Water Movement During Groundwater Recharge: Characterizing the Subsurface

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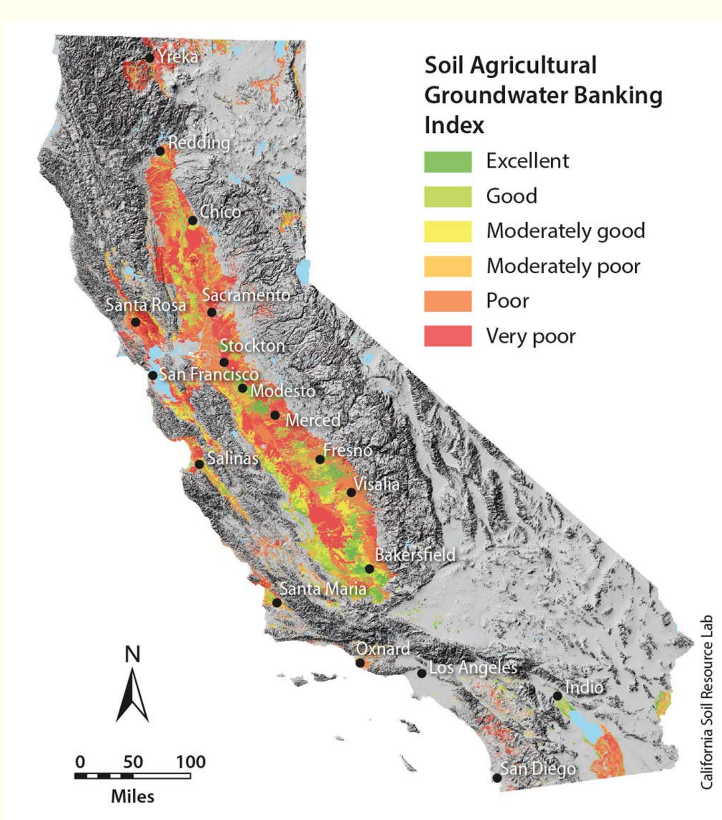
INTRODUCTION

Sustainable groundwater and surface water management is a priority for all growers in the Central Valley of California, including almond growers. One potential tool to achieve sustainable water management is the use of "groundwater banking" where excess surface water is applied to land in the winter, infiltrated, and stored in local groundwater aquifers for reuse during the summer irrigation season. For several years now, strategies for groundwater banking have been investigated by various researchers including the UC Davis team funded by the Almond Board. The UC Davis projects are examining infiltration methods and the potential effects of winter water infiltration on almond trees. In this new project, we are working closely with the UC Davis projects in order to investigate how the water applied to the almond orchards infiltrates past the root zone and enters the aquifer for storage. We will also conduct preliminary analyses examining how the quality of the water may change between the application on the field and the eventual recovery of the banked water at local wells. The approaches used will include geophysical imaging of the subsurface, geochemical and isotopic measurements of applied and collected water, and reactive transport modeling projections. The work reported here focuses mostly on the geophysical imaging and the isotope tracer experiments.

KNOWLEDGE OF SOIL AND SUBSURFACE PROPERTIES

One critical component of predicting the impact of different water management activities is understanding the chemical and physical properties of the soil and subsurface sediments at a particular location. Because of their presence on the surface and long–term efforts in the characterization of soil properties, there is more detailed knowledge of surface soils at any particular location than of the associated subsurface sediments. For example, the U.C. Davis developed Soil Agricultural Groundwater Banking Index (SAGBI) uses, among other things, this detailed knowledge of soil texture to provide an index that is both wide ranging (all of California central valley) and detailed (fine scale resolution).



