METROPOLITAN COAL

SIX MONTHLY REPORT




1 JANUARY TO 30 JUNE 2014

Peabody ENERGY

METROPOLITAN COAL

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1 JANUARY TO 30 JUNE 2014

Project No. MET-08-08/8.1
Document No. 00629674

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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 Approved underground mining Project layout is shown on Figure ES-1.

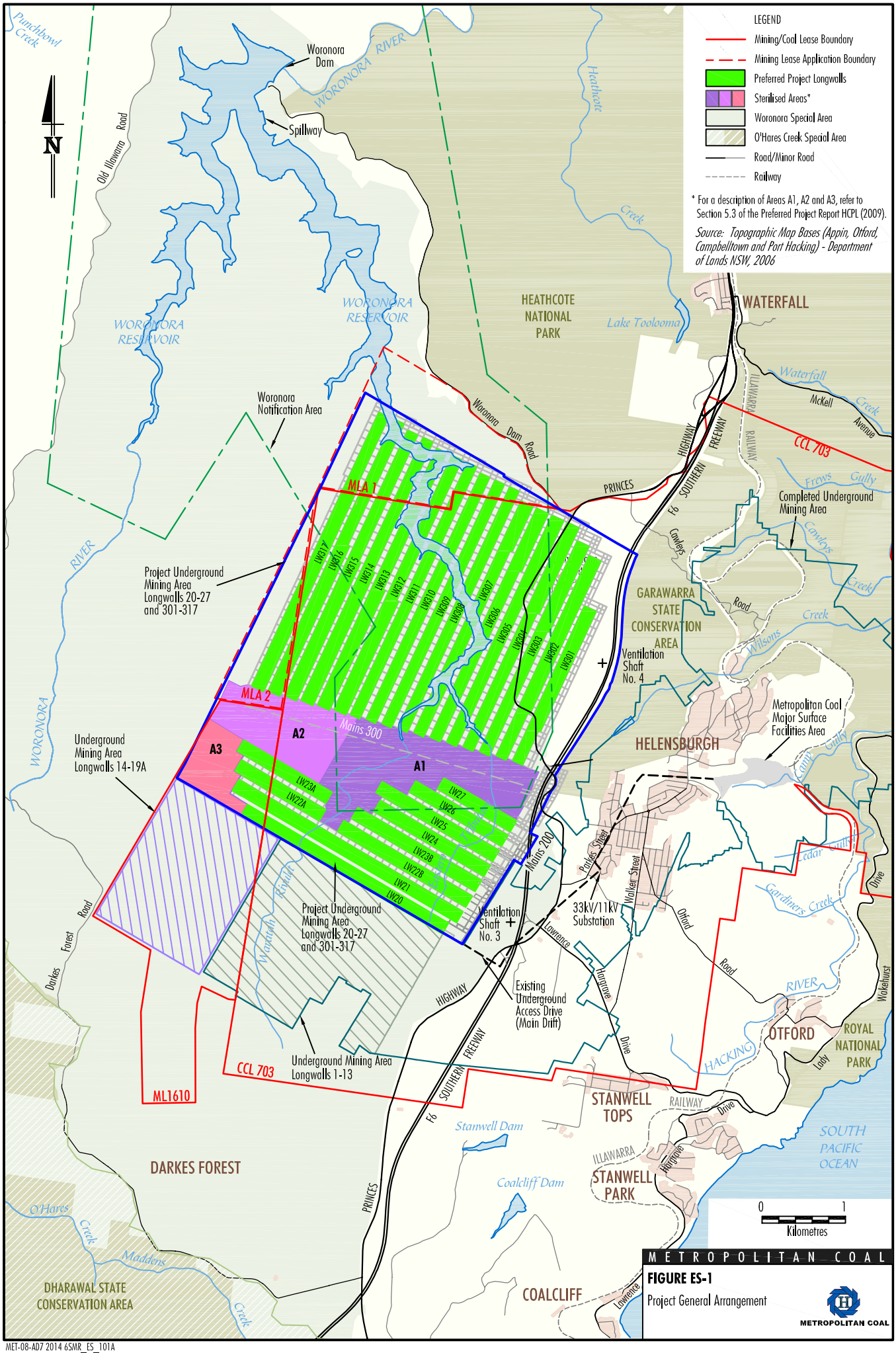
The Metropolitan Coal Environmental Management Structure is shown on Figure ES-2. Consistent with the Environmental Management Structure and in accordance with Condition 6, Schedule 3 of the Project Approval, Metropolitan Coal prepares Extraction Plans for specific mining domains as mining progresses.

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 a review of the environmental performance of Longwalls 20-22. This report presents data for the period 1 January to 30 June 2014. Longwall 22 extraction was completed in April 2014 and Longwall 23 extraction commenced in May 2014.

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, four 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
Surface Water	*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* (performance indicator applicable to Longwalls 20-22 and Longwalls 23-27)	Exceedance of the performance indicator at site WRWQ9 triggered an assessment against the performance measure, *Negligible reduction to the quality of water resources reaching the Woronora Reservoir*. The performance measure was not exceeded.
	No gas releases observed at Pool P on the Waratah Rivulet (Longwalls 20-22 performance indicator) and *No gas releases observed at Pools P to W on the Waratah Rivulet* (Longwalls 23-27 performance indicator)	Exccedance of the performance indicators at Pool P triggered an assessment against the performance measure, *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).* The performance measure was not exceeded.



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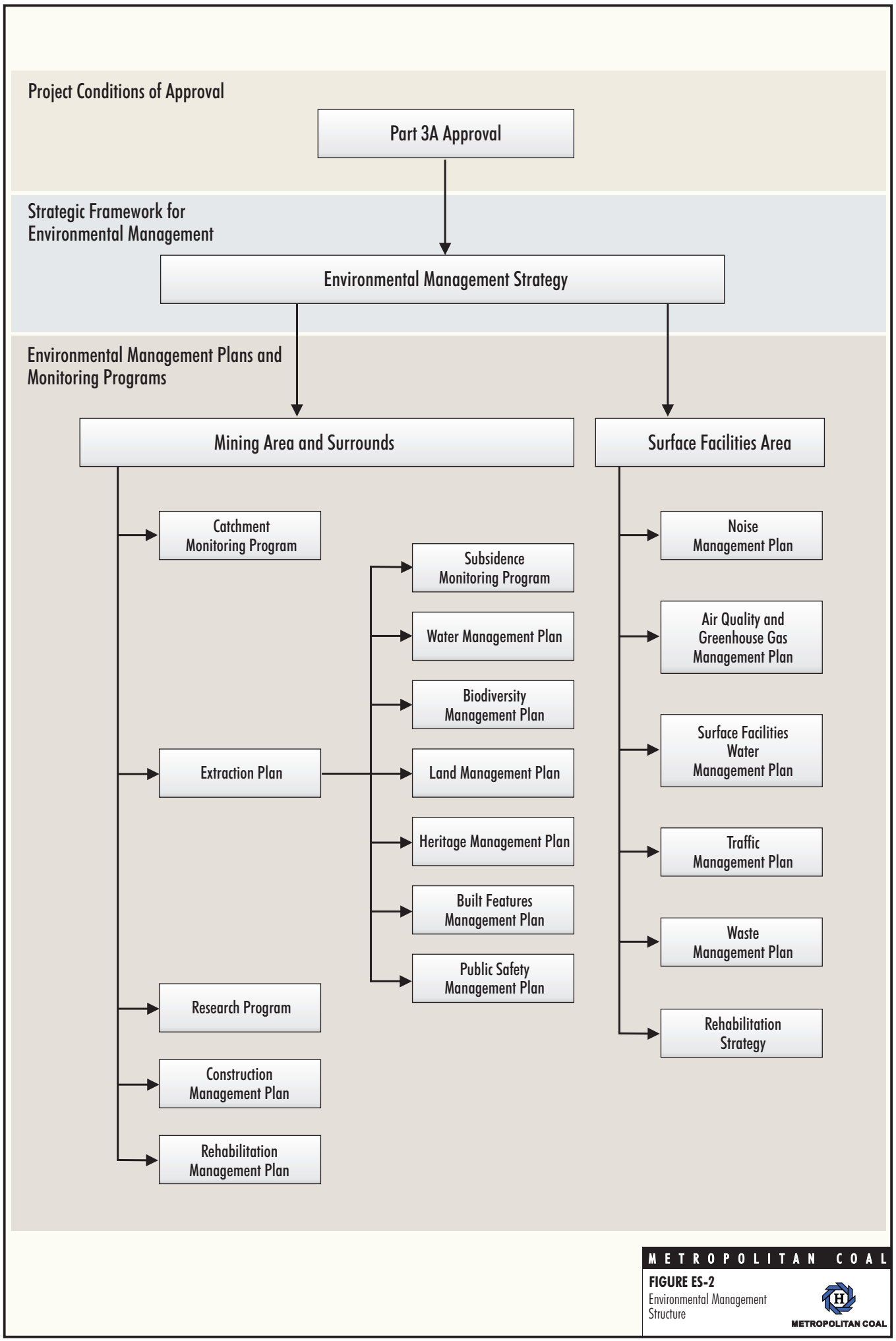

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FIGURE ES-2
Environmental Management Structure

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Table ES-1 (continued)
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 seasonal variations in water levels experienced by upland swamps prior to mining or control swamps* (performance indicator applicable to Longwalls 20-22 and Longwalls 23-27)	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 the Metropolitan Colliery (performance indicator applicable to Longwalls 20-22 and Longwalls 23-27)	Exceedance of the performance indicator at site MRIP02 (overlying Longwall 21) triggered an assessment against the performance measure, *Negligible impact on threatened species and populations.* 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.

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 and Mining Lease 1610. 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 approved underground mining Project layout is shown on Figure 2. The Project Approval authorises mining for a period of 23 years from its date of issue and sets the regulatory framework therein.

The Metropolitan Coal Environmental Management Structure is shown on Figure 3. It includes the Metropolitan Coal Environmental Management Strategy (Metropolitan Coal, 2011a), 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, 2010a) 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, 2014a) on 9 April 2014. The extraction of Longwall 23 commenced in May 2014.

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:

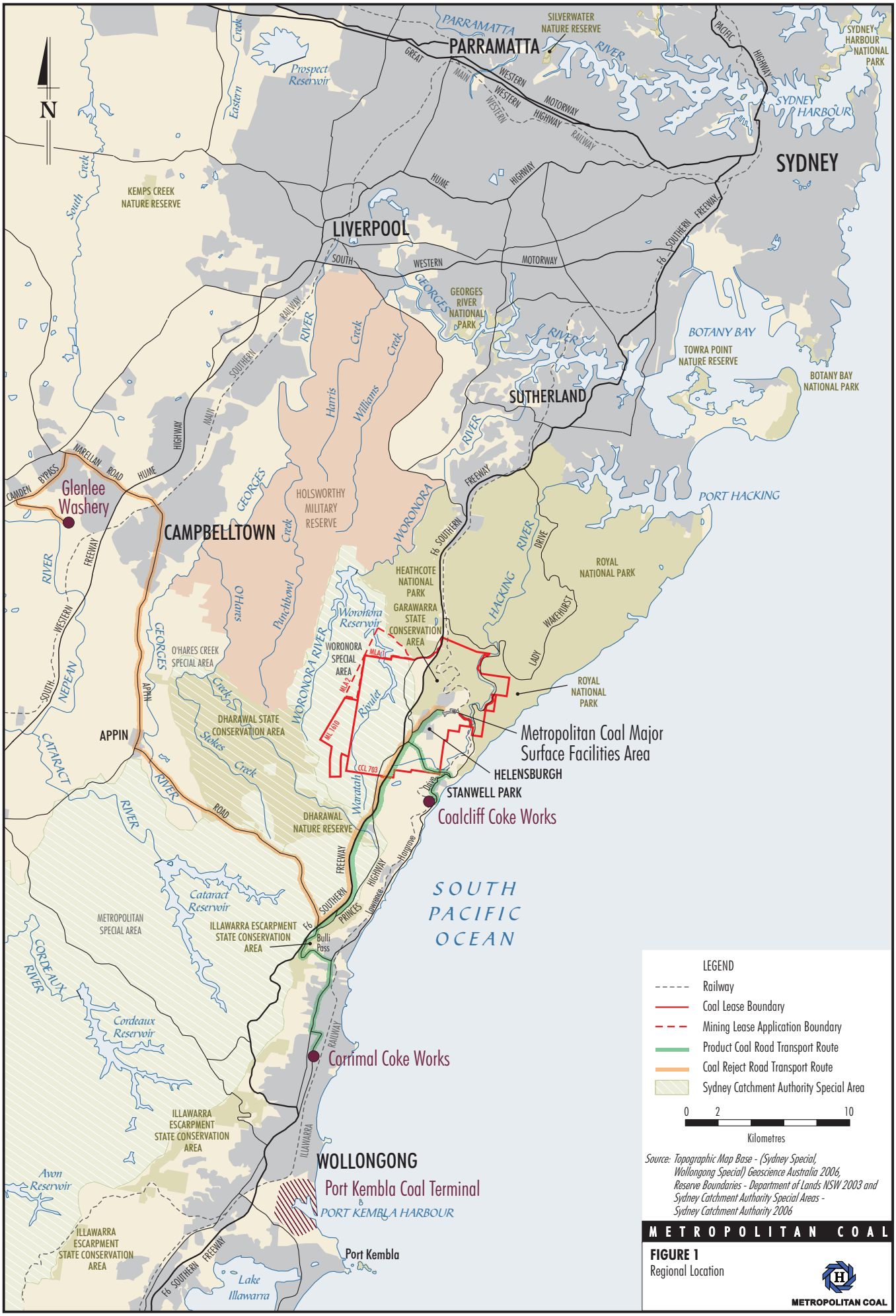
Monitoring and Reporting Requirements

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;*



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

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FIGURE 1
Regional Location

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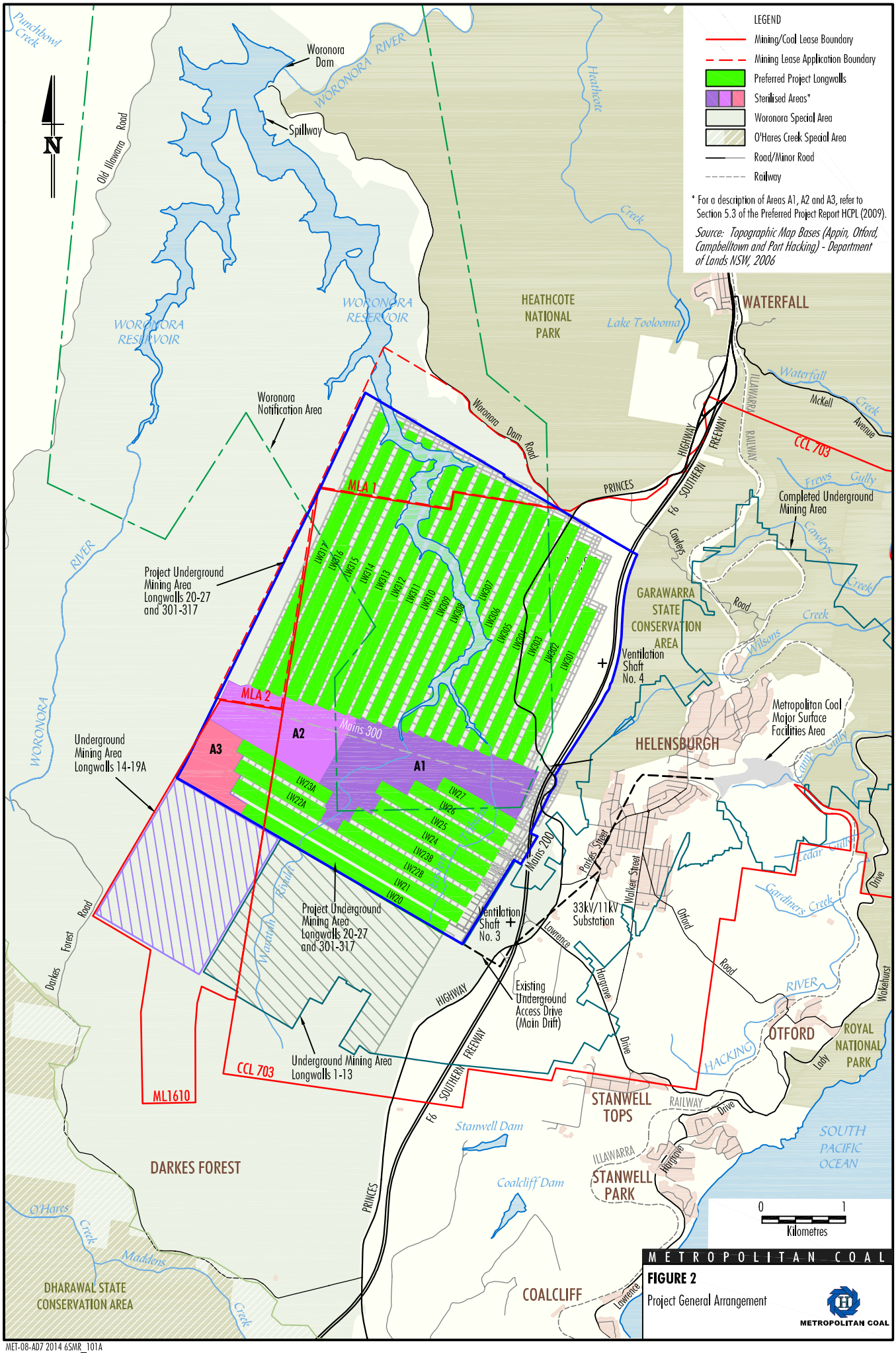

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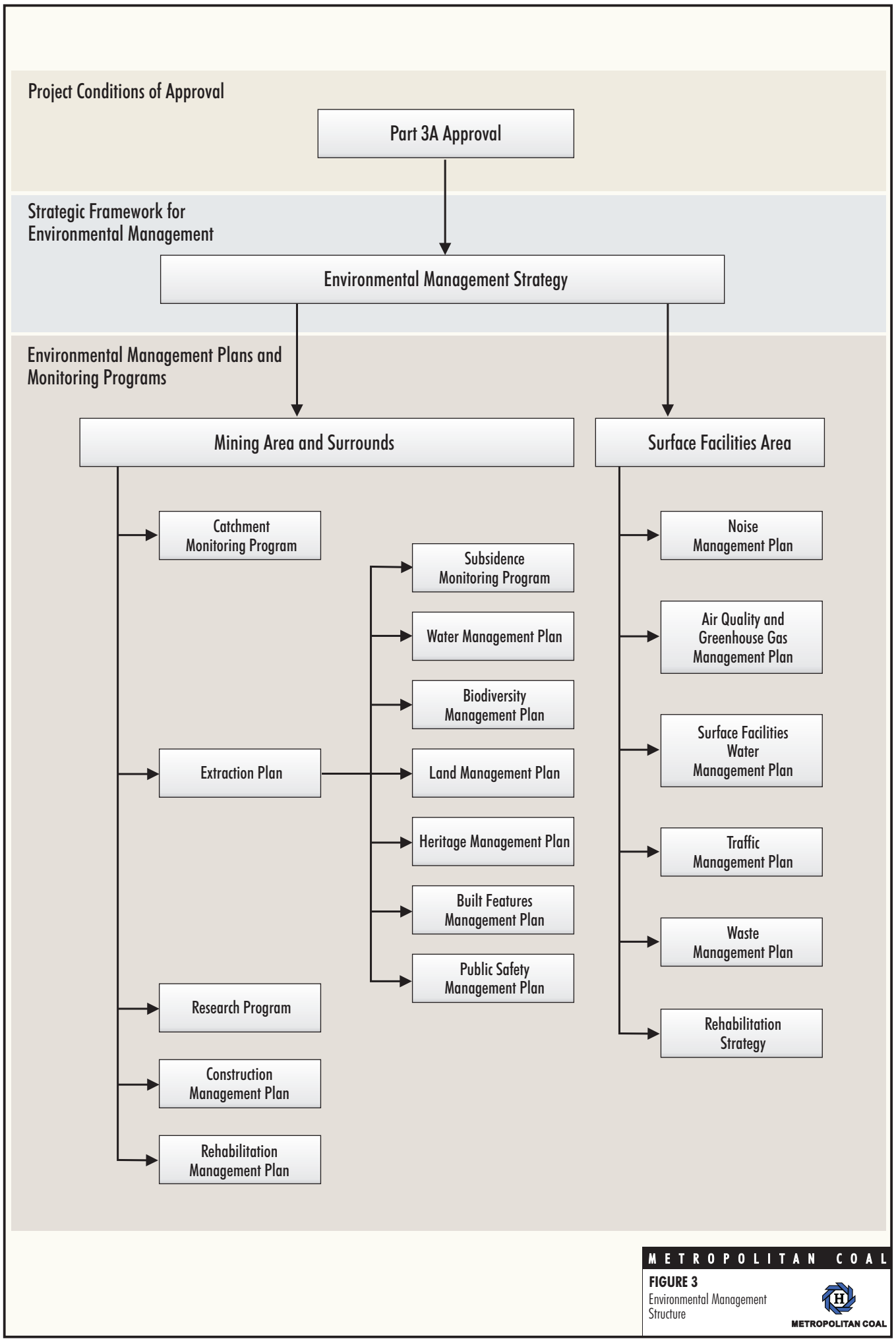

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FIGURE 3
Environmental Management Structure

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- *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, 2014a), 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, 2014a), Metropolitan Coal has also included reporting of impacts and environmental monitoring results associated with Longwalls 20-22 in this Six Monthly Report.

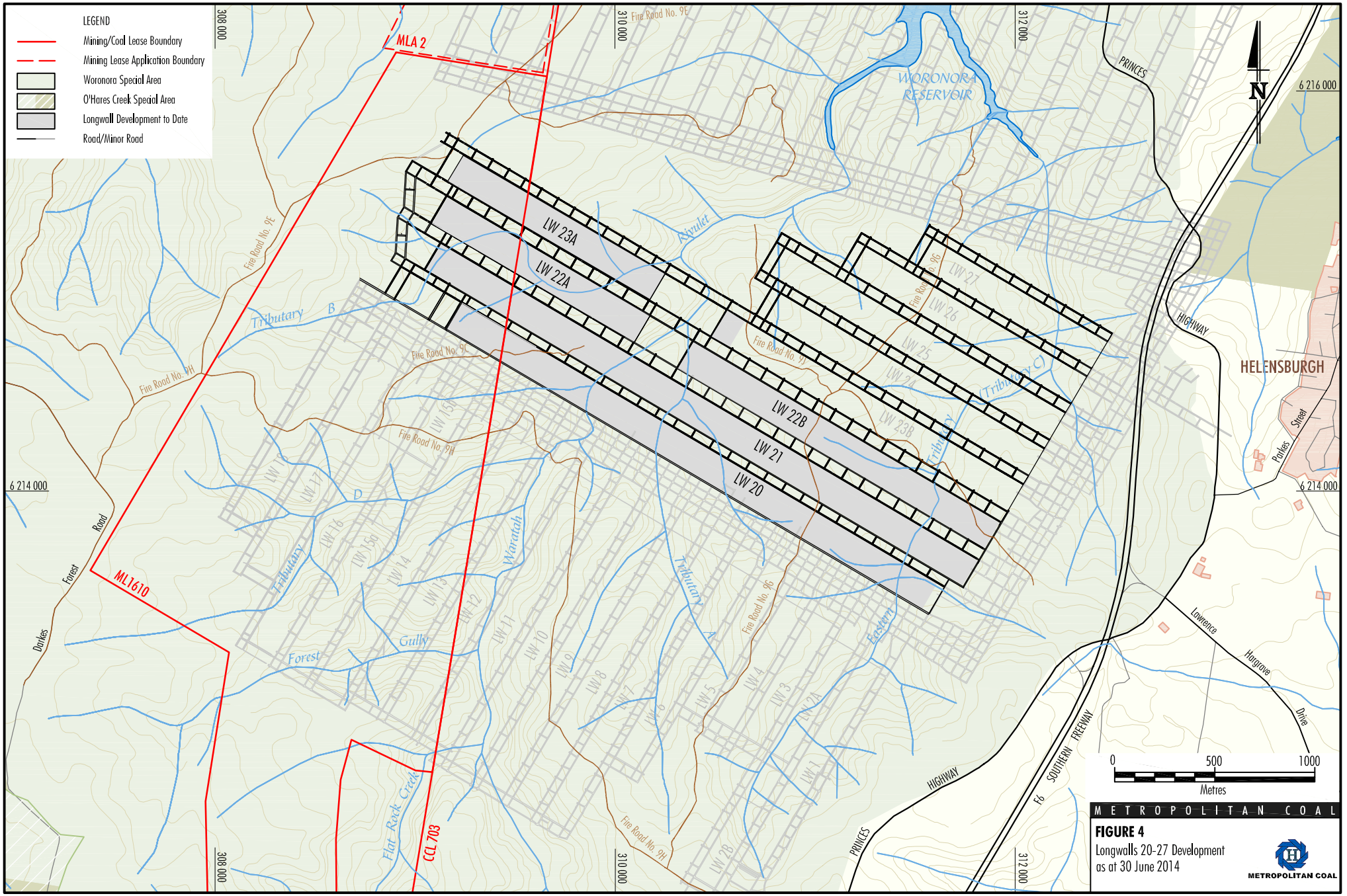
This report presents data for the period 1 January 2014 to 30 June 2014. The status of longwall development at the end of the reporting period is shown on Figure 4. During the reporting period Longwall 22 was completed in April 2014 and Longwall 23 commenced in May 2014.

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).



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2 WATER MANAGEMENT

2.1 BACKGROUND

The Metropolitan Coal Longwalls 20-22 Water Management Plan (Metropolitan Coal, 2013a) and Metropolitan Coal Longwalls 23-27 Water Management Plan (Metropolitan Coal, 2014b) 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) are conducted monthly until subsidence is less than 20 millimetres per month (mm/month), and thereafter within three months of the completion of each longwall.

Visual inspections and photographic surveys of Tributary A and Tributary B (within the 35 degree [°] angle of draw of Longwalls 20-22) are 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, conducted until subsidence is less than 20 millimetres (mm)/month, record the above parameters by exception (i.e. where they differ to the baseline visual and photographic record). During the reporting period (1 January to 30 June 2014) subsidence of Waratah Rivulet was less than 20 mm/month.

The visual and photographic surveys conducted within three months of the completion of each longwall provide a detailed photographic record of subsidence effects/impacts on stream features. A detailed photographic record of Waratah Rivulet, Eastern Tributary, Tributary A and Tributary B was conducted within three months of Longwall 22 completion (subsequent to the reporting period). The results of the visual and photographic surveys will be included in the Metropolitan Coal 2014 Annual Review/Annual Environmental Management Report (AEMR).

During the reporting period, gas releases in the Waratah Rivulet have been observed in Pools K, L O and P (refer Figure 5 for pool locations). In accordance with the Metropolitan Coal Longwalls 20-22 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).

Weekly monitoring of gas releases at Pool K indicates the gas releases have been sporadic. Gas releases in Pool K were initially observed in July 2013, but were not observed again until December 2013. The gas releases continued from December 2013 until late February 2014, at which time they stopped and did not occur again over the remainder of the reporting period.

Gas releases in Pool L have been observed in March 2012 and from July 2013 to December 2013. Gas releases continued to be observed in Pool L throughout the reporting period (i.e. from January to June 2014).

Gas releases in Pool O were observed from April 2012 to December 2013. In the current reporting period the gas releases continued from December 2013 until late February 2014, and then from mid April to mid May 2014.

Gas releases in Pool P were identified for the first time in February 2014 and thereafter were present from May 2014 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.

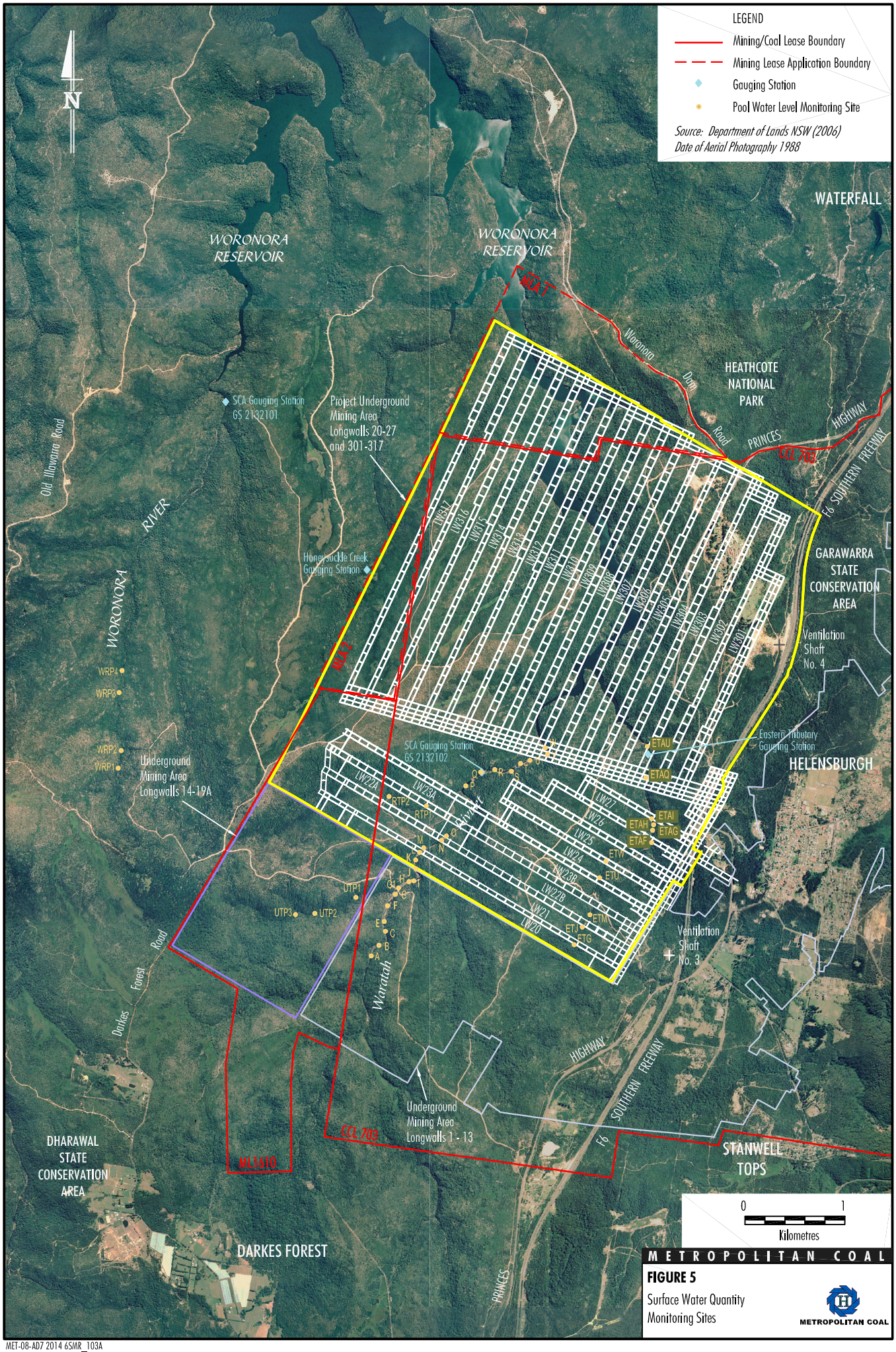

FIGURE 5

Surface Water Quantity Monitoring Sites

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2.2.1.2 Surface Water Flow

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

The results of the stream flow monitoring for the reporting period are described 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).

Pool P is visually inspected on a weekly basis when mining of Longwalls 20-22 is within 400 metres (m) of this pool. All pools between Flat Rock Crossing and Pool N on the Waratah Rivulet are inspected monthly when mining of Longwalls 20-22 is within 400 m of the Waratah Rivulet and until subsidence from Longwalls 20-22 reduces to less than 20 mm/month.

The pool water level monitoring results for Waratah Rivulet and Woronora River are discussed in Section 8 in relation to the initiation of stream remediation.

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 and 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 provided in Section 2.2.2.3 for the reporting period.

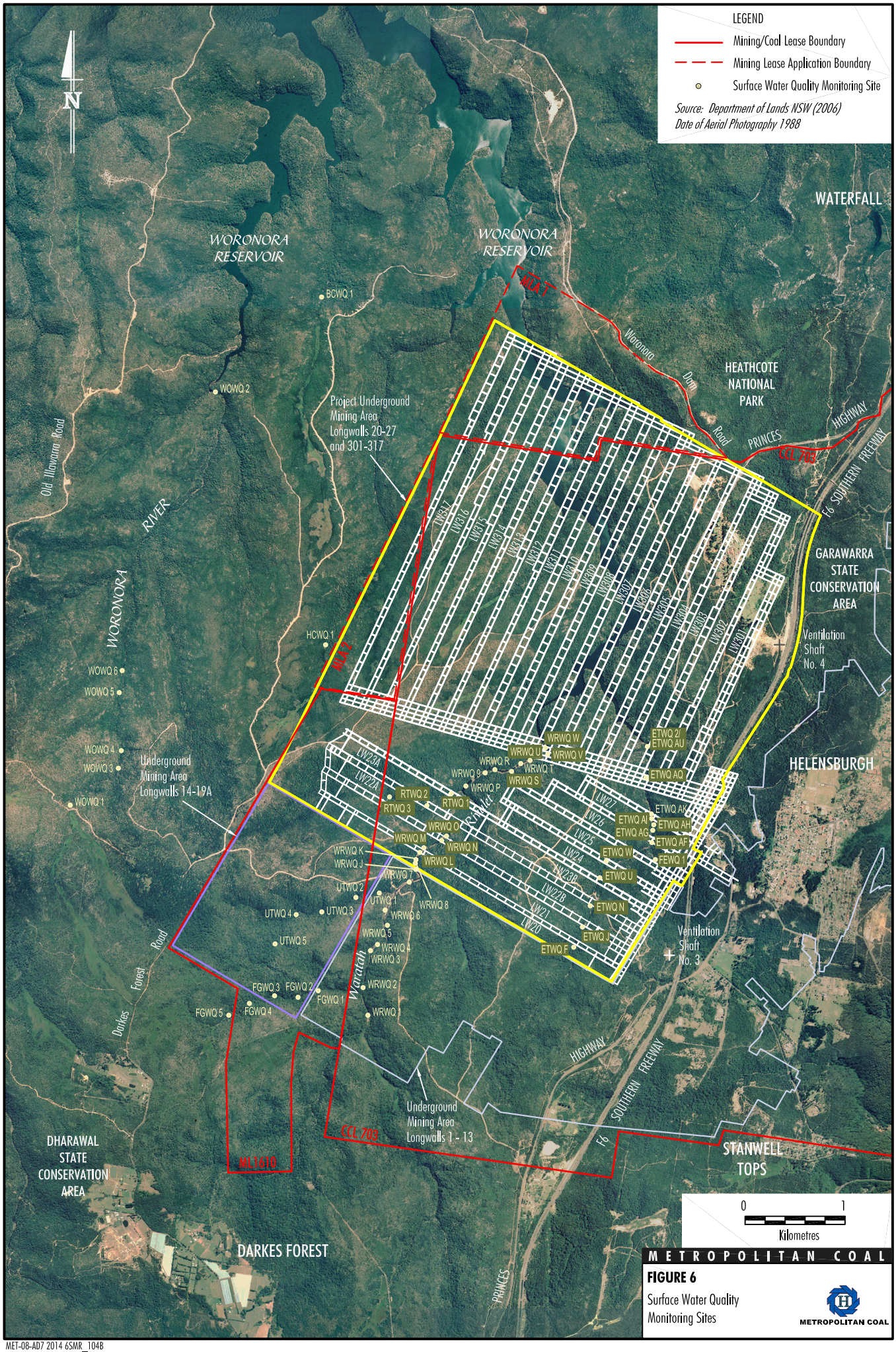
2.2.1.4 Stream Water Quality

Surface water quality sampling for Longwalls 20-22 has been conducted monthly at a number of sites on Waratah Rivulet, Tributary B, Tributary D, Eastern Tributary, Far Eastern Tributary, Honeysuckle Creek, Bee Creek and the Woronora River (Figure 6).

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 were also collected at a number of sites on the Waratah Rivulet, Eastern Tributary and Woronora River (Figure 6) and analysed for total iron.

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



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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 the SCA in accordance with a data exchange agreement.

Results of the analysis of this data are presented in Section 2.3.2.5.

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, WRGW7 and WRGW8 along Waratah Rivulet, site RTGW1A on Tributary B, and sites ETGW1 and ETGW2 on the Eastern Tributary (Figure 7).

Site WRGW8 has anomalous behaviour that is inconsistent with companion bore WRGW7 and does not exhibit the expected correlation with rainfall trend. There is a periodic (almost sinusoidal) pattern in the WRGW8 water levels, truncated by overflow at the top of the piezometer casing. Additional chemical evidence indicates that Site WRGW8 is faulty and is not recording reliable data.

The results of shallow groundwater level monitoring for the reporting period, with the exception of site WRGW8, 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.

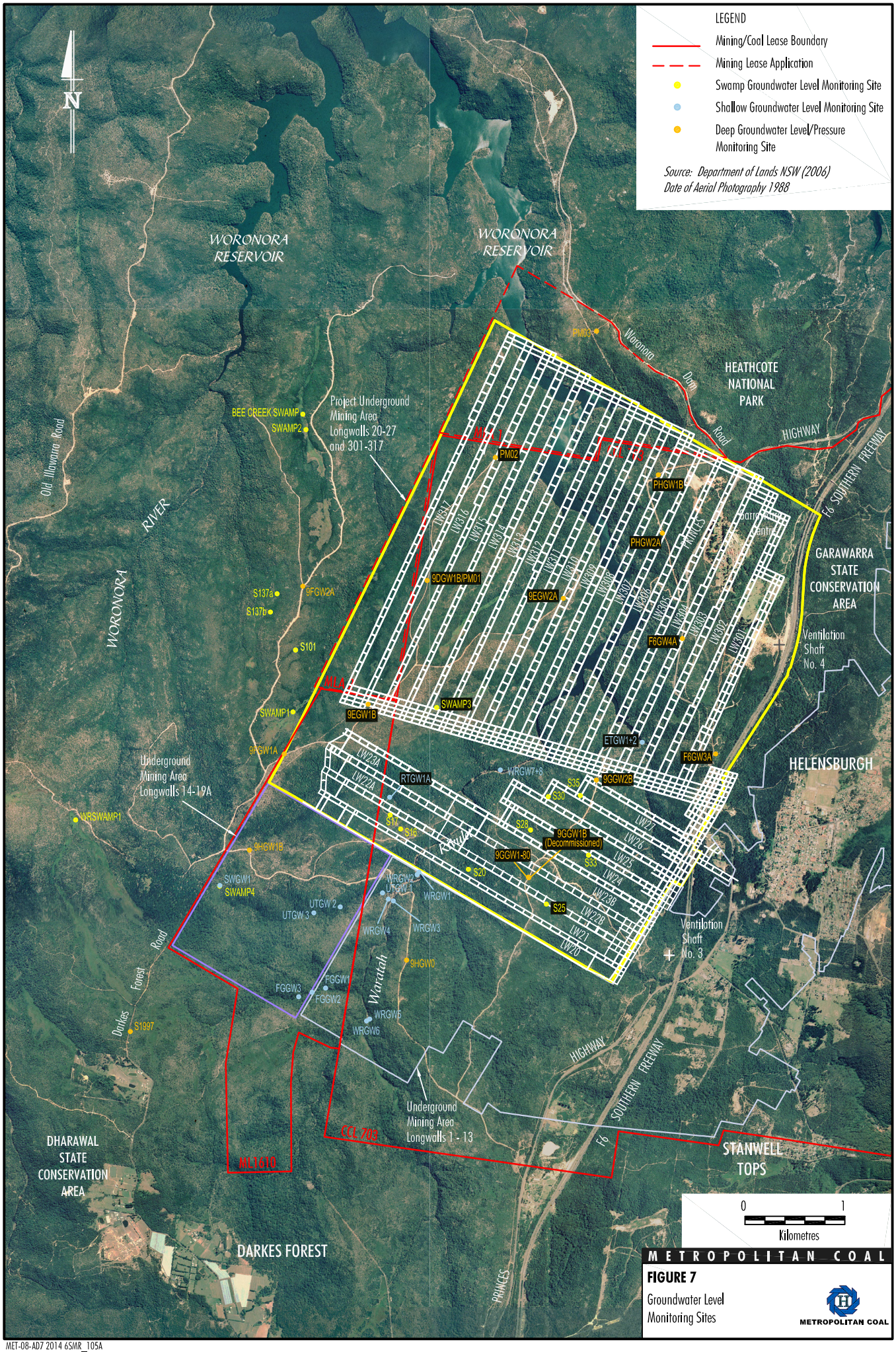
2.2.1.9 Groundwater Quality

Shallow groundwater quality has been sampled monthly at sites WRGW1, WRGW2, WRGW7 and WRGW8 along the Waratah Rivulet, site RTGW1A adjacent to Tributary B, and sites ETGW1 and ETGW2 on the Eastern Tributary (Figure 8).

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.

Bore WRGW8 is considered faulty and is not recording reliable data. Apart from inconsistent water level readings (discussed in Section 2.2.1.7 above), WRGW8 exhibits anomalously low manganese and iron, and higher than normal pH.

The results of groundwater quality monitoring for the reporting period, with the exception of site WRGW8, are described in Section 2.2.2.9.



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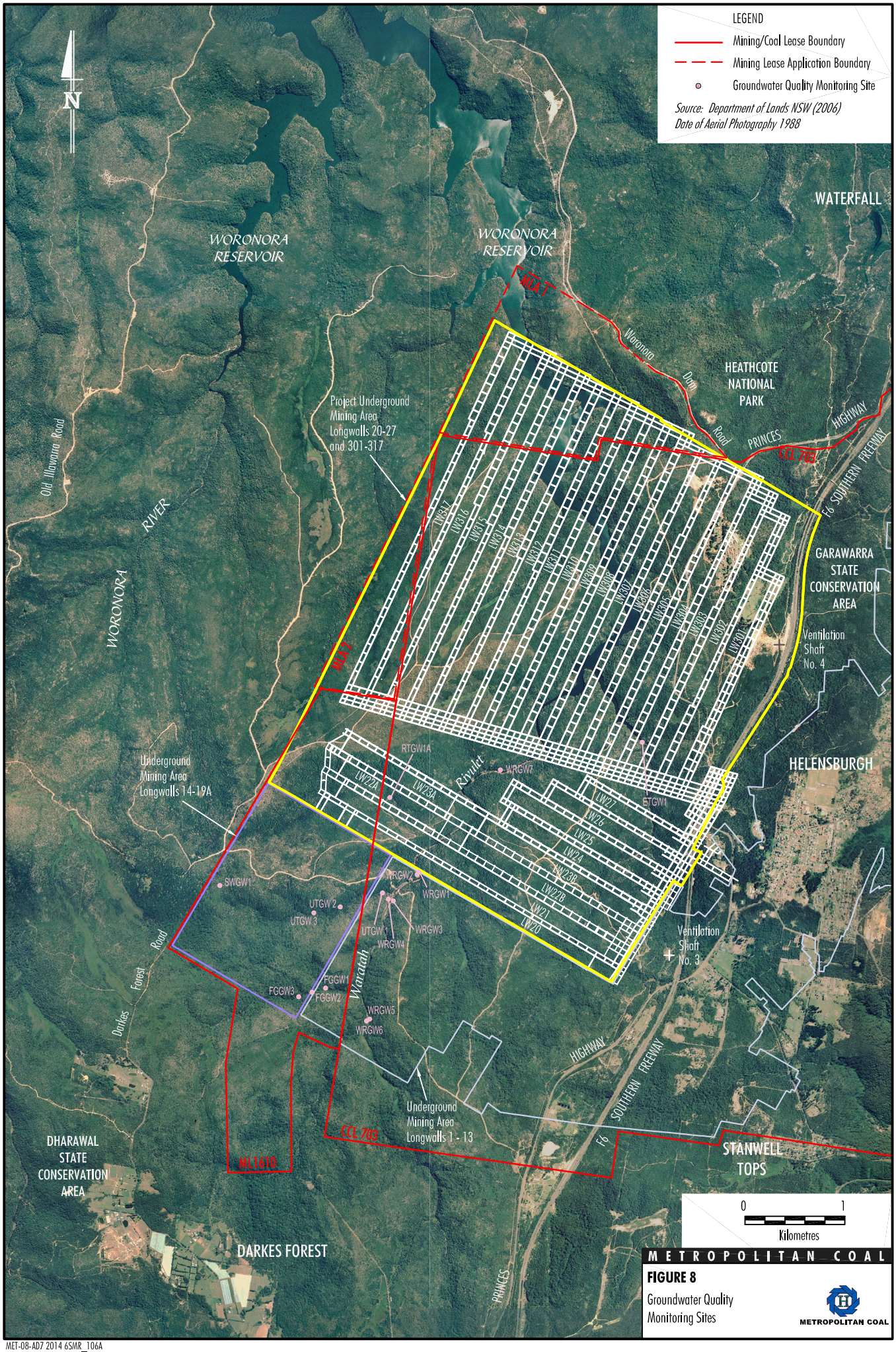

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2.2.1.10 Inspections of Mine Workings

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.

2.2.1.11 Mine Water Make

In accordance with the Metropolitan Coal Longwalls 20-22 Water Management Plan, 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 run-of-mine [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 is 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 routine 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.

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 mine water make for the reporting period is 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 until subsidence is less than 20 mm/month, and thereafter 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 conducted within three months of the completion of each longwall.

The visual and photographic surveys record the same observations as those described in Section 2.2.2.1.1 for Longwalls 20-22.

The monthly visual and photographic surveys, conducted until subsidence is less than 20 mm/month, record the above parameters by exception (i.e. where they differ to the baseline visual and photographic record). During the reporting period (1 January to 30 June 2014), subsidence of Waratah Rivulet and the Eastern Tributary was less than 20 mm/month.

A detailed photographic record of Waratah Rivulet, Eastern Tributary, Tributary A and Tributary B will be conducted within three months of Longwall 23 completion.

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) have been observed in Pools O and P (refer Figure 5 for pool locations). 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 observed from April 2012 to December 2013. In the current reporting period the gas releases continued from December 2013 until late February 2014, and then from mid April to mid May 2014.

Gas releases in Pool P were identified for the first time in February 2014 and thereafter were present from May 2014 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.

2.2.2.2 Surface Water Flow

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

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

Numerical catchment models for the Waratah Rivulet and the Woronora River and O'Hares Creek control catchments have been developed using the nationally recognised Australian Water Balance Model (AWBM) (Boughton, 2004). The AWBM is a catchment-scale water balance model that estimates streamflow from rainfall and evaporation.

Metropolitan Coal has recently received updates from the SCA in relation to the flow rating curves, recent gaugings and revised flow data for the Waratah Rivulet and Woronora River gauging stations. A review by Gilbert & Associates has indicated there are significant, systematic discrepancies in flows generated using the SCA's current rating curves for the Waratah Rivulet and Woronora River gauging stations. These discrepancies compromise the existing surface water model calibrations and Metropolitan Coal's ability to confidently assess the performance indicator for quantity of water resources reaching the Woronora Reservoir.

Metropolitan Coal will seek to remedy this situation by regenenerating the current flow records from the Waratah Rivulet and Woronora River gauging stations using amended rating relationships to be developed by Metropolitan Coal which more closely reflect the results of the historical gaugings. Additional gaugings will also be undertaken during specific flow conditions to enable further refinement of the rating relationships at the Waratah Rivulet and Woronora River gauging stations.

As a result of the current flow data discrepancies it is considered inappropriate to use the current flow data in the performance indicator assessment for the quantity of water resources reaching the Woronora Reservoir.

As described in the Metropolitan Coal Catchment Monitoring Program, catchment models will be developed for the Eastern Tributary and Honeysuckle Creek gauging stations once a suitable period of data has been collected.

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), consistent with the monitoring program for Longwalls 20-22.

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.

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. All pools between Pool ETG and ETAQ on the Eastern Tributary are inspected monthly when mining of Longwalls 23-27 is within 400 m of the Eastern Tributary and until subsidence reduces to less than 20 mm/month. Pool ETAU will be inspected monthly when mining is within 400 m of the Eastern Tributary during extraction of Longwall 27.

The pool water level monitoring results for Waratah Rivulet and Woronora River 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 on the Eastern Tributary are discussed in Sections 2.3.2.7 and 8.3.2.

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 levels in Pools RTP1 and RTP2 on Tributary B are shown on Charts 1 and 2. There are no cease-to-flow levels available for pools RTP1 or RTP2 on Tributary B. The recorded water level hydrograph for Pool RTP1 indicates that it flowed continuously over the period of available data including the reporting period. The recorded water level hydrograph for Pool RTP2 indicates that it fell below its 'normal' low flow level, which is assumed to be near its cease-to-flow level between the 23 and the 26 January 2014.

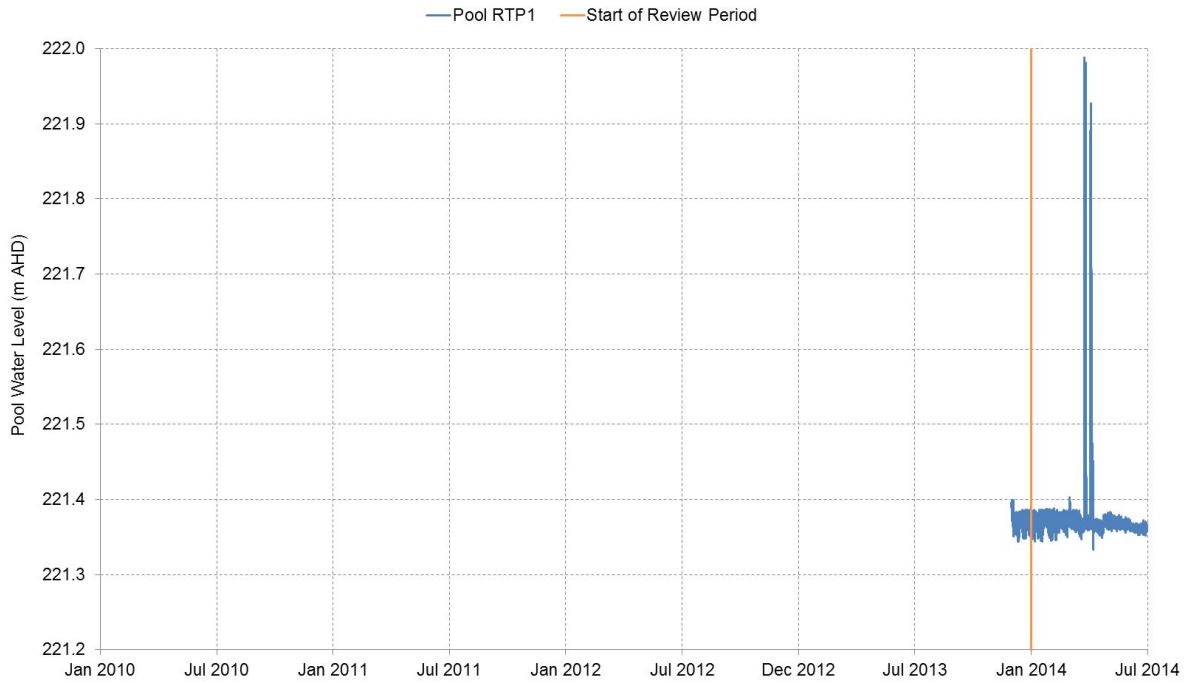


Chart 1 Water Level Hydrograph – Tributary B Pool RTP1

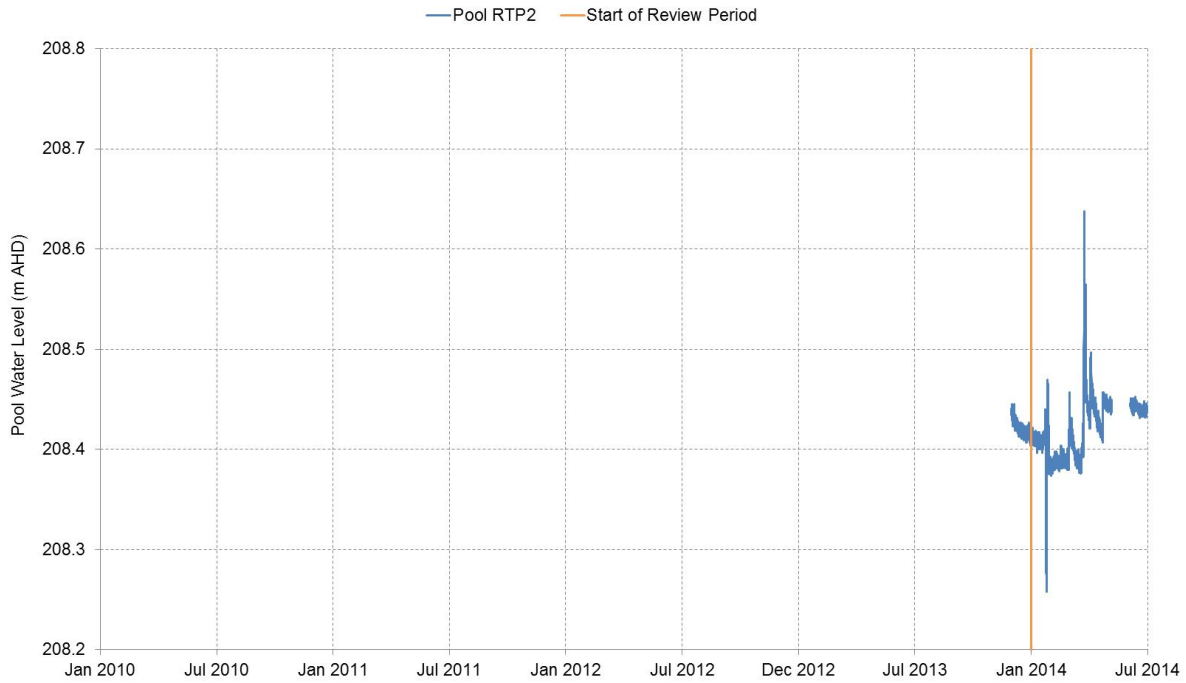


Chart 2 Water Level Hydrograph – Tributary B Pool RTP2

The water levels in Pools ETG, ETJ, ETM, ETU and ETW on the Eastern Tributary are shown on Charts 3 to 7. There was a period during the reporting period when recorded water levels in Pool ETG were below the cease-to-flow level however the sudden fall in water level at the start of this period and subsequent sudden rise at the end of the period make it apparent 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 3). Recorded water levels in Pools ETJ, ETM, ETU and ETW were above the cease-to-flow level during the reporting period (Charts 4 to 7).

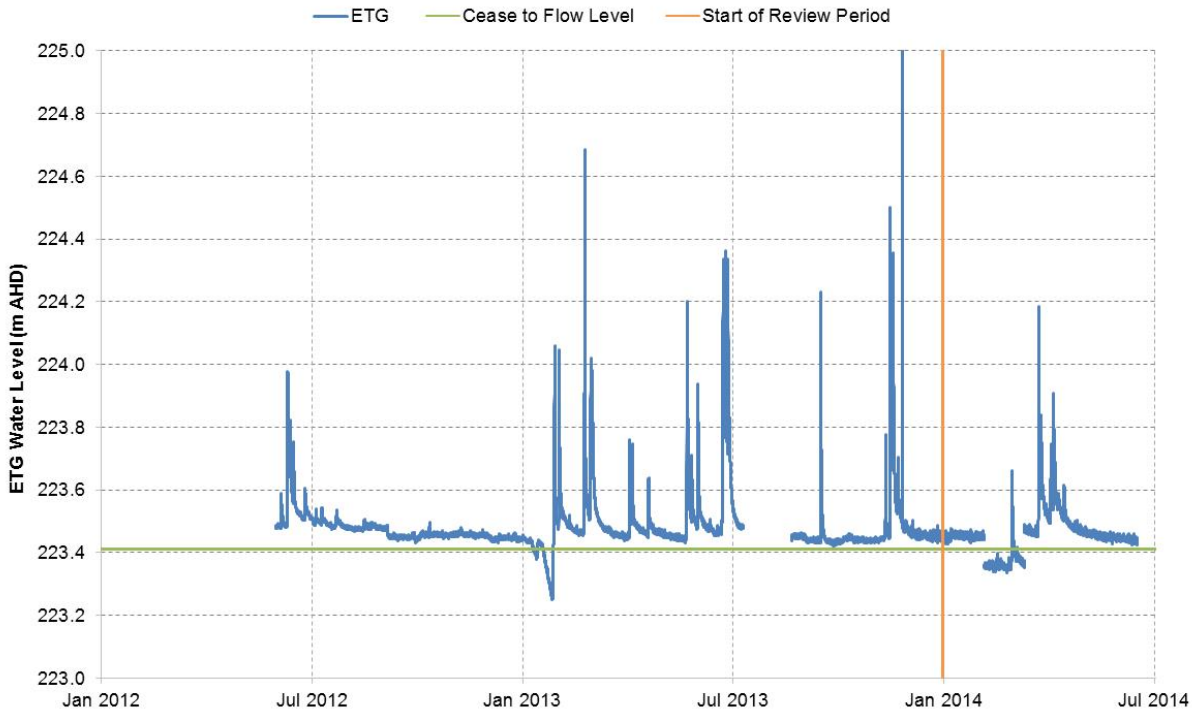


Chart 3 Water Level Hydrograph - Eastern Tributary Pool ETG

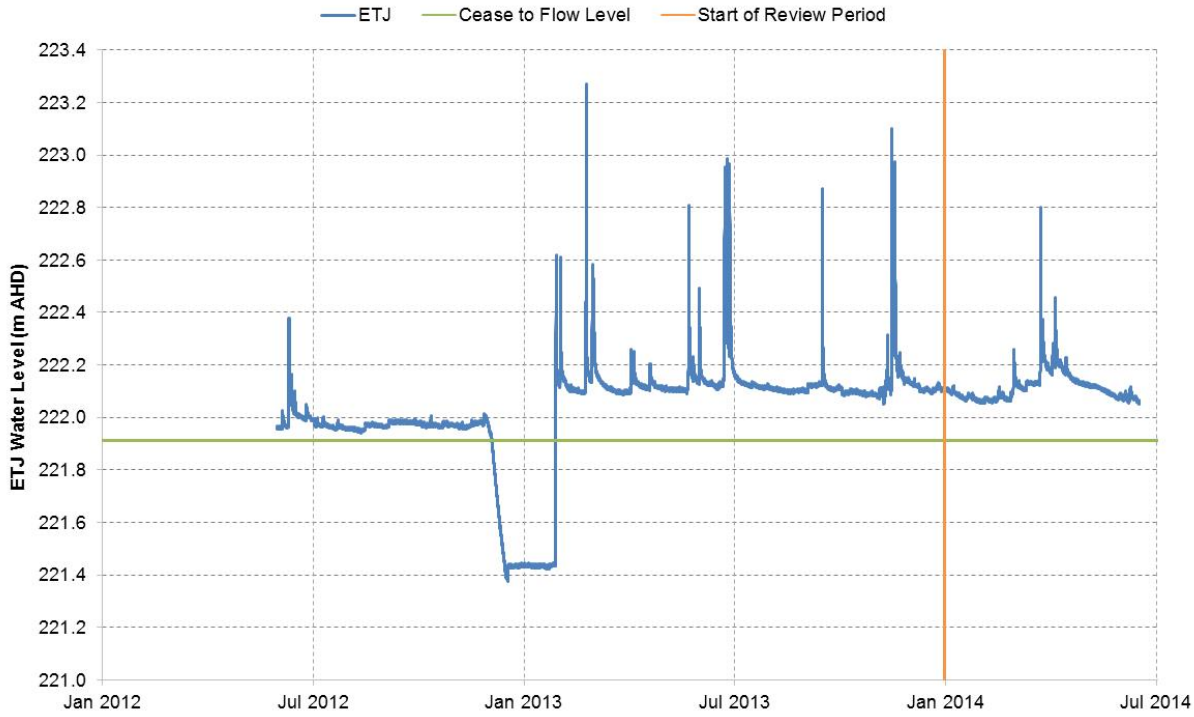


Chart 4 Water Level Hydrograph - Eastern Tributary Pool ETJ

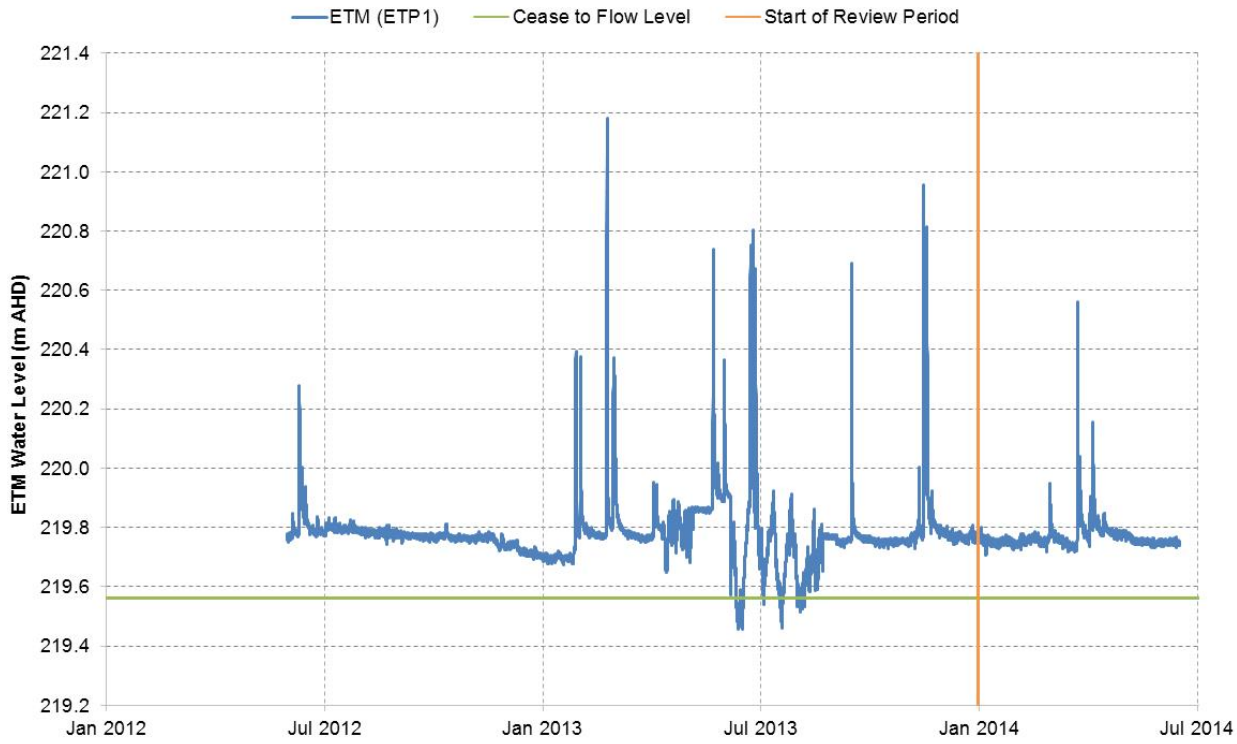


Chart 5 Water Level Hydrograph - Eastern Tributary Pool ETM

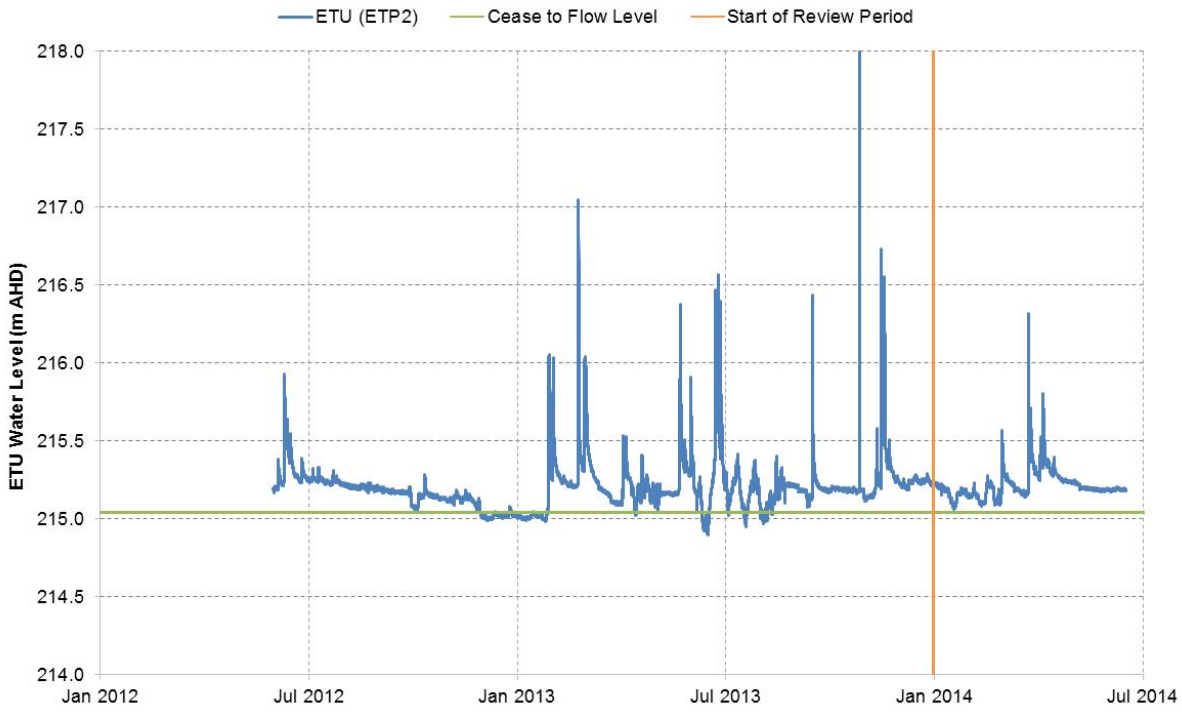


Chart 6 Water Level Hydrograph - Eastern Tributary Pool ETU

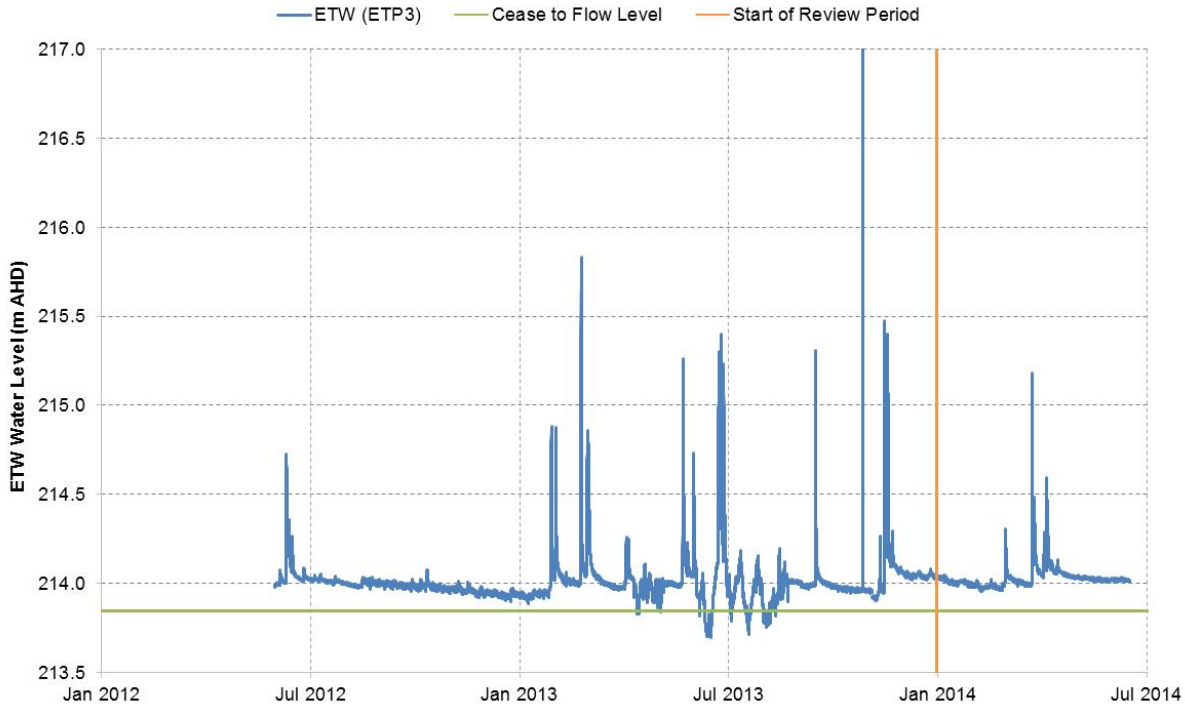


Chart 7 Water Level Hydrograph - Eastern Tributary Pool ETW

2.2.2.4 Stream Water Quality

Surface water quality sampling has been conducted 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 and Longwalls 23-27 Water Management Plans:

- 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 ETWQ2/ETWQ AU[1] on the Eastern Tributary;
- site FEWQ 1 on the Far Eastern Tributary;
- site HCWQ 1 on Honeysuckle Creek;
- site BCWQ 1 along Bee Creek; and
- control sites WOWQ 1 and WOWQ 2 on the Woronora River.

Water quality parameters sampled are the same as those listed for the Longwalls 20-22 stream water quality monitoring described in Section 2.2.1.4.

Unfiltered water quality samples are also collected at a number of sites on the Waratah Rivulet, Eastern Tributary and Woronora River (Figure 6) and analysed for total iron, consistent with surface water quality sampling conducted for Longwalls 20-22.

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 A-1 to A-30 of Appendix A. 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 A-1 to A-30 of Appendix A to show trends over the length of the streams.

With the following three exceptions water quality data over the reporting period has generally been within the normal ranges seen in the historic recorded water quality data:

- pH levels increased from typically slightly acidic values, to near neutral levels at sites on Woronora River, Honeysuckle Creek, Bee Creek and Tributary D. There was one very high pH value (12.3 recorded at WRWQ6 on Waratah Rivulet) which is highly likely to be erroneous given the near neutral values recorded at all other sites on Waratah Rivulet during the reporting period.
- Two relatively elevated dissolved iron concentrations were recorded at site ETWQ N on the Eastern Tributary in April and May 2014.
- The trend of increasing pH and EC at the upstream sampling sites on Tributary B prior to start of the reporting period appear to have plateaued. Dissolved manganese at these sites appears to be trending upward relative to the historical concentrations but still remain relatively low.

[1] The Metropolitan Coal Longwalls 20-22 Water Management Plan refers to site ETWQ2, while the Metropolitan Coal Longwalls 23-27 Water Management Plan refers to site ETWQ AU. They are the same site, as shown on Figure 6.

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 SCA in accordance with a data exchange agreement.

Results of the analysis of this data are presented in Section 2.3.2.5.

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, site RTGW1A on Tributary B, 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 8 and are compared with rainfall events and rainfall trends over a period of six 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. Water levels recovered by about 0.5 m at the end of 2012 but fell again slightly (by about 0.3 m) when the Longwall 22A face was closest to the monitoring sites (at a distance of approximately 500 m). Since then, the water levels at sites WRGW1 and WRGW2 have correlated closely with rainfall trends indicated by the residual mass curve (Chart 8).

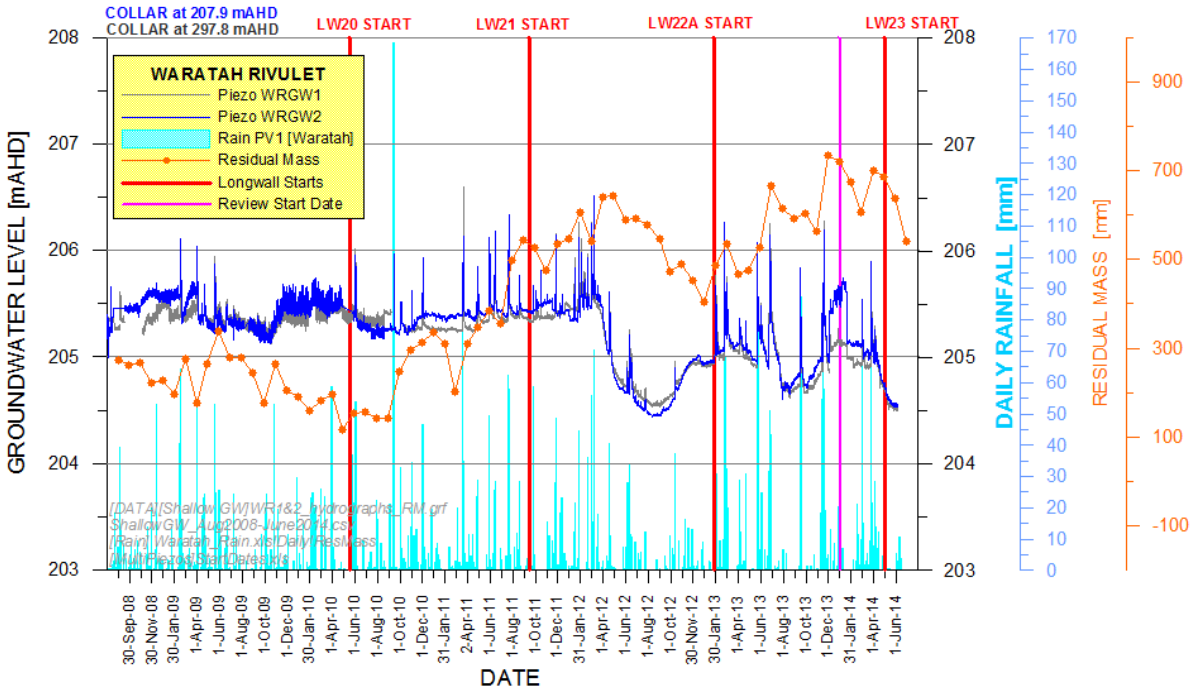
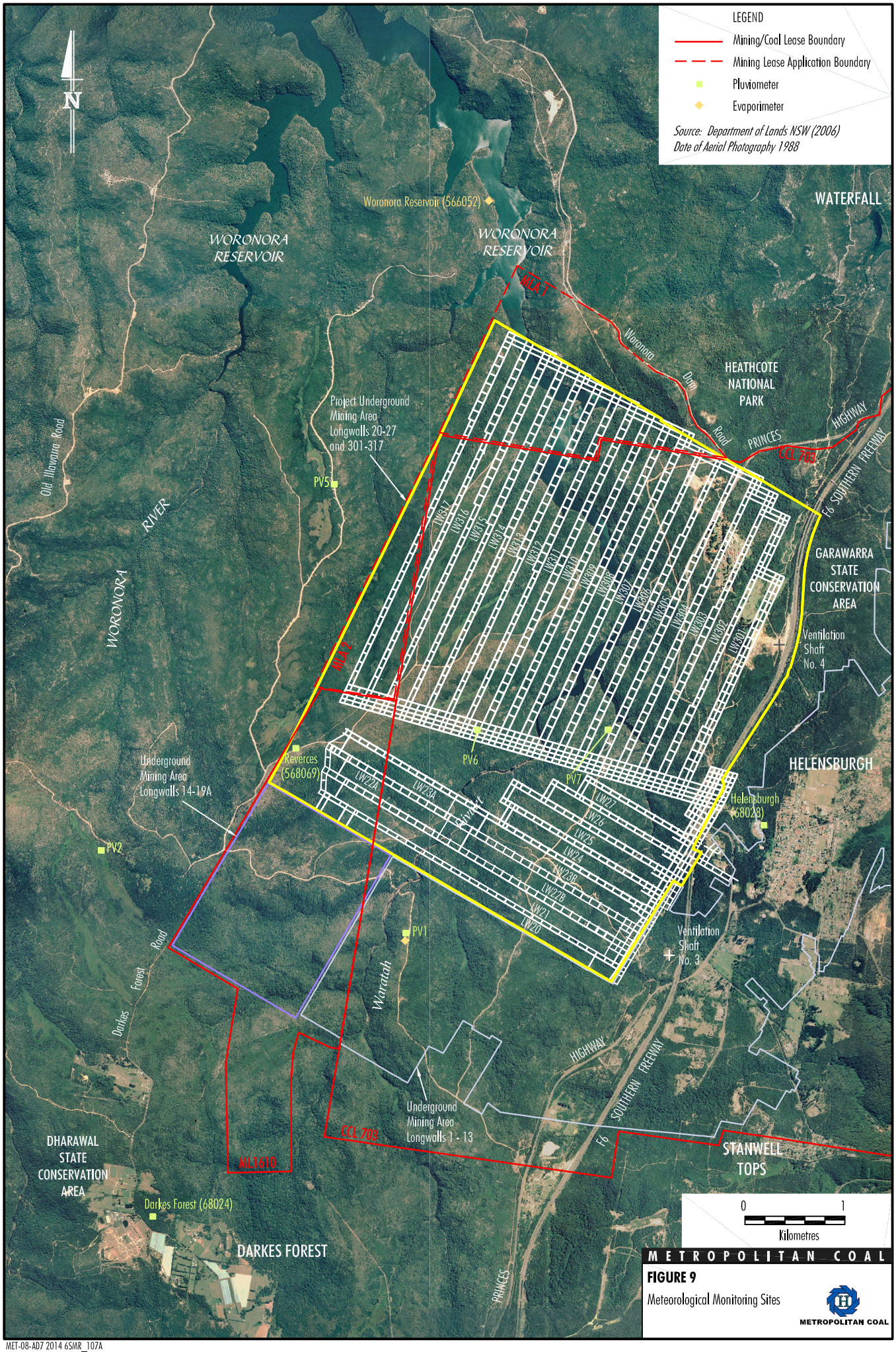


Chart 8 Shallow Groundwater Hydrographs on Waratah Rivulet at WRGW1 and WRGW2



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The shallow groundwater level data that is available for Site WRGW7 on the Waratah Rivulet (Chart 9) 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.

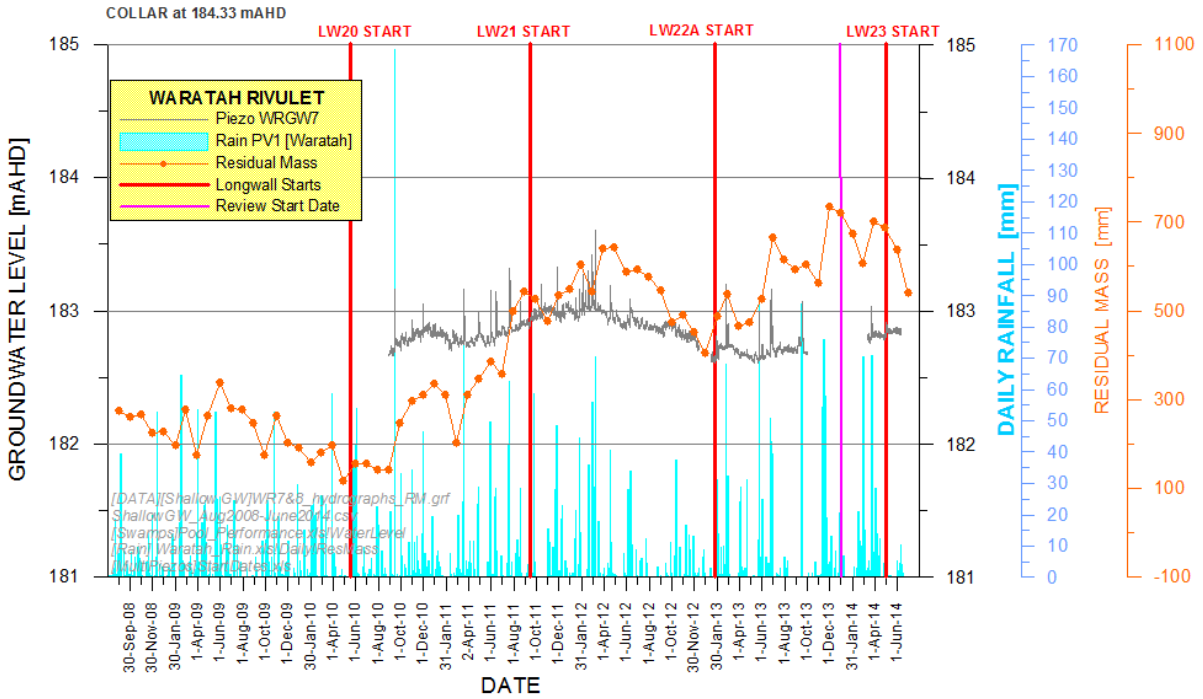


Chart 9 Shallow Groundwater Hydrograph on Waratah Rivulet at WRGW7

Site RTGW1A is located over Longwall 22A. Longwall 22A passed site RTGW1A in May 2013. Around this time the groundwater levels dropped approximately 4 m lower than experienced in the preceding dry period throughout 2012 (Chart 10) as a result of mining.

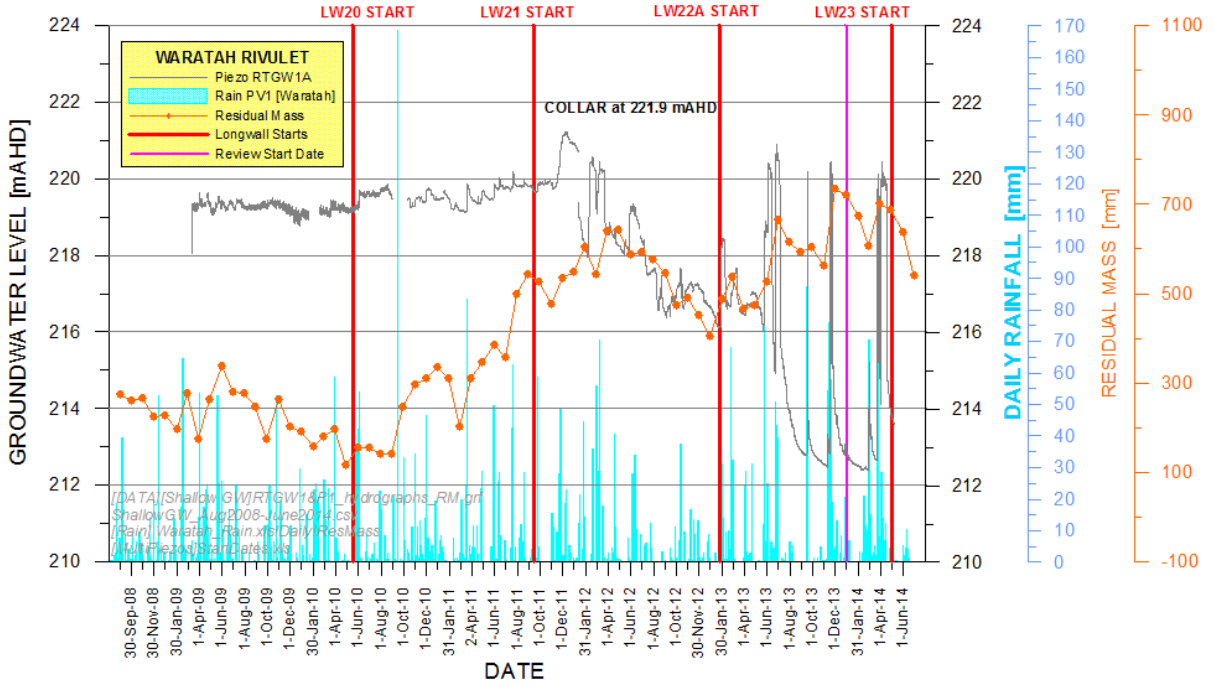


Chart 10 Shallow Groundwater Hydrograph on Tributary B at RTGW1A

At the Eastern Tributary sites ETGW1 and ETGW2, which are located approximately 1.4 km downstream of Longwall 23, shallow groundwater levels follow the rainfall trends closely (Chart 11). The variations at these sites are unrelated to mining.

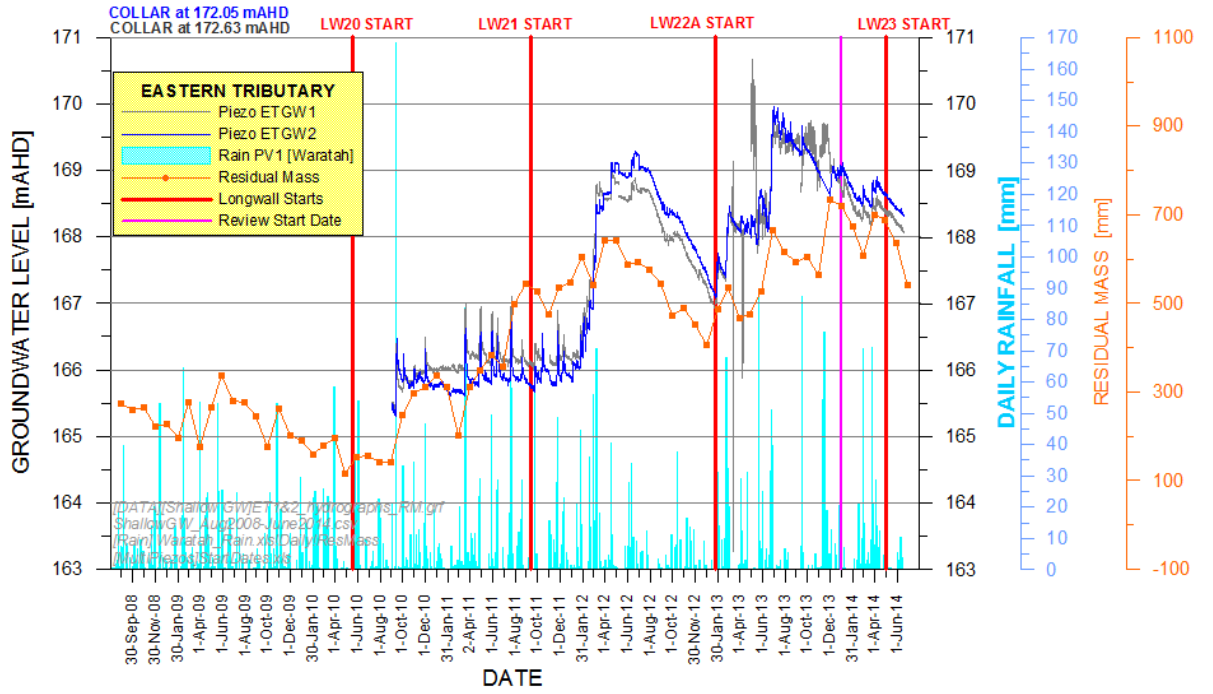


Chart 11 Shallow Groundwater Hydrograph on Eastern Tributary at ETGW1 and ETGW2

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 and PM02 (Figure 7), in accordance with the Longwalls 20-22 Water Management Plan and additional bores PM01, 9EGW2A, PM03, PHGW1B, PHGW2A, F6GW3 and F6GW4 in accordance with the Longwalls 23-27 Water Management Plan (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 12 to 25), 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 Environmental Assessment (EA).

The monitoring sites closest to Longwalls 20-22 are bore 9FGW1A (approximately 600 m west of Longwall 22A) and standpipe bore 9GGW1-80 (above Longwall 22B; replacing 9GGW1B) (Figure 7). The 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).

The time-series record for bore 9FGW1A is shown on Chart 14. The two deepest piezometers (491 m in Wombarra Claystone; 513 m in Bulli Coal seam) had been slow to stabilise but are now generally stable. As the Bulli Seam piezometer has a substantial pressure head of about 300 m, it is likely that the influence of mining on groundwater pressures has stabilised.

The time-series record for standpipe 9GGW1-80 is shown on Chart 15 and is compared with the shallowest piezometer readings for decommissioned bore 9GGW1B[2] (set at 60 m). As the standpipe is open, the water level in the hole is a composite of the heads from the water table down to 80 m depth. As head is expected to decline with depth through the Hawkesbury Sandstone, the reading in 9GGW1-80 should be lower than the actual water table. Due to fluctuations of over 20 m in the standpipe so far, a longer data record is necessary to clarify the contributions of rainfall and possibly mining to the groundwater response at this site.

The time-series record for bore 9EGW1B is shown on Chart 13. This shows stable heads that decline with depth. As the deepest piezometer (542 m in Coal Cliff Sandstone) retains about 360 m pressure head, no significant mining effect is evident apart from far-field depressurisation.

The time-series record for bore 9GGW2B is shown on Chart 16. Gradual depressurisation is evident only in the two deepest piezometers (437 m in Wombarra Claystone; 474 m in Bulli Coal seam). The deepest piezometer retains about 180 m pressure head.

[2] The NSW Department of Trade and Investment (Division of Resources and Energy, Minerals and Petroleum) directed that this bore be decommissioned because the electrical conduit connecting the goaf with the land surface is considered a lightning risk, the hazard being ignition of gas within the goaf. The hole was decommissioned by drilling down into the casing to 15 m depth and backfilling with cement.

