Turning Monitoring Data into Insights: Understanding Shallow Subsurface Dynamics in Closed Tailing Facilities Through Data-Driven Infiltration Modeling

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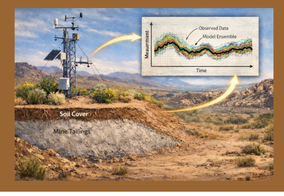


Study Objective and Scope

Demonstrate the use of site-specific, transient evaporation and soil-moisture data to automatically calibrate a one-dimensional tailings storage facilities (TSF) infiltration model, and translate it into a defensible, probabilistic estimate of deep recharge to groundwater.

Deliverables:

- Calibrated soil hydraulic parameters with uncertainty
- Probabilistic bottom-flux (recharge) estimate

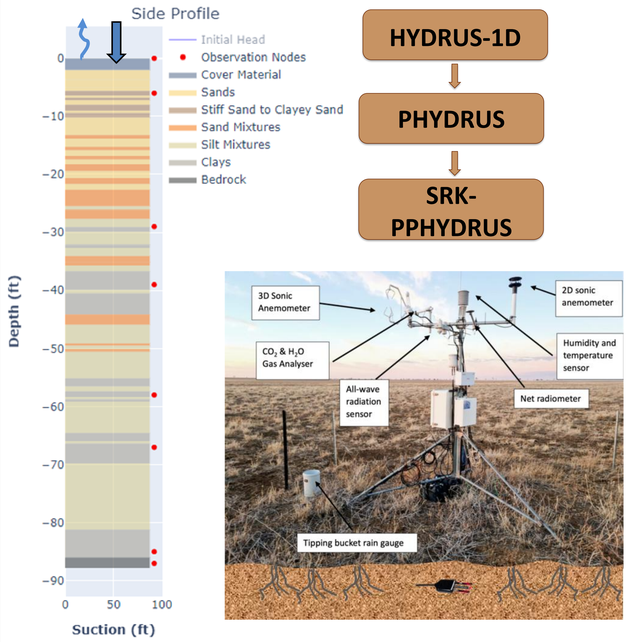
Site Setting and Study Objective

Multiple closed mining facilities: tailings storage facilities (TSFs) and waste rock dumps (WRDs) sit adjacent to a dry wash and an alluvial aquifer in a semi-arid setting.

Two questions drive the work:

- Geotechnical
  How does infiltration affect TSF stability?
- Environmental
  How much do facilities leak to groundwater?

Numerical Simulator and Data Availability



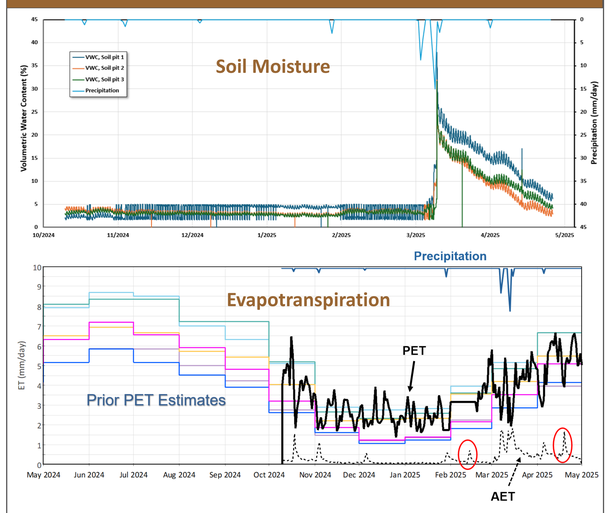
Available

- Daily on-site precipitation record
- Detailed CPT stratigraphy through TSF
- Eddy-covariance flux tower (PET / AET / θ)

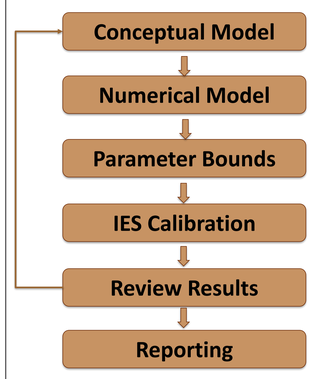
Limited

- No site-specific PET prior to the tower
- Facilities fully drained down (unsaturated)
- Near-zero direct hydraulic-property data

Calibration Data



Modeling Approach: Iterative Ensemble Smoother (IES)

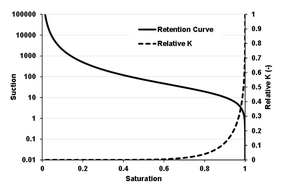


Van Genuchten Equation:

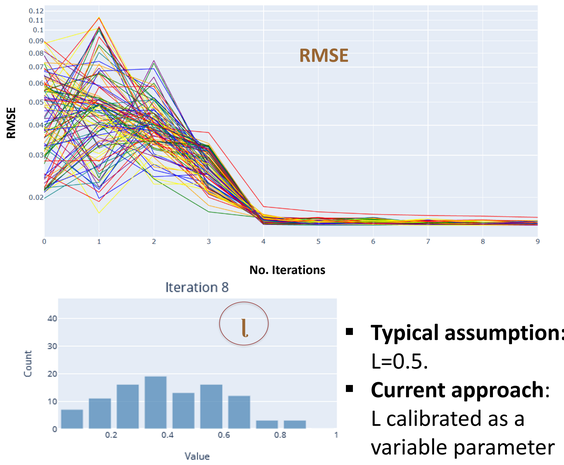
$$\theta = \theta_r + \frac{\theta_s - \theta_r}{[1 + (\alpha\psi)^n]^m}$$

Mualem–Van Genuchten:

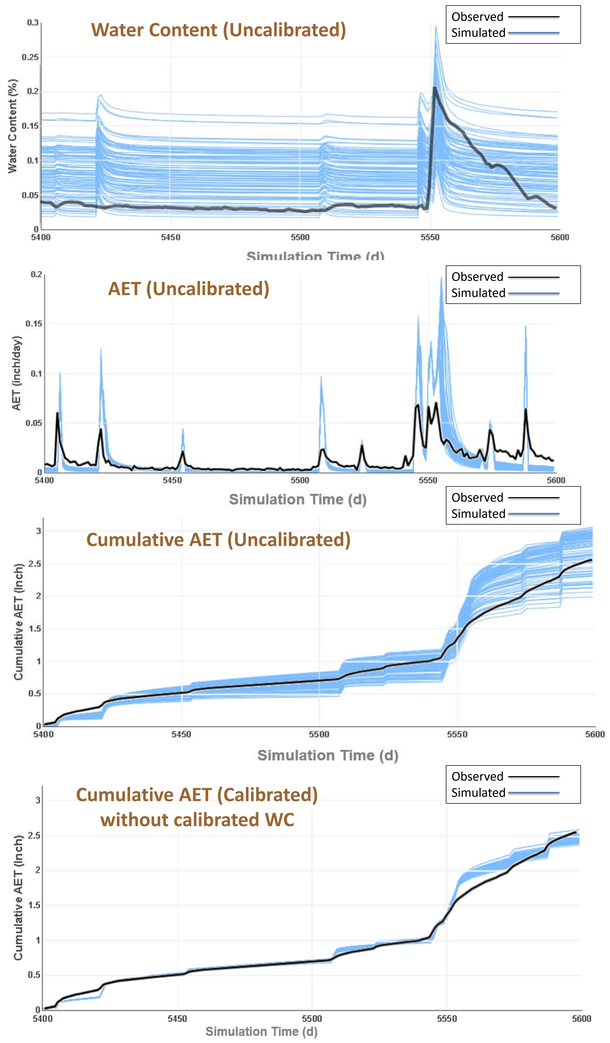
$$K(\psi) = K_s S_e^l \left[1 - (1 - S_e^{1/m})^m\right]^2$$

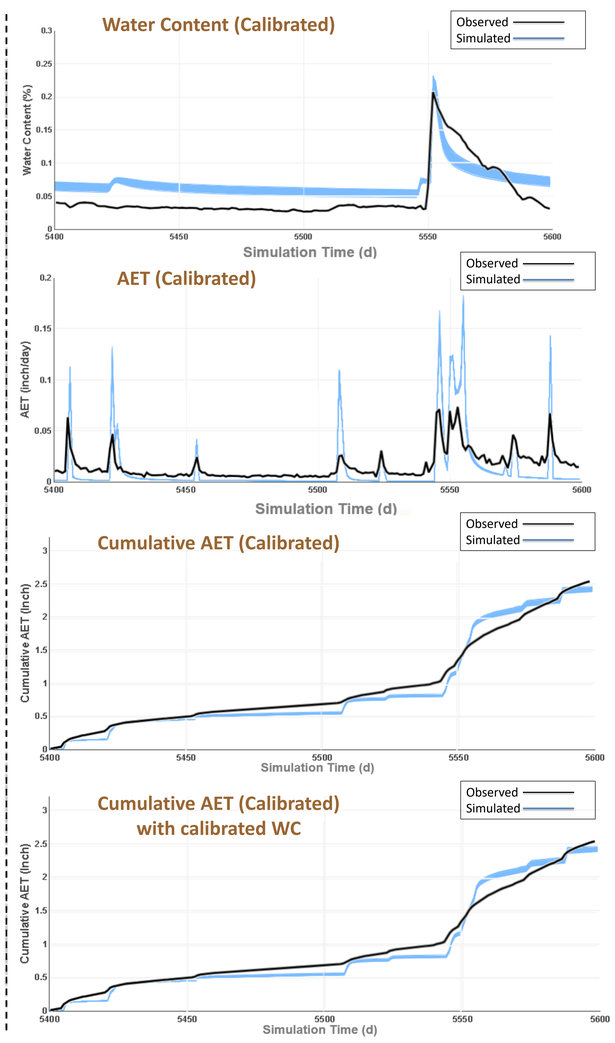


Calibration Results

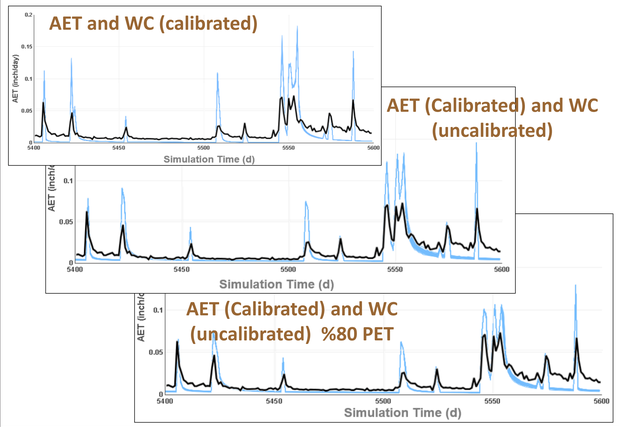


- **Typical assumption:** L=0.5.
- **Current approach:** L calibrated as a variable parameter





Alternative Conceptual Models



Conclusion

"Upgraded" HYDRUS-1D:
Pre / post processing
IES calibration

Eddy covariance data can be used to:
Infer hydraulic properties (shallow subsurface)
Constrain infiltration rates to mining facilities

IES allows quick exploration of alternative models

Scrutinize data

Scrutinize data

Scrutinize data

References

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