



**BHP BILLITON ILLAWARRA COAL PTY LTD**  
**APPIN AREA 7**  
**END OF LONGWALL 705**  
**GROUNDWATER MONITORING REPORT**  
Douglas Park, NSW

BHP10-R1B

7 JULY, 2014

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BHP10-R1B (7 JULY, 2014)

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Michelle,

**RE: BHP Appin Area 7  
Longwall 705 End of Panel Groundwater Monitoring Report**

Please find enclosed a copy of the above mentioned report.

Yours faithfully

**GeoTerra Pty Ltd**




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## 1. INTRODUCTION

Extraction of the Bulli Seam in Longwall 705 by BHP Billiton Illawarra Coal Holdings Pty Ltd (BHPB) at Appin Colliery was approved by the Department of Primary Industries (now known as the Department of Trade and Investment) on 28 February 2012.

Longwall mining in the subject panels has been conducted as shown in **Table 1**, with Longwall 701 being located on the south side of the Nepean River gorge, whilst Longwalls 702 to 705 are located on the northern plateau, as shown in **Drawing 1**.

**Table 1**      **LW701 to 705 Mining**

<b>Longwall</b>	<b>Start</b>	<b>Finish</b>	<b>Width (m)</b>	<b>Length (m)</b>	<b>Depth of Cover (m)</b>
<b>701</b>	27/10/2007	09/05/2008	325	530	500 - 515
<b>702</b>	18/09/2008	20/04/2009	325	1,065	490 - 535
<b>703</b>	22/10/2009	8/03/2011	325	1,965	505 - 555
<b>704</b>	7/05/2011	29/07/2012	325	2,325	490 - 595
<b>705</b>	7/09/2012	27/03/2014	325	2,836	510 - 600

### 1.1 Previous Studies

Description of changes in groundwater associated with the period of extraction for Longwalls 701 to 704 have been prepared by GeoTerra in End of Panel reports between 2008 and 2012 as outlined in the References.

### 1.2 Scope of Work

In accordance with SMP Approval Condition 18 for Longwall 705 to 706, Geoterra were commissioned by BHPB Illawarra Coal to report on comparisons between the predicted and observed groundwater system changes resulting from extraction of Longwall 705.

Changes associated with Longwalls 701 to 704 are outlined in their respective End of Panel reports.

## 2. DESCRIPTION OF BORES AND PIEZOMETERS

### 2.1 Private Bores and BHPB Piezometers

Eight open standpipe piezometers (NGW3, 4, 5, 6, 7, 9, 10 and 11) were installed by BHPB over, or in the vicinity of, Longwalls 701 – 705.

Groundwater level and water quality monitoring within the Hawkesbury Sandstone to 10m below the base of the Nepean River gorge began in June 2004 from locations shown in **Drawing 1**, with their details outlined in **Table 2**.

NSW Office of Water (NOW) Test Monitoring Bore Licences for the NGW series bores were submitted on 20 December 2007 and approved on 3 April 2009.

Due to the advancement of mining to the west, monitoring of piezometers on both the eastern and western side of the gorge was discontinued for the following piezometers:

- NGW7 (18/10/2012)
- NGW8 (not drilled)
- NGE9 (28/11/2012)
- NGW10 (5/6/2013)
- NGW11 (5/6/2013)
- NGW3 (31/3/2014)

Fully cemented, sealed vibrating wire piezometer arrays were also installed by BHPB in bores EAW5 (S1913) and EAW7 (S1936) in the Area 7 monitoring region as shown in **Drawing 1**.

Three NOW registered private bores are located within the Longwall 701 to 705 SMP area (Boustani – GW101437, Nahkle – GW104154 and Zampiron – GW102584), whilst four private bores are outside, although in the vicinity of, the Longwall 701 to 705 SMP area as shown in **Table 2** and **Drawing 1**.

The Boustani bore is occasionally used, the Nahkle bore is currently not used and the Zampiron bore is used for domestic (pool and irrigation) purposes, along with an associated reverse osmosis unit.

Private bores not listed in **Table 2** but shown in **Drawing 1**, are used to demonstrate the distribution of private bores in the region. These regional private bores are not discussed further in this report as they are outside the Longwall 701 to 705 SMP Area.

**Table 2 Private Bore and BHPB Piezometer Summary**

GW	N	E	SWL (m)	Depth (m)	Drilled	Aquifer	Lithology	YIELD (L/s)	EC (mg/L)	Purpose
<b>Private Registered Bores in the Longwall 701 to 705 SMP Area</b>										
Boustani 101437	6216406	291651	75	128	1997	119 - 121	sandstone	0.7	2500	Farming
Nahkle 104154	6216080	291240	74	165	2000	116 - 161	shale / sandstone	1.3	2200	Dom / Stock
Zampiron 102584	6216255	289480	60	186	1999	54 - 179	sandstone	0.9	1300	Dom / Stock
<b>Private Registered Bores in the Vicinity of Longwalls 701 to 705</b>										
34425	6215425	289085	14.6	70	1972	9 – 69.4	sandstone	0.63	good	Waste disposal
104602	6216148	288909	42	231	2002	30 - 213	sandstone	0.75	2500	Stock
104661	6216470	288973	68	219	2003	113 - 212	sandstone	1.05	fresh	Dom / Stock
<b>BHPB Registered Piezometers in the Longwall 701 to 705 SMP Area</b>										
NGW3	6216749.5	275027.4	1.4*	72.1	2004	-	shale / sandstone	-	-	Monit.
NGW4	6216826.2	275789.9	58	78.75	2004	-	sandstone	-	-	Monit.
NGW5	6216327.4	276124	44.3	66.45	2004	-	sandstone	-	-	Monit.
NGW6	6216680.5	276403.3	51.1	66.75	2004	-	sandstone	-	-	Monit.
EAW7	6217767.8	291547.3	various	556.1	2008	n/a	various	n/a	n/a	Monit.
<b>BHPB NOW Registered Piezometers in the Vicinity of Longwall 701 to 705</b>										
NGW7	6216591.4	277026.7	50.5	69.18	2004	-	sandstone	-	-	Monit.
NGW9	6217131.4	277736.9	24.8	69.19	2004	-	sandstone	-	-	Monit.
NGW10	6217333.4	276952.2	52.9	69.5	2004	-	sandstone	-	-	Monit.
NGW11	6217624.6	277104.8	48	72.15	2004	-	sandstone	-	-	Monit.
EAW5	6218729	289027	various	612	2008	n/a	various	n/a	n/a	Monit.

All NOW registered private bores in the region are located on the western plateau of the Nepean River gorge. They were drilled between 70 - 250m below surface, with water obtained primarily from sandstone aquifers, however some thin, perched horizons encountered water in the Wianamatta Shale (GW103161 at 17-18m and GW104602 at 30m).

Reported yields range from 0.2L/sec and 1.63L/sec from inflow zones ranging from 9 - 219m below surface. NOW bore data within the Longwall 701 to 705 (20mm) subsidence zone indicates regionally significant aquifers are generally intersected beneath 100m below surface from sandstone aquifers.

According to available records, private bore groundwater intersections as shallow as 9m may be present in perched aquifers with limited extent, as well as in limited, perched horizons within the Wianamatta Shale.

The actual intersected aquifer horizon is generally deeper than the measured piezometric surface of a bore because when a confined aquifer is drilled into, formation water rises up the bore due to a combination of lithostatic and hydrostatic pressures. Based on this principle, and on assessment of the NOW data, the majority of aquifer intersections over the Longwall 701 to 705 mining area lie at or below the relative height of the Nepean River, even though the bore water levels may rise under pressure to higher elevations in a bore.

The piezometer and bore monitoring data has been used to determine the pre Longwall 705 baseline status and groundwater level and water quality variations within the regional Hawkesbury Sandstone aquifer to a maximum depth of 10m below the relative level of the Nepean River bed.



Groundwater levels are logged hourly using vibrating wire piezometers in the NGW and EAW series piezometers and are downloaded once every two months.

Water levels in the Nahkle bore were automatically measured twice daily and downloaded approximately every 2 months between February 2009 and May 2013, when the logger was removed and no further water level or water quality monitoring was conducted.

No water level monitoring was conducted in the Boustani or Zampiron bores as the wellheads are sealed.

## 2.2 Discussion of Bores and Piezometers in the Longwall 701 to 705 SMP Area

This section discusses the bores and piezometers on the western side of the Nepean River, and does not further discuss the eastern side, which includes Longwall 701, as that area has been covered in previous End of Panel reports.

A manual standing water level and water quality survey of the Nahkle bore (GW104154), which overlies Longwall 703, was conducted prior to and during extraction of Longwalls 702, 703, 704 and up to the early stage of Longwall 705 in May 2013.

A water level logger was installed in the Nahkle bore in February 2009, prior to it subsiding over Longwall 702, and was removed in May 2013.

Water quality surveys of the Boustani bore (GW101437), which also overlies Longwall 703, was conducted between August 2008 and March 2013 during extraction of Longwalls 702, 703, 704 and the early stage of Longwall 705 in March 2013.

According to the NOW drill logs, to the west of the Nepean River gorge, the Boustani and Nahkle bores contain shale in the upper and lower strata, the Zampiron bore has 11m of shale at the surface, whilst the BHPB drill logs indicate NGW3 does not contain shale, NGW4 has a thin band, NGW5 does not contain shale and NGW6 has a few metres of shale in the mid bore depth as shown in **Table 3**.

**Table 3 Longwall 702 to 705 Piezometer and Bore Lithology Summary**

<b>BORE</b>	<b>Clay / Shale (mbgl)</b>	<b>Sandstone (mbgl)</b>
<b>NGW3*</b>	0	0 - 72.14
<b>NGW4*</b>	0 - 8.6	8.6 - 78.75
<b>NGW5*</b>	4.6 - 5.6	0 – 4.6 and 5.6 – 66.45
<b>NGW6*</b>	58.8 - 64.1	0 – 58.8 and 64.1 – 66.75
<b>Boustani (GW101437 )</b>	0 - 41 and 49 - 120	41 - 49 and 120 - 128
<b>Zampiron (GW102584)</b>	0 - 24	24 - 186
<b>Nahkle (GW104154 )</b>	0 - 11 and 114 - 116	11 - 114

**NOTE:** \* denotes BHP piezometers

No piezometers or private bores were directly undermined during extraction of Longwall 705, however the Zampiron bore (GW102584), which overlies the Longwall 705 maingate chain pillar as shown in **Figure 1** was within the 20mm subsidence zone of Longwall 705.



**Figure 1 Zampiron Bore Location**

On the western side of the gorge, as shown in **Drawing 1**:

- Piezometers NGW5 and NGW6 lie between the Nepean River and Longwall 702;
- Piezometer NGW4 overlies Longwall 702;
- Piezometer NGW3 as well as the Nahkle and Boustani private bores overlie Longwall 703;
- No bores or piezometers overlie Longwall 704, and;
- The Zampiron private bore overlies Longwall 705 maingate chain pillar.

