

# Evaluating Long-Term Groundwater Resource Sustainability in Ottawa County with Data-Intensive Scientific Modeling



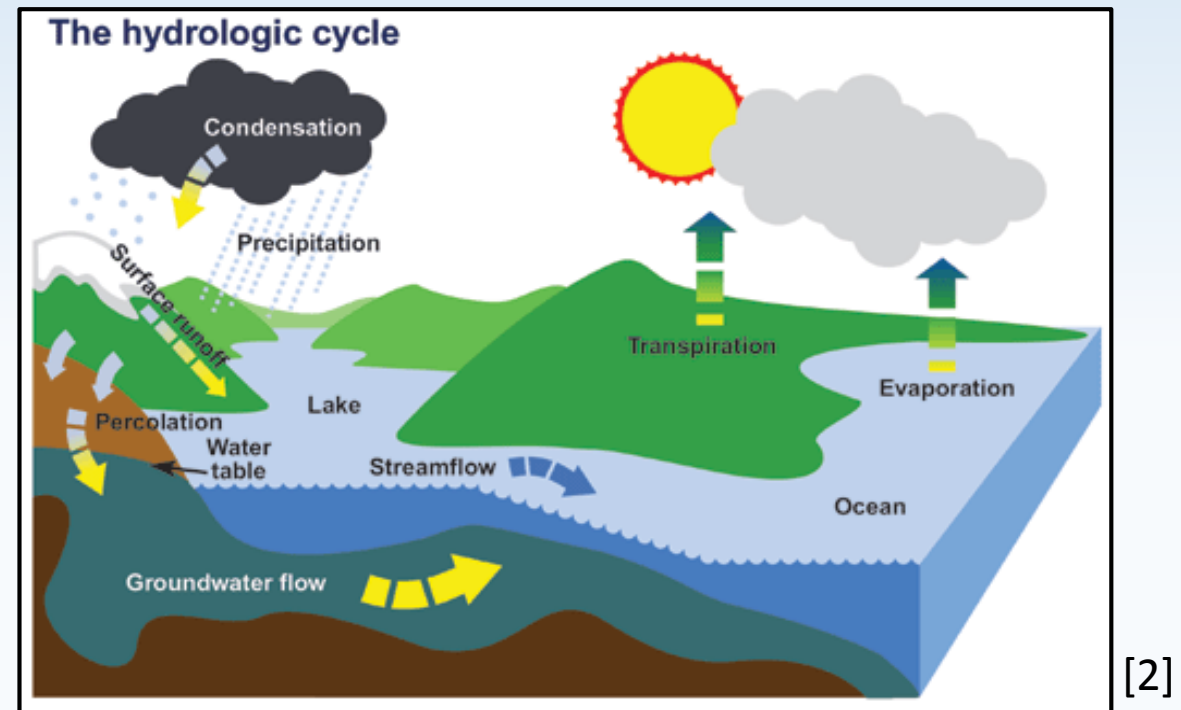
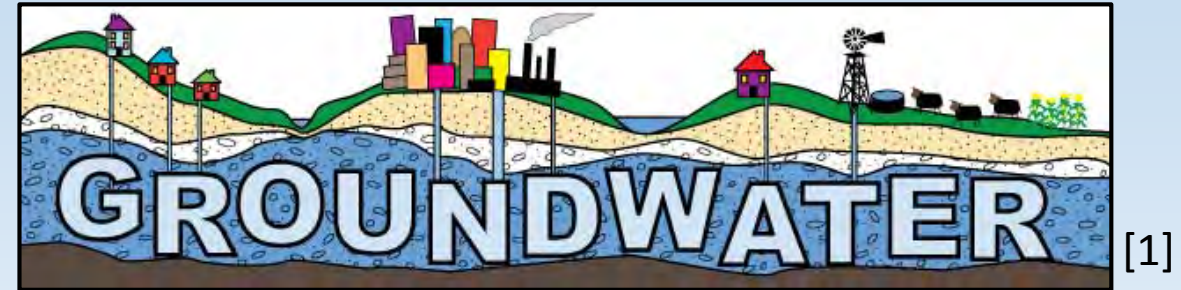
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# “Evaluating Long-term Groundwater Resource Sustainability...”

- How much fresh groundwater is available for long-term use in Ottawa County?
- How does this depend on land use or climate change? Sub-surface geology?
- What does the groundwater quality distribution look like (2D, 3D)?
- Has the water quality changed in recent decades? If so, why?

