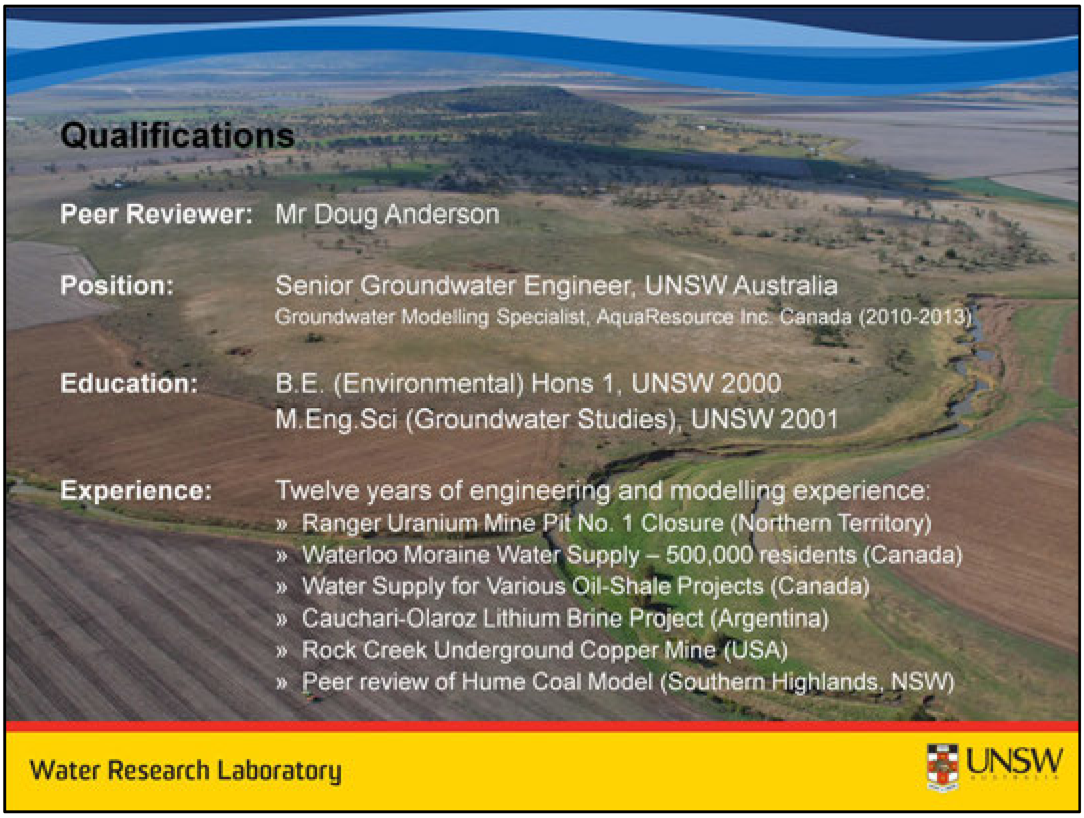
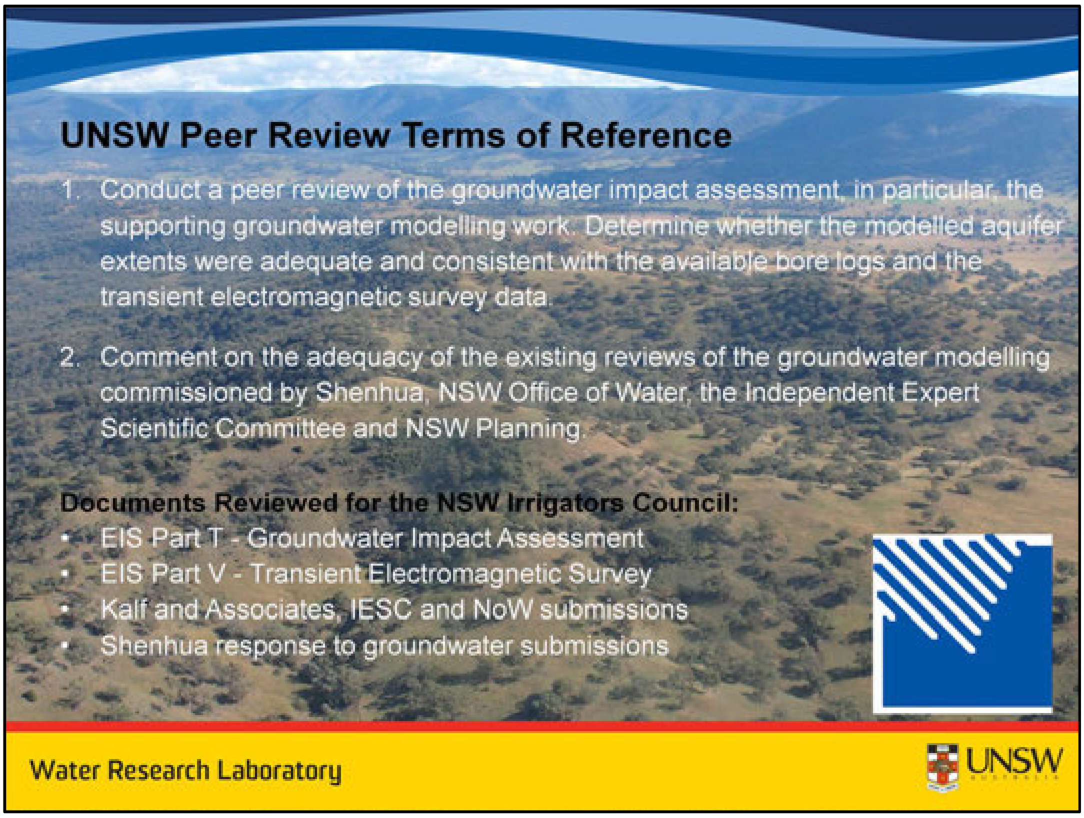
Good morning Madame Chair (Gabrielle Kibble AO), commissioners Payne (AM) and Gilligan.



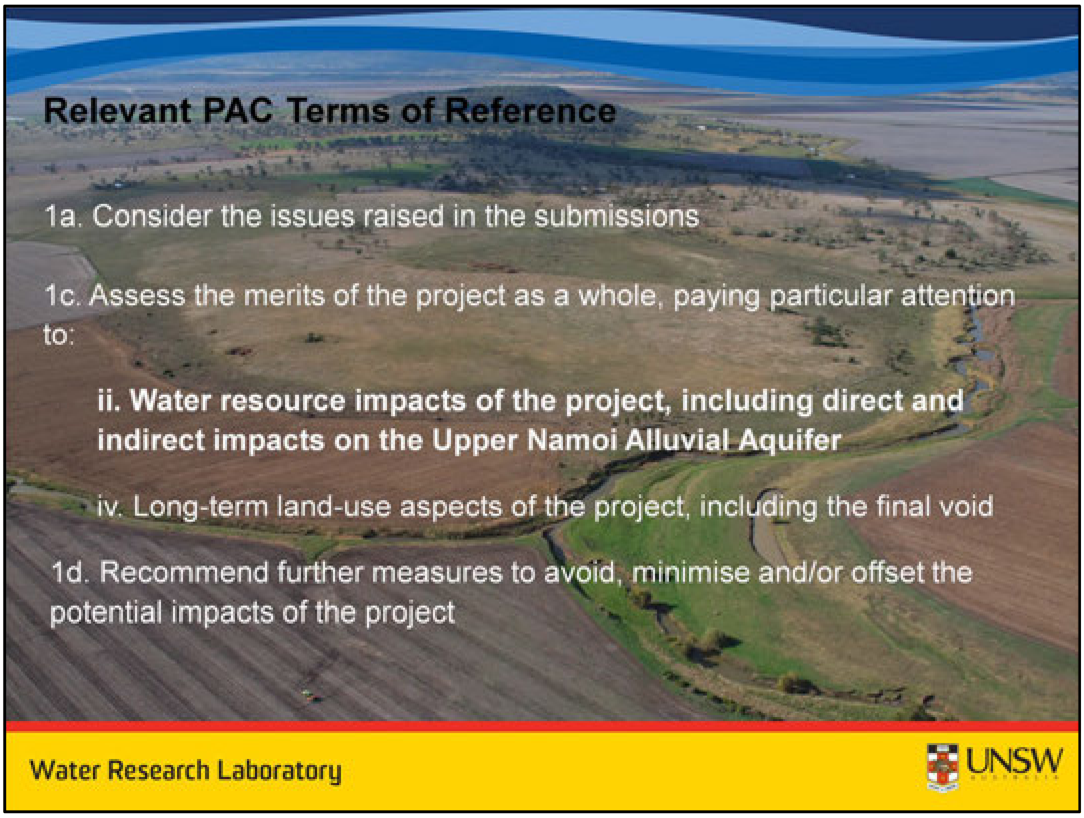
My name is Doug Anderson and I'm a senior groundwater engineer at UNSW Australia. I have a masters of engineering science in groundwater studies and twelve years of engineering and groundwater modelling experience on projects in Canada, Australia, America and Argentina. At UNSW I provide independent expert review and technical advice to all levels of industry and government.

(UNSW adopts a position that is neither for or against large coal mining development)



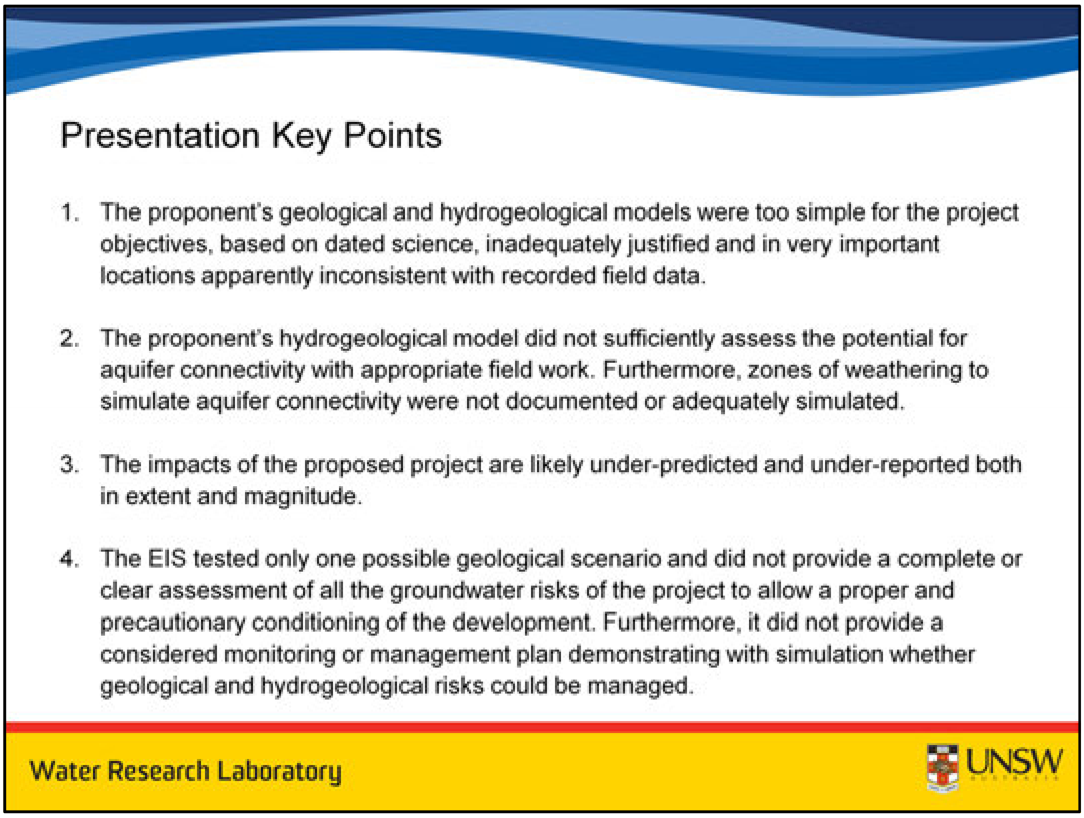
I am presenting today on behalf of the NSW Irrigators Council who was a funding party of my review in keeping with their policy to ensure maximum rigour in the environmental assessment of water impacts from mining and CSG activities.

As shown on the screen I was commissioned to review a number of documents to determine whether the water impact predictions generated by the EIS groundwater model were adequate (and by adequate, I mean both plausible and conservative).

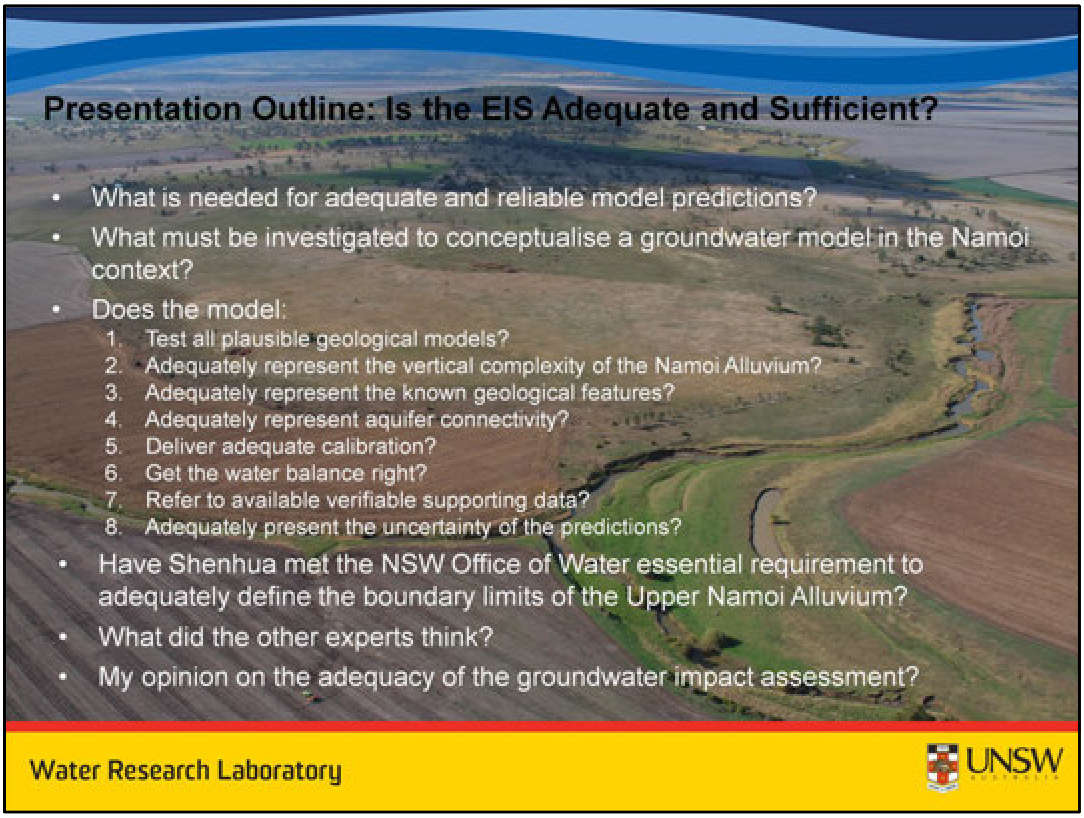


The PAC term of reference most related to my assessment is the water resource impacts of the project, including impacts on the Upper Namoi Alluvial Aquifer – that's the productive braided sand and gravel deposits from which farmers extract highly valuable groundwater from a fully allocated resource to support double cropping on their unique and fertile basaltic soils.

It was outside UNSW's scope to comment on management and other measures as we identified so many potential issues we did not have confidence that the provided model predictions and related assessments were both plausible and conservative.



So what were the problems with the groundwater impact assessment?



So how did I arrive at this conclusion?

