



# WEST CLIFF LONGWALL 38 END OF PANEL LANDSCAPE REPORT

DATE 23/03/2016





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## 1. Introduction

This report has been prepared by the South32 Illawarra Coal Environmental Field Team (ICEFT) as part of the West Cliff Area 5 (WCA5) End of Panel (EoP) Report. It summarises the monitoring of surface features undertaken by the ICEFT within the Longwall 38 Extraction Plan Area.

Extraction of Longwall 38 commenced on the 3<sup>rd</sup> February 2015 and was completed on the 1<sup>st</sup> February 2016.

Environmental monitoring and inspections of watercourses, groundwater, cliffs and steep slopes as well as private properties have been carried out by the ICEFT to observe and record any impacts relating to the extraction of Longwall 38. This monitoring has been conducted in accordance with the *West Cliff Area 5 Longwalls 37 and 38 Extraction Plan* (EP) approved 28<sup>th</sup> March 2014 by the Department of Trade and Investment (DTI). The Trigger Action Response Plans (TARPs) in the EP provide actions to be undertaken for subsidence impacts.

## 2. Summary and Results of the Monitoring Program

Monitoring of landscape features, surface water and groundwater above and adjacent to Longwall 38 has been conducted by the ICEFT in accordance with the EP. The monitoring program includes inspections of:

- surface water quality and water level in pools in the Georges River and its tributaries;
- groundwater quality and water level in monitoring and private boreholes;
- landscape features such as cliffs, steep slopes and all mapped pools in the Georges River and listed tributaries;
- changes in vegetation within the Longwall 38 mining area.

Monitoring of surface and ground water is undertaken to identify any potential mining-induced changes to pool water quality, water levels and flow conditions. Monitoring of landscape features in the zone of influence of the longwall is undertaken to identify mining induced impacts including soil cracks, fractures to exposed rock and watercourses, rockfalls, gas releases and changes to water appearance such as iron staining, increased turbidity and algal growth. These inspections also monitor any notable changes in vegetation.

Refer to **Table 2-1** for an overview of the monitoring program, **Figure 2.1** for the location of monitoring sites and **Figure 2.2** for the location of impact sites.

