Groundwater

The conceptual model developed of the hydrogeological regime at Metropolitan Coal supports three distinct groundwater systems, including:

- Perched groundwater system – generally above and independent of the regional groundwater table.
- Shallow groundwater system – the shallow groundwater system is separate from the perched groundwater system and defines a regional water table.
- Deep groundwater system – although the shallow and deep groundwater systems are connected, low permeability of the Bald Hill Claystone provides a degree of isolation between the Hawkesbury Sandstone that hosts shallow groundwater and the underlying Bulgo Sandstone and deeper formations that host deep groundwater.

Metropolitan Coal's groundwater monitoring program includes monitoring of:

- swamp groundwater levels;
- shallow groundwater levels;
- deep groundwater levels/pressures;
- groundwater quality;
- inspections of mine workings; and
- mine water make.

The monitoring results are described below.

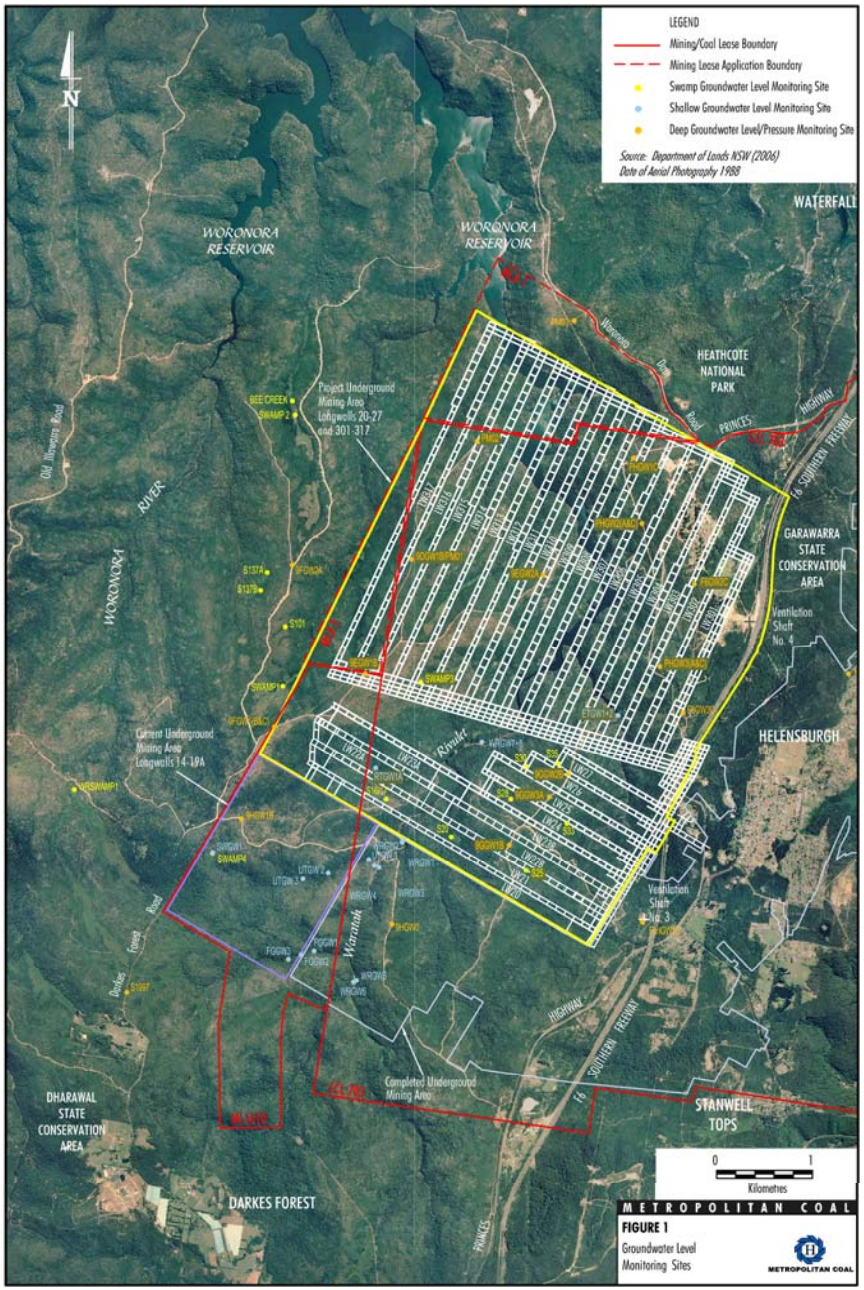
Swamp Groundwater Levels

Piezometers were installed in the following upland swamps in July 2010 to monitor groundwater levels (Figure 1):

- Valley side Swamps 16/17 overlying Longwalls 20-22 (sandstone piezometer to a depth of 10 metres [m]).
- Valley side Swamp 25 overlying Longwalls 20-22 (swamp substrate piezometer to a depth of 0.9 m and sandstone piezometer to a depth of 10 m).
- Valley side Swamp 101 (control - swamp substrate piezometer to a depth of 0.9 m and sandstone piezometer to a depth of 10 m).
- In-valley Swamp 20 overlying Longwalls 20-22 (swamp substrate piezometer to a depth of 0.9 m and sandstone piezometers to depths of 4 and 10 m).
- Headwater Swamp Woronora River 1 (WRSWAMP1) (control - swamp substrate piezometer to a depth of 0.9 m and sandstone piezometers to depths of 4 and 10 m).

Longer-term groundwater level data for upland swamps has been acquired with single piezometers at sites SWAMP1, SWAMP2 and SWAMP3, and paired piezometers at site SWAMP4 and SWGW1 (Figure 1).

Chart 1 shows that the perched groundwater levels at SWAMP1, SWAMP2 and SWAMP3 have a highly dynamic behaviour that is characterised by an immediate response to rainfall events, followed by fairly rapid recessions as water is lost by evaporation and evapotranspiration. The monitored sites are far from current mining, and there is no evidence of any change in behaviour due to mining.



Swamp Groundwater Levels (continued)

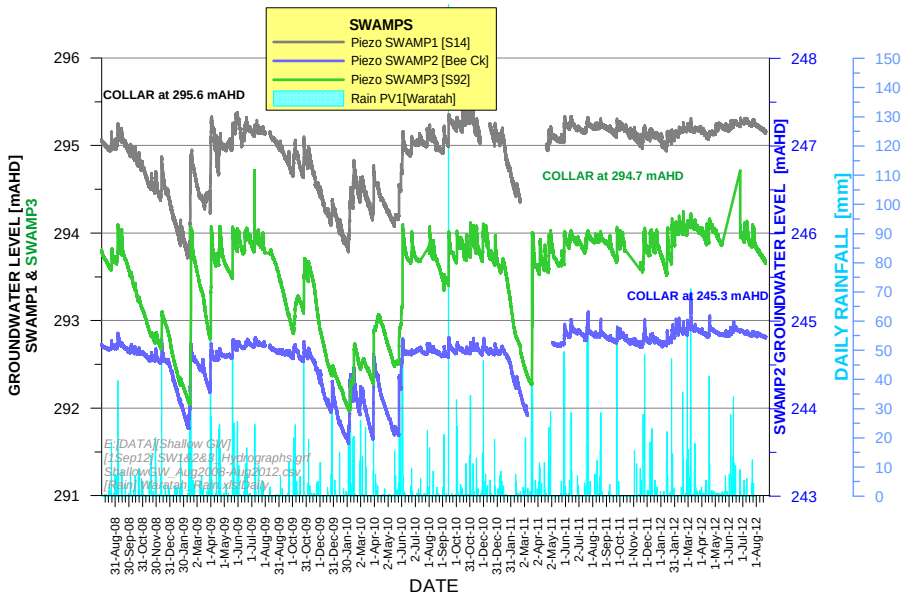


Chart 1 Perched Groundwater Hydrographs in SWAMP1, SWAMP2 AND SWAMP3

The groundwater levels in the paired piezometers at SWAMP4 and SWGW1 and their correlations to rainfall are shown on Chart 2. The groundwater levels at SWAMP4 are perched and hydraulically isolated from a deeper perched water table (or the regional water table) in the underlying sandstone aquifer (measured by site SWGW1).

