of Longwall 23 completion (May 2015) and is provided in Appendix A.

During the reporting period, gas releases in the Waratah Rivulet relevant to the monitoring of Longwalls 23-27 (i.e. within the 35° angle of draw of Longwalls 23-27) were observed in Pools O and P (Figure 5). In accordance with the Metropolitan Coal Longwalls 23-27 Water Management Plan, the following actions were undertaken once the gas release was identified:

- monitoring conducted weekly to determine the extent of the gas releases;
- gas concentration monitoring; and
- identification of any observable environmental effects (e.g. impacts to riparian vegetation or fish).

Gas releases in Pool O were previously observed from April 2012 to February 2014, from mid April to mid May 2014, and from September to December 2014. Gas releases continued to be observed from January to June 2015. Gas releases in Pool P were identified for the first time in February 2014 and continued to the end of the reporting period.

Monitoring indicates that the gas releases were predominantly comprised of methane. No environmental effects resulting from the gas releases (such as riparian vegetation dieback or dead fish) have been observed.

[3] The inspection was due to be carried out in April 2015, however due to catchment closure was not able to be conducted until May 2015.

2.2.2.2 Surface Water Flow

Surface water flow monitoring for Longwalls 23-27 includes continuous flow monitoring at (Figure 5):

- the existing WaterNSW-owned gauging station on the Waratah Rivulet, close to the inundation limits of the Woronora Reservoir (GS2132102);
- the existing WaterNSW-owned gauging station on the Woronora River, close to the inundation limits of the Woronora Reservoir (GS2132101) (control site);
- the existing OEH gauging station on O'Hares Creek at Wedderburn (GS213200) (control site);
- the existing Metropolitan Coal-owned gauging station on the Eastern Tributary, close to the inundation limits of the Woronora Reservoir; and
- the existing Metropolitan Coal-owned gauging station on Honeysuckle Creek (control site).

Revised Rating Curves for Waratah Rivulet, Woronora River and O'Hares Creek

During the reporting period, the flow records from the Waratah Rivulet (GS2132102) and Woronora River (GS2132101) gauging stations were regenerated using amended rating relationships developed by Gilbert & Associates on behalf of Metropolitan Coal. The resultant rating curves are shown in Charts 1 and 2.

A revised rating curve was also developed for O'Hares Creek at Wedderburn (GS213200) based on all NSW Office of Water (NOW) gauging data collected over the period from 1978 to 2003[4] as well as the known shape of the V-notch and concrete weir at this location. Chart 3 shows the adjusted rating curve described immediately together with the gauging data collected by NOW since 1978[5] for O'Hares Creek at Wedderburn GS213200.

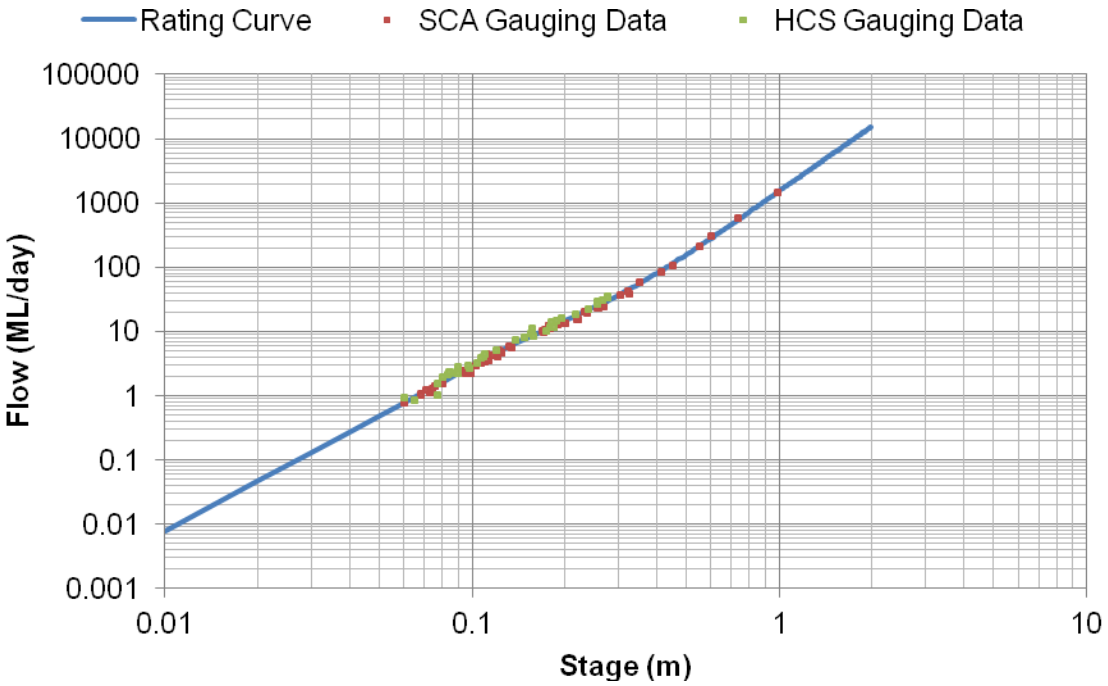


Chart 1 Waratah Rivulet GS2132102 Rating Curve compared to SCA and HCS Gauging Data

[4] All available NOW gauging data for the period since establishment of the weir in its current configuration.

[5] Data collected prior to 1978 is prior to the weir construction and therefore significantly less reliable.

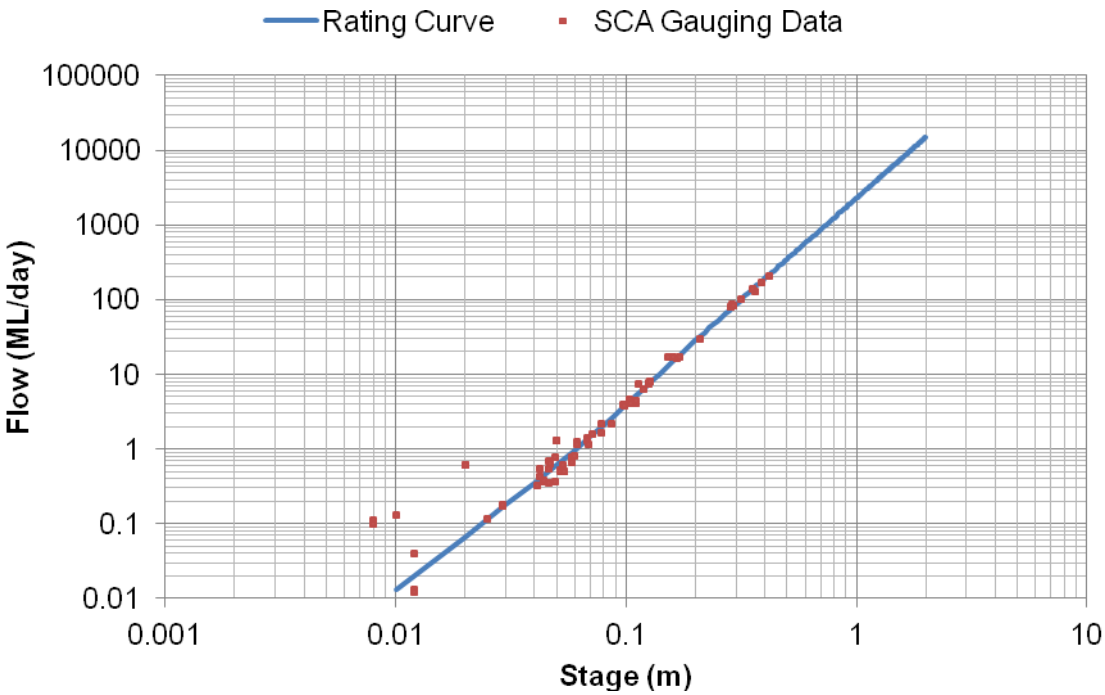


Chart 2 Woronora River GS2132101 Rating Curve compared to SCA Gauging Data

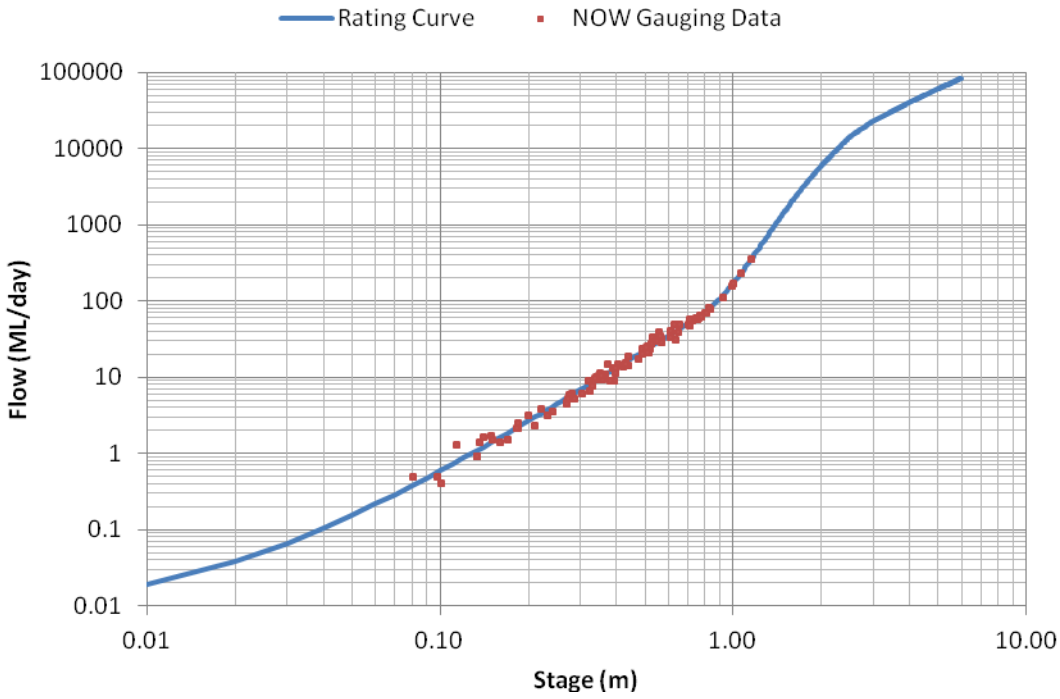


Chart 3 O'Hares Creek at Wedderburn GS213200 Rating Curve compared to NOW Gauging Data

Catchment Model Development and Calibration

Re-calibrated catchment models have also been developed by Gilbert & Associates for the Waratah Rivulet, Woronora River and O'Hares Creek gauging stations using the regenerated flow data.

The models used were adapted from the Australian Water Balance Model (AWBM) originally developed for the environmental impact assessment studies and used for the performance indicator assessment, to include a variable baseflow index.

The baseflow index is defined as the ratio of baseflow to total flow. It is used as a constant parameter in the AWBM. As part of the re-calibration of the AWBM the baseflow index, 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 modelled (calibrated) and recorded flows over the baseline (calibration) period are shown on Charts 4, 5 and 6 for Waratah Rivulet, Woronora River and O'Hares Creek on logarithmic scale. The revised rating curves and re-calibrated models have been peer reviewed by Emeritus Professor Tom McMahon at the University of Melbourne.

As described in the Metropolitan Coal Catchment Monitoring Program, catchment models will be developed for the Eastern Tributary and Honeysuckle Creek gauging stations. A comprehensive assessment of the flow data for these gauging stations will be conducted in the next reporting period.

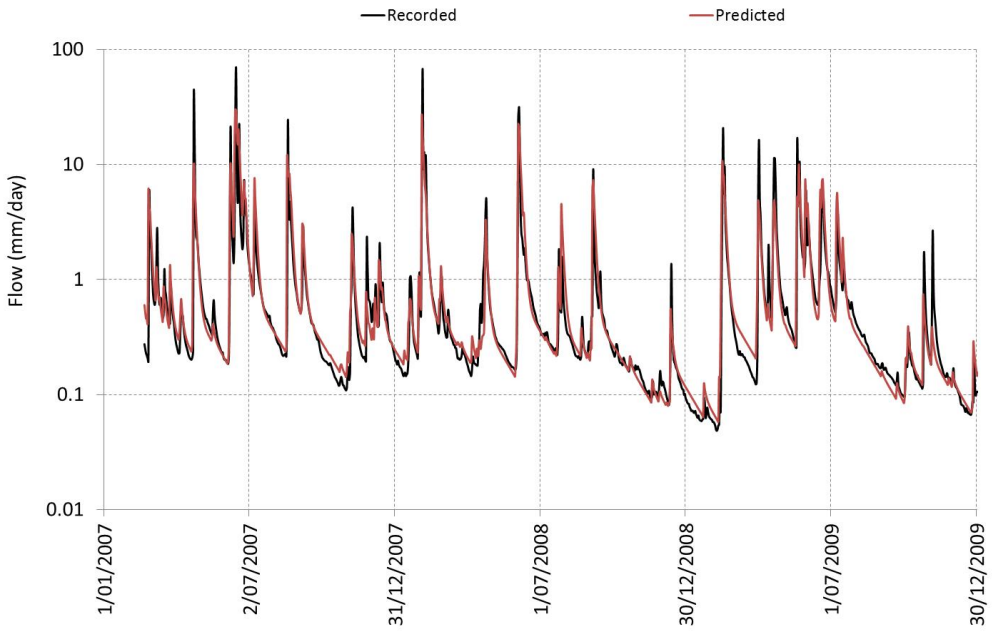


Chart 4 Comparison of Calibrated AWBM with Recorded Flows during Baseline Period (21/2/2007 to 31/12/2009) - Waratah Rivulet

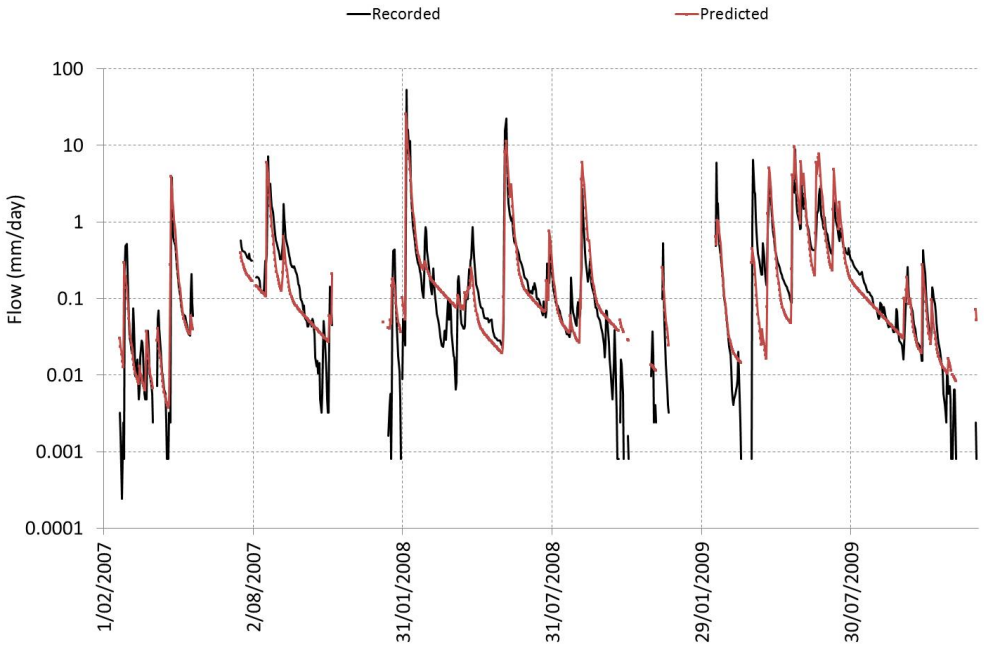


Chart 5 Comparison of AWBM with Recorded Flow during Calibration Period (21/2/2007 to 31/12/2009) – Woronora River

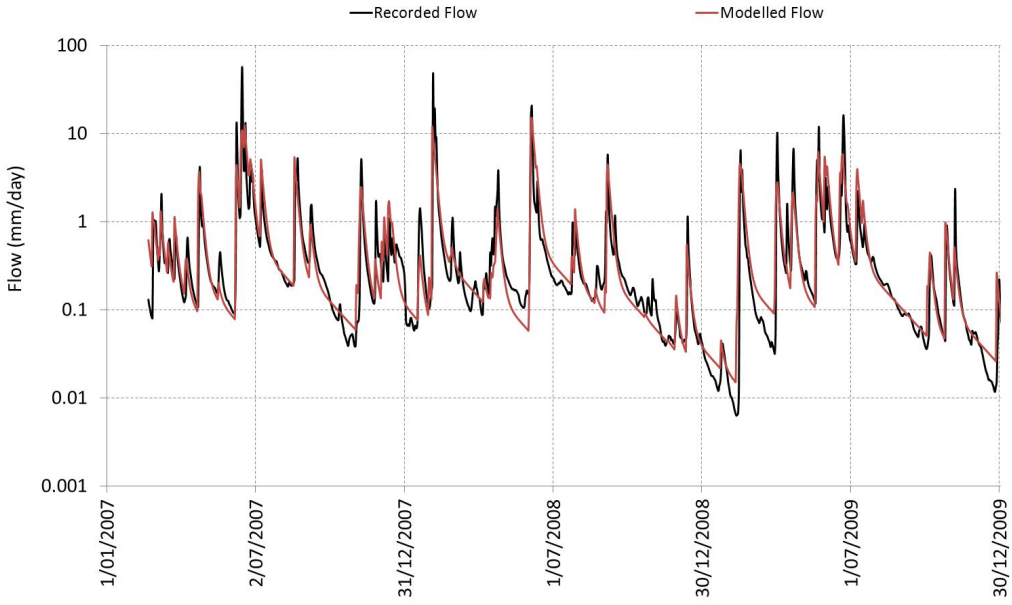


Chart 6 Comparison of AWBM with Recorded Flow during Calibration Period (21/2/2007 to 31/12/2009) – O'Hares Creek

2.2.2.3 Pool Water Levels

Water levels in a number of 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), Eastern Tributary (Pools ETG, ETJ, ETM, ETU, ETW, ETAF, ETAG, ETAH, ETAI, ETAQ and ETAU), Tributary B (Pools RTP1 and RTP2) and Woronora River (Pools WRP1, WRP2, WRP3 and WRP4) have been either manually monitored on a daily basis or monitored using a continuous water level sensor and logger for Longwalls 23-27 (Figure 5).

The pool water level monitoring results for Waratah Rivulet are discussed in Section 8.3.2 in relation to the initiation of stream remediation.

The pool water level monitoring results for Pools ETAF, ETAG, ETAH, ETAI, ETAQ and ETAU the Eastern Tributary are discussed in Section 2.3.2.7.

The pool water level monitoring results for Pools RTP1 and RTP2 on Tributary B and Pools ETG, ETJ, ETM, ETU and ETW on the Eastern Tributary are described below.

The water level in Pool RTP1 on Tributary B is shown on Chart 7. The recorded water level hydrograph for Pool RTP1 indicates that there was a drop in water level in August 2012. The aquatic ecology surveys (refer Section 3.2.1.4) on Tributary B have observed that pools at or in the vicinity of Pool RTP1 almost completely drained of water in spring 2012 and since then, pools have been mostly dry with no surface-flow. The recorded water levels during the reporting period indicate that it has flowed intermittently with significant flow events having occurred in April and May 2015. There is no record available after the 19 May 2015 event due to flood damage.

The water level in Pool RTP2 on Tributary B is shown on Chart 8. The recorded water level hydrograph for Pool RTP2 indicates that water levels have occasionally fallen below its 'normal' low flow level, which is assumed to be near or below its cease to flow level. The large, short duration, fluctuations recorded at this site prior to 2010 makes pool level interpretation difficult. Recorded water levels during the reporting period are however generally consistent with previous pool levels recorded post 2010.

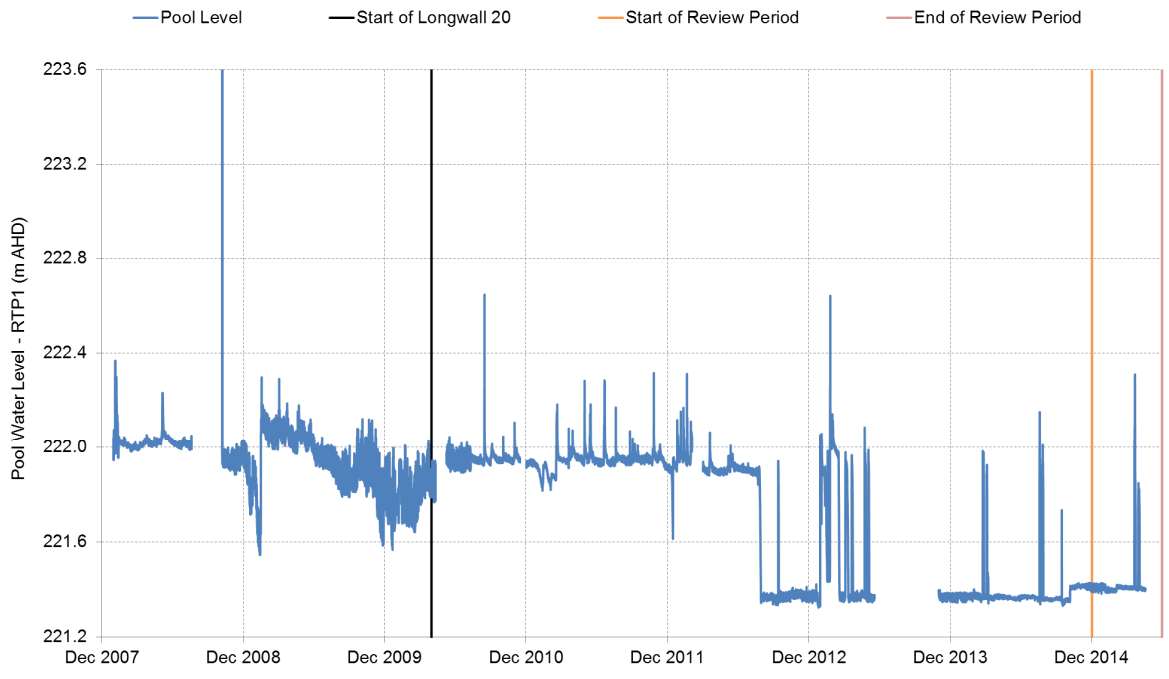


Chart 7 Water Level Hydrograph – Tributary B Pool RTP1

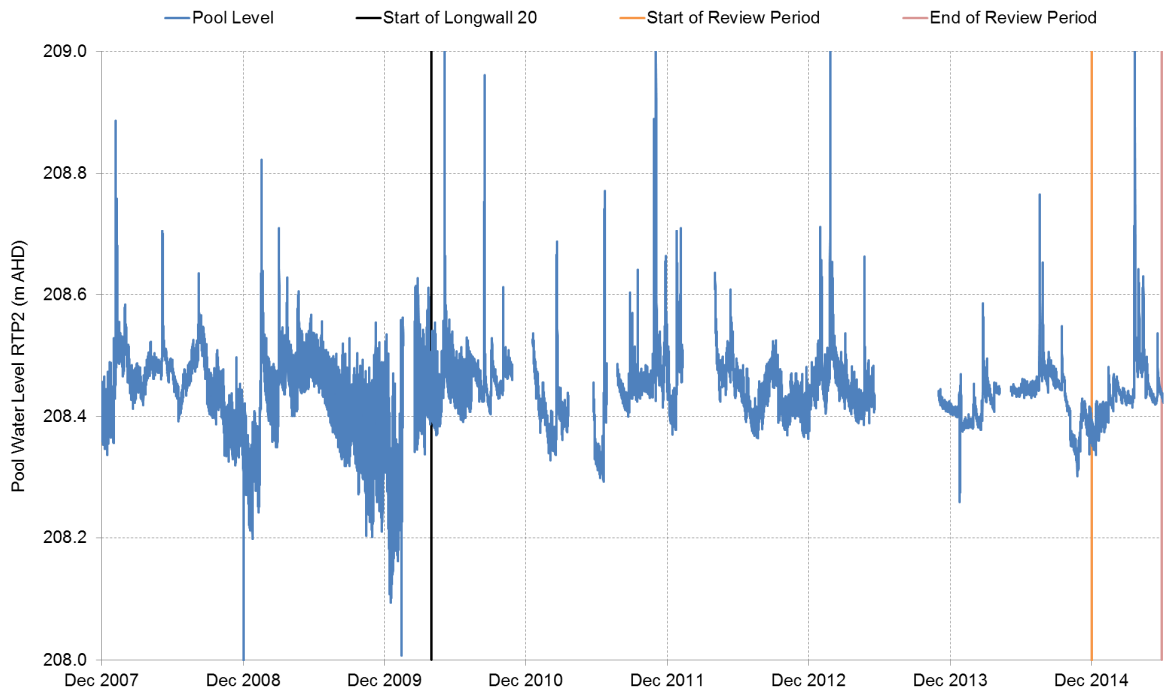


Chart 8 Water Level Hydrograph – Tributary B Pool RTP2

The water levels in Pools ETG, ETJ, ETM, ETU and ETW on the Eastern Tributary are shown on Charts 9 to 13.

Water levels in Pool ETG have remained above the cease to flow level throughout the reporting period. Water levels in Pool ETG were recorded as being below the cease to flow level in early 2014, however the sudden fall, and then subsequent sudden rise in water level indicate that the fall in water level corresponded to a period where the level datum on the water level sensor shifted (which can occur during the downloading of data) rather than a real cease to flow event (Chart 9).

During the reporting period the water level in Pool ETJ appears to have briefly fallen below the pool's cease to flow level between 8 and 11 January 2015 (Chart 10).

Pool ETM also appears to have fallen below its cease to flow level between the 4 and 11 January 2015, on the 12 February and again between the 29 March and 1 April 2015 (Chart 11).

Water levels in Pools ETU and ETW were above the cease to flow levels during the reporting period (Charts 12 and 13).

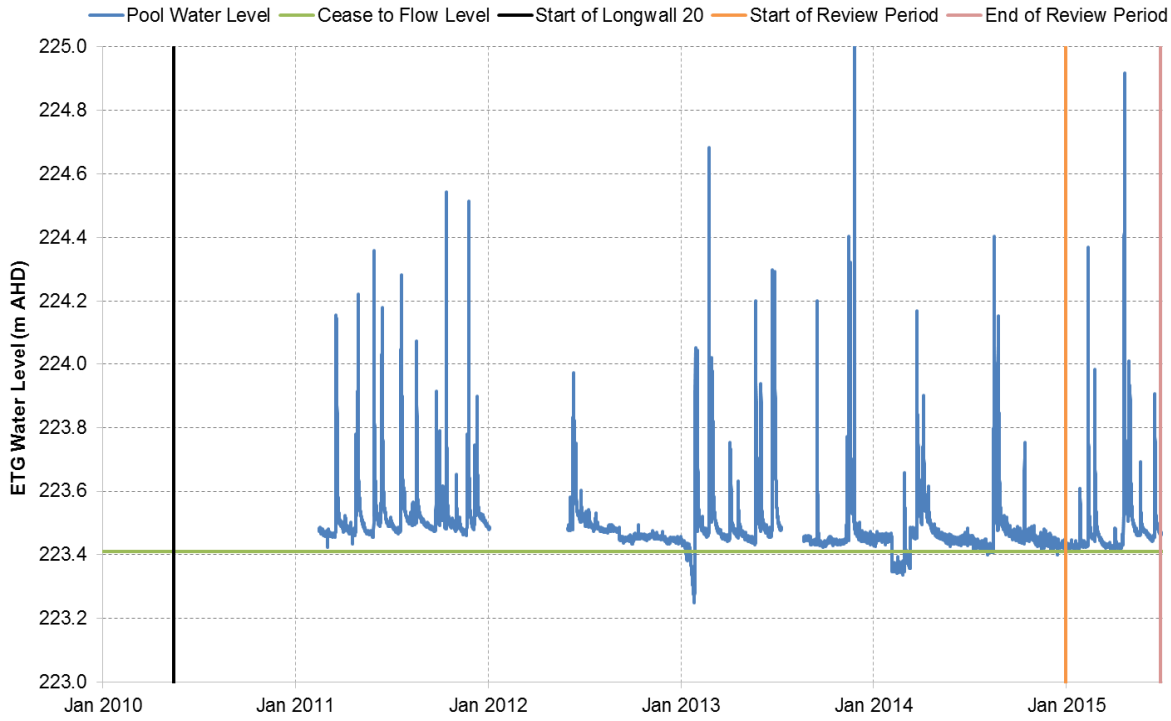


Chart 9 Water Level Hydrograph - Eastern Tributary Pool ETG

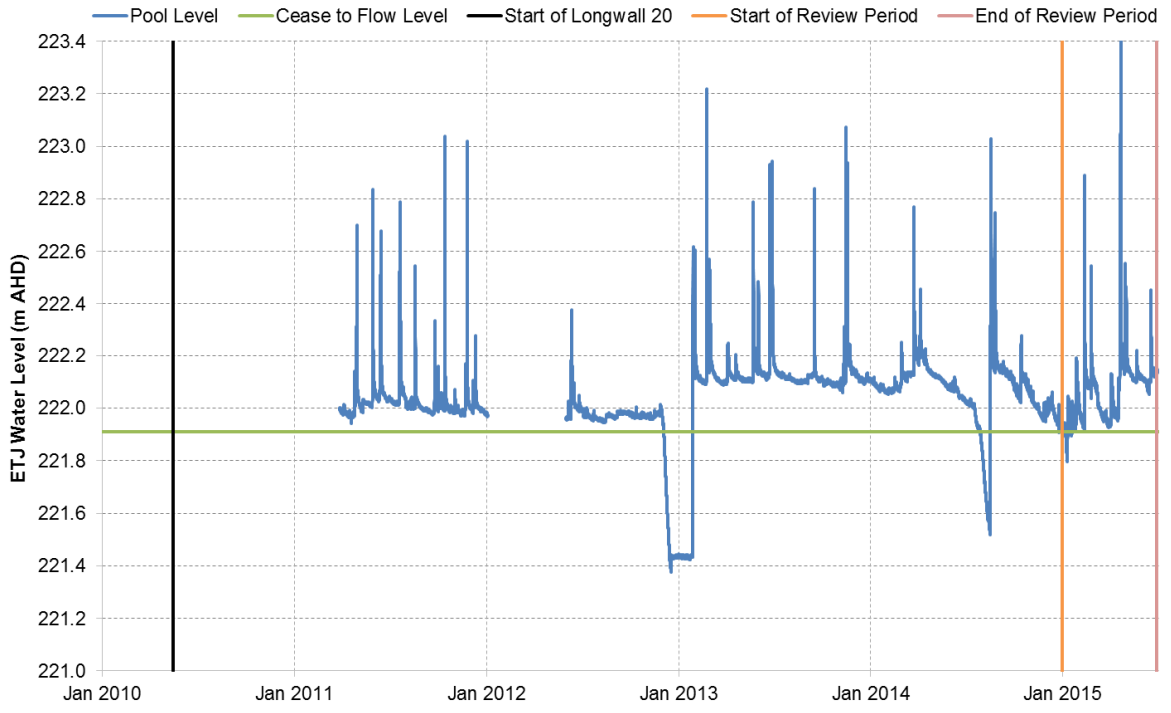


Chart 10 Water Level Hydrograph - Eastern Tributary Pool ETJ

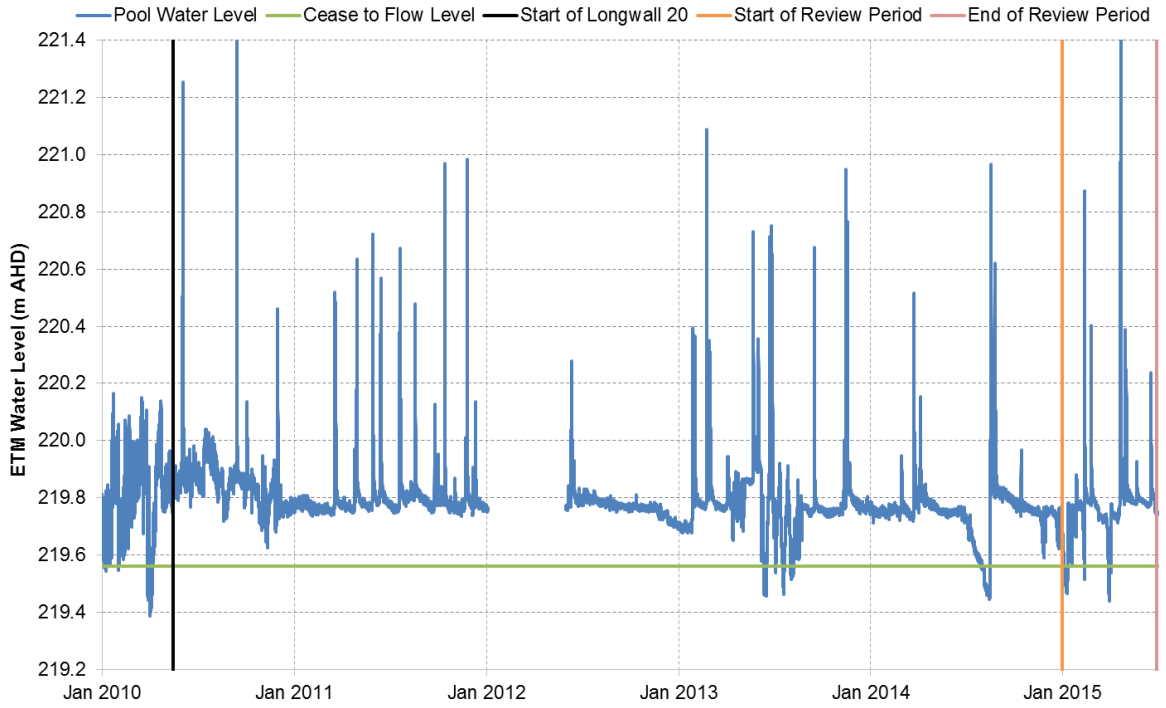


Chart 11 Water Level Hydrograph - Eastern Tributary Pool ETM

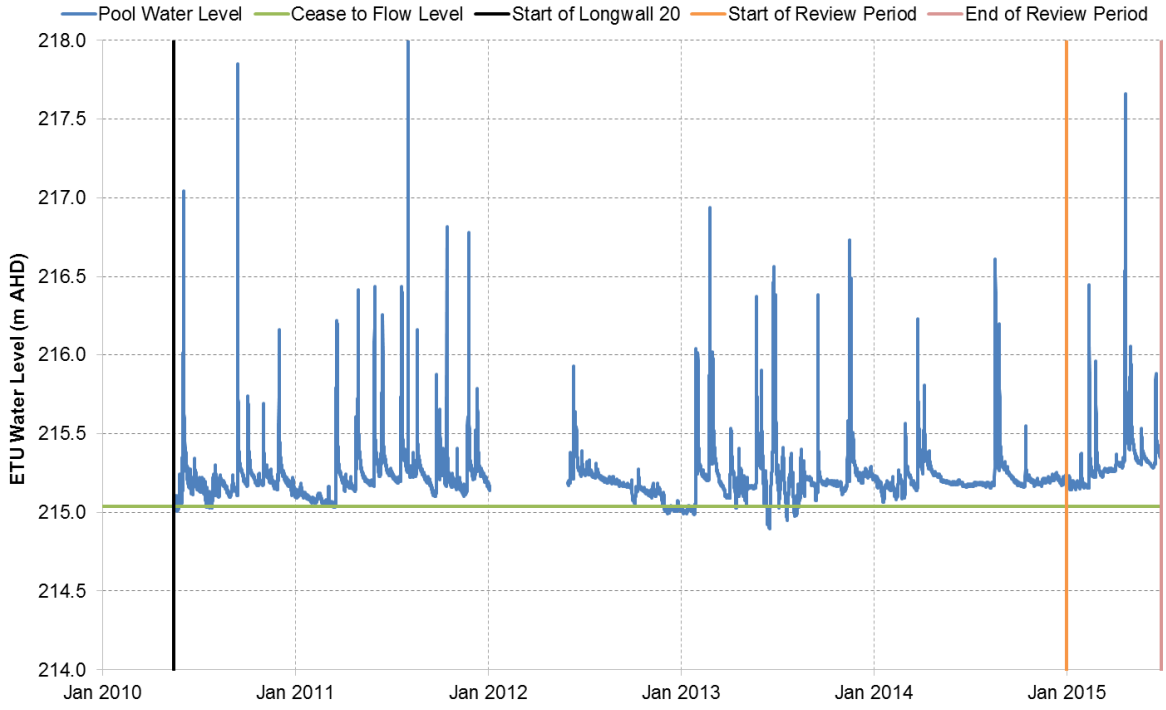


Chart 12 Water Level Hydrograph - Eastern Tributary Pool ETU

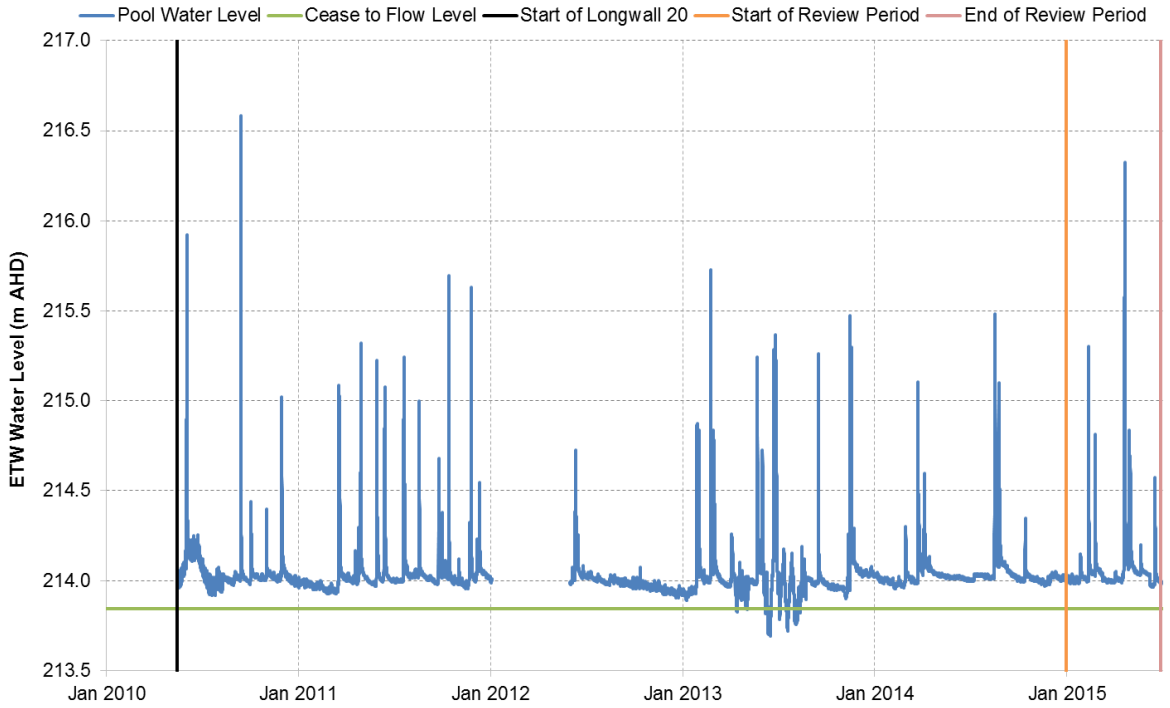


Chart 13 Water Level Hydrograph - Eastern Tributary Pool ETW

Pools P, Q, R, S, T, U, V and W on Waratah Rivulet are visually inspected on a weekly basis when mining of Longwalls 23-27 is within 400 m of these pools. Longwall 24 was within 400 m of the Waratah Rivulet in April 2015[6]. The visual inspections indicated the water levels in Pools P to W on Waratah Rivulet remained above the cease to flow level.

Pools ETAF to ETAQ on the Eastern Tributary are visually inspected on a weekly basis when mining of Longwalls 23-27 is within 400 m of these pools. Longwalls 23 and 24 did not come within 400 m of Pools ETAF to ETAQ.

All pools between Pool ETG and Pool ETAQ on the Eastern Tributary are inspected monthly when mining of Longwalls 23-27 is within 400 m of the Eastern Tributary. Pools between Pool ETG and Pool ETAQ on the Eastern Tributary were inspected in January, February, March and June 2015. The visual inspections indicated the water levels in Pools ETG to ETAQ on Eastern Tributary were above their cease to flow level at the time of the inspections.

Pool ETAU will be inspected monthly when mining is within 400 m of the Eastern Tributary during extraction of Longwall 27.

[6] Due to catchment closures, inspections were conducted in May 2015.

2.2.2.4 Stream Water Quality

Surface water quality sampling has been conducted monthly at the following sites on Waratah Rivulet, Tributary B, Tributary D, Eastern Tributary, Far Eastern Tributary, Honeysuckle Creek, Bee Creek and the Woronora River (Figure 6) in accordance with the Longwalls 23-27 Water Management Plan:

- sites WRWQ 2, WRWQ 6, WRWQ 8, WRWQ 9, WRWQ M, WRWQ N, WRWQ P, WRWQ R, WRWQ T 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 on Bee Creek; and
- control sites WOWQ 1 and WOWQ 2 on the Woronora River.

Water quality parameters sampled 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 phosphorus (Ptot), nitrate (NO_3), barium (Ba), strontium (Sr), manganese (Mn), iron (Fe), zinc (Zn), cobalt (Co) and aluminium (Al). Samples collected for metal analysis have been field filtered.

Unfiltered water quality samples are also collected at a select number of sites on the Waratah Rivulet, Eastern Tributary and Woronora River and analysed for total iron.

Consistent with the Metropolitan Coal Longwalls 20-22 and Longwalls 23-27 Water Management Plans, the key parameters of interest are pH, EC, dissolved aluminium, dissolved iron and dissolved manganese. The results of these key water quality parameters are graphically presented for the sites listed above on Charts B1 to B35 of Appendix B. Monitoring results for other sites on Waratah Rivulet, Tributary B, Tributary D, Eastern Tributary, Far Eastern Tributary, Honeysuckle Creek, Bee Creek, and the Woronora River are also shown on Charts B1 to B35 of Appendix B to show trends over the length of the streams.

Water quality patterns at monitoring sites over the reporting period have generally been consistent with earlier data. Upstream sites on Waratah Rivulet show slightly acidic pH values with higher (near neutral) values being recorded at downstream sites (Charts B1 and B6 in Appendix B). Electrical conductivity has been consistently low. Dissolved iron concentrations have been noticeably higher at the most upstream sites. Dissolved Aluminium and dissolved manganese have been consistently low.

Sampling sites on Woronora River typically show slightly acid and high variability in pH. Electrical conductivity values have been consistently low and similar to values recorded on Waratah Rivulet. Dissolved iron has been generally low but with periodic spikes most notably at site WOWQ2 (downstream). Spikes have occurred more frequently during the summer months. Dissolved aluminium concentrations have been typically low with some notable spikes having been recorded prior to 2011 particularly at site WOWQ1 upstream. Dissolved manganese has been typically low with evidence of more elevated concentrations occurring in summer months.

Sampling sites on Eastern Tributary show variable but typically near neutral pH values, consistently low electrical conductivity values and low dissolved aluminium and dissolved manganese concentrations. Dissolved iron has shown evidence of seasonal effects and some relatively elevated concentrations (e.g. 2.1 mg/L at site ETWQ N in 2014 and 1.8 mg/L at site ETWQ U in 2015).

Sampling sites of Far Eastern Tributary, Bee Creek and Honeysuckle Creek have recorded variable and slightly to moderately acidic pH levels in Bee Creek and Honeysuckle Creek. pH levels in Far Eastern Tributary have been near neutral. Electrical conductivity values have been somewhat higher at Far Eastern Tributary but overall generally similar to other sampled water sampling sites. Dissolved iron, dissolved aluminium and dissolved manganese concentrations have been generally low with periodic small spikes in dissolved iron and dissolved manganese recorded mostly during summer months.

Sampling sites on the Reference Tributary (Tributary B) have recorded an upward trend in pH to near neutral values from mid-2012. Similar trends have been reported for electrical conductivity. Both pH and electrical conductivity appear to have plateaued in 2014. Dissolved iron, dissolved aluminium and dissolved manganese results have generally been low. There have however been several low spikes in concentration recorded during the earlier part of the record (prior to 2013).

Sampling sites on the Un-Named Tributary (Tributary D) have recorded variable and inconsistent pH levels – generally between 5 and 8. Dissolved iron and dissolved manganese concentrations have also been variable with higher concentrations being reported for site UTWQ3. Dissolved aluminium concentrations have been low.

2.2.2.5 Woronora, Nepean and Cataract Reservoir Water Quality

Metropolitan Coal has sourced water quality data for the Woronora Reservoir, Nepean Reservoir and Cataract Reservoir from the WaterNSW in accordance with a data exchange agreement.

Results of the analysis of this data are presented in Section 2.3.1.5.

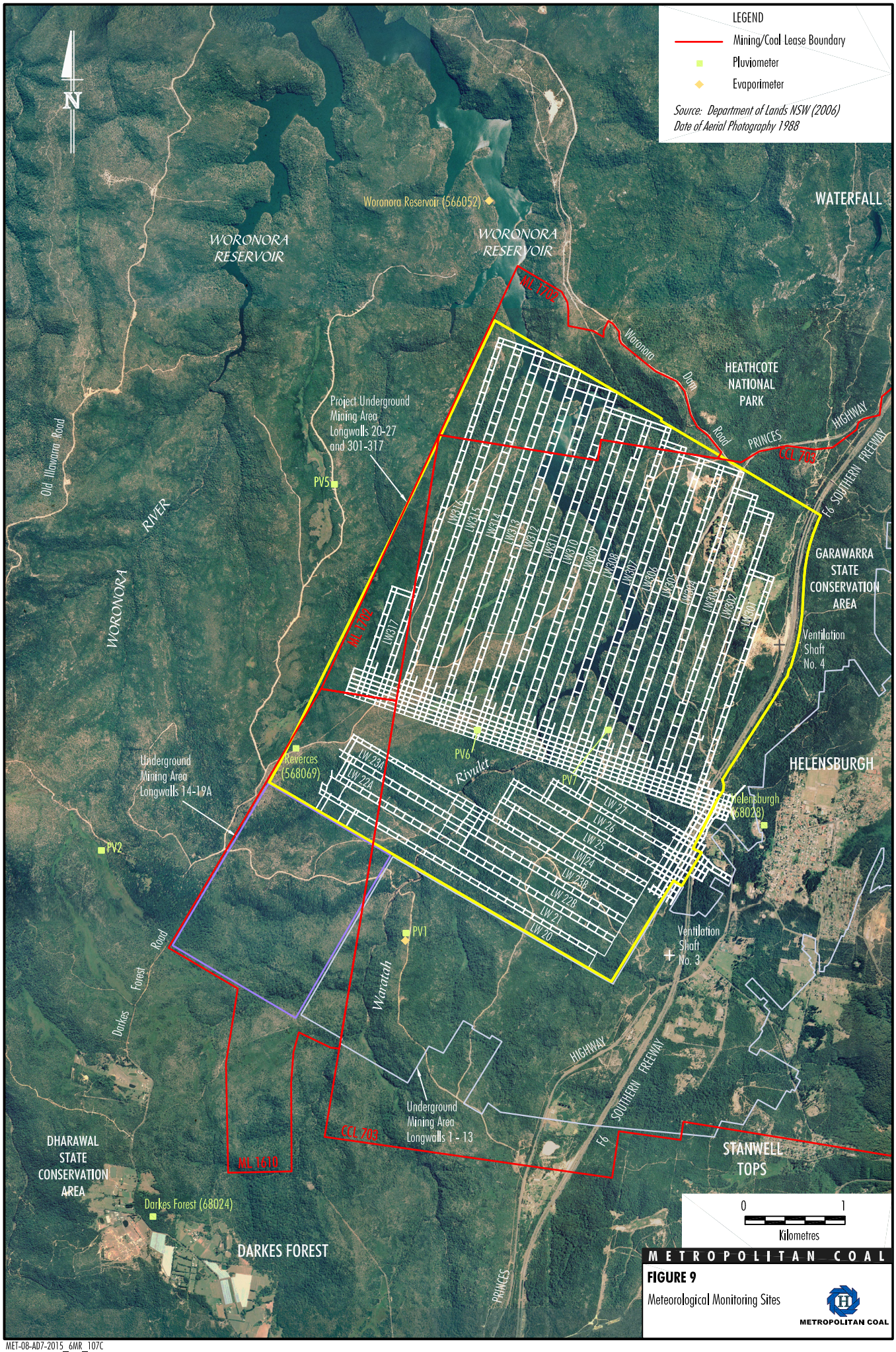
2.2.2.6 Swamp Groundwater Levels

Upland swamp groundwater monitoring for Longwalls 23-27 is described in Section 3.2.2.2.

2.2.2.7 Shallow Groundwater Levels

The results of continuous shallow groundwater level monitoring conducted at sites WRGW1, WRGW2 and WRGW7 along Waratah Rivulet and sites ETGW1 and ETGW2 on the Eastern Tributary (Figure 7) are described for the reporting period below.

Sites WRGW1 and WRGW2 are located on opposite banks of the Waratah Rivulet, to the immediate south of Longwall 20 (Figure 7). The groundwater monitoring results for sites WRGW1 and WRGW2 are shown on Chart 14 and are compared with rainfall events and rainfall trends over a period of eight years as recorded at the Waratah Rivulet catchment PV1 pluviometer (Figure 9). Sites WRGW1 and WRGW2 show comparable information over the reporting period, with rapid response to rainfall events. At the time of passage of the Longwall 21 mining face past the piezometer sites (March 2012), the measured groundwater levels dropped by about 1 m. As wet conditions prevailed at the time, this was not a climatic effect. This conclusion is supported by the observation that none of the other Waratah Rivulet piezometers showed a similar response at this time. The passage of Longwall 20 a year earlier had no obvious effect at WRGW1 or WRGW2. Since March 2012, groundwater levels recorded in WRGW1 and WRGW2 have fluctuated in response to seasonal rainfall variations with a seasonal (dry) minimum that is approximately 0.75 m below previous levels.



MET-08-AD7-2015_6MR_107C

Throughout the reporting period, the water levels at sites WRGW1 and WRGW2 have correlated closely with rainfall trends (as indicated by the residual mass curve on Chart 14) and have shown no further response to mining.

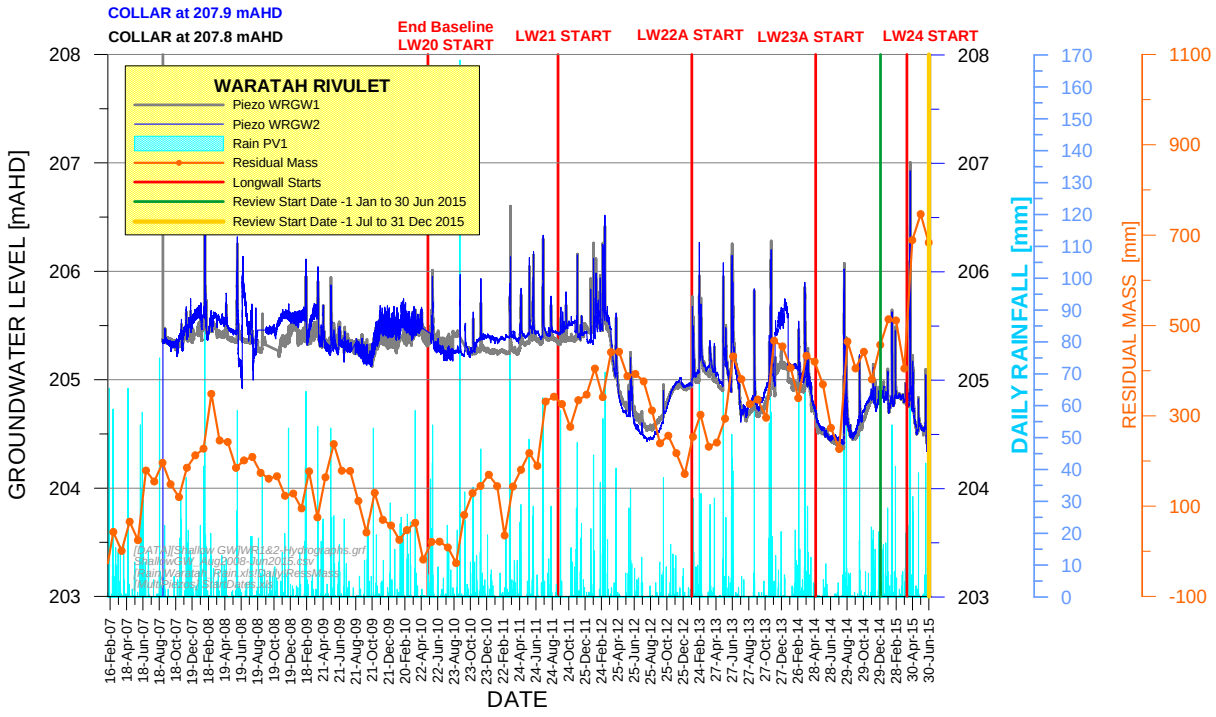


Chart 14 Shallow Groundwater Hydrographs on Waratah Rivulet at WRGW1 and WRGW2

The shallow groundwater level data that is available for Site WRGW7 on the Waratah Rivulet (Chart 15) indicates there is good correlation between the response at WRGW7 and rainfall trend, and good evidence of stream-aquifer interaction for Waratah Rivulet flow events. Site WRGW7 is located approximately 400 m downstream of Longwall 23 (Figure 7). There is a period in which data is missing for site WRGW7 as a result of multiple events of vandalism, which has included removal of the diver sensors. Metropolitan Coal has installed locked monuments at the site to reduce the risk of future vandalism.

At the Eastern Tributary sites ETGW1 and ETGW2, which are located downstream of Longwall 27, shallow groundwater levels have previously followed the rainfall trends closely (Chart 16), and have continued to do so during the reporting period. The variations at these sites are unrelated to mining.

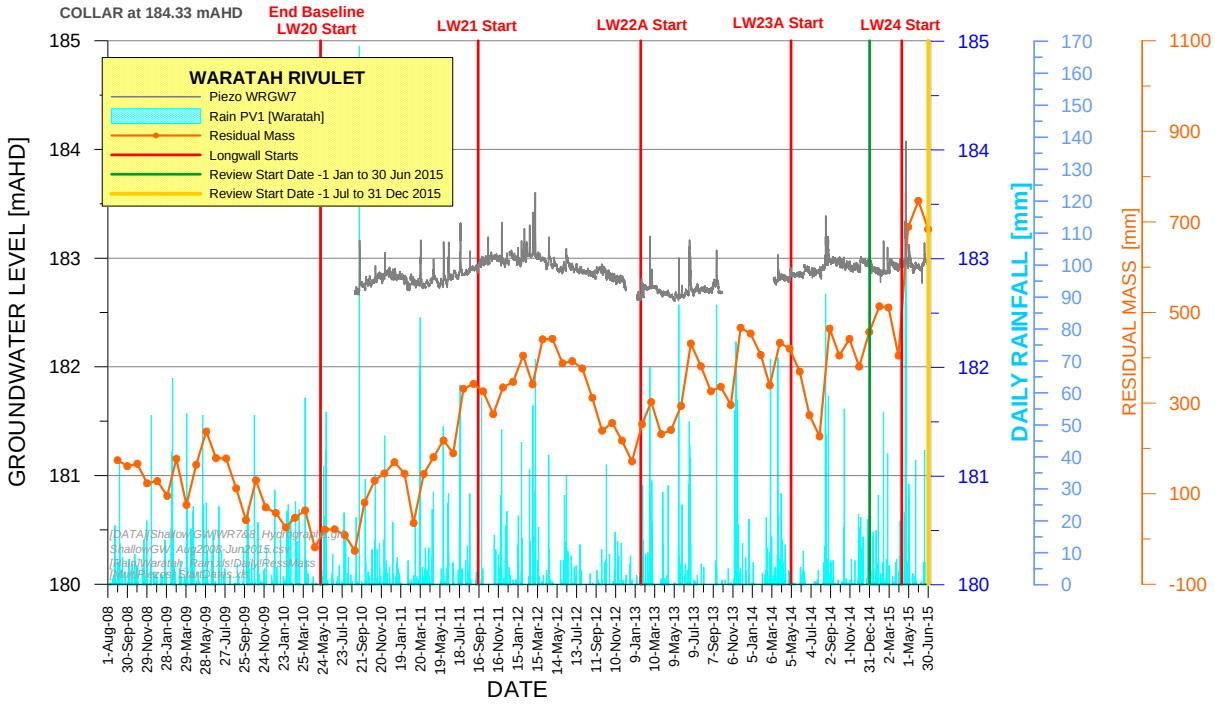


Chart 15 Shallow Groundwater Hydrograph on Waratah Rivulet at WRGW7

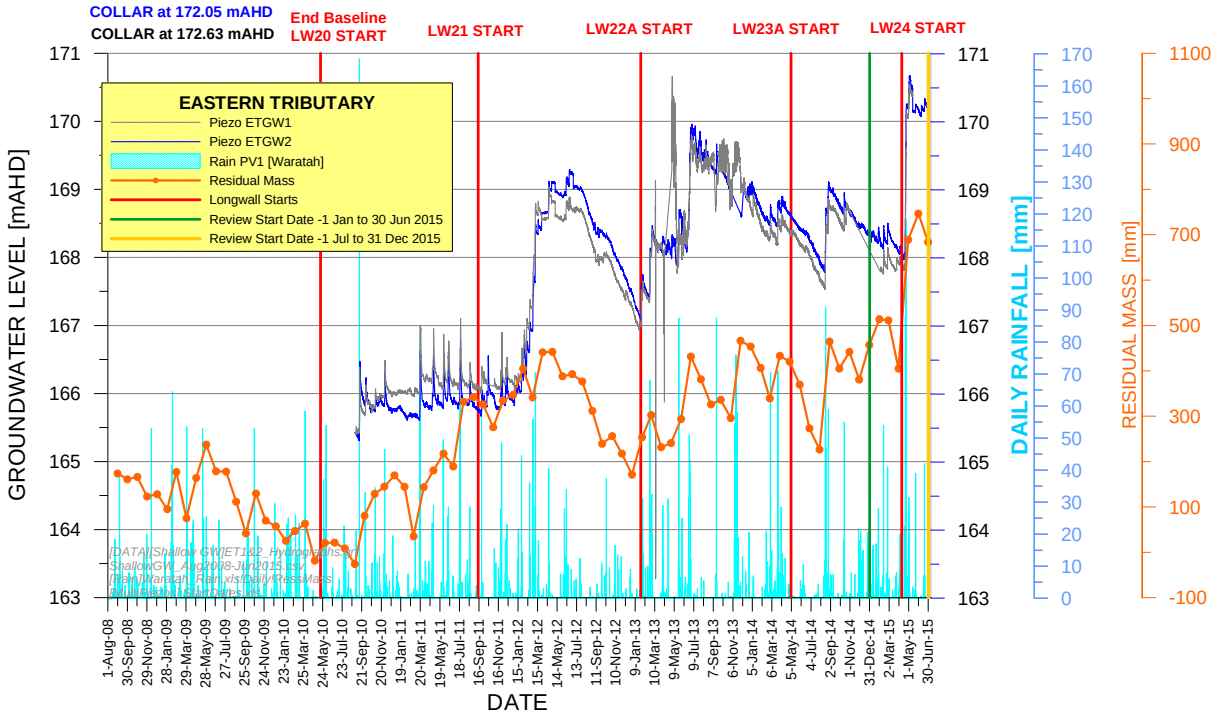


Chart 16 Shallow Groundwater Hydrograph on Eastern Tributary at ETGW1 and ETGW2

2.2.2.8 Deep Groundwater Levels/Pressures

Continuous groundwater level/pressure monitoring has been conducted at bores 9HGW0 (Longwall 10 Goaf Hole), 9EGW1B, 9FGW1A, 9GGW1-80, 9GGW2B, 9HGW1B, PM02, PM01, 9EGW2A, PM03, PHGW1B, PHGW2A, F6GW3 and F6GW4 in accordance with the Longwalls 20-22 and/or Longwalls 23-27 Water Management Plans (Figure 7). The results of deep groundwater level monitoring for the reporting period are described below.

The time-series head variations and vertical head differences for these bores have been examined (Charts 17 to 30), with the following outcomes:

- very few installations are providing unreliable data;
- the vibrating wire piezometers that had been slow to stabilise since installation, particularly those installed in claystones, are now generally stable;
- sites close to current mining show significant depressurisation with depth, consistent with the Project EA (Helensburgh Coal Pty Ltd, 2008); and
- sites close to old workings at Helensburgh show substantial depressurisation with depth, consistent with the Project EA.

The monitoring sites closest to Longwalls 23-27 are bore 9EGW1B (approximately 300 m north of Longwall 23A) and bore 9GGW2B (above Longwall 27 headings) (Figure 7).

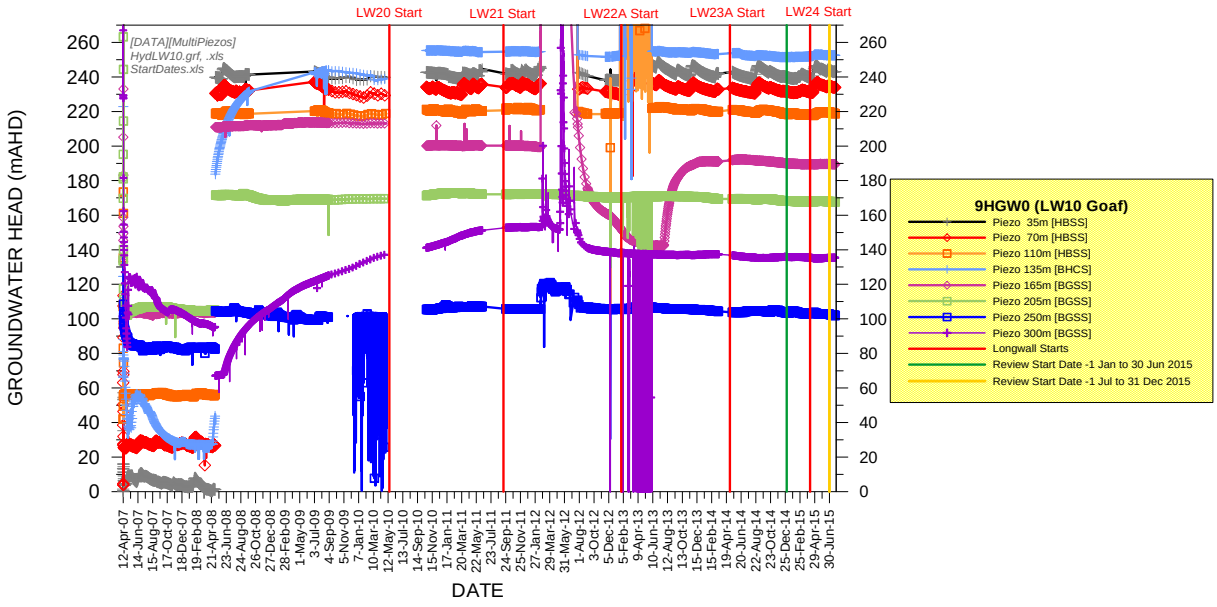


Chart 17 Time Variations in Potentiometric Heads at 9HGW0

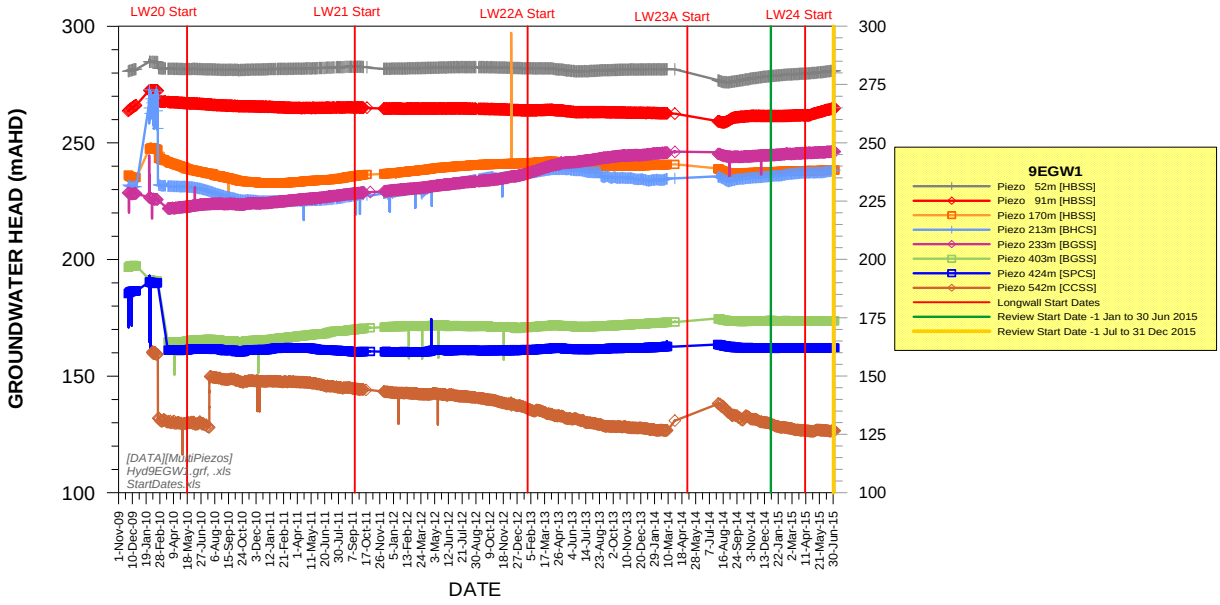


Chart 18 Time Variations in Potentiometric Heads at 9EGW1B

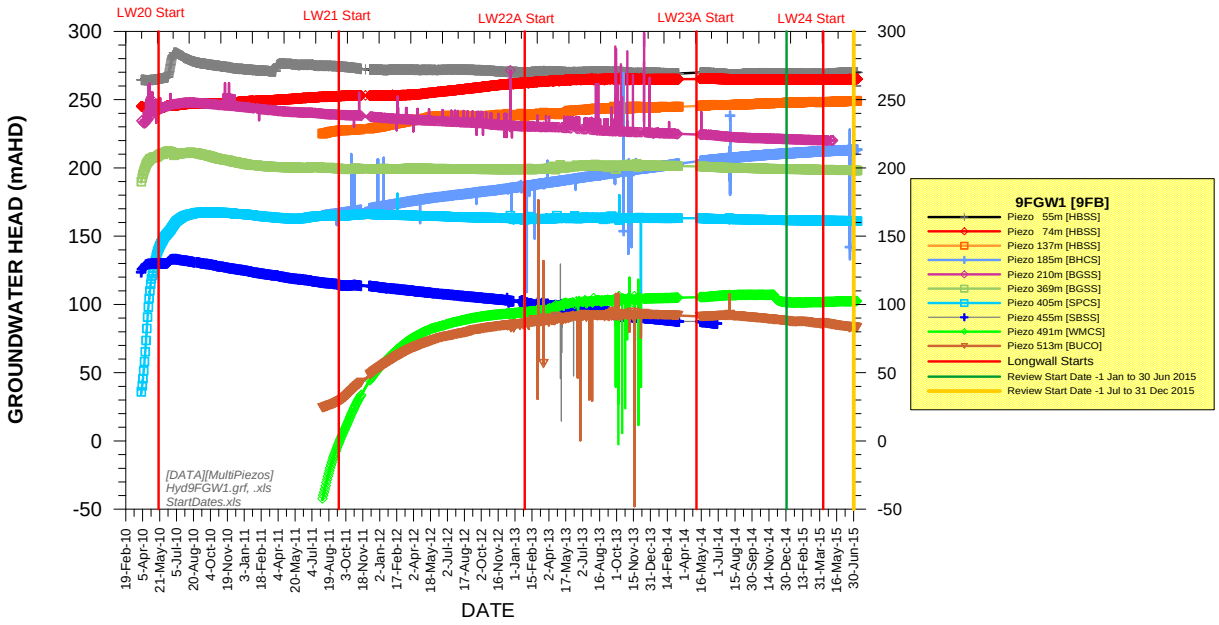


Chart 19 Time Variations in Potentiometric Heads at 9FGW1A

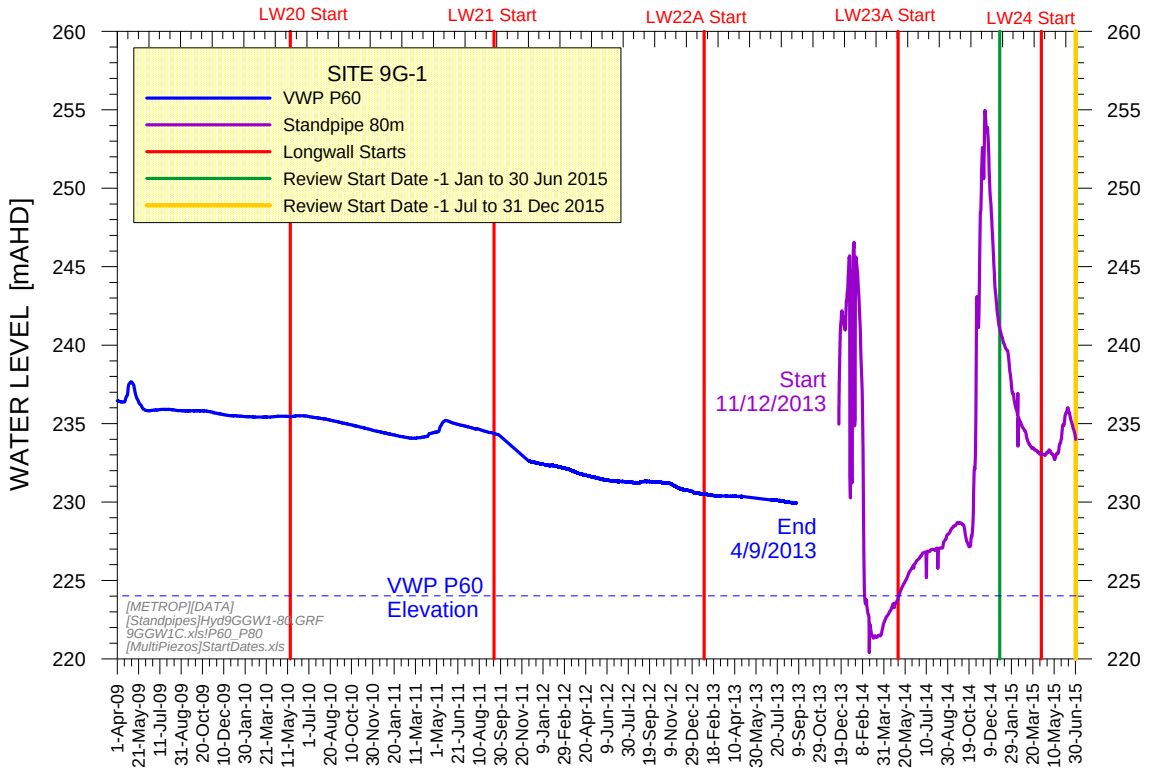


Chart 20 Time Variations in Water Table at Standpipe 9GGW1-80 and Decommissioned Vibrating Wire Piezometer 9GGW1-60

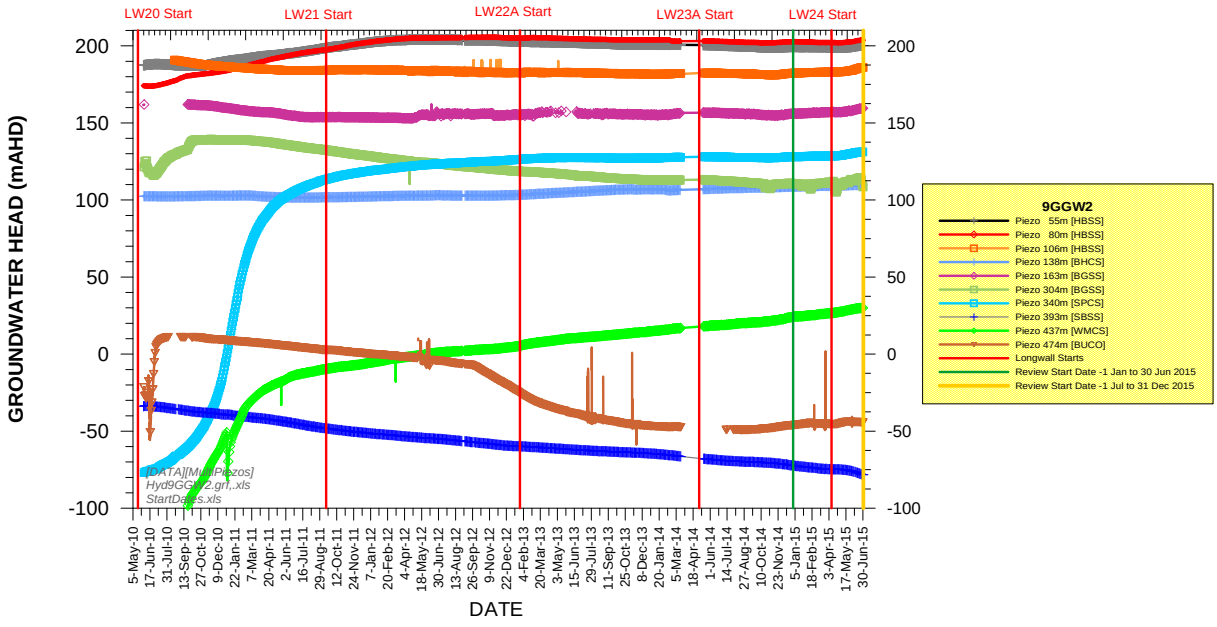


Chart 21 Time Variations in Potentiometric Heads at 9GGW2B

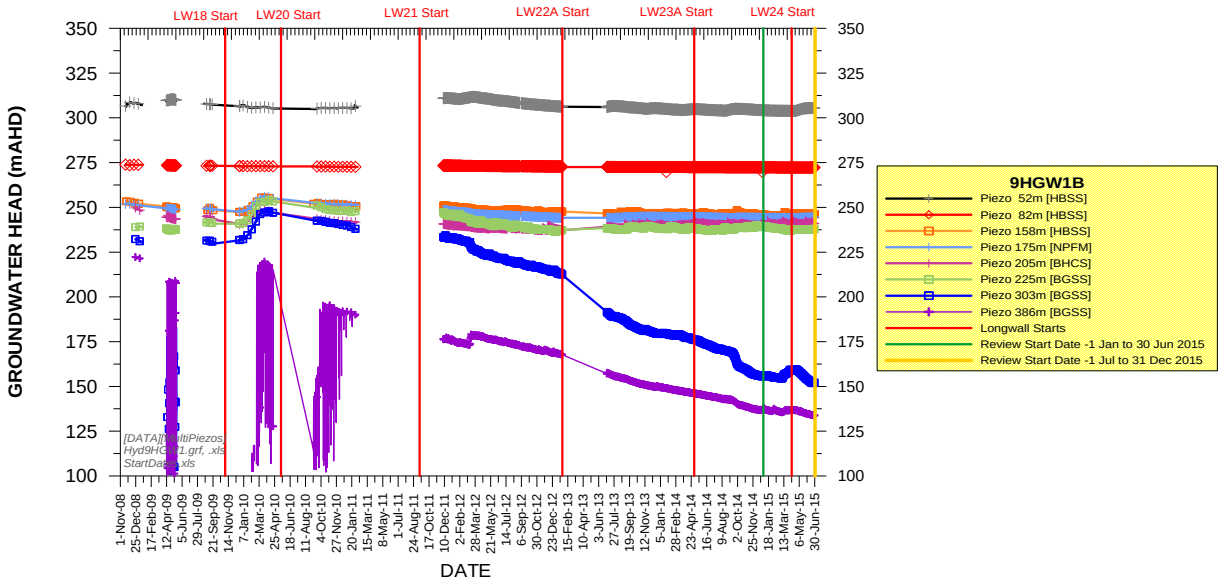


Chart 22 Time Variations in Potentiometric Heads at 9HGW1B

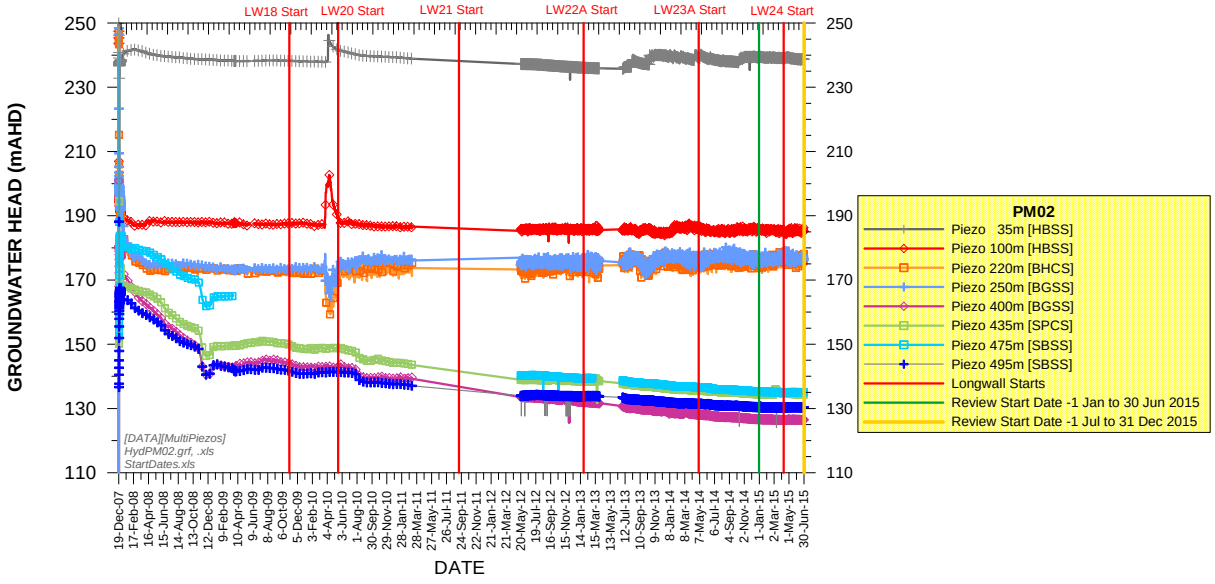


Chart 23 Time Variations in Potentiometric Heads at PM02

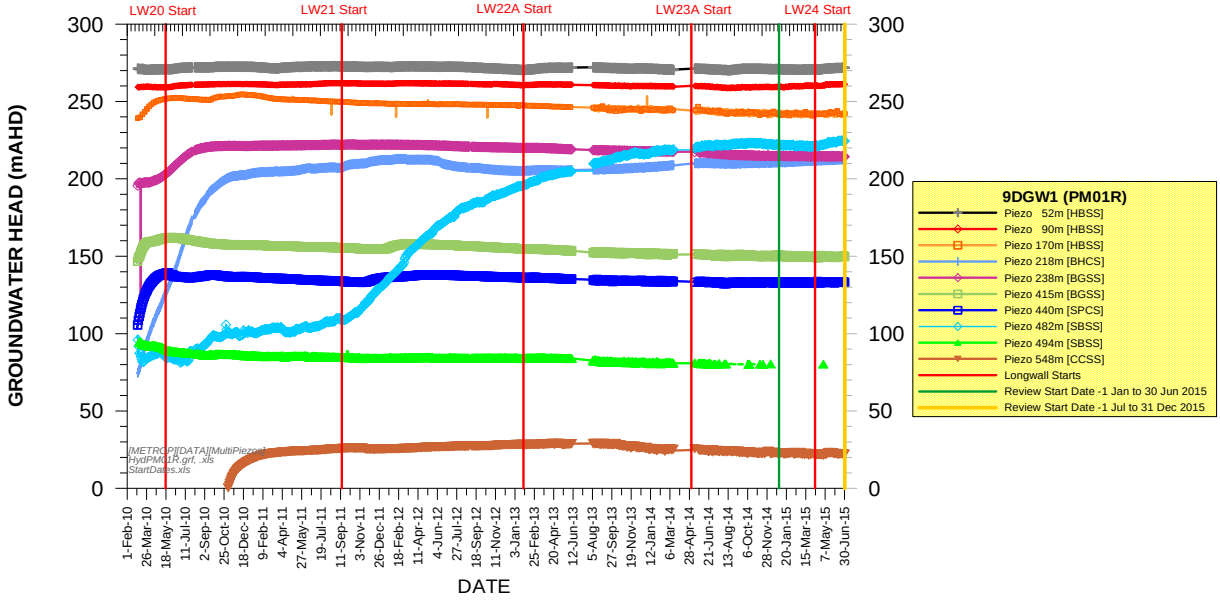


Chart 24 Time Variations in Potentiometric Heads at PM01

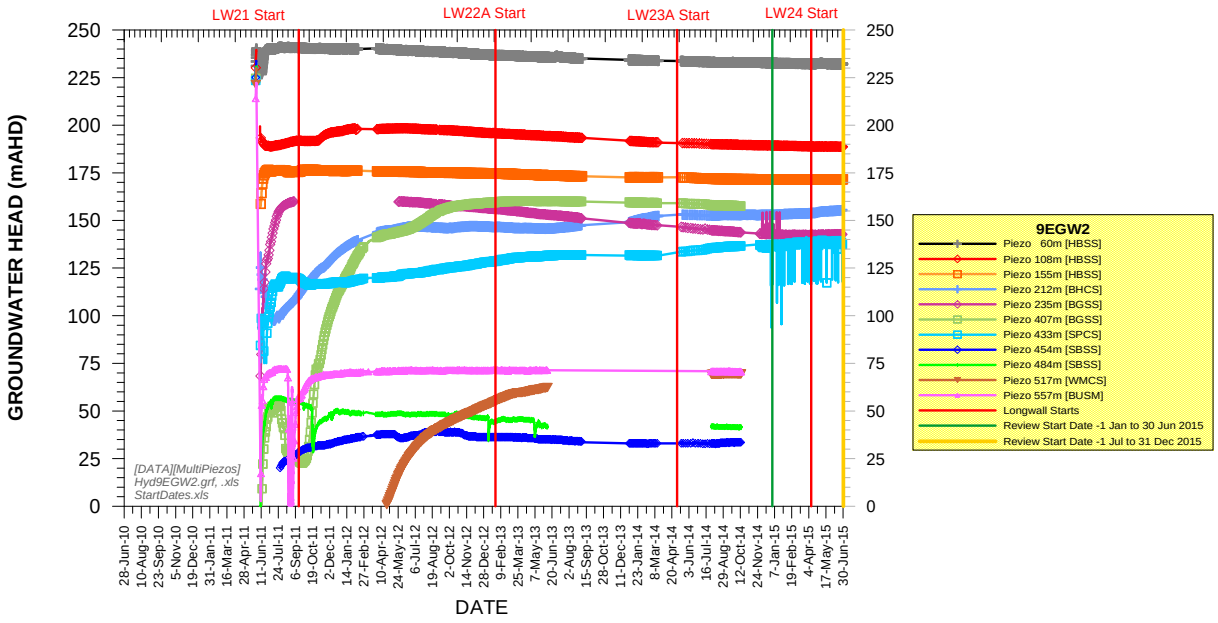


Chart 25 Time Variations in Potentiometric Heads at 9EGW2A

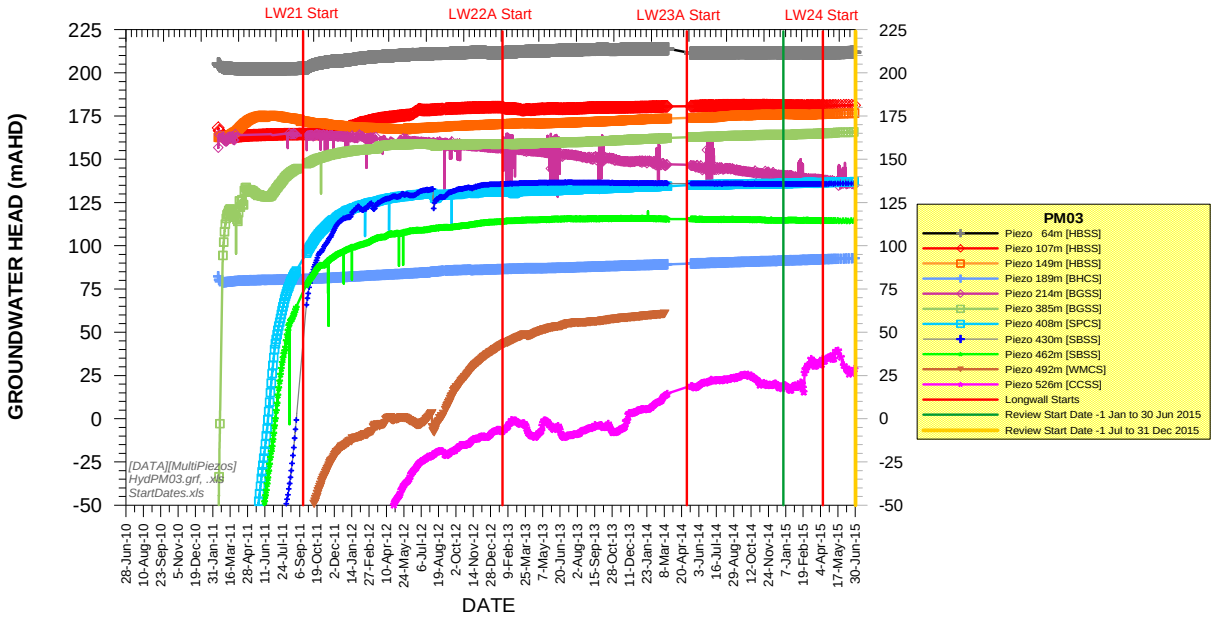


Chart 26 Time Variations in Potentiometric Heads at PM03

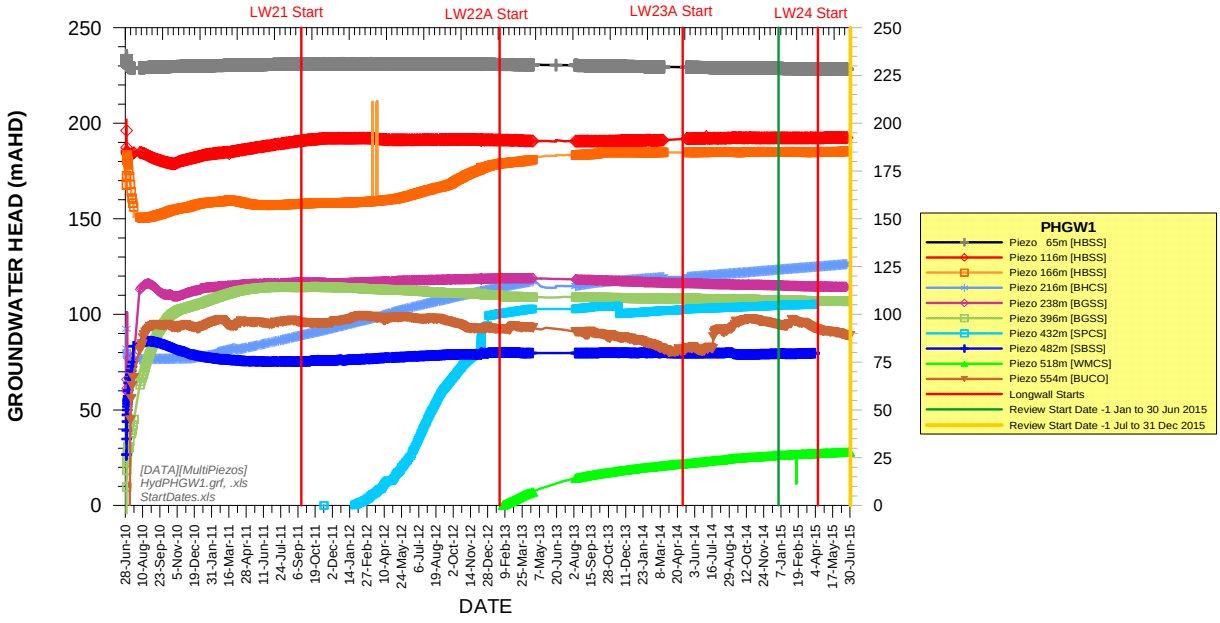


Chart 27 Time Variations in Potentiometric Heads at PHGW1B

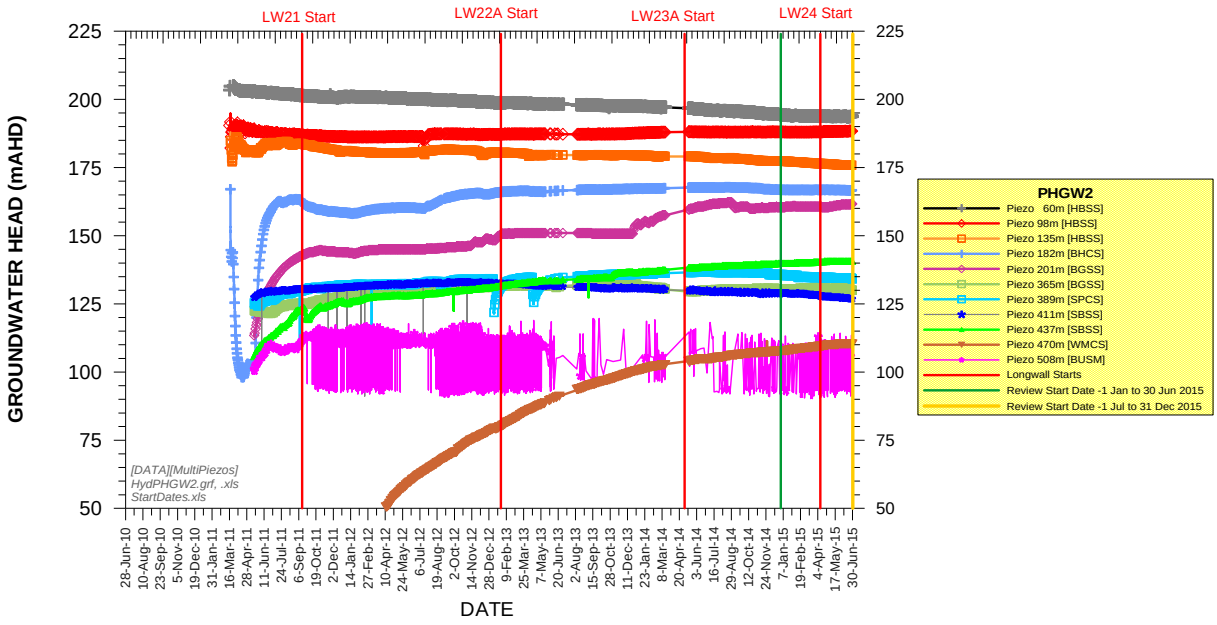


Chart 28 Time Variations in Potentiometric Heads at PHGW2A

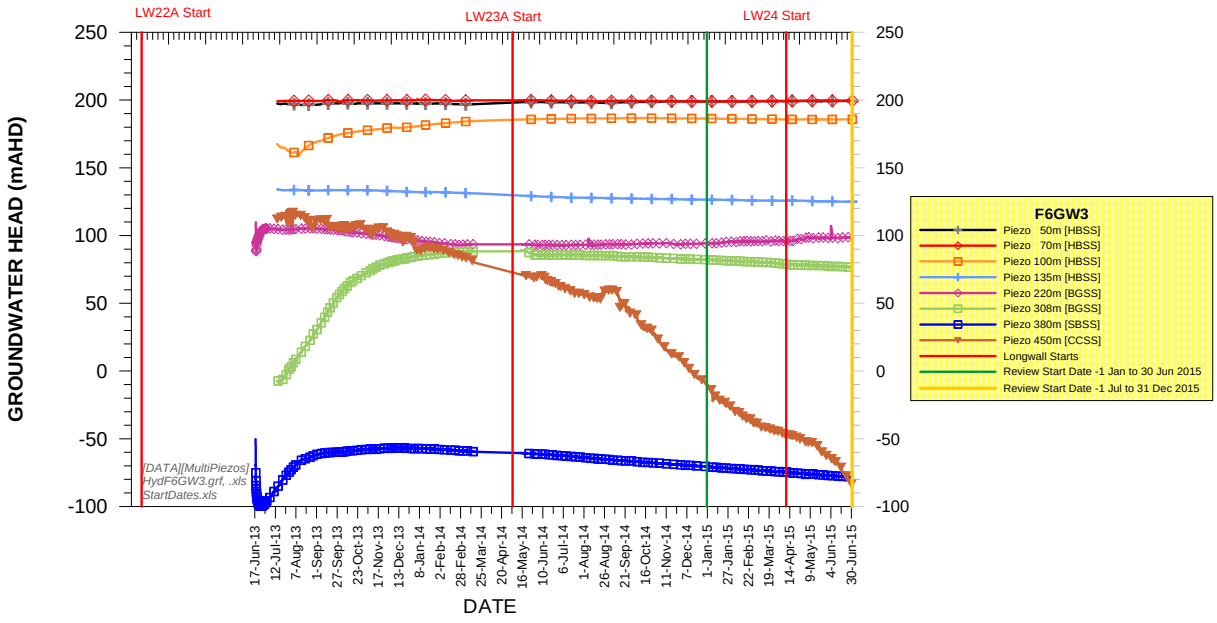


Chart 29 Time Variations in Potentiometric Heads at F6GW3

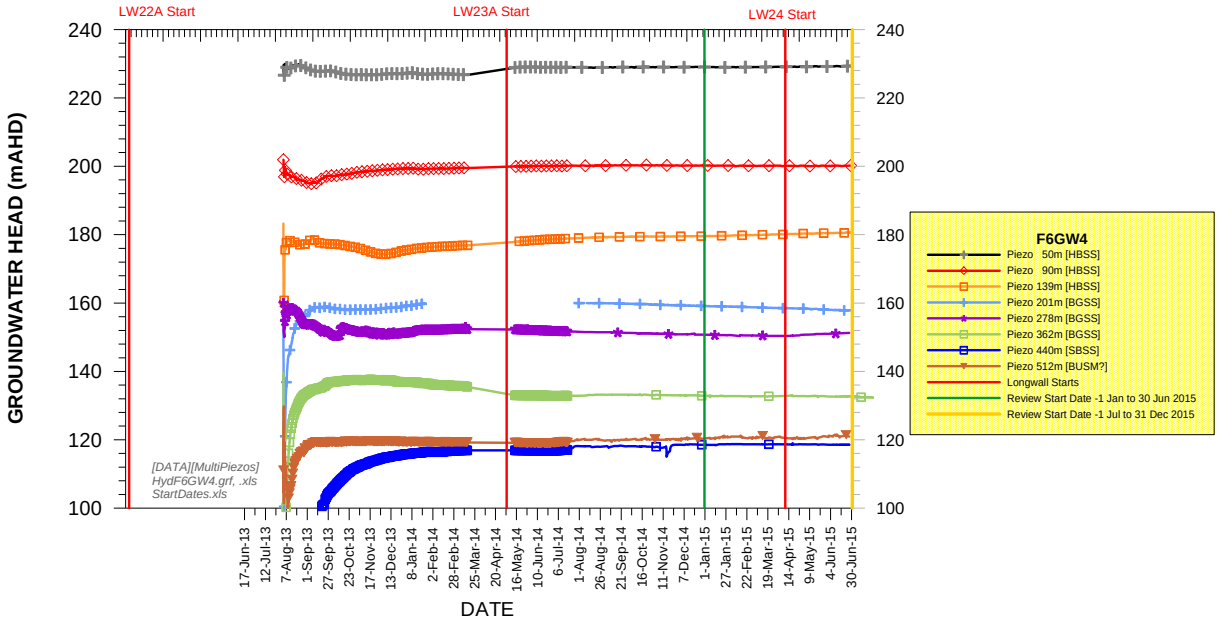


Chart 30 Time Variations in Potentiometric Heads at F6GW4

The time-series record for bore 9EGW1B is shown on Chart 18. This shows fairly stable heads that decline with depth. The deepest piezometer (542 m in Coal Cliff Sandstone) retains about 360 m pressure head, which has been declining slowly since the commencement of Longwall 20 due to far-field depressurisation. Groundwater pressures were relatively stable or increased slightly during the reporting period in all piezometers, except for the piezometer at 91 m (Hawkesbury Sandstone) at which the pressure increased by approximately 5 m.

The time-series record for bore 9GGW2B is shown on Chart 21. As the hydrographs show inconsistent head variations with depth, some of the piezometers are unreliable. Groundwater pressures increased by approximately 5 m in most of the piezometers in the upper part of the stratigraphy during the reporting period. Notably, the groundwater pressure in the Bulli Coal Seam (474 m) continued to increase, while the overlying Scarborough sandstone piezometer (393 m) decreased by 2 to 3 m.

A qualitative assessment of data quality for the vibrating wire piezometer hydrographs in Charts 17 to 30 is presented in Table 1 in terms of "unreliable" and "unstable" responses. Reliability was assessed by considering consistency in the variation of groundwater heads with depth. Instability was assessed in terms of expected trends over the reporting period. The assessment finds that 79 percent (%) of the vibrating wire piezometer records are currently providing useful data, with 11% considered to be unreliable and 10% unstable.

Table 1
Qualitative Assessment of Vibrating Wire Piezometer Data Quality

Site	Number of Vibrating Wire Piezometers	Number of Useful Vibrating Wire Piezometers	Number of Unstable Vibrating Wire Piezometers	Number of Unreliable Vibrating Wire Piezometers
9HGWO	8	6	0	2
9EGW1	8	8	0	0
9FGW1	10	8	2	0
9GGW2	10	8	2	0
9HGW1	8	8	0	0
PM02	8	8	0	0
PM01R	10	8	2	0
9EGW2	11	5	5	1
PM03	11	5	1	5
PHGW1	10	7	0	3
PHGW2	11	10	1	0
F6GW3	8	7	0	1
F6GW4	8	8	0	0
Total	121	96	13	12

2.2.2.9 Groundwater Quality

The results of shallow groundwater quality monitoring at sites WRGW1, WRGW2 and WRGW7 along the Waratah Rivulet, and sites ETGW1 and ETGW2 on the Eastern Tributary (Figure 8) are described below.

Water quality parameters sampled 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 have been field filtered.

Monitoring results for Fe, Mn and pH levels at sites WRGW1, WRGW2 and WRGW7 are provided on Charts 31 to 33. Monitoring results for sites WRGW3 to WRGW6 are also shown on Charts 31 to 33 to show trends over the length of the Waratah Rivulet. Rainfall events over a period of eight years, as recorded at the Waratah Rivulet catchment PV1 pluviometer (Figure 9), provide a context for the substantial fluctuations in parameters; however, there is no obvious relationship with rainfall.

The key observations at the Waratah Rivulet groundwater quality monitoring sites (WRGW1 to WRGW7) are:

- Fe concentrations are usually in the 1 - 10 milligrams per litre (mg/L) range, with the exception of sites WRGW1 and WRGW2 which has peaked to 14 mg/L (2010-2011). Fe concentrations in groundwater at WRGW1 and WRGW2 show a declining trend since 2011, with concentrations at both bores remaining below 10 mg/L during the reporting period (Chart 31). Fe concentrations in groundwater at site WRGW7 have remained slightly higher than previous reporting periods (2010-2013). However, they remain within the range previously observed at upstream sites.
- Mn concentrations are always less than 1 mg/L (Chart 32). No anomalous variations in Mn concentration are apparent during the reporting period (Chart 32).

- Monitoring prior to 2014 showed an apparent increase in Fe and Mn concentrations with distance downstream to WRGW1 and WRGW2 and then decrease (relative to sites WRGW1 and WRGW2) with distance downstream to WRGW7. The overall decrease in Fe and Mn concentrations in groundwater at the downstream sites make this spatial trend less apparent since 2014.
- Groundwater is generally acidic with pH usually between pH 5.5 and 7. Occasional excursions in excess of pH 9 and less than pH 5 in prior reporting periods are unsustained outliers.
- Aluminium was below the detection limit in all samples.

The observations are consistent with those reported previously.

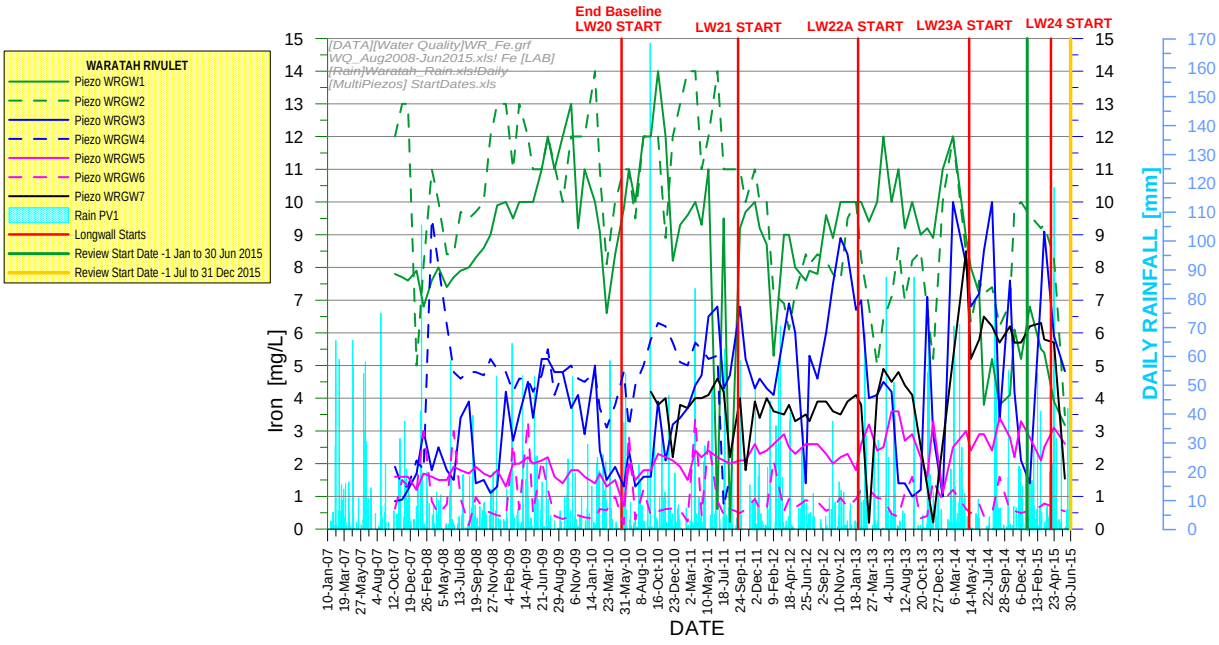


Chart 31 Iron Concentrations at WRGW1 to WRGW7

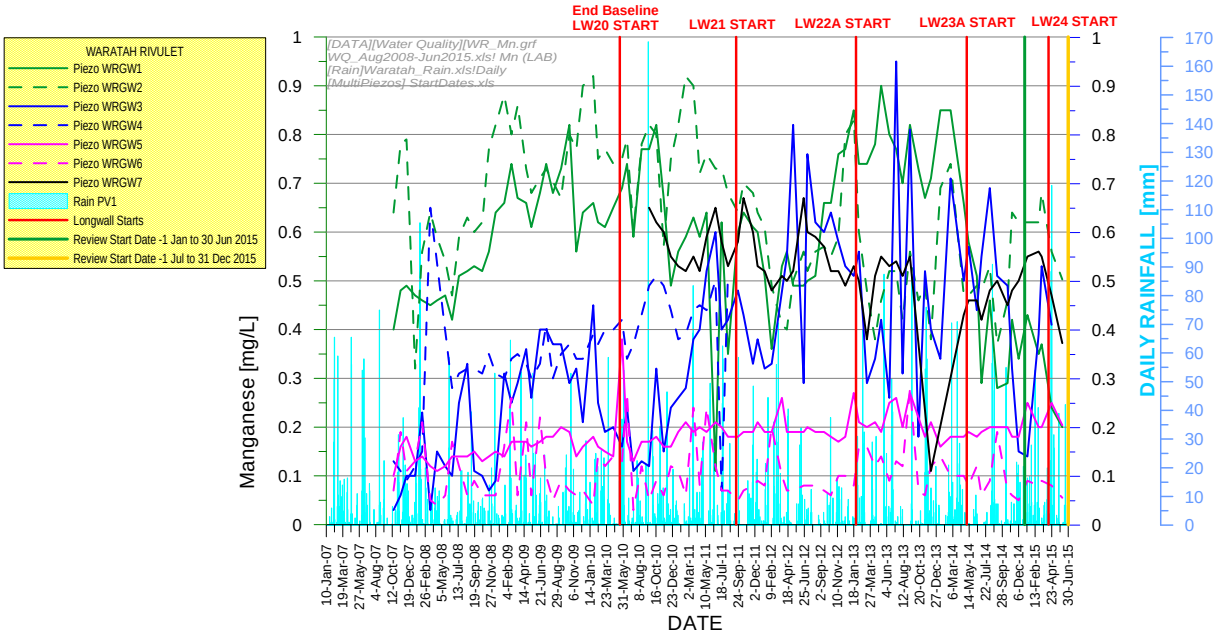


Chart 32 Manganese Concentrations at WRGW1 to WRGW7

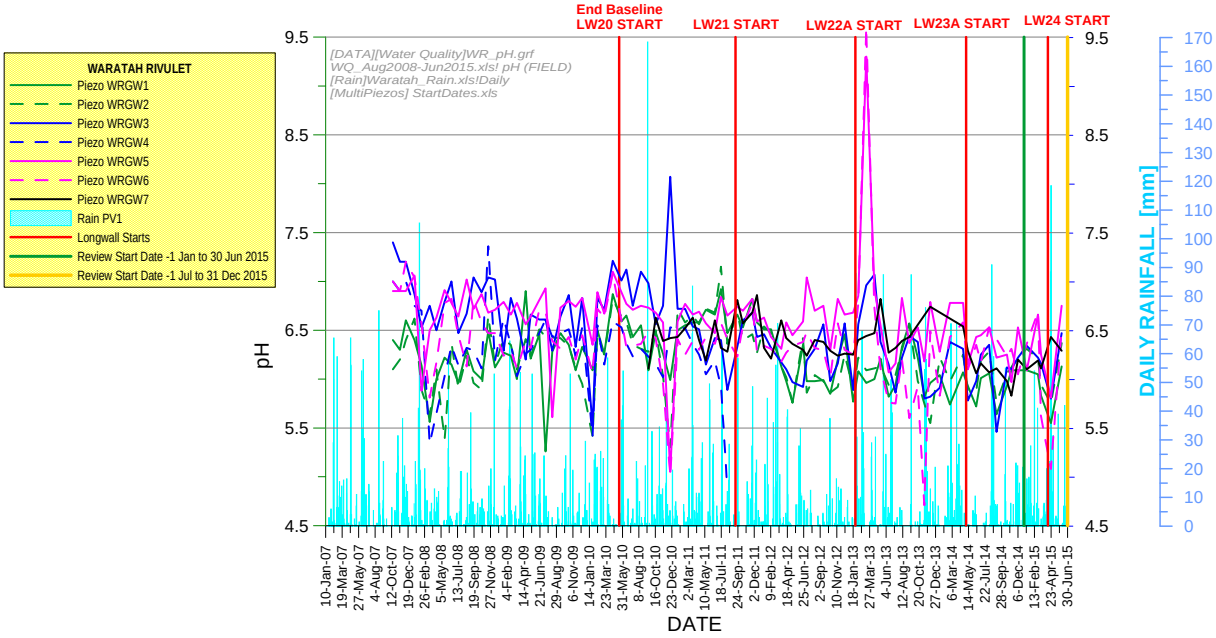


Chart 33 pH Levels at WRGW1 to WRGW7

Groundwater quality at the two Eastern Tributary sites (ETGW1, ETGW2) is shown on Charts 34 to 36 for Fe, Mn and pH, respectively. Rainfall events over a period of seven years, as recorded at the Waratah Rivulet catchment PV1 pluviometer (Figure 9), provide a context for the mild fluctuations in parameters; however, there is no obvious relationship with rainfall. Fe concentrations are high, ranging from 11 to 14 mg/L during the reporting period (Chart 34). Mn concentrations are low at both sites, and have ranged between 0.45 and 0.58 mg/L during the reporting period (Chart 35). No anomalous trends in Fe and Mn concentration in groundwater are apparent at these two sites during the review period. Al was below the detection limit in all samples. The groundwater is generally acidic, predominantly between pH 5.5 and pH 6.8 in the reporting period (Chart 36). The increase in pH at both locations in April 2015 is anomalous compared with previous results.

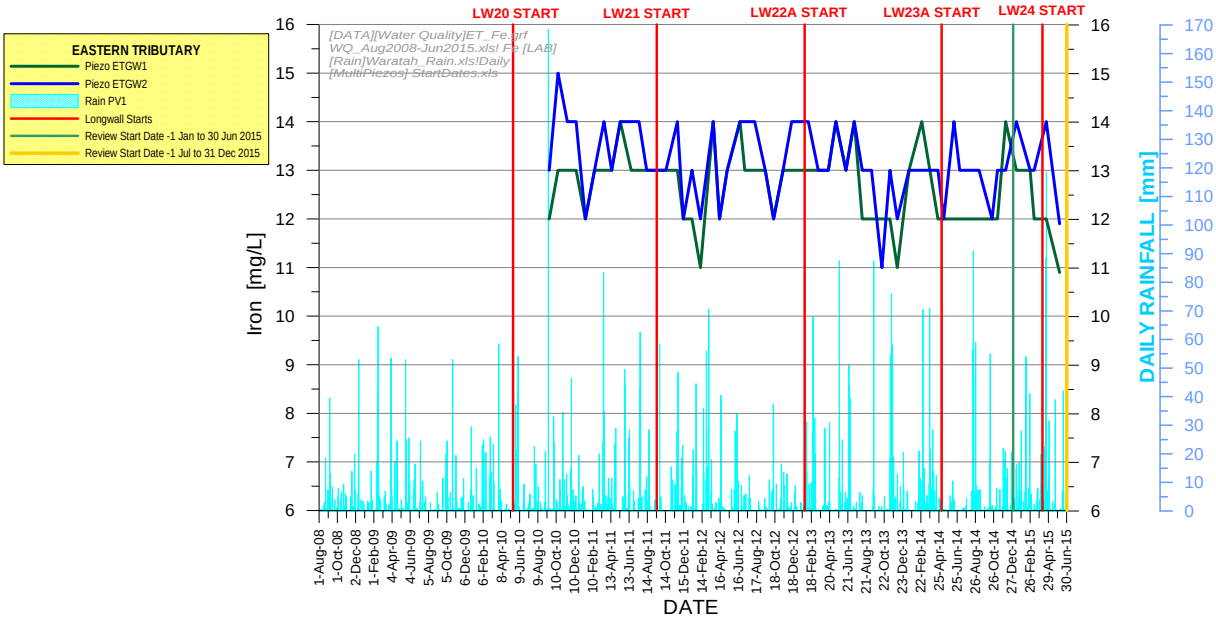


Chart 34 Iron Concentrations at ETGW1 and ETGW2

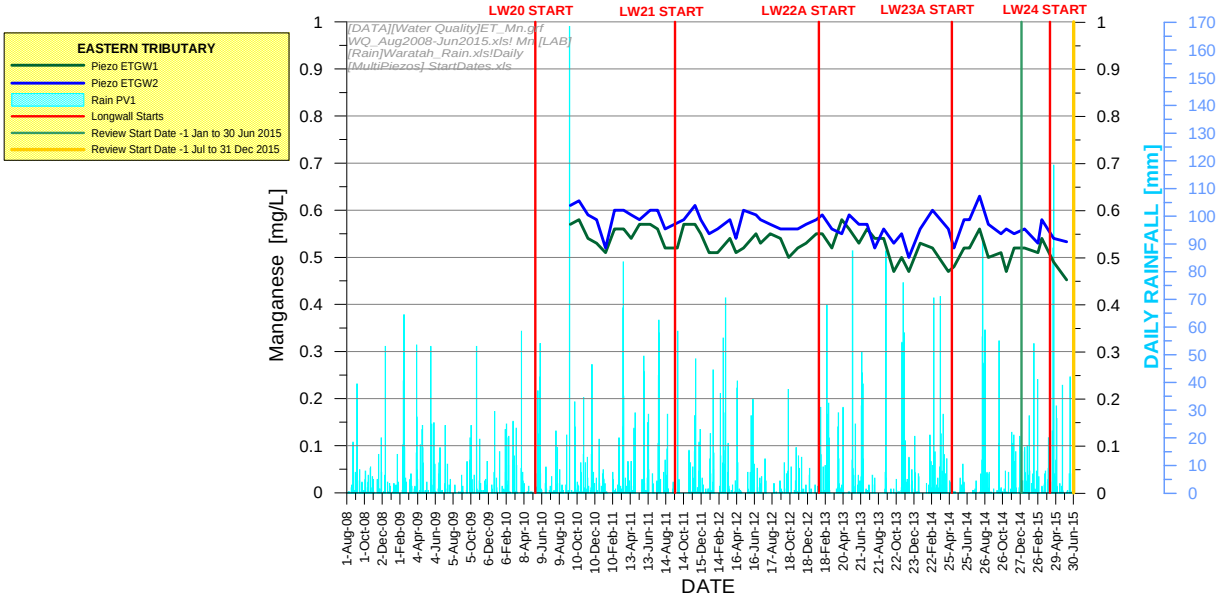


Chart 35 Manganese Concentrations at ETGW1 and ETGW2

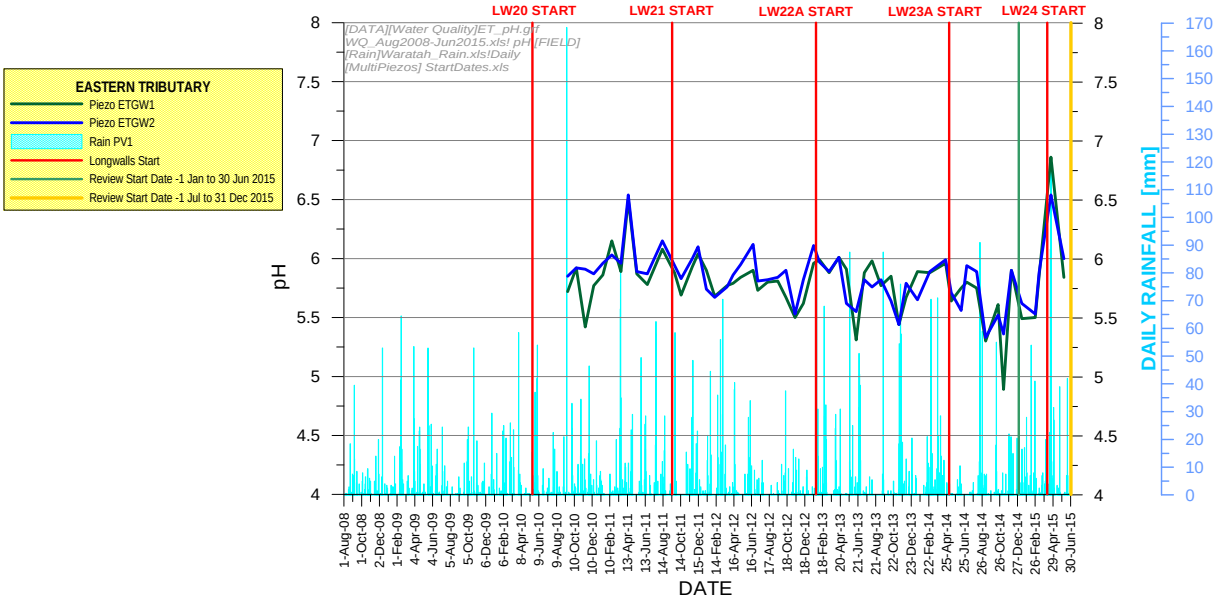


Chart 36 pH Levels at ETGW1 and ETGW2

2.2.2.10 Inspections of Mine Workings

Metropolitan Coal has developed an In-rush Hazard Management Plan required by the NSW *Coal Mines Health and Safety Regulation, 2006* to manage the potential risk of water in-rush. In addition to shift inspections conducted by statutory officials that report on any abnormal conditions at the working face and in outbye areas, Metropolitan Coal conducts statutory weekly inspections of development workings to identify water accumulations. A weekly audit of the statutory inspections is conducted by the shift undermanager. 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 Mine Manager.

