Characterizing Contaminant Vapor Pathways using Geophysics

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Colorado School of Mines | Master's Thesis 2010 - 2012

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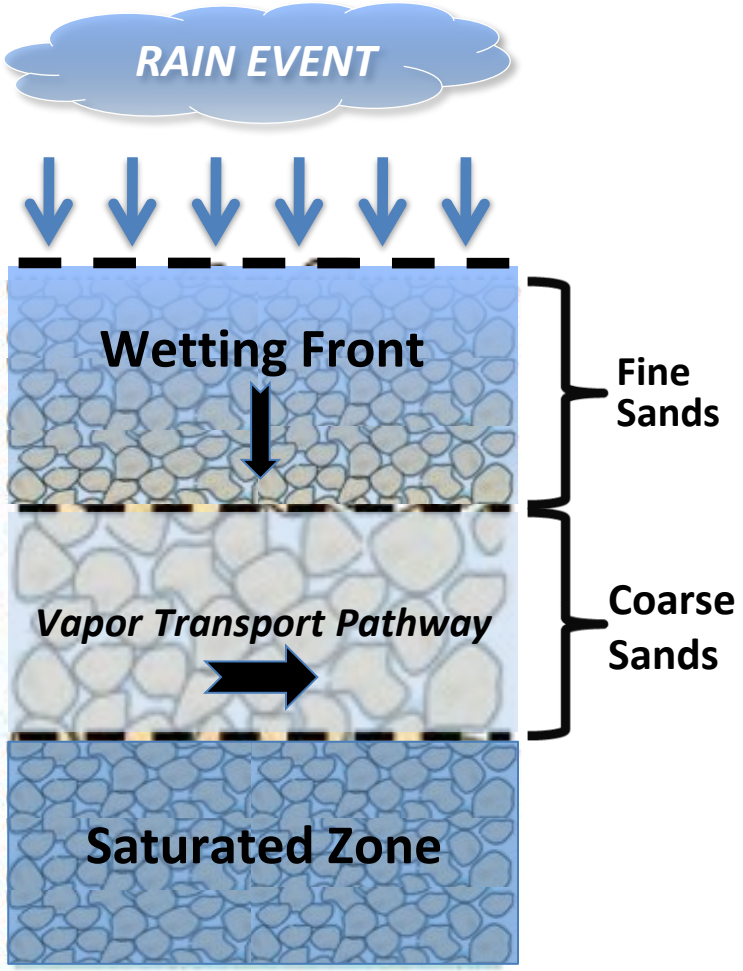
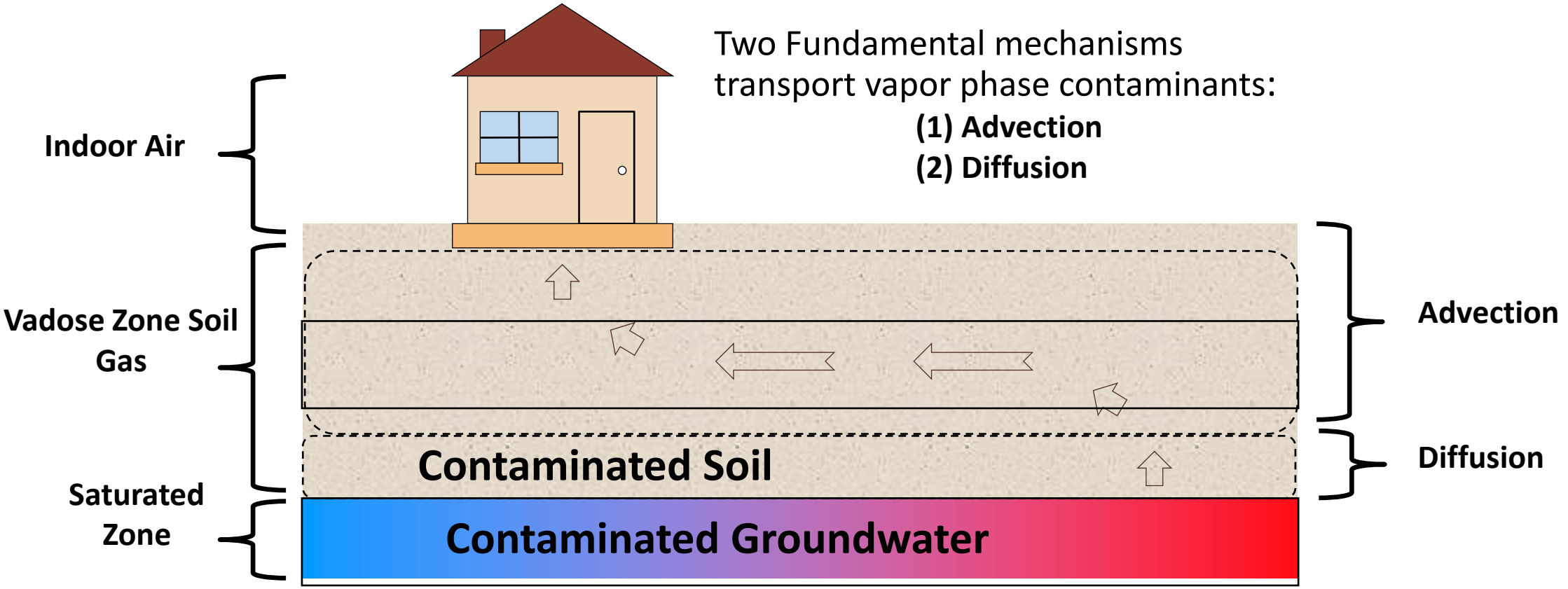
1) EXPERIMENTAL OVERVIEW

PHASE 1: BENCH-SCALE TESTS:
Design a physical model that captures representative elementary volume (REV)-scale VI process and allows for controlled experimental conditions.

