Joint Groundwater Experts Report

Land Court of Queensland

Registry: **Brisbane**

Numbers: **MRA428-14, EPA429-14, MRA430-14, EPA431-14, MRA432-14, EPA433-14, EPA446-14**

Applicant:	ADANI MINING PTY LTD [Adani]
First Respondent:	LAND SERVICES OF COAST AND COUNTRY INC. [LSCCI]
Second Respondent:	CONSERVATION ACTION TRUST [CAT]
Third Respondent:	JAH'SHUA MCAVOY
Statutory Party:	CHIEF EXECUTIVE, DEPARTMENT OF ENVIRONMENT AND HERITAGE PROTECTION [DEHP]

Report date: 9 January 2015

Meeting: 22 December 2014 at 66 Eagle Street, Level 9, Central Plaza 2, Brisbane, Queensland. Subsequently by email correspondence.

Experts Present: John Webb ('**JW**'), Adrian Werner ('**AW**'), John Bradley ('**JB**'), Noel Merrick ('**NM**').

Our understanding of our responsibilities:

We understand that our responsibilities are as described in Orders 11, 12 and 15 made on 20 October 2014 by Acting President Smith:

11. By 4.00pm on Wednesday, 31 December 2014, the identified experts in each field must:
(a) confer with the corresponding expert in the same field, and discuss whether the issues relevant to their field of expertise can be resolved in whole or in part in accordance with the Land Court Rules 2000 (Qld); and
(b) prepare and provide to the parties a joint report in accordance with the Land Court Rules 2000 (Qld).

12. The meetings of experts referred to in order 11 hereof are to take place in the absence of the parties and their legal representative and discussions about working notes of the parties' experts shall, unless otherwise agreed by the parties, be on a 'without prejudice' basis, except for any:
(a) notices given under orders 9 and 10 above; and
(b) joint reports produced pursuant to orders 11(b) or 15(b).

15. Should the identified experts in any discipline agree that a further joint expert meeting is necessary, any:
(a) such further meeting of experts must occur by 4.00pm on Friday, 20 February 2015; and
(b) supplementary joint report must be prepared and provided to the parties by 4.00pm on Friday, 27 February 2015.

We also note the following provisions of the Uniform Civil Procedure Rules 1999 (Qld):

429B Court may direct experts to meet

(1) The court may, at any stage of a proceeding, direct experts to meet and-

(a) identify the matters on which they agree; and

(b) identify the matters on which they disagree and the

reasons why; and

(c) attempt to resolve any disagreement.

(2) The court may, for the meeting-

(a) set the agenda; and

(b) specify the matters the experts must discuss; and

(c) direct whether or not legal representatives may be present; and

(d) give directions about the form of any report to be made to the court about the meeting; and

(e) give any other directions the court considers appropriate.

(3) Evidence of anything done or said, or an admission made, at the meeting is admissible at a trial of the proceeding only if all parties to the proceeding agree.

(4) However, subrule (3) does not apply to a report made to the court about the meeting identifying the matters mentioned in subrule (1)(a) or (1)(b).

In addition, we note the following provisions of the Land Court Rules 2010 (Qld):

24A Experts attending meeting must prepare joint report

(1) The experts attending a meeting of experts must, without further reference to or instruction from the parties, prepare a joint report in relation to the meeting.

(2) However, the experts attending the meeting may, at any time before the joint report is completed, ask all parties to respond to an inquiry the experts make jointly of all parties.

(3) Despite subrule (1), any of the experts may participate in a mediation involving the parties.

(4) The joint report must-

(a) confirm that each expert understands the expert's duty to the court and has complied with the duty; and

(b) be given to the parties.

24C Duty of expert

(1) A witness giving evidence in a proceeding as an expert has a duty to assist the court.

(2) The duty overrides any obligation the witness may have to any party to the proceeding or to any person who is liable for the expert's fee or expenses.

Scope of Discussions:

We understand that the experts are to focus on the First Respondent's *Objection form for a mining lease application* ('LSCCI Objection') dated 16 June 2014 and *Preliminary Identification of Issues* ('LSCCI Issues') dated 28 November 2014.

