Charlie Schlinger, Ph.D., P.E., R.G., C.P.G.
P.O. Box 547
Grand Ledge, Michigan 48337
schlinger@engeo@gmail.com
928-380-1039 mobile

Report: Review of Supplemental Draft Environmental Impact Statement (SDEIS) for the Proposed Stibnite Gold Project: Hydrologic- and Water-Related Impacts, Assumptions, Methodology and Approach

December 28, 2022

Qualifications

I am a registered Professional Engineer (civil) in Minnesota, Arizona, California and Michigan, a Registered Geologist in Arizona, and am a Certified Professional Geologist (American Institute of Professional Geologists). My professional and research work experience spans a 45-year period and includes: water systems analysis, modeling, master planning and design; hydrology and hydraulics analysis, modeling and design; civil & geotechnical engineering analysis, modeling, design and construction; solid earth and applied geophysics analysis and modeling; and geology. Geographically, my experience was gained globally, but primarily in the U.S., and of that the majority has been in the western U.S.

Report Objectives and Actions

This review of and commenting on the Stibnite Gold Project (SGP) Supplemental Draft Environmental Impact Statement (SDEIS) was developed with an emphasis on:

1. accuracy of the characterization of the baseline hydrologic conditions the SDEIS assumes to presently exist within the project area and assessment of the predicted changes to hydrologic conditions throughout the mining period, including the post-closure period, that would result from implementing any SDEIS alternative.

2. describing the potential future implications of any conclusion about future hydrological conditions within the project area and downstream that differ from those conclusions drawn from SDEIS hydrologic and water-related modeling.

In order to complete this review, the following additional specific actions were taken.

1. Together with other reviewers, I reviewed the application of hydrologic models used in the SGP proponents' analyses for validity of assumptions, conceptualization, and development.

2. I reviewed the report by Robert Prucha entitled *Review of Hydrologic Impacts of the Proposed Stibnite Gold Project Draft Environmental Impact Statement (DEIS),* and identified concerns and issues not addressed in the SDEIS.

3. I reviewed the key supporting documents for accuracy, conceptualization, assumptions, methodology and application thereof, as well as conclusions drawn.

Documents Reviewed and Referenced

I have reviewed portions of the following documents in preparing these comments. These documents are referenced within the body of this report.

Brown and Caldwell, 2021a, Stibnite Gold Project Stibnite Hydrologic Site Model Refined Modified Proposed Action (ModPRO2) Report, August 2021, prepared for and released by Perpetua Resources.

Brown and Caldwell, 2021b, Stibnite Gold Project Site-Wide Water Balance Model Refined Proposed Action (ModPRO2) Report, October 2021, prepared for and released by Perpetua Resources.

Brown and Caldwell, 2021c, Water Resources Monitoring Plan (this is Appendix RM-4 of the Environmental Monitoring and Management Program.

Brown and Caldwell, 2021d, Stibnite Gold Project Environmental Monitoring and Management Program.

Brown and Caldwell, 2021e, Stibnite Gold Project Stibnite Hydrologic Site Model (SHSM) Sensitivity Analysis.

Brown and Caldwell, 2021f, Stibnite Gold Project Water Management Plan.

Brown and Caldwell, 2018, Stibnite Gold Project Hydrologic Model Existing Conditions, Final Report, prepared for Midas Gold Idaho, Inc.

Brown and Caldwell, 2018a, Stibnite Gold Project Hydrologic Model Proposed Action Report, prepared for Midas Gold Idaho, Inc.

Brown and Caldwell, 2017, Stibnite Gold Project Water Resources Summary Report.

Doherty, John E.; Hunt, Randall J.; Tonkin, Matthew J., 2010, Approaches to highly parameterized inversion: A guide to using PEST for model-parameter and predictive-uncertainty analysis, USGS SIR 2010-5211.

JSAI (John Shomaker and Associates), 2017, Workplan: Hydrologic Model of the Upper Watershed of the East Fork of the South Fork of the Salmon River, Stibnite, Idaho.

Musselman et al., 2018, Projected increases and shifts in rain-on-snow and flood risks over Western North America, Nature Climate Change 8, 808-812.

Prucha, R.H., Review of the Hydrologic Impacts of the Proposed Stibnite Gold Project Draft Environmental Impact Statement (DEIS), unpublished technical report, 2020.

Semmons, B.A., Review of and comments on the groundwater modeling effort completed as part of draft Environmental Impact Statement (DEIS) development for the proposed Stibnite Gold Project, unpublished untitled technical report, 2020.

SPF Consulting and Associates (SPF), 2017. Stibnite Gold Project: Groundwater Hydrology Baseline Study. Prepared for Midas Gold, June 2017.

USDA Forest Service, 2022a, Stibnite Gold Project Supplemental Draft Environmental Impact Statement.

USDA Forest Service, 2022b, Stibnite Gold Project Water Quantity Specialist Report.

Documents Referenced But Not Available and Not Reviewed

I have referenced the following two documents in preparing these comments. The Tierra (2013) reference was of interest to me and it is referenced, but the Forest Service did not provide it and I thus was not able to review it. The Perpetua Resources (2021) reference was also of interest but it was not available on the USFS Payette National Forest Stibnite Gold Project website at the time of my preparing this report.

Perpetua Resources, 2021, Site-Wide Water Balance Model Sensitivity Analysis

Tierra Group International, Ltd., 2013, Climatology Data Review and Recommendations.

Report: Review of Supplemental Draft Environmental Impact Statement (SDEIS) for the Proposed Stibnite Gold Project: Hydrologic- and Water-Related Impacts, Assumptions, Methodology and Approach

December 28, 2022

Executive Summary

This report presents my review comments on the 2022 Stibnite Gold Project (SGP) Supplemental Draft Environmental Impact Statement, or SGP SDEIS (USDA Forest Service, 2022a) and numerous supporting documents, including the 2022 SGP Water Quantity Specialist Report (USDA Forest Service, 2022b). These review comments were prepared with a general focus on the hydrological and water quantity-related aspects of the project as communicated and documented in the SDEIS, in the Water Quantity Specialist Report and in the available water quantity-related documentation provided to the Forest Service by Perpetua Resources (Perpetua), the project proponent, to inform the SDEIS preparation and prior prepration of the SGP DEIS, in 2020. There are related reports on SGP SDEIS geochemistry and water quality aspects by Ann Maest, Ph.D., and on groundwater modeling aspects by Betsy Semmons, M.S., R.G.

The SDEIS review comments herein focus on a set of overarching water quantity-related issues and concerns, and these include, but are not limited to: water model validity; water model sensitivity analysis; water model suitability; conceptual hydrogeological model; climate data selection, averaging and biasing; and, the complete absence of consideration for forecast future climate change as part of simulations of future hydrological conditions and future environmental impacts. The latter would include failure to consider linked future hydrosystem, ecosystem and geochemical impacts associated with flow reductions in streams due to a combination of mine-related surface water and groundwater abstractions in the presence of climate change. Additionally, it would be a stretch to characterize the SDEIS hydrological supporting studies, the methods, the approaches, the documentation thereof, and the communication thereof as the "best available science". The proponent has made commendable progress in this regard, but still has a way to go.

The SGP is in its second EIS review as part of the USDA Forest Service's implementation of the National Environmental Policy Act (NEPA) process to the SGP. This federal NEPA regulatory action is required because Perpetua will need considerable federal land to construct, operate and, eventually, reclaim and close the proposed mine. There will be unavoidable and significant environmental impacts on federal lands both on and off site. These review comments do not in general consider the merits of the mine or environmental impacts other than direct hydrologic impacts that can be reasonably and more-reliably anticipated for the near term (years to a decade or two) or impacts that can be less-reliably anticipated for the longer term (several decades to a century or more). The review comments do take into consideration environmental impacts on fisheries and ecosystems that may result directly from hydrologic impacts. There are also comments related to mine infrastructure and related design issues, as well as to the larger NEPA EIS review process and to the bigger picture of mine ownership and fulfillment of mine owner obligations in our dynamic economy.

All water-related forecasting and assessment for the SGP SDEIS is based on numerical models of various types. Three such models have been used and they are distinct from one other. At the front end,

and foundational, is the Meteoric Water Balance, or MWB, model. This is a spreadsheet-based proprietary confidential veiled tool used by Perpetua's consultants (Brown and Caldwell) to estimate hydrological quantities such as infiltration to the groundwater system beneath the land surface and runoff from the land surface to surface water conveyances, i.e., channels, either natural, constructed or hybrid. The approach to generating runoff for input to the other model(s) is not fully explained, but it appears to be some sort of lumped approach in combination with a limited amount of spatial discretization of the 4 principal sub-watersheds into two domains each – one being a higher-elevation bedrock-dominated domain and the other being a lower-elevation domain dominated by unconsolidated materials. MWB model output is heavily reliant on climatic data input, as well as a number of parameters, estimated as a part of the linked MWB and Modflow 6 calibration process, that are used to bias (scale) the climatic data. The other two numerical models, Modflow 6 and the SWWB (Site Wide Water Balance, also known as GoldSim) model, depend heavily on MWB model outputs to inform their linked simulations. The exchange of inputs and outputs among the models – the interdependence, is complex, as is the project and as are the environmental impacts.

The first of the other two models is the well-known numerical groundwater model, Modflow and in this case Modflow 6, which is a public-domain software tool created, maintained, documented and periodically updated by the U.S. Geological Survey (USGS). This numerical modeling tool simulates subsurface, or groundwater, flow, and, with the utilization of one of its add-on packages, SFR, it also simulates surface water flow in channels that are coupled to the numerical representation of the groundwater system. The Modflow 6 simulations covered scenarios such as existing conditions and several future conditions. MWB output serves as Modflow 6 input, both as concerns the spatially- and temporally-varying contributions of precipitation and snowmelt runoff to streamflow, and as concerns precipitation and snowmelt to recharge of the groundwater system. Input files necessary to run Modflow 6 simulations were made available by Perpetua to the Forest Service by Perpetua for use in its SDEIS process, and thus for use by the public reviewers.

Key issues with the coupled MWB-Modflow 6 set of models, also known as the SHSM, and the associated modeling include: MWB model validity; model accuracy and unavailability of sensitivity analysis results; one-way coupling of MWB to Modflow 6; suitability of PRISM climate data as inputs to MWB, particularly the absence of consideration for climate change when simulating future conditions; use of monthly averages of climate data inputs; limited conceptualization of the regional groundwater system (e.g, consideration of alternative sub-models for it); and, the apparent absence of uncertainty analysis for both the MWB and Modflow 6 models. The sensitivity analysis done for the Modflow 6 model was informative and beneficial. The proponents should add sensitivity analysis of recharge, and consider how to best conduct sensitivity analysis for these coupled models.

The third model, the Site Wide Water Balance (SWWB) model, was developed using the proprietary GoldSim software. The SWWB, model takes into its accounting static and time-dependent water demands / uses including but not limited to: processing, dust control, tailings conveyance water, tailings consolidation water, storage, inflows due to precipitation and runoff, and outflows / losses that occur within the spatial and temporal domains of the entire anticipated SGP mining operation as conceived of at this time. The SWWB model receives input from the MWB model and it also relies on certain outputs from the Modflow 6 model simulations, for example, water availability from groundwater pumping or pit dewatering (Brown and Caldwell, 2021b). A primary application of the SWWB model is to estimate makeup water (also known as additional water) that must be provided from surface waters, groundwater, and water that is in some way impacted, e.g., in a water quality sense, by mining operations, but is still available for use. The SWWB model also informs the Modflow 6 simulations, for example, when it comes to surface water abstractions that are required as makeup / additional water during the life of mine time period, or groundwater that must be pumped to supply makeup / additional water. The SWWB model appears to consist of a family of models / scenarios, each with a different application or objective on the proposed complex SGP. For any given year of SWWB simulation, upwards of 120 years of MWB output (monthly infiltration and runoff) are apparently cycled through in a Monte Carlo process, yielding forecasts, e.g., of additional water need, that have a probabilistic character. The approach is to use MWB results corresponding to climate years 1900 to 2019 to look at what goes on during the life of mine and and 100 years beyond it. Section 5.5 of the Stibnite Gold Project Site-Wide Water Balance Model Refined Proposed Action (ModPRO2) Report (Brown and Caldwell, 2021b) offers a brief and terse explanation of it all – leaving the reviewer with much to ponder.

