Comparison of simulated travel time distributions and age tracer concentrations in samples from an alluvial fan aquifer, San Joaquin Valley, CA

Christopher T. Green

Barbara A. Bekins

US Geological Survey, Menlo Park, CA 94025
ctgreen@usgs.gov

Funding:

• USGS National Water Quality Assessment Program, Agricultural Chemicals Team (ACT)

Contributors:

• Steve Phillips, USGS
• Graham Fogg, UC Davis
• Many others

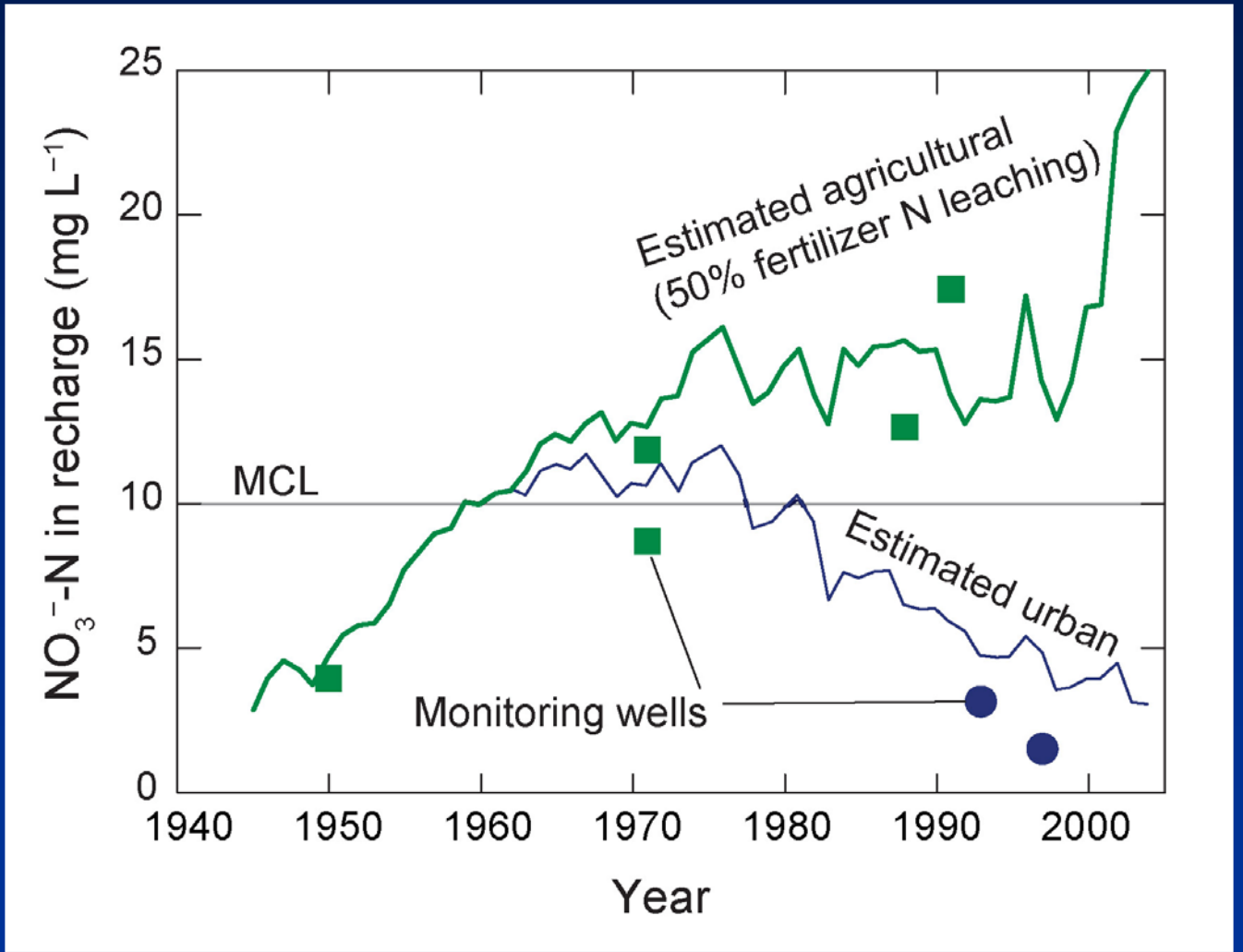
USGS
science for a changing world

Study sites of the Agricultural Chemicals Team (ACT), National Water Quality Assessment Program (NAWQA)

Green et al., 2008
J Environ Qual

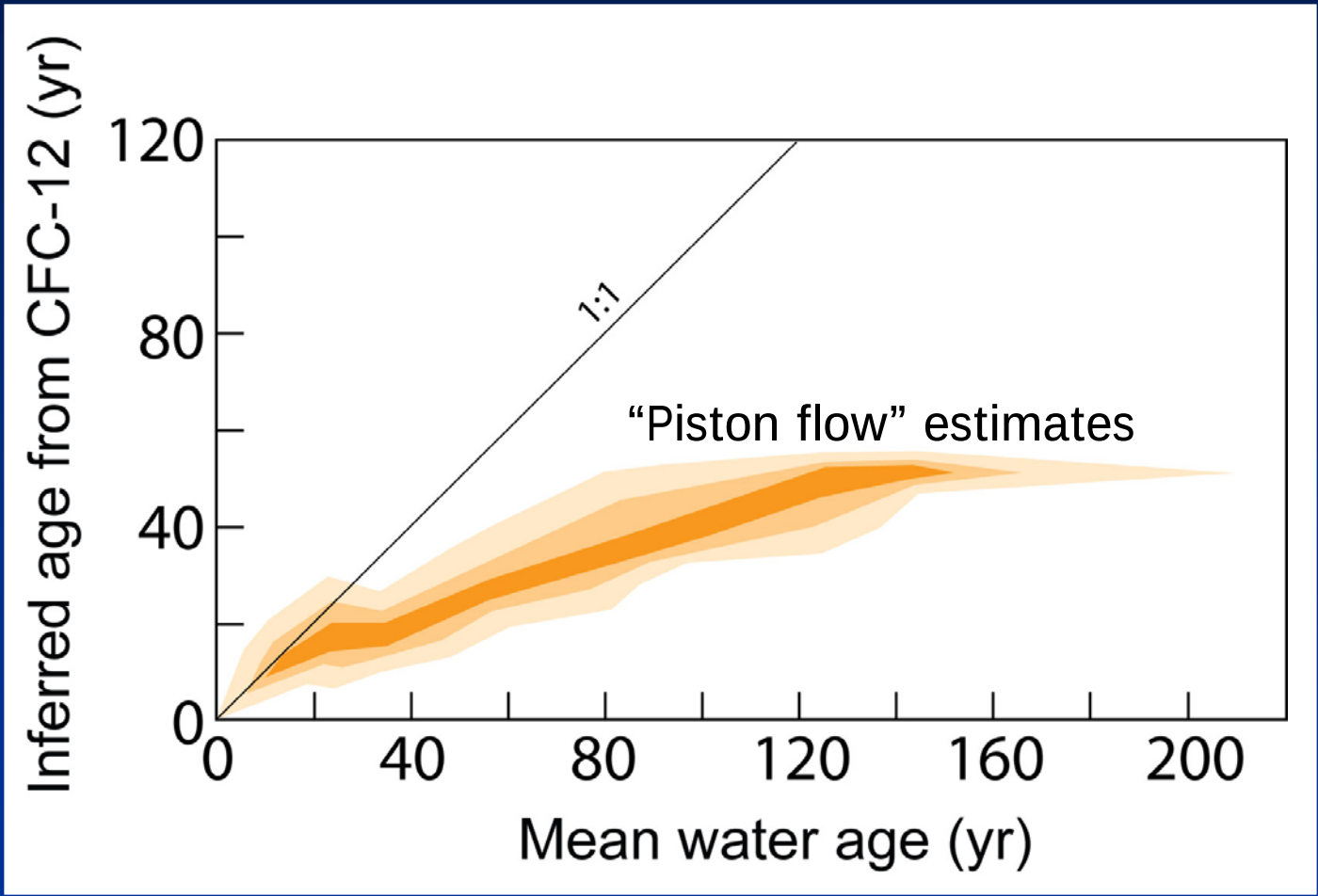
Age tracers are a major component of NAWQA and ACT studies