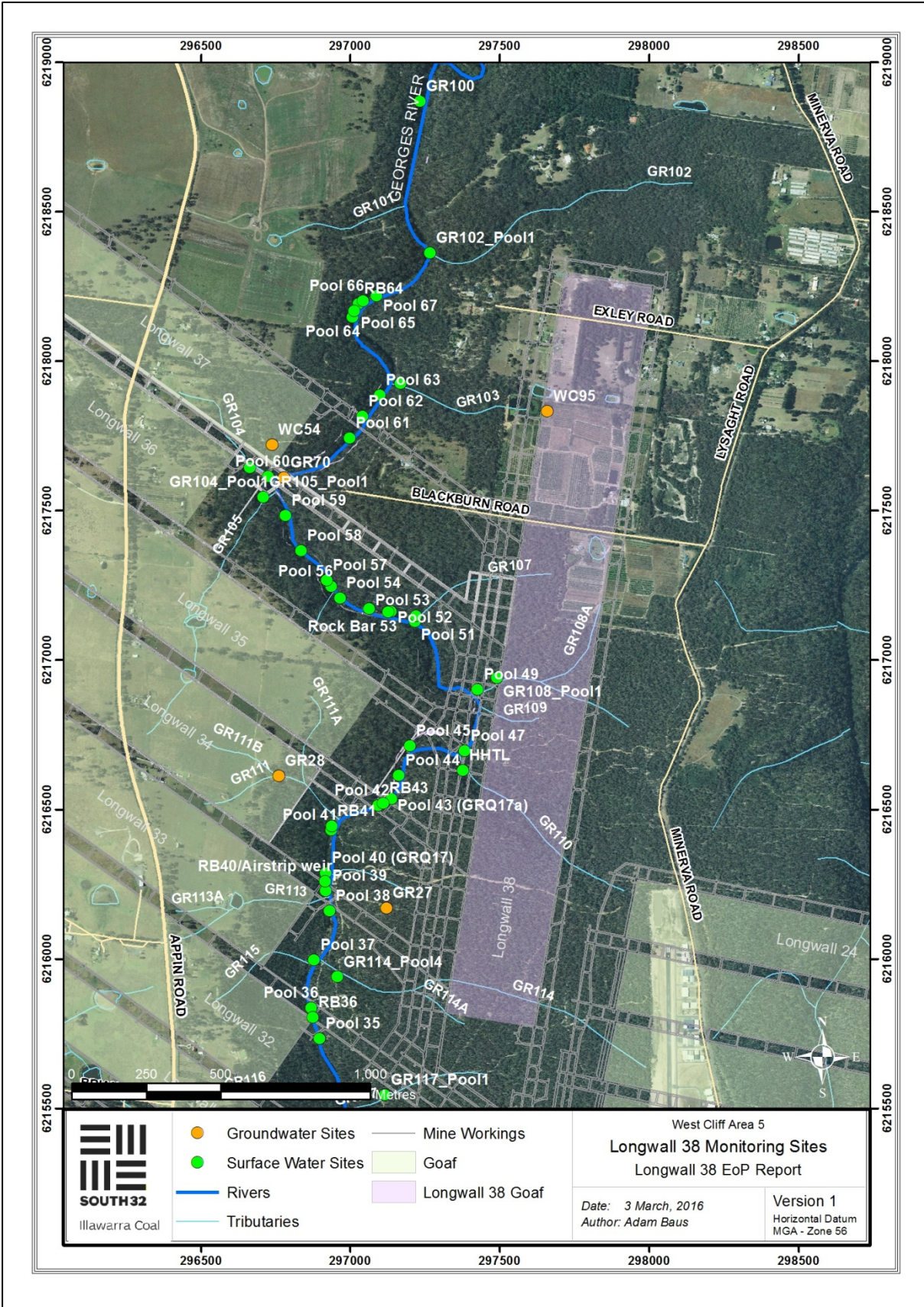


Figure 2.1: ICEFT Longwall 38 Monitoring Site Locations

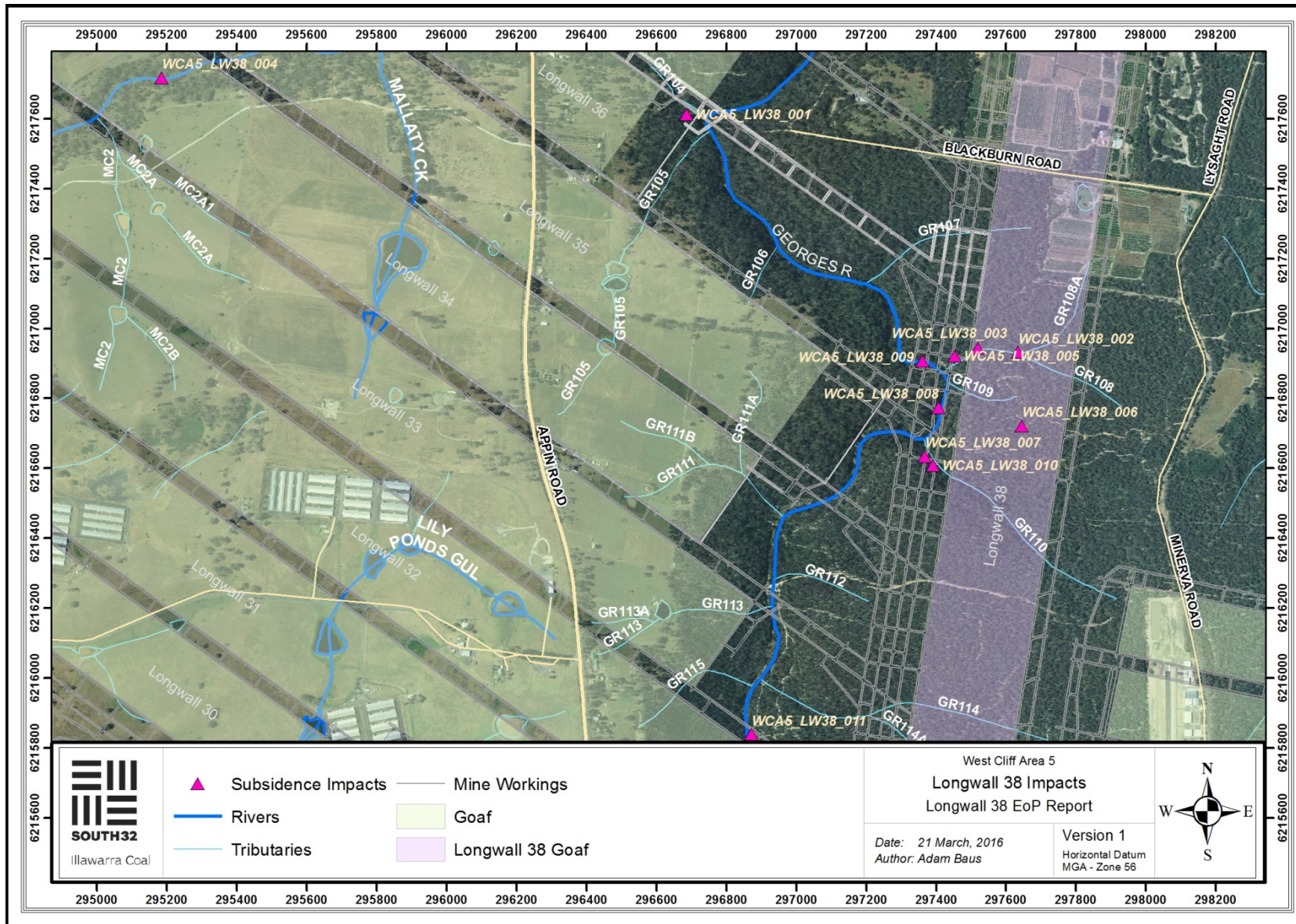


Figure 2.2: Impact sites identified and reported during the extraction of Longwall 38.