In addition, the vibrating wire piezometer array in bore EAW5 lies approximately 2.1km to the north-north west of Longwall 705, whilst EAW7 overlies the north central section of Longwall 706 as shown in **Drawing 1**.

### 3. PREDICTED AND OBSERVED GROUNDWATER IMPACTS

Following the extraction of Longwall 705, monitoring has been conducted to document any observed impacts relating to BHPB “NGW” piezometers to the north-west of the Nepean River gorge, as well as three private boreholes (GW101437 – Boustani, GW102584 – Zampiron and GW104154 – Nahkle).

This monitoring is summarised below along with the predicted impacts for Longwall 705 (Geoterra 2006).

#### 3.1 Aquifer / Aquitard Interconnection Under the Plateau

##### 3.1.1 Predicted Impacts

- No adverse interconnection of aquifers and aquitards anticipated within 20m of the plateau surface
- Potential increase in the rate of groundwater recharge into the plateau following rainfall due to the increased porosity and permeability of the fractured strata.

##### 3.1.2 Observed Impacts During LW705

Based on the limited data available over Longwalls 704 and 705, no adverse interconnection of aquifers and aquitards has been observed within 20m of the plateau surface and no increased rate of groundwater recharge into the plateau has been observed as a result of Longwall 705 extraction.

Previous extraction of Longwalls 702 to 704 was observed to generate strata fracturing and minor bore displacement between 17.1m and 53.7m below ground level in the Nahkle and Boustani bores, with associated increased seepage in both bores, indicating additional aquitard / aquifer interconnection in relation to the previous panel extractions. Increased recharge in the NGW and Nahkle bore was previously indicated under the western plateau of the Nepean River in the vicinity of, and resulting from, extraction of Longwalls 702 to 704 (Geoterra, 2012).

*No TARP trigger levels related to aquifer / aquitard interconnection or changes in recharge have been observed to have been reached or exceeded as a result of Longwall 705 extraction.*

#### 3.2 Groundwater Levels

##### 3.2.1 Predicted Impacts

- Temporary lowering of the piezometric surface over the subsidence area due to horizontal dilation of strata and resultant increase in secondary porosity.
- Groundwater levels may reduce by up to 10m, and may stay at that reduced level until maximum subsidence develops at a specific location.
- Groundwater levels should recover over a few months as the newly developed secondary porosity is recharged by rainfall sourced water.
- No permanent post mining reduction in water level in bores on the plateau unless a new outflow path develops.

- No permanent reduction in groundwater levels underneath the Nepean River.

### 3.2.2 TARP Criteria

The triggers outlined below may be revised in consultation with DoPI and DPI and other key stakeholders as outlined in **Appendix B**.

#### Level 1 (Within Prediction)

- Up to an additional 2.5m reduction from the predicted standing water level or pressure (outside of pumping influences) over 2 consecutive months

#### Level 2 (Within Prediction – CMAs may be required)

- Between 2.5m and 5m additional reduction from the predicted standing water level or pressure (outside of pumping influences) over 2 consecutive months

#### Level 3 (CMAs likely to be required)

- Greater than 5m of additional reduction from the predicted standing water level or pressure (outside of pumping influences) over 2 consecutive months
- Privately owned water supply adversely impacted from the mining, other than impact that is negligible.

### 3.2.3 Observed Impacts During Longwall 705

A summary of the pre-longwall starting water levels in the suite of open standpipe piezometers that continued to be monitored throughout Longwall 705 extraction, as well as groundwater level changes during the extraction of Longwall 705 are summarised in **Table 4**.

**Table 4 Longwall 705 Groundwater Level Changes**

Piezometer	LW701 start (27/10/07) (mAHD)	LW702 start (18/9/08) (mAHD)	LW703 start (22/10/09) (mAHD)	LW704 start (22/10/09) (mAHD)	LW705 start (07/09/12) (mAHD)	Lowest RL During LW705 (mAHD)	Max. Change During LW705 (m)
Nepean River	61	61	61	61	61	61	No change
NGW3	76.93	77.34	76.78	81.72	85.0	85.42	0.42 rise
NGW4	68.17	68.82	65.78	70.75	72.65	72.15	0.50 fall
NGW5	66.19	66.69	65.78	65.65	65.82	65.68	0.14 fall
NGW6	66.12	66.26	62.58	63.67	65.54	63.33	2.21 fall

**NOTES:**

\*\* mbgl = metres below ground level

n/a = not available

Plots of the NGW piezometer water levels are shown in **Figure 2** during extraction of Longwalls 704 and 705, with water level changes for NGW4, 5 discussed below.

**NGW4**

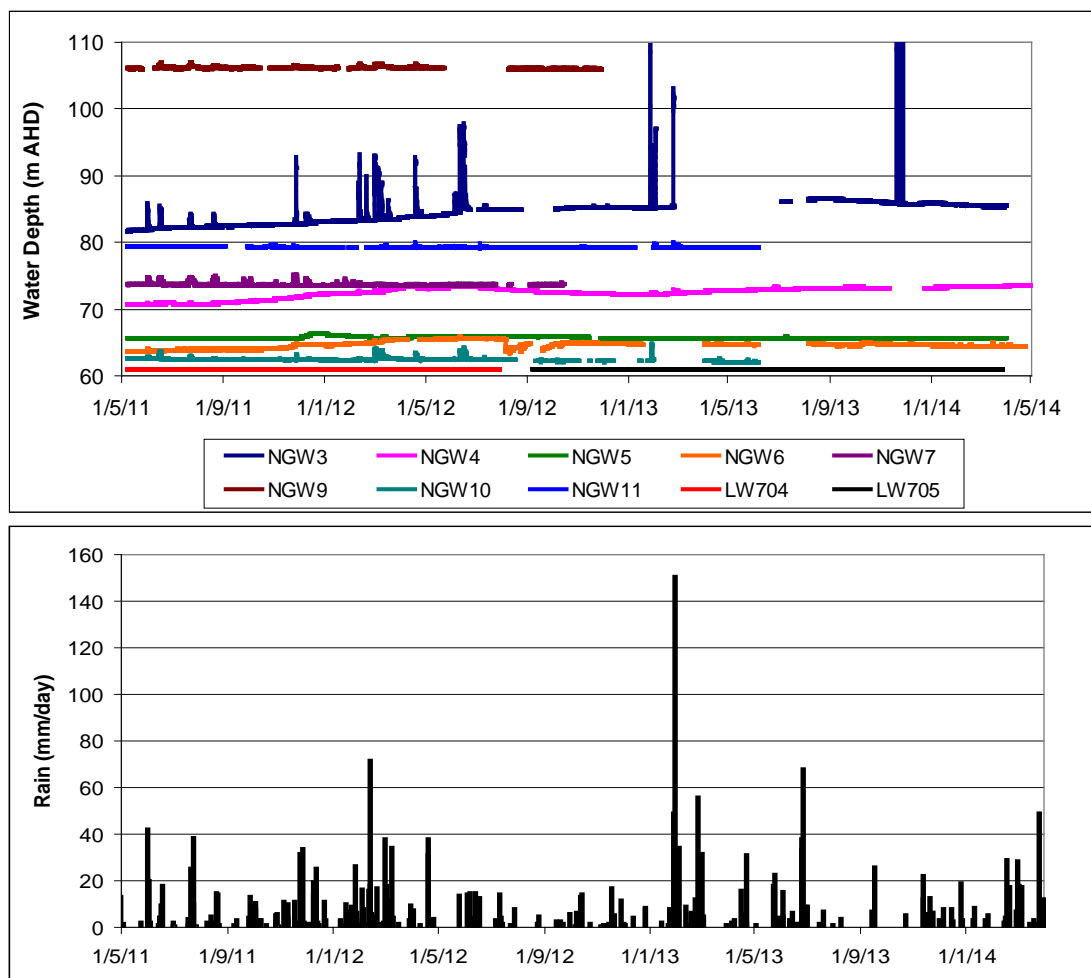
NGW4 was not undermined by Longwall 705 and fell by up to 0.5m during extraction of the longwall.

No adverse subsidence effect on groundwater levels in NGW4 due to extraction of Longwall 705 was observed.

**NGW5**

NGW5 was not undermined by Longwall 705 and fell by up to 0.14m during extraction of the longwall.

No adverse subsidence effect on groundwater levels in NGW5 due to extraction of Longwall 705 was observed.

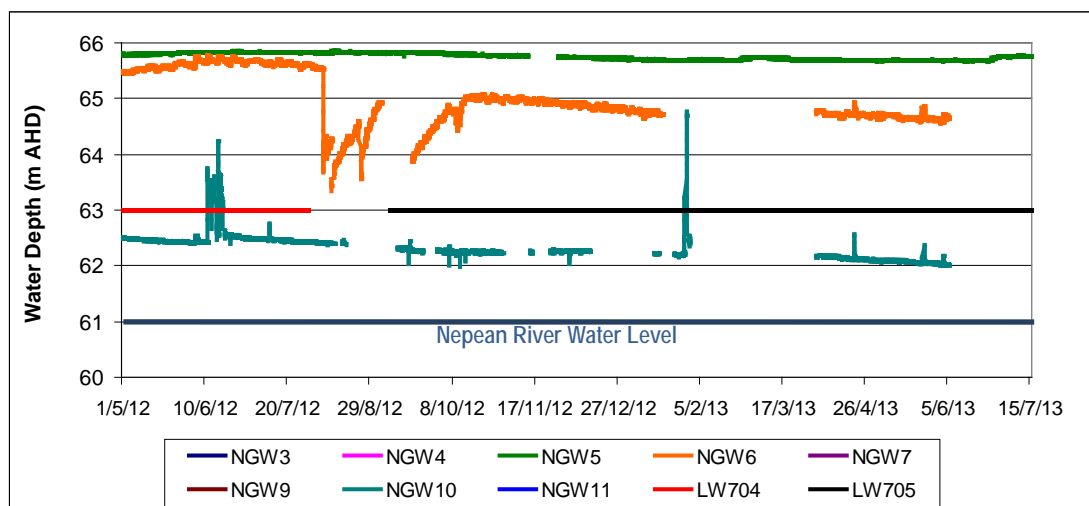


**Figure 2 Longwalls 704 and 705 “NGW” Standing Water Levels and Rainfall**

## NGW6

NGW6 was not undermined by Longwall 704 or Longwall 705, however a definitive response comprising an up to 2.21m fall in groundwater level occurred after Longwall 704 was completed and before Longwall 705 extraction occurred.

