Appin Longwalls 701 to 704 and 705 to 710

Aquatic Ecology Monitoring 2003-2013

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Executive Summary

BHP Billiton Illawarra Coal (BHPBIC) is using underground mining techniques to extract coal from the Bulli Seam in Area 7 of Appin Colliery in the Southern Coalfield of New South Wales. This area includes Longwalls 701 to 710. The extraction of Longwalls 701 to 704 was approved in November 2006 and has now been completed in line with the approved Subsidence Management Plan (SMP). The SMP for Longwalls 705 to 706 was approved in February 2012 and for Longwalls 707 to 710 in September 2012. Extraction of Longwall 705 commenced in September 2012 and was completed in March 2014. Extraction of Longwall 706 commenced in April 2014 and is currently underway. BHPBIC commissioned Cardno Ecology Lab (formerly The Ecology Lab Pty Ltd) to assess and monitor the potential effects of subsidence on aquatic ecology, as outlined in the SMPs for Longwalls 701 to 704 and 705 to 710.

This report describes the results of the latest field survey done in December 2013 and January 2014 at ten sites on the Nepean River in accordance with recommendations made in the SMPs for Longwalls 701 to 704 and 705 to 710. Data collected constitute post-extraction data for Longwalls 701 to 704, during extraction data for Longwall 705 and pre-extraction data for Longwalls 706 to 710. Comparisons have also been made with data collected during previous surveys in 2003, 2005, 2008, 2010, 2011 and 2012.

Aquatic macroinvertebrates, limited *in-situ* water quality, fish and aquatic macrophyte data were collected from up to ten sites on the Nepean River. The aquatic macroinvertebrate fauna in the Nepean River appears to have experienced some degree of environmental stress prior to mining and continues to do so. The limited *in-situ* water quality data indicates stratification of the water column at most sites, with anoxic water at the bottom, and oxygenated water at the top. It is possible that periodic upwelling of anoxic bottom water may influence macroinvertebrate populations. There is no evidence in number of taxa, OE50 Taxa Score and SIGNAL2 Index data to indicate changes in macroinvertebrate populations could be related to the gas releases or small area of uplift identified during and following the extraction of Longwalls 701 to 704, or any other potential mining impact. Where changes did occur at Potential Impact sites following identified mining impacts, similar changes were evident at Control sites and, thus, were not related to mining. There is also no indication that mining of Longwalls 701 to 704 has had any effect on fish populations in the Nepean River. Fish assemblages sampled in 2013 were comparable to those sampled in previous surveys.

Data from this and previous surveys indicate that the extent and distribution of aquatic macropytes at the sites visited on the Nepean River is naturally highly variable, and that it would be difficult to detect any changes associated with potential mining impacts. Notwithstanding this, there is no evidence in data collected in 2013 to indicate any changes in macrophyte species distribution that could be due to mining. All species identifed in the Nepean River during previous studies were also observed in the current study and there were no signs of dessication, die-back or any other indication of mining related impacts.

Three new gas releases zones were identified in the Nepean River during extaction of Longwall 705. There is no evidence of any change in aqautic ecology that could be associated with these gas releases. This is not surprising given that no impacts to water quality, flow and levels, or impacts to physical features, have been observed in the Nepean River during extraction of Longwall 705.

Now that at least two years of post-extraction data has been collected at Potential Impact sites relevant to Longwalls 701 to 704, it is reccomended that monitoring at these cease. Monitoring should continue at Potential Impact sites relavent to Longwalls 705 to 710 to provide further pre, during and post-extraction data for these longwalls. The next survey should be undertaken in spring 2014.

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1 Introduction

BHP Billiton Illawarra Coal (BHPBIC) is using longwall mining techniques to extract coal from the Bulli Seam in Area 7 of Appin Colliery in the Southern Coalfield of New South Wales. The Subsidence Management Plan (SMP) for Longwalls 701-704 was approved in November 2006. The Longwall 701-704 SMP satisfies legislative conditions for the mining and outlines the monitoring and management activities required to assess and mitigate potential impacts due to mining (Hansen Consulting, 2006). Longwalls 701-704 were extracted as follows:

> Longwall 701 between 27 October 2007 and 9 May 2008;

> Longwall 702 between 18 September 2008 and 20 May 2009;

> Longwall 703 between 22 October 2009 and 3 March 2011.

> Longwall 704 between 7 May 2011 and 29 July 2012.

The SMP for Longwalls 705 to 710, which are situated to the north of Longwalls 701-704, was submitted in June 2008 (Cardno Forbes Rigby, 2008). In February 2012, approval was granted for mining of Longwalls 705 and 706 (Department of Trade and Investment, 2012). Extraction of Longwall 705 commenced on 7 September 2012 and was completed on 27 March 2014. Extraction of Longwall 706 commenced in April 2014 and is currently underway.

The section of the Nepean River around the townships of Douglas Park and Appin (in South Western Sydney) and a number of small, ephemeral watercourses, Foot Onslow Creek, Navigation Creek and their respective tributaries; and Harris Creek and a number of small, unnamed drainages flow through the SMP Areas. The Nepean River is a permanent river system and contains significant aquatic habitat, which could potentially be impacted by mine-related subsidence. Water flowing through the Nepean River is derived from rainfall within catchment areas, licensed discharges from collieries, sewage treatment plants, agricultural and industrial sites and stormwater runoff from urban areas and is consequently highly variable in quality (Geoterra, 2005). The water level in this section of the river is regulated by a weir located at Menangle, several kilometres downstream (MSEC 2005 and 2008). All currently extracted and proposed longwalls have been set back from the Nepean River by at least 180 m in order to minimise subsidence effects (MSEC, 2008).

Cardno Ecology Lab (formerly The Ecology Lab Pty Ltd) was commissioned by BHPBIC to assess the potential impact of longwall mining-related subsidence on the aquatic ecology of the Nepean River and other nearby watercourses within the Appin Area 7 SMP areas and implement an aquatic ecology monitoring programme. The aims of the monitoring programme are to:

> Assess the relative abundance of fish and macroinvertebrates, condition of aquatic habitat and the condition and distribution of aquatic macrophytes that may be affected by subsidence related impacts; and,

> Determine whether any changes observed in aquatic habitat or biota may be linked to subsidence related impacts.

In this report, the results of investigations undertaken on 11-12 December 2013 and 30 January 2014, in accordance with the recommendations made in the SMPs for Longwalls 701-704 and 705-710 are presented. The specific aims of the current investigations are:

> Undertake further post-extraction monitoring for Longwalls 701 and 704;

> Undertake the second year of during-extraction monitoring for Longwall 705; and,

> Continue pre-extraction monitoring for Longwalls 706-710.

> Determine whether any changes in aquatic habitat or biota have occurred by comparing the findings of the current investigations with those from previous investigations;

> Determine whether such changes are due to potential subsidence-related impacts; and,

Provide recommendations for further work, if required, and recommendations for ongoing monitoring.

2 Previous Investigations

Cardno Ecology Lab (formerly The Ecology Lab) has produced a number of reports on the aquatic habitat and biota associated with the Nepean River and nearby watercourses. These have incorporated the results of baseline surveys, threatened species searches, predictions of mine-subsidence impacts, and results of during and post-mining monitoring. Monitoring undertaken to date in relation to Longwalls 701-704 and 705 to 710 is summarised in **Tables 2.1** and **2.2**, respectively.

Monitoring in relation to Longwalls 701-704 and 705-710 included *in-situ* water quality, AUSRIVAS, and fish sampling and mapping of macrophytes unless otherwise stated at the sites specified in **Tables 2-1** and **2.2** and at Longwalls 701-704 Control Sites 1, 2, 5 and 6 and Longwalls 705-710 Control Sites 1, 2, 7 and 8. Control Sites 7 and 8 were visited in April 2008, November 2008, December 2010 and December 2012.

