




**GUJARAT NRE FCGL Pty Ltd**

**NRE WONGAWILLI COLLIERY  
LONGWALL 12  
END OF PANEL REPORT**

**FOR THE NSW DEPARTMENT OF INDUSTRY AND INVESTMENT**

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<b>Person Managing This Document</b>	<b>Author(s) of This Document</b>		
Matthew Richardson	Matthew Richardson		
<b>External Review</b>	<b>Name</b>		
	David Clarkson Environment And Community Manager NRE Wongawilli Colliery		
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	The NSW Department Of Industry And Investment And Gujarat NRE FCGL Pty Ltd Cnr Bellambi Lane & Princess Hwy Russell Vale NSW 2517		

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# 1 ABBREVIATIONS AND DEFINITIONS

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**EOP** - End of Panel Report

**ESSMP** - Environment, Subsidence and Safety Management Plan

**Limit of Subsidence** - also described as the Limit of Vertical Subsidence - the area extending beyond the 20mm/m subsidence contour line

**ML** - Mining Lease

**MSEC** - Mine Subsidence Engineering Consultants

**SMP** - Subsidence Management Plan

**SMP Area** - The area considered for the full SMP application for Longwalls 11,12,15,16 & 19 and Pillar Extraction Area 1 (PE1)

## 2 SUMMARY

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This End of Panel (EOP) report has been prepared in accordance with Condition 17 of the NRE Wongawilli Colliery Longwalls 11, 12, 15, 16, 19 and Pillar Extraction Area 1 Subsidence Management Plan (SMP) Approval. This EOP only relates to Longwall 12.

This EOP report outlines the measured and observed impacts following the extraction of Wongawilli Longwall 12 and compares any observed impacts with the relevant impact predictions outlined in the SMP and its supporting expert reports and accompanying documentation.

Longwall 12 occurs within Mining Lease (ML) 1596 and was extracted using conventional longwall mining techniques and equipment. Extraction of coal from Longwall 12 commenced on 25 August 2009 and concluded on 26 November 2009.

### ***Subsidence***

Subsidence movements resulting from the extraction of Longwall 12 were measured along two 2D seismic survey lines known as E&EE and EF.

The maximum observed incremental subsidence along the monitoring lines for Longwall 12 was 130 mm. This is less than the maximum predicted incremental subsidence of 140 mm. The shapes of the observed and predicted incremental subsidence profiles over Longwall 12 are similar and, therefore, the observed tilts are well represented by the predicted profiles. The profile of the observed subsidence is slightly steeper than the predicted profile over the southern edge of Longwall 12 and the resulting observed maximum tilt of 1.5 mm/m is 0.3 mm/m greater than the maximum predicted tilt of 1.2 mm/m. This area to the south of Longwall 12 is adjacent to where the previous second workings within the Wongawilli Seam were located.

### ***Impacts on Man Made Features***

The observed impacts on man made features resulting from the extraction of Longwall 12 were all less than, or in accordance with impacts predicted in the SMP.

No impacts were observed to transmission lines, Fire Roads and 4WD tracks or the Maldon - Dombarton Railway Corridor.

Two Indigenous archaeological sites occur in the proximity of Longwall 12, although both occur outside the limit of subsidence for the Longwall. As a precautionary measure, these sites (both being Grinding Groove sites in the base of a creek) were inspected post mining. There have been no impacts on these sites due to Longwall 12.

### ***Impacts on Natural Features***

The observed impacts on natural features resulting from the extraction of Longwall 12 were all less than or in accordance with impacts predicted in the SMP. Although the data set for monitoring groundwater and surface water levels, flow rates and

quality is incomplete, from the data available there was no indication that Longwall 12 had any impact on these features. Similarly, there have been no observed impacts on mine water inflow as a result of the extraction of Longwall 12.

There have been no observed impacts to cliffs, steep slopes or any other physical natural feature as a result of the extraction of Longwall 12.

There have been no observed impacts to terrestrial or aquatic ecological values or habitats as a result of the extraction of Longwall 12.

#### ***Trigger Action Response Plans (TARP's)***

There have been no observed impacts on any man made or natural features, so trigger thresholds for the TARPS have not been reached. No remediation has been necessary to date.

#### ***Conclusion***

The extraction of coal from NRE Wongawilli Colliery Longwall 12 has not resulted in impacts of concern to any natural or man made features. No remediation has been required.

NRE Wongawilli Colliery Longwall 11 has commenced extraction. Monitoring of natural and man made features in accordance with the NRE Wongawilli Colliery Environment, Subsidence and Safety Management Plan (ESSMP) in relation to Longwall 12 will continue throughout the life of Longwall 11.

## 3 INTRODUCTION

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### 3.1 Background

This End of Panel (EOP) report has been prepared to define impacts observed from subsidence associated with the extraction of coal from Longwall 12 of NRE Wongawilli Colliery. The EOP has been prepared in accordance with Condition 17 of the Subsidence Management Plan (SMP) approval.

Information in this EOP has been supplied by Gujarat NRE FCGL Pty Ltd (Gujarat NRE) and specialist consultants involved in monitoring the effects of mining within the limit of subsidence of Longwall 12.

Longwall 12 is located in Mining Lease (ML) 1596. The longwall was the first mined in a series of five longwalls (Longwalls 11,12,15,16 & 19) and one pillar extraction area (PE1). The extraction area of Longwall 12 is small (357.6m x 130m) compared to other Longwalls in the series and also within adjacent mining operations.

Coal from Longwall 12 was extracted using conventional longwall mining techniques between the following dates:

- ❑ Longwall commencement: 25 August 2009
- ❑ Longwall completion: 26 November 2009.

Longwall 12 is shown in **Figure 1**. Impact predictions associated with Longwall 12 as part of the larger application area are described in the following reports. Copies of these reports reside with the Department of Industry and Investment:

- ❑ Gujarat NRE Minerals Limited 2008: Subsidence Management Plan for NRE Wongawilli Colliery (Longwall Panels 11, 12, 15, 16, & 19, and Pillar Extraction Area 1) - "Written Report"
- ❑ Mine Subsidence Engineering Consultants [MSEC] (2008) NRE Wongawilli Colliery; The Prediction of Subsidence Parameters and the Assessment of Subsidence Impacts on Natural Features and Surface Infrastructure due to Mining Longwalls 11, 12, 15, 16 & 19 & Pillar Extraction Area PE1 (MSEC 360)
- ❑ Wood, J (2008a) Indicative Hydrogeology NRE Wongawilli Colliery. Proposed Extraction of Longwalls 11, 12, 15, 16 & 19 and Pillar Extraction Area 1
- ❑ Wood, J (2008b) Indicative Hydrology NRE Wongawilli Colliery. Proposed Extraction of Longwalls 11, 12, 15, 16 & 19 and Pillar Extraction Area 1
- ❑ Biosis Research (2008a) Terrestrial Flora and Fauna Impact Assessment for Longwalls 11, 12, 15, 16, & 19 & Pillar Extraction Area 1; NRE Wongawilli Colliery

- ❑ Biosis Research (2008b) Archaeological and Cultural Heritage Impact Assessment of Proposed Longwalls 11, 12, 15, 16, & 19 & Pillar Extraction Area 1; NRE Wongawilli Colliery
- ❑ Biosis Research (2008c) Aquatic Ecology Impact Assessment for Proposed Longwalls 11, 12, 15, 16 & 19 & Pillar Extraction Area 1; NRE Wongawilli Colliery
- ❑ Biosis Research (2009) Addendum to the Terrestrial Flora and Fauna Impact Assessment for Proposed Longwalls 11, 12, 15, 16, and 19 and Pillar Extraction Area 1 NRE Wongawilli Colliery
- ❑ Biosis Research (2009) NRE Wongawilli Colliery Longwalls 11, 12, 15, 16 & 19, & Pillar Extraction Area 1 Cultural Heritage Management Plan and Baseline Recording & Monitoring Methodology.

### 3.2 Approval Conditions

Gujarat NRE FCGL Pty Ltd holds Mining Lease 1596 which includes the area to be mined at NRE Wongawilli Colliery (or in the case of Longwall 12, the area that has been mined). The lease was granted on 19 December 2007. Condition 8 of the Lease provides for the extraction of coal from the lease area subject to the preparation and approval of a Subsidence Management Plan (SMP).

Approval of the SMP for Longwalls 11,12,15,16,19 and Pillar Extraction Area 1 was granted for NRE Wongawilli Colliery on 16 July 2009.

Conditions of the SMP approval pertinent to this EOP report include:

**Condition 12: Subsidence Monitoring:** *The leaseholder must submit to the Principle Subsidence Engineer for approval a subsidence monitoring program for the longwall panels which are subject to this approval. This program must include:*

- a. Inspection regimes*
- b. Layout and monitoring points*
- c. Parameters to be measured*
- d. Monitoring methods and accuracy*
- e. Timing and frequencies of surveys and inspections*
- f. Recording and reporting of monitoring results*

*The leaseholder must not commence longwall mining prior to the subsidence monitoring program being approved*

**Condition 13: Environmental Management:** In accordance with Condition 13 of the SMP approval, Gujarat NRE has prepared an *Environment, Subsidence and*

*Safety Management Plan (ESSMP).* The ESSMP itself required approval from the Director, Environmental Sustainability Unit of the NSW Department of Industry and Investment prior to the commencement of extraction from Longwall 12 only as outlined in correspondence from the Director dated 24 August 2009. Approval of the full and final ESSMP was granted on 24 December 2009 for all Longwalls within the SMP application.

The following consent condition as outlined in the ESSMP approval correspondence from the Director dated 24 August 2009 and later updated on 24 December 2009 applies to Longwall 12:

*End of Panel Reports, required by Condition 17 of the Subsidence Management Plan Approval Dated 16 July 2009, must be provided to the Sydney Catchment Authority (SCA) and the Department of Environment, Climate Change and Water (DECCW) at the same time as they are submitted to Industry and Investment NSW.*

This EOP will be supplied to all three departments/agencies simultaneously.

**Condition 17: End of Panel Report:** *Within 4 months of the completion of each longwall panel, an end of panel report must be prepared to the satisfaction of the Director General Sustainability {Department of Industry and Investment}. The end of panel report must:*

- a. *Include a summary of the subsidence and environmental monitoring results for the applicable longwall panel*
- b. *Include an analysis of these monitoring results against the relevant:*
  - ☐ *Impact assessment criteria*
  - ☐ *Monitoring results from the previous panels (not applicable to Longwall 12 EOP)*
  - ☐ *Predictions in the SMP*
- c. *Identify any trends in the monitoring results over the life of the activity and*
- d. *Describe what actions were taken to ensure adequate management of any potential subsidence impacts due to the longwall mining.*

### 3.3 Report Outline and Contributors

The following specialists and experts have contributed to this EOP through the assessments of subsidence impacts from Longwall 12 on their area of specialisation:

Andrew Nesbitt	Survey	(Attachment B & Attachment C)
MSEC	Mine Subsidence	(Attachment C)
GeoTerra	Groundwater & Surface Water	(Attachment D)

**Biosis Research** Aquatic & Terrestrial Ecology (**Attachment E**)

Cultural Heritage (**Attachment F**)

**Niche Environment and Heritage** Landscape Assessment and EOP (this report)

Data and text from specialist reports have been incorporated into this EOP without further reference. Specialist reports are provided as attachments to this EOP.

This EOP is set out according to the following schedule:

**Section 4** outlines the subsidence movements observed during mining and compares those results with the predicted subsidence parameters.

**Section 5** outlines the impacts of mining associated with Longwall 12 on surface infrastructure.

**Section 6** outlines the impacts of mining associated with Longwall 12 on natural features.

**Sections 7** summarises the monitoring program employed for Longwall 12 to date.

**Section 8** outlines the management and remediation of impacts associated with Longwall 12.

## 4 PREDICTED AND OBSERVED SUBSIDENCE

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### 4.1 Monitoring Lines

Subsidence movements resulting from the extraction of Longwall 12 were monitored at various lines and points within the SMP Area. A comparison of the observed and predicted movements resulting from the extraction of Longwall 12 has been prepared by MSEC and is provided in full in **Attachment C**.

The subsidence movements resulting from the extraction of Longwall 12 were measured along two monitoring lines, E&EE Line and EF Line, both of which are 2D monitoring lines. The locations of the longwalls at the Colliery and the monitoring lines are shown in **Figure 1**.

Comparisons between predicted and observed subsidence movements along the monitoring lines are provided in the following sections.

### 4.2 E&EE Monitoring Line

The E&EE Monitoring Line was installed to survey the subsidence movements due to the extraction of Longwalls 1 to 10 at Elouera Colliery. Total subsidence of 1370 mm was monitored along this line above Longwall 6 and a total subsidence of 705 mm was monitored above Longwall 9 after Longwall 10 was extracted.

The E&EE monitoring line is located along the abandoned Maldon - Dombarton rail corridor and is more than 680 m from Longwall 12. At this distance from Longwall 12 no incremental systematic subsidence was predicted along this E&EE Line. Nevertheless, the survey line was monitored on 20 July 2009 on 10 August 2009 (i.e. before extraction commenced on Longwall 12) and then on 27 November 2009 (i.e. after extraction was completed within Longwall 12) to check if there were any movements as a result of the extraction of Longwall 12.

Survey results of the incremental subsidence of E&EE pegs following the extraction of Longwall 12 were all less than 10 mm, which is within survey tolerance. Measured strains along the E&EE Line are also generally within survey tolerance. A plot of the observed subsidence parameters for the E&EE Line is shown in **Figure 2**. The results show that there has not been any significant subsidence movements along the E&EE Line.

There were no observed subsidence impacts to the Maldon - Dombarton rail corridor or any other surface features in the vicinity of the E&EE Line as a result of Longwall 12 extraction.

### 4.3 EF Monitoring Line

The EF monitoring line is located diagonally across the eastern end of Longwall 12 as is shown in **Figure 1**. The route of the monitoring line follows Fire Road 6H and a disused 33kV power line.

The subsidence and strain along the EF Line were measured before the commencement and after the completion of Longwall 12 on the 20th August 2009 and the 27th November 2009, respectively. The profiles of observed incremental subsidence, tilt and strain along the EF Line due to the extraction of Longwall 12 are shown in **Figure 3**.

The predicted profiles of systematic incremental subsidence and tilt along the EF Line due to the extraction of Longwall 12 are also shown in **Figure 3**.

The predicted subsidence profiles along the monitoring line were obtained using the standard Incremental Profile Method for the Southern Coalfield, which uses an empirical database based on monitoring data from the Bulli Seam. The effects of multi-seam mining conditions were taken into account in the prediction model as previous extraction was carried out above Longwall 12 in the Bulli seam. Old pillar extraction workings within the Wongawilli Seam were also extracted beneath the Bulli Seam within 36 m of Longwall 12. The areas of extraction in the Bulli Seam and the Wongawilli Seam are shown in **Figure 1**.

A summary of the maximum predicted and maximum observed incremental subsidence along the EF monitoring line, due to the extraction of Longwall 12 is provided in **Table 4.1**.

**Table 4.1: Maximum Predicted and Maximum Observed Incremental Subsidence along the EF Line due to the Extraction of Longwall 12**

Longwall	Maximum Predicted Incremental Subsidence (mm)	Maximum Observed Incremental Subsidence (mm)
Longwall 12	140	130

The maximum observed incremental subsidence along the monitoring line for Longwall 12 of 130 mm was less than the maximum predicted incremental subsidence of 140 mm. The shapes of the observed and predicted incremental subsidence profiles over Longwall 12 are similar and, therefore, the tilts are well represented. The profile of the observed subsidence was slightly steeper than the predicted profile over the southern edge of Longwall 12 and the resulting observed maximum tilt of 1.5 mm/m is 0.3 mm/m greater than the maximum predicted tilt of 1.2 mm/m. This area to the south of Longwall 12 is adjacent to where the previous second workings within the Wongawilli Seam were located.

The profiles of observed Longwall 12 incremental strain along the EF Line are also shown in **Figure 3**. It can be seen that a majority of the strains are within survey tolerance.

## 5 IMPACTS ON MAN MADE FEATURES

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### 5.1 Surface Infrastructure Within the Application Area

The surface infrastructure that is located above or adjacent to Longwall 12 is shown in **Figure 1**.

There is no significant infrastructure above or adjacent to Longwall 12 however the following items are considered in this EOP:

- ☐ Fire Road 6H and minor sections of 4WD tracks passing directly above Longwall 12;
- ☐ Fire Road 6A (albeit beyond the 20mm limit of subsidence associated with Longwall 12);
- ☐ Maldon - Dombarton rail corridor located over 680 m from Longwall 12;
- ☐ Disused 33 kV power line passing directly above Longwall 12;
- ☐ Survey control marks located within the SMP Area (note none of the survey control marks occur within the limit of subsidence of Longwall 12). Survey control marks will be considered in the Longwall 11 EOP).

### 5.2 Comparison Between Predicted and Observed Impacts on Surface Infrastructure

Comparisons between the observed and the predicted impacts on the man made surface infrastructure above or adjacent to Longwall 12 are summarised in **Table 5.1**. The predicted impacts were detailed in MSEC (2008). Man made infrastructure was inspected as part of the subsidence survey program on 20 July 2009 on 10 August 2009 (i.e. before extraction commenced on Longwall 12) and then on 27 November 2009 (i.e. after extraction was completed within Longwall 12). Further inspections of these items were made on 23 February 2010 where the length of Fire Road 6H and therefore the disused 33kV power line above Longwall 12 were inspected on foot while Fire Road 6A, and the Maldon - Dombarton Rail Corridor were inspected from a vehicle.

It can be seen from **Table 5.1** that there were no reported impacts on the surface infrastructure resulting from the extraction of Longwall 12, with the exception of the survey control marks, which was predicted.

There are no exploration bores within the limit of subsidence for Longwall 12.

**Table 5.1: Summary of Predicted and Observed Impacts from Longwall 12 on Surface Infrastructure**

Surface Infrastructure	Predicted Impacts	Observed Impacts
Fire Roads 6H* and 6A and 4WD Tracks	Changes to surface drainage and some surface cracking of the unsealed road surfaces	No reported or observed impacts
Maldon - Dombarton Rail Corridor*	No predicted impact	No reported or observed impacts
Disused 33kV Powerline	No predicted impacts	No reported or observed impacts
Survey Control Marks	Horizontal movements requiring re-establishment	Horizontal movements require re-establishment

\*Fire Road 6H and the Maldon - Dombarton rail corridor correspond to Survey Lines EF and EE&E respectively (see **Section 4.2** and **4.3**).

**Plate 1: Fire Road 6H and the disused 33kV Power line.** This section of the Fire Road was inspected on foot on 23 February 2010 and no subsidence related impacts were observed.



### 5.3 Indigenous Heritage Sites

Biosis Research Pty. Ltd. (Biosis) prepared an End of Panel assessment on all Aboriginal heritage sites in the vicinity of Longwall 12 and the full report including survey methodology, as well as before and after mining comparison photos of various sites is provided in **Attachment F**.

Two previously recorded Aboriginal archaeological sites occur in the vicinity of Longwall 12. The sites are located approximately 160m from the northern edge of Longwall 12. Several other archaeological sites considered in the SMP occur at a distance greater than 200m from Longwall 12. This distance is considered to be beyond the limit of subsidence for Longwall 12 and therefore the sites have not been considered further.

The two archaeological sites considered in this EOP are:

- ☐ Upper Avon 2 (52-2-1825) - axe grinding groove
- ☐ Upper Avon 3 (52-2-1826) - axe grinding groove.

The risk of impact to these sites from subsidence related to extraction of Longwall 12 was considered to be low. This conclusion relates not only to Longwall 12 but also to all currently approved longwalls and pillar extraction area for NRE Wongawilli Colliery. The maximum predicted cumulative systematic subsidence parameters for these two sites are shown in Table 1 in **Attachment F**.

These two sites were reassessed on 21 January 2010. Other local landscape features such as natural joint and bedding planes within the sandstone platforms on which the sites occur were also inspected for evidence of subsidence related impact.

The sites and associated features were compared with photographs taken during the SMP application (Biosis Research 2008b). The condition of the two sites as observed on 21 January 2010 revealed no changes to either site or nearby joint and bedding planes. Further, an inspection of the site Upper Avon 3 by representatives of Niche Environment and Heritage and Gujarat NRE on 23 February 2010 recorded the presence of standing water in small rock pools immediately adjacent to the site, further indicating a lack of impact from subsidence in this area. A summary of predicted and observed impacts to Aboriginal cultural heritage sites associated with Longwall 12 is shown in **Table 5.2**.

Further details of the recent assessment of the Aboriginal cultural heritage sites are identified in this EOP, including before and after mining comparison photos are provided in **Attachment F**.

**Table 5.2: Summary of Predicted and Observed Impacts for Aboriginal Cultural Heritage Sites**

AHIMS Site Number	Site Name	Site Type	Risk of Impact	Observed Impacts
52-2-1825	Upper Avon 2	Axe Grinding Groove	Low	None
52-2-1826	Upper Avon 3	Axe Grinding Groove	Low	None

## 5.4 European Heritage Sites

There are no historic sites within the limit of subsidence of Longwall 12.

## 6 IMPACTS TO NATURAL FEATURES

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Longwall 12 is located within the Metropolitan Special Areas Water Catchment. By definition the catchment area is relatively undisturbed and therefore contains many important natural features.

Natural features in the vicinity of Longwall 12 include:

- ☐ Cliffs, steep slopes and rock outcrops
- ☐ Creeks and watercourses including the headwaters of Bellbird Creek
- ☐ Lake Avon
- ☐ Upland swamps (Swamp 20)
- ☐ Native vegetation and fauna habitat.

Each of these values are discussed below. Monitoring activities for natural features within the limit of subsidence for Longwall 12 include the following:

- ☐ Landscape assessment
- ☐ Water flow and quality
- ☐ Groundwater
- ☐ Terrestrial flora and fauna
- ☐ Aquatic ecology.

### 6.1 Steep Slopes and Rock Outcrops

There are several areas identified in Figure MSEC 360-08 (MSEC 2008 - not reproduced in this report). One small area of steep slope occurs to the immediate north of Longwall 12. Steep slopes occur in a second area to the immediate east of Longwall 12.

There are no rock outcrops or cliffs in the vicinity of Longwall 12 (Figure MSEC 360-08 from MSEC 2008).

#### ***Predicted Impacts***

Predicted impacts on the steep slopes that occur directly above longwalls and pillar extraction areas of NRE Wongawilli Colliery are defined in MSEC (2008) as:

- ☐ Minor slippage of soils down the steep slopes, resulting in the development of minor cracking in soils at the top of the slopes and minor compression ridges forming at the bottom of the slopes
- ☐ Large scale slope failure was considered unlikely

- ❑ Steep slopes which are not located directly above the longwall goaf were not predicted to experience any significant systematic subsidence movements. The areas of steep slope considered here are not directly above Longwall 12.

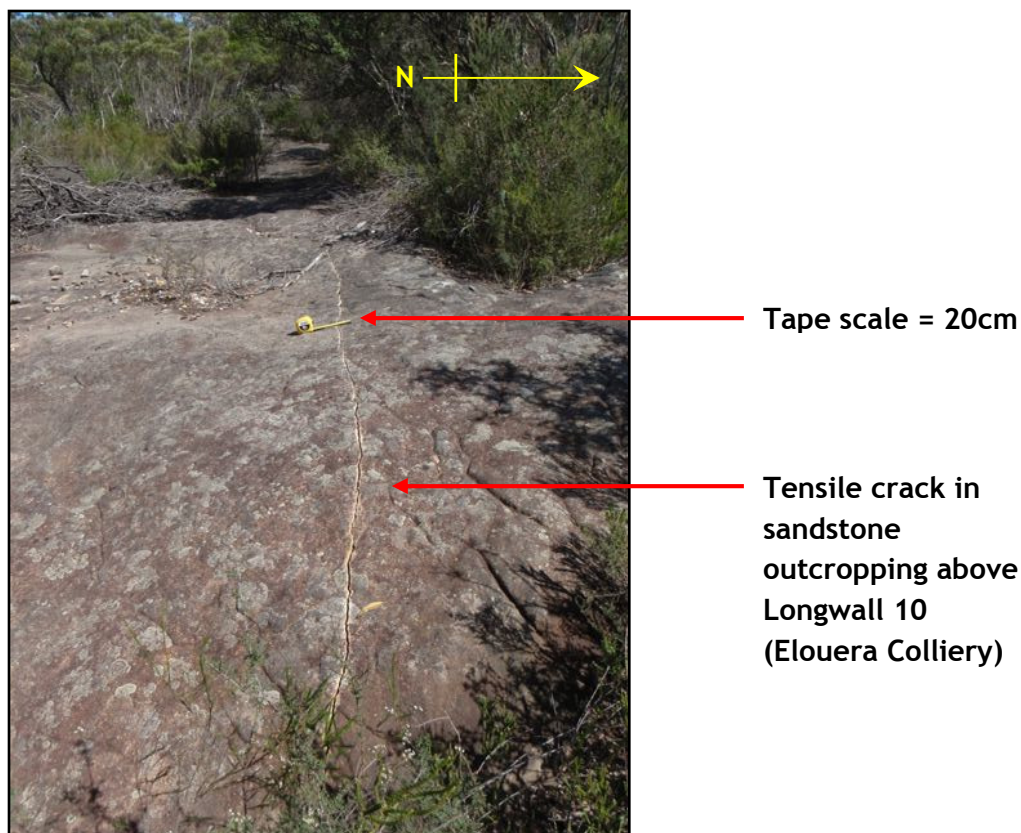
### ***Observed Impacts***

Informal inspections of the two areas of steep slopes in the vicinity of Longwall 12 were undertaken during site inspections by Biosis Research, GeoTerra, Niche Environment and Heritage and personnel from Gujarat NRE.

There have been no observed impacts on steep slopes associated with Longwall 12.

The impacts that may be expected to occur at the top of a slope could include cracking in landscape features such as rock outcrops. **Plate 2** shows a tensile crack in a sandstone outcrop immediately above the edge of a longwall panel in the Southern Coal Field. Cracking like this was not observed in any sandstone outcrop inspected above or in the vicinity of Longwall 12 (see **Plate 2**).

**Plate 2: Cracking in sandstone outcrop above the southern edge of the goaf of Elouera Colliery - Longwall 10**



## 6.2 Surface Waters

There are no significant waterways within the limit of subsidence of Longwall 12. One creek, Bellbird Creek has its headwaters within an Upland Swamp (Swamp 20). A small arm of Swamp 20 crosses the north-western corner of the Longwall. A second creek, Flying Fox No.1 Creek occurs 170m to the south-east of Longwall 12. It occurs outside of the limit of subsidence of Longwall 12 and has not been considered further in this EOP.

Within Swamp 20, Bellbird Creek is obscured for the most part by dense vegetation which only opens into an open channel over short distances where bedrock sandstone is close to the swamp base. In these locations, standing pools of water occur in deeper natural potholes in the sandstone with small volumes of water flowing in naturally eroded drainage depressions located along joint and bedding planes (see **Plate 3**). Longwall 12 did not mine directly beneath Bellbird Creek. A number of smaller, ephemeral drainage lines occur above Longwall 12 and were inspected for this EOP. No impacts to the ephemeral drainage lines were observed.

Lake Avon is located more than 1 km from any of the Longwalls associated with NRE Wongawilli Colliery (i.e. outside the Dam Safety Committee notification zone). Subsequently, Lake Avon is located well outside the area of potential subsidence impacts for Longwall 12. Lake Avon has not been considered further in this EOP.

### 6.2.1 Geomorphic Impacts

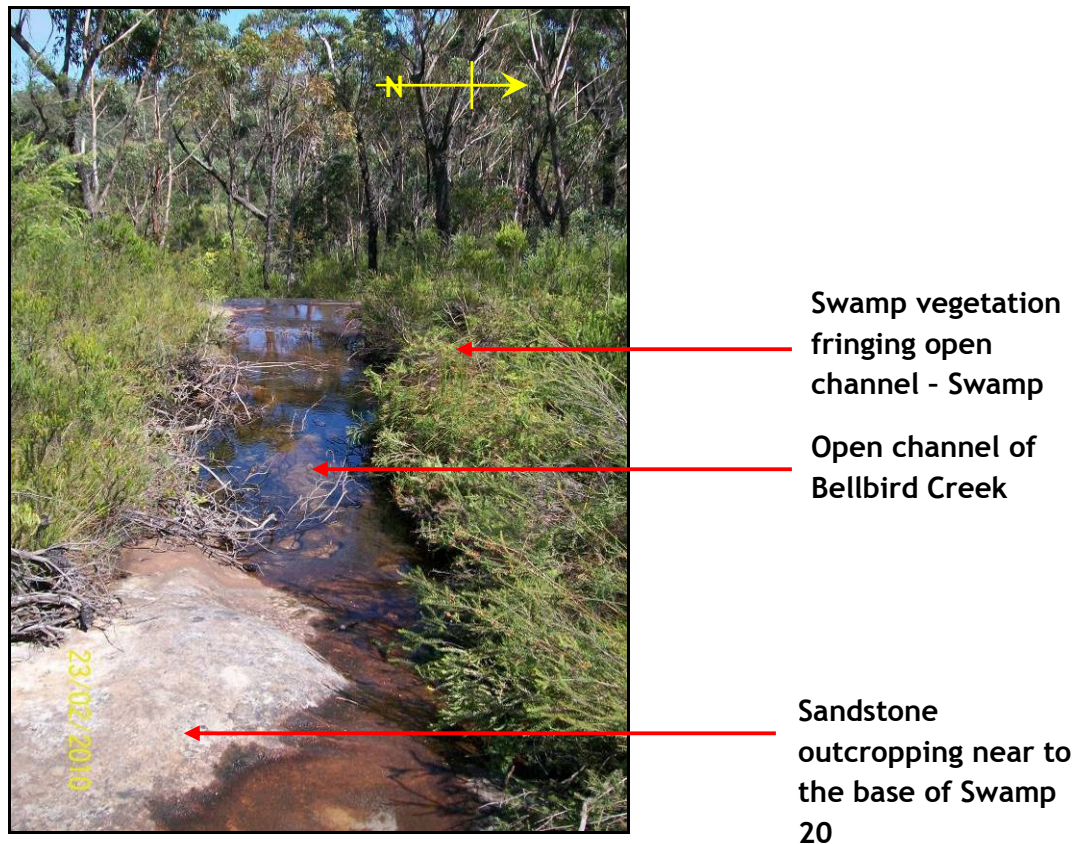
Geomorphic impacts which may arise from subsidence include ponding and flooding or scouring which may result from altered stream gradients. Ponding may occur if creek gradients are decreased. Scouring may occur if creek gradients are increased thereby increasing stream velocity and flooding may occur where the creek bed is raised relative to the creek bank in areas retaining standing water.

#### *Predicted Impacts*

MSEC (2008) did not identify the potential for altered ponding, flooding or scouring as being likely to result specifically from Longwall 12, though the following general predictions for geomorphic impact are noted:

The maximum predicted cumulative changes in grade along the creeks and tributaries, due to the proposed extraction of the Longwalls and Pillar Extraction Area are an order of magnitude smaller than the natural gradients within the SMP Area. It is unlikely therefore, that any additional ponding, flooding or scouring would occur along the creeks and tributaries resulting from the extraction of the proposed longwalls or pillar extraction areas

**Plate 3: The open channel of Bellbird Creek within Swamp 20**



MSEC (2008) does however acknowledge the naturally uneven nature of creek beds and drainage lines which cause them to occur as a series of cascading steps throughout their extent. It was therefore considered that some very minor changes in ponding may occur in some areas along creeks and tributaries but these changes would be very small.

### ***Observed Impacts***

Creeks and drainage lines within the limit of subsidence associated with Longwall 12 were observed during site inspections by Biosis Research, GeoTerra, Niche Environment and Heritage and personnel from Gujarat NRE.

There have been no observed impacts from altered flooding, scouring or ponding in any of the creek or drainage lines associated with Longwall 12.

## **6.2.2 Mining Induced Fractures**

The potential for mining induced fracturing within the base of creeks and drainage lines within the broader SMP Area is described in detail in MSEC (2008). A summary of the potential for mining induced fracturing is provided below.

### ***Potential Impacts***

It was considered possible that tensile cracking could have occurred in the bed of Native Dog Creek and Wongawilli Creek. It was also considered possible that buckling and fracturing of the bedrock along Native Dog Creek, Bellbird Creek, Wongawilli Creek and the Tributaries to Wongawilli Creek, above and adjacent to the proposed longwalls could occur.

Based on the observed impacts along Wongawilli Creek and Native Dog Creek after the extraction of the Elouera Longwalls and observed impacts at other Southern Coalfield Collieries, the fracturing and dilation of strata resulting from the compressive strains due to valley closure movements have generally not occurred more than 250 m from extracted longwall goaf areas.

If fracturing were to occur where the bedrock was exposed along the creeks and tributaries, there may be some diversion of surface water into the dilated strata beneath the beds, and the draining of any pools that might exist within the alignments. However, it is also likely that any tensile cracking which occurs in the alluvial beds of the creeks and tributary would be filled with the alluvial materials during subsequent flow events.

### ***Observed Impacts***

Native Dog and Wongawilli Creek are well beyond 250 m from the extracted longwall goaf area for Longwall 12 and have not been considered further in this EOP. Other creeks and drainage lines within the limit of subsidence associated with Longwall 12 were inspected by Biosis Research, GeoTerra, Niche Environment and Heritage and personnel from Gujarat NRE.

There have been no observed impacts from cracking or fractures as a result of mining Longwall 12. Such impacts would be expected in the form of sandstone buckling and or fractures, loss of surface water flows, drained pools and desiccated riparian vegetation or in-stream vegetation. **Plate 3** shows the open section of Bellbird Creek within Swamp 20 which does not indicate any loss of surface water.

## **6.2.3 Strata Gas Release and Iron Staining**

It is known that the mining of coal results in the fracturing of the strata above the coal seam and this may result in the liberation of methane and other gases from the sandstone strata. Emissions of strata gas have occurred within the Nepean, Cataract and Georges Rivers, and some gas emissions have also been observed in other smaller creek lines and water bores. Analyses of gas compositions indicate that the coal seams were not the direct and major source of the gas and that the most likely source is the Hawkesbury Sandstone.

Iron staining has been reported elsewhere in the Southern Coal fields. Iron staining typically occurs where subsidence induces springs develop, typically in creek beds

or on creek margins. Iron staining is typified by red precipitates entering and staining creek beds and in standing and/or moving waters. No natural springs are known from the SMP Area.

#### ***Predicted Impacts***

The gas reservoir potential and gas content in the rock strata and the geological conditions within the SMP Area are considered to be significantly different from that experienced elsewhere in the Southern Coalfields where gas emissions have been observed. There have been no reported occurrences of gas emissions at the surface above the previously extracted longwalls at NRE Wongawilli Colliery (Elouera Longwalls). On this basis, it was considered unlikely that significant gas emissions would occur within the SMP Area as a result of the proposed extraction of Longwall 11-19 and pillar extraction area PE1. Further, given the nature of the gas and the small period of transmission through the water column if indeed it did occur within the SMP Area, any gas emissions were considered unlikely to have any impact on water quality.

Iron staining was not predicted to occur within the SMP Area.

#### ***Observed Impacts***

No gas emissions have been observed in any creek or drainage line within the limit of subsidence of Longwall 12.

No iron staining was observed within the limit of subsidence of Longwall 12.

### **6.2.4 Water Quality**

In relation to mining water quality may be affected in a number of ways. It is possible that minerals may leach from fractured strata in the upper reaches of the creeks and tributaries, particularly where the predicted compressive strains due to valley closure movements are the greatest. Such impacts, however, tend to be localised and associated with low or no flow conditions.

In times of low water flows in the creeks and tributaries, there may be a localised reduction in water quality and possibly some discolouration, but only a very small quantity of water would be impacted, relative to the total quantity in the catchment. In times of heavy rainfall, the majority of the water in the creeks and tributaries would run over the surface rocks and would not be adversely affected.

#### ***Predicted Impacts***

Wood (2008b) described the possible water quality impacts in the SMP Area as follows:

Local fracturing of rock bars has the effect of local dissolution of fresh mineral surfaces in fractures and bedding plane disruption zones. Dissolution of marcasites

is postulated with the effect of increasing sulphate, iron, manganese and trace elements such as aluminium, zinc and nickel. This process is associated with a local lowering of pH. Local enhanced flow of shallow groundwater into the surface water system has the effect of increasing conductivity, iron and trace elements. This effect may be significant under low flow conditions.

GeoTerra (**Attachment D**) further narrowed the potential impacts of Longwall 12 on surface water quality to include increased iron hydroxide precipitation in stream water and lowering of pH in stream water.

### ***Observed Impacts***

There have been no measured impacts to surface water quality as a result of the extraction of Longwall 12.

## **6.3 Groundwater**

### **6.3.1 Groundwater Levels**

Wood (2008a) describes the known groundwater conditions in relation to the SMP Area in detail. That report details the expected impacts of subsidence on groundwater levels, water quality, seeps and springs, the interaction of groundwater and creeks and Upland Swamps and the potential for groundwater inflows into the goaf. These issues are discussed below.

Two groundwater monitoring boreholes (P20 - located 150m north of Longwall 12 and PWW1 located 600m east of Longwall 12 - See Drawing 1 in **Attachment D**) have been used to infer groundwater level changes associated with the extraction of Longwall 12. These groundwater monitoring boreholes have been installed specifically to monitor groundwater conditions for mining subsequent to Longwall 12 (i.e. Longwall 11 and beyond) and as such were installed immediately after extraction of Longwall 12 commenced. These two boreholes do however provide useful data by which to infer groundwater activity as affected by Longwall 12.

Groundwater monitoring has been conducted since September 2009 in P20 and November 2009 in the multi level piezometer PWW1 as shown in **Table 6.1**, with the monitoring locations shown in Drawing 1 in **Attachment D**. Several other groundwater monitoring boreholes are also shown in that figure which will be used to collect baseline data and infer impacts of extraction of coal from Longwalls 11, 15, 16, 19 and Pillar Extraction Area - PE1.

The multi level vibrating wire piezometer (PWW1) was installed by Gujarat NRE with intakes in the Hawkesbury Sandstone at 90m and 135m below surface, the Bald Hill Claystone at 150m and Bulgo Sandstone at 165m below surface.

P20 was installed by Gujarat NRE in the Quaternary alluvium to 0.85m below surface.

**Table 6.1: Groundwater Monitoring Piezometer Sites**

Groundwater Monitoring Sites		
	Commenced	Lithology
<b>MULTI LEVEL PIEZOMETER (PWW1)</b>		
90m	19.11.09	Hawkesbury Sandstone
135m	19.11.09	Hawkesbury Sandstone
150m	19.11.09	Bald Hill Claystone
165m	19.11.09	Bulgo Sandstone
<b>SWAMP PIEZOMETER P20</b>		
	18.09.09	Swamp Alluvium
<b>Surface Water Monitoring Sites</b>		
<b>BELLBIRD CK</b>		
SWAMP 20	19.07.05	Swamp Alluvium

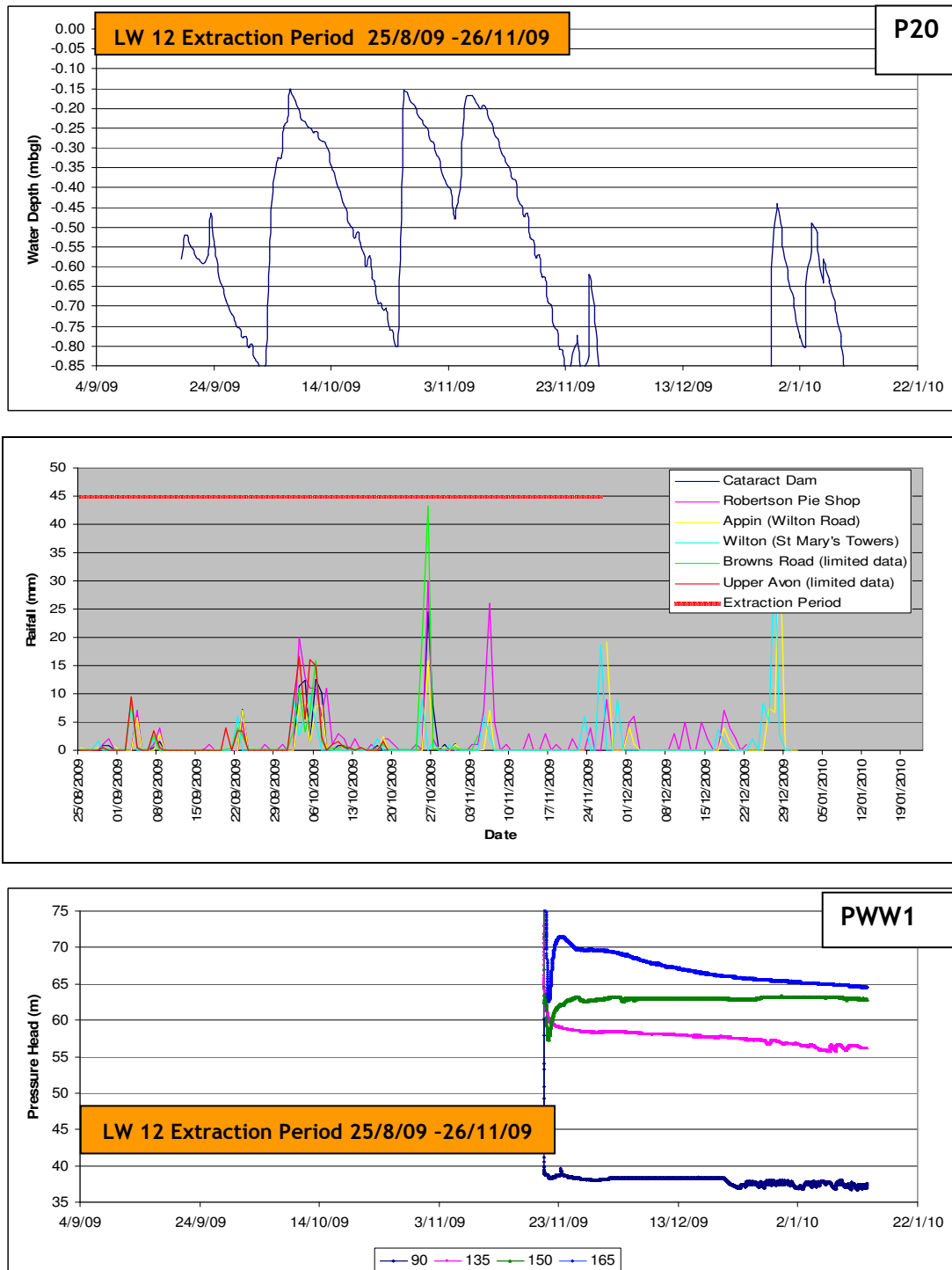
#### ***Predicted Impacts - Groundwater Levels***

Some local impacts on the shallow strata hydraulic potential were predicted. The magnitude of these impacts was considered to be dependent on the degree of interaction of surface subsidence related effects with pre-existing extraction. Local enhancements of horizontal permeability are expected. Recharge mechanisms were considered unlikely to be significantly altered by extraction of the proposed longwall blocks.

GeoTerra (**Attachment D**) describes the potential impacts of extraction of Longwall 12 on groundwater levels as:

- ☐ Temporary lowering of the deep piezometric surface over the subsidence area due to horizontal dilation of strata and resultant increase in secondary porosity
- ☐ Hawkesbury Sandstone groundwater levels may reduce by up to 10m, and may stay at that reduced level until maximum subsidence develops at a specific location
- ☐ No significant change in swamp piezometric levels due to subsidence outside of the effects of the current climatic variability
- ☐ Hawkesbury Sandstone groundwater levels should recover over a few months as the newly developed secondary porosity is recharged by rainfall
- ☐ No permanent post mining reduction in Hawkesbury Sandstone groundwater levels unless a new outflow path develops.

**Diagram 1: P20 and PWW1 Groundwater Levels and Rainfall Records for the Corresponding Period<sup>1</sup>**



<sup>1</sup> Source: Bureau of Meteorology - online rainfall data for rainfall stations 68001, 68016, 68200 and 68224. Gujarat NRE supplied data for Browns Road and Upper Nepean

### ***Observed Impacts - Groundwater Levels***

No groundwater monitoring boreholes are situated directly above Longwall 12. A series of existing groundwater monitoring boreholes associated with the earlier BHP Billiton and Delta Colliery workings are located too far from Longwall 12 to provide any meaningful data on the effect of Longwall 12 on groundwater levels.

Groundwater levels monitored in PWW1 and the Swamp 20 piezometer (P20) are shown in **Diagram 1<sup>2</sup>**.

Water levels in the perched Quaternary sedimentary aquifer at Swamp 20 were dominantly affected by the frequency and quantum of rainfall that occurred during the monitoring period and the water levels in the piezometer have a direct relationship with the amount of rainfall recharge that infiltrates in the 85cm deep swamp at P20 (see **Diagram 1**).

The lack of plotted groundwater levels in P20 during December is due to the piezometer being dry in that period.

The gradually reducing water level in the upper Hawkesbury Sandstone (90mbgl) and the Bald Hill Claystone (150mbgl) are due to the piezometric head “settling in” following installation of the piezometers in November 2009, and is not due to mining subsidence induced depressurisation.

Within the limitations of the data, no mining induced groundwater depressurisation was observed due to extraction of Longwall 12 in any of the monitored piezometers between the Swamp 20 alluvium and the upper Bulgo Sandstone.

### **6.3.2 Groundwater Quality**

#### ***Predicted Impacts - Groundwater Quality***

GeoTerra (**Attachment D**) states that predicted possible impacts to groundwater quality would be limited to the following:

- ☐ Increased iron and manganese hydroxide precipitation in groundwater extracted from piezometers
- ☐ Lowering of pH in piezometer water.

#### ***Observed Impacts - Groundwater Quality***

Groundwater sampling and laboratory analyses in P20 indicates that Swamp 20 exceeds the ANZECC 2000 Upland Streams water quality for total nitrogen, total

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<sup>2</sup> Source: Bureau of Meteorology - online rainfall data for rainfall stations 68001, 68016, 68200 and 68224. Gujarat NRE supplied data for Browns Road and Upper Nepean.

phosphorous, copper, lead, zinc and nickel when the alluvium is saturated. As the perched aquifer runs dry after extended dry periods, there isn't a continual body of water in the piezometer to sample and monitor, so the data plot can have significant gaps.

During and following extraction of Longwall 12, the field water quality in P20 has not changed markedly due to subsidence, although variations in response to the quantum and duration of rainfall recharge in the perched aquifer were observed.

The water quality from the Hawkesbury Sandstone between 23m and 53m below surface is within ANZECC 2000 Freshwater Stream guidelines. No ongoing water quality measurements are available in PWW1 as the bore has been sealed, with vibrating wire piezometers permanently installed in the bore. As the bore is sealed, no ongoing water quality monitoring is available from the bore.

Field groundwater quality monitoring for the Swamp 20 piezometer P20 and Bellbird Creek which drains from Swamp 20 is shown in Figure 3 of **Attachment D**, with laboratory analyses for P20 and PWW1 shown in Appendix A of that attachment.

### **6.3.3 Potential Inflow to Mine Workings**

Wood (2008a) states that BHPB Wongawilli, Nebo, Kemira, Elouera and Dendrobium mines have reported significant increased inflow subsequent to significant rain events. Water chemistry, Tritium, and algal studies have failed to identify direct linkages from the surface water system to the mine water system.

#### ***Potential Impacts - Groundwater inflow into mine workings***

GeoTerra (**Attachment D**) states that there will be no observable increase of mine workings groundwater inflow as a result of extraction of Longwall 12.

#### ***Observed Impacts - Groundwater inflow into mine workings***

GeoTerra (**Attachment D**) reports that there has been no increased inflow into the NRE Wongawilli Colliery workings following the extraction of Longwall 12.

NRE Wongawilli Colliery mine water is discharged from a licensed discharge point (LDP2 under EPL 1087) at one of the former Elouera Colliery portals within the Wongawilli pit top site. This discharge point services the entire Wongawilli and Elouera workings and as such any change in groundwater inflow resulting from the extraction of Longwall 12 is likely to contribute only a very small component of the overall discharge volume.

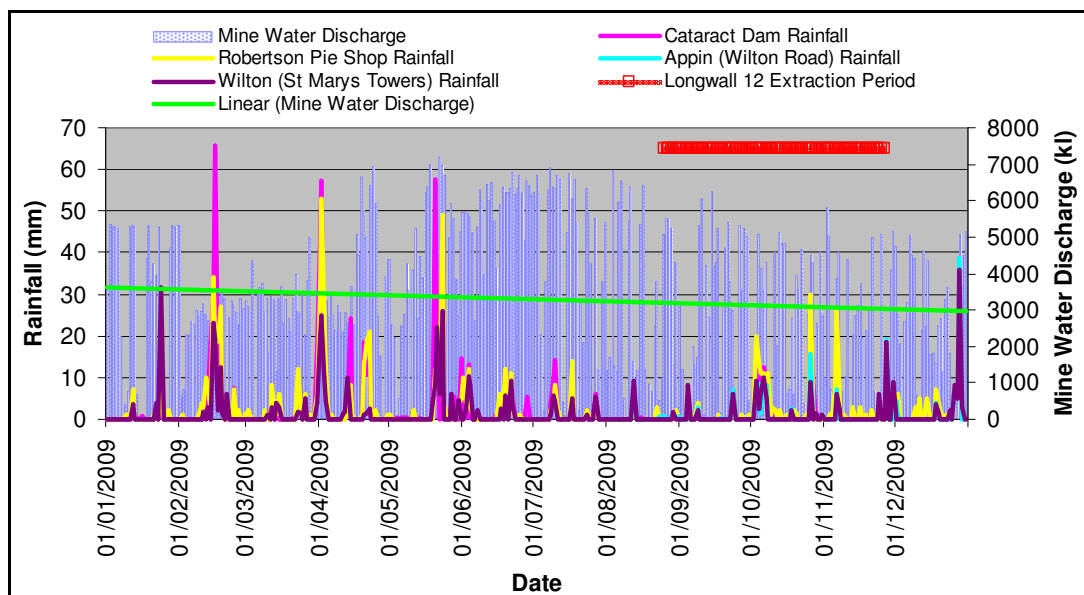
As noted by Wood (2008a) there appears to be some correlation between groundwater inflow into mine workings following rainfall events. Mine water discharge for the combined Elouera and Wongawilli workings for 2009 is shown in

**Diagram 2** below. Also shown in the diagram is rainfall for the region from the same period<sup>3</sup>. The period of extraction of Longwall 12 is also shown.

As can be seen from **Diagram 2** average mine water discharge from the mine workings decreased steadily over the year. There is no noticeable change in the mine water discharge volumes during the period of extraction of Longwall 12, in fact mine water discharge during and after the extraction period continued to decrease from the peak discharge volumes observed in June and July of 2009.

Further, there does not appear to be any direct link to rainfall and mine water discharge volumes for NRE Wongawilli Colliery. High rainfall events in mid February and early April do not appear to be represented in the mine water discharge volumes for the corresponding periods and it is unclear from the data if the rainfall events in late May and at other times throughout the year are represented in the same data. This data needs to be viewed with some caution however as the rainfall data has been sourced from four rainfall monitoring stations that are outside of catchments in which the Elouera and Wongawilli workings occur. They are however located in close proximity to and in various directions surrounding the SMP Area and are likely to provide a very good indication of rainfall events within the SMP Area for the corresponding periods.