SWAMP4 is considered to be characteristic of headwater upland swamps in that they typically obtain most of their moisture from direct rainfall infiltration. The water tables at SWAMP4 are about 3 m apart. There is a strong correlation between swamp and sandstone water level fluctuations which suggests either direct leakage from the swamp to the underlying sandstone, and/or direct rain recharge to adjacent sandstone with lateral groundwater flow to the sandstone beneath the swamp.

The residual mass curves are indicators of rainfall trends. During the review period, rainfall conditions have been wetter than normal. This has resulted in groundwater levels staying close to their maximum observed levels, indicating close to full saturation in the swamp.

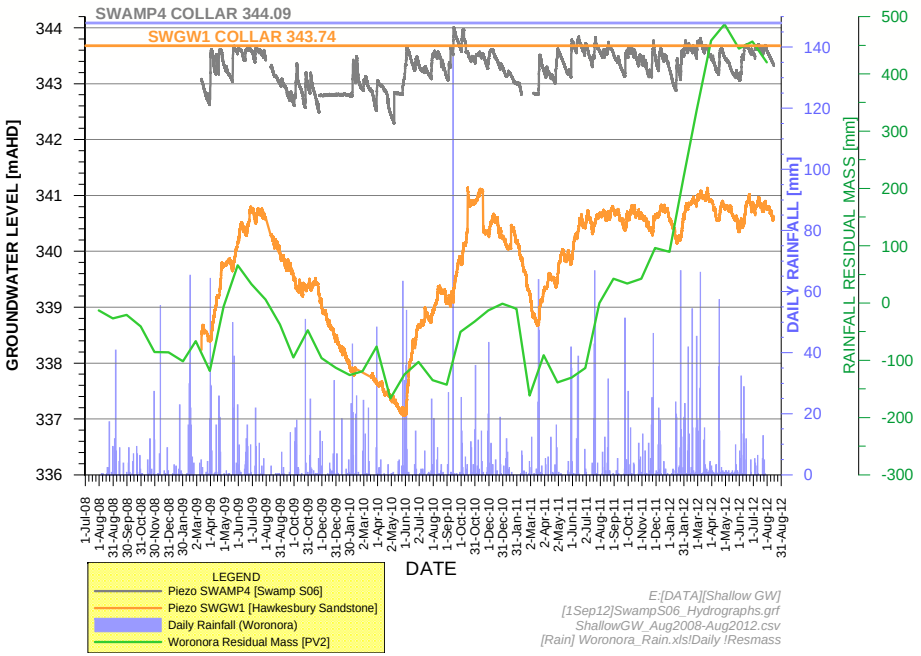


Chart 2 Separation of Water Tables at SWAMP 4

Swamp Groundwater Levels (continued)

The hydrographs at the two control swamps (SWAMP 101 and WRSWAMP1 [Figure 1]) are displayed in Chart 3 and Chart 4. Both sites show a pronounced drop in groundwater levels in February 2011, associated with a rainfall deficit, but there have been mixed responses during the review period. At SWAMP 101, the water tables are always separated, usually by less than 0.5 m, and groundwater flow direction is downwards. Water levels have remained close to full saturation levels during the review period. At site WRSWAMP1, the water level in the swamp (piezometer at 1 m depth) is always lower than the potentiometric level in the deeper sandstone piezometers. This suggests that the swamp is being recharged by groundwater from below and possibly from the sides. The swamp piezometer and the 4 m sandstone piezometer show good connectivity across the swamp/sandstone interface (except during January-March 2012), with separation from the groundwater head at the 10 m sandstone piezometer which reported rises in water level consistent with wetter conditions during the review period.

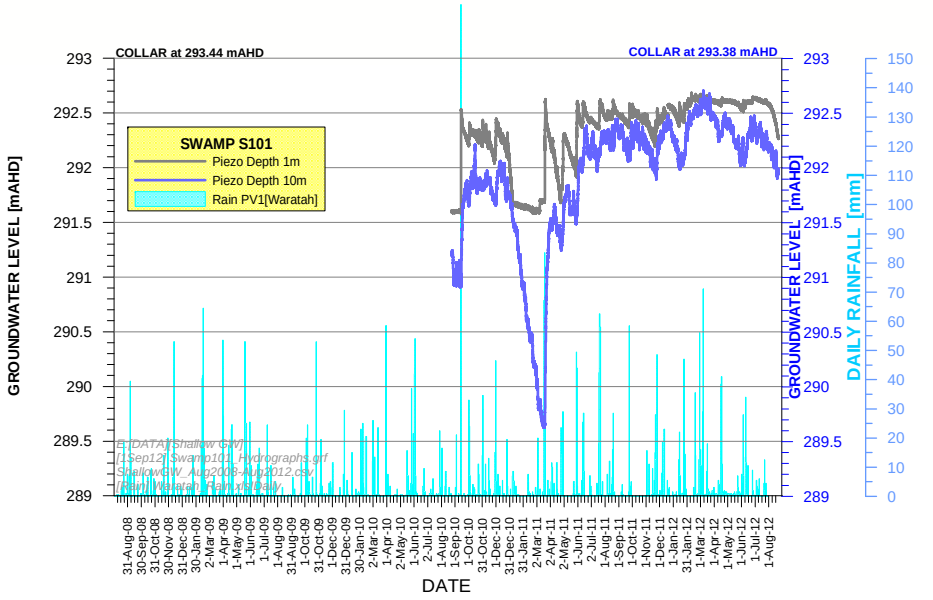


Chart 3 Groundwater Hydrographs at SWAMP 101

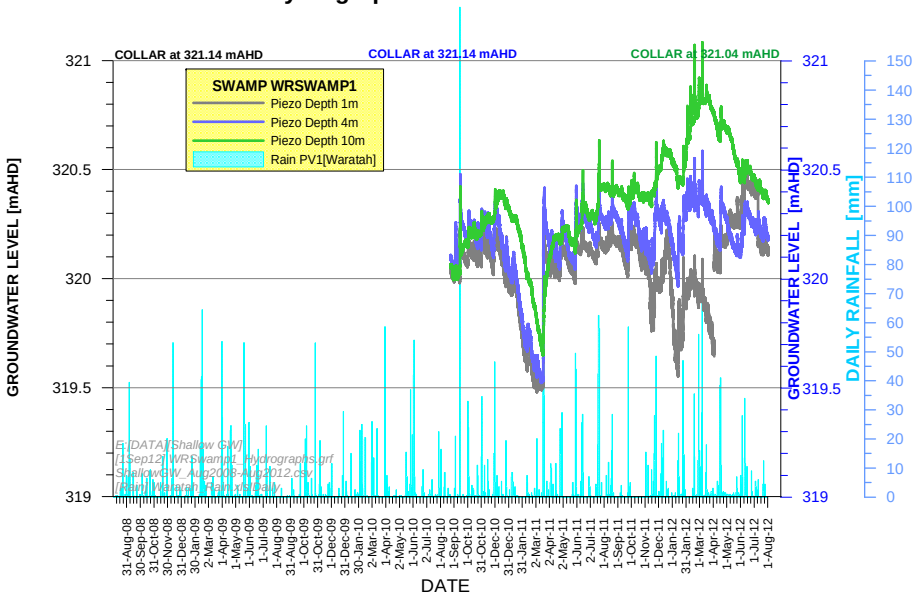


Chart 4 Groundwater Hydrographs at WRSWAMP1

Swamp Groundwater Levels (continued)

Hydrographic responses for the recently monitored swamps overlying or adjacent to Longwalls 20-22 (Swamp 16/17, Swamp 20 and Swamp 25) are displayed in Charts 5 to 7. All sites show a pronounced drop in groundwater levels in February 2011, associated with a rainfall deficit but there have been responses during the review period that are inconsistent with a climate effect.

