3D TSF MODELLING IN GOLDSIM USING MUK3D

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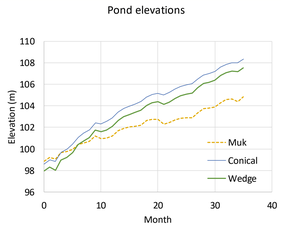
WHY MODEL IN 3D?

- Some structures can't be modelled realistically in 2-dimensions
- Tailings dams have a complex, evolving geometry that can't be reproduced accurately with 2D approximations. The development and evolution of a TSF can depend heavily on its operating conditions.
- Storage elevation curves are scenario dependent .
- 2D approximations do not reliably predict elevations.

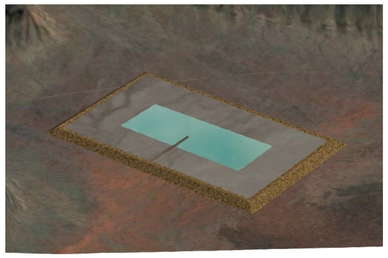


Comparison between simple GoldSim pond models and Muk3D modelling

WHAT IS MUK3D?

Muk3D is tool that is used for the design and planning of TSFs. It models the tailings deposition and interaction of the beaches with the pond, and can be used to predict beach elevations and pond elevations over time.

It also is used to create high quality images and animations of modelling results

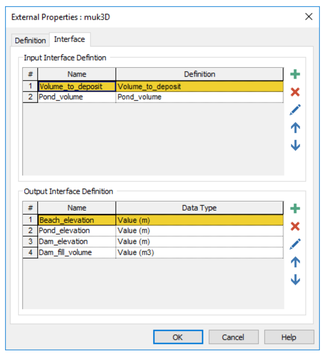


HOW DO MUK3D AND GOLDSIM COMMUNICATE?

Muk3D *Simulation* comes with a DLL that can be used in GoldSim through the External element. Inputs and outputs for the interface are defined in Muk3D and mirrored in GoldSim.

Datatype	Send to Muk3D	Return from Muk-3D
Double	✓	✓
1-D Array	✓	✓
1-D Lookup table		✓

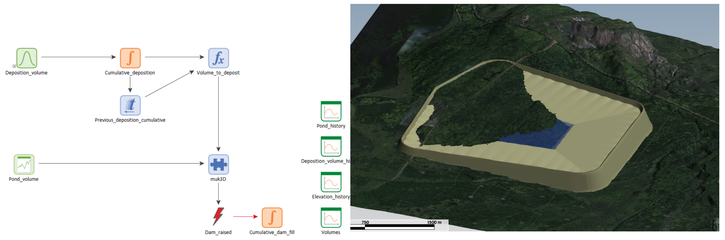
In Muk3D, a Python macro is written that runs each time data is provided to the External element in GoldSim. Results (values, arrays, lookup tables) are returned from each call to Muk3D.



TSF LONG RANGE PLANNING

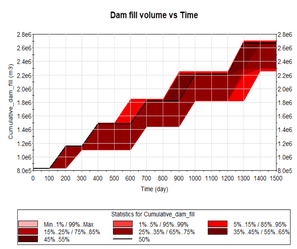
An obvious application for 3D modelling within GoldSim is to represent a TSF as a 3D structure instead of trying to use simplified 2D models (inverted cone model for the pond, or a set of storage elevation curves).

In this example, the GoldSim model provides a monthly volume of tailings to deposit and end of month pond volume. The deposition model will pour the tailings, if there is enough space. Otherwise, a dam raise will be undertaken and then the tailings poured into the TSF.

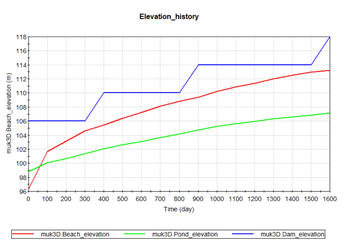


GoldSim		Muk3D
Pond volume, tailings deposition volume	→	Run deposition model, dam raise if needed.
Incorporate results in GoldSim modelling	←	Beach elevation, pond elevation, pond area, storage-elevation curve for new TSF pond.