Key issues with the SWWB / GoldSim model include, but are not limited to: the GoldSim / SWWB SGP input and output files were not made available to the public at the Forest Service SGP NEPA process website; historic climate data going back to 1900 are used to inform the SWWM model as to conditions 100 years into the future; the apparent inclusion of an uncertainty analysis is poorly documented and not interpreted; the use of monthly averaged PRISM climate data is not justified and quite possibly will poorly represent the likely stresses to the proposed complex mining operation that will actually occur during the life of operations as a result of actual climate conditions – which do not correspond to such averaged output.

The main but by no means only points from my review of the water quantity-related modeling and related matters are as follow.

- There was no adoption of science-based widely-available forecasts of climate change in the MWB and SWWB models and simulations that looked out as much as 100 +/- years into the future and informed the Modflow 6 simulations. Thus, there is 100 +/- years worth of bias built into not only these outputs but also in the Modflow 6 simulation outputs, because MWB model outputs of runoff and recharge, used as Modflow 6 inputs and SWWB inputs are based on MWB climate inputs of temperature and total precipitation – with snowfall derived, presumably, from these two time series that start nearly 120 years ago. The temperature and snowfall biases that likely result are unacceptable. The precipitation bias that likely results is small and perhaps acceptable. What was done should not be characterized as the “best available science”.

- Uncertainty, while apparently considered in the SWWB / GoldSim model, has not been addressed for the MWB and Modflow 6 models (which together form the SHSM model couplet). The apparent uncertainty analysis conducted for the SWWB / GoldSim model is identified with that particular adjective because the lack of documentation on what was done, how it was done and why it was done leave this reviewer with more questions than answers on the matter. The Forest Service should stipulate that Perpetua apply the tools in the GoldSim uncertainty analysis toolkit to all elements in the SWWB / GoldSim model that can potentially affect surface water and groundwater quantity demands and the timing of those demands, and to adequately document and interpret the actions taken and the results.

- It appears as though the Water Quantity Specialist Report (USDA Forest Service 2022b) and SDEIS (USDA Forest Service, 2022a) authors did not have the resources necessary to comprehend and understand the MWB model development and simulations, nor the SWWB model development and simulations, based on the very limited coverage given to each in the SDEIS and Water Quantity Specialist Report. This is most regrettable and of dire consequence for the Forest Service's assessment of hydrological environmental impacts and of environmental impacts that stem from hydrosystem impacts. The Forest Service should request all model supporting documents from Perpetua and hire independent third party hydrologists with very strong backgrounds in numerical modeling to reanalyze MWB and SWWB model results. The focus needs to be on the question of whether the assumptions, data selection, and conceptualizations used in development and application of these models were conservative with respect to the environmental impacts that depend on the predicted changes to the hydrologic system.

- The validity of the MWB model has not been established. The validity of the apparent 1-way coupling between the MWB model and the Modflow 6 model has not been established. The Forest Service should require that Perpetua establish validity in both of these regards.

- The validity and logic for the use of monthly averaging for climatic data inputs in the both the MWB and SWWB models has not been established, but needs to be.

- There is considerable groundwater model domain with projected future peak drawdown(s) less than 10 feet that exist outside of the 10-ft drawdown contour used to define what the proponent feels are the areas of certain drawdown, or level of drawdown that is significant in comparison with their estimate (method unknown) of uncertainty. The areas of lesser drawdown, which include wetlands and groundwater-dependent ecosystems (GDE's), are not adequately considered. Also, it is not clear in the SDEIS water-related sections that water resource monitoring will actually occur both outside of and within this artificial boundary. Much greater emphasis needs to be placed on monitoring drawdown(s) less than 10 ft and areas of impact outside of this artificial boundary.

- Forecasts of future stream flow using the Modflow 6 model need to be based on probable future climate conditions, not on improbable past or even present climate conditions. Only then can the associated simulations correctly inform assessments of water quality, ecosystems, fish species and other water-dependent environmental impacts. It is possible that the impacts on stream flow from the combination of mine-related surface water and groundwater abstractions and probable future climate change will leave stream water quality in a state that is inferior to that projected under the no-action alternative. This needs to be addressed by the proponent.

Report Narrative

1) Meteoric Water Balance (MWB) Model Assumptions and Development

I.) It appears that the lumped approach adopted in development and application of MWB output (infiltration and runoff) to the Modflow 6 model utilized a simplification that across the entirety of each MWB model zone, corresponding to each of the eight individual colored areas in Figure 2-1 (reproduced below, from the 89th page in the flow modeling report (Brown and Caldwell, 2021a)), a uniform infiltration and recharge was supplied to the Modflow 6 model for each area. This highlights one aspect of lumping, spatial lumping, that was utilized in applying the MWB model to the SGP. The validity of this approach appears to be nowhere identified or referenced.

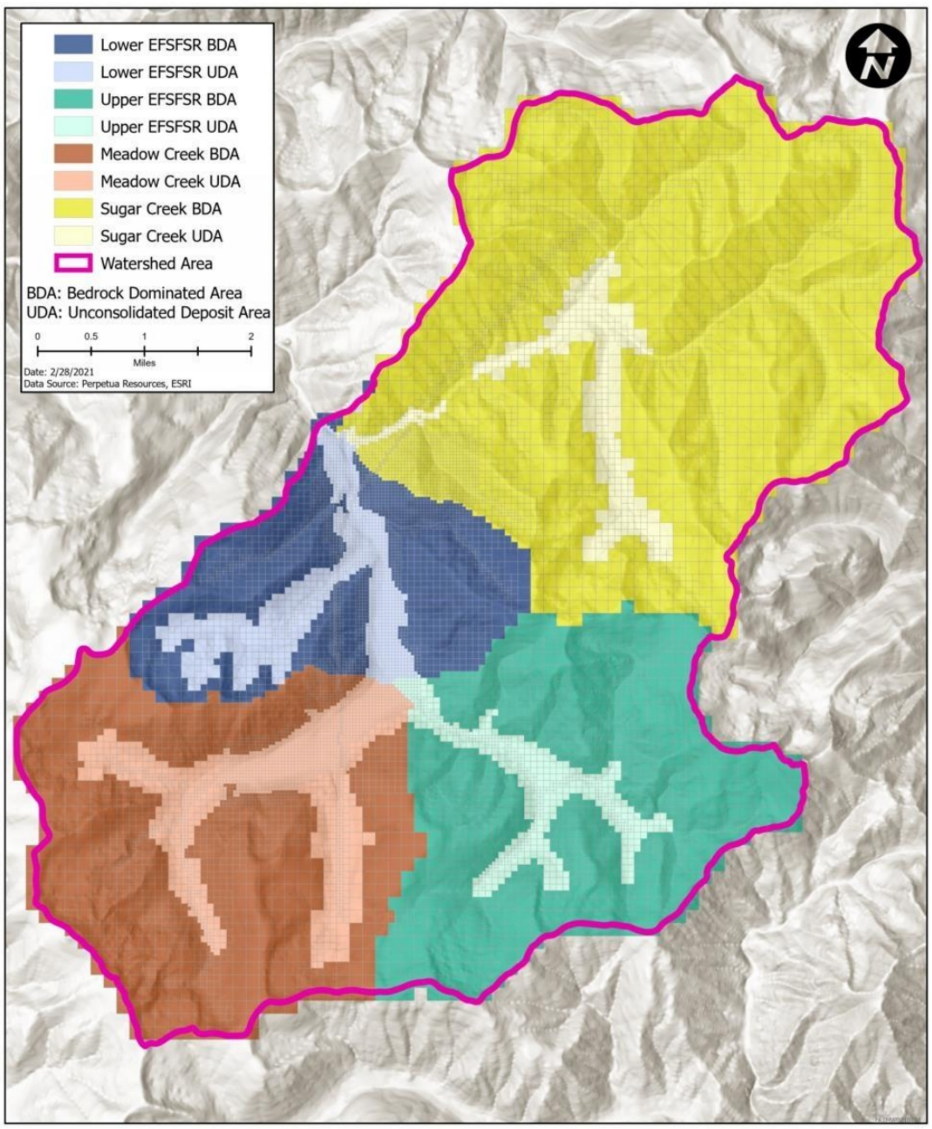


Figure 2-1. Meteoric Water Balance Sub-Basin Model Zones

II. Prucha (2020), in his comments, identified an evapotranspiration-related concern that spans both the MWB and Modflow 6 models. He stated the following.

> *AET loss is COMPLEX and spatially distributed and highly variable throughout the year, and groundwater loss to atmosphere (AET) is a major component of watershed hydrologic cycles, typically second only to total precipitation. It is standard practice to include dynamic simulation of ET from the saturated zone using the Modflow ET package, which removes groundwater from the model based on, dynamic water table depths, Max ET rate, extinction depth (i.e., typically meant to correspond to different vegetation root depths), and ET maximum surface. Yet Brown and Caldwell (2018) did not simulate spatially-distributed dynamic ET loss from groundwater, but instead chose to remove PET from total available rainfall/snowmelt BEFORE water infiltrates / recharges and runs off from the system. This over-rides established physical processes/equations of flow known for many decades. As a result, predicted groundwater levels are incorrect in areas where roots intercept water depths (i.e. stream and wetland areas). This is a major flaw in the Brown and Caldwell Existing Conditions conceptualization and model setup, and affects all predictions.*

The above comment was not addressed as part of the current round of modeling, on which the SDEIS is based, and it needs to be addressed as part of model selection and validation.

III) Bits and pieces of MWB development and application are strewn across nearly a decade of consultant reports, from 2013 to 2021, not all of which were made available to the public, noticed as part of the Forest Service's EIS NEPA process.

The MWB model appears to be proprietary private software tool and the tool itself, the input data, the methodology and the output are not at all or not fully presented to the SDEIS review community.

The two-faceted SHSM (Stibnite Hydrological Site Model) hydrologic modeling approach incorporates the distinct but coupled MWB and Modflow 6 tools used at present on the project and the results of which were used as a basis, in part, for the SGP SDEIS development, appears to have first appeared on the project in 2017. These two coupled tools were identified in a work plan developed by John Shomaker and Associates (JSAI, 2017). There appears to be no specific mention of MWB model selection or validation processes in the JSAI (2017) report.

Unknown is the suitability of the PRISM climatic data that are foundational to the MWB and thus to the SHSM and SWWM models. The SGP Water Resources Summary Report (Brown and Caldwell, 2017) refers to a Climatology Data Review and Recommendations Report (Tierra Group International, Ltd., 2013). In December of 2022, a USDA Forest Service staff member responded by email to a request for this otherwise unavailable Tierra Group International, Ltd., reference, stating that the Tierra study was not directly cited in the 2022 SDEIS (email from Rhymerson to Robison, November 28, 2022).

The MWB model simulations utilize PRISM climate data. It is unacceptable that while not considering the effects of climate change looking forward toward the proposed 14-yr mining period and 100-yr post-mining period, it appears as though the proponent went far back in time, to the 1895-2020 time period, which was considerably cooler than existing conditions, for PRISM climate data to inform the MWB simulation used to establish existing conditions.

Given the above, the SDEIS cannot be reviewed in the context of climatic data suitability, nor can the suitability of the MWB model, its application or the associated calculations or analysis be reviewed. The MWB tool has too many associated unknowns that are known only to the proponent. Thus, the veracity of key hydrological environmental impacts, together with their impacts on GDEs, other ecosystems, fisheries, flows and other species (as illustrative examples) as determined by the SDEIS authors, as based on Brown and Caldwell's reporting, cannot be assessed by this reviewer.

It is revealing to look at what the Forest Service representatives had to say about the MWB model in the Water Quantity Specialist Report (2022b) and the SDEIS (2022a).

The Water Quantity Specialist Report (USDA Forest Service, 2022b) contains a single nebulous statement about the MWB on Specialist Report page 52 (59th page of PDF file), which reads as follows – references cited are specific to the Specialist Report, not to this report.

The meteoric water balance model (MWB) uses monthly meteorological data to provide groundwater recharge and surface water runoff volumes for the site-wide water balance model (SWWB, Brown and Caldwell 2021a) and the Stibnite hydrologic site model (SHSM, Brown and Caldwell 2021b).

The SDEIS (USDA Forest Service, 2022a) contains the same cryptic statement concerning the MWB on Report page 4-143 (919th page of PDF file), which reads as follows – references cited are specific to the SDEIS, not to this report.

The meteoric water balance model (MWB) uses monthly meteorological data to provide groundwater recharge and surface water runoff volumes for the site-wide water balance model (SWWB, Brown and Caldwell 2021a) and the Stibnite hydrologic site model (SHSM, Brown and Caldwell 2021e).

