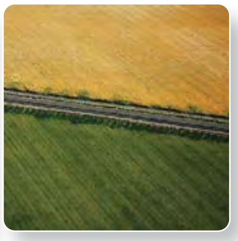
Appendix B

Responses to Key Authority Submissions




Russell Vale Colliery

PRELIMINARY RESIDUAL MATTERS REPORT

for

Wollongong Coal Limited

March 2014

Hansen Bailey
ENVIRONMENTAL CONSULTANTS

RUSSELL VALE COLLIERY
UNDERGROUND EXPANSION PROJECT

PRELIMINARY RESIDUAL MATTERS REPORT

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31 March 2014

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RUSSELL VALE COLLIERY UNDERGROUND EXPANSION PROJECT

PRELIMINARY RESIDUAL MATTERS REPORT

for

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1 OVERVIEW

1.1 INTRODUCTION

This document has been prepared by Hansen Bailey Environmental Consultants (Hansen Bailey) on behalf of Wollongong Coal Limited (Wollongong Coal) to provide a preliminary response to regulator's comments "NRE Underground Expansion Project Preferred Project Report" including Response to Submissions (Gujarat NRE Coking Coal Pty Ltd, 2012) (UEP PPR).

Separate responses will be provided in the near future in relation to a revised Groundwater Impact Assessment and Traffic Impact Assessment.

1.2 BACKGROUND

A Project Application (PA 09_0013) for the UEP was made on 12 August 2009 which sought approval for longwall mining operations in the Wongawilli Seam. The Application proposed the extraction of 11 longwalls in the Wonga East area and 7 longwalls in the Wonga West area. The supporting "NRE No.1 Colliery Project Application (09_0013) Environmental Assessment" (Gujarat NRE Coking Coal Pty Ltd, 2009) (UEP EA) was placed on public exhibition from 13 August 2012 to 3 September 2012. A total of 840 submissions were received including 12 regulators, two special interest groups and 826 individuals (446 of which were in support of the Project and 380 were objections).

NRE submitted its Response to Submissions report (RTS) to Department of Planning and Infrastructure (DP&I) on 23 October 2012. The UEP PPR was also submitted in October 2012 which proposed significant changes to the mine plan to reduce environmental impacts in response to stakeholder comments.

The UEP PPR mine plan comprises eight longwall panels (LW1-3, LW6-7 and LW9-11) and:

- Removal of the Wonga West area from the proposed mine plan;
- Removal of LW8 in the Wonga East area; and
- Amendments to the alignments and dimensions of the other longwalls in the Wonga East area.

The UEP PPR was provided by DP&I to various regulators for comment. Comments were received from 10 regulators and three independent peer reviewers engaged by DP&I. This document provides a preliminary response from Wollongong Coal to these submissions. **Table 1** indicates the regulators and reviewers to which the RTS was provided, the date each responded and whether a response from the proponent is required.

Since the submission of these documents, Gujarat NRE Coking Coal Limited has changed its name to Wollongong Coal Limited; and the mine name, NRE No.1 Colliery, to Russell Vale Colliery.

Table 1
RTS List of Regulator Responses

Ref	Regulator	Date of Response	Response Required
1.	DP&I – Peer Review Coffey	26 November 2013	Yes
2.	DP&I – Peer Review Hebblewhite	17 November 2013	Yes
3.	DP&I – Peer Review Evans & Peck	28 January 2014	Yes
4.	NSW Office of Water (NOW)	30 October 2013	Yes
5.	Wollongong City Council (WCC)	13 November 2013	Yes
6.	Department of Trade & Investment Resources & Energy (DRE)	26 November 2013	Yes
7.	Dams Safety Committee (DSC)	25 October 2013	Yes
8.	Environment Protection Authority (EPA)	25 October 2013	No outstanding issues
9.	Heritage Council of NSW (Heritage)	22 October 2013	Yes
10.	Office of Environment & Heritage (OEH)	15 November 2013	Yes
11.	Roads & Maritime Services (RMS)	22 October 2013	Yes
12.	Sydney Catchment Authority (SCA)	6 November 2013	Yes
13.	NSW Fisheries	29 October 2013	No

1.3 REPORT STRUCTURE

The majority of responses to regulatory issues are provided in individual reports from technical specialists in **Appendix B** to **Appendix G**. Additional issues are discussed in **Section 2**.

To assist the reader, the table in **Appendix A** lists each issue raised by each regulator and indicates where it is addressed in this report.

2 ENVIRONMENTAL AND SOCIO-ECONOMIC ISSUES

This section provides residual regulatory issues in italics; with Wollongong Coal's response in normal type. The regulatory submissions are included in tabular format in ***Appendix A****.*

2.1 DEPARTMENT OF PLANNING AND INFRASTRUCTURE

2.1.1 Issue – Figure

DP&I noted that no scale is shown on the mine plan figure of the UEP PPR and also that it is not geo-referenced. DP&I requires confirmation of the positioning of Cataract Creek with respect to LW7 of the PPR mine plan.

2.1.2 Response

Figure 1 demonstrates scale, geo-referencing and the relative positioning of Cataract Creek.

2.1.3 Other issues

Issues raised by DP&I relating to subsidence, groundwater, surface water, catchment and ecology impacts are addressed in **Appendix B**, **Appendix C**, **Appendix D, Appendix E** and **Appendix F** respectively.

Additional responses, specifically related to the numerical groundwater model and groundwater impact assessment and revised traffic impact assessment are not included in this preliminary response and will be provided separately.

2.1.4 Issue – Environmental Monitoring Program

DP&I make a number of recommendations regarding the site monitoring program, specifically in relation to the integrated surface water, groundwater and ecological monitoring programs.

2.1.5 Response

Wollongong Coal will comply with any conditions of project approval in this regard and is currently re-designing an Environmental Monitoring Program to integrate surface water, groundwater and ecological monitoring programs to ensure an ongoing comprehensive assessment of the ecosystem function of upland swamps within the study area.

This monitoring program will include, but not be limited to:

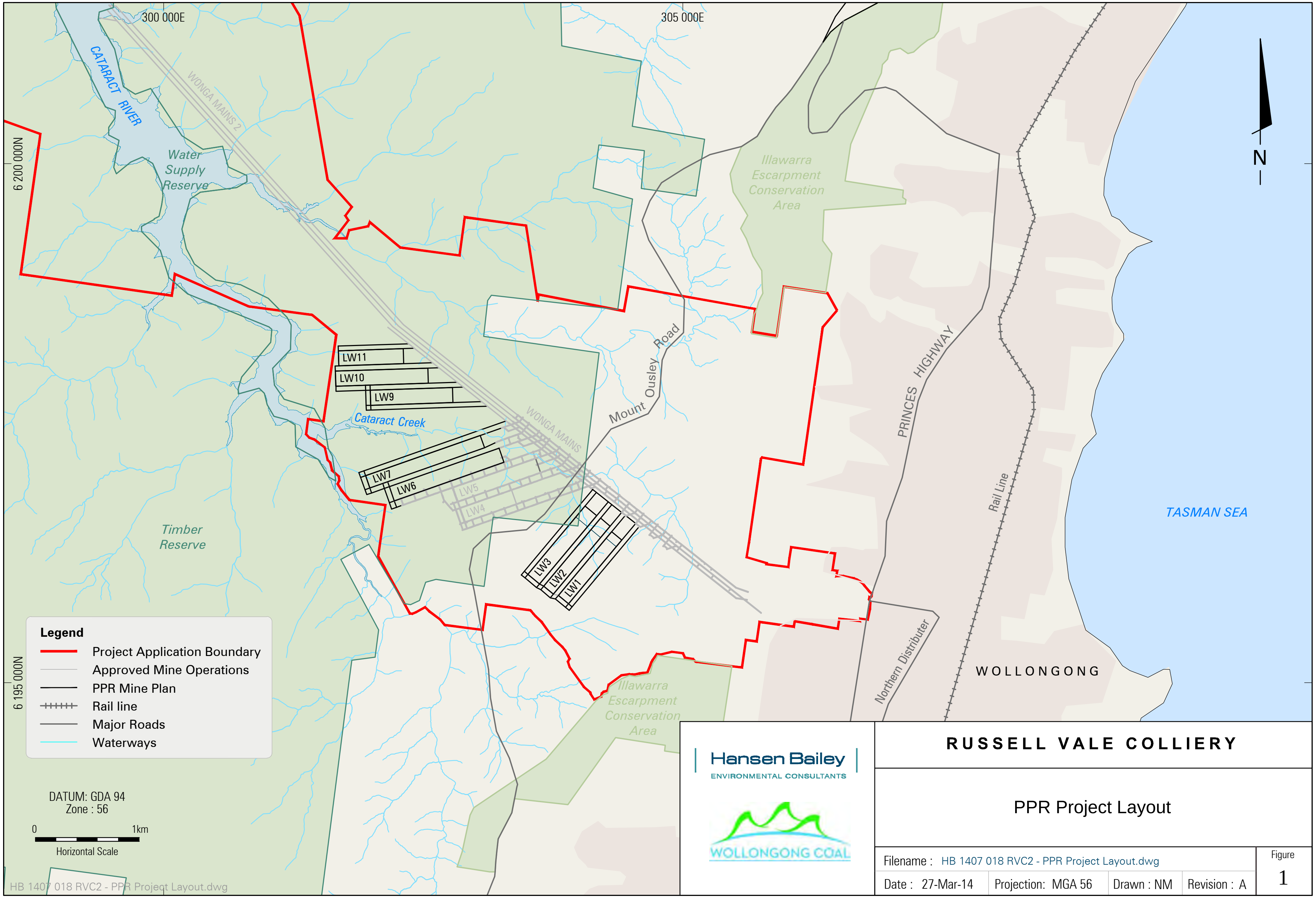
- Subsidence impacts on creeks;
- Stream water quality and quantity;
- Expansion of the existing network of shallow swamp piezometers, and regular review to asses any abnormal behaviour that cannot be attributed to evapotranspiration or drainage to a watercourse;
- Establishment of a meteorological station within the Wonga East area to measure rainfall and potential evapotranspiration;

- Establishing piezometers at the upslope end and downslope end of a minimum of two swamps in order to understand the down-slope movement of shallow groundwater;
- Adding two flow monitoring points to swamps in which pairs of piezometers (upslope and downslope) are to be installed;
- Monthly review of the water balance of each monitored swamp based on recorded rainfall, estimated evapotranspiration and recorded water levels and outflow measurement; and
- Characterisation of soils within the swamps to determine, the:
    - Porosity - in order to provide a basis for relating piezometer water levels to rainfall and evapotranspiration; and
    - Presence (or absence) of clay materials at the interface with the underlying sandstone which could mitigate water loss from the swamp to the underlying sandstone in the event that subsidence induced cracking of the sandstone occurs under a swamp.

2.2 NSW OFFICE OF WATER

Issues raised by NOW in response to the PPR relate generally to subsidence, groundwater, surface water and water catchment and are addressed in **Appendix B**, **Appendix C, Appendix D** and **Appendix E** respectively.

Additional responses, specifically related to the numerical groundwater model and groundwater impact assessment are not included in this preliminary response and will be provided separately.


300 000E
305 000E
6 200 000N
6 195 000N
CATARACT RIVER
WONGA MAINS 2
Water Supply Reserve
Illawarra Escarpment Conservation Area
Mount Ousley Road
PRINCES HIGHWAY
Rail Line
TASMAN SEA
LW11
LW10
LW9
Cataract Creek
WONGA MAINS
LW7
LW6
LW5
LW4
LW3
LW2
LW1
Timber Reserve
Northern Distributer
WOLLONGONG
N
Legend
Project Application Boundary
Approved Mine Operations
PPR Mine Plan
Rail line
Major Roads
Waterways
DATUM: GDA 94
Zone : 56
0
1km
Horizontal Scale
HB 1407 018 RVC2 - PPR Project Layout.dwg
Hansen Bailey
ENVIRONMENTAL CONSULTANTS
WOLLONGONG COAL
RUSSELL VALE COLLIERY
PPR Project Layout
Filename : HB 1407 018 RVC2 - PPR Project Layout.dwg
Date : 27-Mar-14
Projection: MGA 56
Drawn : NM
Revision : A
Figure
1

2.3 WOLLONGONG CITY COUNCIL

2.3.1 Issue - Noise Barriers

WCC cites the EA noise impact assessment (ERM, 2012) and notes the noise modelling in the included the following assumptions:

(i) "A 3 metre high acoustic barrier to the south of Broker Street;
(ii) A 3.6 metre high roadside type barrier to the north of the internal access road from the weighbridge to the Princes Highway; and
(iii) Noise mitigation of certain equipment such as mine ventilation fans and dozers."

WCC's concern relates to the need to construct the barriers to protect surrounding residential areas from noise emanating from the mine's pit top operations.

Further, WCC also notes that the recent noise audit report (i.e. referred to in the Preferred Project Report) does not properly consider how certain weather conditions (i.e. wind speed and direction, cloud cover, etc.) influence noise emanating from the pit top activities.

WCC also notes that the PPR fails to provide conclusive advice as to what noise mitigation measures will be introduced in order to address potential noise impacts from the Pit Top area activities, especially truck loading activities and dozers working upon the stockpile areas. Noise impacts along Bellambi Lane also remain unresolved. The construction of the new screening and sizing station should be a condition of consent if the application is ultimately approved.

2.3.2 Response

It is noted that the EPA submission to the UEP PPR dated 25 October 2013 lists no issues in relation to noise.

The Director-General's Environmental Assessment Report for the Preliminary Works Project (DP&I, 2011) identifies that the predicted noise levels at Receivers 1-4 (R1 – R4) will increase by a maximum of 3 dB as a result of the removal of the acoustic barriers from the noise model. As these receivers are predicted to receive exceedances of the Project Specific Noise Criteria (PSNC) both with and without the barriers, DP&I considers that the barriers are "*of limited beneficial effect*" and that the "*proposed barriers would be visually intrusive*".

As such DP&I (2011) states that Wollongong Coal should "*first implement all reasonable and feasible source controls (through the proposed replacement of various surface facilities and any other appropriate measures) and then conduct a comprehensive noise audit, to ensure that any additional migratory measures are well designed and placed in order to achieve maximum community benefit.*"

Pacific Environment (2012) carried out a noise audit as recommended by DP&I and noted that "*A statistical analysis of the data taken from the Bureau of Meteorology Wollongong weather station (Station Number 068241) provided in NRE No.1 Colliery Preliminary Works assessment, indicate that winds blowing from the site to receivers are not a feature of the area (i.e. >= 3 m/s winds occurring more than 30% of the time).*

In addition, the assessment found that the frequency of occurrence of F and G atmospheric stability categories is less than 30% of the winter evening and night periods. Therefore, in accordance with the INP, wind effects and temperature inversions have not been considered in this analysis. An average temperature of 20 degrees Celsius and a relative humidity of 70% were implemented in the model."

Therefore it can be concluded that the weather conditions were considered in accordance with noise modelling requirements of the INP.

Noise mitigation measures for the preferred project remain as modelled in the UEP EA, with the exception of the acoustic barriers. This includes low noise equipment and restrictions on dozer operating hours (7 am to 6 pm Monday to Friday and 8 am to 6 pm Saturday). Additionally, noise impacts will be monitored and managed in accordance with the Noise Management Plan to be updated in consultation with relevant regulators following determination.

As discussed in Section 2.6.3 of the UEP RTS, noise mitigation (as per existing management plans) along Bellambi Lane includes limits on compression breaking and a voluntary 50 km/h speed limit for coal haulage trucks.

Based on the outcome of liaison with regulators and DP&I during the development of conditions, Wollongong Coal will comply with any final conditions of project approval with regard to the construction of the new screening and sizing station.

2.3.3 Issue - Air Quality

WCC requires that appropriate conditions of consent should also be required which satisfactorily address the air quality (PM10 particulate and total suspended particulate) issues.

2.3.4 Response

Based on the outcome of liaison with regulators and DP&I during the development of conditions, Wollongong Coal will comply with any final air quality conditions of project approval in this regard.

2.3.5 Issue – Employee's Carpark

WCC requests that appropriate conditions of consent be imposed requiring the sealing and line marking of the employee's carpark.

2.3.6 Response

Wollongong Coal does not believe that this action will make any significant contribution to improving water quality on site. However, based on the outcome of liaison with regulators and DP&I during the development of conditions, Wollongong Coal will comply with any final conditions of project approval in this regard.

2.3.7 Other Issues

Other issues raised by WCC in response to the UEP PPR relate generally to subsidence and groundwater and are addressed in **Appendix B** and **Appendix C**. Additional responses, specifically related to the numerical groundwater model and groundwater impact assessment are not included in this preliminary response and will be provided separately.

2.4 DEPARTMENT OF TRADE & INVESTMENT RESOURCES & ENERGY

2.4.1 Issue – Rehabilitation Plan

Rehabilitation Plan

1. *The Proponent must prepare and implement a Rehabilitation Plan to the satisfaction of the Director General of Department of Trade & Investment, Regional Infrastructure and Services.*
2. *Rehabilitation Plan must:*
    a. *Be submitted and approved by the Director general of department of trade and investment, regional infrastructure and services prior to carrying out any surface disturbing activities of the development, unless otherwise agreed by the Minister;*
    b. *Be prepared in accordance with DRE guidelines and in consultation with the department, Office of Environment and Heritage, Environmental Protection Authority, Office of Water, Council and the mine Community Consultative Committee;*
    c. *Incorporate and be consistent with the rehabilitation objectives in the EIS, the statement of commitments and table 1;*
    d. *Integrate and build on, to the maximum extent practicable, the other management plans required under this approval; and*
    e. *Address all aspects of mine closure and rehabilitation, including post mining land use domains, rehabilitation objectives, completion criteria and rehabilitation monitoring and management.*

It is the intention of DRE that the Rehabilitation Plan fulfil the requirements of the Mining Operation Plan (which will become the Rehabilitation and Environmental Management Plan (REMP) once the Mining Act amendments have commenced).

2.4.2 Response

Based on the outcome of liaison with regulators and DP&I during the development of conditions, Wollongong Coal will comply with any final conditions of project approval in this regard and develop a Rehabilitation Plan consistent with all relevant policies and guidelines in consultation with the relevant regulators.

2.4.3 Issue – Extraction Plan

DRE requires the inclusion of the preparation of an Extraction Plan that must take into consideration likely impacts that activities may have on Old Bulli Pillar Workings within the area and on key natural features and public infrastructures; such as angled voltage transmission towers, Mount Ousley Road, the Illawarra Escarpment and Cataract Creek / Cataract Reservoir.

1. *The proponent must undertake Geotechnical Investigations prior to the submission of an extraction plan.*
2. *The extraction plan must:*
    a. *Give consideration to impacts of old workings and include a detailed investigation of overlying old Bulli Pillar workings in consultation with DRE, which:*
        - *Assess the stability of remnant coal pillars in the former Bulli Seam workings;*
        - *Includes revised subsidence predictions for the second working areas*
        - *Recommends final design of the second workings panels and any necessary adaptive management measures;*
    b. *Includes a Built features Management Plan prepared in consultation with DRE, which:*
        - *Address in appropriate detail all items of key public infrastructure, other public infrastructure and all other built features;*
        - *Has been prepared following appropriate consultation with the owner/s of potentially affected features;*
        - *Recommends appropriate remedial measures and includes commitments to mitigate, repair, replace or compensate all predicted impacts on potentially affected built features in a timely manner;*
    c. *Includes a Public Safety Management Plan, which has been prepared in consultation with DRE; and*
    d. *Includes a Subsidence Monitoring Program, which has been prepared in consultation with DRE.*

2.4.4 Response

Based on the outcome of liaison with regulators and DP&I during the development of conditions, Wollongong Coal will comply with any final conditions of project approval in this regard and develop an Extraction Plan consistent with all relevant policies and guidelines in consultation with the relevant regulators.

2.4.5 Issue – First Workings

DRE notes that "First workings on site, other than in accordance with an approved Extraction Plan, may be carried out provided DRE is satisfied that the first workings are designed to remain long term stable and non-subsiding, except insofar as they may be impacted by an approved second working."

2.4.6 Response

Wollongong Coal will ensure that first workings are developed in accordance with the relevant geotechnical and engineering standards sufficient to ensure long term stability, with zero resulting subsidence impacts.

2.4.7 Other Issues

Issues raised by DRE in response to the UEP PPR relate generally to subsidence and are addressed in **Appendix B**.

2.5 DAM SAFETY COMMITTEE

Issues raised by the DSC in response to the UEP PPR relate generally to the numerical groundwater model and groundwater impact assessment. These are not included in this preliminary response and will be provided separately.

2.6 ENVIRONMENT PROTECTION AUTHORITY

No additional issues have been raised by the EPA and as such no response is required.

2.7 HERITAGE COUNCIL

Issues raised by the Heritage Council in response to the UEP PPR are addressed in **Appendix G**.

2.8 NSW OFFICE OF ENVIRONMENT AND HERITAGE

2.8.1 Issue – Further Modifications to Mine Plan

"OEH does not consider that the PPR fully addresses the issues previously identified and therefore recommends the mining plan should be modified further to avoid impacts to these significant natural features."

2.8.2 Response

Significant changes to the mine plan were made for the UEP PPR to minimise the impacts on significant surface features whilst still recovering a commercially viable percentage of the available coal resource. The approach is focused on balancing the predicted environmental impacts on natural and manmade surface features against the legacy of the existing underground roadways and the economics of the reserve within current mining operations.

Further reductions to the mine plan would result in the loss of economic viability of the proposed operations and subsequent sterilisation of the coal resource.

2.8.3 Issue – Fish Monitoring

OEH recommends that a monitoring and management program be developed with Fisheries NSW in regard to Macquarie Perch, Trout Cod and Murray Cod in Cataract Creek.

2.8.4 Response

Wollongong Coal will comply with any conditions of project approval in this regard.

2.8.5 Other issues

Issues raised by OEH relating to subsidence, groundwater, surface water, catchment, ecology and heritage impacts are addressed in **Appendix B**, **Appendix C**, **Appendix D**, **Appendix E**, **Appendix F** and **Appendix G** respectively. Additional responses, specifically related to the numerical groundwater model and groundwater impact assessment are not included in this preliminary response and will be provided separately.

2.9 ROADS AND MARITIME SERVICE

Issues raised by RMS in response to the UEP PPR specifically relate to transport impacts and are not included in this preliminary response. A traffic impact assessment report is currently being prepared which will be provided separately in the near future.

2.10 SYDNEY CATCHMENT MANAGEMENT AUTHORITY

2.10.1 Issue – Exclusion of mining from Notification Area

The SCA recommended that longwall mining should be excluded from the Notification Area for Cataract Reservoir.

2.10.2 Response

Section 89 of the *Mining Act 1992* provides that the DSC must be notified prior to the granting of a mining lease within a notification area for a prescribed dam. The ability to grant a mining lease within a notification area implies that mining is permitted in notification areas. To exclude mining within the Notification Area, as suggested by SCA, would be contrary to the Mining Act.

The proponent looks forward to working closely with the SCA and other key stakeholders to ensure that underground mining within the Notification Area for the Cataract Reservoir is conducted without incident.

2.10.3 Other Issues

Issues raised by the SCA relate generally to subsidence, groundwater, surface water, and catchment impacts are addressed in **Appendix B**, **Appendix C**, **Appendix D**, **Appendix E** and **Appendix F** respectively.

Additional responses, specifically related to the numerical groundwater model and groundwater impact assessment are not included in this preliminary response and will be provided separately.

2.11 NSW FISHERIES

No additional issues have been raised by NSW Fisheries in relation to the UEP PPR.

* * *

for
HANSEN BAILEY

Dianne Munro
Principal

James Bailey
Director

3 REFERENCES

- Department of Planning and Infrastructure, 2011 *Major Project Assessment NRE No. 1 Colliery Preliminary Works Project (MP 10_0046)*.
- Pacific Environment Limited, 2012 *Report – Gujarat NRE No. 1 Colliery Noise Audit*.
- Gujarat NRE Coking Coal Pty Ltd, 2012 *NRE Underground Expansion Project Preferred Project Report.*
- Gujarat NRE Coking Coal Pty Ltd, 2009 *NRE No.1 Colliery Project Application (09_0013) Environmental Assessment*.

Appendix A

REGULATORY SUBMISSIONS

Table 1 – Regulatory Submissions to the PPR and where each is Addressed

Ref	Regulator	Issue	Where Addressed
1.	DP&I	The new mine plan is presented in Figure 4 of the PPR however no scale is shown and it is not georeferenced. This mine plan was positioned with respect to the MGA by overlaying the EA and PPR mine plans of Figure 4 of the PPR onto a georeferenced drawing of the EA mine plan, and scaling it until a visual match was obtained between the two versions of the EA mine plan. The result is shown in Figure 1. This process allowed positioning of Cataract Creek (not shown in Figure 4 of the PPR) with respect to LW7 of the PPR mine plan. However, the positioning error from this process is unknown.	Figure 1
2.	DP&I	The mined thickness will vary between 2.5m and 3.0m (depending mainly on coal quality). The mined height for LW4 was previously reported as 3.1m (Geoterra, 2012a). SG (2012) reported a mined height of 3.2m for this panel.	No response required
3.	DP&I	Based on the new mine plan, the PPR states that there is an interpreted risk of significant secondary impact to swamps BCUS4 and CCUS4.	No response required
4.	DP&I	<u>Longwall LW7</u> The new layout of LW7 (Figure 1) is still considered to pose a risk to the capacity of the channel of Cataract Creek to transmit surface water. A significant element of the risk is demonstrated by the indication provided by subsidence monitoring of Balgownie and Wongawilli Seam panels in Wonga East as discussed in the PPR. Incremental Balgownie panel subsidence ranged between 0.9m and 1.2m where overlying Bulli goaf (room and pillar panels with pillar extraction) was present, approaching 80% of the mined height (implying a mined height of about 1.5m for the Balgownie panels). In unusual areas (latent subsidence, goaf edge), the incremental subsidence reached 1.4m, approaching 100% of the mined height. Figure 2a (after Figure 49 of the PPR) shows these results.	Subsidence discussion provided in Appendix B
5.	DP&I	Maximum incremental subsidence at Wongawilli LW4 was 1.4m. For the mining geometry of LW4, and assuming single seam mining, surface subsidence would be expected to range between 0.1m and 0.3m, about 14% of the observed subsidence where Balgownie and Bulli goafs are present. The PPR states that cross panel subsidence profiles indicate that the maximum subsidence in the centre of the Wongawilli panels is controlled by overburden bridging capacity rather than strata recompression. The presence of overlying goafs reduces the bridging capacity of overlying strata, having a significant effect on maximum incremental subsidence for the Wongawilli panels. It was also observed that the additional subsidence was confined to the panel footprint. Figure 2b (after Figure 58 of the PPR) shows these results.	Subsidence discussion provided in Appendix B

Ref	Regulator	Issue	Where Addressed
6.	DP&I	Although a relationship between surface subsidence and the height of desaturation (H) is unavailable (due to the significantly greater dependence of surface subsidence on overburden depth compared to H), these results indicate that there is a high likelihood that the height of H for a Wongawilli panel will be larger than that calculated using the relationship for single seam mining (Tammetta, 2012). Since the LW7 width has only been reduced by 19m (about 13% of the original width), it is reasonable to conservatively assume that the height of the collapsed zone (H) intersects the ground surface at the northern corner of LW7. The minimum separation distance between the LW7 collapsed zone and the Cataract Creek channel centreline is approximately 45m (at the northern corner of LW7, see Figure 1). The positioning of the new mine plan is approximate (see above) and the channel centreline was digitised from information in Geoterra (2012a, 2012b) and ERM (2013) (see Coffey, 2013).	Appendix D
7.	DP&I	Information relating to changes in hydraulic conductivity just off the panel footprint is particularly sparse, however several authors have estimated the extent of an impact zone from observations of dewatering in water supply wells off the panel footprint. This zone is just off-panel, and adjacent to the panel. It is where a relatively fast response is observed in hydraulic heads following caving, usually because of an immediate change in void ratio from fracturing. Long-term effects on hydraulic heads extend further, but are caused by laminar flow induced by drainage. In the off-panel impact zone, deformation is generally less than, and of a different character to, deformation within the collapsed zone. However, given the small lateral distance to the potential collapsed zone of the panel, and the potential effects of topography on subsidence, there is a risk of direct connection of the creek channel to the collapsed zone, through deformed media having enhanced hydraulic conductivity in the impact zone.	Subsidence discussion provided in Appendix B
8.	DP&I	Ouyang and Elsworth (1993) estimated a probable angle of influence (defined as the angle whose tangent is the lateral distance to an impact at the surface, divided by the overburden thickness) of 42° from 39 off-panel wells (Figure 3). Cifelli and Rauch (1986) estimated an average angle of influence of about 20°, with several observations of impact outside this angle. The Australian Federal Government (2013) estimated a maximum angle of influence for impacts to peat swamps of approximately 45°. These impacts were characterised by deformation of the rock underneath the swamp.	Subsidence discussion provided in Appendix B
9.	DP&I	The overburden thickness at the northern corner of LW7 is approximately 260m, so that the creek channel falls within interpreted zones of impacts to hydraulic heads from longwall mining. Using 45° as an upper limit, the angle of influence would extend surface impacts to a distance of about 260m from the boundary of LW7 in the vicinity of its northern corner. This estimate does not include the effects of multiple mined seams, nor the effects of topographic gradients, both of which may alter the zone of influence.	Subsidence discussion provided in Appendix B

Ref	Regulator	Issue	Where Addressed
10.	DP&I	Where the top of a collapsed zone is some distance below the surface, the surface disturbance at a channel bed may not be strongly hydraulically linked to the collapsed zone. In the case of LW7, there is considered to be a risk of direct hydraulic connection between the creek channel and goaf, through the collapsed zone, where the channel comes to close to the panel edge. The level of risk is difficult to quantify but warrants consideration. Monitoring of groundwater response and ground deformation in this area during the early stages of LW7 retreat may be useful in better informing the risk.	Appendix D
11.	DP&I	Numerical Simulation Strategy In the PPR, the proponent presents a strategy for groundwater numerical simulation which largely satisfies the recommendations made in Coffey (2013). However, this strategy discusses potential or perceived limitations with the recommended probability analysis and the database available for calibration. Further clarification is provided below on these facets. The strategy also makes assumptions which are stated as being based on recommendations in Coffey (2013). The relevant recommendations in Coffey (2013) are clarified in relation to the assumptions made in the proponent's strategy. These clarifications are also provided below.	No response required
12.	DP&I	Probabilistic Analysis The probabilistic analysis of induced seepage from Lake Cataract does not need to be undertaken using the Monte Carlo process. This was not stipulated in Coffey (2013). It is considered that manual running of around 30 to 40 cases, with hydraulic conductivity arrays varied for each, would be sufficient to guide the assessment of uncertainty. Required output would comprise the change in baseflow to, or direct seepage from, the lake and other associated drainages (such as Cataract Creek).	To be provided / addressed separately

Ref	Regulator	Issue	Where Addressed
13.	DP&I	<u>Calibration Database</u> The EA identified a large number of data sources which were considered sufficient (subject to acquisition of near-field drawdown data) to undertake a transient calibration as requested. These are sufficient to undertake a calibration as requested, and develop a useful and robust model. These data are listed in the following sections, and are of sufficient size to allow the development of a reasonable transiently calibrated model. ***Hydraulic Heads*** The hydraulic head monitoring network comprises 40 measuring devices (8 standpipe piezometers and 32 vibrating wire piezometers) distributed throughout the depth profile at 11 locations. Project specific monitoring locations include a number where frequent monitoring has been undertaken since mid 2012. Hydraulic head monitoring data from the vibrating wire piezometer (VWP) nest at GW1 (see Coffey, 2013) were selected by the proponent for collection of near-field drawdown from longwall advance, for the purpose of model calibration. The monitoring data were not presented in the PPR but were supplied by Gujarat by email on 19 November 2013, at the request of the reviewer. Figure 4 shows the supplied data. The key in Figure 4 shows the depth below ground for each VWP, and the lithology at that depth (HBSS, BACS, BGSS, and SPCS denote the Hawkesbury Sandstone, Bald Hill Claystone, Bulgo Sandstone, and Stanwell Park Claystone respectively). The hydrographs for Bulgo Sandstone VWPs capture the effect of depressurisation from LW5 in late 2012. The measured drawdown is considered useful for model calibration of near-field disturbance. Monitoring locations P501 and P502 in Wonga West (monitoring locations WB17 and WB18 respectively, from Singh and Jakeman, 2001) have detailed monitoring data from 1993. These overlie historical Bulli seam longwalls LW501 and LW502 in the Wonga West area, but are still useful for calibration since they are located in the model domain and contain important information regarding vertical hydraulic head gradients. ***Groundwater Fluxes*** The following data were identified in Coffey (2013) for use in model calibration. • Regular flow monitoring data for Lizard Creek for the period October 2009 to August 2012 for monitoring location LC3 (WRM, 2012). Data from February 2011 onward appear well suited to a baseflow analysis. • Publicly available stream flow monitoring data for two gauges located within the area of interest (Bellambi Creek and Loddon River), simultaneously covering the period 1991 to 1995 (WRM,2012). • Flow monitoring at locations CC3 and CC4 on Cataract Creek (see Figure 11 and Table 16 of Geoterra, 2012b), reported to have been commenced using either temporary box notch weirs, or the flow velocity / cross section method, both of which provide direct flow measurements.	To be provided / addressed separately

Ref	Regulator	Issue	Where Addressed
		• Pool depth monitoring at four locations in Cataract Creek since 2010, and at three locations since April 2012. Pool heights are also measured at several monitoring points in Lizard and Wallandoola Creeks. Geoterra (2012b) states that pool depth measurements will be converted to flow rates once rating tables are developed for the monitoring sites. • Detailed monitoring of water extracted from the Wonga East workings (27 Cut Through) from 2010. • Water being pumped out of previous mine workings to the west of Cataract Reservoir. Should pumping rates be available, they would be most useful. The site-specific hydraulic conductivity database accrued by the proponent comprises six short duration pump tests at six locations, and 65 packer tests at eight locations. This is considered reasonable. Coffey (2013) presented other published data for the Southern Coalfield for the purpose of providing (if needed) a basis for constraints in the hydraulic conductivity field for model calibration, and a basis for probabilistic numerical analysis of potential leakage from Lake Cataract. Large databases of pre and post-mining hydraulic conductivity over centre panel were provided to the proponent in Coffey (2013), for the purpose of being considered during model calibration. Of these, Reid (1996) contains useful data for strata impacted by mining, and for undisturbed strata, for the Southern Coalfield.	

