REVIEW
Our Ref:
HC2014/12

Date:	27 October 2014
To:	**Vicki McBride** **Approvals Manager -** **Mount Owen Continued Operations** **Mt Owen Pty Ltd** **Glencore** **PO Box 320** **Singleton NSW 2330** **Vicki.McBride@glencore.com.au**
From:	**Dr Noel Merrick**
Re:	**Mount Owen Continued Operations - Groundwater Impact Assessment Peer Review**

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Introduction

This peer review is provided in response to your initial request of 24 June 2013 on behalf of Mount Owen Pty Ltd (MOPL), discussions in the Newcastle Glencore office on 30 August 2013, and subsequent revision requested on 20 August 2014 due to changes made to the Project. An earlier peer review letter report was issued on 29 March 2014.

A review has been made of modelling conducted by Jacobs Group (Australia) Pty Ltd (Jacobs) for the Mount Owen Continued Operations (MOCO) Project consisting of open-cut coal mines 20 km north-west of Singleton in the Upper Hunter Valley. MOPL is seeking development consent to continue open cut mining operations at Mount Owen and Ravensworth East mines by extending mining of the North Pit to the south of the currently approved mining footprint and to undertake mining operations within the Bayswater North Pit (BNP). This would be followed by mining of the Ravensworth East Resource Recovery (RERR) area.

The peer review is based on an original report by Sinclair Knight Merz (SKM) and an updated report by Jacobs:

1. SKM, 2014, Mount Owen Continued Operations Project: Groundwater Impact Assessment. Report prepared for Mount Owen Pty Ltd. Version V06, 20 February 2014. 126p + 3 Appendices.
2. Jacobs, 2014, Mount Owen Continued Operations Project: Groundwater Impact Assessment. Report prepared for Umwelt (Australia) Pty Ltd and Mount Owen Pty Ltd. Revision B, 31 September 2014. 135p + 4 Appendices.

Document #1 comprised an earlier groundwater impact assessment using groundwater model version 7.1, while Document #2 reports the final groundwater impact assessment using groundwater model version 8.1. It has the following sections:

1. Introduction

2. Context Setting
3. Groundwater Modelling
4. Groundwater Impact Assessment
5. Monitoring and Management
6. Conclusions
7. References.

The reviewer sought clarification (by email) on 20 October 2014 from Jacobs on three matters in Document #2. An email reply was received on 23 October 2014. The responses have been taken into account in formulating the following comments.

Review Methodology

While there are no standard procedures for peer reviews of entire groundwater assessments, there are two accepted guides to the review of groundwater models: the Murray-Darling Basin Commission (MDBC) Groundwater Flow Modelling Guideline[1], issued in 2001,and the newer guidelines issued by the National Water Commission at the end of June 2012 (Barnett *et al.*, 2012[2]). Both guides also offer techniques for reviewing the non-modelling components of a groundwater impact assessment.

The 2012 national guidelines build on the 2001 MDBC guide, with substantial consistency in model conceptualisation, design, construction and calibration principles, and the performance and review criteria, although there are differences in details. The new guide is almost silent on coal mine modelling and offers no direction on best practice methodology for such applications. There is, however, an expectation of more effort in uncertainty analysis, although the guide is not prescriptive as to which methodology should be adopted.

The MOCO groundwater impact assessment has been reviewed according to the 2-page Model Appraisal checklist[3] in MDBC (2001). This checklist has questions on (1) The Report; (2) Data Analysis; (3) Conceptualisation; (4) Model Design; (5) Calibration; (6) Verification; (7) Prediction; (8) Sensitivity Analysis; and (9) Uncertainty Analysis. Non-modelling components of the groundwater impact assessment are addressed by the first three sections of the checklist.

The review has also considered compliance with the Director General's Requirements (DGRs) and NSW Office of Water requirements listed in Section 1.2 of Document #2. It is noted that, for new projects, references to "Director General" are to replaced by "Secretary" and "DGRs" by "SEARs". However, the previous DGRs are applicable. Particular attention is given to whether the minimal harm considerations of the NSW *Aquifer Interference Policy* (AIP) (NSW Government, 2012[4]) have been addressed adequately.