**Table 2-1 - WEST CLIFF LONGWALLS 37 & 38 MONITORING TABLE**

Monitoring Site		Monitoring Type	Monitoring Frequency	Monitoring to Date	Future Monitoring	
<b>SURFACE WATER QUALITY</b>						
<b>AREA 5</b>	<b>Longwall 37</b>			<ul style="list-style-type: none"> <li>• Monthly monitoring before mining</li> <li>• Weekly monitoring during mining</li> <li>• Monthly monitoring after mining</li> </ul>	<ul style="list-style-type: none"> <li>• Monthly monitoring after mining.</li> <li>• Additional monitoring associated with agreed recommendations in the revised Georges River Remediation Plan.</li> </ul>	
	<b>Georges River</b> Upstream monitoring site: <ul style="list-style-type: none"> <li>• Pool 54</li> </ul> Downstream monitoring site: <ul style="list-style-type: none"> <li>• Pool 64</li> </ul>		<ul style="list-style-type: none"> <li>• Field testing of water quality parameters</li> <li>• Grab sample for testing of specific analytes at an accredited laboratory</li> <li>• Water level measurements (using benchmarks where they can be installed and/or photos)</li> <li>• Observational and photographic monitoring</li> </ul>			<ul style="list-style-type: none"> <li>• Monthly before and after mining</li> <li>• Weekly during mining (when the longwall is within 400 m)</li> </ul>
	<b>Mallaty Creek</b> Downstream monitoring sites: <ul style="list-style-type: none"> <li>• MC100, MC106 and MC110</li> </ul>					
	<b>Nepean Creek</b> Downstream monitoring site: <ul style="list-style-type: none"> <li>• NC10</li> </ul>					
	<b>Tributary of Georges River</b> Downstream monitoring site: <ul style="list-style-type: none"> <li>• GR104 and 105</li> </ul>					
	<b>Longwall 38</b>			<ul style="list-style-type: none"> <li>• Monthly before and after mining</li> <li>• Weekly during mining (when the longwall is within 400 m)</li> </ul>		
	<b>Georges River</b> Upstream monitoring site: <ul style="list-style-type: none"> <li>• Pool 34</li> </ul> Adjacent monitoring site: <ul style="list-style-type: none"> <li>• Pool 54</li> </ul> Downstream monitoring site: <ul style="list-style-type: none"> <li>• GR100</li> </ul>		<ul style="list-style-type: none"> <li>• Field testing of water quality parameters</li> <li>• Grab sample for testing of specific analytes at an accredited laboratory</li> <li>• Water level measurements (using benchmarks where they can be installed and/or photos)</li> <li>• Observational and photographic monitoring</li> </ul>			
	<b>Tributaries of Georges River</b> Upstream monitoring site: <ul style="list-style-type: none"> <li>• GR119</li> </ul> Adjacent monitoring sites: <ul style="list-style-type: none"> <li>• GR107, GR108, GR110</li> </ul> Downstream monitoring sites: <ul style="list-style-type: none"> <li>• GR102, GR103, GR114 and GR117</li> </ul>					

Monitoring Site		Monitoring Type	Monitoring Frequency	Monitoring to Date	Future Monitoring	
<b>GROUNDWATER</b>						
<b>AREA 5</b>	<b>BHPBIC piezometers:</b> <ul style="list-style-type: none"> <li>GR27</li> <li>GR28</li> <li>GR29</li> <li>GR70</li> <li>WC54</li> <li>WC95</li> </ul>	<ul style="list-style-type: none"> <li>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)</li> <li>Water level (measured and logged at least twice daily)</li> </ul>	<ul style="list-style-type: none"> <li>At least one pre-mining sample</li> <li>One sample following the completion of Longwall 37</li> <li>One sample following the completion of Longwall 38</li> </ul>	<ul style="list-style-type: none"> <li>One pre-mining sample</li> <li>One sample following the completion of Longwall 38</li> </ul>	<ul style="list-style-type: none"> <li>Continue monthly monitoring for manual measurements and logged water levels for instrumented boreholes as recommended by specialist.</li> </ul>	
	<b>Private bores:</b> <ul style="list-style-type: none"> <li>GW32310</li> <li>GW72454</li> <li>GW105921</li> <li>GW108322</li> </ul>	<ul style="list-style-type: none"> <li>Monitoring as agreed in Property Subsidence Management Plans or as requested by landholder</li> </ul>	<ul style="list-style-type: none"> <li>One pre-mining level measurement and water sample</li> <li>One post mining level measurement and water sample</li> </ul>	<ul style="list-style-type: none"> <li>One pre-mining level measurement and water sample</li> <li>One post-mining level measurement and water sample</li> </ul>	<ul style="list-style-type: none"> <li>S2087 is non-functional and was rehabilitated in 2011.</li> <li><b>NB:</b> No access to boreholes GW32310, GW105921 and GW108322.</li> </ul>	<ul style="list-style-type: none"> <li>No further monitoring required</li> </ul>
	<b>BHPBIC piezometer:</b> <ul style="list-style-type: none"> <li>S2087</li> </ul>	<ul style="list-style-type: none"> <li>Vibrating wire piezometers within a cemented hole (note that some are damaged due to ground shear)</li> </ul>	<ul style="list-style-type: none"> <li>Monitoring of functional piezometers</li> </ul>			
	Groundwater inflows to the mine	<ul style="list-style-type: none"> <li>Mine water budget</li> <li>Statutory inspections</li> </ul>	<ul style="list-style-type: none"> <li>Flow meters</li> </ul>	As part of statutory mine inspections	As part of statutory mine inspections	
<b>LANDSCAPE FEATURES, VEGETATION AND WATERCOURSES</b>						
<b>All mapped cliffs, steep slopes and pools within the mining areas, including:</b> <ul style="list-style-type: none"> <li>Cliffs GR-CL01 and GR-CL02</li> <li>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)</li> <li>Tributaries (GR103, GR104, GR105, GR107, GR108, GR110, GR114)</li> </ul>	Site inspections include: <ul style="list-style-type: none"> <li>General inspection of active subsidence areas</li> <li>Re-visits to identified impact sites</li> <li>Measurement of pool water level</li> </ul>	<ul style="list-style-type: none"> <li>Monthly before and after mining</li> <li>Weekly during mining (when the longwall is within 400 m)</li> </ul>	<ul style="list-style-type: none"> <li>Monthly monitoring before mining</li> <li>Weekly monitoring during mining</li> <li>Twice weekly inspections of targeted pools when "more than negligible diversion of flows or changes in the natural drainage behaviour of pools for less than 20% of stream length subject to vertical subsidence &gt;20mm..." (GRMP, 2013)</li> <li>Monthly monitoring after mining</li> </ul>	<ul style="list-style-type: none"> <li>Monthly monitoring after mining.</li> <li>Fortnightly water level monitoring of pools when levels are below baseline.</li> <li>Additional monitoring associated with agreed recommendations in the revised Georges River Remediation Plan.</li> </ul>		