The initial investigation in September 2003 was completed as part of the Review of Environmental Factors for Longwalls 701-715 (The Ecology Lab 2004) and included:

> A review of existing literature on aquatic ecology in the study area;

> A description of the fieldwork undertaken to define the ecological conditions of the relevant watercourses;

> An assessment of the likely impacts on aquatic habitats and biota based on subsidence / upsidence predictions; and

> Recommendations about additional work.

Following a significant change in the mine layout, BHPBIC commissioned an additional field study (September 2005) and report on the effects of mine subsidence on aquatic ecology in the area that could potentially be affected by the mining of Longwalls 701-704 for inclusion in the SMP (The Ecology Lab 2006).

Table 2-1 Aquatic ecology monitoring events undertaken to date at sites relevant to Longwalls 701-704 in September 2003 (The Ecology Lab 2004), September 2005 (The Ecology Lab 2006) April 2008 (The Ecology Lab 2008b), November 2008 (The Ecology Lab 2009), December 2010 (Cardno Ecology Lab 2011a), December 2011 (Cardno Ecology Lab 2012a), December 2012 (Cardno Ecology Lab 2013) and December 2013 (current study).

Longwall	Extracted	Potential Impact Sites	Sep 2003	Sep 2005*	April 2008**	Nov 2008	Dec 2010	Dec 2011***	Dec 2012***	Dec 2013
701	Oct 07-May 08	3 & 4	Pre	Pre	Dur	Dur	Pos	Pos	Pos	Pos
702	Sep 08-May 09	3 & 4 X1 & X2	Pre (3 & 4)	Pre	Pre	Pre	Pos	Pos	Pos	Pos
703	Oct 09-Mar 11	X1 & X2		Pre	Pre	Pre	Dur	Pos	Pos	Pos
704	May 11-Jul 12	X1 & X2		Pre	Pre	Pre	Pre	Dur	Pos	Pos

*September 2005 – Macrophyte mapping only
**April 2008 – Fish sampling only as part of the End of Panel Assessment for Longwall 701
***December 2011 and 2012 Macroinvertebrates and fish sampling only

The April 2008 field study provided further data to support the assessment of potential effects of mine subsidence on aquatic habitats and biota resulting from the proposed mining of Longwalls 705-710 (The Ecology Lab 2008a). This assessment was included in the SMP for Longwalls 705-710 submitted to the Department of Primary Industries Mineral Resources (Cardno Forbes Rigby 2008).

Additional ongoing monitoring in accordance with the recommendations made in the SMPs for Longwalls 701-704 and 705-710 was undertaken in November 2008 (The Ecology Lab 2009), December 2010 (Cardno Ecology Lab 2011a), December 2011 (Cardno Ecology Lab 2012a) and November 2012 (Cardno Ecology Lab 2013).

End of Panel reports have been prepared following extraction of Longwalls 701-704 (The Ecology Lab 2008b and Cardno Ecology Lab 2009b, 2011b and 2012b).

Table 2-2 Aquatic ecology monitoring events undertaken to date at sites relevant to Longwalls 705-710 in September 2003 (The Ecology Lab 2004), September 2005 (The Ecology Lab 2006) April 2008 (The Ecology Lab 2008b), November 2008 (The Ecology Lab 2009), December 2010 (Cardno Ecology Lab 2011a), December 2011 (Cardno Ecology Lab 2012a), December 2012 (Cardno Ecology Lab 2013) and December 2013 (current study).

Longwalls	Extracted	Potential Impact Sites	Sep 2003	Sep 2005*	April 2008**	Nov 2008	Dec 2010	Dec 2011***	Dec 2012***	Dec 2013
705	Sep 12-Mar 14	5, 6	Pre	Pre	Pre	Pre	Pre	Pre	Dur	Dur
706-710	Apr 14-currently udnderway	5, 6	Pre	Pre	Pre	Pre	Pre	Pre	Pre	Pre

*September 2005 – Macrophyte mapping only
**April 2008 – Fish (check methods) sampling only
***December 2011 and 2012 Macroinvertebrates and fish sampling only

2.2 Predictions

The predicted subsidence parameters, natural characteristics of the watercourses overlying the SMP Areas and experience gained during mining of similar areas indicate that longwall mining is unlikely to have any significant impact on water flow, water quality and water depth in the Nepean River or its tributaries (MSEC 2005 and 2008). There is, however, a possibility that the river will undergo a maximum net vertical uplift of 90-295 mm and 255-345 mm after extraction of Longwalls 701-704 and 705-710, respectively. This uplift is expected to affect the level of the river bed and banks, with some sections of the river experiencing a small reduction in water depth compared to pre-mining levels. Mining may also cause minor fracturing of the river bed, but this is not expected to lead to significant water loss or reductions in flow due to the flooded nature of the river and regulatory influence of Menangle Weir (MSEC 2005 and 2008). There could also be some release of gases and minor iron staining (Ecoengineers 2008). The predictions about the potential for physical and chemical impacts indicate that mining of the longwalls is unlikely to have significant secondary impacts on flow characteristics or connectivity of aquatic habitats and biota (The Ecology Lab 2004 and 2008a). There is, however, a possibility that changes in relative depth of the river bed could expose some wetted substrata in shallow areas of the river and have a localised impact on the extent and composition of macrophyte beds.

In the small, ephemeral watercourses overlying the SMP Areas, including; Foot Onslow Creek, Navigation Creek, Harris Creek, Ousedale Creek, Leafs Gully and small unnamed drainages, mine-related subsidence is expected to lead to an increase in the amount of flooding and ponding, fracturing of stream beds and drainage of some pools MSEC (2005 and 2008). These watercourses are reduced to isolated pools during dry periods, provide minimal to moderate aquatic habitat and are generally highly disturbed with extensive stock access, degraded riparian vegetation, high levels of erosion and extensive flow interruption from the construction of farm dams (The Ecology Lab 2008a). The potential temporary draining of pools within small ephemeral surface watercourses may result in the localised loss of habitat for some invertebrate and fish species, with any resident biota unable to relocate to nearby habitat, and possibly perishing as a result of desiccation and/or predation. This impact is considered to be very minor considering the highly degraded nature of such habitat and the limited aquatic biota present. These watercourses are not considered as providing potential habitat for any listed threatened species.

2.3 Findings

Longwall 701

> Surface monitoring undertaken during and/or following extraction of Longwall 701 (BHPBIC 2008a and b) indicated gas releases in four areas within the Nepean River close to Aquatic Ecology Monitoring Sites 3 and 4 and a single small area in Elladale Creek. These emissions had ceased by October 2008. Gas emissions were also associated with minor iron staining. No impact on flow was detected.

- There is no evidence to suggest changes in the distribution, extent and composition of macrophytes are related to mining (Cardno Ecology Lab 2008b and 2009). The results suggest that large-scale changes in the extent of macrophyte beds occur regardless of mining and that changes in macrophyte beds related to mine subsidence may be difficult to distinguish from temporal variation due to other factors, including natural variability.
- There is no evidence that gas releases and iron staining, and any other potential mining impact, has had any adverse effects on aquatic habitat and biota.

Longwall 702

- Surface monitoring done by BHPBIC (2009) identified three new gas release zones and the reactivation of one gas release zone (associated with the extraction of Longwall 701) as a result of subsidence from Longwall 702. Some very small uplift of banks was also observed (MSEC 2009). No fracturing, flow diversions or further iron staining was observed.
- The gas releases did not have any detectable impact on aquatic habitat and biota (Cardno Ecology Lab 2009b).