Outside of water balance modelling, using this approach for TSF design quickly lets designers understand how the structure reacts to varying operating conditions. The current design process for TSFs used by consultants is generally deterministic, and the sensitivity of the TSF to different design assumptions is often poorly understood.

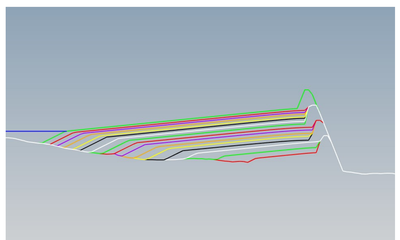


Range of dam construction material required



Dam, beach, and pond elevations for a single realization

In this example, the volume of fill required over time for dam raises has been estimated. This can be cross-referenced with material availability to determine if this is a feasible raise sequence, or if there are points in time where the required volume of material may not be available.



Cross sections through the tailings beach/dam from each deposition run, for a single realization.

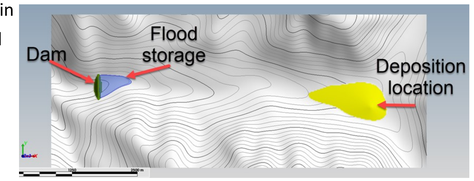
Other useful information can also be generated from Muk3D such as cross sections, exporting snapshots to animations, and pond storage elevations curves at each timestep.

STARTER DYKE SIZING

When planning a new TSF, the starter dyke is sized using some basic assumptions, including:

- Beach slopes
- Operating pond (if any)
- Flood storage
- Target storage volume
- Foundation performance
- Placed tailings density

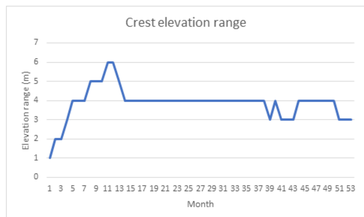
The sensitivity of the structure to variations in these baseline parameters is not always well understood by the designer or operator. By using GoldSim to drive Muk3D, a range of different scenarios can be run for different input parameters to help understand the range of possible outcomes.

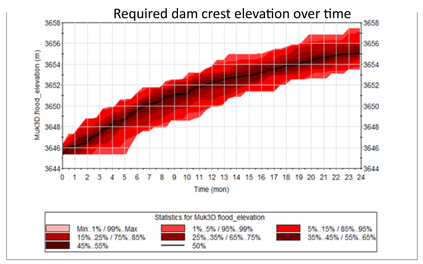


GoldSim		Muk3D
Beach slopes (resampled monthly), target flood storage volume (per realization)	→	Run the deposition model and determine the elevation of tailings against the dam, and the flood storage elevation.
Record the results.	←	Return beach elevation, pond elevation, pond area, storage-elevation curve for new TSF pond.

In this example the beach slope was based off a normal distribution (derived from statistical analysis of actual thickener performance) and a different average beach slope was selected for each month of deposition. Based on a target flood storage volume, the required elevation of the dam was calculated over a 2 year period. These results show that there can be up to a 6m difference in required crest elevations, depending on the slope of the tailings beach.

This information can help a TSF operator make an informed decision when selecting elevations for the starter dyke, as well as subsequent dam raises.





CAN 3D HELP YOU?

Not every GoldSim model of a TSF will benefit from 3D modelling. If the GoldSim model uses TSF pond/beach elevations as triggers for other events, then this approach can be beneficial and incorporate more realism into the simulation. For models that have more than one TSF, incorporating 3D modelling will better predict when a TSF has been filled and the new TSF is required.

Once a Muk3D model has been created for a TSF, its easy to rerun the GoldSim model with different TSF configurations, simply by using different Muk3D input data, allowing a user to investigate many possible designs, quickly.

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