## 2.1. Surface Water Quality

In-situ water quality parameters for surface waters relating to Longwall 38 have been measured by the ICEFT on a weekly basis when mining was within 400m of the area (when access to the monitoring sites is safe and available). Parameters measured include temperature, specific conductivity (SpC), Oxidation-Reduction Potential (ORP), pH and dissolved oxygen (DO). Water samples are collected on a monthly basis to test for a range of parameters by laboratory analysis. Water quality parameters have been assessed by a specialist consultant and results are included in the relevant water quality section of the EoP Report.

## 2.2. Groundwater

Boreholes relevant to Longwall 38 are GR27, GR28, GR70, WC54 and WC95. Shallow groundwater levels and water quality samples were collected from these boreholes by the ICEFT. Water levels in GR27 and GR28 are measured manually while water levels in GR70, WC54 and WC95 are instrumented and logged using vibrating wire piezometers. The water levels and water quality data have been assessed by a specialist consultant and are included in the relevant groundwater section of the EoP Report.

Boreholes GR27, GR28, GR70 and WC54 were not impacted by Longwall 38. The water level in borehole WC95 dropped by 5m on the 5<sup>th</sup> May 2015 coinciding with the progression of the longwall. Since then borehole WC95 has shown continuous recovery and its water level was not reduced by over 5m for longer than 2 months and therefore does not meet a trigger level according to TARPs set in the EP.

Inspections of boreholes on private properties within the zone of influence of Longwall 38 (where access agreements were in place) were conducted by the ICEFT. Inspections of private boreholes include measurement of in-situ water quality and collection of water samples for laboratory analysis. Potential impacts to two privately owned boreholes were reported following extraction of Longwall 38. These included changes in water appearance and water chemistry. Detailed discussion will be included in the groundwater section of the Longwall 38 End of Panel Report.

## 2.3. Watercourse Appearance

Inspections of the Georges River and its tributaries were conducted by the ICEFT in accordance with the EP. These inspections include observations, measurements and photographic records.

### 2.3.1. Georges River

During the extraction of Longwall 38 the ICEFT identified iron staining along a 20m section of the Georges River downstream of GR\_Pool 49. This impact has been reported as WCA5\_LW38\_009 (**Photo 1**) and is a Level 1 Trigger under the TARPs in the EP (**Table 1, Appendix A**).





**Photo 1:** WCA5\_LW38\_009, the extent of iron staining downstream of GR\_Pool 49. Photo taken looking downstream. Taken on 10/12/2015.

### **2.3.1. Georges River Tributaries**

During the extraction of Longwall 38 the ICEFT identified impacts in Georges River tributaries GR104, GR108 and GR110.

#### ***Tributary GR104***

Fracturing and associated uplift was identified at a rockbar in GR104 (impact WCA5\_LW38\_001) (**Photo 2**). As this impact was located outside the zone of influence of Longwall 38 it is likely to be a result of a previous mining.