**Diagram 2: Mine Water Discharge and Rainfall for NRE Wongawilli Colliery in 2009**



<sup>3</sup> Source: Bureau of Meteorology - online rainfall data for rainfall stations 68001, 68016, 68200 and 68224.

## 6.4 Aquatic Ecology

Biosis Research (Biosis 2008c) assessed the aquatic habitat of the Wongawilli SMP Area and potential for that habitat to provide suitable values for threatened aquatic species in August 2008. Aquatic habitats within the limits of subsidence of Longwall 12 were again inspected by Biosis Research in January 2010 following the completion of extraction. The results of the Biosis Research End of Panel assessment for aquatic ecological values are provided in **Attachment E**.

### 6.4.1 Predicted Impacts on Aquatic Ecology

Aquatic habitats in the vicinity of Longwall 12 included Flying Fox No. 1 Creek (approximately 170 m to the southeast), Bellbird Creek (approximately 200 m to the west) and an unnamed tributary of Wongawilli Creek (approximately 500 m to the north). There are also several small ephemeral drainage lines that are associated with Upland Swamps that are located above and adjacent to Longwall 12. These creeks and drainage lines and the potential for Longwall 12 to impact them are described in **Section 6.2**.

Habitat for three Endangered aquatic species, Macquarie Perch (*Macquaria australasica*), Adam's Emerald Dragonfly (*Archaeophya adamsi*) and Sydney Hawk Dragonfly (*Austrocordulia leonardi*) was identified in the broad vicinity of the approved SMP Area (Biosis Research 2008c). Assessments of Significance concluded that the proposal was unlikely to have a significant impact on a local population of any of these species.

In relation to Longwall 12, there is no habitat for any threatened aquatic species within the limit of subsidence of this Longwall. The extraction of Longwall 12 was not predicted to impact any threatened aquatic species. Further, Longwall 12 was not predicted to have any impact on aquatic habitats.

### 6.4.2 Observed Impacts on Aquatic Ecology

There is no habitat for any threatened aquatic species in the vicinity of Longwall 12. Field investigations have not observed any impacts to creeks or drainage lines as a result of the extraction of Longwall 12.

There has been no observed impact on aquatic ecological values within the limit of subsidence of Longwall 12.

## 6.5 Terrestrial Ecology

Biosis Research (Biosis 2008a) assessed the terrestrial ecological values of the Wongawilli SMP Area and potential for those values to provide suitable habitat for threatened aquatic species during several survey campaigns. Surveys were

undertaken initially in the area in June 2006 as part of the assessment for Delta Colliery Longwalls. Further surveys were undertaken in August 2008 and additional targeted surveys for threatened frog species were undertaken in September 2008 and March 2009.

Terrestrial ecological values within the limits of Subsidence of Longwall 12 were again inspected by Biosis Research in January 2010 following the completion of extraction. The results of the Biosis Research End of Panel assessment for terrestrial ecological values are provided in **Attachment E**.

### **6.5.1 Predicted Impacts on Terrestrial Ecology**

Habitat for terrestrial flora and fauna includes creeks, drainage lines, dams, cliffs, pagodas, rock outcrops and steep slopes. The predicted and observed impacts of Longwall 12 on these values have been described elsewhere in this EOP and have not been repeated here other than to say Longwall 12 was not predicted to significantly affect any of these habitat types.

#### ***Native Vegetation***

Six vegetation communities have been recorded within the Wongawilli SMP Area. Two of those communities, Exposed Sandstone Scribbly-Gum Woodland (ESSW) and an Upland Swamp (referred to as Swamp 20), occur within the limit of subsidence of Longwall 12 and were considered by Biosis Research in the terrestrial ecology EOP report (**Attachment E**).

In the instance where rock outcrops, cliffs or steep slopes may be impacted by subsidence, vegetation such as ESSW may be affected by the physical movement of the ground surface which may lead to soil instability and possibly a limited number of tree falls. Such impacts were not considered likely due to the extraction of Longwall 12 as described in **Section 6.1** of this report.

Differential subsidence movements may result in changes in the groundwater levels within the swamps. Consequently, the distribution of various swamp vegetation subunits has the potential to be altered by subsidence.

#### ***Threatened Flora Species***

Large populations of *Pultenaea aristata* (Prickly-bush Pea), listed as Vulnerable on both the TSC and EPBC Acts, were recorded within and associated with Upland Swamps within the Wongawilli SMP Area (Biosis Research 2008a). Further threatened plant species are considered to have potential habitat in the Study Area including *Acacia bynoeana*, *Acacia baueri* ssp. *aspera*, *Cryptostylis hunteriana*, *Leucopogon exolasius*, *Melaleuca deanei*, *Persoonia acerosa*, *Persoonia hirsuta* and *Persoonia bargoensis*.

Biosis Research concluded that Longwall mining was unlikely to have a significant impact on any threatened flora with known or potential habitat in the Wongawilli SMP Area.

#### ***Fauna Habitat and Threatened Fauna***

Three broad fauna habitat types were recorded during the pre-mining survey: creeks and drainage lines, Upland Swamps, and ridgelines. All of these key habitats were assessed to be in a good condition.

The Giant Burrowing Frog (*Heleioporus australiacus*) and Littlejohn's Tree Frog (*Litoria littlejohni*) were recorded during pre-mining surveys (Biosis Research 2008b). Another six threatened species were previously recorded in the Study Area. Additionally, potential habitat was identified for a further 29 threatened or migratory species in the Study Area. Sixteen of these species were determined have habitat which may be impacted by subsidence.

Section 6.1 and Section 6.2 outline the potential impact of mining on surface waters and landscape features which may provide important fauna habitat within the limit of subsidence of Longwall 12. These predictions have not been repeated here.

Assessments of Significance, as required under the TSC and EPBC Acts, were prepared for these species (Biosis Research 2008a). These assessments initially concluded that the proposal was likely to have a significant impact on a local population of Littlejohn's Tree Frog, Giant Burrowing Frog and Red-crowned Toadlet. A subsequent report (Biosis Research 2009) revised these assessments on the basis of further detailed surveys and detailed investigations of the precise subsidence predictions for important habitat features for these species. Consequently, impact assessments carried out on the three threatened frog species concluded that there was unlikely to be a significant impact on a local population on any of these species.

#### **6.5.2 Observed Impacts on Terrestrial Ecology**

The following section describes observations of terrestrial ecological values made during the post mining surveys.

##### ***Native Vegetation***

Random meanders were carried out in the terrestrial native plant communities in the Study Area. No impacts such as water stress or dieback were observed in the Exposed Sandstone Scribbly-Gum Woodland (ESSW) that occurs within the limit of subsidence of Longwall 12. The ESSW in Study Area was in good condition.

Biosis Research (**Attachment E**) noted two recently fallen trees directly above Longwall 12. That report states that it is not possible to ascertain if those tree

falls are a result of subsidence. During a field inspection by personnel from Niche Environment and Heritage and Gujarat NRE these tree falls were inspected in some detail.

Both fallen trees were observed to have rotten root systems and both were situated in very shallow (<5cm deep) sandy soils overlying extensive sandstone platforms (see Plate 4, **Plate 5** and Plate 6). In their vertical position, the mature trees were perched in shallow soils with their root systems spread over sandstone shelves with little depth of soil cover. Upon inspection of a broader area, it was clear that similar tree falls were scattered along the sandstone platforms. From the variation in the extent of decay of the fallen trees, it was evident that tree falls in the area have been common for a period of time well in excess of the mining extraction period of Longwall 12.

Compression ridges in the soil (which would be expected if subsidence resulted in compressive strains) or tensile cracking in the sandstone platforms on which the trees were situated (as per **Plate 2**) were **not** observed anywhere above Longwall 12, and were **not** present in the vicinity of the tree falls.

The two tree falls noted by Biosis Research are therefore not considered to be related to Longwall 12.

Upland Swamp vegetation of Swamp 20 at the western end of Longwall 12 and adjacent areas was inspected by Biosis Research, GeoTerra, Niche Environment and Heritage and Gujarat NRE personnel. No impacts as a result of longwall mining were observed in the current surveys within this plant community. The Upland Swamp vegetation over Longwall 12 and adjoining areas of Swamp 20 was in a good condition.

### ***Threatened Flora Species***

One small patch of the threatened plant species *Pultenaea aristata* (Prickly-bush Pea) was recorded on the southern edge of Longwall 12 in the current surveys (see Figure 3 in **Attachment E**). The species has been recorded in Swamp 20 to the north of Longwall 12 and other nearby locations. The plants observed in the current surveys were reported to be in a healthy condition. Similarly, the ESSW and Upland Swamp provides potential habitat for the species within the Study Area was also reported to be in good condition.

In addition to *Pultenaea aristata* (Prickly-bush Pea), potential habitat for other threatened plant species assessed during the SMP process is unlikely to have been affected by the mining of Longwall 12.

There is no evidence to suggest that threatened plant species occurring within the limit of subsidence of Longwall 12 have been affected by subsidence related impacts.

**Plate 4: Tree Fall - Tree 1 above Longwall 12**



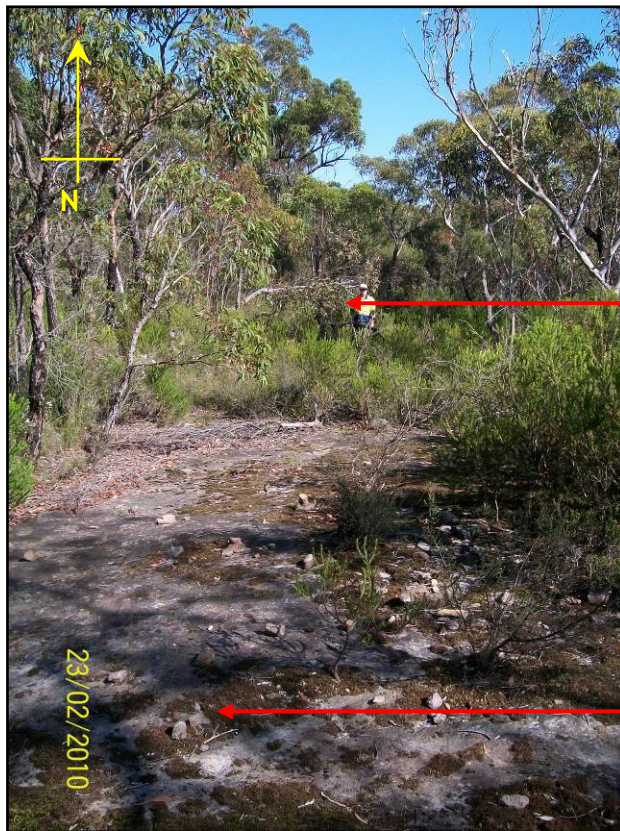
Rotten root systems in shallow sandy soils

**Plate 5: Tree Fall - Tree 2 above Longwall 12**



Sandstone platform immediately below the fallen tree

**Plate 6: Sandstone platform on which the fallen tree - Tree 1 is located**



**Tree One - fallen in the background**

**Sandstone platform - continuous to the base of the fallen - Tree One. No tensile cracking or any other evidence of subsidence was observed on this platform**

### ***Fauna Habitat and Threatened Fauna***

During the post-mining inspection for Longwall 12, all fauna habitats were assessed as being in a similar condition to that before mining. Microhabitat features such as tree-hollows, hollow logs, rock outcrops, dense understorey, drainage lines and soaks were all widely abundant within the Study Area.

Several temporary pools and soaks were observed within the ephemeral drainage lines. These areas contained sufficient resources to provide breeding and foraging habitat for threatened amphibian species, despite there being no recent rainfall activity immediately prior to the survey. In addition, there were no apparent signs of base cracking observed within these pools.

No subsidence related impacts on rock outcrops and crevices were observed during the post mining inspection. These areas provide good quality potential habitat for the threatened Broad-headed Snake (*Hoplocephalus bungaroides*), Red-crowned Toadlet and Rosenberg's Goanna (*Varanus rosenbergi*). Consequently, it is unlikely that these species have been impacted by the mining of Longwall 12.

There was no evidence of any impacts on fauna habitats within the ESSW or Upland Swamp. ESSW provides microhabitats such as leaf litter, undergrowth, various canopy layers, hollow-bearing trees and fallen timber, which provide shelter,

breeding and foraging resources for wide range of birds, mammals and reptiles. Unidentified bandicoot (*Perameles/Isodon* sp) diggings were observed within this habitat in the post mining assessment. As these species require a high degree of structural habitat complexity, their presence is indicative that such features have been maintained.

Threatened animal species with potential habitat in the limit of subsidence of Longwall 12 are unlikely to have been affected by its extraction. Native vegetation and the habitat it provides remains in the same condition to that prior to longwall mining.

### 6.5.3 Conclusion

Vegetation communities, fauna habitats, threatened species, populations and ecological communities are not considered to have been affected by subsidence related impacts associated with the mining of Longwall 12.

Observational as well systematic ecological monitoring in this area will continue and any notable changes to the natural environment will be referred to specialist consultants for further consideration. Unless major changes are noted, no further monitoring is considered necessary in relation to Longwall 12.

## 6.6 Summary of Impacts to Natural Features

A comparison of the predicted and observed impacts on the natural features within the limit of subsidence of Longwall 12

**Table 6.2: Summary of Predicted and Observed Impacts on Natural Features Resulting from Wongawilli Longwall 12**

Natural Feature	Predicted Impacts	Observed Impacts
Steep Slopes and Rock Outcrops	Minor slippage of soils down the steep slopes, resulting in the development of minor cracking in soils at top of the slopes and minor compression ridges forming at the bottom of the slopes	There have been no observed impacts on steep slopes or minor outcrops associated with Longwall 12
	Large scale slope failure was considered unlikely	No slope failure was observed
	The steep slopes not located directly above the longwall goaf, which is the case for the two areas of steep slopes in the vicinity of Longwall 12, were not predicted to experience any significant systematic subsidence movements	No significant systematic subsidence movements were observed

Natural Feature	Predicted Impacts	Observed Impacts
Flying Fox and Bellbird Creeks and Ephemeral Drainage Lines (water flow and quality)	Ponding, flooding and scouring considered unlikely to occur	There have been no observed impacts from altered flooding, scouring or ponding in any of the creek or drainage lines associated with Longwall 12
	Possible tensile cracking in the bed of Native Dog Creek and Wongawilli Creek	Native Dog and Wongawilli Creeks are outside the limit of subsidence of Longwall 12 and will be considered in subsequent EOP reports
	Possible buckling and fracturing of the bedrock along Native Dog Creek, Bellbird Creek, Wongawilli Creek and the Tributaries to Wongawilli Creek, above and adjacent to the proposed longwalls	No buckling or fracturing was observed in the bed of Bellbird Creek or any other creek or drainage line within the limit of subsidence of Longwall 12
	Possible diversion of surface water into dilated strata and the draining of pools	No flow diversion or drained pools observed
	Gas emission could occur but significant emissions considered unlikely	No gas emissions observed
	Iron staining not predicted to occur	No iron staining observed in any creek or drainage line
	Water Quality: Lowering of pH in stream water due to iron staining (precipitate)	Within the limits of the data, no observed changes in surface water quality
Groundwater (within the limitations of the data identified in Attachment D)	Adverse interconnection of aquifers and aquitards is not anticipated within 20m of the surface	No adverse interconnection between aquifers and aquitards has been observed within 20m of the surface
	Potential increased rate of recharge into the plateau	No increased rate of recharge has been observed
	Temporary lowering of piezometric surface by up to 10m which may stay at that level until maximum subsidence develops	No lowering of piezometric surface has been observed
	Groundwater levels should recover over a few months	No lowering of piezometric surface has been observed
	No permanent post mining reduction in water levels in bores on the plateau unless a new outflow path develops	No lowering of piezometric surface has been observed
	Strata dilation and subsequent re-filling of secondary voids may temporarily	No lowering of piezometric surface has

Natural Feature	Predicted Impacts	Observed Impacts
	lower standing water levels	been observed
	Piezometers may experience increased iron / manganese hydroxide precipitation and / or lowering of pH	No piezometers have been affected by subsidence related effects
	Interface drainage, ferruginous, brackish seeps may be generated in streams	No interface drainage, ferruginous, brackish seeps have been generated in streams
	Increased groundwater seepage inflow into the workings should not occur	No increased rate of groundwater seepage into the workings has been detected
	Shallow groundwater level within Swamp 20 will be dependent on rainfall recharge and will not be affected by mining	Although no pre-mining data is available the depth of the shallow groundwater within Swamp 20 is driven by rainfall recharge
	Strata gas discharge into piezometers may occur	No strata gas discharge has been observed
	Stream flow in Bellbird Creek may be adversely affected by subsidence from Longwall 12	Stream flow in Bellbird Creek has not been adversely affected by subsidence related to Longwall 12
	Stream water quality in Bellbird Creek may be adversely affected by subsidence from Longwall 12	Stream water quality in Bellbird Creek has not been adversely affected by subsidence related to Longwall 12
	Stream bed and bank stability in Bellbird Creek may be adversely affected by subsidence from Longwall 12	Stream bed and bank stability in Bellbird Creek has not been adversely affected by subsidence related to Longwall 12
<b>Aquatic Ecology</b>	There is no habitat for any threatened species within the limit of subsidence of this Longwall. The extraction of Longwall 12 was not predicted to impact any threatened aquatic species. Further, Longwall 12 was not predicted to have any impact on aquatic habitats	There has been no observed impact on aquatic ecological values within the limit of subsidence of Longwall 12
<b>Terrestrial Ecology</b>	No impact to woodland vegetation	No impacts observed
	Potential changes in the groundwater levels within the swamp (Swamp 20) may lead to an altered distribution of swamp vegetation subunits	No vegetation change observed. No die-off or desiccation observed
	Unlikely to have a significant impact on any threatened flora with known or	No impact observed

Natural Feature	<u>Predicted Impacts</u>	<u>Observed Impacts</u>
	potential habitat in the Wongawilli SMP Area	
	Unlikely to have a significant impact on a local population on any of threatened fauna or their habitats	No impact observed

## 7 LONGWALL 12 MONITORING PROGRAM

A monitoring program for the Wongawilli SMP Area is outlined in the ESSMP. Not all of the commitments within the ESSMP are applicable to Longwall 12

**Table 7.1** and **Table 7.2** outline the monitoring commitments in the ESSMP for man made and natural features respectively. The monitoring program includes surface water level and quality monitoring, groundwater monitoring, steep slopes, cliffs, rock outcrops, flora and fauna, aquatic ecological values, indigenous heritage, fire roads and 4WD tracks, the Maldon - Dombarton Rail Corridor, transmission lines and survey points.

The monitoring undertaken to date in relation to the ESSMP in relation to Longwall 12 is shown below. All monitoring results have either been reported in the various expert reports in the attachments or will be reported in the Annual Environmental Management Report (AEMR) for NRE Wongawilli Colliery.

**Table 7.1: Monitoring Program for NRE Wongawilli Longwall 12 - Man Made Features**

ESSMP Commitments	Prior to Mining	During Mining	Post Mining and Future Monitoring
<b>Subsidence lines E&amp;EE and EF</b>	2D Survey once prior to mining (completed)	During mining - only if regular inspections identify greater than predicted impacts (not required)	Post mining 2D survey of E&EE and EF lines (completed) Future Monitoring: Monitoring consistent with commitment at the completion of each longwall
<b>330kv Transmission Line (Tower 37-6)</b>	Observation of tower condition and survey measurement for later comparison (not required – tower well beyond limit of subsidence of LW 12 as advised by TransGrid)	None required	Monitoring will be undertaken prior to, during and after extraction of LW's 15, 16, 19 and PE1. NB. TransGrid will undertake monitoring responsibilities as per App 2 of ESSMP
<b>Fire Roads and 4WD Tracks</b>	Observation of road condition once prior to mining and reported in SMP (completed)	Fortnightly observation of roads, tracks and area within 200m of roads/tracks (incomplete)	monthly observation of roads, tracks and area within 200m of roads/tracks for 6 months post mining (ongoing)
<b>Indigenous Heritage</b>	Record significant heritage items once prior to mining (completed) NB:	Section 5.3 identifies two sites requiring consideration in the EOP – Upper Avon 2 and Upper Avon 3. The	Post mining inspection is not necessary (completed anyway) These sites will be monitored

ESSMP Commitments	Prior to Mining	During Mining	Post Mining and Future Monitoring
		approved CHMP* for the Wongawilli SMP states that monitoring for these sites is not required for LW 12 (not required)	for future longwall mining – specifically LW 11

\*a Cultural Heritage Management Plan has been prepared for the Wongawilli SMP Area and has been included in **Attachment G**. The CHMP describes the monitoring requirements for all cultural heritage sites within the Wongawilli SMP Area.

**Table 7.2: Monitoring Program for Wongawilli Longwall 12 - Natural Features**

ESSMP Commitments	Prior to Mining	During Mining	Post Mining and Future Monitoring
<b>Cliffs, Steep Slopes and Rock Outcrops</b>	Observation and documentation of cliff and steep slope condition including CL 19-02, CL 19-03, CL 19-04 and CL 19-05 – (Once prior to mining )  (not necessary – these features are not located within the limit of subsidence of LW 12)	Monthly observations of CL 19-04 and CL 19-05 (not required)	Monthly observations of CL 19-04 and CL 19-05 – for 6 Months  (not required)
<b>Stream Water Quality and Flow<sup>4</sup></b>	Monthly for at least two months prior to mining	Weekly during active undermining of stream	Bi-monthly for one year after subsidence ceases
<u>Field Analysis</u> EC, pH, temp	(partially completed but not required as Swamp 20 site not directly undermined)	(not required – Swamp 20 site not directly undermined)	(not required – Swamp 20 site not directly undermined)
<u>Laboratory Analysis</u> 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, Ba, Cs, Rb, Sr (filtered)	Monthly for at least two months prior to mining  (partially completed but not required as Swamp 20 site not directly undermined)	Bi-monthly during active undermining of stream  (not required – Swamp 20 site not directly undermined)	Every four months for one year until subsidence ceases  (not required – Swamp 20 site not directly undermined)
Observable iron or salinity staining	Monthly for at least two months prior to mining	Weekly during active undermining of stream	Bi-monthly for one year after subsidence ceases

<sup>4</sup> The ESSMP identifies 5 sites that are required to be included in the surface water quality monitoring program (Swamp 20 [Bell Bird Creek site], DAQ10, DAQ20, DAQ30 and DAQ40). Only the Swamp 20 site requires consideration in relation to Longwall 12.

ESSMP Commitments	Prior to Mining	During Mining	Post Mining and Future Monitoring
	(partially completed but not required as Swamp 20 site not directly undermined)	(not required – Swamp 20 site not directly undermined)	(not required – Swamp 20 site not directly undermined)
Photo points	Monthly for at least two months prior to mining  (partially completed but not required as Swamp 20 site not directly undermined)	Weekly during active undermining of stream  (not required – Swamp 20 site not directly undermined)	Bi-monthly for one year after subsidence ceases  (not required – Swamp 20 site not directly undermined)
Water flow in creek	Monthly for at least two months prior to mining  (partially completed but not required as Swamp 20 site not directly undermined)	Weekly during active undermining of stream  (not required – Swamp 20 site not directly undermined)	Bi-monthly for one year after subsidence ceases  (not required – Swamp 20 site not directly undermined)
Areas of increased flooding	Monthly for at least two months prior to mining  (partially completed but not required as Swamp 20 site not directly undermined)	Weekly during active undermining of stream  (not required – Swamp 20 site not directly undermined)	Bi-monthly for one year after subsidence ceases  (not required – Swamp 20 site not directly undermined)
Erosion of stream bank	Monthly for at least two months prior to mining  (partially completed but not required as Swamp 20 site not directly undermined)	Weekly during active undermining of stream  (not required – Swamp 20 site not directly undermined)	Bi-monthly for one year after subsidence ceases  (not required – Swamp 20 site not directly undermined)
<b>Groundwater – Hawkesbury Sandstone</b> in four bores eventually but only PWW1 for LW 12  Water Quality 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, Ba, Cs, Rb, Sr (filtered)	Field water quality – bi monthly  (not completed – delayed installation of boreholes)  Laboratory analysis – every four months  (not completed – delayed installation of boreholes)	Field water quality –monthly during extraction  (Partially completed)  Laboratory analysis – every two months  (partially completed)	Field water quality – bi monthly  (partially completed, monitoring pre-mining and during mining for LW 11 will complete this data set))  Laboratory analysis – every four months  (partially completed)
Resistivity Survey (Swamp 11)	Completed (data provided previously to DECCW)	N/A	as required

ESSMP Commitments	Prior to Mining	During Mining	Post Mining and Future Monitoring
Water Level	Minimum 12 hourly intervals (not completed)	Minimum 12 hourly intervals (partially completed)	Minimum 12 hourly intervals (ongoing)
Groundwater – <b>Upland Swamps</b>  In 5 swamps eventually but only Swamp 20 for LW 12)  Water Quality  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, Ba, Cs, Rb, Sr (filtered)	Field water quality – bi monthly  (not completed – delayed installation of boreholes)    Laboratory analysis – every six months  (not completed – delayed installation of boreholes)	Field water quality –monthly during extraction  (Partially completed)    Laboratory analysis – every two months  (partially completed)	Field water quality – bi monthly  (partially completed, monitoring pre-mining and during mining for LW 11 will complete this data set))       Laboratory analysis – every six months  (partially completed)
Water Level	1 hourly intervals (partially completed)	1 hourly intervals (partially completed)	1 hourly intervals (partially completed, monitoring pre-mining and during mining for LW 11 will complete this data set))
<b>Inflow into mine workings (during all active mining)</b>	Daily monitoring of mine discharge  (completed)  Water quality sample of any measured inflow event  (not required)	Daily monitoring of mine discharge  (completed)  Water quality sample of any measured inflow event  (not required)	Daily monitoring of mine discharge  (ongoing)  Water quality sample of any measured inflow event  (as required)
<b>Aquatic Ecology</b>	Observational monitoring for presence/absence of aquatic habitat during water quality monitoring regime  (completed)  Targeted surveys for threatened aquatic biota in major drainage lines  (completed)	Observational monitoring for presence/absence of aquatic habitat during water quality monitoring regime  (completed)  None	Observational monitoring for presence/absence of aquatic habitat during water quality monitoring regime  (ongoing)  AUSRIVAS sampling of reference and impact sites in the broader SMP Area  (as required)
<b>Terrestrial Ecology</b>	Observational monitoring of	Observational monitoring of	Observational monitoring of

ESSMP Commitments	Prior to Mining	During Mining	Post Mining and Future Monitoring
Threatened species	identified threatened species – once (completed)	identified threatened species – twice annually during entire extraction (ongoing)	identified threatened species – annually for one year (ongoing)
Amphibians	Once prior to mining (completed)	Twice annually during entire extraction period (ongoing)	Annually for one year (ongoing)
Swamp and riparian vegetation	Once prior to mining (completed)	Twice annually during entire extraction period (ongoing)	Annually for one year (ongoing)
General Upland Swamp observations (swamp and drainage depressions – presence/absence of standing water; subsidence fractures; changes in flora/fauna)	Twice per year (completed)	Every second month (partially completed)	Twice per year for one year post mining (ongoing)
Ridge top vegetation	Once prior to mining (completed)	Twice annually during entire extraction period (ongoing)	Annually for one year (ongoing)

## 8 MANAGEMENT OF IMPACTS AND REMEDIATION

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Monitoring of man made and natural features within the SMP Area has not identified any impacts to these values as a result of the extraction of Longwall 12. Longwall 11 has commenced extraction and the monitoring program outlined in **Table 7.1** and **Table 7.2** will continue and be expanded to include the area coincident with the limit of subsidence of Longwall 11.

Neither the SCA, who manage the Metropolitan Water Catchment, nor TransGrid the owner and operator of the 330kv transmission line, which is located to the east of the SMP Area, have reported any environmental impacts related to Longwall 12.

No infrastructural or environmental remediation is required as a result of Longwall 12.

### 8.1 Trigger Action Response Plan

The Trigger Action Response Plan for NRE Wongawilli Colliery Longwalls 11 - 19 and Pillar Extraction Area 1, especially in relation to Longwall 12 are summarised in Table 8.1.

**Table 8.1: TARPs for NRE Wongawilli Colliery Longwall 12 Including the Effects of Longwall 12 and Subsequent Actions**

Monitoring	Trigger	Response	LW12 Effects	Action as a Result of Longwall 12
<b>Subsidence lines E&amp;EE and EF (Pre and post mining)</b>	<input type="checkbox"/> Major surface cracking (>10mm)	<input type="checkbox"/> Notify Principal Subsidence Engineer - I&I NSW; <input type="checkbox"/> Undertake subsidence survey and review against predictions; <input type="checkbox"/> Review mining options	<input type="checkbox"/> No cracking observed or reported	<input type="checkbox"/> None required
<b>330kv Transmission Line (Tower 37-6) (Visual inspections during mining and survey measurement post mining)</b>	<input type="checkbox"/> Observation of unsafe tower conditions as noted by Trasgrid (the owner and operator of the transmission line( who are responsible for observational monitoring	<input type="checkbox"/> Report condition to TransGrid and Mine Subsidence Board <input type="checkbox"/> TransGrid to undertake remediation as necessary	<input type="checkbox"/> No observed or reported effects	<input type="checkbox"/> None required
<b>Fire Roads and 4WD Tracks (Fortnightly visual inspection)</b>	<input type="checkbox"/> Minor cracking on roads and tracks (<10mm)  <input type="checkbox"/> Major cracking (>10mm) or traffic impedance	<input type="checkbox"/> Notification to SCA within 24 hrs, using photographic record  <input type="checkbox"/> Notification to SCA immediately, then to I&I NSW and MSB <input type="checkbox"/> Make area safe as soon as practicable including warning signs <input type="checkbox"/> Proposal for rectification within 1 week upon approval from SCA <input type="checkbox"/> Completion of works following approval from SCA <input type="checkbox"/> Additional daily monitoring	<input type="checkbox"/> No observed or reported effects  <input type="checkbox"/> None observed or reported	<input type="checkbox"/> None required  <input type="checkbox"/> None required
<b>Indigenous Heritage Sites (Inspect once prior to, during and</b>	<input type="checkbox"/> Observation of unstable conditions (in the case of overhangs) or	<input type="checkbox"/> Implement the Cultural Heritage Management Plan (CHMP)	<input type="checkbox"/> None observed or reported	<input type="checkbox"/> None required

Monitoring	Trigger	Response	LW12 Effects	Action as a Result of Longwall 12
post mining)	damage	<input type="checkbox"/> Report impacts as required <input type="checkbox"/> Notify DECCW, I&I NSW, SCA <input type="checkbox"/> Review and undertake remediation options as appropriate		
<b>Cliffs, Steep Slopes and Rock Outcrops</b> (Monthly)	<input type="checkbox"/> Minor cracking on roads and tracks (<10mm)	<input type="checkbox"/> Notification to SCA and I&I NSW within 24 hrs, using photographic record <input type="checkbox"/> Warning sign/s erection <input type="checkbox"/> Reported in AEMR	<input type="checkbox"/> None observed or reported	<input type="checkbox"/> None required
	<input type="checkbox"/> Major cracking (>10mm) or traffic impedence	<input type="checkbox"/> Notification to SCA immediately then I&I NSW <input type="checkbox"/> Make area safe immediately including erection of warning sign/s and barrier fencing <input type="checkbox"/> Reported in AEMR <input type="checkbox"/> Review mining options	<input type="checkbox"/> None observed or reported	<input type="checkbox"/> None required
	<input type="checkbox"/> Major cliff collapse or steep slope movement	<input type="checkbox"/> Notification to SCA immediately then I&I NSW <input type="checkbox"/> Make area safe immediately including warning sign/s erection and barrier fencing <input type="checkbox"/> Proposal for rectification within 1 week <input type="checkbox"/> Completion of works following approval from SCA <input type="checkbox"/> Additional monitoring <input type="checkbox"/> Reported in AEMR	<input type="checkbox"/> None observed or reported	<input type="checkbox"/> None required

Monitoring	Trigger	Response	LW12 Effects	Action as a Result of Longwall 12
Stream Water Quality and Flow (various monitoring periods)	<input type="checkbox"/> Observable increase from baseline in iron hydroxide precipitation (e.g. orange staining in water or on banks/bed) from comparison with pre-mining monitoring and photographs <input type="checkbox"/> Based on the baseline monitoring conducted since July 2005 the following triggers will be used: <input type="checkbox"/> EC > 200uS/cm <input type="checkbox"/> 4.2 > pH > 6.77 <input type="checkbox"/> Fe (Tot) > 6mg/L <input type="checkbox"/> Mn (tot) > 0.1mg/L <input type="checkbox"/> Al (tot) > 0.7mg/L <input type="checkbox"/> Zn (filt) > 0.04mg/L <input type="checkbox"/> SO4 (filt) > 8mg/L <input type="checkbox"/> Dissolved oxygen / ORP / temperature	<input type="checkbox"/> Repeat water quality sampling and initiate laboratory water quality sampling on a monthly basis <input type="checkbox"/> Contract hydrologist investigate and report on changes identified <input type="checkbox"/> Inform SCA, DECCW & I&I NSW of results of investigation <input type="checkbox"/> Prepare and implement a site mitigation/action plan in consultation with key agencies and in accordance with Section 54 of the Water Management Act <input type="checkbox"/> Report in the End of Panel Report	<input type="checkbox"/> Monitoring data incomplete <input type="checkbox"/> No observed water quality impacts	<input type="checkbox"/> None required
	<input type="checkbox"/> Observation of loss of flow connectivity within a flowing ephemeral stream (related to rainfall), compared to the flow regimes evident prior to the extraction of LW's 11-19	<input type="checkbox"/> Repeat water quality sampling and initiate laboratory water quality sampling on a monthly basis <input type="checkbox"/> Contract hydrologist investigate and report on changes identified <input type="checkbox"/> Inform SCA, DECCW & I&I NSW of results of investigation <input type="checkbox"/> Prepare and implement a site mitigation/action plan in consultation with key agencies and in accordance with Section 54	<input type="checkbox"/> Monitoring data incomplete <input type="checkbox"/> No observed water quality impacts	<input type="checkbox"/> None required

Monitoring	Trigger	Response	LW12 Effects	Action as a Result of Longwall 12
		of the Water Management Act <input type="checkbox"/> Report in the End of Panel Report		
	<input type="checkbox"/> Observation of areas of flooded stream in excess of baseline conditions – identified by extended flooding within a terrestrial habitat and from comparison of pre-mining and post-mining photographs	<input type="checkbox"/> Survey area to identify whether earthworks are required <input type="checkbox"/> Contract hydrologist investigate and report on changes identified <input type="checkbox"/> Inform SCA / DECCW of results of investigation <input type="checkbox"/> Prepare and implement a site mitigation/action plan in consultation with key agencies and in accordance with Section 54 of the Water Management Act if required <input type="checkbox"/> Report in the End of Panel Report	<input type="checkbox"/> No observed flooding	<input type="checkbox"/> None required
	<input type="checkbox"/> Observation of erosion of stream bed and banks in excess of baseline conditions identified from comparison of pre-mining and post-mining photographs	<input type="checkbox"/> Contract hydrologist investigate and report on changes identified <input type="checkbox"/> Inform SCA, DECCW & I&I NSW of results of investigation <input type="checkbox"/> Prepare and implement a site mitigation/action plan in consultation with key agencies and in accordance with Section 54 of the Water Management Act <input type="checkbox"/> Report in the End of Panel Report	<input type="checkbox"/> No observed erosion of stream bed and banks	<input type="checkbox"/> None required
<b>Groundwater – Hawkesbury Sandstone (water quality and water levels)</b>	<input type="checkbox"/> <b>Ground Water Quality</b> <input type="checkbox"/> 2 std deviation change, or distinctive diversion over at least 4 months from baseline levels for	<input type="checkbox"/> Investigation initiated within one week of trigger <input type="checkbox"/> Repeat water quality sampling of impacted and adjacent bores if	<input type="checkbox"/> Monitoring data incomplete <input type="checkbox"/> No observed ground water quality impacts	<input type="checkbox"/> None required

Monitoring	Trigger	Response	LW12 Effects	Action as a Result of Longwall 12
	pH, EC, Fe, Mn, Al, Zn and SO <sub>4</sub>	<p>triggers exceeded, as required</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> If trigger is exceeded for at least 4 months, engage hydrogeologist to investigate and report on any identified adverse changes to water level / water quality</li> <li><input type="checkbox"/> Inform SCA, DECCW &amp; I&amp;I NSW of investigation outcomes</li> <li><input type="checkbox"/> Investigation of possible mitigation measures in consultation with SCA / DECCW</li> <li><input type="checkbox"/> Prepare and implement a site mitigation/action plan in consultation with SCA / DECCW if appropriate</li> <li><input type="checkbox"/> Report in SMP / End of Panel reports to inform relevant agencies of results of monitoring</li> </ul>		
	<ul style="list-style-type: none"> <li><input type="checkbox"/> <b>Ground Water Levels</b></li> <li><input type="checkbox"/> Continuous &gt;5m water level reduction over a minimum 2 month period</li> </ul>	<ul style="list-style-type: none"> <li><input type="checkbox"/> Instigate investigation within 1 week of trigger</li> <li><input type="checkbox"/> Engage hydrogeologist to investigate and report on the cause of trigger exceedances where the cause may not be directly related to lack of rainfall recharge</li> <li><input type="checkbox"/> Inform SCA, DECCW &amp; I&amp;I NSW of investigation outcomes</li> <li><input type="checkbox"/> Investigation of possible mitigation measures in consultation with SCA / DECCW</li> </ul>	<ul style="list-style-type: none"> <li><input type="checkbox"/> Monitoring data incomplete</li> <li><input type="checkbox"/> No observed ground water level impacts</li> </ul>	<ul style="list-style-type: none"> <li><input type="checkbox"/> None required</li> </ul>

Monitoring	Trigger	Response	LW12 Effects	Action as a Result of Longwall 12
		<input type="checkbox"/> Prepare and implement a site mitigation/action plan in consultation with SCA / DECCW if necessary <input type="checkbox"/> Report in End of Panel reports ongoing to inform relevant agencies of results of monitoring		
Inflow into mine workings (during all active mining) (daily monitoring)	<input type="checkbox"/> Increase in water discharge of > 1ML/day for 7 successive days from active longwall or pillar extraction areas, which are suspected to be as a result of mine subsidence <input type="checkbox"/> Note: the typical discharge from U/G is 6ML/day	<input type="checkbox"/> Engage contract hydrogeologist to investigate and report on changes identified <input type="checkbox"/> Inform relevant agencies of results of investigation <input type="checkbox"/> Report in Subsidence Management Status Report <input type="checkbox"/> Report in End of Panel Report <input type="checkbox"/> Investigation initiated within one week of trigger <input type="checkbox"/> Monthly updates of investigation process	<input type="checkbox"/> No increase in mine water discharge recorded	<input type="checkbox"/> None required
	<input type="checkbox"/> Inflow event from mining area requiring notification to the mining inspectorate	<input type="checkbox"/> Engage contract hydrogeologist to investigate and report on changes identified <input type="checkbox"/> Inform SCA, DECCW & IIN of investigation outcomes <input type="checkbox"/> Report in Subsidence Management Status Report <input type="checkbox"/> Report in End of Panel Report <input type="checkbox"/> Investigation initiated within one week of trigger	<input type="checkbox"/> No increase in mine water discharge recorded	<input type="checkbox"/> None required

Monitoring	Trigger	Response	LW12 Effects	Action as a Result of Longwall 12
		<input type="checkbox"/> Monthly updates of investigation process		
	<input type="checkbox"/> Water Chemistry or age indicates connectivity to the surface <input type="checkbox"/> NB: this trigger must be derived from a hydrogeologist's investigation report	<input type="checkbox"/> Inform SCA, DECCW & IIN of this change <input type="checkbox"/> Commence preparation of mitigation/action plan within the timeframe agreed with relevant government agencies <input type="checkbox"/> Inform SCA, DECCW & IIN within 24hrs <input type="checkbox"/> Commence preparation of mitigation/action plan within timeframe agreed with relevant agencies <input type="checkbox"/> Monthly updates of investigation progress <input type="checkbox"/> Report in Subsidence Management Status Report <input type="checkbox"/> Report in the End of Panel Report	<input type="checkbox"/> No increase in mine water discharge recorded	<input type="checkbox"/> None required
<b>Aquatic Ecology</b>	<input type="checkbox"/> None anticipated insofar as aquatic biota are concerned. Water flow and quality triggers would appropriate a response for aquatic biota	<input type="checkbox"/> None anticipated	<input type="checkbox"/> No impact to aquatic habitats observed	<input type="checkbox"/> None required
<b>Terrestrial Ecology</b> (twice a year)	<input type="checkbox"/> Observation of mining related impacts to surface	<input type="checkbox"/> Notification to SCA/NPWS within 24 hrs, using photographic record	<input type="checkbox"/> No effects reported to date	<input type="checkbox"/> None required
	<input type="checkbox"/> Major impacts to threatened	<input type="checkbox"/> Notification to SCA/NPWS	<input type="checkbox"/> No effects reported to date	<input type="checkbox"/> None required

Monitoring	Trigger	Response	LW12 Effects	Action as a Result of Longwall 12
	species to include: <input type="checkbox"/> Their habitat; and/or a decline in numbers from baseline observed; and/or <input type="checkbox"/> Change in species composition	immediately <input type="checkbox"/> Proposal for threatened species management within 1 week <input type="checkbox"/> Completion of management task following approval from SCA/NPWS <input type="checkbox"/> Additional monitoring as required by the relevant government agencies		
General Upland Swamp observations (every second month during mining)	<input type="checkbox"/> Minor cracking (<10mm)	<input type="checkbox"/> Report to SCA <input type="checkbox"/> Additional studies as required <input type="checkbox"/> Photographic record <input type="checkbox"/> Review of swamp piezometer data	<input type="checkbox"/> No effects noted in Upland Swamps (Swamp 20) to date	<input type="checkbox"/> None required
	<input type="checkbox"/> Major cracking (>10mm) <input type="checkbox"/> Water loss <input type="checkbox"/> Flora/Fauna changes <input type="checkbox"/> Increased erosion	<input type="checkbox"/> Notification to SCA <input type="checkbox"/> Remediation options developed in consultation with SCA, which may include further mining limitations <input type="checkbox"/> Proposal for rectification within one month <input type="checkbox"/> Completion of works following approval from SCA <input type="checkbox"/> Additional monitoring as required	<input type="checkbox"/> No effects noted in Upland Swamps (Swamp 20) to date	<input type="checkbox"/> None required
Public Safety (fortnightly during extraction)	<input type="checkbox"/> Minor cracking (<10mm)	<input type="checkbox"/> Notification to SCA within 24 hrs, using photographic record	<input type="checkbox"/> No effects recorded or reported to date	<input type="checkbox"/> None required
	<input type="checkbox"/> Major Cracking (>10mm), noticeable instability or traffic impedance	<input type="checkbox"/> Notification to SCA immediately <input type="checkbox"/> Make area safe as soon as	<input type="checkbox"/> No effects recorded or reported to date	<input type="checkbox"/> None required

Monitoring	Trigger	Response	LW12 Effects	Action as a Result of Longwall 12
		<p>practicable</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Proposal for rectification within 1 week</li> <li><input type="checkbox"/> Completion of works following approval from SCA</li> <li><input type="checkbox"/> Additional monitoring</li> </ul>		

## 9 CONCLUSION

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The extraction of coal from NRE Wongawilli Colliery Longwall 12 has not resulted in impacts of concern to any natural or man made feature. No remediation has been required.

NRE Wongawilli Colliery Longwall 11 has commenced extraction. Monitoring of natural or man made features in accordance with the NRE Wongawilli Colliery Environment, Subsidence and Safety Management Plan (ESSMP) in relation to Longwall 12 will continue throughout the life of Longwall 11.

# FIGURES

**Figure 1: Longwall 11, 12, 15, 16, 19, PE1 and PE2 (Source - MSEC443-01)**

**Figure 2: Observed Profiles of Incremental Subsidence, Tilt and Strain Along the E&EE -Line During the Extraction of Longwall 12 (Source MSEC Figure A.02)**

**Figure 3: Observed and Predicted Profiles of Incremental Subsidence, Tilt and Strain Along the EF-Line During the Extraction of Longwall 12 (Source MSEC Figure A.03)**

# ATTACHMENTS

## ATTACHMENT A

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### SMP and ESSMP Approval:

# Subsidence Management Plan Approval

I, the Director-General, Department of Primary Industries, having considered the likely environmental impacts of the mining operations identified in the Project Description specified in Schedule 1 and having had regard to the principles of ecologically sustainable development as defined in the *Protection of the Environment Administration Act 1991*, hereby approve the Subsidence Management Plan identified in Schedule 1 for the purposes of the SMP Condition that became effective on 18 March 2004 in Mining Lease No.1596, subject to the conditions set out in Schedule 2.

This Approval only authorises the underground mining operations identified in the Project Description for the Period and Area identified in Schedule 1. Obligations under this Approval regarding rehabilitation, monitoring and impact management continue to apply after the expiry of this period unless otherwise notified in writing by the Director-General.

These conditions are required to:

- ensure optimal mineral resource recovery;
- prevent, minimise, manage and/or offset adverse impacts;
- provide for the ongoing environmental management of the project;
- ensure the area disturbed by mining is appropriately rehabilitated.

The rights and duties of a Leaseholder are those prescribed by the *Mining Act 1992*, subject to the terms and conditions of the Lease which include a requirement to carry out operations in accordance with the Subsidence Management Plan conditionally approved by this Approval. This Subsidence Management Plan Approval does not override any obligation on the Leaseholder to comply with the requirements of other legislation and regulatory instruments unless specifically provided in the Mining Act or other legislation or regulatory instruments.

**Note:** This Approval does not constitute an approval under Section 138 Coal Mines Regulation Act 1982 or clause 88 of the Coal Mines Health and Safety Regulation 2006.

SIGNED



Lindsay Gilligan  
A/Executive Director, Mineral Resources  
Under delegation for the Director - General

Date of Approval: 16.7.09

File No: 05/2682

## SCHEDULE 1

### Description of Approved Activity

<b>Project Description:</b>	Longwalls 11, 12,15,16,19 & Pillar Extraction Area 1
<b>Subsidence Management Plan:</b>	NRE WONGAWILLI COLLIERY Subsidence Management Plan Application LW 11, 12,15,16,19 & Pillar Extraction Area 1, and any supplementary supporting information provided to the Department.
<b>Seam:</b>	Wongawilli Seam.
<b>Approved Period of Mining:</b>	Date of Approval to 1 July 2012, or the expiry/cancellation of Mining Lease 1596 whichever occurs first.

## SCHEDULE 2

### Definitions

Activity	The proposed longwall mining described in the SMP
Application Area	The area identified within the SMP.
Bore	Any bore or well connected or proposed to be connected with sources of sub-surface water, and used or proposed to be used or capable of being used to obtain supplies of such water
Council	Wollongong City Council
DECC	Department of Environment and Climate Change
Department	Department of Primary Industries
Director General	Director General of the Department of Primary Industries, or delegate
Inspector of Coal Mines	Inspector of Coal Mines with DPI
DWE	Department of Water and Energy
DoP	Department of Planning
Environment	includes all aspects of the surroundings of humans, whether affecting any human as an individual or in his or her social groupings
Leaseholder	The leaseholder of ML1596
Longwall mining	The extraction of the longwall panels covered by the SMP
MSB	Mine Subsidence Board
Negligible	small and unimportant, such as to be not worth considering
Principal Subsidence Engineer	Principal Subsidence Engineer with DPI
PSMP	Property Subsidence Management Plan
SCA	Sydney Catchment Authority
SMP	Subsidence Management Plan, titled NRE WONGAWILLI COLLIERY Subsidence Management Plan Application LW 11, 12,15,16,19 & Pillar Extraction Area 1 dated December 2008 and supplementary supporting information provided to the Department
SMP Approved Plan	Plan No. WON-01-0020 Rev 0 titled 'SMP Application-Approved Plan Longwalls 11, 12, 15, 16, 19 & Pillar Extraction Area 1, signed by the Mine Manager on 9 February 2009 and approved by the Director General, NSW Department of Primary Industries
Subsidence Impacts	Direct or indirect impacts resulting from subsidence from longwall mining
Subsidence	Movement and/or deformation of the ground surface or subsurface strata as a direct and/or indirect result of longwall mining

### Conditions

#### Limits on Approval

- 1 The Leaseholder must carry out the activity strictly in accordance with SMP Approved Plan.
- 2 The Leaseholder must carry out the activity generally in accordance with the SMP; and subject to the conditions of this Approval.  
  
In the event of any inconsistency between the conditions of this Approval and the SMP, the conditions of this Approval prevail to the extent of any inconsistency.
- 3 Where this Approval requires actions to be undertaken by the Leaseholder, including remediation of subsidence impacts, the obligation continues until the Director General notifies the Leaseholder that the action has been completed to his or her satisfaction.
- 4 The Director General may vary the conditions of this Approval by notice in writing.
- 5 The Director General may, at his or her discretion, suspend or revoke this Approval if:
  - a) the Leaseholder fails to adhere to any condition of the Approval; or
  - b) the head of any other government authority requests suspension or revocation on the basis of the Leaseholder's non-compliance, or potential non-compliance, with legislation administered by that agency related to this Approval.

## General Obligation to Minimise Harm to the Environment

- 6 The Leaseholder must implement the SMP (as amended by the conditions of this Approval) and carry out any additional practicable measures necessary to prevent and/or minimise any harm to the environment that may result from the construction, operation, or rehabilitation of the activity.

## Notification of Approval

- 7 The Proponent must give notice of this SMP approval within 30 days to the Council, the local Aboriginal Land Council/s, the owners/operators of any infrastructure, and landowners in the application area and any relevant government agencies or stakeholders that the Director General's approval of the SMP has been granted.

***Note:** Relevant government authorities and stakeholders are listed in the Guideline for Application for Subsidence Management Approvals.*

## Implementation of Approval

- 8 Any plans, programmes, reports or strategies required as a condition of this Approval must be developed having regard to any guidelines adopted by the Director General for the purpose of subsidence management and mine rehabilitation.
- 9 The Leaseholder must implement any plan, programme or strategy required and approved pursuant to this Approval.

***Note:** The Leaseholder may, at any time, submit an amended plan, programme or strategy for approval. Once approved, the amended plan, programme or strategy must be implemented, however, up until the date of approval, the Leaseholder must continue to implement the previously approved plan, programme or strategy.*

- 10 Any modifications to plans, programmes or strategies already approved for the purposes of the conditions of this Approval must have regard to the matters set out in condition 8. Amended plans, programmes or strategies submitted for approval must be accompanied by all relevant supporting documentation to assist in the assessment of the amendment or modification.

***Note:** This condition relates to plans, programmes and strategies required by the conditions of this Approval – it does not apply to variations to the SMP or the SMP Approved Plan which must be done in accordance with the requirements of the Mining Act, the conditions of title and the variation procedures identified in the SMP guidelines.*

## Directions

- 11 The Leaseholder must comply with any written direction given by the Director-General, Director Environmental Sustainability, Director Mine Safety Operations or Principal Subsidence Engineer relating to:
- a) the implementation of any aspect of the SMP or an approved plan, programme or strategy;
  - b) assessing or reviewing the adequacy, effectiveness, or coverage of any approved plan, programme or strategy or any aspect of the SMP;
  - c) the type, timing and/or location of monitoring of baseline conditions, subsidence or subsidence impacts;
  - d) any reporting requirement under this Approval;
  - e) the carrying out of works to address subsidence impacts; and/or
  - f) the carrying out of any studies or investigations related to subsidence or subsidence impacts and the reporting of any findings or conclusions.