In each of these two reports, the Water Quantity Specialist Report and the SDEIS, we find only the same single sentence that tells us little about the MWB, a model that is foundational to the SHSM and SWWB models and modeling process on the SGP, providing SGP site domain runoff and recharge for every stress or simulation period considered throughout the SWWB and SHSM numerical simulations. It seems likely that the Water Quantity Specialist Report and SDEIS authors, not comprehending what the MWB does or how it does it or why it does it, punted by saying nothing about the MWB, other than to note its existence, its inputs and its outputs.

Given the above, what remains open to question, in spite of the available references, is the validity of the MWB model and validity of the coupling between the MWB and the SWWB and Modflow 6 models. That these software tools function numerically and are coupled numerically is not in question. That they can be calibrated numerically is not in question. That when calibrated the Modflow 6 tool yields simulations for stream flow that reasonably match the stream flow gauging data is not in question, or that matches between observed and forecast groundwater levels is acceptable is not in question. MWB model validity is in question. MWB model validity would come from using the MWB model to successfully predict a future, present or even past outcome or set of outcomes, either at the site or at other sites, using data sets that were not entered into the calibration process. The question of MWB model validity was not addressed by Brown and Caldwell in any of its reports. The proponent needs to demonstrate the validity of the MWB modeling tool and reveal its workings.

IV) The MWB input PRISM climate data apparently consist of average values for monthly precipitation and temperature, with spatial variation enabled, for each of the two inputs. The monthly data are scaled. The issue of monthly averaging was raised by Prucha (2020), who flagged it as unacceptable. The monthly averaging issue was not addressed in the latest round (2021 reporting by Perpetua / Brown and Caldwell) of modeling, which informed the SDEIS.

Consider the following. If there is a low-frequency, short-duration, high-magnitude rainfall (storm) event in a given month, the precipitation will typically arrive in periods ranging from a fraction of an hour to several hours, and occasionally up to a day or so. Most of the precipitation is going to run off to the surface water subsystem and leave the model domain area, rather than infiltrate. In this regard, the rain-on-snow mid-late winter storm events that occur occasionally in the mountainous west are predicted to become more prevalent with climate change (Musselman et al., 2018) are less frequently-occurring examples of such storm events. Rain-on-snow events are notorious for their associated flooding. On the other hand, if precipitation from these types of storm events or event is averaged out over a month's time, and thus applied with the MWB tool on a relatively long-term basis – a month, a much greater fraction of the total precipitation for the month will be partitioned to subsurface infiltration, rather than to runoff to the surface water subsystem. There will be positive bias towards infiltration and a negative bias towards runoff – and this will affect the recharge and stream flow input terms in the Modflow 6 model. (There will also be consequences in the SWWB / GoldSim model simulations, as those are informed by MWB outputs.) Depending on climate and weather conditions, there could be months when multiple high-magnitude low-frequency short-duration precipitation occurs. The Brown and Caldwell (2021a) modelers did not speak to the issue in either round one (DEIS) or in round two (SDEIS). Perpetua needs to demonstrate and document that monthly PRISM data may be used in place of daily or hourly data climate data in the MWB simulations without consequence for developing estimated runoff and infiltration data that are then used in the SWWB and Modflow 6 simulations.

It is possible that the above explanation for the consequences of monthly averaging of what are continuous climate inputs, in this case precipitation, which can be better estimated with daily or hourly values, may explain why Brown and Caldwell (2021a) needed to increase spatially-varying precipitation inputs to the MWB model by an average of 19%, as discussed elsewhere in this report. If too much of the precipitation is being shunted to infiltration – due to the monthly averaging process that was used, then stream flows forecast with Modflow 6 and its streams package will be too low, necessitating an introduced bias. Such actions on the part of modelers yield improved metrics of model numerical performance and calibration, however, models in need of such manipulation poorly represent reality.

V) The MWB model relies on climatic data inputs, and MWB outputs of spatially- and temporally-varying runoff and infiltration are inputs to the SHSM (Modflow 6) and the SWWB (GoldSim) water simulation tools used to assess ultimate hydrological impacts resulting from the proposed SGP. Data selection, averaging, scaling ("bias correction") and other reduction of PRISM climate data were foundational to the utilization of the MWB tool on the SGP.

Brown and Caldwell (2021), PDF file page 96) scaled the PRISM climate dataset-derived monthly precipitation average values by a spatially-varying factor, referred to as the precipitation bias correction factor, which had a spatially-average value of 1.19, that was a spatial-average of larger and smaller respective factors used for what are known as bedrock dominated areas (BDAs) and lower elevation valley areas referred to in the reports as unconsolidated deposit areas (UDAs). Only after scaling (bias correction) were the PRISM precipitation data used in the MWB model. Bias correction factor development occurred as part of model calibration. See Brown and Caldwell (2022a, PDF file pages 124-128 for narrative and tables describing the ranges of precipitation bias correction factors adopted. The precipitation bias correction factors were developed and applied so that stream flow simulation results (Modflow 6 modeling) would better match stream flow gauging data. The time period 2011 to 2019 is the period for which gage data for all 5 USGS gages of interest are simultaneous available and it is this time period for which observations and simulation results founded on scaled PRISM precipitation data are compared. See figures 4-4 to 4-8 in Brown and Caldwell (2022a).

This begs a question as to whether the poorly-understood regional flow system contributes to stream flow, or whether the PRISM climate data are in fact biased and in need of unbiasing through application of the precipitation bias correction factors. Another possibility is that the lumped parameter (apparently, this is how the MWB functions) method of estimating runoff-based stream flow contributions for use in Modflow 6 is inaccurate or invalid. Resolving this is something that Perpetua and its consultants should address. They should also consider whether their application of the MWB model using only monthly average precipitation, is accurate in replicating the large amounts of runoff associated in reality with storm event precipitation that is of relatively short-duration and high-intensity. And that takes us back to the inescapable fact that the proponent has failed to accurately model the rainfall-runoff process and instead has approximated it, with some consequences perhaps known and other not – as they haven't been investigated. In other words, Perpetua needs to demonstrate MWB model validity, and validity of their coupled model approach.

VI) There is another concern that I have about the approach using the coupled MWB and Modflow 6 modeling tools. The MWB monthly inputs of runoff to the surface water subsystem and infiltration to the groundwater flow subsystem as represented in the Modflow 6 numerical flow simulation tool appear to be a unidirectional coupling. It appears that infiltration greater than or equal to zero goes from the MWB model into the Modflow 6 model as recharge. The disposition of flow in the other direction (springs, seeps, etc.) is not addressed, apparently. Prucha (2020) also addressed this in his report section 4.7.6 GDE Seepage/Spring Flow Not Simulated.

Any defensible valid hydrologic and hydraulic model is developed through the formal mathematical/numerical application of conservation principles, as applied to mass, momentum or energy. The coupled MWB and Modflow 6 models (Brown and Caldwell, 2021a), which together constitute the Stibnite Hydrologic Site Model, or SHSM, are coupled only in a unidirectional sense, with MWB output used as Modflow 6 input, but apparently without any flow of information, mass, energy or momentum from the latter to the former – contrary to accepted hydrologic modeling principles. No evidence is presented as to the validity of this approach in which the governing hydrologic modeling principle of conservation of mass is apparently set aside. The report authors need to at least acknowledge the bias, as compared to random error, introduced by this uni-directional coupling and quantify the bias in the context of other biases and random errors, relative to overall uncertainty.

Prucha (2020), referring to the coupled MWB and Modflow simulation tools, stated that:

> *...these tools are simply unable to simulate physically-realistic complex, spatially-/temporally-variable, dynamically coupled surface water-groundwater baseline hydrologic conditions, essential to demonstrating defensible and reliable predictions of impacts of mining during and post-closure. Importantly, any flaws identified in developing a model capable of reproducing baseline conditions will be translated into all subsequent models used to predict mine hydrologic impacts, but also water quality/geochemistry impacts, including thermal impacts.*

This set of issues has not been but needs to be addressed.

2) SGP SHSM Hydrogeological Model

I) The Stibnite Gold Project Stibnite Hydrological Site Model or SGP SHSM is the package of the MWB and the Modflow 6 models, as apparently originally conceived by JSAI (2017). The SGP SHSM Existing Conditions and No Action Alternative Report (Brown and Caldwell, 2021a) presents a conceptual hydrogeologic model that goes long on local topographically- and shallow-geologically-controlled hydrogeology and comes up short on the bigger regional hydrogeology picture. As recently as 2017 (JSAI, 2017) the conventional Stibnite groundwater modeling wisdom was that: *Groundwater flows in individual rock fracture networks, but there is no regional groundwater flow system connecting the local groundwater systems.* That same year, SPF prepared a Groundwater Hydrology Baseline Study (SPF, 2017) that made no mention of a regional component to its conceptual hydrogeological model.

The SGP conceptual hydrogeological model has evolved somewhat since 2017 and presently incorporates a limited conceptualization for a regional goundwater system. As an illustration, the SDEIS on page 4-162 states, in reference to groundwater dependent ecosystems (GDEs), that *these surface water features are not controlled by discharge from the regional groundwater system* (USDA Forest Service, 2022a). While the regional system, composed largely of Idaho Batholith rock has relatively low hydraulic conductivity, relatively low storage, unspecified and quite possibly unknown fracture flow characteristics, is does have one thing going for it. That is, it is volumetrically large in comparison to the alluvial aquifers and the roof pendant bedrock. Also, given its physical characteristics, it is relatively slow to respond to longer-term climatic changes and it has a muted response to the short-term climatic events, no matter how intense. To neglect the regional system in long-term simulations may well be hazardous to predictive reliability. This underscores the need, identified by Prucha (2020) for multiple hydrogeological system conceptualizations.

A plausible scenario of interest, but not considered by the proponent or in the SDEIS, is one in which there is a combination of the known high demand for process makeup water during the operational period, combined with extended drought. This scenario would result in diminished supply of mining impacted water (MIW), diminished surface water flows, and greater reliance on groundwater pumping (pit dewatering and valley bottom groundwater pumping from alluvial and shallow aquifers), quite possibly for an extended period (years). There is little elasticity in the groundwater supply, as there is little to no regional groundwater system input. Large negative aggravating impacts on stream flow together with large negative associated impacts on GDEs can be reasonably anticipated if hardrock and groundwater mining under such a scenario were to continue at a pace unabated. This scenario needs to be considered; the southwestern and western U.S. have been in an extended drought for 20-25 years and the long-term forecast is for yet warmer weather.

II) As discussed in the Stibnite Gold Project Stibnite Hydrologic Site Model Refined Modified Proposed Action (ModPRO2) Report (Brown and Caldwell 2021a), two models, the spreadsheet-based non-industry-standard Meteoric Water Balance (MWB) model and the industry-standard Modflow 6 model were coupled together as the SHSM to simulate surface and groundwater under existing and proposed future conditions. It appears that sensitivity analysis continues to be used in place of uncertainty analysis (see page 4-175 to 4-176 of the SDEIS – USDA Forest Service 2022a) with the usual excuse offered up that a formal model uncertain analysis is somehow beyond the abilities of consultants or budget on the industry-standard project. Also, it appears that no sensitivity analysis was done on the chained-together (one-way coupling) MWB and Modflow 6 models. Rather it appears that sensitivity analysis was applied only to the Modflow 6 portion of the SHSM model set (Modflow 6 and MWB). The proponent needs to demonstrate the validity of its approach to sensitivity, that is, either citing published reports or studies that demonstrates such for the SHSM modeling approach, or demonstrating it through their own investigation, and, additionally, examine SHSM output sensitivity to recharge.

III) The USDA Forest Service utilizes the concept of Groundwater Dependent Ecosystems (GDEs) within its organization. GDE impacts are considered in the SDEIS (USDA Forest Service, 2022a) document) on page 4-162 in section 4.8. The Water Quantity Specialist Report (USDA Forest Service, 2022b), addresses GDE impacts in on page 71 of Section 7.2.2.3 Groundwater Quantity. However, within the Stibnite Gold Project Stibnite Hydrologic Site Model Refined Modified Proposed Action (ModPRO2) Report (Brown & Caldwell, 2021a), there is no mention of GDEs, seeps or springs. The Brown and Caldwell (2021a) report is the principal basis for hydrological model forecast information to inform environmental impacts analysis and assessment at either the Forest Service Specialist level (USDA FS, 2022b) or EIS level (USDA FS, 2022a). The project proponent needs to explain whether and how such informing, in the context of GDEs, springs and seeps, occurred, given that GDEs, springs and seeps are nowhere mentioned in the the Brown and Caldwell (2021a) report.