**Elevated groundwater salinity**

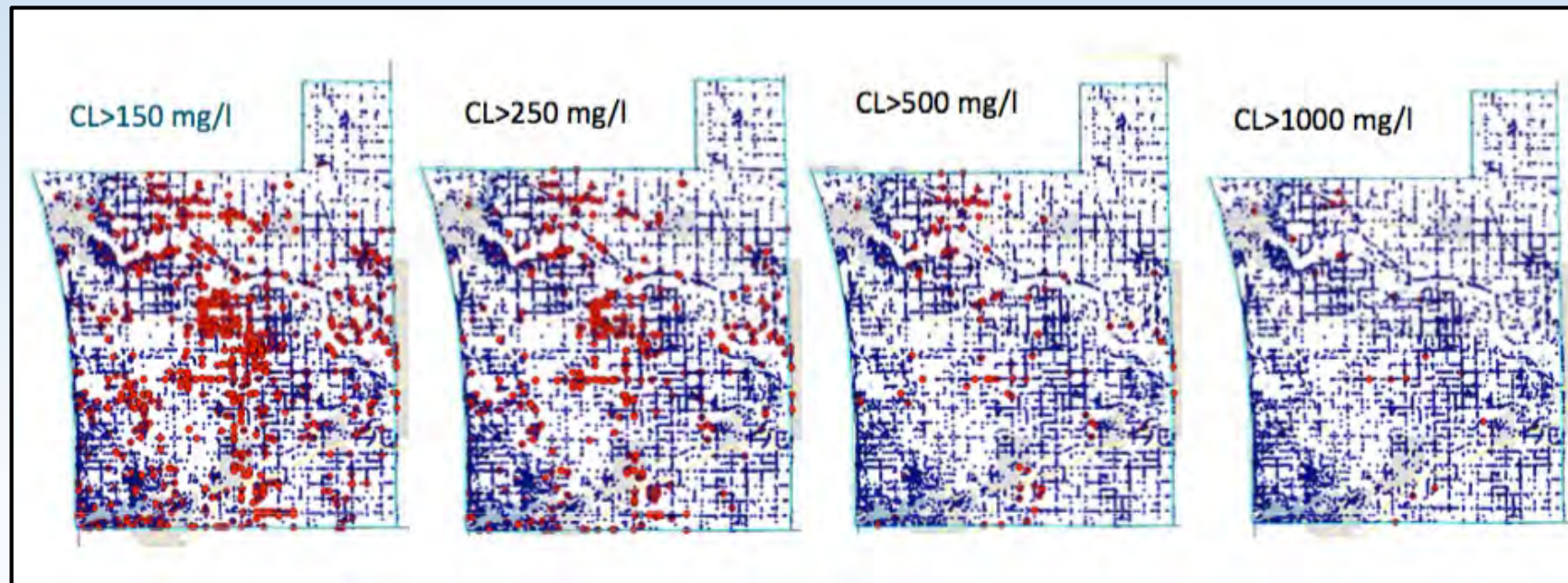


# “...Data-Intensive Scientific Modeling”

- Quantify groundwater use
  - Characterize climate (meteorological observations)
  - Collect water quality data ...
    - identify patterns, connections, relationships (hydrology <-> geology <-> water use <-> water quality)
    - Past and present
      - > determine source(s), controls, non-factors
- Derive “water budget”; predict & forecast future water quality/quantity

# Background & Motivation (Cl<sup>-</sup> issues)

Ottawa County Water Resource Project – Phase 1



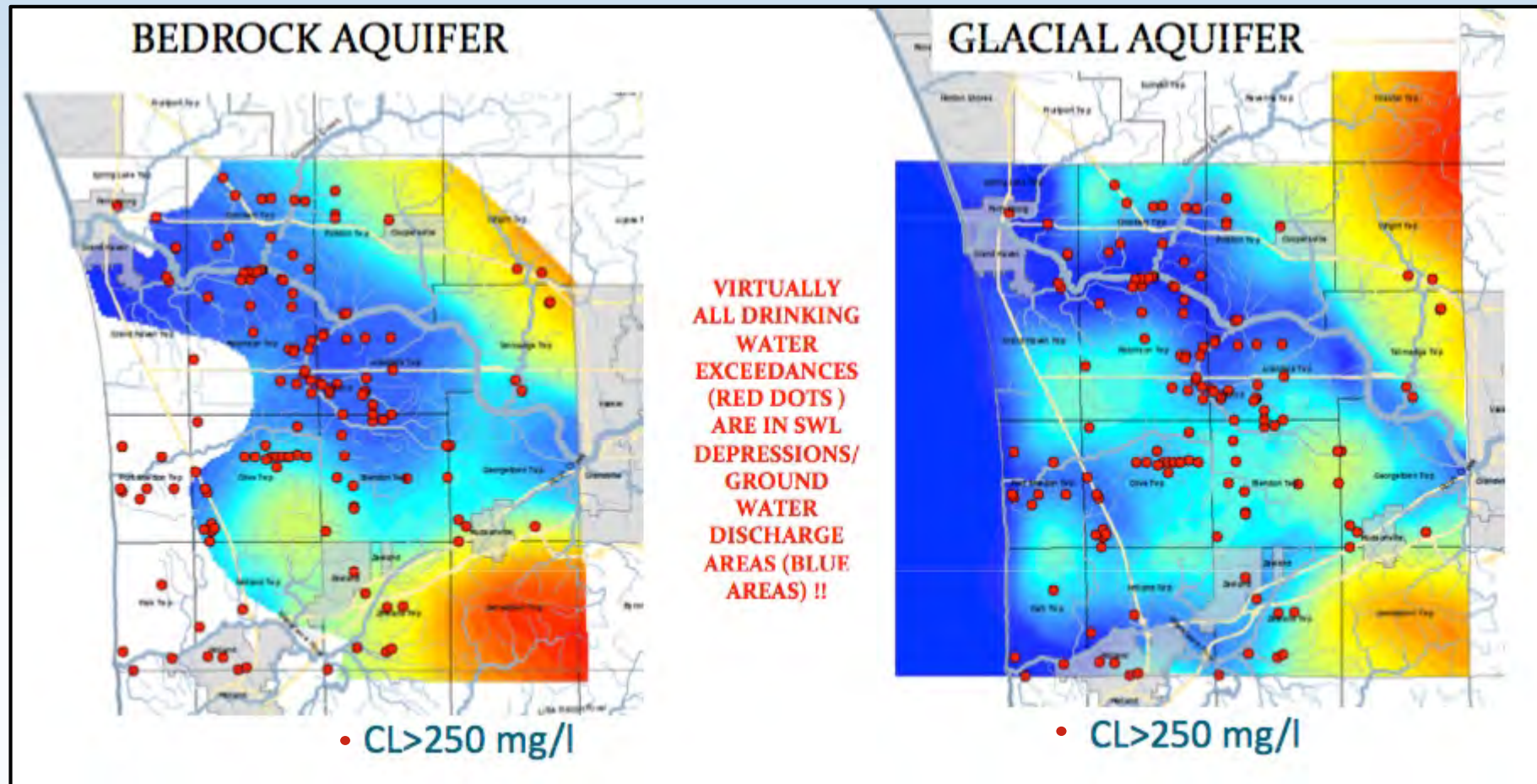
[3]

EPA  
Secondary  
Drinking  
Water  
Standard:  
**250 mg/L**

**Elevated chloride levels across parts of the County...  
Are other areas at risk?**

# Background & Motivation (Cl<sup>-</sup> issues)

## Ottawa County Water Resource Project – Phase 1



Color Map:

Groundwater hydraulic head

Red – high

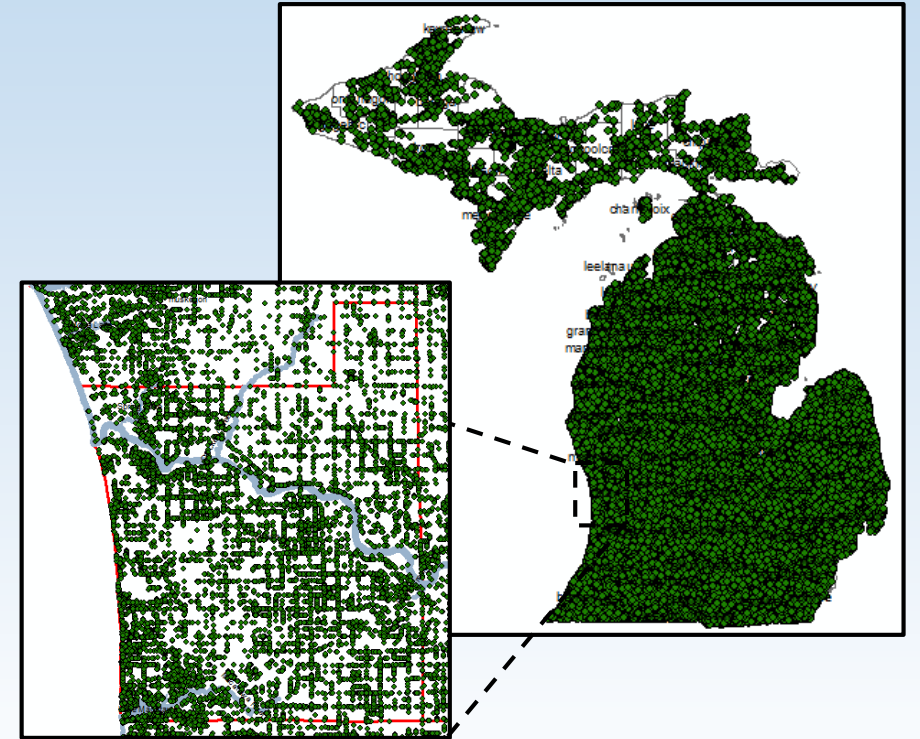
Blue – low

\*Groundwater generally moves upwards in discharge zones

# Phase 1 Cl<sup>-</sup> Mapping – Some Limitations

Cl<sup>-</sup> levels from WaterCHEM:

- Results span decades
  - Current extent of contamination?
  - Inconsistent spatial coverage for temporal analysis
- Surface water samples
- Spatial accuracy can be an issue
- No depth information
  - WaterCHEM linked to Wellogic...but uncertainties in geo-coding, Wellogic



→ **Need for precise groundwater sampling in Ottawa County**

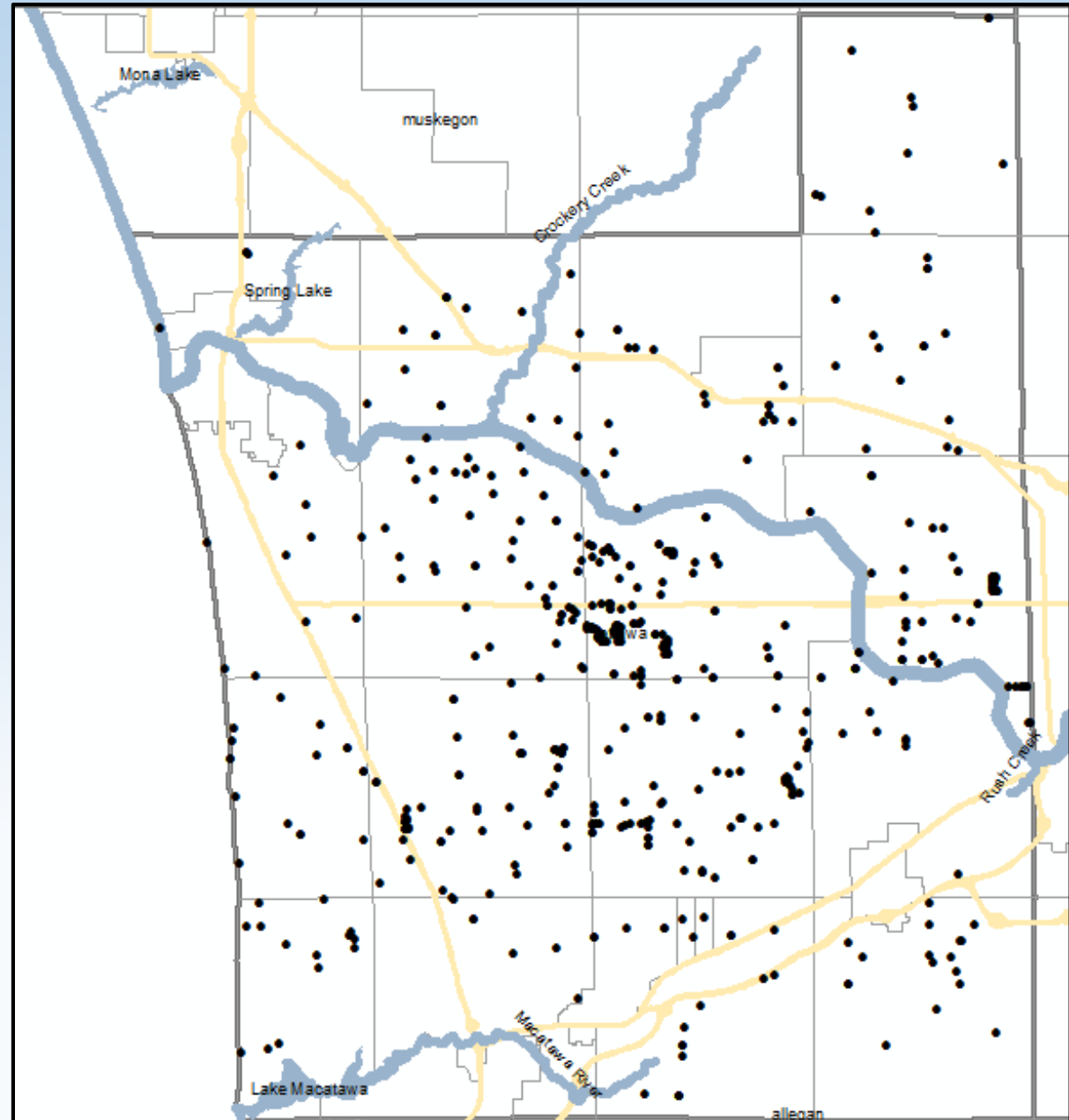
# Collecting Field Samples

- Fall 2014 – present
- 543 samples collected from 468 locations across Ottawa County
- 100% voluntary participation from property owners, private businesses, and municipalities



# Sampling Locations

- Attempted to cover all areas of Ottawa County
- GOAL: sample 75% deep (bedrock) wells, 25% shallow (drift) wells
- 343/543 samples from wells drilled 100+ ft deep (63% of total)
- 200/543 samples from wells drilled <100 ft deep (37% of total)





# Undergraduate Sampling Technicians

- Employed ≈60 undergrads to help
- Sampled 115+ locations in one day, on three separate occasions
- Valuable field experience for students
- Went through mandatory training
  - Handling samples, site safety and clean-up, etc.