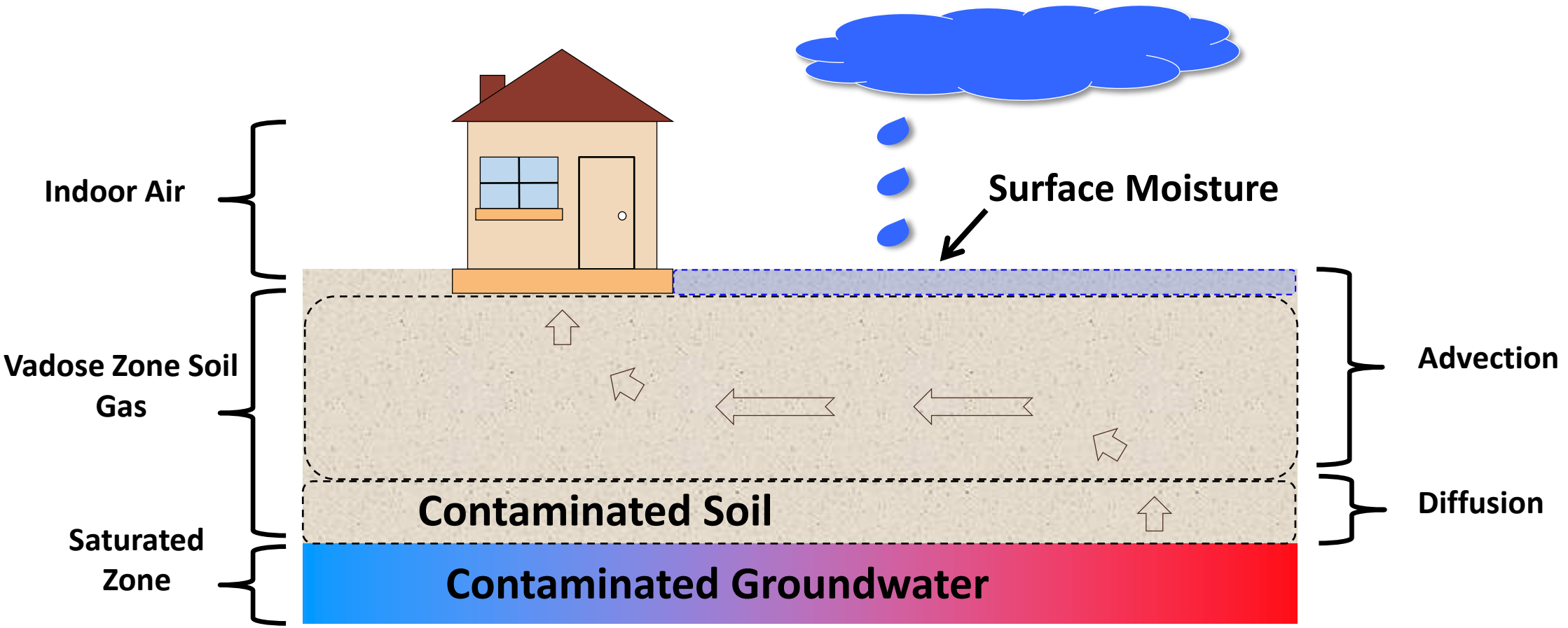
PHASE 2: FIELD-SCALE TESTS:
Upscale the evaluation and apply the REV-scale knowledge developed in the laboratory to show the practical application in the field.



