wrm water + environment

Memorandum

Date	24 September 2021	Pages	6
Attention	Paul Ryall		
Company	RW Corkery and Company		
Job No.	1356-05-C1		
Subject	Bowdens Silver Final Void – Modelled void lake water levels under representative climate change conditions		

Dear Paul,

As requested, we have reviewed the modelled final void lake levels with a view of determining a ‘best-estimate’ timeseries of final void water levels for the purposes of reconciling with the groundwater model and assisting in assessment of the likelihood of the final void lake becoming a long-term groundwater source.

Climatic behaviour under global warming conditions

IPCC AR6

In August 2021, the United Nations’ Intergovernmental Panel on Climate Change (IPCC) published the first part of its sixth assessment report (AR6).

AR6 concludes that temperatures have been rising faster than in previous IPCC assessment cycles. The estimated temperature increase between 1850-1900 and 1986-2005 is 0.08C larger than in AR5.

Warming projections in AR6 are based on a combination of the latest generation of global climate models produced as part of the sixth Coupled Model Intercomparison Project (CMIP6). The report also uses output from CMIP5, which was used in AR5. The CMIP6 reportedly better simulates with high confidence “most large-scale indicators of climate change”.

The model simulations are based on a new set of scenarios, derived from the Shared Socio-economic Pathways (SSPs) describing five broad narratives of future socio-economic development which were used to develop scenarios of energy use, air pollution control, land use and greenhouse gas (GHG) emissions developments using integrated assessment models (IAMs)”.

The core set of five illustrative SSP scenarios span “a wide range of plausible societal and climatic futures from potentially below 1.5C best-estimate warming to over 4C warming by 2100”. These emissions scenarios, span the “very low emissions” SSP1-1.9, “low” SSP1-2.6 and “intermediate” SSP2-4.5, through to “high” SSP3-7.0 and “very high” SSP5-8.5.

The new models project slightly more warming for similar emissions scenarios, with a narrower range of uncertainty. The higher warming projections are due to a

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range of factors, including the higher estimate of historical warming in AR6 and updated estimates of climate sensitivity.

The report also states there is medium confidence that an intermediate emissions pathway would lead to 2.3-4.6C of warming by 2300.

CCS Project and IPCC AR5

For the original EIS assessment, climate-change adjusted SILO climate data was sourced from the Queensland Government Department of Environment and Science's (DES) Consistent Climate Scenarios (CCS) project.

The CCS project was a research and development alliance between Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the former Queensland Government Department of Science, Information Technology and Innovation.

The CCS incorporates high resolution data from Climate Model Intercomparison Project Phase 5 (CMIP5) global climate models incorporated in the United Nations' Intergovernmental Panel on Climate Change (IPCC) fifth assessment report (AR5) which was published in 2014.

The CCS aims to ensure comparability between projects, by using GCMs linked to a common set of climate change scenarios. The CCS project provides data for:

- four Representative Concentration Pathways (RCPs) described in the 5th Assessment Report (AR5) of the IPCC (RCP2.6, RCP4.5, RCP6.0 and RCP8.5);
- three global climate warming sensitivities (high, medium and low);
- 32 global climate models (GCMs) used in the 5th Assessment Report (AR5).

The separate models can be split into four Representative Future Climate (RFC) partitions, defined below:

- HI: a high level of global warming, where the Eastern Indian Ocean (EIO) warms faster than the Western Pacific Ocean (WPO);
- HP: a high level of global warming, where the WPO warms faster than the EIO;
- WI: a low level of global warming, where the EIO warms faster than the WPO; and
- WP: a low level of global warming, where the WPO warms faster than the EIO.

The CCS provides daily timestep rainfall and evapotranspiration data based on the mean result of all models within each RFC quadrant, which greatly simplifies the process of using the climate data.

The final void model was run using composite datasets derived by the CCS for the 2070 horizon for each of the above four pathways and for the RCP8.5 pathways and 3 global warming sensitivities (a total of 12 scenarios) and results were reported for the dataset closest to the mean of all simulations.

