Unsaturated time lag: Managing the expectations of policymakers using numerical models

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Introduction

- **Time lag** = intrinsic delay between remediation measures and improvements in water quality.
- Understanding time lag helps policymakers set realistic water quality targets.
- Time lag includes both groundwater (**t_s**) and unsaturated zone (**t_u**) components (Fig. 1).
- *In situ* measurement of t_u can be prohibitively expensive and slow.
- Numerical models estimate t_u based on soil and met. data.
- Estimates of t_u coupled with groundwater travel times give a holistic appraisal of watershed time lag.

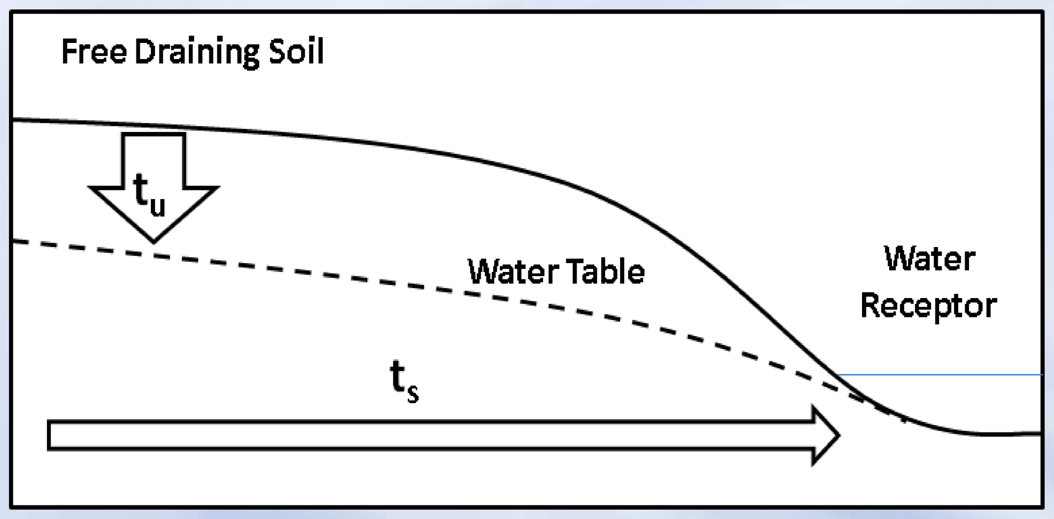

Fig. 1: Time lag from a source to receptor

Purpose

- While numerical models allow estimates of t_u, they are influenced by the quality/resolution of input data.
- This project aimed to determine the optimum:
  - a) meteorological, and
  - b) soil hydraulic input data

for determining t_u using the Hydrus 1D model.

Model Input Data

- Meteorological data at hourly and daily resolution.
- Soil hydraulic parameters determined by:
  - A. Generic textural data incorporated in the model.
  - B. Pedotransfer functions based on detailed textural analysis.
  - C. Measurement of the soil water characteristic curve (SWCC) and fitting of the Van Genuchten Mualem (VGM) equation.
  - D. The VGM equation fitted to a partial SWCC (excluding the -15 bar pressure step).

Methods

- Conservative solute movement was simulated.
- Hourly vs. Daily meteorological resolution – 12 textural classes.
- Simple to complex soil data (Fig. 2) – nine real soil profiles.