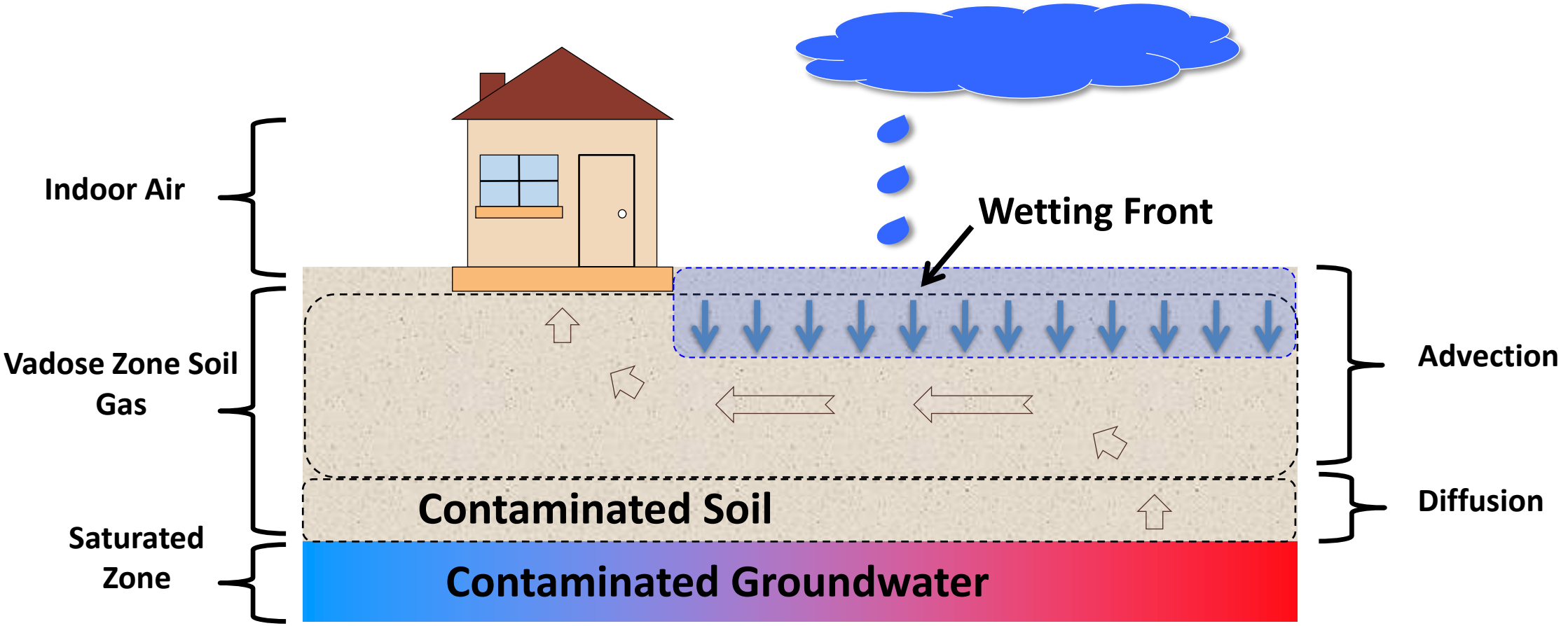
2) CONCEPTUAL MODEL



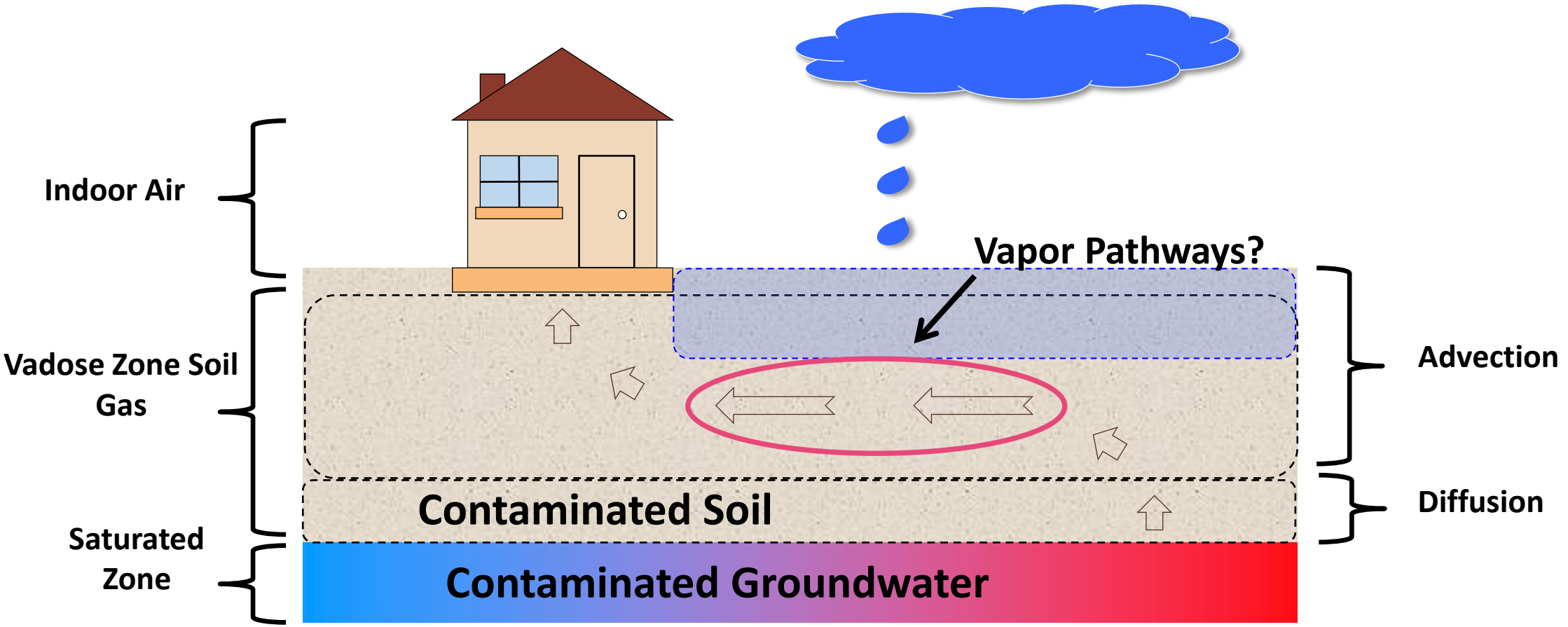
3) CONCEPTUAL MODEL



4) CONCEPTUAL MODEL



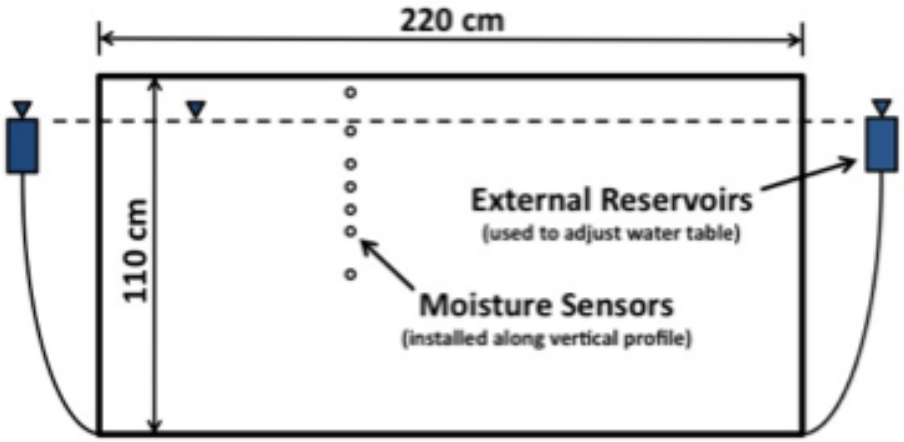
5) CONCEPTUAL MODEL

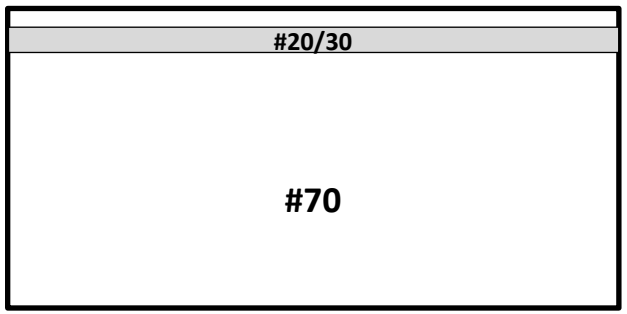


6) EXPERIMENTAL DESIGN

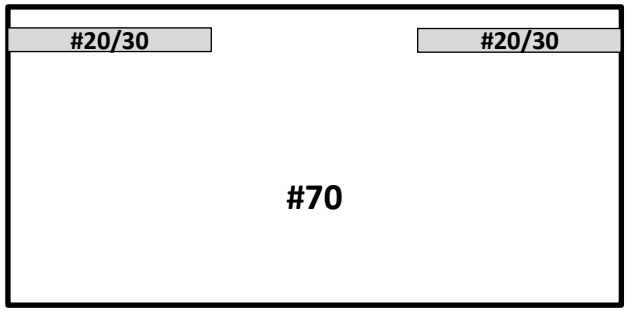
Experimental Apparatus:

- ❑ Bench-scale 2-D sand tank
- ❑ Moisture, temp, press, and EC sensors
- ❑ Three configurations of fine and coarse sands
- ❑ Variable water table elevations