Age tracers have provided important information about historical conditions



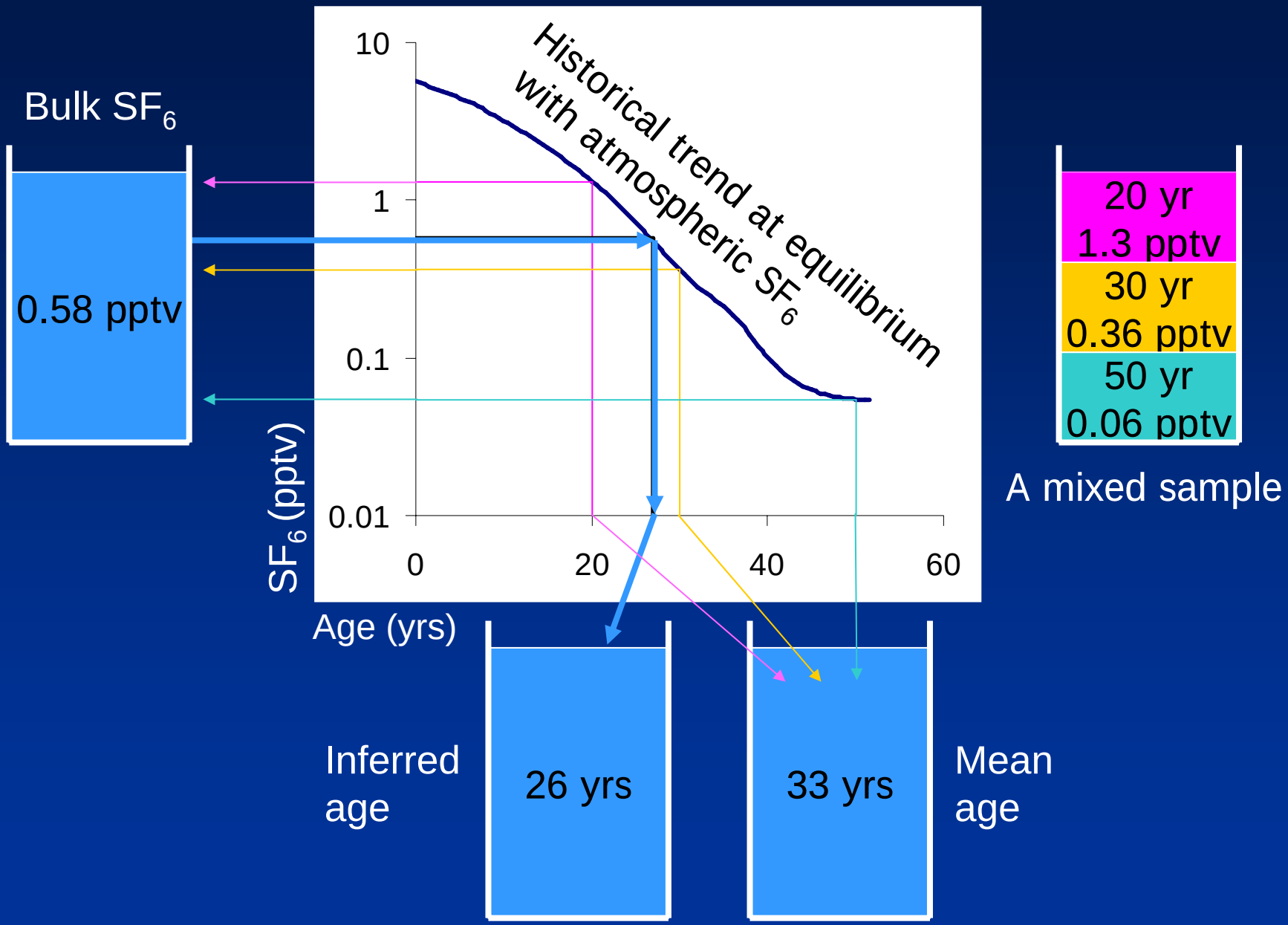
From Burow et al., USGS Scientific Investigations Report, 2008-5035

