LONGWALL 37 END OF PANEL REPORT ILLLAWARRA COAL

ATTACHMENT D – LONGWALL 37 END OF PANEL REPORT

SURFACE AND SHALLOW GROUNDWATER ASSESSMENT

ECOENGINEERS, MAY 2015

END OF PANEL

ASSESSMENT OF SURFACE WATER EFFECTS

WEST CLIFF COLLIERY LONGWALL 37

for

BHP BILLITON ILLAWARRA COAL

May 2015

ecoengineers Pty Ltd
9 Sunninghill Circuit
Mount Ousley NSW
Australia 2519

T: 61 2 4227 4174
F: 61 2 4227 5154
www.ecoengineers.com
ABN 74 078 666 510

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EXECUTIVE SUMMARY

West Cliff Longwall 37 was mined between 10 June 2014 and 30 January 2015. By 18 November 2014 the longwall was approximately 400 m from the Georges River.

This report reviews all available surface and shallow groundwater quality data for Georges River, which is situated to the east of Longwall 37, and for the upstream (first order) sections of Mallaty Creek and Nepean Creek. All field monitoring and laboratory data collected up to 5 February 2015 has been assessed herein.

There were no new impacts on the Georges River observed by the Illawarra Coal Environmental Field Team (ICEFT) during the mining period of Longwall 37.

Impacts resulting from prior Longwalls 35 and 36 were identified by ICEFT and these have been reported-on separately.

ICEFT did not observe any changes in pool water levels, flow diversions or significant new gas releases resulting from the mining of Longwall 37. However, two Level 2, one level 1 and five Level 2 re-occurring impacts during the Longwall 37 mining period were attributed by ICEFT to Longwall 35.

ICEFT field monitoring showed that during periods of low flow, iron staining was visible (from Pool 58 to downstream Pool 67). This iron staining was attributed to Longwall 35 extraction. When flows returned to higher levels there was no evidence of iron staining.

Based partly on the ICEFT field monitoring as well, Ecoengineers data assessments supported the view that there were:

- negligible diversions of flows or changes in the natural drainage behaviour of pools; and confirmed that there were
- no increases in nickel or zinc concentrations; and only
- negligible increases in water turbidity.

Ecoengineers water-related data assessments did however show there was a minor re-activation of gas releases in Pools 58, 59 and 60 over November and December but these terminated in early January 2015.

Hence it may be concluded that there were no subsidence-related impacts or environmental consequences for water quality or River flows other than minor.

In summary; Ecoengineers water-related assessments described herein confirmed that there were no *significant* water quality impacts observed or measured within the Georges River as a result of the mining of Longwall 37.

Our conclusions are based on statistical data analysis of the long-term water quality records for designated monitoring sites upstream and downstream of Longwall 37, i.e. Pools 54 and 64 respectively, in particular with respect to the pH TARP set out in the West Cliff Area 5 Longwalls 37 and 38 Extraction Plan which designated TARP Level 2 and Level 3 impacts as between 1.0 and 1.5, and exceeding 1.5 pH units respectively below the minimum baseline (Pool 54) value.

Other key water quality parameters such as pH, Dissolved Oxygen, Electrical Conductivity (a measure of salinity) and Oxidation Reduction Potential generally remained largely within expected levels (i.e. <2 standard deviations from the long term pre-mining means) during and immediately after the extraction of Longwall 37, in particular following approach of the longwall to within 400 m from the River.

Four gas releases had been observed in the vicinity of Pools 57, 58, 59 and 65 during the period of Longwall 35 mining. As noted above; no new gas zones were detected visually by ICFET during the period of mining Longwall 37.

However, our assessment of Dissolved Oxygen, pH, Electrical Conductivity and Oxidation Reduction Potential data indicated that the previous gas zones observed during the mining of Longwall 35 had reactivated during November and December 2014 but were not detected visually.

The Georges River is relatively shallow and has many rockbars, which gives the River a naturally high Re-Aeration Coefficient.

However, due to relatively low flows (and low local rainfalls) applying in the River in November and December 2014; this re-aeration effect had been insufficient to mask clear Dissolved Oxygen-consuming and weakly acid-generating effects of natural methanotrophic bacteria feeding on re-activated gas releases into Pools 58, 59 and 60 during November and December 2014.

The reactivated gas releases terminated early in January 2015.

With respect to the first order streams Mallaty Creek and Nepean Creek; which drain to the Nepean River, it is noted that each of these streams exhibit highly variable, and often low, Dissolved Oxygen concentrations. This is known to be quite common for streams in this area as a result of:

- limited re-aeration in farm dams and isolated stream pools during dry weather; and the
- often frequent access of stock to the creek lines leading to biological consumption of Dissolved Oxygen during aerobic decomposition of dung and urine deposited in the creek line.

There were significant elevations in Electrical Conductivity (i.e. salinity), Sulfate, Total Manganese and Nickel and Zinc concentrations at Mallaty Creek sites MC100 and MC110 as discussed in Section 2.

However, given the agricultural context; these elevations were considered minor consequences only of the induction of a small saline-non-ferruginous spring in the creek line below Mallaty Creek site MC110 *during the prior mining of Longwall 36*.

Electrical Conductivity (salinity) and laboratory data for dissolved sulfate confirmed that a minor saline spring had been induced in Mallaty Creek during the prior mining of Longwall 36 and that spring had continued to seep during the mining of Longwall 37. The spring was seen to be manganiferous, but non-ferruginous, and also not acid-producing.

The observed elevations in Nickel and Zinc were considered unrelated to any mining effects and were too low to be of any ecological impact.

There were no detectable impacts within Nepean Creek during the mining of Longwall 37.

There was no significant water quality or water level effects in boreholes GR27, GR27, GR70, WC54 and WC95 during or following completion of Longwall 37.

1. INTRODUCTION

Ecoengineers Pty Ltd ('Ecoengineers') was engaged by BHP Billiton Illawarra Coal ('BHPBIC') to provide an assessment of whether there has been:

- any sub-bed flow diversions or water quality effects in the Georges River; and/or
- any water quality effects in the local first order streams Mallaty Creek and Nepean Creek resulting from the mining of West Cliff Longwall 37 between 10 June 2014 and 30 January 2015; and
- whether any such effects identified might have a significant current and/or future water-related environmental impact.

1.1 REGIONAL CONTEXT AND BASES OF ASSESSMENT

The eastern part of the SMP Area drains into the Georges River, while the land in the central and western parts of the SMP Area drain through Mallaty Creek and Nepean Creek, which in turn drain into the Nepean River (refer **Figure 1.1** below).

The Georges River arises approximately five kilometres south east of the township of Appin from where it flows northwards past Campbelltown to Botany Bay.

The stretch of the Georges River passing by the eastern end of Longwall 37 is moderately incised with Hawkesbury Sandstone outcropping to the east and Wianamatta Shale to the west (of the River). The depth of the river valley is between 20 and 35 m with Hawkesbury Sandstone forming the bedrock.

The natural gradient of the Georges River within the SMP Area varies between <1 mm/m and 50 mm/m with an average gradient of approximately 8 mm/m. During dry and low natural flow conditions the major part of the flow in the Georges River is primarily controlled by the Environmental Protection Authority (EPA) licensed discharge from West Cliff Colliery (LDP10).

There are no significant tributaries of the Georges River in the vicinity of Longwall 37. However, two first order streams (Mallaty and Nepean Creeks) are in the Longwall 37 general SMP area and these drain west into the Nepean River.

Mallaty Creek is not located directly above Longwall 37; it generally flows in a westerly direction until it joins Ousedale Creek. The natural gradient of the creek within the general SMP Area varies between 10 mm/m and 250 mm/m, with an average of approximately 60 mm/m.

Nepean Creek flows generally in a north-westerly direction until it joins the Nepean River. The headwaters of Nepean Creek lie above Longwall 37. The natural gradient of the creek within the SMP Area varies between 10 mm/m and 170 mm/m, with an average gradient of approximately 50 mm/m.

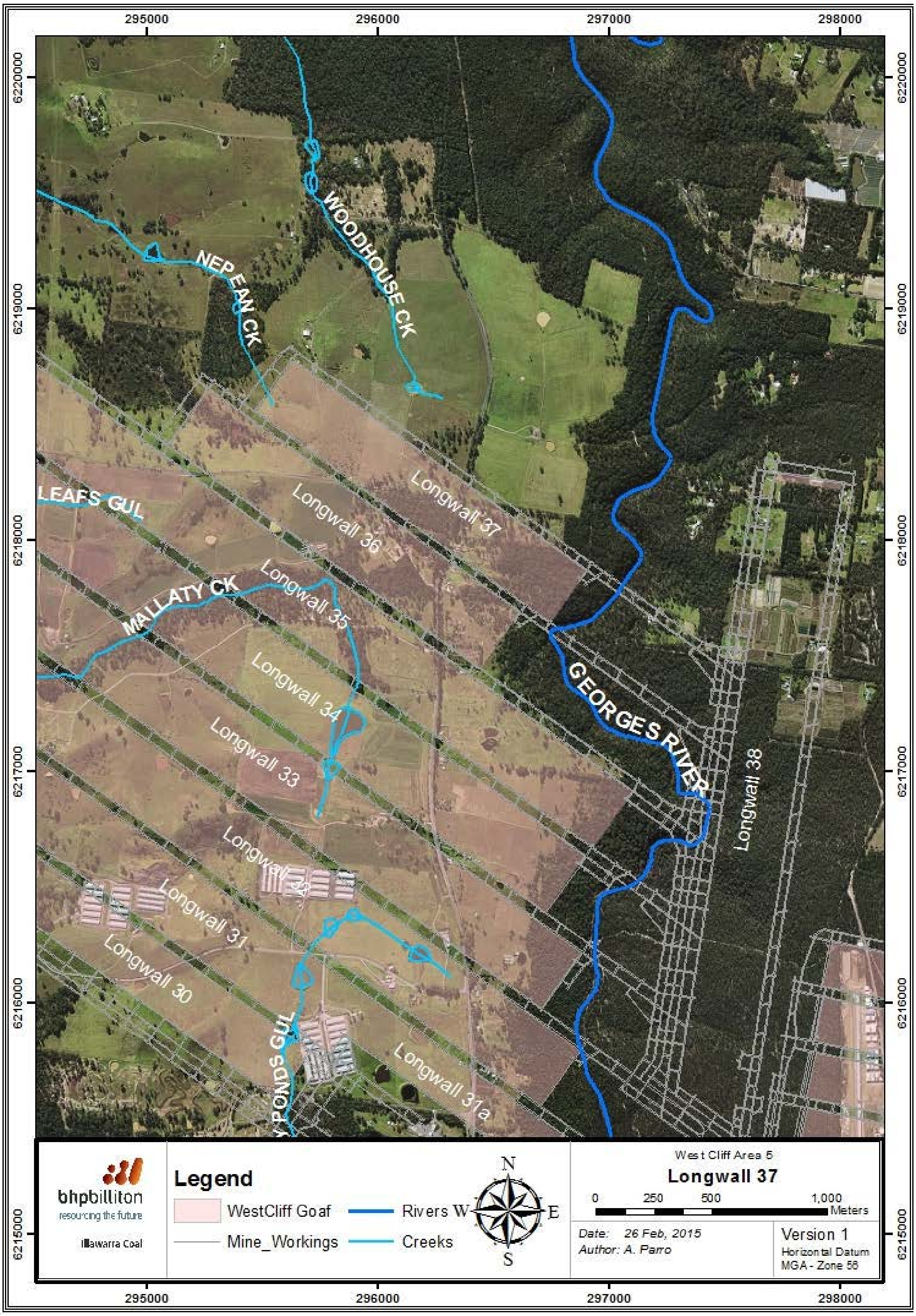

Figure 1.1: Location of watercourses in relation to Longwall 37 (ICEFT, 2015b).

2. WATER QUALITY MONITORING

2.1 Georges River

The BHPBIC monitoring program for Georges River **(ICEFT, 2015b)** is presented below in **Table 2.1**. Locations of the field water quality and flow monitoring sites are as shown below in **Figure 2.1**. The Trigger Action Response Plans ('TARPs') associated with the monitoring are provided in **Appendix 1**.

The key components of the monitoring program provide a basis for the comparison of flow, pool level and water quality in Georges River before, during and after mining impacts as outlined in the West Cliff Area 5 Longwalls 37 and 38 Extraction Plan (BHP Billiton Illawarra Coal, 2014). The TARPs began when Longwall 37 reached a distance of 400 m from the River. This date has been conservatively set at 18 November 2014.

Table 2.1 – WEST CLIFF LONGWALLS 37 & 38 WATER QUALITY MONITORING.

Monitoring Site	Monitoring Type	Monitoring Frequency	Monitoring to Date and Recommendations
SURFACE WATER QUALITY			
Longwall 37			As stated in the Extraction Plan. Post-mining monitoring for Mallaty Creek has been undertaken since April 2014, it is recommended that this monitoring cease. Refer to Section 3 of this report (Recommendations for Further Monitoring) for additional information.
Georges River Upstream monitoring site: • Pool 54 Downstream monitoring site: • Pool 64	• Field testing of water quality parameters • Grab sample for testing of specific analytes at an accredited laboratory • Water level measurements (using benchmarks where they can be installed and/or photos) • Observational and photographic monitoring	•Monthly before and after mining •Weekly during mining (when the longwall is within 400 m)	
Mallaty Creek Downstream monitoring sites: • MC100, MC106 and MC110			
Nepean Creek Downstream monitoring site: • NC10			
Tributary of Georges River Downstream monitoring site: • GR104 and 105			

Monitoring Site	Monitoring Type	Monitoring Frequency	Monitoring to Date and Recommendations
GROUNDWATER			
BHPBIC piezometers: • GR27 • GR28 • GR29 • GR70 • WC54 • WC95	• Field testing of water quality parameters and grab sample for testing of specific analytes at an accredited laboratory (where access is available to the water) • Water level (measured and logged at least twice daily)	• At least one pre-mining sample • One sample following the completion of Longwall 37 • One sample following the completion of Longwall 38	As stated in the Extraction Plan, except GR29 which is inaccessible due to equipment malfunction and unable to be monitored.
Private bores: • GW32310 • GW72454 • GW105921 • GW108322	• Monitoring as agreed in Property Subsidence Management Plans or as requested by landholder	• One pre-mining level measurement and water sample • One post mining level measurement and water sample	Private boreholes were inspected where access to the properties was secured. Monitoring conducted as agreed with the landholders. S2087 is non-functional and was rehabilitated in 2011.
BHPBIC piezometer: • S2087	• Vibrating wire piezometers within a cemented hole (note that some are damaged due to ground shear)	• Monitoring of functional piezometers	
Groundwater inflows to the mine	• Mine water budget • Statutory inspections	• Flow meters	As stated in the Extraction Plan.

LANDSCAPE FEATURES, VEGETATION AND WATERCOURSES				
	All mapped cliffs, steep slopes and pools within the mining areas, including: • Cliffs GR-CL01 and GR-CL02 • Georges River – all mapped pools and rockbars (GR-RB42, GR-RB43, GR-RB44, GR- RB45, GR-RB47, GR-RB48, GR-RB49, GR-RB51, GR-RB52, GR-RB53, GR-RB54, GR-RB55, GR- RB56a, GR-RB56b, GR- RB57, GR-RB59, GR-RB60, GR-RB61, GR- RB62, GR-RB63, GR-RB64, GR-RB65, GR- RB66, GR-RB67) • Tributaries (GR103, GR104, GR105, GR107, GR108, GR110, GR114)	Site inspections include: • General inspection of active subsidence areas • Re-visits to identified impact sites • Measurement of pool water level	• Monthly before and after mining • Weekly during mining (when the longwall is within 400 m)	As stated in the Extraction Plan.

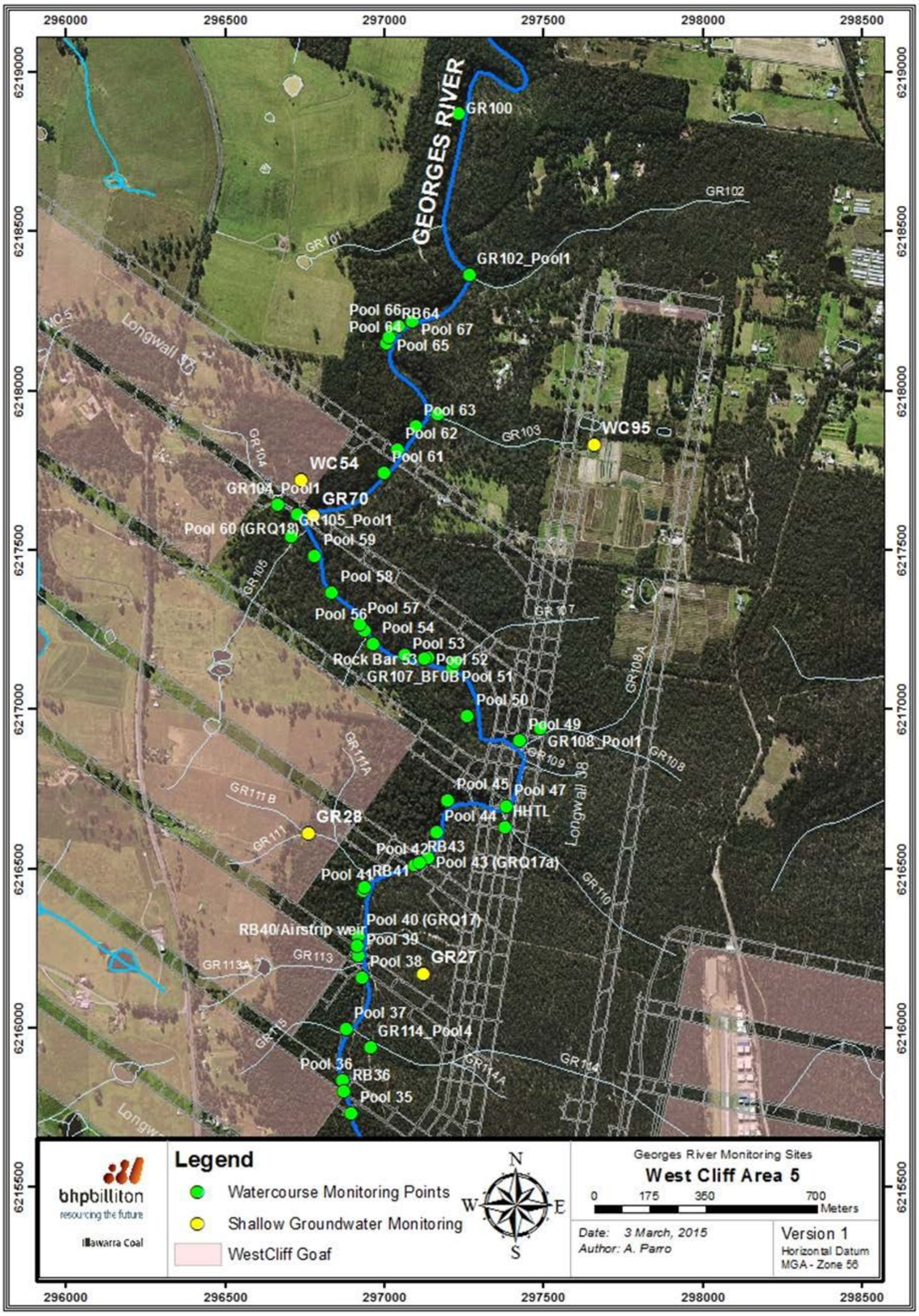

Figure 2.1: Locations of Georges River water quality and flow monitoring sites (ICEFT, 2015b).

