NSW Department of Planning and Infrastructure

GUJARAT NRE NO.1 COLLIERY MAJOR EXPANSION PROJECT PART 3A APPLICATION

Preferred Project Groundwater Assessment

20 December 2013

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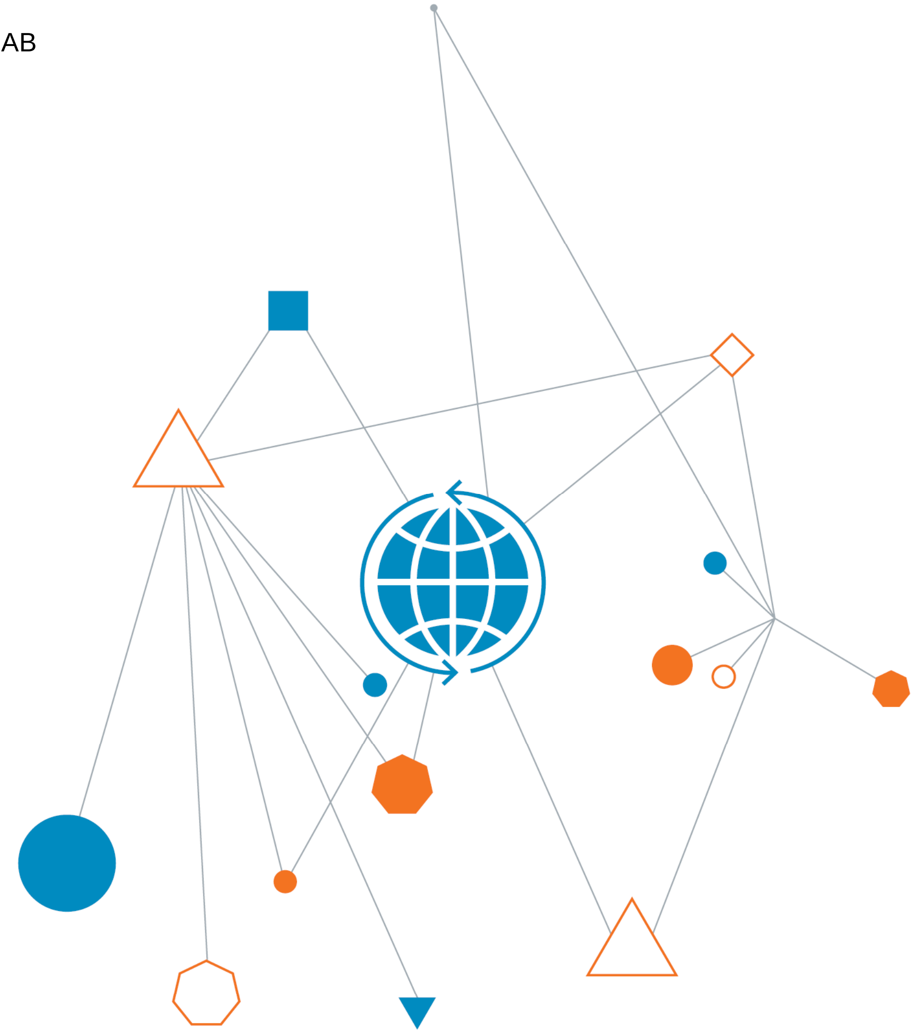

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1. INTRODUCTION

This report presents the results of a review of the groundwater component of the Preferred Project Report (PPR) for the Gujarat NRE No.1 Colliery Major Expansion Part 3A Application (Gujarat, 2013). The review (and associated separate analysis of data presented in the PPR) was conducted by Paul Tammetta of Coffey Geotechnics Pty Ltd (Coffey) for the NSW Department of Planning and Infrastructure (DPI).

This review follows a previous review (Coffey, 2013) of the groundwater components of the Environmental Assessment (EA; ERM, 2013) for the same development application.