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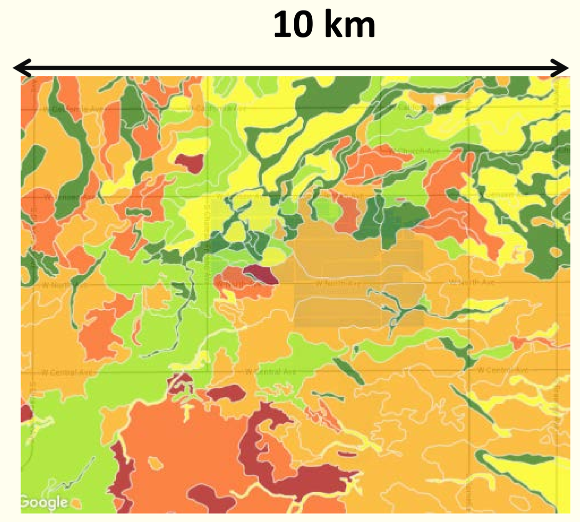
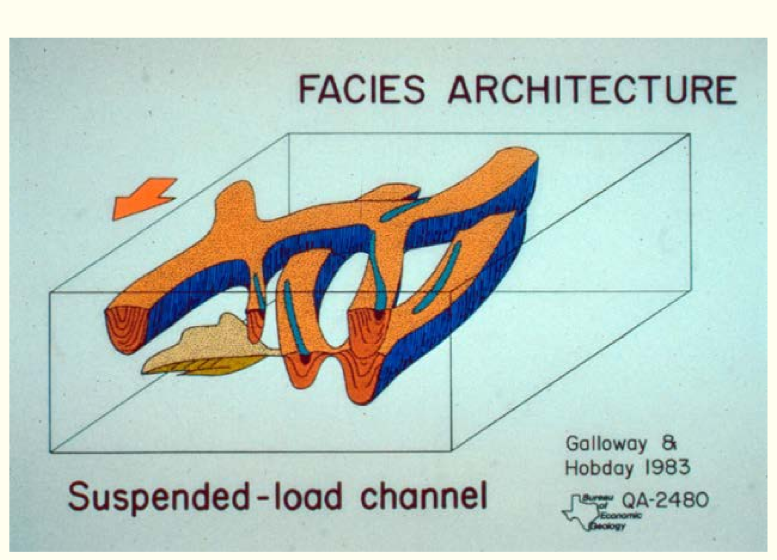
Knowledge of soils is both spatial extensive and detailed and illustrates the highly local nature of suitable groundwater infiltration locations





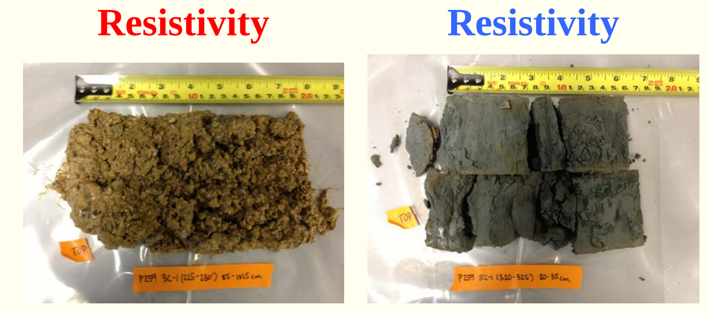
Subsurface structure is also highly complex and important in order to have a predictive understanding of 'local' groundwater dynamics. However, generally subsurface structure is less well known than surface soil characteristics

Although enormous amounts of data have been gathered and interpreted regarding the structure of the subsurface, this knowledge is still generally at a level that is more course than our knowledge of soils and more course than ideal for the evaluation of particular locations as groundwater recharge points.

Electrical Resistivity Tomography

Data Collection: Current is put into the ground with a series of electrodes

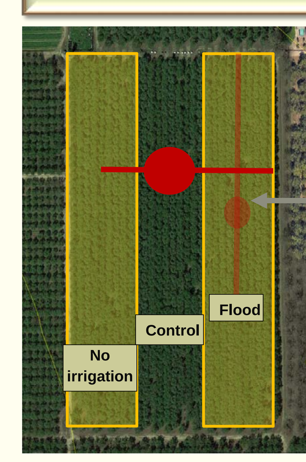
High Electrical Resistivity | **Low Electrical Resistivity**