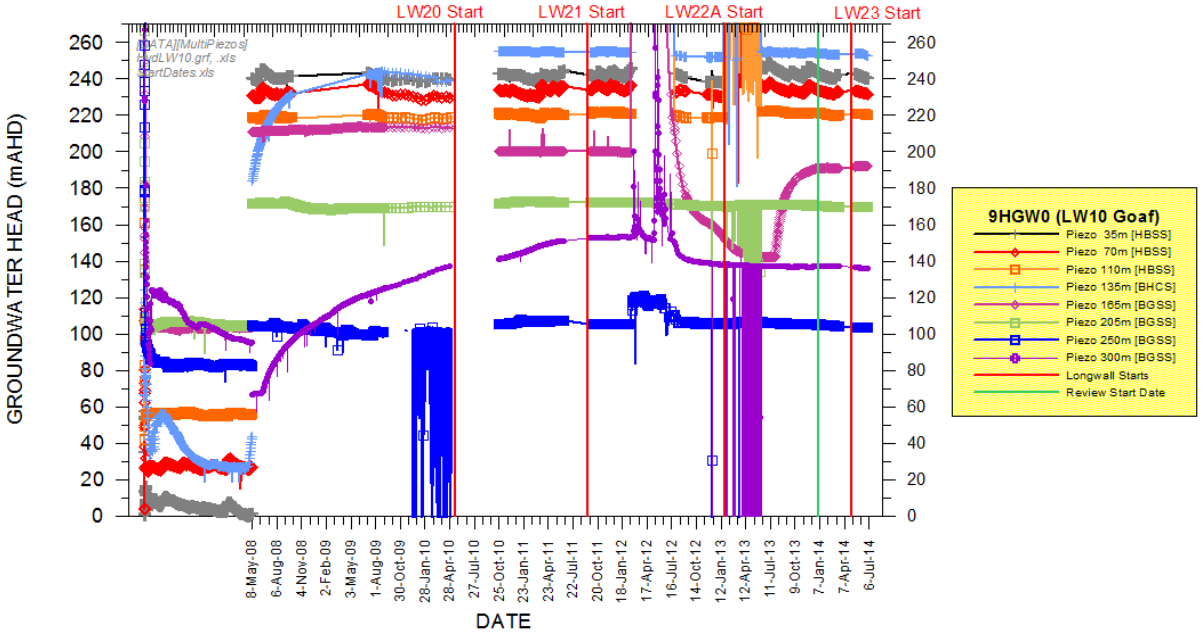


Chart 12 Time Variations in Potentiometric Heads at 9HGW0

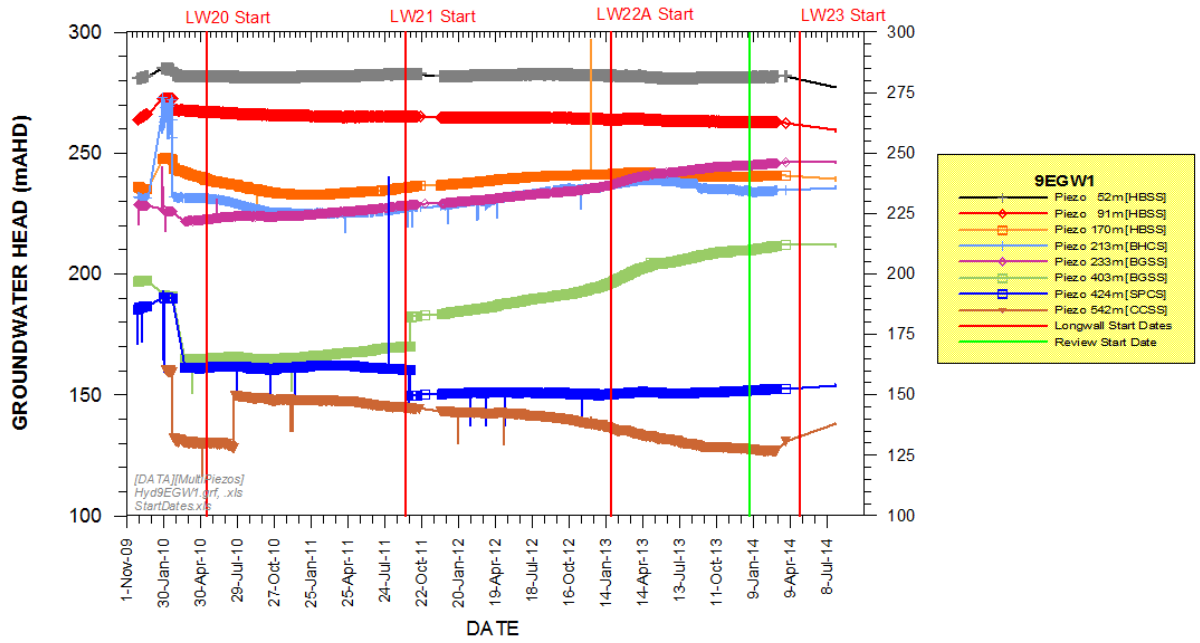


Chart 13 Time Variations in Potentiometric Heads at 9EGW1B

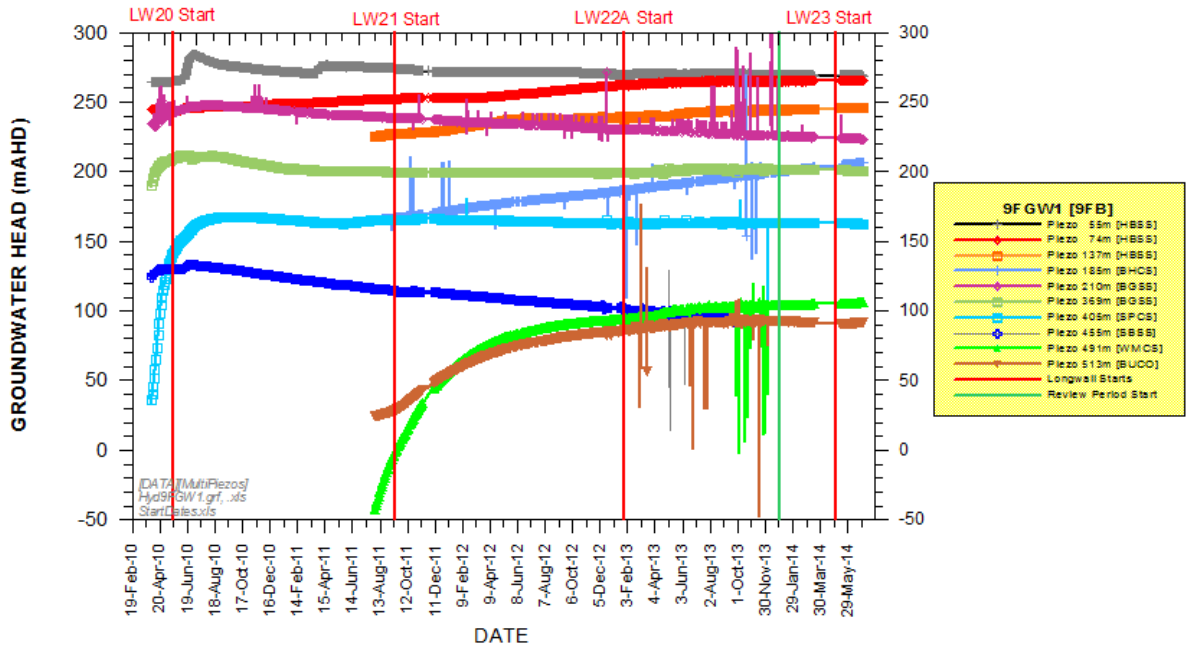


Chart 14 Time Variations in Potentiometric Heads at 9FGW1A

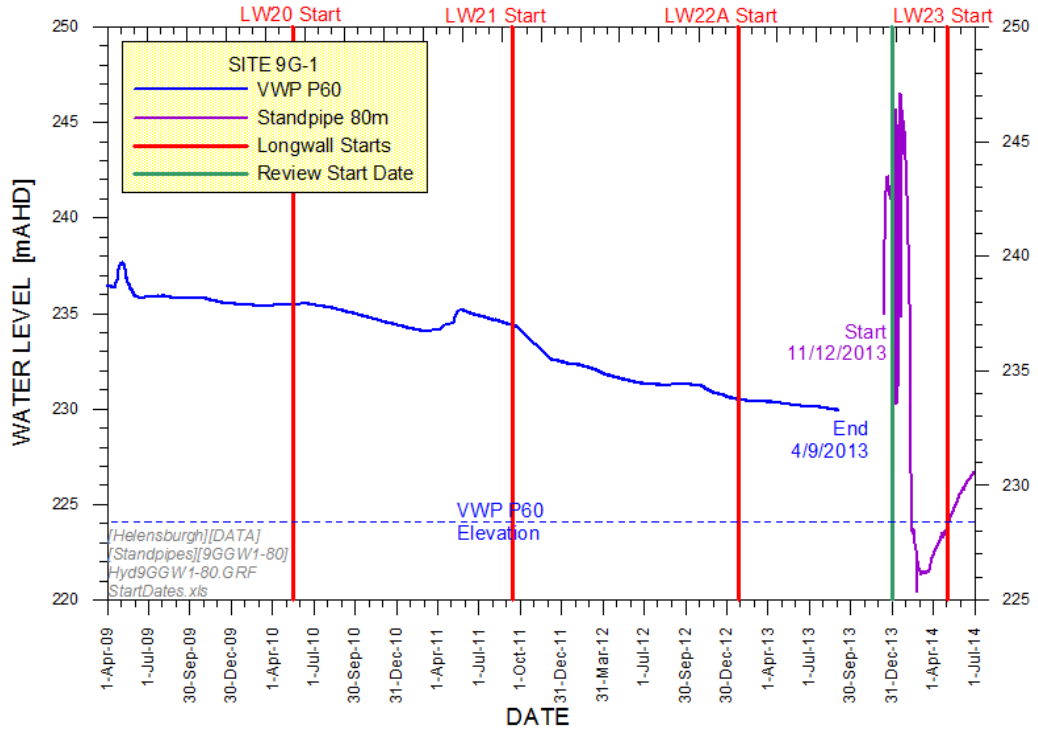


Chart 15 Time Variations in Water Table at Standpipe 9GGW1-80 and Decommissioned Vibrating Wire Piezometer 9GGW1-60

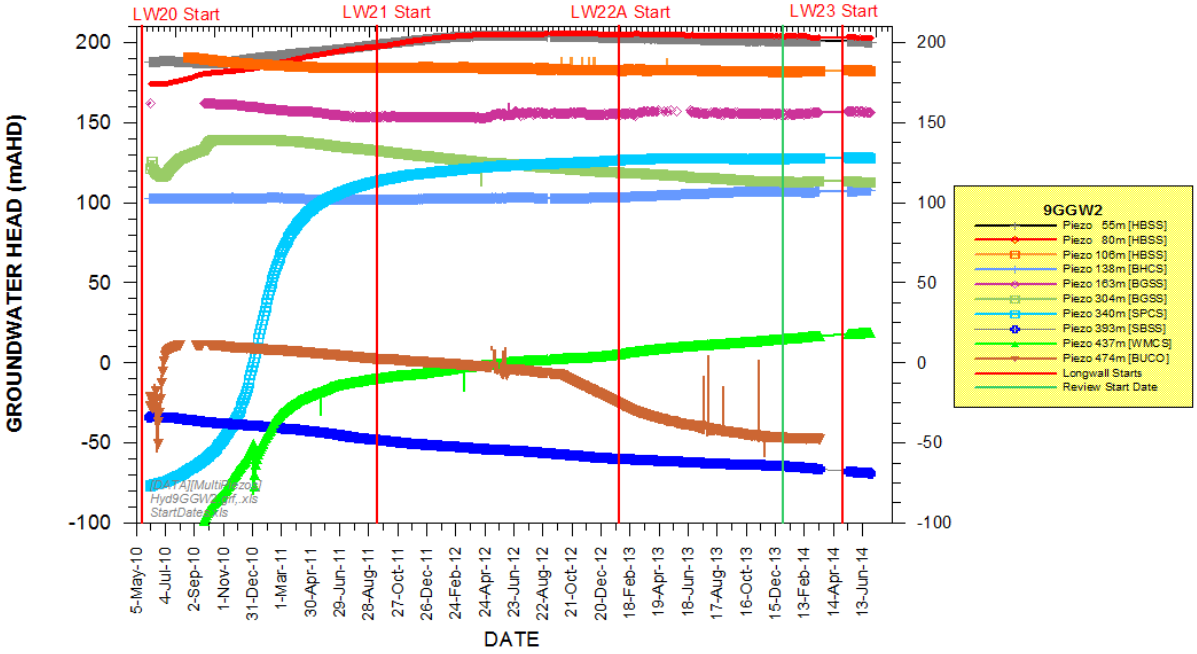


Chart 16 Time Variations in Potentiometric Heads at 9GGW2B

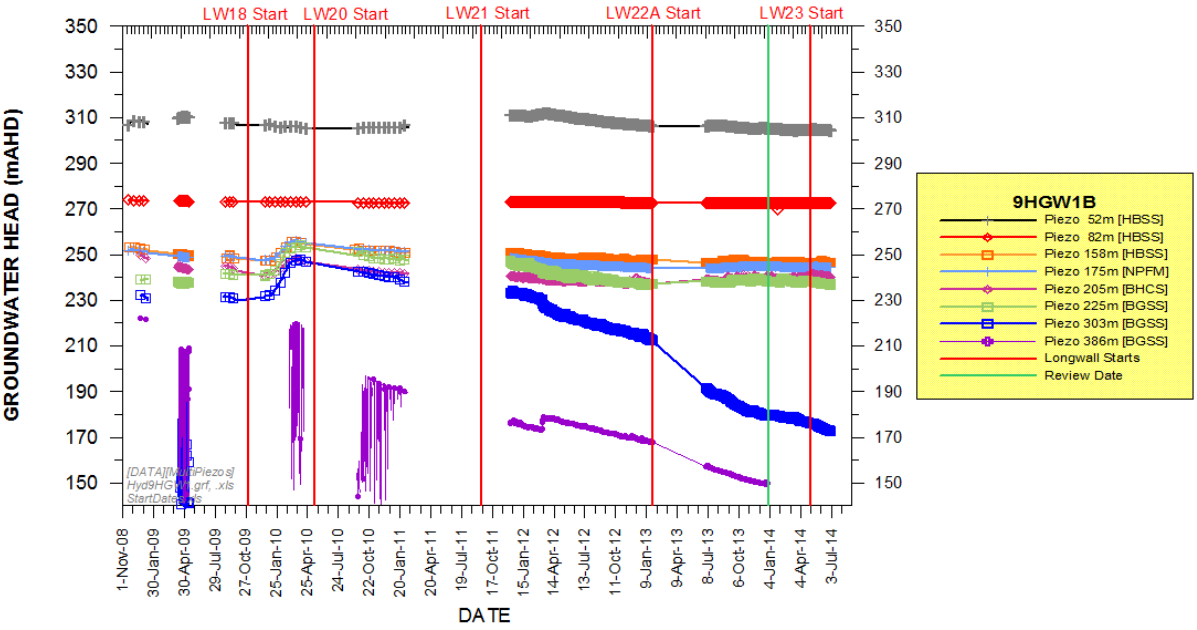


Chart 17 Time Variations in Potentiometric Heads at 9HGW1B

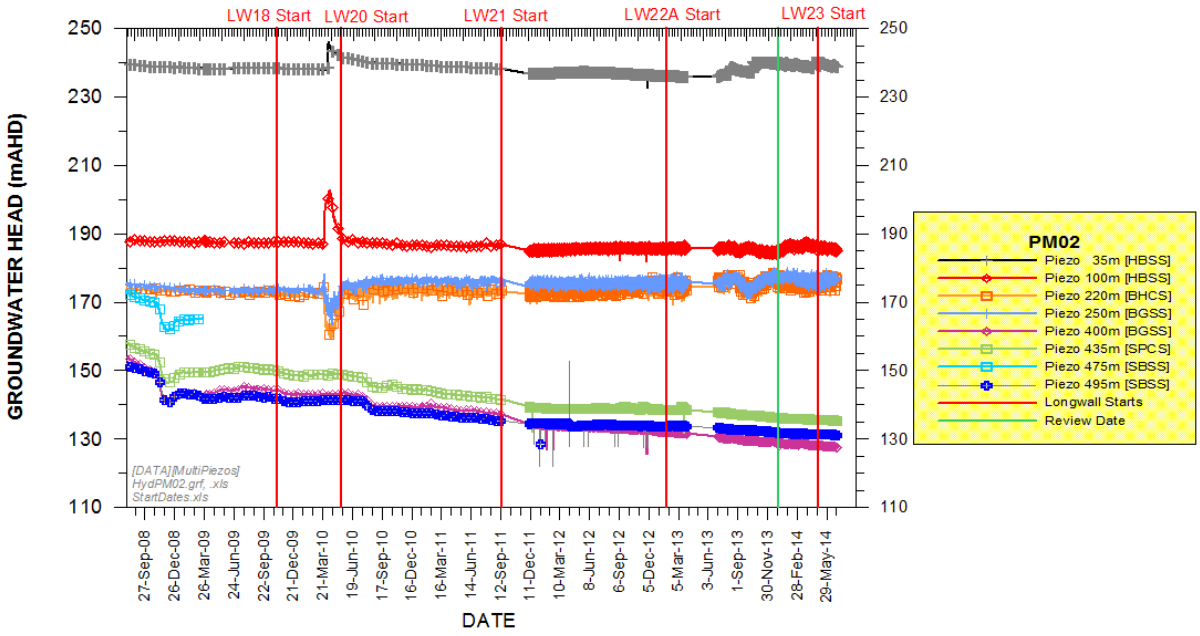


Chart 18 Time Variations in Potentiometric Heads at PM02

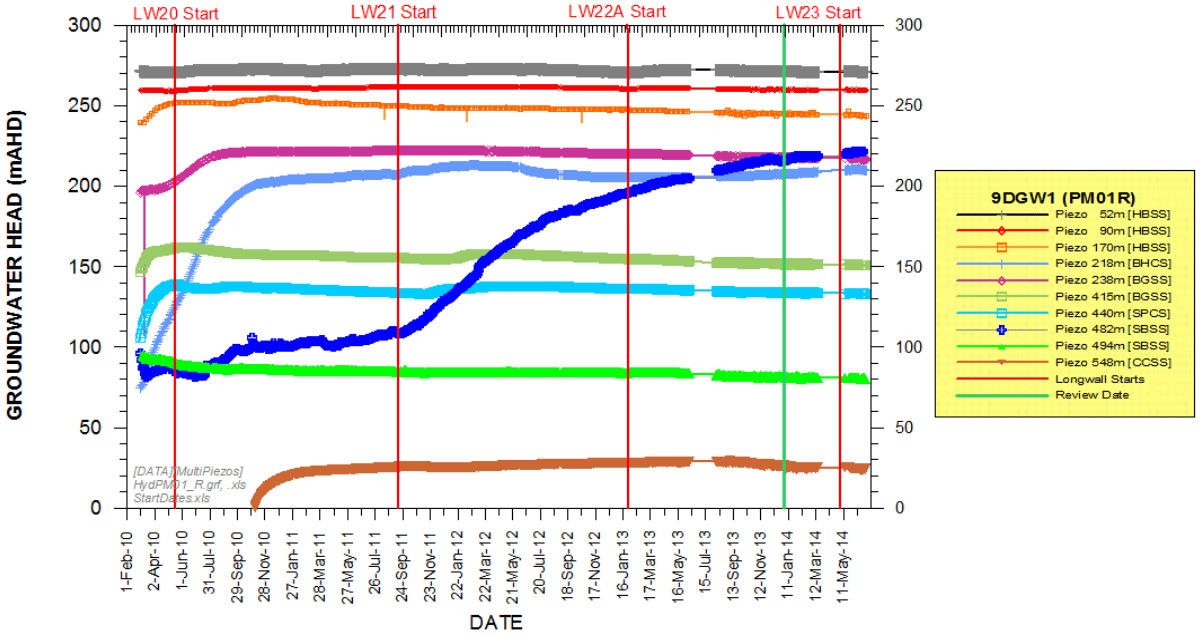


Chart 19 Time Variations in Potentiometric Heads at PM01

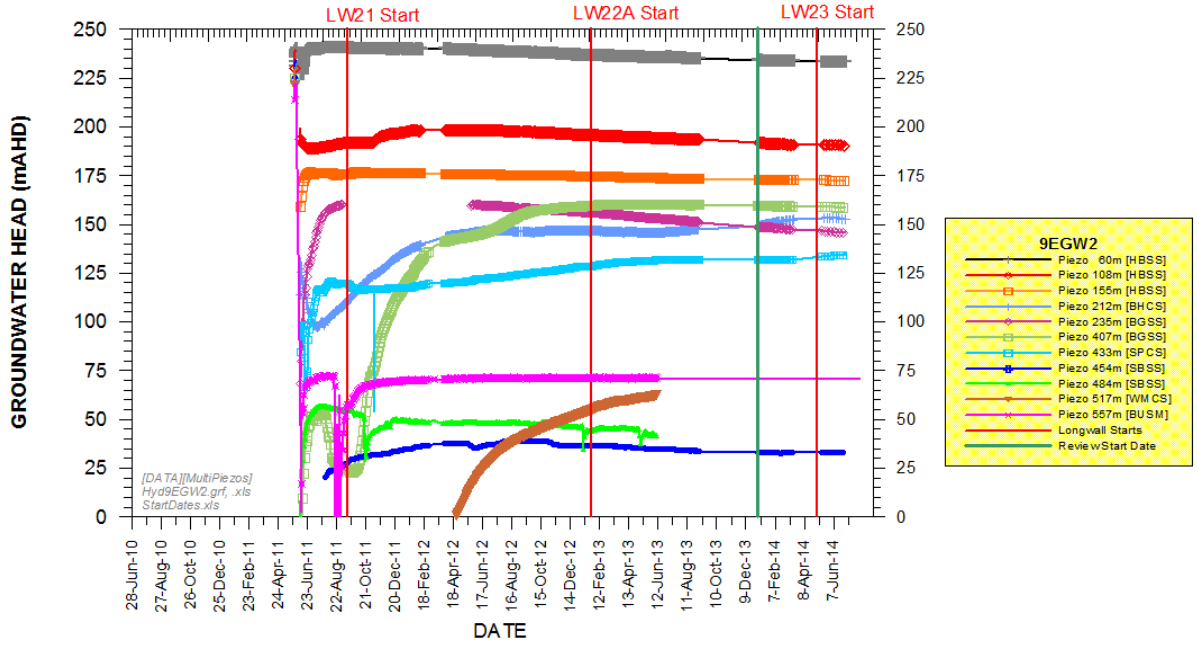


Chart 20 Time Variations in Potentiometric Heads at 9EGW2A

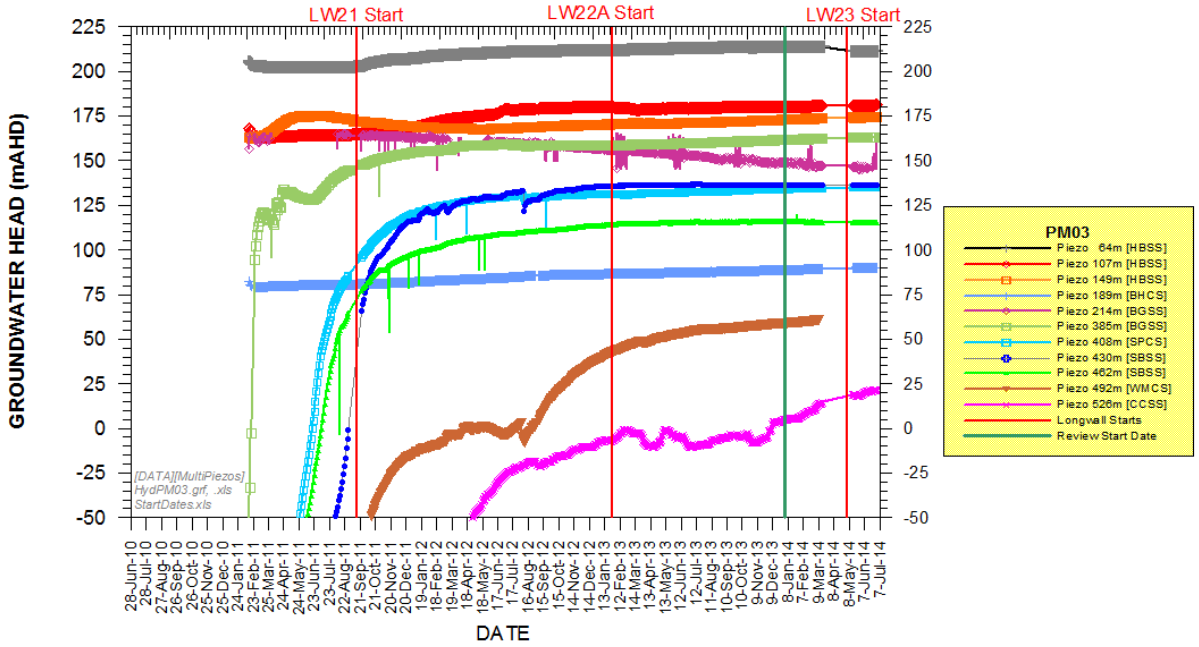


Chart 21 Time Variations in Potentiometric Heads at PM03

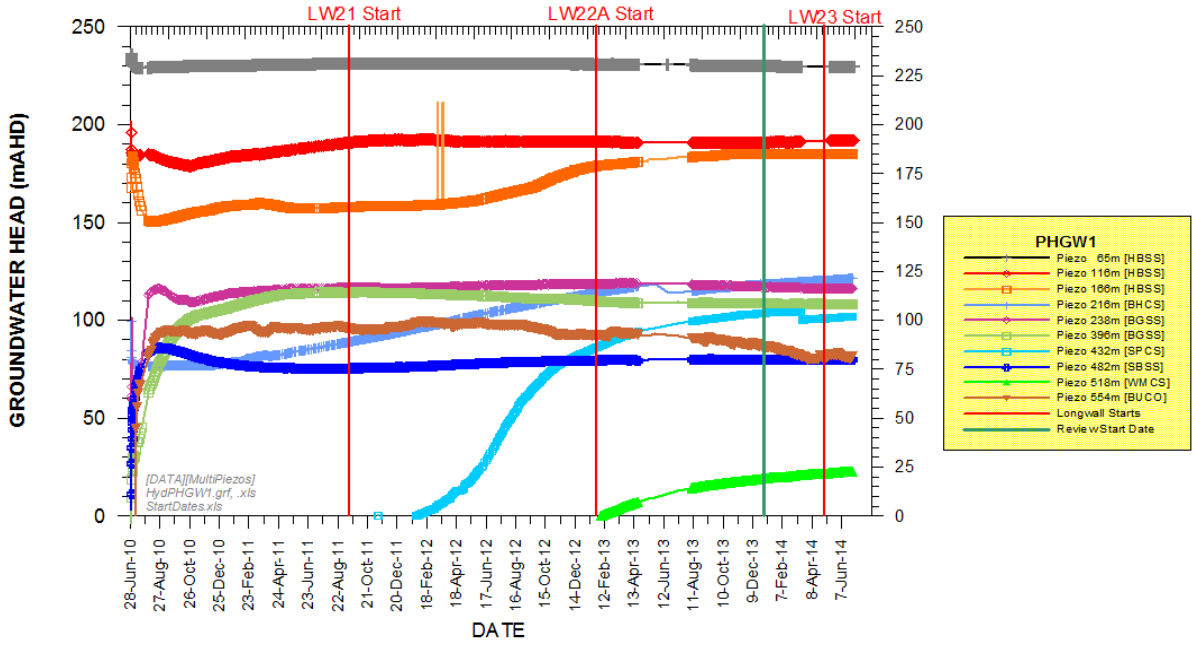


Chart 22 Time Variations in Potentiometric Heads at PHGW1B

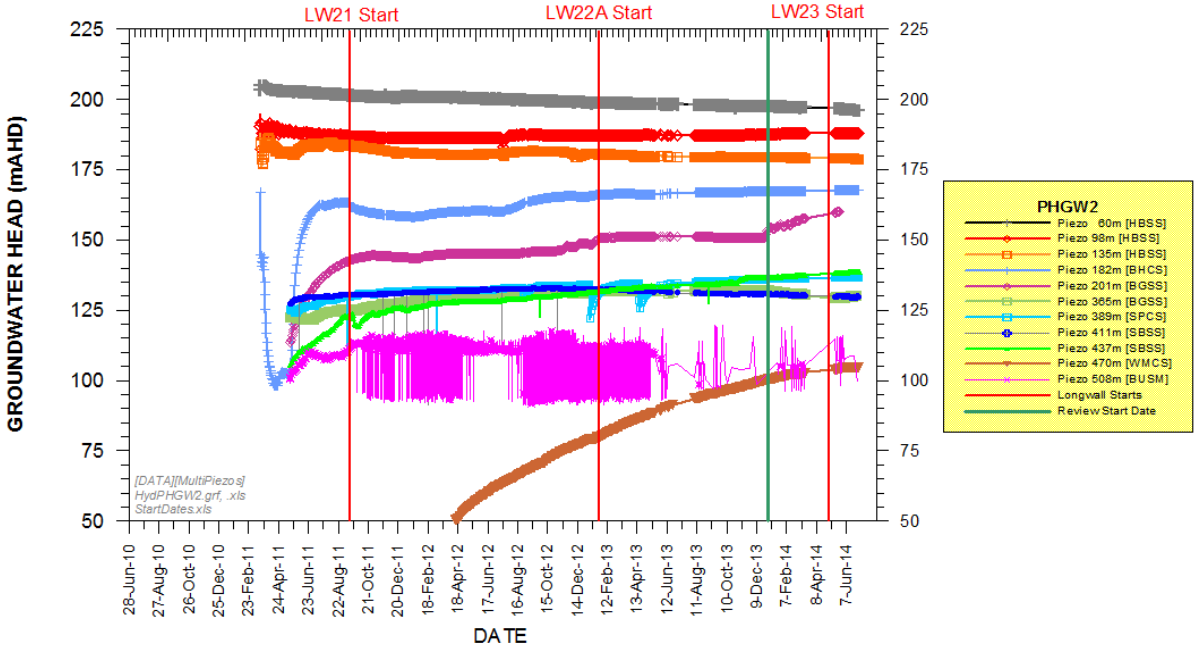


Chart 23 Time Variations in Potentiometric Heads at PHGW2A

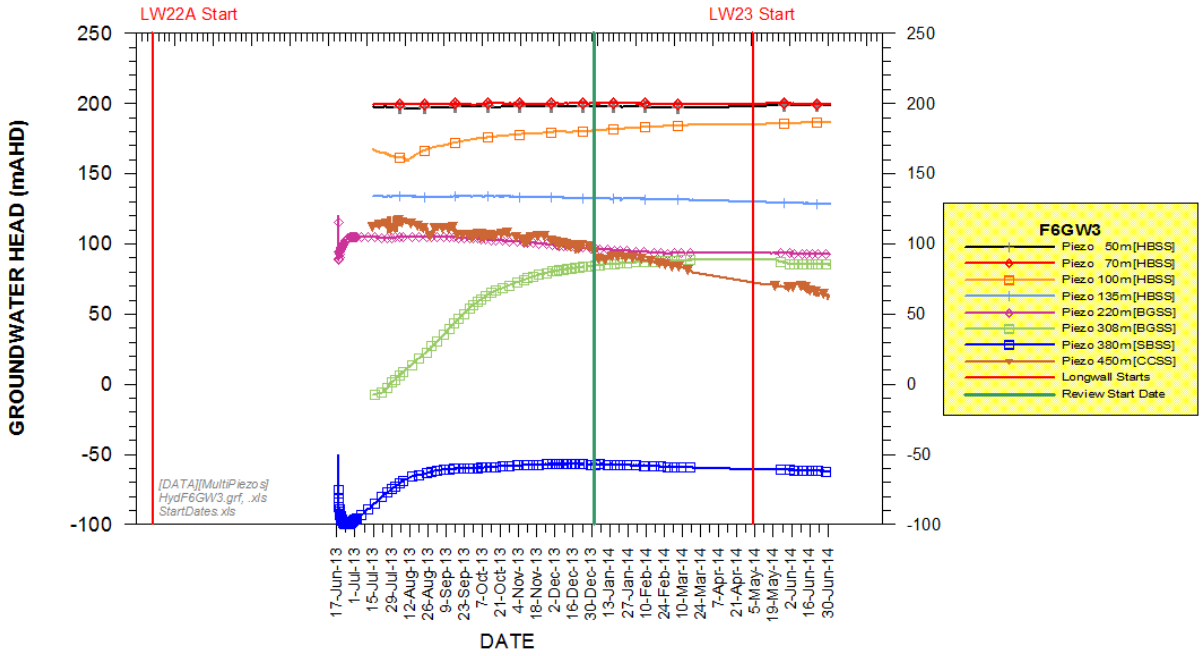


Chart 24 Time Variations in Potentiometric Heads at F6GW3

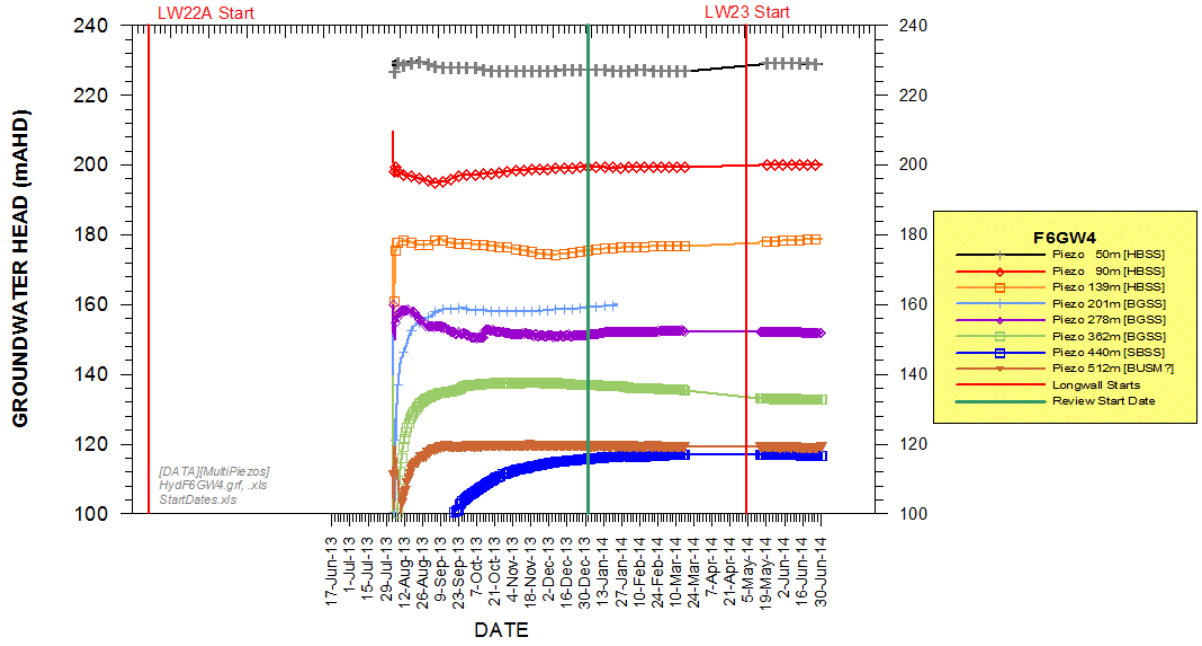


Chart 25 Time Variations in Potentiometric Heads at F6GW4

2.2.2.9 Groundwater Quality

The results of shallow groundwater quality monitoring at sites WRGW1, WRGW2 and WRGW7 along the Waratah Rivulet, site RTGW1A adjacent to Tributary B, and sites ETGW1 and ETGW2 on the Eastern Tributary (Figure 8) are described for the reporting period 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 26 to 28. Monitoring results for sites WRGW3 to WRGW6 are also shown on Charts 26 to 28 to show trends over the length of the Waratah Rivulet. Rainfall events over a period of six 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 at which peak Fe concentrations of 12 mg/L occurred at WRGW1 and WRGW2 in the reporting period.
- Mn concentrations are always less than 1 mg/L. Although the natural fluctuations are large within this range, there is no evidence of systematic trends at any site.
- 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.
- Fe and Mn concentrations increase with distance downstream to WRGW1 and WRGW2 and then decrease (relative to sites WRGW1 and WRGW2) with distance downstream to WRGW7.
- Aluminium was below the detection limit in all samples.
- There is no evidence of irregular behaviour during the mining of Longwall 22 (from January 2013) or Longwall 23A (from May 2014).

The observations are consistent with those reported previously.

Site RTGW1A on Tributary B (over Longwall 22A) is sampled monthly for groundwater quality. To provide context for the monitoring results at site RTGW1A, comparison has been made with the upgradient groundwater quality monitoring site SWGW1 (west of Longwall 18), positioned in shallow Hawkesbury Sandstone (Figure 8). Groundwater quality at both sites is shown on Charts 29 to 31 for Fe, Mn and pH. Rainfall events over a period of six years, as recorded at the Waratah Rivulet catchment PV1 pluviometer (Figure 9), provide context for the moderate fluctuations in parameters; however, there is no obvious relationship with rainfall.

Prior to January 2012, Fe concentrations at site RTGW1A were generally below 1.5 mg/L, with one isolated value of 5.8 mg/L in October 2009. Longwall 21 passed adjacent to site RTGW1A in November 2011 and Longwall 22A passed beneath the site in May 2013. Since January 2012, iron and manganese concentrations have increased to peak levels of 12 mg/L and 0.55 mg/L, respectively (Charts 29 and 30). At the upland swamp site SWGW1, the Fe concentration did not exceed 0.22 mg/L over the same period and the Mn concentrations were always below 0.3 mg/L (Charts 29 and 30). Aluminium was below the detection limit in all samples. The groundwater at the upland swamp (site SWGW1) is acidic, generally between pH 3.5 and pH 5, while the groundwater at site RTGW1A is close to neutral (pH typically from pH 6 to 7) (Chart 31).

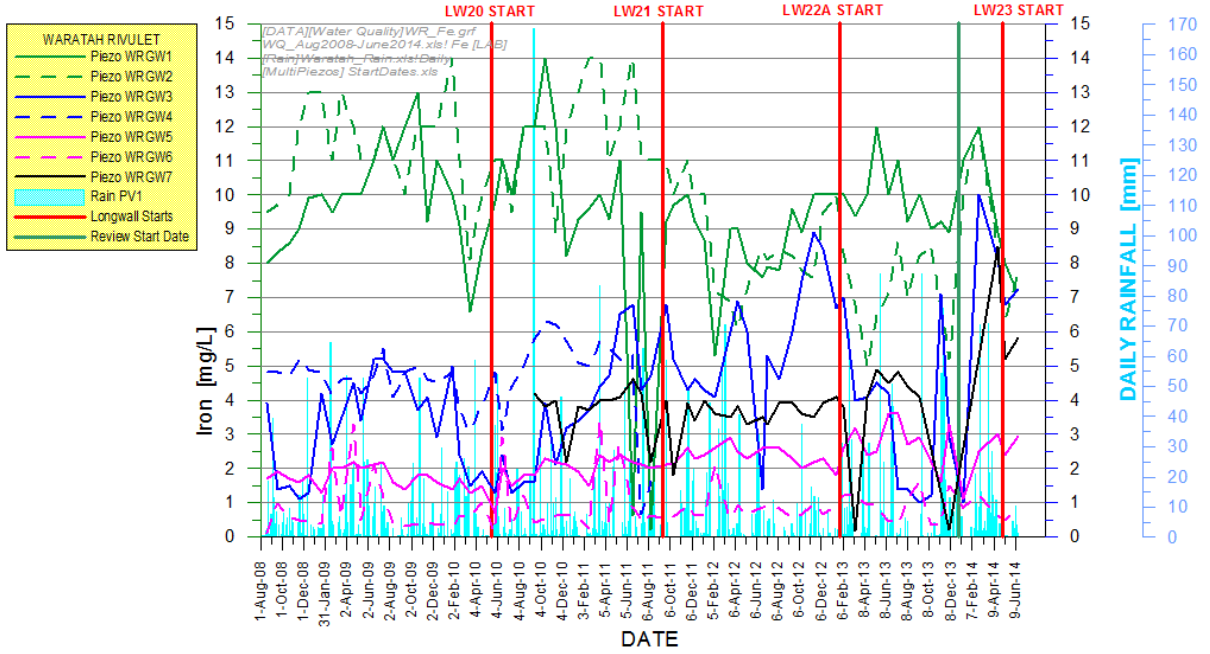


Chart 26 Iron Concentrations at WRGW1 to WRGW7

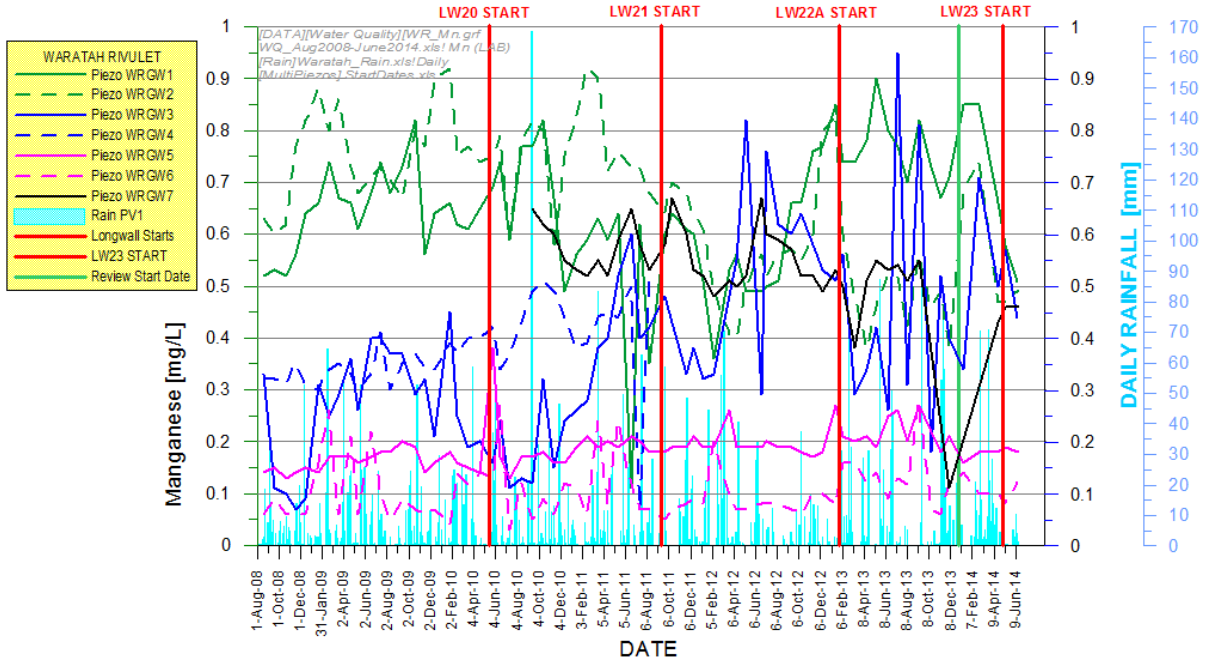


Chart 27 Manganese Concentrations at WRGW1 to WRGW7

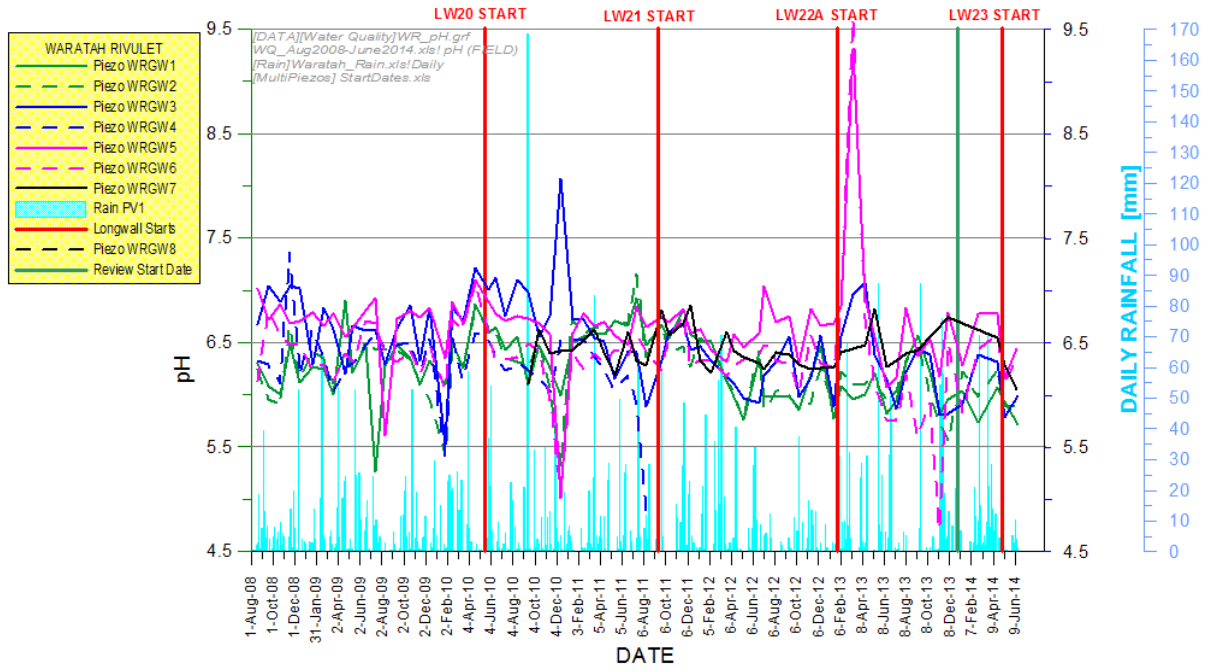


Chart 28 pH Levels at WRGW1 to WRGW7

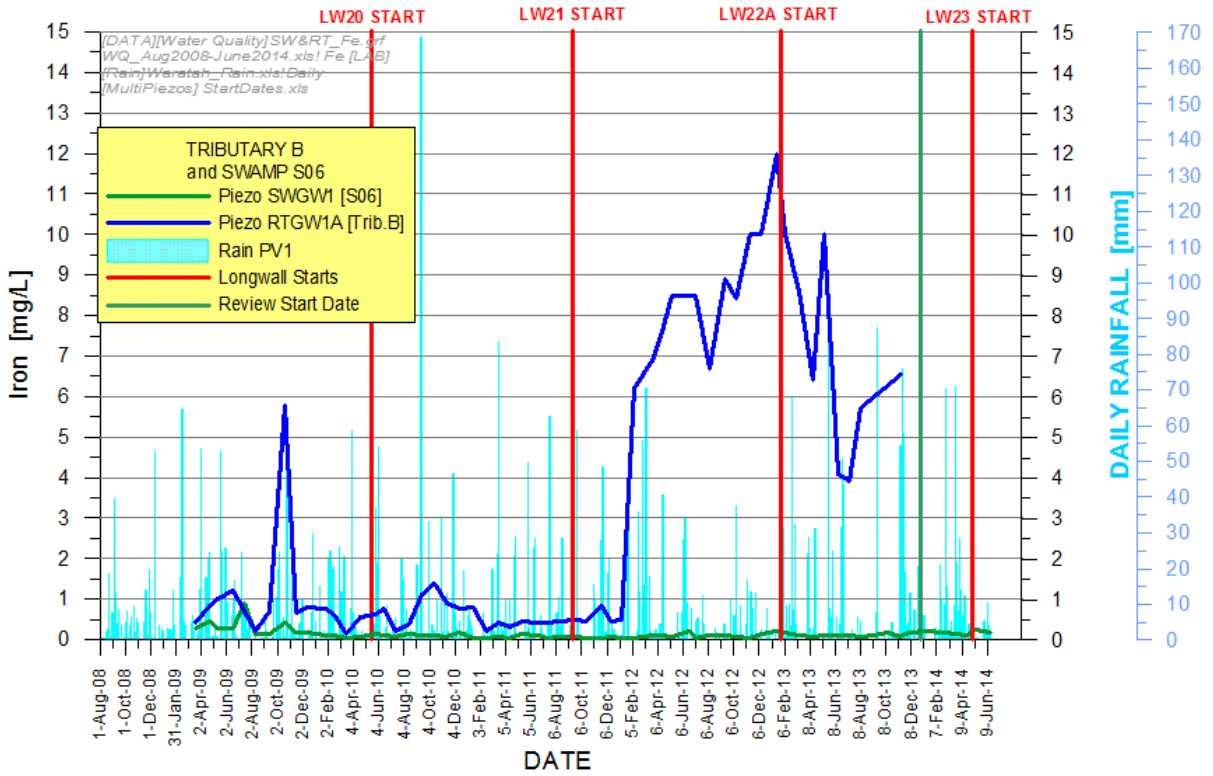


Chart 29 Iron Concentrations at RTGW1A and SWGW1

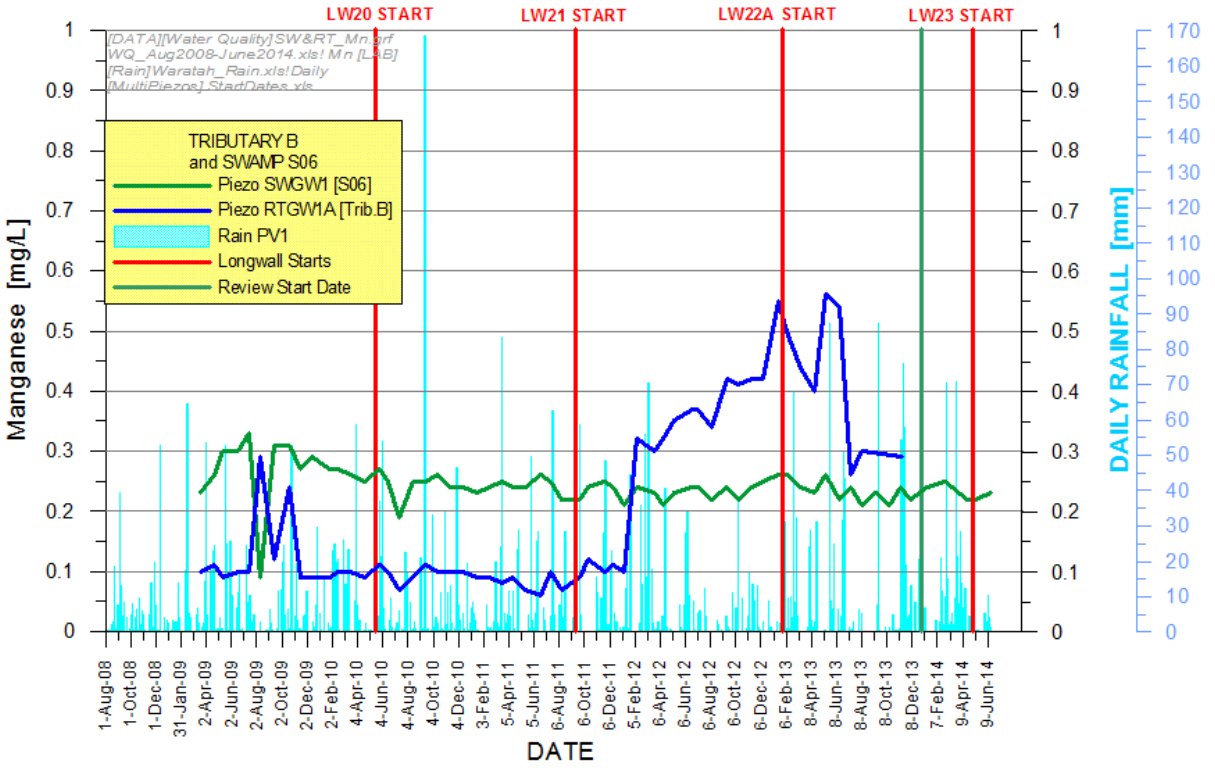


Chart 30 Manganese Concentrations at RTGW1A and SWGW1

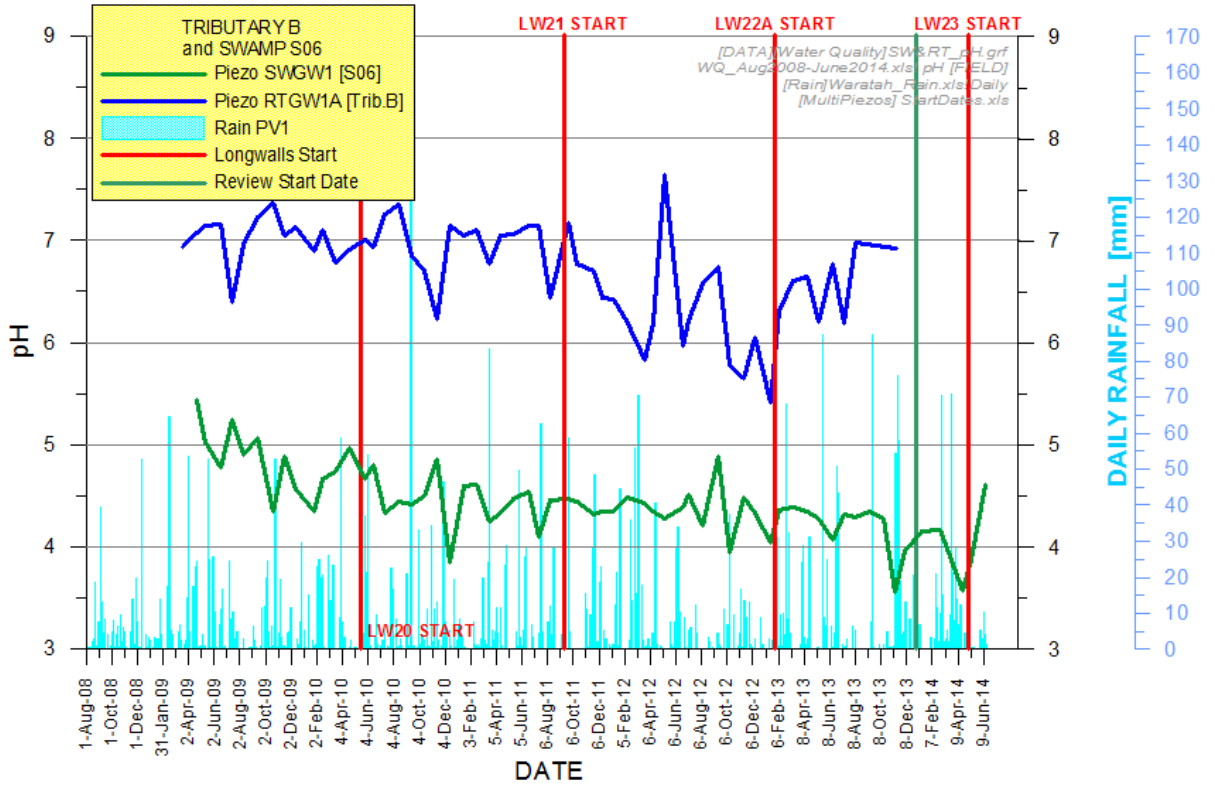


Chart 31 pH Levels at RTGW1A and SWGW1

Groundwater quality at the two Eastern Tributary sites (ETGW1, ETGW2) is shown on Charts 32 to 34 for Fe, Mn and pH, respectively. Rainfall events over a period of six 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 in the reporting period. Mn concentrations are low at both sites, and have ranged between 0.47 and 0.60 mg/L in the reporting period. Al was below the detection limit in all samples. The groundwater is generally acidic, between pH 5.5 and pH 6. There is no systematic temporal pattern for any analyte, and neither site shows any irregularities due to the mining of Longwall 22 (from January 2013) or Longwall 23A (from May 2014).

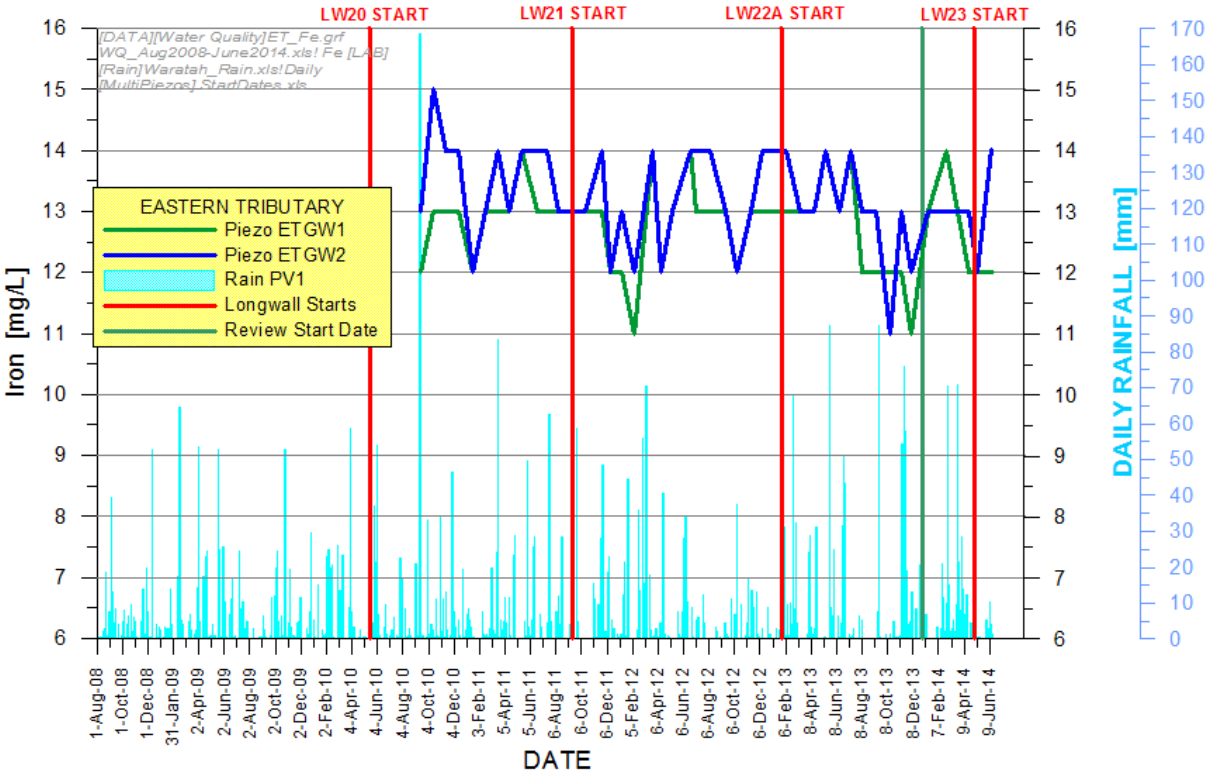


Chart 32 Iron Concentrations at ETGW1 and ETGW2

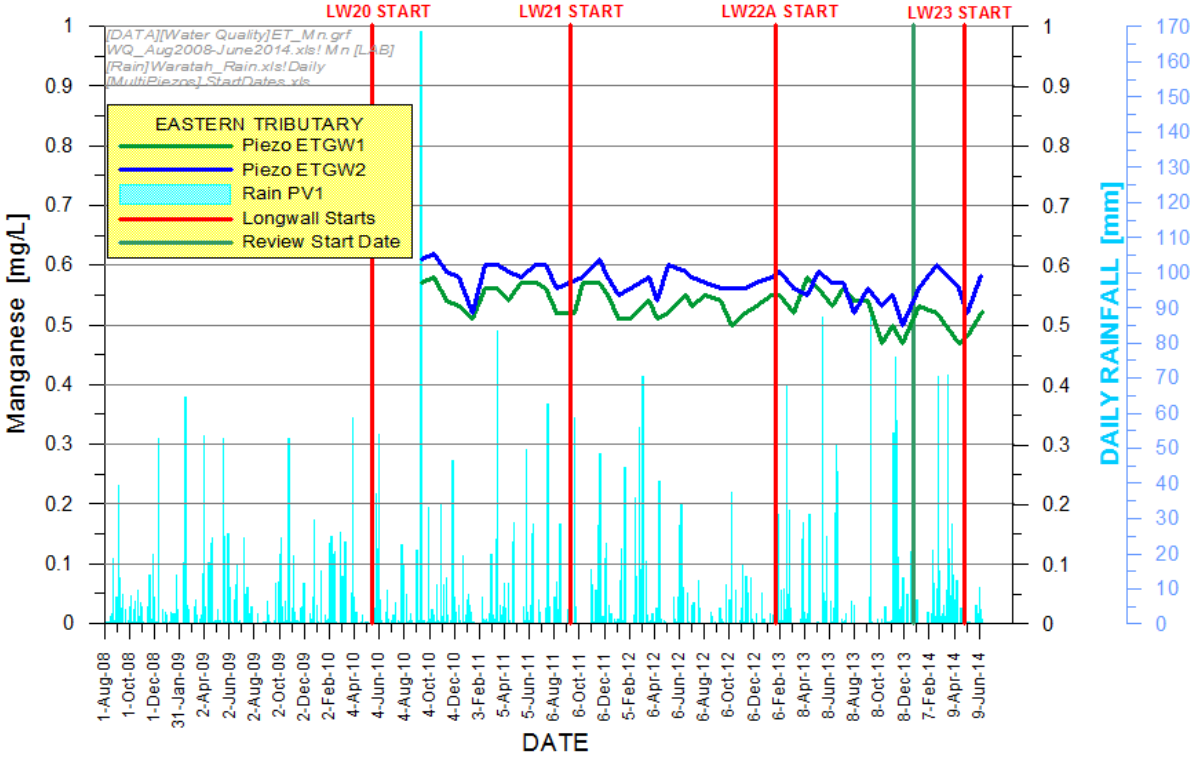


Chart 33 Manganese Concentrations at ETGW1 and ETGW2

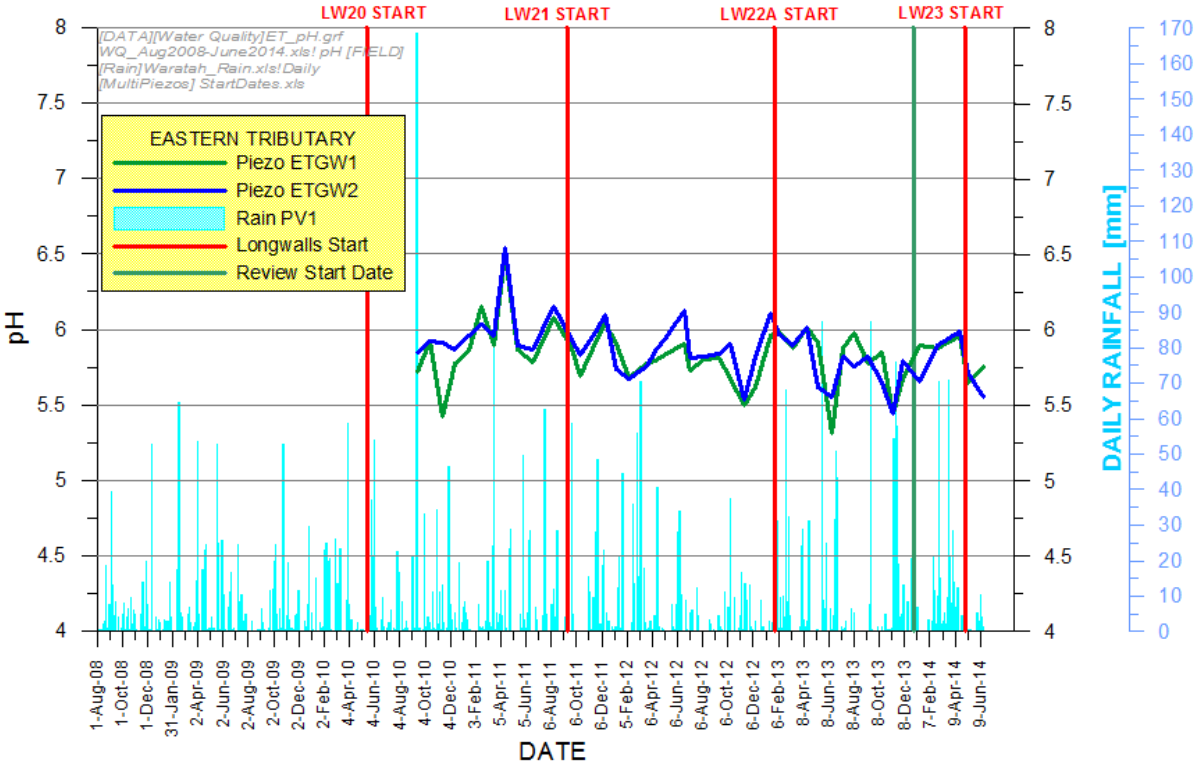


Chart 34 pH Levels at ETGW1 and ETGW2

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 23-27 Water Management Plan, 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.

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 35. 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 all measured values was used (0.159 megalitres per day [ML/day]).
- Where no ROM coal moisture content was available for a given day, the average of all measured values was used (6.83 percent [%]).
- The *in-situ* coal moisture content was assumed to be 1.5%.

The average daily water make during the reporting period was -0.133 ML/day (Chart 35).

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.

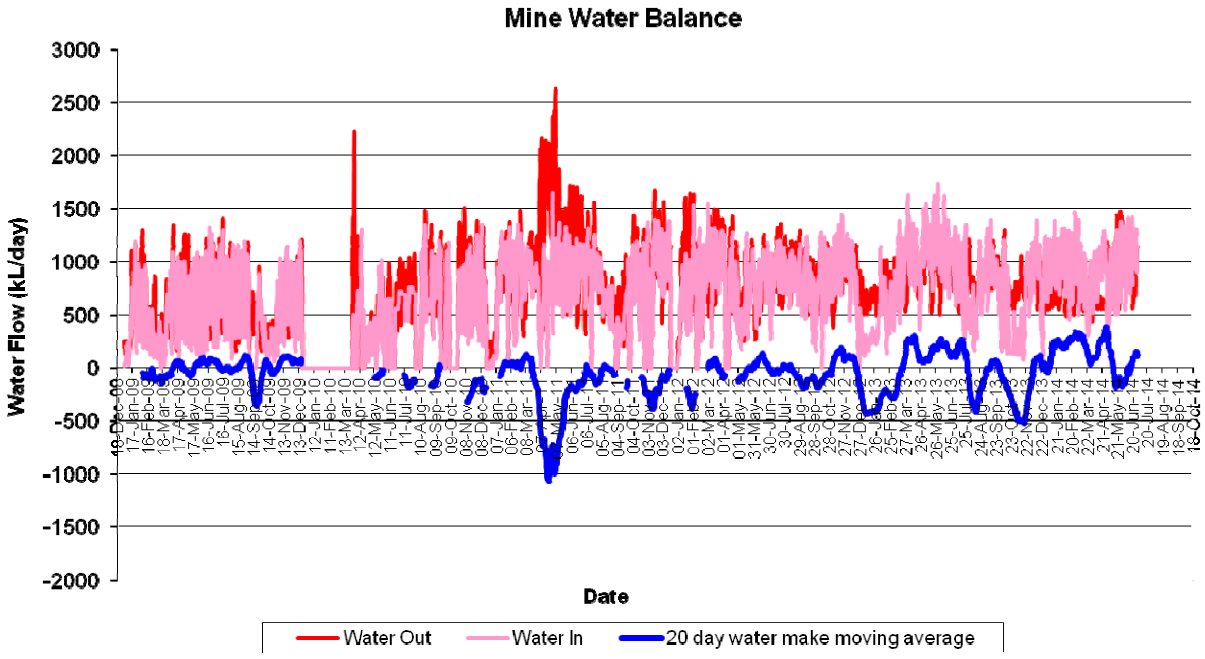


Chart 35 Estimated Daily Mine Water Make

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, 2014a).

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 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).

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 Water Management Plan, 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.

The analysis against the performance indicator for the reporting period is discussed in Section 2.3.2.1.

Analysis against Subsidence Impact Performance Measure

Consistent with the Metropolitan Coal Longwalls 20-22 Water Management Plan, 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 analysis against 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 (ETWQ2/ETWQ AU) and Woronora River (WOWQ2), near the inflow points to the Woronora Reservoir (Figure 6). The field filtered[3] 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 ETWQ2/ETWQ AU collected following the commencement of Longwall 20 is analysed against monitoring data collected at both sites prior to the commencement of Longwall 20 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.

Metropolitan Coal has recently revised the Metropolitan Coal Longwalls 20-22 Water Management Plan (Version F) to include changes to the analysis of this water quality performance indicator in response to the Evans & Peck (2012; 2013) peer review recommendations. As these revisions have not yet been approved, the currently approved analysis methods have been used to assess the water quality performance indicator.

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

Consistent with the existing approved Metropolitan Coal Longwalls 20-22 Water Management Plan, the performance indicator is considered to have been exceeded if data analysis indicates a statistically significant change in the quality of water post-mining of Longwall 20. Specifically if:

- any water quality parameters exceed the baseline mean plus two standard deviations for two consecutive months; or
- the sliding 12 month mean for any water quality parameter exceeds the baseline mean plus one standard deviation; and
- there was not a similar increase in the same measure(s) at the control site.

The analysis against the performance indicator for the reporting period is provided in Section 2.3.2.2.

Analysis against Subsidence Impact Performance Measure

Consistent with the Metropolitan Coal Longwalls 20-22 Water Management Plan, 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 analysis against the performance indicator for the reporting period is provided 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[4]**:** *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 36 and compared with simulated profiles at the end of Longwall 22 (using the 15-layer model which was recalibrated across the Hawkesbury Sandstone in 2012). The current measured head profile is very similar to the previous profiles. As the measured heads have increased slightly at nearly all piezometers in the preceding year, there is no evidence of an incremental effect from Longwall 22. The recalibrated model tracks the Hawkesbury Sandstone heads reasonably well, but the Bald Hill Claystone head is still lower than the simulated value (by about 20 m). 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.

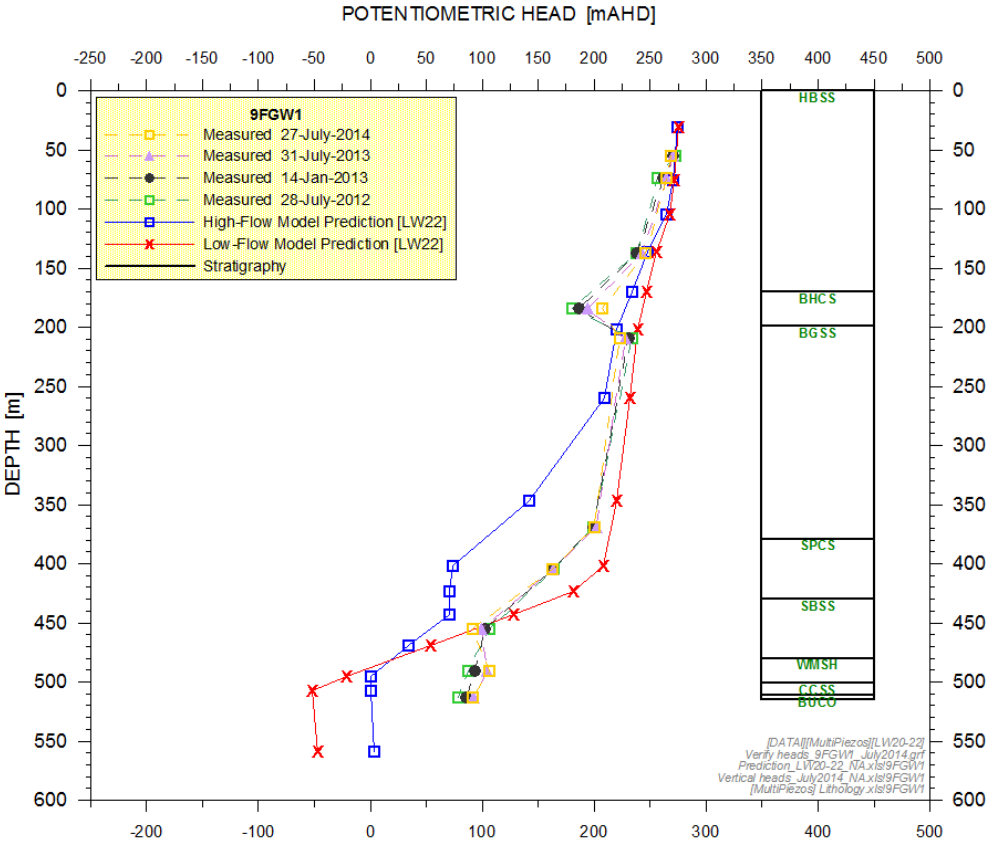


Chart 36 Measured and Simulated Potentiometric Head Profiles at Indicator Site 9FGW1A

[4] 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 Department of Planning and Environment on 30 June 2014.

Bore 9GGW2B is located above Longwall 27 headings. The vertical head profiles for 9GGW2B are shown on Chart 37. As the measured head profile at site 9GGW2B has not changed appreciably over the past 12 months, there is no evidence of an incremental effect from Longwall 22. 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 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.

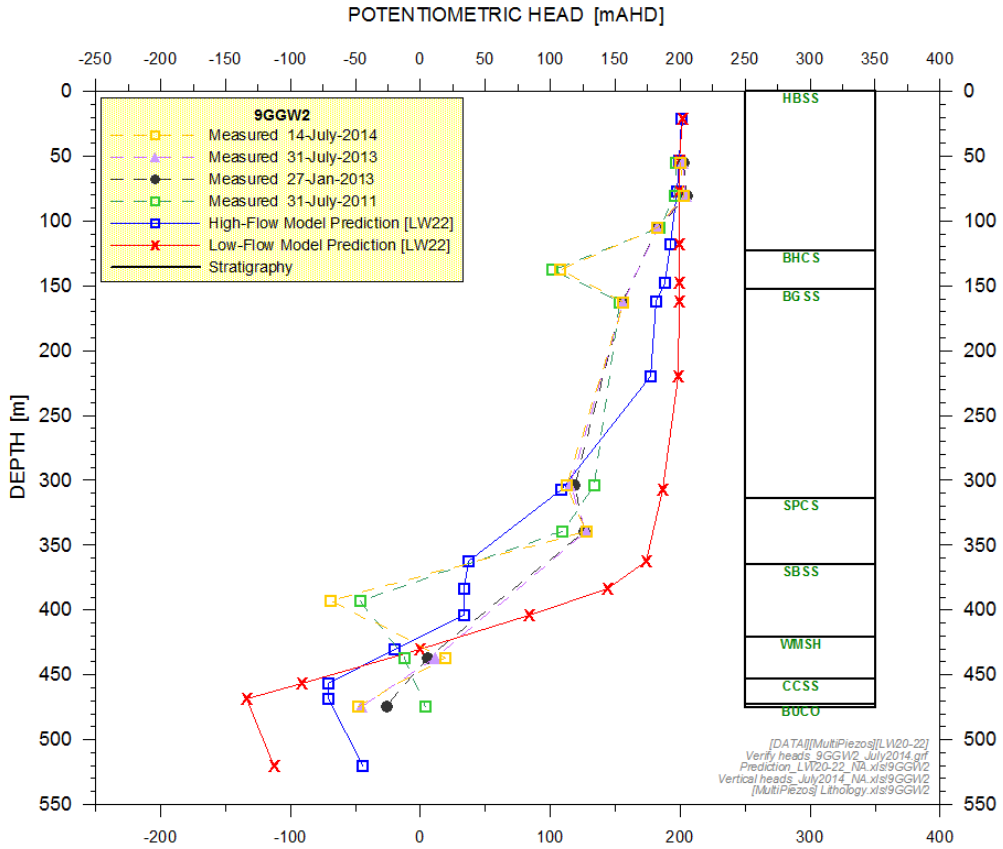


Chart 37 Measured and Simulated Potentiometric Head Profiles at Indicator Site 9GGW2B

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[5]: *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.

Analysis against Subsidence Impact Performance Measure

Consistent with the Metropolitan Coal Longwalls 20-22 Water Management Plan, if data analysis indicates a 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:

No connective cracking between the surface and the mine.

Performance indicator 3 was not exceeded during the reporting period.

The analysis against Performance Indicators 1, 2 and 4 for the reporting period is provided in Section 2.3.2.3.

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.

[5] 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 have been made in the Metropolitan Coal Longwalls 20-22 Water Management Plan (Version E) submitted to the Department of Planning and Environment on 30 June 2014.

Analysis against Subsidence Impact Performance Measure

Consistent with the Metropolitan Coal Longwalls 20-22 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 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), Cataract Reservoir (site DCA1) and Nepean Reservoir (site DNE1) from the SCA 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 that are not also occurring in the Nepean Reservoir (control site).

Metropolitan Coal has recently revised the Metropolitan Coal Longwalls 20-22 Water Management Plan (Version F) to include changes to the analysis of this water quality performance indicator in response to the Evans & Peck (2012; 2013) peer review recommendations. As these revisions have not yet been approved, the currently approved analysis methods have been used to assess the water quality performance indicator.

Water quality data from site DW01 collected following the commencement of Longwall 20 is analysed against monitoring data collected at site DW01 prior to the commencement of Longwall 20 and against water quality data collected from the Nepean Reservoir at site DNE1. Data from the Cataract Reservoir is also sourced from the SCA and considered in the analysis of reservoir water quality.

Consistent with the existing approved Metropolitan Coal Longwalls 20-22 Water Management Plan, the performance indicator is considered to have been exceeded if data analysis indicates a statistically significant change in the quality of water post-mining of Longwall 20. Specifically if:

- any water quality parameter's exceed the baseline mean plus two standard deviations for two consecutive months; or
- the sliding 12 month mean for any water quality parameter exceeds the baseline mean plus one standard deviation; and
- there was not a similar increase in the same measure at the control site.

The analysis against the performance indicator for the reporting period is provided in Section 2.3.2.5.

Analysis against Subsidence Impact Performance Measure

Consistent with the Metropolitan Coal Longwalls 20-22 Water Management Plan, 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 analysis against the performance indicator for the reporting period is provided in Section 2.3.2.5.

2.3.1.6 Waratah Rivulet Downstream of Maingate 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).

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>

Pool P terminates by flowing through and below its rock bar. Pool P (Figure 5) is visually inspected on a weekly basis when mining of Longwalls 20-22 is within 400 m of the pool to observe whether any change to the natural drainage behaviour of the pool has occurred.

Observations include:

- evidence of new cracking within the stream bed or rock bar;
- whether the pond continues to flow through and below its rock bar; and
- whether surface flow is evident along the length of Pool P prior to flowing through/below its rock bar.

During the reporting period Longwall 22 was greater than 400 m from Pool P. The water depth in Pools P, Q, R and S on the Waratah Rivulet (Figure 5) and at control pools WRP1, WRP2, WRP3 and WRP4 on the Woronora River is continuously monitored using a water depth sensor and logger.

Assessment against Performance Indicators

Visual inspections of Pool P are conducted on a weekly basis when mining of Longwalls 20-22 is within 400 m of the pool and assessed against the following performance indicator:

> *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.*

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 Pool P; or water ceases to be ponded upstream of the rock bar; or surface flow ceases along the length of Pool P. If visual observation indicates a potential impact to the natural drainage behaviour of Pool P on the Waratah Rivulet, then pools downstream, and the control pools on the Woronora River (i.e. Pools WRP1, WRP2, WRP3 and WRP4) are inspected and an assessment is made against the subsidence impact performance measure.

During the reporting period, Longwall 22 was greater than 400 m from Pool P. As a result, the visual inspection performance indicator was not exceeded during the reporting period.

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

> *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).*

The performance indicator will be considered to have been exceeded if the water depth in Pool P (when mining is within 400 m of Pool P) has been below the pool's previous minimum (i.e. when mining is beyond 400 m of Pool P). If data analysis indicates the water depth in Pool P (when mining is within 400 m of Pool P) has been below the pool's previous minimum (i.e. when mining is beyond 400 m of Pool P), 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.

Mining of Longwall 22 did not come within 400 m of Pool P during the reporting period, however the recorded water level hydrograph for Pool P (shown on Chart B-18 in Appendix B) indicates that the recorded water level in Pool P did not fall below the pool's previous minimum.

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, including the reporting period, for Pools Q, R and S are shown on Charts 38 to 40. Recorded water levels in Pools Q, R and S have remained above their cease to flow levels over the reporting period. As a result, the performance indicator has not been exceeded.

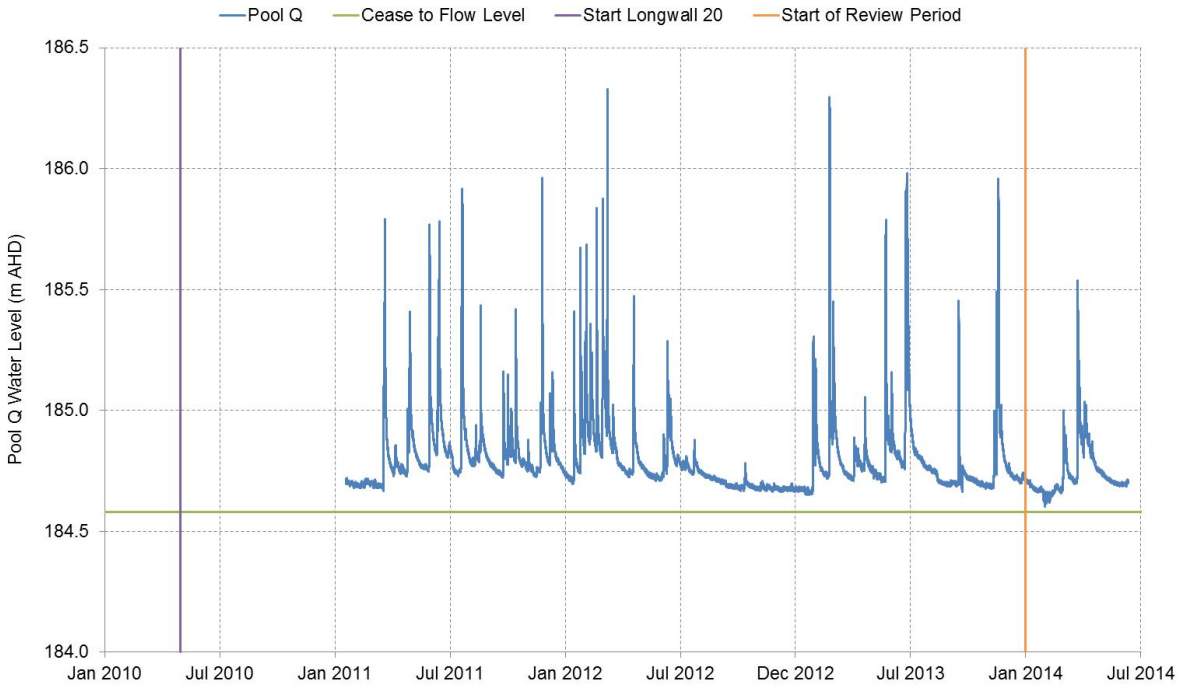


Chart 38 Pool Q Water Level Hydrograph

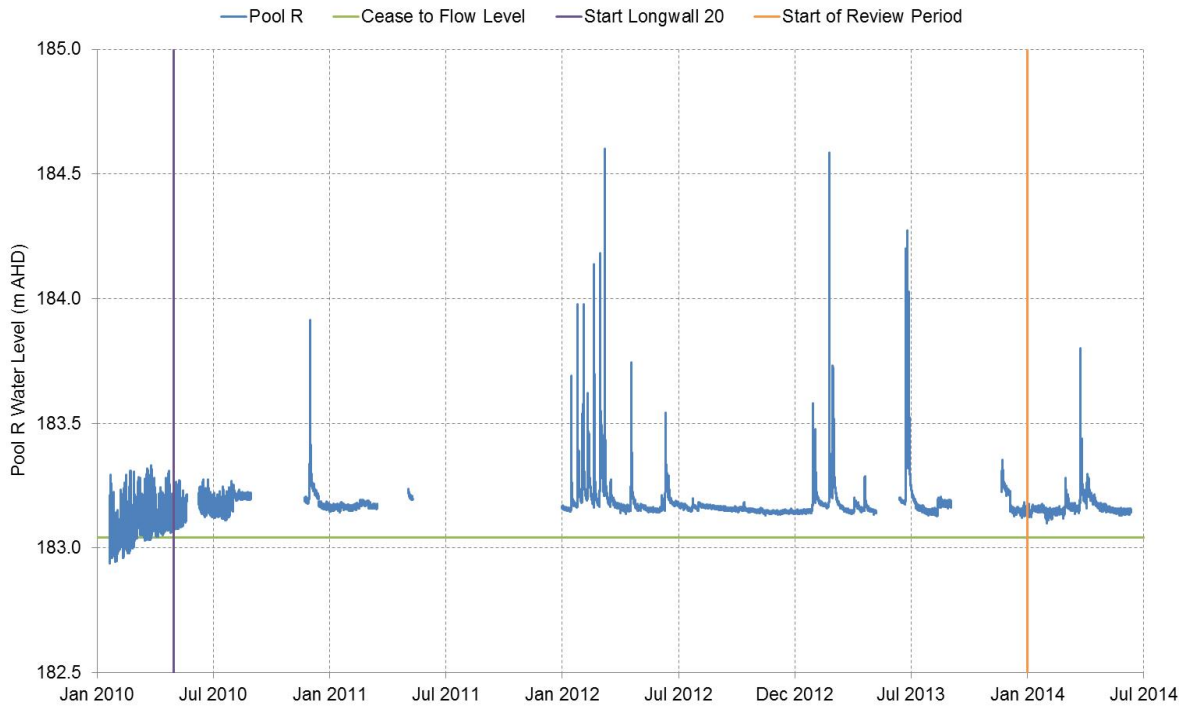


Chart 39 Pool R Water Level Hydrograph

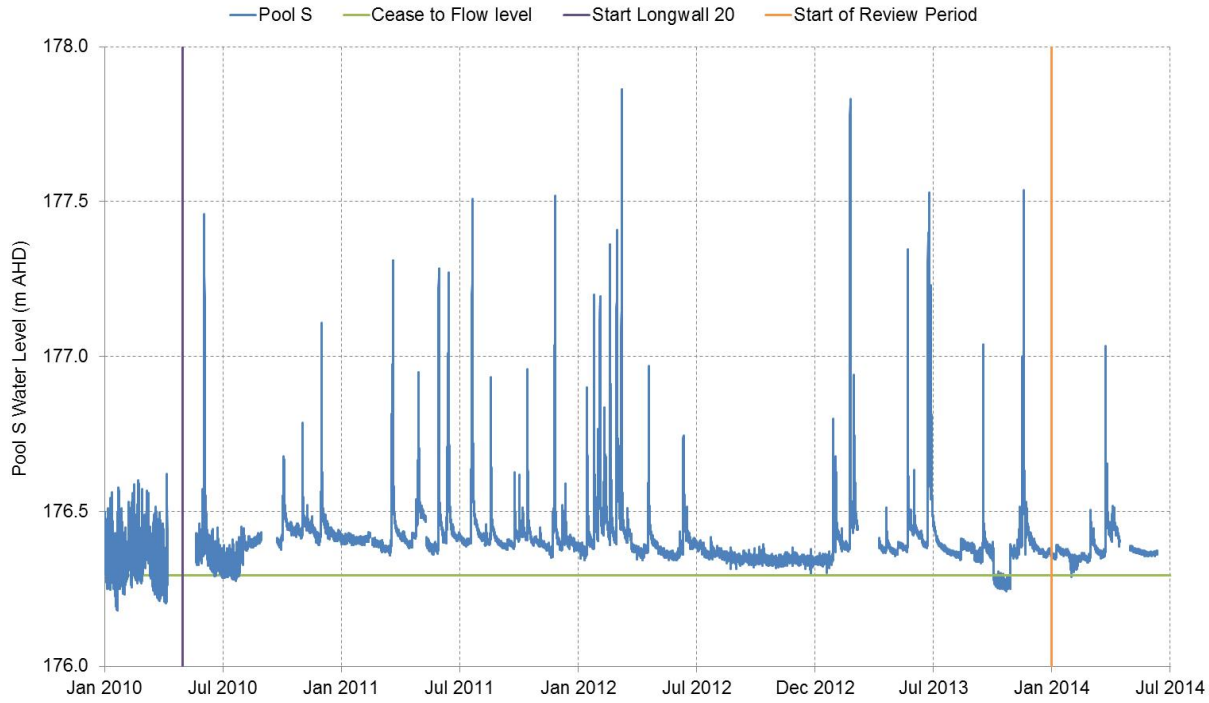


Chart 40 Pool S Water Level Hydrograph

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 pool); 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 Gas Releases

Visual and photographic surveys of the Waratah Rivulet downstream of maingate 23 to the Woronora Reservoir full supply level are conducted monthly until subsidence of Waratah Rivulet is less than 20 mm/month, and thereafter within three months of the completion of each longwall.

Subsidence of Waratah Rivulet was less than 20 mm/month over the reporting period. Visual and photographic surveys have been conducted within three months of the completion of Longwall 22 (subsequent to the reporting period). The results of the visual and photographic surveys will be included in the Metropolitan Coal 2014 Annual Review/AEMR.

Assessment against Performance Indicator

Consistent with the Metropolitan Coal Longwalls 20-22 Water Management Plan, visual surveys assess whether the following performance indicator has been exceeded:

> *No gas releases observed at Pool P on the Waratah Rivulet.*

The performance indicator is considered to have been exceeded if gas releases are observed at Pool P on the Waratah Rivulet.

Subsidence at Pool P was less than 20 mm/month during the reporting period. Notwithstanding, visual inspections conducted by Metropolitan Coal during the reporting period identified gas releases in Pool P (intermittent bubbles, approximately 50 m from the top of the pool) in February 2014 and thereafter from May 2014 to the end of the reporting period.

In accordance with the Metropolitan Coal Longwalls 20-22 Water Management Plan an assessment was made against the subsidence impact performance measure, *minimal gas releases*, and the results of the assessment are presented below.

Assessment against Performance Measure

Metropolitan Coal commissioned Gilbert & Associates to conduct an assessment of the Pool P gas release against the performance measure. Gilbert & Associates' assessment concluded the gas releases at Pool P were considered to be minimal.

Metropolitan Coal commissioned Evans & Peck to conduct a peer review of Gilbert & Associates' assessment. The peer review by Evans & Peck also concluded that the performance measure had not been exceeded.

Assessment against Revised Performance Indicator

Consistent with the revised Metropolitan Coal Longwalls 20-22 Water Management Plan (Version E), subsequent visual surveys (i.e. those conducted following the Gilbert & Associates and Evans & Peck performance assessments) have assessed whether the following performance indicator has 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.*

Gas releases in Pool P were identified for the first time in February 2014 and thereafter from May 2014 to the end of the reporting period. The revised performance indicator was not exceeded during the reporting period as gas releases did not increase beyond those observed at Pool P up to 17 April 2014.

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 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).

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. It is noted that the assessment of the quantity of water resources reaching the Woronora River included in the Metropolitan Coal 2013 Annual Review/AEMR used a 1 year sliding mean rather than 1 year sliding median.

Metropolitan Coal has recently received updates from the SCA in relation to the flow rating curves, recent gaugings and revised flow data for the Waratah Rivulet and Woronora River gauging stations. A review by Gilbert & Associates has indicated there are significant, systematic discrepancies in flows generated using the SCA's current rating curves for the Waratah Rivulet and Woronora River gauging stations. These discrepancies compromise Metropolitan Coal's ability to confidently assess the performance indicator for quality of water resources reaching the Woronora Reservoir.

Metropolitan Coal will seek to remedy this situation by regenenerating the current flow records from the Waratah Rivulet and Woronora River gauging stations using amended rating relationships to be developed by Metropolitan Coal which more closely reflect the results of the historical gaugings. Additional gaugings will also be undertaken during specific flow conditions to enable further refinement of the rating relationships at the Waratah Rivulet and Woronora River gauging stations.

The above corrective actions will be conducted as a matter of priority. Analysis will then be conducted against the performance indicator and reported to Department of Planning and Environment.

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 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.

At this stage the performance indicator cannot be validly assessed as a result of discrepancies in flows generated by the existing rating curves used for the Waratah Rivulet and Woronora River gauging stations. Metropolitan Coal will seek to remedy this situation as soon as practicable.

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 (ETWQ2/ETWQ AU) and Woronora River (WOWQ2), near the inflow points to the Woronora Reservoir (Figure 6). The field filtered[6] 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 ETWQ2/ETWQ AU collected following the commencement of Longwall 20 is analysed against monitoring data collected at both sites prior to the commencement of Longwall 20 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.

Metropolitan Coal has recently revised the Metropolitan Coal Longwalls 20-22 and Longwalls 23-27 Water Management Plans (Version F and D, respectively) to include changes to the analysis of this water quality performance indicator in response to the Evans & Peck (2012; 2013) peer review recommendations. As these revisions have not yet been approved, the currently approved analysis methods have been used to assess the water quality performance indicator.

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

Consistent with the existing approved Metropolitan Coal Longwalls 20-22 and Longwalls 23-27 Water Management Plans, the performance indicator is considered to have been exceeded if data analysis indicates a statistically significant change in the quality of water post-mining of Longwall 20. Specifically if:

- any water quality parameters exceed the baseline mean plus two standard deviations for two consecutive months; or
- the sliding 12 month mean for any water quality parameter exceeds the baseline mean plus one standard deviation; and
- there was not a similar increase in the same measure(s) at the control site.

Assessment of Water Quality at Site WRWQ9

Plots showing the concentrations of dissolved iron, dissolved aluminium and dissolved manganese recorded at sampling site WRWQ9 after the commencement of Longwall 20 in relation to the baseline mean plus two standard deviations are shown on Charts 41 to 43. Charts 44 to 46 show the concentrations of dissolved iron, dissolved aluminium and dissolved manganese recorded at control site WOWQ2 after the commencement of Longwall 20 in comparison to the baseline mean plus two standard deviations.

There were no exceedances of the 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 41 to 43). There were also no exceedances of the 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 44 to 46).