The scope of work comprised:

- Review of the groundwater elements of the PPR (and included Response to Submissions) (Gujarat, 2013) received by Coffey from DoPI by email on 9 October 2013.
- Review of hydraulic head monitoring at VWP piezometer GW1 (not presented in Gujarat, 2013).
- Provision of comments in relation to whether the PPR and RS address issues raised in Coffey's review from Stage 1.

This report should be read in conjunction with Coffey (2013).

2. REVIEW OF THE PPR

2.1. Changes to the Mine Plan

The proponent has made changes to the longwall layout from the EA (ERM, 2013) to the PPR (Gujarat, 2013). Longwalls LW4 and LW5 have already been mined and are not are part of the future mine plan being considered.

In the PPR, the Wonga West longwalls will no longer be mined. The Wonga East longwalls have been changed as follows:

- LW1 to LW3: Length, Width, Orientation (towards the south).
- LW6: Length.
- LW7: Length, Width, Position.
- LW8 removed.
- LW9 to LW11: Length, Position, Orientation (towards the west).

Table 1 (after Table 4 of the PPR) lists the dimensions of the changes to the Wonga East longwalls.

Table 1. Changes to Longwall Dimensions from the Original Mine Plan.

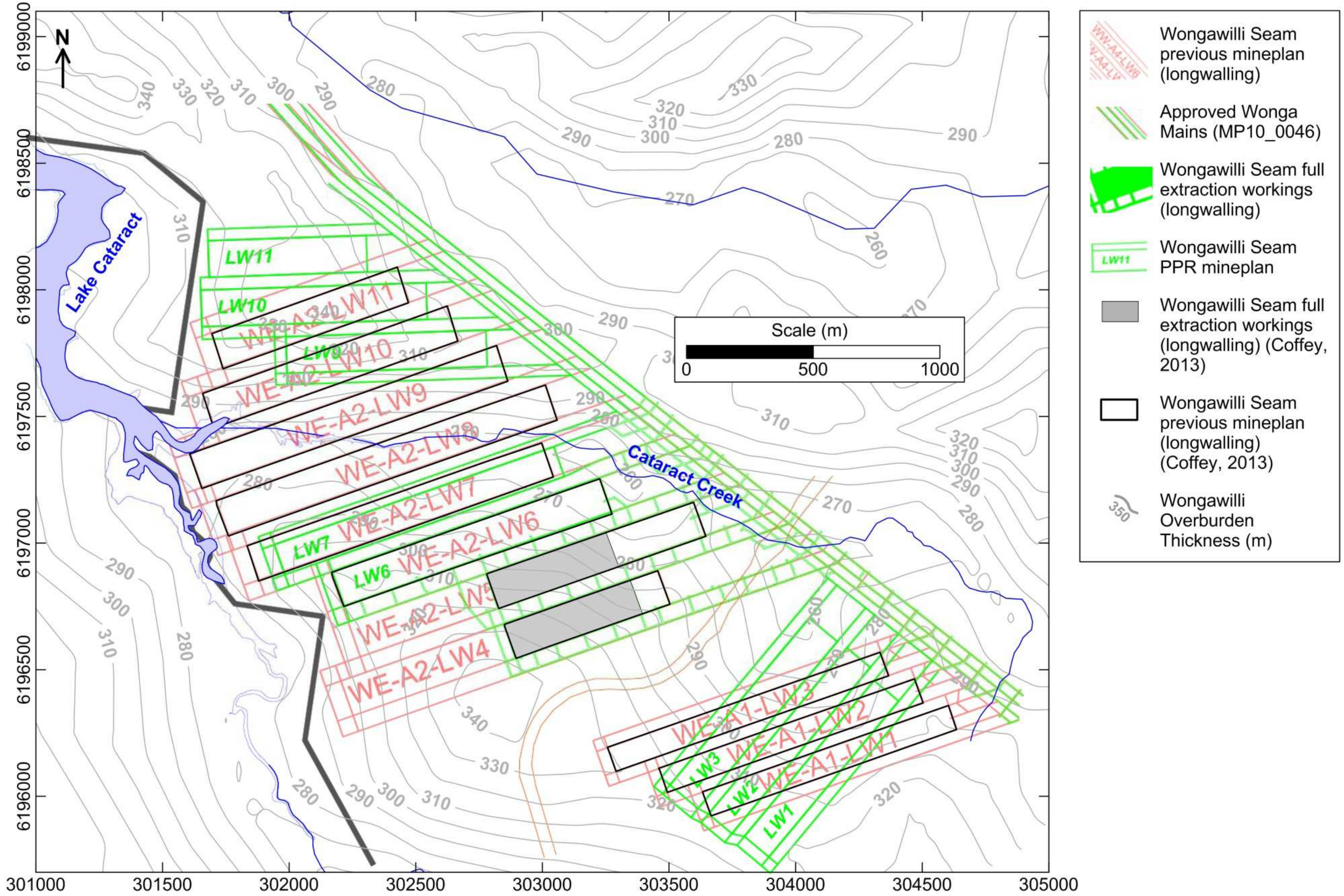
Longwall	Width (rib to rib) (m)		Length (m)		Pillar Width (m)	
	EA	PPR	EA	PPR	EA	PPR
1	105	131	1040	805	40	40
2	105	125	1080	858	40	40
3	105	150	1150	863	40	40
6	150	150	1125	1120	60	45
7	150	131	1230	1175	60	45
8	150	Removed	1375	Removed	60	Removed
9	150	150	1280	796	60	45
10	150	150	1020	896	60	45
11	150	150	780	630	60	40

