Jacobs

Memorandum

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Subject	**DPIE Model Review**	**Project Name**	Bowdens Silver Project
Attention	Paul Ryall	**Project No.**	IA132500
From	Greg Sheppard		
Date	2 June 2021		
Copies to	Nick Warren		

Dear Paul

The following provides a response to an independent peer review of the numerical groundwater model for the Bowdens Silver Project. The peer review was commissioned by the Department of Planning, Industry and Environment (DPIE) and prepared by Hugh Middlemiss of HydroGeoLogic Pty Ltd. It considers whether the model used to predict changes to the groundwater setting as a result of the proposed mining project is fit for purpose. As requested, the information below provides a separate response to the DPIE peer review as it is noted that DPIE Water also provided comments from its own review of the model. Responses to the DPIE Water review are provided in the Updated Groundwater Assessment. Both the DPIE Water review and the peer review commissioned by the NSW Government as well as the peer review commissioned by Bowdens Silver confirm that the model is fit for purpose.

Responses to recommendations for corrective actions arising from the DPIE review are provided below. The Groundwater Assessment has been updated to address some of these and other review comments, however, it is noted that the outcomes of assessment have not changed.

Confirm whether calibration period is from 2011 to April 2017 or to October 2018.

- The transient model calibration period is misreported as being from 1 Jan 2011 to 30 April 2017. This was left over from a previous revision of the groundwater model and reporting. As suggested, the transient calibration period runs from January 2011 through to October 2018, a period of 2831 days. There is a 15 month lead-in period prior to the monitoring data commencing in March 2012.

Groundwater level time series needs labelling of time axis with years (this was identified by Dr Merrick's peer review, but has not been addressed).

- Groundwater level time series plots, time axis present the model time period in days. These are presented as 31/12/2010 as day 1 and 1/11/2018 as day 2,862 and encompassing the calibration period from 1/01/2011 through 31/10/2018.

Scattergram 'ideal fit' line is misaligned (formatting issue, not performance).

- The calibration scattergrams have been updated with a corrected "ideal fit" line. These are presented in Section 4 of Annexure 9 of the Updated Groundwater Assessment and reproduced below.

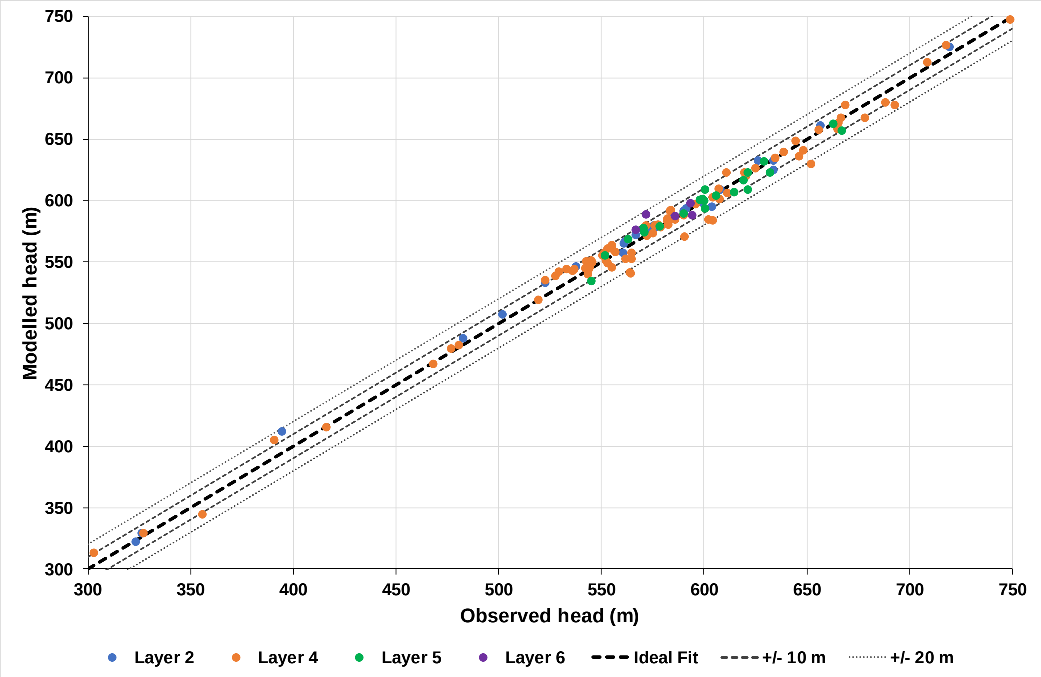

Figure 1 Steady State Model Calibration – Modelled vs Observed Heads (m AHD) (all model targets) (Figure 21 Annexure 9 of Updated Groundwater Assessment)

