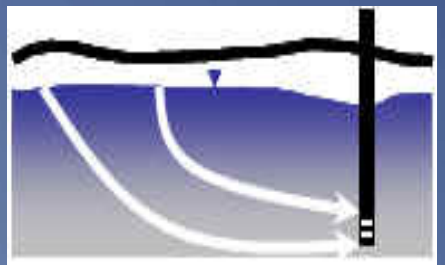
Use of Depth-Dependent Sampling to Determine Source Areas and Short-Circuit Pathways for Contaminants to Reach Public-Supply Wells, High Plains Aquifer, York, Nebraska

Matthew Landon
Brian Clark
Allen Christensen

2006 National Water Quality Monitoring Council Meeting,
San Jose, California
May 9, 2006



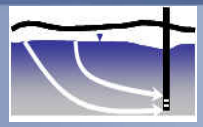
U.S. Department of the Interior
U.S. Geological Survey

Take-Home Messages

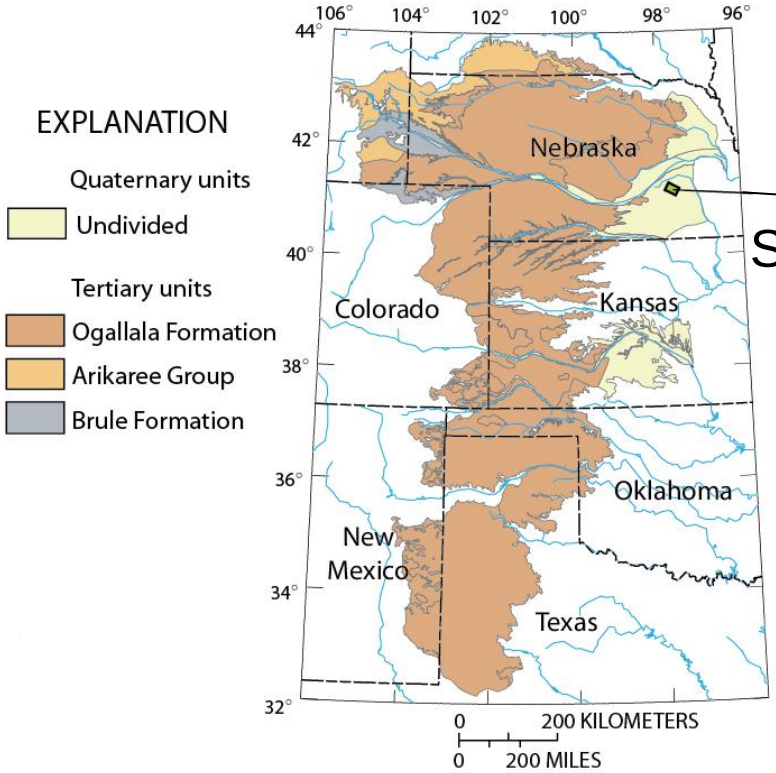
- Supply-well vulnerability can be strongly influenced by wellbores that cross confining units
- Sampling from different depths in supply wells, in addition to nearby monitoring wells, improves understanding of contaminant pathways to supply wells

Objective of Depth-Dependent Measurements

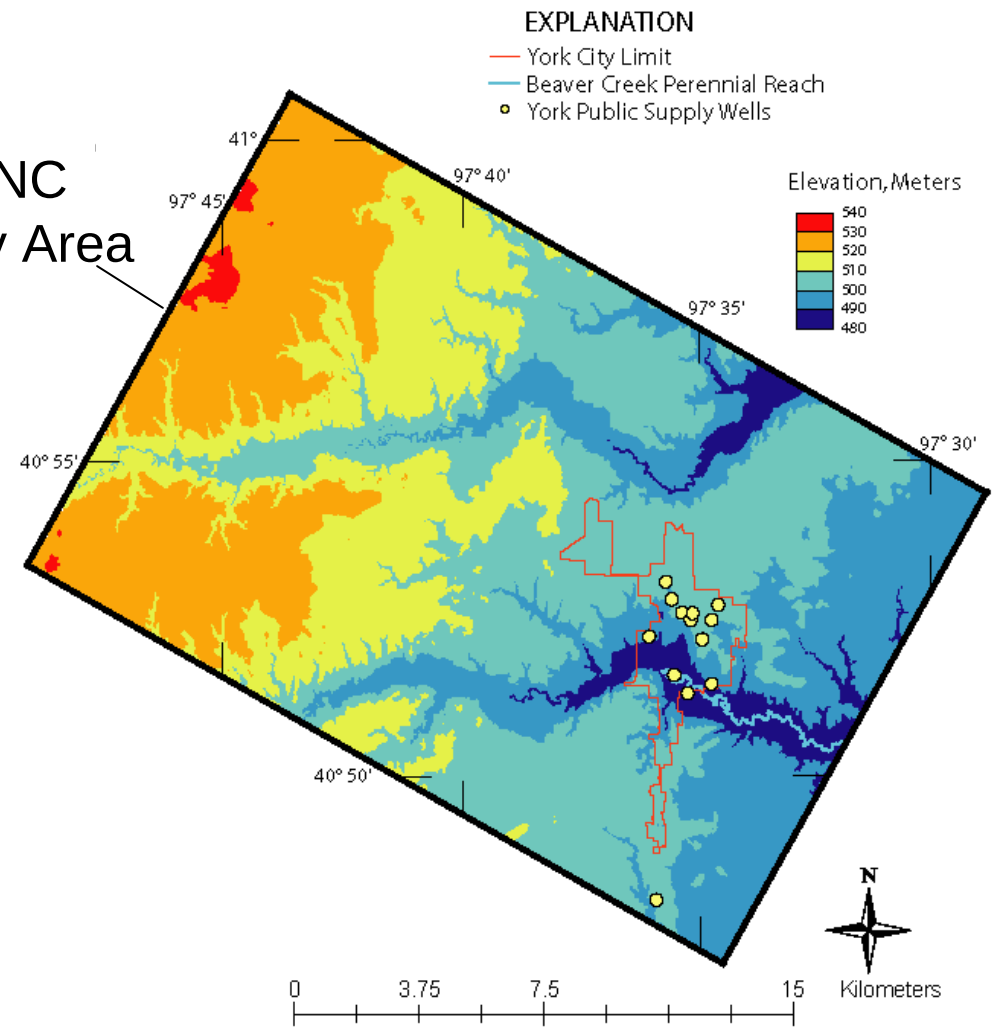
- Develop a refined understanding of where water and contaminants enter supply wells
- Depth-Dependent Sampling:
  - Provides a more detailed vertical profile than is possible with a monitoring well cluster
  - Is potentially useful for identifying short-circuit contamination pathways to the supply well



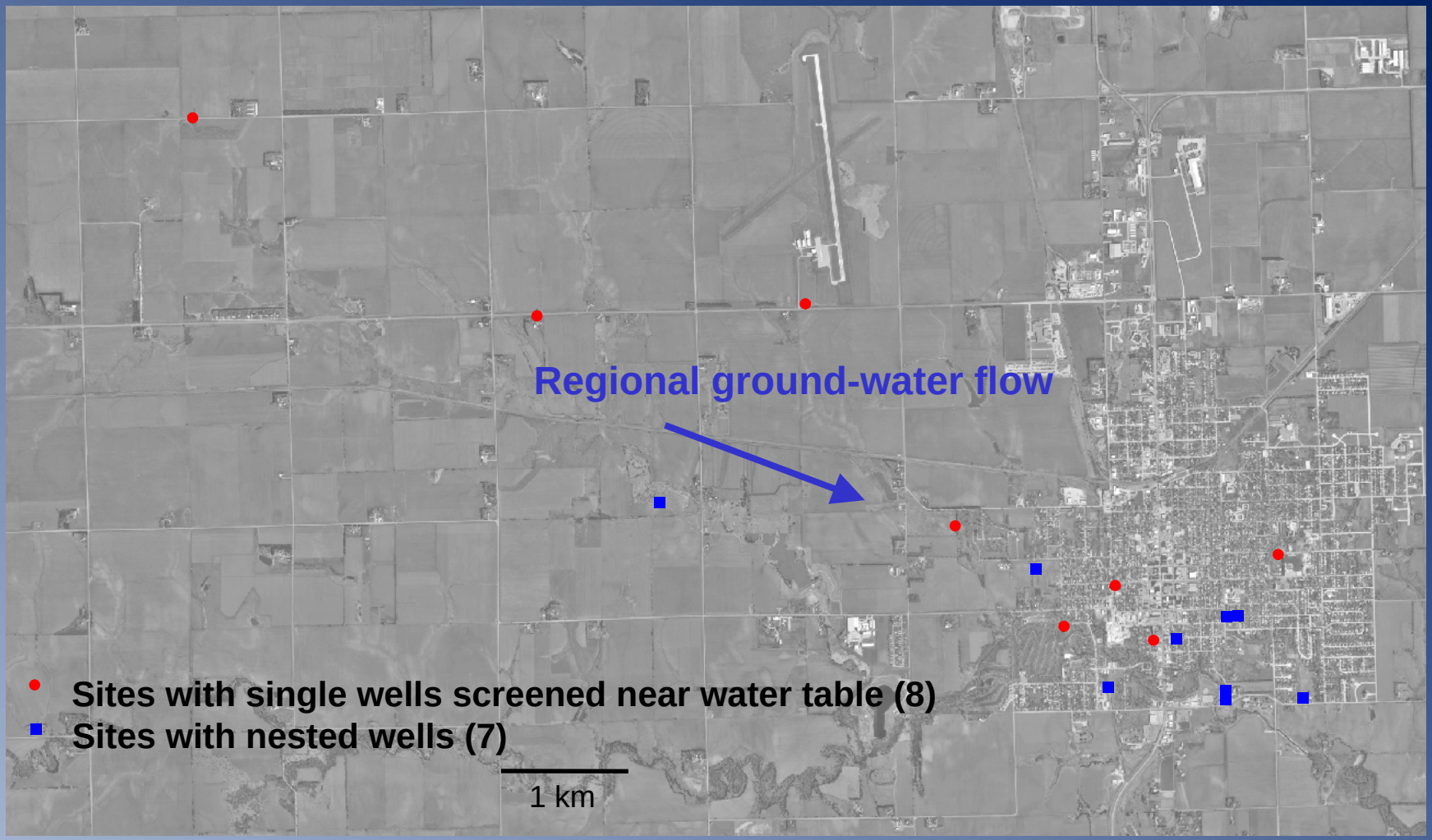
High Plains Aquifer TANC Study Area



TANC Study Area

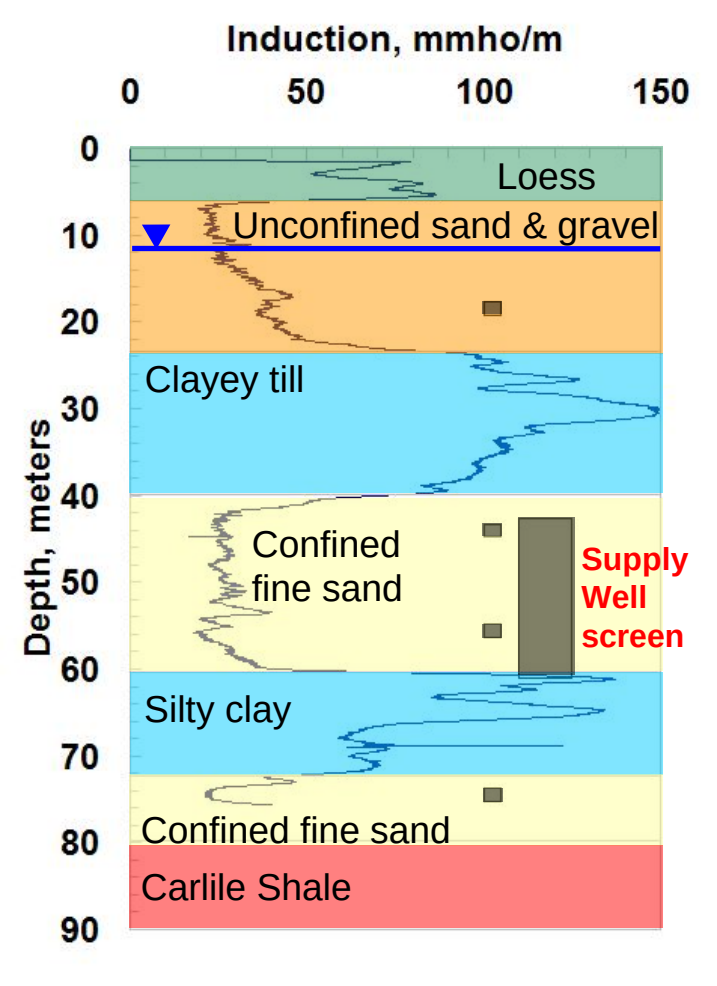


Monitoring network

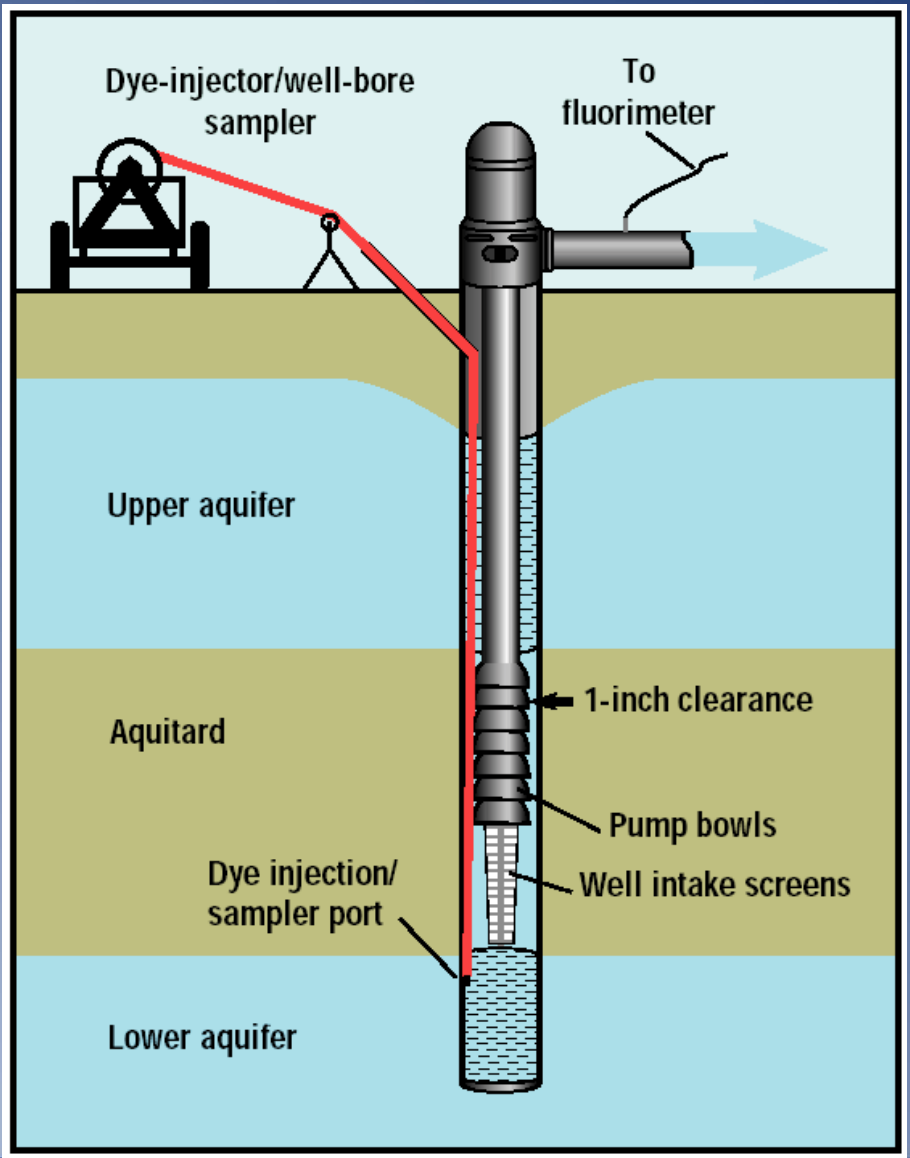


USGS

Geology and Well Construction – Supply Well



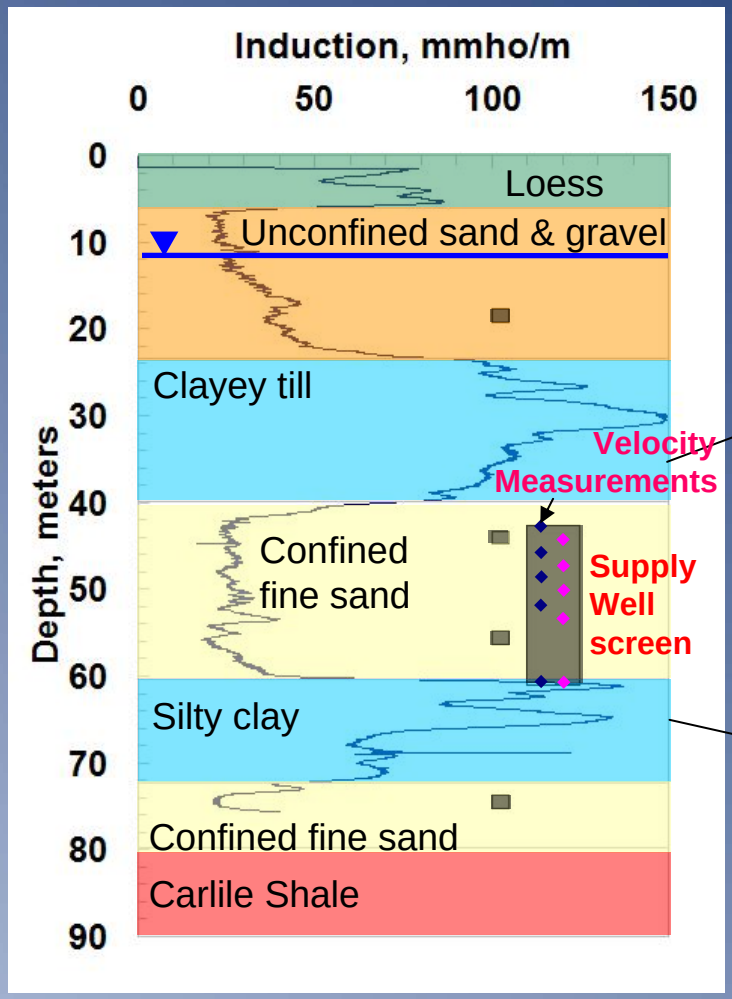
Tracer Pulse Method Conceptual Diagram

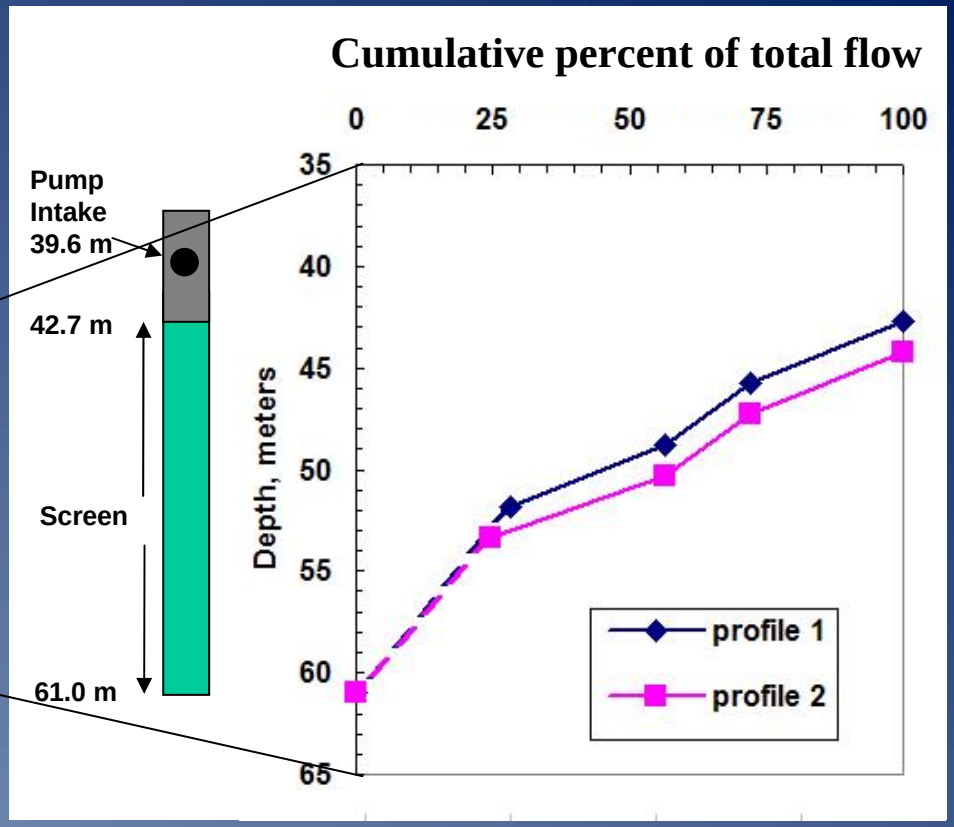


Izbicki et al. (1999)

USGS

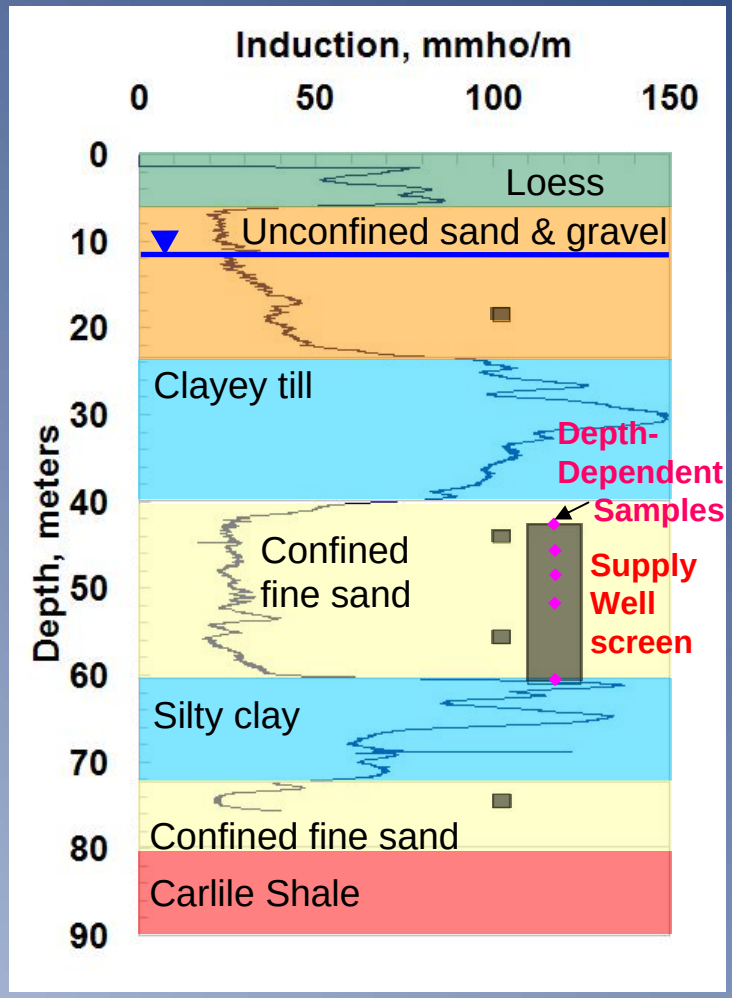
Well-Bore Flow Profile



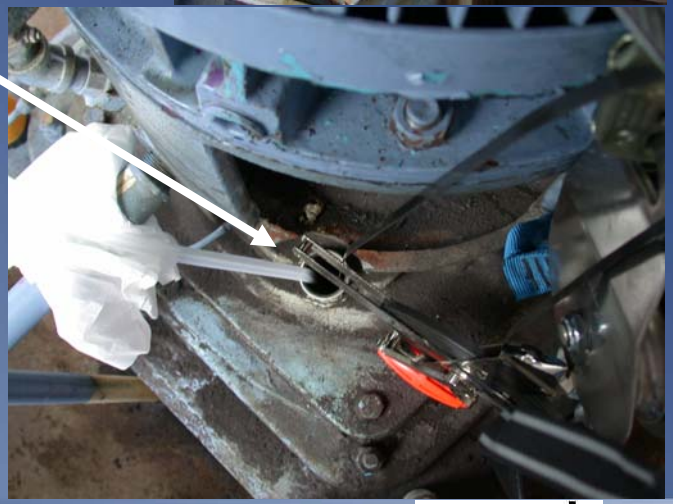


- **25% of flow from bottom half of screen**

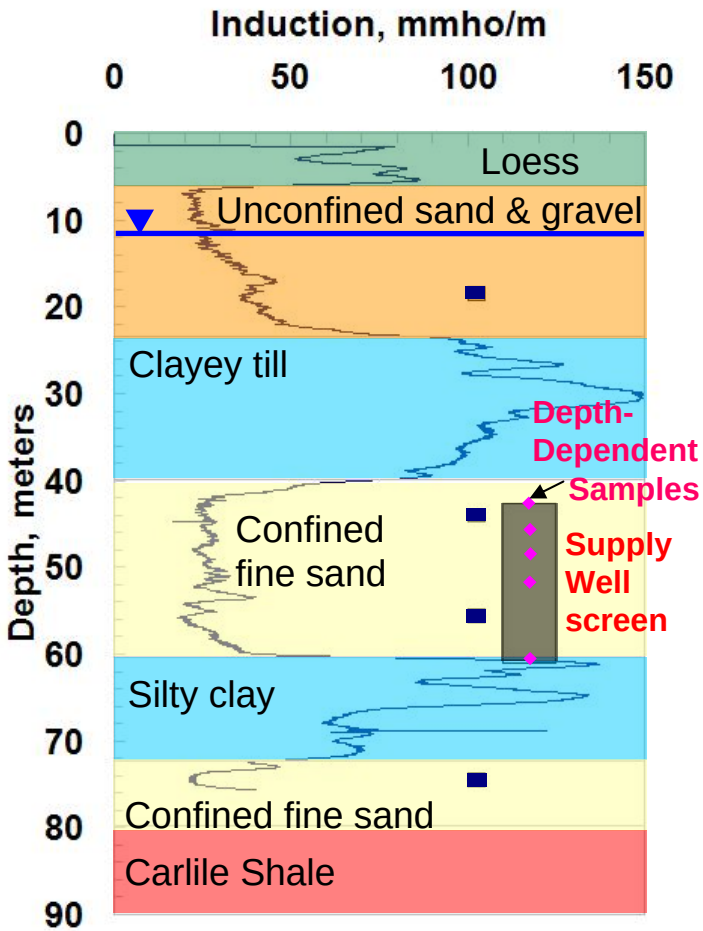
Depth-Dependent Sampling

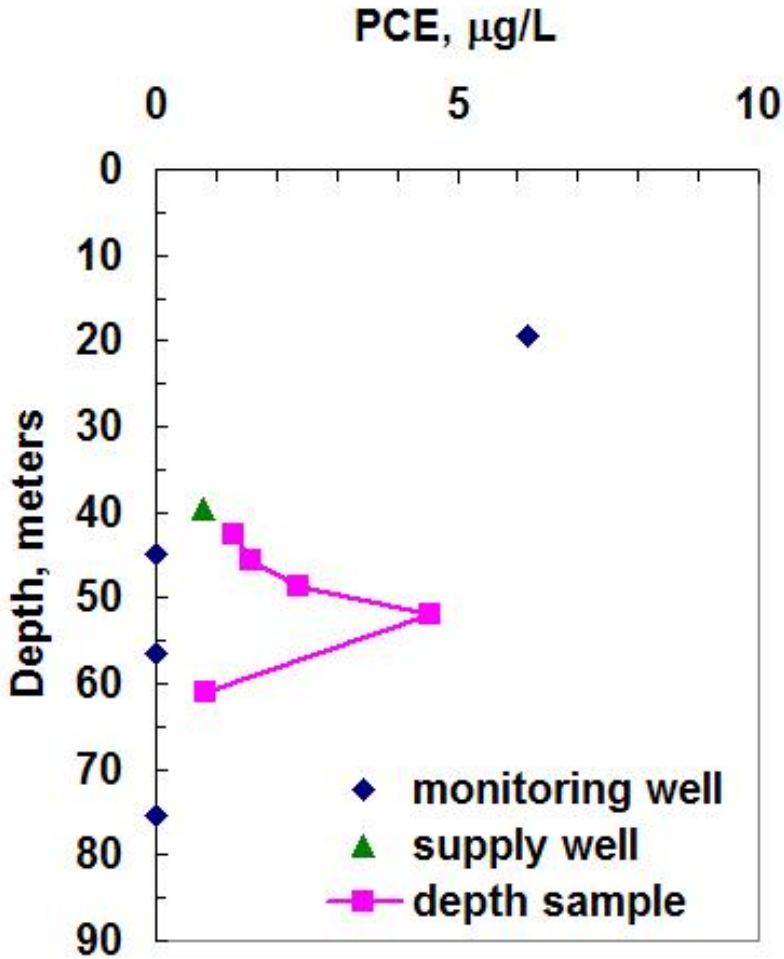


- Samples collected using a narrow-diameter pump lowered down an access tube that extends below the pump intake



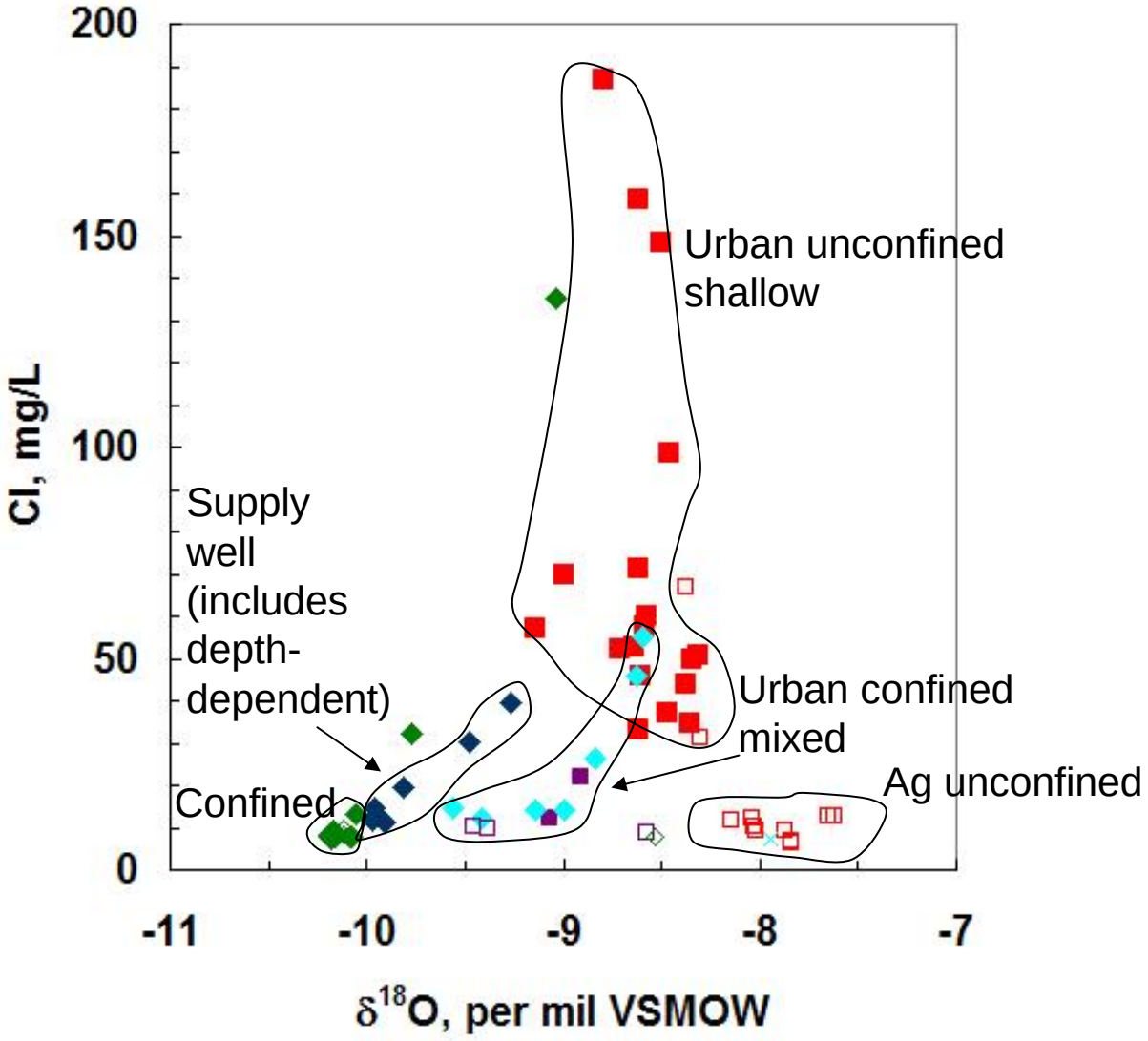
Depth Dependent VOCs



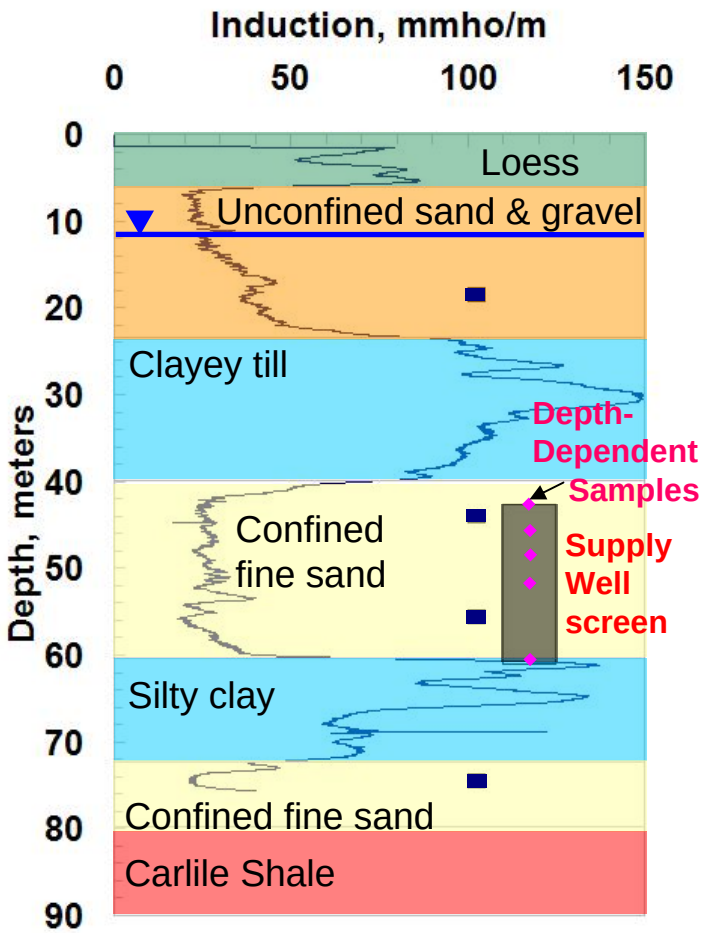


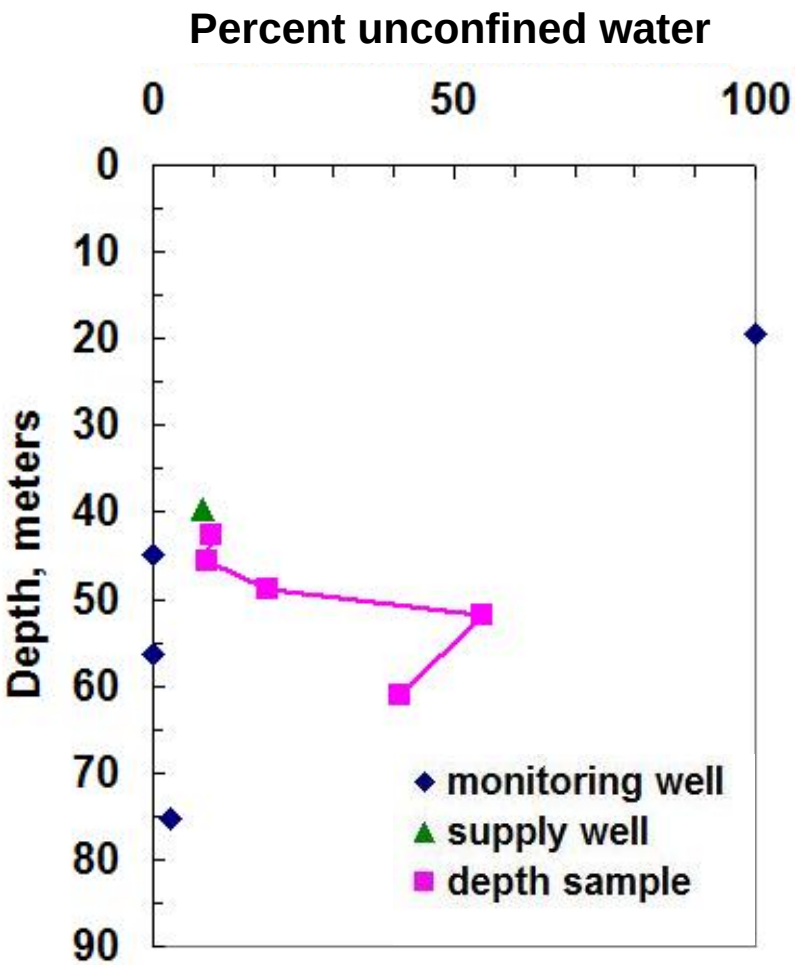
- **Similar results for: TCE, U, major ions, $\delta^{18}O$, δD, N_2**

Water $\delta^{18}O$ and Cl

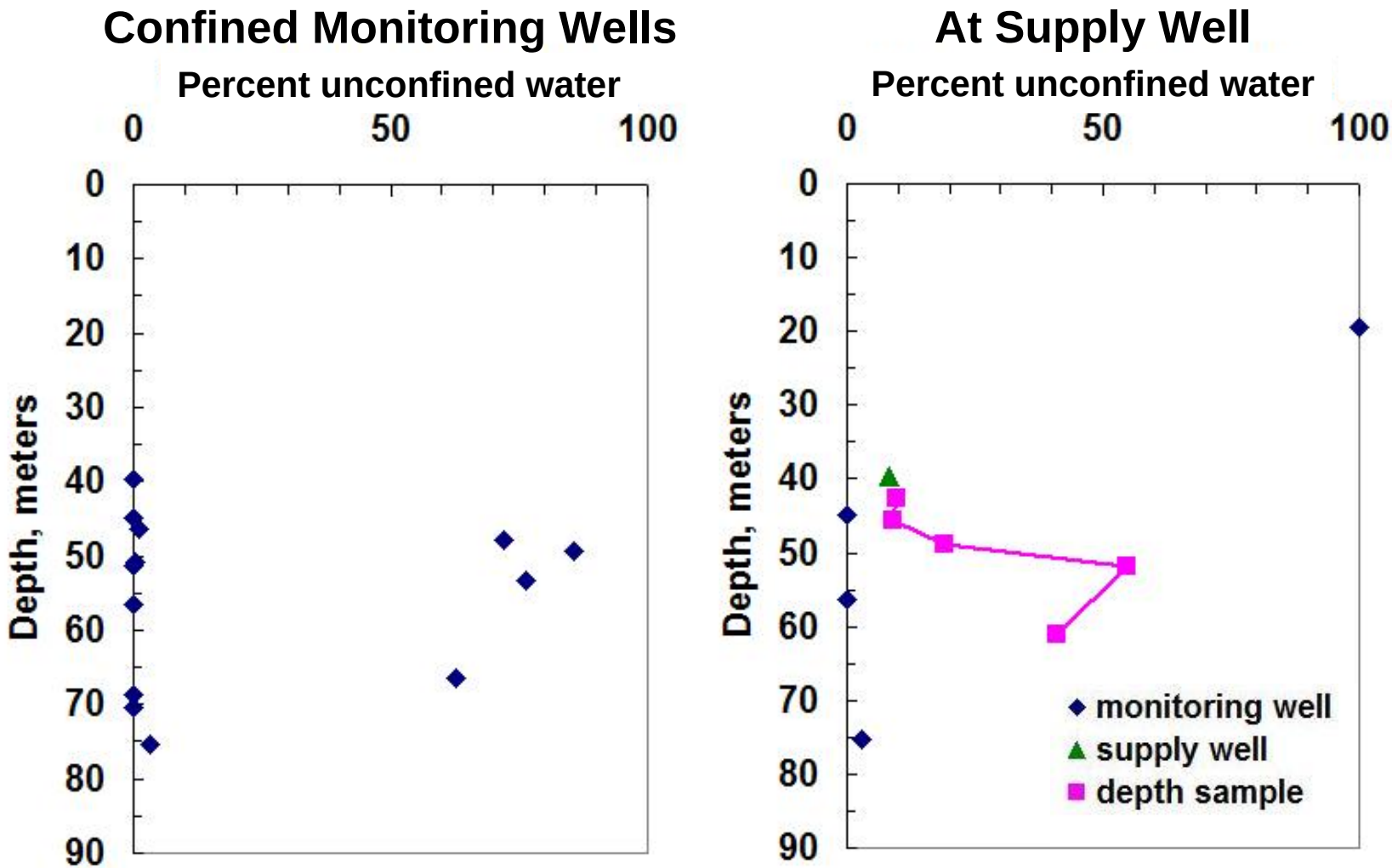


Unconfined-Confined Mixing from δD



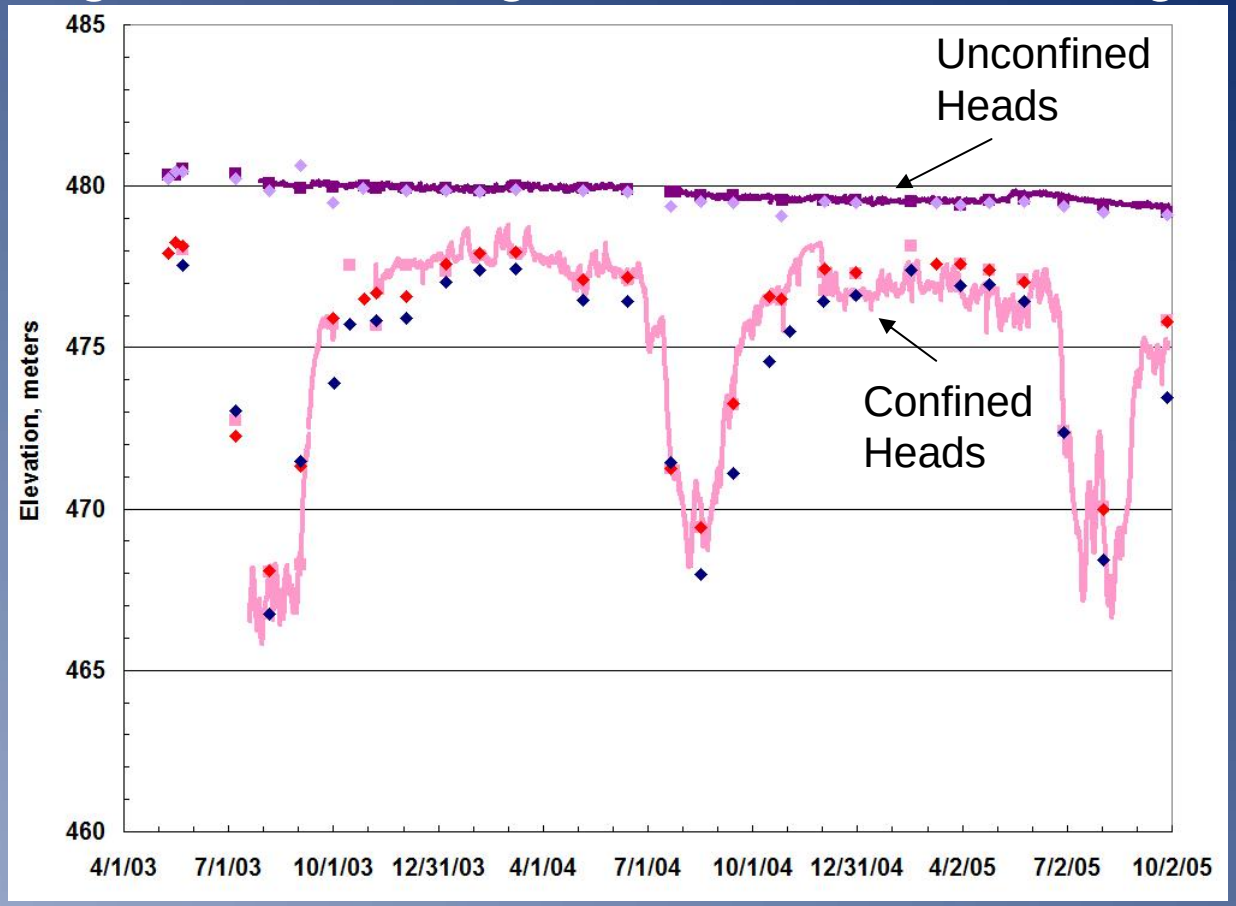


Unconfined Mixing Fraction from δD



Vertical Leakage Through Wellbores

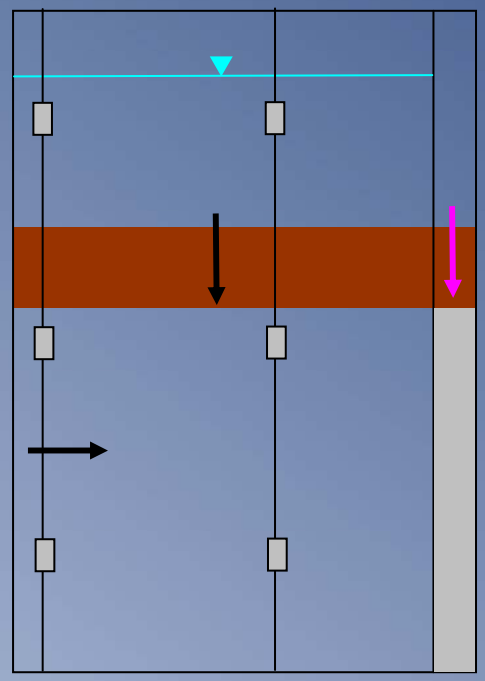
- **Large vertical head gradients across confining layers**



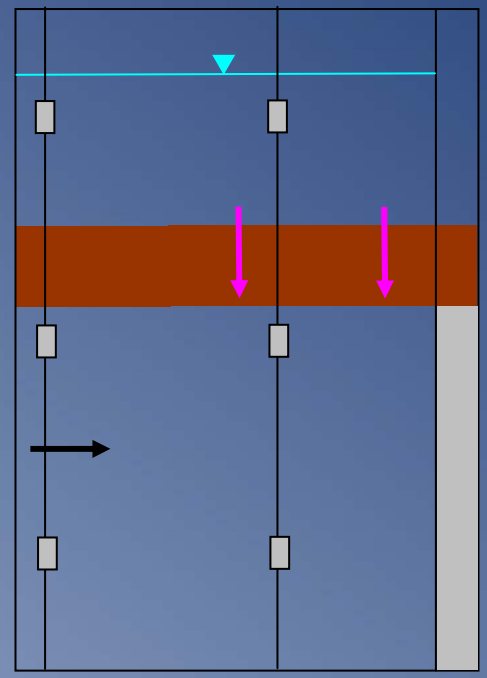
- **Irrigation, commercial and old municipal wells are commonly screened in unconfined and confined sand layers**

Contaminant Pathway Hypotheses

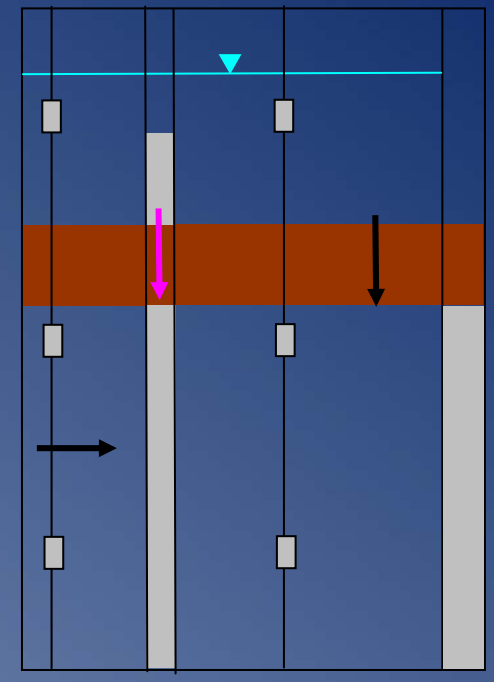
Supply well (SW) leakage or drawdown induced leakage



Areally uniform leakage through confining unit

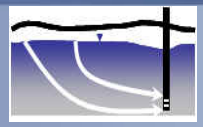


Wellbore leakage in multi-layer wells



MW – Monitoring Well
LW – Leaky Well (Multi-Layer)

USGS

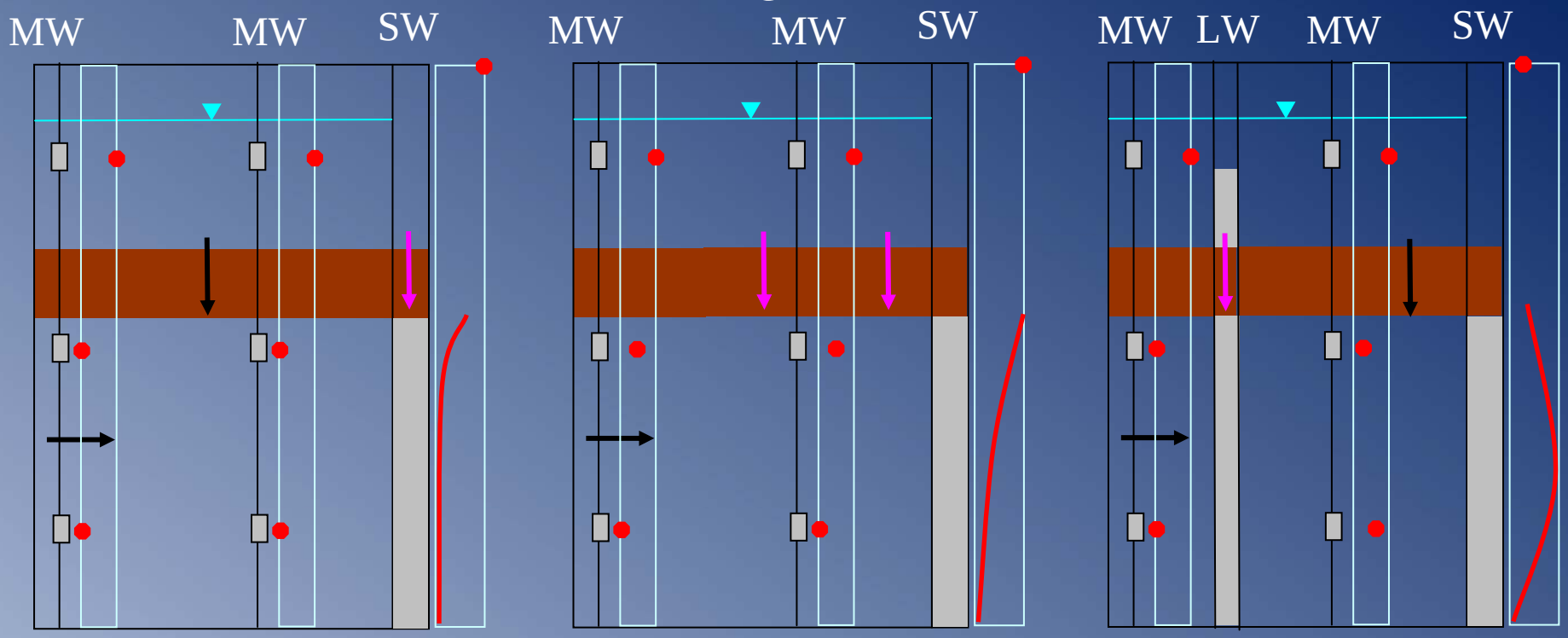


Contaminant Pathway Hypotheses

Supply well (SW) leakage or drawdown induced leakage

Areally uniform leakage through confining unit

Wellbore leakage in multi-layer wells

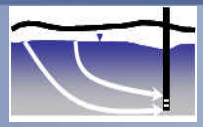


MW – Monitoring Well
LW – Leaky Well (Multi-Layer)

Conceptual background confined concentration

Conceptual unconfined concentration (increasing left to right)

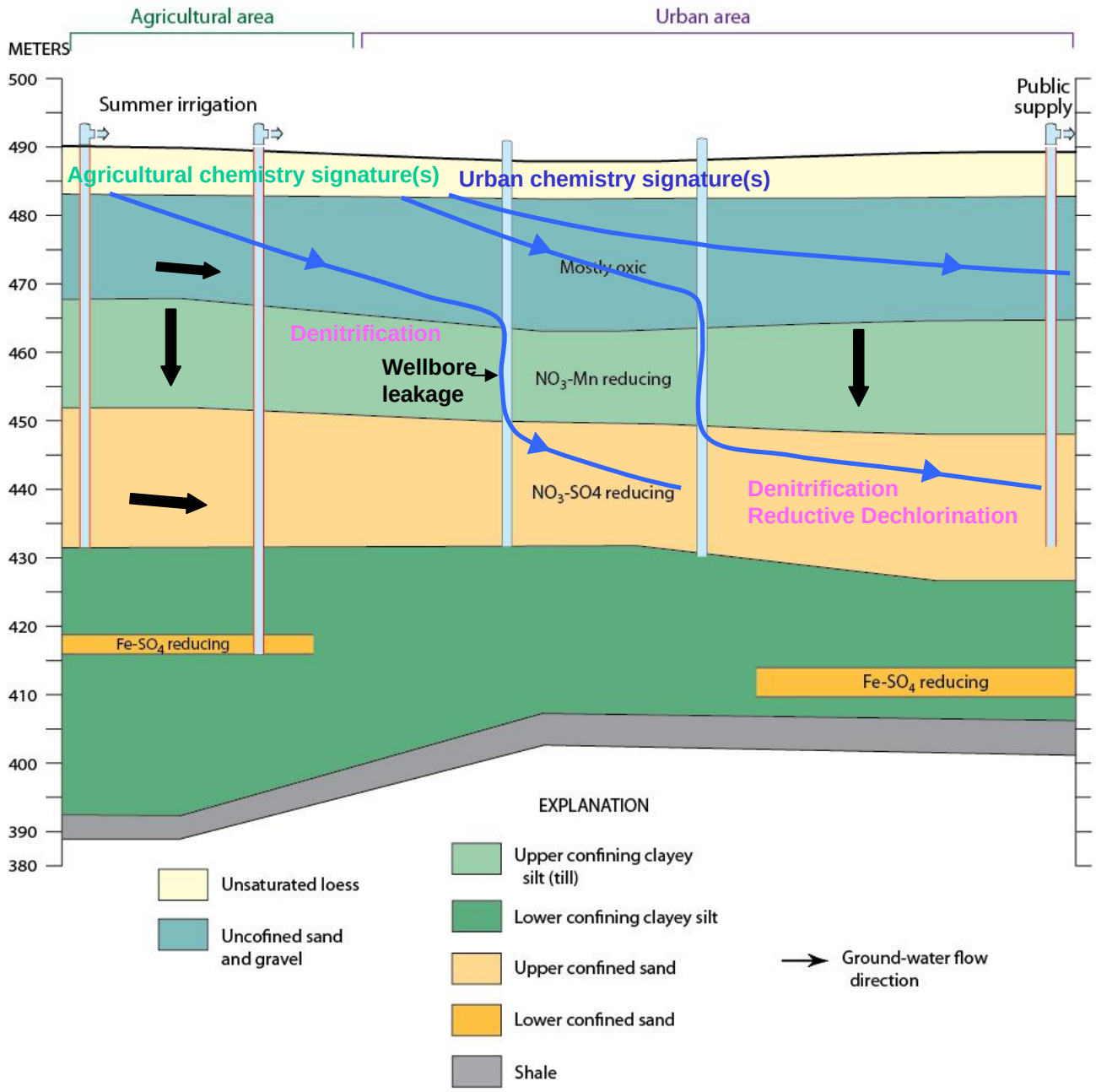
Fits measured chemistry data



Model Simulations

- Model simulations of ground-water age with MODFLOW-GWT (Ground Water Transport) and the MultiNode Well (MNW) package
- Please see talk by Brian Clark at 3:55 today for more details
- Simulations including wellbore leakage in multi-screen wells and known abandoned wells and test holes have the best match with observed age distribution

High Plains TANC Conceptual Model



Conclusions

- Supply well vulnerability can be strongly influenced by wellbores that cross confining units
- Short-circuit pathways need to be considered in protecting ground-water supplies
- Sampling from different depths in supply wells, in addition to nearby monitoring wells, improves understanding of contaminant pathways to supply wells

Acknowlegements

- USGS National Water Quality Assessment Program

- Timothy Boyle
- Benjamin Dietsch
- Michael Turco

- City of York, Nebraska

Contact Information

Matthew Landon
U.S. Geological Survey
4165 Spruance Road, Suite 200
San Diego, CA 92101
Tele: 619-225-6109
Email: landon@usgs.gov

TANC Website:
http://oh.water.usgs.gov/TANCweb/NAWQATANC.htm

USGS