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Gary Brassington
BHP Billiton
Illawarra Coal
PO Box 514 Unanderra NSW 2526

Dear Gary,

RE: Review of Aquatic Flora and Fauna for West Cliff Longwall 34

Background

BHP Billiton, Illawarra Coal (BHPBIC) commissioned Cardno Ecology Lab (formally The Ecology Lab Pty Ltd) to:

- Assess the impact of mine-related subsidence on the aquatic ecology of the watercourses adjacent to Longwalls 34-36 within Area 5 of the West Cliff Colliery; and
- Monitor changes in aquatic habitats and biota in these watercourses before, during and after extraction of the coal, in accordance with the Subsidence Management Plan (SMP) for Longwalls 34-36 (Cardno Forbes Rigby Pty Ltd 2008).

The objective of the monitoring is to determine whether the extent and nature of observed impacts, if any, are consistent with the predictions made in the SMP. This review focuses on the effects of extraction of Longwall 34 on aquatic habitats and biota in nearby sections of the Georges River and Mallaty Creek.

Extraction of Longwall 34 commenced on 6 February 2010 and ended on 14 September 2011. This review includes:

- An overview of the aquatic flora and fauna monitoring undertaken;
- Description of the predicted impacts on aquatic flora and fauna versus those observed;
- Overview of the management of aquatic flora and fauna;
- Recommendations for future aquatic flora and fauna monitoring.

Overview of Aquatic Ecology Monitoring

The recommendations for monitoring of aquatic ecology made by The Ecology Lab (2008a) that were incorporated into the SMP for Longwalls 34-36 are summarised in Table 1.

The monitoring of aquatic ecology undertaken at sites relevant to Longwalls 34-36 is summarised in Table 2. Preliminary baseline monitoring for Longwalls 34-36 was undertaken in May, August and November 2007 (The Ecology Lab 2008a). The findings from this report were incorporated into the monitoring programme proposed in the SMP. In accordance with the SMP requirements, a second year of baseline data was collected during September 2008 (The Ecology Lab 2008b). During-extraction monitoring for Longwall 34 was undertaken in May/June 2010 (Cardno Ecology Lab 2010).

The initial baseline monitoring for Longwalls 32-34 was undertaken at Sites 1-4 on the Georges River and Site 5 on Mallaty Creek, as specified in the SMP (The Ecology Lab 2008a; Cardno Forbes Rigby 2008). The subsequent surveys undertaken by Cardno Ecology Lab in relation to Longwalls 34-36 were done in conjunction with the ongoing monitoring of sites adjacent to Longwalls 29-33. In September 2008, two additional monitoring sites (8 and 9) were also established adjacent to Longwalls 35 and 36, respectively. To

avoid confusion with the nomenclature of the sites monitored in relation to Longwalls 29-33, Sites 1-5 adjacent to Longwalls 32-24 were renamed Sites 6, 7, 10, 11 and 12, respectively.

Table 1: Aquatic Ecology Monitoring Proposed in the SMP for Longwalls 34-36

Attribute	Frequency
Fish sampling (Including Macquarie Perch surveys)	Two baseline monitoring events, two during-extraction events per year and twice per year post-mining survey events for two years or as otherwise required.
Macroinvertebrate sampling (including threatened species)	
Water Quality	
Habitat assessment including observations of physical attributes, water flow characteristics, aquatic habitats and photographic record.	

Table 2: Completed and Proposed Aquatic Ecology Monitoring for Longwalls 34-36

Baseline Monitoring			
Report	**Survey Date**	**Sites**	**Sampling Component**
The Ecology Lab (2008a)	May/August/November 2007	1-5*	Habitat Assessment, Water Quality, Macroinvertebrates
The Ecology Lab (2008b)	September 2008	6-12**	Habitat Assessment, Water Quality, Macroinvertebrates, Fish
During-Extraction Monitoring			
Report	**Survey Date**	**Sites**	**Sampling Component**
Cardno Ecology Lab (2010)	May/June 2010	6-12**	Habitat Assessment, Water Quality, Macroinvertebrates, Fish
Proposed Monitoring			
Report	**Survey Date**	**Sites**	**Sampling Component**
In preparation	Spring 2011	6-12**	Habitat Assessment, Water Quality, Macroinvertebrates, Fish
Following survey completion	Autumn 2011 and/or Spring 2012	6-12**	Habitat Assessment, Water Quality, Macroinvertebrates, Fish