Longwall 703

- There had been no detectable impact on flow within the watercourses by the time the 2010 aquatic ecology surveys were undertaken (BHPBIC 2010). Three new gas release zones in the Nepean River near to Aquatic Ecology Monitoring Sites X1 and X2 were identified during extraction (BHPBIC 2011, Cardno Ecology Lab 2011a and b). No fracturing, changes in water levels, flow diversions or changes to water quality were observed (BHPBIC 2011, Ecoengineers 2011).
- There is no evidence of any significant impact to aquatic macroinvertebrate fauna that may have resulted from mining of Longwalls 701-703 (Cardno Ecology Lab 2011a and b). The species composition of the fish assemblages sampled in December 2010 was broadly comparable with that observed in sampling undertaken in September 2003, November 2008 and April 2008. There is no evidence that mining of the longwalls has had any adverse effects on fish populations.
- Marked changes in the distribution, extent and composition of macrophyte beds have been observed before and after the commencement of mining (Cardno Ecology Lab 2011a). The spatial variation in macrophytes is most likely due to localised differences in the depth of the water column, aspect of the site relative to the sun, suitability of the substratum for attachment, shading effects from vegetation on the banks, water flow, water transparency and availability of nutrients rather than any effects related to mining.

Longwall 704

- Three active gas release zones in the Nepean River adjacent to Aquatic Ecology Monitoring Site X1 were identified during routine investigations on 5 December 2011, just prior to the aquatic ecology sampling and following the commencement of extraction of Longwall 704 (BHPBIC 2011a and b). Other gas release zones were identified around Sites 3 and 4, but had been inactive for several months prior to sampling for aquatic ecology (BHPBIC 2012). There was no evidence of fracturing, uplift, changes in flow, water levels or water quality (Ecoengineers 2012.).
- There is no evidence to suggest changes in AUSRIVAS Macroinvertebrate data are related to potential mining impacts (Cardno Ecology Lab 2012a and b). Fish assemblages sampled in 2011 were comparable to those in 2003, 2008 and 2010, with the exception of freshwater catfish (*Tandanus tandanus*) that was sampled in 2011 only. There was no evidence of any impact to fish.
- Changes in an aquatic ecology indicator (OE50 Taxa Score at Site 5) following extraction of Longwall 704 more likely represent natural variation, rather than any potential impact due to mining. Fish assemblages sampled in 2012 were comparable to those in 2003, 2008, 2010 and 2011, hence there was no evidence of any impact to fish.

3 Study Methods

3.1 Field Methods

3.1.1 Study Sites

The following sites on the Nepean River were sampled on 11 and 12 December 2013 (**Figure 1**).

1. Sites 1 and 2: upstream Control Sites for Longwalls 701 to704 and 705 to 710;
2. Sites 3 and 4: Potential Impact Sites for Longwalls 701 and 702;
3. Sites X1 and X2: Potential Impact Sites for Longwalls 702 to 704;
4. Sites 5 and 6: downstream Control Sites for Longwalls 701 to 704, Potential Impact Sites for Longwalls 705-710; and,
5. Sites 7 and 8: upstream Control Sites for Longwalls 701 to 704 and 705-710.

Monitoring at Sites F1 and F2 on Foot Onslow Creek ceased following the previous aquatic ecology survey in 2012. The aquatic habitat in the sections of this creek visited is extremely limited so further monitoring is no longer appropriate. Monitoring at Site N1 on Navigation Creek is currently postponed and will be considered closer to the extraction date of adjacent Longwall 710.

Each study site is approximately 100m long. Their GPS coordinates are listed in **Appendix A**. Only the macrophyte inspection was completed at Sites 3 and 4. Three post-extraction monitoring events (aquatic macroinvertebrate, fish and *in-situ* water quality sampling) have now been undertaken at these sites and no further monitoring of these indicators was considered necessary.

3.1.2 Water Quality

Water quality was measured with a YSI 6920 water quality probe. The probe was calibrated using standard solutions provided by the manufacturer prior to sampling. Water quality sampling was completed before sampling for aquatic fauna to avoid disturbance to the waterway. The following variables were recorded:

- Temperature (°C);
- Conductivity (µs/cm);
- pH;
- Dissolved oxygen (% saturation);
- Oxidation reduction potential (ORP) (mV); and,
- Turbidity (ntu).

Two replicate readings were taken just below the surface and just off the bottom. Six replicate turbidity readings were taken as this measure can be variable.

The measurements of water quality are relevant only to the time of sampling and were taken to assist with interpretation of patterns in aquatic macroinvertebrate and fish data.

3.1.3 Aquatic Macroinvertebrates

Aquatic macroinvertebrates associated with edge habitats were sampled using the AUSRIVAS rapid assessment methodology (RAM) (Turak *et al.* 2004). Riffle habitat was not sampled, because this habitat was not represented in all the stretches of river surveyed. Samples were collected with dip nets (250 µm mesh) over a period of 3-5 mins from a 10 m length of habitat along the river. The dip net was used to agitate and scoop up material from vegetated river edge habitats. Where the habitat was discontinuous, patches of habitats with a total length of 10 m were sampled. Each RAM sample was rinsed from the net onto a white sorting tray from which animals were picked using forceps and pipettes. Each tray was picked for a minimum period of forty minutes, after which they were picked at ten minute intervals for either a total of one hour or until no new specimens had been found. Care was taken to collect cryptic and fast moving

Figure 3-1 Aerial photograph of the study area showing aquatic ecology monitoring Sites 1 to 8 and X1 to X2 on the Nepean River relative to Appin Longwalls 701 to 704 and 705 to 710 and other nearby watercourses. Gas release zones identified during extraction of Longwall 705 are also shown

animals in addition to those that were conspicuous or slow. The animals collected at each site were placed into a labelled jar containing 70% alcohol / water.

Environmental variables, such as alkalinity, modal river width and depth, percentage boulder or cobble cover, latitude and longitude, which are required for running the spring AUSRIVAS predictive model for edge habitat, were recorded in the field. Distance from source, altitude, and land-slope were determined from appropriate topographic maps. Mean annual rainfall was determined from the regional precipitation maps presented in the AUSRIVAS Sampling and Processing Manual (Turak *et al.* 2004).

3.1.4 Fish

At each site, five baited traps (350 mm long, 200 mm wide with an entrance that tapered in to 45 mm, with 3 mm mesh size) were deployed overnight for approximately 12 hours. Traps were baited with 70 ml of a mixture of chicken pellets and sardines and deployed amongst macrophytes and snags (submerged woody debris). Caught fish were identified and then released. Numbers of fish collected incidentally in the macroinvertebrate dip net samples were also recorded. Fish were also sampled using a seine net (10 m x 1 m x 3 mm mesh). At each site, 1-2 seine nets were deployed near to macrophyte beds. The aim of the seine net sampling was to provide additional information on fish species utilising the Nepean River that may not be caught by bait trapping.

3.1.5 Aquatic Macrophytes

The aquatic macrophytes at each monitoring site on the Nepean River were inspected on 30 January 2014. The inspection included the compilation of a species inventory for each site and observations of any signs of desiccation, die back or other features of the macrophytes that could be indicative of potential mining related impacts. A bathyscope and modified rake were used to view and collect samples of macrophytes.

In previous studies, the extent of each aquatic macrophyte species and group of species was mapped in detail at each site using a Differential GPS. The results of these previous studies indicated that the distribution, extent and composition of aquatic macrophytes was naturally highly variable, and that it would be very difficult to detect any changes due to mining above background variation (see Section 2.3). Following a review of this monitoring component, the focus was shifted to detection of broader scale changes to species composition at each site, rather than the fine scale changes in the extent of beds documented previously. The current method is more appropriate to the magnitude of change that would be required to confidently link changes in aquatic macrophytes with potential mining impacts.

3.2 Laboratory Methods

AUSRIVAS samples were sorted under a binocular microscope (at 40 X magnification) and identified to family level with the exception of Oligochaeta and Polychaeta (to class), Ostracoda (to subclass), Nematoda and Nemertea (to phylum), Acarina (to order) and Chironomidae (to subfamily). Up to ten animals of each family were counted, in accordance with the latest AUSRIVAS protocol (Turak *et al.* 2004).

3.3 Data Analysis

3.3.1 Water Quality

Mean water quality measurements were compared with the Australia, New Zealand Environment Conservation Council (ANZECC/ARMCANZ 2000) default trigger values (DTVs) for physical and chemical stressors for slightly disturbed lowland rivers in southeast Australia.