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.

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.

Based on the new mine plane, the PPR states that there is an interpreted risk of significant secondary impact to swamps BCUS4 and CCUS4.

Figure 1. Comparison of previous and current mine plans for Wonga East. Current mine plan sourced from Gujarat (2013) and overlaid with georeferenced information from Coffey (2013).Comparison of Panel Layouts for Wonga East.



2.2. Longwall LW7

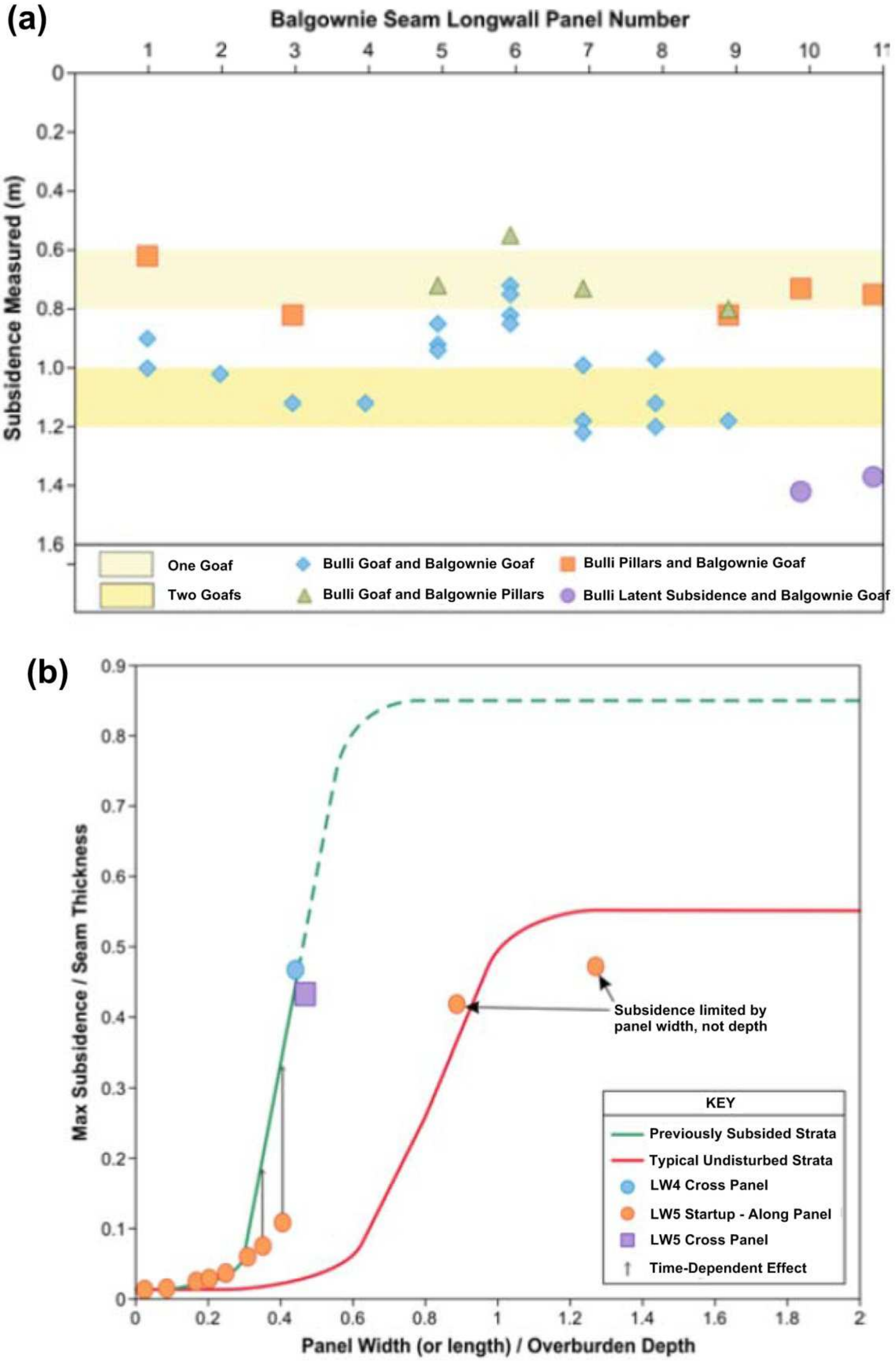
2.2.1. Surface Subsidence Monitoring at Other Panels and Implications for the Height of the Collapsed Zone

Subsidence measurements over existing total extraction workings in the Wongawilli East area are presented in detail in the PPR. These measurements are important as an indicator for the subsidence behaviour in a multiple seam mining environment. Subsidence monitoring of Balgownie and Wongawilli Seam panels in Wonga East indicates that 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.

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.

Surface subsidence results presented in the PPR indicate that the accrued surface subsidence from mulitple seam operations is more than an addition of estimated single seam subsidences. 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), the surface subsidence results would suggest that the accrued height of the collapsed zone for multiple seam operations also may be more than an addition of estimated single-seam H values (Tammetta, 2012). If this is the case, the consequence is that, where a Wongawilli panel underlies existing full extraction workings, the height of H for the Wongawilli panel will be larger than that calculated using the relationship for single seam mining (Tammetta, 2012).

Figure 2. Subsidence monitoring results for the (a) Balgownie and (b) Wongawilli panels at Wonga East (after Figures 49 and 58 of the PPR).