# Scientific Precision & Accuracy

- High spatial accuracy (<5 m lat., long. position; well depth from drilling records)
- [Cl<sup>-</sup>] (mg/L) measured at MSU
  - Ion-selective electrode (ISE), EPA Standard Method 9212
  - Reproducibility  $\approx \pm 2\%$
- QA/QC: Duplicates ( $\approx 10\%$  sites), field blanks ( $\approx 5\%$  sites), lab blanks, standards tested,  $T_{standard} = T_{sample}$



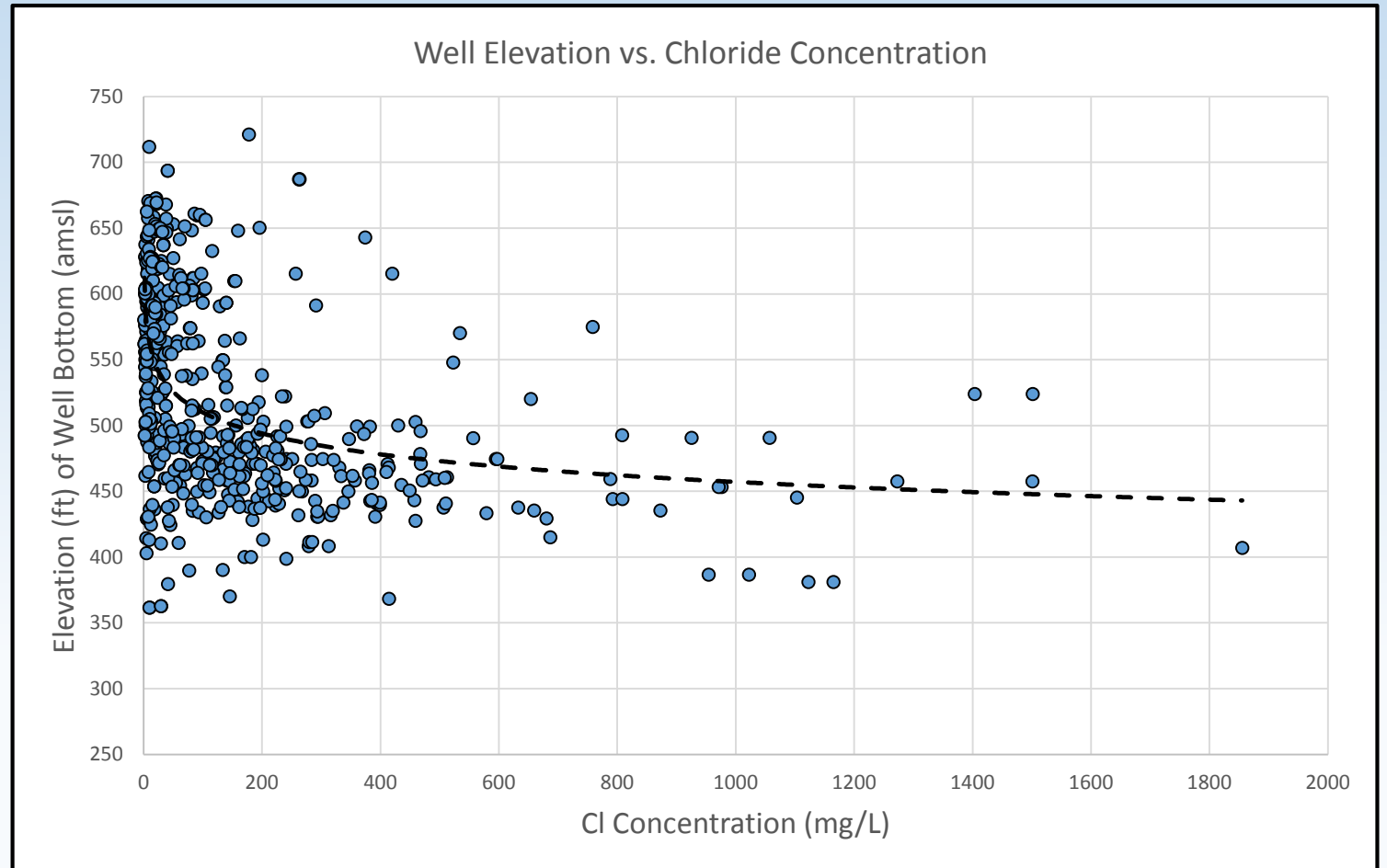
GPS coordinates taken at the wellhead location (when possible)



# Field Sampling Results

## I. Depth analysis

- In general, **chloride concentration increases with depth**
- Some deep wells have low concentrations
- Almost all shallow wells are below 250 mg/L