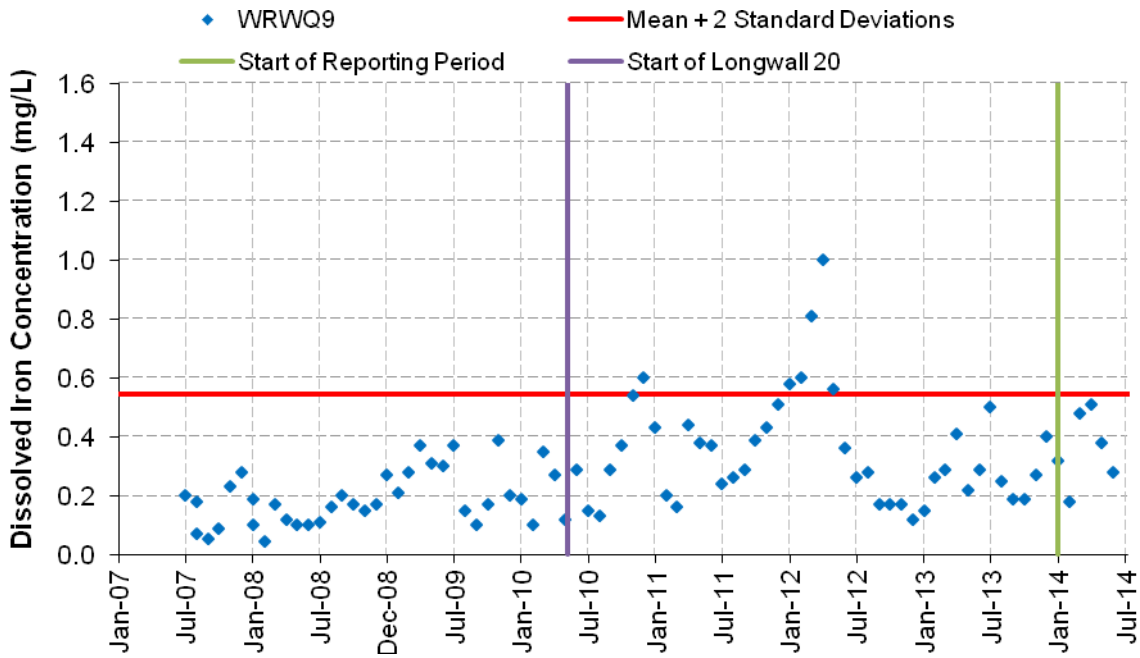


Chart 41 Dissolved Iron Concentrations in Waratah Rivulet at WRWQ9

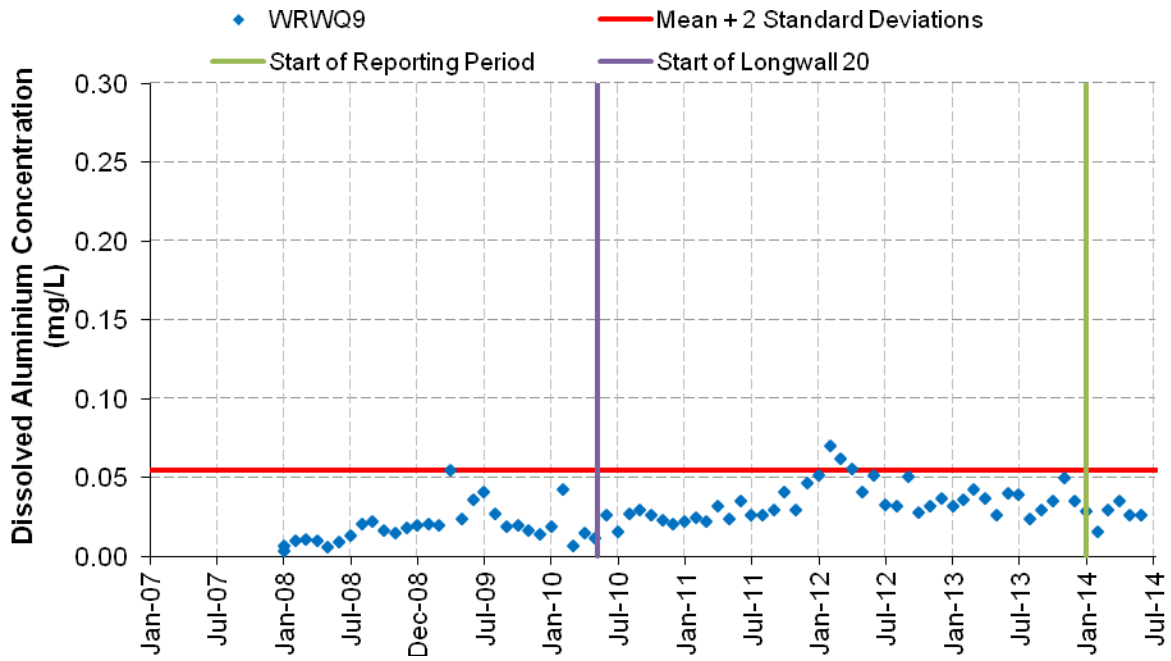


Chart 42 Dissolved Aluminium Concentrations in Waratah Rivulet at WRWQ9

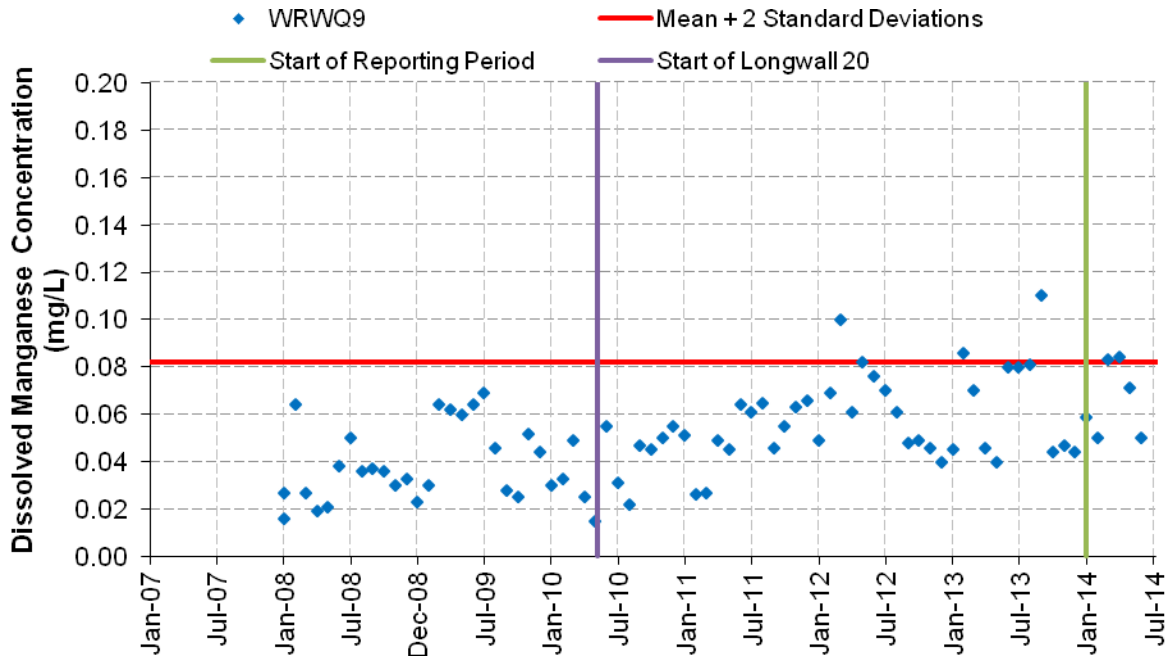


Chart 43 Dissolved Manganese Concentrations in Waratah Rivulet at WRWQ9

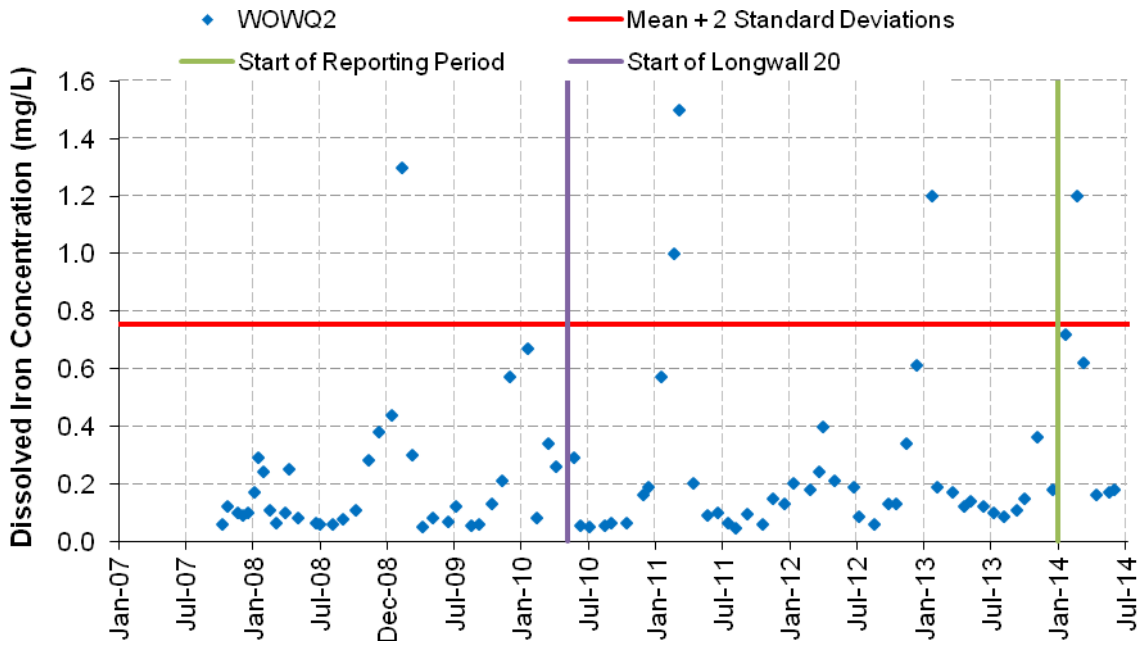


Chart 44 Dissolved Iron Concentrations in Woronora River at WOWQ2

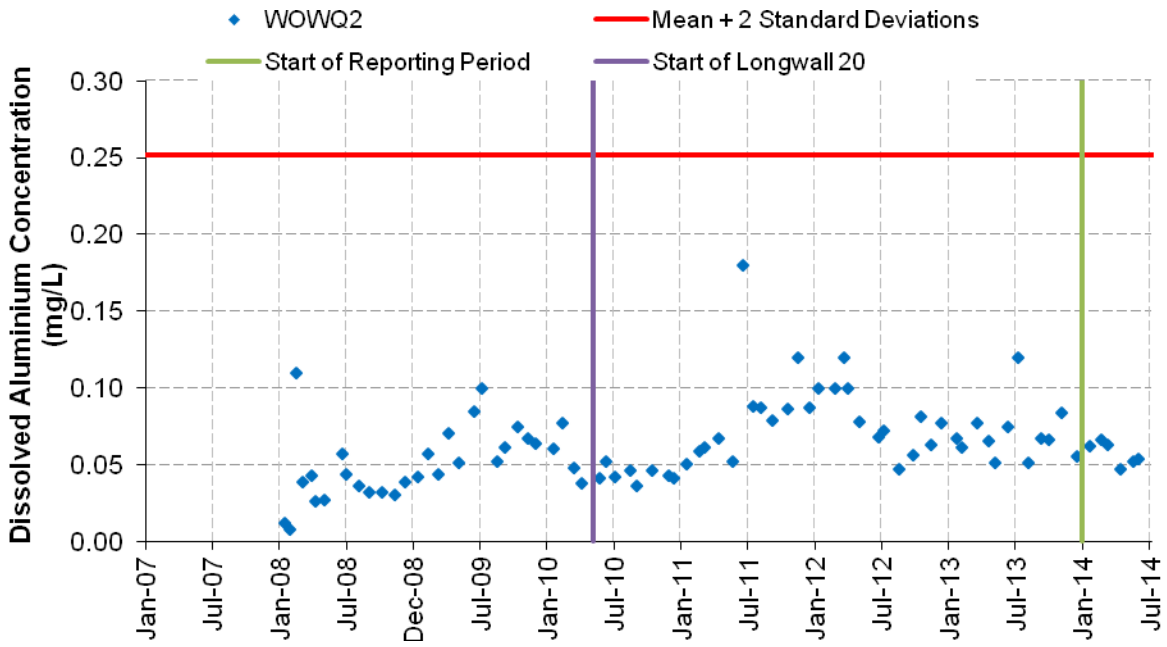


Chart 45 Dissolved Aluminium Concentrations in Woronora River at WOWQ2

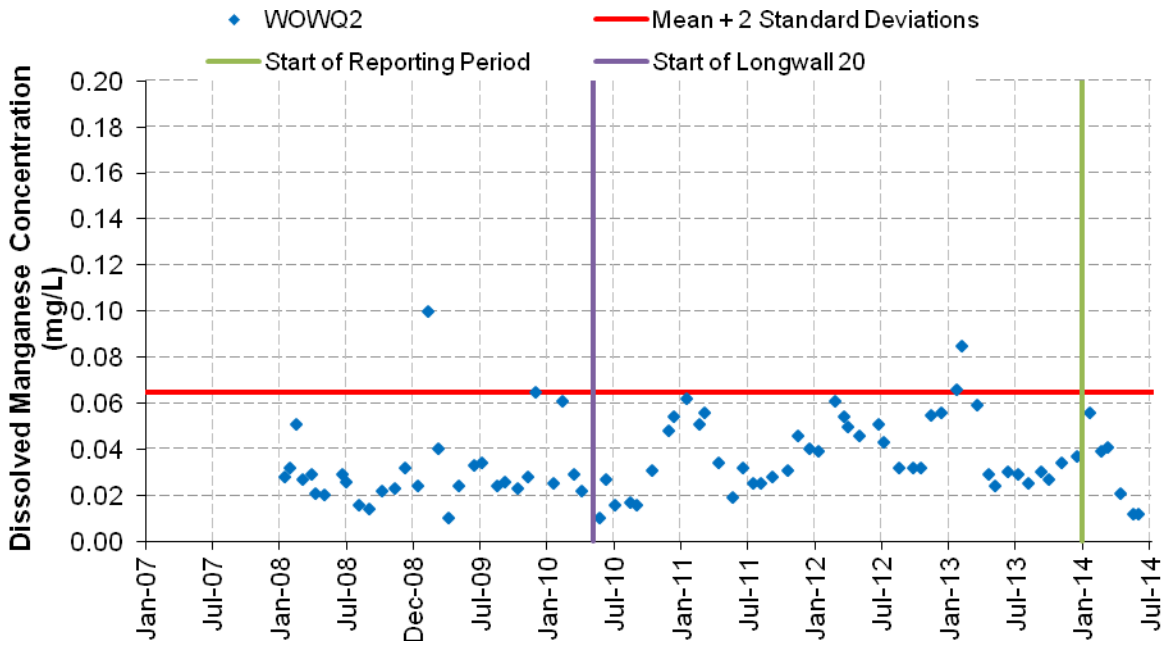


Chart 46 Dissolved Manganese Concentrations in Woronora River at WOWQ2

Plots showing the sliding 12 month mean of the dissolved iron, dissolved aluminium and dissolved manganese concentrations recorded at sampling site WRWQ9 after the commencement of Longwall 20 are shown on Charts 47 to 49. For comparison, plots showing the sliding 12 month mean for the same water quality parameters at control site WOWQ2 are shown on Charts 50 to 52. Each plot shows the baseline mean plus one standard deviation value.

The sliding 12 month mean at WRWQ9 exceeded the baseline mean plus one standard deviation for dissolved iron for four months, for dissolved aluminium for five months and for dissolved manganese for six months during the reporting period (Charts 37 to 39). The sliding 12 month mean for dissolved iron, dissolved aluminium and dissolved manganese at control site WOWQ2 did not exceed the baseline mean plus one standard deviation during the reporting period.

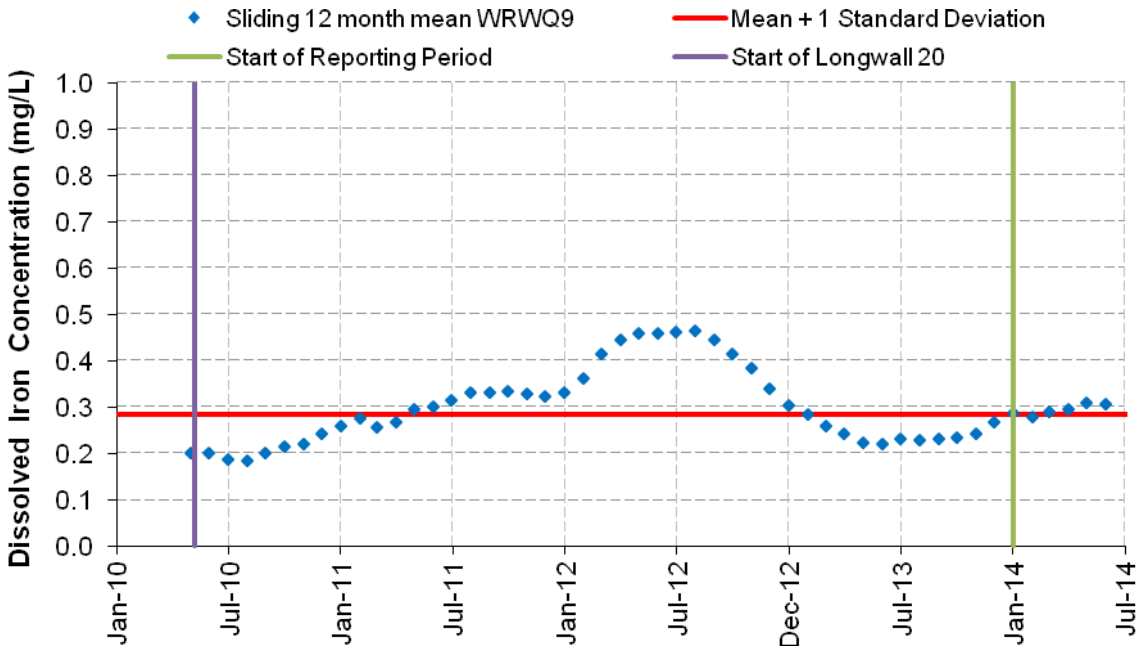


Chart 47 **Sliding 12 Month Mean of Dissolved Iron Concentrations in Waratah Rivulet at WRWQ9**

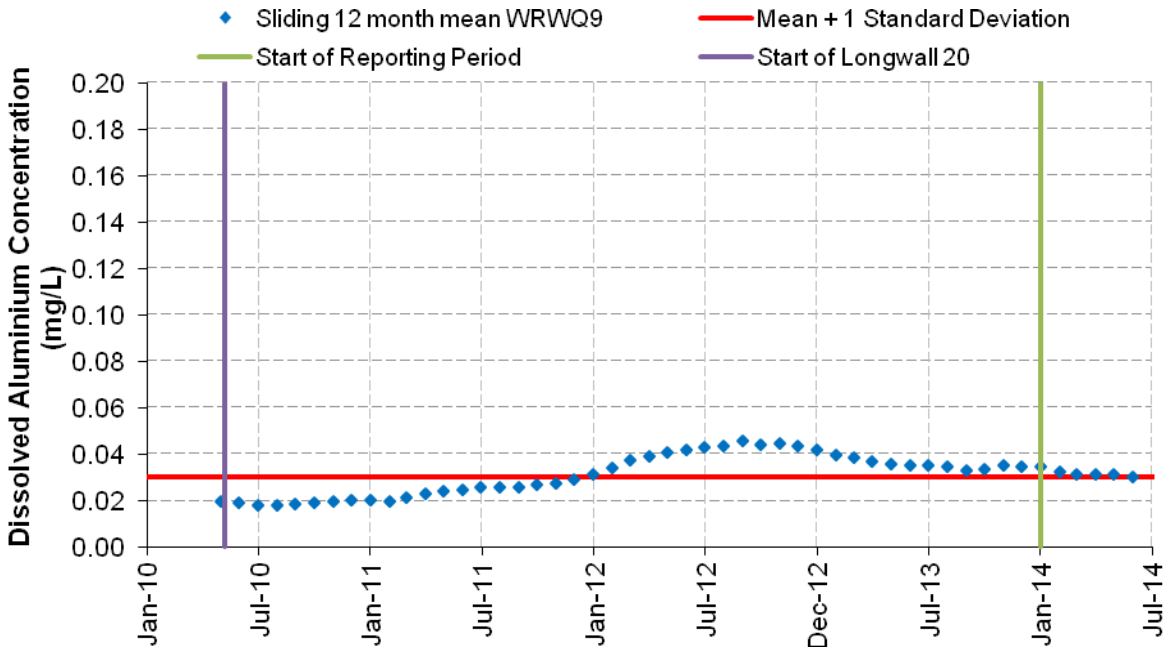


Chart 48 **Sliding 12 Month Sliding Mean of Dissolved Aluminium Concentrations in Waratah Rivulet at WRWQ9**

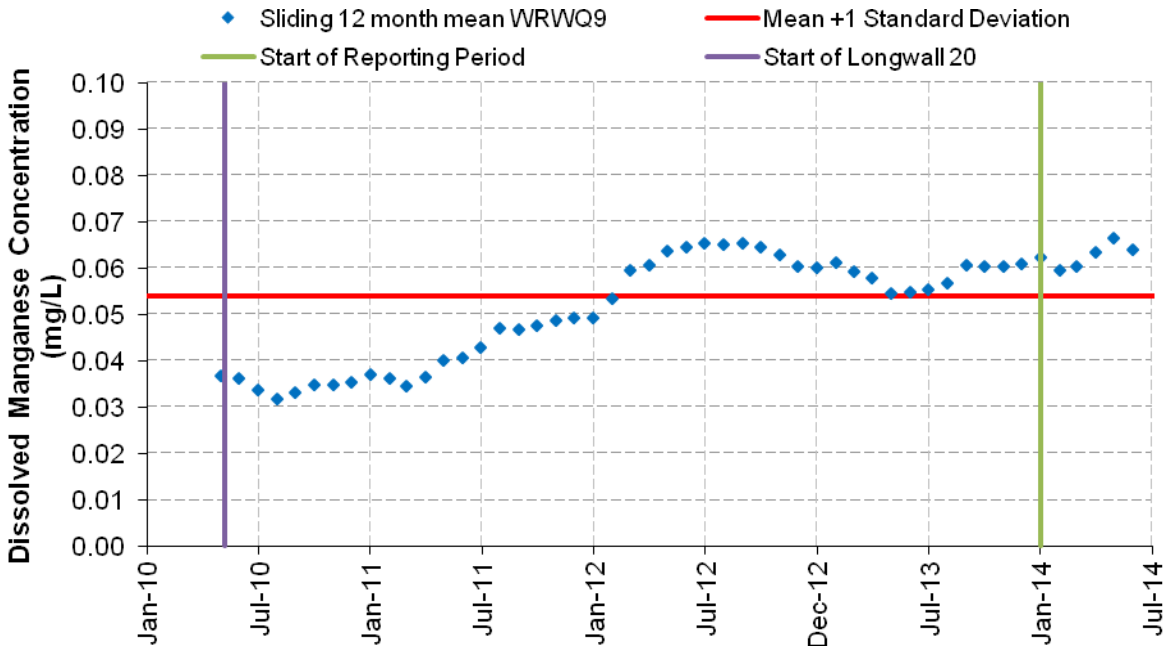


Chart 49 **Sliding 12 Month Mean of Dissolved Manganese Concentrations in Waratah Rivulet at WRWQ9**

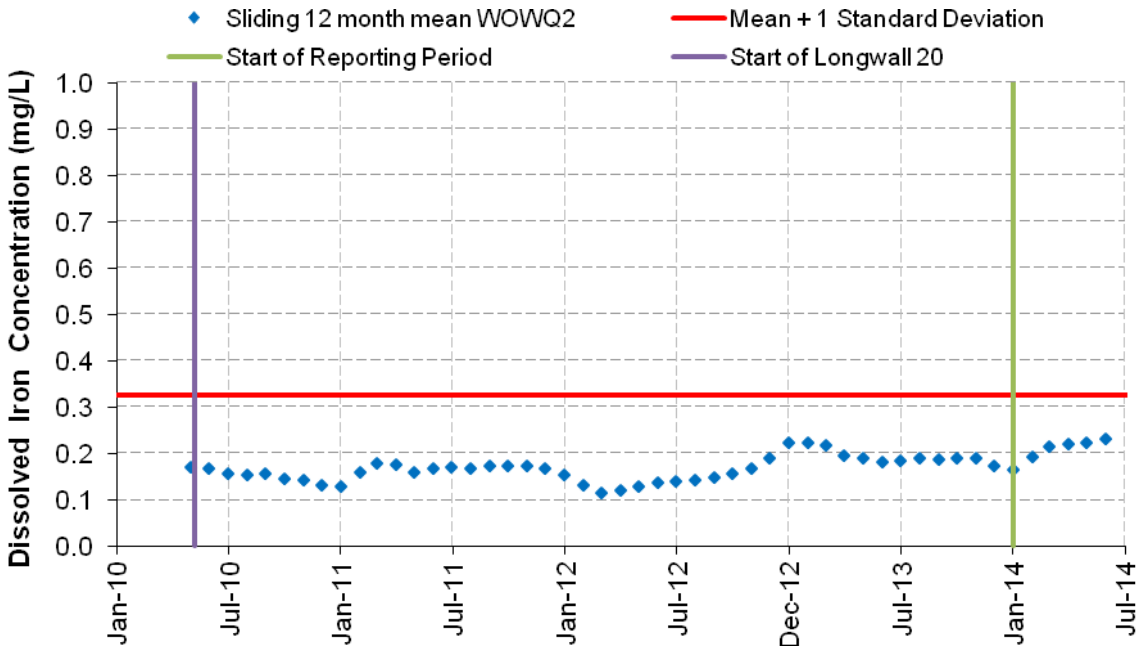


Chart 50 **Sliding 12 Month Mean of Dissolved Iron Concentrations in Woronora River at WOWQ2**

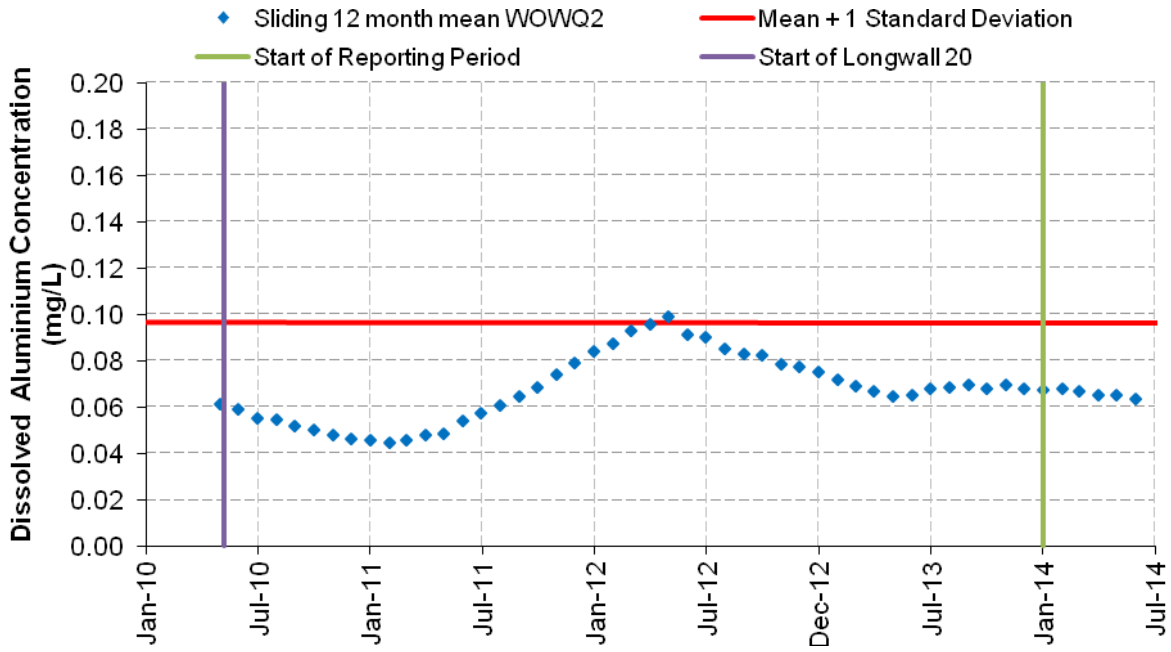


Chart 51 **Sliding 12 Month Mean of Dissolved Aluminium Concentrations in Woronora River at WOWQ2**

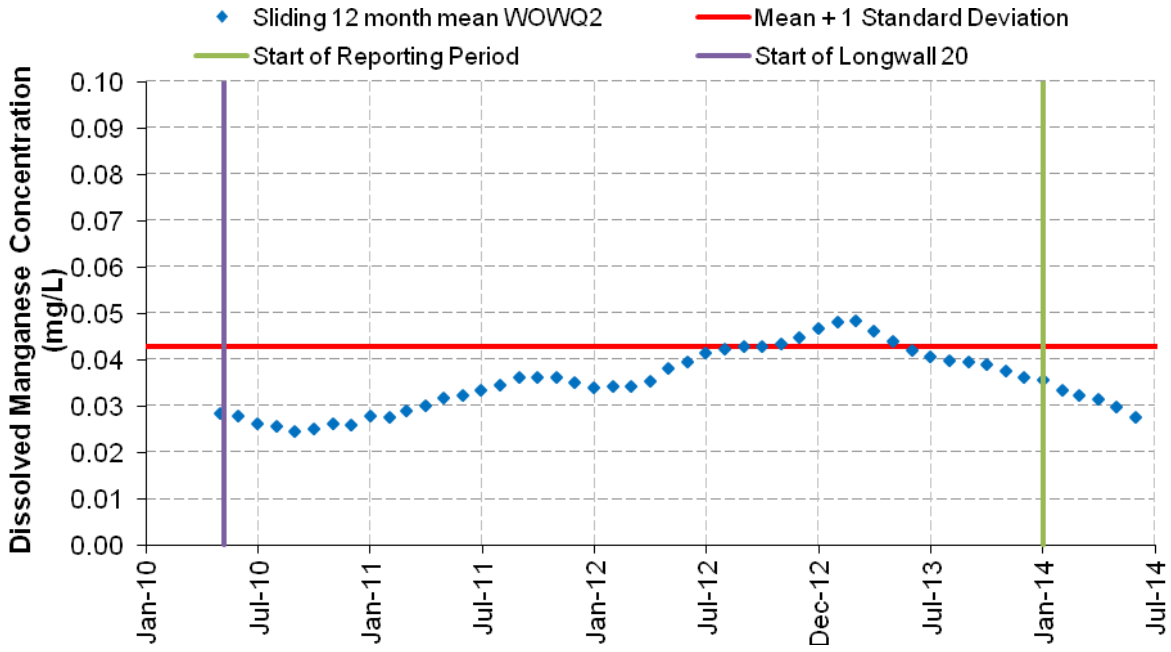


Chart 52 **Sliding 12 Month Mean of Dissolved Manganese Concentrations in Woronora River at WOWQ2**

Assessment of Water Quality at Site ETWQ2/ETWQ AU

Plots showing the concentrations of dissolved iron, dissolved aluminium and dissolved manganese recorded at sampling site ETWQ2/ETWQ AU after the commencement of Longwall 20 in relation to the baseline mean plus two standard deviations are shown on Charts 53 to 55. Charts 44 to 46 above show the concentrations of dissolved iron, dissolved aluminium and dissolved manganese recorded at control site WOWQ2 after the commencement of Longwall 20 in comparison to the baseline mean plus two standard deviations.

Dissolved iron, dissolved aluminium and dissolved manganese concentrations did not exceed the baseline mean plus two standard deviations for two consecutive months during the reporting period at ETWQ2/ETWQ AU (Charts 53 to 55). There were also no exceedances of the 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 44 to 46 above).

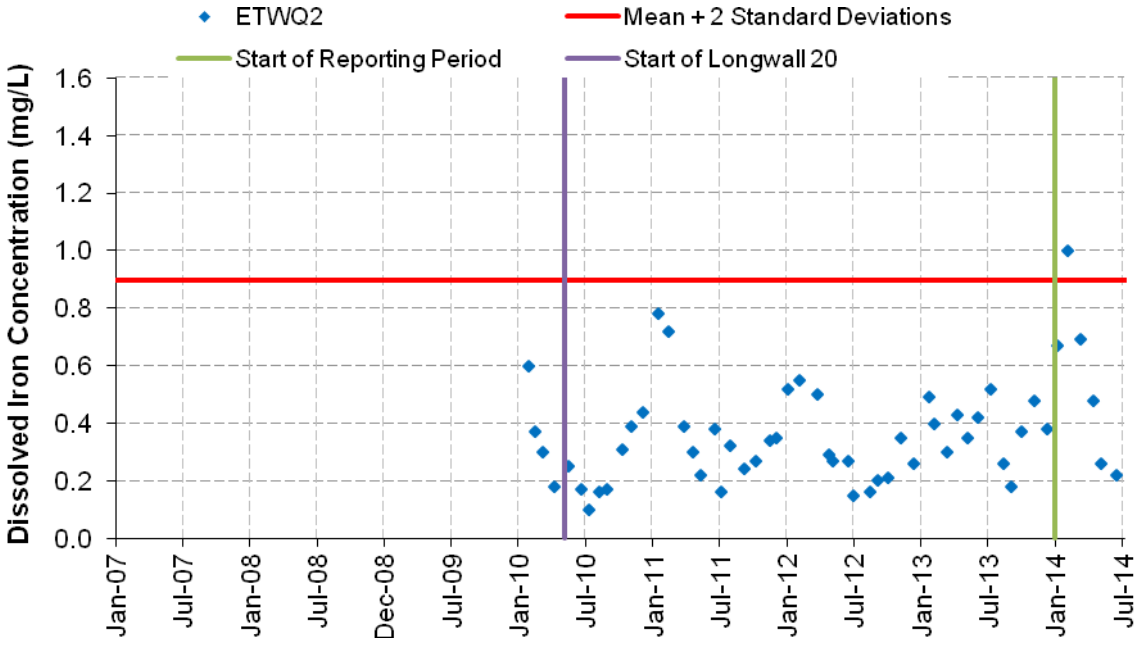


Chart 53 Dissolved Iron Concentrations in Eastern Tributary at ETWQ2/ETWQ AU

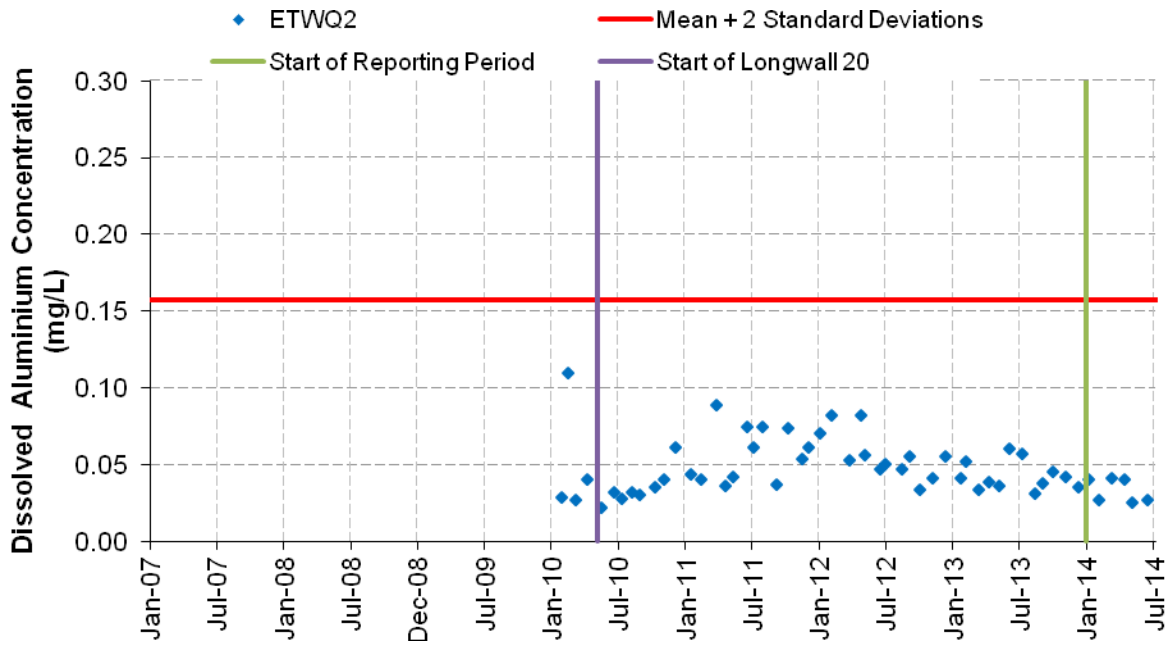


Chart 54 Dissolved Aluminium Concentrations in Eastern Tributary at ETWQ2/ETWQ AU

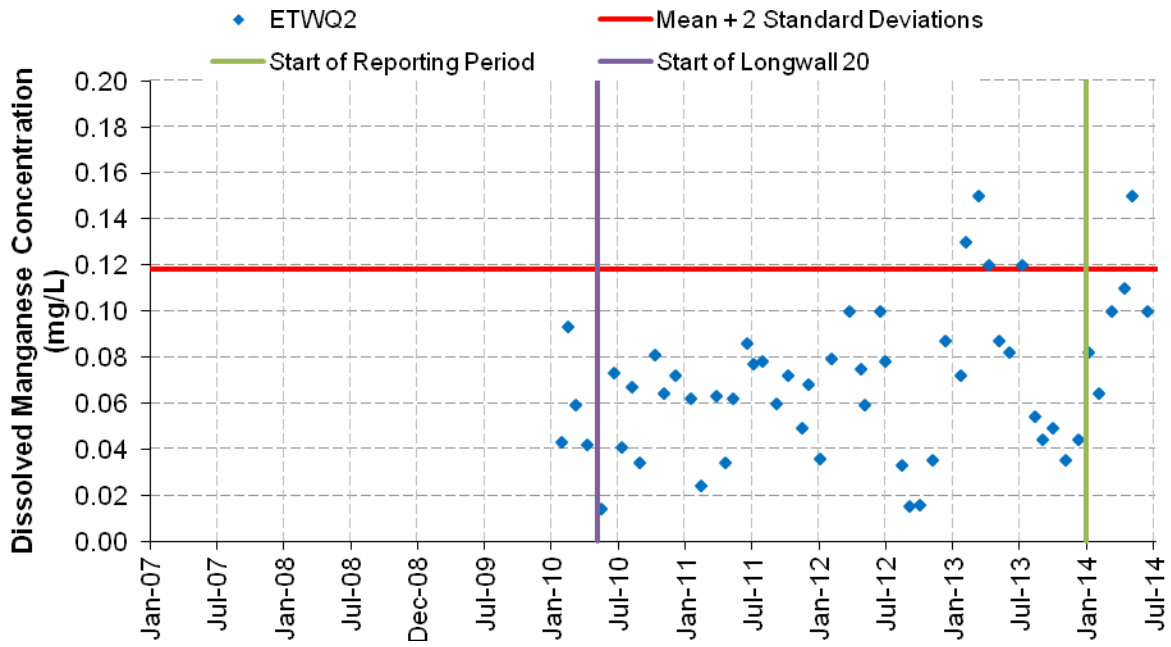


Chart 55 Dissolved Manganese Concentrations in Eastern Tributary at ETWQ2/ETWQ AU

Plots showing the sliding 12 month mean of the dissolved iron, dissolved aluminium and dissolved manganese concentrations recorded at sampling site ETWQ2/ETWQ AU after the commencement of Longwall 20 are shown on Charts 56 to 58. For comparison, plots showing the sliding 12 month mean for the same water quality parameters at control site WOWQ2 are shown on Charts 50 to 52 (above). Each plot shows the baseline mean plus one standard deviation value.

The 12 month sliding means of dissolved iron, dissolved aluminium and dissolved manganese concentrations did not exceed the baseline mean plus one standard deviation at ETWQ2/ETWQ AU (Charts 56 to 58) or control site WOWQ2 (Charts 50 to 52 above) during the reporting period.

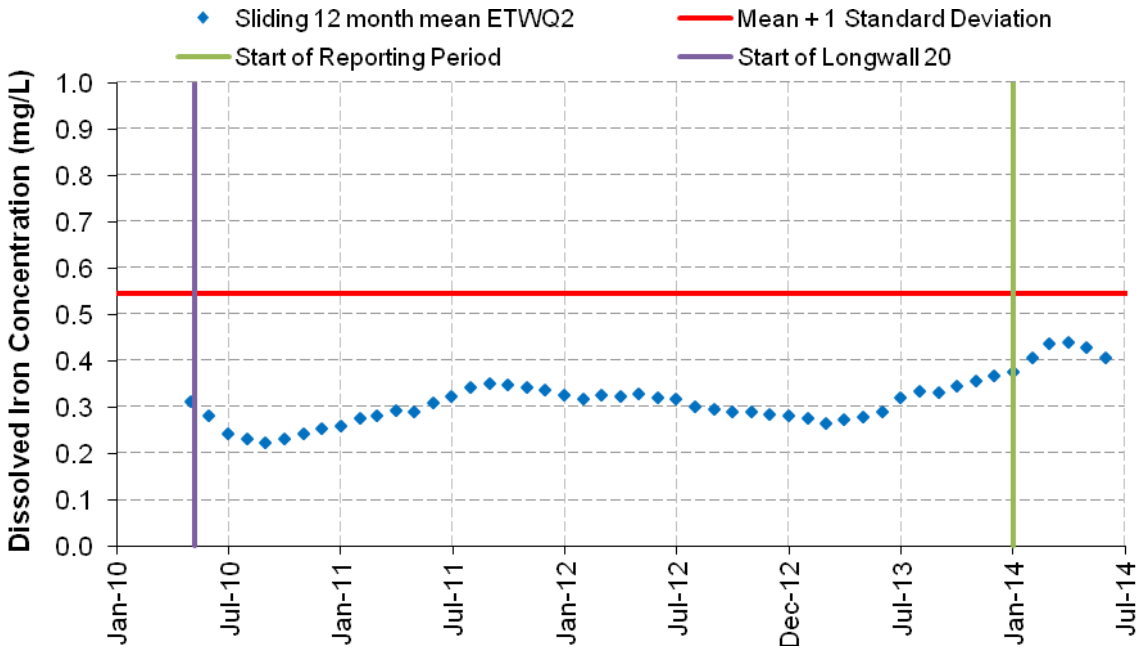


Chart 56 Sliding 12 Month Mean of Dissolved Iron Concentrations in Eastern Tributary at ETWQ2/ETWQ AU

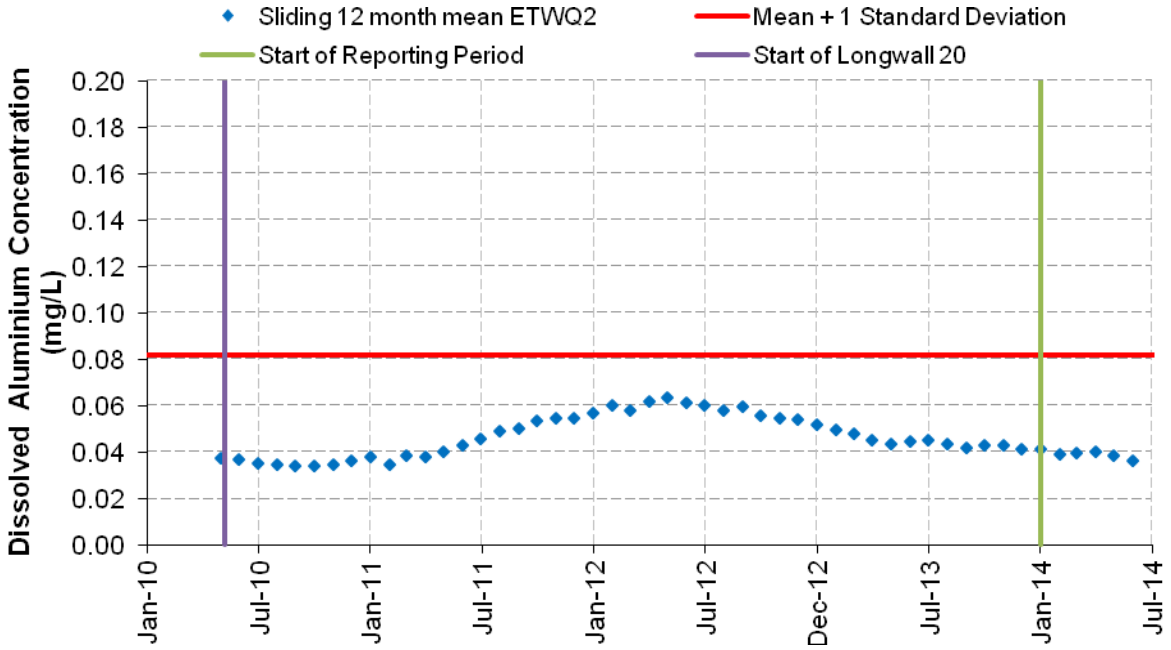


Chart 57 Sliding 12 Month Mean of Dissolved Aluminium Concentrations in Eastern Tributary at ETWQ2/ETWQ AU

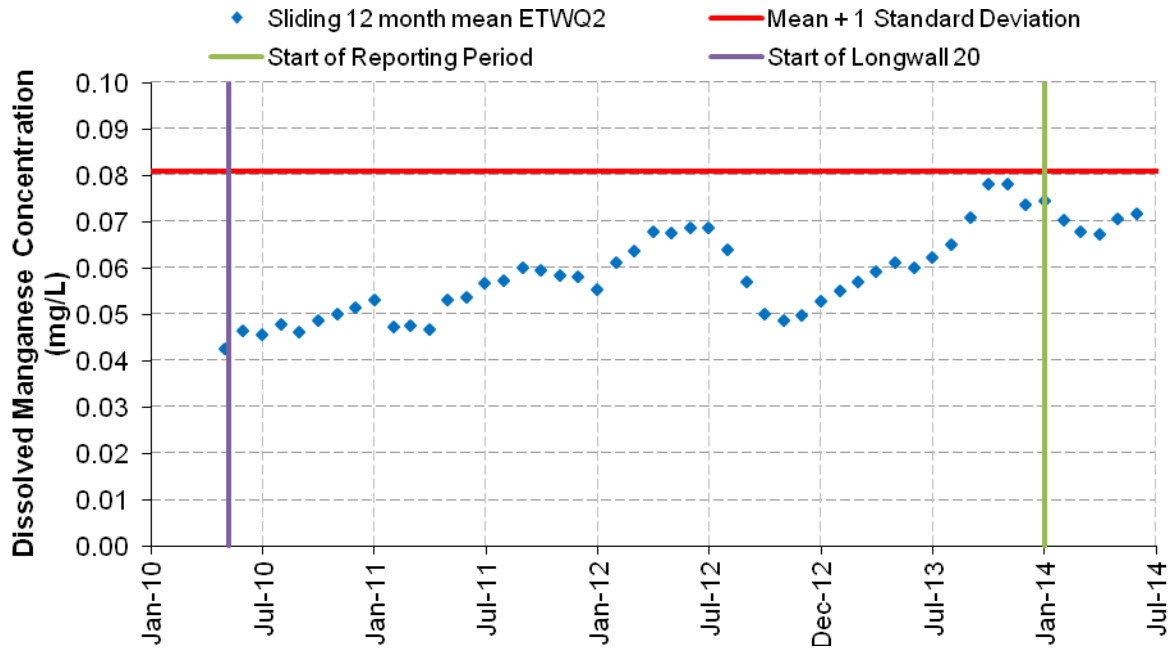


Chart 58 Sliding 12 Month Mean of Dissolved Manganese Concentrations in Eastern Tributary at ETWQ2/ETWQ AU

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.

As the performance indicator was exceeded for dissolved iron, dissolved aluminium and dissolved manganese at site WRWQ9 (as a result of the sliding 12 month mean exceeding the mean plus one standard deviation), an assessment against the subsidence impact performance measure has been conducted.

The exceedances of the sliding 12 month mean concentrations of dissolved iron, dissolved aluminium and dissolved manganese are considered to be negligible.

The sliding 12 month mean for dissolved iron at WRWQ9 was higher during the period from August 2011 to November 2012 than the current reporting period (Chart 47). Similarly, the sliding 12 month mean for dissolved aluminium at WRWQ9 was higher during the period from March 2012 to December 2013 than the current reporting period (Chart 48).

The sliding 12 month mean for dissolved manganese at WRWQ9 reached a maximum concentration of 0.067 mg/L in May 2014 during the current six month reporting period, and ranged between 0.060 and 0.067 mg/L over the reporting period. The sliding 12 month mean for dissolved manganese for the period from May to October 2012 reached a maximum concentration of 0.065 mg/L in July 2012 and ranged between 0.064 and 0.065 mg/L for the remainder of this period.

It is also noted that the dissolved iron, dissolved aluminium and dissolved manganese concentrations observed during the current reporting period (Charts 44 to 46) were below the mean plus two standard deviations during the reporting period. The highest dissolved iron, dissolved aluminium and dissolved manganese concentrations recorded during the reporting period were 0.51 mg/L, 0.035 mg/L and 0.084 mg/L, respectively (Charts 44 to 46).

Assessment of the earlier exceedances against the subsidence impact performance measure was carried out as part of the Metropolitan Coal 2012 Annual Review and Metropolitan Coal 2013 Annual Review/AEMR. The assessments concluded that the subsidence impact performance measure, *Negligible reduction to the quality of water resources reaching the Woronora Reservoir,* had not been exceeded in either 2012 or 2013. Independent peer reviews of those assessments by Evans & Peck (2012 and 2013), a specialist approved by the Department of Planning and Environment, agreed that no exceedance of the subsidence impact performance measure had occurred.

As described above, Metropolitan Coal has recently revised the Metropolitan Coal Longwalls 20-22 and Longwalls 23-27 Water Management Plans (Version F and D, respectively) to include changes to the analysis of this water quality performance indicator in response to the Evans & Peck (2012; 2013) peer review recommendations. These changes include removing the sliding 12 month mean, which is less responsive than the mean/standard deviation trigger, and which has a tendency to falsely trigger an exceedance. Metropolitan Coal has proposed to replace the sliding 12 month mean with an assessment against a six month median.

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 -0.133 ML/day.

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 in Section 2.3.1.3 on Chart 37. As the measured head profile at site 9GGW2B has not changed appreciably since the commencement of Longwall 23, there is no evidence of an incremental effect to date from Longwall 23.

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.

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 20-22 and 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 59 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 29 m higher than the elevation of the nearest downgradient watercourse (Tributary B). At site 9GGW1-80, the water level is about 12 m higher than Eastern Tributary (to its east) but is about 30 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.

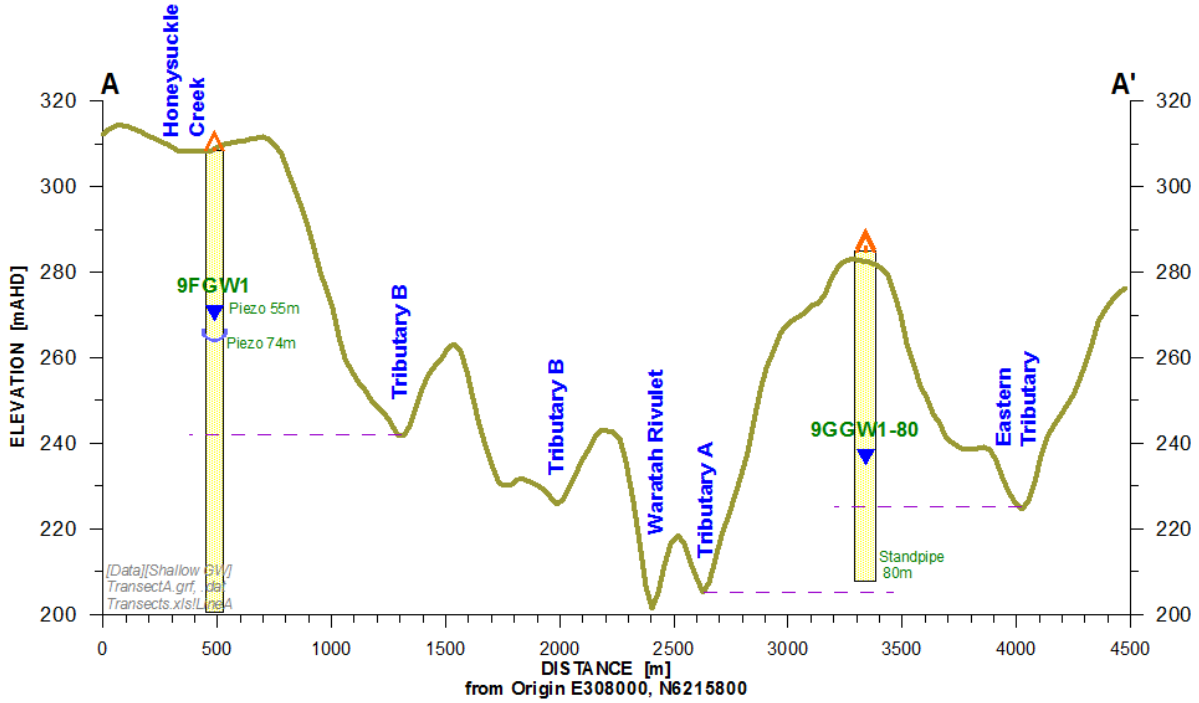


Chart 59 Topographic Transect A-A' along Longwall 22 and Hawkesbury Sandstone Water Levels at 30 June 2014

Analysis against Subsidence Impact Performance Measure

Consistent with the Metropolitan Coal Longwalls 23-27 Water Management Plan, if data analysis indicates a 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:

No connective cracking between the surface and the mine.

None of the performance indicators were exceeded during the reporting period.

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 60. Comparison with the maximum possible Woronora Reservoir water level shows a current clearance (at end of June 2014) of approximately 30 m at 9GGW2B and approximately 68 m at PM02. The shallow groundwater levels are well above reservoir level.

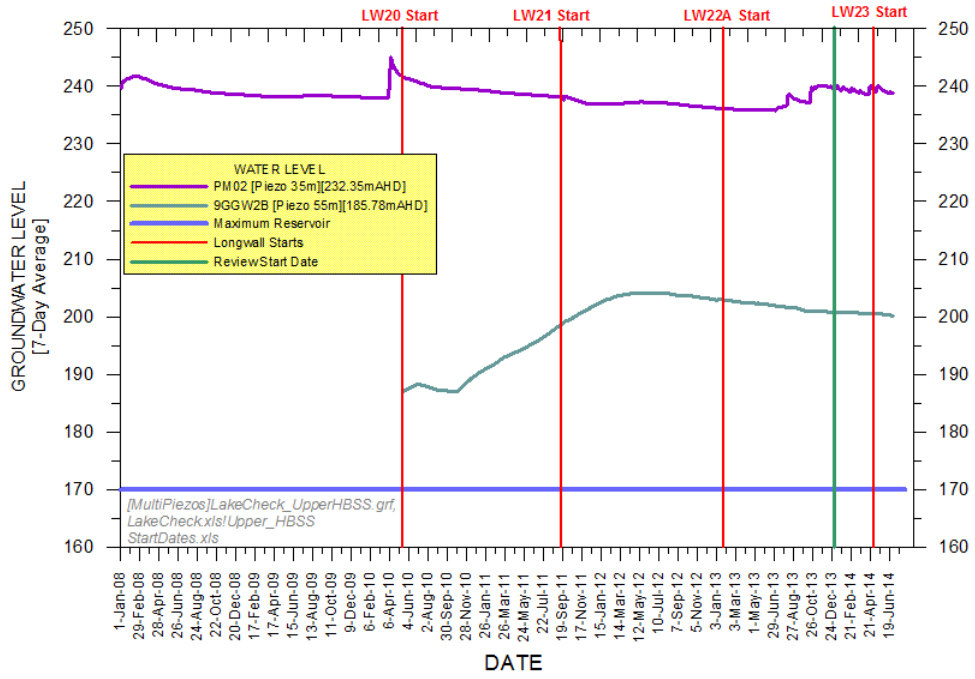


Chart 60 7-day Average Shallow Hawkesbury Sandstone Groundwater Levels at PM02 and 9GGW2B

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 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 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.

2.3.2.5 Woronora Reservoir Water Quality

Metropolitan Coal has sourced surface water quality data for the Woronora Reservoir (site DW01), Cataract Reservoir (site DCA1) and Nepean Reservoir (site DNE1) from the SCA in accordance with a data exchange agreement. Consistent with the monitoring of water reaching the Woronora Reservoir (Section 2.3.2.2), 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 that are not also occurring in the Nepean Reservoir (control site).

Metropolitan Coal has recently revised the Metropolitan Coal Longwalls 20-22 and Longwalls 23-27 Water Management Plans (Version F and D, respectively) to include changes to the analysis of this water quality performance indicator in response to the Evans & Peck (2012; 2013) peer review recommendations. As these revisions have not yet been approved, the currently approved analysis methods have been used to assess the water quality performance indicator.

Water quality data from site DW01 collected following the commencement of Longwall 20 is analysed against monitoring data collected at site DW01 prior to the commencement of Longwall 20 and against water quality data collected from the Nepean Reservoir at site DNE1. Data from the Cataract Reservoir is also sourced from the SCA and considered in the analysis of reservoir water quality.

Consistent with the existing approved Metropolitan Coal Longwalls 20-22 and Longwalls 23-27 Water Management Plans, the performance indicator is considered to have been exceeded if data analysis indicates a statistically significant change in the quality of water post-mining of Longwall 20. Specifically if:

- any water quality parameter's exceed the baseline mean plus two standard deviations for two consecutive months; or
- the sliding 12 month mean for any water quality parameter exceeds the baseline mean plus one standard deviation; and
- there was not a similar increase in the same measure at the control site.

Charts 61 to 63 show the concentrations of total iron, total aluminium and total manganese recorded at site DC01 in the Woronora Reservoir after the commencement of Longwall 20 compared to the baseline mean plus two standard deviations[7]. The concentrations of total iron, total aluminium and total manganese did not exceed the baseline mean plus two standard deviations during the reporting period (Charts 61 to 63).

[7] Note, while Charts 61 to 63 only show pre-Longwall 20 data from January 2010, all available baseline data has been used to calculate the mean plus two standard deviations for the total iron, total aluminium and total manganese concentrations.

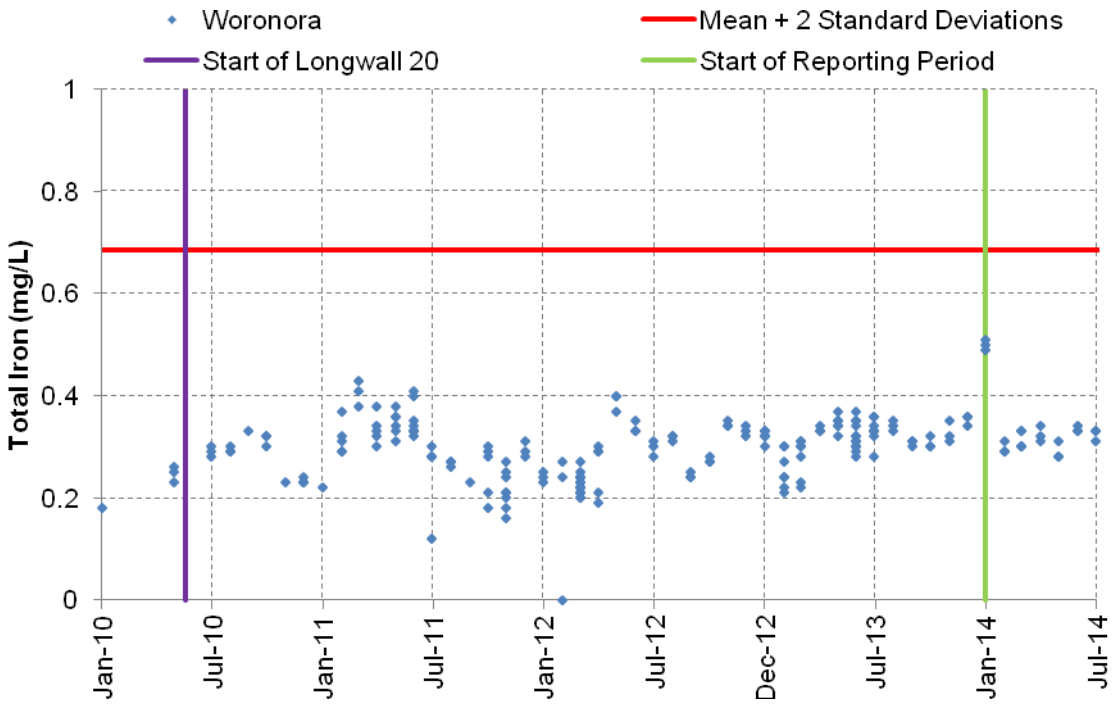


Chart 61 Total Iron Concentrations in Woronora Reservoir

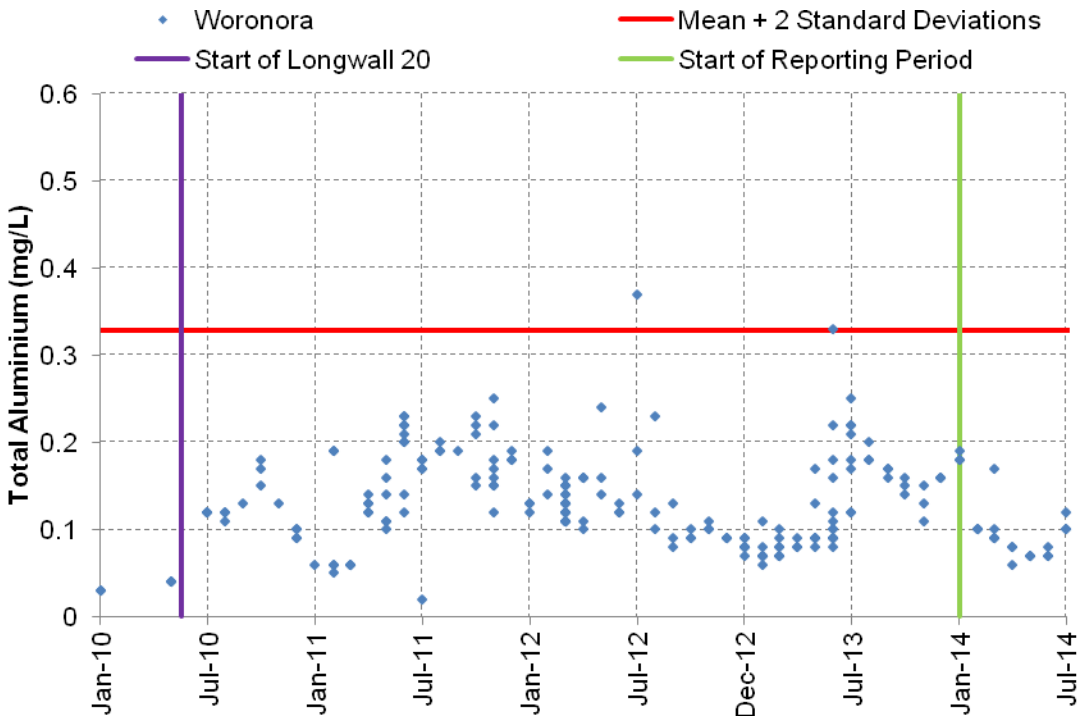


Chart 62 Total Aluminium Concentrations in Woronora Reservoir

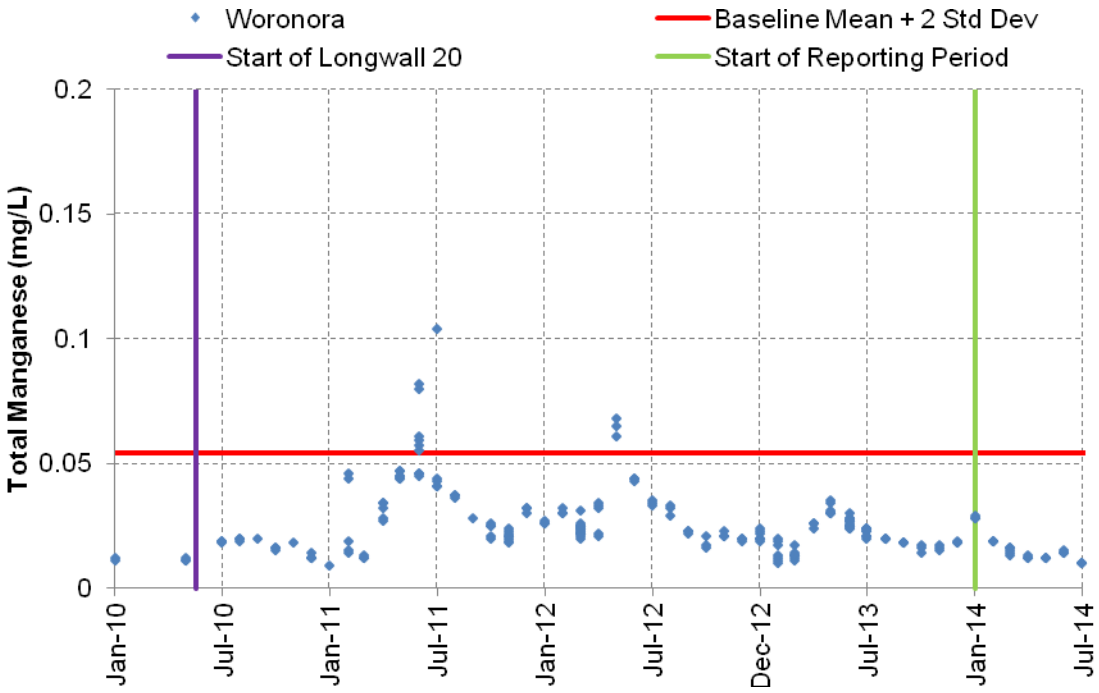


Chart 63 Total Manganese Concentrations in Woronora Reservoir

Charts 64 to 66 show the sliding 12 month mean concentrations for total iron, total aluminium and total manganese recorded at site DW01 in the Woronora Reservoir after the commencement of Longwall 20. The sliding 12 month mean concentrations of total iron, total aluminium and total manganese did not exceed the baseline mean plus one standard deviation during the reporting period (Charts 64 to 66). As a result, the performance indicator was not exceeded during the reporting period.

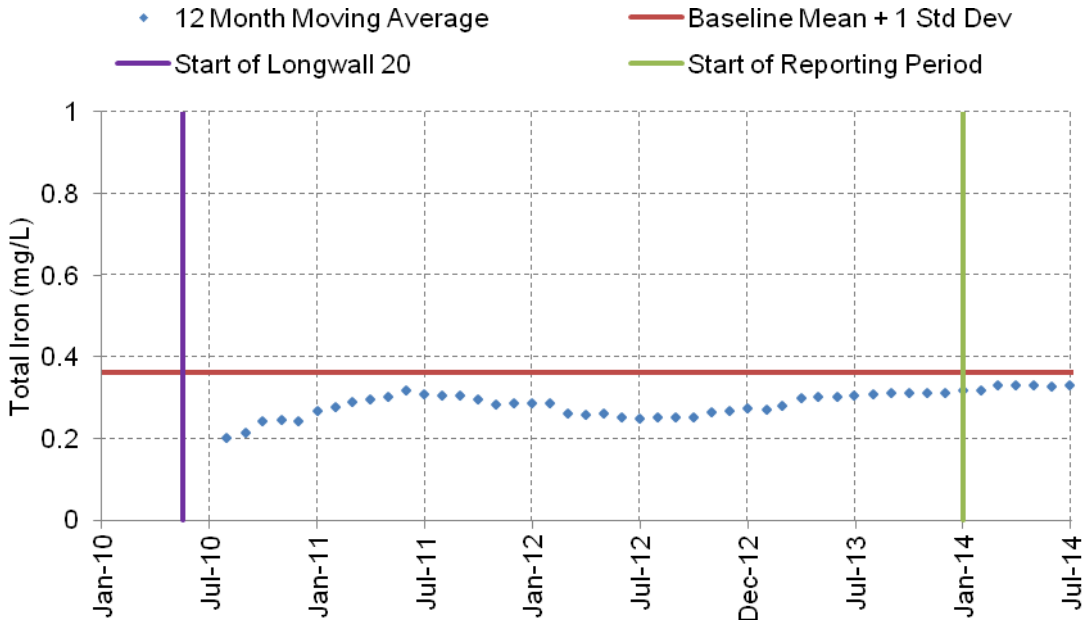


Chart 64 Sliding 12 Month Mean of Total Iron Concentration in Woronora Reservoir

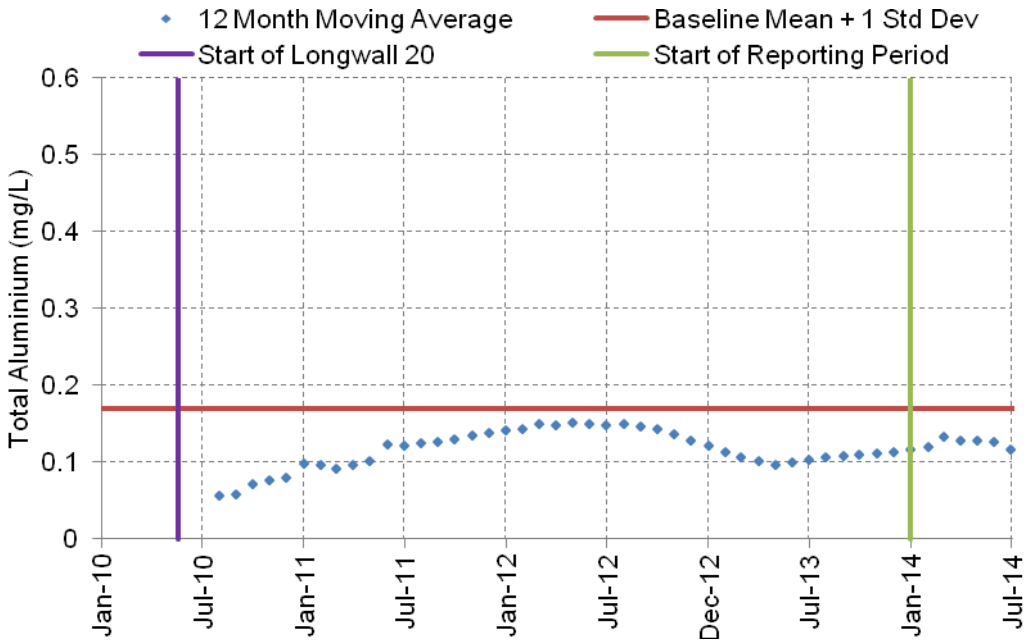


Chart 65 Sliding 12 Month Mean of Total Aluminium Concentration in Woronora Reservoir

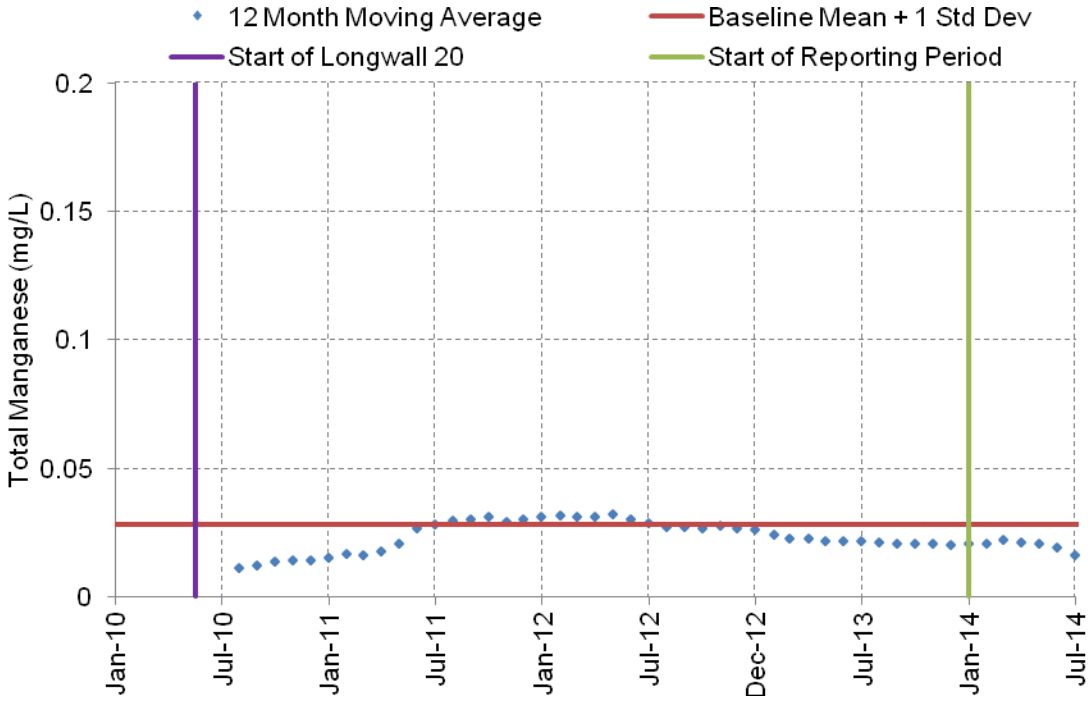


Chart 66 Sliding 12 Month Mean of Total Manganese Concentration in Woronora Reservoir

As described above, Metropolitan Coal has recently revised the Metropolitan Coal Longwalls 20-22 and Longwalls 23-27 Water Management Plans (Version F and D, respectively) to include changes to the analysis of this water quality performance indicator in response to the Evans & Peck (2012; 2013) peer review recommendations. These changes include removing the sliding 12 month mean, which is less responsive and has the potential to falsely trigger an exceedance. Metropolitan Coal has proposed to replace the sliding 12 month mean with an assessment that incorporates both concentration and the duration that concentrations (greater than the baseline mean of specific water quality parameters) have remained above those concentrations.

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 in the water quality of Woronora Reservoir.*

The performance indicator was not exceeded during the reporting period.

2.3.2.6 Waratah Rivulet Downstream of Maingate 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, 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 23 had not advanced to within 400 m of Pools P, Q, R, S, T, U, V and W.

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.

During the reporting period Longwall 23 had not advanced to within 400 m of Pools P, Q, R, S, T, U, V and W.

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.

During the reporting period Longwall 23 had not advanced to within 400 m of Pools P, Q, R, S, T, U, V and W. Notwithstanding, the recorded water level hydrographs for Pools P, T and V (shown on Charts B-18, B-22 and B-24 in Appendix B) indicate that the pools did not cease flowing and that they exhibited natural behaviour during the reporting period.

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, including the reporting period, for Pools Q, R and S are shown on Charts 38 to 40 in Section 2.3.1.6. Recorded water levels in Pools Q, R and S 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 until subsidence of Waratah Rivulet is less than 20 mm/month, and thereafter within three months of the completion of each longwall.

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).

Subsidence of Waratah Rivulet was less than 20 mm/month throughout the reporting period. The visual inspections conducted within three months of the completion of Longwall 22 (and subsequent to the reporting period) will be reported in the 2014 Annual Review/AEMR.

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.

<u>Minimal Gas Releases</u>

Visual and photographic surveys of the Waratah Rivulet downstream of maingate 23 to the Woronora Reservoir full supply level are conducted monthly until subsidence of Waratah Rivulet is less than 20 mm/month, and thereafter within three months of the completion of each longwall.

Subsidence of Waratah Rivulet was less than 20 mm/month over the reporting period. Mining of Longwall 23 commenced in May 2014.

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 gas releases observed at Pools P to W on the Waratah Rivulet.*

The performance indicator is considered to have been exceeded if gas releases are observed at Pools P to W on the Waratah Rivulet.

Subsidence at Pools P to W was less than 20 mm/month during the reporting period. Notwithstanding, visual inspections conducted by Metropolitan Coal during the reporting period identified gas releases in Pool P (intermittent bubbles, approximately 50 m from the top of the pool) in February 2014 (prior to the commencement of Longwall 23) and thereafter from May 2014 to the end of the reporting period.

In accordance with the Metropolitan Coal Longwalls 20-22 and Longwalls 23-27 Water Management Plans an assessment was made against the subsidence impact performance measure, *minimal gas releases*, and the results of the assessment are presented below.

Assessment against Performance Measure

Metropolitan Coal commissioned Gilbert & Associates to conduct the assessment of the Pool P gas release against the performance measure. Gilbert & Associates' assessment concluded the gas releases at Pool P were considered to be minimal.

Metropolitan Coal commissioned Evans & Peck to conduct a peer review of Gilbert & Associates assessment. The peer review by Evans & Peck also concluded that the performance measure had not been exceeded.

Assessment against Revised Performance Indicator

Consistent with the revised Metropolitan Coal Longwalls 20-22 and Longwalls 23-27 Water Management Plans (Versions E and D, respectively), subsequent visual surveys (i.e. those conducted following the Gilbert & Associates and Evans & Peck performance assessments) 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.*

The performance indicators are considered to have been exceeded if gas releases in Pool P on the Waratah Rivulet have increased beyond those observed up to 17 April 2014 (i.e. those assessed by the Gilbert & Associates and Evans & Peck performance measure assessments) or if gas releases are observed at Pools Q to W.

The revised performance indicators were not exceeded during the reporting period as gas releases did not increase beyond those observed at Pool P up to 17 April 2014 and gas releases were not 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 26 (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.

No Diversion of Flows or Change in the Natural Drainage Behaviour of Pools

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 Longwall 23 had not advanced 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, the mining of Longwall 23 had not advanced to within 400 m of Pools ETAF to ETAU.

Water level data for Pool ETAI will be 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).*

The performance indicator is considered to have been exceeded if 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). 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 will be analysed and an assessment will be made against the performance measure.

During the reporting period, the mining of Longwall 23 had not advanced to within 400 m of Pool ETAI.

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.

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 until subsidence is less than 20 mm/month, and thereafter within three months of the completion of each longwall (i.e. Longwalls 23-27).

Assessment against Performance Indicator

Consistent with the Metropolitan Coal Longwalls 23-27 Water Management Plan, the visual surveys will 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 performance indicator is considered to have been exceeded if there is significant change in the extent or nature of iron staining over more than 30% of the Eastern Tributary between maingate 26 and the full supply level of the Woronora Reservoir, and a similar change is not also occurring in the Woronora River (control site).

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.

During the reporting period no visual or photographic surveys of the Eastern Tributary were conducted as subsidence of Eastern Tributary was not greater than 20 mm/month and Longwall 23 has not yet been completed.

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.

Minimal Gas Releases

Visual and photographic surveys of the Eastern Tributary between maingate 26 and the Woronora Reservoir full supply level will be conducted monthly until subsidence of the Eastern Tributary is less than 20 mm/month, and thereafter 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.

During the reporting period no visual or photographic surveys of the Eastern Tributary were conducted as subsidence of Eastern Tributary was not greater than 20 mm/month and Longwall 23 has not yet been completed.

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 measure is exceeded if analysis of the monitoring results confirms that the Project has resulted in greater than minimal gas releases in more than 30% of the Eastern Tributary downstream of maingate 26.

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 during the reporting period is provided in Table 1.

In summary, two performance indicators were exceeded, namely: *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* and *No gas releases observed at Pool P on the Waratah Rivulet.*

Exceedance of the performance indicators triggered an assessment against the relevant performance measures. The performance measures were not exceeded during the reporting period.

2.4.2 Longwalls 23-27

The TARP characterisation for Longwalls 23-27 water management during the reporting period is provided in Table 2.

In summary, the same two performance indicators as Longwalls 20-22 were exceeded, namely: *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* and *No gas releases observed at Pools P to W on the Waratah Rivulet.*

Exceedance of the performance indicators triggered an assessment against the relevant performance measures. The performance measures were not exceeded during the reporting period.

Table 1
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)	Assessment deferred. The performance indicator cannot be validly assessed as a result of current discrepancies in flows generated by the existing rating curves used for the Waratah Rivulet and Woronora River gauging stations.	Metropolitan Coal to remedy the situation by regenerating the current flow records from the Waratah Rivulet and Woronora River gauging stations using amended rating relationships to be developed by Metropolitan Coal which more closely reflect the results of the historical gauging. Additional gaugings will also be undertaken during specific flow conditions to enable further refinement of the rating relationships at the Waratah Rivulet and Woronora River gauging stations.	*Negligible reduction to the quantity of water resources reaching the Woronora Reservoir*	-
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)	Yes	Assessment against the performance measure conducted by Gilbert & Associates and included in Section 2.3.1.2.	*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

Table 1 (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?
Connective Cracking (Sections 2.2.1.8, 2.2.1.10 and 2.2.1.11 continued)	*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 connective cracking between the surface and the mine*	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
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, that are not also occurring in the Nepean Reservoir (control site)* (Section 2.3.1.5)	No	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 2.3.1.6)	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 2.3.1.6)	No	Continue monitoring		No

Table 1 (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?
Waratah Rivulet Environmental Consequences (Sections 2.2.1.1 and 2.2.1.3 continued)	*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 2.3.1.6)	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
	No gas releases observed at Pool P on the Waratah Rivulet[8] (Section 2.3.1.6)	Yes	Assessment against the performance measure conducted by Gilbert & Associates. Peer review of the assessment conducted by Evans & Peck also concluded the performance measure had not been exceeded.		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[9] (Section 2.3.1.6)	No	Continue monitoring		No

[8] Assessment to 17 April 2014 (consistent with Version D of the Metropolitan Coal Longwalls 20-22 Water Management Plan).

[9] Assessment from 17 April to 30 June 2014 (consistent with Version E of the Metropolitan Coal Longwalls 20-22 Water Management Plan).

Table 2
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)	Assessment deferred. The performance indicator cannot be validly assessed as a result of current discrepancies in flows generated by the existing rating curves used for the Waratah Rivulet and Woronora River gauging stations.	Metropolitan Coal to remedy the situation by regenerating the current flow records from the Waratah Rivulet and Woronora River gauging stations using amended rating relationships to be developed by Metropolitan Coal which more closely reflect the results of the historical gauging. Additional gaugings will also be undertaken during specific flow conditions to enable further refinement of the rating relationships at the Waratah Rivulet and Woronora River gauging stations.	*Negligible reduction to the quantity of water resources reaching the Woronora Reservoir*	-
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)	Yes	Assessment against the performance measure conducted by Gilbert & Associates and included in Section 2.3.2.2.	*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 departures from the predicted envelope of vertical potentiometric head profiles at Bores 9GGW2B and 9FGW1A do not occur (Section 2.3.2.3)	No	Continue monitoring		No

Table 2 (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?
Connective Cracking (Sections 2.2.2.8, 2.2.2.10 and 2.2.2.11 continued)	*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 connective cracking between the surface and the mine*	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
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, that are not also occurring in the Nepean Reservoir (control site)* (Section 2.3.2.5)	No	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

Table 2 (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?
Waratah Rivulet Environmental Consequences (Sections 2.2.2.1 and 2.2.2.3 continued)	*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
	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
	No gas releases observed at Pools P to W on the Waratah Rivulet[10] (Section 2.3.2.6)	Yes	Assessment against the performance measure conducted by Gilbert & Associates for Pool P. Peer review of the assessment conducted by Evans & Peck also concluded the performance measure had not been exceeded.		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[11] (Section 2.3.2.6)	No	Continue monitoring		No
	No gas releases observed at Pools Q to W on the Waratah Rivulet[13] (Section 2.3.2.6)	No	Continue monitoring		No

[10] Assessment to 17 April 2014 (consistent with Version C the Metropolitan Coal Longwalls 23-27 Water Management Plan).

[11] Assessment from 17 April to 30 June 2014 (consistent with Version C of the Metropolitan Coal Longwalls 23-27 Water Management Plan).

Table 2 (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 (Metropolitan Coal, 2014c) and Metropolitan Coal Longwalls 23-27 Biodiversity Management Plan (Metropolitan Coal, 2014d) 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 Managment 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 hygrophilic vegetation that in turn traps sediment, thereby increasing the water holding capacity. These swamps usually terminate at points where the watercourse suddenly steepens or drops away at a 'terminal step'. Terminal steps often occur at constrictions in the landscape where two ridges converge, causing a narrowing of the swamp and a concentration of water flows into a central channel.

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

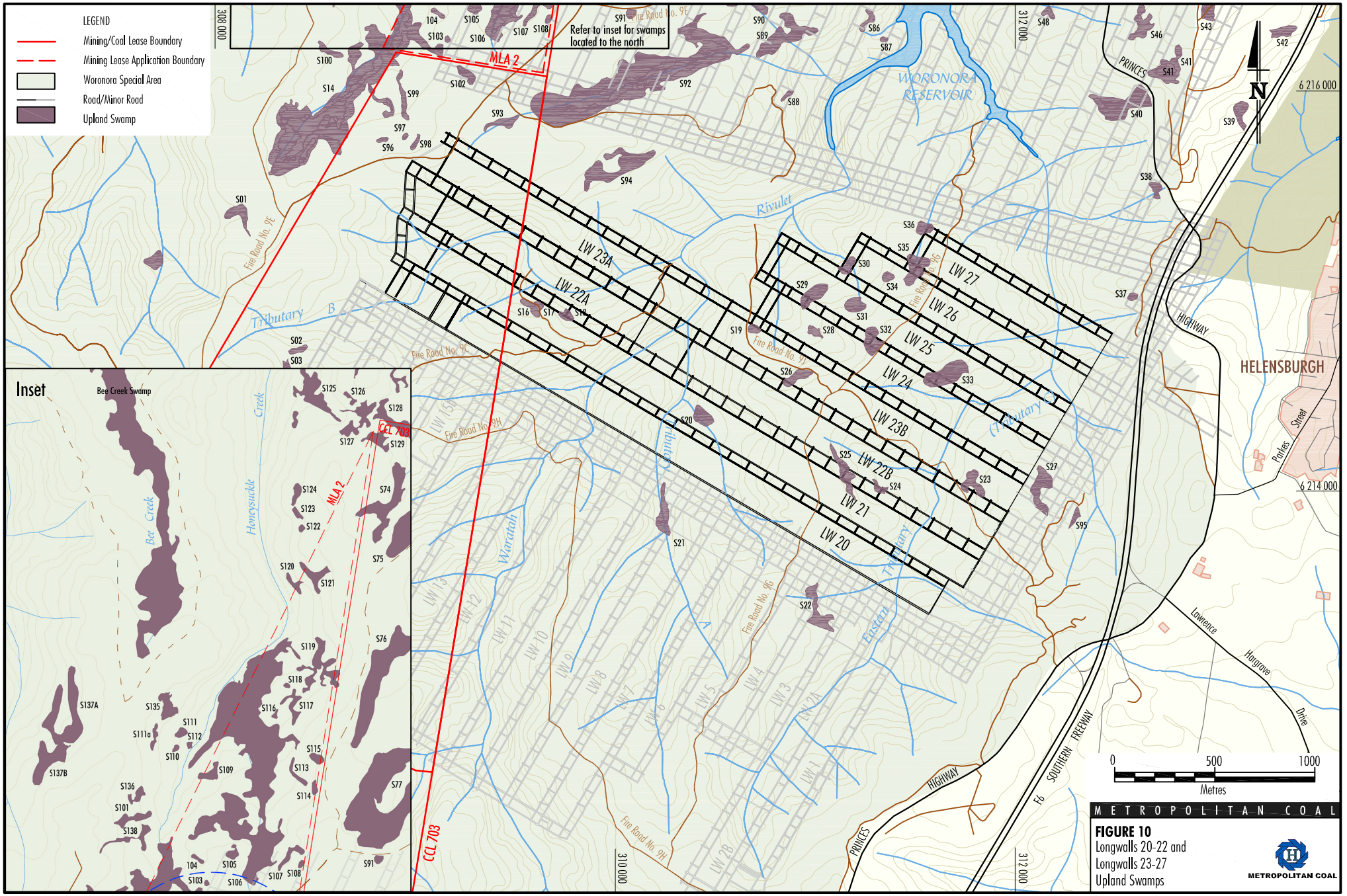
Visual Inspections

Visual inspections are conducted monthly for the period of time that Longwalls 20, 21 or 22 are within 400 m of a swamp to record evidence of potential subsidence impacts. 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.

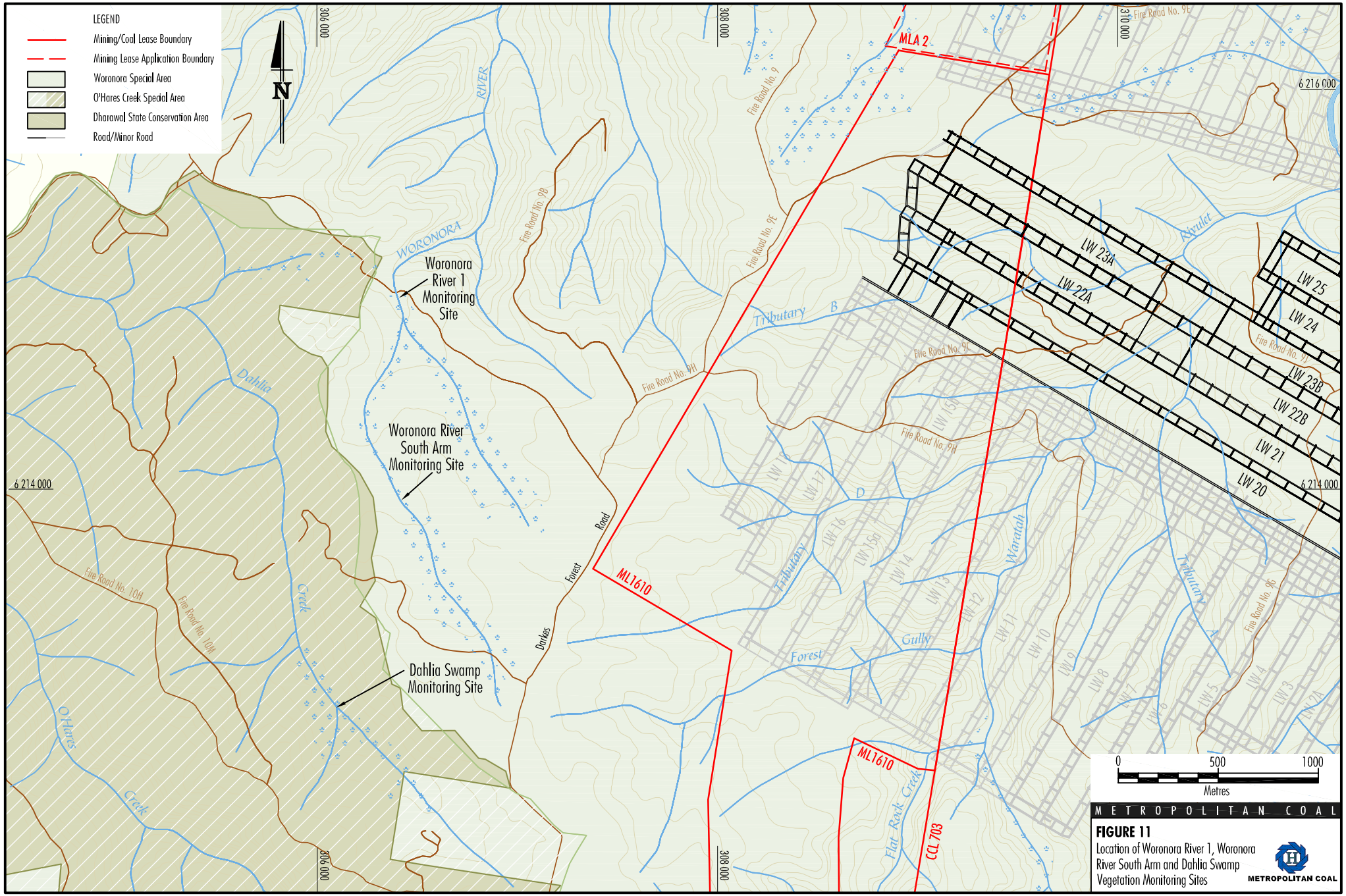


METROPOLITAN COAL

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

METROPOLITAN COAL

MET-08-AD7 2014 6SMR_108A



METROPOLITAN COAL

FIGURE 11
Location of Woronora River 1, Woronora River South Arm and Dahlia Swamp Vegetation Monitoring Sites

METROPOLITAN COAL

MET-08-AD7 2014 6SMR_109A

The Metropolitan Coal 2013 Annual Review/AEMR reported on the visual inspections conducted by Metropolitan Coal to the 31 December 2013. During the reporting period, Swamps 16, 17, 18, 23, 24 and 25 were inspected monthly by Metropolitan Coal when mining was within 400 m of these 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.

The Metropolitan Coal 2013 Annual Review/AEMR reported on the visual inspections conducted by Eco Logical Australia for the spring 2012 and autumn 2013 vegetation surveys. A summary of the visual observations conducted in spring 2013 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 small weathering cracks detected during the baseline and subsequent surveys (autumn and spring 2011) in Swamps 17, 18, 23, and 26, and the rock displacement in Swamp 24.
- New areas of minor erosion on some of the access walking tracks were observed in spring 2013 in Swamp 16 and Swamp 101. Minor erosion was also observed along a drainage line located in Swamp 24 as a result of recent overland flow events. All other observations of increased erosion in spring 2013 were minor and in areas in which erosion has previously been identified, including the table drains adjacent to Swamps 16 and 17, along Fire Road 9J adjacent to Swamp 26, and along access walking tracks within Swamp 125.
- 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:
  - Scattered and isolated dead *Petrophile pulchella* individuals (Swamps 16, 17, 18, 24, 25, 101, 111a and 125), growing among healthy individuals of this species. Dieback was observed in both longwall and control swamps, and areas well beyond the current survey area.
  - Minor yellowing of the foliage and dieback of *Banksia ericifolia* subsp. *ericifolia* and *Petrophile pulchella* was observed within both longwall and control swamps (longwall Swamps 16, 17, 18, 25 and 26, and control Swamps 101, 111a and 125).
  - Sites containing previously recorded small patches of vegetation senescence (i.e. from two to five plants in the one location) in Swamps 17, 18 and 25 were re-inspected during spring 2013. No further senescence was found in these areas and plant growth from adjacent vegetation and natural regeneration has occurred.
- For the Tea Tree Thicket swamps, vegetation of both longwall and control swamps was found to range from good to variable in condition, as follows:
  - Minor yellowing of the foliage of *Baeckea linifolia, Banksia robur*, *Chorizandra cymbaria, Lepidosperma forsythii* and *Acacia longifolia* subsp. *longifolia* was observed within Swamp 20 and Woronora River 1.
  - The canopy of *Acacia longifolia* subsp. *longifolia* in Swamp 20 continues to be found in mixed condition across the swamp, with bare branches and fallen individuals commonly observed. These observations were recorded during both the baseline survey period and the mining period. *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.

  - In Swamp 20 *Gleichenia* spp*., Baumea* sp*.* and *Empodisma minus* were recorded with dieback ranging from minor dieback (Condition 4) to dead (Condition 1). In particular, *Gleichenia microphylla* was generally recorded with many dead stems (Condition 2) to some dead branches/fronds (Condition 3) over much of the swamp. These species were also recorded with dieback within control swamps, however the level of dieback was generally less than in Swamp 20. Since monitoring commenced in spring 2009, Swamp 20 has been observed to be a drier swamp than control swamps Woronora River 1, Woronora River South Arm and Dahlia Swamp (as evident in the higher species richness recorded in Swamp 20). The damper conditions of the control swamps, compared to Swamp 20, may explain the lower level of dieback in these swamps for some species.
  - In Swamp 20 individuals of *Banksia robur* with leaf dieback and desiccation were commonly observed particularly in areas adjacent to the rocky step at the lower end of the swamp, and was similar to that recorded in spring 2012 and autumn 2013. Within control swamps Woronora River 1, Woronora River south arm and Dahlia Swamp scattered individuals of *Banksia robur* also showed signs of dieback with leaf herbivory and some leaf discolouration present. No leaf desiccation, similar to that observed in Swamp 20, was observed. Prior to the spring 2013 surveys, above average rainfall was recorded in September 2013 following a dry end to winter (July and August) where below average rainfall was recorded.