Ref	Regulator	Issue	Where Addressed
14.	DP&I	Other Clarifications **Model Class** The PPR states that a Class 3 model, as defined in Barnett et al (2012), will be required. No class of model was stipulated in Coffey (2013) for the recommended simulation. This is because a strict application of the criteria in Barnett et al (2012) (for example, that predictive stresses should not be more than double the calibration stresses) could rule out an otherwise useful model and leave no tool available for impact prediction. Regardless of model class, any model will have some level of uncertainty which is directly dependent on (amongst other things) the calibration data base and the performance of calibration. Such a model may not meet predictive criteria in Barnett et al (2012) however this is not considered detrimental, particularly if the uncertainty is explored with a probabilistic analysis taking account of observed variations in hydraulic properties. The available calibration data base for the subject area (see above) is considered very large in relation to many other areas in the world, and is considered sufficient to support the development of a numerical model that can provide results that will be useful for decision making. Provided that calibration is conducted as requested, and the uncertainty of the model is addressed as recommended, non-compliance with some criteria in Barnett et al (2012) may be tolerable. Any non-compliances can be raised with an external reviewer, during the modelling effort, for consultation and consideration. The recommendations in Coffey (2013), combined with the available calibration data, might translate to a Class 2 / Class 3 hybrid model, according to the criteria in Barnett (2012). ***General Calibration*** The questioning of the model calibration in ERM (2013) was completely independent of the criteria in Barnett (2012). That calibration was undertaken for steady state conditions and is considered substandard for the purpose of the model. The modelling strategy in the PPR discusses proposed transient calibration using hydraulic heads and fluxes. Calibration to measured hydraulic conductivities is not explicitly stated but these observations would need to be incorporated into the calibration. ***Clarification of Severe Deformation*** Coffey (2013) indicated that laminar flow models are inappropriate for simulation of media where severe deformation has occurred. Severe deformation is defined as the case where strains are exceptionally large and laminar flow no longer occurs. The collapsed zone is a typical example. Strains are typically greater than 6mm/m and flow occurs in unsaturated conditions. The model will need to use approximations for the collapsed zone. Severe strains at the surface (the tensile cracking zone) create hydraulic conductivity fields with extremely high uncertainty ranges. Outside these zones, the laminar flow formulation is appropriate.	To be provided / addressed separately

Ref	Regulator	Issue	Where Addressed
15.	DP&I	Swamps The PPR states that swamps have undergone subsidence due to previous mining, and that despite this, they are reported as thriving. The height of the collapsed zone from previous mining is calculated to not have reached the surface tensile cracking zone, therefore permanent drainage from the swamp to a goaf did not occur. With H reaching to the surface, permanent drainage will occur. Where H does not reach to surface, filling of only a finite surface storage (increased void ratio from surface tensile fracturing) occurs, frequently resulting in temporary water loss.	Subsidence discussion provided in Appendix B
16.	DP&I	Conclusions and Recommendations The new layout of LW7 is still considered to pose a risk to the capacity of the channel of Cataract Creek to transmit surface water. Surface subsidence monitoring for Balgownie Seam and Wongawilli Seam longwalls indicates incremental subsidence that is in excess of that expected for a single seam case. Although a relationship between surface subsidence and the height of desaturation (H) is unavailable, subsidence monitoring results indicate that there is a high likelihood that the height of H for a Wongawilli panel will be larger than that calculated using the relationship for single seam mining (Tammetta, 2012). Since the LW7 width has only been reduced by 19m (about 13% of the original width), it is reasonable to conservatively assume that the height of the collapsed zone (H) intersects the ground surface at the northern corner of LW7. Where the top of a collapsed zone is some distance below the surface, the surface disturbance at a channel bed may not link to the collapsed zone. In the case of LW7, there is considered to be a risk of direct hydraulic connection between the creek channel and goaf, through the collapsed zone, where the channel comes to close to the panel edge. The level of risk is difficult to quantify but warrants consideration. The strategy presented by the proponent for groundwater numerical simulation largely satisfies the recommendations made in Coffey (2013). However, this strategy discusses potential or perceived limitations, and several assumptions (see above), which are not necessarily real. Recommendations in Coffey (2013) are further clarified in relation to the assumptions made by the proponent, and discussion is provided to ameliorate the limitations perceived by the proponent.	Subsidence discussion provided in Appendix B Appendix D
17.	DP&I – Subsidence	**A. Summary Section** 1) Summary, p(i) – SCT notes correctly that the presence of the old workings in the other mined overlying (Balgownie and Bulli) Seams, whilst providing some challenges, does present an advantage in the ability to project the location of known geological structures between the seams into the proposed Wongawilli workings.	Subsidence discussion provided in Appendix B

Ref	Regulator	Issue	Where Addressed
18.	DP&I – Subsidence	2) Summary, p(ii) – SCT notes that previous Bulli Seam longwall experience will assist in understanding the subsidence mechanisms involved (for this geology), and the prediction of actual subsidence values. It is also noted that incremental subsidence and the approach of Holla and Barclay will be used for predicting tilts and strains; and that the ACARP Method (Waddington Kay & Associates (now MSEC)) will be used for predicting maximum closure. These approaches are considered valid and appropriate; furthermore, they now address the shortcomings in the previous Seedsman work which was lacking with respect to predictions in non-conventional subsidence effects such as valley closure due to surface topographic variations.	Subsidence discussion provided in Appendix B
19.	DP&I – Subsidence	3) Summary, p(ii) – It is noted that *"subsidence behaviour is essentially predictable albeit with somewhat different characteristics to subsidence over single seam mining operations".* The term "essentially predictable" is rather vague or imprecise in meaning, presumably due to the complexity of the issue under discussion. As previously noted, it is due to the effect of multiseam mining on subsidence behaviour. It is simply not possible to provide accurate, absolute subsidence predictions, based on such a limited database of current multi-seam experience. SCT identifies the reason for subsidence differences in a multi-seam environment as being due to *"overburden stiffness characteristics and therefore the bridging capacity across individual panels, but is otherwise essentially similar to the subsidence behaviour above single seam operations".* Whilst I agree with this statement to a point, it perhaps over-simplifies the issue of exactly how the assessment of the changed overburden stiffness characteristics can be carried out in order to predict multi-seam subsidence with any degree of certainty. It also makes no reference to the important issue of time-dependency, when previous goaf areas (particularly old partial or first workings panels) are remobilised.	Subsidence discussion provided in Appendix B
20.	DP&I – Subsidence	4) Summary, p(ii) – SCT notes that there is potential for some localised pillar instability in the overlying Bulli Seam workings in the vicinity of Longwall 1 when mining in the Wongawilli Seam takes place.	Subsidence discussion provided in Appendix B
21.	DP&I – Subsidence	5) Summary, pp(iii-iv) – SCT has undertaken an assessment of previous subsidence effects due to the mining of both the Bulli and Balgownie Seams. The Bulli Seam subsidence is estimated (see later in body of report for explanation of basis for estimation technique); this has then been combined with measured data from longwall mining in the Balgownie Seam. An interesting (and considered reasonable) statement is that in the multi-seam environment *"the goaf edge subsidence profile is expected to be softer than elsewhere".*	No response required

Ref	Regulator	Issue	Where Addressed
22.	DP&I – Subsidence	6) Summary, p(iv) – It is noted that the PPR includes an adaptive management strategy *"based on closure monitoring and cessation of mining if there is a likelihood of significant perceptible impacts becoming apparent".* This is discussed in relation to Cataract Creek in particular, and the possible impacts of valley closure effects. Whilst this principle of adaptive management is considered reasonable, it is reliant on several factors which have not as yet been clearly defined, but which are essential to the success of such a strategy. These were identified in my initial report and include: a. What amount of lead time will be available in the relevant monitoring data locations, to provide meaningful data on which decisions can be made prior to the impacts occurring at Cataract Creek? b. What certainty will there be, that the observed surface subsidence effects and related impacts will cease immediately if mining is ceased in the area? c. What is the proposed management structure whereby such decisions will be made – both with regard to the interpretation of the monitoring data; and also with respect to deciding to stop the longwall, and how quickly can such a process take place?	Subsidence discussion provided in Appendix B
23.	DP&I – Subsidence	7) Summary, p(iv) – SCT makes a significant comment and recommendations, with respect to the potential impact of mining on the identified 33 upland swamps identified by Biosis. Firstly, it is stated that mining is not expected to cause significantly different impacts to those already experienced due to earlier mining – however, such previous experience has not been well documented, to date (this is partly due to the simple lack of previous data available). It is therefore difficult to agree with, or endorse this statement, in the absence of any supporting data. Consistent with a lack of real quality data on swamp impacts, SCT then rightly argues for *"more work is required to determine the relationship between mining subsidence and the long term health of swamps".* It is stated that there is a rare opportunity within this lease area where base data, or at least experience exists over many decades, to undertake a more thorough review. SCT further recommends the formation of an ongoing monitoring and review strategy with respect to subsidence impacts on swamps and their subsequent recovery over time.	Subsidence discussion provided in Appendix B
24.	DP&I – Subsidence	8) Such a view is strongly supported, and is in line with some of the recommendations from the Southern Coalfield Review Panel Report (2008). The issue then becomes, how is such a review and further investigation possible without mining progressing in the vicinity of such swamps in order to generate further data? It is proposed that an incremental approach be adopted, with the first stage being a summary of historical impacts and evidence of recovery; followed by more precise monitoring of subsequent impacts as mining proceeds – preferably in relation to less significant swamps in the first instance.	Subsidence discussion provided in Appendix B Appendix D

Ref	Regulator	Issue	Where Addressed
25.	DP&I – Subsidence	9) Summary, pp(iv-vi) – Further summary impacts are discussed, with conclusions that impacts on sandstone cliff formations, aboriginal sites, Mount Ousley Road, Cataract Reservoir, and the Illawarra Escarpment are likely to be minimal to negligible. This view is supported. In relation to electricity transmission towers, it is noted that some protection and remedial actions will be required. In regard to the use of a barrier between mining and the Full Supply Level (FSL) of Cataract Reservoir, a horizontal protection barrier of at least 0.7 times depth has been applied around the FSL which seems reasonable. However SCT then notes on p(vi) that *"the presence of these goafs reduces the effectiveness of the 0.7 times depth barrier".* This is referring to goafs from old workings. If this reduction in effectiveness is real, as stated here by SCT, then surely this requires further justification of the adequacy of the 0.7 barrier, or else a modification to the barrier width or control measure for the FSL? Such an explanation is lacking, but should be provided.	Subsidence discussion provided in Appendix B
26.	DP&I – Subsidence	10) Summary, p(vii) – Discussion of the other submissions includes comments in relation to the subsidence prediction technique(s). It is noted and agreed that prediction techniques are being continually improved, based on available data, to enable better understanding of the subsidence processes involved. The following sentence is then included in this discussion: *"Although there is somewhat greater uncertainty for subsidence predictions in a multi-seam environment, the available data indicates that the behaviour observed is repeatable and consistent with the mechanics of the processes involved".* This statement does not yet appear to be supported by a substantial body of factual data. On the evidence presented to date, there is still a reliance on hypotheses and estimates, to provide a complete understanding of the multi-seam behaviour. It is, to put it simply, early days in relation to this topic, with very little comprehensive quality data available, and I therefore find it difficult to support such a bold statement at this time.	Subsidence discussion provided in Appendix B
27.	DP&I – Subsidence	11) Summary, p(vii) – It is noted that the presence of the old workings in other seams provides valuable data with respect to geological structures, and there are only two major structures in the area, which have been accounted for in the PPR mine design.	Subsidence discussion provided in Appendix B
28.	DP&I – Subsidence	12) Summary, p(vii) – SCT concedes correctly that the prediction of valley closure, upsidence and far-field movements are only approximate, since these techniques are still under development. However, to their credit, SCT has made such predictions (which were absent in the earlier prediction reports), using the best available techniques and sources of data. Reference is again made, with respect to valley closure in the vicinity of Cataract Creek, to *"NRE's commitment to stop the longwalls short if closure movements become likely to cause unacceptable impacts".* As discussed above, the ability, practicality and processes for achieving such a management control require further explanation and justification.	Subsidence discussion provided in Appendix B

Ref	Regulator	Issue	Where Addressed
29.	DP&I – Subsidence	**C. Section 2. Site Description** 1) Section 2, p4 – This includes a useful summary of the subsidence constraints used in the redesign of the mine plan for the PPR. These constraints all seem reasonable and appropriate, however the constraint with respect to the significant upland swamps lacks any quantitative or measurable definition, in terms of how does this translate to a design constraint. Figure 2 is a copy of Figure 2 from the SCT report, showing both original and the revised PPR mine layouts, together with the various constraints identified above.	Subsidence discussion provided in Appendix B
30.	DP&I – Subsidence	2) Section 2, p6 – This provides an appropriate definition of the assessment area as extending 600m horizontally from any proposed longwall panels, and up to 1.5km to allow for far-field horizontal effects on any significant features, such as the Illawarra Escarpment.	No response required
31.	DP&I – Subsidence	3) Section 2, p6 – It is acknowledged that the single seam subsidence seam prediction methodology used in the original assessment was not appropriate, given the measured subsidence values over the current longwalls (LW4) being well above the predictions.	Subsidence discussion provided in Appendix B
32.	DP&I – Subsidence	4) Section 2, Figures 6, 7 and 8 – These figures provide a useful record of the previous workings in each of the Bulli and Balgownie Seams, together with the proposed Wongawilli Seam longwall panels. The location of the major geological structures is also discussed (pp10-16), and it is noted that the major fault structure, known as the Corrimal Fault, while significant in throw towards the southern end of the lease (away from the proposed longwalls), diminishes to the northwest, to the extent that it is believed to be insignificant at the point where it will be intersected by LW6.	No response required
33.	DP&I – Subsidence	**D. Section 3. Previous Mining Activity** 1) Section 3, p18 – It is noted that subsidence from previous mining in the Bulli Seam has been estimated, but for the Balgownie Seam, measurements were taken at the time of mining. The recent mining of LWs 4 and 5 in the Wongawilli Seam has confirmed that observed subsidence does not match single-seam prediction behaviour, although it is claimed that the multi-seam effects are largely restricted to within the chain pillar boundaries of the currently mined panels. SCT again uses the expression “essentially predictable” when referring to multi-seam behaviour, although the basis for such a claim is yet to be substantiated.	Subsidence discussion provided in Appendix B
34.	DP&I – Subsidence	2) Figure 3 provides a good overlay of the proposed Wongawilli longwall panels, together with the location of the previous Balgownie Seam longwalls and the areas of old Bulli Seam bord and pillar workings. This is reproduced from Figure 11 of the SCT report.	No response required

Ref	Regulator	Issue	Where Addressed
35.	DP&I – Subsidence	3) Section 3, p20 – SCT explains that their estimates of Bulli Seam subsidence have been obtained on the basis of previous experience *"from mining in the Bulli Seam further to the west above the T and W (200 and 300 series) longwall panels at South Bulli and subsequent pillar extraction operations".* Whilst it seems reasonable to develop an understanding of subsidence over Bulli Seam bord and pillar workings, the detail is not provided to allow any assessment of the validity or accuracy of this approach, and regardless, it would be very difficult to gain any high levels of confidence in what are no doubt a range of different mining panel geometries and extraction scenarios. This approach is therefore a reasonable one, but there must be a significant note of caution with respect to the confidence in the magnitude or variability of the predicted values, relative to the current areas of interest.	No response required
36.	DP&I – Subsidence	4) Section 3, p20 notes that an extensive underground inspection was undertaken on 21 June 2013 which has identified an area of pillar workings in the Bulli Seam above/adjacent to the proposed Wongawilli panels which are likely to be destabilised as a result of Wongawilli undermining. (This is backed up by evidence of pillar destabilisation caused by the previous Balgownie longwalls, in a similar area of Bulli Seam pillar workings). It is noted that such effects are likely to be localised, and confined close to the new goaf edge, but need to be taken into consideration. This has already been discussed under section A(4), and relates to an area near Longwall 1 (further discussed on SCT Report p23).	Subsidence discussion provided in Appendix B
37.	DP&I – Subsidence	5) Section 3, p23 – Discussion of measured Balgownie Seam longwall-related subsidence confirms that there is evidence from the data that there was additional subsidence at the time due to associated, remobilised pillar instability.	Subsidence discussion provided in Appendix B
38.	DP&I – Subsidence	6) Section 3, p23 – Further discussion addresses the question of pillar run potential. SCT states that such a scenario is certainly possible, in the context of localised pillar regions, as discussed above, but is unlikely to extend over any large distances, based on a combination of assessment of the old mine plans, and underground inspection. This opinion and conclusion is considered reasonable. SCT then extends the definition of "pillar run" to include the impact of additional abutment stresses on pillar regions causing, not instability, but simply an additional increment of elastic compression of the pillars, hence an additional increment (albeit small) of surface subsidence, without pillar failure. This is certainly not only feasible, but a certain outcome, where regional load transfers and abutment stresses change the loading regime on standing pillars. However, it is not considered appropriate to include this under the heading of a "pillar run" which historically has been a term used to describe large scale, dynamic pillar instability and failure. The issue of incremental elastic compression does not fall under this description and it is strongly recommended that such terminology should not be used for such behaviour.	Subsidence discussion provided in Appendix B

Ref	Regulator	Issue	Where Addressed
39.	DP&I – Subsidence	7) Section 3, p24 and following – Section 3.2 discusses the Balgownie Seam subsidence effects. Firstly, it is noted that in areas where there was overlying Bulli Seam goaf, the measured goaf edge region subsidence extends further, but only to the extent of being a secondary effect. It is also noted (pp26-27) that where the Bulli Seam goaf areas were narrow and possibly bridging, the effect of underlying Balgownie workings is to cause a greater increment of additional subsidence, such that the resultant surface subsidence extends up to 100% (1.4m) of the Balgownie Seam mining height, i.e. the Balgownie goaf formation has reactivated the goaf above the Bulli Seam and caused this additional subsidence, over and above what would have been expected from single-seam Balgownie subsidence prediction.	Subsidence discussion provided in Appendix B
40.	DP&I – Subsidence	8) Section 3.2 also discusses both horizontal strains and tilts, and then valley closure effects associated with Balgownie subsidence (p29). The ACARP method of predicting valley closure and upsidence is applied to these sites and compared to measured data in regions around Cataract Creek where previous Bulli Seam mining had taken place. It is found that this method provided good correlation between measured and predicted data and so is considered applicable for assessing upper bound valley closure and upsidence effects in multi-seam applications. This is a reasonable conclusion going forward, in the face of no other current methodology being available. However it is a conclusion based on a very small dataset, and should be applied with great caution, and a lower level of confidence than when working in single-seam situations.	No response required
41.	DP&I – Subsidence	9) Section 3, p32-35 – It is unfortunate that having discussed the Balgownie Seam subsidence data with respect to subsidence effects and impacts, strains, tilts, valley closure, surface cracking, rock falls, Cataract Creek etc, there is no discussion about the subsidence effects in the vicinity of upland swamps that were impacted by the Balgownie longwalls (such as are indicated to exist in Figure 2 in the middle of proposed Wongawilli LW6, which in reference to Figure 3, lies directly above some of the Balgownie longwall panels). It would be extremely valuable to know how much subsidence and strains, tilts etc occurred in the vicinity of those (and any other) swamps, and then to assess what was the immediate impact on the swamps, if that was recorded at the time, and what is the current state of recovery in such swamps to any adverse impacts that occurred. Such a correlation between quantitative subsidence data and resultant impacts is the major missing element in this project assessment. If, as SCT states, such data was collected, it is essential that it be reported in the above manner to provide a valuable benchmark dataset and case study (c/f paragraph A(7) above). (Note: There is some discussion on this point later in the SCT report, and some data is included in Appendix 1 of the report, but there is no discussion of it here in the context raised above).	Subsidence discussion provided in Appendix B

Ref	Regulator	Issue	Where Addressed
42.	DP&I – Subsidence	**E. Section 4. Subsidence Prediction Methodology** 1) Section 4 provides a comprehensive discussion of the methodology adopted for subsidence prediction, based on the available empirical data and understanding of subsidence mechanics behaviour. It is largely based on the experience, to date, from monitoring subsidence above Wongawilli LWs 4 and 5, where previous overlying workings exist in both the Bulli and Balgownie Seams. It is a valuable contribution to understanding the multi-seam subsidence behaviour, and is a sound, and best available source of information on which to base the future prediction methodologies for this project. However, it is important to recognise that it is still a relatively small database, and so predictions must be made with caution, whilst the database is continually expanded, and regularly re-evaluated. A critical part of the management strategy for this project moving forward must be to conduct continual high level comprehensive monitoring; regular data analysis; and regular re-evaluation of the subsidence behavioural models and hence predictions based on such models.	No response required
43.	DP&I – Subsidence	2) Section 4, p37 – SCT draws the appropriate conclusion that in the multi-seam environment, the effect of the overlying goaf areas is to reduce the shear stiffness and rigidity of the overburden strata. Some subsidence data is provided to support this hypothesis. On p43, the logical conclusion from this effect is stated to be *"the reduced shear stiffness leads to reduced bridging capacity of the overburden strata and significantly increased maximum subsidence for the same overburden depth and longwall panel geometry".* This is a particularly important and valid conclusion, and is significant in terms of providing forward predictions of subsidence behaviour. The challenge remains as to how to quantify the magnitude of such increases, and define the conditions under which they occur. SCT does proceed to do this in the best manner available, but the caution remains that (a) it is based on a very limited dataset, and (b) the full knowledge of the nature of the overlying workings and subsequent subsidence is based on estimates only (at least in the case of the Bulli Seam). Therefore the subsequent predictions made (see Section 5) are appropriate, but must be applied with caution.	No response required
44.	DP&I – Subsidence	3) Section 4, p44 – The point that has already been made about the additional subsidence due to these effects being largely confined to within the current panel geometries is an important and positive one. However, the only scenario where this may not be the case is where overlying standing pillars are destabilised, in which case the additional subsidence effects due to such pillar failures may extend to the extent of the overlying pillar regions. This point is made on p45 with respect to the region of Bulli Seam pillars in proximity to Wongawilli LW1. SCT makes some specific recommendations with respect to the length of LW1 and the need to carefully manage this situation. This opinion is strongly endorsed.	No response required
45.	DP&I – Subsidence	4) Section 4, p46 and following – The remainder of this section discusses specific subsidence parameters, effects and impacts – all of which are accepted as stated, based on the previous qualifications discussed above with regard to the prediction methodologies.	No response required

Ref	Regulator	Issue	Where Addressed
46.	DP&I – Subsidence	5) Section 4, p48 and following – SCT confirms the adoption of a purely empirically-based subsidence prediction methodology, for all of the reasons already discussed. The more traditional analytical methods using Influence or Profile Function methods, or the single seam empirical Incremental Profile methods are not considered appropriate to this type of multi-seam subsidence behaviour. This conclusion is accepted as reasonable under the circumstances of this project, albeit that the methodology adopted is in a very preliminary or prototype stage, as discussed previously.	No response required
47.	DP&I – Subsidence	6) Section 4, p50 – In discussing strains and tilts, it is worth emphasising the point made by SCT that it is simply not possible to predict exact locations of maximum or peak strains, and hence potential crack locations, for example. Regions where such strains might occur can be identified, but it is never going to be possible to predict in advance the actual location of actual cracks in the rock mass.	No response required
48.	DP&I – Subsidence	7) Section 4, pp50-52 – SCT discusses accuracy and sensitivity assessment for their prediction methodologies. This leads to the statement discussed earlier, that *“subsidence associated with multi-seam subsidence in this area is essentially similar to the subsidence behaviour in a single seam”.* Once again, although it is only semantics, it is hard to see what is essentially similar about the behaviour predicted. SCT has just discussed significant changes in behaviour due to changes in the overburden characteristics, rendering traditional prediction relationships invalid. This statement is therefore not considered an appropriate description of a quite different world of multi-seam subsidence behaviour, the understanding of which is still relatively embryonic. SCT’s own excellent approach to understanding this is still only based on data from two current longwalls (LWs 4 and 5).	Subsidence discussion provided in Appendix B
49.	DP&I – Subsidence	8) Section 4, p52 – SCT makes a very important and valid conclusion, having discussed the impact of softened overburden leading to a change in bridging characteristics and potential increased subsidence. It is noted that in spite of this changed behaviour, all of the proposed panels within the PPR are of a reduced panel width such that there remains a significant subsidence-limiting control factor present due to the panel widths, such that full subsidence will not develop above these panels, compared to if they were wider, under the multi-seam environment.	No response required
50.	DP&I – Subsidence	**F. Section 5. Predicted Subsidence** 1) This section simply presents the factual predictions for the full range of scenarios and features present – based on all of the assumptions already discussed. These predictions are all accepted at face value, together with the various caveats already mentioned, especially with regard to confidence levels.	No response required

Ref	Regulator	Issue	Where Addressed
51.	DP&I – Subsidence	**G. Section 6. Subsidence Impacts** 1) Section 5, p61-62 – This section returns to the issue of upland swamps and refers to the data contained within the Appendix regarding past estimates, and future predicted subsidence effects. However it still does not address any detail with respect to either previous impacts or future likely impacts (accepting that some of these issues fall outside of the brief of SCT). The most relevant and pertinent statements made on these issues are: o *"It is unclear how sensitive swamps are to mining subsidence"* o *"the swamps located having been previously subsided to levels that expected above future longwall panels"* o *"the drop in piezometric pressure observed when some swamps are mined under may not have a significant impact on their long term condition"* o *"It is considered that more work is required to determine the relationship between mining subsidence and the long term health of swamps"* Clearly there is a need for a more quantity relationships between the swamps and the impact factors – both immediately, based on the known and estimated subsidence data reported here; and also through further work in the future.	Subsidence discussion provided in Appendix B Appendix D
52.	DP&I – Subsidence	**H. Section 7. Management Strategies** 1) The recommended strategies discussed here are all considered of value and worth pursuing. These include the adoption of a higher standard of survey monitoring, including the use of three dimensional GPS arrays, in support of conventional survey data, and also high precision point to point measurement of valley closure.	No response required
53.	DP&I – Subsidence	2) The concept of an adaptive management strategy discussed earlier is not specifically referenced in this section, but is an essential process that brings together the data from various sources of monitoring data and analysis, in order to inform operational mine management and planning decisions. It is critical that an appropriate management system is established to handle this in an effective manner, as previously discussed under paragraph A (6) and elsewhere. This system needs to be developed well in advance, and clearly enunciated including answers to the questions posed in A (6).	Subsidence discussion provided in Appendix B
54.	DP&I – Subsidence	**I. Section 8. Response to Submissions** 1) The issues raised in this section are all ones that have been discussed in earlier sections of the report, and as such, do not warrant further review or comment.	No response required

Ref	Regulator	Issue	Where Addressed
55.	DP&I – Surface Water	**2 Impacts of Mining** **2.1 Subsidence Predictions** The *PPR*, in particular the *Subsidence Assessment* (Annexure B), provides an assessment of the estimated subsidence that occurred as a result of previous mining in the Bulli and Balgownie Seams and the predicted additional subsidence as a result of mining the Wongawilli Seam. It is not the purpose of this review to comment on the subsidence methodology and assumptions. Accordingly, it is assumed that Annexure B provides reasonable estimates of the magnitude and location of subsidence impacts.	No response required
56.	DP&I – Surface Water	The Bulli Seam was mined from the late nineteenth century through to the 1950's using a variety of mining systems including mechanised pillar extraction in the later stages. The Balgownie Seam was mined as one of the first longwall mining operations in Australia from 1970 through to 1982. Consequently, any gradual changes in the vegetation within the headwater swamps as a result of increased drainage resulting from subsidence impacts have had over 30 years to become apparent.	No response required
57.	DP&I – Surface Water	The *PPR* and Annexures contain various figures that separately show the location of the headwater swamps apand the estimated subsidence contours resulting from previous and proposed mining. However, none of the figures show all of the features of relevance together: • Location of swamps and creeks; • Land surface contours; • Estimated subsidence. In order to provide a basis to better understand the spatial relationship of these features, and the surface water context surrounding the swamps, Gujarat NRE provided maps showing these features for historic and predicted subsidence. **Figure 2.1** and **Figure 2.2** are reduced size copies of the original plans that were provide at A1 size to assist with analysis. As shown on both these figures, the modified layout has all longwalls offset by a minimum of 50 m from Cataract Creek and its third order tributaries. All other longwalls except LWs 4, 9, 10 and 11 run under at least one first or second order watercourse.	No response required
58.	DP&I – Surface Water	For purposes of the *EA* and *PPR* all swamps mapped have been mapped on the basis of common features of the relevant vegetation community. This has led to the swamps having highly irregular shapes that do necessarily reflect all the surface water factors that would influence the hydrologic behaviour of the swamps such as any contributing up-slope catchment area and variations in soil characteristics and depth. The likely variation in soil characteristics and depth within a single swamp (defined by the vegetation community), and the area and lateral extent of some swamps implies that each vegetation community is capable of surviving in a variety of hydrologic conditions.	Biodiversity discussion provided in Appendix F

Ref	Regulator	Issue	Where Addressed
59.	DP&I – Surface Water	**Table 2.1** summarises the subsidence data for swamps most likely to be affected by mining in the Wongawilli Seam (taken as maximum tensile strain > 1 mm/m). The data has largely been drawn from the table "*Incremental Subsidence for Proposed Mining in the Wongawilli Seam*" in Appendix 1 of Annexure B to the *PPR* with the exception of the following data taken from Table 15 in Annexure A to the *PPR*: • 'Maximum Subsidence within Swamp' (Column 2); • 'Overburden Depth' (Column 4); • 'Longwall Panel Width' (Column 5); and • 'Ratio of Overburden Depth to Longwall Panel Width' (Column 6).	No response required
60.	DP&I – Surface Water	In the process of compiling the data for **Table 2.1**, a number of differences were noted in the data drawn from the two sources. In particular: • The values of 'Adjacent Subsidence Used to Calculate Strains and Tilts' (Column 3) in Table 15 of Annexure A are inconsistent with the equivalent values quoted in Appendix 1 of Annexure B. It is assumed that this is a transcription error and that the values in Annexure B are correct. • The 'Overburden Depth' quoted in Appendix 1 of Annexure B appear to be the overburden depth above the Wongawilli Seam whereas the values in Table 15 of Annexure A represent the minimum overburden depth above the Bulli Seam. The latter values have been adopted for Table 2.1.	Subsidence discussion provided in Appendix B
61.	DP&I – Surface Water	Unfortunately, the data provided in the *PPR* and Annexures does not include mapping to show the location of maximum tensile stress. For subsequent assessment of the most likely location of any surface cracking (see **Section 4** below), it has been assumed that this would be most likely to occur in the region of maximum convex curvature (as inferred from the subsidence contours).	No response required

Ref	Regulator	Issue	Where Addressed
62.	DP&I – Surface Water	**2.2 Potential Subsidence Effects** The potential effects of subsidence on headwater swamps include: • Differential settlement leading to change in the bed level relative to any drainage outlet (if one exists), and: o Increased water storage capacity of the swamp if the subsidence occurs up-slope of any drainage outlet; o Decreased water storage capacity if the subsidence occurs at the outlet; o Change in flow pathways through the swamp due to changes in ground level (tilt) (as assessed by Biosis using 'flow accumulation modelling'). The *RTS* (**Section 3.1.3**) acknowledges that this analysis is primarily applicable to valley-fill swamps.) Notwithstanding these possible effects, because the surface slope of the headwater swamps is of the order of 10% (10 m in 100 m), subsidence of the order of a few metres is unlikely to significantly impact on the water storage characteristics or flow pathways of these swamps.	No response required
63.	DP&I – Surface Water	• Cracking due to tensile or compressive strains, or unconventional subsidence. The impact of any cracking will depend significantly on nature of the cracking (depth and any sub-surface shearing) and the location of any cracking with respect to the local topography: o Cracking towards the up-slope edge of the swamp has the potential to re-direct surface runoff from the contributing catchment; o Cracking within the body of the swamp or towards the down-slope boundary has the potential to drain any seasonal perched water table; o Cracking towards the sides of the swamp is unlikely to have a significant impact on any runoff contribution from up-slope or the balance of incident rainfall and evapotranspiration loss that leads to a seasonally varying perched water table.	Subsidence discussion provided in Appendix B Appendix D

Ref	Regulator	Issue	Where Addressed
64.	DP&I – Surface Water	In addition, as noted in the *Bulli Seam Operations PAC Report* (PAC, July 2010): *"Consequences of these impacts depend upon a wide variety of factors such as how much water is lost, over what period, whether "self-healing" occurs and to what degree, and whether there are severe rainfall events or fire events. Depending on these factors and their interactions, a swamp could show no evidence of change, or be severely damaged over a relatively short space of time."* It is recognised that subsidence prediction is an imprecise science, particularly in the case of multiseam mining. In his review of the subsidence assessments in the *PPR*, Hebblewhite (November 2013), noted that: *"In discussing strains and tilts, it is worth emphasising the point made by SCT that it is simply not possible to predict exact locations of maximum or peak strains, and hence potential crack locations, for example. Regions where such strains might occur can be identified, but it is never going to be possible to predict in advance the actual location of actual cracks in the rock mass."*	No response required
65.	DP&I – Surface Water	**2.3 Connective Cracking** The *PPR* (Section 2.2.9.3) acknowledges the additional possibility of connective cracking from surface to seam but notes that this has not been observed over longwalls LW4 or LW5 and is considered extremely unlikely. In his review of the groundwater assessment for the project, Tammetta (20/12/2013), (page 11) notes: *"The PPR states that swamps have undergone subsidence due to previous mining, and that despite this, they are reported as thriving. The height of the collapsed zone from previous mining is calculated to not have reached the surface tensile cracking zone, therefore permanent drainage from the swamp to a goaf is unlikely to have occurred. If H intersects the ground surface, permanent drainage will occur. Where H does not reach to surface, filling of only a finite surface storage (increased void ratio from surface tensile fracturing) occurs, frequently resulting in temporary water loss.*	Subsidence discussion provided in Appendix B Appendix D
66.	DP&I – Surface Water	Notwithstanding the possibility of connective cracking raised by Tammetta, Hebblewhite 18/12/2013) reports on joint discussions with Tammetta and Dr Mills (of SCT): *"It is understood that Mr Tammetta's original reported results which suggested an intersection with the surface were based on using the sum of all three mined or proposed to be mined seams, i.e. Balgownie, Bulli and Wongawilli. However, further analysis by Dr Mills suggests that in the area in question above Wongawilli LW7, the Bulli Seam workings only consisted of development roadways, not extraction. As such, it is considered inappropriate to include the thickness of the Bulli Seam workings in the calculation for H. Without the Bulli Seam thickness, the calculated value of H using Tammetta's equations, does not intersect the surface. Therefore based on the above interpretation, the risk of inter-connective cracking is considered low in the vicinity of LW7 (or any other part of the proposed workings)."*	No response required

Ref	Regulator	Issue	Where Addressed
67.	DP&I – Surface Water	Connective cracking between the surface and the mine workings would provide a pathway for water to drain from a creek or swamp. In both cases, it is possible that some reduction in water loss might occur over time as fine sediments gradually fill the surface cracks. However the occurrence and effectiveness of any sealing will be highly dependent on the size of the cracks in the sandstone and the availability of suitable sized soil particles to create a full or partial seal. While the possibility of such self-sealing has been contemplated by others (e.g. the *Bulli Seam Operations PAC Report*, quoted above), there does not appear to be any quantitative evidence of the effectiveness of this mechanism.	Appendix D
68.	DP&I – Surface Water	**Hydrology of Headwater Swamps** **3.1 Upland Swamps** Upland swamps are found on sandstone plateaux areas with rainfall in excess of about 1,200 mm. Any consideration of potential impacts of subsidence on upland swamps needs to clearly distinguish between: • **Valley fill swamps** located either side of drainage lines. These swamps have relatively shallow down slope gradient dictated by the gradient of the drainage line and contain areas of open water. No valley fill swamps are located in the vicinity of the proposed Wonga East mining operations. Because of their topographic location, valley fill swamps are likely to receive some groundwater baseflow. • **Headwater swamps** located on the hillside with typical gradient of the order of 10% in the Wonga East area. Some, but not all, of these swamps drain via first order streams. Because of their topographic position, headwater swamps are reliant on direct rainfall and any contribution of surface runoff from the up-slope contributing catchment. Headwater swamps exhibit seasonally varying perched water tables that are independent of the regional water table in the underlying Hawkesbury Sandstone. All swamps in the vicinity of the proposed Wonga East mining operations are headwater swamps. These swamps vary in area from 0.26 to 9.84 ha and typically extend between 100 and 430 m in the down slope direction.	No response required

Ref	Regulator	Issue	Where Addressed
69.	DP&I – Surface Water	**3.2 Published Assessments and Reviews** Because of the wide distribution of upland swamps on the Woronora plateaux and the potential impacts of underground mining, the hydrology of upland swamps has received considerable public scrutiny, particularly in: • *Impacts of Underground Coal Mining on Natural Features in the Southern Coalfield: Strategic Review* (Department of Planning, July 2008); • *Bulli Seam Operations – PAC Report* (Planning Assessment Commission, July 2010). In addition, the Office of Water Science (Department of the Environment, Canberra) commissioned • *Peat Swamps – Ecological Monitoring* • *Peat Swamps – Engineering Subsidence* These two reports are not yet in the public domain. *Impacts of Underground Coal Mining on Natural Features in the Southern Coalfield: Strategic Review* quotes various sources that indicate the dates of basal sediments vary between roughly 2,000 – 17,000 years. Fryirs et al (2012) describe the upland swamps inn the Blue Mountains as, *"accumulations of mineral sands and organic pert that started forming around 13,000 years BP and have accumulated throughout the Holocene to today".*	No response required
70.	DP&I – Surface Water	As reported by Ross (2009), monitoring of headwater swamps in the Kangaloon area by SCA suggests the water table in the swamps is perched; the water table in the underlying sandstone is situated some 4 to 5 m below the swamp(s). This finding is consistent with the location of headwater swamps away from the main drainage lines.	No response required
71.	DP&I – Surface Water	**3.3 Swamps in the Wonga East Area** Annexure A to the PPR (*NRE No. 1 Colliery – Underground Expansion Project: Preferred Project Report – Biodiversity*, Biosis, 2013) provides additional detail relating to a number of piezometers installed to measure the perched water table levels in a number of the swamps located along the ridge that separates the catchments of Cataract Creek and Cataract River. **Figure 3.1** is a reproduction of the piezometer data depicted in Graph 2 of the Biosis report (raw data provided by Gujarat NRE) together with daily rainfall data for the Bureau of Meteorology site at Darkes Forest (Station No. 068024).	No response required

Ref	Regulator	Issue	Where Addressed
72.	DP&I – Surface Water	For purposes of the analysis provided below, the rainfall data from Darkes Forest has been adopted for **Figure 3.1** because the data from the No 4 Site (collected by Gujarat NRE) has some missing data. As indicated on the rainfall isohetal map of the area (Figure 4.4 in *NRE No 1 Colliery Surface Water Modelling*, WRM, 2012 which forms an appendix to Annex O of the EA), the average annual rainfall at Darkes Forest is comparable to that of the Wonga East project area. **Figure 3.2** shows the vertical profiles of the piezometers taken from Figure 11 of the *Groundwater Assessment* (GeoTerra 2012). The figure shows that all piezometers were constructed to a depth below the interface between the swamp material and the weathered sandstone. **Table 3.1** summarises details of the piezometers extracted from Table 3 of the *Groundwater Assessment*.	No response required
73.	DP&I – Surface Water	The assessment of the groundwater behaviour provided in the text by Biosis is limited to how rapidly the water levels fall following significant rainfall. No assessment has been provided of the hydrologic processes associated with the different behaviour.	In relation to groundwater, preliminary discussion is provided in Appendix C with further detail to be provided / addressed separately Biodiversity discussion provided in Appendix F
74.	DP&I – Surface Water	For purposes of further detailed analysis set out below, the slope of each hydrograph has been compared to the average seasonal point potential evapotranspiration rate that would occur if water supply to vegetation was not limited (derived from the point spatial data on CD for *Climate of Australia: Evapotranspiration*, BoM 2003). The analysis also assumes an effective porosity of 50% for the soils characterised in **Table 3.1**. While values that are more precise could be adopted following field analysis, the assumed value provides a reasonable basis for an indicative analysis.	No response required

Ref	Regulator	Issue	Where Addressed
75.	DP&I – Surface Water	The analysis indicates that the hydrographs fall into four categories: 1) Water level reduction that can be accounted for by evapotranspiration loss. This category includes piezometers PCc5A and PCc5B, both of which are located in swamp CCUS5 in which the water level was drawn down below the interface between the swamp and the underlying weathered sandstone in January 2013. This swamp was subject to an estimated 0.6 m maximum subsidence along its south-eastern edge as a result of mining of the Bulli and Balgownie Seams (see **Figure 2.1**). While the estimated subsidence occurred to the southeast of the locations of the piezometers, the hydrographs infer that water retention characteristics of CCUS5 have not been affected by subsidence.	No response required
76.	DP&I – Surface Water	2) Water level reduction that can be largely, but not fully, accounted for by evapotranspiration loss. This category includes piezometers PCc4 and PCr1, located in swamps CCUS4 and CRUS1 respectively. **Figure 2.1** shows the cumulative subsidence as a result of mining of the Bulli and Balgownie Seams as 0.9 m and 0.6 m respectively. The slope of the water level drawdown after rainfall cannot be fully explained by evapotranspiration. In particular: • The rapid fall in water level in PCc4 following rainfall in the middle of October 2012 which led to a rise of about 0.4 m in PCc4 followed by a return to a 'base' level (assumed to be the interface between the swamp and the underlying sandstone) within about 5 days; • Similar rapid falls in the water level following the rainfall events in February to May 2013; • In the case of PCr1, the water level shows relatively muted response to rainfall in the period up to the end of July 2012. The hydrograph shows no response to the rainfall events in mid-September and mid-October 2012, suggesting that the water level recorder malfunctioned. • For the rainfall events between February and May 2013, the rate of the fall in the water level is significantly greater than can be accounted for any evapotranspiration. It is interesting to note that the recorded water level in PCc4 fell to a level of about 0.95 m below ground level in the period between November 2012 and late January 2013. As this level is below the quoted depth of the base of the piezometer, the accuracy of the level measurements is questionable.	Appendix D
77.	DP&I – Surface Water	3) Water level lowering that follows a characteristic gradual slowing in the rate that suggests drainage from a swamp to a creek, which would help sustain baseflow. This behaviour is exhibited by piezometer PCc2 in swamp CCUS2. This swamp, which is located in the vicinity of proposed longwalls LW2 and LW3, was subject to estimated maximum subsidence of 1.1 m as a result of mining in the Bulli and Balgownie Seams. While the hydrograph recession suggests drainage to a creek, the mapping (**Figure 2.1**) shows the nearest identified drainage line starting about 150 m down-slope of the swamp.	Appendix D

Ref	Regulator	Issue	Where Addressed
78.	DP&I – Surface Water	4) Rapid water level lowering following rainfall, typically falling back to a 'base' level within 5 to 10 days of rainfall, which suggests that water is being lost from the base of the swamp into the underlying sandstone. Piezometers PCc3 and PCc6 (swamps CCUS3 and CCUS6) are examples of this behaviour. Both these swamps are located over LW4 and LW5 and were subject to 1.0 m and 1.8 m maximum subsidence respectively, as a result of previous mining (see **Figure 2.1**). LW4, which runs beneath CCUS6, was extracted between 19 April and 18 September 2012. Because the site of the piezometer is about 30% of the way along the longwall, the site of piezometer itself is unlikely to have been undermined before the start of June 2012. The start of mining occurred after the rise and rapid fall of water level following rainfall in February and early March 2012 (which led to persistent elevated water levels at PCcs5A in Swamp CCUS5). The fact that rapid water level lowering occurred before the influence of subsidence from longwall LW4 infers that the rapid drawdown cannot be attributed to mining of LW4. Notwithstanding the apparent rapid drainage of these 'swamps', the vegetation communities have been classified as consistent with the vegetation communities that define an upland swamp: • CCUS3 Banksia Thicket (MU42) and Sedgeland (MU44a); • CCUS6 Banksia Thicket (MU42). It is interesting to note the fact that only one of the headwater swamps, out of six, exhibits behaviour consistent with the hypothesised significant contribution to baseflow from upland swamps in general. This suggests that the dominant contribution to baseflow may be valley-fill swamps rather than headwater swamps, not upland swamps in general as is commonly supposed.	Appendix D