Inferring age from concentration is not always straight forward

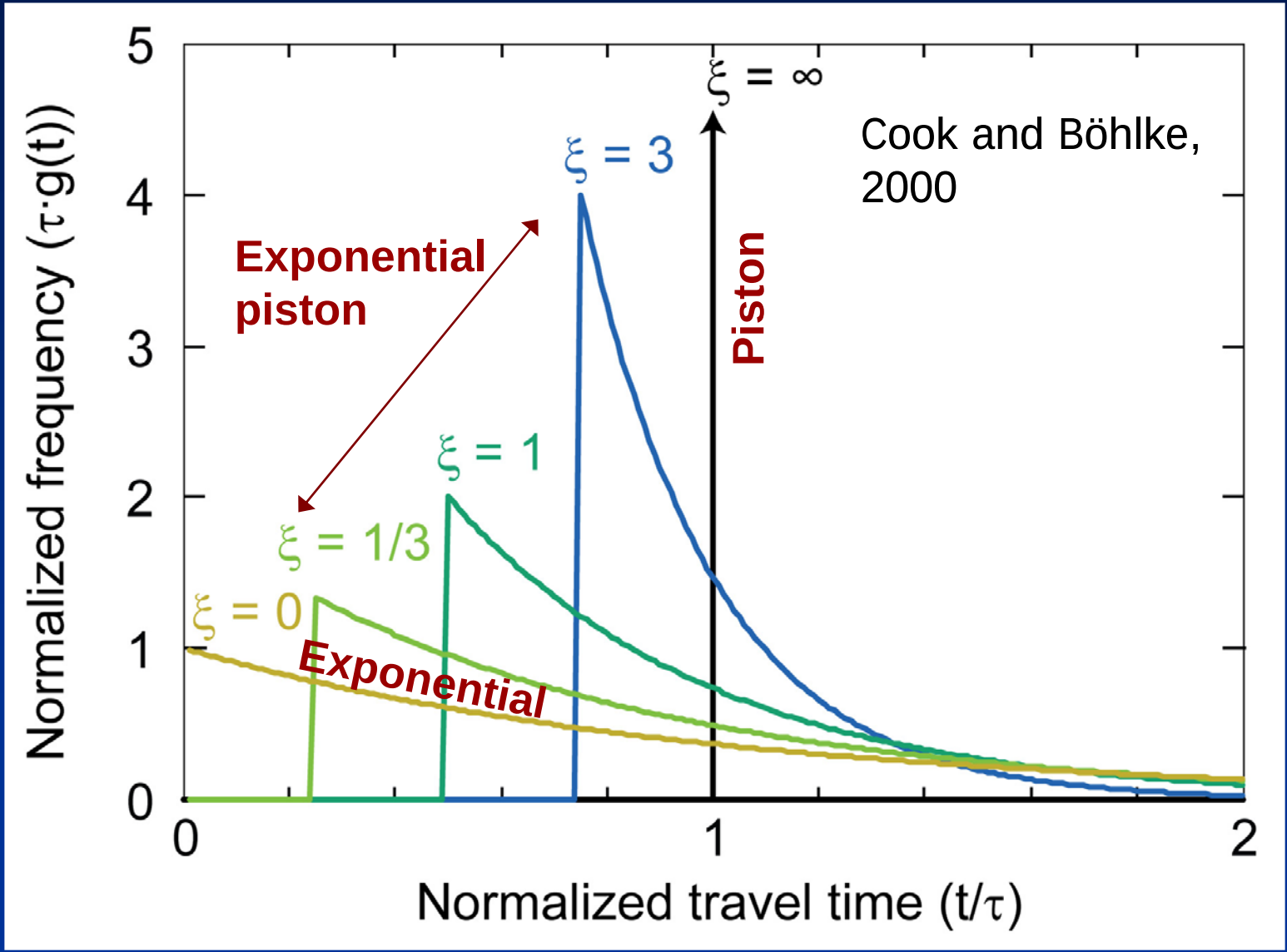


From Weissmann et al., 2002, Water Resources Research

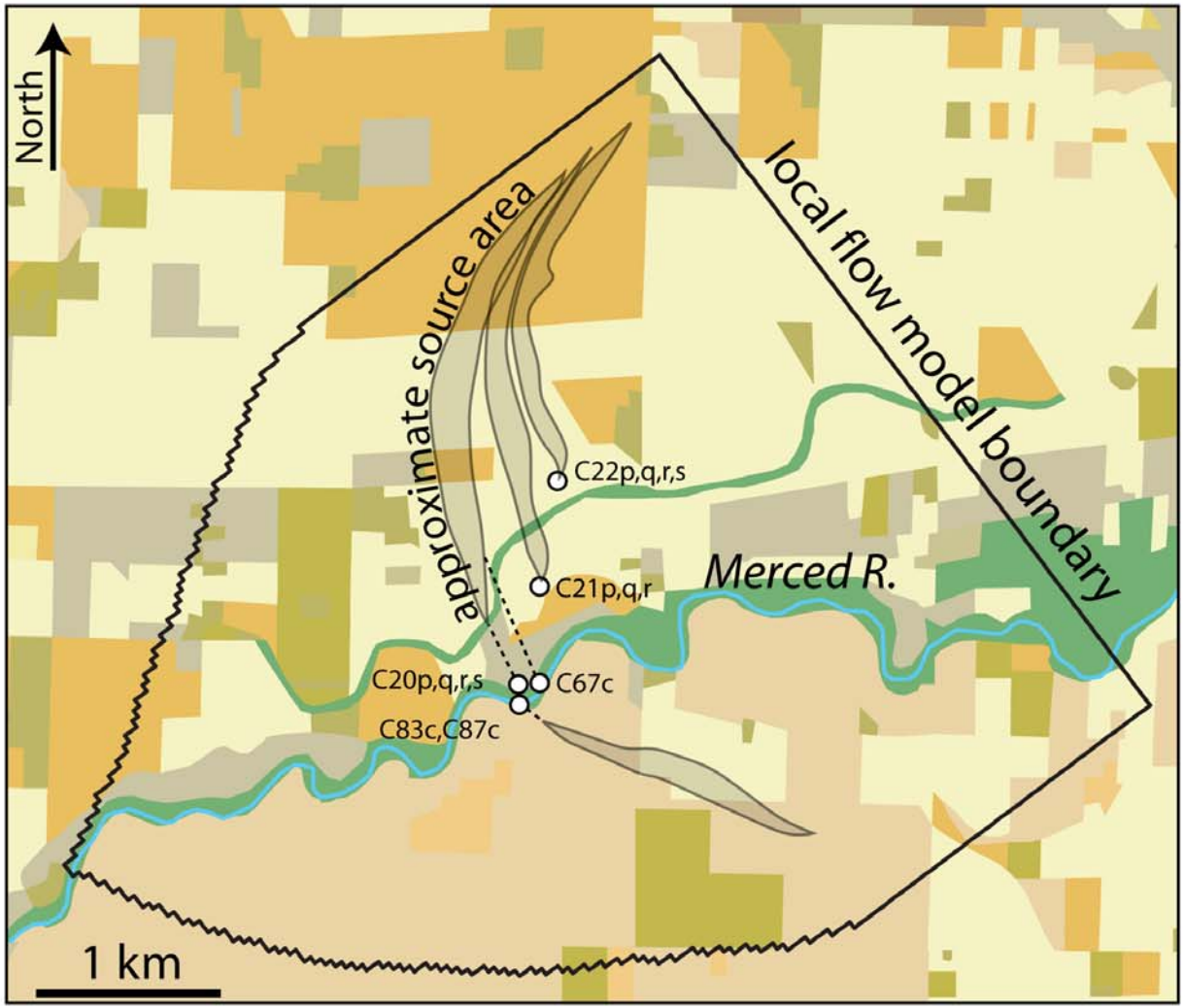
Piston-flow ages are not mean ages



Alternative “lumped parameter” exist, but are they realistic?