- For the valley side swamps, very little seepage was observed in longwall and control sites at the time of the spring 2013 survey, with swamp sediments generally dry (Swamps 17, 23, 25, 26, 101 and 111a). Observations of seepage were limited to scattered occurrences over terminal steps and other rocky areas in Swamps 16, 18 and 24. Copious amounts of seepage was observed in control Swamp 125, particularly across rocky areas adjacent to Transect 2 and within sediments between Transects 2 and 3.
- For the Tea Tree Thicket sites, Swamp 20 was generally found to be drier than the control sites, consistent with results obtained since the commencement of monitoring (with some exceptions during surveys that followed considerable rainfall events). Within Swamp 20 seepage and running water was restricted to the lower portions of the swamp including the terminal step with much of the swamp surface sediments found to be dry. In contrast, control swamps Woronora River 1, Woronora River South Arm and Dahlia Swamp, although drier than previous surveys, all recorded areas of ponded water, with Woronora River South Arm and Dahlia Swamp having damp to saturated sediments throughout.
- Across all upland swamps, no changes in water colour or new areas of water ponding were observed in either longwall or control swamps. In Swamp 20 iron-stained groundwater seepage, previously observed in spring 2012 and autumn 2013, remains present on the terminal rocky step, and small rocky step (adjacent to end of Transect 1) of 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[12].

Permanent photo points have been established along each transect.

The Metropolitan Coal 2013 Annual Review/AEMR reported on the results of the transect and quadrat monitoring conducted by Eco Logical Australia for the spring 2012 and autumn 2013 vegetation surveys. The results of the transect/quadrat monitoring surveys for spring 2013 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 2013 across all longwall and control sites.

In spring 2013 the height and cover/abundance and of the structural layers was generally consistent with that observed in autumn 2013. 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 2013.

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

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 was variable in both longwall and control swamps in spring 2013 when compared to previous seasons (Chart 67). An increase in species richness since autumn 2013 was observed at two longwall sites (Swamps 18 and 25) and one control site (Swamp 111a). A decrease in species richness was observed at three longwall sites (Swamps 16, 17 and 24) and two control swamps (Swamps 101 and 125). Overall, the species richness recorded at all valley side swamps was variable, although remained within the range of previous seasons, with the exception of Swamp 24, which was marginally below that recorded in previous seasons (decreased by one species since autumn 2013).

In general species richness within Tea Tree Thicket sites has been relatively consistent at control sites across all seasons including spring 2013, 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 ten species since the prior survey), similar to that observed for valley side control swamp 101 (decrease of five to ten species in autumn 2012 and spring 2013 since the prior survey, respectively).

Currently no trends are evident that would suggest impacts on upland swamp species richness are occurring as a result of Longwalls 20-22.

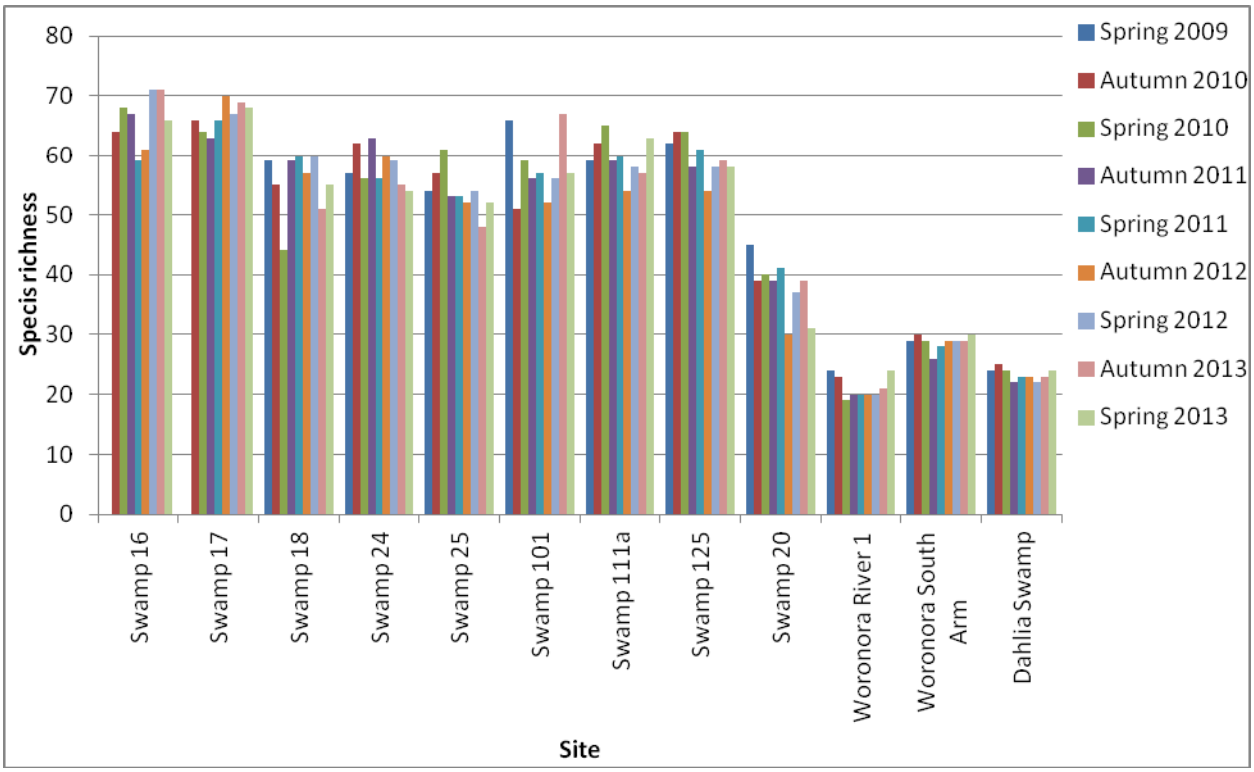


Chart 67 Species Richness in Upland Swamp Sites, Spring 2009 – Spring 2013

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. swamp indicator species, generalist species, shrubs, ground covers) within sites.

Fluctuations in vegetation condition were recorded across all sites, as follows:

- For the valley side swamps, the vast majority of species and individuals were recorded in healthy condition (Condition 5). Vegetation with dieback ranging from Condition 4 (minor dieback) to Condition 3 (some dead branches) was noted occasionally in individuals at all longwall and control sites. Species with dieback commonly included *Acacia longifolia* subsp*. longifolia*, *Chordifex fastigiatus, Empodisma minus, Petrophile pulchella, Platysace linearifolia*, *Sprengelia incarnata, Symphionema paludosum* and *Lepidosperma filiforme*. These species have also been recorded with occasional dieback in previous seasons, including the baseline survey periods.
- For the Tea Tree Thickets, vegetation was generally observed to be in variable condition. Minor yellowing (Condition 4) of the foliage of *Baeckea linifolia, Banksia robur, Chorizandra cymbaria, Lepidosperma forsythii and Acacia longifolia subsp. longifolia* was observed within Swamp 20 and Woronora River 1. A number of other species within Swamp 20 were commonly recorded with dieback ranging from minor (Condition 4) to severe (Condition 1) including *Gleichenia dicarpa, Gleichenia microphylla, Baumea* sp., *Baeckea linifolia, Acacia longifolia subsp. longifolia,* and *Banksia robur*. Within control swamps the occurrences of species or individuals with dieback ranging from minor (Condition 4) to severe (Condition 1) was less common but included *Gleichenia microphylla, Banksia robur, Empodisma minus* and *Chorizandra cymbaria*. *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.

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 2013.

In spring 2013 the mean vegetation condition of tagged indicator species was similar between longwall and control sites, as indicated by overlapping confidence intervals (Charts 68 to 73). Across all sites the mean vegetation condition for tagged indicator species has decreased from spring 2009 to spring 2013, although the size of the decrease varies between species. The decreases in mean vegetation condition were observed at both longwall and control sites.

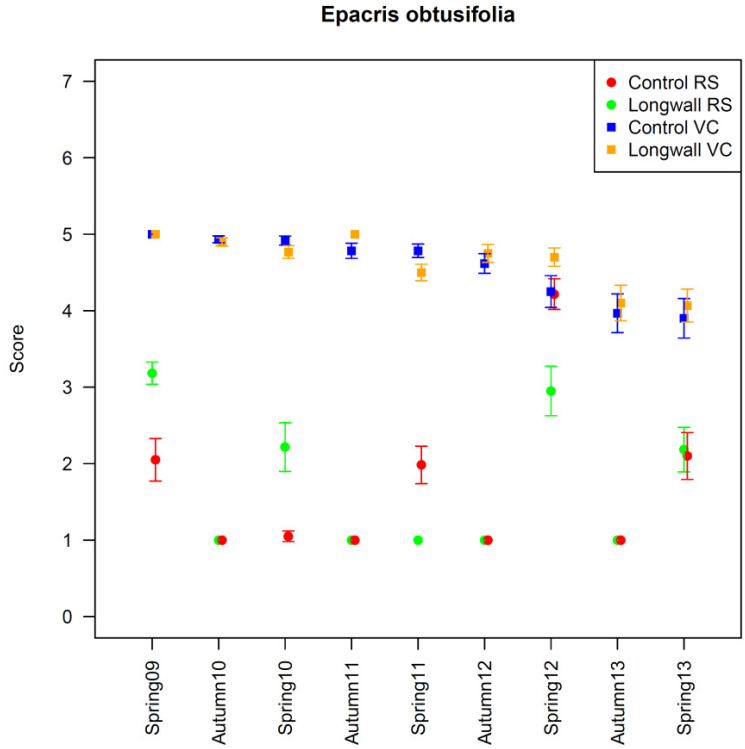


Chart 68 **Mean Scores for Vegetation Condition (VC) and Mean Reproductive Status (RS) for the Indicator Species, *Epacris obtusifolia***

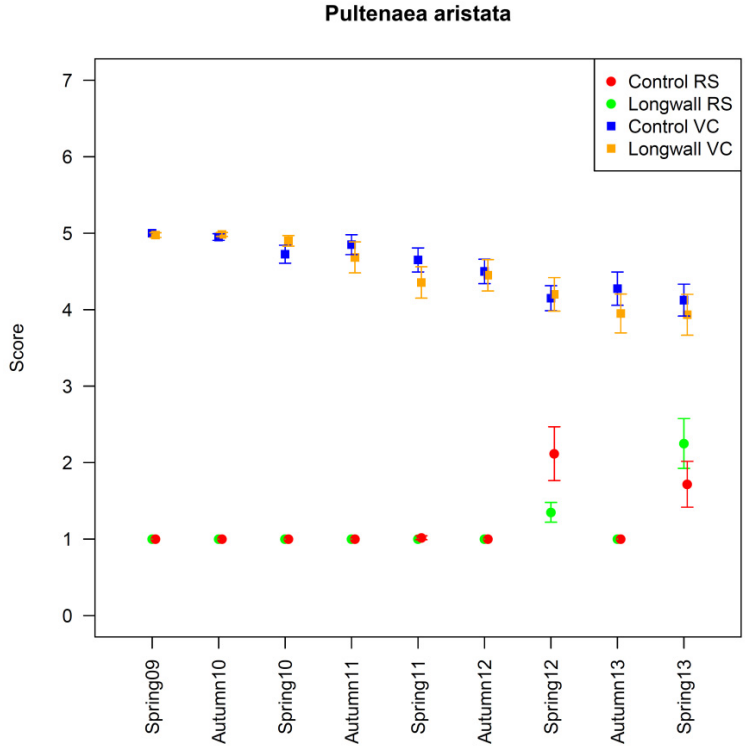


Chart 69 **Mean Scores for Vegetation Condition (VC) and Mean Reproductive Status (RS) for the Indicator Species, *Pultenaea aristata***

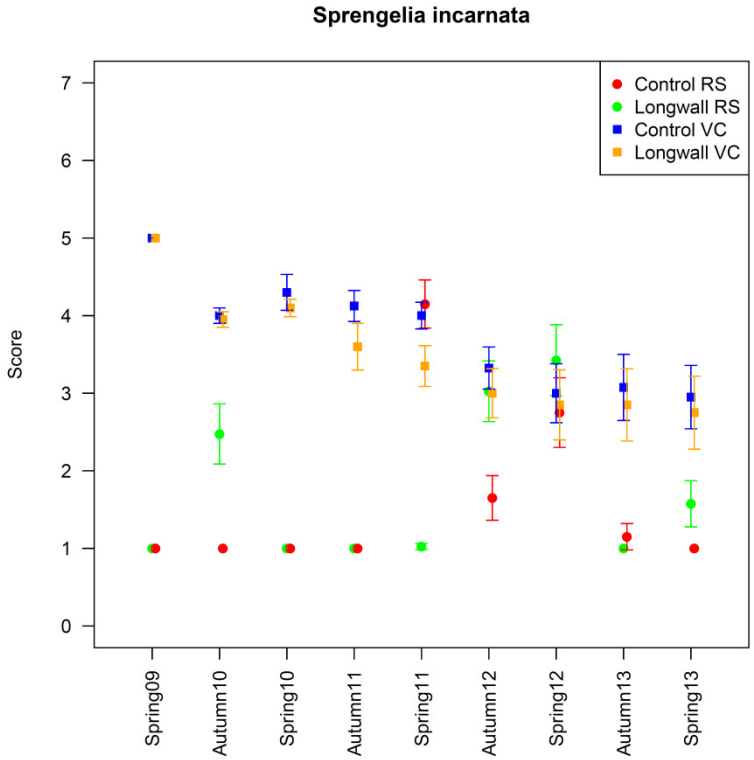


Chart 70 **Mean Scores for Vegetation Condition (VC) and Mean Reproductive Status (RS) for the Indicator Species, *Sprengelia incarnate***

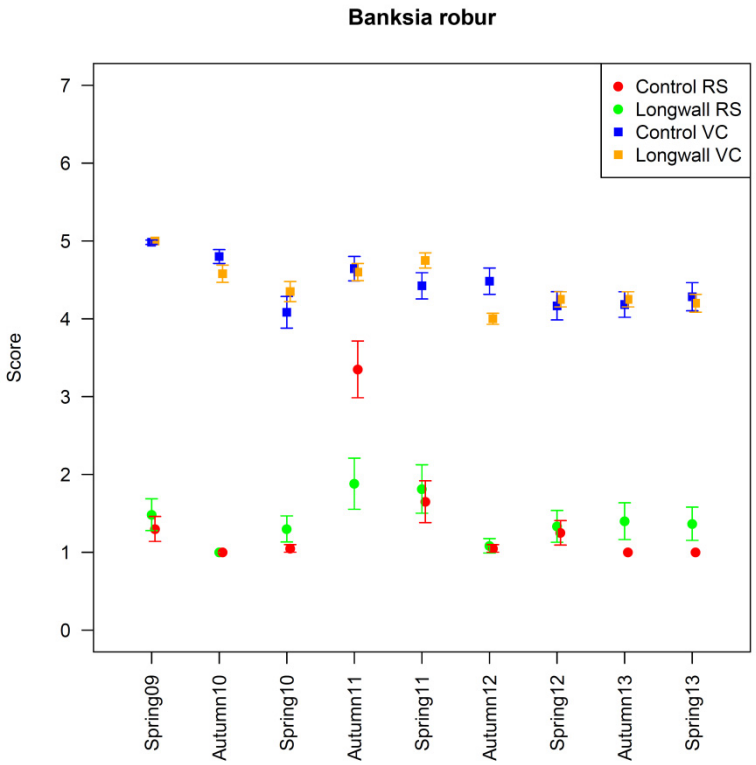


Chart 71 **Mean Scores for Vegetation Condition (VC) and Mean Reproductive Status (RS) for the Indicator Species, *Banksia robur***

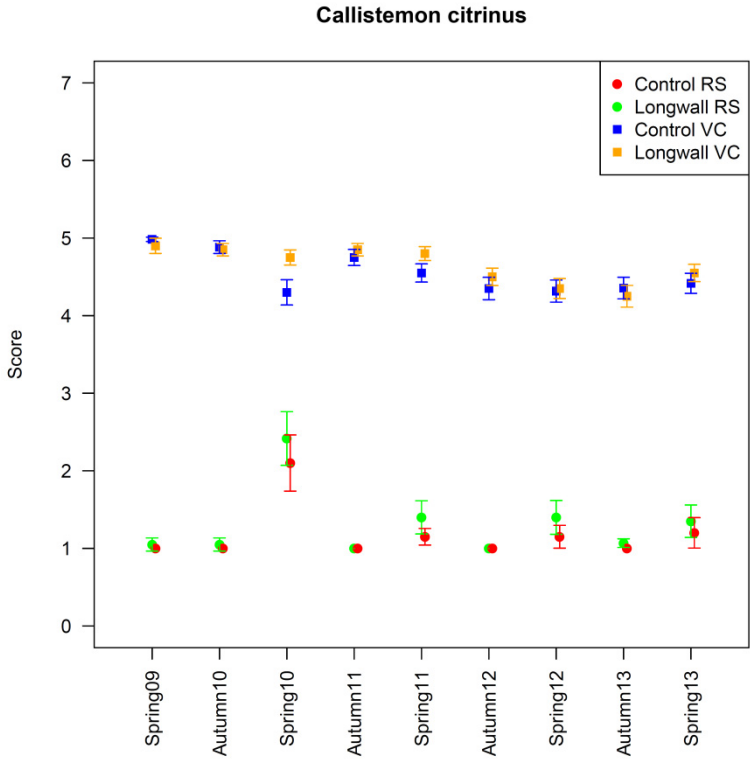


Chart 72 **Mean Scores for Vegetation Condition (VC) and Mean Reproductive Status (RS) for the Indicator Species, *Callistemon citrinus***

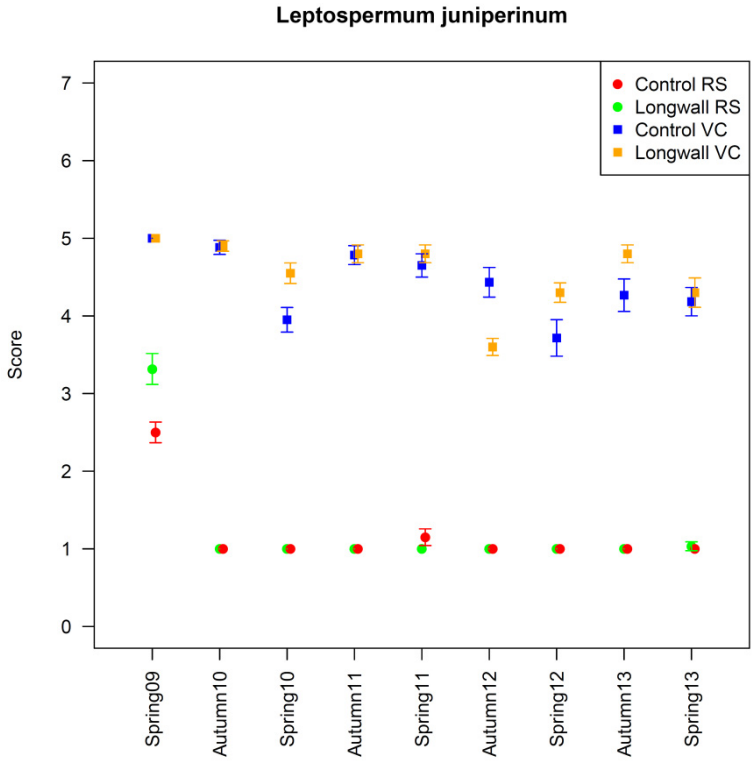


Chart 73 **Mean Scores for Vegetation Condition (VC) and Mean Reproductive Status (RS) for the Indicator Species, *Leptospermum trinervium***

The mean reproductive status of tagged indicator species in spring 2013 was similar between longwall and control sites (Charts 68 to 73), with the exception of *Sprengelia incarnata* and *Banksia robur* where mean reproductive status was higher at longwall sites compared to control swamps. Consistent with previous surveys, mean reproductive status was generally low across all species in spring 2013, which is attributed to survey times not coinciding with peak flowering periods of the indicator species[13].

In spring 2013 a total of 48 individuals of the tagged valley side swamp indicator species were recorded as dead or Condition 1 (severe dieback), which included 44 individuals recorded as dead or Condition 1 prior to spring 2013. The four individuals recorded as Condition 1 for the first time in spring 2013 were:

- Tag K55, *Sprengelia incarnata* in Longwall Swamp 24;
- Tag J83, *Pultenaea aristata* in Longwall Swamp 24;
- Tag L41, *Epacris obtusifolia* in Control Swamp 101; and
- Tag K21, *Sprengelia incarnata* in Control Swamp 101.

Of the 48 Condition 1 individuals of the tagged valley side swamp indicator species, 22 were located within longwall swamps and 26 were located within control swamps, as follows:

- *Epacris obtusifolia,* 15 plants (6 longwall, 9 control);
- *Pultenaea aristata,* 8 plants (6 longwall, 2 control); and
- *Sprengelia incarnata,* 25 plants (10 longwall, 15 control).

In spring 2013 three plants of the tagged Tea Tree Thicket swamp indicator species were recorded in Condition 1, having been recorded previously in this condition, namely *Banksia robur* (Tag A64) in Dahlia Swamp, *Leptospermum juniperinum* (Tag B45) in Woronora 1, and *Leptospermum juniperinum* (Tag B27) in Woronora South Arm. Another plant, *Leptospermum juniperinum* (Tag B47) located in Woronora River 1, which was previously recorded as dead (Condition 1) in spring 2012, was observed to be re-sprouting in spring 2013.

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. 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 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.

[13] 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.

- One sandstone piezometer to a depth of approximately 10 m in valley side Swamp 16 (S16)[14].
- 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 74 and 75, respectively. Both sites are well away from mining, but longwall start dates are included on Charts 74 and 75 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 early 2013 and mid 2013, with infrequent saturation due to drier conditions in late 2013 and over the reporting period (the first half of 2014).

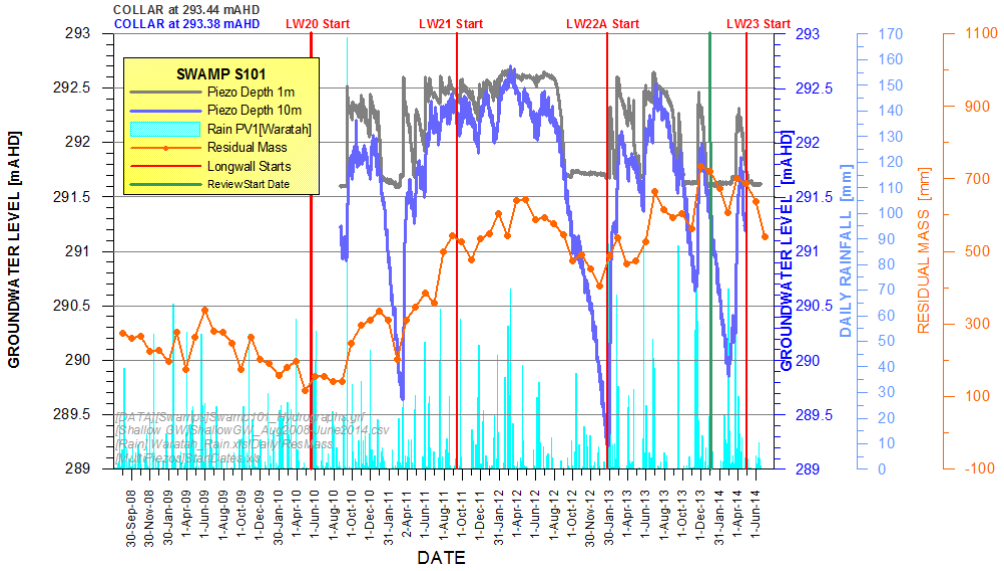


Chart 74 Groundwater Hydrographs at Control Swamp 101

[14] 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.

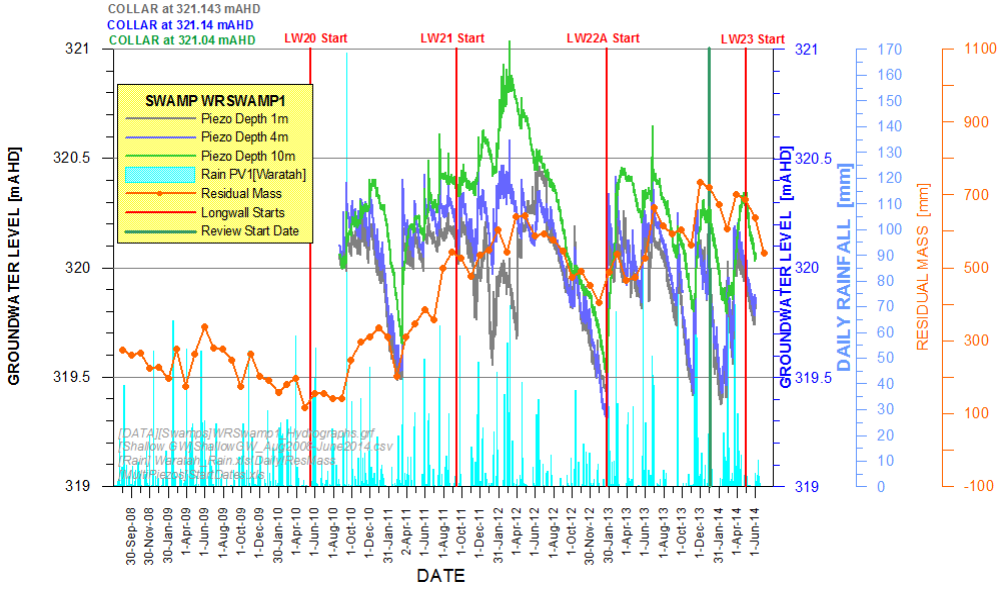


Chart 75 Groundwater Hydrographs at Woronora River 1 Control Swamp

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. This suggests that the swamp is being recharged by groundwater from below and possibly from the sides. An exception occurred during the wet event in February 2013 when, for a short time, water would have seeped downwards from the swamp to the sandstone. 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.

Hydrographic responses for the monitored swamps overlying or adjacent to Longwalls 20-22 (Swamp 17, Swamp 20 and Swamp 25) are shown on Charts 76 to 78. All sites show pronounced drops in the swamp substrate and/or sandstone groundwater levels in the second half of 2012, with intermittent saturation and recession during 2013 and generally lower levels due to drier conditions during the reporting period.

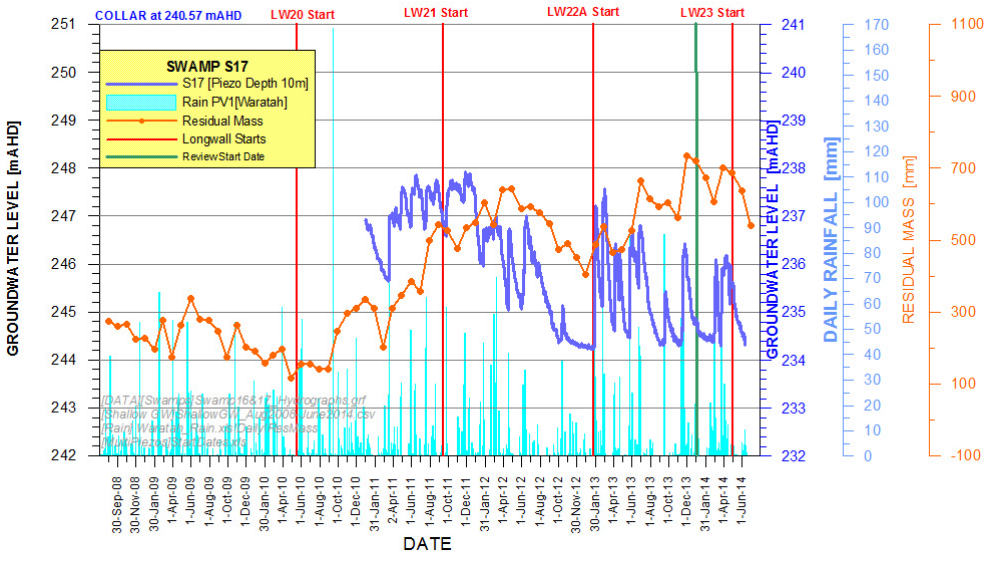


Chart 76 Groundwater Hydrographs at Swamp 17

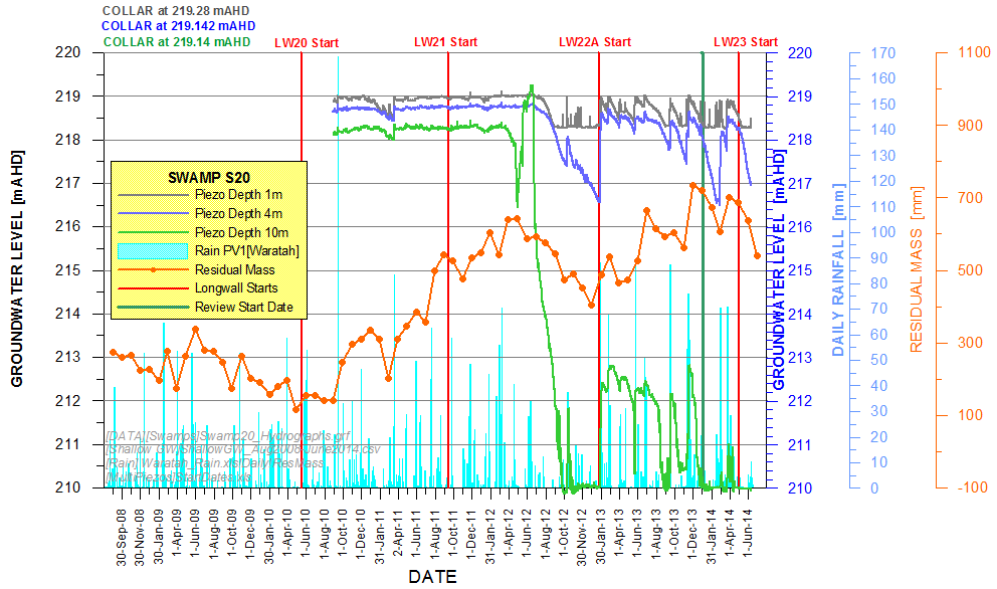


Chart 77 Groundwater Hydrographs at Swamp 20

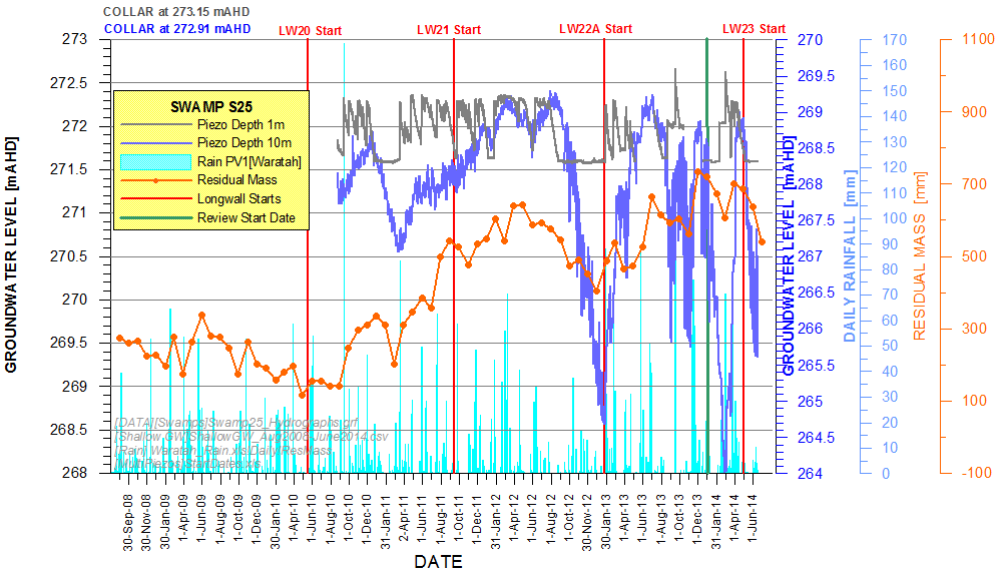


Chart 78 Groundwater Hydrographs at Swamp 25

The excavation front for Longwall 21 passed beneath piezometers Swamp 17, Swamp 20 and Swamp 25 in November 2011, April 2012 and August 2012, respectively. The adjoining Longwall 22A passed alongside piezometer Swamp 17 in May 2013. Longwall 22B passed alongside piezometers Swamp 20 and Swamp 25 in September 2013 and January 2014, respectively.

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 alongside the site in May 2013 (although amplitudes seem higher than normal in January to May 2013). 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. Accordingly, it is most likely a climatic effect.

The average water levels since the passage of Longwall 21 have lowered by about 1 m. It is possible that the advancing Longwall 21 has caused tensional surficial cracks after the longwall face has 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.

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. 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 28-30 January 2013 when 136 mm of rain fell. A rise of 2.5 m occurred immediately in the deepest groundwater level. Water levels since then have fluctuated between 210 mAHD and 213 mAHD in accordance with rainfall variability. The upper two piezometers (one sandstone and one swamp substrate) 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. Although Longwall 22B passed alongside the monitoring site in September 2013, no anomalous response is evident in the shallow piezometers at that time. The swamp has changed from being permanently waterlogged (during the wet period in 2011) to intermittently waterlogged during 2013 and 2014.

As Swamp 25 maintains a consistent separation 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, except possibly for the period from August 2012 to January 2013. 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 declines could be a mixture of climatic and mining effects. However, 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. Hence, it is likely that the observed decline at Swamp 25 is purely a climatic effect.

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.

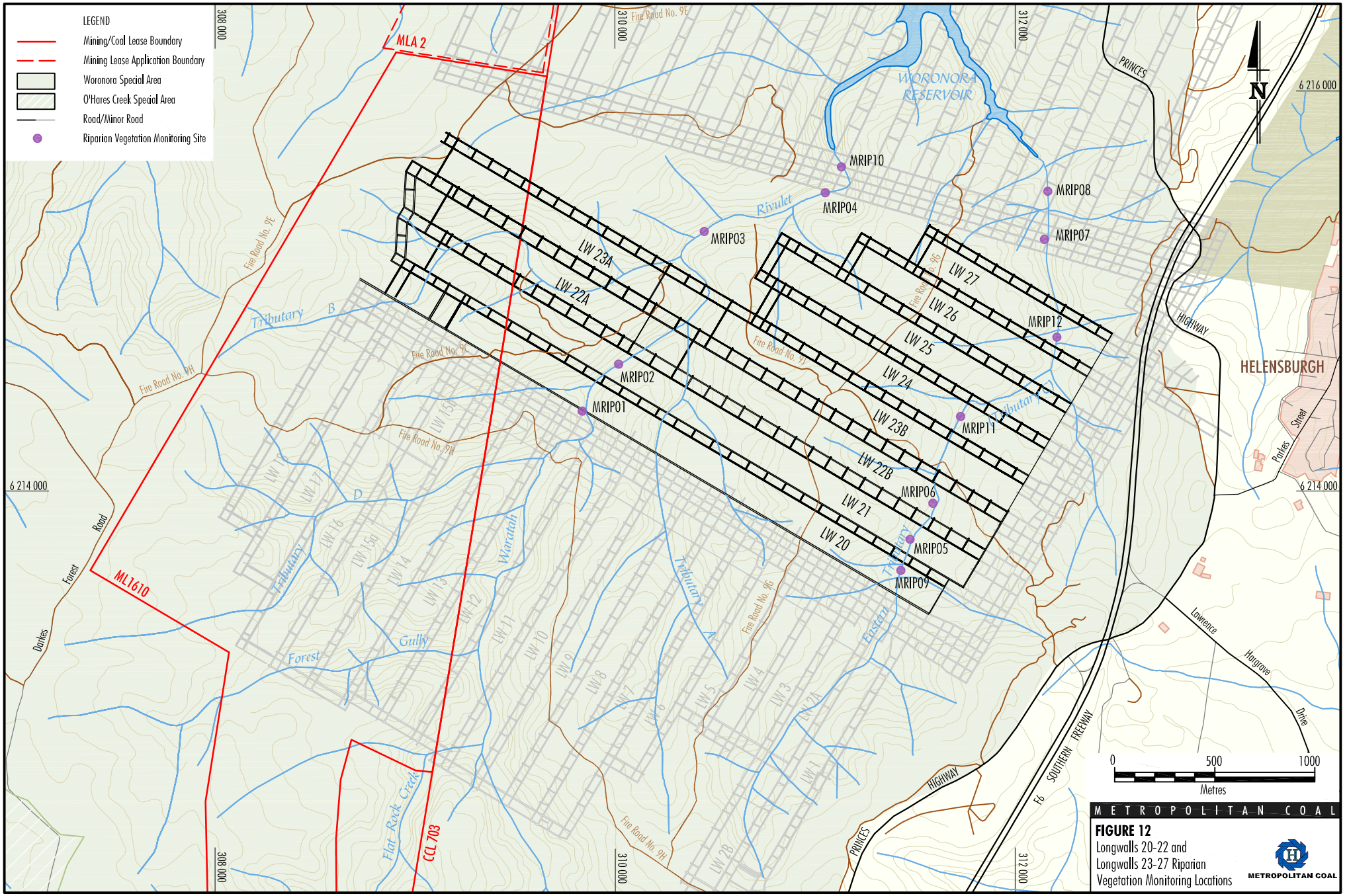


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FIGURE 12
Longwalls 20-22 and Longwalls 23-27 Riparian Vegetation Monitoring Locations

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MET-08-AD7 2014 6SMR_110A

The Metropolitan Coal 2013 Annual Review/AEMR reported on the results of the riparian visual inspection monitoring conducted by Eco Logical Australia for the spring 2012 and autumn 2013 vegetation surveys. The following provides a summary of the results of visual inspections conducted in spring 2013.

- 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.
  - Dieback of groundcover vegetation near the water's edge at site MRIP05, some of which was submerged at the time of the spring 2013 survey (including *Bauera rubioides* and *Gleichenia microphylla*).
  - Dieback of groundcover vegetation along the water's edge at site MRIP09 including *Gleichenia microphylla*. An area downstream of site MRIP09 has undergone scouring of bank sediments and some streamside vegetation was inundated. Individuals of *Allocasuarina littoralis, Hakea teretifolia*, *Banksia ericifolia* subsp. *ericifolia* and *Lomatia myricoides* were observed to be dead in the area of inundation.
  - Downstream from site MRIP08, some *Gleichenia microphylla* was observed with dieback ranging from severe (Condition 1) to many dead stems (Condition 2), although new growth was also present.
  - Within site MRIP02 vegetation along the edge of the Waratah Rivulet was observed with extensive dieback and dead individuals were common (Plates 1 to 3). Dieback was observed along streamside vegetation on both the eastern and western bank, although the band of vegetation with dieback appeared to be more extensive on the eastern bank. Species impacted included groundcovers such as *Gleichenia microphylla, Sticherus flabellatus* var. *flabellatus, Bauera rubioides, Gahnia sieberiana* and the shrubs *Acacia obtusifolia*, *Tristania neriifolia, Lomatia myricoides*, *Prostanthera linearis*, *Persoonia pinifolia*, *Banksia ericifolia* subsp. *ericifolia* and *Grevillea diffusa* subsp. *diffusa*. Some of the dead vegetation continues to be inundated (since first observed autumn 2013).
  - Initially, dieback was observed during the spring 2012 when water levels between MRIP01 and MRIP02 were observed to be substantially lower than previously observed. Dieback of riparian vegetation occurred in narrow continuous strips on both sides of Waratah Rivulet from 15 m upstream of MRIP02, through MRIP02 to the terminal rock bar of Pool N. The dieback was mostly confined to a 40 to 60 centimetres (cm) wide strip along the edge of the watercourse and appeared more extensive on the eastern bank. Dieback occurred in ground cover plants and mid layer shrub species, including *Gleichenia microphylla, Sticherus flabellatus* var. *flabellatus, Leptospermum polygalifolium, Allocasuarina littoralis* and the riparian indicator species *Lomatia myricoides*.
- As reported in the Metropolitan Coal 2013 Annual Review/AEMR, 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 stable. 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 in spring 2013.
- Scouring of the stream bank and erosion of sediments was observed across all riparian monitoring sites, attributed to the high water flows experienced in early 2013. The extent of bank scouring was generally minor.

- Riparian areas that had not previously been inundated were observed to be inundated. This included areas at sites MRIP02 during autumn and spring 2013, and sites MRIP05 and MRIP09 in spring 2013.

Plate 1 View downstream of Eastern Bank of Waratah Rivulet at Site MRIP02 (Photo Point 1), Spring 2013 (Photo taken at 46 m point along MRIP02 transect line)

Plate 2 View upstream of Eastern Bank of Waratah Rivulet at Site MRIP02 (Photo Point 1 view upstream), Spring 2013 (Photo taken at 46 m point along MRIP02 transect line)

Plate 3 View of Eastern Bank of Waratah Rivulet at Site MRIP02 (Photo Point B), Spring 2013 (Photo taken from the western bank approximately 3 m upstream from the start of MRIP02 transect)

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)[15].

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.

[15] 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.

The Metropolitan Coal 2013 Annual Review/AEMR reported on the results of the riparian transect and quadrat monitoring conducted by Eco Logical Australia for the spring 2012 and autumn 2013 vegetation surveys. The following provides a summary of the results of quadrat/transect monitoring for spring 2013.

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

In spring 2013, the precent cover and height of the structural layers was generally similar to that observed and recorded in autumn 2013. Across all seasons (since the 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.

The exception to the above is site MRIP02 where dieback of streamside vegetation has been observed including an associated shift in dominant species of the ground layer. This is considered to be attributable to the water loss experienced at this site in spring 2012 and altered water levels observed after this time, including periods where the vegetation at site MRIP02 has been submerged or inundated.

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 2013 (Chart 79). 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.

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.

It is noted that in spring 2013 at longwall site MRIP02 a number of groundcover species were recorded with reduced cover, or not present, compared to previous seasons as a result of the observed vegetation dieback. 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, Schoenus melanostachys* 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).

With the exception of longwall site MRIP02, vegetation at both longwall and control sites was generally in a healthy condition (Condition 5) and only occasionally with minor dieback (Condition 4), some dead branches (Condition 3) or infrequently with many dead stems (Condition 2). Species including *Gleichenia* spp., *Pteridium esculentum*, *Viminaria juncea* and *Banksia oblongifolia* were observed with some level of dieback at multiple sites, though the majority of individuals were recorded in a good condition across all sites.

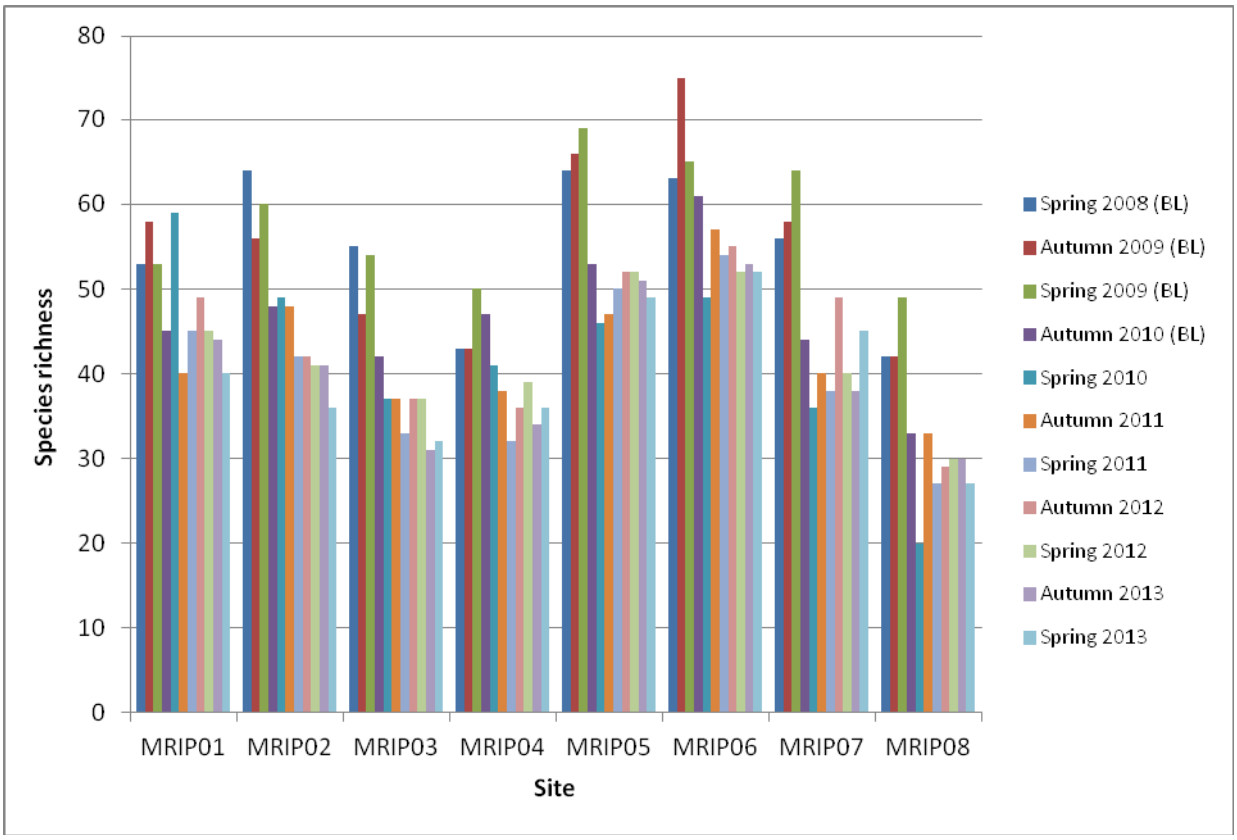

Chart 79 Species Richness in Riparian Monitoring Sites across all Seasons

Baseline seasons are indicated by 'BL'.

Longwall sites – sites MRIP01, MRIP02, MRIP05 and MRIP06. Control sites – sites MRIP03, MRIP04, MRIP07 and MRIP08.

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[16] 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 2013 Annual Review/AEMR reported on the results of the riparian indicator species monitoring conducted by Eco Logical Australia for the spring 2012 and autumn 2013 vegetation surveys. A summary of the results for spring 2013 is presented below.

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

In spring 2013 the mean vegetation condition for tagged riparian indicator species was similar for longwall and control sites, as indicated by overlapping confidence intervals (Charts 80 to 82). As observed in previous seasons, the mean reproductive status of tagged riparian indicator species was more variable than vegetation condition in spring 2013, with differences in mean reproductive status between longwall and control sites observed for *Lomatia myricoides* (higher scores for longwall sites than control sites; Chart 80) and *Schoenus melanostachys* (higher scores for control sites than longwall sites; Chart 82). The difference in mean reproductive status was similar for *Prostanthera linearis* as indicated by overlapping confidence intervals on Chart 81. Generally the mean reproductive scores for *Prostanthera linearis* and *Lomatia myricoides* were low with very little flowering observed, while moderate flowering was observed for *Schoenus melanostachys*.

In spring 2013 a total of 58 individuals of the tagged riparian indicator species were recorded as dead or Condition 1 (severe dieback), including 45 individuals recorded as dead or Condition 1 prior to spring 2013. A total of 18 new individuals were recorded as dead or Condition 1 in spring 2013 (i.e. plants were recorded in healthier condition in autumn 2013), while five individuals were recorded as having re-sprouted in spring 2013 after being recorded in Condition 1 in autumn 2013.

Of the 58 individuals recorded as dead or Condition 1 in spring 2013, 37 were located within longwall sites and 21 were located within control sites, as follows:

- *Prostanthera linearis*, 40 plants (22 longwall and 18 control);
- *Lomatia myricoides*, 9 plants (8 longwall and 1 control); and
- *Schoenus melanostachys*, 9 plants (7 longwall and 2 controls).

The five individuals recorded as having re-sprouted after being recorded as dead or Condition 1 in autumn 2013 were:

- Tag H28 - *Prostanthera linearis* at longwall site MRIP02;
- Tags H61, H67 and H80 - *Prostanthera linearis* at longwall site MRIP05; and
- Tag H86 - *Prostanthera linearis* at longwall site MRIP06.

Additionally, two individuals were not located during the spring 2013 surveys, (Tag G175 *Lomatia myricoides* at control site MRIP07 and Tag I50 *Schoenus melanostachys* at longwall site MRIP09).

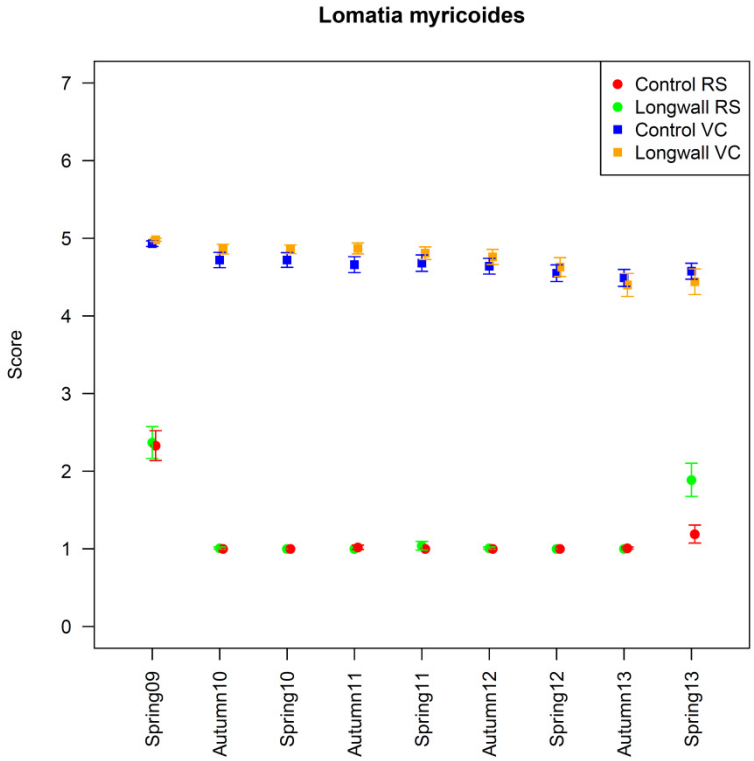

Chart 80 **Mean Scores for Vegetation Condition (VC) and Mean Reproductive Status (RS) for the Indicator Species, *Lomatia myricoides***

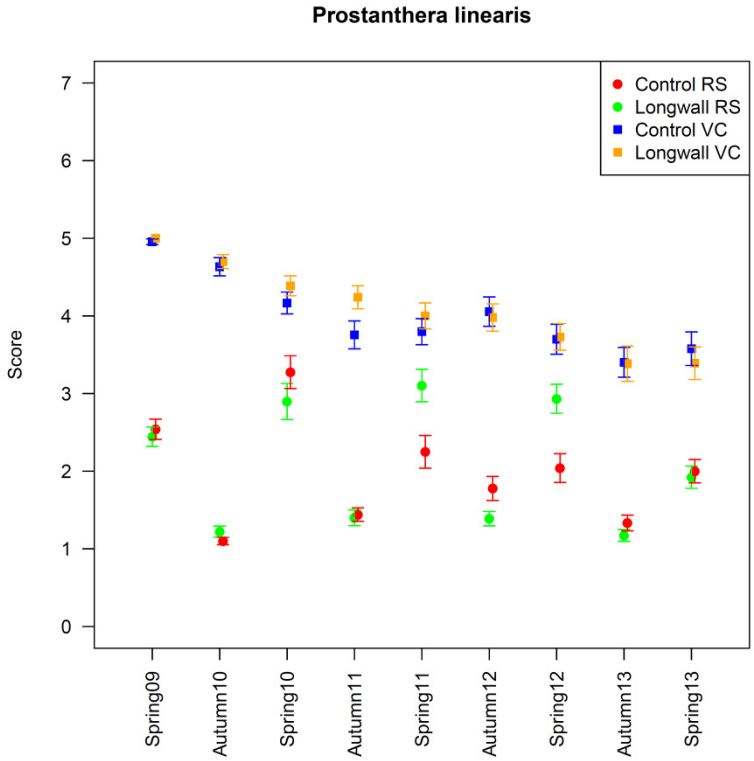

Chart 81 **Mean Scores for Vegetation Condition (VC) and Mean Reproductive Status (RS) for the Indicator Species, *Prostanthera linearis***

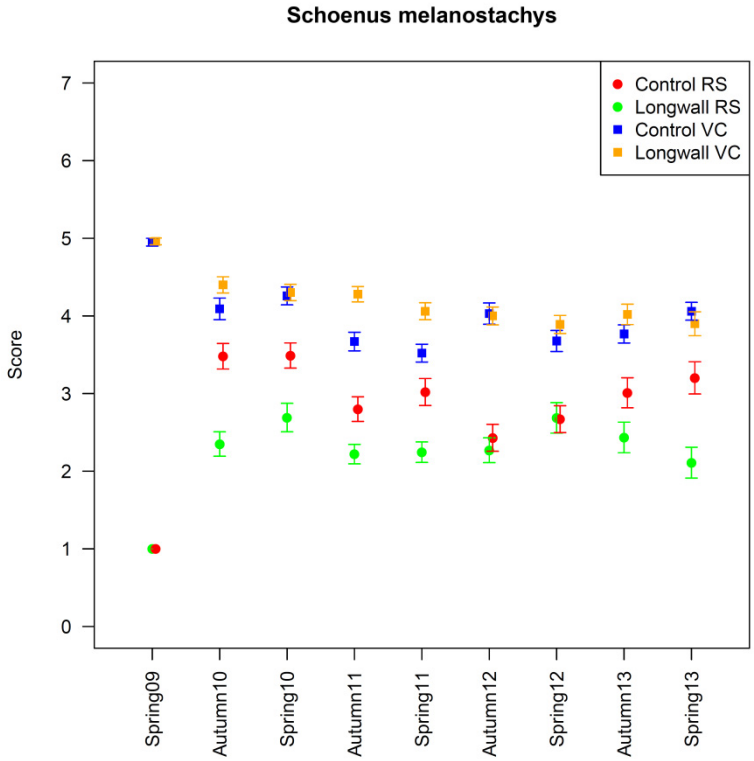

Chart 82 Mean Scores for Vegetation Condition (VC) and Mean Reproductive Status (RS) for the Indicator Species, *Schoenus melanostachys*

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 2 of the Six Monthly Report). 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 from spring 2010 to spring 2013 (i.e. during mining within the Longwalls 20-22 mining area).

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[17] (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[19], 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.

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 2013 Annual Review/AEMR reported on the spring 2012 and autumn 2013 survey results. A summary of the spring 2013 stream monitoring survey results is presented below.

[17] 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 of the Six Monthly Report.

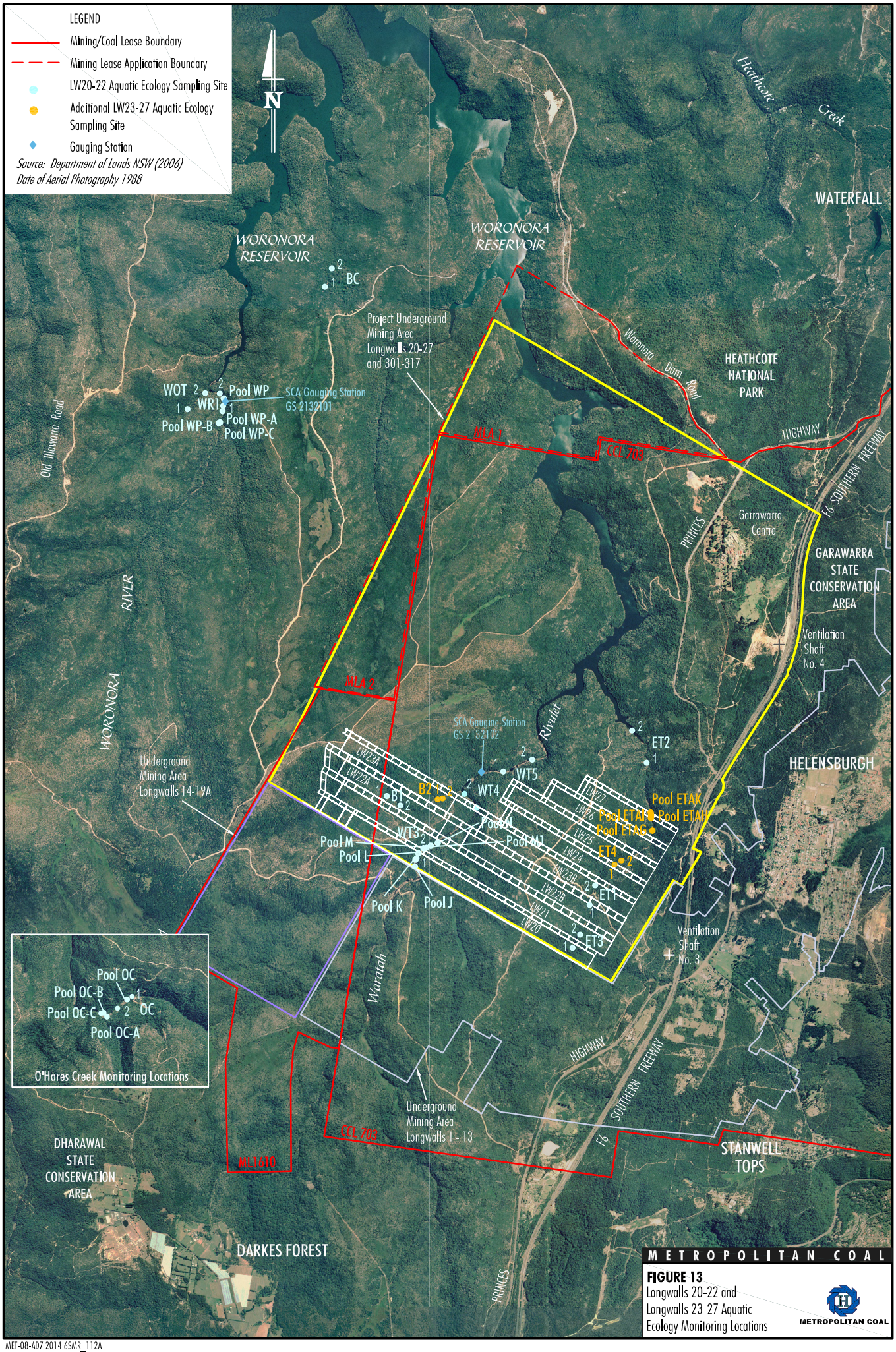

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FIGURE 13
Longwalls 20-22 and Longwalls 23-27 Aquatic Ecology Monitoring Locations

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Stream Characteristics

- There has been no evidence of surface cracking, iron staining or gas releases at the stream monitoring locations sampled along Tributary C/Eastern Tributary (i.e. C1, C2 and C3).
- There was physical evidence of mining related subsidence (i.e. cracking of the stream substratum and an algal/iron floc) at Location WT3 sampled on the Waratah Rivulet, as expected to occur from extraction of Longwalls 20-22 in accordance with the Environmental Assessment.
- A large pool situated within the survey reach in Tributary B was found to have almost completely drained of water in spring 2012. Since then, the pool has remained almost dry. On the last sampling occasion (i.e. spring 2013), there was evidence of surface cracking of the bedrock substratum of the stream channel and no surface-flow along the survey reach.

Macroinvertebrate Assemblages

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

Table 3 presents the AUSRIVAS Band results for each site as a result of sampling of aquatic macroinvertebrates using the AUSRIVAS protocol. Fewer families of macroinvertebrates than expected were commonly collected from all sites sampled (including control sites), compared to reference sites selected by the AUSRIVAS model (Table 3).

A temporal comparison of the aquatic macroinvertebrate data has been carried out for the locations sampled from spring 2008 to spring 2013 using both multivariate and univariate techniques. Charts 83a to 83g present the Principal Coordinates Analysis (PCoA) plots for macroinvertebrates 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.

Charts 84a to 84d 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 85a to 85d 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 86a to 86d 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.

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 only on one occasion in Bee Creek (i.e. T9: spring 2012).

Table 3
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
Tributary C	C1-1	D	C	B	B	C	C	B	B	C	A	D
	C1-2	D	C	C	B	B	B	C	A	B	C	C
	C2-1	D	B	B	C	C	B	C	C	B	C	C
	C2-2	D	C	B	C	C	C	D	B	C	C	C
	C3-1	-	-	B	C	C	C	B	B	B	B	C
	C3-2	-	-	D	C	C	C	C	C	C	A	B
Waratah Rivulet	WT3-1	B	B	B	B	B	C	B	B	C	A	B
	WT3-2	B	B	B	C	B	C	B	B	C	B	C
	WT4-1	D	C	C	C	B	C	C	A	A	B	B
	WT4-2	B	C	C	B	B	C	B	A	B	B	B
	WT5-1	B	C	C	C	C	B	A	B	C	B	C
	WT5-2	D	C	C	C	C	C	C	B	D	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
	BC2	C	A	D	B	C	B	B	B	B	C	B
Woronora Tributary	WOT1	C	B	-*	B	C	C	B	C	B	A	B
	WOT2	C	C	D	C	C	C	C	B	A	C	C
Woronora River	WR1-1	D	B	C	B	C	C	C	C	B	C	C
	WR1-2	C	C	C	B	C	C	C	C	B	B	B
O'Hares Creek	OC1	B	B	B	A	B	B	A	A	A	B	C
	OC2	D	B	B	B	B	B	B	C	C	B	C

* Sites not sampled due to insufficient aquatic habitat.

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

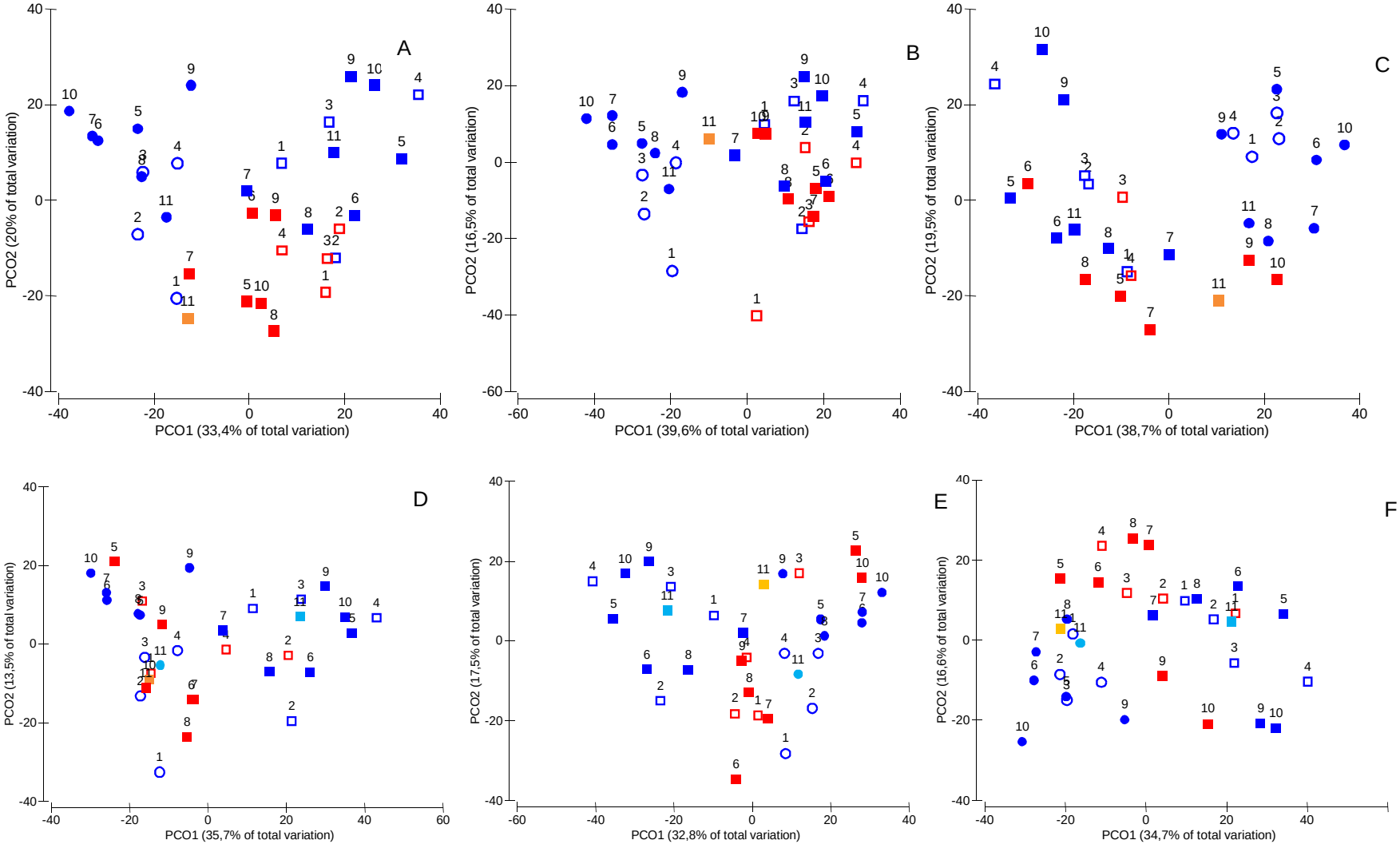

Chart 83a-f Principal Coordinates Analysis (PCoA) plots of macroinvertebrate data for three potential 'impact' locations on Tributary C: a) Location C1; b) Location C2; and c) Location C3) and the Waratah Rivulet: D) Location WT3; E) Location WT4; and F) Location WT5) and two control locations (Woronora 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. Lighter symbols represent last sampling time (spring 2013)

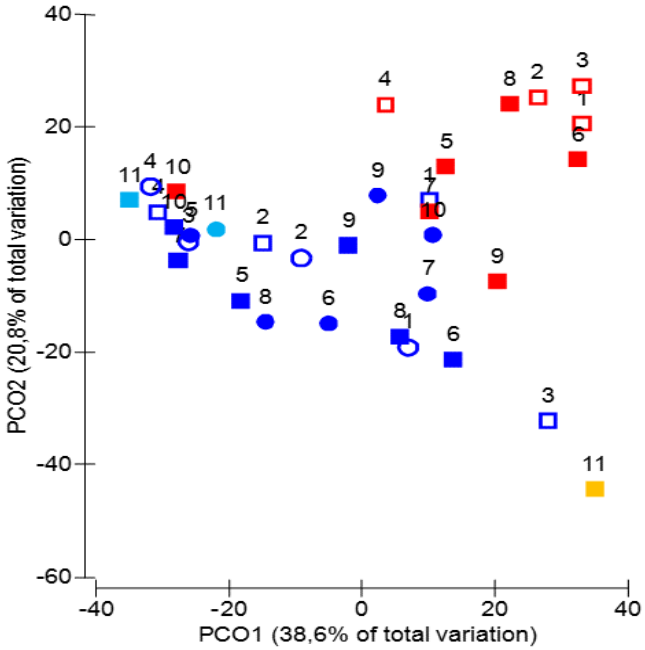

Chart 83g Principal Coordinates Analysis (PCoA) plot of macroinvertebrate data collected at one location on Tributary B and two control locations (Bee Creek and Woronora Tributary) for each time of sampling (*n*= 6). Red symbols: Tributary B location; Blue squares: Bee Creek; Blue circles: Woronora Tributary. Empty symbols: 'Before' commencement of mining; Filled symbols: 'After' mining. Lighter symbols represent last sampling time (spring 2013)

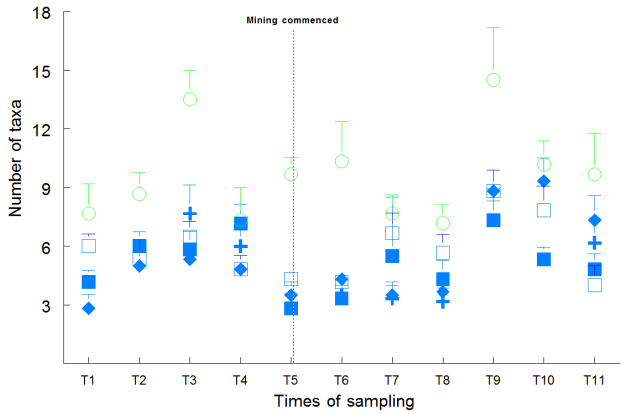

Chart 84a Mean (+SE) Macroinvertebrate Diversity, Stream Monitoring – Tributary C

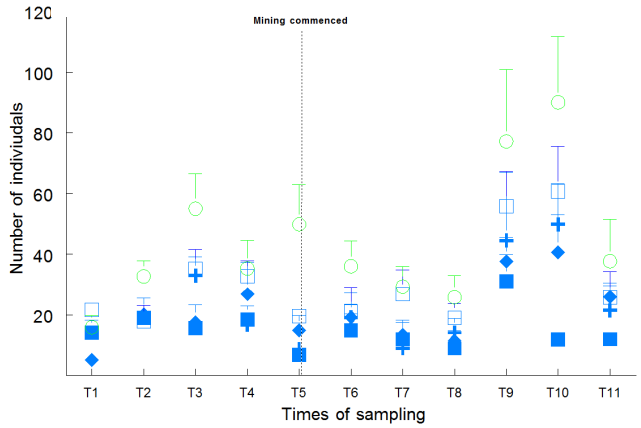

Chart 84b Mean (+SE) Macroinvertebrate Abundance, Stream Monitoring – Tributary C

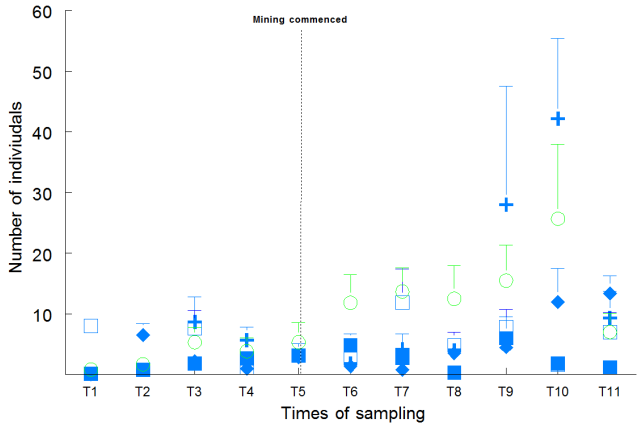

Chart 84c Mean (+SE) Number of Leptophlebiidae, Stream Monitoring- Tributary C

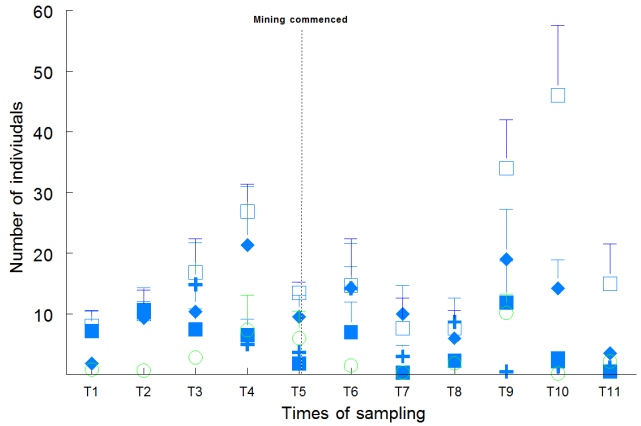

Chart 84d Mean (+SE) Number of Atyidae, Stream Monitoring – Tributary C

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)

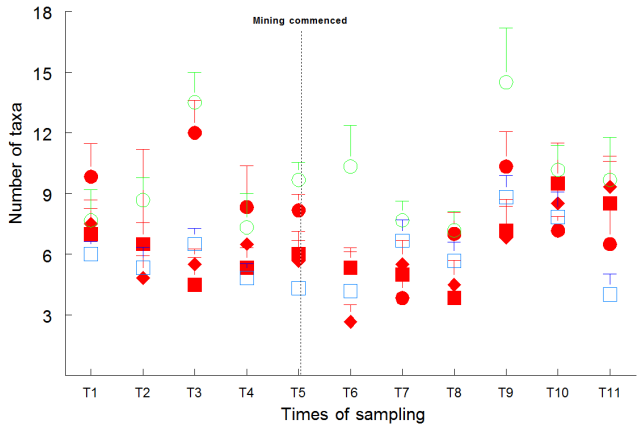

Chart 85a Mean (+SE) Macroinvertebrate Diversity, Stream Monitoring - Waratah Rivulet

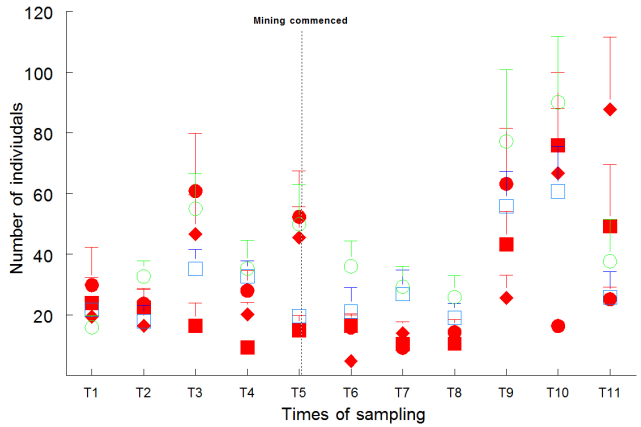

Chart 85b Mean (+SE) Macroinvertebrate Abundance, Stream Monitoring – Waratah Rivulet

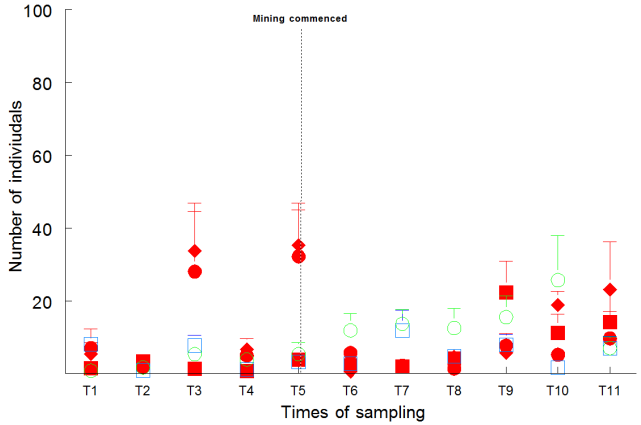

Chart 85c Mean (+SE) Number of Leptophlebiidae, Stream Monitoring- Waratah Rivulet

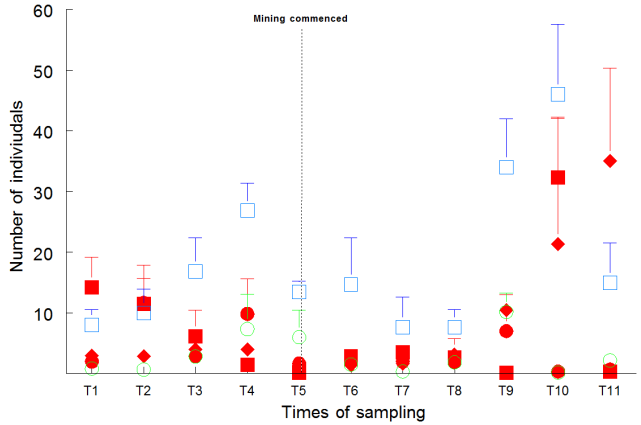

Chart 85d Mean (+SE) Number of Atyidae, Stream Monitoring – Waratah Rivulet

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.

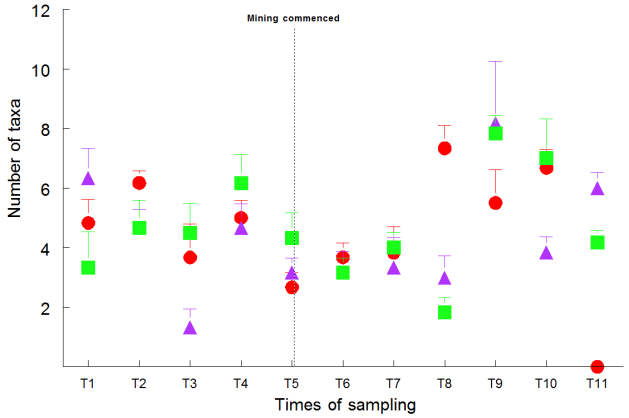

Chart 86a Mean (+SE) Macroinvertebrate Diversity, Stream Monitoring – Tributary B

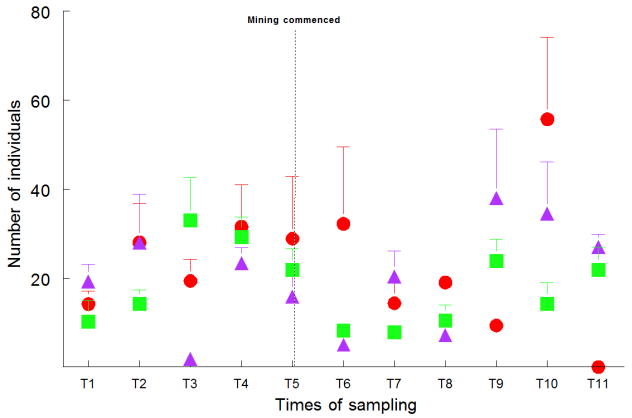

Chart 86b Mean (+SE) Macroinvertebrate Abundance, Stream Monitoring – Tributary B

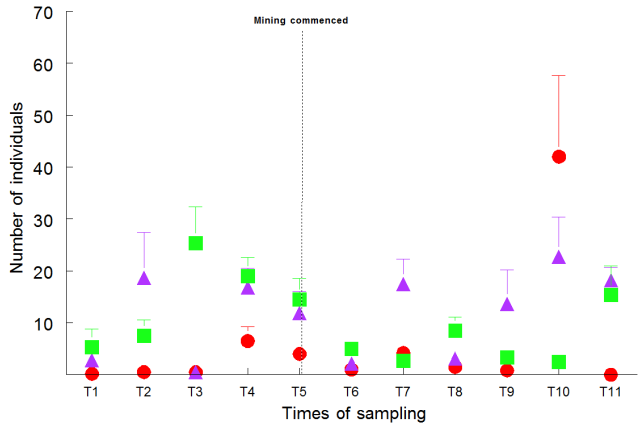

Chart 86c Mean (+SE) Number of Leptophlebiidae, Stream Monitoring- Tributary B

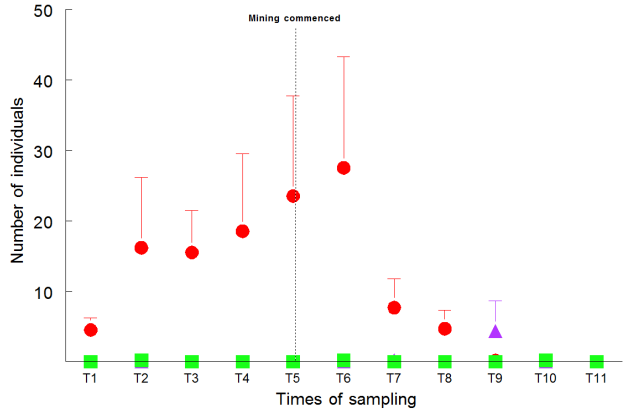

Chart 86d Mean (+SE) Number of Atyidae, Stream Monitoring – Tributary B

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

To date, the monitoring data indicates that any effect of subsidence on assemblages of aquatic macroinvertebrates at locations sampled within the Longwalls 20-22 mining area in Tributary C/Eastern Tributary and the Waratah Rivulet are within the range of natural variability in these assemblages as measured by the control locations.

At the location sampled in Tributary B, patterns of change in the structure of assemblages of macroinvertebrates and components of the assemblage (i.e. diversity, total abundance and abundances of the mayfly family, Leptophlebiidae, and freshwater shrimp family, Atyidae) differed considerably from changes observed at the control locations in spring 2013 and the last two times of sampling (autumn 2013 and spring 2012). Notably, Atyidae have not been collected at Tributary B since spring 2012. It seems likely that observed changes are associated with mining related subsidence impacts that have been observed (i.e. draining of pools and loss of surface flow).

Macrophyte Assemblages

Over the entire sampling period, floating attached species and/or submerged species of macrophytes (i.e. instream macrophytes) have been recorded at sampling locations WT4, WT5, WR1 and OC (*Triglochin procerum*), C1, C2, C3, WT3, WT4, WT5, WR1 and OC (*Chara/Nitella* spp.) and WR1 (*Myriophyllum pedunculatum*).

A temporal comparison of the aquatic macrophyte data has been carried out for the locations sampled from spring 2008 to spring 2013 using both multivariate and univariate techniques. Charts 87a to 87g 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.

Chart 88a to 88b 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 89a and 89b 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 90a and 90b 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.

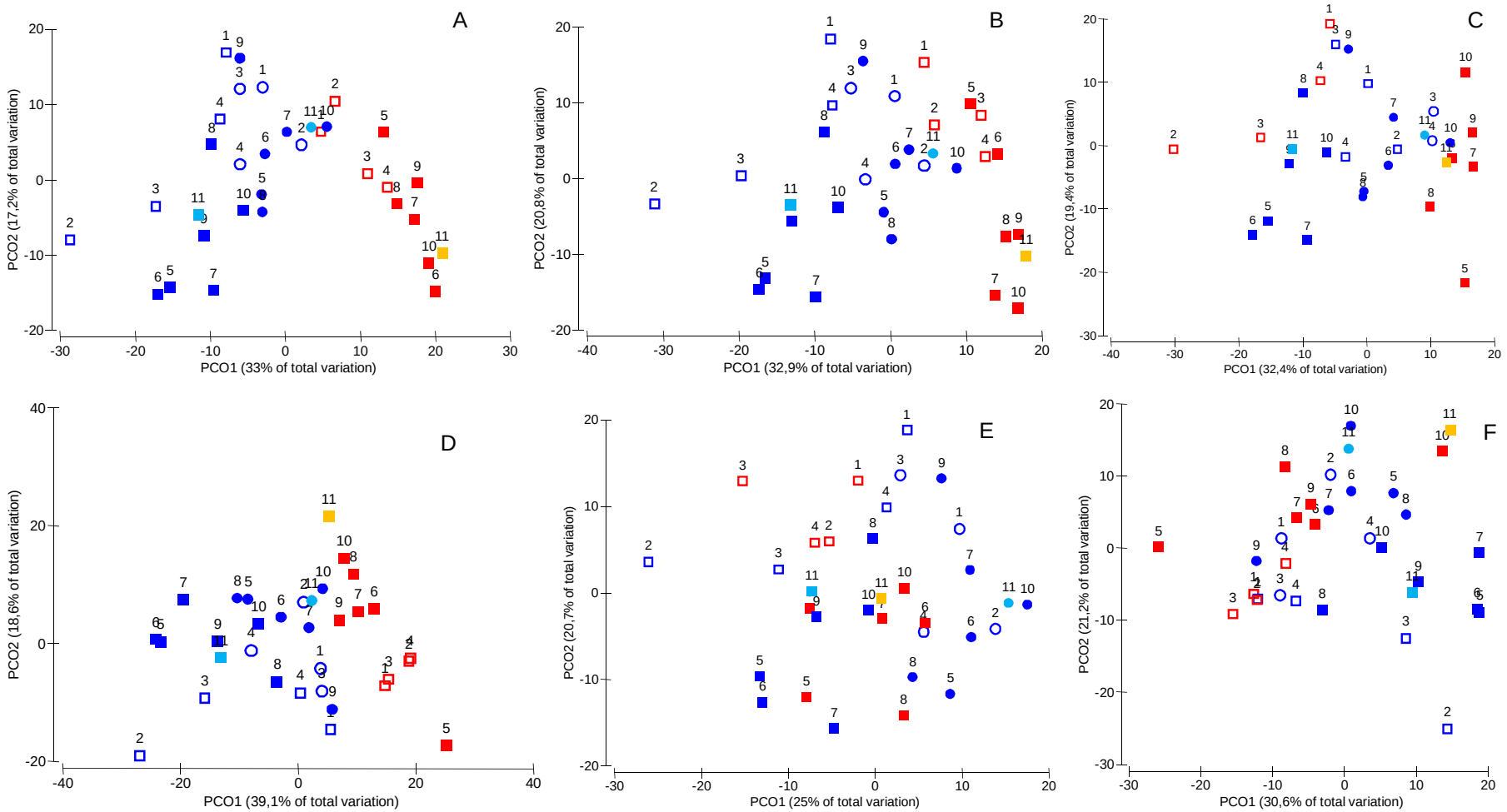

Chart 87a-f Principal Coordinates Analysis (PCoA) plots of macrophyte data for three potential 'impact' locations on Tributary C: a) Location C1; b) Location C2; and c) Location C3) and the Waratah Rivulet: D) Location WT3; E) Location WT4; and F) Location WT5) and two control locations (Woronora River 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' mining. Lighter symbols represent last sampling time (spring 2013)

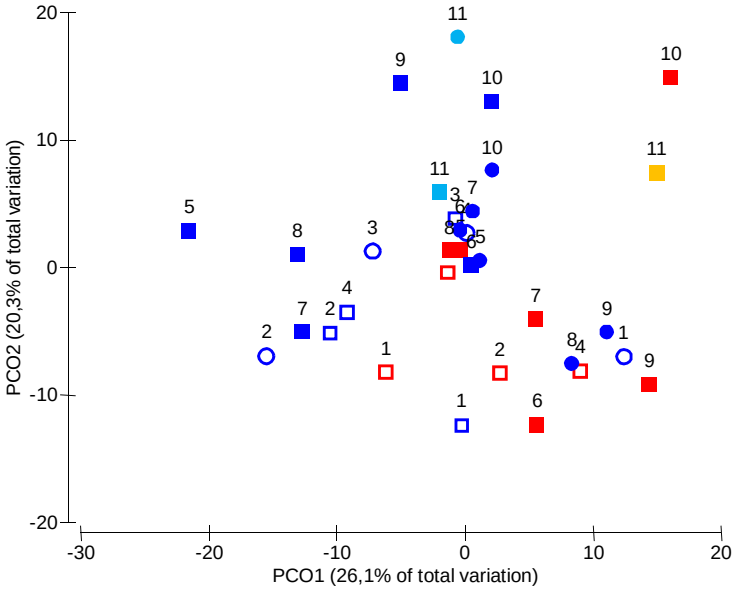

Chart 87g Principal Coordinates Analysis (PCoA) plot of macrophyte data collected at one location on Tributary B and two control locations (Bee Creek and Woronora Tributary) for each time of sampling (*n*= 10). Red symbols: Tributary B; Blue squares: Bee Creek; Blue circles: Woronora Tributary. Empty symbols: 'Before' commencement of mining; Filled symbols: 'After' mining. Lighter symbols represent last sampling time (spring 2013)

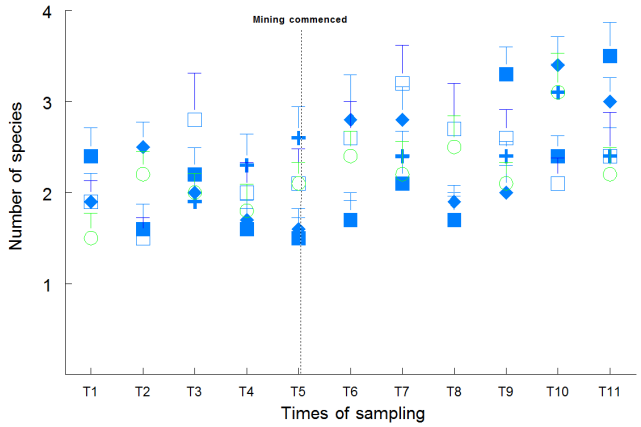

Chart 88a Mean (+SE) Macrophyte Diversity, Stream Monitoring, Tributary C

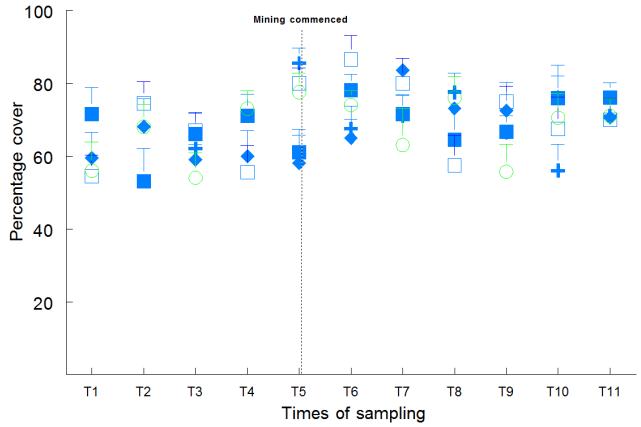

Chart 88b Mean (+SE) Macrophyte Cover, Stream Monitoring, Tributary C

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)

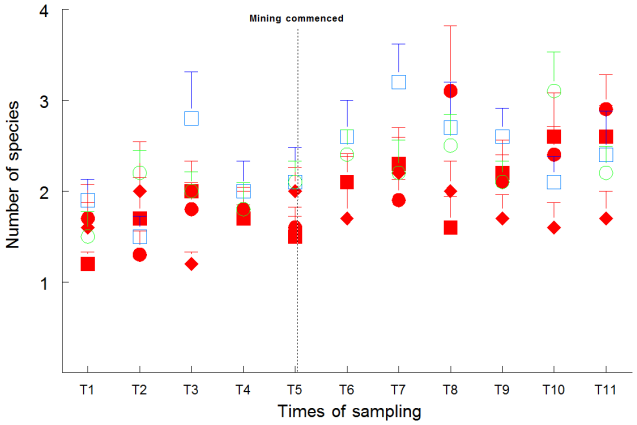

Chart 89a Mean (+SE) Macrophyte Diversity, Steam Monitoring, Waratah Rivulet

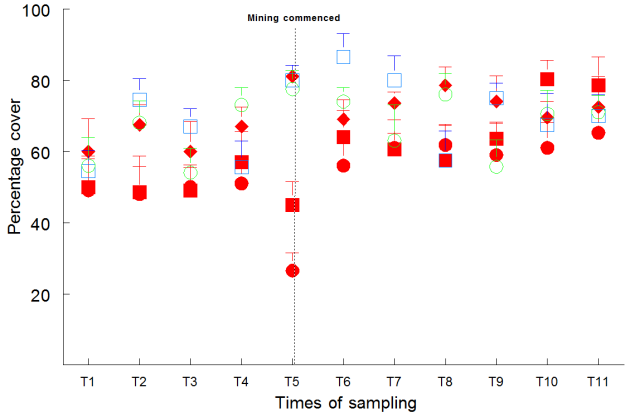

Chart 89b Mean (+SE) Macrophyte Cover, Stream Monitoring, Waratah Rivulet

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)
Time 1 = spring 2008, T2 = autumn 2009, etc. NB Sampling of C3 commenced at T3 (spring 2009)

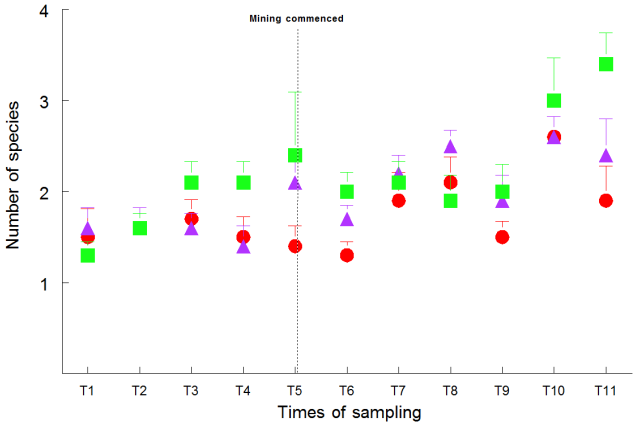

Chart 90a Mean (+SE) Macrophyte Diversity, Steam Monitoring, Tributary B

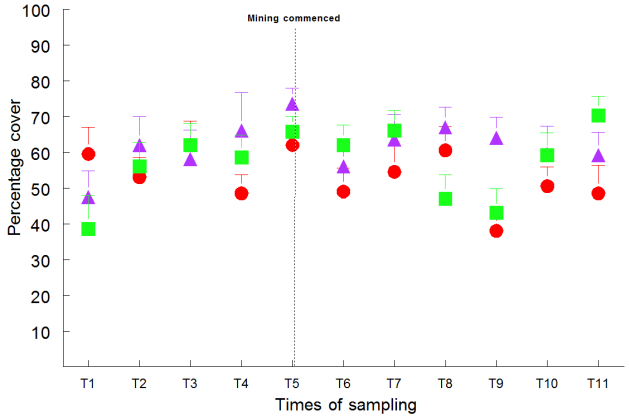

Chart 90b Mean (+SE) Macrophyte Cover, Stream Monitoring, Tributary B

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

To date, the main findings for assemblages of macrophytes include:

- The structure of macrophyte assemblages varied among locations and through time although similar taxa (i.e. *Lepidosperma filiforme, Triglochin procerum and Gleichenia dicarpa*) were consistently ranked as most important.
- A general increase in total cover of macrophytes has been observed at the sampling locations on Tributary C and the Waratah Rivulet causing apparent differences in the structure of assemblages of macrophytes from before to after commencement of mining. Similar patterns of temporal change were observed at the control locations hence apparent differences between the before and after periods were not found to be statistically significant.
- Temporal variability in macrophyte diversity and cover at locations along Tributary C and the Waratah Rivulet within the Longwalls 20-22 area was similar in magnitude and direction as the control locations.
- Temporal variability in macrophyte diversity and cover at sites sampled within Tributary B were not similar in magnitude and direction compared to the control locations. A large proportion (up to 70% in places) of the emergent macrophyte vegetation (particularly *Gleichenia dicarpa* and *Empodisma minus*) at the edges of the stream channel were in poor condition in spring 2013, considered to likely be a result of the effects of subsidence on pools and surface flow.