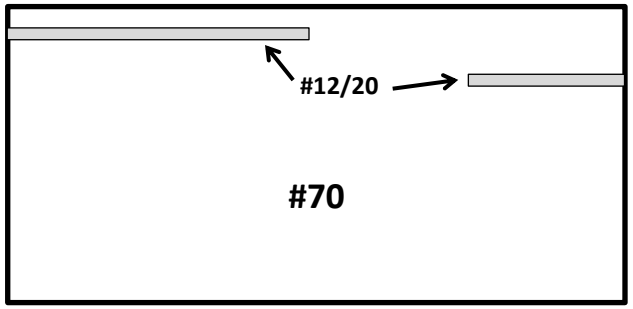




Configuration #1



Configuration #2

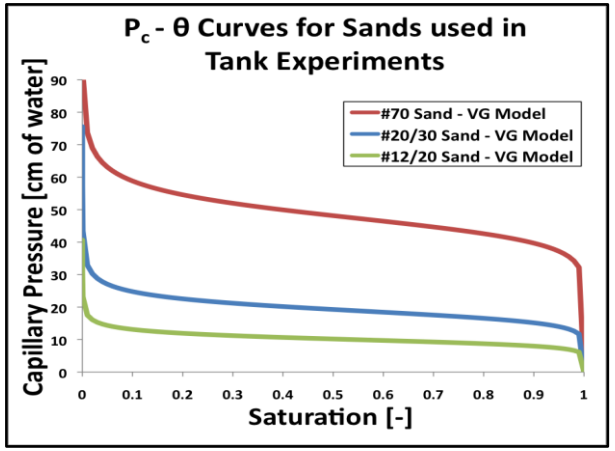


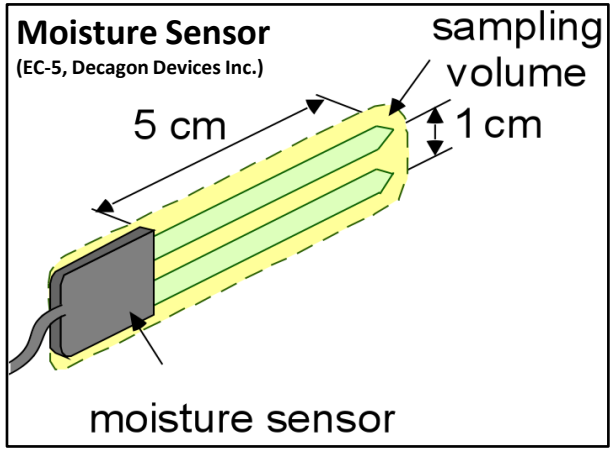
Configuration #3

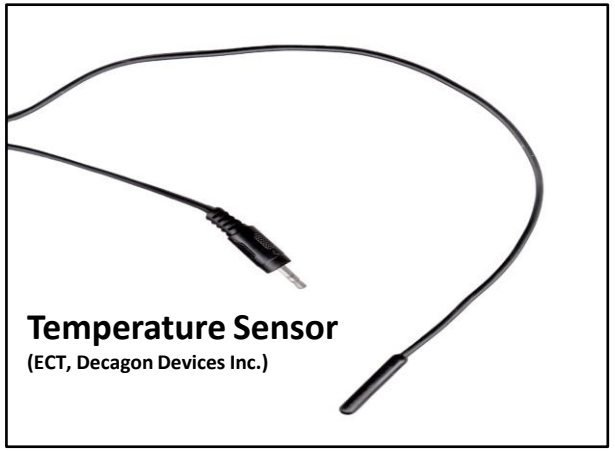
7) EXPERIMENTAL DESIGN

Materials and Methods:

- ❑ Laboratory-grade sands
- ❑ EC-5 soil moisture sensors
- ❑ ECT temperature sensors
- ❑ 5TE soil and water EC sensors
- ❑ SuperSting® ERT meter



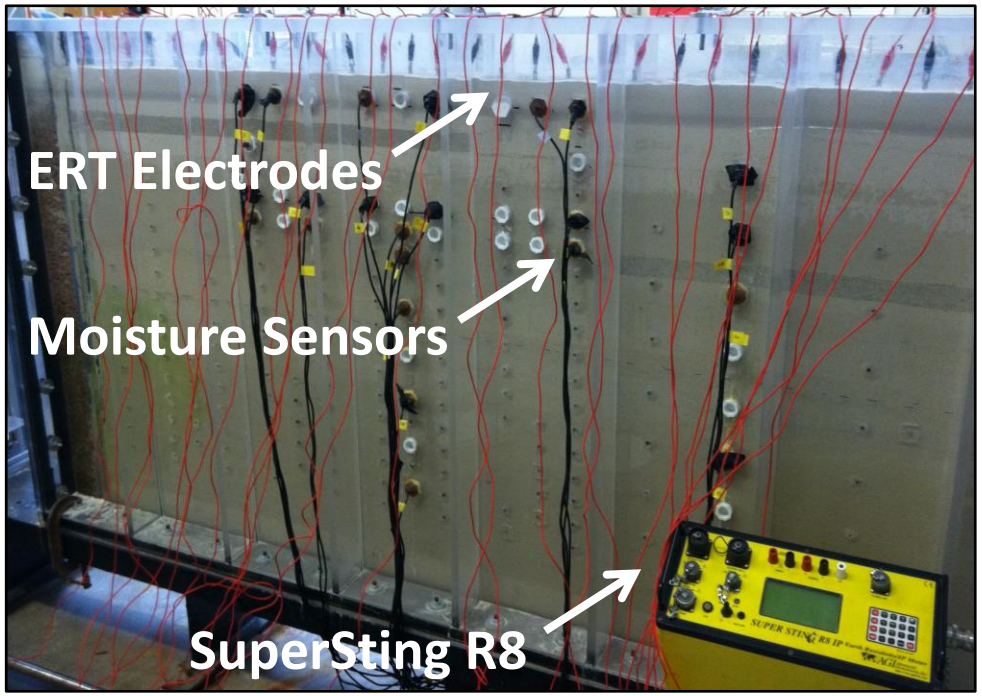


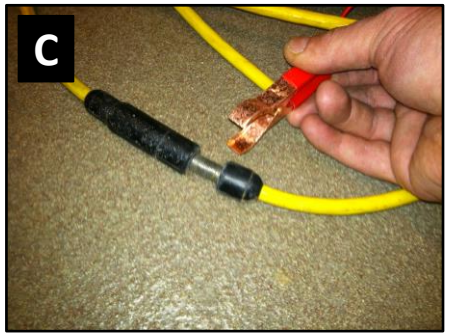


8) EXPERIMENTAL DESIGN

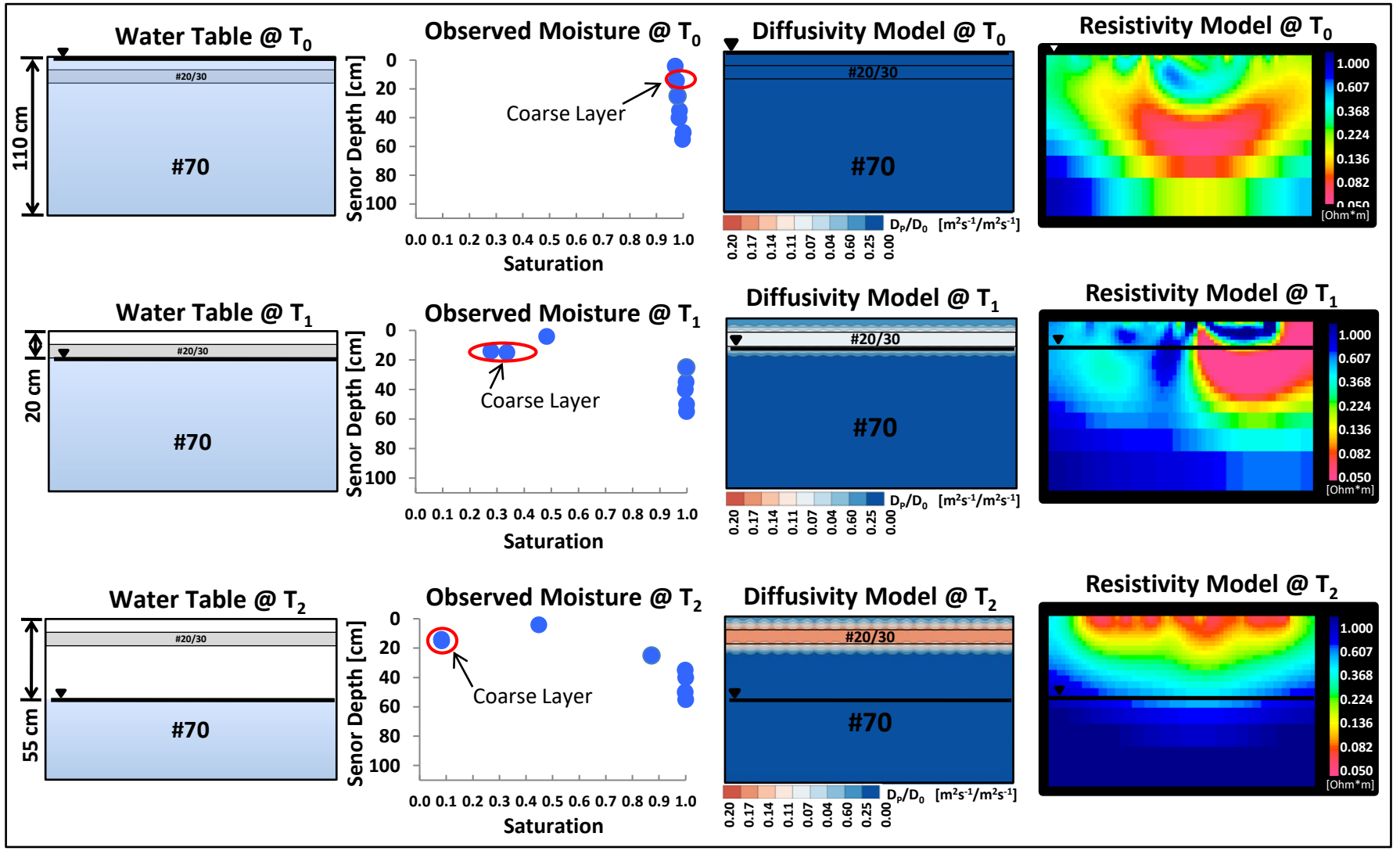
Experimental Procedure:

- ❑ Sand tank wet-packed
- ❑ ERT data was collected along surface
- ❑ Stainless steel electrodes used
- ❑ Custom 12-gaude electrical leads
- ❑ Moisture, temp, press, EC data collected

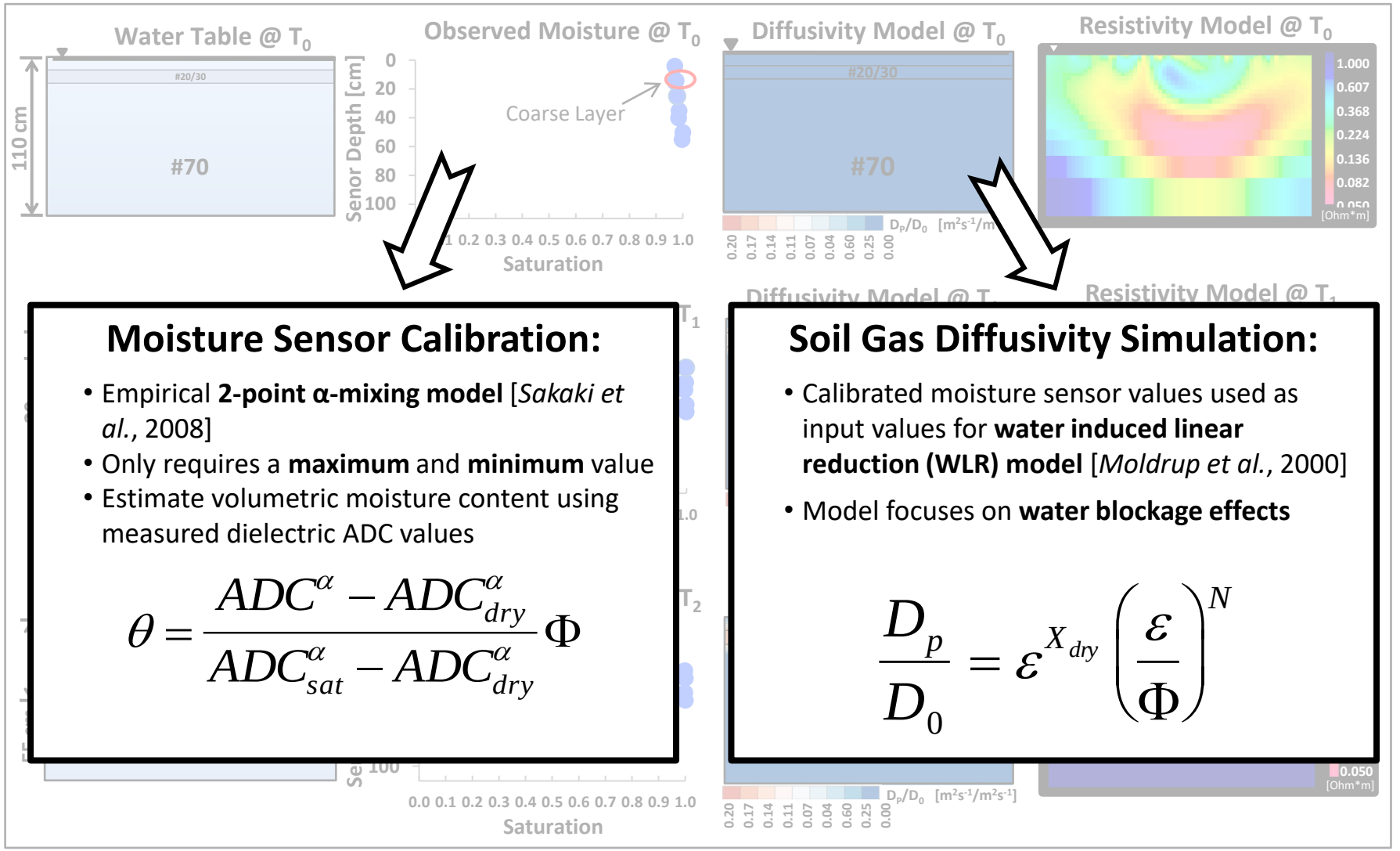




9) EXPERIMENTAL RESULTS



10) NUMERIC MODELS



Moisture Sensor Calibration:

- Empirical **2-point α-mixing model** [*Sakaki et al.*, 2008]
- Only requires a **maximum** and **minimum** value
- Estimate volumetric moisture content using measured dielectric ADC values