Ref	Regulator	Issue	Where Addressed
79.	DP&I – Surface Water	The Biosis report links the different behaviour of the perched groundwater systems to differences in the vegetation: *"Groundwater data from piezometers located in upland swamps within the study area indicates that there are varying degrees of contact with groundwater resources in these upland swamps. CCUS4 and CCUS5 show significant groundwater contact for prolonged periods, CCUS2 shows some contact but recedes rapidly, while CCUS3 and CCUS6 show little groundwater recharge following rainfall. This corresponds with the vegetation communities within these upland swamps, with CCUS4 and CCUS5 supporting areas of MU43 Tea-tree Thicket (both upland swamps) and MU44c Cyperoid Heath (CCUS4 only), which both rely on permanent to intermittent waterlogging. In contrast, CCUS2, CCUS3 and CCUS6 support MU42 Banksia Thicket (CCUS3 and CCUS6) or MU44a Sedgeland and MU44b Restioid Heath (CCUS2) which are less reliant on waterlogging.* *CRUS1, which supports a mix of MU42 and MU43, is an anomaly. This upland swamp has shallow soils and areas of MU43 are likely to be located in areas of terracing, resulting in water accumulation in depressions in bedrock."* The conclusions with respect to the vegetation in CCUS3 and CCUS6 suggest that the episodic perched groundwater conditions in these swamps pre-date the recent mining of longwalls LW4 and LW5. However, the rapid draw down of the water level following rainfall suggests that water is being lost through the base of these swamps, possibly as a result of cracking due to subsidence from previous mining activities. Given that the previous mining occurred 30 years ago, it is possible that the existing vegetation has had time to adapt to any change in swamp hydrology.	Subsidence discussion provided in Appendix B Biodiversity discussion provided in Appendix F Appendix D
80.	DP&I – Surface Water	Biosis (Attachment A to the PPR) concludes that: *"It is worth noting that all of the upland swamps listed above have been subject to significant tilts and strains from past mining (see Table 13 and Table 14), substantially above what has been predicted by MSEC to result in fracturing of bedrock in waterways (DoP 2010) and the criteria listed in OEH (2012) for assessing the risk of negative environmental consequences to upland swamps. These levels of tilts and strains are likely to have resulted in fracturing of the bedrock beneath these upland swamps from past mining. However, monitoring data is not available to confirm whether this has occurred."* Overall, it appears that the majority of the headwater swamps that have been subject to subsidence from previous mining have maintained a perched groundwater system that does not show evidence that cracking may have occurred. The exceptions are swamps CCUS3 and CCUS6. Notwithstanding, it appears that the vegetation in these swamps has similar characteristics to other swamps in the area. Therefore, any link between possible cracking of the base of a swamp and change in vegetation remains an unanswered question.	Subsidence discussion provided in Appendix B Biodiversity discussion provided in Appendix F Appendix D

Ref	Regulator	Issue	Where Addressed
81.	DP&I – Surface Water	In terms of subsidence impacts on swamps, Biosis acknowledges the lack of direct linkage between subsidence and hydrologic changes leading to changes in the vegetation community (**Section 3.1.3** of the *RTS*): *"Biosis does not assert that subsidence associated with longwall mining does not result in impacts to upland swamps, or that changes in groundwater availability are not an impact to upland swamps. Rather, that the maintenance and persistence of upland swamps is much more complex than has been recognised, and that further research and assessment is required to understand the complex processes that maintain upland swamps, particularly in relation to changes brought about by longwall mining."*	No response required
82.	DP&I – Surface Water	**3.4 Groundwater Interactions** The interaction between the perched groundwater in upland swamps and the deeper regional groundwater system in the Hawkesbury Sandstone is not well understood. Golder Associates, (December, 2013) offer the following comments (page 32): *'Water levels within these shallow perched 'swamp' systems are highly variable, subject to climatic and seasonal variations in local rainfall amounts. Post-storm surface runoff into a swamp typically occurs via indistinct drainage channels or flow paths to the swamp.* *Water levels within these shallow swamp systems are entirely separate from the deeper, regional Hawkesbury Sandstone water table…. However in some areas the swamp waters might be at least temporarily hydraulically connected to the uppermost portions of the Hawkesbury Sandstone, where bedding discontinuities or low permeability zones in the sandstone promote lateral flow into or out of a swamp after high rainfall periods. Depending on the relative water levels established soon after rainfall events, ephemeral groundwater seepage from the shallow sandstone might flow to the swamps, or conversely, swamp water might migrate into the underlying shallow ephemeral sandstone aquifer (GeoTerra, 2012).'* Whilst hydraulic connection between a swamp and a temporarily elevated water table in the sandstone is plausible, the overall contribution to the water balance of a swamp will be dependent on specific local topography and geology. Also, it must be noted that, because of their position on the landscape, it is less likely that headwater swamps would receive a significant contribution from the regional groundwater system compared to valley fill swamps which are likely to receive some 'baseflow' in a similar manner to creeks.	No response required

Ref	Regulator	Issue	Where Addressed
83.	DP&I – Surface Water	**3.5 Monitoring and Management** The monitoring undertaken for the piezometers discussed in Section 3.3 provides an excellent basis for achieving a better understanding of the hydrology of headwater swamps. Useful additional monitoring and analysis activities would include: • Establishment of a recording meteorologic station within the Wonga East area to measure rainfall and potential evapotranspiration; • Establishing piezometers at the upslope end and downslope end of a minimum of two swamps in order to understand the down-slope movement of shallow groundwater; • Adding two flow monitoring points to swamps in which pairs of piezometers (upslope and downslope) are to be installed; • Monthly review of the water balance of each monitored swamp based on recorded rainfall, estimated evapotranspiration and recorded water levels and outflow measurement. • Characterisation of soils within the swamps to determine: − the porosity - in order to provide a basis for relating piezometer water levels to rainfall and evapotranspiration; − the presence, or absence, of clay materials at the interface with the underlying sandstone which could mitigate water loss from the swamp to the underlying sandstone in the event that subsidence induced cracking of the sandstone occurred under a swamp.	Section 2.1.5
84.	DP&I – Surface Water	**4 Impact of Proposed Mining on Headwater Swamps** **Figure 4.1** shows the location of headwater swamps with respect to the location of the proposed longwall mining in the Wongawilli Seam. **4.1 Predicted Subsidence and Impacts** **Table 4.1** summarises the predicted subsidence effects on swamps in the Wonga East project area subject to more than 1 mm/m tensile stress from mining in the Wongawilli Seam (from **Table 2.1**), together with some of the factors that influence the hydrologic characteristics including: • Area of the swamp itself; • Effective contributing catchment area, after accounting for any up-slope swamps; • Downslope distance from the nearest ridge; • The down-slope gradient of the swamp; and • The presence of a defined drainage outlet.	No response required

Ref	Regulator	Issue	Where Addressed
85.	DP&I – Surface Water	**Table 4.2** (data from Annexure Q of the *EA*) summarises the various upland swamp vegetation communities and their reliance on waterlogging. The table shows that a number of the communities, while classified as 'swamps' in terms of the vegetation, have vegetation that is less reliant on waterlogging than others. This classification from a vegetation community perspective, together with the recorded behaviour of the piezometers in swamps CCUS3 and CCUS6, suggests that some vegetation communities may lack the characteristics that would classify them as swamps from a hydrologic perspective.	Biodiversity discussion provided in Appendix F
86.	DP&I – Surface Water	The previous analysis of potential subsidence risks to swamps undertaken by Biosis and documented in Annex Q of the *EA* has been updated to account for the modified mine plan described in the *PPR*. The revised analysis identified two swamps in the Wonga East area (BCUS4 and CCUS4) as being at 'moderate' risk. Biosis conclude: • *"The revision of the mine plan has resulted in a reduction in risk for several upland swamps, including CRUS2, CRUS3 and CCUS5, and will result in low risk of impact for all upland swamps except BCUS4 and CCUS4."* • *"The revised mine plan and revised subsidence predictions have resulted in an increase in risk to one upland swamp, CCUS4."*	Biodiversity discussion provided in Appendix F
87.	DP&I – Surface Water	For purposes of this review, a further assessment of the hydrologic risks to the swamps in the Wonga East area has been undertaken considering the topographic and hydrologic features of the swamps set out in **Table 4.1**. As noted in **Section 2**, the *PPR* and Annexure B do not include mapping to show the location of maximum tensile stress. It has therefore been assumed that the most likely location for any surface cracking would be in the area of maximum convex curvature (as inferred from the subsidence contours). **Table A1** in **Appendix A** provides details of this assessment including the risk of subsidence induced cracking and the most likely location of impacts, taking account of the topographic position of the swamp. **Table 4.3** provides a summary of those assessments, together with the risk as assessed by Biosis (based on subsidence impacts occurring anywhere within the swamp).	No response required

Ref	Regulator	Issue	Where Addressed
88.	DP&I – Surface Water	The analysis summarised in Table 4.3 indicates that, notwithstanding the additional features of the individual swamps included in the assessment, the majority of the swamps have a low risk of cracking that would affect the swamp itself or intercept runoff from the contributing catchment. (In this regard, it is acknowledged that the relative contribution of surface runoff or shallow subsurface runoff – at the interface between the soil and underlying weathered rock – is not understood in the context of the overall water balance of a swamp.). Two swamps that show up as having some risk (using either method of analysis) are: • BCUS4 which is located over the footprint of longwall LW10. The Biosis analysis provides a risk rating of 'moderate' whereas the separate analysis for this review rates it as 'minor'. The difference is not just one of semantics. The 'minor' rating was assessed on the basis that convex curvature would, occur through the middle of the swamp.	Subsidence discussion provided in Appendix B Biodiversity discussion provided in Appendix F
89.	DP&I – Surface Water	• CCUS4 which is located over the footprint of LW6. The 'minor' rating was assessed on the basis that, while the main body of the swamp would be subject to subsidence, the greatest convex curvature would occur along the up-slope edge. While this might alter the contribution of up-slope runoff, the majority of the swamp is unlikely to be affected.	Subsidence discussion provided in Appendix B Biodiversity discussion provided in Appendix F
90.	DP&I – Surface Water	In addition, the assessment carried out for this review indicates there could also be a 'minor' risk to swamp CCUS10 located above the footprint of longwall LW10. The 'minor' assessment for this swamp was assessed on the basis that the greatest convex curvature would occur along the up-slope edge, affecting the contribution of up-slope runoff.	Subsidence discussion provided in Appendix B Biodiversity discussion provided in Appendix F

Ref	Regulator	Issue	Where Addressed
91.	DP&I – Surface Water	**4.2 Management, Monitoring and Mitigation** The *EA* (pages 385-386) identifies a range of possible mitigation techniques: • Use of coir logs to control erosion. This is only applicable where there is a distinct flow path through the swamp and relates to conditions in valley fill swamps rather than headwater swamps. • Water spreading to redirect flow. This is also only applicable to valley fill swamps where there is a distinct flow path. • Sealing of observed surface cracks. Because this required cracks to be identified, it is only applicable to the margins of swamps, not the main body of the swamp. • Injection grouting to seal cracks in the sub-surface rock. While technically possible, this option relies on the precise location and extent of any crack to be identified and is of no practical value where a crack occurs in the body of a headwater swamp. It can be seen that none of these techniques are applicable to remediating the effects of cracking of the rock underlying a headwater swamp.	No response required
92.	DP&I – Surface Water	The *RTS* (page 284) acknowledges that it is not feasible to remediate bedrock fractures and changes in groundwater availability in upland swamps because the impacts from the remediation works would likely be far greater than the degree of benefit. Accordingly, in this instance, the primary management mechanism is to design a mine plan that minimises potential subsidence impacts. However, ongoing monitoring of groundwater levels at key locations in potentially affected swamps should continue in order to provide further evidence of any impacts and provide an opportunity to regularly reassess the mine plan in terms of stopping longwalls short of the current layout. The Subsidence Assessment notes that *"It is considered that more work is required to determine the relationship between mining subsidence and the long term health of swamps. The extended baseline of subsidence impacts over 60-100 years in the Bulli Seam and 30-40 years in the Balgownie Seam provides a rare opportunity to study these effects. The changes that are expected from proposed mining are nominally sufficient to cause significant impacts to the rock strata and to surface and near surface water flows in the areas directly mined under, so it would be helpful to study how and if the wide range of swamps present above the site are significantly impacted by further mining."*	No response required

Ref	Regulator	Issue	Where Addressed
93.	DP&I – Surface Water	In this regard, the *RTS* notes that: *"NRE are currently re-designing the monitoring plan to integrate surface water, groundwater and ecological monitoring programs to ensure a comprehensive assessment of the ecosystem function of upland swamps within the study area."* A key element of this monitoring should be the expansion of the existing network of shallow swamp piezometers, and regular review (say monthly) to asses any abnormal behaviour that cannot be attributed to evapotranspiration or drainage to a watercourse. A further relevant undertaking is provided in the *PPR* (page 198): *"Due to the disagreement over the potential impacts of subsidence with regard to subsurface water flow and stream networks that is currently prevalent in the scientific and regulatory community, primarily due to inadequate data on both sides of the argument, a network monitoring methodology is being designed, based around CCUS4 and possibly CCUS5, to capture the total water balance of representative sections of surface waterways in order to determine the effects and impacts of subsidence on stream networks from Upland Swamps to Reservoir. This approach will be designed with input from specialists and agencies to ensure the monitoring is reasonable, effective and scientifically robust."* Overall, the proposed monitoring is likely to significantly enhance the body of knowledge relating to the hydrology of headwater swamps, their role in sustaining different vegetation communities and their role in providing baseflow to the creek system.	Section 2.1.5
94.	DP&I – Surface Water	**5 Potential Mine Impacts on Creeks** **5.1 Geological Setting** The potential effects of subsidence on streamflow and pools are heavily influenced by the geology of the creek bed. The *Subsidence Assessment* (Attachment B to the *PPR*) makes the following general points in relation to the geology of Cataract Creek and its tributaries: • Almost all the second order and higher sections of Cataract Creek that are likely to be influenced by mining flow within Bald Hill Claystone outcrop. However, despite Longwall 11 in the Balgownie Seam causing the creek bed to subside 1.4 m, there have not been any significant long-term effects on the bed of the creek or the character of the creek. • Where valley closure is less than 200 mm, experience in Hawkesbury Sandstone channels elsewhere indicates that there has been not been total loss of surface flow.	No response required

Ref	Regulator	Issue	Where Addressed
95.	DP&I – Surface Water	**5.2 Extent and Magnitude of Subsidence** The *Subsidence Assessment* includes an analysis of the changes in the profile of Cataract Creek as a result of predicted subsidence. **Figure 5.1** below reproduces part of Figure 25 from the subsidence assessment which shows the profile of the Southern Tributary, which crosses LW1 – LW3 and joins the main creek about 350 m downstream of LW3 as shown on **Figure 5.2**.	No response required
96.	DP&I – Surface Water	The profile in **Figure 5.1** shows the following features of note: • Significant vertical subsidence in the reach between Chainage 100 m and 500 m, corresponding to longwalls LW1 and LW2. Although not quoted in the Subsidence Assessment, it appears that maximum subsidence of up to 1.8 m may occur in this area and that the sharp end to the subsidence zone could lead to ponding in this area; • Minor vertical subsidence is predicted upstream of about Chainage 1,650 m, which corresponds to the alignment of the south-east corner of longwall LW6. The maximum magnitude of the predicted subsidence appears to be about 0.5 m and to lead to a relatively sharp downstream 'lip' that could lead to minor additional ponding; • A reach between about Chainage 1,880 m and 2,100 m in which up to 1.2 m vertical subsidence is predicted. These chainages align with the north-eastern end of longwall LW7. • A reach between about Chainage 2,100 m and 2,370 m where up to 0.5 m vertical subsidence is predicted.	No response required
97.	DP&I – Surface Water	The *Subsidence Assessment* also notes other subsidence effects on creeks that are not shown on **Figure 5.1:** • Vertical subsidence is predicted to mainly influence second order creeks above longwalls LW1 to LW3; • Up to 2.6 m of vertical subsidence may occur below these second order creeks above longwall LW1.	No response required

Ref	Regulator	Issue	Where Addressed
98.	DP&I – Surface Water	**5.3 Connective Cracking** The main potential for connective cracking appears to be at the northern corner of Longwall 7 which has been relocated as part of the revised project described in the *PPR*. This relocation has moved the northern corner of the longwall in a south-easterly direction by about 45 m. However the horizontal distance from the vertical projection of the longwall to Cataract Creek remains about 45 m. In this regard, Tammetta (December 2013) notes that: *'Despite the absence of existing full extraction workings over a small strip of about 50m width, there may still be a risk to the capacity of the channel of Cataract Creek to transmit surface water. There may also still be a risk of direct hydraulic connection between the creek channel and goaf, through the collapsed zone, where the channel comes to close to the panel edge. The significance of these risks cannot be quantified, but warrants consideration.'* Whilst there remains some uncertainty regarding the potential for connective cracking, as noted in Section 2.3, the report by Hebblewhite (18/12/2013) on joint discussions with Tammetta and Dr Mills (of SCT) concludes: *"Therefore based on the above interpretation, the risk of inter-connective cracking is considered low in the vicinity of LW7 (or any other part of the proposed workings)."* In addition, it should be noted that the creek bed in this vicinity is predominantly on rock and, therefore, the chance of any cracking being identified and repaired would be greater than if cracking occurred in a section of alluvial creek bed.	Subsidence discussion provided in Appendix B Appendix D
99.	DP&I – Surface Water	**5.4 Impacts on the Flow in Creeks** Key aspects of the potential impacts on ponding and flow identified in the *Subsidence Assessment* include: • Although there is potential for water to pool in second order creeks above LW1 – LW3, valley closure effects are expected to increase the potential for sub-surface flow. Accordingly pooling may only be short lived during periods of heavy rain. • Valley closure is expected to cause perceptible cracking and surface flow diversion in the upper reaches of the southern branch of Cataract Creek, particularly where it flows across Hawkesbury Sandstone outcrop above LW1 leading to some loss of surface water and iron staining. • Further downstream where the bed of the stream is located mainly in Bald Hill Claystone, low levels of perceptible impact are expected. Iron staining and flow diversion into the surface strata are not expected.	No response required

Ref	Regulator	Issue	Where Addressed
100.	DP&I – Surface Water	Section 2.2.9.3 of the *PPR* also notes that: *“Subsidence impacts on Upland Swamps and 1st and 2nd order tributaries are anticipated to have localised effects on the affected tributary stream flow and longevity and increased Fe, reduced DO, increased salinity and potentially increased metal concentrations in the downstream re-emergence and discharge zone*.” In addition, the *PPR* (Section 2.2.9.3) notes that the main effect on overall stream discharge into Cataract Reservoir is expected to be attributable to any regional groundwater depressurisation effects. These effects have yet to be quantified on the basis of the remodelling of catchment groundwater impacts which is underway (as at December 2013). Some indication of the potential impacts of baseflow reduction as a result of regional groundwater depressurisation effect can be gained from the initial analysis in the *Groundwater Assessment* for the EA (data reproduced below). The data in **Table 5.1** indicates that, in the main, Cataract Creek is a ‘gaining’ stream but there is a small section which is a ‘losing’ stream. However, no details are provided to indicate where the gaining and losing sections are located. In order to provide a basis for the assessment of potential impacts on stream ecology, the updated surface water modelling should assess the predicted loss of groundwater derived baseflow in the context of flow duration characteristics, not just average flow. The analysis should include a ‘worst case’ sensitivity assessment that considers the possibility of both shallow bedrock cracking (leading to loss of water in pools, but possible return flow downstream) as well as connective cracking to the mine workings. In both cases it would be useful to consider situations in which no repair work was undertaken and if repairs were undertaken in a similar manner to repairs undertaken on other creeks in the Southern Highlands. A flow duration graph showing existing and predicted flow characteristics would be desirable.	In relation to groundwater, preliminary discussion is provided in Appendix C with further detail to be provided / addressed separately Catchments and streams discussion provided in Appendix E

Ref	Regulator	Issue	Where Addressed
101.	DP&I – Surface Water	**5.5 Water Quality Impacts** Sections 10.5.3 and 10.5.4 of the *Stream Assessment* provide an overview of the water quality monitoring program including locations and periods over which monitoring has occurred. The monitoring program includes: • Bi-monthly monitoring of four sites on Cataract Creek upstream of Mount Ousley Road and one immediately downstream since August 2008; • Bi-monthly monitoring of one site within Cataract Reservoir since August 2008; • Progressive expansion of the monitoring on Cataract Creek to include an additional six sites on Cataract Creek and one of its tributaries since July 2010; • Commencement of monitoring outflow from three swamps and one piezometer since March 2012. The *Stream Assessment* provides graphs of the longitudinal profiles of median values of pH, conductivity, iron (total and filtered) and manganese (total and filtered) as well as graphs of the variability of pH and conductivity over time. • pH shows a slight increasing trend from a median of about 5.6 at the upstream monitoring point to 6.3 upstream of Cataract Reservoir; • Conductivity declines from a median of about 145 μS/cm at the upstream monitoring point to about 120 μS/cm just upsteram of Cataract Reservoir; The assessment of overall water quality is summarised in the following quotations: *"In general, enhanced rainfall in the catchment has the effect of reducing salinity, marginally raising pH, increasing dissolved oxygen, diluting ferruginous discolouring (or deposition), diluting major metals and generally increasing nutrients, with the degree of change relating to the degree and duration of rainfall runoff dilution in the stream."* *"Hydrous ferruginous seeps are relatively common in Cataract Creek, although their exact inflow location has not yet been identified as ferruginous precipitation is relatively ubiquitous in the creek both upstream and downstream of the freeway.*	In relation to groundwater, preliminary discussion is provided in Appendix C with further detail to be provided / addressed separately Appendix D

Ref	Regulator	Issue	Where Addressed
102.	DP&I – Surface Water	**5.6 Monitoring and Management** **5.6.1 Monitoring** The *Stream Assessment* (GeoTerra, 2012 – Annex O to the EA) describes the stream monitoring program together with proposed additional monitoring. Tables 16 and 17 in the *Stream Assessment* list the locations of the various monitoring locations but does not specify the precise monitoring activities at each site. **Table 5.2** is an attempt to consolidate the range of surface water monitoring activities based on the text and graphs in the *Stream Assessment.* The term 'observed flow' in the table is used to designate locations where visual observations of streamflow are made at the time of other monitoring, principally collection of water quality samples. The table shows that Gujarat NRE has established a reasonably comprehensive set of monitoring sites in the Wonga East area. Notwithstanding, in response to one of the submissions regarding water quality monitoring, the *RTS* (page 315) commits as follows: *"The spatial and temporal distribution of water quality monitoring of streams within the project area will be detailed, including the analytes monitored and tables showing key statistics and justification of proposed triggers when the remodelling is complete."* A further relevant undertaking is provided in the PPR (page 197): *"LW5 is currently mining beneath the Cataract Creek tributary CT1. NRE will continue to monitor CT1 tributary flow, water levels and water chemistry as LW5 passes beneath the tributary to clearly identify impacts that mine subsidence may have. There may be some effects on surface flow volumes but little impact on discharge into Cataract Creek. NRE is in the process of establishing monitoring points close to the mouth of CT1 and other tributaries along Cataract Creek to improve its understanding of the effects of mining on tributary discharge volumes."* In addition, the *RTS* (page 314) notes that the available stream level data (sites CC2, CC3, CC6, CC7, CC8 in Cataract Creek and the SCA site in Cataract River) will be used to back calculate streamflow as part of the remodelling of the surface water impacts from the Preferred Project in order to assess the degree of flow loss / gains in the streams.	Section 2.1.5

Ref	Regulator	Issue	Where Addressed
103.	DP&I – Surface Water	**5.6.2 Management** In relation to monitoring of subsidence impacts on creeks, the *Subsidence Assessment* (page 59/60) proposes: *"A management strategy based on closure monitoring and cessation of mining if there is a likelihood of significant perceptible impacts becoming apparent is considered to be an effective method of managing the potential for subsidence impacts on Cataract Creek."* More generally, the PPR (page 198) states: *"Monitoring and management are not intended to vary significantly but will be reviewed on the basis of the revised surface water model and assessment outcomes during the approvals process. A stream network monitoring program is being developed around CCUS4 and possibly CCUS5 and the Cataract Creek tributaries they feed to determine the actual impacts on surface and near surface water balances within a defined catchment area."* As noted in the *Review of Surface Water Issues* (Evans & Peck, June 2013), baseline water quality data has been collected for range of relevant analytes. This data should provide an appropriate basis for establishing baseline water quality for purposes of identifying any water quality impacts as a result of mining. Further analysis of the water quality statistics should also be provided along with justification for any proposed water quality 'trigger' levels that differ from the default values in the ANZECC Guidelines. Provided an appropriate range of analytes has been monitored for sufficient length of time (monthly over 2 years minimum recommended in ANZECC) any proposal to establish locally specific water quality 'trigger' levels (for further investigation) would be consistent with the principles set out in the ANZECC Guidelines.	Subsidence discussion provided in Appendix B Section 2.1.5

<table>
<tr><th>Ref</th><th>Regulator</th><th>Issue</th><th>Where Addressed</th></tr>
<tr><td>104.</td><td>DP&I – Surface Water</td><td>6 Pit Top Water Management
6.1 Russell Vale
The PPR includes all the surface facility upgrades described in the EA including the following relating to surface water management:
Stormwater Management:
• Improved separation and control of conveyance of water from the different catchments;
• Upgrading of about 560 m of the Southern Stormwater Channel to ensure separation of ‘clean’ water from the site and up-slope from ‘dirty’ stormwater from the coal stockpile area;
• Construction of a stormwater energy dissipater and settlement area with a low flow outflow pit to control discharge from the Southern Stormwater Channel into Bellambi Gully;
• Construction of a dry sediment basin to provide pre-treatment of stormwater from the coal stockpile area before it drains to the existing settling ponds;
• Cleaning out and reconfiguration of the existing settling ponds into a single pond.
Flooding and Channel Stability
• Channel protection works including Reno mattresses and gabion basket drop structure at various locations on major conveyance channels (as set out in Annexure B to the EA, Water Management);
• Improvement works to the ‘M3 Culvert’ (to prevent the recurrence of the flooding event of August 1998). Options include:
− Increasing the capacity of the pipe culvert and provision of an overland flow path that would convey water back to Bellambi Creek Gully;
− Increase the capacity of the culvert to sufficient capacity to ensure that it does not become fully blocked and has a freeboard of 500 mm above the 100 year ARI flow conditions.
Subject to clarification or a range of issues identified in Section 4.1.2 of the Review of Surface Water Issues (Evans & Peck, June 2013), these proposed upgrades can be expected to significantly improve on site water management and provide appropriate mitigation against a recurrence of the August 1998 flood event.
Currently stormwater and treated mine water are both discharged to Bellambi Gully. This results in an un-naturally persistent flow regime in the gully and elevated salinity levels compared to what could be expected in a natural creek. Although not documented, the flow and water quality have probably contributed (along with urban runoff) to a severely degraded creek. No consideration has been given to the feasibility or benefit of alternative means of conveyance of the treated mine water (such as via a pipeline)</td><td>To be provided / addressed separately</td></tr>
</table>

Ref	Regulator	Issue	Where Addressed
		The main issue arising from the *PPR* is the proposed staging of the site rehabilitation works including those to address stormwater management and flooding issues. Table 6 of the *PPR* (copy included as **Table 6.1** below) indicates that highest priority for construction is proposed for facilities concerned with the transport of coal (2.5 years), with works associated with water management taking a further year. Some of the works related to stormwater quality control and flooding are considered to warrant higher priority, particularly: • Improvement works to the 'M3 Culvert'; • Cleaning out and reconfiguration of the existing settling ponds into a single pond.	
105.	DP&I – Surface Water	**6.2 Mine Groundwater Inflow and Site Water Balance** Estimates of the groundwater inflow to the workings have been updated for the *PPR* to reflect the reduced scope of mining. Data presented in the *PPR* shows that the average inflow to the workings for 211 and 2012 was about 460 ML/year. **Figure 6.1** shows that the inflow associated with extraction from Longwalls 4 and 5 (from early 2012) was significantly higher than had been previously experienced at the mine. Estimates of future inflows are to be prepared once further groundwater modelling has been undertaken. At that stage it would be appropriate for the site water balance to be re-visited and a range of issues identified in the *Review of Surface Water Issues*.	To be provided / addressed separately
106.	DP&I – Surface Water	**6.3 No 4 Shaft** The *Review of Surface Water Issues* questioned some aspects of the effluent irrigation system at the No 4 Shaft site. On the basis that, as part of the activities to be undertaken to implement the mining described in the *PPR*, the number of employees would remain about the same as currently (13), it is accepted that the effluent disposal system has adequate capacity.	No response required

Ref	Regulator	Issue	Where Addressed
107.	DP&I – Surface Water	**7 Commitments and Conditions of Approval** Is Section 4 of the *PPR*, the Proponent seeks to remove all commitments set out in Table 29.1 of the EA and proposes requests the Department to consider the a range of conditions, if considered necessary, to ensure that specific environmental outcomes are met. The proposed conditions include the following of relevance to matters considered in this review. 1. A general condition in any approval requiring: • NRE to comply with all relevant legislation related to its operational environmental impacts. 2. Specific conditions for the Pit Top areas requiring the preparation of arrange of plans including: • *Construction Management Plan*/s; • *Surface Facilities Water Management Plan.* 3. Specific conditions for Mine Subsidence areas requiring the preparation of an: • *Extraction Plan.* Presumably, any *Extraction Plan* would include a whole series of sub-plans including: • A *Subsidence Management Plan* that included specific proposal regarding cessation of mining in the event of certain subsidence criteria being exceeded (such as valley closure of more than 200 mm). • A *Creek Monitoring and Management Plan* (including pool levels, flow and water quality) as well as criteria for undertaking remediation of any excessive cracking in the creeks; • A *Swamp Management Plan* that included: - a comprehensive program of water level and outflow monitoring; - on-site climate monitoring to enable water balance analysis to be undertaken for individual swaps; - soils investigations to define the water holding characteristics of the soils within the swamps for purposes of relating the observed water levels to a depth of water and assessing the likelihood of ‘self-sealing’.	No response required
108.	NSW Office of Water (NOW)	<u>Refinement of numerical model</u> Numerical computer modelling was undertaken as part of the Environmental Assessment for the original application. That modelling was used to predict the impacts of the originally proposed configuration for both the Wonga East and Wonga West workings. Given the modifications identified within the Preferred Project Report, refinement of the model and generation of new impact predictions based on the current layout is warranted. The proponent has identified that a new groundwater model will be developed to allow the prediction of impacts based on the new mining plans, however the process is indicated as taking up to 3 months (page 128). This prevents the Office of Water from being able to adequately assess the likely impacts of the proposed mining operation.	To be provided / addressed separately

Ref	Regulator	Issue	Where Addressed
109.	NOW	<u>Authorisation of groundwater take</u> The PPR indicates that preliminary estimates of mine water make (in lieu of the results of the revised modelling) indicates volumetric inflows of 840 ML per year could be expected (page 131). The Office of Water previously advised that the proponent is authorised to extract a volume of 365 ML/y under an existing licence. The PPR does not elaborate on the licensing requirements identified in previous agency correspondence, nor does it provide even preliminary advice on the possibility of the proponent obtaining the necessary entitlement for the current or potential future applications. This is despite the Office of Water specifically requiring the proponent to demonstrate an ability to obtain the required entitlement in previous correspondence.	The conceptual model (Appendix C) provided revised prediction of inflows. These will be confirmed using a numerical model to be provided in the future.
110.	NOW	<u>Changes to Panel Dimensions</u> It is noted that the changes to longwall dimensions (page 20) have resulted in reductions in Maingate pillar widths in some locations (from 60 m to 45 m for LW 6, 7, 9 and 10), and widened longwall panels in other places (from 105 to between 125 and 150 m for LW 1, 2 and 3). Whilst the reduced length of the panels is likely to constrain the associated subsidence trough longitudinally, the lateral ground surface settlement effects of multiple parallel longwalls is cumulative and can be substantial. Mining engineering theory suggests that the height of ground displacement is related to the width of the extracted panel, therefore the widening of individual longwalls could result in disturbance of strata at levels closer to the ground surface. Similarly, the height of complete groundwater drainage above the caved zone of mined longwall is related to panel width. As well, a reduction in pillar size is likely to change the tensional and compressional forces around and above each support, thereby potentially changing the bedding plane separation behaviour and extent within overlying strata. Whilst the PPR suggests that the "longwall dimensions are approximately 25% smaller in Wonga East than the original proposal", there is no recognition of the potential changes to engineering behaviour within overlying strata as a result of panel widening. In addition, the repositioning of the proposed longwalls could significantly alter stress and strain dynamics within the overlying strata depending on the final panel orientation in relation to the maximum stress direction. Therefore, despite the reduction in overall area of extraction, the localised impacts could be significantly exacerbated due to the changed widths and orientations.	Subsidence discussion provided in Appendix B

Ref	Regulator	Issue	Where Addressed
111.	NOW	<u>Volumes of water from affected sources</u> The Office of Water previously advised that additional assessment was necessary to identify the "potential for the proposed mining to induce connections to the surface water systems", with particular reference to upland swamps, local creeks and Cataract Dam. The PPR has identified that it would be possible to determine the potential leakage from Cataract reservoir using a probabilistic assessment of a transiently calibrated model (page 129). It has also been identified that such a simulation would require weeks of computer run time for each individual stag and months for multiple stages, therefore it was not proposed for the initial modelling study but "could be done at a later stage, if considered necessary". In order for the proponent to meet the requirements of the Office of Water, as well as those of the NSW Aquifer Interference Policy, this modelling is considered necessary and its commencement should not be deferred until some undefined 'later stage'.	To be provided / addressed separately
112.	NOW	<u>Comments/options</u> The application for consent to undertake longwall mining in the Wonga East area could be supported in the absence of the results of new numerical modelling, provided any recommended conditions stringently bind the proponent to the required actions as well as applying specific time frames and deadlines. In regard to predicted impacts, detailed assessment of the model conceptualisation, structure and adequacy should be undertaken by the Office of Water once the revised modelling has been provided by the proponent. Notwithstanding, the reduced area of mining identified within the PPR, there remains a need for the proponent to meet the requirements of the NSW Aquifer Interference Policy.	To be provided / addressed separately
113.	NOW	<u>Recommendations</u> 1. The proponent commit to the further development of a numerical groundwater flow model designed to meet the modelling requirements specified in the AIP 2. The proponent commit to acquiring sufficient entitlement to account for the volume of estimated water take from all affected water sources. 3. Conditions of consent should be stringently binding on the proponent to meet necessary tasks and deadlines, and incorporate provisions for future changes once the revised modelling has been completed 4. The proponent should address the potential impacts of the proposed widening of the longwall panels 5. The proponent be required to determine the potential leakage from Cataract Reservoir.	To be provided / addressed separately
114.	Wollongong City Council (WCC)	Council notes that Gujarat NRE Coking Coal Ltd through the Preferred Project Report process has significantly modified the original proposal, in response to issues raised by government agencies, Council and public submissions. The main changes in the revised proposal include removing the originally proposed Wonga West longwalls and restricting longwall extraction to the Wonga East area only with a corresponding lesser total resource yield of 4.7 million tonnes of coal, instead of the originally proposed yield of 31.1 million tonnes. In light of these changes, the revised project life for the mine is also reduced from 18 years to 5 years.	Response not required

Ref	Regulator	Issue	Where Addressed
115.	WCC	Council requests that the attached submission be taken into consideration during the Department's assessment of the Preferred Project Report. In this regard, the removal of the Wonga West longwalls as per this revised proposal has resolved a number of issues previously identified by Council in its submission at the time of the original Environmental Assessment review. However, several issues remain unresolved, including the necessary construction of three (3) acoustic barriers, in order to protect surrounding residential areas from noise emanating from the mine's pit top operations. Additionally, the proposed Wonga East longwall panels A2 LW6 and A2 LW7 still sit beneath three (3) 'special significance' swamps and hence, it is recommended that these longwalls either be deleted, reorientated or shortened in length, in order to protect these swamps from subsidence related impacts.	Section 2.3.2
116.	WCC	The longwall panel A2 LW7 is recommended to either be deleted, reorientated or shortened in length to minimise any potential subsidence related impacts upon the 'special significance' upland swamp CCUS5.	Subsidence discussion provided in Appendix B Appendix D
117.	WCC	The longwall panel A2 LW6 is recommended to eíther be deleted, reorientated or shortened in length to minimise any potential subsidence related impacts upon the 'special significance' swamps CCUS4 and CRU51.	Subsidence discussion provided in Appendix B Appendix D
118.	WCC	The longwall panel A2 LW7 is recommended to either be deleted, reorientated or shortened in length to minimise any potential subsidence related impacts upon the 'special significance' upland swamp CCUSS and to further protect the habitat of the Stuttering Barred Frog.	Subsidence discussion provided in Appendix B Appendix D

Ref	Regulator	Issue	Where Addressed
119.	WCC	The original Noise Assessment report by ERM dated 30 November 2012 involved detailed acoustic modelling which was based on certain noise attenuation/mitigation measures being provided on-site, including (iv) A 3 metre high acoustic barrier to the south of Broker Street; (v) A 3.6 metre high roadside type barrier to the north of the internal access road from the weighbridge to the Princes Highway; and (vi) Noise mitigation of certain equipment such as mine ventilation fans and dozers. Therefore, concern is raised about potential noise impacts upon surrounding residential areas from pit top activities, if the noise barriers are not installed. Further, the recent noise audit report (ie referred to in the Preferred Project Report) does not properly consider how certain weather conditions (ie wind speed and direction, cloud cover etc) influence noise emanating from the pit top activities. Therefore, Council reiterates its original EA comments that the three (3) acoustic barriers are necessary and should be subject to appropriate conditions of consent, in the event that the Department ultimately approves the revised proposal.	Section 2.3.2
120.	WCC	The Preferred Project Report fails to provide conclusive advice as to what noise mitigation measures will be introduced in order to address potential noise impacts from the Pit Top area activities, especially truck loading activities and dozers working upon the stockpile areas. Noise impacts along Bellambi Lane also remain unresolved. Therefore, Council requests that the NSW Department of Planning and Infrastructure guarantee that appropriate noise mitigation measures are implemented as part of any such Part 3A approval.	Section 2.3.2
121.	WCC	The construction of the new screening and sizing station should be a condition of consent if the application is ultimately approved. Appropriate conditions of consent should also be required which satisfactorily address the air quality (PM10 particulate and total suspended particulate) issues.	Section 2.3.2
122.	WCC	Council requests that traffic modelling be required for the next 5 years (2018) which deals with affected intersections and midblock performance, prior to the determination of the application.	To be provided / addressed separately
123.	WCC	Therefore, Council requests that the Department impose a condition of consent requiring that appropriate negotiations take place with both Wollongong City Council and the NSW Roads and Maritime Service concerning funding towards road maintenance works as a result of the additional trucks using local and regional roads between the site and the Port Kembla Coal Terminal.	To be provided / addressed separately