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[1] MDBC (2001). Groundwater flow modelling guideline. Murray-Darling Basin Commission. URL: www.mdbc.gov.au/nrm/water_management/groundwater/groundwater_guides

[2] Barnett, B, Townley, L.R., Post, V., Evans, R.E., Hunt, R.J., Peeters, L., Richardson, S., Werner, A.D., Knapton, A. and Boronkay, A. (2012). *Australian Groundwater Modelling Guidelines*. Waterlines report 82, National Water Commission, Canberra.

[3] The new guidelines include a more detailed checklist with yes/no answers but without the graded assessments of the 2001 checklist, which this reviewer regards as more informative for readers.

[4] NSW Government, 2012, NSW Aquifer Interference Policy – NSW Government policy for the licensing and assessment of aquifer interference activities. Office of Water, NSW Department of Primary Industries, September 2012.

It should be recognised that the effort put into the modelling component of a groundwater impact assessment is very dependent on possible timing and budgetary constraints that are generally not known to a reviewer.

A detailed assessment has been made in terms of the peer review checklists in **Table 1** and **Table 2**. Supplementary comments are offered in the following sections.

Report Matters

Document #2 is a good quality document of 135 pages length, plus four appendices that contain vibrating wire piezometer (VWP) hydrographs, ancillary model information, a comparison of observed and simulated hydrographs, and this peer review when finalised. It is well structured, well written and the graphics are mostly of high quality. The report includes a detailed 6-page Executive Summary.

Only minor editorial matters remain in the version of the report that has been reviewed. They are advised separately. One important matter that requires attention is that Section 3.5 (Estimated Pit Inflows and Dewatering) is completely missing from the PDF version of the report but it is included in the DOCX version.

The report serves well as a standalone document, with no undue dependence on earlier work.

A map of Biophysical Strategic Agricultural Land (BSAL) is included as Figure 1-2 that shows proximity of the MOCO Project to BSAL, although the operations are not directly on BSAL. However, the operations could impact on BSAL defined along Glennies Creek and Bowmans Creek and their tributaries.

Although there is no map of groundwater sources classified as "highly productive", it is clear in the report that the Glennies Creek and Bowmans Creek alluvial aquifers and the groundwater systems associated with Main Creek and Bettys Creek have been considered highly productive in this assessment. The alluvial extent (shown in Figure 3-1) covers a broader area than the mapped BSAL. The less productive water source in the region is the fractured and porous rock that hosts the coal measures.

The water takes relevant to the AIP are presented for predictive simulations. The relative contributions of all water balance components for different physical processes are summarised in Table 3-10 for steady-state conditions, presumably pre-Project. Similar detail is not provided for the calibrated model, but a time-series plot of net flux components is provided in Figure 3-36 from 1980 to 2030.

Data Matters

Document #2 provides sufficient detail on the hydrogeological and hydrological characterisation of the area. The groundwater status of the region is sampled by an extensive monitoring network comprising shallow and deep bores, many of them nested, as well as VWPs. The attributes of the bores are included in Table 2-7 and Table 2-8.

Sufficient cause-and-effect data analysis is presented. There seems to be a weak correlation of groundwater levels with rainfall in general, although the scale of the presented hydrographs (Figures 2-11 and 2-12) could disguise real correlations. There are definitely a few good correlations. There is strong evidence of mining effects in many of the hydrographs. Discussion is provided on vertical gradients at nested sites being mostly upwards, but four sites show the reverse. It is noted that one bore provides evidence for the Hunter Thrust being an hydraulic barrier.

Following advice in the earlier peer review report, there are now maps provided for depth to water, water table elevation and Bayswater Seam potentiometric contours. The provided maps show simulated patterns rather than "observed". While difficulties in producing maps of "observed" water levels are explained, it should have been possible (and more instructive) to show posted values of measured deptth to water, while recognising inconsistencies due to perching and depressurisation. It is recognised that groundwater levels are complicated by the net effects of 38 open cut mines and five underground operations.