Well unfortunately my time-slot today is too short to present a complete evidentiary basis for my reasoning and I will need to submit additional details to the PAC after this hearing.

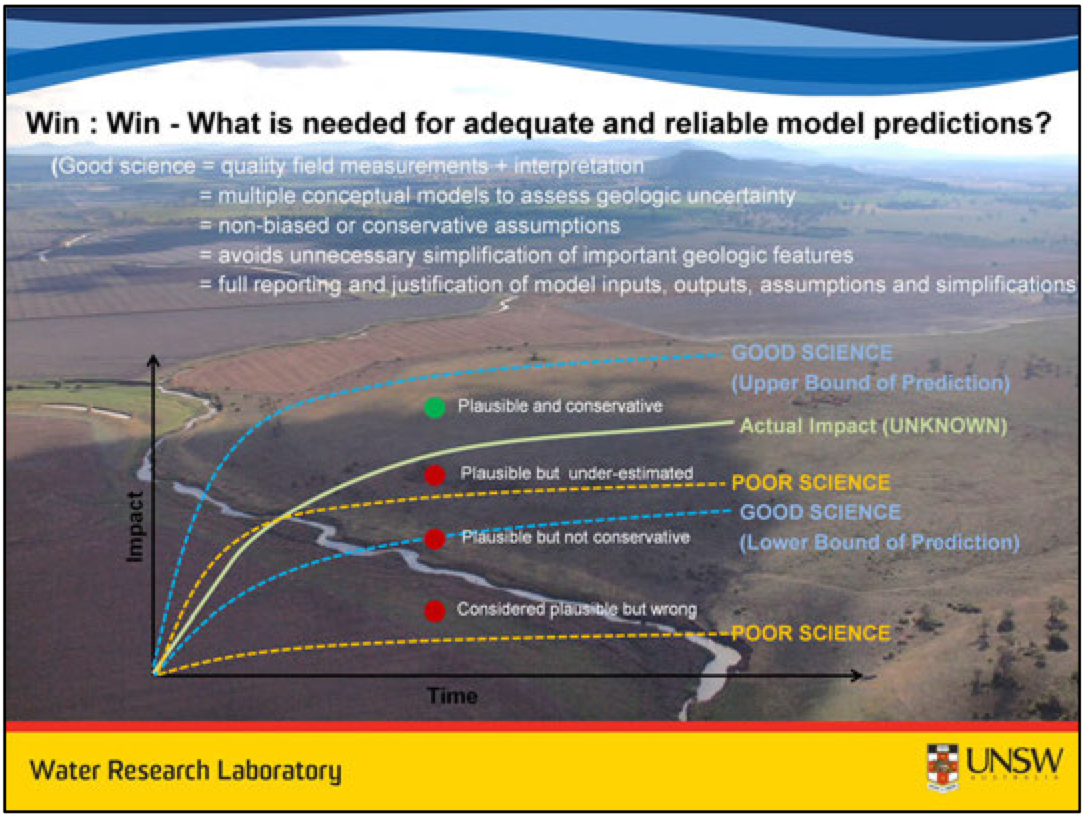
In today's presentation, I will :

-Overview what is needed for an adequate and reliable model prediction.

-Provide answers to a short list of questions that demonstrate aspects of poor scientific assessment

-Summarise the findings of other experts.

-Conclude with a summary of my assessment that I hope you will find useful in your complex deliberations



So, to focus on the Namoi Alluvium, Shenhua are justifying their stance that the water impacts of the project are acceptable based on the predictions of their model. So what is good science and poor science in the groundwater modelling context, when the impact of an activity isn't known in advance?

To be good science a model must:

-be founded on quality field measurements and interpretations

-utilise multiple conceptual models to assess the risks associated with geologic and water use uncertainty

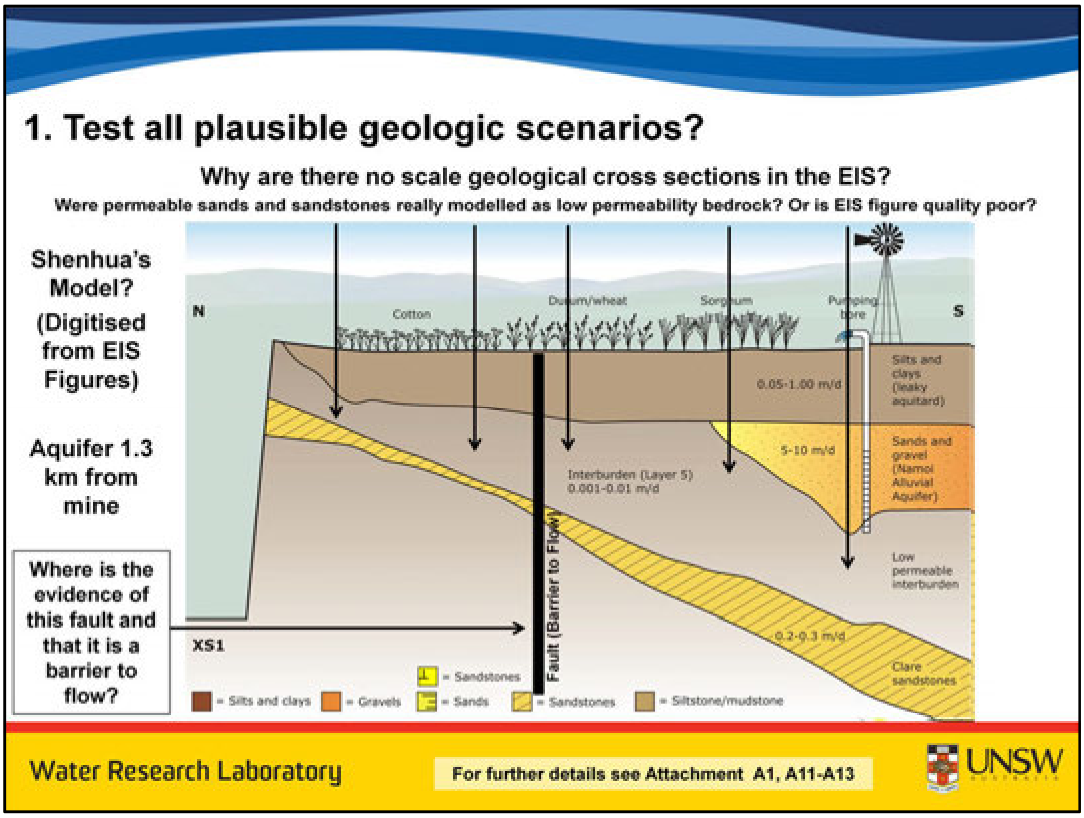
-make non-biased assumptions where possible and conservative assumptions where this isn't possible

-represent the important geologic features with the least amount of simplification

-fully report and justify the modelling inputs, outputs, assumptions, simplifications and uncertainty

With these five things in place a reviewer is able to assess whether the model or models can generate an envelope of prediction that is both plausible and conservative. Miss any one of these five things and there is a risk of under-predicting the impact or making poor engineering decisions that generate unplanned future costs.

And as the screen shows you end up with something like this Coal Mine in Victoria which had captured one tenth of one Sydney Harbour at the time this photo was taken.

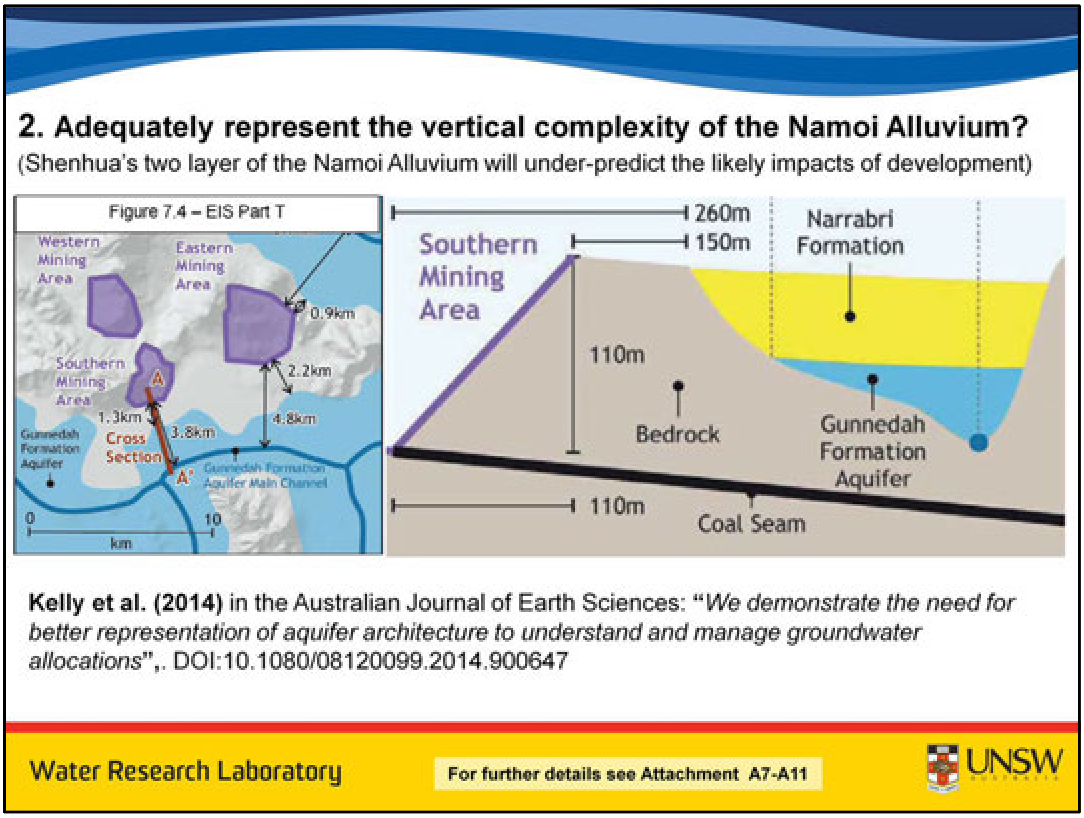


Firstly, we asked, did Shenhua's modelling test and report on all plausible geologic scenarios? No.

As shown on the screen when preparing cross sections and plotting borehole-logs from the EIS figures, we found potential evidence of unconsolidated sands being modelled with properties of sandstone, clay or low permeability bedrock or vice cersa. We also saw evidence of inferred faults being modelled as impermeable barriers to flow without reference to definitive field evidence of their properties or existence. If any of these assumptions were wrong, the model would under-predict groundwater impacts.

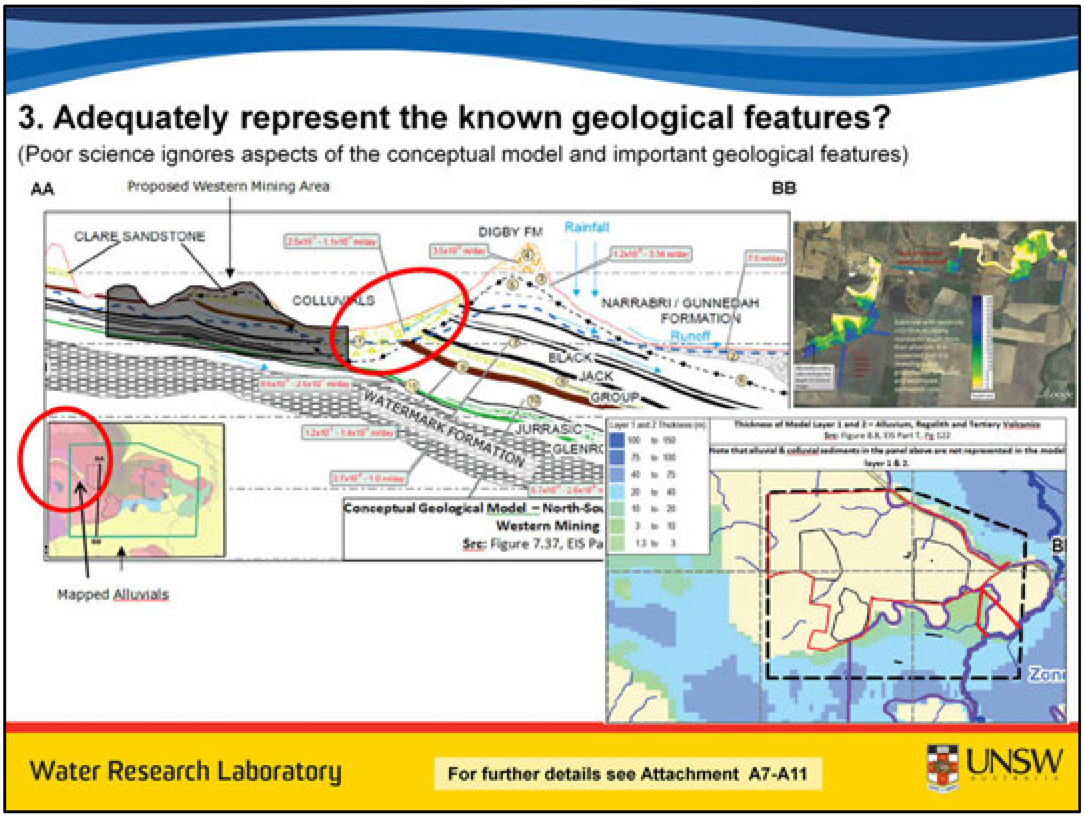
Standard engineering practice to develop multiple conceptual and numerical models of the alternative geological scenarios to determine just how bad a prediction could be. Like this alternate hypothesis of mine shown on the screen. This shows a potential sand aquifer extending to within 240 m of the mine that would increase that rate of groundwater seepage into the mining pit. Contrast that with the 1.3km distance documented by Shenhua. When you review my slides later you will see that my model is a plausible interpretation of the geology data.

PAC should also note that when I inspected the EIS I could find no geological modelling report or actual scale geological cross-section figures. Could it be that no-one has fully and independently scrutinised the EIS geological model? Why not? It is (one of) the most important part(s) of the entire model.



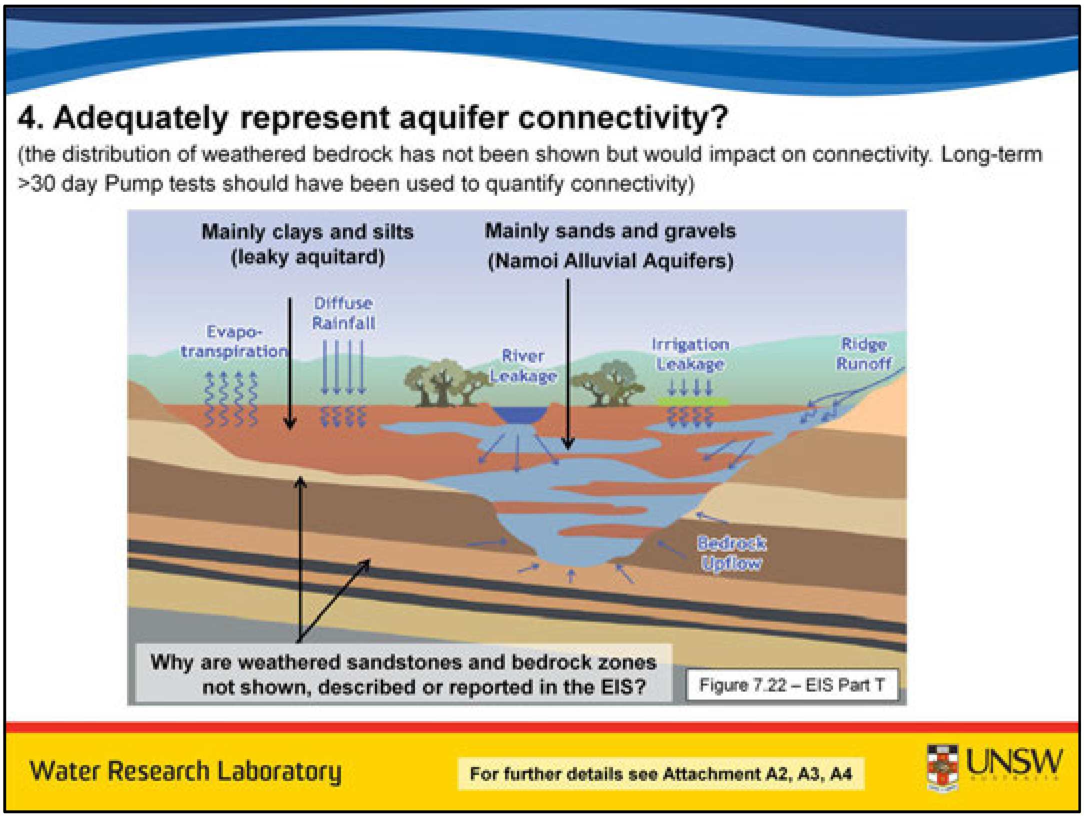
Secondly, does the EIS two layer model adequately represent the vertical complexity of the Namoi Alluvium? No. The low permeability formation comprising mainly of silts and clays, which was previously called the Narrabri Formation, is modelled by Shenhua in yellow overlying a higher permeability more productive unit previously known as the Gunnedah Formation Aquifer in blue.