The mine inspections did not identify any abnormal water flows from the goaf, geological structure, or strata generally during the reporting period.

2.2.2.11 Mine Water Make

In accordance with the Metropolitan Coal Longwalls 20-22 and Longwalls 23-27 Water Management Plans, Metropolitan Coal has also monitored the mine water balance. The inferred water make (i.e. groundwater that has seeped into the mine through the strata) has been calculated from the difference between total mine inflows (reticulated water into the mine, moisture in the downcast ventilation, and the *in-situ* coal moisture content) and total mine outflows (reticulated water out of the mine, moisture in the exhaust ventilation, and moisture in the ROM coal).

Monitoring of the mine water balance comprises:

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

Water Make Calculation Assumptions

The inferred 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, and the *in-situ* coal moisture content) and total mine outflows (reticulated water out of the mine, moisture in the exhaust ventilation, and moisture in the ROM coal).

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

The estimated daily mine water make during the reporting period is shown on Chart 37. The following assumptions were made in the estimation of water make:

- Where metered data was unavailable, no estimation of daily water make was calculated and the graph shows a gap.
- Where no air moisture measurement for the downcast ventilation was available for a given day, the average of the past two years was used (0.163 megalitres per day [ML/day]).
- Where no ROM coal moisture content was available for a given day, the average of the past two years was used (6.11%).
- The *in-situ* coal moisture content was assumed to be 1.5%.

The 20 day average daily mine water make was less than 2 ML/day during the reporting period.

Note that the increased water make during the period April 2011 to July 2011 was a result of dewatering of old workings in advance of the 200 Mains Panel.

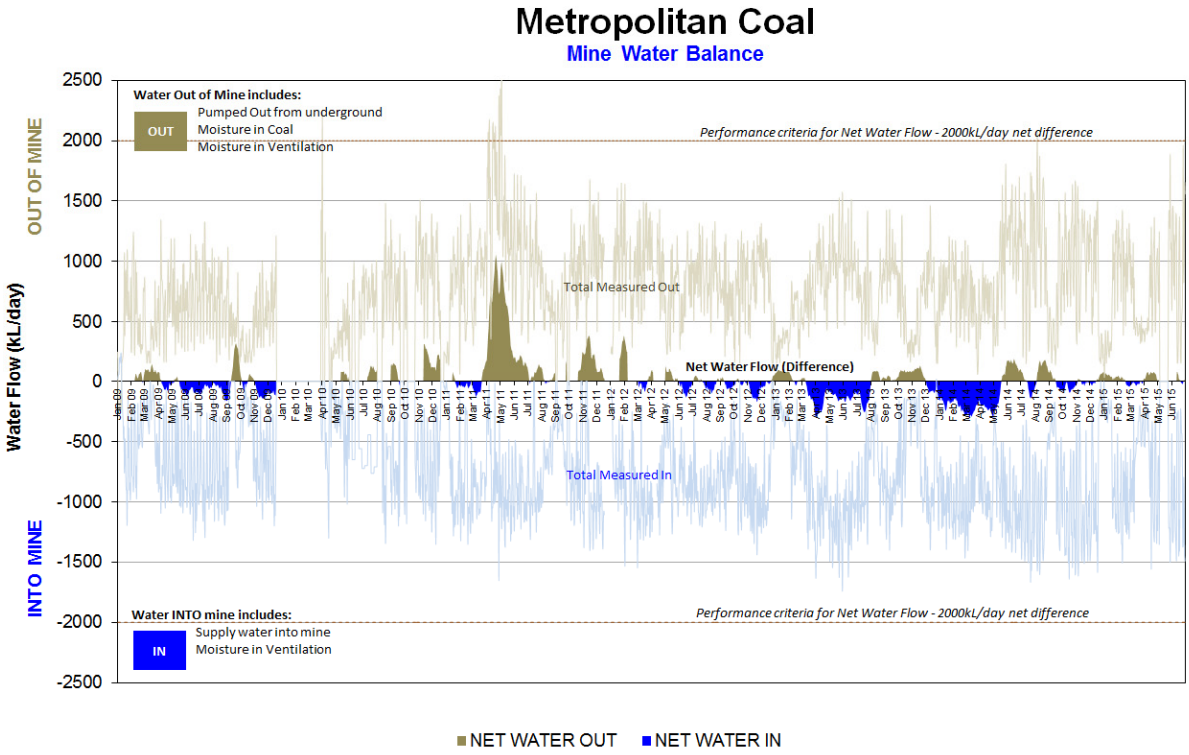


Chart 37 Estimated Daily Mine Water Make

2.3 ASSESSMENT OF ENVIRONMENTAL PERFORMANCE

The performance indicators and subsidence impact performance measures described below have been developed to address the predictions of subsidence impacts and environmental consequences on water resources and watercourses included in the Project EA (Helensburgh Coal Pty Ltd, 2008), Preferred Project Report (PPR) (Helensburgh Coal Pty Ltd, 2009), Metropolitan Coal Longwalls 20-22 Extraction Plan (Metropolitan Coal, 2010) and Metropolitan Coal Longwalls 23-27 Extraction Plan (Metropolitan Coal, 2014).

Where the performance indicators and subsidence impact performance measures are entirely consistent between the Longwalls 20-22 and Longwalls 23-27 Water Management Plans, the assessment results for the reporting period are described holistically in Section 2.3.2. Where there are differences in the performance indicators and subsidence impact performance measures between the Longwalls 20-22 and Longwalls 23-27 Water Management Plans, the results are described in Section 2.3.1 for performance indicators applicable to Longwalls 20-22 and Section 2.3.2 for performance indicators applicable to Longwalls 23-27.

2.3.1 Longwalls 20-22

2.3.1.1 Quantity of Water Resources Reaching the Woronora Reservoir

Surface water flow monitoring is conducted at the WaterNSW-owned gauging stations on the Waratah Rivulet (GS2132102) and Woronora River (GS2132101) and at the OEH gauging station on O'Hares Creek at Wedderburn (GS213200).

Water flow data is analysed to assess whether the performance indicator below has been exceeded.

Analysis against Performance Indicator

Performance Indicator:

Changes in the quantity of water entering Woronora Reservoir is not significantly different post-mining compared to pre-mining, that is not also occurring in the control catchment(s).

Consistent with the Metropolitan Coal Longwalls 20-22 and Longwalls 23-27 Water Management Plans, data is analysed to assess whether a statistically significant reduction in the quantity of water entering Woronora Reservoir in the post-mine period relative to the pre-mine period has occurred, that has not also occurred in the control catchment(s).

The performance indicator is considered to have been exceeded if the median of the ratios for the sliding 1 year period in the Waratah Rivulet falls below the 20th percentile of the baseline data, unless the same is also occurring in data for the control sites.

Analysis of the performance indicator for the reporting period is discussed in Section 2.3.2.1.

2.3.1.2 Quality of Water Resources Reaching the Woronora Reservoir

Water quality sampling is conducted on the Waratah Rivulet (site WRWQ9), Eastern Tributary (ETWQ AU) and Woronora River (WOWQ2). The field filtered[7] water quality data has been analysed for key water quality parameters of relevance to water supply, namely:

- iron;
- aluminium; and
- manganese.

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).

Water quality data from sites WRWQ9 and ETWQ AU is analysed against monitoring data collected in the baseline period and against water quality data collected from site WOWQ2 on the Woronora River. Data analysis is conducted to assess whether the performance indicator below has been exceeded.

[7] The field filtered concentrations are taken to be equivalent to the dissolved fraction.

Analysis against Performance Indicator

Performance Indicator:

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.

Analysis of the performance indicator for the reporting period is discussed in Section 2.3.2.2.

2.3.1.3 Connective Cracking between the Surface and the Mine

Analysis against Performance Indicator 1

Performance Indicator 1: *Visual inspection does not identify abnormal water flow from the goaf, geological structure, or the strata generally.*

The performance indicator is considered to have been exceeded if visual inspections identify abnormal water flow from the goaf, geological structure, or the strata generally.

The analysis against Performance Indicator 1 for the reporting period is provided in Section 2.3.2.3.

Analysis against Performance Indicator 2

Performance Indicator 2: *The 20-day average mine water make does not exceed 2 ML/day.*

The performance indicator is considered to have been exceeded if data analysis indicates the 20 day average mine water make exceeds 2 ML/day.

The analysis against Performance Indicator 2 for the reporting period is provided in Section 2.3.2.3.

Analysis against Performance Indicator 3

Performance Indicator 3[8]: *Significant departures from the predicted envelope of vertical potentiometric head profiles at Bores 9GGW2B and 9FGW1A do not occur.*

The performance indicator is considered to have been exceeded if the measured potentiometric head profile is inconsistent in shape or lies significantly to the left of the predicted high-inflow model curve.

Bore 9FGW1A is located approximately 600 m west of Longwall 22. The vertical head profiles measured up to the end of the reporting period are presented on Chart 38 (a and b) and compared with simulated profiles at the end of Longwall 22 and Longwall 23 respectively (using the 15-layer model which was recalibrated across the Hawkesbury Sandstone in 2012)[9]. The measured head profile (at 30 June 2015) is very similar to the previous profiles.

[8] Bore 9GGW1B (previously used for this performance indicator) was decommissioned in late 2013. Bore 9GGW1B was replaced by Bore 9GGW2B for the purpose of this performance indicator. Bore 9FGW1B (previously referred to in this performance indicator) changed to 9FGW1A to correct a labelling error. These amendments have been made in the Metropolitan Coal Longwalls 20-22 Water Management Plan (Version E) submitted to the DP&E on 30 June 2014.

[9] Longwall 23 was completed in March 2015. At June 2015, the mining face was midway along Longwall 24.

As the measured heads have not changed significantly, there is no evidence of an incremental effect from Longwall 23B or the first half of Longwall 24. The recalibrated model tracks the Hawkesbury Sandstone heads reasonably well. The Bald Hill Claystone head is still lower than the simulated value (by about 20 m), but the measured values are increasing gradually with time. The agreement between measured and simulated head profiles is very good, except that the model predicts lower heads near the coal seam than have actually occurred. The measured data are more closely aligned with heads calculated using the low-inflow model.

Bore 9GGW2B is located above Longwall 27 headings. The vertical head profiles for 9GGW2B measured up to the end of the reporting period are shown on Chart 39 (a and b) and compared with simulated profiles at the end of Longwall 22 and Longwall 23 respectively. As the measured head profile at site 9GGW2B (at 30 June 2015) has not changed appreciably over the previous 12 months, there is no evidence of an incremental effect from Longwall 23B or the first half of of Longwall 24. The model recalibration has given better tracking of the heads across the shallow formations, but the upper Bulgo Sandstone head is lower than the simulated value (by about 25 m). The measured profile for the reporting period agrees better with the shape of the high-inflow simulated profile but departs to the left at higher elevations close to the Bald Hill Claystone. The high-inflow model predicts a pressure head in the Bulli Coal seam that is about 20 m lower than observed. As mining approaches 9GGW2B, the difference in the simulated head profiles at the ends of Longwalls 22 and 23 is pronounced, with heads lower at depth by 50-100 m. However, the stability of the measurements indicates that the model is overestimating the expected impact at this site. The high-inflow model predicts a pressure head in the Bulli Coal seam that is about 120 m lower than observed.

The performance indicator has not been exceeded during the reporting period because the measured potentiometric head profiles are consistent in shape and do not lie significantly to the left of the predicted high-inflow model curves.

Analysis against Performance Indicator 4

Performance Indicator 4[10]: *The water tables measured at Bores 9FGW1A and 9GGW1-80 are higher than the water levels of streams crossed by a transect along Longwall 22 (i.e. a hydraulic gradient exists from each bore to the nearest watercourse).*

The performance indicator is considered to have been exceeded if data analysis indicates that a hydraulic gradient is not maintained between each bore and its neighbouring watercourse (i.e. the water table level at each bore is to be higher than the surface water levels in the streams), specifically if:

- the average water level measured at the 55 m piezometer at 9FGW1A is lower than the floor level of Tributary B (241.7 metres Australian Height Datum [mAHD]); or
- the average water level measured at the 80 m piezometer at 9GGW1-80 is lower than the floor level of Eastern Tributary (224.7 mAHD).

The analysis against Performance Indicator 4 for the reporting period is provided in Section 2.3.2.3.

[10] Bore 9GGW1B (previously used for this performance indicator) was decommissioned in late 2013. Bore 9GGW1B was replaced by Bore 9GGW1-80 for the purpose of this performance indicator. Bore 9FGW1B (previously referred to in this performance indicator) changed to 9FGW1A to correct a labelling error. These amendments were made in the Metropolitan Coal Longwalls 20-22 Water Management Plan (Version E) submitted to the DP&E on 30 June 2014.

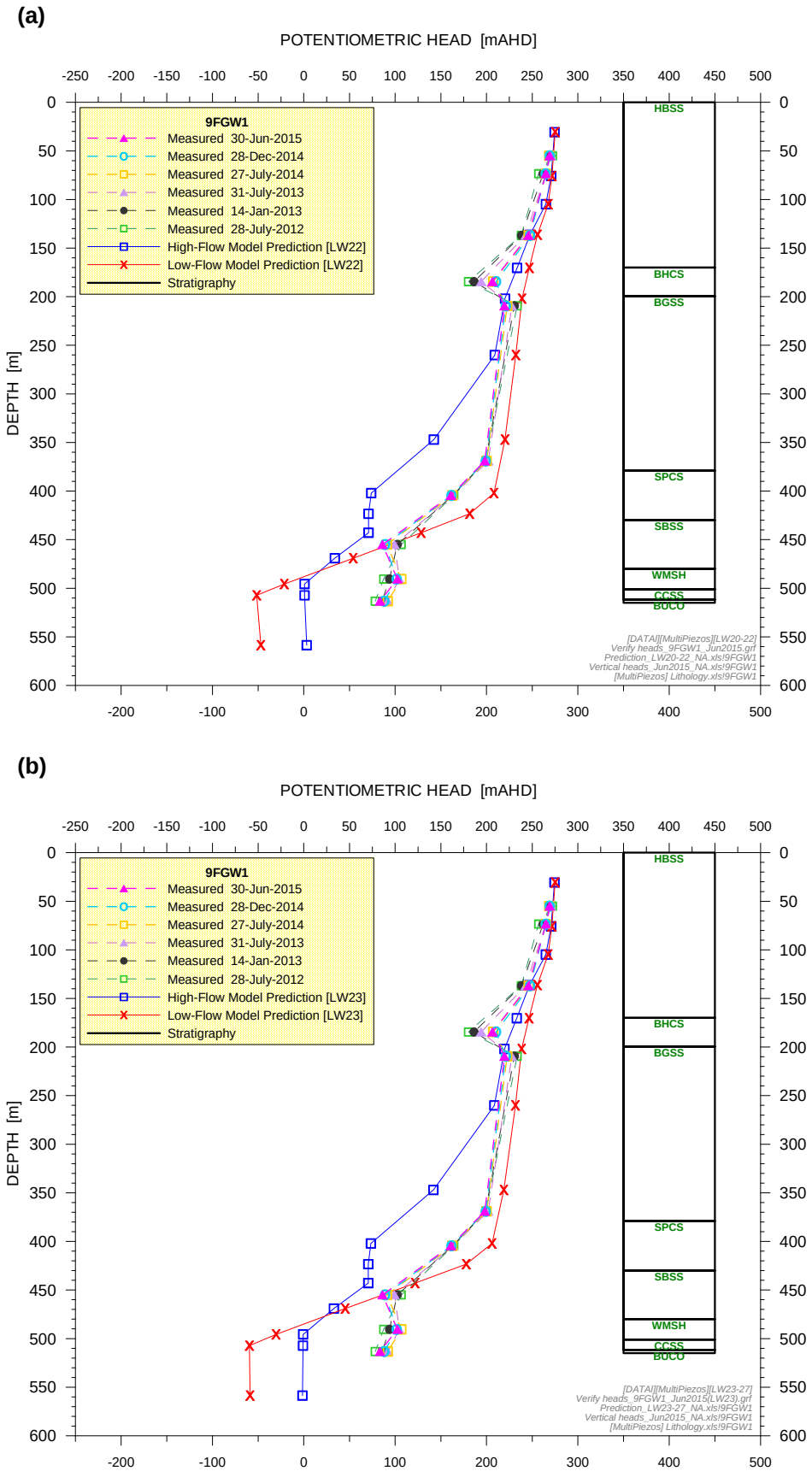


Chart 38 Measured and Simulated Potentiometric Head Profiles at Indicator Site 9FGW1A (a) simulated at the end of Longwall 22 and (b) simulated at the end of Longwall 23

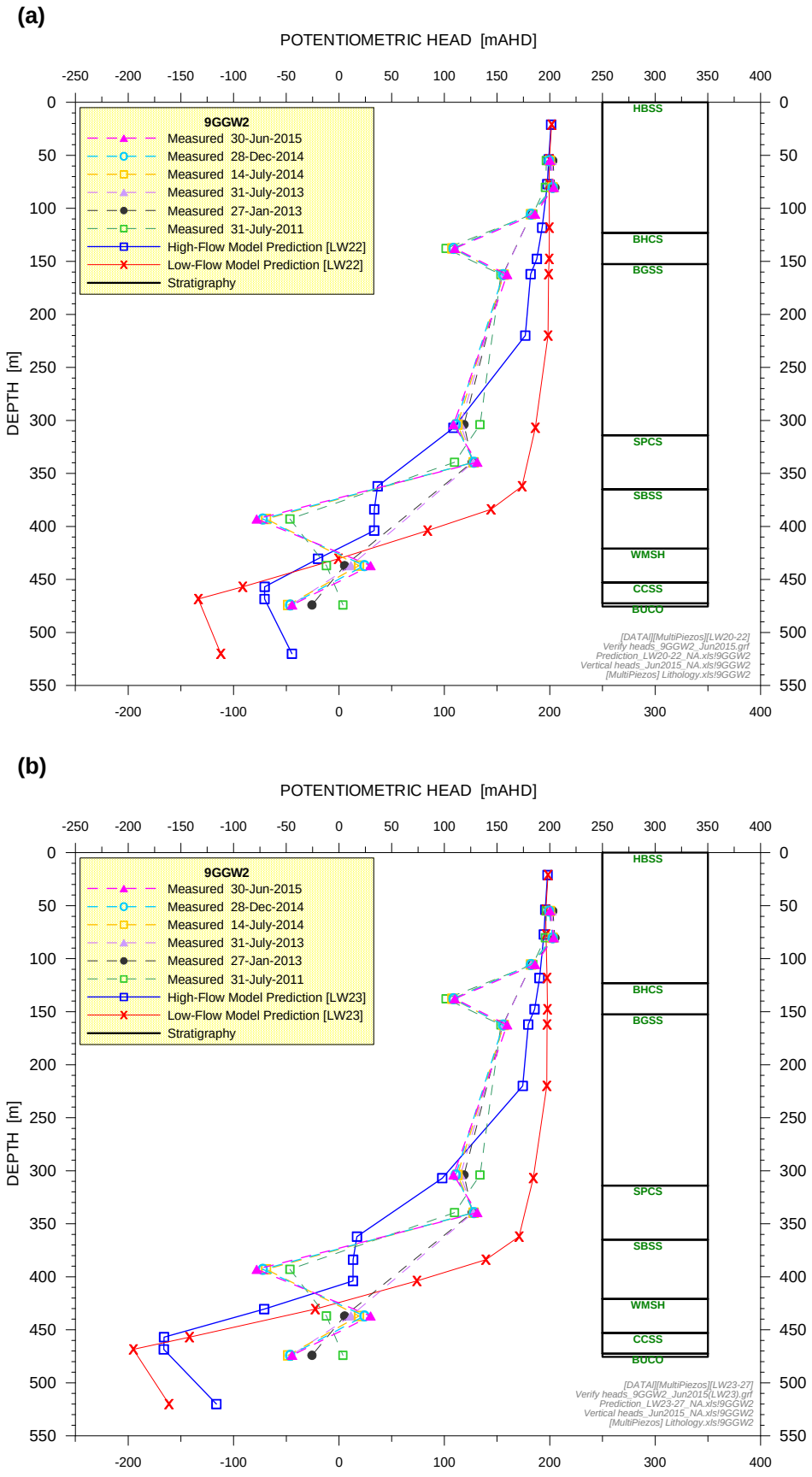


Chart 39 **Measured and Simulated Potentiometric Head Profiles at Indicator Site 9GGW2B (a) simulated at the end of Longwall 22 and (b) simulated at the end of Longwall 23**

2.3.1.4 Leakage from the Woronora Reservoir

Analysis against Performance Indicator

Performance Indicator: *The groundwater head of Bores 9GGW2B and PM02 is higher than the water level of Woronora Reservoir (i.e. a hydraulic gradient exists from the bores to the Woronora Reservoir).*

The performance indicator is considered to have been exceeded if the 7-day average potentiometric head at the uppermost piezometer is less than the reservoir water level for one week.

The analysis against the performance indicator for the reporting period is provided in Section 2.3.2.4.

2.3.1.5 Woronora Reservoir Water Quality

Metropolitan Coal has sourced surface water quality data for the Woronora Reservoir (site DW01) from WaterNSW in accordance with a data exchange agreement. Consistent with the monitoring of water reaching the Woronora Reservoir (Section 2.3.1.2), the water quality data has been analysed for key water quality parameters of relevance to water supply and the effects of subsidence, namely:

- iron;
- manganese; and
- aluminium.

Data analysis is conducted to assess whether the performance indicator below has been exceeded.

Performance Indicator:

Changes in the quality of water in the Woronora Reservoir are not significantly different post-mining compared to pre-mining concentrations.

Analysis of the performance indicator for the reporting period is discussed in Section 2.3.2.5.

2.3.1.6 Waratah Rivulet Downstream of the Maingate of Longwall 23

Table 1 of the Project Approval requires the Project to result in:

> *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).*

Pools P, Q, R, S, T, U, V and W on the Waratah Rivulet are located approximately 390 m, 600 m, 740 m, 980 m, 1,080 m, 1,180 m, 1,350 m and 1,460 m downstream from the maingate of Longwall 22, respectively (Figure 5).

The methods used and the assessment of the performance of the Project against the subsidence impact performance measure are described in Section 2.3.2.6.

2.3.2 Longwalls 23-27

2.3.2.1 Quantity of Water Resources Reaching the Woronora Reservoir

Surface water flow monitoring is conducted at the WaterNSW-owned gauging stations on the Waratah Rivulet (GS2132102) and Woronora River (GS2132101) and at the OEH gauging station on O'Hares Creek at Wedderburn (GS213200).

Water flow data is analysed to assess whether the performance indicator below has been exceeded.

Analysis against Performance Indicator

Performance Indicator:

Changes in the quantity of water entering Woronora Reservoir is not significantly different post-mining compared to pre-mining, that is not also occurring in the control catchment(s).

Consistent with the Metropolitan Coal Longwalls 20-22 and Longwalls 23-27 Water Management Plans, data is analysed to assess whether a statistically significant reduction in the quantity of water entering Woronora Reservoir in the post-mine period relative to the pre-mine period has occurred, that has not also occurred in the control catchment(s), specifically:

- The monitored flow rates on Waratah Rivulet and the control catchments are integrated over successive 14 day periods for comparison with the corresponding integrated flows (14 day totals) predicted by the AWBM models of the same catchments.
- The ratio of total monitored flow divided by AWBM predicted flow is calculated at 14 day intervals commencing at the end of the baseline period and advancing from the commencement of Longwall 20.

The performance indicator is considered to have been exceeded if the median of the ratios for the sliding 1 year period in the Waratah Rivulet falls below the 20th percentile of the baseline data, unless the same is also occurring in data for the control sites.

Chart 40 shows a comparison of the monitored and modified AWBM simulated water flows through Waratah Rivulet (GS2132012) to 30 June 2015.

Chart 41 shows a plot of the sliding 12 month median of the ratio of 14 day sums of monitored flow at Waratah Rivulet (GS2132102) and flows simulated via the modified AWBM. The 12 month sliding median in Chart 41 does not fall below the 20th percentile value of 0.767.

Analysis against Subsidence Impact Performance Measure

Consistent with the Metropolitan Coal Longwalls 20-2 and Longwalls 23-27 Water Management Plans, if data analysis indicates the performance indicator has been exceeded or is likely to be exceeded, an assessment is made against the following subsidence impact performance measure.

Subsidence Impact Performance Measure:

Negligible reduction to the quantity of water resources reaching the Woronora Reservoir.

The subsidence impact performance measure is considered to have been exceeded if analysis of the monitoring and modelling results confirms that the Project has resulted in a greater than negligible reduction in the quantity of water resources reaching the Woronora Reservoir. The performance indicator was not exceeded during the reporting period.

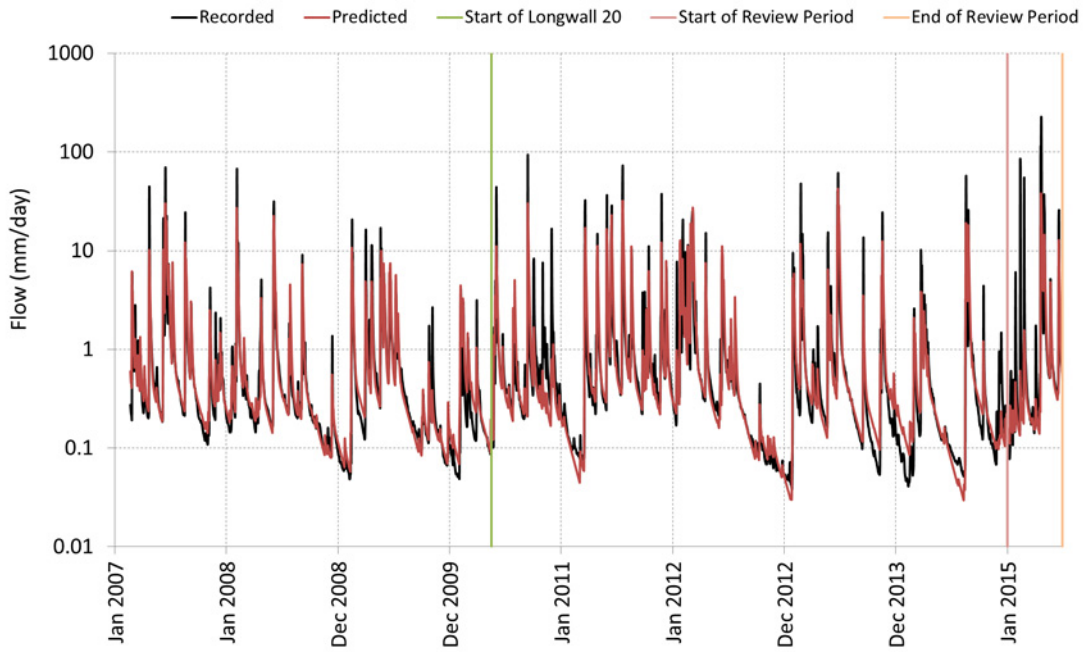


Chart 40 Monitored and Modified AWBM Simulated Average Daily Flow Rates at Waratah Rivulet (GS2132102)

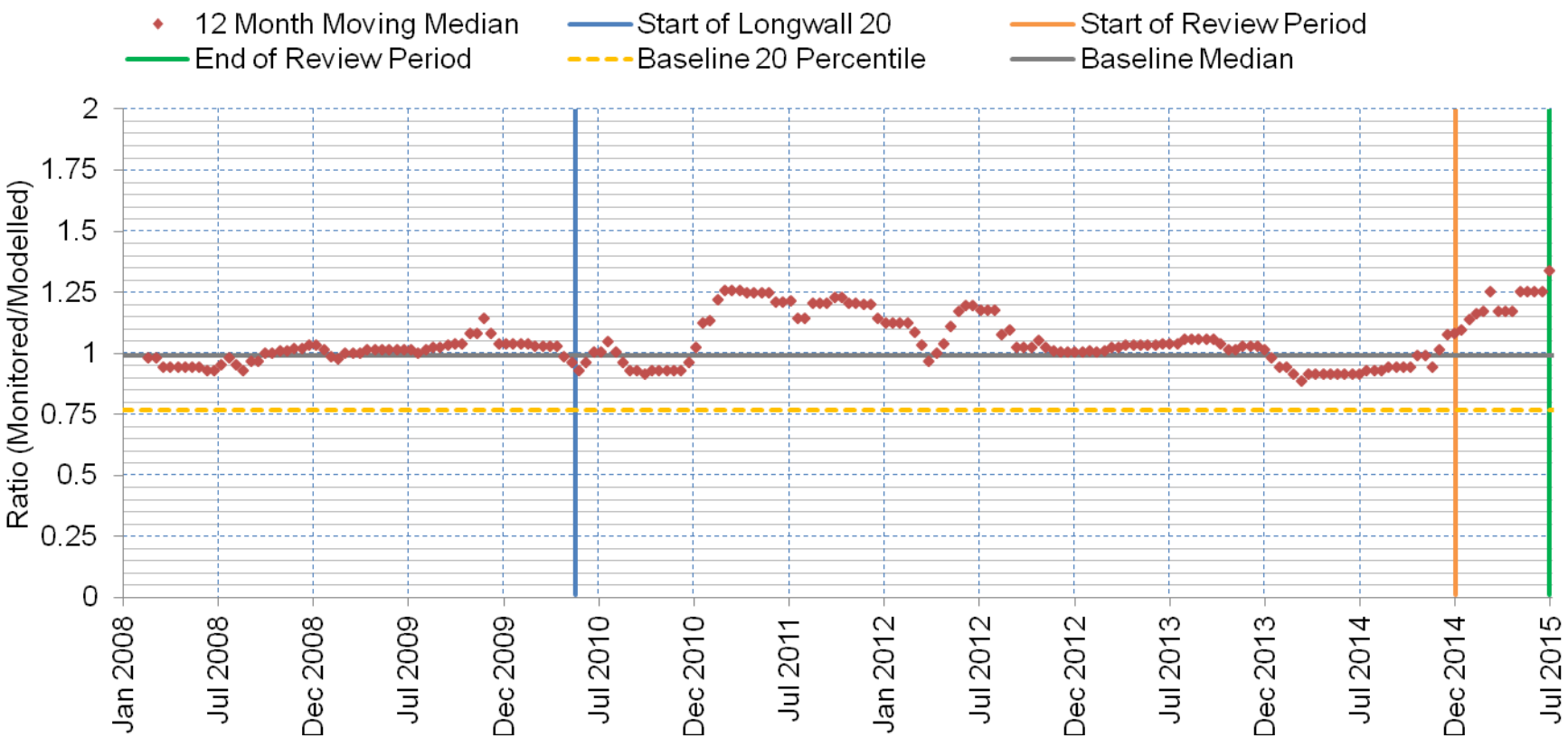


Chart 41 One Year Sliding Median for the Ratios of the 14 Day Sums of Monitored and AWBM (Modified) Simulated Flow Rates at Waratah Rivulet (GS2132102)

2.3.2.2 Quality of Water Resources Reaching the Woronora Reservoir

Water quality sampling is conducted on the Waratah Rivulet (site WRWQ9), Eastern Tributary (ETWQ AU) and Woronora River (WOWQ2), near the inflow points to the Woronora Reservoir (Figure 6). The field filtered[11] water quality data has been analysed for key water quality parameters of relevance to water supply, namely:

- iron;
- aluminium; and
- manganese.

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).

Water quality data from sites WRWQ9 and ETWQ AU is analysed against monitoring data collected at both sites in the baseline period and against water quality data collected from site WOWQ2 on the Woronora River. Data analysis is conducted to assess whether the performance indicator below has been exceeded.

Analysis against Performance Indicator

Performance Indicator:

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.

During 2014 Metropolitan Coal proposed revisions to improve the water quality performance indicator assessment methods in response to the Evans & Peck (2012; 2013) peer review recommendations. Following a detailed review process by the DP&E, the revised assessment methods are used below to assess the water quality performance indicator.

The performance indicator is considered to have been exceeded if data analysis indicates a significant change in the quality of water post-mining of Longwall 20. Specifically if [12,13]:

- any water quality parameter exceeds the adjusted baseline mean plus two standard deviations for two consecutive months; 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.

[11] The field filtered concentrations are taken to be equivalent to the dissolved fraction.

[12] Note each 'mean' is calculated as a geometric mean.

[13] Note, an additional water quality performance indicator assessment method was proposed following the completion of this assessment. The additional assessment method will be included in future Annual Review and AEMR/Rehabilitation Reports and Six Monthly Reports.

Assessment of Water Quality at Site WRWQ9

Plots showing the concentrations of dissolved iron, dissolved aluminium and dissolved manganese recorded at sampling site WRWQ9 in relation to the adjusted baseline mean plus two standard deviations are shown on Charts 42 to 44. Charts 45 to 47 show the concentrations of dissolved iron, dissolved aluminium and dissolved manganese recorded at control site WOWQ2 in comparison to the adjusted baseline mean plus two standard deviations.

There were no exceedances of the adjusted baseline mean plus two standard deviations for two consecutive months for dissolved iron, dissolved aluminium or dissolved manganese in Waratah Rivulet at WRWQ9 during the reporting period (Charts 42 to 44). There were also no exceedances of the adjusted baseline mean plus two standard deviations levels for two consecutive months for dissolved iron, dissolved aluminium or dissolved manganese at the control site WOWQ2 during the reporting period (Charts 45 to 47).

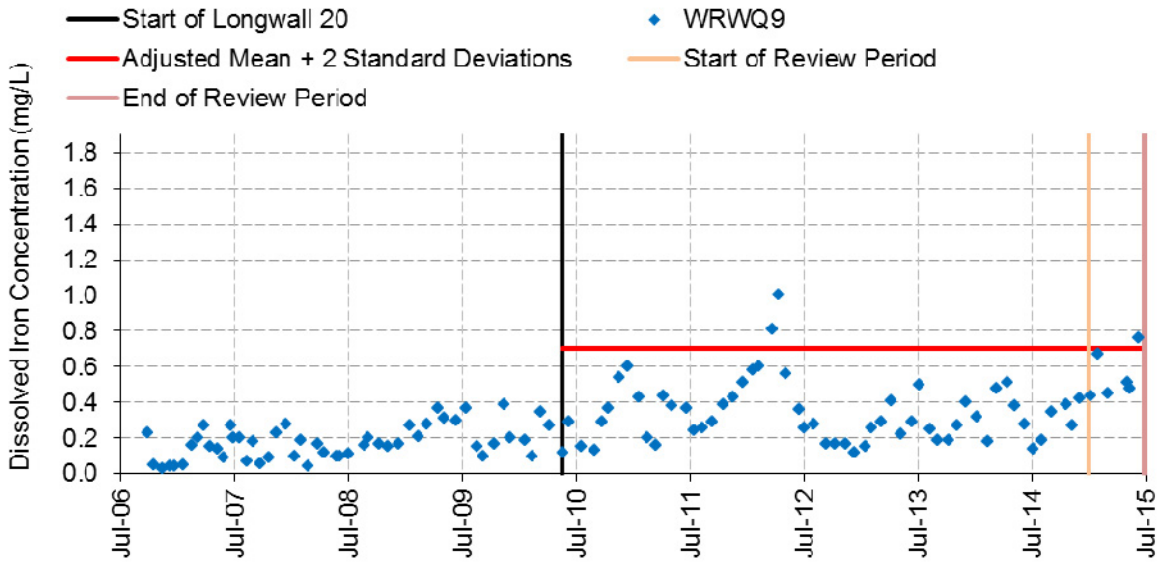


Chart 42 Dissolved Iron Concentrations in Waratah Rivulet at WRWQ9

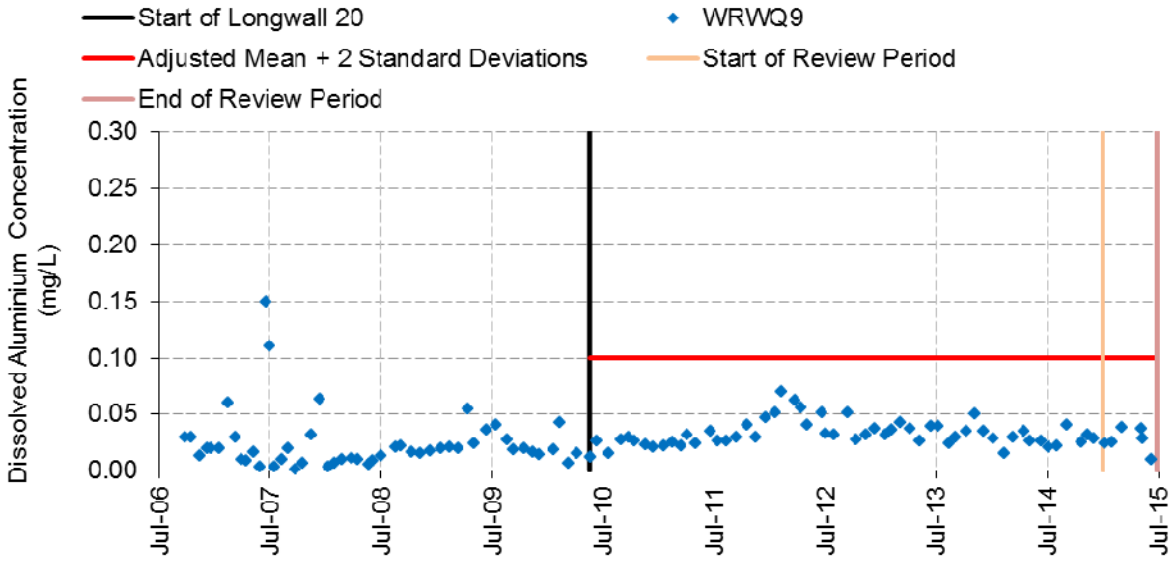


Chart 43 Dissolved Aluminium Concentrations in Waratah Rivulet at WRWQ9

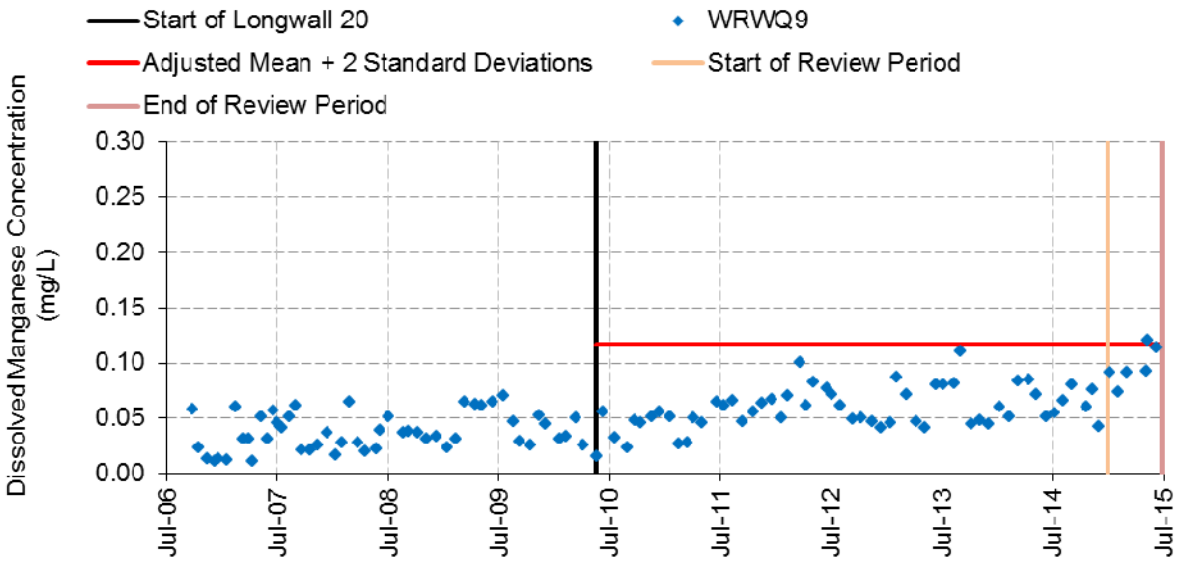


Chart 44 Dissolved Manganese Concentrations in Waratah Rivulet at WRWQ9

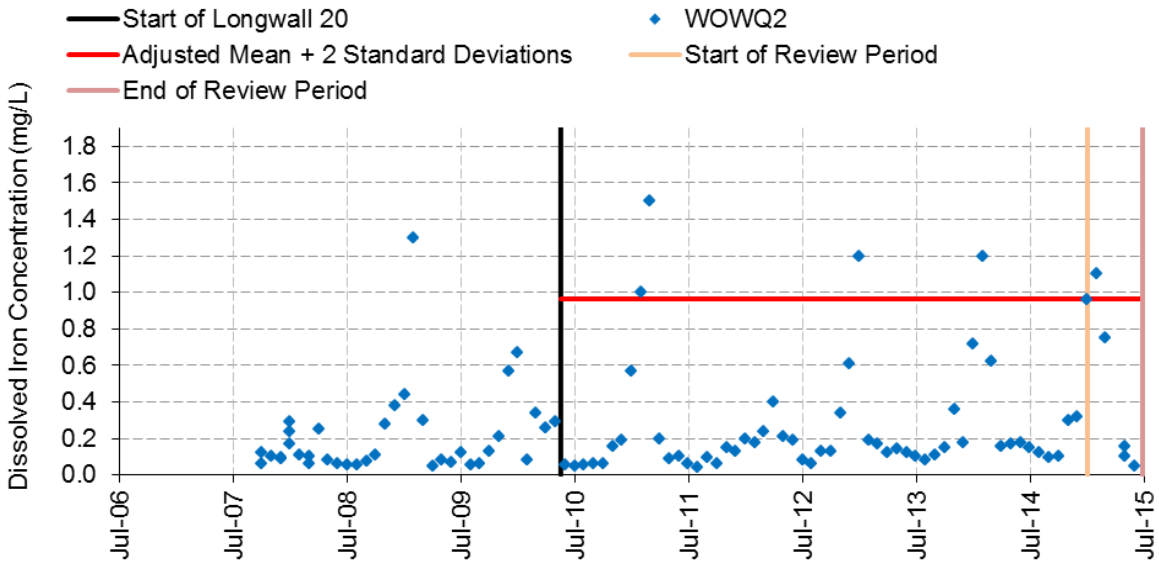


Chart 45 Dissolved Iron Concentrations in Woronora River at WOWQ2

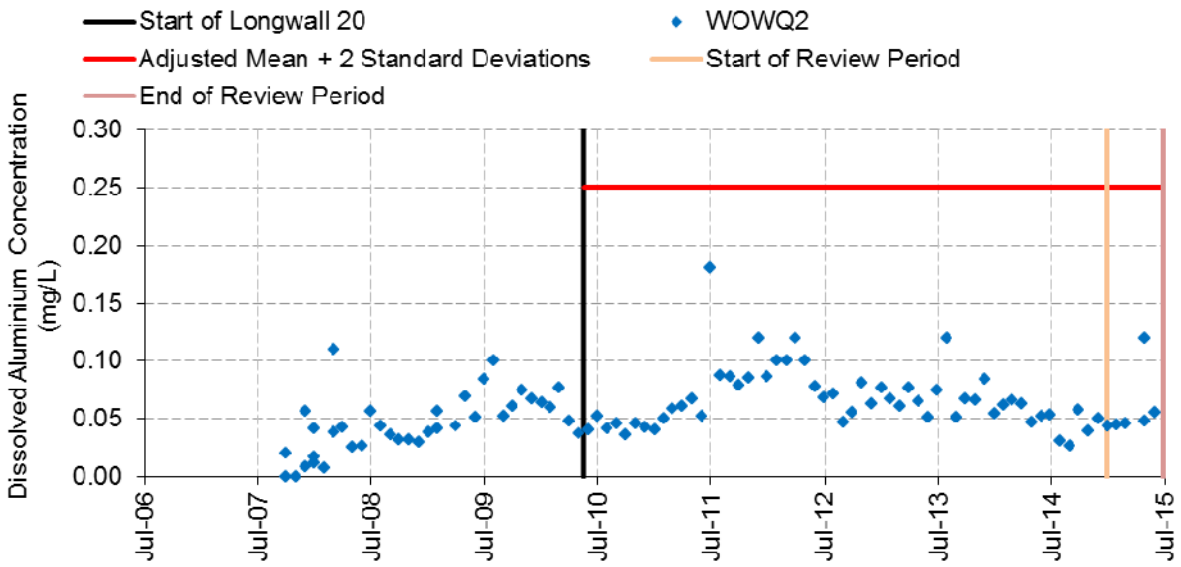


Chart 46 Dissolved Aluminium Concentrations in Woronora River at WOWQ2

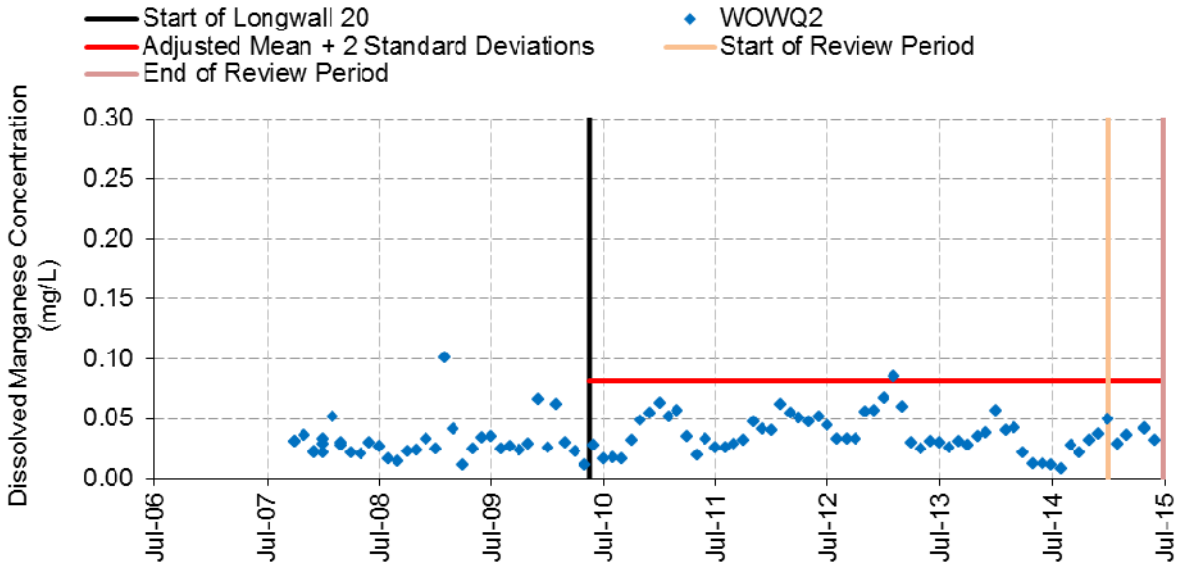


Chart 47 Dissolved Manganese Concentrations in Woronora River at WOWQ2

Plots showing the six monthly mean concentrations for dissolved iron, dissolved aluminium and dissolved manganese recorded at site WRWQ9 are shown on Charts 48 to 50. For comparison, plots showing the six monthly mean concentrations for the same water quality parameters at control site WOWQ2 are shown on Charts 51 to 53. Each plot shows the adjusted baseline mean plus one standard deviation value.

The six month means at site WRWQ9 did not exceed the adjusted baseline mean plus one standard deviation for dissolved iron, dissolved aluminium or dissolved manganese for the two consecutive assessment periods (i.e. December 2014 and June 2015) (Charts 48 to 50). The six month means for dissolved iron, dissolved aluminium and dissolved manganese at control site WOWQ2 did not exceed the adjusted baseline mean plus one standard deviation during the reporting period (Charts 51 to 53).

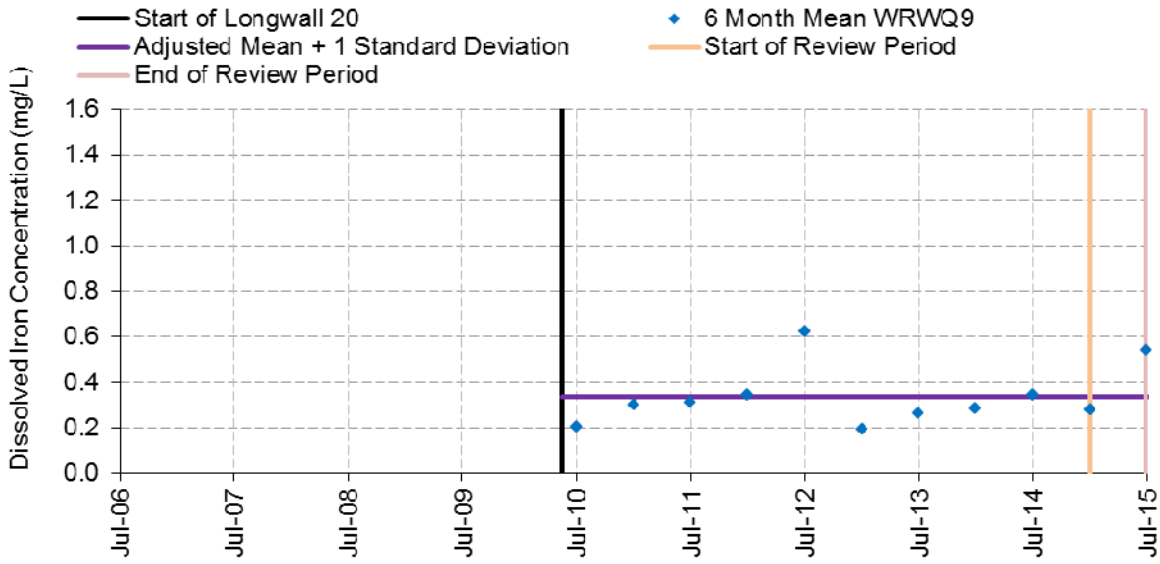


Chart 48 Six Month Means of Dissolved Iron Concentrations in Waratah Rivulet at WRWQ9

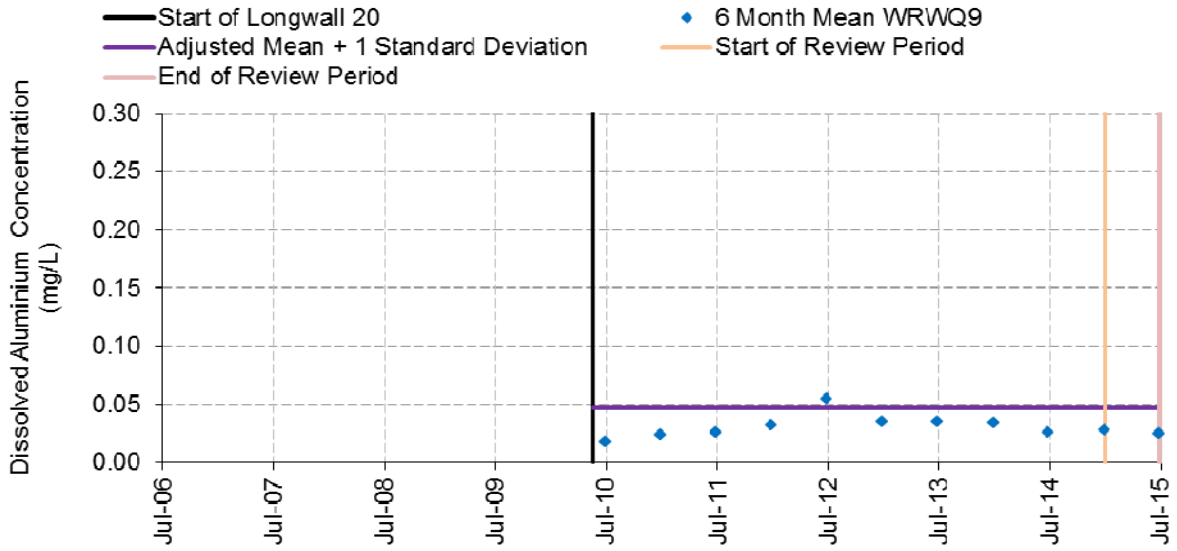


Chart 49 Six Month Means of Dissolved Aluminium Concentrations in Waratah Rivulet at WRWQ9

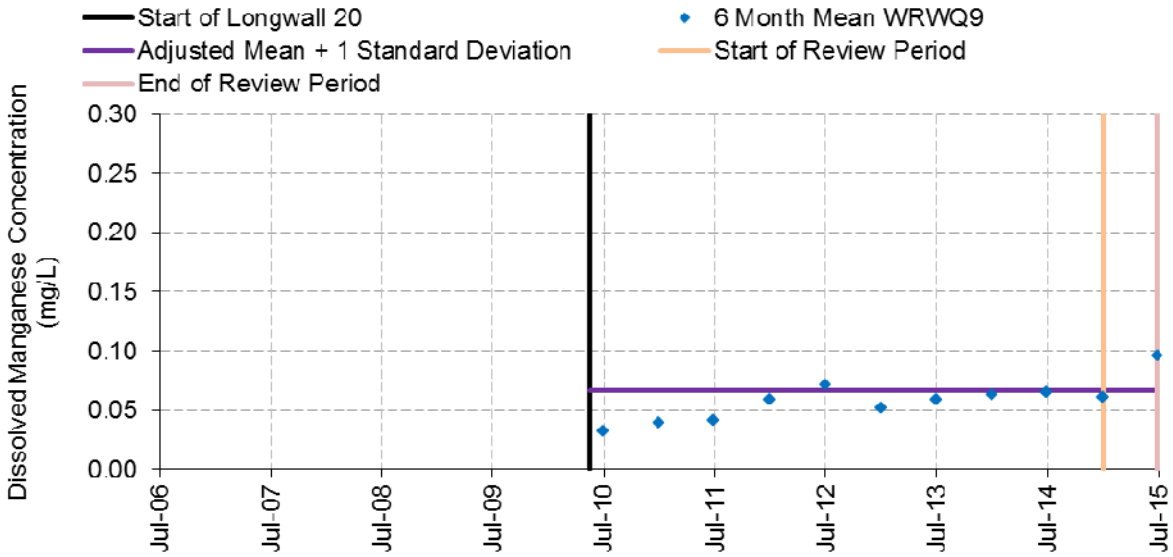


Chart 50 Six Month Means of Dissolved Manganese Concentrations in Waratah Rivulet at WRWQ9

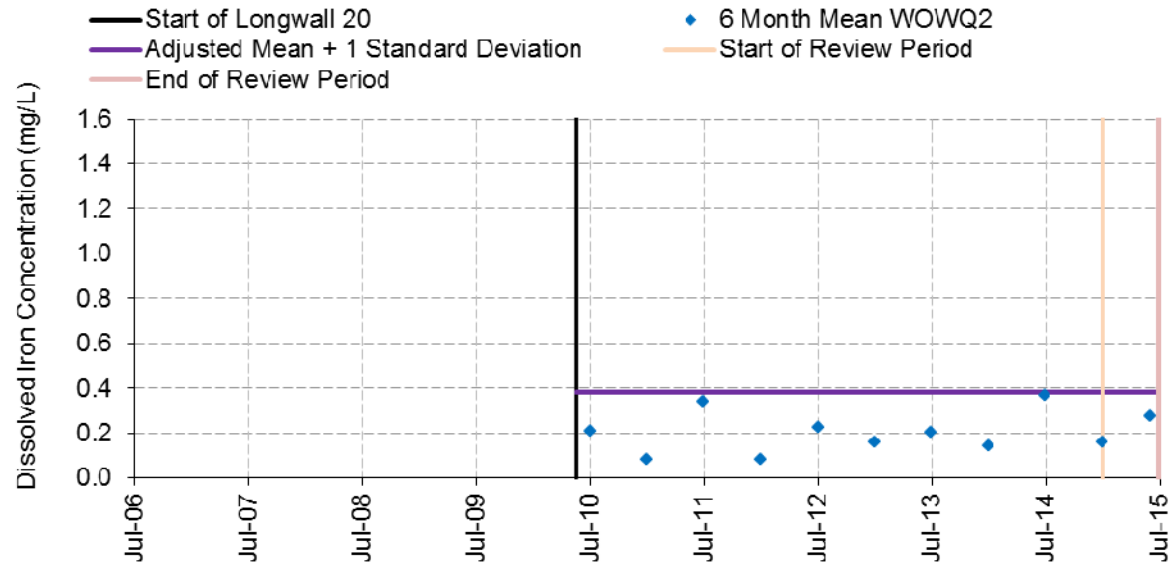


Chart 51 Six Month Means of Dissolved Iron Concentrations in Woronora River at WOWQ2

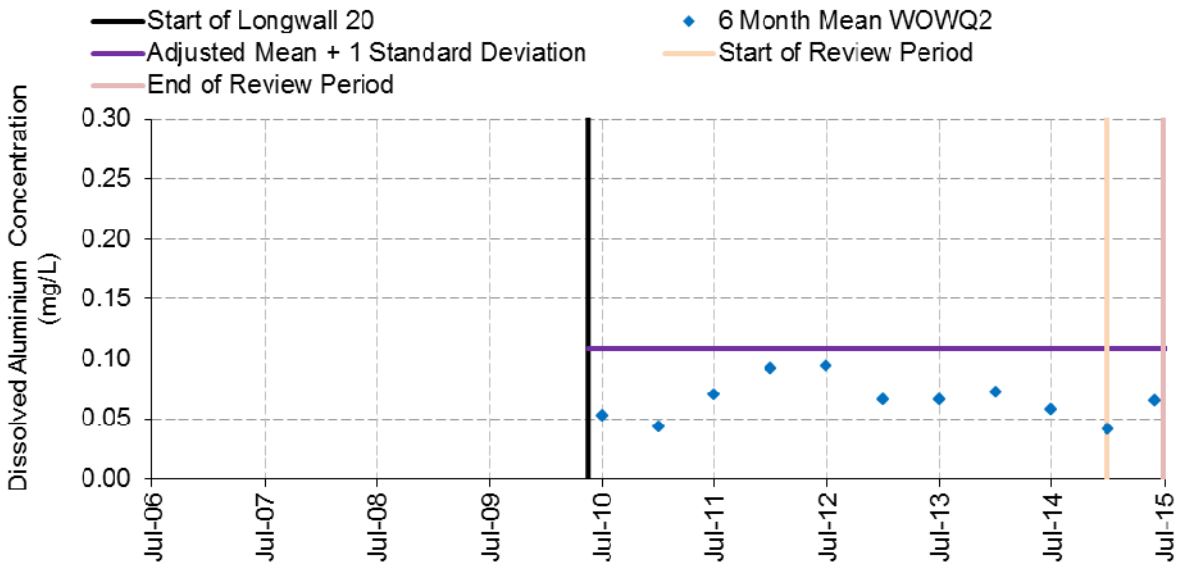


Chart 52 Six Month Means of Dissolved Aluminium Concentrations in Woronora River at WOWQ2

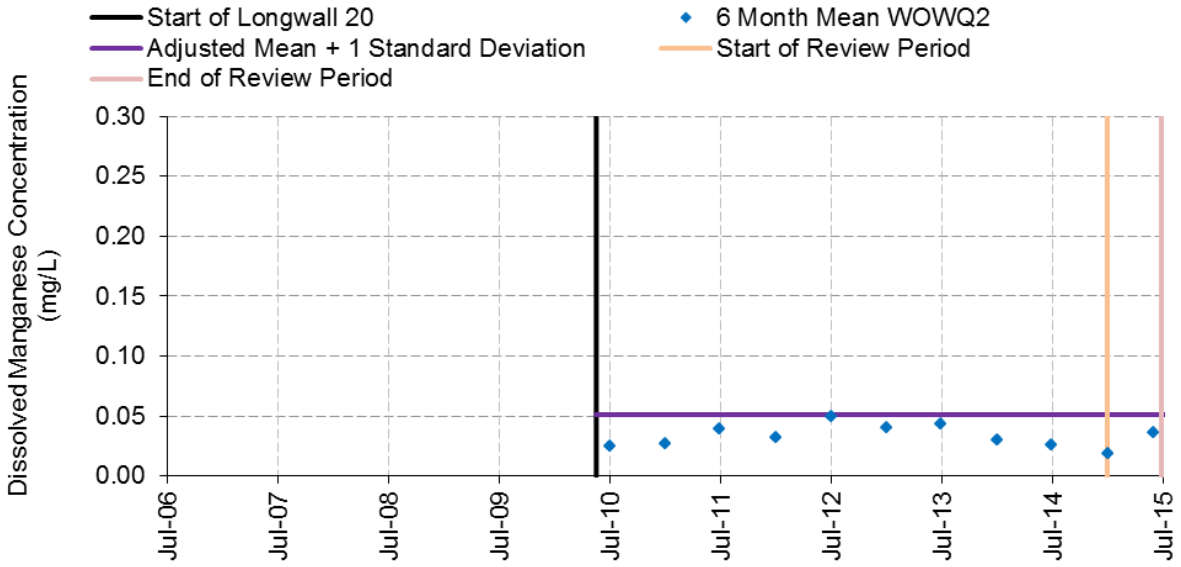


Chart 53 Six Month Means of Dissolved Manganese Concentrations in Woronora River at WOWQ2

Assessment of Water Quality at Site ETWQ AU

Plots showing the concentrations of dissolved iron, dissolved aluminium and dissolved manganese recorded at site ETWQ AU are shown on Charts 54 to 56. Charts 54 to 56 show the dissolved concentrations in relation to the adjusted baseline mean plus two standard deviations value calculated using data prior to potential subsidence effects from Longwall 20 on the Eastern Tributary.

Charts 57 to 59 show the concentrations of dissolved iron, dissolved aluminium and dissolved manganese recorded at control site WOWQ2 in comparison to the adjusted baseline mean plus two standard deviation value calculated using data collected prior to potential subsidence effects from Longwall 20 on the Eastern Tributary.

Dissolved iron, dissolved aluminium and dissolved manganese concentrations did not exceed the adjusted baseline mean plus two standard deviations values for two consecutive months during the reporting period at site ETWQ AU (Charts 54 to 56). There were also no exceedances of the baseline mean plus two standard deviations values for two consecutive months for dissolved iron, dissolved aluminium or dissolved manganese at the control site WOWQ2 during the reporting period (Charts 57 to 59).

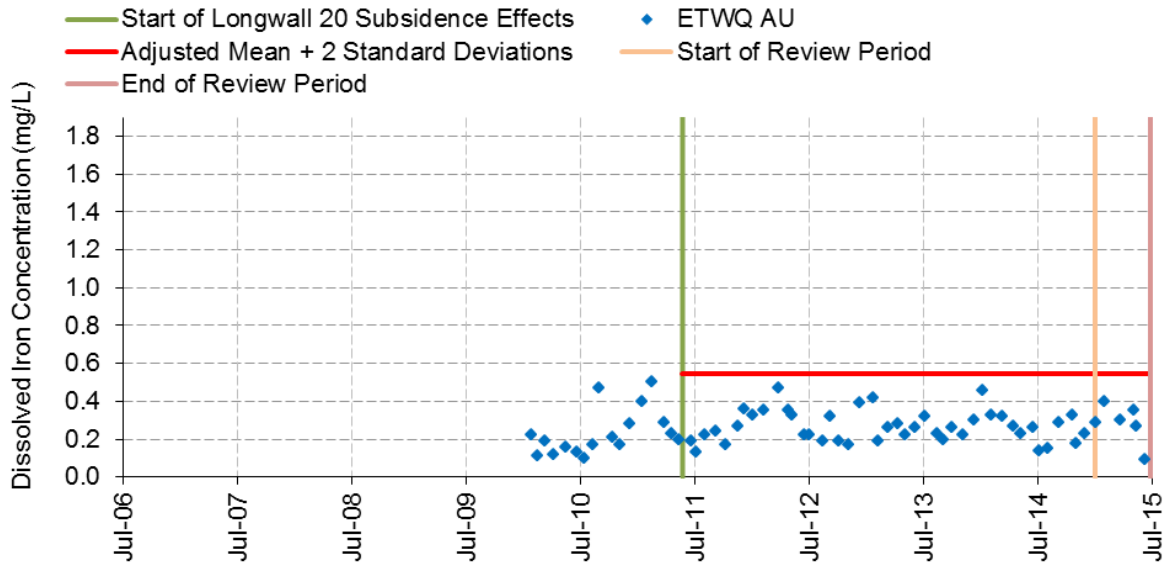


Chart 54 Dissolved Iron Concentrations in Eastern Tributary at ETWQ AU

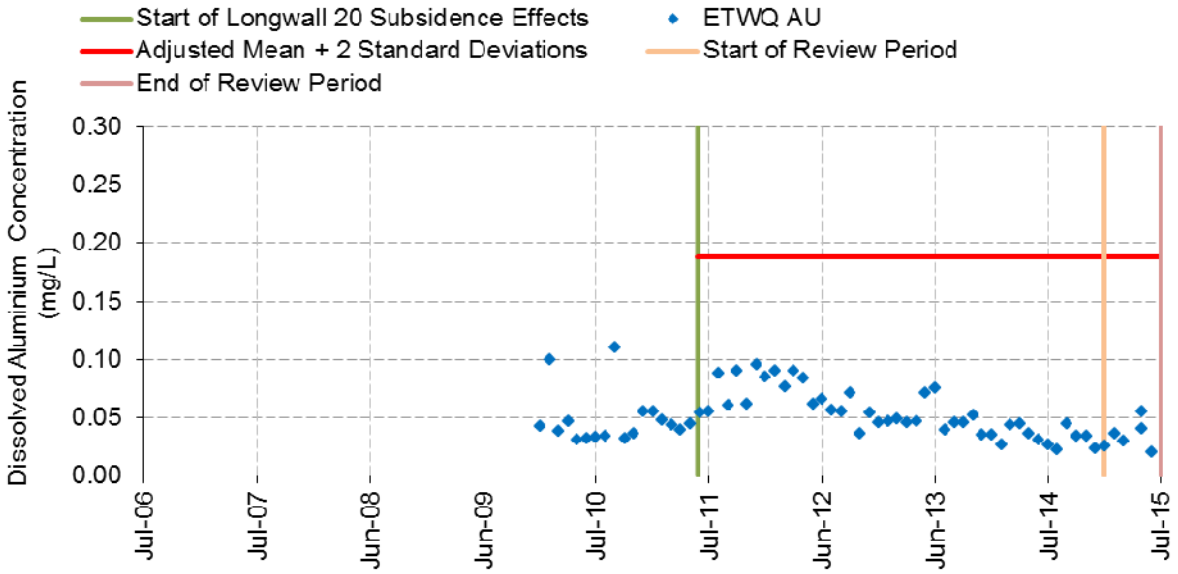


Chart 55 Dissolved Aluminium Concentrations in Eastern Tributary at ETWQ AU

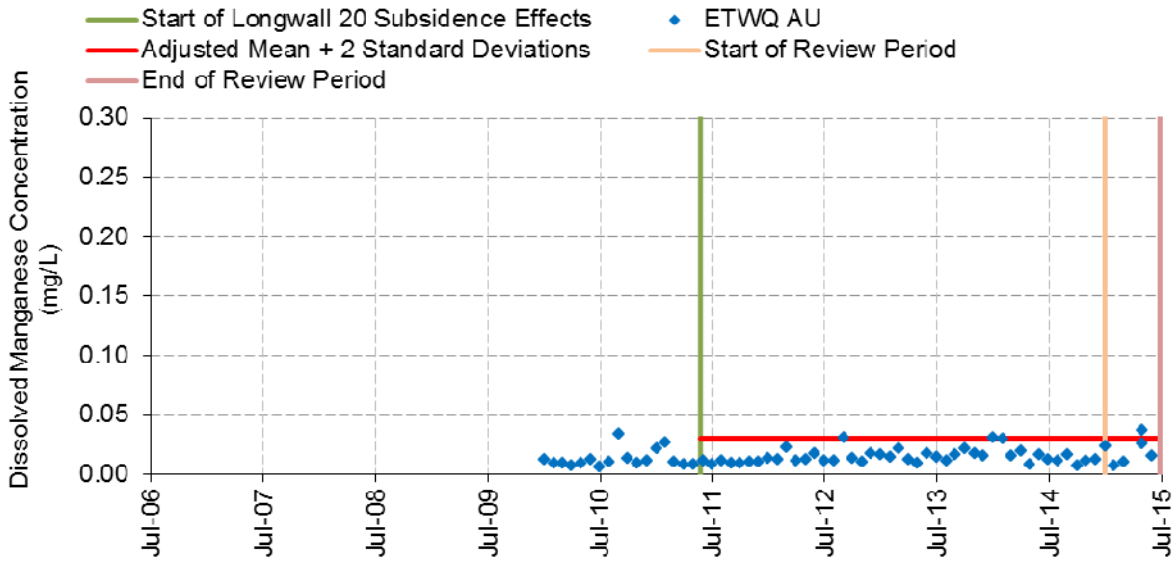


Chart 56 Dissolved Manganese Concentrations in Eastern Tributary at ETWQ AU

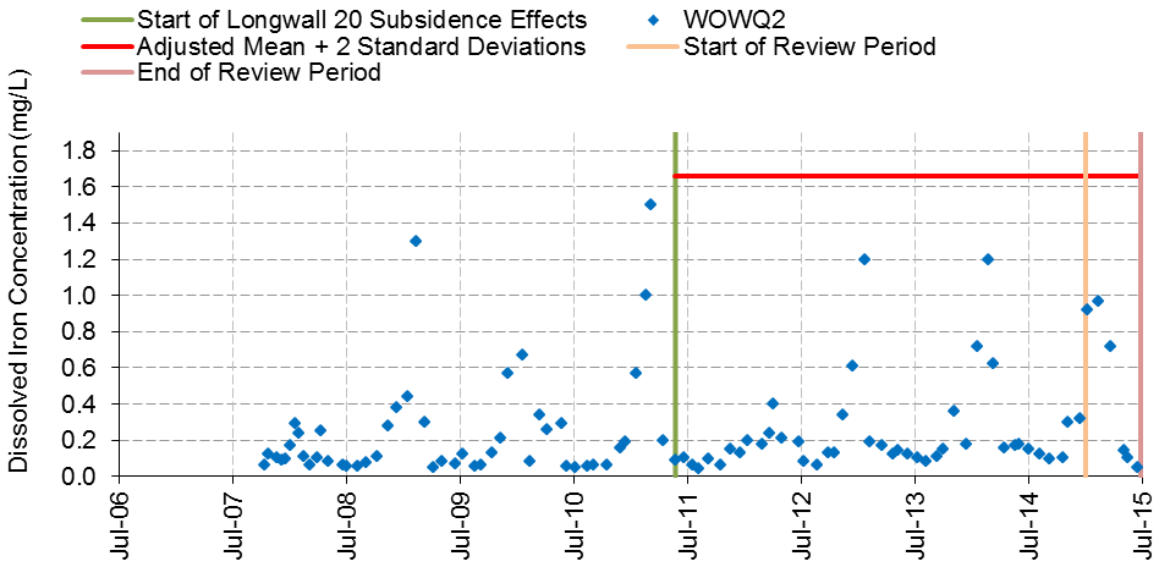


Chart 57 Dissolved Iron Concentrations in Woronora River (WOWQ2)

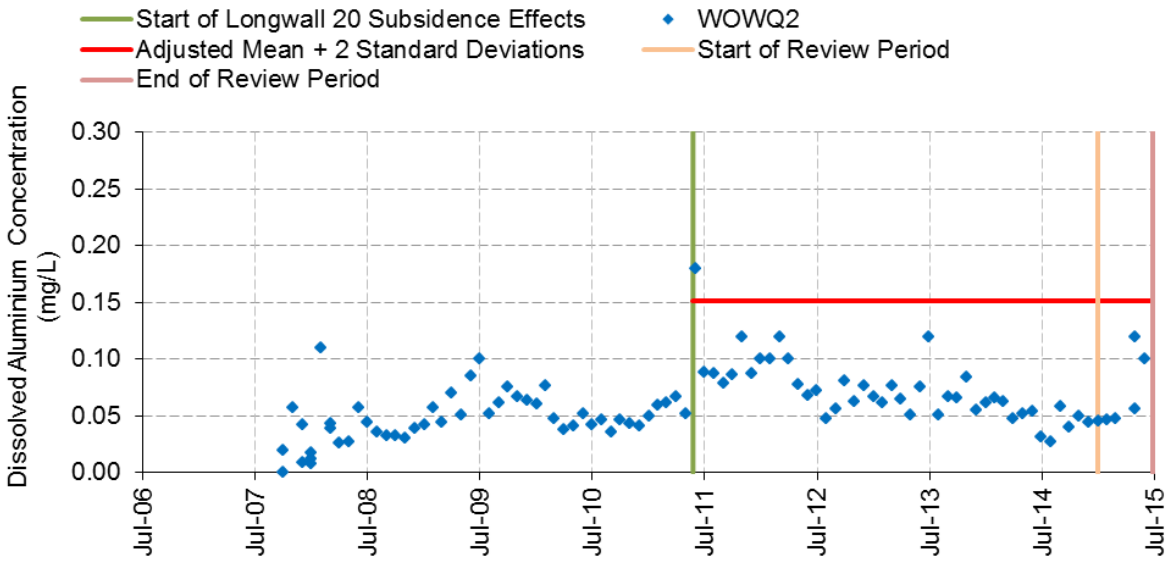


Chart 58 Dissolved Aluminium Concentrations in Woronora River (WOWQ2)

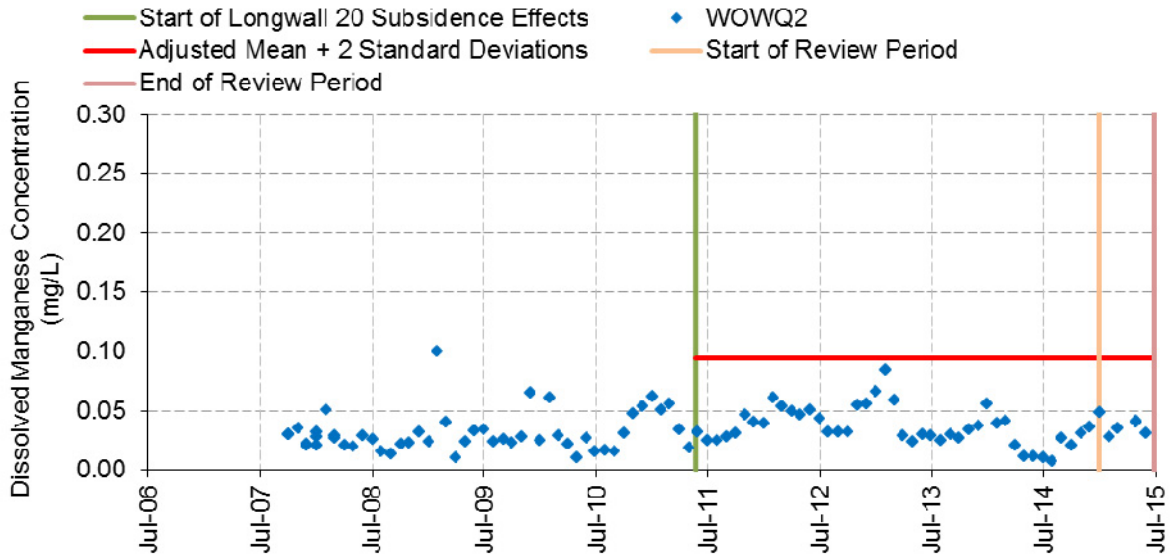


Chart 59 Dissolved Manganese Concentrations in Woronora River (WOWQ2)

Plots showing the six monthly mean concentrations of the dissolved iron, dissolved aluminium and dissolved manganese concentrations recorded at site ETWQ AU are shown on Charts 60 to 62. For comparison, plots showing the six monthly mean concentrations for the same water quality parameters at control site WOWQ2 are shown on Charts 63 to 65. Each plot shows the adjusted baseline mean plus one standard deviation value.

The six month means at ETWQ AU did not exceed the adjusted baseline mean plus one standard deviation for dissolved iron, dissolved aluminium or dissolved manganese during the reporting period (Charts 60 to 62). The six month means for dissolved iron, dissolved aluminium and dissolved manganese at control site WOWQ2 did not exceed the adjusted baseline mean plus one standard deviation during the reporting period (Charts 63 to 65).

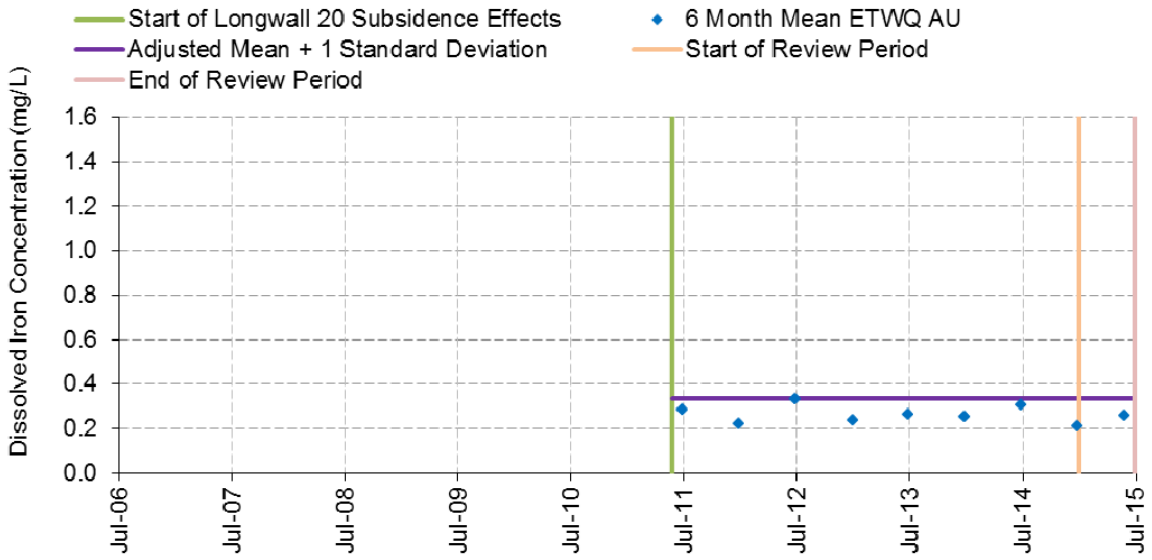


Chart 60 Six Month Means of Dissolved Iron Concentrations in Eastern Tributary at ETWQ AU

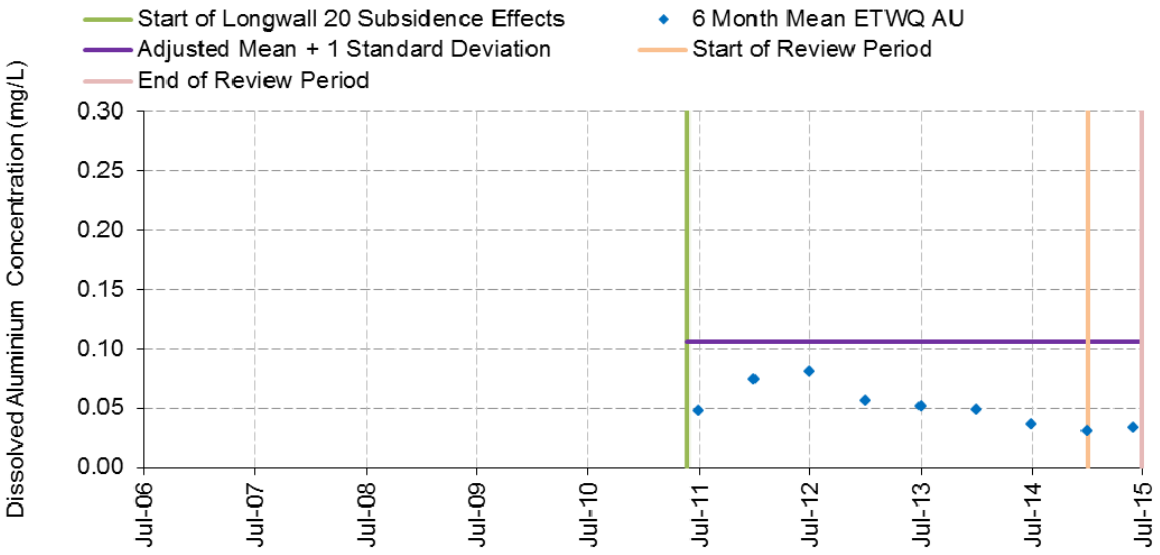


Chart 61 Six Month Means of Dissolved Aluminium Concentrations in Eastern Tributary at ETWQ AU

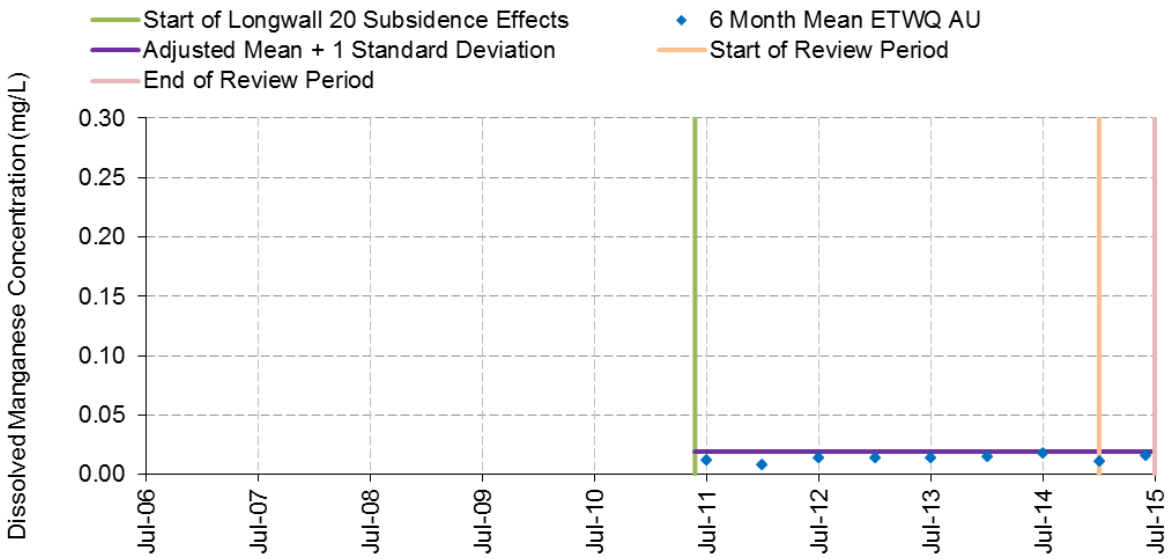


Chart 62 Six Month Means of Dissolved Manganese Concentrations in Eastern Tributary at ETWQ AU

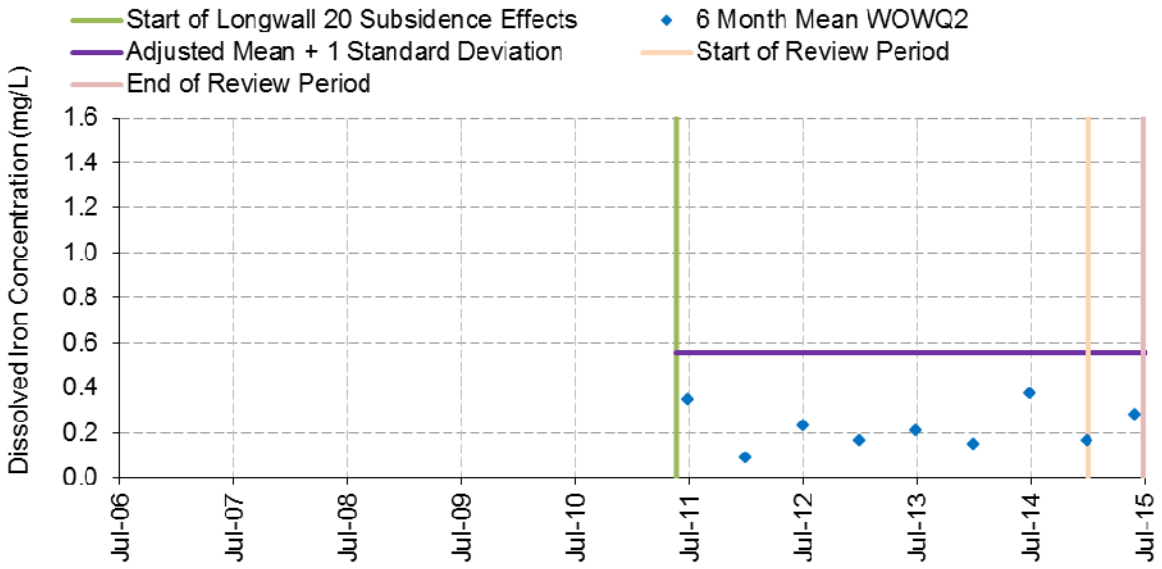


Chart 63 Six Month Means of Dissolved Iron Concentrations in Woronora River at WOWQ2

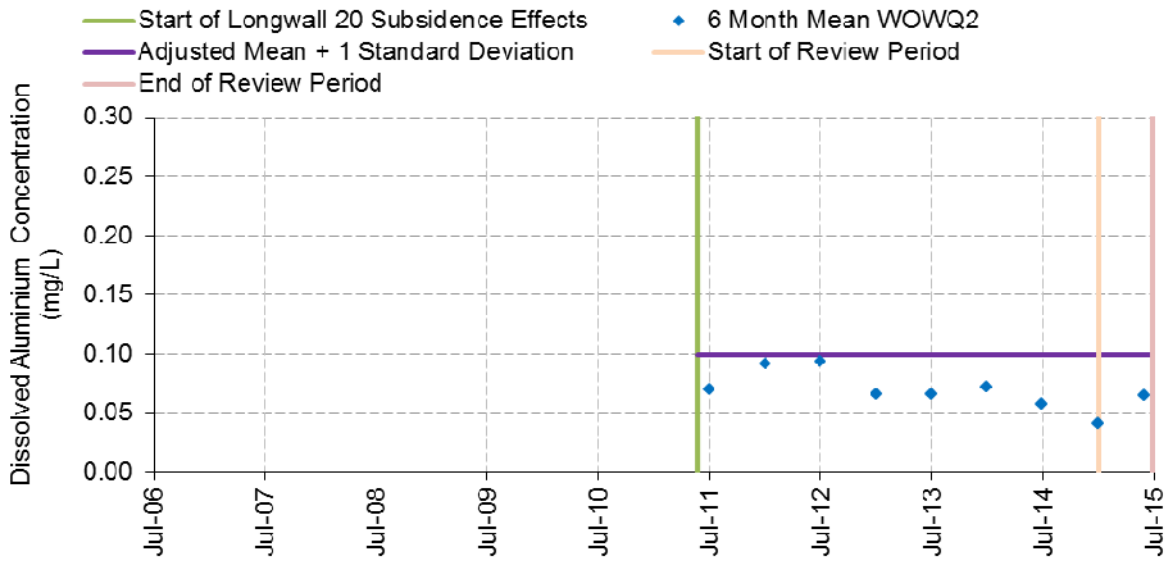


Chart 64 Six Month Means of Dissolved Aluminium Concentrations in Woronora River at WOWQ2

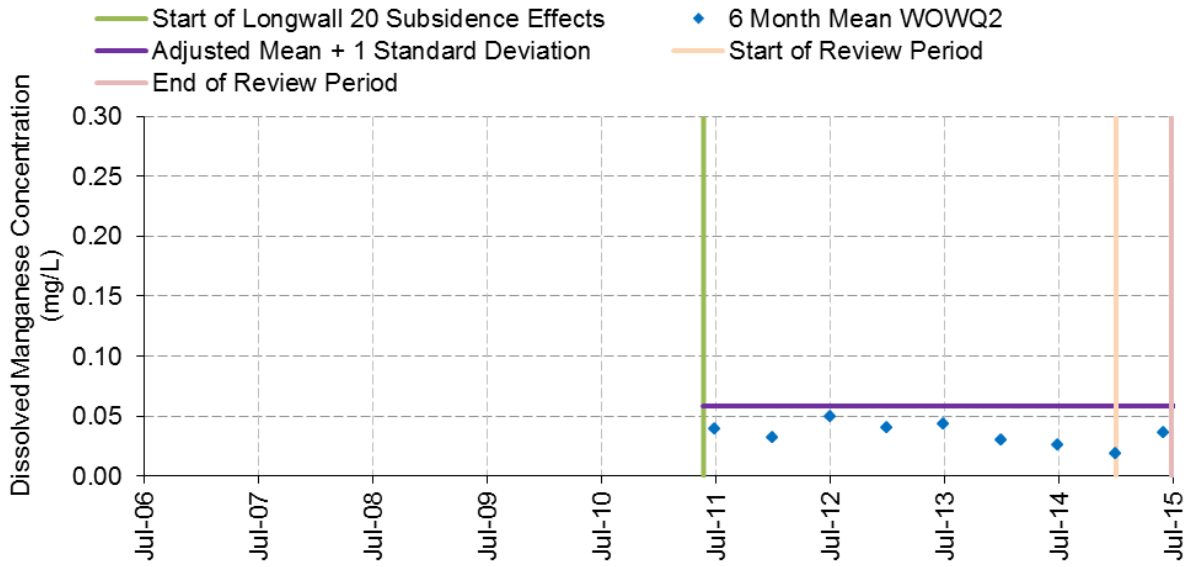


Chart 65 Six Month Means of Dissolved Manganese Concentrations in Woronora River at WOWQ2

Analysis against Subsidence Impact Performance Measure

Consistent with the Metropolitan Coal Longwalls 20-22 and Longwalls 23-27 Water Management Plans, if data analysis indicates the performance indicator has been exceeded or is likely to be exceeded, an assessment is made against the following subsidence impact performance measure.

Subsidence Impact Performance Measure:

Negligible reduction to the quality of water resources reaching the Woronora Reservoir.

The performance indicator was not exceeded during the reporting period.

2.3.2.3 Connective Cracking between the Surface and the Mine

Analysis against Performance Indicator 1

Performance Indicator 1: *Visual inspection does not identify abnormal water flow from the goaf, geological structure, or the strata generally.*

The performance indicator is considered to have been exceeded if visual inspections identify abnormal water flow from the goaf, geological structure, or the strata generally.

The mine inspections did not identify any abnormal water flows from the goaf, geological structure, or strata.

This performance indicator was not exceeded during the reporting period.

Analysis against Performance Indicator 2

Performance Indicator 2: *The 20-day average mine water make does not exceed 2 ML/day.*

The performance indicator is considered to have been exceeded if data analysis indicates the 20 day average mine water make exceeds 2 ML/day.

The 20 day average daily mine water make was less than 2 ML/day during the reporting period.

This performance indicator was not exceeded during the reporting period.

Analysis against Performance Indicator 3

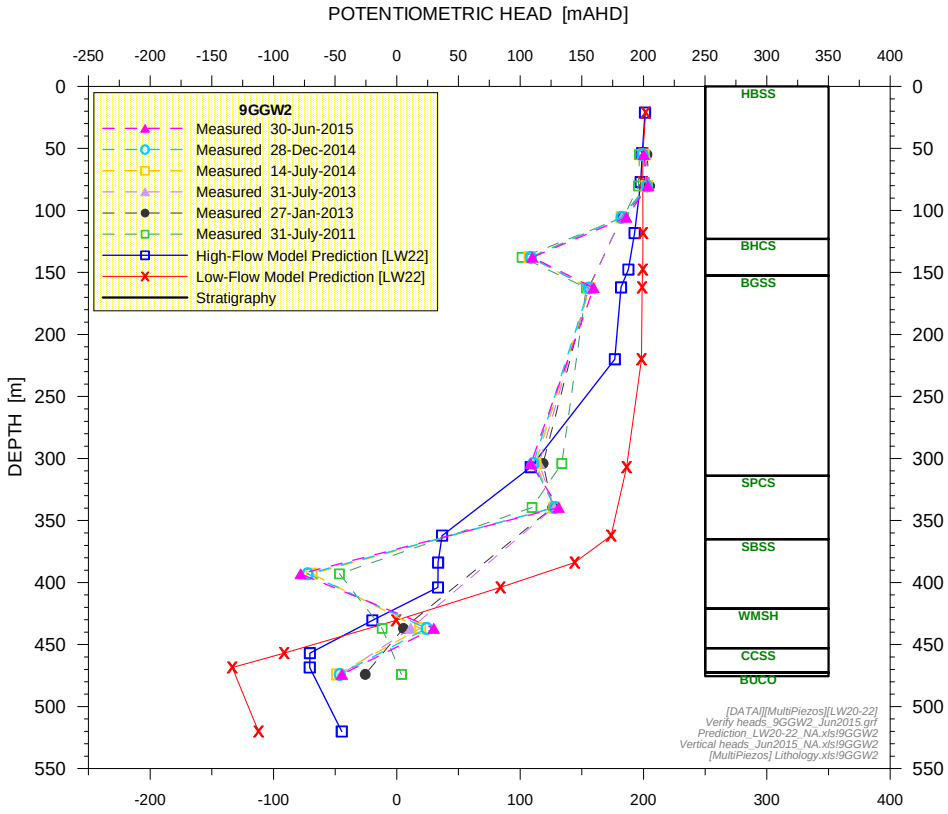
Performance Indicator 3: *Significant departure from the predicted envelope of the vertical potentiometric head profile at Bore 9GGW2B does not occur.*

The performance indicator is considered to have been exceeded if the measured potentiometric head profile is inconsistent in shape or lies significantly to the left of the predicted high-inflow model curve.

Bore 9GGW2B is located above Longwall 27 headings. The vertical head profiles for 9GGW2B are shown on Chart 66. As the measured head profile at site 9GGW2B has not changed appreciably since the commencement of Longwall 23 in May 2014 or Longwall 24 in April 2015, there is no evidence of an incremental effect to date from Longwalls 23 and 24. The measured head profiles at 30 June 2015 are almost identical with the profiles measured at 28 December 2014.

The performance indicator has not been exceeded because the measured potentiometric head profiles are consistent in shape and do not lie significantly to the left of the predicted high-inflow model curve.

(a)



(b)

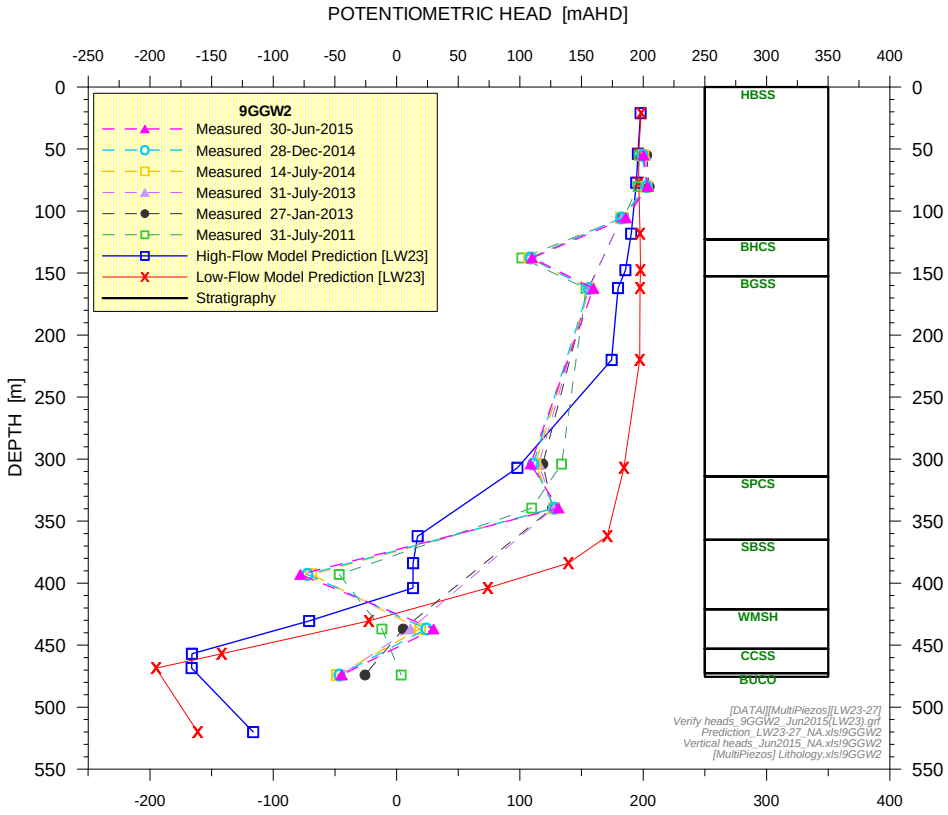


Chart 66 Measured and Simulated Potentiometric Head Profiles at Indicator Site 9GGW2B (a) simulated at the end of Longwall 22 and (b) simulated at the end of Longwall 23

Analysis against Performance Indicator 4

Performance Indicator 4: *The water tables measured at Bores 9FGW1A and 9GGW1-80 are higher than the water levels of streams crossed by a transect along Longwall 22 (i.e. a hydraulic gradient exists from each bore to the nearest watercourse).*

The performance indicator relevant to Longwalls 23-27 is considered to have been exceeded if data analysis indicates that a hydraulic gradient is not maintained between each bore and its neighbouring watercourse (i.e. the water table level at each bore is to be higher than the surface water levels in the streams), specifically if:

- the average water level measured at the 55 m piezometer at 9FGW1A is lower than the floor level of Tributary B (241.7 mAHD); or
- the average water level measured at the 80 m piezometer at 9GGW1-80 is lower than the floor level of Eastern Tributary (224.7 mAHD).

The transect on Chart 67 provides an illustration of relative ground and water levels on transect A-A' along Longwall 22 through indicator sites 9FGW1A and 9GGW1-80. The transect from west to east crosses Tributary B (twice), Waratah Rivulet, Tributary A and the Eastern Tributary. The water level at site 9FGW1A is about 26 m higher than the elevation of the nearest downgradient watercourse (Tributary B). At site 9GGW1-80, the water level is about 10 m higher than Eastern Tributary (to its east) but is nearly 28 m higher than Tributary A (to its west).

The performance indicator has not been exceeded because the average water levels measured in the two piezometers are above the floor levels of the nearest streams.

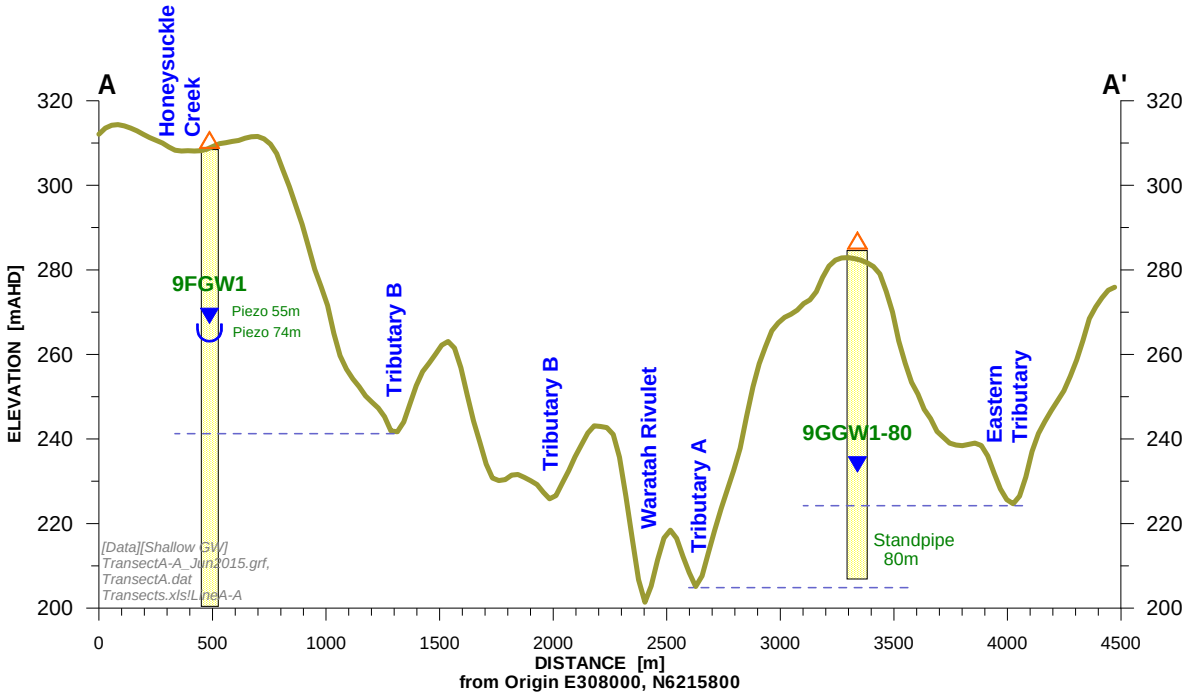


Chart 67 Topographic Transect A-A' along Longwall 22 and Hawkesbury Sandstone Water Levels at 30 June 2015

2.3.2.4 Leakage from the Woronora Reservoir

Analysis against Performance Indicator

Performance Indicator: *The groundwater head of Bores 9GGW2B and PM02 is higher than the water level of Woronora Reservoir (i.e. a hydraulic gradient exists from the bores to the Woronora Reservoir).*

The performance indicator is considered to have been exceeded if the 7-day average potentiometric head at the uppermost piezometer is less than the reservoir water level for one week.

The 7-day average groundwater levels in the uppermost piezometers in the Hawkesbury Sandstone at sites 9GGW2B and PM02 are presented on Chart 68. Comparison with the maximum possible Woronora Reservoir water level shows a current clearance (at end of June 2015) of approximately 30 m at 9GGW2B and approximately 70 m at PM02. The shallow groundwater levels are well above reservoir level.

The performance indicator has not been exceeded because the 7-day average water table levels have not fallen below the reservoir water level.

Analysis against Subsidence Impact Performance Measure

Consistent with the Metropolitan Coal Longwalls 23-27 Water Management Plan, if data analysis indicates the performance indicator has been exceeded or is likely to be exceeded, an assessment will be made against the following subsidence impact performance measure.

Subsidence Impact Performance Measure: *Negligible leakage from the Woronora Reservoir.*

The performance indicator was not exceeded during the reporting period.

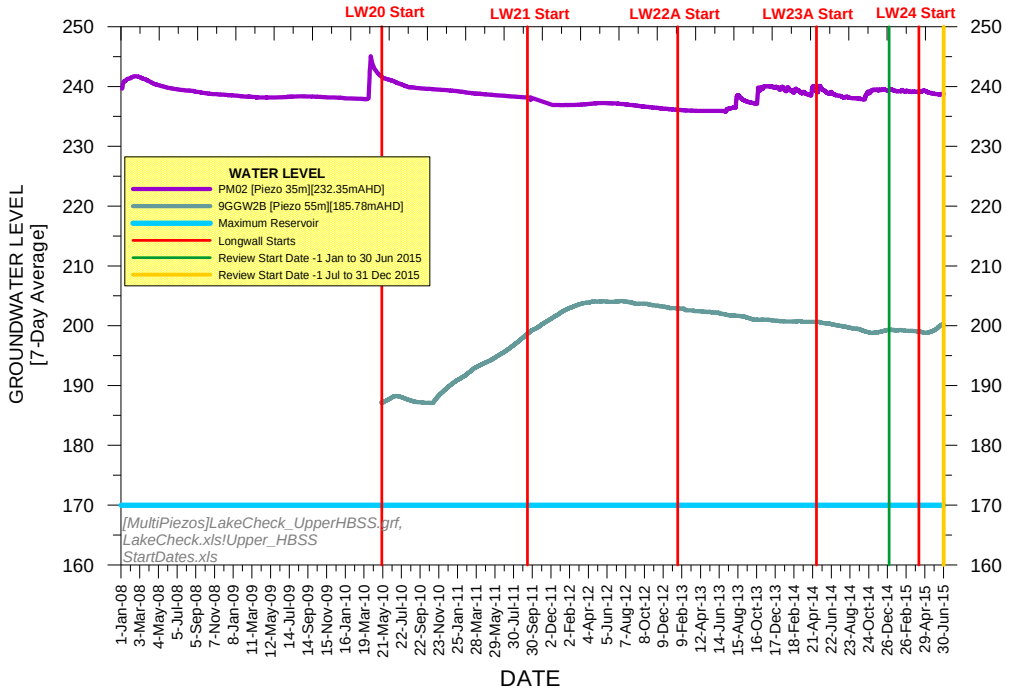


Chart 68 7-day Average Shallow Hawkesbury Sandstone Groundwater Levels at PM02 and 9GGW2B

2.3.2.5 Woronora Reservoir Water Quality

Metropolitan Coal has sourced surface water quality data for the Woronora Reservoir (site DW01) from WaterNSW in accordance with a data exchange agreement. Consistent with the monitoring of water reaching the Woronora Reservoir, the water quality data has been analysed for key water quality parameters of relevance to water supply and the effects of subsidence, namely:

- iron;
- manganese; and
- aluminium.

Data analysis is conducted to assess whether the performance indicator below has been exceeded.

Performance Indicator:

Changes in the quality of water in the Woronora Reservoir are not significantly different post-mining compared to pre-mining concentrations.

During 2014 Metropolitan Coal proposed revisions to the water quality performance indicator assessment methods for Woronora Reservoir water quality in response to the Evans & Peck (2012; 2013) peer review recommendations. Following a detailed review process by the DP&E, the revised assessment methods are used to assess the water quality performance indicator.

The performance indicator is considered to have been exceeded if data analysis indicates a significant change in the quality of water post-mining of Longwall 20. The analysis of water quality data involves:

- Water quality data analysed annually, following the receipt of data from WaterNSW.
- Water quality parameters, measured in the same location on the same day are geometrically averaged.
- The parameter records are interpolated to provide daily records.
- Concentration exceedance duration curves are 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 is analysed in an annual format to determine concentration exceeded with an estimated ARI of 20 years by percentages of days in the year from 0% to 100%. For each percentage of time selected from this range, an annual recurrence interval (ARI) curve is 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 is plotted on a graph.

The performance indicator is considered to have been exceeded if data analysis indicates a significant change in the quality of water post-mining, specifically if 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 20 year ARI curve for any range of the duration percentages above 25%.

As this performance indicator is to be assessed on a 12 monthly basis, it has not been assessed for this Six Monthly Report. The performance indicator will be assessed for 2015 in the next Annual Review and AEMR/Rehabilitation Report and Six Monthly Report.

Analysis against Subsidence Impact Performance Measure

Consistent with the Metropolitan Coal Longwalls 20-22 and 23-27 Water Management Plans, if data analysis indicates the performance indicator has been exceeded or is likely to be exceeded, an assessment is made against the following subsidence impact performance measure.

Subsidence Impact Performance Measure:

Negligible reduction in the water quality of Woronora Reservoir.

The performance indicator is assessed on a 12 monthly basis was not assessed during the current six monthly reporting period. It will be assessed for 2015 during the next reporting period.

2.3.2.6 Waratah Rivulet Downstream of the Maingate of Longwall 23

Table 1 of the Project Approval requires the Project to result in:

> *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).*

Pools P, Q, R, S, T, U, V and W on Waratah Rivulet are situated downstream of maingate 23, and approximately 110 m, 370 m, 290 m, 170 m, 242 m, 298 m, 340 m and 400 m beyond the nearest secondary extraction of Longwalls 23-27, respectively (Figure 5).

Pools P and T on the Waratah Rivulet terminate by flowing through and below their respective rock bars. Pools Q, R and S on the Waratah Rivulet terminate at 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.

The methods used to assess the performance of the Project against the subsidence impact performance measure are described below.

<u>No Diversion of Flows or Change in the Natural Drainage Behaviour of Pools</u>

Pools P, Q, R, S, T, U, V and W (Figure 5) are visually inspected on a weekly basis when mining of Longwalls 23-27 is within 400 m of the pools to observe whether any changes to the natural drainage behaviour of the pools have occurred.

Observations include:

- evidence of new cracking within the stream bed or rock bar (where relevant);
- whether the pools continue to flow over, through and/or below the rock bars (where relevant);
- whether surface flow is evident along the length of Pools P and T prior to flowing through/below the rock bars;
- whether surface flow is evident along the length of Pools Q, R and S prior to flowing over the rock bars;
- whether surface flow is evident along the length of Pool V prior to flowing over/through/below the rock bar; and
- whether surface flow is evident along the length of Pools U and W prior to flowing through the downstream boulder field.

During the reporting period Longwall 24 was within 400 m of Waratah Rivulet in April 2015[14].

The water depth in Pools P, Q, R, S, T, U, V and W on the Waratah Rivulet (Figure 5) and at control pools WRP1, WRP2, WRP3 and WRP4 on the Woronora River are continuously monitored using a water depth sensor and logger.

Assessment against Performance Indicators

Visual inspections of Pools P, Q, R, S, T, U, V and W are conducted on a weekly basis when mining of Longwalls 23-27 is within 400 m of the pool and assessed against the following performance indicator:

> *No change to the natural drainage behaviour of Pools P, Q, R, S, T, U, V and W. Specific indicators include: no new cracking in the stream bed of pools or rock bars (where relevant); continual flow over/through/below the rock bars/terminal boulder fields of pools such that water is ponded upstream; and continual surface water flow along the length of the pools.*

The performance indicator is considered to have been exceeded if the natural drainage behaviour is altered such that either: mining induced cracking is evident in the stream bed or rock bar of Pools P, Q, R, S, T, U, V or W (where relevant); or water ceases to be ponded upstream of the rock bars/terminal boulder fields of Pools P, Q, R, S, T, U, V or W; or surface flow ceases along the length of Pools P, Q, R, S, T, U, V or W. If visual observation indicates a potential impact to the natural drainage behaviour of Pools P, Q, R, S, T, U, V or W, then pools downstream, and the control pools on the Woronora River (i.e. Pools WRP1, WRP2, WRP3 and WRP4) will be inspected and an assessment is made against the subsidence impact performance measure.

The weekly visual observations indicated there was no change to the natural drainage behaviour of the pools.

