Using Enteric Pathogens to Assess Sources of Fecal Contamination in the Silurian Dolomite Aquifer: Preliminary Results

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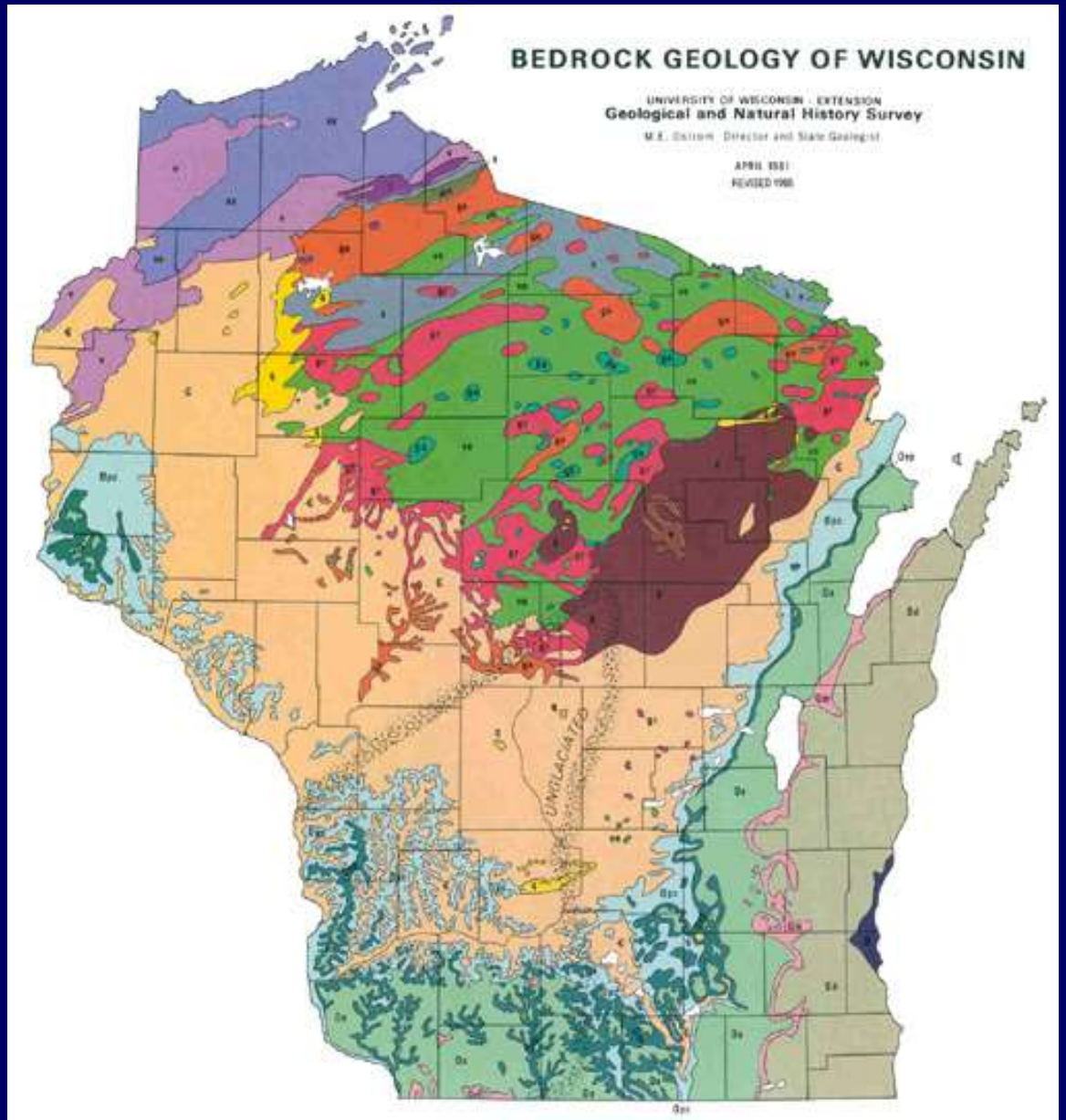
Outline