The West Cliff Mine Water Management System (WMS) has two EPA licensed discharge points under its Environment Protection License (EPL) 2504 for discharge of excess water from the WMS, namely just below the spillway of Brennans Creek Dam (BCD) - Licensed Discharge Point 1 (LDP1) and Licensed Discharge Point 10 (LDP10), which is a piped discharge of water from BCD mixed with dam wall seepage and spring water that accumulates in the Reclaim Pond near the (downside) base of the BCD wall.

Until late June 2013, discharges from BCD through LDP10 were from a large drain valve at the base of the dam, which discharged ‘bottom’ waters from BCD.

This was changed in line with the EPL 2504 Pollution Reduction Program (PRP) 18. PRP18 required that the BCD off-take be changed to a floating off-take, with the aim to “improve the overall quality of, and reduce the ecological risks due to, discharges from BCD via discharge point 10”.

Since August 2004, when the present WMS was introduced, BCD spillway (LDP1) discharges became very rare and flows in the River have been dominated by the discharge from LDP10, which has exhibited a mean pH of 8.47±0.31 (at the one standard deviation level, n=1389) and a mean Electrical Conductivity (EC) of 2496±440 µS/cm (at the one standard deviation level, n=1408).

As **Figure 2.1** above shows, monitoring is and has been conducted at a number of sites in the Georges River upstream of Longwall 37.

Analysis of these data can of course be potentially confounded by the effects of past mining adjacent-to and under the River as well as both natural and mining-related ferruginous springs which release groundwater into the River.

In addition, changes to the mine water discharge from BCD can also influence water quality monitoring between sites as changes in flow rate and/or water quality come into effect.

Three monitoring sites were chosen for assessing mining impacts on water quality based on their proximity to the location of Longwall 37 and the lengths of their monitoring records.

The monitoring sites of main significance for the assessments provided by this report were:

- The designated upriver (of Longwall 37) monitoring site: Pool 54
- The designated adjacent impact monitoring site: Pool 60 (“Blackburn Road”, GRQ18); and
- The designated downriver monitoring site: Pool 64.

To establish the upstream baseline water quality dataset, only the pre-mining body of data at Pool 43 (GRQ17a) was used, i.e. all available data prior to the commencement of Longwall 34 on 6 February 2010.

Other sites further upriver were considered to be inapplicable due to a greater influence of the West Cliff Mine licensed discharge and of reduced influence of potential inflows from minor springs etc.

Salinity in Georges River

Figure 2.2 below shows the salinity (as Electrical Conductivity; EC) in Georges River from 1 January 2009.

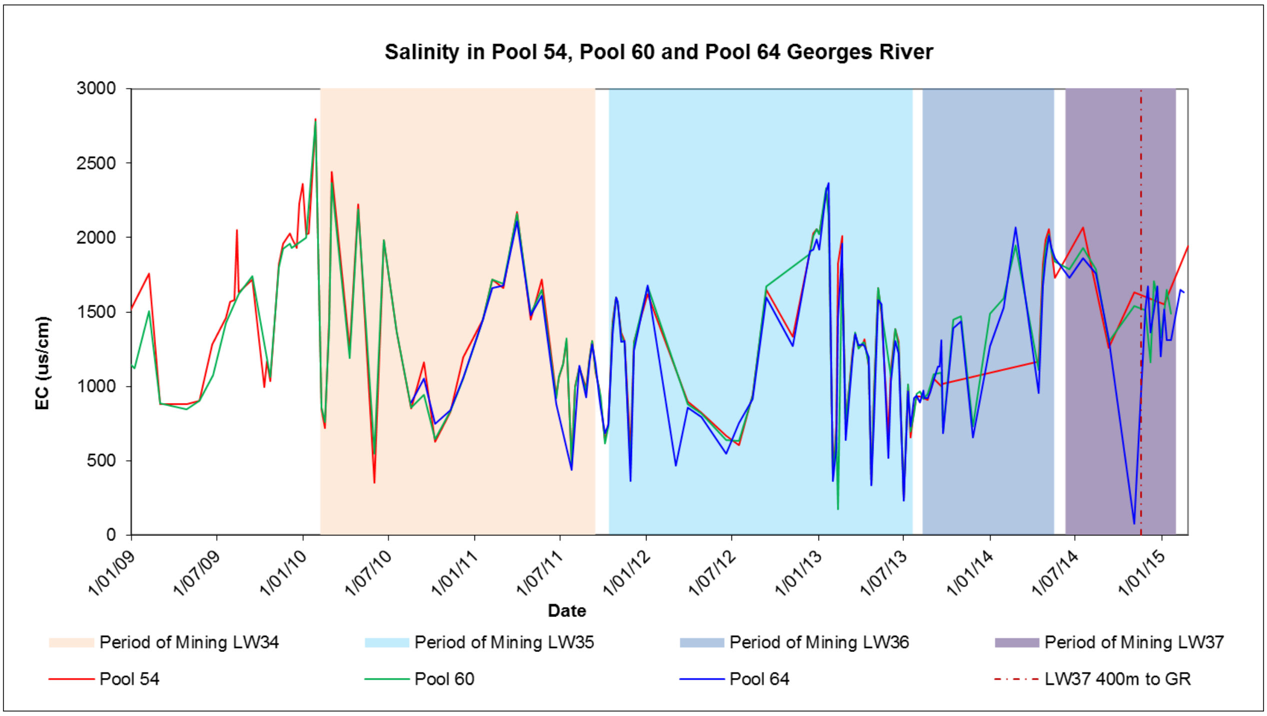

Figure 2.2: Salinity in Georges River upriver, adjacent to, and downriver sites for Longwall 37 since January 2009.

From the data above; it can be seen that there has not been any significant increases in EC at any of the above three pools as a result of the mining of Longwall 37.

pH in Georges River

Figure 2.3 below shows the pHs recorded at Pools 54, 60, and 64 since 1 January 2009.

*Note that the vertical line in **Figure 2.3** and all subsequent figures identifies the point at which mining of Longwall 37 was within 400 m from the river.*

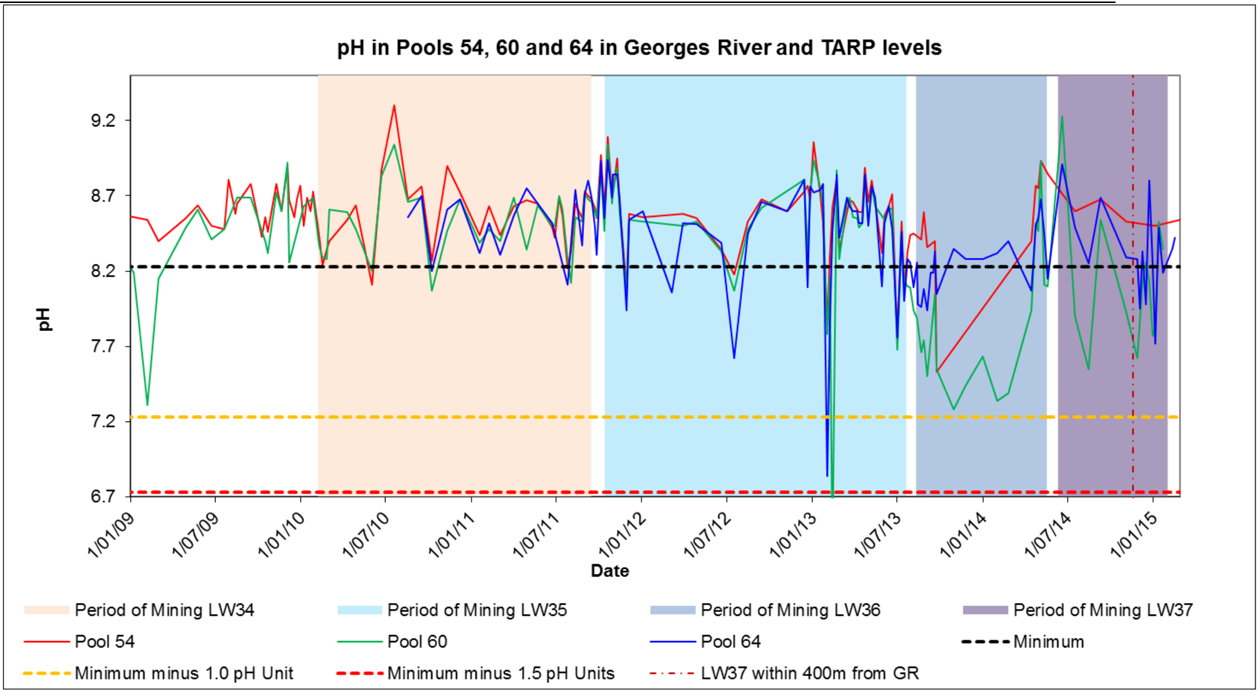

Figure 2.3: pH in Georges River upriver, adjacent to and downriver of Longwall 37 since January 2009.

As shown in this **Figure 2.3** above, pH levels observed after mining of Longwall 37 approached within 400 m from the Georges River (18 November 2014) were shown to be consistently within -1.0 pH units of the pre-existing minimum baseline value for pH at Pool 54 (8.23) and hence the Level 2 TARP was not triggered.

Figure 2.4 below shows the levels of DO saturation recorded at Pools 54, 60 and 64 since 1 January 2009.

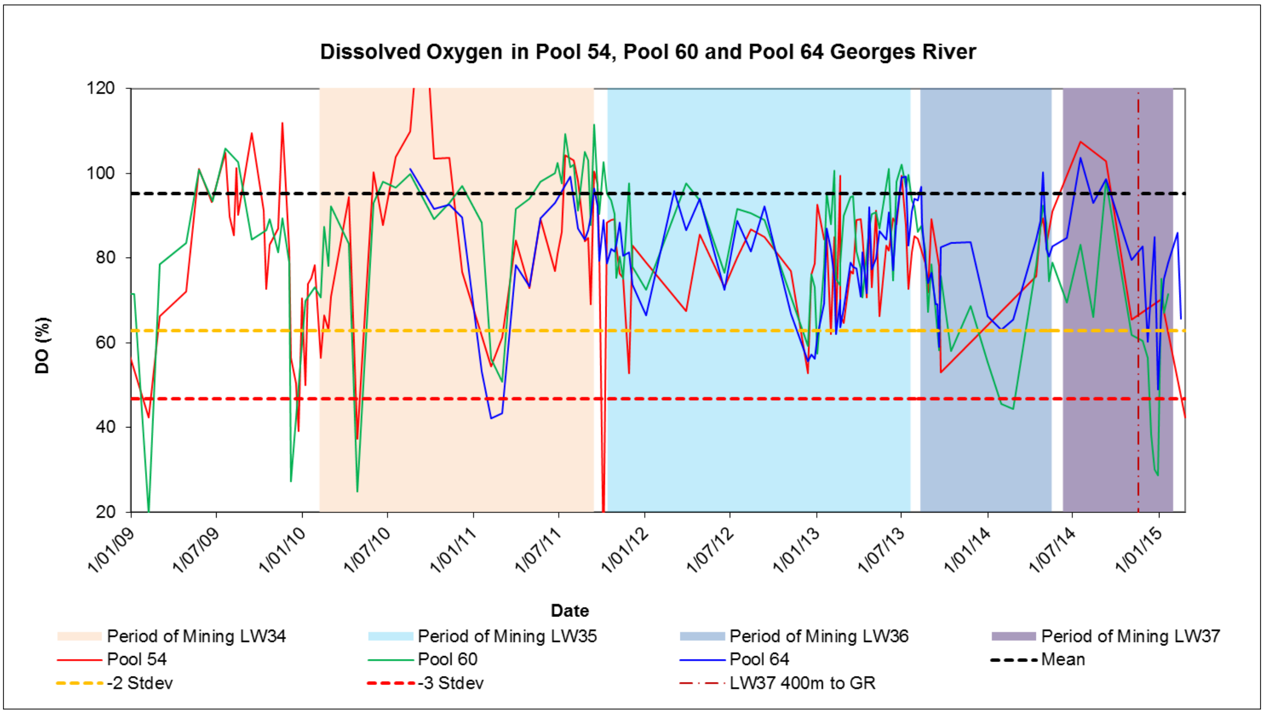

Figure 2.4: Dissolved Oxygen in Georges River upriver, adjacent to and downriver-of Longwall 37 since January 2009.

Gas releases can occur as a result of the fracturing or dilation of near-surface strata, such as Hawkesbury Sandstone, which is considered to be the source of gas releases that have been observed in the Nepean River (Ecoengineers, 2008). Gas emissions derived from Hawkesbury Sandstone consist mainly of methane (CH_4), as well as carbon dioxide and trace amounts of higher-order hydrocarbons.

Four gas releases were observed during the period of Longwall 35 mining, (Ecoengineers, 2013). No new gas zones were detected visually by ICFET during the period of mining Longwall 37 (ICEFT, 2015b).

However, **Figure 2.4** above shows that DO levels at Pool 60 were below minus 3 standard deviation from the previous Longwall 36 GR17 (Pool 43) baseline mean (i.e. 95.3±16.2% saturation) i.e. below 46.7% saturation on various occasions and at Pool 64 levels below minus 2 standard deviations i.e. below 62.9% saturation twice after 4 November 2014 i.e. from just prior to the approach of Longwall 37 within 400 m of the River and up to the end of December 2014.

We investigated this matter further and in **Figures 2.5 through 2.10** below show the DO and pH transects at Pools 57, 58, 59, 60, 61, 62, 63 and 64 on 4 November 2014, 29 December 2014 and 5 January 2015 respectively.

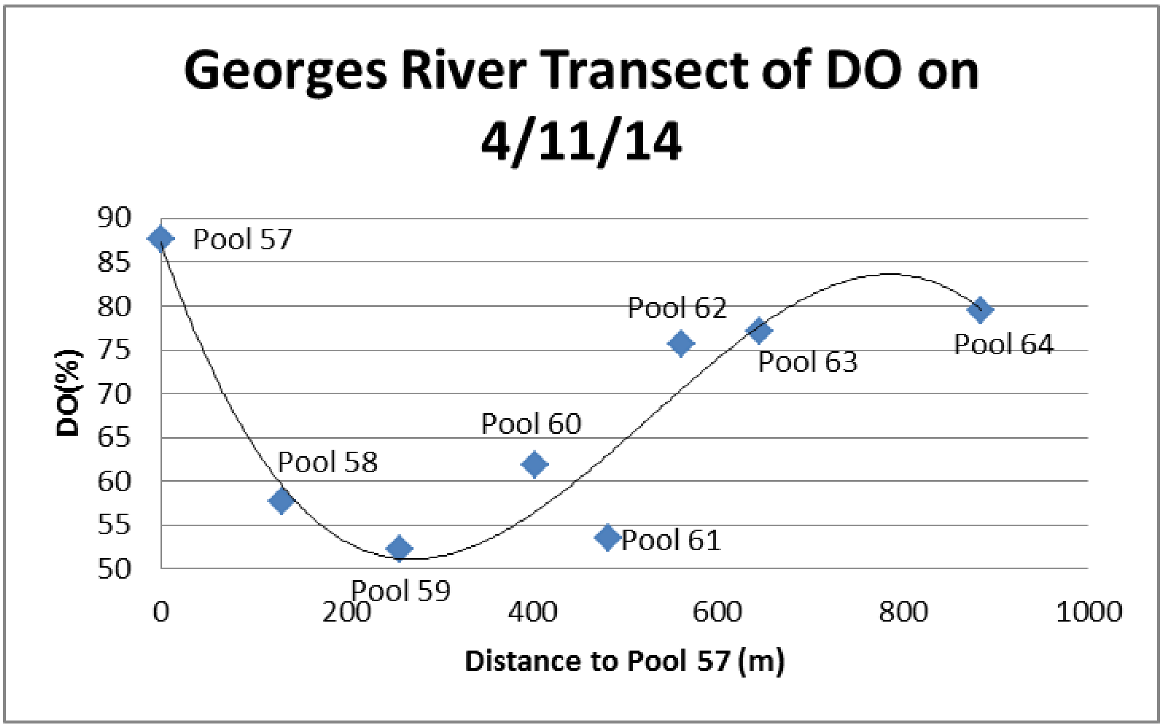

Figure 2.5: Dissolved Oxygen Transect in Georges River 4 November 2014.

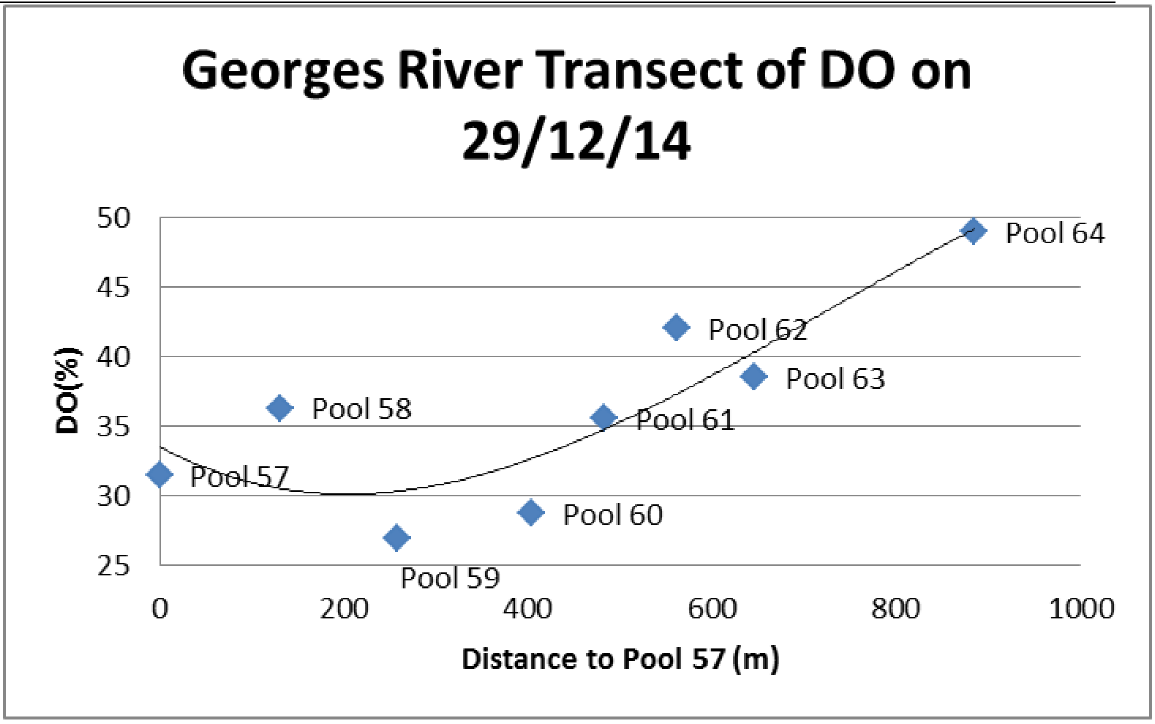

Figure 2.6: Dissolved Oxygen Transect in Georges River 29 December 2014.