#### ***Tributary GR108***

Three zones of fracturing and uplift were identified in GR108 during the extraction of Longwall 38. These impacts have been reported as WCA5\_LW38\_002, WCA5\_LW38\_003 and WCA5\_LW38\_005 (**Photos 2 to 5**). Minor iron staining was noted at impacts WCA5\_LW38\_002 and WCA5\_LW38\_005. No flow diversion was noted at WCA5\_LW38\_005. No flow was present during the inspections of WCA5\_LW38\_002 and WCA5\_LW38\_003 therefore changes to flow conditions are undetermined.

#### ***Tributary GR110***

Fracturing to the base of GR110 with associated loss of flow was identified (impact WCA5\_LW38\_007) (**Photo 6**).



**Photo 2:** WCA5\_LW38\_001, fracturing and dislodged rock in GR104. Taken on 24/04/2015.



**Photo 3:** WCA5\_LW38\_002, fracturing perpendicular to bedding plane with minor iron staining in Rockbar 6A, GR108. Taken on 03/08/2015.



**Photo 4:** WCA5\_LW38\_003, fracturing and uplift within Channel 2, GR108. Taken on 03/08/2015.



**Photo 5:** WCA5\_LW38\_005, fracturing and uplift downstream of Pool 1 in GR108. Taken on 20/08/2015.



**Photo 6:** Impact WCA5\_LW38\_007, fracturing to base of GR110. Taken on 16/11/2015.

### 2.3.2. Other Watercourses

During a Longwall 36 post-mining inspection (conducted during the extraction of Longwall 38) iron staining was identified within a 400m section of Mallaty Creek (**Photos 7 to 9**). This impact (WCA5\_LW38\_004) is located more than 2300m from Longwall 38 and is likely associated with previous mining.



**Photo 7:** WCA5\_LW38\_004, Point of origin of iron staining at MC107, looking downstream. Taken on 19/08/2015.



**Photo 8:** WCA5\_LW38\_004, most downstream point of visible iron, upstream of pool MC120. Taken on 19/08/2015.



**Photo 9:** WCA5\_LW38\_004, Iron staining observed in Mallaty Creek. Taken on 19/08/2015.

### 2.4. Water Levels and Flows

Pool water levels and flow conditions in the Georges River are monitored by the ICEFT using observations, photo comparisons and measured benchmarks. Inspections of water level were conducted weekly during mining (when the longwall is within 400m) and twice weekly when water levels fell below baseline in known impacted pools.

Fracturing was identified in the Georges River at GR\_Rockbar\_49 (impact WCA5\_LW38\_008) (**Photos 10 & 11**). The largest fracture at this site is 10m long and 0.04m wide. Flow diversion was observed at this site and the impact has been reported as a Level 2 Trigger under the TARPs in the EP (**Table 1, Appendix A**).

During monitoring for Longwall 38, below baseline levels were reported for Georges River pools; *GR\_Pool 60, GR\_Pool 59, GR\_Pool 58, GR\_Pool 57, GR\_Pool 56, GR\_Pool 54 and GR\_Pool 44*. These pools have been reported during the extraction of previous longwalls and have been attributed to Longwall 35. During significant rainfall events and increased mitigatory flow from Brennans Creek Dam these pools continue to show water levels similar to baseline. However, these water levels decrease during periods of low rainfall and reduced releases from Brennans Creek Dam.

As these water level impacts are a result of Longwall 35 they have been classified under the West Cliff Area 5 Longwalls 34 to 36 Subsidence Management Plan and Georges River Management Plan (2014). Accordingly, they remain as a Level 2 impact. Trigger levels relating to water level in the Georges River have not changed during the extraction of Longwall 38.

Remediation options for impacted sections of the Georges River as a result of Longwalls 32 to 38 will be addressed in the *Georges River Remediation Plan* (currently under review).



**Photo 10:** WCA5\_LW38\_008, fracturing on the Georges River. Taken on 10/12/2015



**Photo 11:** WCA5\_LW38\_008, fracturing on the Georges River. Taken on 10/12/2015

## 2.5. Landscape Features

The ICEFT conducted inspections of landscape features including cliffs, steep slopes and access tracks within the zone of influence of Longwall 38. Three surface impacts, WCA5\_LW38\_006, WCA5\_LW38\_010 and WCA5\_LW38\_011, were identified to landscape features during or following extraction of Longwall 38.

WCA5\_LW38\_006 is a soil crack which occurred to an access track adjacent to Georges River (**Photo 12**). The crack is approximately 3m long, 0.08m deep and has a maximum width of 0.01m. It does not impact access and is likely to naturally remediate.

WCA5\_LW38\_010 is a zone of fracturing to a rock outcrop adjacent to GR110 (**Photo 13**). The largest fracture is approximately 2.1m long, 0.03m wide and has a measurable depth of 0.414m.

WCA5\_LW38\_011 is a zone of soil cracking on an access track adjacent to the Georges River (**Photo 14**). The largest crack is up to 3m long and 0.004m wide. It does not impact access and is likely to naturally remediate.