Ref	Regulator	Issue	Where Addressed
124.	WCC	Council requests that appropriate conditions of consent be imposed requiring the sealing and line marking of the employee's carpark. However, given that the revised life of the mine is for a maximum 5 year period, it is considered reasonable not to require the construction of a new haulage road or employee access road. In the event that a separate new application is ultimately lodged for the Wonga West mine lease area, then a new haulage road or employee access road should be considered at that time.	Section 2.3.5
125.	WCC	Hydraulic modelling under the NSW Office of Water guidelines is recommended to be undertaken by a suitably qualified groundwater expert, prior to the determination of the Part 3A application.	To be provided / addressed separately
126.	DRE	<u>Subsidence</u> While DRE is supportive of the proposal, consistent with the Division’s previous advice DRE is of the opinion that additional subsidence investigations are required. In particular, further under mining by longwalls within the old Bulli Pillar Workings will have the following risks, which require site specific investigations: • The development of irregular subsidence profiles, which often leads to concentrations of surface deformations and adverse subsidence impacts on the surface features within affected areas; and • Pillar runs, ie propagation of instability and/or reworking of the Old Bulli Pillar workins beyond the normal limit of mine subsidence. Note that this definition differs from what is normally considered as pillar runs for underground safety. In the context of mine subsidence, pillar runs do not have to be a catastrophic event as being assessed by the Applicant. Without these investigations, there will be uncertainty about the predictions made for important surface features, such as Cataract creek or Cataract reservoir, which may be affected by the proposed longwalls 6, 7 & 9 to 11. In regard to Longwalls 1-3, DRE has previously advised that critical surface features, including angled voltage transmission towers, the Illawarra Escarpment and Mount Ousley Road may be affected by longwall mining and require site specific investigations. Geotechnical investigations need to be undertaken prior to the submission of an extraction plan.	Subsidence discussion provided in Appendix B

Ref	Regulator	Issue	Where Addressed
127.	DRE	<u>Recommended Conditions of Approval</u> Rehabilitation Plan 1. The Proponent must prepare and implement a Rehabilitation Plan to the satisfaction of the Director General of Department of Trade & Investment, Regional Infrastructure and Services. 2. Rehabilitation Plan must: a. Be submitted and approved by the Director general of department of trade and investment, regional infrastructure and services prior to carrying out any surface disturbing activities of the development, unless otherwise agreed by the Minister; b. Be prepared in accordance with DRE guidelines and in consultation with the department, Office of Environment and Heritage, Environmental Protection Authority, Office of Water, Council and the mine Community Consultative Committee; c. Incorporate and be consistent with the rehabilitation objectives in the EIS, the statement of commitments and table 1; d. Integrate and build on, to the maximum extent practicable, the other management plans required under this approval; and e. Address all aspects of mine closure and rehabilitation, including post mining land use domains, rehabilitation objectives, completion criteria and rehabilitation monitoring and management. It is the intention of DRE that the Rehabilitation Plan fulfil the requirements of the Mining Operation Plan (which will become the rehabilitation and Environmental Management Plan (REMP) once the Mining Act amendments have commenced).	Section 2.4.2

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<tr><th>Ref</th><th>Regulator</th><th>Issue</th><th>Where Addressed</th></tr>
<tr><td>128.</td><td>DRE</td><td>Extraction Plan
DRE requires the inclusion of the preparation of an Extraction Plan that must take into consideration likely impacts that activities may have on Old Bulli Pillar Workings within the area and on key natural features and public infrastructures; such as angled voltage transmission towers, Mount Ousley Road, the Illawarra Escarpment and Cataract Creek/Cataract Reservoir.
1. The proponent must undertake Geotechnical Investigations prior to the submission of an extraction plan
2. The extraction plan must:
a. Give consideration to impacts of old workings and include a detailed investigation of overlying old Bulli Pillar workings in consultation with DRE, which:
• Assess the stability of remnant coal pillars in the former Bulli Seam workings;
• Includes revised subsidence predictions for the second working areas
• Recommends final design of the second workings panels and any necessary adaptive management measures;
b. Includes a Built features Management Plan prepared in consultation with DRE, which:
• Address in appropriate detail all items of key public infrastructure, other public infrastructure and all other built features;
• Has been prepared following appropriate consultation with the owner/s of potentially affected features;
• Recommends appropriate remedial measures and includes commitments to mitigate, repair, replace or compensate all predicted impacts on potentially affected built features in a timely manner;
c. Includes a Public Safety Management Plan, which has been prepared in consultation with DRE; and
d. Includes a Subsidence Monitoring Program, which has been prepared in consultation with DRE.</td><td>Section 2.4.4</td></tr>
<tr><td>129.</td><td>DRE</td><td>First Workings
First working on site, other that in accordance with an approved Extraction Plan, may be carried out provided DRE is satisfied that the first workings are designed to remain long term stable and non-subsiding, except insofar as they may be impacted by an approved second working.</td><td>Section 2.4.6</td></tr>
<tr><td>130.</td><td>Dams Safety Committee (DSC)</td><td>The DSC's submission on NRE #1 's Environmental Assessment for an Underground Expansion Project, contained 15 concerns. The Preferred Project has addressed 12 of these concerns to the satisfaction of the Committee. The three remaining concerns (i.e. Nos. 12, 13 & 14)) deal with the Groundwater Model. The Committee awaits confirmation that NRE will revise the Groundwater Model for the Preferred Project to address the issues raised by the DSC.</td><td>To be provided / addressed separately</td></tr>
</table>

Ref	Regulator	Issue	Where Addressed
131.	EPA	The Environment Protection Authority (EPA) has reviewed the Submissions Report and believes that its comments on pit top operations have been substantially addressed.	No response required
132.	Heritage Council	In the Preferred Project and Response to Submissions Report the Applicant has stated that the proposed Statement of Commitments above are unnecessary because "NRE has an existing approved Heritage Management Plan for the Pit Top that incorporates these measures and meets the requirements of the Preliminary Works Pt3A. This plan is updated at the end of each approved longwall and resubmitted for approval for the following longwall". As Delegate of the Heritage Council this is not considered adequate. This is particularly the case as a number of issues were identified with the draft Heritage Management Plan when it was reviewed by the Heritage Branch of OEH in September 2012. As the plan was never resubmitted for comment, it is unclear whether these issues were dealt with and whether any actions relating to the Applicants original six statement of commitments were included within that plan. Therefore, it is recommended that if the proposed project is approved, the six original statement of commitments (as listed above), should form part of the approval conditions.	Heritage discussion provided in Appendix G
133.	NSW Office of Environment & Heritage (OEH)	OEH notes that the PPR addresses a number of issues previously identified by OEH, particularly through the modification of the longwall layout to reduce impacts on upland swamps and streams. However, OEH does not consider that the PPR fully addresses the issues previously identified and therefore recommends the mining plan should be modified further to avoid impacts to these significant natural features (see Attachment A for further detail).	Section 2.8.2
134.	OEH	OEH's principal concerns in relation to the PPR are: • impacts to the Coastal Upland Swamps endangered ecological community (EEC), particularly to swamps of 'special significance' • potential loss of surface water to deeper storage via mining induced fracture networks • impacts to threatened species	Biodiversity discussion provided in Appendix F
135.	OEH	OEH also notes that further surface and groundwater behaviour/characteristics modelling is yet to be completed. In the absence of this information, OEH requests an opportunity to comment when the additional information is provided.	No response required

Ref	Regulator	Issue	Where Addressed
136.	OEH	**Upland Swamps** **Impacts to Coastal Upland Swamps endangered ecological community** OEH supports the proponent's identification of upland swamps of 'special significance' in the project area in line with the methodology contained in OEH's draft *Upland Swamp Environmental Assessment Guidelines.* OEH notes that the PPR has modified the longwall layout in the Wonga East domain with the intent of reducing undermining of significant streams and areas of Coastal Upland Swamp endangered ecological community (EEC).	No response required
137.	OEH	OEH has consistently stated that longwall mining under the Sydney Catchment Authority Special Areas of the Woronora Plateau must meet a performance measure for swamps of special significance of no **negative environmental outcomes, or negligible environmental consequence.** OEH considers that all swamps recognised to be of special significance should be protected from the impacts of mining.	No response required
138.	OEH	Results of monitoring by both BHP Billiton Illawarra Coal (BHPBIC) and OEH in upland swamps undermined by longwall mining in Dendrobium mine on the Woronora Plateau has demonstrated that mining resulted in the fracturing of bedrock beneath a swamp causing: • A loss of the perched aquifer in the swamps (determined by piezometer monitoring of shallow groundwater levels) • A loss of water flow at the base of the swamp (determined by V-notch weir monitoring); and • A loss of soil moisture within the swamp (determined by soil moisture probes)	No response required
139.	OEH	Impacts of these types alter the ecological function of the upland swamp with a high likelihood of eventual loss of the vegetation communities and habitats that characterise this EEC.	Biodiversity discussion provided in Appendix F

Ref	Regulator	Issue	Where Addressed
140.	OEH	In the response to submissions, Gujarat states that the modified layout will result in an overall reduced risk of impact for upland swamps across the project area. However, OEH notes that all swamps in the Wonga East area, with the exception of CCUS10, have greater predicted maximum strains and tilts compared to the original EA (Table 29, pg 82, PPR). Of the seven swamps identified as "of special significance" the PPR proposes to directly undermine swamps CCUS4 and CRUS1. Gujarat's risk assessment identifies the maximum tensile and compressive strains and maximum tilts predicted for each swamp (valley closure is not included and would be informative). The Bulli Seam PAC (2010) identified subsidence criteria above which swamps may be at risk of negative environmental outcomes. The risk assessment for Wonga East indicates that swamps CCUS4 and CRUS1 will undergo maximum tensile and compressive strains and tilts of between 5 and 18 times these thresholds for all 3 parameters. A further four swamps (CCUS1, CCUS5, CCUS10, CRUS1) will undergo maximum tensile and compressive strains and tilts at least 3 times greater than these thresholds for all 3 parameters.	Biodiversity discussion provided in Appendix F Appendix D
141.	OEH	As a result OEH believes that the amended mining plan will not meet a performance measure of negligible environmental consequence for swamps of special significance, and that significant impacts to multiple upland swamps in the Wonga East domain are likely. Further amendments to the mining layout should be considered to enable negligible impact criteria to be met.	Mine plan discussion provided in Section 2.8.2 Biodiversity discussion provided in Appendix F Appendix D
142.	OEH	Although the overall risk to upland swamps may be lower as a result of the removal of the Wonga West domain from the PPR, OEH notes that **none** of the upland swamp EECs in Wonga West are protected from future mining developments.	Biodiversity discussion provided in Appendix F Appendix D

Ref	Regulator	Issue	Where Addressed
143.	OEH	**Flow Accumulation** OEH maintains that Biosis has over emphasised the impact of tilt and flow accumulation modelling when developing risk rankings for upland swamps. The types and level of impacts most frequently observed and of concern for upland swamps in the Southern Coalfields, including bedrock fracturing, is more closely related to physical stresses, strains and upsidence than tilt	Biodiversity discussion provided in Appendix F
144.	OEH	OEH accepts that use of additional information in a multi-criteria analysis may be useful, but has serious concerns that the outcome of subsequent risk assessment is affected by the weightings applied in such a multi-criteria analysis. For example, if flow accumulation is given equal weight to bedrock fracturing in such an analysis, a low flow accumulation criteria could artificially deflate the calculated risk to a particular swamp when the subsidence· predictions (both incremental and cumulative) exceed PAC thresholds for bedrock fracturing.	Biodiversity discussion provided in Appendix F
145.	OEH	OEH agrees with Biosis that some of these swamps may already have been impacted by previous mining in the area but notes that a comprehensive monitoring and measurement program was not undertaken prior to mining. A more detailed analysis of these potentially impacted swamps is required to gauge both likelihood and consequence (and therefore risk} for upland swamp EECs above the proposed mine plan. OEH suggests that close attention should be paid to piezometer responses at PCc2, PCc5A, PCc6 and PCc3 and that these should be contrasted with piezometer levels in swamps entirely unaffected by mining (ie reference swamps). Although not certain, this experimental data may be sufficient to resolve the question of potential past impacts.	Biodiversity discussion provided in Appendix F Appendix D
146.	OEH	**Surface Water** **Potential loss of surface catchment water to deeper storage** There appears to be a common, widespread perception in the coal mining industry in the Southern Coalfields that a surface to seam connection, as a result of fracturing, creating a flow path for surface water into deeper storage within the mine, will not or can not occur. There is mounting scientific evidence to suggest that surface and rain water is indeed being lost from upland swamps and streams that supply Sydney's drinking water supply as a result of mining and is potentially making its way into Southern Coalfield mines or lower aquifers. The independent review commissioned by Department of Planning and Infrastructure into this proposal (Coffey 2013) is the latest report to highlight the risk of a surface to seam connection. Other evidence includes Ziegler and Middleton's (2011) analysis of algae in mine and tritium levels in mine inflow water, Heritage Computing's (2012) study of the correlation between rainfall and lagged inflows and Coffey Geotechnics' (2012) study of the potential complete drainage of aquifers above the longwalls, all of which suggest a loss of surface water to the mine network. BHPBIC have recently suggested that approximately 3.2% of total precipitation has moved into "deep storage", which suggests that this too can move into the mine if their deep storage equates to or is connected to the highly fractured goaf areas.	Biodiversity discussion provided in Appendix F Appendix D

Ref	Regulator	Issue	Where Addressed
147.	OEH	OEH is concerned that the general lack of investigation into the phenomenon in NSW may have led to insufficient consideration of the potential risks in recent mining proposals. There has not been any quantitative scientific evidence to support the claim that water returns to the surface at an unknown area downstream or into a reservoir. OEH has previously suggested that the loss of perched aquifers in upland swamp EECs, the consequent loss of baseflow to their connected streams and the alteration of groundwater aquifer levels has serious implications for the continued existence of these threatened ecological communities and the threatened species that rely on these habitats. Threatened species of particular concern in these areas are Littlejohn's Treefrog, Giant Burrowing Frog and the Giant Dragonfly. This situation also clearly has the potential to affect catchment yields.	Biodiversity discussion provided in Appendix F
148.	OEH	OEH believes a reanalysis of the potential surface to seam fracturing and complete aquifer drainage is required for the PPR since: • Longwalls 1-3 have increased panel widths (the largest change being for longwall 3 which is increased from 105m to 150m wide- a 43% increase) • Longwalls 6 to 10 have the pillar widths reduced from 60m to 45m • Longwall 11 has the pillar width reduced from 60m to 40m.	Subsidence discussion provided in Appendix B In relation to groundwater, preliminary discussion is provided in Appendix C with further detail to be provided / addressed separately
149.	OEH	All these changes (Table 4 of the PPR) are likely to lead to greater subsidence in some areas of the modified mine plan for Wonga East, although OEH acknowledges that subsidence will be lower in some areas as a result of the elimination of other longwalls. How these changes in mine layout interact with upland swamp EECs and potential aquifer draining have not been fully considered in the PPR.	Subsidence discussion provided in Appendix B

Ref	Regulator	Issue	Where Addressed
150.	OEH	**Cataract Creek and its tributaries** Alteration of the natural flow regimes of streams is recognised as a major factor contributing to loss of biological diversity and ecological function in aquatic ecosystems (NSW Scientific Committee 2002). The PPR states (2.2.9.3) in regard to current mining beneath a Cataract Creek tributary that that NRE *"will continue to monitor CT1 tributary flow, water levels and water chemistry as LW5 passes beneath the tributary to clearly identify impacts that mine subsidence may have. There may be some effects on surface flow volumes but little impact on discharge into Cataract Creek'.* No evidence is presented to support this hypothesis and OEH contends that it is possible that some of the surface water will not re-emerge downstream.	Subsidence discussion provided in Appendix B Catchments and streams discussion provided in Appendix E
151.	OEH	Longwalls 1-3 will also undermine tributaries of Cataract Creek, one of which is predicted to experience valley closure between 350-650mm (Table 48). The PPR states that valley closures are likely to result in bedrock cracking and surface flow diversion and that this may result in decreased inflow in Cataract Creek and an increase in iron seepage. OEH considers Cataract Creek to be of special significance due to its ecological and biodiversity values, including as habitat to a number of threatened species. Given the interconnected nature of a creek and its tributaries, and the potential for impacts to extend up or downstream of the initial impact area, impacts to water quantity and quality along the entire stretch need to be assessed as a whole.	Appendix D
152.	OEH	The PPR states that *"previous experience of mining under the Bald Hill Claystone outcrop in Cataract Creek indicates that there have not been any significant long term effects on the bed of the creek or the character of the creek despite LW11 in the Balgownie* Seam *causing the creek bed to subside 1.4m"*. OEH is not aware of any baseline monitoring that was undertaken prior to mining in the area to support this claim.	Subsidence discussion provided in Appendix B
153.	OEH	In relation to this issue it is worth reflecting on the following points that were made by the Bulli Seam PAC on the issue of impacts of longwall mining to streams.	No response required
154.	OEH	*1. **The Panel does not subscribe to streams being represented as a series of discrete features in the landscape.** Streams form* a *connected linear network. Many stream values depend on the recognition of the stream system as* a *continuum with the value of any segment heavily dependent on what happens up and downstream and in higher and lower order components of the system. Protecting the values of streams from impacts that are broad in scale will rarely require intervention only at* a *series of discrete locations - it is more likely to require some form of intervention or control throughout the interconnected linear network.*	No response required

Ref	Regulator	Issue	Where Addressed
155.	OEH	2. ***In the remote areas of sandstone gorges to the east and south of the Study Area, the Panel's assessment finds that much of the value of the stream network is closely associated with its natural characteristics and its pristine setting.*** *Values relying on 'naturalness' have two distinguishing traits:* • *Even small impacts can have major consequences for naturalness values. The response is non linear with a major threshold at very low levels of impact.* • *Even with appropriate remediation, recovery of naturalness values has a long hysteresis and may in fact be irreversible. Reliance on remediation as a primaty risk management option does not recognise this trait*	No response required
156.	OEH	**Threatened Species** **Fish Monitoring** OEH previously recommended that a monitoring and management program be developed with Fisheries NSW in regard to Macquarie Perch, Trout Cod and Murray Cod in Cataract Creek. This has not been addressed in the PPR or response to submissions.	Section 2.8.4
157.	OEH	**Giant Dragonfly** OEH previously recommended that survey for the threatened Giant Dragonfly *(Petalura gigantea)* be undertaken. This has not occurred. In the Response to Submissions, CRUS1 was identified as likely habitat for this species and that the alteration of Wonga East longwalls has removed the threat to this species, OEH does not agree with this statement. Despite the revised mine plan, CRUS 1 is still predicted to experience levels of subsidence which will have the potential to result in bedrock fracturing and loss of shallow groundwater. OEH believes that the species may occur in other swamps and targeted surveys are appropriate to understand the spatial distribution of the species in the area so that impacts can be identified and avoided.	Biodiversity discussion provided in Appendix F
158.	RMS	RMS has reviewed the submitted information and is unable to make an informed comment on the proposal. In this regard, RMS provides the following comments: • RMS notes that a revision of the impact assessment is currently being carried out to account for the amendments made to the subject proposal including the reduced life of the project from 18 years to 5 years. RMS will review this report when it is provided. An electronic copy of the SIDRA analysis should be forwarded to RMS for review.	To be provided / addressed separately
159.	RMS	• RMS requests that the proponent provide information regarding the truck configurations to be used, including axle loadings and the additional equivalent standard axle loadings	To be provided / addressed separately

Ref	Regulator	Issue	Where Addressed
160.	Sydney Catchment Authority (SCA)	The SCA has reviewed the PPR and its submission is attached. In summary, while the current proposal has addressed some of the SCA's concerns, significant issues remain. **We object to the proposal as it currently stands, particularly with regard to its incursion into the Dams Safety Committee Notification Area surrounding Cataract Reservoir.**	No response required
161.	SCA	The SCA notes that the PPR proposes changes to the original proposal including: 1. Wonga east longwall layout has been modified. 2. Wonga west longwalls have been removed and are proposed to be revised and resubmitted as a separate application at a later date. 3. Wonga Mains driveage is proposed not to extend northwards under the south arm of the Cataract Reservoir through the known geological feature (in the Bulli seam). 4. The western Balgownie and western Bulli seam first workings have been removed from this application.	No response required
162.	SCA	The PPR proposes to mine Wonga east longwalls only with changes to the longwall (LW) lengths, widths, position and/or alignment and LW8 has been removed. The SCA notes that the changes to Wonga east mine layout include a reduction in the length of longwall panels in both mining areas, an increase in the panel width of Area 1 longwalls and a reduction in the main gate pillar width in Area 2.	No response required
163.	SCA	The PPR provides a revised assessment on subsidence, biodiversity and geological structures. The PPR states that the ground and surface water impacts will be determined on the outcome of surface and ground water re-modelling currently being undertaken. It further states that the ground and surface water impacts will vary due to the modification to the Wonga east layout.	To be provided / addressed separately
164.	SCA	The SCA has adopted a set of principles that underpin its decision making in relation to mining activities in the Special Areas. These have been communicated to Gujarat NRE and to Department of Planning and Infrastructure on previous occasions and are repeated in the attached submission. The SCA has also developed performance measures for natural and built features of interest to the SCA for this project which is included in our submission. The SCA has assessed the proposed mining proposal and associated information contained in the PPR against its mining and coal seam gas principles and performance measures.	No response required
165.	SCA	The SCA has major concerns about the lack of detailed geological investigations. The SCA also has major concerns with regards to induced leakage from the Cataract Reservoir and longwall mining within the Cataract Dam Safety Committee (DSC) notification area. These concerns were highlighted in our earlier submission on the project and in subsequent correspondence.	Appendix D
166.	SCA	While the proposal has been modified, and some further information is available, the preferred project does not fully address the issues raised by the SCA. **We therefore continue to object to the proposal in its current form.**	No response required

Ref	Regulator	Issue	Where Addressed
167.	SCA	The SCA's primary concerns, based on revised information on geological structures and subsidence assessment and as outlined in this submission, relate to the potential impacts on Cataract Reservoir, Cataract River, Cataract Creek and associated tributaries, swamps and cliffs. Of particular concern is: • The potential loss of stored waters from Cataract Reservoir to underground mine workings at the upper arm of Cataract Reservoir as a result of mining induced leakage. • The impact on the environment of Cataract Creek and associated tributaries, swamps and dependent ecosystems as a result of the loss of stream flow, reduction in base flows, increased acidification and iron precipitation, and the reduction in shallow water tables affecting swamp vegetation and significant impacts to the *"Special Significance"* upland swamp CCUS4.	Catchments and streams discussion provided in Appendix E Appendix D
168.	SCA	In light of our objection to the revised proposal, **the SCA recommends:** **1. The DSC Notification Area around Cataract Reservoir be adopted as an Exclusion Zone where no longwall mining is permitted (the SCA is in particular concerned about the significant extension of Longwall 7 into the DSC notification area).** **2. The proposed adaptive management approach proposed for mining activities not be used due to the lag time for mining-related impacts to manifest and changes required to be implemented.** **3. The SCA's performance criteria developed for the proposed mining area to be adopted.**	Subsidence discussion provided in Appendix B Section 2.10.2
169.	SCA	It should also be noted that the SCA may have further comments on the PPR depending upon the findings of the yet to be completed ground and surface water assessments. As such, the SCA requests the opportunity to continue to be involved in any ongoing assessment of the application.	No response required
170.	NSW Fisheries	Fisheries NSW advises that issues raised previously have been addressed by the proponent, but remains concerned about potential impacts of mining in this area.	No response required

Appendix B

RESPONSE TO SUBMISSIONS ON THE PREFERRED PROJECT REPORT –SUBSIDENCE

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23 December 2013

Dave Clarkson
Group Environment & Approvals Manager
Gujarat NRE Wonga Pty Ltd
NRE Wongawilli Colliery
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Dear Dave

RESPONSE TO SUBMISSIONS TO PREFERRED PROJECT REPORT

As requested, please find herein our response to submissions received for the Preferred Project Report (PPR) in relation to surface subsidence issues and groundwater issues that relate to the direct impacts of subsidence. The submissions considered in this letter report are those from:

1. Independent Review of Subsidence Impact Assessment by Professor B. Hebblewhite.
2. NSW Government Department of Resources and Energy (DRE).
3. Sydney Catchment Authority (SCA).
4. NSW Government Office of Environment and Heritage (OEH).
5. Wollongong City Council (WCC).
6. NSW Department of Primary Industries (DPI).
7. Dams Safety Committee (DSC).
8. NSW Government Transport Roads and Maritime Services (RMS).
9. NSW Government Heritage Council (Heritage).
10. Environmental Protection Authority (EPA).

As there are several issues raised in multiple submissions, the response to an issue is presented in most detail the first time it is raised in the order of the list above. Where it is raised in subsequent submissions, reference is made to the earlier response for brevity and expanded as necessary, but reading the document in its entirety is recommended. We note that there are several submissions – specifically those from the DSC, RMS, Heritage, and

EPA – where the PPR has addressed or substantially addressed subsidence related issues raised in earlier submissions to the NRE1 No 1 Colliery – Underground Expansion Project (MP09-0013) and these submissions are not considered further in this report.

1. Independent Review of Subsidence Impacts by Professor B.K. Hebblewhite

Professor Hebblewhite's comments are all considered to be valid points that are well made. The response in this section is mainly in relation to clarification of some of the terms used and further explanation of the reasoning behind some of the issues that may not have come through clearly in the PPR Subsidence Assessment presented in SCT (2013).

1.1 Point A3 – "Essentially Predictable" Behaviour

The use of the term "essentially predictable" in the PPR is intended to convey the concept that the multi-seam subsidence behaviour observed above Longwalls 4 and 5 has characteristics that are very similar to the subsidence behaviour observed above longwall panels where only one seam has been mined. These characteristics are also evident from other sites that have yet to become available in the public domain given the relatively recent development of multi-seam longwall mining in NSW. Although the effects of multi-seam subsidence are yet to be fully characterised, the monitoring experience available confirms that the behaviour is essentially consistent with single seam subsidence but with some differences associated with the disturbance caused by previous mining.

Even for single seam mining, regarding subsidence behaviour as being "entirely predictable" may be somewhat optimistic. However, an approach based on understanding the mechanics of the various processes involved – specifically sag subsidence over individual longwall panels and elastic strata compression above and below the chain pillars but also various forms of non-conventional subsidence behaviour – provides a basis to predict subsidence behaviour with a degree of certainty that is usually sufficient to allow appropriate management of potential impacts.

In a multi-seam subsidence environment where extracted coal seams are relatively close together such as in the PPR project area, there appears to be three main characteristics that are slightly different to single seam subsidence behaviour and they all relate to the fact that initially intact overburden strata is softened somewhat above each extracted panel to a height approximately equal to the panel width. As a result:

1. Overburden strata softened by previous mining has reduced shear stiffness (i.e. is softer in "bending") compared to undisturbed strata so the strata is less effective at bridging across the void created by mining a new panel. The subsidence engineering concepts of sub-critical and super-critical subsidence behaviour still apply, but the width

at which full subsidence develops (supercritical width) is much less in a multi-seam environment.

2. The "reworking" of already subsided overburden strata causes an increase of maximum subsidence in supercritical width panels (very wide relative to depth) from 50-65% of seam thickness typical of single seam operations to 60-80% of combined seam thickness. In the PPR, the panels are still subcritical in width and so maximum subsidence is limited by panel width.

3. Goaf edge subsidence is somewhat greater at 200-300mm where there has been previous mining in the overlying seams compared to 100-200mm typical of undisturbed strata. The goaf edge subsidence profile is also somewhat softer.

Pillar instability may also cause additional subsidence where previously stable standing pillars in the overlying coal seams are destabilised. This effect is considered separately in Section 1.6.

1.2 Points A6 and A7 - Adaptive Management

The concept of adaptive management was forwarded in the PPR as a method of managing closure across Cataract Creek and at a strategic level (rather than on an individual swamp basis) for managing impacts on swamps. In this section, the application of this approach is discussed further.

1.2.1 Point A6 - Cataract Creek

The experience of monitoring closure across Cataract Creek during mining of Longwall 5 indicates characteristics that make an adaptive management approach likely to be suitable to manage the magnitude of closure across Cataract Creek. This monitoring indicates that the closure commenced when Longwall 5 was about 400m from Cataract Creek and has continued at a steady rate of about 12mm/100m of longwall retreat since then. A six week period of longwall stoppage when Longwall 5 was approximately 130m away from finishing showed low level additional closure of less than 5mm. This steady, predictable response allows planning for a pre-determined level of closure across Cataract Creek well in advance of reaching any given set target.

The challenge with an adaptive management approach for Cataract Creek is determining the level of closure when impacts are considered to be significant. A target of 200mm has been adopted based on experience of mining near creeks and rivers in Hawkesbury Sandstone strata. Recognising that the base of Cataract Creek is located within the outcrop of the Bald Hill Claystone, it is possible that closure may be occurring on the Hawkesbury / Bald Hill Claystone contact without causing any perceptible impact to the creek bed.

Available evidence including the absence of any significant fracturing or other impacts in the creek bed from previous mining including Longwalls 4 and 5 indicates that closure movements may be occurring above the level of the creek bed so that the types of impacts observed in Hawkesbury Sandstone where horizontal shear and resulting closure typically occurs below the level of the creek bed may not be occurring in Cataract Creek. However, further surveying scheduled for the end of Longwall 5 and analysis of this monitoring data is required to confirm this hypothesis. In the meantime, visual inspections continue to form a critical part of the adaptive management strategy for Cataract Creek and so far there has been no perceptible impact.

1.2.2 Point A7 - Adaptive Management of Swamps

The concept of adaptive management for swamps is not considered valid on the scale of individual swamps because the changes are unlikely to occur in a timeframe that is appropriate to managing longwall retreat. However, the approach is considered to be a valid method of managing mining impacts on swamps more generally at a strategic level given that the data available from previous longwall mining in the Balgownie Seam does not indicate high levels of subsidence related impact to any of the swamps in the area (Biosis 2013).

While it is accepted that there is no baseline data available from this earlier mining, the fact remains that CCUS4 was subsided by up to 0.9m and appears to have continued to thrive. Other swamps in the general area have also been similarly subsided and also appear to continue to thrive. Thus there is opportunity to study the impacts of previous mining on swamps over the longer terms of 30 years for the Balgownie Seam longwalls and 60-80 years for Bulli Seam monitoring at least on a comparative scale with similar swamps that have not been mined under.

The proposal to mine Longwall 6 below CCUS4 provides the opportunity to get some baseline data and then monitor the changes that occur over the longer term. It is accepted that there may be some changes, but the magnitude of the changes are not thought likely to be significant based on the experience of previous mining below the site. By carefully measuring any physical changes including rainfall, subsidence movements, vegetation, groundwater pressures, and surface flows it should be possible to determine over the medium to long term how significant any impacts may be. This experience will then be available to inform future assessments of similar swamp types.

1.3 Point A9 – Explanation of Bulli Seam Goaf on 0.7 Times Depth Protection Barrier

A 0.7 times depth protection barrier to the full supply level (FSL) of Cataract Reservoir has been used as the basis to design the layout of longwall panels in the Wonga East mining area. The presence of a Bulli Seam goaf in areas between the ends of the proposed longwall panels and the Cataract Reservoir reduces the effectiveness of the 0.7 times depth barrier but it does not mean that the barrier is ineffective. In this section, an explanation of the nature of the barrier and its effectiveness is provided. This explanation drifts into a discussion on groundwater issues which is starting to get outside the domain of a subsidence assessment and therefore wasn't discussed in detail in the subsidence assessment report (SCT 2013). However, given the significance of the issue raised by Professor Hebblewhite, a more detailed explanation is provided here to clarify the point that was being made.

The key issue for controlling the effectiveness of a barrier is maintaining the integrity of the pathway for flow from the reservoir to the mine workings. The FSL is at RL289.5m while in the area beyond the end of Longwall 7, the Bulli Seam mining horizon is approximately RL35m and the Wongawilli Seam horizon is approximately RL0m.

The only credible pathways for leakage from the reservoir to the mine are either horizontally from the reservoir to the subsided strata above the longwall goaf and then downward through this strata into the mine or via geological structures. The potential for through going geological structures is separately in a later submission. Any vertical pathway to the mine roadways directly below the reservoir is clearly not of high enough hydraulic conductivity to be an issue given that these roadways already exist and there is no evidence of any inflow.

The 200m horizontal barrier (equivalent to 0.7 times 290m) provides a significant barrier to horizontal flow given the hydraulic conductivities of rock strata and, supported by the fact that there is no experience of leakage from reservoirs or water bodies for barriers of this size, appears more than adequate. However, the presence of an existing goaf in the Bulli Seam within this barrier may reduce the effectiveness of this barrier against possible leakage into the mine as noted in SCT (2013). Some very good work presented by Tammetta (2012) allows this potential to be investigated.

Tammetta (2012) presents an empirical relationship that is based on published experience from all around the world of longwall mining interactions with groundwater. The relationship allows the height of depressurisation above the mining height to be calculated as a linear function of panel width multiplied by seam thickness mined raised to the power of 1.4 and overburden depth raised to the power of 0.2.

The height of depressurisation is significant because it defines the point above the mining horizon at which the vertical hydraulic conductivity of the overburden strata reduces sufficiently to support a hydrostatic water pressure profile in the overburden strata. Looking at it the other way around, the height of depressurisation is the height below which vertical leakage through the subsided overburden strata starts to become significant as a pathway for inflow. A source of surface recharge is still required for inflow to occur, but the pathway exists at overburden depths less than the height of depressurisation.

Monitoring at NRE and at other sites confirms the Tammetta relationship. The widest of the Bulli Seam goaf areas within the barrier to the reservoir is approximately 180m. For a 2.4m high mining height (assuming complete extraction and a conservative seam height) at 280m deep, the height of depressurisation is approximately 160m, so there is still 120m of strata with sufficiently low hydraulic conductivity to maintain a hydrostatic groundwater profile above the top of any of the Bulli Seam goafs in the barrier. The presence of this 120m of strata means there is still no significant vertical pathway to the mine despite the presence of the extracted panels in the Bulli Seam.

The observation that mining in the Wongawilli Seam causes vertical ground movements that are substantially within the footprint of the panel means that ground movements and overburden disturbance are substantially limited to within the panel footprint. The height of depressurisation can be conservatively estimated as the combined thickness of mining in both seams at the depth of the lowest seam and a panel width of the panel being mined. Monitoring experience at GW-01, a groundwater pressure monitoring borehole near where Mount Ousley Road crosses Cataract Creek, confirms the Tammetta relationship still applies in an area where both the Balgownie and Bulli Seams have been mined.

Longwall 7 is 125m wide at a depth of approximately 290m. Apart from one small area where there is a narrow overlap, there is nowhere that all three seams are fully extracted together and certainly nowhere within the barrier.

For the proposed 125m wide Longwall 7 mined below the Bulli Seam (there is no mining in the Balgownie Seam at the southwestern end of Longwall 7), the height of depressurisation is calculated using the Tammetta relationship to be 260m (for a combined mining height in the two seams of 5.8m). This means that the height of depressurisation may be approaching the surface and although there may still be some barrier to vertical flow near the surface, the main protection against inflow from the reservoir is the horizontal barrier of 200m. This barrier is maintained all around Longwall 7 and so there is considered to be no potential for significantly increased inflow from the reservoir to the mine as a result of mining Longwall 7.

Even if there were to be some further instability in the Bulli Seam goafs within the barrier as a result of mining Longwall 7, which is considered most unlikely, the height of depressurisation considered above is for the worst case of full extraction or complete destabilisation of all pillars and the height of depressurisation is therefore not expected to be greater than 260m.

Notwithstanding the discussion presented above that indicates there is no potential for Longwall 7 to significantly increase inflow from the reservoir to the mine, there is still a need to continue to confirm the heights of depressurisation above multiple goafs and to confirm that any depressurisation over Longwall 7 is not causing a change in the groundwater regime between the reservoir and the mine.

Further groundwater pressure monitoring boreholes are planned to be drilled including one at a site above Longwall 4 where all three seams have been mined, several others between the end of Longwall 7 and the reservoir, and another near Cataract Creek to monitor depressurisation as Longwall 7 approaches. The first borehole is aimed to confirm the height of depressurisation above three mined seams before Longwall 7 starts. The several boreholes between the reservoir and the start of Longwall 7 are aimed to confirm the direction of groundwater flow continues to be toward the reservoir above the 200m barrier. The piezometer at the northeastern end of Longwall 7 is aimed to be used as a basis for adaptive management to shorten Longwall 7 if there is any sense of significant depressurisation associated with mining this panel.

This strategy is expected to be effective to confirm that there is no credible pathway for significantly increased inflow from the reservoir to the mine.

1.4 Point A10 – Body of Evidence to Support Predictions of Multi-Seam Subsidence

The subsidence monitoring data available from NRE is valuable data but there are other sites where high quality multi-seam data is emerging. Unfortunately, it is early days and data from these sites has yet to make its way into the public domain so it can be referenced in a subsidence assessment report of this type. The results are nevertheless convincing and surprisingly consistent. The experience from additional sites should be available in the public domain by mid-2014.

1.5 Point C1 – Swamp Constraints

The point is made that the constraint in relation to upland swamps lacks quantitative or measurable definition of how the impacts of mining are translated into a design constraint. This point is accepted. The challenge is that there does not seem to be a large body of evidence available to confirm whether upland swamps that depend for their water primarily on rainfall recharge are significantly impacted by mining subsidence. The issue of impacts of mining on upland swamps is an area that requires further work at a strategic level to confirm that there are indeed long term impacts and the nature of these impacts.

Previous mining in the Bulli Seam and the Balgownie Seam at NRE and in the Bulli Seam all along the Illawarra Escarpment provide a long history of the effects of mining subsidence on these types of swamps. While there is limited baseline data currently available, it seems that the swamps above Wonga East provide an opportunity to get not only baseline data but also data on the scale of any impacts. A comparative study is therefore planned to monitor swamps where there will be no further mining to swamps that will be mined under.

CCUS4 is a swamp that was mined under and subsided about 0.8m in the early 1980's. CCUS4 appears to still be in good health (Biosis 2013). To step Longwall 6 around CCUS4 would significantly reduce the coal resource able to be recovered from Longwall 6. By accepting that there may be some impacts to this swamp but also that these impacts may not significantly affect the health of the swamp (as per previous mining), the opportunity exists to monitor the ground movements, groundwater impacts, and any ecological changes to provide evidence to guide future strategic planning of longwalls in close proximity to these types of upland swamps.

