

BURNS Ben

From: BLEAKLEY Ashley
Sent: Thursday, 1 February 2018 9:20 AM
To: JOHNSTON Luke; CLAUS Sonia
Cc: LARSEN Daniel; DAVIDSON Kylie; ROSENBERG Megan; BATTS Kathy
Subject: Limited review of Groundwater model - East End
Attachments: Review of Pacific Environment report Januray 2018 AB DL.docx

Luke/ Sonia

Please find a limited review of the new Pacific Environment groundwater model for East End carried out by Daniel and myself.

Hope this assists.

regards

Ashley Bleakley

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From: LARSEN Daniel

Sent: Wednesday, 24 January 2018 8:59 AM

To: DAVIDSON Kylie <Kylie.Davidson@dnrme.qld.gov.au>

Cc: BLEAKLEY Ashley <Ashley.Bleakley@dnrme.qld.gov.au>

Subject: FW: Advice regarding groundwater level triggers

Hi Kylie,

We can probably have a look at it.

We have a few other things on at the moment - so timing may be an issue.

Regards

Daniel

From: DAVIDSON Kylie

Sent: Wednesday, 24 January 2018 8:46 AM

To: LARSEN Daniel <Daniel.Larsen@dnrme.qld.gov.au>

Subject: FW: Advice regarding groundwater level triggers

Hi Daniel, Happy New Year!

This is a request from Dept of Environment and Science for GW advice regarding the GW model for an extension of East End. It's for the EA, I imagine you've already worked on this mine, but then it again came from the Cairns office. BTW I'm OK with the GDE stuff – there isn't GDE mapping for Calliope so it's good they found anything really.

Would you kindly be able to field this one?
Let me know and I'll send it over formally with a CC to Sonia.

Cheers
Kylie

From: CLAUS Sonia
Sent: Monday, 15 January 2018 10:55 AM
To: DAVIDSON Kylie <Kylie.Davidson@dnrme.qld.gov.au>
Subject: Advice regarding groundwater level triggers

Hi Kylie

We have been requested by the Cairns Office (ex EHP) to review a groundwater model report to determine appropriate groundwater level triggers to be applied in an EA for East End Mine. Specially, the Officer has requested "a review of the groundwater model that has been developed for the project site to determine groundwater level triggers and also to ensure the proposed groundwater monitoring bores are within the same hydrogeographical zones."

I have previously provided advice regarding surface and groundwater quality triggers and limits for this site. However, our group doesn't have the expertise required to address the groundwater level modelling and potential impacts on GDEs.

I was wondering whether you would be able to help with this request. I have attached the groundwater model report for your consideration.

Any questions let me know.

Thanks
Sonia



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Review of groundwater modelling report**East End 11 January 2018****Pacific Environment****Introduction**

The following is a result of a brief review of the document referred to above. It is not intended as a complete review but a compilation of the main issues noted in the limited time frame available to assess the report.

One thing that is noted is that DNRME had previously recommended a peer review of any updated transient model. This appears not to have occurred.

Issues**Areal extent of model**

Whilst the model boundaries are wider than in previous modelling work presented and appear reasonable in most areas it is noted in Figure 28 that the predicted 5 m drawdown contours in scenarios 2 and 3 in 2045 intercept the model boundaries in the northern part of the model.

There is no discussion of whether this is a limitation to this model, how this may impact drawdown predictions elsewhere in the model or if alterations should be made to future versions of the model.

Model Layers

The commitment in section 8.3 of the August 2014 SEIS Groundwater report is as follows:

‘Following the acquisition of additional water level data from the monitoring network recommended above and additional pumping test data, refinement of a numerical model of groundwater flow would be feasible and should be completed. Features of such a model would include: (a) additional vertical discretisation of the aquifer(s), (b) development of a transient flow model including delayed recharge, and (c) more accurate representation of groundwater-surface water interaction near creeks and other surface water bodies.’

Firstly whilst additional water level data is now available, based on section 4.4 and table 9, it appears that only one additional pump test (DHH96-43) has been carried out since 1999.