As my colleagues from UNSW have shown repeatedly in the literature, reality is a more complex distribution of clays, silts, sands and gravels deposited over 2.5 million years. So how do you adequately represent all that in a two layer model? And the answer is, in close proximity to a mine body, you just can't (as the previous slide).



Furthermore, when I inspected layers 1 and 2 of the Shenhua's numerical model shown here at the bottom right of the screen I noted that it did not represent any alluvium or colluvium in the cream coloured areas about the proposed mine, despite such features being clearly identified on GHD's conceptual model circled here in red to the left (yellow channel) and top of the slide (marked layer 1) and also in the results of a geophysical survey shown top right. Where did these features go to in the model?

Good science replicates all important geological features.



The next question we asked is does the model adequately represent aquifer connectivity?

Where aquifer connectivity is high, the proposed mining operation will have a greater impact on the aquifers used by agriculture

There are two elements regarding aquifer connectivity that I believe have been neglected in the modelling process:

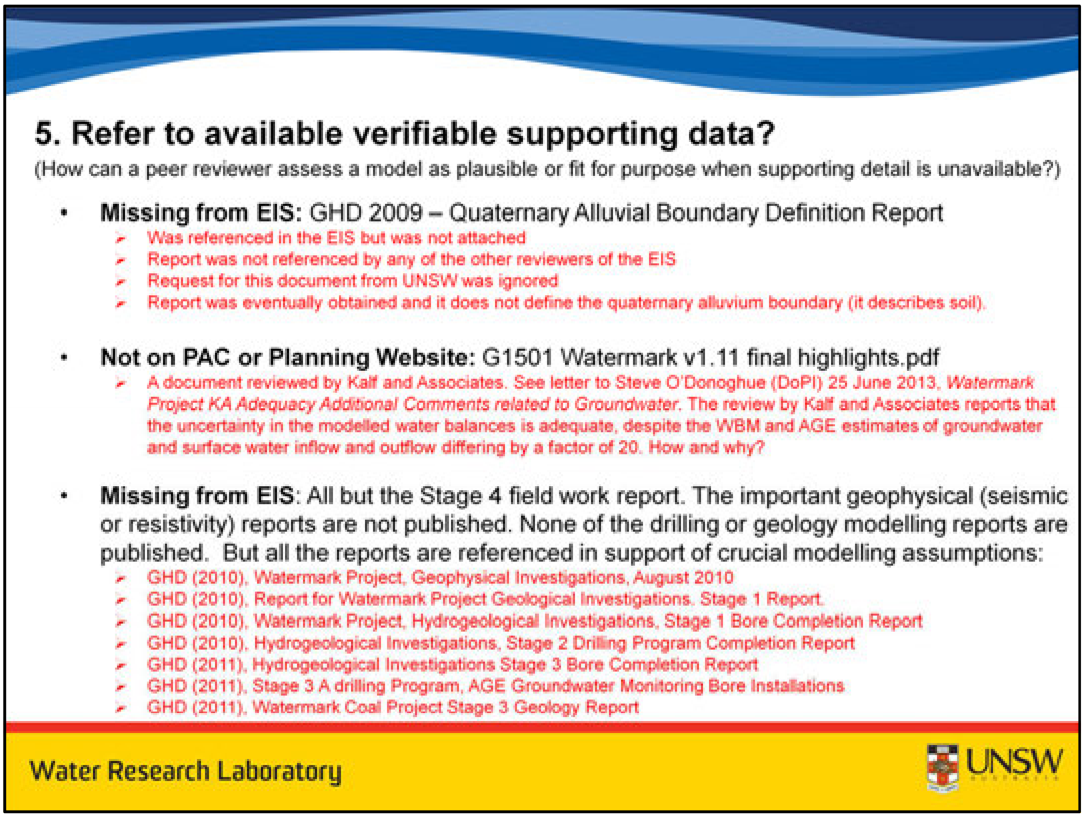
1. Sufficient Pump testing
2. Weathered bedrock representation

Firstly, long term pumping tests, such as a 30-day or longer test, should have been used to assess aquifer connectivity in the vicinity of the mine. The longest test in alluvium in the exploration lease area, however, were only two days long. This is poor science.

Secondly, this EIS figure shows Shenhua's conceptual model of bedrock and the complex so modelled "two layer" Namoi Alluvium. On this figure we noted that zones of bedrock weathering that might increase connectivity were not indicated.

Indeed, neither the EIS conceptual model nor any of the EIS reporting presented the distribution of weathered bedrock across the model, described how it was identified or limited assessment of its properties were interpolated. Furthermore, when I inspected the model calibration results provided in the EIS, I found that the methods used to simulated weathered bedrock were too simplistic, as they did not adequately reproduce the field observations.

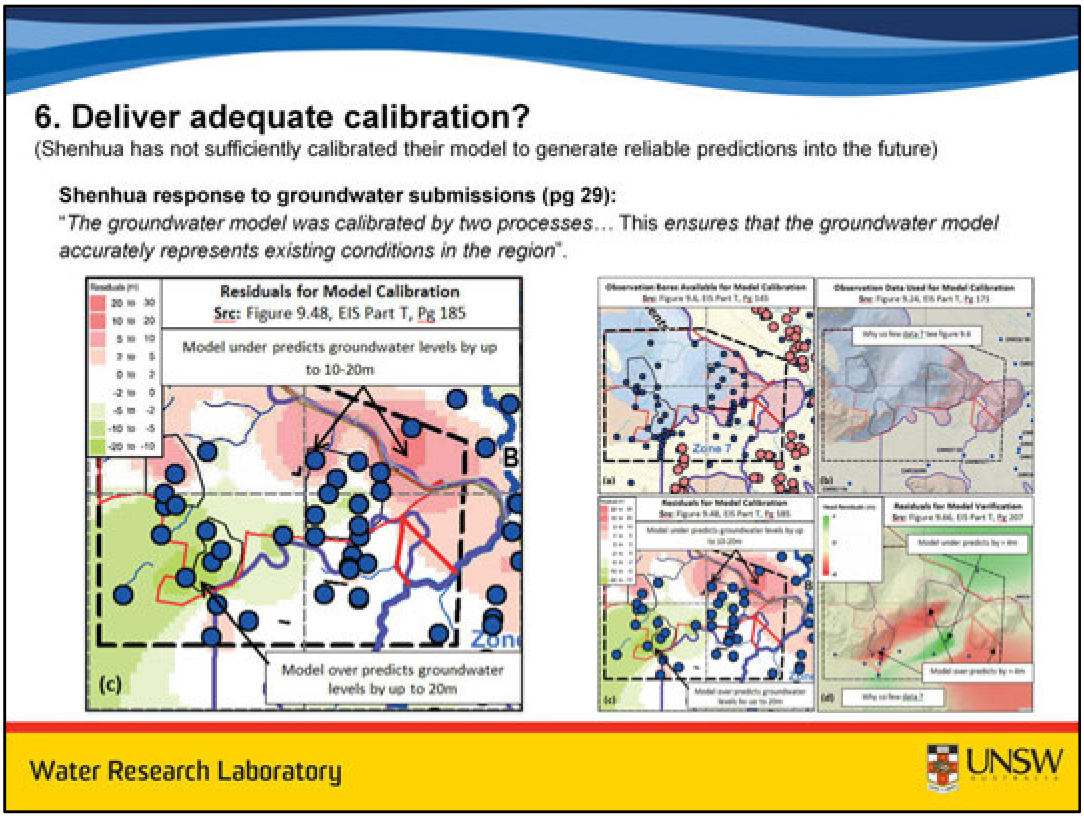
Standard practice is documenting and justifying all the model inputs and revising the model inputs when calibration shows the modelling approach to be inconsistent with field data.



Next we asked, does the EIS refer to available verifiable supporting data to support its geological and hydrogeological model?

As noted on this slide the majority of the geology and geophysical investigation reports referenced in the EIS in support of crucial modelling assumptions **are not published or exhibited by Shenhua.** When I checked the reference lists for all the peer review reports I found no reference to these reports. Why not? If these reports have not been reviewed by anyone, how can a decision maker be sure a model is plausible and conservative or fit for purpose?

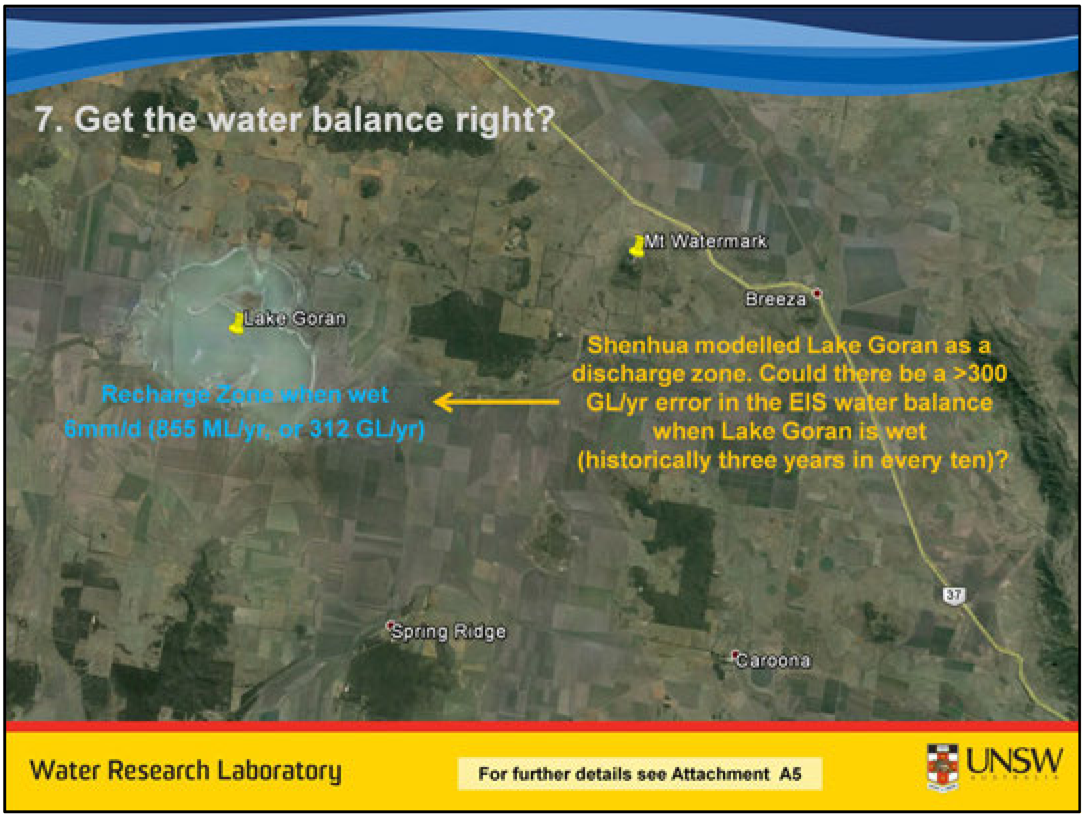
<u>Good science is justifying your work with valid and available references</u>.



Then we asked does the model deliver adequate calibration?

The blue and red dots on this first figure here show all the groundwater bores which could have been used to calibrate the groundwater model. As you can see, there are a number of bores. This second panel here shows the data that was actually used. With so few bores and how can a calibration to this data be accurate and adequate? It simply can't.

And as demonstrated by the next figure in the EIS you can see that the model under-predicts groundwater levels by 10-20m to the north of the mine, possibly because paleochannels have been ignored and because faults have been simulated inappropriately. To the south of the proposed mining area here you can see the model over-predicts groundwater levels by up to 20m, possibly because this is the area where permeable colluvium and alluvial channels were not represented in model layers a 1 and 2. Of course there are other possible reasons but the EIS forgot to mention these ones. That is not good science.



Next we asked does the model get the water balance right?

A water balance is a conceptual model of all the water flows into and out of a groundwater system and it is essential that a model's water balance is based on the best available science. If it is not the model predictions can be erroneous.

When we examined the water balance for Lake Goran to the west of the proposed mining area we identified a potential 300 GL/yr error approximately 30% of the time. What else is wrong with the model's water balance?

(Scientists have classified this ephemeral lake as a major saline aquifer recharge zone providing around 300 GL/yr of groundwater recharge when wet. Heritage Computing, identified that the lake was reportedly simulated as a discharge zone, not a recharge zone. Could there really be a 300 GL/yr error in the EIS groundwater model water balance whenever Lake Goran is wet, which historically has been three years in every ten? Does this mean the modelled properties and impacts of the development are less reliable?)

8. Present the uncertainty of predictions?

(Bad science is discarding model results, failure to clarify model outputs and modelling all scenarios)

Uncertainty Analysis Issues	Consequence
Presented in probabilistic terms (as percentiles) without adequate context	Misleading. Readers may assume that the worst case impacts have a lower probability of occurrence.
50% of the uncertainty analysis results are discarded without re-calibration.	Poor science and misleading. Uncertainty assessment incomplete. Impacts under reported. **Model sensitivity suggests impacts on groundwater in bedrock and alluvium could be a factor of three or six greater than the EIS base case, respectively**
The worst 10% of the model's uncertainty predictions are not reported in the EIS.	
Not all plausible scenarios are modelled.	
Uncertainty is ignored in the executive summary and in the economic assessments.	Bad science and misleading. The economic costs of undertaking the project could be higher for all stakeholders.