Mining is proposed under the fringes of CCUS5 which has been partly mined under previously in the Bulli Seam and CRUS1 which has been significantly mined under previously in the Bulli Seam. The opportunity exists to monitor any ecological changes as a function of distance from Longwall 7 as a guide to offset distances that may be required in the future.

The need for more of this type of monitoring is reiterated elsewhere Professor Hebblewhite's comments and emphasised in Point G1. The need for more monitoring is recognised and accepted.

1.6 Point C6 – Pillar Run

The point made in respect of not including elastic compression subsidence in the same discussion as "pillar run" is accepted and the two mechanisms are recognised to be unrelated. The linking of these two completely separate processes was in response to concerns raised by DRE in earlier submissions to the NRE1 No 1 Colliery – Underground Expansion Project (MP09-0013) and again in their response to the PPR discussed further in Section 2. Their concern under the heading "pillar run" was not just, or even primarily, about conventional pillar run caused by pillar instability, although this is clearly an issue in some localised areas. Their concern appears to be more directed toward possible low level goaf remobilisation from both horizontal stress relief and additional elastic pillar compression of barriers that they were concerned may affect infrastructure such as Mount Ousley Road, Picton Road Interchange, and the high voltage power lines located between Mount Ousley Road and the Illawarra Escarpment. There is not a universal term for these types of movements, but the term "pillar run" is accepted as perhaps not best suited to describe them.

1.7 Point C9 – Balgownie Seam Subsidence Monitoring and Swamp Impacts

SCT is not aware of any ecological monitoring in relation to swamps from the period of mining longwall panels in the Balgownie Seam from 1970 to 1982. This information would be most useful as baseline monitoring if it is available.

Unfortunately, most of the Balgownie Seam subsidence monitoring (all except Longwall 11) comprises only vertical subsidence. The period when the Balgownie Seam was mined was very early in the development of subsidence monitoring in NSW and survey instruments suitable for routine monitoring of subsidence in three dimensions were not yet widely available or affordable. Although the monitoring is considered to be of a high standard for the time, the monitoring detail is relatively limited by contemporary standards.

2. DRE Submission

The DRE submission dated 26 November 2013 presents feedback to the PPR on several areas of DRE responsibility. The response presented in this section relates only to subsidence issues raised in the submission.

We note that although the DRE submission is in response to the entire PPR (Longwalls 1-11), extraction plans being developed currently do not include Longwall 1, 2, and 3 where most of the significant infrastructure of concern to the DRE is located. This change is primarily in response to the DRE's concerns.

The potential for some remobilisation of the overlying Bulli Seam pillars is accepted and the differences of definition between a "pillar run" associated with underground safety and the use of the term to describe irregular or additional subsidence possibly beyond the boundaries of proposed mining are recognised.

Experience to date of monitoring subsidence from Longwalls 4 and 5 does not show any evidence of significant irregular or additional subsidence beyond that which would be expected in a multi-seam environment where both main heading pillars and pillar extraction areas are present. There is some evidence of small movements of less than a few centimetres on Mount Ousley Road that can properly be attributed to normal subsidence beyond the goaf edge, to the far-field redistribution of horizontal stresses, and to downslope movement but these are of low level and these have occurred incrementally rather than suddenly. There is evidence that these low level movements are localised at pre-existing goaf edges consistent with remobilisation of existing fractures within the overburden strata as would be expected.

There is also some evidence from subsidence monitoring undertaken during longwall mining in the Balgownie Seam subsidence of additional subsidence of up to about 0.7m directly over longwall panels that again can be properly attributed to remobilisation of Bulli Seam workings and destabilisation of pillars within the Bulli Seam. These areas have all been associated with areas where additional subsidence would be expected because of the irregular extraction geometry in the Bulli Seam. There is some softening of the goaf edge apparent, but the surface subsidence does not appear to have been unduly irregular as a result of the overlying Bulli Seam pillars.

As suggested in the submission, further geotechnical investigations are planned, but some further consultation with DRE on these concerns is recommended to better understand the basis for their concerns.

3. SYDNEY CATCHMENT AUTHORITY (SCA)

The SCA submission discusses a range of issues. Only those that relate to subsidence, geological structure, and groundwater interactions are discussed in this section. The SCA expresses major concerns about:

- Lack of geological investigations.
- Induced leakage from Cataract Reservoir.
- Longwall mining within the Dams Safety Notification Area.
- Impacts on swamps such as CCUS4.

3.1 Point 4 – Review of Geological Structures

Previous mining in the Bulli Seam and Balgownie Seams are considered to provide a very strong basis for defining geological structures in the area the proposed mining. The degree of confidence is much greater than would normally be possible at a greenfields site based on drilling and seismic investigations because it has been possible to accurately locate all faults and dykes underground, determine their throw, and directly inspect some of them. This circumstance is fortunate given the very real issues of surface access limitations in the SCA administered Special Area.

There still seems to be some confusion about the naming and extent of geological fault structures and the ability of drilling to delineate fault structures. Further discussion with the site geologist is recommended to clarify the confusion that appears to still exist. Some of this may be a result of naming conventions, particularly in relation to the Rixons Pass Fault which is located to the north of the PPR mining area and well outside of any area likely to be affected by mining subsidence. Some may be a result of plans becoming outdated as new information becomes available.

There is also seems to be an underlying concern that the presence of geological faults has potential to significantly modify the response of the 300m of overburden strata to subsidence movements. In the author's experience, the concept of geological fault structures significantly changing the response of the overburden strata is not supported by experience. Near surface thrust faults have occasionally been apparent in subsidence profiles and a closely spaced pair of dykes is known to have once local modified a subsidence profile, but these are very unusual.

The concept of geological structures interacting with overlying pillars causing them to become unstable is not considered a significant issue in the context of the proposed mining. The creation of a longwall goaf directly below remnant pillars in the Balgownie and Bulli Seams is expected to destabilise small pillars as discussed in the PPR subsidence assessment (SCT 2013). The presence or otherwise of geological fault structures does not significantly change this process and the additional subsidence that results from any instability has already been factored into the subsidence estimates.

Again it is reiterated, the level of geological detail available at this site from being able to mine up to and through all the geological structures in the area is far in excess of the detail that is usually available. This detail is more than adequate to confirm that there is no potential for geological fault structures to significantly affect the magnitude of subsidence or the connectivity between the reservoir and the mine.

3.2 Point 4.1 – Subsidence Predictions

In the section of the SCA submission titled "Subsidence Predictions" the method of subsidence prediction and the recommendations from SCT (2013) are restated but with some slight changes compared to what was intended. This section the methods used to predict subsidence and the recommendations are clarified.

The subsidence prediction method is based primarily on empirical observations made during mining of Longwalls 4 and 5 recognising that previous mining in the overlying seams has modified the shear stiffness of the overburden strata.

Previous subsidence data from longwall mining in the Balgownie Seam, and from mining in the Bulli Seam further to the west are also presented to show that there has previously been significant subsidence below Cataract Creek and most of the swamps within the PPR mining area. Bulli Seam subsidence data from further west was used because no subsidence data is available for the mining in the Bulli Seam within the PPR area due to the age of the workings.

Maximum tilts and strains are estimated using empirical data presented by Holla and Barclay (2000) for the increment of subsidence associated with mining the Wongawilli Seam. Holla and Barclay (2000) did not present an incremental subsidence approach. The approach used should not to be confused with the incremental profile method routinely used by Mine Subsidence Engineering Consultants Pty Ltd (MSEC) and which has not been used here.

SCT did not recommend confirmation that there are no geological structures with potential to provide elevated hydraulic conductivity between the reservoir and the mining horizon. SCT already considers that there is sufficient confirmation that there are no such structures based on the high level of geological information available and considers that there is no potential for these structures to be significantly impacted by mining subsidence. However, it was noted that the protection strategy relies on having this information.

SCT is not aware of any recommendation for a program of work to test the hydraulic conductivity of the dyke. The experience of mining through dykes in the Southern Coalfield is that they do provide a pathway for inflow.

The increase in subsidence over Longwall 4 due to mining Longwall 5 is consistent with the elastic compression of the chain pillar and surrounding strata as expected. As the pillar and strata above and below the chain pillar compress at the edge of panel, so the subsidence in the adjacent previously mined panel increases by about half the compression on the edge of the panel. Further subsidence over previous panels is routinely measured and the increased subsidence observed over Longwall 4 is entirely consistent with expectation.

The statement is made that "*SCA considers it highly likely that the actual vertical subsidence of Longwall 5 will surpass the revised predicted values if Longwall 6 and others are mined*". The predictions have been made based on a conservative interpretation of the available information, but SCT would be pleased to learn of the approach that SCA has used to support this statement.

The comment that the "*reliability of subsidence predictions are critical for the assessment of other impacts and environmental consequences*" is considered to be something of an overstatement. Certainly the subsidence predictions need to be soundly based, but it should be recognised that any small differences between predicted and actual subsidence do not usually change the way that surface impacts are managed. The greater challenge is determining the relationship between any given level of subsidence and the environmental consequences so that impacts can be more appropriately assessed.

It is unclear what the call for comprehensive assessment of the behaviour of all faults and dykes in the proposed mining area is aiming to achieve particularly given the high level of detail currently available. The Corrimal Fault tapers out in the vicinity of Longwalls 6 and 7 and the ground movements associated with subsidence from mining in the Bulli Seam mining do not appear to have had any adverse impact on the surface or on hydraulic connectivity with the reservoir. The D8 dyke has been thoroughly tested by mining in the Balgownie and Bulli Seams, again without becoming apparent on the surface in the subsidence profiles or otherwise increasing the hydraulic conductivity of the overburden strata. Some further discussion to better understand the requirements is recommended.

3.3 Point 4.1 – Impacts on Cataract Reservoir

The 200m wide barrier to Cataract Reservoir is considered to provide a high level of protection to the stored waters of Cataract Reservoir. The explanation relating to concerns about the Bulli Seam goafs are discussed above in Section 1.3 of this report.

The concept of restricting mining within the DSC Notification Area does not appear to be based on experience or the understanding outlined in the Reynolds Inquiry and subsequently administered by the DSC. It is entirely appropriate that there be a DSC Notification Area to provide a mechanism to provide timely engagement of mining companies with the DSC so that the stored waters can be appropriately protected.

The recommendation to use exploration drilling to confirm the extent of the Corrimal Fault is not considered practical, likely to be effective, or necessary. However, further discussion is recommended to better understand the concerns that are being raised.

3.4 Point 4.1 – Impacts on Cataract Creek

On the basis that the definition of "presumptive" as stated in the Chambers Twentieth Century Dictionary is "grounded on probable evidence" and "an assumption made failing proof to the contrary" the statement that SCA considers it presumptive of SCT to suggest that there has not been any impact on the creek is accepted. The original comment in SCT (2013) was intended to convey the point that despite 1.4m of subsidence and a probable closure of several hundred millimetres associated with this subsidence, there is no evidence to suggest that Cataract Creek is leaking into the mine or there is significant flow diversion into the stream bed.

The issues relating to adaptive management of closures on Cataract Creek are discussed in Section 1.2.1. The experience to date indicates that closure can be managed through adaptive management practices. The main challenge relates to determining how much closure is tolerable. Surveying data from Longwall 5 will soon be available to provide insight into whether closure is not impacting on Cataract Creek because it is occurring as shear movements above the level of the creek bed.

3.5 Point 4.1 – Impacts on Swamps

The issues relating to adaptive management of swamps are discussed in Section 1.2.2.

While it is considered possible that mining below CCUS4 may cause some physical changes associated with subsidence, the swamp has previously been subsided by up to 0.8m and SCT understands that there are not known to have been any significant adverse consequences over the long term (30 years since that subsidence occurred) so there is some basis to consider that further subsidence will not cause impacts that are significant enough to be an issue for the long term health of the swamp.

The context of the suggestion to monitor CCUS4 closely during mining of Longwall 6 is to provide high quality information that can be used to make informed strategic judgements for other swamps in the area.

4. Office of Environment and Heritage (OEH)

OEH raises concerns in relation to:

- Impacts on coastal upland swamps EEC.
- Potential loss of water to deep storage.
- Impacts on threatened species.

These are not subsidence related issues, but some of the issues raised by OEH relate to subsidence estimates. The following section focuses on clarifying the subsidence related aspects.

4.1 Attachment A - Upland Swamps

The concept of valley closure is raised in respect to upland swamps. Some clarification of this concept may assist the discussion. Valley closure occurs primarily as a result of dilation of the subsiding overburden strata below topographic high ground. Dilation is a natural characteristic or rock and rock like materials when subject to disturbance and occurs in all directions.

When sloping terrain is subsided, strata dilation forces are unopposed on the downslope side and following principles of conservation of energy (i.e. following the path of least resistance) horizontal movements occur in the direction of least resistance which is directly downslope. This direction gives rise to the term "horizontal movements in a downslope direction" or "downslope horizontal movements".

Downslope movements give rise to valley closure in topographic low points and stretching at topographic high points. Below the level of valley floor, the potential for downslope movement is curtailed by the buttressing effect of strata on the opposite bank. The path of least resistance is no longer toward the valley. The difference in movement is accommodated as horizontal shear movements on horizontal bedding planes at a level close to the base of the valley.

In Hawkesbury Sandstone strata, the bedding planes that are activated by horizontal movements in a downslope direction are typically at a level 3-6m below the base of the river channel because these bedding planes appear to be active as part of the natural valley forming processes that occur over geological time. In some circumstances, it is possible for lower strength shear horizons to be preferentially activated above the base of the creek so that the bedrock in the creek bed is not overloaded in compression and fractured.

These processes are occurring on a scale of whole valleys. For instance closure movements measured during mining of Longwall 5 show that closure of up to 50mm has occurred along a 1km section of Cataract Creek. On the scale of individual upland swamps of the size present in PPR mining area, there is typically not enough energy available within the subsiding rock strata either side of the shallow valleys where the swamps are located for valley closure to be significant enough to fracture rock. In effect, the entire swamp moves down the slope toward the main valley of Cataract Creek rather than the sides of the shallow valley moving laterally across the slope toward the swamp.

The main subsidence processes that are likely to cause cracking of the bedrock below the swamps in the PPR are associated with systematic horizontal movements and associated conventional strains. The estimates of maximum strain and tilt provided in SCT (2013) are based on maximum credible values in the general vicinity of the swamp for the level of subsidence anticipated. However, these predictions are not expected to occur at all locations within any given swamp and may not occur within a given swamp at all.

4.2 Attachment A – Surface Water

OEH describes a range of studies that help to quantify the effect of mining on potential inflows from the surface. It is noted that the findings of these studies remain consistent with studies conducted in the 1970's as part of the Reynolds Inquiry and which have been used to regulate mining adjacent to stored waters since that time. The height of depressurisation above individual longwall panels has recently been shown by Tammetta (2012) to be predictable with a high degree of confidence confirming that the Reynolds Guidelines are very conservative (as they should be).

The changes in panel widths and chain pillar widths referred to by OEH have been designed to both control surface inflows and inflows from the reservoir and the third and fourth order sections of Cataract Creek. The first and second order sections of Cataract Creek have not been specifically protected but are generally also protected.

In the original NRE1 No 1 Colliery – Underground Expansion Project (MP09-0013), large chain pillars were required to maintain low levels of surface subsidence in the expectation that the overburden strata would bridge across each individual panel. Subsidence monitoring from Longwalls 4 and 5 have shown that previous mining has compromised the bridging capacity of the overburden strata and, consistent with the adaptive management strategy being used at this site, the mine layout has been redesigned in the PPR so that there is no mining directly below the third and fourth order sections of Cataract Creek. The lack of overburden bridging and the mine layout redesign make the need for overly large chain pillars to reduce subsidence redundant. The chain pillars have consequently be resized to sizes that are appropriate to maintain stable working conditions underground.

It is recognised that OEH and other agencies have not had the benefit of being able to examine the groundwater studies.

5. Wollongong City Council (WCC)

WCC has expressed a number of concerns. The concerns that relate to subsidence that have not been addressed by the PPR are mainly in relation to proposed mining under swamps CCUS4, CCSU5, and CRUS1. These issues are discussed in previous sections of this report, specifically Sections 1.2.2, 1.7, 3.4, and 4.1.

6. NSW Department of Primary Industries (DPI)

DPI has raised a number of concerns. The concerns that relate to subsidence mainly relate to changes in panel dimension. Other concerns relate to groundwater and these are not specifically addressed in this report although some of the discussion around height of depressurisation is relevant. It is recognised that DPI and other agencies have not had the benefit of being able to examine the groundwater studies.

The changes in panel width are discussed in Section 4.2, but are discussed further here for clarification. The width of the longwall panels is maintained at 150m across most of the PPR with reduced width in Longwalls 1, 2, and 7 to fit within various constraints including the existing main heading developments.

The subsidence predictions that have been made are based on the results of monitoring above Longwalls 4 and 5 and these results provide a strong basis for predicting the magnitude of subsidence that can be expected above the remaining panels in the PPR with sufficient accuracy to enable management strategies to be developed.

If you have any queries or require further clarification of any of these issues, please don't hesitate to contact me directly.

Regards

Ken Mills
<u>Principal Geotechnical Engineer</u>

7. REFERENCES

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Appendix C

ASSESSMENT OF GROUNDWATER DATA FOR RUSSELL VALE COLLIERY AND IMPLICATIONS FOR FURTHER MINING IN THE WONGA EAST AREA

R E P O R T   T O :

WOLLONGONG COAL

Assessment of Groundwater Data for Russell Vale Colliery and Implications for Further Mining in the Wonga East Area

WCRV4209

Strata Control Technology

SCT Operations Pty Ltd PO Box 824 Wollongong NSW 2520 Australia
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REPORT TO	Dave Clarkson Group Environment & Approvals Manager Wollongong Coal PO Box 924 Dapto NSW 2530
SUBJECT	Assessment of Groundwater Data for Russell Vale Colliery and Implications for Further Mining in the Wonga East Area
REPORT NO	WCRV4209
PREPARED BY	Ken Mills
DATE	31 March 2014

Ken Mills
Principal Geotechnical Engineer

SUMMARY

Wollongong Coal (WC) is proposing to mine additional longwall panels in an area referred to as the Wonga East mining area of Russell Vale Colliery approximately 9km north-north-west of Wollongong in New South Wales. After consideration of submissions from the community and government agencies to its earlier Underground Expansion Project Part 3A (Pt3A) application, WC (then Gujarat NRE) significantly modified the application in a proposal referred to as the Preferred Project Report (PPR). WC commissioned SCT Operations Pty Ltd (SCT) to review and interpret available groundwater data and to compile a conceptual understanding of the interaction between groundwater, subsidence, and mine water balance as input for the more extensive numerical groundwater model being prepared for the project, and to provide an assessment of the implications of this data for future mining in the Wonga East area. This report presents and analyses the available data from previous mining at the site for inflow rate, vertical and lateral extent of perceptible groundwater impacts, and hydraulic conductivity.

A conceptual/analytical model of the groundwater system in the Wonga East area has been developed based on analysis of the currently available data and its various characteristics. While this model is considered convincing and consistent with the data currently available for the Wonga East area, further calibration and ongoing improved monitoring of underground pumping systems and further monitoring of groundwater pressures using additional vibrating wire piezometers is recommended to allow continuous refinement and improvement of this conceptual model as a basis for understanding and to underpin the more extensive numerical modelling. It should be recognised that the outcomes of the conceptual model presented in this report may differ somewhat from the results of larger scale numerical modelling because of the conceptual model's greater flexibility to address the specific local site conditions in the relatively small area of Wonga East.

A review of the available monitoring data indicates approximately 1.1Ml/day is seeping into the Wonga East underground mine from the surrounding strata once the balance of water being pumped into the mine and leaving the mine in the coal product has been taken into account.

A section of the ridge south of Cataract Creek where the ground is stretched by subsidence movements and there are large tension cracks evident on the surface appears likely to be a significant source for this inflow. The hydraulic conductivity of the overburden strata appears to be significantly enhanced to a depth of at least 140m below surface and there is a downward gradient evident in the piezometer results indicating the potential for elevated downward flow in this area. Mining activity including longwall mining in the Balgownie Seam and more recently Longwalls 4 and 5 in the Wongawilli Seam is likely to have contributed to the increased vertical hydraulic conductivity along the ridge and the volume of the fracture network is estimated to be sufficient to produce the inflows observed underground.

Although surface cracking along the ridge line to the south of Cataract Creek appears likely to be a major source of seepage into the mine, the groundwater levels are still indicating that the headwaters in Cataract Creek are controlling the groundwater level and by implication receiving most of this rainfall recharge flow as a result. This balance between some inflow into the mine, generally at low levels, and lateral flow including along horizontal shear planes to/from adjacent creeks appears to occur all across the site. The inflows into the mine are indicated as being at low levels to achieve the overall water balance observed.

All the piezometers show a downward hydraulic gradient towards the mining horizons, past and present, consistent with downward flow of low magnitude. This downward hydraulic gradient existed prior to recent mining in the Wongawilli Seam and while there has been some increase in the vertical gradient evident during mining in the Wonga East area the additional increases have been relatively small.

The magnitude of downward flow appears to be largely restricted by the naturally low vertical hydraulic conductivity of the deeper overburden strata, particularly around the level the Stanwell Park Claystone, and the relatively large depth of mining. A zone of depressurisation is evident in piezometer GW-1 and the height of this zone is consistent with the method formulated by Tammetta (2012) for the mining geometry of the most recently mined panel and the combined thickness of all the seams that have been mined.

The piezometer monitoring results are consistent with the presence of horizontal shear planes that are inferred to exist from creek closure measurements and have been confirmed to exist at other sites. These shear horizons appear to have a greater hydraulic conductivity than the surrounding strata and are most likely to be present at a level just below the base of the valleys. They occur as part of natural erosion processes but are also activated by mining subsidence.

A shear plane is considered likely to be the pathway by which NRE D, some 540m from Cataract Reservoir, responds to changes in reservoir pressure. A shear plane is also the likely pathway for the upper perched water table in GW-1 to be maintained at close to the level of Cataract Creek some 175m away and for the pressure in NRE B to be drawn to zero at the level of Cataract Creek. These higher conductivity shear planes appear likely to be capable of distributing low level flows over distances of several hundred metres and into the general groundwater system while also collecting rainfall recharge and distributing it back to the creeks and reservoir.

The flow measurements underground indicates that there has been a background inflow into the Bulli and Balgownie Seam up dip of the Wongawilli Seam mining that has a magnitude of about 0.2-0.3Ml/day and this flow has responded to long term trends in rainfall deficit suggesting a degree of hydraulic connectivity with either the surface or the Illawarra Escarpment.

There may also be some minor inflow from Cataract Creek, although the characteristics of the mine inflows recorded during mining of Longwall 5 did not indicate any perceptible increase in inflow as mining approached Cataract Creek. If a significant source of inflow was from the creek, an increase in flow rate would be expected as the flow path length between the creek and the mine reduced. The resolution of the underground monitoring is of the order of 0.1Ml/day indicating any potential increase in flow from Cataract Creek into the mine during mining of Longwall 5 was less than about 0.1Ml/day.

There were no visual indications of flow loss from Cataract Creek and no losses were recorded, but it should be recognised that flow meter systems able to be installed in creek channels without major construction works only have a resolution of the order of ±0.5Ml/day and therefore may not be able to detect changes with a magnitude of 0.1Ml/day or any transient flows that may have been necessary to recharge groundwater within the overburden strata.

Where there is mining in all three seams, there is considered to be high potential for interaction with the surface and the top of the groundwater table recharged from long term rainfall trends and adjacent creeks if there is interaction between the basal shear plane activated by subsidence and the top of the zone of depressurisation above each longwall panel. The height of this zone of depressurisation can be estimated using the empirical approach formulated by Tammetta (2012) for single seam mining operations, but the approach needs to be confirmed as suitable in a multi-seam environment. The following estimates for height of depressurisation above the mining horizon are considered reasonable as a preliminary estimate:

- Bulli Seam - 60m with over 90 years to come into equilibrium

- Balgownie LWs only
  - 43m for 140m panels (T=1.4m, W=140m and D=300m)
  - 60m for 190m panels (T=1.4m, W=190m, and D=300m)

- Balgownie LWs plus Bulli Seam
  - 100m for 140m panels (T=2.6m, W=140m, D=300m)
  - 136m for 190m panels (T=2.6m, W=190m, D=300m)

- Wongawilli LWs only
  - 146m for 145m panels (T=3.2m W=150m, D=330m)

- Wongawilli plus Bulli Seam
  - 222m (T=4.4m, W=150m, D=330m)

- Wongawilli plus Balgownie Seam
  - 235m (T=4.6m, W=150m, D=330m)

- Wongawilli plus Bulli Seam plus Balgownie Seam
  - 316m (T=5.8m, W=150m, D=330m)

There is considered to be some potential for interaction between the zone of depressurisation and the basal shear planes in the shallower areas at the northern ends of Longwall 2 and 3 and at the northern end of Longwall 7.

At the northern end of Longwall 7, the area where three seams have been mined is limited in extent and the height of depressurisation may be less as a result but further monitoring is required to establish the height of depressurisation when all three seams have been mined. Further work is underway to determine the height of depressurisation above the southern end of Longwall 4 where all three seams have been mined because the multi-seam estimates of height of depressurisation are limited to the one measurement in GW-1 at this stage.

The conceptual model developed and presented in this report is not considered suitable to provide a quantitative basis to calculate inflows from further mining activity in the Wonga East mining area. However, some indications of potential for inflow can be provided based on the data available. Areas where there is considered to be increased potential for inflow into the mine can be highlighted and the flows estimated based on previous experience of mining Longwalls 4 and 5.

The total water make from the Wongawilli Seam workings is currently about 1.1Ml/day. Based on considerations of how this flow has developed over time and where it has reported to in the mine, the current water make is estimated to comprise:

- 0.3Ml/day from mining development headings in the Wongawilli Seam.
- 0.2Ml/day for up dip inflow in the Bulli and Balgownie Seams.
- 0.1Ml/day additional inflow from mining Longwall 4.
- 0.5Ml/day from mining Longwall 5.

Based on the conceptual model the following estimates of additional inflow are indicated.

The northern ends of Longwalls 1-3 are located at shallower depths in areas where there has been previous mining in the Balgownie Seam. The potential for interaction with the near surface groundwater systems directly and through the zone of horizontal stretching along the ridge at the southern ends of these panels is expected to cause inflows of the same magnitude or possibly higher than the inflows observed in Longwalls 4 and 5. None of this area is below the fourth order section of Cataract Creek or close to the FSL of Cataract Reservoir.

Longwalls 6 and 7 are expected to contribute similar inflow increases to Longwall 5 (i.e. 0.5Ml/day) with this additional flow coming mainly from the higher conductivity recharge zones along the ridgeline between Cataract Creek and Cataract River. Some additional flow may also come from

Cataract Creek and Cataract Reservoir via the horizontal shear planes that are likely to be mobilised by mining Longwalls 6 and 7.

In the vicinity of Longwalls 6 and 7, the naturally low vertical hydraulic conductivity of the overburden strata and depth of mining is expected to restrict inflows from basal shear planes at the base of Cataract Creek into the mine to low levels provided the zone of depressurisation does not reach high enough to interact with the basal shear planes. Interaction with the zone of depressurisation may be possible at the northern end of Longwall 7 in an area where all three seams have been mined in close lateral proximity but not directly above each other. Further measurements planned above the southern end of Longwall 4 are expected to provide confirmation of the significance of this potential.

Longwalls 9-11 are located away from areas of previous mining in the Balgownie Seam and the potential for interaction with the near surface groundwater system is considered low because of the lower heights of depressurisation expected. Based on experience from other longwalls at similar depths, inflow rates are expected to be less than about 0.2-0.3Ml/day per panel during active mining and to reduce over time to low levels.

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1. INTRODUCTION

Wollongong Coal (WC) is proposing to mine additional longwall panels in an area referred to as the Wonga East mining area of Russell Vale Colliery approximately 9km north-north-west of Wollongong in New South Wales. After consideration of submissions from the community and government agencies to its earlier Underground Expansion Project Part 3A (Pt3A) application, WC (then Gujarat NRE) significantly modified the application in a proposal referred to as the Preferred Project Report (PPR). WC commissioned SCT Operations Pty Ltd (SCT) to review and present the available groundwater data as input for the more extensive numerical groundwater model being prepared for the project by others, and to provide an assessment of the implications of this data for future mining in the Wonga East area. This report reviews and presents the available data from previous mining at the site for inflow rate, vertical and lateral extent of perceptible groundwater impacts, and hydraulic conductivity.

The report reviews and presents the results of:

- Mine water balance specifically for the Wongawilli Seam but also for the Bulli and Balgownie Seam operations where information is relevant to the PPR.

- Piezometric pressure monitoring within the overburden strata around the site but particularly in the Wonga East mining area.

- Hydraulic conductivity measurements representative of the overburden strata including data available from other sites.

The review aims to present the factual data, clarify assumptions, and estimate the effect of unknowns based on the data that is available to help develop a conceptual model suitable to use as a basis for the more extensive numerical groundwater model based on this data.

Section 2 presents the water balance information including detail of the pumping arrangements and interactions with water flowing and stored in the Bulli and Balgownie Seams and the adjacent collieries.

Section 3 reviews the available piezometric data and assesses the implications of this data in the context of the lateral and vertical extent of mining impacts.

Section 4 reviews the hydraulic conductivity measurements available for packer testing in GW-01.

Section 5 considers the implications of the available data for proposed mining in the Wonga East area and the opportunities that are available to better understand the various groundwater interactions.

2. MINE WATER BALANCE

The mine water balance is a measure of the water make from the surrounding strata that cannot otherwise be accounted for. The water balance for mining in the Wonga East area at Russell Vale Colliery is complex because of the long history of mining in the area and the interaction with two overlying seams and adjacent collieries. The water balance for the Wongawilli Seam mining is also somewhat compromised by the incomplete nature of the pumping records for the period to the end of Longwall 4 and the later stages of mining Longwall 5. However despite these complexities and limitations, the water balance is considered to be relatively well understood and the magnitude of maximum incremental increases in water inflow to the mine has been established with some confidence based on the data that is available.

2.1 Overview of Seam Geometry and Mining History

Figure 1 shows a plan of the mining layout at Russell Vale Colliery. Three coal seams have been mined at the colliery. The uppermost of these is the 2-2.5m thick Bulli Seam where most of the previous mining activity has been concentrated. The 1.3m thick Balgownie Seam is located some 5-10m below the Bulli Seam. The 7-9m thick Wongawilli Seam is located a further 20m below the Balgownie Seam, but only the bottom 3-3.5m of this seam is mined.

In the Wonga East mining area, the Bulli Seam was mined between the late 19th Century and about 1950 initially as a hand worked bord and pillar operation and then with some mechanized pillar extraction. Bulli Seam mining continued further west initially as a continuation of Continuous Miner pillar extraction operations and then as a longwall mining operation that continued through under various owners until 2002.

The Balgownie Seam was also started in the late 19th Century in the Wonga East area using hand worked methods for a brief period. Mining in the Balgownie Seam restarted again in the late 1960's with continuous miners and continued through from 1970 until 1982 as one of the first longwall operations in Australia. To the north, some additional mining in the Balgownie Seam included a cut and flit first workings continuous miner bord and pillar operation between 2001 and 2003 (Gibson's Colliery - Thin Seam Mining).

The Wongawilli Seam has been mined since 2008 (start of access to Wongawilli Seam) including two longwall panels to date. Longwalls 4 and 5weremined between April 2012 and September 2012 and January 2013 and January 2014 respectively.

All three seams dip to the west towards a low point in the 200 series longwall panels near No 4 Shaft. Figure 2 shows the floor contours of the Bulli Seam. The natural pathway for water flow underground is from the outcrop on the Illawarra Escarpment down to the low point in the 200 series longwall panels. However, because of the irregular nature of the lease

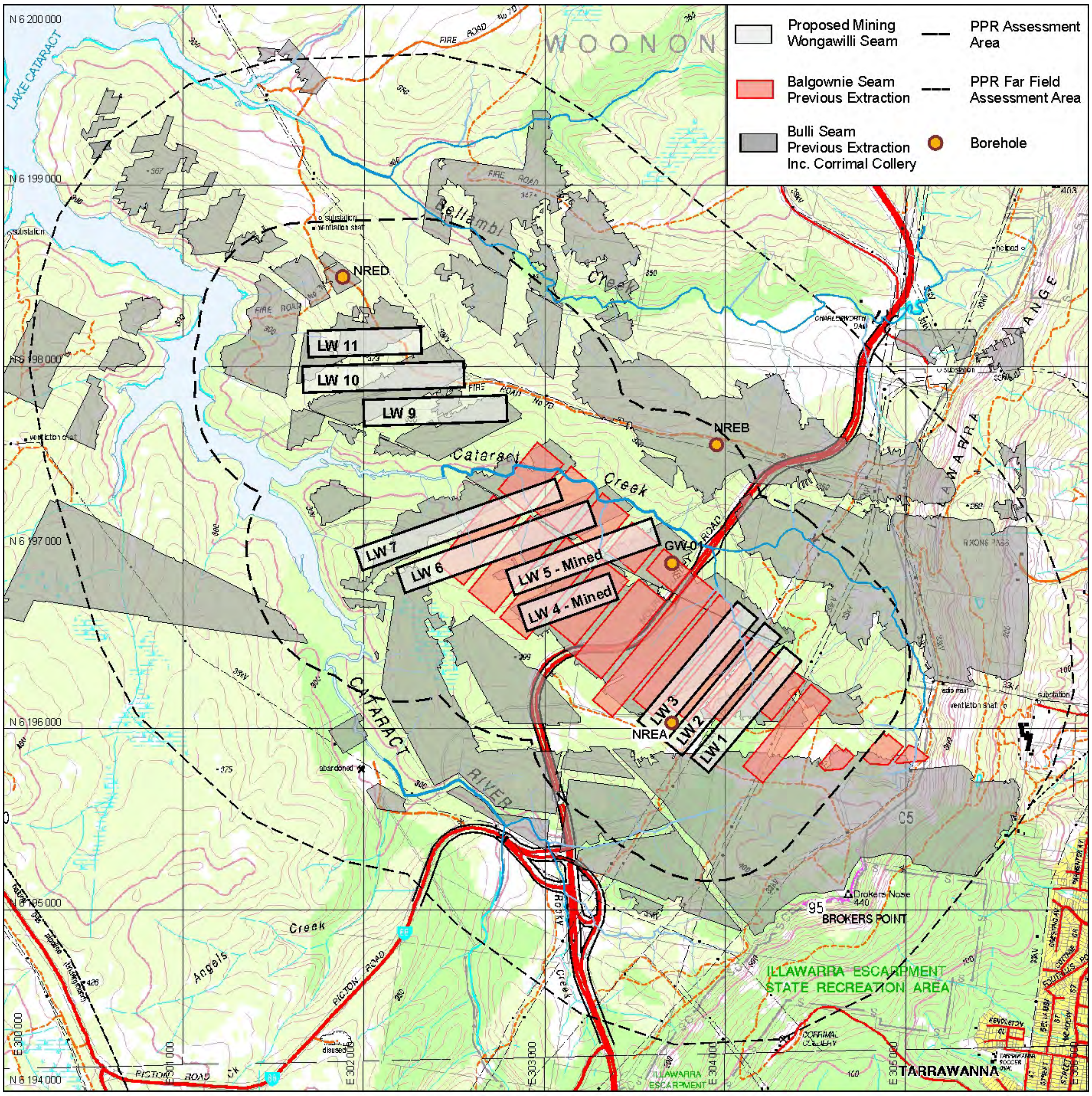


Figure 1: Plan of PPR mining area and previous mining activity.

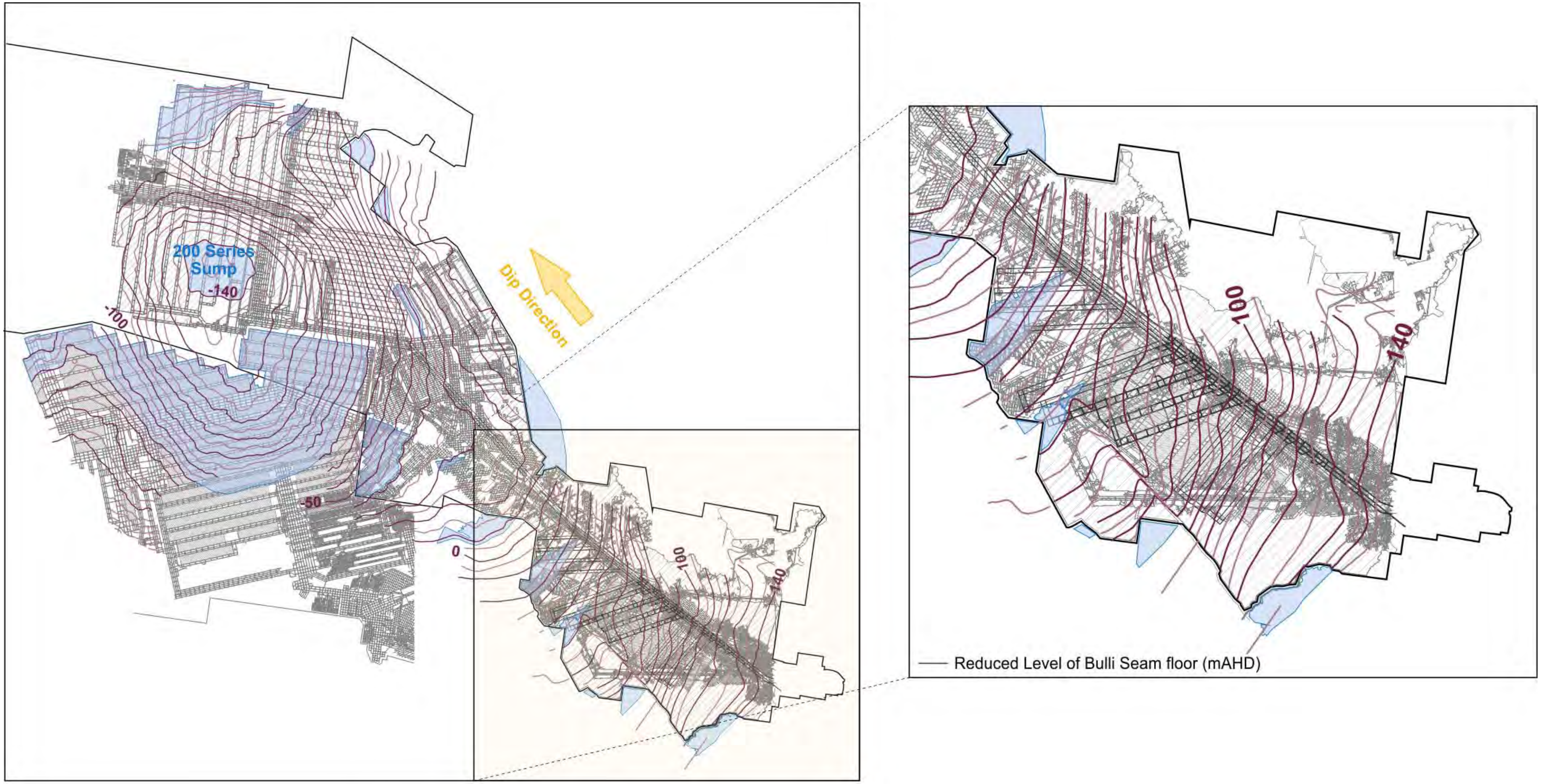


Figure 2: Plan showing floor contours of the Bulli Seam and locations of potential lodgements for water flowing down dip.

boundaries and the various panels within the mine, there are numerous underground storages created where water is impounded behind coal barriers within the mine and between mines. Water flowing from up dip flows into these underground storages until they become full and overtop allowing flow to continue down into the lowest point in the mine. Over time, all the storage areas have filled up and so any additional flow occurs through a chain-of-ponds along each of the barriers. A similar process is occurring in the adjacent Old Bulli and Corrimal Collieries.