3.3.2 AUSRIVAS Samples

The AUSRIVAS protocol uses an internet-based software package to determine the environmental condition of a waterway based on predictive models of the distribution of aquatic macroinvertebrates at undisturbed, reference sites (Coysh *et al.* 2000). The health of the stream is assessed by comparing the observed freshwater macroinvertebrate assemblages (i.e. those collected in the field) with macroinvertebrate assemblages expected to occur in reference waterways with similar environmental characteristics. The data from this study were analysed using the NSW models for pool edge habitat sampled in spring. The AUSRIVAS predictive model generates the following indices:

- OE50Taxa Score – The ratio of the number of macroinvertebrate families with a greater than 50% predicted probability of occurrence that were actually observed (i.e. collected) at a site to the number of macroinvertebrate families expected with a greater than 50% probability of occurrence. OE50 taxa scores provide a measure of the impairment of macroinvertebrate assemblages at each site, with values close to 0 indicating an impoverished assemblage and values close to 1 indicating that the condition of the assemblage is similar to that of the reference streams.
- Overall Bands derived from OE50Taxa scores which indicate the level of impairment of the assemblage. These bands are graded as follows:

  Band X = Richer invertebrate assemblage than reference condition;

  Band A = Equivalent to reference condition;

  Band B = Sites below reference condition (i.e. significantly impaired);

  Band C = Sites well below reference condition (i.e. severely impaired); and,

  Band D = Impoverished.

The SIGNAL2 biotic index (Stream Invertebrate Grade Number Average Level) developed by Chessman (2003) was also used to determine the environmental quality of sites on the basis of the presence or absence of families of macroinvertebrates. This method assigns grade numbers between 1 and 10 to each macroinvertebrate family, based largely on their responses to chemical pollutants. The sum of all grade numbers for that site was then divided by the total number of families recorded in each site to obtain an average SIGNAL2 Index. The SIGNAL2 Index therefore uses the average sensitivity of macroinvertebrate families to present a snapshot of biotic integrity at a site. SIGNAL2 values are as follows:

- SIGNAL > 6 = Healthy habitat;
- SIGNAL 5 – 6 = Mild pollution;
- SIGNAL 4 – 5 = Moderate pollution; and,
- SIGNAL < 4 = Severe pollution.

3.4 QA/QC Procedures

Data generated in the field was checked for accuracy and completeness before leaving each site. On return to the laboratory, field data sheets were photocopied, entered into spreadsheet format and checked using standard QC procedures. Spreadsheet files were locked prior to analysis to prevent accidental over-writes or corruption.

In the laboratory, the remains of each macroinvertebrate sample were retained and checked by another staff member to ensure that no animals were missed. A staff member with appropriate training and experience checked the identifications and counting of samples. These activities were recorded on the Laboratory Management Sheet. Data were entered into an electronic spreadsheet and data for each sample was printed out and checked by a second staff member.

4 Results

4.1 Water Quality

The mean water quality data for each site measured in December 2013 are presented in **Appendix B**. The main findings were:

> Temperature ranged from 23.7 to 25.8 C at the surface and from 16.6 to 23.3 at the bottom. Temperature at the bottom was either lower than, or comparable to, that at the surface;

> Conductivity ranged from 148 to 174 µS/cm at the surface and from 155 to 414 µS/cm at the bottom of the water column and was within the DTVs on each occasion. Conductivity was comparable between surface and bottom water for each site except for Site X2 where levels were greater in deeper water;

> pH ranged from 7.7 to 8.2 at the surface and from 7.0 to 8.1 at the bottom. The pH of the surface water at Site 7 and the bottom water at Site X2 was above the upper DTV. The pH of the bottom water at the other sites was generally lower than, or comparable to, that at the surface;

> Oxidation Reduction Potential (ORP) ranged from 23 to 60 mV at the surface and from -61 to 59 at the bottom. There was no clear trend in ORP data;

> Dissolved oxygen ranged from 99.6 to 111.8 % saturation at the surface and from 7.3 to 102.8 % saturation at the bottom. Dissolved oxygen was within the DTVs at the surface of each site and below the lower DTV at the bottom of Sites 5, 6, 7, X1 and X2, with levels at Sites 6, 7 and X2 at or below 15.0 % saturation; and,

> Turbidity was 0.0 NTU at the surface and ranged from 0.0 to 6.0 at the bottom. Turbidity was below the lower DTV on each occasion except from that at the bottom of Site 2. Turbidity at the bottom was generally slightly greater than that at the surface.

Measures of water quality were generally within the range measured in previous surveys.

4.2 Aquatic Macroinvertebrates

4.2.1 December 2013

A total of 45 macroinvertebrate taxa were recorded (**Appendix C**). Chironominae, Tanypodinae, Corixidae, Elmidae, Hydracarina and Leptoceridae were found at each site.

The number of taxa found ranged from 19 at Site 1 to 27 at Site X2 (**Table 4.1**). The fauna at Sites 5, X1 and X2 was equivalent to the AUSRIVAS reference condition, but that at Sites 1, 2, 6, 7 and 8 was significantly to severely impaired relative to the reference condition as indicated by their B and C ratings. The OE50 Taxa Scores showed that these sites lacked between 18% and 30% of the taxa expected to occur in reference streams with similar environmental characteristics. The SIGNAL2 Index for Sites 1, 6, 8 and X2 was indicative of severe pollution while that for Sites 2, 5, 7 and X1 was indicative of moderate pollution.

4.2.2 2003 to 2013 Surveys

The objective of the following comparisons of macroinvertebrate data among surveys and among sites is to determine whether any changes to aquatic ecology that may have occurred are linked with the extraction of Longwalls 701 to 704 and the commencement of extraction of Longwall 705.

4.2.2.1 Number of Taxa

The number of taxa found ranged from 13 to 33 (**Figure 4.1**). The number of taxa sampled each survey was relatively similar across sites. Fewer taxa were sampled in 2003 while the greatest numbers were generally found in 2008. At sites not sampled in 2003, fewer taxa were generally found in 2013. Following the sampling in 2008, there was a decrease in the number of taxa sampled at Sites 1, 2, 7 and 8. The number of taxa sampled at the remaining sites, except Site 3, has remained relatively stable.

Table 4-1 Total numbers of macroinvertebrate taxa found in AUSRIVAS samples collected from edge habitat at aquatic ecology monitoring sites visited on the Nepean River 11 and 12 December 2013 and their respective AUSRIVAS band, OE50 Taxa Score and SIGNAL 2 Index.

	Number of Taxa	OE50 Taxa Score	AUSRIVAS Band	SIGNAL2 Index
Site 1	19	0.76	B	3.6
Site 2	22	0.82	B	4.6
Site 5	25	0.87	A	4.3
Site 6	22	0.70	B	3.9
Site 7	22	0.82	B	4.2
Site 8	20	0.76	B	3.8
Site X1	22	0.88	A	4.6
Site X2	27	0.93	A	3.8