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 during the review period until April 2012. The upper two piezometers showed no effect but there is evidence of a slight decline in the final month of the review period. It cannot be confirmed whether this is due to a climatic or a mining effect.

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. During the review period, the deeper water table has risen in response to generally wetter conditions.

Swamp 17 sandstone water levels were unaffected by passage of the Longwall 21 front. However, there is a downward trend from January to July 2012 which is inconsistent with climatic trends. This is possibly a post-mining effect.

The piezometer at Swamp 16 is located in weathered Hawksbury Sandstone at a 10 m depth. The water table at Swamp 16 dropped 5.2 m, commencing when the Longwall 21 face was approximately 600 m west of the piezometer. The water level reached a stable minimum as the Longwall 21 was directly below the piezometer and has maintained the new equilibrium for a period of eight months. Despite the decline the piezometer has not been drained.

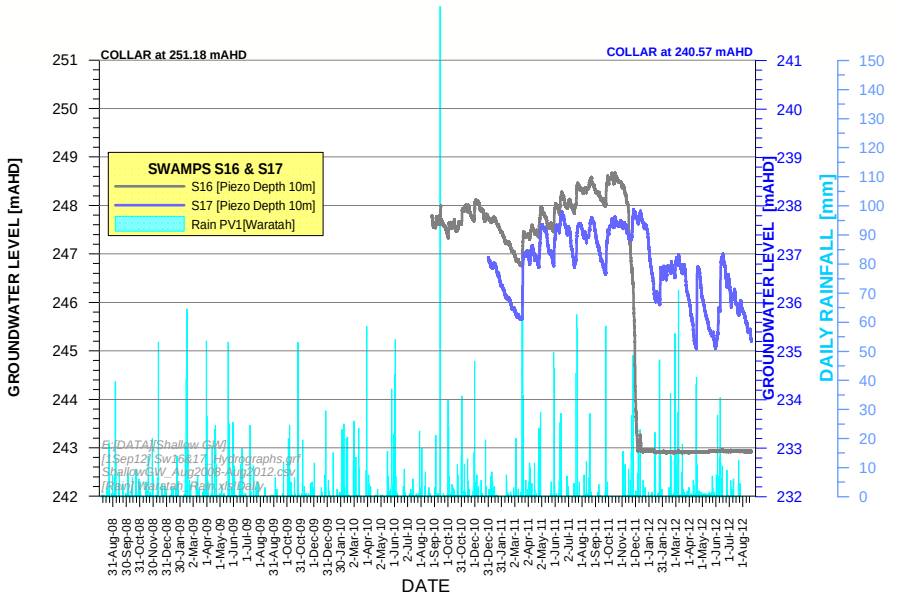


Chart 5 Groundwater Hydrographs at Swamp 16/17

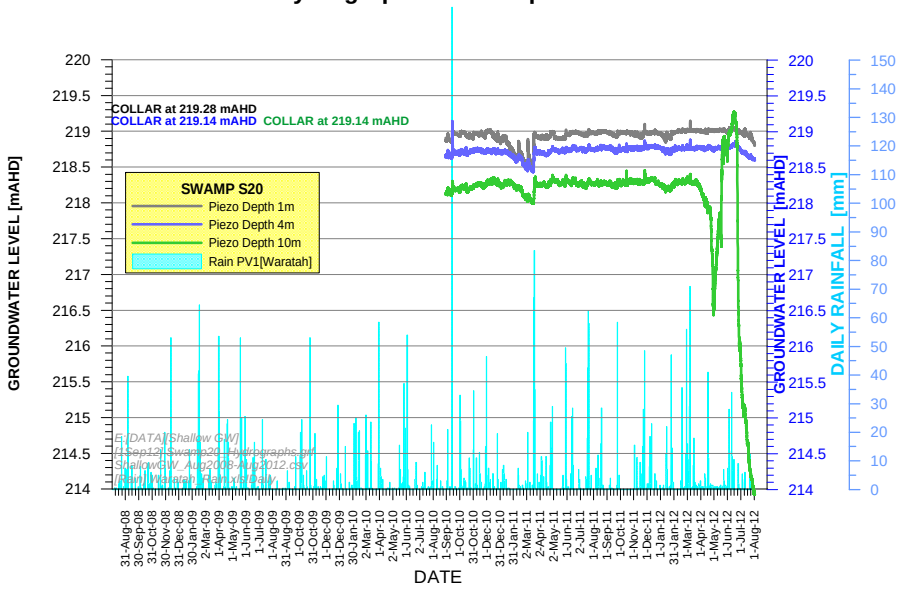


Chart 6 Groundwater Hydrographs Swamp 20

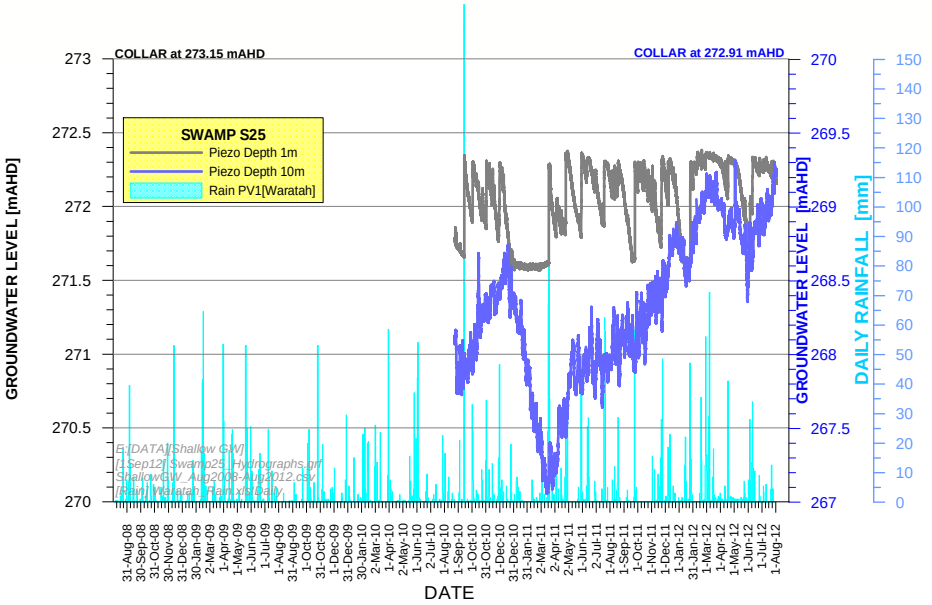


Chart 7 Groundwater Hydrographs at Swamp 25

Shallow Groundwater Levels

Continuous water level monitoring of shallow groundwater levels has been conducted at sites WRGW1 and WRGW2 along Waratah Rivulet upstream of Longwall 20, site RTGW1A on Tributary B over Longwall 22A, sites WRGW7 and WRGW8 along Waratah Rivulet downstream of Longwall 21, and sites ETGW1 and ETGW2 on the Eastern Tributary downstream of Longwall 21 (Figure 1).