Water level data for Pools P, T and V is also downloaded monthly and assessed against the following performance indicator:

> *Analysis of water depth data for Pools P, T and V (when mining is within 400 m of the pools) indicates the water depth is at or above the pool's previous minimum (i.e. when mining is beyond 400 m of the pools).*

The performance indicator is considered to have been exceeded if the water depth in Pools P, T, or V (when mining is within 400 m of the pools) has been below the pool's previous minimum (i.e. when mining is beyond 400 m of the pools). If data analysis indicates the water depth in Pools P, T, or V (when mining is within 400 m of the pools) has been below the pool's previous minimum (i.e. when mining is beyond 400 m of the pools), pools downstream on Waratah Rivulet and the control pools on Woronora River will be analysed and an assessment will be made against the performance measure.

The recorded water level hydrographs for Pools P, T and V (shown on Charts C18, C22 and C24 in Appendix C) indicate the pools did not cease flowing and that they exhibited natural behaviour during the reporting period. As a result, the performance indicator has not been exceeded.

[14] Due to catchment closures, inspections were conducted in May 2015.

Water level data for Pools Q, R and S is also downloaded monthly and assessed against the following performance indicator:

> *Analysis of water depth data for Pools Q, R and S on Waratah Rivulet indicates the water depths are above that required to maintain water over the downstream rock bar.*

The performance indicator is considered to have been exceeded if the water depth in Pools Q, R or S has been below that required to maintain water over the downstream rock bar. If data analysis indicates water depths in Pools Q, R or S have been below that required to maintain water over the downstream rock bar, pools downstream on the Waratah Rivulet and the control pools on Woronora River will be analysed and an assessment will be made against the subsidence impact performance measure.

Recorded water level hydrographs for Pools Q, R and S[15] (shown on Charts C19, C20 and C21 in Appendix C) indicate the pools have remained above their cease to flow levels over the reporting period. As a result, the performance indicator has not been exceeded.

Assessment against Performance Measure

The performance measure, *negligible environmental consequences (that is, no diversion of flows, no change in the natural drainage behaviour of pools ….)*, will be considered to have been exceeded if analysis of water depth data indicates that changes in the drainage behaviour are statistically different from:

- pre-mining conditions (i.e. when mining is greater than 400 m from the pools); and
- the behaviour of downstream unaffected pools;

as a result of the Project and the change in drainage behaviour cannot be explained by climatic conditions.

As described above, the various performance indicators for no diversion of flows or change in the natural drainage behaviour of pools were not exceeded during the reporting period.

Minimal Iron Staining

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.

Previous experience on the Waratah Rivulet at Metropolitan Coal indicates that areas of the substratum have been covered by iron flocculent material for several hundred metres downstream of mine subsidence fractures.

Visual and photographic surveys of the Waratah Rivulet downstream of maingate 23 to the Woronora Reservoir full supply level are conducted monthly when mining is within 400 m of the stream and within three months of the completion of each longwall.

[15] As reported in the Metropolitan Coal 2013 Annual Review/AEMR, the Pool S water level appeared to have fallen below its cease to flow level during the period between 2 and 29 October 2013, however the rapid drop in water level at the start of this period and equally rapid rise at the end of this period indicates water level sensor malfunction.

Assessment against Performance Indicator

Consistent with the Metropolitan Coal Longwalls 23-27 Water Management Plan, visual surveys assess whether the following performance indicator has been exceeded:

> *Visual inspection of the Waratah Rivulet between the full supply level of the Woronora Reservoir and Pool P does not show significant changes in the extent or nature of iron staining that isn't also occurring in the Woronora River (control site).*

The performance indicator is considered to have been exceeded if there is significant change in the extent or nature of iron staining in the Waratah Rivulet between maingate 23 and full supply level, and a similar change is not also occurring in the Woronora River (control site).

The visual inspections of the Waratah Rivulet between the full supply level of the Woronora Reservoir and Pool P did not show significant changes in the extent or nature of iron staining.

If visual observations indicate significant changes to the nature or extent of iron staining in the Waratah Rivulet between maingate 23 and full supply level, the downstream reach of the Waratah Rivulet will be inspected and an assessment will be made against the performance measure.

Assessment against Performance Measure

The performance measure, *negligible environmental consequences (that is, … minimal iron staining,...)* will be considered to have been exceeded if analysis of the monitoring results confirms that the Project has resulted in a significant change to the nature or extent of iron staining on the Waratah Rivulet downstream of maingate 23 and cannot be explained by climatic conditions.

The performance indicator for iron staining was not exceeded during the reporting period.

Minimal Gas Releases

During the reporting period visual and photographic surveys of the Waratah Rivulet downstream of maingate 23 to the Woronora Reservoir full supply level were conducted monthly when Longwall 24 was within 400 m of the stream and within three months of the completion of Longwall 23.

Previously identified gas releases in Pool P have also been monitored weekly in accordance with the Metropolitan Coal Longwalls 23-27 Water Management Plan.

Assessment against Revised Performance Indicator

Consistent with the revised Metropolitan Coal Longwalls 23-27 Water Management Plan (Version D), visual surveys have assessed whether the following performance indicators have been exceeded:

> *Visual observations of gas releases in Pool P on the Waratah Rivulet indicate the gas releases have increased beyond those observed up to 17 April 2014.*
>
> *No gas releases observed at Pools Q to W on the Waratah Rivulet.*

Gas releases in Pool P were identified for the first time in February 2014 and continued to the end of the reporting period. The revised performance indicator for Pool P was not exceeded during the reporting period.

No gas releases were observed at Pools Q to W during the reporting period.

2.3.2.7 Eastern Tributary Downstream of Maingate 26

Table 1 of the Project Approval requires the Project to result in:

> *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.*

Pool ETAF on the Eastern Tributary is situated above maingate 26, Pools ETAG and ETAH above Longwall 27, Pools ETAI, ETAJ and ETAK above maingate 27 and Pools ETAL to ETAU are situated downstream of maingate 27 (Figure 5). The stream length of the Eastern Tributary between maingate 26 and the full supply level of the Woronora Reservoir is approximately 950 m. Accordingly, the Project cannot have greater than negligible environmental consequences over more than approximately 285 m of the Eastern Tributary between maingate 26 and the full supply level of the Woronora Reservoir.

The methods used to assess the performance of the Project against the subsidence impact performance measure are described below.

<u>No Diversion of Flows or Change in the Natural Drainage Behaviour of Pools</u>

Pools ETAF to ETAU (Figure 5) are visually inspected on a weekly basis when mining of Longwalls 23-27 is within 400 m of the pools to observe whether any changes to the natural drainage behaviour of the pools have occurred.

Observations include:

- evidence of new cracking within the stream bed or rock bar (where relevant);
- 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.

During the reporting period, the mining of Longwalls 23 and 24 did not advance to within 400 m of Pools ETAF to ETAU.

The water depth in Pools ETAF, ETAG, ETAH, ETAI, ETAQ and ETAU on the Eastern Tributary (Figure 5) and at control pools WRP1, WRP2, WRP3 and WRP4 on the Woronora River are continuously monitored using a water depth sensor and logger.

Assessment against Performance Indicators

Visual inspections of Pools ETAF to ETAU are conducted on a weekly basis when mining is within 400 m of the pools and assessed against the following performance indicator:

> *No change to the natural drainage behaviour of at least 70% of the stream length (from Pools ETAF to ETAU). Specific indicators include: no new cracking in the stream bed of pools or rock bars (where relevant); continual flow over/ through/below the rock bars/terminal boulder fields such that water is ponded upstream (where relevant); and continual surface water flow along the length of the pools.*

The performance indicator is considered to have been exceeded if the natural drainage behaviour is altered over more than 30% of the relevant stream length such that either: mining induced cracking is evident in the stream bed or rock bars of Pools ETAF to ETAU; or water ceases to be ponded upstream of rock bars/terminal boulder fields; or surface flow ceases along the length of pools. If visual observation indicates a potential impact to the natural drainage behaviour of more than 30% of the stream length (from Pools ETAF to ETAU), then pools downstream, and the control pools on the Woronora River (i.e. Pools WRP1, WRP2, WRP3 and WRP4) will be inspected and an assessment will be made against the subsidence impact performance measure.

During the reporting period, mining did not advance to within 400 m of Pools ETAF to ETAU.

Water level data for Pool ETAI is downloaded monthly and assessed against the following performance indicator:

> *Analysis of water depth data for Pool ETAI (when mining is within 400 m of the pool) indicates the water depth is at or above the pool's previous minimum (i.e. when mining is beyond 400 m of the pools).*

If data analysis indicates the water depth in Pool ETAI (when mining is within 400 m of the pool) has been below the pool's previous minimum (i.e. when mining is beyond 400 m of the pool), pools downstream on the Eastern Tributary and the control pools on Woronora River are analysed and an assessment is made against the performance measure.

During the reporting period, the mining of Longwalls 23 and 24 did not advance to within 400 m of Pool ETAI. Notwithstanding, the recorded water level hydrograph for Pool ETAI indicates the pool did not cease flowing and that it exhibited natural behaviour during the reporting period. As a result, the performance indicator has not been exceeded.

Assessment against Performance Measure

The performance measure, *negligible environmental consequences over at least 70% of the stream length (that is, no diversion of flows, no change in the natural drainage behaviour of pools ….)*, will be considered to have been exceeded if analysis of available water depth data and visual inspections indicates that changes in the drainage behaviour are statistically different from:

- pre-mining conditions (i.e. when mining is greater than 400 m from the pools); and
- the behaviour of downstream unaffected pools;

over more than 30% of the relevant stream length as a result of the Project and the change in drainage behaviour cannot be explained by climatic conditions.

As described above, the various performance indicators for no diversion of flows or change in the natural drainage behaviour of pools were not exceeded during the reporting period.

Minimal Iron Staining

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.

Previous experience on the Waratah Rivulet at Metropolitan Coal indicates that areas of the substratum have been covered by iron flocculent material for several hundred metres downstream of mine subsidence fractures.

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

Assessment against Performance Indicator

Consistent with the Metropolitan Coal Longwalls 23-27 Water Management Plan, the visual surveys assess whether the following performance indicator has been exceeded:

> *No significant change to the extent or nature of iron staining over more than 30% of the Eastern Tributary between maingate 26 and the Woronora Reservoir full supply level, that isn't also occurring in the Woronora River (control site).*

The visual inspections of the Eastern Tributary between maingate 26 and the Woronora Reservoir full supply level did not show a significant change in the extent or nature of iron staining over more than 30% of the Eastern Tributary.

If visual observations indicate significant changes to the nature or extent of iron staining in the Eastern Tributary between maingate 26 and full supply level, the downstream reach of the Eastern Tributary will be inspected and an assessment will be made against the performance measure.

Assessment against Performance Measure

The performance measure, *negligible environmental consequences over at least 70% of the stream length (that is, … minimal iron staining,...)* will be considered to have been exceeded if analysis of the monitoring results confirms that the Project has resulted in a significant change to the nature or extent of iron staining on the Eastern Tributary between maingate 26 and the full supply level of the Woronora Reservoir and cannot be explained by climatic conditions.

The performance indicator for iron staining was not exceeded during the reporting period.

Minimal Gas Releases

Visual and photographic surveys of the Eastern Tributary between maingate 26 and the Woronora Reservoir full supply level are conducted monthly when mining is within 400 m of the Eastern Tributary and within three months of the completion of each longwall.

Assessment against Performance Indicator

Consistent with the Metropolitan Coal Longwalls 23-27 Water Management Plan, the visual surveys assess whether the following performance indicator has been exceeded:

> *Gas releases observed over less than 30% of the Eastern Tributary between the full supply level of the Woronora Reservoir and Pool ETAF.*

If the visual surveys indicate the performance indicator has been exceeded, an assessment will be made against the subsidence impact performance measure.

No gas releases were observed on the Eastern Tributary between the full supply level of the Woronora Reservoir and Pool ETAF during the reporting period.

Assessment against Performance Measure

The performance measure, *negligible environmental consequences over at least 70% of the stream length (that is, … minimal gas releases)*, will be assessed by considering if the gas releases observed have resulted in greater than minimal gas releases.

The performance indicator for gas releases was not exceeded during the reporting period.

2.4 TARP CHARACTERISATION

Sections 2.4.1 and 2.4.2 provide the TARP characterisation for the reporting period for water management for Longwalls 20-22 and Longwalls 23-27, respectively.

2.4.1 Longwalls 20-22

The TARP characterisation for Longwalls 20-22 water management is provided in Table 2. In summary, no performance indicators or performance measures were exceeded during the reporting period.

2.4.2 Longwalls 23-27

The TARP characterisation for Longwalls 23-27 water management is provided in Table 3. In summary, no performance indicators or performance measures were exceeded during the reporting period.

Table 2
TARP Characterisation – Longwalls 20-22 Water Management

Monitoring Components	Subsidence Impact Performance Indicator(s)	Subsidence Impact Performance Indicator Exceeded?	Resulting Actions	Subsidence Impact Performance Measure	Subsidence Impact Performance Measure Exceeded?
Surface Water Flow (Section 2.2.1.2)	*Changes in the quantity of water entering Woronora Reservoir is not significantly different post-mining compared to pre-mining, that is not also occurring in the control catchment(s)* (Section 2.3.1.1)	No	Continue monitoring	*Negligible reduction to the quantity of water resources reaching the Woronora Reservoir*	No
Water Quality Reaching Woronora Reservoir (Section 2.2.1.4)	*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* (Section 2.3.1.2)	No	Continue monitoring	*Negligible reduction to the quality of water resources reaching the Woronora Reservoir*	No
Connective Cracking (Sections 2.2.1.8, 2.2.1.10 and 2.2.1.11)	*Visual inspection does not identify abnormal water flow from the goaf, geological structure, or the strata generally* (Section 2.3.1.3)	No	Continue monitoring	*No connective cracking between the surface and the mine*	No
	The 20-day average mine water make does not exceed 2 ML/day (Section 2.3.1.3)	No	Continue monitoring		No
	Significant departures from the predicted envelope of vertical potentiometric head profiles at Bores 9GGW2B and 9FGW1A do not occur (Section 2.3.1.3)	No	Continue monitoring		No
	The water tables measured at Bores 9FGW1A and 9GGW1-80 are higher than the water levels of streams crossed by a transect along Longwall 22 (i.e. a hydraulic gradient exists from each bore to the nearest watercourse) (Section 2.3.1.3)	No	Continue monitoring		No
Leakage from the Woronora Reservoir (Section 2.3.1.4)	*The groundwater head of Bores 9GGW2B and PM02 is higher than the water level of Woronora Reservoir (i.e. a hydraulic gradient exists from the bores to the Woronora Reservoir)* (Section 2.3.1.4)	No	Continue monitoring	*Negligible leakage from the Woronora Reservoir*	No

Table 2 (Continued)
TARP Characterisation – Longwalls 20-22 Water Management

Monitoring Components	Subsidence Impact Performance Indicator(s)	Subsidence Impact Performance Indicator Exceeded?	Resulting Actions	Subsidence Impact Performance Measure	Subsidence Impact Performance Measure Exceeded?
Water Quality of Woronora Reservoir (Section 2.2.1.5)	*Changes in the quality of water in the Woronora Reservoir are not significantly different post-mining compared to pre-mining concentrations* (Section 2.3.1.5)	Annual assessment	Continue monitoring	*Negligible reduction in the water quality of Woronora Reservoir*	No
Waratah Rivulet Environmental Consequences (Sections 2.2.1.1 and 2.2.1.3)	*No change to the natural drainage behaviour of Pool P. Specific indicators include: no new cracking in the stream bed of Pool P or rock bar; continual flow through/below the rock bar of Pool P such that water is ponded upstream; and continual surface water flow along the length of Pool P* (Section 2.3.2.6)	No	Continue monitoring	*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
	Analysis of water depth data for Pool P (when mining is within 400 m of Pool P) indicates the water depth is at or above the pool's previous minimum (i.e. when mining is beyond 400 m of Pool P) (Section 2.3.2.6)	No	Continue monitoring		No
	Analysis of water depth data for Pools Q, R and S on Waratah Rivulet indicates the water depths are above that required to maintain water over the downstream rock bar (Section 2.3.2.6)	No	Continue monitoring	*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
	Iron staining to be addressed in the Longwalls 23-27 Water Management Plan (Section 2.3.2)	Not applicable to Longwalls 20-22	Not applicable to Longwalls 20-22		Not applicable to Longwalls 20-22
	Visual observations of gas releases in Pool P on the Waratah Rivulet indicate the gas releases have increased beyond those observed up to 17 April 2014 (Section 2.3.2.6)	No	Continue monitoring		No

Table 3
TARP Characterisation – Longwalls 23-27 Water Management

Monitoring Components	Subsidence Impact Performance Indicator(s)	Subsidence Impact Performance Indicator Exceeded?	Resulting Actions	Subsidence Impact Performance Measure	Subsidence Impact Performance Measure Exceeded?
Surface Water Flow (Section 2.2.2.2)	*Changes in the quantity of water entering Woronora Reservoir is not significantly different post-mining compared to pre-mining, that is not also occurring in the control catchment(s)* (Section 2.3.2.1)	No	Continue monitoring	*Negligible reduction to the quantity of water resources reaching the Woronora Reservoir*	No
Water Quality Reaching Woronora Reservoir (Section 2.2.2.4)	*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* (Section 2.3.2.2)	No	Continue monitoring	*Negligible reduction to the quality of water resources reaching the Woronora Reservoir*	No
Connective Cracking (Sections 2.2.2.8, 2.2.2.10 and 2.2.2.11)	*Visual inspection does not identify abnormal water flow from the goaf, geological structure, or the strata generally* (Section 2.3.2.3)	No	Continue monitoring	*No connective cracking between the surface and the mine*	No
	The 20-day average mine water make does not exceed 2 ML/day (Section 2.3.2.3)	No	Continue monitoring		No
	Significant departure from the predicted envelope of vertical potentiometric head profile at Bore 9GGW2B does not occur (Section 2.3.2.3)	No	Continue monitoring		No
	The water tables measured at Bores 9FGW1A and 9GGW1-80 are higher than the water levels of streams crossed by a transect along Longwall 22 (i.e. a hydraulic gradient exists from each bore to the nearest watercourse) (Section 2.3.2.3)	No	Continue monitoring		No
Leakage from the Woronora Reservoir (Section 2.3.2.4)	*The groundwater head of Bores 9GGW2B and PM02 is higher than the water level of Woronora Reservoir (i.e. a hydraulic gradient exists from the bores to the Woronora Reservoir)* (Section 2.3.2.4)	No	Continue monitoring	*Negligible leakage from the Woronora Reservoir*	No

Table 3 (Continued)
TARP Characterisation – Longwalls 23-27 Water Management

Monitoring Components	Subsidence Impact Performance Indicator(s)	Subsidence Impact Performance Indicator Exceeded?	Resulting Actions	Subsidence Impact Performance Measure	Subsidence Impact Performance Measure Exceeded?
Water Quality of Woronora Reservoir (Section 2.2.2.5)	*Changes in the quality of water in the Woronora Reservoir are not significantly different post-mining compared to pre-mining concentrations* (Section 2.3.2.5)	Annual assessment	Continue monitoring	*Negligible reduction in the water quality of Woronora Reservoir*	No
Waratah Rivulet Environmental Consequences (Sections 2.2.2.1 and 2.2.2.3)	*No change to the natural drainage behaviour of Pools P, Q, R, S, T, U, V and W. Specific indicators include: no new cracking in the stream bed of pools or rock bars (where relevant); continual flow over/ through/below the rock bars/terminal boulder fields of pools such that water is ponded upstream; and continual surface water flow along the length of the pools (Section 2.3.2.6)*	No	Continue monitoring	*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
	Analysis of water depth data for Pools P, T and V (when mining is within 400 m of the pools) indicates the water depth is at or above the pool's previous minimum (i.e. when mining is beyond 400 m of the pools) (Section 2.3.2.6)	No	Continue monitoring		No
	Analysis of water depth data for Pools Q, R and S on Waratah Rivulet indicates the water depths are above that required to maintain water over the downstream rock bar (Section 2.3.2.6)	No	Continue monitoring		No
	Visual inspection of the Waratah Rivulet between the full supply level of the Woronora Reservoir and Pool P does not show significant changes in the extent or nature of iron staining that isn't also occurring in the Woronora River (control site) (Section 2.3.2.6)	*No*	Continue monitoring		No
	Visual observations of gas releases in Pool P on the Waratah Rivulet indicate the gas releases have increased beyond those observed up to 17 April 2014 (Section 2.3.2.6)	No	Continue monitoring		No
	No gas releases observed at Pools Q to W on the Waratah Rivulet (Section 2.3.2.6)	No	Continue monitoring		No

Table 3 (Continued)
TARP Characterisation – Longwalls 23-27 Water Management

Monitoring Components	Subsidence Impact Performance Indicator(s)	Subsidence Impact Performance Indicator Exceeded?	Resulting Actions	Subsidence Impact Performance Measure	Subsidence Impact Performance Measure Exceeded?
Eastern Tributary Environmental Consequences (Sections 2.2.2.1 and 2.2.2.3)	*No change to the natural drainage behaviour of at least 70% of the stream reach (from Pools ETAF to ETAU). Specific indicators include: no new cracking in the stream bed of pools or rock bars (where relevant); continual flow over/through/below the rock bar of pools/terminal boulder fields such that water is ponded upstream; and continual surface water flow along the length of pools* (Section 2.3.2.7)	No	Continue monitoring	*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*	No
	Analysis of water depth data for Pool ETAI on the Eastern Tributary (when mining is within 400 m of the pool) indicates the water depth is at or above the pool's previous minimum (i.e. when mining is beyond 400 m of the pool) (Section 2.3.2.7)	No	Continue monitoring		No
	No significant change to the extent or nature of iron staining over more than 30% of the Eastern Tributary between maingate 26 and full supply level (Section 2.3.2.7)	No	Continue monitoring		No
	Gas releases observed over less than 30% of the Eastern Tributary between maingate 26 and full supply level, that is not also occurring in the Woronora River (control site) (Section 2.3.2.7)	No	Continue monitoring		No

3 BIODIVERSITY MANAGEMENT

3.1 BACKGROUND

The Metropolitan Coal Longwalls 20-22 Biodiversity Management Plan and Metropolitan Coal Longwalls 23-27 Biodiversity Management Plan have been prepared to manage the potential environmental consequences of the Metropolitan Coal Longwalls 20-22 Extraction Plan and Metropolitan Coal Longwalls 23-27 Extraction Plan on aquatic and terrestrial flora and fauna, with a specific focus on swamps, in accordance with Condition 6, Schedule 3 of the Project Approval.

3.2 MONITORING

3.2.1 Longwalls 20-22

3.2.1.1 Upland Swamp Vegetation Monitoring

As described in the Longwalls 20-22 Biodiversity Management Plan, several types of upland swamps have been defined in the Metropolitan Coal area and surrounds according to the geomorphological settings in which they occur, as follows:

1. Headwater swamps. These are the largest swamp type. They occupy broad, shallow, trough-shaped valleys, usually on first order watercourses at the head of valleys on broad plateaux. They sit on a relatively impermeable, low gradient sandstone base with dispersed seepage flows that encourage the growth of hydrophilic vegetation that in turn traps sediment, thereby increasing the water holding capacity. These swamps usually terminate at points where the watercourse suddenly steepens or drops away at a 'terminal step'. Terminal steps often occur at constrictions in the landscape where two ridges converge, causing a narrowing of the swamp and a concentration of water flows into a central channel.
2. Valley side swamps. Valley side swamps occur on steeper terrain than headwater swamps and are sustained by small horizontal aquifers that seep from the sandstone strata and flow over unbroken outcropping rock masses. These 'swamps' have shallow soils because the gradient usually limits sediment accumulation. They tend to terminate either on a horizontal step in the bedrock, or where broken rock, scree or deeper soil occurs at the base of the outcropping rock. Swamps 16, 17, 18, 23, 24, 25 and 26 situated above Longwalls 20-22 represent valley side swamps.
3. In-valley swamps. In-valley swamps are uncommon and occur on relatively flat sections of more deeply incised second and third order watercourses. Some of these swamps are thought to develop behind obstructions in the watercourse, such as fallen rocks or log jams that result in a slowing of the water flow and deposition of sediments. Flat Rock Swamp is considered to represent a 'classic' in-valley swamp. However, others, including Swamp 20 over Longwalls 20-22 (situated in a gently inclined valley over solid bedrock), appear to develop behind a terminal step, often at a geological constriction in a valley, in much the same way as for headwater swamps. Because of their relatively large catchment areas these swamps tend to be wetter than many headwater and valley side swamps.

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

Eight upland swamps, *viz*. Swamps 16, 17, 18, 20, 23, 24, 25 and 26 have been mapped above or immediately adjacent to Longwalls 20-22 (Figure 10). A swamp substrate characterisation study has also been conducted to contribute to Metropolitan Coal's understanding of the ecological, hydrological and geomorphic processes of swamps over Longwalls 20-22.

With the exception of in-valley Swamp 20, which supports Tea Tree Thicket, all swamps over Longwalls 20-22 are small valley side swamps and comprise Restioid Heath, with intergrades with Banksia Thicket. Transitions between Restioid Heath and Banksia Thicket are thought to be driven by fire frequency.

Three swamps (Swamps 16, 17 and 23), although showing seepage, are more akin to sandstone heath woodland with low tree densities. The vegetation contains species found in upland swamps, mixed with a range of non-swamp species.

Swamps 101, 111a and 125 were selected as control sites for the Restioid Heath/Banksia Thicket valley side swamps (Figure 10) and Swamps Woronora River 1, Woronora River South Arm and Dahlia Swamp were selected as control sites for the Tea Tree Thicket vegetation of Swamp 20 (Figure 11).

The upland swamp vegetation monitoring program includes visual monitoring, transect/quadrat monitoring and monitoring of indicator species, as described below.

Visual Inspections

Visual inspections have been conducted monthly for the period of time that Longwalls 20, 21 or 22 have been within 400 m of a swamp to record evidence of potential subsidence impacts. Longwall 22 was completed in April 2014. Visual inspections of the swamps overlying and immediately adjacent to Longwalls 20-22 and at the control swamps are also conducted at the same time as the vegetation surveys.

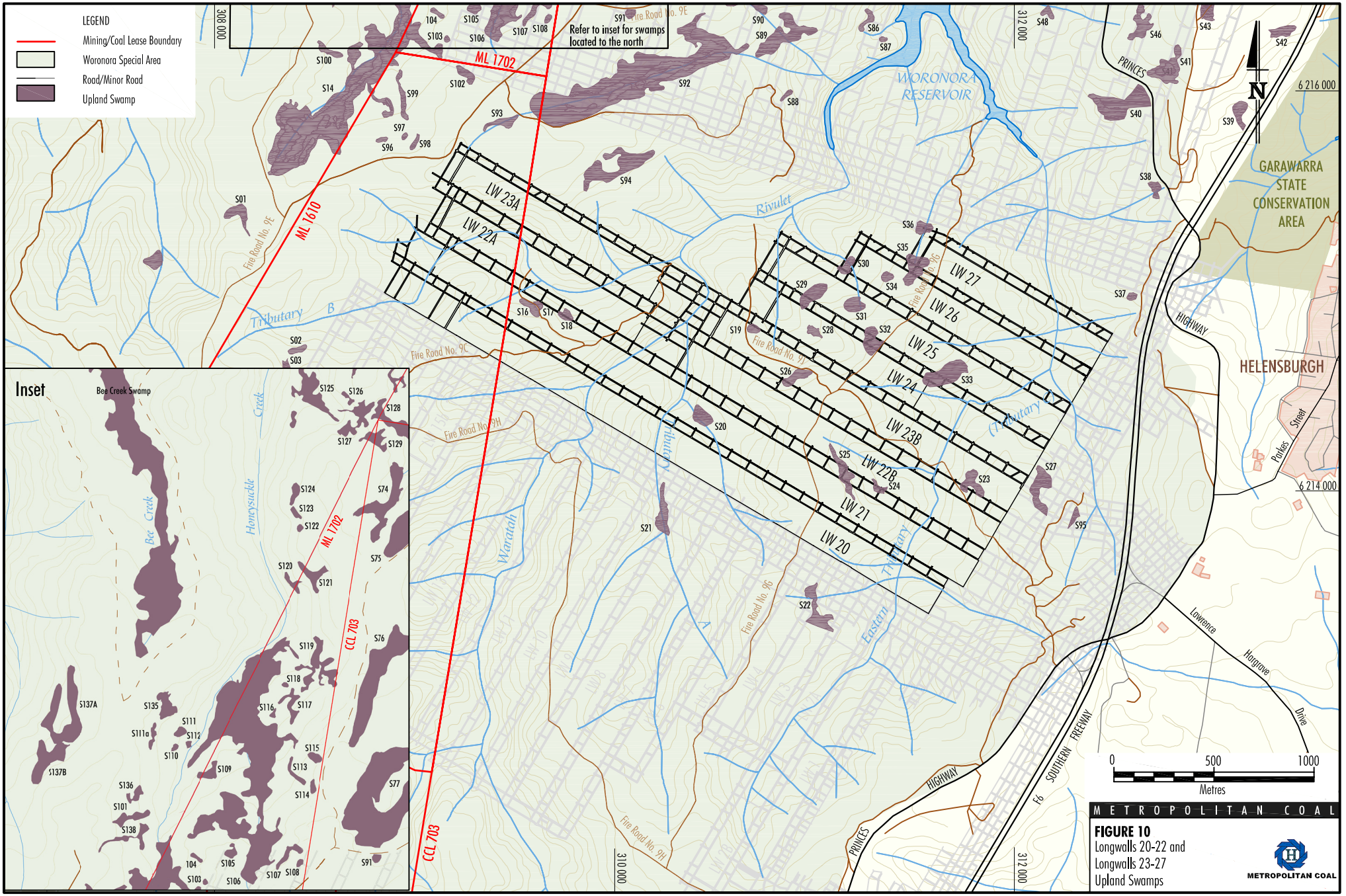
Traverses covering the majority of the extent of the swamp are conducted to record:

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

Photographs of any cracking, erosion, water colour changes and vegetation senescence are taken concurrently with a description of the magnitude and extent of the observations, and appropriate GPS readings. Seepage is documented by photographs of flow over exposed surfaces.

The Metropolitan Coal 2014 Annual Review and AEMR/Rehabilitation Report reported on the visual inspections conducted by Eco Logical Australia for the spring 2013 and autumn 2014 vegetation surveys. A summary of the visual observations conducted in spring 2014 by Eco Logical Australia is provided below.

- No cracking of exposed bedrock areas or swamp sediments was observed in either longwall or control swamps, other than what has been detected during baseline surveys in Swamps 17, 26 and the rock displacement in Swamp 24.

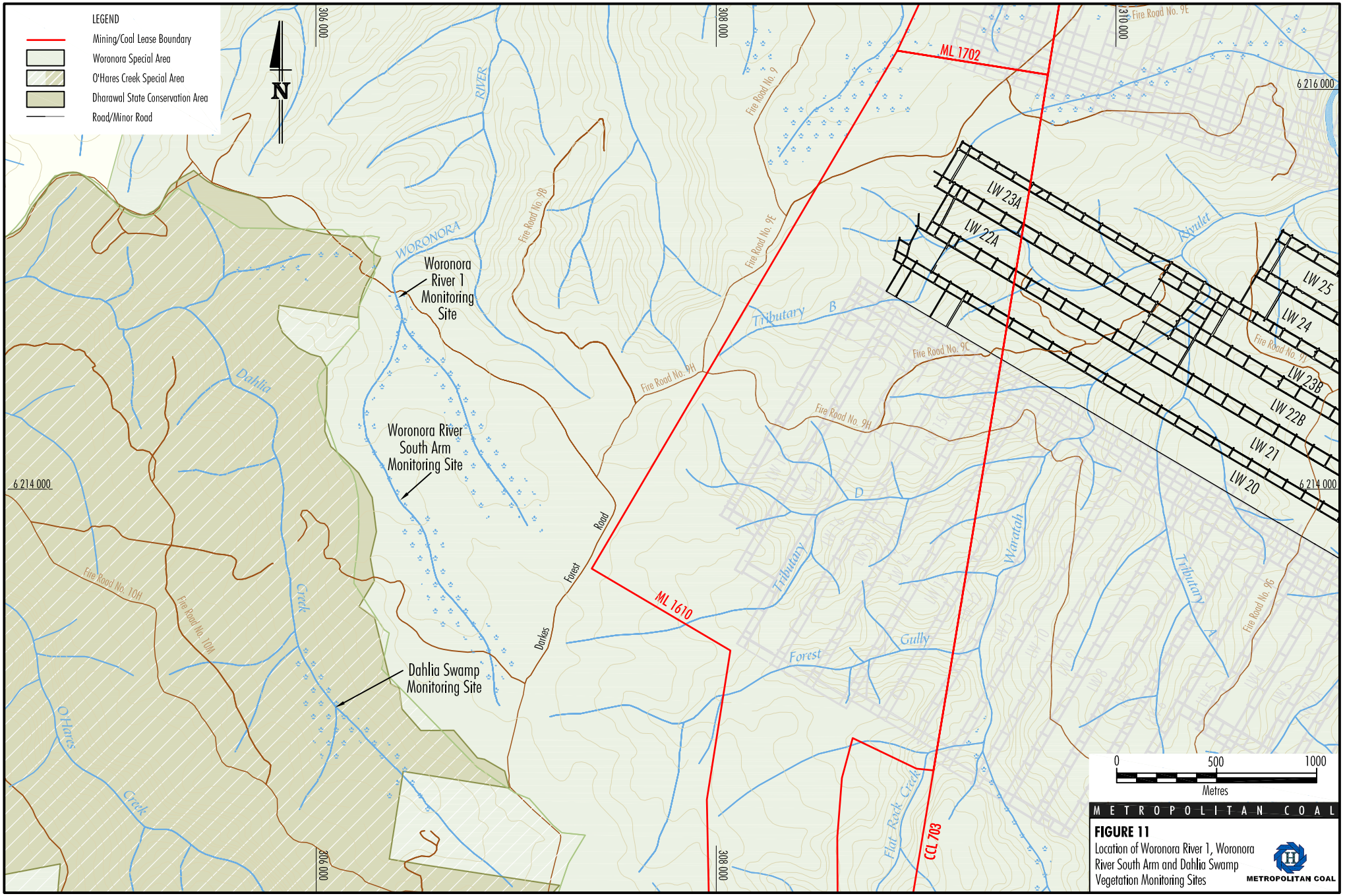


METROPOLITAN COAL

FIGURE 10
Longwalls 20-22 and Longwalls 23-27 Upland Swamps

METROPOLITAN COAL

MET-08-AD7-2015_6MR_108C



METROPOLITAN COAL

FIGURE 11

Location of Woronora River 1, Woronora River South Arm and Dahlia Swamp Vegetation Monitoring Sites

METROPOLITAN COAL

MET-08-AD7-2015_6MR_109C

- Areas in which active erosion were observed were all minor and limited to access tracks (Swamps 16, 17, 18, 20, 26, 101 and Woronora River South Arm), areas of bare earth without vegetation cover (Swamp 101) and the drainage line through Swamp 24. With the exception of minor erosion along access tracks within Swamp 20, all other observations of erosion were located within areas in which erosion had previously been observed.
- For the valley side swamps, vegetation of both longwall and control swamps was found generally to be in good condition. Exceptions include the following observations:
  - Dieback and/or senescence of scattered and isolated *Petrophile pulchella* individuals across all valley side swamps, as observed in previous seasons. Individuals of this species observed with dieback were interspersed with healthy individuals of this species. While the cause of this dieback is unknown, its occurrence within longwall and control swamps, and areas well beyond the current survey area, indicates the dieback is attributable to environmental conditions (previous waterlogging, hot, dry conditions) and not related to mining.
  - With the exception of Swamps 101 and 111a, minor yellowing of the foliage and/or dieback of *Banksia ericifolia* subsp. *ericifolia* was observed within control and longwall valley side swamps (longwall Swamps 16, 17, 18, 23, 25 and 26, and control Swamp 125), similar to that observed in previous seasons.
  - Sites containing small patches of vegetation senescence (*Petrophile pulchella* in Swamps 17, 18, 23, *Banksia ericifolia* var. *ericifolia* and *Banksia oblongifolia* in Swamp 25) recorded in earlier surveys were re-inspected during spring 2014. No further senescence was found in these areas, and in some instances, the adjacent vegetation continues to opportunistically encroach into these areas.
- For the Tea Tree Thicket swamps, vegetation of both longwall and control swamps was found to be good to variable in condition, as follows:
  - *Banksia robur* and *Gleichenia microphylla* were observed with dieback within all Tea Tree Thicket swamps (including longwall and control swamps) related to herbivory and dead fronds, respectively. For *Banksia robur* the range of dieback within the single longwall swamp, Swamp 20, was the same as the range observed within control swamps with dieback ranging from some dead branches (Condition 3) to healthy (Condition 5). For *Gleichenia microphylla* dieback within Swamp 20 ranged from severe (Condition 1) to healthy (Condition 5) while within control swamps the condition of this species ranged from some dead branches (Condition 3) to healthy (Condition 5).
  - A number of other species within Swamp 20 were also observed with dieback during visual inspections including *Acacia longifolia* subsp. *longifolia, Bauera rubioides, Gleichenia dicarpa, Leptospermum juniperinum* and *Empodisma minus.* Within floristic quadrats individuals of these species were observed in mixed condition from healthy (Condition 5) to having dieback ranging from severe (Condition 1) to minor (Condition 4). Corresponding species occurring in control swamps include, *Bauera rubioides, Empodisma minus* and *Leptospermum juniperinum* where *Bauera rubioides* was recorded in a healthy condition (Condition 5), whilst dieback was less for individuals of *Empodisma minus* (some dead branches, Condition 3) and *Leptospermum juniperinum* (minor dieback, Condition 4).
  - The canopy of *Acacia longifolia* subsp. *longifolia* in Swamp 20 continues to be recorded in mixed condition across the swamp, with bare branches and fallen individuals commonly observed. These observations were recorded during both the baseline monitoring period and the mining period. As previously reported, *Acacia longifolia* subsp. *longifolia* is more abundant in Swamp 20 than in control site Woronora River 1, and has not been recorded in Woronora River South Arm or Dahlia Swamp.

  - Within control swamps yellowing/discolouration of the foliage of the sedges was observed including *Lepidosperma limicola, Chorizandra cymbaria* and *Lepidosperma forsythii*. These species were not recorded within Swamp 20.

- The spring 2014 surveys were conducted following a lengthy dry period from April to September 2014 with well below average rainfall in all months during this period except in August when slightly above average rainfall was recorded. Rainfall during the survey months were close to average in October and well below average in November.
  - For the valley side swamps, seepage within longwall and control swamps was generally absent (Swamps 16, 17, 23) or minor (Swamps 18, 24, 25, 26, 101 and 111a) with only the control Swamp 125 recording abundant seepage.
  - For the Tea Tree Thicket sites, the amount of seepage and water held within the soil was generally similar between longwall Swamp 20 and the control sites. Within Swamp 20 standing water was observed along one transect with moderate seepage and standing water observed across rocky areas. Similarly, limited occurrences of standing water were observed within control swamps Woronora River 1 and Woronora River South Arm, while standing water was absent from Dahlia Swamp.
- Across all upland swamps, no changes in water colour or new areas of water ponding were observed in either longwall or control swamps, with the exception of longwall Swamp 20. In Swamp 20 iron-stained groundwater seeps, observed since spring 2012, remain present on the terminal rocky step, and the small rocky step (adjacent to end of Transect 1) within this swamp.

Transect/Quadrat Monitoring

Transect and quadrat monitoring is conducted of:

- Restioid Heath vegetation – in Swamps 16, 17, 18, 24 and 25 overlying Longwalls 20-22, and in control Swamps 101, 111a and 125 (Figure 10); and
- Tea Tree Thicket vegetation – in Swamp 20 overlying Longwalls 20-22, and in control swamps Woronora River 1, Woronora River South Arm and Dahlia Swamp (Figures 10 and 11).

Longwall Swamps 16 and 17 (Restioid Heath/Sandstone Heath Woodland) were added to the vegetation monitoring program in autumn 2010 (Figure 10).

Each swamp has been monitored with three transects, with the exception of Tea Tree Thicket control swamps Woronora River 1, Woronora River South Arm and Dahlia Swamp, where only a single transect has been established owing to the much larger size of the control swamps.

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

The data collected for each quadrat includes:

- vegetation structure;
- dominant species;
- estimated cover and height for each stratum;
- full floristics;

- estimated cover/abundance for each species using seven point Braun-Blanquet scale; and
- condition/health rating for each species in the quadrat[16].

Permanent photo points have been established along each transect.

The Metropolitan Coal 2014 Annual Review and AEMR/Rehabilitation Report reported on the results of the transect and quadrat monitoring conducted by Eco Logical Australia for the spring 2013 and autumn 2014 vegetation surveys. The results of the transect/quadrat monitoring surveys for spring 2014 are provided in the following sections.

Vegetation Structure, Dominant Species and Estimated Cover/Abundance for Each Stratum

The vegetation structure, dominant species and estimated cover/abundance for each stratum has been variable across all seasons with variations recorded between sites, seasons and strata. This variability is considered to reflect both the natural variations in the height and cover/abundance of vegetation structural layers through time, as well as the subjective nature of the data collection. Within the variability of this dataset, a general trend towards increasing height and cover/abundance of vegetation structural layers has occurred from spring 2009 to spring 2014 across all longwall and control sites.

In spring 2014 the height and cover/abundance and of the structural layers was generally similar to that observed in autumn 2014 with minor decreases and increases occurring in some sites and no changes in the vegetation height and density of structural layers at other sites. Although variable, the height and cover/abundance of each stratum continue to steadily increase as plants grow, although the rate of increase is relatively slow and not always detectable from one season to the next when values are similar and subject to surveyor bias.

No notable changes in vegetation structure, dominant species or estimated cover/abundance which could be attributed to impacts associated with the mining of Longwalls 20-22 were recorded within longwall or control swamps in spring 2014.

Species Richness

As previously reported, the drier valley side swamps supporting Restioid-Heath vegetation are more floristically diverse than the wetter Tea Tree Thicket swamps. The difference in floristic diversity is consistent with previous studies within upland swamps vegetation (Keith & Myerscough 1993), where swamps with less fertile soils and increased light penetration to the ground layer (drier valley side sites) were more floristically diverse than the wetter, more densely vegetated in-valley Tea Tree Thicket sites.

In general, species richness within valley side swamps in spring 2014 was within the range of previous seasons (Chart 69), with the majority of sites remaining unchanged or increasing in species richness compared to autumn 2014. At longwall sites a small decrease in species richness was observed at one site (Swamp 16), two sites remained unchanged (Swamps 24 and 25), and two sites (Swamps 17 and 18) increased from autumn 2014. At control sites a large increase in species richness was recorded at one site (Swamp 125), whilst two sites (Swamps 101 and 111a) remained unchanged.

[16] Condition Rating: Healthy – 5; Minor dieback – 4; Some dead branches – 3; Many dead stems – 2; Severe damage/ dieback – 1.

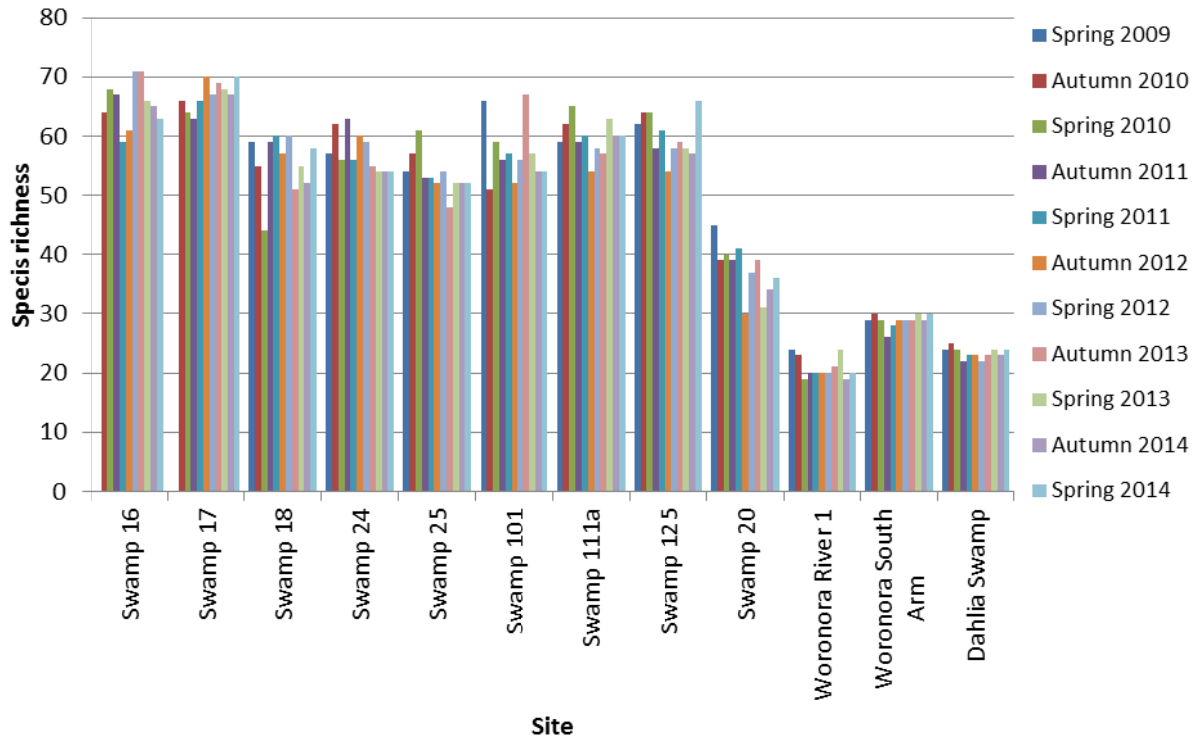


Chart 69 Species Richness in Upland Swamp Sites, Spring 2009 – Spring 2014

In general, species richness within Tea Tree Thicket sites has been relatively consistent at control sites across all seasons, with small decreases and increases observed from season to season. At the single longwall swamp, Swamp 20, decreases in species richness have been recorded in autumn 2012 and spring 2013 (some 11 and 8 species since the prior survey, respectively), similar to that observed for valley side control Swamp 101 (decreases of five and ten species in autumn 2012 and spring 2013 since the prior survey, respectively). In autumn 2014 species richness increased, with a further increase in spring 2014, however, the number of species recorded in spring 2014 is still below that recorded for the period spring 2009 to spring 2011.

The decline in species richness from spring 2011 to autumn 2012 included both generalist species (including *Aotus ericoides, Cassytha glabella, Leptospermum trinervium, Lomandra longifolia*) and swamp species (including *Drosera binata, Drosera peltata, Selaginella uliginosa, Utricularia sp.*), although was limited to species which are rare to uncommon within Swamp 20.

Cover/Abundance and Condition for Each Species

Fluctuations in species cover/abundance were recorded across all sites in spring 2014. No patterns of increasing or decreasing cover/abundance were identified in relation to individual species across sites or groups of species (i.e. swamp indicator species, generalist species, shrubs, ground covers) within sites.

Fluctuations in vegetation condition were also recorded across all sites. Generally, vegetation within valley side swamps was in a healthy condition throughout the survey period and observations of dieback were limited to isolated individuals within swamps.

A number of species were observed with dieback ranging from minor (Condition 4) to severe (Condition 1) with the following species most commonly observed with some dieback: *Banksia oblongifolia; Symphionema paludosum; Platysace linearifolia; Chordifex fastigiatus; Empodisma minus; Angophora hispida; Dillwynia floribunda; Hakea dactyloides; Petrophile pulchella; Leptocarpus tenax; Lepidosperma filiforme; Lomandra obliqua,; Cassytha glabella; Lepyrodia scariosa; Tetrarrhena turfosa;* and *Xanthorrhoea resinosa*. These species were occasionally observed with dieback at both longwall and control sites, in previous seasons, including the baseline survey periods.

The majority of species which were observed with dieback within longwall swamps in spring 2014, were also observed with dieback within control swamps (where the species occurred in both longwall and control swamps). For those species observed with dieback in longwall swamps and not observed with dieback within control swamps (including *Hibbertia serpyllifolia, Pultenaea aristata, Dampiera stricta, Leptospermum squarrosum, Darwinia diminuta, Isopogon anethifolius, Hakea gibbosa, Hakea dactyloides, Baloskion gracile, Stylidium lineare* and *Xyris operculata*), the observed dieback within longwall swamps was generally limited to minor dieback (Condition 4) of a small number of individuals. No species were commonly observed with dieback within longwall swamps whilst remaining in a healthy condition within control swamps.

For the Tea Tree Thickets, vegetation was observed to be in variable condition. A number of species within Swamp 20 were recorded with a condition score of less than 5, or with a variable condition score. Several species had minor dieback (Condition 4) including *Bauera rubioides*, *Gahnia sieberiana, Leptospermum grandiflorum, Banksia ericifolia* subsp. *ericifolia*, *Symphionema paludosum, Lepyrodia scariosa* and *Xanthorrhoea resinosa*. Of these species only *Symphionema paludosum* also occurred within a control site (Woronora River South Arm), where it was recorded with severe dieback (Condition 1). Species within Swamp 20 with variable condition scores, including the lower condition classes of Condition 1 (severe dieback) to Condition 3 (some dead branches), included *Banksia robur*, *Gleichenia dicarpa, Gleichenia microphylla, Acacia longifolia* subsp. *longifolia, Melaleuca squarrosa* and *Empodisma minus*. Of these species, *Banksia robur, Empodisma minus* and *Gleichenia microphylla* also occur within the control swamps. A similar range of dieback was recorded within longwall and control swamps for the first two species, however for *Gleichenia microphylla* the condition score within Swamp 20 ranged from 1-5, whilst at control sites it ranged from 3-5. A number of species within control swamps were recorded with a condition score of less than 5, or with a variable condition score. However, only two species, *Baumea* sp. and *Symphionema paludosum* were recorded with lower condition scores at control sites compared with longwall sites.

Indicator Species Monitoring

Twenty tagged individuals of *Epacris obtusifolia*, *Sprengelia incarnata* and *Pultenaea aristata* have been monitored in each of the following valley side swamps, commencing spring 2009:

- *Epacris obtusifolia* – longwall Swamps 18, 24 and 25 and control Swamps 101, 111a and 125.
- *Sprengelia incarnata* – longwall Swamp 24 and control Swamps 101 and 125.
- *Pultenaea aristata* – longwall Swamps 18, 24 and 25 and control Swamps 101 and 111a. Note, survey of *Pultenaea aristata* in Swamp 24 commenced in autumn 2010.

Twenty tagged individuals of *Banksia robur, Callistemon citrinus* and *Leptospermum juniperinum* have also been monitored in longwall Swamp 20 and at the associated control sites (Woronora River 1, Woronora River South Arm and Dahlia Swamp).

Population monitoring data collected includes a condition/health rating and a reproductive rating for each plant. The following provides a summary of the results of population monitoring for spring 2014.

In spring 2014 the mean vegetation condition of tagged indicator species was similar between longwall and control sites, for all species within valley side swamps, as indicated by overlapping confidence intervals (Charts 70 to 72). The mean vegetation condition for tagged indicator species within Tea Tree Thicket swamps in spring 2014 was greater at the single longwall swamp (Swamp 20) than in control swamps, for all indicator species (Charts 73 to 75). Across all sites the mean vegetation condition for tagged indicator species has decreased from spring 2009 to spring 2014, although the size of the decrease varies between species. The decreases in mean vegetation condition were observed at both longwall and control sites.

The mean reproductive status of tagged indicator species in spring 2014 was similar between longwall and control sites for *Sprengelia incarnata, Banksia robur* and *Leptospermum juniperinum* (as indicated by overlapping confidence intervals), while mean reproductive status was higher at control sites than longwall sites for *Epacris obtusifolia, Pultenaea aristata* and *Callistemon citrinus* (Charts 68 to 73). The observed differences in mean reproductive status for *Epacris obtusifolia, Pultenaea aristata* and *Callistemon citrinus* are similar to observations for these species in previous seasons, including baseline monitoring seasons, where the mean reproductive status were different between longwall and control sites. The observed differences in mean reproductive status between control and longwall sites for these species do not coincide with any observed differences in their mean vegetation condition. As such the observed differences in mean reproductive status for *Epacris obtusifolia, Pultenaea aristata* and *Callistemon citrinus* are not thought to be related to the mining of Longwalls 20-22.

Consistent with previous surveys, mean reproductive status was generally low across all species in spring 2014, which is attributed to survey times not coinciding with peak flowering periods of the indicator species[17].

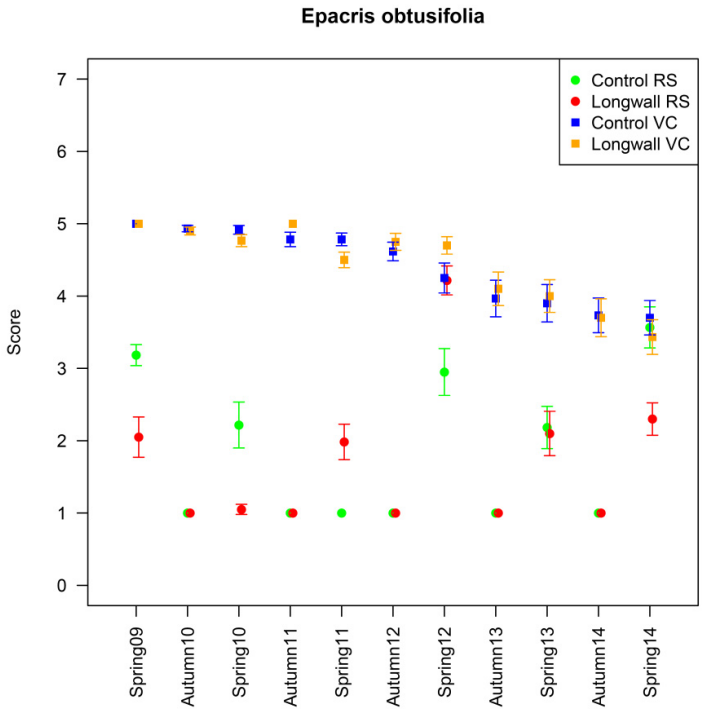


Chart 70 Mean Scores for Vegetation Condition (VC) and Mean Reproductive Status (RS) for the Indicator Species, *Epacris obtusifolia*

[17] Surveys are conducted during the months of autumn and spring as specified in the Longwalls 20-22 Biodiversity Management Plan. The peak flowering times for each of the indicator species do not necessarily coincide with the survey periods, although some flowering does occur during this time.

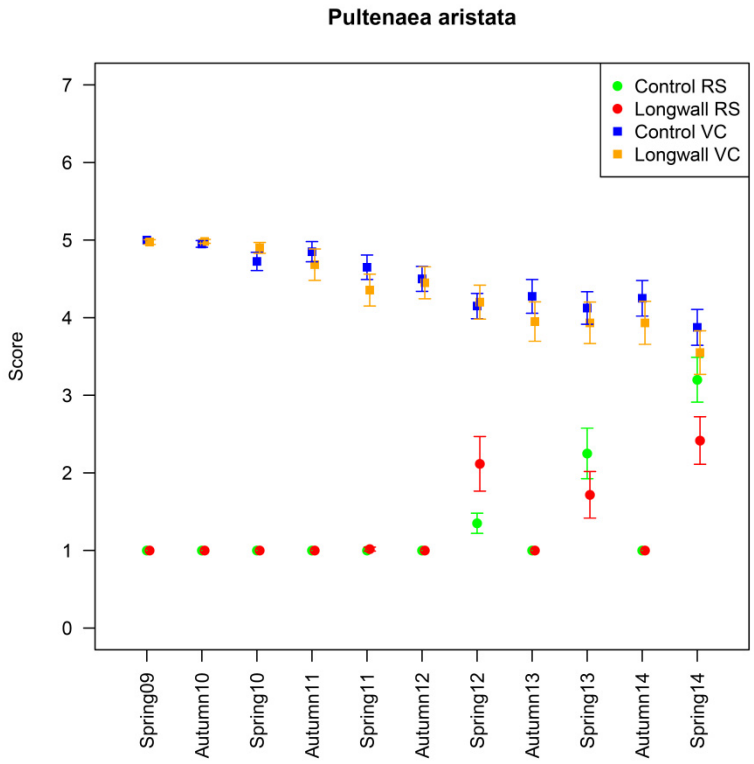


Chart 71 **Mean Scores for Vegetation Condition (VC) and Mean Reproductive Status (RS) for the Indicator Species, *Pultenaea aristata***

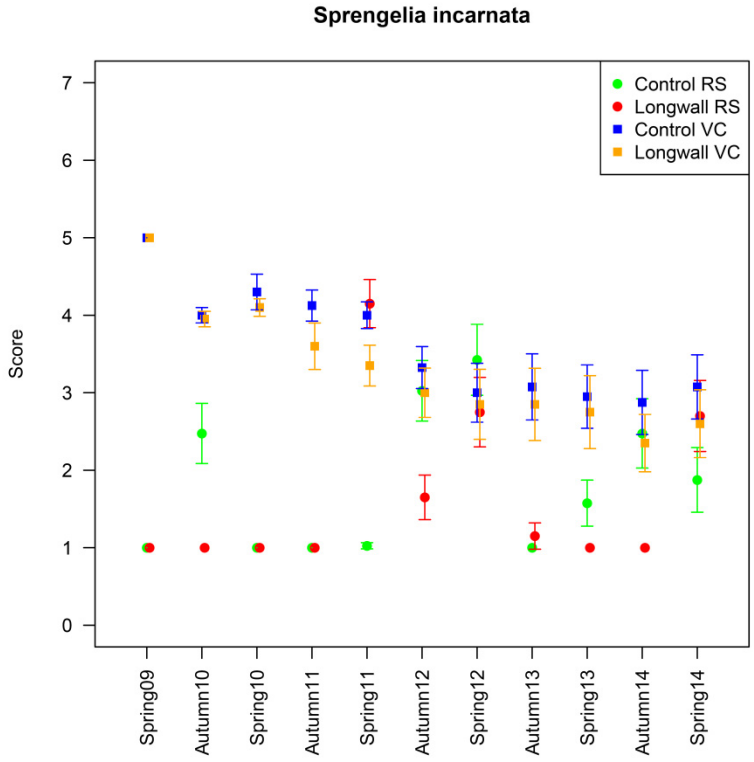


Chart 72 **Mean Scores for Vegetation Condition (VC) and Mean Reproductive Status (RS) for the Indicator Species, *Sprengelia incarnata***

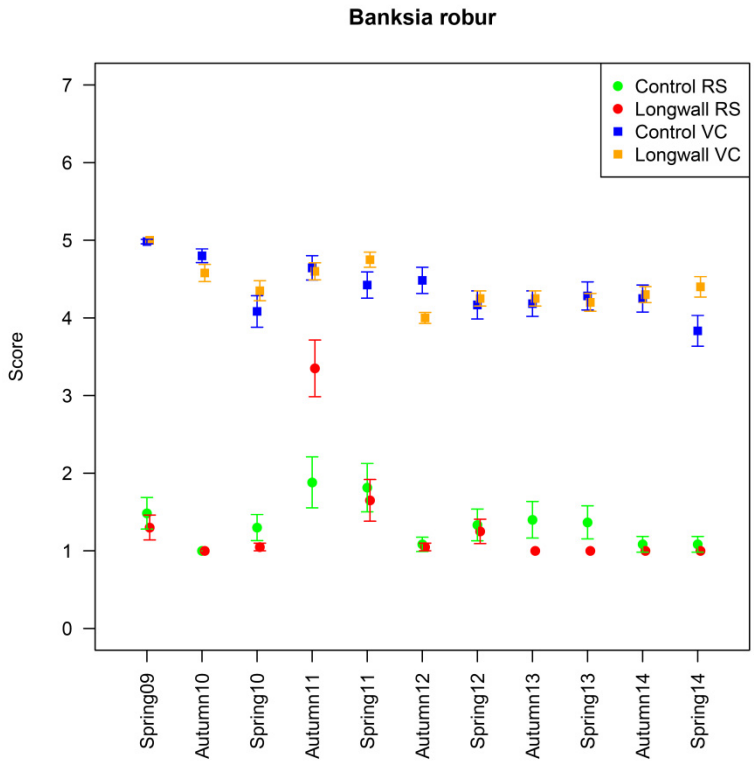


Chart 73 **Mean Scores for Vegetation Condition (VC) and Mean Reproductive Status (RS) for the Indicator Species, *Banksia robur***

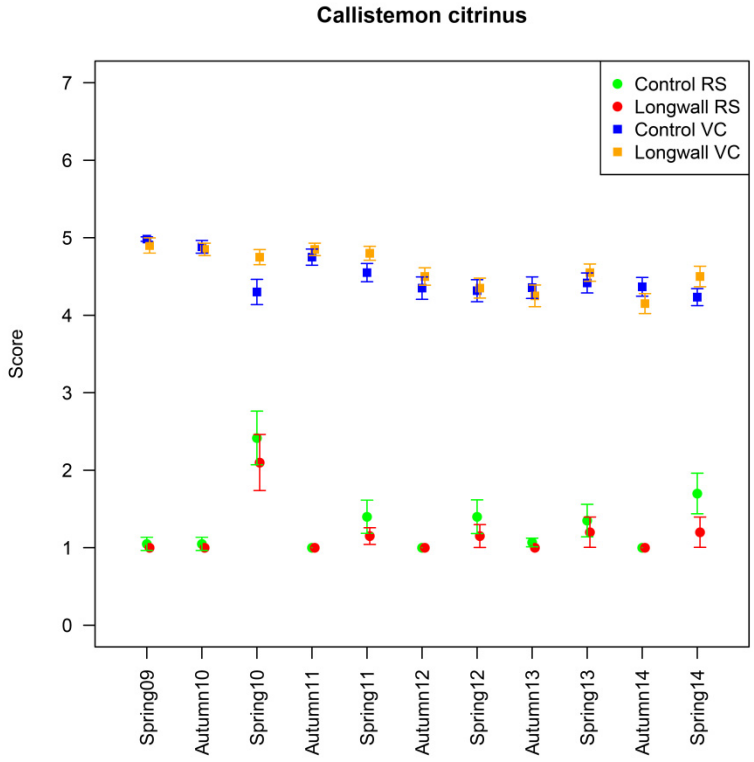


Chart 74 **Mean Scores for Vegetation Condition (VC) and Mean Reproductive Status (RS) for the Indicator Species, *Callistemon citrinus***

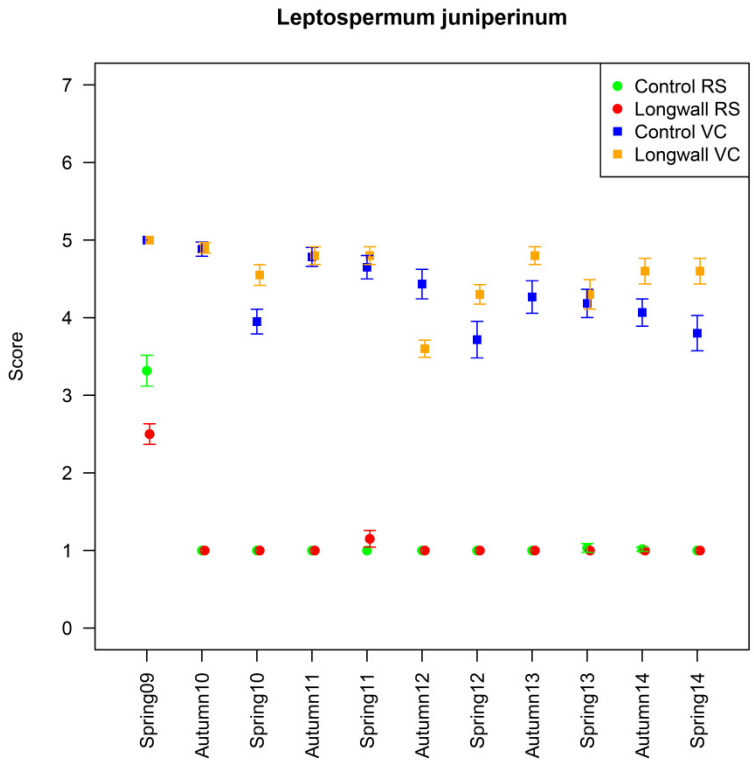


Chart 75 Mean Scores for Vegetation Condition (VC) and Mean Reproductive Status (RS) for the Indicator Species, *Leptospermum juniperinum*

A total of 55 individuals of the tagged valley side swamp indicator species were recorded as dead or Condition 1 (severe dieback) in spring 2014. This represents a decrease from 57 individuals in autumn 2014, with two tagged indicator species recorded in Condition 1 for the first time in spring 2014 (recorded in healthier condition in autumn 2014) and four individuals which were recorded in Condition 1 in autumn 2014 being recorded in an improved condition in spring 2014.

Of the 55 individuals of the tagged valley side swamp indicator species were recorded as dead or Condition 1 (severe dieback) in spring 2014, 29 were located within longwall swamps and 26 were located within control swamps, as follows:

- *Epacris obtusifolia,* 18 plants (9 longwall, 9 control);
- *Pultenaea aristata,* 13 plants (10 longwall, 3 control); and
- *Sprengelia incarnata,* 24 plants (10 longwall, 14 control).

A total of eight individuals of the tagged indicator species within Tea Tree Thicket swamps were recorded as dead or Condition 1 in spring 2014, increasing from one individual in autumn 2014. All of the tagged individuals of the indicator species recorded as dead or in Condition 1 within Tea Tree Thicket swamps were located within control swamps. No Tea Tree Thicket indicator species individuals were recorded as dead or with severe dieback (Condition 1) within the single longwall swamp, Swamp 20.

3.2.1.2 Upland Swamp Groundwater Monitoring

Groundwater monitoring of upland swamps has involved the use, where practicable, of paired piezometers, one in the swamp substrate and one sandstone piezometer. This allows direct measurement of the vertical hydraulic gradient beneath the swamp. Where a swamp substrate piezometer has not been practicable to install due to there being insufficient depth of swamp sediments, deeper piezometers have been installed in the shallow sandstone.

Groundwater monitoring of upland swamps includes the monitoring of:

- Paired piezometers (i.e. one swamp substrate piezometer to a depth of approximately 0.9 m and one sandstone piezometer to a depth of approximately 10 m), located in Swamp 25 overlying Longwalls 20-22.
- Paired piezometers (i.e. one swamp substrate piezometer to a depth of approximately 0.9 m and one sandstone piezometer to a depth of approximately 10 m), located in control Swamp 101.
- One sandstone piezometer to a depth of approximately 10 m in valley side Swamp 16 (S16)[18].
- One sandstone piezometer to a depth of approximately 10 m in valley side Swamp 17 (S17).
- Multiple piezometers (i.e. one swamp substrate piezometer to a depth of approximately 0.9 m and two sandstone piezometers to depths of approximately 4 and 10 m), located in Swamp 20 overlying Longwalls 20-22.
- Multiple piezometers (i.e. one swamp substrate piezometer to a depth of approximately 0.9 m and two sandstone piezometers to depths of approximately 4 and 10 m), located in control swamp Woronora River 1.

The hydrographs at the two control swamps (Swamp 101 and Woronora River 1 [Figures 7, 10 and 11]) are shown on Charts 76 and 77, respectively. Both sites are well away from mining, but longwall start dates are included on Charts 76 and 77 to facilitate comparison with swamp responses within the mining footprint. The rainfall residual mass curve is included as a guide to the influence of rainfall on groundwater responses.

Both sites show pronounced drops in swamp substrate and sandstone groundwater levels associated with a rainfall deficit. At Swamp 101, the water tables are always separated, generally by less than 0.5 m, and groundwater flow direction is downwards. Water levels were close to full saturation levels in April-June 2015 over the reporting period in response to higher rainfall during that time.

At the Woronora River 1 swamp, the water level in the swamp substrate (piezometer at 1 m depth) is almost always lower than the potentiometric level in the deepest sandstone piezometer. Normally, therefore, the swamp is being recharged by groundwater from below and possibly from the sides. A slight upward hydraulic gradient persisted during most of the reporting period, apart from a brief period of high rainfall in April 2015 when there was a slight downward gradient. The swamp substrate piezometer and the 4 m sandstone piezometer show good connectivity across the swamp/sandstone interface, with consistent separation from the groundwater head at the 10 m sandstone piezometer.

[18] As described in the Metropolitan Coal 2013 Annual Review/AEMR, the sensor in the Swamp 16 piezometer is considered to have malfunctioned. Accordingly, the results for Swamp 16 are not discussed in this report.

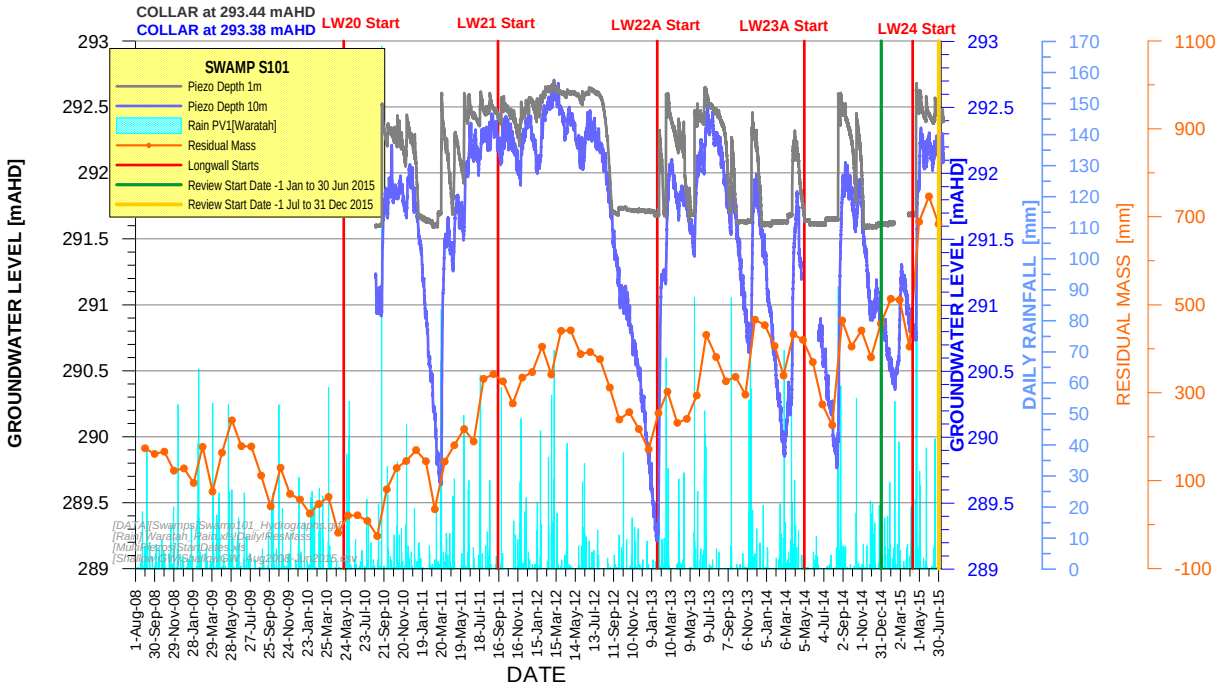


Chart 76 Groundwater Hydrographs at Control Swamp 101

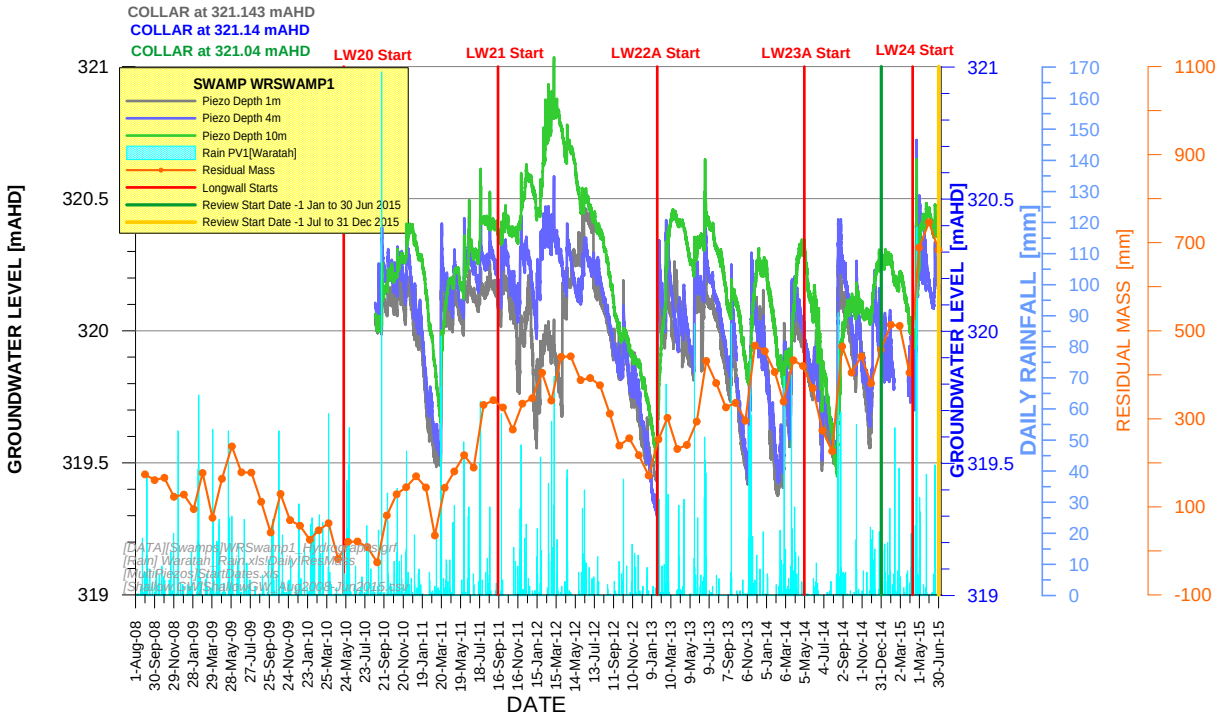


Chart 77 Groundwater Hydrographs at Woronora River 1 Control Swamp

Hydrographic responses for the monitored swamps overlying or adjacent to Longwalls 20-22 (Swamp 17, Swamp 20 and Swamp 25) are shown on Charts 78 to 80. A pronounced drop in the swamp substrate occurred at Swamp 20 and in the sandstone groundwater levels (4 m and 10 m piezometers) at Swamps 17, 20 and 25 in the second half of 2012, following the end of the baseline period (to 31 May 2012), with intermittent saturation and recession during 2013. These recurrent episodes of saturation and recession continued over the reporting period, with higher levels between April and June 2015.

The excavation front for Longwall 21 passed beneath piezometers at Swamp 17, Swamp 20 and Swamp 25 in November 2011, April 2012 and August 2012, respectively. The adjoining Longwall 22A passed alongside the piezometer at Swamp 17 in May 2013. Longwall 22B passed alongside piezometers at Swamp 20 and Swamp 25 in September 2013 and January 2014, respectively. Longwall 23A passed by the piezometer at Swamp 17 in July 2014 and Longwall 23B passed by the piezometers at Swamp 20 and Swamp 25 in September 2014 and December 2014 respectively. Longwall 24 passed by Swamp 25 in early June 2015.

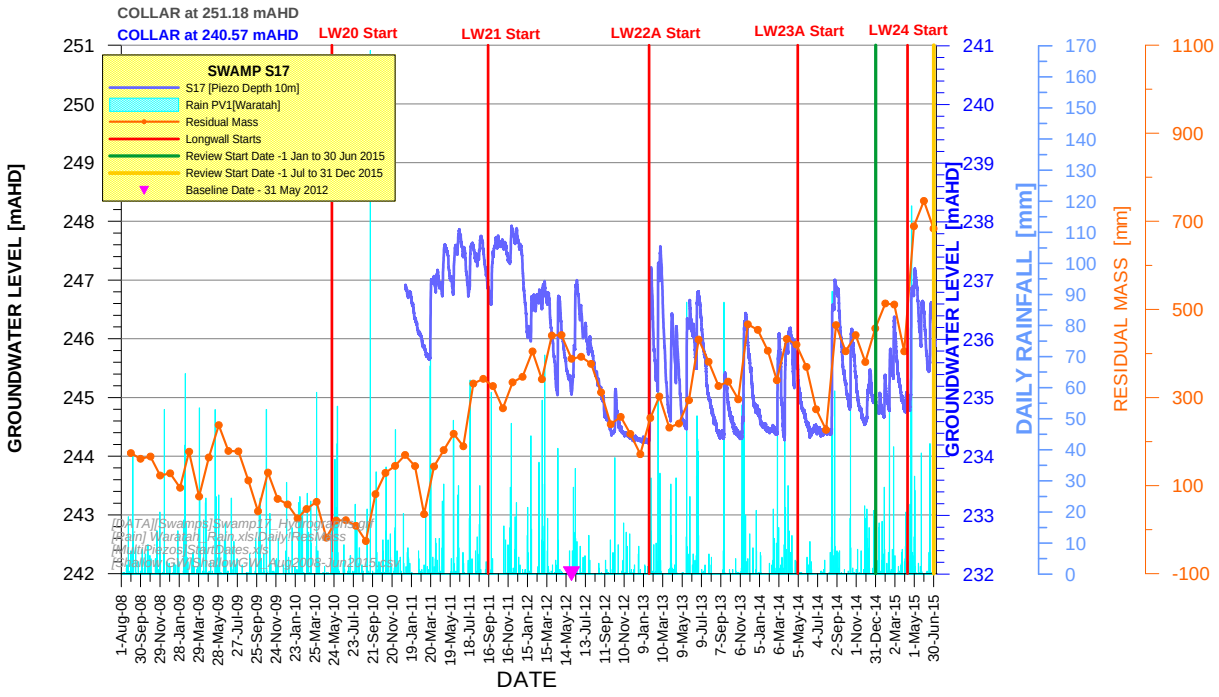


Chart 78 Groundwater Hydrographs at Swamp 17

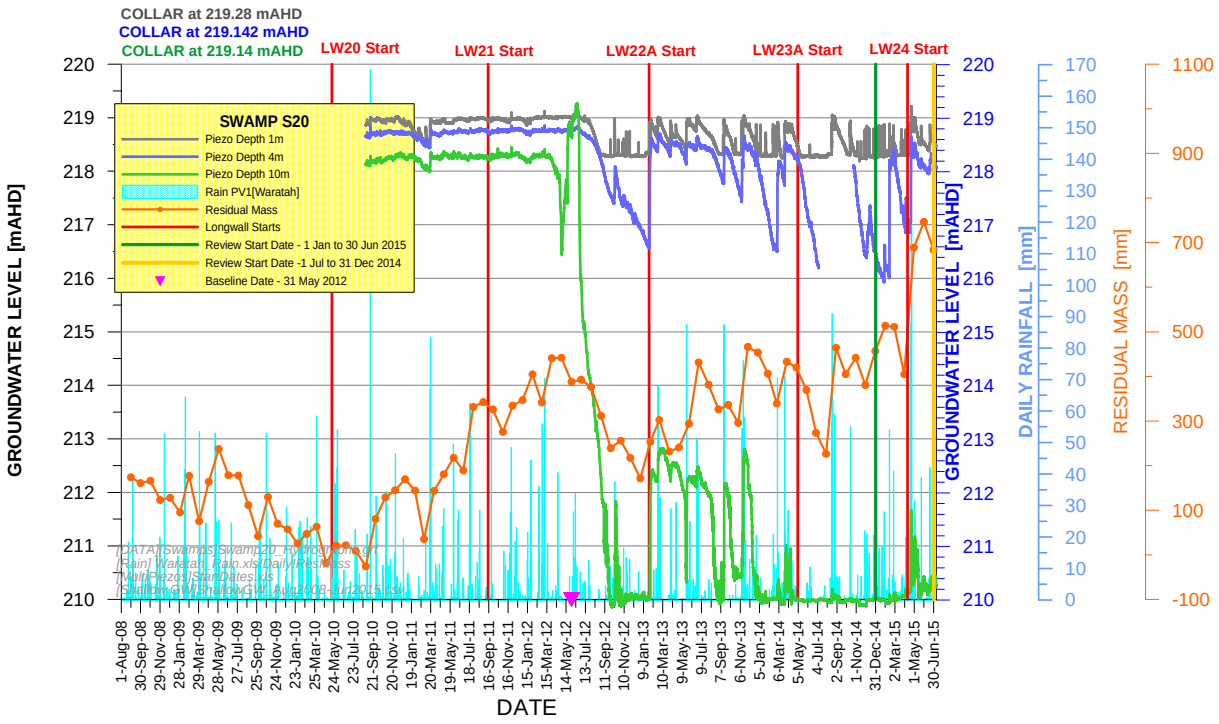


Chart 79 Groundwater Hydrographs at Swamp 20

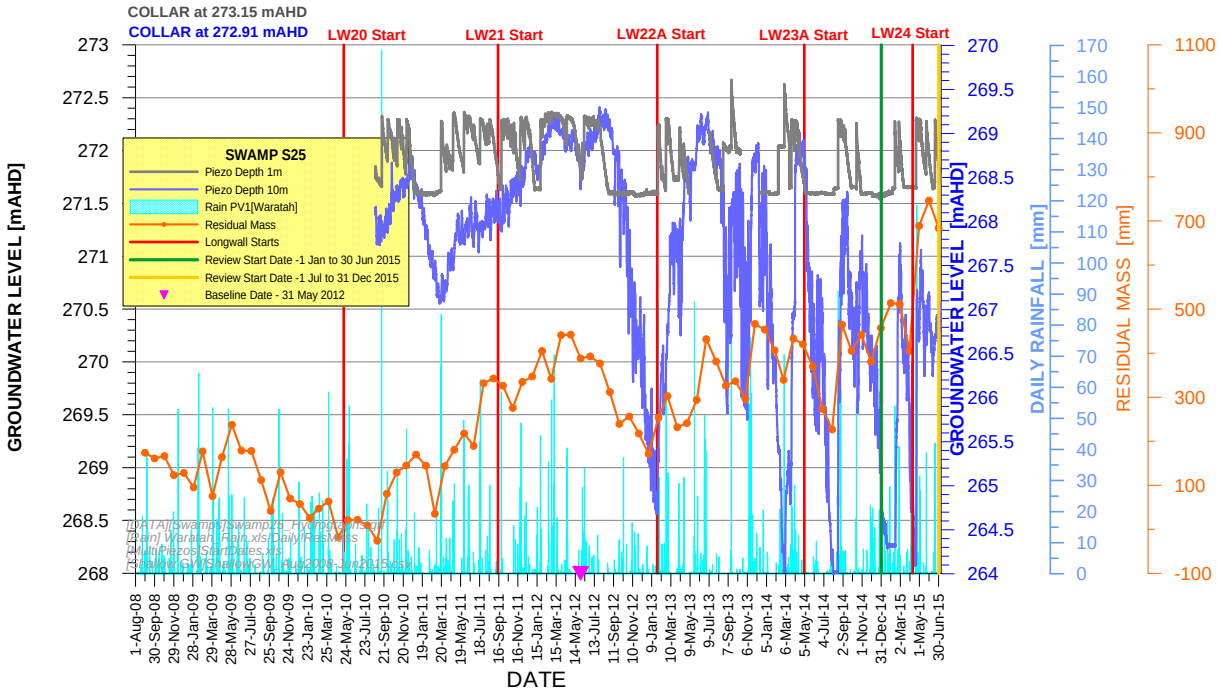


Chart 80 Groundwater Hydrographs at Swamp 25

Swamp 17 sandstone water levels were initially unaffected by passage of the Longwall 21 front beneath the monitoring site in November 2011 and appear to have been unaffected by the passage of Longwall 22A and Longwall 23A alongside the site in May 2013 and July 2014 (although amplitudes [the variation in water level] appear to be higher from January 2013 to December 2014 than during the baseline period). The decline of 1.8 m in January 2012 is possibly a mining effect as the corresponding decline at the control Swamp 101 is much less. The 2.5 m decline in water level from June 2012 to January 2013 correlates closely with the dry period indicated in the rainfall trend curve and corresponds with a 3 m decline at the control site. The average water levels since the passage of Longwall 21 have lowered by about 1 m. It is possible that the advancing Longwall 21 caused tensional surficial cracks about two weeks after the longwall face passed, known elsewhere at the Metropolitan Mine to extend to 10-20 m depth, which have opened up the inferred low permeability fine-sandstone base that would support the 10 m piezometer water table below Swamp 17. During the reporting period, the sandstone water levels showed amplitude responses similar to those observed during the baseline period, and generally higher levels in response to high rainfall between April and June 2015.

At Swamp 20, water appears to be infiltrating downwards to a series of perched water tables monitored by sandstone piezometers at 4 m depth and 10 m depth. The sandstone water levels remained stable from March 2011 (after a dry episode) until April 2012 when the deepest piezometer reacted to the approach and passage of the Longwall 21 mining face, combined with lower than average rainfall. The deepest water level dropped suddenly by 1.8 m, then rose by 2.8 m, then declined by about 5 m by September 2012. It remained around 210 mAHD, about 1 m above the bottom of the hole, until January 2013 when water levels rose by 2.5 m in the deepest piezometer in response to a high rainfall event. Water levels from January to December 2013 fluctuated between 209.8 m AHD and 213 m AHD in accordance with rainfall variability. Groundwater levels at 10 m depth remained depressed throughout most of 2014, but increased and fluctuated between 210.2 and 211.7 m AHD during April-June 2015 in response to higher than average rainfall during that period.

The upper two piezometers (one sandstone and one swamp substrate) at Swamp 20 exhibited clear mining effects from August 2012 to January 2013, after which time the water levels recovered in response to heavy rain. The water levels in the swamp substrate have been fluctuating from dry to full saturation since then, in line with rainfall, and have continued to do so during the reporting period. Although Longwall 22B passed alongside the monitoring site in September 2013, no anomalous response is evident in the swamp substrate piezometer at that time. Sensor malfunction at the 4 m shallow piezometer caused loss of data at this time. The swamp has changed from being permanently waterlogged (during the wet period in 2011) to intermittently waterlogged during 2013 and throughout the reporting period.

As Swamp 25 maintains a consistent separation (about 2.5 m in dry periods) between swamp water levels and the water table level in sandstone at depth 10 m, water is likely to be infiltrating downwards from the swamp. The deeper sandstone hydrograph correlates fairly well with the rainfall trend but the swamp substrate hydrograph fluctuates within the historical bandwidth with no obvious mining effect. At the time Longwall 21 passed beneath the monitoring site (August 2012), there was a decline of about 4 m in the deeper water level and the water level in the swamp dropped to the bottom of the hole. Coincidentally, the longwall crossing coincided with a particularly dry period so that the observed decline could potentially have been due to climatic effects. Comparison with the control swamp hydrograph shows that there was a corresponding decline in water levels there at the same time, with a similar magnitude. During the reporting period, the water level in both piezometers fluctuated in a similar range to that in the baseline period. It is noted that the piezometer at depth 10 m remained below 267.6 m AHD, despite higher than average rainfall between April and June 2015. During previous high rainfall periods the groundwater level at 10 m depth has risen to between 268 and 269 m AHD. It is therefore possible that the groundwater response to rainfall at Swamp 25 observed in the 10 m piezometer has changed following the passage of Longwalls 23B and 24.

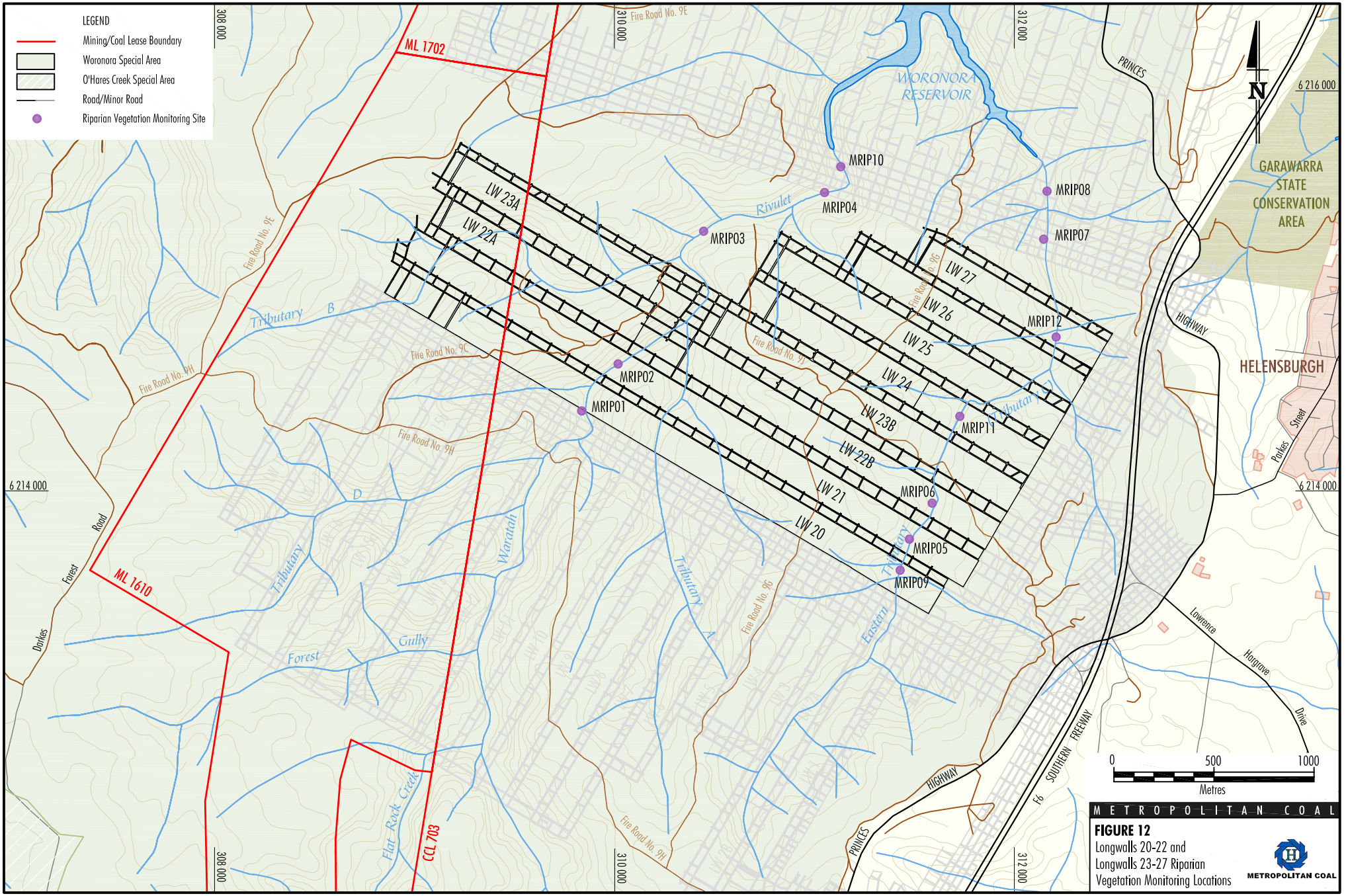
3.2.1.3 Riparian Vegetation Monitoring

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

Visual Inspections

Visual inspections of riparian areas have been conducted in locations adjacent to riparian vegetation monitoring sites (longwall sites MRIP01, MRIP02, MRIP05, MRIP06 and MRIP09, and control sites MRIP03, MRIP04, MRIP07, MRIP08 and MRIP10) (Figure 12), and areas traversed whilst accessing the monitoring sites, to record:

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



MET-08-AD7-2015_6MR_116A

The Metropolitan Coal 2014 Annual Review and AEMR/Rehabilitation Report reported on the results of the riparian visual inspection monitoring conducted by Eco Logical Australia for the spring 2013 and autumn 2014 vegetation surveys. The following provides a summary of the results of visual inspections conducted in spring 2014.

- Vegetation was generally observed in good condition across and adjacent to the riparian monitoring sites. Exceptions to the generally good condition of riparian vegetation included:
  - Isolated and scattered individuals observed with dieback across all sites.
  - Within site MRIP02 vegetation along the edge of the Waratah Rivulet was observed with extensive dieback and dead individuals were common. At MRIP02 dieback was initially recorded during spring 2012 and has remained evident up to the current spring 2014 survey with the extent and level of dieback similar to that observed in autumn 2014.
  - At MRIP05 dieback of groundcover and shrub layer vegetation was observed along the water's edge including inundation of vegetation near the water's edge. Dieback of vegetation near the water's edge at MRIP05 was observed in spring 2013, though was restricted to ground cover species including *Bauera rubioides* and *Gleichenia microphylla*. In autumn 2014 dieback was recorded across a greater number of species including shrubs such as *Lomatia myricoides*, *Schoenus melanostachys, Acacia longifolia* subsp*. longifolia, Hakea teretifolia, Tristania neriifolia, Prostanthera linearis, Allocasuarina littoralis, Baeckea linifolia, Banksia ericifolia* subsp*. ericifolia*, *Gleichenia microphylla* and *Sporadanthus gracilis*. The extent and level of dieback in spring 2014 was similar to that observed in autumn 2014, with both shrub and groundcover species impacted.
  - Dieback of groundcover vegetation along the water's edge was observed from MRIP09 (Photo Point 2) and downstream extending through to MRIP05. In spring 2013 dieback of groundcover vegetation along the water's edge was observed at MRIP09, including *Gleichenia microphylla*. Additionally, in spring 2013 scouring of bank sediments and inundation of streamside vegetation was observed with individuals of *Allocasuarina littoralis, Hakea teretifolia, Banksia ericifolia* subsp*. ericifolia* and *Lomatia myricoides* dead. In autumn 2014, dieback of vegetation downstream from site MRIP09 in association with inundation included additional individuals and species including groundcover and shrubs such as *Acacia longifolia* subsp*. longifolia, Allocasuarina littoralis, Lomatia myricoides, Hakea salicifolia, Banksia ericifolia* subsp*. ericifolia, Gleichenia microphylla, Sporadanthus gracilis* and *Bauera rubioides*. In spring 2014, the level and extent of dieback was similar to that observed in autumn 2014.
- Cracking of streamside rocky areas at the downstream end of MRIP01 was first observed during the autumn 2011 survey. Cracking of streamside rocky areas were first observed between longwall sites MRIP01 and MRIP02 during the autumn 2012 survey. Further inspections in spring 2012 indicated that the existing cracking had remained consistent with previous years. During autumn 2013, a piece of cracked bedrock at the downstream end of MRIP01 had been transported downstream by higher water flows, while the cracking between sites MRIP01 and MRIP02 had increased slightly in width compared to the spring 2012 observations. No dieback of vegetation was observed in the areas adjacent to the cracked bedrock. No new areas of cracked bedrock were observed within streamside rocky areas from spring 2013 to spring 2014.
- Scouring of the stream bank and erosion of sediments was observed across all riparian monitoring sites in spring 2014, attributed to high water flows. The extent of bank scouring was generally minor, with scouring and slumping of bank sediments more commonly observed at longwall sites MRIP02, MRIP05, and MRIP09 in association with continued submergence of portions of the stream bank due to increased ponding of water in adjacent pools.
- Areas of riparian vegetation at sites MRIP02, MRIP05 and MRIP09 previously observed to be inundated by water remained inundated in spring 2014 with the level and areas of inundation generally similar to that observed in autumn 2014.

- No weed species were recorded within any of the riparian longwall monitoring sites, though weed species were recorded upstream of MRIP01 in the vicinity of Flat Rock Crossing. Weed species were observed within control sites MRIP04, including three individuals of *Conyza* sp. (Fleabane) and one individual of *Senecio madagascariensis* (Fireweed), and at MRIP10 amongst the creek bed and boulders at the transition area of the Rivulet and inundation zone of the Woronora Reservoir, *Andropogon virginicus* (Whiskey Grass).

Transect/Quadrat Monitoring

A permanent quadrat (20 m x 2 m) has been used to monitor riparian vegetation on the Waratah Rivulet and Eastern Tributary at sites MRIP01, MRIP02, MRIP05 and MRIP06 (overlying Longwalls 20-22) and at sites MRIP03, MRIP04, MRIP07 and MRIP08 (downstream of Longwalls 20-22) (Figure 12)[19].

The data collected for each quadrat includes:

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

A permanent transect (50 m x 2 m, i.e. a 30 m extension of each quadrat) has also been used to monitor riparian vegetation at sites MRIP01 to MRIP08. The data collected along each transect includes the occurrence of weed species (species and location) and a condition/health rating for each plant along the transect.

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

The Metropolitan Coal 2014 Annual Review and AEMR/Rehabilitation Report reported on the results of the riparian transect and quadrat monitoring conducted by Eco Logical Australia for the spring 2013 and autumn 2014 vegetation surveys. The following provides a summary of the results of quadrat/transect monitoring for spring 2014.

<u>Vegetation Structure, Dominant Species and Estimated Cover/Abundance for each Stratum</u>

In spring 2014, the precent cover and height of the structural layers was generally similar to that observed and recorded in autumn 2014. Across all seasons, the vegetation structure, dominant species and estimated cover/abundance for each stratum has varied between sites and between seasons within sites. Results have generally fluctuated with no clear trends towards increasing or decreasing height or cover/abundance for individual strata across multiple seasons. These fluctuations are considered to reflect both the natural variations in the height and cover/abundance of vegetation structural layers through time (including in response to flooding impacts), as well as the subjective nature of the data collection.

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

The exception to the above includes:

- a trend towards increasing height of the mid storey at site MRIP01 since autumn 2013; and
- a decrease in the foliage cover of the lower layer at site MRIP02 since autumn 2012 from an average cover of 60% to 80% (spring 2008 to autumn 2012) to fluctuating values between 20 and 45% (spring 2012 to spring 2014) as a result of dieback of streamside vegetation and an associated shift in dominant species of the ground layer.

Species Richness

Species richness was generally higher at sites during the period spring 2008 – spring 2009 followed by reduced species richness in the period autumn 2010 – spring 2014 (Chart 81). The decrease in species richness occurred at both longwall and control sites and coincides with a period of drier conditions (spring 2008 – spring 2009) changing to wetter conditions, with floods occurring in the wetter seasons since autumn 2010. The species richness at riparian sites in spring 2014 was within the range of previous seasons.

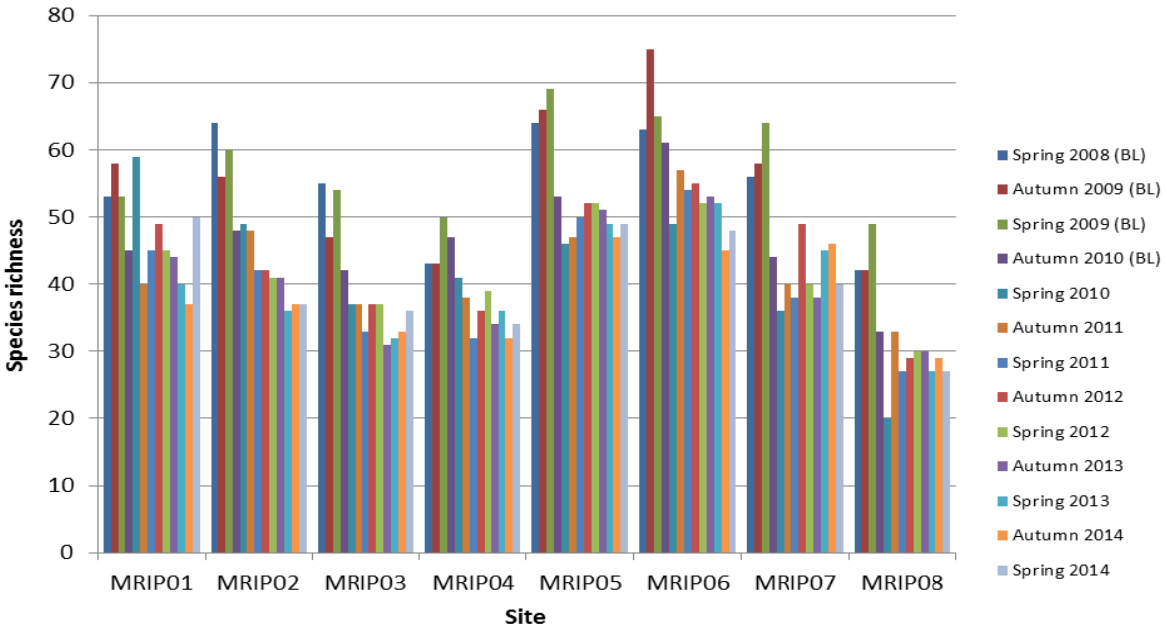


Chart 81 Species Richness in Riparian Monitoring Sites across all Seasons

Baseline seasons are indicated by 'BL'. Longwall sites – sites MRIP01, MRIP02, MRIP05 and MRIP06. Control sites – sites MRIP03, MRIP04, MRIP07 and MRIP08.

Cover/Abundance and Condition for Each Species

Fluctuations in species cover/abundance were recorded across all sites. No patterns of increasing or decreasing cover/abundance were identified in relation to individual species across sites or groups of species (i.e. riparian species, generalist species, shrubs, ground covers) within sites, with the exception of site MRIP02 where dieback of streamside vegetation has been recorded along a narrow strip. The foliage cover of *Gleichenia microphylla* at site MRIP02 has been recorded under 5% in all seasons since dieback was first recorded in spring 2012, including the current spring 2014 survey. The cover of *Gleichenia microphylla* at MRIP02 was recorded at between 20-50% for the three seasons prior to dieback being observed (i.e. in autumn 2011, spring 2011, autumn 2012). Similar declines in cover abundance have also been observed for *Bauera rubioides* at this site.

With the exception of longwall sites MRIP02 and MRIP05, in spring 2014 vegetation within riparian quadrats at both longwall and control sites was generally in a healthy condition (Condition 5) and only occasionally with minor dieback (Condition 4), and rarely with some dead branches (Condition 3). The majority of species were recorded in a good condition across all sites, although the following species were recorded with dieback at multiple sites: *Acacia longifolia* subsp*. longifolia*; *Banksia* spp.; *Bauera rubioides; Gleichenia microphylla; Schoenus melanostachys; Sporadanthus gracilis*; *Sticherus flabellatus* var*. flabellatus; Pomaderris elliptica* subsp*. elliptica; Prostanthera linearis;* and *Tristania neriifolia.*

At longwall site MRIP02 senescent vegetation was observed along and adjacent to the water's edge, dominated by the groundcover species *Gleichenia microphylla, Bauera rubioides* and *Sticherus flabellatus* var. *flabellatus*, all of which were recorded within the quadrat with many dead stems (Condition 2) or some dead branches (Condition 3). Some improvement in the condition of *Schoenus melanostachys* was observed in spring 2014, with many dead culms observed in autumn 2014 (Condition 3) and only minor dieback (Condition 4) recorded in spring 2014. Additionally, a number of shrubs were observed with minor dieback (Condition 4) or some dead branches (Condition 3) including *Allocasuarina littoralis, Acacia longifolia* subsp*. longifolia, Prostanthera linearis, Banksia ericifolia* subsp*. ericifolia* and *Pomaderris elliptica* subsp*. elliptica* while the shrub *Ceratopetalum apetalum* was recorded with many dead stems (Condition 2). Some species previously observed with dieback were observed in a healthy condition in spring 2014 at MRIP02 including the shrub species *Lomatia myricoides* and *Grevillea diffusa* subsp*. diffusa.* Other individuals such as *Tristania neriifolia*, recorded with some dead branches in autumn 2014, were not observed in spring 2014. While changes in the level of dieback were recorded for individual species within MRIP02, it was noted that across the site as a whole, dieback in spring 2014 was similar to that observed in the previous autumn 2014 monitoring period.

At site MRIP05 senescent vegetation was observed along and adjacent to the water's edge, including the groundcover species *Sporadanthus gracilis* (many dead stems – Condition 2)*, Gleichenia microphylla* (some dead branches – Condition 3) and *Bauera rubioides* (minor dieback – Condition 4). Several other ground-cover and shrub species were also observed with minor dieback including *Acacia longifolia* subsp. *longifolia, Schoenus melanostachys* and *Hakea salicifolia*.

Indicator Species Monitoring

Twenty tagged individuals of *Prostanthera linearis*, *Schoenus melanostachys* and *Lomatia myricoides* have been monitored at sites MRIP01, MRIP02, MRIP05, MRIP06 and MRIP09 (overlying Longwalls 20-22) and at sites MRIP03, MRIP04, MRIP07, MRIP08[20] and MRIP10 (downstream of Longwalls 20-22) (Figure 12).

Population monitoring data collected includes a condition/health rating and a reproductive rating for each plant.

Monitoring of indicator species is conducted bi-annually in autumn and spring.

The Metropolitan Coal 2014 Annual Review and AEMR/Rehabilitation Report reported on the results of the riparian indicator species monitoring conducted by Eco Logical Australia for the spring 2013 and autumn 2014 vegetation surveys. A summary of the results for spring 2014 is presented below.

In spring 2014 the mean vegetation condition was similar for selected riparian indicator species at both longwall and control sites, as indicated by overlapping confidence intervals (Charts 82 to 84).

[20] Note: Only 10 individuals of *Prostanthera linearis* were available for tagging at site MRIP08.

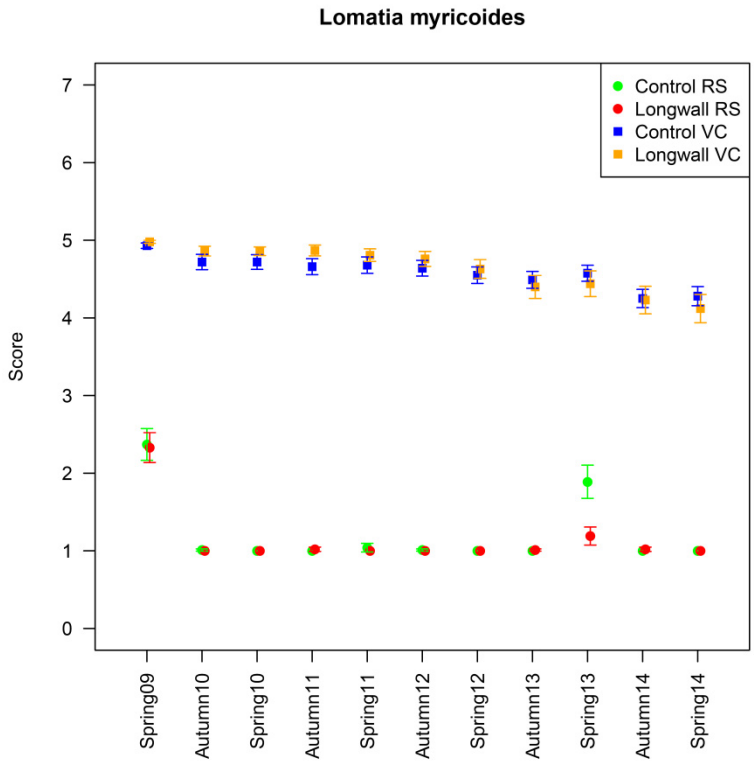


Chart 82 **Mean Scores for Vegetation Condition (VC) and Mean Reproductive Status (RS) for the Indicator Species, *Lomatia myricoides***

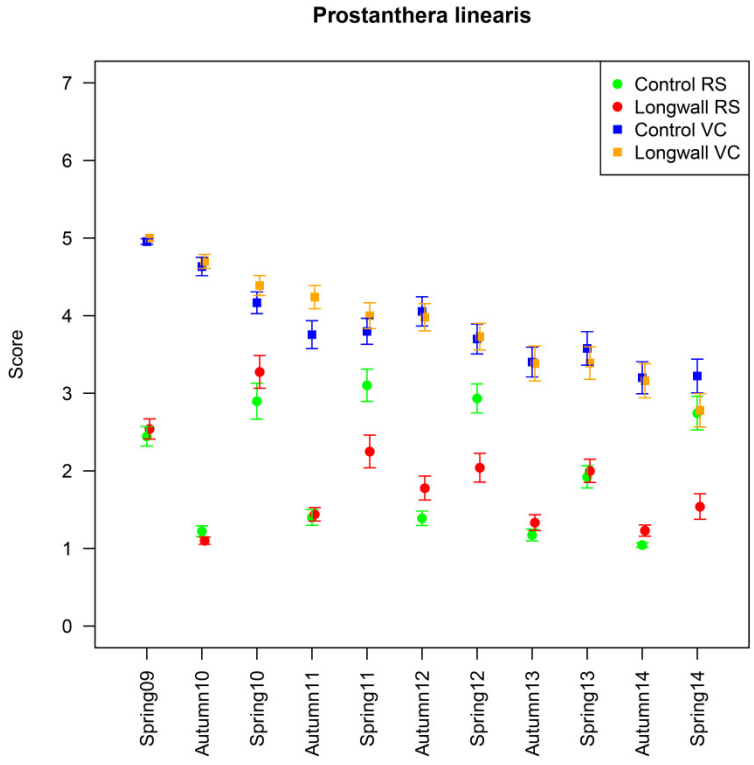


Chart 83 **Mean Scores for Vegetation Condition (VC) and Mean Reproductive Status (RS) for the Indicator Species, *Prostanthera linearis***

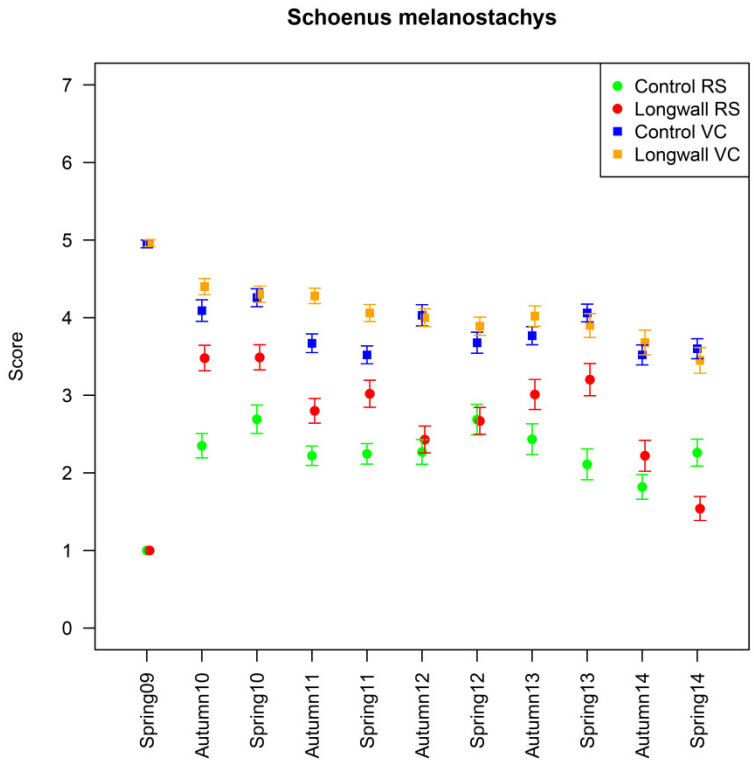


Chart 84 Mean Scores for Vegetation Condition (VC) and Mean Reproductive Status (RS) for the Indicator Species, *Schoenus melanostachys*

In spring 2014 the mean reproductive status of tagged riparian indicator species was more variable than vegetation condition, with potential similarities (indicated by overlapping confidence intervals) between longwall and control sites for *Lomatia myricoides* (Chart 82) as well as potential differences (as indicated by non-overlapping confidence intervals) between longwall and control sites for *Prostanthera linearis* and *Schoenus melanostachys* (Charts 83 and 84). The mean reproductive status for *Prostanthera linearis* and *Schoenus melanostachys* was greater at control sites than longwall sites, although the reproductive status was low for both these species at longwall and control sites. The mean reproductive status for *Prostanthera linearis* and *Schoenus melanostachys* at longwall sites in spring 2014 was within the range of previous surveys including surveys during the baseline monitoring period. The observed differences in flowering of indicator species between control sites and longwall sites did not coincide with any differences in the condition of the respective species. Differences observed are considered to reflect natural variability in the reproductive status of this species, rather than an impact related to mining Longwalls 20-22.

In spring 2014, a total of 80 individuals of the tagged riparian indicator species were recorded as dead or Condition 1 (severe dieback), increasing from 67 individuals in autumn 2014. Of the 80 individuals recorded in Condition 1, 56 were located within longwall sites and 24 were located within control sites, as follows:

- *Prostanthera linearis*, 55 plants (34 longwall and 21 control). Of the 34 individuals recorded at longwall sites 3 individuals each were recorded at sites MRIP01 and MRIP09, 9 individuals at site MRIP02, 12 individuals at MRIP05, and 7 individuals at MRIP06;
- *Lomatia myricoides*, 13 plants (11 longwall and 2 control). Of the 11 individuals recorded at longwall sites 1 individual was recorded at site MRIP01, 7 individuals at site MRIP02, and 3 individuals at site MRIP05; and

- *Schoenus melanostachys*, 12 plants (11 longwall and 1 control). Of the 11 individuals recorded at longwall sites 8 individuals were recorded at site MRIP02, 2 individuals at site MRIP05 and 1 individual at site MRIP09.

Of the 56 individuals recorded in Condition 1 at all longwall sites, a total of 41 (73%) were recorded at sites MRIP02 and MRIP05 and an additional 4 individuals at site MRIP09.