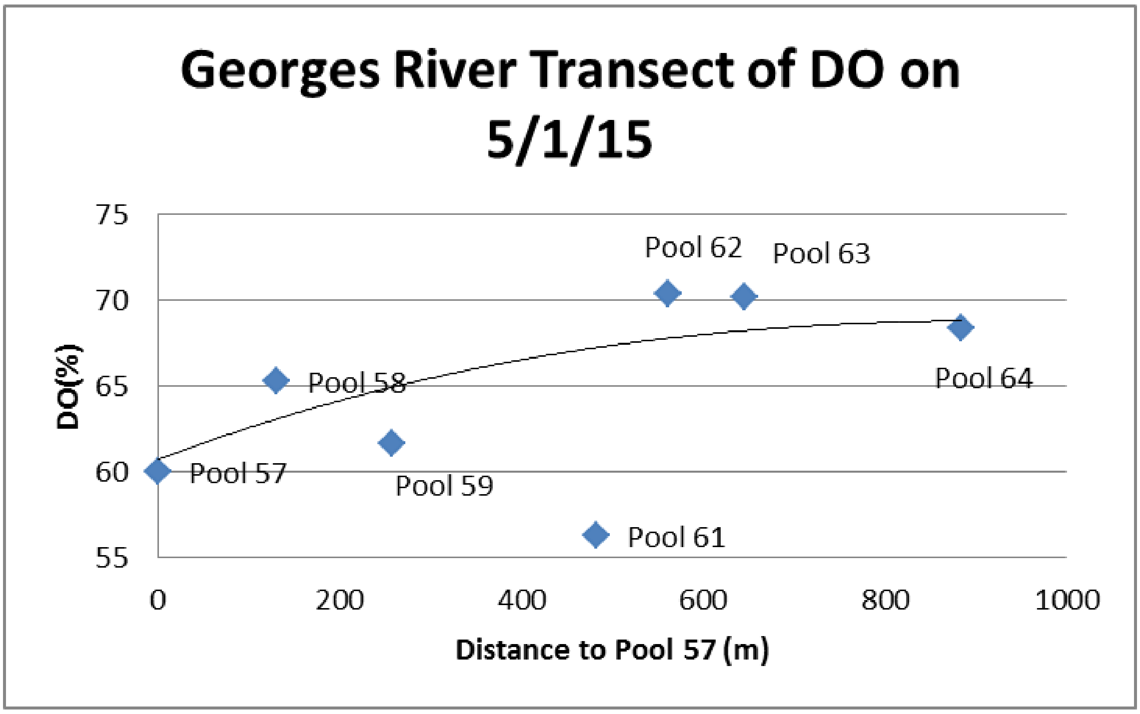

Figure 2.7: Dissolved Oxygen Transect in Georges River 5 January 2015.

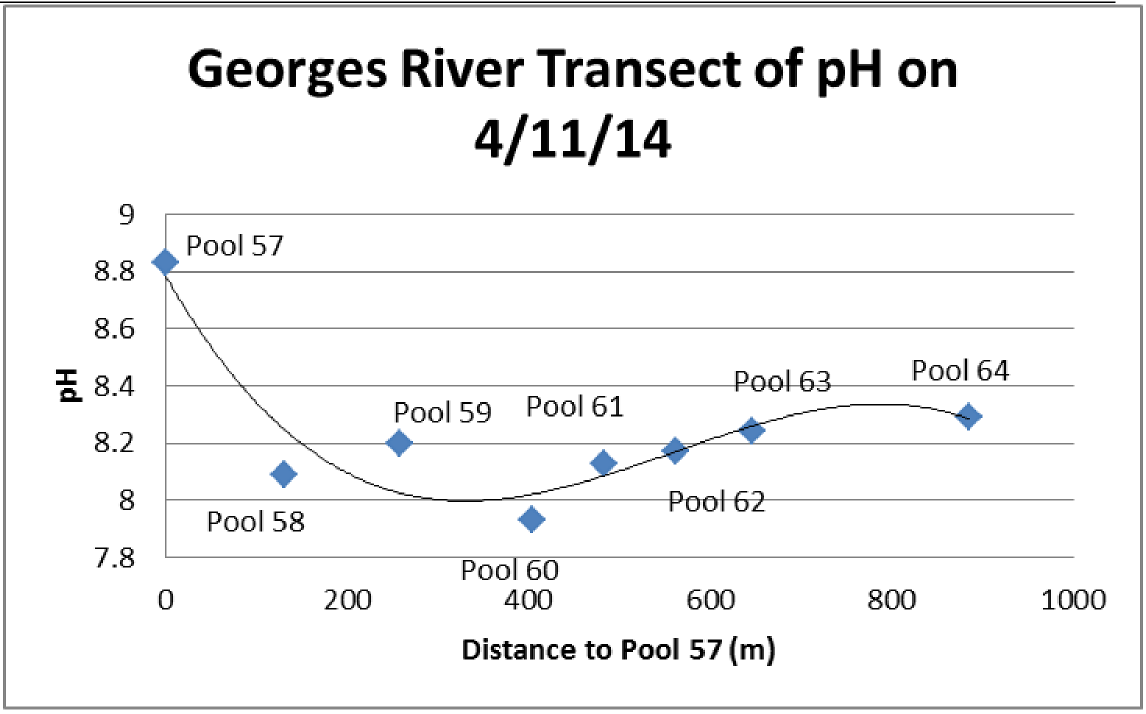

Figure 2.8: pH Transect in Georges River 4 November 2014.

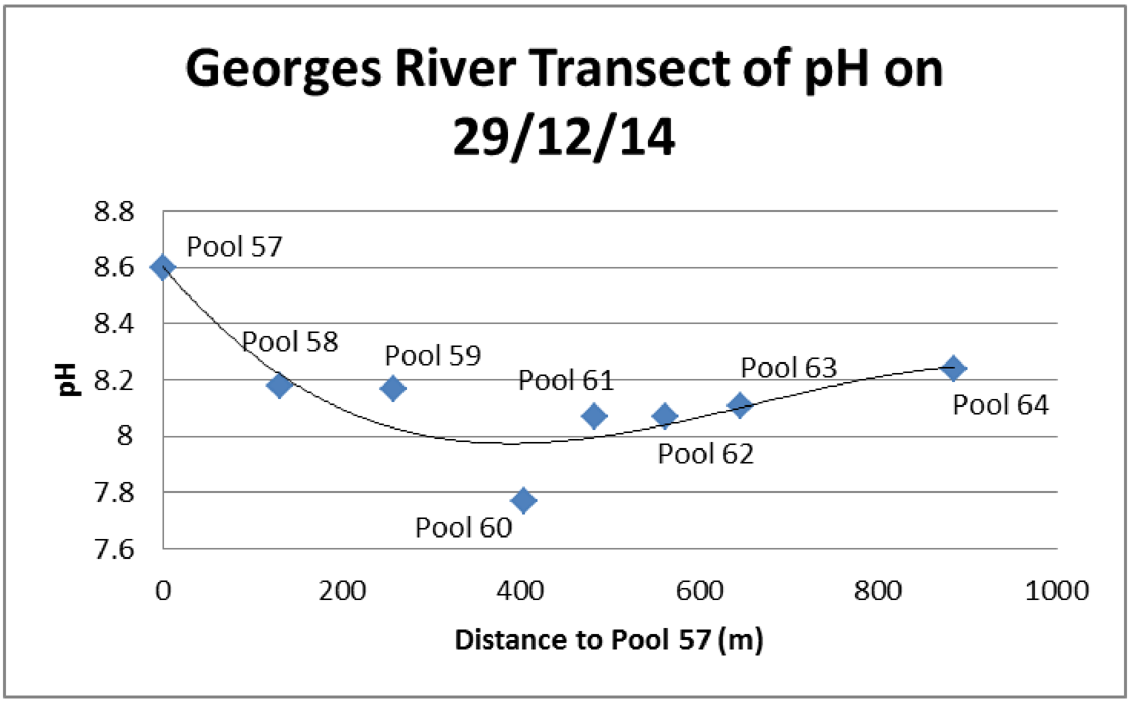

Figure 2.9: pH Transect in Georges River 29 December 2014.

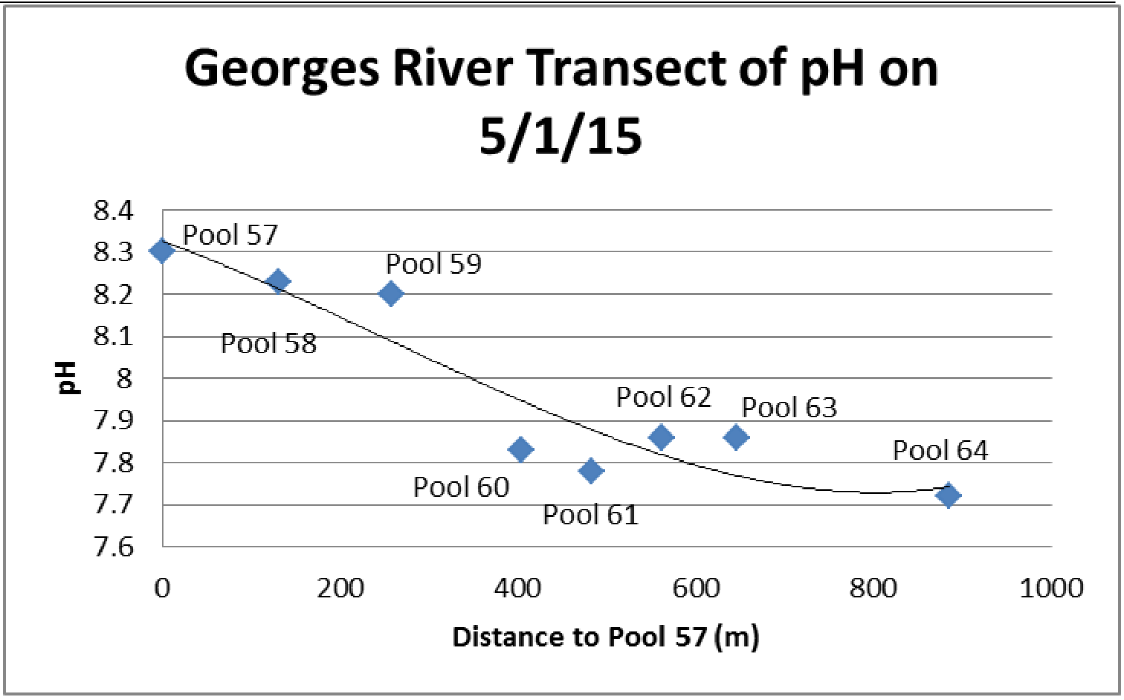

Figure 2.10: pH Transect in Georges River on 5 January 2015.

These DO and associated pH 'sags' which had already commenced by 4 November 2014 continued until late December with a minimum DO value of 25% of saturation but as can be seen the sagging were essentially over by 5 January 2015.

Table 2.2 below shows the key monitoring data (DO, pH, EC, ORP and water levels) at Pools 57, 58, 59, 60 and 61 in the Georges River on 4 November 2014, 27 November 2014, 8 December 2014, 15 December 2014, 22 December 2014 and 29 December 2014.

The minus one pH unit below baseline minimum Level 2 TARP is 7.23 (refer **Appendix 1**).

The minimum pH observed in this section of the River over November and December 2014 period was at Pool 60 on 27 November was 7.62 so the Level 2 pH TARP was not triggered on any occasion in November and December 2014.

Table 2.2 – Key pH, EC and DO Monitoring Data for Pools in the Georges River Adjacent Longwall 37 November and December 2014.

Date	Site	DO (%)	pH	EC (us/cm)	ORP (mV)	Water Level (Depth from Nail, m)	Max depth (m)	Water Level (%)
04/11/14	Pool 57	87.7	8.83	1640	312.0	0.427	0.442	3.4%
	Pool 58	63.0	8.27	1600	320.0	3	0.336	0.0%
	Pool 59	52.2	8.20	1610	318.0	0.027	0.287	90.6%
	Pool 60	61.8	7.93	1540	333.0	0.638	0.702	9.1%
	Pool 61	53.5	8.13	1570	331.0	0.507	0.795	36.2%
27/11/14	Pool 57	81.8	9.02	1680	278.1	4	0.442	0.0%
	Pool 58	57.7	8.09	1570	291.8	4	0.336	0.0%
	Pool 59	57.8	7.96	1580	286.7	#N/A	0.287	>100%
	Pool 60	60.5	7.62	1510	278.8	0.653	0.702	7.0%
	Pool 61	71.3	7.88	1490	333.1	0.563	0.795	29.2%
08/12/14	Pool 57	60.3	8.56	1150	376.2	0.233	0.442	47.3%
	Pool 58	45.4	8.42	1160	378.6	0.22	0.336	34.5%
	Pool 59	44.1	8.40	1160	369.6	-0.163	0.287	156.8%
	Pool 60	56.5	8.12	1160	377.2	0.565	0.702	19.5%
	Pool 61	52.1	8.20	1200	385.4	0.39	0.795	50.9%
15/12/14	Pool 57	25.1	8.49	1690	351.9	0.363	0.442	17.9%
	Pool 58	26.1	8.57	1710	348.3	3	0.336	0.0%
	Pool 59	33.8	8.58	1690	341.4	0.108	0.287	62.4%
	Pool 60	38.3	8.26	1710	351.2	0.6	0.702	14.5%
	Pool 61	32.5	8.23	1620	354.2	0.424	0.795	46.7%
22/12/14	Pool 57	62.2	9.71	1890	312.1	3	0.442	0.0%
	Pool 58	25.9	8.76	1580	334.3	3	0.336	0.0%
	Pool 59	47.3	8.88	1530	326.0	3	0.287	0.0%
	Pool 60	30.1	8.13	1600	353.2	0.681	0.702	3.0%
	Pool 61	84.5	8.78	1600	353.2	0.598	0.795	24.8%
29/12/14	Pool 57	31.5	8.60	1240	448.6	3	0.442	0.0%
	Pool 58	36.3	8.18	1150	474.3	3	0.336	0.0%
	Pool 59	27.0	8.17	1330	477.7	0.136	0.287	52.6%
	Pool 60	28.8	7.77	1330	489.3	0.613	0.702	12.7%
	Pool 61	35.6	8.07	1290	488.2	0.48	0.795	39.6%

It is particularly noted that Pool 59 was found to hold significant volumes of water on 5 out of the 6 occasions listed in Table 2.2 yet the water in that pool was measured to have a wide range of relatively low DOs and pHs and a generally significant water depth (relative to the nail location).

This strongly suggests the observed DO sags were not simply due to the effects of low pool levels and aerobic decomposition of natural woody and leafy material accumulated in the base of the pools and within wet refugia (cracks and crevices).

The Pool 59 data however suggests that; whatever is causing the low DO is reasonably well mixed within the water column – such as e.g. dissolved methane - as opposed to solid rotting leaves etc., in the bottom of the pool.

On 5 of the 6 dates assessed in **Table 2.2**, the immediately upstream Pool 58 was near empty so there is no way any significant amount of water could flow from Pool 58 into Pool 59.

In fact conversely; inspection of the above pH, EC and ORP data indicates it is highly likely that; on all dates except 22 December water from the at least half full Pool 59 had actually seeped backwards into the near-dry upstream Pool 58. The very close similarities in the water DO, pH, EC and ORP levels in these two pools *could not be ascribed to water which is other than well mixed within the source Pool 59 water column.*

It is noted that the ECs are very similar but with the EC in Pool 59 slightly exceeding that in Pool 58 on average – especially from 4 November through to 8 December when they equalised with then the EC in Pool 58 exceeding that in Pool 9 on 15 and 22 December and finally with that in Pool 59 markedly exceeding that in Pool 58 on 29/12.

As noted above; there was apparently no transfer of water from Pool 59 to Pool 58 on and about 22 December simply because both pools were near empty – in which case the gas would presumably have been largely venting directly to the atmosphere.

However it also appears likely that such DO-deficient water also seeped back into Pool 57 on 15 and 27 December.

We also infer that what is occurring here with respect to the observed small differences in EC are the effects of small volumes of produced water being brought up with the gas – predominantly into Pool 59 of course which consistently held, contained and probably received more water.

Gas releases can occur as a result of the fracturing or dilation of near-surface strata, such as Hawkesbury Sandstone, which is considered to be the source of gas releases that have also been observed in the Nepean River (Ecoengineers, 2008). Gas emissions derived from Hawkesbury Sandstone consist mainly of methane (CH_4), as well as carbon dioxide and trace amounts of higher-order hydrocarbons.

Four gas releases were observed in these same pools during the period of Longwall 35 mining, all of which subsequently became inactive (Ecoengineers, 2013a, 2014).

No new gas zones were observed by ICFET during the period of mining Longwall 37 (ICEFT, 2015b).

The above data indicates that the previous gas zones observed during the mining of Longwall 35 reactivated during November and December 2014 but were not detected visually.

The Georges River is relatively shallow and has many rockbars, which gives the River a naturally high Re-Aeration Coefficient (‘RAC’; e.g. USEPA, 1985). However, due to relatively low flows (and low local rainfalls) in the River in November and December 2014 (refer **Section 3** below); this effect was obviously insufficient to mask the DO-consuming effects of the re-activated gas releases into Pools 58, 59 and 60.

Total Iron in Georges River

Figure 2.11 below shows the total iron (Fe) concentrations at the Georges River sites Pool 54, Pool 60 (GRQ18) and Pool 64 since January 2009.

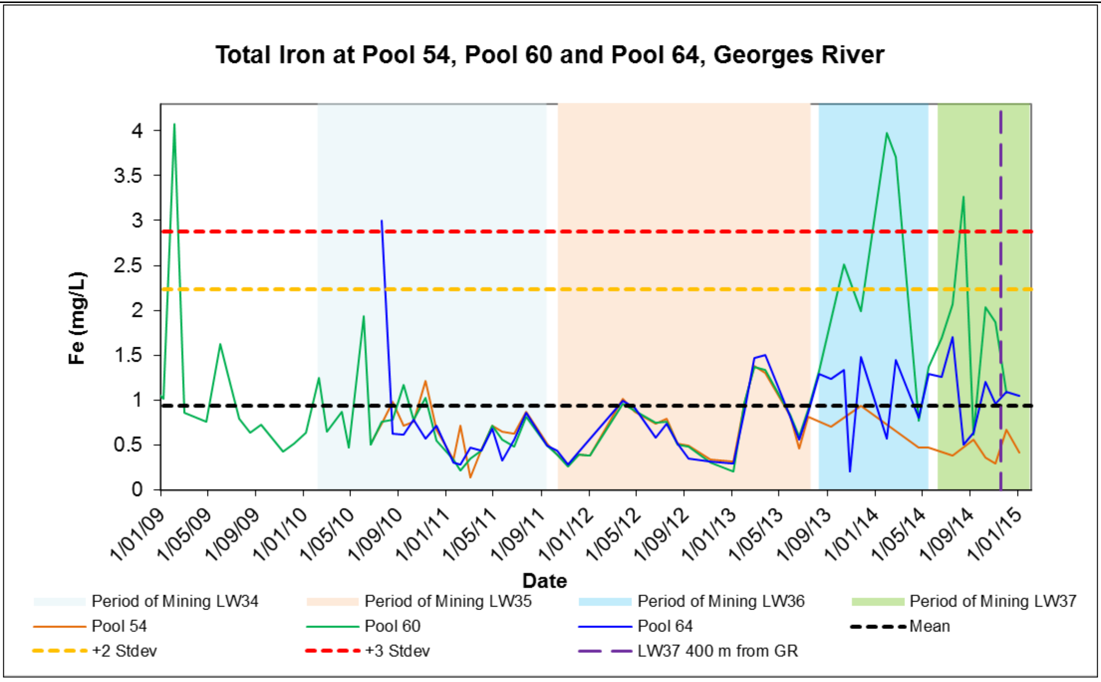

Figure 2.11: Total iron at Georges River upriver, adjacent to and downriver of Longwall 37.