In regard to the additional vertical discretisation of aquifer(s) referred to above, this would need to occur by either incorporating a number of model layers or utilising some sort of ramp function to alter hydraulic conductivity (K) values with depth in a single layer. The Pacific Environment 2018 model uses one layer to a depth of 100 metres with a single uniform K value. The reasoning for the one layer can be found in section 4.4.1 which utilises existing pumping test data. It is noted that any test with a K value of less than 1 m/day have been discarded in the Pacific Environment assessment. The majority of these discarded tests appear to have been carried out on the deeper bores.

This reasoning for the single layer of uniform K also includes the construction method of most of the monitoring bores which have long screen lengths which make it difficult to calibrate a multi-layer model. The inference here is that water levels monitored are not representative of a specific depth.

There is however no recommendation as to future construction requirements for monitoring bores or additional pumping tests that might address this issue.

Model boundaries

Section 5.2.3.1 discusses model boundaries. In this section it states that *the model boundary generally follows the high points in the topography. As such, all boundaries along those high points are no-flow boundaries.*

It then goes on to state exceptions where constant head boundaries have been implemented. This section requires a map to clearly demonstrate where no flow and constant head boundaries are located in the model.

Storage Coefficient / porosity

It is noted that there is no characterisation of the aquifers in the report. It is noted in the 2014 report that the limestone aquifer is assumed to be unconfined.

It appears that the same assumption is made here. The storage parameter is referred to as a storage coefficient (generally used to describe confined aquifers) but the 1% figure adopted is in line with a specific yield used to describe an unconfined aquifer.

In section 5.4.5.1 it is stated that as the value used in the model (to represent storage) was already at the lower range of the values documented in literature, the value was only increased (not decreased) for the sensitivity analysis. In other words a lower storage coefficient was not trialled in the sensitivity analysis.

There is however little discussion about the literature values in the report.

Recharge

The 2014 report suggested the need for applying delayed recharge in the model. This issue appears not to have been discussed in the Pacific Environment 2018 report.

Section 5.2.5.1 provides details of the different recharge rates applied to limestone and volcanoclastic rocks. However there appears to be no map showing these 2 zones where the varying recharge rates were applied. It is assumed that it was applied on the basis of Figure 24 which sets up zones for limestone and volcanoclastic rocks.

4.3.2 Machine Creek

There is a short description of a theory which concludes that alluvial groundwater and surface water in Machine creek will not be impacted by further dewatering of the bedrock. This statement cannot be confidently supported by the limited information provided.

It is noted that in the 2014 EIS report commitments were given to carry out additional drilling adjacent Machine Creek.