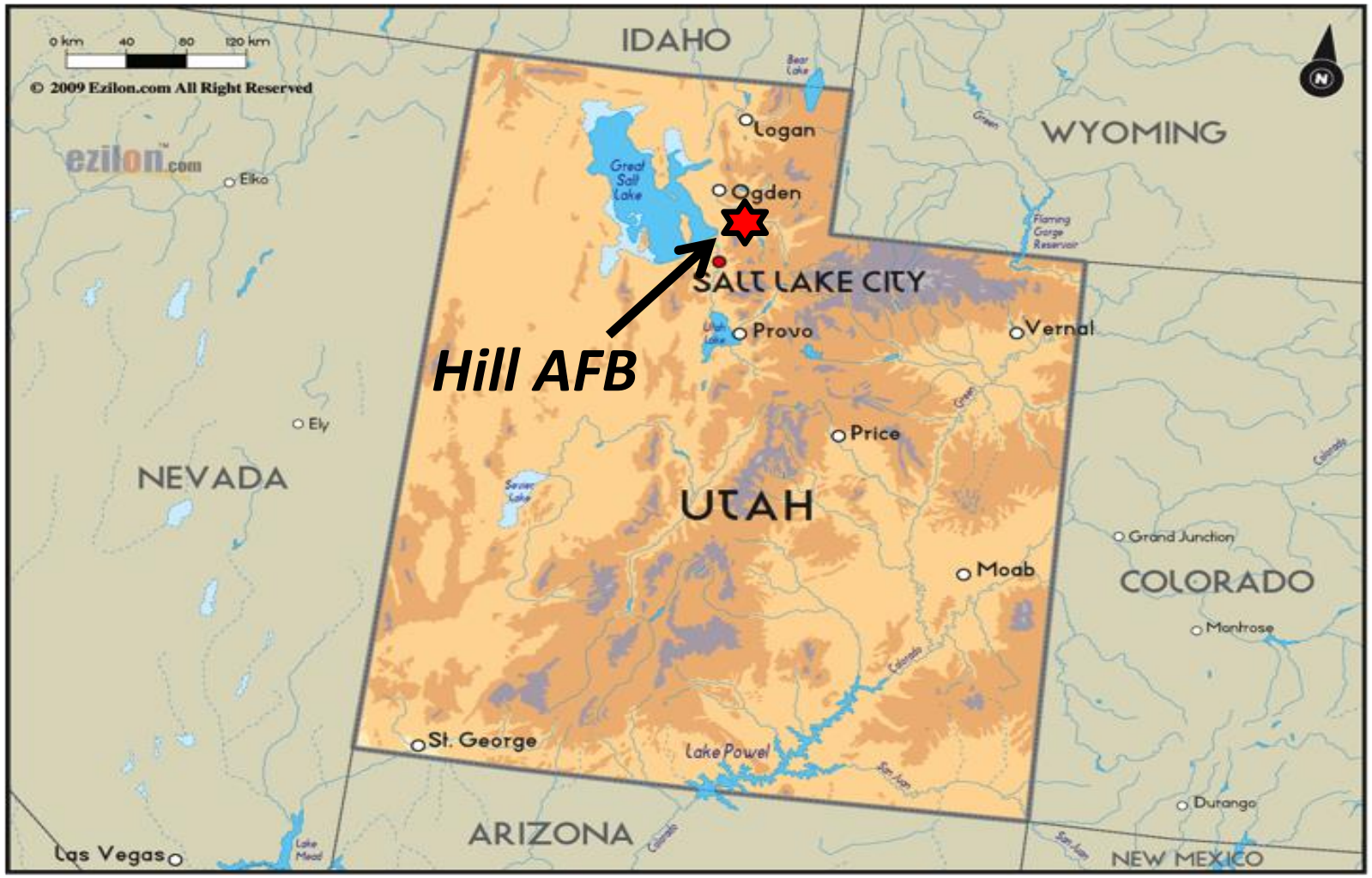
$$\theta = \frac{ADC^{\alpha} - ADC^{\alpha}_{dry}}{ADC^{\alpha}_{sat} - ADC^{\alpha}_{dry}}\Phi$$

Soil Gas Diffusivity Simulation:

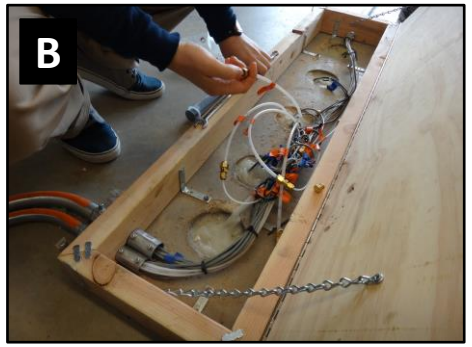
- Calibrated moisture sensor values used as input values for **water induced linear reduction (WLR) model** [*Moldrup et al.*, 2000]
- Model focuses on **water blockage effects**

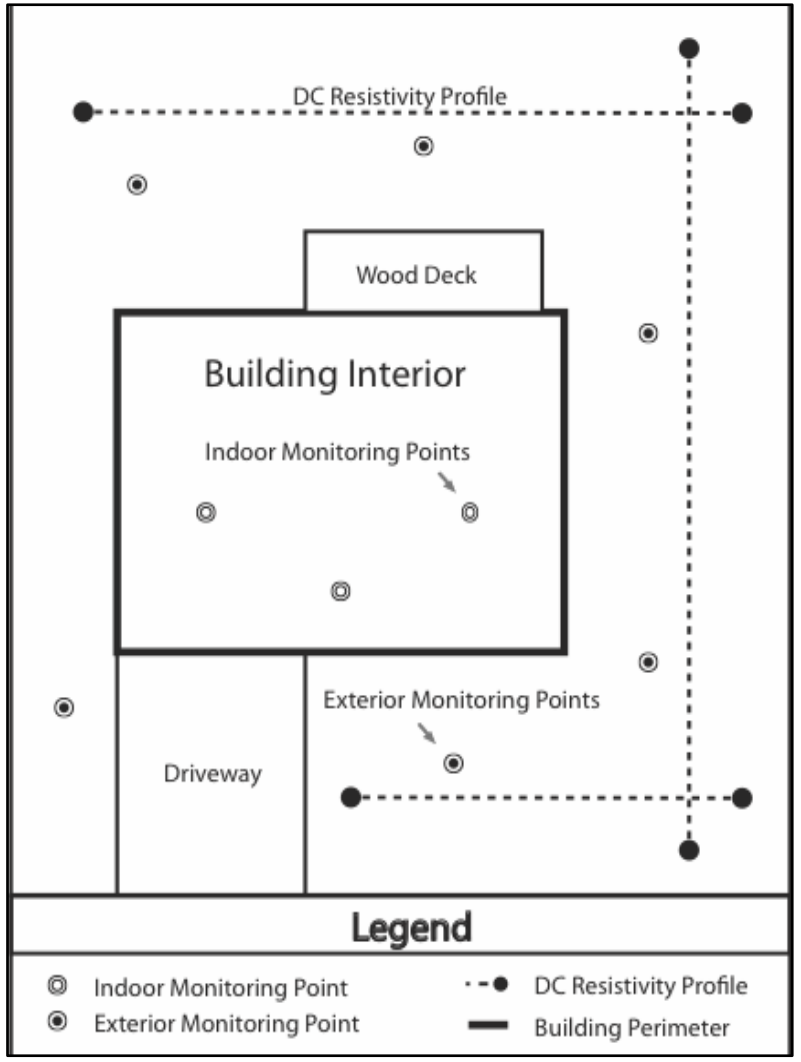
$$\frac{D_p}{D_0} = \varepsilon^{X_{dry}}\left(\frac{\varepsilon}{\Phi}\right)^{N}$$