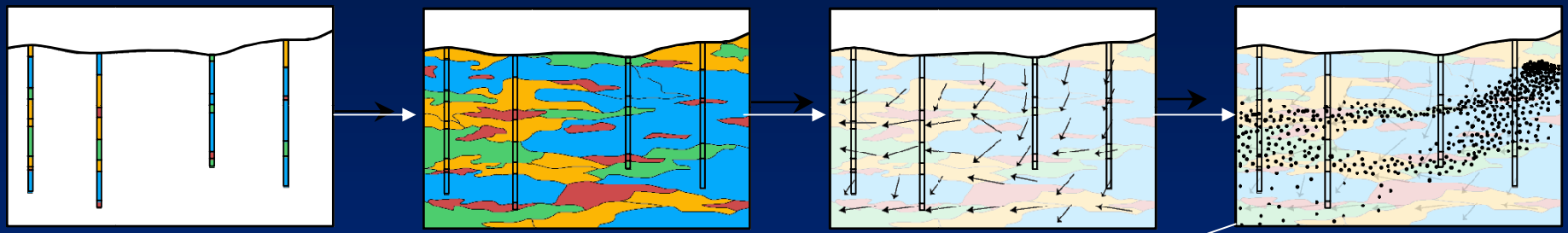


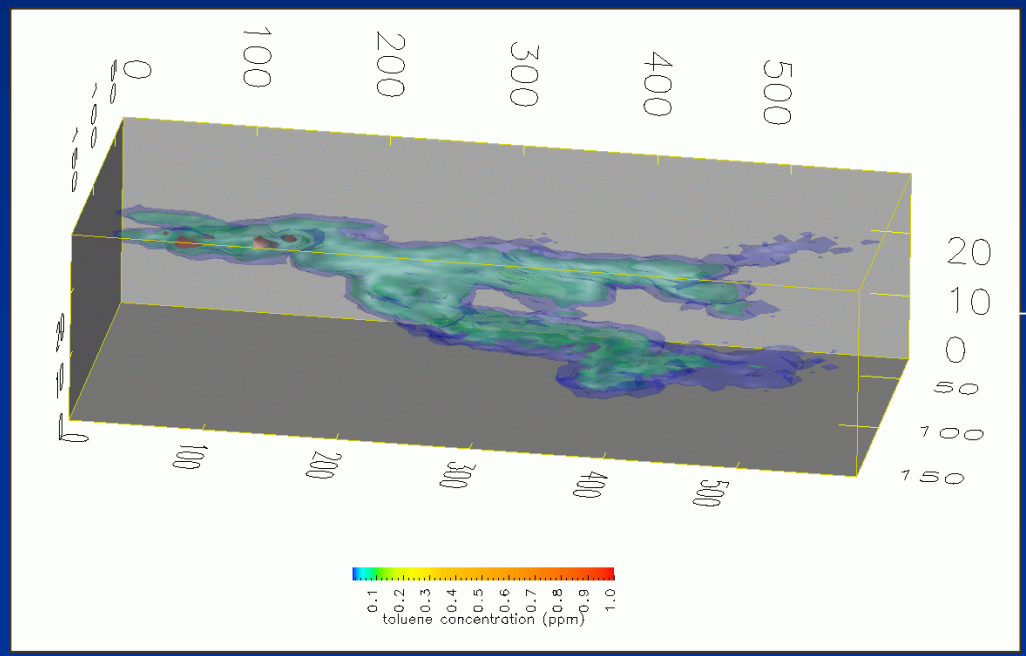
A local model area was chosen to simulate travel times

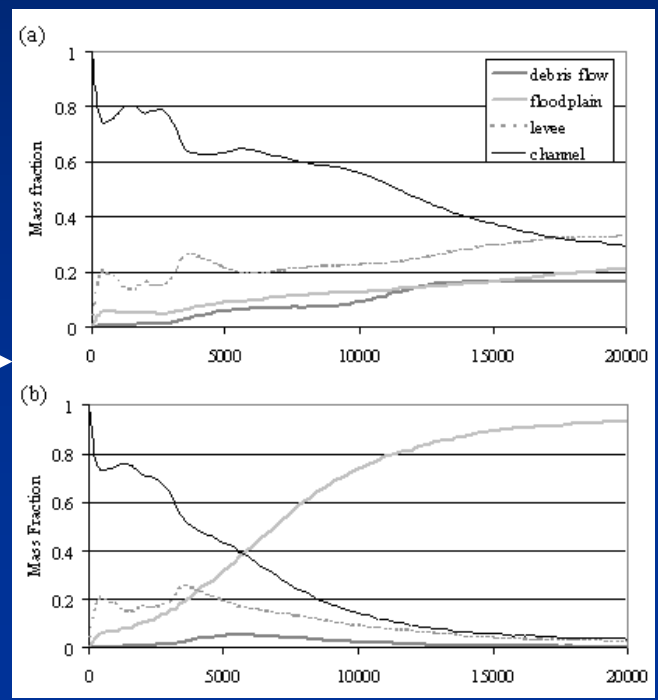


- orchard
- field crops
- dairy/ feed operation
- waterway/ riparian
- vineyards
- other
- USGS well cluster

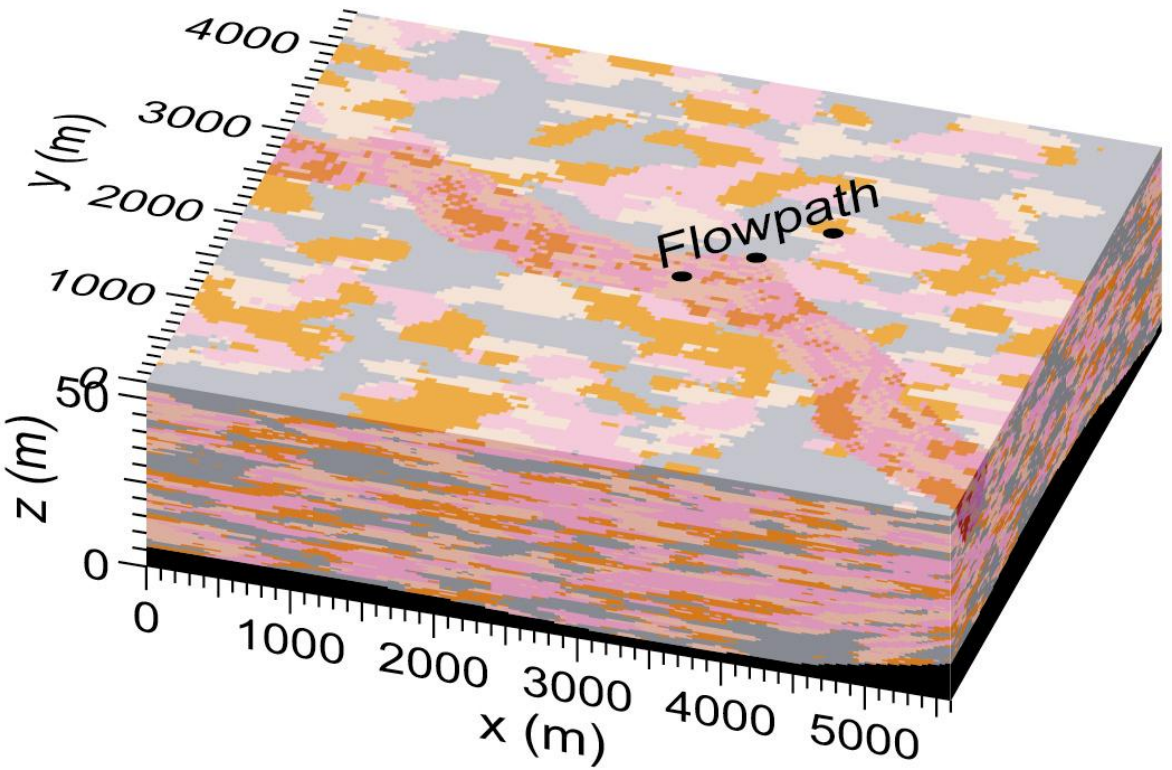
Simulating travel times in a heterogeneous aquifer system







Geological information was used to generate 3-D realizations for transport models