As shown in **Figure 2.11**, the total Fe concentration at Pool 60 was greater than the plus 3 standard deviation level above the baseline mean once during the mining period of Longwall 37. This was observed prior to the approach of Longwall 37 within 400 m of the Georges River and, as such, is not considered an impact in Georges River as a result of the mining of Longwall 37.

Total Manganese in Georges River

Figure 2.12 below shows the total manganese (Mn) concentrations at Georges River sites Pool 54, Pool 60 and Pool 64 since January 2009.

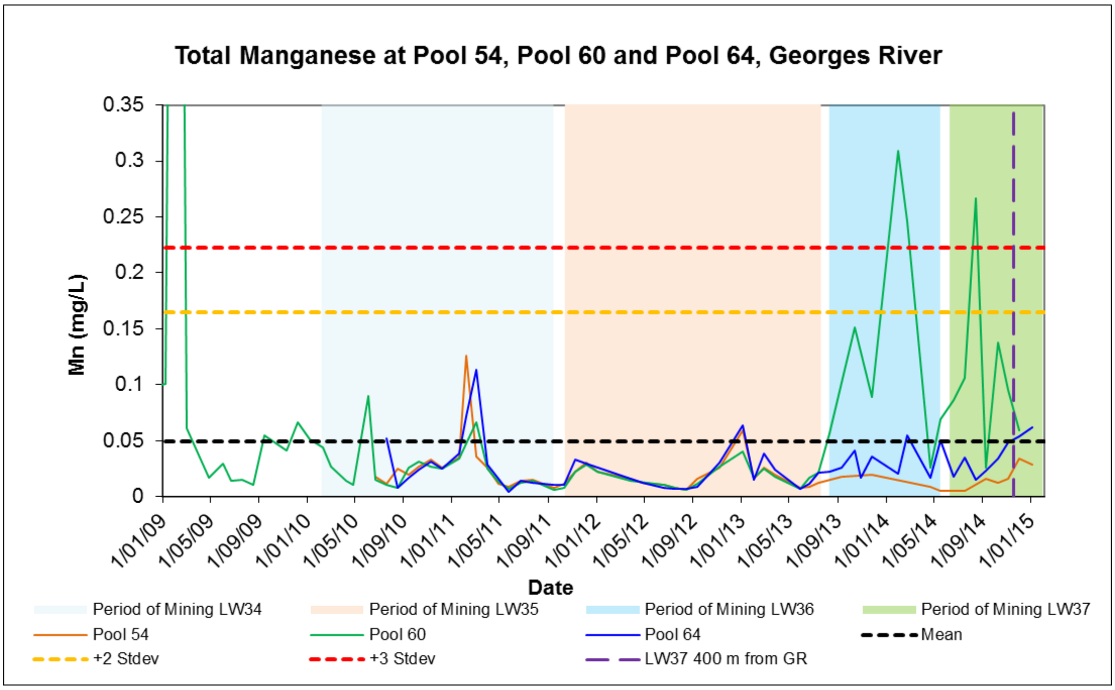

Figure 2.12: Total manganese at Georges River upriver, adjacent to and downriver of Longwall 37.

As can be seen in **Figure 2.12**, the total Mn concentration also exceeded the plus 3 standard deviation level once during the period of mining of Longwall 36. However this observation was also made prior to approach of Longwall 37 within 400 m to the Georges River and also not considered as an impact of mining of Longwall 37.

Sulfate in Georges River

Figure 2.13 below shows the sulfate (SO_4) concentrations in Georges River sites Pool 54, Pool 60 and Pool 64 since January 2009.

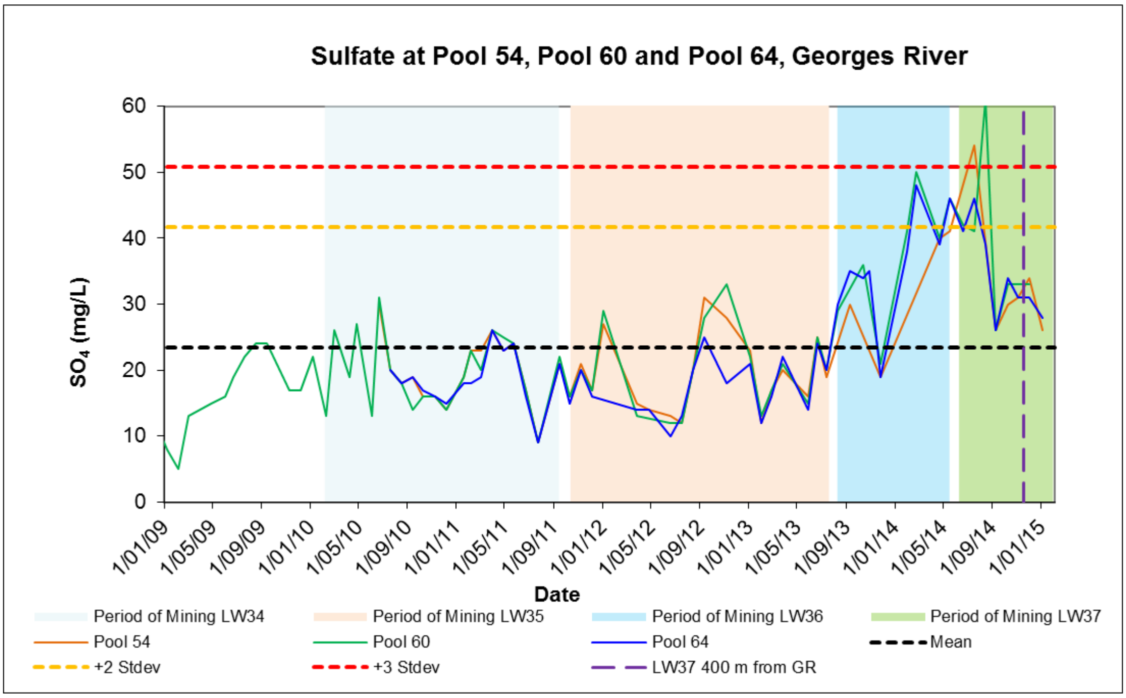

Figure 2.13: Sulfate at Georges River upriver, adjacent to and downriver of Longwall 37.

During the mining period of Longwall 36, sulfate (SO_4) concentrations at sites Pool 54, Pool 60 and Pool 64 generally increased and peaked around the first half of the Longwall 37 mining period, so these observations indicate that the likely source of increased SO_4 concentrations was upstream inputs (Ecoengineers, 2014)

The data seen in **Figure 2.13** shows that during the Longwall 37 mining period, SO_4 concentrations at sites Pool 54, Pool 60 exceeded the plus 3 standard deviation level above baseline mean once respectively and that concentration at Pool 64 exceeded the plus 2 standard deviation level once.

However these observations were made prior to the approach of Longwall 37 within 400m to the Georges River and as such, are not considered as impacts of mining of Longwall 37.

Nickel in Georges River

Figure 2.14 shows the dissolved nickel (Ni) concentrations in Georges River sites Pool 54, Pool 60 and Pool 64 since January 2009.

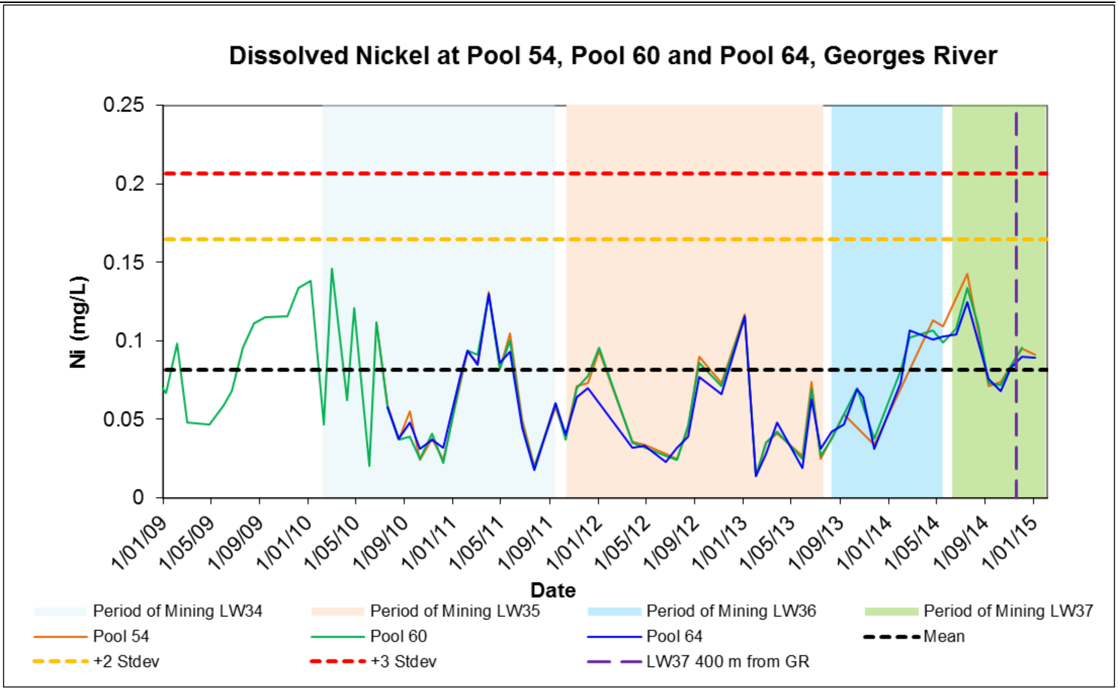

Figure 2.14: Dissolved Nickel at Georges River upriver, adjacent to and downriver of Longwall 37.

Figure 2.14 above shows that there is no evidence of any short or long-term increase in dissolved Ni concentrations in the River due to the mining of Longwall 37.

Zinc in Georges River

Figure 2.15 shows the dissolved zinc (Zn) concentrations in Georges River sites Pool 54, Pool 60 and Pool 64 since August 2004.

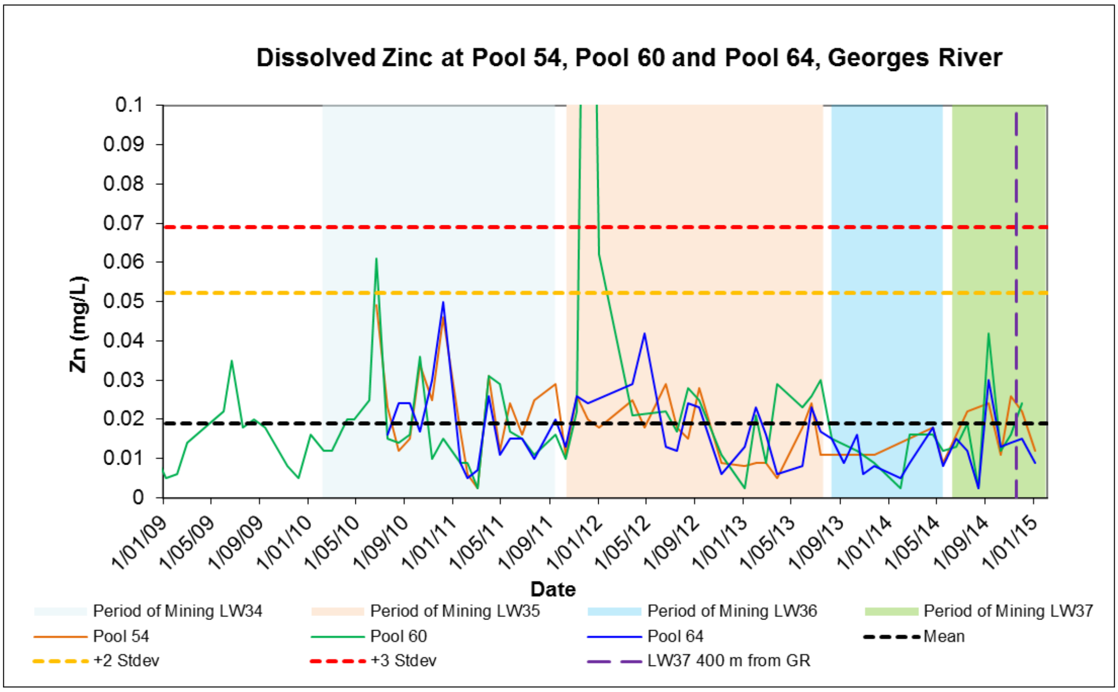

Figure 2.15: Dissolved Zinc at Georges River upriver, adjacent to and downriver of Longwall 37.

As **Figure 2.15** shows, no elevated Zn concentrations were observed in the Georges River during mining of Longwall 37 and hence there is no evidence of any impact in dissolved Zn concentrations in the River due to the mining of Longwall 37.

2.2 Other Streams

Two first order streams within the Longwall 37 and 38 SMP Area are located in close proximity to Longwall 37. These are;

- Mallaty Creek – which generally flows in a westerly direction until it joins Ousedale Creek, approximately 2 km south-west of Longwall 37.
- Nepean Creek – which flows in a north-westerly direction until it joins Menangle Creek approximately 2.8 km to the north-west of Longwall 37.

The locations of the stream monitoring sites referred to herein are shown in **Figure 2.16** below.

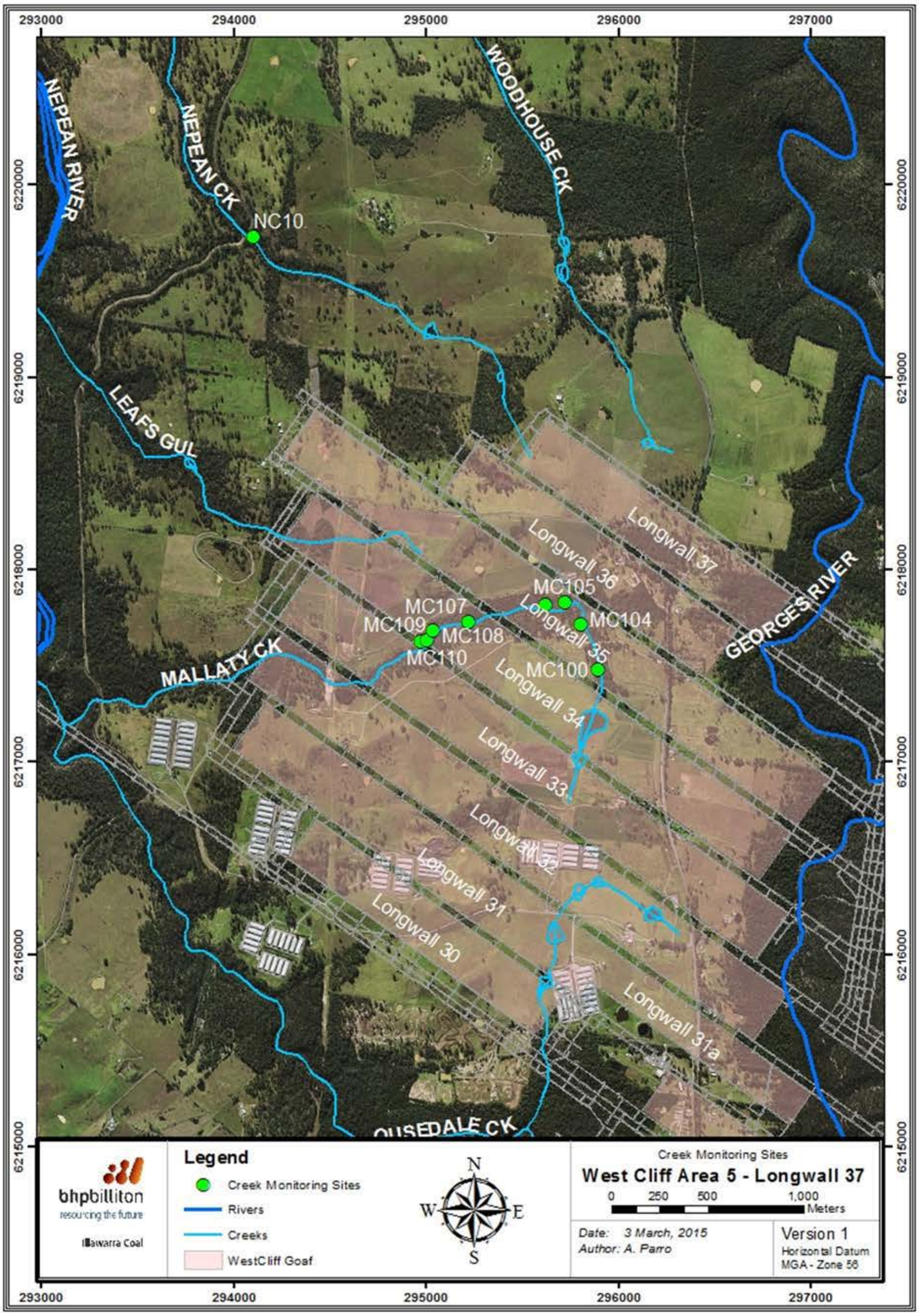

Figure 2.16: Water quality monitoring sites in first order streams (ICEFT, 2015b).

2.2.1 Mallaty Creek

Mallaty Creek was not directly undermined by Longwall 37. As **Figure 2.16** above shows, monitoring sites MC100 and MC110 are upstream and downstream respectively of the section of the Creek which is the closest to Longwall 37.

Salinity in Mallaty Creek

Figure 2.17 below shows the ECs recorded at MC100 and MC110 for the entire period that each site has been monitored.