3.2.1.4 Aquatic Biota and their Habitats

Metropolitan Coal assesses subsidence impacts and environmental consequences on aquatic habitats in accordance with the Metropolitan Coal Longwalls 20-22 Water Management Plan (Section 3.3). Surface water monitoring includes monitoring of surface water flow, pool water levels, surface water quality, iron staining and gas release. Observations of surface cracking, iron staining and gas release are also made during the conduct of the aquatic ecology surveys.

The aquatic ecology monitoring program for Longwalls 20-22 has been designed to:

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

The design of the monitoring programs uses a "Beyond BACI" type experimental design and focuses on representative sampling within streams and pools in the Longwalls 20-22 mining area and in suitable control streams and pools not subject to mine subsidence.

Stream Monitoring

The stream monitoring program includes bi-annual (autumn and spring) monitoring of aquatic habitat characteristics, water quality, aquatic macroinvertebrates and aquatic macrophytes.

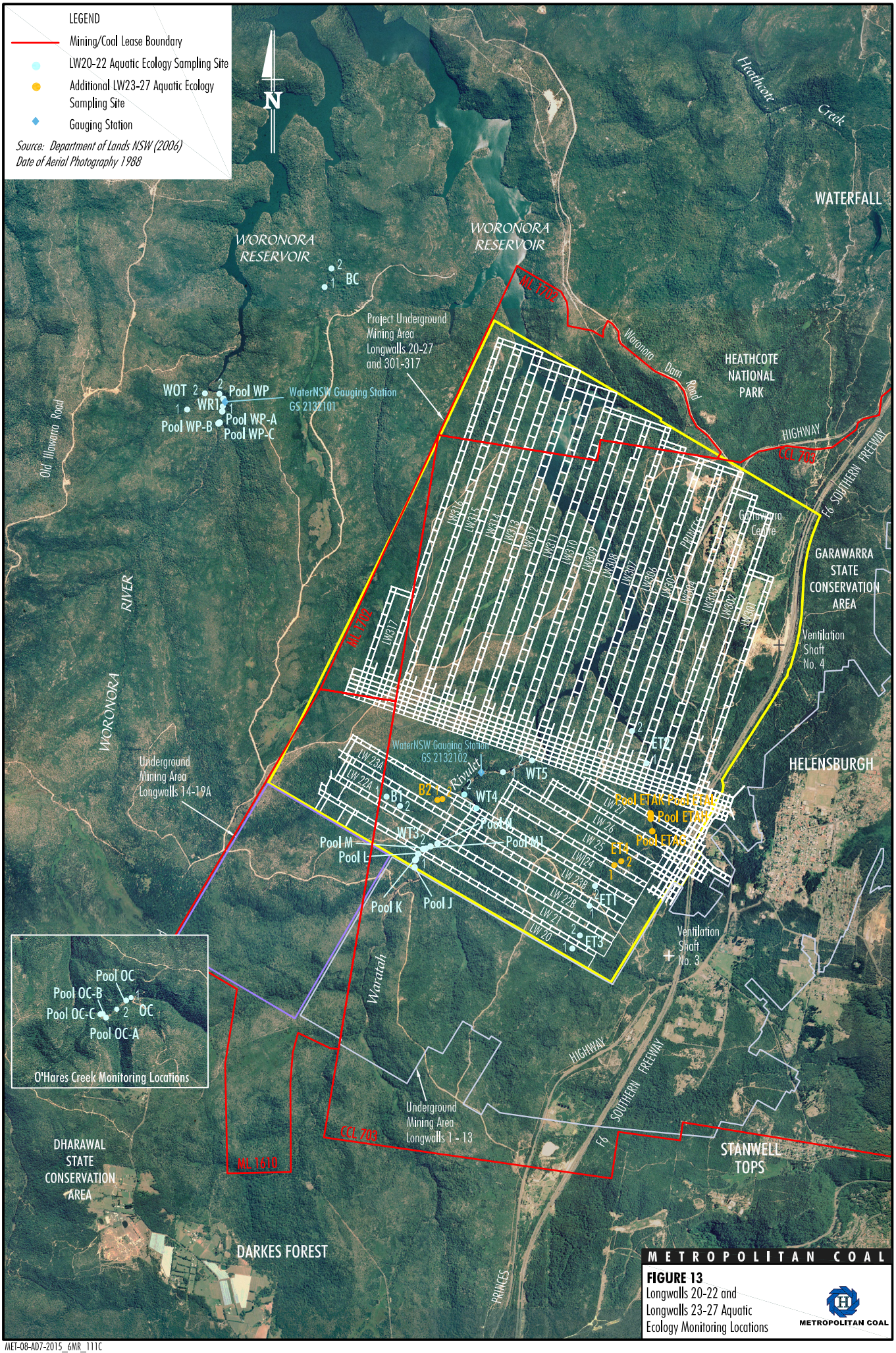
Longwalls 20-22 stream monitoring surveys have been carried out from spring 2008 to autumn 2010 (i.e. pre-mining within the Longwalls 20-22 mining area) and since spring 2010 (i.e. during or after mining within the Longwalls 20-22 mining area). Mining of the Longwall 23-27 mining area commenced in May 2014.

Monitoring has been carried out at two sampling sites (approximately 100 m long) at the following stream sampling locations:

- Locations WT3 on Waratah Rivulet, C1 and C3 on Tributary C[21] (also referred to as Eastern Tributary) and B1 on Tributary B, overlying Longwalls 20-22.
- Locations WT4 and WT5 on Waratah Rivulet and C2 on Tributary C[21], downstream of Longwalls 20-22.
- Control Locations: WR1 on Woronora River; OC on O'Hares Creek; BC on Bee Creek; and WOT on Woronora Tributary.

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

[21] Locations C1, C2 and C3 are referred to as Locations ET1, ET3 and ET2 in the *Metropolitan Coal Longwalls 20-22 Biodiversity Management Plan* and on Figure 13.



METROPOLITAN COAL

FIGURE 13
Longwalls 20-22 and Longwalls 23-27 Aquatic Ecology Monitoring Locations

METROPOLITAN COAL

MET-08-AD7-2015_6MR_111C

The methods used to survey aquatic biota and their habitats at each site are:

- Stream characteristics are recorded in accordance with the Australian River Assessment System (AUSRIVAS) protocol (including, visual assessment of stream width and depth, composition of the substratum, riparian conditions, signs of disturbance, water quality and percentage cover of the substratum by algae).
- Water quality sampling is conducted for electrical conductivity, dissolved oxygen, pH, temperature, turbidity, oxygen reduction potential, alkalinity, total phosphorous and total nitrogen to provide information relevant to water quality at the time of sampling.
- Aquatic macroinvertebrate sampling is conducted using the AUSRIVAS protocol, as well as quantitative sampling where three replicate macroinvertebrate samples are collected within each site using timed sweeps.
- The distribution of submerged and emergent (occurring in-stream and in the riparian zone) aquatic macrophytes is estimated along each sampling location by assigning a cover class to each species. The cover classes are: (1) one plant or small patch (i.e. few), (2) not common, growing in a few places (i.e. scattered), and (3) widespread (i.e. common). In addition, an assessment of the in-stream (i.e. submerged and emergent) aquatic vegetation is made within each site by estimating the relative abundance (i.e. percentage cover) of aquatic macrophytes within five haphazardly placed 0.25 m^2 quadrats, using a stratified sampling technique.

The 2014 Annual Review and AEMR/Rehabilitation Report reported on the spring 2013 and autumn 2014 survey results. A summary of the spring 2014 stream monitoring surveys conducted by BIO-ANALYSIS Pty Ltd is presented below.

Stream Characteristics

- Iron staining was first noted at Locations C1 and C3 on Tributary C/Eastern Tributary in autumn 2014 and covered up to 100% of the stream substratum at sites C1-1, C1-2 (at Location C1) and C3-2 (at Location C3) in spring 2014. To date (i.e. spring 2014), no cracking of the stream or bank sandstone substratum has been observed at those locations. No evidence of mining related subsidence (i.e. cracking of the stream substratum or an algal/iron floc) has been observed at sampling Location C2 to date.
- The stream channel at Location WT3 on the Waratah Rivulet has commonly been observed to be covered by an algal/iron floc since spring 2009. In spring 2014, up to 95% of the stream substratum was covered by an algal/iron floc. For the first time since sampling commenced at Location WT4 (at site WT4-2) on the Waratah Rivulet in spring 2008, patches of an algal/iron floc complex were noted to occur in shallower sections of the stream channel in spring 2014. To date, no evidence of mining related subsidence (i.e. cracking of the stream substratum or an algal/iron floc) has been observed at sampling Location WT5 on the Waratah Rivulet.
- A large pool situated within the survey reach in Tributary B at Location B1 was found to have almost completely drained of water in spring 2012. Since then, pools along the study reach have been mostly dry and there has been no surface-flow (including spring 2014). Quantitative sampling of aquatic macroinvertebrates was not carried out at Location B2 in spring 2013 or spring 2014 due to insufficient habitat available for sampling.

Macroinvertebrate Assemblages

The results indicate that generally, the structure of assemblages of macroinvertebrates are typical of Hawkesbury sandstone environments.

Table 4 presents the AUSRIVAS Band results for each site as a result of sampling of aquatic macroinvertebrates using the AUSRIVAS protocol. Site C3-2 on Tributary C/Eastern Tributary had more taxa than the AUSRIVAS reference collection in spring 2014 (Table 4). Sites C1-2 and C3-1 on Tributary C/Eastern Tributary, Site WT5-2 on the Waratah Rivulet, Site WR1-2 on the Woronora River, and Sites OC1 and OC2 on O'Hares Creek had a similar number of taxa to the AUSRIVAS reference collection in spring 2014 (Table 4). Fewer families of macroinvertebrates than expected were collected from all other sites sampled (including control sites), compared to reference sites selected by the AUSRIVAS model (Table 4).

Principal Coordinates Analysis (PCoA) is a multi-dimensional scaling technique that illustrates similarities or dissimilarities in the data. Charts 85a to 85g present the PCoA plots for macroinvertebrate assemblages at each sampling location using the quantitative sampling data. Temporal and spatial variability in the structure of assemblages of macroinvertebrates was observed at all locations. Macroinvertebrate taxa that commonly distinguished between locations within the Longwalls 20-22 area and control locations were Leptophlebiidae and Atyidae. With the exception of Atyidae at sites on the Woronora Tributary and Bee Creek, dissimilarities between Longwalls 20-22 and control locations were commonly due to relatively small differences in abundance of these taxa rather than due to the presence or absence of specific taxa. Atyidae have not been collected at sites sampled within the Woronora Tributary since sampling commenced in spring 2008 and on only one occasion in Bee Creek (i.e. T9: spring 2012) (Chart 88d).

Charts 86a to 86d present the mean diversity of macroinvertebrates, mean abundance of macroinvertebrates, mean number of Leptophlebiidae and mean number of Atyidae, respectively, at each location sampled on Tributary C/Eastern Tributary (i.e. Locations C1, C2 and C3) and at the control locations (i.e. Woronora River and O'Hares Creek) using the quantitative sampling data.

Charts 87a to 87d present the mean diversity of macroinvertebrates, mean abundance of macroinvertebrates, mean number of Leptophlebiidae and mean number of Atyidae respectively, at each location sampled on Waratah Rivulet (i.e. Locations WT3, WT4 and WT5) and the control locations (i.e. Woronora River and O'Hares Creek) using the quantitative sampling data.

Charts 88a to 88d present the mean diversity of macroinvertebrates, mean abundance of macroinvertebrates, mean number of Leptophlebiidae and mean number of Atyidae at Tributary B (Location B1) and the control locations (i.e. Bee Creek and Woronora Tributary), respectively, using the quantitative sampling data.

A temporal comparison of the aquatic macroinvertebrate data has been carried out for the locations sampled from spring 2008 to spring 2014 using both multivariate and univariate techniques.

Multivariate analyses of the monitoring data before and after the commencement of Longwall 20 indicates that any effect of longwall mining on assemblages of aquatic macroinvertebrates at Locations C1, C2 and C3 on Tributary C/Eastern Tributary and Locations WT3, WT4 and WT5 on the Waratah Rivulet to date are within the range of natural variability in these assemblages as measured by the control locations.

Table 4
Band levels Generated by the AUSRIVAS Model for Sites within Locations Sampled as Part of the Longwalls 20-22 Stream Monitoring Program

System	Site Code	Sp-08	Aut-09	Sp-09	Aut-10	Sp-10	Aut-11	Sp-11	Aut-12	Sp-12	Aut-13	Sp-13	Aut-14	Sp-14
Tributary C	C1-1	D	C	B	B	C	C	B	B	C	A	D	C	B
	C1-2	D	C	C	B	B	B	C	A	B	C	C	A	A
	C2-1	D	B	B	C	C	B	C	C	B	C	C	C	B
	C2-2	D	C	B	C	C	C	D	B	C	C	C	C	B
	C3-1	-	-	B	C	C	C	B	B	B	B	C	C	A
	C3-2	-	-	D	C	C	C	C	C	C	A	B	B	X
Waratah Rivulet	WT3-1	B	B	B	B	B	C	B	B	C	A	B	C	B
	WT3-2	B	B	B	C	B	C	B	B	C	B	C	C	B
	WT4-1	D	C	C	C	B	C	C	A	A	B	B	B	B
	WT4-2	B	C	C	B	B	C	B	A	B	B	B	B	B
	WT5-1	B	C	C	C	C	B	A	B	C	B	C	C	B
	WT5-2	D	C	C	C	C	C	C	B	D	B	A	B	A
Tributary B	B1-1	B	C	C	C	C	C	B	C	-*	-*	-*	-*	-*
	B1-2	C	B	C	B	C	C	C	B	-*	B	-*	-*	-*
Bee Creek	BC1	D	B	C	B	C	C	D	C	A	B	B	C	C
	BC2	C	A	D	B	C	B	B	B	B	C	B	C	B
Woronora Tributary	WOT1	C	B	-*	B	C	C	B	C	B	A	B	C	B
	WOT2	C	C	D	C	C	C	C	B	A	C	C	C	C
Woronora River	WR1-1	D	B	C	B	C	C	C	C	B	C	C	C	B
	WR1-2	C	C	C	B	C	C	C	C	B	B	B	C	A
O'Hares Creek	OC1	B	B	B	A	B	B	A	A	A	B	C	B	A
	OC2	D	B	B	B	B	B	B	C	C	B	C	B	A

* Sites not sampled due to insufficient aquatic habitat.

Note: the sampling of Location C3 (sites C3-1 and 3-2) commenced in spring 2009.

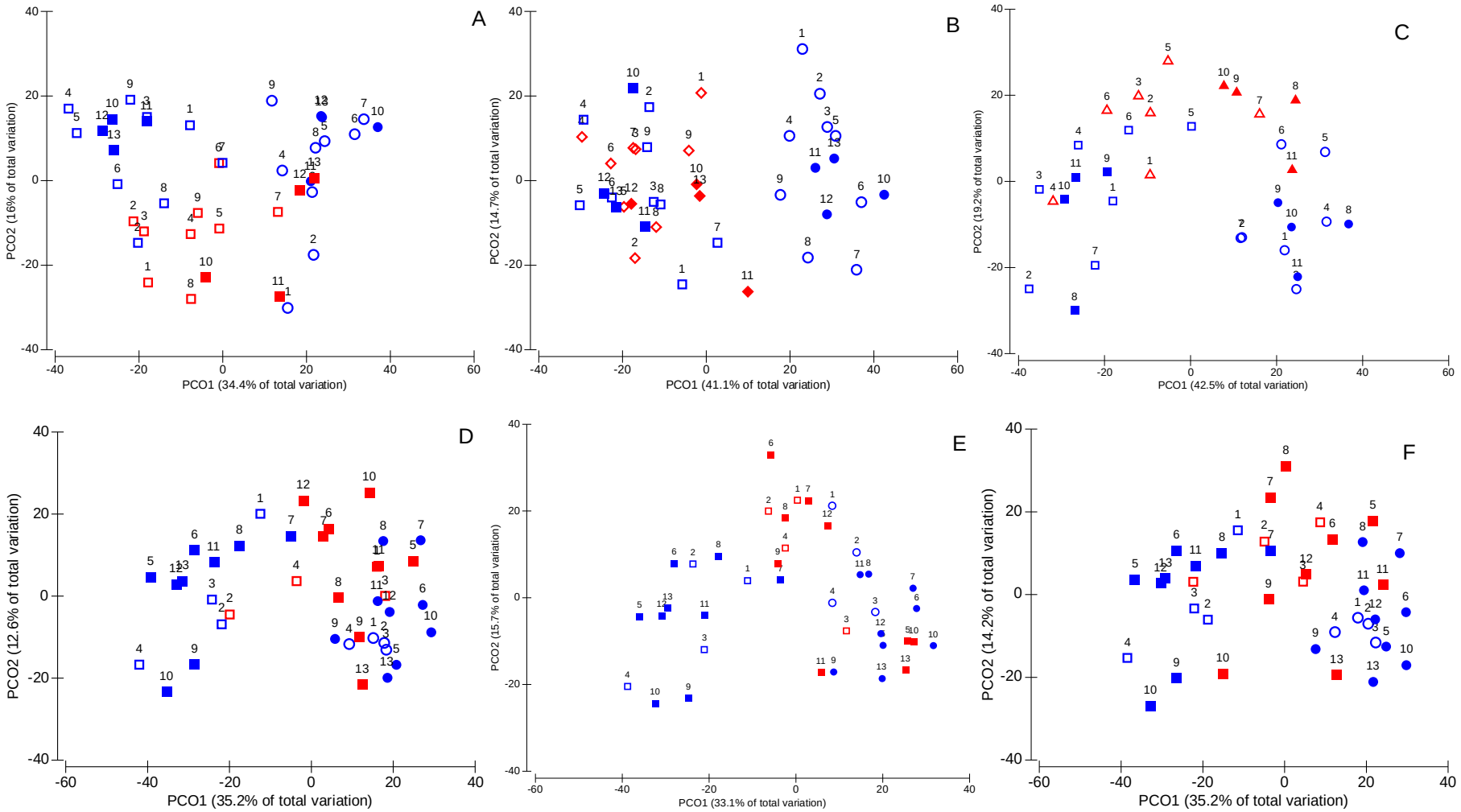


Chart 85a-f Principal Coordinates Analysis (PCoA) plots of macroinvertebrate data for three locations on Tributary C: A) Location C1; B) Location C2; and C) Location C3 and the Waratah Rivulet: D) Location WT3; E) Location WT4; and F) Location WT5) and two control locations (Woronora River and O'Hare's Creek) for each time of sampling (*n*= 6). Red symbols: Tributary C and Waratah Rivulet; Blue squares: Woronora River; Blue circles: O'Hares Creek. Empty symbols: 'Before' commencement of mining; Filled symbols: 'After' mining. Numbers indicate sampling time. Sampling commenced in spring 2008, with the exception of Location C3 which commenced in spring 2009.

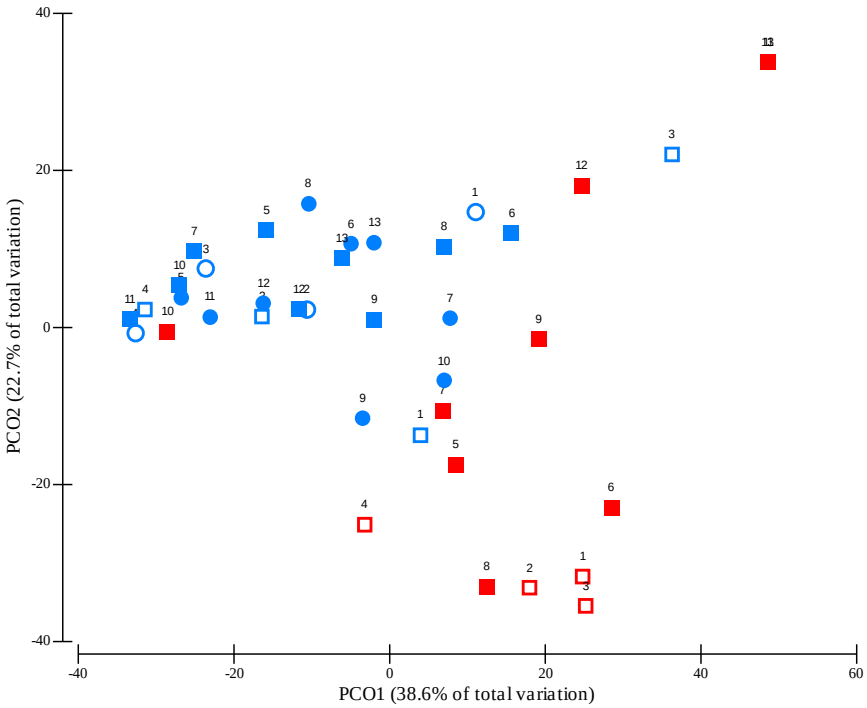


Chart 85g Principal Coordinates Analysis (PCoA) plot of macroinvertebrate data collected at one location on Tributary B and two control locations (Bee Creek and Woronora Tributary) for each time of sampling (*n*= 6). Red symbols: Tributary B location; Blue squares: Bee Creek; Blue circles: Woronora Tributary. Empty symbols: 'Before' commencement of mining; Filled symbols: 'After' mining. Sampling commenced in spring 2008 (T1).

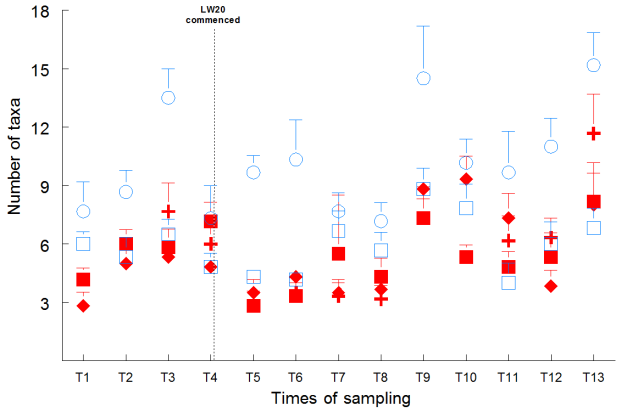


Chart 86a Mean (+SE) Macroinvertebrate Diversity, Stream Monitoring – Tributary C

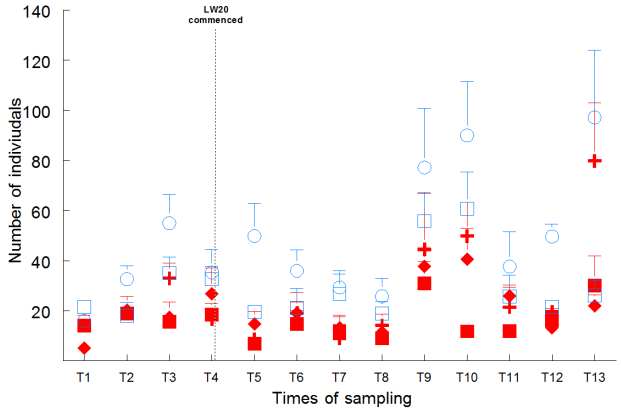


Chart 86b Mean (+SE) Macroinvertebrate Abundance, Stream Monitoring – Tributary C

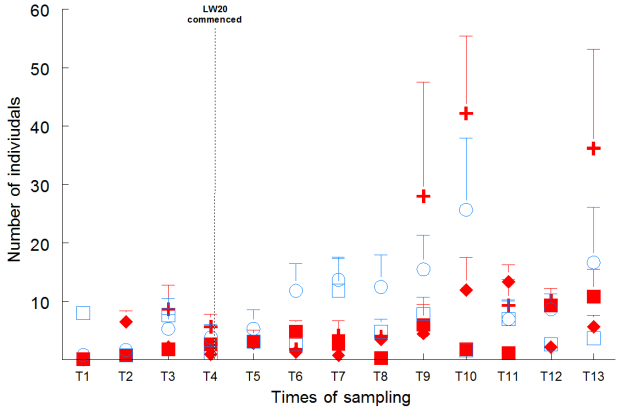


Chart 86c Mean (+SE) Number of Leptophlebiidae, Stream Monitoring- Tributary C

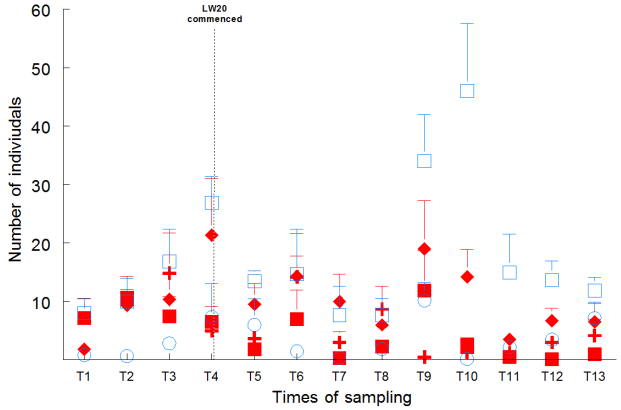


Chart 86d Mean (+SE) Number of Atyidae, Stream Monitoring – Tributary C

Key: Tributary C/Eastern Tributary (Location C1: solid squares; Location C2: diamond; Location C3: plus symbols) and the control locations (Woronora River: empty square; O'Hares Creek: empty circle) (*n* = 6). Time 1 = spring 2008, T2 = autumn 2009, etc. NB Sampling of Location C3 commenced at T3 (spring 2009).

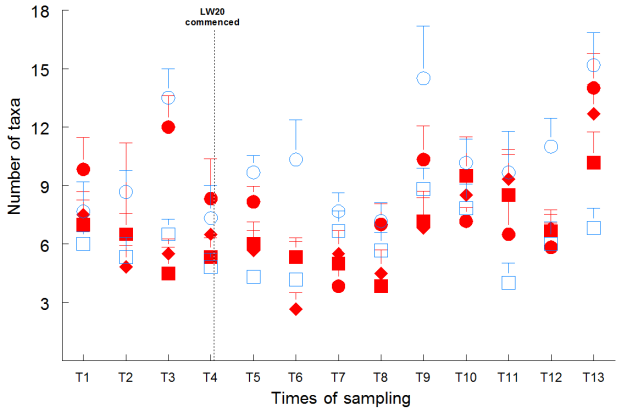


Chart 87a Mean (+SE) Macroinvertebrate Diversity, Stream Monitoring - Waratah Rivulet

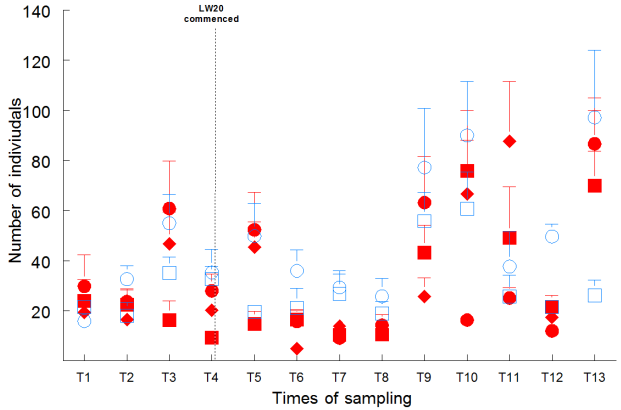


Chart 87b Mean (+SE) Macroinvertebrate Abundance, Stream Monitoring – Waratah Rivulet

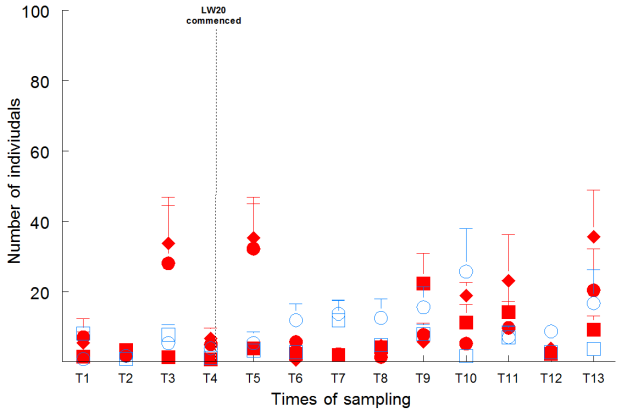


Chart 87c Mean (+SE) Number of Leptophlebiidae, Stream Monitoring- Waratah Rivulet

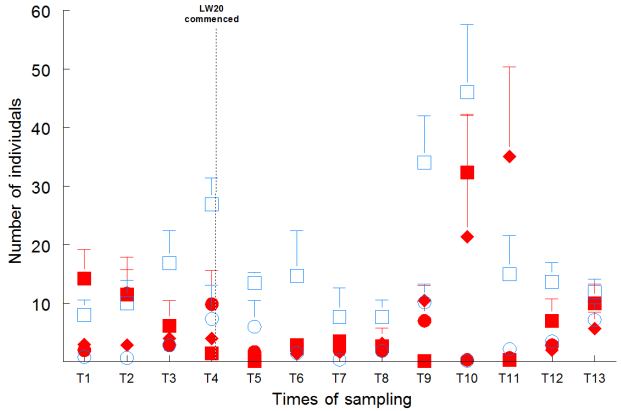


Chart 87d Mean (+SE) Number of Atyidae, Stream Monitoring – Waratah Rivulet

Key: Waratah Rivulet (Location WT3: solid circle; Location WT4: solid diamond; Location WT5: solid square) and the control locations (Woronora River: empty square; O'Hares Creek: empty circle) (*n* = 6). Time 1 = spring 2008, T2 = autumn 2009, etc.

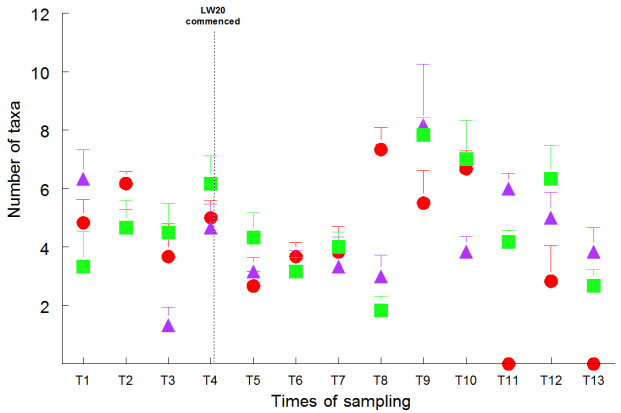


Chart 88a Mean (+SE) Macroinvertebrate Diversity, Stream Monitoring – Tributary B

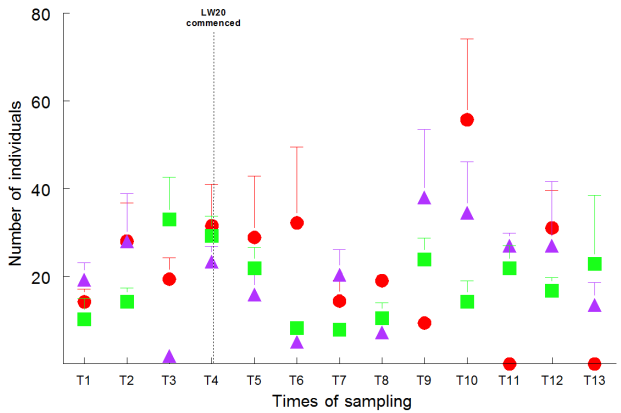


Chart 88b Mean (+SE) Macroinvertebrate Abundance, Stream Monitoring – Tributary B

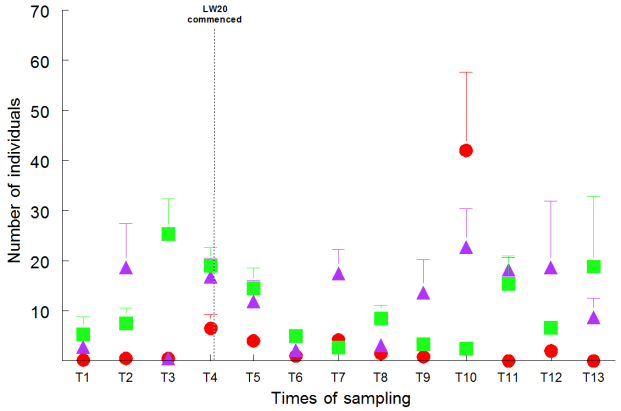


Chart 88c Mean (+SE) Number of Leptophlebiidae, Stream Monitoring- Tributary B

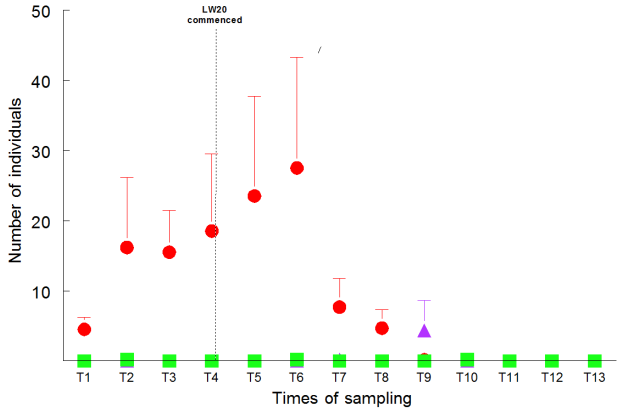


Chart 88d Mean (+SE) Number of Atyidae, Stream Monitoring – Tributary B

Key: Tributary B (circles) and the control locations (Bee Creek: triangles; Woronora Tributary: squares) (*n* = 6). Time 1 = spring 2008, T2 = autumn 2009, etc.

However, Chart 85c shows that the assemblages of macroinvertebrates at Location C3 on Tributary C/Eastern Tributary have grouped separately from prior sampling occasions since spring 2012. The spring 2012 survey coincided with observed inundation of the stream bank as a result of subsidence. Dieback of riparian vegetation was noted at Location C3 in the following season (i.e. autumn 2013). Additional multivariate analyses were carried out to assess whether there was a greater change in the macroinverterbrate assemblage 'before' versus 'after' the riparian vegetation dieback was observed at Location C3 when compared to the control locations. A significant difference was detected between Location C3 and the control locations, which SIMPER analyses indicated were mostly due to spikes in mean abundance of the mayfly family, Leptophlebiidae and decreased numbers of the freshwater shrimp family, Atyidae at Location C3. Univariate analyses however indicated there was no significant difference in the mean diversity of macroinvertebrates, mean number of macroinvertebrates, mean number of Leptophlebiidae or mean number of Atyidae at Location C3 after spring 2012 when compared to the control locations.

Quantitative sampling of aquatic macroinvertebrates was not carried out at Location B2 in spring 2013 or spring 2014 due to insufficient habitat available for sampling. Chart 85g shows that the assemblages of macroinvertebrates at Location B1 on Tributary B have been more variable, and have grouped separately from prior sampling occasions, since autumn 2013. In spring 2012 a considerable drop in water level was noted in a large pool at Location B1. Since autumn 2013 pools along the study reach have been mostly dry and there has been no surface-flow. Additional multivariate analyses were carried out to assess whether there was a greater change in the macroinverterbrate assemblage 'before' spring 2012 versus 'after' (i.e. from spring 2012) when compared to the control locations. A significant difference was detected between Location B1 and the control locations, which SIMPER analyses indicated were mostly due to the freshwater shrimp family, Atyidae, which have not been collected at Tributary B since spring 2012 (Chart 88d). Univariate analyses indicated there was no significant difference in the mean abundance of macroinvertebrates or the mean number of Leptophlebiidae, however there was a significant difference in the mean diversity of macroinvertebrates and mean number of Atyidae at Location B1 after spring 2012 when compared to the control locations.

Macrophyte Assemblages

Over the entire sampling period, the following floating attached species and/or submerged species of macrophytes (i.e. instream macrophytes) have been recorded:

- *Triglochin procerum* at sampling Locations WT4, WT5, WR1 and OC;
- *Chara/Nitella* spp. has commonly been recorded at Locations C1, C2, C3, WT3, WT4, WT5, WR1 and OC; and
- *Myriophyllum pedunculatum* at Location WR1.

Emergent macrophyte species are also recorded by the quantitative sampling program and include macrophyte species within the stream and on the adjacent stream bank.

Charts 89a to 89g present the PCoA plots for macrophytes at each sampling location using the quantitative sampling data. Temporal and spatial variability in the structure of assemblages of aquatic macrophytes was observed at all locations.

Charts 90a and 90b present the mean diversity of macrophytes and mean abundance of macrophytes respectively, at each location sampled on Tributary C/Eastern Tributary (i.e. Locations C1, C2 and C3) and at the control locations (i.e. Woronora River and O'Hares Creek) using the quantitative sampling data.

Charts 91a and 91b present the mean diversity of macrophytes and mean abundance of macrophytes respectively, at each location sampled on Waratah Rivulet (i.e. Locations WT3, WT4 and WT5) and the control locations (i.e. Woronora River and O'Hares Creek) using the quantitative sampling data.

Charts 92a and 92b present the mean diversity of macrophytes and mean abundance of macrophytes, respectively at Tributary B and the control locations (i.e. Bee Creek and Woronora Tributary), respectively, using the quantitative sampling data.

A temporal comparison of the aquatic macrophyte data (including floating attached, submerged and emergent species) has been carried out for the locations sampled from spring 2008 to spring 2014 using both multivariate and univariate techniques. To date, the main findings for assemblages of macrophytes include:

- The structure of macrophyte assemblages has varied among locations and through time although similar taxa (i.e. *Lepidosperma filiforme, Triglochin procerum* and *Gleichenia dicarpa*) were consistently ranked as most important.
- The temporal variability in macrophyte diversity and cover at Locations C1, C2 and C3 on Tributary C/Eastern Tributary and at locations along the Waratah Rivulet (Locations WT3, WT4 and WT5) has not differed significantly to the temporal changes at the control locations, recorded before to after the commencement of mining (Charts 89d-f).
- Charts 89(a) and 89(b) indicate that the assemblages of macrophytes at Locations C1 and C2 on Tributary C/Eastern Tributary have grouped separately from prior sampling occasions since autumn 2013. SIMPER showed that differences between the before and after periods were mostly due to a general increase in total cover of macrophytes at these sampling locations. Univariate analyses did not find this increase at Locations C1 and C2 to be significant in relation to the control locations.
- Temporal changes in assemblages of macrophytes at Location C3 on Tributary C/Eastern Tributary were not found to differ significantly from changes at the control locations. Field observations at Location C3 indicate that the riparian vegetation dieback has not affected emergent macrophytes. Rather, emergent macrophytes have colonised the inundated area.
- Chart 89g shows that the assemblages of macrophytes at Location B1 on Tributary B have changed since spring 2012. In spring 2012 a considerable drop in water level was noted in a large pool at Location B1. Since autumn 2013 pools along the study reach have been mostly dry and there has been no surface-flow. Additional multivariate analyses were carried out to assess whether there was a greater change in the macrophyte assemblage 'before' spring 2012 versus 'after' (i.e. from spring 2012) when compared to the control locations. A significant difference was detected between Location B1 and the Woronora Tributary control location, which SIMPER analyses indicated were mostly due to a considerable decrease in the fern, *Gleichenia dicarpa* at Location B1 since spring 2012. Univariate analyses indicated that a notable increase in diversity of macrophytes at Woronora Tributary within the after period, but not at Tributary B, also contributed significantly to the differences. Dieback of the fern, *Gleichenia dicarpa* at Location B1 since spring 2012 has been a major contributor to the decrease in mean total cover of macrophytes observed in Chart 92b.

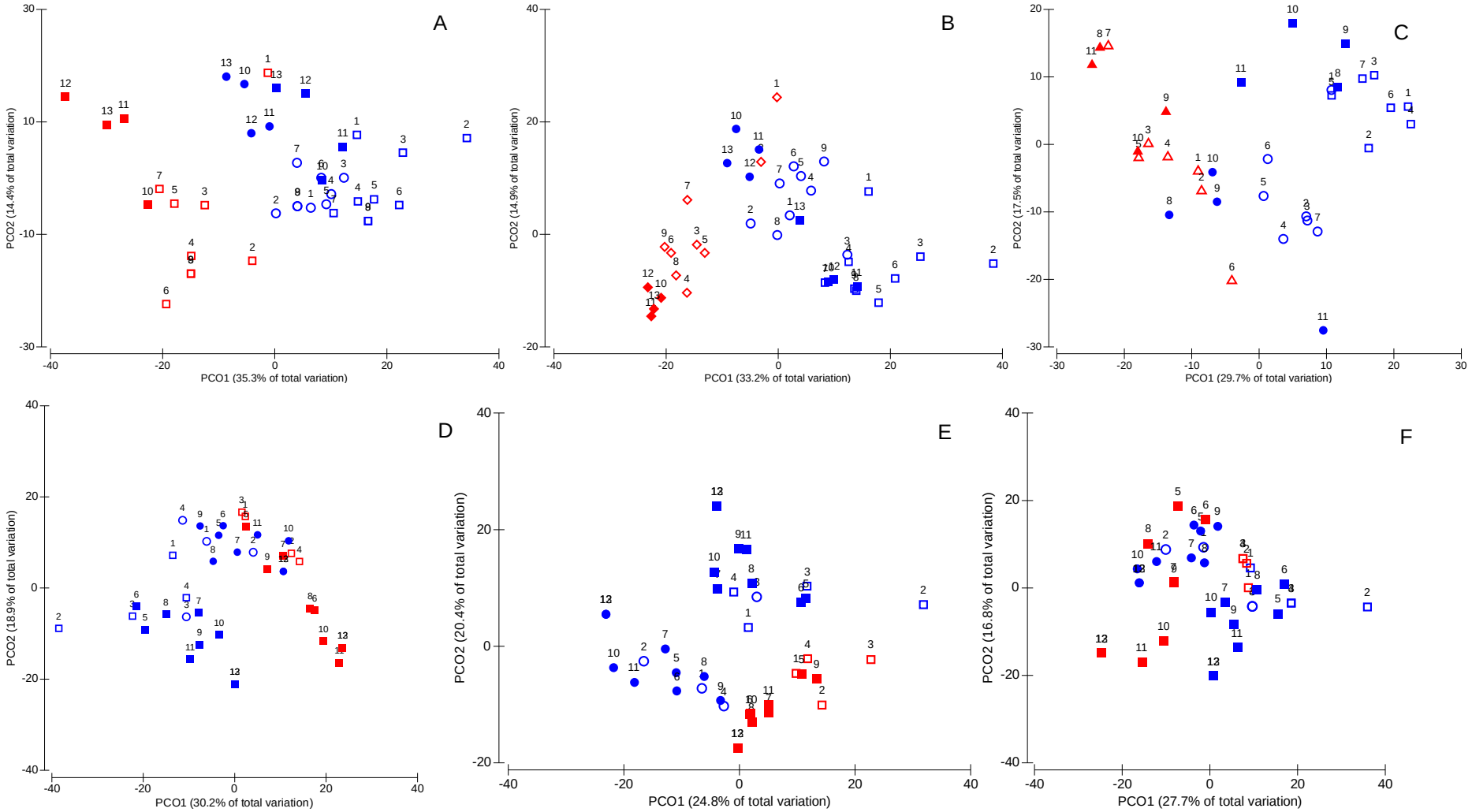


Chart 89a-f Principal Coordinates Analysis (PCoA) plots of macrophyte data for three locations on Tributary C: A) Location C1; B) Location C2; and C) Location C3) and the Waratah Rivulet: D) Location WT3; E) Location WT4; and F) Location WT5) and two control locations (Woronora River and O'Hare's Creek) for each time of sampling (*n*= 10). Red symbols: Tributary C and Waratah Rivulet; Blue squares: Woronora River; Blue circles: O'Hares Creek. Empty symbols: 'Before' commencement of mining; Filled symbols: 'After' commencement of mining. Numbers indicate sampling time. Sampling commenced in spring 2008, with the exception of Location C3 which commenced in spring 2009.

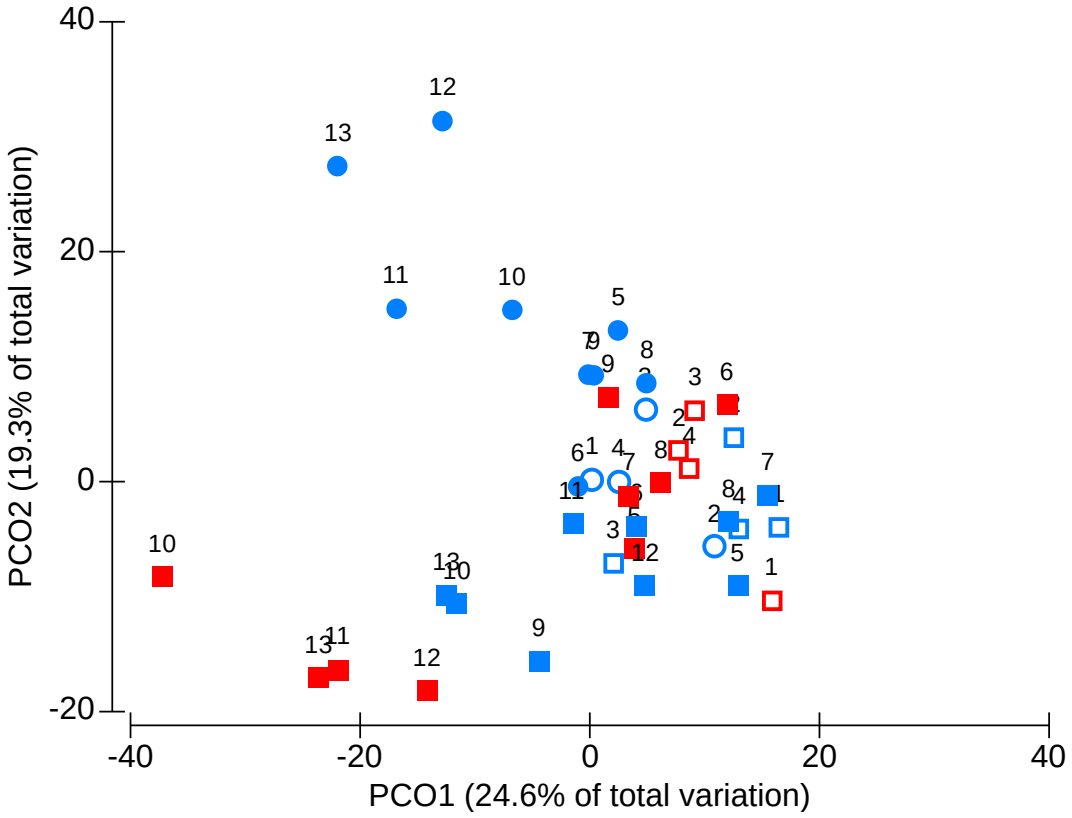


Chart 89g Principal Coordinates Analysis (PCoA) plot of macrophyte data collected at one location on Tributary B and two control locations (Bee Creek and Woronora Tributary) for each time of sampling (*n*= 10). Red symbols: Tributary B; Blue squares: Bee Creek; Blue circles: Woronora Tributary. Empty symbols: 'Before' commencement of mining spring 2012; Filled symbols: 'After' commencement of mining. Sampling commenced in spring 2008 (T1).

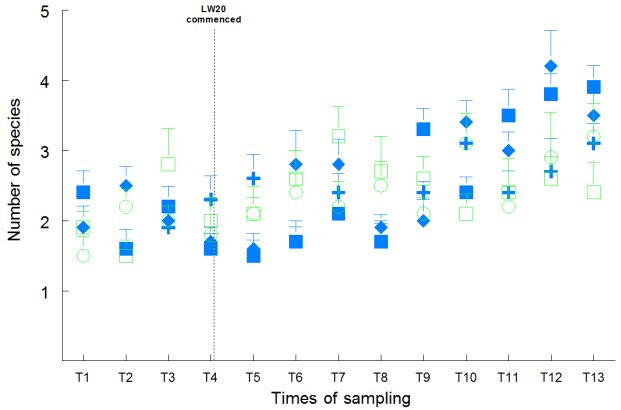


Chart 90a Mean (+SE) Macrophyte Diversity, Stream Monitoring, Tributary C

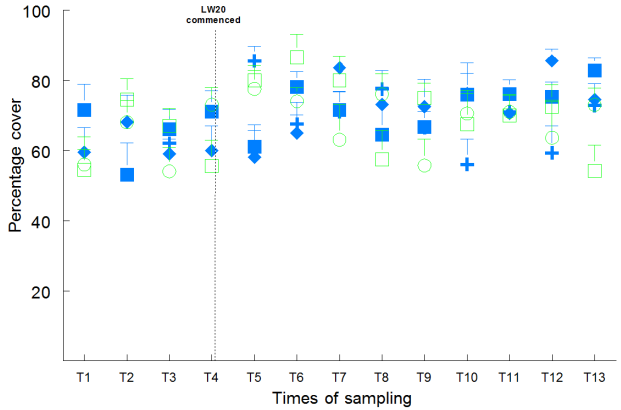


Chart 90b Mean (+SE) Macrophyte Cover, Stream Monitoring, Tributary C

Key: Tributary C/Eastern Tributary (Location C1: solid squares; Location C2: diamond; Location C3: plus symbols) and the control locations (Woronora River: empty square; O'Hares Creek: empty circle) (*n* = 10) Sampling commenced in spring 2008, with the exception of Location C3 which commenced at T3 (spring 2009). Time 1 = spring 2008, T2 = autumn 2009, etc.

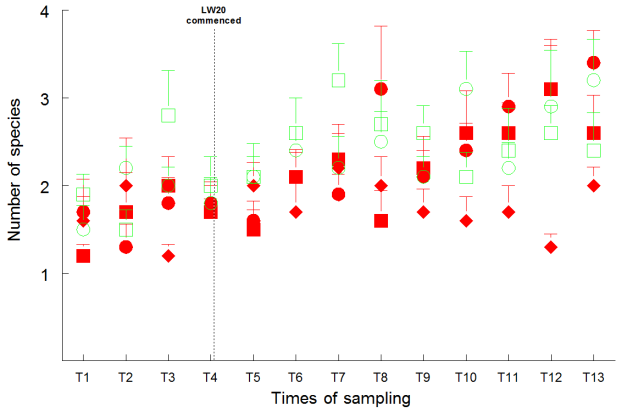


Chart 91a Mean (+SE) Macrophyte Diversity, Steam Monitoring, Waratah Rivulet

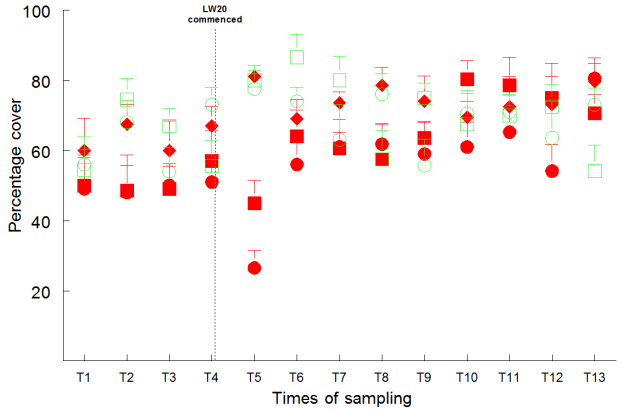


Chart 91b Mean (+SE) Macrophyte Cover, Stream Monitoring, Waratah Rivulet

Key: Waratah Rivulet (Location WT3: solid circle; Location WT4: solid diamond; Location WT5: solid square) and the control locations (Woronora River: empty square; O'Hares Creek: empty circle) (*n* = 10) Sampling commenced in spring 2008, with the exception of Location C3 which commenced at T3 (spring 2009). Time 1 = spring 2008, T2 = autumn 2009, etc.

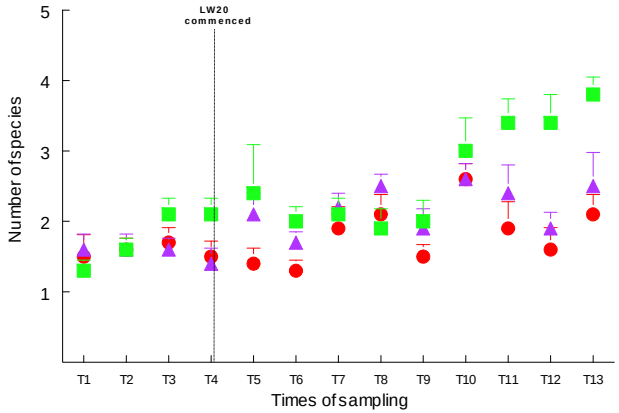


Chart 92a Mean (+SE) Macrophyte Diversity, Stream Monitoring, Tributary B

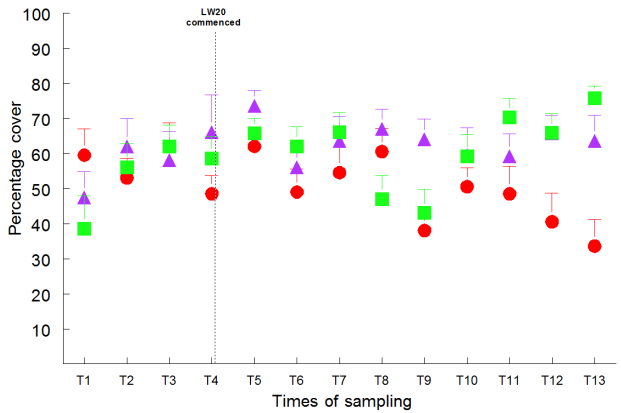


Chart 92b Mean (+SE) Macrophyte Cover, Stream Monitoring, Tributary B

Key: Tributary B (circles) and the control locations (Bee Creek: triangles; Woronora Tributary: squares) (*n* = 6). Time 1 = spring 2008, T2 = autumn 2009, etc.

Pool Monitoring

The pool monitoring program includes bi-annual (autumn and spring) monitoring of aquatic macroinvertebrates and macrophytes in pools to allow the response of aquatic ecosystems to the implementation of future stream remediation works on the Waratah Rivulet to be assessed.

Longwalls 20-22 pool monitoring surveys have been carried out from spring 2008 to autumn 2010[22] (i.e. pre-mining within the Longwalls 20-22 mining area) and since spring 2010 (i.e. during or after mining of Longwalls 20-22).

Monitoring has been carried out at the following pools:

- Larger pools, J, M1 and N on Waratah Rivulet overlying Longwalls 20-22.
- Smaller pools K, L and M on Waratah Rivulet overlying Longwalls 20-22.
- One larger control pool on Woronora River (Pool WP) and one larger control pool on O'Hares Creek (Pool OC).
- Three smaller control pools on Woronora River (Pool WP-A, WP-B and WP-C) and three smaller control pools on O'Hares Creek (Pool OC-A, OC-B and OC-C).

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

Sampling is carried out at two random sites within the larger pools and at one site within the smaller pools.

Within each site in each pool, aquatic macroinvertebrates and macrophytes are sampled using the same quantitative techniques described for stream monitoring above. The AUSRIVAS sampling technique is not used for macroinvertebrate sampling in the pool monitoring.

Quantitative estimates of aquatic macrophytes (i.e. emergent, floating attached and/or submerged species of aquatic plants) are collected at one site at each small pool and at two sites at each large pool. In addition, the spatial distribution of floating attached and/or submerged macrophytes (e.g. *Myriophyllum penduculatum* and *Triglochin procerum*) is mapped in each pool, to provide a visual comparison of their distribution through time.

A summary of the pool monitoring survey results for spring 2008 to spring 2014 is presented below.

Pool Characteristics

In spring 2014, an algal/iron floc was observed to cover up to approximately 95% of the substratum of the pools sampled along the Waratah Rivulet (i.e. Pools J, K, L, M, M1 and N). Overall, cover of the substratum by an algal/iron floc at the Waratah Rivulet pools has been observed to fluctuate considerably among sampling times. For example, an algal/iron floc was observed to cover approximately 15% of the substratum of Pool N in autumn and spring 2013 but up to 75% of the substratum in spring 2012.

[22] Pools monitored since spring 2008: larger pools - Pool N on Waratah Rivulet, Pool WP on Woronora River and Pool OC on O'Hares Creek.

Pools monitored since spring 2009: larger pools - Pools J and M1 on Waratah Rivulet; smaller pools: Pools K, L and M on Waratah Rivulet, Pools WP-A, WP-B, WP-C on Woronora River and Pools OC-A, OC-B, OC-C on O'Hares Creek.

To date, the main findings for the large pools sampled along the Waratah Rivulet include:

- Cracking of the sandstone substratum of Pools J and M1 was first noted in spring 2013 and spring 2012, respectively.
- A considerable drop in water level (~ 1.8 m) was observed in Pool N in spring 2012. Since then, water level within the pool has fluctuated. In autumn and spring 2013 and spring 2014, the water level in Pool N was similar to that reported by surveys carried out prior to spring 2012 (~ 2.0 m at its deepest point). In autumn 2014, the pool water level was noted to have dropped by ~ 0.8 m.
- For small pools sampled along the Waratah Rivulet, gas release has been observed at the upstream end of Pool L in spring 2012, spring 2013, autumn 2014 and spring 2014.

Macroinvertebrate Assemblages

Charts 93a to 93c present PCoA plots for macroinvertebrates at the larger pools using the quantitative sampling data. Charts 94a to 94d present the mean diversity of macroinvertebrates, mean abundance of macroinvertebrates, mean number of Leptophlebiidae and mean number of Atyidae, respectively, at the larger pools using the quantitative sampling data.

Chart 95 presents PCoA plots for macroinvertebrates at the smaller pools, using the quantitative sampling data. Charts 96a and 96b present the mean diversity of macroinvertebrates and mean abundance of macroinvertebrates at the smaller pools, respectively, using the quantitative sampling data.

Consistent with the findings from the autumn and spring 2013 and autumn 2014 reports, the results indicate the structure of assemblages of macroinvertebrates in the large pools sampled along the Waratah Rivulet did not differ significantly between periods (i.e. from before to after the commencement of mining), however temporal (i.e. among sampling times) variation of assemblages was larger than that measured for assemblages collected from control pools, particularly at Pools J and N. Changes in abundance of the mayfly family, Leptophlebiidae, and freshwater shrimp family, Atyidae, contributed greatly to the observed differences. A considerable spike in numbers of individuals of Leptophlebiidae and Atyidae was measured in Pool N in spring 2012 (Time 9) (Charts 94c and 94d), which coincided with a considerable drop in water level within Pool N. The next four surveys (Times 10 [autumn 2013], 11 [spring 2013], 12 [autumn 2014] and 13 [spring 2014]) found that abundances of Leptophlebiidae and Atyidae were lower than those recorded in spring 2012, yet similar to those reported by surveys carried out prior to the reduction in pool water level (Charts 94c and 94d). Most notable in spring 2014 was a considerable spike in mean abundance of Leptophlebiidae in Pool M1 (Chart 94c).

Analyses comparing temporal and spatial patterns of change in assemblages of aquatic macroinvertebrates in small pools sampled on the Waratah Rivulet with the control pools found that to date, any effect of subsidence on assemblages and their main components (e.g. Leptophlebiidae and Atyidae) appears to be within the range of natural variability as measured by the control locations (Chart 95). Notable on this sampling occasion (spring 2014), was a considerable spike in mean diversity and abundance of macroinvertebrates in the small pools sampled along the Waratah Rivulet and in the control pools (Charts 96a and 96b).

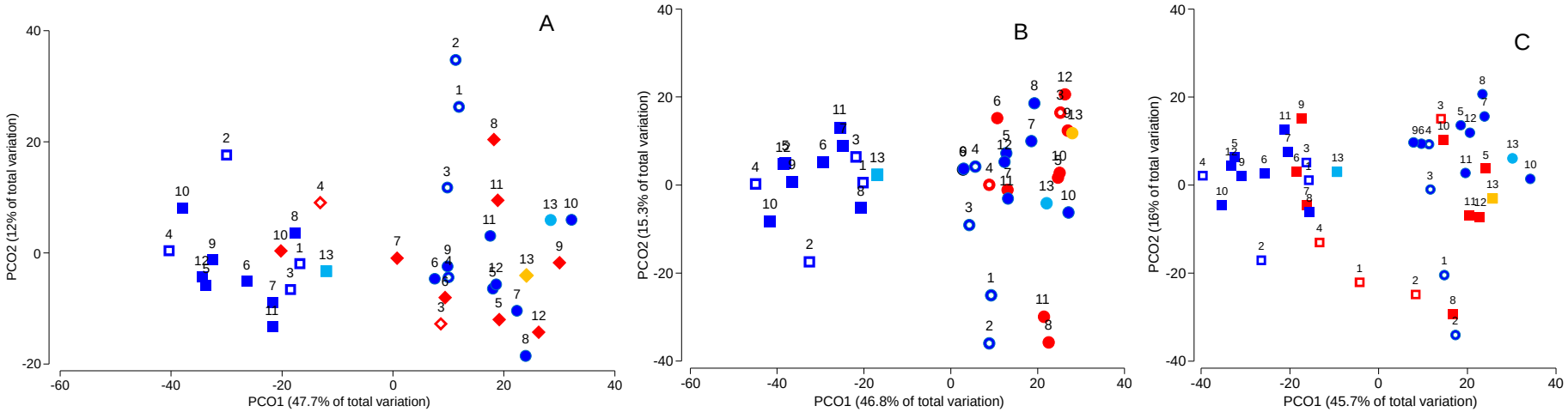


Chart 93a-c Principal Coordinates Analysis (PCoA) plots of macroinvertebrate data for each pool for each time of sampling (*n* = 6). A) Pool J: red diamonds, B) Pool M1: red circles and C) Pool N: red squares; and two control pools: Woronora River (blue squares) and O'Hares Creek (blue circles). Empty symbols: 'Before' commencement of mining; Filled symbols: 'After' mining. Numbers indicate time of sampling. Time 1 = spring 2008, T2 = autumn 2009, etc. Sampling commenced in spring 2008, with the exception of Pools J and M1 which commenced at T3 (spring 2009). Lighter symbols represent last sampling time (spring 2014).

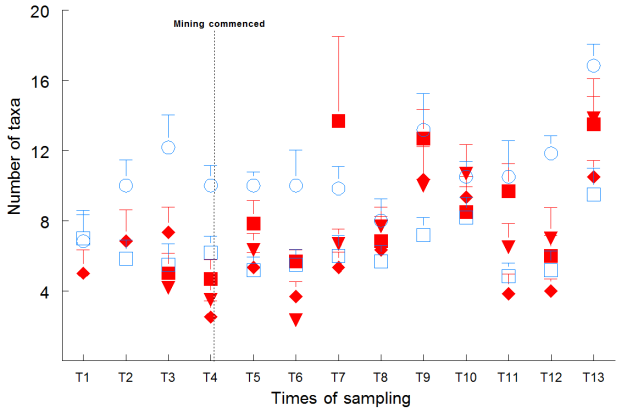


Chart 94a Mean (+SE) Macroinvertebrate Diversity, Large Pool Monitoring

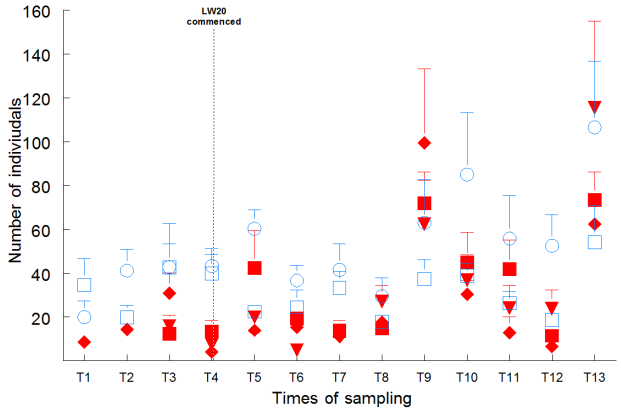


Chart 94b Mean (+SE) Macroinvertebrate Abundance, Large Pool Monitoring

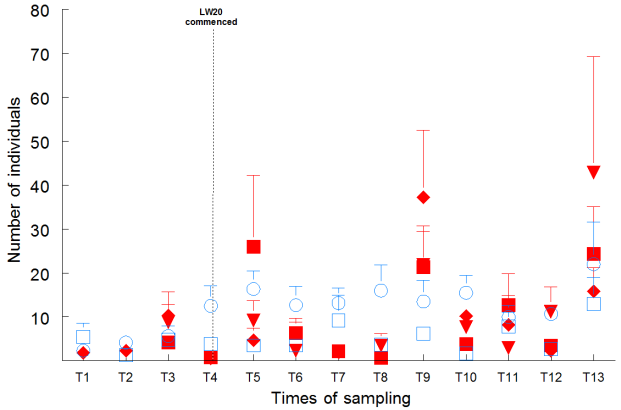


Chart 94c Mean (+SE) Number of Leptophlebiidae, Large Pool Monitoring

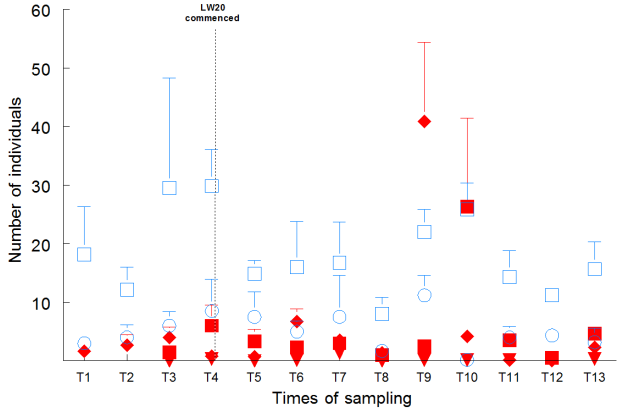


Chart 94d Mean (+SE) Number of Atyidae, Large Pool Monitoring

Key: Pool J: solid red squares; Pool M1: solid red triangles, Pool N: solid red diamonds and the control pools (Woronora Pool: open blue squares, O'Hares Pool: open blue circles).
NB Sampling of Pools J and M1 commenced at T3 (spring 2009) (*n* = 6).

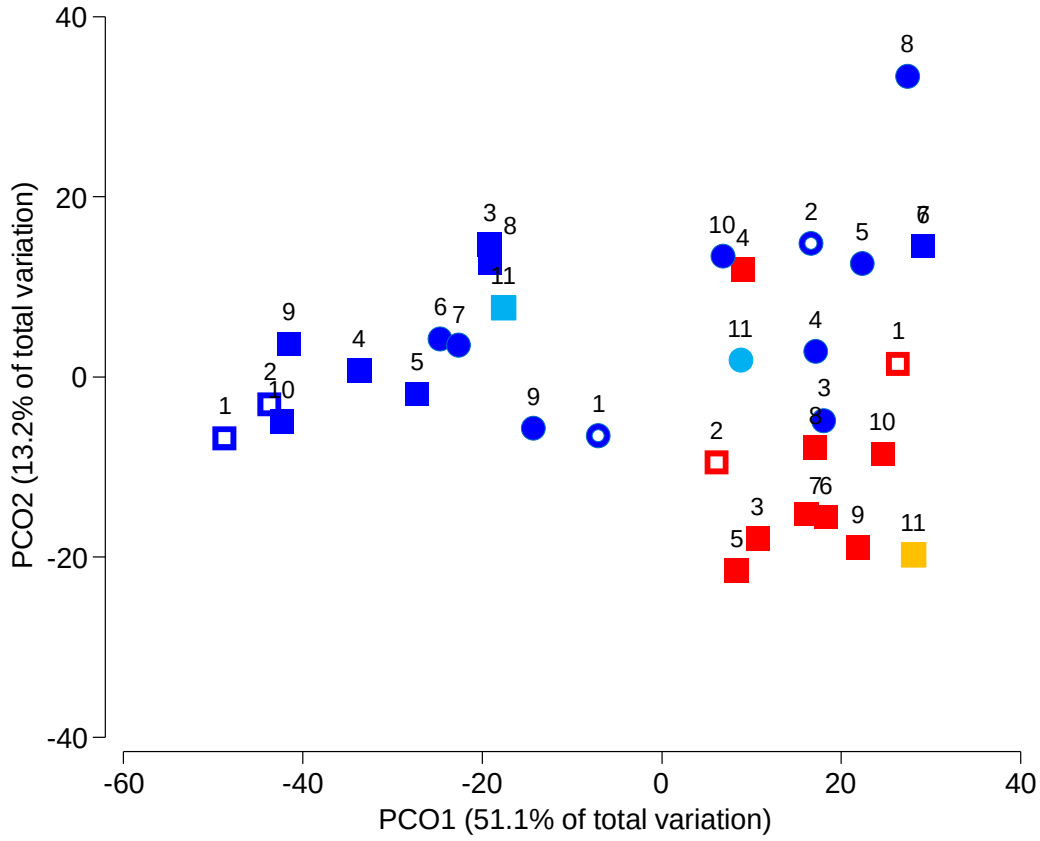


Chart 95 Principal Coordinates Analysis (PCoA) plot of macroinvertebrate data for small pools in Waratah Rivulet (red symbols), and two control streams: Woronora River (blue squares) and O'Hares Creek (blue circles). (n = 6) Empty symbols: 'Before' commencement of mining; Filled symbols: 'After' mining. Numbers indicate time of sampling. Time 1 = spring 2009, T2 = autumn 2010, etc. Sampling commenced in spring 2009. Lighter symbols represent last sampling time (spring 2014).

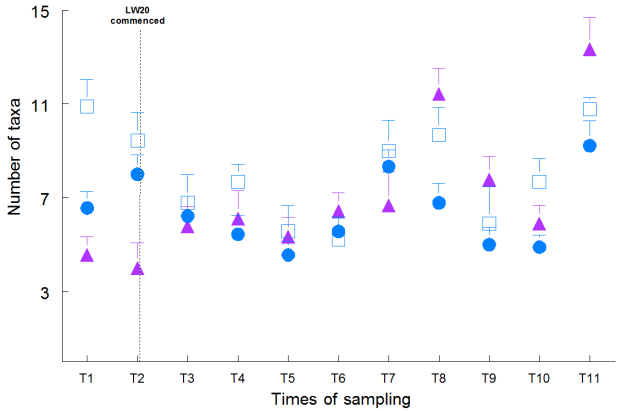


Chart 96a Mean (+SE) Macroinvertebrate Diversity, Small Pool Monitoring

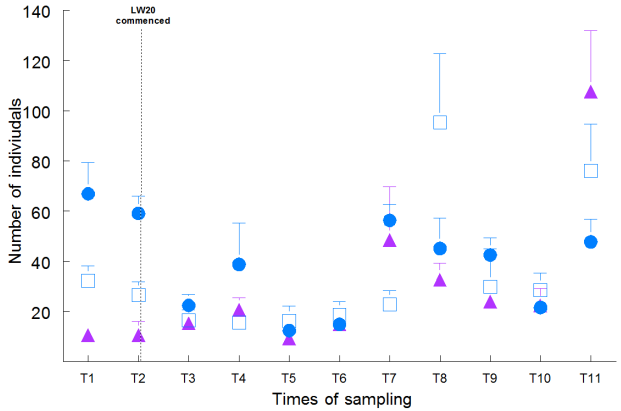


Chart 96b Mean (+SE) Macroinvertebrate Abundance, Small Pool Monitoring

Key: Waratah Rivulet Pools: solid purple triangles and the control pools (Woronora River Pools: solid blue circles, O'Hares Creek Pools: open blue squares) (*n* = 9)
NB Sampling of small pools commenced in spring 2009.

Macrophyte Assemblages

A temporal comparison of the aquatic macrophyte data has been carried out for the pools sampled from spring 2008 to spring 2014 using both multivariate and univariate techniques.

Charts 97a to 97c present the PCoA plots for macrophytes at each large pool using the quantitative sampling data. Temporal and spatial variability in the structure of assemblages of aquatic macrophytes was observed at all locations. Charts 98a and 98b present the mean diversity and mean abundance of macrophytes at the larger pools using the quantitative sampling data.

Chart 99 presents PCoA plots for macrophytes at the smaller pools, using the quantitative sampling data. Charts 100a and 100b present the mean diversity and mean abundance of macrophytes at the smaller pools, respectively, using the quantitative sampling data.

Results from analyses examining patterns of change of aquatic macrophytes in large pools found that in general:

- Assemblages in Pools J and M1 on Waratah Rivulet have consistently differed from those found in control pools (WR1 and OC pools) (Charts 98a and 98b), most likely due to the absence of *Triglochin procerum* in Pools J and M1.
- Chart 97c shows that the assemblages of macrophytes in Pool N have grouped separately from prior sampling occasions since spring 2012 (when the pool water level dropped considerably). SIMPER analyses show that changes were mostly due to a general decrease in the mean total percentage cover of macrophytes, particularly *Triglochin procerum* and *Gleichenia dicarpa*, which occurred after the water level in the pool dropped substantially in spring 2012.

Assemblages of macrophytes at the small pools on the Waratah Rivulet have changed since spring 2012, but not at the control pools (Chart 99). The differences were found to be statistically significant. Macrophyte assemblages found at the small pools are quite distinctive among streams, due to the fact that different species dominated assemblages in small pools in each stream. For example, the species *Gleichenia dicarpa* has commonly been the most abundant species recorded at small pools on Waratah Rivulet, whereas *Triglochin procerum,* which has not been recorded in the small pools sampled along the Waratah Rivulet, has commonly been very abundant in pools sampled on the Woronora River. Temporal changes in the small pools sampled along the Waratah Rivulet were due to an increase of relative cover of the species *Drosera binata, Eurychorda complanata, Isolepis inundata* and *Viminaria juncea.* These changes are not considered to be related to mining activities.

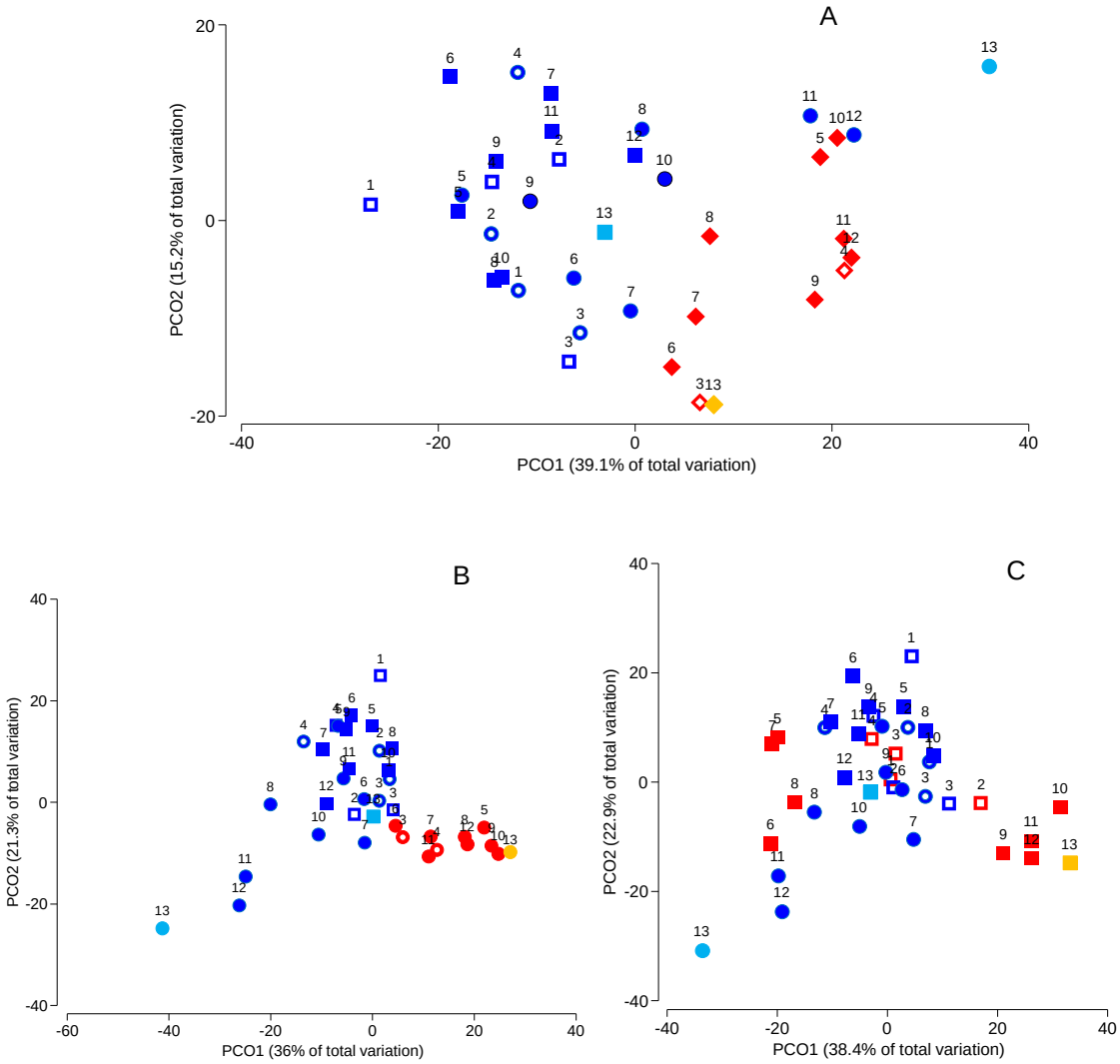


Chart 97a-c Principal Coordinates Analysis (PCoA) plots of macrophyte data for each large pool for each time of sampling (*n* = 10). A) Pool J: red diamonds, B) Pool M1: red circles and C) Pool N: red squares; and two control pools: Woronora River (blue squares) and O'Hares Creek (blue circles). Empty symbols: 'Before' commencement of mining; Filled symbols: 'After' mining. Numbers indicate time of sampling. Time 1 = spring 2008, T2 = autumn 2009, etc. Sampling commenced in spring 2008, with the exception of Pools J and M1 which commenced at T3 (spring 2009). Lighter symbols represent last sampling time (spring 2014).

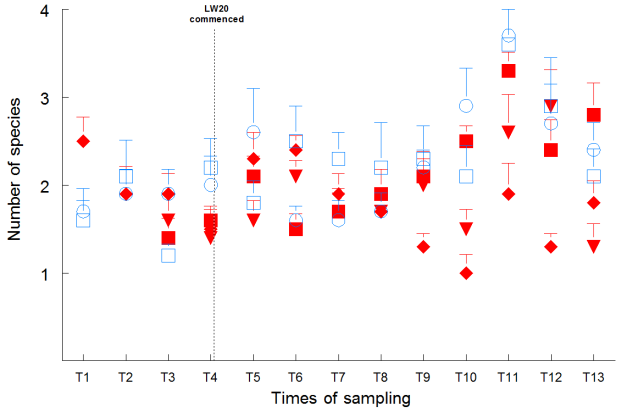


Chart 98a Mean (+SE) Macrophyte Diversity, Large Pool Monitoring

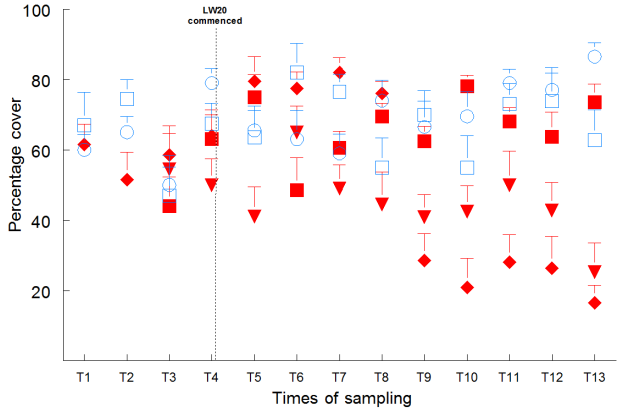


Chart 98b Mean (+SE) Macrophyte Percentage Cover, Large Pool Monitoring

Key: Pool J: solid red squares; Pool M1: solid red triangles, Pool N: solid red diamonds and the control pools (Woronora Pool: open blue squares, O'Hares Pool: open blue circles).
NB Sampling of Pools J and M1 commenced at T3 (spring 2009) (*n* = 10).

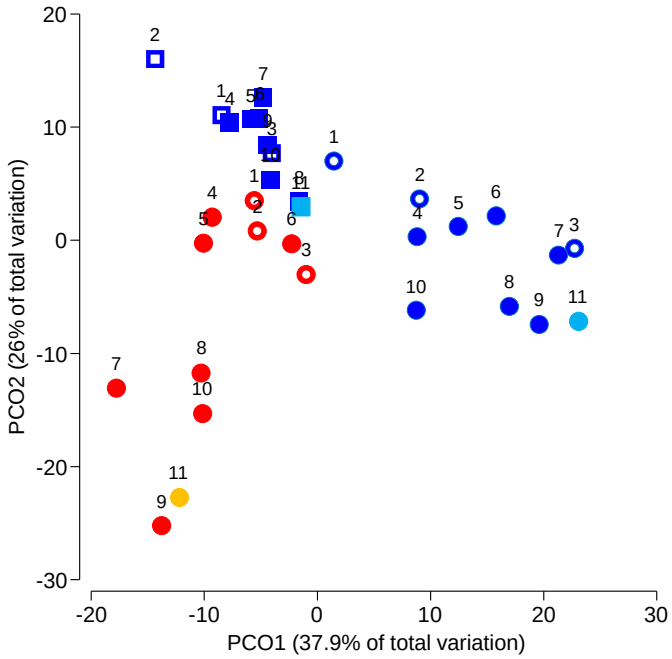


Chart 99 Principal Coordinates Analyses (PCoA) of centroids per location per time using Bray-Curtis dissimilarities based on macrophyte data (non-transformed) for small pools in Waratah Rivulet (red symbols), and two control streams: Woronora River (blue squares) and O'Hares Creek (blue circles). Empty symbols: 'Before' commencement of mining; Filled symbols: 'After' mining. Time 1 = spring 2009, T2 = autumn 2010, etc. Sampling commenced in spring 2009. Lighter symbols represent last sampling time (spring 2014).

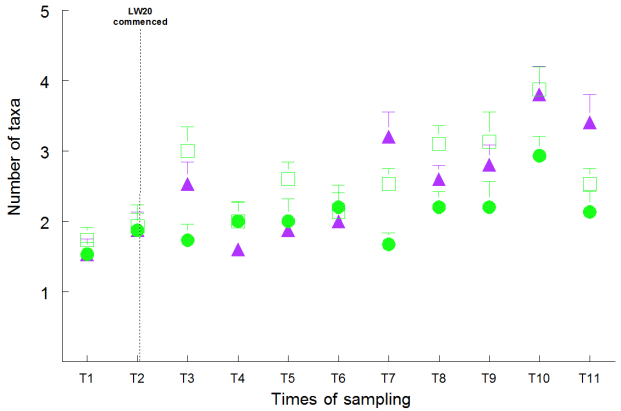


Chart 100a Mean (+SE) Macrophyte Diversity, Small Pool Monitoring

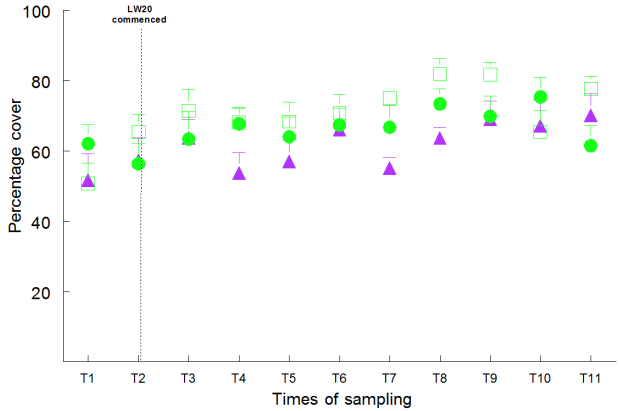


Chart 100b Mean (+SE) Macrophyte Abundance, Small Pool Monitoring

Key: Waratah Rivulet Pools: solid purple triangles and the control pools (Woronora River Pools: solid green circles, O'Hares Creek Pools: open green squares) (*n* = 12)
NB Sampling of small pools commenced in spring 2009.

3.2.1.5 Amphibian Surveys

A monitoring program has been developed for Longwalls 20-22 to monitor amphibian species, with a focus on the habitats of the Giant Burrowing Frog (*Heleiporus australiiacus*) and Red-crowned Toadlet (*Pseudophryne australis*) associated with tributaries.

Six test sites overlying Longwalls 20-22 and six control sites are surveyed annually in spring/summer (i.e. October to February) during suitable weather conditions. The approximate locations of the sampling sites in relation to longwall panels are shown on Figure 14.

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

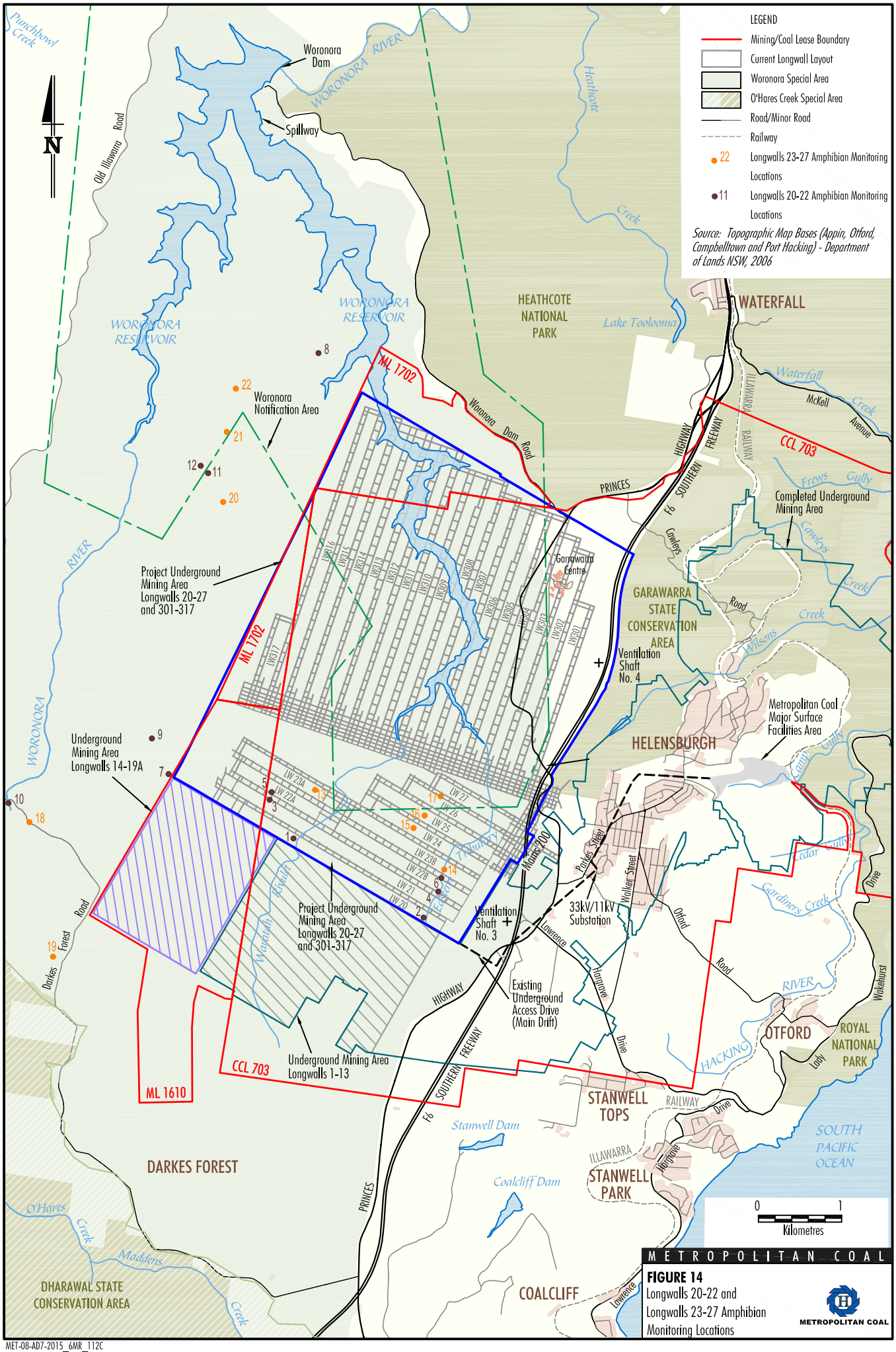
Species are assigned to the following relative abundance categories for tadpole and adult stages:

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

Baseline monitoring was conducted in spring/summer 2009 and 2010. Longwall 20 commenced in May 2010 and Longwall 22 was completed in April 2014. Longwall 23 commenced in May 2014. At the time of the spring/summer 2014 survey all test sites had been undermined.

The results of the six surveys to date (2009-2014) are summarised in Table 5, Table 6 and Chart 101.

Chart 101 presents the number of amphibian species recorded at each site in 2009 to 2014.



MET-08-AD7-2015_6MR_112C

Table 5
Amphibian Species Diversity and Abundance for Longwalls 20-22, Spring/Summer 2009 – 2014

Scientific Name	Common Name	Survey	Sites Above Longwalls 20-22						Control Sites						Total		Relative Abundance[2]	
			1	2	3	4	5	6	7	8	9	10	11	12	Test	Control	Test	Control
Myobatrachidae																		
Crinia signifera	Common Eastern Froglet	2009	1[1] 0	1 0	1 0	>10 0	2 0	1 0	1 0	0 0	0 0	5 >10	0 0	0 0	>16 0	6 >10	MC 0	UC MC
		2010	3 0	4 0	3 c100	2 0	3 0	5 0	4 0	3 0	0 0	4 30	1 27	2 6	20 c100	14 c233	MC A	MC A
		2011	3 0	9 0	7 0	3 0	7 0	0 0	10 0	4 10	3 0	8 c100	0 0	0 0	29 0	25 c110	C 0	C A
		2012	3 0	0 0	5 100	1 0	6 10	0 0	23 0	20 6	5 0	12 25	0 0	3 0	15 110	63 31	MC A	A A
		2013	2 1	1 0	11 0	3 16	3 0	1 0	0 0	2 0	1 0	7 5	0 0	0 0	21 17	10 5	C MC	UC UC
		2014	7 0	3 0	2 30	0 0	3 10	3 0	8 0	22 0	6 0	22 200+	24 0	3 0	18 40	85 200	MC C	A A
Heleiporus australiiacus	Giant Burrowing Frog[v, v]	2009	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 1	0 0	0 0	0 0	0 1	0 0	0 1
		2010	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2011	0 0	0 0	0 0	1 0	0 0	0 0	0 5	0 0	0 0	0 0	0 0	0 0	1 0	0 5	1 0	0 UC
		2012	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2013	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2014	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0

Table 5 (Continued)
Amphibian Species Diversity and Abundance for Longwalls 20-22, Spring/Summer 2009 – 2014

Scientific Name	Common Name	Survey	Sites Above Longwalls 20-22						Control Sites						Total		Relative Abundance[2]	
			1	2	3	4	5	6	7	8	9	10	11	12	Test	Control	Test	Control
Myobatrachidae																		
Limnodynastes peronii	Brown-striped Frog	2009	0 0	0 0	0 0	1 0	1 0	1 0	0 0	0 0	0 0	2 0	0 0	0 0	3 0	2 0	UC 0	UC 0
		2010	0 0	0 0	0 53	0 0	0 76	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 129	0 0	0 A	0 0
		2011	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 c100	0 0	0 0	0 0	0 0	0 0	0 c100	0 0	0 A
		2012	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2013	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2014	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
Limnodynastes tasmaniensis	Spotted Grass Frog	2009	0 0	0 0	0 0	0 0	0 0	0 0	1 0	0 0	0 0	0 0	0 0	0 0	0 0	1 0	0 0	1 0
		2010	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2011	0 0	0 0	1 0	0 0	3 0	0 0	0 0	0 c100	0 0	0 0	0 0	0 0	4 0	0 c100	UC 0	0 A
		2012	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2013	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2014	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 100+	0 0	0 0	0 0	0 0	0 0	0 100	0 0	0 A

Table 5 (Continued)
Amphibian Species Diversity and Abundance for Longwalls 20-22, Spring/Summer 2009 – 2014

Scientific Name	Common Name	Survey	Sites Above Longwalls 20-22						Control Sites						Total		Relative Abundance[2]	
			1	2	3	4	5	6	7	8	9	10	11	12	Test	Control	Test	Control
Myobatrachidae																		
Pseudophryne australis	Red-crowned Toadlet[v]	2009	0 0	1 0	2 0	2 0	0 0	0 0	1 0	0 0	1 0	1 0	0 0	0 0	5 0	3 0	UC 0	UC 0
		2010	0 0	1 0	7 0	1 0	6 0	9 0	0 0	0 0	0 0	1 0	1 0	2 0	24 0	4 0	C 0	UC 0
		2011	0 0	1 0	1 10	3 0	4 0	0 0	0 0	0 5	0 0	0 c100	0 0	0 0	9 10	0 c105	UC UC	0 A
		2012	0 0	0 0	1 0	0 0	2 0	0 0	0 0	2 0	0 0	1 1	0 0	0 0	3 0	3 1	UC 0	UC 1
		2013	0 0	0 0	1 5	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	1 5	0 0	1 UC	0 0
		2014	1 0	0 0	3 0	0 0	1 0	0 0	4 0	6 0	2 0	1 0	2 0	2 0	5 0	17 0	UC 0	MC 0
Uperoleia laevigata	Smooth Toadlet	2009	0 0	0 0	0 0	1 0	0 0	0 0	0 0	0 0	0 0	1 0	0 0	0 0	1 0	1 0	1 0	1 0
		2010	0 0	2 0	2 10	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	4 10	0 0	UC UC	0 0
		2011	0 0	0 0	0 0	0 0	0 0	0 0	2 0	0 0	0 5	0 0	0 0	0 0	0 0	2 5	0 0	UC UC
		2012	0 0	0 0	0 0	0 0	0 0	0 0	0 0	1 0	0 0	0 0	0 0	0 0	0 0	1 0	0 0	1 0
		2013	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2014	0 0	0 0	0 0	0 0	0 0	0 0	1 0	0 0	0 0	0 100+	0 0	0 0	0 0	1 100	0 0	1 A

Table 5 (Continued)
Amphibian Species Diversity and Abundance for Longwalls 20-22, Spring/Summer 2009 – 2014

Scientific Name	Common Name	Survey	Sites Above Longwalls 20-22						Control Sites						Total		Relative Abundance[2]	
			1	2	3	4	5	6	7	8	9	10	11	12	Test	Control	Test	Control
Hylidae																		
Litoria citropa	Blue Mountains Tree Frog	2009	0 0	1 0	0 0	1 0	0 0	1 0	0 0	0 0	0 0	0 0	0 0	0 0	3 0	0 0	UC 0	0 0
		2010	4 0	0 0	3 4	0 0	2 0	0 0	0 0	0 0	0 0	1 0	0 0	0 0	9 4	1 0	UC UC	1 0
		2011	0 0	0 0	0 2	0 0	2 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	2 2	0 0	UC UC	0 0
		2012	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	2 0	1 0	0 0	0 0	0 0	3 0	0 0	UC 0
		2013	0 0	1 0	0 0	1 3	0 0	0 0	0 0	0 0	0 0	0 35	0 0	0 0	2 3	0 35	UC UC	0 C
		2014	0 0	2 0	0 0	1 0	0 0	0 0	0 0	0 0	0 0	0 10	0 0	0 0	3 0	0 10	UC 0	0 UC
Litoria dentata	Bleating Tree Frog	2009	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2010	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	3 0	3 15	0 0	0 0	6 15	0 0	UC MC
		2011	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2012	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2013	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2014	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0

Table 5 (Continued)
Amphibian Species Diversity and Abundance for Longwalls 20-22, Spring/Summer 2009 – 2014

Scientific Name	Common Name	Survey	Sites Above Longwalls 20-22						Control Sites						Total		Relative Abundance[2]	
			1	2	3	4	5	6	7	8	9	10	11	12	Test	Control	Test	Control
Hylidae																		
Litoria freycineti	Southern Rocket Frog	2009	0	0	0	0	5	1	0	0	0	2	0	0	6	2	UC	UC
			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2010	3	1	2	0	0	0	1	0	0	4	0	1	6	6	UC	UC
			0	8	0	0	0	0	0	c1000	0	38	0	3	8	c1041	UC	A
		2011	0	0	0	0	0	0	6	1	6	0	0	0	0	13	0	MC
			0	0	30	0	0	0	0	c200	40	1	0	0	30	c241	C	A
		2012	0	0	0	1	0	0	0	1	2	0	0	0	1	3	1	UC
			0	0	0	0	0	0	0	10	0	1	0	0	0	11	0	MC
		2013	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0
			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2014	0	1	0	1	0	0	1	1	0	0	0	0	2	2	UC	UC
			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Litoria latopalmata	Broad-palmed Frog	2009	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	c500	0	0	0	c500	0	0	c1000	0	A
		2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2014	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 5 (Continued)
Amphibian Species Diversity and Abundance for Longwalls 20-22, Spring/Summer 2009 – 2014

Scientific Name	Common Name	Survey	Sites Above Longwalls 20-22						Control Sites						Total		Relative Abundance[2]	
			1	2	3	4	5	6	7	8	9	10	11	12	Test	Control	Test	Control
Hylidae																		
Litoria lesueurii	Lesueur's Frog	2009	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2010	0	2	0	2	0	4	0	0	0	0	0	0	8	0	UC	0
			42	0	10	0	0	0	0	0	0	0	0	0	52	0	A	0
		2011	2	2	0	3	0	1	0	0	0	2	0	0	8	2	UC	UC
			0	0	4	0	0	0	0	0	0	5	0	0	4	5	UC	UC
		2012	1	0	0	1	0	0	0	0	0	0	0	0	2	0	UC	0
			0	0	0	0	0	0	0	0	0	10	0	0	0	10	0	UC
		2013	0	1	0	2	0	2	0	0	0	0	0	0	5	0	UC	0
			20	0	0	1	0	0	0	0	0	0	0	0	21	0	C	0
		2014	0	0	0	0	0	0	0	0	0	10	0	0	0	10	0	UC
			0	0	0	0	0	0	0	0	0	5	0	0	0	5	0	UC
Litoria wilcoxii	Stony Creek Frog	2009	0	10	0	0	3	0	0	0	0	4	0	0	13	4	MC	UC
			0	0	0	0	0	0	0	0	0	2	0	0	0	2	0	UC
		2010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2014	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 5 (Continued)
Amphibian Species Diversity and Abundance for Longwalls 20-22, Spring/Summer 2009 – 2014

Scientific Name	Common Name	Survey	Sites Above Longwalls 20-22						Control Sites						Total		Relative Abundance[2]	
			1	2	3	4	5	6	7	8	9	10	11	12	Test	Control	Test	Control
Hylidae																		
Litoria peronii	Peron's Tree Frog	2009	0 0	1 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	1 0	0 0	1 0	0 0
		2010	0 0	0 0	0 0	0 0	0 0	0 0	3 c1000	0 0	0 0	2 0	0 0	2 0	0 0	7 c1000	0 0	UC A
		2011	0 0	0 0	0 0	0 0	0 0	0 0	0 0	1 1	0 0	0 0	0 0	0 0	0 0	1 1	0 0	1 1
		2012	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	1 0	0 0	0 0	0 0	1 0	0 0	1 0
		2013	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2014	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 10	0 0	0 0	0 0	0 10	0 0	0 UC
Litoria phyllochroa	Green Stream Frog	2009	0 0	0 0	0 0	2 0	1 0	>5 0	0 0	0 0	0 0	0 0	0 0	0 0	>8 0	0 0	UC 0	0 0
		2010	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2011	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2012	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2013	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2014	0 0	1 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	1 0	0 0	1 0	0 0
Species Diversity at Each Site		2009	**1**	**5**	**2**	**6**	**5**	**5**	**3**	**0**	**1**	**7**	**0**	**0**				
		2010	**4**	**5**	**7**	**3**	**4**	**3**	**4**	**2**	**0**	**6**	**4**	**4**				
		2011	**3**	**3**	**6**	**4**	**4**	**1**	**3**	**6**	**3**	**5**	**0**	**0**				
		2012	**2**	**0**	**2**	**3**	**2**	**0**	**1**	**4**	**3**	**6**	**0**	**1**				
		2013	**2**	**3**	**2**	**3**	**2**	**2**	**0**	**1**	**1**	**2**	**0**	**0**				
		2014	**2**	**4**	**2**	**2**	**1**	**1**	**4**	**4**	**2**	**6**	**2**	**2**				

Table 5 (Continued)
Amphibian Species Diversity and Abundance for Longwalls 20-22, Spring/Summer 2009 – 2014

Scientific Name	Common Name	Survey	Sites Above Longwalls 20-22						Control Sites						Total		Relative Abundance[2]	
			1	2	3	4	5	6	7	8	9	10	11	12	Test	Control	Test	Control
Species Diversity in all Control and all Test sites		2009													**9**	**8**		
		2010													**7**	**7**		
		2011													**7**	**9**		
		2012													**4**	**7**		
		2013													**5**	**2**		
		2014													**5**	**8**		
Species Diversity across the survey site		2009													**11**			
		2010													**10**			
		2011													**10**			
		2012													**7**			
		2013													**5**			
		2014													**9**			

[1] First line of data refers to the presence or absence of adults, while the second line of data refers to absence or presence of tadpoles.

[2] Relative Abundance of adult and tadpole stage assessed independently: 0 – no sightings, 1 – One sighting, UC – Uncommon, 2 to 10 individuals, MC – Moderately common, 11 to 20 individuals, C – Common, 21 to 40 individuals, A – Abundant, >40 individuals, c1000 = approximately 1,000 animals estimated.

[V, V] Listed as vulnerable under the TSC Act and EPBC Act. [V] Listed as vulnerable under the TSC Act.

Table 6
Number of Longwalls 20-22 Sites used per Amphibian Species in 2009 - 2014

Species	Test Sites						Control Sites					
	2009	2010	2011	2012	2013	2014	2009	2010	2011	2012	2013	2014
Common Eastern Froglet	6	6	5	4	6	5	2	5	4	5	3	6
Giant Burrowing Frog [V, V]	0	0	1	0	0	0	1	0	1	0	0	0
Brown-striped Frog	3	2	0	0	0	0	1	0	1	0	0	0
Spotted Grass Frog	0	0	2	0	0	0	1	0	1	0	0	1
Red-crowned Toadlet [V]	3	5	4	2	1	3	3	3	2	2	1	6
Smooth Toadlet	1	2	0	0	0	0	1	0	2	1	0	2
Blue Mountains Tree Frog	3	3	2	0	2	2	0	1	0	2	2	1
Bleating Tree Frog	0	0	0	0	0	0	0	2	0	0	0	0
Southern Rocket Frog	2	3	1	1	1	2	1	4	4	3	0	2
Broad-palmed Frog	0	0	0	0	0	0	0	2	0	0	0	0
Lesueur's Frog	0	5	5	2	4	0	0	0	1	1	0	1
Stony Creek Frog	2	0	0	0	0	0	1	0	0	0	0	0
Peron's Tree Frog	1	0	0	0	0	0	0	3	1	1	0	1
Green Stream Frog	3	0	0	0	0	1	0	0	0	0	0	0

Note: Test sites include 1 to 6 and control sites include 7 to 12 (i.e. a total of 6 test sites and 6 control sites).
[V, V] Listed as vulnerable under the TSC Act and EPBC Act. [V] Listed as vulnerable under the TSC Act.

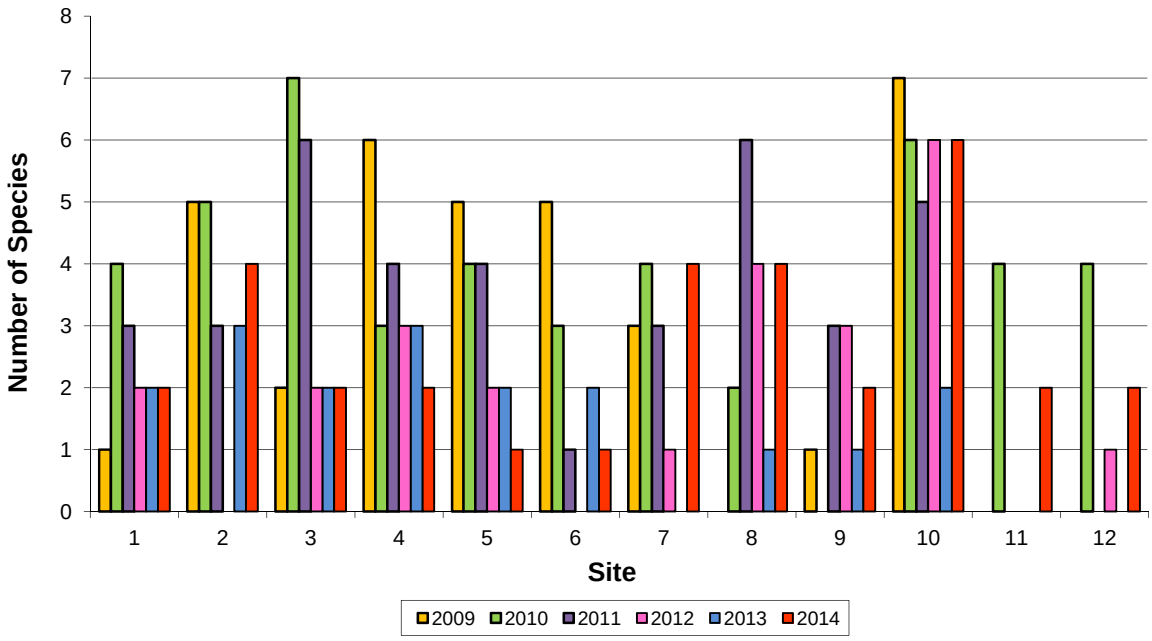


Chart 101 **Amphibian Species Diversity, 2009 – 2014**

In summary, the amphibian survey results from 2009 to 2014 indicated:

- A total of 14 amphibian species have been recorded in the 2009 to 2014 surveys, namely the Common Eastern Froglet (*Crinia signifera*), Giant Burrowing Frog (*Heleiporus australiiacus*), Brown-striped Frog (*Limnodynastes peronii*), Spotted Grass Frog (*Limnodynastes tasmaniensis*), Red-crowned Toadlet (*Pseudophryne australis*), Smooth Toadlet (*Uperoleia laevigata*), Blue Mountains Tree Frog (*Litoria citropa*), Bleating Tree Frog (*Litoria dentata*), Southern Rocket Frog (*Litoria freycineti*), Broad-palmed Frog (*Litoria latopalmata*), Lesueur's Frog (*Litoria lesueurii*), Stony Creek Frog (*Litoria wilcoxii*), Peron's Tree Frog (*Litoria peronii*) and Green Stream Frog (*Litoria phyllochroa)*.
- In 2009, 11 amphibian species were located across the survey area including nine in test sites and eight in control sites. In comparison ten amphibian species were located in the survey area in 2010 including seven species in test sites and seven species in control sites. In 2011, ten species were located in the survey area including seven species in test sites and nine species in control sites. Seven amphibian species were located in the survey area in 2012 including four species in test sites and seven species in control sites. In 2013, five amphibian species were located across the survey area including five in test sites and two in control sites. In 2014, nine species were located in the survey area including five in test sites and eight in control sites.
- Species diversity at individual sites ranged from 1-6 species at test sites and 0-7 species at control sites in 2009, from 3-7 species at test sites and 0-6 species at control sites in 2010, 1-6 species at test sites and 0-6 species at control sites in 2011, 0-3 species at test sites and 0-6 species at control sites in 2012, 2-3 species at test sites and 0-2 species at control sites in 2013, and 1-4 species at test sites and 2-6 species at control sites in 2014.
- The most species diverse site in 2009 was control site 10 with seven species recorded. In 2010 the most species diverse site was test site 3 with seven species. In 2011 the most species diverse sites were test site 3 and control site 8, both with six species. In 2012 the most species diverse site was control site 10 with six species recorded. In 2013 the most species diverse sites were test sites 2 and 4, both with three species. In 2014 the most species diverse site was control site 10 with six species recorded.
- Breeding success has been infrequently observed over the 2009 to 2014 survey period:
  - In 2009, breeding events were identified for no species at test sites and three species at control sites (Common Eastern Froglet, Giant Burrowing Frog and Stony Creek Frog).
  - In 2010, breeding events were identified for six species at test sites (Common Eastern Froglet, Brown-striped Frog, Smooth Toadlet, Blue Mountains Tree Frog, Southern Rocket Frog and Lesueur's Frog) and five species at control sites (Common Eastern Froglet, Bleating Tree Frog, Southern Rocket Frog, Broad-palmed Frog and Peron's Tree Frog).
  - In 2011, breeding events were identified for four species at test sites (Red-crowned Toadlet, Blue Mountains Tree Frog, Southern Rocket Frog and Lesueur's Frog) and nine species at control sites (Common Eastern Froglet, Giant Burrowing Frog, Brown-striped Frog, Spotted Grass Frog, Red-crowned Toadlet, Smooth Toadlet, Southern Rocket Frog, Lesueur's Frog and Peron's Tree Frog).
  - In 2012, breeding events were identified for one species at test sites (Common Eastern Froglet) and four species at control sites (Common Eastern Froglet, Red-crowned Toadlet, Southern Rocket Frog and Lesueur's Frog).
  - In 2013, breeding events were identified for four species at test sites (Common Eastern Froglet, Red-crowned Toadlet, Blue Mountains Tree Frog and Lesueur's Frog) and two species at control sites (Common Eastern Froglet and Blue Mountains Tree Frog).

  - In 2014, breeding events were identified for one species at test sites (Common Eastern Froglet) and six species at control sites (Common Eastern Froglet, Spotted Grass Frog, Smooth Toadlet, Lesueur's Frog, Blue Mountains Tree Frog and Peron's Tree Frog).

- The Giant Burrowing Frog (*Heleiporus australiiacus*) was not present during the 2014 surveys. The species has only been recorded at test site 4 in 2011.
- The Red-crowned Toadlet (*Pseudophryne australis*) was recorded in 2009 (uncommon), 2010 (common), 2011 (uncommon), 2012 (uncommon), 2013 (one individual), and 2014 (uncommon) at test sites and in 2009 (uncommon), 2010 (uncommon), 2011 (no sightings), 2012 (uncommon), 2013 (no sightings) and 2014 (moderately common) at control sites.
- A Poisson regression analysis has been used to analyse the amphibian survey results obtained to date. The adult amphibian data gathered since 2009 is non-normally distributed and characterised by significant occurrences of zero data. Such data require non-normal analysis to determine if potential adverse impacts are significant at the 95% confidence level. To date, no adverse impact from mining has been detected for any frog species including the Giant Burrowing Frog and Red-crowned Toadlet, at the 95% confidence level.
- The amphibian species diversity and abundance data are consistent with population variations and cycles in response to seasonal variations. There are no significant differences between the test and control sites.

3.2.2 Longwalls 23-27

3.2.2.1 Upland Swamp Vegetation Monitoring

Thirteen upland swamps, *viz*. Swamps 19, 23, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35 and 36[23] occur above or immediately adjacent to Longwalls 23-27 (Figure 10).

Two swamp substrate characterisation studies have also been conducted to contribute to Metropolitan Coal's understanding of the ecological, hydrological and geomorphic processes of swamps over Longwalls 23-27.

With the exception of Swamp 28, which supports Banksia Thicket and in the lower portion of the swamp Tea Tree Thicket, all the swamps over Longwalls 23-27 comprise either Banksia Thicket or Restioid Heath, or a combination of the two. Transitions between Restioid Heath and Banksia Thicket are thought to be driven by fire frequency.

The upland swamp vegetation monitoring program includes visual monitoring, transect/quadrat monitoring and monitoring of indicator species, as described below.

Visual Inspections

Visual inspections are conducted monthly of Swamps 19, 23, 26, 27, 28, 30, 31, 32, 33, 34, 35, 36, 93, 94, 96, 97 and 98 overlying or adjacent to Longwalls 23-27 for the period of time that Longwalls 23-27 are within 400 m of the swamp to record evidence of potential subsidence impacts.

[23] Thirteen swamps mapped by Bangalay Botanical Surveys (2008) are located above or immediately adjacent to Longwalls 23-27, namely, Swamps 19, 23, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35 and 36 (Figure 10). Swamp 29 (Figure 10) is mapped as Sedgeland-heath Complex (Bangalay Botanical Surveys, 2008; National Parks and Wildlife Service, 2003), however field inspections by Eco Logical Australia for the Longwalls 23-27 vegetation monitoring program indicated that this is not a swamp. The vegetation is similar to sandstone heath woodland, being dominated by *Angophora costata, Corymbia gummifera* and *Eucalyptus oblonga,* with an understorey of *Banksia ericifolia, Acacia ulicifolia, Leptospermum trinervium, Kunzea ambigua, Dillwynia retorta* and *Schoenus ericetorum*. Accordingly, no further consideration of Swamp 29 is given (in the context of it being an upland swamp).

Visual inspections of the swamps overlying and immediately adjacent to Longwalls 23-27 and at the control swamps (Swamps 101, 111a, 125, 135, 136, 137a, 137b, 138, Bee Creek Swamp, Woronora River 1, Woronora River South Arm and Dahlia Swamp) (Figures 10 and 11) are also conducted at the same time as the vegetation surveys.

Traverses covering the majority of the extent of the swamp are conducted to record:

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

Photographs of any cracking, erosion, water colour changes and vegetation senescence are taken concurrently with a description of the magnitude and extent of the observations, and appropriate GPS readings. Seepage is documented by photographs of flow over exposed surfaces.