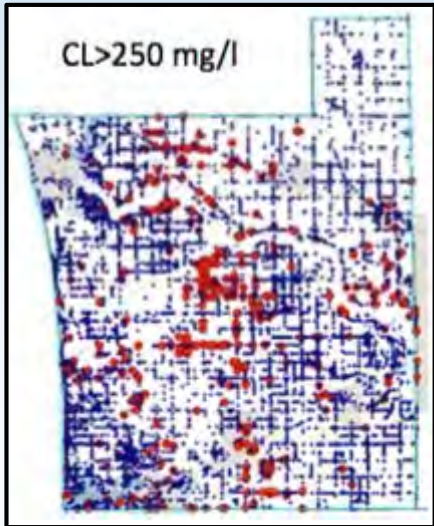


# Field Sampling Results

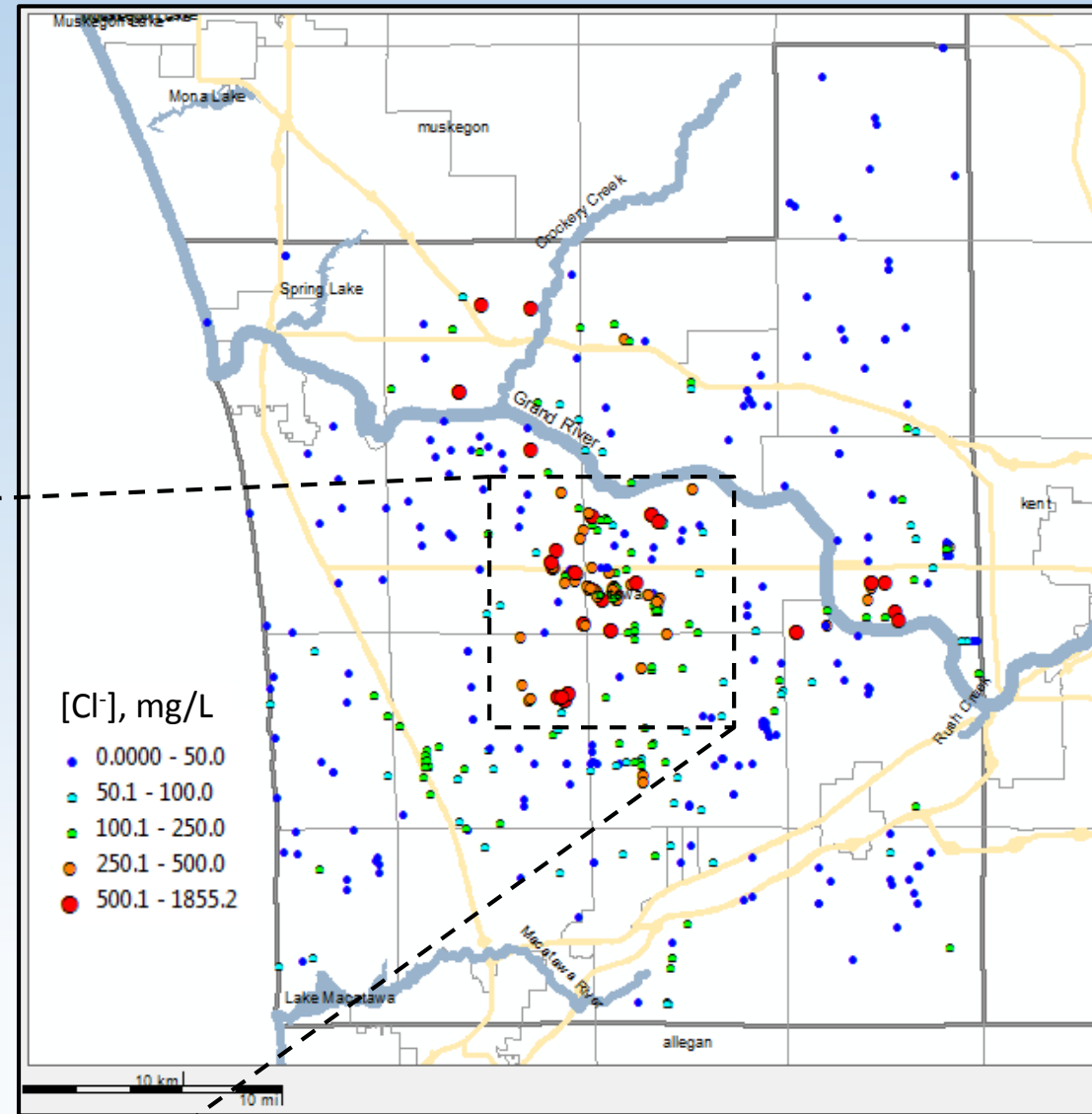
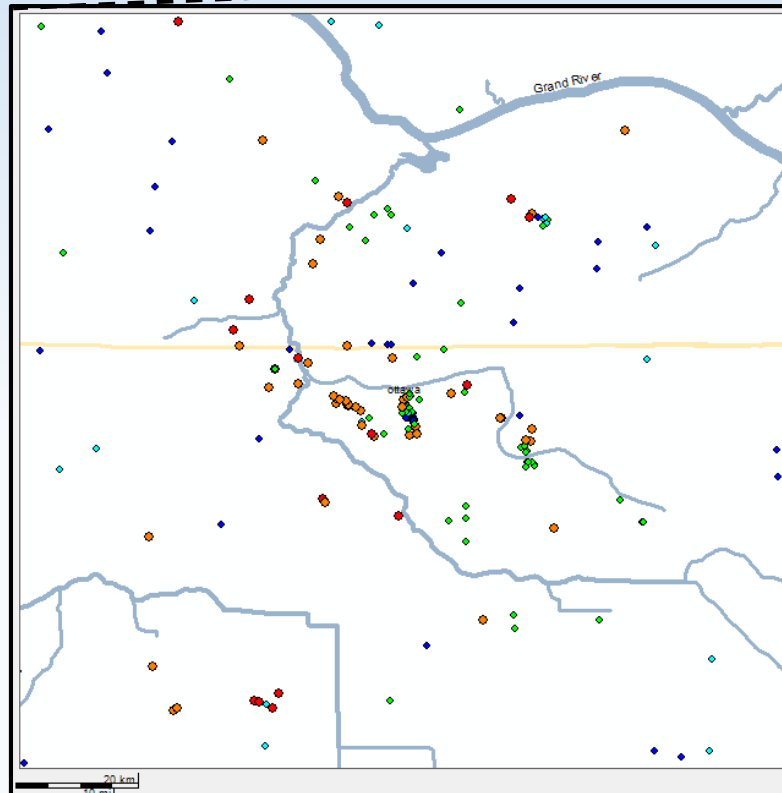
## II. Areal distribution of $[Cl^-]$

(plan view)

Phase I:



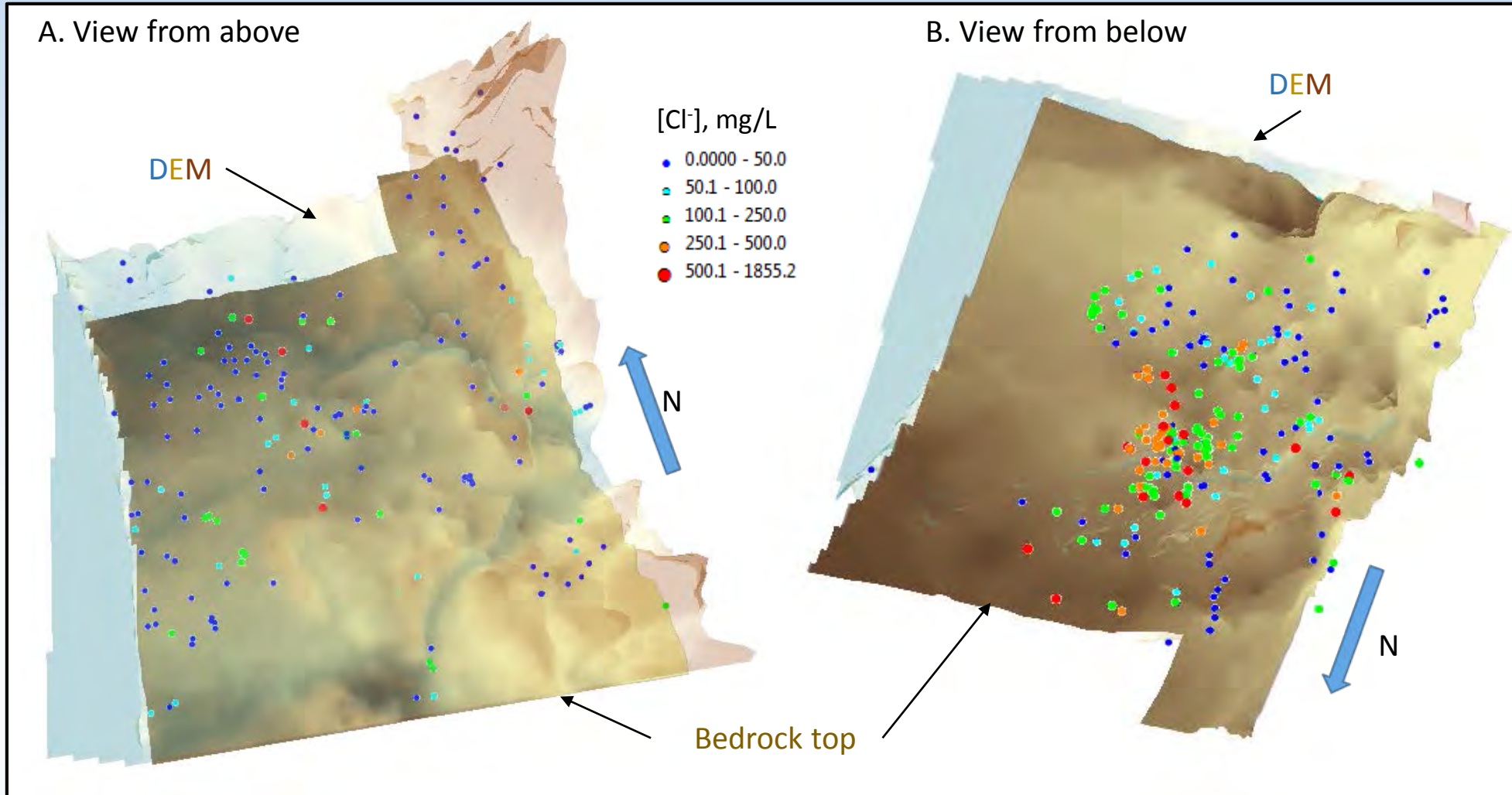
\*Field sampling results confirm  $[Cl^-]$  distribution found in Phase I



→ Some areas have wells with elevated  $Cl^-$  in close vicinity to wells with low  $Cl^-$ ...are the wells at different depths (see next slide)?

# Field Sampling Results

## III. 3D visualization

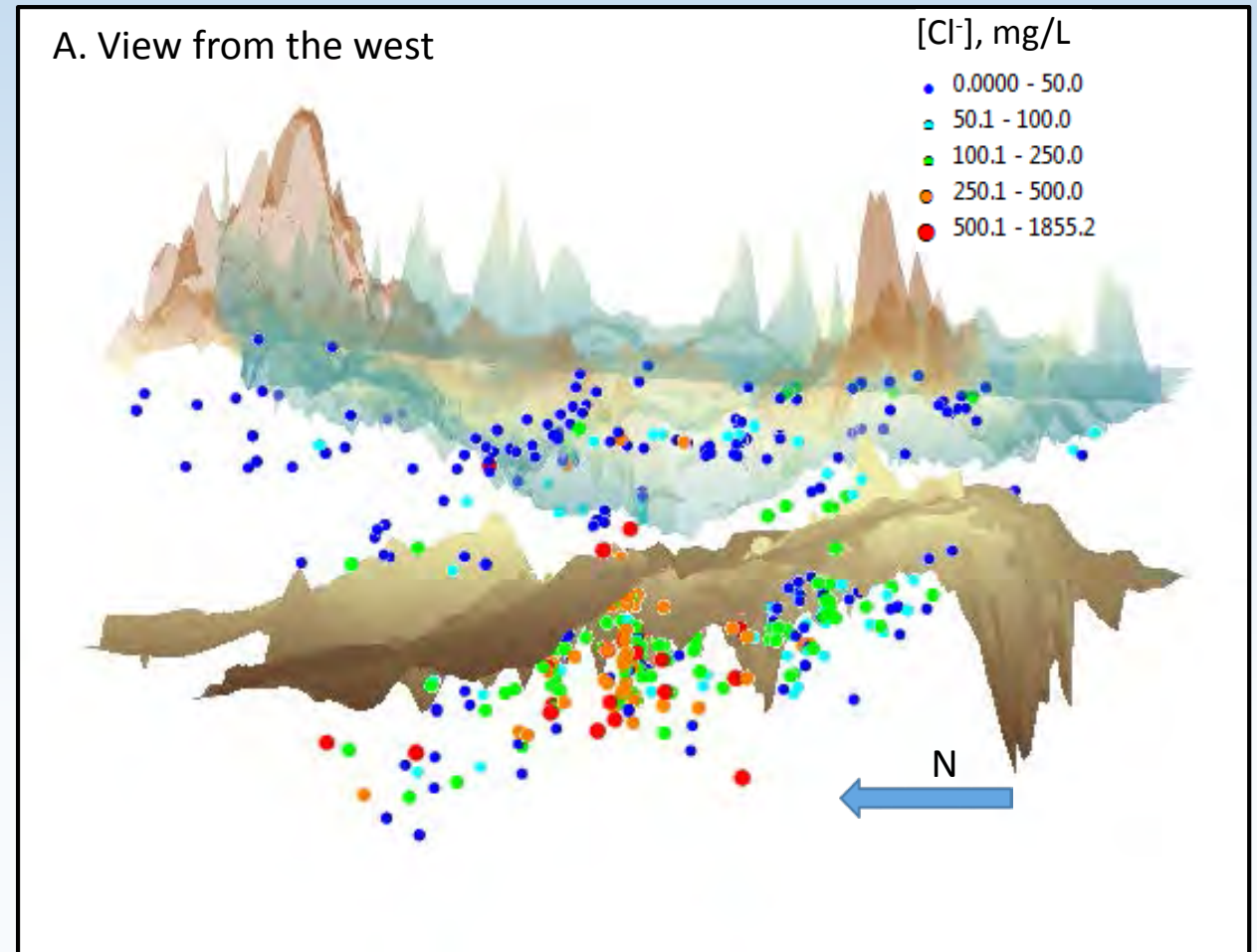


# Field Sampling Results

## III. 3D visualization

→ Wells with elevated chloride levels (>250 mg/L) are **primarily concentrated in the bedrock aquifer (or deep drift), in the central part of Ottawa County**

\*Consistent with Phase 1 depth analysis (WaterCHEM <-> Wellogic)



\* Vertical Exaggeration factor: 75

# Critical Question...

We know how the elevated chlorides are currently distributed in space...