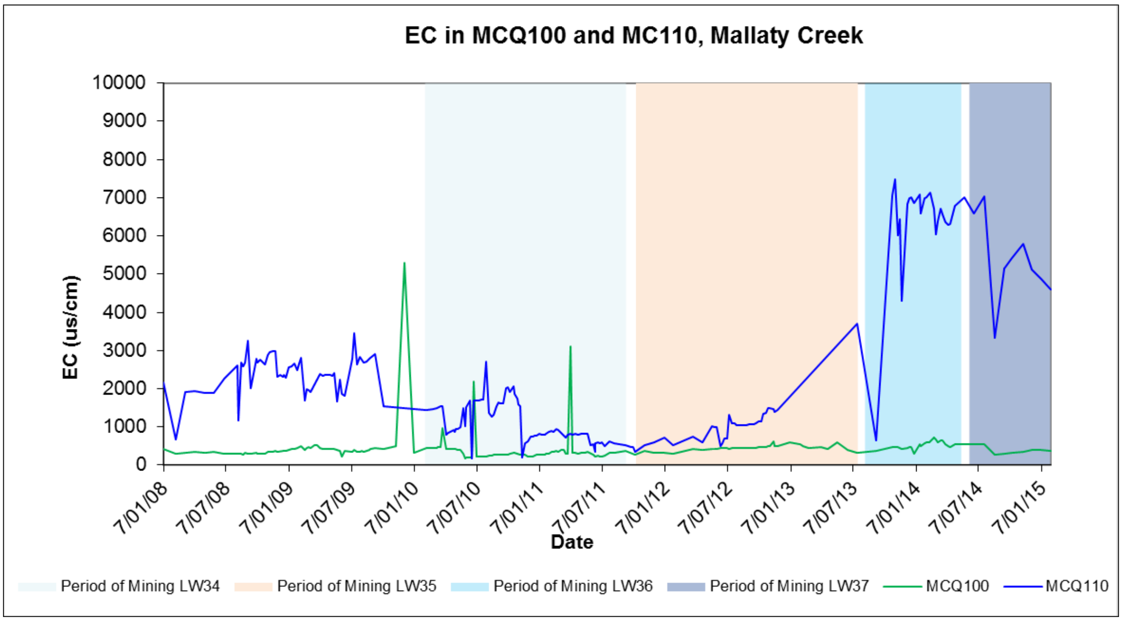

Figure 2.17: EC at sites MC100 and MC110.

Figure 2.17 shows that EC at the downstream Mallaty Creek monitoring site MC110 had been substantially elevated for the majority of the period of mining of both Longwall 36 (Ecoengineers, 2014) and Longwall 37.

These increased EC values indicate that a small saline spring into the creek line was induced during the period of mining of Longwall 36. The spring has continued but declined somewhat since the mining of Longwall 37 commenced.

pH in Mallaty Creek

Figure 2.18 below shows the pH at MC100 and MC110 for the entire period that each site has been monitored.

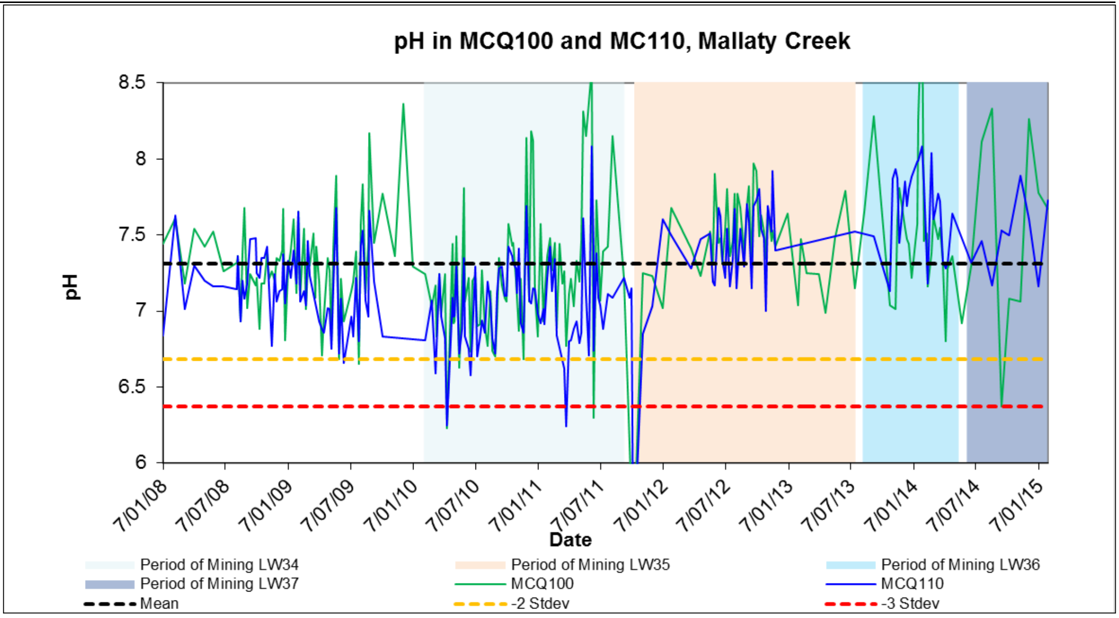

Figure 2.18: pH at site MC100 and MC110.

Figure 2.18 shows that there has been an observable decrease in pH at site MC100 on 18 September 2014. However this decreased pH is not considered to be an impact of the mining of Longwall 37, since it did not occur at the downstream site, MC110, on the same date.

Dissolved Oxygen in Mallaty Creek

Figure 2.19 below shows the DOs recorded at MC100 and MC110 for the entire period that each site has been monitored.

As seen in **Figure 2.19**, DO in Mallaty Creek is shown to be highly variable, which is simply due to the ephemeral nature of the creek.

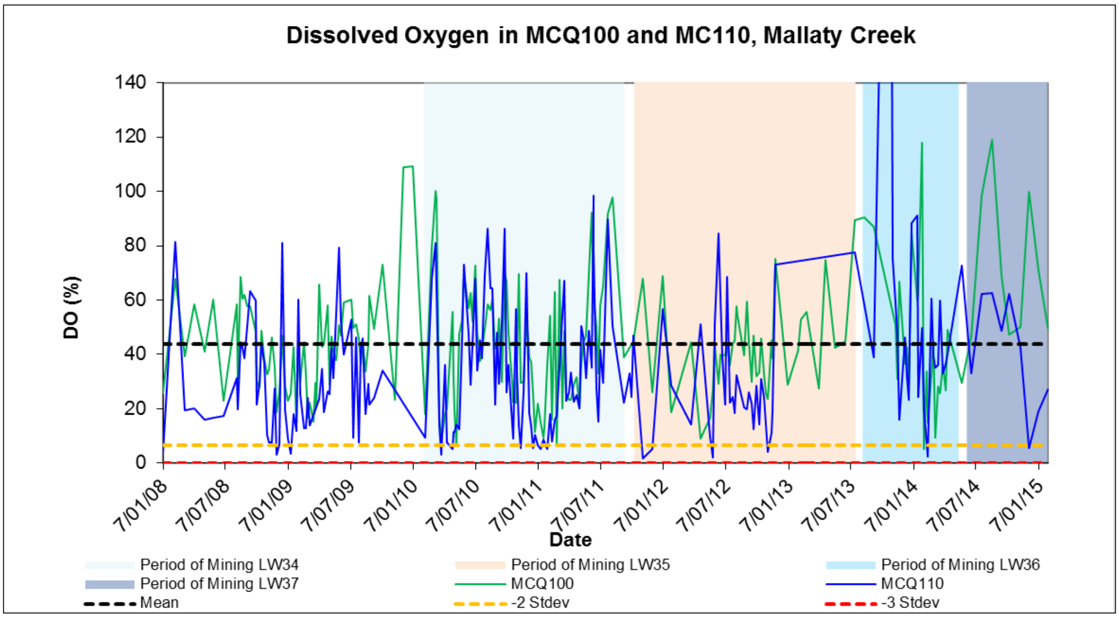

Figure 2.19: DO at Mallaty Creek sites MC100 and MC110.

Total Iron in Mallaty Creek

Figure 2.20 shows the concentrations of total Fe at MC100 and MC110 for the entire period that each site has been monitored.

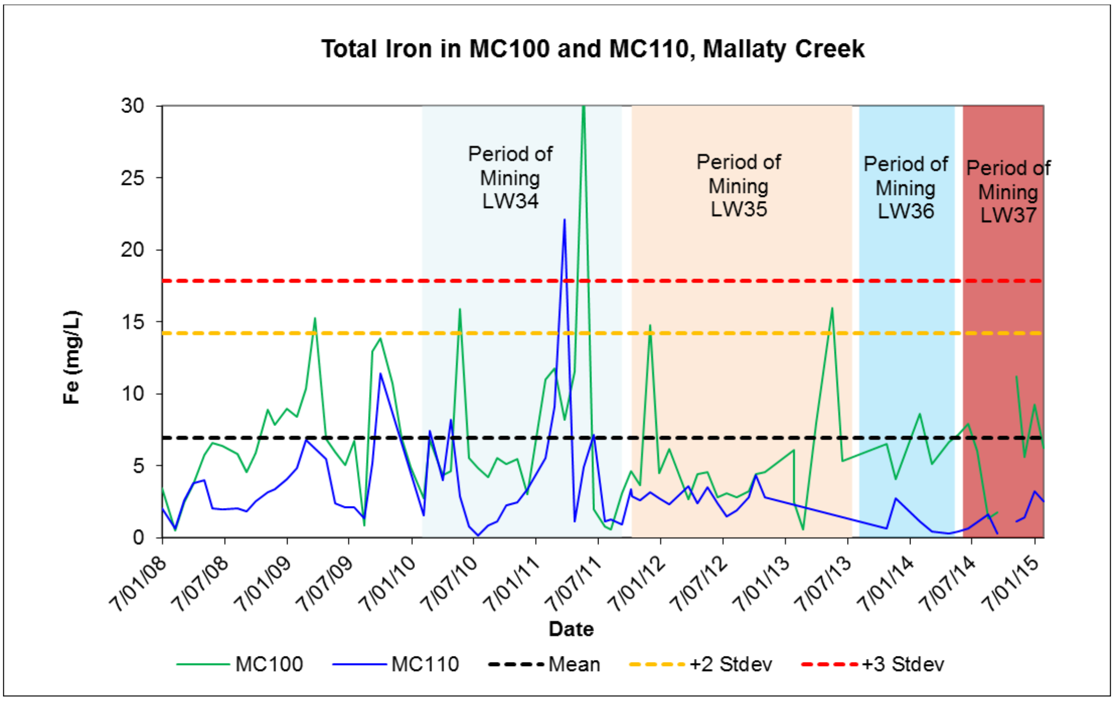

Figure 2.20: Total Iron at MC100 and MC106.

Figure 2.20 shows that there were no apparent effects on total iron concentrations in Mallaty Creek as a result of the mining of Longwall 37.

This suggests that the inferred saline spring induced upstream of MC110 during the mining of Longwall 36 was not ferruginous in nature.

Total Manganese in Mallaty Creek

Figure 2.21 below shows the concentrations of total manganese at the MC100 and MC110 sites for the entire period that each site has been monitored.

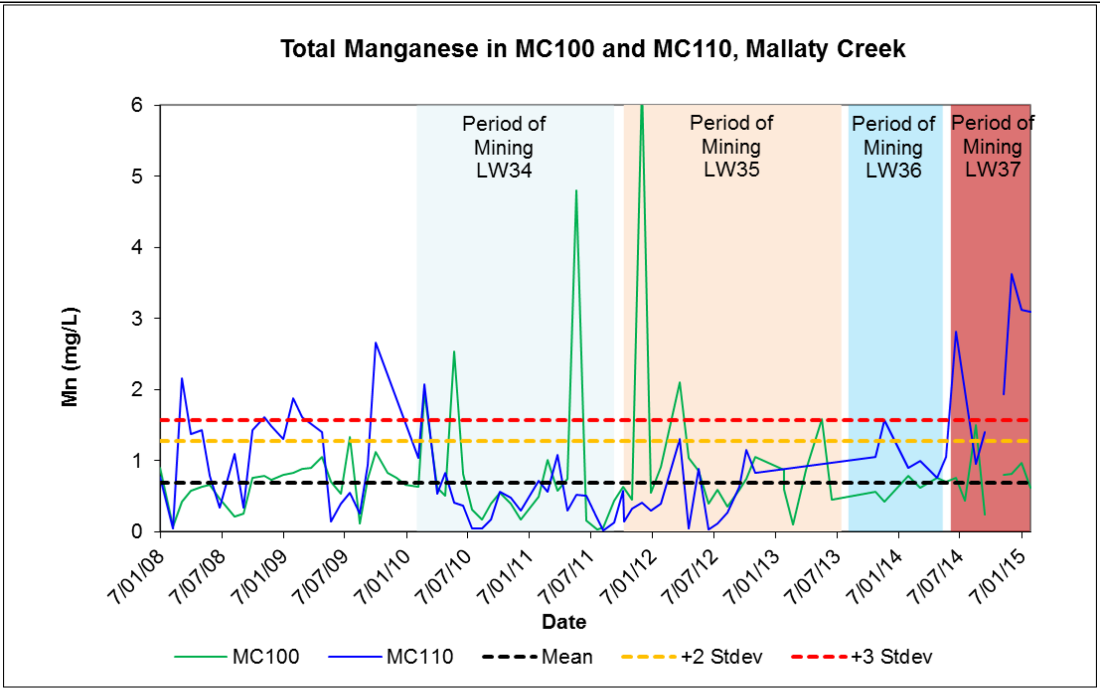

Figure 2.21: Total Manganese at MC100 and MC110.

Figure 2.21 above indicates there has been a significant elevation in Total Manganese concentrations at site MC110 during the mining of Longwall 37. The cause of this effect is uncertain but may be associated with agricultural and/or industrial activities within the catchment.

Sulfate in Mallaty Creek

Figure 2.22 below shows the concentrations of SO_4 at MC100 and MC110 for the entire period that each site has been monitored.

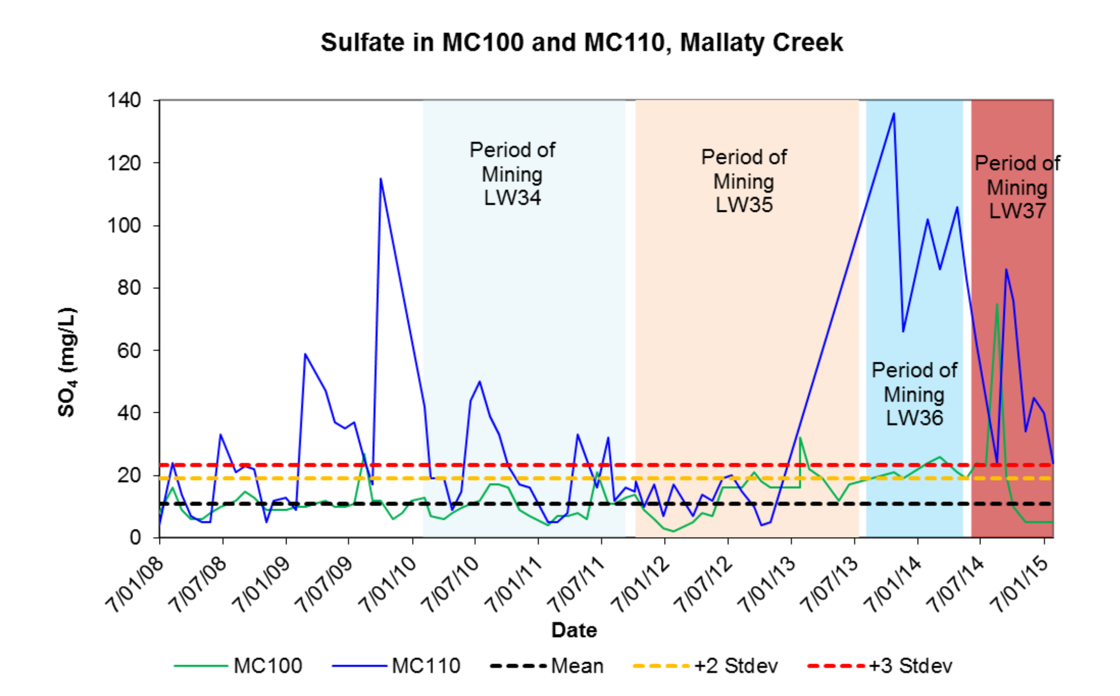

Figure 2.22: Sulfate at MC100 and MC110.

As can be seen above in **Figure 2.22** above there was a sustained increase in SO_4 concentrations at site MC110 during the mining period of Longwall 36 and a decreasing trend during Longwall 37 period.

These trends were concurrent with the observed increase and decreases in salinity shown in **Figure 2.17** and also log the formation and decline of a small saline spring.

Filterable Nickel in Mallaty Creek

Figure 2.23 below shows the concentrations of filterable Ni at MC100 and MC110 for the entire period that each site has been monitored.

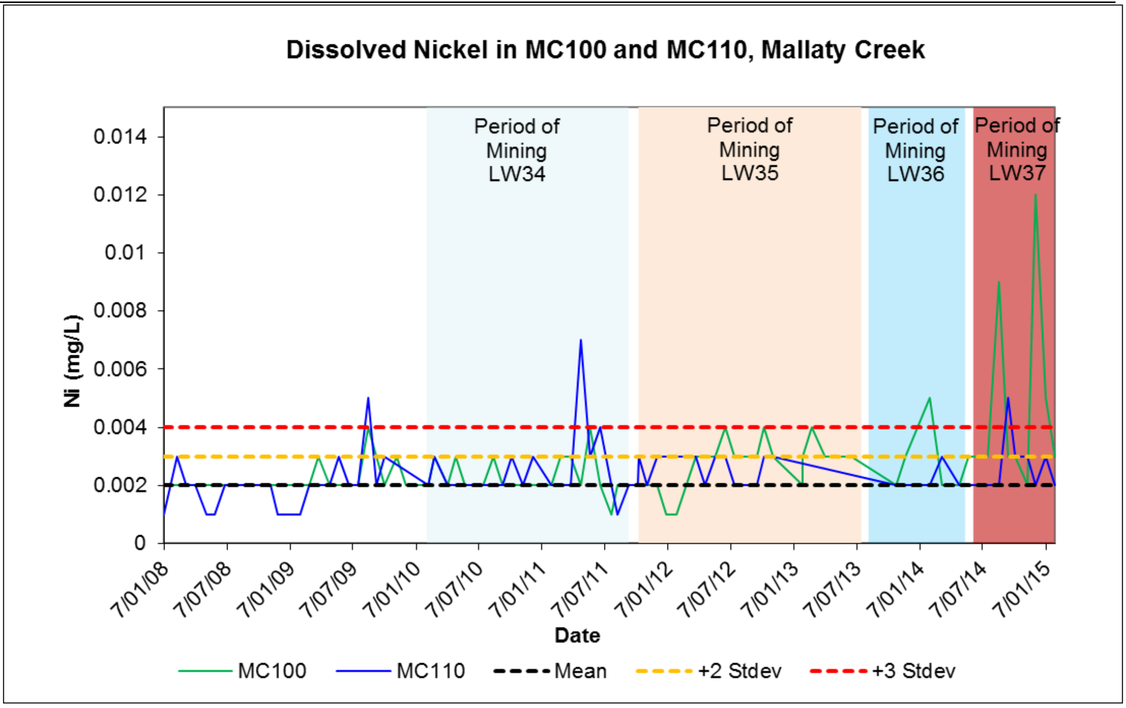

Figure 2.23: Filterable Nickel at MC100 and MC110.

Two Ni elevations at MC100 and one at MC110 exceeded plus 3 standard deviations level over the pre-Longwall 34 mean were observed during the Longwall 37 mining period. However these elevations were very minor in absolute terms, not exceeding 12 µg/L (12 ppb) and are typical of detects occasionally found in farmland on Wianamatta Shale landscape. They do not appear to be associated with the small saline spring downstream of site MC110.

Filterable Zinc in Mallaty Creek

Figure 2.24 below shows the concentrations of filterable Zn at MC100 and MC110 for the entire period that each site has been monitored.