High Permeability | **Low Permeability**

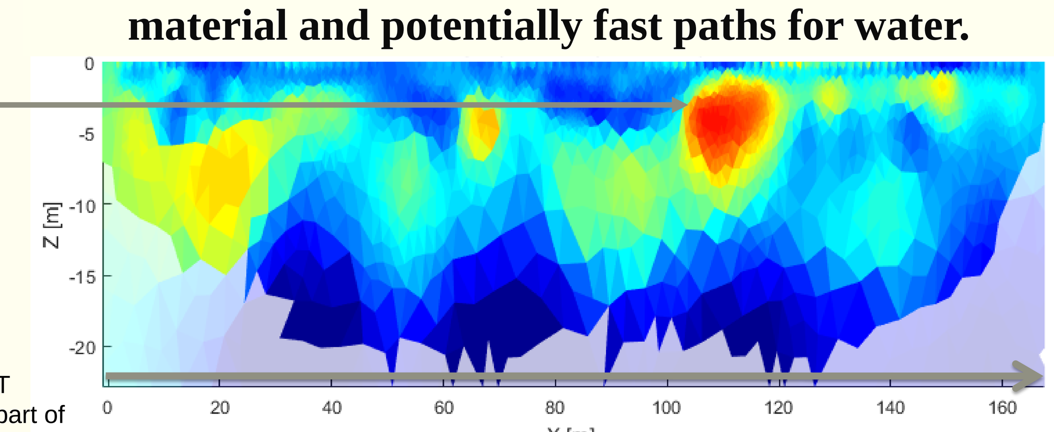
Electrical Resistivity Tomography (ERT) provides an image of below ground structure based on the electrical properties of the material. In general, coarser materials (sand) have higher resistivity (red) and more fine grained materials (clay) have lower (blue) resistivity

Modesto Time Lapse Imaging

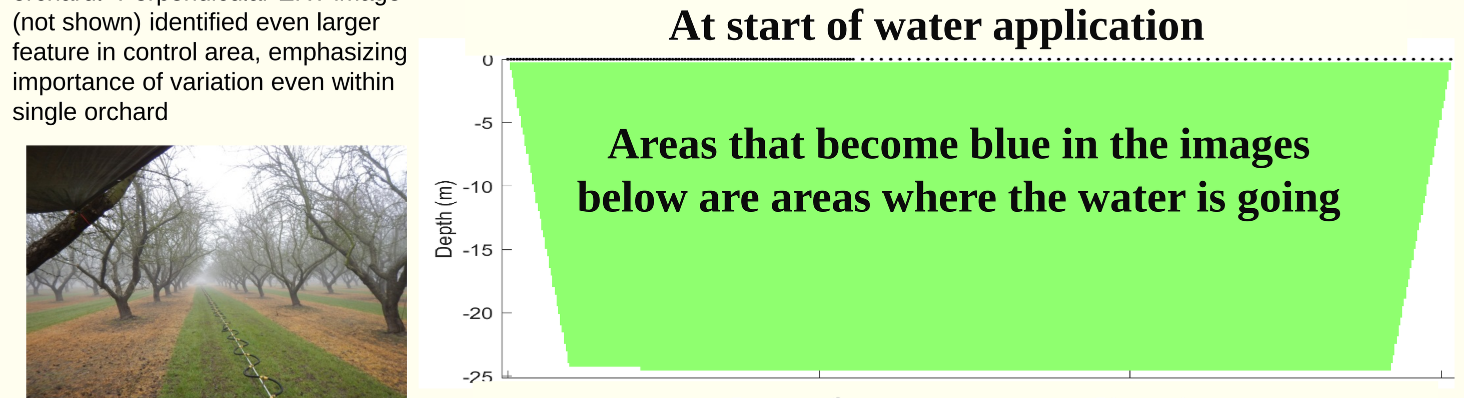


Location of large red area on ERT image shown as red dot in flood part of orchard. Perpendicular ERT image (not shown) identified even larger feature in control area, emphasizing importance of variation even within single orchard

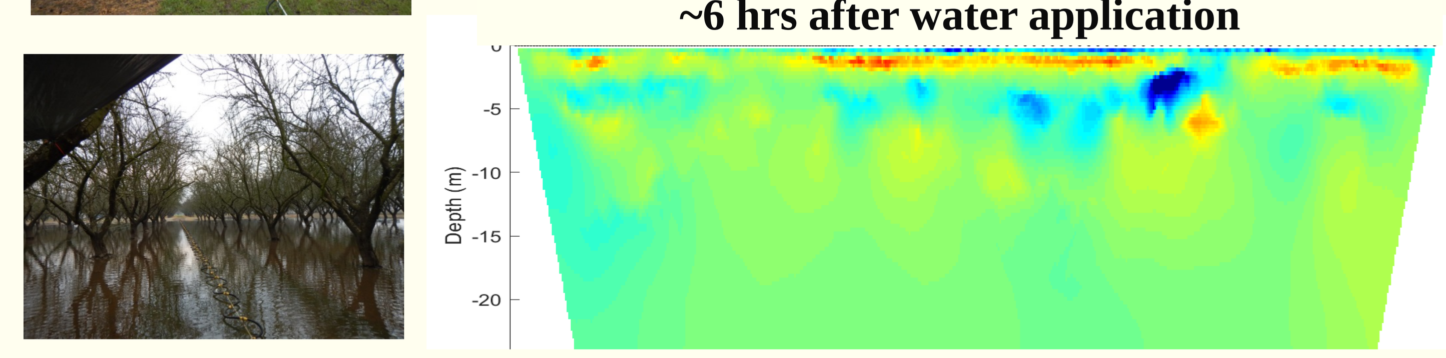
Modesto 1: Baseline image. Red areas are sandier material and potentially fast paths for water.



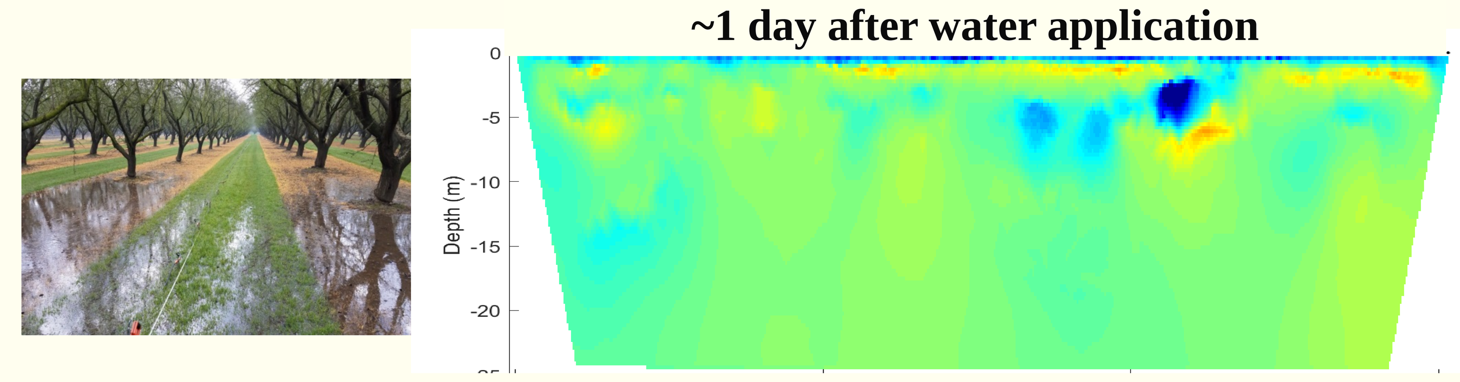
At start of water application



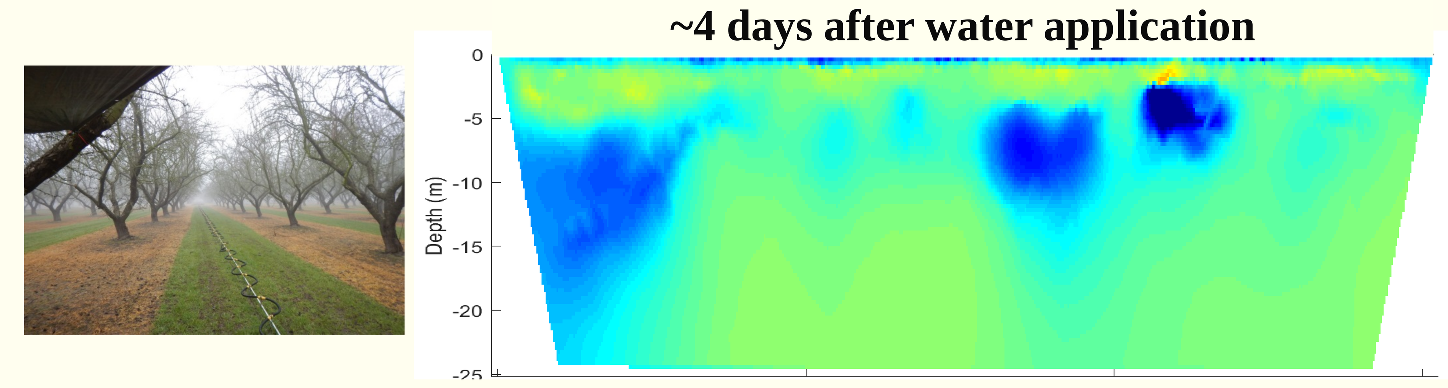
~6 hrs after water application



~1 day after water application

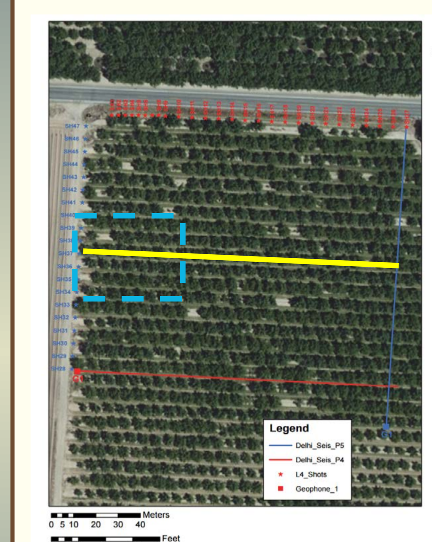


~4 days after water application

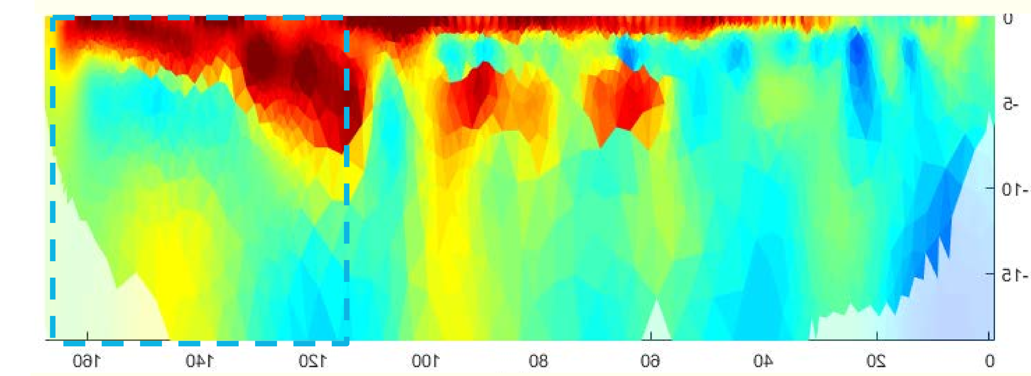


Time lapse images show the importance of texture in determining where the water flows in the subsurface. Areas that become more blue are becoming more wet. These are the same areas identified as courser material in the baseline image (red areas in top image).

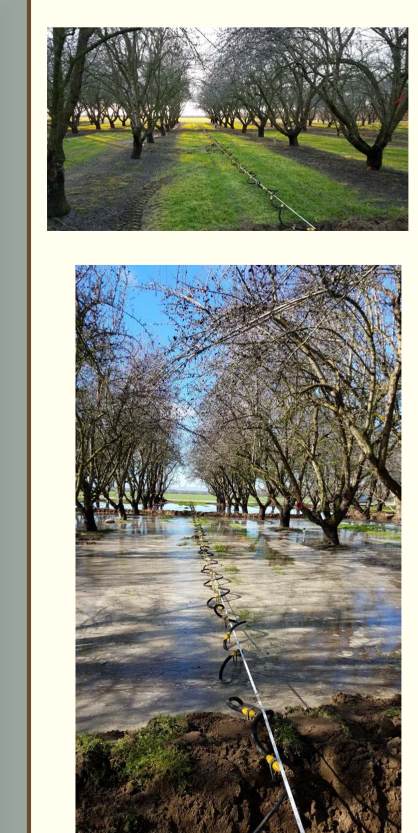
Delhi Time Lapse Imaging



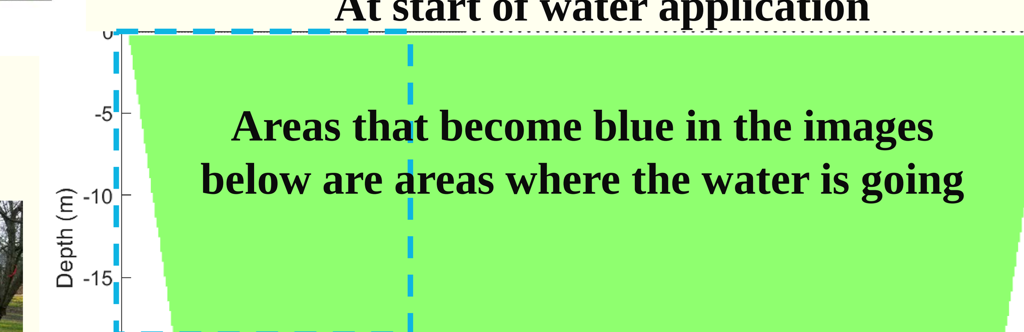
Delhi 1: Baseline image. Red areas are potentially sandier areas



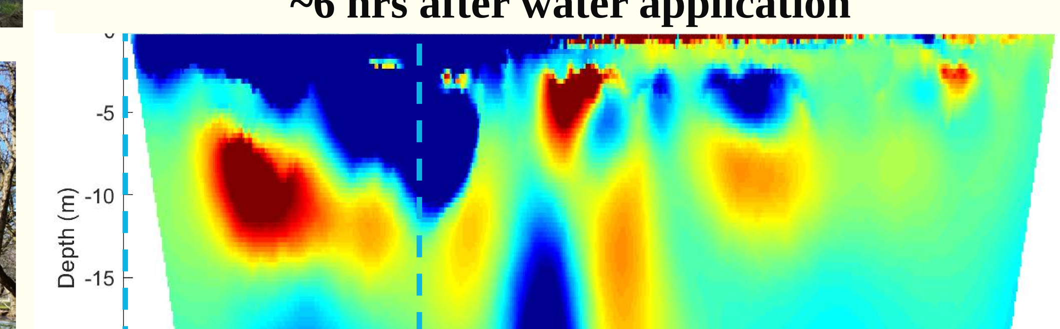
Blue box shows flooding test area on areal photo and on ERT images