The obligations under this condition prevail over any other obligation under this Approval.

***Note:** Compliance with a written direction will not operate as a defence to a breach of any obligation under this Approval that occurred prior to the Direction being given.*

## Subsidence Monitoring

- 12 The Leaseholder must submit to the Principal Subsidence Engineer for approval a subsidence monitoring programme for the longwall panels which are the subject of this Approval. This programme must include:
- inspection regimes;
  - layout of monitoring points;
  - parameters to be measured;
  - monitoring methods and accuracy;
  - timing and frequencies of surveys and inspections;
  - recording and reporting of monitoring results.

The Leaseholder must not commence longwall mining prior to the subsidence monitoring programme being approved.

***Note:** The programme should be submitted to the Principal Subsidence Engineer at least 30 days prior to the expected commencement of operations to enable sufficient time for the assessment of the programme. The Principal Subsidence Engineer may require the provision of further information to assist in the assessment of the programme or a resubmission of the programme if it is considered inadequate. Complex issues or the need for additional information or a resubmission of the programme may require a longer assessment period.*

## Environmental Management

- 13 The Leaseholder must ensure that the impacts of extraction on the following features do not result in more than negligible environmental consequences (see definitions):
- surface water (quality and quantity) particularly Bellbird, Native Dog, Wongawilli and Flying Fox creeks;
  - groundwater (quality and quantity);
  - swamps 20, 21a, 24 and 46;
  - threatened species, populations, or ecological communities.

The leaseholder must not operate other than in accordance with an Environmental Management Plan (EMP) approved by the Director Environmental Sustainability. This plan must address subsidence impacts on i-iv above and must include:

- a detailed monitoring programme;
- trigger levels for subsidence impacts that require actions and responses;
- the procedures that would be followed in the event that the monitoring indicates an exceedance of trigger levels;
- measures to mitigate, remediate and/or compensate any identified impacts;
- a protocol for the notification of identified exceedances of the trigger levels; and
- a contingency plan.

This plan must be prepared in consultation with relevant landholders and government agencies. The Groundwater EMP must be consistent with Sydney Catchment Authority's draft guidelines titled "The design of a hydrological and hydro-geological monitoring program to assess the impact of longwall mining in SCA catchments July 2007" and the Department of Water and Energy's "Draft Guidelines for Groundwater Monitoring".

***Note:** The programme should be submitted to the Director Environmental Sustainability at least 30 days prior to the expected commencement of operations. The EMP may be submitted on a progressive basis.*



## Public Safety

- 14 The Leaseholder must prepare and implement a public safety management plan to ensure public safety in any structures, houses and surface areas that may be affected by subsidence, to the satisfaction of the Director, Mine Safety Operations. The plan must include, but not be limited to:
- a) identification of houses which are hazardous or could become hazardous due to subsidence impacts;
  - b) regular monitoring of areas or infrastructure/structures posing safety risks;
  - c) measures to prevent, mitigate and promptly remediate hazards and safety risks referred to in (a) and (b) above;
  - d) erection of warning signs;
  - e) entry restrictions;
  - f) backfilling of dangerous surface cracks;
  - g) securing of unstable built structures or rockmass where required and appropriate; and
  - h) provision of timely notification of mining progress to the community and any other relevant stakeholders where management of public safety is required.

## Incident and Ongoing Management Reporting

- 15 The Leaseholder must, within 24 hours of becoming aware of the occurrence, notify:
- i. the Principal Subsidence Engineer;
  - ii. The Mine Subsidence Board;
  - iii. The Department of Water and Energy;
  - iv. The Sydney Catchment Authority;
  - v. other relevant stakeholders and Government Agency with a regulatory role if they request such notifications, of the following:
- a) Any significant unpredicted and/or higher-than-predicted subsidence and/or abnormalities in the development of subsidence;
  - b) Any exceedance of predicted impacts on groundwater resources and/or the natural environment that may have been caused (whether partly or wholly) by subsidence;
  - c) Any observed subsidence impacts adverse to the serviceability and/or safety of infrastructure and other built structures that may be affected by longwall mining;
  - d) Any significant subsidence-induced cracking and/or ground deformations observed in any surface areas within the SMP application area

**Note:** Under Condition 11, the Leaseholder can be directed to, among other things, prepare a report on an incident reported under this condition. A report on the details of the incident, including likely or known causes, response action and proposed response measures will generally be required for incidents that involve material property or environmental damage or have the potential to cause such damage.



- 16 The Leaseholder must prepare and maintain a Subsidence Management Status Report which must include but not be limited to:
- the current face position of the longwall panel being extracted;
  - a summary of any subsidence management actions undertaken by the Leaseholder in the period subsequent to the last regular submission of the Status Report;
  - a summary of any comments, advice and feedback from consultation with stakeholders in relation to the implementation of this Approval (including the preparation, implementation and review of plans, programmes, reports or strategies required by this approval) undertaken or received in the period subsequent to the last regular submission of the Status Report and a summary of the Leaseholder's response to the comments, advice and feedback given by the stakeholders;
  - a summary of the observed and/or reported subsidence impacts, incidents, service difficulties, community complaints, and any other relevant information reported to the Leaseholder in the period subsequent to the last regular submission of the Status Report and a summary of the Leaseholder's response to these impacts, incidents, service difficulties and complaints;
  - a summary of subsidence development based on monitoring information compared with any defined triggers and/or the predicted subsidence to facilitate early detection of potential subsidence impacts;
  - a summary of the adequacy, quality and effectiveness of the implemented management processes based on the monitoring and consultation information summarised above; and
  - a statement regarding any additional and/or outstanding management actions to be undertaken or the need for early responses or emergency procedures to ensure adequate management of any potential subsidence impacts due to longwall mining.

The Subsidence Management Status Report must be updated at least every 14 days to reflect any changes in the information required to be included in the Report. The Status Report must be regularly submitted to the Principal Subsidence Engineer, the Department of Water and Energy and Sydney Catchment Authority every four (4) months from the date of this Approval. The Status Report (as updated from time to time) must be provided, upon request, to the Mine Subsidence Board, the Director of Environmental Sustainability, the Principal Subsidence Engineer of the Department of Primary Industries, owners/operators of any infrastructure within the application area and any other stakeholders.

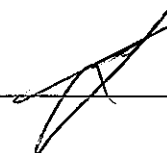
#### End of Panel Report

- 17 Within 4 months of the completion of each longwall panel, an end of panel report must be prepared to the satisfaction of the Director Environmental Sustainability. The end of panel report must:
- include a summary of the subsidence and environmental monitoring results for the applicable longwall panel;
  - include an analysis of these monitoring results against the relevant;
    - impact assessment criteria;
    - monitoring results from previous panels; and
    - predictions in the SMP;
  - identify any trends in the monitoring results over the life of the activity; and
  - describe what actions were taken to ensure adequate management of any potential subsidence impacts due to longwall mining.

#### Access to Information

- 18 Within 3 months of the submission of an End of Panel Report (as required by Condition 17) or the approval of a plan, programme or strategy required under this Approval or the SMP (or any subsequent revision of these documents), the Leaseholder must, to the satisfaction of the Director General:
- provide a copy of these document/s to all relevant agencies;
  - ensure that a copy of the relevant documents is made publicly available at the Leaseholder's regional office; and
  - put a copy of the relevant document/s on the Leaseholder's website.

**Note:** Relevant agencies currently include SCA,DSC,MSB,DECC, DWE and DoP.



### Survey Marks

- 19 At the completion of subsidence, or otherwise as required by the Department of Lands, the functionality of any survey marks affected by subsidence must be fully restored to the satisfaction of the Department of Lands.

A handwritten signature in black ink, consisting of several overlapping loops and strokes, located in the bottom right corner of the page.



File 09/4938

The Manager  
NRE Wongawilli Colliery  
PO Box 281  
FAIRY MEADOW NSW 2519

Attention: Chris Harvey

Dear Sir

**Environmental Subsidence and Safety Management Plan (ESSMP) for NRE  
Wongawilli Colliery**

Pursuant to condition 13 of the SMP approval dated 16 July 2009 I have approved the following document for the purposes of Longwall 12 only:

The "Environment, Subsidence and Safety Management Plan (ESSMP) for NRE Wongawilli Colliery LWs 11, 12, 15, 16, 19 and PEA 1" (Version Final 2a).

The plan is approved subject to the measures outlined in your letter dated 21 August 2009 being implemented. In particular, the Resistivity Survey for Swamp 20 must be undertaken in accordance with Department of Environment, Climate Change and Water (DECCW) requirements and completed within the shortest feasible timeframe.

A revised ESSMP, or equivalent, needs to be prepared for approval prior to the commencement of Longwalls 11, 15, 16, 19 and PEA 1. Consultation with other agencies and compliance with their requirements will need to be demonstrated in the revised ESSMP. Full compliance with Condition 13 of the Subsidence Management Plan approval will also need to be demonstrated.

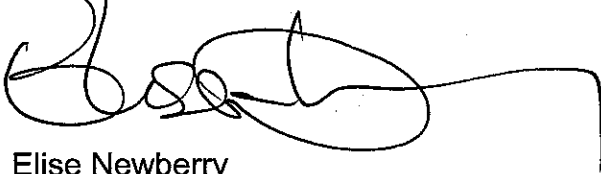
Specific deficiencies noted in the current ESSMP which require detailed consideration include:

- A lack of quantitative elements in the monitoring program
- Does not demonstrate sufficient consultation with agencies
- Does not include adequate groundwater monitoring
- Does not demonstrate sufficient baseline monitoring
- Does not have well defined trigger levels

It is recommended that you prepare a revised ESSMP after further agency consultation. Once the revised ESSMP has been prepared a meeting involving Gujarat NRE and the various agencies can be arranged to discuss any further requirements.

If you require further information with regard to this issue please contact Judith Egan on (02) 4222 8304.

Yours sincerely

A handwritten signature in black ink, appearing to read 'Elise Newberry', with a long horizontal line extending to the right.

Elise Newberry  
**Director, Environmental Sustainability Branch**  
24 August 2009

## ATTACHMENT B

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### Raw Data: Subsidence Survey Data



ORIGINAL SURVEY		
Survey Date: 20/07/2009		
PEG	R.L.	Distance
EE13	443.185	15.601
EE14	444.157	14.831
EE15	444.301	13.525
EE16	444.465	15.946
EE17	444.521	16.335
EE18	444.676	14.010
EE19	444.778	15.783
EE20	444.701	13.666
EE21	444.796	15.652
EE22	444.800	13.133
EE23	445.043	12.954
EE24	444.733	18.530
EE25	444.506	12.671
EE26	444.428	17.141
EE27	444.248	15.134
EE28	444.170	12.451
EE29	444.143	14.367
EE30	443.873	17.686
EE31	443.730	13.948
EE32	443.542	14.769
EE33	443.540	15.548
EE34	443.461	14.697
EE35	443.297	14.645
EE36	443.077	15.920
EE37	441.834	14.661
EE38	442.132	15.499

CHECK SURVEY		
Date of Survey: 10/08/2009		
PEG	Subsidence	Strain
EE13	-0.002	-0.048
EE14	0.000	0.033
EE15	0.000	-0.048
EE16	0.000	-0.059
EE17	0.000	0.071
EE18	-0.001	0.000
EE19	-0.002	-0.147
EE20	-0.001	0.190
EE21	-0.002	-0.058
EE22	-0.002	-0.054
EE23	-0.002	-0.063
EE24	-0.002	-0.116
EE25	-0.001	0.289
EE26	-0.002	-0.001
EE27	-0.002	0.083
EE28	-0.002	-0.085
EE29	-0.002	0.052
EE30	-0.002	-0.068
EE31	-0.002	-0.036
EE32	-0.002	0.092
EE33	-0.002	-0.177
EE34	-0.002	0.130
EE35	-0.002	-0.042
EE36	-0.003	-0.128
EE37	-0.003	0.177
EE38	-0.004	0.223

CHECK SURVEY END LW12		
Date of Survey: 27/11/2009		
PEG	Subsidence	Strain
EE13	-0.004	0.038
EE14	-0.006	0.010
EE15	-0.007	0.059
EE16	-0.007	0.089
EE17	-0.008	-0.042
EE18	-0.006	-0.094
EE19	-0.006	-0.013
EE20	-0.007	0.185
EE21	-0.007	-0.028
EE22	-0.005	0.019
EE23	-0.006	-0.054
EE24	-0.007	0.181
EE25	-0.005	-0.076
EE26	-0.006	-0.073
EE27	-0.007	0.071
EE28	-0.007	0.057
EE29	-0.006	0.041
EE30	-0.004	0.049
EE31	-0.006	-0.062
EE32	-0.005	0.022
EE33	-0.003	0.222
EE34	-0.005	-0.043
EE35	-0.005	0.240
EE36	-0.007	-0.103
EE37	-0.001	-0.057
EE38	-0.002	-0.283

ORIGINAL SURVEY		
Survey Date: 20/07/2009		
PEG	R.L.	Distance
EE39	441.927	14.856
EE40	441.888	15.449
EE41	441.541	15.370
EE42	441.378	14.744
EE43	441.249	15.100
EE44	441.156	15.313
EE45	441.002	15.000
EE46	440.817	14.905
EE47	440.681	14.602
EE48	440.532	16.071
EE49	440.413	13.957
EE50	440.251	14.963
EE51	440.153	14.653
EE52	439.974	15.186
EE53	439.828	14.797
EE54	439.679	14.869
EE55	439.582	15.371
EE56	439.444	14.314
EE57	439.339	14.894
EE58	439.212	14.792
EE59	439.029	14.863
EE60	438.967	15.049
EE61	438.829	14.711
EE62	438.691	14.713
EE63	438.616	15.167
EE64	438.371	15.018

CHECK SURVEY		
Date of Survey: 10/08/2009		
PEG	Subsidence	Strain
EE39	-0.004	-0.173
EE40	-0.004	0.046
EE41	-0.003	-0.187
EE42	-0.003	0.080
EE43	-0.003	-0.112
EE44	-0.003	0.215
EE45	-0.003	-0.156
EE46	-0.004	0.077
EE47	-0.003	-0.236
EE48	-0.003	0.249
EE49	-0.003	-0.192
EE50	-0.003	0.108
EE51	-0.003	0.219
EE52	-0.003	0.042
EE53	-0.003	0.100
EE54	-0.003	-0.073
EE55	-0.003	-0.207
EE56	-0.004	-0.105
EE57	-0.003	0.186
EE58	-0.004	0.056
EE59	-0.003	-0.135
EE60	-0.004	-0.206
EE61	-0.004	0.293
EE62	-0.004	0.204
EE63	-0.004	-0.112
EE64	-0.004	0.270

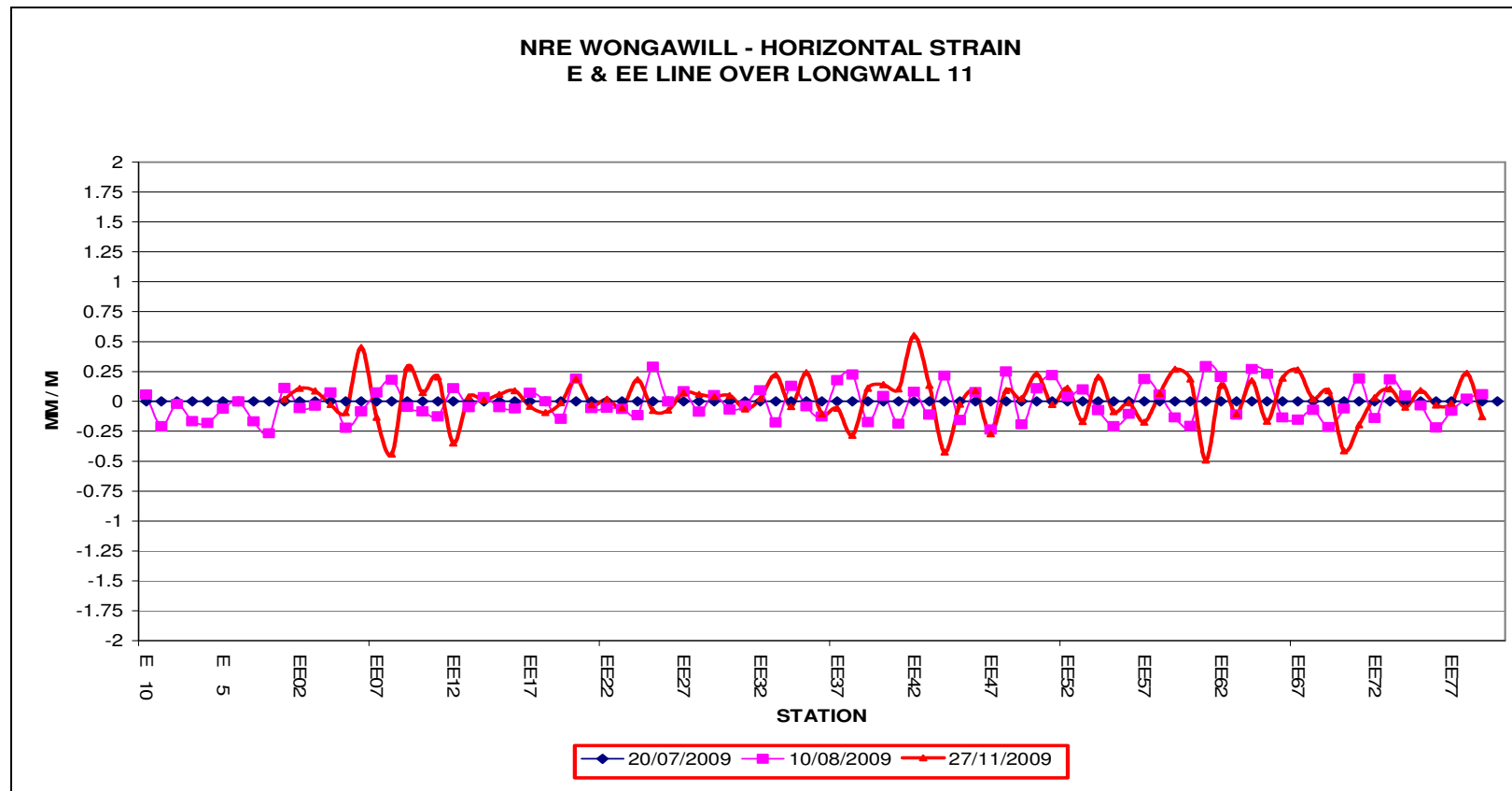
CHECK SURVEY END LW12		
Date of Survey: 27/11/2009		
PEG	Subsidence	Strain
EE39	-0.001	0.110
EE40	-0.001	0.139
EE41	-0.001	0.103
EE42	0.000	0.549
EE43	0.000	0.133
EE44	0.000	-0.424
EE45	-0.001	-0.024
EE46	0.001	0.089
EE47	0.001	-0.271
EE48	0.000	0.091
EE49	0.000	0.023
EE50	0.000	0.228
EE51	0.000	-0.027
EE52	0.001	0.112
EE53	0.002	-0.167
EE54	0.001	0.203
EE55	0.000	-0.086
EE56	0.000	-0.013
EE57	-0.001	-0.173
EE58	0.000	0.067
EE59	0.000	0.269
EE60	0.000	0.186
EE61	-0.001	-0.490
EE62	-0.001	0.135
EE63	-0.001	-0.105
EE64	-0.001	0.172

ORIGINAL SURVEY		
Survey Date: 20/07/2009		
PEG	R.L.	Distance
EE65	438.209	14.638
EE66	437.947	15.018
EE67	437.660	14.956
EE68	437.270	14.891
EE69	436.824	14.939
EE70	436.328	14.765
EE71	435.859	17.806
EE72	436.366	13.791
EE73	434.760	15.284
EE74	435.328	14.907
EE75	434.931	18.223
EE76	434.355	12.566
EE77	433.698	12.381
EE78	433.406	15.008
EE79	433.076	15.375
EE80	432.575	

CHECK SURVEY		
Date of Survey: 10/08/2009		
PEG	Subsidence	Strain
EE65	-0.004	0.230
EE66	-0.003	-0.134
EE67	-0.004	-0.153
EE68	-0.003	-0.072
EE69	-0.004	-0.215
EE70	-0.003	-0.060
EE71	-0.003	0.192
EE72	-0.002	-0.139
EE73	-0.001	0.184
EE74	-0.001	0.048
EE75	-0.001	-0.035
EE76	-0.002	-0.218
EE77	-0.002	-0.079
EE78	-0.002	0.022
EE79	-0.003	0.059
EE80	-0.002	

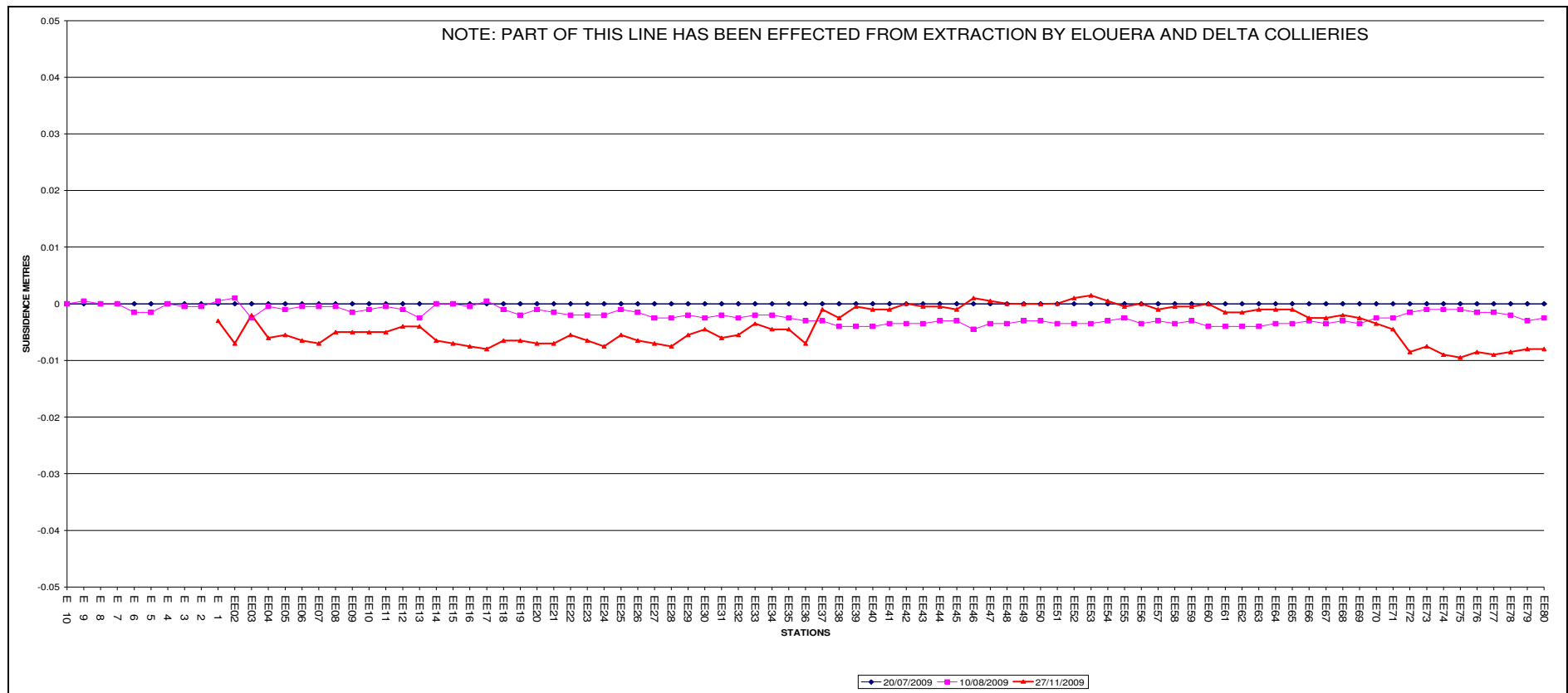
CHECK SURVEY END LW12		
Date of Survey: 27/11/2009		
PEG	Subsidence	Strain
EE65	-0.001	-0.166
EE66	-0.002	0.194
EE67	-0.002	0.263
EE68	-0.002	0.021
EE69	-0.002	0.089
EE70	-0.003	-0.414
EE71	-0.004	-0.197
EE72	-0.008	0.031
EE73	-0.007	0.104
EE74	-0.009	-0.049
EE75	-0.009	0.091
EE76	-0.008	-0.032
EE77	-0.009	-0.015
EE78	-0.008	0.235
EE79	-0.008	-0.127
EE80	-0.008	#DIV/0!

Diagram 3: Subsidence Survey Line E&EE - Horizontal Strain Measured Pre and Post Mining<sup>6</sup>



<sup>6</sup> Diagram supplied by Gujarat NRE

Diagram 4: Subsidence Survey Line E&EE - Incremental Subsidence Resulting From the Extraction of Longwall 12<sup>7</sup>



<sup>7</sup> Diagram supplied by Gujarat NRE

**Table 9.2: Subsidence Survey Line EF - Subsidence Survey Data**

ORIGINAL SURVEY				NEW SURVEY					NEW SURVEY				
Survey Date:		20/07/2009		Date of Survey:		10/08/2009			Date of Survey:		27/11/2009		
PEG		R.L.	Distance	PEG	Subsidence	Strain	R.L.	Dist.	PEG	Subsidence	Strain	R.L.	Dist.
EF01	0	459.245	15.25144581	EF01	-0.006	0.069	459.239	15.25250143	EF01	-0.0075	0.122	459.2375	15.25331
EF02	0	459.641	15.41425892	EF02	-0.0055	-0.056	459.6355	15.41340157	EF02	-0.0085	0.048	459.6325	15.415
EF03	0	460.3345	14.81621519	EF03	-0.0065	0.155	460.328	14.81851775	EF03	-0.011	-0.052	460.3235	14.81545
EF04	0	461.1095	15.26582626	EF04	-0.005	-0.221	461.1045	15.26244569	EF04	-0.008	-0.109	461.1015	15.26417
EF05	0	461.7825	14.22943247	EF05	-0.007	-0.091	461.7755	14.22813292	EF05	-0.008	0.069	461.7745	14.23041
EF06	0	462.395	15.38363091	EF06	-0.006	0.256	462.389	15.38756989	EF06	-0.0075	0.307	462.3875	15.38836
EF07	0	463.014	14.85149781	EF07	-0.0065	0.317	463.0075	14.85619834	EF07	-0.01	0.191	463.004	14.85434
EF08	0	463.5625	14.82742832	EF08	-0.005	-0.231	463.5575	14.82400132	EF08	-0.0095	0.095	463.553	14.82883
EF09	0	464.1655	15.33022037	EF09	-0.0065	-0.299	464.159	15.32562992	EF09	-0.011	-0.194	464.1545	15.32724
EF10	0	464.7575	17.28326018	EF10	-0.006	-0.156	464.7515	17.2805717	EF10	-0.011	-0.068	464.7465	17.28208
EF11	0	466.032	13.96804611	EF11	-0.0065	0.212	466.0255	13.97100057	EF11	-0.0105	-0.086	466.0215	13.96685
EF12	0	466.898	15.09582971	EF12	-0.007	-0.159	466.891	15.09343033	EF12	-0.011	0.249	466.887	15.09958
EF13	0	467.7875	15.28432427	EF13	-0.007	0.116	467.7805	15.28609074	EF13	-0.011	-0.021	467.7765	15.28401
EF14	0	468.8915	15.19141235	EF14	-0.0045	0.236	468.887	15.19499668	EF14	-0.0115	0.244	468.88	15.19512
EF15	0	470	14.79570049	EF15	-0.007	-0.208	469.993	14.79261587	EF15	-0.014	0.212	469.986	14.79884
EF16	0	471.0975	13.65030242	EF16	-0.01	0.301	471.0875	13.6544149	EF16	-0.0125	-0.286	471.085	13.6464
EF17	0	473.1555	16.20850562	EF17	-0.0105	-0.35	473.145	16.20283124	EF17	-0.0135	0.091	473.142	16.20998
EF18	0	474.9475	14.21216044	EF18	-0.009	0.237	474.9385	14.21552529	EF18	-0.015	0.042	474.9325	14.21276
EF19	0	477.127	16.12702468	EF19	-0.0065	0.176	477.1205	16.12987022	EF19	-0.013	0.192	477.114	16.13012
EF20	0	479.5595	16.4039103	EF20	-0.0065	-0.021	479.553	16.40357255	EF20	-0.015	0.059	479.5445	16.40488
EF21	0	480.57	15.22342028	EF21	-0.007	-0.113	480.563	15.22169626	EF21	-0.0125	-0.404	480.5575	15.21727
EF22	0	481.5215	14.61080379	EF22	-0.0065	-0.307	481.515	14.60632521	EF22	-0.013	-0.04	481.5085	14.61022
EF23	0	482.141	14.231	EF23	-0.0065	0.3	482.1345	14.23526671	EF23	-0.0135	0.374	482.1275	14.23632
EF24	0	482.1685	14.51509631	EF24	-0.0065	-0.268	482.162	14.51120564	EF24	-0.014	-0.075	482.1545	14.51401

ORIGINAL SURVEY			
Survey Date:		20/07/2009	
PEG		R.L.	Distance
EF25	0	482.2725	15.85923201
EF26	0	482.5425	15.06068129
EF27	0	483.001	14.90826731
EF28	0	483.126	15.35154458
EF29	0	483.3905	14.619
EF30	0	483.917	14.32999208
EF31	0	484.492	15.62100746
EF32	0	484.403	15.07588526
EF33	0	484.17	15.29933365
EF34	0	483.91	14.91666714
EF35	0	483.6355	15.52765831
EF36	0	483.368	14.66122977
EF37	0	483.033	15.49882867
EF38	0	483.0595	15.30270126
FE39	0	483.0075	15.1579334
EF40	0	483.0355	14.96139032
EF41	0	483.0925	14.95829445
EF42	0	483.2095	15.0566328
EF43	0	483.4185	15.73710485
EF44	0	483.699	14.37300008
EF45	0	483.7215	15.05677422
EF46	0	483.7785	15.03093148
EF47	0	483.708	15.08688517
EF48	0	483.738	15.48565905
EF49	0	483.489	14.68146782
EF50	0	483.3825	15.23708793

NEW SURVEY				
Date of Survey:		10/08/2009		
PEG	Subsidence	Strain	R.L.	Dist.
EF25	-0.007	-0.076	482.2655	15.85803121
EF26	-0.007	0.247	482.5355	15.06439491
EF27	-0.007	-0.171	482.994	14.90571995
EF28	-0.008	0.032	483.118	15.3520287
EF29	-0.007	0.307	483.3835	14.62349455
EF30	-0.005	0.088	483.912	14.3312565
EF31	-0.007	-0.326	484.485	15.61591906
EF32	-0.0065	-0.1	484.3965	15.07438003
EF33	-0.0065	-0.171	484.1635	15.29671328
EF34	-0.007	0	483.903	14.91666566
EF35	-0.007	0.083	483.6285	15.52895129
EF36	-0.0075	-0.039	483.3605	14.66065253
EF37	-0.0065	0.198	483.0265	15.50190493
EF38	-0.0075	-0.147	483.052	15.30045536
FE39	-0.0055	0.062	483.002	15.15886877
EF40	-0.006	-0.091	483.0295	14.96002173
EF41	-0.0055	-0.039	483.087	14.95770588
EF42	-0.0055	0.095	483.204	15.05805651
EF43	-0.006	0.092	483.4125	15.73855854
EF44	-0.0055	-0.011	483.6935	14.37283797
EF45	-0.0055	-0.03	483.716	15.05631739
EF46	-0.0055	-0.349	483.773	15.02569221
EF47	-0.0055	-0.053	483.7025	15.08609028
EF48	-0.007	0.215	483.731	15.48899339
EF49	-0.0055	-0.251	483.4835	14.67778336
EF50	-0.005	0.346	483.3775	15.24235694

NEW SURVEY				
Date of Survey:		27/11/2009		
PEG	Subsidence	Strain	R.L.	Dist.
EF25	-0.0155	0.004	482.257	15.85929
EF26	-0.0165	0.008	482.526	15.0608
EF27	-0.0175	-0.044	482.9835	14.90761
EF28	-0.02	0.01	483.106	15.35169
EF29	-0.019	0.177	483.3715	14.62159
EF30	-0.0185	0.285	483.8985	14.33407
EF31	-0.021	-0.223	484.471	15.61753
EF32	-0.0235	-0.115	484.3795	15.07416
EF33	-0.0265	0.092	484.1435	15.30074
EF34	-0.028	-0.355	483.882	14.91137
EF35	-0.0305	0.234	483.605	15.5313
EF36	-0.0335	0.199	483.3345	14.66415
EF37	-0.0345	0.021	482.9985	15.49915
EF38	-0.039	0.013	483.0205	15.3029
FE39	-0.041	-0.15	482.9665	15.15565
EF40	-0.0475	0.013	482.988	14.96159
EF41	-0.057	0.183	483.0355	14.96104
EF42	-0.075	-0.075	483.1345	15.0555
EF43	-0.0985	-0.226	483.32	15.73355
EF44	-0.1225	-0.528	483.5765	14.36541
EF45	-0.1315	-0.1	483.59	15.05527
EF46	-0.1305	-0.635	483.648	15.02139
EF47	-0.1225	0.101	483.5855	15.08842
EF48	-0.112	-0.067	483.626	15.48462
EF49	-0.0955	-0.323	483.3935	14.67673
EF50	-0.084	0.295	483.2985	15.24159

ORIGINAL SURVEY			
Survey Date:		20/07/2009	
PEG		R.L.	Distance
EF51	0	483.297	15.13495347
EF52	0	483.244	14.95894711
EF53	0	483.1355	15.61411404
EF54	0	483.0595	14.65080962
EF55	0	482.9885	15.04254341
EF56	0	482.9895	14.54581023
EF57	0	482.8935	15.26196142
EF58	0	483.0725	15.86449485
EF59	0	482.7865	15.3293784
EF60	0	482.972	14.83896985
EF61	0	483.2055	15.17143765
EF62	0	483.3975	14.94963411
EF63	0	483.5975	14.62197068
EF64	0	483.7355	15.89
EF65	0	484.2655	16.59812636
EF66	0	484.5575	14.01771531
EF67	0	484.9435	14.97383819
EF68	0	485.2955	15.42083967
EF69	0	485.635	16.58011214
EF70	0	486.1915	15.74376677
EF71	0	487.0355	15.32335293
EF72	0	487.652	15.30910126
EF73	0	488.4895	15.07268928
EF74	0	489.5065	14.46355372
EF75	0	490.6165	16.55879628
EF76	0	492.075	14.98722423

NEW SURVEY				
Date of Survey:		10/08/2009		
PEG	Subsidence	Strain	R.L.	Dist.
EF51	-0.0055	-0.059	483.2915	15.13405828
EF52	-0.0045	0.022	483.2395	14.95927392
EF53	-0.0045	-0.204	483.131	15.61092914
EF54	-0.0045	0.212	483.055	14.65391993
EF55	-0.004	-0.006	482.9845	15.04245749
EF56	-0.004	0.148	482.9855	14.54796289
EF57	-0.0045	0.107	482.889	15.26359732
EF58	-0.004	-0.201	483.0685	15.86130999
EF59	-0.005	-0.245	482.7815	15.32562133
EF60	-0.0055	0.228	482.9665	14.84235306
EF61	-0.0055	0.245	483.2	15.17514996
EF62	-0.005	-0.203	483.3925	14.94659685
EF63	-0.0055	0.269	483.592	14.62590437
EF64	-0.005	-0.202	483.7305	15.88678577
EF65	-0.004	0.098	484.2615	16.59975374
EF66	-0.004	0.052	484.5535	14.01843862
EF67	-0.0045	-0.189	484.939	14.97100611
EF68	-0.0045	-0.129	485.291	15.41884646
EF69	-0.0045	0.101	485.6305	16.58178772
EF70	-0.0045	0.072	486.187	15.74489524
EF71	-0.004	0.065	487.0315	15.32434603
EF72	-0.005	0.09	487.647	15.31048622
EF73	-0.0045	-0.256	488.485	15.06883808
EF74	-0.003	0.056	489.5035	14.46436421
EF75	-0.003	0.253	490.6135	16.56298308
EF76	-0.0015	-0.218	492.0735	14.98395349

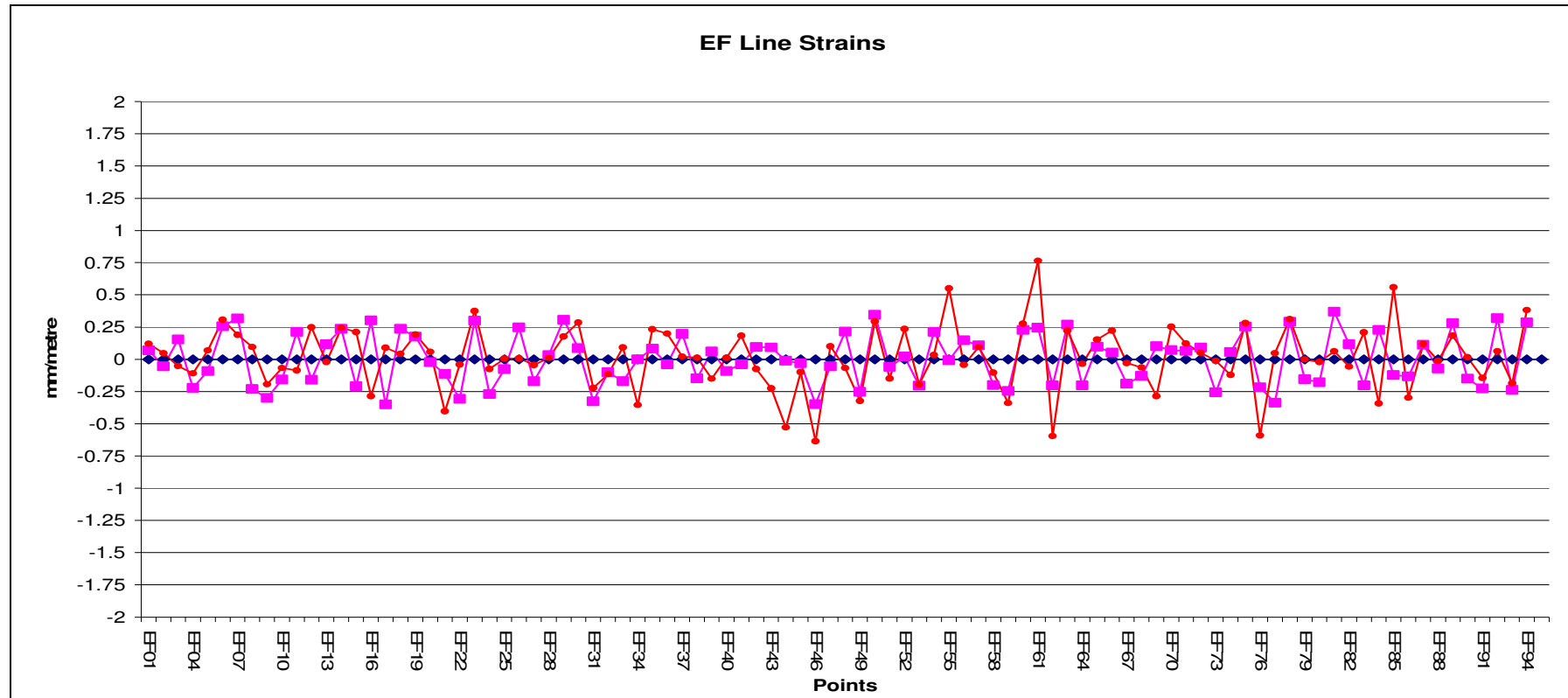
NEW SURVEY				
Date of Survey:		27/11/2009		
PEG	Subsidence	Strain	R.L.	Dist.
EF51	-0.0735	-0.149	483.2235	15.13271
EF52	-0.063	0.235	483.181	14.96246
EF53	-0.0555	-0.195	483.08	15.61107
EF54	-0.048	0.034	483.0115	14.65132
EF55	-0.0405	0.551	482.948	15.05083
EF56	-0.0365	-0.043	482.953	14.54518
EF57	-0.0335	0.095	482.86	15.26342
EF58	-0.0305	-0.103	483.042	15.86285
EF59	-0.027	-0.339	482.7595	15.32419
EF60	-0.0245	0.277	482.9475	14.84308
EF61	-0.0215	0.764	483.184	15.18303
EF62	-0.0185	-0.596	483.379	14.94072
EF63	-0.0175	0.222	483.58	14.62522
EF64	-0.0155	-0.036	483.72	15.88943
EF65	-0.0125	0.154	484.253	16.60067
EF66	-0.0105	0.223	484.547	14.02085
EF67	-0.01	-0.029	484.9335	14.9734
EF68	-0.0095	-0.063	485.286	15.41986
EF69	-0.0085	-0.286	485.6265	16.57538
EF70	-0.0055	0.253	486.186	15.74775
EF71	-0.0075	0.123	487.028	15.32524
EF72	-0.008	0.051	487.644	15.30989
EF73	-0.0075	-0.013	488.482	15.07249
EF74	-0.0065	-0.122	489.5	14.46179
EF75	-0.0065	0.281	490.61	16.56345
EF76	-0.0065	-0.591	492.0685	14.97837

ORIGINAL SURVEY			
Survey Date:		20/07/2009	
PEG		R.L.	Distance
EF77	0	492.74	15.54575601
EF78	0	493.2515	15.392
EF79	0	494.5745	15.753
EF80	0	495.482	14.85527019
EF81	0	496.8435	16.10270695
EF82	0	498.3875	13.91346472
EF83	0	499.3665	15.67282544
EF84	0	500.1785	15.426852
EF85	0	501.5425	14.881
EF86	0	503.29	15.09598173
EF87	0	505.9455	15.06074853
EF88	0	508.2165	14.76707799
EF89	0	509.6195	17.866
EF90	0	511.1355	13.287
EF91	0	511.9885	14.42954172
EF92	0	512.8765	15.04830197
EF93	0	514.1095	14.63910206
EF94	0	515.065	16.03486805
EF95	0	515.7195	

NEW SURVEY				
Date of Survey:		10/08/2009		
PEG	Subsidence	Strain	R.L.	Dist.
EF77	-0.003	-0.337	492.737	15.54052034
EF78	-0.0035	0.291	493.248	15.39647195
EF79	-0.004	-0.155	494.5705	15.75055324
EF80	-0.006	-0.178	495.476	14.85262886
EF81	-0.0015	0.369	496.842	16.10864356
EF82	-0.0005	0.117	498.387	13.91509077
EF83	5.68434E-14	-0.202	499.3665	15.66965661
EF84	-0.0005	0.229	500.178	15.43038101
EF85	0	-0.121	501.5425	14.87920455
EF86	0	-0.133	503.29	15.09396904
EF87	5.68434E-14	0.113	505.9455	15.06245373
EF88	5.68434E-14	-0.072	508.2165	14.76601132
EF89	5.68434E-14	0.28	509.6195	17.871
EF90	-0.0005	-0.151	511.135	13.285
EF91	-0.0035	-0.226	511.985	14.42628439
EF92	-0.003	0.32	512.8735	15.05312394
EF93	-0.0035	-0.237	514.106	14.63563296
EF94	-0.0035	0.285	515.0615	16.03943547
EF95	-0.0045	#DIV/0!	515.715	

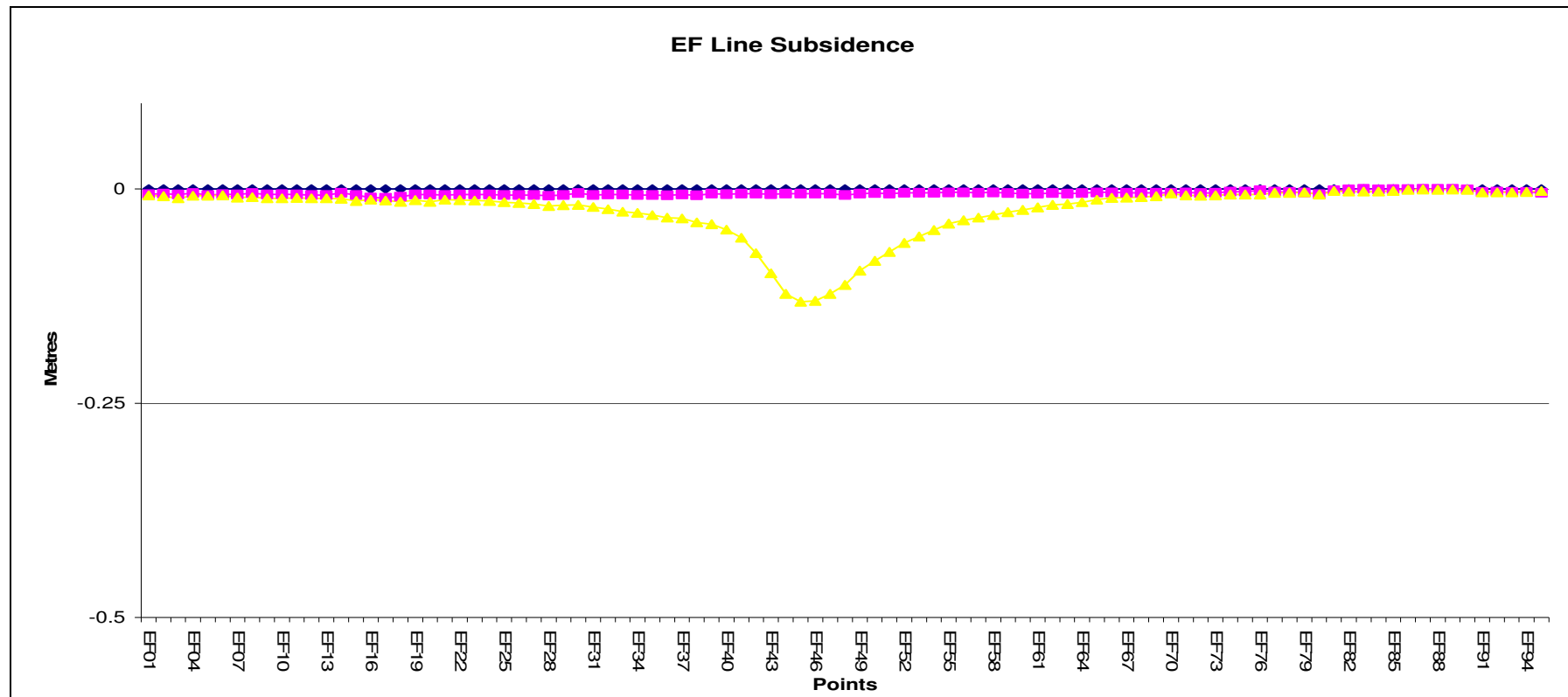
NEW SURVEY				
Date of Survey:		27/11/2009		
PEG	Subsidence	Strain	R.L.	Dist.
EF77	-0.0045	0.047	492.7355	15.54649
EF78	-0.0045	0.312	493.247	15.3968
EF79	-0.004	0	494.5705	15.753
EF80	-0.0065	-0.021	495.4755	14.85496
EF81	-0.0025	0.063	496.841	16.10373
EF82	-0.003	-0.057	498.3845	13.91268
EF83	-0.003	0.209	499.3635	15.6761
EF84	-0.003	-0.342	500.1755	15.42157
EF85	-0.0025	0.558	501.54	14.8893
EF86	-0.001	-0.298	503.289	15.09149
EF87	-0.0005	0.118	505.945	15.06253
EF88	-0.001	-0.013	508.2155	14.76689
EF89	-0.0005	0.183	509.619	17.86927
EF90	-0.001	0.015	511.1345	13.2872
EF91	-0.004	-0.144	511.9845	14.42746
EF92	-0.004	0.063	512.8725	15.04926
EF93	-0.004	-0.185	514.1055	14.63639
EF94	-0.0035	0.382	515.0615	16.04099
EF95	-0.0025	#DIV/0!	515.717	

**Diagram 5: Subsidence Survey Line EF - Horizontal Strain Measured Pre and Post Mining<sup>8</sup>**



<sup>8</sup> Diagram supplied by Gujarat NRE

**Diagram 6: Subsidence Survey Line E&EE - Incremental Subsidence Resulting From the Extraction of Longwall 12<sup>9</sup>**



<sup>9</sup> Diagram supplied by Gujarat NRE

## ATTACHMENT C

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### Subsidence Report:

End of Panel Monitoring Report for Longwall 12 at Wongawilli  
Colliery. Mine Subsidence Engineering Consultants (MSEC)  
Report # MSEC443 - Revision A. February 2010-02-22

# **GUJARAT NRE MINERALS LIMITED**



## **NRE Wongawilli Colliery**

### **END OF PANEL MONITORING REPORT FOR LONGWALL 12 AT WONGAWILLI COLLIERY**



**Mine Subsidence Engineering Consultants**  
**Level 1, 228 Victoria Avenue – Chatswood – NSW 2067**  
**PO Box 3047 – Willoughby North – NSW 2068**  
**Tel. (02) 9413 3777 Fax. (02) 9413 3822**  
**Email: [enquiries@minesubsidence.com](mailto:enquiries@minesubsidence.com)**  
**[www.minesubsidence.com](http://www.minesubsidence.com)**

**Report Number MSEC443**  
**Revision A**  
**February 2010**

## **DOCUMENT REGISTER**

<b>Revision</b>	<b>Description</b>	<b>Author</b>	<b>Checker</b>	<b>Date</b>
A	End of Panel Report for Wongawilli Longwall 12	PD	DRK	3 <sup>rd</sup> Feb 10

Report produced for:- Compliance with conditions attached to the SMP Approval set by The Department of Primary Industries.

Previous reports:- MSEC360 (September 2008) – The Prediction of Subsidence Parameters and the Assessment of Subsidence Impacts on Natural Features and Surface Infrastructure Due to Mining Longwalls 11, 12, 15, 16 & 19 and due to Pillar Extraction Areas 1 & 2 (In Support of a SMP Application).

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### Figures

The figures are provided in Appendix A at the end of this report.

<i>Figure</i>	<i>Description</i>
Fig. A.01	Elouera Colliery E & EE Line Subsidence Monitoring Results Longwalls 1 to 10
Fig. A.02	Observed Profiles of Incremental Subsidence, Tilt and Strain along the E&EE Line During the Extraction of LW12
Fig. A.03	Observed and Predicted Profiles of Incremental Subsidence, Tilt and Strain along the EF Line During the Extraction of LW12

### Drawings

The drawings are provided in Appendix A at the end of this report.

<i>Drawing No.</i>	<i>Description</i>
MSEC443-01	Wongawilli Colliery, LW12 End of Panel, Monitoring and Infrastructure

## **CHAPTER 1. BACKGROUND**

### **1.1. Introduction**

Gujarat NRE Minerals Limited (NRE) has completed the extraction of Longwall 12 at NRE Wongawilli Colliery in the Southern Coalfield of New South Wales. NRE Wongawilli Colliery was previously operated as Elouera Colliery and Delta Colliery. The location of Longwall 12 is shown in Drawing No. MSEC443-01 in Appendix A.

The extraction of Longwall 12 commenced on the 25<sup>th</sup> August 2009 and was completed on the 26<sup>th</sup> November 2009.

In accordance with approval conditions detailed in the Environmental Subsidence and Safety Management Plan, (ESSMP), this report provides a comparison between the predicted and observed subsidence movements along the monitoring lines at Wongawilli Colliery resulting from the extraction of Longwall 12 and an analyses of these monitoring results.

This report also details the observed impacts on the manmade surface infrastructure within the Application Area resulting from the extraction of Longwall 12. Descriptions of impacts on natural features within the Application Area are provided in the reports by other consultants, and the observations provided in this report should be read in conjunction with all other relevant reports.