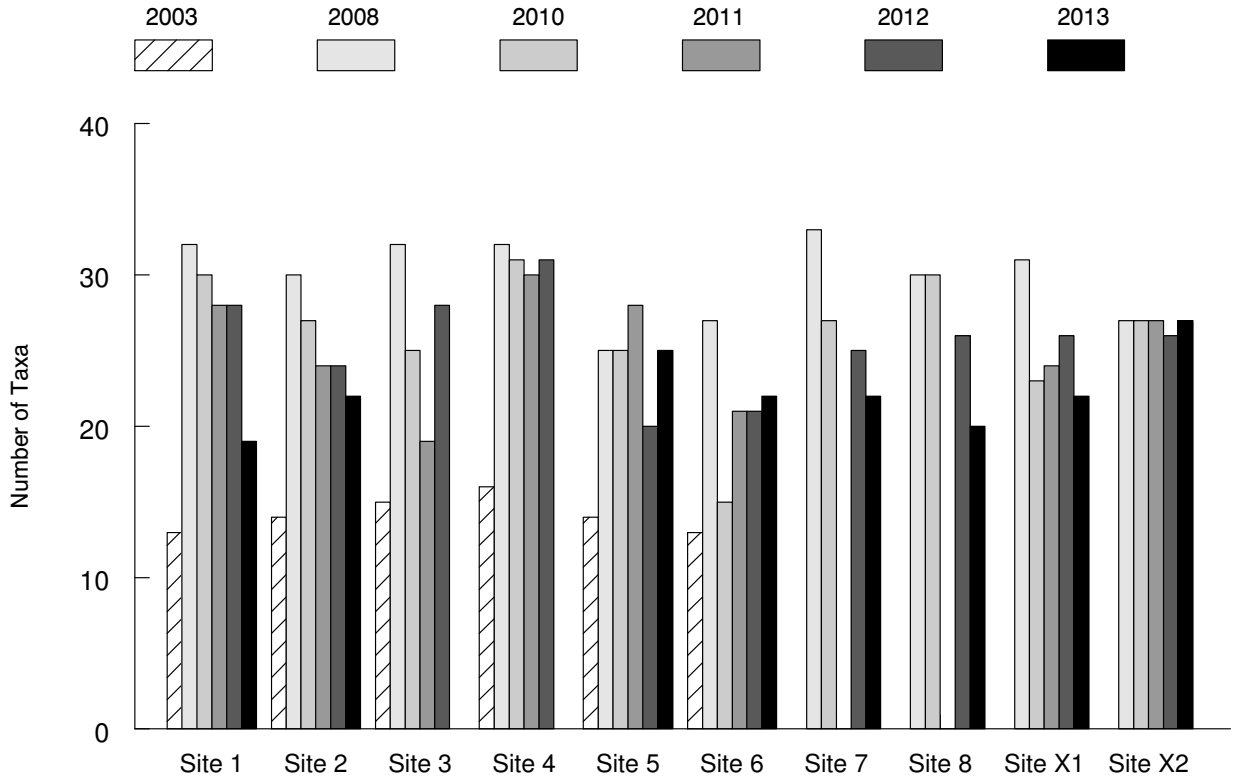

Figure 4-1 Number of macroinvertebrate taxa found in AUSRIVAS samples collected from edge habitat at Sites 1 to 8, X1 and X2 on the Nepean River from 2003 to 2013

4.2.2.2 OE50 Taxa Score and AUSRIVAS Bands

OE50 Taxa Scores ranged from 0.47 to 1.05 (**Figure 4.2**) and were frequently below 0.84, indicating that on most occasions fewer taxa were observed than expected relative to AUSRIVAS reference watercourses. The OE50 Taxa Scores recorded during a particular survey were generally similar across sites except for Site 6, which had the lowest OE50 Taxa Score in 4 out of 6 surveys. The samples that were collected in 2003 generally had the lowest OE50 Taxa Score, except for Site 6 where the sample collected in 2010 had the lowest OE50 Taxa Score.

The trends in AUSRIVAS Bands reflect those in OE50 Taxa Scores on which they are based. The condition of the aquatic macroinvertebrate fauna at the sites on the Nepean River has ranged from Band A (equivalent to AUSRIVAS reference condition) to Band C (severely impaired). At most sites the condition of the fauna has changed by one AUSRIVAS Band over time between Band A and Band B, however, at Site 6 it has changed between Band B and Band C and at Site 7 it has remained in Band B.

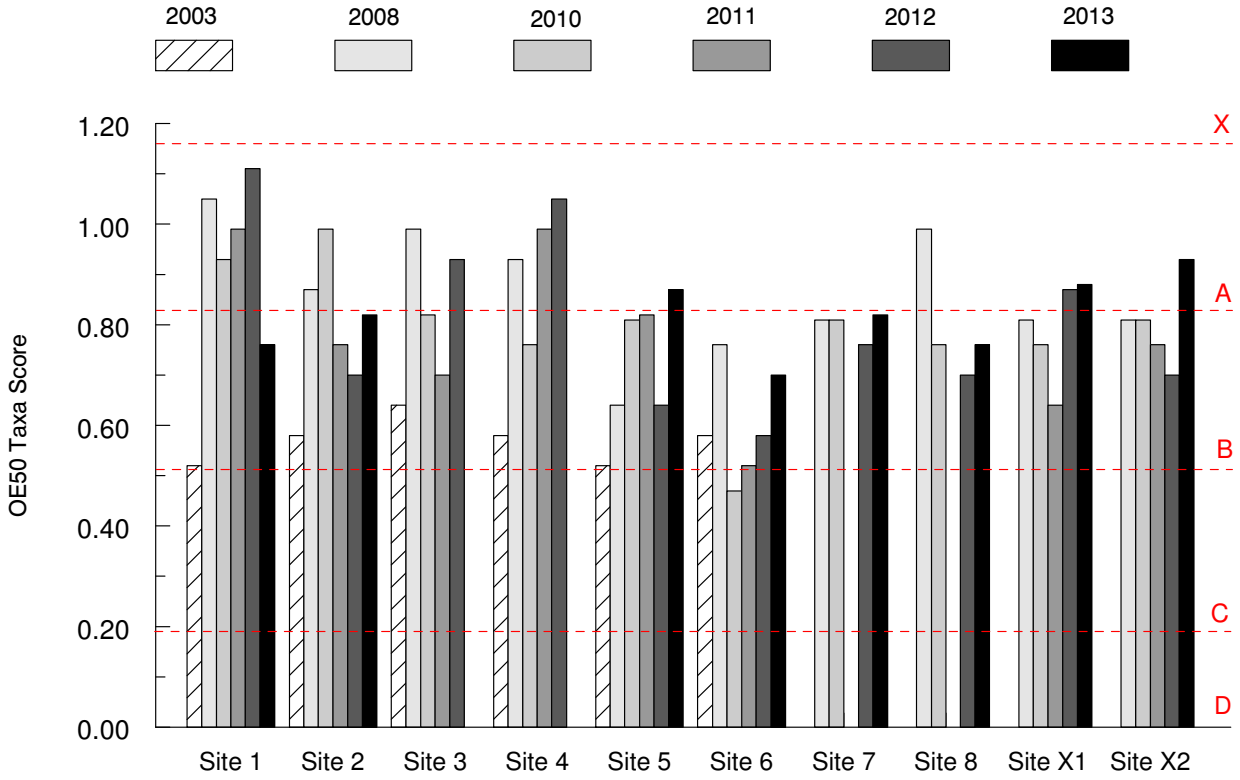

Figure 4-2 OE50 Taxa Scores and their Respective Band Scores (A-D) from AUSRIVAS Samples Collected from edge habitat at Sites 1 to 8, X1 and X2 on the Nepean River from 2003 to 2013

4.2.2.3 SIGNAL2 Index

The SIGNAL2 Index ranged from 3.2 to 4.6 (indicative of severe pollution) to 4.6 (indicative of moderate pollution) (**Figure 4.3**). A large proportion of SIGNAL2 Indices were less than 4 indicating macroinvertebrate assemblages dominated by pollution tolerant taxa. SIGNAL2 Indices were comparable among sites and there was no clear trend in the data.