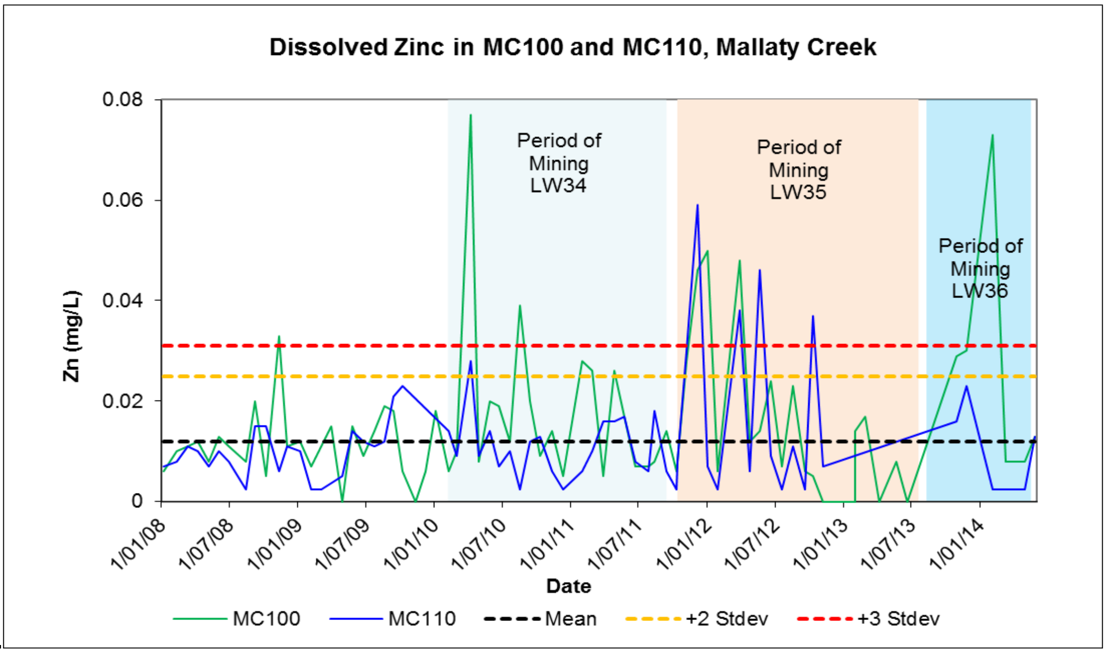

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Figure 2.24: Filterable Zinc at MC100 and MC110.

One Zn elevation only at MC100 exceeded plus 3 standard deviations level over the pre-Longwall 34 mean was observed during the Longwall 37 mining period.

However this elevation was very minor in absolute terms, not exceeding 75 µg/L (75 ppb) and also typical of detects occasionally found in farmland on Wianamatta Shale landscape. It does not appear to be associated with the small saline spring downstream of site MC110.

2.2.3 Nepean Creek

Salinity in Nepean Creek

Figure 2.25 below shows the EC values observed at NC10 for the entire period that the site has been monitored.

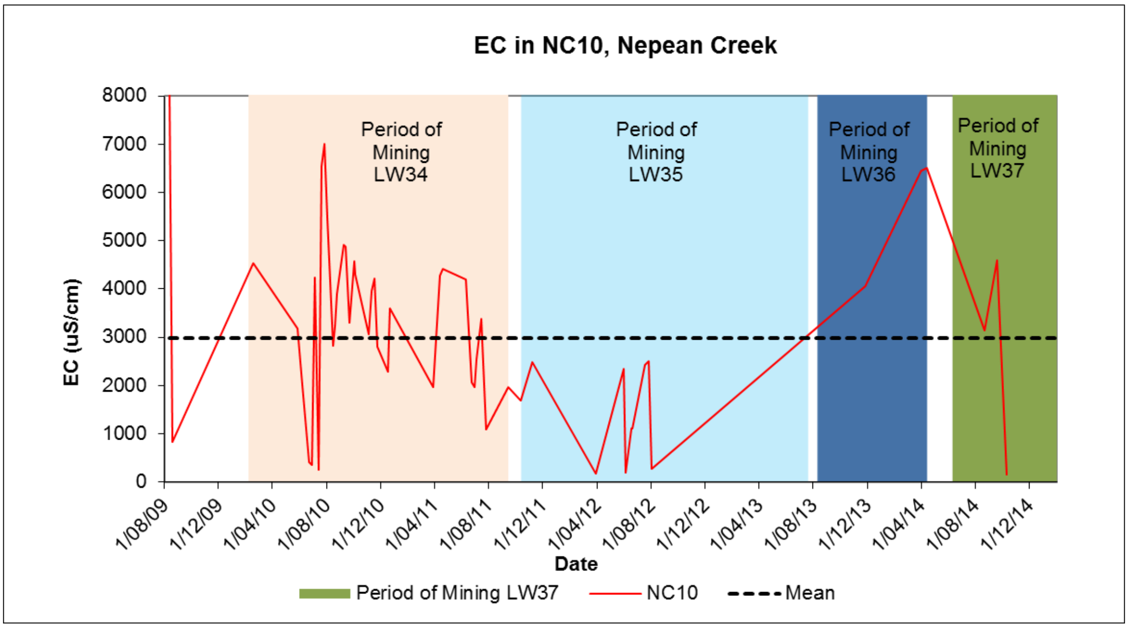

Figure 2.25: EC at NC10.

The EC at site NC10 was shown to increase during the period of mining of Longwall 36 and significantly decrease during Longwall 37. As such, no clear mining impact on the salinity of Nepean Creek is apparent.

pH in Nepean Creek

Figure 2.26 below shows the pH at NC10 for the entire period that the site has been monitored.

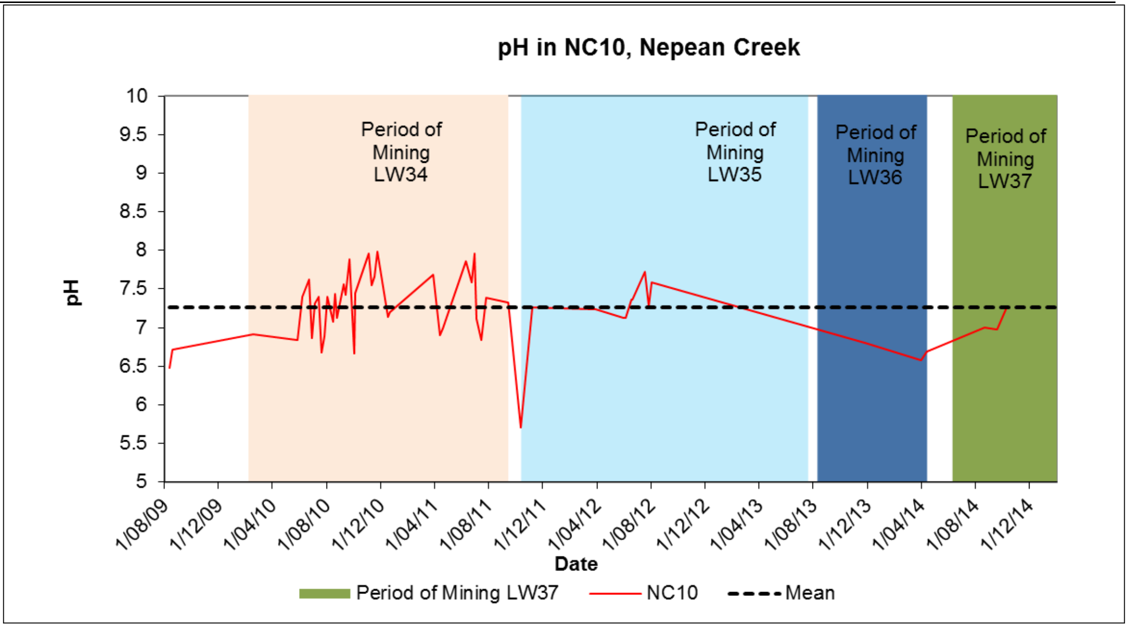

Figure 2.26: pH at NC10.

Figure 2.26 shows that pH values remained within two standard deviations from the baseline mean for NC10 during the period of mining of Longwall 37.

DO in Nepean Creek

Figure 2.27 below shows the DO saturations observed at site NC10 for the entire period that the site has been monitored.

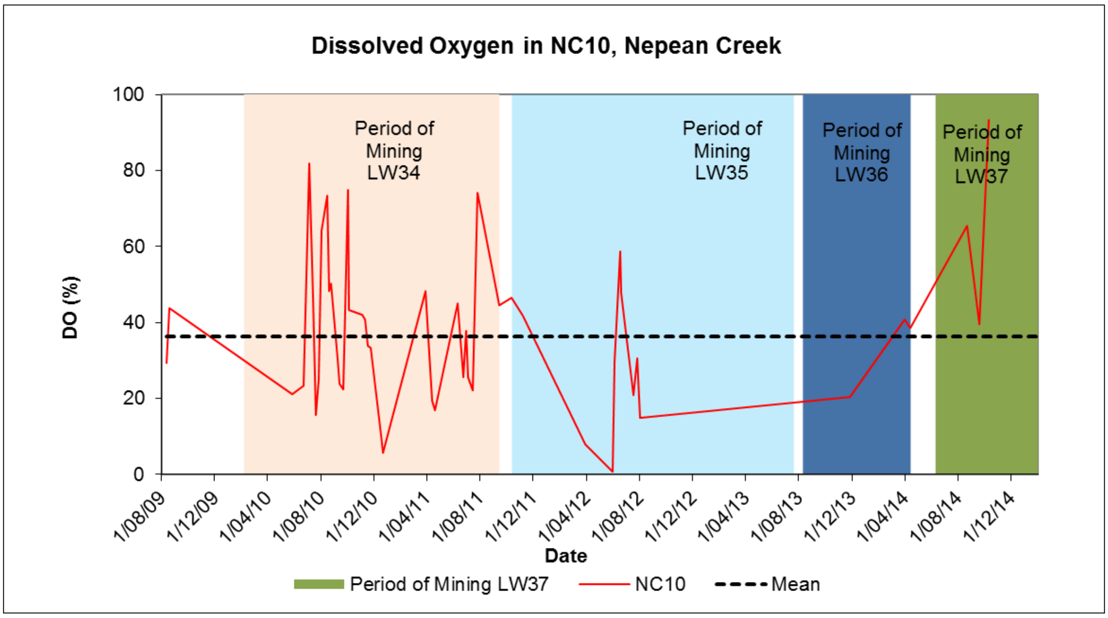

Figure 2.27: DO at NC10.

As shown in **Figure 2.27** above, there was no impact on DO in Nepean Creek observed during the period of mining of Longwall 37.

Total Iron in Nepean Creek

Figure 2.28 below shows total Fe concentrations at site NC10 for the entire period.

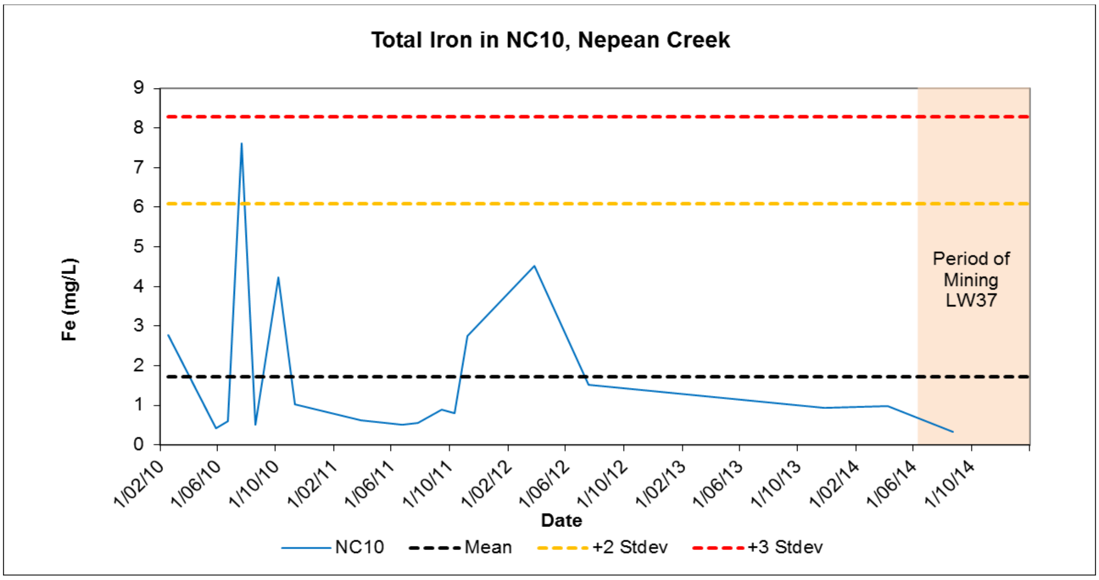

Figure 2.28: Total Iron at NC10.

As shown in **Figure 2.28** above, there have been no short or long-term increases in total Fe concentration at NC10 during the mining of Longwall 37.

Total Manganese in Nepean Creek

Figure 2.29 below shows the total Mn concentrations at NC10 for the entire period that the site has been monitored.

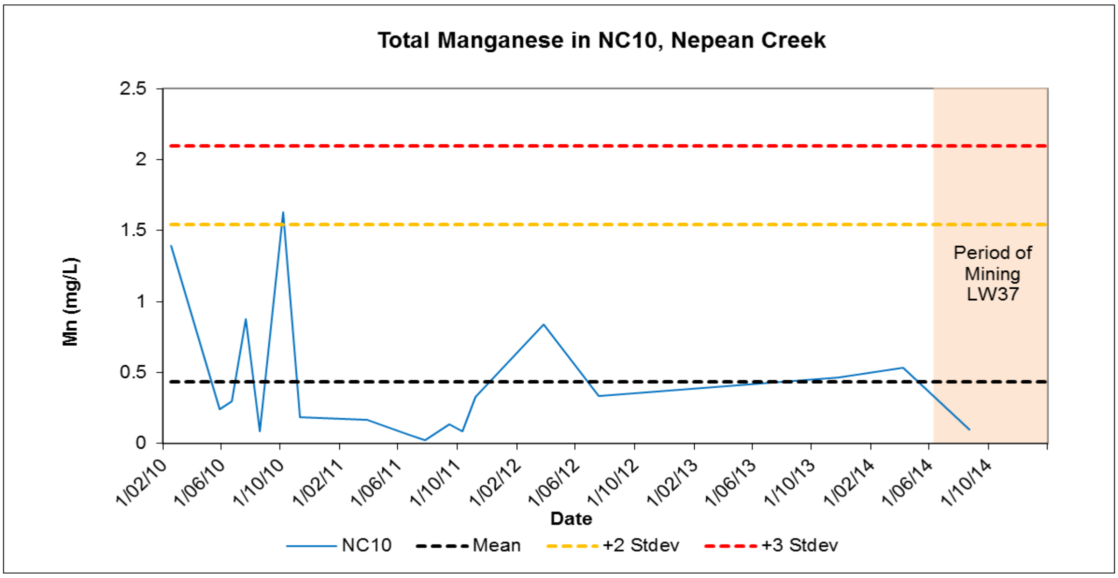

Figure 2.29: Total Manganese at NC10.

There has been no observed short or long-term increase in the concentrations of total Mn at NC10 during the mining of Longwall 37 (**Figure 2.29**).

Sulfate in Nepean Creek

Figure 2.30 below shows the sulfate concentrations at NC10 for the entire period that the site has been monitored.

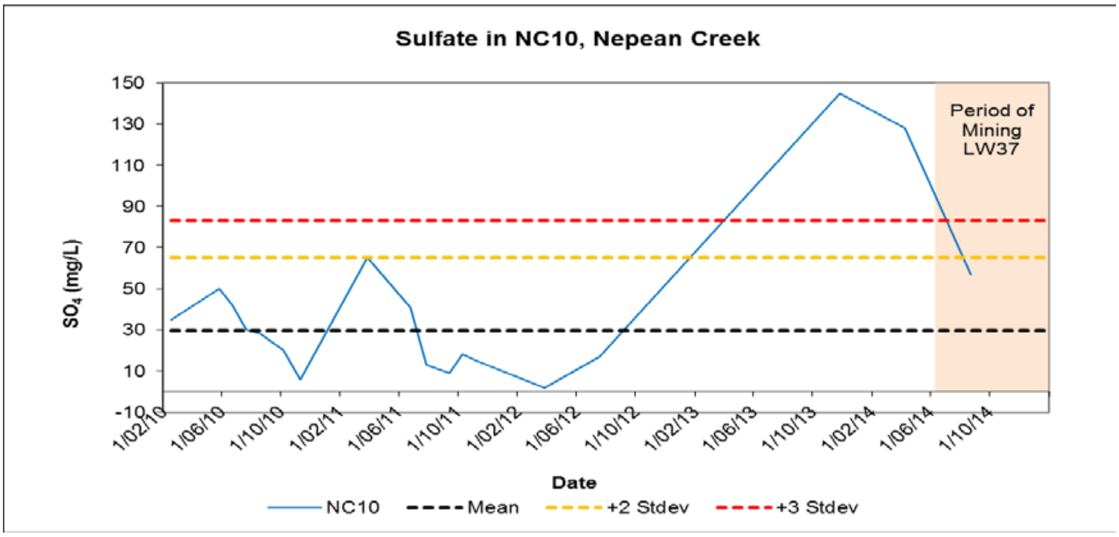

Figure 2.30: Sulfate at NC10.

Figure 2.30 above shows the most recent SO_4 concentrations observed at site NC10 declined to below the plus 2 standard deviation level above the mean during the period of mining of Longwall 37.

Dissolved Nickel in Nepean Creek

Figure 2.31 below shows the dissolved Ni concentrations at site NC10.

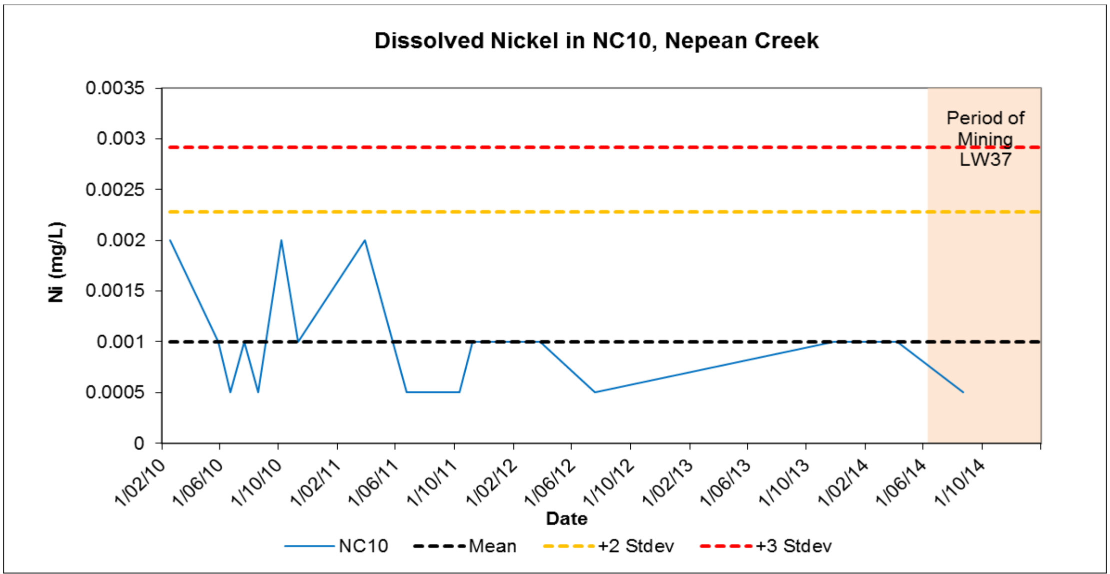

Figure 2.31: Dissolved Nickel at NC10.