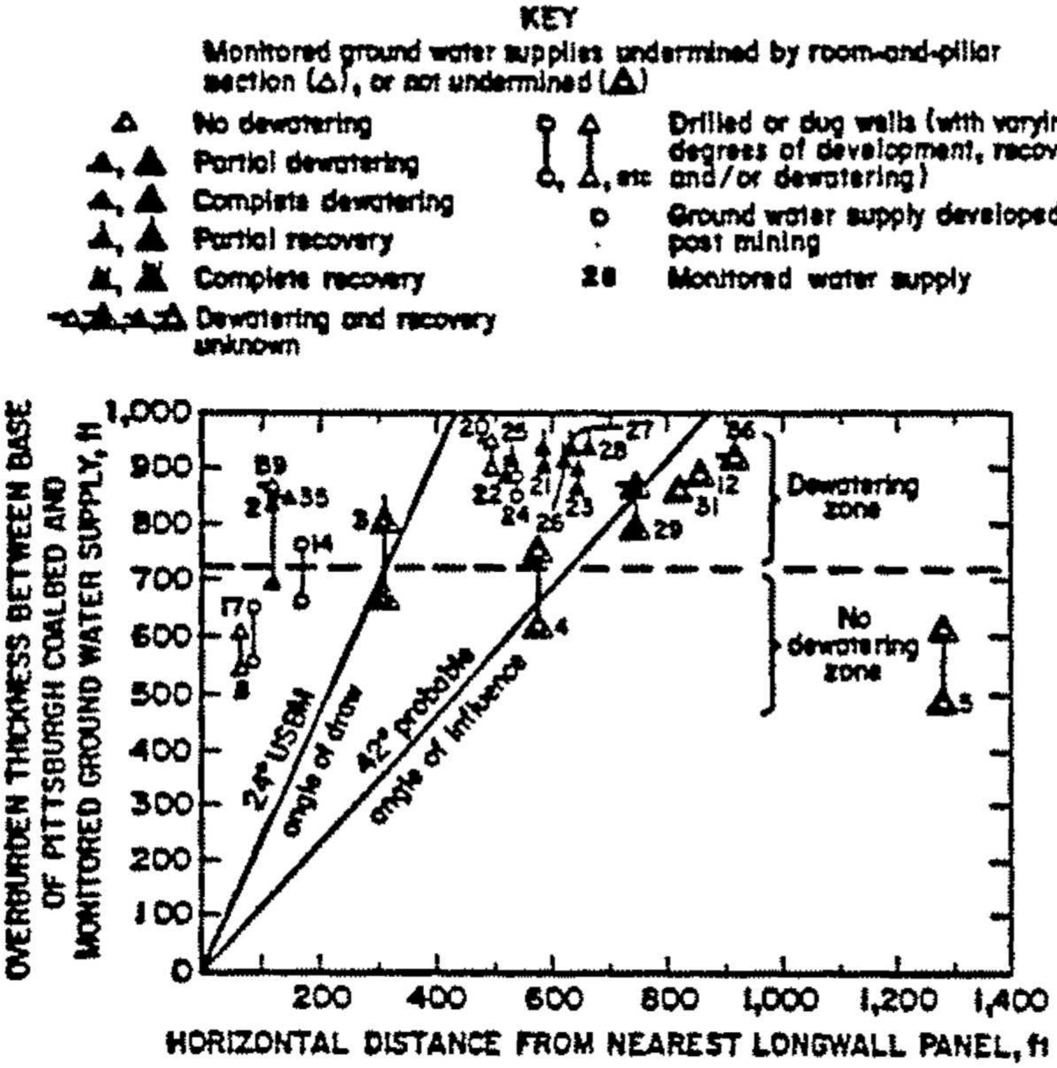
2.2.2. Surface Impacts outside the Panel Footprint

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.

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.

Where there may be a small lateral distance between the surface impact zone and the potential collapsed zone of the panel, there is a risk of direct connection between the fracturing of the surface impact zone and the collapsed zone, through deformed media having enhanced hydraulic conductivity in the impact zone. High-relief topography may exacerbate this connection through enhanced lateral movement. Where the top of a collapsed zone is some distance below the surface, the surface disturbance may not be strongly hydraulically linked to the collapsed zone.

Figure 3. Estimated angle of hydraulic head influence for longwall panels (after Ouyang and Elsworth, 1993).