2.2 Pumping from the Balgownie Seam at 48 Cut-Through

A borehole located at 48 Cut-through in the Bulli Seam is used to pump water from the Balgownie Seam and any water that may have drained down into the Balgownie Seam from up dip in the Bulli Seam.

During mining in the Balgownie Seam, the mine plan shows that headings that were planned to be mined below underground storages in the overlying Bulli Seam had to be stopped until the overlying storages were drained so as to eliminate any potential for an inrush of water from the Bulli Seam into the underlying Balgownie Seam workings only 5-10m below.

At the completion of mining in the Balgownie Seam and with direct hydraulic connection between the two seams through the Balgownie Seam goaf in each of the eleven longwall panels, some of the water that previously flowed down dip in the Bulli Seam was redirected into the lower seam and continued to flow down the dip in the Balgownie Seam. The lowest point in the Balgownie Seam is at the bottom of No 1 Shaft where water impounded in the Balgownie Seam, and any additional water captured in the Bulli Seam, is pumped from a borehole at 48 Cut-through to a holding tank at 47 Cut-through and then to a holding tank at 27 Cut-through. The flow in this line is metered.

When headings were developed in the Wongawilli Seam, there was a similar requirement for water stored in the overlying seams to be pumped out before mining could continue. This draining of water from the overlying seams had the effect of diverting flow from the Balgownie Seam pump out at 48 Cut-through into the Wongawilli Seam pump out. Once Longwalls 4 and 5 were mined, this diversion became permanent.

Figure 3 shows a history of the flow from the 48 Cut-through borehole into the Balgownie Seam and the rainfall deficit relative to a long term average for the same period. The pump out rate for most of 2011 increased gradually from 0.15Ml/day to a peak in late September 2011 of 0.25Ml/day. The reasons for this gradual increase in rate prior to September 2011 are not entirely certain, but it appears likely to be associated with an increase in long term rainfall recharge during this period. The possibility of rainfall recharge is considered reasonable based on experience at other sites given the 1-2m of subsidence associated with previous mining in the Bulli Seam and Balgownie Seam between the escarpment and Wonga East at overburden depths ranging between 200m and 300m.

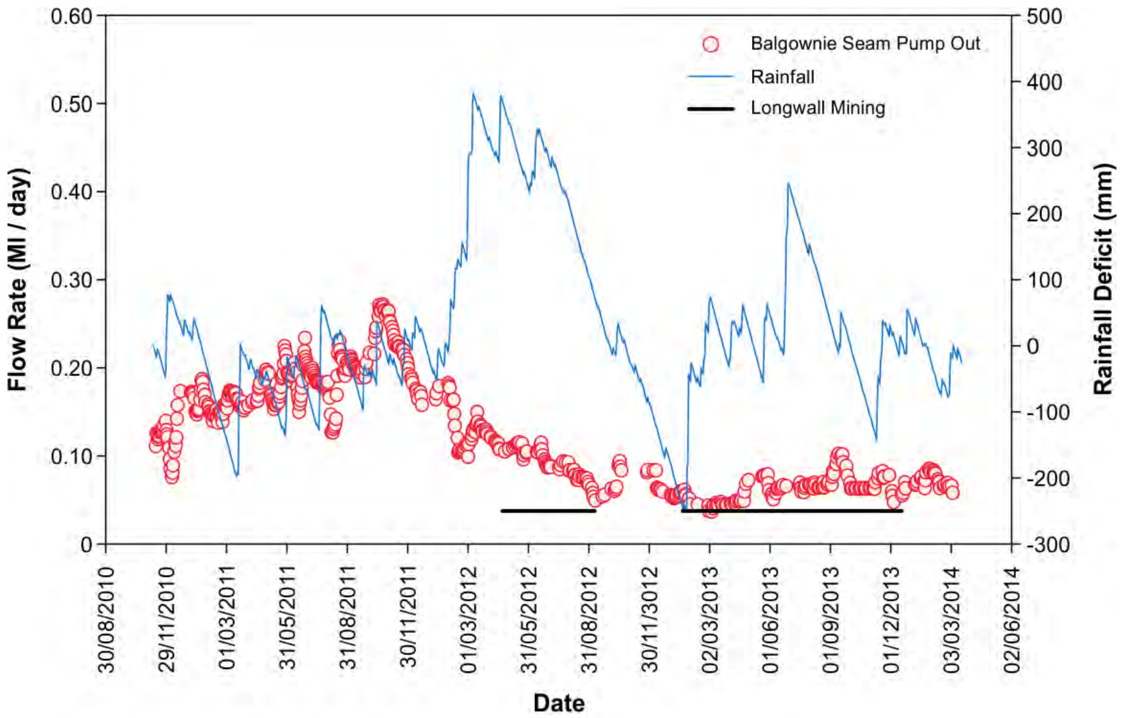


Figure 3: History of pump out from the Balgownie Seam at 48 Cut-through together with long term rainfall deficit.

A sharp drop in pump out rate occurred in October 2011 when drainage of Balgownie Seam storages (lodgements) into the Wongawilli Seam started to divert flow in the Balgownie / Bulli Seams into the Wongawilli Seam system and away from the 48 Cut-through borehole. Since then 48 Cut-through has stopped providing any useful indication of inflow from the Bulli and Balgownie Seams. While it was indicating an inflow into the Balgownie / Bulli goafs, the rate was about 0.2Ml/day on average when the rainfall is trending at average rates. Pumping from the Wongawilli Seam is now providing an indication of inflow from the Balgownie and Bulli Seams but combined with inflows from other sources.

Once Longwall 4 finished, the rate of pump out at 48 Cut-through stabilised at about 0.05Ml/day. Mining of Longwall 5 has had no further effect on the rate.

These results are interpreted as indicating that 0.20Ml/day flows over the floor of the Bulli Seam and into the Balgownie Seam and now into the Wongawilli Seam. A further 0.05Ml/day still flows to the low point of the Balgownie Seam, most likely from the northern side of Balgownie Seam workings that are not intercepted by the two longwall panels mined so far in the Wongawilli Seam.

2.2 Pumping from the Bulli Seam at R Mains 29 Cut-Through (Wonga West Area)

A holding tank located at 27 Cut-through in the Bulli Seam captures water pumped from the Balgownie Seam at 48 Cut-through and water pumped from the Bulli Seam sump that has formed at the low point in the 200 series longwall panels shown in Figure 2. Water from both sources is then pumped out of the mine through the Russell Vale portal and metered at the portal.

The long term average for pump out from 27 Cut-through since mining in the Bulli Seam finished is about 0.8Ml/day. However, a pump out test conducted at the R Mains 29 Cut-Through holding tank on 19 March 2014 indicated an average pump out rate of only 0.23Ml/day. This discrepancy is significant and further work is recommended to better understand the basis for the difference.

Discussion with mine personnel indicated that water was being pumped into the holding tank from X Mains (approximately 70% of the total) and 9 Cut-through S Mains (approximately 30% of the total). The X Mains low point is adjacent to the boundary with Cordeaux Colliery but also captures all the flow from up-dip. The S Mains 9 Cut-through site pumps from the 200 series longwall panel sump and this captures water from the 200, 300 and 500 series longwall panels. Further work is recommended to differentiate the flow that may be coming from the Cordeaux Colliery from that coming from up dip in the Bulli Seam.

2.3 Pumping from the Wongawilli Seam

Pumping from the Wongawilli Seam occurs in several stages. The main sump is a tank at 18 ½ Cut-through in the main headings. Water that emerges from the bottom of Longwalls 4 and 5 (south-western ends) flows along the floor and collects in a sump in the bleeder headings where it is pumped out to the main sump at 18 ½ Cut-through. Water from the Maingate 6 development headings is pumped into a holding tank in the panel and from there to the main sump at 18 ½ Cut-through. Water from the main sump is pumped up to a holding tank at 12 Cut-through and from there out of the mine to the Wongawilli Seam portal using one of two centrifugal pumps located at 12 Cut-through. There are various operations that recycle water underground for cleaning tanks, but these do not involve the main pumps at 12 Cut-through. The flow delivered by the 12 Cut-through pumps represents the pump out from the Wongawilli Seam. This flow was determined from pump hours assuming a flow of 50l/s until recently when a flow meter was installed at the surface.

To determine the reliability of the pump out rate requires an understanding of the detail of the pumping arrangements at 12 Cut-through. There are two Hydro-Titan centrifugal pumps of similar capacity installed at 12 Cut-through. Each pump has a non-return valve and they can both work in parallel if necessary. However, so far only one pump has been required to operate at any one time and even this pump is only required to operate about 5 hours a day to clear the water from the mine, typically in short bursts of about 80 seconds at a time when about 5m^3 is pumped into a 2km long, 150mm diameter pipe range leading out of the mine. The volume of this main range is about 35m^3 so a significant part of the pump cycle involves accelerating the fluid in the pipe range.

The first pump, Pump 101 (also referred to as Pump 2) was installed on 13 June 2012 soon after Longwall 4 started. The hour meter read zero hours at this time. Although the hours of operation of this pump were recorded from time to time, the early records are considered by the mine to be unreliable. A second pump, Pump 100 (also referred to as Pump 1) was installed in March 2013 soon after Longwall 5 commenced mining. This second pump has been used as the primary duty pump since then. Reliable pump hour readings are available from 31 October 2012 when Longwall 4 was complete until October 2013 and from February 2014.

The known zero hour reading at installation and the relatively steady nature of the pump out records since the completion of Longwall 4 allows the average hours of operations of the pumps during Longwall 4 to be estimated with reasonable confidence. A conservative approach has been adopted.

Figure 4 shows a summary of the pump out rates measured and estimated since the first pump was installed in June 2012. Both pumps appear to pump at essentially the same rate based on recent testing. Although there is an apparent change in the hours pumped when Pump 100 was installed, this seems likely to be associated with a period of reduced pumping requirements between longwall panels and the end of drier period when inflows to the mine were reduced or possibly a change in the float arrangements at the pump station.

The hours of operation of the centrifugal pumps at 12 Cut-through have been used by the mine as the primary basis for estimating pump out from the Wongawilli. Historically, an assumption has been made that the flow can be calculated from the characteristic pumping curves for each pump, nominally at a rate of 50l/s. A recent program of testing has been conducted to confirm the reliability of this rate.

A flow meter installed at the portal indicates a flow rate of 59l/s but this installation is not ideal in terms of location and the results from the flow meter were independently confirmed using a volume / time based flow test.

Pump out volume measurements conducted on 18 March 2014 indicate that the pump out rate varies from 47l/s to 64l/s depending on the volume pumped in each cycle because of the overhead associated with initially accelerating water in the pipe range. The volume pumped each cycle is a constant and the rate of 59l/s is considered reasonable for this volume. The testing conducted on 18 March confirmed the practicality of using this measurement system but further testing is recommended to confirm this rate and the characteristics of the pump out system. An average flow of 60l/s has been adopted for both pumps as a conservative estimate.

Other sources of water flow into and out of the mine are recognised. Water is pumped into the mine at an average rate of about 0.23Ml/day for dust

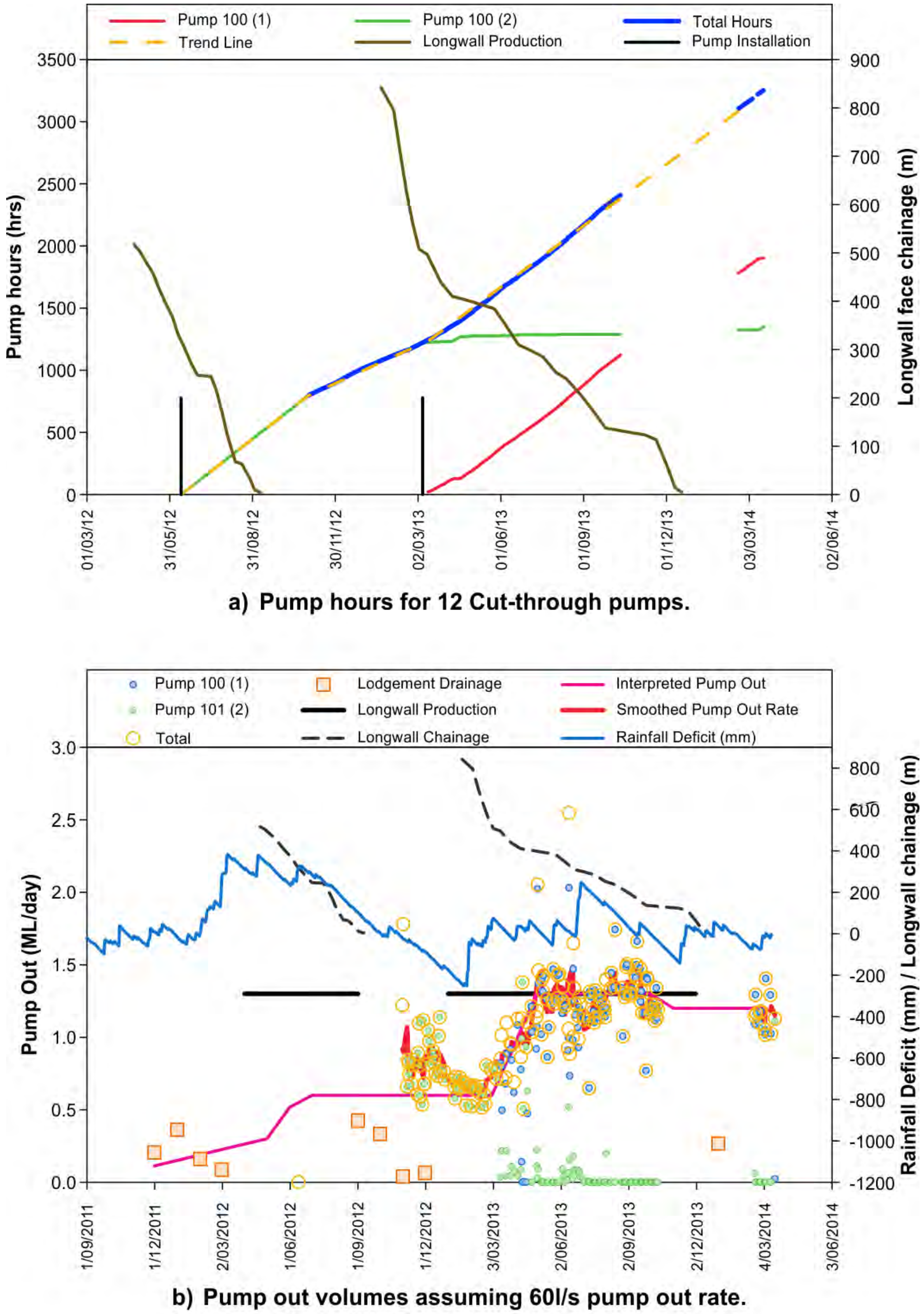


Figure 4: History of Pumping at 12 Cut-through in Wongawilli Seam.

suppression, drilling operations, and other purposes. This rate increases during longwall operations. Water also leaves the mine in the coal product. In situ moisture of coal is about 2% and the run of the mine product on the belt has a moisture content of about 6.5% so between 0.1Ml/day and 0.3Ml/day leaves the mine in the coal product when the longwall is operating and less than 0.02Ml/day leaves the mine at other times. Moisture also leaves the mine in the ventilation air, but measurements provided by the mine indicate this flow is very small.

Water is also released from time to time from storages either within the Wongawilli Seam, sumps that have been allowed to fill, or from the overlying seams, as dewatering of lodgements in the Balgownie Seam prior to mining development roadways. The rates of inflow associated with dewatering these lodgements are shown in Figure 4 but they are relatively small by comparison with other inflows.

Figure 5 shows the water balance that is considered to provide a reasonable estimate of the various inflows and outflows based on the available data. The accuracy of this water balance is considered to be about ±0.2Ml/day at any given time because of the uncertainties involved with short term variations caused by different reporting timeframes but about ±0.1Ml/day over the longer term when the short term fluctuations even out.

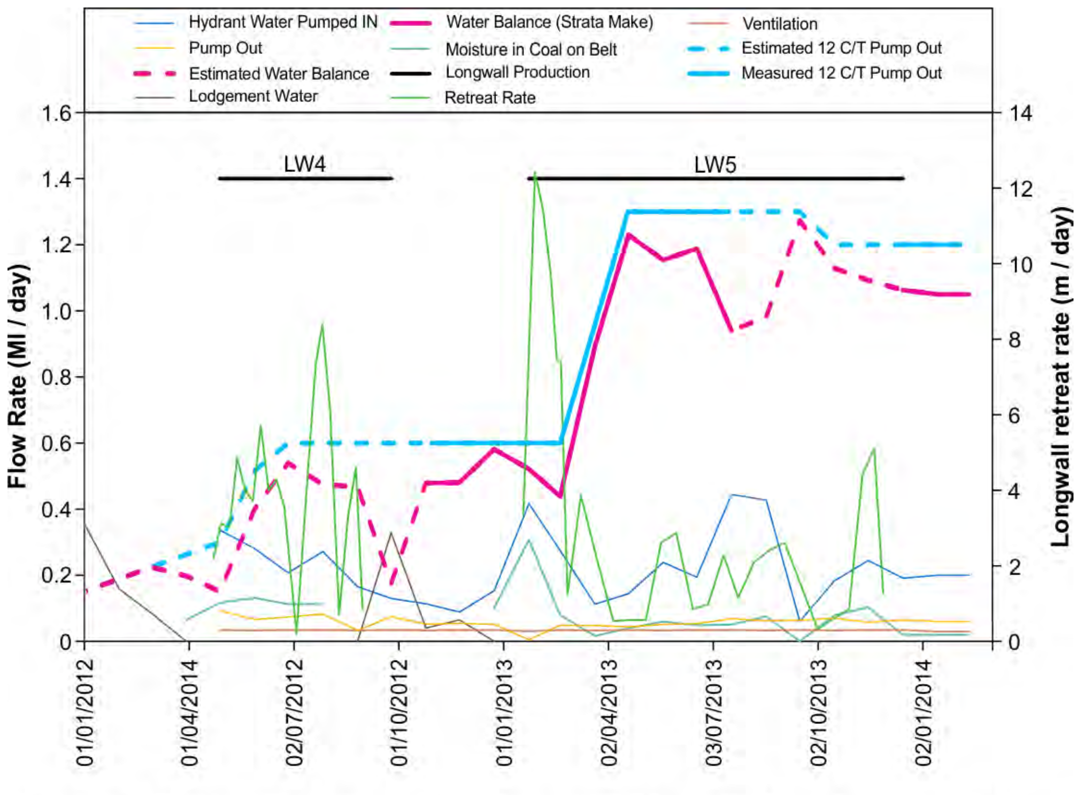


Figure 5: Mine water balance based on available and inferred pump out data.

Assigning sources to the water is recognised to be somewhat speculative. The apportionment considered to provide an overall balance is based on the following observations:

- Observations of flow from the down dip ends of Longwalls 4 and 5 observed on 18 March 2014 after a period of three months of no longwall activity estimated to be 2-3l/s and 4-5l/s respectively.

- Drawdown observed at 48 Cut-through prior to dewatering the Balgownie Seam of 0.2Ml/day.

- Changes in the water balance during mining of Longwalls 4 and 5.

- Estimated flow from Wongawilli Seam first workings.

Based on these observations and estimates, the water balance is apportioned as:

- 0.3Ml/day from Wongawilli Seam first workings.

- 0.2Ml/day from overlying Balgownie / Bulli Seam goaf (previously reporting to No 1 Shaft and now reporting to Longwall 4 goaf).

- 0.1Ml/day from Longwall 4 goaf (additional to that intercepted from Balgownie / Bulli Seam).

- 0.5Ml/day from Longwall 5 goaf (does not appear to have any intercepted Balgownie / Bulli Seam component).

There are some indications of an association between long term rainfall and the pump out records shown in Figure 4, but there is insufficient data to make a convincing association. Ongoing refinement of the underground water balance monitoring is recommended to help establish the characteristics of potential inflow sources and the potential for hydraulic connection with the groundwater recharge systems.

3. PIEZOMETER MONITORING

Vibrating wire piezometers have been installed at four locations in the Wonga East mining area. The results of these instruments are discussed in this section to provide an understanding of the groundwater system at the site. The results from these piezometer strings provide information on the height and lateral extent of perceptible changes from both short and long term rainfall trends, previous longwall mining in the Balgownie Seam, and changes in level in Cataract Reservoir. It is recognised that further piezometer monitoring is required to extend these initial findings and to confirm the hypotheses that have been drawn from these results. Additional installations are currently in progress through the approval process.

The locations of the vibrating wire piezometers in the Wonga East mining area are shown in Figure 1. The details of these piezometers are summarised in Table 1.

Table 1: Wonga East Vibrating Wire Piezometers

	Installed	Easting (m MGA)	Northing (m MGA)	Collar RL (mAHD)	Bulli Seam RL (mAHD)
NREA	18/11/09	303680	6196034	376.23	85
GW-1	23/8/12	303693	6196913	318.2	80
NREB	28/11/09	303939	6197567	372.69	90
NRED	6/11/09	301870	6198509	348.83	5

Individual piezometer results are discussed in the following sections followed by a compilation of results from all four sites.

3.1 Piezometer NRE A - East of Mount Ousley Road

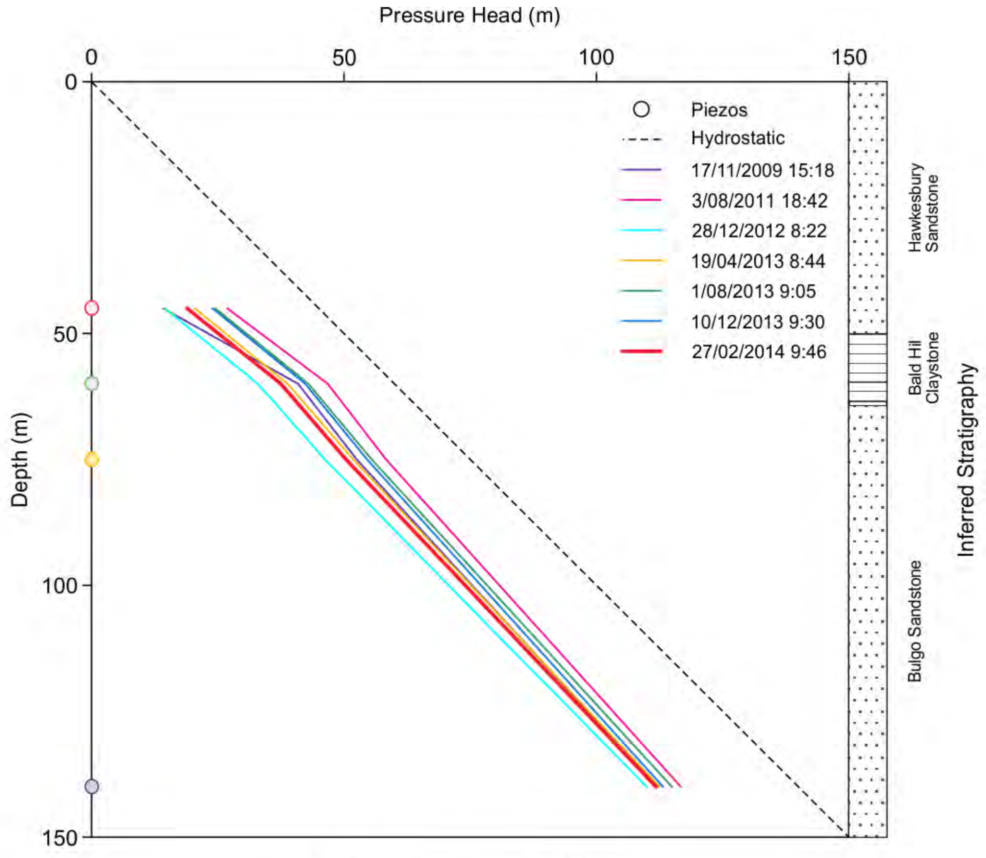
Piezometer NRE A is located on a ridge in the Hawkesbury Sandstone in an area where there are first workings in the Bulli Seam, nearby longwall mining in the Balgownie Seam and no nearby mining in the Wongawilli Seam.

Figure 6 shows the pressure profile measured on the four piezometers installed in this hole. These piezometers indicate a hydraulic gradient that is close to hydrostatic with the indicated phreatic surface varying from 15m to 30m below surface (RL360m to RL345m).

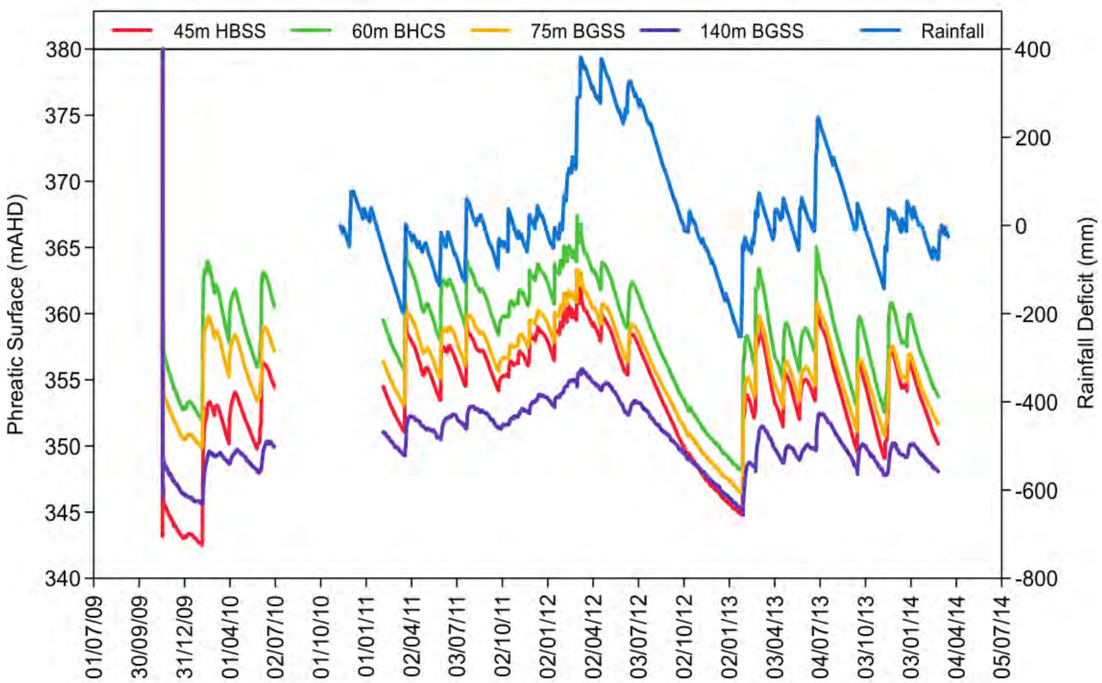
The hydrograph shows a clear and immediate response to short term rainfall trends consistent with the full column being vertically well connected through the Hawkesbury Sandstone, the Bald Hill Claystone and approximately 75m into the Bulgo Sandstone. There is some slight muting of the pressure response by a depth below surface of 140m in the Bulgo Sandstone, but the immediacy of the response in all the piezometers indicates there is nevertheless a high degree of vertical conductivity and the Bald Hill Claystone is not acting in any capacity to slow vertical flow at this location.

The individual piezometers indicate approximately the same phreatic surface level, but there is a slight trend of decreasing head with depth consistent with downward flow gradient from the surface toward the mining horizons. Given the high vertical conductivity indicated at this site by the rainfall response, the presence of a downward hydraulic gradient indicates a strong potential for this area to be a source of inflow into the mine, particularly if the height of depressurisation above the mining horizon interacts with the zone of elevated vertical connectivity from the surface.

While it is possible that the piezometer is not properly installed and the borehole is the source of the vertical conductivity, the downward trend with pressure does not support this hypothesis. A different explanation is considered much more likely. The piezometer NRE A is located on the same topographic ridge where there is clear evidence of horizontal stretching on the surface of Mount Ousley Road and open cracks in the adjacent terrain.



a) Piezometric profile.



b) Hydrograph and rainfall deficit.

Figure 6: Piezometer results for NRE A.

There were also tension cracks observed close to the site of NRE A during mining of Longwall 3 in the Balgownie Seam. The high level of vertically connected cracking and consequently a high level of vertical conductivity observed in NRE A is considered to be a result of the presence of vertical fractures and opening of existing joints caused by horizontal stretching. A second piezometer is proposed in this area in the near future and will help confirm the depth of elevated vertical conductivity.

The elevation of the phreatic surface at the NRE A site ranges from RL340m to RL360m. This elevation is at the level of the upper headwaters of Cataract Creek near the site. A phreatic surface at the levels indicated in NRE A is likely to contribute to a semi-permanent groundwater flow into the headwaters of Cataract Creek. Although there is a vertical hydraulic gradient downward toward the mine at NRE A and by implication some flow, there is also lateral flow into the headwaters of Cataract Creek at the same time and this lateral flow into the creek is still the primary control on the level of the phreatic surface.

A significant observation from NRE A is that with the high level of vertical connectivity associated with stretching movements caused by subsidence to a depth of at least 140m, the potential for downward flow into the mine is likely to be greatest directly below the stretching zone along the ridge top.

This piezometer string was installed well before the commencement of Longwall 4 and so there is a relatively long baseline of rainfall events prior to a series of high intensity rainfall events in early 2012 and the commencement of mining Longwall 4.

There is a clear reduction in piezometric pressure response post the start of mining Longwall 4 and this has continued through into Longwall 5, but close examination of the step change in the correspondence between rainfall and piezometric head change shows that the rainfall events prior to the start of Longwall 4 may have contributed to the initial lateral movement of the hillside toward the valley of Cataract Creek causing the increased correlation.

This lateral sliding mechanism occurs naturally but can also be mobilised by dilational subsidence movements generated by mining induced subsidence. This mechanism has been observed and closely monitored at Sandy Creek Waterfall (Walsh et al 2014 and Mills 2014) and observed at other sites where lateral movement on bedding plane shears in limiting equilibrium are mobilised by periods of intense rainfall. Glastonbury (2000) describes the deformation behaviour of rock slopes on pre-existing shear surfaces more generally. Young (1979) describes similar relationships between intense rainfall and slope instability on the Illawarra Escarpment. The mechanism of horizontal shear on a pre-existing natural bedding plane surface mobilised initially by mining in the Balgownie Seam and remobilised by intense rains appears likely to be operating at Wonga East as well.

The effect of the stretching movement induced by a combination of the intense rainfall, previous mining activity and recent mining activity has been to reduce the head of the background phreatic surface by about 5-10m post March 2012. Rainfall events appear capable of recharging the phreatic surface to pre-2012 levels, but the level drops back more quickly to the lower background levels. The volumes stored in open fractures in the recharge zone appear sufficient to account for the additional inflow volumes into the mine. Several large cracks observed during routine subsidence monitoring on the ridge above Longwalls 4 and 5 soon after the start of mining Longwall 5 have an estimated volume sufficient to account for the increased inflows observed underground soon after the start of Longwall 5.

3.2 Piezometer NRE B – West of Mount Ousley Road on Fire Road 7D

Figure 7 shows the results of piezometer monitoring at NRE B. Piezometer NRE B is located on a ridge to the north of Cataract Creek in an area where there has been secondary workings in the Bulli Seam but no mining in the Balgownie or Wongawilli Seams.

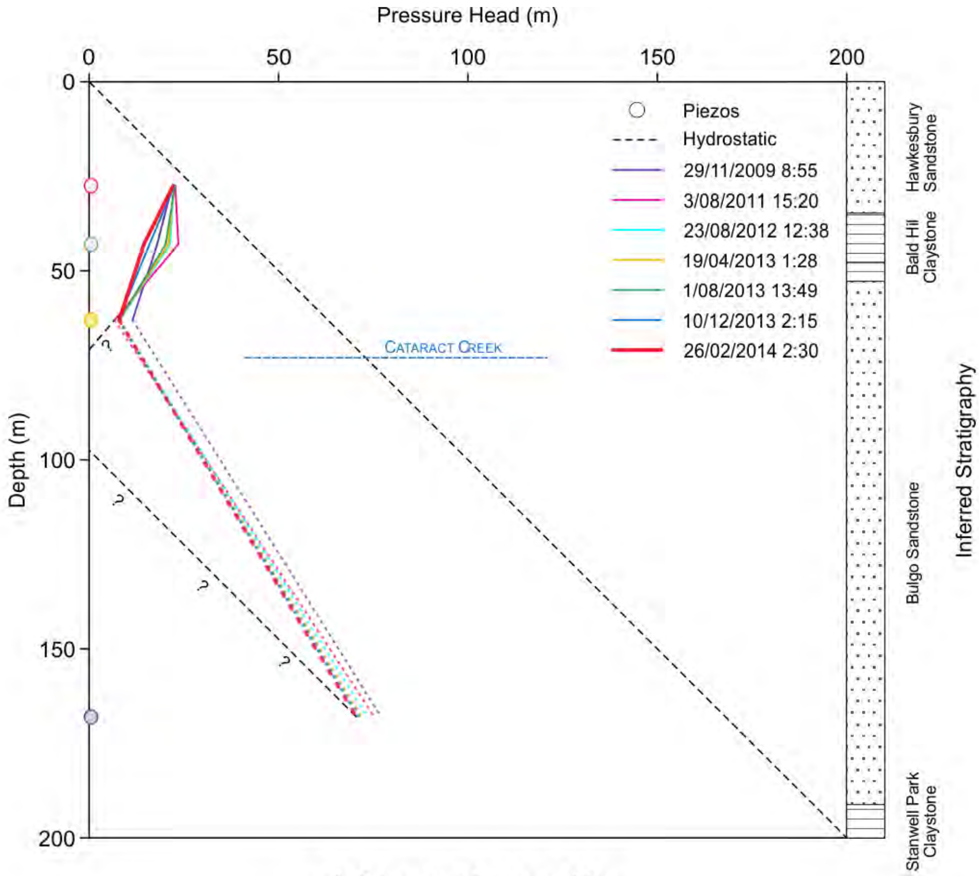
The piezometric profile shows a perched water table under the ridge that is drawn down to zero at an elevation above Cataract Creek. It is difficult to draw many conclusions from the single pressure reading at 168m depth below surface in the Bulgo Sandstone, but this single value is consistent with a groundwater level at about 100m below the surface or 30m below the base of Cataract Creek. The upper two piezometers in the Hawkesbury Sandstone respond slightly to long term rainfall trends, but the correlation is much less clearly evident in NRE B compared to NRE A.

Although there has been some mining below this site in the Bulli Seam, the extraction of coal has been much less systematic compared to the southern side of Cataract Creek where eleven longwall panels were mined in the Balgownie seam. The pore pressures in the Hawkesbury Sandstone are perched well above the level of Cataract Creek and the Cataract Reservoir. The pore pressure in the Bulgo Sandstone is below the RL289.87m Full Supply Level (FSL) of Cataract Reservoir.

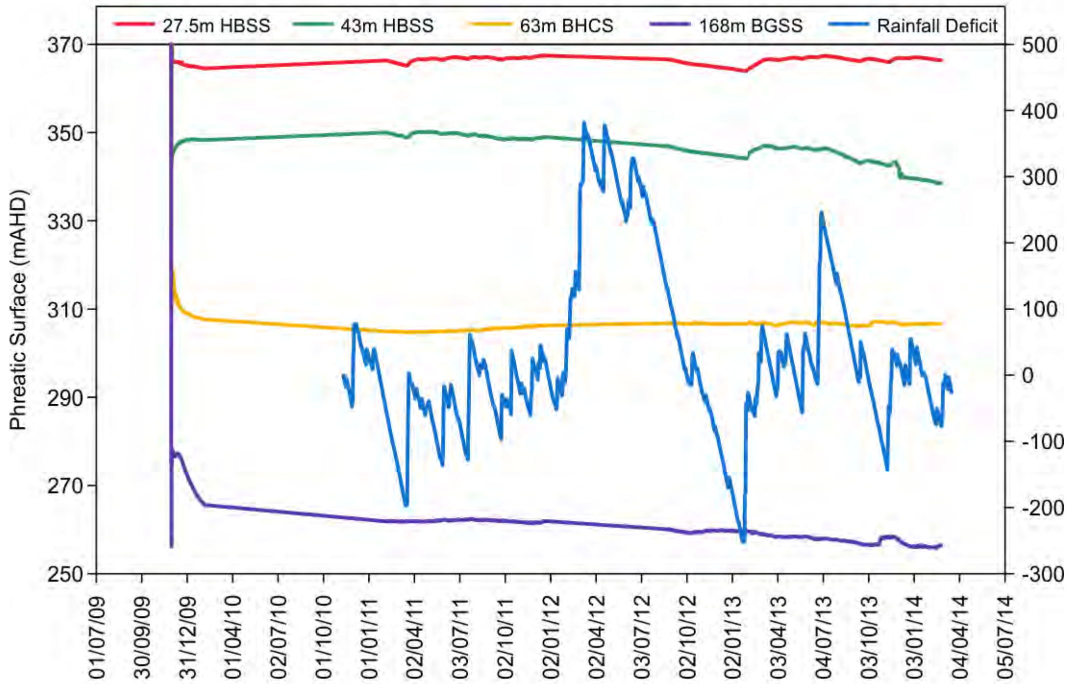
The piezometer data from NRE B indicates that there is a downward hydraulic gradient, but the hydraulic properties of the intact strata are sufficiently low in the undisturbed strata that there is almost no flow. The response to long term rainfall trends even at relatively shallow depths within the Hawkesbury Sandstone is muted and only varies around a long term average by a few metres. There is a slow downward trend evident in the lower Hawkesbury Sandstone at 43m and the Bulgo Sandstone at 168m from about July 2011, but there is not clear reason for this trend and it is not replicated in the piezometer located vertically between the two that are trending downward.

3.3 Piezometer NRE D – Western Edge of Wonga East Mining Area

Figure 8 shows the results of piezometer monitoring in piezometer NRE D. Piezometer NRE D is located further west along the ridge to the north of Cataract Creek from NRE B. The strata dips to the west so the equivalent geological units are about 75m lower at NRE D compared to NRE B. There have been some limited secondary workings in the Bulli Seam but no mining in the Balgownie or Wongawilli Seams.