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[18] (i.e. pre-mining within the Longwalls 20-22 mining area) and from spring 2010 to spring 2013 (i.e. during mining within the Longwalls 20-22 mining area).

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.

[18] 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.

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 2013 is presented below.

Pool Characteristics

An algal/iron floc was observed to cover approximately 15% of the substratum of Pool N situated on the Waratah Rivulet. Overall, cover of the substratum by the algal/iron floc complex had decreased considerably at all of the pools sampled on Waratah Rivulet (i.e. Pools J, K, L, M, M1 and N) in spring 2013 since the last sampling occasion (i.e. autumn 2013).

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

- At Pool J, there were no obvious signs of disturbance thought to be associated with mining activities.
- There was evidence of cracking of bedrock in the stream channel and bank of Pool M1 in some places. Cracking in the vicinity of Pool M1 was first observed by the spring 2012 survey.
- A considerable drop in water level (up to approximately 1.8 m) in Pool N was noted by the spring 2012 survey. In autumn 2013 and spring 2013, the water level in Pool N was similar to that reported by surveys carried out prior to spring 2012.
- For small pools sampled along the Waratah Rivulet, gas releases were observed at the upstream end of Pool L in spring 2013 and previously in spring 2012.

Macroinvertebrate Assemblages

Chart 91 presents PCoA plots for macroinvertebrates at the larger pools using the quantitative sampling data. Charts 92a to 92d 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 93 presents PCoA plots for macroinvertebrates at the smaller pools, using the quantitative sampling data. Charts 94a and 94b present the mean diversity of macroinvertebrates and mean abundance of macroinvertebrates at the smaller pools, respectively, using the quantitative sampling data.

Results indicated that temporal (i.e. among sampling times) variation of assemblages of macroinvertebrates collected from large pools sampled on the Waratah Rivulet, particularly at Pools J and N was larger than that observed for assemblages collected from control pools. Changes in abundance of the mayfly family, Leptophlebiidae, and freshwater shrimp family, Atyidae, contributed greatly to the observed differences. Notably, a considerable spike in numbers of individuals of Leptophlebiidae and Atyidae was measured in Pool N in spring 2012 (Time 9) (Charts 92c and 92d), which coincided with a considerable drop in water level (up to approximately 1.8 m) within the pool. Subsequent surveys found that the pool had refilled and abundances of Leptophlebiidae and Atyidae were similar to those reported by surveys carried out prior to the reduction in pool water level.

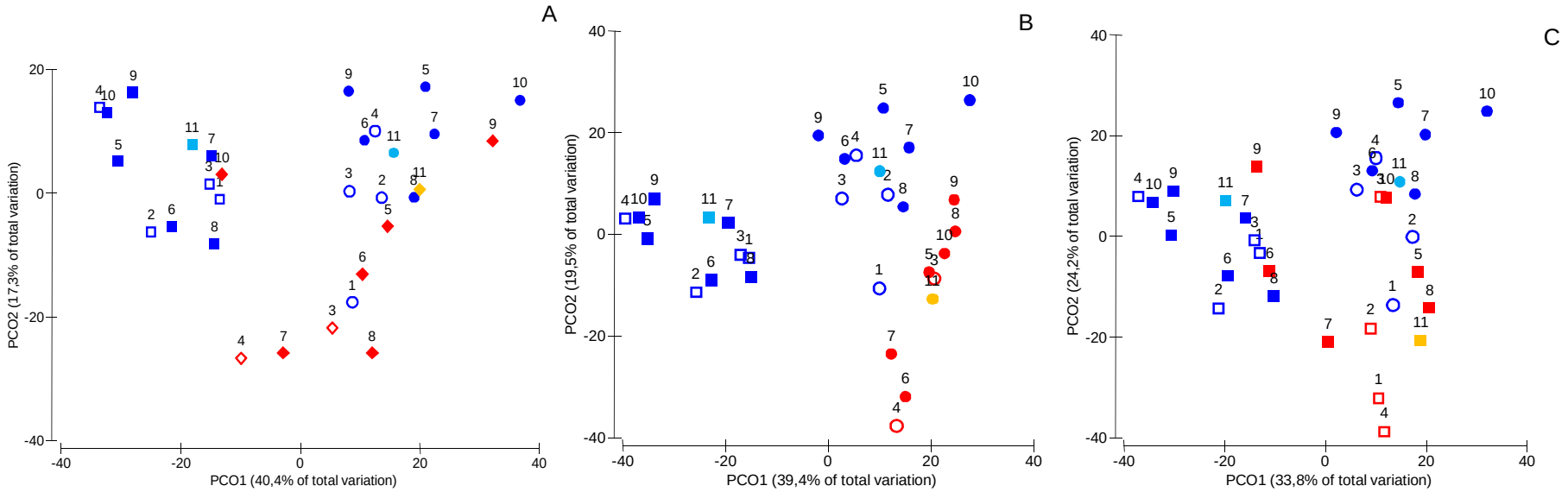

Chart 91a-c Principal Coordinates Analysis (PCoA) plots of macroinvertebrate data for each pool for each time of sampling (*n* = 6). A) Pool J: red diamonds, B) Pool M1: red circles and C) Pool N: red squares; and two control pools: Woronora River (blue squares) and O'Hares Creek (blue circles). Empty symbols: 'Before' commencement of mining; Filled symbols: 'After' mining. Numbers indicate time of sampling. Lighter symbols represent last sampling time (spring 2013)

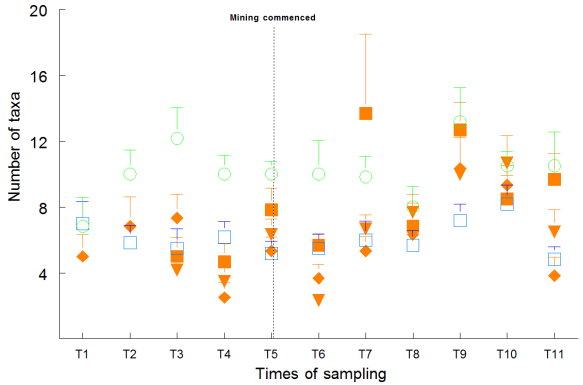

Chart 92a Mean (+SE) Macroinvertebrate Diversity, Large Pool Monitoring

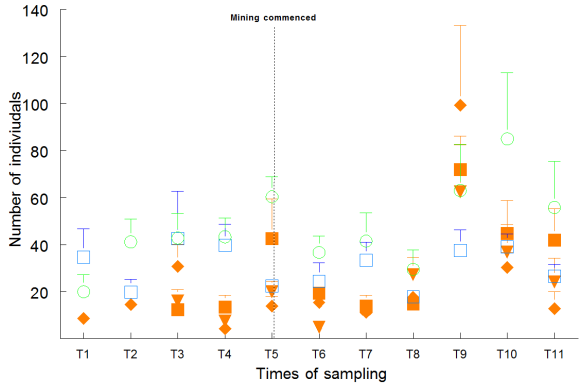

Chart 92b Mean (+SE) Macroinvertebrate Abundance, Large Pool Monitoring

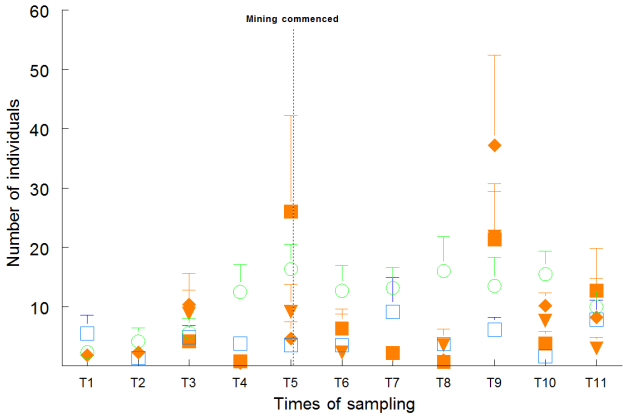

Chart 92c Mean (+SE) Number of Leptophlebiidae, Large Pool Monitoring

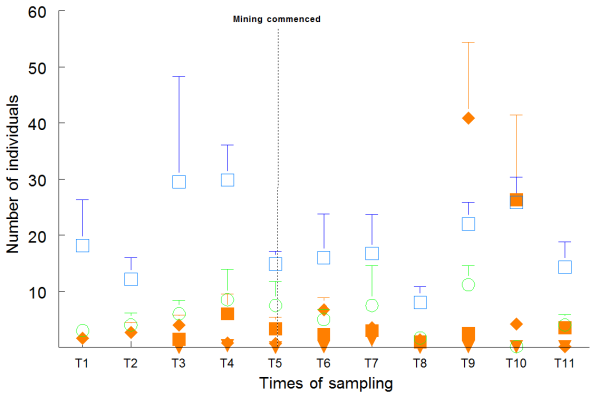

Chart 92d Mean (+SE) Number of Atyidae, Large Pool Monitoring

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

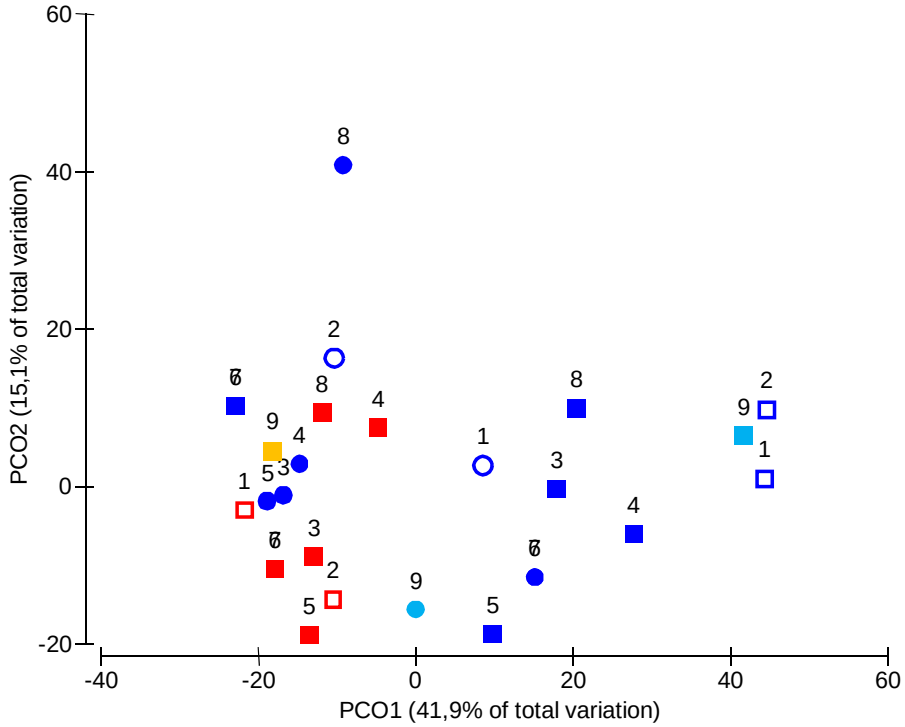

Chart 93 Principal Coordinates Analysis (PCoA) plot of macroinvertebrate data for small pools in Waratah Rivulet (red symbols), and two control streams: Woronora River (blue squares) and O'Hares Creek (blue circles). Empty symbols: 'Before' commencement of mining; Filled symbols: 'After' mining. Numbers indicate time of sampling. Lighter symbols represent last sampling time (spring 2013) (n = 6)

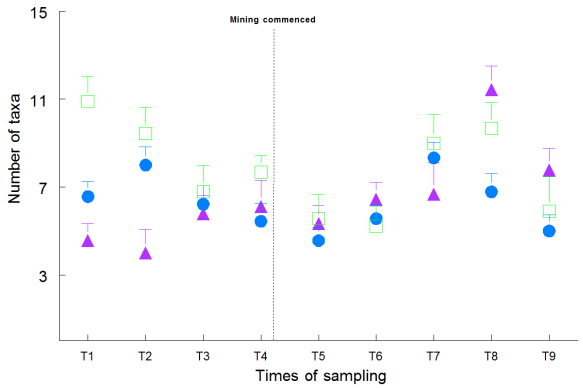

Chart 94a Mean (+SE) Macroinvertebrate Diversity, Small Pool Monitoring

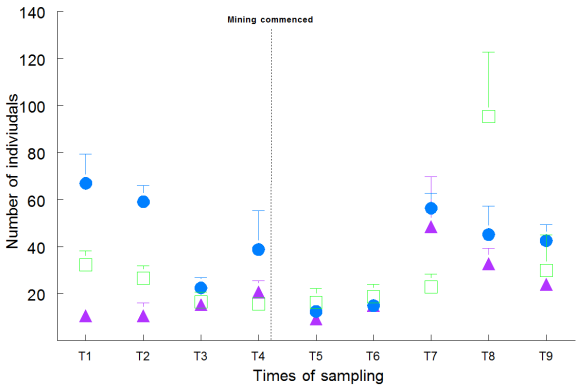

Chart 94b Mean (+SE) Macroinvertebrate Abundance, Small Pool Monitoring

Key: Waratah Rivulet Pools: solid purple triangles and the control pools (Woronora River Pools: solid blue circles, O'Hares Creek Pools: open green squares) (*n* = 9)

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) within the Longwalls 20-22 mining area appears to be within the range of natural variability as measured by the control locations (Chart 93).

Macrophyte Assemblages

A temporal comparison of the aquatic macrophyte data has been carried out for the locations sampled from spring 2008 to spring 2013 using both multivariate and univariate techniques. Charts 95a to 95c 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 96a to 96b present the mean diversity and mean abundance of macrophytes at the larger pools using the quantitative sampling data.

Chart 97 presents PCoA plots for macrophytes at the smaller pools, using the quantitative sampling data. Charts 98a and 98b 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 96a and 96b), most likely due to the absence of *Triglochin procerum* in Pools J and M1.
- The structure of assemblages of macrophytes recorded at Pool N prior to spring 2012 differs from subsequent surveys (Chart 95c). Changes were mostly due to a general decrease in total percentage cover of macrophytes, particularly *Triglochin procerum* and *Gleichenia dicarpa*, which occurred after the water level in the pool dropped by up to approximately 1.8 m).

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* was most abundant at small pools on Waratah Rivulet, whereas *Triglochin procerum* was more abundant in pools sampled on the Woronora River. No conspicuous changes in assemblages of macrophytes at small pools sampled on Waratah Rivulet have been observed in comparison to assemblages at the control pools.

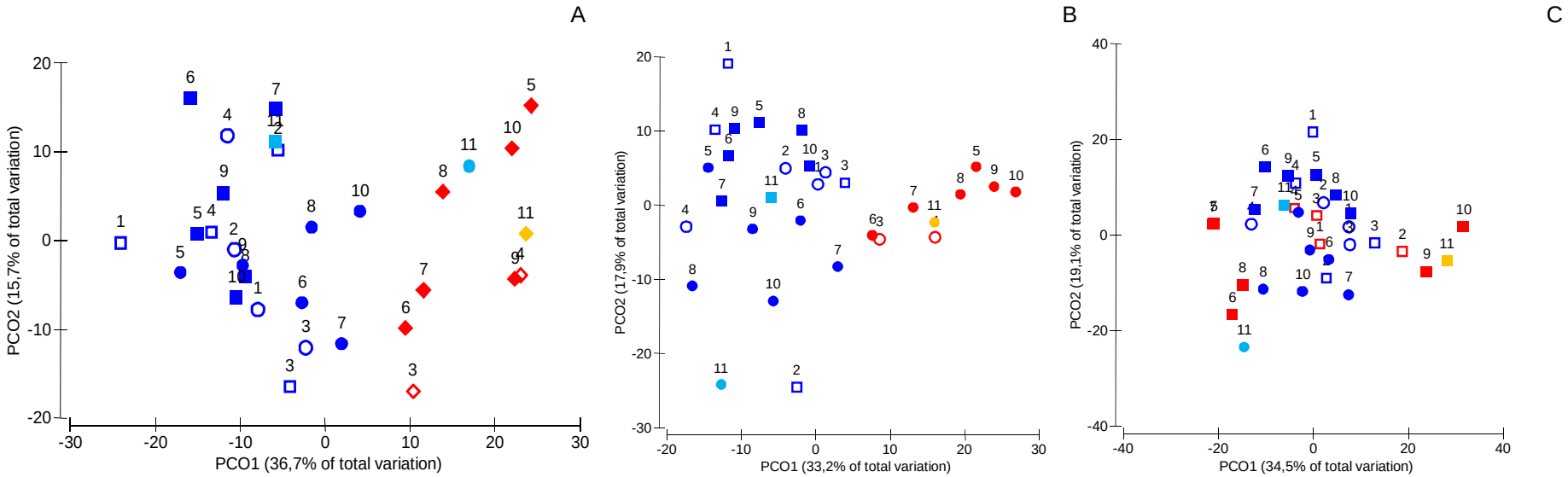

Chart 95a-c Principal Coordinates Analysis (PCoA) plots of macrophyte data for each large pool for each time of sampling (*n* = 10). A) Pool J: red diamonds, B) Pool M1: red circles and C) Pool N: red squares; and two control pools: Woronora River (blue squares) and O'Hares Creek (blue circles). Empty symbols: 'Before' commencement of mining; Filled symbols: 'After' mining. Numbers indicate time of sampling. Lighter symbols represent last sampling time (spring 2013).

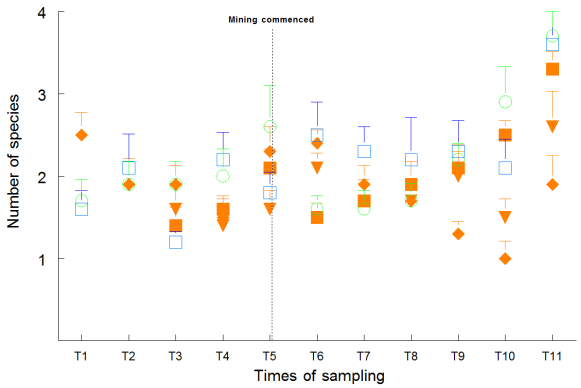

Chart 96a Mean (+SE) Macrophyte Diversity, Large Pool Monitoring

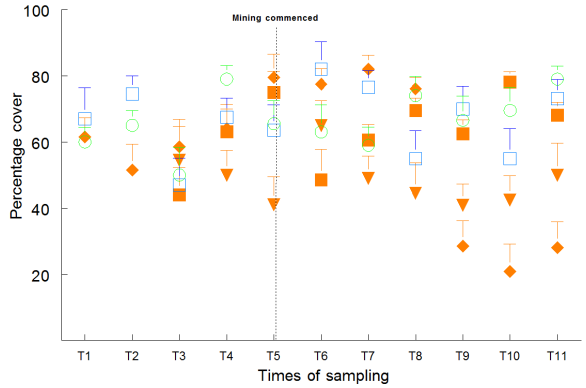

Chart 96b Mean (+SE) Macrophyte Percentage Cover, Large Pool Monitoring

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

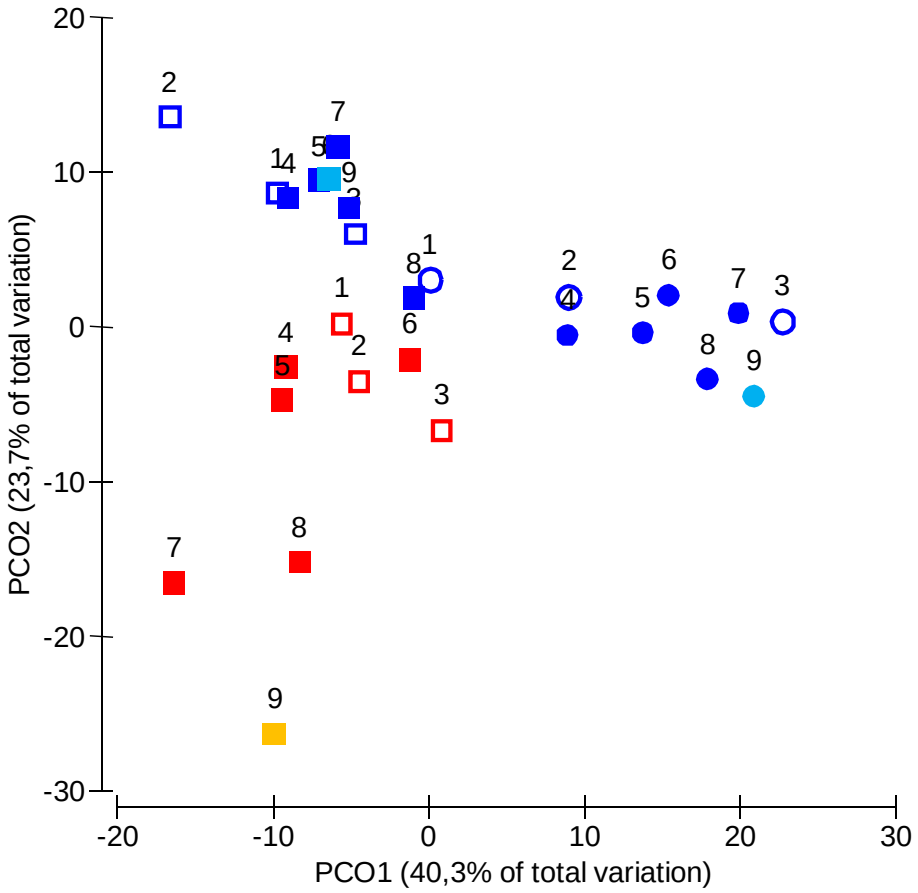

Chart 97 Principal Coordinates Analyses (PCoA) of centroids per location per time using Bray-Curtis dissimilarities based on macrophyte data (non-transformed) for small pools in one impacted creek (Waratah Rivulet, red symbols), and two control streams: Woronora River (blue squares) and O'Hares Creek (blue circles). Empty symbols: 'Before' commencement of mining; Filled symbols: 'After' mining

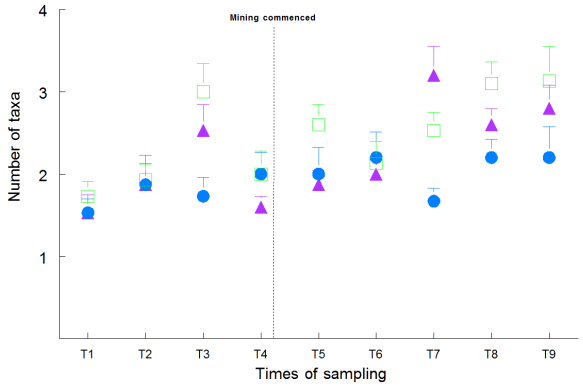

Chart 98a Mean (+SE) Macrophyte Diversity, Small Pool Monitoring

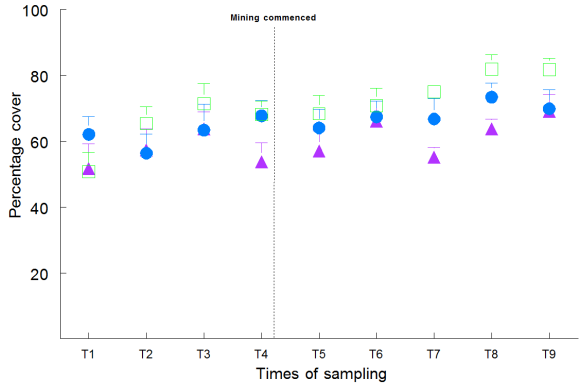

Chart 98b Mean (+SE) Macrophyte Abundance, Small Pool Monitoring

Key: Waratah Rivulet Pools: solid purple triangles and the control pools (Woronora River Pools: solid blue circles, O'Hares Creek Pools: open green squares) (*n* = 12)

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. At the time of the spring/summer 2013 survey the following test sites had been undermined: site 1 (undermined by Longwall 20), site 2 (undermined by Longwall 20), site 3 (undermined by Longwall 21) and site 5 (undermined by Longwall 22A). Site 4 (overlying Longwall 22B) and site 6 (between Longwalls 22B and 23B) were not undermined, however, occur within the 35° angle of draw.

The results of the five surveys to date (2009-2013) are summarised in Table 4, Table 5 and Chart 99 below.

Chart 99 shows the number of amphibian species recorded at each site in 2009 to 2013.

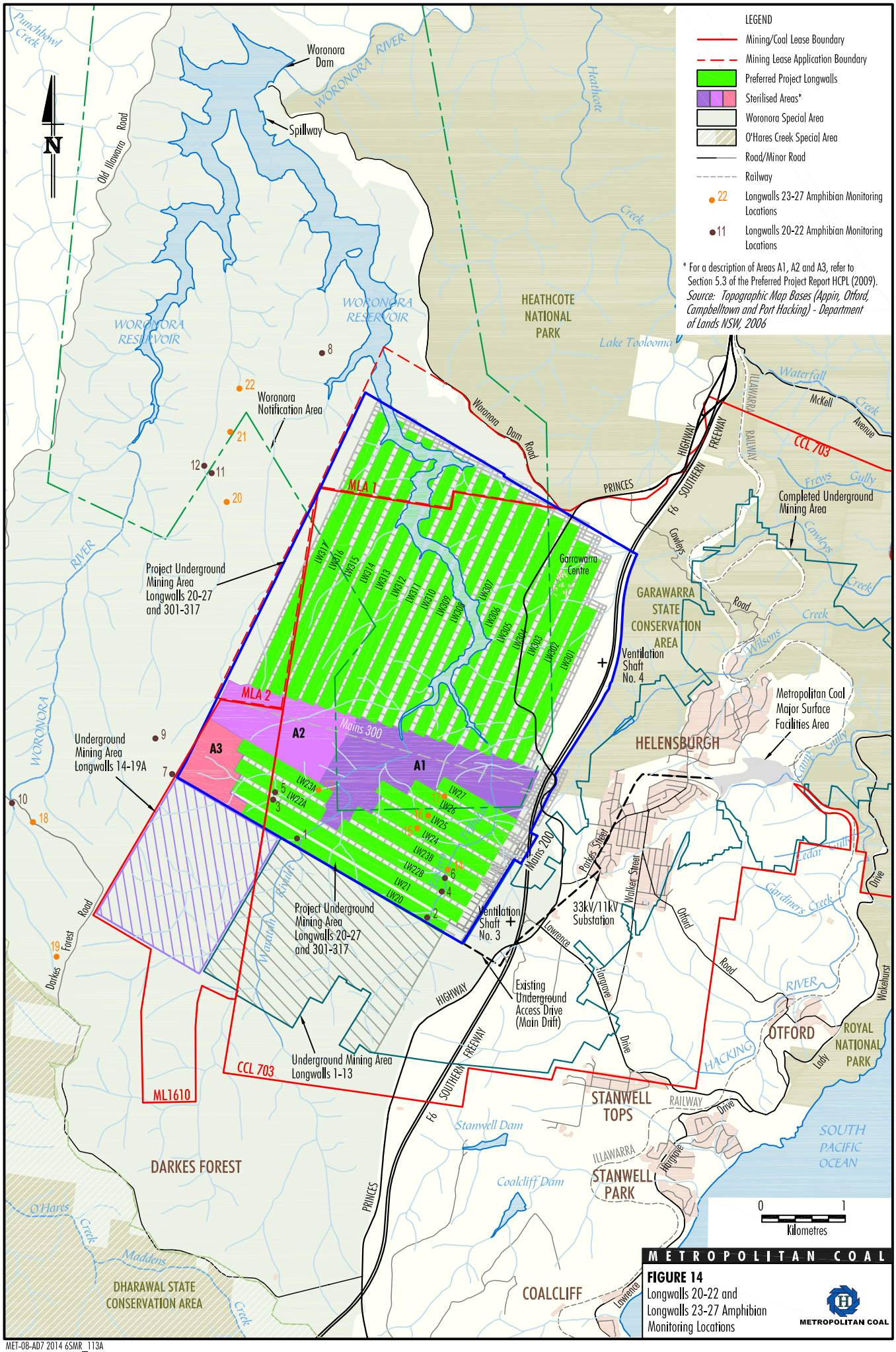

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Table 4
Amphibian Species Diversity and Abundance for Longwalls 20-22, Spring/Summer 2009 – 2013

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]	1	1	>10	2	1	1	0	0	5	0	0	>16	6	MC	UC
			0	0	0	0	0	0	0	0	0	>10	0	0	0	>10	MC	MC
		2010	3	4	3	2	3	5	4	3	0	4	1	2	20	14	MC	MC
			0	0	c100	0	0	0	0	0	0	30	27	6	c100	c233	A	A
		2011	3	9	7	3	7	0	10	4	3	8	0	0	29	25	C	C
			0	0	0	0	0	0	0	10	0	c100	0	0	0	c110	0	A
		2012	3	0	5	1	6	0	23	20	5	12	0	3	15	63	MC	A
			0	0	100	0	10	0	0	6	0	25	0	0	110	31	A	A
		2013	2	1	11	3	3	1	0	2	1	7	0	0	21	10	C	UC
			1	0	0	16	0	0	0	0	0	5	0	0	17	5	MC	UC
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	0	0	0	0	0	0	1	0	0	0	1	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	1	0	0	0	0	0	0	0	0	1	0	1	0
			0	0	0	0	0	0	5	0	0	0	0	0	0	5	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
Limnodynastes peronii	Brown-striped Frog	2009	0	0	0	1	1	1	0	0	0	2	0	0	3	2	UC	UC
			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	53	0	76	0	0	0	0	0	0	0	129	0	A	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	c100	0	0	0	0	0	c100	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

Table 4 (Continued)
Amphibian Species Diversity and Abundance for Longwalls 20-22, Spring/Summer 2009 – 2013

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 tasmaniensis	Spotted Grass Frog	2009	0	0	0	0	0	0	1	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
		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	1	0	3	0	0	0	0	0	0	0	4	0	UC	0
			0	0	0	0	0	0	0	c100	0	0	0	0	0	c100	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
Pseudophryne australis	Red-crowned Toadlet[V]	2009	0	1	2	2	0	0	1	0	1	1	0	0	5	3	UC	UC
			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2010	0	1	7	1	6	9	0	0	0	1	1	2	24	4	C	UC
			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2011	0	1	1	3	4	0	0	0	0	0	0	0	9	0	UC	0
			0	0	10	0	0	0	0	5	0	c100	0	0	10	c105	UC	A
		2012	0	0	1	0	2	0	0	2	0	1	0	0	3	3	MC	MC
			0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1
		2013	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0
			0	0	5	0	0	0	0	0	0	0	0	0	5	0	U	0
Uperoleia laevigata	Smooth Toadlet	2009	0	0	0	1	0	0	0	0	0	1	0	0	1	1	1	1
			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2010	0	2	2	0	0	0	0	0	0	0	0	0	4	0	UC	0
			0	0	10	0	0	0	0	0	0	0	0	0	10	0	UC	0
		2011	0	0	0	0	0	0	2	0	0	0	0	0	0	2	0	UC
			0	0	0	0	0	0	0	0	5	0	0	0	0	5	0	UC
		2012	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1
			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

Table 4 (Continued)
Amphibian Species Diversity and Abundance for Longwalls 20-22, Spring/Summer 2009 – 2013

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	1	0	1	0	1	0	0	0	0	0	0	3	0	UC	0
			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2010	4	0	3	0	2	0	0	0	0	1	0	0	9	1	UC	1
			0	0	4	0	0	0	0	0	0	0	0	0	4	0	UC	0
		2011	0	0	0	0	2	0	0	0	0	0	0	0	2	0	UC	0
			0	0	2	0	0	0	0	0	0	0	0	0	2	0	UC	0
		2012	0	0	0	0	0	0	0	0	2	1	0	0	0	3	0	MC
			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2013	0	1	0	1	0	0	0	0	0	0	0	0	2	0	UC	0
			0	0	0	3	0	0	0	0	0	35	0	0	3	35	UC	C
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	3	3	0	0	6	0	UC
			0	0	0	0	0	0	0	0	0	0	15	0	0	15	0	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
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	MC
			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

Table 4 (Continued)
Amphibian Species Diversity and Abundance for Longwalls 20-22, Spring/Summer 2009 – 2013

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 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
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	MC	0
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

Table 4 (Continued)
Amphibian Species Diversity and Abundance for Longwalls 20-22, Spring/Summer 2009 – 2013

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	1	0	0	0	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
		2010	0	0	0	0	0	0	3	0	0	2	0	2	0	7	0	UC
			0	0	0	0	0	0	c1000	0	0	0	0	0	0	c1000	0	A
		2011	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1
			0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1
		2012	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1
			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
Litoria phyllochroa	Green Stream Frog	2009	0	0	0	2	1	>5	0	0	0	0	0	0	>8	0	UC	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	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
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**				
Species Diversity in all Control and all Test sites		2009													**9**	**8**		
		2010													**7**	**7**		
		2011													**7**	**9**		
		2012													**4**	**7**		
		2013													**5**	**2**		

Table 4 (Continued)
Amphibian Species Diversity and Abundance for Longwalls 20-22, Spring/Summer 2009 – 2013

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 across the survey site		2009													**11**			
		2010													**10**			
		2011													**10**			
		2012													**7**			
		2013													**5**			

[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 5
Number of Longwalls 20-22 Sites used per Amphibian Species in 2009 - 2013

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

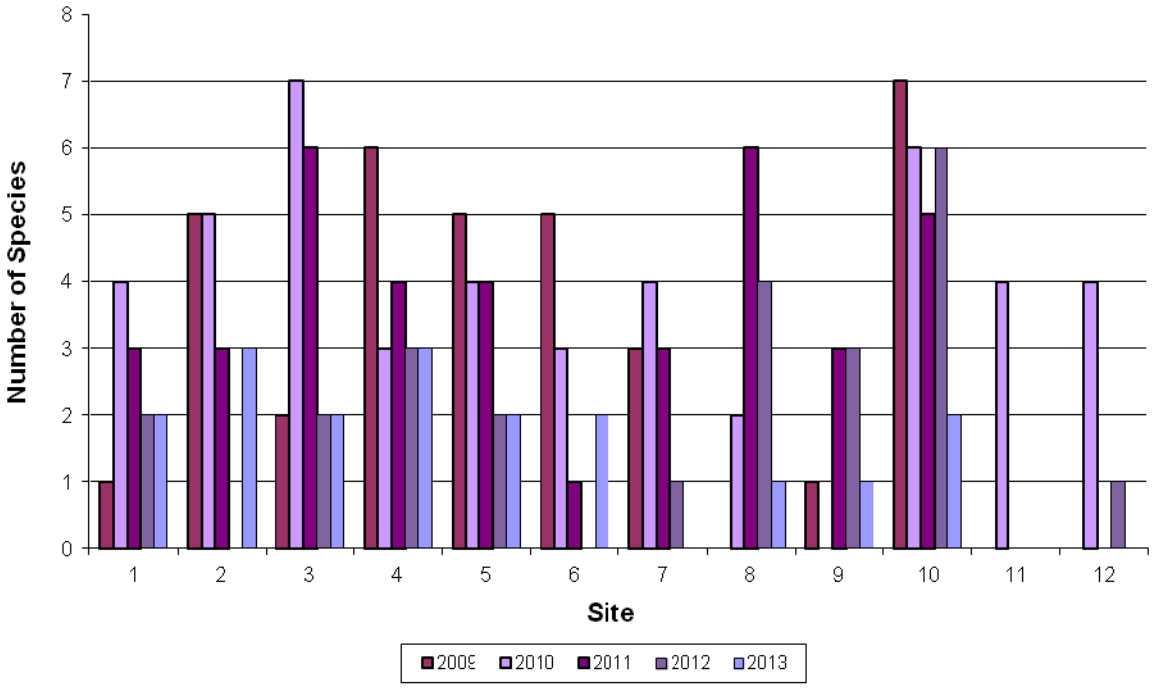

Chart 99 Amphibian Species Diversity, 2009, 2010, 2011, 2012 and 2013

In summary, the amphibian survey results from 2009 to 2013 indicated:

- A total of 13 amphibian species have been recorded in the 2009 to 2013 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.
- 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 and 2-3 species at test sites and 0-2 species at control sites in 2013.
- 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.

- Breeding success has been infrequently observed over the 2009 to 2013 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).
- The Giant Burrowing Frog (*Heleiporus australiiacus*) was only recorded at test site 4 in 2011.
- The Red-crowned Toadlet (*Pseudophryne australis*) was recorded in 2009 (uncommon), 2010 (common), 2011 (uncommon), 2012 (moderately common) and 2013 (one individual) at test sites and in 2009 (uncommon), 2010 (uncommon) and 2012 (moderately common) at control sites.
- The changes in species diversity observed at the test sites from 2009 to 2013 are also reflected in the changes at control sites.
- The amphibian species diversity and abundance data are consistent with population variations and cycles in response to seasonal variations.
- A Poisson regression analysis is currently being conducted to analyse the 2009 – 2013 spring/summer amphibian survey results.

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[19] 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.

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.

The visual inspection survey methods are the same as those described for the Longwalls 20-22 upland swamp vegetation monitoring program in Section 3.2.1.1.

During the reporting period, Longwall 23 was within 400 m of Swamps 16, 17 and 18 in June 2014. 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 from spring 2010 to spring 2013 at 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 (i.e. prior to the commencement of Longwall 23). 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 (described in Section 3.2.1.1).

[19] 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).

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. Surveys conducted up to and including the spring 2013 survey represent baseline surveys.

- No cracking of exposed bedrock areas or swamp sediments was observed in either longwall or control swamps, other than those recorded in Swamp 31 where minor cracks in exposed bedrock, considered to be a weathering artefact, occur.
- Areas of minor erosion have been observed as a result of overland flow along walking access tracks, drainage lines or areas of bare earth at Swamps 30, 93, 95, 97, 101, 111a, 125, 136, Woronora River South Arm and Dahlia Swamp.
- For both longwall and control swamps the pattern of seepage was similar. Abundant seepage across swamp sediments, rocky areas and terminal steps was recorded for all seasons since spring 2010 excluding spring 2012 and spring 2013 where seepage was absent or only of minor occurrence reflecting the below average rainfalls preceding these surveys, with the exception of Swamp 125 were seepage was common.
- Across all upland swamps, no changes in water colour or areas of water ponding were observed in either longwall or control swamps since the first survey. Following seasonally wet periods, where seepage and standing water was abundant, some swamps were found to have small areas of iron-stained groundwater seeps. The associated water surface often displayed a metallic sheen which cracked and separated upon disturbance. Swamps where this occurred include, longwall Swamps 19 (autumn 2012), 27 (spring 2011), 30 and 35 (autumn 2012) and control Swamps 101, 137a and 138 (autumn 2012).
- For the valley side swamps (restioid heath and banksia thicket), vegetation at both longwall and control sites was found to be generally in good condition throughout all surveys seasons with no unusual areas of vegetation senescence observed. Some isolated dieback and senescence of individuals occurred throughout all longwall and control swamps over the survey period and commonly included individuals of *Banksia ericifolia* subsp. *ericifolia, Hakea teretifolia, Petrophile pulchella, Leptospermum squarrosum* and *Viminaria juncea.* Exceptions include the following observations:
  - In autumn 2012 many individuals of *Pultenaea aristata* at longwall Swamp 34 were found to be senescing, whilst adjacent vegetation was observed in good condition. No further senescence was observed in any subsequent survey in Swamp 34. It is unclear as to why this senescence occurred but may be related to the drying off of swamp sediments during summer and autumn 2012 following the preceding wetter soil conditions.
  - *Petrophile pulchella* at longwall Swamps 34 and 35: in spring 2012, a number of individuals in the central regions of these swamps were found to have died, despite the presence of adjacent healthy specimens.
  - *Phyllota phylicoides* and *Acacia myrtifolia* were observed senescing in Swamp 93 during autumn and spring 2012.
- 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 but with some variability reflecting seasonal rainfall patterns, as follows:
  - Minor yellowing of the foliage of *Baeckea linifolia, Banksia robur*, *Chorizandra cymbaria, Lepidosperma forsythii* and *Acacia longifolia* subsp. *longifolia* within Woronora River 1.
  - Minor dieback of *Gleichenia microphylla* recorded in all swamps during a number of survey seasons including autumn 2012, spring 2012 and autumn 2013.

  - Leaf herbivory and dieback of individuals of *Banksia robur* has been recorded at Woronora River 1, Woronora River South Arm and Dahlia Swamp over the survey period. Leaf desiccation was recorded over a number of individuals in spring 2012 following a dry winter and early spring. These were found to be in improved condition during subsequent surveys.
  - Dieback of the swamp sedge *Empodisma minus* was recorded within the lower portion of Swamp 28 during the spring 2012 survey period, particularly in areas where the canopy is most dense causing shading. Unlike preceding seasons, the soil sediments were dry during the 2012 survey period. Some recovery was recorded in subsequent seasons with minor dieback (Condition 4) recorded in spring 2013.
- For both longwall and control swamps the pattern of seepage was similar. Abundant seepage across swamps sediments, rocky areas and terminal steps was recorded for all seasons since spring 2010 excluding spring 2012 and spring 2013 where seepage was absent or only of minor occurrence reflecting the preceding below average rainfalls of the preceding winter and spring survey period.

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 from spring 2010 to spring 2013 in Swamps 28, 30, 33, 35, 94, 135, 136, 137a, 137b, 138 and Bee Creek Swamp (i.e. prior to the commencement of Longwall 23). 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 (described in Section 3.2.1.1). Surveys conducted up to and including the spring 2013 survey represent baseline surveys.

The methods used to survey Restioid Heath/Banksia Thicket vegetation are the same as those described for the Longwalls 20-22 upland swamp vegetation monitoring program in Section 3.2.1.1. 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 results of the transect/quadrat monitoring surveys for the biannual surveys 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 2013 across longwall and control 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 is presented on Charts 100 and 101. Species richness was generally similar between the valley side swamps supporting Restioid Heath and Banksia Thicket sites (mean species richness of 52.5 and 46.4 respectively) with species richness in these vegetation types consistently higher than the swamps supporting Tea Tree Thicket (mean species richness of 23.8).

Generally, small fluctuations in species richness have occurred within individual swamps between seasons. No consistent trends in terms of changes in species richness were observed across sites between seasons or at individual sites across all seasons. At several swamps small decreases in species richness were observed from spring 2010 to spring 2013 (including Swamps 33, 35, 94, 125, 137b, 138 and the Tea Tree Thicket of Swamp 28). All observed changes in species richness represent natural fluctuations in response to weather, population dynamics, seasonality of survey and natural disturbances including grazing by fauna species.

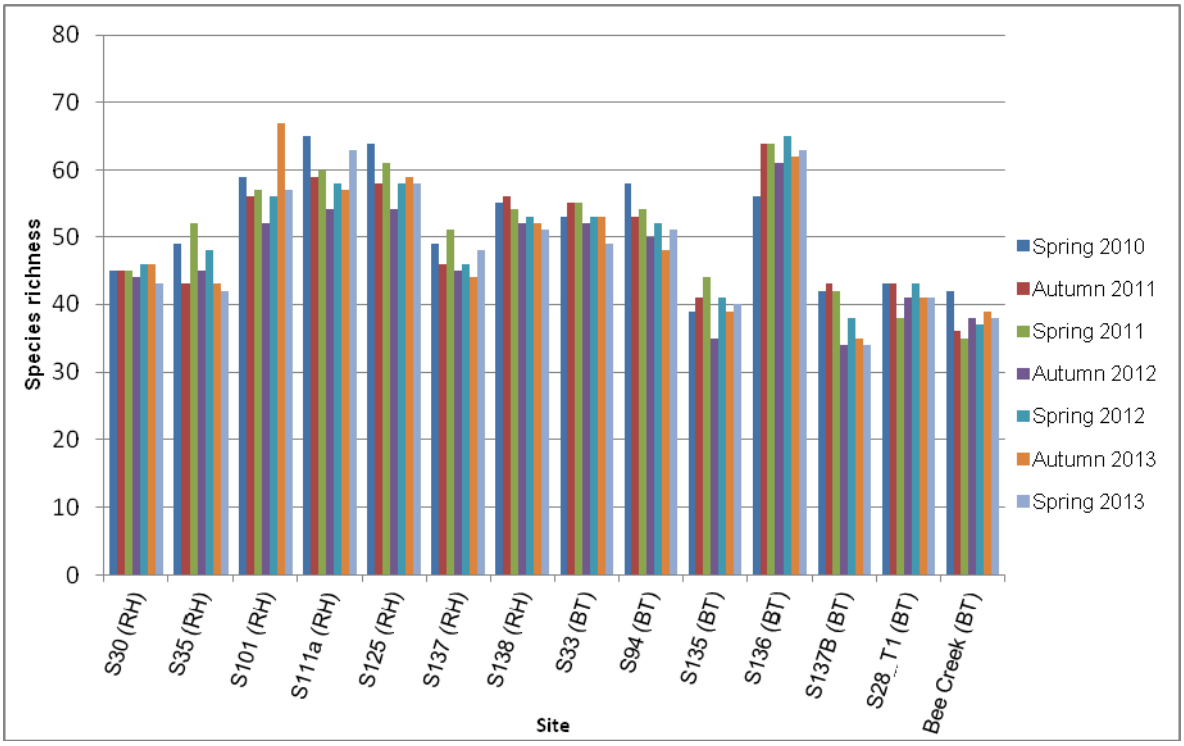

Chart 100 Species Richness within Restioid Heath/Banksia Thicket Swamps
RH = Restioid Heath; BT = Banksia Thicket

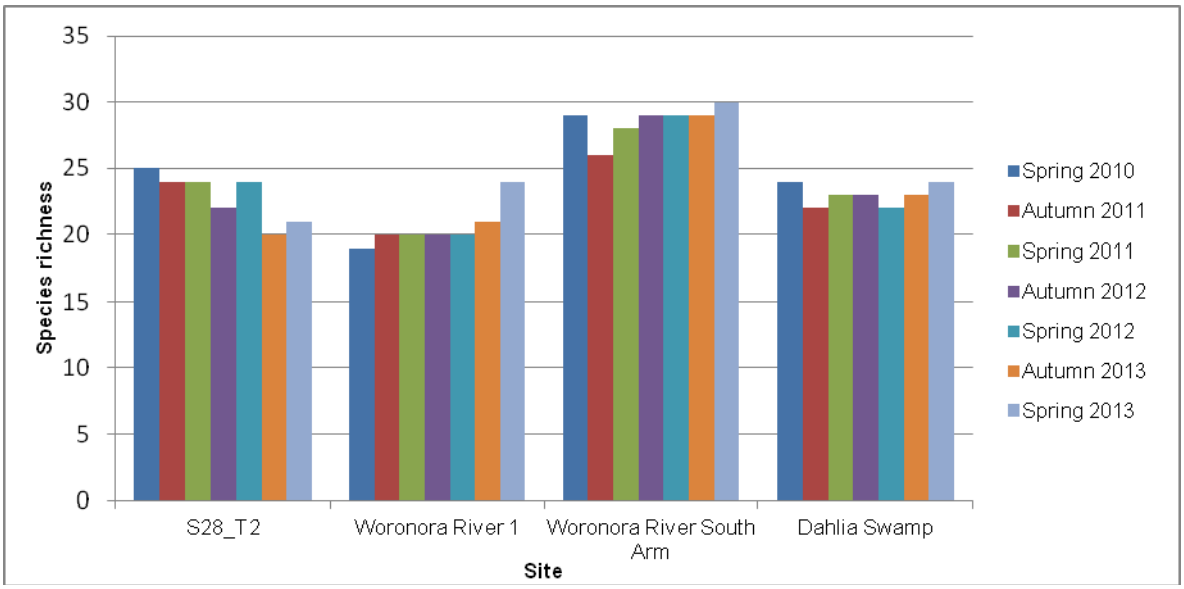

Chart 101 Species Richness within Tea Tree Thicket Swamps
TTT = Tea Tree Thicket

Cover/Abundance and Condition

Fluctuations in species cover/abundance were recorded across all sites across the baseline period. 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 recorded across all sites. Generally, vegetation within both Restioid Heath and Banksia Thicket swamps and Tea Tree Thicket swamps was in a healthy condition throughout the baseline survey period. Vegetation with dieback ranging from Condition 4 (minor dieback) to Condition 3 (some dead branches) was noted occasionally in individuals at all longwall and control sites. Species with dieback included *Acacia* spp., *Banksia oblongifolia, Dillwynia floribunda, Isopogon* spp., *Sprengelia incarnata, Symphionema paludosa, Viminaria juncea,* and the groundcover species *Actinotus minor, Chordifex fastigiatus, Empodisma minus, Lepidosperma filiforme* and *Schoenus brevifolius.* Within Tea Tree Thicket sites, the fern *Gleichenia microphylla*, was also observed with dieback in multiple sites and seasons.

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, 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 from spring 2010 to spring 2013 at Swamps 19, 30, 33, 35, 94, 135, 136, 137a, 137b and 138 (i.e. prior to the commencement of Longwall 23). 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 (described in Section 3.2.1.1).

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 upland swamp vegetation monitoring program in Section 3.2.1.1.

The following provides a summary of the results of population monitoring for the baseline surveys conducted up to and including spring 2013.

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 102 to 104). This decrease has occurred at both longwall and control Restioid Heath/Banksia Thicket swamps with mean vegetation condition generally similar between longwall and control swamps for each species in each season, as indicated by overlapping confidence intervals. Exceptions to the generally similar mean vegetation condition for tagged indicator species at longwall and control Restioid Heath/Banksia Thicket swamps included *Pultenaea aristata* in autumn 2011, autumn 2013 and spring 2013, *Epacris obtusifolia* in autumn and spring 2013 and *Sprengelia incarnata* in spring 2010. In all instances where potential differences were observed, as indicated by non-overlapping confidence intervals, the scale of these differences were generally small (less than 1) with mean vegetation condition being greater at control swamps than longwall swamps.

Over the baseline survey period 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 106 and 107). 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 and spring 2013, as indicated by non-overlapping confidence intervals. In particular the mean vegetation condition of *Banksia robur* in Swamp 28 decreased in autumn 2013 and spring 2013. For *Callistemon citrinus*, mean vegetation condition within Swamp 28 has been greater than in control swamps across several seasons (spring 2010, spring 2011, spring 2012 and autumn 2013) although the differences have been generally small (less than 1).

Reproductive Status

The flowering status of tagged indicator species, as recorded in the reproductive scale, shows that across the entire baseline monitoring period (i.e. up to and including spring 2013) limited flowering was recorded across all species (Charts 103 to 107). The infrequent recording of flowering plants of indicator species is thought to be related to the timing of surveys which do not coincide with peak flowering periods[20].

[20] 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 during this time.

Within Restioid Heath and Banksia Thicket swamps the mean reproductive status of tagged indicator species has generally been variable when comparing longwall and control valley side swamps with potential differences, as indicated by non-overlapping confidence intervals, observed in individual seasons for all species (Charts 102 to 104). Generally, the scale of these differences was small (less than 1) although larger differences were observed for *Pultenaea aristata* in spring 2013 (greater mean reproductive status at control swamps) and *Sprengelia incarnata* in spring 2011 (greater mean reproductive status at longwall sites). Where larger differences in reproductive status were observed, they did not appear to be related to vegetation condition.

Within Tea Tree Thicket swamps mean reproductive status was generally similar between longwall and control swamps, as indicated by overlapping confidence intervals, for both *Banksia robur* and *Callistemon citrinus* (Charts 105 and 106). For those seasons where mean reproductive status was different between the single longwall swamp (Swamp 28) and control swamps, the scale of these differences was generally small with the exception of *Banksia robur* in spring 2010, where mean reproductive status at Swamp 28 was greater than control swamps.

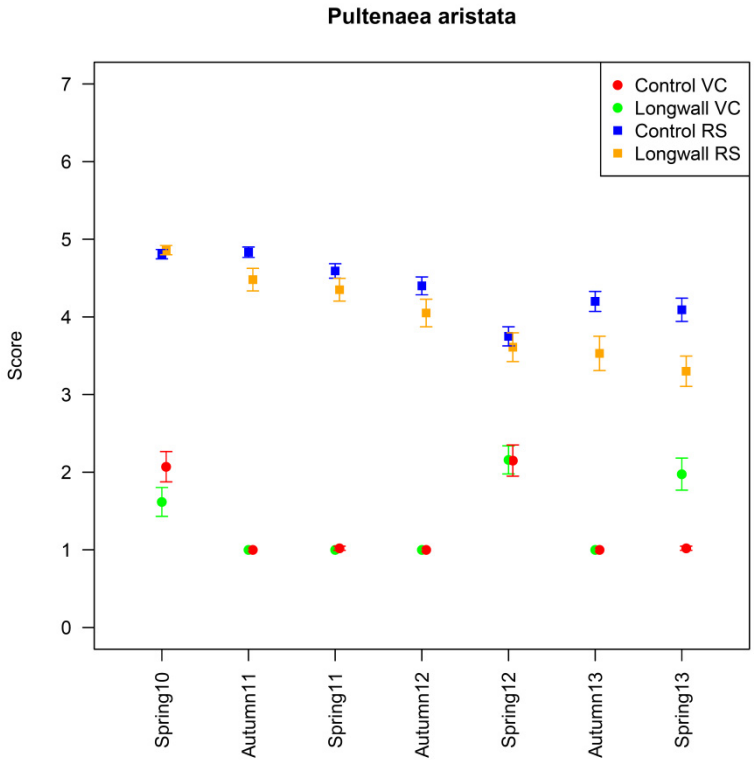

Chart 102 Mean Scores for Vegetation Condition (VC) and Mean Reproductive Status (RS) for the Indicator Species, *Pultenaea aristata*

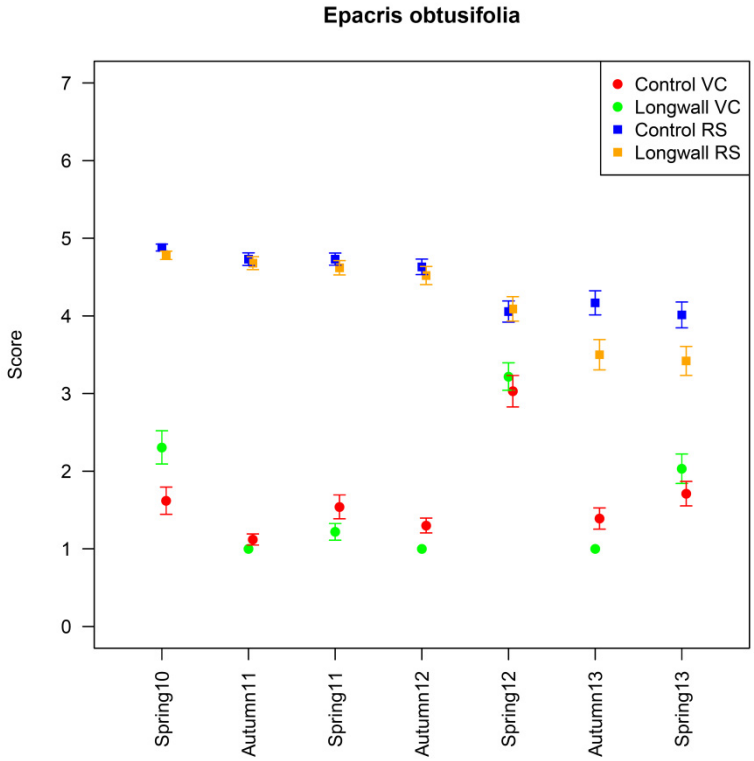

Chart 103 **Mean Scores for Vegetation Condition (VC) and Mean Reproductive Status (RS) for the Indicator Species, *Epacris obtusifolia***

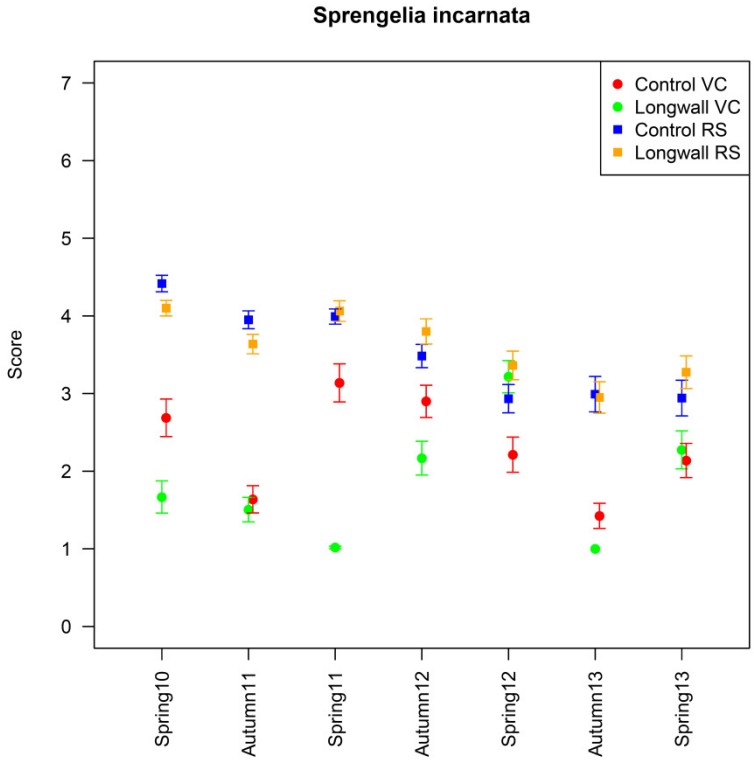

Chart 104 **Mean Scores for Vegetation Condition (VC) and Mean Reproductive Status (RS) for the Indicator Species, *Sprengelia incarnata***

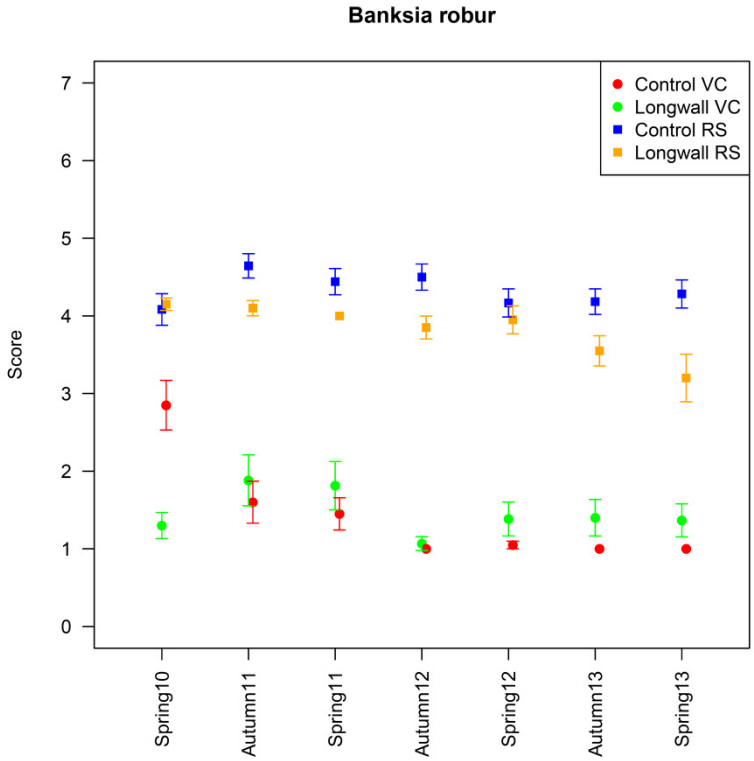

Chart 105 **Mean Scores for Vegetation Condition (VC) and Mean Reproductive Status (RS) for the Indicator Species, *Banksia robur***

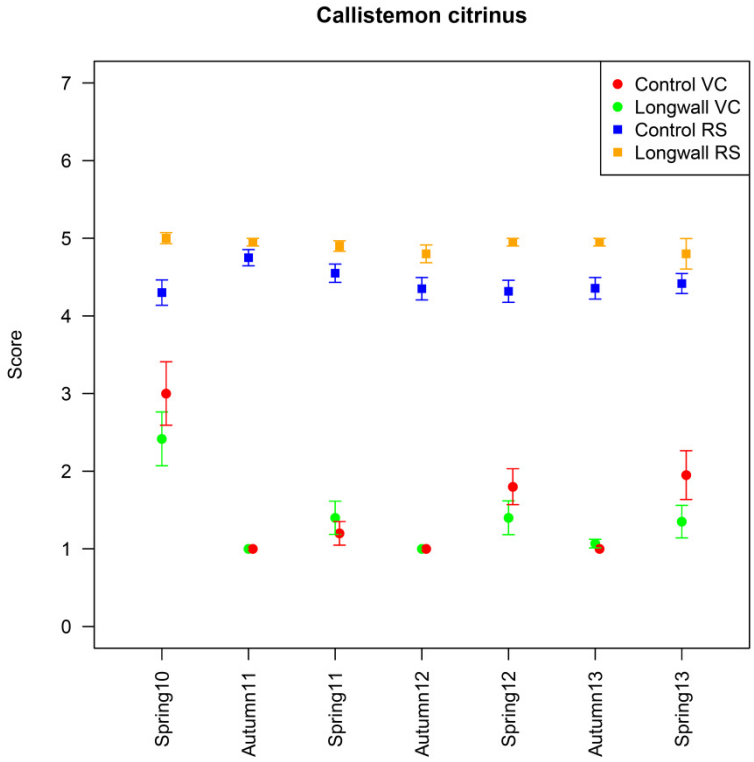

Chart 106 **Mean Scores for Vegetation Condition (VC) and Mean Reproductive Status (RS) for the Indicator Species, *Callistemon citrinus***

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.
- 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 107 to 109, 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. Erroneous data obtained for the 1 m substrate piezometer in Swamp 137b prior to November 2013 is not shown on Chart 108.

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. The 10 m sandstone piezometer is not shown as the data is considered to be erroneous, the reasons for which are currently being investigated.

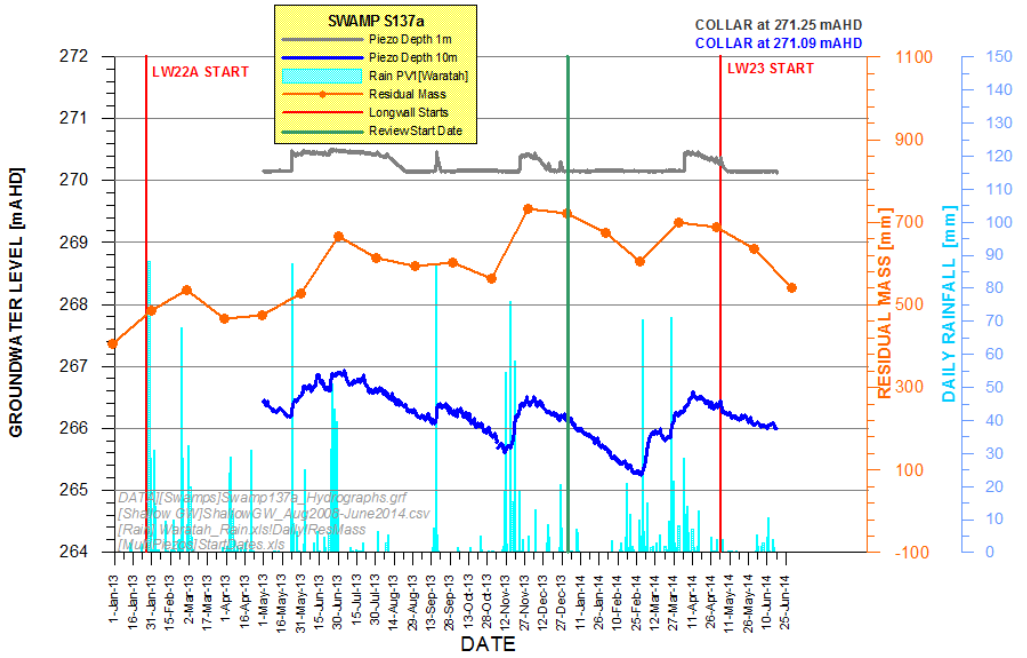

Chart 107 Groundwater Hydrographs at Control Swamp 137a

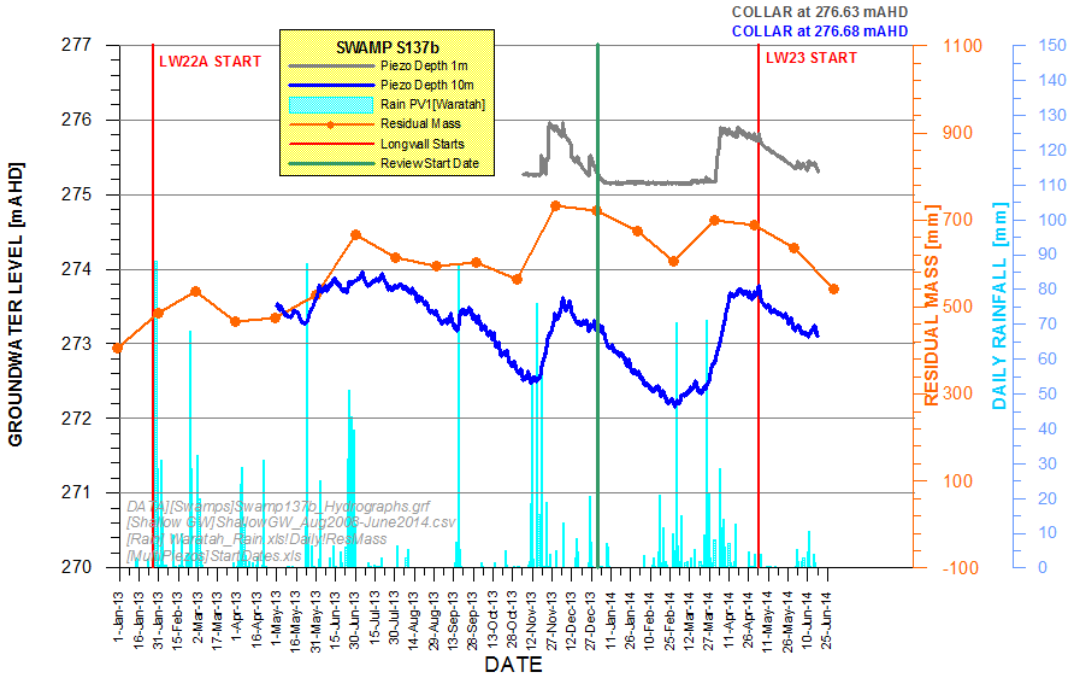

Chart 108 Groundwater Hydrographs at Control Swamp 137b

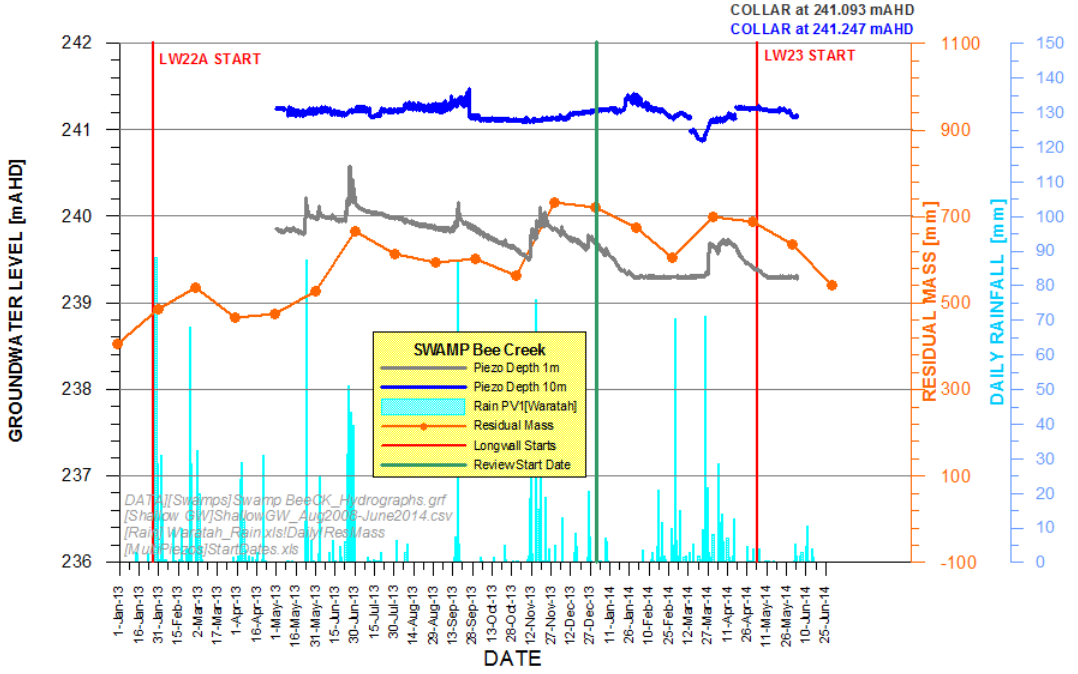

Chart 109 Groundwater Hydrographs at Bee Creek Control Swamp

Hydrographic responses for the monitored swamps overlying Longwalls 23-27 (Swamp 28, Swamp 30, Swamp 33 and Swamp 35) are shown on Charts 110 to 113. As the observed fluctuations in water levels are all consistent with the rainfall trend, there are no mining effects on the swamp substrate or sandstone piezometers. Data obtained to the end of the reporting period (i.e. 30 June 2014) is considered to represent baseline data for these swamps.

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.

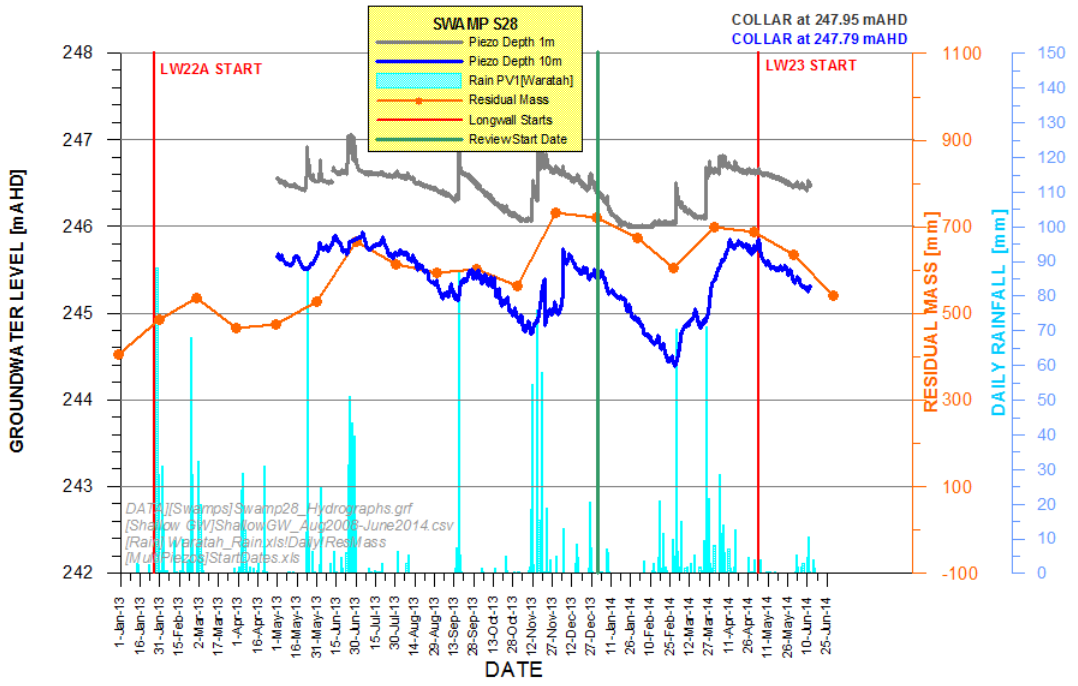

Chart 110 Groundwater Hydrographs at Swamp 28

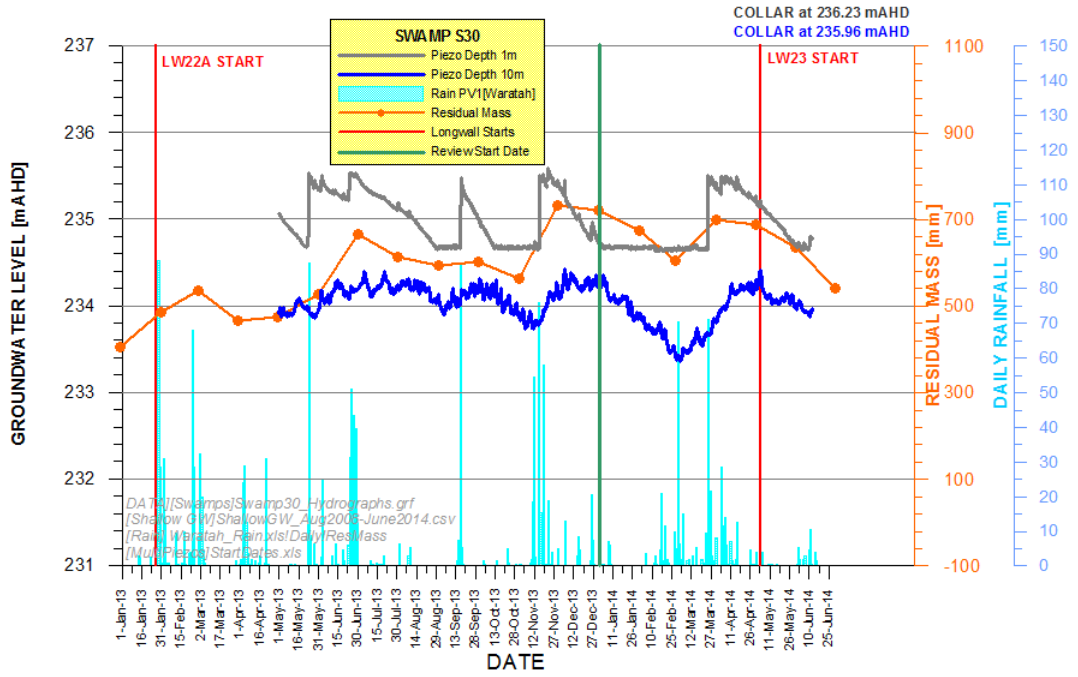

Chart 111 Groundwater Hydrographs at Swamp 30

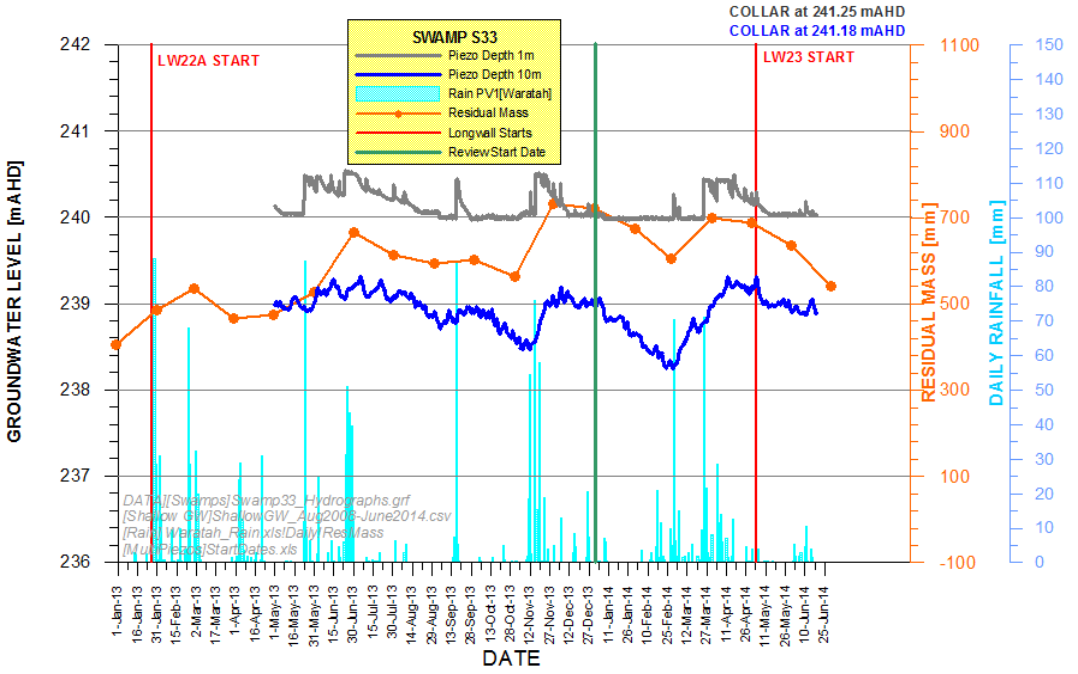

Chart 112: Groundwater Hydrographs at Swamp 33

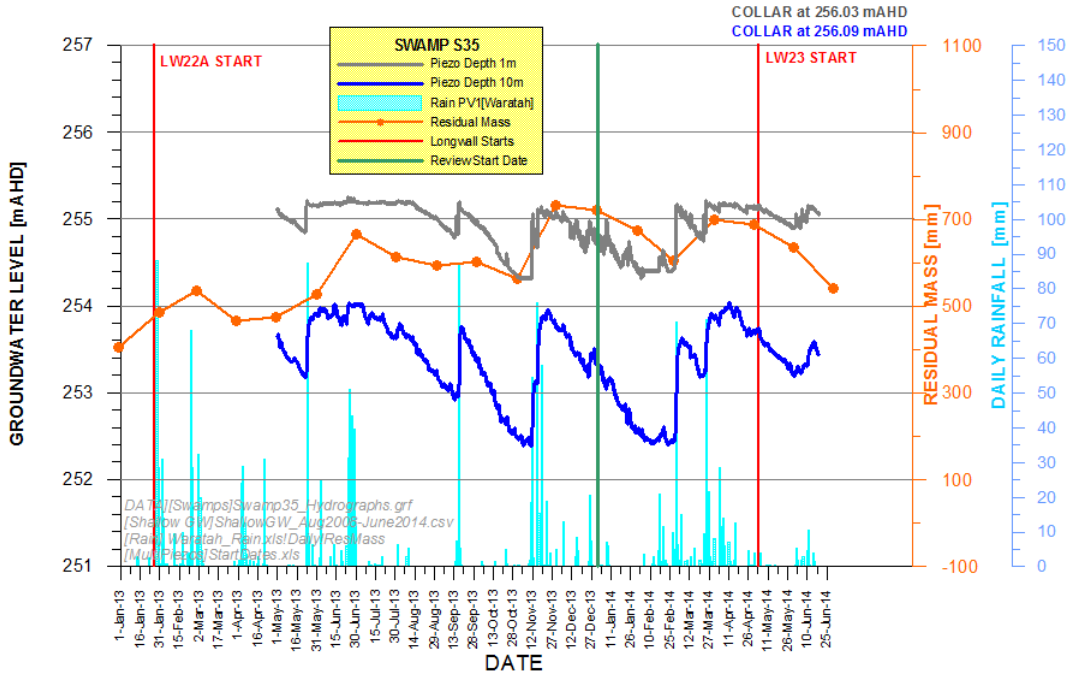

Chart 113 Groundwater Hydrographs at Swamp 35

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 from spring 2010 to spring 2013 at sites MRIP11 and MRIP12 (i.e. prior to the commencement of Longwall 23). 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 (described in Section 3.2.1.3).

Section 3.2.1.3 provides a summary of the results of visual inspections in spring 2013 of sites MRIP01 to MRIP10 as a component of the Longwalls 20-22 riparian vegetation monitoring program. The following provides a summary of the results of visual inspections of the biannual surveys of sites MRIP11 and MRIP12 (the additional sites on the Eastern Tributary over Longwalls 23-27) from spring 2010 to spring 2013.

- No areas of altered water ponding were observed within sites MRIP11, MRIP12 or control sites over the baseline survey period.
- Signs of erosion and scouring of sediments from stream bank areas were observed across all riparian monitoring sites, including sites MRIP11 and MRIP12 and was attributed to successive flooding in association with heavy rainfalls from spring 2010 to autumn 2012 and autumn 2013.
- No areas of cracked or displaced bedrock were observed within sites MRIP11, MRIP12 or any of the control riparian monitoring sites.
- Vegetation has generally been in good condition within sites MRIP11 and MRIP12 during the baseline monitoring period (up to and including spring 2013). Isolated individuals with some level of dieback have been observed within sites MRIP11 and MRIP12 and at the control sites downstream of Longwalls 23-27. Some dieback is attributed to flooding impacts. 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 and bank scouring and erosion was commonly observed. Subsequent high water flows have continued to impact all sites over the subsequent surveys 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 10):

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

The methods used to survey riparian vegetation are the same as those described for the Longwalls 20-22 riparian vegetation monitoring program in Section 3.2.1.3.

Quadrat and transect monitoring has been conducted biannually from spring 2010 to spring 2013 at sites MRIP11 and MRIP12 (i.e. prior to the commencement of Longwall 23). 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).

Section 3.2.1.3 provides a summary of the results of the quadrat/transect monitoring in spring 2013 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 of the biannual surveys of sites MRIP11 and MRIP12 (the additional sites on the Eastern Tributary over Longwalls 23-27) from spring 2010 to spring 2013.

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 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.

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 114**.** 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.

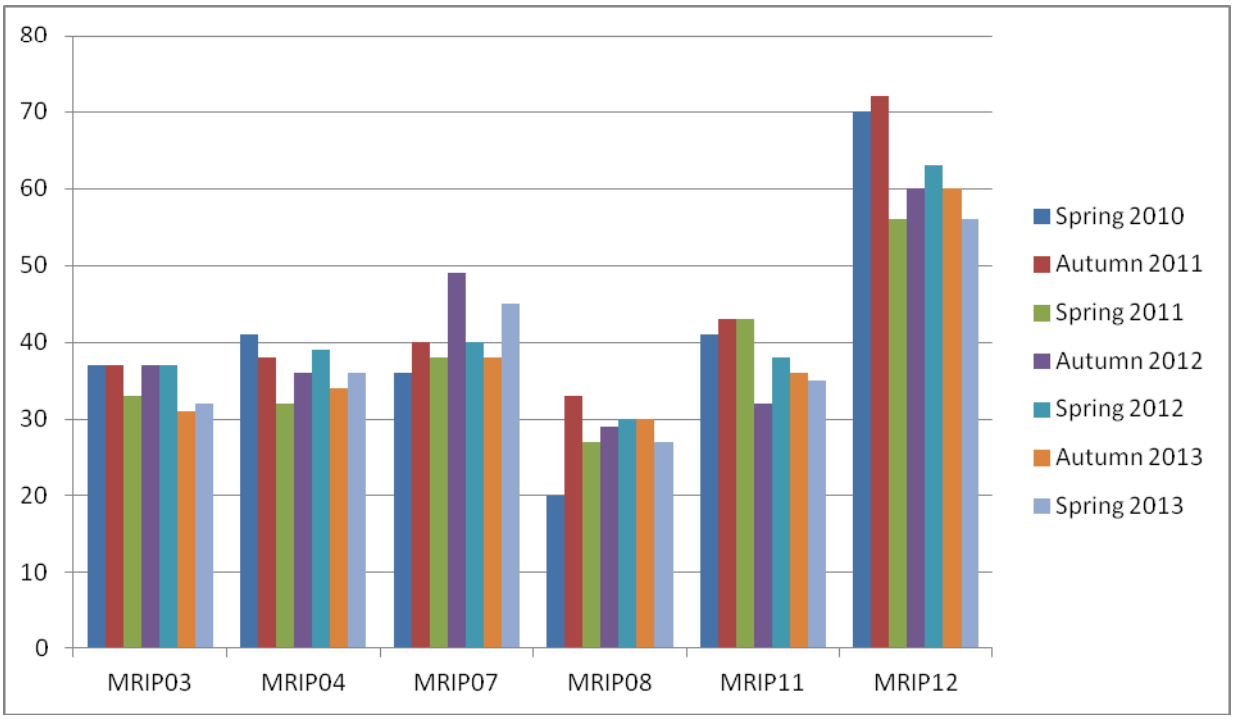

Chart 114 Species Richness within Riparian Monitoring Sites, Spring 2010 to Spring 2013

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 indicator species, generalist species, shrubs, ground covers) within sites.

Fluctuations in vegetation condition were recorded across all sites. Generally, vegetation within the riparian monitoring sites was in a healthy condition throughout the baseline survey period, with the vast majority of species and individuals recorded in a healthy condition (Condition 5). Vegetation with dieback ranging from Condition 4 (minor dieback) to Condition 1 (severe dieback) was noted occasionally in individuals at all longwall and control sites. Species with dieback included *Acacia terminalis*, *Acacia longifolia* subsp. *longifolia*, *Banksia* spp., *Gleichenia microphylla*, *Lomandra fluviatilis* and *Schoenus melanostachys*.

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[21] and MRIP10 downstream of Longwalls 23-27.

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

Population monitoring of indicator species has been conducted biannually from spring 2010 to spring 2013 at sites MRIP11 and MRIP12 (i.e. prior to the commencement of Longwall 23). 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 (described in Section 3.2.1.3).

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.

Section 3.2.1.3 provides a summary of the results of the population monitoring in spring 2013 of sites MRIP01 to MRIP10 as a component of the Longwalls 20-22 riparian vegetation monitoring program. The following provides a summary of the population monitoring results of the biannual surveys of sites MRIP11 and MRIP12 (the additional sites on the Eastern Tributary over Longwalls 23-27) from spring 2010 to spring 2013.

Vegetation Condition

Across the entire baseline monitoring period (up to and including spring 2013) mean vegetation condition has generally been similar between longwall and control sites for *Lomatia myricoides* and *Schoenus melanostachys* in each season, as indicated by overlapping confidence intervals (Charts 115 to 117). Exceptions to the generally similar mean vegetation condition for these two tagged indicator species at longwall and control sites included *Lomatia myricoides* in spring 2012 and *Schoenus melanostachys* in autumn 2011 and spring 2012 where mean vegetation condition was higher at longwall sites. For *Prostanthera linearis*, mean vegetation condition was higher at longwall sites in all seasons except spring 2011, though the size of the difference was generally small.

As the monitoring to date for these sites has comprised baseline monitoring, the differences in mean vegetation condition observed between longwall and control sites represent natural fluctuations in vegetation condition in response to factor including weather condition, flooding and the age of plants.

Reproductive Status

The flowering status of tagged indicator species, as recorded in the reproductive scale, shows that across the entire baseline monitoring period (up to and including spring 2013) limited flowering was recorded across all species (Charts 115 to 117). The infrequent recording of flowering plants of indicator species is thought to be related to the timing of surveys which do not coincide with peak flowering periods.

Generally, over the baseline monitoring period (up to and including spring 2013) mean reproductive status was similar between longwall and control sites for *Lomatia myricoides* and *Prostanthera linearis* (Charts 115 to 117), as indicated by overlapping confidence intervals. For *Schoenus melanostachys* results were more variable with mean reproductive status higher at control sites from spring 2010 to spring 2012, though greater at longwall sites in spring 2013. As the monitoring to date for these sites has comprised baseline monitoring, the differences in mean reproductive status observed between longwall and control sites represent natural fluctuations in vegetation condition in response to factors including weather condition, flooding and the age of plants.

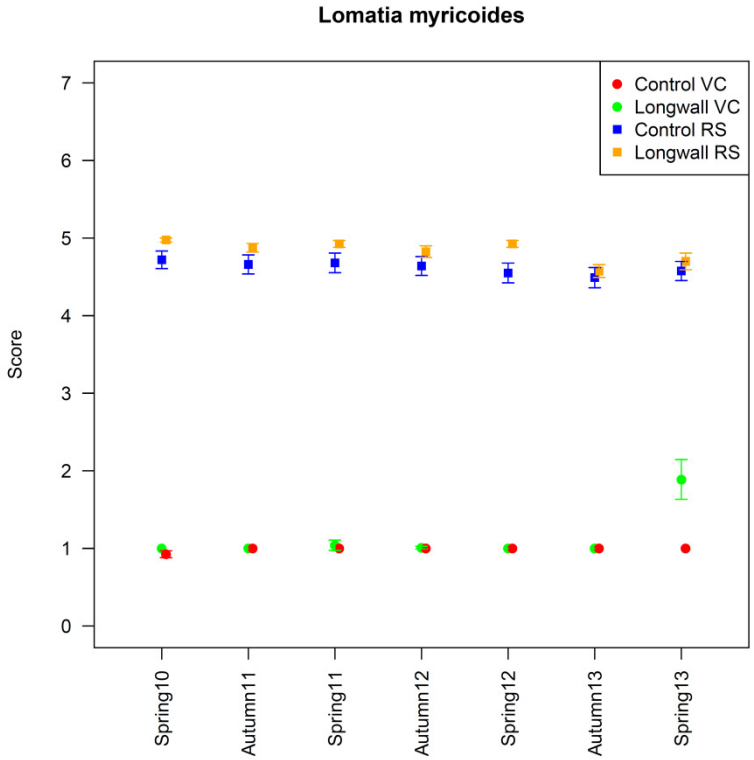

Chart 115 **Mean Scores for Vegetation Condition (VC) and Mean Reproductive Status (RS) for the Indicator Species, *Lomatia myricoides***

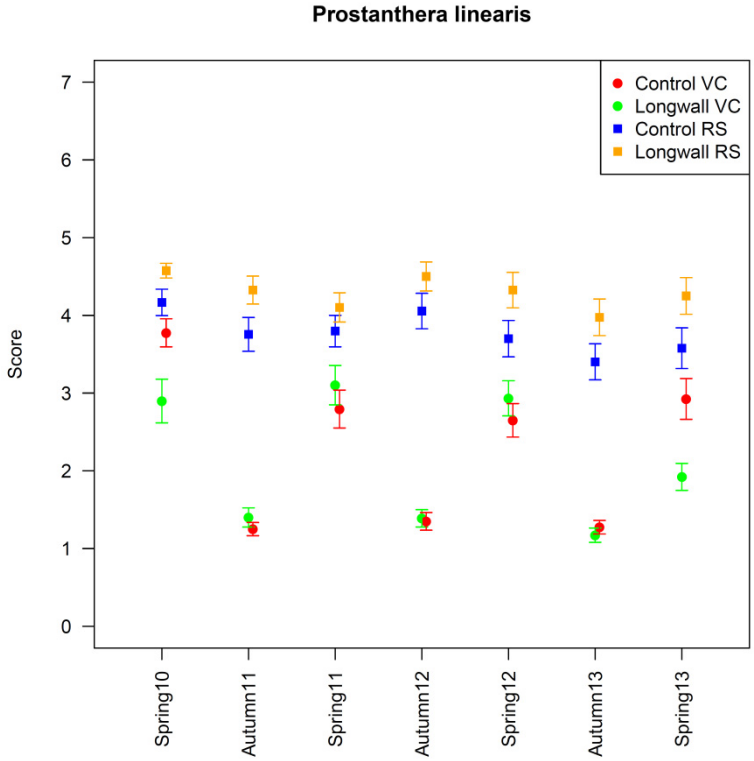

Chart 116 **Mean Scores for Vegetation Condition (VC) and Mean Reproductive Status (RS) for the Indicator Species, *Prostanthera linearis***

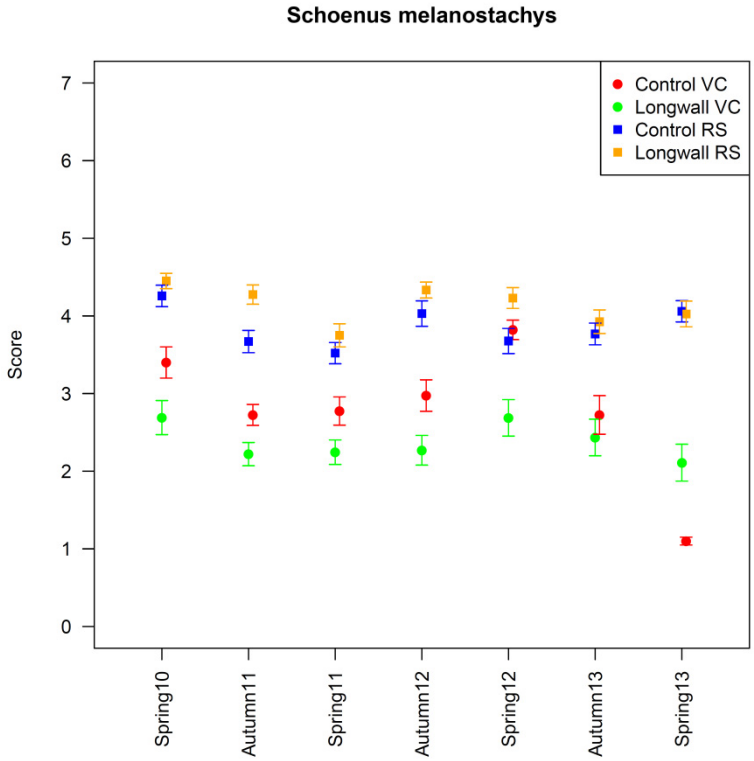

Chart 117 Mean Scores for Vegetation Condition (VC) and Mean Reproductive Status (RS) for the Indicator Species, *Schoenus melanostachys*

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 of the Six Monthly Report). 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.