Sites WRGW1 and WRGW2 are located on opposite banks of the Waratah Rivulet, to the immediate south of Longwall 20 (Figure 1). The groundwater level monitoring results for sites WRGW1 and WRGW2 are shown on Chart 8, and are compared with rainfall events over a period of four years as recorded at the Waratah Rivulet catchment PV1 pluviometer. Sites WRGW1 and WRGW2 show comparable information over the review period. 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. No similar response was observed with the passage of Longwall 20 a year earlier.

All Waratah Rivulet piezometers (i.e. WRGW1 to WRGW8, refer to Figure 1) show the same dynamic responses to stream flow interaction and rainfall, with rapid response to rainfall events. However, no other piezometers show a decline from March 2012. Down-gradient site WRGW8 does not exhibit the rapid recession observed at the other sites on the rivulet. Up-gradient sites (WRGW3 to WRGW6) have the greater response amplitude.

The down-gradient sites on the Eastern Tributary (ETGW1 and ETGW2) show an increase in water level of about 3 m from February to July 2012 (Chart 9). This coincides with a period of higher rainfall.

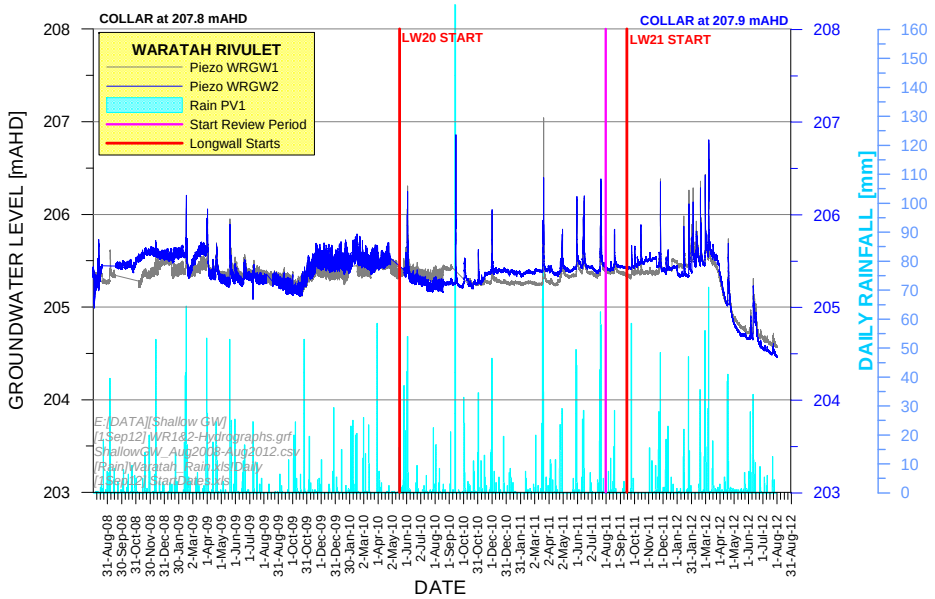


Chart 8 Shallow Groundwater Hydrographs on Waratah Rivulet at WRGW1 and WRGW2

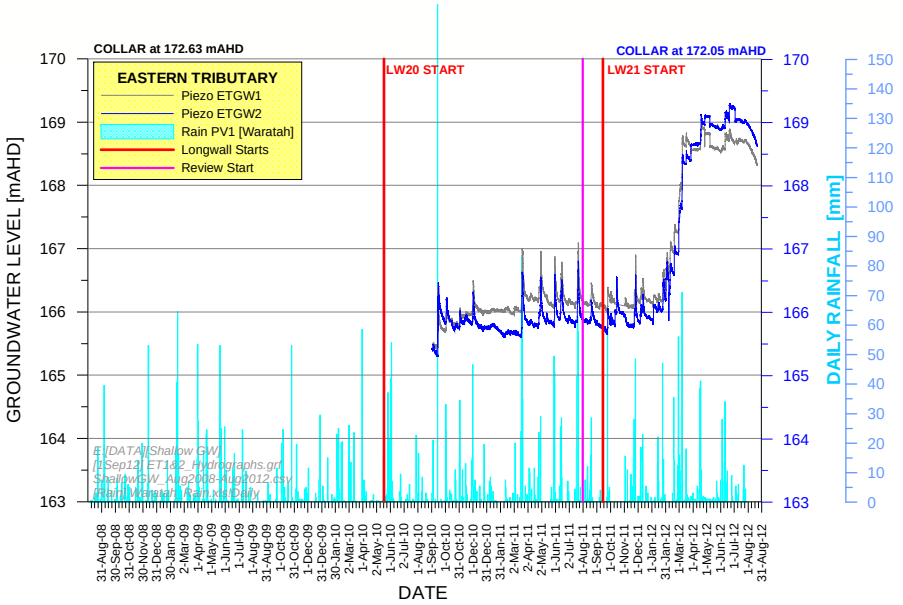


Chart 9 Shallow Groundwater Hydrographs on Eastern Tributary at ETGW1 and ETGW2

Deep Groundwater Levels/Pressures

Continuous groundwater level/pressure monitoring has been conducted at site 9EGW1B, site 9FGW1B, site 9GGW1B, site 9GGW2B, site 9HGW0 (Longwall 10 Goaf Hole), site 9HGW1B, site PHGW1, site PM01R, site PM02 and site PM03 (Figure 1).

The measured vertical hydraulic head profiles for these bores have been examined and selected stable bores compared against the predicted vertical hydraulic head profiles by Dr Noel Merrick, with the following outcomes:

- some installations are providing unreliable data;
- some vibrating wire piezometers have been slow to stabilise since installation, particularly those installed in claystones;
- sites close to current mining show significant depressurisation with depth, consistent with the Project Environmental Assessment;
- sites close to old workings at Helensburgh show substantial depressurisation with depth, consistent with the Project Environmental Assessment; and
- the pressure reductions with depth agree well with model predictions.

The monitoring sites closest to recent mining include site 9FGW1B (900 m north-west of Longwall 20) and site 9GGW1B (above Longwall 22) (Figure 1).

The time-series record for site 9FGW1B is shown on Chart 10. The two deepest peizometers (491 m in Wombarra Claystone; 513 m in Bulli Coal seam) have been slow to stabilise.

The excavation of Longwalls 20 and 21 might be responsible for the slow decline in head in the Scarborough Sandstone (piezometer at 455 m). However, it is unclear what effect mining has had on the Bulli Seam piezometer (at 513 m), due to unstable readings when Longwall 20 commenced. At the end of the review period, this piezometer seems to have stabilised with a substantial pressure head of about 280 m.