*Sites defined in the SMP for Longwall 34 (Cardno Forbes Rigby Pty Ltd 2008).
**Sites re-defined to incorporate SMP sites and additional monitoring sites (see – The Ecology Lab 2008b)

Predicted versus Observed Impacts on Aquatic Flora and Fauna

The potential impacts on aquatic ecology due to predicted subsidence associated with extraction of Longwalls 34-36 identified by The Ecology Lab (2008a) are listed in Table 3 along with the observed effects. Some fracturing and iron staining was observed by the Illawarra Coal Environmental Field Team (ICEFT) in the Georges River during extraction of Longwall 34 (ICEFT 2011). The impacts were restricted to a small number of pools and within predictions. The minor fracturing, surface flow diversions and localised reductions in pool water levels observed in Mallaty Creek during extraction were also within predictions.

There was no evidence of any impacts on the water quality of the Georges River or Mallaty Creek due to the extraction of Longwall 34 (Ecoengineers 2011). The aquatic ecology monitoring undertaken by Cardno Ecology Lab did not detect any impacts to macroinvertebrates, fish, aquatic habitat or any other aspect of aquatic ecology that could be attributed to mining activities (Cardno Ecology Lab 2010).

Table 3: Predicted and Observed Impacts on Aspects of Aquatic Ecology Associated with Extraction of Longwall 34

Impacts on Aquatic Ecology Associated with LW34 Extraction	
Predicted	**Observed**
The small changes in creek gradient predicted by MSEC (2007) should not alter levels of ponding or flooding in the river. However, some minor, localised increases are possible in areas where maximum tilts coincide with existing pools, steps or cascades. Scouring of aquatic habitats is also likely to be minimal as the river bed is composed primarily of sandstone. Only minor, localised impacts on aquatic habitat due to increased levels of ponding, flooding or scouring are therefore expected.	No significant reductions in pool water levels (ICEFT 2011a) or changes in ponding, flooding or scouring levels have been observed (MSEC 2011). No impacts on aquatic habitat attributable to these features have been detected.
Changes in the alignment of the Georges River are expected to be very small and an order of magnitude smaller than natural cross-bed gradients (MSEC 2007). Potential impacts on aquatic habitats due to changes in the alignment of the Georges River are therefore expected to be insignificant.	There is no evidence of changes in stream alignment (MSEC 2011). No impacts on aquatic habitat have been observed.
The subsidence movements that are likely to occur above Longwalls 34 to 36 are not expected to be of sufficient magnitude to cause significant fracturing of sandstone bedrock or result in significant diversion of surface water flow (MSEC 2007). It is therefore unlikely that there will be any significant water loss from the Georges River or loss of water from pools.	A zone of fracturing was observed near Rockbar 41 (near Cardno Ecology Lab aquatic ecology monitoring Site 7) (ICEFT 2011). No surface water flow diversions have been observed (MSEC 2011). Recent areas of fracturing and uplift in the Georges River have been observed downstream of Pool 43 (ICEFT 2011b). No flow diversion was observed during the inspection and the water level in Pool 43 upstream of the area was consistent with baseline levels. No obvious changes in water level at sites in the Georges River were observed by Cardno Ecology Lab apart from the normal fluctuations associated with rainfall. Minor fracturing has been observed by Cardno Ecology Lab along stretches of the Georges River. However, there appears to be no significant water loss. The degree of aquatic habitat loss, where present, is minimal and temporary with water reappearing downstream of fracture points. Minor compression fracturing and surface flow diversions were observed in Mallaty Creek in pool MC 109 (ICEFT 2011). Localised reduction in pool water level occurred as a result of this impact. No water was found at Site 12 (Mallaty Creek) in May 2010 (Cardno Ecology Lab 2010). This probably reflects the ephemeral nature of this watercourse and lack of recent rainfall rather than a subsidence-induced impact.