- Hydrogeologic Setting
  - Silurian Aquifer
  - Land-use
  - Water-quality data
- Preliminary Virus Sampling
  - Methods
  - Results
- Summary of Current Knowledge
- Proposed Research

WI Geology



Extent of glaciation

PHANEROZOIC

DEVONIAN FORMATIONS

D — dolomite and shale

SILURIAN FORMATIONS

Sd — dolomite

ORDOVICIAN FORMATIONS

Om — Maquoketa Formation—shale and dolomite

Os — Sinnipee Group—dolomite with some limestone and shale

Osp — St. Peter Formation—sandstone with some limestone shale and conglomerate

Opc — Prairie du Chien Group—dolomite with some sandstone and shale

CAMBRIAN FORMATIONS

C — sandstone with some dolomite and shale

PRECAMBRIAN

MIDDLE PROTEROZOIC ROCKS

Keweenawan Rocks—
ss, sandstone
v, basaltic to rhyolitic lava flows
i, gabbroic, anorthositic and granitic rocks

Wolf River Rocks—
g, rapakivi granite, granite and syenite
a, anorthosite and gabbro

LOWER PROTEROZOIC ROCKS

q — quartzite

gr — granite, diorite and gneiss

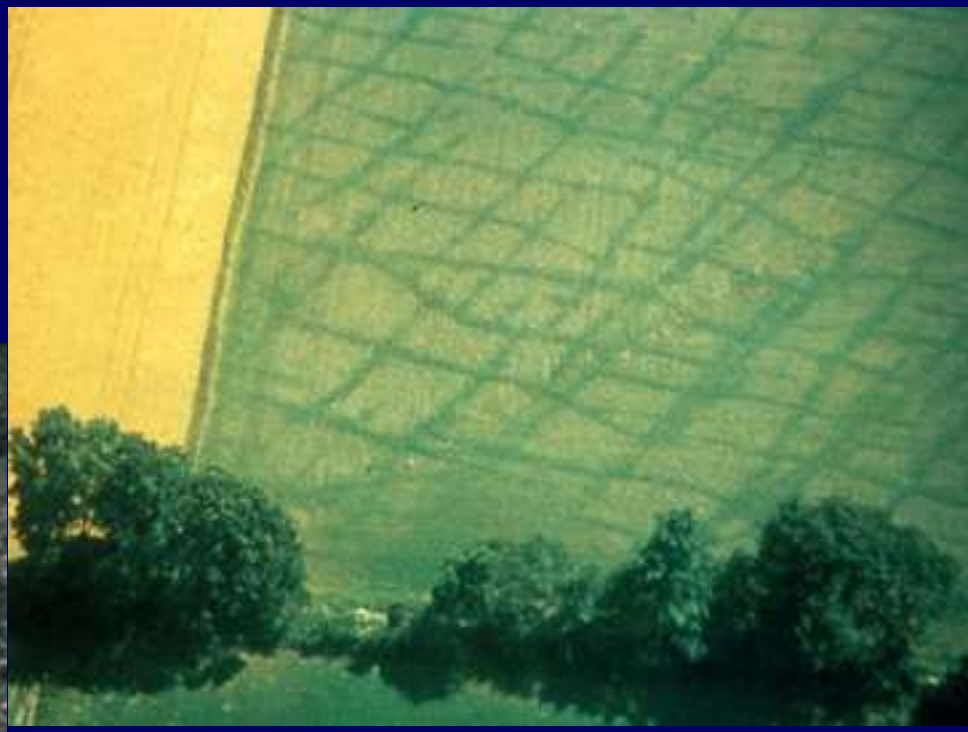
s, argillite, siltstone, quartzite, graywacke, and iron formation
vo, basaltic to rhyolitic metavolcanic rocks with some metasedimentary rocks
ga, meta-gabbro and hornblende diorite