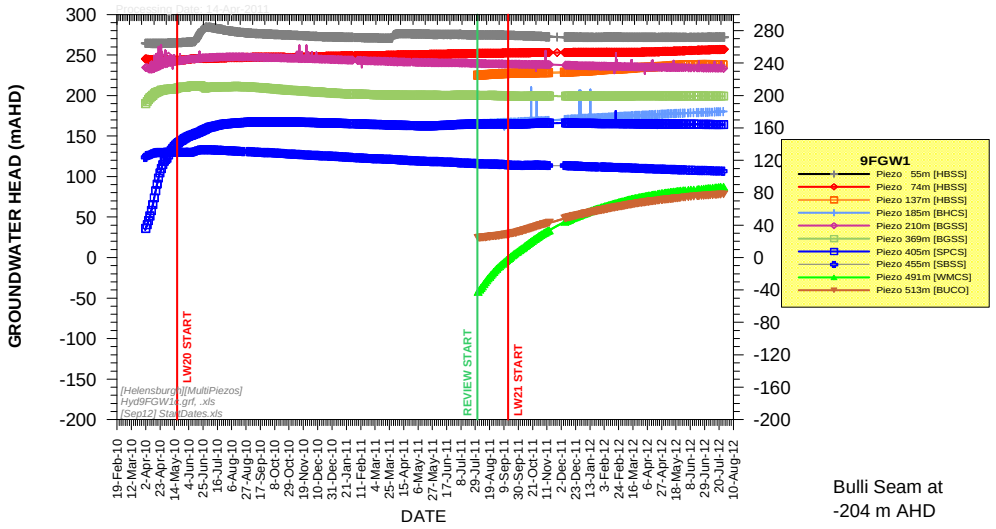


Chart 10 Time Variations in Potentiometric Heads at Site 9FGW1B

Deep Groundwater Levels/Pressures (continued)

The time-series record for site 9GGW1B is shown on Chart 11. Site 9GGW1B (located over Longwall 22 about 100 m from the nearest edge of Longwall 21) shows strong depressurisation below the Bulgo Sandstone, with heads about -10 to -20 m Australian Height Datum in the Scarborough Sandstone and the Coal Cliff Sandstone.

While the heads in this hole showed significant abrupt effects from Longwall 20 mining, the responses to Longwall 21 mining have been less abrupt. Nevertheless, there was a characteristic rise in pressure in the middle of the review period from the Bald Hill Claystone down to the lower Bulgo Sandstone as the longwall face approached the bore. As the longwall face passed the bore in July 2012, the pressure dropped sharply in the bottom seven piezometers. The Hawkesbury Sandstone peizometers appear to have been unaffected.

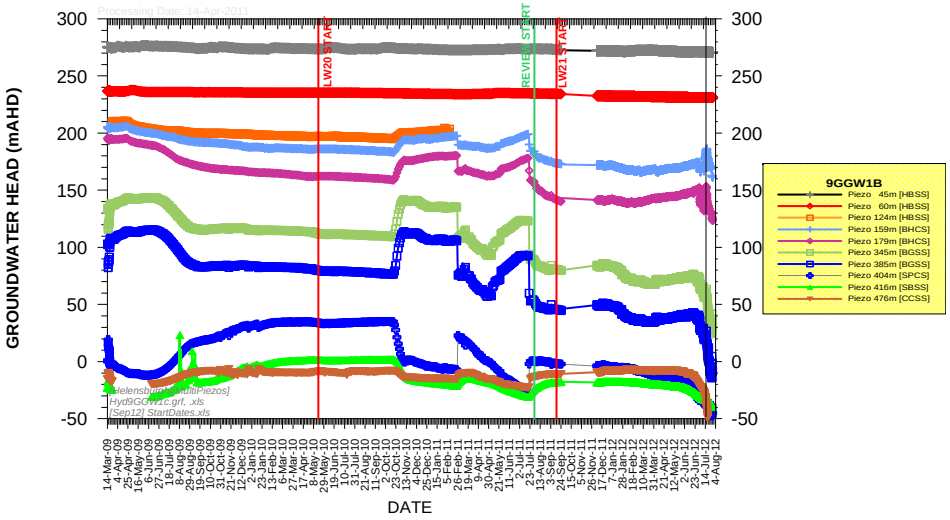


Chart 11 Time Variations in Potentiometric Heads at Site 9GGW1B

Groundwater Quality

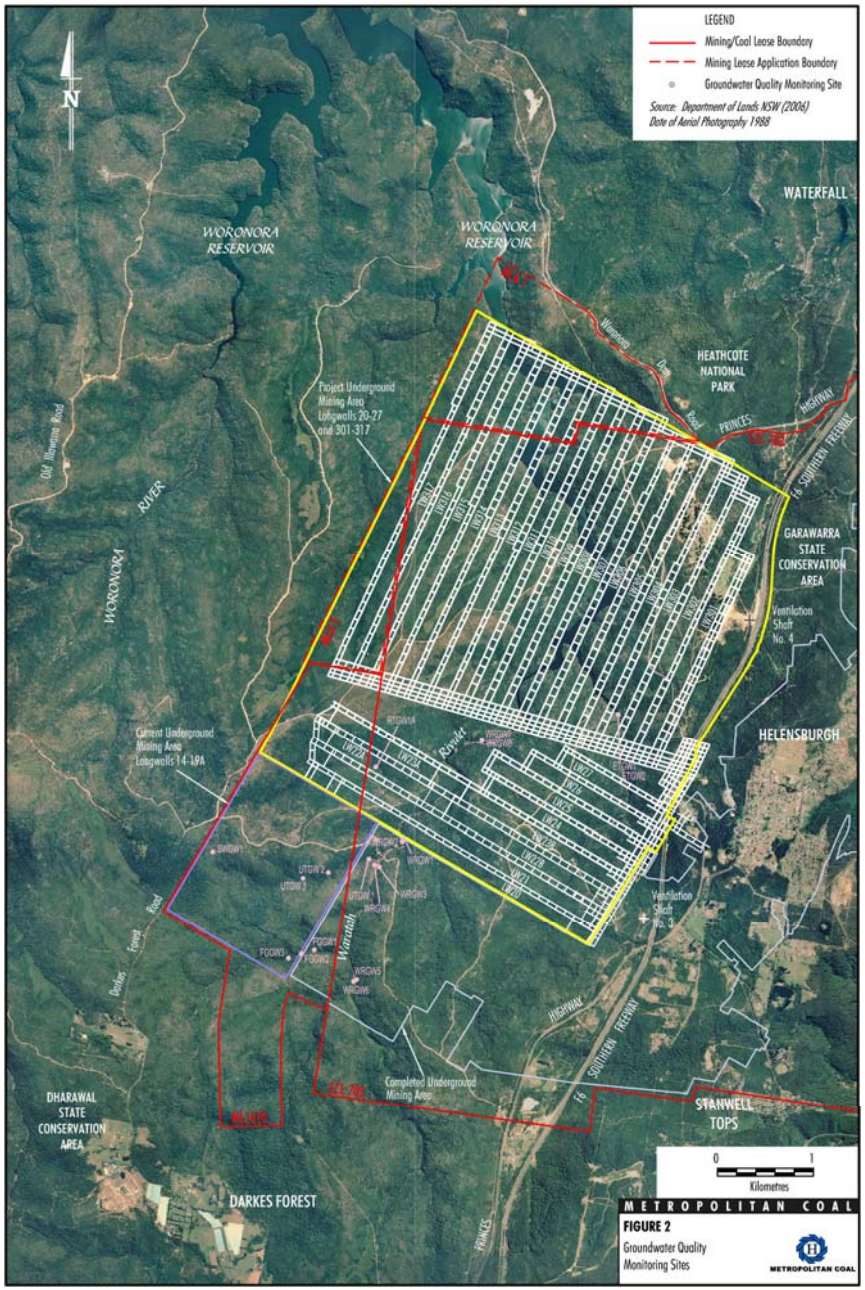
Shallow groundwater quality has been sampled monthly at sites WRGW1 and WRGW2 along the Waratah Rivulet and site RTGW1A adjacent to Tributary B (Figure 2). During the current review period, groundwater quality was monitored also at downstream monitoring sites WRGW7 and WRGW8 established on the Waratah Rivulet and ETGW1 and ETGW2 on the Eastern Tributary.