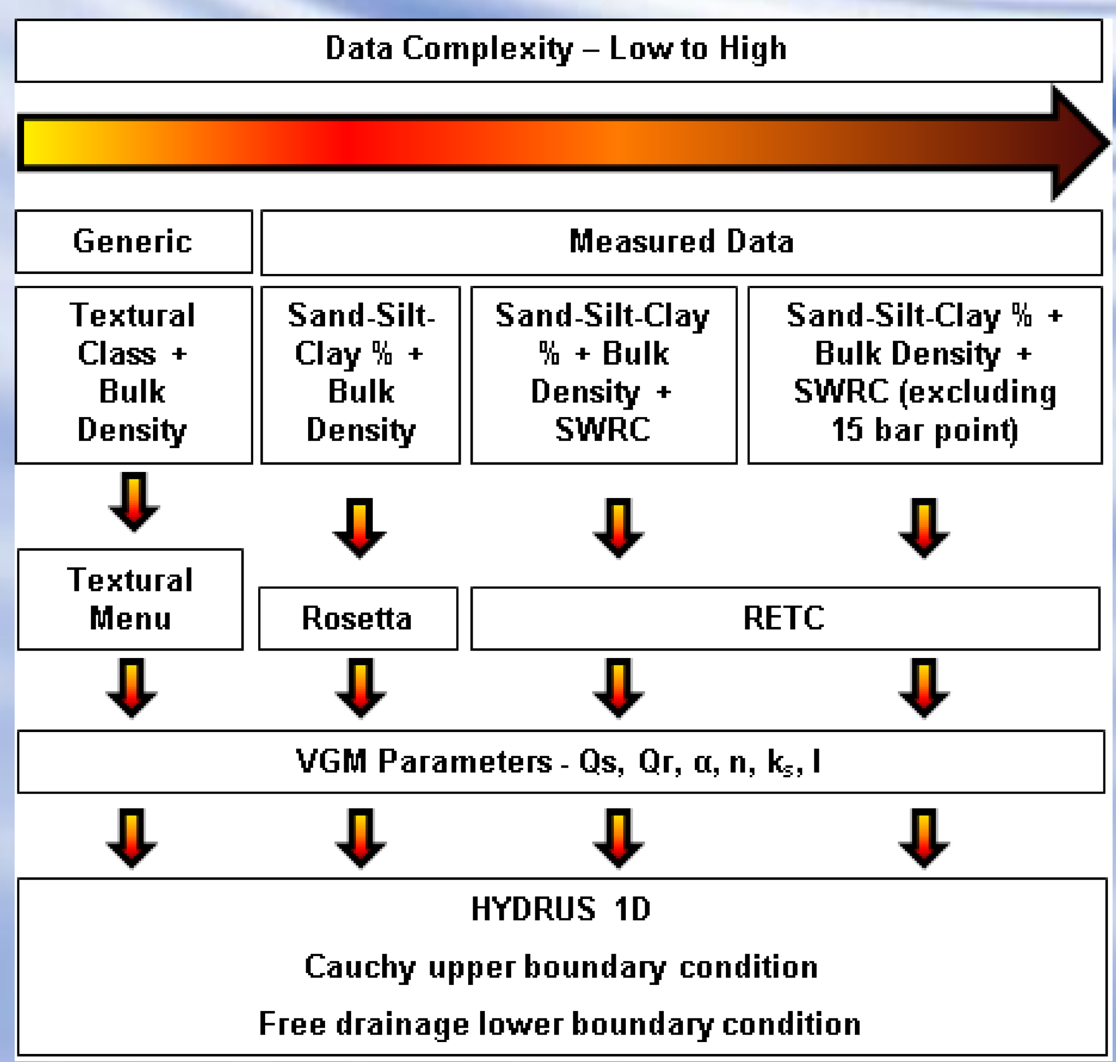

Fig. 2: Simple to complex input data for the 9 soil profiles

Results

- Daily meteorological data underestimated t_u (>**0.47 years)** compared to hourly resolution – hourly data were consequently used for soil parameter analysis.
- Typically small standard deviation in initial and peak breakthrough using various methods of parameter estimation (**<0.10 years** and **<0.28 years**, respectively).
- Regarding centre of mass and solute exit, standard deviation ranged between **0.03** and **0.24 years**, and **0.14** and **0.70 years**, respectively.
- Saturated assumptions dramatically underestimate t_u compared to simulations.