**Photo 12:** WCA5\_LW38\_006, soil crack looking across the access track. Taken on 25/09/15.



**Photo 13:** WCA5\_LW38\_010, Fracturing to rock outcrop adjacent to GR110. Taken on 17/02/16.



**Photo 14:** WCA5\_LW38\_011, soil crack on access track. Taken on 16/03/16.

### 3. Summary of Impacts

A summary of the impacts observed during the extraction of Longwall 38 is included in **Table 3-1**; refer to **Figure 2** for locations. A detailed description of each impact identified following

extraction of Longwall 38 can be found in their respective impact reports, attached to the EoP Report. A summary of the TARPs and impacts observed is provided in **Appendix A**.

**Table 3-1: Summary of Impacts Activated by Longwall 38**

Site ID	Impact Type	Identification Date	Activating Longwall	Feature Affected	Impact Description	Trigger Level	Relevant Impact Report/s
WCA5_LW38_001	Rock Fracturing	24/04/2015	LW36/7	Georges River Tributary GR104	Rock fracture up to 4m long and dislodgment of rock fragments up to 0.08m <sup>3</sup> in GR104	n/a	<i>West Cliff Area 5 Longwall 38 Update Report - Dated: 27<sup>th</sup> April 2015</i>
WCA5_LW38_002	Rock Fracturing	03/08/2015	LW38	Georges River Tributary GR108	Fracturing and extension of bedding plane in Rockbar 6A of GR108. Maximum fracture measurements are approx. 1.4m long, 0.008m wide and >0.025m deep. Minor iron staining present.	n/a	<i>West Cliff Area 5 Longwall 38 Impact Report - Dated: 4<sup>th</sup> August 2015</i>
WCA5_LW38_003	Rock Fracturing	03/08/2015	LW38	Georges River Tributary GR108	Fracturing and uplift in Channel 2 of GR108. Maximum fracture measurements are approx. 10m long, 0.015m wide and >0.25m deep.	n/a	<i>West Cliff Area 5 Longwall 38 Impact Report - Dated: 4<sup>th</sup> August 2015</i>
WCA5_LW38_004	Iron Staining	19/08/2015	LW38	Mallaty Creek	Iron staining in Mallaty Creek along a 400m section between pools MC107 and MC120. (Likely associated with a previous Longwall due to distance from Longwall 38)	n/a	<i>West Cliff Area 5 Longwall 38 Impact Report - Dated: 21<sup>st</sup> August 2015</i>
WCA5_LW38_005	Rock Fracturing	20/08/2015	LW38	Georges River Tributary GR108	Fracturing and uplift downstream of GR108_Pool 1 covering an area of approx. 3m <sup>2</sup> . Largest fracture is approx. 1.2m long with 0.03m of uplift. No active flow diversion evident. Minor iron staining present	n/a	<i>West Cliff Area 5 Longwall 38 Impact Report - Dated: 21<sup>st</sup> August 2015</i>

Site ID	Impact Type	Identification Date	Activating Longwall	Feature Affected	Impact Description	Trigger Level	Relevant Impact Report/s
					originating from upstream.		
<b>WCA5_LW38_006</b>	Soil Crack	25/09/2015	LW38	Access Track	Soil cracking across a fire trail adjacent to the Georges River. Approx. 3m long, 0.01m wide and >0.08m deep. No impact to track access.	n/a	<i>West Cliff Area 5 Longwall 38 Impact Report - Dated: 28<sup>th</sup> September 2015</i>
<b>WCA5_LW38_007</b>	Rock Fracturing	02/10/2015 <i>(update: 16/11/2015)</i>	LW38	Georges River Tributary GR110	Fracturing to boulders in and to the base of GR110. Fractures up 2.1m long. Fractures in the base of the tributary up to 0.15m wide. Loss of surface flow.	n/a	<i>West Cliff Area 5 Longwall 38 Impact Report - Dated: 6<sup>th</sup> October 2015 &amp; West Cliff Area 5 Longwall 38 Impact Report - Dated: 17<sup>th</sup> November 2015</i>
<b>WCA5_LW38_008</b>	Rock Fracturing	10/12/2015	LW38	Georges River, GR_Rockbar 49	Multiple fractures and dislodgment of rocks on GR_Rockbar 49. Fractures range from 1.3m to 10m long. Largest fracture is 10m long and 0.04m wide. Flow diversion evident.	Level 2	<i>West Cliff Area 5 Longwall 38 Impact Report - Dated: 11<sup>th</sup> December 2015</i>
<b>WCA5_LW38_009</b>	Iron Staining	10/12/2015	LW38	Georges River, Downstream of GR_Pool 49	Iron staining along a 20m section downstream of GR_Pool 49.	Level 1	<i>West Cliff Area 5 Longwall 38 Impact Report - Dated: 11<sup>th</sup> December 2015</i>
<b>WCA5_LW38_010</b>	Rock Fracturing	17/02/2016	LW38	Rock Outcrop adjacent to GR110	Fractures to rock outcrop. The largest fracture is vertical and approx. 2.1m long, 0.03m wide and >0.414m deep.	n/a	<i>West Cliff Area 5 Longwall 38 Impact Report - Dated: 18<sup>th</sup> December 2015</i>