Some discussion on the possible effect of flooding on alluvial water levels could have been included. The report specifically states that flooding is excluded from the model.

Model Matters

A good conceptual model graphic is included as Figure 2-19 and there is an adequate description of the key processes acting on the regional groundwater system. More information is now provided on fracturing above underground mines.

Actual Evapotranspiration (AET) is now used in the model as a better estimate of the maximum ET rate from the regolith.

The model extent is said to be 20.5 km (N-S) by 22.1 km (E-W)[5] but Figure 3-1 is broader than this in the east-west direction. The extent is sufficient for inclusion of regional geology and other mines, and the boundaries are sufficiently distant to have no significant edge effects on model results. The model has about 676,000 cells consisting of 205 rows and 221 (or 274?) columns, each cell being 100 m square. Subdivision into 20 layers provides more than adequate vertical resolution. As model layers combine coal seams and interburden, modellers must be careful to assign properly weighted average hydraulic conductivities as initial estimates. An alternative approach is to aggregate coal thicknesses over a depth interval and apply a true coal hydraulic conductivity to a coal layer, and a true interburden hydraulic conductivity to an interburden layer.

A Class 2 confidence classification, according to the NWC 2012 guidelines, is appropriate.

Model calibration has been performed using a *monte carlo* approach. While this is a common approach during prediction, where alternative models centred on one calibrated model are explored, its application to calibration is non-standard. The NWC 2012 guidelines do not endorse (or mention) a *monte carlo* approach for model calibration. This reviewer does not regard *monte carlo* calibration as an efficient targeted procedure and would much prefer to see a traditional well-accepted systematic approach. Nevertheless, the procedure has found a number of alternative model parameterisations that give acceptable calibration performance statistics. In Document #1, some use was made of traditional automated (PEST) procedures to refine estimates of specific yield. This approach has not ben carried through to Document #2. The reviewer holds to the opinion that closer matches to the hydrographs in Appendix C could have been achieved with standard procedures.

The reviewer notes the dramatic improvement that has been reported for successful model realisations. In Document #1, the success rates for realisations were 7.8% (satisfying criterion 1), 3.0% (criteria 1&2), 1.1% (criteria 1&2&3), and 0.2% (criteria 1&2&3&4). In Document

[5] The corresponding Liddell model v7.2 was said to have 274 columns covering 27.4 km

#2, the success rates are claimed to be 87% (satisfying criterion 1), 72% (criteria 1&2), 72% (criteria 1&2&3), 71% (criteria 1&2&3&4), and 7.1% (criteria 1&2&3&4&5a). This apparent improvement is due to selection of different parameter sets from narrow probability distributions, rather than an outcome of an unbiased stochastic process. This means that a model realisation is not allowed to stray far from a previously acceptable model. This results in a misleading impression of the accuracy of the model and the near-uniqueness of possible model realisations because of an underlying assumption that the base model (consisting of the median values for each property) is optimal. The reviewer contends that the *monte carlo* calibration process can find a few models that meet statistical performance criteria by chance, but there is no mechanism in this process for optimal convergence (unlike other traditional methods). The inability of the *monte carlo* calibration process to find optimal solutions is indicated by the anomalous trends on Figure 3-5 and Figure 3-6 (reproduced and discussed below).

It is not clear in Document #2 how the probability distributions in Table 3-4 have been specified for different properties. However, the clarification email of 23 October 2014 from Jacobs makes clear that the values are fractions of an order of magnitude. These fractions are then taken to be standard deviations of each property's assumed probability distribution. The reviewer has examined the distributions for width, and makes the following observations:

- Median standard deviation: 0.29 of an order of magnitude;
- Mean standard deviation: 0.47 of an order of magnitude;
- 46 percent of properties have a standard deviation more than a quarter of an order of magnitude;
- 36 percent of properties have a standard deviation more than half of an order of magnitude;
- The median multiplier for minimum to maximum specific yield is 5.7;
- The median multiplier for minimum to maximum horizontal hydraulic conductivity is 10.4; and
- The median multiplier for minimum to maximum vertical hydraulic conductivity is 61.3.