Water quality parameters sampled include electrical conductivity, pH, redox potential, calcium, magnesium, sodium, potassium, chloride, sulphate, bicarbonate, barium, strontium, manganese, iron, zinc, cobalt and aluminium. The samples collected for the analysis of cations, anions and metals have been field filtered.

Monitoring results for iron, manganese and pH levels at sites WRGW1 and WRGW2 are provided on Charts 12 to 14. Monitoring results for sites WRGW3 to WRGW8 are also shown on Charts 12 to 14 to show trends over the length of the Waratah Rivulet. Rainfall events over a period of four years, as recorded at the Waratah Rivulet catchment PV1 pluviometer, 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 WRGW8) are:

- iron concentrations are usually in the 1 - 10 milligrams/Litre (mg/L) range;
- peak value iron concentrations of 14 mg/L occur at WRGW1 and WRGW2;
- manganese concentrations are typically always less than 1 mg/L;
- groundwater is generally acidic with pH usually between pH 5.5 and 7;
- iron and manganese concentrations increase with distance downstream to WRGW1 and WRGW2 and then decrease to WRGW7 and WRGW8;
- aluminium was below the detection limit in all samples;
- there is no evidence of irregular behaviour during the mining of Longwall 21 (from September 2011); and
- there is a downwards trend in iron and manganese concentrations during the review period at WRGW1 and WRGW2.



