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| **Model** | 1. Right click Inputs_Checking, select Properties, and Enable Time History Results  
2. Set Write_Inputs equal to true (in the Globals container)  
3. Go to the menu "Model" and select Options  
4. Go the Results tab and make sure "Export results after simulation" is selected in the dropdown menu. | To use the model to check inputs:  
1. Right click Results, select Properties, and Enable Time History Results  
2. Set Write_Results equal to true (in the Globals container)  
3. Go to the menu "Model" and select Options  
4. Go to the Results tab and select Edit next to the Display settings for probability density function  
5. Make sure the statistics to plot are the Mean, 10th/90th, and Median ONLY!  
6. Go to the Results tab and make sure "Export results after simulation" is selected in the dropdown menu. | |
| **Randomly-generated mean groundwater concentrations** |  
- Capricorn distributions fit to the entire sample dataset X  
  - Mean \( \mu = \text{E}(X) \)  
  - Standard deviation \( \sigma = \text{Std}(X) \)  
  - Mean and standard deviation of log transformed data  
  - Log mean \( \alpha = \text{E}(\ln X) \)  
  - Log standard deviation \( \beta = \text{Std}(\ln X) \)  
  - Uncertainty in the true mean \( \mu \) simulated by random number generator  
  - Log mean \( \alpha \) assumed to be normally distributed, generated once per realization  
  - Standard deviation of \( \alpha \) is the standard error of \( \alpha \) (\( \sigma / \sqrt{N} \) where \( N \) is number of samples)  
  - Log standard deviation \( \beta \) assumed to be known from sample dataset  
  - \( \mu \) for each realization calculated by \( \exp(\alpha + 0.5(\beta^2)) \) | **Inputs**: Background  
- Concentration caps from AMAX data  
- Lookup tables for observed concentration percentiles as a function of pH  
  - Based on data from AMAX 0.64% sulfur piles  
  - Used with randomly generated pH and percentile to define concentration cap  
  - Generated once per realization  
- Humidity cell rates  
  - Release rates developed directly from humidity cell data  
- Aqua regia ratios  
  - Metal-to-metal or metal-to-sulfur ratios from aqua regia analysis of drill core data | **Inputs**: Buttress_Geochem\( \cdot \)Cat1\( \cdot \)Cat1_Inputs_LAM\( \cdot \)AMAX_pH_Lookups_LAM  
- Concentration caps from AMAX data  
- Constituent release rate methods  
  - Humidity cell rates  
  - Aqua regia ratios  
  - Other methods  
    - Release rates from humidity cell metal-to-metal release ratios  
    - Metal-to-metal or metal-to-sulfur ratios from microprobe analysis of specific minerals  
    - Metal-to-metal ratios from mineral formulae | Convert from Oxygen Consumption to Sulfide Generation  
\[ D = D_0 \left(1 + \frac{1}{[S]} \right) \left(1 + \frac{1}{[S]} \right) \]  
\[ 4FeS_2(s) + 9O_2(s) + 10H_2O(l) \rightarrow 4Fe(OH)_3(s) + 8H_2S(g) \]  
\[ \text{Conversion from Oxygen Consumption to Sulfide Generation} \]  
\[ \text{Diffusion from the Eberhard Equation} \] |
The hydraulic conductivity, $K_{Surficial}$, is randomly generated. Recharge is also randomly generated but is limited in function $R_{Calc}$. $R_{Calc}$ takes the minimum of the randomly generated value, Recharge, and a calculated maximum acceptable recharge which would cause $Qu_{Max}$ to equal zero. The control is to force $Qu_{Max}$ to be greater than or equal to zero always.

The initial concentration in each cell is the flow-weighted average of the seepage concentration and the recharge concentration. If the recharge concentration is lower than the seepage concentration at time zero, then initial concentrations in the mixing cells will decrease with respect to distance from the Tailings Basin, and vice-versa.

Volume of water is width * depth * individual cell length * porosity (assuming fully saturated).

Mass of surficial material is width * depth * individual cell length * (1 – porosity) * material density.

Initial mass of each constituent takes into account the initial concentration, the volume of water, and the mass of the surficial material, and assumes a linear isotherm for sorption.

$V = V_{water} + K_p M_{surficial}$
Iteration Method to Solve for Saturation

The standard Newton-Raphson iteration method is used here. The looping process is to initially guess a saturation ($\text{Sat}_e\text{Guess}$), to calculate the relative conductivity ($\text{Calc}_K_r$), and the slope of $K_r$ as a function of saturation ($\text{d}K_r/\text{d}x$) at the initially guessed saturation. Using $\text{Sat}_e\text{Guess}$, $\text{d}K_r/\text{d}x$, and the error in relative conductivity ($\text{Calc}_K_r - \text{Calc}_K_r$), the Newton-Raphson method solves for a new guess of saturation $\text{New Sat}_e\text{Guess}$ which is closer to the solution. This process is kept until the convergence criteria is met, defined by $\text{New Sat}_e\text{Guess} - \text{Sat}_e\text{Guess} < 0.0001$.