Consistent with the Longwalls 20-22 program, 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

Similar to the Longwalls 20-22 stream monitoring program, 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:

- Location C1 and C4[22] on Tributary C/Eastern Tributary and B2 on Tributary B overlying Longwalls 23-27.
- Location C2[24] 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.

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 2013. 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).

[22] 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 of the Six Monthly Report.

A summary of the stream monitoring survey results up to and including spring 2013 is presented below[23].

Stream Characteristics

To date, there has been no evidence of subsidence-induced surface cracking, iron staining or gas releases at any of the sites sampled on Tributary C (Locations C1, C2 or C4) or Tributary B (Location B2).

Macroinvertebrate Assemblages

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

Table 6 presents the AUSRIVAS Band results for each site as a result of sampling aquatic macroinvertebrates using the AUSRIVAS protocol. Fewer families of macroinvertebrates than expected were commonly collected from all sites sampled (including control sites), compared to control sites selected by the AUSRIVAS model (Table 6).

Charts 118a to 118d present the 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 119a to 1190d 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 120a to 120d 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 clear differences in the structure of assemblages of macroinvertebrates at Location C4 on Tributary C/Eastern Tributary and the control locations sampled along the Woronora River and O'Hares Creek. Notably, the structure of the assemblage at Location C4 on the last sampling occasion (i.e. spring 2013) appeared to be considerably different from assemblages collected at that location previously.

There were also clear differences in the structure of assemblages of macroinvertebrates at Location B2 on Tributary B and the control locations sampled along Bee Creek and the Woronora Tributary. Assemblages collected at Location B2 in autumn 2013 (T8) and spring 2013 (T9) appeared to be considerably different from assemblages collected on previous sampling occasions, mostly due to decreased abundances of Atyidae.

[23] For sampling locations at which monitoring commenced in spring 2008, the results are included in the Principal Coordinates Analysis (PCoA) plots in Charts 118 and 121. The spring 2008 and autumn 2009 macroinvertebrate survey results for Locations C1 and C2 on Tributary C, Location WR1 on the Woronora River, Location OC on OHare's Creek, Location BC on Bee Creek and Location WOT on the Woronora Tributary is presented in Section 3.2.1.4. Charts 119, 120, 122 and 123 include survey data from spring 2009 to spring 2013.

Table 6
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
Tributary C	C1-1	B	B	C	C	B	B	C	A	D
	C1-2	C	B	B	B	C	A	B	C	C
	C2-1	B	C	C	B	C	C	B	C	C
	C2-2	B	C	C	C	D	B	C	C	C
	C4-1	B	B	C	B	D	B	B	C	C
	C4-2	B	B	C	C	B	C	C	C	B
Tributary B	B2-1	C	B	C	C	B	B	D	A	B
	B2-2	C	C	C	B	B	C	B	C	C
Bee Creek	BC1	C	B	C	C	D	C	A	B	B
	BC2	D	B	C	B	B	B	B	C	B
Woronora Tributary	WOT1	-*	B	C	C	B	C	B	A	B
	WOT2	D	C	C	C	C	B	A	C	C
Woronora River	WR1-1	C	B	C	C	C	C	B	C	C
	WR1-2	C	B	C	C	C	C	B	B	B
O'Hares Creek	OC1	B	A	B	B	A	A	A	B	C
	OC2	B	B	B	B	B	C	C	B	C

* 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 and C2-2 on Tributary C, Sites WR1-1 and WR1-2 on the Woronora River, Sites OC1 and OC2 on OHare's Creek, Sites BC-1 and BC-2 on Bee Creek, and Sites WOT1 and WOT2 on the Woronora Tributary is presented in Table 3 in Section 3.2.1.4.

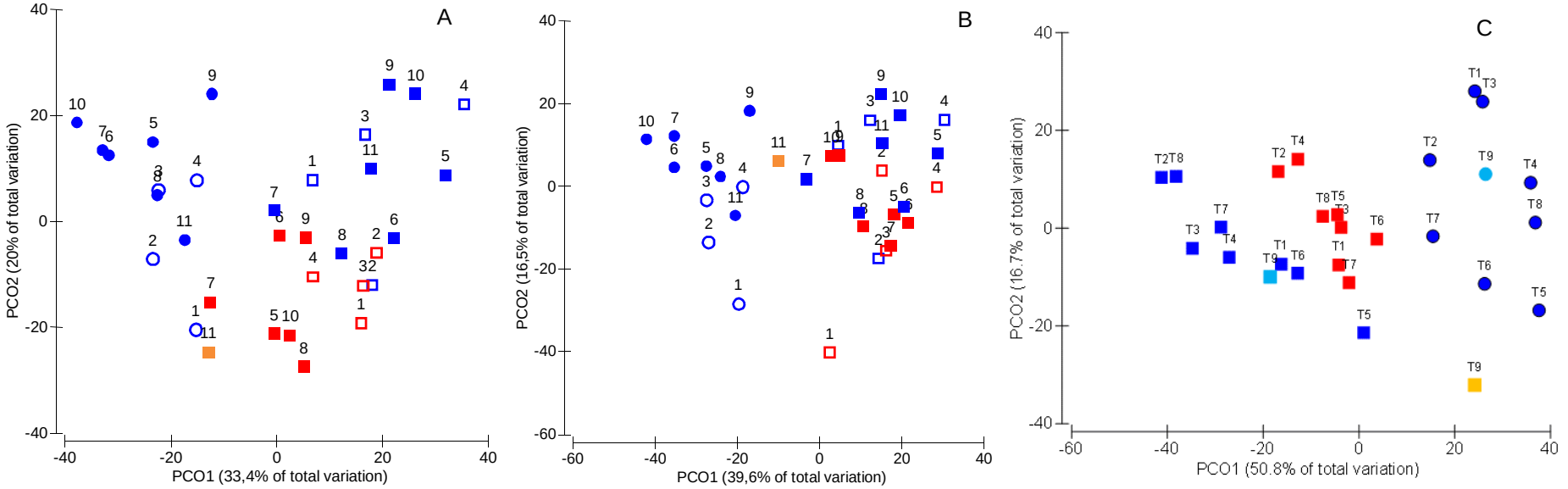

Chart 1198a-c Principal Coordinates Analysis (PCoA) plots of macroinvertebrate data for three locations on Tributary C: a) Location C1; b) Location C2; and c) Location C4) and two control locations (Woronora River and O'Hare's Creek) for each time of sampling (*n*= 6). Red symbols: Tributary C location; Blue squares: Woronora River; Blue circles: O'Hares Creek. Lighter symbols represent last sampling time (spring 2013). Note sampling of Locations C1 and C2 commenced in spring 2008, and sampling of Location C4 commenced in spring 2009

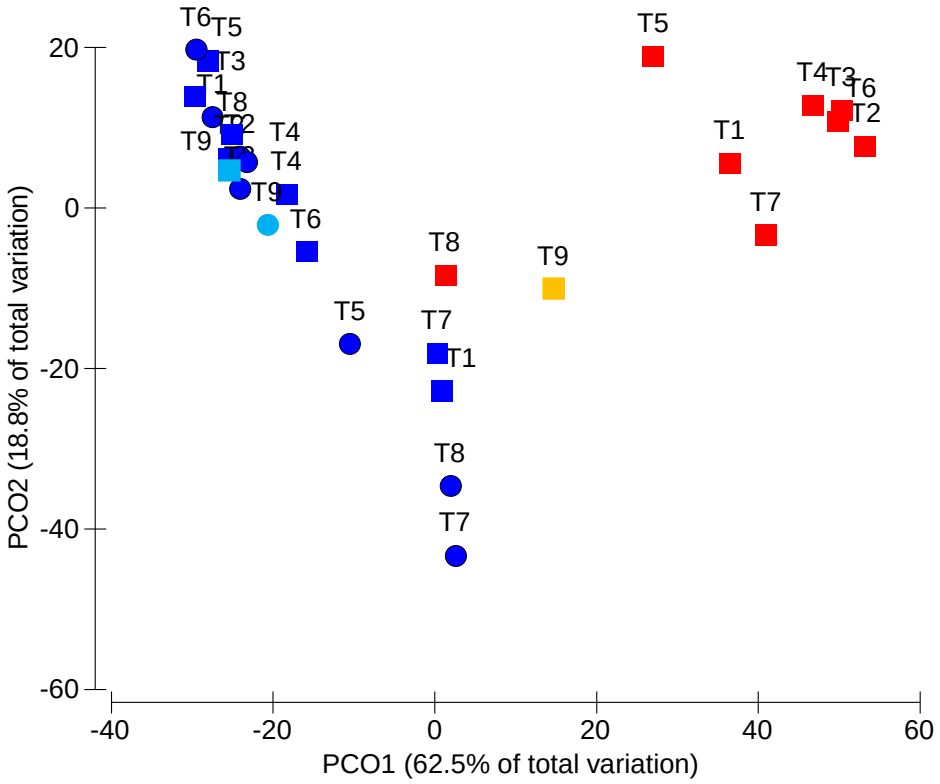

Chart 118d Principal Coordinates Analysis (PCoA) plot of macroinvertebrate data collected at one location on Tributary B (i.e. Location B2) and two control locations (Bee Creek and Woronora Tributary) for each time of sampling (*n*= 6) from spring 2009 (T1). Red symbols: Tributary B; Blue squares: Bee Creek; Blue circles: Woronora Tributary. Lighter symbols represent last sampling time (spring 2013)

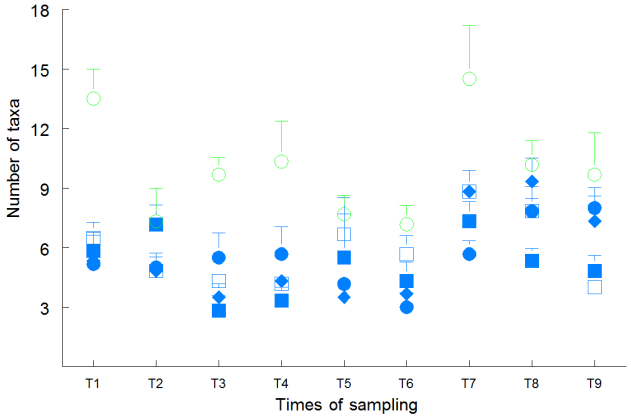

Chart 119a Mean (+SE) Macroinvertebrate Diversity, Stream Monitoring – Tributary C

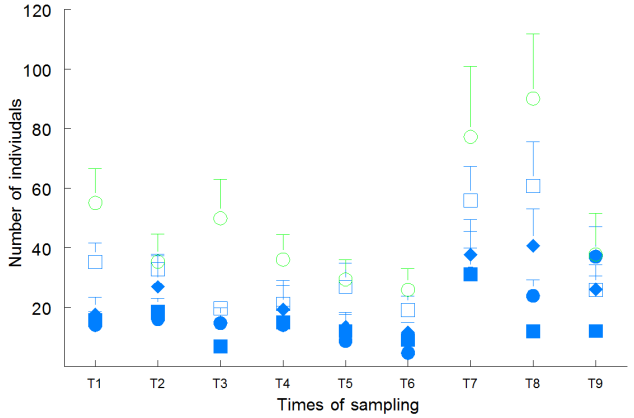

Chart 119b Mean (+SE) Macroinvertebrate Abundance, Stream Monitoring – Tributary C

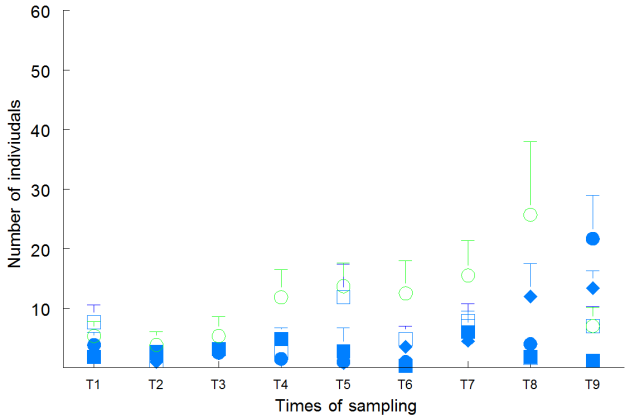

Chart 119c Mean (+SE) Number of Leptophlebiidae, Stream Monitoring- Tributary C

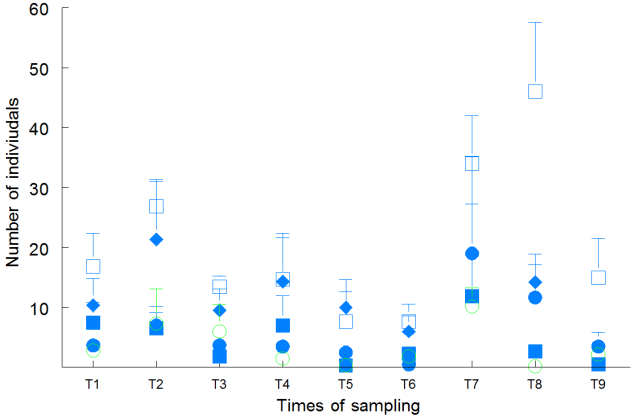

Chart 119d Mean (+SE) Number of Atyidae, Stream Monitoring – Tributary C

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

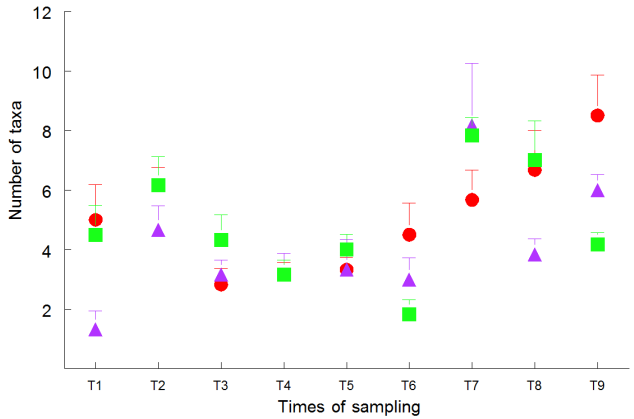

Chart 120a Mean (+SE) Macroinvertebrate Diversity, Stream Monitoring – Tributary B

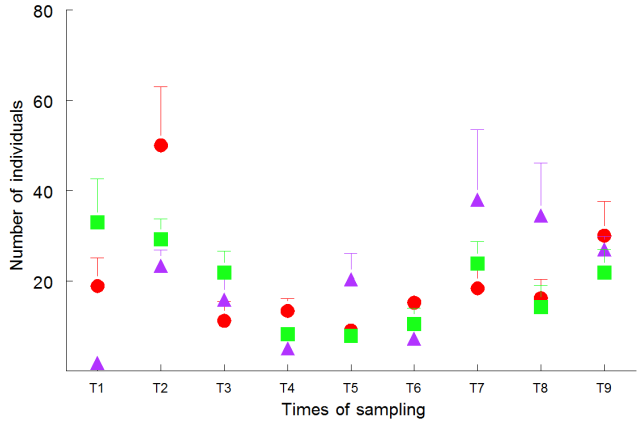

Chart 120b Mean (+SE) Macroinvertebrate Abundance, Stream Monitoring – Tributary B

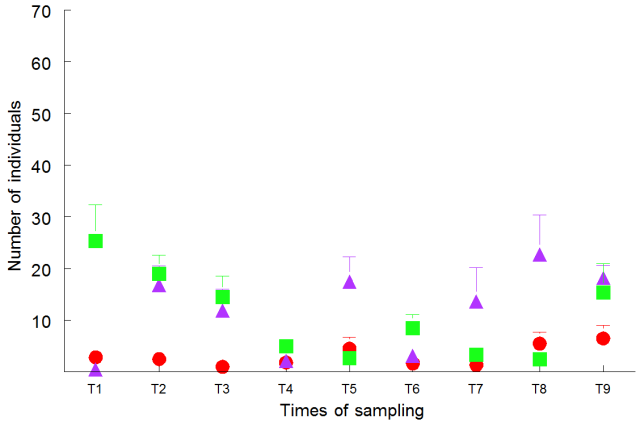

Chart 120c Mean (+SE) Number of Leptophlebiidae, Stream Monitoring- Tributary B

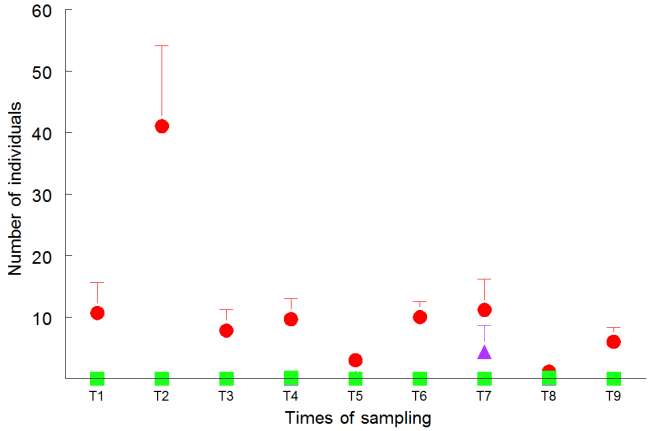

Chart 120d Mean (+SE) Number of Atyidae, Stream Monitoring – Tributary B

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

Macrophyte Assemblages

Floating attached species and/or submerged species of macrophytes (i.e. instream macrophytes) have been recorded at Locations WR1 and OC (*Triglochin procerum*), Locations C1, C2, C4, WR1 and OC (*Chara/Nitella* spp.) and Location WR1 (*Myriophyllum pedunculatum*).

A temporal comparison of the aquatic macrophyte data has been carried out for the locations sampled up to and including spring 2013. Chart 121 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 122a and 122b 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 123a and 123b present the mean diversity of macrophytes and mean percentage cover of macrophytes, respectively, at each 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 are clear differences in the structure of assemblages of macrophytes between location C4 sampled on Tributary C/Eastern Tributary and the control locations sampled on the Woronora River and O'Hares Creek. The presence of the floating-attached species, *Triglochin procerum,* at the control locations but not at Location C4 contributes greatly to observed differences.

Similar species (i.e. *Gleichenia dicarpa* and *Lepidosperma filiforme*) contributed to the structure of assemblages of macrophytes at Location B2 on Tributary B and the control locations sampled along Bee Creek and the Woronora Tributary.

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).

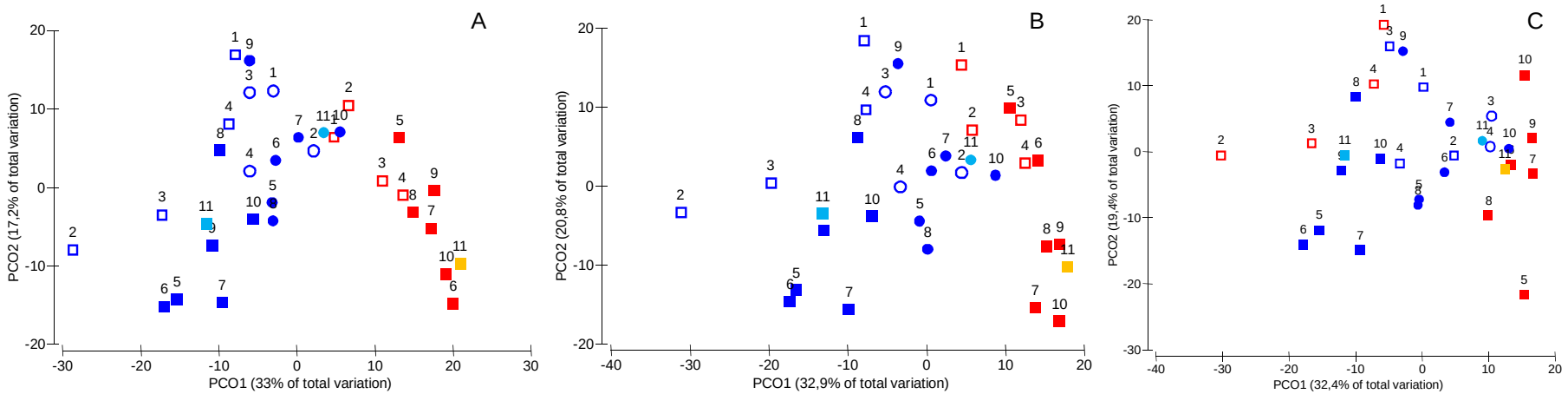

Chart 121a-c Principal Coordinates Analysis (PCoA) plots of macrophyte data for three locations on Tributary C: a) Location C1; b) Location C2; and c) Location C4 and two control locations (Woronora River and O'Hare's Creek) for each time of sampling (*n*= 10). Red symbols: Tributary C locations; Blue squares: Woronora River; Blue circles: O'Hares Creek. Lighter symbols represent last sampling time (spring 2013). Note sampling of Locations C1 and C2 commenced in spring 2008, and sampling of Location C4 commenced in spring 2009

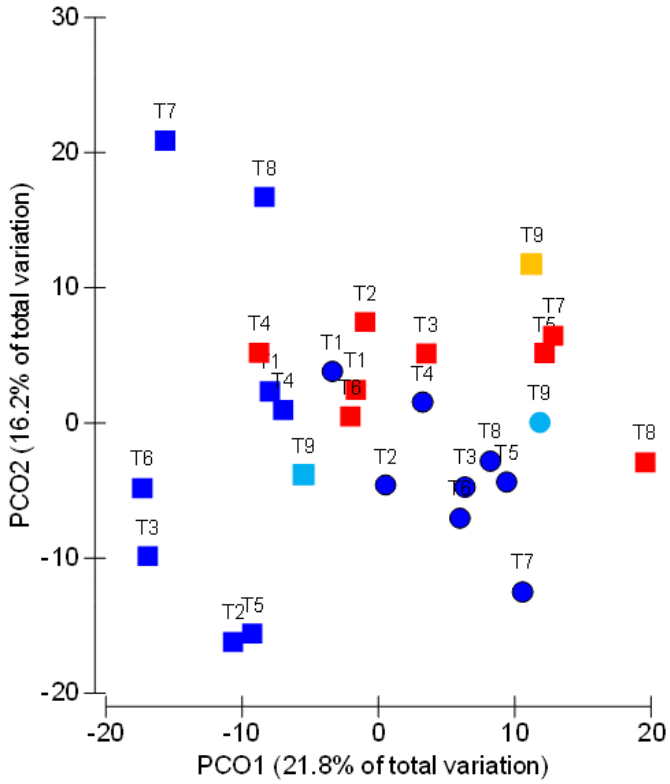

Chart 121d Principal Coordinates Analysis (PCoA) plot of macrophyte data collected at one location on Tributary B (i.e. location B2) and two control locations (Bee Creek and Woronora Tributary) for each time of sampling (*n*= 10) from spring 2009 (T1). Red symbols: Tributary B; Blue squares: Bee Creek; Blue circles: Woronora Tributary. Lighter symbols represent last sampling time (spring 2013)

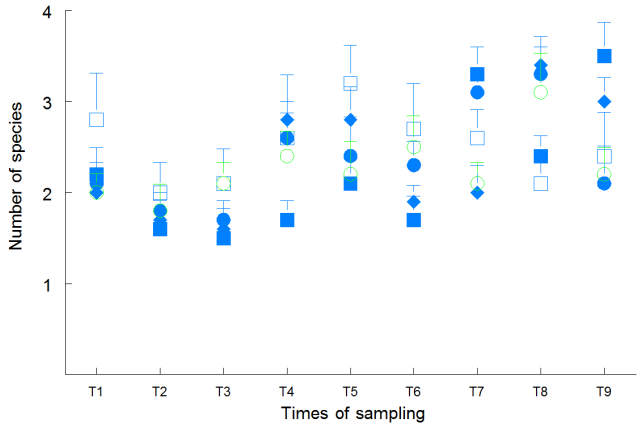

Chart 122a Mean (+SE) Macrophyte Diversity, Stream Monitoring, Tributary C

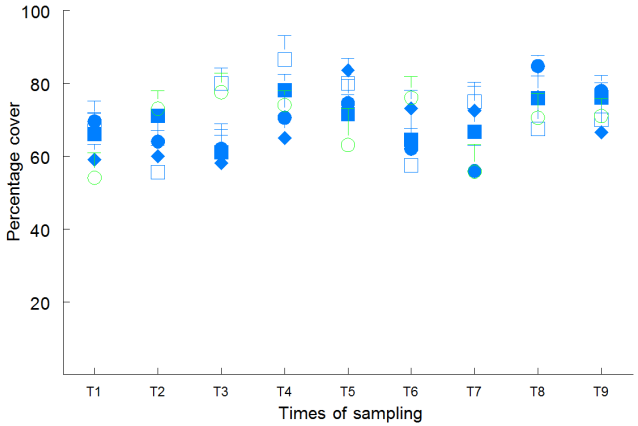

Chart 122b Mean (+SE) Macrophyte Cover, Stream Monitoring, Tributary C

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

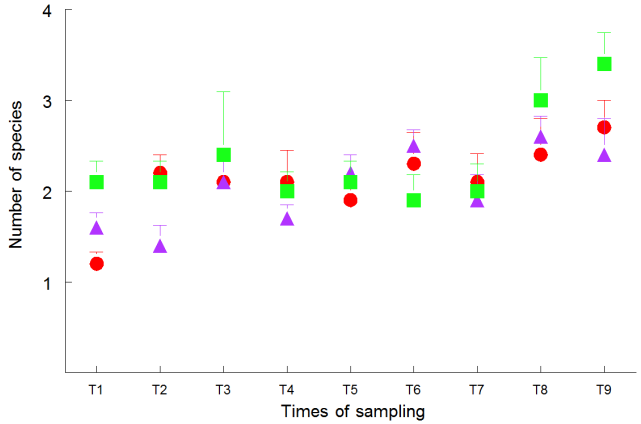

Chart 123a Mean (+SE) Macrophyte Diversity, Steam Monitoring, Tributary B

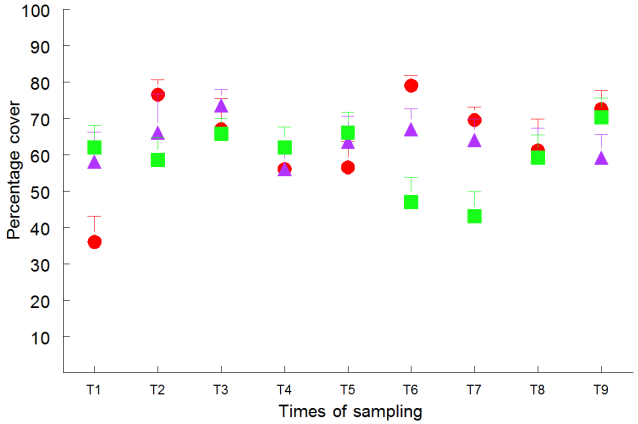

Chart 123b Mean (+SE) Macrophyte Cover, Stream Monitoring, Tributary B

Key: Tributary B (circles) and the control locations (Bee Creek: triangles; Woronora Tributary: squares) (*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 from spring 2009 to spring 2013. 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, described in Section 3.2.1.4).

A summary of the pool monitoring survey results from spring 2009 to spring 2013 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 2013.

Chart 124 presents the PCoA plot for macroinvertebrates at the larger pools using the quantitative sampling data. Charts 125a to 125d 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 126 presents the PCoA plot for macroinvertebrates at the smaller pools using the quantitative sampling data. Charts 127a and 127b present the mean diversity of macroinvertebrates and mean abundance of macroinvertebrates at the smaller pools, respectively, using the quantitative sampling data.

Results indicated clear differences in the structure of assemblages of macroinvertebrates collected among the large and small pools sampled. In particular, assemblages in pools sampled on O'Hares Creek grouped separately from the pools sampled on Tributary C/Eastern Tributary and the Woronora River.

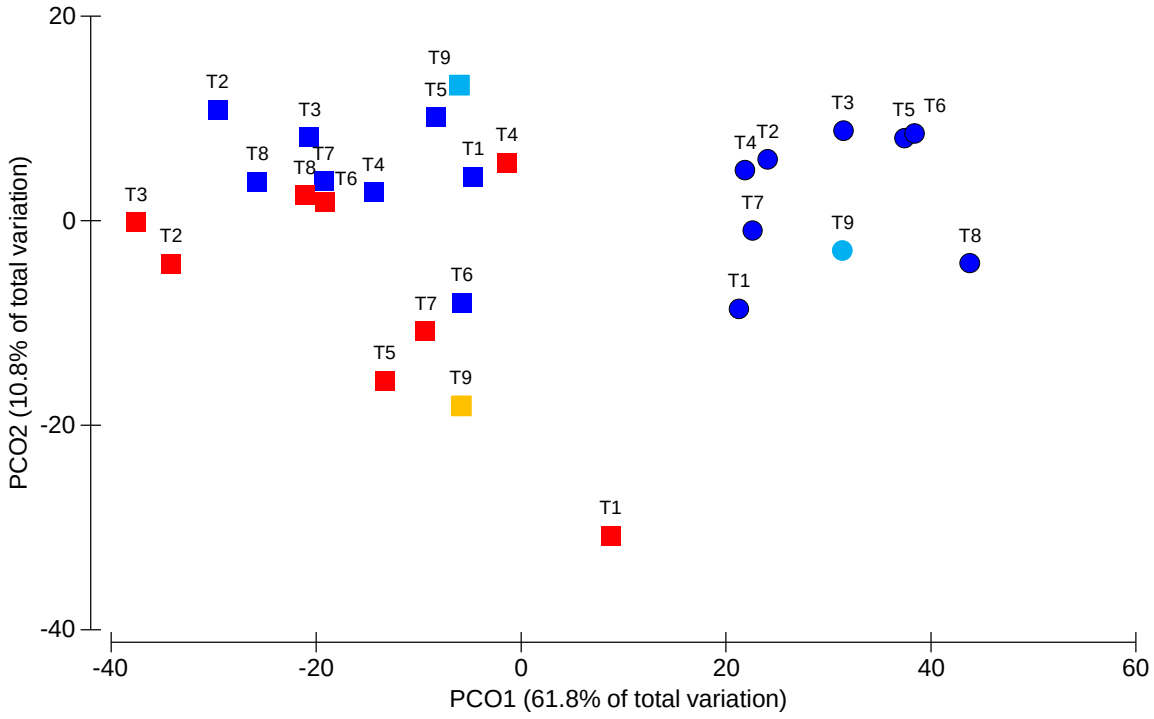

Chart 124 Principal Coordinates Analysis (PCoA) plot of macroinvertebrate data (standardized) for Pool ETAH on Tributary C (red squares) and two control pools: Woronora River (blue squares) and O'Hares Creek (blue circles) for each time of sampling (*n* = 6). Lighter symbols represent last sampling time (spring 2013). Time 1 = spring 2009, T2 = autumn 2010, etc.

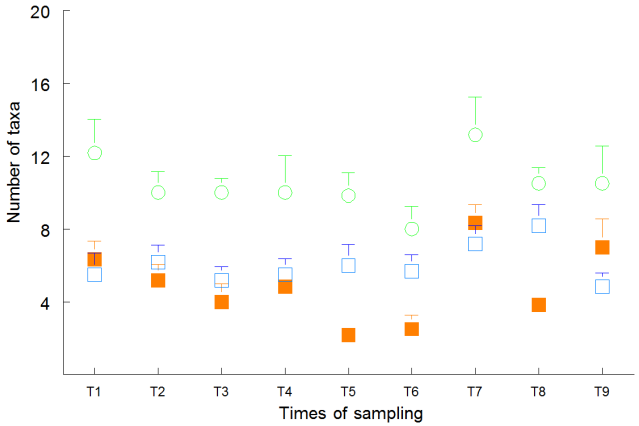

Chart 125a Mean (+SE) Macroinvertebrate Diversity, Large Pool Monitoring

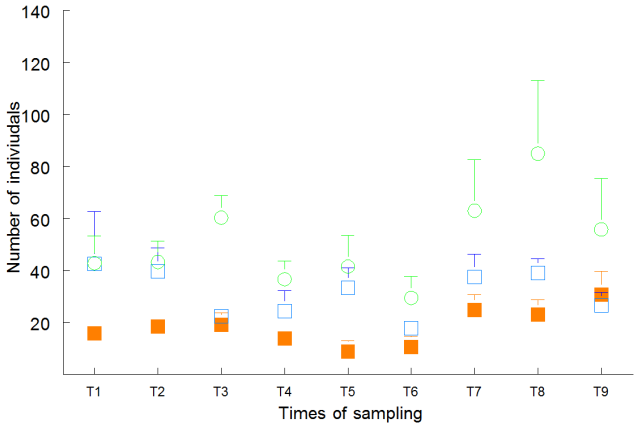

Chart 125b Mean (+SE) Macroinvertebrate Abundance, Large Pool Monitoring

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

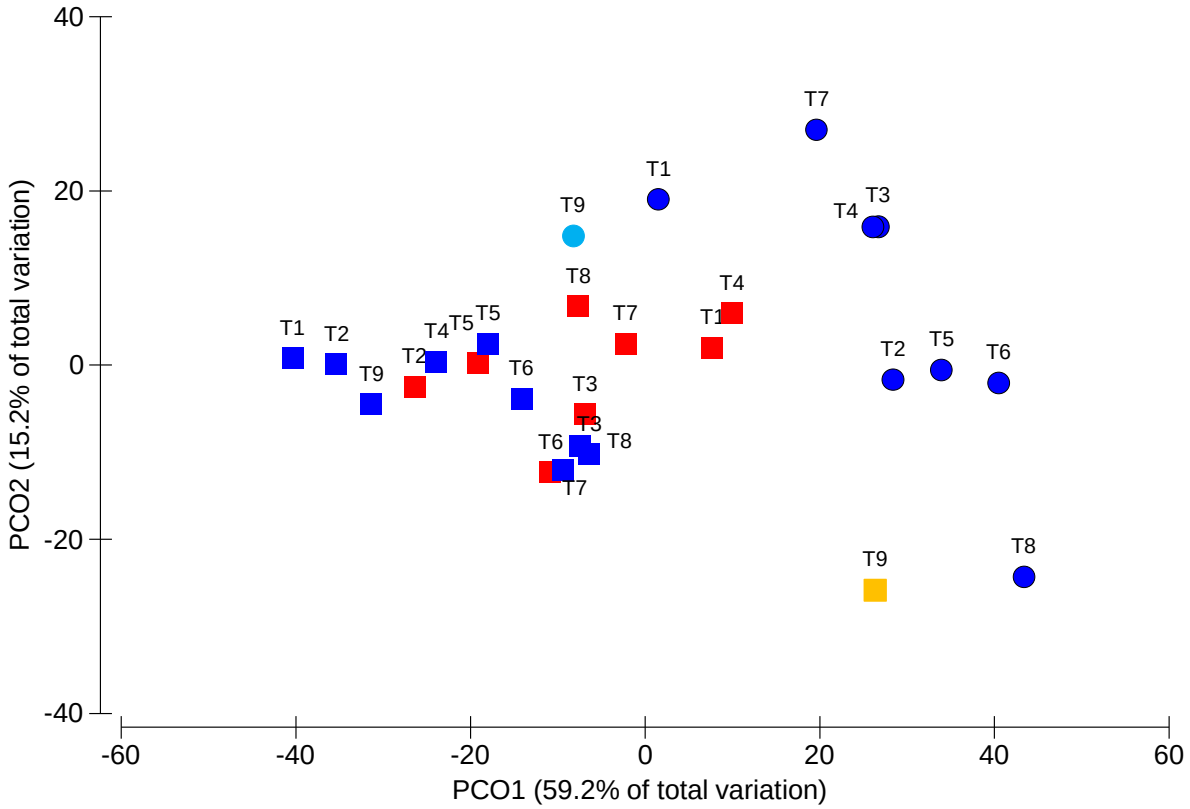

Chart 126 Principal Coordinates Analysis (PCoA) plots of macroinvertebrate data (standardized) for small pools on Tributary C (red squares) and small control pools on Woronora River (blue squares) and O'Hare's Creek (red circles) for each time of sampling (*n*= 9). Lighter symbols represent last sampling time (spring 2013). Time 1 = spring 2009, T2 = autumn 2010, etc.

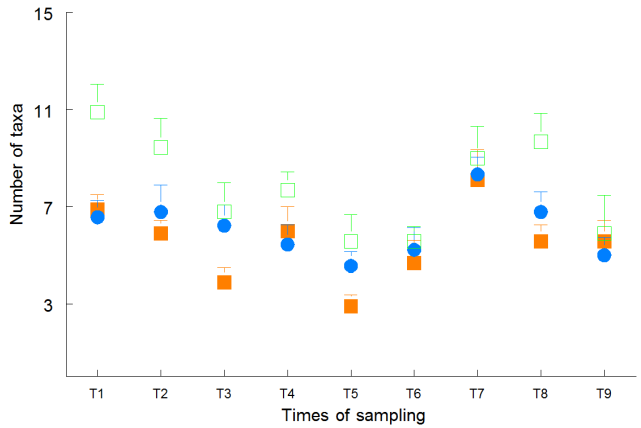

Chart 127a Mean (+SE) Macroinvertebrate Diversity, Small Pool Monitoring

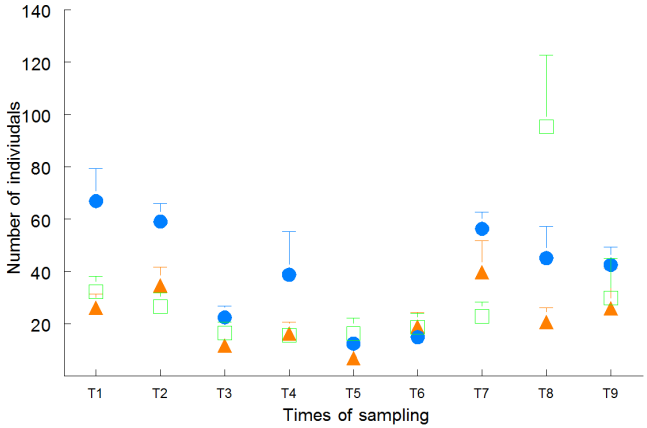

Chart 127b Mean (+SE) Macroinvertebrate Abundance, Small Pool Monitoring

Key: Tributary C pools: solid orange squares or triangles and the control pools (Woronora River Pool: solid blue circles, O'Hares Creek Pool: open green 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 2013.

Chart 128 presents the PCoA plots for macrophytes at the larger pools using the quantitative sampling data. Charts 129a and 129b present the mean diversity and mean abundance of macrophytes at the larger pools using the quantitative sampling data.

Chart 130 presents PCoA plots for macrophytes at the smaller pools, using the quantitative sampling data. Charts 131a and 131b present the mean diversity and mean abundance of macrophytes at the smaller pools, respectively, using the quantitative sampling data.

Results indicated clear differences in the structure of assemblages of macrophytes collected among the large and small pools sampled. In particular, assemblages in pools sampled on Tributary C/Eastern Tributary grouped separately from the pools sampled along the Woronora River and O'Hares Creek.

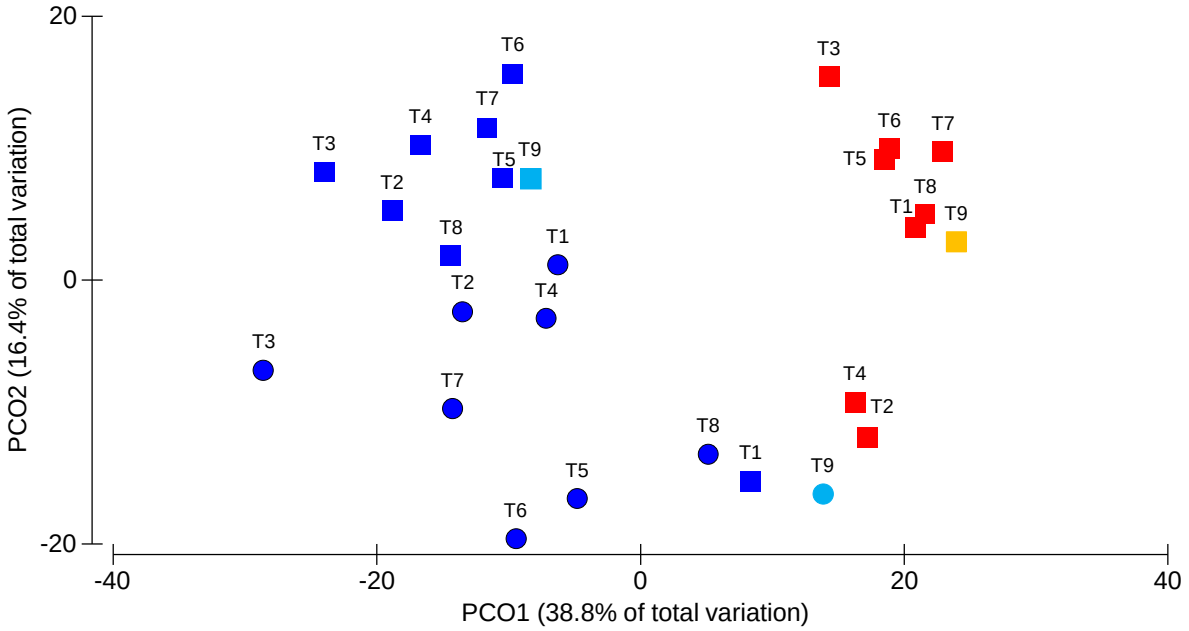

Chart 128 Principal Coordinates Analysis (PCoA) plots of macrophyte data for small pools in Tributary C (red symbols) and two control streams: Woronora River (blue squares) and O'Hares Creek (blue circles). Lighter symbols represent last sampling time (spring 2013). Time 1 = spring 2009, T2 = autumn 2010, etc.

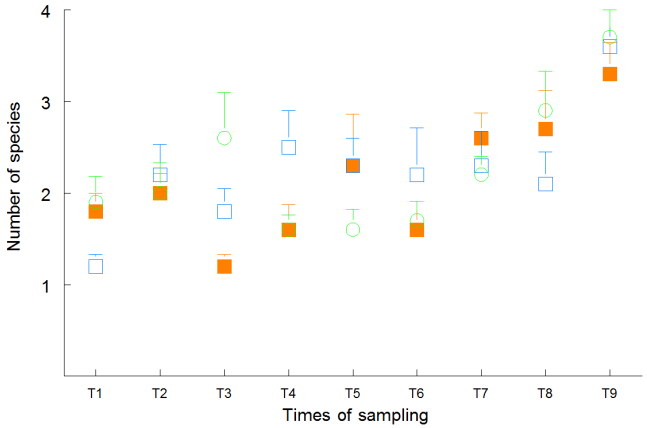

Chart 129a Mean (+SE) Macrophyte Diversity, Large Pool Monitoring

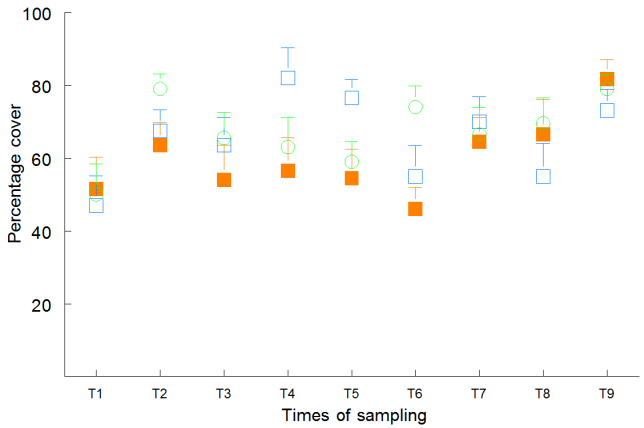

Chart 129b Mean (+SE) Macrophyte Percentage Cover, Large Pool Monitoring

Key: Pool ETAH on Tributary C: solid orange squares and the control pools (Woronora River Pool: open blue squares, O'Hares Creek Pool: open green circles). Sampling of Pools commenced spring 2009 (*n* = 10). Time 1 = spring 2009, T2 = autumn 2010, etc.

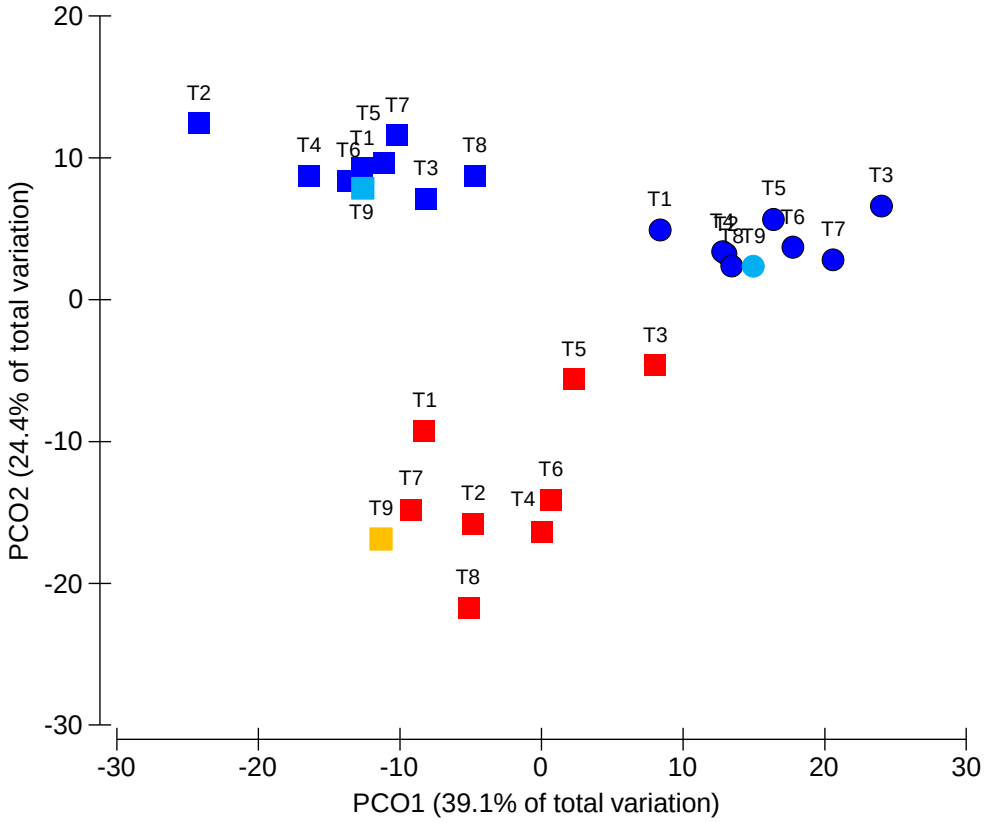

Chart 130 Principal Coordinates Analysis (PCoA) plots of macrophyte data (standardized) for small pools on Tributary C (red squares) and small control pools on Woronora River (blue squares) and O'Hare's Creek (blue circles) for each time of sampling (*n*= 9) from spring 2009. Lighter symbols represent last sampling time (spring 2013)

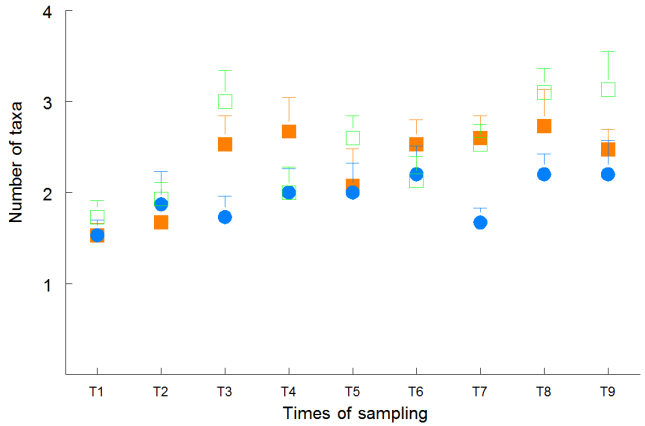

Chart 131a Mean (+SE) Macrophyte Diversity, Small Pool Monitoring

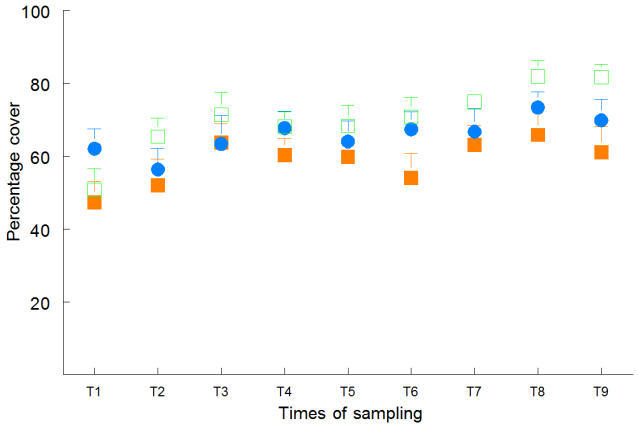

Chart 131b Mean (+SE) Macrophyte Abundance, Small Pool Monitoring

Key: Tributary C pools: solid orange squares and the control pools (Woronora River Pool: solid blue circles, O'Hares Creek Pool: open green circles). Sampling of Pools from spring 2009 (*n* = 15).

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. At the time of the spring/summer 2010 to 2013 surveys, the test sites had not yet been undermined (Longwall 23 commenced in May 2014).

The results of the four surveys to date (2010 - 2013) are summarised in Table 7, Table 8 and Chart 132 below.

Chart 132 shows the number of amphibian species recorded at each site in 2010 to 2013.

Table 7
Amphibian Species Diversity and Abundance for Longwalls 23-27, Spring/Summer 2010 - 2013

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	3	0	0	1	9	2	2	1	3	6	17	UC	MC
			0	0	6	0	0	c100	0	0	c100	75	6	c275	UC	A
		2011	0	11	0	3	6	1	21	1	0	2	21	25	MC	MC
			0	4	0	0	0	0	0	0	2	15	4	17	U	MC
		2012	5	2	2	0	1	10	0	5	11	5	10	31	UC	C
			0	0	0	0	0	0	0	0	10	0	0	10	0	UC
		2013	13	1	1	0	0	3	1	0	3	1	15	5	C	UC
			0	10	0	0	0	0	0	0	0	0	10	0	UC	0
Heleiporus australiiacus	Giant Burrowing Frog[v, v]	2010	1	0	1	0	0	1	0	0	0	1	2	2	UC	UC
			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
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	0	0	0	0	0	0	0
			0	0	0	1	0	0	0	0	0	0	1	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

Table 7 (Continued)
Amphibian Species Diversity and Abundance for Longwalls 23-27, Spring/Summer 2010 – 2013

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																
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
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
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
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 C
		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

Table 7 (Continued)
Amphibian Species Diversity and Abundance for Longwalls 23-27, Spring/Summer 2010 - 2013

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 freycineti	Southern Rocket Frog	2010	2	1	1	0	0	0	0	3	2	2	4	7	UC	UC
			4	3	6	0	0	0	0	7	50	0	13	57	MC	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	0	0	0	0	0	0	0	0	0	0	0
			0	7	0	0	0	0	0	0	0	0	7	0	UC	0
		2013	2	0	0	0	1	0	0	0	0	0	3	0	UC	0
			0	0	0	0	0	0	0	0	0	0	0	0	0	0
Litoria lesueurii	Lesueur's Frog	2010	1	0	2	0	0	0	0	0	0	0	3	0	UC	0
			0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2011	1	6	0	0	0	0	0	0	0	0	7	0	UC	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	26	0	0	0	0	0	0	0	0	26	0	A	0
		2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			0	5	0	0	0	0	0	0	0	0	5	0	UC	0
Litoria peronii	Peron's Tree Frog	2010	0	0	0	0	1	0	2	0	0	0	1	2	UC	UC
			0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2011	0	0	0	1	0	0	0	0	0	0	1	0	UC	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

Table 7 (Continued)
Amphibian Species Diversity and Abundance for Longwalls 23-27, Spring/Summer 2010 – 2013

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
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				
Species Diversity in all Control and all Test sites		2010											7	6		
		2011											6	5		
		2012											4	3		
		2013											5	2		
Species Diversity across the survey site		2010											8			
		2011											7			
		2012											5			
		2013											5			

[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 8
Number of Longwalls 23-27 Sites used per Amphibian Species in 2010 – 2013

Species	Test Sites				Control			
	2010	2011	2012	2013	2010	2011	2012	2013
Common Eastern Froglet	4	3	4	3	5	5	4	4
Giant Burrowing Frog [v, v]	2	0	0	0	2	0	0	0
Spotted Grass Frog	0	0	1	0	0	0	0	0
Red-crowned Toadlet [v]	3	3	0	1	0	1	4	1
Smooth Toadlet	0	0	0	0	0	2	0	0
Blue Mountains Tree Frog	1	1	0	2	1	1	0	0
Bleating Tree Frog	0	0	0	0	1	0	0	0
Southern Rocket Frog	3	0	1	2	3	0	0	0
Lesueur's Frog	2	2	1	2	0	0	0	0
Peron's Tree Frog	1	1	0	0	1	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.

Chart 132 Amphibian Species Diversity 2010, 2011, 2012 and 2013

In summary, the amphibian survey results from 2010 to 2013 indicated:

- Nine amphibian species were recorded in the 2010 to 2013 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*).
- The test sites had not been undermined at the time of the spring/summer 2010 to 2013 surveys. Longwall 23 commenced in May 2014.
- In 2010, eight amphibian species were located across the survey area including seven in test sites and six in control sites. In comparison seven amphibian species were located in the survey area including six species in test sites and five species in control sites in 2011. Five amphibian species were located in the survey area including four species in test sites and three species in control sites in 2012. In 2013, five amphibian species were located in the survey area including five species in test sites and two species 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 and 0-4 species at test sites and 0-2 species at control sites in 2013.
- The most species diverse site in 2010 was test site 15 with six species recorded. In 2011 the most species diverse site was test site 13 and control site 22, both with five species. In 2012 three species were recorded at test site 14 and four species were recorded at test site 13 in 2013.
- Breeding success has been infrequently observed over the 2010 to 2013 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).
- The Giant Burrowing Frog (*Heleiporus australiiacus*) has been recorded at test sites 13 and 15 and at control sites 18 and 22 in 2010.
- The Red-crowned Toadlet (*Pseudophryne australis*) has been recorded in 2010 (uncommon), 2011 (uncommon) and 2013 (one individual) at test sites and in 2011 (uncommon), 2012 (uncommon) and 2013 (uncommon) at control sites.
- The changes in species diversity observed at the test sites from 2010 to 2013 are also reflected in the changes at control sites.
- The amphibian species diversity and abundance data are consistent with population variations and cycles in response to seasonal variations.
- A Poisson regression analysis is currently being conducted to analyse the 2010 – 2013 spring/summer amphibian survey results.

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 seasonal variations in water levels experienced by upland swamps prior to mining or control swamps.*

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 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 133), about 1.4 m, is conditioned by the strong dry episode in February 2011. Swamp 101 is the control swamp for longwall Swamp 25.

The performance assessment for Swamp 25 is illustrated on Chart 134. The swamp substrate (1 m) piezometer indicates ongoing intermittent wetness. 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). 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 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 be a mixture of climatic and mining effects. However, comparison with the control swamp hydrograph on Chart 135 shows that there was a corresponding decline in water levels there at the same time, with a similar magnitude. Hence, it is considered that the observed decline at Swamp 25 is purely a climatic effect. Since then, the water levels at the two sites show sympathetic responses due to rainfall variability.

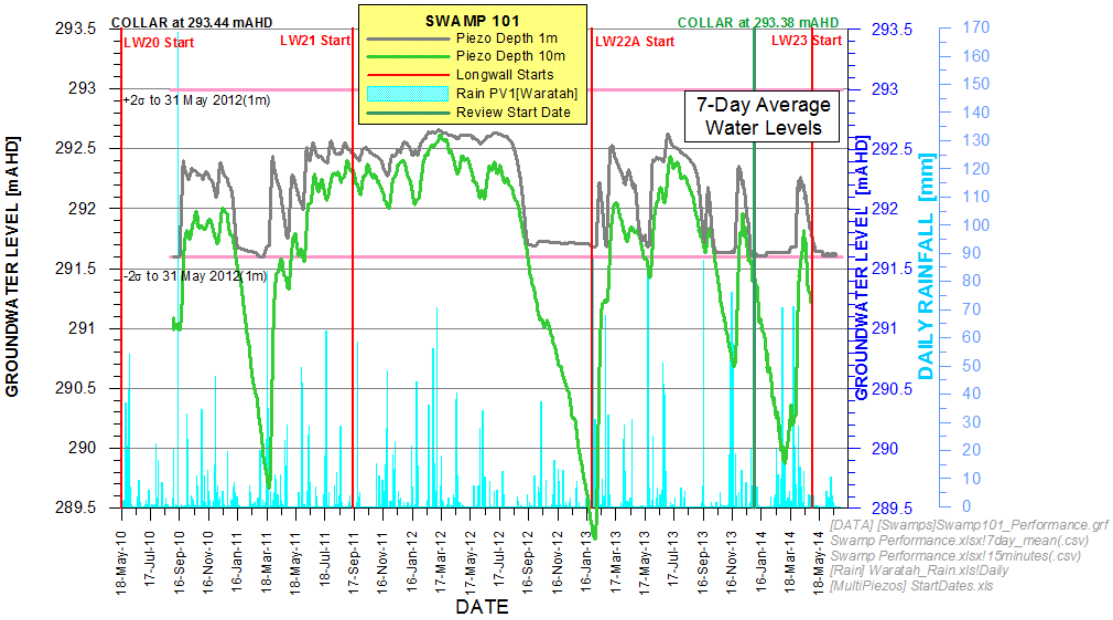

Chart 133 Performance Assessment of Groundwater Hydrograph at Control Swamp 101

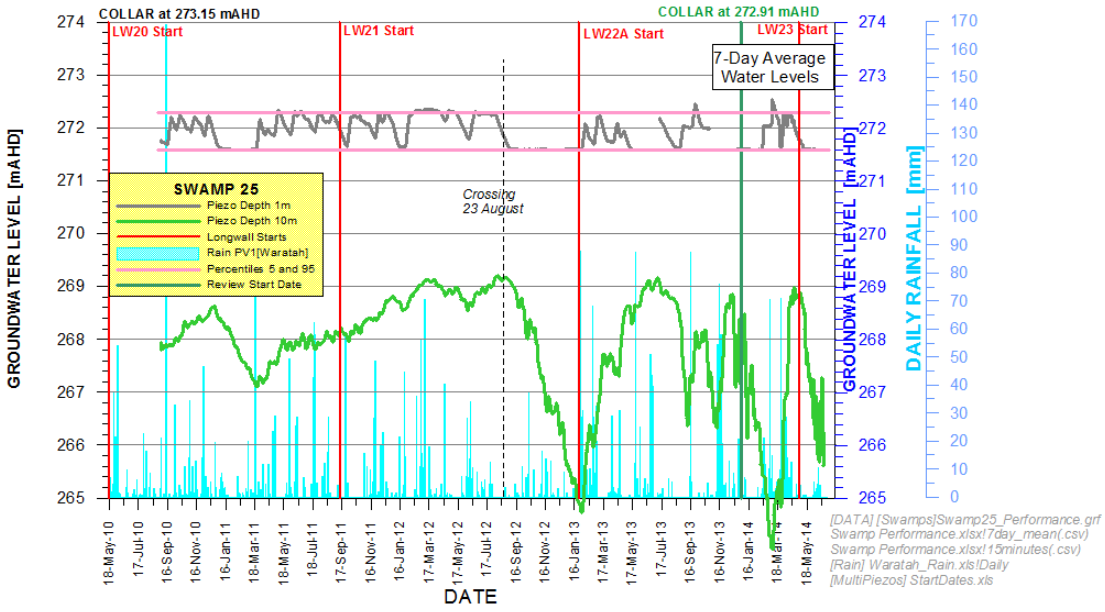

Chart 134 Performance Assessment of Groundwater Hydrograph at Swamp 25

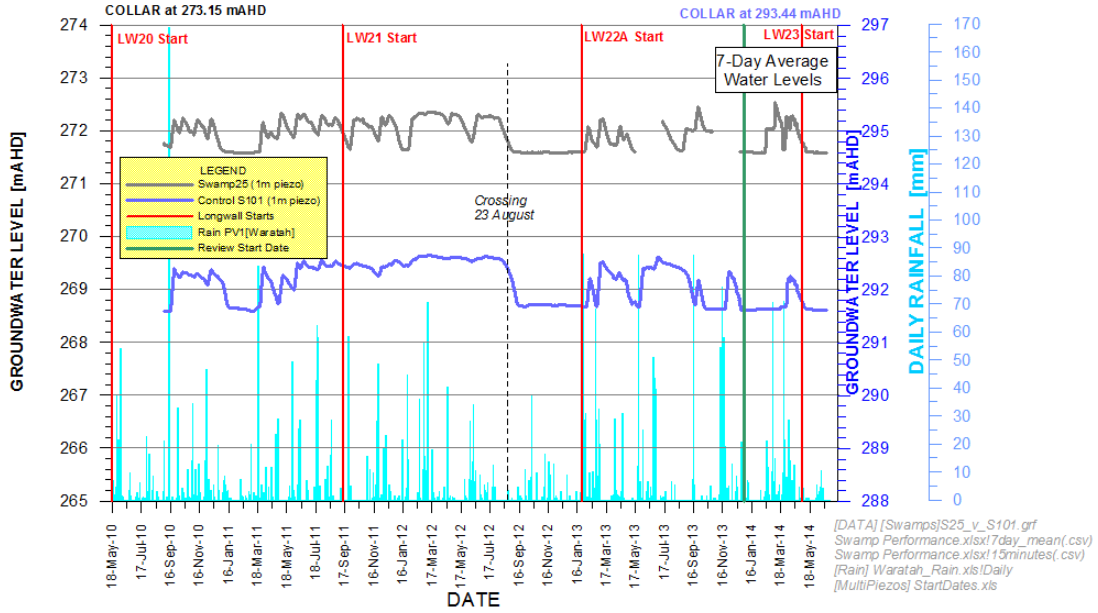

Chart 135 Comparison of Piezometer Responses at Swamp 25 and Control Swamp 101

The bandwidth for the Woronora River 1 control swamp (Chart 136) (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, 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 and February 2014, due to dry conditions. During the reporting period, water levels did not exceed the +2σ limit.

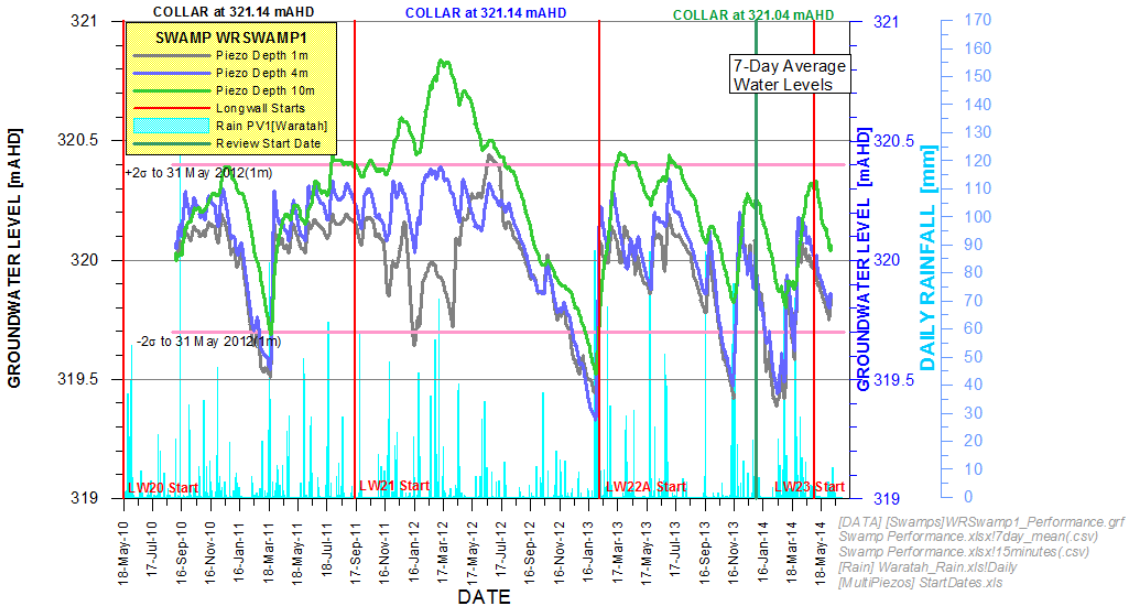

Chart 136 Performance Assessment of Groundwater Hydrograph at Woronora River 1 Control Swamp

The performance assessment during the reporting period for Swamp 20 is illustrated on Chart 137. 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 2011, as they did at the Woronora River 1 control swamp (Chart 138). During the previous reporting period, 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. Exceedances of the performance indicator (mean-2σ) have occurred during the periods listed in Table 9 for 48 percent of days from February 2011 to June 2014. As the rainfall residual mass values declined 53 percent of the time during the same period, the exceedances are largely influenced by dry conditions.

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.

To discriminate between climatic and mining effects, comparison is made on Chart 138 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 in 2013 and 2014, but different in 2012, it is likely that Longwall 21 has caused a mining effect at Swamp 20 but Longwall 22 has not.

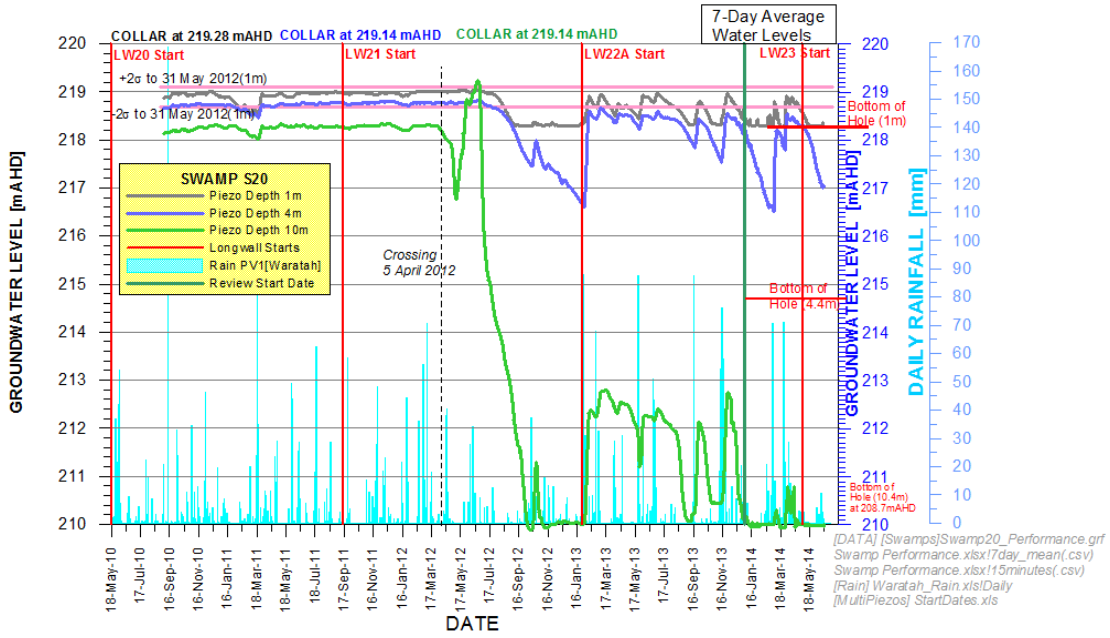

Chart 137 Performance Assessment of Groundwater Hydrograph at Swamp 20

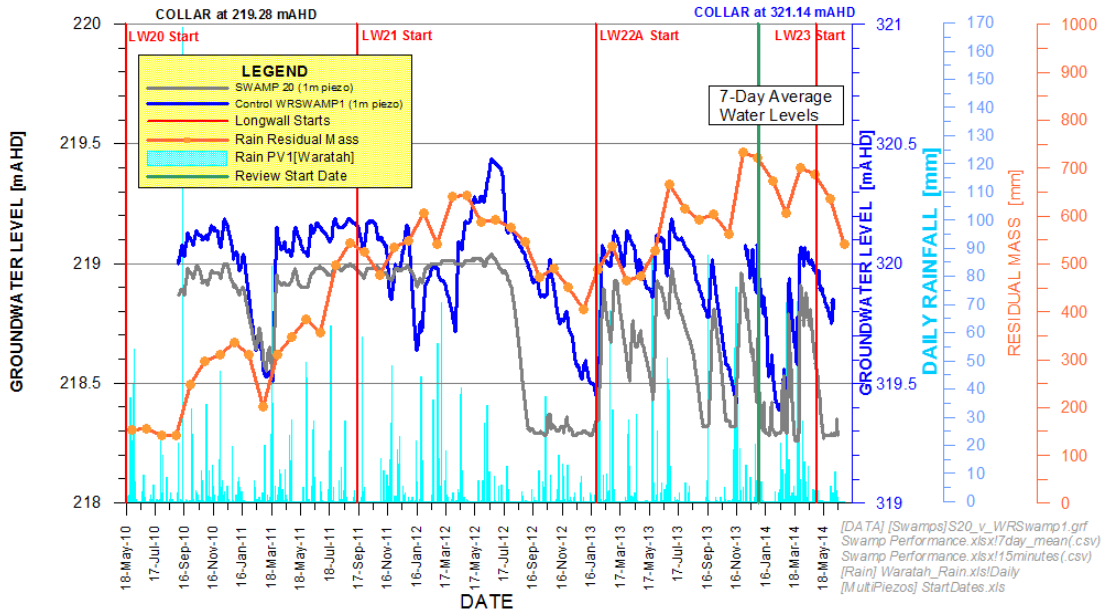

Chart 138 Comparison of Piezometer Responses at Swamp 20 and Woronora River 1 Control Swamp

Table 9
Exceedances of the Performance Indicator for Swamp 20

Duration (Days)	Total (Days)	Start Date	End Date
48	48	1/02/2011	20/03/2011
178	226	10/08/2012	3/02/2013
8	234	18/02/2013	25/02/2013
70	304	19/03/2013	27/05/2013
58	362	28/07/2013	23/09/2013
50	412	1/10/2013	19/11/2013
109	521	8/12/2013	26/03/2014
1	522	15/04/2014	15/04/2014
57	579	19/04/2014	14/06/2014

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 *Threatened Species Conservation Act, 1995* 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 Metropolitan Coal 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 *Threatened Species Conservation Act, 1995* or Commonwealth *Environment Protection and Biodiversity Conservation Act, 1999* 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 *Threatened Species Conservation Act, 1995* were recorded in the baseline flora survey for the Metropolitan Coal Environmental Assessment (Metropolitan 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.

Only one of these, the Prickly Bush-pea, which is listed as Vulnerable under the NSW *Threatened Species Conservation Act, 1995* 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 and reported in the Metropolitan Coal 2013 Annual Review/AEMR.

Dr. Colin Bower (FloraSearch) inspected Swamp 20 and control swamp Woronora River 1 on 30 September 2014. The September 2014 site inspection by FloraSearch revealed minor differences in vegetation condition between Swamp 20 and Woronora River Swamp 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 good recent new growth in the understorey in both swamps in response to the higher than average August rain. 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 through most of 2014 has depleted water levels in both Swamp 20 and Woronora Swamp 1, and that the heavy August rains were insufficient to fully recharge both swamps.

Observations in Swamp 20 and Woronora River Swamp 1 on 30 September 2014 by FloraSearch found dry soil and a lack of free water in both swamps and no significant differences in the condition of the vegetation between swamps. 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 Metropolitan Coal Environmental Assessment (Metropolitan 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 and reported in the Metropolitan Coal 2013 Annual Review/AEMR.

Dr. David Goldney (Cenwest Environmental Services) inspected Swamp 20 and control swamp Woronora River 1 on 30 September 2014. 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 change 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 the Metropolitan Colliery.*

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 identified vegetation dieback greater than 50 cm from the Waratah Rivulet at site MRIP02 (overlying Longwall 21) in the spring 2013 vegetation survey, and as a result the performance indicator has been exceeded. Photographs of the vegetation dieback are provided in Plates 1 to 3 in Section 3.2.1.3.

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 *Threatened Species Conservation Act, 1995* 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 *Threatened Species Conservation Act, 1995* or Commonwealth *Environment Protection and Biodiversity Conservation Act, 1999* 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 *Threatened Species Conservation Act, 1995* were recorded in the baseline flora survey for the Metropolitan Coal Environmental Assessment (Metropolitan 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.

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 (Metropolitan 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 within the areas affected by dieback which are regularly traversed as part of the flora monitoring program.

Previous threatened flora species assessment, for exceedances of the riparian vegetation performance indicator at site MRIP02, since spring 2012 was conducted by FloraSearch in January 2014 and reported in the Metropolitan Coal 2013 Annual Review/AEMR.

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 from subsidence has resulted in prolonged inundation of streamside vegetation causing death of terrestrial shrubs and ground cover species. 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 Metropolitan Coal Environmental Assessment (Metropolitan Coal, 2008). Of these, only two species are considered likely to potentially 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.

Previous threatened fauna species assessment, for exceedances of the riparian vegetation performance indicator at site MRIP02 since spring 2012, was conducted by Cenwest Environmental Services in January 2014 and reported in the Metropolitan Coal 2013 Annual Review/AEMR.

Dr. David Goldney (Cenwest Environmental Services) inspected riparian vegetation of Waratah Rivulet on 30 September 2014. Death and/or senescence of riparian plants has been observed at site MRIP02 due to increased ponding resulting in prolonged inundation of the riparian vegetation as a result of subsidence. 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.

3.3.1.4 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 Annual Reviews/AEMRs 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.

As discussed in Section 3.2.1.5, the amphibian species diversity and abundance data appear to be consistent with expected population variations and cycles in response to seasonal variations. There does not appear to be significant differences between the test and control sites. Thus, this 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 10. 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 10
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 have not been undermined by Longwalls 20-22.

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.

This Six Monthly Report includes baseline data for upland swamp vegetation up to and including spring 2013. Performance indicator 1 will be assessed in the Metropolitan Coal 2014 Annual Review/AEMR (which will include the autumn 2014 survey results [post the commencement of Longwall 23]).

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 seasonal variations in water levels experienced by upland swamps prior to mining or control swamps.*

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]. Data acquired at the swamp substrate piezometers up to 30 June 2014 are unaffected by mining and serve as a suitable baseline for assessment of subsequent potential impacts.

As the reporting period (1 January to 30 June 2014) includes the baseline period, the performance indicator will be assessed in the Metropolitan Coal 2014 Annual Review/AEMR.

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 the 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.

Section 3.2.2.3 indicates that visual inspections of riparian vegetation identified vegetation dieback greater than 50 cm from the Waratah Rivulet at site MRIP02 (overlying Longwalls 20-22) in the spring 2013 vegetation survey (priot to the commencement of Longwall 23). As a result the 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,* and the results of the assessment are summarised in Section 3.3.1.3.

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/AEMRs, 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.

The test sites had not been undermined at the time of the spring/summer 2010 to 2013 surveys (Longwall 23 commenced in May 2014). The amphibian species diversity and abundance data are consistent with population variations and cycles in response to seasonal variations.

The performance indicator will be assessed using the 2014 spring/summer survey results in the Six Monthly Report for the period 1 January to 30 June 2015.

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 11. 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 11
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 during the reporting period is provided in Table 12.

In summary, two performance indicators were exceeded, namely: *Surface cracking within upland swamps resulting from mine subsidence is not expected to result in measurable changes to swamp groundwater levels when compared to seasonal variations in water levels experienced by upland swamps prior to mining or control swamps* at Swamp 20 overlying Longwall 21 and *Impacts to riparian vegetation are expected to be localised and limited in extent, similar to the impacts previously experienced at the Metropolitan Colliery* at site MRIP02 overlying Longwall 21.

Exceedance of the performance indicators triggered an assessment against the performance measure. No performance measures were exceeded during the reporting period.

3.4.2 Longwalls 23-27

The TARP characterisation for Longwalls 23-27 biodiversity management during the reporting period is provided in Table 13.

In summary, one performance indicator was exceeded: *Impacts to riparian vegetation are expected to be localised and limited in extent, similar to the impacts previously experienced at the Metropolitan Colliery* at site MRIP02 overlying Longwall 21 (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 during the reporting period.

Table 12
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 seasonal variations in water levels experienced by upland swamps prior to mining or control swamps* (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 the Metropolitan Colliery* (Section 3.3.1.3)	Yes – performance indicator exceeded at site MRIP02 overlying Longwall 21	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 13
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 seasonal variations in water levels experienced by upland swamps prior to mining or control swamps* (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 overlying Longwall 21	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 (Metropolitan Coal, 2011b) and Metropolitan Coal Longwalls 23-27 Land Management Plan (Metropolitan Coal, 2013b) 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 Cliffs and Overhangs

Visual inspections are conducted monthly for the period of time that longwall extraction takes place 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 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 22 did not advance to within 400 m of sites COH1, COH2, COH3, COH4 or COH14 during the reporting period.

Additional opportunistic observations of subsidence impacts conducted during routine works and sampling by Metropolitan Coal and its contractors did not identify any subsidence impacts.

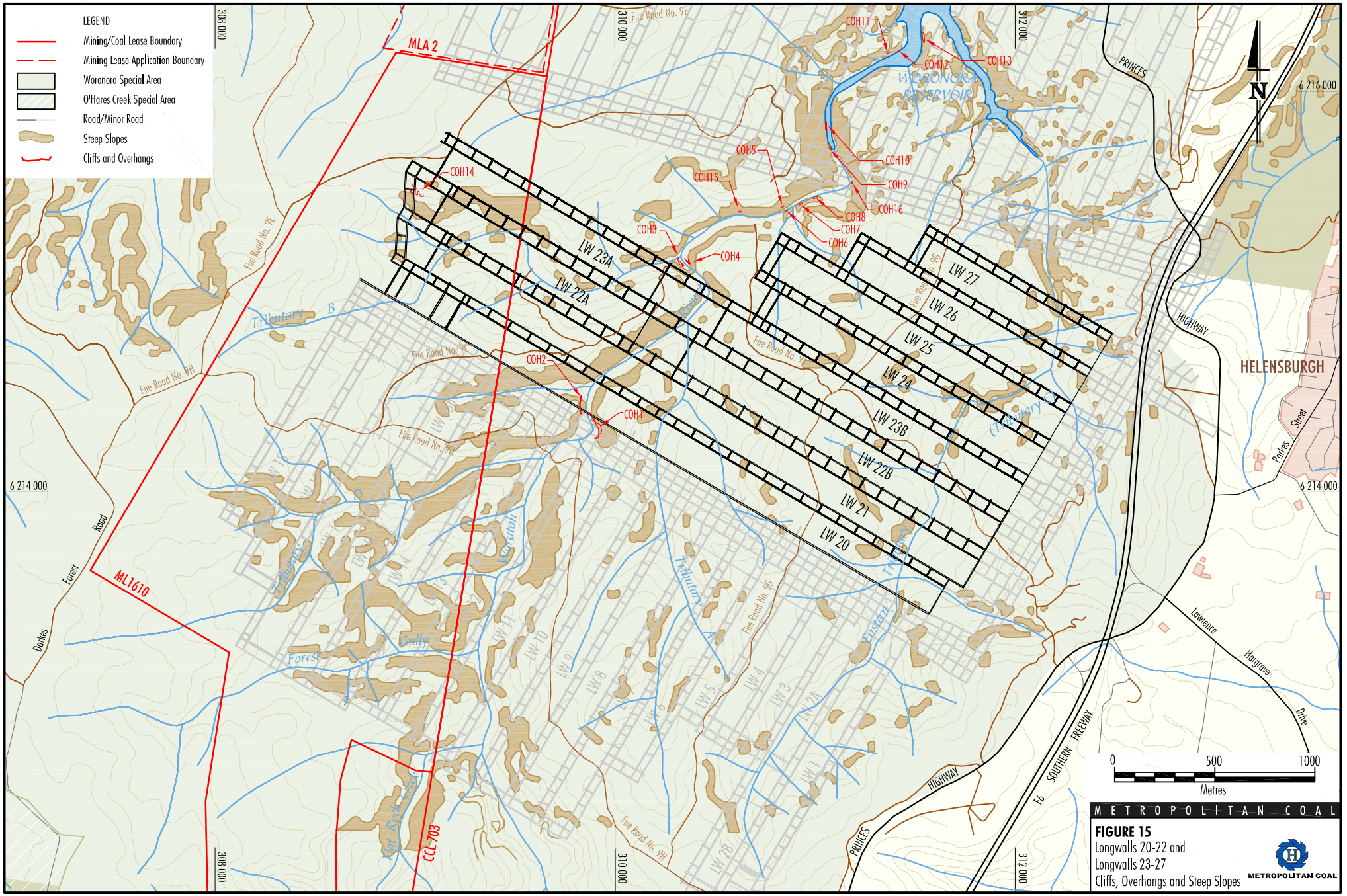

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FIGURE 15
Longwalls 20-22 and
Longwalls 23-27
Cliffs, Overhangs and Steep Slopes

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4.2.1.2 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);
- 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 additional surface tension cracks or rock falls, to those reported previously, were observed in the catchment during the reporting period.

4.2.2 Longwalls 23-27

4.2.2.1 Cliffs and Overhangs

Visual inspections are conducted monthly for the period of time that longwall extraction 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 are the same as those described in Section 4.2.1.1 for Longwalls 20-22.

Mining did not advance to within 400 m of sites COH2, COH3, COH4, CHO5, COH6, COH6A, COH7, COH8, COH9, COH10, COH15 and COH16 during the reporting period. A visual inspection of site COH14 was conducted in May and June 2014 when Longwall 23 extraction was within 400 m of the site.

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 site COH14.

Additional opportunistic observations of subsidence impacts conducted during routine works and sampling by Metropolitan Coal and its contractors did not identify any subsidence impacts.

4.2.2.2 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 during the mining of Longwall 23 in the reporting period.

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, 2014a).

The results of the assessment are described below.

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

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 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 and 4.2.2, no additional surface tension cracks, to those reported previously, were observed in the catchment during the reporting period.

The performance indicator was not exceeded during the reporting period.

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 2013 Annual Review/AEMR reported a small rock fall (approximately 1.5 m long, 0.5 m wide and approximately 0.5 cubic metres) at site COH2. No other rock falls at the cliff or overhang sites have been recorded.

The subsidence impact performance measure was not exceeded during the reporting period.

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 during the reporting period is provided in Table 14. In summary, neither the performance indicator nor the performance measure were exceeded during the reporting period.

4.4.2 Longwalls 23-27

The TARP characterisation for Longwalls 23-27 land management during the reporting period is provided in Table 15. In summary, neither the performance indicator nor the performance measure were exceeded during the reporting period.

Table 14
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

Table 15
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 (Metropolitan Coal, 2011c) and Metropolitan Coal Longwalls 23-27 Heritage Management Plan (Metropolitan Coal, 2013c) 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

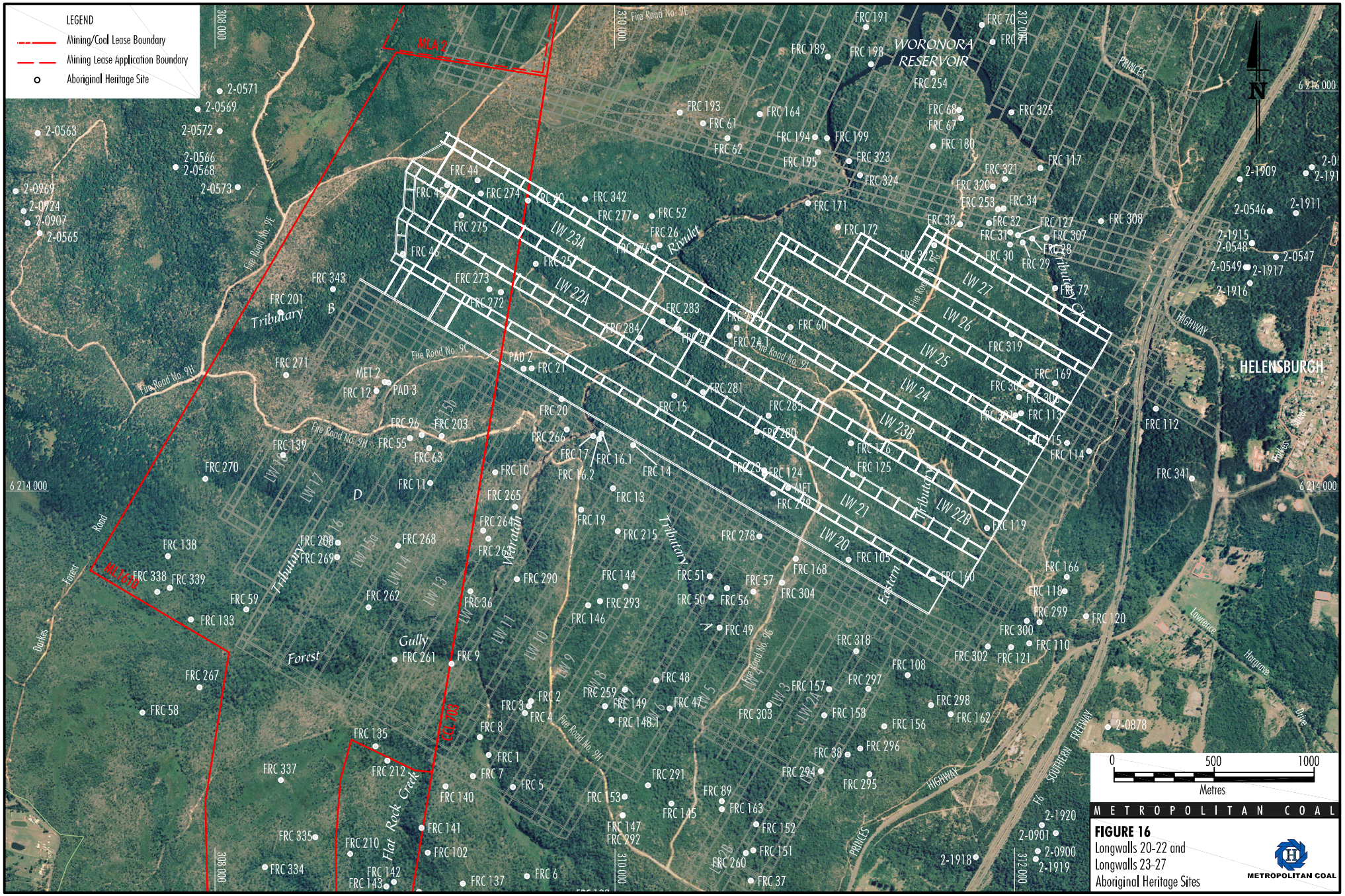
A monitoring program has been implemented to monitor the impacts and consequences of Project related subsidence on Aboriginal heritage sites located within the 35º Angle of Draw of Longwalls 20-22 (Figure 16).

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 first round of monitoring (Round 1) was conducted in January and March 2012 and included all Aboriginal Heritage sites located within the 35° Angle of Draw for Longwall 20.

The second round of monitoring (Round 2) was conducted in July/August 2013 and included all Aboriginal heritage sites located within the 35º Angle of Draw for Longwalls 20 and 21. To date, three sites have been observed to have changes attributable to mine subsidence, namely sites FRC 15, FRC 284 and FRC 281. The results to date have been described in the Metropolitan Coal 2012 Annual Review (Metropolitan Coal, 2011d) and the Metropolitan Coal 2013 Annual Review/AEMR.



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The third round of monitoring (Round 3) will be conducted three to six months after the completion of Longwall 22 (i.e. subsequent to the reporting period) and the results will be provided in the Metropolitan Coal 2014 Annual Review/AEMR.

Subsequent monitoring will be undertaken as part of future Extraction Plans beyond Longwall 22 and will include any sites at which monitoring conducted for Longwalls 20-22 (i.e. Rounds 1-3) indicates continued change due to mining induced subsidence.

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).

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 (i.e. Longwalls 23A and 23B) and any sites at which the Metropolitan Coal Longwalls 20-22 Heritage Management Plan monitoring program indicates change due to mining induced subsidence. Round 1 will be undertaken between three to six months following the completion of Longwall 23B (anticipated to occur in February 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, 2014a).

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).

The Metropolitan Coal 2013 Annual Review/AEMR reported on the results of the Round 2 Aboriginal heritage monitoring. There are 143 sites (142 sites identified in the Project Environmental Assessment and one new site identified during Round 2 monitoring) within the mining area. The Heritage Management Plan – Subsidence Impact Register is used to progressively monitor the cumulative number and percentage of Aboriginal heritage sites affected by subsidence impacts. To date, three sites (sites FRC 15, FRC 284 and FRC 281) have been identified as being impacted by the effects of mining induced subsidence. This means 2% of the total Aboriginal heritage sites within the mining area have been affected to date.

The Round 3 Aboriginal heritage monitoring survey will be conducted in the next reporting period and reported in the Metropolitan Coal 2014 Annual Review/AEMR.

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 between three to six months following the completion of Longwall 23B (anticipated to occur in February 2015).

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 during the reporting period is provided in Table 16. In summary, the performance measure was not exceeded during the reporting period.

Table 16
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 during the reporting period is provided in Table 17. The performance measure will be assessed following the completion of the Longwalls 23-27 Round 1 Aboriginal heritage surveys.

Table 17
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 (Metropolitan Coal, 2013d) and Metropolitan Coal Longwalls 23-27 Built Features Management Plan (Metropolitan Coal, 2013e) 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. Each plan was developed in consultation with the relevant asset owner.

6.2 MONITORING

6.2.1 Longwalls 20-22

Site inspections were conducted prior to the commencement of secondary extraction of Longwall 20 to establish the condition of the infrastructure items.

A monitoring program has been implemented to monitor subsidence impacts on the following infrastructure at the various frequencies described in the Metropolitan Coal Longwalls 20-22 Built Features Management Plan:

- Endeavour Energy infrastructure;
- Nextgen infrastructure;
- TransGrid infrastructure;
- Optus infrastructure;
- Telstra infrastructure;
- Roads and Maritime Services 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. No subsidence movements above 20 mm were recorded at any of the built features over the reporting period.

Longwall 22 advanced to within 1,000 m of Bridge 1 in January 2014. Cardno Pty Ltd assessed the monitored bridge movements monthly until the completion of Longwall 22 in late April 2014. The assessments concluded that there were no differential movements of any concern.

Monitoring of built features was also conducted within three months of Longwall 22 completion. No impact to any built feature was evident over the reporting period.

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.

A monitoring program was 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;
- Roads and Maritime Services 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. No subsidence movements above 20 mm were recorded at any of the built features over the reporting period.

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

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 22 advanced to within 1,000 m of Bridge 1 in January 2014. Cardno Pty Ltd assessed the monitored bridge movements monthly until the completion of Longwall 22 in late April 2014. The assessments concluded that there were no differential movements of any concern.

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 3 km from Longwalls 20-22 and at this distance no measurable systematic or non-systematic subsidence movements were indicated.

6.3.2 Longwalls 23-27

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. 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 TARP CHARACTERISATION

Sections 6.4.1 and 6.4.2 provide the TARP characterisation for the reporting period for Longwalls 20-22 and Longwalls 23-27, respectively.

6.4.1 Longwalls 20-22

The TARP characterisation for Longwalls 20-22 built features management during the reporting period is provided in Table 18. In summary, no performance measures were exceeded during the reporting period.

Table 18
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 Mine Subsidence Board (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

6.4.2 Longwalls 23-27

The TARP characterisation for Longwalls 23-27 built features management during the reporting period is provided in Table 19. In summary, no performance measures were exceeded during the reporting period.

Table 19
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 (Metropolitan Coal, 2010b) and Metropolitan Coal Longwalls 23-27 Public Safety Management Plan (Metropolitan Coal, 2013f) 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 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 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.

Further, no safety incidents were reported by visitors, personnel or contractors to Metropolitan Coal in the underground mining area during the reporting period.

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 are the same as those described in Section 7.2.1.

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

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 performance indicator and the built features subsidence impact performance measure.

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 during the reporting period is provided in Table 20. In summary, neither the performance indicator nor the performance measure were exceeded during the reporting period.

Table 20
TARP Characterisation – Longwalls 20-22 Public Safety

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 during the reporting period is provided in Table 21. In summary, neither the performance indicator nor the performance measure were exceeded during the reporting period.

Table 21
TARP Characterisation – Longwalls 23-27 Public Safety

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 (Metropolitan Coal, 2014e) 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

Stream remediation activities have previously been conducted at Pools A and F on the Waratah Rivulet in accordance with approvals obtained from the SCA under Part 5 of the EP&A Act. Stream remediation activities at these pools have included the drilling of holes and the injection of grout (polyurethane resin) into sub-surface fractures. Associated activities have included the mobilisation, placement and operation of equipment and the implementation of a variety of environmental management measures.