IV) The Water Quantity Specialist Report (USDA Forest Service, 2022b, page 85) speaks to uncertainty analysis. The author of the report expresses opinions as to why Perpetua and its consultants should be granted dispensation to forego modeling uncertainty analysis, citing an obscure and unprovided reference attributed to Rzepecki (2012). That dispensation is unacceptable.

Further, consider that the GoldSim software used for the SWWB model and the associated simulations has built-in functionality for conducting uncertainty analysis. At:

> https://www.goldsim.com/Web/Products/GoldSim/Overview/

it is stated that:

> *GoldSim has powerful probabilistic simulation features to quantitatively represent the inherent variability and uncertainty present in all real-world systems. This allows you to realistically evaluate how systems are likely to change and evolve over time in order to compare alternative designs, plans and policies, minimize risks and make better decisions in an uncertain world.*

Perpetua and its consultants made use of this tool and briefly explain the its application in Section 5.5 of their Stibnite Gold Project Site-Wide Water Balance Model Refined Proposed Action (ModPRO2) Report (Brown and Caldwell, 2021b). Apparently the SDEIS authors did not pick up on this.

Prucha (2020) commented at length about the absence of predictive uncertainty evaluation for SGP flow modeling at the time of SGP DEIS review. An excerpt of his comments in that regard appears below.

The reliability of the model findings is implicitly tied to the accuracy of the model, which by default is uncertain, like all models. Model accuracy can be improved by collecting more data, increasing discretization and better reproducing observations, but in reality this is impossible to achieve, given that models are simplifications of flow systems, and data will always be limited. As such, it is far more important for...consultants to acknowledge uncertain model predictions, and instead conduct a detailed and robust predictive uncertainty analysis which focuses not just on predicted groundwater inflow to the pit lake, but also on predicted response at all other mine components, at the same time. A sensitivity analysis (e.g., per ASTM D561131) doesn't provide a range of possible predicted responses given ranges of uncertain model inputs like an uncertainty analysis, which constrains realizations to maintain calibration within acceptable targets (Doherty et al., 2010).

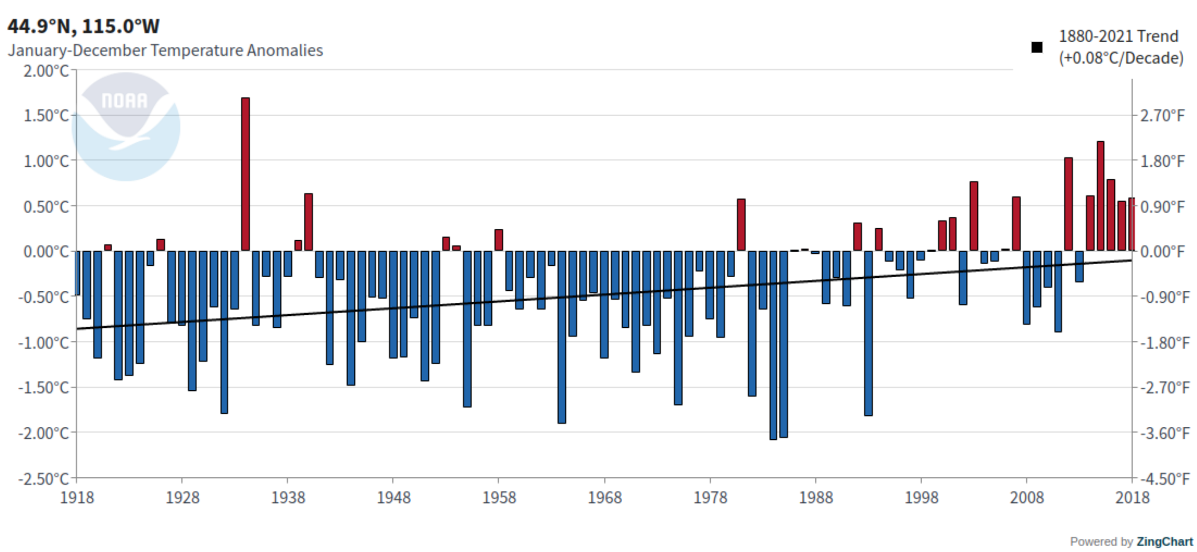
Note: in the above paragraph, the ASTM standard should have been ASTM D-5611-94 (2016). A summary of the copyright-protected commercially available standard is provided at: astm.org/d5611-94r16.html). It appears as though Perpetua and its consultants have taken one step in response to Prucha's extensive comments on the missing predictive uncertainty evaluation(s) and this is commendable. Perpetua needs to finish what it has only begun, by considering uncertainty in the MWB and Modflow 6 modeling, with attention to the various linkages among the various models.

V) There is little to no mention of climate change in either the SGP surface water and groundwater flow modeling report (Brown and Caldwell, 2021a) or the Water Quantity Specialist's report (USDA Forest Service, 2022b) that presumably informed the SGP Supplemental Draft Environmental Impact Statement (USDA Forest Service, 2022a). Given the simulations of conditions 112 years into the future either presented (Brown and Caldwell, 2021a) or relied upon for SDEIS development (USDA Forest Service, 2022a), and given ongoing significant and significant forecast future climate change, that this failure to acknowledge ongoing climate change would somehow qualify as "best available science" is not defensible, given the implications of such an intentional oversight – as this failure was already commented on in the 2020 DEIS review process. The proponent has already demonstrated a willingness to rely on model-dependent estimates of PRISM climate variables going back to the mid 1890's. The proponent should utilize climate model-based estimates of climate variables for its simulations of the 14-yr long mining period and the 100-year long post-mining period, which is defined as follows.

According to Brown and Caldwell (2022b, page 5-18):

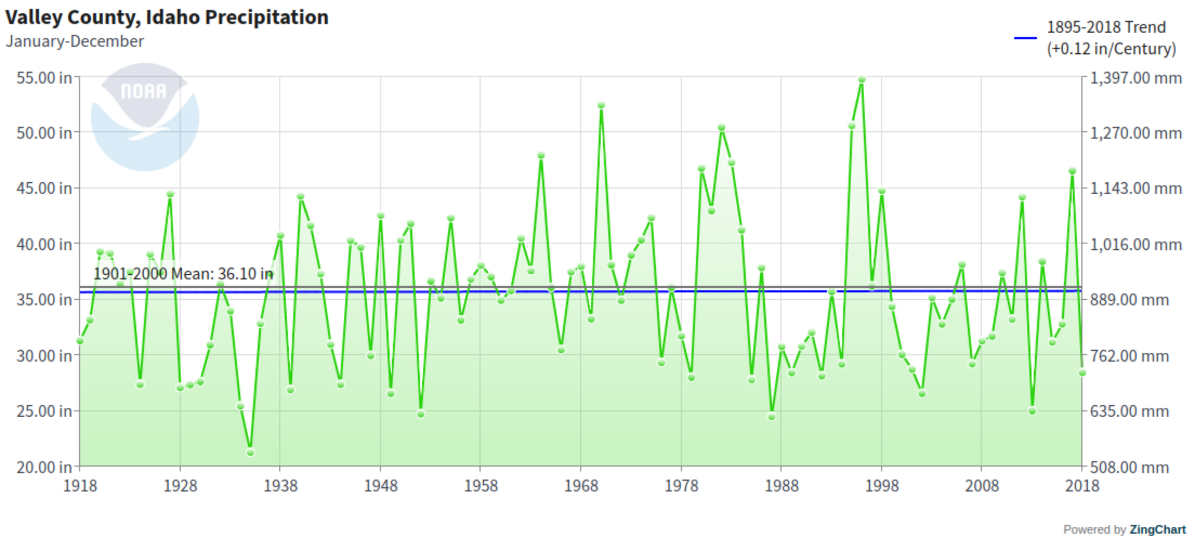
> during mining operations, the MWB PRISM climate data inputs derived from calendar years 2004 through 2018 are mapped to mine years -2 through 12 (14-yr simulation);
>
> after mining operations cease, the MWB PRISM climate data derived from calendar years 1918 through 2018 are mapped to mine years 14 through 114 (100-yr simulation)

Below is a graph of how annual average temperature at Stibnite has varied from 1918 to 2018 (sourced from: https://www.ncei.noaa.gov/access/monitoring/climate-at-a-glance/global/time-series). Warming over the past century is evident.

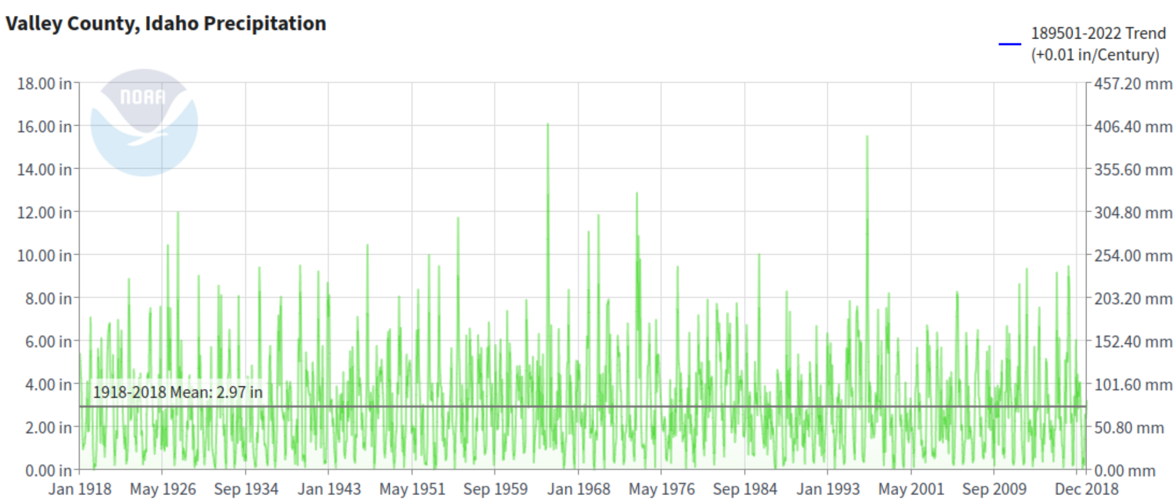


Below is a graph of how annual average precipitation in Valley County has varied from 1918 to 2018 (sourced from: https://www.ncei.noaa.gov/access/monitoring/climate-at-a-glance/global/

time-series). Annual average precipitation, while fluctuating considerably, has a trend over the past century that is small.

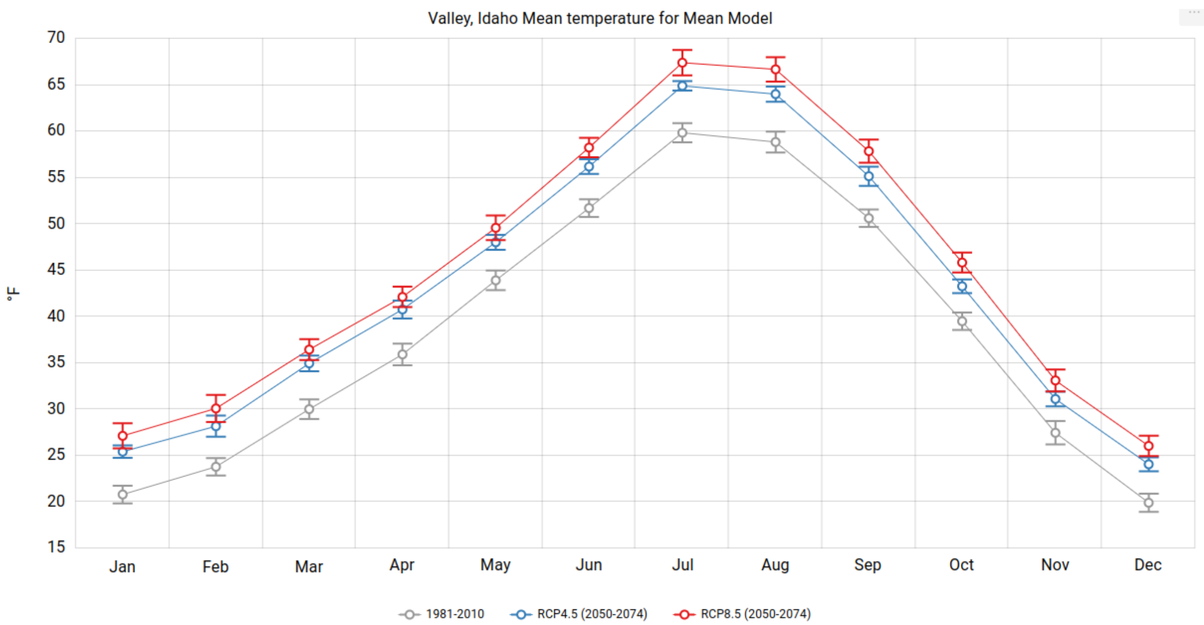


Below is a graph of how monthly average precipitation in Valley County has varied, generally, from 1918 to 2018 (sourced from: https://www.ncei.noaa.gov/access/monitoring/climate-at-a-glance/global/time-series). Monthly average precipitation has a trend over the past century that is also small. This is the type of data used in part to inform the MWB simulations, the results of which were used to inform the SWWB and Modflow 6 simulations. Peak precipitation is diminished for monthly averaging, relative to annual averaging, as expected.