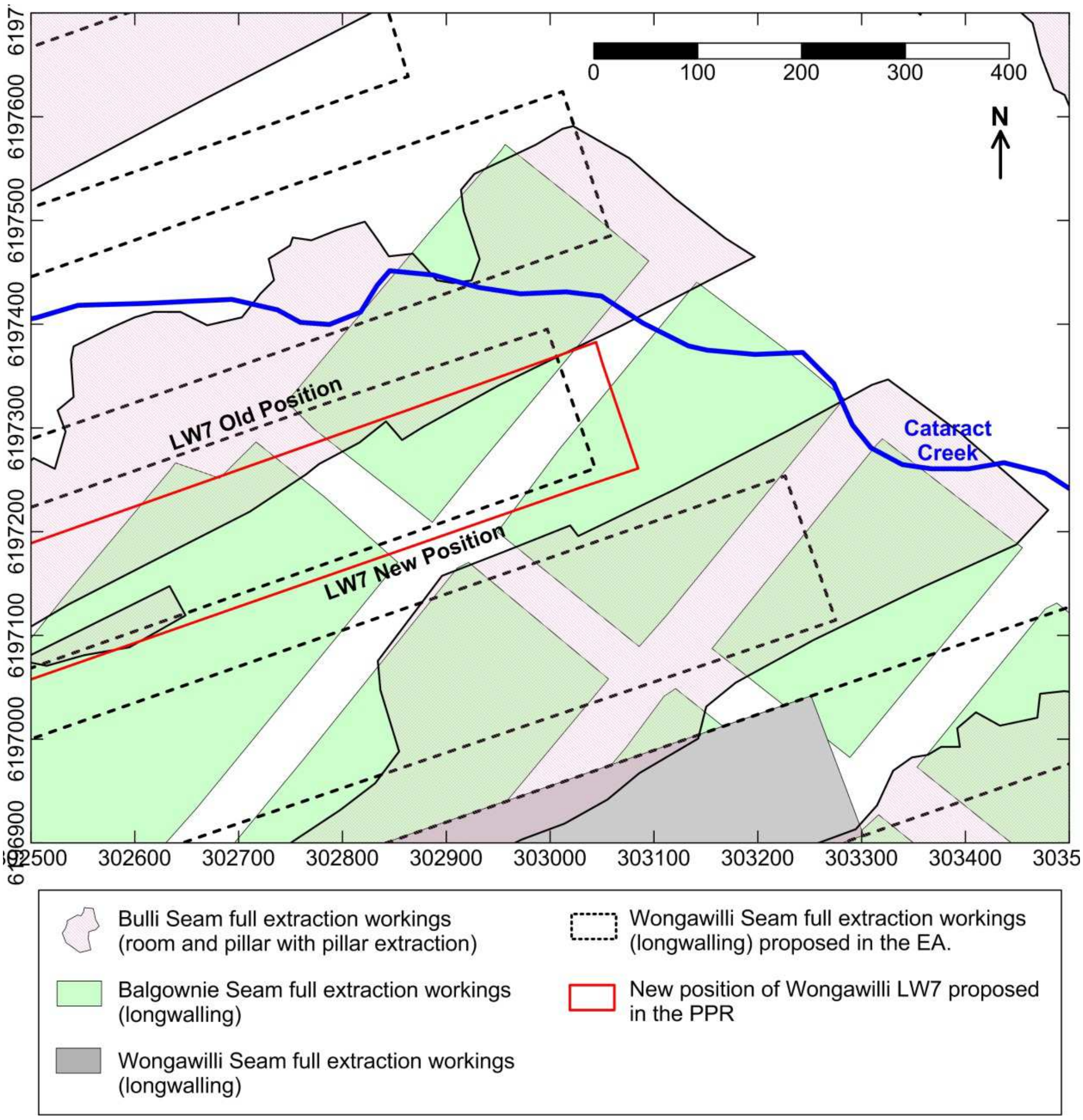
2.2.3. New Proposed Position of LW7

The new layout of LW7 is shown in detail in Figure 4. Subject to the accuracy of the positioning of the panels (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 also Coffey, 2013), it appears that the last 40m of the new LW7 position ceases to be overlain by any part of the adjacent Bulli room and pillar panel. The localised northern corner of LW7 is now positioned under a small, about 50m wide, devoid of existing full extraction workings.

While the method of Tammetta (2012) is useful for estimating H for a single seam operation, and was useful in identifying areas of concern for the EA longwall layout, it cannot be used over such a small area of observation for multiple seam mining.