The observations confirm that each parameter distribution is narrower than is likely to occur in nature.

Many of the resulting calibrated specific yield values are generally too low to be physically reasonable. It should be noted that only those groundwater hydrographs monitoring unconfined conditions would convey any information on specific yield. It is expected that most of the reported specific yield values are effectively uncontrolled in the *monte carlo* process, and are not accurate values.

The model realisations are necessarily constrained to reasonable physical properties but there is no guarantee that they are optimal parameter sets. In all, 53 parameter sets have been retained as acceptable model realisations for predictive purposes. Groundwater levels (shallow and deep) and mine inflows at Cumnock underground workings and North Pit have been used as calibration targets.

A comparison of calibration and observed hydrographs is offered in Appendix C. It is noted that most modelled hydrographs have roughly the right absolute level, but trends are not always honoured, and temporal fluctuations are not replicated.

The scattergrams in Figure 3-5 (for alluvium) and Figure 3-6 (for hard rock) - reproduced below - show diagnostic features of the model's performance.

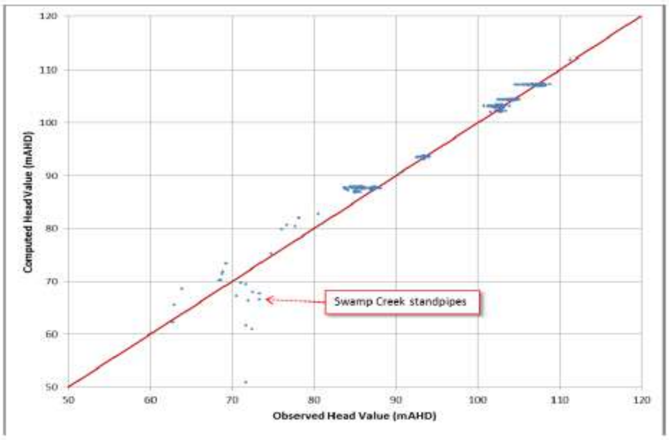

Figure 3-5 – Observed vs. Simulated Levels for all Alluvial Bores

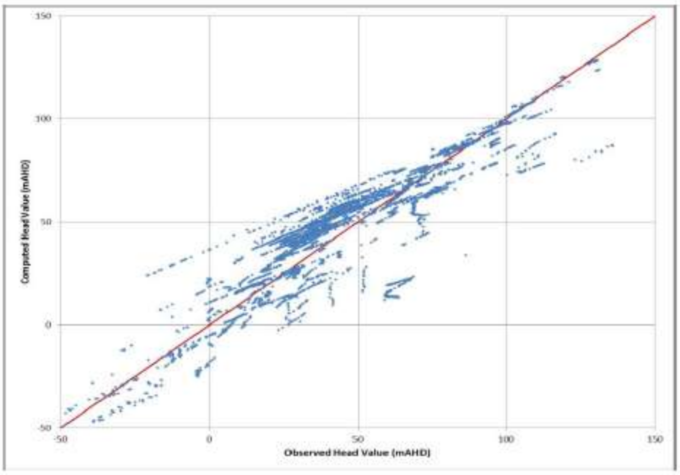

Figure 3-6 – Observed vs. Simulated Groundwater Levels for Hard Rock Calibration Bores

The horizontal lines in Figure 3-5 are due to the model's inability to match natural fluctuations, due either to the values adopted for specific yield or use of a stress period (1 year) that is too long. The sloping lines in Figure 3-6 suggest that the model generally is unable to reproduce the strength of drawdowns caused by mining.

The fractured zone in the model was set at a uniform height of 200 m, which should be sufficiently conservative. The enhanced vertical hydraulic conductivity in the fractured zone appears to range from 1E-4 to 5E-4 m/day. These values are appropriate in the experience of the reviewer. However, it is not clear where the fracturing has been taken to land surface in the model, but the report notes this has been done at some locations.

Some check on the reasonableness of modelled baseflows has been reported for Bowmans Creek in Figure 3-7, although the baseflow analysis in Table 2-3 is limited to Glennies Creek. Baseflow can be used as a second-order calibration target to check that the simulated rates are of a similar magnitude to those derived by baseflow analysis. The modelled baseflows are on the low side but are within one order of magnitude.