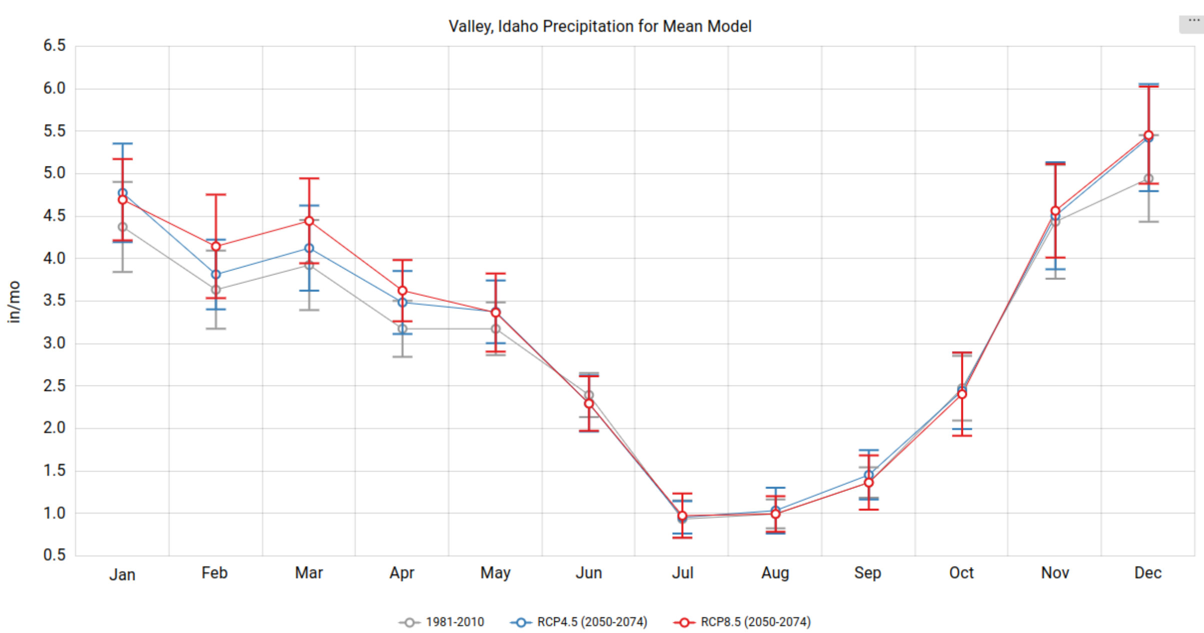


Next, let's look at global climate model-based forecasts for future temperature, precipitation and snowfall for Valley County, Idaho, as reported by the USGS National Climate Change Viewer, which can be accessed at: https://www2.usgs.gov/landresources/lcs/nccv/maca2/). In these graphs, RCP refers to Representative Carbon Pathways. Each RCPs corresponds to a specific greenhouse gas emission scenarios and it provides a trajectory of the resulting average atmospheric greenhouse gas concentration for the time period 2000 to 2100. For example, RCP

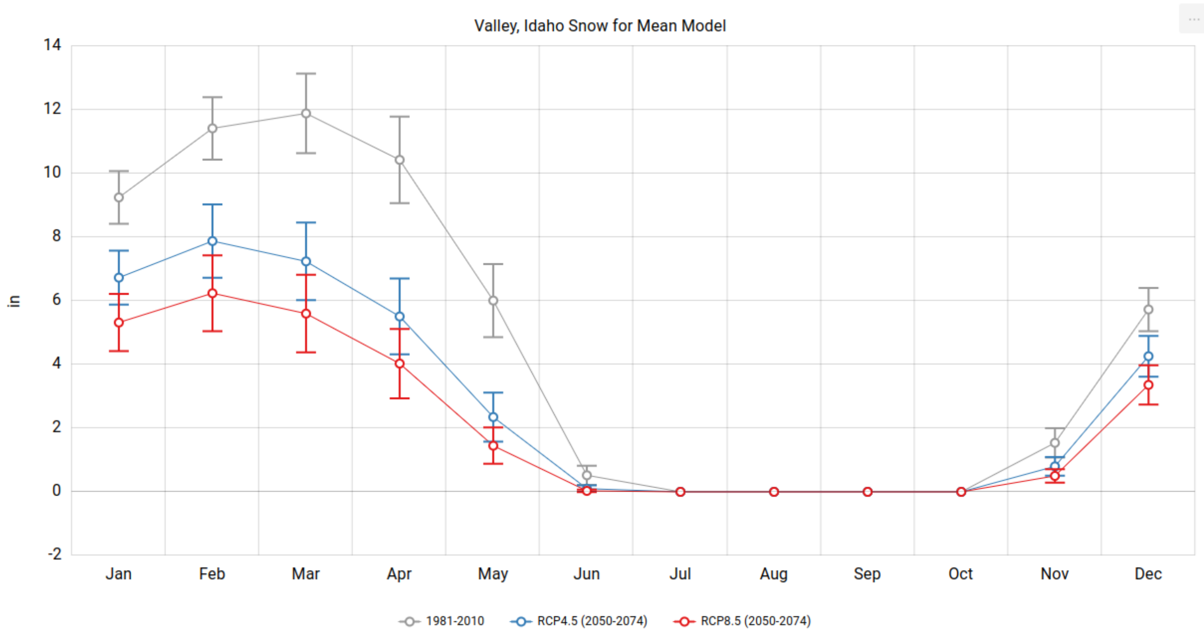
8.5 and RCP 4.5, respectively, are greenhouse gas atmospheric concentration time-trajectories that correspond to low and moderate efforts to reduce emissions in the 2000-2100 time period. The climate parameter estimates presented in these 3 graphs were developed from an ensemble of global climate model output informed by one or the other greenhouse gas scenario. The RCP 8.5 results reflect a future in which little is done to reduce greenhouse gas emissions; this translates to greater climate change. The RCP 4.5 results indicate a future in which more is done to reduce greenhouse gas emissions; this translates to lesser climate change.



Relative to mean temperature values for the period 1981-2010, mean temperature values for the period 2050-2074, which is about midway in the 100-yr-long post mine simulation period, are forecast to be elevated by approximately 4-5 degrees F.



Relative to mean precipitation values (in inches per month) for the period 1981-2010, mean precipitation values for the period 2050-2074, which is about midway in the 100-yr-long post mine simulation period, are forecast to increase by 5 to 10% during the wet season from December to May. However, there are much greater impacts when one considers the amount of precipitation that if forecast to occur as snowfall, as shown in the following graph.

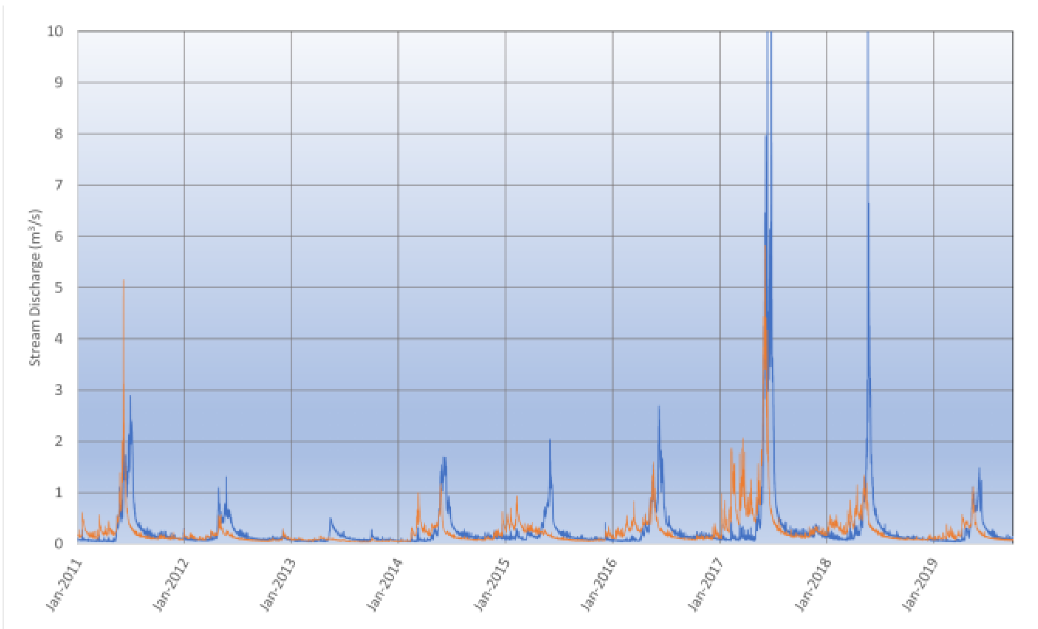


Relative to mean snowfall values (in inches per month) for the period 1981-2010, mean snowfall values for the period 2050-2074, which is about midway in the 100-yr-long post mine simulation period, are forecast to decline significantly when considering the December to May period during a typical year. These declines will have significant impacts on mine area and local hydrology (SHSM simulation impacts), as well as on the Site Wide Water Balance (SWWB). Presently, these types of climate change-related impacts are not at all captured in Perpetua's modeling approach.

The bottom line is that global climate models forecast significant temperature increases and snowfall decreases, with anticipated minor change in precipitation, for Valley County, Idaho, for the 2050-2074 time period.

Climate data inputs informed by this type of information should have been but were not used in the 100-yr post-mining simulation and even for the 14-yr mine-period simulation, The implications of these Global Climate Model forecast changes on simulations of the hydrologic system include: higher evapotranspiration, diminished snowmelt, diminished runoff and diminished infiltration. Impacts of these sorts of forecast changes due to climate change, change that is in progress and occurring at an increasing rate, were simulated by Prucha (2020) for the SGP area using an integrated hydrological modeling approach that took advantage of Danish Hydraulic Institute (DHI) MIKE-SHE software. DHI software allows for integrated physical-process-based, conservation law abiding, surface water flow and groundwater flow simulation in a distributed rather than lumped-parameter fashion.

Two of Prucha's (2020) simulations over the 2011-2019 period, one for baseline climate as used by Perpetua (existing conditions – blue line) for discharge at the Meadow Creek USGS gage location, and one for based on the year 2100 climate change scenario (orange line), based on the SRA2 global climate model, for the same location are shown in the illustration below. The dramatic reductions in stream flow due to a significantly warmer climate are evident.



If a physical process-based distributed integrated hydrological modeling approach is informed by global climate model forecasts of climate data, estimates of hydrological conditions, such as stream flow, groundwater levels, exchanges between the surface water and groundwater subsystems, etc., for the 14-yr future simulation period or the 100-yr future simulation period can be done in a manner that will yield defensible results and a defensible SDEIS, as it pertains to hydrological impacts. Presently, we do not have that. Perpetua needs to improve its simulations in support of a defensible SDEIS, as concerns hydrologic environmental impacts and all the other environmental impacts that depend on those hydrologic impacts.

VI) In his DEIS comments, Prucha (2020), provided the following; note that references cited are specific to the Prucha's (2020) report, not to this report. The B&C 2017 Water Resources Study cited in the paragraph below is Brown and Caldwell (2017) in this report. The cited B&C 2018 study is Brown and Caldwell (2018) in this report.

> *Why weren't gaining/losing reaches and associated flow measurements (i.e., Figure 7-14 and 7-15 in B&C 2017 Water Resources Study) used to calibrate the B&C 2018 Existing Conditions monthly coupled Meteoric Water Balance spreadsheet-Modflow model? This is a critical dataset that the baseline model should have reproduced, before attempting to use this model to predict mine impacts/closure conditions.*

This oversight was not but needs to be addressed by the project proponent, as it appears that gaining/losing reaches and the associated flow measurements (summarized in Brown and Caldwell (2017) Figures 7-14 and 7-15) were not used to calibrate the Existing Conditions monthly-coupled Meteoric Water Balance (MWB) spreadsheet – Modflow 6 model (Brown and Caldwell, 2021a).