Holocene alluvium
- silt
- silty sand
- sand

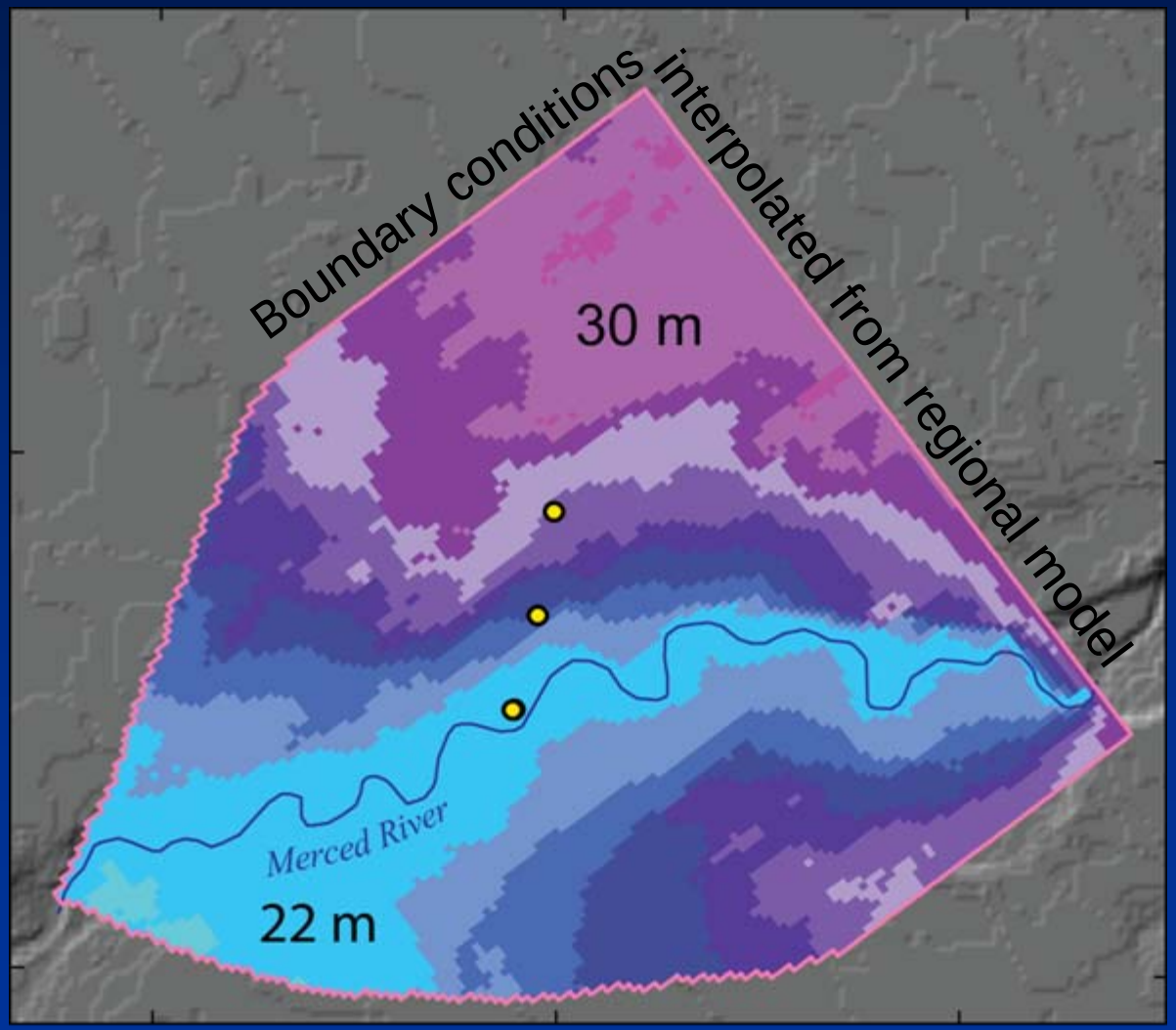
Pre-Holocene fans
- clay
- silt
- silty sand
- sand

Corcoran clay
- clay

Phillips, Green, Burow, Shelton, and Rewis, SIR 2007-5009.

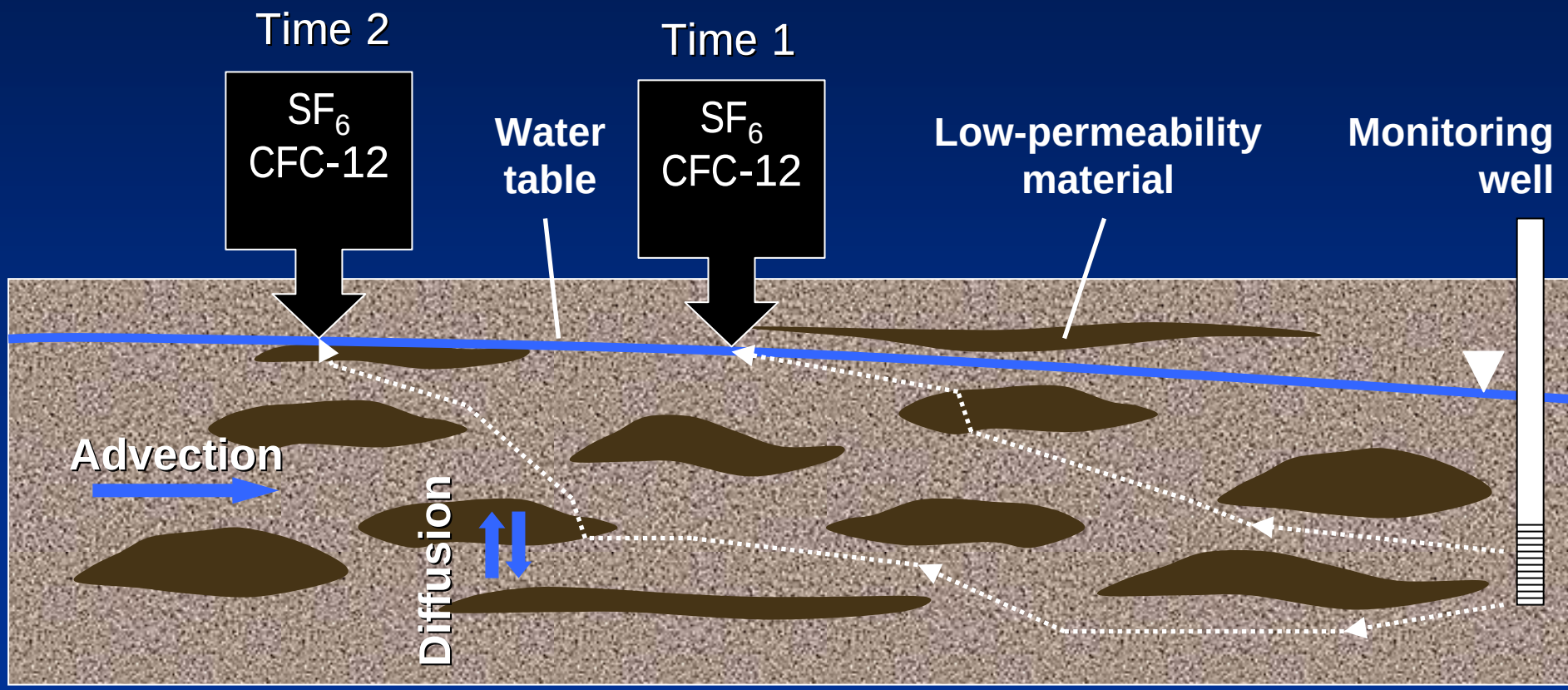
Green et al., 2008, J.E.Q.