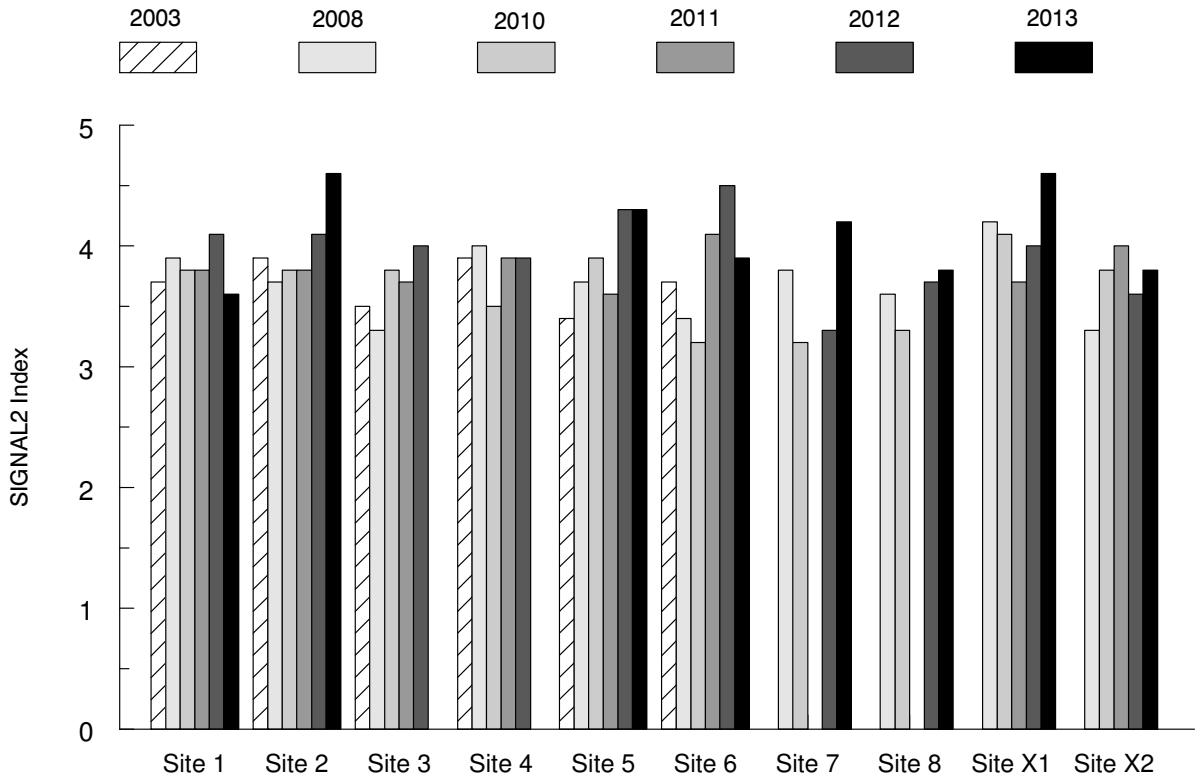

Figure 4-3 OE50 Taxa Scores and their Respective Band Scores (A-D) from AUSRIVAS Samples Collected from edge habitat at Sites 1 to 8, X1 and X2 on the Nepean River from 2003 to 2013

4.3 Fish

Four fish species were caught by bait trapping in December 2013; flathead gudgeon (*Philypnodon grandiceps*), firetail gudgeon (*Hypseleotris gali*), dwarf flathead gudgeon (*Philypnodon macrostomus*) and eastern gambusia (*Gambusia holbrooki*) (**Appendix D**). The AUSRIVAS samples included Flathead gudgeon at Sites 1, 7 and 8, eastern gambusia at Sites 1, 6, 7 and 8 and firetail gudgeon and Australian smelt (*Retropinna semoni*) at Site 8. Flathead gudgeon, firetail gudgeon and Australian smelt were caught in seine nets at all sites, often in large abundance (several hundred individuals) (**Plate 1**). Dwarf flathead gudgeon and eastern gambusia were caught in seine nets at Sites 2 and 7, respectively. All of these species have been recorded during previous surveys for the Appin Area 7 Aquatic Ecology Monitoring Program (**Table 4.2**). Freshwater catfish (*Tandanus tandanus*) and empire gudgeon (*Hypseleotris compressa*) were not caught in the current survey, but were found in one previous survey (2008 in the case of empire gudgeon) or in very low abundance in earlier surveys (in the case of freshwater catfish). Large numbers of Eastern gambusia were observed at the majority of sites.

Freshwater shrimp (Family: Atyidae) and freshwater prawns (*macrobrachium* sp.) were also caught at several sites in December 2013.

Table 4-2 Fish species caught by bait trapping in the Nepean River during the aquatic ecology monitoring undertaken for the Appin Area 7 Longwalls in September 2003 (The Ecology Lab 2004), April 2008 (The Ecology Lab 2008b), November 2008 (The Ecology Lab 2009), December 2010 (Cardno Ecology Lab 2011a), December 2011 (Cardno Ecology Lab 2012a), December 2012 (Cardno Ecology Lab 2013) and December 2013 (current study)

Scientific Name	Common Name	Sep 2003	April 2008	Nov 2008	Dec 2010	Dec 2011	Dec 2012	Dec 2013
Philypnodon grandiceps	Flathead gudgeon	x	x	x	x	x	x	x
Hypseleotris gali	Firetail gudgeon	x	x	x	x	x	x	x
Philypnodon macrostomus	Dwarf flathead gudgeon	x		x	x	x	x	x
Gambusia holbrooki	Eastern gambusia		x		x			x
Retropinna semoni	Australian smelt		x		x	x	x	x
Tandanus tandanus	Freshwater catfish					x	x	
Hypseleotris compressa	Empire gudgeon			x				

4.4 Aquatic Macrophytes

In 2013, nine species of aquatic macrophyte were observed across the ten sites (**Appendix E**). An additonal species (clasped pondweed (*Potamogeton perfoliatusi*)) was also observed just downstream of the Site 3 boundary. All species identified in previous surveys were observed in 2013. Hydrilla (*Hydrilla verticillata*) (**Plate 2**), floating pondweed (*Potamogeton tricarinatus*), elodea (*Elodea canadensisi*) and ribbonweed (*Vallisneria* sp.) (**Plate 3**) were the most common species, occurring at the majority of sites visited. The invasive alligator weed (*Alternanthera philoxerides*) was observed along the banks at Sites 7 and 8 (**Plate 4**). Species absent from specific sites in 2013 included curly (*Potamogeton cripus*) and blunt (*Potamogeton ochreatus*) pondweed from Sites 5 to 8 and X1, curly pondweed from Site 3, hydrilla from site X2, floating pondweed and elodea from Site 6 and clasped pondweed from Sites 4 and 8. Most of the species not observed in the current survey were either absent or present in low abundance during one or more previous surveys. The species observed at Sites 1 and 2 included all those observed at these sites in previous surveys. Ribbonweed was observed for the first time at two of the monitoring sites.

No signs of desiccation or die-back were observed during the inspection. The water visibility (1 to 2 m) may have resulted in some macrophyte species being obscured from view.

1)

2)

3)

4)

Plate 1) Flathead gudgeon (*Philypnodon grandiceps*), firetail gudgeon (*Hypseleotris gali*) and Australian smelt (*Retropinna semoni*) caught in a seine net in the Nepean River in December 2013, and 2) dense beds of ribbonweed (*Vallisneria* sp.), 3) lighter green alligator weed (*Alternanthera philoxerides*) and 4) hydrilla (*Hydrilla verticillata*) observed the Nepean River in January 2014.

5 Discussion

The aquatic macroinvertebrate fauna in the Nepean River appears to have experienced some degree of environmental stress prior to mining and continues to do so. Surface water quality measures in the current and previous surveys were generally within DTVs, however, low levels of dissolved oxygen have often been recorded in bottom water. This observation is indicative of stratification of the water column with anoxic water at the bottom and oxygenated water at the surface. Stratification is a natural phenomenon that occurs in summer due to limited vertical mixing between the warm upper water layer and colder denser water layer below. Stratification could lead to impacts on aquatic systems, particularly if the water column mixes dramatically, possibly in a flood event or through gas releases. It can be deleterious to biota due to anoxia, or toxicity from upwelling contaminants liberated from bottom sediments during periods of reduced pH. Gas releases could also result in reductions in dissolved oxygen due to microbial consumption of dissolved methane (see Ecoengineers 2009).