The minimum separation distance between the northern corner of LW7 and the Cataract Creek channel centreline is approximately 45m (see Figure 4). 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.

Figure 4. New proposed position of Wongawilli LW7 as per the PPR.



2.3. 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.

2.3.1. 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).

2.3.2. Calibration Database

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.

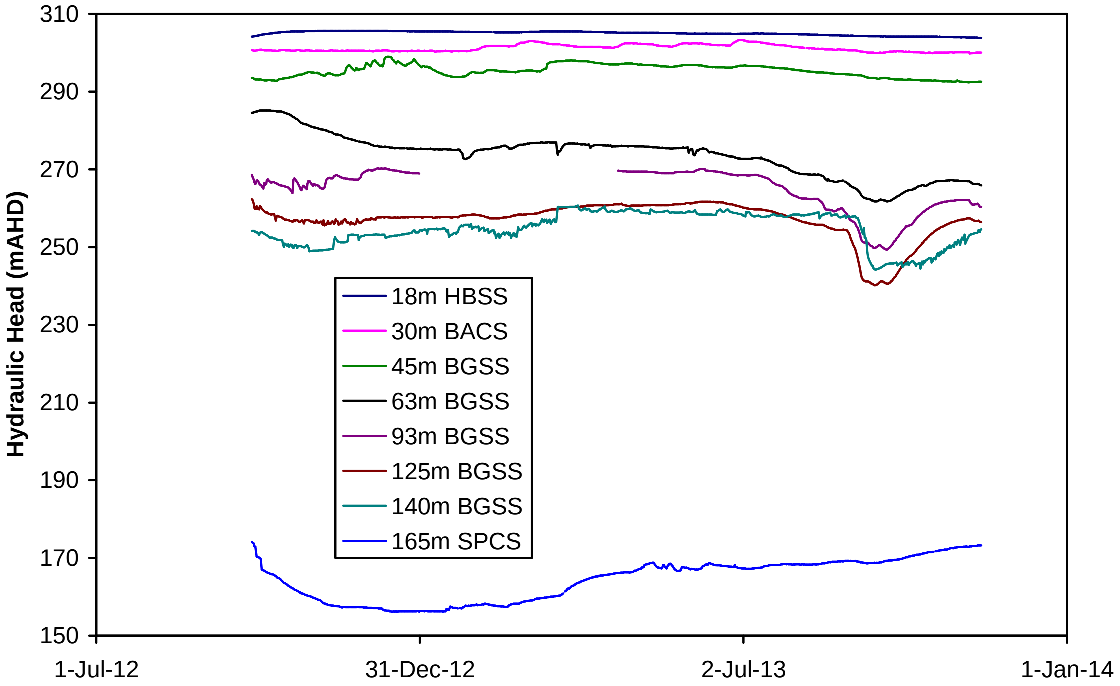
Hydraulic Heads

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 5 shows the supplied data. The key in Figure 5 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.

Figure 5. VWP hydrographs for Monitoring Location GW1 (see Coffey, 2013).



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.
- 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.

Hydraulic Conductivity

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.

2.3.3. 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 noncompliances 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.

2.4. 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 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.

3. CONCLUSIONS AND RECOMMENDATIONS

3.1. LW7

By corollary, surface subsidence results presented in the PPR suggest that the accrued height of the collapsed zone for multiple seam operations may be more than an addition of estimated single-seam H values. If this is the case, the consequence is that, where a Wongawilli panel underlies existing full extraction workings, the height of H for the Wongawilli panel will be larger than that calculated using the relationship for single seam mining (Tammetta, 2012).

The new layout of LW7 places its northern corner under a small localised strip, of about 50m width, devoid of existing full-extraction workings. Despite the absence of existing full extraction workings over this strip, there may still be a risk to the capacity of the channel of Cataract Creek to transmit surface water. 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. Where the collapsed zone intersects ground surface, there is considered to be a risk of direct hydraulic connection between the creek channel and goaf, through the collapsed zone, for small separation distances between a channel and the panel edge. The level of risk is difficult to quantify but warrants consideration.