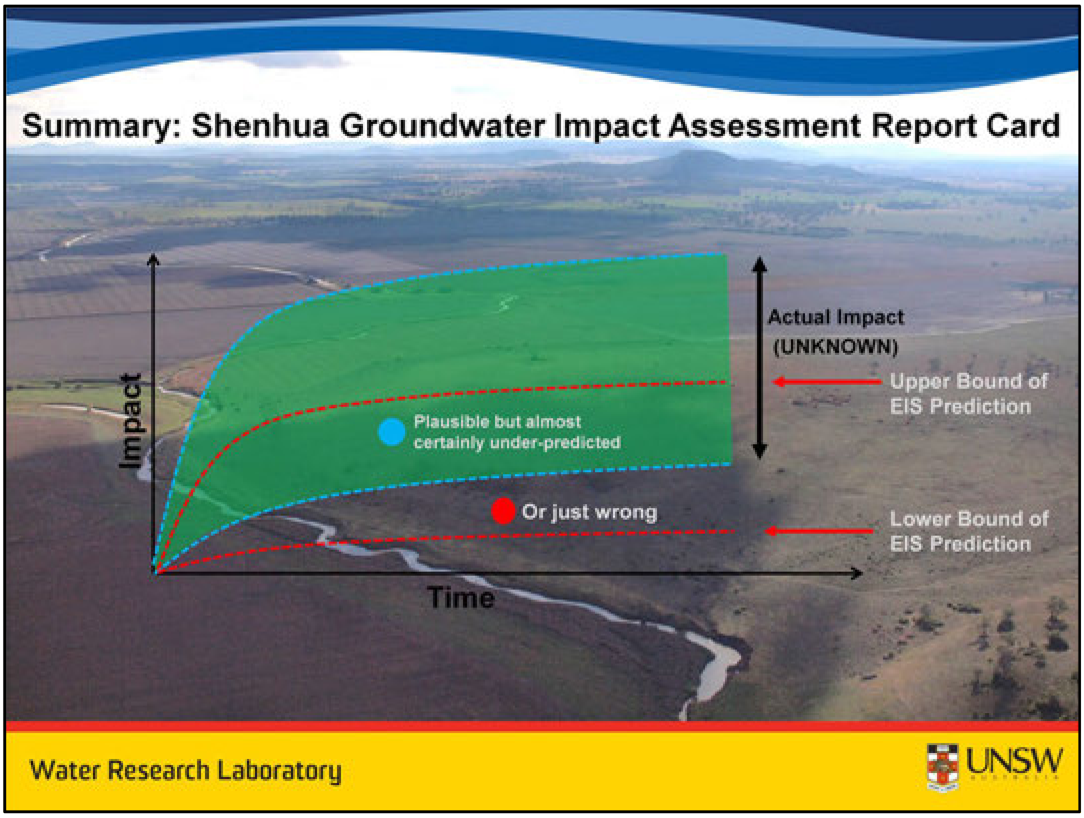
Water Research Laboratory UNSW

Finally we asked, does the model adequately present the uncertainty of its predictions?

And the answer was no on several counts:

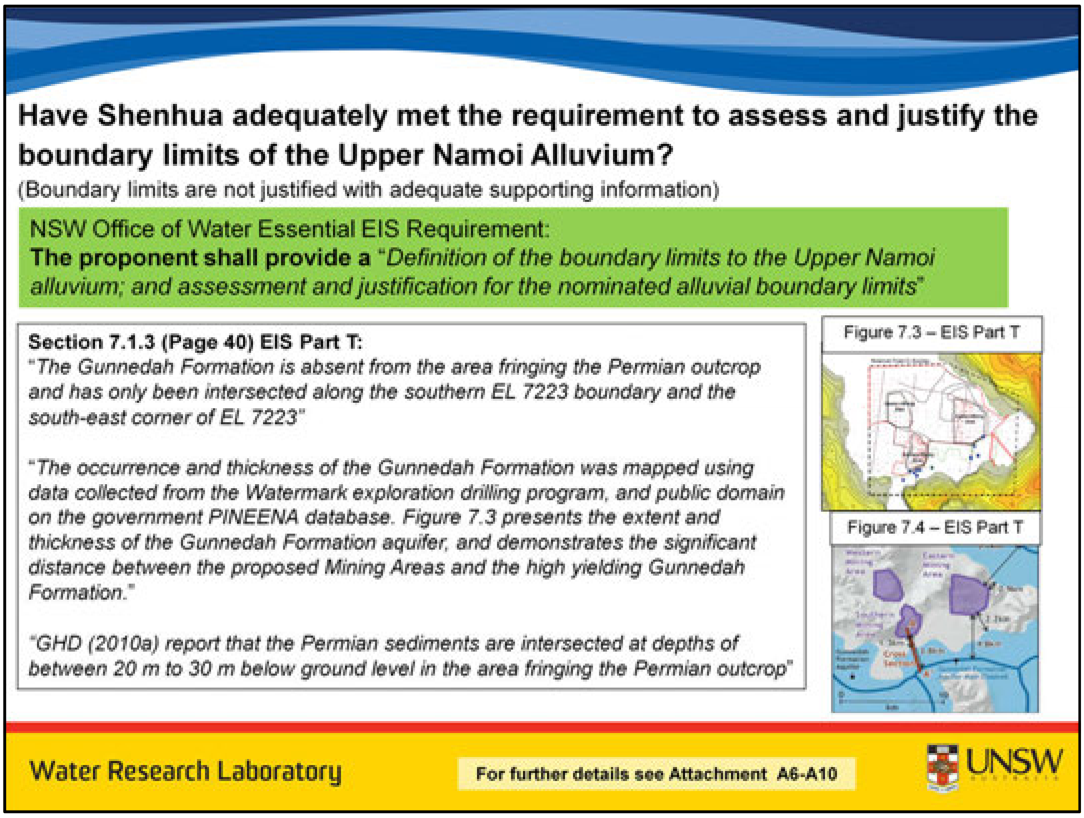
- Firstly, model uncertainty results were presented in probabilistic terms from which some readers might conclude that worst case impacts have a lower probability of occurrence. This is not true as all model predictions are uncertain and have an equal probability of being correct.
- Secondly, not all scenarios were considered and the worst case model uncertainty results were excluded from reporting
- Thirdly, the results of the uncertainty analysis did not appear to carry through the rest of the EIS.

All of these aspects are poor science that potentially mislead some readers. We assessed from all of Shenhua's model sensitivity analyses that their proposed mine could plausibly intercept up to 2300 ML of groundwater per year. That is three times greater than the base case reported in Shenhua's EIS. And that is a prediction based not on my assessment of the geology but Shenhua's assessment.



So in summary we formed the opinion that the proponents assessment of impact was:

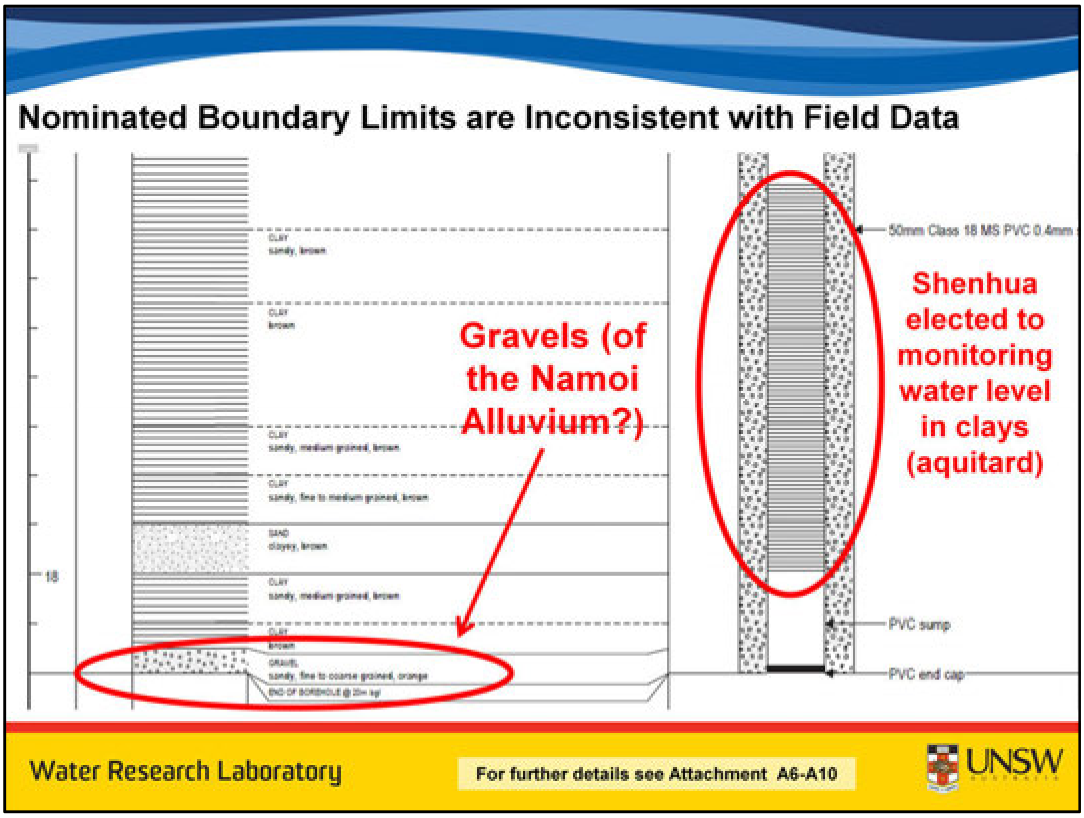
- Plausible but almost certainly under-predicted, or
- just wrong.



So we have seen that Shenhua have not adequately represented or reported the geological information and uncertainty in their model. Now I need to emphasise, that apart from creating a model that is fit- for-purpose, as a starting point they were required to assess and justify the boundary limits of the Upper Namoi Alluvium. Have they adequately done this?

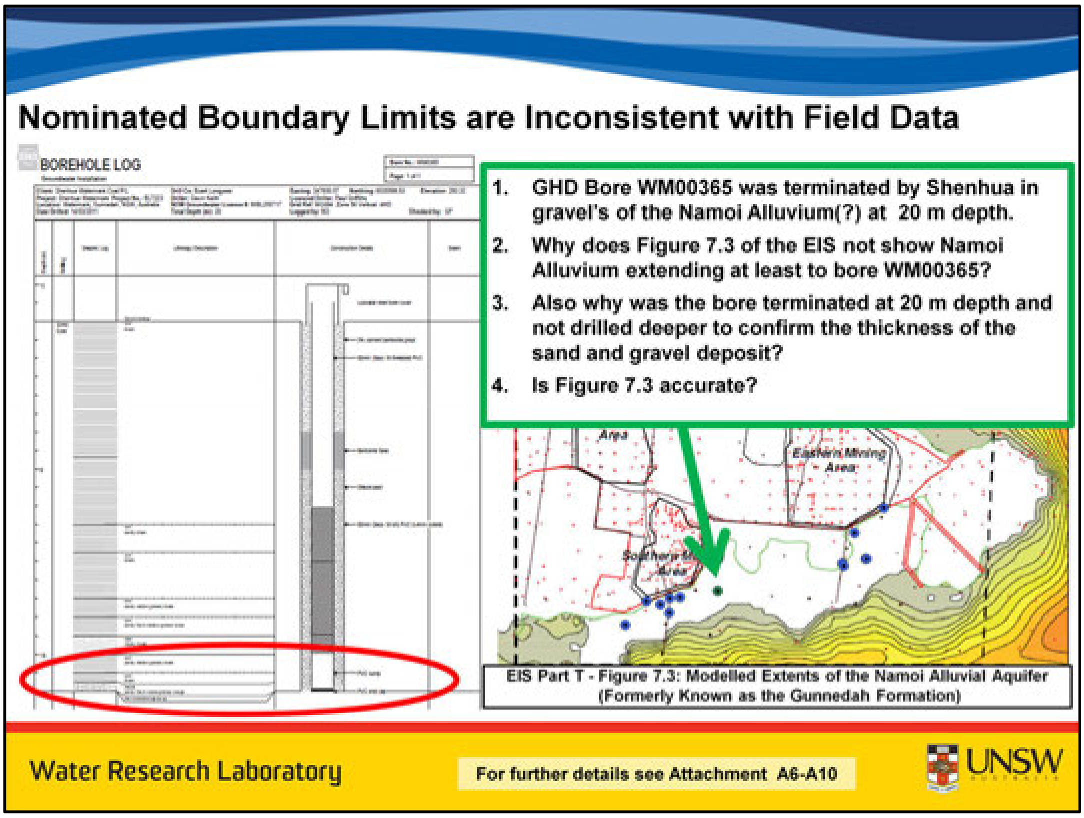
The proponent's response to this requirement was this text on page 40 of the EIS and the provision of figures 7.3 and 7.4.

You will notice that this text contains no justification of the boundary, no reference to a geological modelling assessment report, no reference to mapping of the sands and gravels in the Narrabri Formation and no mapping of sands overlying sandstones which occur close to the proposed mine. The referenced GHD report is also not published or exhibited for verification.



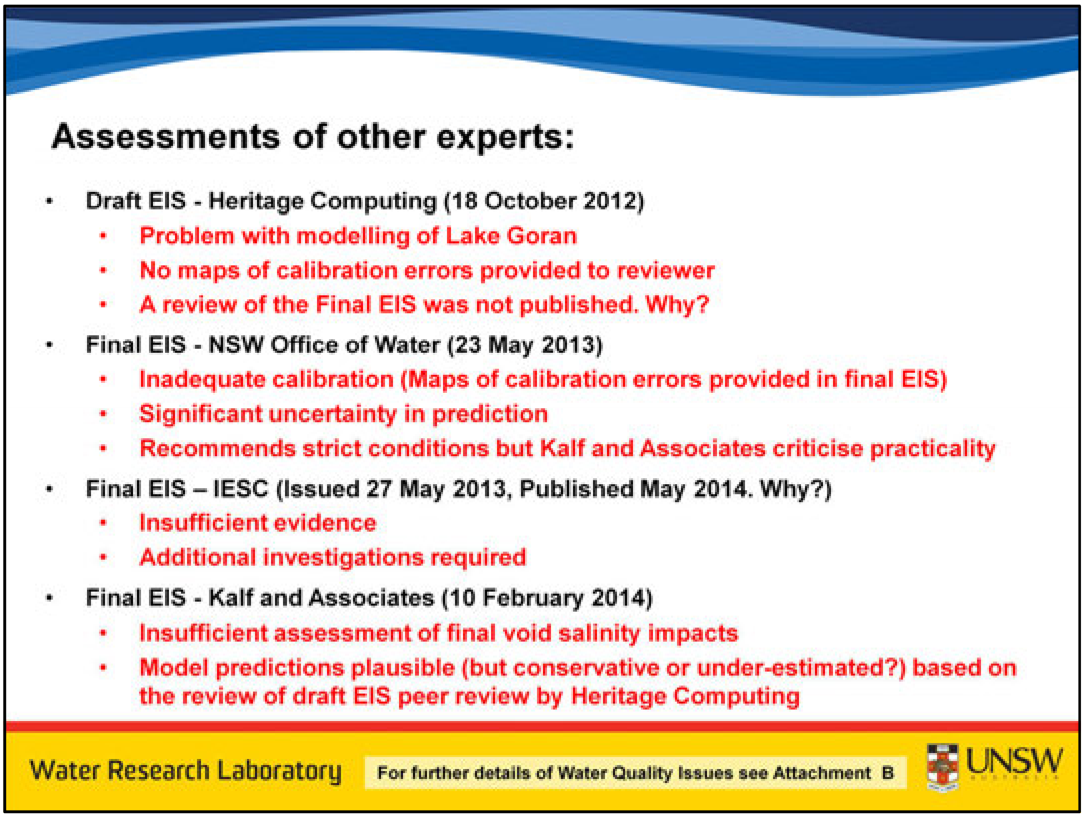
Furthermore, the report does not adequately address the findings of Shenhua's own geophysical survey and bore-logging data which appears to be in direct conflict with the presentation in Figure 7.3. Shown here on the screen is just one example from bore WM00365 on page 589 of the EIS.

Note how at the very bottom of the log after reaching sandy gravel, the hole was terminated (is this alluvium or colluvium?)



So where is this hole? It is located here on Figure 7.3 as shown by the green arrow. Why therefore, does Figure 7.3 not show the colourful Namoi Alluvial aquifer contours extending to at least this point?

There are numerous other pieces of data in the EIS which point to Figure 7.3 being incomplete and I am concerned the EIS has failed to adequately address an essential government requirement.