Site ID	Impact Type	Identification Date	Activating Longwall	Feature Affected	Impact Description	Trigger Level	Relevant Impact Report/s
WCA5_LW38_011	Soil Cracking	16/03/2016	LW38	Access Track	Soil cracking on access track. Up to 3m long and 0.004m wide. No impact to track access.	n/a	<i>West Cliff Area 5 Longwall 38 Impact Report - Dated: 17<sup>th</sup> March 2016</i>

## 4. Recommendations for Future Monitoring and Rehabilitation

It is proposed that monitoring for Longwall 38 continue as required under the West Cliff Area 5 Longwalls 37 and 38 EP and as presented in the EoP Report. This will involve the continuation of post-mining monitoring which started after the completion of the longwall on the 1<sup>st</sup> February 2016. **Table 2-1** summarises the future monitoring for West Cliff Area 5.

A draft *Georges River Remediation Plan* (GRRP) was submitted to the Department of Planning and Environment (DPE) and DTI in January 2015. The GRRP details the observations and proposed remediation activities for subsidence impacts in the Georges River as a result of Longwalls 32 to 36. The plan also details environmental monitoring and reporting on the effectiveness of rehabilitation measures. The GRRP is currently being reviewed and revised to consider Longwall 38 impacts and comments received from DTI and Office of Environment and Heritage (OEH).

## 5. Appendix

Feature	Performance Measure*	Potential Impacts	Exceeding Prediction	TARP Trigger Level	Observed Impacts	Additional Comments / Recommendations
<b>Appearance and Pool Water Level</b>						
<b>Georges River</b>  All mapped pools within the mining area	Negligible environmental consequences including: <ul style="list-style-type: none"> <li>negligible diversion of flows or changes in the natural drainage behaviour of pools;</li> <li>negligible gas releases and iron staining; and</li> <li>negligible increase in water cloudiness,</li> </ul> over at least 80% of the stream length subject to vertical subsidence >20 mm.	<ul style="list-style-type: none"> <li>Fracturing and pool water level loss</li> <li>Subsidence induced springs</li> <li>Gas releases</li> <li>Fracturing of rockbars and the stream bed where the subsidence movements are predicted to be highest</li> <li>Changes in grade of drainage lines are considered small in comparison to natural grades. This is unlikely to result in significant increases in ponding or flooding, although some very localised impacts may occur</li> <li>Diversion of surface water flows where fracturing coincides with a water controlling feature e.g. rock bar.</li> </ul>	<ul style="list-style-type: none"> <li>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 &gt;20mm</li> <li>More than negligible increase in water cloudiness over more than 20% of the stream length subject to vertical subsidence &gt;20mm</li> <li>More than negligible increase in iron staining over more than 20% of the stream length subject to vertical subsidence &gt;20mm</li> <li>Subsidence impacts or environmental consequences greater than minor</li> </ul>	<b>Level 1</b> <ul style="list-style-type: none"> <li>Fracturing with no observable surface water diversion</li> <li>Pool water level lower than baseline in any mapped pool located in the mining area (within 400m of the longwall)</li> <li>Increase in turbidity, iron staining, algal growth, or other visible water quality parameters determined by comparing baseline photos with photos during the mining period.</li> </ul>	<ul style="list-style-type: none"> <li><b>WCA5_LW38_009</b> Iron Staining downstream of Georges River GR_Pool 49</li> </ul>	
				<b>Level 2</b> <ul style="list-style-type: none"> <li>Pool water level lower than baseline in the majority of mapped pools located in the mining area (within 400m of the longwall)</li> <li>Fracturing with observable surface water diversion.</li> </ul>	<ul style="list-style-type: none"> <li><b>WCA5_LW38_008</b> Rock Fracturing in Georges River GR_Rockbar 49</li> </ul>	To be addressed in the Gorges River Rehabilitation Plan

Feature	Performance Measure*	Potential Impacts	Exceeding Prediction	TARP Trigger Level	Observed Impacts	Additional Comments / Recommendations
				<p><b>Level 3</b></p> <ul style="list-style-type: none"> <li>Pool water level lower than baseline in all mapped pools in the mining area (within 400m of the longwall)</li> <li>Fracturing with observable water diversion results in any mapped pool becoming dry during a mitigation flow in the River.</li> </ul>		
<p><b><u>Tributaries of the Georges River</u></b></p> <p><b>Longwall 38</b> Upstream monitoring site:</p> <ul style="list-style-type: none"> <li>GR119</li> </ul> <p>Adjacent monitoring sites:</p> <ul style="list-style-type: none"> <li>GR107, GR108, GR110</li> </ul> <p>Downstream monitoring sites:</p> <ul style="list-style-type: none"> <li>GR102, GR103, GR114 and GR117</li> </ul>	<p>No greater subsidence impact or environmental consequences than predicted in the EA and PPR.</p>	<ul style="list-style-type: none"> <li>Changes in grade of drainage lines are considered small in comparison to natural grades. This is unlikely to result in significant increases in ponding or flooding, although some very localised impacts may occur</li> <li>Some compressive buckling and dilation of the uppermost bedrock could occur. However, the natural surface soil beds would limit exposure of fracturing at the surface and any</li> </ul>			<ul style="list-style-type: none"> <li><b>WCA5_LW38_001</b> Rock Fracturing in GR104</li> <li><b>WCA5_LW38_002</b> Rock Fracturing in GR108</li> <li><b>WCA5_LW38_003</b> Rock Fracturing in GR108</li> <li><b>WCA5_LW38_004</b> Iron Staining in Mallaty Creek</li> <li><b>WCA5_LW38_005</b> Rock Fracturing in GR108</li> <li><b>WCA5_LW38_007</b> Rock Fracturing in GR110</li> </ul>	<p>To be addressed in the Gorges River Rehabilitation Plan</p>