Table 3: Continued...

Impacts on Aquatic Ecology Associated with LW34 Extraction	
Predicted	**Observed**
The likelihood of ferruginous springs forming is minor in Mallaty Creek and minimal in the Georges River (Ecoengineers 2007).	Zone of iron staining identified in Pool 40d near Rockbar 41 (ICEFT 2011). The staining is restricted to the edge of the pool and not visible downstream.
Minor flow diversions due to fracturing could impact water quality through increased acidity, decreased dissolved oxygen and increased levels of metals (Ecoengineers, 2007). However, as extraction will not be undertaken directly under the Georges River and only minor fracturing is expected, such impacts on water quality are expected to be minor, transient and localised, if present.	No significant water quality impacts have been observed or measured within the Georges River or Mallaty Creek as a result of the mining of Longwall 34 (Ecoengineers 2011). No decline in water quality has been observed directly downstream of the fracturing and surface flow diversions in Mallaty Creek (Ecoengineers 2011). It is consequently unlikely that there will be any significant impacts to aquatic ecology. No evidence of mining-induced impacts in the limited water quality data collected by Cardno Ecology Lab.
Changes in aquatic habitat and water quantity and quality resulting from the diversion of surface water flows, water loss, the formation of ferruginous springs and any other subsidence induced impact could potentially have concurrent impacts on aquatic flora and fauna.	No evidence of any mining-induced impacts on either fish or macroinvertebrates (Cardno Ecology Lab 2010). Assemblages sampled during mining in 2010 were broadly comparable to that sampled previously.
Assessments of potential impacts undertaken in accordance with State and Commonwealth legislation on Sydney hawk dragonfly, Adams emerald dragonfly and Macquarie Perch indicate that the proposed longwall mining does not pose a significant threat to any of these species.	No threatened species or impacts to threatened species have been detected during monitoring.

Overview of management of aquatic flora and fauna

The SMP indicates that further investigations into potential effects on aquatic ecology would be triggered by:

- Fracturing of rockbars and loss of pools or significant changes in water chemistry in areas with moderate or significant aquatic habitat;
- Observations of mortality of fish, crayfish or macrophyte beds; and
- Significant changes in aquatic biota during mining.

If necessary, it was recommended that rehabilitation of aquatic habitat be done in conjunction with mitigative works, such as grouting, and this be followed by monitoring to assess recovery. None of these “Trigger-Action Response Plans” have been triggered.

Recommendations

Mallaty Creek is ephemeral and subjected to periods with no surface flow (ICEFT 2011). The lack of water observed during the 2010 survey (Cardno Ecology Lab 2010) is most likely due to its ephemeral nature. Although minor subsidence-induced impacts have been observed in Mallaty Creek, it is difficult to determine the influence, if any, that these may have had on water levels within the creek. As extraction of Longwalls 35 and 36 will occur directly under Mallaty Creek it is recommended that monitoring continue at Site 12 on Mallaty Creek. The ephemeral nature of the creek may make it difficult to assess the likely influence of any

mining induced impacts on water levels in the creek, however, continued monitoring of Mallaty Creek and the assessment of any potential mining induced impacts in light of rainfall and runoff observations would provide additional information of the level of mining induced impacts in the creek.

Post extraction monitoring for Longwall 34 was undertaken in November 2011 as part of the ongoing monitoring recommended in the SMP for Longwalls 34-36. A report on the findings of this survey is currently under preparation. To fulfil the requirements of the SMP for Longwalls 34-36, it is recommended that post-extraction monitoring of aquatic ecology at the sites relevant to Longwall 34 be undertaken in Autumn and/or Spring 2012. An assessment of the frequency of future aquatic ecology monitoring events will be made following completion of the latest report on the latest round of monitoring for Longwalls 34-36. This monitoring would be incorporated into the ongoing monitoring for Longwalls 34-36.

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Yours faithfully,

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