Model Calibration and Validation 5.3

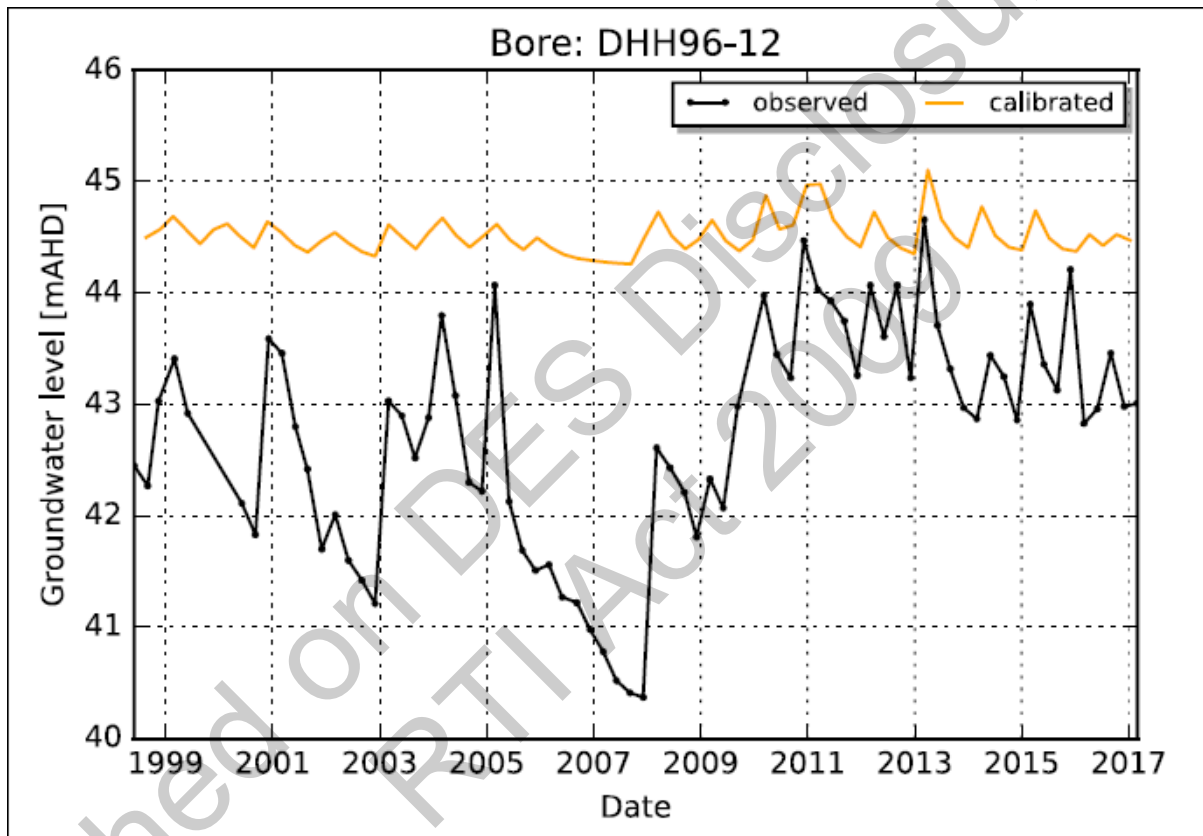
It appears from section 5.3 that a steady state calibration was carried out to determine K in the 15 zones and the 11 creek leakage factors. Figure 24 shows the locations of the 15 K zones and table 15 discusses the creek sections. A map showing the creek sections would assist. The draft report currently does not label any streams on any of the maps which makes it difficult to follow the discussion.

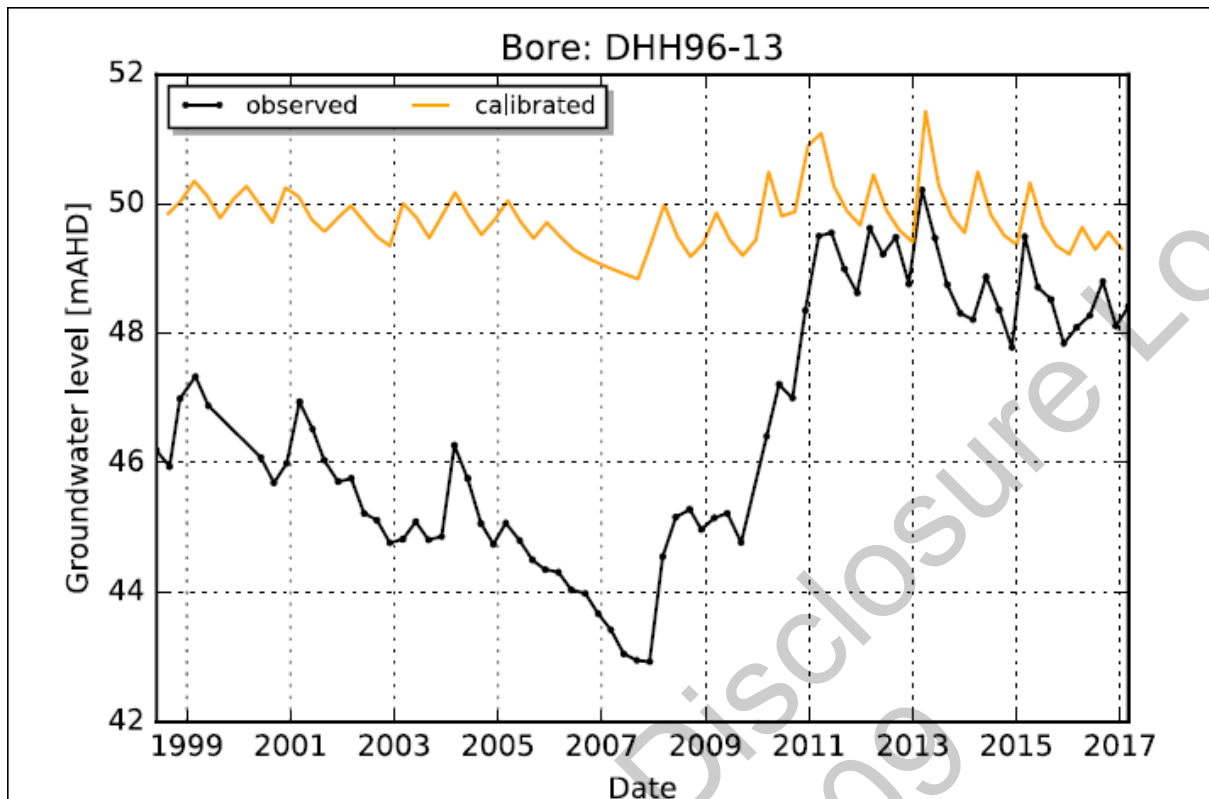
It is then assumed that these parameters were accepted and used to run the transient model from 1980 to 2017 as a validation. Hence K appears not to have been calibrated in transient mode. It appears that during this process a storage coefficient of 1% was adopted by way of some manual best fit process.