Surface monitoring undertaken during and following the extraction of Longwalls 701 to 704 identified several areas of gas releases in the Nepean River adjacent to Aquatic Ecology Monitoring Sites 3, 4, X1 and X2. A very small uplift of banks associated with Longwall 702 was also identified (see Section 2.3). There is no evidence in number of taxa, OE50 Taxa Score and SIGNAL2 Index data to indicate a change to macroinvertebrate populations occurring that could be related to these or any other mining impact. Reductions in the number of taxa and OE50 Taxa Score at Site 3 in 2010 and 2011 and in the OE50 Taxa Score at Site 4 in 2010, following the gas releases observed near these sites and associated with the extraction of Longwalls 701 to 702, are unlikely to be related to mining as similar changes were seen at upstream and downstream Control sites. Similarly, the reductions in the number of taxa at Site X1 in 2010, and the reductions in the OE50 Taxa Score at Site X1 in 2010 and 2011 and at Site X2 in 2011 and 2012, following the gas releases associated with the extraction of Longwalls 702 to 704 observed near these sites, were also evident at Control sites. These findings are not surprising as no water quality impacts associated with gas releases have been detected (Ecoengineers 2011, Cardno Ecology Lab 2012b). Although OE50 Taxa Scores at Site 6 tended to be lower than those at the other sites, there is no evidence of any trends indicative of a mining impact. Rather, the low OE50 Taxa Scores most likely represent the natural condition of the habitat at this site.

The fish assemblage sampled using bait traps in 2013 was comparable to that sampled in previous surveys. The few species sampled previously that were not caught in bait traps in 2013 were either caught in low abundance in previous surveys, or in only one previous survey. The fish species caught in seine nets in 2013 were also all sampled using bait traps in 2013. There is no indication that mining of Longwalls 701 to 704 has had any effect on fish populations in the Nepean River.

All the species of aquatic macrophyte identified in the Nepean River in previous surveys were observed in 2013. Some species, however, were absent from sites where they had previously been identified. In most cases, these species were either not identified in all previous surveys and/or were found in low abundance. Except for hydrilla, species that were absent from Longwall 701-704 Potential Impact sites in 2013 were also absent at one or more of the Control sites (hydrilla, which was absent from Site X1, was present in high abundance at other Potential Impact and also Control sites in 2013). Consequently, and given the absence of any sign of macrophyte desiccation and die-back and any identified uplift or reductions in water levels in the Nepean River since the last macrophyte survey in 2010, there is no evidence to suggest the changes in macrophyte distribution in 2013 are outside what would be expected due to natural variation. There is no indication that mining of Longwalls 701 to 704 has impacted aquatic macrophytes in the Nepean River.

Surface monitoring undertaken as part of the Longwalls 705-706 SMP by the ICEFT has not indicated any impacts to the water levels or the appearance of the Nepean River or its tributaries during the extraction of Longwall 705 (BHPBIC 2014). No fracturing of the river bed, surface water flow diversions, iron staining, uplift or changes in water level (aside from normal fluctuations associated with rainfall and SCA discharges) were observed in the Nepean River during extraction of Longwall 705 by Mine Engineering Subsidence Consultants (MSEC 2014), nor was any fracturing, ponding, flooding or desiccation observed in the monitored tributaries of the Nepean River. No loss or diversions of flow or impacts to water quality were observed in the Nepean River during extraction of Longwall 705 by Ecoengineers (Ecoengineers 2014).

Three new gas release zones (Gas Zones 16, 17 and 18) upstream of Sites 3 to 6, X1 and X2 were detected during extraction of Longwall 705. These zones are located some distance upstream of monitoring Sites 5 and 6, which were established to provide data relevant to Longwalls 705 to 710, and the gas releases observed here could represent cumulative impacts associated with the extraction of Longwalls 701 to 704.

By May 2014, gas releases at Gas Zones 16 and 17 appeared to have ceased, with gas releases in these zones last observed on 17 January 2014 and 19 February 2014, respectively. Gas releases at Gas Zone 18 were last observed on 16 April 2014. There is no evidence in aquatic macroinvertebrate, macrophyte and fish data to indicate a change to aquatic ecology has occurred that could be related to the recent gas releases observed during the extraction of Longwall 705.

6 Conclusion and Recommendations

The gas releases and the very small uplift of banks identified in the Nepean River associated with the extraction of Longwalls 701 to 704 do not appear to have had any effect on aquatic macroinvertebrates. This is not surprising as no associated water quality impacts have been detected. The relatively poor condition of the macroinvertebrate fauna in the section of the Nepean River visited during the Aquatic Ecology Monitoring Program is not related to mining. There is also no evidence that mining of these longwalls has had any impact on fish populations. The relatively large changes in the extent and distribution of aquatic macrophytes that have been observed since the commencement of the monitoring program represent natural variation unrelated to mining.

The gas releases identified in the Nepean River associated with the extraction of Longwall 705 also do not appear to have had any effect on macroinvertebrates, fish and macrophytes in the Nepean River. This is not surprising given that no impacts to water quality, flow and levels, or impacts to physical features have been observed in the Nepean River during extraction of Longwall 705 (MSEC 2014, Ecoengineers 2014).

Two years of post-extraction data has been collected at Potential Impact sites relevant to Longwalls 701-704. However, as these sites may experience cumulative impacts associated with the extraction of Longwalls 701 to 704 and 705 to 710, monitoring should continue here during extraction of Longwall 706. The next sampling event should take place in spring 2014 at these sites and sites relevant to Longwalls 705 to 710 to provide further pre, during and post-mining data for these Longwalls.

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Appin Longwalls 701 to 704 and 705 to 710 -
Aquatic Ecology Monitoring 2003-2013

APPENDIX A

GPS COORDINATES FOR APPIN AREA 7 AQUATIC ECOLOGY MONITORING SITES ON THE NEPEAN RIVER.

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Site	Easting	Northing
Site 1 upstream extent	288463	6214100
Site 1 downstream extent	288780	6214152
Site 2 downstream extent	289008	6214219
Site 2 upstream extent	288851	6214182
Site 3 downstream extent	291889	6215263
Site 3 upstream extent	291644	6215370
Site 4 upstream extent	292071	6215217
Site 4 downstream extent	292281	6215350
Site X1 upstream extent	292378	6216501
Site X1 downstream extent	292348	6216638
Site X2 upstream extent	292356	6216590
Site X2 downstream extent	292379	6216875
Site 5 downstream extent	292791	6218045
Site 5 upstream extent	293002	6217805
Site 6 downstream extent	292647	6218567
Site 6 upstream extent	292785	6218240
Site 7 upstream extent	292582	6220829
Site 7 downstream extent	292581	6221116
Site 8 upstream extent	292815	6221295
Site 8 downstream extent	292963	6221582

Datum: WGS 84, Zone 56H

Appin Longwalls 701 to 704 and 705 to 710 -
Aquatic Ecology Monitoring 2003-2013

APPENDIX B

MEAN *IN-SITU* WATER QUALITY DATA COLLECTED FROM THE SURFACE AND BOTTOM OF AQUATIC ECOLOGY MONITORING SITES ON THE NEPEAN RIVER IN DECEMBER 2013.