## **CHAPTER 2. COMPARISON BETWEEN PREDICTED AND OBSERVED SUBSIDENCE MOVEMENTS**

### **2.1. Monitoring Lines**

The subsidence movements resulting from the extraction of Longwall 12 were measured along two monitoring lines, E&EE Line and EF Line, both of which are 2D monitoring lines. The locations of the longwalls at the Colliery and the monitoring lines are shown in Drawing No. MSEC443-01 in Appendix A.

Comparisons between predicted and observed subsidence movements along the monitoring line are provided in the following sections.

### **2.2. E&EE Monitoring Line**

The E&EE Monitoring Line was installed to survey the subsidence movements due to the extraction of LWs 1 to 10 at Elouera Colliery. Total subsidence of 1370 mm was monitored along this line above LW6 and a total subsidence of 705 mm was monitored above LW9 after LW10 was extracted, as is shown on the attached Fig. A.01.

The E&EE monitoring line is located along the Maldon Dombarton rail corridor and is more than 680 metres from Longwall 12. At this distance from Longwall 12 no incremental systematic subsidence is predicted along this E&EE Line. Nevertheless, the survey line was monitored on 20<sup>th</sup> July 2009, (i.e. before extraction commenced on Longwall 12), on 10<sup>th</sup> August 2009, and on 27<sup>th</sup> November 2009 ( i.e. after extraction was completed within Longwall 12), to check if there were any movements as a result of the extraction of LW12.

Survey results of the incremental subsidence of E&EE pegs following the extraction of LW12 were all less than 10 mm, which is within survey tolerance. Measured strains along the E&EE Line are also generally within survey tolerance. A plot of the observed subsidence parameters for the E&EE Line is included in Fig. 02 in Appendix A. These results do not indicate that any significant subsidence movements have occurred along the E&EE Line.

There were no observed subsidence impacts to the Maldon Dombarton rail corridor or any other surface features in the vicinity of the E&EE Line as a result of LW12 extraction.

### **2.3. EF Monitoring Line**

The EF monitoring line is located diagonally across the eastern end of Longwall 12 as is shown in Drawing No. MSEC443-01. The route of the monitoring line follows Fire Road 6H and a disused 33kV power line.

The subsidence and strain along the EF Line were measured before the commencement and after the completion of Longwall 12 on the 20<sup>th</sup> August 2009 and the 27<sup>th</sup> November 2009, respectively. The profiles of observed incremental subsidence, tilt and strain along the EF Line due to the extraction of Longwall 12 are shown in Fig. A.03 in Appendix A.

The predicted profiles of systematic incremental subsidence and tilt along the EF Line due to the extraction of Longwall 12 are also shown in Fig. A.03.

The predicted subsidence profiles along the monitoring line were obtained using the standard Incremental Profile Method for the Southern Coalfield, which uses an empirical database based on monitoring data from the Bulli Seam. The effects of multi-seam mining conditions were taken into account in the prediction model as previous extraction was carried out above Longwall 12 in the Bulli seam. Old pillar extraction workings within the Wongawilli Seam were also extracted beneath the Bulli Seam within 36 metres of Longwall 12. The areas of extraction in the Bulli seam and the Wongawilli Seam are shown in Drawing No. MSEC443-01 in Appendix A.

A summary of the maximum predicted and maximum observed incremental subsidence along the EF monitoring line, due to the extraction of Longwall 12 is provided in Table 2.1.

**Table 2.1 Maximum Predicted and Maximum Observed Incremental Subsidence along the EF-Line due to the Extraction of Longwall 12**

<b>Longwall</b>	<b>Maximum Predicted Incremental Subsidence (mm)</b>	<b>Maximum Observed Incremental Subsidence (mm)</b>
Longwall 12	140	130

The maximum observed incremental subsidence along the monitoring line for Longwall 12 of 130 mm is less than the maximum predicted incremental subsidence of 140 mm. The shapes of the observed and predicted incremental subsidence profiles over Longwall 12 are similar and, therefore, the tilts are well represented. The profile of the observed subsidence is slightly steeper than the predicted profile over the southern edge of Longwall 12 and the resulting observed maximum tilt of 1.5 mm/m is 0.3 mm/m greater than the maximum predicted tilt of 1.2 mm/m. This area to the south of Longwall 12 is adjacent to where the previous second workings within the Wongawilli Seam were located.

The profiles of observed Longwall 12 incremental strain along the EF Line are also shown in Fig. A.03. It can be seen that a majority of the strains are within survey tolerance.

## CHAPTER 3. IMPACTS ON SURFACE INFRASTRUCTURE

### 3.1. Surface Infrastructure within the Application Area

The surface infrastructure that is located above or adjacent to Longwall 12 is shown in Drawing No. MSEC443-01 and are listed below:-

- Fire trails 6H and minor sections of 4WD tracks passing directly above Longwalls 12,
- Maldon-Dombarton rail corridor located over 680 metres from Longwall 12,
- Disused 33 kV powerline passing directly above Longwall 12,
- Survey control marks located near to Longwalls 12.

### 3.2. Comparison between Predicted and Observed Impacts on Surface Infrastructure

A comparison between the observed and the predicted impacts on the manmade surface infrastructure above or adjacent to Longwall 12 is summarised in Table 3.1. The predicted impacts were detailed in the report that was titled “*The Prediction of Subsidence Parameters and the Assessment of Subsidence Impacts on Natural Features and Surface Infrastructure Due to Mining Longwalls 11, 12, 15, 16 & 19 and due to Pillar Extraction Areas 1 & 2 (In Support of a SMP Application)*” and this report was issued in September 2008 as MSEC360.

Comparisons between predicted and observed impacts on the natural features above or adjacent to the Longwall 12 are provided in other consultant reports.

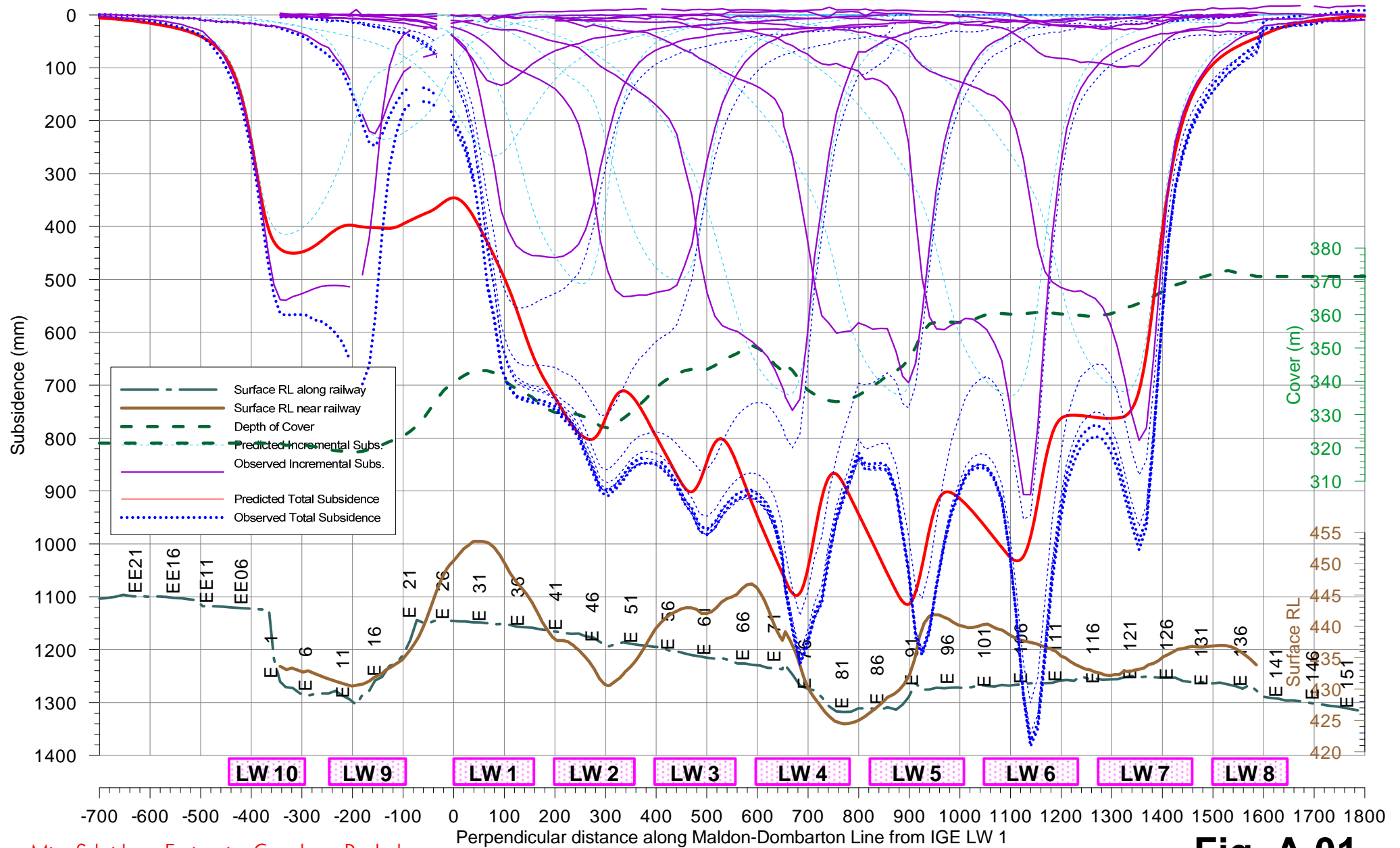
**Table 3.1 Summary of Predicted and Observed Impacts Resulting from Longwall 12**

<b>SURFACE INFRASTRUCTURE</b>	<b>PREDICTED IMPACTS</b>	<b>OBSERVED IMPACTS</b>
Fire trails and 4WD tracks	Changes to surface drainage and some surface cracking of the unsealed road surfaces	No reported impacts
Maldon-Dombarton rail corridor	No predicted impact	No reported impact
Disused 33 kV powerline	No predicted impact	No reported impact
Survey control marks	Horizontal movements requiring re-establishment	Horizontal movements require re-establishment

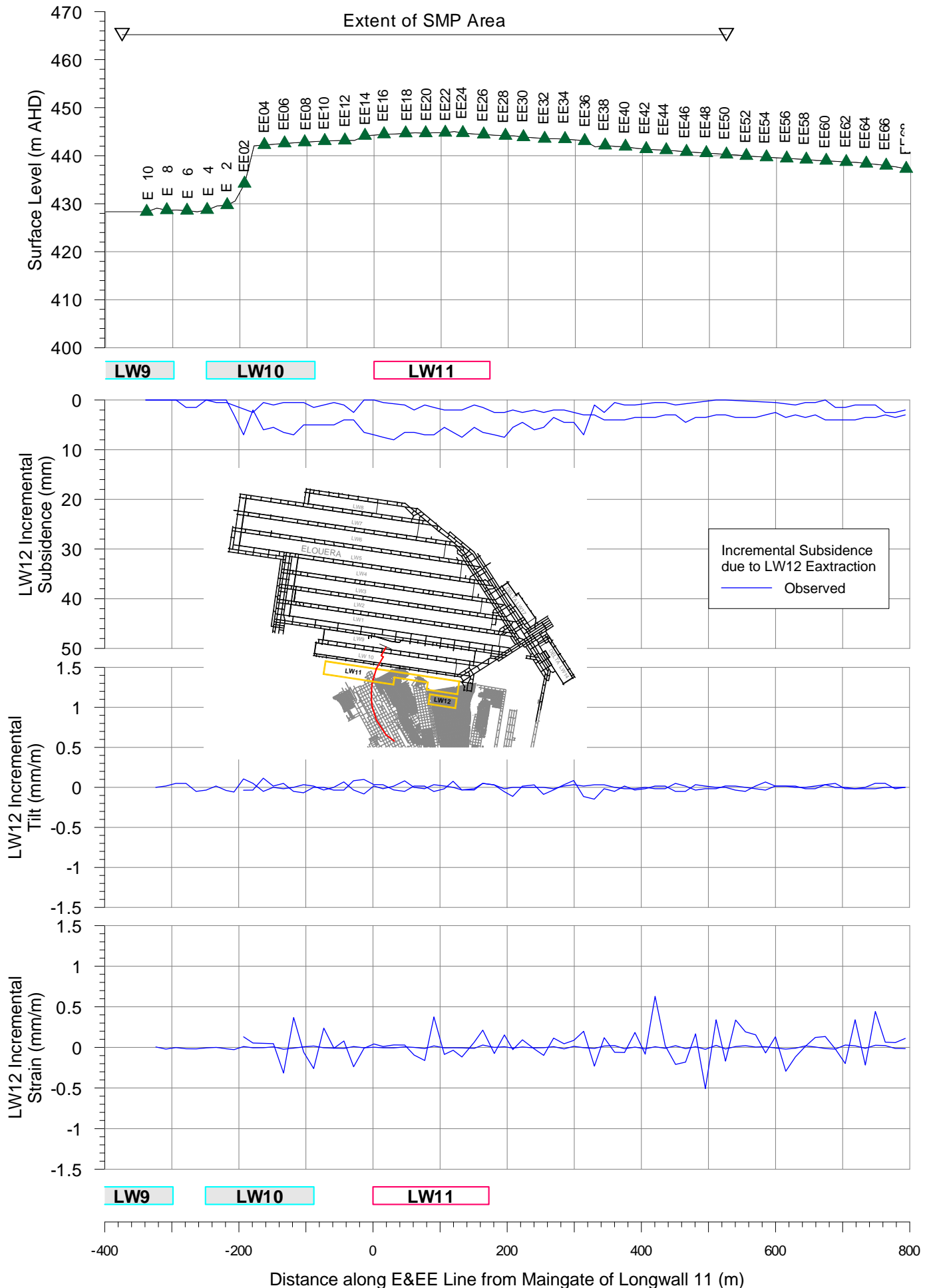
It can be seen from Table 3.1, that there were no reported impacts on the surface infrastructure resulting from the extraction of Longwall 12, with the exception of the survey control marks, which was predicted.

## **APPENDIX A. FIGURES AND DRAWINGS**

# Elouera Colliery E & EE Line Subsidence Monitoring Results Longwalls 1 to 10

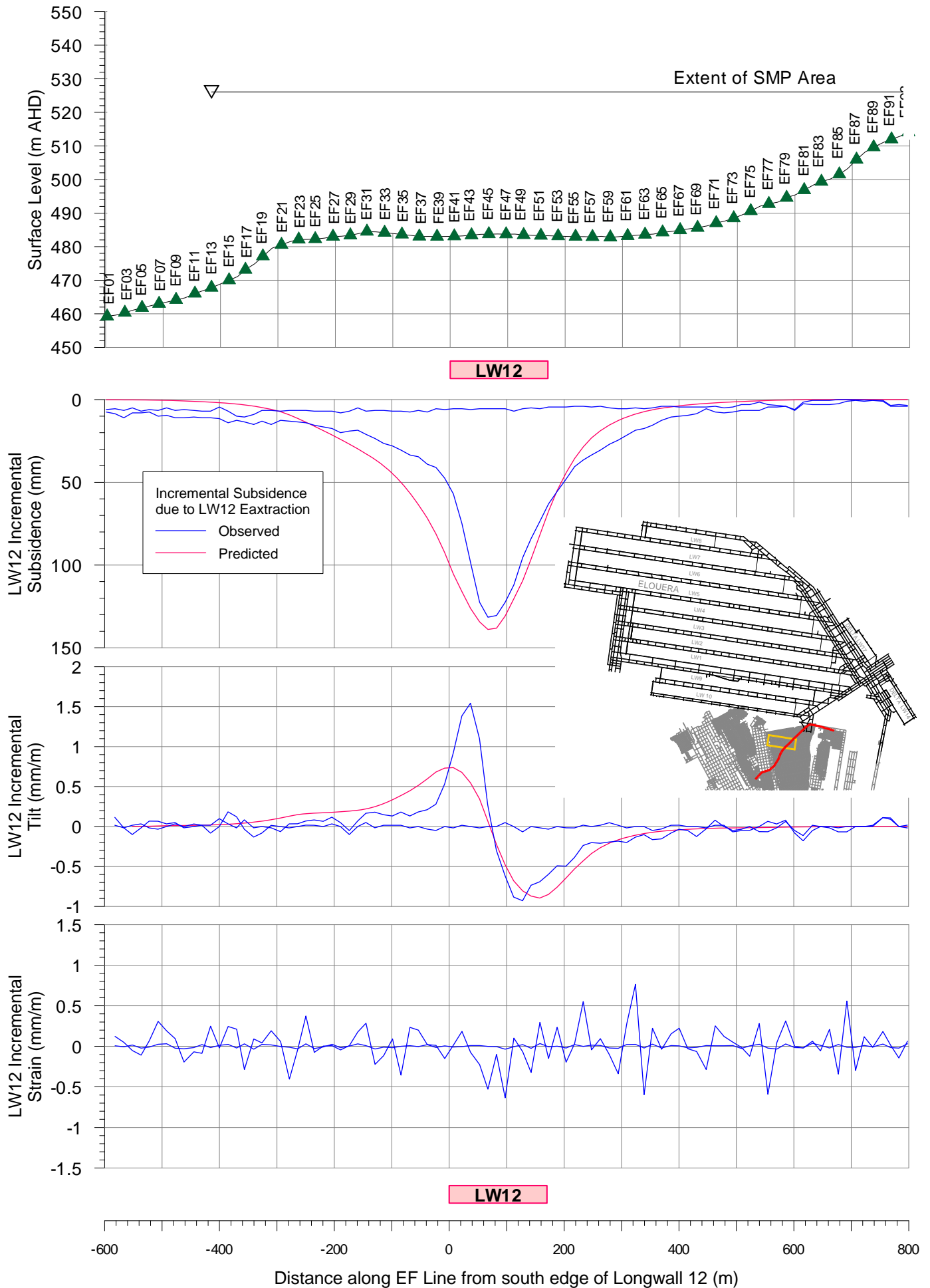


## Observed Profiles of Incremental Subsidence, Tilt and Strain along the E&EE-Line during the Extraction of LW12



**Fig. A.02**

# Observed and Predicted Profiles of Incremental Subsidence, Tilt and Strain along the EF-Line during the Extraction of LW12





## ATTACHMENT D

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### Groundwater and Surface Water:

Wongawilli Colliery End Of Longwall 12 Extraction  
Groundwater & Surface Water Report. GeoTerra Report: GUJ5-  
R1A, March 2010



**GUJARAT NRE FCGL PTY LTD**  
**WONGAWILLI COLLIERY**  
**END OF LONGWALL 12 EXTRACTION**  
**GROUNDWATER & SURFACE WATER REPORT**  
Wollongong, NSW

GUJ5-R1B  
13 MARCH, 2010

**GeoTerra** PTY LTD ABN 82 117 674 941

77 Abergeldie Street Dulwich Hill NSW 2203

Phone: 02 9560 6583 Fax: 02 9560 6584 Mobile 0417 003 502 Email: [geoterra@iinet.net.au](mailto:geoterra@iinet.net.au)

GUJ5-R1B (13 MARCH, 2010)

**GeoTerra**

Gujarat NRE FCGL Pty Ltd  
PO Box 924  
DAPTO NSW 2530

Attention: David Clarkson

David,

**RE: Wongawilli Colliery Longwall 12 End of Panel Groundwater &  
Surface Water Report**

Please find enclosed a copy of the above mentioned report.

Yours faithfully

**GeoTerra Pty Ltd**



**Andrew Dawkins** (AuSIMM CP-Env)


Managing Geoscientist

Distribution:	Original	GeoTerra Pty Ltd
	1 electronic copy	Gujarat NRE FCGL Coal Pty Ltd
	1 electronic copy	Niche Environment and Heritage Pty Ltd

**GeoTerra PTY LTD ABN 82 117 674 941**

77 Abergeldie Street Dulwich Hill NSW 2203

Phone: 02 9560 6583 Fax: 02 9560 6584 Mobile 0417 003 502 Email: [geoterra@inet.net.au](mailto:geoterra@inet.net.au)

Authorised on behalf of Geoterra Pty Ltd:	
<b>Name:</b>	Andrew Dawkins
<b>Signature:</b>	
<b>Position:</b>	Managing Geoscientist

Date	Rev	Comments
24.02.2010		Initial Draft
08.03.2010	A	Incorporate review comments
13.03.2010	B	Incorporate review comments

**GeoTerra** PTY LTD ABN 82 117 674 941

77 Abergeldie Street Dulwich Hill NSW 2203

Phone: 02 9560 6583 Fax: 02 9560 6584 Mobile 0417 003 502 Email: geoterra@inet.net.au

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## APPENDIX A

### Groundwater Laboratory Analyses Summary

## 1. INTRODUCTION

Extraction of the Wongawilli Seam in Longwalls 11 to 19 by Gujarat NRE FCGL Pty Ltd (Gujarat) at Wongawilli Colliery was approved by the Department of Primary Industries (DPI) on 16<sup>th</sup> July 2009.

Longwall mining in Panel 12 occurred between the 25<sup>th</sup> of August 2009 and 26<sup>th</sup> November 2009, with Longwall 12 located as shown in **Drawing 1**.

The overlying Bulli Seam has previously been mined, and subsided, to an unmeasured degree, in the vicinity of Longwall 12 by bord and pillar extraction.

## 2. SCOPE OF WORK

Geoterra were commissioned by Gujarat to report on any observed groundwater system or surface water changes resulting from extraction of Longwall 12 in accordance with the SMP Approval Conditions for Longwalls 11, 12, 15, 16, 19 and Pillar Extraction Area 1, as well as within the Environmental Subsidence and Safety Management Plan (ESSMP).

## 3. DESCRIPTION OF GROUNDWATER AND SURFACE WATER MONITORING LOCATIONS IN THE VICINITY OF THE LONGWALL 12 SUBSIDENCE ZONE

### 3.1 Groundwater Locations

There is one vibrating wire piezometer (PWW1) and one swamp piezometer (P20) located in the vicinity of the Longwall 12.

Of the above mentioned monitoring locations, only P20 is located directly within the Longwall 12, 20mm subsidence zone.

Although PWW1 is located approximately 570m to the east of Longwall 11, it has been included in this discussion to provide background to future potential mining depressurisation effects in the vicinity of Panels 11,12,15 and 16.

PWW1 was not installed prior to extraction of Longwall 11 due to difficulties in obtaining a drill rig and the time required to obtain approvals to install the bore. Piezometer P20 was also installed after the commencement of Longwall 11 for similar reasons.

Other groundwater monitoring sites are located, and regularly monitored, within the overall Wongawilli region (particularly the old Illawarra Coal Elouera Colliery). Results for this monitoring are not presented or discussed in this report as they are outside the Longwall 12, 20mm subsidence zone or the nearby vicinity of Longwall 12.

The results for these locations will be discussed in subsequent End of Panel reports for Wongawilli Colliery longwalls.

Groundwater monitoring has been conducted since September 2009 in P20 and November 2009 in the multi level piezometer PWW1 as shown in **Table 1**, with the monitoring locations shown in **Drawing 1**.

The multi level vibrating wire piezometer (PWW1) was installed by Gujarat with intakes in the Hawkesbury Sandstone at 90m and 135m below surface, the Bald Hill Claystone at 150m and Bulgo Sandstone at 165m below surface.

P20 was installed by Gujarat in the Quaternary alluvium to 0.85m below surface.

Four other potential swamp piezometer locations were investigated within 75m of P20, however the alluvium was only up to 50cm deep and dry and therefore were not suitable locations for shallow groundwater monitoring piezometers.

NSW Office of Water (NOW) Test Monitoring Bore Licences and Sydney Catchment Authority (SCA) approval for the piezometers was received prior to their installation.

The first water intersection encountered whilst drilling PWW1 was at 23m below surface in the upper Hawkesbury Sandstone.

The Bellbird Creek Swamp 20 site was monitored by BHP Billiton in Bellbird Creek, downstream of, and not within, Swamp 20, between July 2005 and December 2007 for field pH and electrical conductivity. Monitoring at the re-named site (Bellbird Ck down) is planned to commence in March 2010 and data from that survey period was not available for this report.

**Table 1 Longwall 12 Groundwater Monitoring Sites**

GW	E	N	Intake Depth (m)	SWL (m)	Commenced	Lithology	pH	EC (uS/cm)
<b>MULTI LEVEL PIEZO</b>								
PWW1	291677.1	6187507.1	90	See plot	19.11.09	Hawkesbury Sandstone	6.17	102
			135	See plot	19.11.09	Hawkesbury Sandstone	—	—
			150	See plot	19.11.09	Bald Hill Claystone	—	—
			165	See plot	19.11.09	Bulgo Sandstone	—	—
<b>SWAMP PIEZO</b>								
P20	291144	6187583	0.3 – 0.85	See plot	18.09.09	Swamp Alluvium	see	plot

Five shallow Hawkesbury Sandstone piezometers installed by BHP between 35m and 51.5m below surface (known as EGW 2, 3, 4A, 5 and 6) are located to the north of the Longwall 12 subsidence area as shown in **Drawing 1**, with selected details listed in **Table 2**.

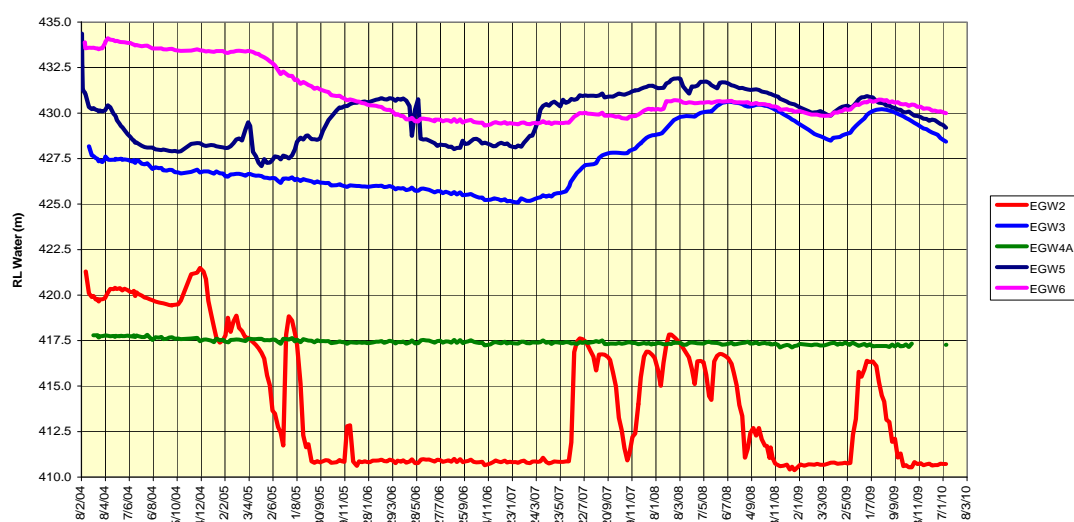
Standing water levels monitored since February 2004 in the BHP piezometers range from 29.42m to 48.50m below surface. Note that the **Figure 1** plot shows groundwater depths as relative levels to the Australian Height datum (AHD), not depth below surface. The BHP water levels vary by either being undermined by the old BHP Elouera Longwalls, or where they have not been undermined, or have previously been undermined, by seasonal and longer term climatic variations in rainfall recharge.

A full discussion on the monitoring results and interpretations of the EGW series bore results will be included in the Longwall 11 End of Panel report.

As shown in **Table 2**, the piezometers of the PWW, P and EGW series bores range from 155m to 1390m away from Longwall 702. As stated previously, only P20 occurs within the Longwall 12, 20mm subsidence zone.

**Table 2 Piezometer Distance to Longwall 12**

Piezometer	Distance from Longwall 12 (m)	Comment
P20	155	North of LW12
PWW1	600	East of LW12
EGW2	1390	North West of LW12
EGW3	1015	North West of LW12
EGW4A	1095	North West of LW12
EGW5	455	North West of LW12
EGW6	680	North West of LW12

EGW holes: Water Level Monitoring  
Swamps 18a and 36**Figure 1 BHP Hawkesbury Sandstone Water Levels**

BHP also conduct regular water level and water quality monitoring in Swamps 18 and 36, however as they are well outside any subsidence influence of Longwall 12, the data is not discussed in this report.

No NOW registered private bores are located within the SMP area as it is a restricted access water catchment area administered by the SCA.

The stream and piezometer monitoring has been used to determine the pre Longwall 12 baseline water level and water quality, where they were installed prior to commencement of Longwall 12. In addition the data is used to indicate variations in the surface water system and groundwater systems within the regional Hawkesbury Sandstone aquifer, Bald Hill Claystone and the upper Bulgo Sandstone to a maximum depth of 165m below surface.

Groundwater levels are logged using vibrating wire piezometers in the EGW and PWW series piezometers, and by a pressure transducer in the swamp piezometer

(P20).

### 3.2 Surface Water Locations

Bellbird Creek field water pH and electrical conductivity was measured by BHP Billiton using hand held field meters between July 2005 and December 2007 at a site called "Swamp 20", which is located at a culvert underneath the decommissioned Dombarton railway line.

It should be noted that the BHP "Swamp 20" monitoring site is not actually in or near Swamp 20. To avoid confusion, in the next Longwall 11 End of Panel report, this site will be re-named "Bellbird Creek down"

**Table 3 Longwall 12 Surface Water Monitoring Sites**

BELLBIRD Ck	E	N	Commenced	Location	pH	EC (uS/cm)
SWAMP 20	289962	6187290	19.07.05	Creek bed at culvert under railway	see	plot

## 4. PIEZOMETER INSTALLATION AND HYDRAULIC TESTING

The hydrogeology of the Longwall 11 to 19 SMP area was investigated by water intersection observations during drilling, packer testing and piezometer installation in the Swamp 20 alluvium open standpipe piezometer during September 2009 and in the multi level vibrating wire piezometer (now sealed) bore PWW1 during November 2009.

Further details of the packer testing on PWW1 will be outlined in the Longwall 11 End of Panel Report.

## 5. PREDICTED AND OBSERVED GROUNDWATER IMPACTS

The observed impacts discuss observations from the Gujarat PWW1 and the P20 piezometers only.

Due to the separation distance from the BHP piezometers to Longwall 12, a discussion on the BHP (EGW series) piezometers will be provided after LW11 is extracted which is in much closer proximity to that array.

It should be noted that the predicted impacts derived from the SMP do not separate the potential groundwater impacts of Longwall 12, individually, from the overall impacts of the entire mining program.

## 5.1 Piezometer Subsidence

### 5.1.1 Potential Impacts

- Maximum subsidence of 140mm along Subsidence Line EF.

### 5.1.2 Observed Impacts

- Maximum subsidence of 130mm along Subsidence Line EF.

No TARP trigger levels have been reached or exceeded and no ameliorative actions are required.

## 5.2 Aquifer / Aquitard Interconnection

### 5.2.1 Potential Impacts

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

### 5.2.2 Observed Impacts

- Based on available data, no adverse aquitard / aquifer interconnection or increased recharge has occurred in the vicinity of, or resulting from, extraction of Longwall 12.

No TARP trigger levels have been reached or exceeded and no ameliorative actions are required.

## 5.3 Groundwater Levels

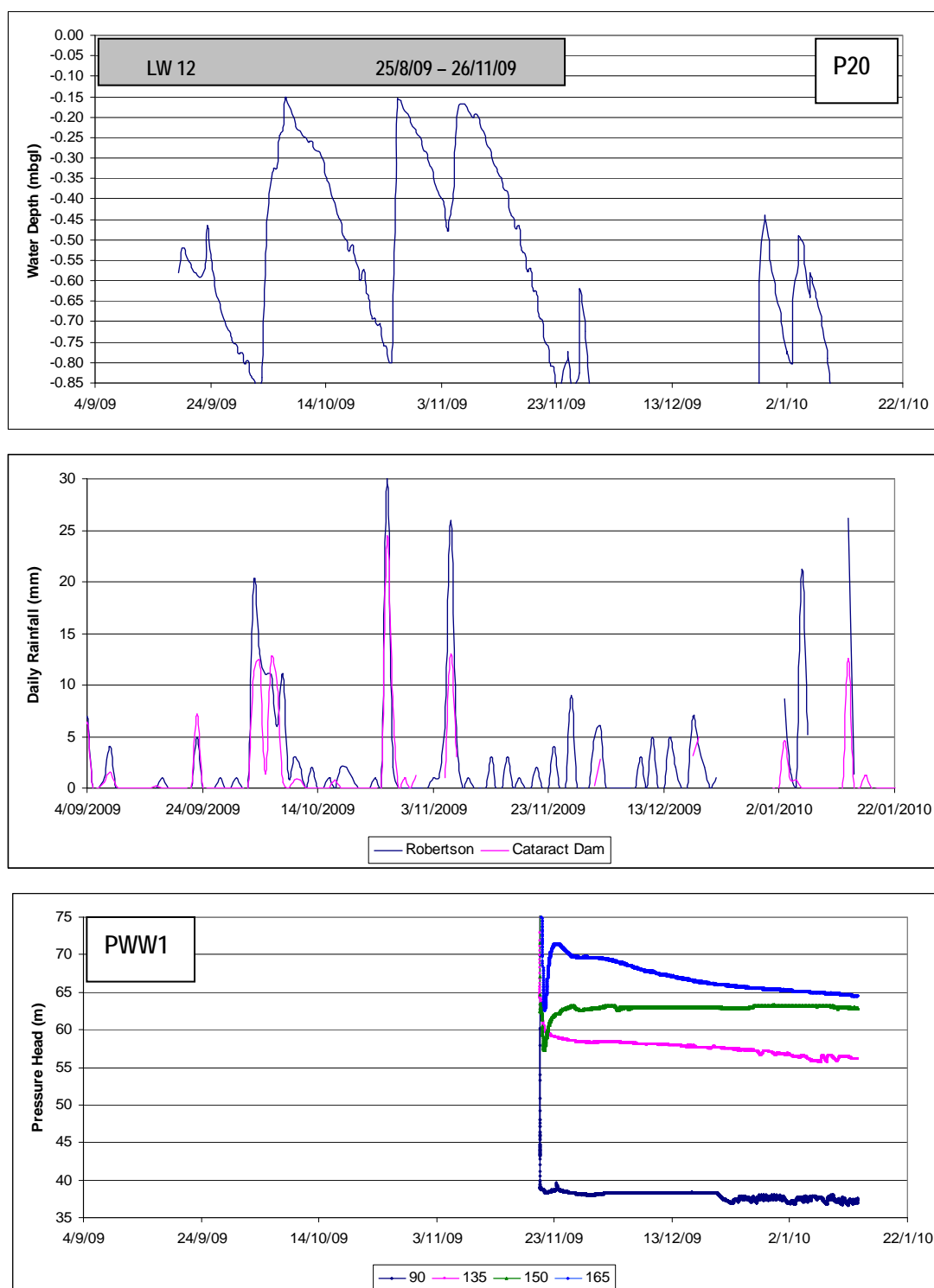
### 5.3.1 Potential Impacts

The following potential groundwater level impacts could occur;

- Temporary lowering of the deep piezometric surface over the subsidence area due to horizontal dilation of strata and resultant increase in secondary porosity.
- Hawkesbury Sandstone groundwater levels may reduce by up to 10m, and may stay at that reduced level until maximum subsidence develops at a specific location.
- No significant change in swamp piezometric levels due to subsidence outside of the effects of the current climatic variability.
- Hawkesbury Sandstone groundwater levels should recover over a few months as the newly developed secondary porosity is recharged by rainfall.
- No permanent post mining reduction in Hawkesbury Sandstone groundwater levels unless a new outflow path develops.

### 5.3.2 Observed Groundwater Levels

Groundwater levels monitored in PWW1 and the Swamp 20 piezometer (P20) are shown in **Figure 2**.



**Figure 2 P20 and PWW1 Groundwater Levels and Rainfall**

The monitoring data indicates there was no change in groundwater levels in either Swamp 20 or in the Hawkesbury Sandstone, Bald Hill Claystone or upper Bulgo Sandstone due to subsidence induced impacts.

Water levels in the perched Quaternary sedimentary aquifer at Swamp 20 were dominantly affected by the frequency and quantum of rainfall that occurred during the monitoring period and the water levels in the piezometer have a direct relationship with the amount of rainfall recharge that infiltrates in the 85cm deep swamp at P20.

The lack of plotted groundwater levels in P20 during December is due to the piezometer being dry in that period.

No evidence of swamp desiccation due to mining was observed during the field inspection.

The gradually reducing water level in the upper Hawkesbury Sandstone (90m bgl) and the Bald Hill Claystone (150m bgl) are due to the piezometric head “settling in” following installation of the piezometers in November 2009, and is not due to mining subsidence induced depressurisation.

Note there is no ongoing water quality in PWW1 as the bore now has sealed multi level vibrating wire piezometers cemented into the bore.

### 5.3.3 Groundwater Level Impacts

Within the limitations of the data no mining induced groundwater depressurisation was observed due to extraction of Longwall 12 in any of the monitored piezometers between the Swamp 20 alluvium and the upper Bulgo Sandstone.

*No TARP trigger levels were reached or exceeded and no ameliorative actions were required.*

## 5.4 Groundwater Quality

### 5.4.1 Potential Impacts

- Increased iron and manganese hydroxide precipitation in groundwater extracted from piezometers.
- Lowering of pH in piezometer water.

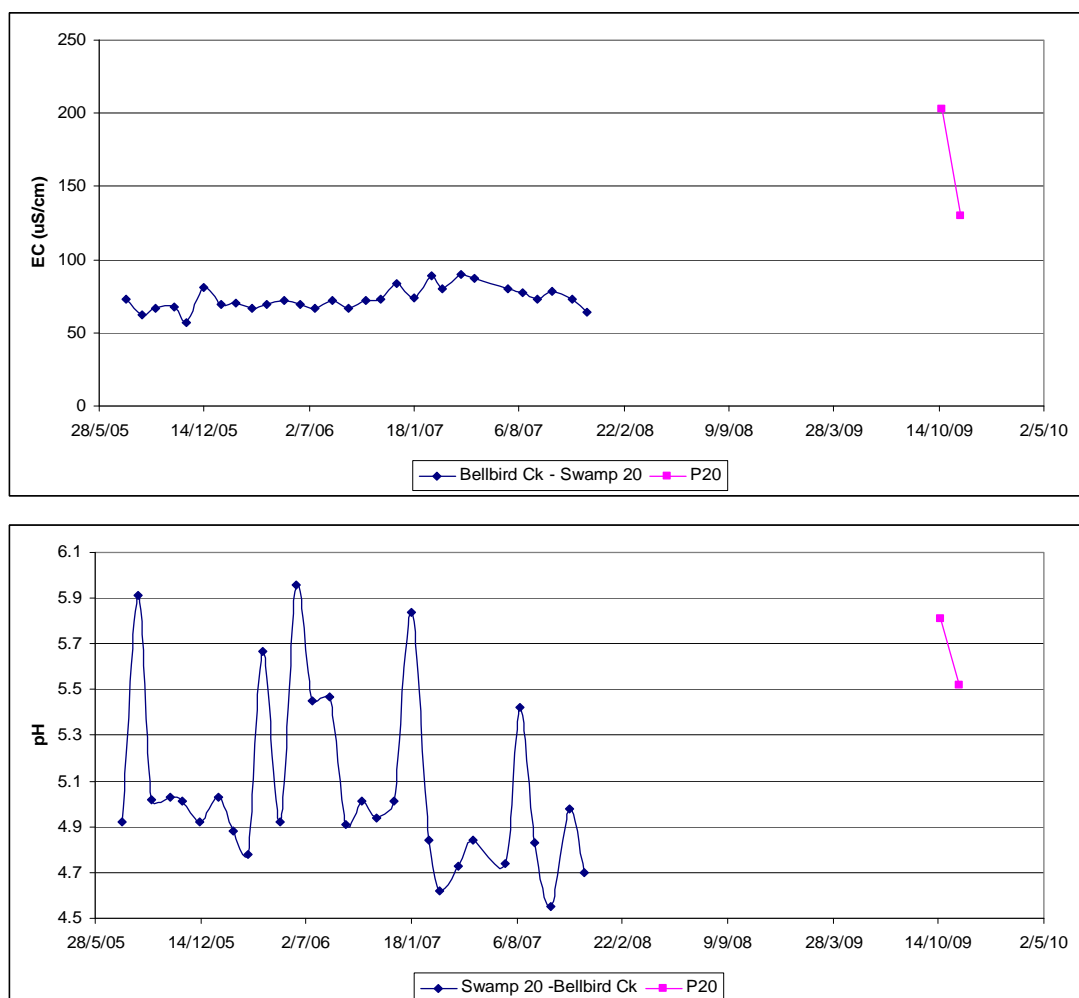
### 5.4.2 Observed Impacts

Groundwater sampling and laboratory analyses in P20 indicates that Swamp 20 exceeds the ANZECC 2000 Upland Streams water quality for total nitrogen, total phosphorous, copper, lead, zinc and nickel when the alluvium is saturated. As the perched aquifer runs dry after extended dry periods, there isn't a continual body of water in the piezometer to sample and monitor, so the data plot can have significant gaps.

Since and during extraction of Longwall 12, the field water quality in P20 has not changed markedly due to subsidence, although variations in response to the quantum and duration of rainfall recharge in the perched aquifer were observed.

The water quality from the Hawkesbury Sandstone between 23m and 53m below surface is within ANZECC 2000 Freshwater Stream guidelines. No ongoing water quality measurements are available in PWW1 as the bore has been sealed, with vibrating wire piezometers permanently installed in the bore. As the bore is sealed, no ongoing water quality monitoring is available from the bore.

Field groundwater quality monitoring for the Swamp 20 piezometer P20 and Bellbird Creek which drains from Swamp 20 is shown in **Figure 3**, with laboratory analyses for P20 and PWW1 shown in **Appendix A**.



**Figure 3 Swamp Surface Water (Bellbird Creek) and Shallow Groundwater Quality in P20**

No adverse effects on groundwater quality in Swamp 20 due to subsidence effects from extraction of Longwall 12 have been observed, no TARP water quality trigger levels have been reached or exceeded and no ameliorative actions are required.

## 5.5 Potential Inflow to Mine Workings

### 5.5.1 Predicted Impacts

- No observable increase in mine workings groundwater inflow.

### 5.5.2 Observed Impacts

Based on mine pump out data records, no observable increased inflow to the Wongawilli mine workings following extraction of Longwall 12 has occurred and no TARP trigger levels have been reached or exceeded.

## 5.6 Gas

### 5.6.1 Predicted Impacts

- Potential discharge of strata gas into private bores.

### 5.6.2 Observed Impacts

No discharge of strata gas has been observed to be discharging at surface or in the open standpipe piezometers in the monitoring area following extraction of Longwall 12.

No TARP trigger levels have been reached or exceeded due to extraction of Longwall 12.

## 6. PREDICTED AND OBSERVED SURFACE WATER IMPACTS

The observed impacts discuss general observations from Bellbird Creek, downstream of Swamp 20.

It should be noted that as Bellbird Creek was not undermined by Longwall 12, and due to the 170m separation distance from Bellbird Creek to Longwall 12, a detailed discussion on Bellbird Creek will be provided after LW11 is extracted.

It should also be noted that the predicted impacts are derived from the SMP which do not separate the potential surface water impacts of Longwall 12 from the overall impacts of the entire mining program.

### 6.1 Creek Subsidence

#### 6.1.1 Potential Impacts

- Maximum subsidence of <100mm along the creek line to the west of Bellbird Creek.

#### 6.1.2 Observed Impacts

- Maximum subsidence of 130mm along Subsidence Line EF, which does not intersect Bellbird Creek. No direct measurements have been conducted along Bellbird Creek.

No TARP trigger levels have been reached or exceeded and no ameliorative actions are required due to extraction of Longwall 12.

### 6.2 Stream Flow

#### 6.2.1 Potential Impacts

- No anticipated adverse effect on stream flow in Bellbird Creek.

#### 6.2.2 Observed Impacts

No observed adverse effect on Bellbird Creek resulting from extraction of Longwall 12.

No TARP trigger levels have been reached or exceeded and no ameliorative actions are required due to extraction of Longwall 12.

### 6.3 Stream Water Quality

#### 6.3.1 Potential Impacts

- Increased iron hydroxide precipitation in stream water.
- Lowering of pH in stream water.

#### 6.3.2 Observed Impacts

No observed adverse effect on Bellbird Creek resulting from extraction of Longwall 12.

No TARP trigger levels have been reached or exceeded and no ameliorative actions are required due to extraction of Longwall 12.

### 6.4 Stream Bed and Bank Stability

#### 6.4.1 Potential Impacts

- Increased stream bed or bank instability.
- Cracking of exposed sandstone rock faces.
- No anticipated adverse effect on Bellbird Creek resulting from extraction of Longwall 12.

#### 6.4.2 Observed Impacts

No observed adverse effect on Bellbird Creek resulting from extraction of Longwall 12.

No TARP trigger levels have been reached or exceeded and no ameliorative actions are required due to extraction of Longwall 12.

### 6.5 Summary of Results

During extraction of Longwall 12, no groundwater or surface water TARP triggers were exceeded.

**Table 4** summarises the predicted and observed effects on the Longwall 11 to 19 SMP area surface water and groundwater system in relation to extraction of Longwall 12.

**Table 4      Summary of Predicted and Observed Groundwater and Surface Water Impacts**

<b>Predicted Impacts</b>	<b>Observed Impacts Due to Extraction of Longwall 12</b>
<i>Adverse interconnection of aquifers and aquitards is not anticipated within 20m of the surface</i>	No adverse interconnection between aquifers and aquitards has been observed within 20m of the surface
<i>Potential increased rate of recharge into the plateau</i>	No increased rate of recharge has been observed
<i>Temporary lowering of shallow Hawkesbury Sandstone piezometric surface by up to 10m which may stay at that level until maximum subsidence develops</i>	Based on the available data, no lowering of the shallow Hawkesbury Sandstone piezometric surface has been observed in the nearest adjacent bore PWW1 in relation to extraction of Longwall 12
<i>Shallow Hawkesbury Sandstone groundwater levels should recover over a few months</i>	Based on the available data, no lowering of piezometric surface has been observed in association with Longwall 12
<i>No permanent post mining reduction in the shallow Hawkesbury Sandstone water levels unless a new outflow path develops</i>	Based on the available data, no lowering of the piezometric surface has been observed due to mining subsidence associated with Longwall 12
<i>Strata dilation and subsequent re-filling of secondary voids may temporarily lower the shallow Hawkesbury Sandstone standing water levels</i>	Based on the available data, no lowering of the shallow Hawkesbury Sandstone piezometric surface has been observed due to extraction of Longwall 12
<i>No observable lowering of the Upland Swamp piezometric surface due to subsidence, although there is expected to be a direct relationship between the lack of rainfall recharge and reduced water levels</i>	Lowering of the piezometric surface has been observed in association with low rainfall, although, based on the available data, no direct relationship to undermining Swamp 20 by LW 12
<i>The shallow Hawkesbury Sandstone piezometers may experience increased iron / manganese hydroxide precipitation and / or lowering of pH</i>	Based on the available data, the water quality in the shallow Hawkesbury Sandstone piezometers have not been affected by subsidence related effects due to extraction of Longwall12
<i>Upland Swamp piezometers may experience increased iron / manganese hydroxide precipitation and / or lowering of pH</i>	The Swamp 20 piezometer has not been adversely, or observably, affected by subsidence effects due to Longwall 12
<i>Interface drainage, ferruginous, brackish seeps may be generated in streams</i>	No interface drainage, ferruginous, brackish seeps have been generated in streams
<i>Ferruginous seeps may develop in the local creeks</i>	No ferruginous seeps have developed in Bellbird Creek due to extraction of LW12
<i>Increased basement groundwater seepage inflow into the workings should not occur</i>	No increased rate of groundwater seepage into the workings has occurred
<i>Strata gas discharge into piezometers may occur</i>	No strata gas discharge has occurred
<i>Stream flow in Bellbird Creek may be adversely affected by subsidence from Longwall 12</i>	Stream flow in Bellbird Creek has not been adversely affected by subsidence related to Longwall 12
<i>Stream water quality in Bellbird Creek may be adversely affected by subsidence from Longwall 12</i>	Stream water quality in Bellbird Creek has not been adversely affected by subsidence related to Longwall 12
<i>Stream bed and bank stability in Bellbird Creek may be adversely affected by subsidence from Longwall 12</i>	Stream bed and bank stability in Bellbird Creek has not been adversely affected by subsidence related to Longwall 12

## 7. PROPOSED AND ONGOING MONITORING

Swamp and basement groundwater as well as swamp and stream based surface water monitoring proposed for the Longwall 11 to 19 SMP Area was detailed in the ESSMP.

Future monitoring will be in accordance with the ESSMP and its contained Trigger Action Response Plan (TARP) for each component of the plan.

The monitoring program has been clarified since the ESSMP was produced to include the components outlined in **Tables 5 and 6**.