The description of this transient process is very limited.

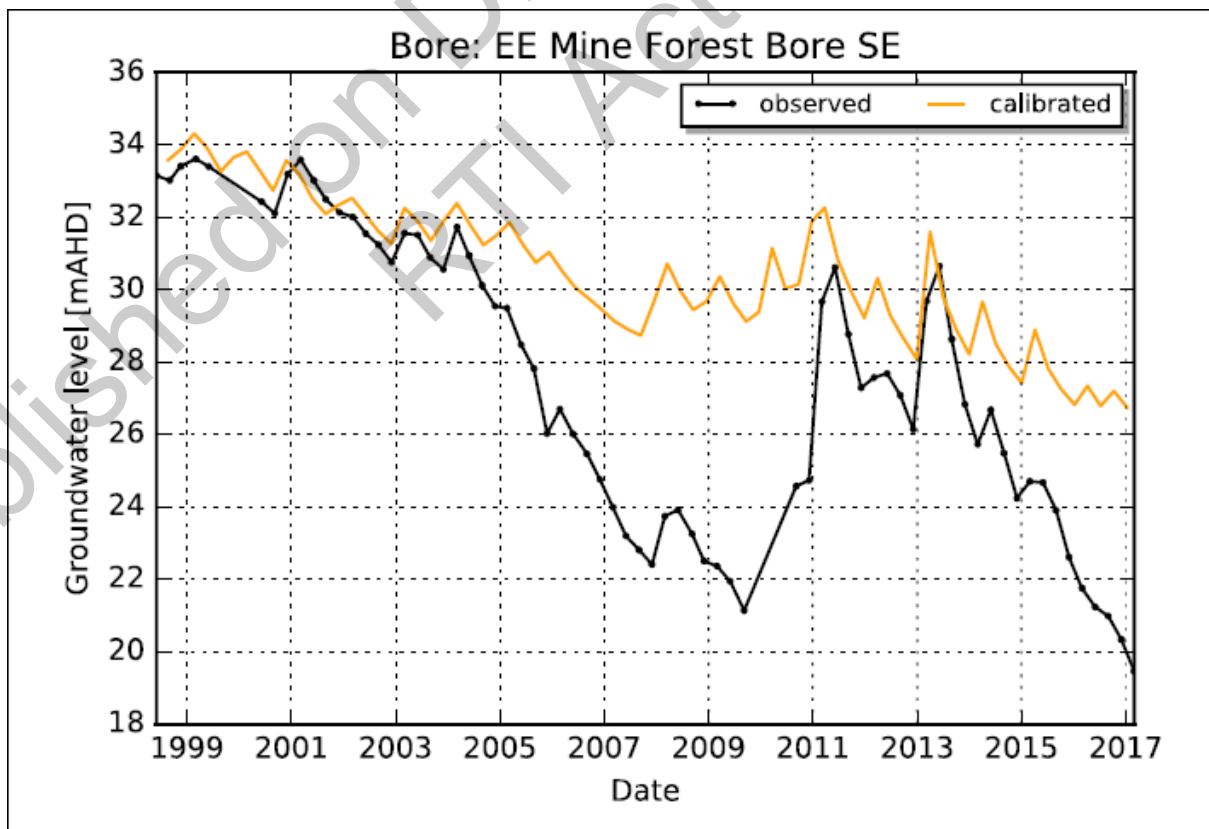
In most calibration bores the elevation of the calibrated water level in the validation period looks reasonably good in comparison to the observed water levels.