LSCCI has raised objections to the applications in the following areas:

(a) groundwater;

(b) groundwater dependent ecosystems;
(c) surface water;
(d) biodiversity (primarily focused on impacts to the black throated finch);
(e) climate change; and
(f) economic and social matters.

In terms of groundwater impacts, LSCCI has specifically raised the following matters in the LSCCI Objection :

(a) if the mine proceeds, it will cause severe adverse environmental impacts to groundwater (paragraph 11);
(b) if the mine proceeds, it will impact groundwater dependent springs including the Doongmabulla Springs Complex and Mellaluka Springs Complex (paragraph 12);
(c) that the full extent of such impacts cannot be stated due to inadequate information having been provided in the applications, EIS and SEIS (paragraph 13); and
(d) it has not been demonstrated adequately that the mine will not have unacceptable adverse impacts on groundwater, particularly in terms of quality and quantity (paragraph 14(a)).

Matters relating to *Groundwater and Groundwater Modelling* are Issues 1 to 11 in the LSCCI Issues. This joint report is limited to opinions on those matters.

Points of agreement:

In this matter we **agree** on the following:

Regional geology

1. No agreement.

Groundwater flow directions

2. We agree that the flow directions as presented in the HydroSimulations report of 31 March 2014[1] are a reasonable best estimate of groundwater flow at depth (reproduced here as **Figure 1**).

3. We agree that the head contours for the Colinlea Sandstone suggest a groundwater divide which is offset (to the west) from the Doongmabulla Springs and is offset also from the groundwater divide presented in the conceptual model, which was the basis for the original numerical model.

4. The contours shown for the Clematis Sandstone in the latest numerical model report (GHD, November 2014[2]; Figure 31 - reproduced here as **Figure 2**) suggest flow directions reasonably consistent with those in **Figure 1**, with the exception of areas in the north and northwest of the model domain.

5. There remains significant uncertainty regarding flow at and beyond the western boundary of the model due to a lack of field measurements.

Conceptual model

6. We agree that the conceptual cross sections (e.g. Figures 9 and 10 of GHD (2013)[3]) are simplistic and that they do not accurately represent the probable flow conditions.

Source aquifer for Doongmabulla Springs Complex

7. We agree that the source of the Doongmabulla Springs is inconclusive and that there are two potential sources that need to be considered; one a source below the Rewan Formation, the other a source from above the Rewan Formation. Methods such as isotope sampling, in conjunction with analysis of existing data (water chemistry, water level, geology) would potentially assist in resolving the question.

Source aquifer for Mellaluka Springs Complex

8. We agree that the source for the Mellaluka Springs is beneath the coal-bearing sequence of the Colinlea Sandstone. **JB** believes that it is likely to be a permeable layer at the top of the Joe Joe Formation and not the Colinlea Sandstone as currently conceptualised (**JW** accepts that this is likely, but notes that it is also possible that the source is the sub-E sandstone in the Colinlea Sandstone). We agree that if the source is the Joe Joe Formation, it means that the drawdown impact on this spring may be somewhat less than modelled but is likely to be still substantial. The model currently does not have a layer for the Joe Joe Formation; we agree that addition of an additional model layer is not

[1] HydroSimulations (2014) CPD-1-2014: A Review of the Carmichael Coal Mine and Rail Project Water Hydrogeology Report. Report HS2014/7 for Department of State Development, Infrastructure and Planning, Queensland. 31 March 2014.

[2] GHD (2014) Carmichael Coal Project. Response to Federal Approval Conditions - Groundwater Flow Model. November 2014. Report for Adani Mining Pty Ltd.

[3] GHD (2013) Carmichael Coal Mine and Rail Project SEIS. Mine Hydrogeology Report Addendum, 24 October 2013. Report for Adani Mining Pty Ltd.

necessary for modelling spring impacts at this stage but should be included in future model updates.

Numerical Modelling

9. All modelling contains a level of uncertainty.

10. The claims for conservatism of the model appear to be overstated. While the adopted vertical hydraulic conductivities (being 10% of the horizontal) are likely to lead to conservative prediction of impacts, the same cannot be said for a lower degree of lateral heterogeneity. If strong layering exists, and layers are continuous over large areas, then the vertical hydraulic conductivity will be limited by the lowest permeability of the sequence. The adoption of 160 m as a uniform fracturing height above longwall panels is not necessarily conservative due to the lack of field evidence for fracturing heights associated with multi-seam mining.