The Nepean River water surface averages 61.10m AHD at Douglas Park weir and 60.84m AHD at Menangle, and as a result, the NGW6 water level varied from 2.33 – 4.75m higher in elevation than the river during the LW704 and LW705 monitoring period as shown in **Figure 3**.



**Figure 3 Longwalls 704 and 705 NGW6 Standing Water Level**

The decline in water level occurred just after Longwall 704 was completed and then erratically rose, fell, then continued to rise until the logger trace cut out on 03/09/12. Prior to re-establishment of the logger in a rising limb of the water level trace, the water level had previously fallen by 1.02m.

The water level rise significantly flattened out around mid October 2012, then continued to fall at a lower rate after that time until early October 2013, then rose and fell a minor amount after that time to the end of the monitoring period.

## Boustani and Nahkle Bores

The Boustani and Nahkle bores were not undermined by Longwall 704 or Longwall 705 and no adverse effect on their water levels was observed due to extraction of Longwall 705.

Due to lack of access inside the casing, no water level data is available for the Zampiron bore which overlies the Longwall 705 maingate chain pillar.

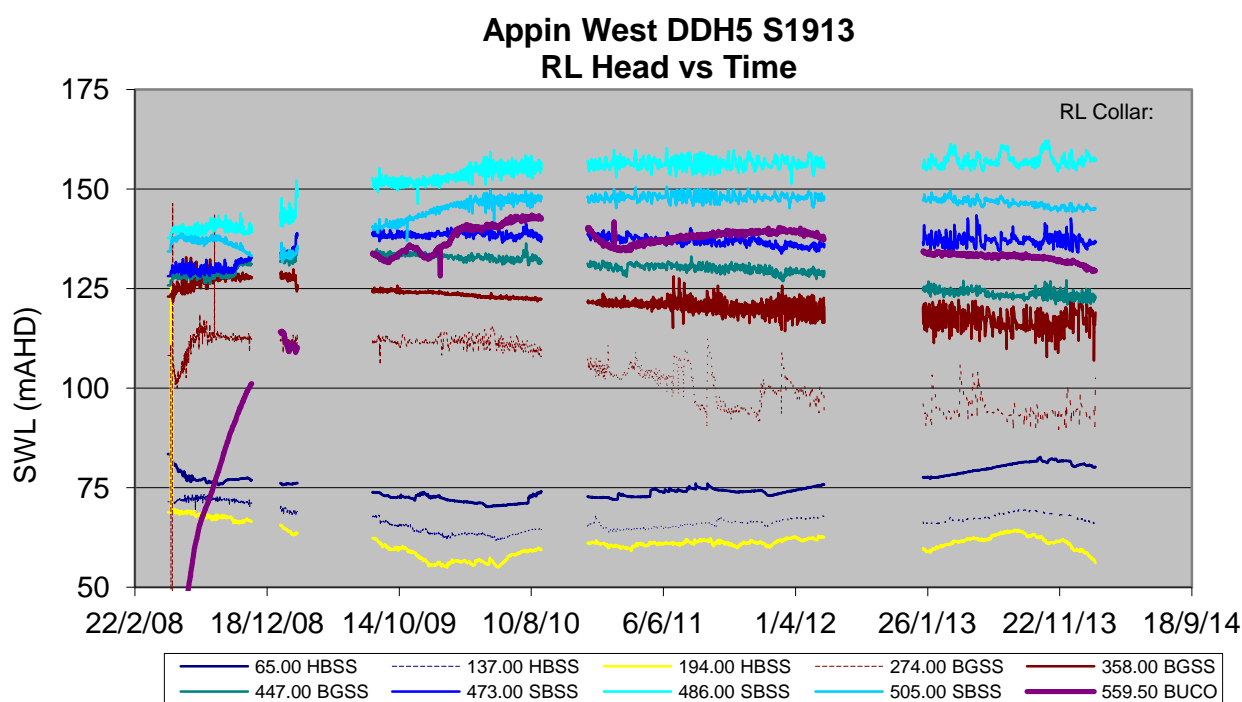
**Groundwater Levels Outside Longwall 702 to 705 (20mm) Subsidence Area**

Bore EAW5 [S1913] is located 2.3 km north or northwest of Longwall 705.

Head declines linearly at EAW5 in the Hawkesbury Sandstone and there is a clear difference in the behaviour of groundwater pressures above and below the Bald Hill Claystone.

This is evidence of the contiguous nature of the claystone across the general Appin Area 7 Project area and evidence of the pre-mining separation between shallow and deep aquifer heads. Within the upper Bulgo Sandstone the heads become artesian (at or above ground level), except for a slightly lower head in the Bulli Seam. The vertical profiles between the 2008-09 and June 2012 data are quite consistent, although the Bulli Seam water level rose from 2008-09 to June 2012 to an artesian level, unlike the 2008-09 data which is sub-artesian (HydroSimulations, 2013).

The EAW5 water levels were essentially unaffected by Longwall 705 extraction, outside of a gradual water level decline in the Bulli Seam and Scarborough Sandstone (505mbgl) and a rise, then equivalent fall in the Hawkesbury Sandstone at 65,137 and 194mbgl.



**Figure 4 EAW5 Water Levels**

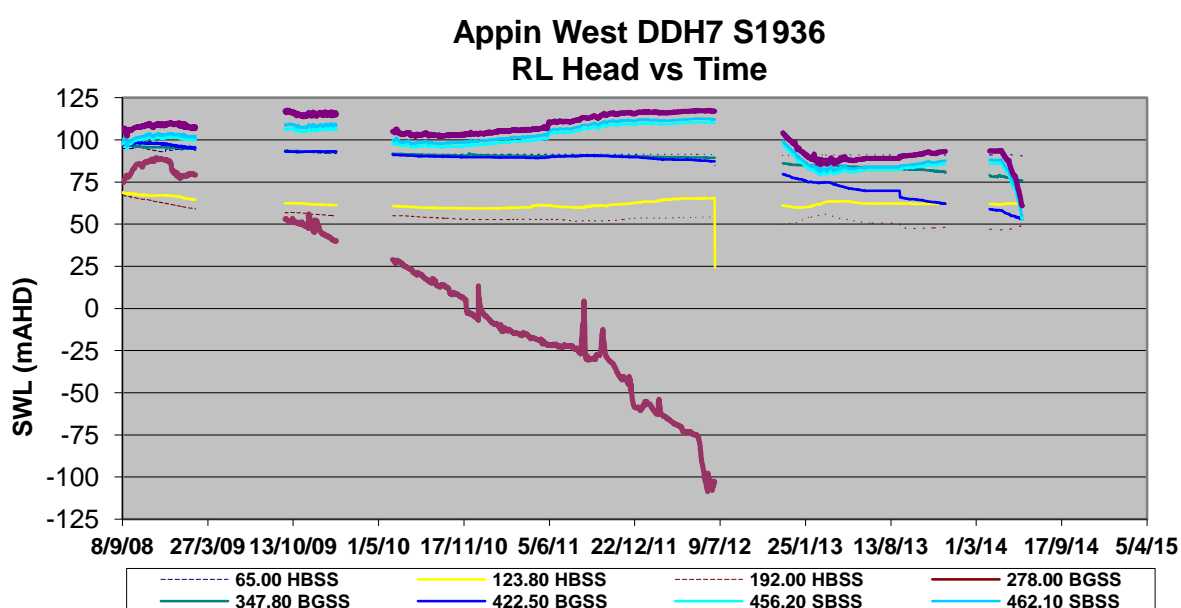
EAW7 (S1936) is located 300m north of Longwall 705 over the proposed Longwall 706.

The deeper heads are sub-artesian at EAW7, although were generally higher than the Hawkesbury Sandstone levels at June 2012 and lower at June 2013. The head profile patterns at June 2012 and June 2013 are similar, although there is clearly more variation between 2009, 2012 and 2013 in the deeper water levels than in the

Hawkesbury Sandstone. For example, within the Bulgo Sandstone, there was a decline in levels of about 6 - 17m between June 2012 and June 2013 in the middle and lower Bulgo Sandstone respectively.

The decline was greater at around 30m in the Scarborough Sandstone, which is a clear mining effect due to Longwall 705. There is minimal difference in the lower Hawkesbury Sandstone water levels between 2012 and 2013 and no change was observed in the upper Hawkesbury Sandstone (HydroSimulations, 2013).

A definitive sharp fall in water levels occurred around late April 2014 in the Scarborough Sandstone at 456.2, 462.1 and 468mbgl, along with a continued enhanced reduction in water levels in the Bulgo Sandstone at 347.8 and 422.5mbgl as shown in **Figure 5**.



**Figure 5 EAW7 Water Levels**

No groundwater level reduction TARP triggers were exceeded during extraction of Longwall 705 in any private bores and no changes outside of predictions for the VWP bores occurred.

### 3.3 Well Yield and Bore Serviceability

#### 3.3.1 Predicted Impacts

- Four registered bores within or near the Longwall 702 to 705 (20mm) subsidence zone may have been affected by subsidence. Two are located over Longwall 703 (GW101437 - Boustani and GW104154 - Nahkle) and two are located on the edge of the 20mm subsidence zone, northwest of the proposed Longwall 705 (GW102584 and GW103161).
- Horizontal displacement of strata may make some bores inaccessible.



- Strata dilation and subsequent refilling of the secondary voids may temporarily lower standing water levels, whilst increasing the potential yield of a bore through enhanced permeability and secondary porosity.

### 3.3.2 Observed Impacts during Longwall 705

No adverse effects on groundwater supply, well yield or bore serviceability have been monitored or reported during and following extraction of Longwall 705 within the Longwall 702 to 705 (20mm) subsidence area.

No well yield or bore serviceability TARP triggers were exceeded during or following the extraction of Longwall 705.

## 3.4 Groundwater Quality

### 3.4.1 Predicted Impacts

- Potential increased iron and manganese hydroxide precipitation in discharged bore water
- Potential lowering of pH in discharged bore water

### 3.4.2 TARP Criteria

The triggers outlined below may be revised in consultation with DoPI and DPI and other key stakeholders as outlined in **Appendix B**.

#### **Level 1 (Within Prediction)**

Groundwater quality reduction greater than 1 standard deviation but less than 2 standard deviation from pre-mining mean resulting from the mining for two consecutive months

#### **Level 2 (Within Prediction – CMAs may be required)**

Groundwater quality reduction greater than 2 standard deviation from pre-mining mean resulting from the mining for two consecutive months

#### **Level 3 (CMAs likely to be required)**

Level 2-type reduction in water quality resulting from the mining observed for more than 6 consecutive months.

### 3.4.3 Observed Impacts

Groundwater sampling and laboratory analyses since December 2007 in the “NGW” series piezometers and the private bores is shown in **Appendix A**.