VII) Also in regard to calibration, Prucha (2020) provided the following comment. Note that references cited are specific to the Prucha's (2020) report, not to this report. The B&C 2017 reference cited in the Prucha (2020) paragraph, below, is Brown and Caldwell (2017) in this report. The B&C 2018 Existing Conditions report cited in the Prucha (2020) paragraph, below, is Brown and Caldwell (2018) in this report.

> *Why weren't seep and spring locations and associated discharge rates used to calibrate the B&C 2018 Existing Conditions modflow model (i.e., Figure 7-4 in B&C, 2017 Water Resources Summary report) to any of these numerous GDE discharge or head data, if these features represent hydraulically connected locations? Many appear to exceed 20 gpm from the 2012 Seeps and Springs survey, though it's unclear if discharge or heads were monitored over time at any of these important features. This is a notable calibration oversight, which even the mining industry typically attempts to calibrate to. It would have been easy to use the MODFLOW-NWT drain package to simulate discharge at these locations, which could have been compared against the 2012 seep/spring surveyed discharge, or time-varying monitoring*

It appears that Perpetua and its consultants did not respond to the above Prucha (2020) calibration-related comment, at considerable hazard to their quest for the "best available science".

3) SDEIS Surface-Water-Quantity and Process-Water-Quantity Related Comments

I) Within section 4.18.2 Direct and Indirect Effects (p. 4-523) of the SDEIS (USDA Forest Service, 2022), the following is stated.

> *There are no active groundwater wells within 15 miles of the site. Results of the 1997 and 1999 sampling data indicate that the groundwater at Stibnite contains concentrations of antimony and arsenic in excess of the MCLs for drinking water. However, since groundwater at the site is not currently utilized as a drinking water source and is unlikely to serve as a drinking water source in the future, this pathway was eliminated from consideration."*

This contradicts what is stated on page 2-71 concerning Water Use and Supply:

> *A separate wellfield of up to four wells would be developed in the East Fork SFSR drainage adjacent to the worker housing facility to provide potable water for the housing facility. The use of water from pit dewatering, contact water from precipitation runoff, surface water, and development of separate wellfields for supplemental industrial water and potable water at the worker housing facility would require*

permitting through the IDWR as new water rights or transfer of the place of use for one of Perpetua's existing water rights.

Thus, the analysis presented in section 4.18.2 is based on an incorrect assumption. Further, any drinking water served to the SGP workforce would need to be in full compliance with the Safe Drinking Water Act and related regulations that are implemented and enforced by the Idaho Department of Environmental Quality or U.S. Environmental Protection Agency.

II) The 33 U.S. Code § 1321 (27) defines "best available science" as

...science that—

(A) maximizes the quality, objectivity, and integrity of information, including statistical information;

(B) uses peer-reviewed and publicly available data; and

(C) clearly documents and communicates risks and uncertainties in the scientific basis for such projects;

In the SDEIS or the supporting documents there is minimal documentation or communication of risks and uncertainty associated with hydrogeological and hydrological modeling / simulation tools. Thus, "best available science" is not a characteristic of the supporting documents used to inform water aspects of the SDEIS. Perpetua needs to quantify and communicate risk and uncertainty.

III) Nowhere in the SGP SDEIS or supporting documents is there a frank and honest discussion, regarding model selection for the: 1) meteoric water balance (MWB); 2) numerical groundwater model; or, 3) the Site Wide Water Balance Model. In each instance, a specific software tool was selected by Perpetua consultants, but there is no discussion in the proponent's project documents of the various analytical and simulation software tools generally available and suitable for each task at hand, there is no discussion of pros and cons of each tool, and there is no discussion of how a decision was made. In each case, there is simply a pronouncement of what tool was selected, with, in some instances, an itemization of the tool's favorable traits. This approach to model selection can in no way be characterized as "best available science". This deficiency needs to be remedied.

IV) The Water Quantity Specialist Report (USDA Forest Service, 2022b) devotes but a paragraph to the matter of losing and gaining versus static stream reaches. It is puzzling why this is glossed over. For example, the losing reaches have considerably greater potential to suffer loss of above-ground flow, subflow and ecosystem support function during periods of diminished stream flow, diminished groundwater recharge, or diminished groundwater levels.

V) It is stated that storm water infrastructure will remain in place through closure (SDEIS p. 4-149); the design / operations & maintenance life is roughly 20 yrs (SDEIS p. ES-5). However, much of the mine infrastructure will remain for much longer periods of time, e.g., open pit, stockpiles, TSF, etc. These long-lived features all have a finite unspecified design life. While the stockpiles and pit are relative stable features on a time scale of hundreds to thousands of years, the same cannot be said for the TSF, which is a very large several-hundred-foot high mass of fine-grained mine milling waste material intentionally placed in a mountain valley, even if the tailings dam itself, due to butressing, has a high factor of safety against various modes of failure. There is little information on Perpetua's concept for TSF functioning post-closure and reclamation. Closure and reclamation criteria have yet to be determined. The missing information needs to be supplied by Perpetua, so that informed development of the SDEIS may occur and likewise so that informed SDEIS review comments can be provided to the Forest Service as part of the NEPA process.

VI) The Water Quantity Specialist's Report (USDA Forest Service, 2022b) indicates that "A liner would be installed under the Meadow Creek stream/floodplain corridor to minimize water seepage into the Hangar Flats pit or the pit dewatering well system, and to avoid potential pit wall instability or loss of stream habitat as a result of stream dewatering." The design life of this liner is not indicated. All such constructed liners have a finite design life. Is this a life of mine facility (approximately 20 yrs) or is intended for perpetuity? This is not a matter only for functional and operational consideration. It links back to the conceptual hydrogeological model and the need for multiple conceptual models for complex systems – in this case a conceptual hydrogeological model in which such engineered are fail-safe, and one or more additional models, in which one or more of these features fails to perform as intended, together with the associated groundwater level, stream flow, and related hydrological forecasts of interest to fisheries, water quality and ecosystems impacts assessment to name three critical areas.

VII) The SDEIS on page 4-148 (USDA Forest Service, 2022) indicates that East Fork SFSR flow will be returned to a restored stream channel crossing the Yellow Pine pit backfill. It appears that this geosynthetically-lined channel will be constructed above the geosytheticc liner that will be installed above the Yellow Mine pit backfill. The design life of this channel is not indicated. Over time, post reclamation, the channel will be impacted by an array of high-magnitude low-frequency storm flows with associated erosion and deposition. The design life is unspecified and neither is responsibility for care of this artificial channel. Is this channel something that the USDA Forest Service will maintain going forward? How will the hydrologic system operate when the channel eventually migrates laterally in places and the channel liner may no longer exist beneath the channel? What will be the probable short- and long-term impacts on the East Fork of the South Fork of the Salmon River and associated ecosystems and species if and when that happens?

VIII) Aspects of the SDEIS impacts discussion are very qualitative, lacking quantitative data even when such data are readily available. For example, in geosynthetic liner-covered areas there is no mention of the land areas of these facilities. It seems not to matter to the SDEIS authors whether the Forest Service takes on responsibility for 1, 10, 100, 1000 or even more acres of liner-covered area. Neither is the anticipated character of these geosynthetic liners provided. For example, would they be cast from readily biodegradable synthetics, relatively inert long-lasting synthetics, clay materials, composites or other synthetics?

IX) In SDEIS (USDA Forest Service, 2022) Section 4.8.3 Mitigation Measures, the following is stated on page 4-177:

Mitigation measures required by the Forest Service would represent reasonable and effective means to reduce the impacts identified in the previous section or to reduce uncertainty regarding the forecasting of impacts into the future. The mitigation measures described below in addition to the Forest Service requirements and EDFs (Section 2.4.9) have been accounted for in the preceding impact analysis.

The first such mitigation issue is presented on pages 4-177:

Mine-induced drawdown of water levels could impact flows in springs that were hydrologically connected with the aquifer.

The following is proposed on pages 4-177 to 4-178 for mitigation of this issue using a monitoring measure:

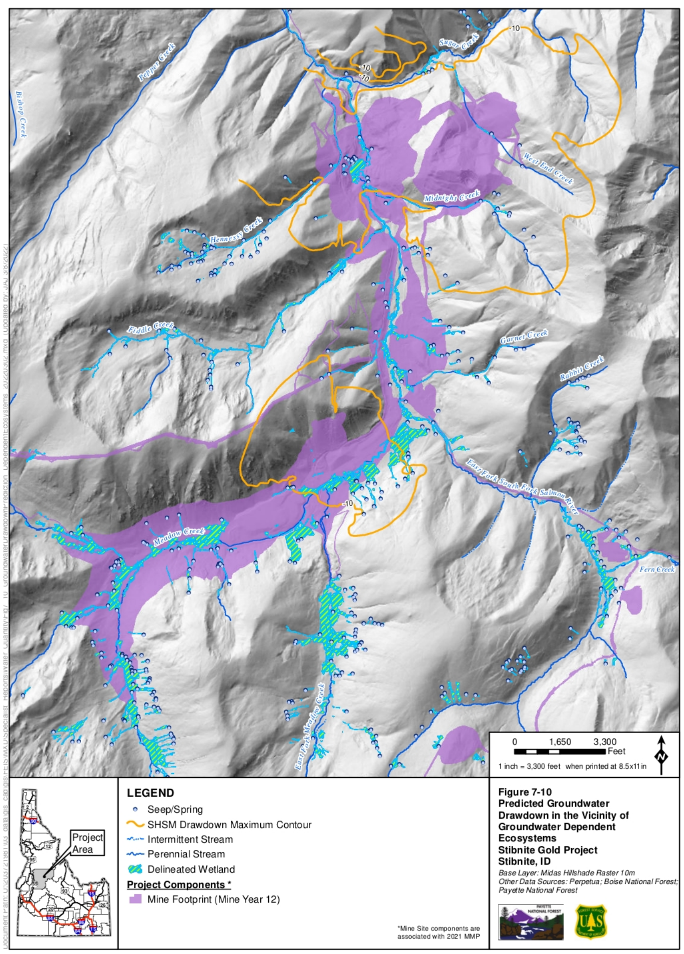
Monitoring Measure - Water Resource Monitoring Plan Implementation: Because construction, operation, and closure of the SGP has the potential to impact surface or groundwater resources. A focused water resources monitoring plan for the proposed operations would be implemented by the proponent.

The mine owner/operator would be responsible for the implementation of a Water Resources Monitoring Plan focused on confirming the predicted groundwater drawdown within allowance for model uncertainty and its relationship to discharges at proximal surface water resources. The plan would include surface water, groundwater, and meteorological monitoring requirements for the approved project. Water quantity measurements would include diversion rates from groundwater pumping, water levels in groundwater monitoring wells and piezometers located within the Operations Area Boundary, and flow rates of streams and springs at USGS monitoring stations as well as spring locations characterized in the baseline program within the predicted 10-foot drawdown contour. Monitoring results would be provided to the Forest Service on a quarterly basis and summarized in an annual report. The mine owner/operator would be responsible for continued monitoring and reporting of changes in groundwater levels and surface water flows prior to, and during, operation and for a period of time in the post-reclamation period. The plan would be reviewed and approved by Forest Service and implemented prior to the commencement of mining. State authorizations may also have monitoring requirements and these requirements along with monitoring already conducted or proposed could be applied to satisfy the needs of this mitigation measure.

Effectiveness: This monitoring measure would provide for identification of potential flow-related impacts that deviate outside uncertainty of model forecasts to groundwater and surface water resources as a result of mine-related water management activities. Implementation of this monitoring measure in conjunction with associated mitigation measures is anticipated to mitigate potential adverse impacts to surface water resources resulting from mine-related drawdown during the mining and post-mining period. If such deviation is observed, actions may consist of additional investigation and evaluation, including additional monitoring as necessary, to determine effective management practices and prevent adverse impacts.

This mitigation measure is intended to provide for *identification of potential flow-related impacts that deviate outside uncertainty of model forecasts to groundwater and surface water resources as a result of mine-related water management activities* by means of *measurements would include diversion rates from groundwater pumping, water levels in groundwater monitoring wells and piezometers located within the Operations Area Boundary, and flow rates of streams and springs at USGS monitoring stations as well as spring locations characterized in the baseline program within the predicted 10-foot drawdown contour*.

This mitigation measure is vague when it comes to specifics concerning the 10-ft drawdown contour. Monitoring needs to occur in sensitive locations outside of the 10-ft drawdown contour and in accordance with a peer-reviewed monitoring plan. The measure doesn't but should indicate operational actions, e.g., throttling or cessation of dewatering pumping, that will be taken once unacceptable impacts are observed. It doesn't but should quantify monitoring well locations and corresponding drawdowns / groundwater levels that are deemed unacceptable. Quarterly reporting to the USFS is too infrequent, given the ramifications of GDS impacts. There needs to be immediate notification to the FS when drawdown thresholds are exceeded.



