Arsenic variability and geochemistry at a domestic bedrock well in New Hampshire

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Joe Levitt, James Degnan, Sarah Flanagan, Bryant Jurgens

U.S. Geological Survey

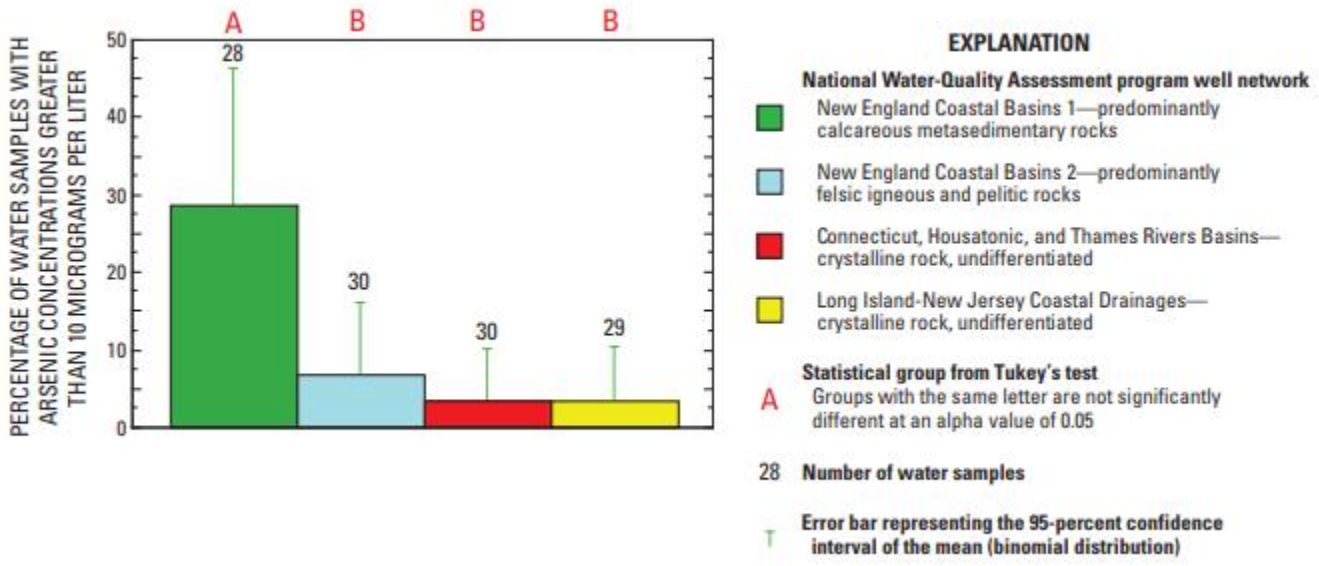
New England Water Science Center

Objectives

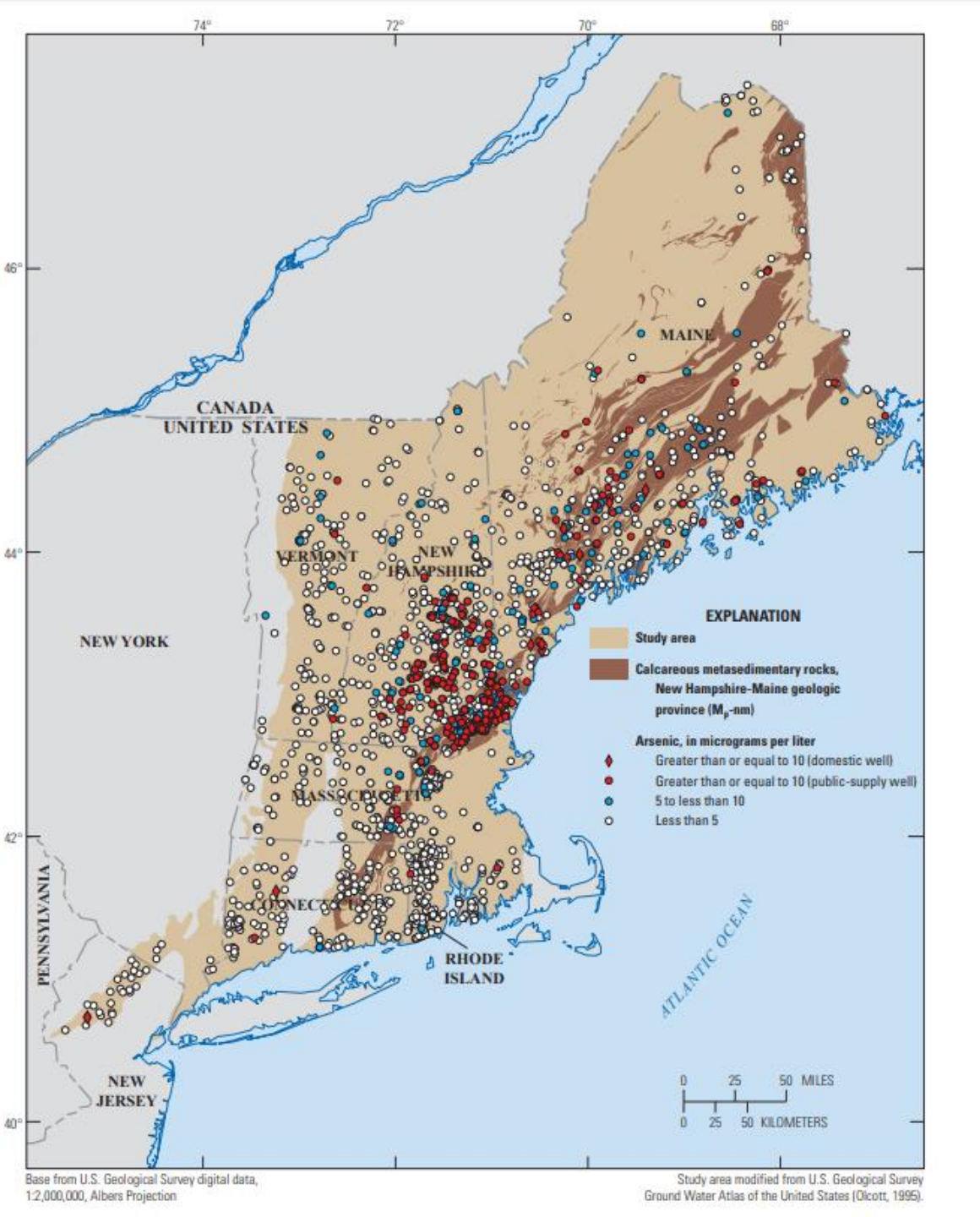
1. Over what time scales does water quality change?

2. What are the drivers of change?
    1. Geochemical processes
    2. Groundwater age

Background- Arsenic in New England

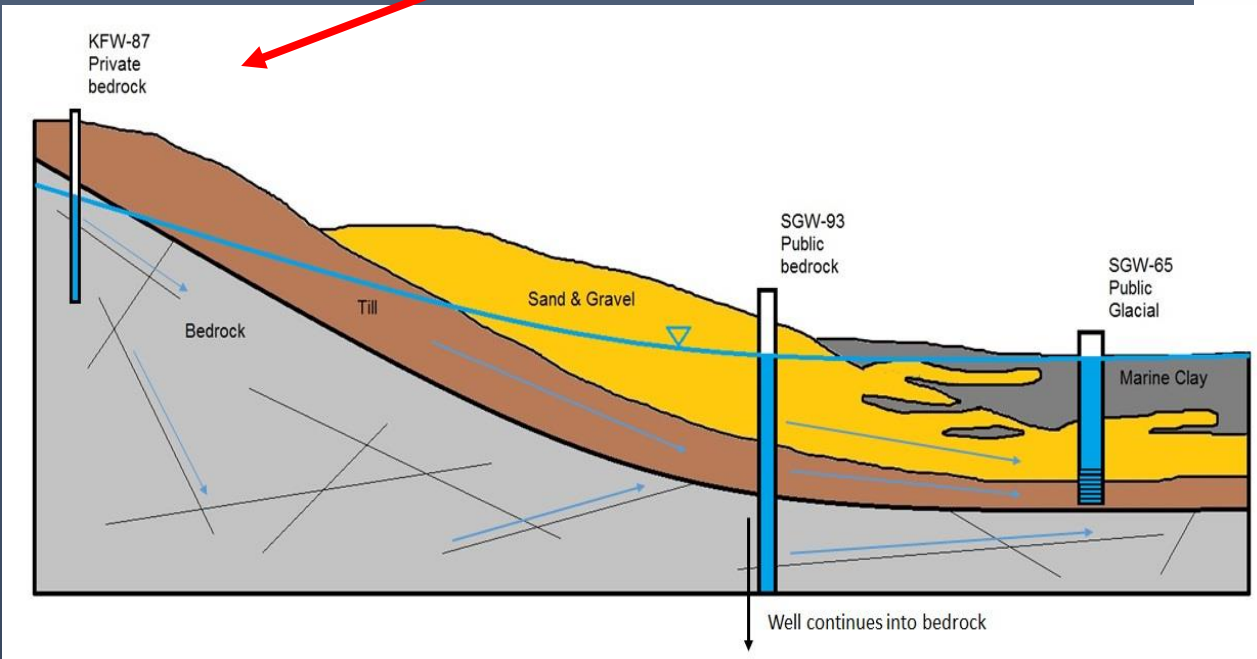


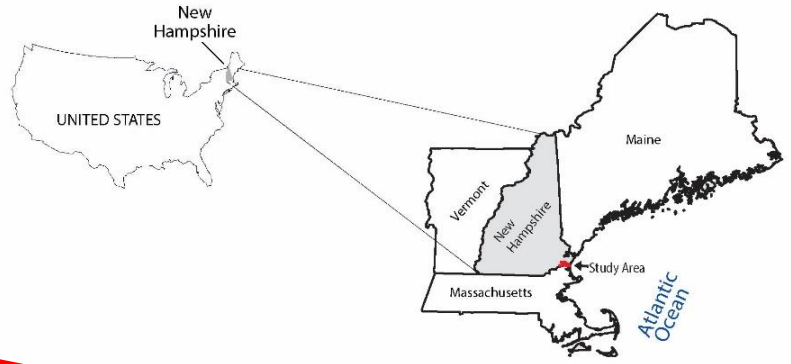
From Flanagan and others (2012)

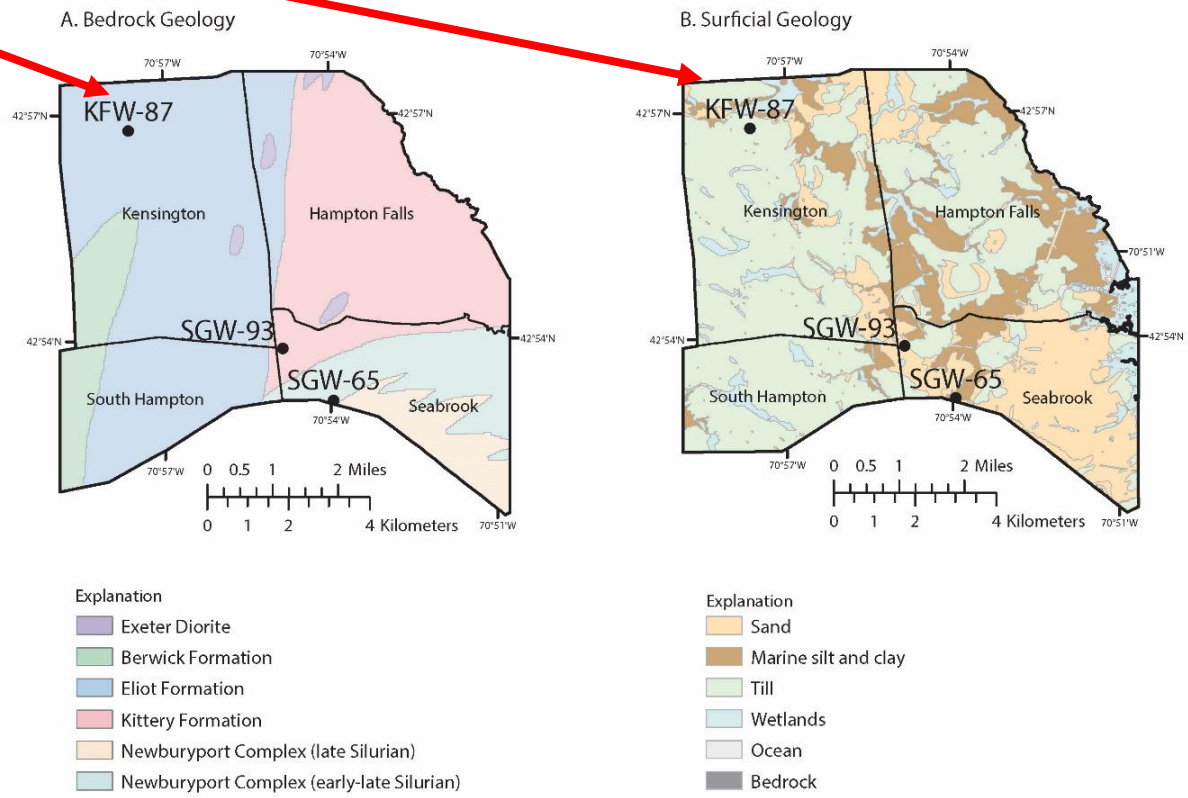


Background - Setting

KFW-87

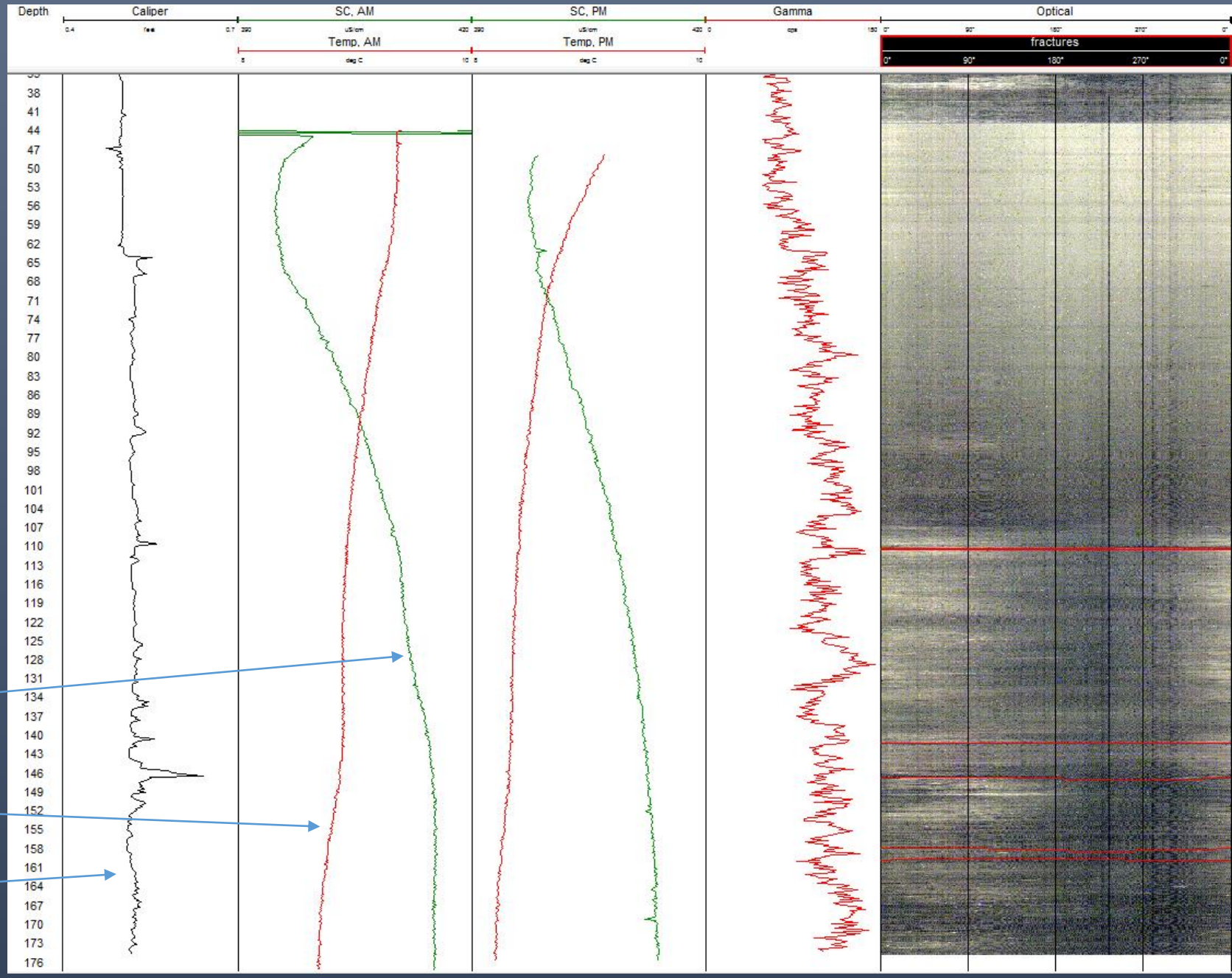






Background - Geophysical Log

- Various (5+) fracture zones
- Generally, >100 feet depth



Specific Conductance

Temperature

Caliper

Background - Summary

Low DO and high pH are arsenic's happy state!*

- High arsenic occurs in locations with both:
  - Sources of arsenic (calcareous metasedimentary rock)
  - Geochemical state conducive to arsenic mobility

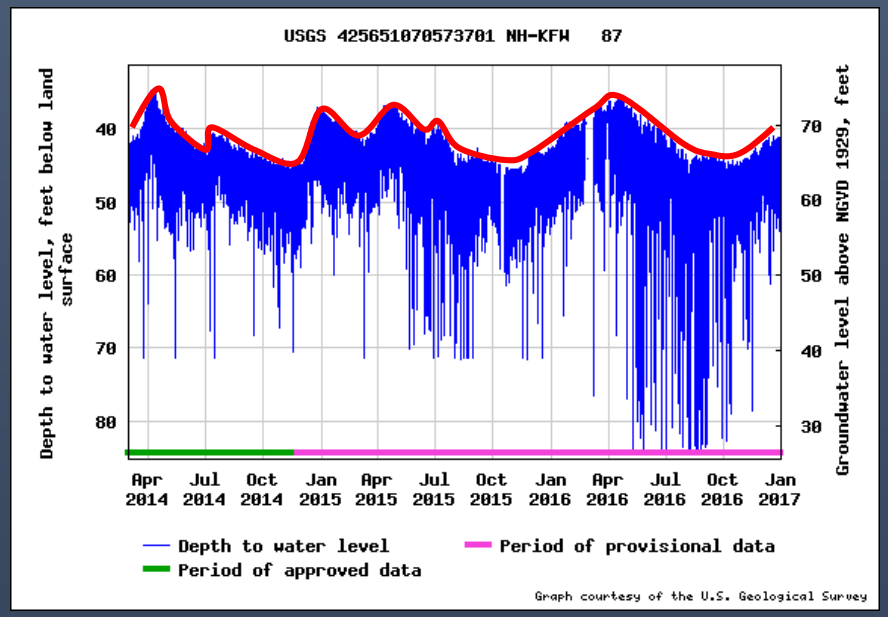
Parameter	pH (standard units)	DO (mg/L)	As (ug/L)
Median	8	0.1	37.2

*Ayotte and others (2003), Bondu and others (2017), Flanagan and others (2012)

Methods - Sampling

Continuous

- pH
- Specific conductivity
- Water temperature
- Dissolved oxygen
- Water level



https://waterdata.usgs.gov/nwis/

Discrete

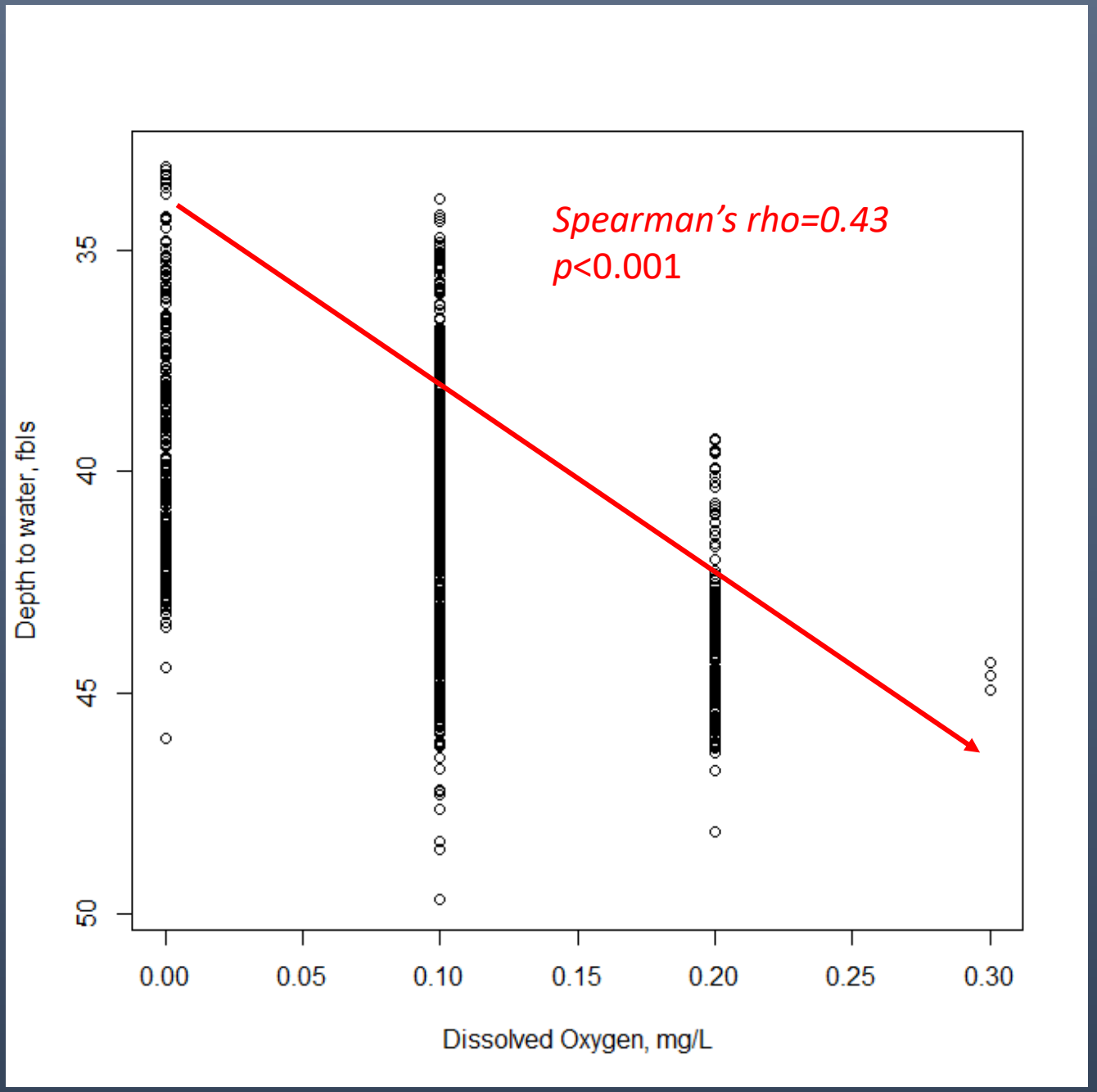
- Major ion chemistry
- Alkalinity
- Nutrients
- Arsenic and other trace elements
- As(III) and As(V) species
- Radionuclides
- Stables isotopes
- Age tracers
- Atmospheric gases

Analysis - Correlations

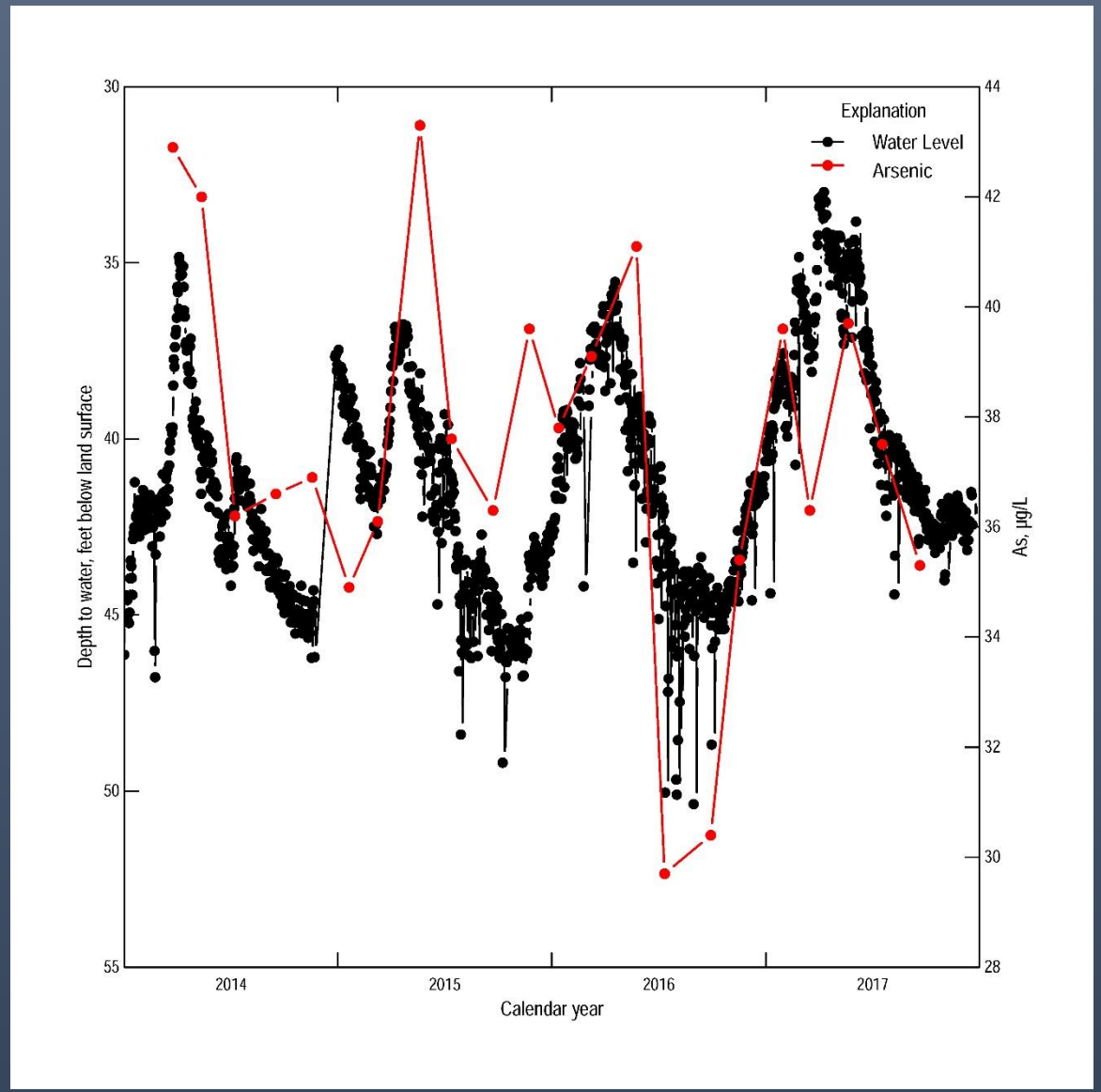
ALWAYS ANOXIC! (DO <0.5 mg/L)

DO decreases when water level is up –

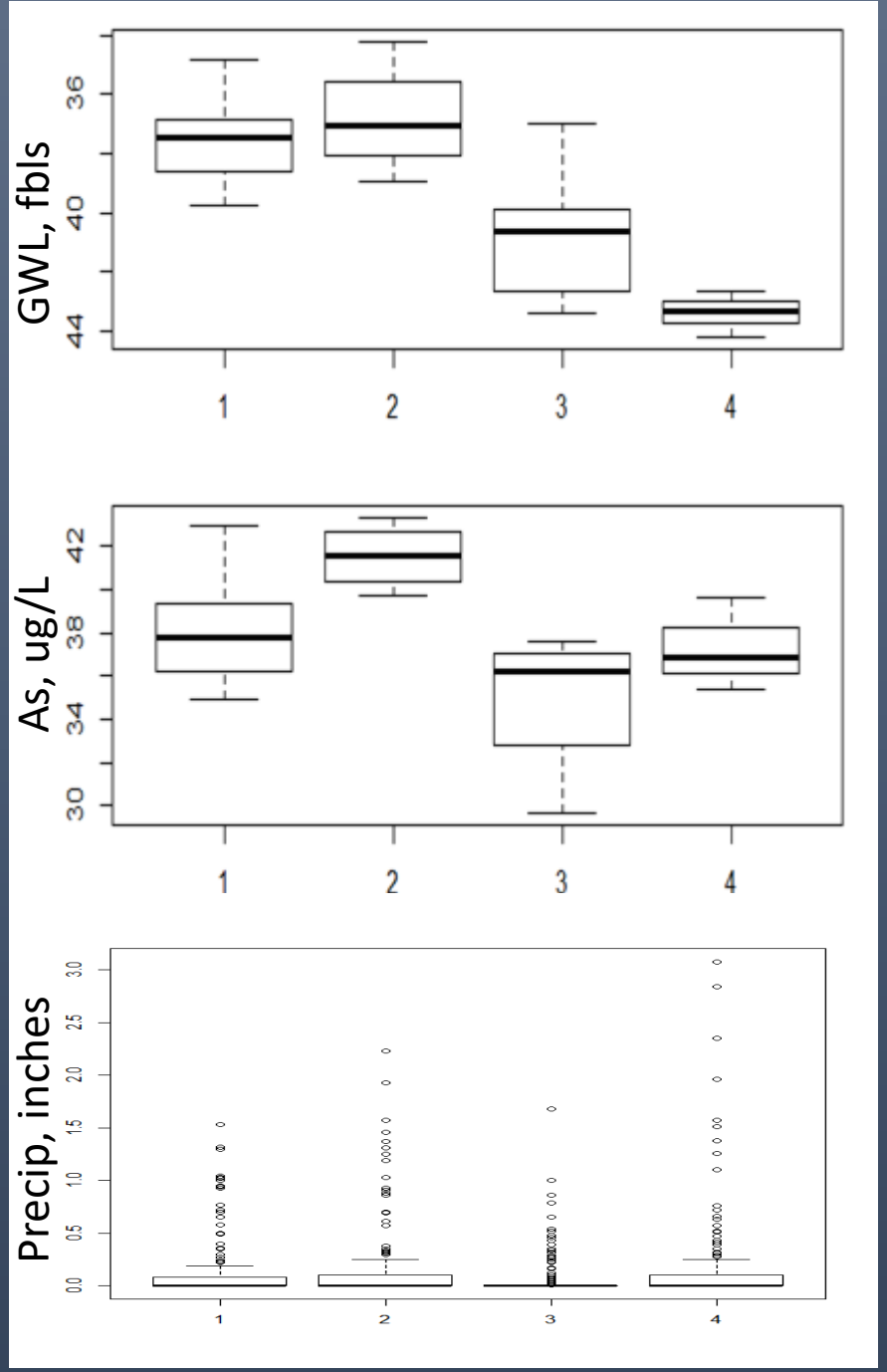
More anoxic water with recharge



Analysis - Correlations

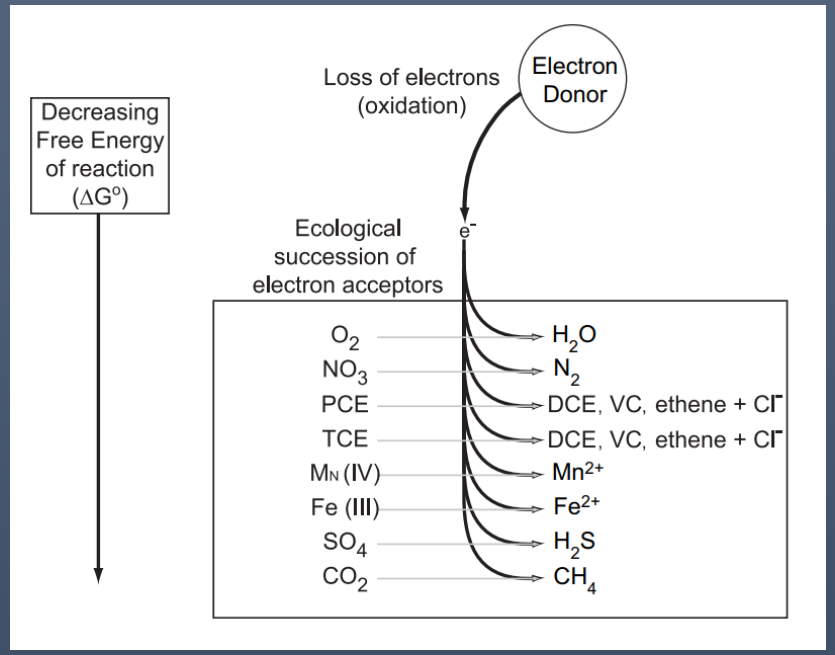


More arsenic with recharge

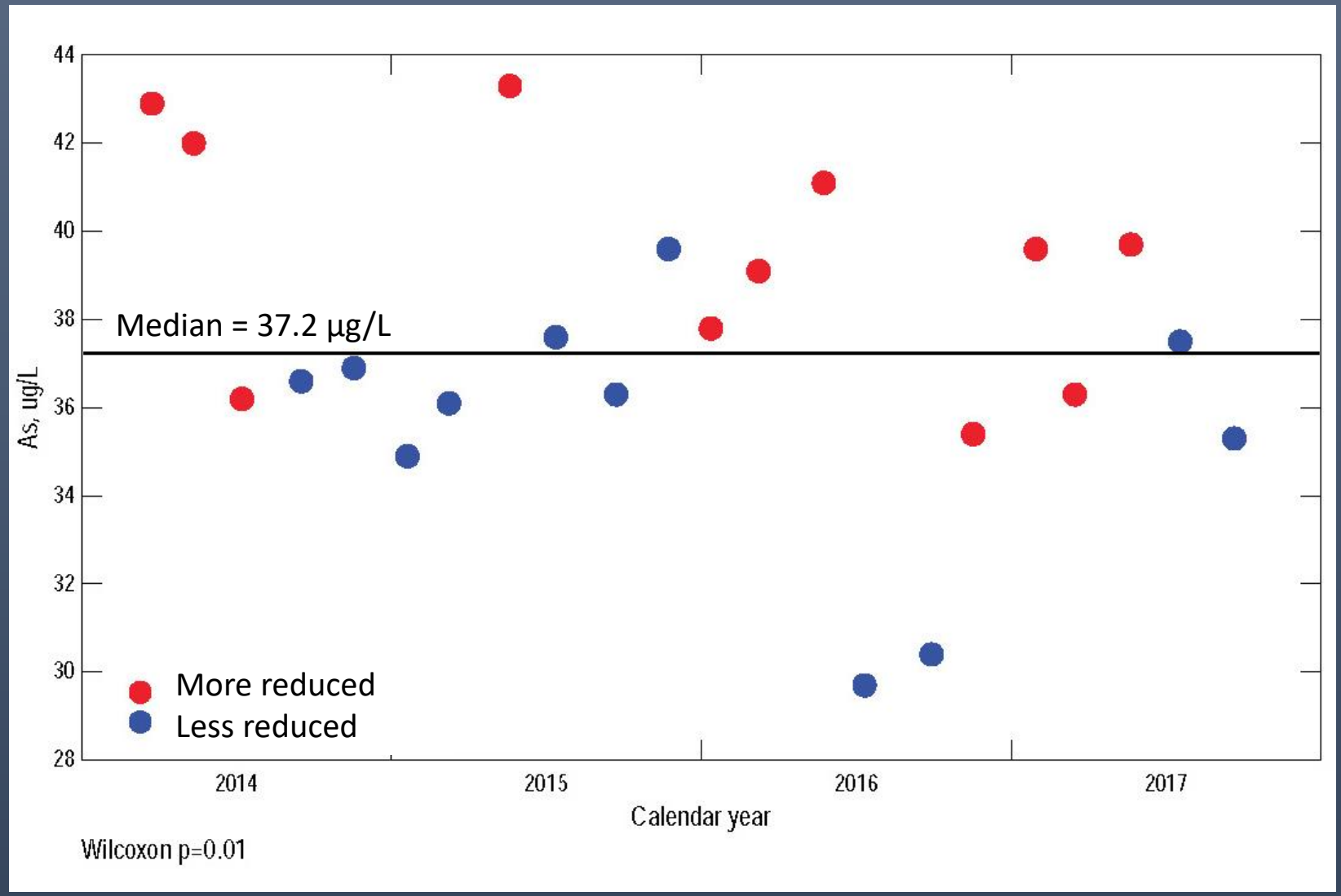


Analysis - Redox Processes

Terminal Electron-Accepting Processes (TEAP)

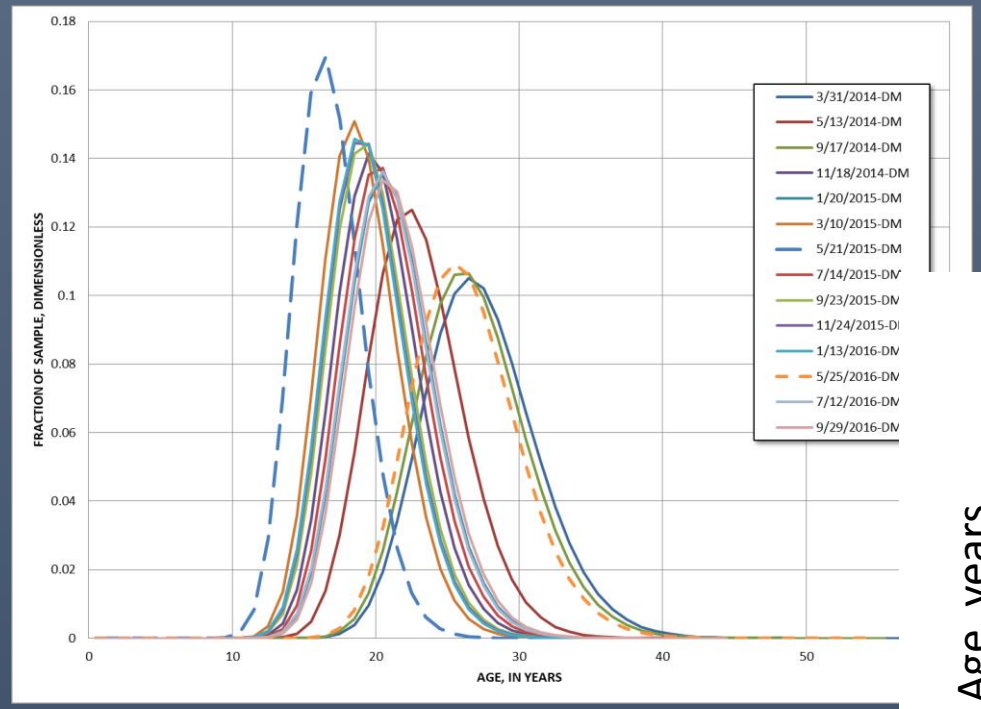


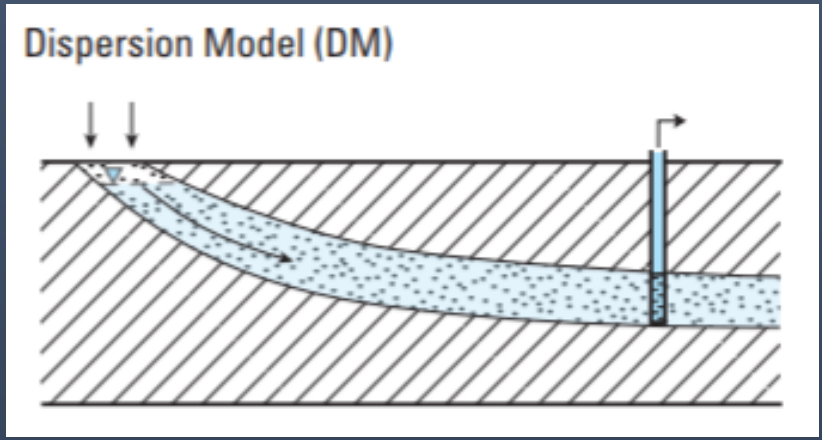
From McMahon and Chappelle (2008)



More reduced water with recharge

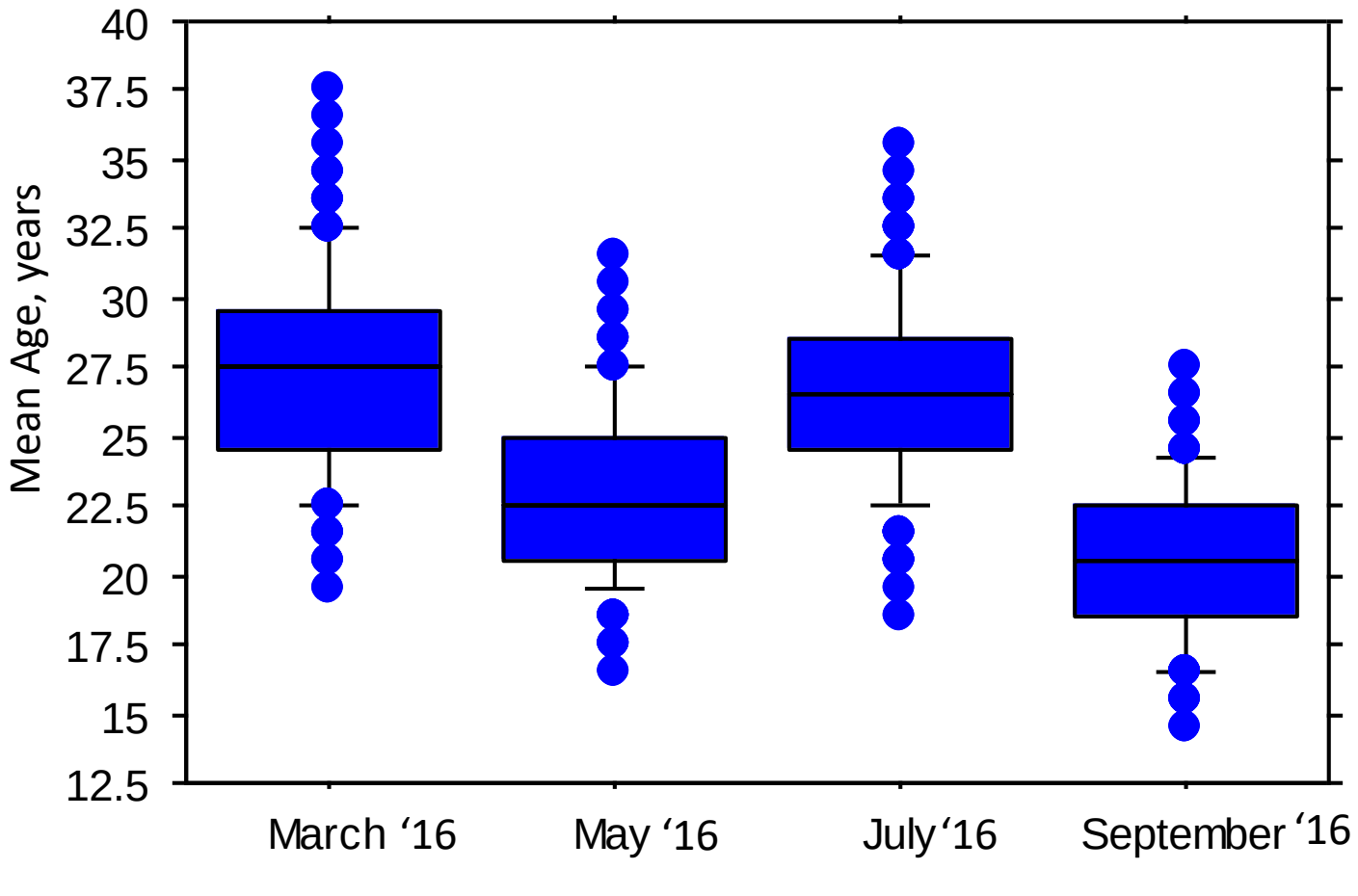
Analysis - Age distributions





Jurgens and others (2012)

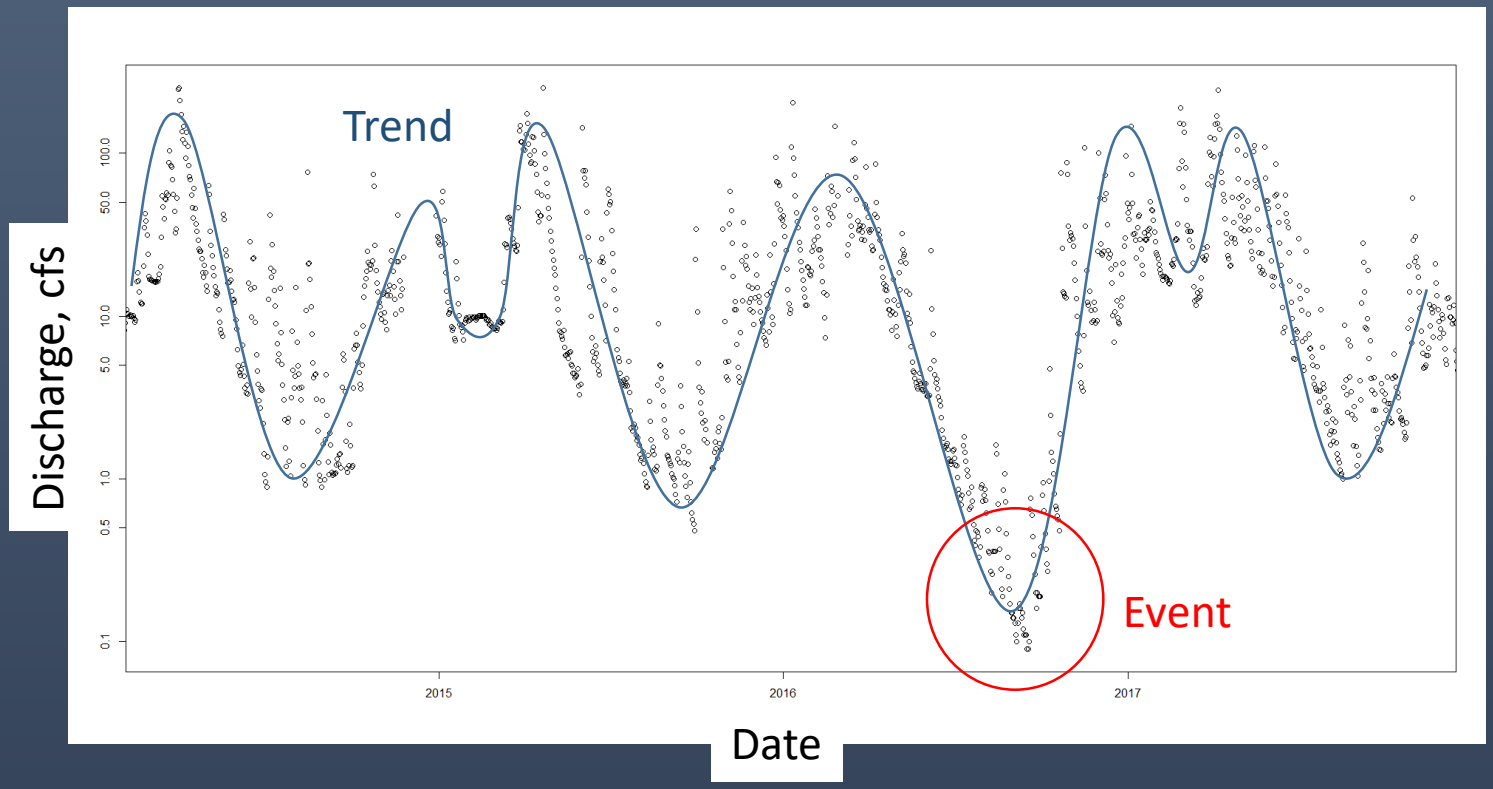
Older water with recharge?



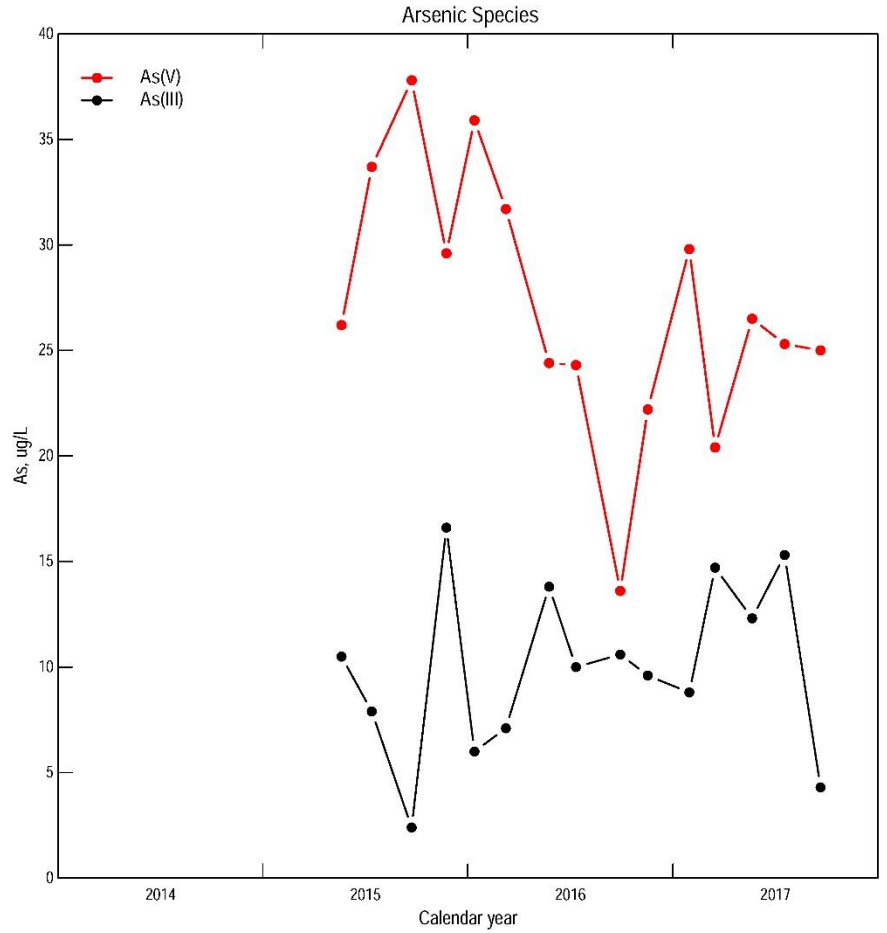
Going Forward – Further Analysis

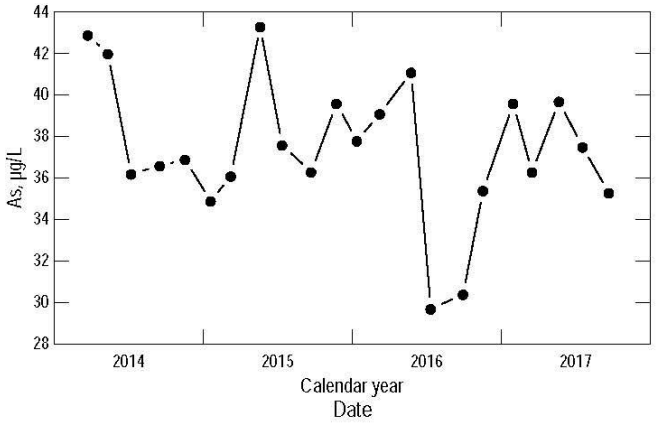
- Trend
  - Occurs over sampling period
  - Repeating or monotonic
- Event
  - Occurs once
  - High or low value

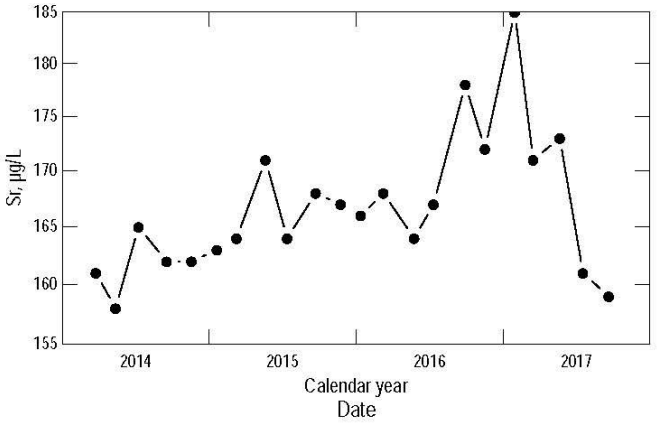
Winnicut River

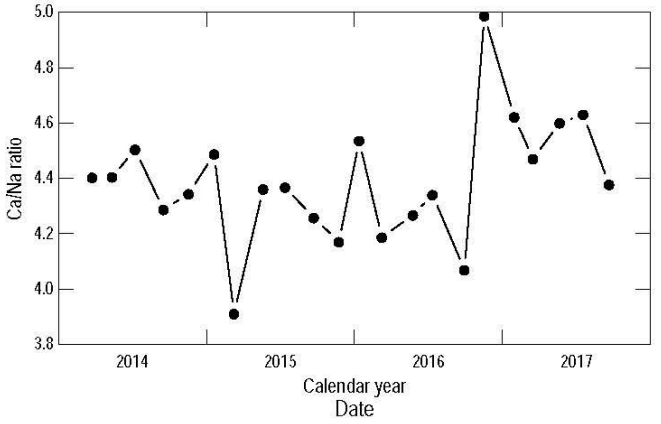


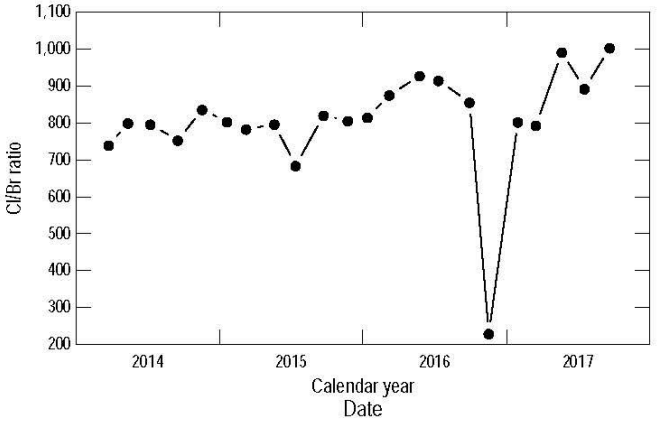
Trends and Events

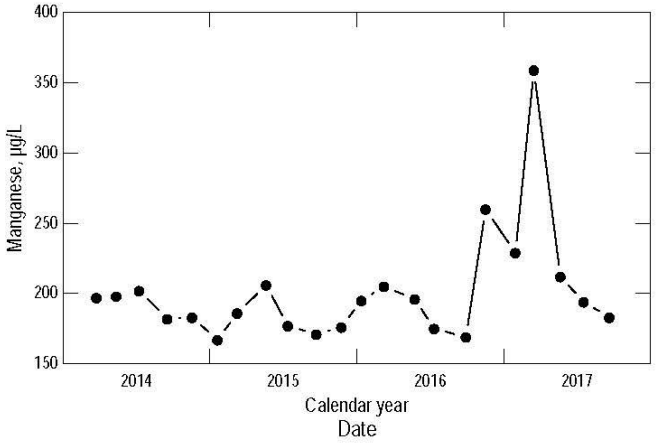


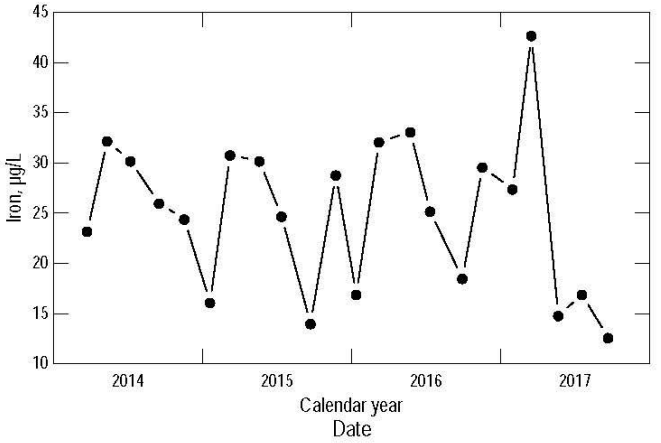




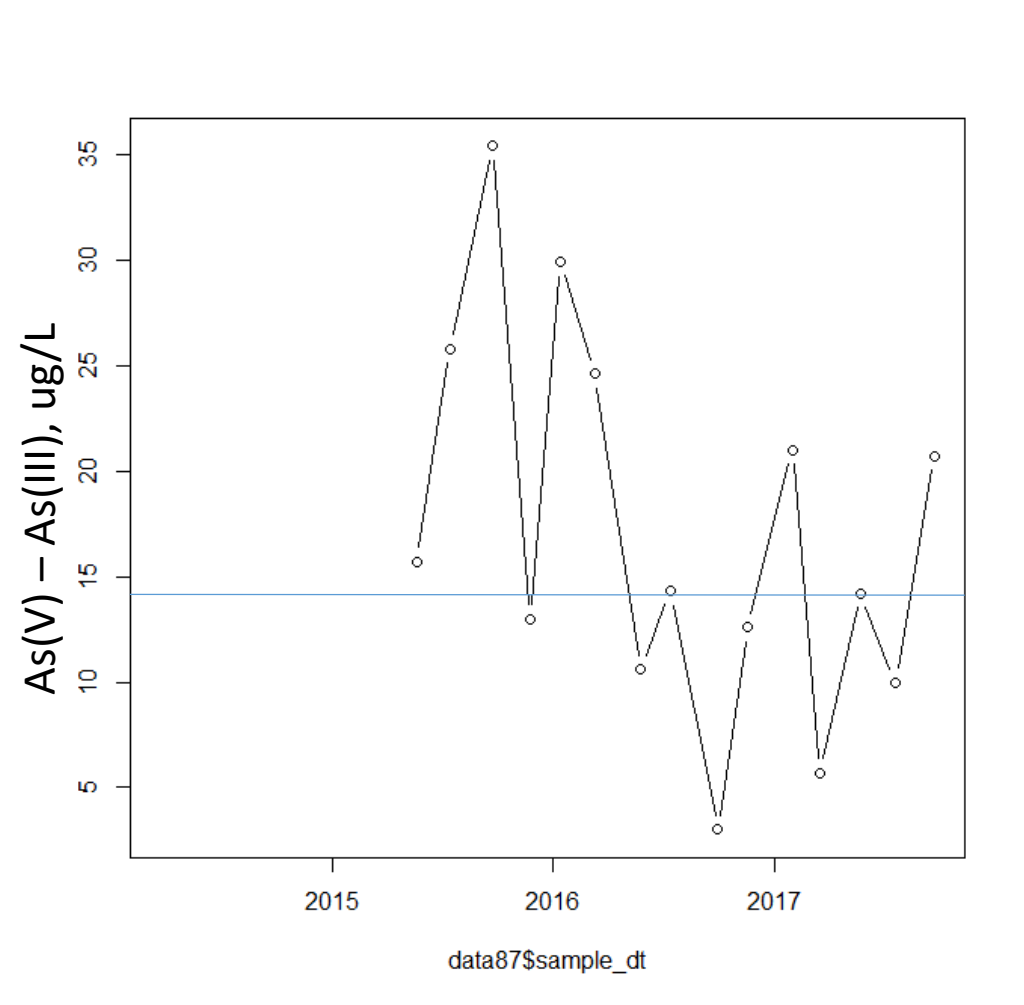


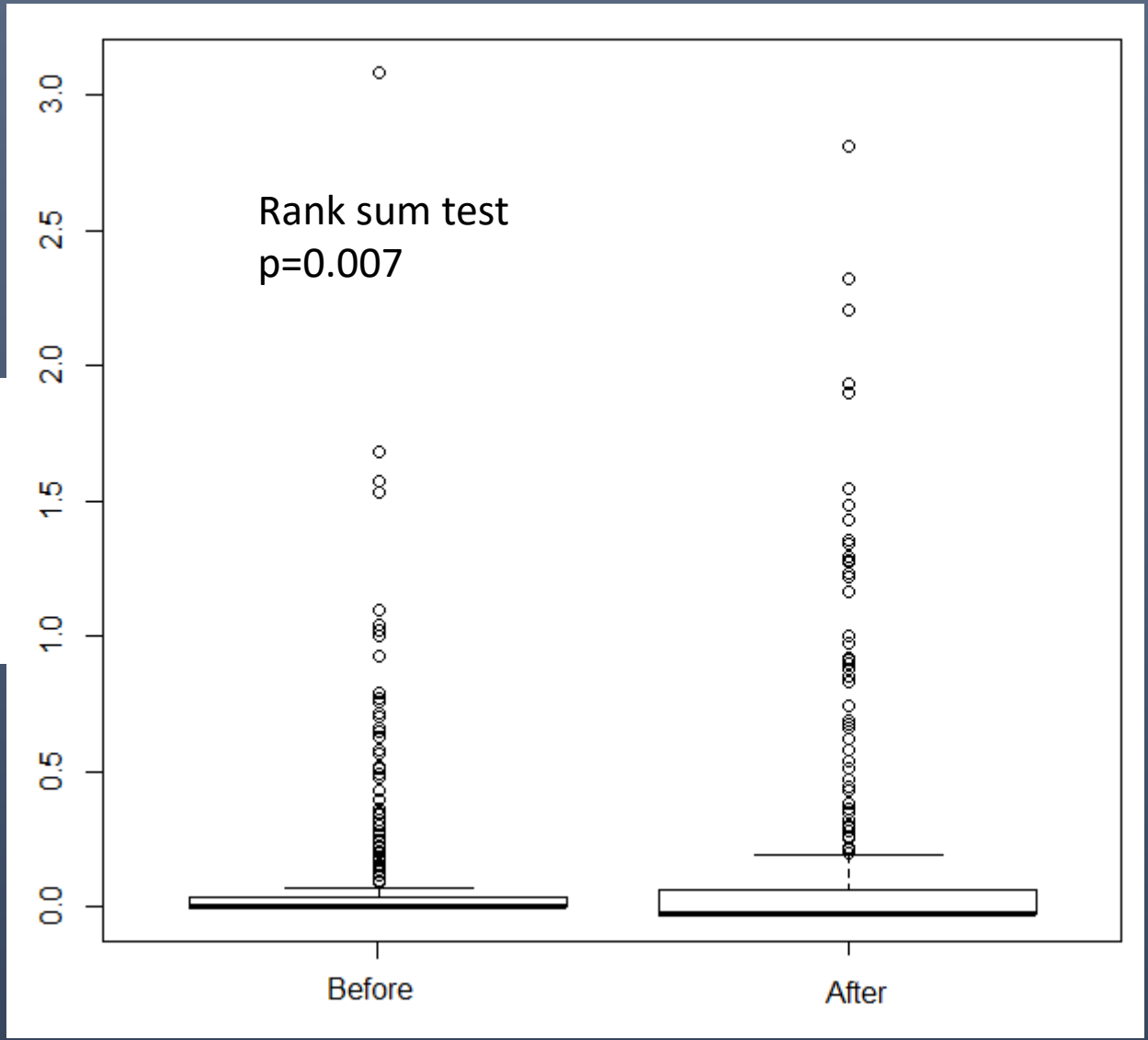




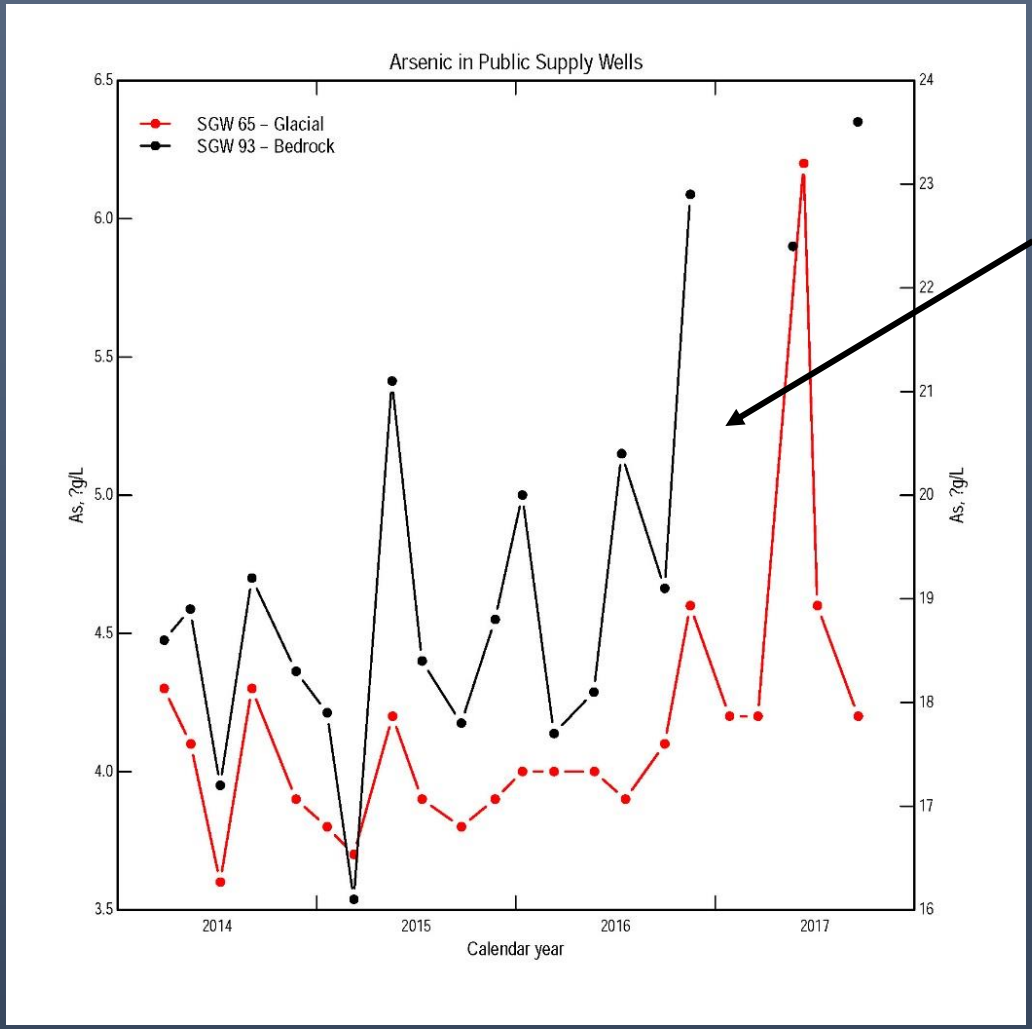


As Species and Drought



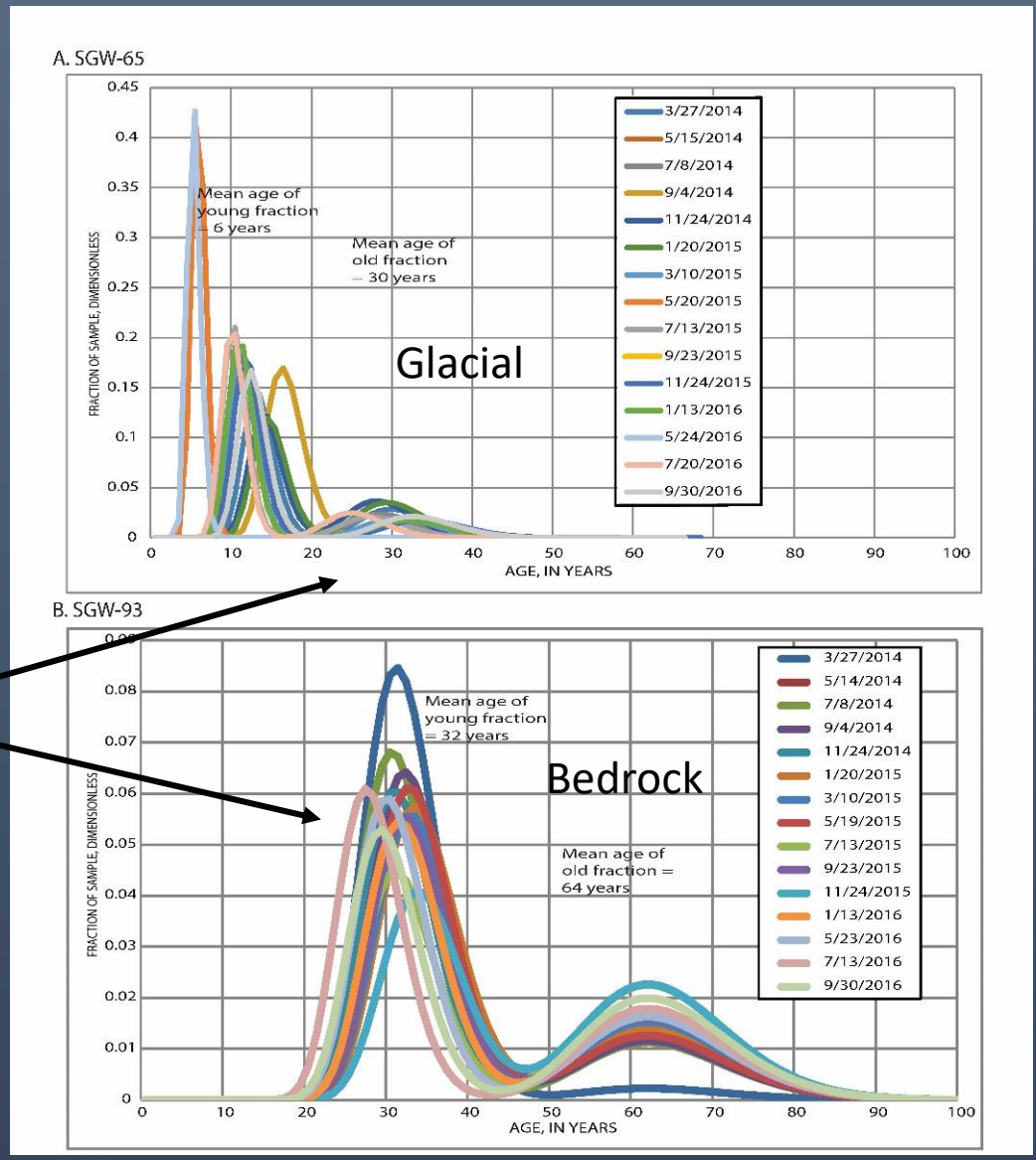


Further Analysis – Age Dating



Arsenic correlates (rho=0.81, p<0.001)

Young and old ages correlate (rho=0.53, p<0.05)



Summary

- Highest arsenic occurs with high water levels (seasonally)
- Secondary arsenic peak at lowest water levels
- Arsenic highs are related to lower redox state (more reduced)
- Drought causes spikes and troughs in chemical constituents
- Age distributions were not particularly informative, other than as evidence of modern recharge.

- May not be indicative of all wells in the area
  - BUT similar patterns seen at 2 nearby public supply wells in network.

Questions?

Contact:

Joe Levitt

Physical Scientist

U.S. Geological Survey

New England Water Science Center

jlevitt@usgs.gov

603-226-7802