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Site/ Measure	DTV	Surface Water		Bottom Watter	
		Mean	SE	Mean	SE
Site 1					
Temperature (°C)		23.7	0.0	23.3	0.0
Conductivity	125-2200	173	0	174	1
pH (units)	6.5-8.0	7.8	0.0	7.7	0.0
ORP (mV)		60	0	59	0
DO (% Sat)	85-110	103.9	0.0	100.5	2.1
Turbidity (NTU)	6-25	0.0	0.0	4.5	0.7
Site 2					
Temperature (°C)		23.9	0.0	23.1	0.0
Conductivity	125-2200	174	1	173	0
pH (units)	6.5-8.0	7.7	0	7.7	0.0
ORP (mV)		55	0	57	1
DO (% Sat)	85-110	102.5	0.2	102.8	0.3
Turbidity (NTU)	6-25	0.0	0.0	6.0	0.0
Site 5					
Temperature (°C)		25.7	0.2	20.6	0.3
Conductivity	125-2200	149	0	161	7
pH (units)	6.5-8.0	7.7	0.0	7.2	0.1
ORP (mV)		34	2	57	2
DO (% Sat)	85-110	111.8	0.0	46.9	1.8
Turbidity (NTU)	6-25	0.0	0.0	3.5	0.7
Site 6					
Temperature (°C)		25.3	0.0	18.6	1.1
Conductivity	125-2200	148	0	173	12
pH (units)	6.5-8.0	8.0	0.0	7.4	0.2
ORP (mV)		42	4	-61	10
DO (% Sat)	85-110	107.4	0.6	15.0	1.3
Turbidity (NTU)	6-25	0.0	0.0	3.6	1.6
Site 7					
Temperature (°C)		24.9	0.0	18.6	1.1
Conductivity	125-2200	155	0	173	12
pH(units)	6.5-8.0	8.2	0.1	7.4	0.2
ORP (mV)		23	0	-61	10
DO (% Sat)	85-110	111.4	0.1	9.4	0.1
Turbidity (NTU)	6-25	0.0	0.0	3.6	1.6
Site 8					
Temperature (°C)		23.9	0.1	16.6	0.1
Conductivity	125-2200	156	1	167	1
pH(units)	6.5-8.0	8.0	0.0	7.8	0.1
ORP (mV)		43	0	51	0
DO (% Sat)	85-110	103.9	0.0	100.1	0.7
Turbidity (NTU)	6-25	0.0	0.0	0.0	0.0

Site/ Measure	DTV	Surface Water		Bottom Watter	
		Mean	SE	Mean	SE
Site X1					
Temperature (°C)		24.9	0.1	23.1	0.0
Conductivity	125-2200	154	1	155	0
pH (units)	6.5-8.0	7.7	0.0	8.1	0.0
ORP (mV)		42	1	33	2
DO (% Sat)	85-110	99.6	0.0	74.7	0.4
Turbidity (NTU)	6-25	0.0	0.0	1.4	0.6
Site X2					
Temperature (°C)		25.8	0.0	19.3	0.1
Conductivity	125-2200	151	0	414	2
pH (units)	6.5-8.0	7.7	0.0	7.0	0.0
ORP (mV)		49	1	-51	0
DO (% Sat)	85-110	101.0	0.0	7.3	1.6
Turbidity (NTU)	6-25	0.0	0.0	1.0	0.4

n=2 for all parameters except turbidity where n=6; SE = Standard Error. Default Trigger Values (DTVs) taken from ANZECC (2000) guidelines for lowland river ecosystems in south-east Australia. Grey shading indicates measure outside of DTVs.

Appin Longwalls 701 to 704 and 705 to 710 -
Aquatic Ecology Monitoring 2003-2013

APPENDIX C

MACROINVERTEBRATE TAXA FOUND IN AUSRIVAS SAMPLES COLLECTED FROM EDGE HABITAT AT AQUATIC ECOLOGY MONITORING SITES ON THE NEPEAN RIVER IN DECEMBER 2013

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Taxa	Site 1	Site 2	Site 5	Site 6	Site 7	Site 8	Site X1	Site X2
Aeshnidae			x					
Araneae				x				
Atyidae	x		x	x	x	x	x	x
Baetidae	x		x		x	x	x	x
Caenidae	x		x		x		x	x
Calamoceratidae		x	x			x		x
Ceinidae				x				x
Ceratopogonidae		x						
Chironomidae/Chironominae	x	x	x	x	x	x	x	x
Chironomidae/Orthocladiinae	x	x		x	x		x	x
Chironomidae/Tanypodinae	x	x	x	x	x	x	x	x
Cladocera		x	x	x	x	x	x	x
Coenagrionidae	x		x	x	x	x		x
Copepoda	x	x	x		x	x	x	x
Corbiculidae/Sphaeriidae			x		x			x
Cordulephyidae/Corduliidae)			x					
Corixidae	x	x	x	x	x	x	x	x
Culicidae		x						
Dugesiidae			x		x	x		x
Dytiscidae			x				x	x
Ecnomidae				x				
Elmidae	x	x	x	x	x	x	x	x
Gerridae		x				x		
Hebridae						x		
Hydracarina	x	x	x	x	x	x	x	x
Hydraenidae/Limnebiidae)				x				
Hydrometridae		x					x	
Hydrophilidae		x	x	x		x	x	x
Hydroptilidae	x	x		x	x		x	
Isostictidae		x	x	x		x		x
Leptoceridae	x	x	x	x	x	x	x	x
Leptophlebiidae		x	x		x		x	x
Megapodagrionidae		x						
Nepidae								x
Notonectidae	x			x				x
Oligochaeta			x		x			
Ostracoda			x	x	x		x	x
Physidae	x	x	x		x	x		x
Protoneuridae	x			x			x	
Pyralidae					x	x		
Scirtidae/Helodidae, Cyphonidae)		x		x	x		x	x
Staphylinidae	x							
Telephlebiidae/Aeshnidae)		x	x	x			x	
Tetragnathidae	x							x
Veliidae	x					x	x	

X indicates the taxon was recorded.

Appin Longwalls 701 to 704 and 705 to 710 -
Aquatic Ecology Monitoring 2003-2013

APPENDIX D

NUMBERS OF EACH FISH SPECIES CAUGHT USING BAIT TRAPS AT AQUATIC ECOLOGY MONITORING SITES ON THE NEAPEAN RIVER IN DECEMBER 2013

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Site	Flathead Gudgeon (*Philypnodon grandiceps*)	Firetail Gudgeon (*Hypseleotris galii*)	Dwarf flathead gudgeon (*Philypnodon macrostomus*)	Eastern gambusia (*Gambusia holbrooki*)
Site 1				
Rep 1		1		
Rep 2		1		
Rep 3	1	1		
Rep 4				
Rep 5				
Site 2				
Rep 1	1	3		
Rep 2				
Rep 3				
Rep 4		2		
Rep 5				
Site 5				
Rep 1				
Rep 2		5		
Rep 3	2			
Rep 4		1		
Rep 5				
Site 6				
Rep 1				14
Rep 2	1			
Rep 3				
Rep 4				
Rep 5				
Site 7				
Rep 1		1		
Rep 2	1			
Rep 3				
Rep 4	1			
Rep 5				
Site 8				
Rep 1				
Rep 2				
Rep 3	1	1	1	
Rep 4	1			
Rep 5	1			
Site X1				
Rep 1	1	2		
Rep 2		7		
Rep 3	1			
Rep 4				
Rep 5	1			
Site X2				
Rep 1	2	21		
Rep 2				
Rep 3				
Rep 4	3	37		
Rep 5				

Appin Longwalls 701 to 704 and 705 to 710 -
Aquatic Ecology Monitoring 2003-2013

APPENDIX E

SPECIES OF AQUATIC MACROPHYTES OBSERVED AT AQUATIC ECOLOGY MONITORING SITES ON THE NEPEAN RIVER ON 30 JANUARY 2014

Cardno
Shaping the Future

Common Name	Scientific Name	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site X1	Site X2
Hydrilla	*Hydrilla verticulata*	x	x	x	x	x	x	x	x	x	
Curly pondweed	*Potamogeton crispus*	x	x								
Floating pondweed	*Potamogeton tricarinatus*	x	x	x	x	x		x	x	x	x
Blunt pondweed	*Potamogeton ochreatus*	x	x	x						x	
Elodea	*Elodea canadensis*	x	x	x	x	x		x	x	x	x
Ribbonweed	*Vallisneria sp.*			x	x	x	x	x	x	x	x
Alligator weed	*Alternanthera philoxeroides*							x	x		
Cumbungi	*Typha* sp.							x	x		
Tall spikerush	*Eleocharis sphacelata*							x			
Clasped pondweed	*Potamogeton perfoliatus*	*Observed just upstream of Site 3*									

X indicates the taxon was recorded.