Dissolved Ni concentrations at site NC10 were seen to remain at or below the laboratory Limit of Resolution (LOR) of 0.001 mg/L during the mining of Longwall 37.

Dissolved Zinc in Nepean Creek

Figure 2.32 below shows the dissolved Zn concentrations at NC10 for the entire period that the site has been monitored.

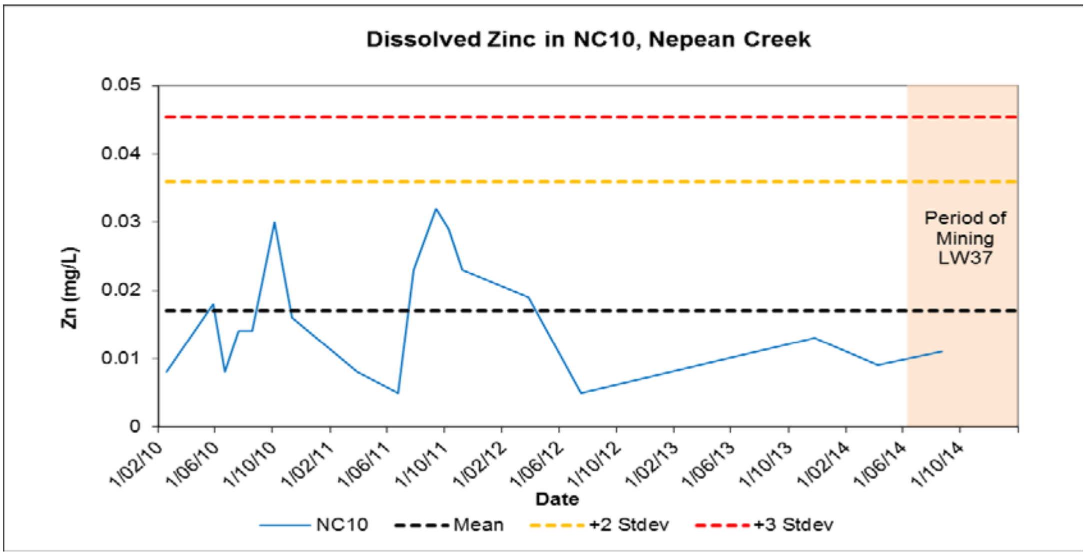

Figure 2.32: Dissolved Zinc at NC10.

Dissolved Zn concentrations at NC10 were observed to remain below the pre Longwall 34 average during the mining of Longwall 37 (**Figure 2.32**).

3. RIVER FLOW MONITORING

Sites where water flow monitoring was performed are shown in **Figure 3.1** below.

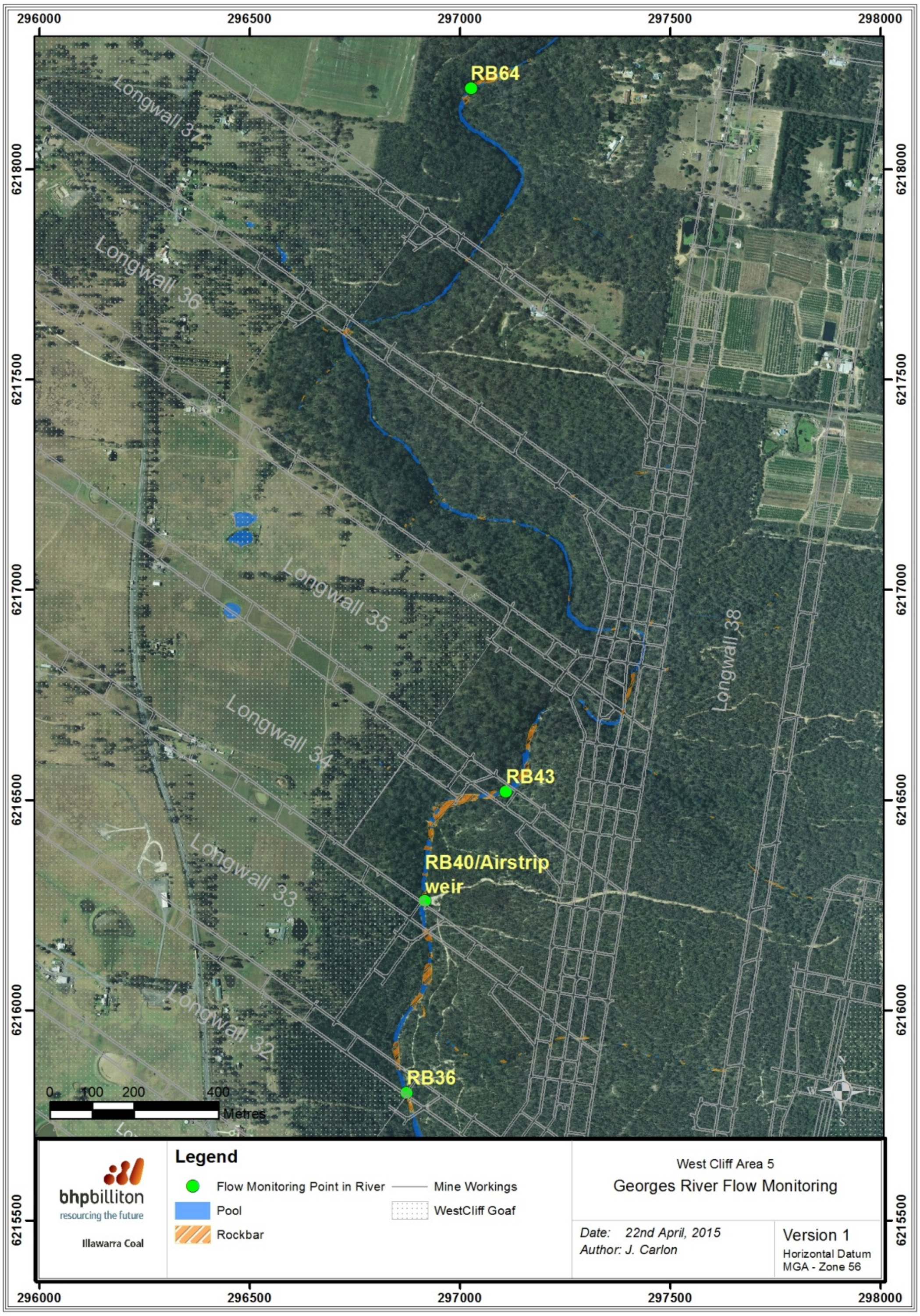

Figure 3.1: Georges River Manual Spot Flow Monitoring Sites.

Figure 3.2 below shows the results of spot flow measurements taken at Rockbars 43 and 64 over the period 1 January 2014 to 16 February 2015. The most recent valid measurements taken at Rockbars 43 and 64 are on 12 August 2014 and 16 February 2015 respectively.

The dotted line marks the date from when Longwall 37 was within 400 m of the Georges River (18 November 2014).

It is important to appreciate that paired upriver and downriver flows can only be compared when flows are measured (manually) on the same, dry weather day at approximately the same time.

It is also noted that, due to practical measurement constraints, ICFET are unable to take flow readings during periods of no flow or during periods where flows overtop the confines of the natural rockbar.

For rockbars 43 and 64 this is at a minimum flow rate of approximately 3 ML/day.

Due to discharge rates from Brennans Creek Dam regularly exceeding 3 ML/day, flow rates downstream in the Georges River were and are often too high to be measured.

Water flow rate data is only accurate to the level of precision to be expected from manual spot water flow rate measurements which have been made by water flow rate measurements at rated natural cross sections (i.e. associated with rockbars).

We estimate from long experience with repeated measurements at similar stream and river sites in dry weather that a typical minimum error of this method is about ±0.2 ML/day (2.3 L/s) *at the one standard deviation level.* This error is represented by the vertical error bars shown in **Figure 3.2** below but higher errors would have applied whenever measurements were made on days lying in close proximity to wet weather periods.

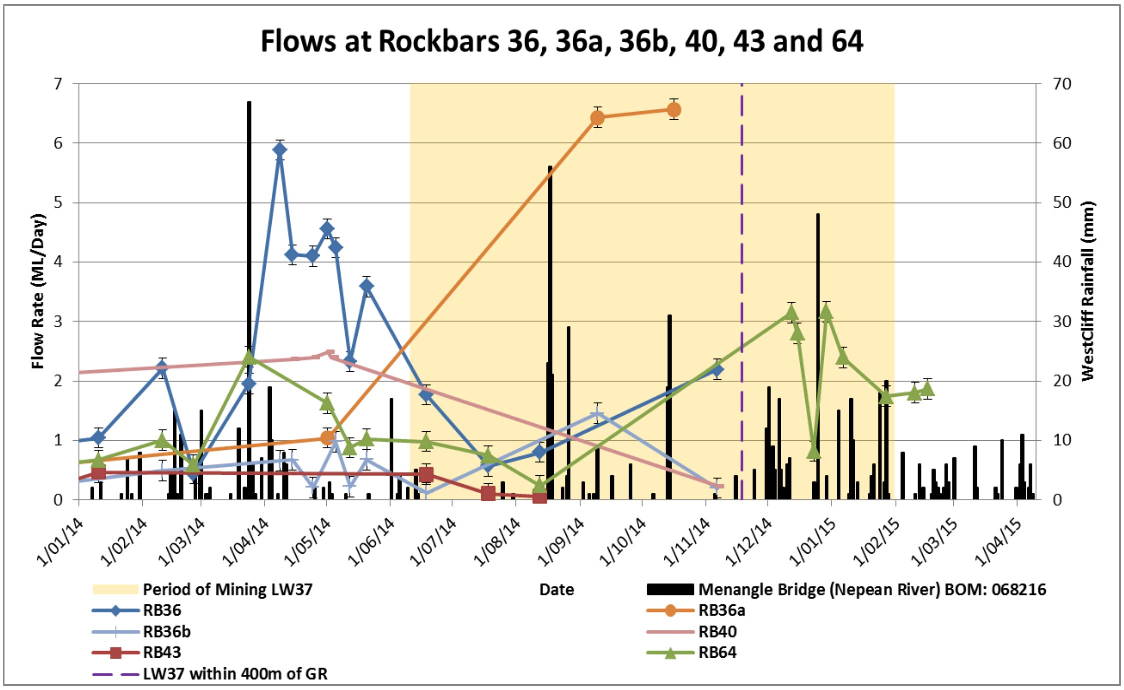

Figure 3.2: Flow Measurements made at Rockbars 43 and 64 Upriver and Downriver of Georges River: Period 1 January 2014 through 16 February 2015.

As there were no paired manual flow measurements at the rockbar 40 or 43 sites on the same day that such flow measurements occurred downstream of Longwall 37 at rockbar 64 during the period Longwall 37 approached within 400 m of the River i.e. after 18 November 2014, we are unable identify any possible flow losses after that date.

However we do note that November 2014 was a very dry month and that the general profile of all measured flows at rockbar 64 does not suggest there were any flow losses unrelated to local rainfall in the period after 18 November 2014.

4. SHALLOW GROUNDWATER MONITORING

Shallow groundwater in the Georges River catchment is monitored at five boreholes: GR28, GR27, GR70, WC54 and WC95, the locations of which are shown in **Figure 2.1** above

As can be seen in **Figure 4.1** below, the mining of Longwall 34 beneath borehole GR28 caused a step fall in the standing water level in the borehole from around 5.9 m Below Ground Level (BGL) by about 6.0 m to about 11.9 m BGL between 8 July 2011 and 11 August 2011.

This period also coincided closely with the time when Longwall 34 was approaching to within 400 m of the River.

We had estimated in our Longwall 34 End of Panel report that the longwall was about 409 m from the River on 11 July 2011. There was no concurrent effect on the groundwater level in borehole GR27 east of the River (Ecoengineers, 2011).

During the mining period of Longwall 37, there is no evidence that any significant comparable impact on water levels had occurred in both boreholes GR27 and GR28.

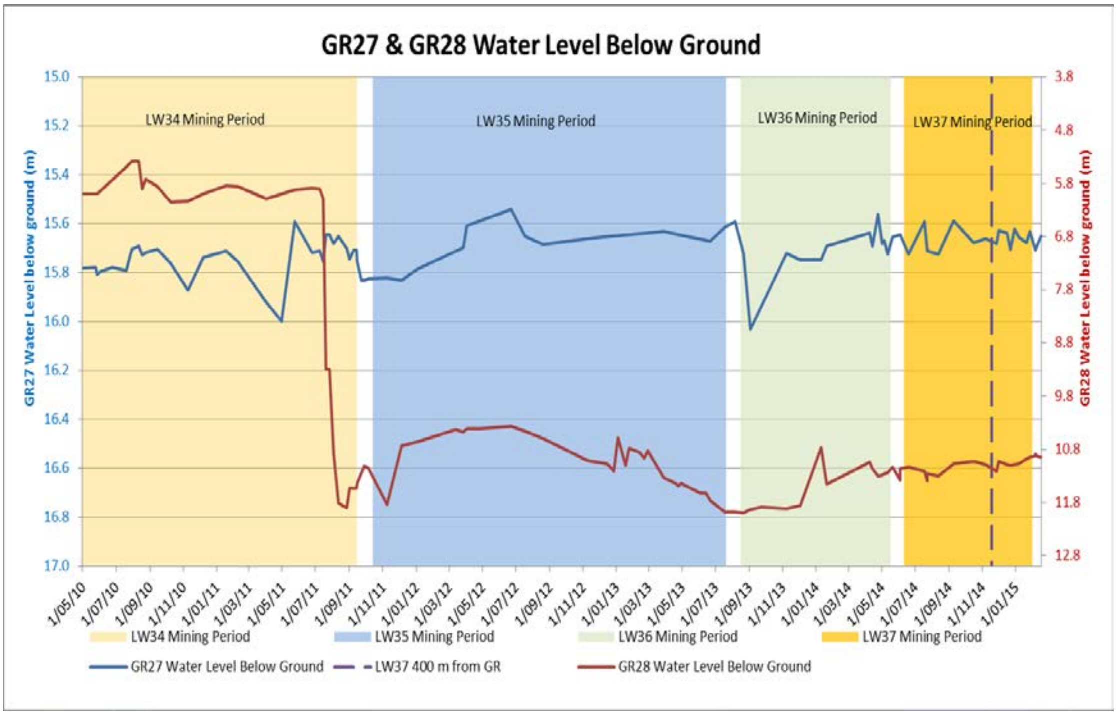

Figure 4.1: GR27 & GR28 water levels below ground level

Figure 4.2 below shows the water levels below ground level at shallow boreholes GR70, WC54 and WC95 for the entire period that the sites have been monitored. (February 2014 through February 2015).

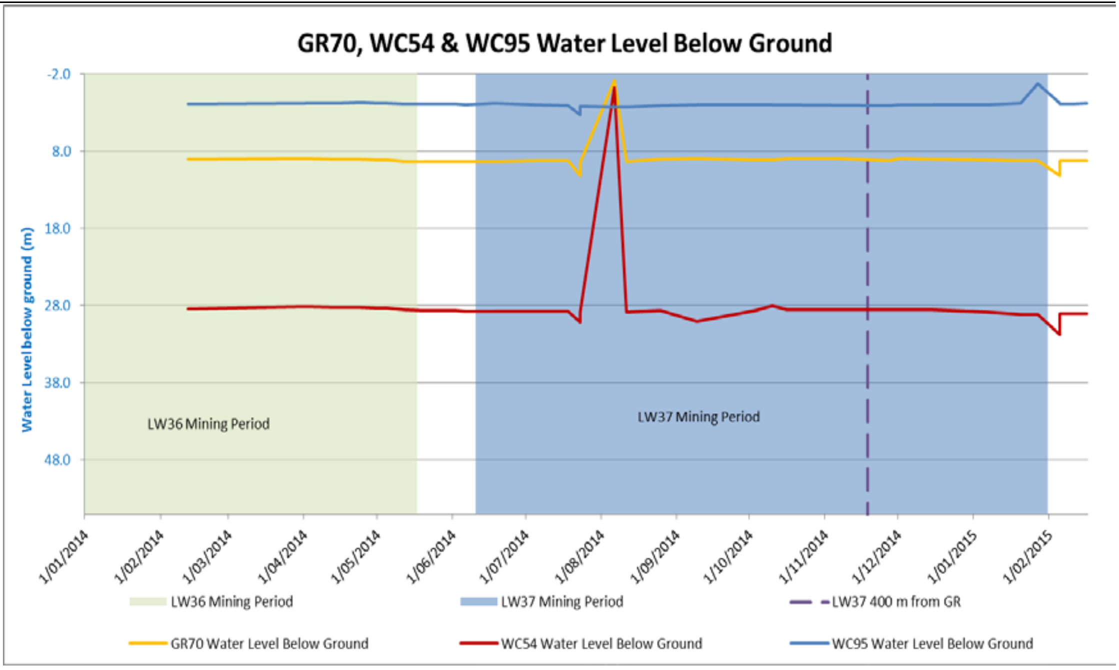

Figure 4.2: GR70, WC54 & WC95 water levels below ground level

As can be seen in **Figure 4.2** above, there is no evidence showing that the mining of Longwall 37 (directly beneath borehole WC54) caused any significant water level impact in these bores

The key water quality data, along with the depths of water below ground level for boreholes GR28, GR27, GR70, WC54 and WC95 are shown in **Tables 4.1, 4.2 and 4.3** below.