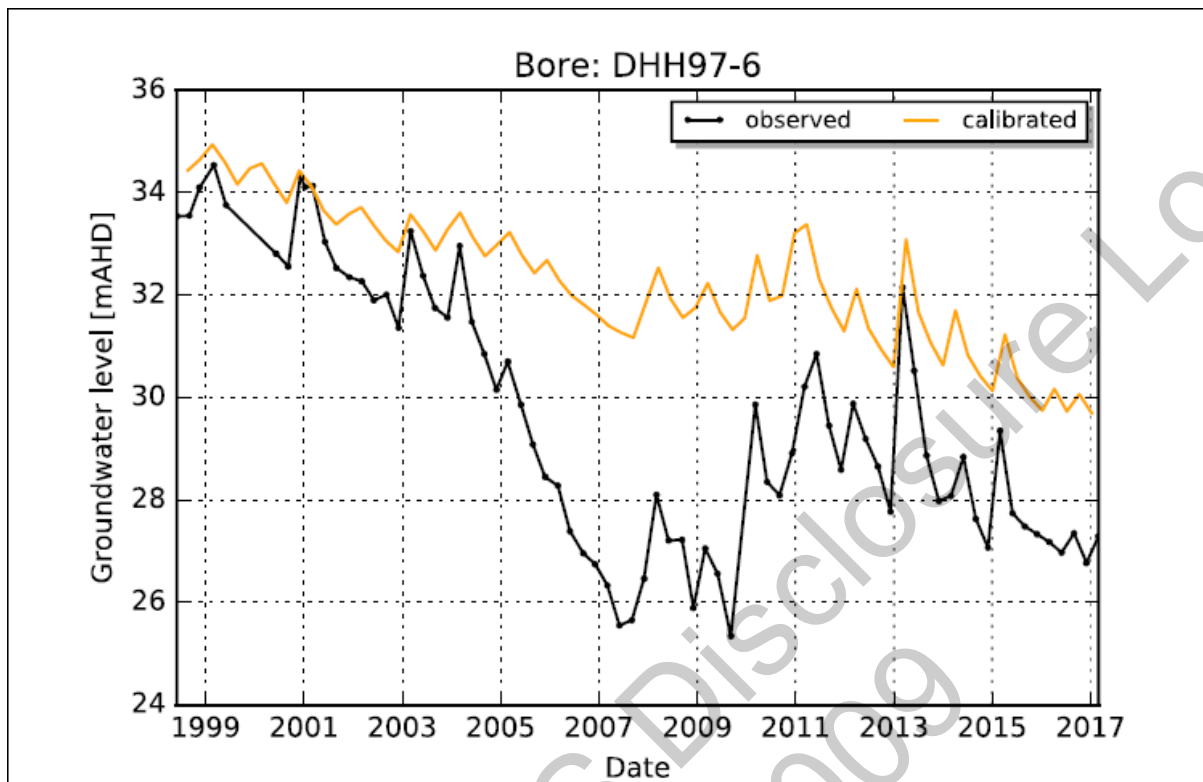
West of the pit the elevation of the calibrated water levels look ok but reproduction of drawdown and recharge response is poor. Typically the model is not predicting enough drawdown in the calibration (validation) period in this area. DHH96-12 and DHH96-13 are examples.





Then to the east, EE Mine Forest Bore SE and to the south east, bore DHH97-6, similar issues are noted.





Hence this can be an issue in some areas where the model is consistently under predicting drawdown given that prediction of drawdown is a key aim of the model.