No stream remediation activities were conducted on the Waratah Rivulet during the reporting period.

During the reporting period Metropolitan Coal revised the Metropolitan Coal Rehabilitation Management Plan (Version E) to include an improved stream remediation methodology. The revised Metropolitan Coal Rehabilitation Management Plan was approved by the Division of Resources and Energy in May 2014.

Metropolitan Coal will recommence stream remediation activities in the next reporting period at Pool F. Thereafter, stream remediation activities will be conducted at Flat Rock Crossing and Pool N.

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, Metropolitan Coal Longwalls 20-22 Water Management Plan and Metropolitan Coal Longwalls 23-27 Water Management Plan.

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 5). Water level monitoring of Pools A, B, C, E, F, G, G1, H and I are shown on Charts B-1 to B-15 in Appendix B. A description of water levels in each pool compared to its cease to flow level is provided below.

Pool A stopped overflowing its downstream rock bar between 7 December 2012 and 25 January 2013. Pool B also 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 (Charts B-1 and B-2 in Appendix B).

Water levels in Pool C fell below the cease to flow level between the 22 November 2012 and the 25 January 2013, again between the 7 and 8 November 2013 and on the 4 February 2014 (Chart B-3 in Appendix B). 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 B-4 in Appendix B).

Water levels in Pool F fell below the cease to flow level between the 2 January and 25 January 2013, but have not fallen below the level since, including during the reporting period (Chart B-5 in Appendix B).

Water levels in Pool G have periodically fallen below the cease to flow level between the 12 December 2013 and 21 March 2014 and again between the 26 May 2014 and the end of the reporting period (Chart B-6 in Appendix B).

Water levels in Pool G1 fell below the cease to flow level between the 10 and 25 January 2013. The water levels have not fallen below the cease to flow level since, including during the reporting period (Chart B-7 in Appendix B).

Water levels records in Pool H and Pool I indicate that these pools have not fallen below their cease to flow levels (Charts B-8 and B-9 in Appendix B).

In summary, all pools except Pool C (on the 4 February 2014) and Pool G remained above their cease to flow levels during the reporting period. 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 Longwalls 20-22 Water Management Plan and Metropolitan Coal Rehabilitation Management Plan. Pools H and I have not fallen below their cease to flow levels over the period of available water level data.

As described in Section 8.2.2, 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.

Automatic pool water level monitoring is also conducted for Pools A and F and for pools further downstream of Flat Rock Crossing (Pools H, I, 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 B10 to B25 in Appendix B. Where available[24], the surveyed cease-to-overflow levels of the pools are also shown on Charts B10 to B25 in Appendix B.

Recorded water levels in Pools A, K, L, M, N, P, Q, R, S and V (Charts B10 to B25 in Appendix B) 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. As indicated in the Metropolitan Coal 2013 Annual Review/AEMR, Pool N has previously fallen below its cease to flow level in September 2012 (during the period of missing water data).

The recorded water levels in Pool J (Chart B-12 in Appendix B) appear to have fallen below the pool cease to flow level over most of the reporting period. The shape of the water level hydrograph however suggests the pool water levels are behaving naturally and based on observation by Metropolitan Coal personnel that this pool was always overflowing during the reporting period, it is therefore concluded that either the sensor datum is incorrect or the surveyed cease to flow level is incorrect.

[24] Surveyed cease-to-flow levels are available for Pools A, J, K, L, M, N, P, Q, R, S and V.

Pools F, O, T, U and W do not have established surveyed cease to flow levels, however the shape of the recorded pool water level hydrographs in all pools suggest these pools did not cease flowing and that these pools exhibited natural behaviour during the reporting period. Recorded water levels in Pool O fell to relatively low levels on two occasions in February 2014 consistent with other falls in the December 2012 to January 2013 period (Chart B-17 in Appendix B). These types of water level responses have been observed in control pools on Woronora River and are consistent with water level responses in pools with open boulder-field controls and pools with naturally highly fractured (permeable) rock-bars. The lowest recorded water level in Pool O was higher than the historical minimum and is consistent with what is considered natural drainage behaviour for this pool.

Monitoring of Eastern Tributary Pools

On the Eastern Tributary, surface flow and pool holding capacity is required to be restored 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 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 Six Monthly and Annual Review/AEMR 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 Six Monthly and Annual Review/AEMR 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.

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 Six Monthly and Annual Review/AEMR reports.

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Metropolitan Coal (2011c) *Metropolitan Coal Longwalls 20-22 Heritage Management Plan*.

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Metropolitan Coal (2013b) *Metropolitan Coal Longwalls 23-27 Land Management Plan*.

Metropolitan Coal (2013c) *Metropolitan Coal Longwalls 20-22 Heritage Management Plan*.

Metropolitan Coal (2013d) *Metropolitan Coal Longwalls 20-22 Built Features Management Plan*.

Metropolitan Coal (2013e) *Metropolitan Coal Longwalls 23-27 Built Features Management Plan*.

Metropolitan Coal (2013f) *Metropolitan Coal Longwalls 23-27 Public Safety Management Plan*.

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Metropolitan Coal (2014c) *Metropolitan Coal Longwalls 20-22 Biodiversity Management Plan.*

Metropolitan Coal (2014d) *Metropolitan Coal Longwalls 23-27 Biodiversity Management Plan.*

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APPENDIX A

SURFACE WATER QUALITY MONITORING RESULTS FOR SELECT SITES

pH, ELECTRICAL CONDUCTIVITY, DISSOLVED IRON, DISSOLVED MANGANESE AND DISSOLVED ALUMINIUM

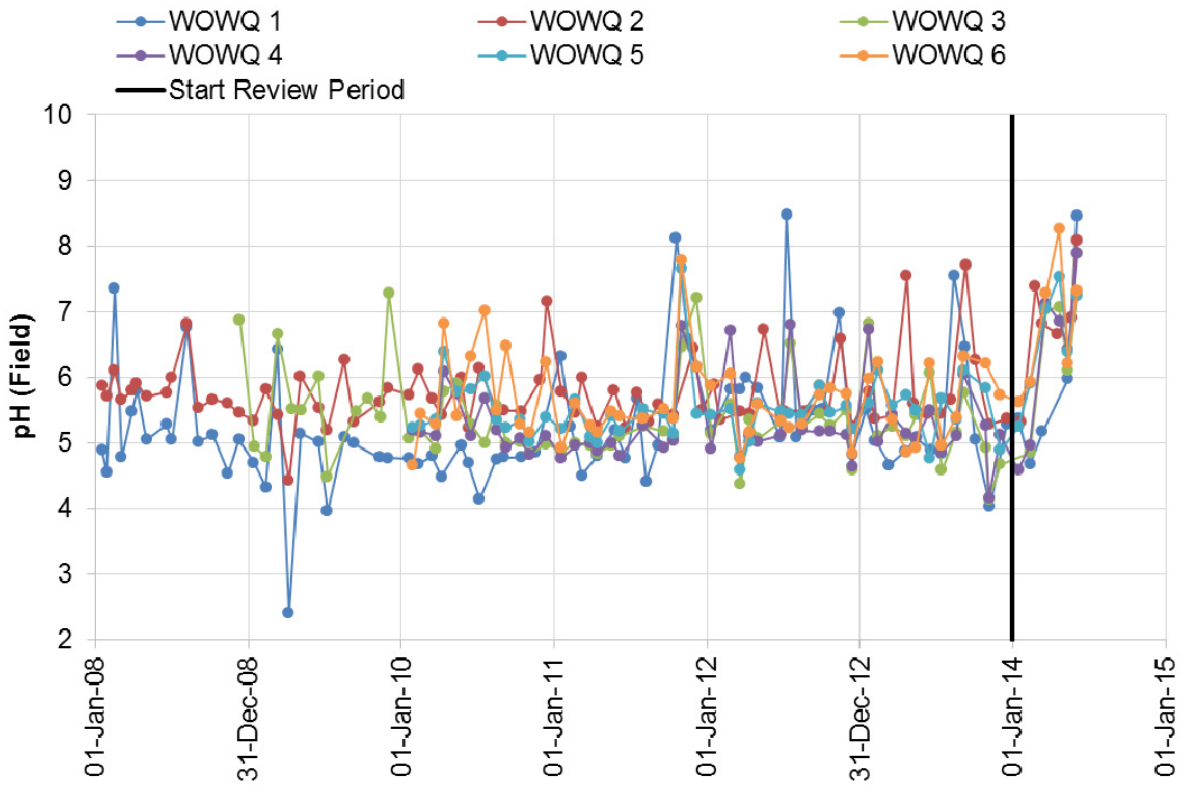


Chart A-1 pH levels in Woronora River

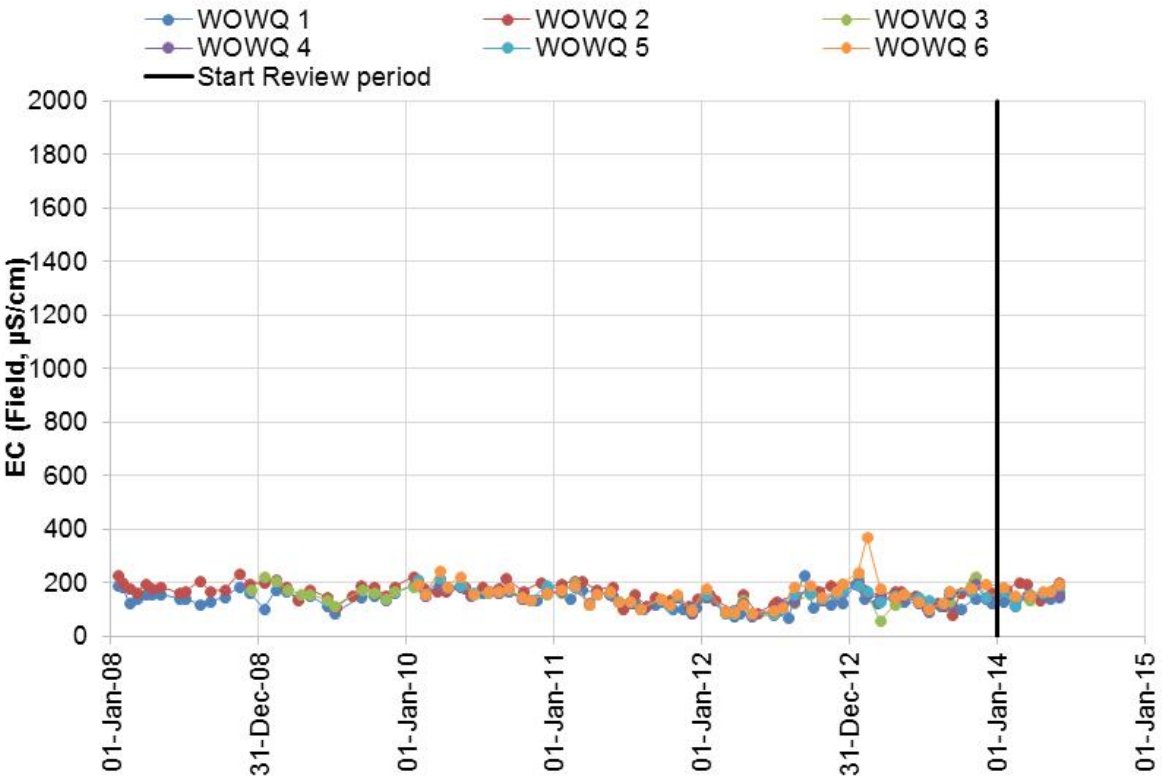


Chart A-2 Electrical Conductivity in Woronora River

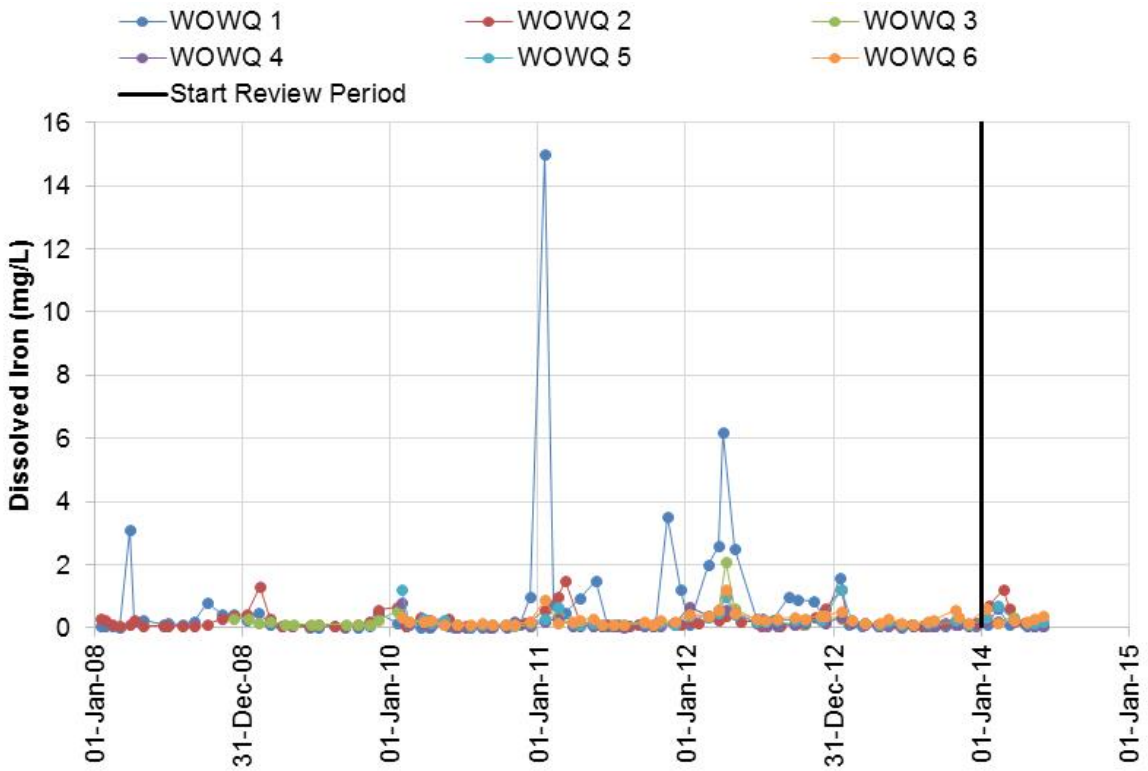


Chart A-3 Dissolved Iron Levels in Woronora River

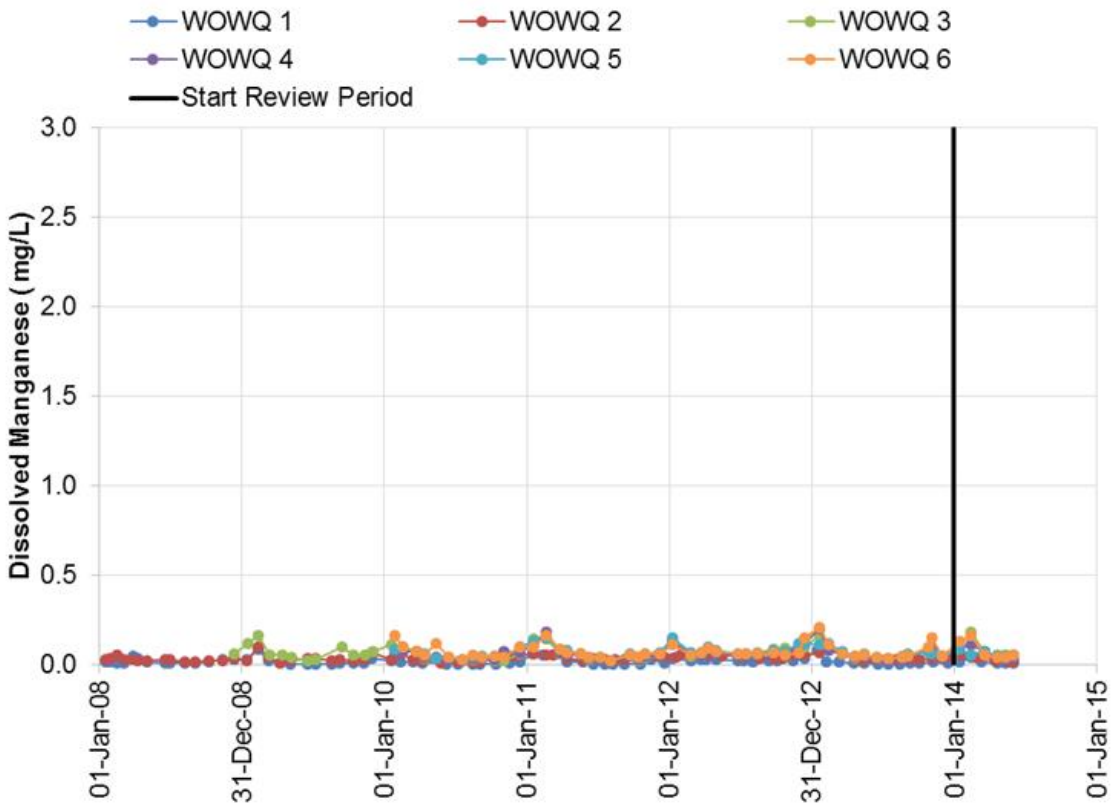


Chart A-4 Dissolved Manganese Levels in Woronora River

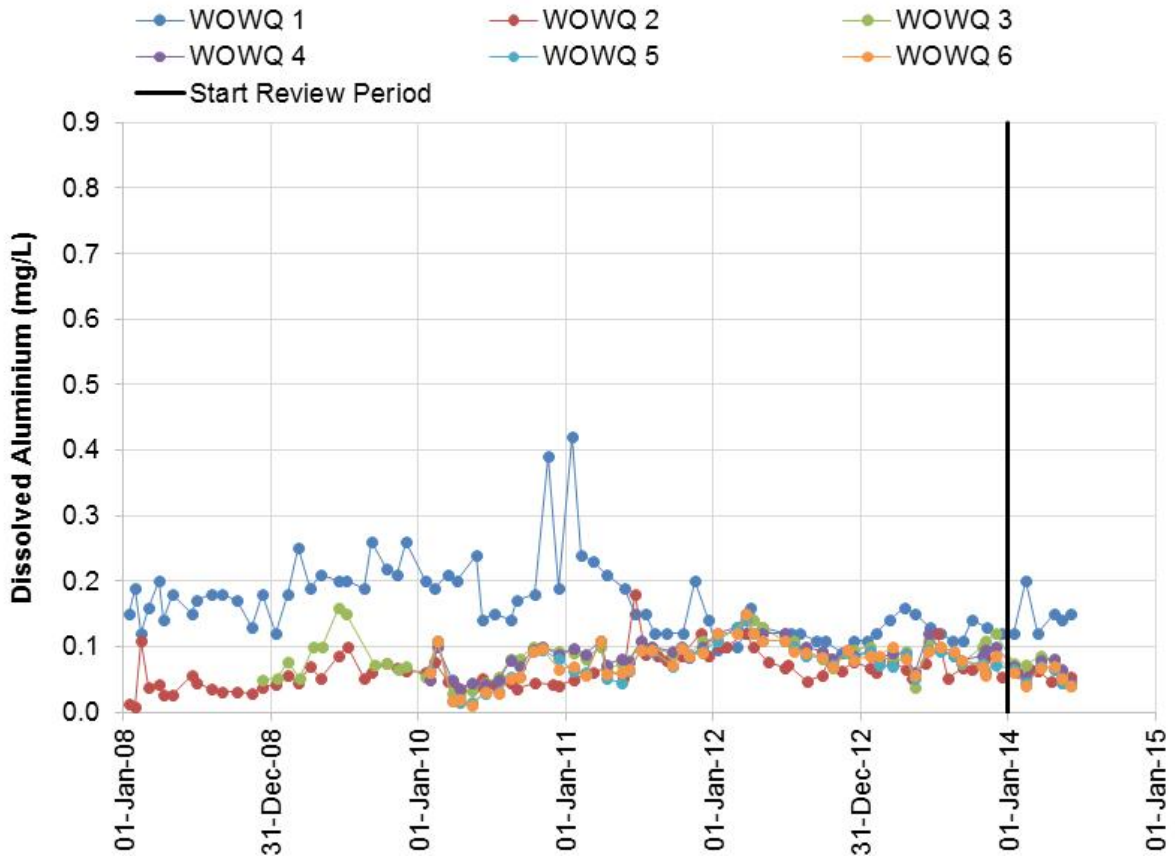


Chart A-5 Dissolved Aluminium Levels in Woronora River

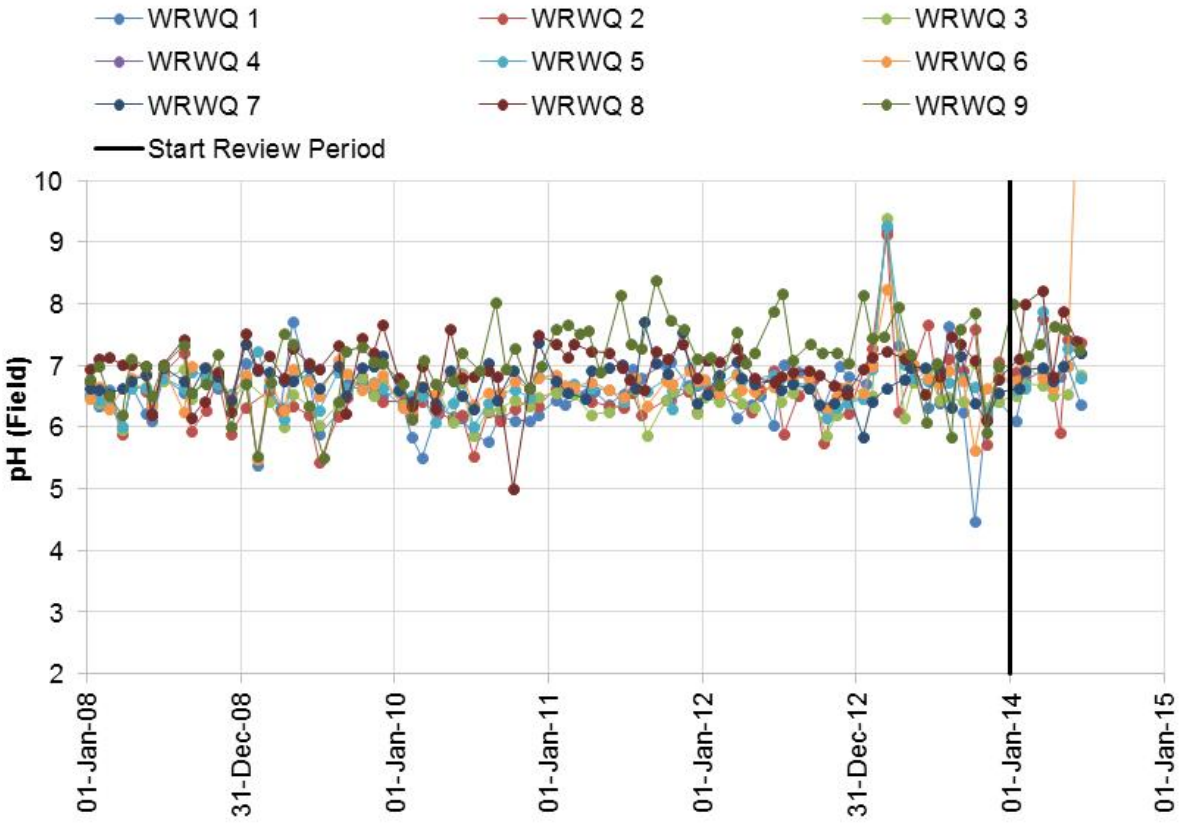


Chart A-6a pH levels in Waratah Rivulet

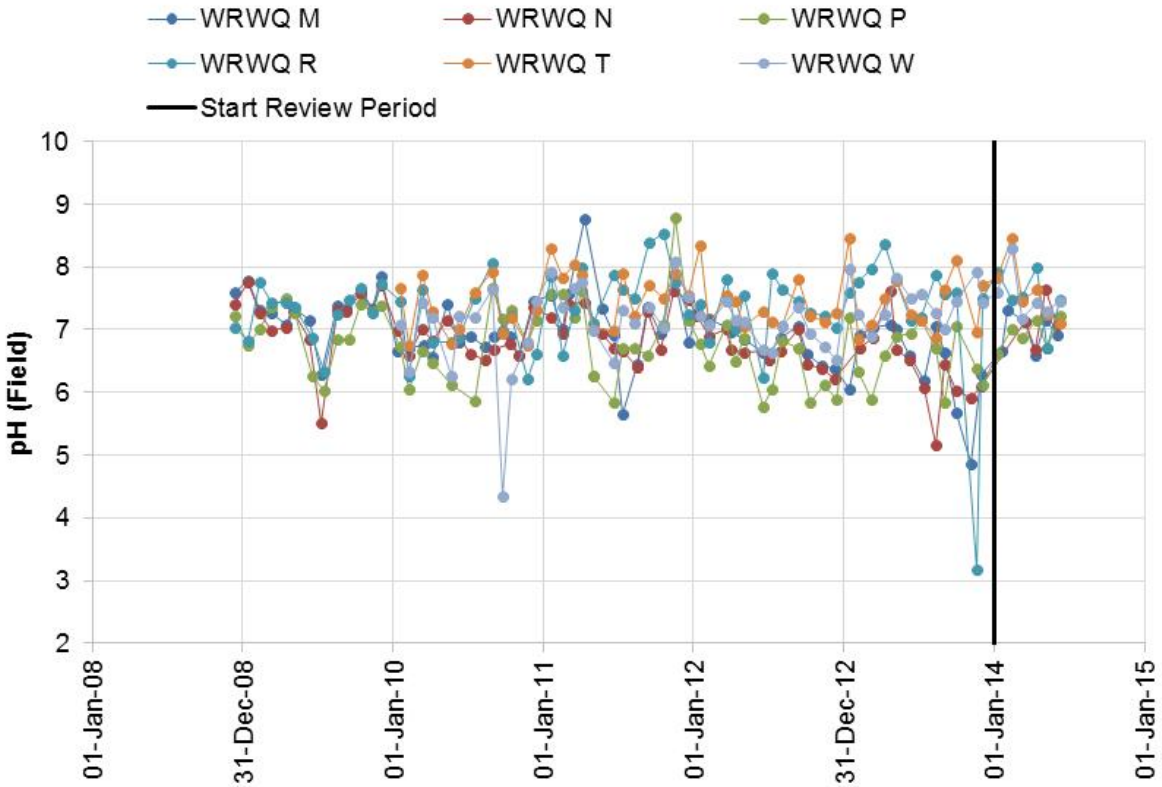


Chart A-6b pH levels in Waratah Rivulet Pools

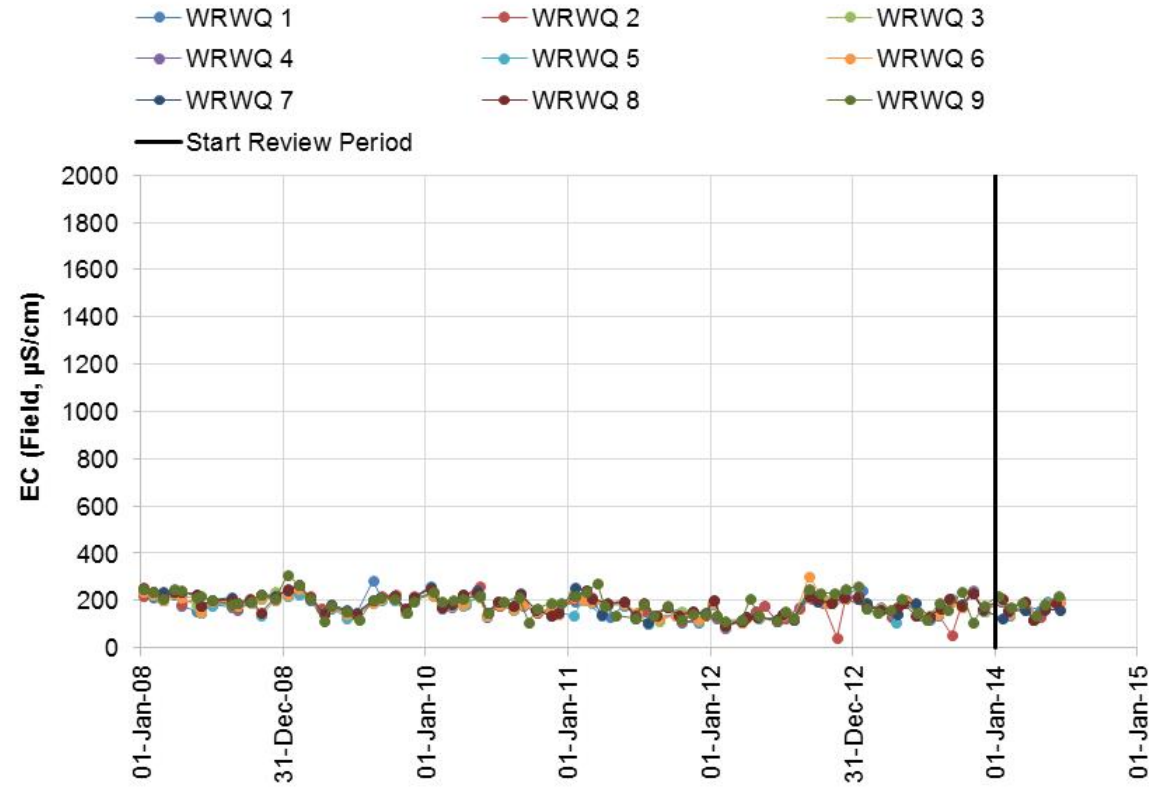


Chart A-7a Electrical Conductivity in Waratah Rivulet

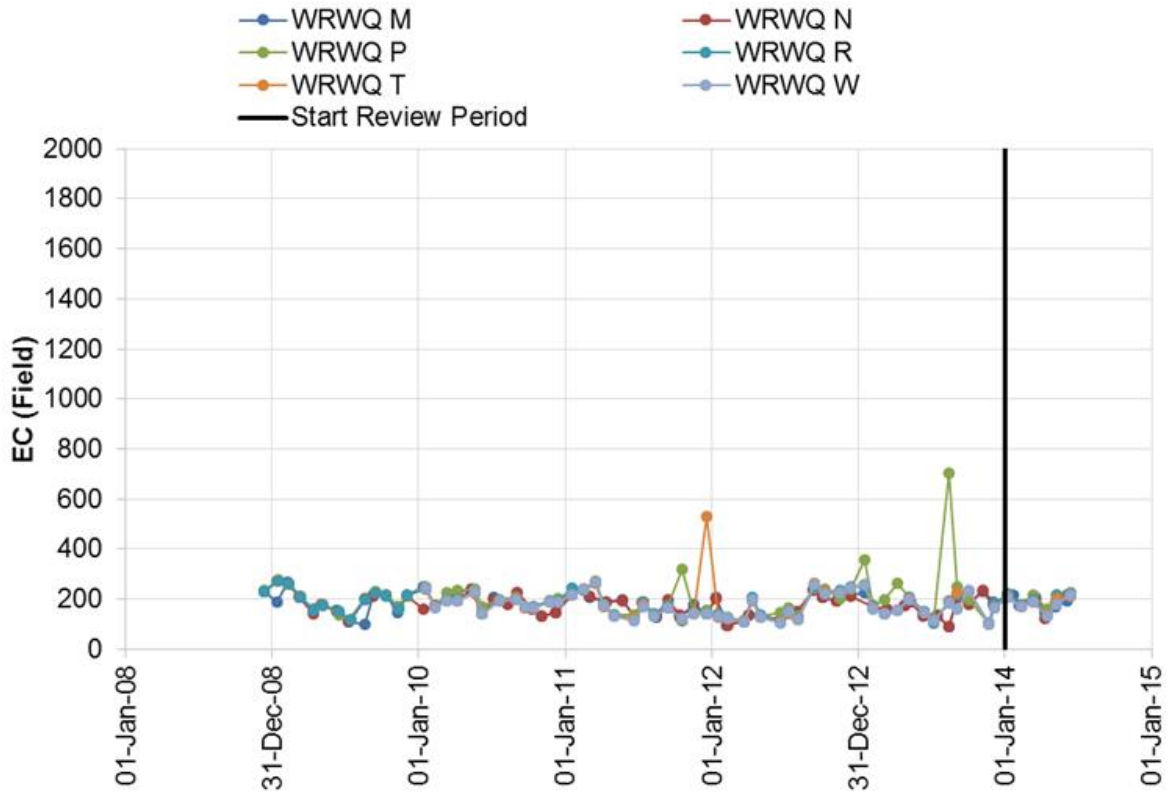


Chart A-7b Electrical Conductivity in Waratah Rivulet Pools

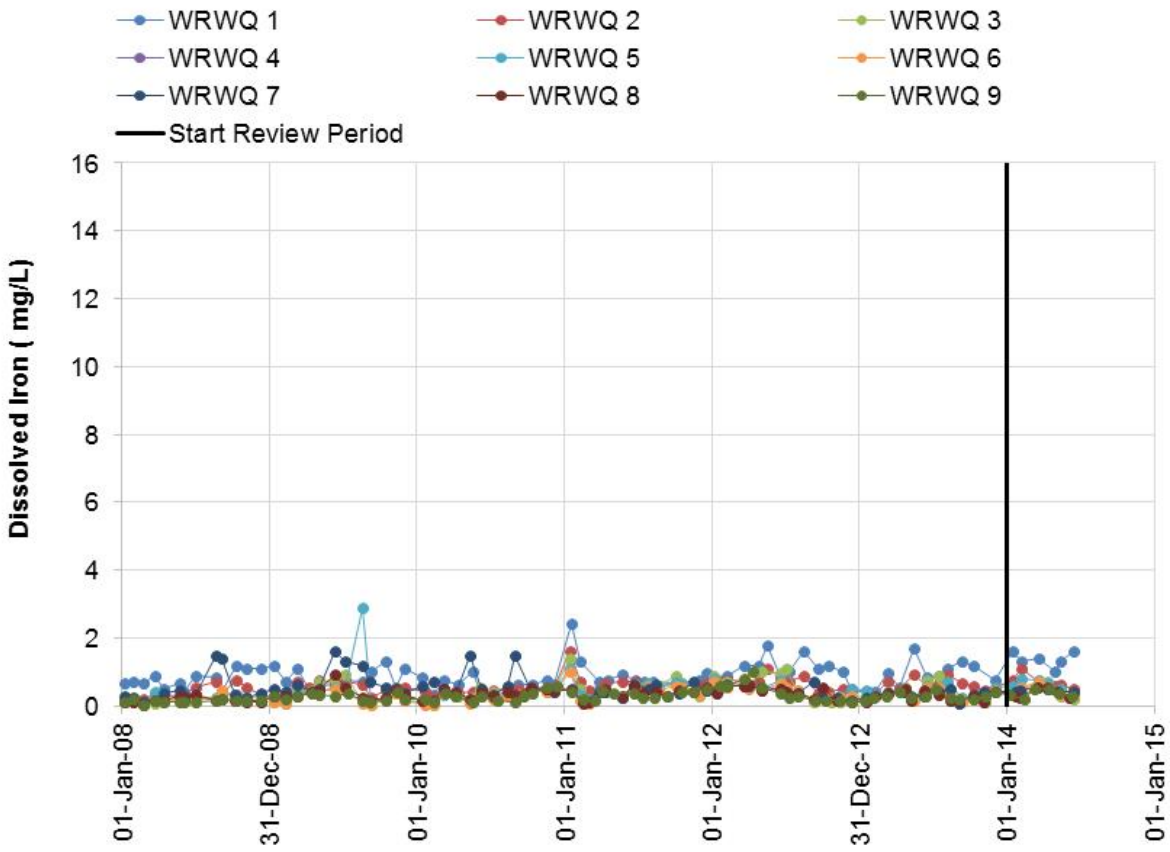


Chart A-8a Dissolved Iron Levels in Waratah Rivulet

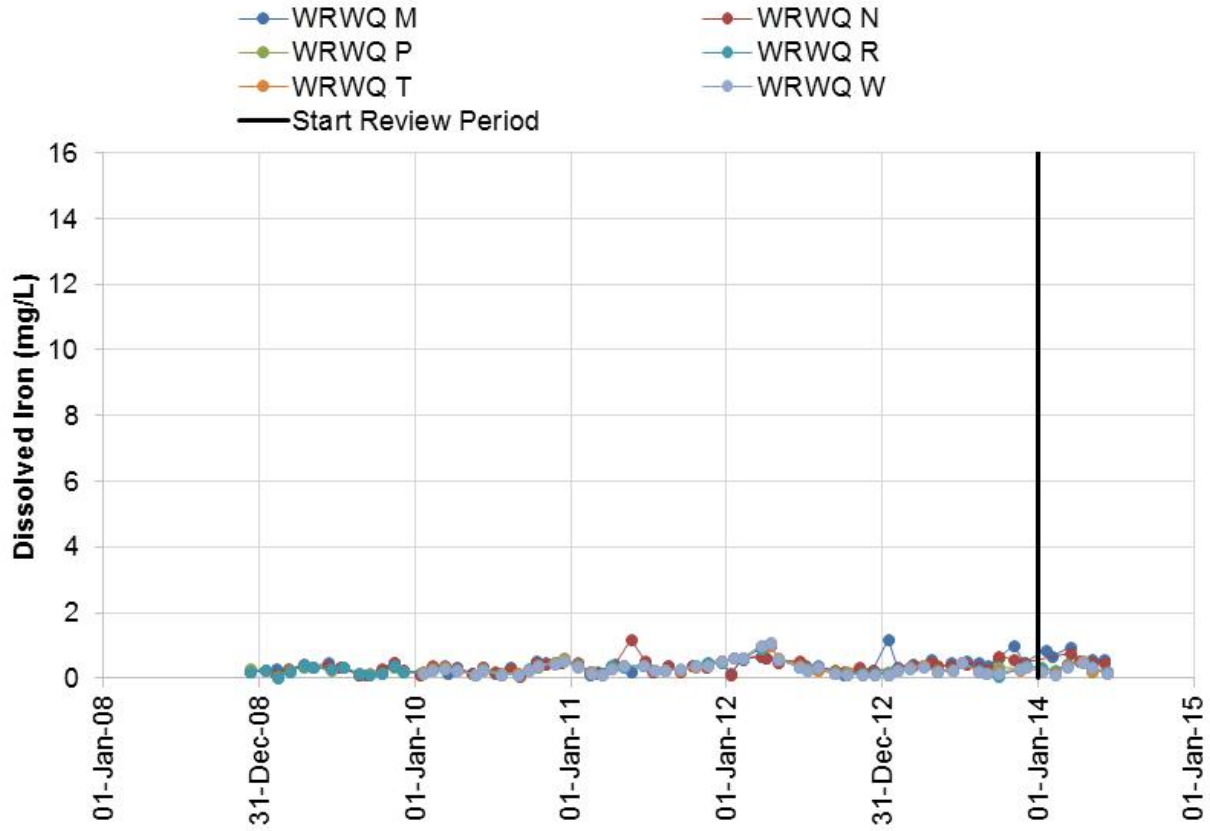


Chart A-8b Dissolved Iron Levels in Waratah Rivulet Pools

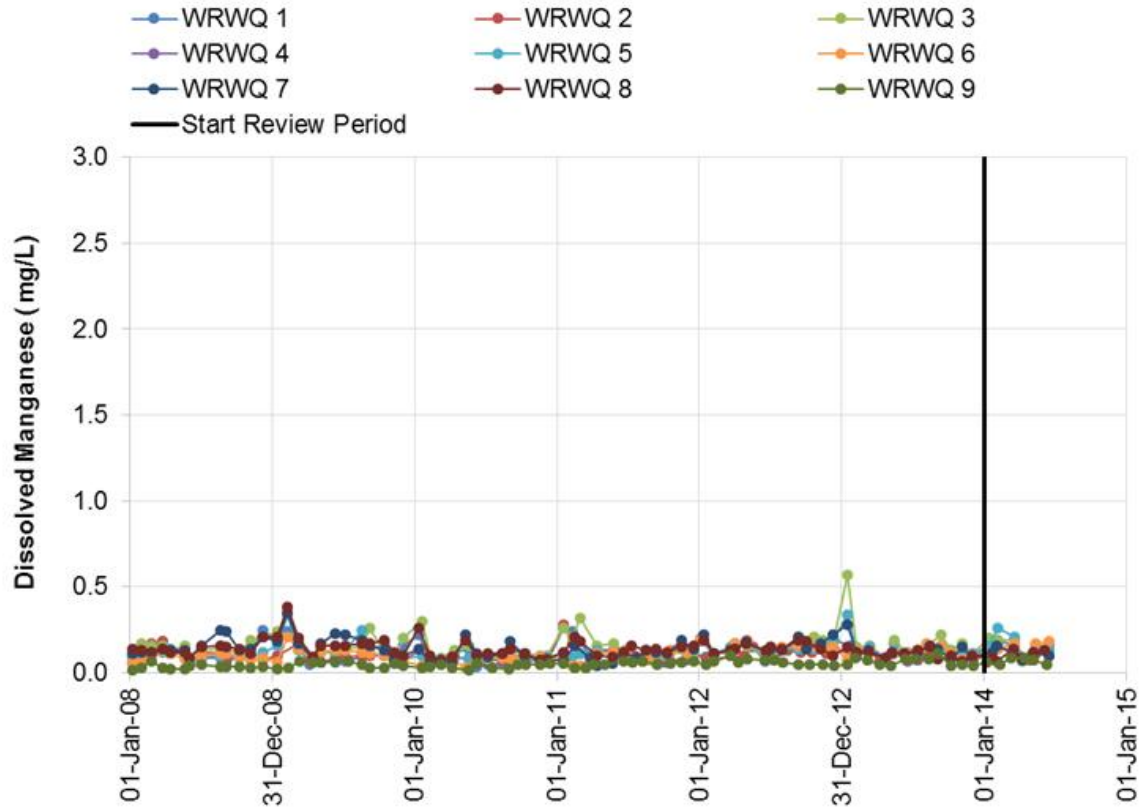


Chart A-9a Dissolved Manganese Levels in Waratah Rivulet

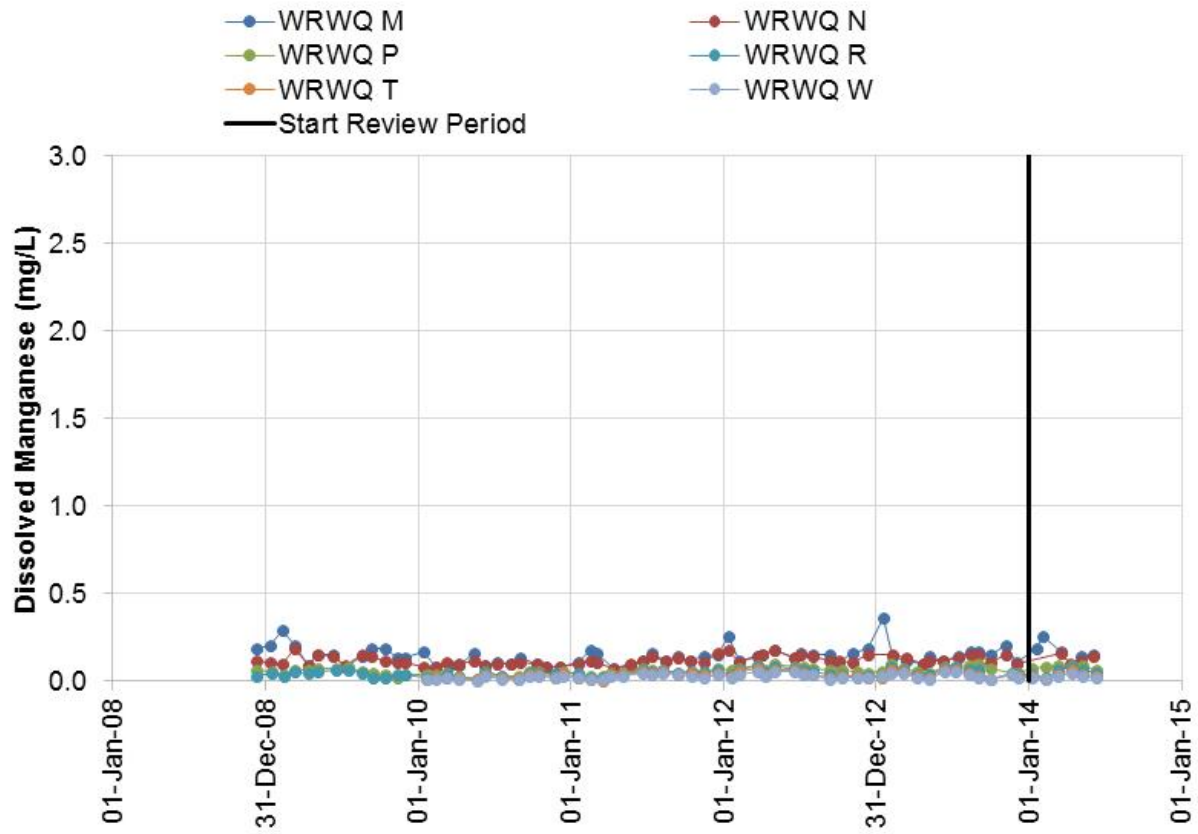


Chart A-9b Dissolved Manganese Levels in Waratah Rivulet Pools

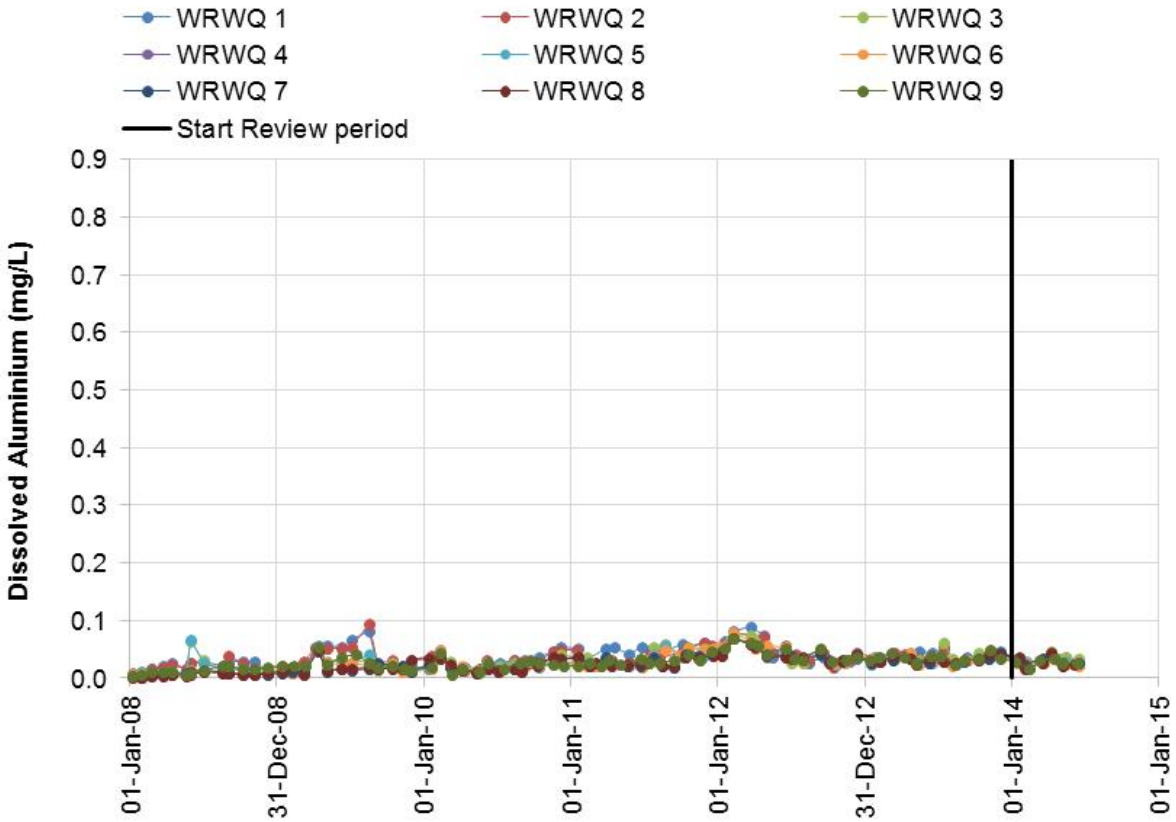


Chart A-10a Dissolved Aluminium Levels in Waratah Rivulet

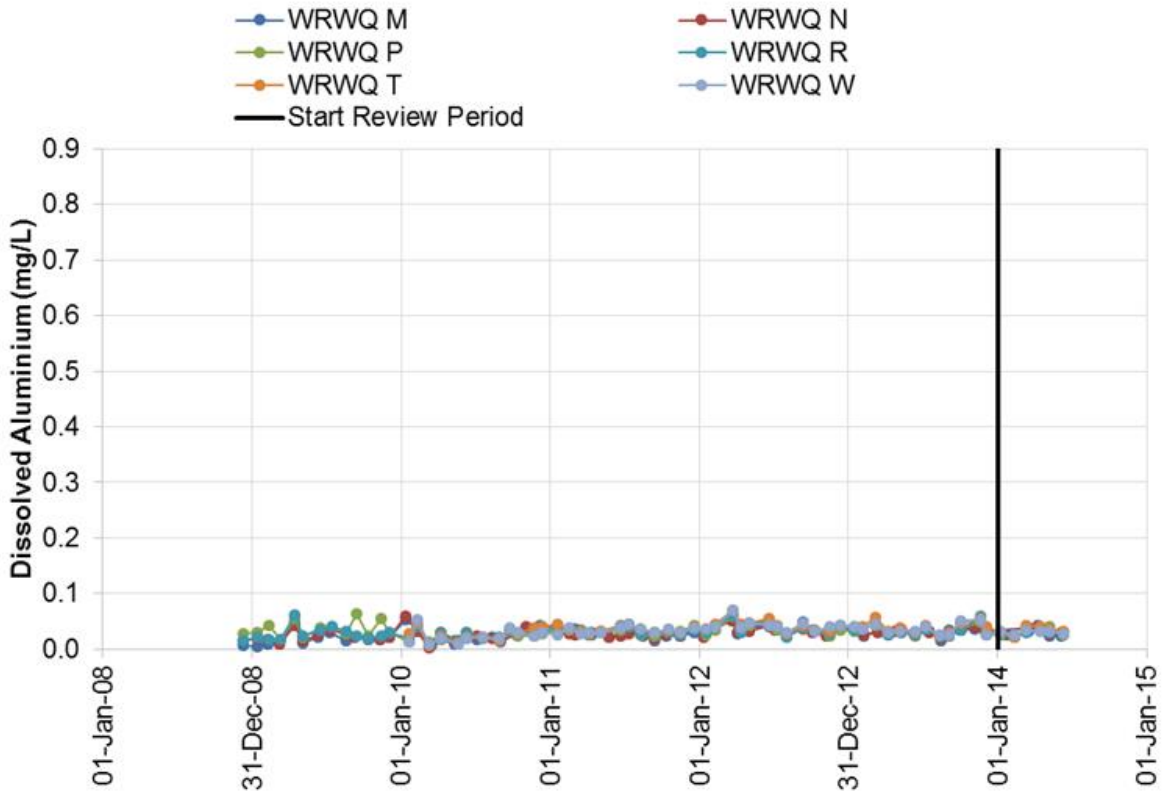


Chart A-10b **Dissolved Aluminium Levels in Waratah Rivulet Pools**

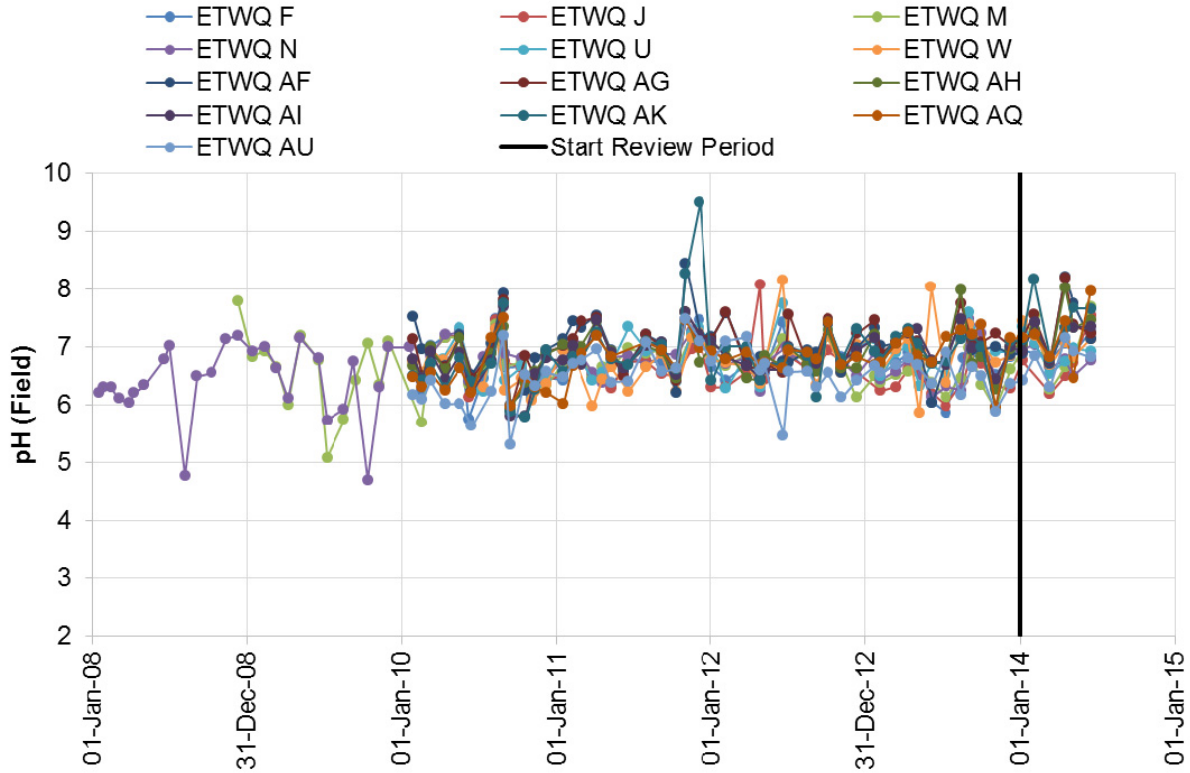


Chart A-11 **pH levels in Eastern Tributary**

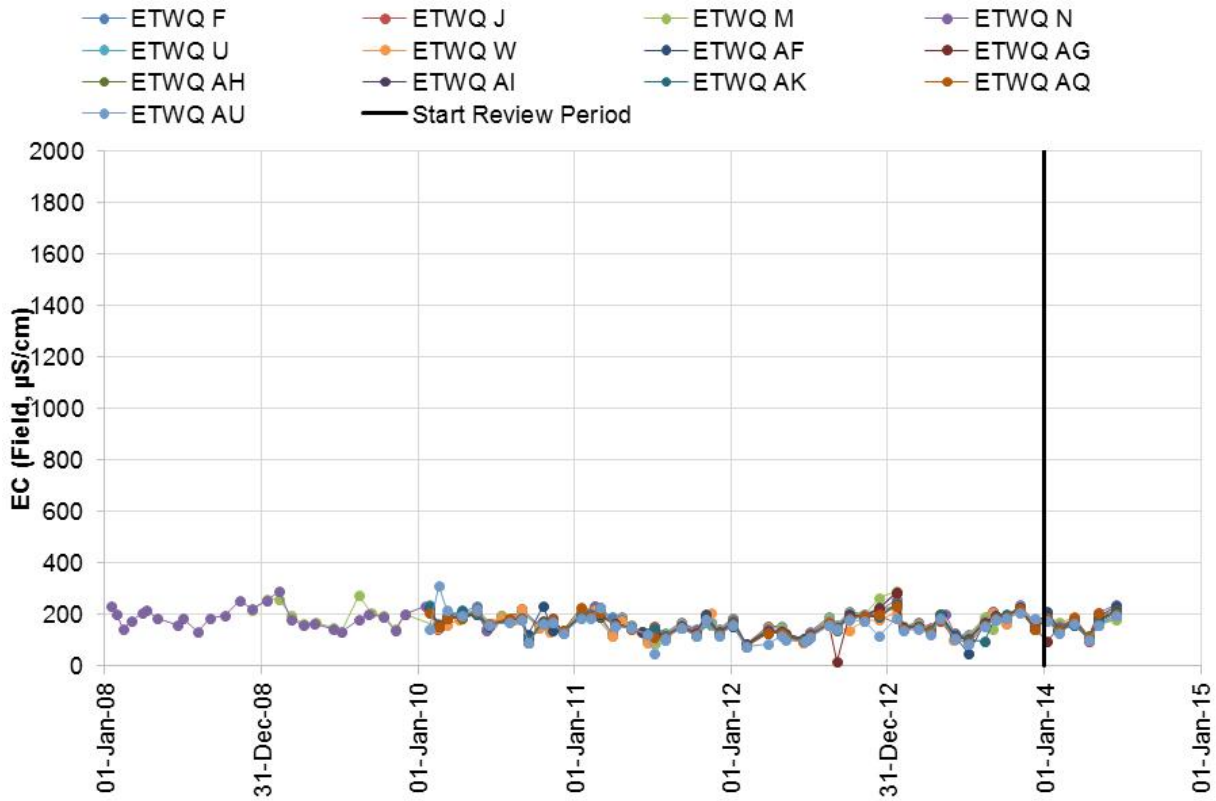


Chart A-12 Electrical Conductivity in Eastern Tributary

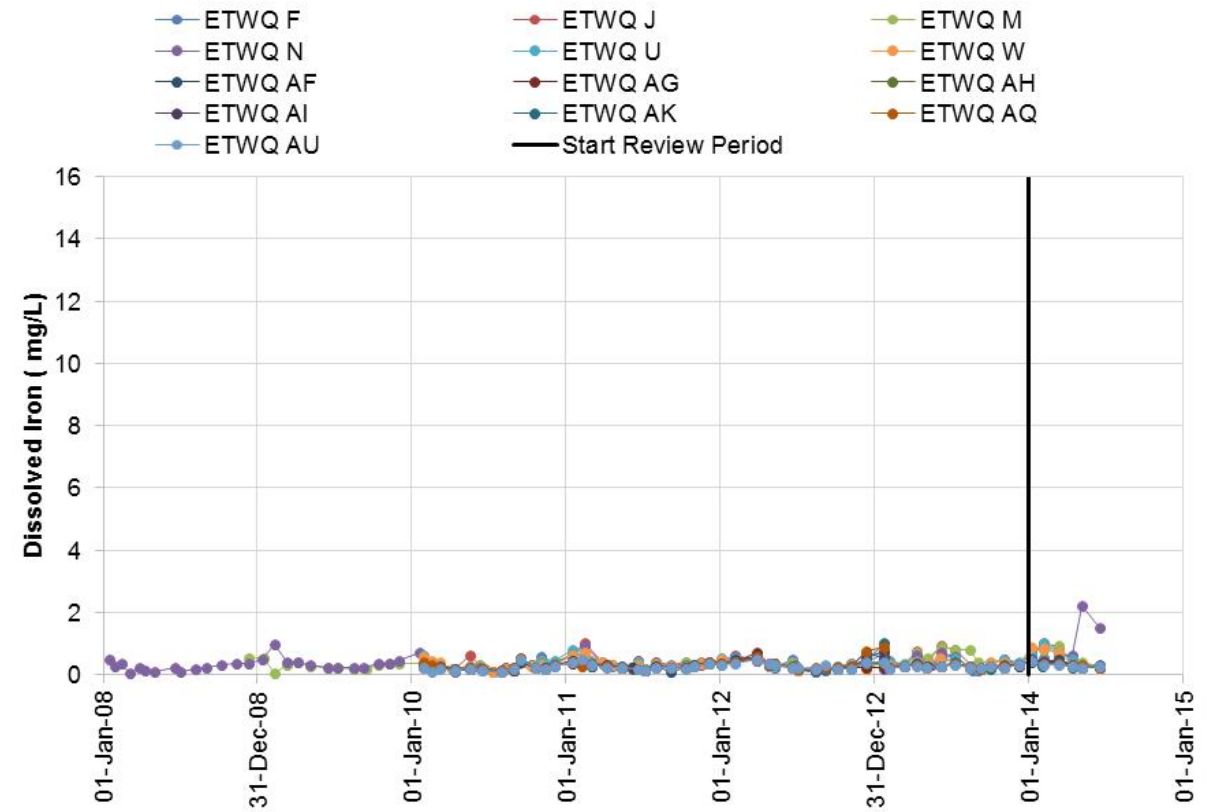


Chart A-13 Dissolved Iron Levels in Eastern Tributary

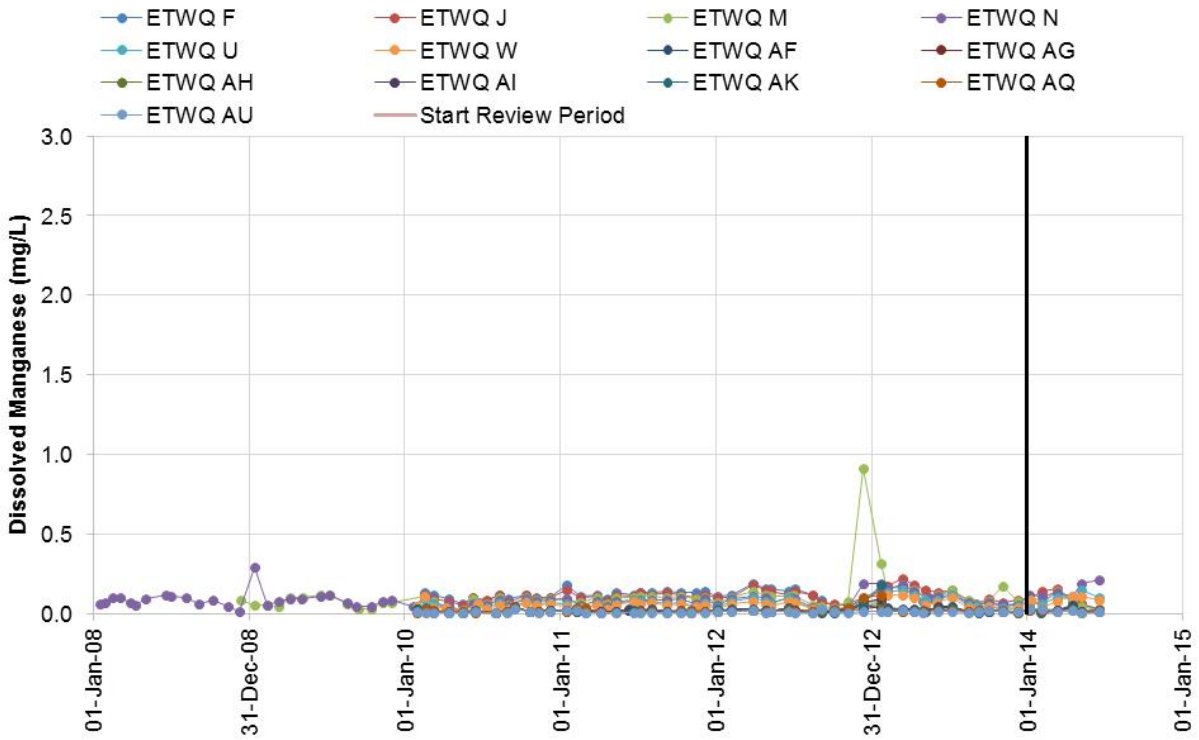


Chart A-14 Dissolved Manganese Levels in Eastern Tributary

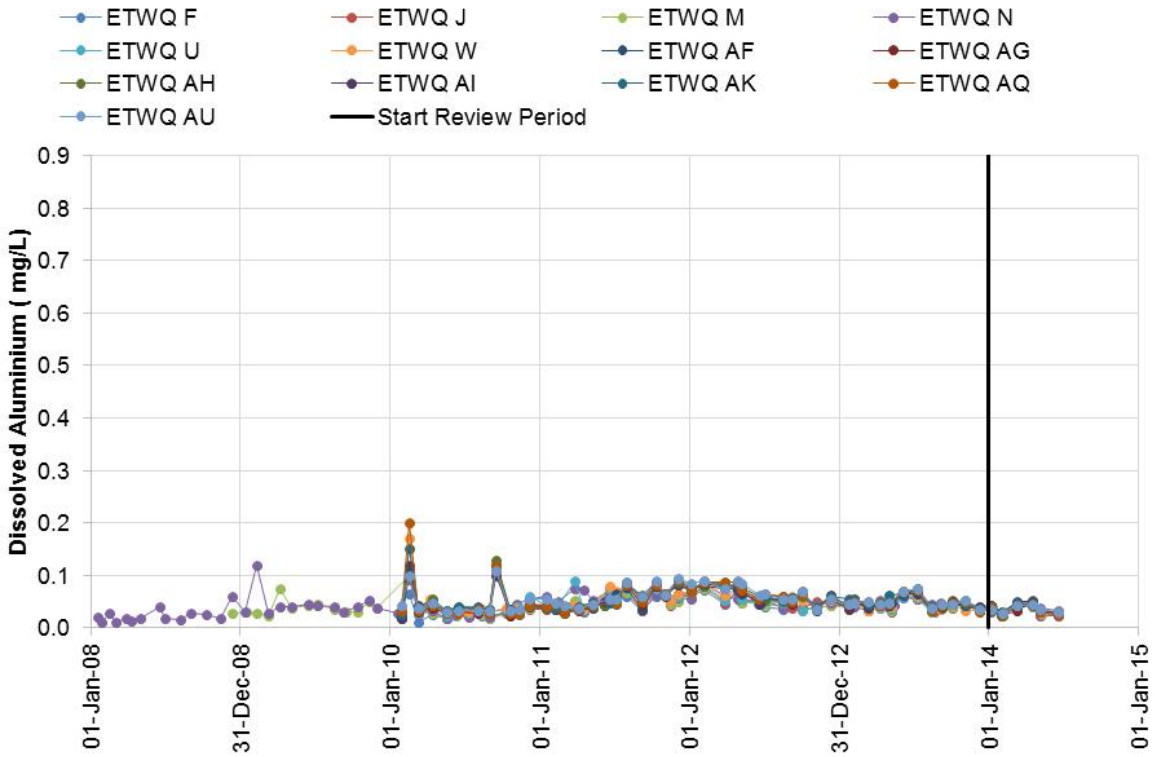


Chart A-15 Dissolved Aluminium Levels in Eastern Tributary

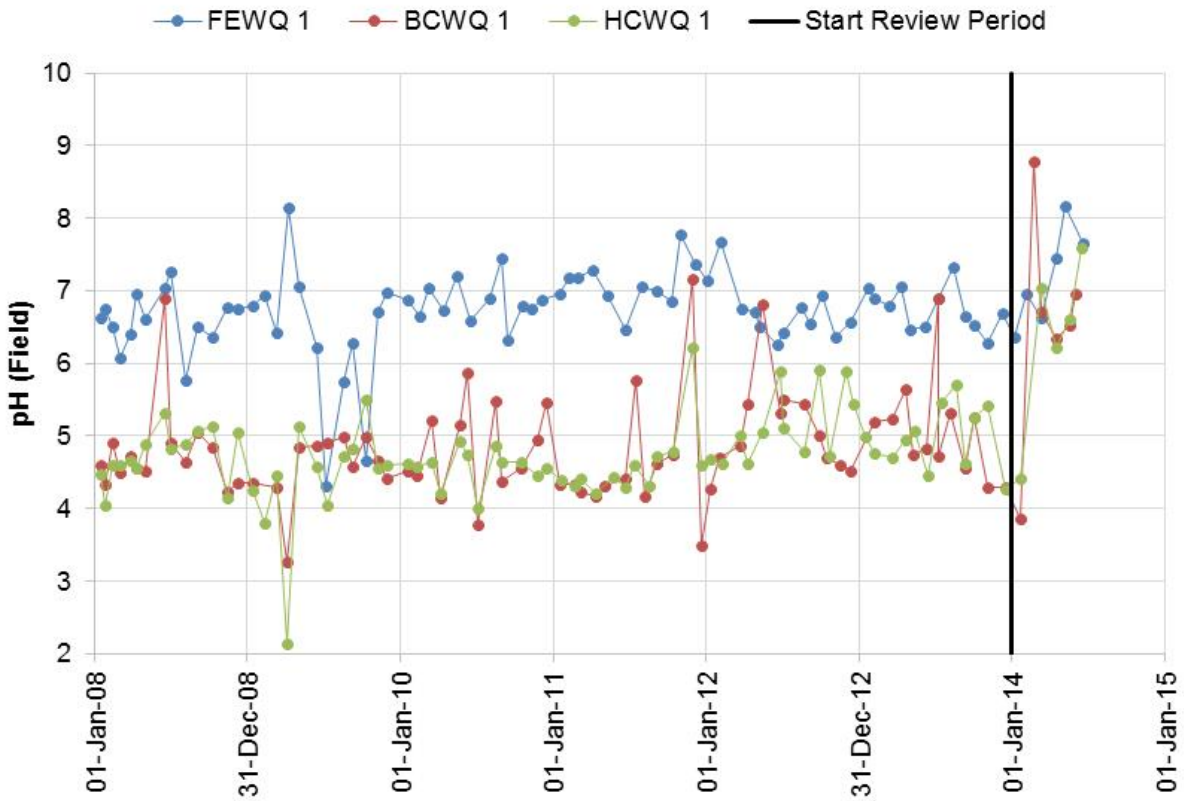


Chart A-16 pH levels in Far Eastern Tributary, Honeysuckle Creek and Bee Creek

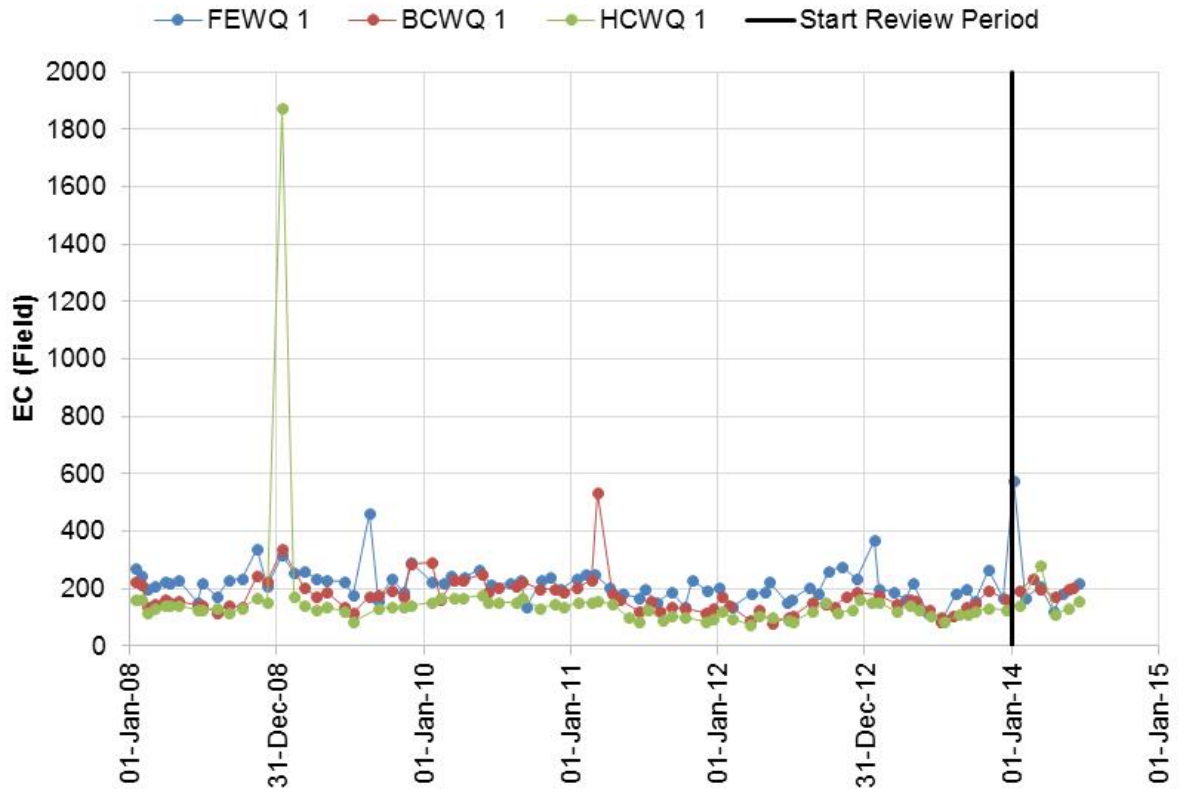


Chart A-17 Electrical Conductivity in Far Eastern Tributary, Honeysuckle Creek and Bee Creek

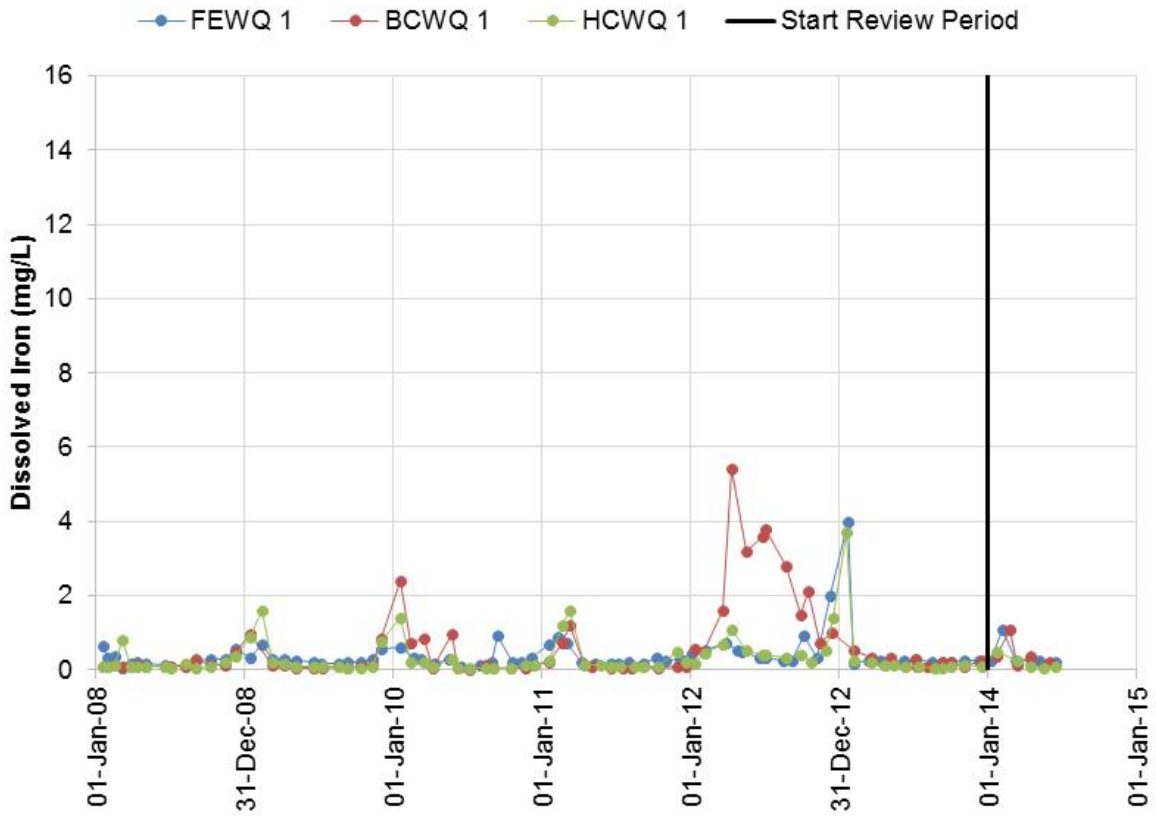


Chart A-18 Dissolved Iron Levels in Far Eastern Tributary, Honeysuckle Creek and Bee Creek

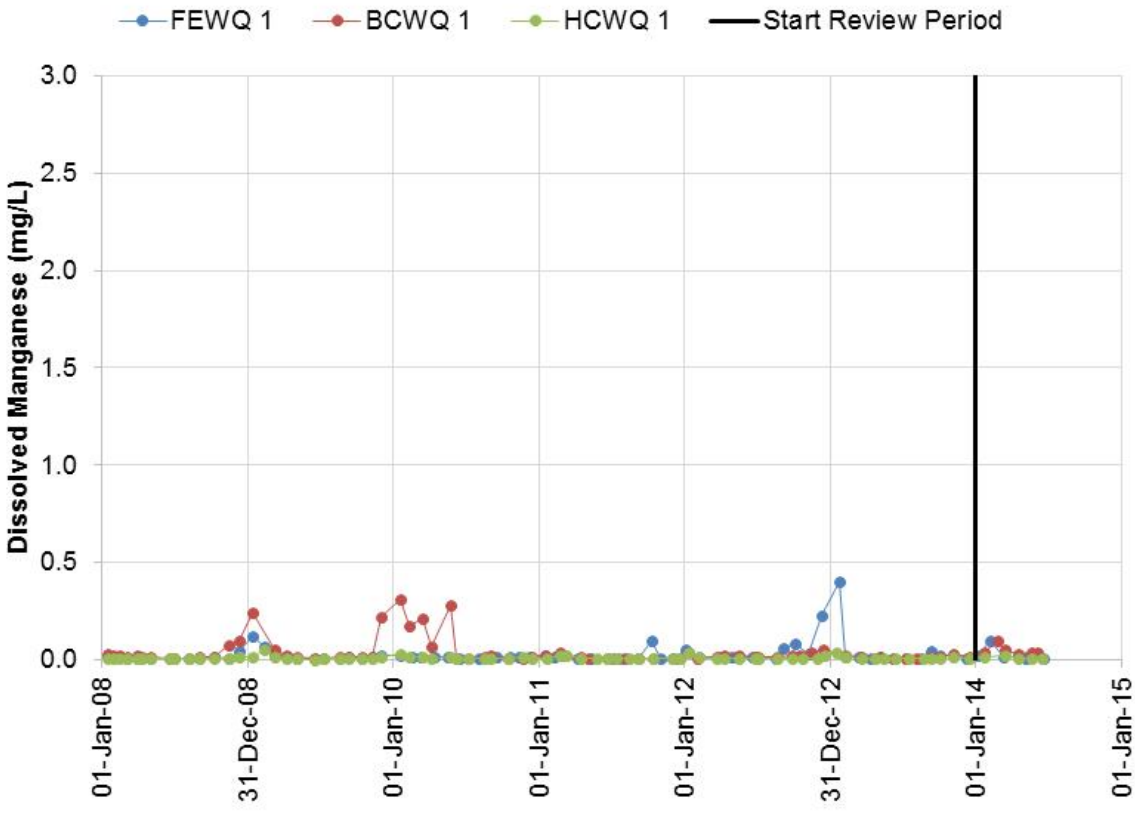


Chart A-19 Dissolved Manganese Levels in Far Eastern Tributary, Honeysuckle Creek and Bee Creek

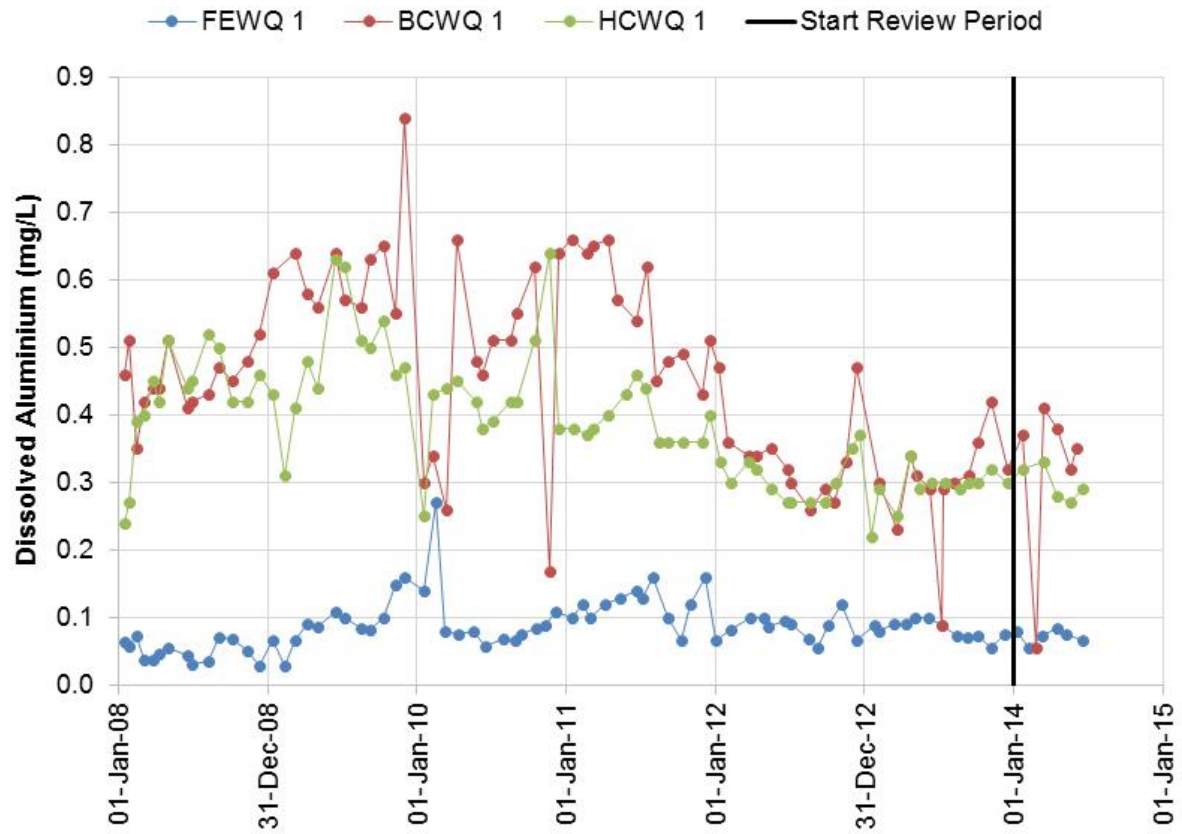
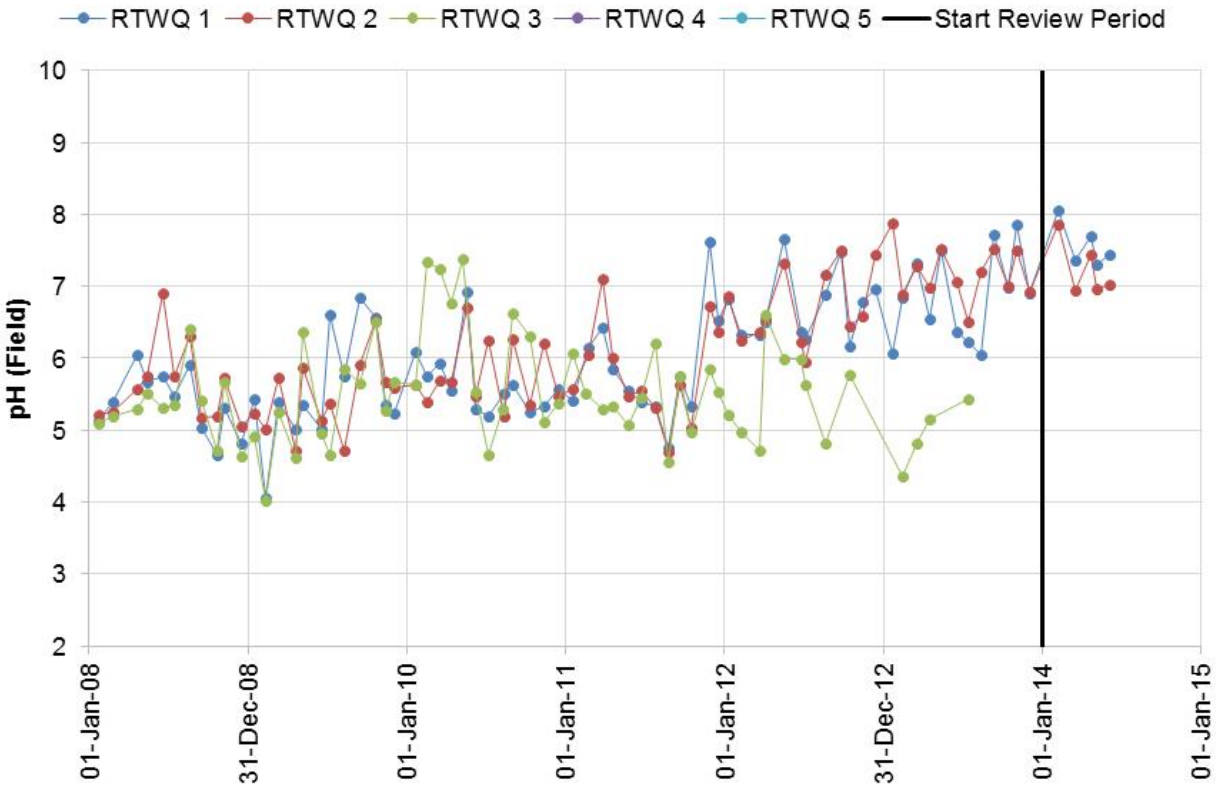


Chart A-20 Dissolved Aluminium Levels in Far Eastern Tributary, Honeysuckle Creek and Bee Creek