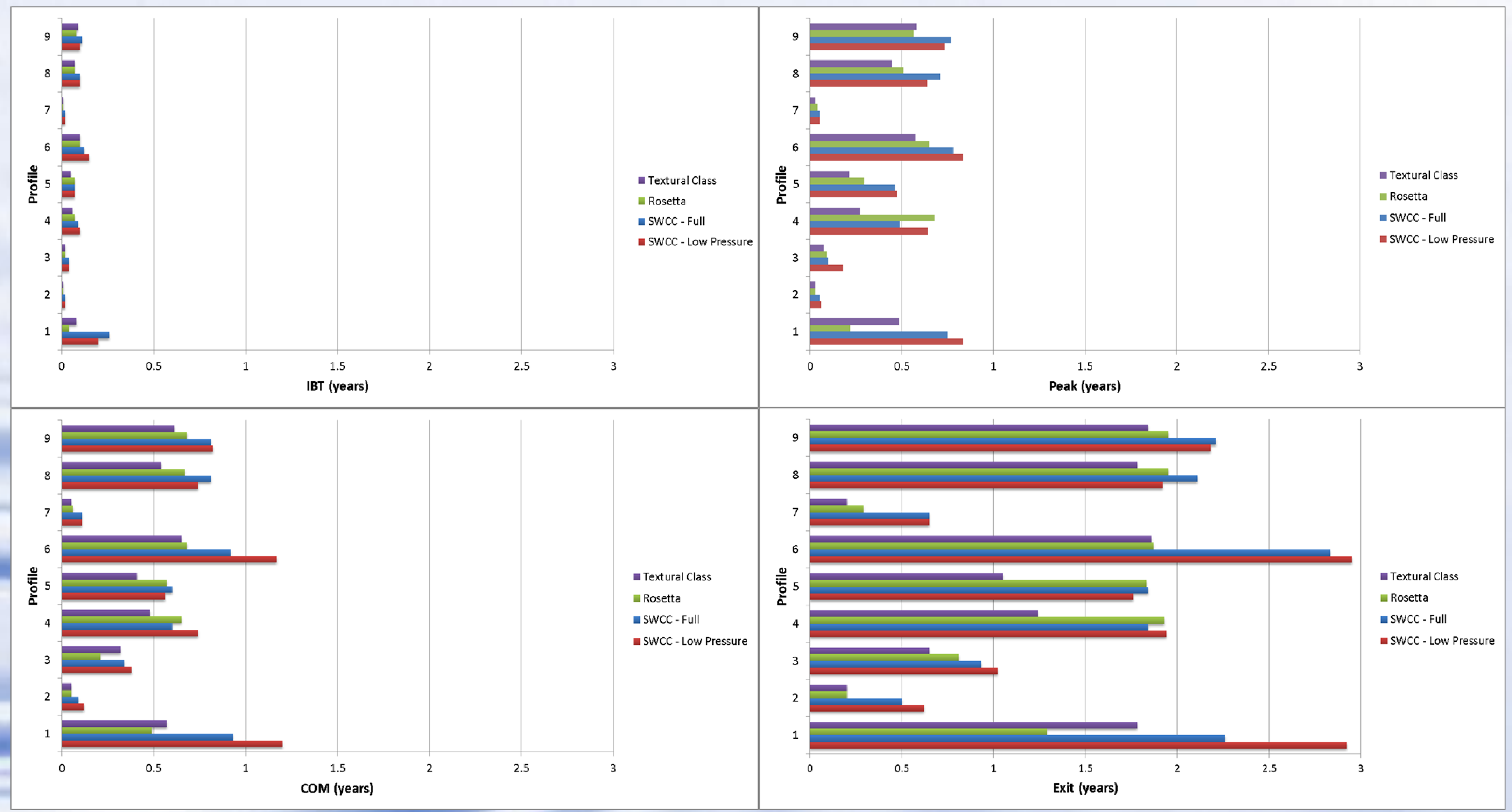

Fig. 3: Solute breakthrough at the base of the profiles; initial breakthrough (IBT), peak, centre of mass (COM) and solute Exit.

Conclusions

- Hourly meteorological data are preferable.
- For initial or peak breakthrough, generic soil data are sufficient, precluding the need for SWCC construction.
- For centre of mass (indicating the bulk effect of measures) or total solute exit, the SWCC should be measured.
- The challenging -15 bar pressure step can be excluded from the SWCC with minimal effect on t_u estimates – improving the speed and ease of analysis.
- These results should enable the judicious use of resources in calculating t_u using Hydrus 1D.
- Validation of these estimates against *in situ* tracer tests in two vulnerable watersheds is in progress.

References

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Acknowledgements

The authors gratefully acknowledge the funding supplied by the Teagasc Walsh fellowship Scheme, the Irish Geological Association and the International Association of Hydrogeologists – Irish Group.

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