Proposed climate model dataset for this update

Neither the CCS or the CSIRO and Bureau of Meteorology, Climate Change in Australia website (http://www.climatechangeinaustralia.gov.au/) have updated their guidance to incorporate the results or downscaling of the CMIP6 modelling. We have therefore adopted the previously used CMIP datasets for this update.

In the original assessment, the WI.M composite dataset was adopted for reporting "representative" climate change conditions. However, the CCS project notes that models centred on the WI RFC quadrant tend to have low reliability in representing Australian climate characteristics. This is supported by the CSIRO and Bureau of Meteorology, Climate Change in Australia website (http://www.climatechangeinaustralia.gov.au/), which rejects some of these models with low-ranking performance across a number of metrics. Therefore, for the purpose of this update, we have adopted the HI.H composite dataset, which is also similar to the mean of all modelled climate datasets.

While the RCP8.5 pathway represents the 'worst-case' mitigation scenario (no additional climate policy), it does not represent the most-conservative pathway in terms of equilibrium void lake water levels, as the higher AR5 emissions scenarios tend to lead to higher annual evaporation and lower annual runoff compared to lower emissions scenarios.

The IPCC states there is medium confidence that an intermediate emissions pathway would lead to 2.3-4.6C of warming by 2300. This is reasonably consistent with the "very likely" range of 2.1 to 3.5 degrees of warming under the SSP2-4.5 scenario in AR6. We therefore propose adopting the RCP4.5 2070 AR5 pathway for this assessment which is more conservative in terms of estimating high final void water levels.

Other modifications

Runoff modelling

An error in the calculation of catchment runoff in the model was corrected (caused by the GoldSIM model being configured to allow unscheduled timestep updates – inconsistent with the AWBM – which is a daily timestep model). This had the effect of increasing catchment runoff compared to the EIS modelling. The results are now consistent with the site water balance model.

Evaporation modelling

The evaporation component of the model was improved to take into account the effect of salinity on reducing evaporation rates according to Morton's relationship with total dissolved salts (TDS).

The pit factor relationship was modified to better reflect observed evaporation rates in existing final void lakes. The pit factor accounts for the effect of shading and sheltering on void lakes compared to open water bodies – and now varies in the linearly from 0.5 when the void is near-empty, to 0.95 at an elevation of 597 mAHD (previously 0.8 - which was conservatively low). At equilibrium, the pit factor now varies in the range 0.85 to 0.87.

Modelled results

Modelled water levels

Modelled water levels under the RCP4.5 scenario are presented in Figure 1.

As with the previously modelled RCP8.5 pathway, all modelled water levels are less than the bases case (existing climate) scenario.

The void water level reaches equilibrium after around 100 years. The long-term average water level of all simulations is approximately 569.8 m AHD. The composite dataset giving behaviour closest to this average is the HI.H model (Refer Figure 2), which gives long-term results fluctuating between 564.7 mAHD and 571.9 mAHD as shown in Figure 3 (in the EIS, adopted climate change water levels fluctuated between 566.5 mAHD and 572.5 mAHD). Figure 3 presents this information as a frequency curve.