Finally, based on the effective saturation and other hydraulic properties, the water content and the saturation are calculated and used to eventually determine constituent loading.
<table>
<thead>
<tr>
<th>Project/Tailings Basin/NorthMet Basin/CELL_1E/Pond/H2O Balance/Cell1E_Precip</th>
<th>If the ponds have combined, the precipitation amount in L/T is applied to the calculated pond area, else, the precipitation amount in L/T is applied to the initial, existing pond area in Cell 1E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project/Tailings Basin/NorthMet Basin/CELL_1E/Pond/H2O Balance/Pump_1E_to_Plant</td>
<td>If the Plant Site is closed (closure), then the closure open water evaporation rate in L/T is applied to the calculated pond area, else, if the ponds have combined, the later operational open water evaporation rate in L/T is applied to the calculated pond area, else, the earlier open water evaporation rate in L/T is applied to the initial, existing pond area in Cell 1E.</td>
</tr>
<tr>
<td>Project/Interception System/Controlled_Pumping_Percent</td>
<td>If the project is 30 years into closure (50 years in project life), pumping may cease because the Tailings Basin is at steady state, else, if Cell 2W is not included in the seepage limitation because it's not part of the project, then the West Toe does not need to be pumped, else, if the seepage lost is greater than the allowable limit even if the North and Northwest Toes are fully captured, then the West Toe does not need to be pumped, else, collecting seepage along only the North and Northwest Toes is sufficient to meet the requirement and the West Toe does not need to be pumped.</td>
</tr>
<tr>
<td>Project/Interception System/Min_Intercept_Percentage</td>
<td>If the project is 30 years into closure (50 years in project life), pumping may cease because the Tailings Basin is at steady state, else, under all conditions, if the year is less than 5 years, which is the minimum travel time for loading from the Tailings Basin, the capture percentage is based on the flow constraint because the low water quality has not yet been affected by the project, else, if Cell 2W is not included in the seepage limitation, then the capture percentage is based on only the seepage from the North Toe, else, if the West Toe has to be pumped (see H2O balance, control), then the capture percentage is based on seepage from the North, NorthWest, and West Toes, else, the capture percentage is based on the seepage from the North and NorthWest Toes.</td>
</tr>
<tr>
<td>Project/Interception System/Interception_Flow</td>
<td>If the project is 30 years into closure (50 years in project life), pumping may cease because the Tailings Basin is at steady state, else, under all conditions, if the year is less than 5 years, which is the minimum travel time for loading from the Tailings Basin, the capture percentage is based on the flow constraint because the low water quality has not yet been affected by the project, else, if Cell 2W is not included in the seepage limitation, then the capture percentage is based on only the seepage from the North Toe and the greater of the flow-based (Min_Intercept_Percentage) or the quality-based (Controlled_Pumping_Percent) capture percentages, else, if the West Toe has to be pumped (see H2O balance, control), then the capture percentage is based on seepage from the North, NorthWest, and West Toes and the greater of the flow-based (Min_Intercept_Percentage) or the quality-based (Controlled_Pumping_Percent) capture percentages, else, the capture percentage is based on the seepage from the North and NorthWest Toes.</td>
</tr>
</tbody>
</table>
If in closure, the excess system water is the inflows less the outflows to Cell 1E, plus the collected water (Trench_Sum or Total_Flow_Intercepted depending on Use_Trench), minus any desired volume change in the pond of Cell 1E over one time step duration in case the pond is not at the design volume. Else, if the ponds of Cell 1E and 2E have combined, the excess system water is the inflows less the outflows to Cell 1E, plus the collected water (Trench_Sum or Total_Flow_Intercepted depending on Use_Trench), minus any desired volume change in the pond of Cell 1E over one time step duration in case the pond is not at the design volume, minus the demand of NOT clean water from the Beneficiation Plant. Else, if the ponds of Cell 1E and 2E have NOT combined, the excess system water is the inflows less the outflows to Cell 1E and to Cell 2E, plus the collected water (Trench_Sum or Total_Flow_Intercepted depending on Use_Trench), minus any desired volume change in the ponds of Cell 1E and of Cell 2E over one time step duration in case the pond is not at the design volume, minus the demand of NOT clean water from the Beneficiation Plant. This determines how much water cannot be handled by the system and must be treated and discharged.

First, the total flow is either the total flow collected by the wells (Total_Flow_Intercepted) or by the trench (Trench_Sum), depending on Use_Trench. The collected water, less the excess system water, is sent to either Cell 1E or Cell 2E, depending on whether the ponds have combined or not respectively (Combined Switch_Completion_Status becomes true). Collected water is sent to the Mine Site West Pit in closure until the West Pit has received all that it can handle (Stop Sending_Water_to_Mine becomes true). Any unused water that cannot be sent to the Mine Site or to the FTB pond must be treated and is sent to the FTB WWTP.