#### **NGW Piezometers**

The groundwater quality in NGW3 is generally fresh (344 - 434 mg/L) with circum-neutral to slightly alkaline pH (7.1 – 7.7), however as the piezometer is regularly inundated with rainwater recharge down the bore annulus, the data does not represent the actual formation water quality and is not further considered.

NGW4 may also be affected by rainwater recharge, although it does not show in the water level trace after significant storms as it also has a low salinity (434 – 458mg/L) and circum-neutral to slightly alkaline pH (7.5 – 8.0).

NGW 5, 6 and 10 generally exceed the ANZECC 2000 irrigation water quality for chloride and sodium, whilst NGW7, 9 and 11 are relatively fresh with a circum-neutral to slightly acidic pH.

Since December 2007, on-going monitoring indicates that:

- NGW5 salinity has remained essentially unchanged, and its pH has reduced from 7.9 to 6.3, whilst;
- NGW6 salinity has reduced from 5,180 to 729 $\mu$ S/cm, and its pH has reduced from 7.5 to 7.0.

No additional monitoring of the NGW piezometers to the west of the Nepean River occurred during extraction of Longwall 705.

#### **Boustani and Nahkle Bores**

Limited additional water quality monitoring occurred in the Nahkle and Boustani Bores during extraction of Longwall 705 as outlined in **Appendix A**, and no significant change in water quality was observed with the limited data available.

Discussion of further details regarding the private bore water quality is contained in Geoterra (2012).

#### **Zampiron Bore**

The NOW database indicates the Zampiron 1999 installation water salinity was 1300mg/L. Monitoring by BHPB during Longwall 705 extraction on 11/10/2013 and after Longwall 705 on 14/05/2014 indicate a salinity of 3990 – 4010 $\mu$ S/cm (2300 - 1960mg/L) and pH between 7.17 and 7.50 as shown in **Appendix A**.

Laboratory analysis indicates the bore has no monitored metals outside of the ANZECC 200 criteria.

*The Zampiron bore increased its pre-subsidence salinity of 1,3000mg/L to 2,300mg/L in October 2013. However, no pre Longwall 705 controlled water quality sampling was conducted and the installation water quality reported from 1999 is probably affected by injected fresh water during the drillhole cleaning process.*

*No bore water quality TARP triggers were exceeded during and after the extraction of Longwall 705.*

### 3.5 Potential Inflow to Mine Workings

#### 3.5.1 Predicted Impacts

- no observable increase in mine workings groundwater inflow

#### 3.5.2 TARP Criteria

These triggers outlined below may be revised in consultation with DoPI and DPI and other key stakeholders as outlined in **Appendix B**.

##### **Level 1 (Within Prediction)**

- Abnormal rise in water flow from the goaf between 2.7 and 3ML/day (over 20 day average)

##### **Level 2 (Within Prediction – CMAs may be required)**

- Abnormal rise in water flow from the goaf between 3 and 3.4ML/day (over 20 day average)

##### **Level 3 (CMAs likely to be required)**

- Abnormal rise in water flow from the goaf >3.4ML/day (over 20 day average)

#### 3.5.3 Observed Impacts

No increased inflow to the Appin mine workings following extraction of Longwall 705 has occurred and no TARP trigger levels have been reached or exceeded, based on statutory inspection data.

### 3.6 Gas

#### 3.6.1 Predicted Impacts

There is a potential for discharge of strata gas into private bores

#### 3.6.2 Observed Impacts

No discharge of strata gas has been observed or reported in private bores or BHPB piezometers following extraction of Longwall 704 and no TARP trigger levels have been reached or exceeded.

### 3.7 Summary of Results

No groundwater TARP triggers were exceeded during extraction of Longwall 705.

**Table 5** summarises the predicted and observed effects on the groundwater system in relation to the extraction period for Longwalls 701 to 705.

**Table 5 Summary of Predicted and Observed Impacts**

<b>Predicted Impacts</b>	<b>Observed Impacts Due to Extraction of Longwalls 701 to 705</b>
<i>Adverse interconnection of aquifers and aquitards is not anticipated within 20m of the surface</i>	Interconnection between aquifers and aquitards has been observed within 20m of the surface over Longwall 703 in the Boustani and Nahkle private bores
<i>Potential increased rate of recharge into the plateau</i>	An increased rate of recharge into the western plateau has been observed in both BHPB piezometers and the Nahkle bore
<i>Temporary lowering of piezometric surface by up to 10m which may stay at that level until maximum subsidence develops</i>	Lowering of the piezometric surface by up to 14m has been observed in NGW4 over LW702, which recovered to above its pre LW702 level. Up to 6m reduction and subsequent recovery occurred in NGW6, and is interpreted to be due to enhanced recharge responsiveness from mining LW702
<i>Groundwater levels should recover over a few months</i>	The piezometric surface recovered to pre LW702 levels in 4 to 5 months, and to pre LW703 levels in approximately 4 months. Ongoing groundwater level recovery is being observed during extraction of LW704
<i>No permanent post mining reduction in water levels in bores on the plateau unless a new outflow path develops</i>	No permanent lowering of piezometric surface has been observed.
<i>No permanent reduction in groundwater levels under the Nepean River</i>	No permanent reduction in groundwater levels in the vicinity of the Nepean River has been observed
<i>The well yield and bore serviceability in four NOW registered bores (GW101437, 102584, 103161, 104154,) may be affected by subsidence</i>	One complaint regarding reduced bore yield was received from the Boustani property. After removing the bore pump and conducting on site maintenance, the bore yield is not reduced due to subsidence related effects
<i>Horizontal displacement may make the four private bores inaccessible</i>	No private bores have been made inaccessible by subsidence related effects, although minor lateral displacement was observed in the Nahkle and Boustani bores
<i>Strata dilation and subsequent re-filling of secondary voids may temporarily lower standing water levels and increase the potential private bore well yields</i>	Standing water levels have increased by 2.3m (Boustani) to 31m (Nahkle), with no monitored increase in yield in the private bores
<i>Private bore groundwater may experience increased iron / manganese hydroxide precipitation and / or lowering of pH</i>	No private bores have been affected by adverse subsidence related increases in iron / manganese hydroxide precipitation or lower pH
<i>Lowering of perched ephemeral seeps along the Nepean River gorge cliffs may occur</i>	No lowering of perched ephemeral seeps along the Nepean River gorge cliffs has been observed
<i>Interface drainage, ferruginous, brackish seeps may be generated in streams on the plateau</i>	No interface drainage, ferruginous, brackish seeps have been generated in streams on the plateau
<i>Ferruginous seeps may develop in the Nepean River</i>	The EoP report for LW703 assessed that ferruginous seeps had developed in the Nepean River, upstream of Elladale Creek (Ecoengineers, 2008B). No additional seeps observed during LW704 extraction
<i>Increased groundwater seepage inflow into the Bulli Seam workings should not occur</i>	No increased rate of groundwater seepage into the Bulli Seam workings has occurred due to extraction of LW701 to 704
<i>Strata gas discharge into private bores may occur</i>	No strata gas discharge into private bores has occurred

**NOTE:** (observed impacts shown in red)

#### **4. PROPOSED AND ONGOING MONITORING**

Groundwater monitoring proposed for Longwall 705 is detailed in the BHPB piezometer and NOW registered bore groundwater components of the BHPB Longwall 705 to 710 Trigger Action Response Plan (TARP). The TARP was approved by the NSW DPI (now the DT&I) on 28 February 2012.

The Area 7 TARP was amended on 23/07/2012 as shown in **Appendix B**.

Future monitoring will be in accordance with the BHPB piezometer and NOW registered bore groundwater components of the approved Area 7 TARP.

The current monitoring program and TARP procedures are outlined in **Tables 6 and 7**.

**Table 6 Current and Proposed Monitoring (Private Bores)**

SMP Commitment	Monitoring To Date	Proposed Monitoring
<b>Aspect: Private Bore Baseline Data</b>		
Assess bore location, depth drilled, date drilled, aquifer depth, lithologies, yield and purpose for private bores within SMP area	Private bore database compilation completed and pre / post Longwall 701, 702, 703 and 704. GW101437 / 102584 / 104154 monitoring conducted.	No additional baseline database compilation required
<b>Aspect: Private Bore Water Quality</b>		
Sample and monitor pumped bore water iron, field parameters and selected laboratory analytes for private bores within the SMP area. Laboratory/field analysis of: EC, Eh, pH, temp, TDS, Na, K, Ca, Mg, F, Cl, SO <sub>4</sub> , HCO <sub>3</sub> , NO <sub>3</sub> , Total N, Total P, Cu, Pb, Zn, Ni, Fe, Mn, As, Se, Cd, Cr, Li, B, Ba, Cs, Rb, Sr (filtered)	Pre and post Longwall 705 extraction monitoring and laboratory analysis conducted	<p>Prior to mining of longwall underlying bore or mining of any immediately adjacent longwall (if in agreement with landholder).</p> <p>Post-mining – following the development of incremental subsidence for each longwall that will impact on the borehole (if in agreement with landholder).</p> <p>As requested by landholder or if physical impacts to bore identified (landholder to observe during use of bore).</p> <p>Parameters include iron, field parameters and selected laboratory analytes in accordance with the revised TARP</p>
<b>Aspect: Private Bore Water Levels and Pumping Level</b>		
<p>Monitor bore standing water levels in private bores within SMP area</p> <p>Bore pumping behaviour to be assessed before and after undermining</p>	Twice daily water level monitoring in the Nahkle GW104154 bore completed and discontinued. Limited access now available in the Boustani bore GW101437 and no access to GW102584.	<p>Prior to mining of longwall underlying bore or mining of any immediately adjacent longwall (if in agreement with landholder) using a dip meter.</p> <p>Post-mining – following the development of incremental subsidence for each longwall that will impact on the borehole (if in agreement with landholder) using a dip meter.</p> <p>As requested by landholder or if physical impacts to bore identified (landholder to observe during use of bore)</p>
<b>Aspect: Private Bore Strata Gas</b>		
Monitor bore strata gas discharges (if any) in private bores within SMP area, and any gas observed or smelled to be noted.	Bores monitored during pre and post Longwall 705 monitoring / sampling by BHPB	Landowner to report any bore strata gas discharges (if any)