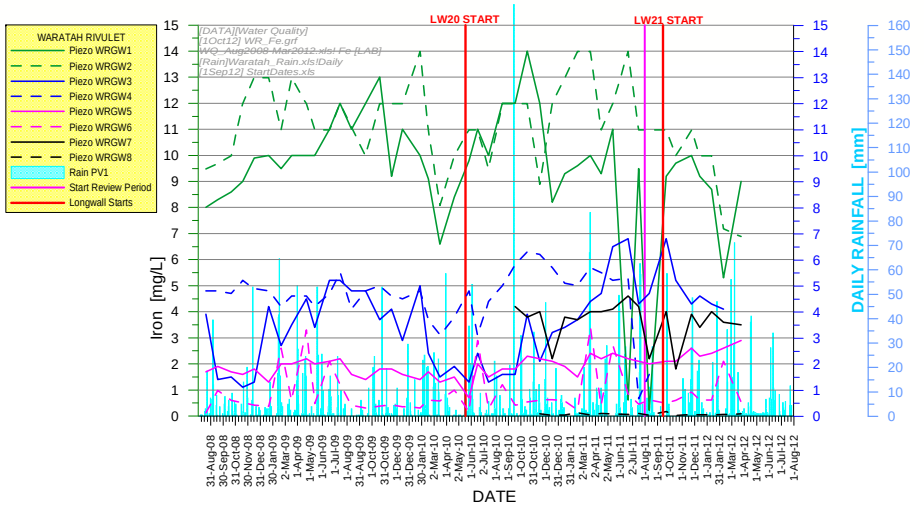


Chart 12 Iron Concentration at Sites WRGW1 to WRGW8

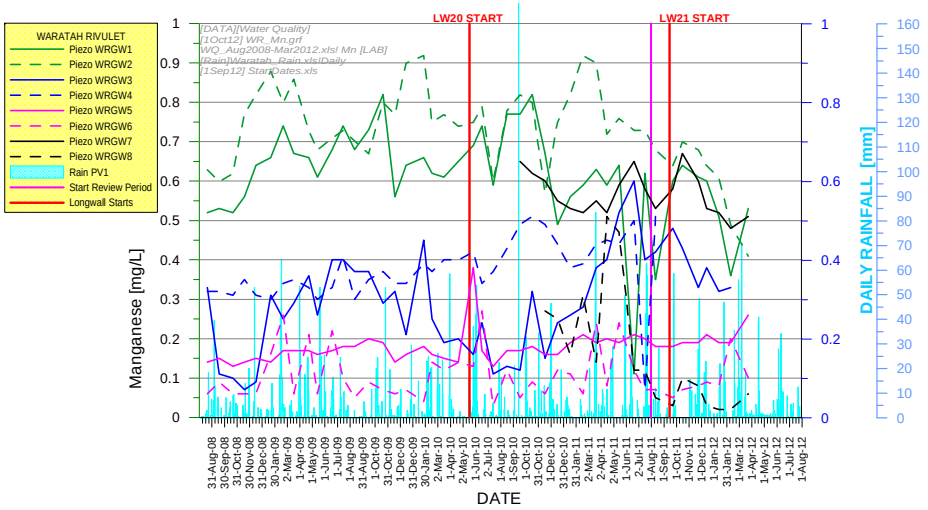


Chart 13 Manganese Concentration at Sites WRGW1 to WRGW8

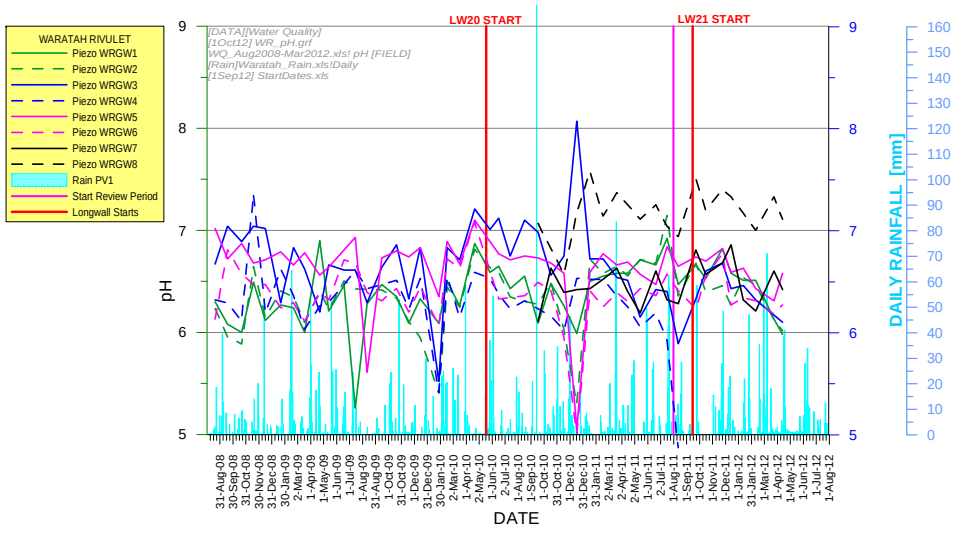


Chart 14 pH Levels at Sites WRGW1 to WRGW8

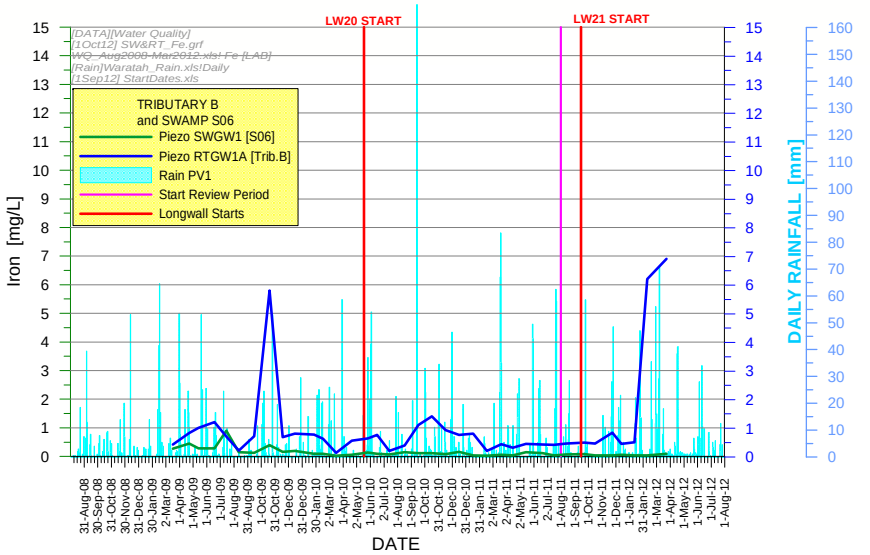


Chart 15 Iron Concentrations at Sites RTGW1A and SWGW1

Groundwater Quality (continued)

Site RTGW1A on Tributary B (north of Longwall 20) is sampled monthly for groundwater quality. To provide context for the monitoring results at site RTGW1A, comparison has been made with the up-gradient groundwater quality monitoring site SWGW1 (west of Longwall 18) (Figure 2), positioned in shallow Hawkesbury Sandstone. Groundwater quality at both sites is shown on Charts 15 to 17 for iron, manganese and pH. Rainfall events over a period of four years, as recorded at the Waratah Rivulet catchment PV1 pluviometer, provide a context for the moderate fluctuations in parameters; however, there is no obvious relationship with rainfall.

Iron concentrations are generally equal to or below 1 mg/L, with two isolated values of 6-7 mg/L at the end of the review period at site RTGW1A. A similar isolated value occurred prior to the commencement of Longwall 20. At the upland swamp, the iron concentration did not exceed 0.10 mg/L during the review period. Manganese concentrations are low at both sites, being always below 0.3 mg/L during the review period. Aluminium was below the detection limit in all samples. The groundwater at the upland swamp (site SWGW1) is acidic, generally around between pH 4 and pH 5, while the groundwater at site RTGW1A is generally neutral (pH generally around pH 6 to 7).

There is no systematic temporal pattern for any analyte, and neither site shows any irregularities due to the mining of Longwall 20 (from May 2010).

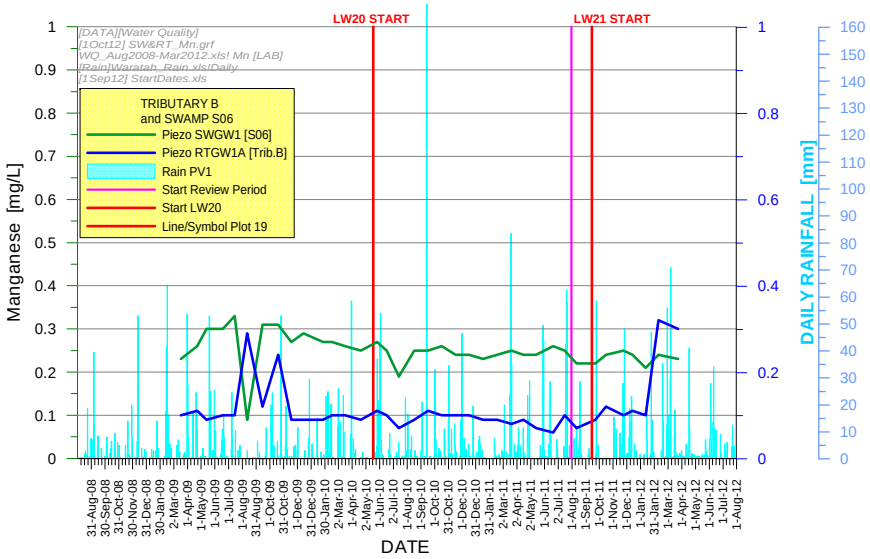


Chart 16 Manganese Concentrations at Sites RTGW1A and SWGW1

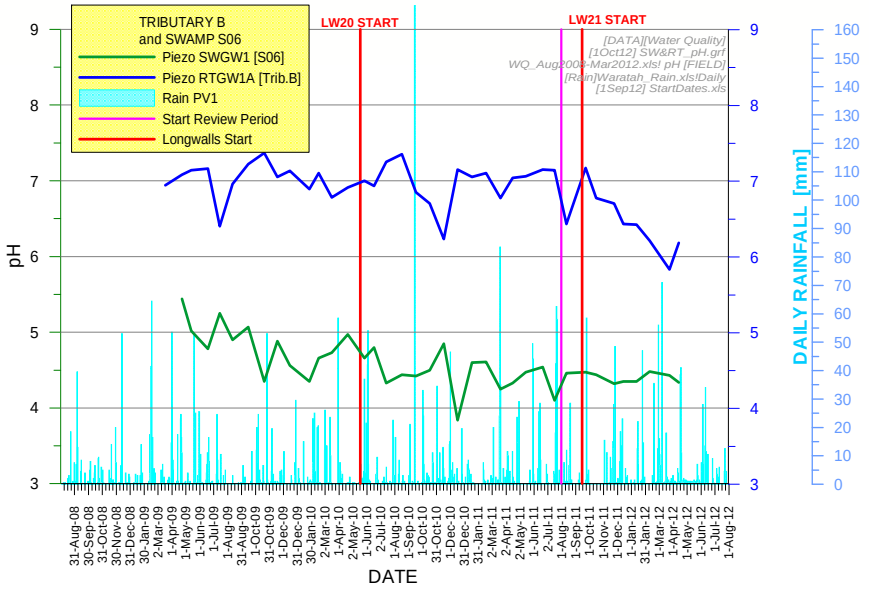


Chart 17 pH Levels at Sites RTGW1A and SWGW1

Groundwater Quality (continued)

Groundwater quality at the two Eastern Tributary sites (ETGW1, ETGW2) is shown on Charts 18 to 20 for iron, manganese and pH. Rainfall events over a period of four years, as recorded at the Waratah Rivulet catchment PV1 pluviometer, provide a context for the substantial fluctuations in parameters; however, there is no obvious relationship with rainfall.

Iron concentrations are high, ranging from 11 to 14 mg/L. Manganese concentrations are low at both sites, in the range 0.5 to 0.6 mg/L. Aluminium 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 21 (from September 2011).