Swamps overlying and immediately adjacent to Longwalls 23-27 have been inspected monthly by Metropolitan Coal when mining was within 400 m of the swamps. No major cracking of exposed bedrock areas or swamp sediments was observed during the visual inspections by Metropolitan Coal. Similarly, no areas of increased erosion, changes in water colour or changes in vegetation condition were observed. The amount of seepage observed during the visual inspections was relative to rainfall events prior to the inspections.

Visual inspections by Eco Logical Australia have been conducted biannually since spring 2010 in Swamps 19, 27, 28, 30, 31, 32, 33, 34, 35, 36, 93, 94, 96, 97, 98, 135, 136, 137a, 137b, 138 and Bee Creek Swamp. Visual inspection monitoring at Swamps 23, 26, 101, 111a and 125 has been conducted biannually since spring 2008 as a component of the Longwalls 20-22 upland swamp vegetation monitoring program. Surveys conducted up to and including the spring 2013 survey represent baseline surveys.

A summary of the visual observations by Eco Logical Australia up to spring 2013 (i.e. prior to the commencement of Longwall 23) is provided in the Metropolitan Coal Six Monthly Report, 1 January to 30 June 2014. A summary of the visual observations by Eco Logical Australia in autumn 2014 is provided in the Metropolitan Coal Six Monthly Report, 1 July to 31 December 2014 and the Metropolitan Coal 2014 Annual Review and AEMR/Rehabilitation Report.

The following provides a summary of the visual observations made during traverses covering the majority of the extent of each swamp by Eco Logical Australia in spring 2014 during the mining of Longwall 23.

- No cracking of exposed bedrock areas or swamp sediments was observed in either longwall or control swamps, other than where minor cracks in exposed bedrock identified during the baseline surveys, considered to be a weathering artefact, occur (Swamps 23, 26 and 31).
- Active erosion was absent from most upland swamps in spring 2014. Minor erosion was observed at Swamps 26, 32 and 98, and at control swamps 101 and Woronora River South Arm. In these locations the observed erosion was minor and limited in extent to access tracks or areas of bare soil.

- For the Restioid Heath and Banksia Thicket swamps the occurrence of seepage in spring 2014 was variable within longwall and control swamps. In longwall swamps the amount of seepage observed ranged from absent (Swamps 23, 28, 32, 34, 93, 95, 96, 97 and 98) to minor (Swamps 26, 27, 31 and 33), to common or abundant (Swamps 19, 30, 35, 36 and 94). Similarly within control swamps seepage ranged from absent (Swamps 101, 111a, 136, 137b and Bee Creek Swamp) to minor (Swamps 135, 137a and 138) to abundant (Swamp 125).
- For the Tea Tree Thicket sites Woronora River 1 and Woronora River South Arm moist to saturated soils and areas of minor standing water were observed, whilst Dahlia Swamp contained moist soils only. Soil sediments were dry at longwall Swamp 28, no water ponding was recorded and the drainage lines adjacent to the swamp were dry.
- Across all upland swamps, no changes in water colour or areas of water ponding were observed in either longwall or control swamps in spring 2014.
- For the valley side swamps (Restioid Heath and Banksia Thicket swamps), vegetation at both longwall and control sites was found to be generally in good condition in spring 2014 with no unusual areas of vegetation senescence observed. Some isolated dieback and senescence of individuals occurred throughout all longwall and control swamps. Exceptions to vegetation generally found to be in good condition within upland swamps in spring 2014 included:
  - Small areas containing scattered senescent shrubs were observed adjacent to rocky areas within several longwall and control swamps (Swamps 19, 23, 27, 31, 36, 95, 137a and 137b). These areas of senescence were limited in extent and in areas adjacent to exposed sandstone where soil depth is very shallow and at the lower areas of swamps where saturation of soils occurs more regularly. The observed senescence is attributed to frequent and continued inundations of the shallow soils which restricts uptake of oxygen by plant roots. This senescence was observed within longwall and control swamps and is not attributed to the mining of Longwalls 23-27.
  - Scattered senescent individuals of *Petrophile pulchella*, or individuals with yellowing foliage, were observed in several longwall and control upland swamps (Swamps 26, 34, 35, 94, 97, 101, 111a, 125, 136 and 138). This senescence was also observed within longwall and control swamps during the baseline monitoring period. Healthy individuals of *Petrophile pulchella* were observed within these swamps and were interspersed with senescent individuals.
  - *Phyllota phylicoides, Hakea gibbosa* and *Acacia myrtifolia* have previously been observed senescing in Swamp 93. In spring 2014 the extent and degree of this dieback remained similar to that observed during baseline monitoring seasons. Senescence and yellowing foliage of *Petrophile sessilis, Micromyrtus sessilis* and *Cyathochaeta diandra* was also observed within this swamp in spring 2014.
  - Dieback of *Banksia robur*, the upper fronds of *Gleichenia microphylla* and stems and leaves of *Empodisma minor, Lepidosperma limicola* and *Chorizandra cymbaria* were observed within the control Bee Creek Swamp.
- For the Tea Tree Thicket swamps, vegetation of both longwall (lower portion of Swamp 28) and control swamps was found to be generally in good condition in spring 2014. Exceptions to vegetation generally in good condition included the following:
  - *Banksia robur* was frequently observed from Condition 2 (many dead stems) and Condition 3 (some dead branches) within the lower portion of Swamp 28. This species was also frequently observed in Condition 3 and Condition 4 (minor dieback) within control swamps Woronora River 1, Woronora River South Arm and Dahlia Swamp. The dieback of *Banksia robur* observed within longwall and control swamps presented as leaf herbivory and discolouration, which was also recorded in baseline monitoring surveys.

- Dieback of the understorey species *Empodisma minus* and *Gleichenia microphylla* was observed within the lower portion of longwall swamp 28, similar to autumn 2014. Within the lower portion of Swamp 28, the condition of *Empodisma minus* and *Gleichenia microphylla* ranged from Condition 1 (severe dieback) to Condition 3 (some dead branches). These species were also recorded with dieback within control swamps, however the level of dieback and its extent was generally less than in Swamp 28. The dieback within Swamp 28 was also observed within baseline surveys and was attributed to the dense mid-storey vegetation shading the understorey. The drier conditions within Swamp 28, relative to control swamps, which has been observed since monitoring began in spring 2010, may also contribute to the increased dieback within Swamp 28 compared to the control sites.

Transect/Quadrat Monitoring

Transect and quadrat monitoring is conducted in Swamps 28, 30, 33, 35 and 94 overlying or adjacent to Longwalls 23-27 and in a selection of control swamps.

Transect and quadrat monitoring is conducted biannually of:

- Banksia Thicket and/or Restioid Heath vegetation – in Swamps 28 (upper portion), 30, 33, 35 and 94 overlying or adjacent to Longwalls 23-27, and in control Swamps 101, 111a, 125, 135, 136, 137a, 137b, 138 and Bee Creek Swamp (Figure 10); and
- Tea Tree Thicket vegetation – in lower portion of Swamp 28 overlying Longwalls 23-27, and in control swamps Woronora River 1, Woronora River South Arm and Dahlia Swamp (Figures 10 and 11).

Transect/quadrat monitoring by Eco Logical Australia has been conducted biannually since spring 2010 in Swamps 28, 30, 33, 35, 94, 135, 136, 137a, 137b, 138 and Bee Creek Swamp. Transect/quadrat monitoring by Eco Logical Australia in Swamps 101, 111a and 125 has been conducted biannually since spring 2008 as a component of the Longwalls 20-22 upland swamp vegetation monitoring program. Surveys conducted up to and including the spring 2013 survey represent baseline surveys.

Each swamp has been monitored with three transects, with the exception of Swamp 28 and Tea Tree Thicket control swamps Woronora River 1, Woronora River South Arm and Dahlia Swamp. Swamp 28 is a small valley side swamp which supports Banksia Thicket in the upper portion of the swamp and Tea Tree Thicket in the lower portion of the swamp. Vegetation within Swamp 28 has been monitored along two transects, one within the Banksia Thicket and one within Tea Tree Thicket vegetation within this swamp. The Tea Tree Thicket control swamps Woronora River 1, Woronora River South Arm and Dahlia Swamp have been monitored with a single transect, owing to the much larger size of the control swamps.

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

The data collected for each quadrat includes:

- vegetation structure;
- dominant species;
- estimated cover and height for each stratum;

- full floristics;
- estimated cover/abundance for each species using seven point Braun-Blanquet scale; and
- condition/health rating for each species in the quadrat[24].

Permanent photo points have been established along each transect.

The results of the transect/quadrat monitoring surveys conducted by Eco Logical Australia up to spring 2013 (i.e. prior to the commencement of Longwall 23) are provided in the Metropolitan Coal Six Monthly Report, 1 January to 30 June 2014. The results of the transect/quadrat surveys conducted by Eco Logical Australia in autumn 2014 is provided in the Metropolitan Coal Six Monthly Report, 1 July to 31 December 2014 and the Metropolitan Coal 2014 Annual Review and AEMR/Rehabilitation Report.

The results of the transect/quadrat surveys conducted by Eco Logical Australia in spring 2014 are provided in the following sections.

Vegetation Structure, Dominant Species and Estimated Cover/Abundance for each Stratum

The vegetation structure, dominant species and estimated cover/abundance for each stratum has been variable across all seasons with variations recorded between sites, seasons and strata. This variability is considered to reflect both the natural variations in the height and cover/abundance of vegetation structural layers through time, as well as the subjective nature of the data collection. Within the variability of this dataset, a general trend towards increasing height and cover/abundance of vegetation structural layers has occurred from spring 2010 to spring 2014 across longwall and control sites.

In spring 2014 the height and cover/abundance and of the structural layers was generally similar to that observed in autumn 2014 with minor decreases and increases occurring in some sites and no changes in the vegetation height and density of structural layers at other sites. Although variable, the height and cover/abundance of each stratum continue to steadily increase as plants grow, although the rate of increase is relatively slow and not always detectable from one season to the next when values are similar and subject to surveyor bias.

Species Richness

Species richness within all monitored upland swamps from spring 2010 to spring 2014 is presented on Charts 102 and 103. Species richness has generally been similar between the valley side swamps supporting Restioid Heath and Banksia Thicket sites with species richness in these vegetation types consistently higher than the swamps supporting Tea Tree Thicket.

In general, species richness within the Restioid Heath and Banksia Thicket swamps in spring 2014 was within the range of previous seasons, with the majority of sites increasing in species richness compared to autumn 2014. At longwall sites a small decrease in species richness was observed at two sites (Swamp 30 and 28), whilst three sites (Swamps 33, 35 and 94) increased from autumn 2014, the later considerably so. At control sites a small decrease in species richness was observed at two sites (Swamp 137a and 138), two sites remained unchanged (Swamps 101 and 111a), and five sites (Swamps 125, 135, 136, 137b and Bee Creek Swamp) increased from autumn 2014.

[24] Condition Rating: Healthy – 5; Minor dieback – 4; Some dead branches – 3; Many dead stems – 2; Severe damage/ dieback – 1.

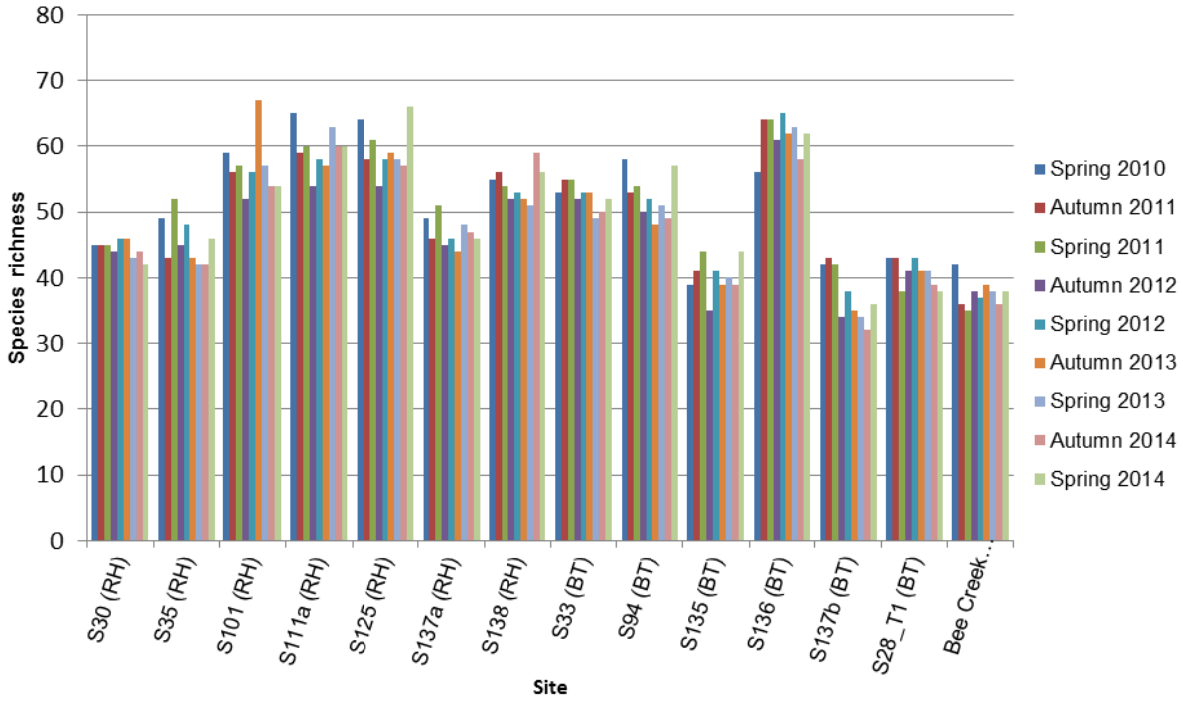


Chart 102 Species Richness within Restioid Heath/Banksia Thicket Swamps

RH = Restioid Heath; BT = Banksia Thicket

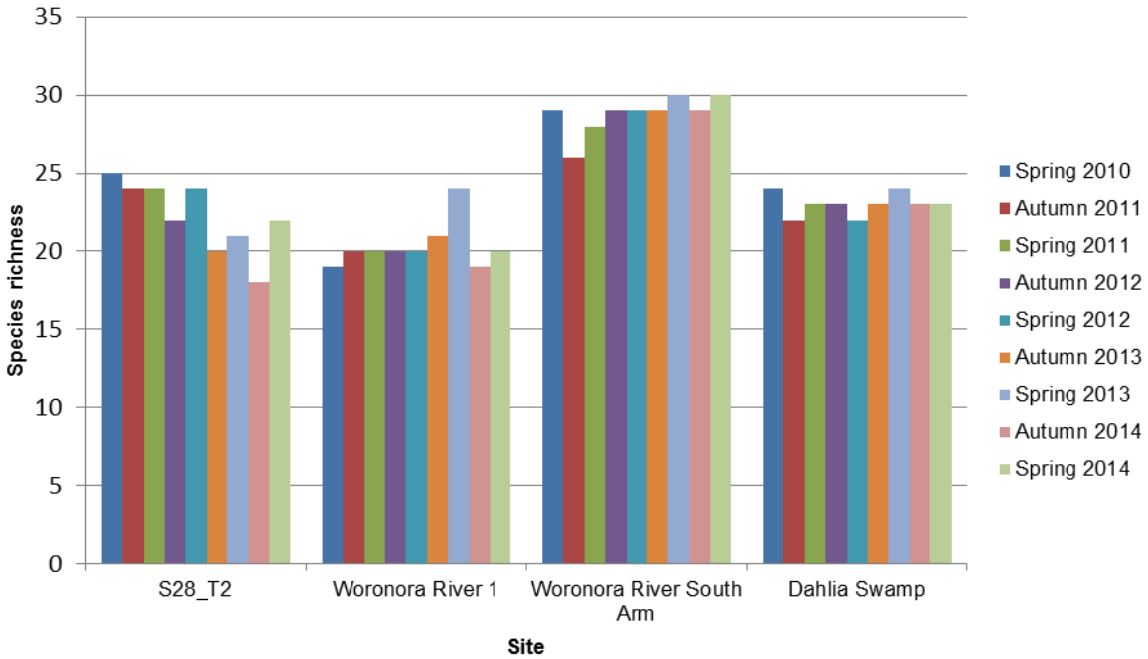


Chart 103 Species Richness within Tea Tree Thicket Swamps

Species richness within Tea Tree Thicket sites in spring 2014 was also within the range of previous seasons. The single longwall swamp supporting Tea Tree Thicket, Swamp 28, slightly increased in species richness compared to autumn 2014. At control sites a small increase in species richness was observed at two sites (Woronora River 1 and Woronora River South Arm), whist one site (Dahlia Swamp) remained unchanged from autumn 2014.

The changes in species richness recorded in spring 2014 are consistent with the fluctuations observed within the baseline monitoring period. All observed changes in species richness are considered to represent natural fluctuations in response to weather, population dynamics, seasonality of survey and natural disturbances including grazing by fauna species.

Cover/Abundance and Condition

Similar to the baseline monitoring period, fluctuations in species cover/abundance were recorded across all sites in spring 2014. No patterns of increasing or decreasing cover/abundance were identified in relation to individual species across sites or groups of species (i.e. swamp indicator species, generalist species, shrubs, ground covers) within sites.

Fluctuations in vegetation condition were also recorded across all sites. Generally, vegetation within both valley side swamps and Tea Tree Thicket swamps was in a healthy condition throughout the survey period and observations of dieback were limited to isolated individuals and within swamps. A number of species were observed with dieback ranging from minor (Condition 4) to severe (Condition 1) with the following species most commonly observed with some dieback: *Banksia oblongifolia; B. robur; Chordifex fastigiatus; Empodisma minus; Gleichenia microphylla; Lepidosperma filiforme; Lepidosperma limicola; Lepyrodia scariosa; Petrophile pulchella; Schoenus brevifolius; Sprengelia incarnata; and Symphionema paludosum*. These species were occasionally observed with dieback at both longwall and control sites.

All of the species which were observed with dieback within longwall swamps in spring 2014, were also observed with dieback within control swamps (where the species occurred in both longwall and control swamps) with the exception of *Isopogon anethifolius, Lambertia formosa, Selaginella uliginosa* and *Viminaria juncea*. Observations of dieback of *Isopogon anethifolius, Lambertia formosa* and *Viminaria juncea* within longwall swamps were limited to single quadrats, while *Selaginella uliginosa* was observed with dieback in two quadrats within longwall swamps. The species and levels of dieback observed in 2014 were generally similar to previous seasons, including baseline monitoring periods.

Indicator Species Monitoring

Twenty tagged individuals of *Epacris obtusifolia*, *Sprengelia incarnata* and *Pultenaea aristata* have been monitored in each of the following Restioid Heath/Banksia Thicket swamps:

- *Epacris obtusifolia* – longwall Swamps 19, 30, 33, 35 and 94, and control Swamps 101, 111a, 125 and 137a, 137b and 138.
- *Sprengelia incarnata* – longwall Swamps 19, 30, 33, 35 and 94, and control Swamps 101, 125, 135, 136, 137a and 138.
- *Pultenaea aristata* – longwall Swamps 19, 30, 33, 35 and 94, and control Swamps 101, 111a, 135, 136,137a and 138.

Twenty tagged individuals of *Banksia robur* and *Callistemon citrinus* have also been monitored in the Tea Tree Thicket vegetation of longwall Swamp 28 and at the associated control sites (Woronora River 1, Woronora River South Arm and Dahlia Swamp).

Population monitoring of indicator species has been conducted biannually since spring 2010 at Swamps 19, 30, 33, 35, 94, 135, 136, 137a, 137b and 138. Population monitoring of indicator species at control Swamps 101, 111a and 125 has been conducted biannually since spring 2009 as a component of the Longwalls 20-22 upland swamp vegetation monitoring program. Surveys conducted up to and including the spring 2013 survey represent baseline surveys.

Population monitoring data collected includes a condition/health rating and a reproductive rating for each plant.

A summary of the results of population monitoring for the baseline surveys conducted up to spring 2013 (i.e. prior to the commencement of Longwall 23) is provided in the Metropolitan Coal Six Monthly Report, 1 January to 30 June 2014. A summary of the results of population monitoring in autumn 2014 (i.e. following the commencement of Longwall 23) is provided in the Metropolitan Coal Six Monthly Report, 1 July to 31 December 2014 and the Metropolitan Coal 2014 Annual Review and AEMR/Rehabilitation Report.

The following provides a summary of population monitoring by Eco Logical Australia in spring 2014 (i.e. during the mining of Longwall 23).

Vegetation Condition

Over the entire baseline monitoring period (i.e. all surveys up to and including spring 2013), and across all Restioid Heath/Banksia Thicket swamps, there has been a general decrease in the mean vegetation condition of the tagged indicator species (Charts 104 to 106). This decrease has occurred at both longwall and control Restioid Heath/Banksia Thicket swamps.

The results for autumn 2014 are generally similar to those for autumn 2013 and/or spring 2013. In spring 2014, the mean vegetation condition for the tagged indicator species *Pultenaea aristata* and *Epacris obtusifolia* varied between longwall and control sites, as indicated by non-overlapping confidence intervals (Charts 104 and 105), with mean vegetation condition greater at control swamps than longwall swamps. In spring 2014 mean vegetation condition for *Sprengelia incarnata* was similar between longwall and control swamps as indicated by overlapping confidence intervals (Chart 106).

The results for the mean vegetation condition of tagged indicator species in Restioid Heath/Banksia Thicket sites in spring 2014 are similar to results since autumn 2013 for each species which includes the baseline monitoring period. The observed differences between mean vegetation condition of tagged indicator species within control and longwall swamps is attributed to natural fluctuations in health in response to ageing plants, herbivory and abiotic factors including aspect and shading from adjacent vegetation.

Within Tea Tree Thicket monitoring sites, the mean vegetation condition of tagged indicator species in longwall and control sites (*Banksia robur* and *Callistemon citrinus*) has remained relatively consistent across all seasons with no generaldecrease compared to observations in Restioid Heath/Banksia Thicket sites. The mean vegetation condition of tagged indicator species within Tea Tree Thicket vegetation has been variable between longwall and control swamps for individual species (Charts 107 and 108). The mean vegetation condition of *Banksia robur* within the single longwall swamp (Swamp 28) has been below that within control swamps in autumn 2011, spring 2011, autumn 2012, autumn 2013, spring 2013, autumn 2014 and spring 2014, as indicated by non-overlapping confidence intervals. The mean vegetation condition of *Banksia robur* in Swamp 28 decreased in autumn 2013 to spring 2014. Across this period mean vegetation condition of *Banksia robur* within control swamps has remained relatively consistent. For *Callistemon citrinus*, mean vegetation condition within Swamp 28 has been greater than in control swamps across all seasons except autumn 2011, although the differences have been generally small (less than 1). The results for spring 2014 including the magnitude of differences between longwall and control sites are similar to the results for the baseline monitoring period.

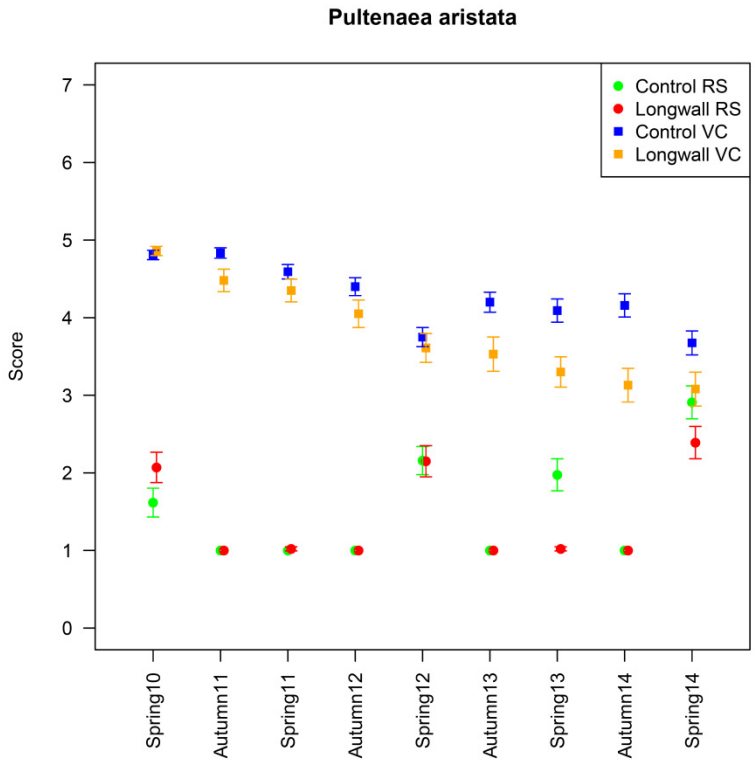


Chart 104 **Mean Scores for Vegetation Condition (VC) and Mean Reproductive Status (RS) for the Indicator Species, *Pultenaea aristata***

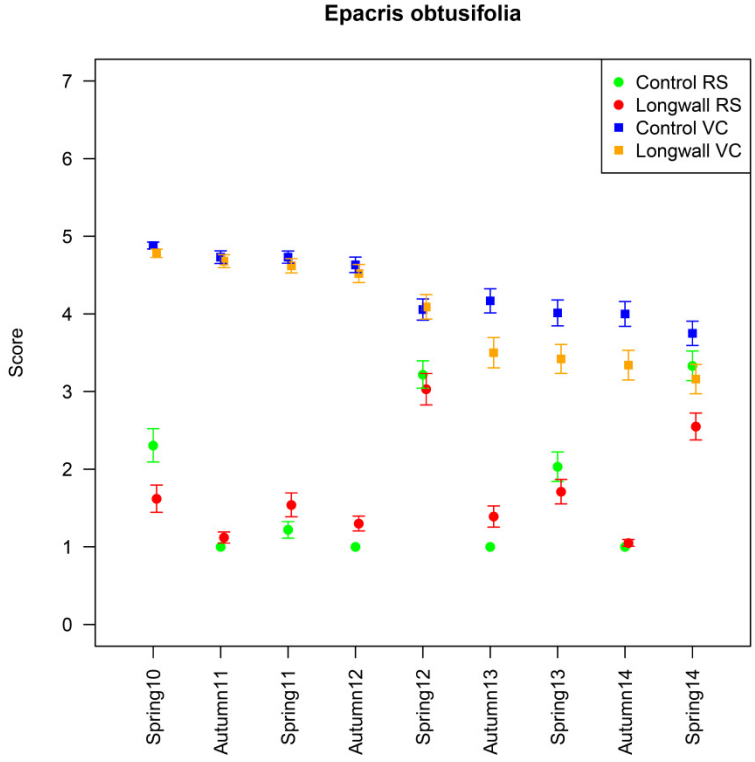


Chart 105 **Mean Scores for Vegetation Condition (VC) and Mean Reproductive Status (RS) for the Indicator Species, *Epacris obtusifolia***

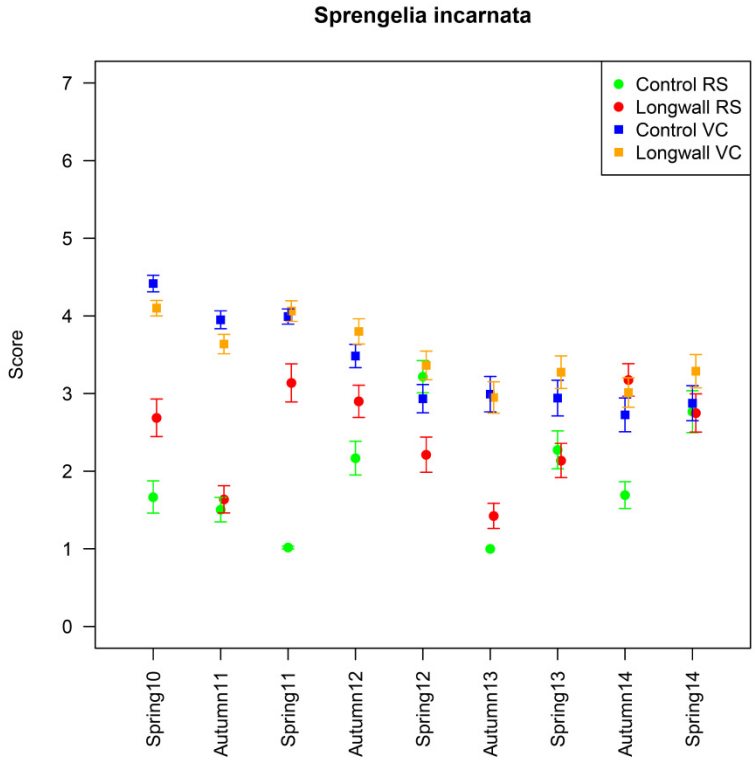


Chart 106 **Mean Scores for Vegetation Condition (VC) and Mean Reproductive Status (RS) for the Indicator Species, *Sprengelia incarnata***

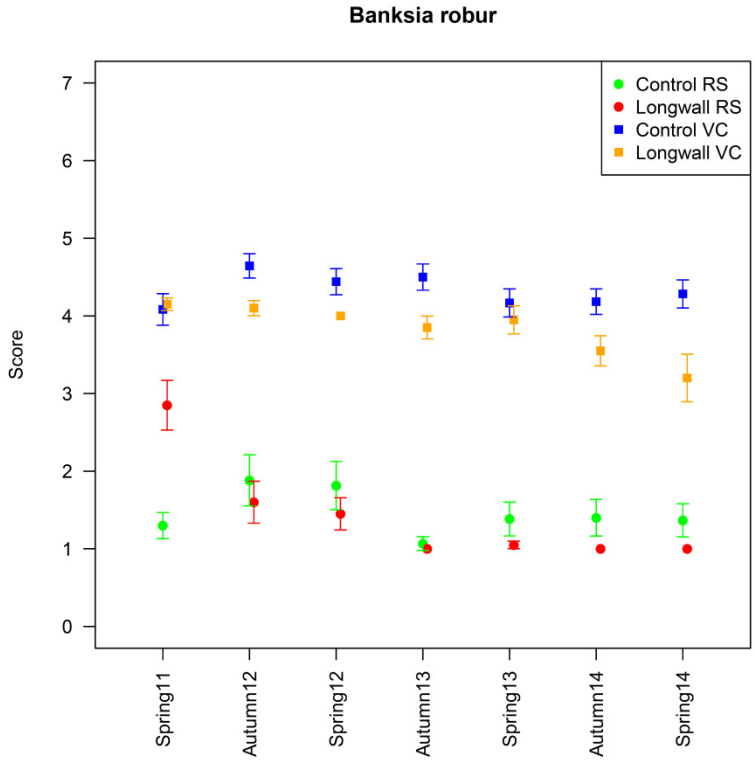


Chart 107 **Mean Scores for Vegetation Condition (VC) and Mean Reproductive Status (RS) for the Indicator Species, *Banksia robur***

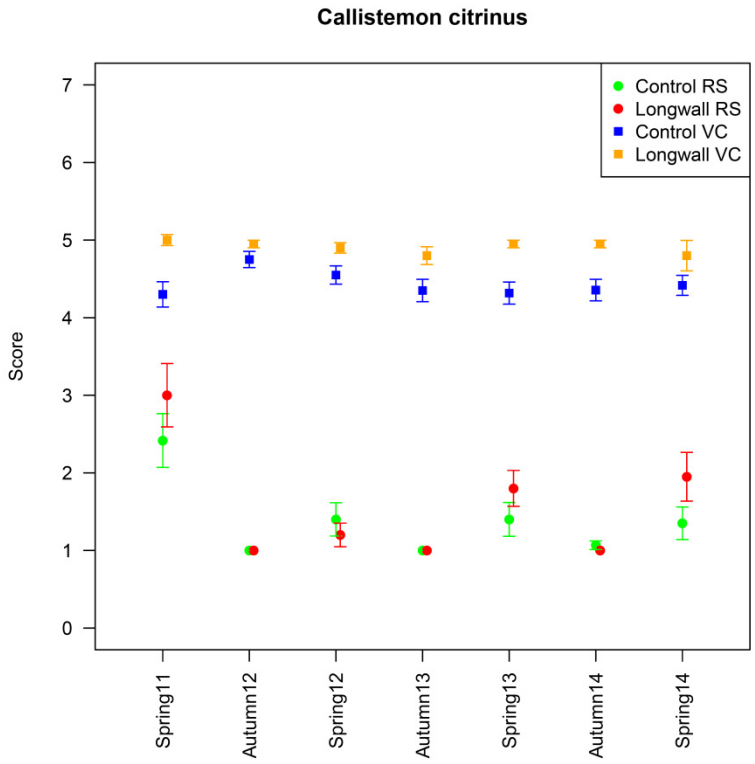


Chart 108 Mean Scores for Vegetation Condition (VC) and Mean Reproductive Status (RS) for the Indicator Species, *Callistemon citrinus*

In spring 2014, 160 individuals of the tagged valley side swamp indicator species were recorded in Condition 1, increasing from 159 individuals in autumn 2014. From autumn 2014 to spring 2014, six tagged indicator species individuals declined to Condition 1 in spring 2014 after being in a healthier condition in autumn 2014, while 5 individuals recorded in Condition 1 in autumn 2014 were recorded in an improved condition in spring 2014.

Of the 160 individual tagged valley side swamp indicator species recorded in Condition 1 in spring 2014, 82 were located within longwall swamps and 78 within control swamps, as follows:

- *Epacris obtusifolia*, 46 plants (26 longwall, 20 control);
- *Pultenaea aristata,* 44 plants (34 longwall, 10 control); and
- *Sprengelia incarnata*, 70 plants (22 longwall, 48 control).

In Tea Tree Thicket Swamps observations of tagged indicator species in Condition 1 have been limited to *Banksia robur* individuals across all seasons (i.e. no *Callistemon citrinus* individuals were recorded in Condition 1). In spring 2014 seven of the tagged *Banksia robur* individuals were recorded in Condition 1 increasing from six in autumn 2014. From autumn 2014 to spring 2014, three of the tagged *Banksia robur* individuals declined in condition to Condition 1, while two individuals recorded in Condition 1 in autumn 2014 were recorded in an improved condition in spring 2014. Of the seven tagged individuals recorded in Condition 1 in spring 2014 three were located within the single longwall swamp (Swamp 28) and four were located within control swamps.

Reproductive Status

The flowering status of tagged indicator species, as recorded in the reproductive scale, shows that limited flowering was recorded across all species across the entire baseline monitoring period (i.e. up to and including spring 2013) and in autumn 2014. Moderate flowering of tagged indicator species was observed in spring 2014 for the Restioid Heath and Banksia Thicket swamps (Charts 104 – 106) with very little flowering observed at Tea Tree Thicket swamps (Charts 107 – 108). The infrequent recording of flowering plants of indicator species across the entire survey period is thought to be related to the timing of surveys which do not coincide with peak flowering periods[25].

Within the Restioid Heath and Banksia Thicket swamps the mean reproductive status of tagged indicator species has been variable between seasons and also between longwall and control swamps in individual seasons (Charts 104 – 106). In spring 2014, mean reproductive status of *Sprengelia incarnata* was similar for longwall and control swamps, while mean reproductive status of *Pultenaea aristata* and *Epacris obtusifolia* were greater at control swamps than longwall swamps. For both these species similar results were observed during the baseline monitoring period up to and including spring 2013.

Within Tea Tree Thicket swamps mean reproductive status of both *Banksia robur* and *Callistemon citrinus* has been low across all seasons (Charts 107 and 108). Generally, mean reproductive status has been similar between longwall and control swamps, though potential differences, as indicated by non-overlapping confidence intervals, have been observed in individual seasons including in spring 2014 for both species. The mean reproductive status of tagged *Banksia robur* individuals was greater at control swamps compared to longwall Swamp 28 in spring 2014 similar to the results for autumn 2014 and during spring 2013 (Chart 107). The mean reproductive status of tagged *Callistemon citrinus* individuals was greater at the single longwall swamp (Swamp 28) compared to the control swamps in spring 2014 (Chart 108). While the results for *Callistemon citrinus* in spring 2014 represent the first season in which a potential difference has been identified (by non-overlapping confidence intervals) the results are generally comparable to those from previous seasons including spring 2013 and are within the range of results across the entire baseline monitoring period (i.e. surveys up to and including spring 2013).

3.2.2.2 Upland Swamp Groundwater Monitoring

Groundwater monitoring of upland swamps has involved the use, where practicable, of paired piezometers, one in the swamp substrate and one sandstone piezometer. Where a swamp substrate piezometer has not been practicable to install due to the depth of the swamp sediments, deeper piezometers have been installed in the shallow sandstone.

Groundwater monitoring of upland swamps has included 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), located in Swamp 28 overlying Longwalls 23-27.
- 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), located in Swamp 30 overlying Longwalls 23-27.
- 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), located in Swamp 33 overlying Longwalls 23-27.

[25] Surveys are conducted during the months of autumn and spring as specified in the Metropolitan Coal Longwalls 23-27 Biodiversity Management Plan. The peak flowering times for each of the indicator species do not necessarily coincide with the survey period, although some flowering does occur at this time.

- 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), located in Swamp 35 overlying Longwalls 23-27.
- 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), located in control Swamp 137 (at site 137a).
- 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), located in control Swamp 137 (at Site 137b).
- 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), located in control swamp Bee Creek Swamp.

The hydrographs at the three control swamps (Swamp 137a, Swamp 137b and Bee Creek Swamp [Figures 7, 10 and 11]) are shown on Charts 109 to 111, respectively. All sites are well away from mining, but longwall start dates are included on the charts to facilitate comparison with swamp responses within the mining footprint of Longwalls 23-27. The rainfall residual mass curve is included as a guide to the influence of rainfall on groundwater responses. All swamp substrate sites show intermittent saturation in agreement with rainfall trends.

At Swamps 137a and 137b the water tables are always separated, generally by 2-4 m, and groundwater flow direction is downwards. The two swamps have similar long durations with no saturation in the swamp substrate. From mid-October 2014 to April 2015, the sensor at Swamp 137a provided erroneous data. Erroneous data obtained for the 1 m substrate piezometer in Swamp 137b prior to November 2013 is not shown on Chart 110.

At the Bee Creek Swamp, the swamp has perched water conditions most of the time except for a period of dryness from February to March 2014 and May to August 2014. The 10 m sandstone piezometer shows groundwater levels that are typically 1.5 m higher than the swamp substrate, implying an upward gradient and upward seepage of groundwater to the swamp from the sandstone. Groundwater levels in the sandstone have varied over a narrow range (241.1 m - 241.5 m AHD), showing significant recessions only during prolonged dry periods (January to March 2014, and from July to August 2014).

Hydrographic responses for the monitored swamps overlying Longwalls 23-27 (Swamp 28, Swamp 30, Swamp 33 and Swamp 35) are shown on Charts 112 to 114. The excavation front for Longwall 23B passed alongside piezometers at Swamp 28 and Swamp 33 in October 2014 and December 2014, respectively. The excavation front for Longwall 24 passed Swamp 28 in May 2015 and was approaching Swamp 33 in June 2015 (Figures 4 and 10). Swamps 30 and 35 are located above Longwall 26 and Longwalls 26 and 27, respectively (Figure 10). In all cases, the sandstone heads are lower than the perched water levels in the swamps, indicating the potential for downward flow of water. The separation between the water tables is generally 0.5 m to 2 m across the four sites. All swamps have intermittent saturation with occasional periods of dryness.

The observed fluctuations in water levels at Swamps 30, 33 and 35 are consistent with the rainfall trend, there are no mining effects on the swamp substrate or sandstone piezometers at those locations. Groundwater levels in the 10 m piezometer at Swamp 28 show a possible mining effect. The piezometer in sandstone at 10 m depth shows a decline of 3 m in April-May 2015, following the passage of Longwall 24 beneath the swamp. The groundwater level decline at Swamp 28 contrasts with responses at the control swamps and at Swamps 30, 33 and 35, and is therefore likely to be a mining effect. The water level in the substrate of Swamp 28 does not appear to be affected and indicates that the swamp remains perched.

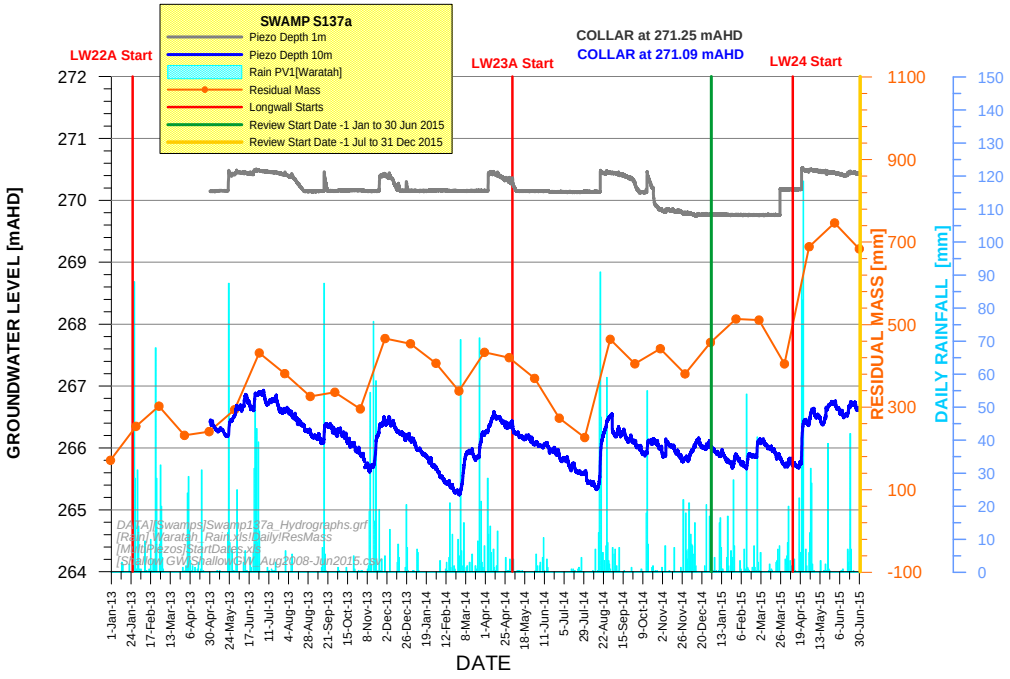


Chart 109 **Groundwater Hydrographs at Control Swamp 137a**

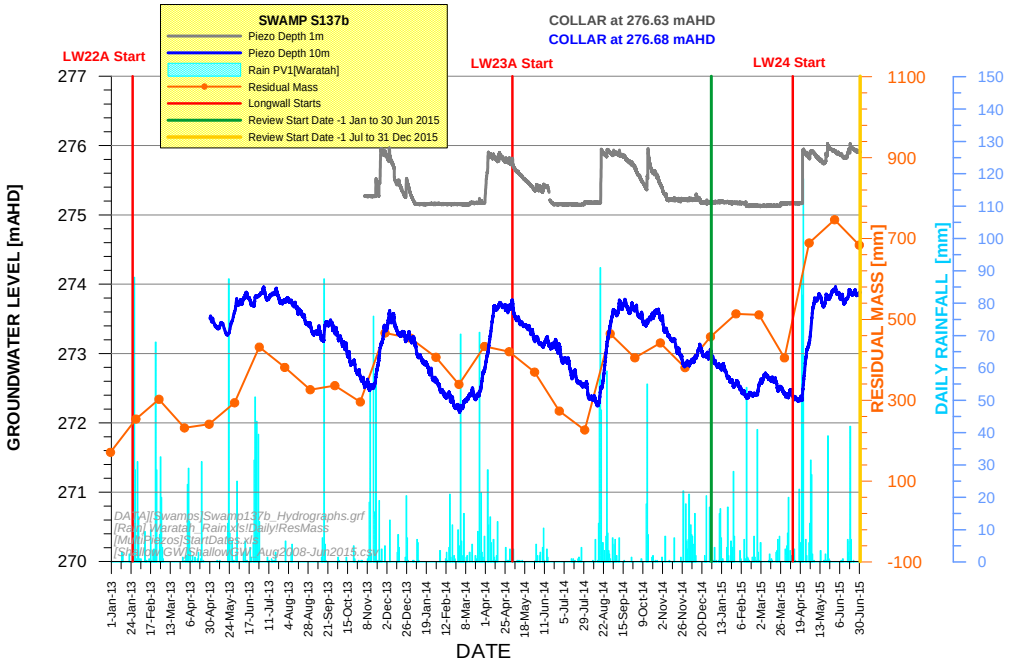


Chart 110 **Groundwater Hydrographs at Control Swamp 137b**

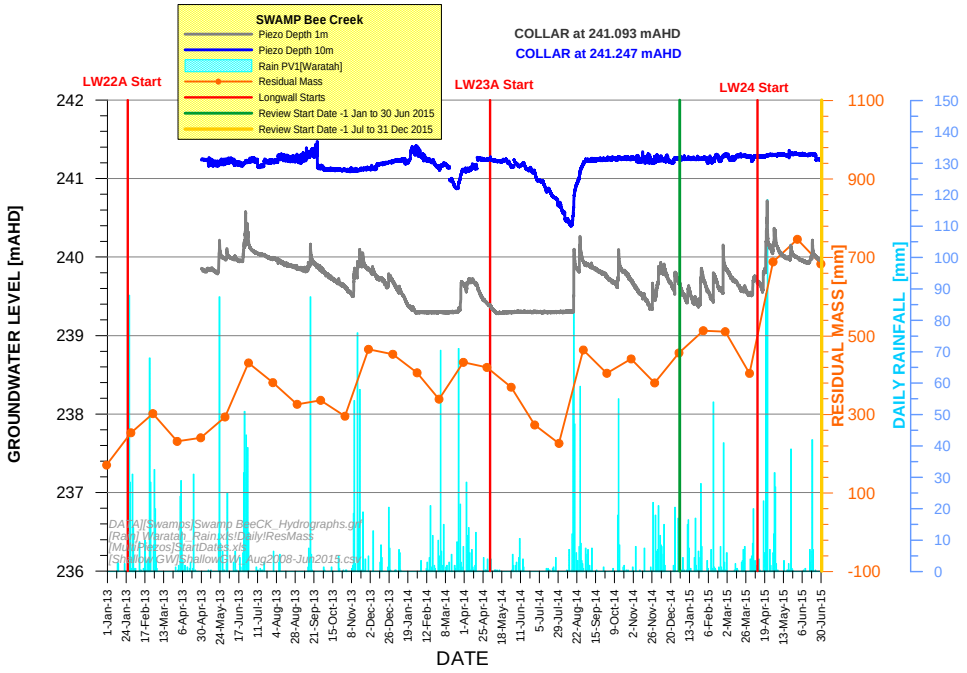


Chart 111 **Groundwater Hydrographs at Bee Creek Control Swamp**

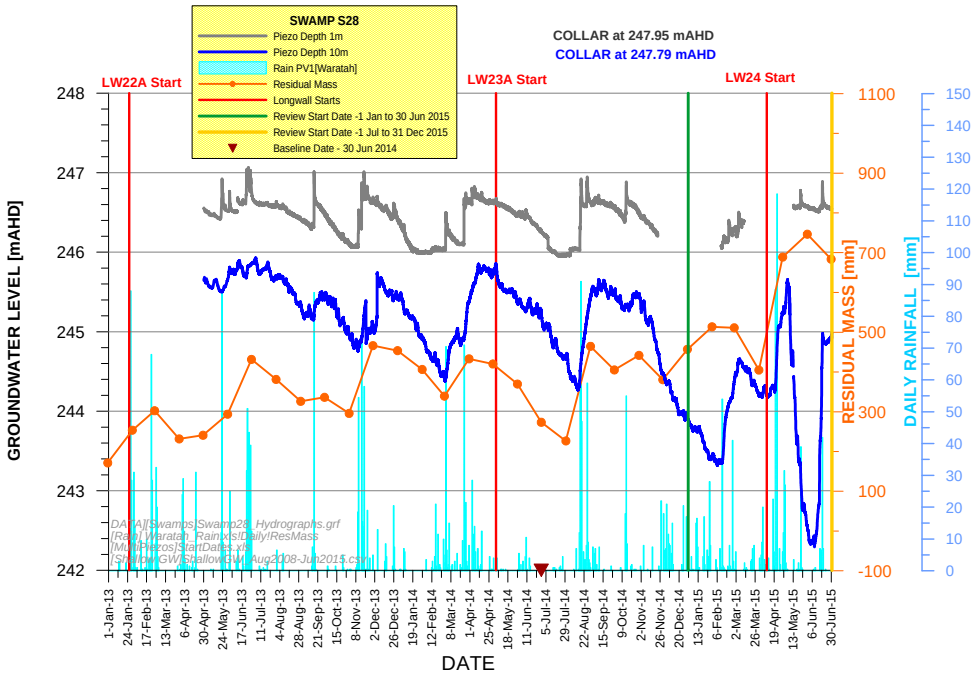


Chart 112 **Groundwater Hydrographs at Swamp 28**

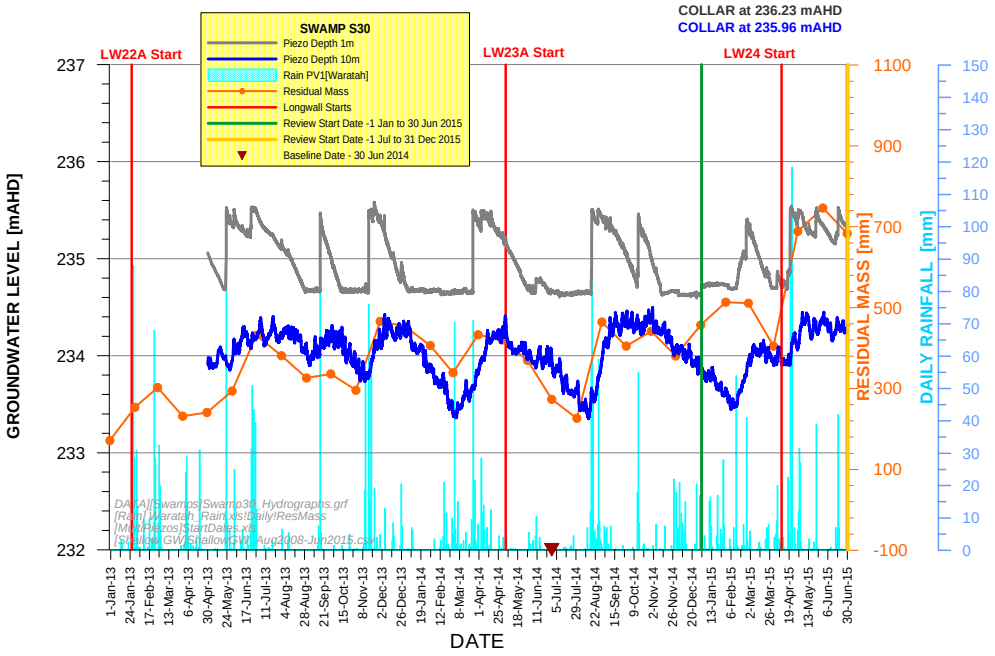


Chart 113 **Groundwater Hydrographs at Swamp 30**

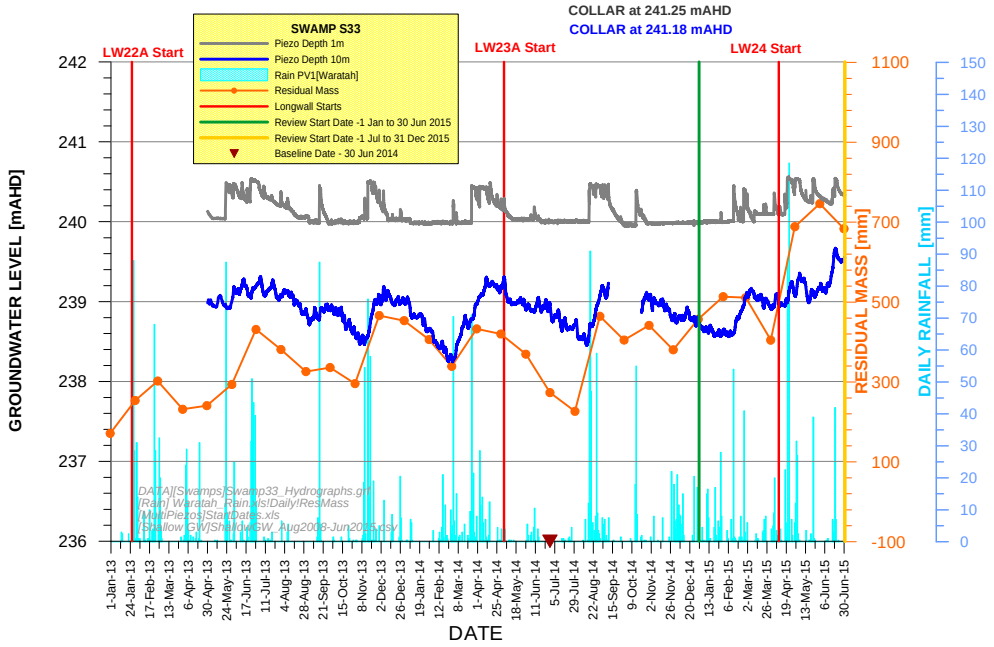


Chart 114 **Groundwater Hydrographs at Swamp 33**

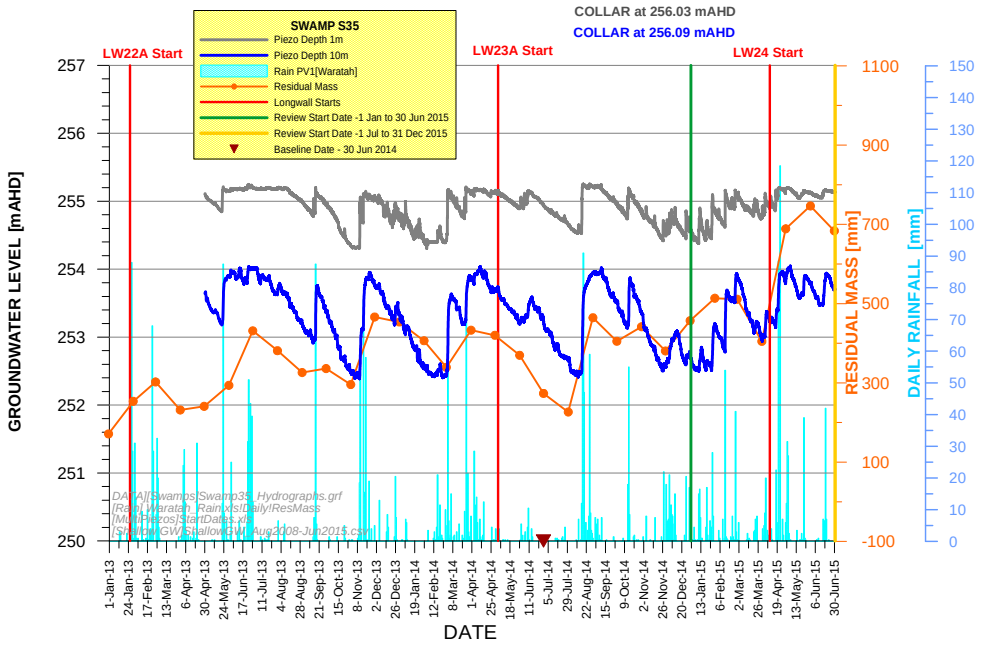


Chart 115 Groundwater Hydrographs at Swamp 35

3.2.2.3 Riparian Vegetation Monitoring

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

Visual Inspections

Visual inspections of riparian areas are conducted biannually in locations adjacent to riparian vegetation monitoring sites (longwall sites MRIP01, MRIP02, MRIP05, MRIP06, MRIP09, MRIP11 and MRIP12 and control sites MRIP03, MRIP04, MRIP07, MRIP08 and MRIP10) (Figure 12), and areas traversed whilst accessing the monitoring sites, to record:

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

Visual inspections have been conducted biannually since spring 2010 at sites MRIP11 and MRIP12. Visual inspections have been conducted biannually since spring 2008 at the remainder of the sites as a component of the Longwalls 20-22 riparian vegetation monitoring program. Surveys conducted up to and including the spring 2013 survey were conducted prior to the commencement of Longwall 23.

The Metropolitan Coal 2014 Annual Review and AEMR/Rehabilitation Report reported on the results of the riparian visual inspection monitoring conducted by Eco Logical Australia for the spring 2013 and autumn 2014 vegetation surveys. The following provides a summary of the results of visual inspections conducted in spring 2014.

Visual inspections conducted of sites MRIP01 to MRIP10 in spring 2014 are presented in Section 3.2.1.3.

The following provides a summary of the results of visual inspections conducted of sites MRIP11 and MRIP12 (the additional sites on the Eastern Tributary over Longwalls 23-27) in spring 2014, compared to the control sites (MRIP03, MRIP04, MRIP07, MRIP08 and MRIP10) (Figure 12).

- No areas of cracked or displaced bedrock were observed within sites MRIP11 and MRIP12 in spring 2014.
- No areas of altered water ponding were observed within sites MRIP11, MRIP12 or control sites in spring 2014.
- Signs of erosion and scouring of sediments from stream bank areas were observed at sites MRIP11 and MRIP12 and was attributed to successive flooding in association with heavy rainfall from spring 2010 to autumn 2012 and subsequent rainfall events. The extent of bank scouring was generally minor.
- A single weed species, *Andropogon virginicus* (Whiskey Grass) was recorded approximately 10 m upstream of the start of transect MRIP11. No weeds were recorded at site MRIP12.
- Vegetation was recorded in good condition within sites MRIP11 and MRIP12 in spring 2014. Isolated individuals with some level of dieback have been observed within sites MRIP11 and MRIP12 and at the control sites in spring 2014. Species include individuals of *Banksia ericifolia* var. *ericifolia, Tristania neriifolia* and *Acacia longifolia* subsp. *longifolia* as previously recorded.

  The dieback is attributed to flooding impacts and natural causes. The first flooding event occurred in spring 2010 after a considerable dry period. Streamside vegetation was impacted at all sites and flood-swept and prone vegetation, sediment deposition, woody flood debris dams, bank scouring and erosion was commonly observed. Subsequent high water flows have continued to impact all sites over the subsequent survey seasons.

Transect/Quadrat Monitoring

A permanent quadrat (20 m x 2 m) and permanent transect (50 m x 2 m, i.e. a 30 m extension of each quadrat) have been used to monitor riparian vegetation on the Waratah Rivulet and Eastern Tributary at (Figure 12)[26]:

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

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

The data collected for each quadrat includes:

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

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

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

Quadrat and transect monitoring has been conducted biannually since spring 2010 at sites MRIP11 and MRIP12. Quadrat and transect monitoring has been conducted biannually since spring 2008 at the remainder of the sites as a component of the Longwalls 20-22 riparian vegetation monitoring program (described in Section 3.2.1.3). Surveys conducted up to and including the spring 2013 survey were conducted prior to the commencement of Longwall 23.

The Metropolitan Coal 2014 Annual Review and AEMR/Rehabilitation Report reported on the results of the riparian quadrat and transect monitoring conducted by Eco Logical Australia for the spring 2013 and autumn 2014 vegetation surveys.

Section 3.2.1.3 provides a summary of the quadrat/transect monitoring in spring 2014 of sites MRIP01 to MRIP08 as a component of the Longwalls 20-22 riparian vegetation monitoring program.

The following provides a summary of the quadrat/transect monitoring results in spring 2014 of sites MRIP11 and MRIP12 (the additional sites on the Eastern Tributary over Longwalls 23-27) compared to the control sites.

Vegetation Structure, Dominant Species and Estimated Cover/Abundance for each Stratum

The vegetation structure, dominant species and estimated cover/abundance for each stratum has been variable across all seasons with variations recorded between sites, seasons and strata prior to the commencement of Longwall 23. This variability is considered to reflect both the natural variations in the height and cover/abundance of vegetation structural layers through time, as well as the subjective nature of the data collection. Within the variability of this dataset, a general trend towards increasing height and cover/abundance of vegetation structural layers has occurred across all sites.

Although variable, the height and cover/abundance of each stratum have steadily increased as plants grow, although the rate of increase is relatively slow and not always detectable from one season to the next when values are similar and subject to surveyor bias, as well as taking into account other factors such as impacts to vegetation by high water flows.

The vegetation structure, dominant species and estimated cover/abundance for each stratum at sites MRIP11 and MRIP12 in autumn 2014 was similar to that observed during surveys conducted prior to the commencement of Longwall 23. Values for height and cover were within the range of pre-Longwall 23 surveys for all stratum with the exception of the lower stratum at site MRIP11, which was taller in autumn 2014 than during the pre-Longwall 23 monitoring period. While values were generally in the range of those previously values, trends towards increasing vegetation height continued in autumn 2014, in particular for mid-storey vegetation at site MRIP12.

In spring 2014, the precent cover and height of the structural layers was generally similar to that recorded in the preceding season. Across all seasons (since surveys commenced in spring 2008), the vegetation structure, dominant species and estimated cover/abundance for each stratum has varied between sites and between seasons within sites. Results have generally fluctuated with no clear trend towards increasing or decreasing height or cover/abundance for individual strata across multiple seasons. These fluctuations are considered to reflect both the natural variations in the height and cover/abundance of vegetation structural layers through time (including in response to flooding impacts), as well as the subjective nature of the data collection.

Species Richness

Species richness within riparian monitoring sites MRIP11 and MRIP12 over Longwalls 23-27 and riparian control sites (MRIP03, MRIP04, MRIP07 and MRIP08) is presented on Chart 116. Species richness has fluctuated within both longwall and control sites including relatively large decreases from spring 2011 to autumn 2012 at site MRIP11 and from autumn 2011 to spring 2011 at site MRIP12. These relatively large fluctuations in species richness, and the smaller ones observed at these sites and control sites, represent natural fluctuations in response to climatic changes, the cryptic nature of some flora species, individual plant population dynamics and natural disturbances including floods.

In spring 2014 species richness within riparian monitoring site MRIP11 was within the range of values recorded at this site over all previous seasons up to and including autumn 2014. In spring 2014 species richness within riparian monitoring site MRIP12 was less than all previous seasons, although one less species was recorded in spring 2014 (55 species) than in spring 2011 and spring 2013 (56 species).

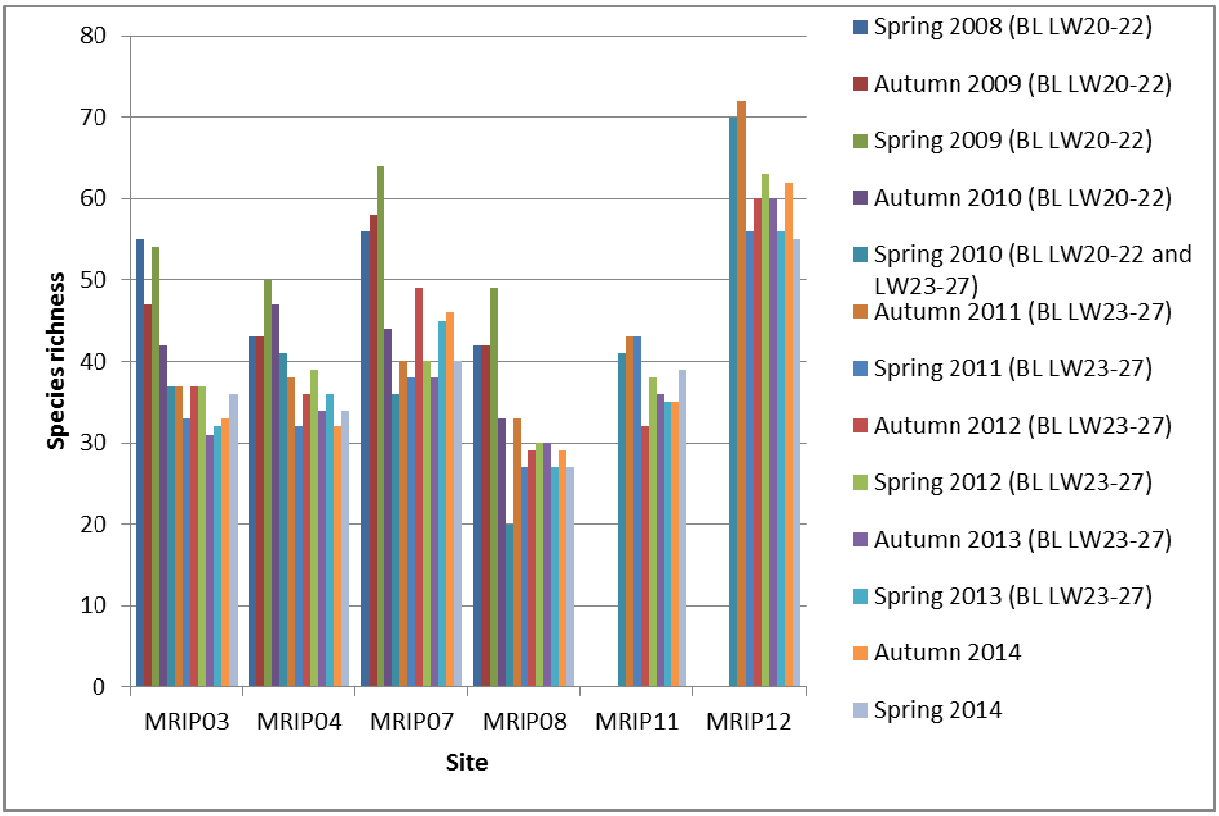


Chart 116 Species Richness within Riparian Monitoring Sites, Spring 2010 to Spring 2014
(BL – baseline monitoring periods for respective longwall programs)

Cover/Abundance and Condition for each Species

Fluctuations in species cover/abundance were recorded across all sites prior to the commencement of Longwall 23, in autumn 2014 and in spring 2014. No patterns of increasing or decreasing cover/abundance were identified in relation to individual species across sites or groups of species (i.e. riparian indicator species, generalist species, shrubs, ground covers) within sites.

Fluctuations in vegetation condition were recorded across all sites prior to the commencement of Longwall 23, in autumn 2014 and in spring 2014. Generally, vegetation within the riparian monitoring sites was in a healthy condition during the baseline and subsequent surveys, and for spring 2014, the vast majority of species and individuals were recorded in a healthy condition (Condition 5) with occasional individuals recorded with minor dieback (Condition 4), and rarely with some dead branches (Condition 3) at both longwall and control sites.

In spring 2014, observations of vegetation with dieback at sites MRIP11 and MRIP12 were mostly limited to individuals with minor dieback (Condition 4) and included the streamside plants *Gleichenia microphylla, Lepyrodia scariosa, Sporadanthus gracilis* and *Schoenus melanostachys* and the shrub species *Banksia ericifolia* subsp. *ericifolia, Tristania neriifolia, Leptospermum morrisonii* and *Leptospermum squarrosum*. Occasional individuals were recorded with Condition 3 at both sites having recorded similar conditions during previous seasons.

The exotic grass species *Andropogon virginicus* recorded within site MRIP12 in autumn 2014 was not recorded during the spring 2014 survey.

Indicator Species Monitoring

Three indicator species have been selected for monitoring riparian vegetation of Waratah Rivulet and the Eastern Tributary, namely, *Prostanthera linearis*, *Schoenus melanostachys* and *Lomatia myricoides*. Twenty tagged individuals have been monitored at each monitoring site:

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

Population monitoring of indicator species has been conducted biannually since spring 2010 at sites MRIP11 and MRIP12. Population monitoring of indicator species at the remainder of the sites has been conducted biannually since spring 2008 as a component of the Longwalls 20-22 riparian vegetation monitoring program (as described in Section 3.2.1.3). Surveys conducted up to and including the spring 2013 survey were conducted prior to the commencement of Longwall 23.

Population monitoring data collected includes a condition/health rating and a reproductive rating for each plant. The methods used for population monitoring are the same as those described for the Longwalls 20-22 riparian vegetation monitoring program in Section 3.2.1.3.

The Metropolitan Coal Six Monthly Report 1 July to 31 December 2013, the Metropolitan Coal Six Monthly Report 1 January to 30 June 2014 and 2014 Annual Review and AEMR/Rehabilitation Report reported on the results of the riparian indicator species monitoring conducted by Eco Logical Australia for the spring 2013 and autumn 2014 vegetation survey. A summary of the results for spring 2014 is presented below.

The Metropolitan Coal 2014 Annual Review and AEMR/Rehabilitation Report reported on the results of the riparian indicator species monitoring conducted by Eco Logical Australia for the spring 2013 and autumn 2014 vegetation surveys.

Section 3.2.1.3 provides a summary of the indicator species monitoring in spring 2014 of sites MRIP01 to MRIP08 as a component of the Longwalls 20-22 riparian vegetation monitoring program.

[27] Note: Only 10 individuals of *Prostanthera linearis* were available for tagging at site MRIP08.

The following provides a summary of the indicator species monitoring results in spring 2014 of sites MRIP11 and MRIP12 (the additional sites on the Eastern Tributary over Longwalls 23-27) compared to the control sites. Charts 117 to 119 provide an update of Charts 82 to 84 in Section 3.2.1.3 to include the results from sites MRIP11 and MRIP12 obtained since spring 2010.

Vegetation Condition

Prior to the commencement of Longwall 23 (up to and including spring 2013) mean vegetation condition was generally similar between longwall and control sites for *Lomatia myricoides, Prostanthera linearis* and *Schoenus melanostachys* in each season, as indicated by overlapping confidence intervals (Charts 117 to 119). Exceptions to the generally similar mean vegetation condition for these tagged indicator species at longwall and control sites included *Prostanthera linearis* in autumn 2011 and *Schoenus melanostachys* in autumn 2011 and spring 2011 where mean vegetation condition was higher at longwall sites than control sites, although the size of the difference was generally small.

In autumn and spring 2014 the mean vegetation condition for tagged riparian indicator species was similar between longwall and control sites for all species as indicated by overlapping confidence intervals (Charts 117 to 119). The mean vegetation condition for both longwall and control sites in autumn 2014 was lower than previous seasons for *Lomatia myricoides* and *Prostanthera linearis* and similar to previous surveys for *Schoenus melanostachys*. The mean vegetation condition for all species at both longwall and control sites in spring 2014 remained similar to autumn 2014, although a slight drop in condition of *Prostanthera linearis* is recorded for longwall sites.

No additional individuals of the tagged indicator plants were recorded as dead or Condition 1 (severe dieback) at sites MRIP11 and MRIP12 in spring 2014.

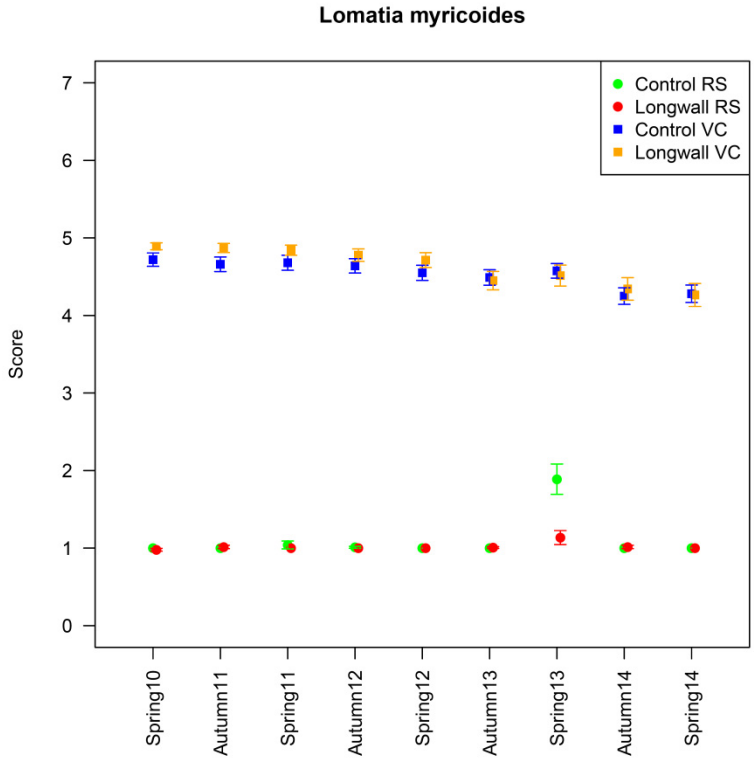


Chart 117 Mean Scores for Vegetation Condition (VC) and Mean Reproductive Status (RS) for the Indicator Species, *Lomatia myricoides* for sites MRIP01 to MRIP12

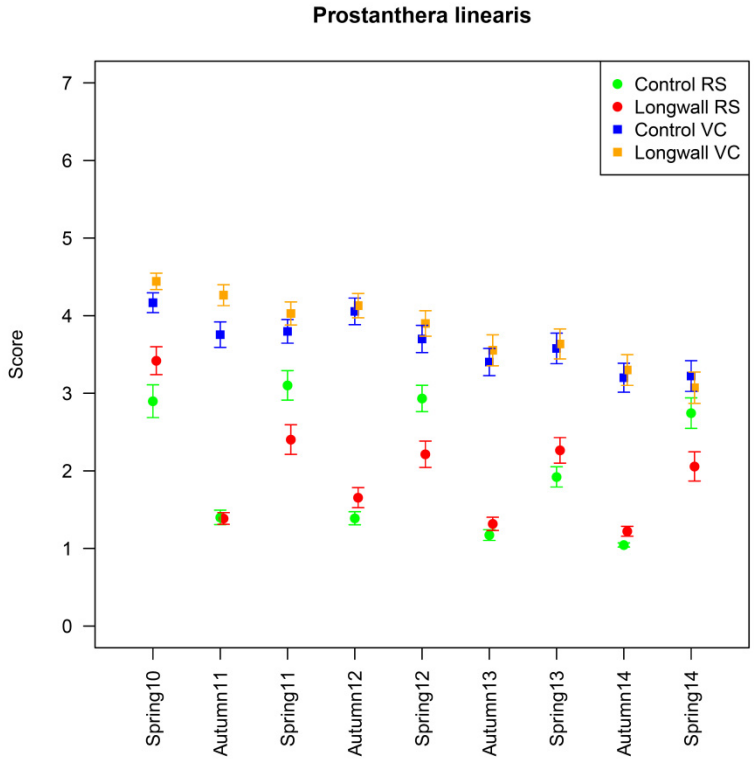


Chart 118 **Mean Scores for Vegetation Condition (VC) and Mean Reproductive Status (RS) for the Indicator Species, *Prostanthera linearis* for sites MRIP01 to MRIP12**

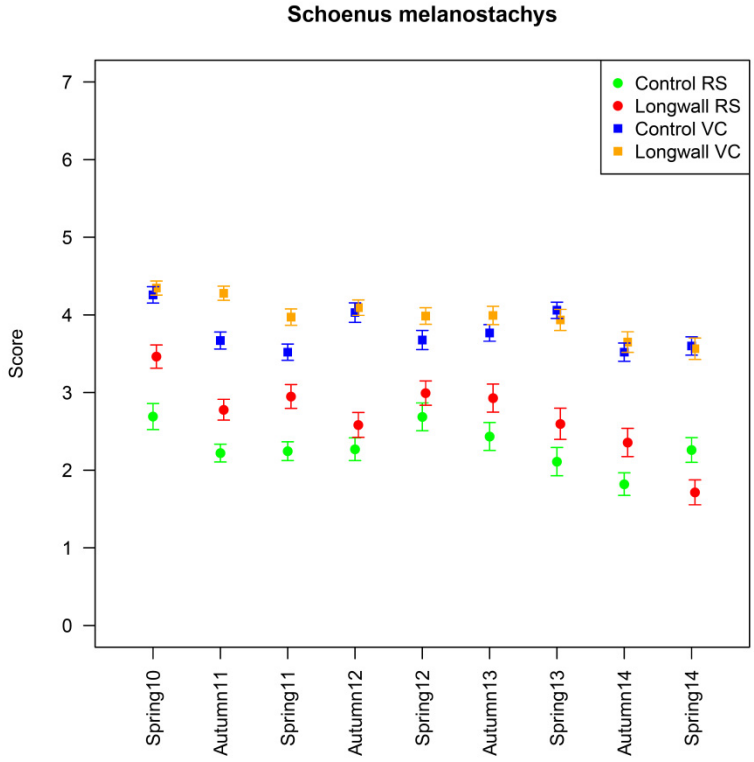


Chart 119 **Mean Scores for Vegetation Condition (VC) and Mean Reproductive Status (RS) for the Indicator Species, *Schoenus melanostachys* for sites MRIP01 to MRIP12**

Reproductive Status

In spring 2014, the mean reproductive status for *Lomatia myricoides* at longwall and control monitoring sites was equal, with no flowering recorded for this species at any sites (Chart 117). For *Prostanthera linearis* and *Schoenus melanostachys*, the mean reproductive status in spring 2014 was greater at control sites compared to longwall sites (Chart 118 and Chart 119).

For *Prostanthera linearis* the greater mean reproductive status at control sites compared to longwall sites in spring 2014 was similar to results from previous seasons including surveys during the baseline monitoring period (spring 2011 and spring 2012).

For *Schoenus melanostachys*, the greater mean reproductive status at control sites compared to longwall sites in spring 2014 was unprecedented with mean reproductive status at longwall sites being greater than, or generally similar to, control sites in all seasons except spring 2014. While unprecedented, the magnitude of the difference in mean reproductive status of *Schoenus melanostachys* between control and longwall sites was small and did not coincide with any observable difference in the condition between control sites.

3.2.2.4 Aquatic Biota and their Habitats

Metropolitan Coal assesses subsidence impacts and environmental consequences on aquatic habitats in accordance with the Metropolitan Coal Longwalls 23-27 Water Management Plan (Section 2). Surface water monitoring includes monitoring of surface water flow, pool water levels, surface water quality, iron staining and gas release. Observations of surface cracking, iron staining and gas release are also made during the conduct of the aquatic ecology surveys.

The aquatic ecology monitoring program for Longwalls 23-27 has been designed to:

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

The design of the monitoring programs uses a “Beyond BACI” type experimental design and focuses on representative sampling within streams and pools in the Longwalls 23-27 mining area and in suitable control streams and pools not subject to mine subsidence.

Stream Monitoring

Surveys of aquatic habitat characteristics, water quality, aquatic macroinvertebrates and aquatic macrophytes have been carried out bi-annually (autumn and spring).

Monitoring has been carried out at two sampling sites (approximately 100 m long) at the following stream sampling locations:

- Locations C1 and C4[28] on Tributary C/Eastern Tributary and Location B2 on Tributary B overlying Longwalls 23-27.
- Location C2[28] on Tributary C/Eastern Tributary downstream of Longwalls 23-27.
- Control Locations: WR1 on Woronora River; OC on O’Hares Creek; BC on Bee Creek; and WOT on Woronora Tributary.

[28] Locations C1, C2 and C4 are referred to as Locations ET1, ET2 and ET4 in the *Metropolitan Coal Longwalls 20-22 Biodiversity Management Plan* and on Figure 13.

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

The methods used to survey aquatic biota and their habitats at each site are:

- Stream characteristics are recorded in accordance with the AUSRIVAS protocol (including, visual assessment of stream width and depth, composition of the substratum, riparian conditions, signs of disturbance, water quality and percentage cover of the substratum by algae).
- Water quality sampling is conducted for electrical conductivity, dissolved oxygen, pH, temperature, turbidity, oxygen reduction potential, alkalinity, total phosphorous and total nitrogen to provide information relevant to water quality at the time of sampling.
- Aquatic macroinvertebrate sampling is conducted using the AUSRIVAS protocol, as well as quantitative sampling where three replicate macroinvertebrate samples are collected within each site using timed sweeps.
- The distribution of submerged and emergent (occurring in-stream and in the riparian zone) aquatic macrophytes are estimated along each sampling location by assigning a cover class to each species. The cover classes are: (1) one plant or small patch (i.e. few), (2) not common, growing in a few places (i.e. scattered), and (3) widespread (i.e. common). In addition, an assessment of the in-stream (i.e. submerged and emergent) aquatic vegetation is made within each site by estimating the relative abundance (i.e. percentage cover) of aquatic macrophytes within five haphazardly placed 0.25 m^2 quadrats, using a stratified sampling technique.

Surveys have been carried out at Location C4 on Tributary C and Location B2 on Tributary B from spring 2009 to spring 2014. Locations C1 and C2 on Tributary C, Location WR1 on the Woronora River, Location OC on O'Hares Creek, Location BC on Bee Creek and Location WOT on the Woronora Tributary have been monitored since spring 2008 (as a component of the Longwalls 20-22 aquatic ecology monitoring program described in Section 3.2.1.4).

A summary of the stream monitoring survey results obtained prior to the commencement of Longwall 23 (i.e. up to and including spring 2013) by BIO-ANALYSIS Pty Ltd as well as stream monitoring results for autumn 2014 (during the mining of Longwall 23) is provided in the Metropolitan Coal 2014 Annual Review and AEMR/Rehabilitation Report.

A summary of the stream monitoring survey results for spring 2014 (i.e. during the mining of Longwall 23) is presented below.

Stream Characteristics

Iron staining was first noted at Locations C1 and C4 on Tributary C/Eastern Tributary in autumn 2014. In spring 2014, an algal/iron floc covered up to 100% of the shallow stream substratum at Location C1 and approximately 20% of the stream substratum at Location C4. To date (i.e. spring 2014), no cracking of the stream or bank sandstone substratum has been observed at those locations. No evidence of mining related subsidence (i.e. cracking of the stream substratum or an algal/iron floc) has been observed at Location C2 to date.

For the first time since sampling commenced in spring 2009, there was evidence of an algal/iron floc complex (< ~95%) on the surface of the stream substratum at sampling Location B2 on Tributary B. Water visibility was clear and free of sediment.

Macroinvertebrate Assemblages

In summary, the results indicate that generally, the structure of assemblages of macroinvertebrates are typical of Hawkesbury sandstone environments. Table 7 presents the AUSRIVAS Band results for each site as a result of sampling aquatic macroinvertebrates using the AUSRIVAS protocol. Site C1-2 on Tributary C/Eastern Tributary, Site WR1-2 on the Woronora River, and Sites OC1 and OC2 on O'Hares Creek had more taxa than the AUSRIVAS reference collection in spring 2014 (Table 7). Fewer families of macroinvertebrates than expected were collected from all other sites sampled (including control sites), compared to control sites selected by the AUSRIVAS model (Table 7).

Charts 120a and 120b present the Principal Coordinates Analysis (PCoA) plots for macroinvertebrates at each sampling location on each sampling occasion using the quantitative sampling data. Temporal and spatial variability in the structure of assemblages of macroinvertebrates was observed at all locations.

Charts 121a to 121d present the mean diversity of macroinvertebrates, mean abundance of macroinvertebrates, mean number of Leptophlebiidae and mean number of Atyidae at each location sampled on Tributary C/Eastern Tributary (i.e. Locations C1, C2 and C4) and at the control locations (i.e. Woronora River and O'Hares Creek) using the quantitative sampling data.

Charts 122a to 122d present the mean diversity of macroinvertebrates, mean abundance of macroinvertebrates, mean number of Leptophlebiidae and mean number of Atyidae at Tributary B (i.e. Location B2) and the control locations (i.e. Bee Creek and Woronora Tributary), respectively, using the quantitative sampling data.

In general, the most abundant macroinvertebrate taxon collected include the freshwater shrimp family, Atyidae, and the mayfly family, Leptophlebiidae.

There have been differences in the structure of assemblages of macroinvertebrates at Locations C1, C2 and C4 on Tributary C/Eastern Tributary and the control locations sampled along the Woronora River and O'Hares Creek since the commencement of sampling (Chart 120a). Analyses of the structure of assemblages of aquatic macroinvertebrates found that observed differences among locations sampled throughout the study period, particularly comparisons between each of Locations C1, C2 and C4 and the control locations, were not related to the commencement of mining activities within the Longwalls 23-27 underground mining area.

The structure of assemblages of aquatic macroinvertebrates at Location B2 on Tributary B were found to differ significantly before vs after commencement of mining of the Longwalls 23-27 underground mining area in comparison to the control locations (Chart 120b). Declines in mean numbers of individuals of Leptophlebiidae and Atyidae contributed greatly to the significant result (Charts 122c and 122d).

Table 7
Band Levels Generated by the AUSRIVAS Model for Sites within Locations Sampled as Part of the Longwalls 23-27 Stream Monitoring Program

System	Site Code	Sp-09	Aut-10	Sp-10	Aut-11	Sp-11	Aut-12	Sp-12	Aut-13	Sp-13	Aut-14	Sp-14
Tributary C	C1-1	B	B	C	C	B	B	C	A	D	C	B
	C1-2	C	B	B	B	C	A	B	C	C	A	A
	C2-1	B	C	C	B	C	C	B	C	C	C	B
	C2-2	B	C	C	C	D	B	C	C	C	C	B
	C4-1	B	B	C	B	D	B	B	C	C	B	C
	C4-2	B	B	C	C	B	C	C	C	B	A	C
Tributary B	B2-1	C	B	C	C	B	B	D	A	B	B	C
	B2-2	C	C	C	B	B	C	B	C	C	C	C
Bee Creek	BC1	C	B	C	C	D	C	A	B	B	C	C
	BC2	D	B	C	B	B	B	B	C	B	C	B
Woronora Tributary	WOT1	-*	B	C	C	B	C	B	A	B	C	B
	WOT2	D	C	C	C	C	B	A	C	C	C	C
Woronora River	WR1-1	C	B	C	C	C	C	B	C	C	C	B
	WR1-2	C	B	C	C	C	C	B	B	B	C	A
O'Hares Creek	OC1	B	A	B	B	A	A	A	B	C	B	A
	OC2	B	B	B	B	B	C	C	B	C	B	A

* Sites not sampled due to insufficient aquatic habitat.

Note: The spring 2008 and autumn 2009 survey results for Sites C1-1, C1-2, C2-1, C2-2 on Tributary C, Sites WR1-1 and WR1-2 on the Woronora River, Sites OC-1 and OC-2 on O'Hares Creek, Sites BC-1 and BC-2 on Bee Creek, and Sites WOT1 and WOT2 on the Woronora Tributary is presented in Table 4 in Section 3.2.1.4.

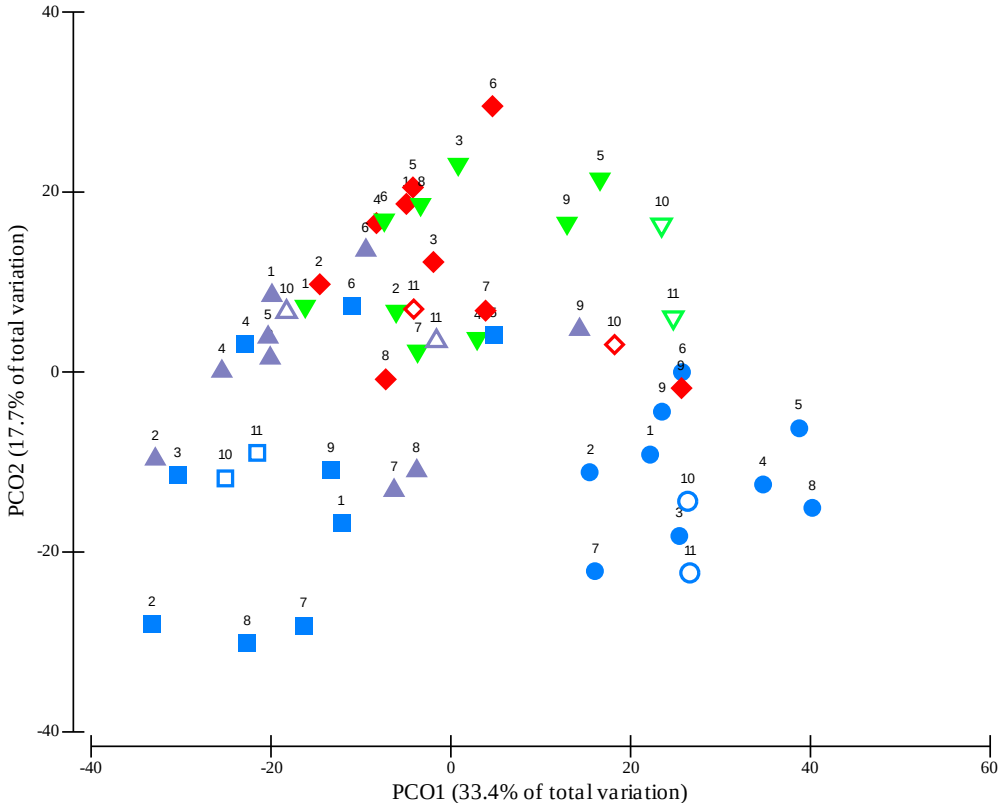


Chart 120a Principal Coordinates Analysis (PCoA) plot of macroinvertebrate data for three locations on Tributary C: Location C1 (green triangles); Location C2 (purple triangles); and Location C4 (red diamonds) and two control locations (Woronora River: blue squares and O'Hare's Creek: blue circles) for each time of sampling (*n*= 6) from spring 2009 (T1). Filled symbols: 'Before' commencement of Longwall 23; Empty symbols: 'After' commencement of Longwall 23.

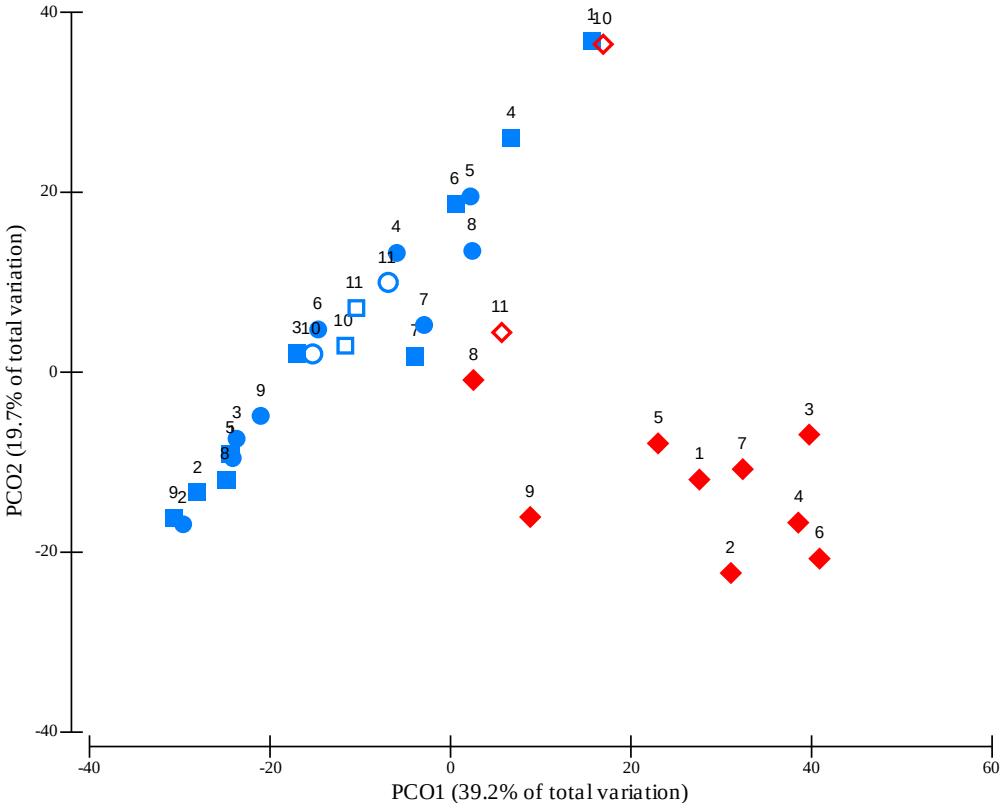


Chart 120b Principal Coordinates Analysis (PCoA) plot of macroinvertebrate data collected at one location on Tributary B (i.e. Location B2) and two control locations (Bee Creek and Woronora Tributary) for each time of sampling (*n*= 6) from spring 2009 (T1). Red symbols: Tributary B; Blue squares: Bee Creek; Blue circles: Woronora Tributary. Filled symbols: 'Before' commencement of Longwall 23; Empty symbols: 'After' commencement of Longwall 23.

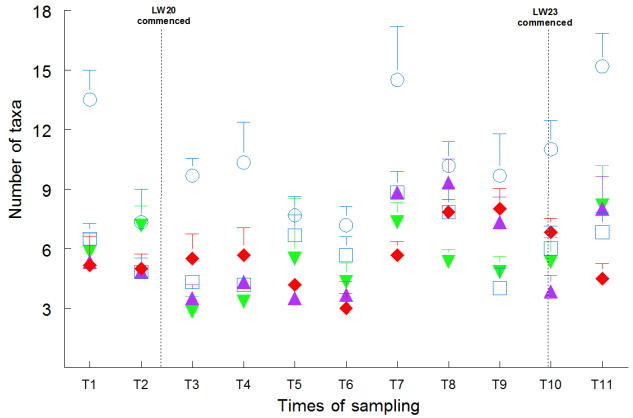


Chart 121a Mean (+SE) Macroinvertebrate Diversity, Stream Monitoring – Tributary C

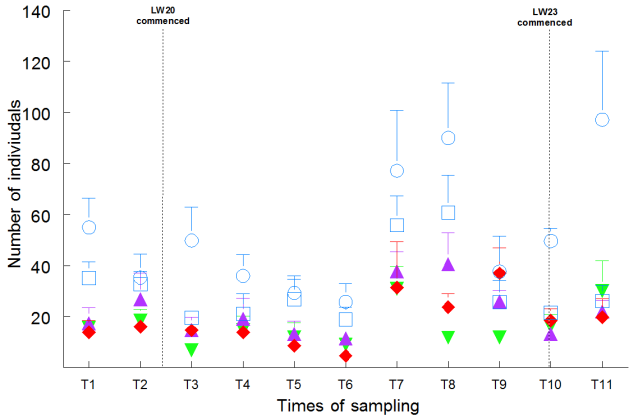


Chart 121b Mean (+SE) Macroinvertebrate Abundance, Stream Monitoring – Tributary C

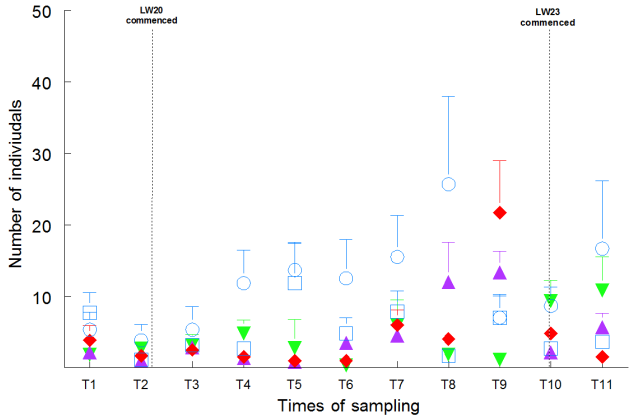


Chart 121c Mean (+SE) Number of Leptophlebiidae, Stream Monitoring- Tributary C

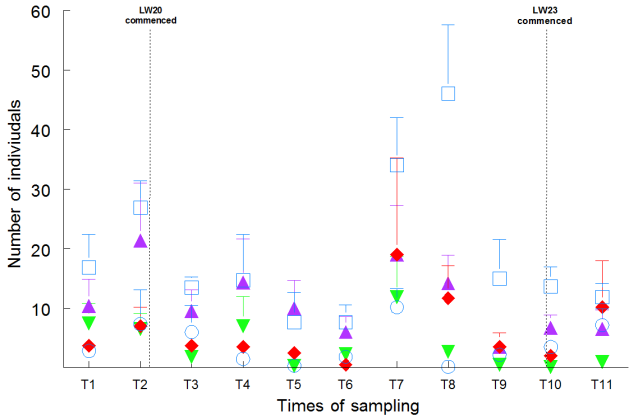


Chart 121d Mean (+SE) Number of Atyidae, Stream Monitoring – Tributary C

Key: Tributary C/Eastern Tributary (Location C1: green, solid inverted triangle; Location C2: solid purple triangle; Location C4: solid red diamond) and the control locations (Woronora River: empty square; O'Hares Creek: empty circle) (*n* = 6). Time 1 = spring 2009, T2 = autumn 2010, etc.

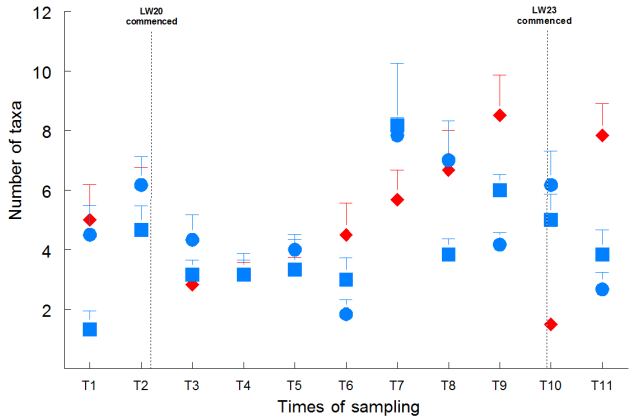


Chart 122a Mean (+SE) Macroinvertebrate Diversity, Stream Monitoring – Tributary B

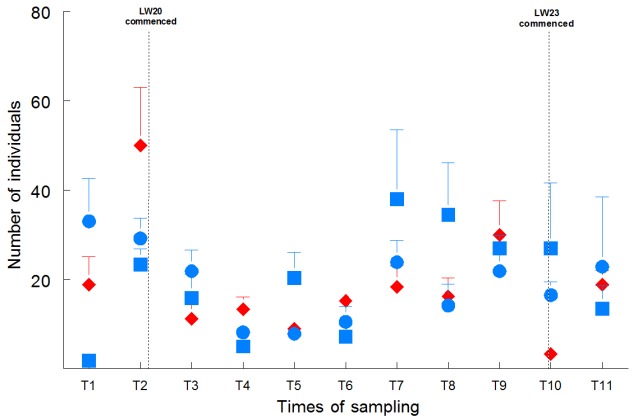


Chart 122b Mean (+SE) Macroinvertebrate Abundance, Stream Monitoring – Tributary B

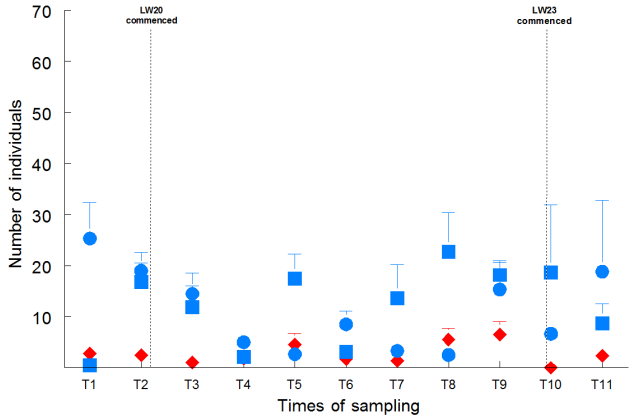


Chart 122c Mean (+SE) Number of Leptophlebiidae, Stream Monitoring- Tributary B

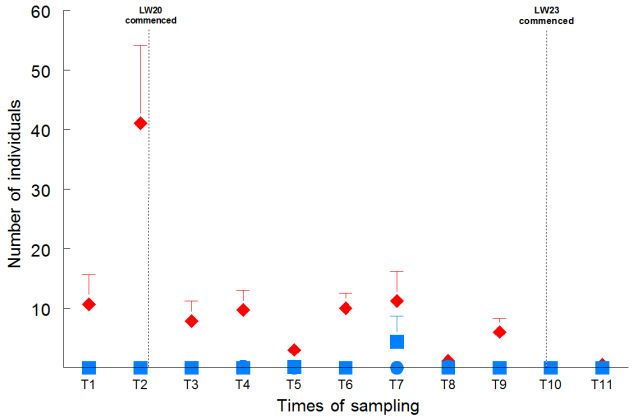


Chart 122d Mean (+SE) Number of Atyidae, Stream Monitoring – Tributary B

Key: Tributary B, Location B2 (diamonds) and the control locations (Bee Creek: squares; Woronora Tributary: circles) (*n* = 6). Time 1 = spring 2009, T2 = autumn 2010, etc.

Macrophyte Assemblages

Over the entire sampling period, the following floating attached species and/or submerged species of macrophytes (i.e. instream macrophytes) have been recorded:

- *Triglochin procerum* at sampling Locations WR1 and OC;
- *Chara/Nitella* spp. has commonly been recorded at Locations C1, C2, C4, WR1 and OC; and
- *Myriophyllum pedunculatum* at Location WR1.

A temporal comparison of the aquatic macrophyte data has been carried out for the locations sampled up to and including spring 2014. Charts 123a and 123b presents the PCoA plots for macrophytes at each sampling location using the quantitative sampling data. Temporal and spatial variability in the structure of assemblages of macrophytes was observed at all locations.

Charts 124a and 124b present the mean diversity of macrophytes and mean percentage cover of macrophytes, respectively, at each location sampled on Tributary C/Eastern Tributary (i.e. Locations C1, C2 and C4) and at the control locations (i.e. Woronora River and O'Hares Creek) using the quantitative sampling data.

Charts 125a and 125b present the mean diversity of macrophytes and mean percentage cover of macrophytes, respectively, at the location sampled along Tributary B and the control locations (i.e. Bee Creek and Woronora Tributary), respectively, using the quantitative sampling data.

Examination of the data show that there have been differences in the structure of assemblages of macrophytes between all of the locations sampled on Tributary C/Eastern Tributary (C1, C2 and C4) and the control locations sampled on the Woronora River and O'Hares Creek since the commencement of sampling (Chart 123a). The presence of the floating-attached species, *Triglochin procerum* (recorded at the control locations but not at locations sampled in Tributary C/Eastern Tributary), *Baumea juncea* (recorded at the Tributary C/Eastern Tributary locations but not at the control locations) and *Myriophyllum pedunculatum* (only recorded at the Woronora River location) contributes greatly to observed differences.

There was no evidence to suggest that there were spatial and/or temporal patterns of distributions of aquatic macrophytes at Locations C1, C2 and C4 or Location B2 related to the commencement of mining of the Longwalls 23-27 underground mining area.

Pool Monitoring

The pool monitoring program includes bi-annual (autumn and spring) monitoring of aquatic macroinvertebrates and macrophytes in pools to allow the response of aquatic ecosystems to the implementation of future stream remediation works on Tributary C to be assessed.

Monitoring has been carried out at the following pools:

- Large pool (defined as pools >40 m in length), Pool ETAH on Tributary C/Eastern Tributary overlying Longwalls 23-27.
- Smaller pools (defined as pools <40 m in length) Pools ETAG, ETAK and ETAI on Tributary C/Eastern Tributary overlying Longwalls 23-27.
- One larger control pool on Woronora River (Pool WP) and one larger control pool on O'Hares Creek (Pool OC).
- Three smaller control pools on Woronora River (Pools WP-A, WP-B and WP-C) and three smaller control pools on O'Hares Creek (Pools OC-A, OC-B and OC-C).

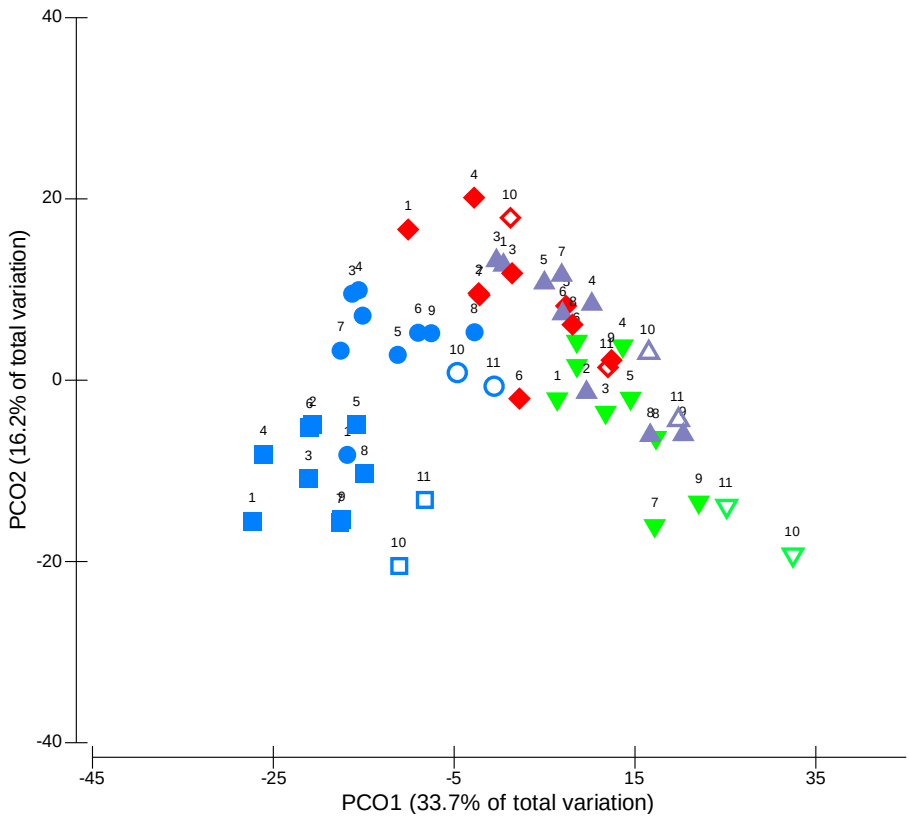


Chart 123a Principal Coordinates Analysis (PCoA) plots of macrophyte data for three locations on Tributary C: Location C1 (green inverted triangles); Location C2 (purple triangles); and Location C4 (red diamonds) and two control locations (Woronora River: blue squares and O'Hare's Creek: blue circles) for each time of sampling (*n*= 10) from spring 2009 (T1). Filled symbols: 'Before' commencement of Longwall 23; Empty symbols: 'After' commencement of Longwall 23.

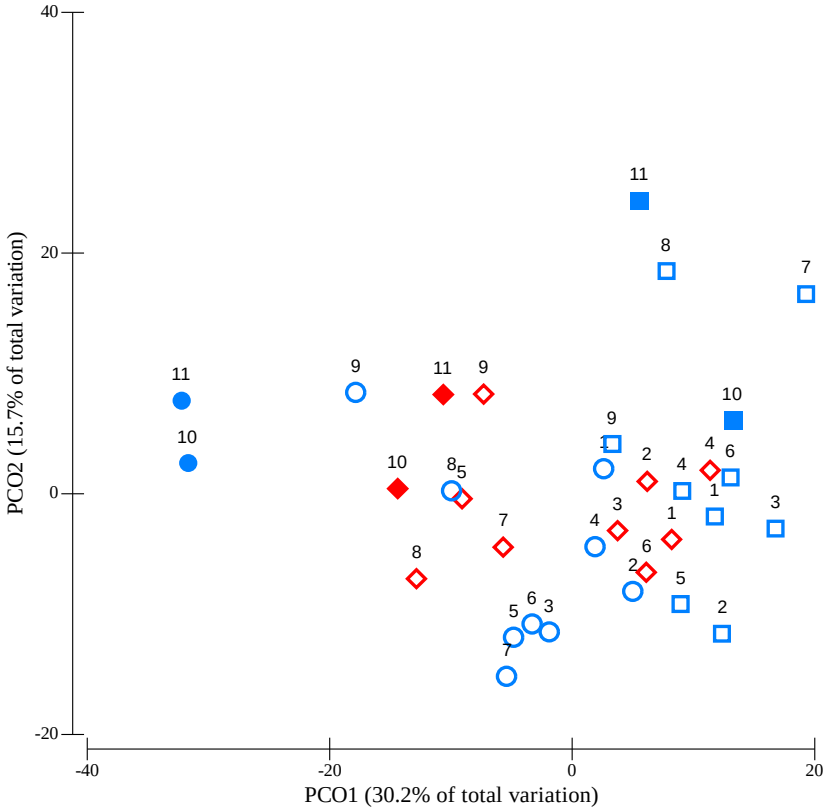


Chart 123b Principal Coordinates Analysis (PCoA) plot of macrophyte data collected at one location on Tributary B (i.e. Location B2) and two control locations (Bee Creek and Woronora Tributary) for each time of sampling (*n*= 10) from spring 2009 (T1). Red symbols: Tributary B; Blue squares: Bee Creek; Blue circles: Woronora Tributary. Filled symbols: 'Before' commencement of Longwall 23; Empty symbols: 'After' commencement of Longwall 23.

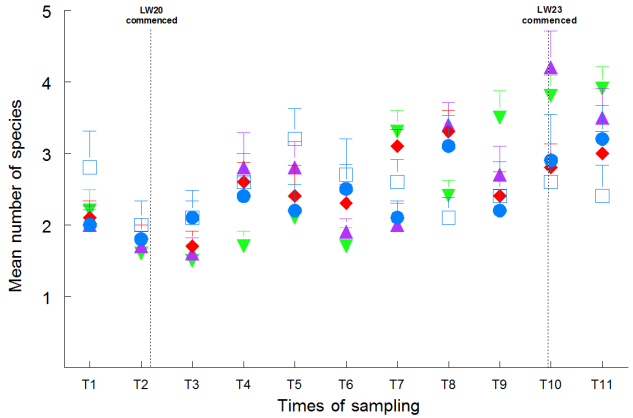


Chart 124a Mean (+SE) Macrophyte Diversity, Stream Monitoring, Tributary C

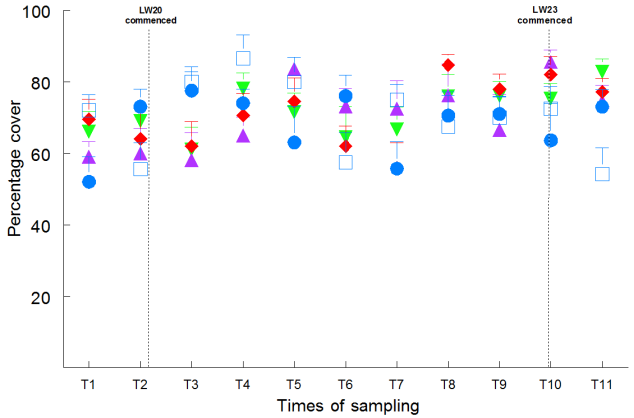


Chart 124b Mean (+SE) Macrophyte Cover, Stream Monitoring, Tributary C

Key: Tributary C/Eastern Tributary (Location C1: inverted green triangles; Location C2: solid purple triangles; Location C4: solid red diamonds) and the control locations (Woronora River: empty blue squares; O'Hares Creek: solid blue circles) (*n* = 10).

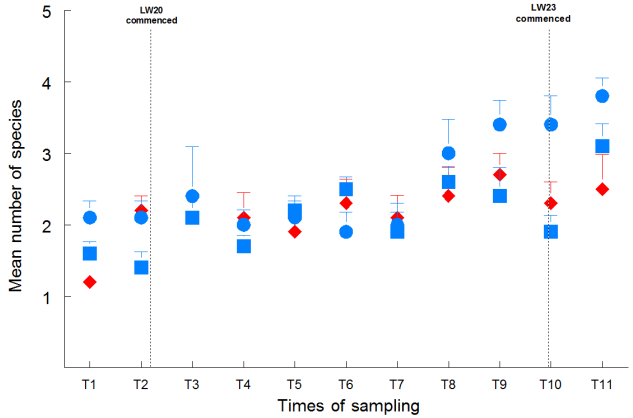


Chart 125a Mean (+SE) Macrophyte Diversity, Steam Monitoring, Tributary B

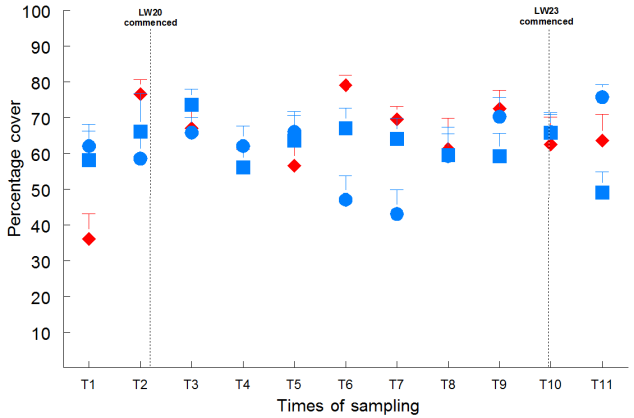


Chart 125b Mean (+SE) Macrophyte Cover, Stream Monitoring, Tributary B

Key: Tributary B (diamonds) and the control locations (Bee Creek: squares; Woronora Tributary: circles) (*n* = 10).
Time 1 = spring 2009, T2 = autumn 2009, etc.

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

Sampling is carried out at two random sites within the larger pools and at one site within the smaller pools.

Within each site in each pool, aquatic macroinvertebrates and macrophytes are sampled using the same quantitative techniques described for stream monitoring above. The AUSRIVAS sampling technique is not used for macroinvertebrate sampling in the pool monitoring.

Quantitative estimates of aquatic macrophytes (i.e. emergent, floating attached and/or submerged species of aquatic plants) are collected at one site at each small pool and at two sites at each large pool. In addition, the spatial distribution of floating attached and/or submerged macrophytes (e.g. *Myriophyllum penduculatum* and *Triglochin procerum*) is mapped in each pool, to provide a visual comparison of their distribution through time.

Surveys have been carried out at Pools ETAH, ETAG, ETAK and ETAI on Tributary C/Eastern Tributary since spring 2009. Surveys have been carried out at control Pools WP, WP-A, WP-B, WP-C, OC, OC-A, OC-B and OC-C since spring 2008 (as a component of the Longwalls 20-22 aquatic ecology monitoring program).