11. Adoption in the model of low rainfall recharge along the Great Dividing Range has led to an inconsistency with the conceptual model drawings, which anticipate enhanced recharge along the ridge and formation of a groundwater mound beneath the ridge, with westward groundwater flow on one side and eastward flow on the other side of the ridge. While this conceptualisation is applicable for mining projects to the south, model results and field observations suggest a groundwater divide farther west (in the vicinity of Lake Galilee) and a groundwater mound farther south (towards Jericho).

12. We note that the occurrence of easterly groundwater flow does not necessarily preclude the occurrence of GAB impacts as stated in project groundwater reports. As drawdown propagates independently of the groundwater flow direction, under the principle of superposition for linear systems, the direction of flow is irrelevant to the potential for impacts from drawdown.

13. We agree that the absence of transient calibration is a model weakness. As a first step, transient verification is encouraged to assess the dynamic response of the model to historical stresses. The transient behaviour of the system is not well understood and in future refinements of the model transient calibration should be undertaken.

14. We agree that the Option 2 scenario (250 mAHD boundary) in the latest GHD model (November 2014) is unrealistic. Lowering all of the boundary heads by 25 m is an indefensible approach which has created a greater degree of inconsistency with the field data than is already apparent in Option 1 (275 mAHD boundary). It is understood that Option 2 is an approval condition imposed by the Australian Government Department of the Environment.

15. Ephemeral streams have been modelled as drain cells and therefore can only take water from the model rather than allowing recharge into the model. While we recognise that modelling of ephemeral streams is difficult, they may in reality present an additional source of recharge to the groundwater system.

16. We agree that altering the western boundary conditions changed significantly the Carmichael River/ aquifer interactions and that clarification is needed on the distribution of these changes to clarify whether the changes are restricted to upstream reaches far from the mine lease. Figure 60 in the GHD November 2014 report suggests minimal differences in predicted baseflow across the mine lease.

17. The latest SEIS model calibration statistics (12 %RMS on mine lease; 7 %RMS overall) are at the limit of acceptability.

18. An improved analysis of uncertainty is encouraged for future model development.

19. In the 2012 groundwater modelling guidelines, the Type I to Type IV sensitivity analysis is no longer recommended and the analysis as presented in the SEIS modelling report is not instructive.

20. There is a need for clarification of conditions relating to the backfilling associated with final voids, with an expectation of adequate sealing against coal seam contacts.