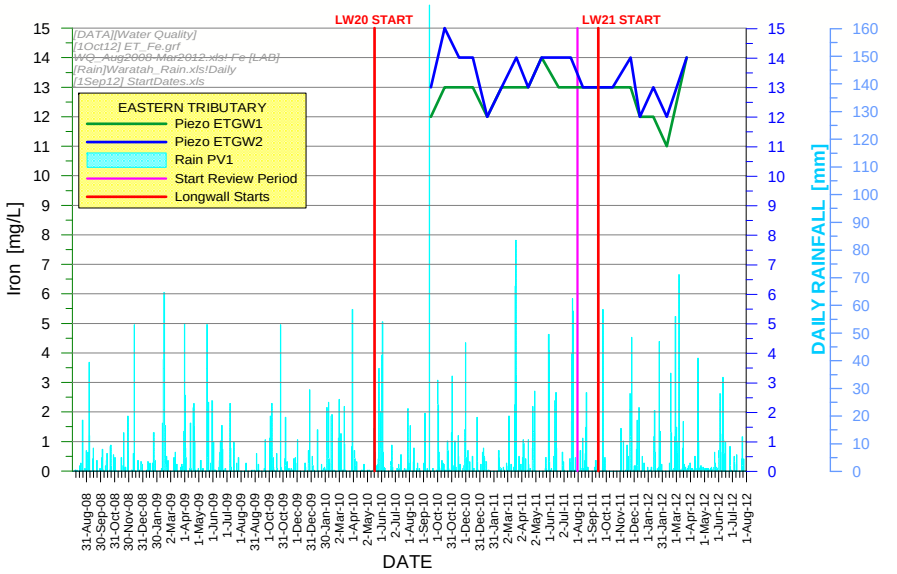


Chart 18 Iron Concentrations at Sites ETGW1 and ETGW2

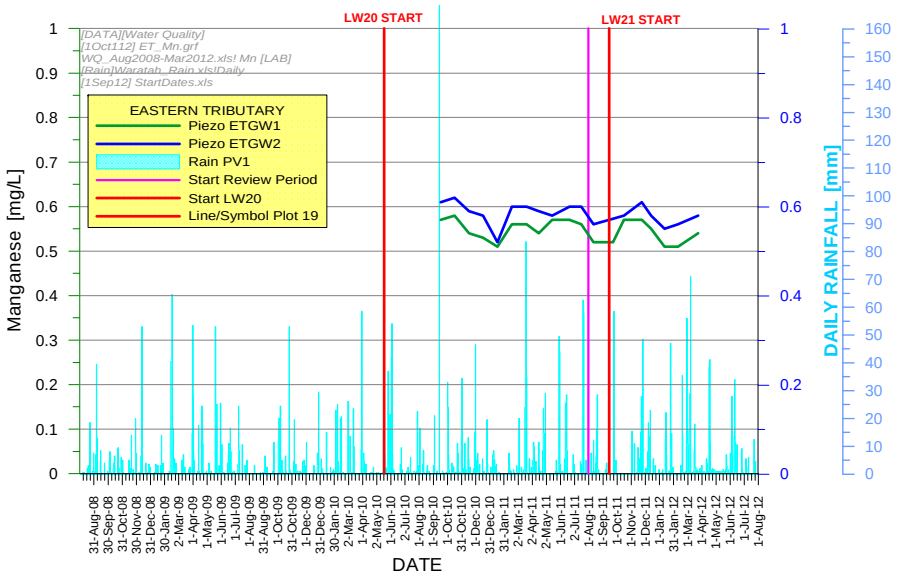


Chart 19 Manganese Concentrations at Sites ETGW1 and ETGW2

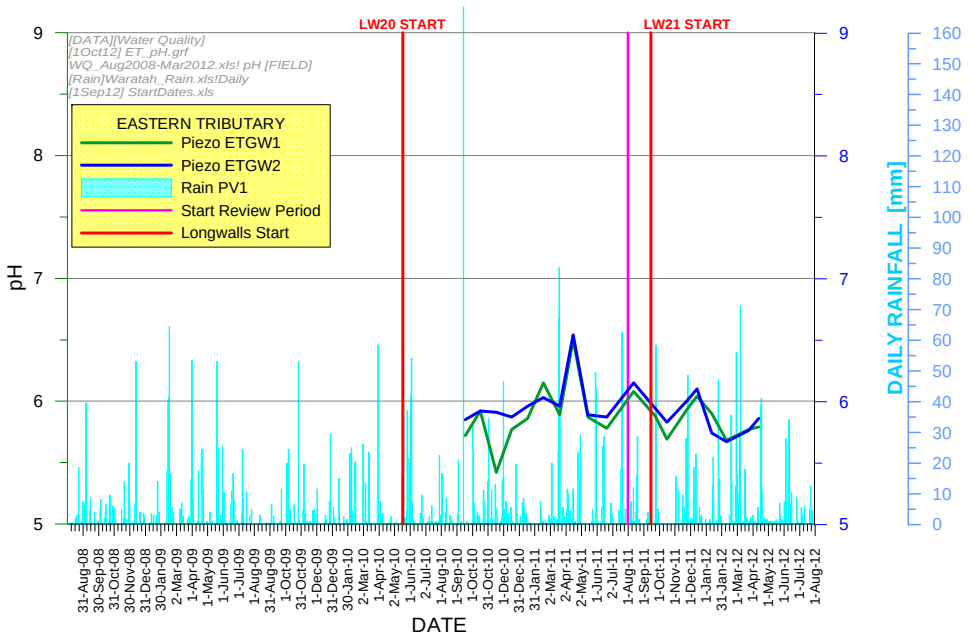


Chart 20 pH Levels at Sites ETGW1 and ETGW2

Mine Water Make and Inspections of Mine Workings

Metropolitan Coal conducts inspections of mine workings and monitors mine water make as indicators of potential connective cracking from the surface to the mine.

The inspections of mine workings have not identified any abnormal water flows from the goaf, geological structure, or strata generally.

Monitoring of the mine water balance includes calculation of the inferred water make. 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 run-of-mine 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 average daily water make during the review period was 0.084 megalitre/day (Chart 21). 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.

The inspections of mine workings, monitoring of mine water make and analysis of deep groundwater level/pressure results indicates that the following subsidence impact performance measures relevant to groundwater have not been exceeded:

No connective cracking between the surface and the mine.

Negligible leakage from the Woronora Reservoir.

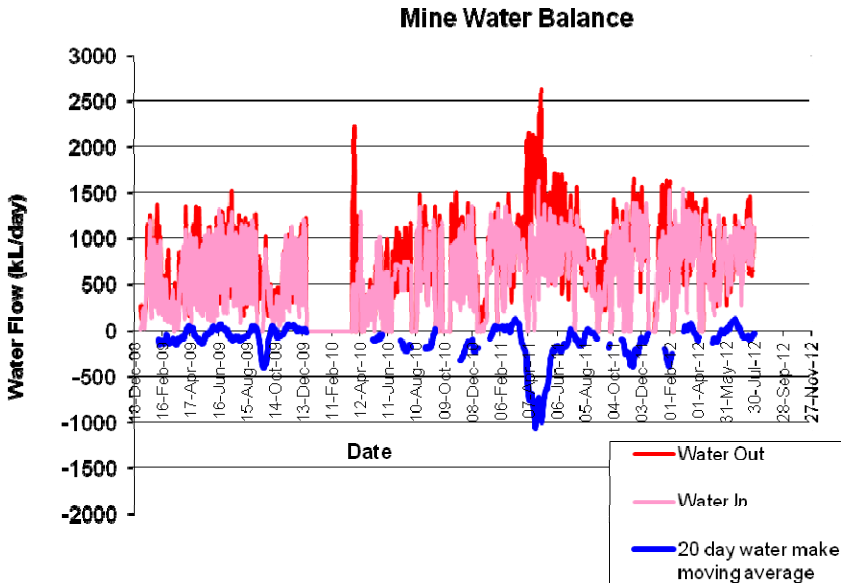


Chart 21 Estimated Daily Mine Water Make