Flow was simulated for six realizations with MODFLOW

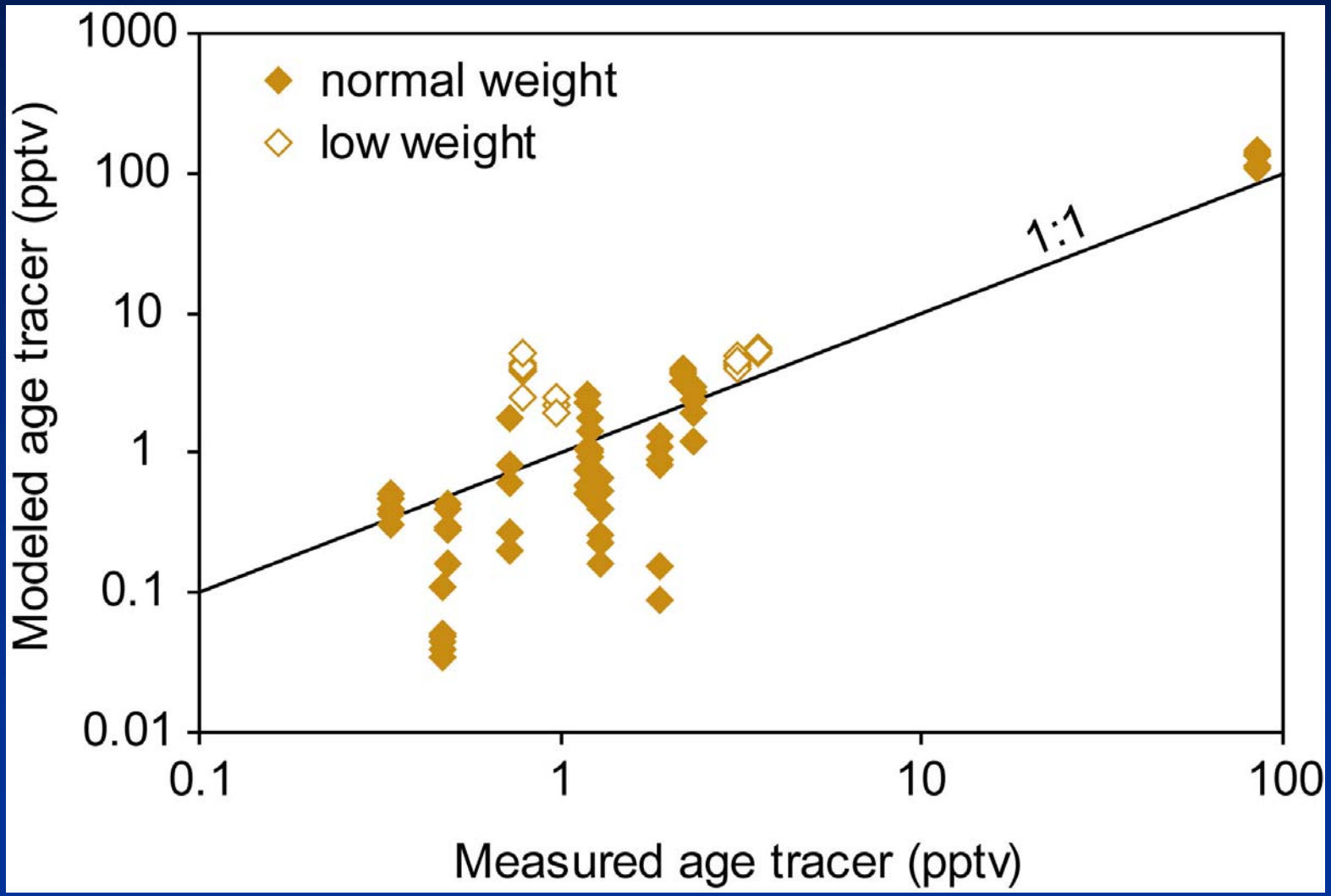


From Phillips et al., 2007

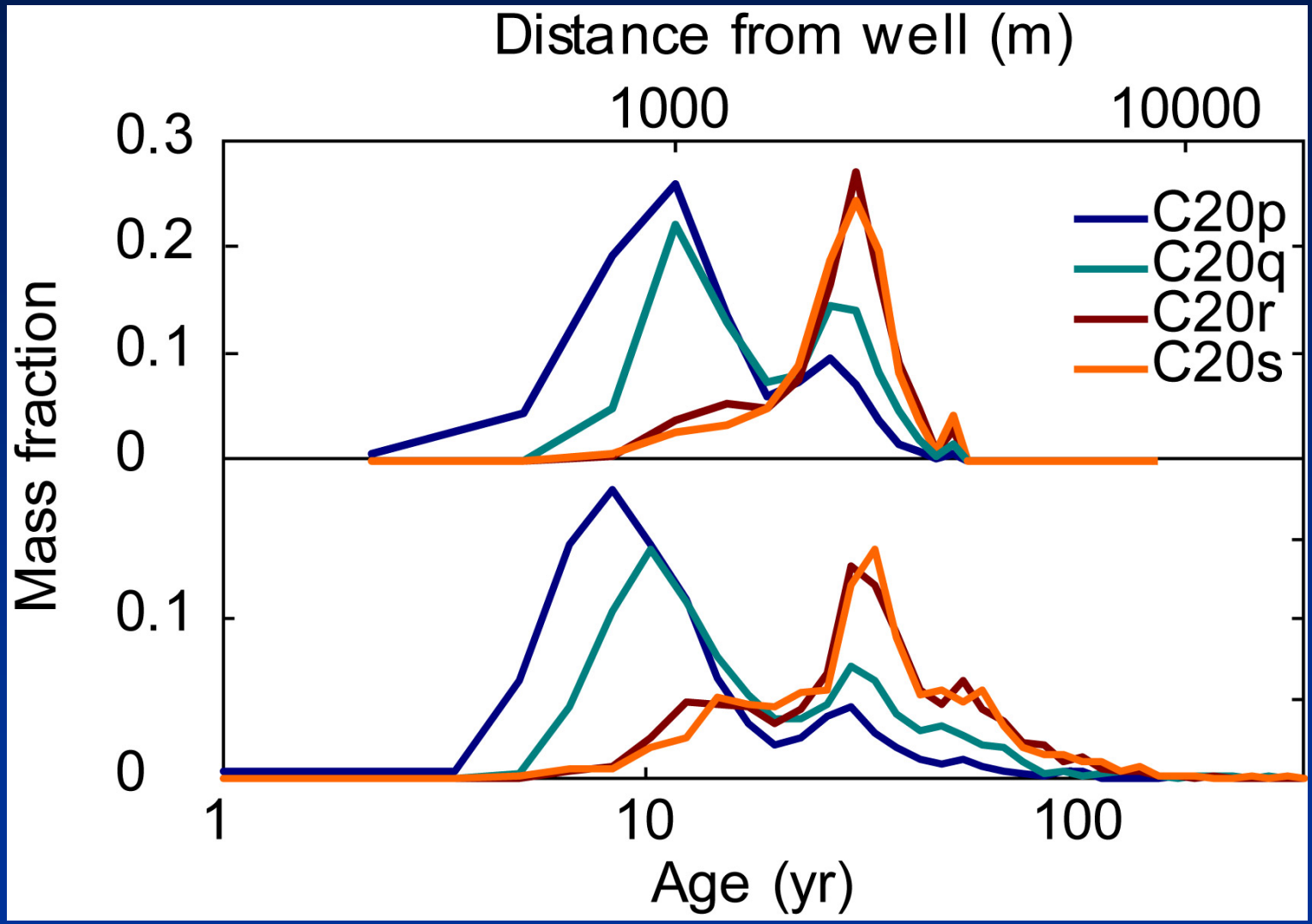
Backward random walk particle tracking simulates sample composition with mixing



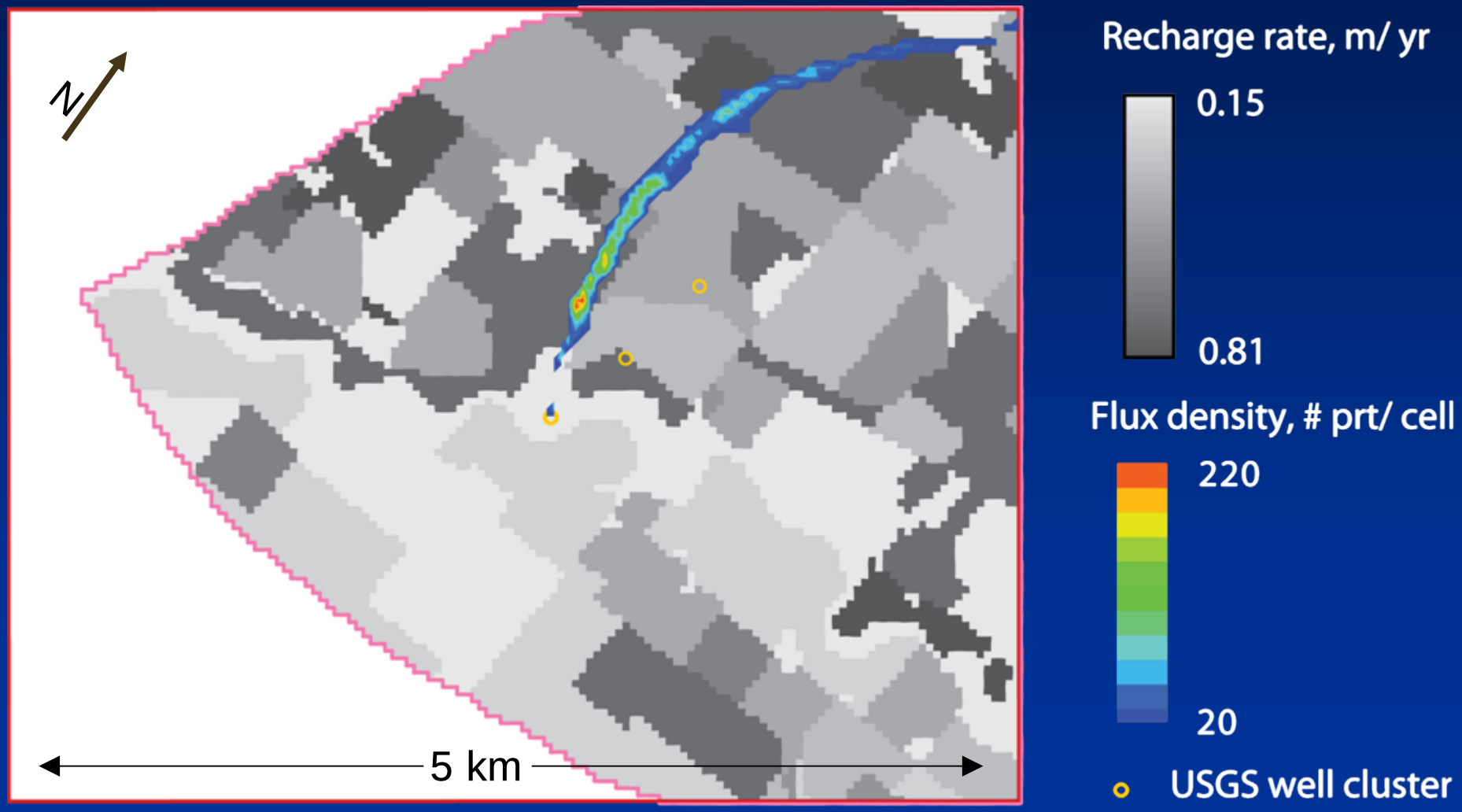
Model reasonably represents flow and transport



Complex age distributions correspond to recharge location

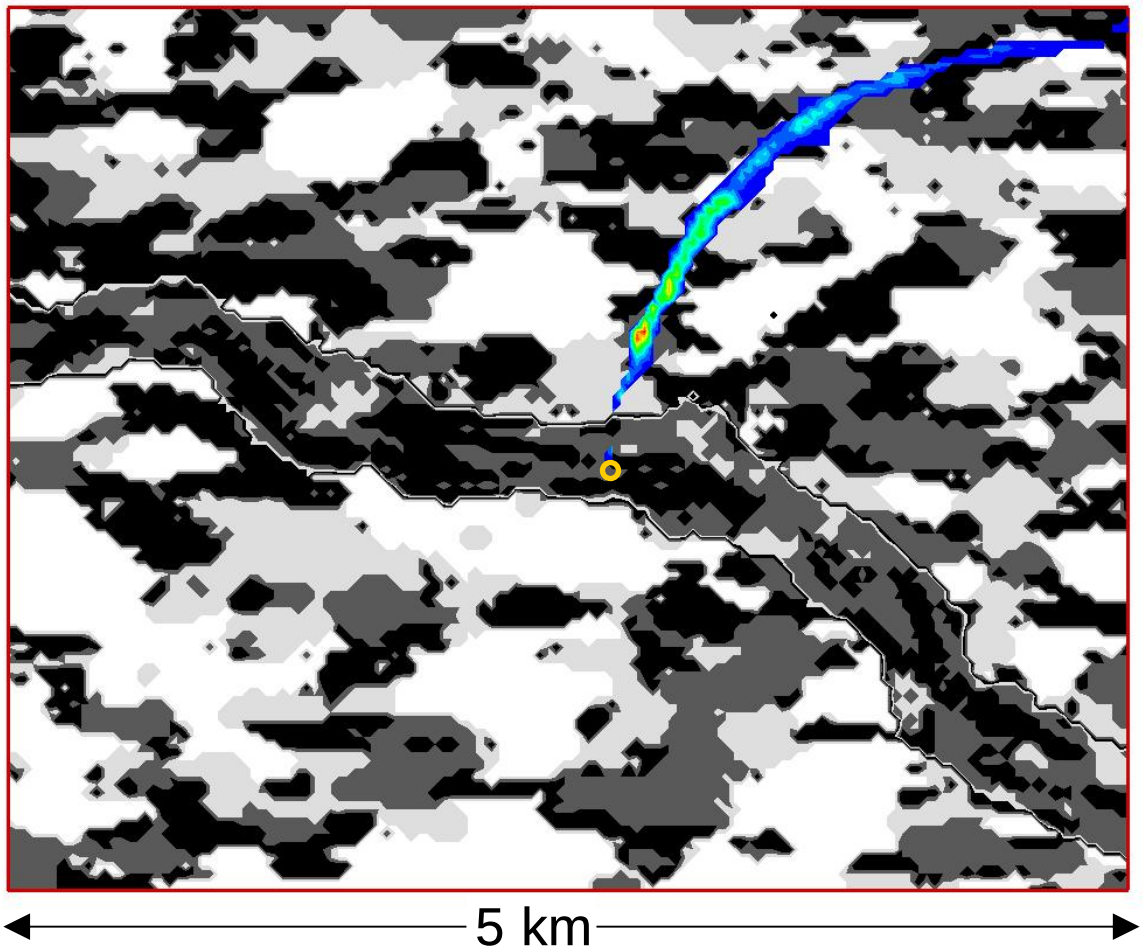


Recharge rates affect location of source fluxes



Geology affects location of source fluxes

Plan view map of geology near the water table

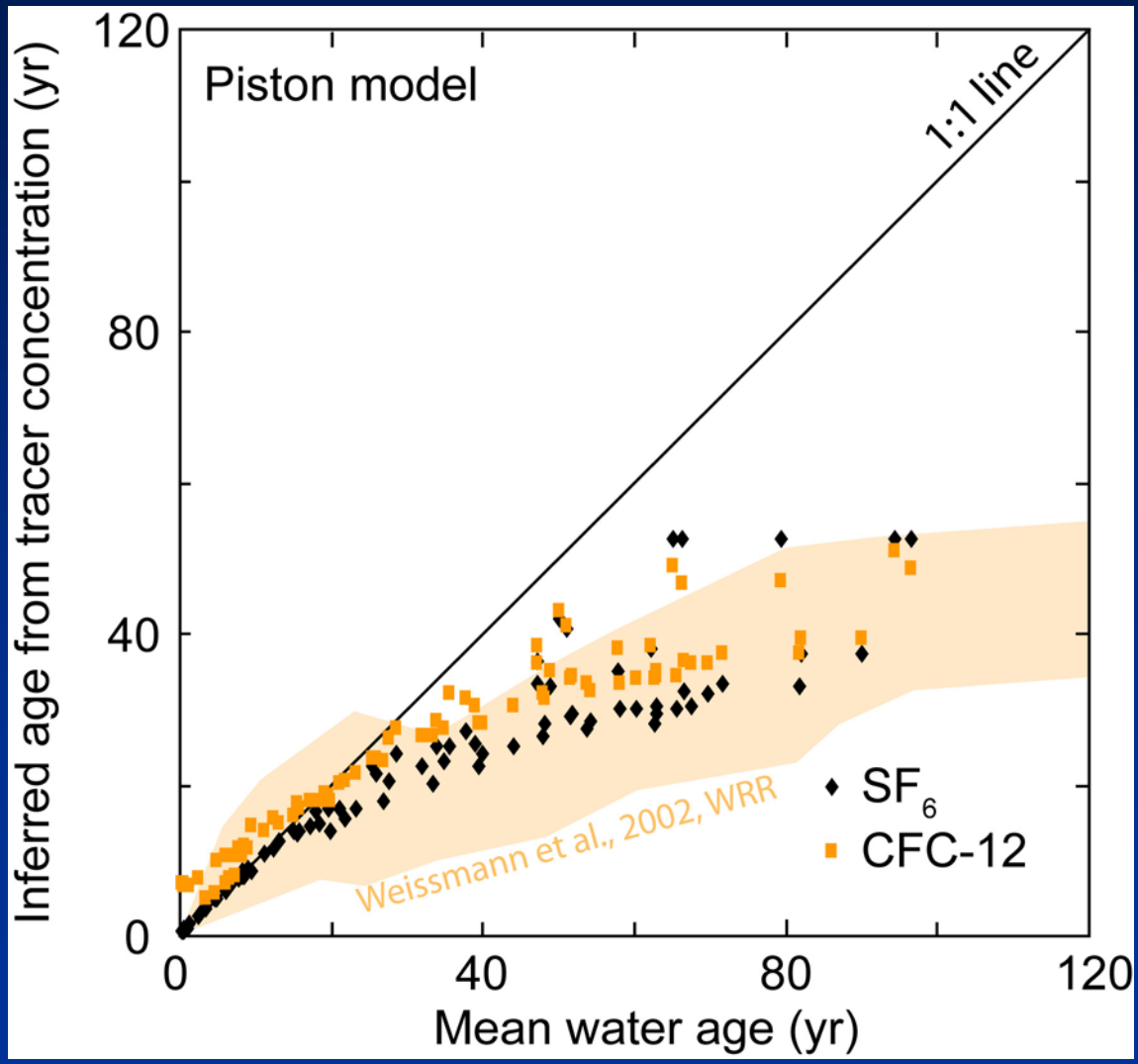


Clay
Silt
Silty sand
Sand

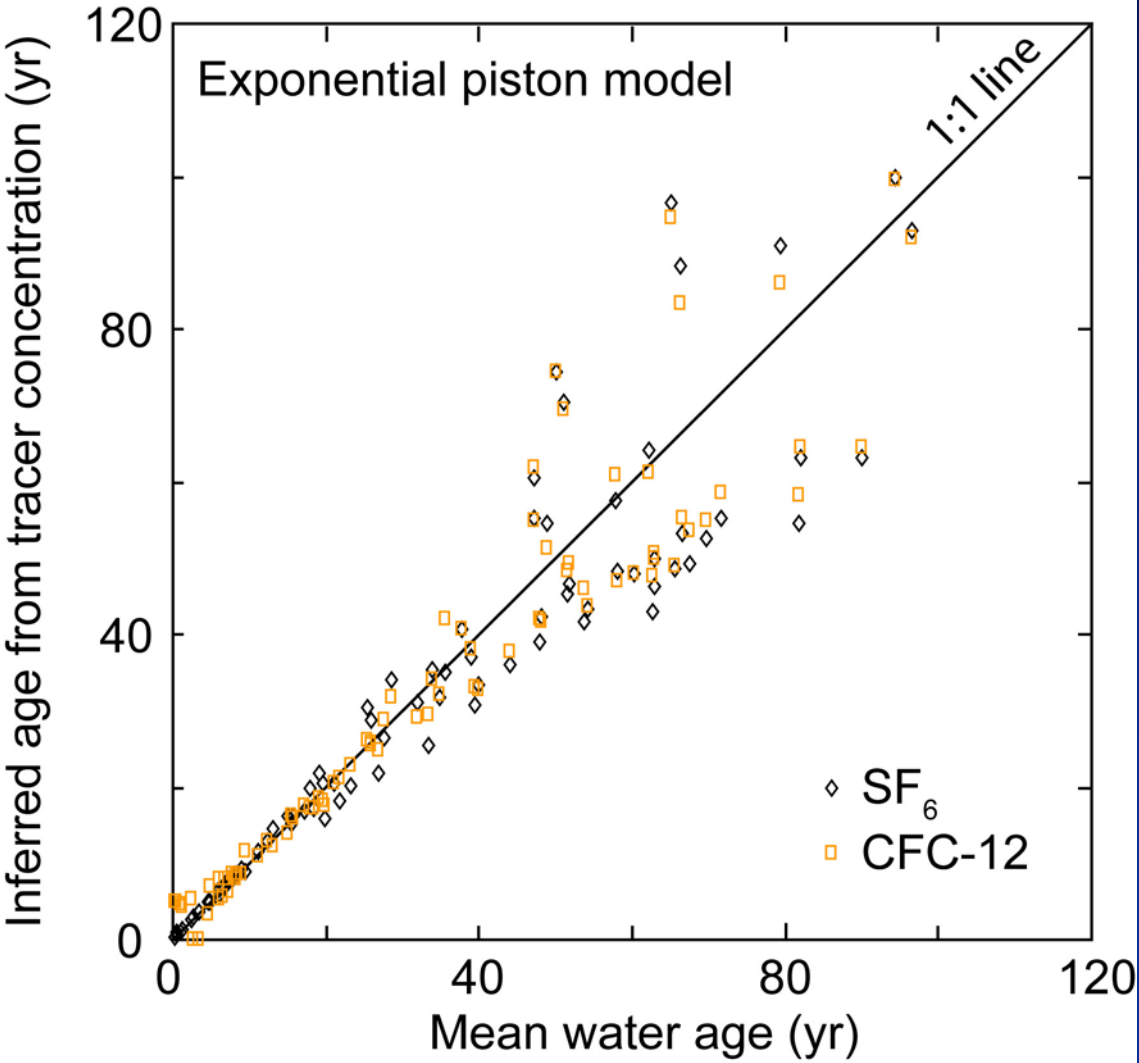
High source flux density

Low source flux density

Piston model of age distributions underestimates the average age



Exponential piston model of age gives unbiased estimate of the average age



Conclusions:

- Complex, multimodal age distributions result from complex geology and recharge location
- Exponential piston model can be used to estimate mean ages in heterogeneous aquifers

Parallel ongoing work

- Effects of mixing on reaction rates and isotopic fractionation of nitrate

Any questions?