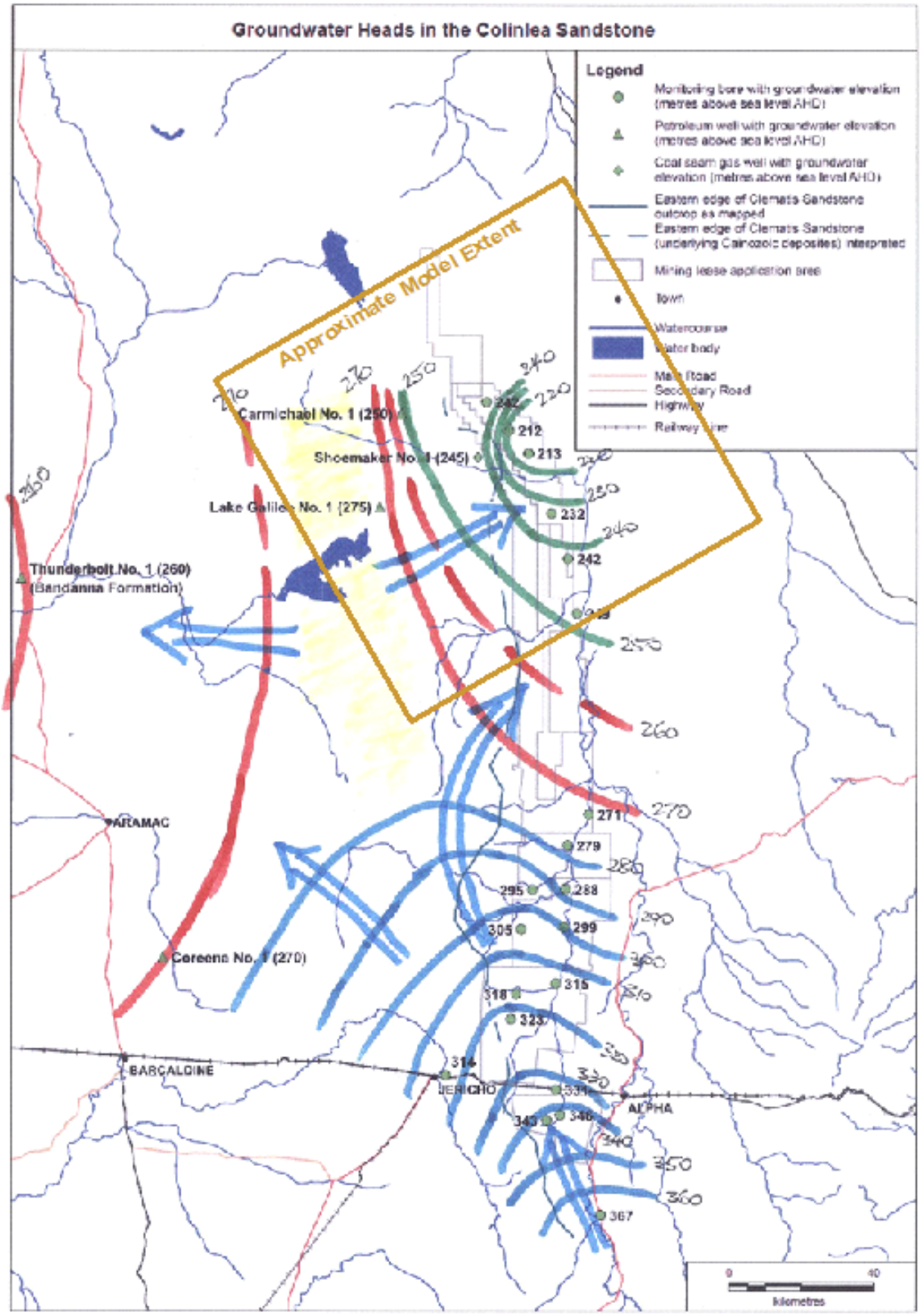

Figure 1. Groundwater Heads and Flow Directions in the Colinlea Sandstone [after Bleakley 2014[4] and HydroSimulations 2014]

[4] Bleakley, A. (2014) Groundwater Flow Direction Carmichael Project Area. 3 March 2014.