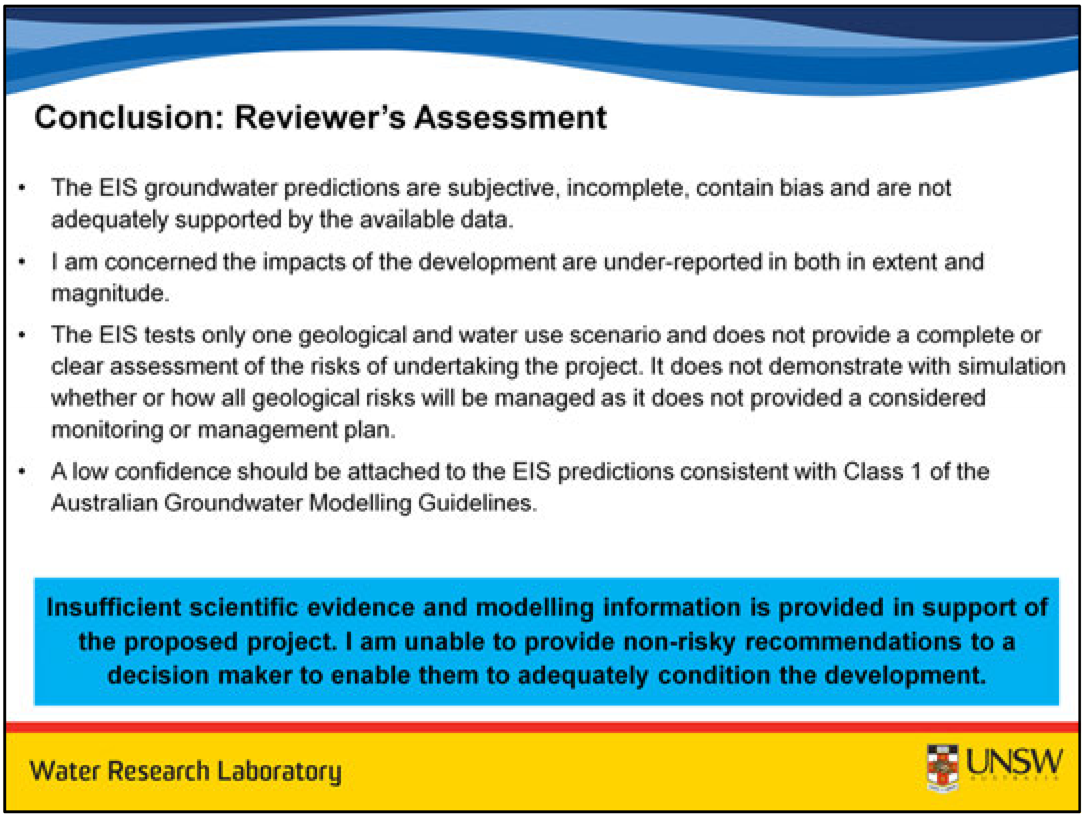


Now I'd like to point out that over the last 18 months, not one expert in my field has been able to give an unconditional signoff of the groundwater impact assessment.

Firstly, when reviewing the draft EIS Heritage Computing identified issues with water balance modelling of Lake Goran and were not furnished with maps of the model's calibration in the vicinity of the mine. When I inspected the PAC and major planning project websites I found no report detailing Heritage Computing's assessment of the final groundwater model. Why not?

Secondly, NSW Office of Water raised pages of concerns on model uncertainty and inadequacy. Their opinions and recommendations for stringent conditions were subsequently criticised by Kalf and Associates as impracticable. I agree with the concerns raised by the Office of Water, but not their recommendations for conditions. In the face of significant uncertainty in the geological and numerical model it is my professional opinion that a conditioned development is not the appropriate course of action. Mining actions are irreversible and a precautionary approach is required.

And this also appears to be the view of the Independent Expert Scientific Committee who recommended further investigations before the project proceeds, if it is to proceed. They indicated that the proponent had provided insufficient scientific evidence to justify their assumptions, their model conceptualisation and their predictions. They identified concerns with the model input data, assumptions, sensitivities, scenarios, water balance modelling, presentation and interpretation of results which decreased confidence in the model output. They stated that "not all reasonably foreseeable scenarios have been considered by the proponent in their modelling".



In conclusion it is my assessment that:

Madame Chair and commissioners, yesterday the Australia Institute highlighted the economic tight-rope that Shenhua must cross to deliver a positive net present value at the end of the project. And they identified externalities within the assessment. Today, with respect to groundwater, I have highlighted that insufficient scientific evidence and modelling information is provided in support of the proposed project. Thus, I am unable to provide non-risky recommendations to a decision maker to enable them to adequately condition the development.

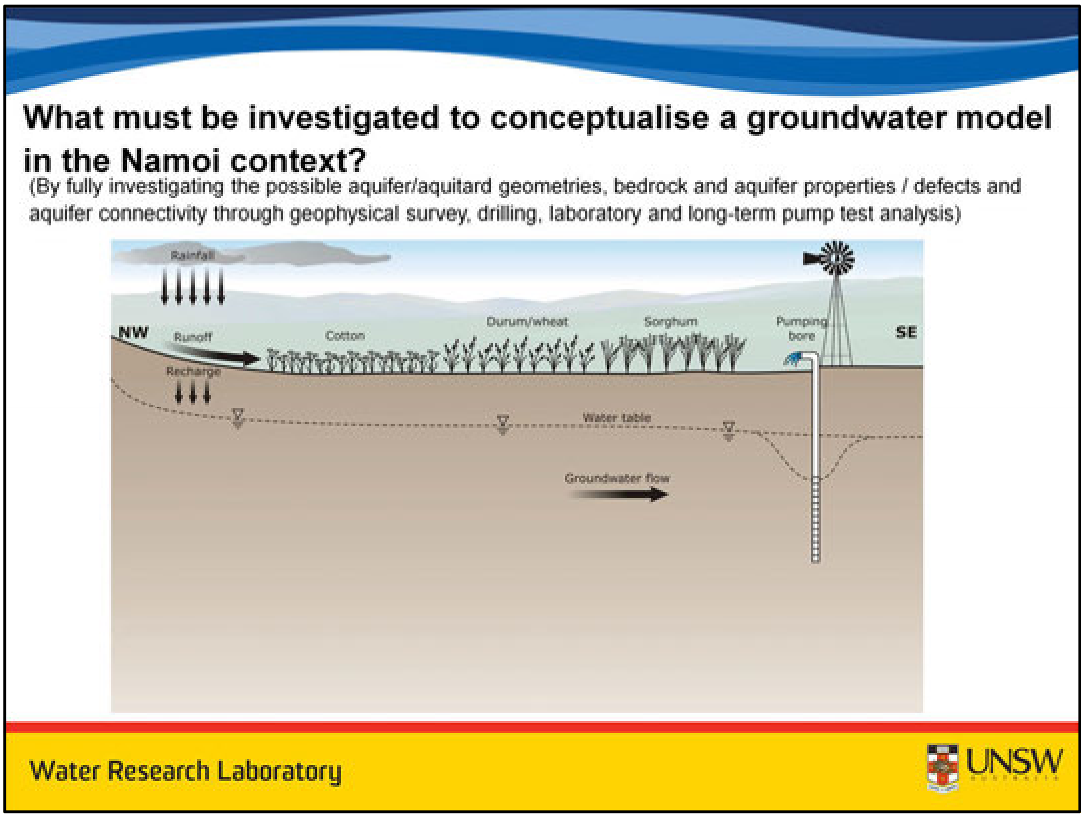
Madame Chair and commissioners, thank you for your time and your service in the weeks ahead.

Additional Material

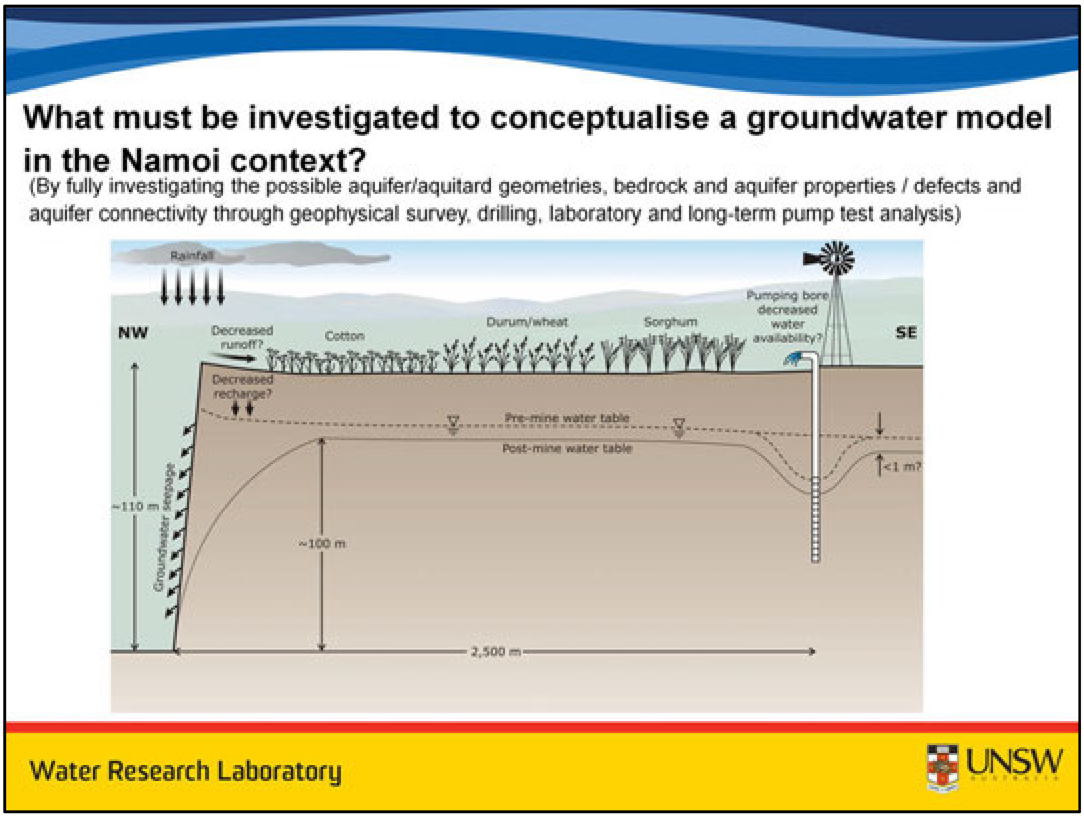
ATTACHMENT A
Supporting Examples of Poor Science in the Groundwater Impact Assessment

Water Research Laboratory

UNSW

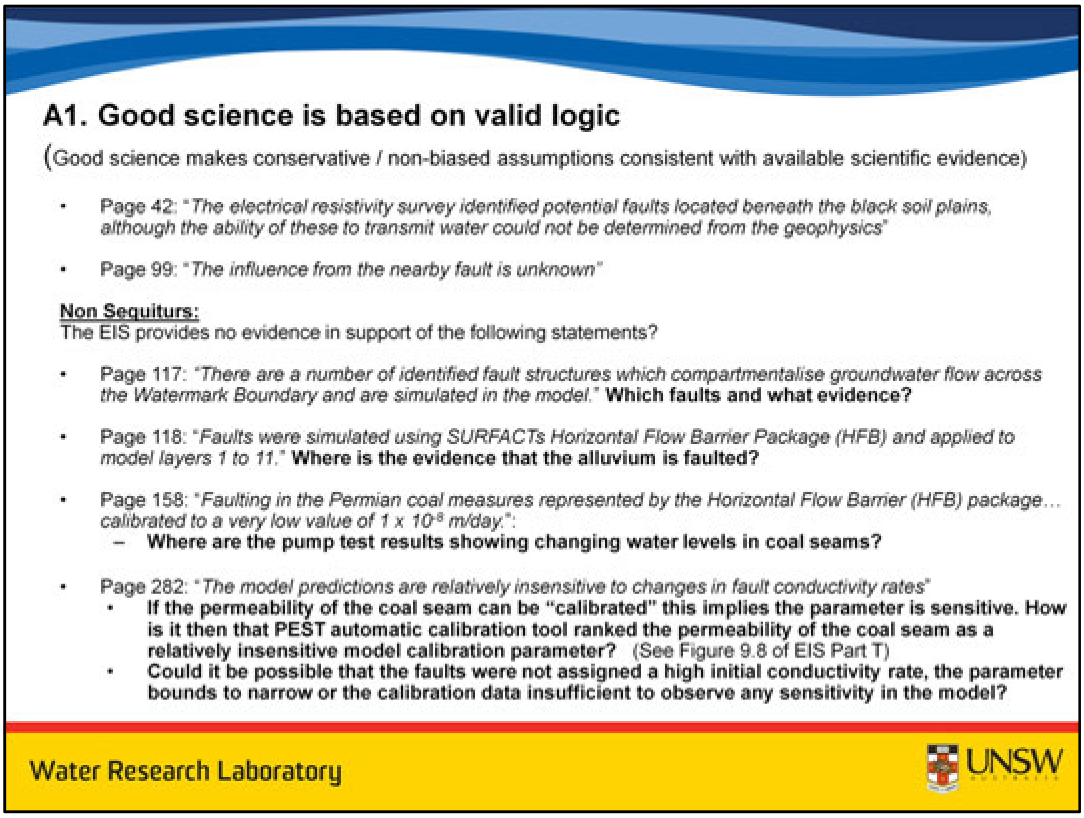


Demonstrating that the Watermark Coal Project will not significantly impact water resources is a time consuming and challenging task that involves considerable investment and much hard work. For the engineers must demonstrate that three large mining pits extending well below the level of the fertile Upper Namoi Plains will not significantly impact the water resources of the adjacent aquifers that support agricultural productivity. There are many risks and uncertainties that must be assessed when the groundwater levels in adjacent aquifers are up to 100m above the base of the pit. Getting it right means detailed investigations of geology and aquifer connectivity with several types of geophysical survey, drilling, careful lithological logging, laboratory testing and long-term pump test analysis.



UNSW conceptual sketch: Shenhua's model predicts a change in groundwater level of less than 1m at most bores.

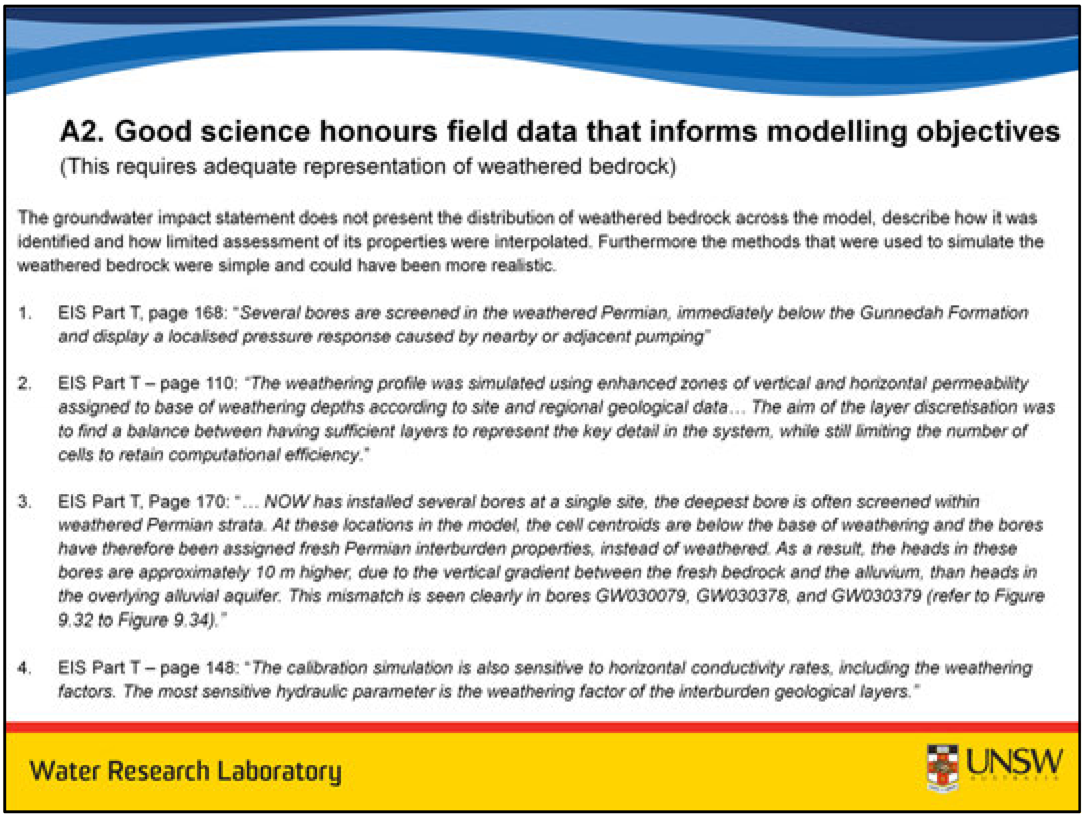
(water levels in multiple aquifers are not shown and are simplified for illustrative purposes only)



Consider these first two statements from Part T of the EIS indicating that the proponent does not know whether potential geological faults can or cannot transmit water. Also consider the next four statements where the proponent confidently concludes that the fault structures are geological barriers that compartmentalise groundwater both in bedrock and alluvium.