Table 4.1: Key Monitoring Data for Borehole GR28 2010 - 2014

GR28							
Date Sample	27/05/10	11/08/10	26&27/09/11	02/09/13	3/06/14	23/07/14	5/02/15
pH	7.63	7.8	6.35	6.79	6.9	6.72	6.72
EC (uS/cm)	9540	9410	2772	3220	4680	4080	2670
Ca Filt. (mg/L)	74	117	23	27	39	34	20
Mg Filt. (mg/L)	286	294	72	76	116	94	52
Mg/Ca Mole Ratio	6.4	4.1	5.2	4.6	4.9	4.6	4.3
Na Filt. (mg/L)	1760	1720	724	588	817	736	510
K Filt. (mg/L)	14	14	2	4	4	4	3
Alkalinity as CaCO3 (mg/L)	737	664	261	310	512	540	414
Sulfate Filt. (mg/L)	189	198	59	75	81	73	47
Chloride (mg/L)	3130	3150	1060	790	1060	892	610
Fe Filt. (mg/L)	<0.05	<0.05	2.52	5.5	1.73	1.87	0.05
Al Filt. (mg/L)	0.02	0.04	0.02	<0.01	<0.01	<0.01	<0.01
Mn Filt. (mg/L)	0.018	0.018	0.398	0.505	0.422	0.298	0.056
Ni Filt. (mg/L)	0.014	0.014	0.041	0.039	0.061	0.084	0.064
Zn Filt. (mg/L)	0.127	0.122	0.009	0.021	0.38	0.354	0.036

Table 4.2: Key Monitoring Data for Borehole GR27 2010 - 2014

GR27							
Date Sample	27/05/10	11/08/10	26&27/09/11	02/09/13	03/06/14	23/07/14	5/02/15
pH	5.67	6.42	4.46	4.78	4.19	4.3	4
EC (uS/cm)	92	110	226.4	338	401	421	424
Ca Filt. (mg/L)	4	4	2	3	2	2	0.5
Mg Filt. (mg/L)	1	1	5	6	7	7	7
Mg/Ca Mole Ratio	0.4	0.4	4.1	3.3	5.8	5.8	23.1
Na Filt. (mg/L)	10	11	42	48	60	56	60
K Filt. (mg/L)	2	2	1	2	1	1	<1
Alkalinity as CaCO3 (mg/L)	11	12	<1	<1	<1	<1	<1
Sulfate Filt. (mg/L)	4	6	6	15	12	13	12
Chloride (mg/L)	14	16	78	90	111	110	113
Fe Filt. (mg/L)	<0.05	<0.05	<0.05	0.3	0.15	0.09	<0.05
Al Filt. (mg/L)	0.09	0.15	1.2	0.99	1.61	1.78	1.94
Mn Filt. (mg/L)	0.03	0.031	0.04	0.064	0.051	0.046	0.046
Ni Filt. (mg/L)	0.003	0.004	0.005	0.004	0.003	0.003	0.003
Zn Filt. (mg/L)	0.064	0.12	0.102	0.086	0.05	0.069	0.055

As can be seen in **Table 4.1** and **Table 4.2** above, there were some changes in groundwater chemistry in borehole GR27 between August 2010 and late September as we discussed previously in our Longwall 36 End of Panel report (Ecoengineers, 2014) and an EC decrease between July 2014 and February 2015 in borehole GR28.

However none of them are considered an impact due to the mining of Longwall 37.

Table 4.3: Key Monitoring Data for Borehole GR70, WC54 & WC95 June 2014 to February 2015

	GR70			WC54			WC95		
	2/06/14	23/07/14	5/02/15	2/06/14	23/07/14	5/02/15	2/06/14	23/07/14	5/02/15
EC (us/cm)	396	467	706	717	681	629	304	336	357
pH	6.32	6.49	7.04	5.81	5.58	5.31	5.80	3.92	4.07
Ca Filt. (mg/L)	10	12	24	11	6	7	2	1	0.5
Mg Filt. (mg/L)	6	7	13	17	18	17	6	6	7
Na Filt. (mg/L)	74	81	116	97	90	90	51	49	53
K Filt. (mg/L)	5	4	4	4	2	3	1	0.5	1
Total Alkalinity as CaCO3 (mg/L)	86	120	178	70	72	25	6	0.5	0.5
SO4 Filt. (mg/L)	32	10	13	17	14	11	8	6	6
Cl Filt. (mg/L)	52	74	118	171	203	176	72	82	91
Fe Filt. (mg/L)	0.59	0.74	0.07	21.9	28.4	4.43	0.025	0.025	0.025
Al Filt. (mg/L)	0.42	0.26	0.03	0.005	0.005	0.01	0.07	0.17	0.37
Mn Filt. (mg/L)	0.25	0.295	0.467	2.08	2.25	2.32	0.104	0.095	0.116
Ni Filt. (mg/L)	0.022	0.022	0.034	0.022	0.024	0.026	0.003	0.004	0.005
Zn Filt. (mg/L)	0.151	0.062	0.034	0.052	0.118	0.168	0.064	0.084	0.073

As can be seen in **Table 4.3** above, there were no significant impacts on water qualities of groundwaters in these shallow boreholes as a result of mining of Longwall 37.

5. ASSESSMENTS

It was estimated that on 18 November 2014 the centre of the longwall was 400 m from the River, and this date was conservatively chosen by ICEFT and Ecoengineers as the period of influence on the Georges River.

5.1 Predicted and Observed Impacts on Flow and Water Quality in Georges River

Predicted Impacts

The maximum cumulative upsidence predicted by Mine Subsidence Engineering Consultants ('MSEC') to occur in the Georges River was 185 mm (O line) (MSEC, 2015).

Due to the possibility of reduced flow and the increase in interaction between surface and groundwaters, impacts on water quality were also considered possible.

These impacts were likely to include reduced DO and higher concentrations of dissolved ions and precipitates. Lower pHs and lower temperature variation due to groundwater inflows were also predicted as possible occurrences. (Ecoengineers, 2013b)

Major reductions in water quality resulting from mining were not expected to occur at downstream monitoring sites when compared to pre-mining baseline data and/or upstream samples.

Observed Impacts

The maximum cumulative upsidence observed by MSEC (2015) in the Georges River was 404 mm (M line in River).

After 18 November 2014 when Longwall 37 approached within 400 m of the River; pH values were shown to be below the minus 2 standard deviation level (relative to Pools 60 and 64), DO levels at Pool 60 were below minus 3 standard deviation on various occasion and at Pool 64 levels below minus 2 standard deviations twice.

5.2 Predicted and Observed Impacts on Water Quality in First Order Streams

Predicted Impacts

The maximum cumulative subsidence expected to occur in Mallaty and Nepean Creeks was <3 mm. Maximum predicted upsidence for these creeks was <3 mm (MSEC, 2015).

Due to the possibility of reduced flow in the ephemeral streams and the increase in interaction between surface and groundwaters, impacts on water quality were also considered possible.

These impacts were considered likely to include reduced DO and higher concentrations of dissolved ions and precipitates. Lower pH and lower temperature variation due to groundwater inflows were also predicted as possible occurrences. Major reductions in water quality were not expected to occur. (Ecoengineers, 2014)

Observed Impacts

Mallaty Creek

The cumulative subsidence and upsidence observed in Mallaty Creek were <3 and <-2 mm respectively (MSEC, 2015).

There were significant elevations in EC, SO_4, Total Mn and Ni and Zn concentrations at sites MC100 and MC110 as discussed in **Section 2** above.

The elevations in EC, SO4 and Total Mn at site MC110 were considered minor consequences of the induction of a small saline-non-ferruginous spring in the creek line below site MC110 during the prior mining of Longwall 36.

The observed elevations in Ni and Zn were considered unrelated to any mining effects and were too low to be of any ecological impact.

Nepean Creek

The cumulative subsidence and upsidence observed in Nepean Creek were <3 and <-2 mm respectively (MSEC, 2015).

There were no observable effect on pH, DO and Fe, Mn, Ni and Zn concentrations in Nepean Creek as a result of the mining of Longwall 37.

5.3 Trigger, Action and Response Plan for Georges River in the Longwall 37 SMP Area

Appendix 1 attached below outlines the TARP for Georges River.

6. RECOMMENDATIONS

Table 6.1 below shows the current monitoring parameter set (laboratory analysed) for the Georges River, and provides recommendations on which parameters could be removed, retained or implemented based on their importance in determining whether various mining impacts have occurred.

Table 6.1: Georges River Laboratory Parameters and Recommendations for Ongoing Monitoring Before and During Longwall 38.

Parameter	Retain/Remove/Implement	Reason
pH	Retain	Important for checking against field pH. TARP parameter.
Electrical Conductivity at 25 Degrees C	Retain	Important for checking against field EC
Total Suspended Solids	Retain	Can indicate mining impact
Total Dissolved Solids	Remove	Can be estimated from EC, or calculated from major cations and anions
Major Anions (Alkalinity, Chloride, Sulfate)	Retain	Can indicate mining impact. Important for speciation modelling. SO_4 is a TARP parameter.
Major Cations (Calcium, Magnesium, Sodium, Potassium)	Retain	Can indicate mining impact. Important for speciation modelling.
Dissolved Aluminium	Retain	Can indicate mining impact
Dissolved Iron	Retain	Can indicate mining impact. TARP parameter.
Dissolved Manganese	Retain	Can indicate mining impact. TARP parameter.
Dissolved Nickel	Retain	Can indicate mining impact. TARP parameter.
Dissolved Zinc	Retain	Can indicate mining impact. TARP parameter.
Total Aluminium	Retain	Can indicate mining impact
Total Iron	Retain	Can indicate mining impact. TARP parameter.
Total Manganese	Retain	Can indicate mining impact. TARP parameter.
Dissolved Organic Carbon	Retain	Important for detecting rotting natural organic matter and metals speciation modelling.
Dissolved Methane	Implement	Important for detecting, confirming and locating gas emissions (even if undetected visually).

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ICEFT (2014f) West Cliff Area 5 Longwall 37 Impact Report, 28/11/2014

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Appendix 1 West Cliff Area 5 Longwall 37 and 38 Water TARP

Monitoring	Trigger	Action
WATER QUALITY		
Adjacent and downstream sites for Longwalls 37 and 38. • Georges River: - Pool 54 - Pool 64 - GR100	***Level 1 **** • Temporary reduction in water quality (observed for 2 consecutive months) at any site when comparing the baseline period to mining period for that site i.e. : – pH drop between 0.5 and 1.0 units from the minimum baseline value	• Continue monitoring program • Report trigger to key stakeholders • Summarise impacts and report in the End of Panel Report and AEMR
	Level 2 * • Temporary reduction in water quality (observed for 2 consecutive months) at any site when comparing the baseline period to mining period for that site i.e.: – pH drop between 1.0 and 1.5 units from the minimum baseline value	• *Actions as stated for Level 1* • Review monitoring program • Notify relevant technical specialists and seek advice on any CMA required • Implement agreed CMAs as approved *Note: CMAs are to be proposed based on appropriate management of environmental and other consequences of mining impacts i.e. cracking at the surface with insignificant consequences may not require specific CMAs other than ongoing monitoring to confirm there are no ongoing impacts*
	Level 3 * • Reduction in water quality (observed for more than 2 consecutive months) when comparing the baseline period to mining period for that site i.e.: – pH drop of 1.5 units from the minimum baseline value	• *Actions as stated for Level 2* • Notify DP&I, DPI, relevant resource managers and technical specialists and seek advice on any CMA required • Invite stakeholders for site visit • Develop site CMA (subject to stakeholder feedback). This may include: - Emplacement of sandstone rocks in constricted stream flow areas to increase the aeration capacity where it is appropriate to do so - Grouting of fractures which result in flow diversion • Completion of works following approvals • Issue CMA report within 1 month of works completion • Review the TARP and Management Plan in consultation with key stakeholders *Note: CMAs are to be proposed based on appropriate management of environmental and other consequences of mining impacts i.e. cracking at the surface with insignificant consequences may not require specific CMAs other than ongoing monitoring to confirm there are no ongoing impacts*
	Exceeding Performance Measures • Subsidence impacts or environmental consequences greater than minor	• *Actions as stated for Level 3* • Investigate reasons for the exceedance • Update future predictions based on outcomes of the investigation • Provide environmental offset if CMAs are unsuccessful

Monitoring	Trigger	Action
GROUNDWATER		
BHPBIC Piezometers: • GR27 • GR28 • GR29 • GR70 • WC54 • WC95 **Private bores:** • GW32310 • GW72454 • GW105921 • GW108322 Mine water budget	***Level 1 **** • Increase in water flow from the goaf between 2.7-3 ML/day (20 day average) • 5.0 – 7.5 m reduction in the Hawkesbury Sandstone greater than predicted standing water level or pressure (outside of pumping influences in private bores) over a minimum 2 month period	• Continue monitoring program • Report trigger to key stakeholders • Summarise impacts and report in the End of Panel Report and AEMR
	Level 2 * • Rise in water flow from the goaf between 3-3.4ML (20 day average) • 7.5 – 10 m reduction in the Hawkesbury Sandstone greater than predicted standing water level or pressure (outside of pumping influences in private bores) over a minimum 2 month period	• *Actions as stated for Level 1* • Review monitoring program • Review impacts against the Performance Measures • Notify relevant technical specialists and seek advice on any CMA required • Implement agreed CMAs as approved
	Level 3 * • Abnormal rise in water flow from the goaf >3.4ML (20 day average) • >10m reduction in the Hawkesbury Sandstone standing water level or pressure (outside of pumping influences in private bores) over a minimum 2 month period • Total loss of groundwater level within a private bore	• *Actions as stated for Level 2* • Notify DP&I, DPI, relevant resource managers and technical specialists and seek advice on any CMA required • Invite stakeholders for site visit • Develop site CMA (subject to stakeholder feedback). This may include: - Any actions agreed to in the Property Subsidence Management Plan - Provision of alternate water supply where this has been impacted by mining • Completion of works following approvals • Issue CMA report within 1 month of works completion • Review the TARP and Management Plan in consultation with key stakeholders
	Exceeding Performance Measures • Subsidence impacts or environmental consequences greater than minor	• *Actions as stated for Level 3* • Investigate reasons for the exceedance • Update future predictions based on outcomes of the investigation • Provide environmental offset if CMAs are unsuccessful
APPEARANCE AND POOL WATER LEVEL		
Georges River: • All mapped pools in the mining area	***Level 1 **** • Fracturing with no observable surface water diversion • Pool water level lower than baseline in any mapped pool located in the mining area (within 400m of the longwall) • Increase in turbidity, iron staining, algal growth, or other visible water quality parameters determined by comparing baseline photos with photos during the mining period	• Continue monitoring program • Report trigger to key stakeholders • Summarise impacts and report in the End of Panel Report and AEMR

Monitoring	Trigger	Action
	Level 2 * • Pool water level lower than baseline in the majority of mapped pools located in the mining area (within 400m of the longwall) • Fracturing with observable surface water diversion	• *Actions as stated for Level 1* • Review monitoring program • Review impacts against the Performance Measures • Notify relevant technical specialists and seek advice on any CMA required • Implement agreed CMAs as approved *Note: CMAs are to be proposed based on appropriate management of environmental and other consequences of mining impacts i.e. cracking at the surface with insignificant consequences may not require specific CMAs other than ongoing monitoring to confirm there are no ongoing impacts. Prevailing rainfall and catchment conditions will be taken into account when assessing pool water level response and the need for CMAs*
	Level 3 * • Pool water level lower than baseline in all mapped pools in the mining area (within 400m of the longwall) • Fracturing with observable water diversion results in any mapped pool becoming dry during a mitigation flow in the River	• *Actions as stated for Level 2* • Notify DP&I, DPI, relevant resource managers and technical specialists and seek advice on any CMA required • Invite stakeholders for site visit • Develop site CMA (subject to stakeholder feedback). This may include: - Grouting of fractures which result in flow diversion • Completion of works following approvals • Issue CMA report within 1 month of works completion • Review the TARP and Management Plan in consultation with key stakeholders *Note: CMAs are to be proposed based on appropriate management of environmental and other consequences of mining impacts i.e. cracking at the surface with insignificant consequences may not require specific CMAs other than ongoing monitoring to confirm there are no ongoing impacts. Prevailing rainfall and catchment conditions will be taken into account when assessing pool water level response and the need for CMAs*
	Exceeding Performance Measures • More than negligible diversion of flows or changes in the natural drainage behaviour of pools over more than 20% of the stream length subject to vertical subsidence >20mm • More than negligible increase in water cloudiness over more than 20% of the stream length subject to vertical subsidence >20mm • More than negligible increase in iron staining over more than 20% of the stream length subject to vertical subsidence >20mm • Subsidence impacts or environmental consequences greater than minor	• *Actions as stated for Level 3* • Investigate reasons for the exceedance • Update future predictions based on outcomes of the investigation • Provide environmental offset if CMAs are unsuccessful

<table>
<tr><th colspan="3">LANDSCAPE FEATURES</th></tr>
<tr><td rowspan="3">Cliffs:
• GR-CL01 and
• GR-CL02

Steep slopes

Georges River – including pools and rockbars:
• GR-RB42
• GR-RB43
• GR-RB44
• GR-RB45
• GR-RB47
• GR-RB48
• GR-RB49
• GR-RB51
• GR-RB52
• GR-RB53
• GR-RB54
• GR-RB55
• GR-RB56a
• GR-RB56b
• GR-RB57
• GR-RB59
• GR-RB60
• GR-RB61
• GR-RB62
• GR-RB63
• GR-RB64
• GR-RB65
• GR-RB66
• GR-RB67</td>
<td>Level 1 *
• Rock fall from a cliff where the cliff is left mostly intact (<10% length of the cliff)
• Surface movement or rock displacement where any exposed soil surface is stable
• Crack at the surface which does not result in ongoing erosion or ground movement
• Erosion which stabilises within the period of monitoring without CMA
• Crack or fracture up to 100mm width
• Crack or fracture up to 10m length</td>
<td>• Continue monitoring program
• Report trigger to key stakeholders
• Summarise impacts and report in the End of Panel Report and AEMR</td></tr>
<tr><td>Level 2 *
• Rock fall from cliff where the characteristics of the cliff change (>10% length of the cliff)
• Ground disturbance that is unlikely to stabilise within the period of monitoring without CMA
• Mass movement of a slope causing areas of exposed soil
• Crack or fracture between 100 and 300mm width
• Crack or fracture between 10 and 50m length</td>
<td>• Actions as stated for Level 1
• Review monitoring program
• Review impacts against the Performance Measures
• Notify relevant technical specialists and seek advice on any CMA required
• Provide safety signage and barricades as appropriate
• Implement agreed CMAs as approved
<u>Note:</u> CMAs are to be proposed based on appropriate management of environmental and other consequences of mining impacts i.e. cracking at the surface with insignificant consequences may not require specific CMAs other than ongoing monitoring to confirm there are no ongoing impacts</td></tr>
<tr><td>Level 3 *
• Cliff collapse (100% length of cliff)
• Ground disturbance that does not stabilise within the period of monitoring
• Mass movement of a slope causing areas of exposed soil that does not stabilise within the period of monitoring
• Crack or fracture over 300mm width
• Crack or fracture over 50m length</td>
<td>• Actions as stated for Level 2
• Notify DP&I, DPI, relevant resource managers and technical specialists and seek advice on any CMA required
• Invite stakeholders for site visit
• Develop site CMA (subject to stakeholder feedback). This may include:
- Erosion prevention works
- Establishment of vegetation
• Completion of works following approvals
• Issue CMA report within 1 month of works completion
• Review the TARP and Management Plan in consultation with key stakeholders
<u>Note:</u> CMAs are to be proposed based on appropriate management of environmental and other consequences of mining impacts i.e. cracking at the surface with insignificant consequences may not require specific CMAs other than ongoing monitoring to confirm there are no ongoing impacts</td></tr>
</table>

	Exceeding Performance Measures • For cliffs of 'special significance' - more than negligible environmental consequences (i.e. more than occasional rockfalls, displacement or dislodgement of boulders or slabs, or fracturing, that in total impact more than 0.5% of the total face area of such cliffs within any longwall mining domain) • Other cliffs - more than minor environmental consequences (that is occasional rockfalls, displacement or dislodgment of boulders or slabs or fracturing, that in total impact more than 3% of the total face area of such cliffs within any longwall mining domain)	• *Actions as stated for Level 3* • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation

* These may be revised in consultation with DP&I and DPI and other key stakeholders following analysis of natural variability within the pre-mining baseline data. These TARPs relate to West Cliff Area 5 Longwalls 37 and 38.

Office of Environment and Heritage (OEH)

Department of Planning and Infrastructure (DP&I)

Department of Primary Industries: including Division of Resources and Energy, Office of Water, Fisheries (DPI)