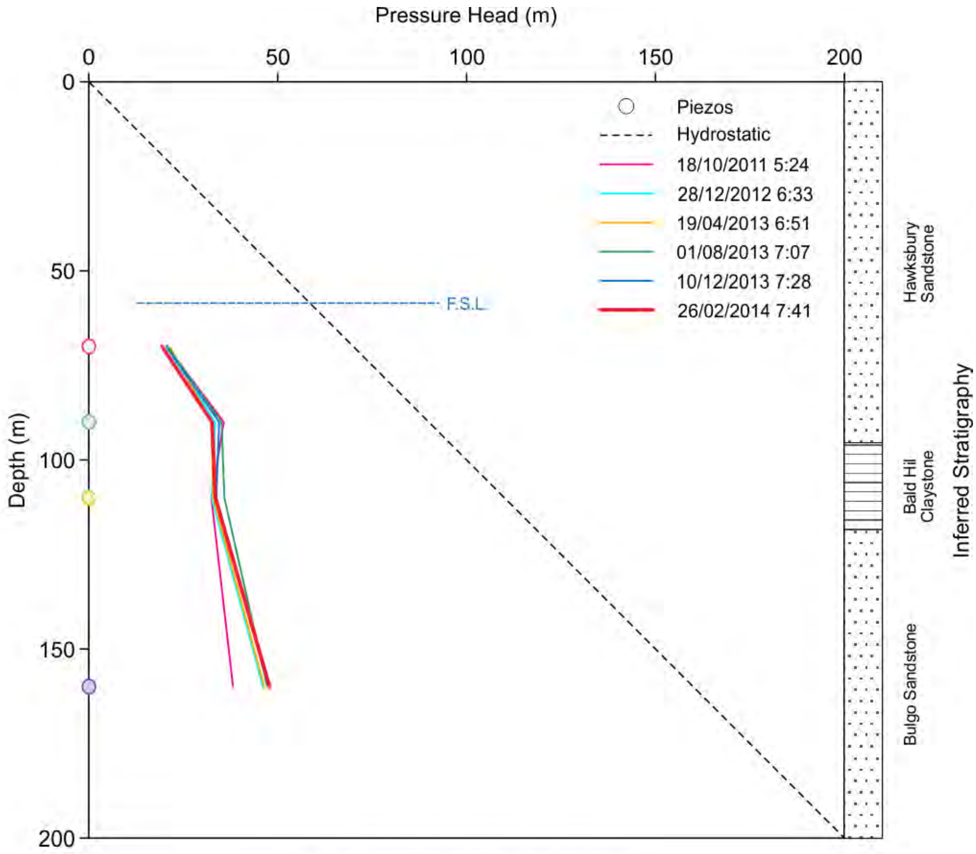


a) Piezometric profile.

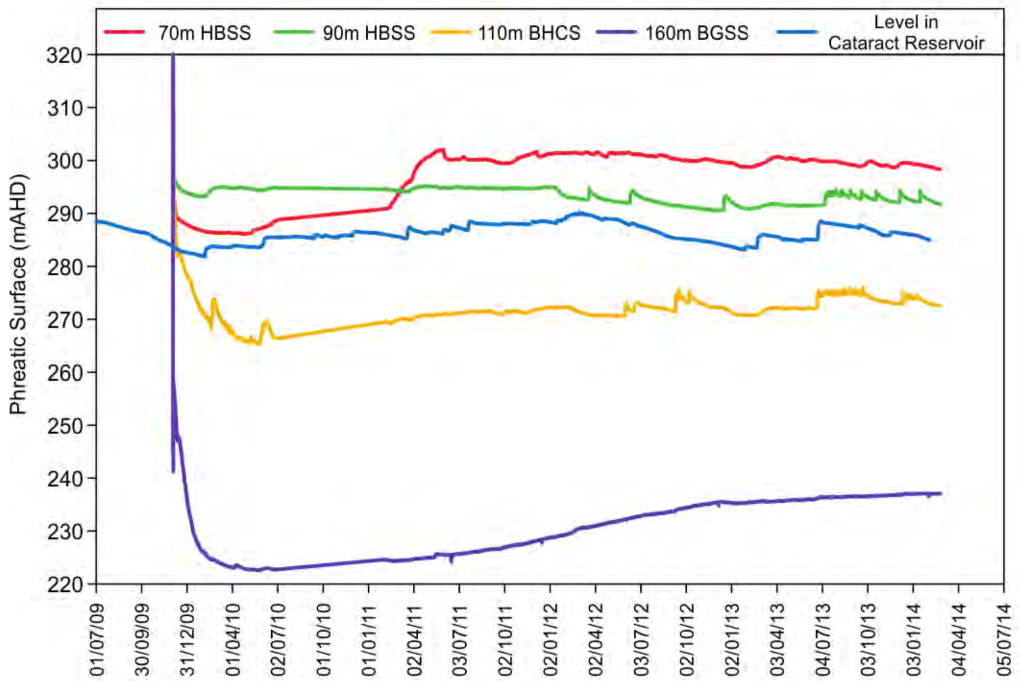


b) Hydrograph and rainfall deficit.

Figure 7: Piezometer results for NRE B.



a) Piezometric profile.



b) Hydrograph and level in Cordeaux Reservoir.

Figure 8: Piezometer results for NRE D.

The piezometric profile shows the phreatic surface in the Hawkesbury Sandstone under the ridge is only slightly above the Full Supply Level (FSL) of Cataract Reservoir (RL289.87m). The pore pressure in the Bald Hill Claystone is drawn down 20m below FSL and the pore pressure in the Bulgo Sandstone is drawn down about 60m below FSL. This profile indicates a downward hydraulic gradient but the mine pump out records indicate there is very limited vertical flow down into the Bulli Seam workings so the in situ vertical hydraulic conductivity appears to be limiting the downward flows to the low levels observed underground.

The piezometer responses show a slight correlation with long term rainfall trends particularly the responses of the two lower piezometers. However in addition to the gradual rainfall deficit trends, there is a very strong correlation with the level of Cataract Reservoir, particularly for the piezometer located in the Bald Hill Claystone.

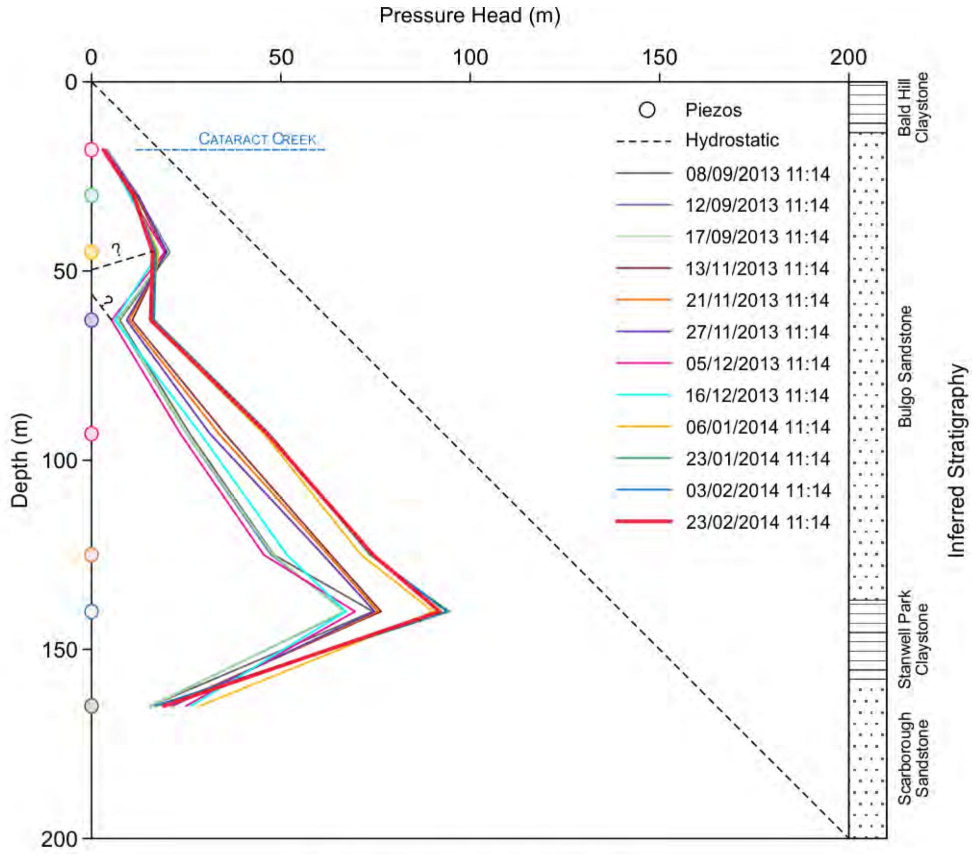
The correlation indicates that there is some lateral connectivity between the reservoir and the NRE D piezometer. NRE D is located approximately 540m from the nearest edge of Cataract Reservoir. This lateral connection is considered most likely to be along a bedding plane shear at a level just below the base of Cataract Reservoir (estimated in this area to be at about RL282m) and an equivalent depth below surface of about 70m in NRE D.

The piezometric pressure in the Bald Hill Claystone and Bulgo Sandstone below hydrostatic and below the level of Cataract Reservoir indicates there is a downward hydraulic gradient towards the mine in these units. The correlation with the changes in water level in Cataract Reservoir indicates there is a connection between NRE D and the reservoir even at a distance of 540m. There is a hydraulic gradient away from the mine towards the reservoir in the Hawkesbury Sandstone and a hydraulic gradient from the reservoir back toward the mine at the Bald Hill Claystone and Bulgo Sandstone horizons. The very low levels of inflow observed into the Bulli Seam indicate the hydraulic conductivity of the strata must be sufficiently low to limit any significant inflows into the mine to low levels despite this apparent connection.

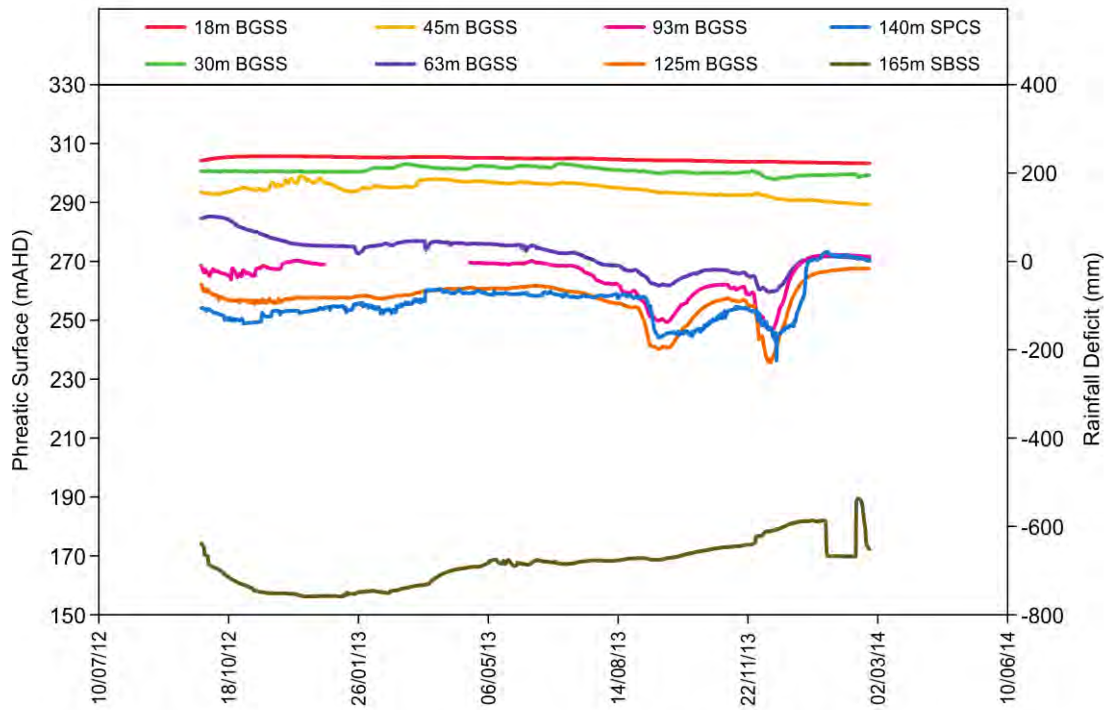
3.4 Piezometer GW-1 – Old Mount Ousley Road South of Cataract Creek

Figure 9 shows the results from Piezometer GW-1. Piezometer GW-1 was installed on the original alignment of Mount Ousley in September 2012 after completion of Longwall 4. The borehole is located above the goaf of Longwall 7B in the Balgownie Seam in an area where the Hawkesbury Sandstone has been completely eroded away. The site is approximately 175m from Cataract Creek, 345m from the northern end of Longwall 4 and 125m from the finishing corner of Longwall 5.

The piezometric pressure profile in GW-1 indicates there are two groundwater systems operating in this area. There is a near surface perched water table and a second deeper groundwater system. Both are located within the Bulgo Sandstone. There is likely to be a degree of vertical connection between the two, but they are regarded in this report as being essentially separate systems.



a) Piezometric profile.



b) Hydrograph and rainfall deficit.

Figure 9: Piezometer results for GW-1.

3.4.1 Perched Water Table

Figure 10 shows close ups of the hydrographs for the piezometers in the two groundwater systems at GW-1; the perched water table and the deeper piezometers both in the Bulgo Sandstone.

Figure 10a shows that the phreatic surface of the perched water table indicated by all three piezometers in the perched water table is close to the level of Cataract Creek (approximately RL300m). During the period of monitoring to date only the lower two piezometers have correlated responses to rainfall and the effect has not been strong.

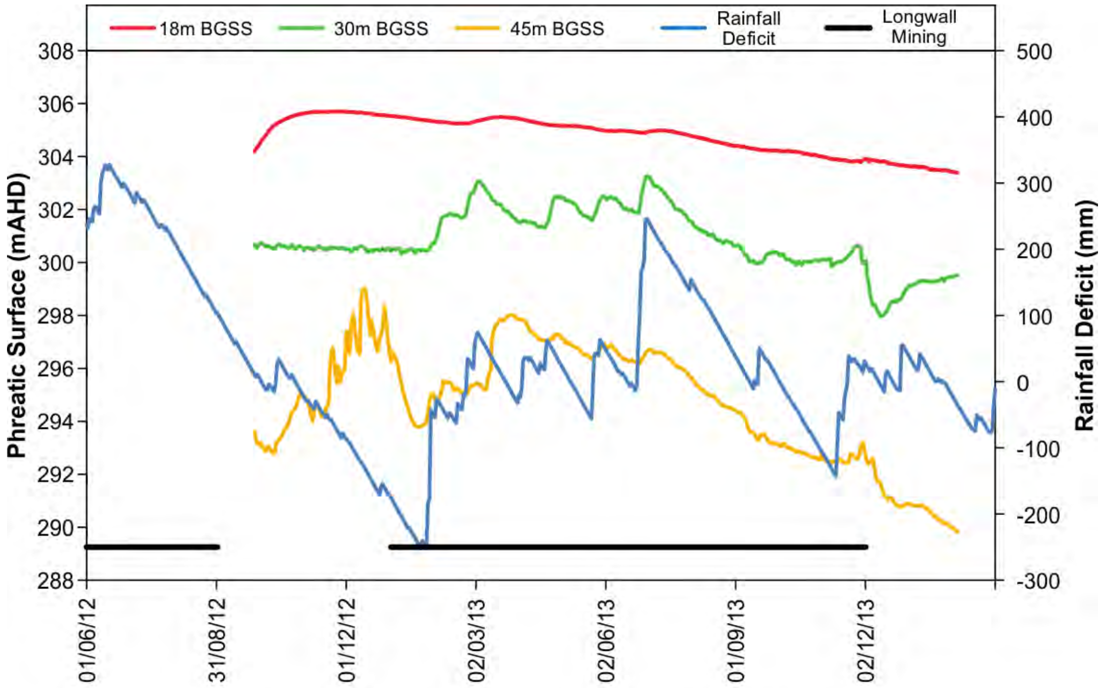
There is a slight reduction in the level of the phreatic surface in all three piezometers located in this perch. The reduction commenced soon after Longwall 5 started and continued throughout the period of mining Longwall 5. The long term downward trend from the start of Longwall 5 is considered to be a result of mining and the reactivation of a basal shear plane that may have originally been natural but was likely also reactivated or formed during previous mining in the Balgownie Seam and Longwall 4.

The approach of Longwall 5 appears to have caused a reduction in the level of the phreatic surface that is still nominally above the level of Cataract Creek at 18m below the surface (RL300m) but is lower than the creek at 30m and 45m below the surface. The effect of mining Longwall 5 appears to have been to slightly elevate the horizon separating a flow gradient toward Cataract Creek from the flow gradient toward the mine, in effect increasing slightly the potential for flow from Cataract Creek toward the mine via the deeper strata. The surface strata is still indicated as having a flow gradient toward the creek at the top of the perch but this gradient has been reduced slightly by mining Longwall 5.

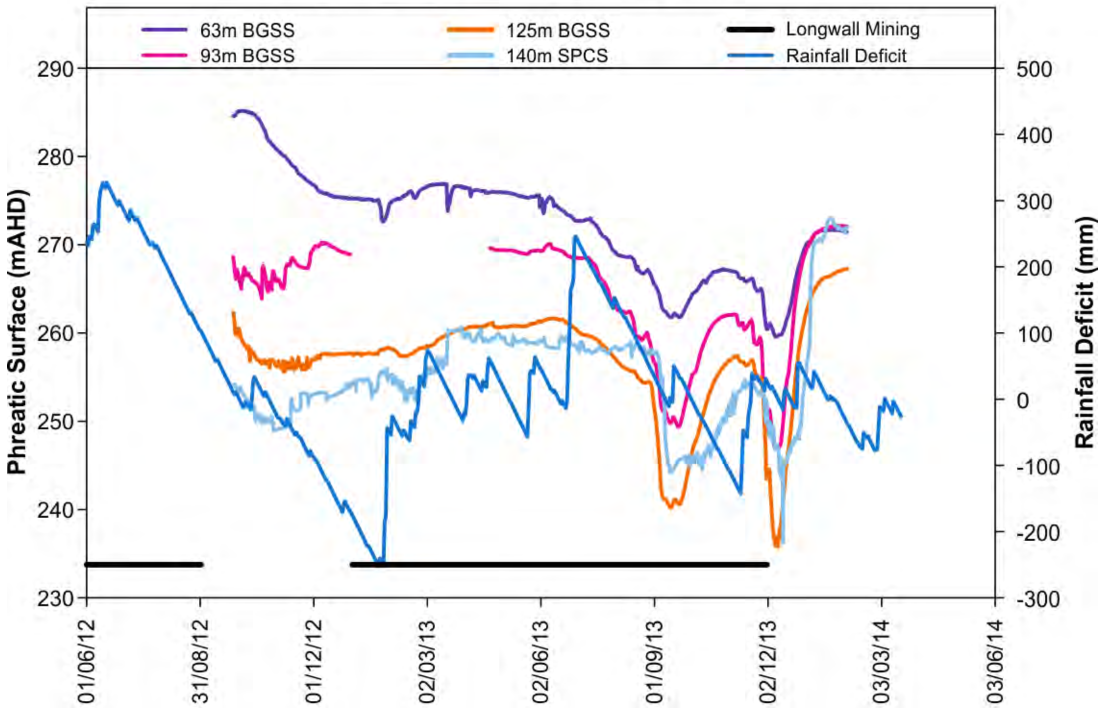
The uppermost piezometer at 18m below the surface does not change significantly over time or show much response to rainfall but this may be because it is operating at very low pressures and is close to dry.

The 30m piezometer is steady prior to the start of Longwall 5, possibly because of an extended dry period prior to installation, but coincident with the start of Longwall 5 and an intense rainfall event there is a clear response to rainfall that continues from then on. The level of the phreatic surface indicated by the 30m piezometer was initially several metres higher than the RL300m level of nearest point on Cataract Creek, but with the mining of Longwall 5, the phreatic surface indicated is 299.5m or about half a metre below the level of the nearest point on Cataract Creek. In other words, at the 30m depth horizon in GW-1 (about 12m below the level of Cataract Creek) the hydraulic gradient is slightly away from Cataract Creek toward the mine.

The deepest of the three piezometers in the near-surface perch at 45m shows a more muted response to rainfall but shows the strongest decline in head of the three with a fall from RL298m to RL290m during the period of mining Longwall 5.



a) Hydrograph in the perched water table.



b) Hydrograph in the deeper water table.

Figure 10: Close up of the hydrographs for GW-1.

The relative water levels indicated by each of the piezometers shows that there is a slight downward gradient within the perch suggesting downward flow from the perch into the lower groundwater system and the change in gradient indicates the downward gradient has increased during the period of mining Longwall 5.

The perched water level is interpreted as being hydraulically connected to Cataract Creek most likely via a horizontal shear horizon just below the level of Cataract Creek. The hydraulic conductivity of this connection is such that rainfall recharge from the surface is able to flow back into Cataract Creek but mining increased the gradient toward the mine, particularly in the deeper strata.

3.4.2 Deeper Water Table

Figure 10b shows that the deeper groundwater table has clearly responded to the later stages of mining Longwall 5. As the longwall approached within about 400m of the piezometer, there was a drop in pressure that was greater with depth below surface. Mining then ceased for a period, recommenced and then the longwall finished. The pore pressure recovered each time to pre-mining levels and following the completion of Longwall 5 the pore pressures have recovered to levels higher than at any time in the past.

This response is thought to be a result of mining activity slightly increasing the volume of pore space within the strata causing the pore pressure to be temporarily reduced. Inflow from above and possibly laterally has allowed the pore pressures to recover to above pre-Longwall 5 levels, possibly as a result of enhanced vertical connectivity caused by mining induced ground movements. The volumes involved in this process are likely to be transitory but may have caused a temporary period of increased recharge from Cataract Creek.

There is still a downward hydraulic gradient toward the mine evident throughout the Bulgo Sandstone but the flows appear to be of a low magnitude based on the mine inflow records. The low flow would be consistent with the low hydraulic conductivity of only slightly disturbed strata.

3.4.3 Height of Depressurisation

The piezometric profile in GW-1 shows the height above the mining horizon where there is depressurisation below hydrostatic and by implication the vertical height above an existing mined void where there is sufficient downward flow into the mine that the pressure profile can no longer be maintained. Extrapolation indicates that the point of zero pressure has occurred at a depth of approximately 170m below surface in the Scarborough Sandstone.

For the longwall panel geometry in the Balgownie Seam (in this case the 150m length of Longwall 7B) and a depth to the mining horizon of 240m, the height of depressurisation calculated using the approach formulated by

Tammetta (2012) is approximately 200m for a nominal 1.3m mining height in the Balgownie Seam. The effective mining height from two seams would need to be about 2.0m for the observed height of depressurisation to be 170m below surface.

The Bulli Seam is nominally 2.2m thick but mining in this area did not involve full extraction. It is credible that the effective height of mining in both seams could be 2.0m and that the Tammetta approach provides a basis to estimate the height of depressurisation above the most recent panel mined if the combined mining height is assumed. Further measurements in a multi-seam mining environment are planned to confirm this single data point.

3.5 Compilation of Piezometer Measurements

Figure 11 shows the four vibrating wire piezometer installations NRE A, GW-1, NRE B, and NRE D plotted at a common scale and reduced level. The stratigraphy indicated is only approximate and a composite based on the known depth to the Bulli Seam at each location and a geological section interpreted from geophysical logs in GW-1, but it serves to show the approximate position of the various measurements relative to stratigraphy.

Figure 11 shows that only GW-1 goes deep enough to measure the piezometric pressure in the Scarborough Sandstone and the inferred top of the zone of depressurisation above the Balgownie Seam longwall panels. GW-1 and NRE B indicate that there is effectively zero pressure at the level of Cataract Creek. NRE D shows that the groundwater table at a location 540m from the reservoir is influenced by the level of Cataract Reservoir.

Figure 12 shows the four vibrating wire piezometer installations plotted at scale on both the horizontal and vertical axes along a section that joins them all. No attempt is made to estimate the variation between boreholes; the connections are shown as straight lines except for Cataract Creek which provides another control point. The surface and the stratigraphy are based on the measured collar heights and the stratigraphy at each location. The reduced levels of the phreatic surfaces indicated by piezometers in the Bulgo Sandstone and in the Bald Hill are also plotted.

This data indicates that apart from in the vicinity of Cataract Creek near the Mount Ousley Road Crossing, the phreatic surface in the Bald Hill Claystone is above the level of the Bald Hill Claystone itself. The phreatic surface in the Bulgo Sandstone is only above the level of the Bald Hill Claystone at NRE A.

In the vicinity of GW-1, NRE B, and to a lesser extent at NRE D, the groundwater level in the Bulgo Sandstone is drawn down below the level of both Cataract Creek and the FSL of Cataract Reservoir. The phreatic surface of the Bulgo Sandstone is also indicated as being drawn down below the phreatic surface indicated in the Bald Hill Claystone by between 50m and 55m at all three locations. This indicates that there is a consistent downward hydraulic gradient evident at GW-1, NRE B, and NRE D. There is also some lesser downward hydraulic gradient evident at NRE A but given the elevated vertical hydraulic gradient at NRE A, the inflow potential at NRE A is considered much more significant.

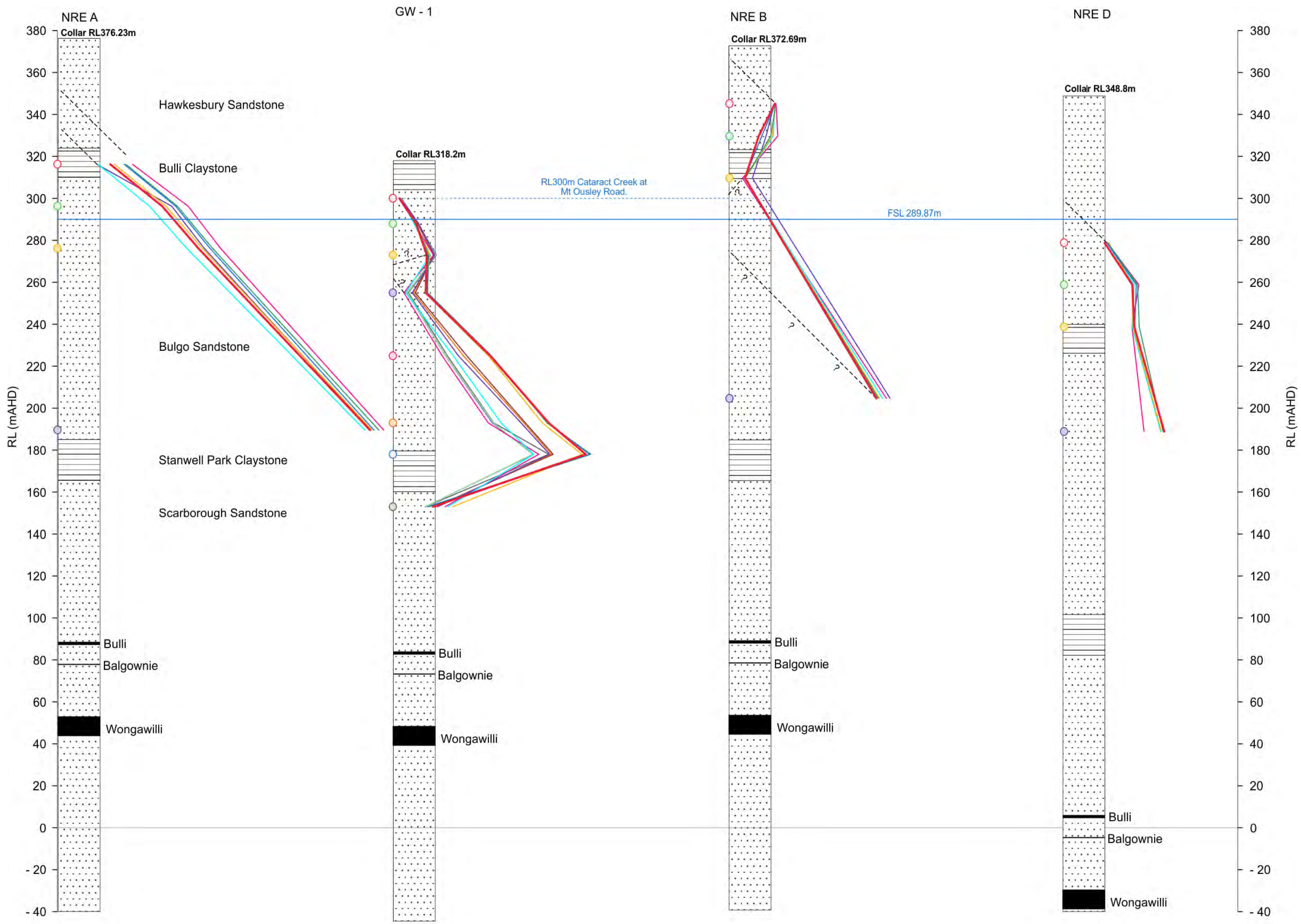
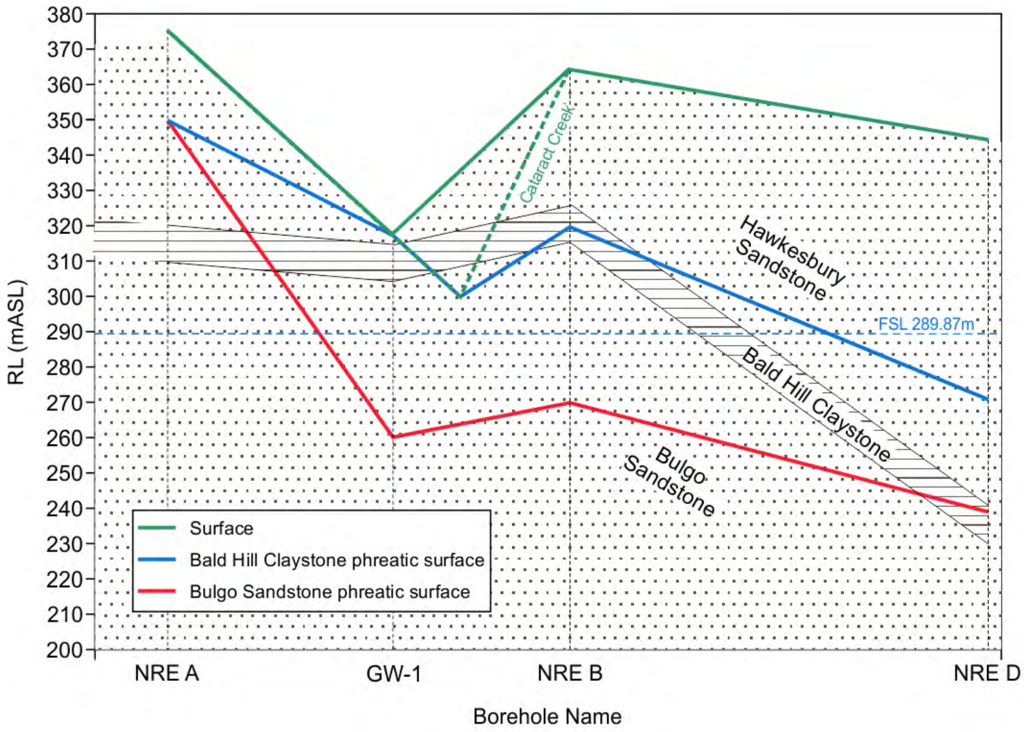


Figure 11: Piezometer monitoring across the Wonga East area plotted at the same vertical scale and elevation.



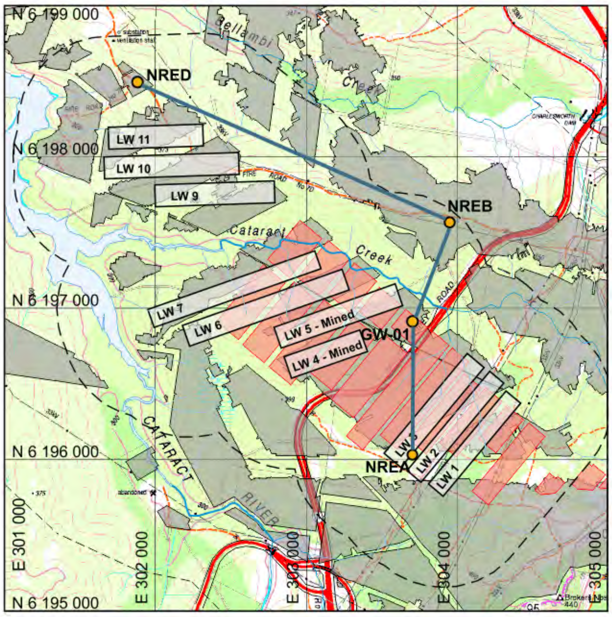


Figure 12: Piezometer monitoring across the Wonga East area plotted in section at a common horizontal and vertical scale.

By comparison with the other sites, NRE A is clearly in a location where there is elevated vertical hydraulic conductivity and a likely source of recharge from surface rainfall and over land flow into a large open fracture network. The other piezometers are located in areas where the vertical hydraulic conductivity is indicated as being low and the downward hydraulic gradients is interrupted by lateral flow into and out of Cataract Creek and Cataract Reservoir at different horizons.

4. HYDRAULIC CONDUCTIVITY MEASUREMENTS

Hydraulic conductivity measurements from the Wonga East area that have been reviewed for this assessment are limited to packer testing in GW-1. The results from GW-1 are considered to be within the range that would be expected for Bulgo Sandstone.

The results of the packer testing are summarised in Figure 13. These results indicate that the hydraulic conductivity of the overburden strata reduces with depth below surface. At 20m below surface, the hydraulic conductivity is about 1×10^{-6}m/s. At 150m below surface the hydraulic conductivity has reduced to about 2×10^{-9}m/s. There are several zones of higher hydraulic conductivity apparent and some of these are considered likely to be mining induced.

The packer testing measurements do not provide any differentiation between hydraulic conductivity in a vertical direction and hydraulic conductivity in a horizontal direction. Horizontal hydraulic conductivity is usually assumed to be about an order of magnitude greater than vertical hydraulic conductivity in horizontal bedded strata but this ratio needs to be confirmed at this site.

Assuming the hydraulic conductivities measured in GW-1 are representative of the strata generally, inflow rates from the surface are expected to be of a low magnitude. However, the data that is most relevant to mine inflows is directly over the longwall panels and in the vicinity of the ridge where NRE A is located and stretching subsidence movements have occurred. There are currently no hydraulic conductivity measurements in either area but WC is expanding the groundwater monitoring program in the near future to include piezometer and packer testing in both areas.

5. CONCEPTUAL MODEL AND IMPLICATIONS FOR FURTHER MINING

A conceptual/analytical model of the groundwater system in the Wonga East area has been developed based on analysis of the currently available data and its various characteristics. While this model is considered convincing and consistent with the data currently available for the Wonga East area, further calibration and ongoing improved monitoring of underground pumping systems and further monitoring of groundwater pressures using piezometers will allow continuous refinement and improvement as a basis for understanding as well as to underpin the more extensive numerical modelling. It should be recognised that the outcomes of the conceptual model presented in this report may differ somewhat from the results of larger scale numerical modelling because of the conceptual model's greater flexibility to address the specific local site conditions in the relatively small area of Wonga East.

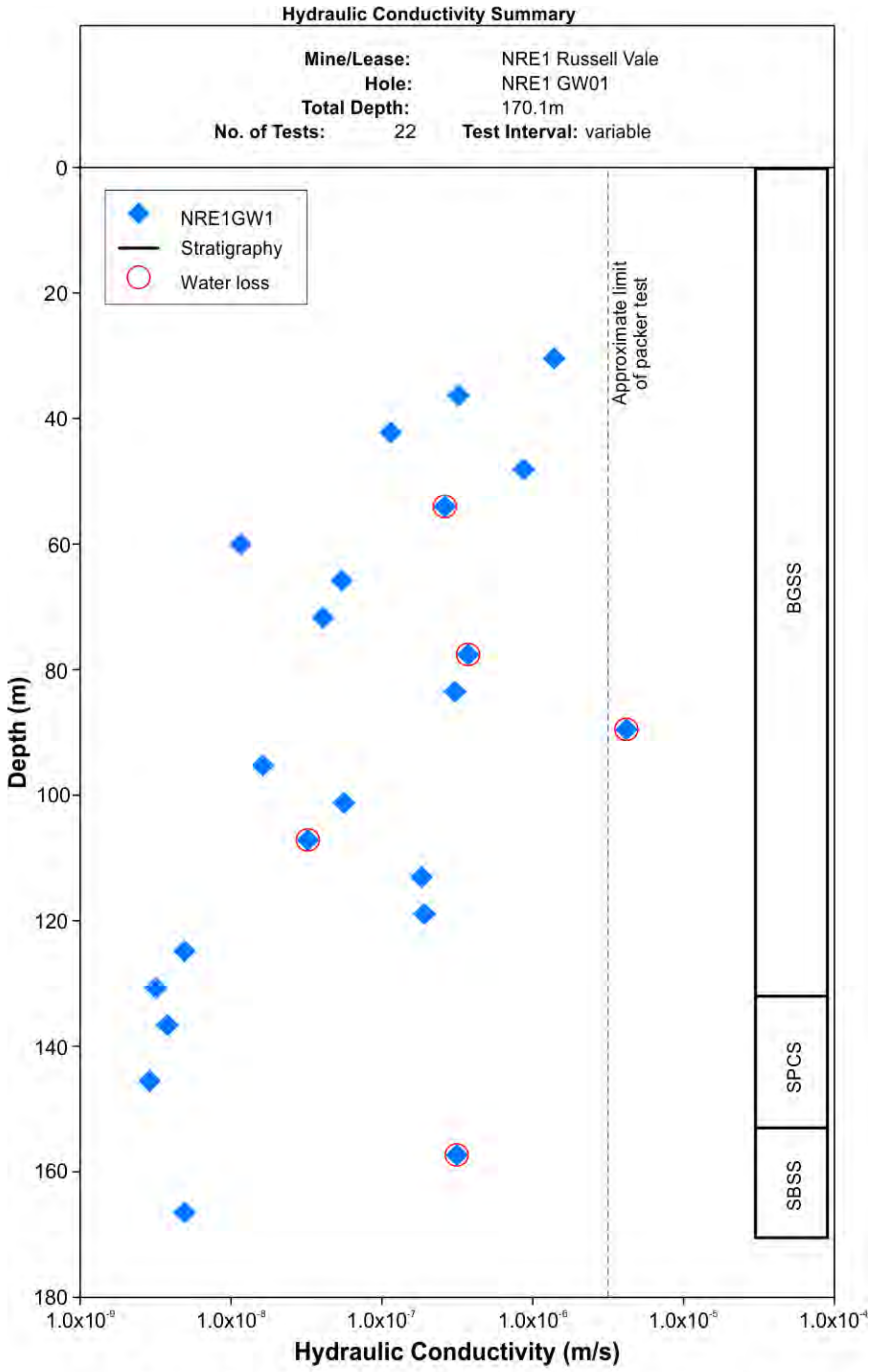


Figure 13: Summary of packer testing in GW - 1.

This model indicates that approximately 1.1Ml/day is seeping into the Wonga East underground mine from the surrounding strata once the balance of water that is pumped into the mine and leaving the mine in the coal product and ventilation has been taken into account.