How has the proponent reached this conclusion when just pages before there are admissions that the hydrogeological properties of some faults are unknown?

The Independent Expert Scientific Committee on large coal mines reached a similar conclusion that evidence of the role of faulting was not provided. See their advice to the decision maker dated 27 May 2013.



If the proposed mine were to intersect a conductive weathered zone additional engineering works would be required to manage the additional groundwater as it enters the pit, to capture it through pumping or to potentially divert it with engineered barrier systems.

Now weathering was incorporated into the EIS computer modelling, however it appeared to be represented as an afterthought as zones in model layers rather than as a specific model layer. Whilst this is a computationally efficient method, the zones either convert a model layer containing fresh and weathered rock to weathered rock or fresh rock only. This has the effect of limiting the extent of groundwater level changes predicted by the model. Given the purpose of the EIS is to demonstrate an absence of significant impact it is the assessment of this reviewer that this simplification defeats the purpose of the modelling objective and it would have been better to design a more realistic model that took a little longer to run. The review acknowledges that this would require a model with more than one million computational nodes given the expansive spatial extent of the model. Given the model asserts that the impacts are so limited in extent would it not have been more efficient to model a smaller area with better accuracy in the vicinity of the mine to better inform the process?

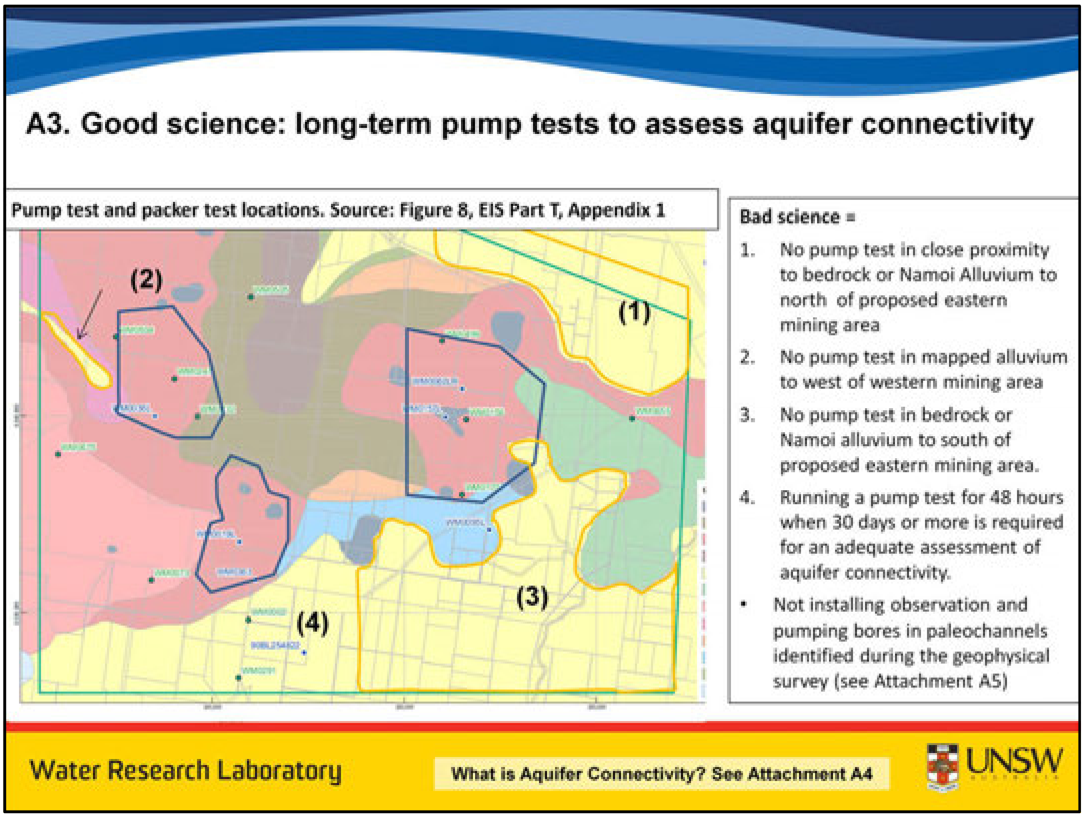
The statements on this slide demonstrate the reliability of the proponents method of simulating weathered bedrock:

1. This first statement indicates that monitoring bores in weathered bedrock in the basin (which would be intersected by the proposed mining puts) are potentially connected to the Upper Namoi alluvial aquifers used by irrigators

2. This second statement suggests that the modellers decided not to model the weathered bedrock as a separate model layer, despite it being the appropriate course of action, because they wanted their model to be slightly faster.

3. This third statement indicates that the simplified representation of weathering was inadequate and resulted in an under-estimate of the extent and magnitude of aquifer connectivity under natural conditions.

4. This fourth statement indicates that the model was highly sensitive to the simplified approach for simulating weathering. This should have been a queue to the modellers to improve the simulation of weathering in the model, however, the original potentially inadequate conceptualisation was maintained.



Refer to source figure to identify which locations are aquifer pump testing locations, not packer test locations which provided limited assessment beyond the immediate zone of the well.

A4. Good science: long-term pump tests to asses aquifer connectivity

What is aquifer connectivity?
Aquifer connectivity is the ease with which water moves from one geological formation, such as the permian bedrock and coal seams which would host the proposed Watermark Coal Mine, to another geological formation, such as the Upper Namoi alluvial aquifers that support irrigated agriculture.

Why is aquifer connectivity important?
Aquifer connectivity measurements help to assess how much water will leak into the mine workings once they are constructed. If the measurements are not available the model results are speculation (low confidence).

How is aquifer connectivity assessed?
Aquifer connectivity is usually assessed by applying large scale water stresses to the system to observe and understand the rates at which groundwater moves from one formation to another. This is normally achieve by installing bores in alluvium at the base of sandy/gravelly paleochannels near the mine boundary and in all the underlying and nearby rock, weathered rock and coal formations. Water is then pumped from the formation for a period of 30 days or more and computer models are created to reproduce the observations in bedrock, weathered bedrock and alluvium.

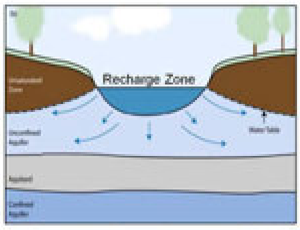
Was aquifer connectivity in weathered bedrock and alluvial paleochannels assessed with field data and adequate modelling as part of the Shenhua Watermark Coal Project EIS?
No. The EIS has not demonstrated a suitable assessment of aquifer connectivity.

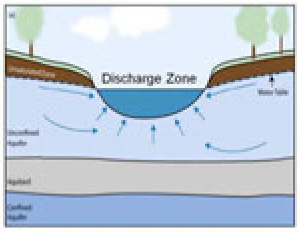
Water Research Laboratory

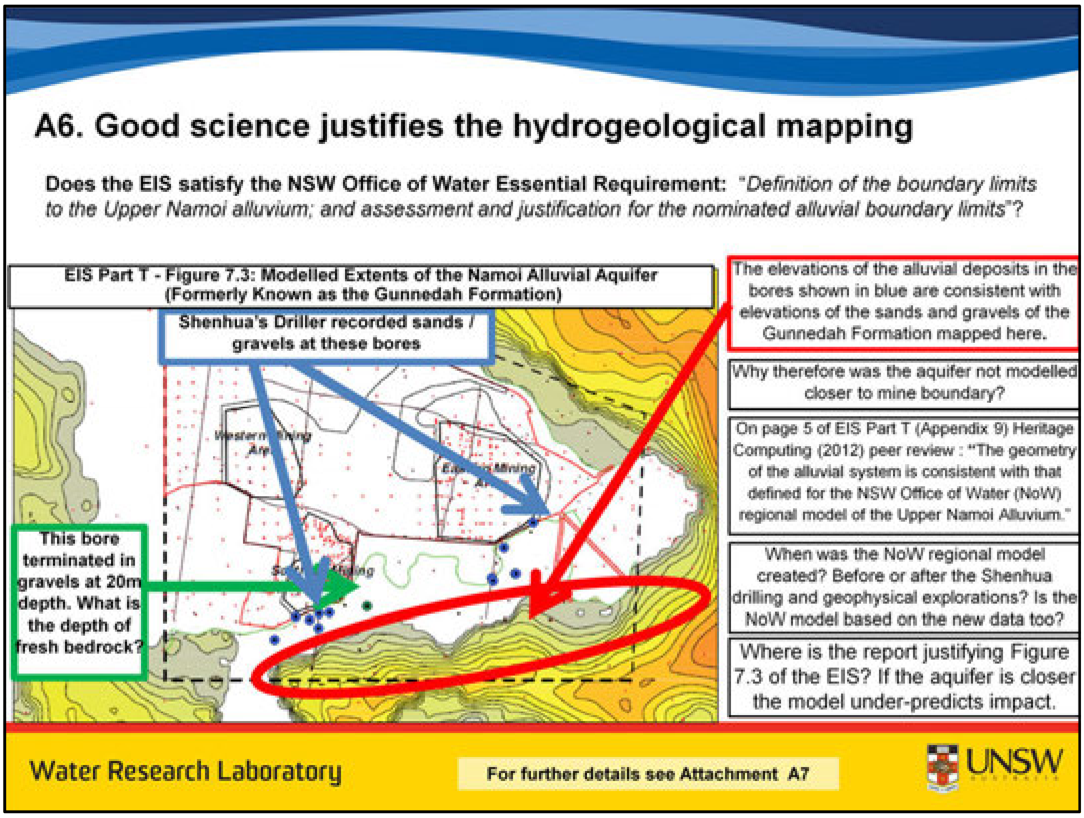
UNSW

A5. Good science is getting the water balance right

- Water balances document the inflow and outflow of a groundwater system
- Accurate water balances are required for accurate model calibration. Model calibration is the ability of a model to match historical observations.
- Australian Government: "*Lake Goran is part of a major saline aquifer recharge zone*". Zhang et al. (1997): When wet, the lake is estimated to provide 6 mm/yr of recharge
- Heritage Computing (2012) on Draft EIS: "*In Section 9.1, Lake Goran is said to be set up as a discharge zone. However, in the conceptualisation stage, it was described as a source of recharge*"
- Final EIS: "*Minor creeks, drainage lines and Lake Goran were set as 'river drains' and act as discharge zones for groundwater only… Lake Goran removes 2 ML/day over an area of approximately 52 km*^{2}"
- WRL (2013) Peer Review: "*The numerical representation of Lake Goran may be inconsistent with scientific knowledge. A recharge of 6 mm/yr over an area of 52 km*^{2} *corresponds to an addition of 855 ML/d of groundwater, not a removal of 2 ML/d. Could it be possible that the model has failed to simulate the addition of some 312 GL/yr of groundwater recharge during wet years? If that is the case how wrong are the simulated aquifer properties in this region of the model? How does this impact the predictions of the model beside the proposed mine?*"

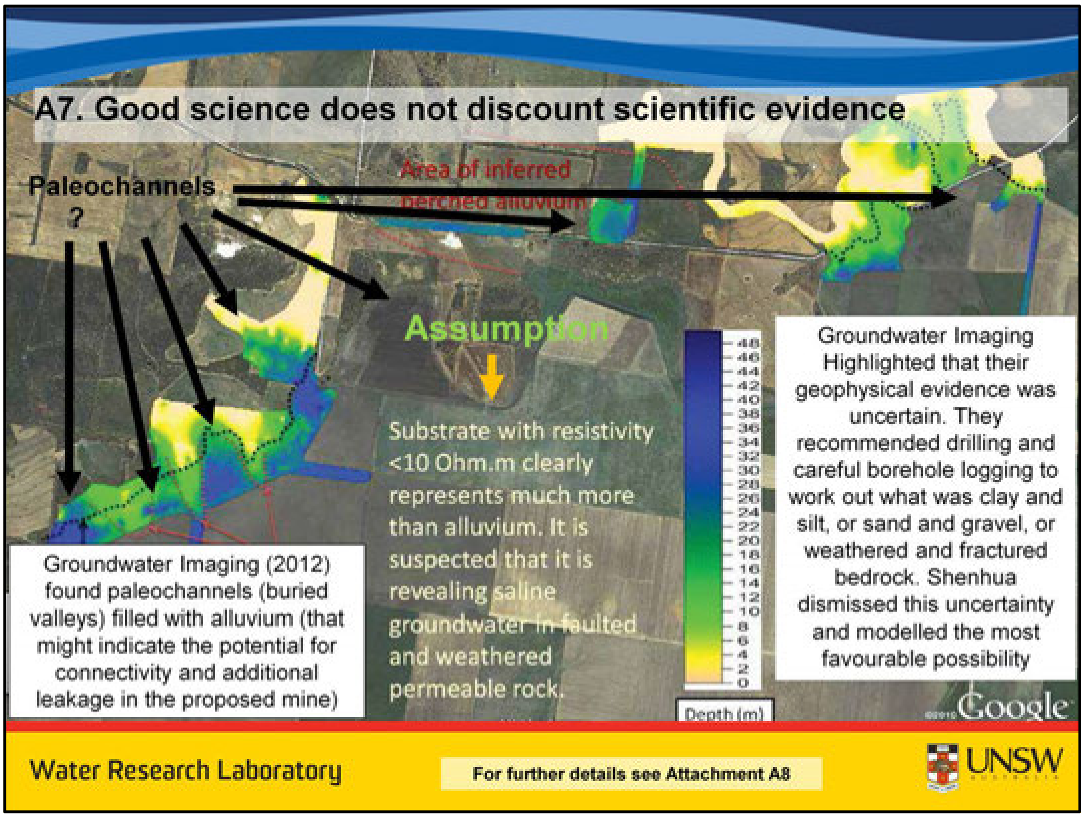






The original NSW Office of Water (NoW) Namoi model (Circa 2005) did not to our knowledge include Zone 7 of the water sharing plan. That was included in a separate model with Zone 8. The original Namoi Water model was last updated to our knowledge in 2010 with updated pumping and boundary conditions (not geology).

To which NoW regional model does Dr Merrick of Heritage Computing refer and when was it last updated? Is it the model developed by SWS and published in 2012 as part of the Namoi Water Study? In either case does the NoW regional model include the new geology data from Shenhua's investigations and if it does not how are the extents of the Namoi Alluvium in the two models consistent?