A summary of the pool monitoring survey results obtained prior to the commencement of Longwall 23 (i.e. up to and including spring 2013) by BIO-ANALYSIS Pty Ltd as well as the stream monitoring results for autumn 2014 (during the mining of Longwall 23) is provided in the Metropolitan Coal 2014 Annual Review and AEMR/Rehabilitation Report.

A summary of the pool monitoring survey results in spring 2014 (i.e. during the mining of Longwall 23) is presented below.

Stream Characteristics

To date, there has been no evidence of subsidence-induced surface cracking, iron staining or gas releases at any of the pools sampled on Tributary C.

Macroinvertebrate Assemblages

A temporal comparison of the aquatic macroinvertebrate data has been carried out for the pools sampled from spring 2009 to spring 2014.

Chart 126 presents the PCoA plot for macroinvertebrates at the larger pools using the quantitative sampling data. Charts 127a to 127d present the mean diversity of macroinvertebrates, mean abundance of macroinvertebrates, mean number of Leptophlebiidae and mean number of Atyidae respectively, at the larger pools using the quantitative sampling data.

Chart 128 presents the PCoA plot for macroinvertebrates at the smaller pools using the quantitative sampling data. Charts 129a and 129b present the mean diversity of macroinvertebrates and mean abundance of macroinvertebrates at the smaller pools, respectively, using the quantitative sampling data.

The results indicate there have been differences in the structure of assemblages of macroinvertebrates collected among the large and small pools sampled since the commencement of sampling (Charts 126 and 128). In particular, macroinvertebrate assemblages in the large pool sampled on O'Hares Creek grouped separately from the pools sampled on Tributary C/Eastern Tributary and the Woronora River.

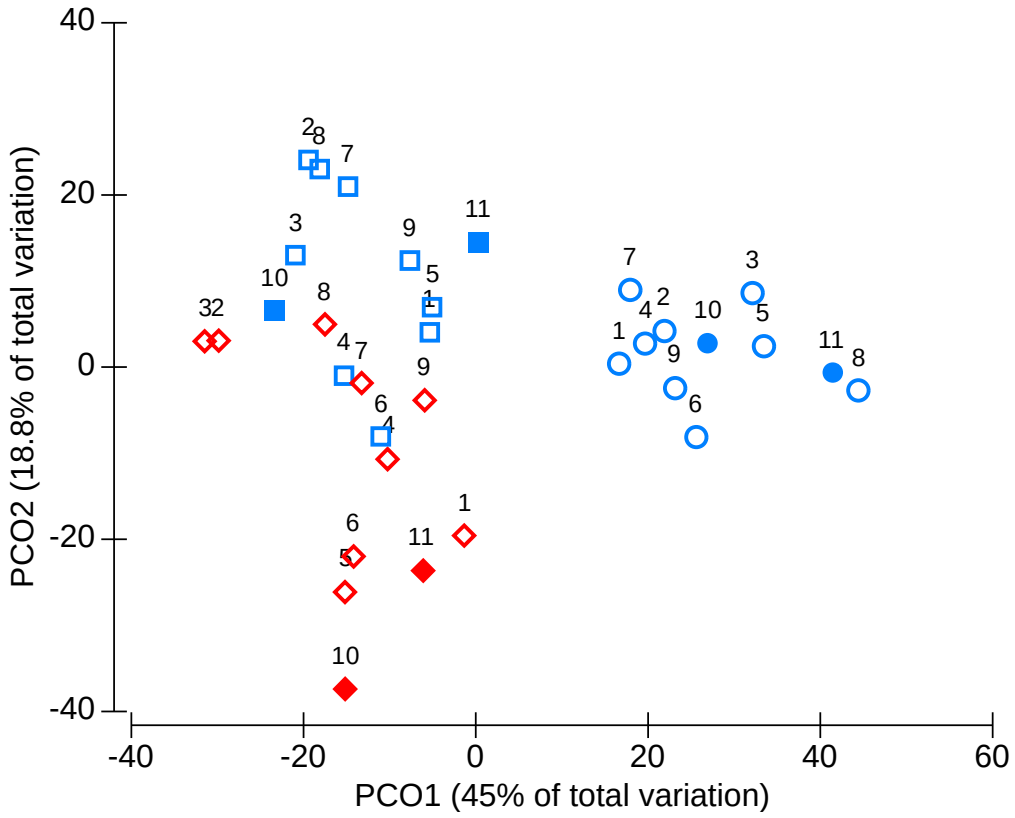


Chart 126 Principal Coordinates Analysis (PCoA) plot of macroinvertebrate data (standardized) for large Pool ETAH on Tributary C (red diamonds) and two large control pools: Woronora River (blue squares) and O'Hares Creek (blue circles) for each time of sampling (*n* = 6), from spring 2009 (T1). Empty symbols: 'Before' commencement of Longwall 23; Filled symbols: 'After' commencement of Longwall 23.

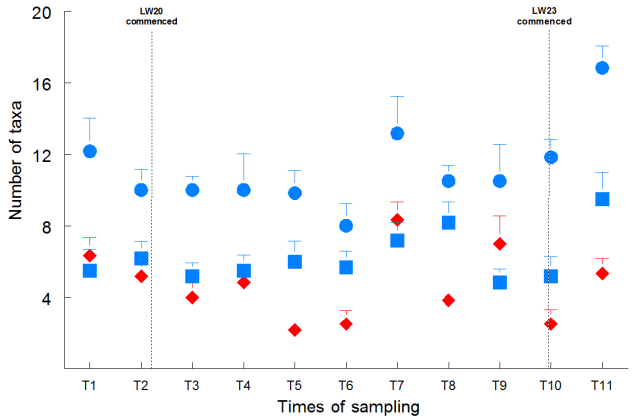


Chart 127a Mean (+SE) Macroinvertebrate Diversity, Large Pool Monitoring

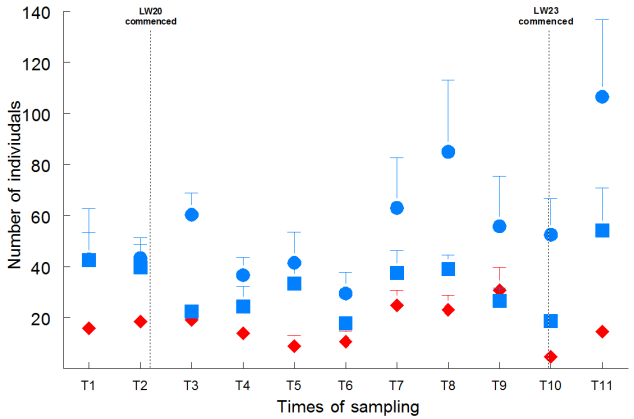


Chart 127b Mean (+SE) Macroinvertebrate Abundance, Large Pool Monitoring

Key: Pool ETAH on Tributary C: red diamonds and the control pools (Woronora River Pool: blue squares, O'Hares Creek Pool: blue circles). Sampling of Pool ETAH commenced spring 2009 (*n* = 6).

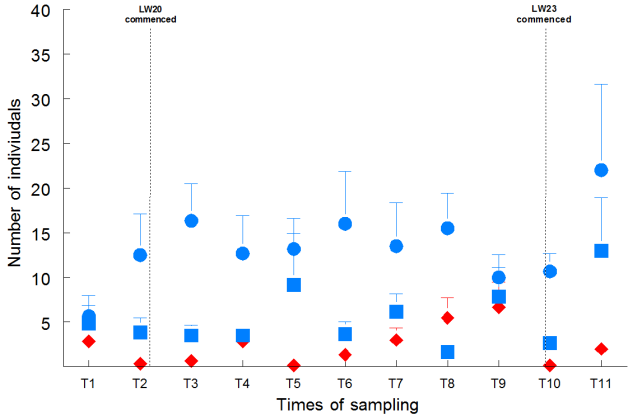


Chart 127c Mean (+SE) Number of Leptophlebiidae, Large Pool Monitoring

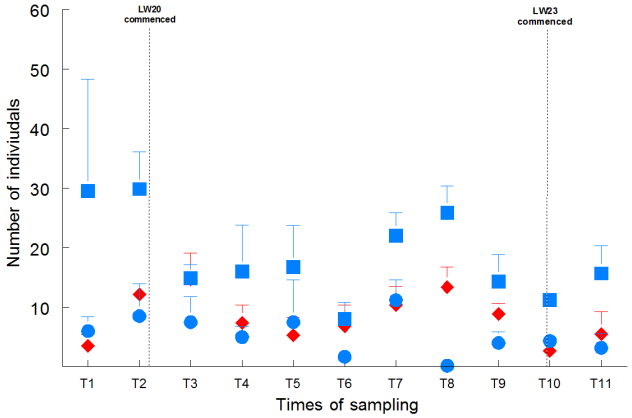


Chart 127d Mean (+SE) Number of Atyidae, Large Pool Monitoring

Key: Pool ETAH on Tributary C: red diamonds and the control pools (Woronora River Pool: blue squares, O'Hares Creek Pool: blue circles). Sampling of Pool ETAH commenced spring 2009 (*n* = 6).

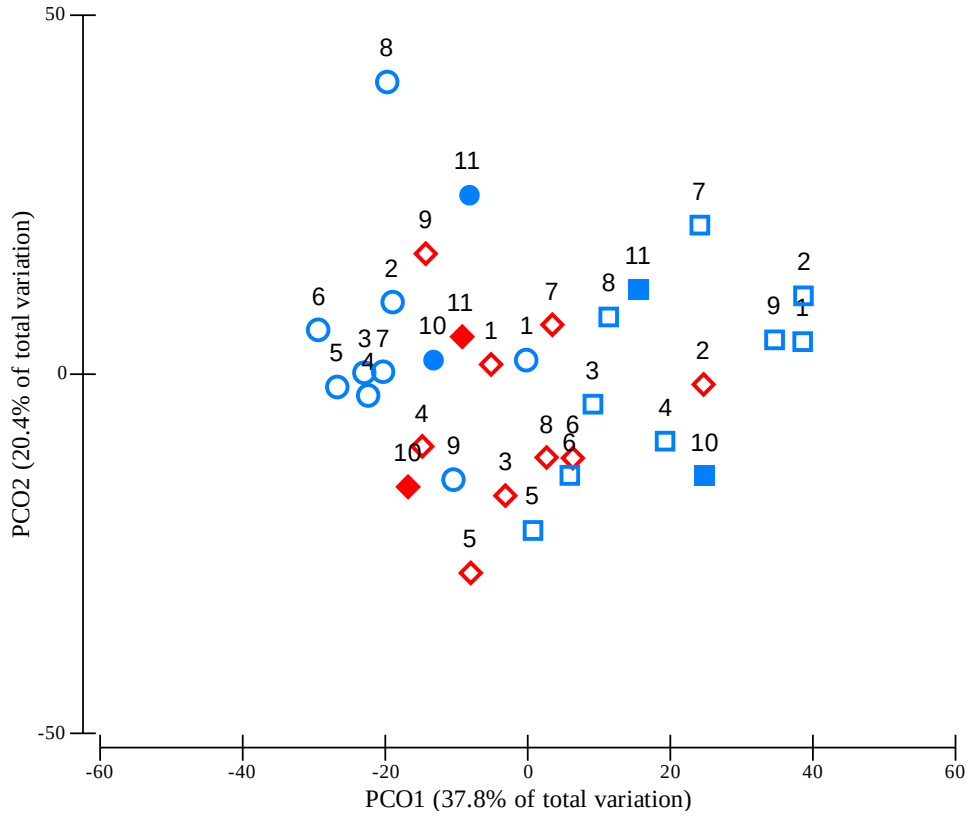


Chart 128 Principal Coordinates Analysis (PCoA) plots of macroinvertebrate data (standardized) for small pools on Tributary C (red diamonds) and small control pools on Woronora River (blue squares) and O'Hare's Creek (blue circles) for each time of sampling (*n*= 9), from spring 2009 (T1). Empty symbols: 'Before' commencement of Longwall 23; Solid symbols: 'After' commencement of Longwall 23.

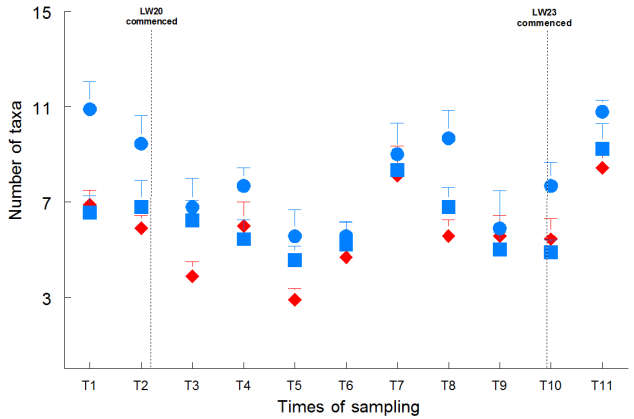


Chart 129a Mean (+SE) Macroinvertebrate Diversity, Small Pool Monitoring

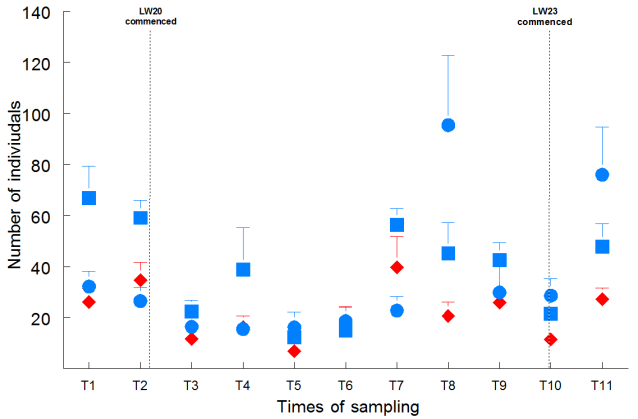


Chart 129b Mean (+SE) Macroinvertebrate Abundance, Small Pool Monitoring

Key: Tributary C pools: red diamonds and the control pools (Woronora River Pool: solid blue squares, O'Hares Creek Pool: solid blue circles).
Sampling of Pools commenced spring 2009 (*n* = 6).

Macrophyte Assemblages

A temporal comparison of the aquatic macrophyte data has been carried out for the pools sampled from spring 2009 to spring 2014.

Chart 130 presents the PCoA plots for macrophytes at the larger pools using the quantitative sampling data. Charts 131a and 131b present the mean diversity and mean abundance of macrophytes at the larger pools using the quantitative sampling data.

Chart 132 presents PCoA plots for macrophytes at the smaller pools, using the quantitative sampling data. Charts 133a and 133b present the mean diversity and mean abundance of macrophytes at the smaller pools, respectively, using the quantitative sampling data.

Macrophyte assemblages collected at the large and small pools have been distinctive among streams since the commencement of sampling. Differences among streams are mostly due to the different species that dominate the assemblages. For example, *Baumea juncea* is commonly ranked as an important component of assemblages at pools on Tributary C/Eastern Tributary, whereas *Triglochin procerum* is an important component of assemblages in pools sampled on the Woronora River (Charts 130 and 132).

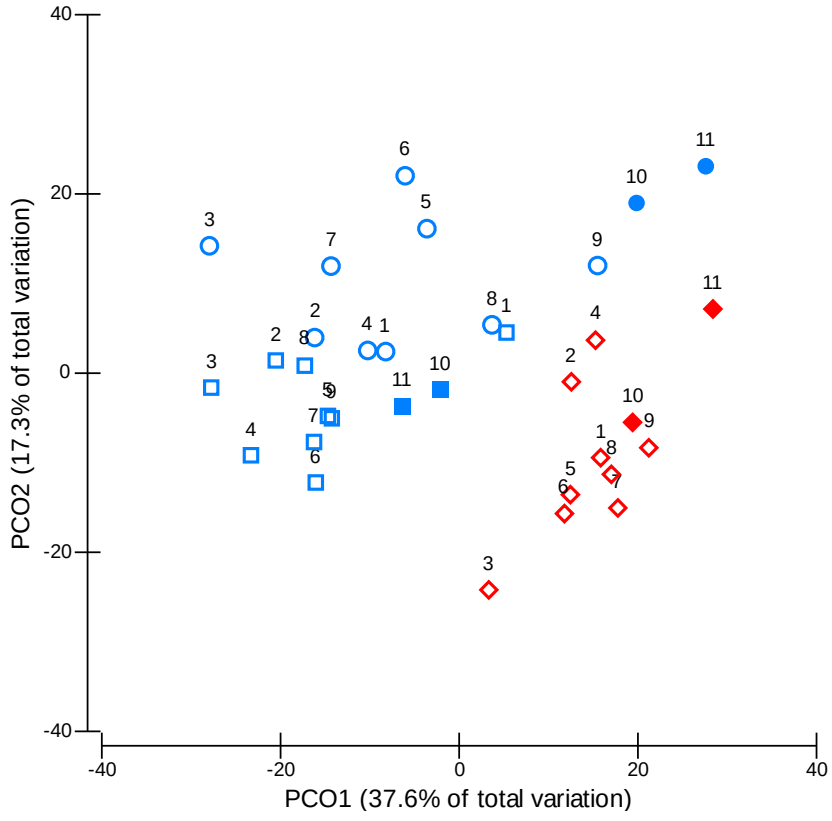


Chart 130 Principal Coordinates Analysis (PCoA) plots of macrophyte data for the large pool (Pool ETAH) in Tributary C (red diamonds) and two control streams: Woronora River (blue squares) and O'Hares Creek (blue circles) (*n*=10), from spring 2009 (T1). Empty symbols: 'Before' commencement of Longwall 23; Filled symbols: 'After' commencement of Longwall 23.

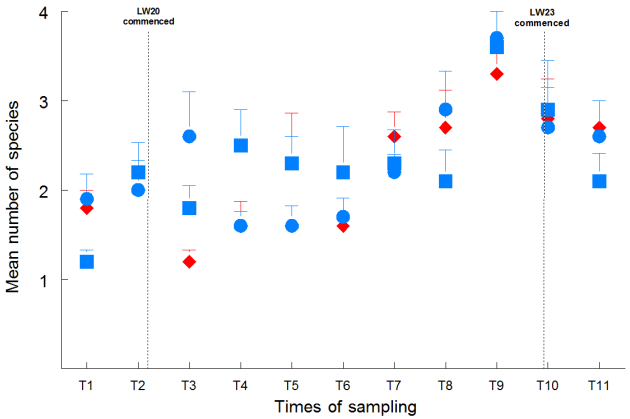


Chart 131a Mean (+SE) Macrophyte Diversity, Large Pool Monitoring

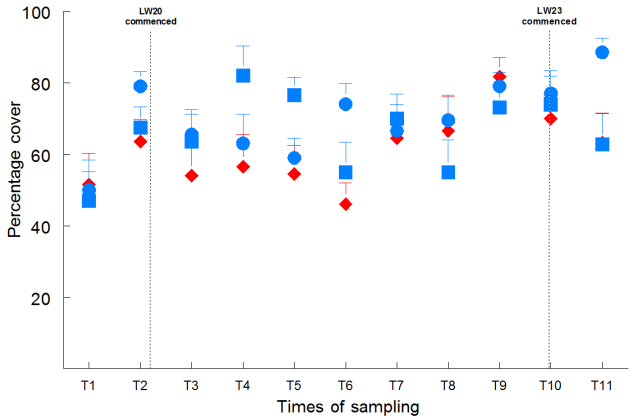


Chart 131b Mean (+SE) Macrophyte Percentage Cover, Large Pool Monitoring

Key: Pool ETAH on Tributary C: solid red diamonds and the control pools (Woronora River Pool: solid blue squares, O'Hares Creek Pool: solid blue circles) (*n* = 10). Sampling of Pools commenced spring 2009. Time 1 = spring 2009, T2 = autumn 2010, etc.

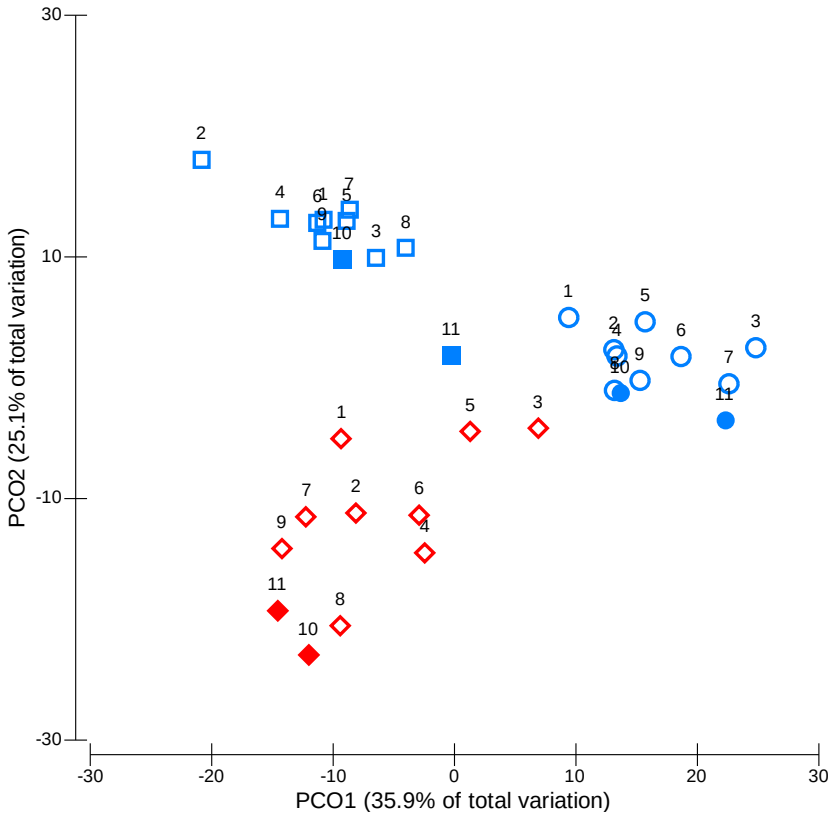


Chart 132 Principal Coordinates Analysis (PCoA) plots of macrophyte data for small pools on Tributary C (red diamonds) and small control pools on Woronora River (blue squares) and O'Hare's Creek (blue circles) for each time of sampling (*n*= 9) from spring 2009 (T1). Empty symbols: 'Before' commencement of Longwall 23; Filled symbols: 'After' commencement of Longwall 23.

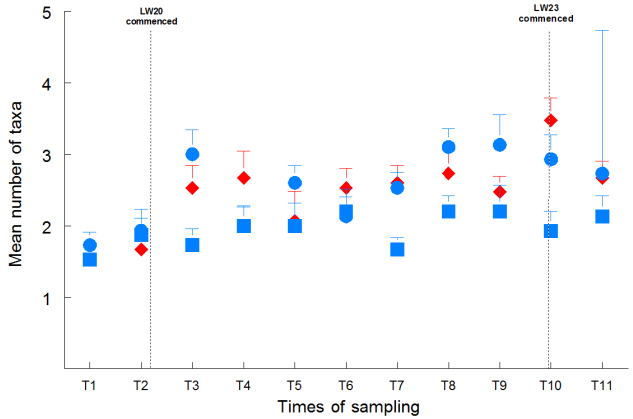


Chart 133a Mean (+SE) Macrophyte Diversity, Small Pool Monitoring

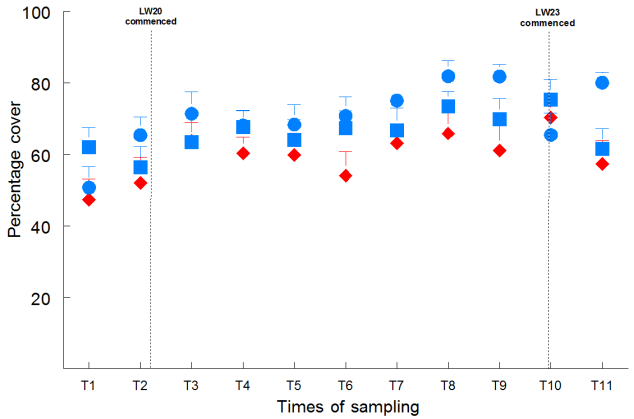


Chart 133b Mean (+SE) Macrophyte Abundance, Small Pool Monitoring

Key: Tributary C pools: solid red diamonds and the control pools (Woronora River Pool: solid blue squares, O'Hares Creek Pool: solid blue circles). Sampling of Pools from spring 2009 (*n* = 15). Time 1 = spring 2009, T2 = autumn 2010, etc.

3.2.2.5 Amphibian Surveys

A monitoring program has been developed for Longwalls 23-27 to monitor amphibian species, with a focus on the habitats of the Giant Burrowing Frog (*Heleiporus australiiacus*) and Red-crowned Toadlet (*Pseudophryne australis*) associated with tributaries.

Five test sites overlying Longwalls 23-27 and five control sites are surveyed annually in spring/summer (i.e. October to February) during suitable weather conditions. The approximate locations of the sampling sites in relation to longwall panels are shown on Figure 14.

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

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

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

Baseline monitoring was conducted in spring/summer 2010, 2011, 2012 and 2013. Longwall 23 commenced in May 2014 and was completed in March 2015. Longwall 24 commenced in April 2015. At the time of the spring/summer 2014 survey, the following test sites had been undermined: site 13 (undermined by Longwall 23A) and site 14 (undermined by Longwall 23B).

The results of the five surveys to date (2010 - 2014) are summarised in Table 8, Table 9 and Chart 134.

Chart 134 presents the number of amphibian species recorded at each site in 2010 to 2014.

Table 8
Amphibian Species Diversity and Abundance for Longwalls 23-27, Spring/Summer 2010 – 2014

Scientific Name	Common Name	Survey	Sites Above Longwalls 23-27 (Test)					Control Sites					Total		Relative Abundance[2]	
			13	14	15	16	17	18	19	20	21	22	Test	Control	Test	Control
Myobatrachidae																
Crinia signifera	Common Eastern Froglet	2010	2 0	3 0	0 6	0 0	1 0	9 c100	2 0	2 0	1 c100	3 75	6 6	17 c275	UC UC	MC A
		2011	0 0	11 4	0 0	3 0	6 0	1 0	21 0	1 0	0 2	2 15	21 4	25 17	C UC	C MC
		2012	5 0	2 0	2 0	0 0	1 0	10 0	0 0	5 0	11 10	5 0	10 0	31 10	UC 0	C UC
		2013	13 0	1 10	1 0	0 0	0 0	3 0	1 0	0 0	3 0	1 0	15 10	5 0	MC UC	UC 0
		2014	5 0	3 135	10 0	14 0	10 0	19 0	2 0	20 0	10 0	25 0	42 135	76 0	A A	A 0
Heleiporus australiiacus	Giant Burrowing Frog[v, v]	2010	1 0	0 0	1 0	0 0	0 0	1 0	0 0	0 0	0 0	1 0	2 0	2 0	UC 0	UC 0
		2011	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2012	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2013	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2014	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
Limnodynastes peronii	Brown-striped Frog*	2010	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2011	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2012	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2013	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2014	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0

Table 8 (Continued)
Amphibian Species Diversity and Abundance for Longwalls 23-27, Spring/Summer 2010 – 2014

Scientific Name	Common Name	Survey	Sites Above Longwalls 23-27 (Test)					Control Sites					Total		Relative Abundance[2]	
			13	14	15	16	17	18	19	20	21	22	Test	Control	Test	Control
Myobatrachidae																
Limnodynastes tasmaniensis	Spotted Grass Frog	2010	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2011	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2012	0 0	0 0	0 0	0 1	0 0	0 0	0 0	0 0	0 0	0 0	0 1	0 0	0 1	0 0
		2013	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2014	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
Pseudophryne australis	Red-crowned Toadlet[v]	2010	2 3	2 0	1 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	5 3	0 0	UC UC	0 0
		2011	2 0	3 0	0 0	0 0	1 0	0 0	0 0	0 0	0 0	2 7	6 0	2 7	UC 0	UC UC
		2012	0 0	0 0	0 0	0 0	0 0	1 0	0 0	1 0	1 0	4 0	0 0	7 0	0 0	UC 0
		2013	1 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	2 0	1 0	2 0	1 0	UC 0
		2014	1 0	0 0	2 0	0 0	0 0	6 0	0 0	1 0	5 0	5 0	3 0	17 0	UC 0	MC 0
Uperoleia laevigata	Smooth Toadlet	2010	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2011	0 0	0 0	0 0	0 0	0 0	0 0	2 8	0 0	0 0	0 1	0 0	2 9	0 0	UC UC
		2012	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2013	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2014	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0

Table 8 (Continued)
Amphibian Species Diversity and Abundance for Longwalls 23-27, Spring/Summer 2010 – 2014

Scientific Name	Common Name	Survey	Sites Above Longwalls 23-27 (Test)					Control Sites					Total		Relative Abundance[2]	
			13	14	15	16	17	18	19	20	21	22	Test	Control	Test	Control
Hylidae																
Litoria citropa	Blue Mountains Tree Frog	2010	0 0	0 0	2 0	0 0	0 0	2 0	0 0	0 0	0 0	0 0	2 0	2 0	UC 0	UC O
		2011	3 0	0 0	0 0	0 0	0 0	0 0	2 8	0 0	0 0	0 5	3 0	0 5	UC 0	0 UC
		2012	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2013	2 0	0 43	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	2 43	0 0	UC C	0 0
		2014	6 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	6 0	0 0	UC 0	0 0
Litoria dentata	Bleating Tree Frog	2010	0 0	0 0	0 0	0 0	0 0	1 24	0 0	0 0	0 0	0 0	0 0	1 24	0 0	1 MC
		2011	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2012	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2013	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2014	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
Litoria freycineti	Southern Rocket Frog	2010	2 4	1 3	1 6	0 0	0 0	0 0	0 0	3 7	2 50	2 0	4 13	7 57	UC MC	UC A
		2011	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2012	0 0	0 7	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 7	0 0	0 UC	0 0
		2013	2 0	0 0	0 0	0 0	1 0	0 0	0 0	0 0	0 0	0 0	3 0	0 0	UC 0	0 0
		2014	9 0	2 C100	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	11 100	0 0	MC A	0 0

Table 8 (Continued)
Amphibian Species Diversity and Abundance for Longwalls 23-27, Spring/Summer 2010 – 2014

Scientific Name	Common Name	Survey	Sites Above Longwalls 23-27 (Test)					Control Sites					Total		Relative Abundance[2]	
			13	14	15	16	17	18	19	20	21	22	Test	Control	Test	Control
Hylidae																
Litoria latopalmata	Broad-palmed Frog*	2010	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2011	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2012	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2013	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2014	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
Litoria lesueurii	Lesueur's Frog	2010	1 0	0 0	2 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	3 0	0 0	UC 0	0 0
		2011	1 0	6 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	7 0	0 0	UC 0	0 0
		2012	0 0	0 26	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 26	0 0	0 A	0 0
		2013	0 0	0 5	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 5	0 0	0 UC	0 0
		2014	0 0	1 29	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	1 29	0 0	1 C	0 0
Litoria wilcoxii	Stony Creek Frog*	2010	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2011	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2012	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2013	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2014	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0

Table 8 (Continued)
Amphibian Species Diversity and Abundance for Longwalls 23-27, Spring/Summer 2010 – 2014

Scientific Name	Common Name	Survey	Sites Above Longwalls 23-27 (Test)					Control Sites					Total		Relative Abundance[2]	
			13	14	15	16	17	18	19	20	21	22	Test	Control	Test	Control
Hylidae																
Litoria peronii	Peron's Tree Frog	2010	0 0	0 0	0 0	0 0	1 0	0 0	2 0	0 0	0 0	0 0	1 0	2 0	UC 0	UC 0
		2011	0 0	0 0	0 0	1 0	0 0	0 0	0 0	0 0	0 0	0 0	1 0	0 0	UC 0	0 0
		2012	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2013	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2014	1 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	1 0	0 0	1 0	0 0
Litoria phyllochroa	Green Stream Frog*	2010	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2011	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2012	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2013	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
		2014	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
Species Diversity at Each Site		2010	**5**	**3**	**6**	**0**	**2**	**4**	**2**	**2**	**2**	**3**				
		2011	**5**	**4**	**0**	**2**	**2**	**2**	**2**	**2**	**1**	**5**				
		2012	**1**	**3**	**1**	**1**	**1**	**2**	**0**	**2**	**2**	**2**				
		2013	**4**	**3**	**1**	**0**	**1**	**1**	**1**	**0**	**1**	**2**				
		2014	**5**	**3**	**2**	**1**	**1**	**2**	**1**	**2**	**2**	**2**				
Species Diversity in all Control and all Test sites		2010											**7**	**6**		
		2011											**6**	**5**		
		2012											**4**	**3**		
		2013											**5**	**2**		
		2014											**6**	**2**		

Table 8 (Continued)
Amphibian Species Diversity and Abundance for Longwalls 23-27, Spring/Summer 2010 – 2014

Species Diversity in all Control and all Test sites	2010											**8**		
	2011											**7**		
	2012											**5**		
	2013											**5**		
	2014											**6**		

* Species not recorded at the Longwalls 23-27 monitoring sites, but included for ease of future comparison to the Longwalls 20-22 monitoring results.

[1] First line of data refers to the presence or absence of adults, while the second line of data refers to absence or presence of tadpoles.

[2] Relative Abundance of adult and tadpole stage assessed independently: 0 – no sightings, 1 – One sighting, UC – Uncommon, 2 to 10 individuals, MC – Moderately common, 11 to 20 individuals, C – Common, 21 to 40 individuals, A – Abundant, >40 individuals, c1000 = approximately 1,000 animals estimated.

[V, V] Listed as vulnerable under the TSC Act and EPBC Act. [V] Listed as vulnerable under the TSC Act.

Table 9
Number of Longwalls 23-27 Sites used per Amphibian Species in 2010 - 2014

Species	Test Sites					Control Sites				
	2010	2011	2012	2013	2014	2010	2011	2012	2013	2014
Common Eastern Froglet	4	3	4	3	5	5	5	4	4	5
Giant Burrowing Frog [V, v]	2	0	0	0	0	2	0	0	0	0
Brown-striped Frog*	0	0	0	0	0	0	0	0	0	0
Spotted Grass Frog	0	0	1	0	0	0	0	0	0	0
Red-crowned Toadlet [V]	3	3	0	1	2	0	1	4	1	4
Smooth Toadlet	0	0	0	0	0	0	2	0	0	0
Blue Mountains Tree Frog	1	1	0	2	1	1	1	0	0	0
Bleating Tree Frog	0	0	0	0	0	1	0	0	0	0
Southern Rocket Frog	3	0	1	2	2	3	0	0	0	0
Broad-palmed Frog*	0	0	0	0	0	0	0	0	0	0
Lesueur's Frog	2	2	1	2	1	0	0	0	0	0
Stony Creek Frog*	0	0	0	0	0	0	0	0	0	0
Peron's Tree Frog	1	1	0	0	1	1	0	0	0	0
Green Stream Frog*	0	0	0	0	0	0	0	0	0	0

Note: Test sites include 13 to 17 and control sites include 18 to 22 (i.e. a total of 5 test sites and 5 control sites).
[V, v] Listed as vulnerable under the TSC Act and EPBC Act. [V] Listed as vulnerable under the TSC Act.

* Species not recorded at the Longwalls 23-27 monitoring sites, but included for ease of future comparison to the Longwalls 20-22 monitoring results.

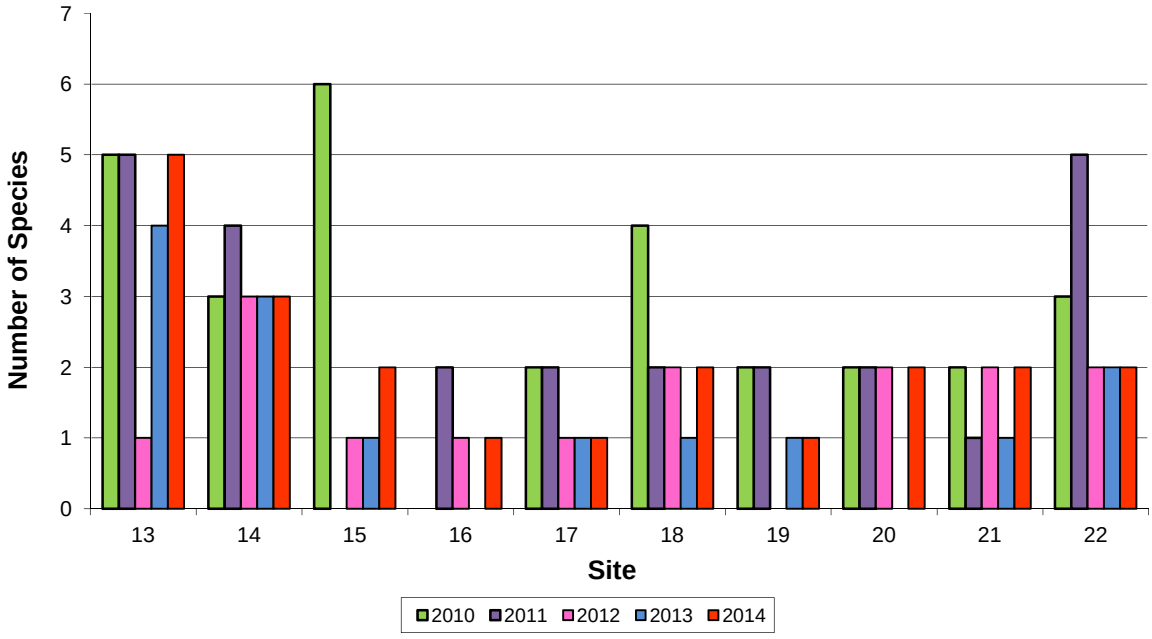


Chart 134 Amphibian Species Diversity, 2010 – 2014

In summary, the amphibian survey results from 2010 to 2014 indicated:

- A total of 10 amphibian species have been recorded in the 2010 to 2014 surveys, namely the Common Eastern Froglet (*Crinia signifera*), Giant Burrowing Frog (*Heleiporus australiiacus*), Spotted Grass Frog (*Limnodynastes tasmaniensis*), Red-crowned Toadlet (*Pseudophryne australis*), Smooth Toadlet (*Uperoleia laevigata*), Blue Mountains Tree Frog (*Litoria citropa*), Bleating Tree Frog (*Litoria dentata*), Southern Rocket Frog(*Litoria freycineti*), Lesueur's Frog (*Litoria lesueurii*) and Peron's Tree Frog (*Litoria peronii*).
- There has been no evidence of four species, located during baseline studies, at test or control sites during amphibian surveys from 2010 – 2014, namely the Brown-striped Frog, Broad-palmed Frog, Stony Creek Frog and Green Stream Frog.
- In 2010, eight amphibian species were located in the survey area including seven species in test sites and six species in control sites. In 2011, seven species were located in the survey area including six species in test sites and five species in control sites. In comparison in 2012, five amphibian species were located in the survey area including four species in test sites and three species in control sites. In 2013, five amphibian species were also located across the survey area including five in test sites and two in control sites. In 2014, six species were located in the survey area including five in test sites and two in control sites.
- Species diversity at individual sites ranged from 0-6 species at test sites and 2-4 species at control sites in 2010, 0-5 species at test sites and 1-5 species at control sites in 2011, 1-3 species at test sites and 0-2 species at control sites in 2012, 0-4 species at test sites and 0-2 species at control sites in 2013 and 1-5 species at test sites and 1-2 species at control sites in 2014.
- The most species diverse site in 2010 was test site 15 with six species recorded. In 2011 the most species diverse sites were test site 13 and control site 22, both with five species. In 2012 the most species diverse site was test site 14 with three species recorded. In 2013 the most species diverse site was test site 13 with four species. In 2014 the most species diverse site was test site 13 with five species recorded.
- Breeding success has been infrequently observed over the 2010 to 2014 survey period:
  - In 2010, breeding events were identified for three species at test sites (Common Eastern Froglet, Red-crowned Toadlet and Southern Rocket Frog) and three species at control sites (Common Eastern Froglet, Bleating Tree Frog and Southern Rocket Frog).
  - In 2011, breeding events were identified for one species at test sites (Common Eastern Froglet) and four species at control sites (Common Eastern Froglet, Red-crowned Toadlet, Smooth Toadlet and Blue Mountains Tree Frog).
  - In 2012, breeding events were identified for three species at test sites (Spotted Grass Frog, Southern Rocket Frog and Lesueur's Frog) and one species at control sites (Common Eastern Froglet).
  - In 2013, breeding events were identified for three species at test sites (Common Eastern Froglet, Blue Mountains Tree Frog and Lesueur's Frog) and no species at control sites.
  - In 2014, breeding events were identified for three species at test sites (Common Eastern Froglet, Southern Rocket Frog and Lesueur's Frog) and no species at control sites.
- The Giant Burrowing Frog was only recorded in the 2010 survey at test sites 13 and 15 (uncommon) and control sites 18 and 22 (uncommon).
- The Red-crowned Toadlet was recorded in 2010 (uncommon), 2011 (uncommon), 2013 (one individual) and 2014 (uncommon) at test sites and in 2011 (uncommon), 2012 (uncommon), 2013 (uncommon) and 2014 (moderately common) at control sites.

- Test sites consistently had greater species diversity compared to control sites in each survey period.
- A Poisson regression analysis has been used to analyse the amphibian survey results obtained to date. The adult amphibian data is non-normally distributed and characterised by significant occurrences of zero data. Such data require non-normal analysis to determine if potential adverse impacts are significant at the 95% confidence level. To date, no adverse impact from mining has been detected for any frog species including the Giant Burrowing Frog and Red-crowned Toadlet, at the 95% confidence level.
- The amphibian species diversity and abundance data are consistent with population variations and cycles in response to seasonal variations. There are no significant differences between the test and control sites.

3.3 ASSESSMENT OF ENVIRONMENTAL PERFORMANCE

3.3.1 Longwalls 20-22

3.3.1.1 Analysis against Performance Indicator 1 – Vegetation in Upland Swamps

Analysis against Performance Indicator 1

Performance Indicator 1: *The vegetation in upland swamps is not expected to experience changes significantly different to vegetation in control swamps.*

This indicator is considered to have been exceeded if:

- data indicates a declining trend in the condition of swamp vegetation; or
- data analysis indicates statistically significant changes in vegetation between the mined and control swamps.

Detailed analysis of the above performance indicator is provided in Section 3.2.1.1. In summary:

- Visual inspections of upland swamp vegetation indicate that the upland swamp vegetation performance indicator has not been exceeded (i.e. the observations have not identified a declining trend in the condition of vegetation in swamps overlying Longwalls 20-22 that were not also observed in the control swamps).
- Analysis of quadrat/transect data indicates that the upland swamp performance indicator '*The vegetation in upland swamps is not expected to experience changes significantly different to changes in control swamps'* has not been exceeded.
- Analysis of indicator species data indicates that the upland swamp performance indicator '*The vegetation in upland swamps is not expected to experience changes significantly different to changes in control swamps'* has not been exceeded.

3.3.1.2 Analysis against Performance Indicator 2 – Swamp Groundwater Levels in Upland Swamps

Analysis against Performance Indicator 2

Performance Indicator 2: *Surface cracking within upland swamps resulting from mine subsidence is not expected to result in measurable changes to swamp groundwater levels when compared to control swamps or seasonal variations in water levels experienced by upland swamps prior to mining.*

This indicator is considered to have been exceeded if data analysis indicates statistically significant changes in swamp substrate groundwater levels. Groundwater level bandwidths defined by two standard deviations (2σ) from the mean have been determined for the full period of record up to 31 May 2012 for all swamp substrate piezometers associated with Longwalls 20-22 (and their controls) except for Swamp 25 where a 5-95th percentile bandwidth applies. Data acquired at the swamp substrate piezometers up to 31 May 2012 are unaffected by mining and serve as a suitable baseline for assessment of subsequent potential impacts. As the performance indicator applies only to swamp substrate groundwater levels, bandwidths are not defined for the sandstone piezometers underlying the swamps.

The bandwidth for control Swamp 101 (Chart 135), about 1.4 m, is conditioned by the strong dry episode in February 2011 and during the last quarter of 2012. Swamp 101 is the control swamp for longwall Swamp 25. Higher than average rainfall conditions prevailed during the latter half of the reporting period (April-June 2015). The water level in the substrate of Swamp 101 remained in the midrange of the bandwidth during that period.

The performance assessment for Swamp 25 is illustrated on Chart 136. The swamp substrate (1 m) piezometer indicates ongoing intermittent saturation. The 5%/95% bandwidth shows that the lower percentile coincides with the minimum recorded levels, presumably the bottom of the hole (which is 1.55 m below the surveyed collar level). Swamp 25 recorded saturated conditions for 60% of the reporting period. As all swamp substrate groundwater levels have remained within the bandwidth, there is no exceedance of the performance indicator for Swamp 25.

At the time Longwall 21 passed beneath the Swamp 25 monitoring site, there was a decline of about 4 m in the deeper water level and the water level in the swamp dropped to the bottom of the hole. Coincidentally, the longwall crossing coincided with a particularly dry period so that the observed declines could potentially have been a mixture of climatic and mining effects. Comparison with the control swamp hydrograph on Chart 137 shows that there was a corresponding decline in water levels there at the same time, with a similar magnitude. Similarly, during the reporting period, the water level in Swamp 25 and at control Swamp 101 dropped to the bottom of the hole during much of the first quarter of 2015. It is considered that the observed water levels at Swamp 25 are related to climate.

The bandwidth for the Woronora River 1 control swamp (Chart 138) (i.e. the control swamp for Swamp 20) is about 0.7 m for the swamp substrate piezometer. This piezometer had reductions in water level during parts of the reporting period that correlate well with rainfall trends (Chart 77 in Section 3.2.1.2), indicating a sensitivity to short duration rainfall events and poor facility for storage of rain water in the swamp. It is noted that groundwater levels in the swamp substrate were outside the -2σ limit in December 2012, November 2013, January/February 2014, July/August 2014 and December 2014 due to dry conditions. During the reporting period, swamp substrate water levels remained within the bandwidth limits with the exception of a brief period in March 2015 when the substrate water level was approximately at the -2σ limit.

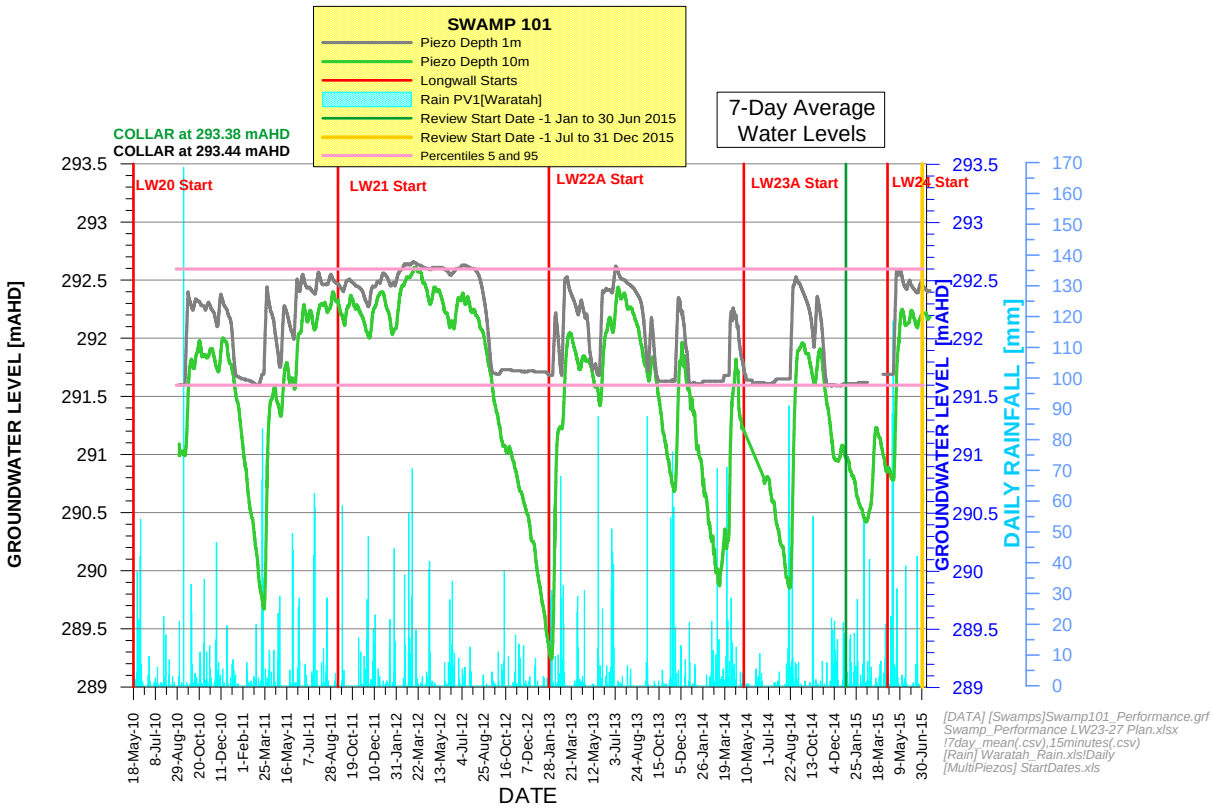


Chart 135 Performance Assessment of Groundwater Hydrograph at Control Swamp 101

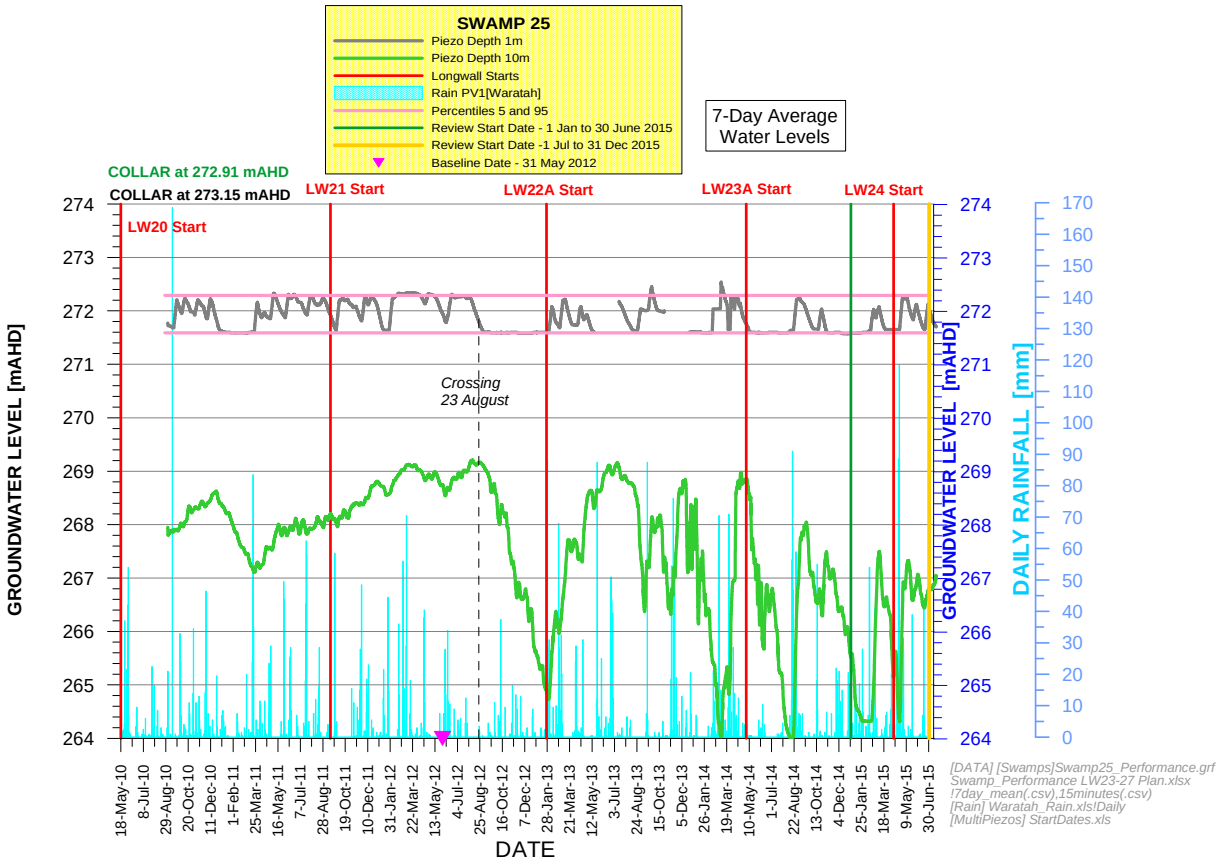


Chart 136 Performance Assessment of Groundwater Hydrograph at Swamp 25

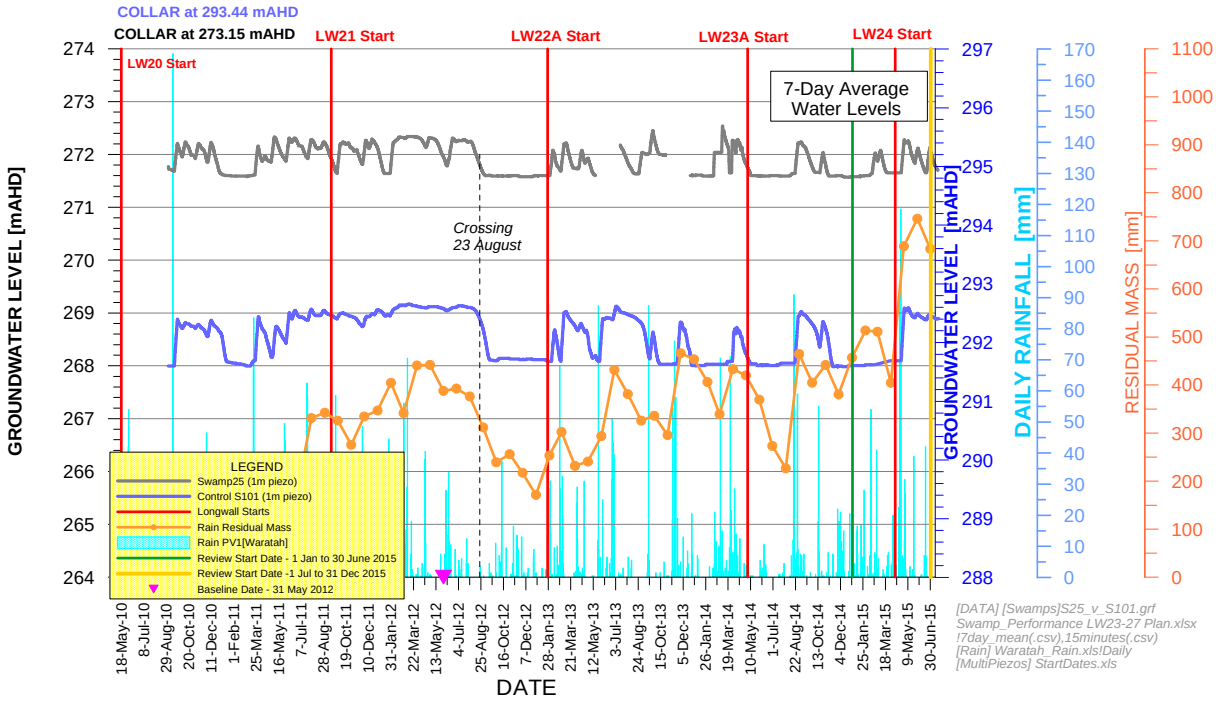


Chart 137 Comparison of Piezometer Responses at Swamp 25 and Control Swamp 101

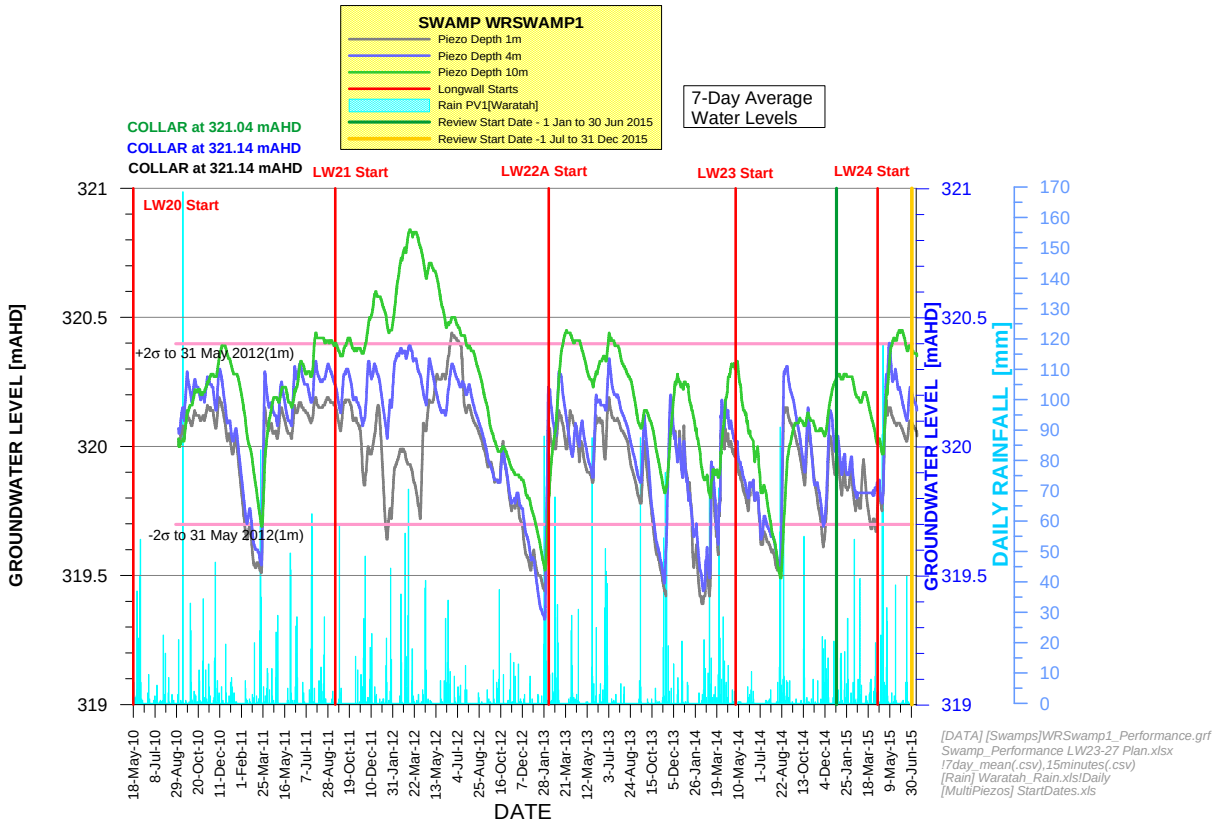


Chart 138 Performance Assessment of Groundwater Hydrograph at Woronora River 1 Control Swamp

The performance assessment during the reporting period for Swamp 20 is illustrated on Chart 139. The bandwidth for the full length of record (to 31 May 2012) is quite narrow at 0.5 m. Only rare exceedances occurred prior to this date, namely in February/March 2011, as they did at the Woronora River 1 control swamp (Chart 140). During the last quarter of 2012, the swamp substrate piezometer changed character from being permanently waterlogged to being periodically waterlogged and now the groundwater levels regularly drop below the -2σ limit. The swamp substrate piezometer in Swamp 20 exhibited clear mining effects from August 2012 to January 2013, after which time the water levels recovered in response to heavy rain. The water levels have fluctuated since then between the top and bottom of the hole. The passing of Longwall 22B alongside the monitoring site (September 2013) seems to have had no additional effect. Similarly, no obvious effect was observed for the closest approach of Longwall 23B (September 2014) or Longwall 24 (April 2015). Since the end of the baseline period (31 May 2012) exceedances of the performance indicator (mean-2σ) have occurred during the periods listed in Table 10 for 80% of days from June 2012 to June 2015. The exceedances are considered to be partly influenced by dry conditions but some mining effect is indicated.

To discriminate between climatic and mining effects, comparison is made on Chart 140 between the 1 m piezometers at Swamp 20 and the control swamp, and with rainfall residual mass. There is a very strong correlation with rainfall trend at both sites. As the rate of decline in the two piezometers is similar between 2013 and 2015, but different in 2012, it is likely that Longwall 21 has caused a mining effect at Swamp 20 but Longwalls 22, 23 and 24 have not.

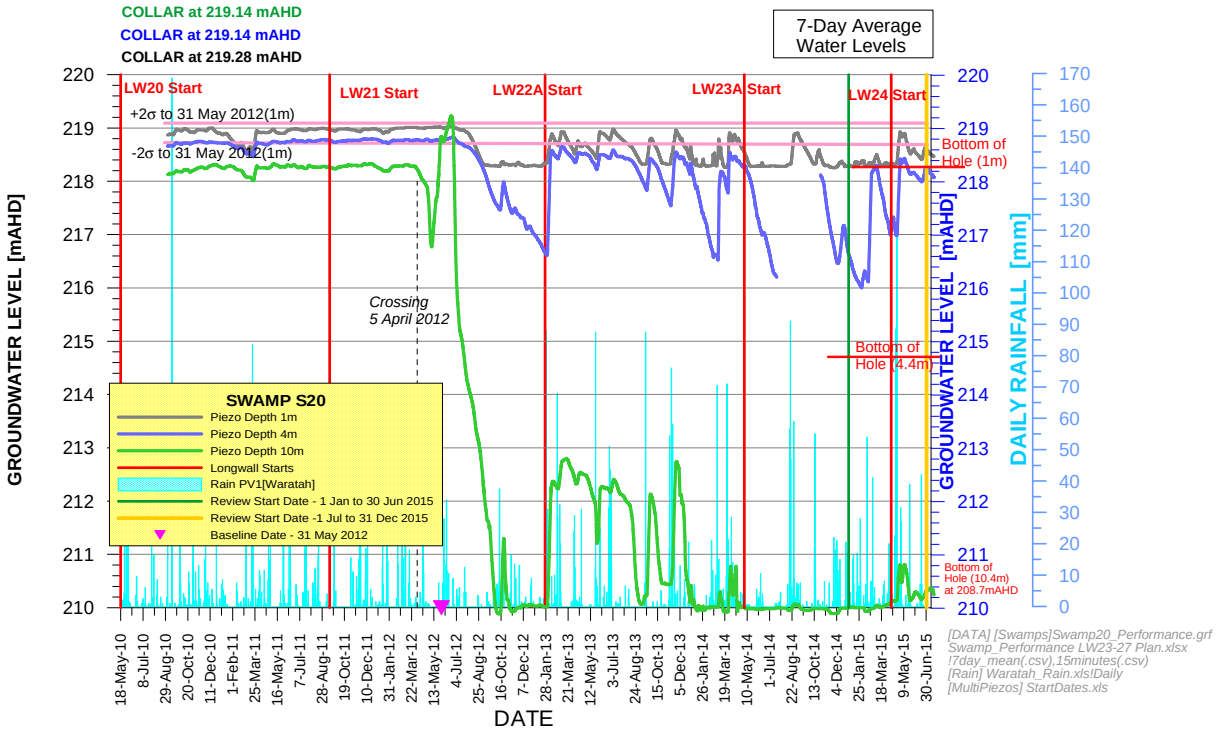


Chart 139 Performance Assessment of Groundwater Hydrograph at Swamp 20

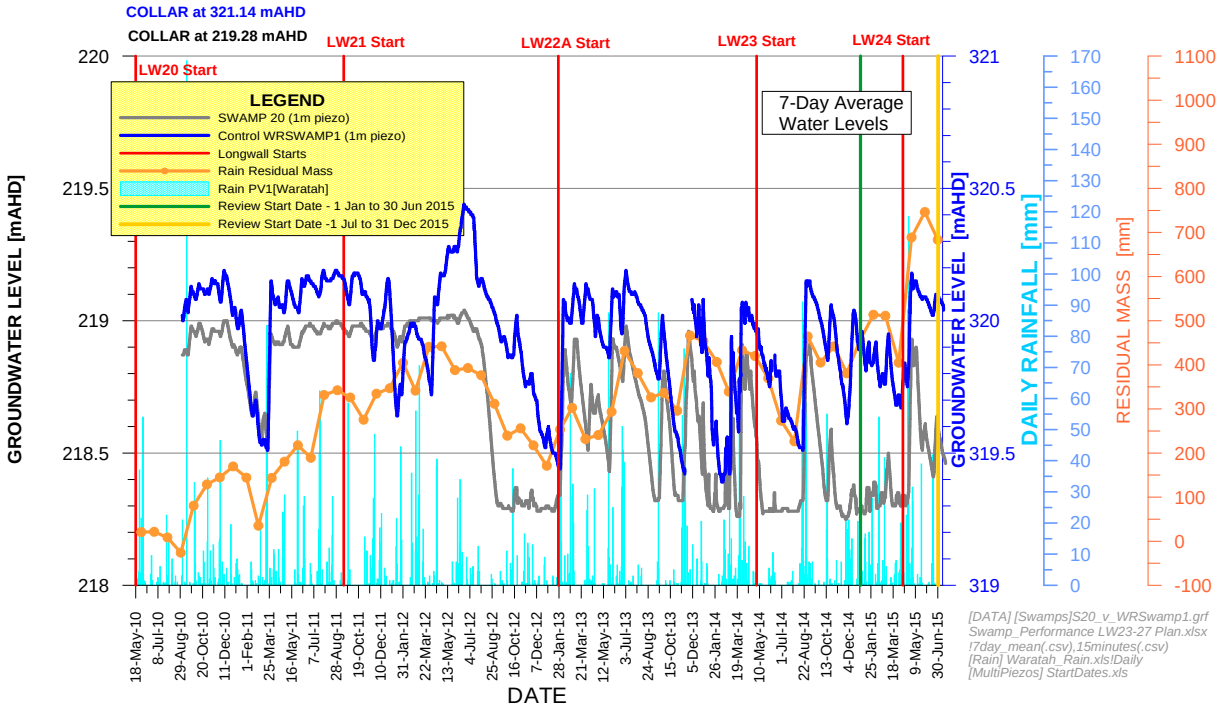


Chart 140 Comparison of Piezometer Responses at Swamp 20 and Woronora River 1 Control Swamp

Table 10
Exceedances of the Performance Indicator for Swamp 20

Duration (Days)	Start Date	End Date
48	1/02/2011	20/03/2011
178	10/08/2012	3/02/2013
8	18/02/2013	25/02/2013
70	19/03/2013	27/05/2013
58	28/07/2013	23/09/2013
50	1/10/2013	19/11/2013
109	8/12/2013	26/03/2014
1	15/04/2014	15/04/2014
126	19/04/2014	22/08/2014
224	12/09/2014	24/04/2015
48	15/05/2015	30/06/2015

In accordance with the Metropolitan Coal Longwalls 20-22 Biodiversity Management Plan, Dr. Colin Bower (FloraSearch) and Dr. David Goldney (Cenwest Environmental Services) were commissioned by Metropolitan Coal to undertake an assessment against the subsidence impact performance measure, *Negligible impact on threatened species and populations,* and the results of the assessment are summarised below.

No endangered flora or fauna populations listed under the NSW TSC Act are known to occur within 600 m of Longwalls 20-22 secondary extraction or in the surrounding area. As a result, the performance measure, *Negligible impact on threatened populations,* has not been exceeded. At the time the Project was approved, there were no listed threatened ecological communities involving upland swamps on the Woronora Plateau.

In relation to threatened species, a number of threatened flora and fauna species listed under the NSW TSC Act or Commonwealth EPBC Act are known to occur, or have the potential to occur within 600 m of Longwalls 20-22 secondary extraction or in the surrounding area.

Consistent with the Metropolitan Coal Longwalls 20-22 Biodiversity Management Plan, the key assessment considerations taken into account to assess whether there has been a greater than negligible impact on threatened species are:

1. *What is the nature of the environmental consequence (e.g. the potential for adverse impacts on upland swamps, riparian vegetation, slopes and ridgetops or aquatic habitats)?*
2. *What are the potential factors that may have contributed to the environmental consequence (e.g. the degree of subsidence effects, ineffective management measures or prevailing climatic conditions)?*
3. *Which threatened species have the potential to be impacted?*
4. *What are the potential impacts on the lifecycle of the potential threatened species (e.g. foraging, breeding/reproduction, nesting, shelter and movement/dispersal)?*
5. *What are the potential impacts on the habitat of the potential threatened species (e.g. area affected)?*
6. *Has the habitat connectivity of the threatened species been affected (e.g. loss of stream pool habitat connectivity)?*
7. *What actions, if any, are most appropriate to mitigate the impacts and/or to minimise future impacts?*

Threatened Flora

Six threatened flora species listed under the NSW TSC Act were recorded in the baseline flora survey for the Project EA (Helensburgh Coal, 2008), namely, *Acacia bynoeana* (Bynoe's Wattle), *Astrotricha crassifolia* (Thick-leaf Star-hair), *Epacris purpurascens* var*. purpurascens, Leucopogon exolasius, Melaleuca deanei* (Deane's Paperbark) and *Pultenaea aristata* (Prickly Bush-pea). An additional threatened flora species, *Acacia baueri* subsp. *aspera*, was subsequently identified in the underground mining area by Eco Logical Australia.

Only one of these, the Prickly Bush-pea, which is listed as Vulnerable under the NSW TSC Act is known to inhabit upland swamps, where it occurs generally on the drier margins. The Prickly Bush-pea is a widespread and common species in the underground mining area and surrounds (Bangalay Botanical Surveys, 2008).

Previous threatened flora species assessments for exceedances of the upland swamp groundwater performance indicator at Swamp 20 were conducted by FloraSearch in December 2012 and January 2014 (reported in the Metropolitan Coal 2013 Annual Review/AEMR) and September 2014 (reported in the Metropolitan Coal 2014 Annual Review and AEMR/Rehabilitation Report).

Dr. Colin Bower (FloraSearch) inspected Swamp 20 and control swamp Woronora River 1 on 19 October 2015. The site inspection by FloraSearch revealed minor differences in vegetation condition between Swamp 20 and Woronora River 1. Most shrubs in both swamps were in good health. The understorey in both swamps showed dieback, which appeared more severe in Swamp 20. However, there was recent new growth in the understorey in both swamps. The unusually dry surface soil in both swamps appears to explain the dieback in the understorey. By contrast, the shrubs, which are likely to be drawing moisture from the subsoil, were in much better condition. It appears that ongoing dry conditions from June to October 2015 depleted water levels in both Swamp 20 and Woronora River 1, although Swamp 20 was generally drier.

Only one threatened flora species has potential to be impacted by reduced water levels in Swamp 20; the Prickly Bush-pea, *Pultenaea aristata*. This species occurs commonly around the drier outer margins of swamps on the northern Woronora Plateau. One population is known to occur on the edge of Swamp 20, although others may be present. No evidence of decline in the health of the Prickly Bush Pea was observed.

The assessment by Dr. Colin Bower concluded that the impact performance measure, *Negligible impact on threatened species and populations,* had not been exceeded for threatened flora species.

Threatened Fauna

Thirteen threatened fauna species were recorded within the underground mining area and surrounds including two frog, one reptile, five bird and five mammal species during baseline surveys conducted for the Project EA (Helensburgh Coal, 2008). Of these, only two species were considered likely to potentially be present within Swamp 20, namely, the Red-crowned Toadlet (*Pseudophryne australis*) and the Giant Burrowing Frog (*Heleiporus australiacus*).

The Red-crowned Toadlet mainly occupies the upper parts of ridges, usually being restricted to within about 100 m of the ridgetop. Favoured microhabitats for shelter sites are under flat sandstone rocks (‘bush-rock’) either resting on bare rock or damp loamy soils. Red-crowned Toadlets have also been found under logs on soil, and beneath thick ground litter. Red-crowned Toadlets do not usually live along permanent flowing water courses occurring in gullies, instead preferring permanently moist soaks or areas of dense ground vegetation or litter along or near headwater stream beds. The main vegetation communities found in association with this species are open woodland and heath communities that are typical for Hawkesbury and Narabeen geology. The Project area and/or surrounds is considered to contain high quality habitat for the Red-crowned Toadlet.

The Red-crowned Toadlet is a relatively long-lived species (8-10 years) and is able to withstand prolonged periods of drought through its nocturnal, semi-fossorial lifestyle and use of moist microhabitat refugia. The Red-crowned Toadlet has a unique terrestrial reproductive strategy: small nests are formed within decomposing accumulated leaf matter and clutch sizes are small, consisting of around 20-24 large eggs. The nests retain the eggs through the early stages of tadpole development; then rainfall events flush the embryos from the nest, and tadpoles complete development within transient pools. The timing of follow up rain events and duration of temporary pools is critical to reproductive success and therefore recruitment is usually in low numbers. Egg hatching times vary between 15-120 days. Larval development can vary from 31-180 days depending on environmental conditions.

The northern populations of the Giant Burrowing Frog are largely confined to sandstone ridgetop habitat and broader upland valleys, where the species is associated with small headwater creek lines and slow flowing to intermittent creek lines in undisturbed areas. The vegetation in these areas is typically woodland, open woodland and heath, with riparian components in and along the sides of early order streams. The species may also utilise upland swamps as a component of the range of habitats it is able to exploit. Much of the Giant Burrowing Frog's existence is spent burrowed underground sometimes beneath deep leaf-litter or in earth-filled rock crevices interspersed with brief periods of activity throughout the year during rainy weather. Adults usually mate in a burrow adjacent to a stream relying on subsequent rainfall events to wash the eggs into a pool or small stream.

Previous threatened fauna species assessments for exceedances of the upland swamp groundwater performance indicator at Swamp 20 were conducted by Cenwest Environmental Services in December 2012 and January 2014 (reported in the Metropolitan Coal 2013 Annual Review/AEMR) and 30 September 2014 (reported in the Metropolitan Coal 2014 Annual Review and AEMR/Rehabilitation Report).

Dr. David Goldney (Cenwest Environmental Services) inspected Swamp 20 and control swamp Woronora River 1 on 19 October 2015. The surface impacts of low rainfall on the control swamp appeared similar to those exhibited in Swamp 20 (e.g. some evidence of stressed vascular plants, few to no surface pools suitable for tadpole development, and absence of tadpoles of the two threatened amphibian species). Based on the baseline studies and the ongoing amphibian monitoring program associated with the mining of Longwalls 20-22 and Longwalls 23-27, both species are likely to be present in Swamp 20 in relatively small numbers.

The environmental consequences of the changes in Swamp 20 (from being permanently waterlogged to intermittently waterlogged) are likely to be the subjecting of Swamp 20 habitats to increased water stress, decreased downstream runoff (normally likely to be very low outside of rainfall induced surface flows), fewer semi-permanent rock pools, and the drying out of refugia habitat (e.g. surface and deeper litter, earthen burrows, damp loamy soils, under rock etc), hence subjecting amphibians, including the two threatened species to additional environmental stresses, during their quiescent non-breeding phase. Such stresses could lead to the death of some quiescent adults *in situ*, but unlikely all adults. The greatest potential impact is likely to be to pool characteristics associated with Swamp 20 exhibiting more frequent drying out periods and therefore resulting in a decrease in the available time for larvae of the two species to complete metamorphosis.

Notwithstanding, such impacts would be limited to individuals of the two threatened species at Swamp 20 and the immediate surrounds rather than to the wider populations. The impact of adverse changes to the hydrology of Swamp 20 on the wider populations of both the Giant Burrowing Frog and the Red-crowned Toadlet, however, is likely to be negligible.

The assessment by Dr. David Goldney concluded that the subsidence impact performance measure, *Negligible impact on threatened species and populations,* had not been exceeded for threatened fauna species.

3.3.1.3 Analysis against Performance Indicator 3 – Riparian Vegetation

Analysis against Performance Indicator 3

Performance Indicator 3: *Impacts to riparian vegetation are expected to be localised and limited in extent, similar to the impacts previously experienced at Metropolitan Coal.*

This indicator is considered to have been exceeded if:

- Visual inspections identify vegetation dieback greater than 50 cm from the stream; or
- Data analysis indicates the riparian vegetation has not recovered after one year of the completion of stream remediation on Waratah Rivulet.

Visual inspections of riparian vegetation in spring 2014 identified continued vegetation dieback greater than 50 cm from the Waratah Rivulet at site MRIP02 and between sites MRIP09 and MRIP05 on the Eastern Tributary as a result of water inundation. The vegetation dieback was first observed at site MRIP02 in spring 2012 and between sites MRIP09 and MRIP05 in autumn 2014. As a result, the riparian vegetation performance indicator has been exceeded.

In accordance with the Metropolitan Coal Longwalls 20-22 Biodiversity Management Plan, Dr. Colin Bower (FloraSearch) and Dr. David Goldney (Cenwest Environmental Services) were commissioned by Metropolitan Coal to undertake an assessment against the subsidence impact performance measure, *Negligible impact on threatened species and populations.* The results of the assessment are provided in Section 3.3.2.3.

3.3.1.4 Analysis against Performance Indicator 4 – Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion EEC

Analysis against Performance Indicator 4

Performance Indicator 4: *Subsidence effects at the occurrences of the Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion EEC situated approximately 400 m to the east of Longwalls 20-22 are expected to be negligible.*

This indicator is considered to have been exceeded if the assessment of subsidence parameters indicates the subsidence effects at the occurrences of the Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion Endangered Ecological Community (EEC) situated to the east of Longwalls 20-22 are an order of magnitude above those predicted.

Subsidence effects in the area approximately 400 m to the east of Longwalls 20-22 at the occurrences of the Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion EEC are within subsidence predictions. The performance indicator has not been exceeded.

3.3.1.5 Analysis against Performance Indicator 5 – Aquatic Macroinvertebrate and Macrophyte Assemblages

Analysis against Performance Indicator 5

> **Performance Indicator 5:** *The aquatic macroinvertebrate and macrophyte assemblages in streams and pools are not expected to experience long-term impacts as a result of mine subsidence.*

This indicator is considered to have been exceeded if data analysis indicates significant changes in relation to reference places before (i.e. pre-mining) to after (i.e. post-mining) mining of Longwalls 20-22:

- occur in the aquatic macroinvertebrate and macrophyte assemblages in streams at Locations WT3, ET1, ET3 and B1 after the completion of Longwall 26; and
- occur in the aquatic macroinvertebrate and macrophyte assemblages at Pools J, K, L, M1, M and N after one year of the completion of stream remediation on Waratah Rivulet.

This performance indicator will be assessed and reported on in future Six Monthly Reports and Annual Review and AEMR/Rehabilitation Reports subsequent to monitoring conducted after the completion of Longwall 26 and one year after the completion of stream remediation on Waratah Rivulet at Pools J, K, L, M1, M and N.

3.3.1.6 Analysis against Performance Indicator 6 – Amphibian Assemblage

Analysis against Performance Indicator 6

> **Performance Indicator 6:** *The amphibian assemblage is not expected to experience changes significantly different to the amphibian assemblage at control sites.*

This indicator is considered to have been exceeded if data analysis identifies a significant decline in the amphibian population.

A Poisson regression analysis has been used to analyse the amphibian survey results obtained to date. No adverse impact from mining has been detected for any frog species including the Giant Burrowing Frog and Red-crowned Toadlet, at the 95% confidence level.

As discussed in Section 3.2.1.5, the amphibian species diversity and abundance data are consistent with population variations and cycles in response to seasonal variations. There are no significant differences between the test and control sites. The performance indicator has not been exceeded.

3.3.1.7 Subsidence Impact Performance Measures included in the Land Management Plan and Water Management Plan

Subsidence impact performance measures of relevance to the Metropolitan Coal Longwalls 20-22 Biodiversity Management Plan are also contained in the Metropolitan Coal Longwalls 20-22 Land Management Plan and Metropolitan Coal Longwalls 20-22 Water Management Plan. In the event the subsidence impacts observed exceed the land subsidence impact performance measure or an applicable water resource/water course subsidence impact performance measure, Metropolitan Coal will conduct a review of potential impacts on flora, fauna, and their habitats in accordance with the Metropolitan Coal Longwalls 20-22 Biodiversity Management Plan.

Subsidence impact performance measures of relevance to the Metropolitan Coal Longwalls 20-22 Biodiversity Management Plan are outlined in Table 11. None of the subsidence impact performance measures of relevance to the Metropolitan Coal Longwalls 20-22 Biodiversity Management Plan have been exceeded during the reporting period.

Table 11
Other Subsidence Impact Performance Measures of Relevance to the Longwalls 20-22 Biodiversity Management Plan

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

3.3.1.8 Swamps 76, 77 and 92

Subsidence Impact Performance Measure:

Swamps 76, 77 and 92 - Set through condition 4

Metropolitan Coal is not permitted to undermine Swamps 76, 77 and 92 without the written approval of the Director-General.

Swamps 76, 77 and 92 will be subject to assessment in future Extraction Plan(s) and future Biodiversity Management Plans.

3.3.2 Longwalls 23-27

3.3.2.1 Analysis against Performance Indicator 1 – Vegetation in Upland Swamps

Analysis against Performance Indicator 1

Performance Indicator 1: *The vegetation in upland swamps is not expected to experience changes significantly different to vegetation in control swamps.*

This indicator is considered to have been exceeded if:

- data indicates a declining trend in the condition of swamp vegetation; or
- data analysis indicates statistically significant changes in vegetation between the mined and control swamps.

Detailed analysis of the above performance indicator is provided in Section 3.2.2.1. In summary:

- Visual inspections of upland swamp vegetation indicate that the upland swamp vegetation performance indicator has not been exceeded (i.e. the observations have not identified a declining trend in the condition of vegetation in swamps overlying Longwalls 23-27 that were not also observed in the control swamps).
- Analysis of quadrat/transect data indicates that the upland swamp performance indicator '*The vegetation in upland swamps is not expected to experience changes significantly different to changes in control swamps*' has not been exceeded.
- Analysis of indicator species data indicates that the upland swamp performance indicator '*The vegetation in upland swamps is not expected to experience changes significantly different to changes in control swamps*' has not been exceeded.

3.3.2.2 Analysis against Performance Indicator 2 – Swamp Groundwater Levels in Upland Swamps

Analysis against Performance Indicator 2

Performance Indicator 2: *Surface cracking within upland swamps resulting from mine subsidence is not expected to result in measurable changes to swamp groundwater levels when compared to control swamps or seasonal variations in water levels experienced by upland swamps prior to mining.*

This indicator is considered to have been exceeded if data analysis indicates statistically significant changes in swamp substrate groundwater levels (i.e. if the seven day moving average data lie outside two standard deviations from the mean established for the full length of record [i.e. to 30 June 2014]).

The performance assessment for Swamp 28 is illustrated on Chart 141. The bandwidth for the Swamp 28 swamp substrate piezometer is about 0.9 m which is restrained by the recurrent dry episodes in 2013 and the first half of 2014. The water table in the substrate piezometer during the reporting period correlates well with the rainfall trends (Chart 112 in Section 3.2.2.2), despite the 3 m decline in water level observed in the sandstone (10 m) piezometer. During the reporting period, the water levels in the swamp substrate did not exceed the +2σ and -2σ limit. The face of Longwall 24 passed Swamp 28 during April 2015.

The bandwidth for the Swamp 30 substrate piezometer is 1.2 m (Chart 142). The minimum value of the seven day average of substrate water levels always remained within the $5^{th}/95^{th}$ percentiles for the reporting period. Swamp water levels correlate well with the rainfall trends (Chart 113 in Section 3.2.2.2) and do not show any mining impact of Longwall 23B or Longwall 24. As all swamp substrate groundwater levels have remained within the bandwidth, there is no exceedance of the performance indicator for Swamp 30.

The Swamp 33 performance assessment is illustrated on Chart 143. It has a bandwidth of 0.7 m and substrate water levels remain in the $5^{th}/95^{th}$ percentiles over the reporting period. The water levels (piezometer 1m) maintain a steady position over the time with occasional wetting conditions occurring that match well with the rainfall. The face of Longwall 23B (started September 2014) would have passed Swamp 33 during December 2014 and the face of Longwall 24 would have passed beneath Swamp 33 in June 2015. There is no indication of a mining effect at this time. Assessment using the 5th and 95th percentiles, and comparison with baseline period behaviour and control swamp behaviour, indicates that the performance indicator has not been exceeded.

The performance assessment for Swamp 35 is illustrated on Chart 144. The bandwidth limit is 1 m. Groundwater levels within the substrate of Swamp 35 have remained within the bandwidth for the reporting period to 30 June 2015. As with other swamps overlying Longwalls 23-27, groundwater levels correlate with the rainfall trend (Chart 115 in Section 3.2.2.2). This monitoring site is about 600 m from Longwall 23B and 320 m from the closest approach of Longwall 24 which occurred in May 2015.

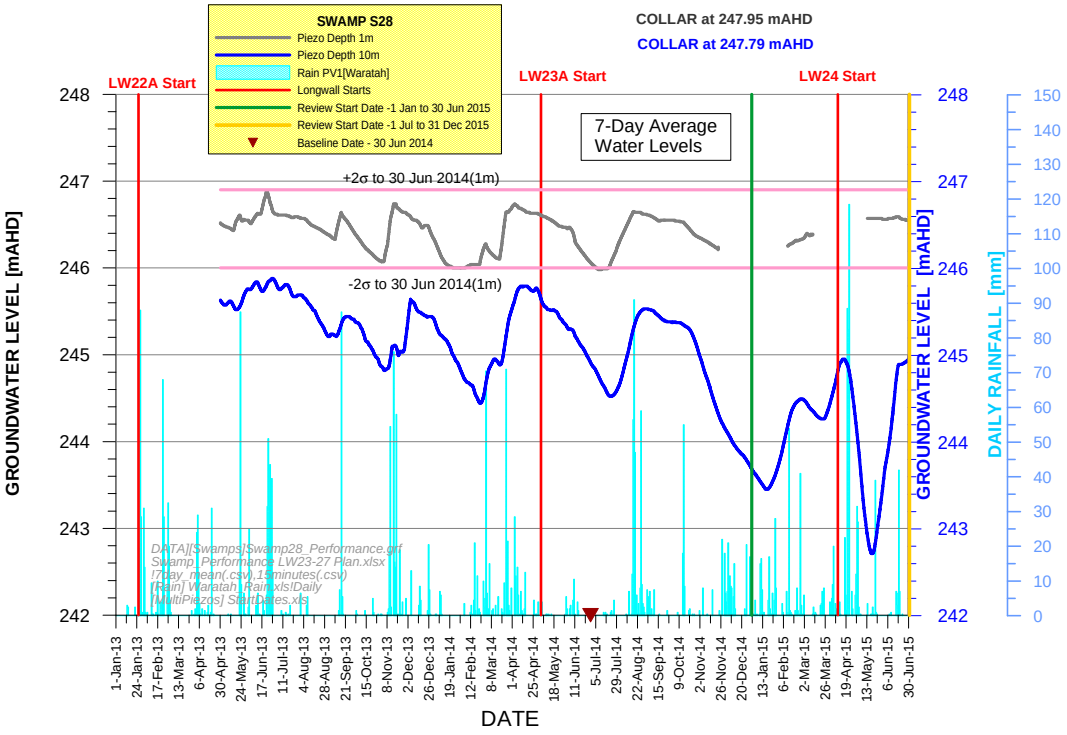


Chart 141 Performance Assessment of Groundwater Hydrograph at Swamp 28

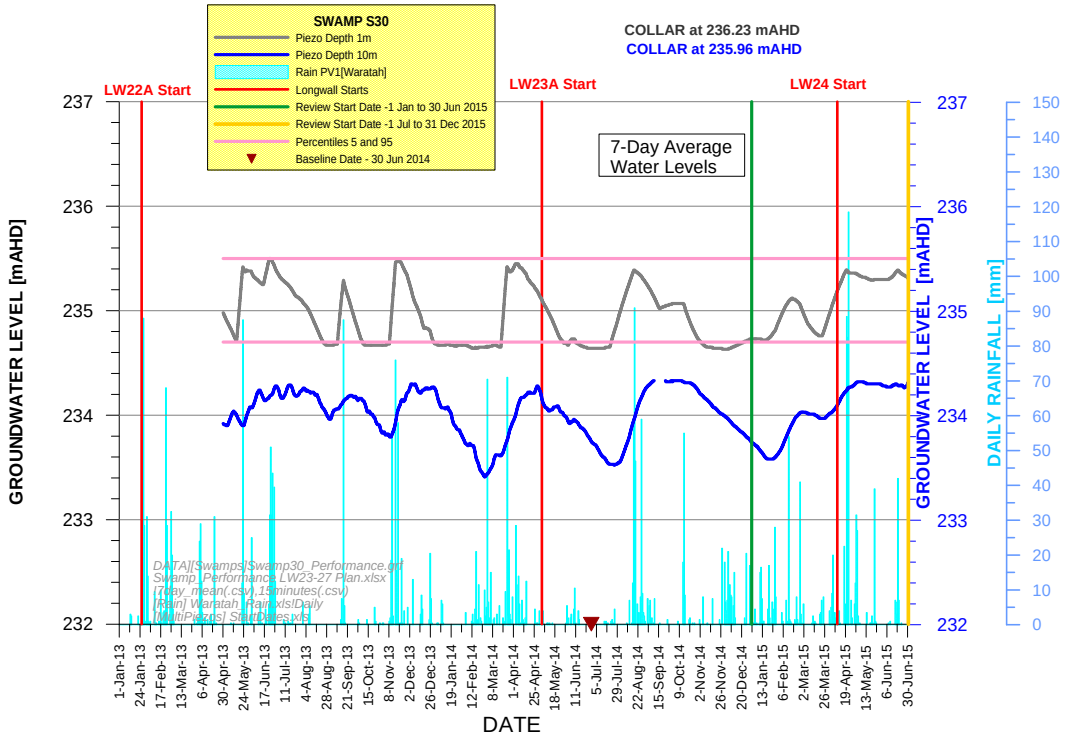


Chart 142 Performance Assessment of Groundwater Hydrograph at Swamp 30

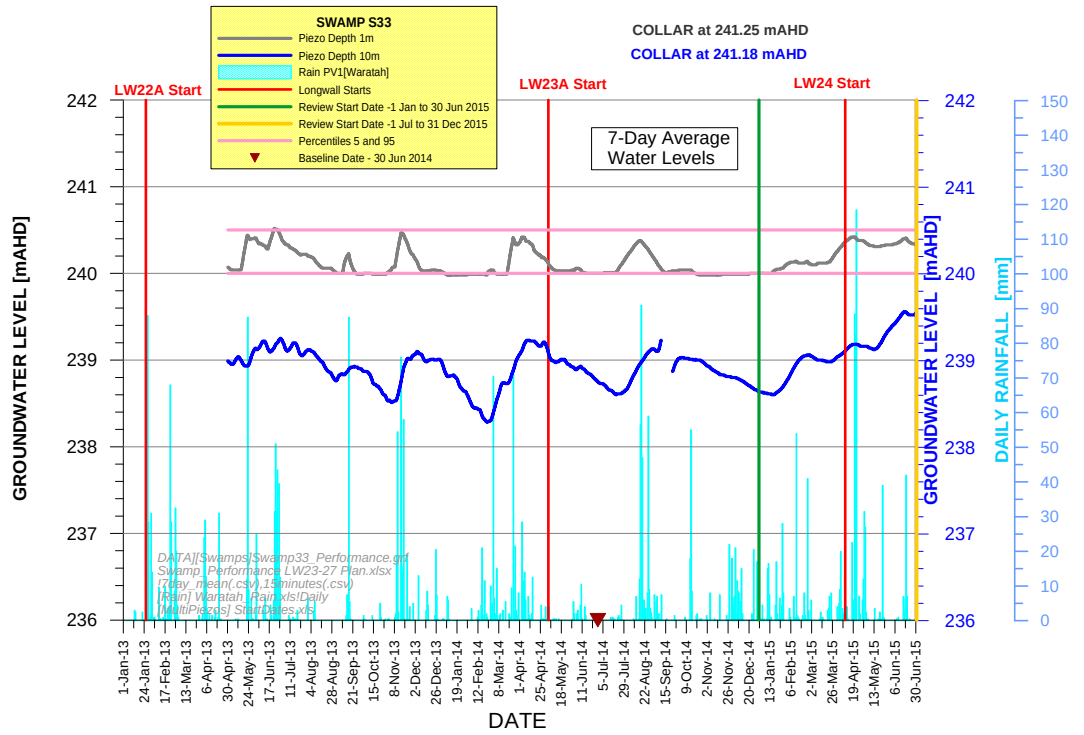


Chart 143 Performance Assessment of Groundwater Hydrograph at Swamp 33

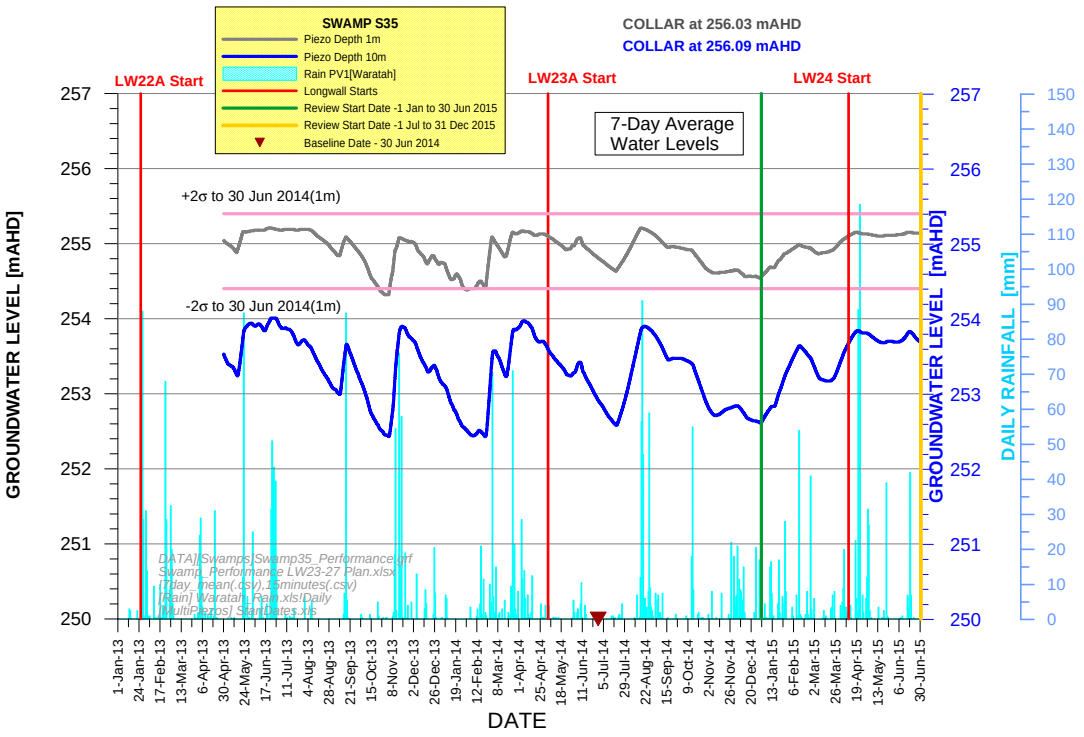


Chart 144 Performance Assessment of Groundwater Hydrograph at Swamp 35

In summary, the performance indicator for upland swamp groundwater levels has not been exceeded for Swamps 28, 30, 33 or 35. While data analysis indicates statistically significant changes in swamp substrate groundwater levels have occurred previously, analysis of seasonal variations in water levels experienced in the baseline period, and at the control swamps, indicates that the previous excursions are not mining effects.

3.3.2.3 Analysis against Performance Indicator 3 – Riparian Vegetation

Analysis against Performance Indicator 3

Performance Indicator 3: *Impacts to riparian vegetation are expected to be localised and limited in extent, similar to the impacts previously experienced at Metropolitan Coal.*

This indicator is considered to have been exceeded if:

- visual inspections identify vegetation dieback greater than 50 cm from the stream; or
- data analysis indicates the riparian vegetation has not recovered after one year of the completion of stream remediation on Waratah Rivulet.

As described in Section 3.3.1.3, visual inspections of riparian vegetation in spring 2014 identified continued vegetation dieback greater than 50 cm from the Waratah Rivulet at site MRIP02 and from the Eastern Tributary from site MRIP09 downstream to site MRIP05. As a result, the performance indicator has been exceeded. The vegetation dieback was first observed at site MRIP02 in spring 2012 and between sites MRIP09 and MRIP05 in autumn 2014.

Previous threatened flora and fauna species assessments for exceedances of the riparian vegetation performance indicator at site MRIP02 on the Waratah Rivulet and between site MRIP09 and MRIP05 on the Eastern Tributary were conducted by FloraSearch and Cenwest Environmental Services in December 2012 and January 2014 (reported in the Metropolitan Coal 2013 Annual Review/AEMR) and/or September 2014 (reported in the Metropolitan Coal 2014 Annual Review and AEMR/Rehabilitation Report).

In accordance with the Metropolitan Coal Longwalls 20-22 and Longwalls 23-27 Biodiversity Management Plans, Dr. Colin Bower (FloraSearch) and Dr. David Goldney (Cenwest Environmental Services) were commissioned by Metropolitan Coal to undertake an assessment against the subsidence impact performance measure, *Negligible impact on threatened species and populations,* and the results of the assessment are summarised below.

No endangered flora or fauna populations listed under the NSW TSC Act are known to occur within 600 m of Longwalls 20-22 and Longwalls 23-27 secondary extraction or in the surrounding area. As a result, the performance measure, *Negligible impact on threatened populations,* has not been exceeded.

In relation to threatened species, a number of threatened flora and fauna species listed under the NSW TSC Act or Commonwealth EPBC Act are known to occur, or have the potential to occur within 600 m of Longwalls 20-22 and Longwalls 23-27 secondary extraction or in the surrounding area.

Consistent with the Metropolitan Coal Longwalls 20-22 and Longwalls 23-27 Biodiversity Management Plans, the key assessment considerations taken into account to assess whether there has been a greater than negligible impact on threatened species are:

1. *What is the nature of the environmental consequence (e.g. the potential for adverse impacts on upland swamps, riparian vegetation, slopes and ridgetops or aquatic habitats)?*
2. *What are the potential factors that may have contributed to the environmental consequence (e.g. the degree of subsidence effects, ineffective management measures or prevailing climatic conditions)?*
3. *Which threatened species have the potential to be impacted?*

4. *What are the potential impacts on the lifecycle of the potential threatened species (e.g. foraging, breeding/reproduction, nesting, shelter and movement/dispersal)?*
5. *What are the potential impacts on the habitat of the potential threatened species (e.g. area affected)?*
6. *Has the habitat connectivity of the threatened species been affected (e.g. loss of stream pool habitat connectivity)?*
7. *What actions, if any, are most appropriate to mitigate the impacts and/or to minimise future impacts?*

Threatened Flora

Six threatened flora species listed under the NSW TSC Act were recorded in the baseline flora survey for the Project EA (Helensburgh Coal, 2008), namely, *Acacia bynoeana* (Bynoe's Wattle), *Astrotricha crassifolia* (Thick-leaf Star-hair), *Epacris purpurascens* var*. purpurascens, Leucopogon exolasius, Melaleuca deanei* (Deane's Paperbark) and *Pultenaea aristata* (Prickly Bush-pea). An additional threatened flora species, *Acacia baueri* subsp. *aspera*, was subsequently identified in the underground mining area by Eco Logical Australia.

Three of these, the Thick-leaf Star-hair, the Prickly Bush-pea and *Leucopogon exolasius*, have potential to occur in riparian vegetation. The Prickly Bush-pea is a widespread and common species in the Metropolitan Coal underground mining area and surrounds (Helensburgh Coal, 2008). The Thick-leaf Star-hair most often occurs on lower slopes above water courses and is uncommon in the underground mining area. *Leucopogon exolasius* generally occurs on broad flood-prone parts of watercourses on the lowest slopes or in sparsely vegetated sand deposits. None of these species has been recorded on riparian monitoring sites on the Waratah Rivulet or Eastern Tributary, or within the areas affected by dieback which are regularly traversed as part of the flora monitoring program.

Dr. Colin Bower (FloraSearch) inspected the riparian vegetation of Waratah Rivulet and Eastern Tributary on 19 October 2015. Despite extensive survey and observation by qualified personnel, no threatened flora species are known to occur in the area of affected vegetation.

Increased ponding at site MRIP02 on the Waratah Rivulet and at sites MRIP05 and MRIP09 on the Eastern Tributary from subsidence has resulted in prolonged inundation of streamside vegetation causing death of terrestrial shrubs and ground cover species. The extent of vegetation dieback has not increased and no recovery has occurred. Flooding in April 2015 has also impacted the vegetation in both watercourses.

No evidence of decline in the health of any threatened species was observed. Since the Thick-leaf Star-hair, Prickly Bush-pea and *Leucopogon exolasius* are not known to occur in the area impacted, no impacts on the species are expected. Habitat connectivity for the Thick-leaf Star-hair, the Prickly Bush-pea and *Leucopogon exolasius* has not been affected and is unlikely to be affected. The area affected is limited, narrow and unlikely to restrict the movements of propagules of these plants or their pollinators. The affected area is surrounded by potential habitat for the three species such that habitat connectivity would not be significantly reduced.

The assessment by Dr. Colin Bower concluded that the impact performance measure, *Negligible impact on threatened species and populations,* had not been exceeded for threatened flora species.

Threatened Fauna

Thirteen threatened fauna species were recorded within the underground mining area and surrounds including two frog, one reptile, five bird and five mammal species during baseline surveys conducted for the Project EA (Helensburgh Coal, 2008). Of these, only two species are considered likely to be present in riparian zone habitat, namely, the Red-crowned Toadlet (*Pseudophryne australis*) and the Giant Burrowing Frog (*Heleiporus australiacus*).

A description of the lifecycle and habitats of the Red-crowned Toadlet and Giant Burrowing Frog is provided in Section 3.3.1.2. Whilst these species can occasionally be located in riparian zones of more-or-less permanent waterways such as the Waratah Rivulet and Eastern Tributary, their preferred habitat and where it is mostly found, is as described in Section 3.3.1.2.

Dr. David Goldney (Cenwest Environmental Services) inspected riparian vegetation of Waratah Rivulet and Eastern Tributary on 19 October 2015. Death and/or senescence of riparian plants has been observed at site MRIP02 on the Waratah Rivulet and at sites MRIP05 and MRIP09 on the Eastern Tributary due to increased ponding resulting in prolonged inundation of the riparian vegetation as a result of subsidence. The dieback observed in 2015 is similar to that observed in 2014 – that is the riparian dieback has not increased nor has there been any riparian vegetation recovery. It was also noted that flooding that occurred in April 2015 had significantly impacted both dead and healthy vegetation in both watercourses as well as modifying stream banks and bars.

If present in the riparian zone, the Red-crowned Toadlet and Giant Burrowing Frog would likely be in very low numbers and in what is effectively marginal habitat for both species. The potential impacts on the lifecycle of the two threatened species are likely to be negligible to non-existent.

The assessment by Dr. David Goldney concluded that the subsidence impact performance measure, *Negligible impact on threatened species and populations,* has not been exceeded for threatened fauna species.

3.3.2.4 Analysis against Performance Indicator 4 – Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion EEC

Analysis against Performance Indicator 4

Performance Indicator 4: *Subsidence effects at the occurrences of the Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion EEC situated approximately 300 to 500 m to the east of Longwalls 23-27 are expected to be negligible.*

This indicator is considered to have been exceeded if the assessment of subsidence parameters indicates the subsidence effects at the occurrences of the Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion EEC situated to the east of Longwalls 23-27 are an order of magnitude above those predicted.

Subsidence effects in the area to the east of Longwalls 23-27 at the occurrences of the Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion EEC are within subsidence predictions. The performance indicator has not been exceeded.

3.3.2.5 Analysis against Performance Indicator 5 – Aquatic Macroinvertebrate and Macrophyte Assemblages

Analysis against Performance Indicator 5

Performance Indicator 5: *The aquatic macroinvertebrate and macrophyte assemblages in streams and pools are not expected to experience long-term impacts as a result of mine subsidence.*

This indicator will be considered to have been exceeded if data analysis indicates significant changes in relation to reference places before (i.e. pre-mining) to after (i.e. post-mining) mining of Longwalls 23-27:

- occur in the aquatic macroinvertebrate and macrophyte assemblages in streams at Locations C1, C4 and B2 after the completion of Longwall 303; and
- occur in the aquatic macroinvertebrate and macrophyte assemblages at Pools ETAG, ETAH, ETAI and ETAK after one year of the completion of stream remediation on Tributary C/Eastern Tributary.

This performance indicator will be assessed and reported on in future Six Monthly Reports or Annual Reviews and AEMR/Rehabilitation Reports, subsequent to monitoring conducted after the completion of Longwall 303 and one year after the completion of stream remediation on Eastern Tributary.

3.3.2.6 Analysis against Performance Indicator 6 – Amphibian Assemblage

Analysis against Performance Indicator 6

Performance Indicator 6: *The amphibian assemblage is not expected to experience changes significantly different to the amphibian assemblage at control sites.*

This indicator is considered to have been exceeded if data analysis identifies a significant decline in the amphibian population.

A Poisson regression analysis has been used to analyse the amphibian survey results obtained to date. No adverse impact from mining has been detected for any frog species including the Giant Burrowing Frog and Red-crowned Toadlet, at the 95% confidence level.

As discussed in Section 3.2.2.5, the amphibian species diversity and abundance data are consistent with population variations and cycles in response to seasonal variations. There are no significant differences between the test and control sites. The performance indicator has not been exceeded.

3.3.2.7 Subsidence Impact Performance Measures included in the Land Management Plan and Water Management Plan

Subsidence impact performance measures of relevance to the Metropolitan Coal Longwalls 23-27 Biodiversity Management Plan are also contained in the Metropolitan Coal Longwalls 23-27 Land Management Plan and Metropolitan Coal Longwalls 23-27 Water Management Plan. In the event the subsidence impacts observed exceed the land subsidence impact performance measure or an applicable water resource/water course subsidence impact performance measure, Metropolitan Coal will conduct a review of potential impacts on flora, fauna, and their habitats in accordance with the Metropolitan Coal Longwalls 23-27 Biodiversity Management Plan.

Subsidence impact performance measures of relevance to the Metropolitan Coal Longwalls 23-27 Biodiversity Management Plan are outlined in Table 12. None of the subsidence impact performance measures of relevance to the Metropolitan Coal Longwalls 23-27 Biodiversity Management Plan have been exceeded during the reporting period.

Table 12
Other Subsidence Impact Performance Measures of Relevance to the Longwalls 23-27 Biodiversity Management Plan

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

3.3.2.8 Swamps 76, 77 and 92

Subsidence Impact Performance Measure:

Swamps 76, 77 and 92 - Set through condition 4

Metropolitan Coal is not permitted to undermine Swamps 76, 77 and 92 without the written approval of the Director-General. Swamps 76, 77 and 92 will not be undermined by Longwalls 23-27.

Swamps 76, 77 and 92 will be subject to assessment in future Extraction Plan(s) and future Biodiversity Management Plans.

3.4 TARP CHARACTERISATION

Sections 3.4.1 and 3.4.2 provide the TARP characterisation for the reporting period for biodiversity management of Longwalls 20-22 and Longwalls 23-27, respectively.

3.4.1 Longwalls 20-22

The TARP characterisation for Longwalls 20-22 biodiversity management is provided in Table 13. In summary, two performance indicators were exceeded, as described below.

The performance indicator for upland swamp groundwater monitoring: *Surface cracking within upland swamps resulting from mine subsidence is not expected to result in measurable changes to swamp groundwater levels when compared to control swamps or seasonal variations in water levels experienced by upland swamps prior to mining* was exceeded at Swamp 20 overlying Longwall 21.

The performance indicator for riparian vegetation: *Impacts to riparian vegetation are expected to be localised and limited in extent, similar to the impacts previously experienced at Metropolitan Coal* was exceeded at site MRIP02 on the Waratah Rivulet and between sites MRIP09 and MRIP05 on the Eastern Tributary.

Exceedance of the performance indicators triggered an assessment against the performance measure. No performance measures were exceeded.

3.4.2 Longwalls 23-27

The TARP characterisation for Longwalls 23-27 biodiversity management is provided in Table 14.

In summary, one performance indicator was exceeded. The performance indicator for riparian vegetation: *Impacts to riparian vegetation are expected to be localised and limited in extent, similar to the impacts previously experienced at Metropolitan Coal* was exceeded at site MRIP02 on the Waratah Rivulet and between sites MRIP09 and MRIP05 on the Eastern Tributary (as described in Section 3.4.1 above).

Exceedance of the performance indicator triggered an assessment against the performance measure. The performance measure was not exceeded.

Table 13
TARP Characterisation – Longwalls 20-22 Biodiversity Management

Monitoring Components	Subsidence Impact Performance Indicator(s)	Subsidence Impact Performance Indicator Exceeded?	Resulting Actions	Subsidence Impact Performance Measure	Subsidence Impact Performance Measure Exceeded?
Upland Swamps Vegetation Monitoring (Section 3.2.1.1)	*The vegetation in upland swamps is not expected to experience changes significantly different to vegetation in control swamps* (Section 3.3.1.1)	No	Continue monitoring	*Negligible impact on threatened species and populations*	No
Upland Swamps Groundwater Monitoring (Section 3.2.1.2)	*Surface cracking within upland swamps resulting from mine subsidence is not expected to result in measurable changes to swamp groundwater levels when compared to control swamps or seasonal variations in water levels experienced by upland swamps prior to mining* (Section 3.3.1.2)	Yes – performance indicator exceeded for Swamp 20 overlying Longwall 21	Assessment against the performance measure conducted by FloraSearch (flora) and Cenwest Environmental Services (fauna) and included in Section 3.3.1.2 Continue monitoring		No
Riparian Vegetation (Section 3.2.1.3)	*Impacts to riparian vegetation are expected to be localised and limited in extent, similar to the impacts previously experienced at Metropolitan Coal* (Section 3.3.1.3)	Yes – performance indicator exceeded at site MRIP02 on the Waratah Rivulet (overlying Longwalls 20-22) and between sites MRIP09 and MRIP05 on the Eastern Tributary	Assessment against the performance measure conducted by FloraSearch (flora) and Cenwest Environmental Services (fauna) and included in Section 3.3.1.3 Continue monitoring		No
Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion EEC (Section 3.3.1.4)	*Subsidence effects at the occurrences of the Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion EEC situated approximately 400 m to the east of Longwalls 20-22 are expected to be negligible* (Section 3.3.1.4)	No	Continue monitoring		No
Aquatic Biota (Section 3.2.1.4)	*The aquatic macroinvertebrate and macrophyte assemblages in streams and pools are not expected to experience long-term impacts as a result of mine subsidence* (Section 3.3.1.5)	No[1]	Continue monitoring		No
Amphibian Monitoring (Section 3.2.1.5)	*The amphibian assemblage is not expected to experience changes significantly different to the amphibian assemblage at control sites* (Section 3.3.1.6)	No	Continue monitoring		No

[1] Note the performance indicator will be assessed after the completion of Longwall 26 and one year after the completion of stream remediation on Waratah Rivulet at Pools J, K, L, M1, M and N.

Table 14
TARP Characterisation – Longwalls 23-27 Biodiversity Management

Monitoring Components	Subsidence Impact Performance Indicator(s)	Subsidence Impact Performance Indicator Exceeded?	Resulting Actions	Subsidence Impact Performance Measure	Subsidence Impact Performance Measure Exceeded?
Upland Swamps Vegetation Monitoring (Section 3.2.2.1)	*The vegetation in upland swamps is not expected to experience changes significantly different to vegetation in control swamps* (Section 3.3.2.1)	No	Continue monitoring	*Negligible impact on threatened species and populations*	No
Upland Swamps Groundwater Monitoring (Section 3.2.2.2)	*Surface cracking within upland swamps resulting from mine subsidence is not expected to result in measurable changes to swamp groundwater levels when compared to control swamps or seasonal variations in water levels experienced by upland swamps prior to mining* (Section 3.3.2.2)	No	Continue monitoring		No
Riparian Vegetation (Section 3.2.2.3)	*Impacts to riparian vegetation are expected to be localised and limited in extent, similar to the impacts previously experienced at Metropolitan Coal* (Section 3.3.2.3)	Yes – performance indicator exceeded at site MRIP02 on the Waratah Rivulet (overlying Longwalls 20-22) and between sites MRIP09 and MRIP05 on the Eastern Tributary	Assessment against the performance measure conducted by FloraSearch (flora) and Cenwest Environmental Services (fauna) and included in Section 3.3.1.3 Continue monitoring		No
Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion EEC (Section 3.3.2.4)	*Subsidence effects at the occurrences of the Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion EEC situated approximately 300 to 500 m to the east of Longwalls 23-27 are expected to be negligible* (Section 3.3.2.4)	No	Continue monitoring		No
Aquatic Biota (Section 3.2.2.4)	*The aquatic macroinvertebrate and macrophyte assemblages in streams and pools are not expected to experience long-term impacts as a result of mine subsidence* (Section 3.3.2.5)	No[1]	Continue monitoring		No
Amphibian Monitoring (Section 3.2.2.5)	*The amphibian assemblage is not expected to experience changes significantly different to the amphibian assemblage at control sites* (Section 3.3.2.6)	No	Continue monitoring		No

[1] Note the performance indicator will be assessed after the completion of Longwall 303 and one year after the completion of stream remediation on Eastern Tributary.