**but has the contamination become worse in recent years?**

-> evaluate the temporal variation of chloride concentrations across decades (groundwater moves slow!)

• *Ideally*...evaluate chloride concentrations at different times for the same well...at many locations across the County

-> **New opportunity: mine/analyze Ottawa County Environmental Health private well records**

- water quality test results (well installation, real estate transfer, etc.)

- Cl<sup>-</sup> (mg/L), date, sample point, etc.



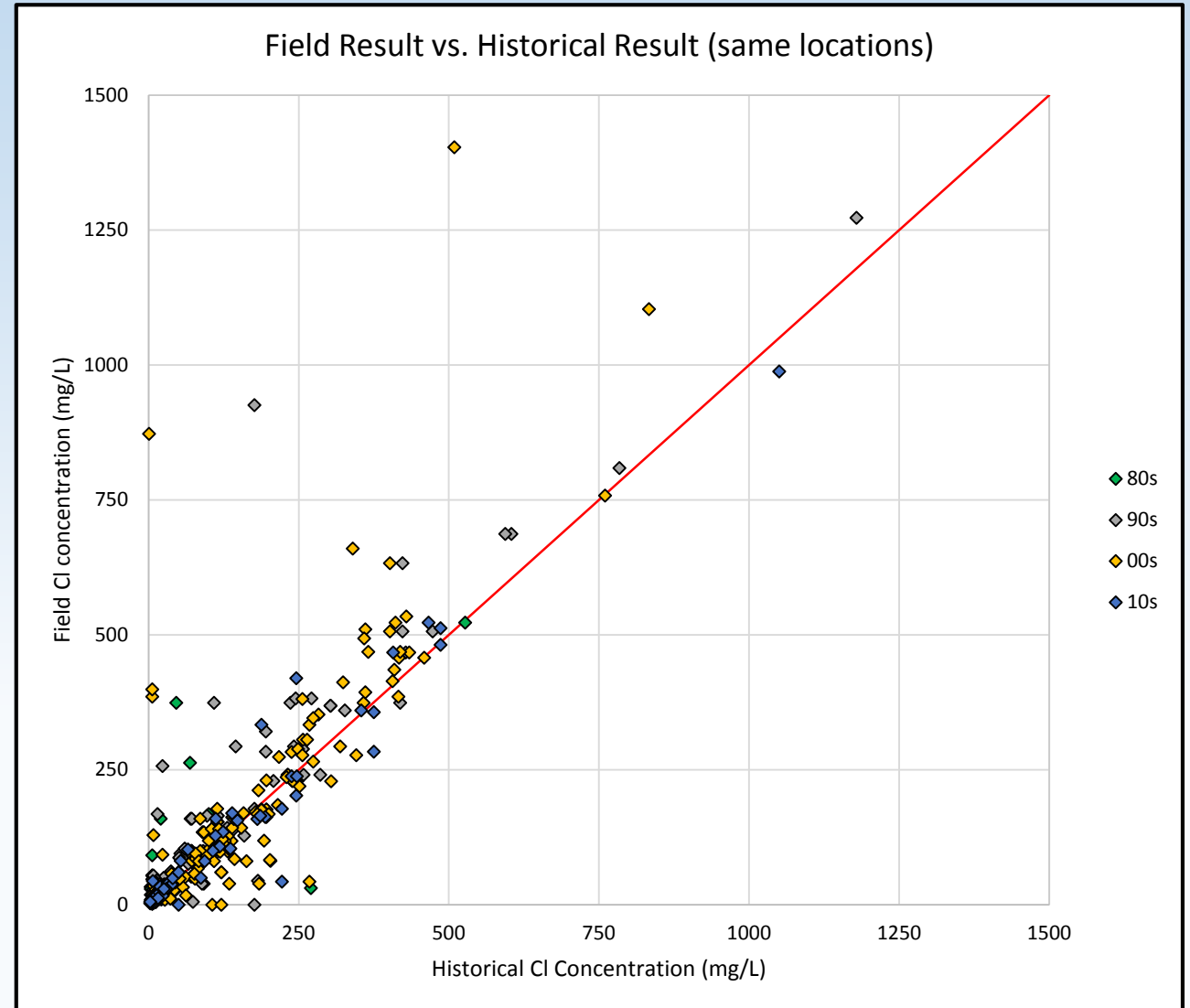
# “First-cut” Temporal Analysis

Mined historical data from 249/468 properties visited in the field

**Plot:** Comparing the field result (current) to the historical result at the *same* location

- 378 data points (some locations had 2+ historical Cl<sup>-</sup> results)
- Above 1:1 red line -> Field > Historical
- Below 1:1 red line -> Field < Historical

**→ General increase in [Cl<sup>-</sup>]...**

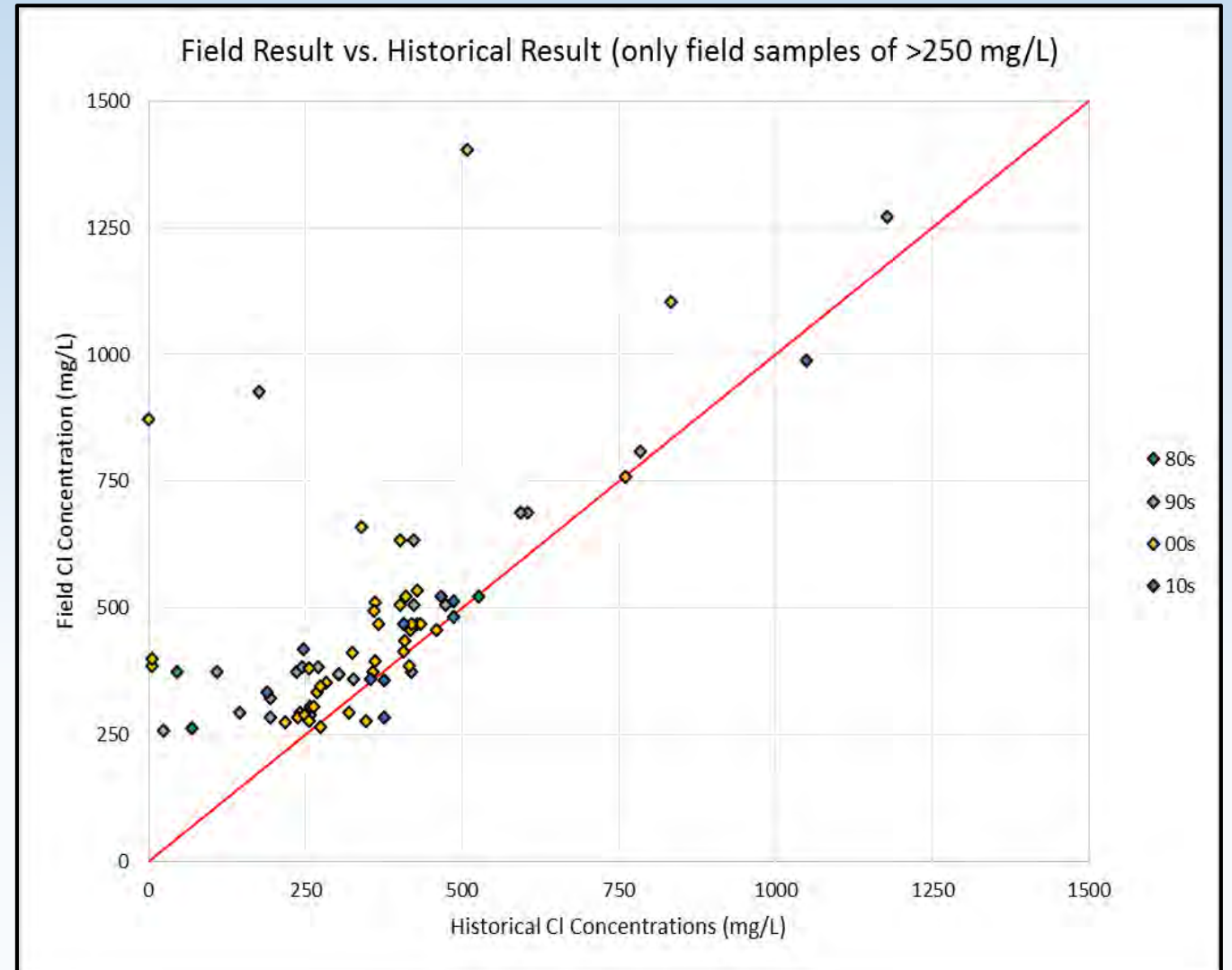




# “First-cut” Temporal Analysis

62/75 field samples that are >250 mg/L have a higher Cl<sup>-</sup> concentration than the historical result at the *same* location

General increase in [Cl<sup>-</sup>]... **especially for [Cl<sup>-</sup>] > 250 mg/L**



# Digging Deep Through the Data

The “first-cut” temporal analysis indicates the Cl<sup>-</sup> concentrations at different locations across Ottawa County have **INCREASED** in recent decades

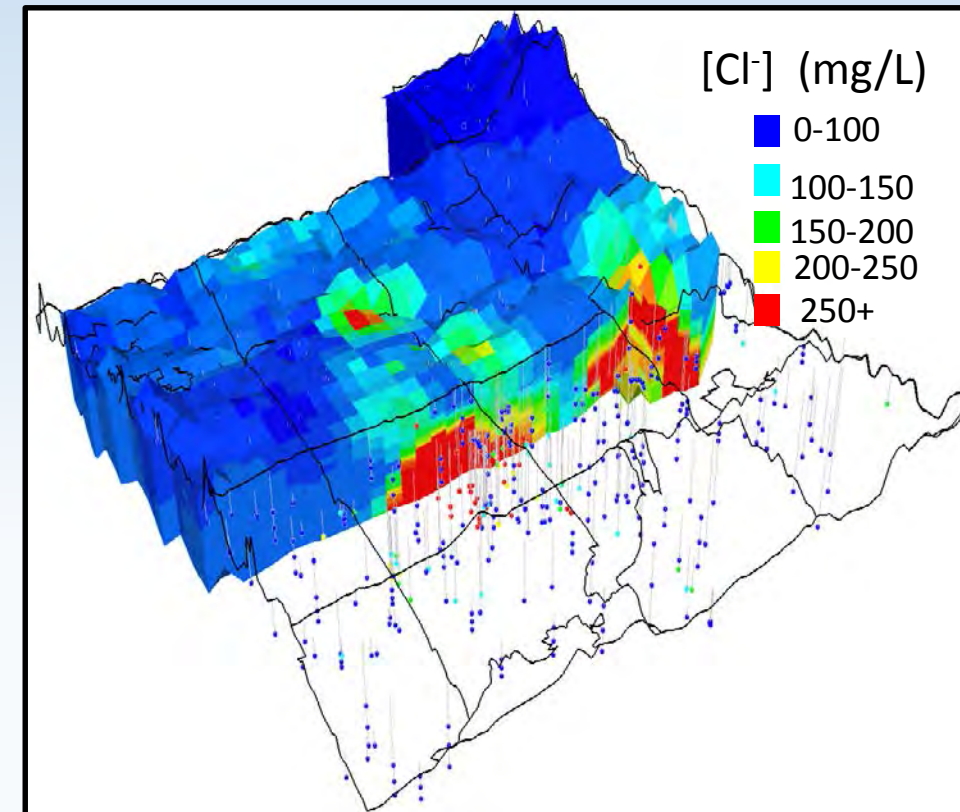
## Questions to pursue:

- *Where* are the increases occurring?
- What is *causing* Cl<sup>-</sup> levels to increase?
- What does the chloride “plume” *look like* at different points in time? (e.g., 1980s vs. 1990s vs 2000s)

-> Continue mining data from areas of concern

- To date, ≈2,400 records mined from central Ottawa County
- Continue mining 16,000+ records

-> 3D plume delineation and transport modeling



# Research Network

## Civil & Environmental Engineering (MSU)

### Groundwater:

- Zachary Curtis
- Dr. Hua-sheng Liao
- Dr. Prasanna Sampath
- Dr. Shu-Guang Li

### Surface Water

- Dr. Phanikumar Mantha
- Guoting Kang

## Ottawa County Land Use & Planning

- Aaron Bodbyl-Mast

### Groundwater Task Force

## Institute of Water Research (MSU)

### GIS/Geography

- Dr. Dave Lusch

# Thank you!...Questions?



## Image references:

1. Texas Water Development Board: <https://www.twdb.texas.gov/groundwater/>
2. Environment Canada: <https://www.ec.gc.ca/eau-water/default.asp?lang=En&n=23CEC266-1>
3. Final report, Ottawa County Water Resource Project, Phase I. Institute of Water Research, Michigan State University.
4. Ottawa County Environmental Health: <https://www.miottawa.org/Health/OCHD/enviro.htm>