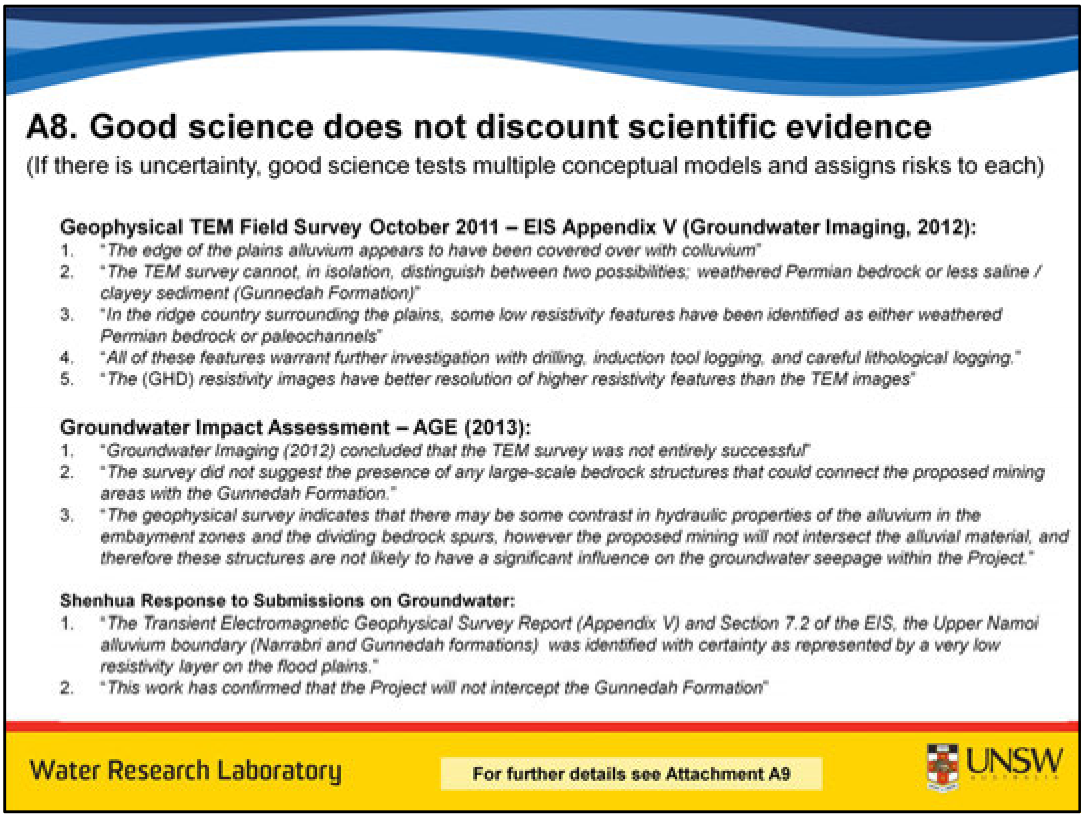


Good science does not discount or favourably interpret scientific evidence collected in the field.

Take for example, this geophysical survey conducted for Shenhua by Groundwater Imaging in October 2011. They detected the outline of the ancient bedrock valleys to the south of the eastern and southern mining areas that had been in-filled with alluvium. These buried valleys or paleochannels as they are known, will be a conduit for groundwater if they contain sands or gravels or fractured bedrock. If the project is approved, any groundwater in these alluvial filled paleochannels may start to flow towards the mine.

Now, it is important to realise that Groundwater Imaging were unable to confidently assess the depth that alluvium transitioned to weathered bedrock and that the GHD 2010 geophysical survey results had better resolution. Groundwater Imaging recommended further field investigations to ground truth the uncertainty. That uncertainty could be the connection of these inferred paleochannels to the Namoi Alluviul Aquifer (formerly known as the Gunnedah Formation). The groundwater level data plotted on page 20 of EIS Part T – Appendix 1 of the EIS could certainly be interpreted as evidence of focused groundwater recharge through a paleochannel.

If the Water Research Laboratory received this advice what would we do? Firstly, we would commission additional drilling to assess the uncertainty. Secondly we would commission additional modelling of the paleochannels to ascertain the groundwater impacts to assess the uncertainty in the original conceptual model. Thirdly, we would thoroughly and carefully document the results of all their investigations in reports for investors and mining engineers alike. An engineering failure of a coal mine would be a bad outcome for all stakeholders. Where is the mining engineers assessment of these paleochannels and their potential impacts?



As you read this slide you will note that:

1. Confirmation cannot be derived from Shenhua's own expert reports that the extent of the Namoi Alluvium has been identified with certainty
2. AGE's comments are speculative and appear to be inconsistent with the work of Groundwater Imaging?, and
3. Shenhua's response to submissions on the EIS appears inconsistent with the advice of Groundwater Imaging?

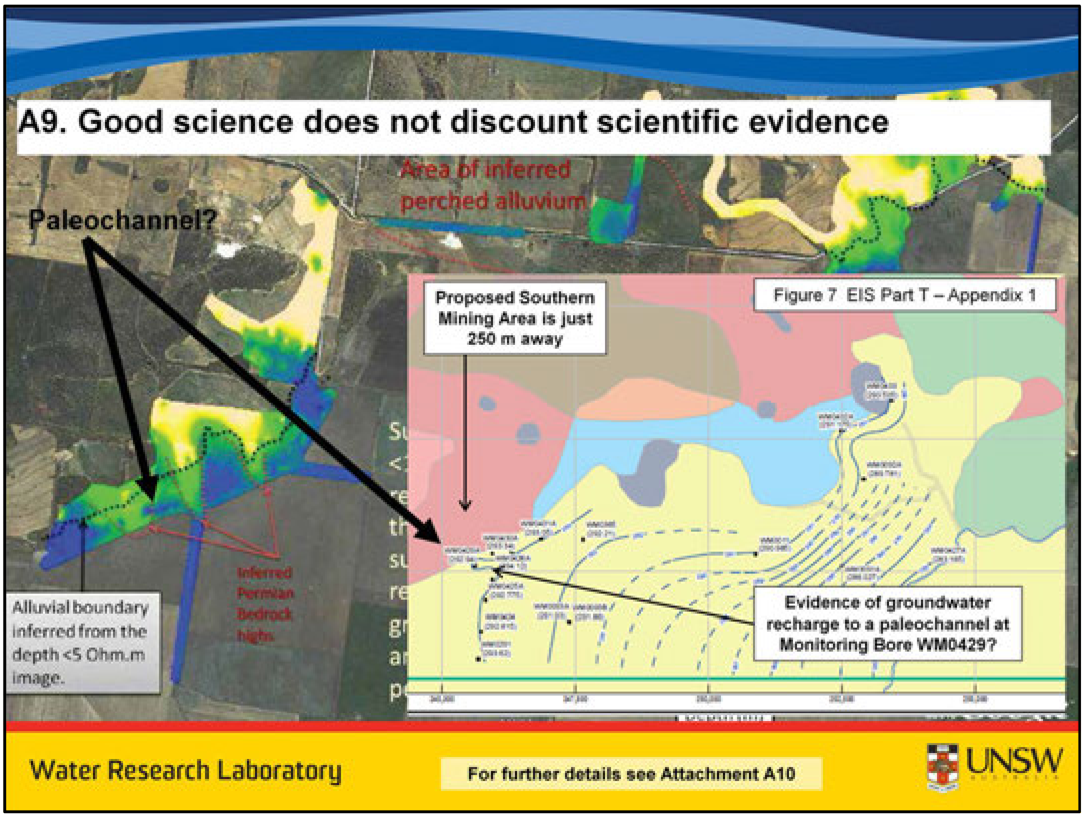
In response to comments by AGE:

1. The geophysical survey was successful. It produced data from which multiple interpretations could be made. That's what geophysical surveys do. All geophysical surveys must be ground truthed by drilling exploration holes and carefully logging the geology.
2. The geophysical survey resolution was low as acknowledged by Groundwater Imaging. That the survey could not find large-scale connective bedrock structures does not mean they do not exist.
3. Groundwater Imaging called for field investigations. AGE speculates that the alluvial paleochannels will not have a significant influence on groundwater seepage. Where is the numerical or analytical modelling evidence to support this assertion?

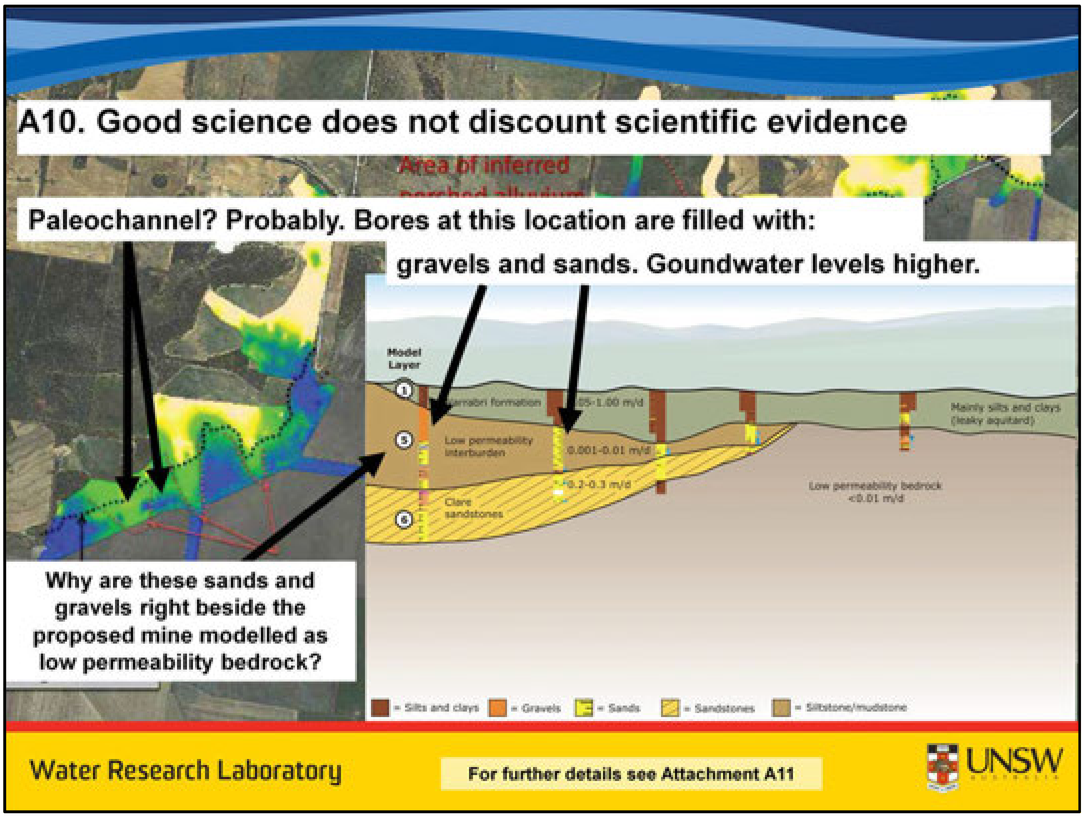
In response to Shenhua's response to the EIS submissions:

1. The first statement indicates that the soils and clays that can be seen at ground surface are mapped with certainty? This does not counter the claim made in the submission that the extents of the Namoi Alluvium sands and gravels (formerly known as the Gunnedah Formation) are uncertain.
2. The second statement provides no reference to support the claim that the project will not intercept the Namoi Alluvium sands and gravels (formerly known as the Gunnedah Formation). What is the logic step by step for this conclusion?

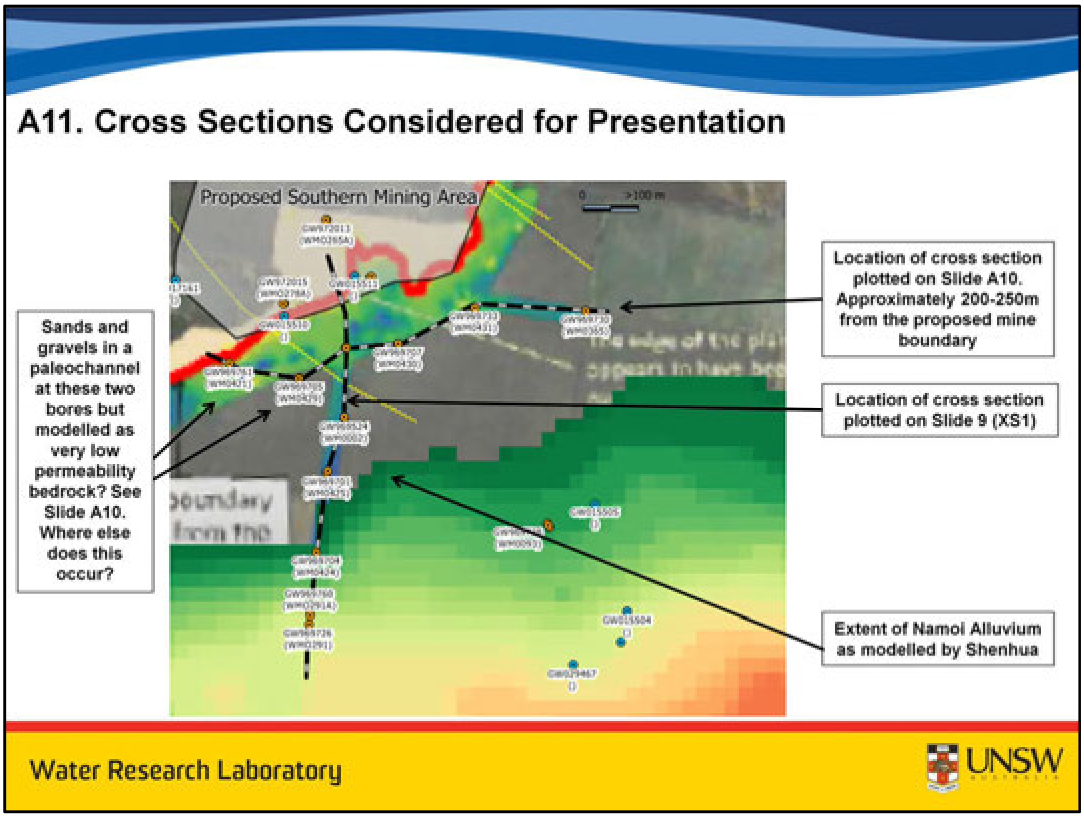
What does the data say? (see over)



This figure demonstrates that elevated groundwater levels were found in bore WM0429 by GHD which is less than 250 m away from the proposed southern mining area. The location of WM0429 corresponds with one of the potential paleochannels identified by Groundwater Imaging. Is this evidence of an aquifer being located less than 1.3km away from the Namoi Alluviul aquifer, contrary to Figure 7.3 of the EIS (See Attachment A6)? See Attachment A10 for further evidence of this potential aquifer.