**Table 7 Current and Proposed Monitoring (BHPB Piezometers)**

<b>SMP Commitment</b>	<b>Monitoring To Date</b>	<b>Proposed Monitoring</b>
<b>Aspect: BHPB Piezometer Baseline Data</b>		
Assess bore location, depth drilled, date drilled, aquifer depth, lithologies and purpose for piezometers within SMP area	BHPB piezometer database compilation completed	No additional data compilation required
<b>Aspect: BHPB Piezometer Water Quality</b>		
Sample and monitor BHPB piezometer iron, field parameters and selected laboratory analytes in SMP area. EC, Eh, pH, temp, TDS, Na, K, Ca, Mg, F, Cl, SO <sub>4</sub> , HCO <sub>3</sub> , NO <sub>3</sub> , Total N, Total P, Cu, Pb, Zn, Ni, Fe, Mn, As, Se, Cd, Cr, Li, B, Ba, Cs, Rb, Sr (filtered)	Pre and post Longwall 701 - 705 sampling / monitoring completed.	<p>Pre-mining – prior to mining of longwall underlying bore or mining of any immediately adjacent longwall.</p> <p>Post-mining – following the development of incremental subsidence for each longwall that will impact on the feature (i.e. each longwall).</p> <p>As required to provide additional data for any bore impact investigation or if physical impacts to bore identified.</p> <p>Parameters include iron, field parameters and selected laboratory analytes in NGW4,5,6 in accordance with the revised TARP</p>
<b>Aspect: BHPB Piezometer Water Levels</b>		
Monitor piezometer standing water levels within SMP area	Automated daily monitoring conducted in all piezometers since June 2004	<p>Water level logged hourly</p> <p>Post-mining – following the development of incremental subsidence for each longwall that will potentially impact on the borehole.</p> <p>Monitoring to continue for at least 12 months post mining.</p> <p>Parameters to measure include: Standing groundwater level in NGW open bores using vibration wire, 1 hourly. Piezometric head using vibrating wire piezometers in grouted bores in various strata, 1 hourly.</p>
<b>Aspect: BHPB Piezometer Strata Gas</b>		
Monitor piezometer strata gas discharges (if any) within SMP area	Strata gas discharges (if any) being monitored when groundwater samples collected and groundwater level loggers downloaded from open standpipe piezometers	BHPB to continue to monitor strata gas discharges (if any) when groundwater samples collected and groundwater level loggers downloaded from open standpipe piezometers

## 5. POTENTIAL ACTIONS

No further actions are currently required in regard to the salinity in the Nahkle, Boustani and Zampiron bores, outside of ongoing monitoring of the Zampiron bore.

In the eventuality that the Boustani or Nahkle bores are required to be used, and the water quality has not adequately improved for the required water use, BHPB may conduct the following options;

- Combining the bore water with town water or water collected off the property shed roofs.
- Re-drill the bore, at least 10m away from the current bore to seal off the current upper saline leakage. Consideration should be given to the potential for ongoing saline leakage into the new bore after it is re-drilled through potential connective cracking in the region around the bore over Longwall 703, even if the new bore's annulus is sealed. It is also possible that low flow saline leakage is occurring below the standing water level in each bore, however no distinctive inflows were observed with the downhole camera in the Boustani bore, and the Nahkle bore could not be inspected below 72m due to lack of visibility.

## 6. REFERENCES

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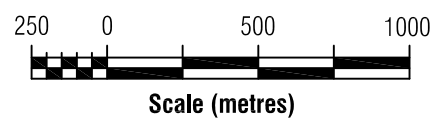
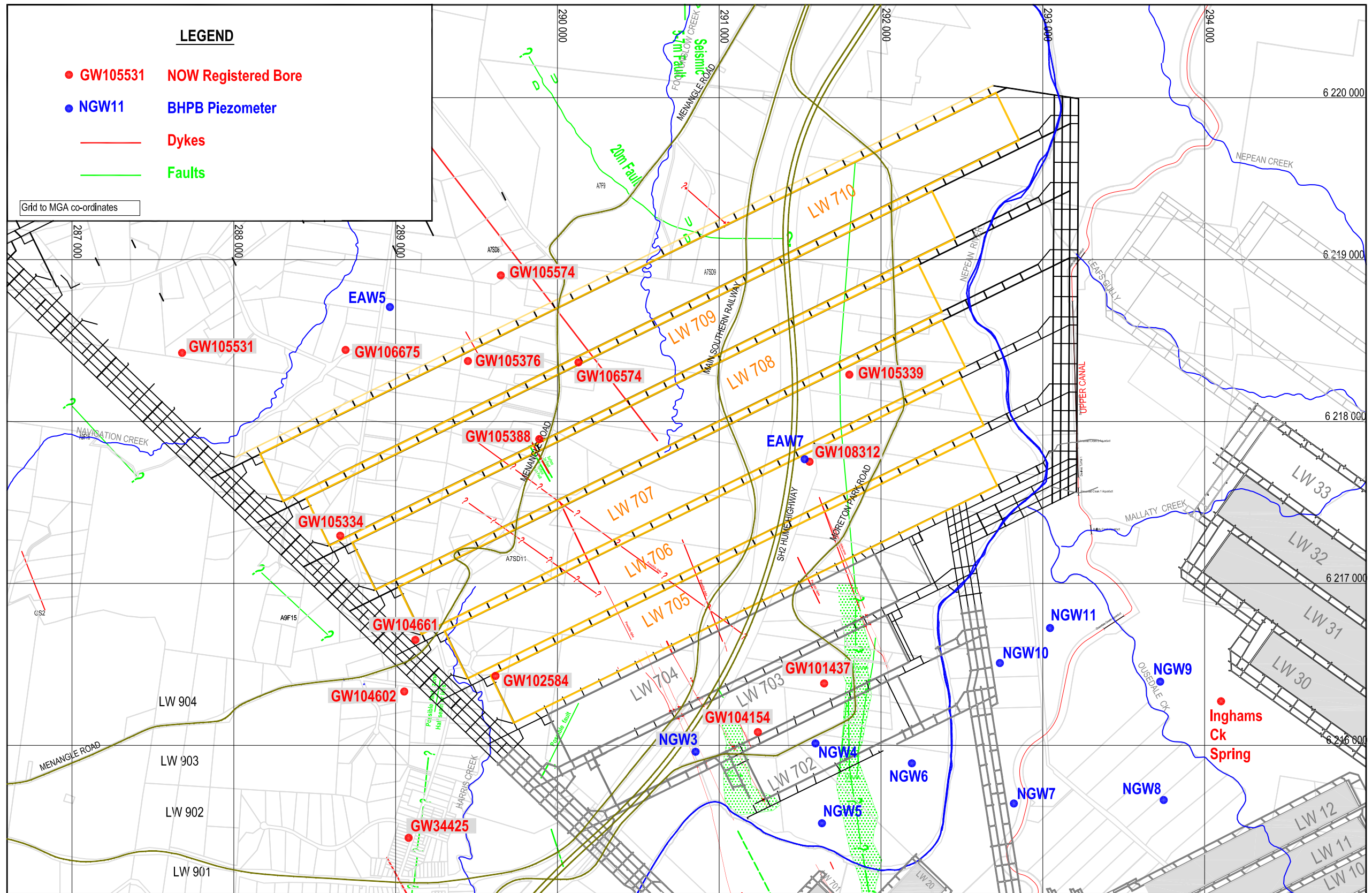
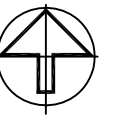
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PROJECT:	BHPB7-R1
DRAWN:	A. DAWKINS
DATE:	17 06 2014
SCALE:	AS SHOWN

**BHP BILLITON ILLAWARRA COAL P/L**  
**LONGWALLS 705 TO 710**  
**DOUGLAS PARK**

**Piezometer, Bore Locations and Geology**

**GeoTerra**

**DRAWING 1**

Drawing Base Courtesy MSEC

# APPENDIX A





## **APPENDIX B**

Monitoring	Trigger	Action
<b>WATER QUALITY</b>		
<p><b>Nepean River</b> Impact monitoring sites adjacent to each Longwall:</p> <ul style="list-style-type: none"> <li>▪ NR11</li> <li>▪ NR12</li> <li>▪ NR13</li> <li>▪ NR20</li> <li>▪ NR30</li> </ul> <p>Refer Figure 1a</p> <p><b>Notes:</b> <i>Baseline upriver sites will be used for cross-checking for upriver perturbations<sup>(3)</sup></i> <i>Baseline Upriver site NR2 data to be updated at end of panel following completion of each longwall, subject to checks-for, and discard-of upriver perturbed data</i></p>	<p><b>Level 1 (Within Prediction)<sup>(1)</sup></b> Impact monitoring sites:</p> <ul style="list-style-type: none"> <li>▪ pH reduction greater than 1 standard deviation but less than 2 standard deviation from pre-mining mean resulting from the mining for two consecutive months</li> <li>▪ DO reduction greater than 1 standard deviation but less than 2 standard deviation from pre-mining mean resulting from the mining for two consecutive months</li> <li>▪ Identification of strata gas plume of flow rate &lt; 3000 L/min <sup>(2)</sup></li> </ul>	<ul style="list-style-type: none"> <li>▪ Continue monitoring program</li> <li>▪ Report impacts to key stakeholders</li> <li>▪ Summarise impacts and record</li> </ul>
	<p><b>Level 2 (Within Prediction – CMAs may be required)<sup>(1)</sup></b> Impact monitoring sites:</p> <ul style="list-style-type: none"> <li>▪ pH reduction greater than 2 standard deviation from pre-mining mean resulting from the mining for two consecutive months</li> <li>▪ DO reduction greater than 2 standard deviation from pre-mining mean resulting from the mining for two consecutive months</li> <li>▪ EC, total Fe and total Mn increases greater than 2 standard deviation from pre-mining mean resulting from the mining for two consecutive months</li> <li>▪ Identification of strata gas plume of flow rate &gt;3000 L/min<sup>(2)</sup></li> </ul>	<ul style="list-style-type: none"> <li>▪ Actions as stated for Level 1 plus:</li> <li>▪ Review monitoring program</li> <li>▪ Notify relevant specialists (BHPBIC) and develop and implement remedial action if necessary</li> </ul> <p><i>Strata Gas Emission Plume:</i></p> <ul style="list-style-type: none"> <li>▪ Estimate gas emission flow rates. Re-estimate should significant change be observed</li> <li>▪ Take sample of plume (if possible) for: <ul style="list-style-type: none"> <li>- chemical composition</li> <li>- dissolved methane from exactly above gas plume and at established downriver monitoring sites</li> <li>- dissolved sulfide and total phenols from exactly above gas plume and at nearest downriver monitoring site(s)</li> </ul> </li> </ul>
	<p><b>Level 3 (CMAs likely to be required)<sup>(1)</sup></b> Impact monitoring sites:</p> <ul style="list-style-type: none"> <li>▪ Level 2-type reduction in water quality resulting from the mining observed for more than 6 consecutive months</li> </ul>	<ul style="list-style-type: none"> <li>▪ Actions as stated for Level 2 plus:</li> <li>▪ Immediately notify OEH, D&amp;PI, NoW &amp; DRE and any other relevant specialist.</li> <li>▪ Consultation with stakeholders.</li> <li>▪ Collect laboratory samples and analyse for: <ul style="list-style-type: none"> <li>- pH, EC, Total Fe and Mn</li> <li>- Suite of Filterable metals.</li> <li>- Dissolved methane, sulfide and total phenols (if relevant).</li> </ul> </li> <li>▪ Develop site management measures as soon as practically possible (pending stakeholder availability) and seek any approvals required to implement</li> </ul>
	<p><b>Exceeding Prediction</b></p> <ul style="list-style-type: none"> <li>▪ More than negligible gas releases</li> </ul>	<ul style="list-style-type: none"> <li>▪ <i>Actions as stated for Level 3</i></li> <li>▪ Investigate reasons for the exceedance</li> <li>▪ Update future predictions based on the outcomes of the investigation</li> </ul>