ChartA-21 pH levels in Tributary B

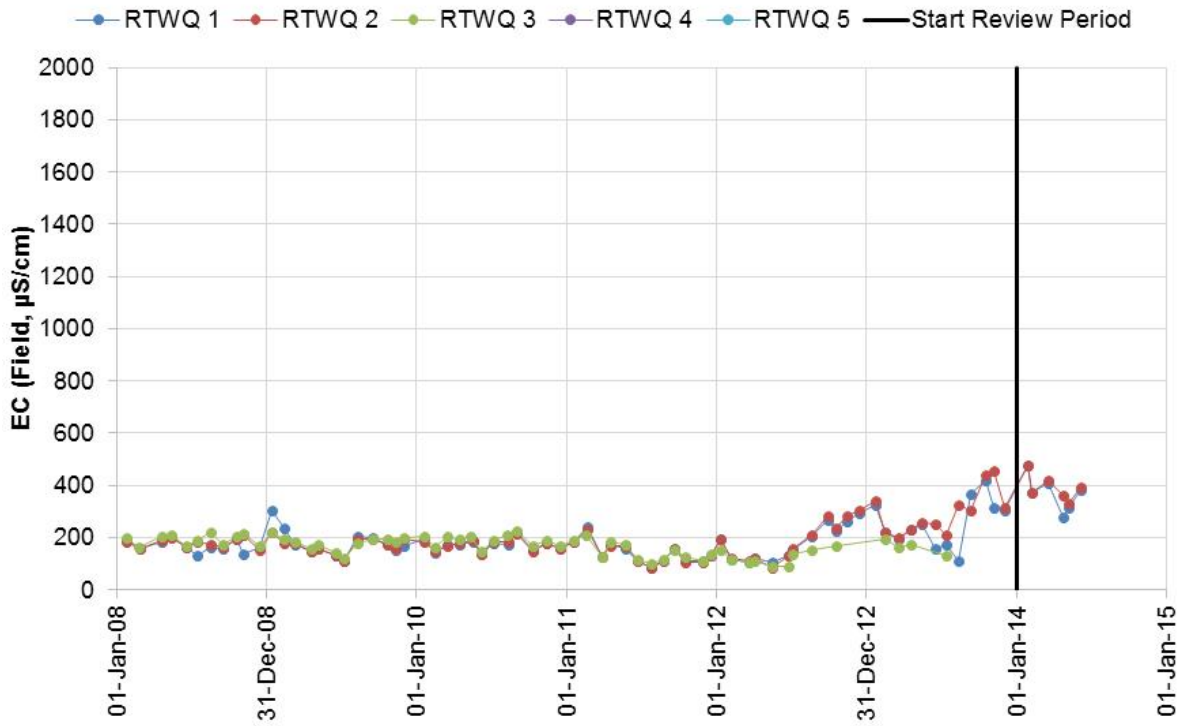


Chart A-22 Electrical Conductivity in Tributary B

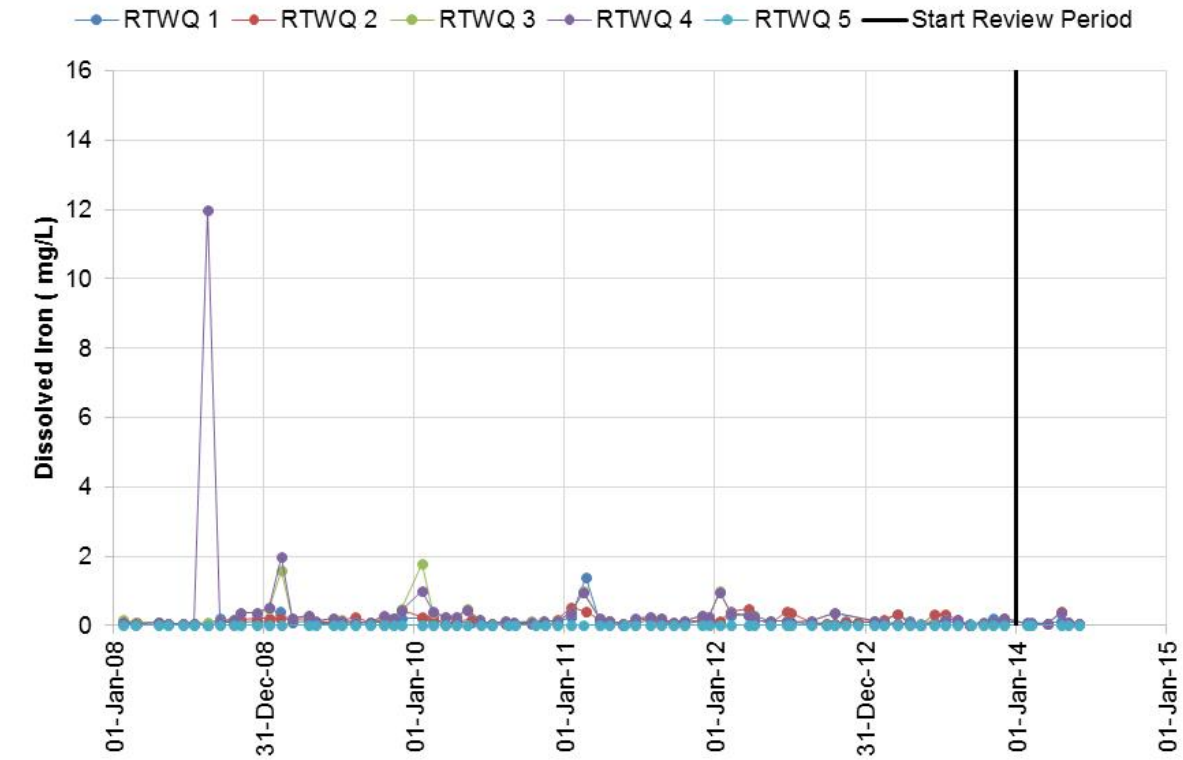


Chart A-23 Dissolved Iron Levels in Tributary B

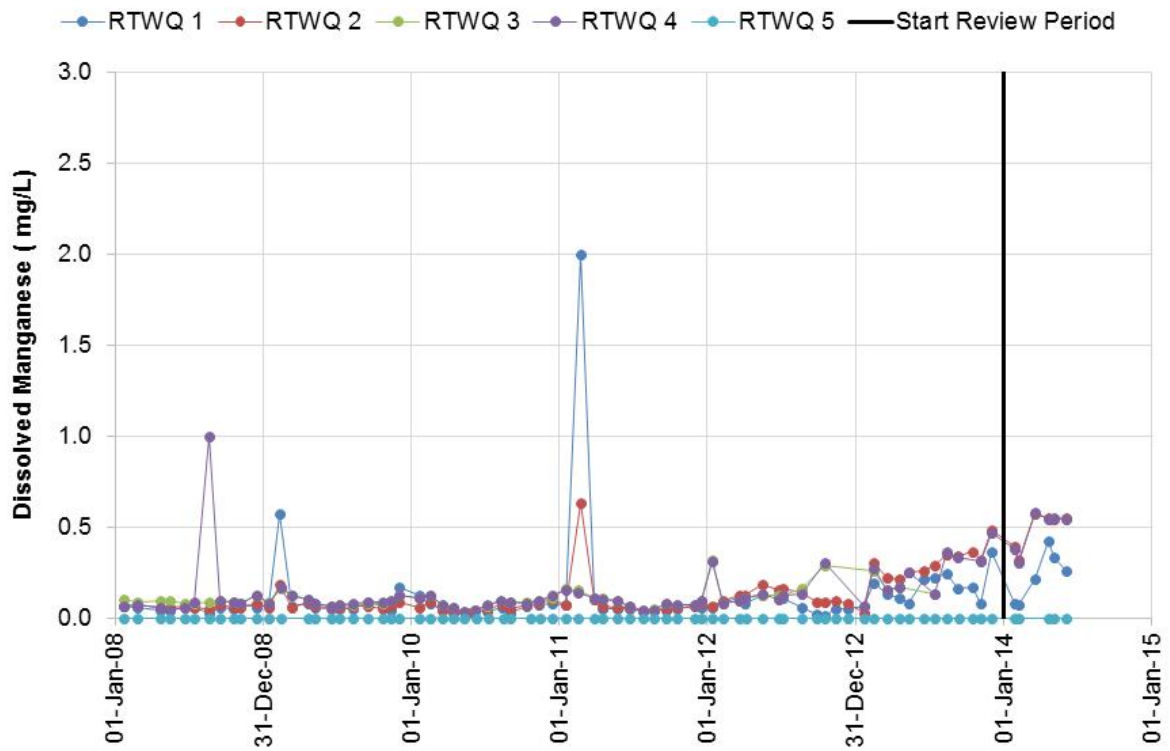


Chart A-24 Dissolved Manganese Levels in Tributary B

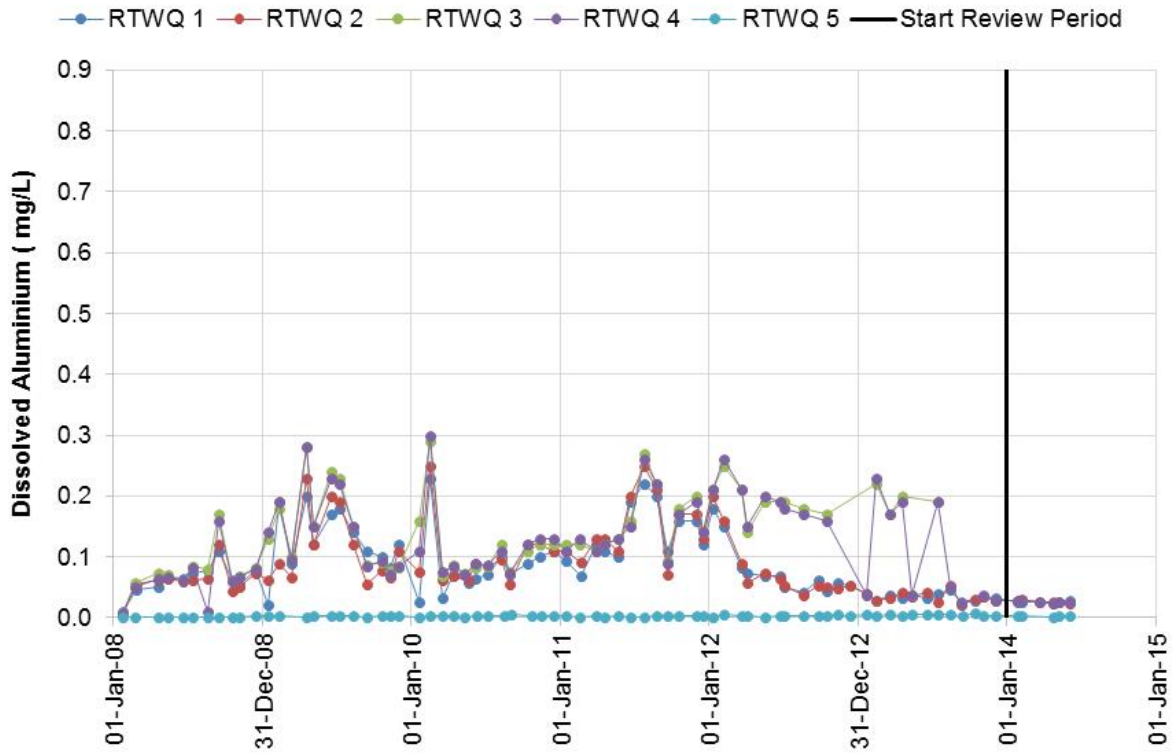


Chart A-25 Dissolved Aluminium Levels in Tributary B

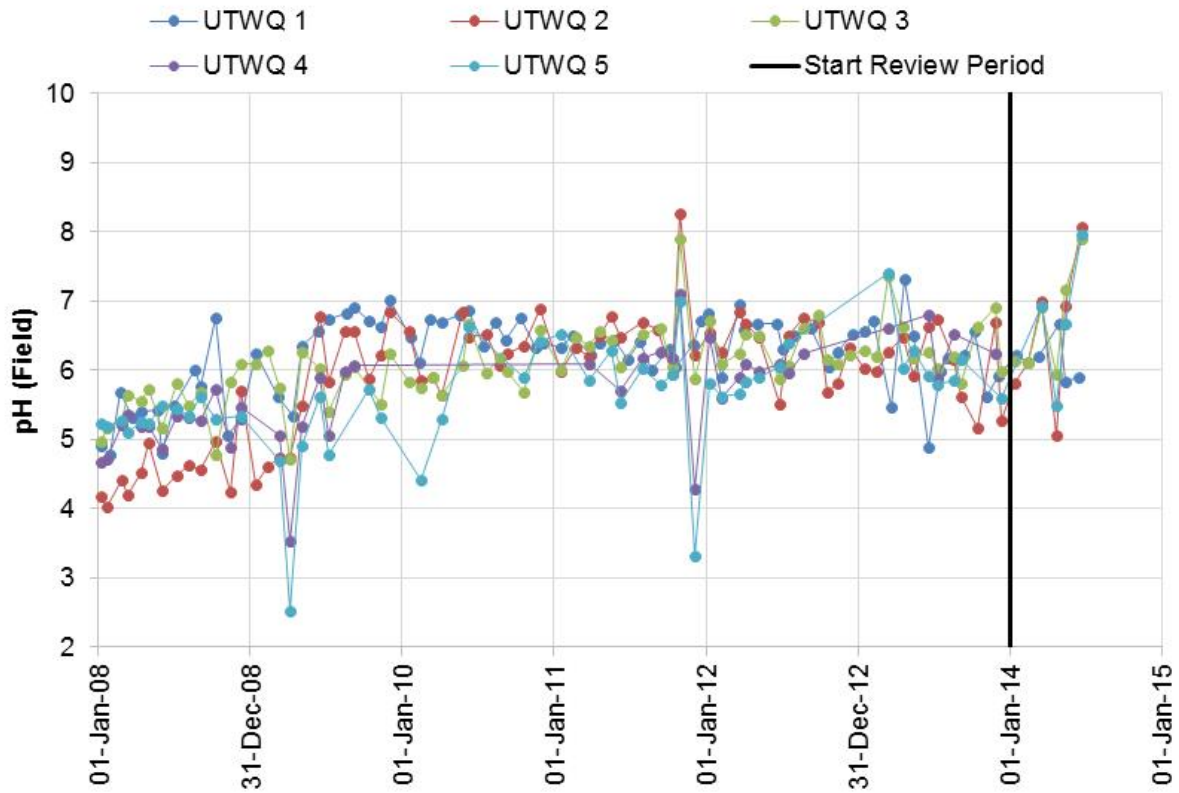


Chart A-26 pH levels in Tributary D

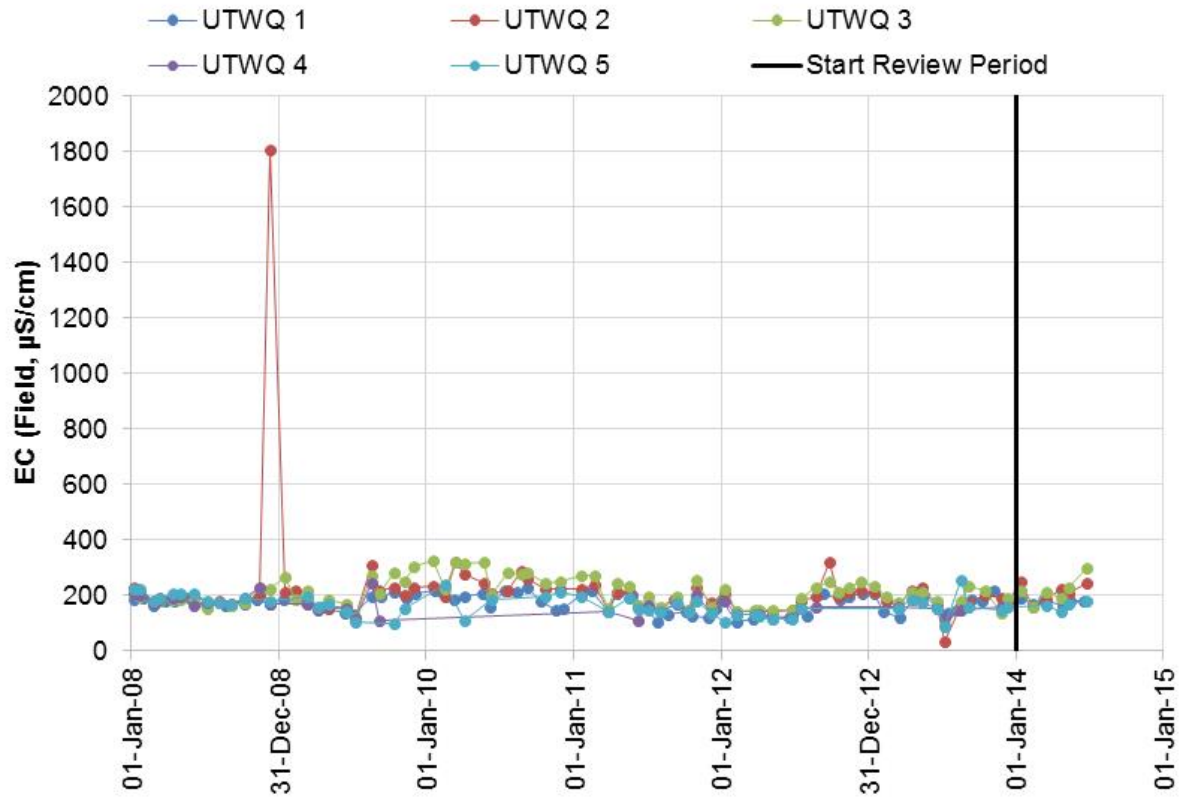


Chart A-27 Electrical Conductivity in Tributary D

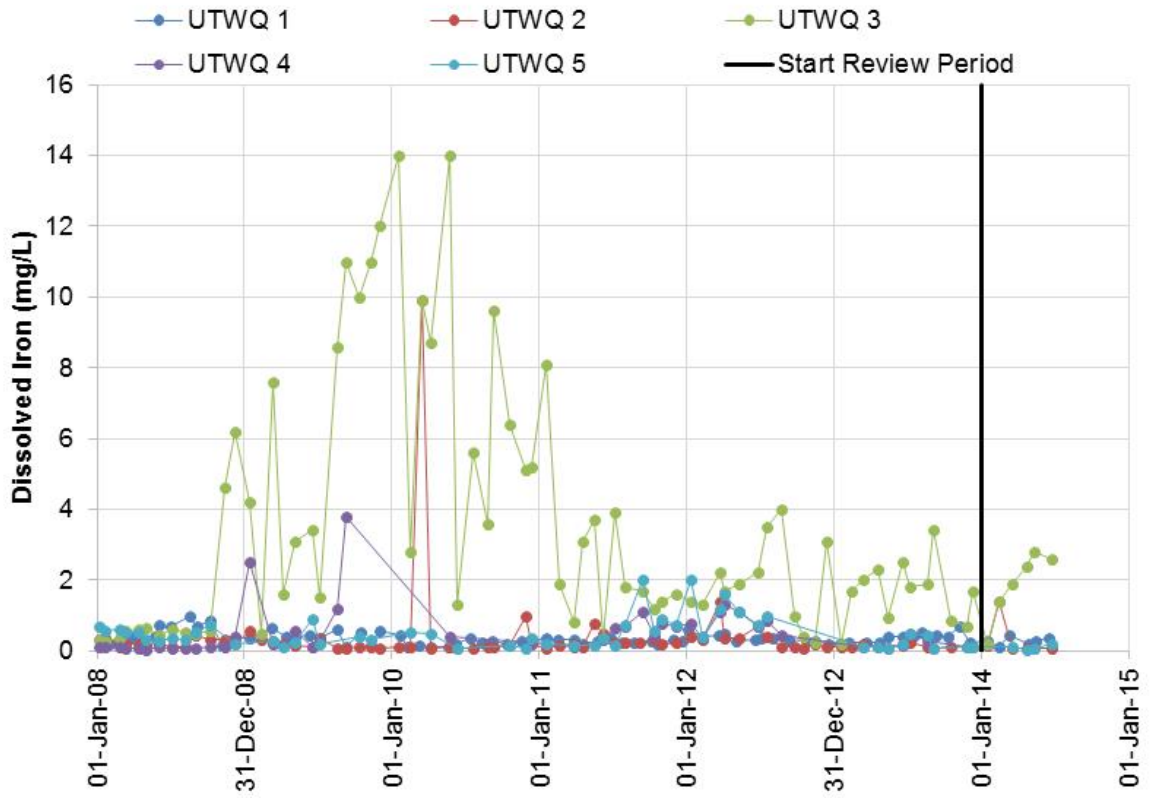


Chart A-28 Dissolved Iron Levels in Tributary D

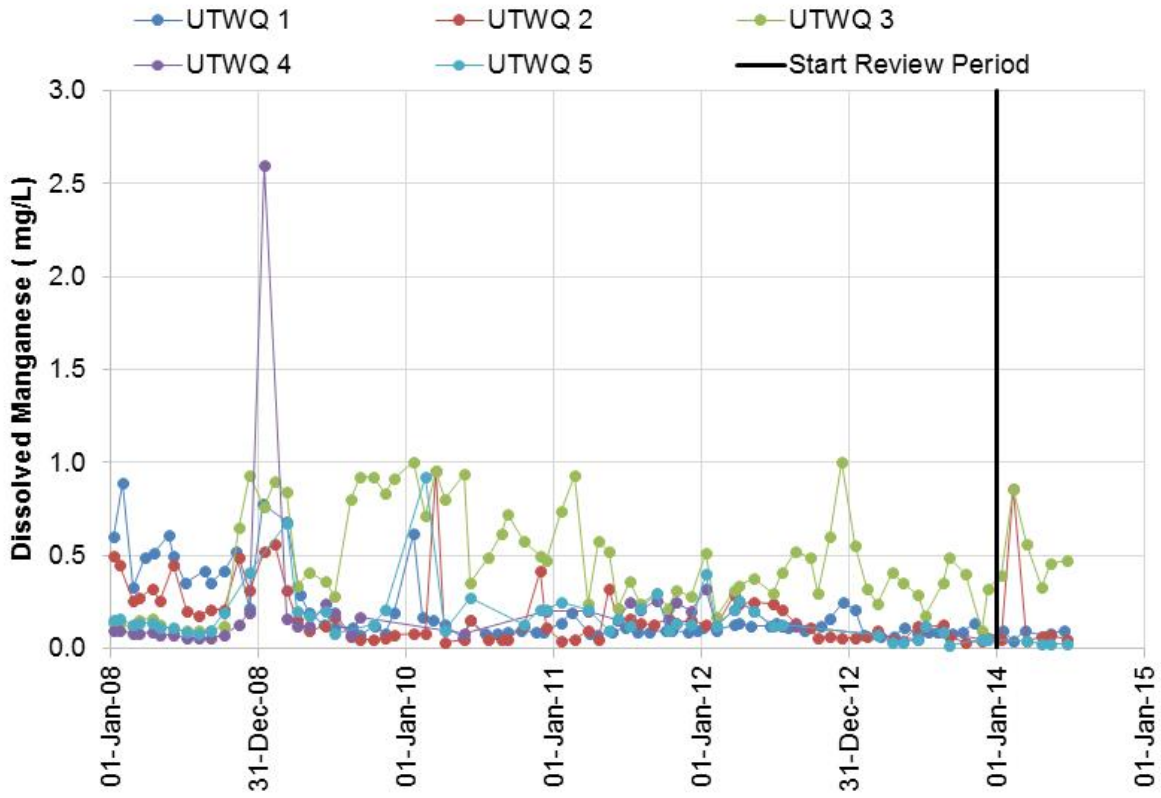


Chart A-29 Dissolved Manganese Levels in Tributary D

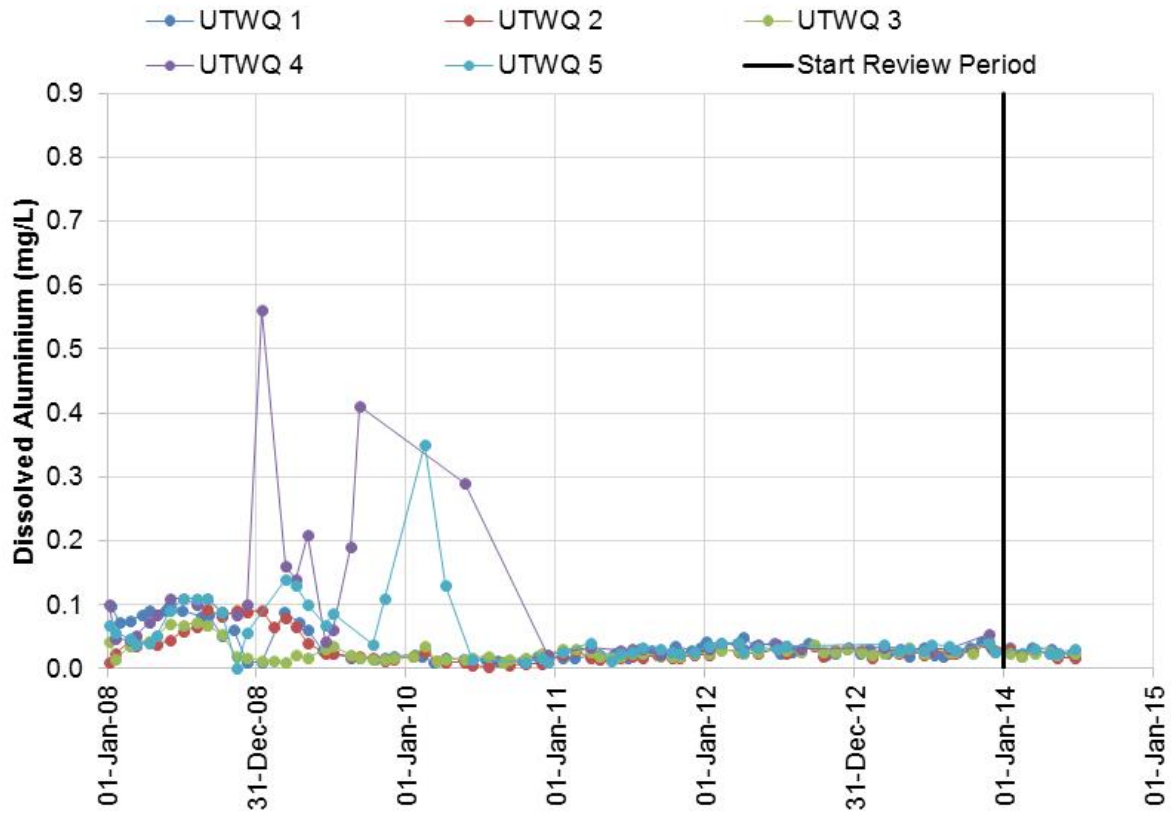


Chart A-30 Dissolved Aluminium Levels in Un-named Tributary

APPENDIX B

WARATAH RIVULET POOL WATER LEVEL MONITORING RESULTS

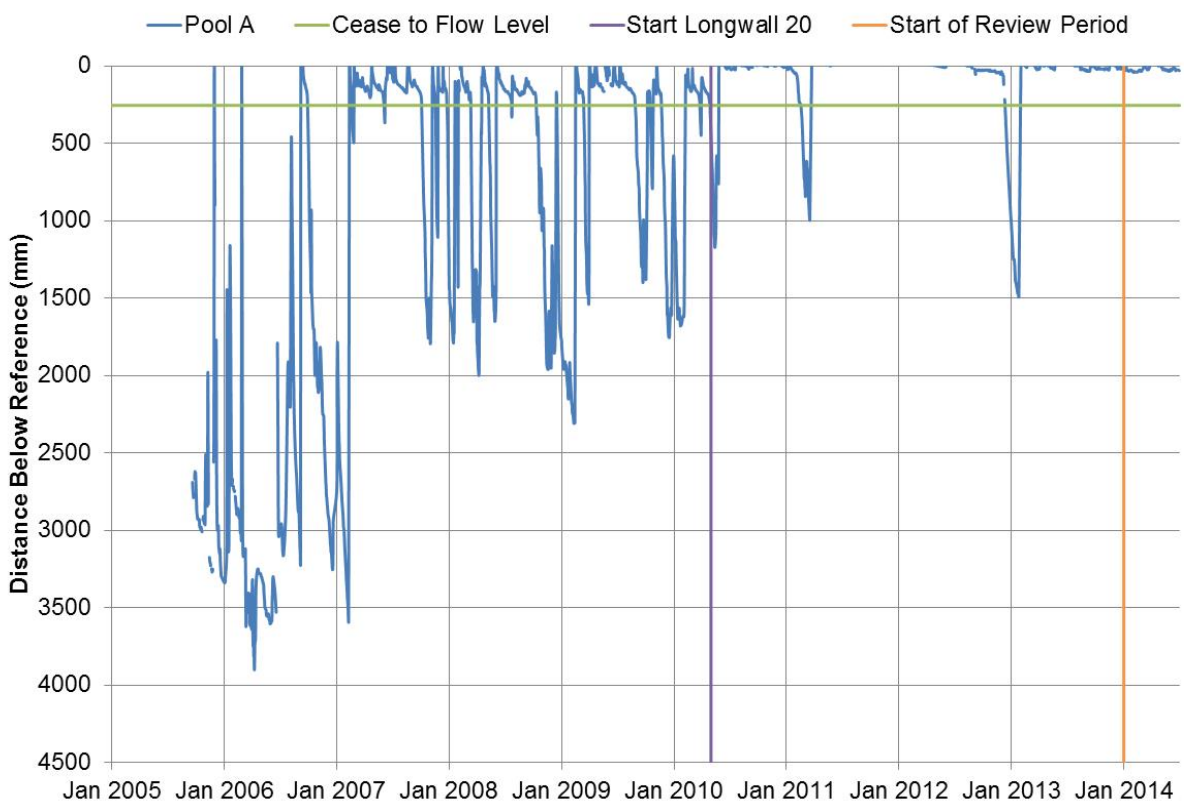


Chart B-1 Pool A Water Level Observations Compared with Cease-to-flow Level

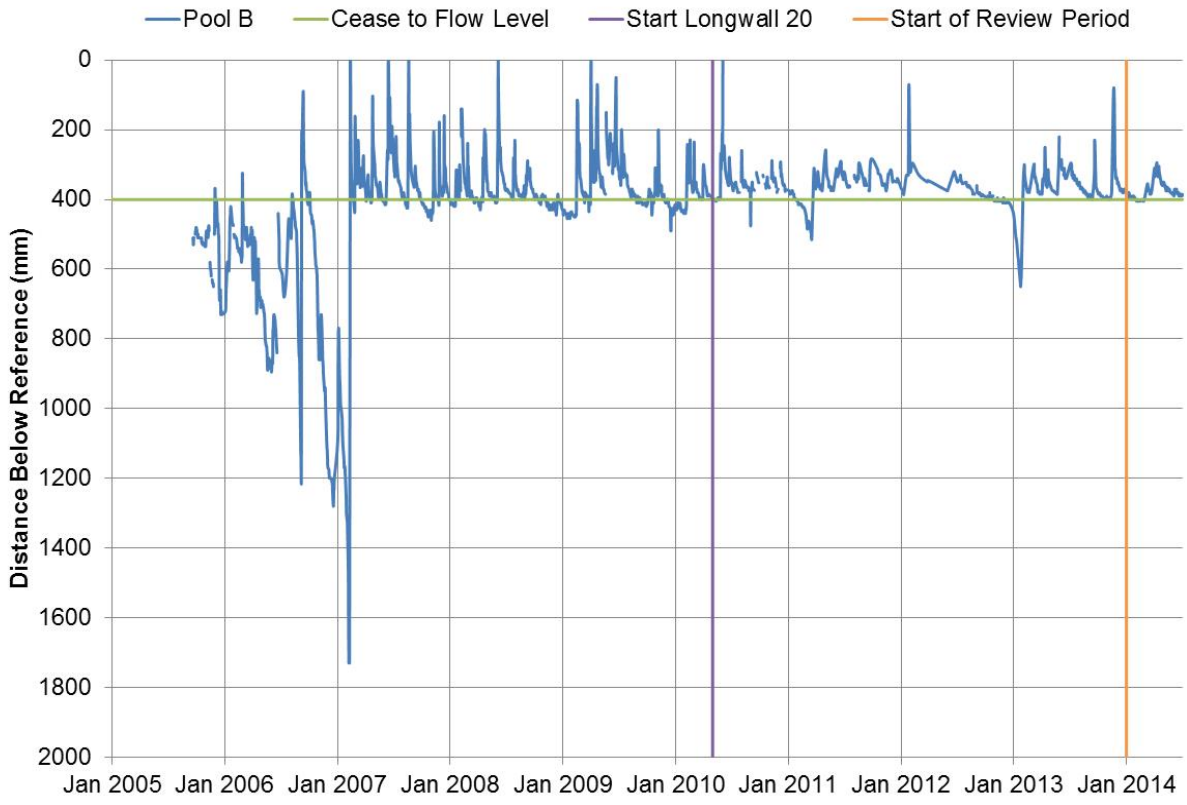


Chart B-2 Pool B Water Level Observations Compared with Cease-to-flow Level

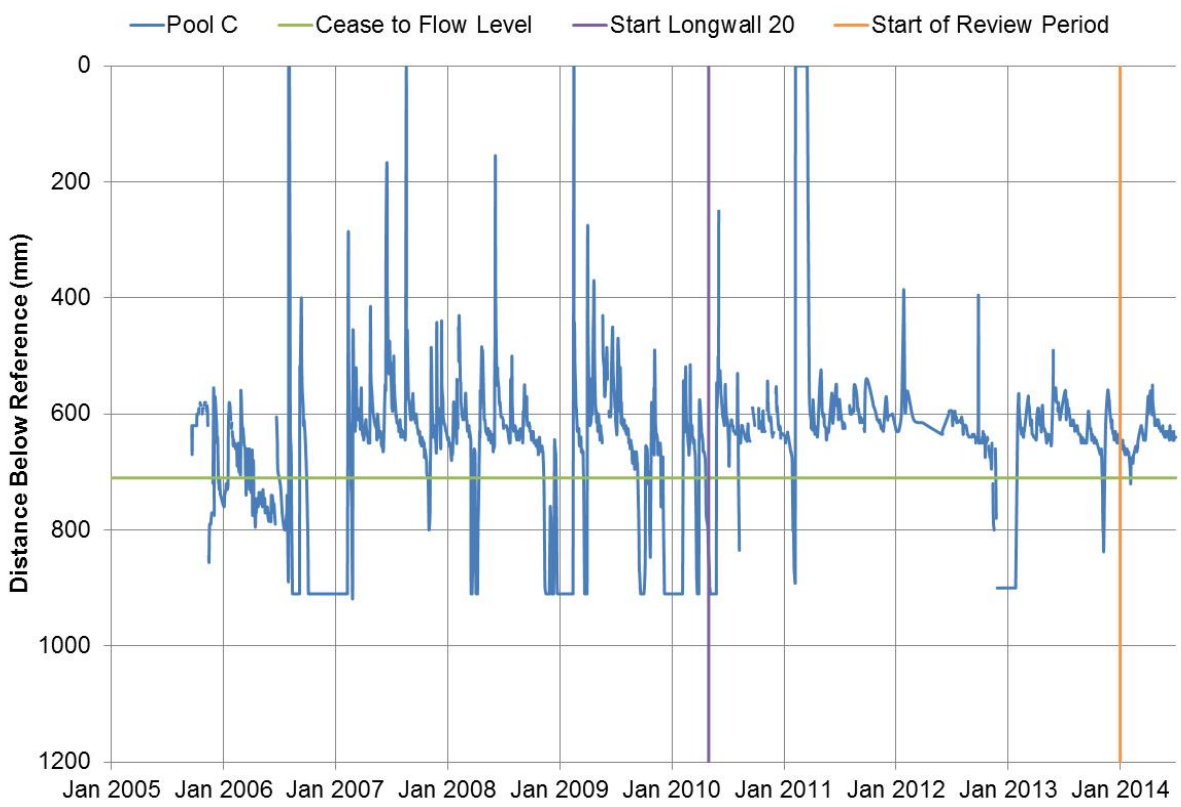


Chart B-3 Pool C Water Level Observations Compared with Cease-to-flow Level

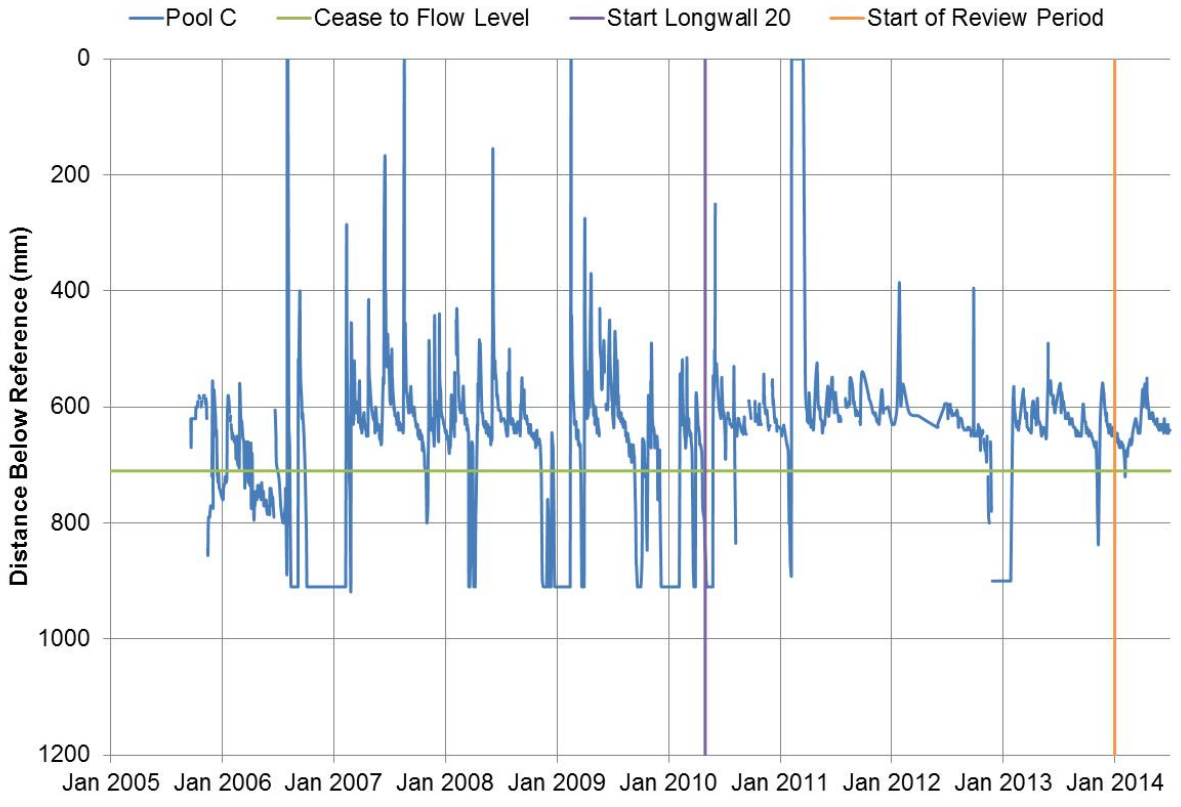


Chart B-4 Pool E Water Level Observations Compared with Cease-to-flow Level

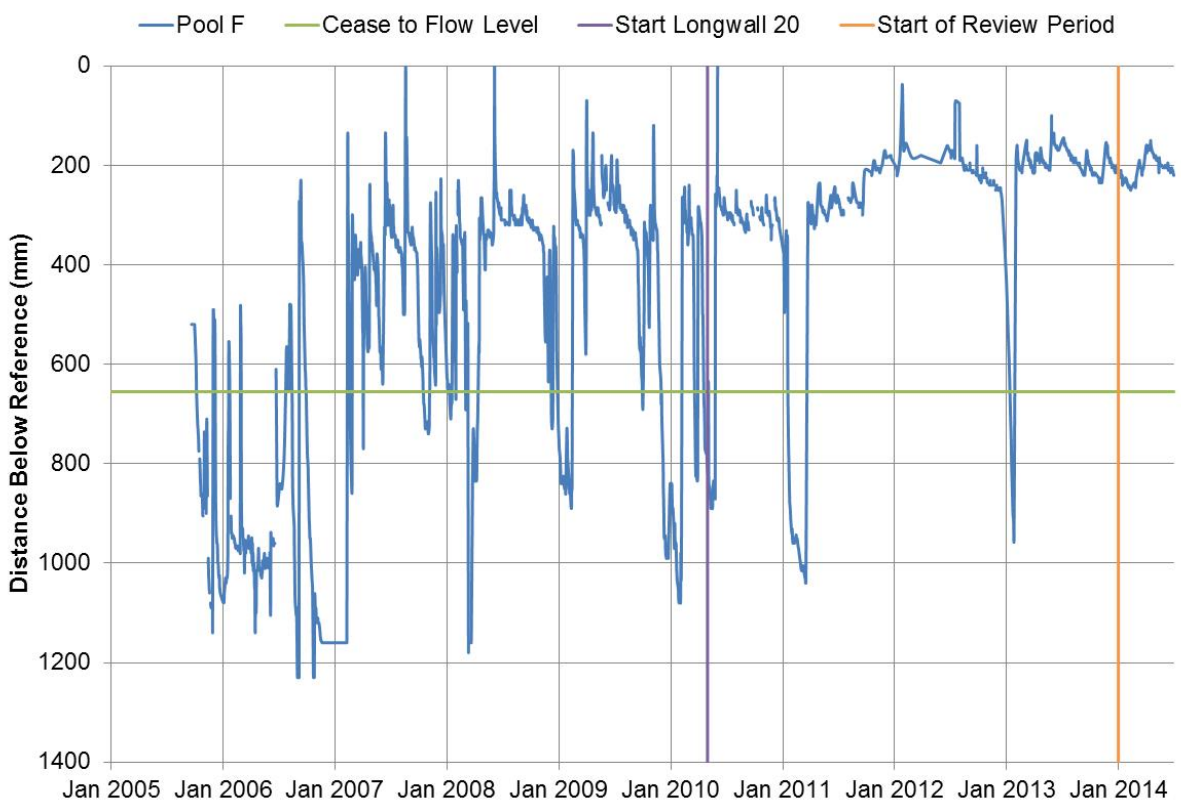


Chart B-5 **Pool F Water Level Observations Compared with Cease-to-flow Level**

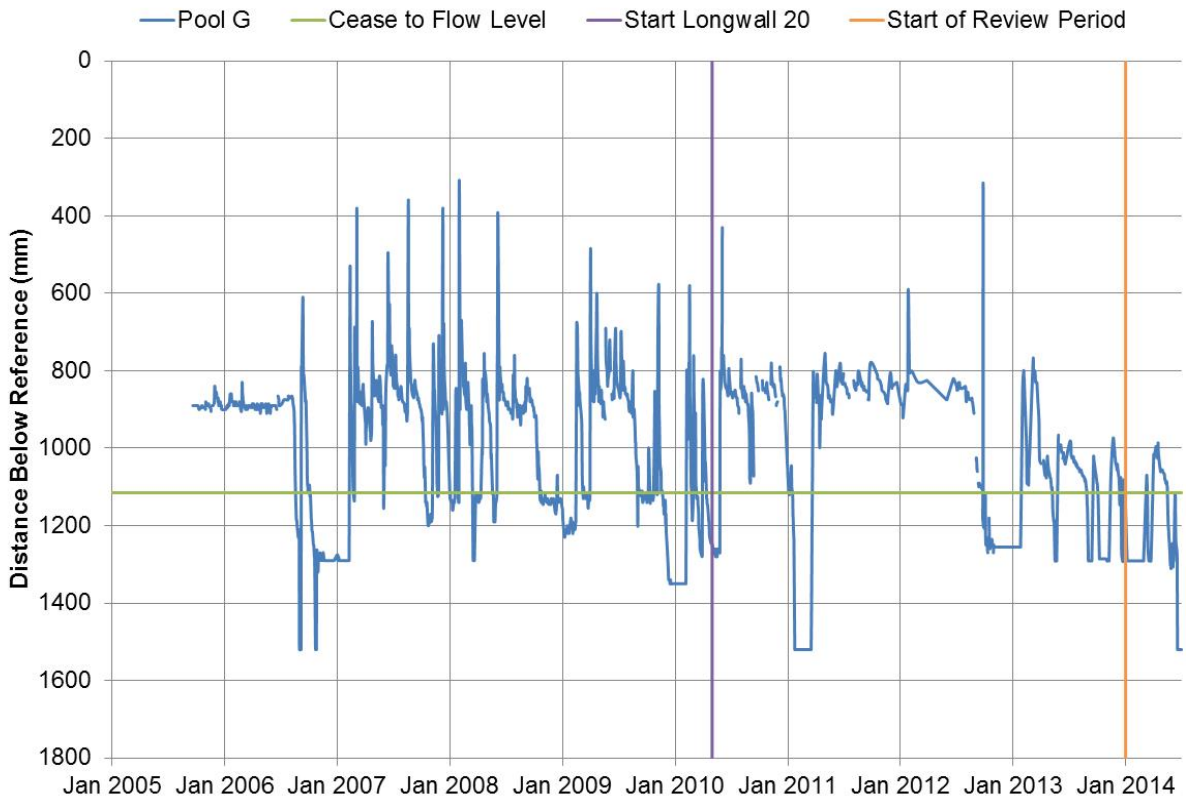


Chart B-6 **Pool G Water Level Observations Compared with Cease-to-flow Level**

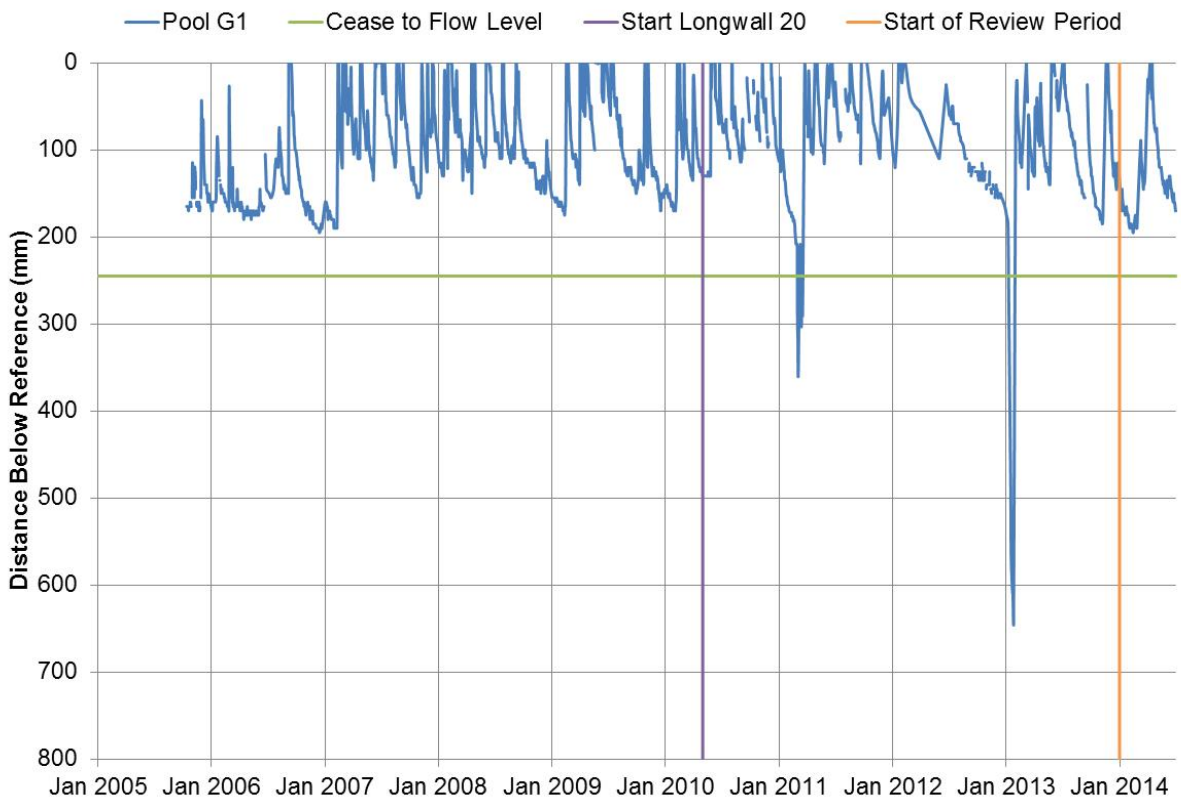


Chart B-7 **Pool G1 Water Level Observations Compared with Cease-to-flow Level**

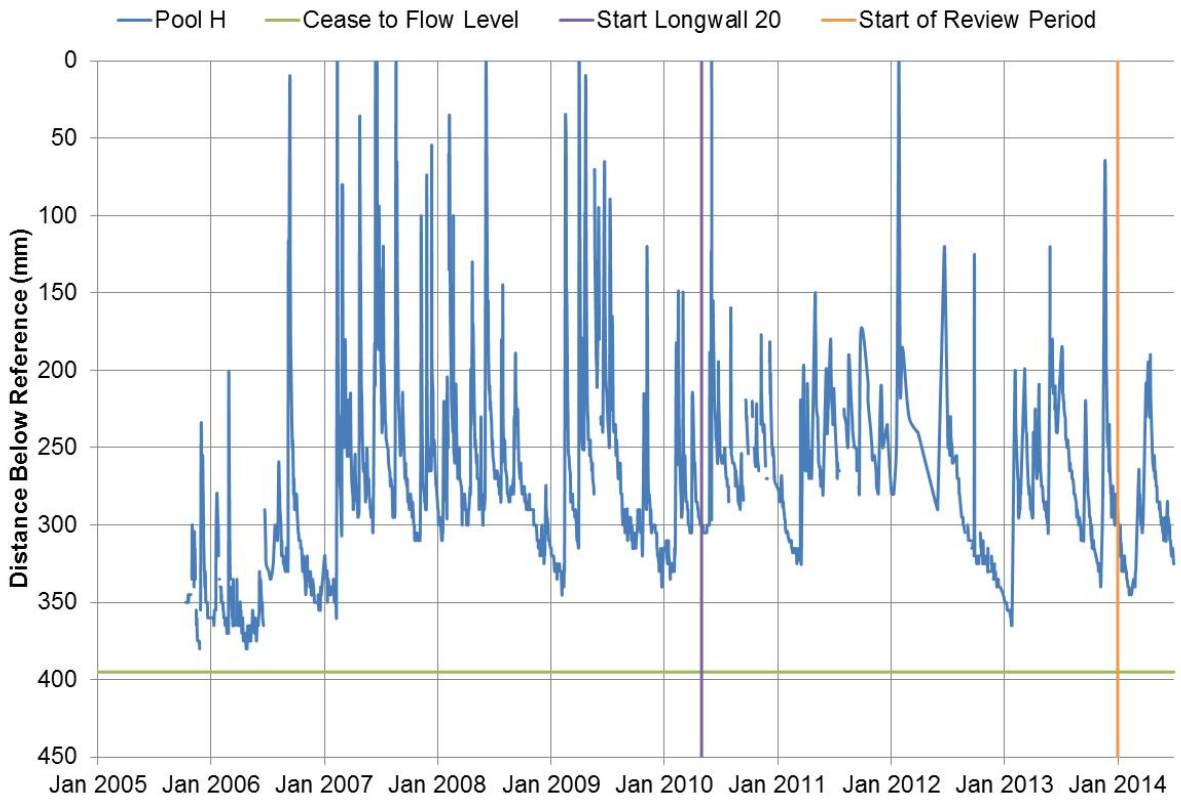


Chart B-8 **Pool H Water Level Observations Compared with Cease-to-flow Level**

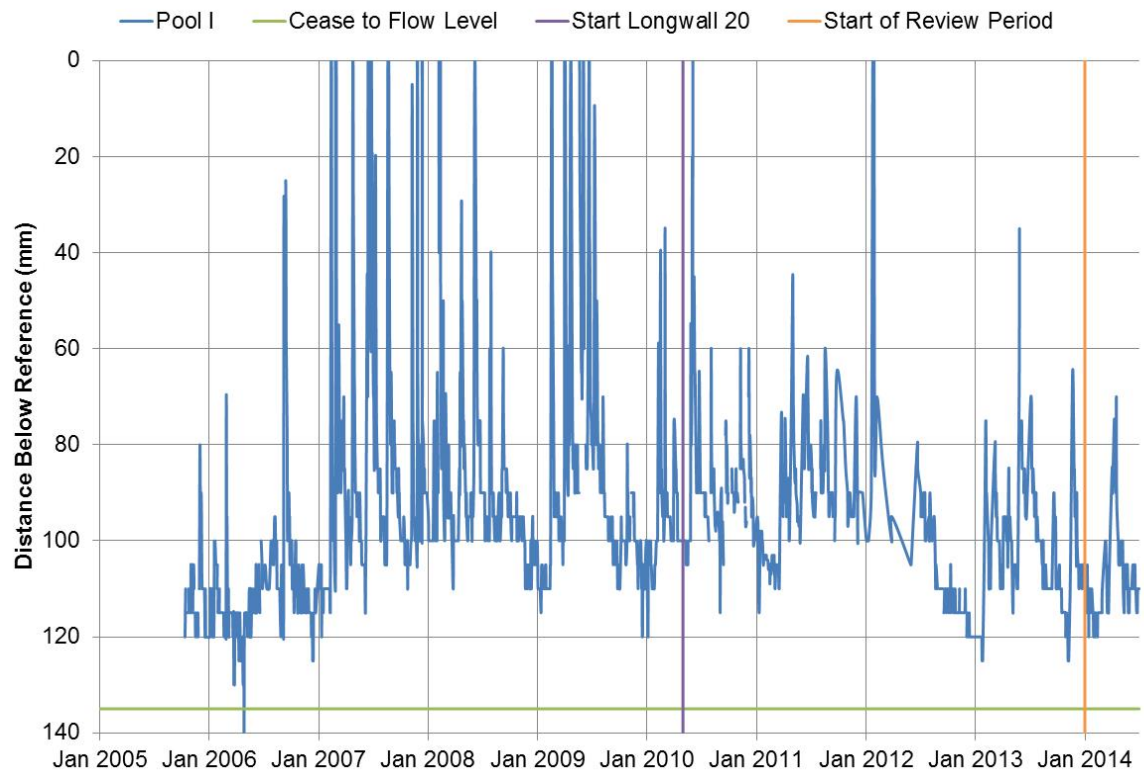


Chart B-9 Pool I Water Level Observations Compared with Cease-to-flow Level

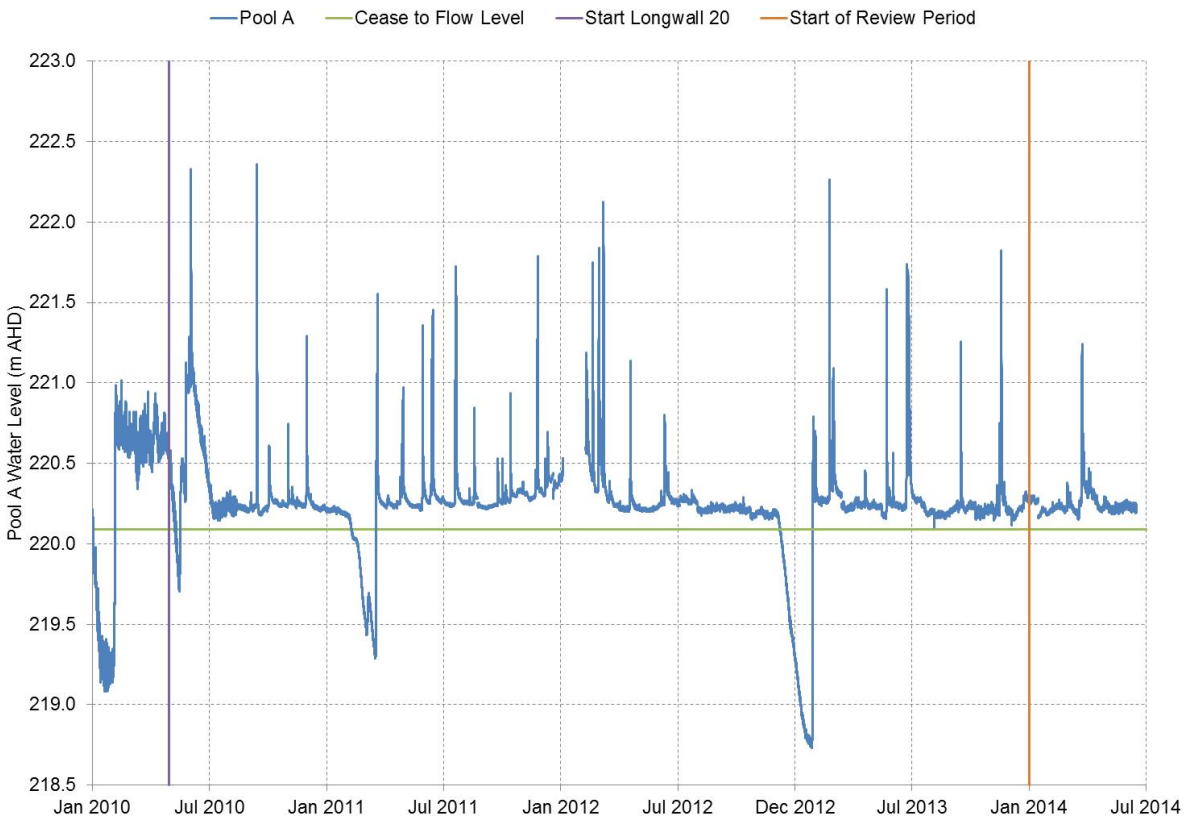


Chart B-10 Pool A - Recorded Pool Water Level

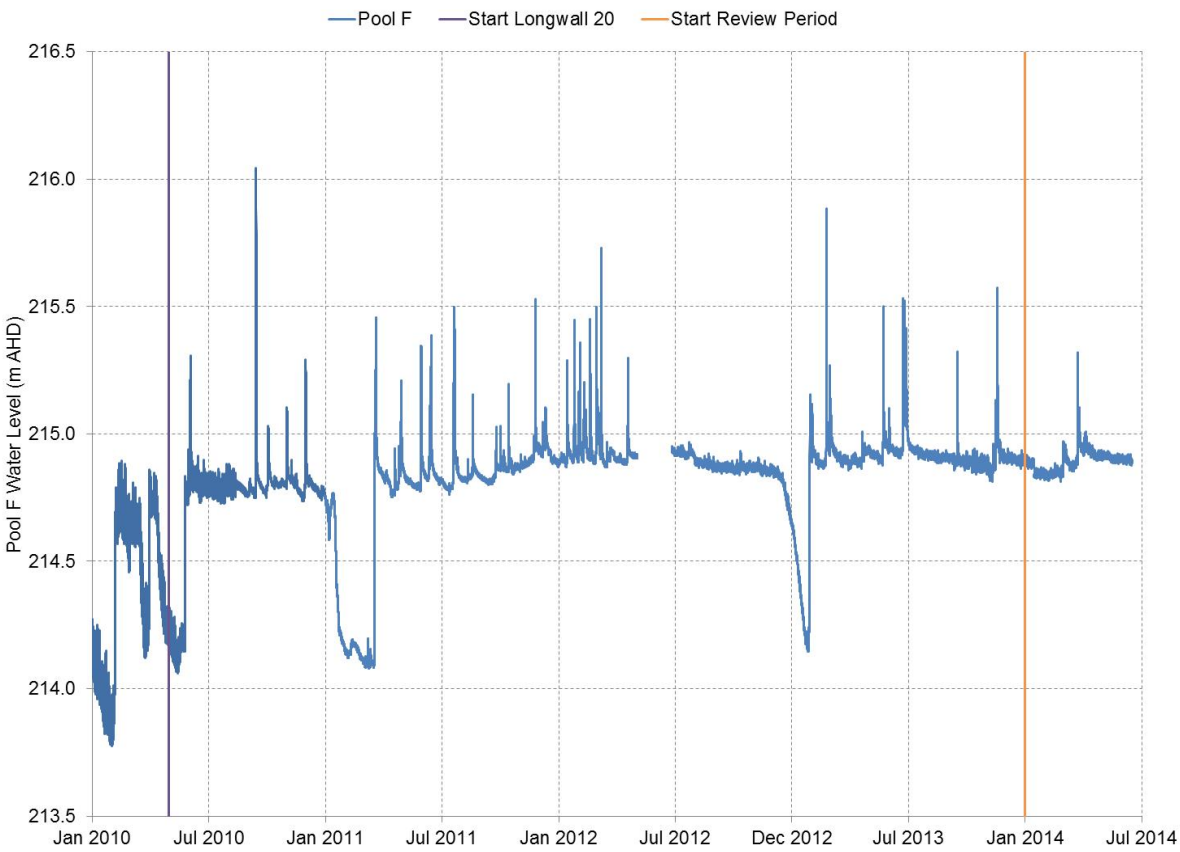


Chart B-11 Pool F - Recorded Pool Water Level

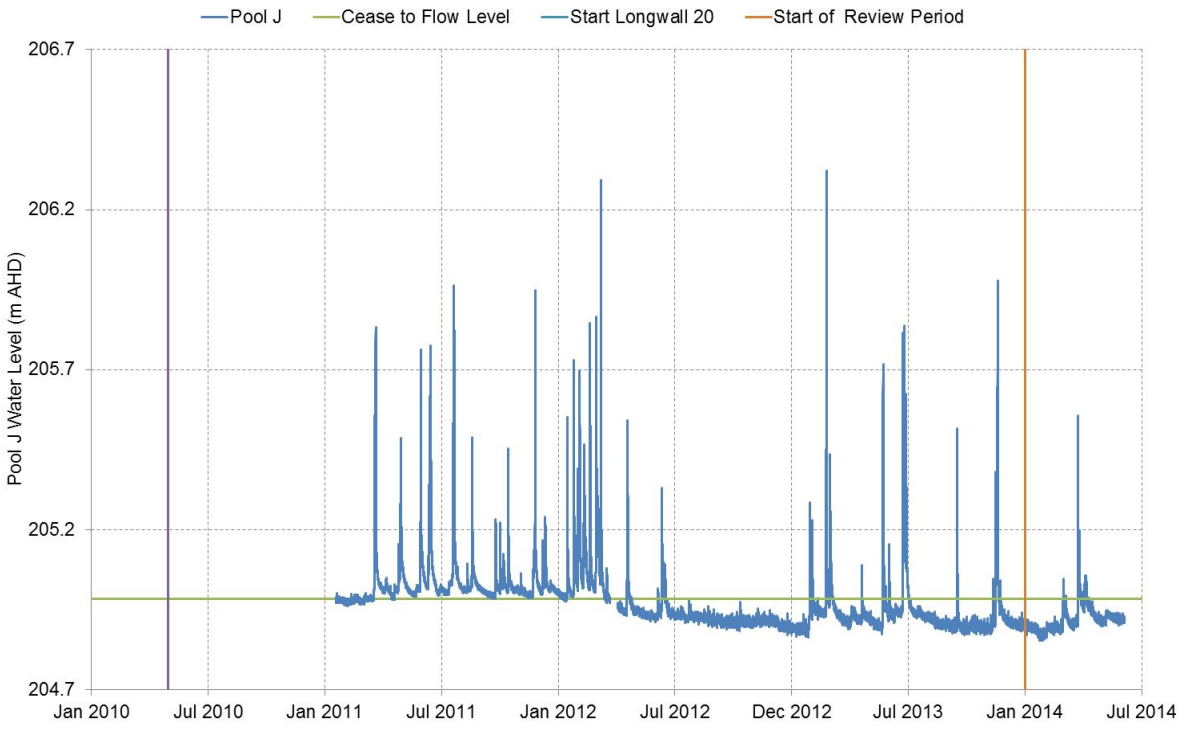


Chart B-12 Pool J - Recorded Pool Water Level

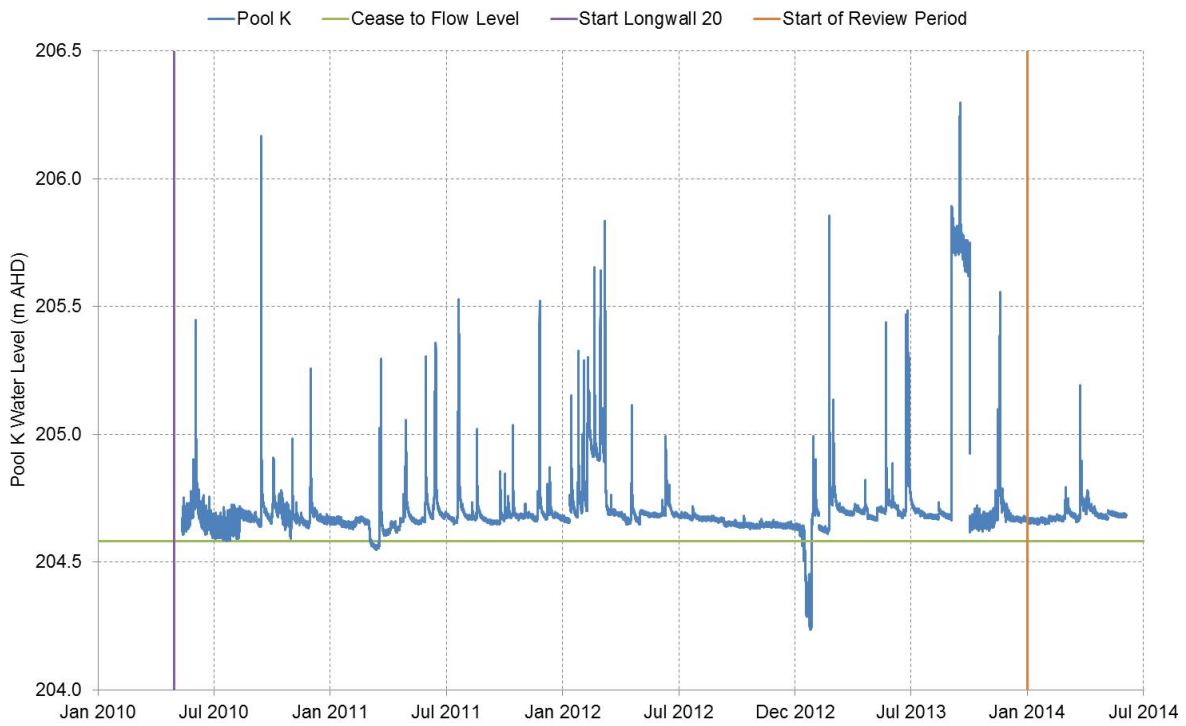


Chart B-13 Pool K - Recorded Pool Water Level

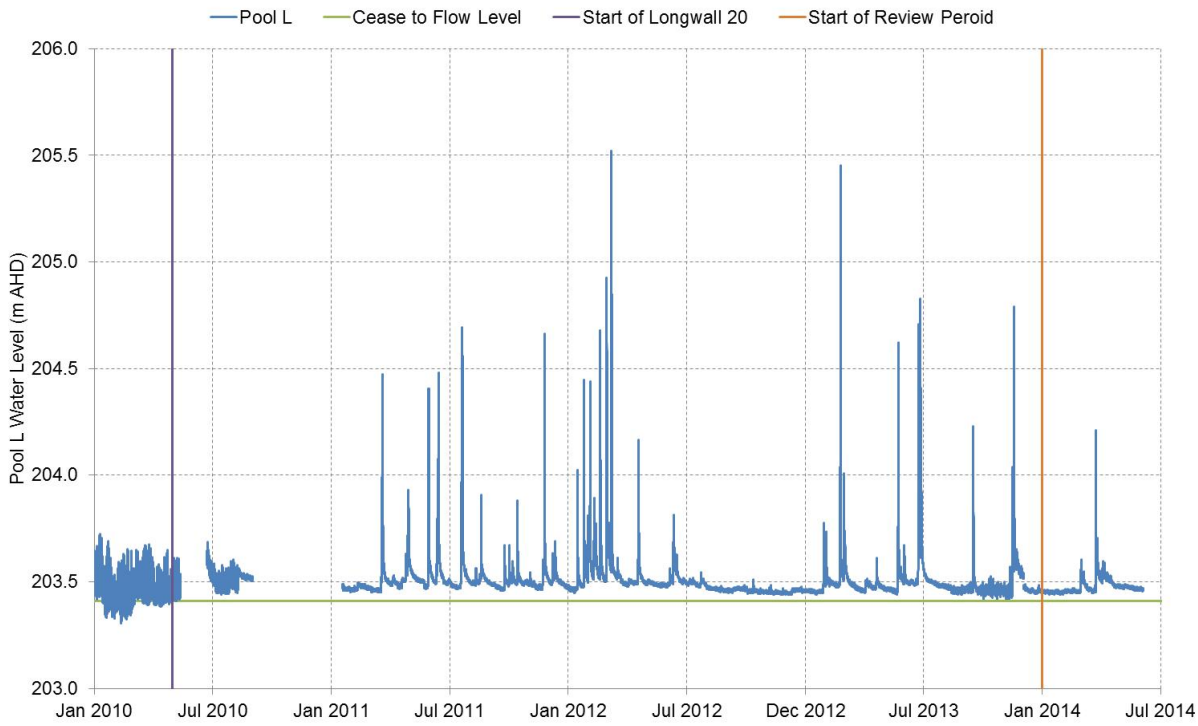


Chart B-14 Pool L - Recorded Pool Water Level

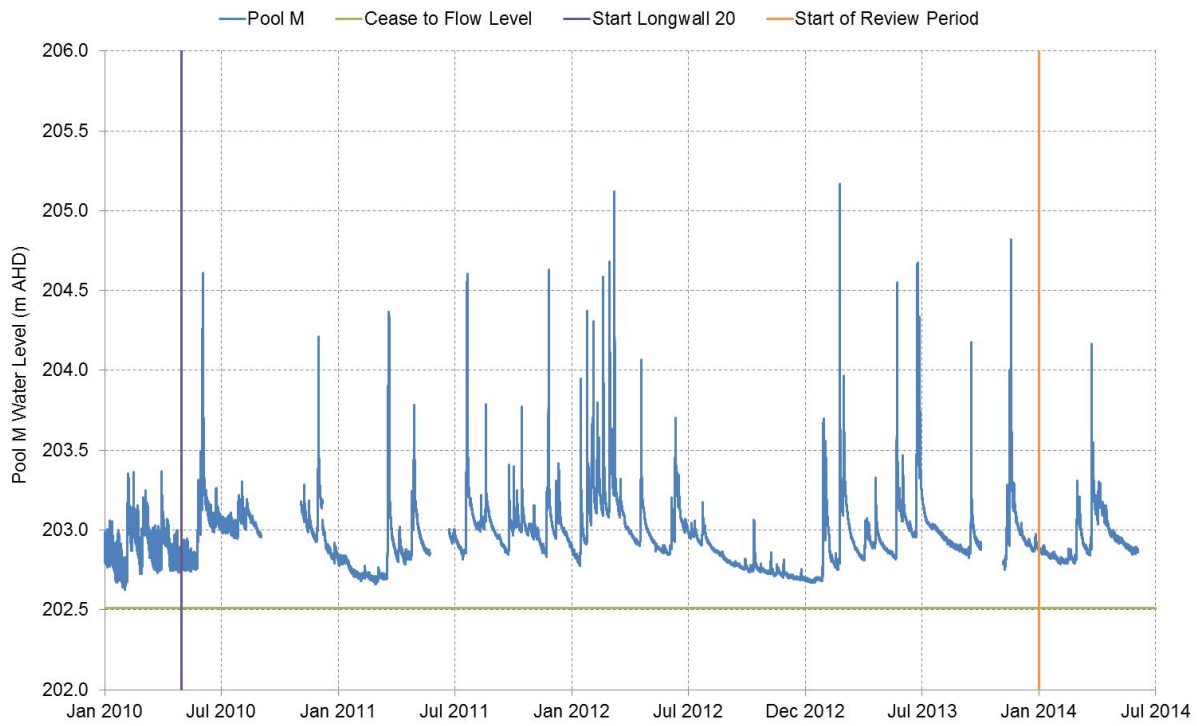


Chart B-15 Pool M - Recorded Pool Water Level

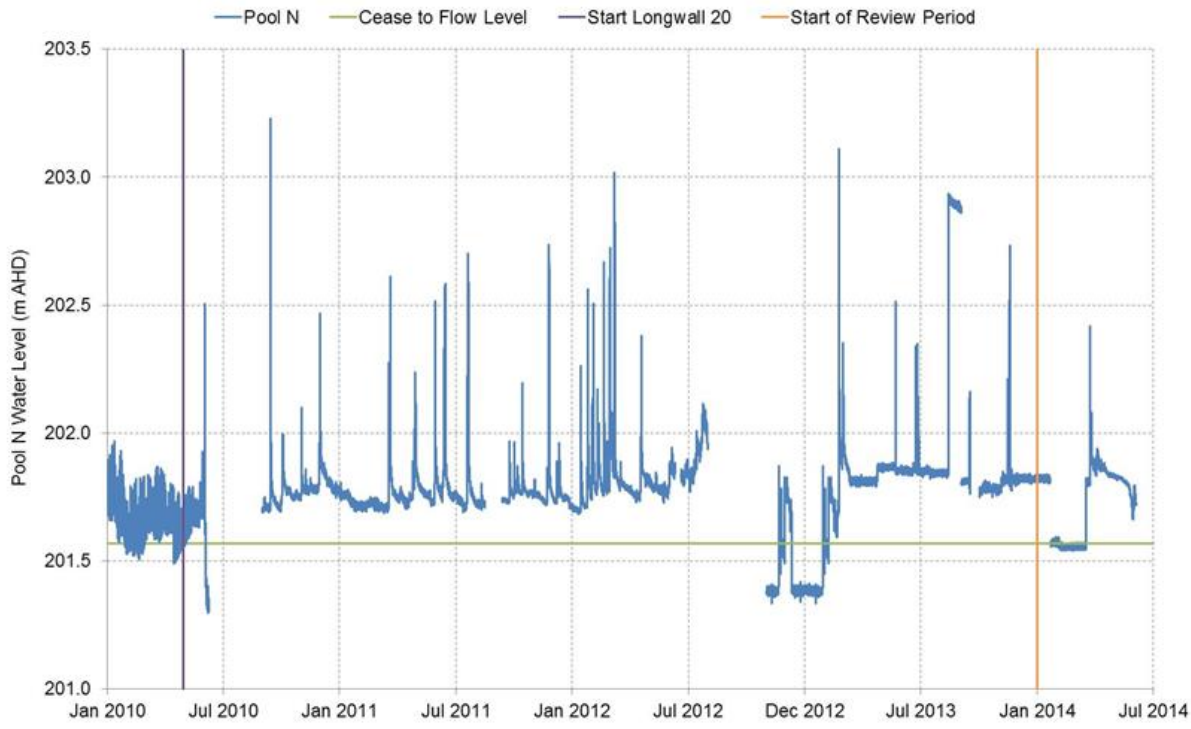


Chart B-16 Pool N - Recorded Pool Water Level

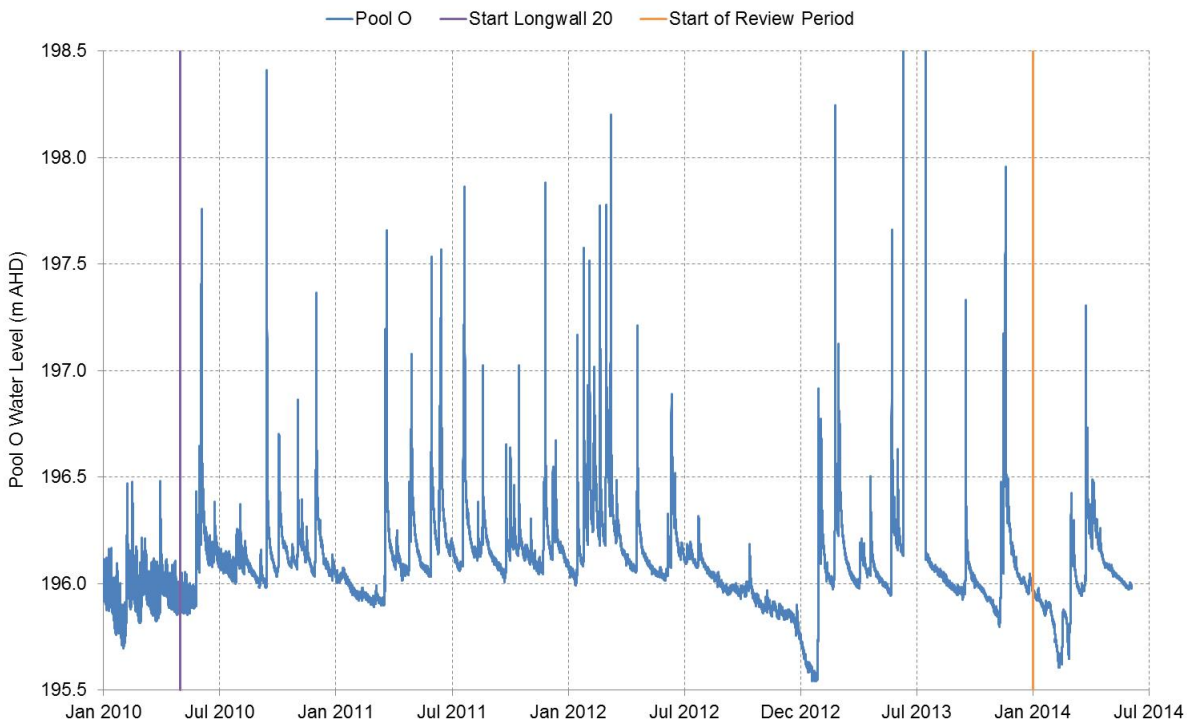


Chart B-17 Pool O - Recorded Pool Water Level

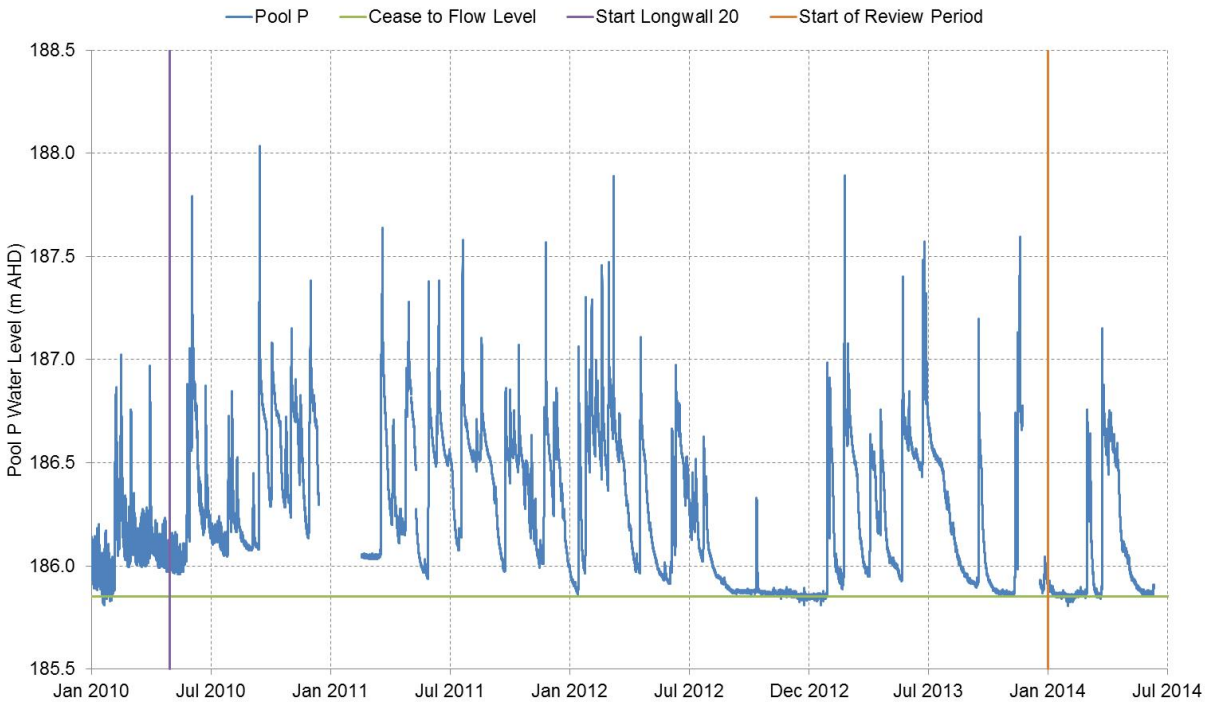


Chart B-18 Pool P - Recorded Pool Water Level

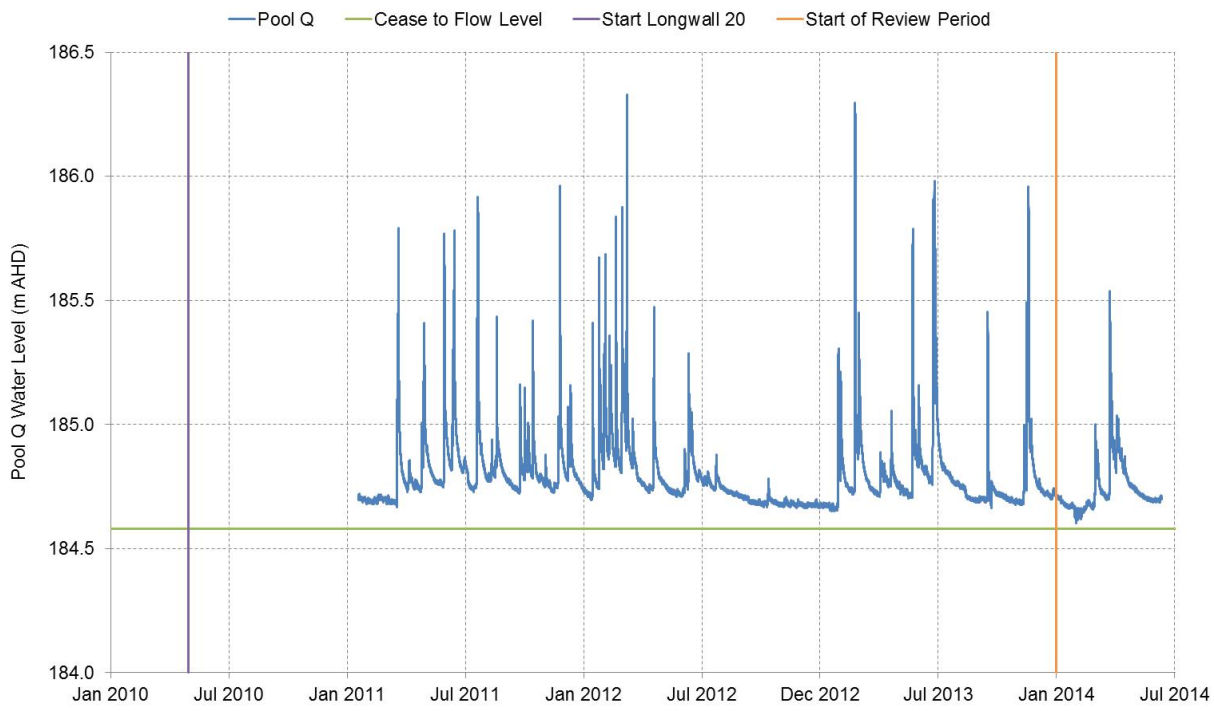


Chart B-19 Pool Q - Recorded Pool Water Level

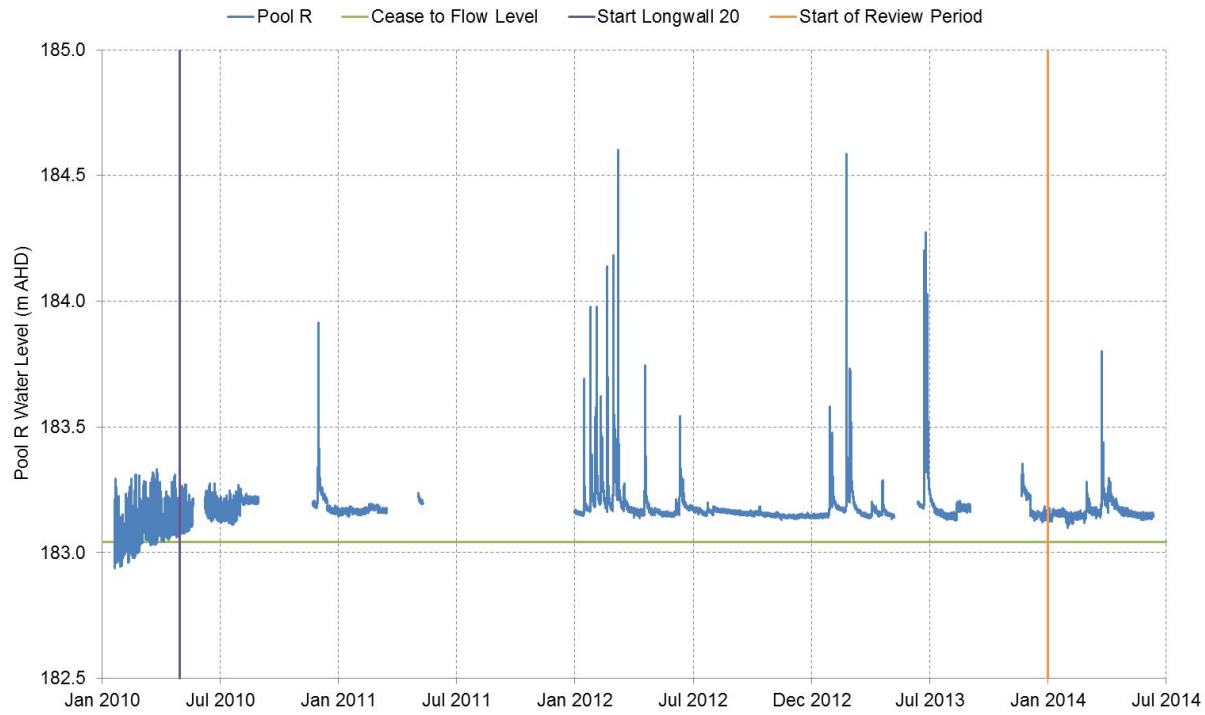


Chart B-20 Pool R - Recorded Pool Water Level

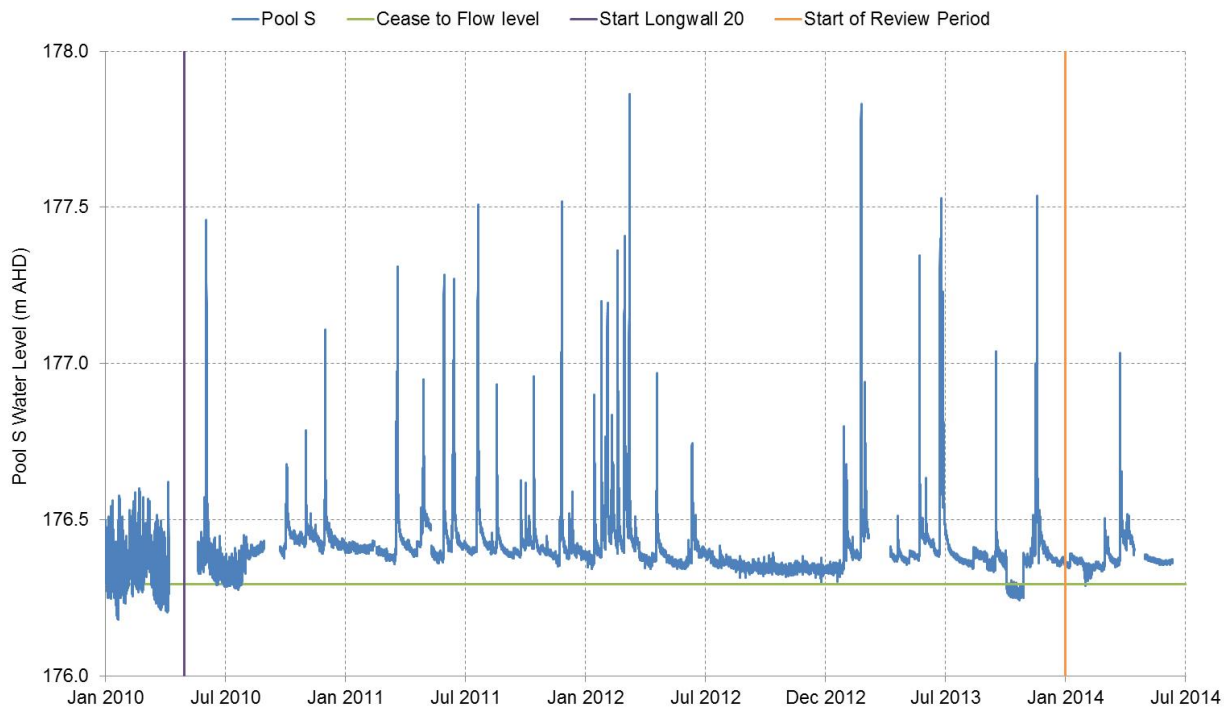


Chart B-21 Pool S - Recorded Pool Water Level

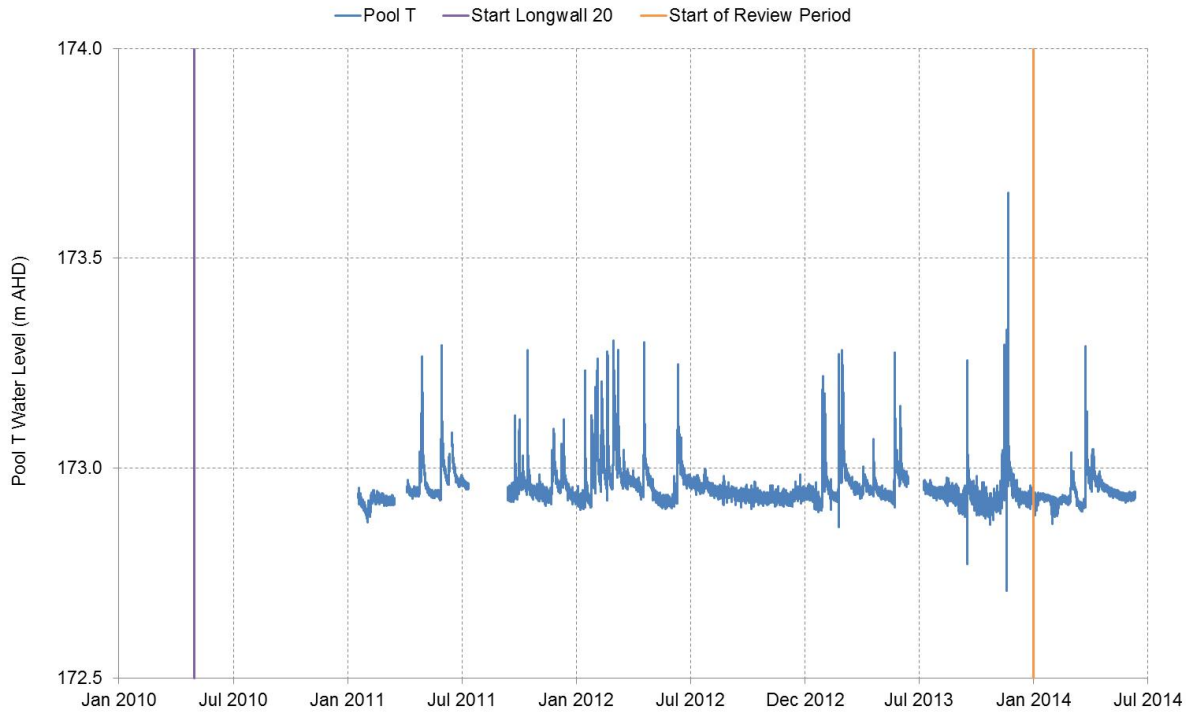


Chart B-22 Pool T - Recorded Pool Water Level

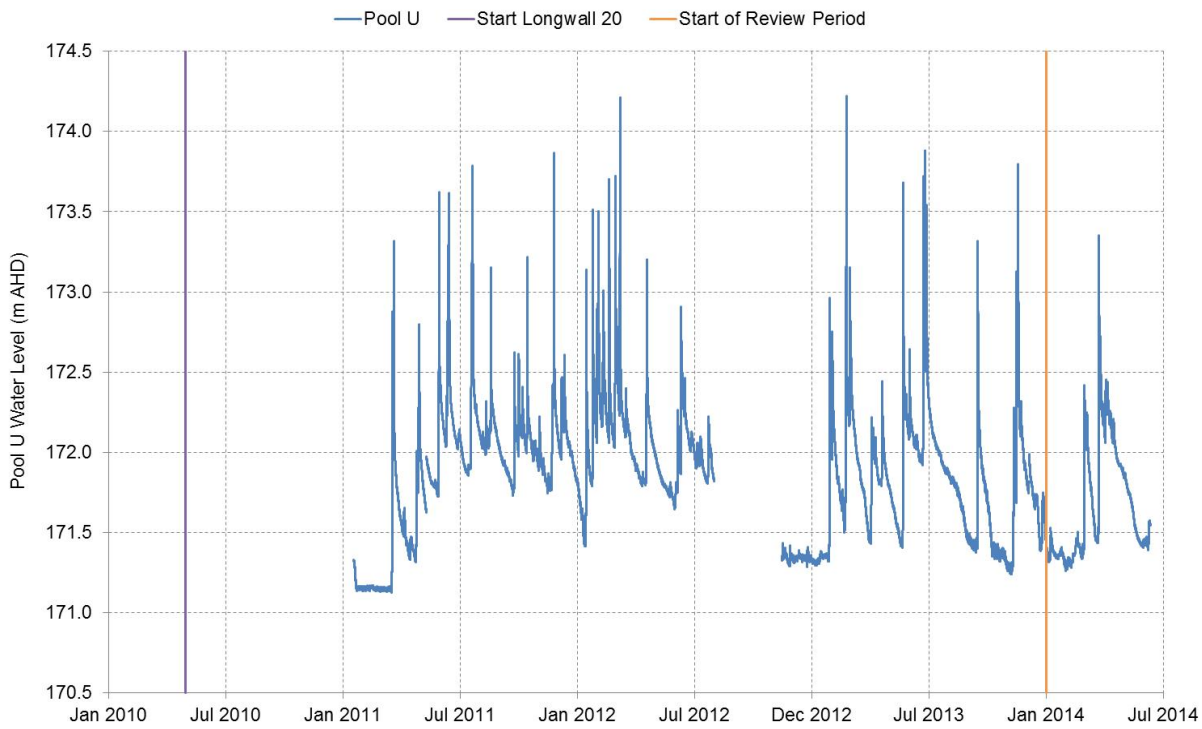


Chart B-23 Pool U - Recorded Pool Water Level

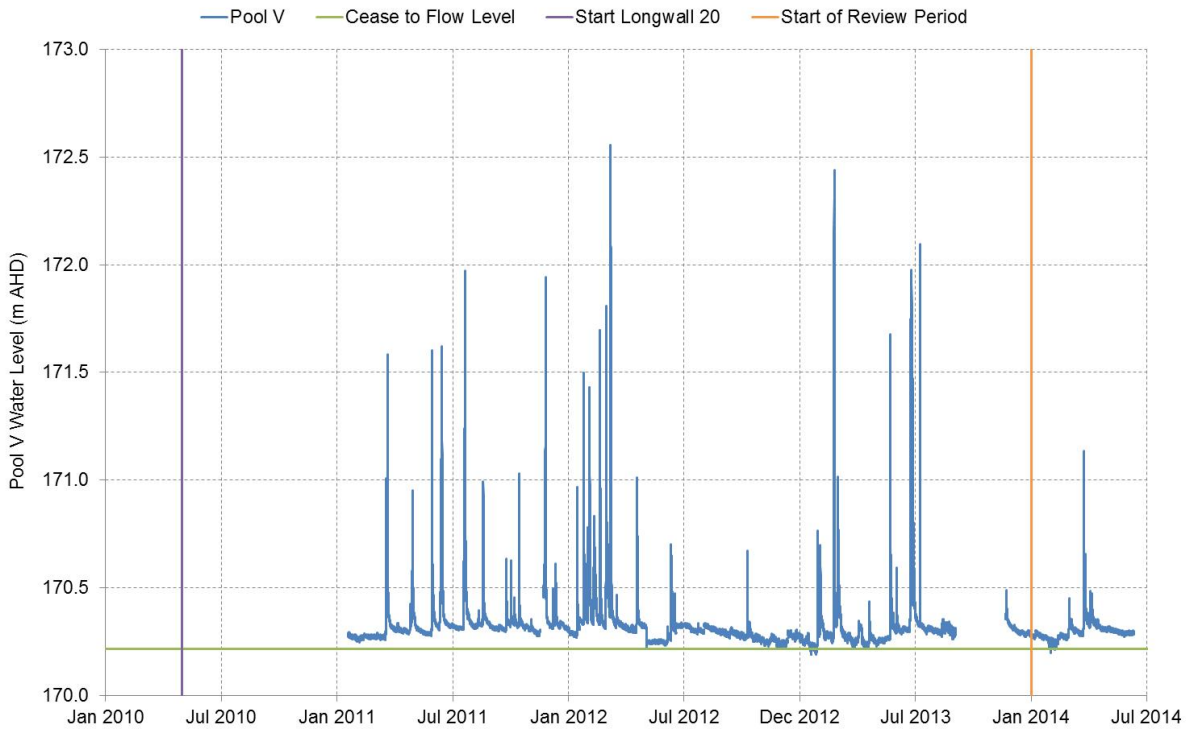


Chart B-24 Pool V - Recorded Pool Water Level

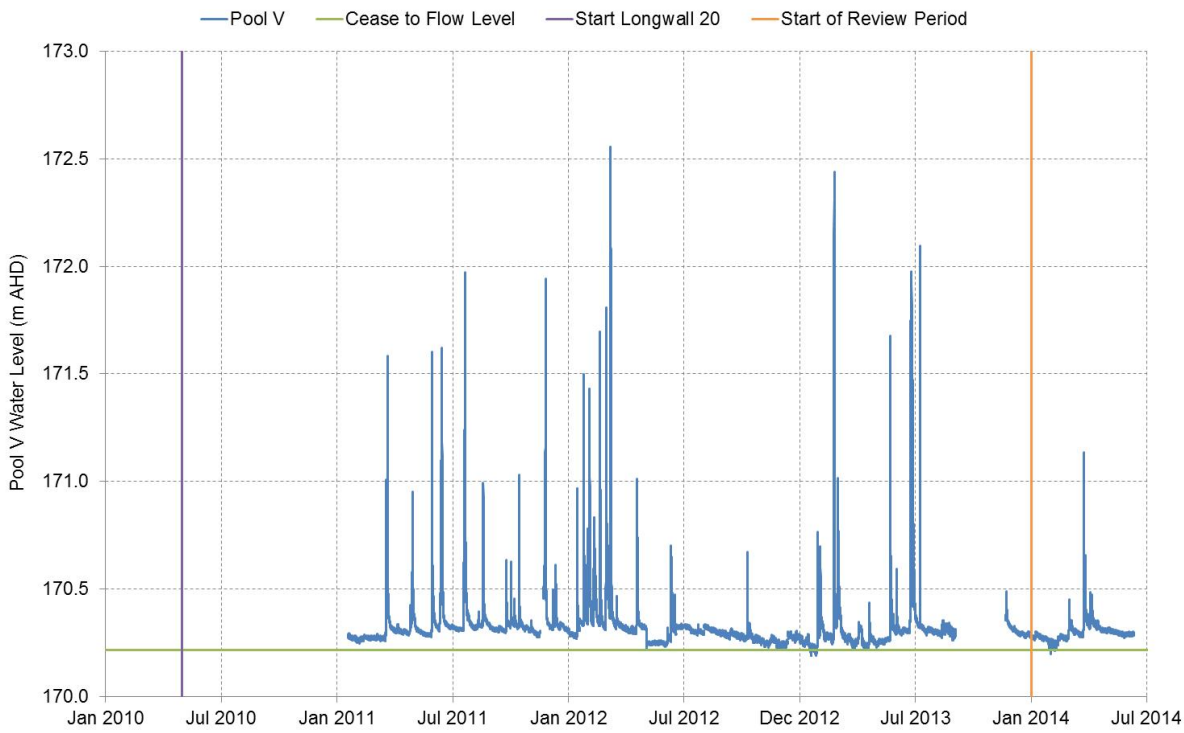


Chart B-25 Pool W - Recorded Pool Water Level