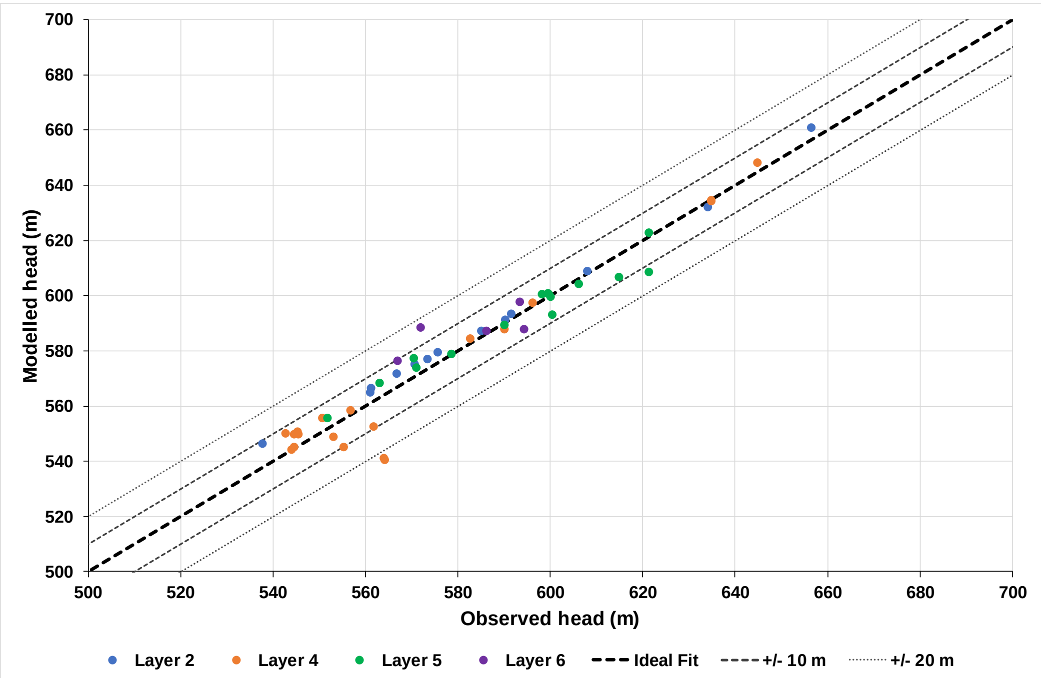

Figure 2 Steady State Model Calibration – Modelled vs Observed Heads (m AHD) (Bowdens Silver model targets) (Figure 22 Annexure 9 of Updated Groundwater Assessment)

Re Table 29 recharge zones, clarify whether the 0.025 recharge factor for zone 4 is a typo (should be 0.25?), and if not, provide a reasoned explanation to justify this rate being 10-16 times lower than the other floodplain rates.

Zone 4 is described in the report as being "flood plain", a more accurate description would be "valley floor". In the vicinity of the mine there is very little actual floodplain associated with Hawkins Creek and Lawsons Creek. For the most part, the majority of Zone 4 in the vicinity of the mine area comprises broad areas of shallow regolith and exposed outcrop with only limited occurrence of alluvial deposits.

The recharge factor of 0.025 (2.5%) for zone 4 is correct. The recharge factor to the Lawsons Creek and Hawkins Creek "flood plain" areas in Zone 4 was refined during transient calibration to shallow water table observations in alluvial monitoring bores and to baseflow estimates derived from Hawkins Creek flow gauging. It is noted that with the adopted calibrated recharge factor a good fit to both baseflow and water level hydrographs is achieved.

Assess sensitivity effects of applying steady state heads as initial heads for transient calibration.

The initial stress period in the transient calibration is already in steady state. Therefore, applying simulated heads from the calibrated steady state model as initial heads to the first timestep of the transient model during calibration would make little significant difference. From review of transient calibration hydrographs, very little settling in is apparent and head matching is considered to be acceptable.

Confirm accuracy and resolution of topographic data and whether regional LiDAR data set is available and/or has been applied (important for rivers, creeks & ET).

LiDAR data covers the mine site and reaches of Hawkins and Lawsons Creeks from Hawkins Creek upstream of the mine site to Lawsons Creek below the confluence with Walker Creek (below TSF).

This data set contains a ground surface model in a 2 metre grid format derived from Spatial Services Category 2 LiDAR sourced from the ELVIS – elevation and depth – foundation Spatial Data (https://elevation.fsdf.org.au/). The data used to create this DEM has an accuracy of 0.3m (95% Confidence Interval) vertical and 0.8m (95% Confidence Interval) horizontal. It is noted, however, that adaptation to the model grid (minimum cell dimensions of 31.25 x 31.25 m) somewhat negates the use of high resolution topographic data.

Regional LiDAR data is available but would be of little benefit outside of the area of refined model grid. It is noted that future, post approval, model updates incorporating a model grid with quad tree refinement, would make better use of high resolution topographic data sets.