A sensitivity analysis has been done by normalising the adopted parameter range to the (arbitrary) parameter bounds placed on the *monte carlo* simulations. However, this is not an unbiased procedure as the *monte carlo* ranges are not the same for each parameter. The analysis is strictly valid only for specific yield (Sy) where the ranges are generally similar (usually 0.25 of an order of magnitude). Nevertheless, the procedure does identify parameters that are clearly sensitive and others that are clearly insensitive.

Two scenarios are defined for predictive analysis: Base and Proposed. The base scenario includes all cumulative stresses from other mines and approved mining at the Mount Owen Complex. Identification of MOCO impacts is performed correctly by differencing the outputs of the two scenario simulations.

The simulated North Pit pre-evaporation inflow (about 1.2 ML/day) is consistent with recent dry-weather inflow (about 0.8 ML/day).

The predicted drawdown maps (Figures 3-16 to 3-27) for the median and one standard deviation uncertainty in alluvium and the Bayswater Seam at different years are sensible. Statements on the drawdown extents would have been informative, but they appear to be narrow.

Spatial head distribution maps are included for the Bayswater Seam at 2014 at the end of calibration (Figure 2-15) and at 2025 when drawdown would be at its maximum (Figure 3-28). Changes in groundwater flow direction would inform comment on potential water quality changes in the groundwater system. Comment on potential water quality impacts is thorough for the three final voids. Two are likely to remain groundwater sinks (North Pit and RERR), while the other (Bayswater North Pit) would be a source of water that would migrate to the RERR void.

There is substantial and adequate discussion on groundwater impacts (Section 4). Aquifer Interference Policy minimal harm considerations are addressed except for the estimated percentage increase in the average salinity of water in the nearest stream. However, there is a statement that the final void water source would not impact the alluvium and, by inference, the surface waterbodies.

Although the AIP has no minimal harm criterion for reduced baseflow or enhanced leakage from a stream, it is necessary to interrogate the model for this impact so that the loss in stream water can be licensed. Appropriate quantification of stream and alluvial water losses and attribution to the relevant water sources has been reported in Document #2.

For Bowmans Creek and its tributaries the surface water and the groundwater belong to a common water source (Jerrys Water Source). Groundwater associated with Glennies Creek and its tributaries is covered by the Hunter Regulated River Water Sharing Plan. The predicted reductions in groundwater fluxes to the four considered alluvial aquifers, due to the MOCO Project, are certainly small.

As no transient recovery run was undertaken for the groundwater system, there is no determination of the time required for groundwater levels to recover towards pre-mining levels. However, reference is made to a separate study in the companion surface water assessment where final void water levels are expected to equilibrate within 200 years for BNP and 500 years for North Pit and RERR voids.

Cumulative impact findings are clear.

The DGRs and NOW comments in Tables 1-1 and 1-2 are addressed satisfactorily throughout the report.

Conclusion

This reviewer is of the opinion that "Model Version 8.1 Mount Owen" is *fit for purpose*.

Although the *monte carlo* method of calibration is non-standard, sufficient model parameterisations have been identified that give acceptable global calibration performance statistics. Nevertheless, it is expected that better replication of hydrographic trends and fluctuations could have been achieved using standard calibration procedures.

The anticipated mine inflows are considered reliable as they are well constrained by field control at North Pit during calibration.

The objectives expressed in terms of DGR and NOW requirements have been addressed satisfactorily. It is noted that the drawdown in the Main Creek and Bettys Creek alluvial aquifers is expected to exceed 2 metres but there are no affected production bores in those groundwater systems.

The quantitative estimates of water takes for licensing purposes are reasonable and the investigation of environmental impacts related to groundwater extraction during mining has been sufficiently thorough.