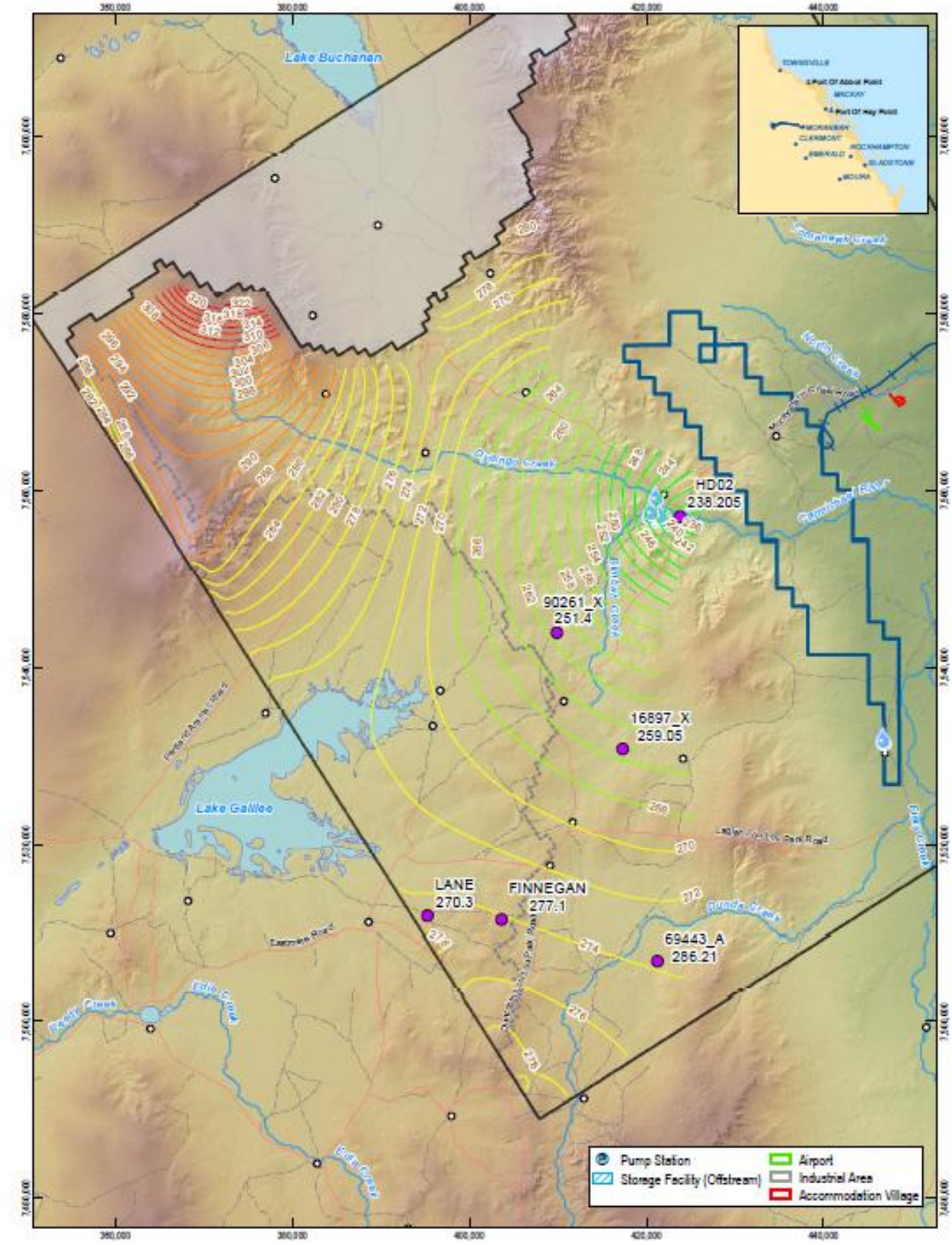

Figure 2. Simulated Groundwater Heads (mAHD) for the Clematis Sandstone - Option 1 Scenario [after Figure 31 in GHD November 2014]

Points of disagreement

In this matter we **disagree** on the following:

Regional geology

21. The experts disagree on the need to reconsider the published regional geology.
22. **JB** takes the view that the regional groundwater flow patterns and spring occurrence can be conceptualised without a need to reconsider the published geology and the Project geology.
23. **JW** takes the view that the regional geology needs to be revised in order to present a coherent conceptualisation of groundwater flow and spring hydrology.

Groundwater flow directions

24. No disagreement.

Conceptual model

25. We disagree on the need for exactitude in schematic conceptual model diagrams. **NM** and **JB** regard such diagrams as merely indicative of major water sources and sinks and regional flow directions. **AW** prefers to see detailed flow directions that honour the refraction caused by aquitards; flow lines are drawn crossing the Rewan Formation to create flow in an easterly direction – this violates the basic premise of this formation being an aquitard.
26. We disagree on the need to invoke faults as a major feature in the conceptual model. **JB** and **NM** consider that the Principle of Parsimony should be applied (consistent with groundwater modelling guidelines) when there is no definitive evidence of faults affecting the groundwater system. The Principle of Parsimony is also known as Occam's Razor - "*Entia non sunt multiplicanda sine necessitate*". This may be translated literally as "*The number of entities should not be increased without good reason*", or loosely as "*It is vain to do with more what can be done with fewer*" (Constable et al., 1987[5]). **AW**'s view is that the analysis of faults (and other preferential pathways such as abandoned wells) is inadequate to predict with reasonable certainty the competence of the aquitards as barriers to flow. **JW** believes that because faulting may be feeding Doongmabulla Springs (para 28), it could be a major feature of the conceptual model in places.
27. We disagree on the suitability of adopted hydraulic conductivities for the Rewan Formation aquitard. **JB** and **NM** consider that the adopted hydraulic conductivities are appropriate and sufficiently justified. **AW** notes that the Rewan hydraulic conductivity values are at the lower end of field-based values, and therefore, the calibrated groundwater model may under-predict leakage through the Rewan. **JW** points out that a small percentage of Rewan hydraulic conductivity values are quite high and would allow substantial groundwater flow; this has been entirely neglected in the model.