X) The second of the two issues identified in the mitigation measure section, together with the monitoring measure and its effectiveness are presented on p. 4-178 of the SDEIS and are as follows.

> *Issue: Despite the best efforts at calibration and validation, predictive modeling of groundwater flow and stream flow entails uncertainty and future field conditions may vary from predictions.*
>
> *Monitoring Measure - Groundwater Modeling Validation and Update: Since there is uncertainty in the numerical groundwater model developed for the project, a work plan would be developed to revise the model and update it as necessary 1 year after mining intercepts the groundwater table and then again whenever monitoring data demonstrates a change in conditions that would significantly influence prediction and recognition of potential mine impacts. The model update would be based on the actual observed changes in groundwater elevations and additional hydrogeologic or groundwater-related data collected during operation. The Forest Service's annual review of monitoring results combined with the updated groundwater modeling, if necessary, would provide early warning of potentially unanticipated, undesirable impacts to water resources to allow for implementation of appropriate mitigation measures.*
>
> *Effectiveness: Implementation of this monitoring measure is expected to be effective in sustaining predictive models as usable evaluation tools that reflect site conditions and monitoring data for the purpose of predicting impacts and developing effective management practices.*

The above monitoring measure will not be nearly as effective as it could be, because there is no stated goal of modifying the conceptual hydrogeological model as need be, re-calibrating, or taking the deep dive to understand and analyze for the various sources of uncertainty.

XI) In SDEIS (USDA Forest Service, 2022) Section 4.8.4 Irreversible and Irretrievable Commitments of Public Resources, Subsection 4.8.4.2 Action Alternatives, the following is stated on page 4-180:

> *Long-term, groundwater levels would be locally affected by the geosynthetic covers that would be placed over the TSF and TSF Buttress during closure activities plus the geosynthetic covers placed over the Yellow Pine pit and Hangar Flats pit backfills. These covers are intended to significantly reduce infiltration of recharge from precipitation which would permanently limit groundwater recharge rates over the areas covered by these liners. In these areas, precipitation would not recharge groundwater but instead would remain in the shallow subsurface where it would be available for evapotranspiration and discharge to surface water in the East Fork SFSR. This would be an irreversible commitment of the groundwater resource in these locations.*

The geosynthetic covers proposed for the areas identified in the above paragraph have a finite design life. In other words, the finished engineered and constructed ground surface in this area has a desired function for a given time interval, and that would be either to drain and shed or to hold and release water for evaporative-transpirative processes. That design life is unspecified and neither is a concept for system performance at times greater than the finite design life. This is a glaring omission, because in time, the covers at shallow depths will be perforated by roots and burrowing by fauna, as well as potentially disrupted and damaged by erosive action from low-frequency high-magnitude strom events. The physical environment is dynamic, rather than static, and must be conceptualized as such. The federal agency (Forest Service) responsible for perpetual care of engineered and constructed geosystems that have a specific long-term function and finite design life should be identified, but is not. Implicit in the SDEIS is the presumption that the Forest Service and U.S. taxpayer will be providing long-term maintenance and care of Perpetua's installations. This ties into the closure and reclamation documents, which don't exist in approved form. The review and approval of such plans, prepared by proponent, is generally but not always done through a negotiation / process involving the Idaho Department of Lands and the proponent. Reclamation bonding amounts and success / performance criteria for release of bond would be established – again, through a process in which the public rarely if ever participates. As a result, longer-term environmental impacts that may be of interest to members of the public are not addressed by this implementation of the NEPA process for review of what is, in effect, an incomplete SDEIS.

XI) In the Section Surface Water and Groundwater Quantity on page ES-14 in the SDEIS (USDA Forest Service, 2022a) the projected SGP-induced impacts on the EFSFSR and Meadow Creek are divorced from anticipated but unspecified climate change-induced impacts acknowledged on page ES-10 in the Section Climate Change. The SDEIS authors appear to have completely skirted the following question. At what point do cumulative impacts of climate change, together with impacts from the proposed mining-related abstractions of groundwater, the proposed mining activity itself, and the proposed surface water diversion on stream flow and stream water temperature induce environmental degradation in fish habitat and GDEs to the point where species viability in these areas may be threatened or endangered? This does not appear to have been considered, but should have been.

3) Mining Operational Water Demands Analysis and Balancing

I) Perpetua continues to rely on a proprietary application, GoldSim for its site-wide water balance (SWWB) simulations, with the following summary (Brown & Caldwell, 2021b; section 5.1).

> *The SWWB model was developed using the GoldSim software that is widely used in the mining industry for a diverse set of applications. GoldSim is a proprietary software developed by and available for purchase from the GoldSim Technology Group, LLC. It is a flexible, object-oriented system analysis simulation tool that acts like a "visual spreadsheet" allowing for the creation and manipulation of data and equations using visual objects. GoldSim is a Monte Carlo simulation software for dynamically modeling complex systems and supports decision-making by simulating future scenarios while quantitatively representing the uncertainty and risks inherent in complex systems. GoldSim provides several advantages over simple spreadsheet models for the following reasons:*

- *Commonly used for a wide variety of mining applications, including mine water balance, water quality, and water and waste management*
- *Includes a visual development environment with many elements (or objects) including logical operators and discrete event capabilities for efficient model development*
- *Includes integrated probabilistic capabilities that allow for simple, straightforward probability assessments*
- *Based on a hierarchical structure, such that individual components (individual development rock facilities, the TSF, dewatering supply, pit sumps, etc.) are separately input and managed, and then linked to the broader model hierarchy*
- *Seamless integration with data in Microsoft Excel and other database formats that allows for real-time data updates*
- *Serves as an ongoing regulatory and operations management tool for the life of the mine*
- *Includes sensitivity and optimization tools*
- *Can be reviewed and used without a software license (GoldSim Player dashboard models)*

The next to the last point indicates that a tool for sensitivity analysis is available for the SWWB. Brown and Caldwell (2021b) indicate that a sensitivity analysis was done for SWWB elements, and referenced the analysis as “Perpetua Resources 2021a” on page 5-4 in their report. However the Perpetua document that they reference: Site-Wide Water Balance Model Sensitivity Analysis (October of 2121), is nowhere to be found in the Forest Service’s SDEIS website’s Supporting Documents set.

The last point in the list is confounding for a reviewer interested in the SWWB modeling assumptions, framework, input or output. Perpetua could have, but apparently did not provide the GoldSim input and output files for use by either the USDA Forest Service in SDEIS preparation or public reviewers (during the public comment period). Thus, the proponent’s modeling assumptions and modeling cannot be critically examined. Any conclusions they present are unsubstantiated unverifiable claims. This approach to preparing critical information for the SDEIS process, e.g., water rights needed and stream flow diversion amounts, is not at all consistent with what most understand to be the “best available data and science”. Perptetua should make all GoldSim model input and output files available, together with an explanation of each file’s function, format, character set and contents, as well as the relevant sensitivity analysis document.

II) From the SGP SWWB Model Refined Proposed Action (MODPRO2) Report Oct 21, 2021, page ES-1:

The SWWB is used to predict the water needed to mine and process ore for the SGP including the quantity of water that is above and beyond the mine-impacted water (MIW) collected such as dewatering water or precipitation onto mine features. The deficit between water collected and water needed is termed additional water requirement. This requirement calculated in the SWWB is used by the Stibnite Hydrologic Site Model (SHSM) to assess impacts to surface and groundwater. The SWWB calculates the collected MIW that is temporally in excess of water needs in order to determine the flow of water for treatment and release. This flow to treatment has been significantly reduced in operations and <u>the additional water required has increased</u>

from previous SWWBs primarily due to changes in the SHSM and to a lesser degree, changes in the mine plan.

The unquantified increase in additional water required is a glaring omission in a document that is strategically interspersed with data-rich content. In the instance of "additional water required", zero data is provided, that is, there is no indication as to the degree, e.g., percentage, that the additional water required has increased, relative to the previous mine plan. Neither is there any statement of such in the remainder of the document. Perpetua needs to supply the missing information to facilitate SDEIS review.

III) The SDEIS, under Water Use and Supply (USDA Forest Service, 2022a, pages 2-71 to 2-72) indicates that makeup water will be required to sustain the overall mine water demand of 4,431 gpm during the operational period. Makeup water sources include but are not limited to groundwater wells and diversion from the EFSFSR. The SGP Water Management Plan (Brown and Caldwell, 2021f, page 5-5 (84th PDF file page) indicates the following.

> *The most significant project water use will be for ore processing during operations, which accounts for 97 percent of the total water usage for the life of the project and includes tailings management. The primary source of water to be used in the ore processing circuit will be water recycled from the TSF (i.e., reclaim water). Other sources will include makeup water supplied from the pit dewatering wells, water supply wells, EFSFSR surface intake, and collected MIW. Makeup water is needed because of losses within the ore processing circuit and TSF. During normal operations, it is anticipated that, on average, approximately 80 percent (approximately 2,960 gallons per minute [gpm]) of the water used for ore processing will be reclaim water while the remaining 20 percent (approximately 940 gpm) will be makeup (Perpetua Resources 2021b).*

The basis for the estimate of makeup water, which is intended to offset the loss term in the SWWB, is critical but is not detailed in the Water Management Plan (Brown and Caldwell, 2021f). On page 6-21 of Brown and Caldwell (2021b), we are told the following.

> *Water needed for ore processing above the water available from reclaim is termed additional water. Additional water needs are a direct result or prediction of the SWWB, and makeup water is sourced from stored MIW, dewatering, or freshwater supply. The predicted additional freshwater need is used by the SHSM to predict surface stream and groundwater impacts from water withdrawals via the groundwater supply wells and the surface water intake.*

It appears that the terms "additional water" and "makeup water" may be interchangeable in the Brown and Caldwell (2021b) report, but perhaps not. Assuming that they are interchangeable, let's look at the "additional" water, or "makeup" water needs on the project. Below is Brown and Caldwell's (2021b) SWWB / GoldSim projection for additional water during the projected life of the mining operation. The first 2 years are for construction of the SGP; the remaining 14 years are the estimated life of the mining and ore processing operations.

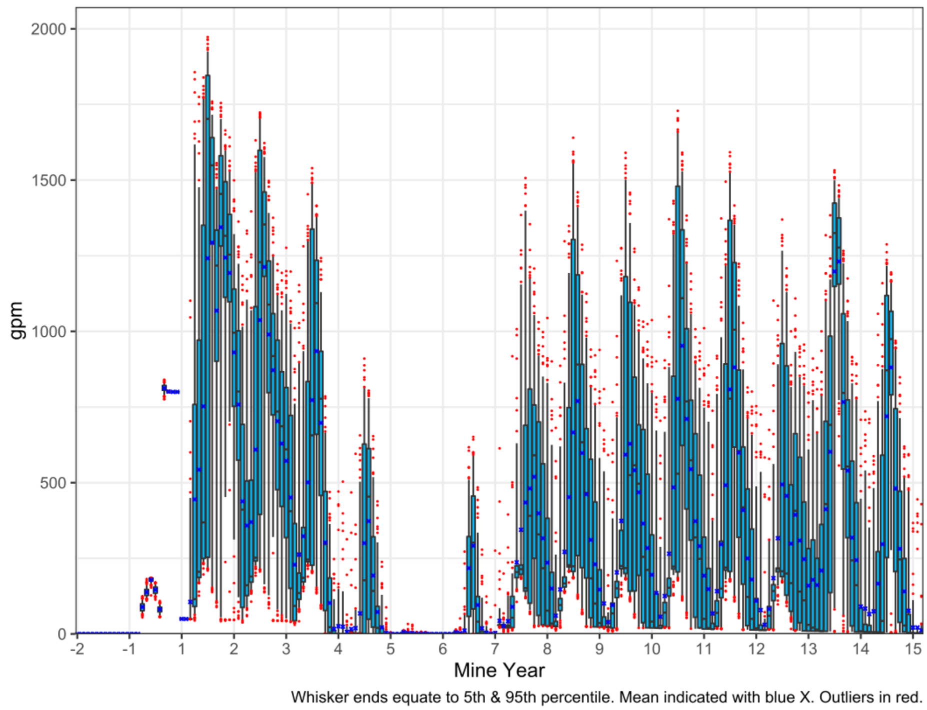


Figure 6-18. Additional Water Needs Boxplot

The breakdown of additional water needs as sourced from surface water as compared to that sourced from groundwater is shown in the next two plots, also from Brown and Caldwell (2021b)