Yours sincerely,

NPMerrick

Dr Noel Merrick

Table 1. MODEL APPRAISAL: Mount Owen Version 8.1 Model Preparation

Q.	QUESTION	Not Applicable or Unknown	Score 0	Score 1	Score 3	Score 5	Score	Max. Score (0, 3, 5)	COMMENT
1.0	THE REPORT								
1.1	Is there a clear statement of project objectives in the modelling report?		Missing	Deficient	Adequate	Very Good			Sections 1.2, 1.3.
1.2	Is the level of model complexity clear or acknowledged?		Missing	No	Yes				Reference to new national guidelines. Class 2 confidence classification. Equivalent to Impact Assessment Model, medium complexity.
1.3	Is a water or mass balance reported?		Missing	Deficient	Adequate	Very Good			Table for steady-state. Time-series plot for calibration and prediction. Provided for prediction scenarios for AIP measures, but not full components.
1.4	Has the modelling study satisfied project objectives?		Missing	Deficient	Adequate	Very Good			DGRs and NOW requirements are assessed.
1.5	Are the model results of any practical use?			No	Maybe	Yes			The findings of minimal impact are plausible.
2.0	DATA ANALYSIS								
2.1	Has hydrogeology data been collected and analysed?		Missing	Deficient	Adequate	Very Good			Sufficient cause & effect analysis; monitoring network details in Tables 2-7, 2-8; good hydrology.
2.2	Are groundwater contours or flow directions presented?		Missing	Deficient	Adequate	Very Good			Only simulated contours due to substantial depressurisation. Posted measured depth to water could have been done.
2.3	Have all potential recharge data been collected and analysed? (rainfall, streamflow, irrigation, floods, etc.)		Missing	Deficient	Adequate	Very Good			Flood recharge specifically excluded.
2.4	Have all potential discharge data been collected and analysed? (abstraction, evapotranspiration, drainage, springflow, etc.)		Missing	Deficient	Adequate	Very Good			Actual ET (BoM) now used in place of evaporation. Private groundwater usage assumed negligible.

2.5	Have the recharge and discharge datasets been analysed for their groundwater response?		Missing	Deficient	Adequate	Very Good			Residual mass compared with groundwater hydrographs - poor rain correlation; strong mining evidence. There is discussion on general upwards flow - statistics on vertical head gradients would be useful. One bore is evidence for Hunter Thrust hydraulic barrier.
2.6	Are groundwater hydrographs used for calibration?			No	Maybe	Yes			Shallow and deep hydrographs date back to 2001 - long record. State natural fluctuation in water levels for application of AI Policy minimal harm rules.
2.7	Have consistent data units and standard geometrical datums been used?			No	Yes				
3.0	CONCEPTUALISATION								
3.1	Is the conceptual model consistent with project objectives and the required model complexity?		Unknown	No	Maybe	Yes			
3.2	Is there a clear description of the conceptual model?		Missing	Deficient	Adequate	Very Good			Section 2.6.6
3.3	Is there a graphical representation of the modeller's conceptualisation?		Missing	Deficient	Adequate	Very Good			Perspective diagram in Fig.2-19. Also geology x-sections Figures 2-6, 2-7.
3.4	Is the conceptual model unnecessarily simple or unnecessarily complex?			Yes	No				Major processes are included. Stratigraphy is detailed.
4.0	MODEL DESIGN								
4.1	Is the spatial extent of the model appropriate?			No	Maybe	Yes			Dimensions 21 km x 22 km (but Liddell model 27 km?). Cell size uniform 100m. 20 layers, 205 rows, 221 columns (or 274?), 677,000 active cells. Expanded from prior MER model.
4.2	Are the applied boundary conditions plausible and unrestrictive?		Missing	Deficient	Adequate	Very Good			Reasonable no-flow boundaries. Heads at GHB boundaries are not shown or defended, as there is no supplied regional observed groundwater contour map. RCH algorithm is %rain. Predicted drawdown contours for proposed development do not reach boundaries.
4.3	Is the software appropriate for the objectives of the study?			No	Maybe	Yes			MODFLOW-SURFACT and Groundwater Vistas.