Monitoring	Trigger	Action
<b>WATER LEVEL AND FLOW</b>		
<b>Nepean River</b> <ul style="list-style-type: none"> <li>Visual observations along the length of the Nepean River within the active mining area</li> </ul>	<b>Level 1 (Within Prediction)<sup>(1)</sup></b> <ul style="list-style-type: none"> <li>Observation of areas of dry and/or flooded riverbed in comparison to pre-mining baseline observations and flows, for less than 2 consecutive months.</li> </ul>	<ul style="list-style-type: none"> <li>Continue monitoring program</li> <li>Report impacts to key stakeholders</li> <li>Summarise impacts and record</li> </ul>
	<b>Level 2 (Within Prediction – CMAs may be required)<sup>(1)</sup></b> <ul style="list-style-type: none"> <li>Observation of areas of dry and/or flooded riverbed in comparison to pre-mining baseline observations and flows, for more than 2 consecutive months.</li> </ul>	<ul style="list-style-type: none"> <li><i>Actions as stated for Level 1</i></li> <li>Review monitoring program</li> <li>Notify relevant technical specialists and seek advice on any CMA required</li> <li>Implement agreed CMAs as approved</li> </ul>
	<b>Level 3 (CMAs likely to be required)<sup>(1)</sup></b> <ul style="list-style-type: none"> <li>Observation of areas of dry and/or flooded riverbed in comparison to pre-mining baseline observations and flows, for more than 6 consecutive months.</li> </ul>	<ul style="list-style-type: none"> <li><i>Actions as stated for Level 2</i></li> <li>Immediately notify relevant government agencies, other resource managers and relevant technical specialists and seek advice on any CMA required.</li> <li>Site visits with stakeholders if required</li> <li>Develop site CMA in consultation with key stakeholders within 1 month.</li> <li>Completion of works following approvals</li> <li>Issue CMA report within 1 month of works completion</li> <li>Conduct initial follow up monitoring &amp; reporting within 2 months of CMA completion if required</li> <li>Review the relevant TARP and Management Plan in consultation with key stakeholders</li> </ul>
<b>APPEARANCE</b>		
<b>Nepean River</b> <ul style="list-style-type: none"> <li>Visual observations along the length of the Nepean River within the active mining area</li> </ul>	<b>Level 1 (Within Prediction)<sup>(1)</sup></b> <ul style="list-style-type: none"> <li>Identified iron staining resulting from the mining for two consecutive months</li> <li>Identified water cloudiness resulting from the mining for two consecutive months</li> </ul>	<ul style="list-style-type: none"> <li>Continue monitoring program</li> <li>Report impacts to key stakeholders</li> <li>Summarise impacts and record</li> </ul>
	<b>Level 2 (Within Prediction – CMAs may be required)<sup>(1)</sup></b> <ul style="list-style-type: none"> <li>Iron staining greater than baseline monitoring resulting from the mining for two consecutive months</li> <li>Water cloudiness greater than baseline monitoring resulting from the mining for two consecutive months</li> </ul>	<ul style="list-style-type: none"> <li><i>Actions as stated for Level 1</i></li> <li>Review monitoring program</li> <li>Notify relevant technical specialists and seek advice on any CMA required</li> <li>Implement agreed CMAs as approved</li> </ul>

Monitoring	Trigger	Action
	<p><b>Level 3 (CMAs likely to be required)<sup>(1)</sup></b></p> <ul style="list-style-type: none"> <li>Iron staining greater than baseline monitoring resulting from the mining for six consecutive months</li> <li>Water cloudiness greater than baseline monitoring resulting from the mining for six consecutive months</li> </ul>	<ul style="list-style-type: none"> <li>Actions as stated for Level 2</li> <li>Immediately notify relevant government agencies, other resource managers and relevant technical specialists and seek advice on any CMA required.</li> <li>Site visits with stakeholders if required</li> <li>Develop site CMA in consultation with key stakeholders within 1 month.</li> <li>Completion of works following approvals</li> <li>Issue CMA report within 1 month of works completion</li> <li>Conduct initial follow up monitoring &amp; reporting within 2 months of CMA completion if required</li> <li>Review the relevant TARP and Management Plan in consultation with key stakeholders</li> </ul>
	<p><b>Exceeding Prediction</b></p> <ul style="list-style-type: none"> <li>More than negligible iron staining resulting from the mining</li> <li>More than negligible increase in water cloudiness resulting from the mining</li> </ul>	<ul style="list-style-type: none"> <li>Actions as stated for Level 3</li> <li>Investigate reasons for the exceedance</li> <li>Update future predictions based on the outcomes of the investigation</li> </ul>
<p><b>Ephemeral Watercourses</b></p> <ul style="list-style-type: none"> <li>Upper Harris Creek (HC10)</li> <li>Foot Onslow Creek (FO1)</li> <li>Navigation Creek (NAV1)</li> </ul> <p>Visual observations at water quality monitoring sites and along the length of the stream within the active mining area where landholder access is granted</p>	<p><b>Level 1 (Within Prediction)<sup>(1)</sup></b></p> <ul style="list-style-type: none"> <li>Fracturing with no observable loss of surface water flow</li> <li>Fracturing with no reduction in pool water level when compared to similar environmental conditions in baseline period</li> <li>Increase in turbidity, iron staining, algal growth, or other visible water quality parameters resulting from the mining for two consecutive months determined by comparing baseline photos with photos during the mining period</li> </ul>	<ul style="list-style-type: none"> <li>Continue monitoring program</li> <li>Report impacts to key stakeholders</li> <li>Summarise impacts and record</li> </ul>
	<p><b>Level 2 (Within Prediction – CMAs may be required)<sup>(1)</sup></b></p> <ul style="list-style-type: none"> <li>Fracturing resulting in loss of surface flow in some creeks or tributary</li> <li>Fracturing resulting in water loss from some permanent pools</li> <li>Reduced water retention time in pools</li> <li>Increase in turbidity, iron staining, algal growth, or other visible water quality parameters resulting from the mining for two consecutive months determined by comparing baseline photos with photos during the mining period</li> </ul>	<ul style="list-style-type: none"> <li>Actions as stated for Level 1</li> <li>Review monitoring program</li> <li>Notify relevant technical specialists and seek advice on any CMA required</li> <li>Implement agreed CMAs as approved</li> </ul>

Monitoring	Trigger	Action
	<p><b>Level 3 (CMAs likely to be required)<sup>(1)</sup></b></p> <ul style="list-style-type: none"> <li>▪ Fracturing resulting in total loss of surface flow in all sections of a creek or tributary</li> <li>▪ Fracturing resulting in total water loss from all permanent pools in the mining area</li> <li>▪ Reduced water retention time in all pools in the mining area</li> </ul> <p><b>Exceeding Prediction</b></p> <ul style="list-style-type: none"> <li>▪ Fracturing of controlling rockbars and/or stream bed, resulting in the diversion of all stream flow in the mining area</li> <li>▪ Increased leakage from all pools in the mining area</li> </ul>	<ul style="list-style-type: none"> <li>▪ <i>Actions as stated for Level 2</i></li> <li>▪ Immediately notify relevant government agencies, other resource managers and relevant technical specialists and seek advice on any CMA required.</li> <li>▪ Site visits with stakeholders if required</li> <li>▪ Develop site CMA in consultation with key stakeholders within 1 month.</li> <li>▪ Completion of works following approvals</li> <li>▪ Issue CMA report within 1 month of works completion</li> <li>▪ Conduct initial follow up monitoring &amp; reporting within 2 months of CMA completion if required</li> <li>▪ Review the relevant TARP and Management Plan in consultation with key stakeholders</li> </ul> <ul style="list-style-type: none"> <li>▪ <i>Actions as stated for Level 3</i></li> <li>▪ Investigate reasons for the exceedance</li> <li>▪ Update future predictions based on the outcomes of the investigation</li> </ul>
<p><b>Water Pumps</b></p> <ul style="list-style-type: none"> <li>▪ There are six pumps in the Nepean River which will be monitored for the effects from subsidence: <ul style="list-style-type: none"> <li>- Pump 1</li> <li>- Pump 2</li> <li>- Pump 3</li> <li>- Pump 4</li> <li>- Pump 5</li> <li>- Pump 6</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>▪ Pump not functioning due to physical disturbance from subsidence</li> </ul>	<ul style="list-style-type: none"> <li>▪ Continue monitoring program</li> <li>▪ Report impacts to key stakeholders</li> <li>▪ Summarise impacts and record</li> <li>▪ Develop and implement CMA (if required) in consultation with key stakeholders</li> </ul>
<b>AQUATIC ECOLOGY</b>		
<p><b>Nepean River</b></p> <ul style="list-style-type: none"> <li>▪ Sites 5 and 6 (located adjacent to Longwalls 705 and 706 downstream of the confluences with Mallaty and Ouesdale Creeks)</li> </ul>	<p><b>Level 1 (Within Prediction)<sup>(1)</sup></b></p> <ul style="list-style-type: none"> <li>▪ 1 season reduction in aquatic habitat resulting from the mining when comparing to baseline condition</li> </ul>	<ul style="list-style-type: none"> <li>▪ Continue monitoring program</li> <li>▪ Report impacts to key stakeholders</li> <li>▪ Summarise impacts and record</li> </ul>

Monitoring	Trigger	Action
<ul style="list-style-type: none"> <li>▪ Sites 7 and 8 (located downstream of all proposed Longwalls 701-710)</li> </ul> <p><b>Ephemeral Watercourses</b></p> <ul style="list-style-type: none"> <li>▪ Sites F1 and F2 (located on Foot Onslow Creek, over Longwalls 708 and 710)</li> <li>▪ Site N1 (located on Navigator Creek northeast of Longwall 710)</li> <li>▪ General observation of all other watercourses in active mining areas</li> </ul> <p>Refer Figure 20.1 in LW705-710 SMP</p>	<p><b>Level 2 (Within Prediction – CMAs may be required)<sup>(1)</sup></b></p> <ul style="list-style-type: none"> <li>▪ 2 consecutive season reduction in aquatic habitat resulting from the mining when comparing to baseline condition</li> </ul>	<ul style="list-style-type: none"> <li>▪ <i>Actions as stated for Level 1</i></li> <li>▪ Review monitoring program</li> <li>▪ Notify relevant technical specialists and seek advice on any CMA required</li> <li>▪ Implement agreed CMAs as approved</li> </ul>
	<p><b>Level 3 (CMAs likely to be required)<sup>(1)</sup></b></p> <ul style="list-style-type: none"> <li>▪ Reduction in aquatic habitat resulting from the mining for &gt; 2 consecutive seasons or complete loss of habitat</li> </ul>	<ul style="list-style-type: none"> <li>▪ <i>Actions as stated for Level 2</i></li> <li>▪ Immediately notify relevant government agencies, other resource managers and relevant technical specialists and seek advice on any CMA required.</li> <li>▪ Site visits with stakeholders if required</li> <li>▪ Develop site CMA in consultation with key stakeholders within 1 month.</li> <li>▪ Completion of works following approvals</li> <li>▪ Issue CMA report within 1 month of works completion</li> <li>▪ Conduct initial follow up monitoring &amp; reporting within 2 months of CMA completion if required</li> <li>▪ Review the relevant TARP and Management Plan in consultation with key stakeholders</li> </ul>
	<p><b>Exceeding Prediction</b></p> <ul style="list-style-type: none"> <li>▪ More than negligible environmental consequences for a threatened species, threatened population or endangered ecological community</li> </ul>	<ul style="list-style-type: none"> <li>▪ <i>Actions as stated for Level 3</i></li> <li>▪ Investigate reasons for the exceedance</li> <li>▪ Update future predictions based on the outcomes of the investigation</li> </ul>
<b>GROUNDWATER</b>		
<p><b>Water Level</b></p> <p>IC monitoring bores:</p> <ul style="list-style-type: none"> <li>▪ NGW3</li> <li>▪ NGW4</li> <li>▪ NGW6</li> <li>▪ NGW5</li> <li>▪ EAW5</li> <li>▪ EAW7 (S1936)</li> </ul> <p>Private Bores</p> <ul style="list-style-type: none"> <li>▪ Registered bores and any new bores within the SMP area</li> </ul>	<p><b>Level 1 (Within Prediction)<sup>(1)</sup></b></p> <ul style="list-style-type: none"> <li>▪ Up to an additional 2.5m reduction from the predicted standing water level or pressure (outside of pumping influences) over 2 consecutive months</li> </ul>	<ul style="list-style-type: none"> <li>▪ Continue monitoring program</li> <li>▪ Report impacts to key stakeholders</li> <li>▪ Summarise impacts and record</li> </ul>
	<p><b>Level 2 (Within Prediction – CMAs may be required)<sup>(1)</sup></b></p> <ul style="list-style-type: none"> <li>▪ Between 2.5m and 5m additional reduction from the predicted standing water level or pressure (outside of pumping influences) over 2 consecutive months</li> </ul>	<ul style="list-style-type: none"> <li>▪ <i>Actions as stated for Level 1</i></li> <li>▪ Review monitoring program</li> <li>▪ Notify relevant technical specialists and seek advice on any CMA required</li> <li>▪ Implement agreed CMAs as approved</li> </ul>

Monitoring	Trigger	Action
<p><b>Notes:</b> Impact monitoring data during longwall mining is compared to predicted groundwater levels from the BSOP (or later updates) groundwater model, during preparation of the End of Panel Report</p> <p>Privately owned water supplies are monitored as agreed with landowners in the Built Feature Management Plans</p> <p>Refer Figure 1a</p>	<p><b>Level 3 (CMAs likely to be required)<sup>(1)</sup></b></p> <ul style="list-style-type: none"> <li>▪ Greater than 5m of additional reduction from the predicted standing water level or pressure (outside of pumping influences) over 2 consecutive months</li> <li>▪ Privately owned water supply adversely impacted from the mining (other than impact that is negligible)</li> </ul>	<ul style="list-style-type: none"> <li>▪ <i>Actions as stated for Level 2</i></li> <li>▪ Immediately notify relevant government agencies, other resource managers and relevant technical specialists and seek advice on any CMA required.</li> <li>▪ Site visits with stakeholders if required</li> <li>▪ Develop site CMA in consultation with key stakeholders within 1 month.</li> <li>▪ Completion of works following approvals</li> <li>▪ Issue CMA report within 1 month of works completion</li> <li>▪ Conduct initial follow up monitoring &amp; reporting within 2 months of CMA completion if required</li> <li>▪ Review the relevant TARP and Management Plan in consultation with key stakeholders</li> <li>▪ Compensatory water supply measures must be provided as an alternative long-term supply that is equivalent to the loss attributed to the mining impact, and be provided (at least on an interim basis) within 24 hours of the loss being identified.</li> </ul>
<p><b>Water Quality</b></p> <p>IC monitoring bores</p> <ul style="list-style-type: none"> <li>▪ NGW6</li> <li>▪ NGW5</li> </ul> <p>Private Bores</p> <ul style="list-style-type: none"> <li>▪ Registered bores and any new bores within the SMP area (where water quality samples can be taken)</li> </ul>	<p><b>Level 1 (Within Prediction)<sup>(1)</sup></b></p> <ul style="list-style-type: none"> <li>▪ Groundwater quality reduction greater than 1 standard deviation but less than 2 standard deviation from pre-mining mean resulting from the mining for two consecutive months</li> </ul>	<ul style="list-style-type: none"> <li>▪ Continue monitoring program</li> <li>▪ Report impacts to key stakeholders</li> <li>▪ Summarise impacts and record</li> </ul>
	<p><b>Level 2 (Within Prediction – CMAs may be required)<sup>(1)</sup></b></p> <ul style="list-style-type: none"> <li>▪ Groundwater quality reduction greater than 2 standard deviation from pre-mining mean resulting from the mining for two consecutive months</li> </ul>	<ul style="list-style-type: none"> <li>▪ <i>Actions as stated for Level 1</i></li> <li>▪ Review monitoring program</li> <li>▪ Notify relevant technical specialists and seek advice on any CMA required</li> <li>▪ Implement agreed CMAs as approved</li> </ul>
	<p><b>Level 3 (CMAs likely to be required)<sup>(1)</sup></b></p> <ul style="list-style-type: none"> <li>▪ Level 2-type reduction in water quality resulting from the mining observed for more than 6 consecutive months</li> </ul>	<ul style="list-style-type: none"> <li>▪ <i>Actions as stated for Level 2</i></li> <li>▪ Immediately notify relevant government agencies, other resource managers and relevant technical specialists and seek advice on any CMA required.</li> <li>▪ Site visits with stakeholders if required</li> <li>▪ Develop site CMA in consultation with key stakeholders within 1 month.</li> <li>▪ Completion of works following approvals</li> <li>▪ Issue CMA report within 1 month of works completion</li> <li>▪ Conduct initial follow up monitoring &amp; reporting within 2 months of CMA completion if required</li> <li>▪ Review the relevant TARP and Management Plan in consultation with key stakeholders</li> <li>▪ Compensatory water supply measures must be provided as an alternative long-term supply that is equivalent to the loss attributed to the mining impact, and be provided (at least on an interim basis) within 24 hours of the loss being identified</li> </ul>

Monitoring	Trigger	Action
<b>Mine Water Inflows</b>	<b>Level 1 (Within Prediction)<sup>(1)</sup></b> <ul style="list-style-type: none"> <li>Abnormal rise in water flow from the goaf between 2.7 and 3ML/day (over 20 day average)</li> </ul>	<ul style="list-style-type: none"> <li>Continue monitoring program</li> <li>Report impacts to key stakeholders</li> <li>Summarise impacts and record</li> </ul>
	<b>Level 2 (Within Prediction – CMAs may be required)<sup>(1)</sup></b> <ul style="list-style-type: none"> <li>Abnormal rise in water flow from the goaf between 3 and 3.4ML/day (over 20 day average)</li> </ul>	<ul style="list-style-type: none"> <li>Actions as stated for Level 1</li> <li>Review monitoring program</li> <li>Notify relevant technical specialists and seek advice on any CMA required</li> <li>Implement agreed CMAs as approved</li> </ul>
	<b>Level 3 (CMAs likely to be required)<sup>(1)</sup></b> <ul style="list-style-type: none"> <li>Abnormal rise in water flow from the goaf &gt;3.4ML/day (over 20 day average)</li> </ul>	<ul style="list-style-type: none"> <li>Actions as stated for Level 2</li> <li>Immediately notify relevant government agencies, other resource managers and relevant technical specialists and seek advice on any CMA required.</li> <li>Site visits with stakeholders if required</li> <li>Develop site CMA in consultation with key stakeholders within 1 month.</li> <li>Completion of works following approvals</li> <li>Issue CMA report within 1 month of works completion</li> <li>Conduct initial follow up monitoring &amp; reporting within 2 months of CMA completion if required</li> <li>Review the relevant TARP and Management Plan in consultation with key stakeholders</li> </ul>
<b>LANDSCAPE FEATURES</b>		
<b>Cliffs</b> <ul style="list-style-type: none"> <li>Along Nepean Gorge</li> </ul> <b>Steep Slopes</b> <ul style="list-style-type: none"> <li>Along Nepean Gorge, associated tributaries and above western end of the proposed Longwalls</li> </ul> <p>Refer Figure 19.1 in LW705-710 SMP</p>	<b>Level 1 (Within Prediction)<sup>(1)</sup></b> <ul style="list-style-type: none"> <li>Any rock fall, displacement, dislodgement of boulders or slabs or fracturing of a cliff line flanking the Nepean River resulting from mining</li> <li>Erosion resulting from mining localised to a small area that should naturally stabilise within the monitoring period</li> <li>Surface movement resulting from mining with no more than negligible soil surface exposed</li> </ul>	<ul style="list-style-type: none"> <li>Continue monitoring program</li> <li>Report impacts to key stakeholders</li> <li>Summarise impacts and record</li> </ul>
	<b>Level 2 (Within Prediction – CMAs may be required)<sup>(1)</sup></b> <ul style="list-style-type: none"> <li>Any rock falls, displacements, dislodgements of boulders or slabs or fracturing of a cliff line(s) flanking the Nepean River resulting from mining that in total impacts 0.3% of the total cliff line face area of the mining domain.</li> <li>Erosion resulting from mining likely to naturally stabilise within the monitoring period.</li> <li>Surface movement or rock displacement resulting from mining with no more than minor soil surface exposed</li> </ul>	<ul style="list-style-type: none"> <li>Actions as stated for Level 1</li> <li>Review monitoring program</li> <li>Notify relevant technical specialists and seek advice on any CMA required</li> <li>Implement agreed CMAs as approved</li> </ul>

Monitoring	Trigger	Action
	<p><b>Level 3 (CMAs likely to be required)<sup>(1)</sup></b></p> <ul style="list-style-type: none"> <li>▪ Any rock falls, displacements, dislodgements of boulders or slabs or fracturing of a cliff line(s) flanking the Nepean River resulting from mining that in total impacts up to 0.5% of the total cliffline face area of the mining domain.</li> <li>▪ Any rock falls, displacements, dislodgements of boulders or slabs or fracturing of a cliffline(s) flanking the Nepean River resulting from mining that in total impacts 0.4% of the total cliffline face area of the mining domain after 1 longwall.</li> <li>▪ Mass movement of a slope causing large areas of exposed soil</li> <li>▪ Any form of rockfall or erosion that poses a threat to public safety</li> </ul>	<ul style="list-style-type: none"> <li>▪ <i>Actions as stated for Level 2</i></li> <li>▪ Immediately notify relevant government agencies, other resource managers and relevant technical specialists and seek advice on any CMA required.</li> <li>▪ Site visits with stakeholders if required</li> <li>▪ Develop site CMA in consultation with key stakeholders within 1 month.</li> <li>▪ Completion of works following approvals</li> <li>▪ Issue CMA report within 1 month of works completion</li> <li>▪ Conduct initial follow up monitoring &amp; reporting within 2 months of CMA completion if required</li> <li>▪ Review the relevant TARP and Management Plan in consultation with key stakeholders</li> </ul>
<ul style="list-style-type: none"> <li>▪ Cliffs flanking the Nepean River</li> </ul>	<p><b>Exceeding Prediction</b></p> <ul style="list-style-type: none"> <li>▪ More than negligible environmental consequences (that is occasional rockfalls, displacement or dislodgement of boulders or slabs, or fracturing, that in total impacts more than 0.5% of the total face area of such cliffs within the Longwall mining domain)</li> <li>▪ Rockfall or erosion that poses more than a negligible increased risk to public safety</li> </ul>	<ul style="list-style-type: none"> <li>▪ <i>Actions as stated for Level 3</i></li> <li>▪ Investigate reasons for the exceedance</li> <li>▪ Update future predictions based on the outcomes of the investigation</li> </ul>
<b>TERRESTRIAL ECOLOGY</b>		
<p>Monitored in conjunction with general observational monitoring for the Nepean River, ephemeral watercourses and active mining area</p>	<p><b>Level 1 (Within Prediction)<sup>(1)</sup></b></p> <ul style="list-style-type: none"> <li>▪ Vegetation impacted by mining (by rockfalls, soil slippage, gas emissions) that is likely to naturally regenerate within the monitoring period</li> </ul>	<ul style="list-style-type: none"> <li>▪ Continue monitoring program</li> <li>▪ Report impacts to key stakeholders</li> <li>▪ Summarise impacts and record</li> </ul>
	<p><b>Level 2 (Within Prediction – CMAs may be required)<sup>(1)</sup></b></p> <ul style="list-style-type: none"> <li>▪ Vegetation impacted by mining (by rockfalls, soil slippage, gas emissions) that is unlikely to naturally regenerate within the monitoring period</li> </ul>	<ul style="list-style-type: none"> <li>▪ <i>Actions as stated for Level 1</i></li> <li>▪ Review monitoring program</li> <li>▪ Notify relevant technical specialists and seek advice on any CMA required</li> <li>▪ Implement agreed CMAs as approved</li> </ul>

Monitoring	Trigger	Action
	<p><b>Level 3 (CMAs likely to be required)<sup>(1)</sup></b></p> <ul style="list-style-type: none"> <li>Vegetation impacted by mining that is not responding to CMAs</li> </ul>	<ul style="list-style-type: none"> <li>Actions as stated for Level 2</li> <li>Immediately notify relevant government agencies, other resource managers and relevant technical specialists and seek advice on any CMA required.</li> <li>Site visits with stakeholders if required</li> <li>Develop site CMA in consultation with key stakeholders within 1 month.</li> <li>Completion of works following approvals</li> <li>Issue CMA report within 1 month of works completion</li> <li>Conduct initial follow up monitoring &amp; reporting within 2 months of CMA completion if required</li> <li>Review the relevant TARP and Management Plan in consultation with key stakeholders</li> </ul>
	<p><b>Exceeding Prediction</b></p> <ul style="list-style-type: none"> <li>More than negligible environmental consequences on threatened species, threatened populations, or endangered ecological communities</li> </ul>	<ul style="list-style-type: none"> <li>Actions as stated for Level 3</li> <li>Investigate reasons for the exceedance</li> <li>Update future predictions based on the outcomes of the investigation</li> </ul>
<b>ABORIGINAL ARCHAEOLOGY</b>		
<ul style="list-style-type: none"> <li>Nepean River 4 (52-2-2098)</li> <li>Nepean River 5 (52-2-2097)</li> <li>Nepean River 6 (52-2-2095)</li> <li>Nepean River 7 (52-2-2096)</li> <li>Nepean River 8 (52-2-2239)</li> <li>Upper Nepean Hand Stencils</li> <li>Bulli Site 40 (BS 40)</li> </ul> <p>Any other newly identified Aboriginal Archaeology sites</p> <p>Refer to Figure 5-22 of Bulli Seam Operations EA and Figure 3 Bulli Seam Operations Appendix G (Aboriginal Cultural Heritage Assessment)</p>	<p><b>Level 1 (Within Prediction)<sup>(1)</sup></b></p> <ul style="list-style-type: none"> <li>Change in shelter conditions not attributable to natural weathering or preservation – mineral growth or micro-organism growth (as observed by comparing pre-mining photographs with post-subsidence/mining photographs)</li> <li>Changes external to the shelter that affect the site context – ground cracking, boulder slumping, rock and/or tree falls</li> </ul>	<ul style="list-style-type: none"> <li>Continue monitoring program</li> <li>Report impacts to key stakeholders</li> <li>Summarise impacts and record</li> </ul>
	<p><b>Level 2 (Within Prediction – CMAs may be required)<sup>(1)</sup></b></p> <ul style="list-style-type: none"> <li>Change in shelter conditions not attributable to natural weathering or preservation – change in drip line or seepage, cracking or exfoliation of overhang or shelter, movement or opening of existing planes and joints at panel, block fall within shelter or overhang</li> </ul>	<ul style="list-style-type: none"> <li>Actions as stated for Level 1</li> <li>Review monitoring program</li> <li>Notify relevant technical specialists and seek advice on any CMA required</li> <li>Implement agreed CMAs as approved</li> </ul>
	<p><b>Level 3 (CMAs likely to be required)<sup>(1)</sup></b></p> <ul style="list-style-type: none"> <li>Shelter or overhang collapse not attributable to natural weathering</li> <li>Level 2 impacts at greater frequency than predicted</li> <li>Level 2 impacts attributable to mining remote from the mining area</li> </ul>	<ul style="list-style-type: none"> <li>Actions as stated for Level 2</li> <li>Immediately notify relevant government agencies, other resource managers and relevant technical specialists and seek advice on any CMA required.</li> <li>Site visits with stakeholders if required</li> <li>Develop site CMA in consultation with key stakeholders within 1 month.</li> <li>Completion of works following approvals</li> <li>Issue CMA report within 1 month of works completion</li> <li>Conduct initial follow up monitoring &amp; reporting within 2 months of CMA completion if required</li> <li>Review the relevant TARP and Management Plan in consultation with key stakeholders</li> </ul>



Monitoring	Trigger	Action
<ul style="list-style-type: none"> <li>Sites determined to hold high or moderate significance as a result of studies required for Extraction Plans</li> <li>Other Aboriginal heritage sites</li> </ul>	<p><b>Exceeding Prediction</b></p> <ul style="list-style-type: none"> <li>More than 10% of such sites across the mining area are affected by subsidence impacts (other than negligible impacts or environmental consequence)</li> <li>Less than 10% of such sites (or 1 such site, whichever is the greater) within any longwall mining domain are/is affected by subsidence impacts (other than minor impacts or environmental consequence)</li> </ul>	<ul style="list-style-type: none"> <li>Actions as stated for Level 3</li> <li>Investigate reasons for the exceedance</li> <li>Update future predictions based on the outcomes of the investigation</li> </ul>
<b>HISTORIC HERITAGE</b>		
<ul style="list-style-type: none"> <li>Buildings or structures of identified heritage significance</li> </ul> <p><b>Note:</b> Detailed Heritage Management Plans to be developed prior to any heritage item being influence by mining.</p>	<p><b>Exceeding Prediction</b></p> <ul style="list-style-type: none"> <li>Loss of heritage value greater than predicted under the Heritage Management Plan</li> </ul>	<ul style="list-style-type: none"> <li>Continue monitoring program</li> <li>Report impacts to key stakeholders</li> <li>Summarise impacts and record</li> <li>Immediately notify relevant government agencies, other resource managers and relevant technical specialists and seek advice on any CMA required.</li> <li>Site visits with stakeholders if required</li> <li>Develop site CMA in consultation with key stakeholders within 1 month.</li> <li>Completion of works following approvals</li> <li>Issue CMA report within 1 month of works completion</li> <li>Conduct initial follow up monitoring &amp; reporting within 2 months of CMA completion if required</li> <li>Review the relevant TARP and Management Plan in consultation with key stakeholders</li> <li>Investigate reasons for the exceedance</li> <li>Update future predictions based on the outcomes of the investigation</li> </ul>

(1) These may be revised in consultation with DoPI and DPI and other key stakeholders

(2) If strata gas emission plumes are detected – particularly coinciding with low river flow and significant gas evolution

(3) Baseline upriver sites for cross-checking for upriver perturbations impacting Area 7 monitoring sites:

- NR0 - possible perturbations from Allens Creek (>2 standard deviation)
- NR2 - upstream perturbations (>2 standard deviations) pre-Area 9 mining
- New site NR110 - possible perturbations from Area 9 (>2 standard deviations) post-Area 9 mining commencement
- Checks at Upriver sites NR4, NR5 and NR6 for possible Cataract River-based perturbations (>2 standard deviation)

Current values:

**Level 1**

**NR11**

- pH>6.93;<7.33
- DO>47.8%;<66.0%
- EC>561 uS/cm;<758 uS/cm
- Total Fe>0.589;<0.866mg/L
- Total Mn>0.044;<0.074 mg/L

**NR2 upstream normality checks**

- pH>7.01
- DO>55.3%
- EC<890 uS/cm
- Total Fe<1.220 mg/L
- Total Mn<0.090 mg/L

**Level 2 and 3**

**NR11**

- pH<6.93
- DO<47.8%
- EC>758 uS/cm
- Total Fe>0.866
- Total Mn>0.074

**NR2 upstream normality checks**

- pH>7.01
- DO>55.3%
- EC<890 uS/cm
- Total Fe<1.220 mg/L
- Total Mn<0.090 mg/L

The above data values are updated during the preparation of each End of Panel Report