Hydraulic Conductivities

Whilst it is accepted that the volcanoclastics are likely to have generally lower K values than the limestone there should be some discussion as to the difference in values in the pump test results in table 10 for volcanoclastic bores where 4 bores returned K values of between 1.5 and 11.6 and the calibrated values of 0.02 to 0.14.

Additionally given the colour coding of Figure 24 the boundaries of zones 1 and 2 are difficult to determine but given the similar K values the issue is not critical.

It would however be helpful to have a map where the locations of both the calibration / validation bores and the K zone boundaries are provided. This would assist in understanding the likely impact of K zone values on calibrated water levels at specific bores.

Predictive Model Runs Section 5.4

Table 14 describes Scenarios 1, 2 and 3.

Based on the descriptions in the report it appears that scenario 1 is a no mining scenario, scenario 2 includes the current mining operations out to 2045 and scenario 3 includes current and proposed extension mining operations out to 2045.

Table 14 references Figure 29 as providing the results of scenarios 1, 2 and 3. This appears incorrect.

Figure 29 appears to show the difference between scenario 3 and 2 which equates to the predicted drawdown at 2045 for the mining extension.

Figure 28 appears to show the predicted drawdown at 2045 of scenarios 2 and 3.

Apart from this obvious confusion it would have been helpful to have predicted drawdown at various time periods from current day through to 2045. This has not been provided.

Additionally we are provided with 5 metre contours. It would have been helpful to see a 1 metre contour to determine if predicted drawdown approaches any other model boundaries in addition to those in the north.

Predicted Pit Inflows

Based on discussion in section 1.2.1 and 5.4.4 the predicted inflows to the pit in 2017 is similar to that observed. The report does not provide a graph showing predicted inflow over the life of the mine (Figure 30 only shows inflow up to 2017. The report does not provide information or graphs showing post mining recovery of water levels in the final void. (post recovery of bores are in App G). The report briefly notes that evaporation exceeds rainfall, however does not provide a full water balance including runoff etc.

Larcom Creek

Figure 28 indicates at least 5 metres of drawdown adjacent Larcom Creek and in places in excess of 5 metres. More detailed predicted drawdown contours should be provided in such areas.

The following recommendations in relation to Larcom, Scrub and Machine creeks are noted in the 2014 EIS groundwater report

Other recommendations additional to those contained in the monitoring review are:

- *Additional and replacement monitoring bores to be installed in the vicinity of Larcom Creek and Scrub Creek to confirm the extent of groundwater-surface water interaction. Such installation must occur well in advance of mining commencing in the Project Area. Similarly, installation of monitoring bores within the Machine Creek alluvium has been recommended.*
- *Any additional bores drilled adjacent to Larcom and Scrub Creeks should be hydraulically tested in order to develop understanding of the connectivity between the river and the adjacent aquifer/s including the potentially low permeability volcanic layer identified within the limestone.*

The current report makes reference to at least some of this work in section 6.2 but it appears no closer to happening.

Surface water interaction

Section 5.4.4, Table 15 notes that some streams will change from gaining streams to losing streams during mine life. The streams, however, are predicted to revert back upon recovery post mining (Table 17). DES may wish to consider whether there are any environmental values that may be affected by these changes during mine life.

Sensitivity Analysis

The sensitivity analysis is considered useful. The predicted drawdown appears most sensitive to changes in K. This combined with some under prediction of drawdown in the validation period may be an indication that a further calibration of K under transient conditions (assuming that has not already occurred) should be performed.

It is also noted that recharge has not been included in the sensitivity analysis and no discussion as to why it has been omitted.

Summary

Subject to addressing the comments above, and noting the caveat in the introduction in regards to a peer review, the model overall appears to be reasonable, however it is noted that the calibrated (validated) drawdowns in ~10 bores are underestimated by more than 5m. This would possibly present a problem in that some bores may not be identified as being potentially impacted in the immediate and long term impact areas. DNRME has not assessed the locations of landholders bores to see if this poses a potential risk, or whether an absence of landholder bores in those areas would lessen the impact of the discrepancy between actual and modelled impacts.

A. Bleakley

D. Larsen