No groundwater tools or theory are known that could provide a quantification of this risk, however the risk warrants consideration, and deferral is made on this issue to subsidence engineers.

3.2. Numerical Simulation Strategy

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.

3.3. Recommendations

Since the potential risk to Cataract Creek revolves around H for LW7, it is recommended that the height of the collapsed zone be measured at LW4 or LW5, at a location where all three coal seams have been mined. At least one borehole should be installed for this purpose, however two would be preferable. Since this survey would benefit all parties, and the cost is not small, perhaps some of the cost can be born by government. Should this be possible, the government should retain rights to the data.

Appropriate monitoring of groundwater response and ground deformation should be undertaken for LW7, from LW7 startup or earlier, whereby sufficient warning is available to allow termination of LW7 before connection of the creek channel to the goaf occurs. Deferral is made to ground movement experts on the appropriate type of ground movement monitoring and instrumentation (and its location) to fulfil this purpose.

4. REFERENCES

Australian Federal Government Department of Sustainability, Environment, Water, Population and Communities. Water Science Operations Branch. 2013. Final Report Project 2: Peat Swamps and Longwall Mine Engineering.

Barnett B, Townley LR, Post V, Evans RE, Hunt RJ, Peeters L, Richardson S, Werner AD, Knapton A, and Boronkay A. 2012. Australian groundwater modelling guidelines. Waterlines Report, National Water Commission, Canberra. June.

Cifelli, R.C., and H.W. Rauch. 1986. Dewatering effects from selected underground coal mines in north-central West Virginia. Proceedings of the 2nd Workshop on Surface Subsidence due to Underground Mining, West Virginia University, Morgantown, WV, p. 249-263.

Coffey Geotechnics Pty Ltd. 2013. Gujarat NRE No.1 Colliery Major Expansion Part 3A Application Groundwater Analysis. Report GEOTLCOV24840AA-AB prepared for the NSW Department of Planning and Infrastructure. June.

ERM. 2013. NRE No.1 Colliery Project Application (09_0013) Environmental Assessment. Report 0079393RP01 prepared for Gujarat NRE Coking Coal Pty Ltd. February.

GeoTerra Pty Ltd. 2012a. NRE No.1 Colliery Major Expansion Groundwater Assessment. Report GUJ1-GWR1C, prepared for Gujarat NRE Coking Coal Pty Ltd. November.

GeoTerra Pty Ltd. 2012b. NRE No.1 Colliery Major Expansion Stream Assessment. Report GUJ1-SWR1D, prepared for Gujarat NRE Coking Coal Pty Ltd. November.

Gujarat NRE Coking Coal Ltd. 2013. Underground Expansion Project Preferred Project Report, Including Response to Submissions. October.

Ouyang, Z., and D. Elsworth. 1993. Evaluation of groundwater flow into mined panels. Int. J. R. Mechs. Min. Sci. & Geomechs. Abstracts, Volume 30, No. 2, p. 71-79.

Seedsman Geotechnics Pty Ltd (SG). 2012. Gujarat NRE No.1 Colliery: Management of subsidence risks and associated with Wongawilli Seam Extraction. Report GNE-136.docx, prepared for Gujarat NRE Minerals. July.

Singh RN and Jakeman M. 1999. Longwall mining under the Cataract Reservoir. Proceedings, Mine, Water and Environment, IMWA Congress, Sevilla, Spain, 1999, p27-34.

Singh RN and Jakeman M. 2001. Strata monitoring investigations around longwall panels beneath the Cataract Reservoir. Mine Water and the Environment, Volume 20 (2), p55-64.

WRM Water and Environment (WRM). 2012. NRE No.1 Colliery Surface Water Modelling. Report 0637-01-B[Rev7] prepared for Gujarat NRE Coking Coal Limited. November.