5.1 Sources of Mine Inflow

A section of the ridge south of Cataract Creek where the ground is stretched by subsidence movements and there are large tension cracks evident on the surface appears likely to be a significant source of inflow into the mine. In this area, the hydraulic conductivity of the overburden strata appears to be significantly enhanced to a depth of at least 140m below surface and yet there is still a downward gradient evident in the piezometer results. Mining activity including longwall mining in the Balgownie Seam and more recently Longwalls 4 and 5 in the Wongawilli Seam is likely to have contributed to the increased vertical hydraulic conductivity observed and is estimated to be sufficient to produce the inflows observed underground.

Although surface cracking along the ridge line to the south of Cataract Creek appears likely to be a major source of seepage into the mine, the groundwater levels are still indicating the headwaters in Cataract Creek are controlling the groundwater level and by implication receiving most of this rainfall recharge flow as a result. This balance between some inflow into the mine, generally at low levels, and lateral flow including along horizontal shear planes from/to adjacent creeks appears to occur all across the site. The inflows into the mine are indicated as being at low levels based on the overall water balance observed.

Further work is underway to test the calibration of the underground pump out system and measure the hydraulic conductivity and deeper piezometric pressure profile at two locations along the ridge line to the south of Cataract Creek.

All the piezometers show a downward hydraulic gradient towards the mining horizons past and present consistent with downward flow of low magnitude. This downward hydraulic gradient existed prior to recent mining in the Wongawilli Seam and while there has been some increase in the vertical gradient evident during mining in the Wonga East area the additional increases have been relatively small.

The magnitude of downward flow appears to be largely restricted by the naturally low vertical hydraulic conductivity of the deeper overburden strata, particularly around the level the Stanwell Park Claystone, and the relatively large depth of mining. A zone of depressurisation is evident in piezometer GW-1 and the height of this zone is consistent with the method formulated by Tammetta (2012) for the mining geometry of the most recently mined panel and the combined thickness of all the seams that have been mined.

The flow measurements underground indicates that there has been a background inflow into the Bulli and Balgownie Seam up dip of the Wongawilli Seam mining that has a magnitude of about 0.2-0.3Ml/day and this flow has responded to long term trends in rainfall deficit suggesting a degree of hydraulic connectivity with either the surface or the Illawarra Escarpment.

There may also be some minor inflow from Cataract Creek, although the characteristics of the mine inflows recorded during mining of Longwall 5 did not indicate any perceptible increase in inflow as mining approached Cataract Creek. If a significant source of inflow was from the creek, an increase in flow rate would be expected as the flow path length between the creek and the mine reduced. The resolution of the underground monitoring is of the order of 0.1Ml/day indicating any potential increase in flow from Cataract Creek into the mine during mining of Longwall 5 was less than about 0.1Ml/day.

There were no visual indications of flow loss from Cataract Creek and no losses were recorded, but it should be recognised that flow meter systems able to be installed in creek channels without major construction works only have a resolution of the order of ±0.5Ml/day and therefore may not be able to detect changes with a magnitude of 0.1Ml/day or any flows that may have recharged groundwater levels in the deeper strata.

5.2 Horizontal Shear Planes

The piezometer monitoring results from the Wonga East area are consistent with the presence of horizontal shear planes with higher hydraulic conductivity than the surrounding strata. These shear planes are inferred to be associated with creek closure both natural and mining induced and have been confirmed to exist at other sites. These shear horizons are most likely to be present at a level just below the base of the valleys. They occur as part of natural erosion processes but are also activated by mining subsidence. These shear planes appear likely to be capable of distributing low level flows over distances of several hundred metres and into the general groundwater system while also collecting rainfall recharge and distributing it back to the creeks and reservoir.

A shear plane is considered likely to be the pathway by which NRE D, some 540m from Cataract Reservoir, responds to changes in reservoir pressure. A shear plane is also the likely pathway for the upper perched water table in GW-1 to be maintained at close to the level of Cataract Creek some 175m away and for the pressure in NRE B to be drawn to zero at the level of Cataract Creek.

5.3 Height of Depressurisation

Where there is mining in all three seams, there is considered to be high potential for interaction with the surface and the top of the groundwater table recharged from long term rainfall trends and adjacent creeks if there is interaction between the basal shear plane reactivated by subsidence and the top of the zone of depressurisation above each longwall panel. The height of this zone of depressurisation can be estimated using the empirical approach formulated by Tammetta (2012) for single seam mining operations, but the approach needs to be confirmed as suitable in a multi-seam environment. The following estimates for height of depressurisation above the mining horizon are considered reasonable as a preliminary estimate:

- Bulli Seam - 60m with over 90 years to come into equilibrium

- Balgownie LWs only
  - 43m for 140m panels (T=1.4m, W=140m and D=300m)
  - 60m for 190m panels (T=1.4m, W=190m, and D=300m)

- Balgownie LWs plus Bulli Seam
  - 100m for 140m panels (T=2.6m, W=140m, D=300m)
  - 136m for 190m panels (T=2.6m, W=190m, D=300m)

- Wongawilli LWs only
  - 146m for 145m panels (T=3.2m W=150m, D=330m)

- Wongawilli plus Bulli Seam
  - 222m (T=4.4m, W=150m, D=330m)

- Wongawilli plus Balgownie Seam
  - 235m (T=4.6m, W=150m, D=330m)

- Wongawilli plus Bulli Seam plus Balgownie Seam
  - 316m (T=5.8m, W=150m, D=330m)

There is considered to be some potential for interaction between the zone of depressurisation and the basal shear planes in the shallower areas at the northern ends of Longwall 2 and 3 and at the northern end of Longwall 7.

At the northern end of Longwall 7, the area where three seams have been mined is limited in extent and the height of depressurisation may be less as a result but further monitoring is required to establish the height of depressurisation when all three seams have been mined. Further work is underway to determine the height of depressurisation above the southern end of Longwall 4 where all three seams have been mined because the multi-seam estimates of height of depressurisation are limited to the one measurement in GW-1 at this stage.

5.4 Estimated Inflows from Proposed Panels

The conceptual model developed and presented in this report is not considered sufficiently robustness to provide a strong quantitative basis to calculate inflows from further mining activity in the Wonga East mining area. However, some indications of potential for inflow can be provided based on the data available. Areas where there is considered to be increased potential for inflow into the mine can be highlighted and the flows estimated based on previous experience of mining Longwalls 4 and 5.

The total water make from the Wongawilli Seam workings is currently about 1.1Ml/day. Based on considerations of how this flow has developed over time and where it has reported to in the mine, the current water make is estimated to comprise:

- 0.3Ml/day from mining development headings in the Wongawilli Seam.
- 0.2Ml/day for up dip inflow in the Bulli and Balgownie Seams.
- 0.1Ml/day additional inflow from mining Longwall 4.
- 0.5Ml/day from mining Longwall 5.

Based on the conceptual model the following estimates of additional inflow are indicated.

The northern ends of Longwalls 1-3 are located at shallower depths in areas where there has been previous mining in the Balgownie Seam. The potential for interaction with the near surface groundwater systems directly and through the zone of horizontal stretching along the ridge at the southern ends of these panels is expected to cause inflows of the same magnitude or possibly higher than the inflows observed in Longwalls 4 and 5. None of this area is below the fourth order section of Cataract Creek or close to the FSL of Cataract Reservoir so any recharge is likely to be more closely related to rainfall.

Longwalls 6 and 7 are expected to contribute similar inflow increases to Longwall 5 (i.e. 0.5Ml/day) with this additional flow coming mainly from the higher conductivity recharge zones along the ridgeline between Cataract Creek and Cataract River. Some additional flow may also come from Cataract Creek and Cataract Reservoir via the horizontal shear planes that are likely to be mobilised by mining Longwalls 6 and 7.

The relatively low vertical hydraulic conductivity of the overburden strata and depth of mining is expected to restrict inflows from these basal shear planes into the mine to low levels in the vicinity of Longwalls 6 and 7 provided the zone of depressurisation does not reach high enough to interact with the basal shear planes. Interaction with the zone of depressurisation may be possible at the northern end of Longwall 7 in an area where all three seams have been mined in close lateral proximity but not directly above each other. Further measurements planned above the southern end of Longwall 4 are expected to provide confirmation of the significance of this potential.

Longwalls 9-11 are located away from areas of previous mining in the Balgownie Seam and the potential for interaction with the near surface groundwater system is considered likely to be much lower because of the lower heights of depressurisation expected. Based on experience from other longwalls at similar depths, inflow rates are expected to be less than about 0.2-0.3Ml/day per panel during active mining and to reduce over time to low levels.

6. REFERENCES

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Appendix D

RESPONSE TO SUBMISSIONS ON THE PREFERRED PROJECT REPORT – SURFACE WATER AND GROUNDWATER ISSUES

28 MARCH 2014

GeoTerra

David Clarkson
Group Environment and Approvals Manager
Wollongong Coal Ltd
PO Box 281
FAIRY MEADOW NSW 2519

David

Response to Submissions on the Preferred Project Report – Surface Water and Groundwater Issues

Please find enclosed our responses to the submissions received in relation to the Preferred Project Report (PPR) for Wollongong Coal Limited's Underground Expansion Project (UEP).

Eight submissions in relation to surface water and groundwater were received from:

- NSW Office of Water (NOW)
- Coffey Geotechnics Pty Ltd (Coffey) (on behalf of Department of Planning and Infrastructure)
- Evans and Peck Pty Ltd (EP) (on behalf of Department of Planning and Infrastructure)
- Office of Environment and Heritage (OEH)
- Sydney Catchment Authority (SCA)
- Dams Safety Committee (DSC)
- B K Hebblewhite (BKH) (on behalf of Department of Planning and Infrastructure)
- Wollongong City Council (WCC)

The submissions indicate that a number of issues raised in the initial response to submissions on the Environmental Assessment (EA) have either been fully or partially addressed, due principally to the modified proposed mining layout at Wonga East and exclusion of the proposed Wonga West mining domain from the current PPR application.

In addition, the departmental reviewers essentially all called for a revised numerical groundwater model, and to a lesser degree an updated surface water model and the associated assessments that follow on from the model analyses. As the updated / revised models are in the process of being completed, issues related to this body of work will be addressed separately when the modelling studies are completed.

Responses to comments related to swamp related hydrology are discussed here with, whilst the ecological aspects are principally covered in the PPR response provided by Biosis Pty Ltd.

As there is a degree of repetition of themes in the departmental PPR reviews, a summarised version of the issues and responses are contained in the following Table.

regards

GeoTerra Pty Ltd

Andrew Dawkins
Director (AuSIMM CP-Env)

Submission	Contributor/s	Response
Potential Impacts to Coastal Upland Swamps endangered ecological community (EEC), particularly swamps of "special significance" Crus1, Ccus4, Ccus5	SCA / OEH / WCC/ BKH / EP	Refer to Biosis PPR response
Partial loss of stream flow from upland swamps, tributaries and main streams that supply Sydney's drinking water and potentially making its way into deeper storage lower aquifers or the mine itself via mining induced fracture pathways	SCA / OEH / NOW / EP	It is anticipated that some loss of swamp and tributary baseflow discharge, and subsequently flow in Cataract Creek / Cataract River and yield to Cataract Reservoir will occur, along with recharge to deeper storage. Evans and Peck interpreted the swamp piezometer water level monitoring data to indicate that, overall, headwater swamps that have been subject to subsidence from previous mining (ie prior to LW4) have maintained a perched groundwater system that does not show evidence that cracking may have occurred except for swamps Ccus3 and Ccus6. However, it appears that the vegetation in Ccus3 and Ccus6 has similar characteristics to other swamps in the area, therefore any link between possible cracking of the base of the swamp and change in vegetation remains unanswered. The other factors that can lead to the more rapid water level lowering as observed in the swamp piezometers following rainfall (as discussed by EP) in Ccus3 and Ccus6 are their relative; • lack of humic material and greater proportion of highly permeable sand, leading to less water retention and faster drainage out of the swamp; • closer location of the piezometer to the edge of the swamp • smaller upslope catchment / overland flow recharge areas, for a particular swamp sub-catchment within which the piezometer is located; and • laterally discontinuous swamp soil extent, which is interspersed with shallow / outcropping / subcropping sandstone or sandstone derived soils. Evans and Peck also note that only one out of the six monitored headwater swamps exhibits behaviour consistent with the hypothesized significant contribution of baseflow from upland swamps in general. This suggested to Evans and Peck that the dominant contribution to baseflow may be valley fill swamps rather than headwater swamps. The in-progress surface water and groundwater modelling, in association with the ongoing subsidence, surface and groundwater system and mine water monitoring being conducted will be used to assess the quantum, significance and impacts on swamp / tributary and stream flow as well as overburden recharge. This will enable outlining of the potential impacts of subsidence on stream flow, catchment yield and overburden recharge and to develop mining strategies, processes and criteria against which to assess and manage the proposal

Submission	Contributor/s	Response
Potential for surface to seam fracturing and complete aquifer drainage into the mine	SCA / OEH / NOW / BKH / EP	BKH concluded that "the risk of inter-connective cracking is considered low in the vicinity of LW7 (or any other part of the proposed workings)" The groundwater model will be used to predict the potential surface water / groundwater / mine working hydraulic interconnection through the combined use of the theoretical "height of depressurisation" equation developed by Paul Tammetta. This is being conducted in conjunction with empirical observation of the strata groundwater system and mine inflow response to LW4 and LW5. Data from VWP piezometer GW1 and open standpipe piezometer GW1A are being used to assess the applicability of the Tammetta equation to the site specific situation at Wonga East. In addition, monitoring of the groundwater system changes associated with mining LW4 and LW5 are being used to calibrate the model, through adjusting the input hydraulic parameters such as vertical and horizontal hydraulic conductivity, storativity and recharge so a correlation between the input parameters, observed water levels, stream flows and mine inflow is achieved
Requirement to assess the connected linear network nature of the swamps, tributaries and main stream channels and effects of subsidence on stream flows, catchment yields and water quality (particularly increased acidification and iron precipitation) as well as the full or partial loss and subsequent downstream re-appearance of stream flow over subsided affected reaches	SCA / OEH / NOW / EP	Monitoring of the stream depth / flows/ water quality, swamp standing water levels and water quality, tributary stream depth / flows/ water quality and subsidence effects observed at surface (strain / tilt / subsidence / crack development) associated with the pre and post extraction of period of LW4 and LW5 is currently being conducted. The monitoring data will be used as an input and calibrant in the surface water model to assess the connected linear network in the proposed mining area and to develop mining strategies, processes and criteria against which to assess and manage the proposal. The current and potential aspect of stream water acidification and iron hydroxide precipitation will be addressed in the updated surface water report.
Monitoring undertaken for the swamp piezometers provides an excellent basis for achieving a better understanding of the hydrology of headwater swamps. Useful additional monitoring and analysis activities would include: (see response column)	EP	As recommended by Evans and Peck, the following monitoring and analysis activities will be undertaken as part of the proposed Upland Swamp Technical Management Committee and Monitoring Plan: • establishment of a recording meteorological station at Wonga East • establishing piezometers at the upslope and downslope end of a minimum of two swamps • adding two flow monitoring points to swamps in which pairs of piezometers are installed • monthly review of the swamp water balance soil characterization, porosity, clay and humic content

Submission	Contributor/s	Response
Swamps Bcus4, Ccus4 and Ccus10 are rated to have “minor” risk of subsidence related impacts due to extraction of the proposed longwalls at Wonga East	EP	Refer to Biosis PPR response
Lack of detailed geological investigations and drilling investigations to assess the potential for induced hydraulic connection between the proposed mining area and Cataract Reservoir, as well as induced leakage from Cataract Reservoir	SCA / OEH	Concern has been raised about the potential for hydraulic connection between the mine workings and the reservoir, and any associated induced leakage from the reservoir to the mine workings, particularly the western ends of LW6 and LW7. Structures of concern to the departments are Fault F1 (Corrimal Fault) and dykes D7 and D8 and their potential associated faults. The concern is raised due to the potential subsidence induced hydraulic interconnection of the structures and either the channel of Cataract Creek, Cataract River or the reservoir itself. The geological study at Wonga East combined and interpreted all the current data, knowledge and understanding about the geology and structures in the Wonga East area in a clear and concise assessment that provides a very useful description of the areas geology. As outlined by SCT Operations, and re-affirmed by BKH in his submission, the Corrimal Fault (F1) diminishes in throw to the northwest , to the extent that it is believed to be insignificant at the point where it will be intersected by LW6. Further confirmation of the existence, throw and hydraulic significance of Fault F1 will be obtained on driving the first workings for LW6 and LW7. In addition, observation of the highly weathered nature of Dykes D7 and D8 at surface, as well as the lack of any observable water make during intersection of Dyke D8 during extraction of LW5 in the Wongawilli Seam indicates the structure is not acting as a post mining conduit or providing enhanced hydraulic connection between the surface water systems or overburden aquifers and the mine workings.
Interaction of the proposed mining and pre-existing goaf areas with subsequent hydraulic connection between the reservoir and the mining area	SCA	Use of the 0.7 times depth protection offset distance between the mine and the full supply level of Cataract Reservoir has been discussed in the SCT Operations PPR response.
Potential for loss of Reservoir waters via a change in water pressure	DSC	The in-progress groundwater modelling and associated reporting will address this issue

Submission	Contributor/s	Response
No baseline monitoring against which to compare the historical, current and proposed impacts on Cataract Creek	SCA / EP	There is no pre mining stream flow, pool level and water quality data that pre dates the Bulli Seam mining at Wonga East. However, observation since July 2008 of the absence of cracks in the main stream bed, maintenance of pool levels, along with a geological understanding of the exposed Hawkesbury Sandstone / Newport / Garie Formation / Bald Hill Claystone and Bulgo Sandstone reaches of the channel along with observation of the very high iron flocculate, slightly acidic to circum neutral pH and low salinity of Cataract Creek based on water quality monitoring conducted since July 2008 gives a clear observation that the stream does not dry up and that its linear connected nature has been maintained even though 2, and in some cases 3 sequences of mining have been conducted. The lack of pre Bulli Seam Wonga East baseline data does not indicate what the level of iron flocculant was pre mining, however as the highly ferruginous (hematitic) Bald Hill Claystone is weathered, eroded and exposed at surface in the catchment, it generates elevated iron levels in its streams compared to Hawkesbury Sandstone dominated bedrock reaches. Water quality data collected since July 2008 will provide an appropriate basis for establishing baseline water quality for purposes of identifying water quality impacts as a result of mining Longwalls 4 and 5 as well as the proposed workings at Wonga East and to establish locally specific water quality "trigger" levels consistent with the ANZECC guidelines
A flow duration graph showing existing and predicted flow characteristics would be desirable	EP	This is shown in the WRM Water and Environment PPR response.
Hydraulic conductivity used in the groundwater model underestimates the actual hydraulic conductivity and doesn't take into account the impact of mining on hydraulic conductivity	DSC	The in-progress groundwater modelling and associated reporting will address this issue
Available data regarding connection to the reservoir is not integrated into the conceptual or actual groundwater model, ie correlation with piezometer P514 and the reservoir water levels	DSC	The in-progress groundwater modelling and associated reporting will address this issue
Opportunity to review the revised groundwater model and associated peer review report	NOW / SCA / OEH	Once completed and published, the in-progress groundwater modelling and associated reporting will address this issue
Proponent to obtain additional licensed entitlement to account for increased inflows to the proposed workings	NOW	The proponent currently holds a bore licence with an entitlement to 365ML/year. The in-progress groundwater model will be used to determine the licensing requirements for the Project.

Submission	Contributor/s	Response
Potential interconnection between the height of the potential collapsed zone and ground surface over the north eastern end of LW7. Subsequently, the small lateral distance (45m) and potential topographic effects on subsidence associated with LW7 may form a direct connection from Cataract Creek to the collapsed zone and reduce stream flow in Cataract Creek	Coffey / BKH	The initial review provided by Coffey incorrectly interpreted that the workings overlying the proposed LW7 were composed of longwall extraction in the Bulli Seam. However, SCT Operations (Ken Mills) pointed out that it is actually composed of development roadways. As a result, BKH considered it inappropriate to include the thickness of the Bulli Seam workings in the calculations of H, and concluded that using Tammetta's equations, *H* does not intersect the surface and that the risk of inter-connective cracking is considered low in the vicinity of LW7 (or any other part of the proposed workings). The in-progress groundwater modelling and associated comparison between the theoretical height of depressurisation equation and observed groundwater stratigraphic responses and subsequent reporting will address this issue
Mine inflow (groundwater make) associated with extraction from Longwalls 4 and 5 (from early 2012) was significantly higher than had been experienced at the mine	EP	Further data collection and QA / QC assessment indicates that the mine inflows assessed with LW4 / 5 extraction by Evans and Peck were incorrect as shown in their review and that the significant increase in groundwater make did not occur as shown. The corrected mine water balance / groundwater make data will be incorporated in to the upcoming groundwater assessment report.
Use of an Adaptive Management Approach and issues relating to the time lag for mining induced impacts to manifest and changes to be implemented	SCA / DSC	Wollongong Coal accepts that Adaptive Management during the extraction of a LW panel is not an effective management tool for Upland Swamps. The company intends to work closely with the SCA, OEH and independent experts during the extraction of LW's to ensure that the maximum level of necessary and relevant data is collected to significantly improve both industry and regulator data on which to devise more appropriate guidelines around swamp management.
Adoption of the SCA Performance Measures for Cataract Reservoir, watercourses and swamps and to adhere to the requirements of the NSW Aquifer Interference Policy	SCA / OEH	The PPR assessment will outline Wollongong Coal's proposed adherence to the relevant SCA / NOW / OEH Policies, Principles, Guidelines and Criteria

Appendix E

SURFACE WATER MODELLING

Appendix F

RESPONSE TO SUBMISSIONS ON THE PREFERRED PROJECT REPORT – BIODIVERSITY

24 March 2014

David Clarkson
Group Environment and Approvals Manager
Wollongong Coal Ltd
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Dear Dave

Underground Expansion Project: Response to Submissions on the Preferred Project Report - Biodiversity

Our Ref: Matter 16646

The purpose of this letter is to provide responses to the submissions received in relation to the Preferred Project Report (PPR) for Wollongong Coal Ltd's (WCL) Underground Expansion Project (UEP).

A total of six submissions related to biodiversity were received from:

- Department of Primary Industries (Fisheries NSW)
- Office of Environment and Heritage (OEH)
- Sydney Catchment Authority (SCA)
- Wollongong City Council (WCC)
- Bruce Hebblewhite (on behalf of the Department of Planning and Infrastructure (DP&I))
- Evans & Peck (on behalf of DP&I)

The submissions indicate that a number of issues raised in the initial response to submissions on the Environmental Assessment (EA) have been addressed, including:

- Underestimation of subsidence impacts and consequent level of impact to upland swamps.
- Monitoring of upland swamps.
- Impacts to upland swamps of special significance CCUS1, CCUS5, CCUS10, CRUS2, CRUS3 and BCUS.
- Undermining of Cataract Creek and consequent impacts to threatened species.
- Impact to threatened fish species, including survey techniques and effort.
- Potential impacts to threatened frog species.

Table 1 provides a summary of submissions received in relation to the PPR along with who raised them, and provides responses to these submissions.

Table 1: Summary of submissions, including responses

Submission	Response
Upland Swamps	
Mining under swamps of special significance (WCC, DP&I, Evans & Peck, OEH, SCA)	The PPR proposes to mine beneath upland swamps of 'special significance' CCUS4 (wholly) and CCUS5, CCUS10 and CRUS1 (partially). Of these, CCUS5, CCUS10 and CRUS1 are considered to be at negligible risk of impact. CCUS4 is considered to be at a moderate risk of impact. Evans & Peck in its analysis of risk of impact to upland swamps has concluded that the risk of impact to all upland swamps is low to minor, and has downgraded the risk of impact for BCUS4 and CCUS4 to Minor while upgrading the risk of impact to CCUS21 from Low to Minor. It has been noted that monitoring by BHP Billiton Illawarra Coal (BHPBIC) and OEH has demonstrated that mining has resulted in fracturing of bedrock beneath upland swamps and consequent loss of the perched aquifer, loss of water flow at the base of the swamp and loss of soil moisture. Such impacts have been posited to *'alter the ecological function of the upland swamp and a high likelihood of eventual loss of vegetation communities and habitat that characterize upland swamps'* (OEH submission on the PPR). Section 3.3.3 of Biosis (2013) provides an assessment of the historic impacts to upland swamps in the Wonga East area from mining of the Bulli and Balgownie seams. The data from this assessment indicates that at least some of the upland swamps in the Wonga East area have experienced subsidence is considered likely to have resulted in fracturing of bedrock. A previous report by Biosis (2013) concluded that data from piezometers located in some of these upland swamps show regression of groundwater consistent with a 'fractured' swamp (e.g. CCUS3, CCUS6 and CRUS1), whilst others do not (e.g. CCUS2, CCUS4 and CCUS5). A subsequent review undertaken by Evans & Peck, on behalf of DP&I, concluded that the water retention characteristics of upland swamps had not been affected by past mining and that the majority of upland swamps in this area have maintained a perched

Submission	Response
	groundwater system and do not show any evidence of cracking (see below for further information). Biosis believes that there is currently insufficient data available to draw the conclusion that fracturing of bedrock beneath an upland swamp leads to a high likelihood of eventual loss of the vegetation communities and habitat that characterise upland swamps. Furthermore, there is data to illustrate that the resilience of upland swamps is much more complex. The paucity of suitable monitoring data from past mining illustrates the difficulty in determining the nature and extent of past impacts. Previous conditions of approval for longwall mining projects in the Southern Coalfield have required "negligible impacts" to upland swamps of special significance. Biosis (2013) concludes that CCUS4 is the only upland swamps of 'special significance' at risk of a more than negligible impact. A detailed upland swamp network monitoring program is currently being developed. This monitoring program will assist WCL in determining whether impacts are negligible, as well as providing information on primary and secondary effects of longwall mining on upland swamps. The Biodiversity Management Plan, currently being developed, will outline how Wollongong Coal Ltd (WCL) proposes to achieve these aims and what corrective actions will be undertaken should greater than negligible impacts to CCUS4 occur.
Subsidence predictions exceed those that are predicted to result in fracturing of bedrock beneath upland swamps **(DP&I, Evans & Peck, OEH, SCA)**	The subsidence criteria adopted in the Bulli Seam Operations Planning and Assessment Commission (PAC) report (DoP 2010) and by OEH in their Draft Upland Swamp Environmental Impact Assessment Guidelines (2012) are a '*threshold for investigation – not a conclusion that the swamp will be impacted or suffer consequences*' (DoP 2010, p. 120). The PPR report for Biodiversity (Biosis 2013) sets out how this further investigation has been undertaken, and provides a comprehensive assessment of upland swamps. Based on the historical analysis of upland swamps it is clear that fracturing of bedrock beneath upland

Submission	Response
	swamps does not necessarily result in the loss of the swamp. This is supported by the review undertaken by Evans & Peck, which concluded that the water retention characteristics of upland swamps had not been affected by past mining, except, potentially, for CCUS3 and CCUS6. Evans & Peck conclude that the majority of upland swamps in this area have maintained a perched groundwater system and do not show any evidence of cracking, despite past mining (with the possible exception of CCUS3 and CCUS6). With regard to CCUS3 and CCUS6, Geoterra, in its response to submissions on the PPR, notes that other factors, such as higher soil porosity, lower humic content, location of the piezometer in the swamp, lower catchment area, discontinuous swamp soil extent and a greater proportion of outcropping / subcropping sandstone lead to more rapid water level lowering in these two swamps. The scale of impacts from past mining is currently unknown due to a paucity of monitoring data from past mining activities. However, large scale loss of upland swamps in the study area has not resulted from past mining, and some upland swamps, such as CCUS4, show healthy vegetation communities and significant baseflow. The proposed upland swamp network monitoring program currently being developed will provide additional information on the scale of primary and secondary impacts.
Loss of base flow from upland swamps and consequent impacts to Cataract Creek and Cataract River **(OEH, DP&I, Evans & Peck, SCA)**	See Geoterra PPR response. It is worth noting that Evans & Peck concluded that only one out of six upland swamps with piezometer data "*exhibits behaviour consistent with the hypothesized significant contribution to baseflow from upland swamps in general*". Evans & Peck conclude that upland swamps CCUS3 and CCUS6 would not be classified as upland swamps from a hydrological perspective. Biosis and Geoterra agree with this assessment due to the absence of significant perched groundwater table and significant contribution to baseflow. However, as these two upland swamps

Submission	Response
	meet the characteristics of the Coastal Upland Swamps EEC they have been included in this assessment. There is currently minimal robust data on impacts to baseflow resulting from fracturing of bedrock beneath upland swamps. To date, the only study looking at this issue is being undertaken by OEH, with baseflow measured at the exit point of an upland swamp in the Dendrobium area. WCL is proposing an upland swamp network monitoring program that will assess changes in baseflow from upland swamps as well as a holistic view of catchment process to look at inflows from upland swamps into Cataract Creek.
Lack of analysis of subsidence effects from past mining on upland swamps, particularly CCUS4. (OEH, DP&I, Evans & Peck)	Section 3.3.3 of the *NRE No. 1 Colliery – Underground Expansion Project: Preferred Project Report – Biodiversity* (Biosis 2013) provides a summary of historic mining beneath CCUS4. Mining of the Balgownie seam has resulted in compressive and tensile strains and tilts that exceed criteria used to determine risk of negative environmental consequences to upland swamps (DoP 2010, OEH 2012). CCUS4 contains patches of MU43 Tea-tree Thicket and MU44c Cyperoid Heath, both of which are reliant on permanent and semi-permanent water logging. Further, piezometer data from CCUS4 shows significant groundwater contact for prolonged periods following rainfall. This data appears to illustrate that CCUS4 has undergone minimal levels of impact from past mining activities. However, other swamps that have previously been mined beneath in this area show rapid regression of groundwater levels following rainfall, which may indicate fracturing of bedrock beneath these swamps (see previous comments on other factors that may influence piezometer regression rates). Despite this, the vegetation in these areas is consistent with upland swamps, albeit often drier representation of swamp communities. In the absence of historic monitoring data it is difficult to make any conclusions on what impacts if any, have occurred.
Over reliance on flow accumulation in risk assessment for upland swamps. (OEH)	Comments from OEH on over reliance on flow accumulation to assess risk to upland swamps is noted. However, the assessment of historic impacts to upland

Submission	Response
	swamps in Wonga East from past mining see Section 3.3.3 of Biosis 2013) indicates that the fracturing of bedrock beneath swamps alone does not result in catastrophic loss of upland swamps. We are of the view that the upland swamp impact assessment includes additional geomorphic, hydrologic and pedological criteria that facilitate a more robust assessment of potential impacts. However, we would welcome the opportunity to work with OEH to refine these criteria if they feel the assessments are still weighted towards flow accumulation impacts.
Threatened Species	
Potential impacts to threatened frogs. (WCC, OEH)	Biosis has now completed four targeted surveys for the Giant Burrowing Frog, Littlejohn's Tree Frog and Stuttering Frog as a part of the ecological monitoring program over two years. These species have not been recorded within the subsidence impact zone despite targeted survey. These species are now considered unlikely to be present within the Wonga East area and are unlikely to be impacted by the proposed extraction of coal in this area. Upland swamps, particularly CCUS5, do not provide suitable habitat for the Stuttering Frog.
Impacts to Cataract Creek, including loss of inflow and increase in iron seepage. Cataract Creek provides habitat Macquarie Perch and Trout Cod, particularly spawning habitat and refugia for juveniles . **(OEH)**	See Geoterra PPR response. The in-progress surface water and groundwater modelling will enable a more thorough assessment of the potential impacts to in-flows to Cataract Creek. The Geoterra PPR report states that although there may be some effects on surface flow volumes, there is anticipated to be little impact on discharge into Cataract Creek. There are currently significant levels of iron flocculent in Cataract Creek due to the hematitic / sideritic nature of the Bald Hill Claystone and potentially past mining of the Bulli and Balgownie seams. It is anticipated that there will be no discernible change in iron levels in Cataract Creek. These findings will be considered further, if required once the updated surface water model is made available.

Submission	Response
	As per page 65 of Biosis (2013), additional surveys have been undertaken for threatened fish species. Fisheries NSW in their submission on the PPR stated that the issues they previously raised were addressed.
Impacts to habitat for the Giant Dragonfly. (OEH)	The PPR incorrectly stated that areas of Tea-tree Thicket, particularly in upland swamp CRUS1, provide likely habitat for this species. Preferred habitat identified by OEH (2013) includes open vegetation with free-standing water. In the PPR report for biodiversity (Biosis 2013), CCUS4 was identified as suitable habitat for this species. Potential breeding habitat for the Giant Dragonfly can be identified based on the hydrogeomorphology, rainfall range and soils (Baird 2012). Breeding habitat is presumed to be associated with groundwater dependent habitat with some associated development of organic-rich or peaty soils. Swamp types with a negative water balance and prolonged periods of surface drying, or characterised by permanent or prolonged seasonal inundation, are not considered to provide potential breeding habitat for this species. Based on this information, Biosis has undertaken a review of potential habitat within the Wonga East area and identified upland swamps CCUS1, CCUS4, CCUS5, CCUS10, CRUS1 and BCUS4 as potential habitat for this species based on presence of communities reliant on presence of groundwater and potential for organic-rich soils. Additional surveys of these areas were undertaken in December 2013 and January to February 2014. These additional surveys focused on identifying significant breeding habitat through surveys for exuviae of the Giant Dragonfly, as it is breeding habitat for this species that is likely to be susceptible to impacts from subsidence and consequent changes in soil moisture. Exuviae were located in upland swamps CCUS4, CRUS1 and BCUS4. In all upland swamps exuviae were located in areas with deep, organic soils. In CCUS4 and BCUS4 this was at the downstream extent of these swamps, where there was an accumulation of groundwater and

Submission	Response
	open vegetation. In CRUS1 this was in pockets of groundwater dependent Tea-tree Thicket with an open overstorey, created by underlying geology. Of the locations where exuviae were observed only CCUS4 will be directly undermined. The potential for other locations listed above to support breeding habitat for this species cannot be discounted; however other locations will not be directly undermined.

Yours sincerely

Nathan Garvey
Resource Group Manager

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Appendix G

RESPONSE TO SUBMISSIONS ON THE PREFERRED PROJECT REPORT – HERITAGE

27 March 2014

David Clarkson
Group Environment and Approvals Manager
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Dear David

Underground Expansion Project: Response to Submissions on the Preferred Project Report - Heritage

Our Ref: Matter 16646

The purpose of this letter is to provide a response to submissions received on the Preferred Project Report (PPR) for Wollongong Coal Ltd's (WCL) Underground Expansion Project (UEP).

A total of two submissions related to heritage were received from:

- Wollongong City Council (WCC); and,
- Heritage Council of NSW.

WCC identified that previous Aboriginal heritage issues had been addressed and did not raise any new heritage issues.

The Heritage Council has queried a WCL statement, made in the PPR, in regards to commitments to heritage made in the Statement of Commitments (SoC). In the PPR, WCL has stated that the SoC contained in the EA has been "*eclipsed by activities for the Preliminary Works Project Part 3A approval (MP 10-0046)*" and provide a summary of activities undertaken according to the Conditions of Approval for the Preliminary Works Project against these SoC.

WCL is not concluding that the Statement of Commitments is unnecessary; rather that the activities associated with these SoC are either completed or on-going. Table 1 below provides an update on activities associated with the SoC, including whether they are complete or ongoing.

Table 1: Status of activities associated with the Statement of Commitments

Statement of Commitment	Status	Notes
A Conservation Management Plan will be prepared for the Project. The plan will reflect the future need of the site as a continuing mine and include procedures to follow for the discovery of unanticipated 'Relics'.	Completed	The final versions of the Heritage Management Plan (HMP; Biosis 2012b) and Conservation Management Plan (CMP; Biosis 2013a) were submitted to DP&I in October 2012 and February 2013 respectively. Procedures for the discovery of unanticipated 'Relics" have been detailed in the CMP and HMP.

Statement of Commitment	Status	Notes
No items identified as having heritage value or contributing to the heritage value of the site will be demolished as part of this project.	Ongoing	The CMP (Biosis 2013a) and HMP (Biosis 2012b) identify those items within the Russell Vale Colliery that have heritage value or contribute to heritage value. Heritage items need to be managed in accordance with the CMP (Biosis 2013a) and HMP (Biosis 2012b) requirements. This will be an ongoing task managed by Wollongong Coal.
A photographic recording of the 1887 portal and the site will be undertaken and copies will be lodged with the appropriate local and state repositories.	Completed	An archival recording of the Russell Vale Colliery (Biosis 2013b) was undertaken between 2011 and 2013, including photographic recordings of the 1887 portal and other site features to Heritage Archival Recording standards. Copies of the Archival Recording were lodged with NSW State Library and Wollongong City Library in August 2013.
A photographic recording of the site should be undertaken to Heritage Archival Recording standards, prior to commencement of construction for the Project, to provide a lasting record for the site prior to the new development. Copies of the recording should be lodged with the appropriate local and state repositories.	Completed	See above
Items of moveable heritage, including historical photos, plans, maps, records and the like will be documented, collated and catalogued. Items of moveable heritage will be retained at their current location on site and documented including historical photos, plans, maps and records to Heritage Archival Recording Standards. A conservator will provide advice regarding the long term storage of items to maximise their survival. When the item has been appropriately catalogued it will be donated to a suitable repository. Appropriate repositories will be identified prior to project works commencing.	Ongoing	A catalogue of heritage items has been be prepared; including historical documents as well as physical heritage elements, and has been included in the archival recording (Biosis 2013b). Historical documents are currently retained in Wollongong Coal archives on-site. If required, the Wollongong Library Local Studies Section has indicated it is prepared to be a repository for historical documents; however it is intended to keep documents on-site as a first preference. Conservator advice for other items of moveable heritage has been provided to Wollongong Coal and conservation actions are ongoing.
No secondary extraction will occur beneath or within 1 km of the Cataract Dam Wall.	Completed	There is 1.5 km exclusion zone for secondary extraction around the dam wall.

As can be seen, the vast majority of activities arising from the SoC have been completed. Only those activities associated with the conservation and management of heritage items are ongoing.

The Heritage Council also identified that it was unclear if issues previously raised by the OEH Heritage Branch with the previous version of the HMP (Biosis 2012a) had been addressed. Comments on the HMP were received from OEH Heritage Branch on 4 September 2012 and were addressed in Section 3.1 of the revised HMP (Biosis 2012b). The revised HMP was re-submitted to DP&I in October 2012.

Yours sincerely

Nathan Garvey
Resource Group Manager

References

Biosis 2012a. *NRE No. 1 Colliery Heritage Management Plan. NREN EMSMP 008. Revision number 2.* Report prepared for Gujarat NRE Coking Coal Ltd.

Biosis 2012b. *NRE No. 1 Colliery Heritage Management Plan. NREN EMSMP 008. Revision number 4.* Report prepared for Gujarat NRE Coking Coal Ltd.

Biosis 2013a. *NRE No. 1 Colliery, Russell Vale: Conservation Management Plan.* Report prepared for Gujarat NRE Coking Coal Ltd.

Biosis 2013b. *NRE No. 1 Mine Preliminary Works Project: Archival Recording Report.* Report prepared for Gujarat NRE Coking Coal Ltd.