4 LAND MANAGEMENT

4.1 BACKGROUND

The Metropolitan Coal Longwalls 20-22 Land Management Plan and Metropolitan Coal Longwalls 23-27 Land Management Plan were prepared to manage the potential environmental consequences of the Metropolitan Coal Longwalls 20-22 Extraction Plan and Metropolitan Coal Longwalls 23-27 Extraction Plan on cliffs, overhangs, steep slopes and land in general, in accordance with Condition 6, Schedule 3 of the Project Approval.

4.2 MONITORING

4.2.1 Longwalls 20-22

4.2.1.1 Steep Slopes and Land in General

Opportunistic visual inspections for subsidence impacts on steep slopes and land in general are conducted by Metropolitan Coal and its contractors as part of routine works conducted in the catchment. Specific details that are noted and/or photographed during the inspections are consistent with those described in Section 4.2.2.1 for Longwalls 23-27.

Longwall 22 extraction was completed in April 2014. No additional surface tension cracks or rock falls within 600 m of Longwalls 20-22 secondary extraction, to those reported previously, were observed during the reporting period.

4.2.1.2 Cliffs and Overhangs

Visual inspections were conducted monthly for the period of time that extraction of Longwalls 20-22 was within 400 m of sites COH1, COH2, COH3, COH4 and COH14 (Figure 15) and following the completion of each longwall to record evidence of potential subsidence impacts. Specific details that have been noted and/or photographed during the inspections are consistent with those described in Section 4.2.2.2 for Longwalls 23-27 cliff and overhang sites.

Longwall 22 extraction was completed in April 2014. Additional opportunistic observations of subsidence impacts conducted during routine works and sampling by Metropolitan Coal and its contractors did not identify any subsidence impacts at the cliff and overhang sites.

4.2.2 Longwalls 23-27

4.2.2.1 Steep Slopes and Land in General

Opportunistic visual inspections for subsidence impacts on steep slopes and land in general are conducted by Metropolitan Coal and its contractors as part of routine works conducted in the catchment. Specific details that are noted and/or photographed during the inspections include:

- the location, approximate dimensions (length, width and depth), and orientation of surface tension cracks;
- the location of the surface tension crack in relation to fire trails;
- the location and approximate dimensions of rock falls (e.g. rock ledges that occur along the Waratah Rivulet and the Eastern Tributary);

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

The date of the observation, details of the observer and the location of longwall extraction are also documented.

No surface tension cracks or rock falls were observed within 600 m of Longwalls 23-27 secondary extraction during the reporting period.

4.2.2.2 Cliffs and Overhangs

Visual inspections are conducted monthly for the period of time that extraction of Longwalls 23-27 takes place within 400 m of sites COH2, COH3, COH4, CHO5, COH6, COH6A, COH7, COH8, COH9, COH10, COH14, COH15 and COH16 (Figure 15) and following the completion of each longwall to record evidence of potential subsidence impacts. Specific details that are noted and/or photographed during the inspections include:

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

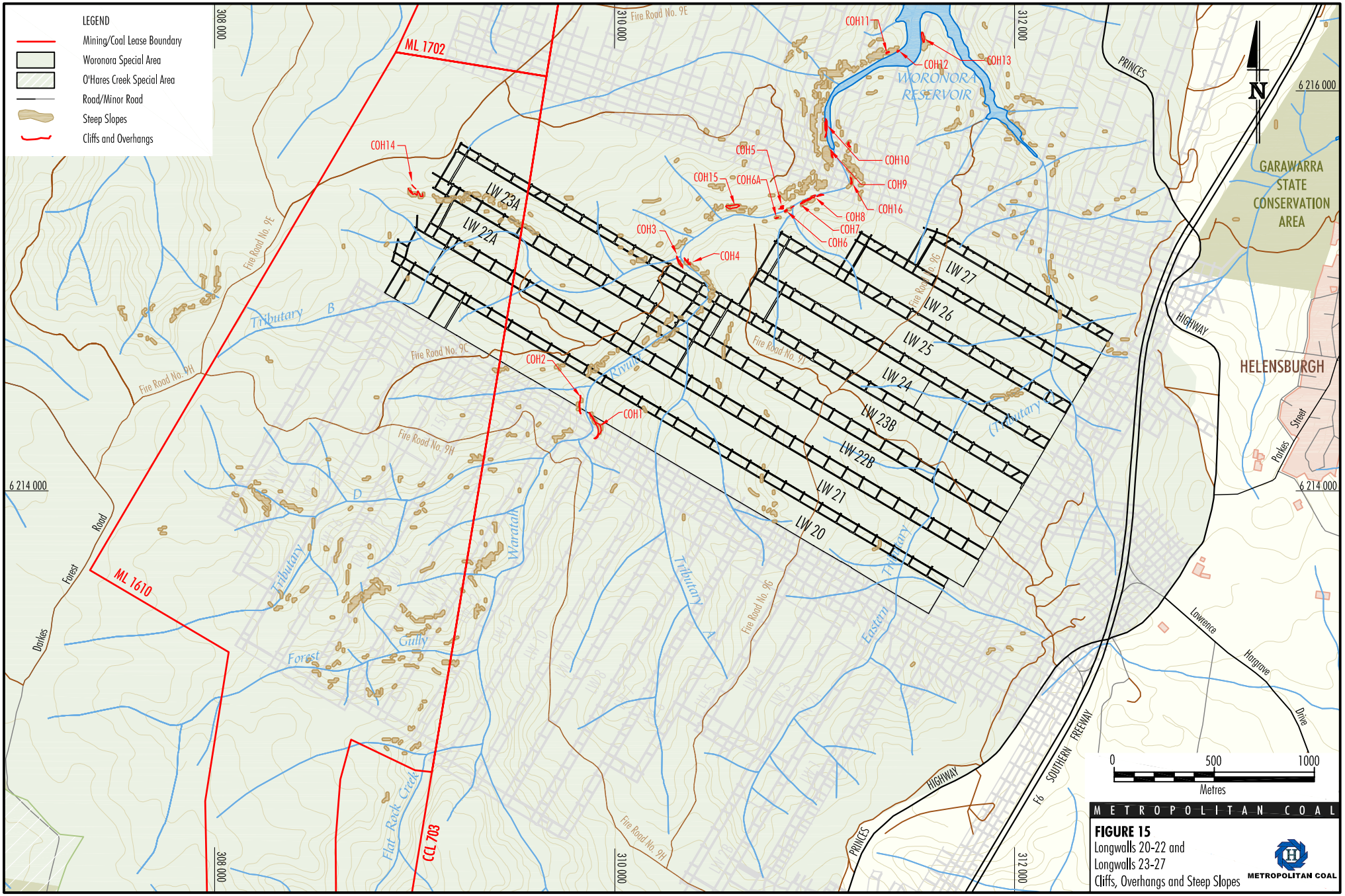
Longwall 23 was not within 400 m of sites COH2, COH3, COH4, CHO5, COH6, COH6A, COH7, COH8, COH9, COH10, COH14, COH15 or COH16 during the reporting period. The start of Longwall 24 was within 400 m of sites COH4, COH5, COH6, COH6A and COH7 in April 2015.

No cliff instabilities (i.e. freshly exposed rock face and debris scattered around the base of the cliff or overhang) or areas of water seepage in excess of that expected to result from rainfall conditions were evident at any of the sites.

4.3 ASSESSMENT OF ENVIRONMENTAL PERFORMANCE

The performance indicator and subsidence impact performance measure described below have been developed to address the predictions of subsidence impacts and environmental consequences on land included in the Project EA (Helensburgh Coal Pty Ltd, 2008), PPR (Helensburgh Coal Pty Ltd, 2009), Metropolitan Coal Longwalls 20-22 Extraction Plan (Metropolitan Coal, 2010) and Metropolitan Coal Longwalls 23-27 Extraction Plan (Metropolitan Coal, 2014).

The results of the assessment are described in Sections 4.3.1 and 4.3.2.



METROPOLITAN COAL

FIGURE 15
Longwalls 20-22 and
Longwalls 23-27
Cliffs, Overhangs and Steep Slopes

METROPOLITAN COAL

MET-08-AD7-2015_6MR_113B

4.3.1 Longwalls 20-22

The subsidence impact performance indicator and subsidence impact performance measure detailed in the Metropolitan Coal Longwalls 20-22 Land Management Plan are the same as those included in the Metropolitan Coal Longwalls 23-27 Land Management Plan.

Assessment of the subsidence impact performance indicator and subsidence impact performance measure for the reporting period is provided in Section 4.3.2 below.

4.3.2 Longwalls 23-27

4.3.2.1 Steep Slopes and Land in General

Analysis against Performance Indicator

Performance Indicator: *Steep slopes and land in general are expected to experience surface tension cracking no greater than 0.1 m wide and 25 m in length.*

The subsidence impact assessment in the Metropolitan Coal Longwalls 20-22 and Longwalls 23-27 Land Management Plans indicate that the size and extent of surface cracking at the steep slopes is expected to be similar to that observed during the extraction of previous longwalls at the Colliery (i.e. where surface cracking up to approximately 25 m long and 0.1 m wide has been observed).

As described in Sections 4.2.1.1 and 4.2.2.1, no additional surface tension cracks to those reported previously, were observed within 600 m of Longwalls 20-22 or Longwalls 23-27 secondary extraction during the reporting period.

The performance indicator was not exceeded during the reporting period.

4.3.2.2 Cliffs and Overhangs

Analysis against Subsidence Impact Performance Measure

Subsidence Impact Performance Measure:

Less than 3% of the total length of cliffs (and associated overhangs) within the mining area experience mining-induced rock fall.

The Metropolitan Coal Longwalls 20-22 and Longwalls 23-27 Land Management Plans indicate the approximate overall length of cliffs and overhangs within the mining area (Table 15). The mining area is defined by the Project Approval and is shown on Figure 2 of this report (labelled Project Underground Mining Area Longwalls 20-27 and 301-317).

Table 15 indicates the total length of cliffs and associated overhangs within the mining area is approximately 772 m. The total length of cliffs and associated overhangs within the mining area to experience cliff instability (i.e. the exposure of a fresh face of rock and debris scattered around the base of the cliff or overhang) is to be less than 23 m.

The Metropolitan Coal 2013 Annual Review/AEMR reported a small rock fall (approximately 1.5 m long, 0.5 m wide and approximately 0.5 m^3) at site COH2. No additional rock falls at the cliff or overhang sites have been recorded.

The subsidence impact performance measure has not been exceeded.

Table 15
Length of Cliffs and Overhangs within the Mining Area

Site	Approximate Overall Length (m)
COH1	143
COH2	95
COH3	55
COH4	19
COH5	35
COH6	35
COH6A	10
COH7	50
COH8	40
COH9	30
COH10	50
COH11	35
COH12	40
COH13	50
COH14	45
COH15	20
COH16	30
Total Length	772

4.4 TARP CHARACTERISATION

Sections 4.4.1 and 4.4.2 provide the TARP characterisation for the reporting period for Longwalls 20-22 and Longwalls 23-27, respectively.

4.4.1 Longwalls 20-22

The TARP characterisation for Longwalls 20-22 land management is provided in Table 16. In summary, neither the performance indicator nor the performance measure were exceeded during the reporting period.

Table 16
TARP Characterisation – Longwalls 20-22 Land Management

Monitoring Components	Subsidence Impact Performance Indicator	Subsidence Impact Performance Indicator Exceeded?	Resulting Actions	Subsidence Impact Performance Measure	Subsidence Impact Performance Measure Exceeded?
Steep Slopes and Land in General	*Steep slopes and land in general are expected to experience surface tension cracking no greater than 0.1 m wide and 25 m in length.*	No	No management measures required. Continue monitoring.	-	-
Cliffs and Overhangs	-	-	-	*Less than 3% of the total length of cliffs (and associated overhangs) within the mining area experience mining-induced rock fall.*	No

4.4.2 Longwalls 23-27

The TARP characterisation for Longwalls 23-27 land management is provided in Table 17. In summary, neither the performance indicator nor the performance measure were exceeded during the reporting period.

Table 17
TARP Characterisation – Longwalls 23-27 Land Management

Monitoring Components	Subsidence Impact Performance Indicator	Subsidence Impact Performance Indicator Exceeded?	Resulting Actions	Subsidence Impact Performance Measure	Subsidence Impact Performance Measure Exceeded?
Steep Slopes and Land in General	*Steep slopes and land in general are expected to experience surface tension cracking no greater than 0.1 m wide and 25 m in length.*	No	No management measures required. Continue monitoring.	-	-
Cliffs and Overhangs	-	-	-	*Less than 3% of the total length of cliffs (and associated overhangs) within the mining area experience mining-induced rock fall.*	No

5 HERITAGE MANAGEMENT

5.1 BACKGROUND

The Metropolitan Coal Longwalls 20-22 Heritage Management Plan and Metropolitan Coal Longwalls 23-27 Heritage Management Plan were prepared to manage the potential environmental consequences of the Metropolitan Coal Longwalls 20-22 Extraction Plan and Metropolitan Coal Longwalls 23-27 Extraction Plan on Aboriginal heritage sites or values in accordance with Condition 6, Schedule 3 of the Project Approval.

5.2 MONITORING

5.2.1 Longwalls 20-22

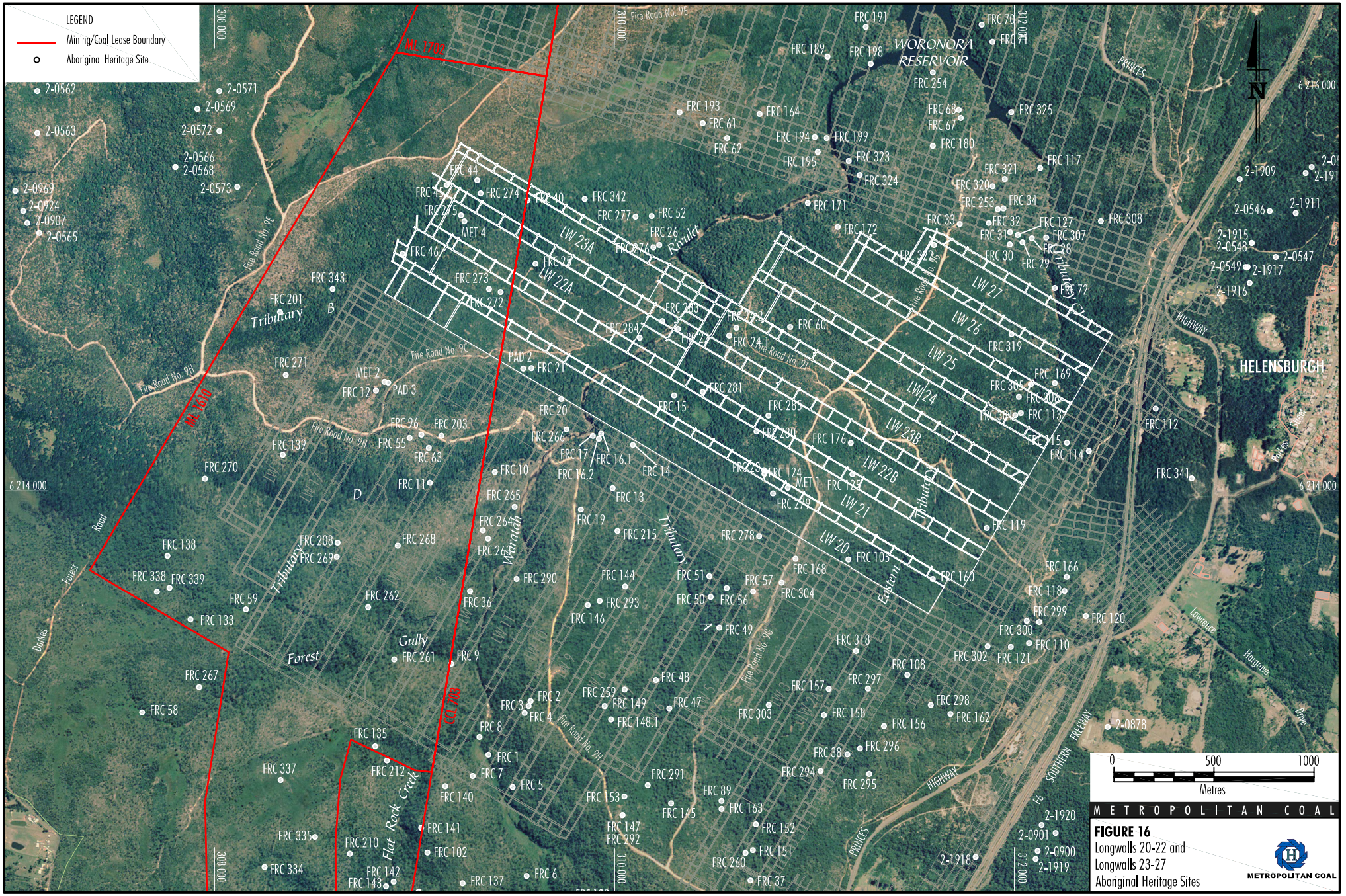
A monitoring program was implemented to monitor the impacts and consequences of Project related subsidence on Aboriginal heritage sites located within the 35º Angle of Draw of Longwalls 20-22 (Figure 16).

Specific details recorded during the monitoring program include:

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

The monitoring program was carried out by an archaeologist (with experience in rock art recording and management) and Aboriginal stakeholder representatives.

Three rounds of monitoring were conducted in accordance with the Longwalls 20-22 Heritage Management Plan (Rounds 1, 2 and 3).



MET-08-AD7-2015_6MR_114B

Five heritage sites (FRC 15, FRC 281, FRC 283, FRC 284 and MET 1) have been determined to have changes due to mining induced subsidence from Longwalls 20-22. The changes are described in the Metropolitan Coal 2014 Annual Review and AEMR/Rehabilitation Report.

5.2.2 Longwalls 23-27

A monitoring program has been established to monitor the impacts and consequences of Project related subsidence on Aboriginal heritage sites located within the 35º Angle of Draw of Longwalls 23-27 (Figure 16) and any sites at which the Longwalls 20-22 Heritage Management Plan monitoring program indicates change due to mining induced subsidence.

The first round of monitoring for Longwalls 23-27 (Round 1) will include all Aboriginal heritage sites located within the 35º Angle of Draw for Longwalls 22 and 23 and any sites at which the Metropolitan Coal Longwalls 20-22 Heritage Management Plan monitoring program indicates continued change due to mining induced subsidence.

In accordance with the Longwalls 23-27 Heritage Management Plan, Round 1 is to be undertaken between three to six months following the completion of Longwall 23B. The first round of monitoring for Longwalls 23-27 will be conducted in the next reporting period (i.e. 1 July to 31 December 2015).

Specific details that will be recorded during the monitoring program include:

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

5.3 ASSESSMENT OF ENVIRONMENTAL PERFORMANCE

The subsidence impact performance measure described in Sections 5.3.1 and 5.3.2 below has been developed to address the predictions of subsidence impacts and environmental consequences on Aboriginal heritage included in the Project EA (Helensburgh Coal Pty Ltd, 2008), PPR (Helensburgh Coal Pty Ltd, 2009), Metropolitan Coal Longwalls 20-22 Extraction Plan (Metropolitan Coal, 2010) and Metropolitan Coal Longwalls 23-27 Extraction Plan (Metropolitan Coal, 2014).

5.3.1 Longwalls 20-22

The Longwalls 20-22 Aboriginal heritage monitoring results are used to assess the Project against the Aboriginal heritage subsidence impact performance measure:

> *Less than 10% of Aboriginal heritage sites within the mining area are affected by subsidence impacts.*

For the purpose of measuring performance against the Aboriginal heritage subsidence impact performance measure, sites are considered to be "affected by subsidence impacts" if they exhibit one or more of the following consequences that cannot be attributed to natural weathering or deterioration:

- overhang collapse;
- cracking of sandstone that coincides with Aboriginal art or grinding grooves; and
- rock fall that damages Aboriginal art.

The mining area is defined by the Project Approval and is shown on Figure 2 of this report (labelled Project Underground Mining Area Longwalls 20-27 and 301-317).

There are 143 sites within the mining area. To date, five heritage sites (FRC 15, FRC 281, FRC 283, FRC 284 and MET 1) have been determined by the Longwalls 20-22 Rounds 1, 2 and 3 Aboriginal heritage surveys to have changes due to mining induced subsidence. In terms of the performance measure, sites FRC 283, MET 1, FRC 15 and FRC 284 have not been affected by subsidence impacts as no overhang collapse, cracking of sandstone that coincides with Aboriginal art or grinding grooves, or rock fall that damages Aboriginal art have occurred. Site FRC 281 has been affected by subsidence impacts as a result of cracking of sandstone that coincides with Aboriginal art. This means that less than 1% of sites within the mining area have been affected, which is within the approved performance measure.

Subsequent monitoring will be undertaken in accordance with the Longwalls 23-27 Heritage Management Plan and will include sites at which monitoring conducted for Longwalls 20-22 (i.e. Rounds 1 to 3) indicates continued change due to mining induced subsidence.

5.3.2 Longwalls 23-27

The Longwalls 23-27 Aboriginal heritage monitoring results will be used to assess the Project against the Aboriginal heritage subsidence impact performance measure:

> *Less than 10% of Aboriginal heritage sites within the mining area are affected by subsidence impacts.*

The first round of Longwalls 23-27 Aboriginal heritage monitoring (i.e. Round 1) will be conducted in the next reporting period (i.e. between three to six months following the completion of Longwall 23B).

5.4 TARP CHARACTERISATION

Sections 5.4.1 and 5.4.2 provide the TARP characterisation for the reporting period for Longwalls 20-22 and Longwalls 23-27, respectively.

5.4.1 Longwalls 20-22

The TARP characterisation for Longwalls 20-22 Aboriginal heritage management is provided in Table 18. In summary, the performance measure was not exceeded during the reporting period.

Table 18
TARP Characterisation – Longwalls 20-22 Aboriginal Heritage Management

Monitoring Component	Subsidence Impact Performance Measure	Subsidence Impact Performance Measure Exceeded?
Aboriginal Heritage Sites	*Less than 10% of Aboriginal heritage sites within the mining area are affected by subsidence impacts.*	No

5.4.2 Longwalls 23-27

The TARP characterisation for Longwalls 23-27 Aboriginal heritage management is provided in Table 19. The performance measure will be assessed following the completion of the Longwalls 23-27 Round 1 Aboriginal heritage surveys.

Table 19
TARP Characterisation – Longwalls 23-27 Aboriginal Heritage Management

Monitoring Component	Subsidence Impact Performance Measure	Subsidence Impact Performance Measure Exceeded?
Aboriginal Heritage Sites	*Less than 10% of Aboriginal heritage sites within the mining area are affected by subsidence impacts.*	No. To be assessed following the completion of the Longwalls 23-27 Round 1 Aboriginal heritage surveys.

6 BUILT FEATURES MANAGEMENT

6.1 BACKGROUND

The Metropolitan Coal Longwalls 20-22 Built Features Management Plan and Metropolitan Coal Longwalls 23-27 Built Features Management Plan were developed to manage the potential environmental consequences of the Metropolitan Coal Longwalls 20-22 Extraction Plan and Metropolitan Coal Longwalls 23-27 Extraction Plan on built features in accordance with Condition 6, Schedule 3 of the Project Approval. The Longwalls 20-22 and Longwalls 23-27 Built Features Management Plans were developed in consultation with the relevant asset owner.

6.2 MONITORING

6.2.1 Longwalls 20-22

The Longwalls 20-22 Built Features Management Plan has been discontinued as the appropriate monitoring for built features has been incorporated into the Longwalls 23-27 Built Features Management Plan. The built features monitoring associated with the Longwalls 23-27 Built Features Management Plan is described in Section 6.2.2.

6.2.2 Longwalls 23-27

Site inspections were conducted prior to the commencement of secondary extraction of Longwall 20 to establish the condition of the infrastructure items. Site inspections were also conducted prior to the commencement of Longwall 23 in accordance with the Metropolitan Coal Longwalls 23-27 Built Features Management Plan.

A monitoring program has been implemented to monitor subsidence impacts on the following infrastructure at the various frequencies described in the Metropolitan Coal Longwalls 23-27 Built Features Management Plan:

- Endeavour Energy infrastructure;
- Nextgen infrastructure;
- TransGrid infrastructure;
- Optus infrastructure;
- Telstra infrastructure;
- RMS infrastructure;
- RailCorp infrastructure;
- Sydney Water infrastructure; and
- Wollongong City Council.

Monitoring relevant to each Built Features Management Plan has been conducted in accordance with each plan and within three months of Longwall 23 completion (completed in March 2015).

Analysis of measured subsidence was conducted at the end of Longwall 23 by MSEC. MSEC concluded that subsidence impacts to built features were similar to or less than those predicted. No impact to any built feature was evident over the reporting period.

6.3 ASSESSMENT OF ENVIRONMENTAL PERFORMANCE

The results of the subsidence impact monitoring in relation to the built features subsidence impact performance measures are provided below.

Specific performance measures have been developed for the various infrastructure items and are outlined in the Metropolitan Coal Longwalls 20-22 Built Features Management Plan and Metropolitan Coal Longwalls 23-27 Built Features Management Plan.

6.3.1 Longwalls 20-22

The results of the subsidence impact monitoring in relation to the built features subsidence impact performance measures relevant to Longwalls 20-22 are the same as those for Longwalls 23-27 described in Section 6.3.2.

6.3.2 Longwalls 23-27

Specific performance measures have been developed for the various infrastructure items and are outlined in the Metropolitan Coal Longwalls 23-27 Built Features Management Plan.

Built Features Subsidence Impact Performance Measure

The Project Approval requires Metropolitan Coal not to exceed the following built features subsidence impact performance measure:

> *Safe, serviceable and repairable, unless the owner and the MSB agree otherwise in writing.*

Longwall 23 commenced in May 2014 and was completed in March 2015. Longwall 24 commenced in April 2015. The built features subsidence impact performance measure was not exceeded during the reporting period.

Heritage Subsidence Impact Performance Measure – Garrawarra Centre Historical or Heritage Significance Items

The Project Approval also requires Metropolitan Coal not to exceed the following heritage subsidence impact performance measure for items of heritage or historical significance at the Garrawarra Centre:

> *Negligible damage (fine or hairline cracks that do not require repair), unless the owner of the item and the appropriate heritage authority agree otherwise in writing.*

The Garrawarra Complex is located more than 2.5 km from Longwalls 23-27 and at this distance no measurable systematic or non-systematic subsidence movements were indicated.

6.4 MANAGEMENT AND MITIGATION MEASURES

Over the reporting period, Metropolitan Coal held meetings with the RMS Technical Committee which was established to facilitate consultation in regard to the Built Features Management Plan – RMS in relation to the M1 Princes Motorway and associated bridges.

An extensive structural investigation was completed for Bridge 2 to determine the safe and serviceable criteria. Real time monitoring provisions and mining stand-off requirements were established for Bridge 2 to meet the safe and serviceable criteria.

6.5 TARP CHARACTERISATION

Sections 6.5.1 and 6.5.2 provide the TARP characterisation for the reporting period for Longwalls 20-22 and Longwalls 23-27, respectively.

6.5.1 Longwalls 20-22

The TARP characterisation for Longwalls 20-22 built features management is provided in Table 20. In summary, no performance measures were exceeded during the reporting period.

Table 20
TARP Characterisation – Longwalls 20-22 Built Features Management

Monitoring Component	Subsidence Impact Performance Measure	Subsidence Impact Performance Measure Exceeded?
Built Features	*Safe, serviceable and repairable, unless the owner and the MSB agree otherwise in writing.*	No
	Negligible damage (fine or hairline cracks that do not require repair), unless the owner of the item and the appropriate heritage authority agree otherwise in writing.	No

6.5.2 Longwalls 23-27

The TARP characterisation for Longwalls 23-27 built features management is provided in Table 21. In summary, no performance measures were exceeded during the reporting period.

Table 21
TARP Characterisation – Longwalls 23-27 Built Features Management

Monitoring Component	Subsidence Impact Performance Measure	Subsidence Impact Performance Measure Exceeded?
Built Features	*Safe, serviceable and repairable, unless the owner and the MSB agree otherwise in writing.*	No
	Negligible damage (fine or hairline cracks that do not require repair), unless the owner of the item and the appropriate heritage authority agree otherwise in writing.	No

7 PUBLIC SAFETY MANAGEMENT

7.1 BACKGROUND

The Metropolitan Coal Longwalls 20-22 Public Safety Management Plan and Metropolitan Coal Longwalls 23-27 Public Safety Management Plan were prepared to manage the potential consequences of the Metropolitan Coal Longwalls 20-22 Extraction Plan and Metropolitan Coal Longwalls 23-27 Extraction Plan on public safety within the underground mining areas in accordance with Condition 6, Schedule 3 of the Project Approval.

7.2 MONITORING

7.2.1 Longwalls 20-22

Hazards identified in relation to public access to the underground mining area that may arise as a result of the Metropolitan Coal Longwalls 20-22 Extraction Plan are described in Section 7.2.2.

Monitoring of cliffs and overhangs, steep slopes and land in general has been conducted for subsidence impacts in accordance with the Metropolitan Coal Longwalls 20-22 Land Management Plan, and of infrastructure items in accordance with the Metropolitan Coal Longwalls 20-22 Built Features Management Plan. No subsidence impacts were identified during the reporting period that were considered to pose a risk to public safety.

7.2.2 Longwalls 23-27

Hazards identified in relation to public access to the underground mining area that may arise as a result of the Metropolitan Coal Longwalls 23-27 Extraction Plan include:

- damage to fire trails (e.g. cracks);
- dislodgement of rocks onto fire trails or roads;
- dislodgement of rocks from cliffs and overhangs;
- entrapment by fire caused by locked gates;
- vehicle collision with monitoring equipment located near fire trails;

- slips, trips and falls by visitors to the tributaries; and
- snake bite, spider bite or other animal encounter.

Monitoring of cliffs and overhangs, steep slopes and land in general has been conducted for subsidence impacts in accordance with the Metropolitan Coal Longwalls 23-27 Land Management Plan, and of infrastructure items in accordance with the Metropolitan Coal Longwalls 23-27 Built Features Management Plan. No subsidence impacts were identified during the reporting period that were considered to pose a risk to public safety.

Further, no safety incidents were reported by visitors, personnel or contractors to Metropolitan Coal in the underground mining area during the reporting period.

7.3 ASSESSMENT OF ENVIRONMENTAL PERFORMANCE

The monitoring results have been used to assess the Project against the public safety performance indicator and the built features subsidence impact performance measure for Longwalls 20-22 and Longwalls 23-27 in Sections 7.3.1 and 7.3.2 below.

7.3.1 Longwalls 20-22

The monitoring results have been used to assess the Project against the public safety performance indicator and the built features subsidence impact performance measure for Longwalls 20-22 below.

Analysis against Performance Indicator

Performance Indicator: *Public safety will be ensured in the event that any hazard to the general public arising from subsidence effects becomes evident.*

No subsidence impacts were identified during the reporting period that were considered to pose a risk to public safety.

Analysis against Subsidence Impact Performance Measure

Subsidence Impact Performance Measure:

Safe, serviceable and repairable, unless the owner and the MSB agree otherwise in writing.

Neither the performance indicator, nor the built features subsidence impact performance measure were exceeded during the reporting period.

7.3.2 Longwalls 23-27

The monitoring results have been used to assess the Project against the public safety performance indicator and the built features subsidence impact performance measure for Longwalls 23-27 below.

Analysis against Performance Indicator

Performance Indicator: *Public safety will be ensured in the event that any hazard to the general public arising from subsidence effects becomes evident.*

No subsidence impacts were identified during the reporting period that were considered to pose a risk to public safety.

Analysis against Subsidence Impact Performance Measure

Subsidence Impact Performance Measure:

Safe, serviceable and repairable, unless the owner and the MSB agree otherwise in writing.

Neither the performance indicator, nor the built features subsidence impact performance measure were exceeded during the reporting period.

7.4 TARP CHARACTERISATION

Sections 7.4.1 and 7.4.2 provide the TARP characterisation for the reporting period for Longwalls 20-22 and Longwalls 23-27, respectively.

7.4.1 Longwalls 20-22

The TARP characterisation for Longwalls 20-22 public safety management is provided in Table 22. In summary, neither the performance indicator nor the performance measure were exceeded during the reporting period.

Table 22
TARP Characterisation – Longwalls 20-22 Public Safety Management

Monitoring Component	Subsidence Impact Performance Indicator	Subsidence Impact Performance Indicator Exceeded?	Resulting Actions	Subsidence Impact Performance Measure	Subsidence Impact Performance Measure Exceeded?
Public Safety	*Public safety will be ensured in the event that any hazard to the general public arising from subsidence effects becomes evident.*	No	None required	*Safe, serviceable and repairable, unless the owner and the MSB agree otherwise in writing.*	No

7.4.2 Longwalls 23-27

The TARP characterisation for Longwalls 23-27 public safety management is provided in Table 23. In summary, neither the performance indicator nor the performance measure were exceeded during the reporting period.

Table 23
TARP Characterisation – Longwalls 23-27 Public Safety Management

Monitoring Component	Subsidence Impact Performance Indicator	Subsidence Impact Performance Indicator Exceeded?	Resulting Actions	Subsidence Impact Performance Measure	Subsidence Impact Performance Measure Exceeded?
Public Safety	*Public safety will be ensured in the event that any hazard to the general public arising from subsidence effects becomes evident.*	No	None required	*Safe, serviceable and repairable, unless the owner and the MSB agree otherwise in writing*.	No

8 REHABILITATION

8.1 BACKGROUND

A Metropolitan Coal Rehabilitation Management Plan has been prepared for the underground mining area for areas requiring rehabilitation or remediation measures including surface disturbance areas and stream pool/rock bar remediation in accordance with Condition 4, Schedule 6 of the Project Approval.

8.2 REHABILITATION AND REMEDIATION MEASURES

8.2.1 Surface Disturbance Areas

A Rehabilitation Management Plan – Surface Disturbance Register is used to manage the implementation of rehabilitation measures.

No surface disturbance areas were rehabilitated during the reporting period.

8.2.2 Stream Pool/Rock Bar Remediation

During the reporting period stream remediation activities continued to be conducted at Pool F on the Waratah Rivulet until June 2015. Stream remediation activities included drilling and injection of grout (polyurethane resin) to create a grout curtain, the implementation of environmental management measures and permeability testing.

In the next reporting period stream remediation activities will include aesthetic remediation at Pool F and the commencement of stream remediation at Pool G.

8.3 MONITORING

8.3.1 Surface Disturbance Areas

Some surface disturbance areas will be able to be rehabilitated during the life of the Project (e.g. monitoring sites no longer required), while other surface disturbance areas will likely remain until after the completion of mining operations.

Once a surface disturbance area is no longer being utilised, monitoring will be conducted to assess:

- where appropriate, whether equipment/infrastructure items have been removed;
- whether the area is tidy or rubbish removal is required;
- whether erosion and sediment controls are required and if so, the effectiveness of those installed;
- the presence of weeds and the need for the implementation of weed control measures;
- where appropriate, whether vegetation is re-establishing naturally or whether active revegetation is required; and
- if active revegetation is conducted, whether vegetation is establishing.

No surface disturbance areas were rehabilitated during the reporting period as the majority of disturbance pertained to the installation of environmental monitoring sites which are a life of mine asset. These sites will be rehabilitated to appropriate standards following cessation of mining.

In accordance with the Metropolitan Coal Rehabilitation Management Plan, the Rehabilitation Management Plan – Surface Disturbance Register is used to monitor the performance of the measures implemented to rehabilitate surface disturbance areas.

8.3.2 Stream Pool/Rock Bar Remediation

Monitoring of Pool Water Levels

Water levels in pools on the Waratah Rivulet and Eastern Tributary are monitored in accordance with the Metropolitan Coal Catchment Monitoring Program and Metropolitan Coal Longwalls 20-22 and Longwalls 23-27 Water Management Plans.

Monitoring of Waratah Rivulet Pools

Stream remediation is initiated at pools/rock bars on Waratah Rivulet between the downstream edge of Flat Rock Swamp and the full supply level of the Woronora Reservoir if the water level in a pool falls below its cease to overflow level (i.e. stops overflowing), except as a result of climatic conditions.

An assessment of the monitored pool water levels on Waratah Rivulet between Flat Rock Swamp and the full supply level of the Woronora Reservoir has been conducted, as described below.

Pools A, B, C, E, F, G, G1, H and I on the Waratah Rivulet are situated in the completed mining area (i.e. overlying Longwalls 1 to 13) between Flat Rock Swamp and the tailgate of Longwall 20 (Figure 12). As a result of previous mining, the water levels in pools upstream of Flat Rock Crossing (i.e. Pools A to F) and immediately downstream of Flat Rock Crossing (Pools G and G1) have previously been impacted by mine subsidence as described in the Metropolitan Coal Rehabilitation Management Plan (i.e. the pool water level has fallen below the cease to flow level). Water level monitoring of Pools A, B, C, E, F, G, G1, H and I are shown on Charts C1 to C9 in Appendix C. A description of water levels in each pool compared to its cease to flow level is provided below.

Most recently, Pool A stopped overflowing its downstream rock bar between 7 December 2012 and 25 January 2013 and Pool B stopped overflowing from the 28 December 2012 to the 25 January 2013. The water levels in both pools have remained above their cease to flow levels since that time and throughout the reporting period (Charts C1 and C2 in Appendix C).

During the reporting period water levels in Pool C did not fall below the cease to flow level (Chart C3 in Appendix C) the most recent fall below the cease to flow level was from the 6 to 8 November 2013.

Water levels in Pool E did not fall below its cease to flow level during the reporting period, the most recent fall being between the 10 and 25 January 2013 (Chart C4 in Appendix C).

Water levels in Pool F did not fall below the cease to flow level during the reporting period, the most recent fall being between the 2 January and 25 January 2013 (Chart C5 in Appendix C).

Water levels in Pool G have regularly fallen below the cease to flow level in the past. During the reporting period the water level fell below the pool's cease to flow level during the following periods: 1 to 19 January 2015; 9 to 12 February 2015; 17 to 20 March 2015; and 30 March to 2 April 2015 (Chart C6 in Appendix C).

Water levels in Pool G1 did not fall below the cease to flow level during the reporting period, the most recent fall being between the 10 and 25 January 2013 (Chart C7 in Appendix C).

Water levels in Pool H and Pool I indicate that these pools have not fallen below their cease to flow levels (Charts C8 and C9, respectively, in Appendix C).

In summary, all pools except Pool G (which fell below its cease to flow level on four separate occasions during the reporting period) remained above their cease to flow levels during the reporting period. Pools H and I have not fallen below their cease to flow levels over the period of available water level data.

Stream remediation activities have previously been undertaken at Pools A and F on the Waratah Rivulet. 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 will assess whether stream remediation is required at any additional pools/rock bars between Flat Rock Swamp and Pool F once stream remediation activities at Pools A and F have been completed. Stream remediation activities at Flat Rock Crossing (Pool G) will commence in the next reporting period and as described in Section 8.3.3.2.

Automatic pool water level monitoring is also conducted for Pools A and F and for pools further downstream of Flat Rock Crossing (Pools J, K, L, M, N, O, P, Q, R, S, T, U, V and W). The recorded water level responses in pools are presented on Charts C10 to C25 in Appendix C. Where available[29], the surveyed cease to flow levels of the pools are also shown on Charts C10 to C25 in Appendix C[30].

There are periods of missing data at a number of pools during the reporting period. A review of the data by Metropolitan Coal indicates that this was caused by damage to several sites including loss of loggers, during floods in April 2015 and also due to instrument malfunction.

The recorded water levels in Pools A, F, K, L, M, O, P, Q, R, S and V (Charts C10, C11, C13 to C15, C17 to C21 and Chart C24 in Appendix C) did not fall below the surveyed cease to flow levels during the reporting period. This and the shape of the recorded water level hydrographs in these pools suggest they exhibited natural behaviour.

Recorded water levels in Pool J (Chart C12 in Appendix C) are considered to be largely erroneous during the reporting period due to logger malfunction. The diver has been replaced on two occasions, however the large fluctuations in water levels over the reporting period do not reflect pool water level behavior. Visual inspections conducted by Metropolitan Coal throughout the reporting period suggest that this pool did not stop overflowing the downstream rockbar. Stage levels from the Metropolitan Coal gauging station (GS 300017) which is located in Pool J are presented in Chart 145 and also indicate that Pool J did not stop overflowing during the reporting period.

Visual observations by Metropolitan Coal personnel indicated Pool N first ceased overflowing in early September 2012 (during a period of missing water level data) (Chart C16 in Appendix C). Recorded pool water levels in Pool N appear to have remained above the cease to flow level during the reporting period. Visual inspections by Metropolitan Coal also indicate Pool N remained above the cease to flow level during the reporting period. There has however been an apparent change in low flow levels which may be associated with subsidence. The pool datum and cease to flow levels will be re-surveyed by the mine's surveyors in the next reporting period, and where appropriate, corrections will be made to the pool water levels.

[29] Surveyed cease to flow levels are available for Pools A, J, K, L, M, N, P, Q, R, S and V.

[30] Charts in Appendix C do not show all data available since the commencement of monitoring for Pool A (Chart C10), Pool F (Chart C11), Pool J (Chart C12), Pool L (Chart C14), Pool M (Chart C15), Pool N (Chart C16), Pool O (Chart C17), Pool P (Chart C18), Pool R (Chart C20) and Pool S (Chart C21) as the early recorded pool water level responses in these pools during low flow periods were affected by daily temperature fluctuations, but were otherwise consistent with natural pool behaviour (as described in the Metropolitan Coal 2010 Annual Review [Metropolitan Coal, 2010d]). Metropolitan Coal upgraded the pool water level meter instrumentation in order to remove the effects of daily temperature fluctuations.

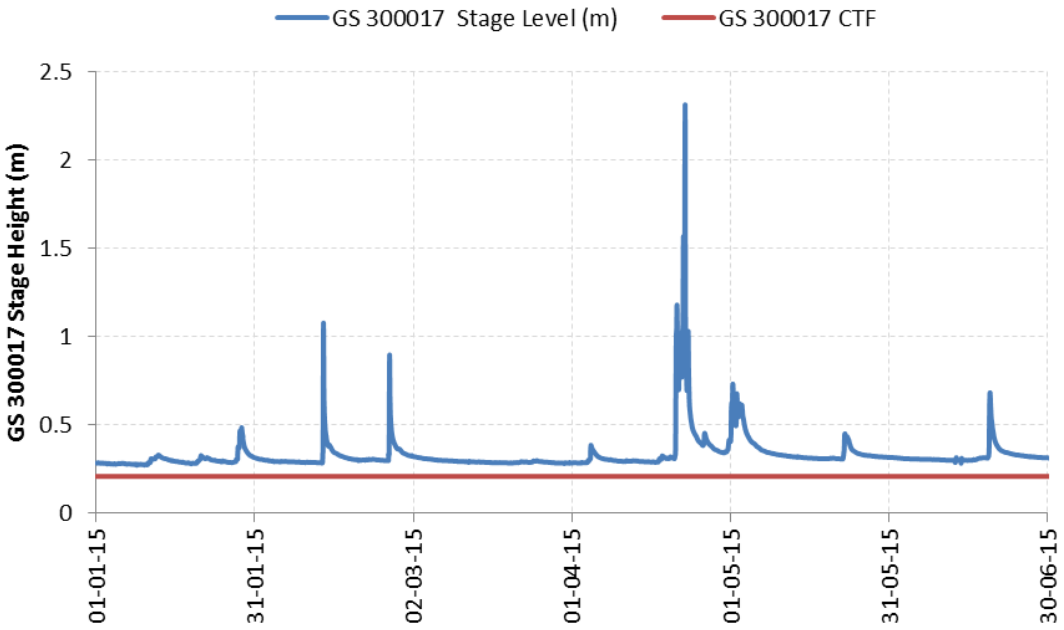


Chart 145 Recorded Stage Height in Pool J at GS 300017 During Reporting Period

Pools O, T, U and W do not have established surveyed cease to flow levels because these pools do not have 'solid' rock-bar controls, however the shape of the recorded pool water level hydrographs in all pools suggest that these pools exhibited natural behaviour during the reporting period (Charts C17, C22, C23 and C25, respectively, in Appendix C). There were extended periods of missing data at Pools T, U and W during the reporting period due to flood damage and instrument malfunction. The available data and visual inspections by Metropolitan Coal however suggest that these pools behaved naturally, consistent with past behaviour.

Monitoring of Eastern Tributary Pools

On the Eastern Tributary, surface flow and pool holding capacity is required to be preserved over 70% of the stream length between the maingate of Longwall 26 and the full supply level of the Woronora Reservoir. Pools ETAF to ETAU on the Eastern Tributary are situated between maingate 26 and the full supply level. Pools ETAF, ETAH, ETAI, ETAQ and ETAU are monitored continuously with a data logger.

Stream remediation will be triggered at Pools ETAF to ETAU if the assessment of monitoring results indicates the performance measure:

> *negligible environmental consequences over at least 70% of the stream length (that is, no diversion of flows, no change in the natural drainage behaviour of pools, …….) on the Eastern Tributary between the full supply level of the Woronora Reservoir and the maingate of Longwall 26.*

has been exceeded.

Monitoring of the Eastern Tributary Pools ETAF to ETAU is described in Section 2.3.2.7.

8.3.3 Assessment of Environmental Performance

8.3.3.1 Surface Disturbance Areas

Analysis against Performance Indicators

Metropolitan Coal will assess the progress of the rehabilitation measures against the following performance indicators:

Redundant equipment/infrastructure items have been removed.

The site is neat and tidy (i.e. it does not contain any rubbish).

No weed management measures are required.

No erosion or sediment control measures are required.

Where appropriate, native vegetation is naturally regenerating or active revegetation is establishing.

No further active revegetation measures are required.

The progress of the rehabilitation will be recorded in the Rehabilitation Management Plan – Surface Disturbance Register and reported in future Annual Review and AEMR/Rehabilitation Reports and Six Monthly Reports.

Analysis against Rehabilitation Objective

When appropriate, an assessment of the site will be made against the rehabilitation objective for other land affected by the Project, *viz*. *Restore ecosystem function, including maintaining or establishing self-sustaining native ecosystems: comprised of local native plant species; with a landform consistent with the surrounding environment*.

The rehabilitation objective will be considered to have been met if:

- the site contains self-sustaining native vegetation (i.e. the vegetation is able to sustain itself, without the implementation of any management measures);
- the vegetation is healthy;
- the native vegetation is comprised of local native plant species, as assessed by a suitably qualified botanist;
- ecosystem function is considered to have been restored (i.e. ecosystem processes [water cycle, nutrient cycle and energy interception] at site scale are functioning well); and
- the landform is consistent with the surrounding environment.

The assessment will be recorded in the Rehabilitation Management Plan – Surface Disturbance Register and the progress of rehabilitation will be reported in future Annual Review and AEMR/Rehabilitation Reports and Six Monthly Reports.

8.3.3.2 Stream Pool/Rock Bar Remediation

Analysis against Performance Indicators

Metropolitan Coal will assess the progress of the stream remediation measures against the following performance indicator:

> *Analysis of water level recession rates for a pool indicates a similar pool behaviour to that which existed prior to being impacted by subsidence.*

The water level recession rates performance indicator will be considered to have been met if data analysis indicates there is not a statistically significant change in pool water level recession rates after stream remediation, compared to pool water level recession rates prior to the triggering of stream remediation. Analysis of water level recession rates will be conducted following completion of stream remediation measures.

Pool A on the Waratah Rivulet is situated in the completed Longwalls 1 to 13 mining area downstream of Flat Rock Swamp (Figure 12). A substantial grout curtain at Pool A was established along the length of the river cross section in early 2012 and permeability testing of the structure in June 2012 indicated a low hydraulic conductivity. In June 2012 drill rigs, site shed, product lines and related stream remediation equipment was removed from the site. Water level monitoring of Pool A is shown on Charts C1 and C10 in Appendix C. Since June 2012, Pool A stopped overflowing its downstream rock bar between 7 December 2012 and 25 January 2013 and has remained above its cease to flow level since that time. The reference pools WRP2, WRP3 and WRP4 on Woronora River also ceased overflowing during the same December 2012 to January 2013 period. The cease to flow behaviour of pools on Waratah Rivulet would have been influenced by the same period of low flow. Metropolitan Coal will continue to monitor pool water levels in Pool A and will conduct an analysis of the stream remediation activities at Pool A against the stream remediation performance indicator detailed in the Rehabilitation Management Plan once a significant period of drier climatic conditions has been experienced.

Pool F on the Waratah Rivulet is situated in the completed Longwalls 1 to 13 mining area and approximately 200 m upstream of Flat Rock Crossing (Figure 12). Metropolitan Coal conducted trial stream remediation activities at Pool F (also known as the WRS4 rock bar), which involved the drilling of holes and injection of polyurethane (PUR) grout into sub-surface fractures and associated activities, in consultation with WaterNSW from March to May 2008. Associated activities included the mobilisation, placement and operation of equipment and the implementation of a variety of environmental management measures. The objective of the trial was to investigate the effectiveness of the PUR grouting products and associated injection methods in reducing the hydraulic conductivity of the fractured rock mass. As anticipated, further subsidence movement at Pool F occurred subsequent to the trial. Subsequent drilling and grout injection activities at Pool F were conducted from June 2011 to May 2012 and June to December 2014. During the reporting period, stream remediation activities at Pool F were conducted from January to June 2015. In the next reporting period stream remediation activities will include aesthetic remediation at Pool F and the commencement of stream remediation at Pool G. Water level monitoring of Pool F is shown on Chart C5 (manual observations) and Chart C11 (automatic monitoring) in Appendix C. Water levels in Pool F did not fall below the cease to flow level during the reporting period, the most recent fall was between the 2 and 25 January 2013.

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 will assess whether stream remediation is required at any additional pools/rock bars between Flat Rock Swamp and Pool F once stream remediation activities at Pools A and F have been completed and once a significant period of drier climatic conditions has been experienced.

Analysis against Rehabilitation Objective

The rehabilitation objective for the Waratah Rivulet between the downstream edge of Flat Rock Swamp and the full supply level of the Woronora Reservoir and the Eastern Tributary between the maingate of Longwall 26 and the full supply level of the Woronora Reservoir, *viz. Restore surface flow and pool holding capacity as soon as reasonably practicable*, will be assessed using the results of the assessment of the performance indicator and progress reported in Annual Review and AEMR/Rehabilitation Reports and Six Monthly Reports.

9 REFERENCES

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

Evans & Peck (2012) *2012 Annual Review – Independent Review of Compliance with Water Quality Performance Measures*. Report prepared for Metropolitan Coal.

Evans & Peck (2013) *2013 Annual Review – Independent Review of Compliance with Water Quality Performance Measures*. Report prepared for Metropolitan Coal.

Gilbert & Associates (2008) *Metropolitan Coal Project Surface Water Assessment*, Appendix C in Helensburgh Coal Pty Ltd (2008) *Metropolitan Coal Project Environmental Assessment.*

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

Helensburgh Coal Pty Ltd (2009) *Metropolitan Coal Project Preferred Project Report.*

Keith, D. and Myerscough, P.J. (1993) Floristics and soil relations of upland swamp vegetation near Sydney. Australian Journal of Ecology 18, 325-344.

Metropolitan Coal (2010) *Metropolitan Coal Longwalls 20-22 Extraction Plan*.

Metropolitan Coal (2011) *Metropolitan Coal Environmental Management Strategy.*

Metropolitan Coal (2013) *Metropolitan Coal 2013 Annual Review/AEMR*.

Metropolitan Coal (2014) *Metropolitan Coal Longwalls 23-27 Extraction Plan*.

National Parks and Wildlife Service (2003) *The Native Vegetation of the Woronora, O'Hares and Metropolitan Catchments.* NSW National Parks and Wildlife Service, Hurstville.

APPENDIX A

VISUAL AND PHOTOGRAPHIC SURVEY MAPPING OF THE WARATAH RIVULET, EASTERN TRIBUTARY, TRIBUTARY A AND TRIBUTARY B

(Refer to DVD Provided)

APPENDIX B

SURFACE WATER QUALITY MONITORING RESULTS FOR SELECT SITES - PH, ELECTRICAL CONDUCTIVITY, DISSOLVED IRON, DISSOLVED MANGANESE AND DISSOLVED ALUMINIUM

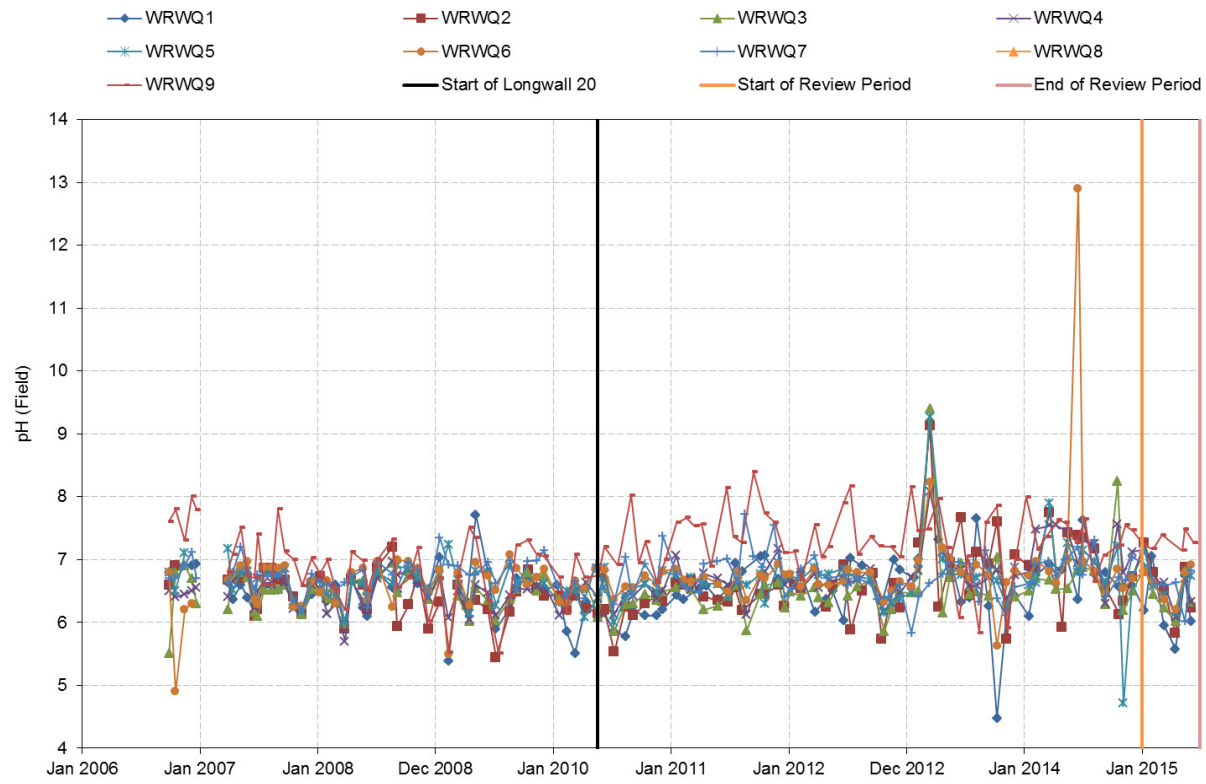


Chart B1 pH Levels Waratah Rivulet

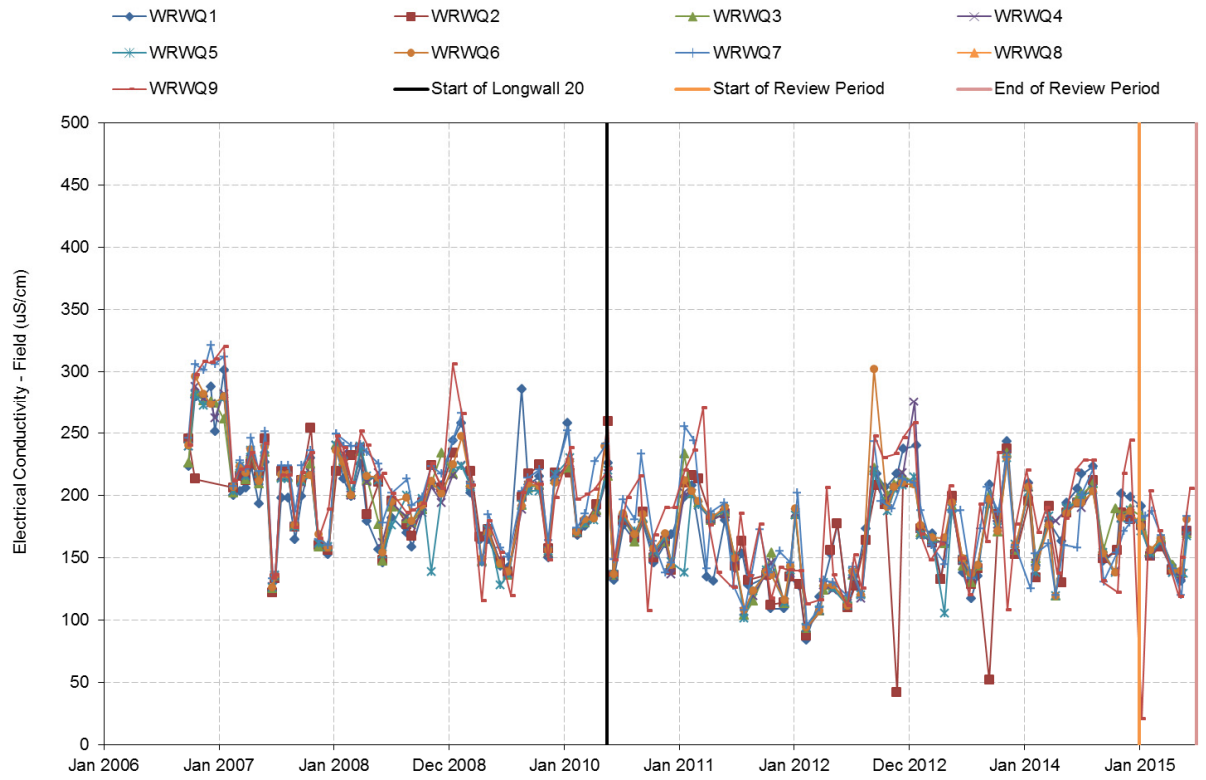


Chart B2 Electrical Conductivity (EC) Waratah Rivulet

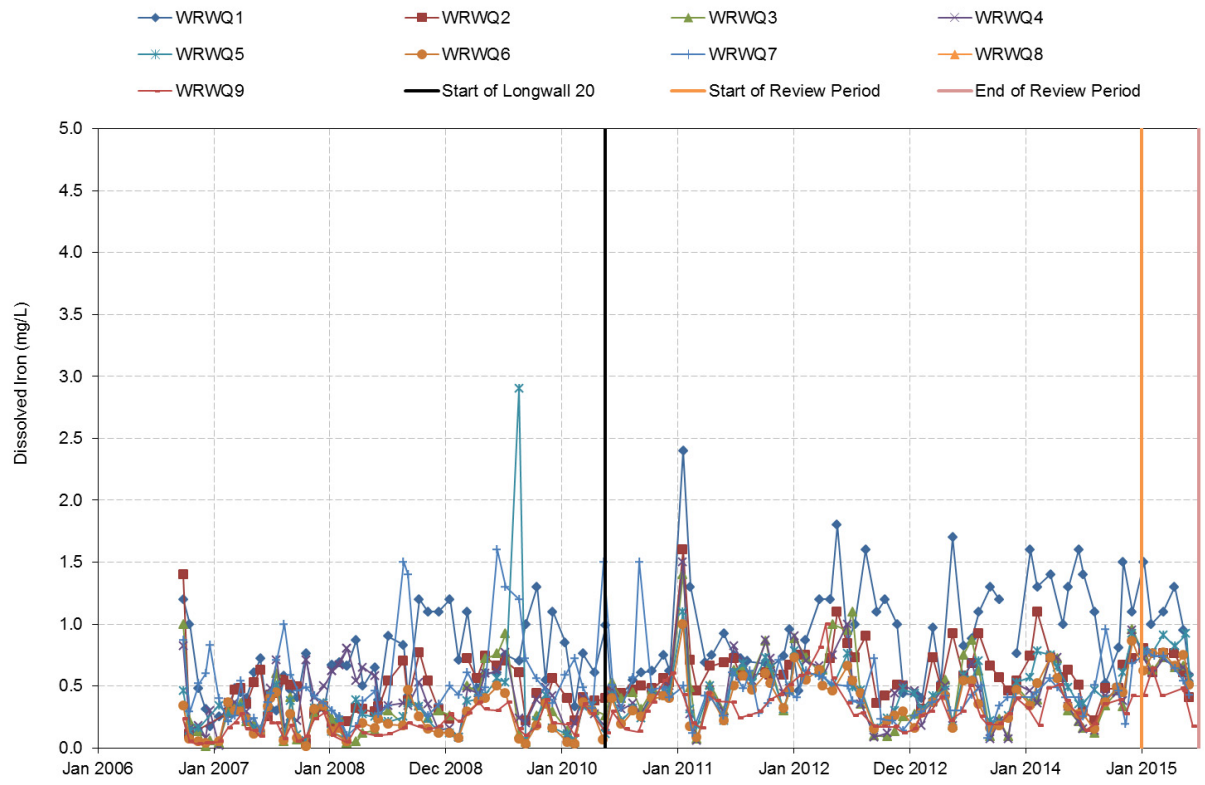


Chart B3 Dissolved Iron Concentrations Waratah Rivulet

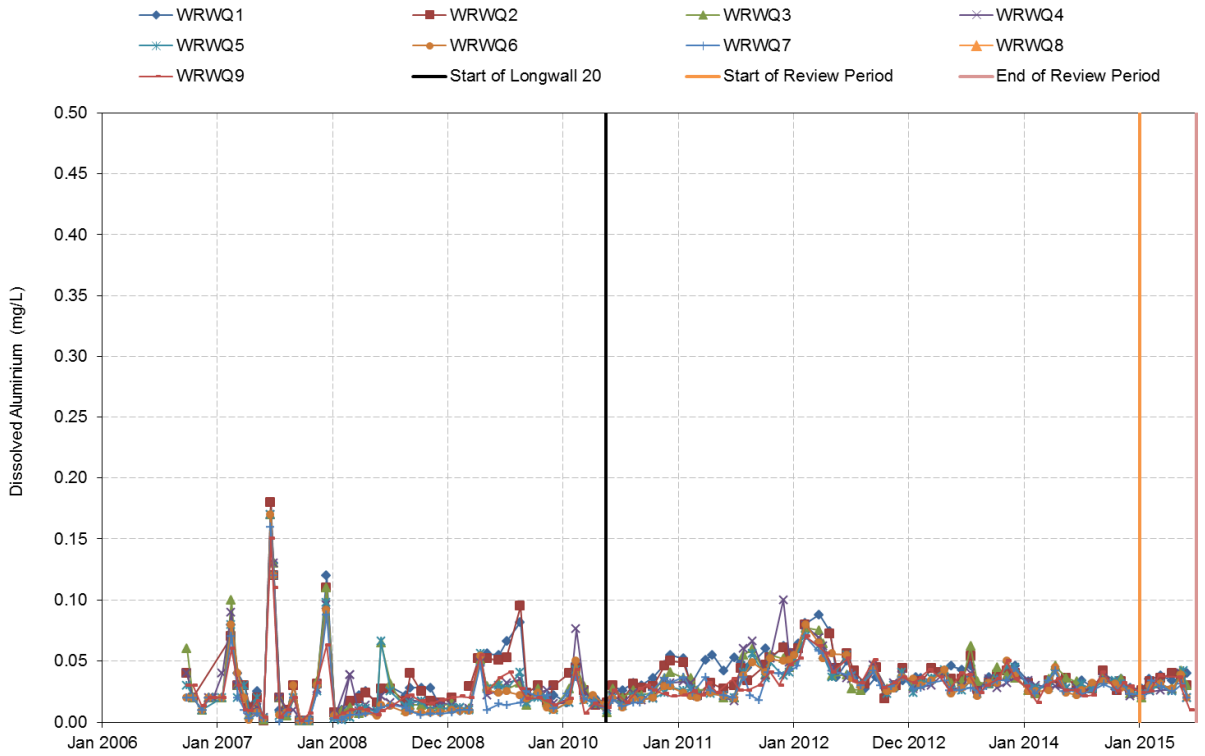


Chart B4 Dissolved Aluminium Concentrations Waratah Rivulet

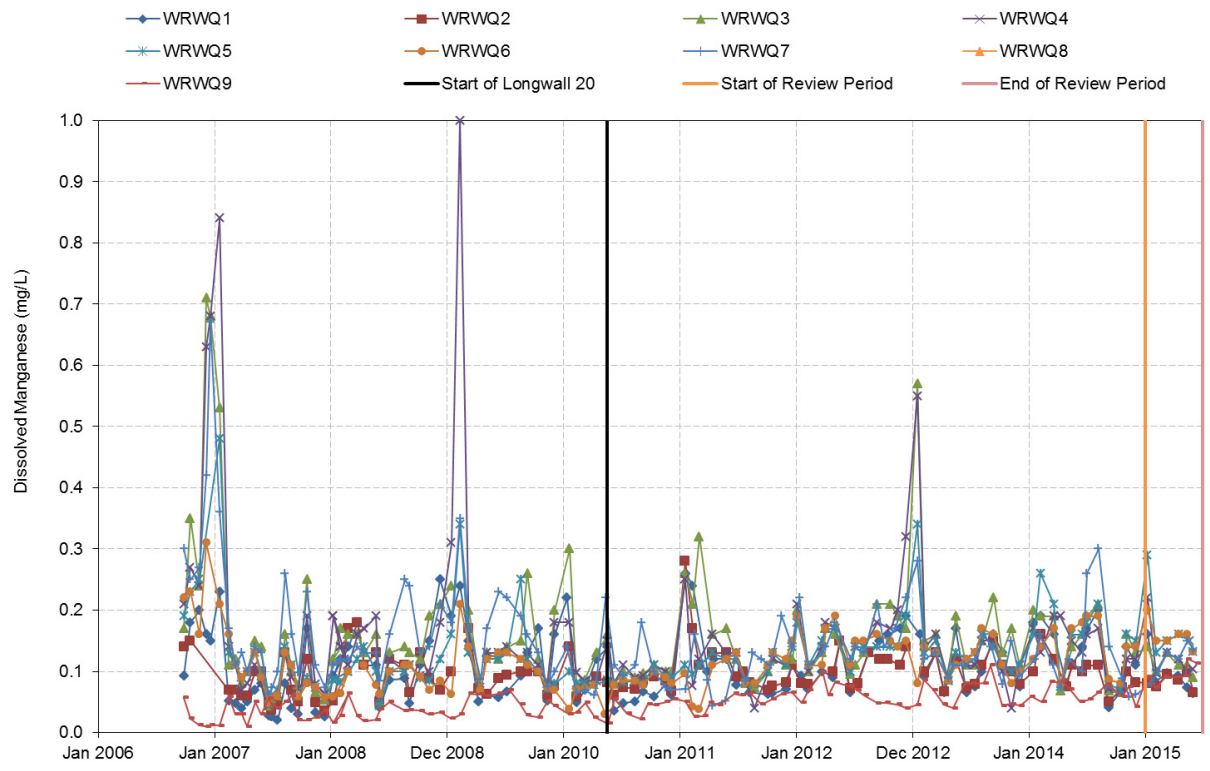


Chart B5 Dissolved Manganese Concentrations Waratah Rivulet

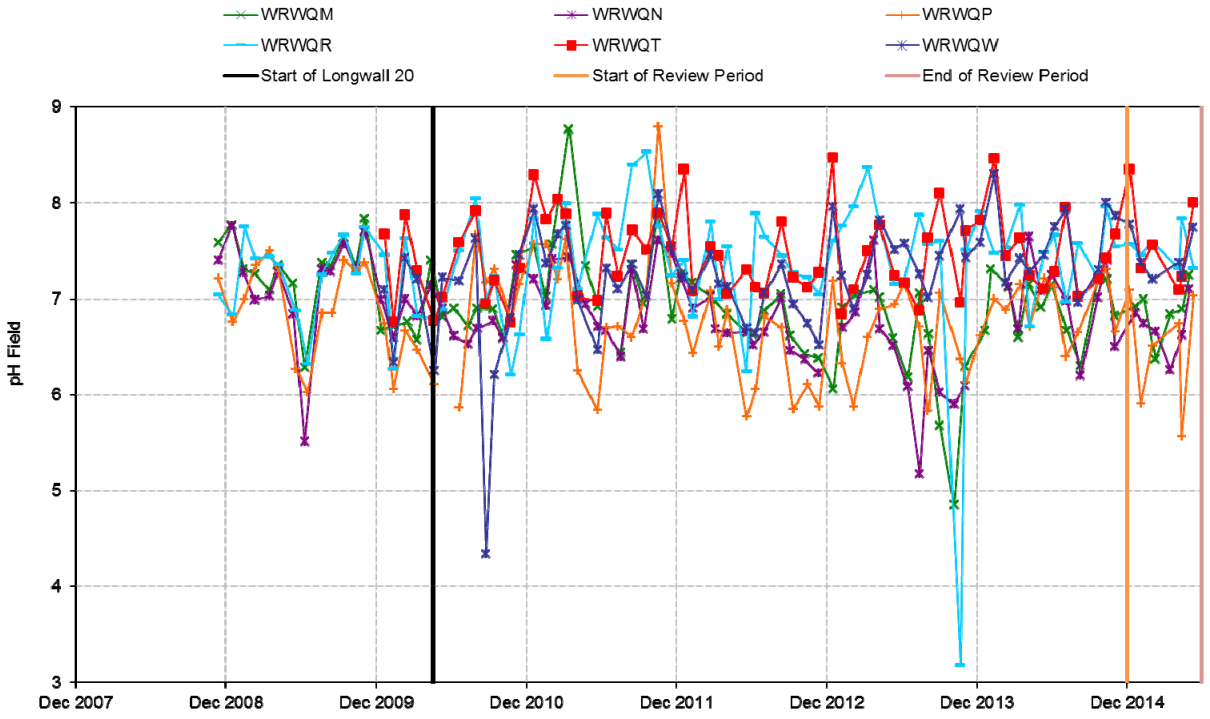


Chart B6 pH Levels Waratah Rivulet Pools

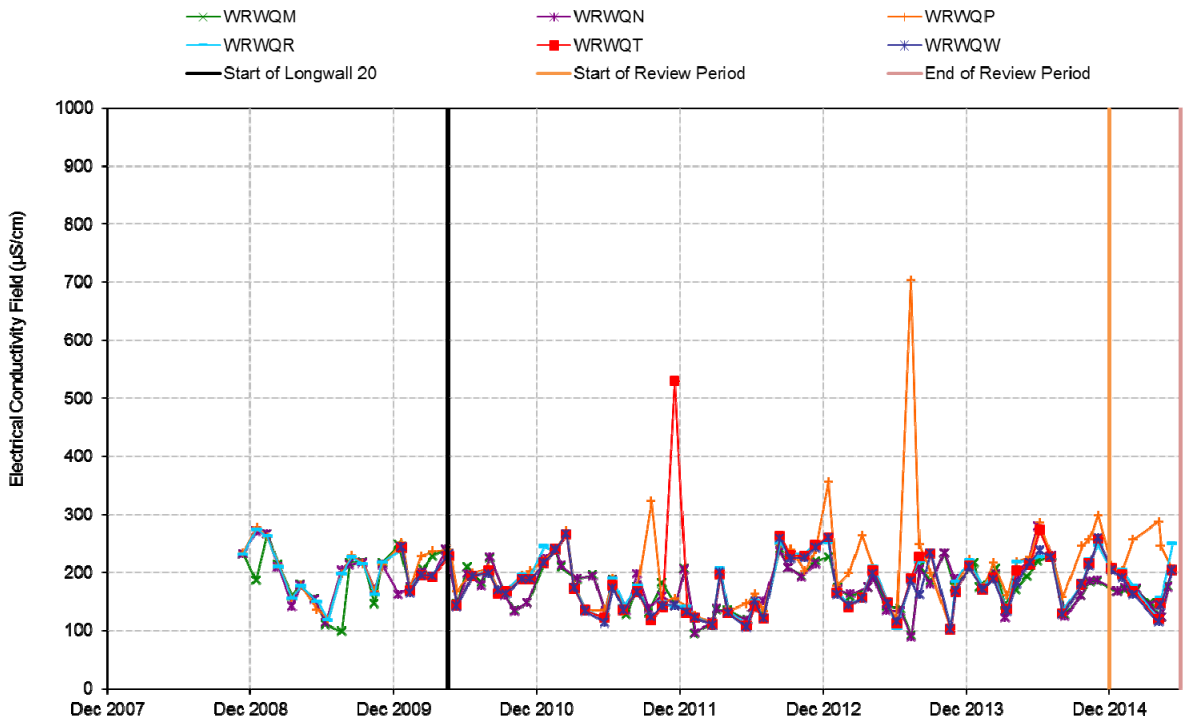


Chart B7 Electrical Conductivity (EC) Waratah Rivulet Pools

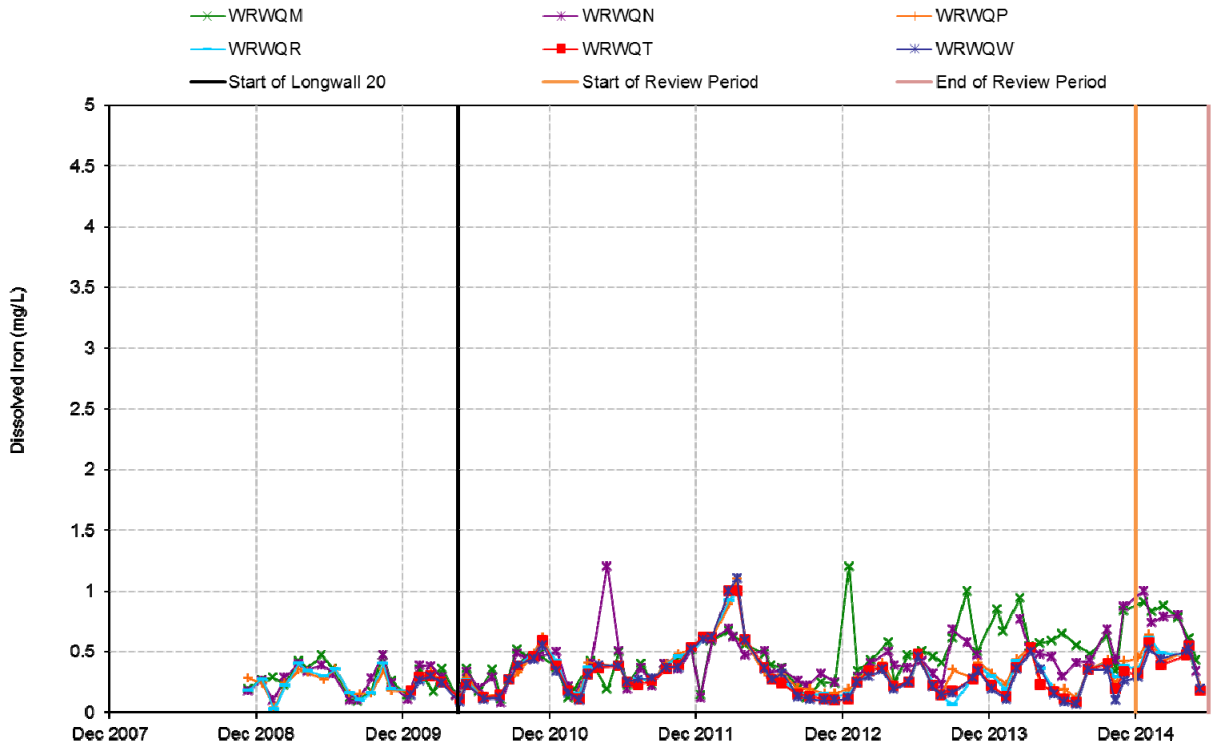


Chart B8 Dissolved Iron Concentrations Waratah Rivulet Pools

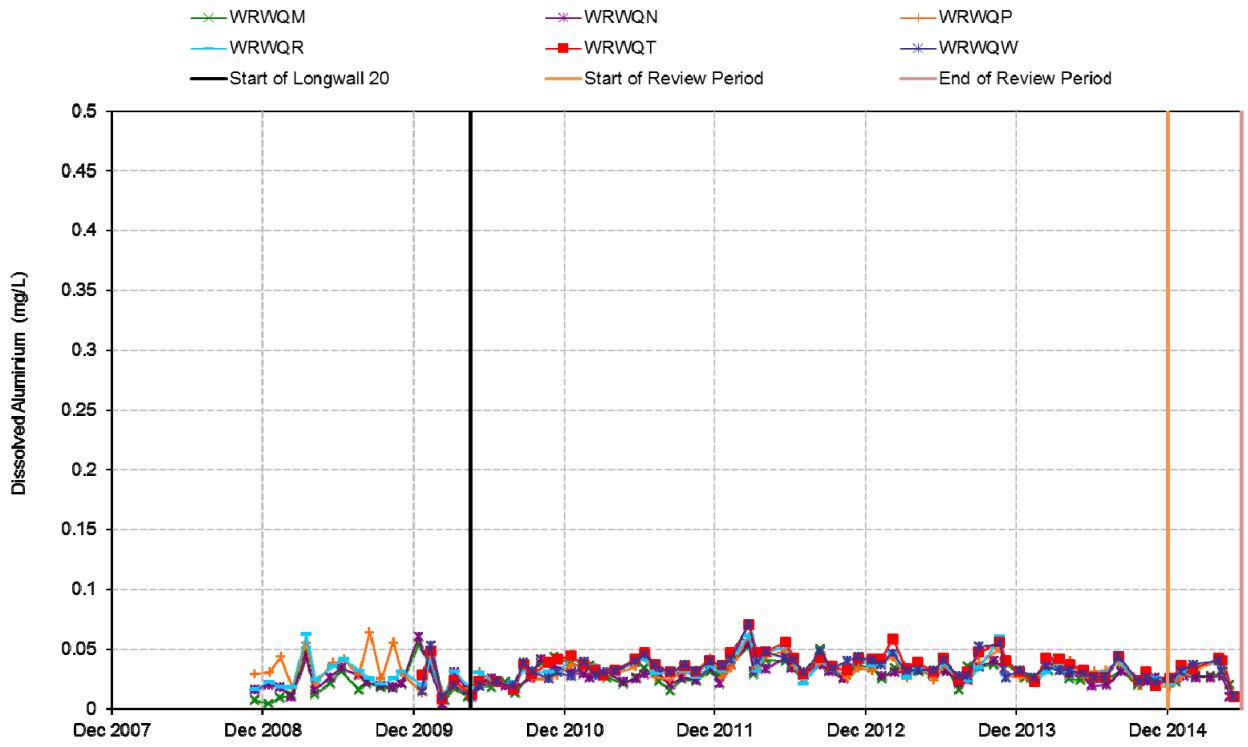


Chart B9 Dissolved Aluminium Concentrations Waratah Rivulet Pools

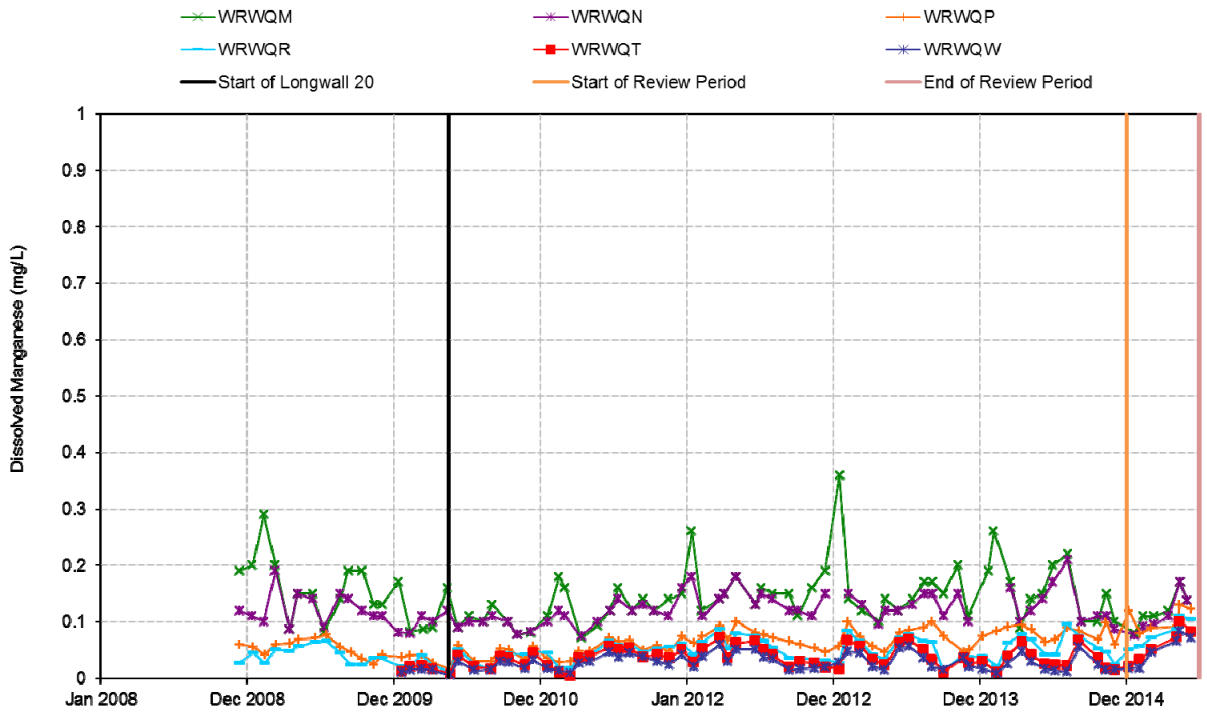


Chart B10 Dissolved Manganese Concentrations Waratah Rivulet Pools

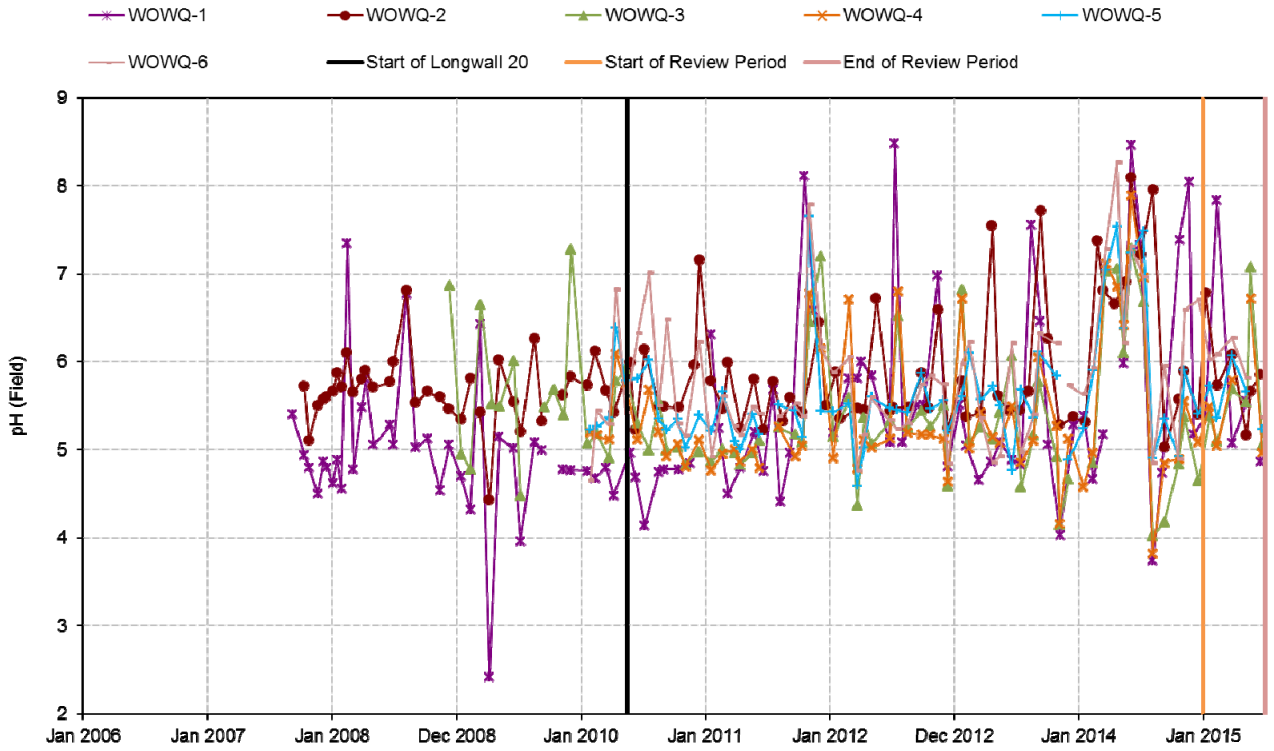


Chart B11 pH Levels Woronora River

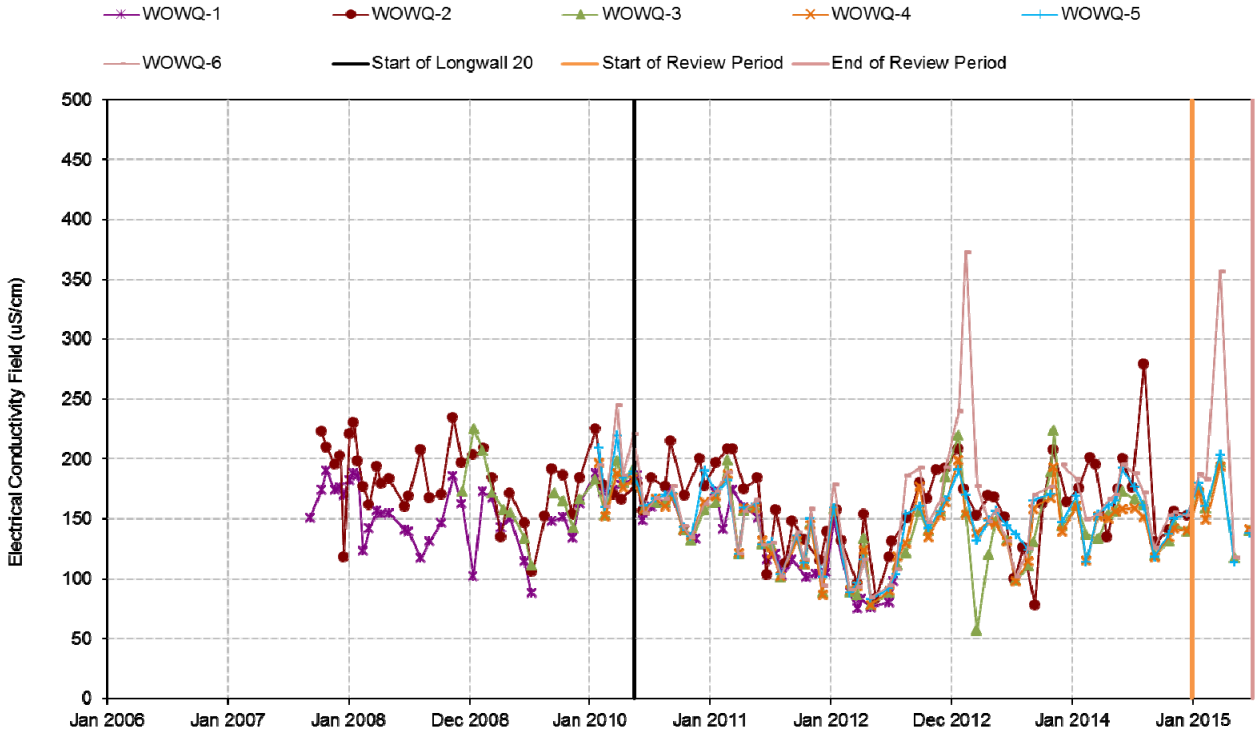


Chart B12 Electrical Conductivity (EC) Woronora River

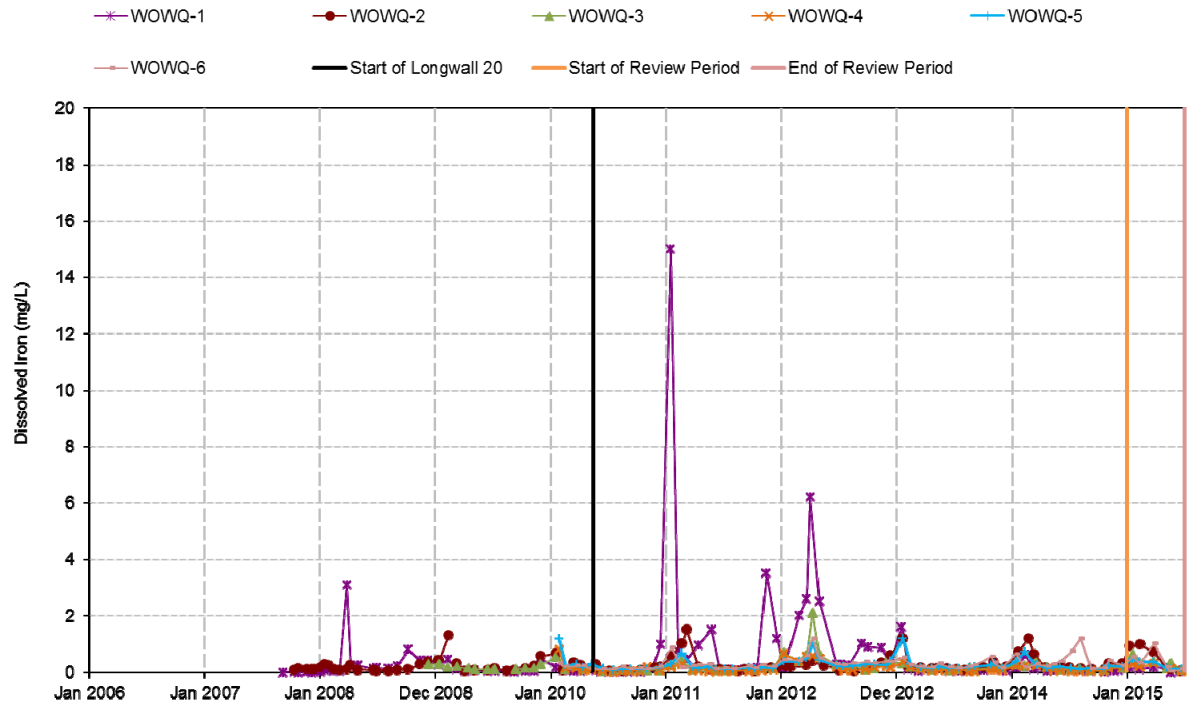


Chart B13 Dissolved Iron Concentrations Woronora River

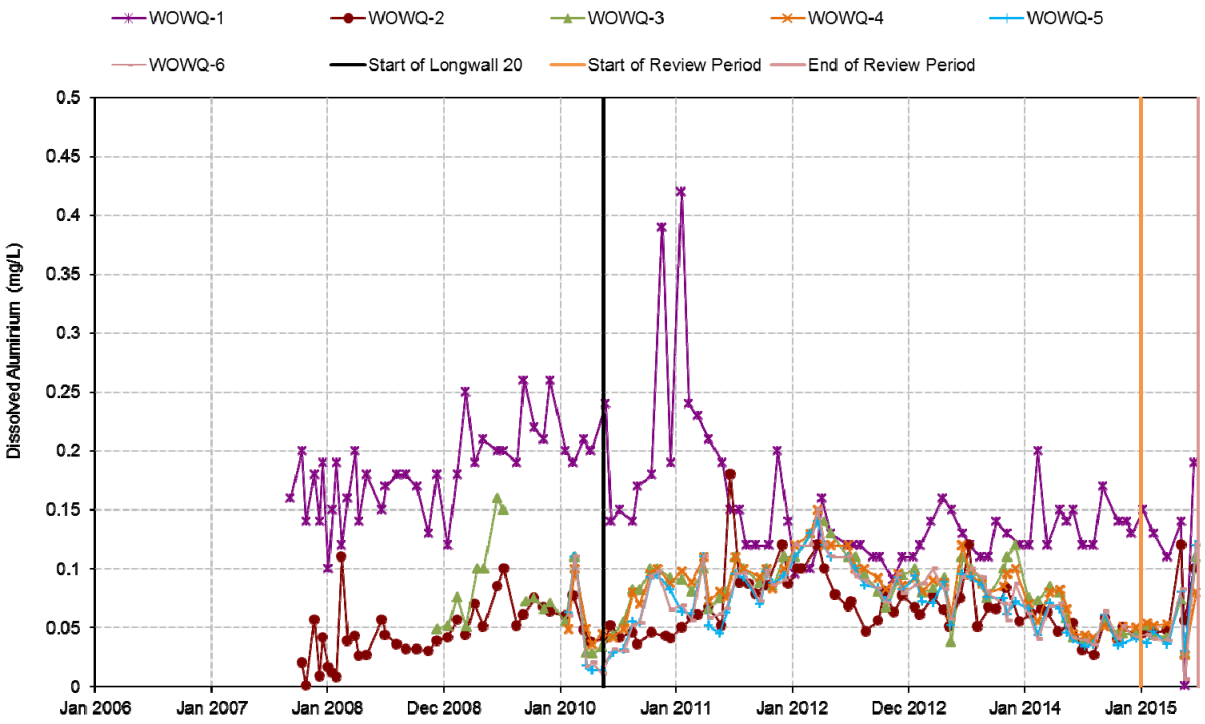


Chart B14 Dissolved Aluninium Concentrations Woronora River

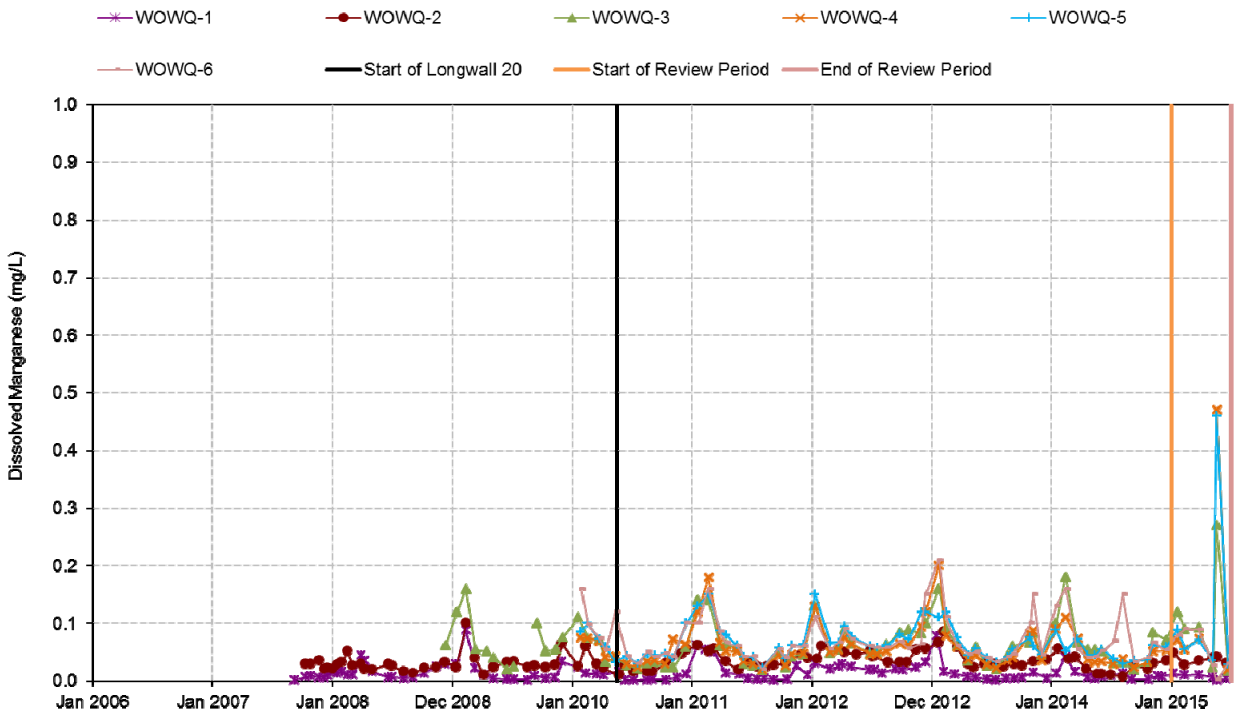


Chart B15 Dissolved Manganese Concentrations Woronora River

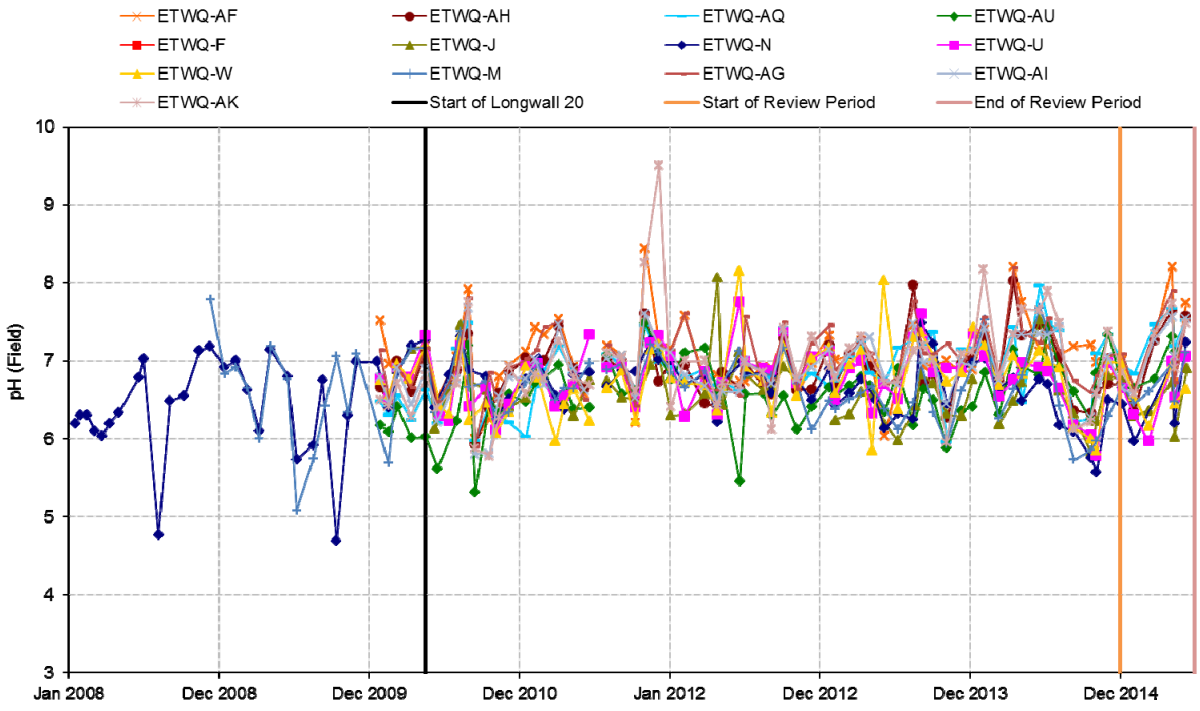


Chart B16 pH Levels Eastern Tributary

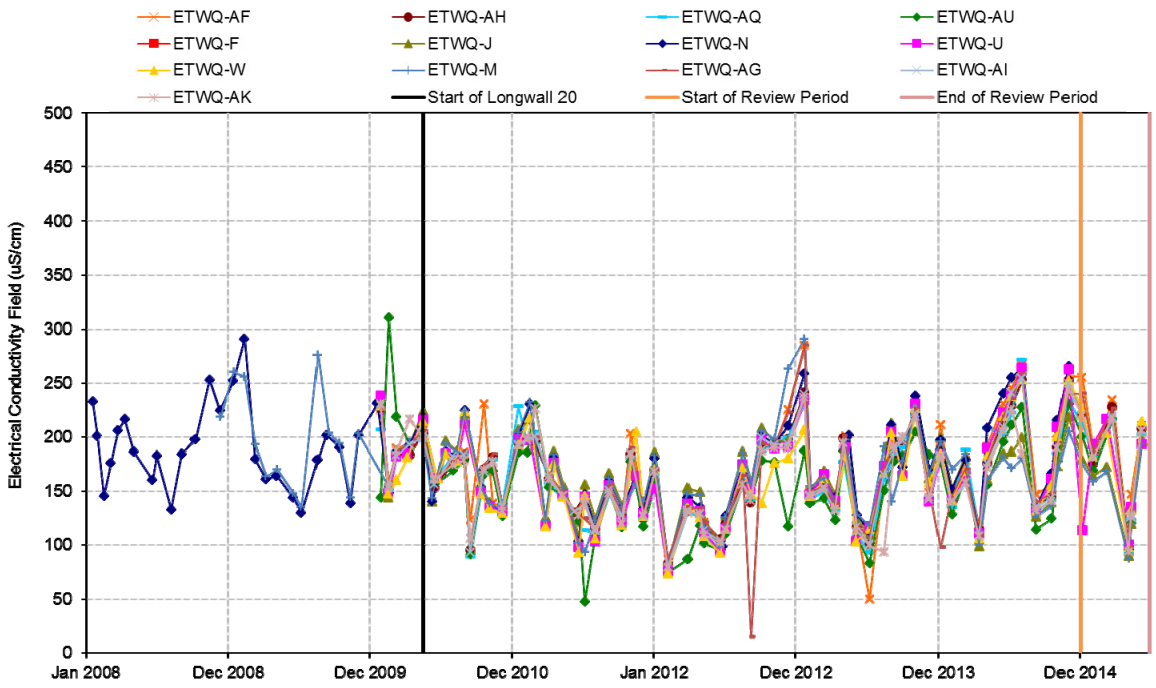


Chart B17 Electrical Conductivity (EC) Eastern Tributary

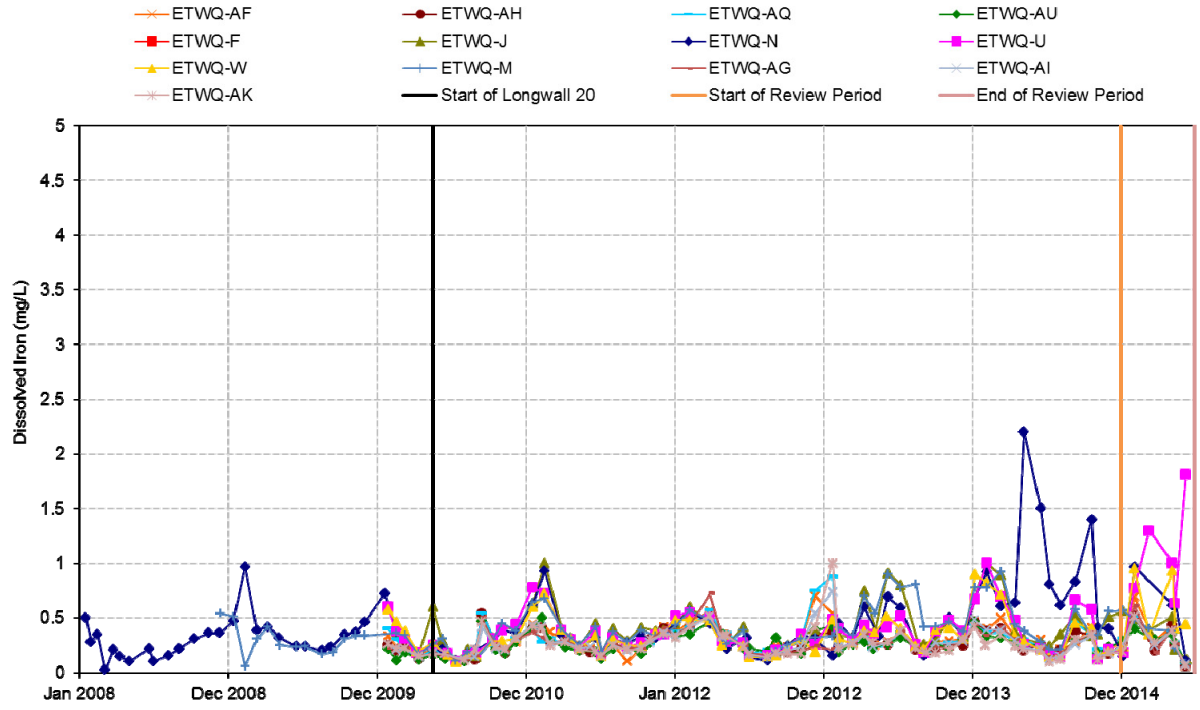


Chart B18 Dissolved Iron Concentrations Eastern Tributary

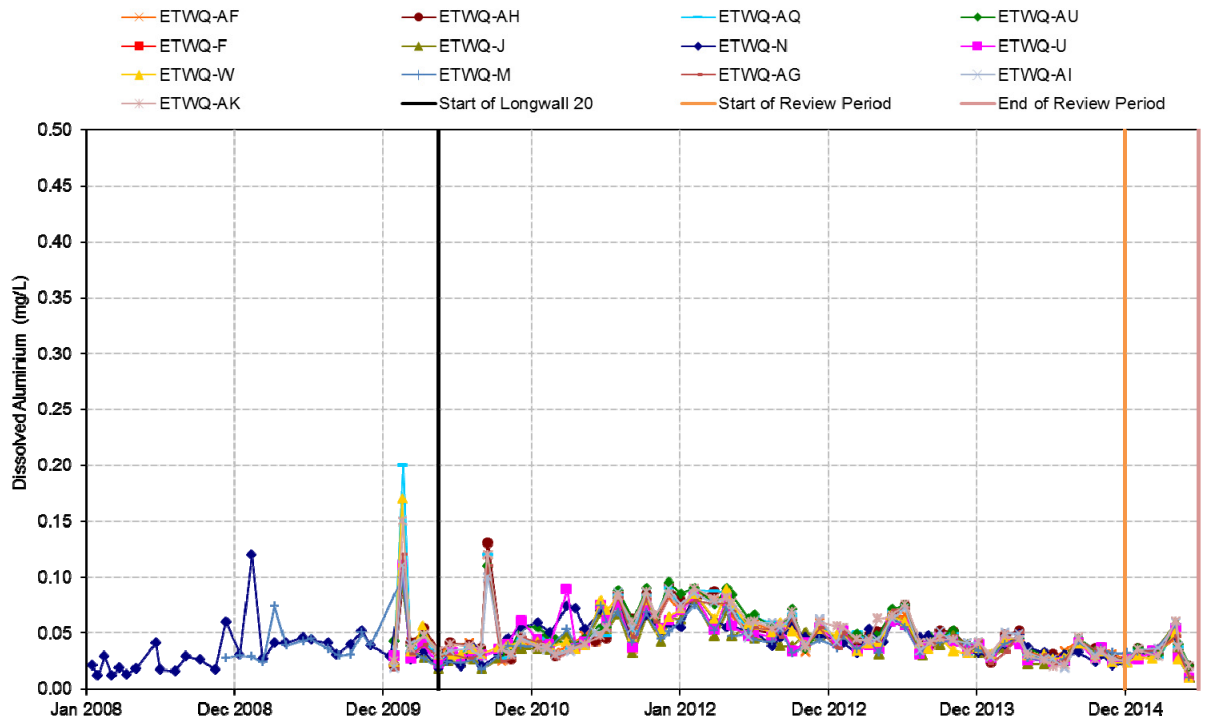


Chart B19 Dissolved Aluminium Concentrations Eastern Tributary

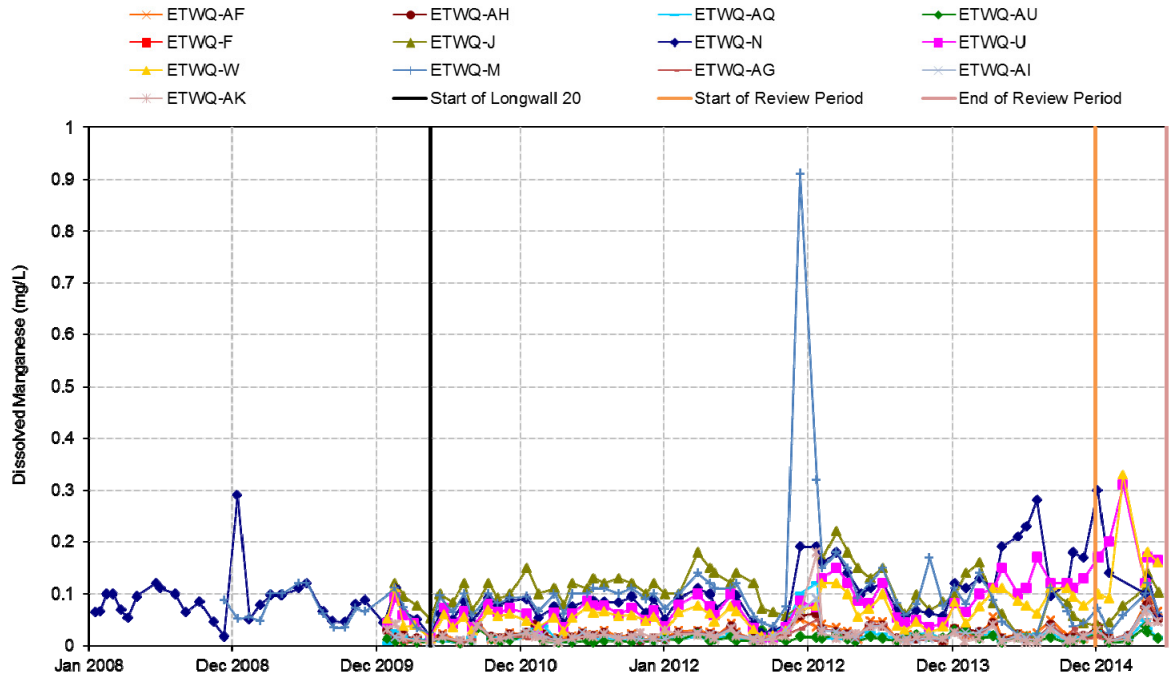


Chart B20 Dissolved Manganese Concentrations Eastern Tributary

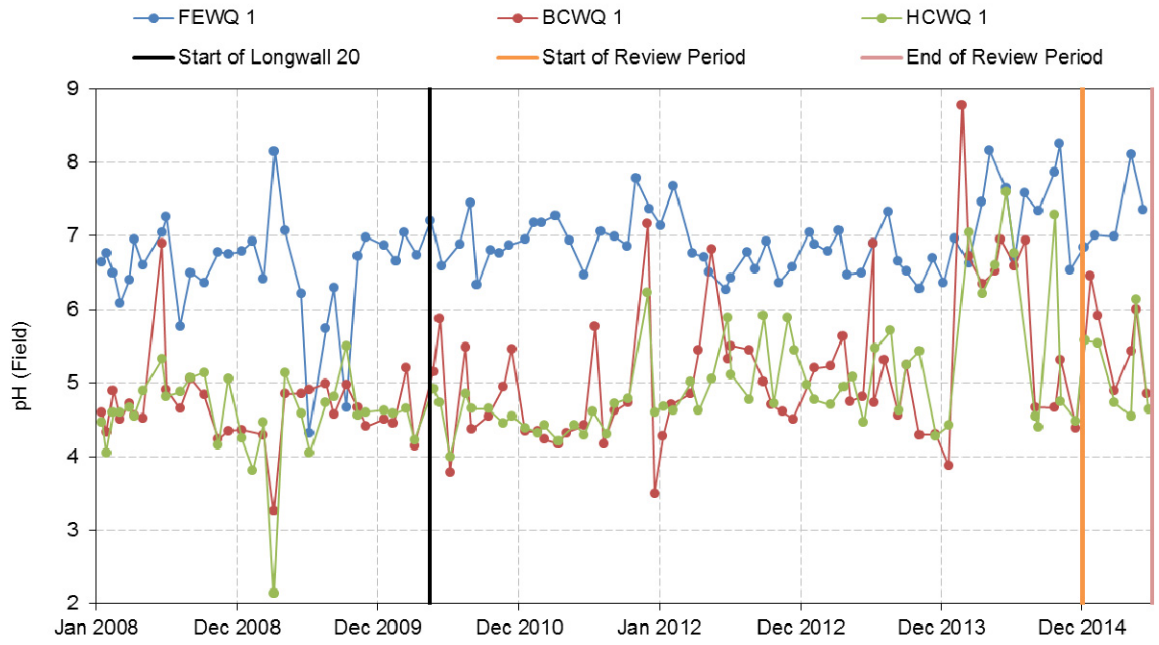


Chart B21 pH Levels Far Eastern Tributary, Bee Creek and Honeysuckle Creek

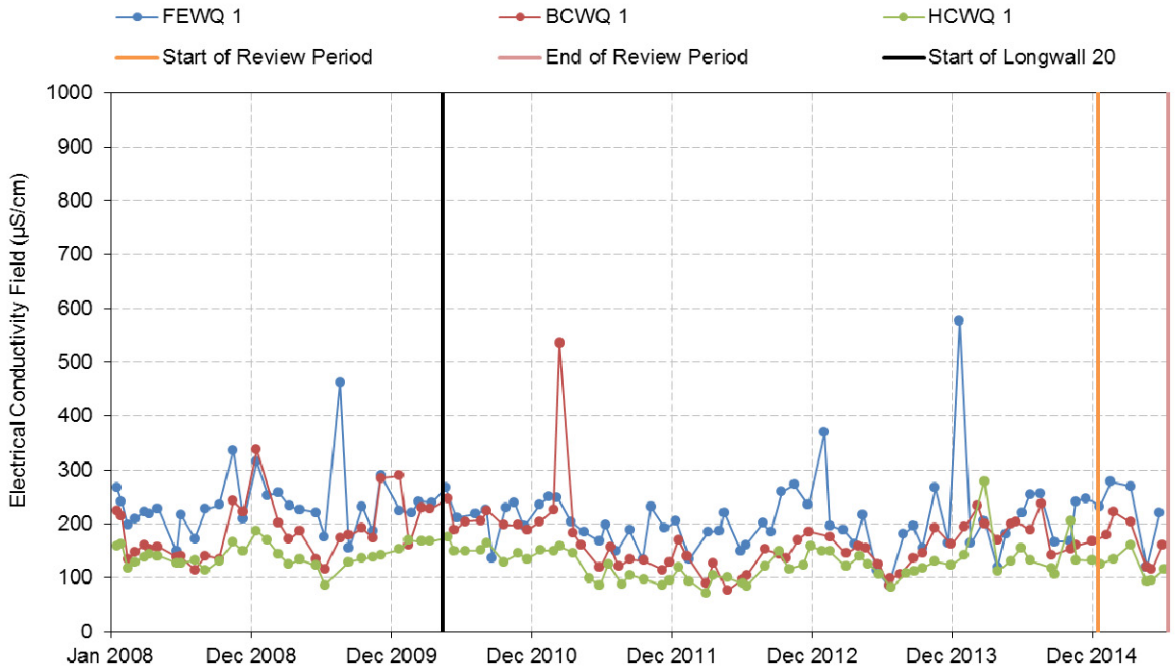


Chart B22 Electrical Conductivity (EC) Far Eastern Tributary, Bee Creek and Honeysuckle Creek