11) FIELD-SCALE TESTS



12) MATERIALS & METHODS

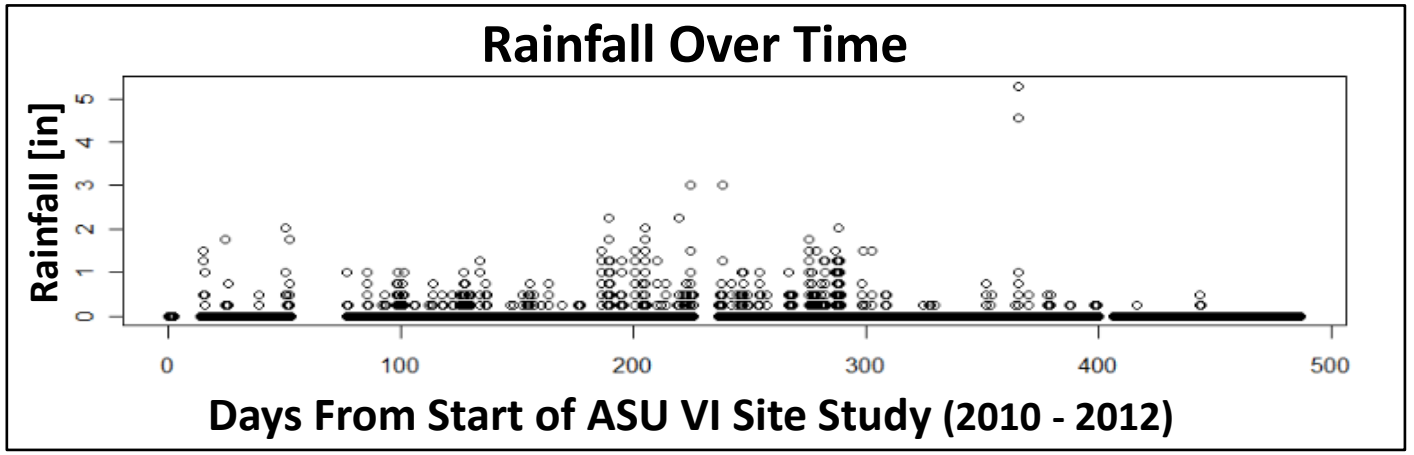




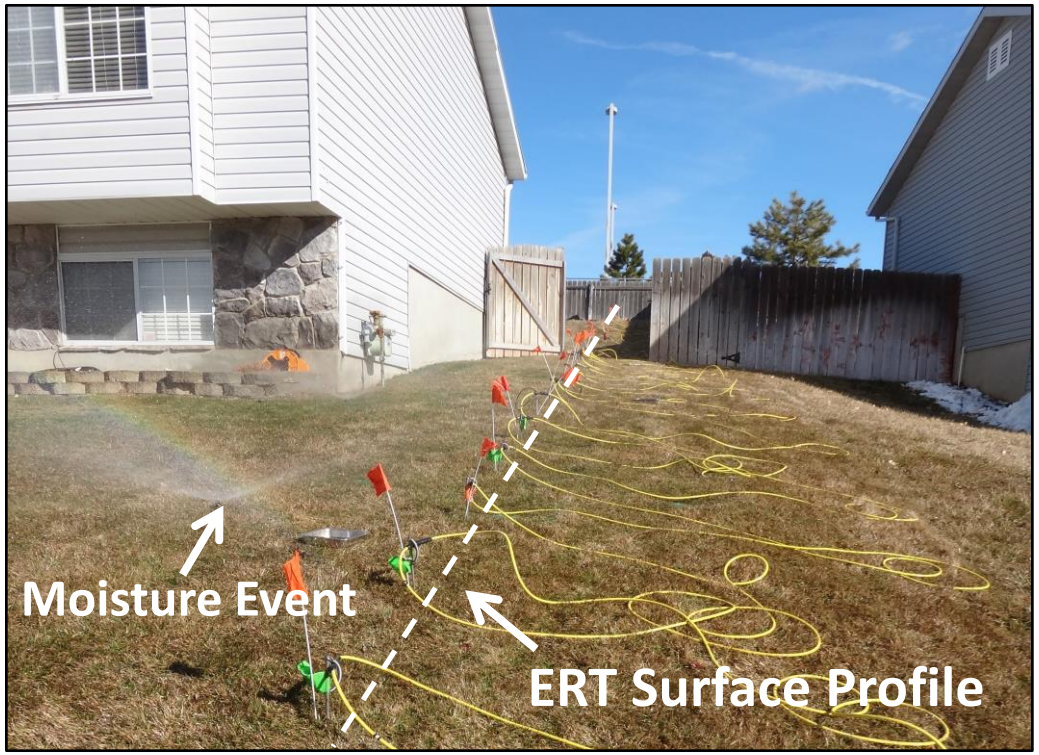
13) EXPERIMENTAL DESIGN

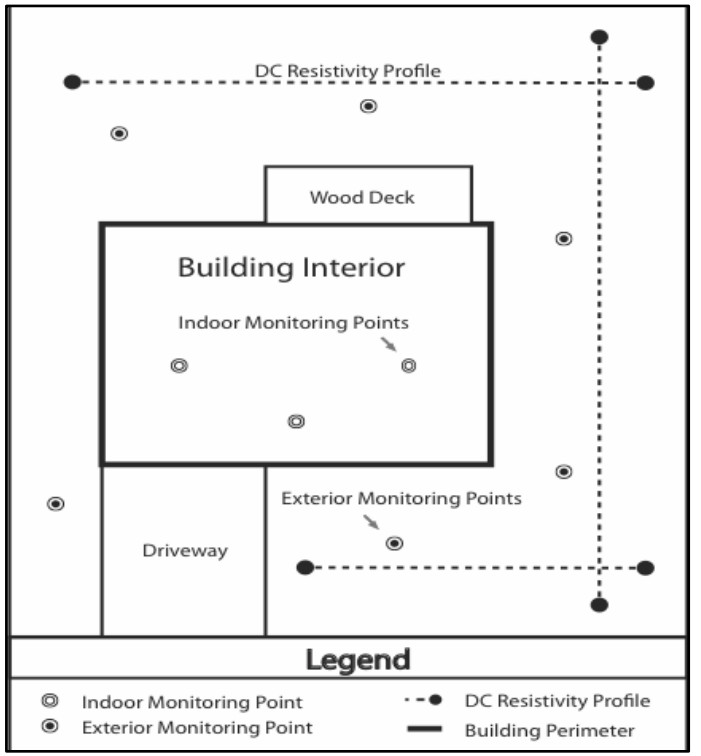
Experimental Approach:

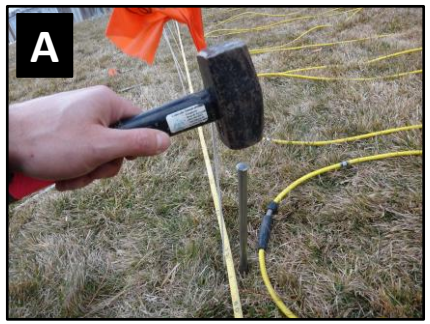
- ❑ Create an artificial rain event (using sprinklers)
- ❑ Monitor the induced wetting front using geophysics
- ❑ Track VI signal via on-site gas chromatograph/mass spec
- ❑Develop a joint-interpretation using “soft” and “hard” data