Table 2. MODEL APPRAISAL: Mount Owen Version 8.1 Model Implementation

Q.	QUESTION	Not Applicable or Unknown	Score 0	Score 1	Score 3	Score 5	Score	Max. Score (0, 3, 5)	COMMENT
5.0	CALIBRATION								Jan.1980 - Dec.2012
5.1	Is there sufficient evidence provided for model calibration?		Missing	Deficient	Adequate	Very Good			Sufficient for performance against groundwater levels, and historical mine inflow (Cumnock & North Pit). No indication of spatial distribution of residuals except weakest at Swamp Creek (Glendell). Scattergrams and performance statistics are given.
5.2	Is the model sufficiently calibrated against spatial observations?		Missing	Deficient	Adequate	Very Good			Regional calibration on many regional shallow and deep bores.
5.3	Is the model sufficiently calibrated against temporal observations?		Missing	Deficient	Adequate	Very Good			Hydrographs for all bores are presented for comparison in App.C. Simulated hydrographs generally have less amplitude than observed and do not always follow the same trends.
5.4	Are calibrated parameter distributions and ranges plausible?		Missing	No	Maybe	Yes			Consistent with previous studies and site tests. Specific yield values are generally low.
5.5	Does the calibration statistic satisfy agreed performance criteria?		Missing	Deficient	Adequate	Very Good			Alluvial bores: 3-5%RMS, 1.2-2.6mRMS. Project bedrock bores: 3-5%RMS, 6-10mRMS. All bedrock bores: 7-9%RMS, 12-17mRMS.
5.6	Are there good reasons for not meeting agreed performance criteria?	N/A	Missing	Deficient	Adequate	Very Good			
6.0	VERIFICATION								
6.1	Is there sufficient evidence provided for model verification?	N/A	Missing	Deficient	Adequate	Very Good			All data used for calibration.

6.2	Does the reserved dataset include stresses consistent with the prediction scenarios?	N/A	Unknown	No	Maybe	Yes			
6.3	Are there good reasons for an unsatisfactory verification?	N/A	Missing	Deficient	Adequate	Very Good			
7.0	PREDICTION								
7.1	Have multiple scenarios been run for climate variability?		Missing	Deficient	Adequate	Very Good			The assumptions for future rainfall appear to be unstated. It is likely that a single average climate has been used in accordance with standard practice.
7.2	Have multiple scenarios been run for operational /management alternatives?		Missing	Deficient	Adequate	Very Good			2 scenarios: Base, Proposed. Base includes cumulative stresses. Stochastic results and statistics are based on 53 realisations.
7.3	Is the time horizon for prediction comparable with the length of the calibration / verification period?		Missing	No	Maybe	Yes			The time period for transient calibration is 32 years from 1980 to 2012. Prediction period is 18 years from 2013 to 2030. There is no reported transient recovery simulation but there is steady-state post-mining equilibrium simulation.
7.4	Are the model predictions plausible?			No	Maybe	Yes			Plausible drawdown magnitudes and drawdown extent. Plausible stream and alluvial losses.
8.0	SENSITIVITY ANALYSIS								
8.1	Is the sensitivity analysis sufficiently intensive for key parameters?		Missing	Deficient	Adequate	Very Good			Investigated during *monte carlo* simulations. Not an unbiased procedure as the adopted parameter range is normalised to arbitrary parameter bounds. Strictly valid only for Sy where ranges are common.
8.2	Are sensitivity results used to qualify the reliability of model calibration?		Missing	Deficient	Adequate	Very Good			Figures 3-8 to 3-12. Adopted parameter ranges are not limited by calibration performance, but only by successful convergence.
8.3	Are sensitivity results used to qualify the accuracy of model prediction?		Missing	Deficient	Adequate	Very Good			Stochastic results and statistics are based on best 53 realisations.

9.0	UNCERTAINTY ANALYSIS								
9.1	If required by the project brief, is uncertainty quantified in any way?		Missing	No	Maybe	Yes			Stochastic results and statistics are based on 53 realisations. This does not guarantee reliable standard deviations, as many more realisations are possible. Although the global statistics appear OK, the different realisations can give simulated hydrographs with wide offsets in absolute magnitudes.
	TOTAL SCORE								PERFORMANCE: