Soil Science of Groundwater Flow
Weaknesses of MODFLOW Water Modeling

Presented to

District Representatives
Groundwater Management Area 12
Post Oak Savannah GCD
Fayette County GCD
Lost Pines GCD
Mid-East Texas GCD
Brazos Valley GCD

Milano Civic Center
120 west Avenue E
Milano, Texas

by

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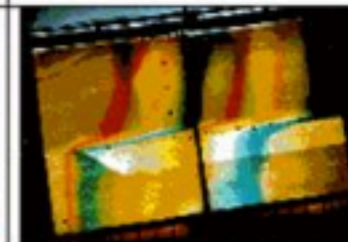
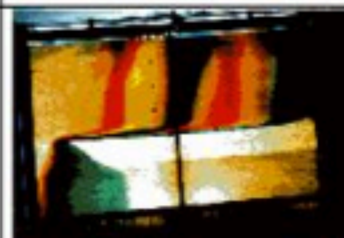
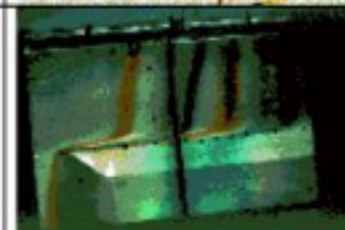
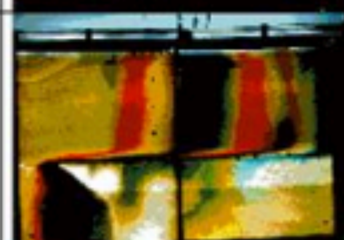
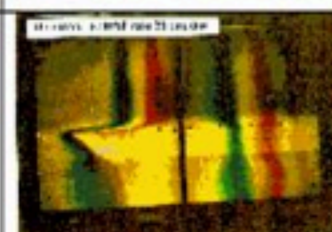
Effect of Finger Funnel Flow on Estimated Recharge Rates

Surface water does not infiltrate nor redistribute uniformly into soils and groundwater structures, such as aquifers, springs, streams, and water tables. It follows natural and man made preferential flow paths called finger funnel flow micropores and macropores.

Finger funnel flow paths constitute significant cumulative connections between surface water and groundwater in the soils.

IMAGES ON FUNNEL FLOW

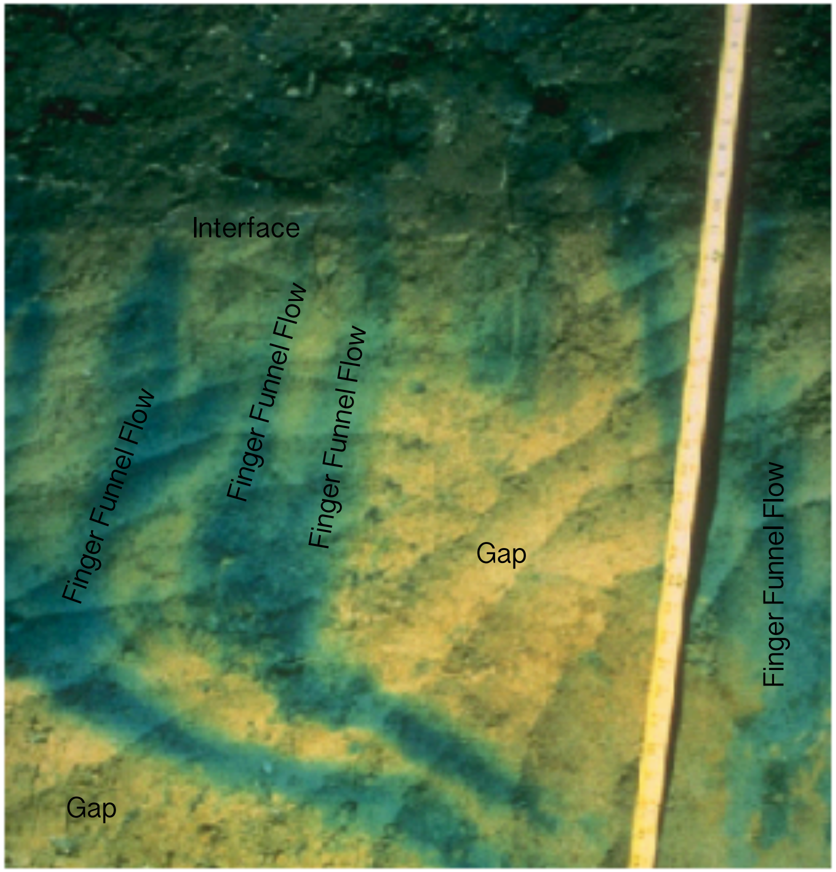
Small scale laboratory modeling of finger funnel flow infiltration

Flow / Slope	120 mm day^{-1}	280 mm day^{-1}	680 mm day^{-1}
11.7°			
7.1°			
3.5°			
0°			

Effect of Finger Funnel Flow on Estimated Recharge Rates

Surface water does not percolate through soils and groundwater uniformly into aquifers, springs, streams, and water tables. It follows natural and man made preferential flow paths. Some of the flow paths are called finger funnel flow. This non-uniform flow may affect sampling collection and data.

These finger funnel flow paths may create gaps in the vadose zone that may be hit by monitoring wells when sampling for tracers to estimate recharge rates and water age. They may also form significant cumulative connections between surface water and groundwater structures.



Legend:
Gap = Infiltration Gaps
Interface = Material Interface

Figure 2. Finger funnel flow (Source: Soil and Water Lab, Cornell University)

Redirected Finger Funnel Flow infiltration and redistribution with unstable flow at layered soil profiles

Surface water does not percolate through soils and groundwater uniformly into aquifers, springs, streams, and water tables. It flows through natural and man made preferential flow paths called finger funnel flow micropores and macropores. Additionally, water may be channeled laterally by obstructions in the soil profile like coarse textured layers or lenses. Vertical flow is altered by interfaces between soil materials of differing particle size.

Water will move in response to the net forces acting upon it from all directions, and this is not always in a uniform direction or manner. Water models can not comprehend this activity. They require saturated conditions with uniform orthagonal (linear) flow.

These finger funnel flow paths may create gaps in the vadose zone that may be hit by monitoring wells when sampling for tracers to estimate recharge rates and water age. Finger funnel flow paths may also create significant cumulative connections between surface water to groundwater structures.

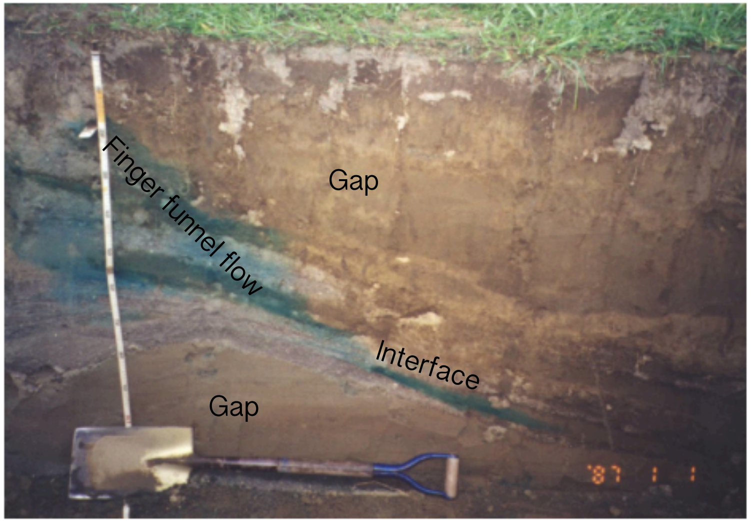


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Figure 3a. Funnel flow at field site. Initially blue dye (FD &C blue dye #1) was placed near the soil surface and the field was irrigated weekly (7.5 mm/h for 12-13 hours) for several weeks, the the site was excavated to examine water and chemical distributions throughout the soil profile. This figure shows the dye distribution after 22 cm of water application. Blue dye flowing vertically (unsaturated flow) moves laterally when it encounters a sloping coarse-texture lens. (Source: Soil and Water Lab, Cornell University)

Redirected Finger Funnel Flow infiltration and redistribution with unstable flow at layered soil profiles

Additionally, water may be channeled laterally by obstructions in the soil profile like coarse textured layers. Non-uniform water flow through soils may create significant disparity between precipitation measurements, infiltration, redistribution, soil moisture measurements, and bore hole sampling of tracers for estimation and interpretation of the above parameters. Erratic non-uniform movement of water does not fit well into Groundwater Availability Models designed for saturated orthagonal water flow.

These finger funnel flow paths may create gaps in the vadose zone that may be hit by monitoring wells when sampling for tracers to estimate recharge rates and water age. Finger funnel flow paths may also create significant cumulative connections between surface water to groundwater structures.

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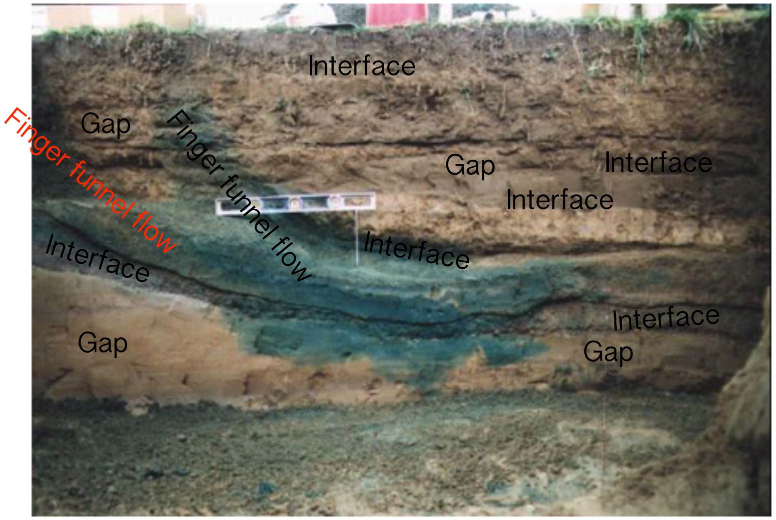
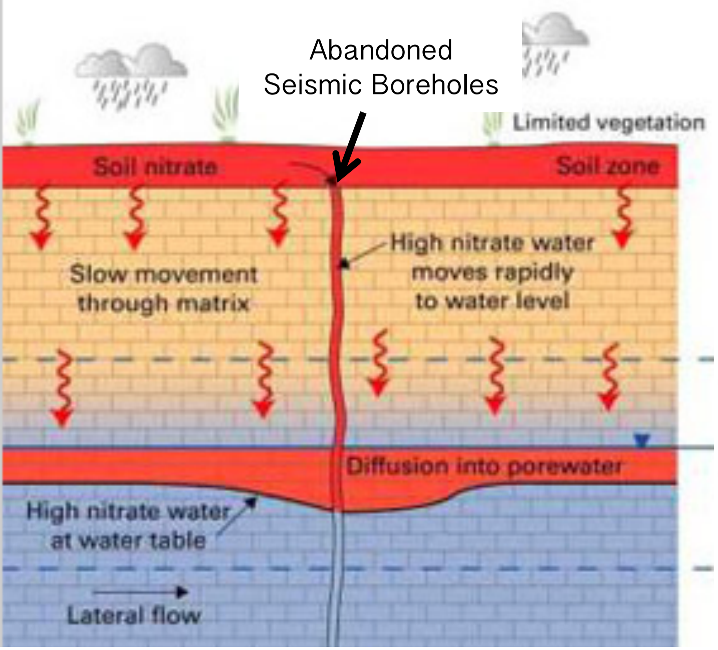


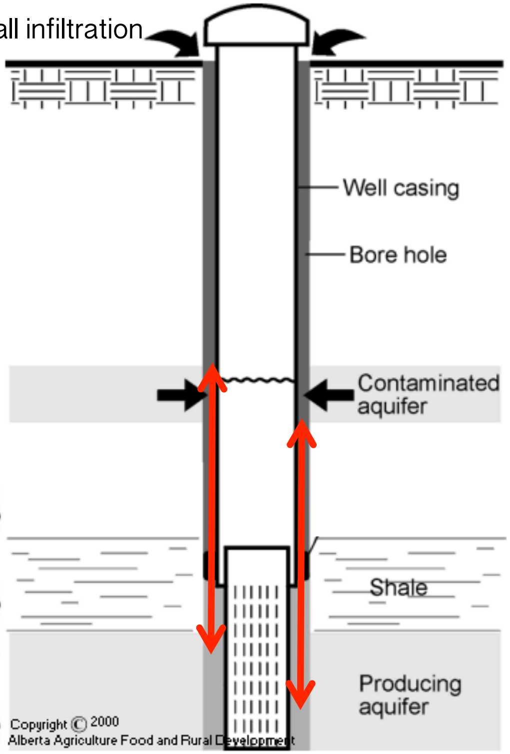
Figure 3b. This figure shows the dye distribution after 75 cm of water application. Additional dye penetrating into the coarse sand (from Fig 3a) appears to have moved freely and directly into the fine sand below. (Source: Soil and Water Lab, Cornell University)

Effects of natural and man made macropores upon surface water infiltration and groundwater redistribution non-conducive to modeling accuracy

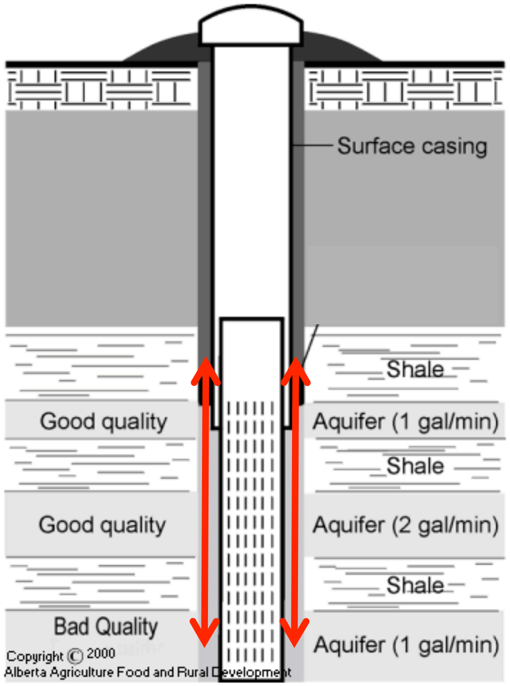
Water wells, sampling wells, seismic boreholes, and seismic vibrations may cause sidewall infiltration of surface water into groundwater and comingling of groundwater perched, unconfined, and confined aquifers.



Improperly completed water wells



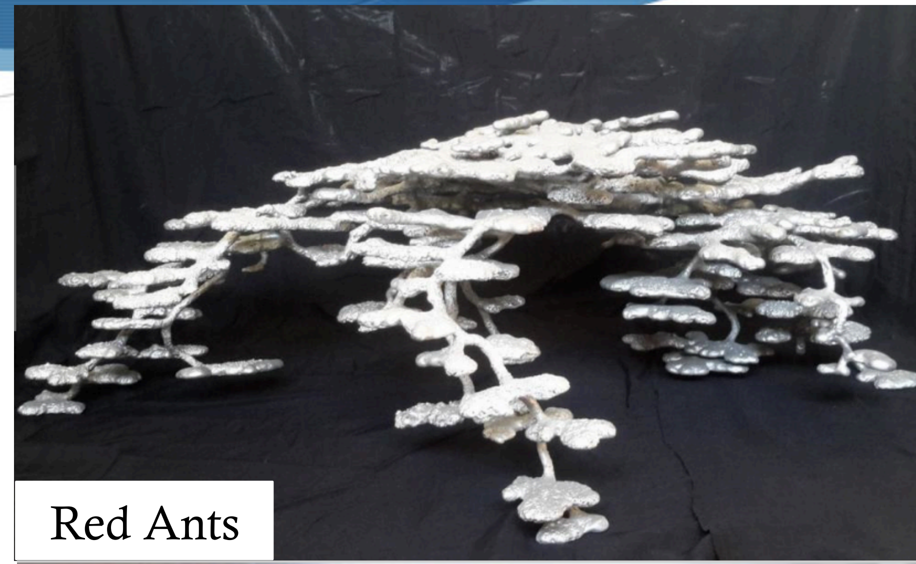
Comingling with inadequate annulus seal



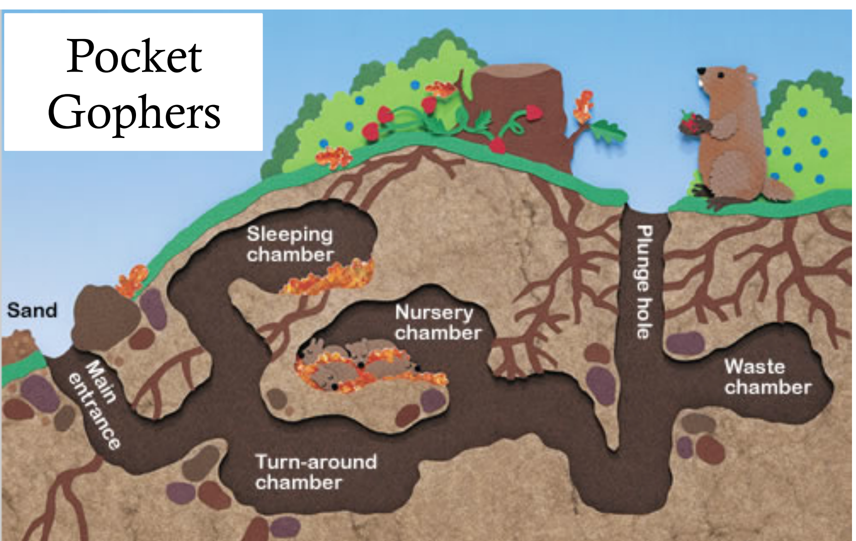
Comingling aquifers with multi aquifer screens

Effects of natural and man made macropores upon surface water infiltration and groundwater redistribution non-conducive to modeling accuracy

Rabbits



Red Ants



Pocket Gophers

Fire Ants

Effects of natural and man made macropores upon surface water infiltration and groundwater redistribution non-conducive to modeling accuracy

Fossil of Rodent Burrow

Bigheaded Ants

Model Limitations:
TWDB and National Research Council (2007) noted:

"Models will always be constrained by computational limitations, assumptions, and knowledge gaps. They can best be viewed as tools to help inform decisions rather than as machines to generate truth or make decisions. Scientific advances will never make it possible to build a perfect model that accounts for every aspect of reality or to prove that a given model is correct in all respects for a particular regulatory application. These characteristics make evaluation of a regulatory model more complex than solely a comparison of measurement data with model results."

Given these limitations, users of modeled information are cautioned that the modeled available groundwater numbers should not be considered a definitive, permanent description of the amount of groundwater that can be pumped to meet the adopted desired future condition.

NO WARRANTY OF MODELING

The Texas Water Development Board makes no warranties or representations relating to the actual conditions of any aquifer at a particular location or at a particular time.

1. *National Research Council, 2007, Models in Environmental Regulatory Decision Making Committee on Models in the Regulatory Decision Process, National Academies Press, Washington D.C., 287 p.*
2. *GAM Run 12-012: Goliad County Groundwater Conservation District Management Plan November 30, 2012*