Feature	Performance Measure*	Potential Impacts	Exceeding Prediction	TARP Trigger Level	Observed Impacts	Additional Comments / Recommendations
		minor occurrences are likely to be filled with the natural soils during subsequent flow events.				
<b>Landscape Features</b>						
<p><b>Cliffs</b> GR-CL01 and GR-CL02</p> <p><b>Steep Slopes</b></p> <p><b>Georges River – including pools and rockbars</b></p> <ul style="list-style-type: none"> <li>• GR-RB42</li> <li>• GR-RB43</li> <li>• GR-RB44</li> <li>• GR-RB45</li> <li>• GR-RB47</li> <li>• GR-RB48</li> <li>• GR-RB49</li> <li>• GR-RB51</li> <li>• GR-RB52</li> <li>• GR-RB53</li> <li>• GR-RB54</li> <li>• GR-RB55</li> <li>• GR-RB56a</li> <li>• GR-RB56b</li> <li>• GR-RB57</li> <li>• GR-RB59</li> <li>• GR-RB60</li> </ul>	<p><i>Cliffs of 'special significance' (i.e. cliffs longer than 200m and/or higher than 40m; and cliff-like rock faces higher than 5m constitute waterfalls)</i></p> <p>- Negligible environmental consequences (that is occasional rockfalls, displacement or dislodgement of boulders or slabs, or fracturing, that in total do not impact more than 0.5% of the total face area of such cliffs within the longwall mining domain).</p> <p><i>Other cliffs</i></p> <p>- Minor environmental consequences (that is occasional rockfalls,</p>	<ul style="list-style-type: none"> <li>• Minor cracking at the tops of steep slopes where the longwall mines directly beneath steep slopes.</li> <li>• Fracturing is possible to a small percentage of rock outcrops where located directly above Longwalls.</li> <li>• Possible for rock falls from cliffs</li> <li>• Low risk of cliff failures as there is no longwall mining directly beneath cliffs.</li> </ul>	<ul style="list-style-type: none"> <li>• 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)</li> <li>• Other cliffs - more than minor environmental consequences (that is occasional rockfalls, displacement or dislodgement of boulders or slabs or fracturing, that in total impact more than 3% of the total face area of such cliffs within any</li> </ul>	<p><b>Level 1</b></p> <ul style="list-style-type: none"> <li>• Rock fall from a cliff where the cliff is left mostly intact (&lt;10% length of the cliff)</li> <li>• Surface movement or rock displacement where any exposed soil surface is stable</li> <li>• Crack at the surface which does not result in ongoing erosion or ground movement</li> <li>• Erosion which stabilises within the period of monitoring without CMA</li> <li>• Crack or fracture up to 100mm width</li> <li>• Crack or fracture up to 10m length</li> </ul> <p><b>Level 2</b></p> <ul style="list-style-type: none"> <li>• Rock fall from cliff where the characteristics of the cliff change</li> </ul>	<ul style="list-style-type: none"> <li>• <b>WCA5_LW38_006</b> soil crack along a access track adjacent to Georges River</li> <li>• <b>WCA5_LW38_010</b> zone of fracturing to a rock outcrop adjacent to GR110</li> <li>• <b>WCA5_LW38_011</b> soil crack along a access track adjacent to Georges River</li> </ul>	

Feature	Performance Measure*	Potential Impacts	<i>Exceeding Prediction</i>	TARP Trigger Level	Observed Impacts	Additional Comments / Recommendations
<ul style="list-style-type: none"> <li>• GR-RB61</li> <li>• GR-RB62</li> <li>• GR-RB63</li> <li>• GR-RB64</li> <li>• GR-RB65</li> <li>• GR-RB66</li> <li>• GR-RB67</li> </ul>	displacement or dislodgement of boulders or slabs, or fracturing, that in total do not impact more than 3% of the total face area of such cliffs within any longwall mining domain).		longwall mining domain)	(>10% length of the cliff) <ul style="list-style-type: none"> <li>• Ground disturbance that is unlikely to stabilise within the period of monitoring without CMA</li> <li>• Mass movement of a slope causing areas of exposed soil</li> <li>• Crack or fracture between 100 and 300mm width</li> <li>• Crack or fracture between 10 and 50m length</li> </ul>		

\* Performance Measure as defined in BSO Development Consent Approval (Table 1).

## **References**

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