Source aquifer for Doongmabulla Springs Complex

28. Whilst it is agreed (refer point number 7) that the source aquifer for the Doongmabulla Springs Complex is inconclusive and that two potential sources need to be considered (one being a source above the Rewan Formation and the other being a source from below the Rewan Formation), we disagree on the extent to which a source from below the Rewan Formation is probable. **JW**'s view is that the potential for upward flow through

[5] Constable. S. C., Parker, R. L. and Constable, C. G. (1987) Occam's inversion: A practical algorithm for generating smooth models from electromagnetic sounding data. *Geophysics* **52**, 289-300.

the Rewan Formation via a permeable fault or fracture is a viable option. **JB**'s view is that there are sufficient zones of low-permeability clay material within the Rewan Formation to "heal" any existing faults or fractures and that the probability of a continuously permeable fault/fracture through the entire thickness of Rewan Formation is low. **JB** therefore favours a source aquifer for the Doongmabulla Springs complex that is above the Rewan Formation.

Source aquifer for Mellaluka Springs Complex

29. Minor disagreement; **JW** contends that the source could be the sub-E sandstone in the Colinlea Sandstone, as well as **JB**'s preferred option of a permeable layer at the top of the Joe Joe Formation.

Numerical Modelling

30. We disagree on the significance of reported calibration performance against vertical head gradients but we agree that vertical head differences (m units over unspecified depth intervals) have been misrepresented as vertical gradients (m/m units) in project modelling reports. **AW** disagrees that gradients are in "generally good agreement", and that "The model also replicates reasonably well the magnitude of vertical gradients" as stated in modelling reports. **NM** notes there are compelling reasons for often poor matches between measured and simulated vertical head differences (e.g. differences between point measurements in the field and depth-averaged heads across a model layer; and differences in depth intervals between sensor measurements in the field and the midpoints of vertically adjacent model layers).

31. We disagree on the significance of a number of errors in the groundwater modelling reports (which are acknowledged by **NM** and **AW**). **NM** considers that in spite of a number of minor errors, the modelling is generally satisfactory and that the model is fit for purpose. **AW** considers that the number of errors call into question the overall validity of the modelling.

32. We have differing expectations on the degree of uncertainty analysis that should be undertaken. **NM** considers that the substantial amount of sensitivity analysis gives a sufficient indication of uncertainty in predictions, although model realisations with high calibration RMS measures should have been excluded. He agrees with GHD (Nov.2014) that the "level of uncertainty is commensurate with the confidence required in a groundwater model at the current stage of project maturity". **AW** is of the view that multiple calibration realisations are required to understand the uncertainty of predictions. **NM** acknowledges this as an aspirational target but it is beyond current best practice in the groundwater modelling of mines. **AW** also considers that sensitivity analysis is not an adequate assessment of uncertainty.

33. We disagree on the findings of experimental scenarios for three different western boundary head scenarios (known as the SEIS model and Options 1 and 2 scenarios). **NM** maintains that the three model variants show insignificant differences in predicted environmental impacts of importance and that the adoption of different boundary conditions proved to be inconsequential. **AW** notes that changes to the western boundary introduce major changes to the model's predictions.

34. We have differing expectations on the degree of effort required for adequate diffuse recharge estimation. **NM** considers that ballpark recharge rates have been reached through a comprehensive assessment of relevant literature, several analytical interpretation methods, and two forms of modelling. However, the adopted rates do appear to be at the low end of what might be expected. **AW** is critical of the rigour applied to several of the interpretation methods, the completeness of reporting, and the exclusion of other forms of recharge (e.g. episodic flooding and leakage from ephemeral streams).

Expert's statement:

I confirm that I understand I have a duty to assist the court and that duty overrides any obligation I may have to any party to these proceedings or any person who is liable for my fees or expenses and I have complied with that duty.

Signed:

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John Webb

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John Bradley

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Adrian Werner

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Noel Merrick

9 January 2015