**Table 5                      Current and Proposed Monitoring  
(Basement and Swamp Groundwater) For Longwalls 11 and 12**

SMP Commitment	Monitoring To Date	Future Monitoring
<b>Aspect: Piezometer Baseline Data</b>		
Assess piezometer location, depth drilled, date drilled, aquifer depth, lithologies, yield and purpose for piezometers within LW11 to 19 SMP area	Piezometer database compilation completed	No additional baseline database compilation required
<b>Aspect: Piezometer Water Quality</b>		
Sample and monitor open standpipe piezometer water iron, field parameters and selected laboratory analytes for piezometers within LW11 to 19 SMP area	Longwall 12 extraction period monitoring and laboratory analysis conducted	Sample and monitor open standpipe piezometer iron, field parameters and selected laboratory analytes prior to and after each piezometer is undermined, or extraction is in the vicinity of an active panel, on a panel by panel basis
<b>Aspect: Piezometer Water Levels</b>		
Monitor standing water levels in open standpipe and multi level vibrating wire piezometers within the LW11 to 19 SMP area	Water level monitoring in all swamp and basement piezometers initiated	Monitor pressure heads in VWP multi level piezometers and standing water levels in open standpipe piezometers prior to and after each piezometer is undermined on a panel by panel basis
<b>Aspect: Strata Gas</b>		
Monitor strata gas discharges (if any) in piezometers within the LW11 to 19 SMP area	Piezometers monitored at time of t Longwall 12 extraction	Report any strata gas discharges (if any)

**Table 6 Current and Proposed Surface Water Monitoring for Longwalls 11 and 12**

<b>SMP Commitment</b>	<b>Monitoring To Date</b>	<b>Future Monitoring</b>
<b>Aspect: Stream Flow and Swamp Water Levels</b>		
Assess stream location within LW11 to 19 SMP area	Stream database completed	No additional data compilation required
<b>Aspect: Stream and Swamp Water Quality</b>		
Sample and monitor Bellbird Ck and Swamp 20 iron, field parameters and selected laboratory analytes in LW 11 to 19 SMP area	Longwall 12 sampling / monitoring completed.	Sample and monitor Bellbird Ck and Swamp 20 iron, field parameters and selected laboratory analytes prior to and after the stream and swamp are undermined
<b>Aspect: Stream and Swamp Bed and Bank Stability</b>		
Monitor Bellbird Ck and Swamp 20 stream bed and bank stability and presence of cracking	Monitoring conducted in Swamp 20 and Bellbird Ck	Continue regular monitoring
<b>Aspect: Strata Gas</b>		
Monitor strata gas discharges (if any) within LW 11 to 19 SMP area	Strata gas discharges (if any) being monitored when stream and swamp samples collected	Continue to monitor strata gas discharges (if any) when stream and swamp samples collected

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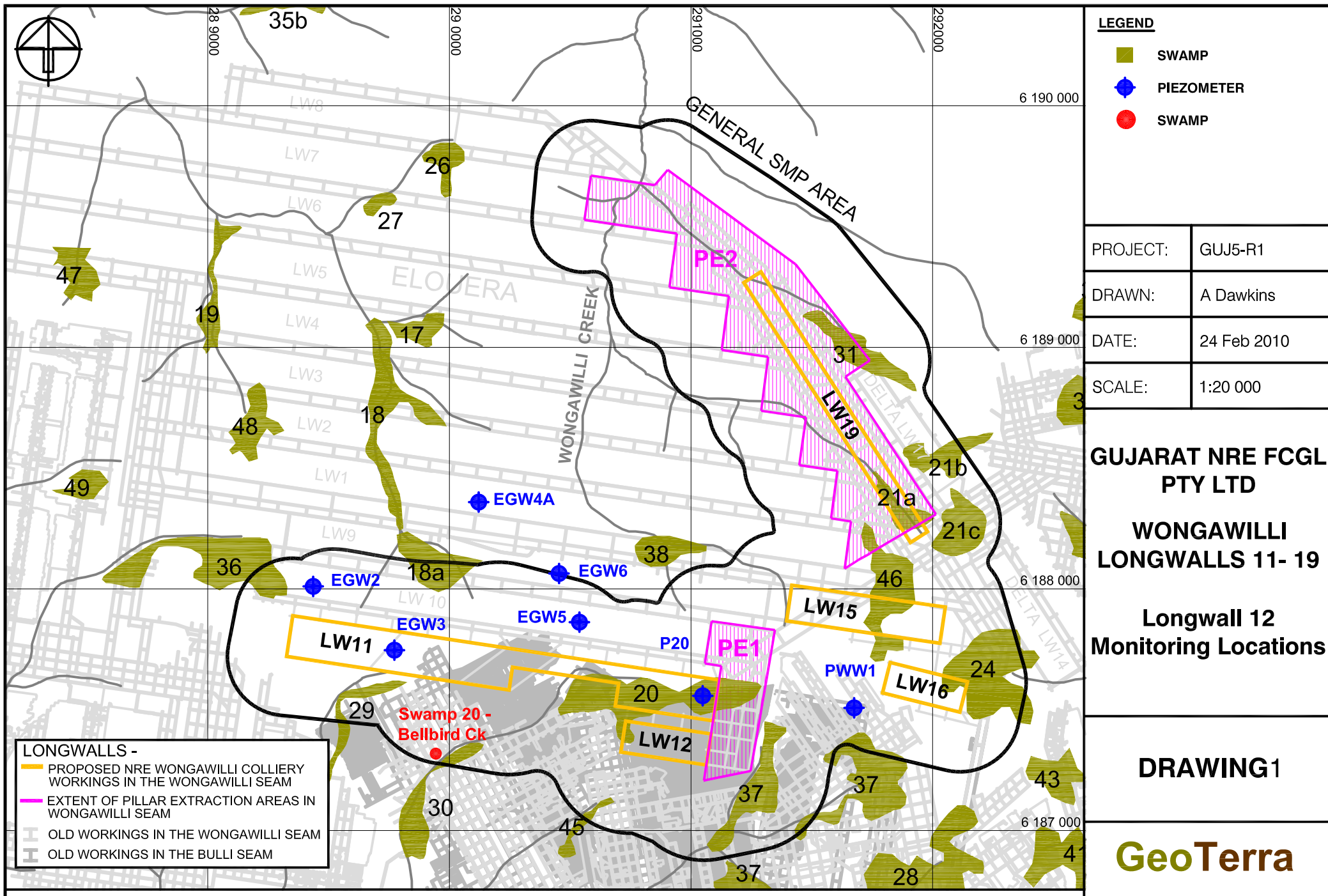
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## APPENDIX A

### WATER QUALITY MONITORING

TABLE A1 WONGAWILLI LONGWALLS 11 TO 19 GROUNDWATER QUALITY

ANZECC	2000									0.25	0.02			1.9	1.9	0.0014	0.0034	0.008	0.011	0.055	0.013(V)			
Date	TDS	Na	Ca	K	Mg	Cl	F	HCO3	SO4	Tot N	Tot P	Fe	Fe f	Mn	Mn f	Cu f	Pb f	Zn f	Ni f	Al f	As f	Li f	Ba f	Sr f
25/11/09 PWW1 (23-53)	47	13	2.3	2.8	0.7	18	<0.1	11	3	0.2	0.02	0.44	0.05	0.02	<0.01	<0.001	<0.001	0.005	<0.01	0.02	<0.01	<0.001	0.015	0.016
20/10/09																								
P20	92	23	5.1	1.4	3.9	46	<0.1	7	7	10	0.09	2	0.05	0.11	0.09	0.004	0.51	0.02	0.03	<0.01	<0.01	<0.001	<0.001	<0.001

## ATTACHMENT E

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### Terrestrial and Aquatic Ecology:

Terrestrial and Aquatic Flora and Fauna Assessment  
Wongawilli Colliery: Longwall 12 End of Panel Report. Biosis  
Research Pty. Ltd., March 2010 Ref: 5757



Terrestrial and Aquatic Flora and  
Fauna Assessment  
Wongawilli Colliery: Longwall 12  
End of Panel Report

March 2010

Biosis Research

Report for  
GUJARAT NRE FCGL Pty. Ltd.

Terrestrial and Aquatic Flora and  
Fauna Assessment  
Wongawilli Colliery - Longwall 12  
End of Panel Report

March 2010

Michael Roberts  
Brett Morrissey

**Ballarat:**

449 Dovelon Street North, Ballarat VIC 3354  
Ph: (03) 5331 7000 Fax: (03) 5331 7033  
email: [ballarat@biosisresearch.com.au](mailto:ballarat@biosisresearch.com.au)

**Melbourne:**

38 Bertie Street, Port Melbourne VIC 3207  
Ph: (03) 9646 9499 Fax: (03) 9646 9242  
email: [melbourne@biosisresearch.com.au](mailto:melbourne@biosisresearch.com.au)

**Canberra:**

Unit 16 / 2 Yallourn Street, Fyshwick ACT 2609  
Ph: (02) 6228 1599 Fax: (02) 6280 8752  
email: [canberra@biosisresearch.com.au](mailto:canberra@biosisresearch.com.au)

**Sydney:**

18-20 Mandible Street, Alexandria, NSW 2015  
Ph: (02) 9690 2777 Fax: (02) 9690 2577  
email: [sydney@biosisresearch.com.au](mailto:sydney@biosisresearch.com.au)

**Wangaratta:**

26a Reid Street, Wangaratta  
Ph: (03) 5721 9453 Fax: (03) 5721 9454  
Email: [wangaratta@biosisresearch.com.au](mailto:wangaratta@biosisresearch.com.au)

**Wollongong**

8 Tate Street Wollongong NSW 2500  
Ph: (02) 4229 5222 Fax: (02) 4229 5500  
Email: [wollongong@biosisresearch.com.au](mailto:wollongong@biosisresearch.com.au)

**BIOSIS RESEARCH** Pty. Ltd. A.C.N. 006 175 097  
Natural & Cultural Heritage Consultants

*Project no: s5757*

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- Ashleigh Pritchard (Biosis Research)

## ABBREVIATIONS

EEC	Endangered Ecological Community
EPBC Act	<i>Environment Protection and Biodiversity Conservation Act 1999</i>
ESSGW	Exposed Sandstone Scribbly Gum Woodland
ESSMP	Environment Subsidence and Safety Management Plan
MSEC	Mine Subsidence Engineering Consultants
ROTAP	Rare or Threatened Australian Plant as listed by Briggs and Leigh (1995)
SMP	Subsidence Management Plan
sp.	Species (singular)
spp.	Species (plural)
ssp.	Subspecies
TSC Act	<i>Threatened Species Conservation Act 1995</i>
var.	Variety

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# 1.0 INTRODUCTION

Biosis Research Pty. Ltd. was commissioned by Gujarat NRE FCGL Pty. Ltd. to undertake a post mining assessment of the terrestrial and aquatic ecological values in the area above Longwall 12 in the southern section of the Wongawilli Colliery, within the Metropolitan Special Area (Figure 1). This information will be used in the End of Panel Report, which is a condition of the approved *Wongawilli Environment Subsidence and Safety Management Plan* (ESSMP) (Gujarat NRE Minerals 2009).

Extraction of coal from Longwall 12 commenced on 25 August 2009 and was completed on 26 November 2009. The Study Area and surrounds have been subjected to previous mining activities associated with the Delta and Elouera Colliery. Longwall 12 is the first longwall extracted from Wongawilli Colliery under the current ESSMP approval.

Pre-mining flora and fauna surveys were conducted throughout the ESSMP approval area to provide an assessment of the potential subsidence related impacts of Wongawilli Colliery on the terrestrial flora and fauna throughout the surface area over Longwalls 11, 12, 15, 16, 19 and Pillar Extraction Area 1 (Biosis Research 2008b). Focal areas for the initial pre-mining surveys were Upland Swamps, creeklines, cliffs and rock outcrops within the approved ESSMP area, as well as any other areas determined to provide potential habitat for threatened flora and fauna species that have been previously recorded within the locality and that would be at risk of impacts due to mining induced subsidence. On the basis of these surveys, Assessments of Significance under the provisions of s5A of the NSW *Environmental Planning and Assessment Act 1979* were prepared for three threatened plant species and twelve threatened fauna species, which included:

- Prickly Bush Pea (*Pultenaea aristata*);
- Leafless Tongue Orchid (*Cryptostylis hunteriana*);
- Woronora Bearded Heath (*Leucopogon exolasius*);
- Threatened amphibian species; Littlejohn's Tree Frog (*Litoria littlejohni*), Giant Burrowing Frog (*Heleioporus australiacus*) and Red-crowned Toadlet (*Pseudophryne australis*);
- Broad-headed Snake (*Hoplocephalus bungaroides*);
- Southern Brown Bandicoot (*Isodon obesulus*);
- Giant Dragonfly (*Petalura gigantea*);

- Eastern Pygmy Possum (*Cercartetus nanus*);
- Spotted-Tailed Quoll
- Brush-tailed Rock Wallaby
- Cave dwelling microbats – Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*), Little Bentwing-bat (*Miniopterus australis*), Eastern Cave Bat (*Vespadelus troughtoni*) and Large-eared Pied Bat (*Chalinolobus dwyeri*);
- Large-footed Myotis (*Myotis macropus*);
- Long-nosed Potoroo (*Potorous tridactylus*); and
- Rosenberg's Goanna (*Varanus rosenbergii*).

Pre-mining aquatic ecology assessments were also carried out within the approved ESSMP area to determine potential subsidence related impacts of Wongawilli Colliery on the aquatic habitats throughout the surface area over Longwalls 11, 12, 15, 16, 19 and Pillar Extraction Area 1. These assessments focussed on parts of Wongawilli Creek, Native Dog Creek, Bellbird Creek, Flying Fox Creek and the associated tributaries. Habitat for three Endangered aquatic species, Macquarie Perch (*Macquaria australasica*), Adam's Emerald Dragonfly (*Archaeophya adamsi*) and Sydney Hawk Dragonfly (*Austrocordulia leonardi*) was identified in the broad vicinity of the approved ESSMP area (Biosis Research 2008a).

The size of Longwall 12 is relatively small in comparison to other longwalls within the approved ESSMP area. Thus, the Study Area for the current post-mining survey incorporates the area immediately above Longwall 12, extending to the limit of subsidence associated with Longwall 12 only. The key locations for inspection of possible impacts on terrestrial ecological values were Swamp 20, ephemeral drainage lines, rock outcrops and areas where threatened flora and fauna have previously been mapped (Figure 2 and Figure 3). As there were no aquatic habitats within the Study Area, aquatic surveys were considered unnecessary. It is anticipated that some of the survey locations inspected during the current survey will be revisited during future inspections to monitor residual and cumulative subsidence induced impacts.

This End of Panel (EoP) inspection and report compares the qualitative descriptions of ecological values observed pre-mining (Biosis Research 2008b) and the current condition of those values observed by Biosis Research on 27 January 2010 (post mining).

The current ecological assessment was undertaken two months following the cessation of Longwall 12 mining operations in accordance with the requirements of the ESSMP approval (Gujarat NRE Minerals 2009). As such, some longer term subsidence induced impacts may yet be realised for Longwall 12, although any further subsidence impacts are expected to be minor.

## 2.0 PREDICTED IMPACTS

The predicted impacts of longwall mining throughout the Wongawilli Colliery area of operations have been discussed by Biosis Research (2008b). This report summarises the types of impacts that may potentially result from longwall mining and how these may affect significant landscape units such as creeks, ephemeral drainage lines, Upland Swamps, rock outcrops or steep slopes.

For the purposes of framing the context for which this assessment and report is provided, the discussion by Biosis Research (2008b) is summarised below with reference to the full ESSMP area.

### 2.1 Natural features with the ESSMP area

The ESSMP area contains a range of natural features that may or may not be subject to impacts from subsidence. Subsidence is the relative lowering of the surface due to coal extraction through longwall mining methods and it has the potential to result in surface cracking and other related effects. Surface cracking can lead to redirection of water from rock bar controlled pools into the dilated strata below, before it emerges further downstream. From an ecological perspective, this fracturing can result in the draining of pools or substrates supporting vegetation dependent on surface water flows.

This section details the natural features that were identified in the pre-mining surveys to be at risk of subsidence induced impacts associated with the extraction of coal from Longwalls 11, 12, 15, 16, and 19 and Pillar Extraction Area 1. Habitats more likely to be affected by subsidence are those that rely on the presence of surface water, such as Upland Swamps, creeklines and drainage lines. Therefore, the discussion of predicted impacts focuses on the flora and fauna whose potential habitat occurs within these landscape features, and whose specific habitat requirements within these areas may be impacted by longwall mining and pillar extraction.

Predicted impacts of subsidence discussed below are based on the summary of the MSEC (2009) predictions provided in the Biosis Research (2008b) report. Where possible, specific reference has been made to Longwall 12 in relation to each of these features.

#### 2.1.1 Creeks

There are several creek lines and tributaries situated within the approved ESSMP area. These include Native Dog Creek, Bellbird Creek, Flying Fox No. 1 Creek, Wongawilli Creek and two unnamed tributaries of Wongawilli Creek.

These creeklines are predominantly ephemeral with significant flows only occurring after significant rainfall events. Some of the larger and deeper pools in these drainage lines retain permanent water between rainfall events particularly in association with Upland Swamps. Permanent flows within some of these creeks (e.g. Wongawilli Creek) occur downstream and outside the boundary of the ESSMP area.

In relation to Longwall 12, the nearest creek line is Flying Fox No. 1 Creek (approximately 170 m to the southeast), followed by Bellbird Creek (approximately 200 m to the west) and an unnamed tributary off Wongawilli Creek (approximately 500 m to the north). There are also several small ephemeral drainage lines that are associated with Upland Swamps that are located above and adjacent to Longwall 12.

#### ***Potential for Ponding and Flooding***

- Subsidence induced ponding and flooding changes within the creeklines present in the ESSMP area were considered unlikely to be significant, as a result of the pre-existing steep gradients along these creeks.
- Ponding and flooding associated with the extraction of coal from within the ESSMP area would therefore be considered unlikely to significantly impact terrestrial flora and fauna values.
- Several small ephemeral drainage lines occur within the limit of subsidence of Longwall 12. Although not specifically identified in the ESSMP, the predictions associated with ponding and flooding were restricted to the larger waterways. As such, small ephemeral drainage lines could be extrapolated to exhibit fewer impacts than the larger waterways as they rarely exhibit surface flows.

#### ***Potential for Desiccation and Scouring***

- Desiccation impacts on existing pools was considered unlikely to be significant in the creeklines within the ESSMP area, as a result of them being predominantly rock strata rather than alluvial deposits. In addition, existing natural gradients along the creeks are much steeper than the maximum predicted tilts.
- Scouring associated with the extraction of coal from within the ESSMP area was considered unlikely to significantly impact terrestrial flora and fauna values.
- In relation to LW 12, desiccation and scouring of pools within ephemeral drainage lines was therefore considered unlikely.

### ***Potential for Fracturing and Surface Flow Diversion***

- It was considered possible that tensile cracking could occur in the bed of Native Dog Creek, Wongawilli Creek and the tributaries of Wongawilli Creek. It was also considered possible that there may be some buckling and fracturing of the bedrock along Native Dog Creek, Bellbird Creek, Wongawilli Creek and the tributaries of Wongawilli Creek, above and adjacent to the proposed longwalls.
- If fracturing did occur, it was predicted to result in some surface water diversion into the dilated strata beneath the beds, and the draining of pools that may exist within the alignments. In times of heavy rainfall, a majority of runoff was expected to flow over the beds and would not be diverted into the dilated strata. Conversely, in periods of low rainfall, runoff may flow into the dilated strata and this could affect the quality and quantity of water in creeklines and tributaries. The latter was considered to have the potential to impact on terrestrial flora and fauna values by reducing surface water flows and impacting native vegetation. Runoff entering the dilated strata was predicted to not enter mine working areas, as a result of the presence of Bald Hill Claystone, which tends to act as an aquitard or aquiclude.
- These impacts were not however considered to be a significant concern for Longwall 12, as surface water flow in the ephemeral drainage lines is likely to occur only during or following rainfall events with the majority of flows passing over dilated strata. Consequently, in relation to Longwall 12 the potential for fracturing and surface flow diversion is considered unlikely.

#### **2.1.2 Lake Avon**

Lake Avon is located more than 1 km from any of the Longwalls associated with Wongawilli Colliery. Subsequently, Lake Avon is located well outside the area of potential subsidence impacts for Longwall 12.

#### **2.1.3 Cliffs, Steep Slopes and Pagodas**

- Any tension cracks or soil slumping that may be associated with subsidence in the ESSMP area were considered unlikely to result in any significant environmental impact.
- Large scale slope failure was considered unlikely in all areas except for those mined beneath Longwall 19.

- Impacts on steep slopes were not anticipated to have any significant impact on terrestrial flora and fauna values.
- No cliffs, steep slopes or pagodas were identified above Longwall 12 (Drawing No: MSEC360-08) (MSEC (2009)).

#### **2.1.4 Rock Outcrops**

- Any cracking in rock outcrops were expected to be of a minor nature, as a majority of the predicted subsidence parameters are relatively small, and the rock outcrops are discontinuous and relatively low in height and, therefore, less susceptible to subsidence induced impacts.
- Impacts on rock outcrops were not anticipated to have any significant impact on terrestrial flora and fauna values.
- Rock outcrops were identified above Longwall 12, particularly along ridgelines and between the woodland and Upland Swamp interface (Drawing No: MSEC360-08) (MSEC (2009)).

#### **2.1.5 Upland Swamps**

- It was considered unlikely that the predicted levels of subsidence, tilts, strains, upsidence and closure ground movements or the potential bedrock and surface cracking would have a significant impact on Upland Swamps, because they have naturally developed on strata with notable pre-existing cracks and porous strata. Furthermore, as the swamps in the approved ESSMP area are considered to be ‘headwater swamps’ and not ‘infill swamps’ impacts were expected to be low.
- The maximum predicted differential subsidence (635 mm) was greatest in Swamp 20, which lies adjacent to Longwall 12. This level of tilt was considered to potentially result in local changes in the water levels within the swamp and, consequently, the local distribution of vegetation.

#### **2.1.6 The Likelihood of Gas Emissions at the Surface**

- Gas emissions associated with the extraction of coal from Longwalls within the ESSMP area were considered to be extremely unlikely.
- Therefore, gas emissions in response to the extraction of coal from Longwall 12 were considered unlikely to occur.

### 2.1.7 Water quality

- Within the approved ESSMP area, it was considered that any subsidence induced impacts on water quality, as a result of leaching of minerals from fractured strata along a creek bed, would be localised.
- Impacts on water quality were not anticipated to have any significant impacts on terrestrial flora and fauna values.
- Therefore, in relation to Longwall 12 impacts on water quality would be considered low as the drainage lines affected by Longwall 12 are ephemeral.

## 2.2 Native Vegetation

Field surveys conducted by Biosis Research (2008b) confirmed that the vegetation communities within the ESSMP area were primarily consistent with the broad scale vegetation mapping of the region by NPWS (2003). Biosis Research (2008b) reported that the native plant communities in the broader area encompassing the approved ESSMP area were in good condition, with the exception of vegetation occurring under the powerlines which were rated as moderate..

### 2.2.1 Plant communities

Six plant communities were identified as occurring within the ESSMP area (Figure 2). These are:

- Exposed Sandstone Scribbly Gum Woodland – this community occurs along the main ridgelines within the SMP area, which are dissected by fire trails and powerlines.
- Sandstone Gully Peppermint Forest – occurs along the main creek lines within the SMP area and adjacent slopes.
- Rock Plate Heath Mallee – this community typically occurs on large sandstone outcrops and rock plates. This vegetation type is present along creek lines and lower slopes throughout the SMP area.
- Upland Swamps – this community comprises five sub-communities including Banksia Thicket, Tea-Tree Thicket, Sedgeland-Heath Complex, Fringing Eucalypt Woodland and Mallee-Heath. Three of these communities occur in the SMP area:
  - Banksia Thicket,

- Sedgeland-Heath Complex; and
- Fringing Eucalypt Woodland.

Vegetation communities occurring above Longwall 12 predominantly comprised ESSGW and a small patch of Upland Swamp in the north-western part of the Study Area.

The assessment by MSEC (2008) concluded that the predicted differential subsidence movements may result in changes in the water levels within the swamps. Consequently, this was predicted to potentially change the distribution of local vegetation within these communities. Importantly, potential surface fracturing and gas emissions were considered unlikely to result in the broad scale alteration of species composition or distribution of other communities identified to occur with the ESSMP.

## 2.3 Threatened Flora

Large populations of *Pultenaea aristata* Prickly-bush Pea, listed as Vulnerable on both the TSC and EPBC Acts, were recorded within and associated with Upland Swamps during pre-mining surveys (Biosis Research 2008b). Further threatened plant species are considered to have potential habitat in the Study Area including *Acacia bynoeana*, *Acacia baueri* ssp. *aspera*, *Cryptostylis hunteriana*, *Leucopogon exolasius*, *Melaleuca deanei*, *Persoonia acerosa*, *Persoonia hirsuta* and *Persoonia bargoensis*.

Assessments of Significance as required under the TSC and EPBC Acts were prepared for three of these species (Biosis Research 2008b). These assessments concluded that Longwall mining was unlikely to have a significant impact on any threatened flora with known or potential habitat in the Study Area.

## 2.4 Threatened Fauna and Fauna Habitat

The Giant Burrowing Frog (*Heleioporus australiacus*) and Littlejohn's Tree Frog (*Litoria littlejohni*) were recorded during pre-mining surveys (Biosis Research 2008b). Another six threatened species were previously recorded in the Study Area. Additionally, potential habitat was identified for a further 29 threatened or migratory species in the Study Area. Sixteen of these species were determined have habitat which may be impacted by subsidence.

Assessments of Significance, as required under the TSC and EPBC Acts, were prepared for these species (Biosis Research 2008b). These assessments initially concluded that the proposal was likely to have a significant impact on a local population of Littlejohn's Tree Frog, Giant Burrowing Frog and Red-crowned

Toadlet. A subsequent report revised this assessment on the basis of discussions with MSEC and further surveys and detailed assessments of the potential impacts of subsidence on sensitive habitat features (Biosis Research 2009). Consequently, impact assessments carried out on the three threatened frog species concluded that there was unlikely to be a significant impact on a local population on any of these species.

Three broad fauna habitat types were recorded during the pre-mining survey: creeks and drainage lines, Upland Swamps, and ridgelines. All of these key habitats were assessed to be in a good condition.

## **2.5 Threatened Aquatic Species and Habitat**

Habitat for three Endangered aquatic species, Macquarie Perch (*Macquaria australasica*), Adam's Emerald Dragonfly (*Archaeophya adamsi*) and Sydney Hawk Dragonfly (*Austrocordulia leonardi*) was identified in the broad vicinity of the approved SMP area (Biosis Research 2008a). Assessments of Significance concluded that the proposal was unlikely to have a significant impact on local populations of these species.

In relation to Longwall 12, there is no aquatic habitat within the limit of subsidence of this Longwall that would constitute potential habitat for these species.

### 3.0 SURVEY METHOD

Post-mining surveys were conducted for Longwall 12 on 27 January 2010. In order to provide information against which pre-mining habitat types and condition can be compared, the methods utilised in this report follow those described in the pre-mining assessment (Biosis Research 2008b). Survey effort was focussed on natural landscape features within the limit of subsidence of Longwall 12 that have been identified to be most likely subjected to subsidence induced impacts. These areas included rock outcrops, ephemeral drainage lines and Upland Swamps (Swamp 20). It must be noted that there were no creekline or major tributaries or aquatic habitats located above Longwall 12. As such, the current surveys focused on terrestrial habitats within the Study Area only.

In general, the field survey involved qualitative assessments of vegetation condition and fauna habitats and an inventory of incidental fauna sightings was compiled. Visual impacts to vegetation and fauna habitats or evidence of other possible impacts of longwall mining such as tree falls, vegetation dieback and recent erosion that might affect ecological processes and functions were noted if encountered.

## 4.0 OBSERVED IMPACTS

At the time of writing the Flora and Fauna Assessment EoP report, there have been no identified subsidence induced landscape impacts within the Study Area (e.g. fracturing, surface cracks etc.).

### 4.1 Observed Impacts on Plant Communities

Random meanders were carried out in the terrestrial native plant communities in the Study Area. No impacts such as water stress or dieback were observed in the Exposed Sandstone Scribbly Gum Woodland (ESSGW) that occurs within the Study Area (Figure 2). However, two recently fallen trees were observed in the current surveys over Longwall 12 (Plates 1 and 8), but it was difficult to ascertain if this was in response to subsidence as there were no apparent soil cracks or rock fractures near the root zone. The ESSGW in Study Area was in good condition.

Upland Swamp vegetation of Swamp 20 at the western end of Longwall 12 and adjacent areas was inspected. No impacts as a result of longwall mining were observed in the current surveys within this plant community. The Upland Swamp vegetation over Longwall 12 and adjoining areas of Swamp 20 was in a good condition.

### 4.2 Observed Impacts on Significant Plant Species

One small patch of the threatened plant species *Pultenaea aristata* Prickly-bush Pea was recorded on the southern edge of Longwall 12 in the current surveys (Figure 3). The species has been recorded in Swamp 20 to the north of Longwall 12 and other nearby locations. The specimens observed in the current surveys were in a healthy condition. Similarly, the ESSGW and Upland Swamp provides potential habitat for the species within the Study Area and remains in good condition.

In addition to *Pultenaea aristata* Prickly-bush Pea, potential habitat for other threatened plant species assessed for the approved ESSMP area is unlikely to have been affected by subsidence related impacts associated with the mining of Longwall 12.

### 4.3 Observed Impacts on Threatened Fauna and Fauna Habitats

During the post-mining inspection for Longwall 12, all fauna habitats were assessed as being in a similar condition to that before mining. Microhabitat

features such as tree-hollows, hollow logs, rock outcrops, dense understorey, drainage lines and soaks were all widely abundant within the Study Area.

Several temporary pools and soaks were observed within the ephemeral drainage lines. These areas contained sufficient resources to provide breeding and foraging habitat for threatened amphibian species, despite there being no recent rainfall activity immediately before the time of the survey. In addition, there were no apparent signs of base cracking observed within these pools.

No subsidence related impacts on large rock outcrops and crevices were observed during the post mining inspection. These areas provide good quality potential habitat for the threatened Broad-headed Snake (*Hoplocephalus bungaroides*), Red-crowned Toadlet and Rosenberg's Goanna (*Varanus rosenbergi*). Consequently, it is unlikely that these species have been impacted by the mining of Longwall 12 at this stage.

Apart from the two trees that had recently fallen, there was no evidence of any impacts on fauna habitats within the ESSGW or Upland Swamp. ESSGW provides microhabitats such as leaf litter, undergrowth, various canopy layers, hollow-bearing trees and fallen timber, which provide shelter, breeding and foraging resources for wide range of birds, mammals and reptiles. Unidentified bandicoot (*Perameles/Isoodon* sp) diggings were observed within this habitat at the time of the current study. As these species require a high degree of structural habitat complexity, their presence is indicative that such features have been maintained.

Threatened animal species with potential habitat in the Study Area are unlikely to have been affected by subsidence related impacts associated with the mining of Longwall 12. The broad scale habitat of native vegetation communities remains in the same condition to that prior to longwall mining.

## 4.4 Summary of Predicted and Observed Impacts

Table 1 is a summary of the comparison between the predicted and observed impacts of mining on general habitat features and threatened terrestrial flora and fauna. Predicted impacts have been drawn from the pre-mining flora and fauna assessment and reports from specialist consultants (Biosis Research 2008b; Biosis Research 2008a; MSEC 2009).

**Table 1: Predicted and Observed Impacts of mining on general habitat and threatened terrestrial and aquatic flora and fauna.**

Flora and fauna features	Predicted Impact	Observed Impact
Plant communities and fauna habitat	Minor impacts to Upland Swamp vegetation through change in water levels, and the cracking of soils.	No impacts were observed to terrestrial native plant communities or terrestrial and riparian fauna habitats.
	Tension cracks or soil slumping on steep slopes possible, but unlikely to result in significant environmental impact. Large scale slope failures were considered unlikely.	Minor tree falls observed, difficult to ascertain if this is in response to subsidence.
	Rock shelves, outcrops and overhang structures unlikely to be impacted.	None observed.
	Unlikely that the proposed longwall mining activities and the associated subsidence impacts would have a significant impact on any plant community within the Study Area.	No significant impacts to plant communities observed.
Threatened Fauna	Threatened amphibian species (Littlejohn's Tree Frog, Red-crowned Toadlet and Giant Burrowing Frog) – potential alteration to breeding, sheltering and foraging habitat.	The mining of Longwall 12 is not considered to have impacted any threatened animal species. There has been no observable or measurable alteration or damage to potential habitat such as pools, ephemeral drainage lines or rock outcrops.
Threatened Flora	Unlikely that any threatened flora would be significantly impacted by subsidence resulting from Longwall mining.	The mining of Longwall 12 is not considered to have impacted any threatened plant species. There has been no observable or measurable alteration or damage to habitat for threatened flora species either known from or potentially occurring over Longwall 12 or the Study Area during the current surveys.
Aquatic	Unlikely that any threatened aquatic species would be significantly impacted by subsidence resulting from Longwall mining.	There are no aquatic habitats within the limit of subsidence above Longwall 12.

## 5.0 COMPLIANCE WITH APPROVAL

Biosis Research (2008b) outlined a number of recommendations in the pre-mining flora and fauna assessment to minimise the impact of the proposal on the environment, including threatened species that occur within and adjacent to the Study Area. These recommendations are presented in Table 2 (Biosis Research 2008b).

**Table 2: Recommendations to minimise the impact of the proposal on the environment and current implementation**

Recommendations	Current Implementation
Where subsidence-related fracturing or dilation occurs, remediation works could be employed	No subsidence-related fracturing or dilation was observed above Longwall 12 during the current assessment. Consequently, no further action is required at this stage.
Where surface water is lost due to subsidence induced fracturing these areas should be mitigated as soon as feasible following subsidence movements completing in order to minimise any impact on frog recruitment.	No surface water or drainage of pools as a result of any subsidence related fractures was observed during the current assessment. Therefore, no further action is required at this stage.
Where surface cracks occur within general woodland and/or forest areas they should be mitigated as soon as feasible following subsidence movements completing in order to minimise impacts of fauna entrapment	No subsidence-related surface cracks or fracturing was observed above Longwall 12 during the current assessment. Consequently, no further action is required at this stage.

Table 3 is a summary of the monitoring programs undertaken as part of the ESSMP commitments (Gujarat NRE Minerals 2009).

**Table 3: ESSMP monitoring commitments and status**

ESSMP Commitments	Monitoring to date	Future Monitoring
<b>Aquatic Ecology</b>		
<b>Baseline:</b> <ul style="list-style-type: none"> <li>Pre-mining surveys and assessment for threatened aquatic fauna and water quality impacts in major drainage lines of Study Area</li> </ul>	<ul style="list-style-type: none"> <li>Targeted surveys for threatened aquatic fauna in major drainage lines of the Study Area (Biosis Research 2008a).</li> <li>Predictive water quality impact assessments (Wood 2008).</li> </ul>	<ul style="list-style-type: none"> <li>AUSRIVAS sampling of reference and impact locations.</li> </ul>
<b>During active mining:</b> <ul style="list-style-type: none"> <li>Incidental observations of impacts to aquatic habitats as part of the water quality monitoring programme.</li> </ul>	<ul style="list-style-type: none"> <li>Comparisons of predicted and observed groundwater and surface water changes and analysis of water quality parameters (GeoTerra 2010).</li> </ul>	<ul style="list-style-type: none"> <li>AUSRIVAS sampling of reference and impact locations.</li> </ul>
<b>Post mining:</b> <ul style="list-style-type: none"> <li>As for active mining.</li> </ul>	<ul style="list-style-type: none"> <li>Sampling and monitoring of surface and groundwater levels and analysis of water quality parameters (GeoTerra 2010).</li> </ul>	<ul style="list-style-type: none"> <li>Continued incidental observations of impacts to aquatic habitats as part of the water quality monitoring program.</li> <li>AUSRIVAS sampling of reference and impact locations.</li> </ul>
<b>Terrestrial Ecology</b>		
<b>Baseline:</b> <ul style="list-style-type: none"> <li>Observation of identified threatened species</li> <li>Amphibian monitoring</li> <li>Swamp and riparian vegetation monitoring</li> <li>Ridgetops – vegetation and fauna habitats</li> </ul>	<ul style="list-style-type: none"> <li>Flora and fauna habitat-based assessments and nocturnal frog monitoring (Biosis Research 2008b).</li> <li>Spring flora and fauna monitoring of reference and impact creeks and Upland Swamps at long term monitoring locations in the ESSMP area.</li> </ul>	<ul style="list-style-type: none"> <li>Assessment of sites established for the current survey to examine cumulative impacts of ongoing longwall mining in the ESSMP area and residual impacts associated with the mining of Longwall 12.</li> </ul>

ESSMP Commitments	Monitoring to date	Future Monitoring
<b>During active mining:</b> <ul style="list-style-type: none"> <li>As above</li> <li>Bi-annual monitoring during entire extraction period</li> </ul>	<ul style="list-style-type: none"> <li>Not required due to the relatively small size of the longwall.</li> </ul>	<ul style="list-style-type: none"> <li>Biannual flora and fauna surveys at long term ESSMP monitoring sites.</li> <li>Assessment of sites established for the current survey to examine cumulative impacts of ongoing longwall mining in the ESSMP area and residual impacts associated with the mining of Longwall 12.</li> </ul>
<b>Post mining:</b> <ul style="list-style-type: none"> <li>As above</li> <li>Annual monitoring for 1 year post extraction</li> </ul>	<ul style="list-style-type: none"> <li>Flora and fauna assessment (this report).</li> </ul>	<ul style="list-style-type: none"> <li>Continued biannual flora and fauna surveys at long term ESSMP monitoring sites.</li> </ul>

## 6.0 CONCLUSION

Biosis Research prepared terrestrial and aquatic flora and fauna impact assessments for Longwalls 11, 12, 15, 16, 19 and Pillar Extraction 1 in December 2008 (Biosis Research 2008b; Biosis Research 2009; Biosis Research 2008a). This assessment concluded that the proposed extraction would be unlikely to significantly impact on threatened flora species and aquatic species that occur or are considered likely to occur within the approved ESSMP area, whilst significant impacts were predicted and later revised on the basis of further investigations and discussions with MSEC for three threatened fauna species: Giant Burrowing Frog, Red-crowned Toadlet and Littlejohn's Tree Frog (Biosis Research 2009).

The extraction of coal from Longwall 12 was completed in November 2009. As a requirement of the ESSMP, a post-mining habitat condition assessment of the area above Longwall 12 was undertaken in January 2010 by Biosis Research. Plant communities, fauna habitats and threatened species, are not considered to have been affected by subsidence related impacts associated with the mining of Longwall 12 at this stage.

Terrestrial and aquatic observational monitoring in the ESSMP area will continue for at least 12 months following mining as a component of the Wongawilli Colliery Ecological Monitoring Program (Gujarat NRE Minerals 2009). Throughout this process, any significant changes to the natural environment will be referred to specialist consultants for further assessment with regards to the associated affect on threatened species, populations or ecological communities. Furthermore, it is anticipated that some survey locations used in this assessment will need to be re-visited during inspections of future longwall operations within the ESSMP area to identify potential cumulative and residual impacts on threatened terrestrial and aquatic flora, fauna and their habitats.

# PLATES

## TABLE OF PLATES



**Plate 1:** Tree fall *Eucalyptus piperita* within ESSGW Wpt 1 (290978 E, 6187348N), 27 January 2010



**Plate 2:** ESSGW in good condition. Wpt 2 (290978E, 6187348N), 27 January 2010



**Plate 3:** Unidentified Bandicoot (*Perameles/Isodon* sp) digging within ESSGW, Wpt 4 (290798E, 6187320N), 27<sup>th</sup> January 2010



**Plate 4:** Edge of Upland Swamp (Swamp 20) and ESSGW, Wpt 5 (290798E, 6187373N), 27<sup>th</sup> January 2010



**Plate 5:** Ephemeral drainage line and rock outcrop (upstream) leading into Swamp 20, Wpt 6 (290710E, 6187447N), 27 January 2010



**Plate 7:** Ephemeral drainage line and rock outcrop (downstream) leading into Swamp 20, Wpt 6 (290710E, 6187447N), 27 January 2010



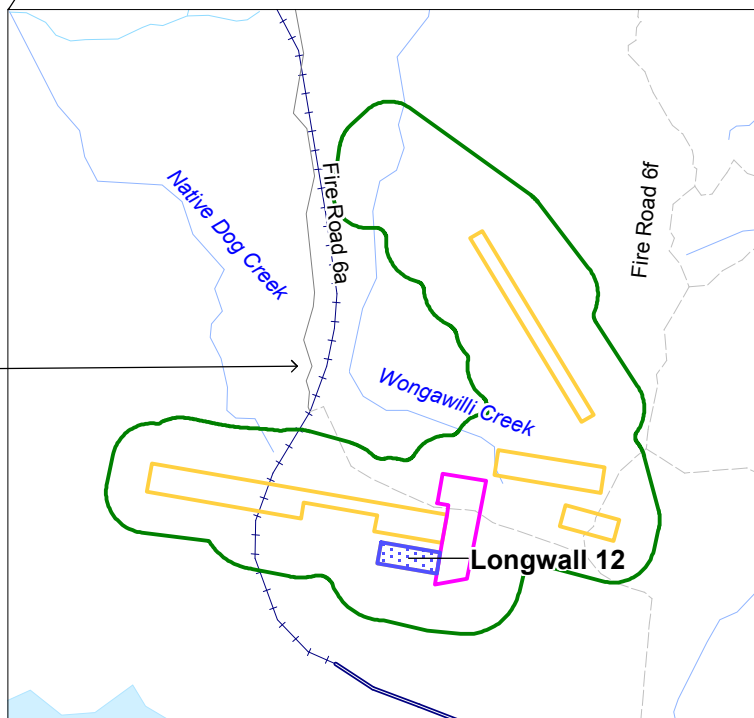
**Plate 8:** *Eucalyptus haemostoma* tree fall within ESSGW Wpt 7 (290978E, 6187269N), 27 January 2010

Note: See Figure 4 for Waypoint (Wpt) locations and Appendix 1 for details of survey sites at each Waypoint location.

# FIGURES



SMP area



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NEW SOUTH WALES 2500

Figure 1: Location of the SMP Area and Study Area in a regional context

Date: 5 February 2010

Drawn by: ANP

File number: S5757

Checked by: MWR

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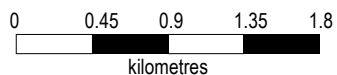
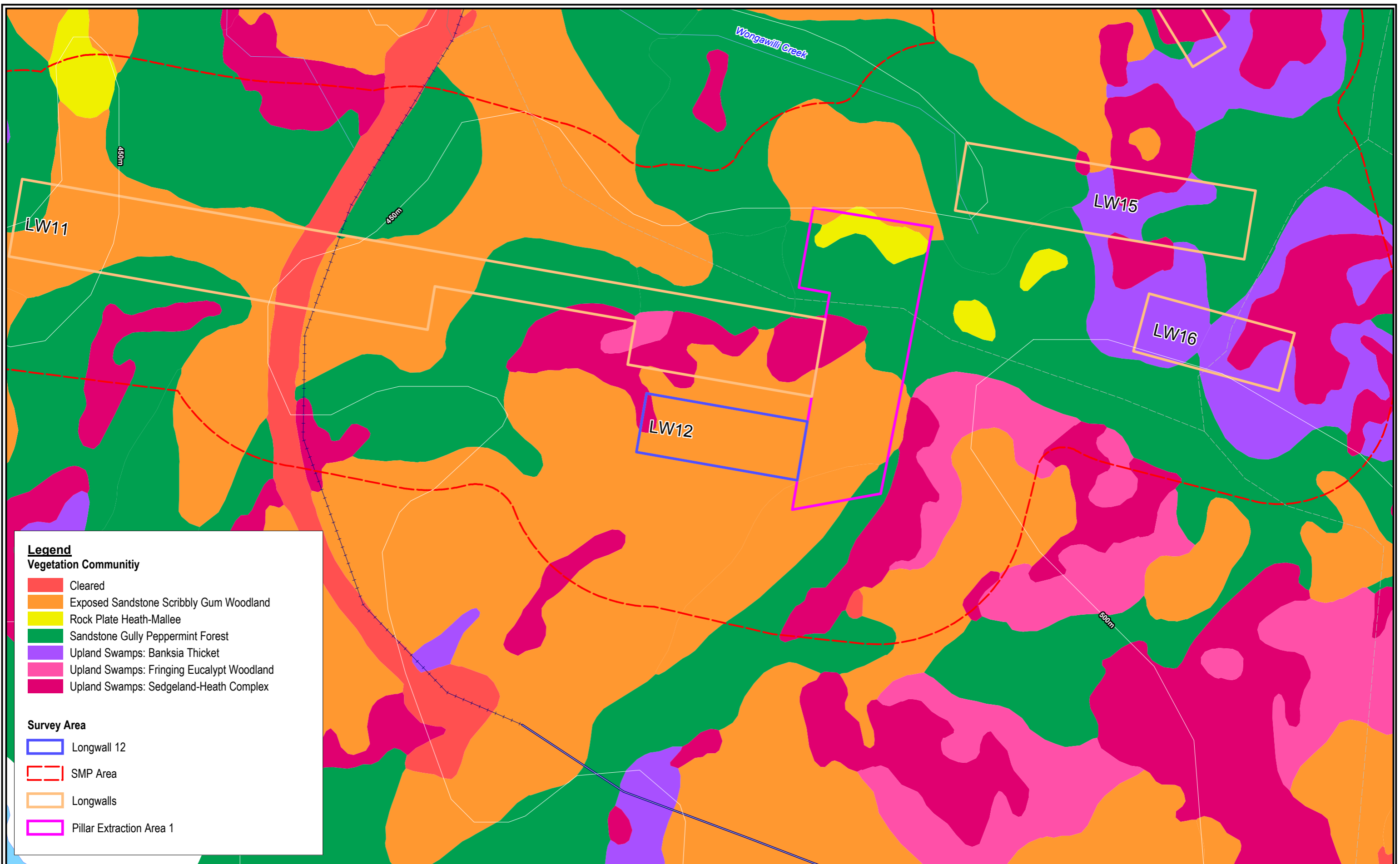


Figure 1



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Figure 2: Vegetation mapping of the Study Area

Date: 5 February 2010

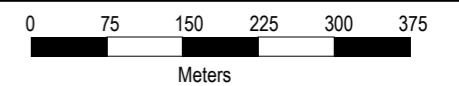
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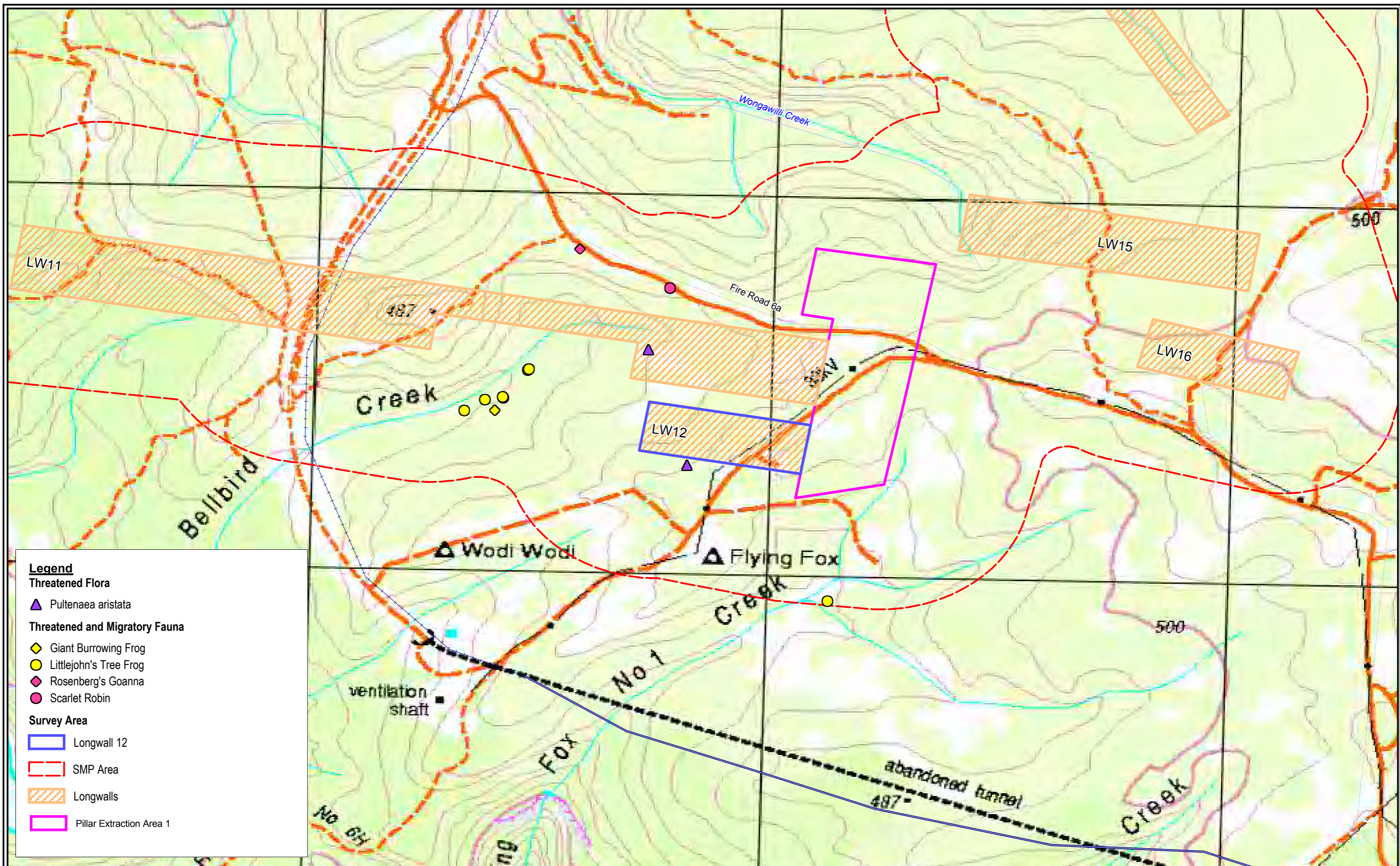
**Acknowledgements:**  
DECCW/NPWS  
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Scale: 1:7,500 at A3  
Map Projection: Transverse Mercator  
Horizontal Datum: Geocentric Datum of Australia 1994  
Grid: Map Grid of Australia, Zone 56



Figure 2



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Figure 3: Threatened Flora and Fauna located within the Study Area.

Date: 5 February 2010

File number: S5757

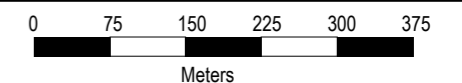
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**Acknowledgements:**

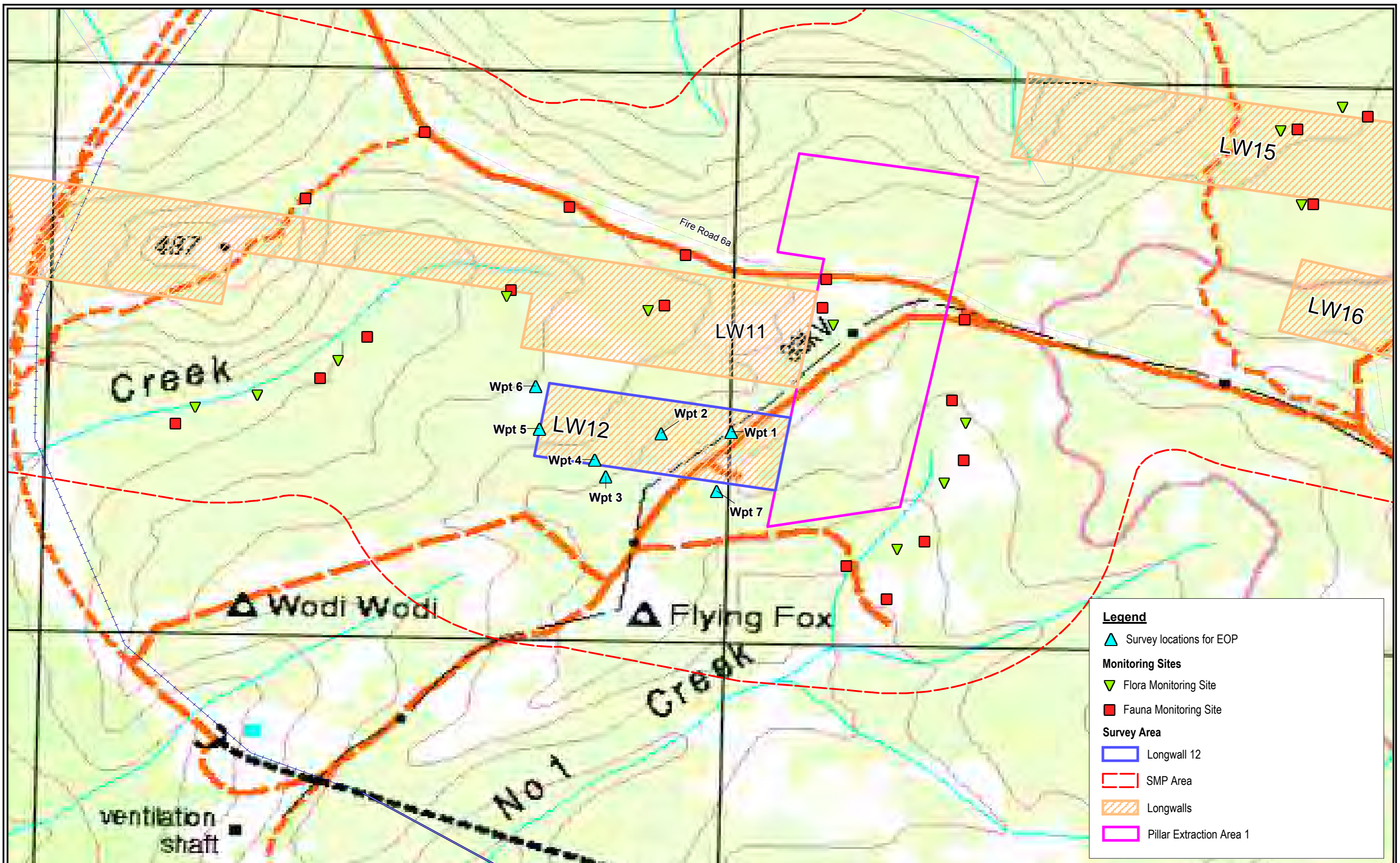
Site data from DECCW and Biosis Research Pty Ltd  
Topographic Image from Land and Property Management  
Authority 1:25000 topographic map series (2006)  
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Scale: 1:7,500 at A3  
Map Projection: Transverse Mercator  
Horizontal Datum: Geocentric Datum of Australia 1994  
Grid: Map Grid of Australia, Zone 56



Figure 3



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Figure 4: Longwall 12 flora and fauna EoP survey locations and existing long-term monitoring points

Date: 5 February 2010

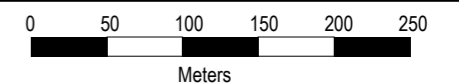
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Topographic Image from Land and Property Management  
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Scale: 1:5,000 at A3  
Map Projection: Transverse Mercator  
Horizontal Datum: Geocentric Datum of Australia 1994  
Grid: Map Grid of Australia, Zone 56



Figure 4

# APPENDICES

# APPENDIX 1: DETAILS OF SURVEY SITES (JANUARY 2010 SURVEY)

Survey Site	Location	Description	Potential/ Observed Subsidence Impacts	Impact Consistent with Predictions? Y/N	Observed Impact to Threatened Flora	Observed Impact to Threatened Fauna and Fauna Habitat
Wpt1 290978E 6187348N	Near Fire Rd 6H	ESSGW and fauna habitats in good condition.	One fallen <i>Eucalyptus piperita</i> .	Y	None.	None
Wpt2 290978E 6187348N	Central zone of LW12	ESSGW and fauna habitats in good condition.	None	Y	None	None
Wpt3 290814E 6187295N	Sthn margin of LW12	ESSGW and fauna habitats in good condition. <i>Pultenaea aristata</i> recorded in healthy condition.	None	Y	None	None
Wpt4 290798E 6187320N	Sthn margin of LW12	ESSGW and fauna habitats in good condition, observation of Bandicoot sp diggings.	None	Y	None	None
Wpt5 290717E 6187373N	Wstn margin of LW12	ESSGW, Upland Swamp and fauna habitats in good condition. Observation of Bandicoot sp diggings.	None	Y	None	None
Wpt6 290710E 6187447N	Wstn margin of LW12	Upland Swamp and fauna habitats in good condition.	None	Y	None	None
Wpt7 290978E 6187269N	Sth Estn margin of LW12	ESSGW and fauna habitats in good condition.	One fallen <i>Eucalyptus haemastoma</i>	Y	None	None

**Note:** Refer to Figure 4 for location of survey sites.

# REFERENCES

## REFERENCES

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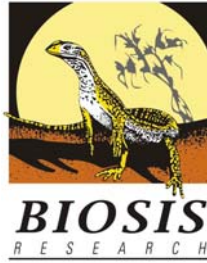
Wood J (2008) 'Indicative Hydrogeology NRE Wongawilli Colliery (Proposed extraction of Longwalls 11, 12, 15, 16 & 19 and Pillar Extraction Area 1).' No. Version 2B.