Improve the evapotranspiration (ET) rate information and provide cogent technical justification for 40% factor applied to SILO FAO56 values; test model sensitivity to rates or justify clearly why not tested, given that ET comprises around half the model water balance.

During preliminary calibration of earlier versions of the groundwater model, it was observed that the model was relatively insensitive to changes in ET and, as a result, a fixed value of 0.4 was applied to most land-use types. It was, therefore, considered unnecessary to refine the ET zonation further from the almost uniform representation of ET in the preliminary calibrated model.

Uncertainty analysis for ET has been undertaken with discussion presented in Section 6 of Annexure 9 of the Updated Groundwater Assessment.

Provide cogent and physically realistic justification for post-mining pit void evaporation rate of 4.15mm/d and extinction depth of 55m (ie. not simply describe it as 'model sensitivity testing', but provide some results and interpretations); provide detail on the reported analytical estimates of pit void water balances; test model sensitivity to the effect of applying a lower maximum ET rate (eg. implications for water balances and higher lake levels) or justify clearly why not tested.

Following the example of Anderson et al (2002) the post-mining pit void (pit-lake) was simulated as part of the aquifer by assigning artificially high hydraulic conductivity and storage values. The pit-lake was represented in layers 1 to 4 of the model.

In the initial stages of recovery, it is likely that the pit-lake surface will be a considerable distance below the pre-mining ground surface. Therefore, for purposes of simulating evaporation during the early stages of pit-lake water recovery, it was necessary to apply a relatively deep extinction depth (to the MODFLOW EVT package) to enable evaporation to occur at depth during the initial recovery period. The following MODFLOW EVT settings were assigned:

- the evaporation surface from which depth to extinction is measured is the top of model layer 1, and
- evaporation occurs from the top active cell.

The maximum evaporation rate and extinction depth assigned to the MODFLOW EVT boundary in the MODFLOW-USG groundwater recovery model were adjusted to match analytical evaporative fluxes calculated from the pit-lake when applying regional class A pan evaporation and a pan factor of 0.65.

It is important to note that the Goldsim water balance model prepared by WRM Water + Environment Pty Ltd is the primary assessment tool that was used to calculate the post mining pit-lake water balance and predict the final void water level. The MODFLOW-USG groundwater recovery model was primarily used to assess regional impacts against post mining water level recovery.

Provide justifications for the perturbations to the regional geological layering that are apparent in the mine site area in Figures 51 & 52.

The perturbations to regional geological layering are left over from the early construction of the groundwater model prior to confirmation of the final mine design. The layering was to allow for simplification and versatility if an expansion of the preliminary mine design was to be adopted. It is noted that due to the adopted parameter zonation in the mining area, the perturbations are of little consequence to predictions of mine dewatering or associated groundwater drawdown and impacts.

Clarify whether the aquifer storage parameters tested for sensitivity are for unconfined specific yield (Sy) and/or confined specific storage (Ss)?

Aquifer storage parameters tested were for both unconfined specific yield (Sy) and confined specific storage (Ss).

Clarification and additional discussion are included in Section 6 of Annexure 9 of the Updated Groundwater Assessment.

Revisit assessment of sensitivity analysis results (eg. Jacobian figures 59-60) in terms of whether a more comprehensive uncertainty analysis may be warranted and provide reasoned justification for methods adopted or proposed.

The purpose of the sensitivity analysis (with results shown in Figures 59 and 60) was to identify the parameters that have the greatest and least influence on model calibration. Extended calibration of parameters identified as insensitive would not provide any meaningful improvement in reliability of the model since the calibration statistics are insensitive to these parameters. Moreover, further adjusting insensitive parameters could lead to assigning physically unrealistic values to the parameters.

The objectives of the sensitivity analysis were to:

1. aid model calibration and/or

2. provide a means of evaluating the calibration

Both objectives were achieved because a reasonably good model calibration was achieved against calibration measures outlined in the Australian modelling guidelines. Therefore, the sensitivity analysis met its objectives.

Regarding the requirement for a comprehensive uncertainty analysis, we note that the DPIE reviewer, in question 9, Table 1 agrees with our approach that qualitative uncertainty assessment can be suitable for a moderately low risk context groundwater assessment, consistent with AIP minimal impact considerations. As noted in Section 3.1 and Table 1of Annexure 9 of the Updated Groundwater Assessment, the model confidence classification meets or exceeds most Class 2 – Impact Assessment criteria of the Australian Groundwater Modelling Guidelines (Barnett *et al.* 2012).

I trust the above and the minor updates to the Groundwater Assessment assist to clarify the queries from DPIE. We remain confident the data by which the groundwater model was developed, coupled with the adopted parameters provide for realistic predictions of the potential groundwater implications arising from the Bowdens Silver Project.

Yours Faithfully

Greg Sheppard