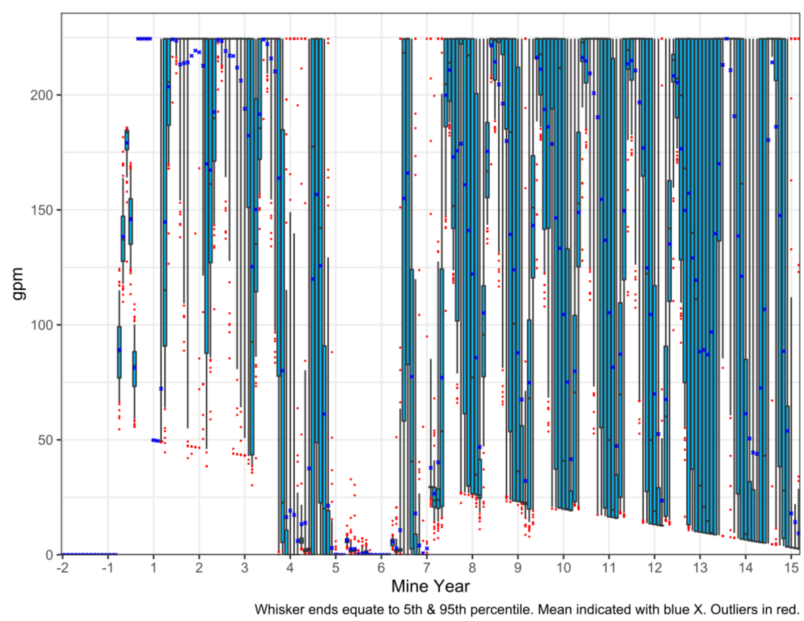


Figure 6-19. Additional Water Needs from Groundwater Boxplot

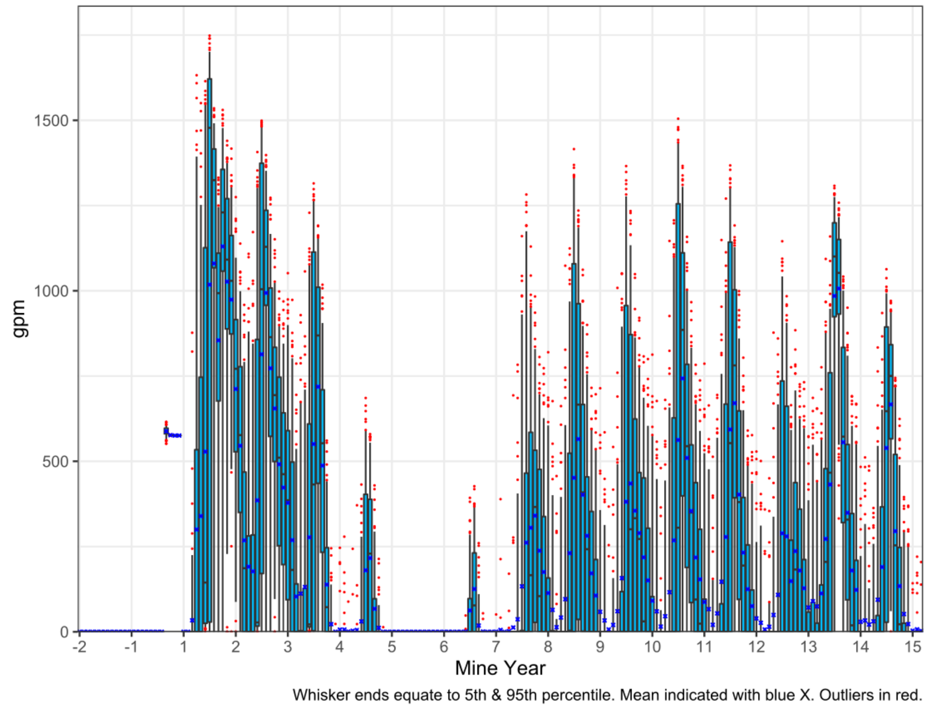


Figure 6-20. Additional Water Needs from Surface Water Boxplot

Since the SWWB modeling basis for the makeup water volumetric flow rate is unknown, presumably because it is based on a proprietary model, and given the supporting documents' shielding of methodology, data, and parameters used in the SWWB / GoldSim model and modeling, the validity of estimating of the above-presented additional water requirements cannot be assessed.

Brown and Caldwell (2021b) reveal that a Monte Carlo methodology was used to develop the boxplot information presented in these 3 illustrations and discuss the overall procedure followed. However, the interpretation and implications of the Monte Carlo results are never discussed. Uncertainty is a term that appears exactly 4 times in the report, and when used it is never in the context of an uncertainty analysis.

There are failures involving reporting, documentation, transparency, and communication in the GoldSim / SWWB model document (Brown and Caldwell, 2021b). The utilization of century-old climate inputs to forecast and analyze conditions a century into the future is a major failing.Thesee shortcomings should all be remedied by Perpetua. The uncertainty analysis should be explained and clarified.

IV) It seems as though much of the makeup water needs – a volumetric flow rate, for the project will ultimately come from the EFSFSR no matter whether through direct diversion of existing flow or through groundwater pumping of wells developed in Holocene or other alluvium, in pit dewatering pumping – diversions of future stream flow, and quite possibly in the interception and use of Mining-Impacted Water (MIW). Since the provided conceptual hydrogeological model indicates minimal contribution from / interaction with the regional groundwater system, at least 3 of the 4 sources of makeup water, whether groundwater supply well pumping, pit dewatering well pumping or direct diversion from the EFSFSR, and possibly all 4 sources of makeup water, appear to amount to abstraction of current or future stream flow.

V) It seems as though the TSF is designed to handle storage of the PMP/PMF, though other stormwater infrastructure appears to be designed only to handle the 100-yr storm runoff. Presumably that reflects regulatory or other criteria. However, PMF water does need to make its way to the TSF, and, other stormwater infrastructure may, at times, be overwhelmed, disrupted or destroyed by spatially-varying flows intermediate between the 100-yr runoff and the PMF, as well as from post-wildfire debris flows and flood flows from watershed areas that have recently burned or will burn in the future. How are those flows to be conveyed? Additionally, hydrologic extreme events are not necessarily isolated occurrences. If ever necessary during life of mine and reclamation, or looking beyond, how will overflow of the TSF be routed from the facility?

VI) A concern parallel to one voiced about the MWB model, stated above, is whether and how the Water Quantity Specialist Report (2022b) and the SDEIS (2022a) authors perceived and made use of the SWWB / GoldSim model simulation results concerning makeup (additional) water needs, illustrated above in the three graphs.

The Water Quantity Specialist Report (USDA Forest Service, 2022b) contains not a single reference to makeup water, make up water, or additional water. On pages 52-53 of the report, it is stated that:

> *The SWWB evaluates operational consumptive use (e.g., mill water supply, dust control), TSF water volumes, and contact water volumes generated over the span of the project from construction through closure*

This single sentence appears to summarize the report preparers' comprehension of and attention to the SWWB model simulation results as concerns additional or makeup water requirements on the project.

The SDEIS (USDA Forest Service, 2022a) authors' apparent comprehension of and attention to SWWB model-based estimates of additional or makeup water requirements on the project follows a trajectory similar to that in the Water Quantity Specialist Report.

In Section 4.1.2.2 Water Balance Model section of the SDEIS (USDA Forest Service, 2022a), the following is stated as concerns the SWWB:

A site-wide water balance model was performed by Brown & Caldwell to assess:

> *meteoric precipitation contributions (i.e., rainfall and snowmelt) to surface water and groundwater,*
>
> *volumes of water requiring storage and management due to contact with mine facilities (i.e., contact water),*

consumptive use needs and water sourcing for mining and ore processing,
volume of water requiring water treatment during operations and post-closure following the installation of geosynthetic covers over reclaimed mine facilities, and

runoff, infiltration, and seepage of meteoric waters incident on stockpiles, the TSF Buttress, and other mined materials.

The modeling was conducted using the commercial GoldSIM software which is widely used in the mining industry for site and facility water balances.

In each of the Water Quantity Specialist Report and the SDEIS, I find little apparent comprehension or attention to the SWWB / GoldSim model development and approach, or to its dependency on MWB model climatic inputs. This is most unfortunate, since the SWWB / GoldSim model simulation results are key to quantitative estimates of makeup / additional water, and thus to surface water and groundwater abstractions over the life of the mining and ore processing operations. The SDEIS and Water Quantity Specialist Report authors need to comprehend and incorporate these dependencies into their evaluations, analyses and assessments.

4) Water Resources Monitoring Plan

I) There is a near-complete absence in the Water Resources Monitoring Plan (Brown and Caldwell, 2021c) of meaningful actions to identify early hydrologic impacts that may eventually lead to unacceptable impacts in Groundwater-Dependent Ecosystems (GDEs). I do wonder if this may be addressed, for example, in the unprovided Appendix RM: Resource Management (e.g., plans RM-1 Aquatic Habitat Monitoring and Management, RM-1.1 Fisheries and Aquatic Habitat Monitoring and Management Plan, RM-1.2 Stream and Wetlands Monitoring and Management Plan) of the Stibnite Gold Project Environmental Monitoring and Management Program report (Brown and Caldwell, 2021d)?

II) The authors of the Water Resources Plan declare at the outset (page 3 of the plan) that they are responding only to Agency comments. Perpetua should respond to all comments received from all parties, in this and other regards.

The authors of the Plan indicate in section 3.3.6 Reclamation and Closure Monitoring that *water resource monitoring for closure and post-closure will be addressed in an update to this plan toward the end of the operations period based on site conditions at that time*. This is not acceptable. Perpetua should have provided for the SDEIS preparation its best estimate and anticipation as to what site conditions are probable at closure and post-closure, and what water resource monitoring will be put in place under such probable conditions, rather than leaving things open-ended and nonspecific, which prevents assessment for the EIS and prevents comments on the important set of long-term impacts.

III) The modeling questions pertaining to model selection, model validation, climate data input, uncertainty analysis, etc., raised both during this SDEIS review and those raised during the DEIS review, underscore the inescapable fact that the coupled SGP model set (MWB, SWWB, Modflow 6) constitutes an estimating tool with approximate results at best. The model set may or may not ever be refined to be anything more than that, mitigation measures offered in the SDEIS not withstanding. These limitations highlight the need to have:

- a complete set of superior hydrological modeling tools that are continuously improved in a peer-reviewed framework, with the mine owner and operator obligated to update and apply these models and apply them in support of minimizing and if need be mitigating environmental impacts; and,
- a well-conceived water resources monitoring plan that is comprehensive, sustained, informed, tunable and peer-reviewed prior to and during the course of its implementation.

5) General

I) It is stated on the 158th page of the Stibnite Gold Project Stibnite Hydrologic Site Model Refined Modified Proposed Action (ModPRO2) Report (Brown and Caldwell 2021a), prepared for and released by Perpetua Resources, that: *The updates to the EC SHSM model result in an improved model that represents the best available data and science. As such it is an appropriate tool to assess potential impacts due to proposed mining within the Study Area.* Since the updating done is not specified and since it appears to have been done without consideration for numerous model selection, model development, model application and modeling flaws identified as part of 2020 public commenting (e.g., Prucha, 2020), this is a statement of opinion rather than of fact.

II) Within the Stibnite Gold Project Site-Wide Water Balance Model Refined Proposed Action (ModPRO2) Report (B & C, 2021) report Figure 6-10 indicates that initial tailings dam construction will increment dam height by nearly 225 ft in a period of a few months. Is that in fact planned, and if so, is it even feasible, or is the graphic purely conceptual in nature?

III) The SGP SHSM Existing Conditions and No Action Alternative Report is an Appendix in Brown & Caldwell, 2021a. Here, Brown and Caldwell report authors indicate that only comments from the Agencies are worthy, declaring at the outset (first page) that:

Comments on previous reports and model development were received from participating regulatory agencies (agencies), including the United States Forest Service (USFS), the Idaho Department of Environmental Quality, and the United States Environmental Protection Agency, as well as AECOM. The comments provided by the various parties led to refinements to the hydrologic conceptual site model (HCSM), the meteoric water balance (MWB) portion of the model, and the development of an updated groundwater flow model capable of representing important geologic features that were not included in the previous model.

This exclusion of public comments from consideration represents a corruption of the NEPA process. Furthermore, there is no indication as to which comments were addressed and how they were addressed; this is generally true as concerns other project documents provided by Perpetua in support of the 2022 SDEIS preparation.