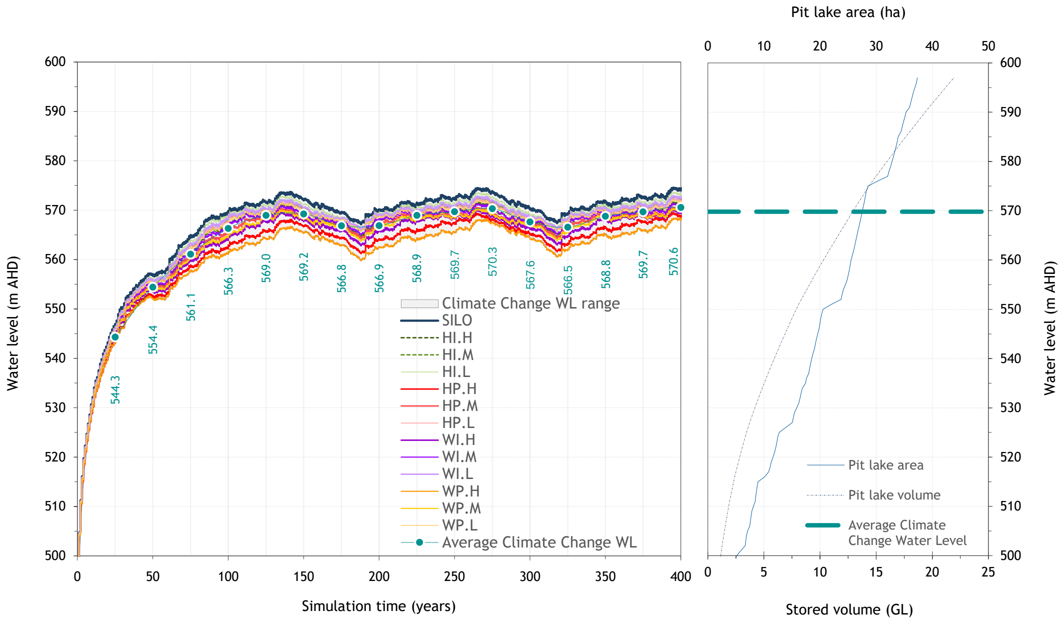

Figure 1 Modelled scenarios for final void filling

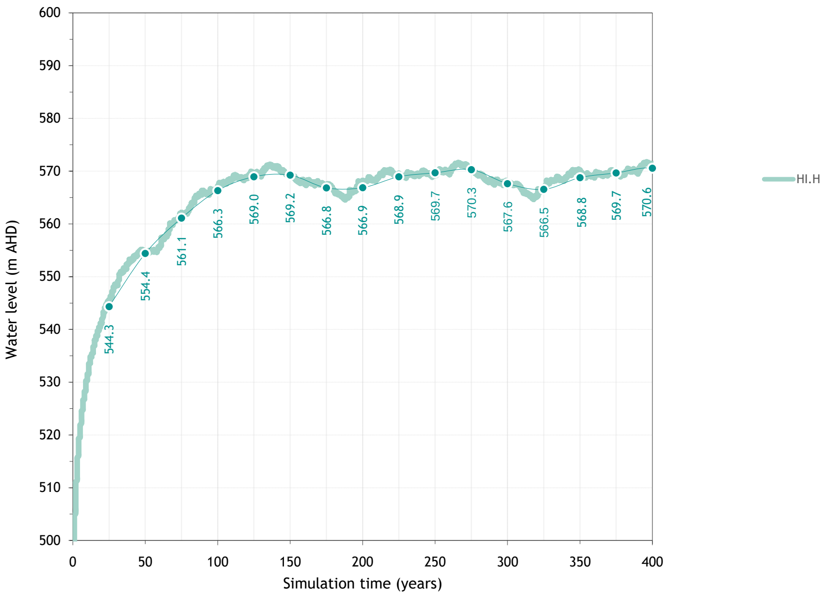

Figure 2 Comparison of HIH and average of climate change scenarios

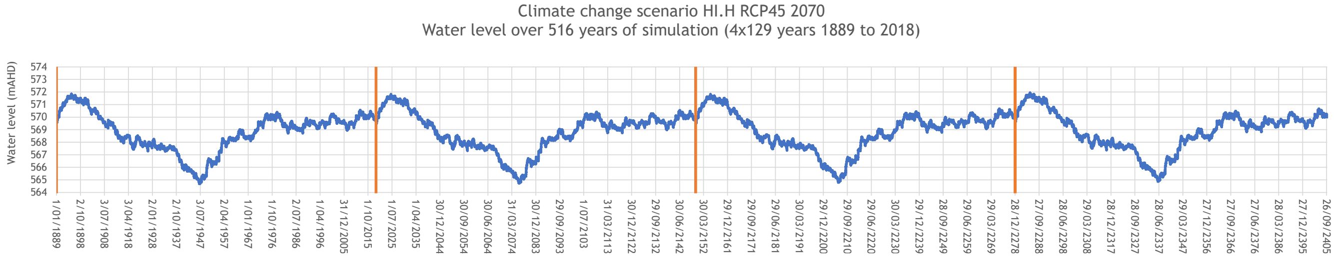

Figure 3 Equilibrium behaviour of final void lake water level

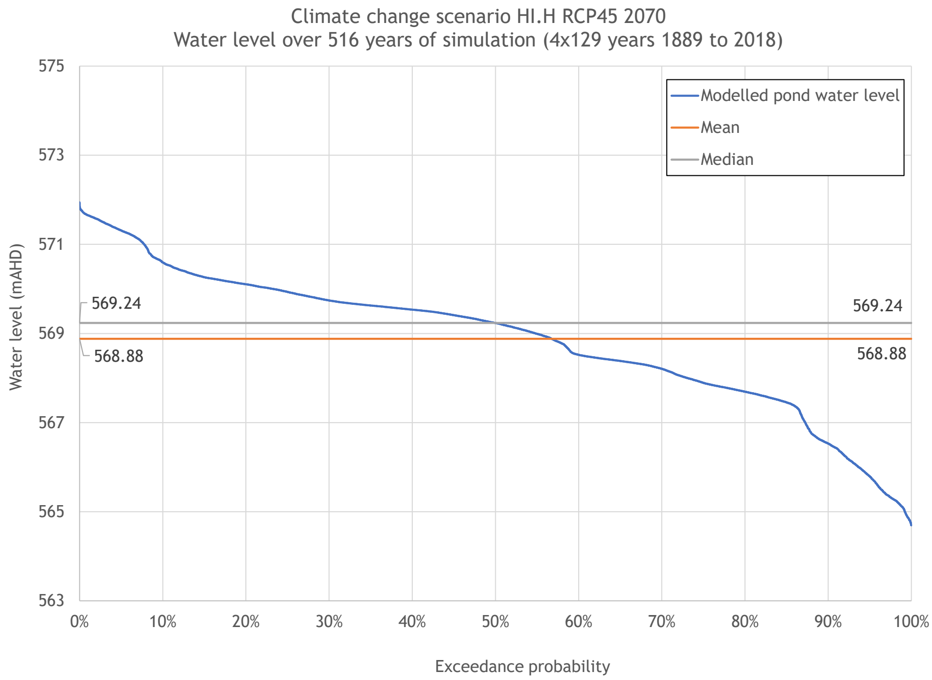

Figure 4 Depth frequency - equilibrium behaviour of final void lake water level

Water balance

Table 1 shows the revised average annual water balance under the RCP4.5 scenario.

Table 1 Revised final void lake average annual water balance

		Climate Scenario	
		Existing (SILO)	Average Climate Change (HI.H)
Climate Averages			
Evaporation	mm/a	1 354	1 501
Rainfall	mm/a	674	689
Runoff characteristics			
Pit Wall Runoff	mm/a	*178.5*	*192.7*
Pit Wall runoff/rainfall		26.5%	28.0%
Inflows			
Direct Rainfall	ML/a	188	188
Pit runoff	ML/a	45	50
GW inflow	ML/a	92	112
Outflows			
Pit evaporation	ML/a	325	350

We believe the above dataset is suitable for use in 'base-case' long-term groundwater modelling, but given the very large uncertainties in global climate modelling, a range of potential climate pathways should be considered.

For and on behalf of

WRM Water & Environment Pty Ltd

Michael Batchelor

Director

References:

WRM, 2020 — *'Bowdens Silver Project Part 6_Surface Water Assessment'* Version 4, WRM 42925, May 2020.

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