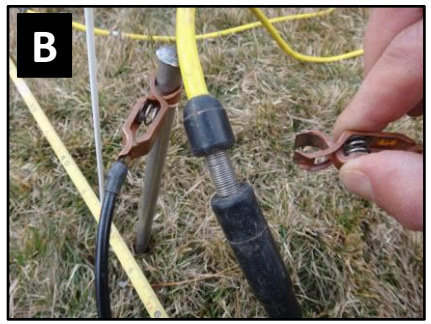


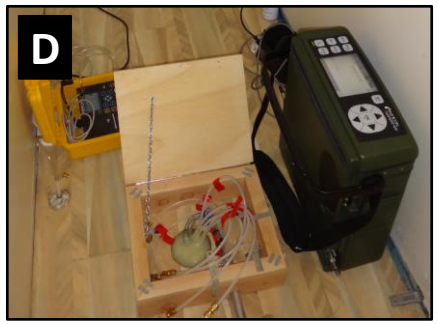
14) EXPERIMENTAL DESIGN











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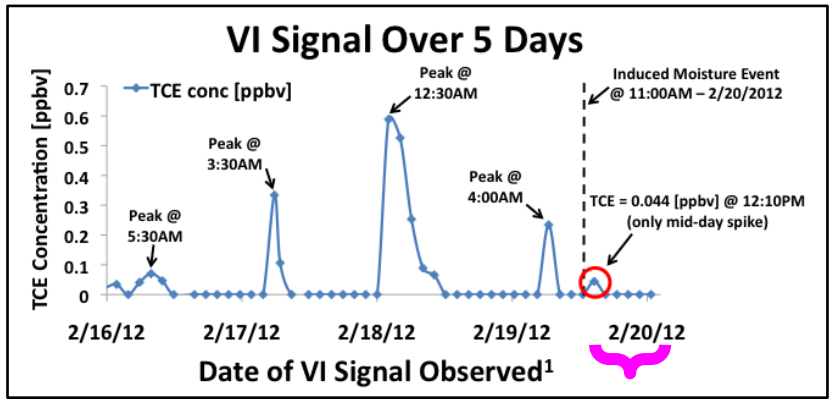

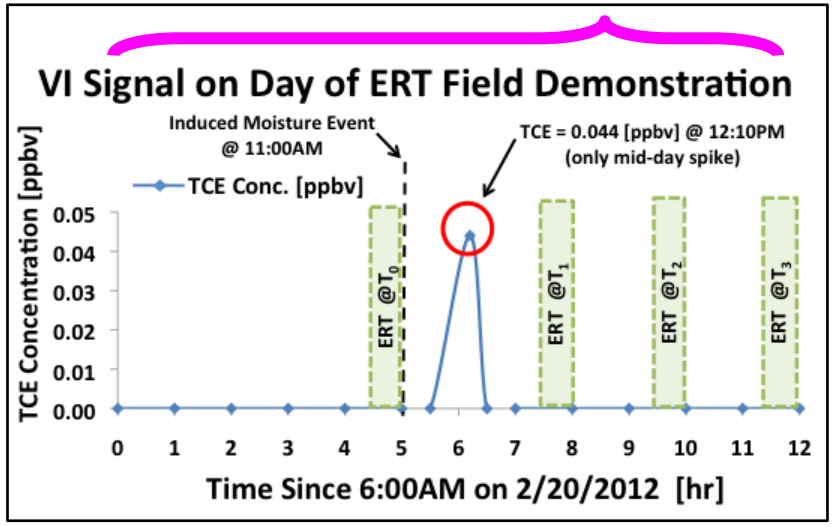

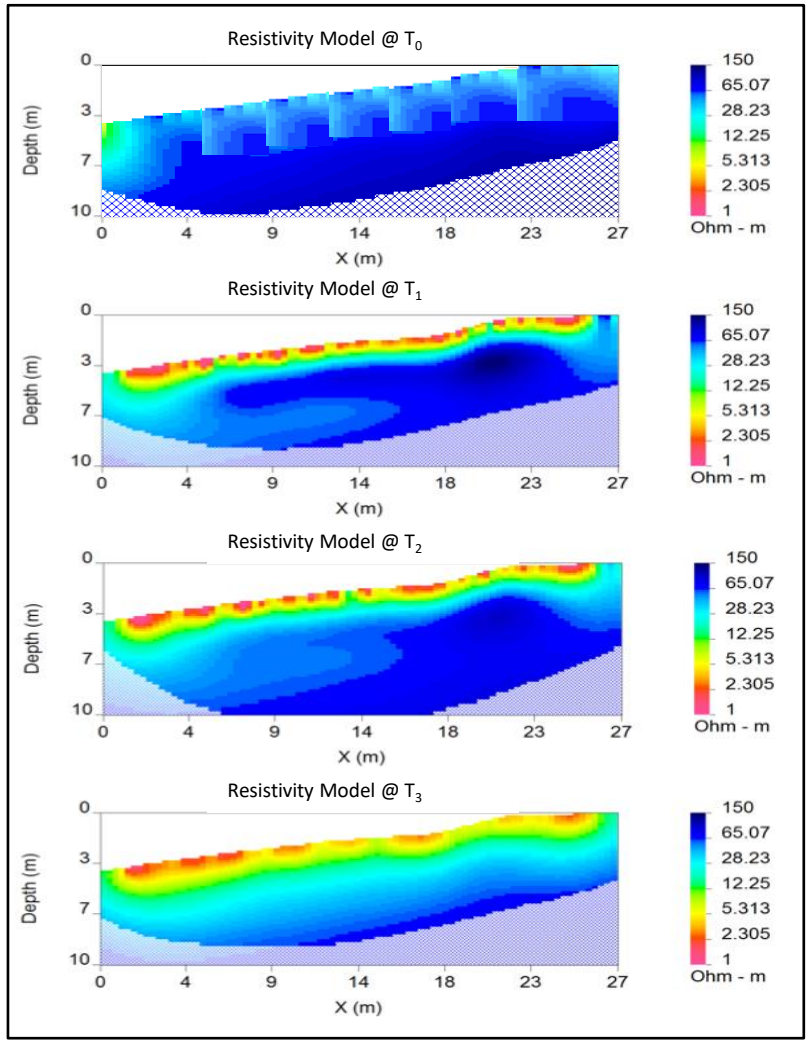

16) ACKNOWLEDGEMENTS

Principal Investigator:

Dr. Tissa Illangasekare – Colorado School of Mines/CESEP Laboratory Director

Co-Investigator:

Dr. Yaoguo Li – Colorado School of Mines/Geophysics Department

Colorado School of Mines Students:

Dr. Kathleen Smits, Dr. Toshi Sakaki, Benjamin Petri, and Christopher Jenkins – Colorado School of Mines/CESEP Laboratory

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