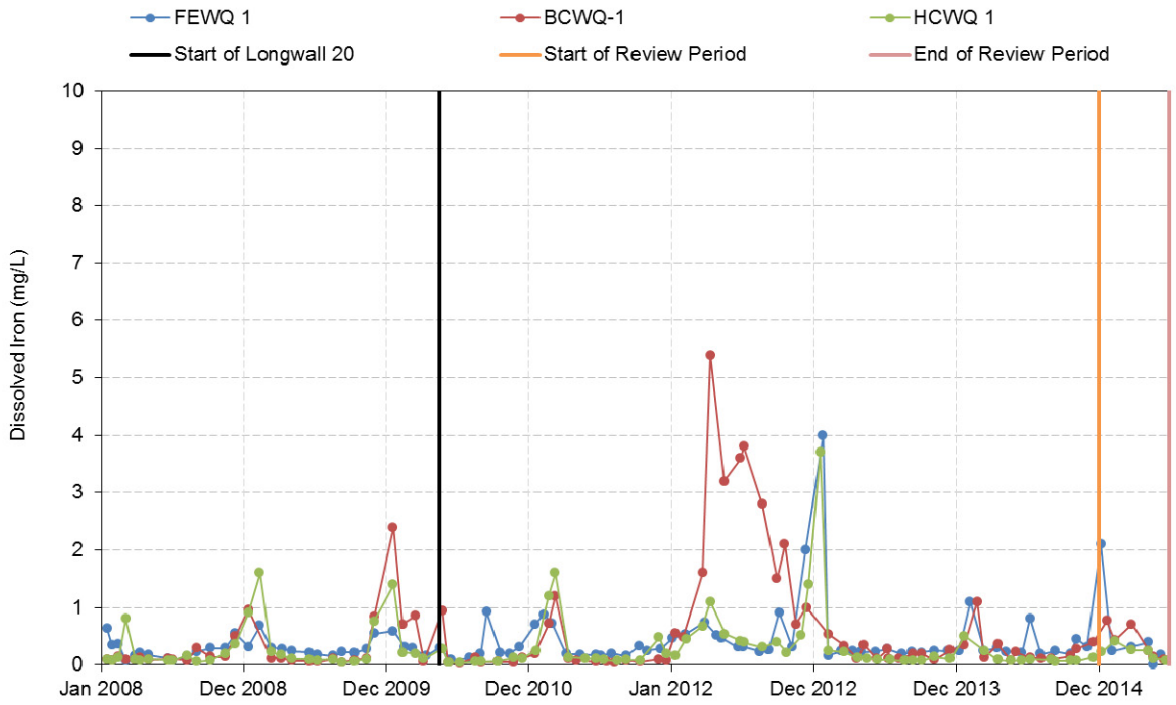


Chart B23 Dissolved Iron Concentrations Far Eastern Tributary, Bee Creek and Honeysuckle Creek

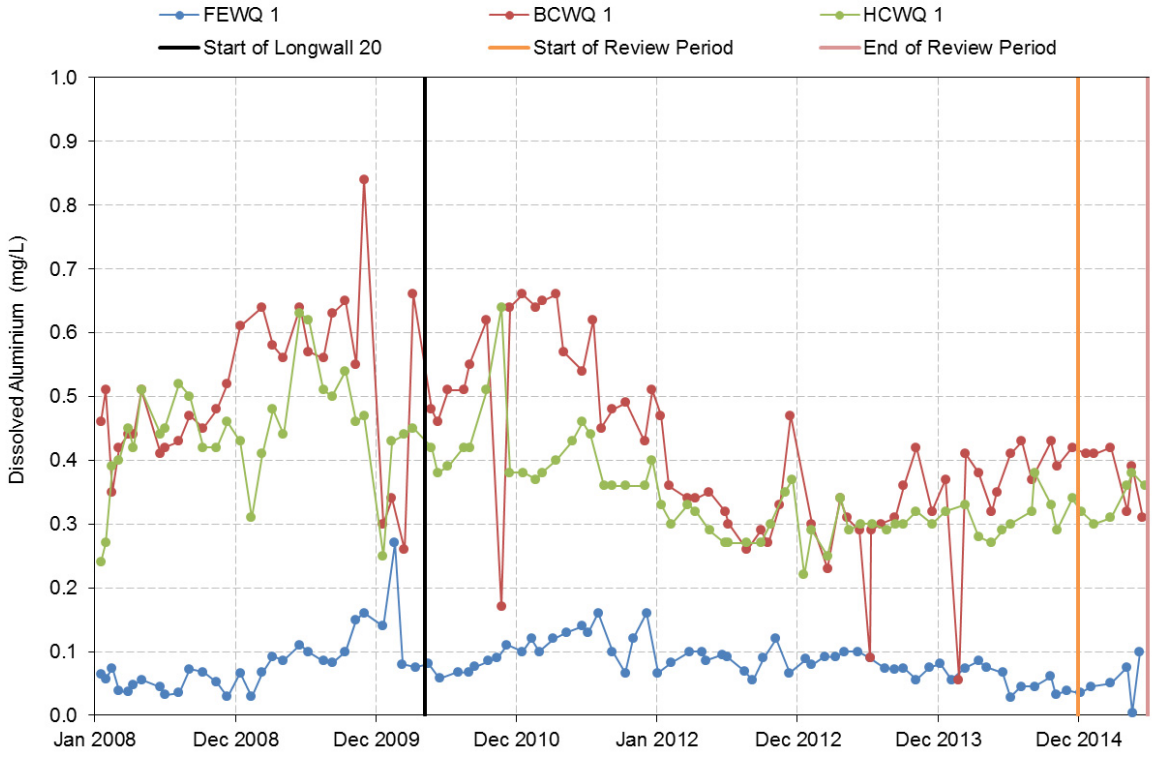


Chart B24 Dissolved Aluminium Concentrations Far Eastern Tributary, Bee Creek and Honeysuckle Creek

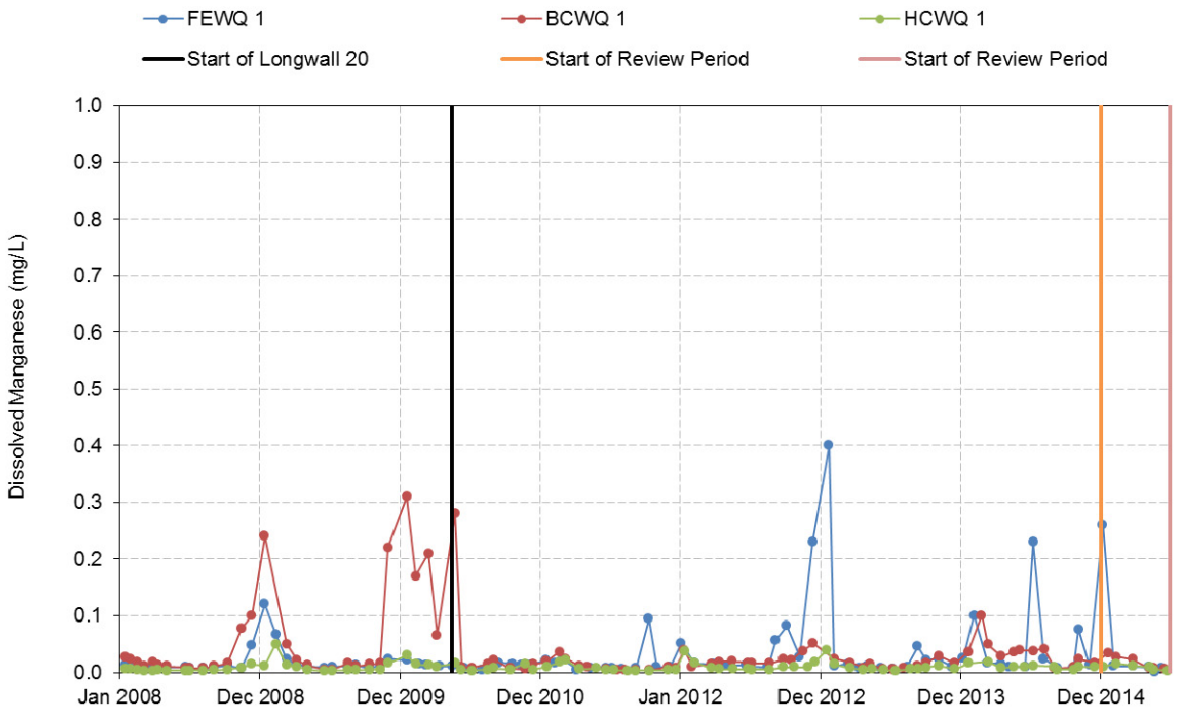


Chart B25 Dissolved Manganese Concentrations Far Eastern Tributary, Bee Creek and Honeysuckle Creek

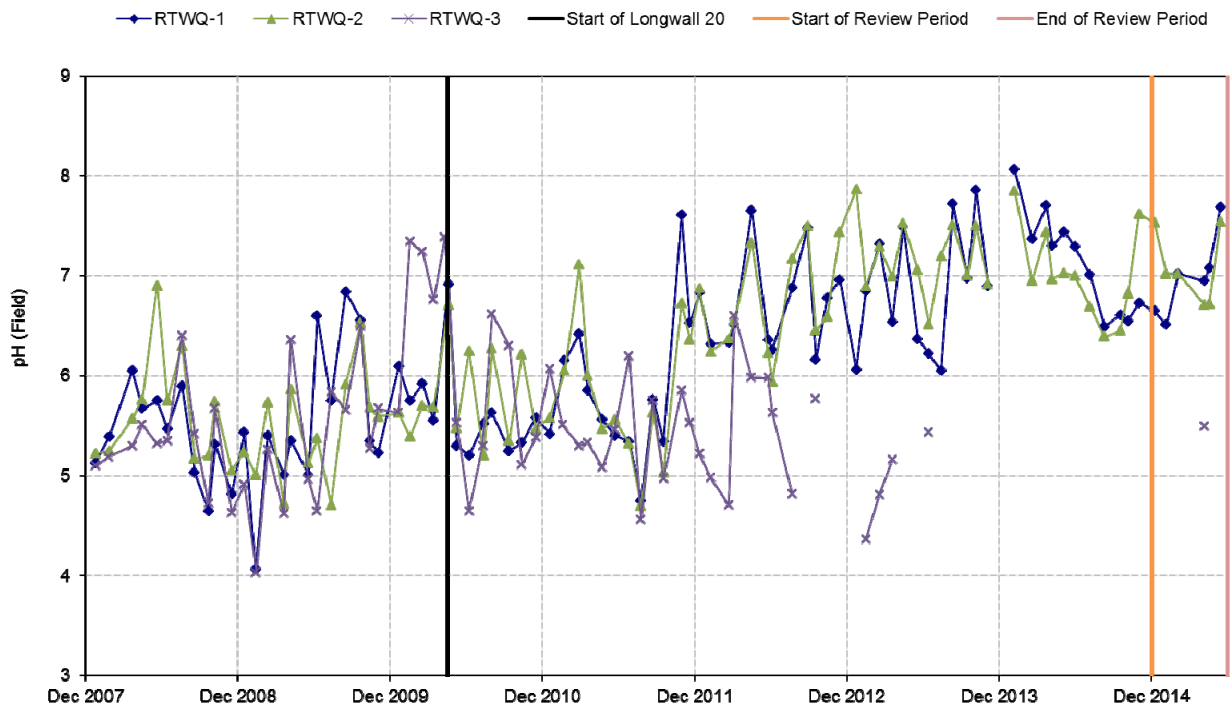


Chart B26 pH Levels Tributary B (Reference Tributary)

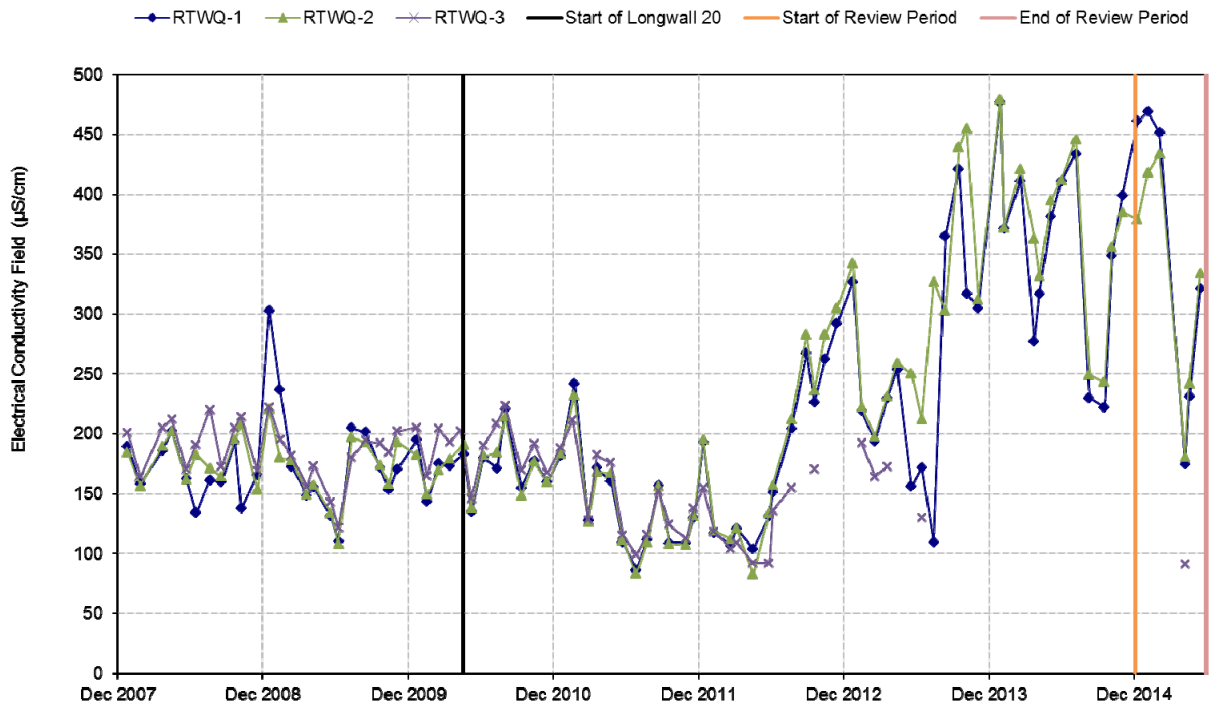


Chart B27 Electrical Conductivity (EC)Tributary B (Reference Tributary)

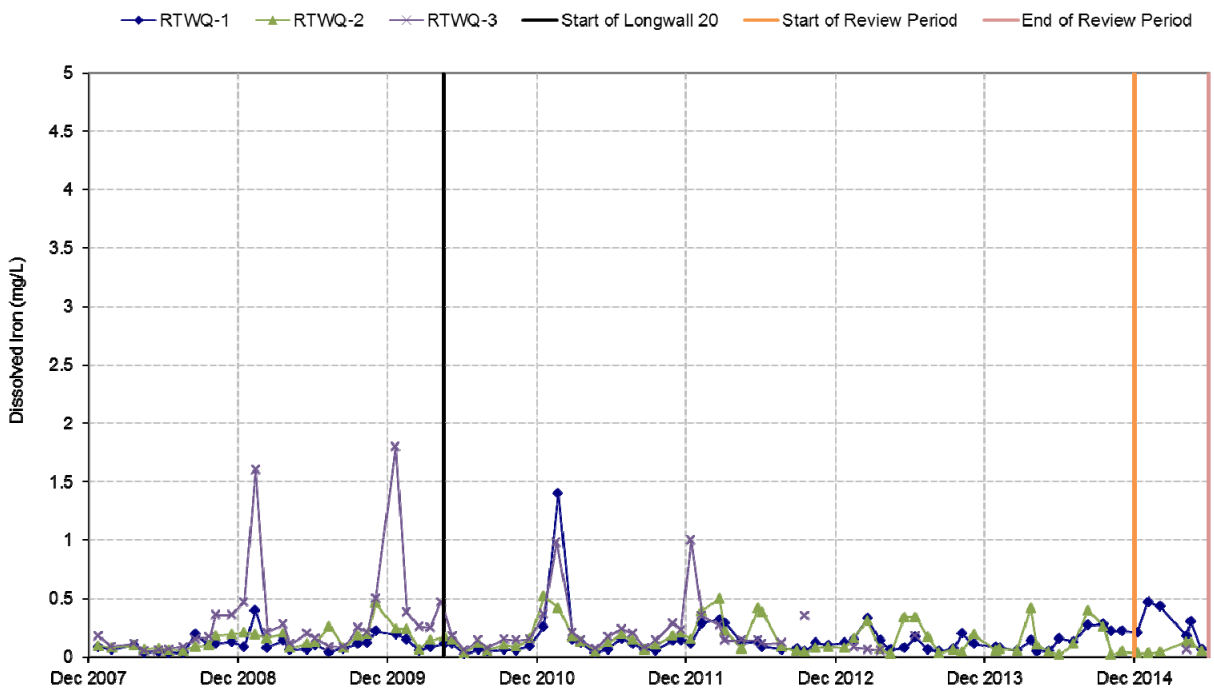


Chart B28 Dissolved Iron Tributary B (Reference Tributary)

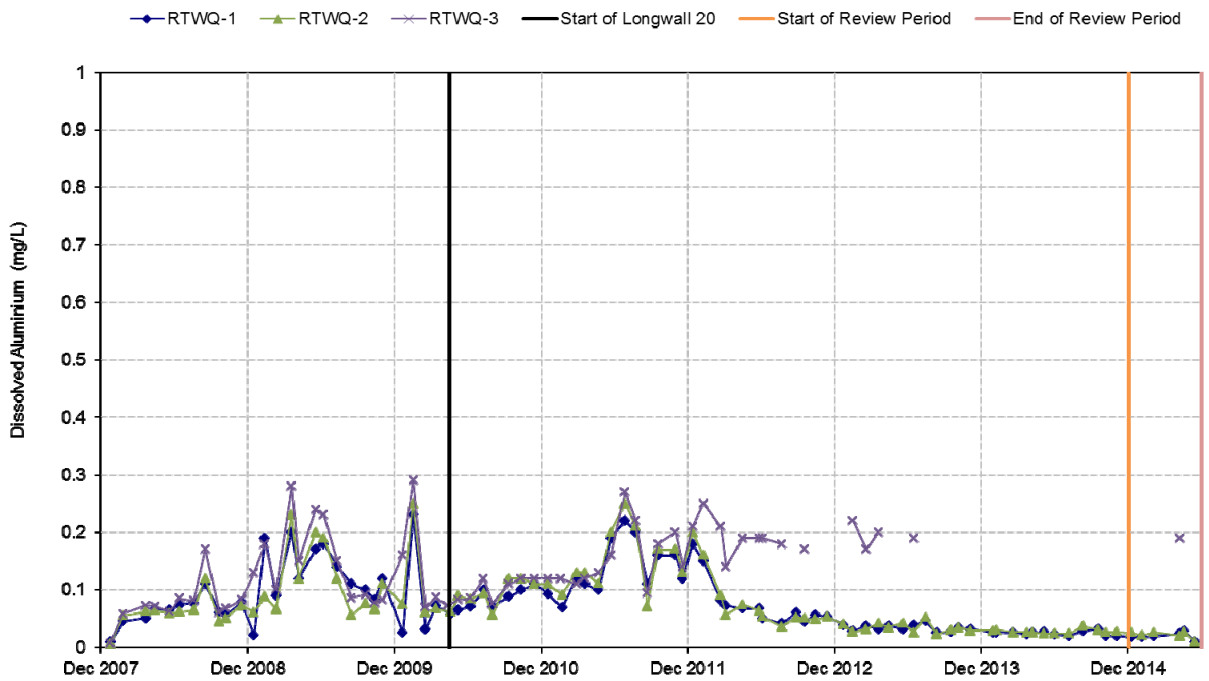


Chart B29 Dissolved Aluminium Tributary B (Reference Tributary)

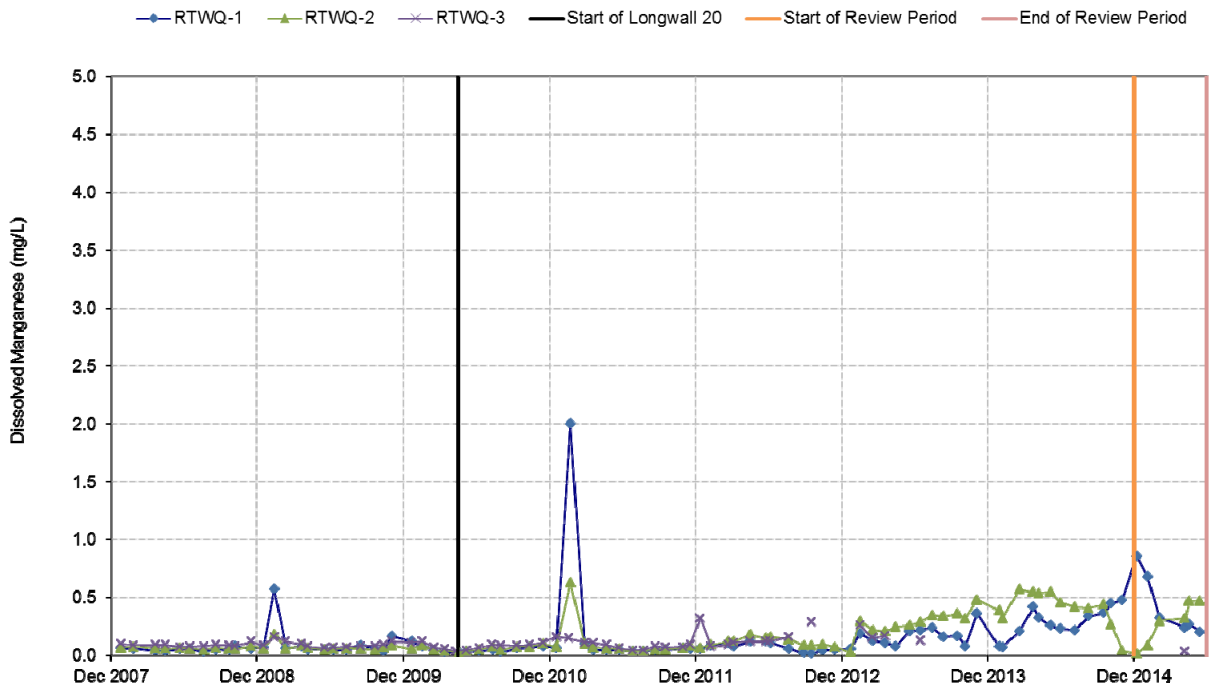


Chart B30 Dissolved Manganese Tributary B (Reference Tributary)

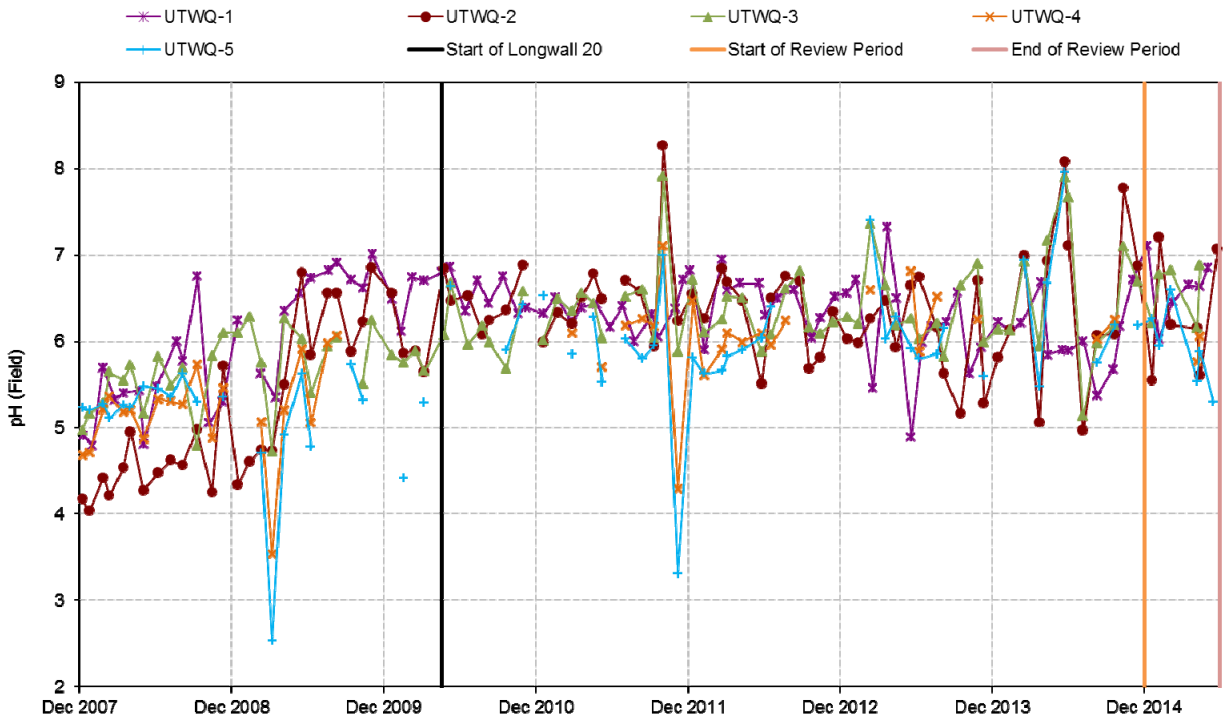


Chart B31 pH Levels Un-named Tributary (Tributary D)

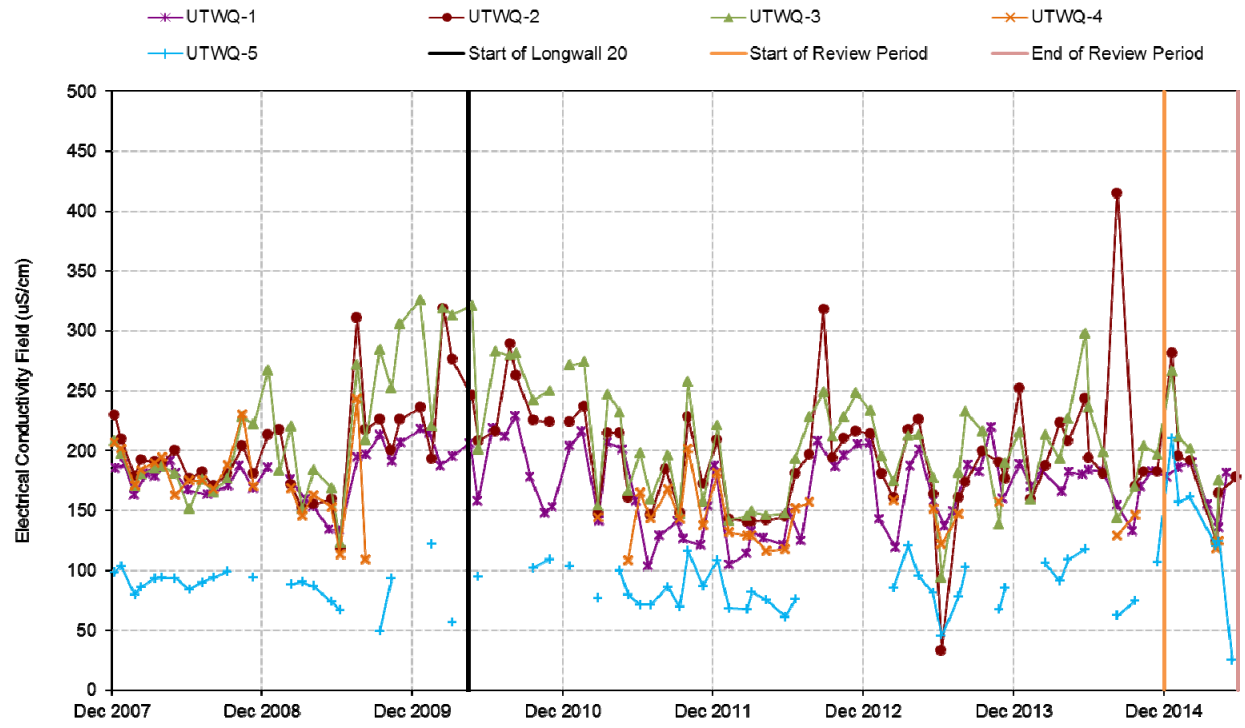


Chart B32 Electrical Conductivity (EC)Tributary D (Un-named Tributary)

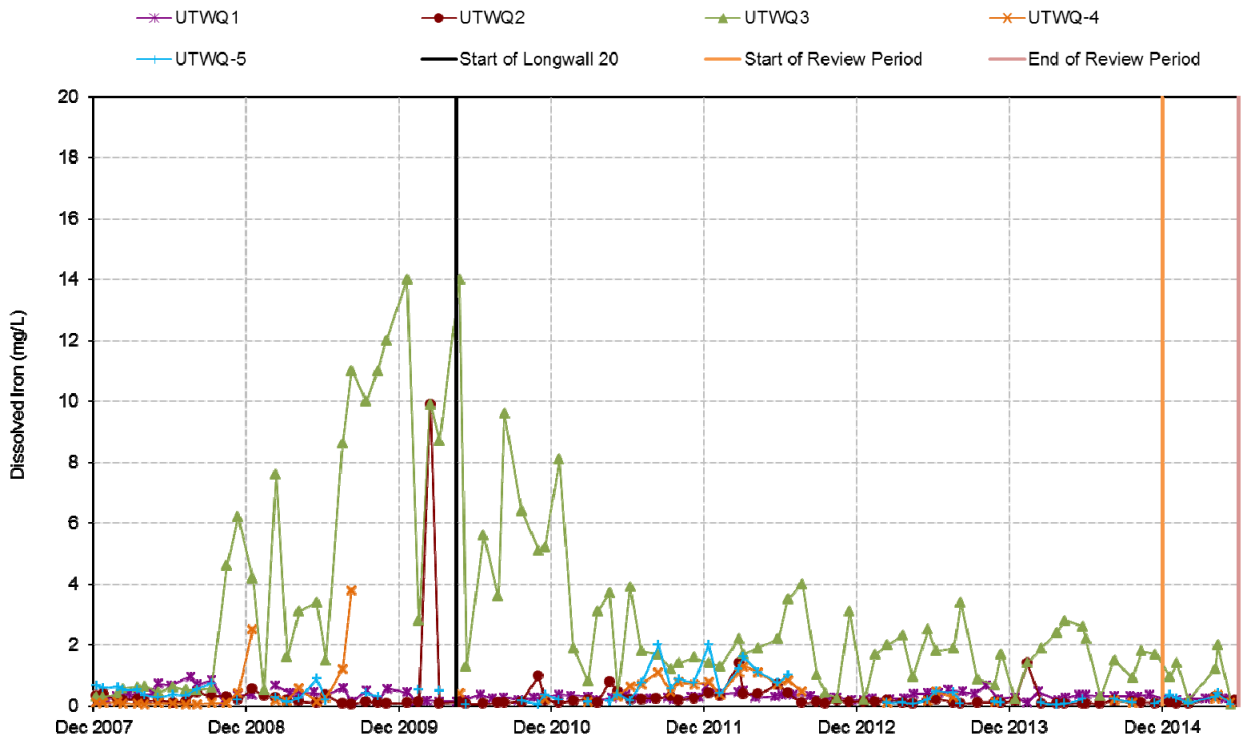


Chart B33 Dissolved Iron Tributary D (Un-named Tributary)

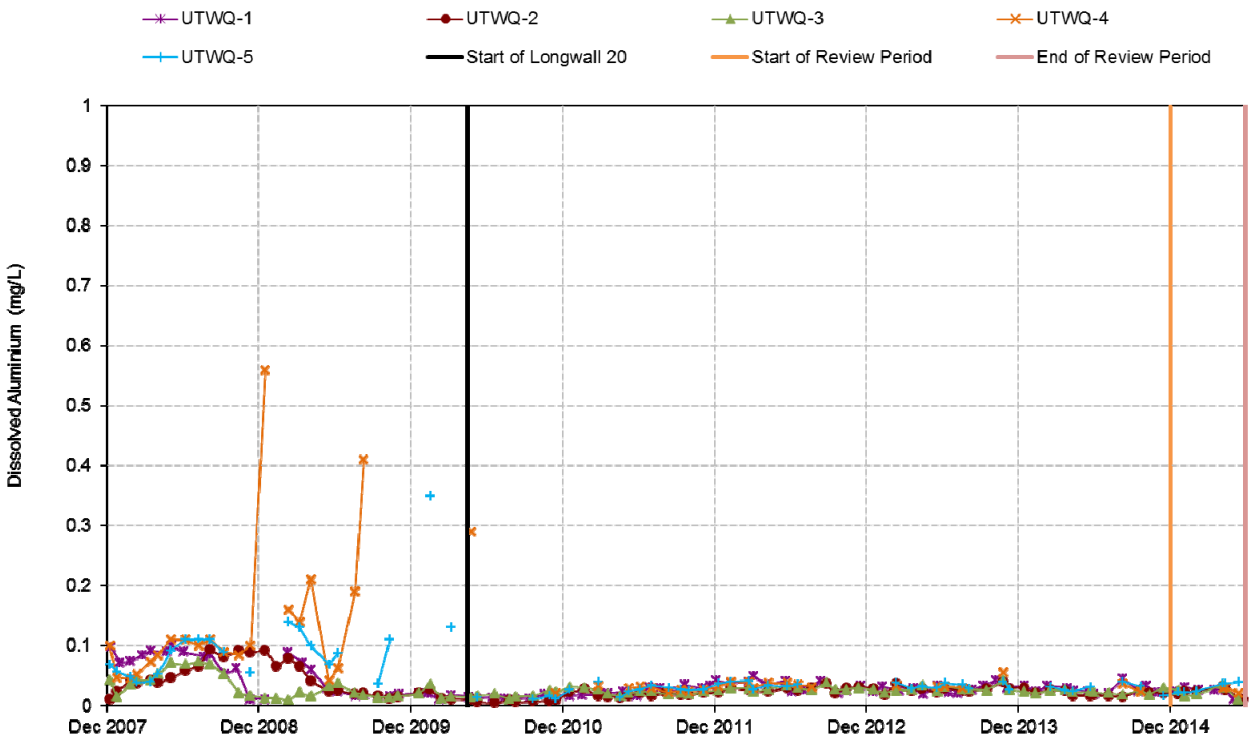


Chart B34 Dissolved Aluminium Tributary D (Un-named Tributary)

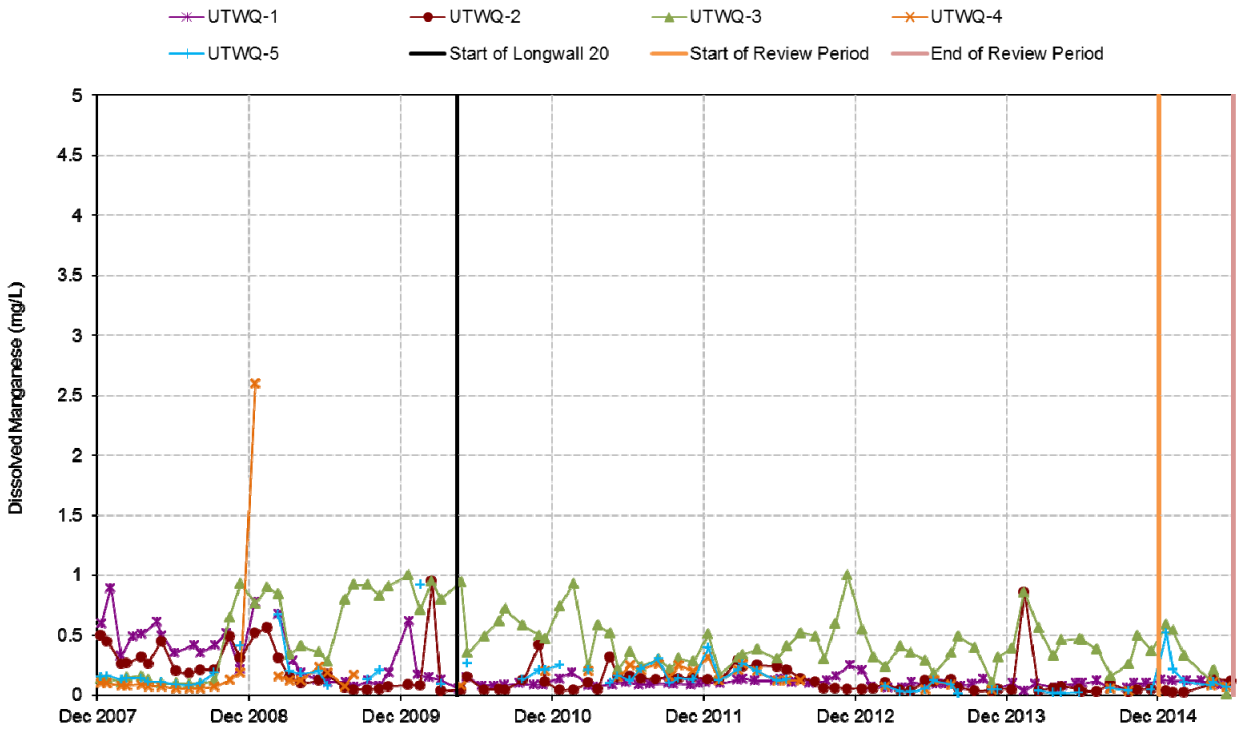


Chart B35 Dissolved Manganese Tributary D (Un-named Tributary)

APPENDIX C

WARATAH RIVULET POOL WATER LEVEL MONITORING RESULTS

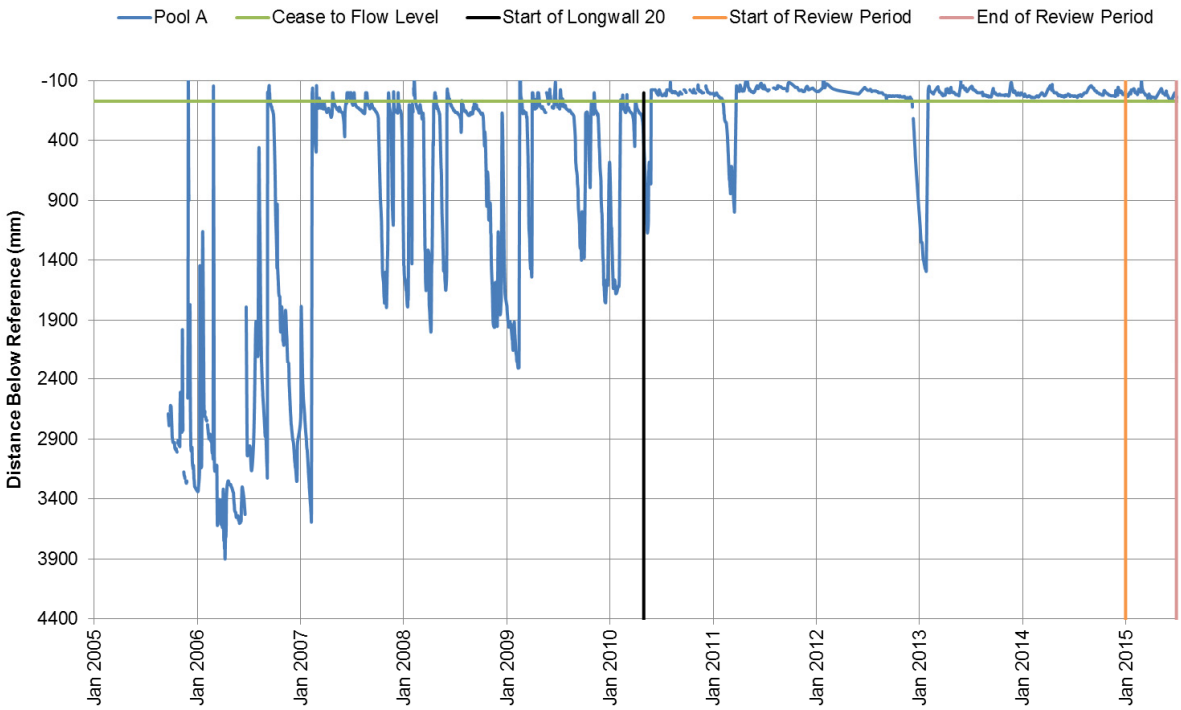


Chart C1 Waratah Rivulet Pool A Water Level Observations Compared with Cease-to-flow Level

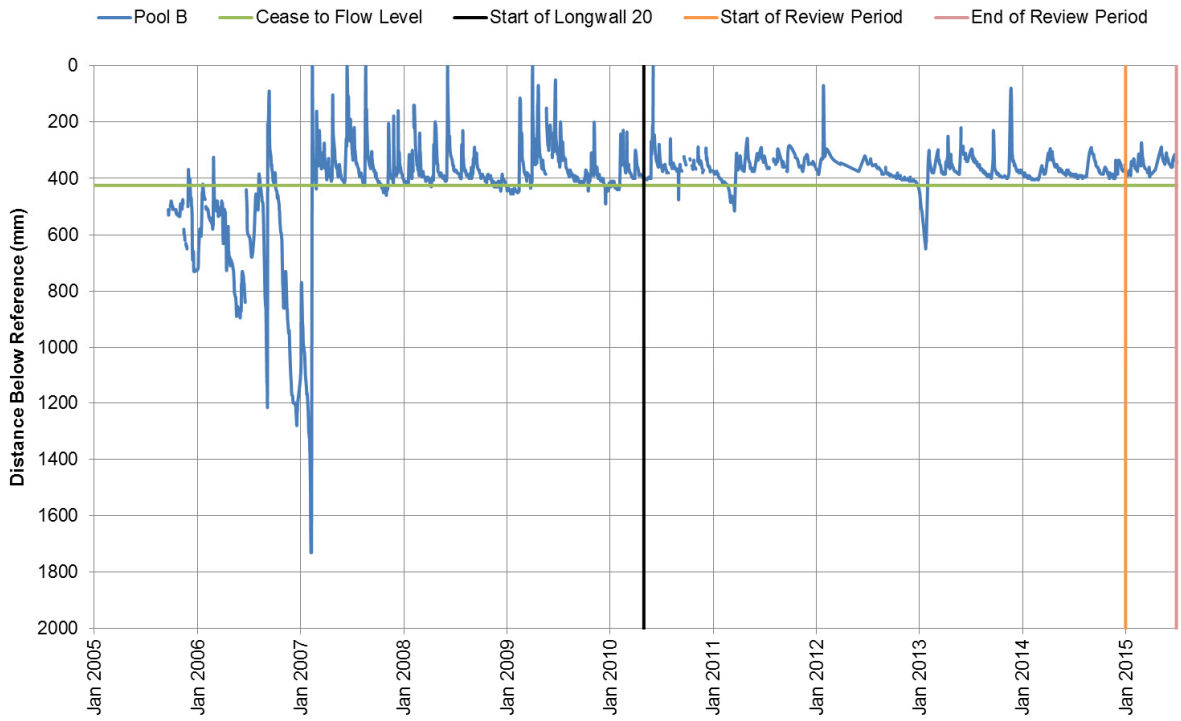


Chart C2 Waratah Rivulet Pool B Water Level Observations Compared with Cease-to-flow Level

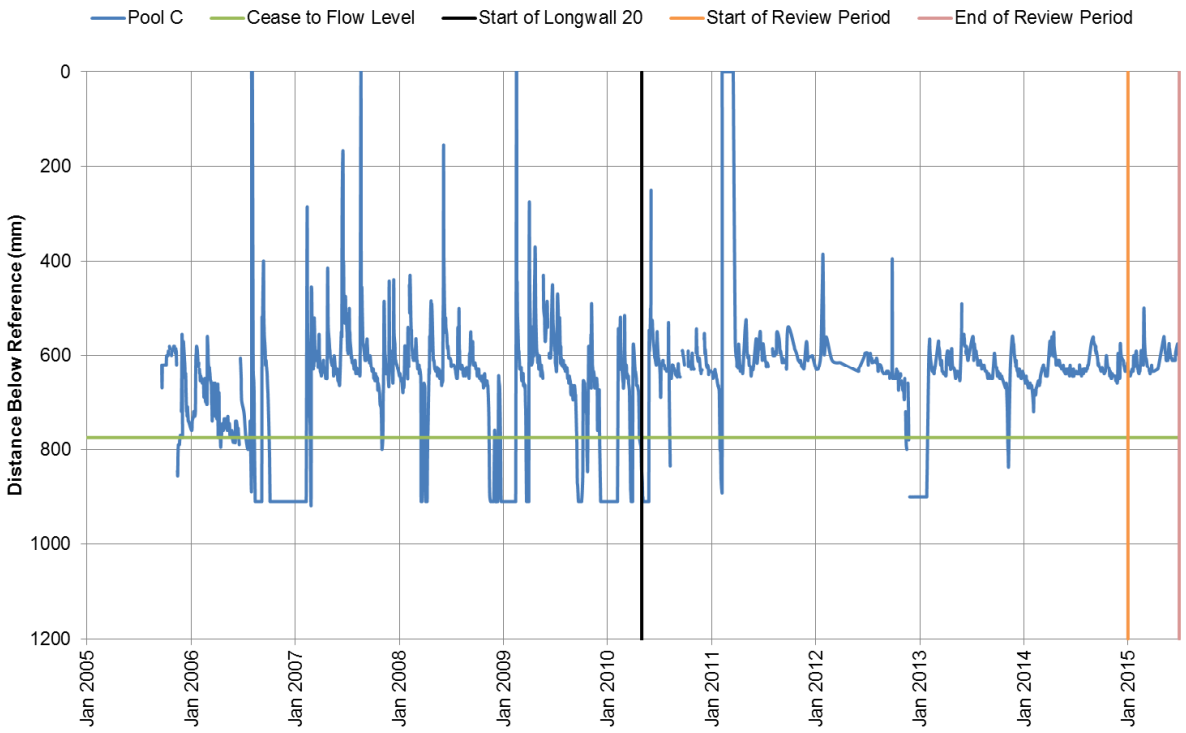


Chart C3 Waratah Rivulet Pool C Water Level Observations Compared with Cease-to-flow Level

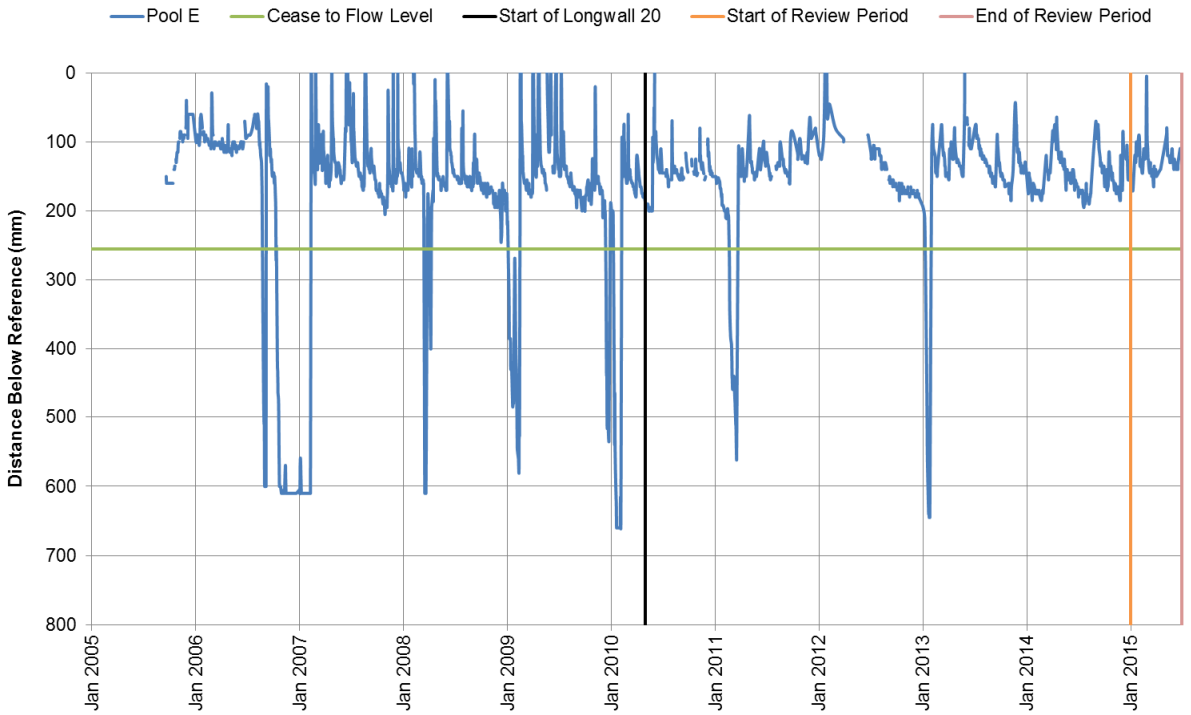


Chart C4 Waratah Rivulet Pool E Water Level Observations Compared with Cease-to-flow Level

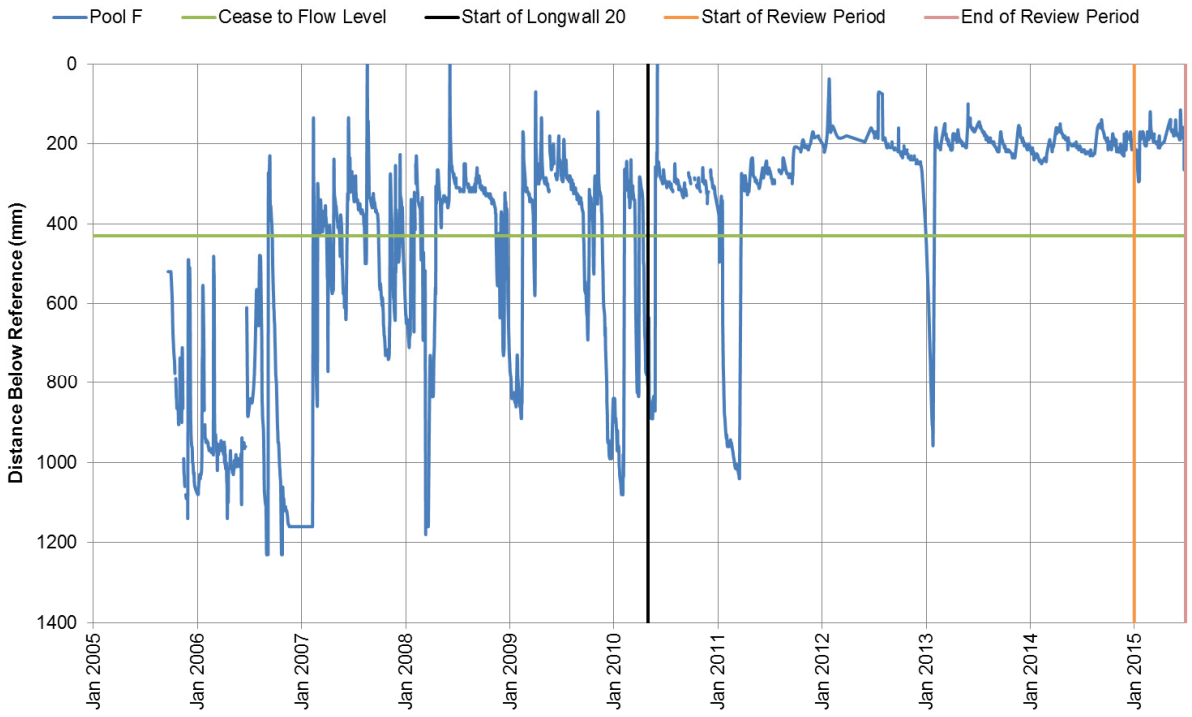


Chart C5 Waratah Rivulet Pool F Water Level Observations Compared with Cease-to-flow Level

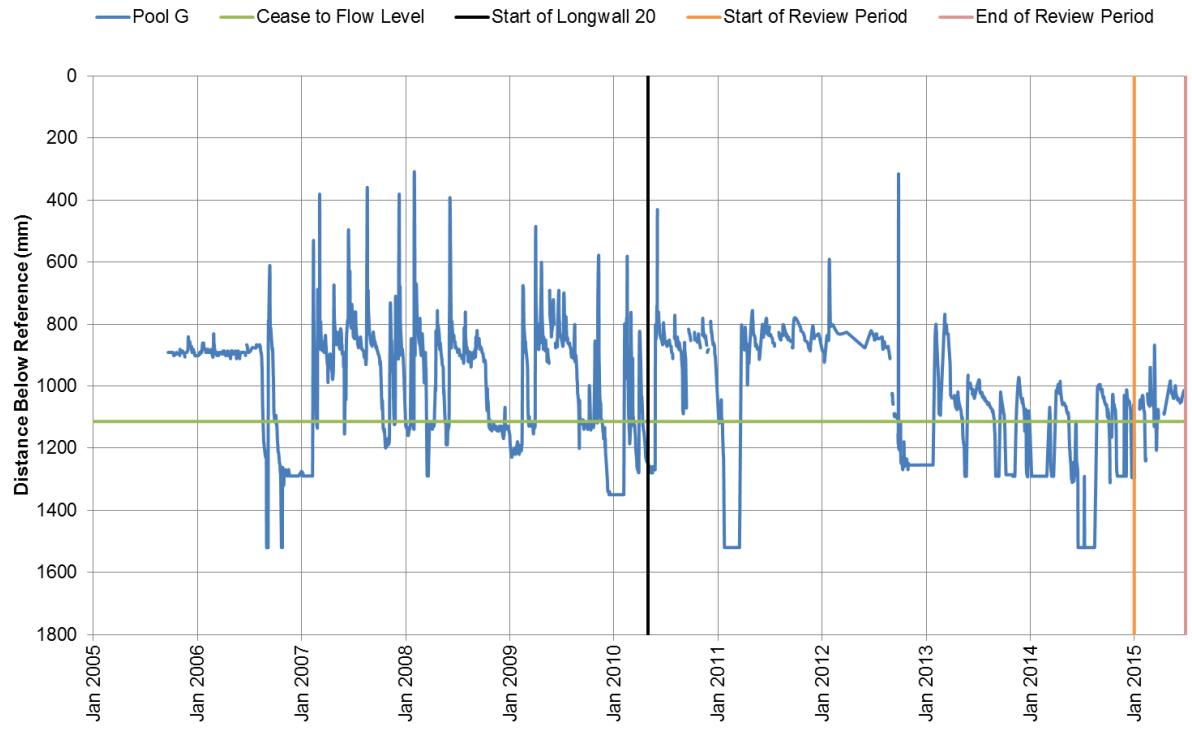


Chart C6 Waratah Rivulet Pool G Water Level Observations Compared with Cease-to-flow Level

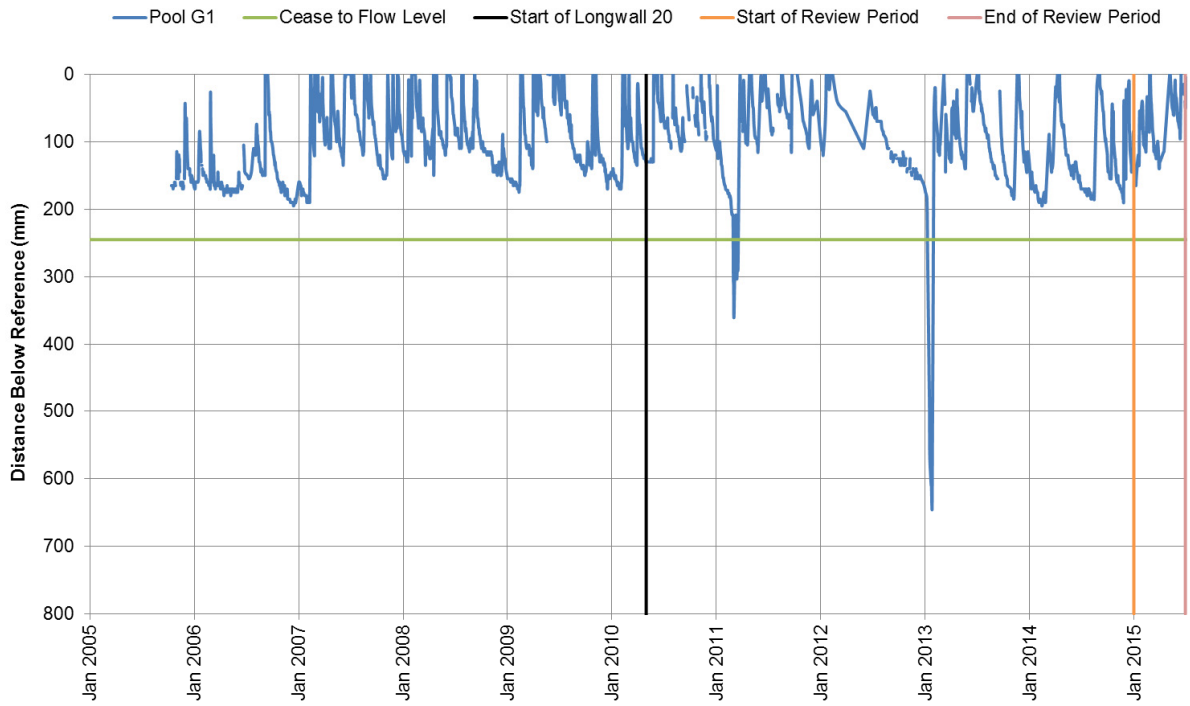


Chart C7 Waratah Rivulet Pool G1 Water Level Observations Compared with Cease-to-flow Level

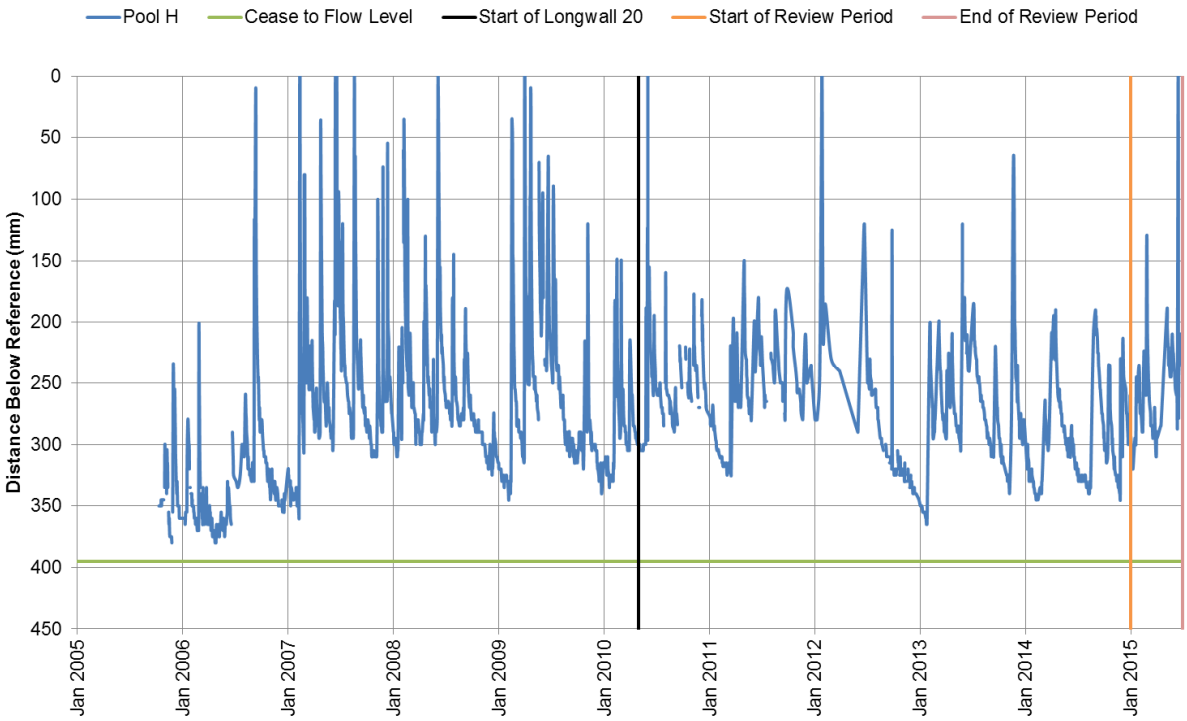


Chart C8 Waratah Rivulet Pool H Water Level Observations Compared with Cease-to-flow Level

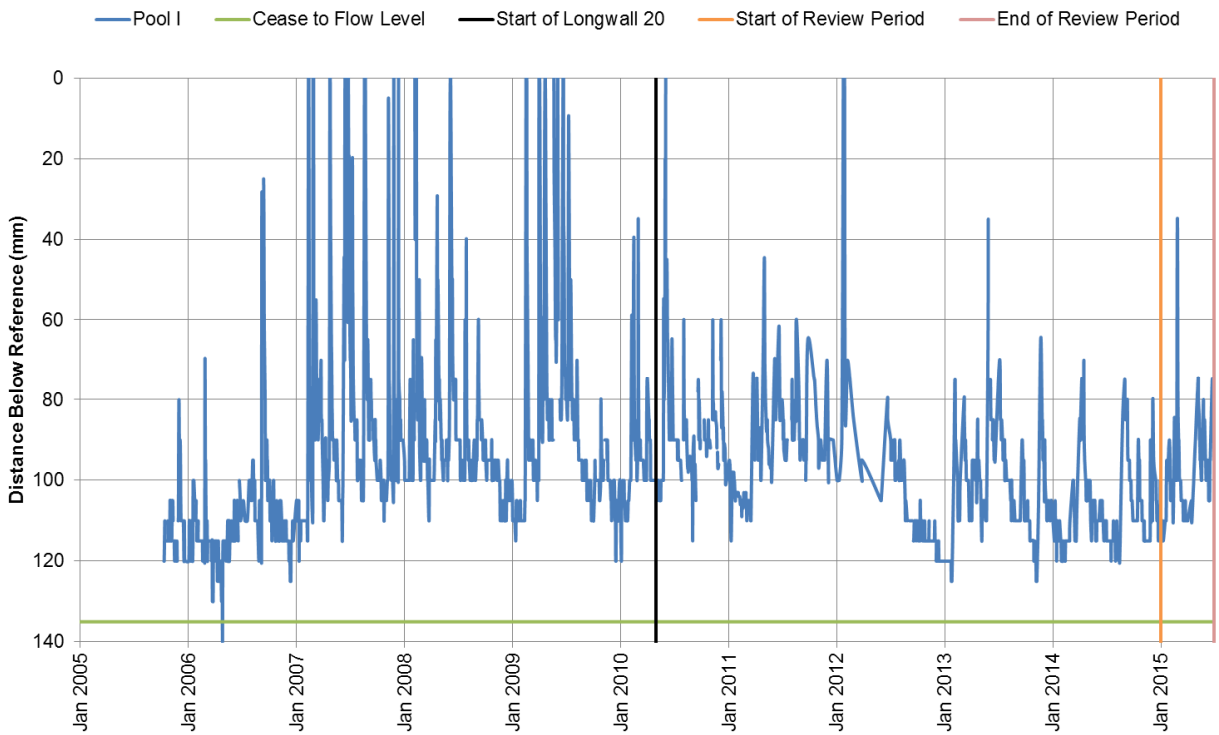


Chart C9 Waratah Rivulet Pool I Water Level Observations Compared with Cease-to-flow Level

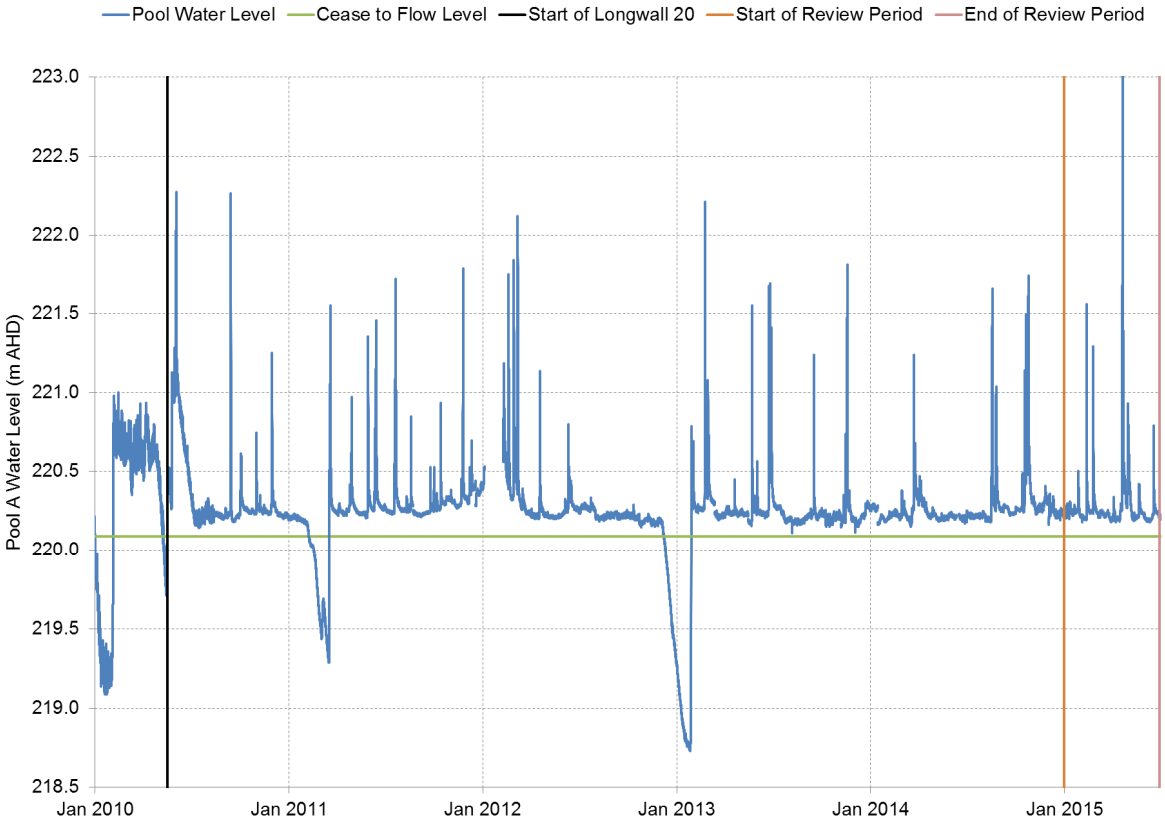


Chart C10 Waratah Rivulet Pool A - Recorded Pool Water Level

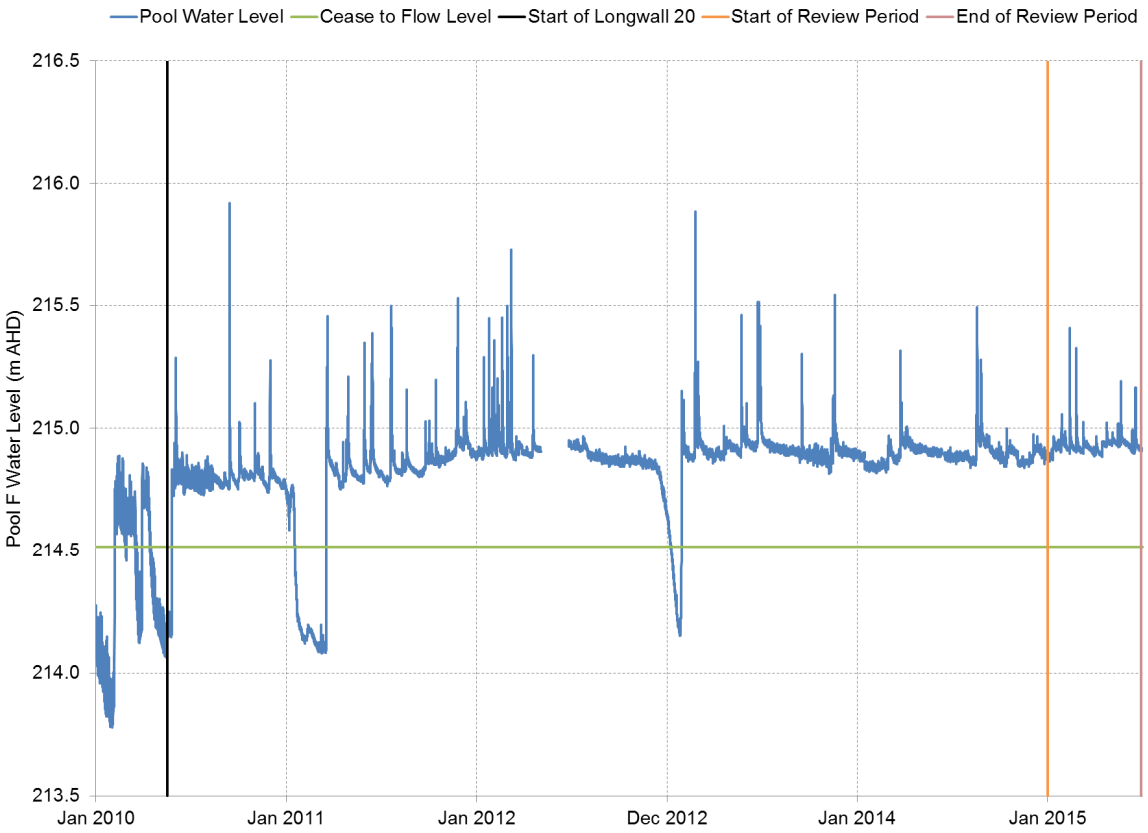


Chart C11 Waratah Rivulet Pool F - Recorded Pool Water Level

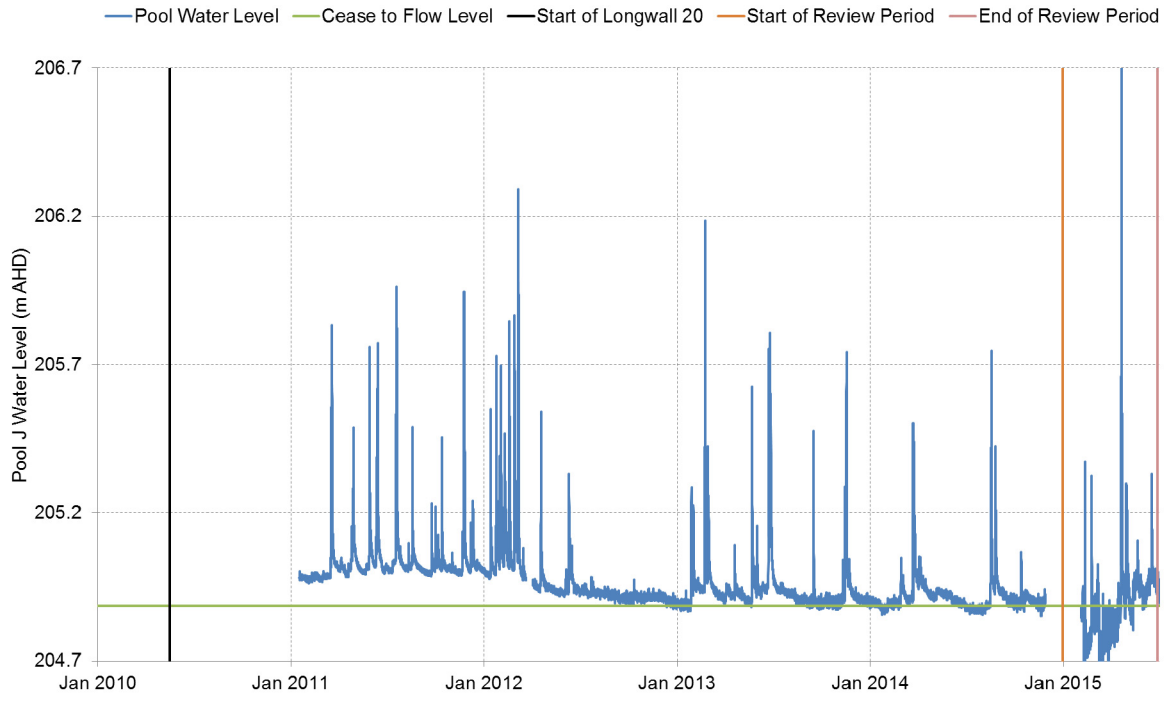


Chart C12 Waratah Rivulet Pool J - Recorded Pool Water Level

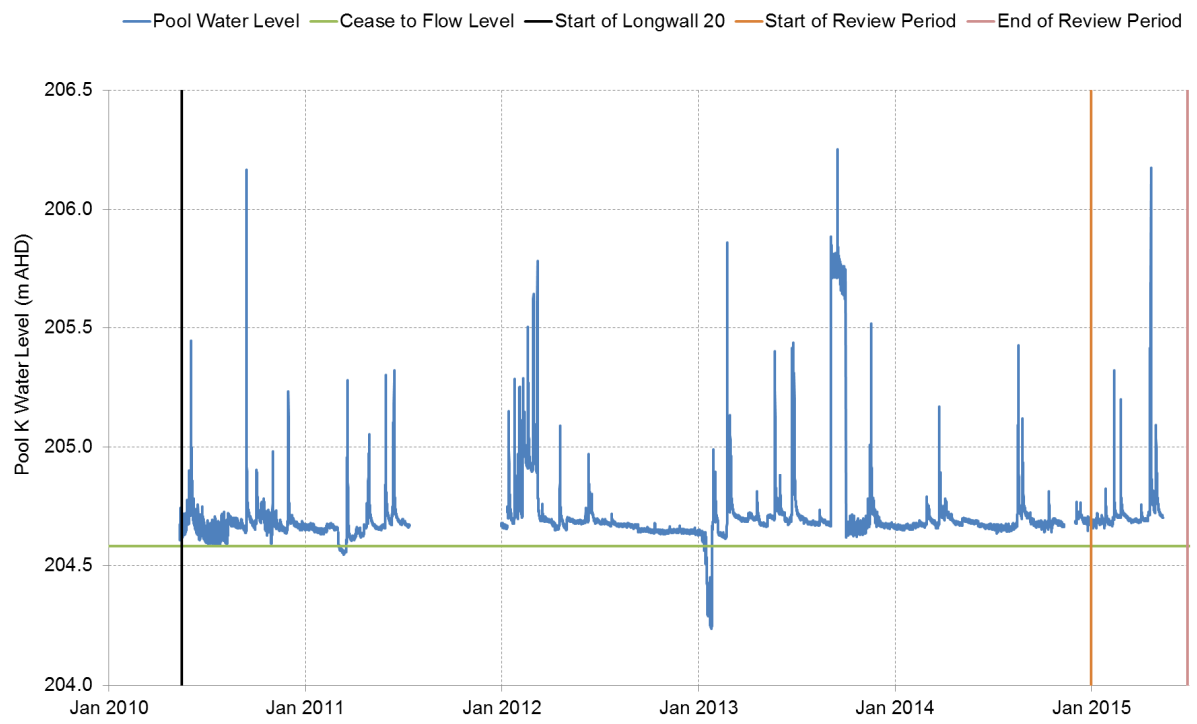


Chart C13 Waratah Rivulet Pool K - Recorded Pool Water Level

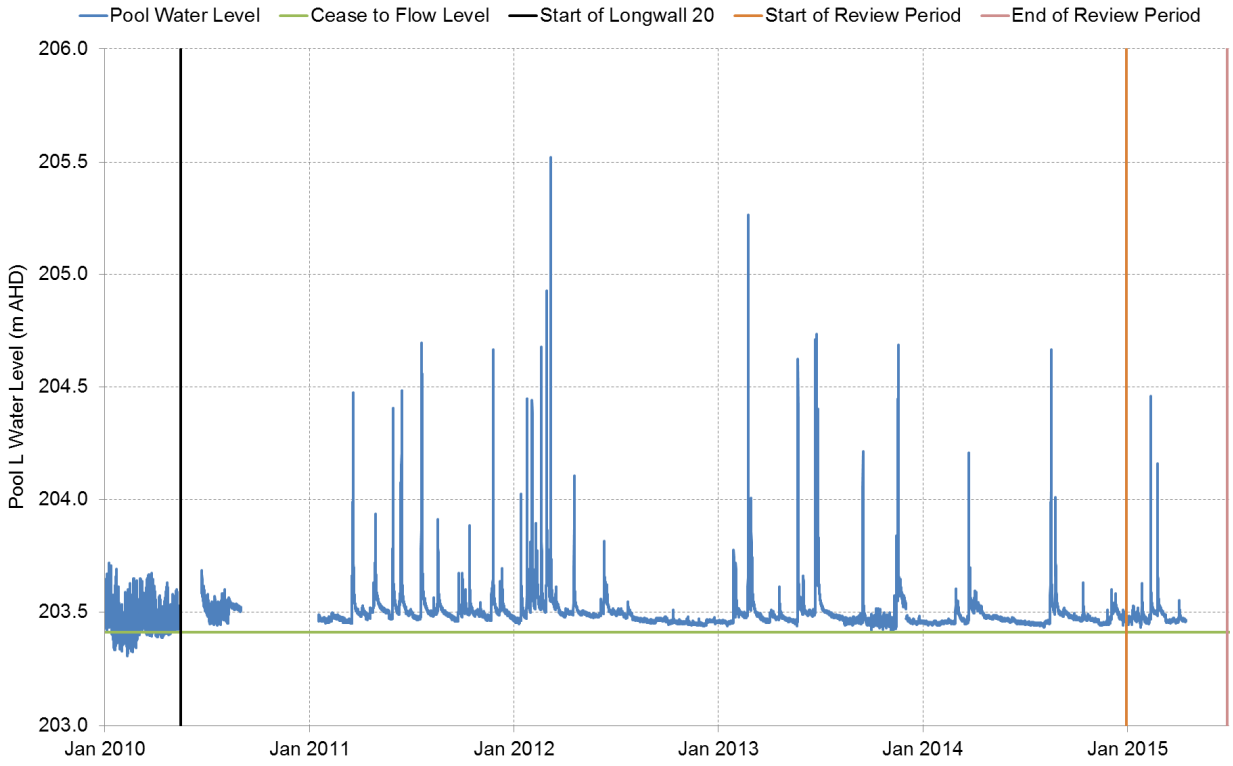


Chart C14 Waratah Rivulet Pool L - Recorded Pool Water Level

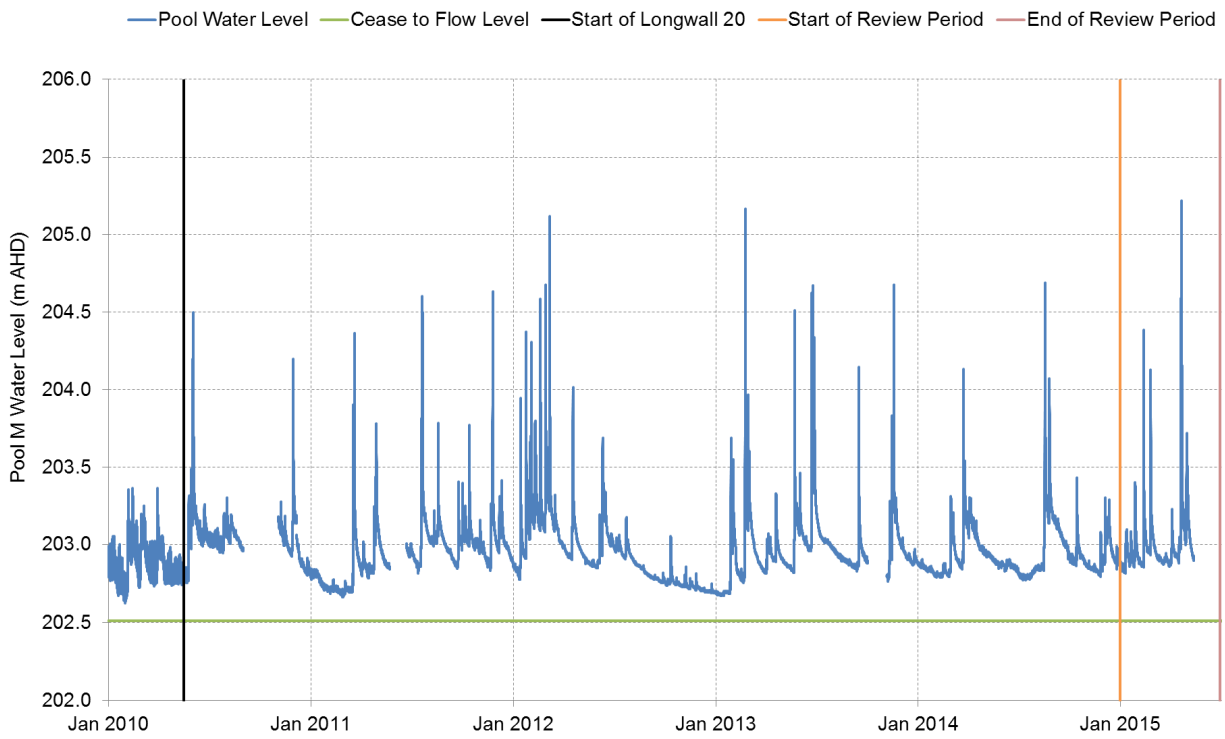


Chart C15 Waratah Rivulet Pool M - Recorded Pool Water Level

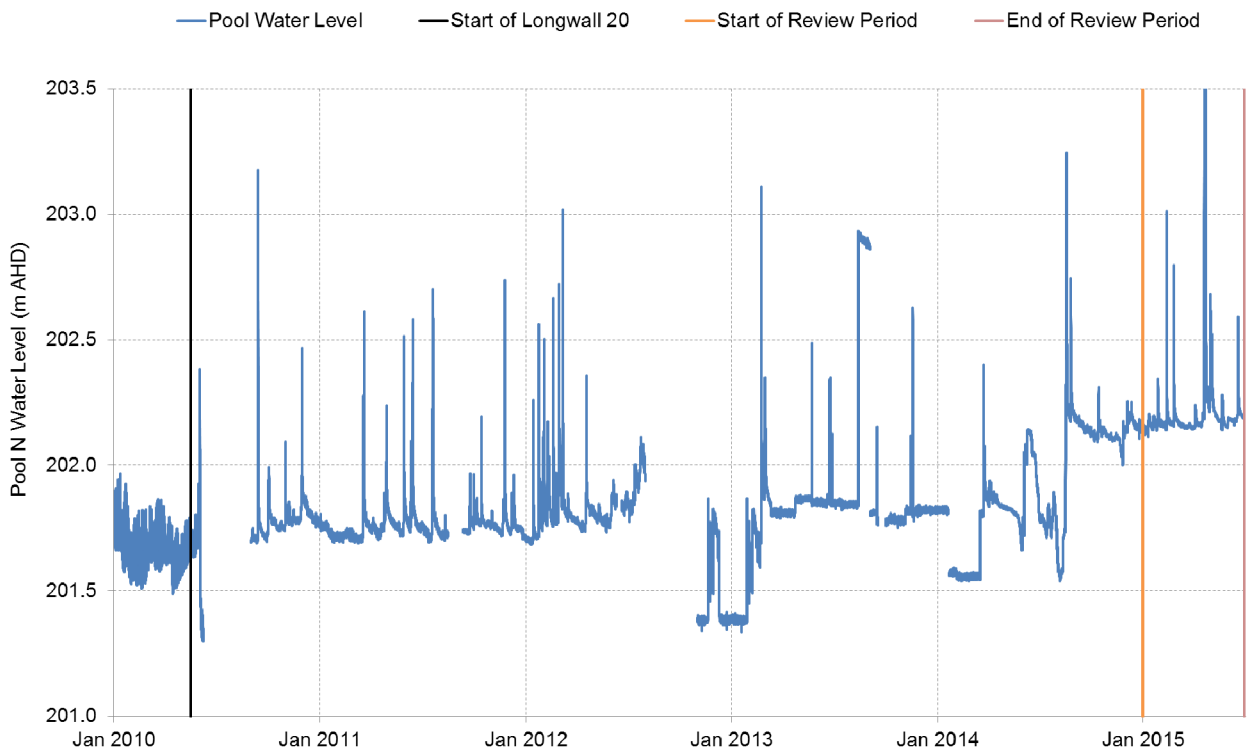


Chart C16 Waratah Rivulet Pool N - Recorded Pool Water Level

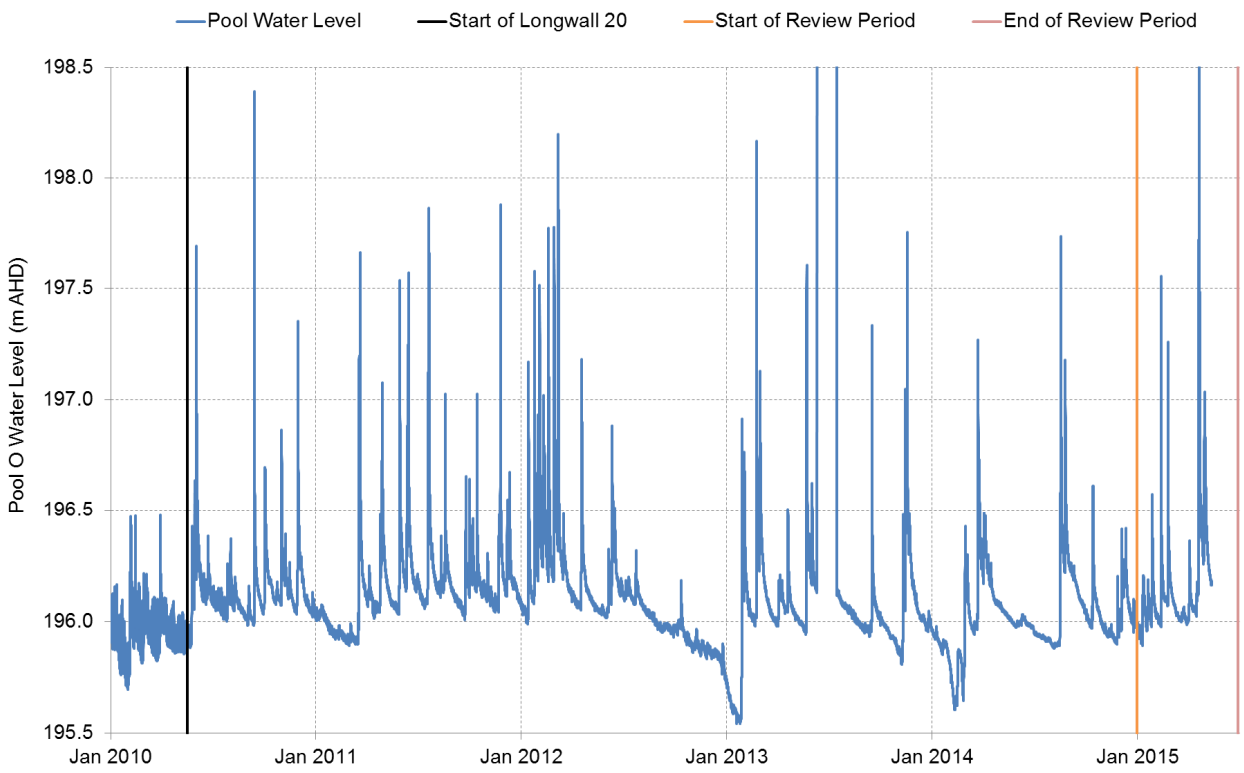


Chart C17 Waratah Rivulet Pool O - Recorded Pool Water Level

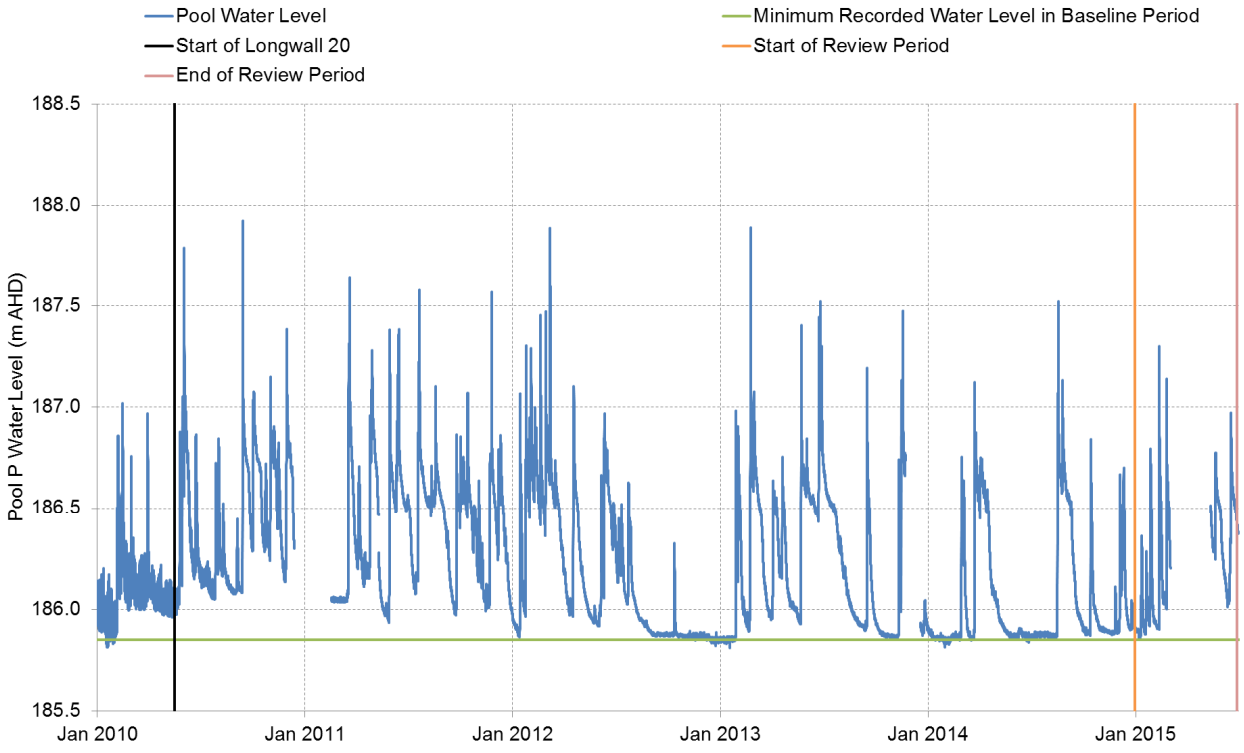


Chart C18 Waratah Rivulet Pool P - Recorded Pool Water Level

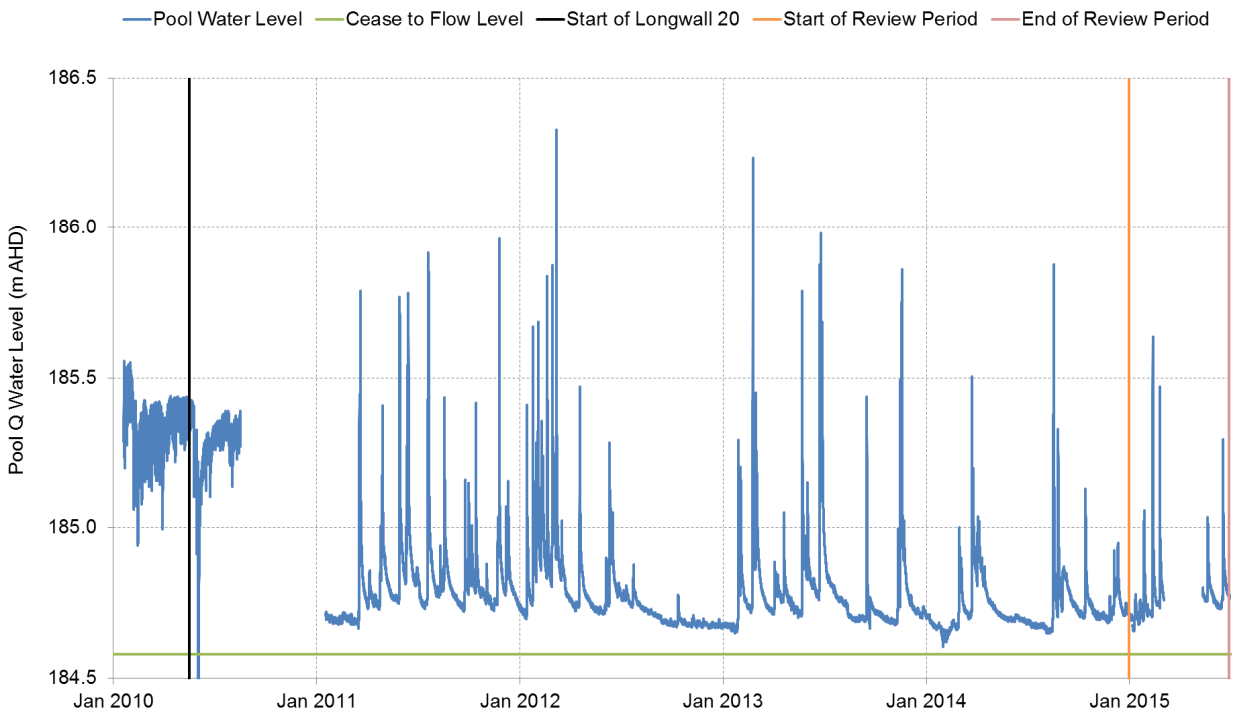


Chart C19 Waratah Rivulet Pool Q - Recorded Pool Water Level

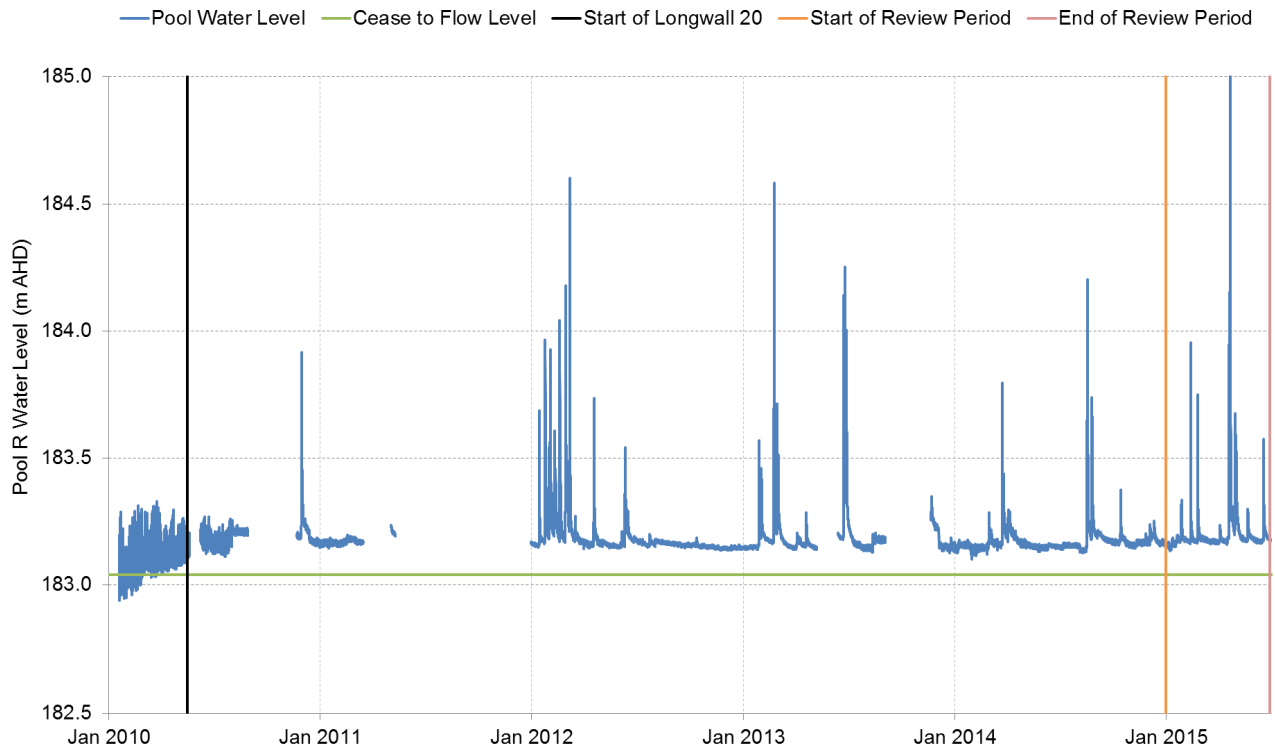


Chart C20 Waratah Rivulet Pool R - Recorded Pool Water Level

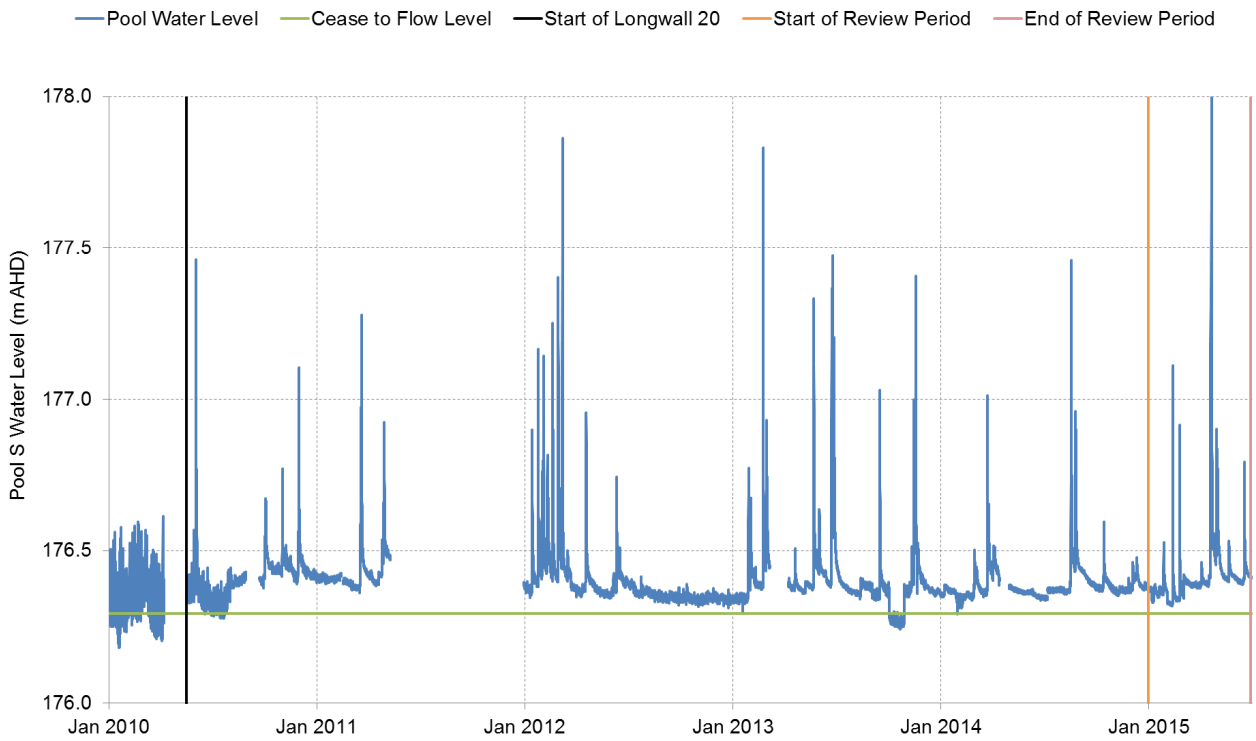


Chart C21 Waratah Rivulet Pool S - Recorded Pool Water Level

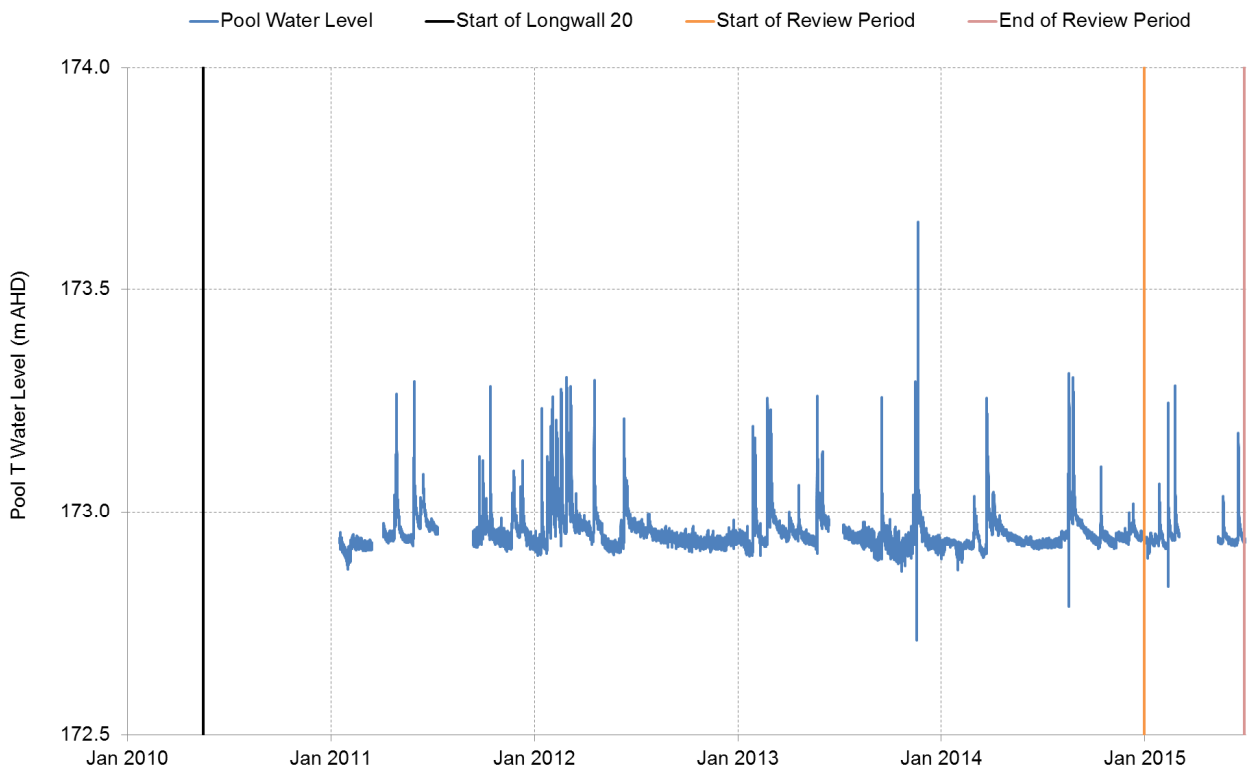


Chart C22 Waratah Rivulet Pool T - Recorded Pool Water Level

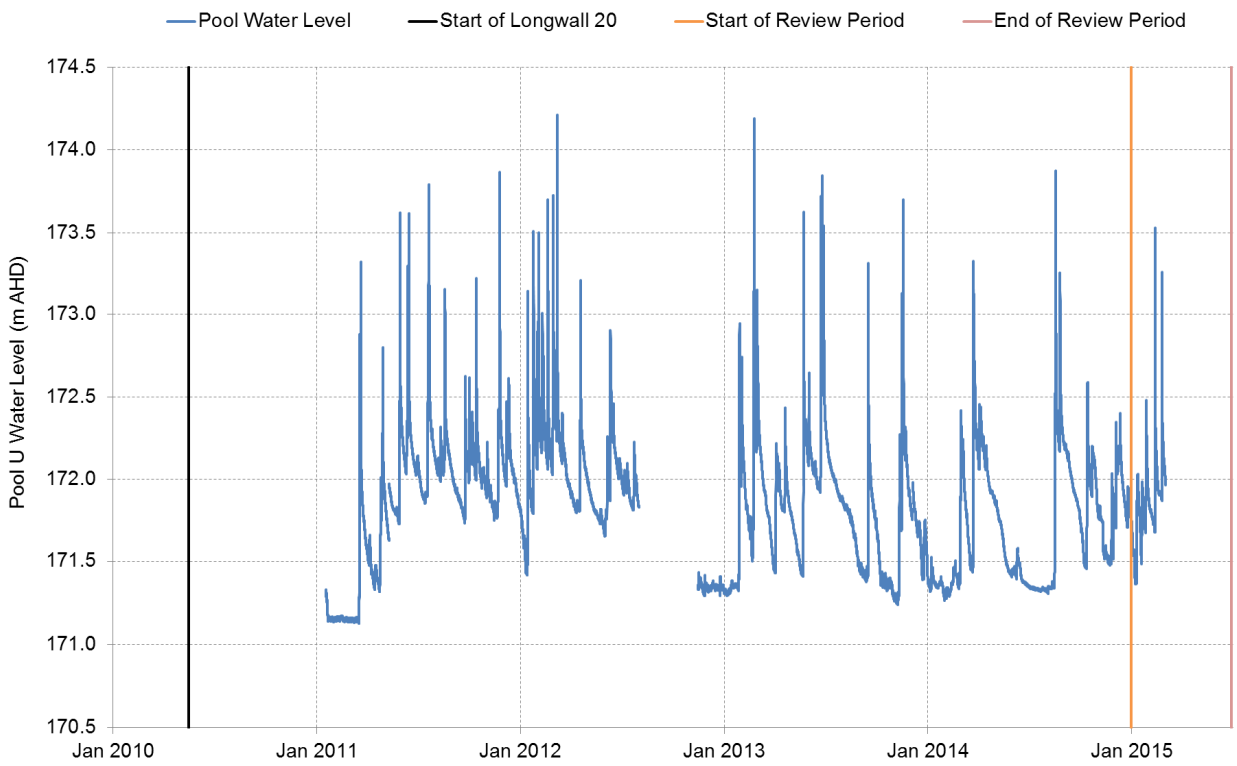


Chart C23 Waratah Rivulet Pool U - Recorded Pool Water Level

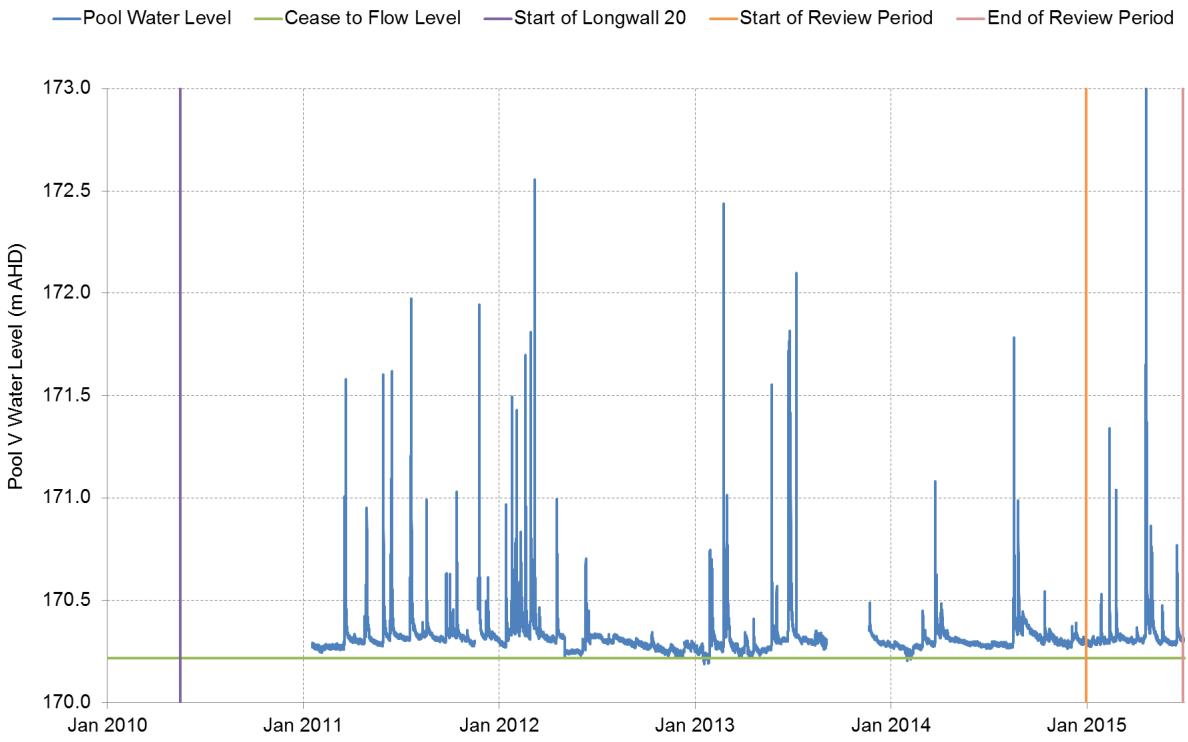


Chart C24 Waratah Rivulet Pool V - Recorded Pool Water Level

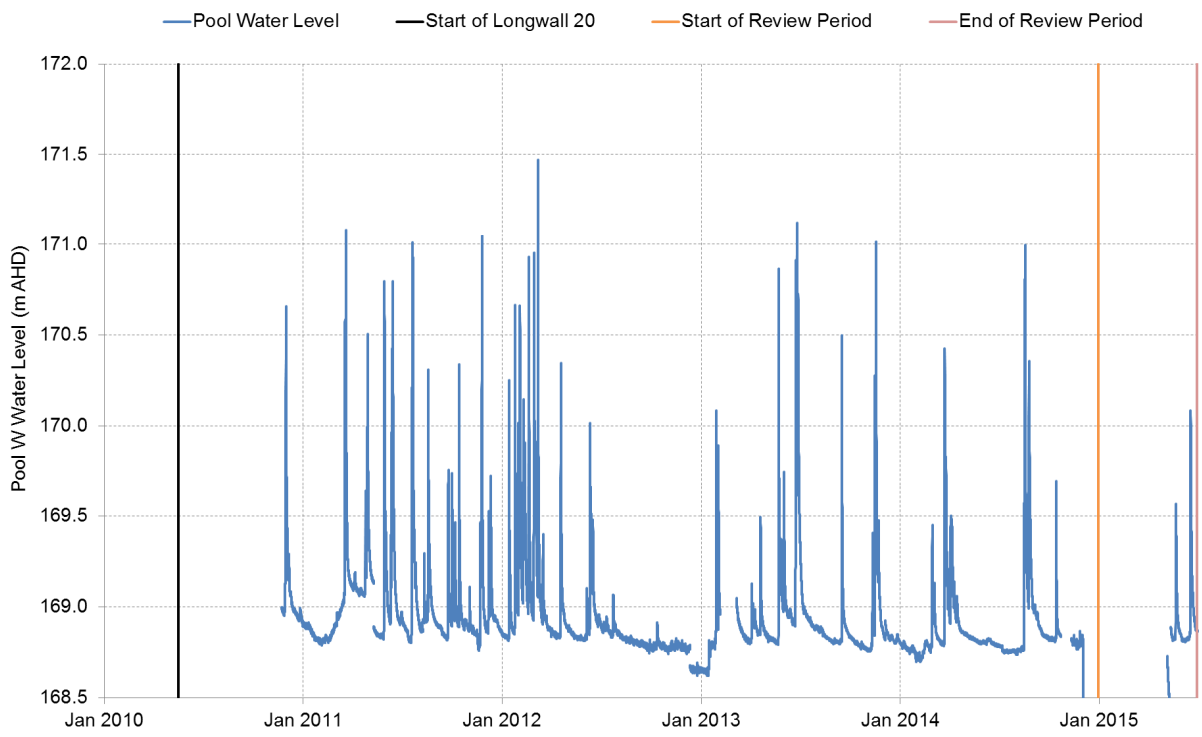


Chart C25 Waratah Rivulet Pool W - Recorded Pool Water Level