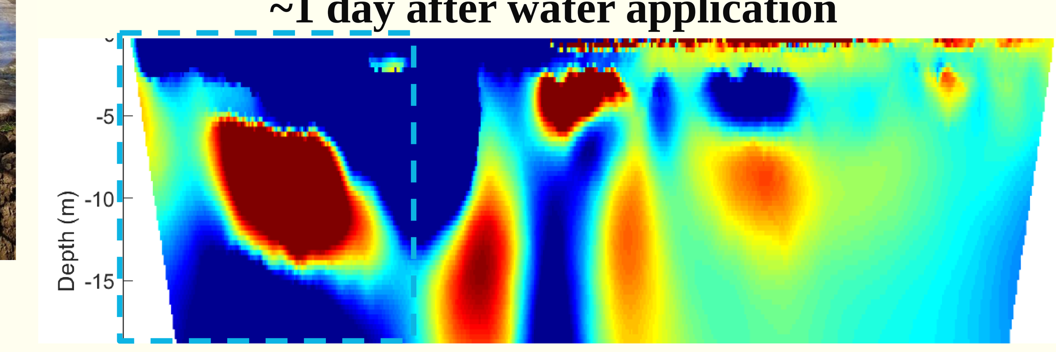
At start of water application



~6 hrs after water application

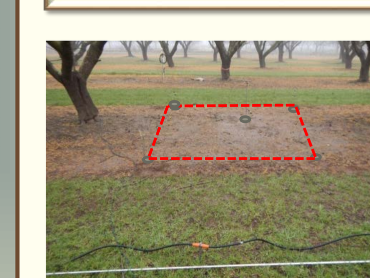


~1 day after water application

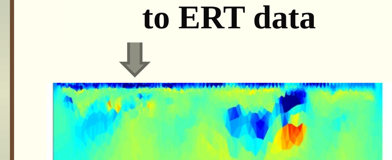


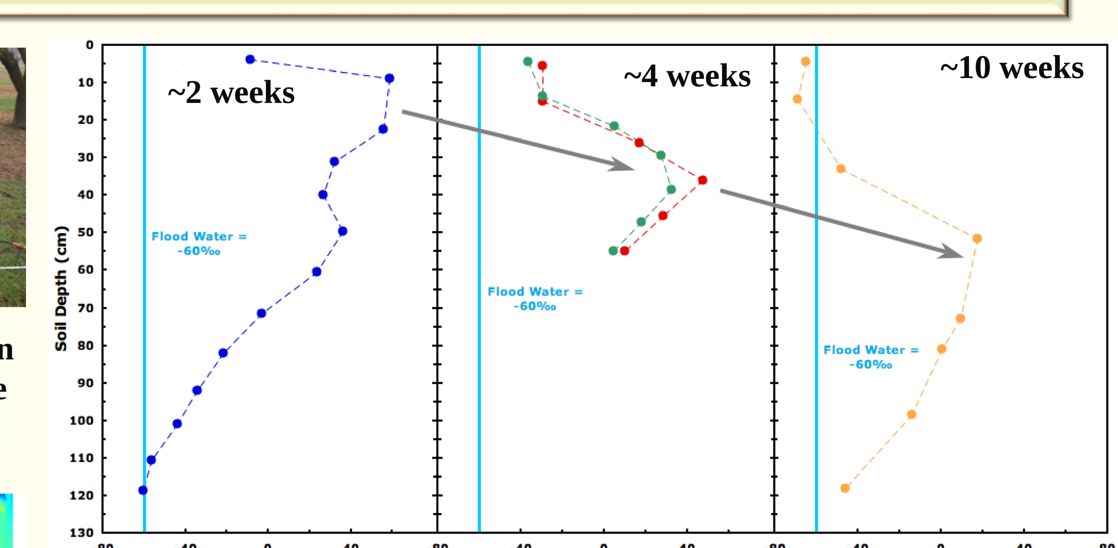
Significantly faster water infiltration to depth which is consistent with the sandier soils. Interestingly, large changes in moisture outside of test flooding area emphasizing the important of horizontal movement of water even in short time periods and still relatively shallow.

Isotope Tracking



Approximate location of tracer test relative to ERT data





Application of isotope tracer, D_2O, with water application shows less movement than expected based on the amount of water applied, which is consistent with its location on ERT line away from most dramatic moisture changes. This potentially further emphasizes the importance of fast flow paths for water in getting into the subsurface and can be used to test models of contaminant transport.

Acknowledgements

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