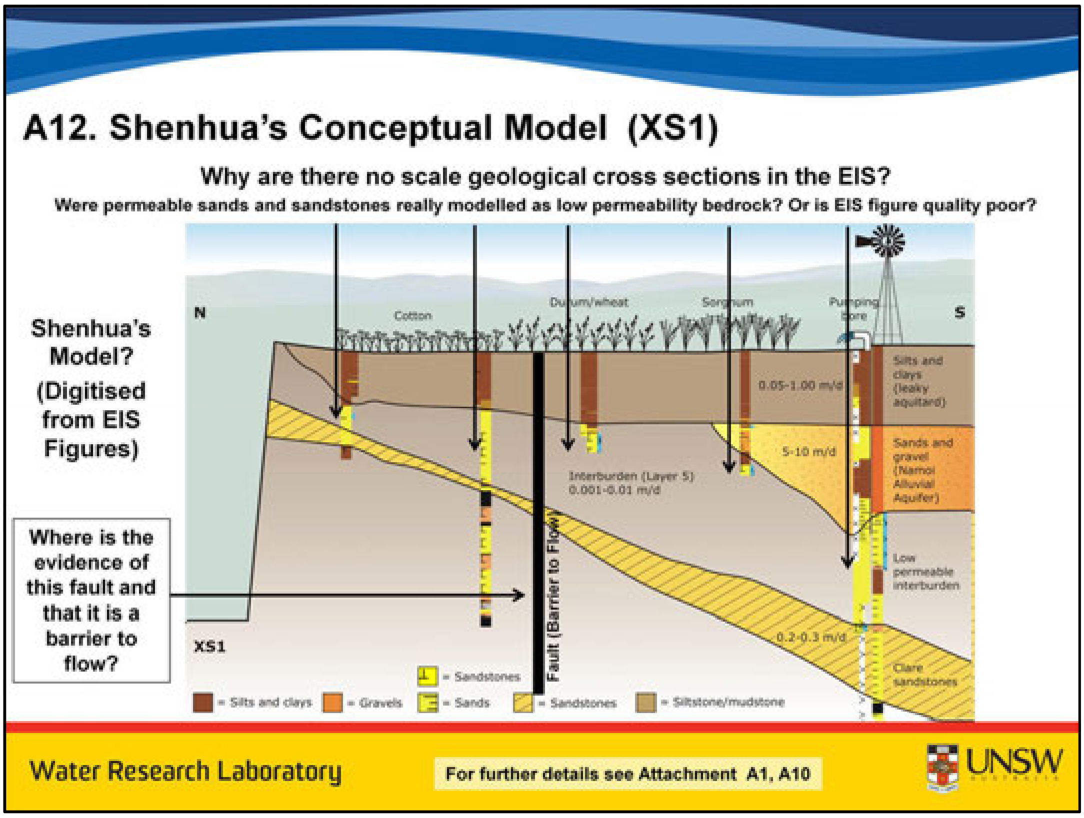


This slide shows that WM0429 and WM0421 contain gravels and sands and these are (generally) both excellent aquifer materials. Therefore, it would appear that the geophysical survey work of Groundwater Imaging has detected permeable paleochannels extending to within approximately 250m of the mine and possibly right to the edge of the current mine layout at other locations. This is at odds with Figure 7.3 of the EIS (refer Attachment A6) which suggests the aquifer is 1.3km away. Attachment A10 shows the location of this cross section and a close up of the extents of the Namoi Alluvium (formerly known as the Gunnedah Formation) as mapped by Shenhua.



This slide shows the locations of cross sections utilised in this presentation. It demonstrates the proximity of sands and gravel channels to the proposed mining operation (i.e. < 250m).

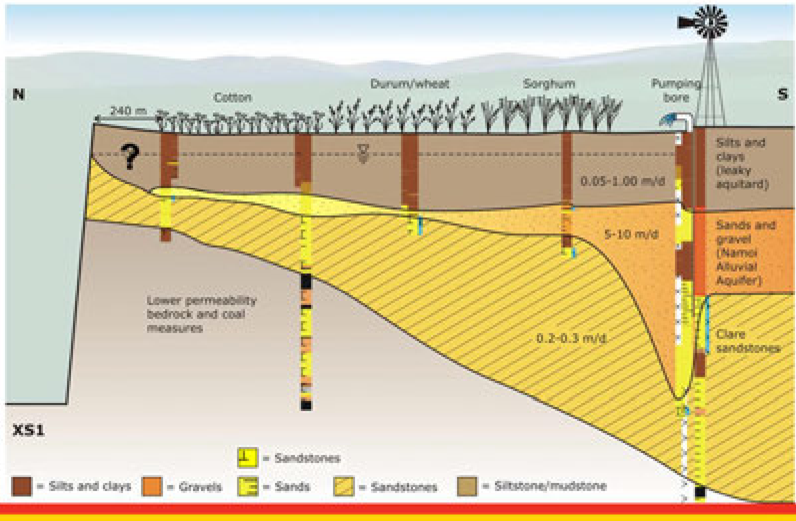
In summary, the extents of the Namoi Alluvium modelled by Shenhua ignore the paleochannels detected by Groundwater Imaging, despite demonstrable proof existing that at least one of these paleochannels is filled with gravels and sands and that it appears to convey water to the main Namoi Alluvial Aquifer. It would therefore appear that the design of the EIS model is insufficient for thoroughly assessing the impact of the proposed mining operation. The model presented in the EIS will therefore under-report the impacts.



The numbers on this figures with units of m/d are the modelled hydraulic conductivity values for the numerical model layers. All data in this figure was digitised from the EIS and/or from the NSW Office of Water PINEENA database. The reviewer acknowledges some uncertainty in the plotted elevation of the formations in cross section. This is because the quality and resolution of the plan view model layer figures are of low quality with contour intervals of 50 m which is too coarse.

A13. UNSW's Conceptual Model (XS1)

UNSW Model of EIS Borehole Data



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For further details see Attachment A1, A10

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Water Quality
Peer Review Comments

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Adequacy of EIS Predicted Water Quality Impacts (1)

Kalf and Associates Adequacy Review, 10 June December 2013:

- Earth Systems noted that "*The void water rate [KA: actually full recovery time] has been estimated as 100 years (WRM) and 2000 years (AGE).*" Kalf and Associates Response: "*This issue was highlighted in KA Stage 1 adequacy review that should be resolved*"

- Earth Systems noted that "*Aspects of water quality from saline drainage from mine waste not assessed.*" Kalf and Associates Response: "*This is a issue and needs to be addressed if not done already since my Stage 1 report.*"

Adequacy of EIS Predicted Water Quality Impacts (2)

Kalf and Associates Stage 1 Adequacy Review, 3 December 2013:

- *"The standard evapotranspiration (ETP) function available in MS was used with an imaginary ground surface above the void… The ETP rate at the initial void water level is some finite value not stated. AGE need to confirm that this interpretation is correct, or not, and to provide a better description and the missing values as indicated."*
- *"AGE should also liase with WRM to provide a more consistent and agreed analysis of a) equilibrium time b) effective evaporation from the void water storage, and c) determination of maximum water level in the void. When a final equilibrium water level is agreed on, the consequences, if any, of such a water level with respect to the surrounding groundwater system should be addressed."*
- *"The comments in section 10.11.2 page 262 of the AGE report indicates beyond 300 years that inflow to the void will reverse into the groundwater system at a very low rate. The consequences of such outflow should be provided in slightly more detail (i.e. runoff of evaporated seepage) given that seepage could comprise saline water as predicted in the WRM report."*
- *"Some comments need to be made about the consequences of higher rainfall periods and the possibility and fate of saline runoff from these areas into the local drainage channels and whether this would be important given the existing high salinity environment… it would be expected that such runoff would not impact more than 1% the 'long-term average salinity' of the highly connected surface water source (i.e. Mooki River), but this needs some form of confirmation"*
- *"Subject to resolution of the requests made above, KA considers that the EIS with respect to groundwater assessment to be suitable for public exhibition."*

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Adequacy of EIS Predicted Water Quality Impacts (3)

Independent Expert Scientific Committee (27 May 2013) - Advice to decision maker

Question 1: Does the Committee consider that the proponent has provided sufficient information on the water resources and its management to assess likely significant impacts from its proposed action? If the information is considered insufficient for that purpose, what advice regarding areas of inadequacy can the Committee provide?

a. In relation to the site water balance, the earliest and latest periods of historical data are underrepresented in the realisations modelled. The Committee has limited confidence in the predicted lack of release of mine water and recommends that, in order to minimise downstream water quality and ecological impacts, the proponent:

i. Undertake sensitivity analysis on the site water balance;

ii. Use the results of the site water balance sensitivity analysis, as well as predicted available water determinations, surface water availability and any applicable access rules to ensure that water supply licences will meet site water requirements under a full range of foreseeable conditions;

iii. Design mine water storages to contain a 1:1000 year average recurrence interval storm event; and

iv. Develop contingency plans to deal with the event of an emergency discharge of water from a mine water dam.

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Adequacy of EIS Predicted Water Quality Impacts (4)

Independent Expert Scientific Committee (27 May 2013) - Advice to decision maker (continued)

b. In relation to a regional water balance, the Committee recommends that a regional water balance be developed to allow for assessment of significant impacts. This water balance should:

- i. Extend across the regional surface and groundwater systems to defined monitoring points, beyond which there will be no measurable impacts as a result of the proposed project, e.g. groundwater to Gin's Leap and surface water to the Namoi River at Boggabri gauging station;
- ii. Detail the set of water stores and the flow of water between those stores under current conditions

c. Significant impacts are also likely as a result of the proposed project's increase in salt loads downstream of the proposed project site, into a catchment already at risk from salinity. The project assessment documentation would therefore benefit from the inclusion of a local and regional salt balance. A salt balance should:

- i. Detail the set of salt stores and the transfer of salt between those stores under current conditions within this region;
- ii. Assess the change as a result of the proposed project to the quantity of salt within any store or transfer of salt between these stores;
- iii. Take into account a range of foreseeable climatic scenarios; and
- iv. Undergo sensitivity analysis.

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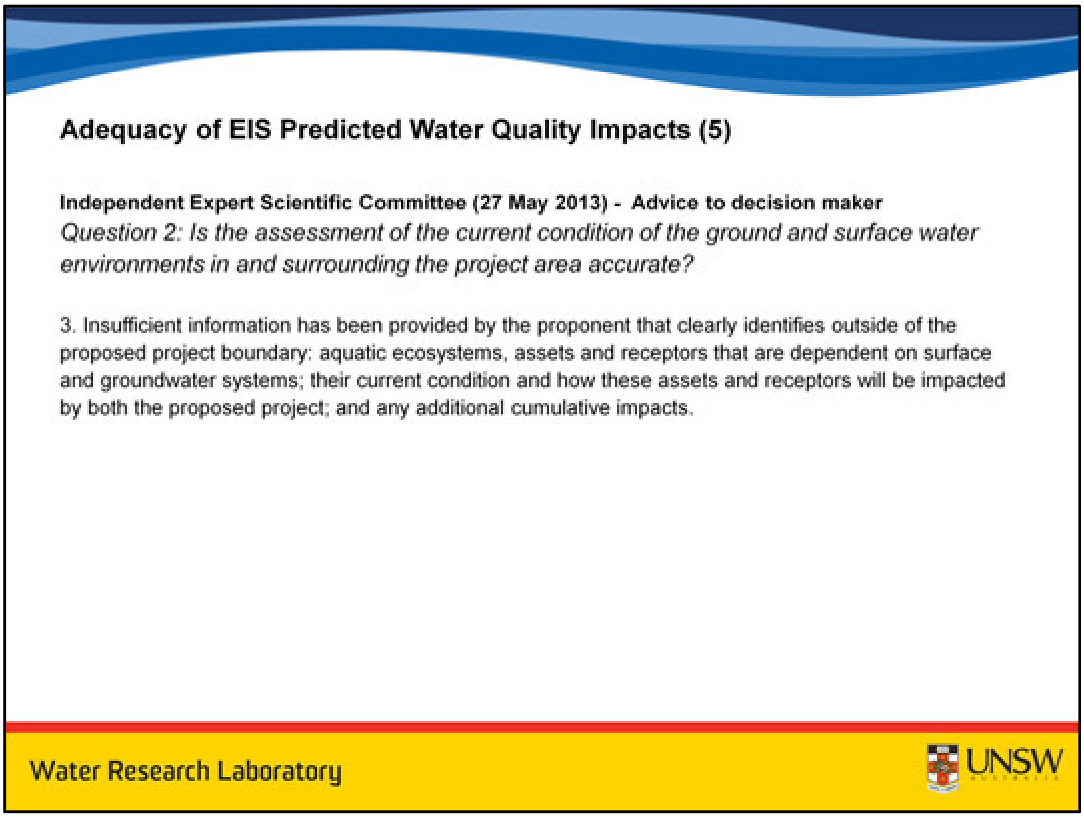
Adequacy of EIS Predicted Water Quality Impacts (5)
Independent Expert Scientific Committee (27 May 2013) - Advice to decision maker
Question 2: Is the assessment of the current condition of the ground and surface water environments in and surrounding the project area accurate?
3. Insufficient information has been provided by the proponent that clearly identifies outside of the proposed project boundary: aquatic ecosystems, assets and receptors that are dependent on surface and groundwater systems; their current condition and how these assets and receptors will be impacted by both the proposed project; and any additional cumulative impacts.
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Adequacy of EIS Predicted Water Quality Impacts (6)

NSW Office of Water (23 May 2013)

1.1.6 ***Requirement 6: Salinity budget.***

The proponent has concluded that the Mooki River salinity will likely not increase by more than 1% by the very minor seepage (Section 10.12) of relatively fresh water (Appendix W) recharged through the spoil material (Section 10.9, Appendix T).

Issue: A salinity mass balance for the Mooki River was not presented.

The adopted maximum leachate concentration used in salt export calculations was estimated incorrectly from kinetic leaching columns. A large portion of the added water had remained within the columns (Section 3 of Appendix 6 of T, pp. 12-15) and was likely more saline and of different chemistry.

An assessment of surface runoff impacts on the salt load of receiving surface waters indicates no net increase in salt export from the project area apart from a 30% increase of the Watermark Gully salt load (Appendix S, Section 7.13). However, under the assumptions and errors in the water balance and in average source contributions, this increase could be within analytical error, which is not shown.
The transience, final storage and water quality of the final void were modelled (Appendix S, Section 7.14); predictions suggest that the water level will reach equilibrium at 20-30 m below the overflow level, where it cannot contribute to external environments, at about 100 years of simulation.

Potential exists for molybdenum and selenium in seepage and runoff from overburden/interburden and coal reject material to occur at above background concentrations (Appendix W, ES4, p. ii).

An evaluation of geochemical risks to receiving environments has not been done with regard to parameters other than increased salinity, such as those associated with dilution, positive residual alkalinity, and high alkalinity, pH, sodium adsorption ratios, organic compounds and suspended solids. Results in Appendix W indicate that the leachate can be expected to have a high pH, alkalinity, and sodium adsorption ratio.

The salinity measurement of a 1:5 solid:water solution using sample pulps (Section 3 of Appendix 6 of T, p. 11) is difficult to relate to natural leaching or weathering conditions; this aspect has not been adequately addressed.

The geochemical assessment was done on drill core samples that had very likely been geochemically altered via oxidation, degassing, and potentially other processes prior to being tested, giving misleading acidity and associated pH and dissolved metal analytical results.

Authors of the geochemical assessment incorrectly claim that, for the acid-base accounting results, the main host phase of sulphur is evident from the total sulphur concentration (Appendix W, Section 4.1.1, p. 7), which therefore cannot be used to indicate the risk of acidity.

Bulk geochemistry was used for comparison to guideline values to assess trace-metal risk (Appendix W, Section 4.2, p. 21), yet has very little bearing on specific host phase stability and hence metal mobility. Soluble-metal extracts, EC and pH from 1:5 solid:water solutions were measured and, inappropriately, used for geochemical characterisation and comparison to water quality guidelines (Section 4.4, p. 25); preparation of 1:5 solid:water solutions induces numerous fundamental geochemical reactions that result in non-representative chemistry.

Kinetic leach column test result pH-time plots in Fig. KLC1 (Attachment C of Appendix W) show irregular trends which should be explained. Element concentrations should be normalised with respect to salinity so that they don't primarily present salinity trends.

A decline in salt generation and release rates post mine closure is stated as expected, but this and especially the rates of other longer-term geochemical reactions have not been demonstrated.

Issue (repeated above): Analytical errors are not presented for all data.

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