## ATTACHMENT F

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### Cultural Heritage:

Longwall 12 - Aboriginal Archaeological Sites Assessment End of Panel Report. Biosis Research Pty. Ltd., March 2010 Ref: 5757



Gujarat NRE FCGL Pty Ltd  
Mr David Clarkson  
Jersey Farm Rd  
Wongawilli  
New South Wales 2530

03/03/2010

**Re: Longwall 12 – Aboriginal Archaeological sites assessment End of Panel Report (Biosis Research reference #5757)**

Dear David,

Biosis Research Pty Ltd was commissioned by Gujarat NRE FCGL Pty Ltd to undertake an assessment of potential subsidence impacts to archaeological sites for the Longwall 12 End of Panel (EoP) report (Figure 1). Biosis Research previously assessed all Aboriginal and Heritage sites and features for Longwall 12 for Wongawilli Colliery (Biosis Research 2008) and during baseline recording as outlined in the Cultural Heritage Management Plan (2009). Two previously recorded Aboriginal archaeological sites are located 160m from the northern edge of Longwall 12 (Figure 2). All other recorded archaeological sites occur at a distance greater than 200m from Longwall 12 which is considered to be beyond the limit of subsidence for Longwall 12. The two archaeological sites within 200m of Longwall 12 include:

- Upper Avon 2 (52-2-1825) – axe grinding groove
- Upper Avon 3 (52-2-1826) – axe grinding groove

Neither site had been impacted by subsidence at the time of inspection.

### **Predicted Impacts**

The maximum predicted cumulative systematic subsidence parameters resulting from extraction of the proposed NRE longwalls 11, 12, 15, 16 & 19 and Pillar Extraction Area PE1 are outlined in Table 1 below. Tensile strains greater than 0.5 mm/m and compressive strains greater than 2 mm/m are sufficient to result in the fracturing of the sandstone (MSEC 2008:68). The tensile strains and compressive strains at Upper Avon 2 are less than this, at 0.4 mm/m and 0.3 mm/m respectively. At Upper Avon 3, tensile strains and compressive strains are also less, at <0.1 mm/m and 0.7 mm/m respectively. Based on the maximum predicted systematic strains, fracturing of the sandstone bedrock at the grinding groove sites is considered unlikely (MSEC 2008: 68).

Upper Avon 2 and 3 are located along the alignment of Bellbird Creek and associated swamp, both of which may be subject to valley related upsidence and closure movements, with a predicted total upsidence of 51mm and the predicted total closure of 24mm. These valley related upsidence and closure parameters are predicted from the centreline of the creeks and tributaries, therefore, the

likelihood of cracking of the sandstone coinciding with an axe grinding groove site reduces with greater distance from the centreline (MSEC 2008:69). Based on the location of the axe grinding grooves on the margins of the swamp, the likelihood of mining related impact to Upper Avon 2 and Upper Avon 3 was considered to be low.

**Table 1:** Maximum Predicted Cumulative Systematic Subsidence Parameters at the Archaeological Sites after the Extraction of the Proposed NRE Longwalls 11, 12, 15, 16 & 19 and Pillar Extraction Area 1 (results provided by MSEC 2008:67, Table 5.25).

Site Number	Site Name	Site Type	Maximum Predicted Cumulative Systematic Subsidence Parameters:			
			Subsidence (mm)	Tilt (mm/m)	Tensile Strain (mm/m)	Compressive Strain (mm/m)
52-2-1825	Upper Avon 2	Axe Grinding Groove	540	2.4	0.4	0.3
52-2-1826	Upper Avon 3	Axe Grinding Groove	820	0.2	<0.1	0.7

**Table 2:** Summary of risk of impact to Aboriginal archaeological sites within the limit of subsidence of LW 12.

Site Number	Site Name	Site Type	Significance	Risk of Impact
52-2-1825	Upper Avon 2	Axe Grinding Groove	Low	Low
52-2-1826	Upper Avon 3	Axe Grinding Groove	High	Low

## Potential Areas of Impact

Natural features, such as cracks, pot holes or bedding planes, are often areas where subsidence impacts present. As such, these features were examined prior mining and following extraction to identify if these features had been in any way affected. No features were identified at Upper Avon 2 (52-2-1825). Several features were, however, identified at the Upper Avon 3 (52-2-1826) site, which include deep incised drainage lines within the sandstone platform and natural erosional cracking. The location of these features is outlined below. These features are therefore the focus of comparative monitoring.

### *Upper Avon 3 (52-2-1826)*



**Plate 1:** A series of incised pools (yellow) and natural erosion crack (red) within the sandstone platform on the western side of the site. View west.



**Plate 2:** A deep incised drainage line within the sandstone platform on the south-eastern side of the site (highlighted in red). View east.

## Observed Impacts

On 21 January 2010 Biosis Research conducted an assessment of Aboriginal archaeological sites to determine if impacts had occurred as a result of subsidence. The following comparative photos show that no visible damage has occurred as the result of the extraction of Longwall 12. The maximum observed incremental subsidence along the EF monitoring line for Longwall 12 of 130 mm is less than the maximum predicted incremental subsidence of 140 mm (MSEC 2010:5). The observed movements along the E&EE Line did not indicate that any significant subsidence occurred (MSEC 2010:4). The MSEC (2010) report concluded overall that the majority of strains were within survey tolerance and did not exceed predicted maximum subsidence parameters (MSEC 2010).

### *Upper Avon 2 (52-2-1825)*

Upper Avon 2 is located in the centre of the eastern end of Longwall 11 and was reassessed with little difficulty due to easy access via Fire Trail 6A, immediately north of the site. It is situated on the northern edge of the swamp at the head of Bell Bird Creek (Plate 3). It is 150 m east of recorded axe grinding groove site Upper Avon 3 (52-2-1826).



**Plate 3:** Large upland swamp at head of Bell Bird Creek where site 52-2-1825 is located.



**Plate 4:** One of the more prominent grinding grooves at site 52-2-1825 in November 2008 (Biosis 2008).



**Plate 5:** Site 52-2-1825 facing SW at the time of the current study (taken in 2010).



**Plate 6:** One of the grinding grooves at site 52-2-1825 at the time of the current study (refer to Plate 4).

The grinding grooves are situated on a 7.5 m long by 6 m wide sandstone outcrop/platform on the edge of Bellbird Creek in Swamp 20. The site comprises 4 grinding grooves; all located separately across the platform and with the largest being located adjacent to a large water hole (Plate 4 and Plate 6). There was no water seepage occurring across the site during the current assessment. There have been no changes to this site since it was originally recorded, apart from some leaf litter obscuring some of the grooves.

***Upper Avon 3 (52-2-1826)***

This site is situated in the western central area of Longwall 11 and was reassessed with little difficulty due to easy access via Fire Trail 6A, situated immediately north of the site. The site is located on the northern edge of the Swamp 20 at the head of Bell Bird Creek.

The grinding grooves are situated on a sandstone outcrop/platform measuring 18 m in length and 9 m wide, on the northern margin of Bellbird Creek in Swamp 20, 150 m directly west of recorded axe grinding groove site Upper Avon 2 (52-2-1825) (Plate 9). In total, there are 24 grinding grooves that form a fan like shape at the top of the site (Plate 7, Plate 8 and Plate 10). A further 4 grinding grooves are located adjacent to a large water hole (two on either side of the water hole) and 4 more are located downstream (Plate 8). On the edge of the sandstone platform 5 more grooves are located in the main water flow. A small pecked channel is also present, leading from one of the larger grinding grooves to a large water hole, which at the time of recording was largely covered by vegetation.



**Plate 7:** 'Fanning' grinding grooves and pecked channel at site 52-2-1826 in November 2008 (Biosis 2008).



**Plate 8:** Other grinding grooves located away from main group at site 52-2-1826 in November 2008 (Biosis 2008).



**Plate 9:** Upper Avon 3 at the time of the current study, facing SW.



**Plate 10:** The main concentration of grinding grooves located within the Upper Avon 3 site at the time of the current study, facing SW.

Only 36 of the 41 grinding groves originally recorded could be reassessed as they were obscured by vegetation growth and other debris. The pecked channel runs from an existing grinding groove to a small pothole downstream. At this point there is a minor drop-off at the end of the sandstone platform.

Overall, there have been no changes to this site since it was originally recorded.

**Table 3:** Summary of Predicted and Observed Impacts Resulting from Wongawilli Longwall 12 on Aboriginal Archaeological Sites.

AHIMS #	Site Name	Predicted Impacts	Observed Impacts
52-2-1825	Upper Avon 2	Unlikely to experience subsidence impacts	No impacts observed
52-2-1825	Upper Avon 3	Unlikely to experience subsidence impacts	No impacts observed

## Ongoing Monitoring

Biosis Research prepared an Aboriginal Cultural Heritage Management Plan (CHMP) for the Wongawilli Colliery to manage potential mine subsidence related impacts of Longwalls 11, 12, 15, 16 and 19, and Pillar Extraction Area PE1 (Biosis Research 2009). The ACHMP document sets out the requirements for the management of Aboriginal archaeological sites within Wongawilli SMP Area, including Upper Avon 2 and Upper Avon 3.

Table 11 in the CHMP indicates the monitoring regime for all Aboriginal archaeological sites within the current Wongawilli SMP area. Upper Avon 2 and Upper Avon 3 are to be monitored:

- Prior to extraction of Longwall 11
- During extraction of Longwall 11
- 3-6 months following extraction

Despite these sites being located some distance from Longwall 12, both were inspected as part of the Longwall 12 End of Panel Assessment, and will be inspected during Longwall 11 extraction (Table 4). No further monitoring is required in association with Longwall 12.

**Table 4:** Monitoring Program of Aboriginal Archaeological Sites in relation to Wongawilli SMP Monitoring Programs, including Longwall 12.

Archaeological Sites Monitoring Program for Longwall 12		
SMP Commitments	Monitoring to Date	Future Monitoring
Baseline: Baseline recording undertaken as per the CHMP (Biosis Research 2009)		
During Active Mining During extraction 3-6 months following extraction	Inspection undertaken during the extraction of Longwall 12	Sites will be monitored during extraction of Longwall 11
Following Active Mining 12 months after cessation of mining	Inspection undertaken following the extraction of Longwall 12	No further monitoring required in relation to Longwall 12

All natural and cultural features identified at this site remain unchanged following the extraction of Longwall 12.

## **Conclusions**

Biosis Research completed the EoP Assessments of two Aboriginal archaeological sites in the vicinity as the result of the mining of Longwall 12 in January, 2010.

The registered Aboriginal archaeological sites Upper Avon 2 (52-2-1825) and Upper Avon 3 (52-2-1826) did not exhibit any changes as a result of the extraction of Longwall 12.

Both archaeological sites were observed to be in the same condition as they were prior to mining.

## **Recommendations**

Monitoring of both these sites is required during and after the extraction of Longwall 11, as both sites are located directly above the extraction zone.

A copy of this report should be distributed to all registered Aboriginal stakeholders listed in the Cultural Heritage Management Plan (Biosis Research 2009).

If you have any queries please don't hesitate to contact me on the numbers below.

Yours sincerely,

A handwritten signature in cursive script that reads "G. Roberts".

Georgia Roberts  
Archaeologist, Wollongong Resource Group

## References

Biosis Research. 2008. *Archaeological and Cultural Heritage Impact Assessment of Proposed Longwalls 11, 12, 15, 16 and 19 and Pillar Extraction Area 1 – NRE Wongawilli Colliery, NSW*

*Report B.* Unpublished report to NRE Gujarat Minerals Limited.

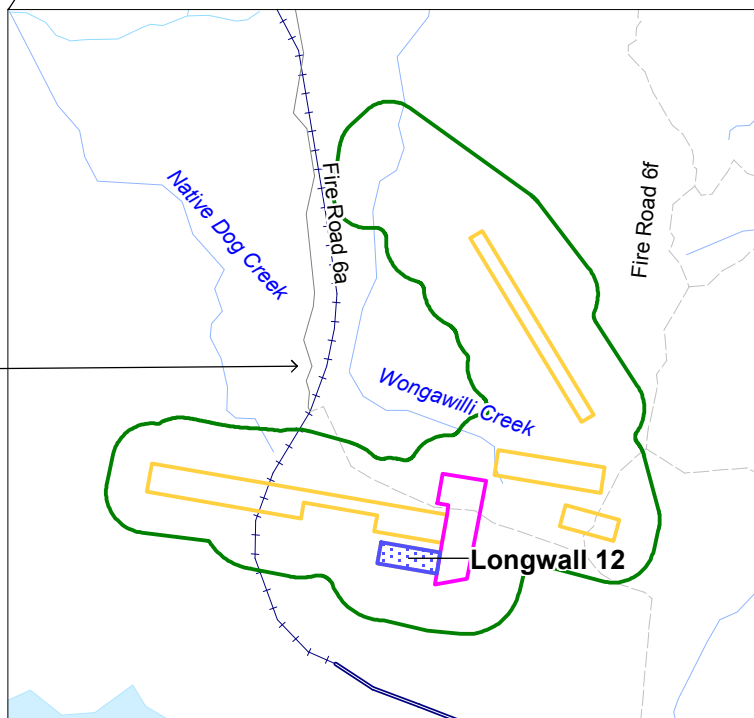
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Sefton, C. 1991. *1990-1991 Archaeological Survey of the Cordeaux River by the Illawarra Prehistory Group.* Unpublished report to the Australian Institute of Aboriginal and Torres Strait Islander Studies.

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SMP area



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8 Tate Street  
Wollongong  
NEW SOUTH WALES 2500

Figure 1: Location of the SMP Area and Study Area in a regional context

Date: 5 February 2010

Drawn by: ANP

File number: S5757

Checked by: MWR

Location: ...5757\Mapping\S5757 F1\_Locality.WOR

Scale:

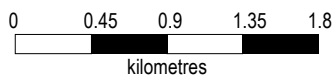
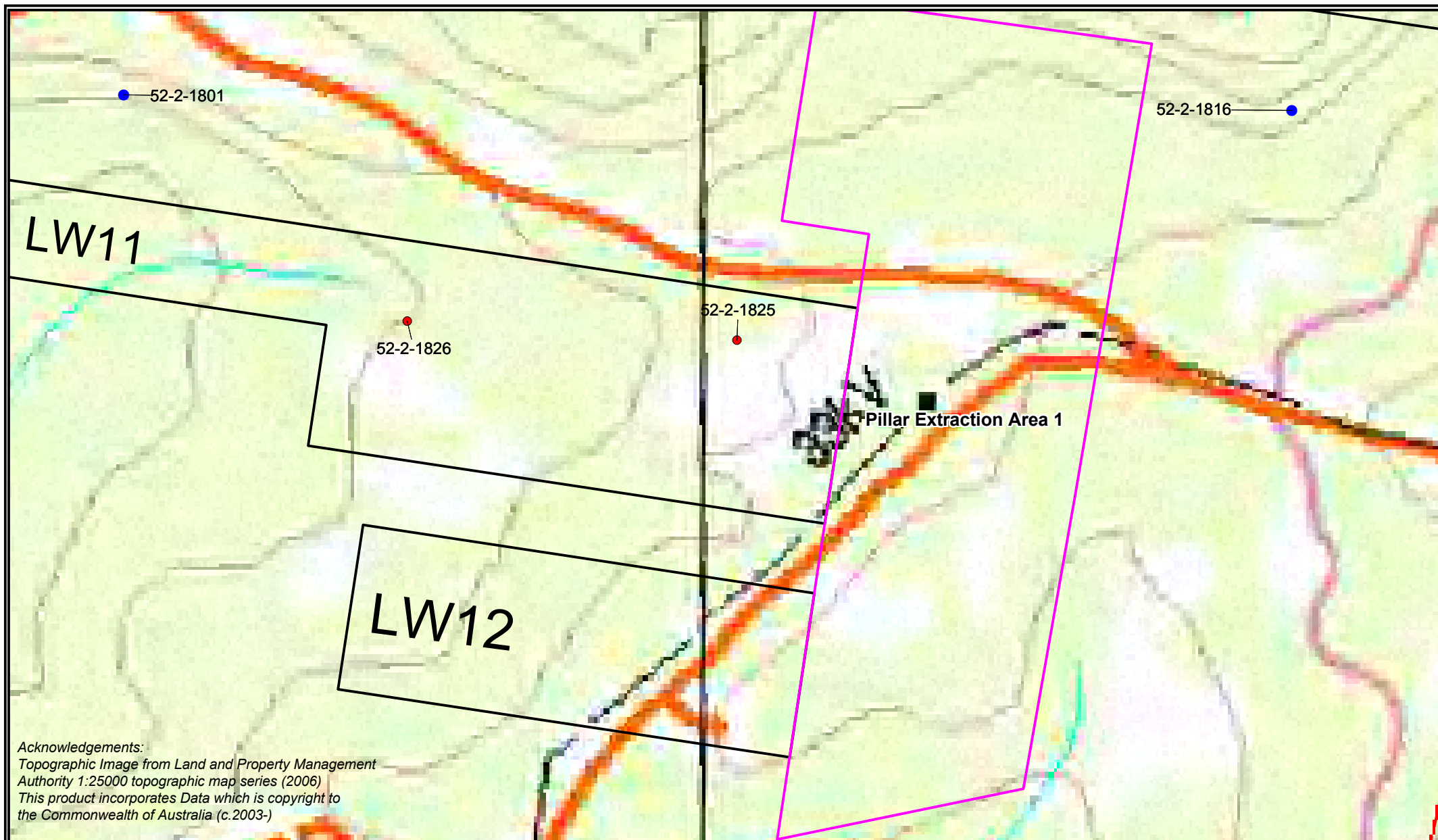


Figure 1



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8 Tate Street  
 Wollongong  
 NEW SOUTH WALES 2500

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 RESEARCH

Figure 2: Aboriginal Archaeological sites in proximity to longwall 12.

Date: 25 February 2010

Drawn by: ANP

File number: S5757

Checked by: MT

Location:-.P:\5000\5700s\5757\Mapping\5757 F2\_Aboriginal Sites.WOR

Scale:

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Metres



## ATTACHMENT G

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**Wongawilli Colliery Cultural Heritage Management Plan (CHMP):**

**NRE Wongawilli Colliery Longwalls 11, 12, 15, 16 & 19, & Pillar  
Extraction Area 1 Cultural Heritage Management Plan and Baseline  
Recording & Monitoring Methodology. Biosis Research Pty. Ltd.,  
March 2010 Ref: 5348**

# NRE Wongawilli Colliery

Longwalls 11, 12, 15, 16 & 19,  
& Pillar Extraction Area 1

Cultural Heritage Management Plan and  
Baseline Recording & Monitoring Methodology

Report for Gujarat NRE Minerals Pty  
Limited

November 2009

**Ballarat:**

449 Doveton Street North Ballarat 3350

Ph: (03) 5331 7000 Fax: (03) 5331 7033

email: [ballarat@biosisresearch.com.au](mailto:ballarat@biosisresearch.com.au)

**Melbourne:**

38 Bertie Street Port Melbourne 3207

Ph: (03) 9646 9499 Fax: (03) 9646 9242

email: [melbourne@biosisresearch.com.au](mailto:melbourne@biosisresearch.com.au)

**Queanbeyan:**

55 Lorn Road Queanbeyan 2620

Ph: (02) 6284 4633 Fax: (02) 6284 4699

email: [queanbeyan@biosisresearch.com.au](mailto:queanbeyan@biosisresearch.com.au)

**Sydney:**

18-20 Mandible Street, Alexandria 2015

Ph: (02) 9690 2777 Fax: (02) 9690 2577

email: [sydney@biosisresearch.com.au](mailto:sydney@biosisresearch.com.au)

**Wangaratta:**

26A Reid Street, Wangaratta VIC 3677

Ph: (03) 5721 9453 Fax: (03) 5721 9454

email: [Wangaratta@biosisresearch.com.au](mailto:Wangaratta@biosisresearch.com.au)

**Wollongong:**

8 Tate Street Wollongong 2500

Ph: (02) 4229 5222 Fax: (02) 4229 5500

email: [wollongong@biosisresearch.com.au](mailto:wollongong@biosisresearch.com.au)

**Project no: s5348**

**Authors:**

Melanie Thomson

**Reviewed:**

Georgia Stannard

## ABBREVIATIONS

AHIMS	Aboriginal Heritage Information Management System
DECCW	NSW Department of Environment, Climate Change and Water
DoP	NSW Department of Planning
DPI	NSW Department of Primary Industries

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## SUMMARY

Gujarat NRE Minerals Pty Limited commissioned Biosis Research to prepare a Cultural Heritage Management Plan (CHMP) for the Wongawilli Colliery to manage mine subsidence in proposed Longwalls 11, 12, 15, 16 and 19, and Pillar Extraction Area 1. This document is a Cultural heritage Management Plan that sets out the requirements for the management of Aboriginal Cultural heritage sites within Wongawilli SMP Area to support applications for Consent to Damage under s.90 of the *National Parks and Wildlife Act 1974* (NSW).

Included in this CHMP are those sites that fall within the current SMP Area. Those sites that are of greatest risk of impact, as outlined in the 'risk assessment' in Section 4.0, will be subject to s90 (AHIP) approval from DECCW (see Figure 1). However, all sites considered to be of a low risk, and located above the longwalls, will be subject to a program of monitoring (Section 5.0).

**Table 1:** Aboriginal archaeological sites within the Wongawilli SMP Area.

<i>SITE NUMBER</i>	<i>SITE NAME</i>	<i>SITE TYPE</i>
52-2-0966; 3096	Native Dog Creek Shelter	Shelter with Art
52-2-1616	Browns Road Site 1	Shelter with Art and Deposit
52-2-1617	Browns Road Site 2	Shelter with Art
52-2-1620	Browns Road Site 5	Shelter with Art
52-2-1621	Browns Road Site 6	Shelter with Art
52-2-1622	Browns Road Site 7	Shelter with Art
52-2-1624	Browns Road Site 9	Axe Grinding Grooves
52-2-1630	Browns Road Site 15	Shelter with Art
52-2-1631	Browns Road Site 16	Axe Grinding Grooves
52-2-1635	Browns Roads Site 21	Shelter with Art and Deposit
52-2-1638	Browns Roads Site 24	Shelter with Art
52-2-1639	Browns Roads Site 25	Axe Grinding Grooves
52-2-1763	Upper Avon 27	Shelter with Art
52-2-1801	Upper Avon 4	Shelter with Art
52-2-1825	Upper Avon 2	Axe Grinding Grooves
52-2-1826	Upper Avon 3	Axe Grinding Grooves
52-2-3668	Flying Fox Creek	Shelter with Deposit
52-2-3669	Wongawilli 1	Shelter with Deposit
52-2-3670	Wongawilli 2	Shelter with Art

Some of the sites listed in Table 1 have been undermined and subject to previous monitoring programs and baseline recording (Sefton 1998; 2003; 2005; Biosis Research 2006). Sandstone shelter sites are required to be monitored before, during and subsequent to longwall mining. This CHMP describes the methodology of the monitoring program.

## 1.0 INTRODUCTION

This CHMP document sets out the requirements for the management of Aboriginal archaeological sites within Wongawilli SMP area. The CHMP outlines protocols for the baseline recording and ongoing management of Aboriginal archaeological sites in proximity to Longwalls 11, 12, 15, 16 and 19, and Pillar Extraction Area 1. The CHMP is designed to support an application for Consent to Damage archaeological sites at Wongawilli Colliery, as recommended in the Archaeological and Cultural Heritage Impact Assessment of Proposed Longwalls 11, 12, 15, 16 & 19, and Pillar Extraction Area; NRE Wongawilli Colliery, NSW – Report B (Biosis Research 2008).

The methodology outlined in this document details the procedures that will be undertaken in respect to subsidence movements at the known sites in proximity to mining of NRE Wongawilli Colliery; Longwalls 11, 12, 15, 16 and 19, and Pillar Extraction Area 1.

### 1.1 Project Background

The initial environmental assessments for Wongawilli Colliery (formerly Elouera) were undertaken in 2006 by Biosis Research on behalf of BHP Billiton. At that stage, no formal Longwall Mine Plan was proposed and the assessment was undertaken to survey for new Aboriginal sites and re-assess registered sites within a general area. Subsequent to this, BHP Billiton Illawarra Coal transferred ownership to Gujarat NRE Minerals Pty Limited. In 2008, Gujarat NRE Minerals Pty Limited developed a Mine Plan, including a series of Longwalls and Pillar Extraction Areas.

The preferred longwalls and pillar extraction area were subject to detailed Environmental Assessment (EA), including a detailed archaeological and cultural heritage assessment, undertaken by Biosis Research (2009). All previously and newly recorded sites were subject to detailed assessment, including updated photography and condition observations. The information provided in the EA will support the SMP Application to the Department of Primary Industries, in accordance with the requirements of the Written Report, as described in Chapter 6 of the “Guidelines for Applications for Subsidence Management Plan Approvals”, issued by the NSW Department of Primary Industries.

Although it was concluded that there was generally a low risk of impact to Aboriginal archaeological sites from the proposed longwall extraction, it was recommended that those sandstone shelter sites considered to be any risk should be subject to monitoring in accordance with the Subsidence Management Plan and the previous monitoring programs established in the Southern Coalfield.

This Cultural Heritage Management Plan has been prepared specifically for those Aboriginal archaeological sites most at risk of subsidence impacts within the current SMP area for Wongawilli Colliery.

## 1.2 Objectives

The objectives of the Cultural Heritage Management Plan are to:

- Present descriptions and significance assessment for the Aboriginal archaeological sites within the Wongawilli SMP area.
- Identify the likelihood of subsidence impacts for Aboriginal archaeological sites within the SMP using Sefton (2000) parameters and MSEC (2008) predictions.
- Describe protocols for ongoing Aboriginal Community engagement.
- Establish methods for suitable baseline recording.
- Establish and conduct a monitoring program to detect and measure any changes at the sites due to mining subsidence.
- Propose management options for any sites that may be affected due to mining subsidence.

## 2.0 CONSULTATION WITH THE ABORIGINAL COMMUNITY

A cultural heritage consultation program was undertaken as per the DECC *Part 6 Approvals – Interim Community Consultation Requirements for Applicants*.

Biosis Research notified the following bodies regarding the Wongawilli Longwall Mine Area:

- Illawarra Local Aboriginal Land Council;
- The Registrar of Aboriginal Owners;
- Native Title Services;
- The Wollondilly Shire Council; and
- The NSW Department of Environment and Climate Change.

In addition to the written notifications, advertisements were placed in the following local print media on 6 and 13 September 2008:

- The Illawarra Mercury

A register for interested parties was opened on 6 September 2008 and registrations were received by Biosis Research until 20 September 2008. The study area lies within the administrative boundary of the Illawarra Local Aboriginal Land Council (ILALC).

The following bodies responded to the above calls for registrations. These bodies are referred to below as ‘the registered stakeholders’.

- Illawarra Local Aboriginal Land Council (Sharralyn Robinson)
- Northern Illawarra Aboriginal Corporation (Daniella Reverberi)
- Kullila Welfare and Housing Aboriginal Corporation (Maria Maher)
- Gary Caines

The DECC’s *Part 6 Approvals – Interim Community Consultation Requirements for Applicants* requires the registered stakeholders are to be provided with a methodology for the proposed cultural assessment and given at least 21 days to review the methodology and provide feedback.

A proposed assessment methodology and request for cultural knowledge was provided to the following Aboriginal groups on 20 September 2008:

- Illawarra Local Aboriginal Land Council (Sharralyn Robinson)
- Northern Illawarra Aboriginal Corporation (Daniella Reverberi)
- Kullila Welfare and Housing Aboriginal Corporation (Maria Maher)

- Gary Caines

The Illawarra Local Aboriginal Land Council responded to this in writing on 23 March 2009 and Daniella Reverberi from NIAC called to discuss their involvement on the 08 December 2008 (see Appendix 1).

Prior to the submission of the s90 application, all registered Aboriginal stakeholders were contacted and were sent a copy of the original Archaeological Assessment (Biosis Research 2008) and a DRAFT Cultural Heritage Management Plan.

Further advertising was also completed at this time. One additional stakeholder groups was identified:

- National Koorie Site Management (Ali Maher)

In addition to all of the above registered stakeholder groups, other known Aboriginal stakeholders who have previously participated in archaeological assessment were also contacted.

- Wodi Wodi Elders Coporation (Cheryl Fulcher)

All registered stakeholder groups for the project include:

- Illawarra Local Aboriginal Land Council
- Cubbitch Barta Native Title Claimants Aboriginal Corporation
- Wodi Wodi Elders Coporation (Cheryl Fulcher)
- Kullila Welfare and Housing Aboriginal Corporation (Maria Maher)
- National Koorie Site Management (Ali Maher)
- Northern Illawarra Aboriginal Corporation (Daniella Reverberi)
- Gary Caines

No comments were received regarding the CHMP or the Baseline Recording Methodology described.

All of the above stakeholders were invited to participate in an on-site meeting and site visit to all Aboriginal archaeological sites included in the CHMP for Baseline Recording. This took place on the 14 October 2009 and individuals from the following groups participated:

- Illawarra Local Aboriginal Land Council
- Cubbitch Barta Native Title Claimants Aboriginal Corporation
- Gary Caines
- Kullila Welfare and Housing Aboriginal Corporation (Maria Maher)

- National Koorie Site Management (Ali Maher)

Formal response to the cultural values of archaeological sites for Baseline Recording was received from the Illawarra LALC, Kullila Welfare and Housing Aboriginal Corporation (Maria Maher) and Ali Maher.

A detailed consultation log of all dates for key consultation and field surveys is provided in Appendix 1.

## **2.1 Consultation with NSW DECCW**

The intention to submit an application for consent to damage the listed Aboriginal archaeological sites was discussed with Fran Scully from DECCW on 24 August 2009 and the consultation process was discussed with Miranda Firman on the 2 September 2009. Further discussion have taken place regarding mitigation and remediation processes.

## **2.2 Ongoing Aboriginal Stakeholder Consultation**

### **2.2.1 Baseline Recording and Monitoring**

For baseline recording and scheduled monitoring visits the Aboriginal Stakeholders will be notified in writing – either by letter, facsimile or e-mail - 3 weeks prior to the scheduled work commencing.

Attendance and participation in site inspections will be subject to attendees satisfying standard requirements for contractors and meeting mutually agreeable terms of involvement and payment with Gujarat NRE Minerals Limited. These requirements will be advised to the Aboriginal Stakeholders in the written notification described above. Prior on-site incidents have lead to a very precautionary approach when involving multiple stakeholders in the field on the same day. This will limit each group seeing all sites due to these ongoing OH&S issues.

Written correspondence describing the results of scheduled monitoring activities will be provided to all Aboriginal Stakeholders subsequent to each monitoring visit.

### **2.2.2 Recording of New Sites**

Should previously unknown Aboriginal archaeological cultural heritage sites be identified the Aboriginal Stakeholders (if not present at the site visit) will be notified. The notification will be made via letter, facsimile or e-mail.

### **2.2.3 Review of Consultation**

At the conclusion of each of the longwalls, the Aboriginal Stakeholder list will be subject to review. If Aboriginal Stakeholders are consistently unable to be contacted, or if they have requested no further involvement in the project, they will cease to be notified unless Gujarat NRE Minerals Limited is notified by the group that they wish to recommence consultation.

Any Aboriginal groups not listed as registered stakeholders who wish to be included in ongoing consultation will be included in the notification and reporting process described above, however this will not automatically translate into participation in monitoring visits.

### 3.0 BACKGROUND INFORMATION

The following section presents background and contextual information on each Aboriginal archaeological site derived from various archaeological surveys for the Elouera Workings and Wongawilli Colliery. The following site description and condition assessments has been summarised from Sefton 1992, 1996 & 2002, and results of the Elouera Archaeological Assessment report in 2006, and the Wongawilli Colliery Impact Assessment in 2009 undertaken by Biosis Research.

The Aboriginal archaeological sites that are considered as part of the Aboriginal Cultural Heritage Management Plan are listed in Table 2 below.

**Table 2:** All Aboriginal Cultural Heritage sites within the Wongawilli Colliery SMP Area.

<i>SITE NUMBER</i>	<i>SITE NAME</i>	<i>SITE TYPE</i>	<i>RELATIONSHIP TO LONGWALLS</i>
52-2-0966; 3096	Native Dog Creek Shelter	Shelter with Art	Within LW11A
52-2-1616	Browns Road Site 1	Shelter with Art and Deposit	
52-2-1617	Browns Road Site 2	Shelter with Art	
52-2-1620	Browns Road Site 5	Shelter with Art	
52-2-1621	Browns Road Site 6	Shelter with Art	
52-2-1622	Browns Road Site 7	Shelter with Art	
52-2-1624	Browns Road Site 9	Axe Grinding Grooves	On the goaf of LW15
52-2-1630	Browns Road Site 15	Shelter with Art	On the goaf of LW15
52-2-1631	Browns Road Site 16	Axe Grinding Grooves	On the goaf of LW15
52-2-1635	Browns Roads Site 21	Shelter with Art and Deposit	On the goaf of LW19
52-2-1638	Browns Roads Site 24	Shelter with Art	
52-2-1639	Browns Roads Site 25	Axe Grinding Grooves	
52-2-1763	Upper Avon 27	Shelter with Art	
52-2-1801	Upper Avon 4	Shelter with Art	
52-2-1825	Upper Avon 2	Axe Grinding Grooves	Within LW15
52-2-1826	Upper Avon 3	Axe Grinding Grooves	Within LW15
52-2-3668	Flying Fox Creek	Shelter with Deposit	
52-2-3669	Wongawilli 1	Shelter with Deposit	
52-2-3670	Wongawilli 2	Shelter with Art	

All sites situated within the current approved Wongawilli SMP are described below, along with the original assessment of significance.

### 3.1 Native Dog Creek Shelter, 52-2-0966 / 3096 (Shelter with Art)

#### 3.1.1 Site Description

This site is located on the southern goaf wall of Longwall 11 and consists of a rock shelter with art that has been recorded on two separate occasions. The site is situated within close proximity to the Wodi Wodi Survey Landmark. The small sandstone overhang, measuring 11 m in length, 2.1 m in width and 2.8 m in height, was relocated on the upper slopes of a prominent ridge overlooking Native Dog Creek to the north (Plate 1).



**Plate 1:** Small sandstone overhang at 52-2-0966/52-2-3096 shelter, facing east



**Plate 2:** Back wall of shelter indicating two clearly defined red ochre hand stencils

The features of the site that had been previously recorded were still distinguishable, with two obvious hand stencils being noted and a number of other areas of faded red pigment (Plate 2). No stone artefacts could be relocated within the drip line of the shelter. The site condition appears to be unchanged from that when it was originally recorded, despite the section of the shelter on which the art is painted being exposed to the elements. Small areas of water seepage were evident along the base of the back wall of the overhang, with small ferns growing in some sections. Some mineral leeching was evident of the surface of the shelter in close proximity to the rock art.

#### 3.1.2 Statement of Significance

This site comprises a low density of red ochre hand stencils only, with no other styles present. Few sites within the Cordeaux Catchment contain red ochre hand stencils; this rarity gives it a high representative value. Although the size of the overhang is relatively small, its location on the upper western slopes of a ridge line overlooking Native Dog Creek valley to the north-west giving it some aesthetic value. The site has a shallow archaeological deposit of limited potential and low value.

Significance: **MODERATE**

### 3.2 Browns Road Site 1, 52-2-1616 (Shelter with Art; Shelter with Deposit)

This rock shelter with art is located 80 m south of Longwall 15, east of PE 1, along a large continuous sandstone cliff line, on the south side of the head of Wongawilli Creek. Access to the shelter is via a very steep gully line to the west. The hanging swamp situated above this section of sandstone escarpment results in water running over the edge of the highest lip of the shelter in wetter months.

The shelter is approximately 31 m long, 3.2 m wide and 3.3 m high. The shelter faces northwest into the large open gully of Wongawilli Creek. The height of the shelter is quite significant although the living area is quite limited (Plate 3). The site comprises charcoal motifs in poor condition, including 4 charcoal outline and infill indeterminate on separate panels along the entire length of the shelter. Distinguishable motifs include echidnas and birds (Plate 4). Two previously unrecorded indeterminate charcoal motifs were noted on one panel that is partially covered by hanging vegetation. The associated deposit consists of several quartz flakes, and a small number of silcrete, fossilised wood and quartzite artefacts, two of which were relocated in the drip line of the shelter during the survey. One comprises a large fossilised wood core and one non-retouched quartz flake.



**Plate 3:** Large narrow overhang with open floor at 52-2-1616, facing east



**Plate 4:** Infill charcoal motif of small bird situated in central section of shelter site 52-2-1616

At the time of the survey this shelter was relatively dry. However, it was evident from the thick ferny vegetation hanging from the upper lip of the shelter that during wetter months, water seepage is high. Only some sections of shelter are affected by this water seepage/flow. The shelter is situated such that it is sheltered and remains cool even during the summer months. Unfortunately, the water flow/seepage through the winter months produces a moist environment within the shelter. Thus, the surface of the shelter has been significantly impacted by moss, algal growth and leeching across most of the shelter surfaces and panels. Other sections of the shelter surface have suffered significant exfoliation and weathering. Overall, the rock art is in poor condition, however, this is the same condition as was when it was originally recorded.

#### 3.2.1 Statement of Significance

This is a large site in a prominent position above the head waters of the Wongawilli Creek, giving it some aesthetic value. The range of outline and infill charcoal motifs have moderate representative value, as this is a common media and art component, and this is the most common type of site found

regionally. The art is in a state of poor preservation. The site has a narrow floor with shallow deposit, with some artefacts present that are of limited archaeological potential and low scientific value.

Significance: **LOW**

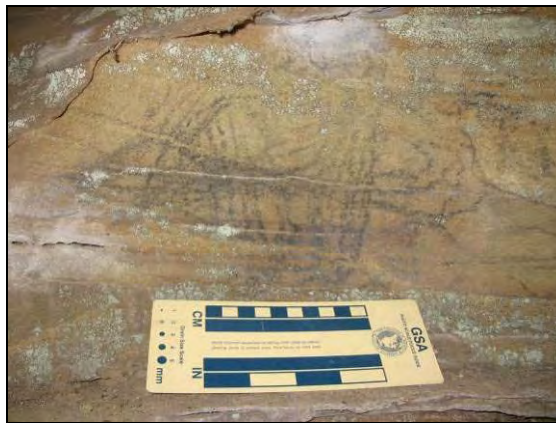
### 3.3 Browns Road Site 2, 52-2-1617 (Shelter with Art)

The site is located 320m to the north of Longwall 11 and consists of a small sandstone shelter with art situated on the mid level slope (Plate 5). The shelter is situated 250 m south of Wongawilli Creek, overlooking a small side creek, 20 m to the south west. Access to this site is difficult due to the thick vegetation along the small creek gully.

The rock shelter faces west across a small tributary of Wongawilli Creek and measures 12 m in length, 2.5 m in depth and 1.8 m in height. The site contains 3 obvious indeterminate charcoal motif panels comprising what appear to be an echidna, an infill indeterminate animal and other indeterminate (Plate 6). No further motifs were identified at this site and the grey/yellow/brown sandy deposit present across the floor of the shelter is quite shallow. No stone artefacts were identified during the original recording or during the current assessment despite the large living area.



**Plate 5:** View of back wall of shelter 52-2-1617 comprising 3 separate art panels



**Plate 6:** One of the art panels containing an indeterminate infill motif partially damaged by lichen growth and leeching

The art contained within the shelter is in poor condition, as the surface of the shelter has suffered significant leeching and mould and lichen growth. The shelter is relatively protected, with no damage from water seepage evident.

#### 3.3.1 Statement of Significance

This small sandstone shelter site is situated on the northern face of a detached sandstone outcrop and on a prominent ridge giving it some aesthetic value. The art comprises indeterminate charcoal lines and one kangaroo charcoal outline motif, these features are considered to be common and have low representativeness. There is a termite mound situated in the centre of the shelter which detracts from the potential and value of the archaeological deposit.

Significance: **LOW**

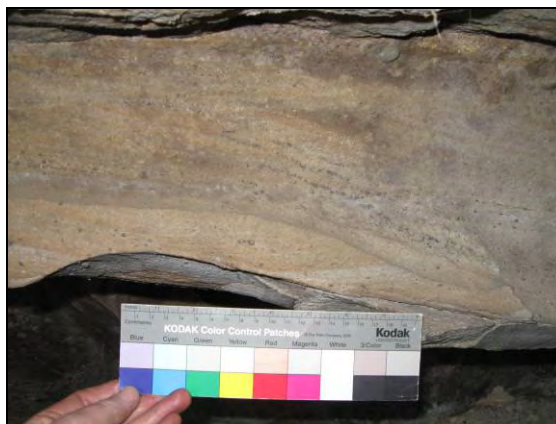
### 3.4 Browns Road Site 5, 52-2-1620 (Shelter with Art)

This shelter with art site is located on the west side of Wongawilli creek about 100 m up from the creek, and 400 m west of Fire Road 6A. The sandstone overhang measures 14 m in length, 4 m in width and 2.5 m in height, with a level living area of approximately 5 m x 1 m (Plate 7). This shelter was formed by blockfall and cavernous weathering and has an easterly aspect.

The art of this shelter is in very poor condition and consists of 3 indeterminate charcoal outline drawings (Plate 8). The small deposit consists of a cream sandy loam that has formed during weathering and slope wash. That has been disturbed by some recent wombat activity, although no artefacts could be identified.



**Plate 7:** View of shelter facing South-south west



**Plate 8:** Horizontal charcoal lines – one of the indeterminate motifs located at 52-2-1620

Along the horizontal bedding planes there has been some chemical leeching and many of the surfaces are case hardening. Some water seepage also occurs over the lip of the shelter. The art is generally in poor condition and appears to have deteriorated further since the original site recording.

#### 3.4.1 Statement of Significance

This moderately sized shelter with art is located on the mid-valley slope. The overhang contains a limited number of indeterminate charcoal outline and infill drawings. Despite the location of the shelter, the site has little aesthetic value. Charcoal drawings are not rare in this region, indicating the high representational values of the site. The deposit is limited as the floor of the shelter comprises flat open rock. The art is also in very poor condition due to natural weathering, seepage and microflora growth, reducing the archaeological potential and scientific value of this site.

Significance: **LOW**

### 3.5 Browns Road Site 6, 52-2-1621 (Shelter with Art)

This site is located on the western side of Wongawilli Creek about 200m upstream from the creek and 200m from Fire Trail 6A. The site consists of a shelter with art. The shelter faces east and measures approximately 6m in length, 1.2m wide and a height of 1.3m (Plate 9). The shelter itself is quite low, with a long narrow living area measuring 4 m x 1 m with a deposit of creamy-yellow loamy sand that has a depth of less than 50 cm and has been partly disturbed by wombats.

The art is located on the back wall of the shelter and comprises one charcoal indeterminate motif (Plate 10). The location of the art could only be determined from photos attached to the original site card. The art may no longer be present due to natural weathering processes.



**Plate 9:** View of shelter with art site 52-2-1621 facing north



**Plate 10:** Small black indeterminate charcoal motif located at site 52-2-1621

The conditions within the shelter are relatively dry and the rear wall is free of micro flora and water seepage. The roof contains some leeching and microflora. Overall, the art is considered to be in poor condition.

#### 3.5.1 Statement of Significance

This is a small shelter with no notable aesthetic values, containing 1 indeterminate charcoal drawing that has low rarity and representative value and is very poorly preserved. There is an intact, shallow deposit located along the narrow shelter floor although no artefacts have been recorded. Overall, there is very limited archaeological potential and scientific value.

Significance: **LOW**

### 3.6 Browns Road Site 7, 52-2-1622 (Shelter with Deposit)

This site is located under the third cliff line from the top, about 200 m west of Wongawilli Creek and 500 m east of Fire Road 6A; about 2 km north of the 6A-6H junction. Facing east, the sandstone overhang measures 15 m in length, 2 m in height and 1.5 m in depth, containing two possible living spaces of 5 m x 2 m and 1 m x 2 m. The shelter was formed by block-fall. The deposit in these living spaces is comprised of undisturbed grey loamy sand which appears to have formed from slope wash and weathering and is estimated to have a depth of 30 cm.

This shelter contains a deposit of 1 chert flake, 1 fossilised wood flake, 2 quartz bipolar pieces and a broken chert flake with use wear on one margin. These artefacts are situated along the shelter's drip line.

Although the drainage feature on which this site is located was identified, the site could not be identified during recent surveys based on the information provided on the site card.

#### 3.6.1 Statement of Significance

This site comprises a shelter with deposit and is located on a small drainage features that leads into Wongawilli Creek. It was not relocated during this study, so there is no recent assessment of significance. Sefton (1992) indicated that the site had limited research potential, was a common site type better represented elsewhere and hence had low value and significance.

Significance: **LOW**

### 3.7 Browns Road Site 9, 52-2-1624 (Axe Grinding Grooves)

Browns Road Site 9 is located in the central section of Longwall 15, 40 m north of the southern goaf wall. The site consists of a number of medium to large grinding grooves across a medium open sandstone platform (Plate 11). This is situated on the north western edge of a large open hanging swamp, on the main water flow/seepage, before dropping off over a small waterfall and into the head of Wongawilli Creek. The site was accessed using a former fire track (6H) that begins at the junction of Fire Trails 6A and 6F. Some difficulty was encountered in locating due to thick swamp vegetation and moss growth along the water line/seepage area that flows across the open sandstone platform.



**Plate 11:** Facing south east back along water seepage, to grinding grooves situated on open sandstone platform



**Plate 12:** Exposed area of sandstone platform on which the grinding grooves from site 52-2-1624 were relocated

The open sandstone platform/outcrop is 16 m long and 4 m wide, and contains a total of 24 grinding grooves at the top of the main water flow (Plate 12). A number of small naturally formed water holes are also present on part of the sandstone platform. Not all 24 grinding grooves were evident due to thick moss growth and leaf litter debris across the sandstone platform. No water was flowing across the site at the time it was relocated. There have been no changes to this site since it was originally recorded, apart from some minor vegetation growing obscuring some of the grooves. The condition of the site is good.

#### 3.7.1 Statement of Significance

This is an axe grinding groove site containing 24 grinding grooves. The grooves are located on a small sandstone platform in a large upland swamp, surrounded by dense vegetation and meaning the site has limited aesthetic value. The site has a high number of grooves, but no other features. Axe grinding groove sites are not rare, however the number of grooves and good state of preservation mean the site has moderate representative value.

Significance: **MODERATE**

### 3.8 Browns Road Site 15, 52-2-1630 (Shelter with Art)

This site is located 40 m to the south of Longwall 15. The site consists of a small sandstone shelter with art situated on a small isolated sandstone outcrop of the top of a secondary ridge (Plate 13). The shelter is 300 m north of Fire Trail 6A, looking north across the Wongawilli Creek valley to the opposite ridge line. The site was accessed using a former fire trail (6H) on foot that begins at the junction of Fire Trails 6A and 6F.

The shelter measures 5 m in length, 2.6 m in depth and 2.4 m in height. The art comprises a small number of indeterminate charcoal motifs that are in poor condition, apart from a large charcoal kangaroo motif on the back of the shelter wall (Plate 14). The charcoal kangaroo motif is in good condition despite being drawn on a rough, uneven surface, and constant exposure to sunlight. The other charcoal drawings are barely distinguishable due to their direct exposure to sunlight.



**Plate 13:** Small overhang on an isolated sandstone outcrop at site 52-2-1630



**Plate 14:** Large charcoal kangaroo motif located at 52-2-1630

The deposit in the small overhang consists of yellow loamy sand. No stone artefacts were identified during the original or subsequent assessments. A large termite mound is located in the middle of the shelter which was not present when the site was originally recorded. This has caused some damage to the deposit located on the floor of the shelter.

#### 3.8.1 Statement of Significance

This small sandstone shelter site is situated on the northern face of a detached sandstone outcrop and on a prominent ridge giving it some aesthetic value. The art comprises indeterminate charcoal lines and one kangaroo charcoal outline motif, these features are considered to be common and have low representativeness. There is a termite mound situated in the centre of the shelter which detracts from the potential and value of the archaeological deposit.

Significance: **LOW**

### 3.9 Browns Road Site 16, 52-2-1631 (Axe Grinding Grooves)

Browns Road Site 16 is located 20 m north of the southern goaf wall of Longwall 15. The site consists of a small number of grinding grooves across a narrow section of closed sandstone platform (Plate 15).



**Plate 15:** Narrow section of sandstone platform at site 52-2-1631 on the edge of the swamp



**Plate 16:** Three of the more obvious grinding grooves at site 52-2-1631

The site is situated on the north western edge of a large open upland swamp, on the main water flow/seepage, that flows into the head of Wongawilli Creek. It is located less than 50 m, from recorded site 52-2-1624. The site was accessed using a former fire track (6H) that begins at the junction of Fire Trails 6A and 6F. Some difficulty was encountered in locating the site due to thick swamp vegetation and moss growth along the water line/seepage area that flows across the open sandstone platform.

The narrow sandstone platform/outcrop measures 9 m in length and 3 m in width, and contains a total of 7 grinding grooves situated on the edge of a small creek line/seepage that flows along the edge of the swamp (Plate 16). A number of small naturally formed water holes are also present on part of the sandstone platform and a large open waterhole is located on the northern margin of the sandstone platform. A small amount of water was flowing across the site at the time of its relocation. There have been no changes to this site since it was originally recorded, apart from some minor vegetation growing obscuring some of the grooves.

#### 3.9.1 Statement of Significance

This is an axe grinding groove site containing nine grinding grooves. The grooves are located on a small sandstone platform on the edge of a small creek in thick swamp vegetation giving the site limited aesthetic value. The site has a low number of grooves and no other features. Axe grinding groove sites are not rare, nor are sites with between 1 to 10 grooves meaning the site has low representative value.

Significance: **LOW**

### 3.10 Browns Roads Site 21, 52-2-1635 (Shelter with Art; Shelter with Deposit)

This rock shelter with art and deposit is situated 50 m south west of Longwall 19. It is situated on the northern side of the first Wongawilli tributary along a section of steep sandstone outcrop, on the lowest level before the water line (Plate 17). Access to the shelter was via a very steep ridge line to the east of Wongawilli Creek. The large sandstone overhang is 20 m in length, 6.6 m wide and 4 m in depth. The shelter itself faces south east to the nearby tributary and is positioned such that it is well protected being low down in the gully.



**Plate 17:** Large overhang with open floor at 52-2-1635, facing north west



**Plate 18:** Fire damaged charcoal motifs situated in central section of shelter site 52-2-1635



**Plate 19:** Volcanic retouched flake located on the floor of shelter site 52-2-1635

The shelter site contains a number of charcoal motifs, including 1 frontal figure, 1 kangaroo and 7 indeterminate outline and infill motifs. The shelter consists of at least 3 open living floor areas (Plate 18). The majority of the motifs were re-identified; however, bushfires 2 - 3 years prior had caused significant heat damage to the surface of the shelter. This then caused large sections of sandstone to exfoliate from the surface of the shelter. Some of the exfoliated pieces were up to 40 cm in size, resulting in sections and whole motifs being removed from the surface of the shelter. It was noted that many of these motifs were still intact on the flaked sandstone on the floor of the shelter.

The associated deposit consisted of one silcrete bipolar core. This was not relocated however one other stone artefact was identified in the drip line of the shelter, being a black volcanic retouched flake (Plate 19).

Conditions in the shelter were quite damp, with a number of ferns and mosses growing at the back of the shelter along the drip line. The upper lip of the shelter indicates that during wetter months, water would flow over this and down part of the shelter wall. Generally, only small sections of shelter are affected by this water seepage/flow. The shelter is situated such that it is sheltered and would remain cool all year round. The water flow/seepage has caused some parts of the shelter surface to be covered by algal growth and lichen, and leeching and calcification. Other sections of the shelter surface have suffered significant exfoliation, primarily due to heat exposure from the recent bushfires, destroying much of the rock art at this site. The condition of the shelter is good, however the art has been significantly impacted by natural processes and is in poorer condition than when originally recorded.

#### 3.10.1 Statement of Significance

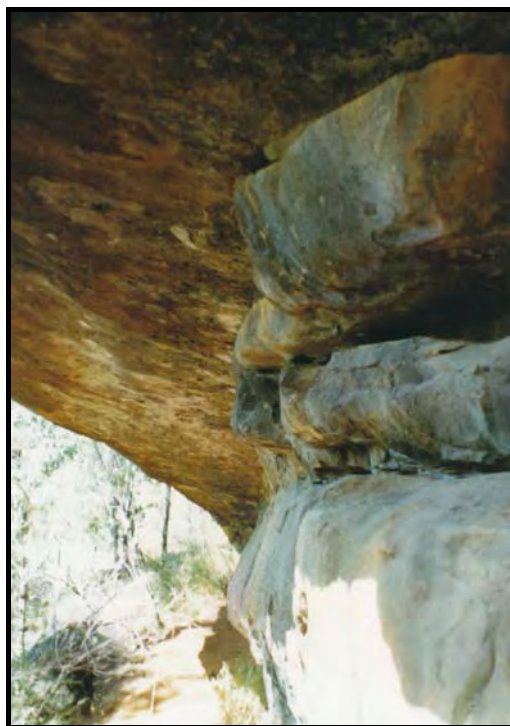
This site is a large overhang containing mostly indeterminate charcoal outline and infill motifs, with one frontal human figure and one kangaroo also present. This is a very large overhang, which gives it some aesthetic value. The art is very poorly preserved and is a small assemblage of the most common media and type of art in the area, meaning it has low representative value and is not rare. The site has surface artefacts and moderately deep archaeological deposit with good research potential, suggesting moderate value of the deposit as an archaeological resource.

Significance: **LOW**

### 3.11 Browns Roads Site 24, 52-2-1638 (Shelter with Art)

This site is located under a ridge 200 m south of the first eastern tributary to Wongawilli Creek. The sandstone overhang measures 7 m in length, 3 m in height and 2 m in width, with a sloping rock floor (Plate 20). As a result, the site contains no deposit, the living area is limited and no stone artefact was evident.

The art is present on the rear wall, and is in a very poor condition, due to severe surface flaking and exfoliation. There is approximately 1 mm of salt accretion forming behind the surface to cause this exfoliation process. The art is present on both the flaking and non flaking sections of the wall. The art consists of one red ochre frontal human figure drawing and one red ochre indeterminate motif.



**Plate 20:** Narrow sandstone overhang at shelter with art site 52-2-1638

The site was not re-assessed during recent field survey due to the incorrect co-ordinates on the registered site card. The site is 200 m from the end of proposed Longwall 19.

#### 3.11.1 Statement of Significance

This large shelter with art site is situated on the only large cliff line along this section of the tributary, affording the site some aesthetic value. The range and type of motifs depicted have moderate representational value, as this is a common media and art component, and the most common site type that occurs in the region. The art is in a state of poor preservation.

Significance: **MODERATE**

### 3.12 Browns Road Sites 25, 52-2-1639 (Axe Grinding Grooves)

Browns Road Site 25 was relocated using a hand held GPS. The original recorded site was 100 m from the actual site location. The site comprises 32 medium to large grinding grooves across a large open sandstone platform (Plate 21), and is situated on the second eastern tributary of Wongawilli Creek, where the tributary comes out at the bottom of an open upland swamp (Plate 22). At this point, the tributary forms a distinct channel and drops off. Some difficulty was encountered in accessing the site due to thick vegetation.



**Plate 21:** Large open section sandstone exposure on small tributary, facing south east



**Plate 22:** Facing north west across sandstone containing grinding grooves

The open sandstone platform/outcrop is 26 m long and 8 m wide above a small waterfall. A number of small, naturally formed water holes are also present on part of the sandstone platform, separating each cluster of grinding grooves. There was no vegetation or debris across the sandstone to hinder locating the grooves.

Overall, the condition of the site is good and it remains unchanged since it was originally recorded.

#### 3.12.1 Statement of Significance

This is an axe grinding groove site with 36 axe grinding grooves, located in the head waters of a main tributary of the Wongawilli Creek, the open, clear context contributes to the site's aesthetic value. The grooves are located in three groups, clustered around a shallow pool on the sandstone shelf. Axe grinding groove sites are not rare, however the number of well preserved grooves at this site mean the site has moderate representative value.

Significance: **MODERATE**

### 3.13 Upper Avon 27, 52-2-1763 (Shelter with Art)

This site comprises a very small isolated cavern that has been formed through cavernous weathering. The weathered cavern is situated on the northern goaf wall of Longwall 11 on the northern face of a large flat sandstone outcrop on the top of a small ridge (Plate 23). It overlooks Native Dog Creek to the north. Access to the shelter is via a small unnamed track that runs off the abandoned Dombarton-Maldon railway, just north of where it crosses Bell Bird Creek.



**Plate 23:** Northern lip of flat sandstone outcrop in which the small cavern is situated.



**Plate 24:** Rock art situated within the small cavern of site 52-2-1763

The cavern is approximately 2 m in length, 1.5 m in width and 0.9 m in height. The site would not have been used as a shelter and no floor is present as it is situated 0.6 m from the ground. It comprises a number of charcoal motifs, including 2 anthropomorphs (humans), 2 birds and 4 indeterminate (Plate 24).

The art in this shelter is in the same condition as it was when it was originally recorded. The site is situated such that it is well protected. A small area of one motif has at one time had a small wasps nest built on it and a number of spider webs were noted on the roof of the cavern. There is no evidence of water seepage or other potentially damaging features, such as lichen or calcification.

#### 3.13.1 Statement of Significance

This site contains a high number and diversity of line and motif art on a limited surface area. The site is situated within a small eroded cavern with no living floor, on the edge of a large open, flat sandstone shelf on the peak of a minor ridge, giving the site aesthetic value. Further aesthetic value is derived from the art panel being positioned in a small, isolated cavernously weathered cavity. The art media is charcoal, with infill motifs including 1 frontal human figure, 2 birds and 4 indeterminate images, indicating that the site is of moderate representational value. The art is well preserved. Charcoal motif sites are not rare; however this site is unique in terms of its setting and context which contribute striking aesthetic value.

Significance: **HIGH**

### 3.14 Upper Avon 2, 52-2-1825 (Axe Grinding Grooves)

Upper Avon 2 is located in the centre of Longwall 11 and was relocated with little difficulty due to easy access via Fire Trail 6A, situated immediately north of the site. It is situated on the northern edge of the swamp at the head of Bell Bird Creek (Plate 25). It is 150 m east of recorded grinding groove site 52-2-1826. Some difficulty was encountered in getting through thick swamp vegetation to the site.



**Plate 25:** Large open swamp at head of Bell Bird Creek where site 52-2-1825 is located



**Plate 26:** One of the grinding grooves at site 52-2-1824

The grinding grooves are situated on a 7.5 m long by 6 m wide sandstone outcrop/platform on the edge of Bellbird Creek swamp. The site comprises 4 grinding grooves, all located separately across the platform, and with the largest being located adjacent to a large water hole (Plate 26). There was no water seepage occurring across the site during the current assessment. There have been no changes to this site since it was originally recorded, apart from some leaf litter obscuring some of the grooves.

#### 3.14.1 Statement of Significance

This is an axe grinding groove site with four grinding grooves, in an unremarkable setting with low aesthetic value. The grooves are well preserved, however the site is an average representative of a common site type, giving it low representational value. It is located on the same tributary / swamp as the highly significant site Upper Avon 3 (52-2-1826) giving it moderate associational value in a wider context.

Significance: **LOW**

### 3.15 Upper Avon 3, 52-2-1826 (Axe Grinding Grooves)

This site is situated in the western central area of Longwall 11 and was relocated with little difficulty due to easy access via Fire Trail 6A, situated immediately north of the site. The site is located on the northern edge of the swamp at the head of Bell Bird Creek. It is 150 m west of recorded grinding groove site 52-2-1825. Some difficulty was encountered with site access due to thick swamp vegetation.



**Plate 27:** 'Fanning' grinding grooves and pecked channel at site 52-2-1826



**Plate 28:** Other grinding grooves located away from main group at site 52-2-1826

The grinding grooves are situated on a sandstone outcrop/platform measuring 18 m in length and 9 m wide, on the northern margin of Bellbird Creek swamp. In total, there are 41 grinding grooves that form a fan like shape at the top of the site (Plate 27). A further 2 grinding grooves are located adjacent to a large water hole, and 4 more are located downstream (Plate 28). On the edge of the sandstone platform 5 more grooves are located in the main water flow. A small pecked channel is also present, leading from one of the larger grinding grooves to a large water hole. Almost all 41 grinding grooves were relocated during this assessment. Those that could not be identified were most likely obscured by vegetation growth and other debris. There was some water flow across the site at the time of the survey, but this did not hinder site recording. The pecked channel runs from an existing grinding groove to a small pothole downstream. At this point there is a minor drop-off at the end of the sandstone platform. Overall, there have been no changes to this site since it was originally recorded.

#### 3.15.1 Statement of Significance

This site contains 41 axe grinding grooves on an expansive sandstone shelf. The site is located on a small creek within a large upland swamp and has an open context at the head of a large gorge that, with the stepped sandstone shelving at this locality, provides moderate aesthetic value. The 41 grinding grooves occur in separate localities at the site, with a group of 27 grooves clustered around potholes in one location, and the other grooves dispersed elsewhere at the site. An engraved channel is also present at the main groove cluster. Axe grinding groove sites are not rare, however this site is notable for the high number of grooves present and the presence of an engraved channel, which are an uncommon feature usually associated with larger axe grinding groove sites. The site has high research potential and high representative value.

Significance: **HIGH**

### 3.16 Upper Avon 4, 52-2-1801 (Shelter with Art)

This rock shelter with art is situated 50 m from the north eastern corner of Longwall 11, along a substantial escarpment, on the upper cliffs of a moderate ridge (Plate 29). The site was accessed via an old track which leads into the Wodi Wodi Survey Landmark. The shelter is 9 m long, has a width of 4.2 m and is 4 m in height. The shelter faces south and comprises one indeterminate charcoal motif on a small panel.



**Plate 29:** Large open sandstone escarpment and overhang at site 52-2-1801



**Plate 30:** Very faint charcoal lines are all that remains of the art at site 52-2-1801

The charcoal lines were identified on a small panel in the middle of the shelter, immediately above a large wombat burrow. The art is in very poor condition and was quite difficult to distinguish (Plate 30). One bipolar flake was originally recorded within the drip line of the shelter. During the reassessment, no stone artefacts could be relocated due to significant animal activity across the floor of the shelter.

The condition of the overhang is unchanged, despite the condition of the art is very poor. Large sections of the shelter wall have been subject to extensive weathering. Other sections of shelter have been affected by water seepage/flow over the upper lip. These areas exhibit mould growth and calcification. These factors have greatly impacted the art at this site, which is now quite faint.

#### 3.16.1 Statement of Significance

This site is a large overhang located on an extensive section of escarpment, it has some aesthetic value. The site contains one indeterminate charcoal outline motif, which is very poorly preserved. There is one stone artefact present in the drip line, however the deposit has been highly disturbed by wombats. It is a poorly preserved example of the most common site type, and has very limited potential and low representative value.

Significance: **LOW**

### 3.17 Flying Fox No. 1, 52-2-3668 (Shelter with Deposit)

One previously unidentified archaeological site was identified during the survey work undertaken for this project. The site comprises a small sandstone overhang 5 m in length, 2.2 m in width and 3.2 m in height that contains archaeological deposits comprising stone artefacts (Plate 31).

It is located 240 m south of Longwall 12 and the end of a small sandstone cliff line situated on the north western side of Flying Fox No1 Creek, only 60 m from a small junction point between the creek and a major tributary. The site was recorded using a hand held GPS. The small sandstone overhang was inspected in detail, and new recordings and photographs were taken.

The stone artefacts recorded at the site include 1 silcrete flake, 1 chert core, and 3 quartz flakes (Plate 32). The deposit in which they were identified comprised medium grey white sand that was approximately 25 cm in depth. The floor area in the shelter is only small however it is likely that further cultural material will be present sub-surface. The floor of the shelter had been partially disturbed, most likely from animal activity, such as wombats. The overhang itself seems stable and no part of the overhang has previously collapsed.



**Plate 31:** Small sandstone shelter in which cultural material was recorded, facing north east



**Plate 32:** Silcrete and quartz artefacts recorded at Flying Fox No. 1 Creek 1

The walls of the shelter were rough and covered in lichen. It is highly likely that it would have been unsuitable for rock art, although any art is now obscured by the lichen growth.

#### 3.17.1 Statement of Significance

This is a small overhang at the terminal end of a sandstone cliff line on Flying Fox Creek No. 1. The site has limited aesthetic value. The site contains 5 stone artefacts and an in situ deposit with good archaeological potential. The deposit is partly disturbed, but otherwise the site has some value as a representative of this site type, which is common.

Significance: **LOW**

### 3.18 Wongawilli 1, 52-2-3669 (Shelter with Deposit)

This large shelter with possible art and deposit site is located on the on a continuous cliff line on the upper valley slopes. It can be accessed via Fire Trail 6F by following a former track for 1.2 km along the top of the ridge to the end. The site is located immediately below on top cliff line to the west of the former track and is situated approximately 200 m north of longwall 19. This overhang measures 22 m in length, 3.6 m wide and 2.6 m in height, with a south westerly aspect across the tributary to Wongawilli Creek (Plate 33). A small section of one surface contains a small indeterminate black charcoal drawing, although it is difficult to determine if this is simply microflora growth or staining. Most other suitable surfaces contain seepage, microflora, and salt mineralisation. Other surfaces have been heavily impacts by surface exfoliation and flaking.



**Plate 33:** Large continuous shelter at Wongawilli 1 site, facing south east



**Plate 34:** Sample of stone artefacts identified in the drip line

The deposit within the shelter is limited due to the open sandstone floor within the overhang. Some pale grey sandy loam soil is present at the front of the shelter on and outside the drip line that runs the entire length of the shelter. A small number of stone artefacts were recovered from the drip line, including a petrified wood flake, a complete quartz flake, a quartzite flake and a small silcrete flake fragment (Plate 34). Shelter conditions are very damp and most surfaces have been subject to high levels of seepage. At the site of recording, the site was relatively dry but would be quite damp with extensive seepage during wetter months. If the black line is Aboriginal in origin, then is very poorly preserved. There are a number of horizontal bedding planes within the shelter from which the water seeps.

#### 3.18.1 Statement of Significance

This large overhang is situated on a continuous cliff line on the upper valley slopes. It contains a number of stone artefacts in a limited but undisturbed deposit of limited potential and low value. Shelter conditions are very damp and the most surfaces have been subject to high levels of seepage and microflora growth. There is one possible remnant of a charcoal motif that is considered to be highly representative and the most common site type in the region. If the black line is Aboriginal in origin, then is very poorly preserved. The site has some aesthetic value due to it location looking across the tributary into the Wongawilli.

Significance: **LOW**

### 3.19 Wongawilli 2, 52-2-3670 (Shelter with Art)

This moderate shelter with art site is located on a continuous cliff line on the upper valley slopes. It can be accessed via Fire Trail 6F by following a former track for 1.2 km along the top of the ridge to the end. The site is located below the third cliff line from the top of the ridge on a small drainage feature where a small water fall / seepage flow runs across the face of the cliff line. This section is continuous, although very uneven as large sections of the block fall have separated from the cliff line and rolled down slope making the site difficult to access. The overhang measures 12 m in length, 3 m in width and 2 m in height with a north easterly aspect (Plate 35).

The art within the shelter comprises at least 5 charcoal outline and infill indeterminate motifs across two separate art panels. Several sections of the first panel have suffered extensive surface seepage destroying the art in these areas. In between the art panels have formed a silica skin, preserving these sections (Plate 36).



**Plate 35:** Small overhang on south edge of drainage feature and water fall where art is located at Wongawilli 2 site



**Plate 36:** One of the art panels at Wongawilli 2 – orange seepage streaks are where the art has been washed away

The second panel exhibits high levels of salt mineralisation and surface exfoliation and flaking. Only one undisturbed section contains a single charcoal indeterminate motif. The floor of the shelter is relatively undisturbed and the living area is approximately 2 m x 3 m in size. The deposit depth is between 5 and 15 cm and comprises yellow brown sand.

Overall, the actual sandstone overhang is in good condition despite the high levels of water seepage and microflora growth.

#### 3.19.1 Statement of Significance

This small shelter overhang has no notable aesthetic values, contains a number of indeterminate charcoal outline and infill art that has low rarity and representative value and is very poorly preserved. There is an intact, shallow deposit although no artefacts have been recorded, meaning there is very limited potential and low value.

Significance: **LOW**

## 4.0 BACKGROUND TO ROCK ART MONITORING

Long term programs monitoring the impact of subsidence to Aboriginal shelter sites have been conducted in the southern coalfield by Sefton (2000) and more recently Biosis Research (2007-2009), and Kayandel (2008-2009). After several years of monitoring, Sefton reviewed the effects of longwall mining on sandstone overhang Aboriginal archaeological sites over a 10 year period (Sefton 2000). The review included data collected from the longwall mine areas of Tahmoor, Appin, Tower, West Cliff, Metropolitan, Elouera and Cordeaux Collieries. At the time of the review 52 sandstone overhang sites had been monitored by Sefton prior to, during and after longwall mining in the vicinity of the sites (Sefton 1998: 15). Of the 52 sites monitored only five had evidence of impact from longwall mining (Sefton 2000: 17-18; included in Appendix 2). The impacts can be grouped into four effect categories:

- cracking;
- movement along existing joints / bedding planes;
- block fall; and,
- change of water seepage.

No art panels in the monitoring program have been directly impacted by subsidence effects noted by Sefton.

Sefton conducted a Principal Components Analysis using 16 variables recorded for all the sites, including the subsidence parameters (2000:30). Sefton found that the components most associated with observed changes were the overhang size (particularly length), wet overhangs, locations near the valley bottom, location above the goaf, and block-fall type shelters. No monitored overhang has collapsed. High predicted strain values were also associated with observed changes (Sefton 2000:31). Sefton concludes that 'the over-riding factor which appears to be significant is overhang size where large overhangs are at greater risk' (Sefton 2000:38). In particular, no monitored overhang less than 50m<sup>3</sup> has suffered subsidence impacts, regardless of other risk components. Not all sites larger than 50m<sup>3</sup> will be impacted. Of those monitored overhangs larger than 50m<sup>3</sup> only one-fifth (5 of 23) have suffered impacts. Where impacts were present, these were not noticeable until 3- 6 months subsequent to the nearest longwall panel being mined. However despite the findings of Sefton (2000) the causal mechanism for the failure of this shelter is poorly understood, and the correlation between the subsidence parameters and observed conditions has yet to be conclusively shown.

Despite Sefton describing the task of predicting subsidence impacts to individual sites as 'difficult and complex' (2000a), predicting subsidence effects to the landscape is constantly improving. In general, changes that are attributable to mining are due to overhang destabilisation. These include block fall, exfoliation, cracking and associated changes in water seepage. However these changes also occur naturally in the absence of mining, as a result of weathering (Sefton 2000a). Sefton recommended that shelters smaller than 50 m<sup>3</sup> need not be monitored because no shelters in this size class had been

impacted in her sample and that shelters with archaeological deposit or PAD need not be monitored because changes or impacts from subsidence could not be demonstrated to this site type (Sefton 2000a).

Biosis Research (2009) recently completed a large scale assessment of Aboriginal sites within future proposed mining areas on the Woronora Plateau. At the time the report was completed, a total of 103 sites had been monitored, 11 (11% of monitored sites) of which exhibited visual effects at the same time as being subject to mining induced subsidence and as such the effects are attributed to mining (Biosis Research 2009; Table 3). Only one of these 11 sites has exhibited an impact to the archaeological features present, being the fracturing of an art panel (see Appendix 2 for details). These sites were located either above the longwalls or within 100m of the longwalls.

**Table 3.** Changes to sites observed during archaeological monitoring programs to date.

Site Name	Site Type	Observed changes / impacts	Proximity to Longwall	Reference
Flat Rock Creek 4	Sandstone Shelter with Art	Opening of existing open bedding plane at roof/rear wall and minor roof fall	Between Longwalls 9 and 10 in the centre	Kayandel 2008
Flat Rock Creek 10	Sandstone Shelter with Art	Cracks in rear wall, potential for altered seepage to impact art mitigated with artificial drip-line	Located above Longwall 13 in the middle	Kayandel 2008
Flat Rock Creek 11	Sandstone Shelter with Art	Exfoliation and block fall at rear wall	Located above pillar between Longwalls 14 and 15 in centre	Kayandel 2008
Flat Rock Creek 49	Sandstone Shelter with Art	Minor block fall from rear wall and ceiling	Located above Longwall 6 at the end	Kayandel 2008
Flat Rock Creek 57	Sandstone platform with engraving and grinding grooves	Crack in sandstone platform	Located above Longwall 5 at the end	Kayandel 2008
Flat Rock Creek 152	Sandstone Shelter with Art	Cracking and minor block fall at rear wall	Located between Longwalls 1 and 2B at end of Longwall 2B	Sefton 2000a, Kayandel 2008
Browns Road 4	Sandstone Shelter with Art	Cracking and block fall at rear wall	Located above Longwall 2 in centre of longwall	Sefton 2000a
PAD 3	Sandstone Shelter with PAD	Minor block fall from rear wall	Located above Longwall 7 at the end	Sefton 2000a
Wedderburn 1	Sandstone Shelter with Art	Cracking and minor block fall at rear wall	Located above pillar between longwalls 23 and 24	Sefton 2000a
Wedderburn 2	Sandstone Shelter with Art	Cracking in floor and rear wall	Located above Longwall 24	Sefton 2000a
Dendrobium 4	Sandstone Shelter with Art	Opening of crack in back wall	Located above Longwall 3	Biosis Research 2008b

Monitoring programs and site inspections (undertaken prior to subsidence effects) have documented natural deterioration of shelter sites including minor and large roof-falls, fading of art, exfoliation of case hardened surfaces and total site collapse (Sefton 2000a, Kayandel 2008, Biosis Research 2007c).

In the 1980s, ‘Whale Cave’ (52-2-0018/52-3-0754) (McCarthy 1961; McDonald 1994), suffered a failure resulting in the collapse of the lower roof at the back of the shelter. The site itself was a very

large, cavernously weathered overhang in a very advanced stage of natural deterioration, meaning it was inherently unstable, and hence especially susceptible to fall with or without subsidence related movements. The lower roof collapse was also partly associated with pre-existing cracks caused by tree roots (Lambert 1994: 20). Coal beneath Whale Cave had been extracted prior to or around the time of collapse of the site. The site is located outside the current SMP for the Wongawilli Colliery and 400 m from the end of proposed Longwall 16. The following monitoring methods and baseline recording developed by Biosis Research have been based upon Sefton's original methods and the development of more detailed methods (image manipulation and spherical photography).

## 5.0 SUBSIDENCE IMPACT ASSESSMENT

### 5.1 Potential Impacts from Mine Subsidence

During and following the extraction of coal via longwall mining methods overlying rock strata are subject to varying degrees of subsidence, tilt and strain (MSEC 2008:24). At the surface, the ground subsides vertically and also moves horizontally towards the centre of the mined goaf area (MSEC 2008:25). These movements can cause slumping of soils or poorly consolidated landform elements such as talus slopes and cracking of rigid areas such as sandstone platforms, ledges and cliffs. These ground surface changes can potentially impact Aboriginal cultural heritage sites. The main mechanisms that are used to describe subsidence related movements, stresses and strains are described below (MSEC 2008).

#### 5.1.1 Systematic Movements

##### **Subsidence**

Subsidence refers to vertical and associated horizontal displacement of a point. In the case of this study it refers to subsidence resulting from the extraction of coal using longwall methods. The amplitude of subsidence is usually expressed in millimetres (MSEC 2008).

##### **Tilt**

Tilt is calculated as the change in subsidence between two points divided by the distance between those points. Tilt is, therefore, the first derivative of the subsidence profile. The convention usually adopted is for a positive tilt to indicate the ground increasing in subsidence in the direction of measurement. The maximum tilt, or the steepest portion of the subsidence profile, occurs at the point of inflection in the subsidence trough, where the subsidence is roughly equal to one half of the maximum subsidence. Tilt is usually expressed in millimetres per metre (mm/m) (MSEC 2008: 25).

##### **Strain**

Strain is caused by bending and differential horizontal movements in the strata. Measured strain is determined from monitored survey data by calculating the horizontal change in length of a section of a subsidence profile and dividing this by the initial horizontal length of that section. If the section has been extended, the ground is in tension and the change in length and the resulting strain are positive. If the section has been shortened, the ground is in compression and the change in length and the resulting strains are negative. The unit of measurement adopted for strain is millimetres per metre (mm/m). The maximum strains coincide with the maximum curvature and hence the maximum tensile strains occur towards the sides of the panel whilst the maximum compressive strains occur towards the bottom of the subsidence trough (MSEC 2008:25). Tensile strains greater than 0.5mm/m and compressive strains greater than 2mm/m are sufficient to result in fracturing of sandstone (MSEC 2008:69).

## Upsidence

Upsidence is the reduced subsidence, bulging, or net uplift movement within the base of a valley. Upsidence predominantly results from the buckling of near surface strata in the base of the valley, where there are lower vertical confining stresses and increased horizontal stresses caused by a redistribution of in-situ horizontal stresses around the collapsed zones above the extracted longwalls (MSEC 2008:26).

## Closure

Closure is the reduction in the horizontal distance between the valley sides. Closure predominantly results from the above redistribution of and increase in the horizontal stresses around the collapsed zones above extracted longwalls coupled with failure of the rocks in the base of the valley. Additional closure can result from additional localised stress relaxation and slippage between bedding planes above the floor of the valley (MSEC 2008:27).

Predicted mining subsidence data were calculated for the study area by Mine Subsidence Engineering Consultants (MSEC 2008:65). Table 4 below shows the results of the subsidence modelling of Aboriginal cultural heritage sites in Wongawilli SMP Area. The potential impacts that may occur at each site area also indicated. An impact assessment for each of the sites is presented in more detail in Section 5.2 and Table 6 below.

**Table 4:** Maximum Predicted Cumulative Systematic Subsidence Parameters at the Archaeological Sites within the SMP area following the Extraction of the Proposed NRE Longwalls 11, 12, 15, 16 & 19 and Pillar Extraction Area 1 (results provided by MSEC 2008:65, Table 5.25); and potential impacts relating to each individual site.

Site Number	Site Name	Site Type	Maximum Predicted Cumulative Systematic Subsidence Parameters:				
			Subsidence (mm)	Tilt (mm/m)	Tensile Strain (mm/m)	Compressive Strain (mm/m)	Type of Potential Impact based on overhang attributes
52-2-0966 / 52-2-3096	Native Dog Creek Shelter	Shelter with Art; Shelter with Deposit	670	2.0	<0.1	1.2	Movement sandstone block increased by old Bulli Seam workings
52-2-1616	Browns Road Site 1	Shelter with Art; Shelter with Deposit	30	0.1	<0.1	<0.1	Movement of cliff line
52-2-1617	Browns Road Site 2	Shelter with Art	85	0.6	<0.1	<0.1	Movement of sandstone block
52-2-1620	Browns Road Site 5	Shelter with Art	<20	<0.1	<0.1	<0.1	Movement of sandstone block; opening of existing cracks
52-2-1621	Browns Road Site 6	Shelter with Art	<20	<0.1	<0.1	<0.1	Movement of sandstone block
52-2-1622	Browns Road Site 7	Shelter with Deposit	<20	<0.1	<0.1	<0.1	Movement of sandstone block
52-2-1624	Browns Road Site 9	Axe Grinding Groove	270	1.8	<0.1	0.3	Fracturing of sandstone platform
52-2-1630	Browns Road Site 15	Shelter with Art	140	1.5	0.4	<1.0	Movement of sandstone block

52-2-1631	Browns Road Site 16	Axe Grinding Groove	230	2.0	<0.1	<0.1	Fracturing of sandstone platform
52-2-1635	Browns Road Site 21	Shelter with Art; Shelter with Deposit	<20	<0.1	<0.1	<0.1	Movement of sandstone block; may accelerate exfoliation of already weakened surfaces
52-2-1638	Browns Road Site 24	Shelter with Art	<20	<0.1	<0.1	<0.1	May accelerate exfoliation of already weakened surfaces
52-2-1639	Browns Road Site 25	Axe Grinding Groove	20	0.1	<0.1	<0.1	Fracturing of sandstone platform
52-2-1763	Upper Avon 27	Shelter with Art	440	1.0	0.6	<0.1	Fracturing of sandstone platform on which site is located
52-2-1801	Upper Avon 4	Shelter with Art; Shelter with Deposit	390	<0.1	0.2	<0.1	Opening of natural bedding planes
52-2-1825	Upper Avon 2	Axe Grinding Groove	540	2.4	0.4	0.3	Fracturing of sandstone platform
52-2-1826	Upper Avon 3	Axe Grinding Groove	820	0.2	<0.1	0.7	Fracturing of sandstone platform
52-2-3668	Flying Fox No. 1 Creek	Shelter with Deposit	40	0.3	<0.1	<0.1	Movement of sandstone block
52-2-3669	Wongawilli 1	Shelter with Art; Shelter with Deposit	<20	<0.1	<0.1	<0.1	Collapse of cliff line
52-2-3670	Wongawilli 2	Shelter with Art	<20	<0.1	<0.1	<0.1	Movement of sandstone block

### 5.1.2 Whale Cave

Whale Cave is not situated within the current Wongawilli SMP. However, due to the high archaeological significance of this particular site, subsidence predictions have been calculated (Table 5).

**Table 5:** Maximum Predicted Cumulative Systematic Subsidence Parameters for Aboriginal archaeological site Whale Cave

Site Number	Site Name	Site Type	Maximum Predicted Cumulative Systematic Subsidence Parameters:				
			Subsidence (mm)	Tilt (mm/m)	Tensile Strain (mm/m)	Compressive Strain (mm/m)	Type of Potential Impact based on overhang attributes
52-2-0018; 0754	Sandy Creek Road 10 / Whale Cave	Shelter with Art; Shelter with Deposit	<20	<0.1	<0.1	<0.1	Collapse of overhang; further collapse of internal shelf features

## 5.2 Risk of Impact for all Aboriginal archaeological sites within Wongawilli SMP

Previous studies have identified the following factors as important determinates in the potential and likelihood of a shelter site being impacted by mine subsidence (Sefton 2000a, Biosis Research 2007b):

- overhang size (particularly volume);

- presence of existing water seepage;
- presence and location of jointing and bedding planes;
- topographic location in relation to a valley bottom;
- location above the goaf; and
- block-fall weathering the main shelter formation process.

The method described by Biosis Research (2007) considers risk factors as being present or not, and ‘sums’ these to produce an overall risk category (described above). The more risk factors exhibited by a site then the greater the determined risk category. In particular the following reasoning has been used to formulate the risk assessments for the sites of high and moderate archaeological significance, where sites are considered to be at risk if:

- the shelter size is >50 m<sup>3</sup>;
- the shelter has existing water seepage;
- the site is located near the valley bottom; or
- the shelter is a block-fall type shelter.

The highest category used for risk of impact is *moderate*: this done to recognise the difficulty in making precise statements of impact, and to incorporate Sefton’s (2000) observations that generally impacts to sites are rare (occurring in <10% of monitored cases) and that when impacts have been recorded they have been relatively minor - rarely impacting art surfaces for example. Hence, the category moderate means impacts are possible, but likely to occur in roughly 10% (or less) of cases. The other categories used to describe risk includes sites whose features, size and position over longwall goafs places them in a class that has not previously been impacted in formal monitoring regimes. These categories are: *low* (impacts are unlikely); *very low* (impacts are highly unlikely); and *negligible* (impacts are highly unlikely, and would likely be indistinguishable from the natural background environment).

#### 5.2.1 Site Specific Risk of Impact Assessment for all Aboriginal archaeological site within Wongawilli SMP

The site specific impact assessments for the sites in Wongawilli SMP area are presented below and are summarised in Table 6. This information is used to determine the likelihood of impact relating to subsidence on archaeological sites using the parameters in Sefton’s Principal Components, in conjunction with the subsidence predictions.

**Table 6:** Assessment of risk of impact using Sefton's' (2000) 'Principal Components' and Biosis Research 2007 'Risk Categories' for all archaeological sites within Wongawilli SMP area.

SITE NAME	SITE NUMBER	L (m)	W (m)	H (m)	Volume m <sup>2</sup>	Aspect	BF / CW / SP	ART Y/N	Location	Wet / DRY	Location End LW	Location in LW	DIR	SUBS	Tensile Strain	Comp Strain	Tilt	Previously Undermined	Previously monitored
Native Dog Creek Shelter	52-2-0966 / 3096	11	2.1	2.8	65m <sup>2</sup>	NW	CW	Y	UVS	D	N	CP	E-W	670	2.0	<0.1	1.2	Yes	Yes
Browns Road Site 1	52-2-1616	31	3.2	3.3	327m <sup>2</sup>	NW	BF	Y	UVS	W	N	O	E-W	30	0.1	<0.1	<0.1	No	No
Browns Road Site 2	52-2-1617	12	2.5	1.6	48m <sup>2</sup>	W	BF	Y	LVS	D	N	O	N-W	85	0.6	<0.1	<0.1	Yes	Yes
Browns Road Site 5	52-2-1620	14	4	3	168m <sup>2</sup>	E	BF	Y	UVS	W	N	O	E-W	<20	<0.1	<0.1	<0.1	Yes	Yes
Browns Road Site 6	52-2-1621	6	3	1	18m <sup>2</sup>	E	BF	Y	UVS	D	N	O	E-W	<20	<0.1	<0.1	<0.1	Yes	Yes
Browns Road Site 7	52-2-1622	15	2	1.5	45m <sup>2</sup>	SE	BF	Y	UVS	W	N	O	N-W	<20	<0.1	<0.1	<0.1	No	Yes
Browns Road Site 9	52-2-1624	16	4	-	-	Open	SP	-	RT	W	N	CP / M	E-W	270	1.8	<0.1	0.3	No	No
Browns Road Site 15	52-2-1630	5	2.6	2.4	31.2m <sup>2</sup>	NW	BF	Y	RT	D	Y	M	E-W	140	1.5	0.4	<1.0	No	No
Browns Road Site 16	52-2-1631	9	3	-	-	Open	SP	-	RT	W	N	CP / M	E-W	230	2.0	<0.1	<0.1	No	No
Browns Road Site 21	52-2-1635	20	7	4	480m <sup>2</sup>	S	BF	Y	LVS	W	Y	O	E-W	300	0.5	0	0	Yes	Yes
Browns Road Site 24	52-2-1638	26	3	4	312m <sup>2</sup>	NE	BF	Y	LVS	W	Y	CP	E-W	30	0.1	0	0.1	Yes	Yes
Browns Road Site 25	52-2-1639	26	8	-	-	Open	SP	-	LVS	D	N	M	N-W	20	0.1	<0.1	<0.1	No	No
Upper Avon 27	52-2-1763	2	1.5	0.9	2.7m <sup>2</sup>	N	CW	Y	RT	D	N	O	E-W	440	1.0	0.6	<0.1	No	Yes
Upper Avon 2	52-2-1825	7.5	6	-	-	Open	SP	-	RT	W	N	CP / M	E-W	540	2.4	0.4	0.3	No	Yes
Upper Avon 3	52-2-1826	18	9	-	-	Open	SP	-	RT	W	N	CP / M	E-W	820	0.2	<0.1	0.7	No	Yes
Upper Avon 4	52-2-1801	9	4.2	4	745m <sup>2</sup>	S	BF	Y	RT	D	N	M	E-W	390	<0.1	0.2	<0.1	Yes	Yes
Flying Fox No. 1	52-2-3668	5	2.2	3.2	38.5m <sup>2</sup>	SE	BF	N	LVS	W	N	O	E-W	40	0.3	<0.1	<0.1	No	No
Wongawilli 1	52-2-3669	22	3.6	2.6	205.92 m <sup>2</sup>	SW	BF	N	LVS	W	Y	O	N-W	<20	<0.1	<0.1	<0.1	No	No
Wongawilli 2	52-2-3670	12	3	2	72m <sup>2</sup>	NE	BF	Y	UVS	W	Y	O	N-W	<20	<0.1	<0.1	<0.1	No	No

**Abbreviations:**

L	overhang / sandstone platform length
W	overhang / sandstone platform width
H	overhang height
Volume	in m <sup>2</sup>
Aspect	direction shelter faces
Faces aspect	main apparent formation process either block fall (BF) or cavernous weather (CW) or sandstone platform (SP)
Art	Y = present N = absent
LOC	RT = ridge top UVS = upper valley slope LVS = lower valley slope VB = valley bottom (lowest cliff line)
Wet / dry	D = surfaces mainly not affected by water seepage W = surface mainly affected by water seepage
LOC END LW	Y = located within 100m of the end of a longwall, wither inside or outside the longwall N = not located within 100m of the end of a longwall, wither inside or outside the longwall
LOC IN LW	O = located outside the longwall and chain pillar CP = located under the longwall and chain pillar E = located closer to the edge of the longwall than the middle (centre) M = located closer to the centre of the longwall than the end
DIR LW	Direction of the nearest longwall
SUBS	Maximum predicted subsidence
Tensile Strain	Maximum predicted tensile strain
Comp. Strain	Maximum compressive strain
Tilt	Maximum tilt

Based on the above information, the following impact assessments are described in terms of ‘risk of impact’ for each archaeological site within the current SMP Area.

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<b><i>Native Dog Creek Shelter</i></b>	<b><i>52-2-0966 / 3096</i></b>	<b><i>Shelter with Art</i></b>
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This site has low predicted systematic tensile strains, an overall subsidence movement of 670 mm, and is located over the goaf area of Longwall 11. The site is situated on the north western face of a small, separate sandstone block on the upper valley slope. The site has a low volume – 65 m<sup>3</sup> – placing it just inside the risk category for large sites. Despite the site being located above the goaf of Longwall 11, the site situation, volume, and subsidence predictions indicate that the risk of impact at this site is very low.

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<b><i>Browns Road Site 1</i></b>	<b><i>52-2-1616</i></b>	<b><i>Shelter with Art; Shelter with Deposit</i></b>
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This site has very low predicted systematic tensile strains and is not located over a longwall goaf area or the chain & pillar area. The site’s volume is quite large at 327 m<sup>3</sup>, which places it in the risk category of larger sites. Although rock falls, fracturing of strata and shear movements near the surface are very rare outside of goaf areas, the site is situated on a very large continuous cliff line (CL15-01) at the head of Wongawilli Creek (MSEC 2008: 49), with evidence of continuous water seepage affecting most art surfaces. These factors increase the likelihood of potential impacts, resulting in the risk of impact at this site to be moderate.

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<b><i>Browns Road Site 2</i></b>	<b><i>52-2-1617</i></b>	<b><i>Shelter with Art</i></b>
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This site has low predicted systematic tensile strains and is not located over a goaf area. The site’s volume is 48 m<sup>3</sup>, placing it outside the risk category of larger sites. Rock falls, fracturing of strata and shear movements near the surface are very rare outside of goaf areas. The site is located 200 m from the chain & pillar extraction area 1. This site was previously monitored during the extraction of Longwall 1 and 9 – no impacts were observed due to longwall extraction. The risk of impact at this site is very low.

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<b><i>Browns Road Site 5</i></b>	<b><i>52-2-1620</i></b>	<b><i>Shelter with Art</i></b>
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This site has very low predicted systematic tensile strains and is not located over a goaf area. The site’s volume is 168 m<sup>3</sup>, placing it in the risk category of larger sites. However rock falls, fracturing of strata and shear movements near the surface are very rare outside of goaf areas. This site is located 900 m from the end of Longwall 19 – no changes to the site were recorded during monitoring for the extraction of Longwall 5. The risk of impact at this site is considered to be negligible.

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<b><i>Browns Road Site 6</i></b>	<b><i>52-2-1621</i></b>	<b><i>Shelter with Art</i></b>
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This site has very low predicted systematic tensile strains, and is not located over a goaf area. The site’s volume is only 18 m<sup>3</sup>, which place it outside the risk category of larger sites. Rock falls, fracturing of strata and shear movements near the surface are very rare outside of goaf areas. This site is located 1000 m from the end of Longwall 19 – no changes to the site were recorded during monitoring for the extraction of Longwall 6. The risk of impact at this site is considered to be negligible.

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<b><i>Browns Road Site 7</i></b>	<b><i>52-2-1622</i></b>	<b><i>Shelter with Art</i></b>
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This site has very low predicted systematic tensile strains, and is not located over a goaf area. The site’s volume is only 45 m<sup>3</sup>, which place it outside the risk category of larger sites. Rock falls, fracturing of strata

and shear movements near the surface are very rare outside of goaf areas. This site is located 1150 m from the end of Longwall 19 – no changes to the site were recorded during monitoring for the extraction of Longwall 8. The risk of impact at this site is considered to be negligible.

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<b><i>Browns Road Site 9</i></b>	<b><i>52-2-1624</i></b>	<b><i>Axe Grinding Grooves</i></b>
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This site has low predicted systematic tensile strains, has an overall subsidence movement of 270 mm, and is located above the longwall goaf. The axe grinding grooves are situated on a small sandstone platform on the edge of a large upland swamp above Wongawilli Creek. The site is not situated in a valley bottom. The risk of impact at this site is low.

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<b><i>Browns Road Site 15</i></b>	<b><i>52-2-1630</i></b>	<b><i>Shelter with Art</i></b>
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This site has low predicted systematic tensile strains, an overall subsidence movement of 140 mm, and is located above the southern roadway of Longwall 15. The site is situated on the north western face of a small, separate sandstone block on the upper valley slope. The site has a low volume – 31.2 m<sup>3</sup> – placing outside the risk category for large sites. Despite the site being located above the goaf of Longwall 15, the site situation, volume, and subsidence predictions indicate that the risk of impact at this site is very low.

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<b><i>Browns Road Site 16</i></b>	<b><i>52-2-1631</i></b>	<b><i>Axe Grinding Groove</i></b>
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This site has very low predicted systematic tensile strains, has an overall subsidence movement of 230 mm and is located above the longwall goaf. The axe grinding grooves are situated on a narrow sandstone platform on the edge of a large upland swamp above Wongawilli Creek. The site is not situated in a valley bottom. The risk of impact at this site is low.

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<b><i>Browns Road Site 21</i></b>	<b><i>52-2-1635</i></b>	<b><i>Shelter with Art; Shelter with Deposit</i></b>
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This site has very low predicted systematic tensile strains, and is not located over a longwall goaf area. The site's volume is quite large at 480 m<sup>3</sup>, which places it in the risk category of larger sites. Although, rock falls, fracturing of strata and shear movements near the surface are very rare outside of goaf areas, the site is situated on a very large continuous cliff line (CL19-03) on a Wongawilli Creek 1<sup>st</sup> order tributary (MSEC 2008: 49). The surface of the shelter has been significantly affected by water seepage, mineral accretions and intense heat from the 2001 bushfires, resulting in accelerated surface exfoliation. This site is located 150 m from the end of Longwall 19 – no changes to the site were recorded during monitoring for the extraction of Longwall 4. Despite the distance from the proposed longwall, the above mentioned existing site conditions increase the likelihood of potential impacts. The risk of impact at this site is low.

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<b><i>Browns Road Site 24</i></b>	<b><i>52-2-1638</i></b>	<b><i>Shelter with Art; Shelter with Deposit</i></b>
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This site has low predicted systematic tensile strains, and is not located over the goaf area. The site's volume is 48 m<sup>3</sup>, placing it outside the risk category of larger sites. Rock falls, fracturing of strata and shear movements near the surface are very rare outside of goaf areas. The site is located 300m from the chain & pillar extraction area 1. This site was previously monitored during the extraction of Longwall 1 and 9 – no impacts were observed due to longwall extraction. The risk of impact at this site is very low.

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**Browns Road Site 25****52-2-1639****Axe Grinding Groove**

This site has low predicted systematic tensile strains, and is not located over the goaf area. The axe grinding grooves are situated on a large open sandstone platform adjacent to a small waterfall feature in the tributary. The site is located 100m from Longwall 19. The site is not situated in a valley bottom. The risk of impact at this site is very low.

**Upper Avon 27****52-2-1763****Shelter with Art**

This site has low predicted systematic tensile strains, an overall subsidence movement of 440 mm, and is not located over a goaf area. The site is located in a very small weathered cavern with a very low volume – 2.7 m<sup>3</sup> - placing outside the risk category of larger sites. Rock falls, fracturing of strata and shear movements near the surface are very rare outside of goaf areas. No changes to the site were recorded during monitoring for the extraction of Longwall 10, immediately north. The risk of impact at this site is very low.

**Upper Avon 2****52-2-1825****Axe Grinding Groove**

This site has very low predicted systematic tensile strains, has an overall subsidence movement of 540 mm, and is located above the longwall goaf. The axe grinding grooves are situated on a very small sandstone platform on the edge of a large upland swamp above Bellbird Creek. The site is not situated in a valley bottom. The risk of impact at this site is very low.

**Upper Avon 3****52-2-1826****Axe Grinding Groove**

This site has very low predicted systematic tensile strains, has an overall subsidence movement of 820 mm, and is located above the longwall goaf. The axe grinding grooves are situated on a large open sandstone platform on the edge of a large upland swamp above Bellbird Creek. The site is not situated in a valley bottom. The risk of impact at this site is low.

**Upper Avon 4****52-2-1801****Shelter with Art**

This site has low predicted systematic tensile strains, and is not located over a goaf area. The site's volume is 745 m<sup>3</sup>, placing it in the risk category of larger sites. However, rock falls, fracturing of strata and shear movements near the surface are very rare outside of goaf areas. The site is located 100 m north of proposed Longwall 11. This site was previously monitored during the extraction of Longwall 9 and 10 – no impacts were observed due to longwall extraction. The risk of impact at this site is very low.

**Flying Fox Creek No. 1****52-2-3668****Shelter with Deposit**

This site has very low predicted systematic tensile strains, and is not located over a goaf area. The site's volume is 38.5 m<sup>3</sup>, placing it outside the risk category of larger sites. The site is a very small, stand alone sandstone block adjacent to Flying Fox creek. Rock falls, fracturing of strata and shear movements near the surface are very rare outside of goaf areas. The site is located 300m south of proposed longwall 12. The risk of impact at this site is very low.

**Wongawilli 1****52-2-3669****Shelter with Deposit**

This site has very low predicted systematic tensile strains, and is not located over a longwall goaf area. The site's volume is quite large at 205 m<sup>3</sup>, which places it in the risk category of larger sites. Although rock falls, fracturing of strata and shear movements near the surface are very rare outside of goaf areas, the site is situated on a very large continuous cliff line (CL19-06) on a Wongawilli Creek 1<sup>st</sup> order tributary (MSEC 2008: 49). Although the site contains no art, the surfaces of the overhang have been significantly affected by water seepage, mineral accretions and chemical weathering. This site is located 200 m from the end of Longwall 19. Despite the distance from the proposed longwall, the above mentioned existing site conditions increase the likelihood of potential impacts. The risk of impact at this site is low.

**Wongawilli 2****52-2-3670****Shelter with Art**

This site has low predicted systematic tensile strains, and is not located over a goaf area. The site's volume is 72 m<sup>3</sup>, placing just inside the risk category of larger sites. However, rock falls, fracturing of strata and shear movements near the surface are very rare outside of goaf areas. The site is located 250 m north of proposed Longwall 19. The risk of impact at this site is very low.

The results of the archaeological significance assessments and the risk of impact assessments are summarised in Table 6 below.

**Table 7:** Summary of the predicted risk of impact to the archaeological sites in Wongawilli SMP area, as well as the assessed archaeological significance, and those sites subject to Baseline recording and monitoring

Site Number	Site Name	Site Type	Significance	Risk of Impact	Subject to Baseline Recording	Subject to Monitoring
52-2-0966; 3096	Native Dog Creek Shelter	Shelter with Art	Moderate	Very Low	Yes	Yes
52-2-1616	Browns Road Site 1	Shelter with Art and Deposit	Low	Moderate	Yes	Yes
52-2-1617	Browns Road Site 2	Shelter with Art	Low	Very low	No	Yes
52-2-1620	Browns Road Site 5	Shelter with Art	Low	Negligible	No	Yes
52-2-1621	Browns Road Site 6	Shelter with Art	Low	Negligible	No	Yes
52-2-1622	Browns Road Site 7	Shelter with Deposit	Low	Negligible	No	Yes
52-2-1624	Browns Road Site 9	Axe Grinding Grooves	Moderate	Low	Yes	Yes
52-2-1630	Browns Road Site 15	Shelter with Art	Low	Very low	Yes	Yes
52-2-1631	Browns Road Site 16	Axe Grinding Grooves	Low	Low	Yes	Yes
52-2-1635	Browns Roads Site 21	Shelter with Art and Deposit	Low	Moderate	Yes	Yes
52-2-1638	Browns Roads Site 24	Shelter with Art	Moderate	Very low	No	Yes
52-2-1639	Browns Roads Site 25	Axe Grinding Grooves	Moderate	Very low	No	Yes
52-2-1763	Upper Avon 27	Shelter with Art	High	Very low	Yes	Yes
52-2-1801	Upper Avon 4	Shelter with Art	Low	Very low	No	Yes
52-2-1825	Upper Avon 2	Axe Grinding Grooves	Low	Very low	Yes	Yes
52-2-1826	Upper Avon 3	Axe Grinding Grooves	High	Low	Yes	Yes
52-2-3668	Flying Fox Creek	Shelter with Deposit	Low	Very low	No	Yes
52-2-3669	Wongawilli 1	Shelter with deposit	Low	Moderate	Yes	Yes
52-2-3670	Wongawilli 2	Shelter with art	Low	Very low	No	Yes

There are 3 sites with negligible (16%) risk and a further 10 (52%) sites that have very low risk of impact from the proposed mining, including the only shelter with art site assessed to have high archaeological significance in the Wongawilli SMP area (Table 6). Three sites (16%) are considered to have moderate risk of impact due to the nature of the sandstone overhangs in combination with the subsidence prediction. The remaining sites (16%) are considered to be of low potential for impacts to occur.

Based on the risk assessment, archaeological sites identified as being of low and moderate risk, sites of higher archaeological significance and sites located directly above the proposed longwall goafs will be subject to a program of monitoring. Sites located at distance from the longwalls, considered to be of lower archaeological significance and that have been previously undermined and monitored will not be included in the monitoring program (Table 7).

### 5.2.2 Whale Cave

Although this site is located outside the current Wongawilli SMP area, the following risk assessment has been completed for the site.

**Table 8:** Assessment of risk of impact using Sefton's' (2000) 'Principal Components' and Biosis Research 2007 'Risk Categories' for archaeological site Whale Cave.

SITE NAME	SITE NUMBER	L (m)	W (m)	H (m)	Volume m <sup>2</sup>	Aspect	BF / CW / SP	ART Y/N	Location	Wet / DRY
Whale Cave	52-2-0018; 0754	16	8	2.4	307.2m <sup>2</sup>	NW	BF / CW	Y	UVS	D
Location End LW	Location in LW	DIR	SUBS	Tensile Strain	Comp Strain	Tilt	Previously Undermined	Previously monitored		
N	O	EW	<20	<0.1	<0.1	<0.1	Yes	Yes		

#### **Whale Cave**

**52-2-0754**

***Shelter with Art; Shelter with deposit***

This site has low predicted systematic tensile strains, and is not located over a goaf area. The site's volume is 307.2 m<sup>3</sup>, placing inside the risk category of larger sites. However, rock falls, fracturing of strata and shear movements near the surface are very rare outside of goaf areas. The site is located 400 m east of proposed Longwall 16. The site has been previously monitored following rock falls that were observed in November 1981 following chain and pillar extraction between 1978 and 1981. The risk of impact at this site is very low.

**Table 9:** Summary of the predicted risk of impact to archaeological site Whale Cave as, well as the assessed archaeological significance.

Site Number	Site Name	Site Type	Significance	Risk of Impact	Subject to Monitoring
52-2-0018; 0754	Sandy Creek Road 10 / Whale Cave	Shelter with Art; shelter with deposit	High	Very Low	Yes

Despite the low likelihood of impact to Whale Cave, the site is considered to be of high significance, and will be included in the monitoring program. Recent recording has been completed by Gillian Ford for her PhD and this information will be included as base line records for this monitoring program. It should be noted that no impacts were observed following the extraction of Longwall 14, situated 200 m north of the site (Biosis Research 2007b; MSEC 2008 Drawing No. MSEC360-12).

## 6.0 MANAGEMENT AND MITIGATION MEASURES

In the event that there are subsidence impacts noted at the site, management strategies specific to the impact will be developed. No sites currently located within the Wongawilli SMP Area are considered to be of high risk of impact resulting from the extraction of the proposed longwalls or pillar extraction area.

Management strategies will be implemented in accordance with current conservation practice and the conservation principles contained within the Australia International Council on Monuments and Sites (ICOMOS) *Burra Charter*, and the NSW Department of Environment and Conservation *Guidelines for Aboriginal Heritage Impact Assessment* (Draft). The advice of the identified Aboriginal communities regarding appropriate management methodologies will form an integral part of the development of the management strategies.

All contingent management strategies will be developed in consultation with the identified Aboriginal communities, Gujarat NRE Minerals Pty Limited, and DECCW. The proposed assessment, strategies, timing and nomination of all activities are detailed in 10 below.

**Table 10.** Management Activities, mitigation and timeframes of Baseline Recording and Monitoring Programs for all sites within Wongawilli SMP Area.

Management Activity	To Be Completed by	In Consultation With	Timeframe	Impact = Mitigation		Outcomes
<b>Baseline Recording</b>	Qualified archaeological consultant with skill in Rock Art recording	Registered Aboriginal stakeholders, including: <ul style="list-style-type: none"> <li>▪ Illawarra LALC</li> <li>▪ Kullila WHAC</li> <li>▪ NKSM</li> <li>▪ NIAC</li> <li>▪ Gary Caines</li> <li>▪ Wodi Wodi</li> <li>▪ CBNTCAC</li> </ul>	<b>Prior to the Commencement of Longwall Mining – December 2009</b>	None required at this stage – no invasive ‘preventative’ mitigation measures are recommended for any of the Aboriginal sites within the current SMP Area		Completion of Baseline Recording report to be lodge with DECCW and Aboriginal stakeholder groups
<b>Monitoring – During Extraction</b>	Qualified archaeological consultant with experience in rock art monitoring	Registered Aboriginal stakeholders, including: <ul style="list-style-type: none"> <li>▪ Illawarra LALC</li> <li>▪ Kullila WHAC</li> <li>▪ NKSM</li> <li>▪ NIAC</li> <li>▪ Gary Caines</li> <li>▪ Wodi Wodi</li> <li>▪ CBNTCAC</li> </ul>	<p>During the extraction of those longwalls associated with identified Aboriginal archaeological sites.</p> <p>The following longwalls will be extracted over a period of 5 years.</p> <p>Longwall 12 – Dec 2009</p> <p>Longwall 11 – Jan 2010</p> <p>PEA 1 – June 2011</p> <p>Longwall 19 – July 2012</p> <p>Longwalls 15 + 16 – Jan 2013</p>	<p><b>Impact / Change Observed</b></p> <p>Includes:</p> <ul style="list-style-type: none"> <li>▪ Cracking</li> <li>▪ Opening of natural bedding planes</li> <li>▪ Blockfall</li> <li>▪ Exfoliation</li> <li>▪ Water seepage changes</li> </ul>	<p>Inform Aboriginal stakeholders and DECCW in writing prior to site inspection</p> <p>Consultation with DECCW will be required if remediation or mitigation measure affect the archaeological values at individual sites</p> <p>Site inspection to document and photograph the observed changes / impacts</p> <p>Discussion of potential remediation / mitigation that might include:</p> <ul style="list-style-type: none"> <li>▪ Seepage – Artificial drip line</li> <li>▪ Cracks – silica fill</li> </ul> <p>Use appropriate specialists to undertake physical remediation activities</p> <p>Impacts, such as blockfall and exfoliation will be difficult to manage / remediate</p> <p>Modification of monitoring methodology if site is considered ‘outside’ the measure parameters of subsidence impacts</p> <p>Continue monitoring</p>	<p>Completion of End of Panel report that details following information relating to relevant Aboriginal archaeological sites</p> <ul style="list-style-type: none"> <li>▪ Impacts / no impacts</li> <li>▪ Mitigation / Remediation undertaken</li> <li>▪ Consultation</li> <li>▪ Recommendations</li> </ul>

<b>Monitoring – Following Extraction</b>			Following the extraction of individual longwalls as part of the End of Panel reports (3 months following mining activities)	<b>No Impact / Change Observed</b>	No further mitigation or management required	
<b>Monitoring – Long Term</b>			Long-term site monitoring – undertaken 2 years following the extraction of each of the proposed longwalls			

The following Table indicates which of the above mention activities corresponds to Aboriginal archaeological sites within the SMP area.

**Table 11:** Monitoring requirements for all Aboriginal archaeological, sites situated within Wongawilli SMP Area.

Site Number	Site Name	Site Type	Subject to Baseline Recording	Subject to Monitoring	Monitoring to occur
52-2-0966; 3096	Native Dog Creek Shelter	Shelter with Art	Yes	Yes	<ul style="list-style-type: none"> <li>Prior to extraction of Longwall 11</li> <li>During extraction of Longwall 11</li> <li>3-6 months following extraction</li> <li>2 years following extraction</li> </ul>
52-2-1616	Browns Road Site 1	Shelter with Art and Deposit	Yes	Yes	<ul style="list-style-type: none"> <li>Prior to extraction of both Longwall 15 and PEA 1</li> <li>During extraction of both Longwall 15 and PEA 1</li> <li>3-6 months following extraction</li> <li>2 years following extraction</li> </ul>
52-2-1617	Browns Road Site 2	Shelter with Art	No – previously completed	Yes	<ul style="list-style-type: none"> <li>Prior to extraction of Longwall 19</li> <li>6 months following extraction</li> <li>2 years following extraction</li> </ul>
52-2-1620	Browns Road Site 5	Shelter with Art	No – previously completed	Yes	<ul style="list-style-type: none"> <li>Prior to extraction of Longwall 19</li> <li>6 months following extraction</li> <li>2 years following extraction</li> </ul>

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52-2-1621	Browns Road Site 6	Shelter with Art	No – previously completed	Yes	<ul style="list-style-type: none"> <li>▪ Prior to extraction of Longwall 19</li> <li>▪ 6 months following extraction</li> <li>▪ 2 years following extraction</li> </ul>
52-2-1622	Browns Road Site 7	Shelter with Deposit	No – previously completed	Yes	<ul style="list-style-type: none"> <li>▪ Prior to extraction of Longwall 19</li> <li>▪ 6 months following extraction</li> <li>▪ 2 years following extraction</li> </ul>
52-2-1624	Browns Road Site 9	Axe Grinding Grooves	Yes	Yes	<ul style="list-style-type: none"> <li>▪ Prior to extraction of Longwall 15</li> <li>▪ During extraction of Longwall 15</li> <li>▪ 3-6 month following extraction</li> <li>▪ 2 years following extraction</li> </ul>
52-2-1630	Browns Road Site 15	Shelter with Art	Yes	Yes	<ul style="list-style-type: none"> <li>▪ Prior to extraction of Longwall 15</li> <li>▪ During extraction of Longwall 15</li> <li>▪ 3-6 months following extraction</li> <li>▪ 2 years following extraction</li> </ul>
52-2-1631	Browns Road Site 16	Axe Grinding Grooves	Yes	Yes	<ul style="list-style-type: none"> <li>▪ Prior to extraction of Longwall 15</li> <li>▪ During extraction of Longwall 15</li> <li>▪ 3-6 months following extraction</li> <li>▪ 2 years following extraction</li> </ul>
52-2-1635	Browns Roads Site 21	Shelter with Art and Deposit	Yes	Yes	<ul style="list-style-type: none"> <li>▪ Prior to extraction of Longwall 15</li> <li>▪ During extraction of Longwall 15</li> <li>▪ 3-6 months following extraction</li> <li>▪ 2 years following extraction</li> </ul>
52-2-1638	Browns Roads Site 24	Shelter with Art	No – previously completed	Yes	<ul style="list-style-type: none"> <li>▪ Prior to extraction of Longwall 19</li> <li>▪ 6 months following extraction</li> <li>▪ 2 years following extraction</li> </ul>
52-2-1639	Browns Roads Site 25	Axe Grinding Grooves	No	Yes	<ul style="list-style-type: none"> <li>▪ Prior to extraction of Longwall 19</li> <li>▪ 6 months following extraction</li> <li>▪ 2 years following extraction</li> </ul>
52-2-1763	Upper Avon 27	Shelter with Art	Yes	Yes	<ul style="list-style-type: none"> <li>▪ Prior to extraction of Longwall 11</li> <li>▪ During extraction of Longwall 11</li> <li>▪ 3-6 months following extraction</li> <li>▪ 2 years following extraction</li> </ul>
52-2-1801	Upper Avon 4	Shelter with Art	No	Yes	<ul style="list-style-type: none"> <li>▪ Prior to extraction of Longwall 19</li> <li>▪ 6 months following extraction</li> <li>▪ 2 years following extraction</li> </ul>
52-2-1825	Upper Avon 2	Axe Grinding Grooves	Yes	Yes	<ul style="list-style-type: none"> <li>▪ Prior to extraction of Longwall 11</li> <li>▪ During extraction of Longwall 11</li> <li>▪ 3-6 months following extraction</li> </ul>

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52-2-1826	Upper Avon 3	Axe Grinding Grooves	Yes	Yes	<ul style="list-style-type: none"> <li>▪ Prior to extraction of Longwall 11</li> <li>▪ During extraction of Longwall 11</li> <li>▪ 3-6 months following extraction</li> </ul>
52-2-3668	Flying Fox Creek	Shelter with Deposit	No	Yes	<ul style="list-style-type: none"> <li>▪ Prior to extraction of PEA 1</li> <li>▪ 6 months following extraction</li> <li>▪ 2 years following extraction</li> </ul>
52-2-3669	Wongawilli 1	Shelter with deposit	Yes	Yes	<ul style="list-style-type: none"> <li>▪ Prior to extraction of Longwall 19</li> <li>▪ During extraction of Longwall 19</li> <li>▪ 3-6 months following extraction</li> <li>▪ 2 years following extraction</li> </ul>
52-2-3670	Wongawilli 2	Shelter with art	No	Yes	<ul style="list-style-type: none"> <li>▪ Prior to extraction of Longwall 19</li> <li>▪ 6 months following extraction</li> <li>▪ 2 years following extraction</li> </ul>

**\*\*Note: if changes to any sites are observed, additional monitoring at these sites will occur to measure, manage and mitigate further impact\*\***

## 7.0 MONITORING METHODS

### 7.1.1 Baseline Recording

All the currently known Aboriginal archaeological sites within Wongawilli SMP Area have been subject to recording at the level appropriate for registration on the *Aboriginal Heritage Information Management System* (AHIMS) at DECC. The purpose of the detailed recording proposed in this Cultural Heritage Management Plan is to:

- Mitigate the risk of potential impact through more detailed archival recording of all shelter sites.
- Provide a set of baseline records for the monitoring program.

A monitoring regime established by Sefton (2000) and amended and continued by Biosis Research, has proven effective in observing changes to Aboriginal shelter sites due to subsidence movements. The recording and monitoring regime described in this Aboriginal Heritage Plan aims to implement a similar monitoring program, and to establish recording procedures that are up-to-date with current technologies and practice and capture a record of the rock art in its current context.

Recording of each sandstone shelter site including information outlined below that is part of the standard recording forms used by Biosis Research. This includes:

- Site Information - site name, site type, AGD co-ordinates, amount of time spent on-site recording, lighting conditions, weather conditions and an overall description of the site within the landscape.
- Environment Information – landform, landform unit, vegetation, landuse, name and distance to permanent and temporary water source
- Shelter Details – length, width and height of shelter, dimensions of living area, how the site was measured, overhang formation processes and internal features
- Deposit Details – Depth and description of deposit, living area description, details of artefacts, location of artefacts and condition of the archaeological deposit.

Scale plans and drawings of the shelter will be drawn.

Comprehensive recording of art panels and motifs including;

- detailed drawings of panel showing clearly showing motifs located on individual panels;
- photos using high resolution digital photography, of each motif, of each art panel and panels in their wider context and in relation to each other;
- spherical photography will be completed of select sites;
- details of natural impacts to art panels will be noted, including:
  - details of insect impacts on art surfaces

- other animal impact such as bat guano
- human impacts such as graffiti
- exposure to direct sunlight
- surface impacts from fire
- water seepage from cracks across art surfaces
- microflora growing on art surfaces
- mineral accretions on art surfaces
- exfoliated sections of art panels

Elevation plans of shelter walls recording structural and surface features including but not limited to art, joints, bedding planes, exfoliation scars, cracks, mineral and micro-organism growth, chemical weathering, drip line and water seepage locations.

### Monitoring Points

The identification and recording through digital photography of specific monitoring points, informed by Sefton's and Biosis Research's previous work, including:

- Bedding planes;
- Joints;
- Areas of seepage; and
- Case hardened surfaces.

These features will be identified, numbered and mapped on an elevation plan of the overhang. Each feature is also photographed in detail, forming a baseline photographic record for ongoing comparison during the monitoring program

Upon completion of the baseline recording a report and archival material will be submitted to the NSW Department of Environment, Climate Change and Water.

The report will include a detailed description of each of the shelter sites recorded, including in the case of rock art sites a full list of the art present describing media, application techniques and motif types. In addition the rock art present at each site will be interpreted using an appropriate level of observation (the more complex the site the more detailed the interpretation), including digital enhancement where appropriate (David *et al.* 2001). The archival material will consist of all digital photographs, spherical photography and written records for each site transferred to archival quality CD-ROM in accordance with the NPWS Standards and Guidelines (NSW NPWS 1997).

### 7.1.2 Timing

Mining at Wongawilli Colliery will commence in 2009 and continue over a 5 year period. All sites will be monitored over this period.

Baseline recording and monitoring will be undertaken at three stages of the longwall extraction for Longwalls 11, 12, 15, 16 & 19, and Pillar Extraction Area 1:

- Baseline archival recording:  
Prior to commencement of mining.
- Impact assessment recording:  
Three months after each predicted subsidence movement at the site (that is when a longwall makes it closest traverse to the site).
- Final assessment recording:  
Following the completion of mining and reported in End of Panel Assessments and/or Annual Environmental Management Reports (6-12 months following extraction).

Any impacts will be assessed by comparing the results of the impact recording stages with the baseline data. Movement at and within the site will be monitored by comparing monitoring points, and general observations of the surrounding landscape and whether it shows evidence of subsidence impact.

### 7.1.3 Review of Methodology

A review of the methodology and monitoring regime will be undertaken during the course of this program.

A review of the archival recording procedure will be conducted at the end of the collection of the baseline data. This review will assess the collection process and the amount of data that is collected and its relevance to the project. An additional review of the archival recording procedure will take place at the conclusion of archival recording.

A review of the monitoring methodology will also be undertaken. This will be completed at the conclusion of each of the scheduled monitoring periods. The review will assess the time period between monitoring events and the effectiveness for gathering the required data.

It may be deemed necessary to undertake a final post-extraction site monitor up to 2 years following the completion of mining to observe any long-term changes that may have resulted from mining related subsidence.

### 7.1.4 Reporting

Reports will be produced and submitted to the NSW DECCW and Aboriginal stakeholders at the following project milestones:

- Completion of baseline recording – to be submitted in January 2010

- Completion of each monitoring activity, including End of Panel assessment – this will be ongoing through the mining of Wongawilli Longwalls.

The baseline recording report will include and an inventory with a detailed description of each of the shelter sites recorded, including in the case of rock art sites a full list of the art present describing media, application techniques and motif types. In addition the rock art present at each site will be interpreted using an appropriate level of observation (the more complex the site the more detailed the interpretation), including digital enhancement where appropriate (David *et al.* 2001).

The monitoring reports will include observations on any changes observed within the monitored shelters, and an interpretation of the mechanisms effecting those changes. Ongoing review of the factors influencing the preservation of shelters and the rock art within them will be included in each report where relevant observations and findings are made.

# FIGURES

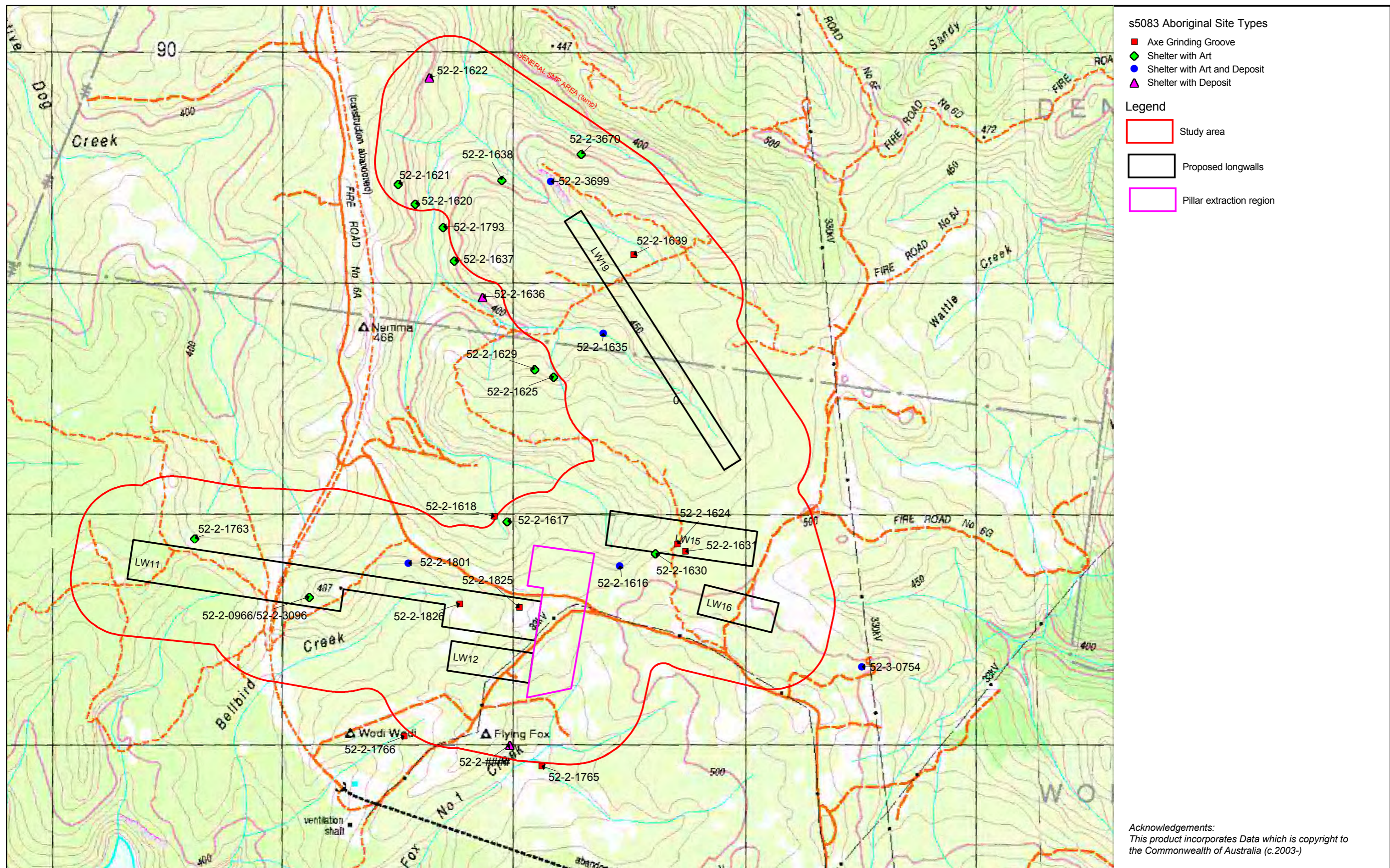


Figure 1 : Previously recorded and newly recorded Aboriginal archaeological sites within the SMP area

Figure 1 : Previously recorded and newly recorded Aboriginal archaeological sites within the SMP area

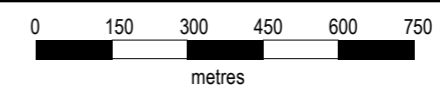
Date: 30 October 2008

Checked by: MT

File number: S5083

Location: ..\5000\5000s\5083\Mapping\s5083\_Figure 4\_New and Relocated Sites.WOR

Scale:



BIOSIS RESEARCH Pty. Ltd.

8 Tate Street  
Wollongong  
NEW SOUTH WALES 2500

# APPENDICIES

# APPENDIX 1

## A1. Consultation Log

Aboriginal Group	Type of Consultation	Date/Time of Consultation	Response
<b>Field Work – Biosis Research 2005, 2006, 2007</b>			
Illawarra Local Aboriginal Land Council	Participated in Field Survey proposed BHP Longwalls		No response
Cubbitch Barta Native Title Claimants	Participated in Field Survey proposed BHP Longwalls		Written response
Wodi Wodi Elders Corporation	Participated in Field Survey proposed BHP Longwalls		Written response
<b>Report Comments – Biosis Research 2008</b>			
Illawarra Local Aboriginal Land Council	Informed of completion of report from previous field surveys – gap field survey undertaken		Written Response received on 23 March 2009
Cubbitch Barta Native Title Claimants	Informed of completion of report from previous field surveys – gap field survey undertaken		No written response
Wodi Wodi Elders Corporation	Informed of completion of report from previous field surveys		No response
<b>Part 6 Consultation Notifications – Biosis Research September 2008</b>			
Illawarra Local Aboriginal Land Council	Written Notification of Proposed Longwalls and Pillar Extraction Area at Wongawilli Colliery	Letter sent 8 September 2008	Response in writing received on 16 September 2008
The Registrar of Aboriginal Owners	Written Notification of Proposed Longwalls and Pillar Extraction Area at Wongawilli Colliery	Letter sent 8 September 2008	No response
Native Title Services	Written Notification of Proposed Longwalls and Pillar Extraction Area at Wongawilli Colliery	Letter sent 8 September 2008	No response
The Wollondilly Shire Council	Written Notification of Proposed Longwalls and Pillar Extraction Area at Wongawilli Colliery	Letter sent 8 September 2008	No response
The NSW Department of Environment and Climate	Written Notification of Proposed Longwalls and Pillar	Letter sent 8 September	No response

Change	Extraction Area at Wongawilli Colliery	2008	
<b>Part 6 Consultation Media Advertisements – Biosis Research September 2008</b>			
Illawarra Local Aboriginal Land Council	Advertisement place in Illawarra Mercury on the 6 and 13 September 2008	17 September 2008	Responded via email to confirm involvement
Kullila Welfare & Housing Aboriginal Corporation	Advertisement place in Illawarra Mercury on the 6 and 13 September 2008	10 September 2008	Responded via phone call and then in writing
Northern Illawarra Aboriginal Collective Inc.	Advertisement place in Illawarra Mercury on the 6 and 13 September 2008	1 October 2008	Responded via email to Gujarat and subsequently via phone call to Biosis Research
Gary Caines	Advertisement place in Illawarra Mercury on the 6 and 13 September 2008	25 September 2008	Responded via email to register interest in project
<b>Part 6 Consultation Methodology – Biosis Research October 2008</b>			
Illawarra Local Aboriginal Land Council	Proposed Methodology for Reporting of results and consultation sent via registered post	6 October 2008	No response
Kullila Welfare & Housing Aboriginal Corporation	Proposed Methodology for Reporting of results and consultation sent via registered post	6 October 2008	No response
Northern Illawarra Aboriginal Collective Inc.	Proposed Methodology for Reporting of results and consultation sent via registered post	6 October 2008	<ul style="list-style-type: none"> <li>- Called to discuss future involvement in field work - agreed that area had been sufficiently surveyed previously</li> <li>- want to be involved in future site visits as long as Biosis can guarantee safety on site with other Aboriginal community groups – requested that at least 2 NIAC person minimum to ensure safety</li> <li>- Did not discuss consultation methodology, how to consult with NIAC or forward any cultural knowledge of that area verbally or in writing</li> </ul>
Gary Caines	Proposed Methodology for Reporting of results and consultation sent via registered post	6 October 2008	No response
<b>Part 6 Consultation – AHIP (90) Intention to submit application – Biosis Research July 2009</b>			
Illawarra Local Aboriginal Land Council	CHMP report and original Survey report sent via registered post, along with cover letter informing of	27 July 2009	No written or verbal comments

	intent to submit an AHIP (90)		
Kullila Welfare & Housing Aboriginal Corporation	CHMP report and original Survey report sent via registered post, along with cover letting informing of intent to submit an AHIP (90)	27 July 2009	No written or verbal comments
Northern Illawarra Aboriginal Collective Inc.	CHMP report and original Survey report sent via registered post, along with cover letting informing of intent to submit an AHIP (90)	27 July 2009	No written or verbal comments
Gary Caines	CHMP report and original Survey report sent via registered post, along with cover letting informing of intent to submit an AHIP (90)	27 July 2009	No written or verbal comments
Wodi Wodi Elders Corporation	CHMP report and original Survey report sent via registered post, along with cover letting informing of intent to submit an AHIP (90)	27 July 2009	No written or verbal comments
Cubbitch Barta Native Title Claimants	CHMP report and original Survey report sent via registered post, along with cover letting informing of intent to submit an AHIP (90)	27 July 2009	Comments in writing received on 1 August 2009. See attached letter.
<b>Readvertised prior to s90 AHIP application – 3 and 10 September 2009</b>			
Kullila Welfare & Housing Aboriginal Corporation	Advertisement place in Illawarra Mercury on the 3 and 10 September 2009	11 September 2009	Responded via phone call
National Koorie Site Management	Advertisement place in Illawarra Mercury on the 3 and 10 September 2009	14 September 2009	Responded in writing
Illawarra Local Aboriginal Land Council	Advertisement place in Illawarra Mercury on the 3 and 10 September 2009	15 September 2009	Responded via phone call
<b>On-site Consultation to assess Aboriginal Cultural Values / Baseline Recording – September 2009</b>			
Illawarra Local Aboriginal Land Council	Invited to participate in on-site assessment of Aboriginal sites within SMP for cultural assessment	14 October 2009	Written comments received 22 October 2009
Kullila Welfare & Housing Aboriginal Corporation	Invited to participate in on-site assessment of Aboriginal sites within SMP for cultural assessment	14 October 2009	Written comments received 16 October 2009
National Koorie Site Management	Invited to participate in on-site assessment of Aboriginal sites within SMP for cultural assessment	14 October 2009	Written comments received 16 October 2009
Northern Illawarra Aboriginal Collective Inc.	Invited to participate in on-site assessment of	Did no participate	Written comments received 1 October 2009

	Aboriginal sites within SMP for cultural assessment		
Gary Caines	Invited to participate in on-site assessment of Aboriginal sites within SMP for cultural assessment	Did not participate for health reasons	Written comments received 30 October 2009
Wodi Wodi Elders Corporation	Invited to participate in on-site assessment of Aboriginal sites within SMP for cultural assessment	No response	None received
Cubbitch Barta Native Title Claimants	Invited to participate in on-site assessment of Aboriginal sites within SMP for cultural assessment	14 October 2009	None received

# APPENDIX 2

## A2. Shelters monitored to date (103 in Total)

Full Site Name	Site Type	Site Number	L m	W m	H m	Volume m <sup>3</sup>	Aspect	BF CW	ART Y/N	LOC	Wet Dry	Loc End LW	Loc In LW	DIR LW	SUBS Mm	Tensile Strain Mm/m	Comp Strain Mm/m	Tilt	Damage
Couridja 1	Shelter with Art	52-2-1719	10	2	2	40	NW	CW	Y	UVS	D	N	M	MW	690	1.5	2.25	4	No
Couridja 2	Shelter with Art	52-2-1720	5	5	2	50	W	CW	Y	UVS	D	N	O	NW	160	0.15	0	1	No
Couridja 3	Shelter with Art	52-2-1721	4	2	2	16	W	CW	Y	UVS	D	N	E	NW	660	0.9	1.2	2.3	No
<b>Browns Road 4</b>	<b>Shelter with art; shelter with deposit</b>	<b>52-2-1619</b>	<b>20</b>	<b>5</b>	<b>2</b>	<b>200</b>	<b>W</b>	<b>CW</b>	<b>Y</b>	<b>RT</b>	<b>D</b>	<b>N</b>	<b>E</b>	<b>E</b>	<b>900</b>	<b>2.5</b>	<b>0</b>	<b>0</b>	<b>Yes</b>
Browns Road 10	Shelter with art	52-2-1625	7	3	2	42	NE	BF	Y	UVS	W	Y	O	E	300	0.5	0	0	No
Browns Road 14	Shelter with art	52-2-1629	6	4	4	96	N	CW	Y	UVS	D	N	CP	E	1800	0	5	0	No
Browns Road 21	Shelter with Art; shelter with deposit	52-2-1635	20	7	4	560	S	BF	Y	LVS	W	Y	O	E	300	0.5	0	0	No
Upper Avon 28	Shelter with art	52-2-1679	9	4	3	108	E	BF	Y	UVS	D	N	CP	E	1800	0	5	0	No
Browns Road 5	Shelter with art	52-2-1620	14	4	3	168	E	BF	Y	UVS	W	N	E	E	840	0.8	0	5.6	No
Browns Road 6	Shelter with art	52-2-1621	6	3	1	18	E	BF	Y	UVS	D	N	M	E	608	0.005	0.9	5	No
Browns Road 7	Shelter with deposit	52-2-1622	15	2	1.5	45	SE	BF	N	UVS	D	Y	O	E					No
Browns Road 22	Shelter with deposit	52-2-1636	7	3	2	42	SW	BF	N	UVS	D	N	E	E	990	1.5	0	2.2	No
Browns Road 23	Shelter with art	52-2-1637	6	2	2	24	W	BF	Y	LVS	D	N	E	E	840	0.8	0	5.6	No
Browns Road 24	Shelter with art	52-2-1638	26	3	4	312	NE	BF	Y	LVS	W	Y	CP	E	30	0.1	0	0.1	No
Browns Road 34	Shelter with art	52-2-1793	6	3	1	18	W	BF	Y	LVS	D	N	E	E	840	0.8	0	5.6	No
Browns Road PAD1	Potential Archaeological Deposit	n/a	5	2.4	2.3	27.6	W	CW	N	LVS	D	N	CP	E	505	0.9	0	2.5	No

Browns Road 1	Shelter with art; shelter with deposit	52-2-1616	31	3.2	3.3	327.36	NNW	BF	N	UVS	W	N	O	E	<20	Neg	0	<0.2	No
Browns Road 2	Shelter with art	52-2-1617	12	2.5	1.6	48	W	BF	-	LVS	W	N	M	E	520	1.3	0	5	No
Browns Road 3	Axe grinding groove	52-2-1618	5	6	n/a	-	Open	SP	Y	VB	D	Y	CP	E	500	1.3	0	4.5	No
Upper Avon 2	Axe grinding groove	52-2-1825	7.5	6	n/a	-	Open	SP	-	RT	W	N	O	E	30	Neg	0	0.3	No
Upper Avon 3	Axe grinding groove	52-2-1826	18	9	n/a	-	Open	SP	-	RT	W	N	O	E	<10	Neg	0	Neg	No
Upper Avon 4	Shelter with art	52-2-1801	9	4.2	4	151.2	S	BF	Y	UVS	D	N	CP	E	225	0.8	0	3.8	No
Upper Avon 27	Shelter with art	52-2-1763	2	1.5	0.9	2.7	N	CW	Y	UVS	D	N	CP	E	80	0.5	0	1.3	No
Flat Rock Creek 156	Shelter with art		16	3	3	144	NW	BF	Y	UVS	D	N	E	N	390	0.12	0	1.1	No
Flat Rock Creek 37	Shelter with art; axe grinding groove	52-2-0173	30	22	n/a	-	Open	SP	Y	UVS	W				125	0.25	0	1.2	No
PAD 1	Potential Archaeological Deposit	n/a	6	3	2	36	S	BF	N	UVS	D				200	1	0	-	No
<b>Flat Rock Creek 152</b>	<b>Shelter with art; shelter with deposit</b>	<b>52-2-0176</b>	<b>20</b>	<b>3.4</b>	<b>1</b>	<b>68</b>	<b>W</b>	<b>BF</b>	<b>Y</b>	<b>LVS</b>	<b>W</b>	<b>Y</b>	<b>CP</b>	<b>N</b>	<b>345</b>	<b>0</b>	<b>0.15</b>	<b>1.7</b>	<b>Yes</b>
Flat Rock Creek 41	Shelter with art; shelter with deposit; axe grinding groove	52-2-0167	20	2	2	80	NE	BF	Y	UVS	W	N	M	N	470	0	0.1	1.5	No
Flat Rock Creek 163	Shelter with art	52-2-0165	8	2	2	32	NE	BF	Y	UVS	D	N	O	N	667	0	0.65	1.5	No
Flat Rock Creek 89	Shelter with art; shelter with deposit	52-2-0164	10	4	1	40	NE	BF	Y	UVS	D	N	O	N	640	0.4	0	2	No
<b>Flat Rock Creek 57</b>	<b>Engraving</b>		<b>90</b>	<b>46</b>	<b>n/a</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>Y</b>	<b>RT</b>	<b>-</b>	<b>N</b>	<b>CP / E</b>	<b>NE</b>	<b>290</b>	<b>0.75</b>	<b>0</b>	<b>3.576</b>	<b>Yes</b>
<b>Flat Rock Creek 4</b>	<b>Shelter with art; shelter with deposit</b>	<b>52-2-0094</b>	<b>18</b>	<b>2.4</b>	<b>1.2</b>	<b>51.84</b>	<b>NW</b>	<b>BF</b>	<b>Y</b>	<b>UVS</b>	<b>W</b>	<b>N</b>	<b>CP / M</b>	<b>SW</b>					<b>Yes</b>
<b>Flat Rock Creek</b>	<b>Shelter with art</b>	<b>52-2-0106</b>	<b>12</b>	<b>2.9</b>	<b>2.1</b>	<b>73.08</b>	<b>N</b>	<b>BF</b>	<b>Y</b>	<b>LVS</b>	<b>W</b>								<b>Yes</b>

<b>10</b>																			
<b>Flat Rock Creek 11</b>	<b>Shelter with art; shelter with deposit</b>	<b>52-2-0089</b>	<b>23</b>	<b>4</b>	<b>2.7</b>	<b>248.4</b>	<b>SE</b>	<b>BF</b>	<b>Y</b>	<b>LVS</b>	<b>W</b>								<b>Yes</b>
Flat Rock Creek 47	Shelter with art; shelter with deposit	52-2-0155 / 0324	8	2	1	16	W	BF	Y	UVS	D	N	E	NE	950	0.56	0	1.95	No
<b>Flat Rock Creek 49</b>	<b>Shelter with art; axe grinding grooves</b>	<b>52-2-0154 / 0327</b>	<b>48</b>	<b>8</b>	<b>4</b>	<b>1,536</b>	<b>W</b>	<b>BF</b>	<b>Y</b>	<b>LVS</b>	<b>W</b>	<b>N</b>	<b>CP</b>	<b>NE</b>	<b>910</b>	<b>0.72</b>	<b>0</b>	<b>3</b>	<b>Yes</b>
Flat Rock Creek 50	Shelter with art	52-2-0147 / 0317	18	6	3	324	W	BF	Y	LVS	W	N	E	NE	700	0	-0.7	5.34	No
Flat Rock Creek 51	Shelter with art	52-2-0146	36	4	2	288	S	BF	Y	LVS	W	N	E	NE	300	0.86	0	3.93	No
Flat Rock Creek 56	Shelter with art	52-2-0163	18	3	3	162	W	CW	Y	RT	D	N	E	NE	190	0.48	0	2.11	No
Flat Rock Creek 260	Shelter with deposit	52-2-1885	9	2	1	18	E	BF	N	UVS	D	Y	E	N	200	1	0	0	No
PAD 1	Potential Archaeological Deposit	n/a	9	5	2	90	N	BF	N	UVS	D	Y	E	E	180	1.5	0	0	No
PAD 2	Potential Archaeological Deposit	n/a													-	-	-	-	No
<b>PAD 3</b>	<b>Potential Archaeological Deposit</b>	<b>n/a</b>	<b>18</b>	<b>4</b>	<b>5</b>	<b>360</b>	<b>SE</b>	<b>BF</b>	<b>N</b>	<b>UVS</b>	<b>W</b>	<b>Y</b>	<b>E</b>	<b>E</b>	<b>931</b>	<b>0.04</b>	<b>0</b>	<b>0</b>	<b>Yes</b>
PAD 4	Potential Archaeological Deposit	n/a	10	2	1	20	SE	BF	N	LVS	W	Y	O	E	10	0.2	0	0	No
PAD 5	Potential Archaeological Deposit	n/a	7	2	2	28	SE	BF	N	LVS	D	Y	O	E	10	0	0	0	No
PAD 6	Potential Archaeological Deposit	n/a	15	2	2	60	SE	BF	N	LVS	D	Y	E	E	770	2	0	3	No
PAD 7	Potential Archaeological Deposit	n/a	7	1	2	14	NE	CW	N	UVS	D	Y	E	E	70	0.5	0	0	No
PAD 8	Potential Archaeological	n/a	10	6	4	240	E	CW	N	VB	D	Y	O	E	10	0.1	0	0	No

	Deposit																		
PAD 9	Potential Archaeological Deposit	n/a	23	12	2	552	E	BF	N	VB	D	Y	O	E	10	0.1	0	0	No
PAD 19	Potential Archaeological Deposit	n/a	11	5	5	275	S	BF	N	LVS	D								No
PAD 27	Potential Archaeological Deposit	n/a	8	5	1	40	W	BF	N	UVS	D	Y	O	E	130	1	0	0	No
PAD 28	Potential Archaeological Deposit	n/a	10	6	5	300	W	CW	N	UVS	D				10	0.1	0	0	No
PAD 29	Potential Archaeological Deposit	n/a	10	3	3	90	W	CW	N	BV	D				10	0.1	0	0	No
Sawpit Gully 1	Shelter with art		37	4	4	593	SW	BF	Y	UVS	W	Y	M	E	200	0.2	0	0	No
Stokes Creek 65	Shelter with art	52-2-1164	3	1	3	9	SE	BF	Y	VB	D	Y	M	E	10	0.2	0	0	No
Stokes Creek 66	Shelter with art	52-2-1163	4	1	1	4	E	BF	N	UVS	W	N	M	E	810	2	0	3	No
Stokes Creek 67	Shelter with art	52-2-1162	4	1	6	24	SE	BF	Y	LVS	D	Y	M	E	800	2	0	3	No
Stokes Creek 68	Shelter with art	52-2-1161	6	2	1	12	NW	CW	N	UVS	D	N	E	E					No
Stokes Creek 69	Shelter with art	52-2-1160	4	2	2	16	SW	CW	Y	UVS	D	N	E	E					No
Stokes Creek 87	Shelter with deposit	52-2-1603	5	2.5	1.4	17.5	N	CW	Y	UVS	D				5	0.1	-	-	No
<b>Wedderburn 1</b>	<b>Shelter with art</b>	<b>52-2-0989</b>	<b>8</b>	<b>3</b>	<b>4</b>	<b>96</b>	<b>S</b>	<b>BF</b>	<b>Y</b>	<b>VB</b>	<b>W</b>	<b>N</b>	<b>CP</b>	<b>E</b>	<b>638</b>	<b>0.4</b>	<b>0</b>		<b>Yes</b>
<b>Wedderburn 2</b>	<b>Shelter with art</b>	<b>52-2-0990</b>	<b>50</b>	<b>9</b>	<b>6</b>	<b>2,700</b>	<b>SE</b>	<b>BF</b>	<b>Y</b>	<b>VB</b>	<b>W</b>	<b>N</b>	<b>M</b>	<b>E</b>	<b>341</b>	<b>0</b>	<b>0.1</b>		<b>Yes</b>
Wedderburn 3	Shelter with art	52-2-0991	11	2	4	88	SW	BF	Y	VB	D	N	E	E	900	2	0.4	0.3	No
Wedderburn 4	Shelter with art	52-2-0992	6	3	1	18	NW	BF	Y	VB	W	N	M	E	579	0	0.4		No
Wallandoola 2	Shelter with art; shelter with deposit; axe grinding grooves	52-2-1223	6.5	2	1.4	18	W	BF	N	RT	N								No
Wallandoola 16	Shelter with art	52-2-1252	6	2	2	24	W	BF	N	UVS	D	N	CP	W	980	0.35	1.1	1.5	No
Wallandoola 18	Shelter with art100	52-2-1254	3	3	2	18	SW	CW	Y	UVS	D	N	E	W	980	0.8	0.55	3.5	No

Wallandoola 19	Shelter with art	52-2-1255	7	4	3	84	NE	CW	Y	UVS	D	N	O	W	30	0.1	0.1	0.1	No
Appin Falls 5	Shelter with art	52-2-1595	6	2	2	24	S	BF	Y	LVS	D	N	E	SW					No
Appin Falls 6	Shelter with art	52-2-1594	6	2	1	12	SW	BF	Y	LVS	D	N	E	SW					No
Appin Falls 15	Shelter with deposit	52-2-2075 / 2092	10	2	1	20	SW	BF	N	LVS	D	N	M	SW					No
Upper Georges River 3	Shelter with art	52-2-0496	8	2	8	128	N	BF	Y	LVS	D	Y	M	SW	169	0.5	0	2.2	No
Upper Georges River 4	Shelter with art; shelter with deposit	52-2-0497	29	7	3	609	N	CW	N	LVS	D	Y	E	SW	174	0.6	0	2.4	No
Brooks Point 1	Shelter with deposit	52-2-1876	10	5	3	150	E	BF	N	UVS	D	Y	O	SW	70	<0.04	<0.01	<0.6	No
Brooks Point 2	Shelter with deposit; axe grinding grooves	52-2-1877	35	5	7	1,225	SW	BF	N	UVS	D								No
Brooks Point 5	Shelter with art	52-2-1880	14	3.2	2.2	98.56	NE	CW	Y	LVS	D	Y	E	SW	1135	<0.1	0.8	3.9	No
Brooks Point 6	Shelter with art	52-2-1881	13	3.7	1.7	81.77	NE	CW	Y	UVS	D	Y	E	SW	1025	1	0	3.1	No
Lizard Creek 22	Shelter with art	52-2-1228	7	2.2	0.85	13.09	NE	BF	Y	RT	D	N	O	NW	20	0.1	0.1	0.1	No
Lizard Creek 27	Shelter with art	52-2-1231	11.6	3.6	3.5	146.16	W	BF	Y	UVS	D	N	O	NW	20	0.1	0.1	0.1	No
Lizard Creek 28	Shelter with art	52-2-1233	9	4	8	288	SW	BF	Y	LVS	D	N	O	NW	20	0.1	0.1	0.1	No
Lizard Creek 29	Shelter with art	52-2-1234	16	4.3	3.5	240.8	SW	CW	Y	UVS	D	N	O	NW	20	0.1	0.1	0.1	No
Appin Falls 13	Shelter with art	52-2-1497	36	4	7.5	1,080	S	BF	Y	UVS	D	N	O	NW	20	0.1	0.1	0.1	No
Appin Falls 14	Shelter with art	52-2-1498	8	1.8	4	57.6	SE	BF	Y	UVS	D	N	O	NW	20	0.1	0.1	0.1	No
Ashleys Hole	Axe grinding groove	52-2-2047	0	0	0	0	Open	SP	N	RT	D	N	O	NW	333	0.1	0.2	2.4	No
NAS1	Shelter with art	tba	5	2.5	2	25	S	BF	Y	UVS	D	N	O	NW	20	0.1	0.1	0.1	No
NAS2	Shelter with art	tba	15	3	6	270	SW	CW	Y	LVS	D	N	O	NW	20	0.1	0.1	0.5	No
NAS3	Shelter with art	tba	16	3	1	48	NE	CW	Y	UVS	D	N	O	NW	36	0.1	0.1	0.5	No
NGG1	Axe grinding groove	tba	0	0	0	0	Open	SP	N	RT	D	N	O	NW	20	0.1	0.1	0.1	No
Sawpit Gully 4	Axe grinding groove	52-2-2034	7	3	n/a	-	Open	SP	Y	LVS	W				<20	<0.1	<0.1	<0.1	No
Sawpit Gully 5	Shelter with art; shelter with	52-2-2058 / 2109	5	4	2	40	W	BF	Y	LVS	D	N	E	SW	16	0.03	0	0.2	No

	deposit																		
Sawpit Gully 6	Shelter with art; shelter with deposit	52-2-2056 / 2108	5	2	1	10	S	BF	Y	VB	D	N	E	SW	860	1.11	0	3.9	No
Sawpit Gully 7	Shelter with art; shelter with deposit	52-2-2057 / 2107	3	3	2	18	W	BF	Y	VB	D	N	E	SW	848	1.69	0	4.2	No
Sawpit Gully 12	Shelter with art; shelter with deposit	52-2-2060 / 2103	11	5	3.3	181.5	S	BF	Y	UVS	D	N	O	EW					No
Sawpit Gully 15	Shelter with art	52-2-2055 / 2112	11	7	1.6	123	W	BF	Y	UVS	D			EW					No
Sawpit Gully PAD 3	Potential Archaeological Deposit	n/a	9	3	2	54	E	BF	N	LVS	D	N	O	EW	<20	<0.1	<0.1	<0.1	No
Georges River 1	Open Campsite	52-2-2264	n/a	n/a	n/a	n/a	Open	n/a	n/a	n/a	n/a	N	N	E	<20	<0.1	<0.1	<0.1	No
Georges River 2	Open Campsite	52-2-2266	n/a	n/a	n/a	n/a	Open	n/a	n/a	n/a	n/a	N	N	E	185	0.9	0.2	<0.1	No
Ousedale Creek 1	Shelter with art; shelter with deposit	52-2-2101	23	5	3.8	437	E	BF	Y	UVS	D								No
Ousedale Creek 3	Shelter with art; shelter with deposit	52-2-2237	16	5	3.4	272	N	BF	Y	UVS	D	N	CP	E					No
Ousedale Creek 4	Shelter with art; shelter with deposit	52-2-2238	2.4	6	3.3	47.52	NW	BF	Y	UVS	D								No
Nepean River 2	Shelter with art	52-2-1922	6	3.8	1.7	38.76	W	BF	Y	UVS	D	N	N	N					No
<b>Dendrobium 4</b>	<b>Shelter with art</b>	<b>52-2-2252</b>	<b>11.25</b>	<b>3.5</b>	<b>1.8</b>	<b>70.875</b>	<b>E</b>	<b>BF</b>	<b>Y</b>	<b>UVS</b>	<b>D</b>	<b>N</b>	<b>E</b>	<b>N</b>	<b>993</b>	<b>4.1</b>	<b>3.5</b>	<b>18.6</b>	<b>Yes</b>
Dendrobium 9	Shelter with art	tba	14	5.5	1.9	123.2	NW	BF	Y	UVS	D	Y	CP	NW	137	0.9	0	3.2	No

\*\*\*Note: some information is missing from the above table as this has not yet been provided by other consultants – this is currently being sought and will be included in an overview monitoring report to be completed in early 2010\*\*\*

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