LOWER PROTEROZOIC OR UPPER ARCHEAN ROCKS

mv, metavolcanic rocks
gn, granite, gneiss and amphibolite

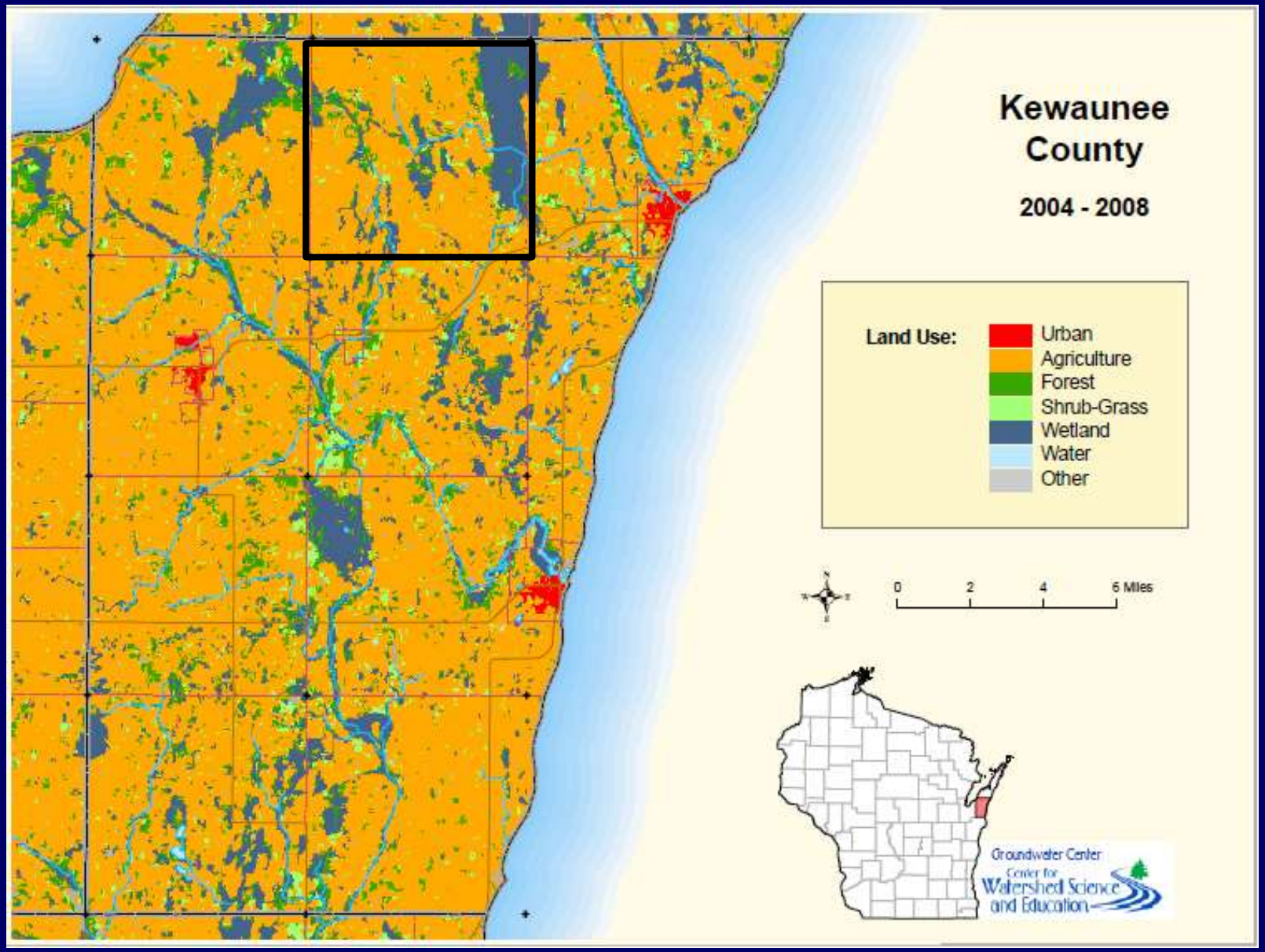
Silurian Dolomite Aquifer

Silurian Dolomite Aquifer



Bedding-plane Fractures

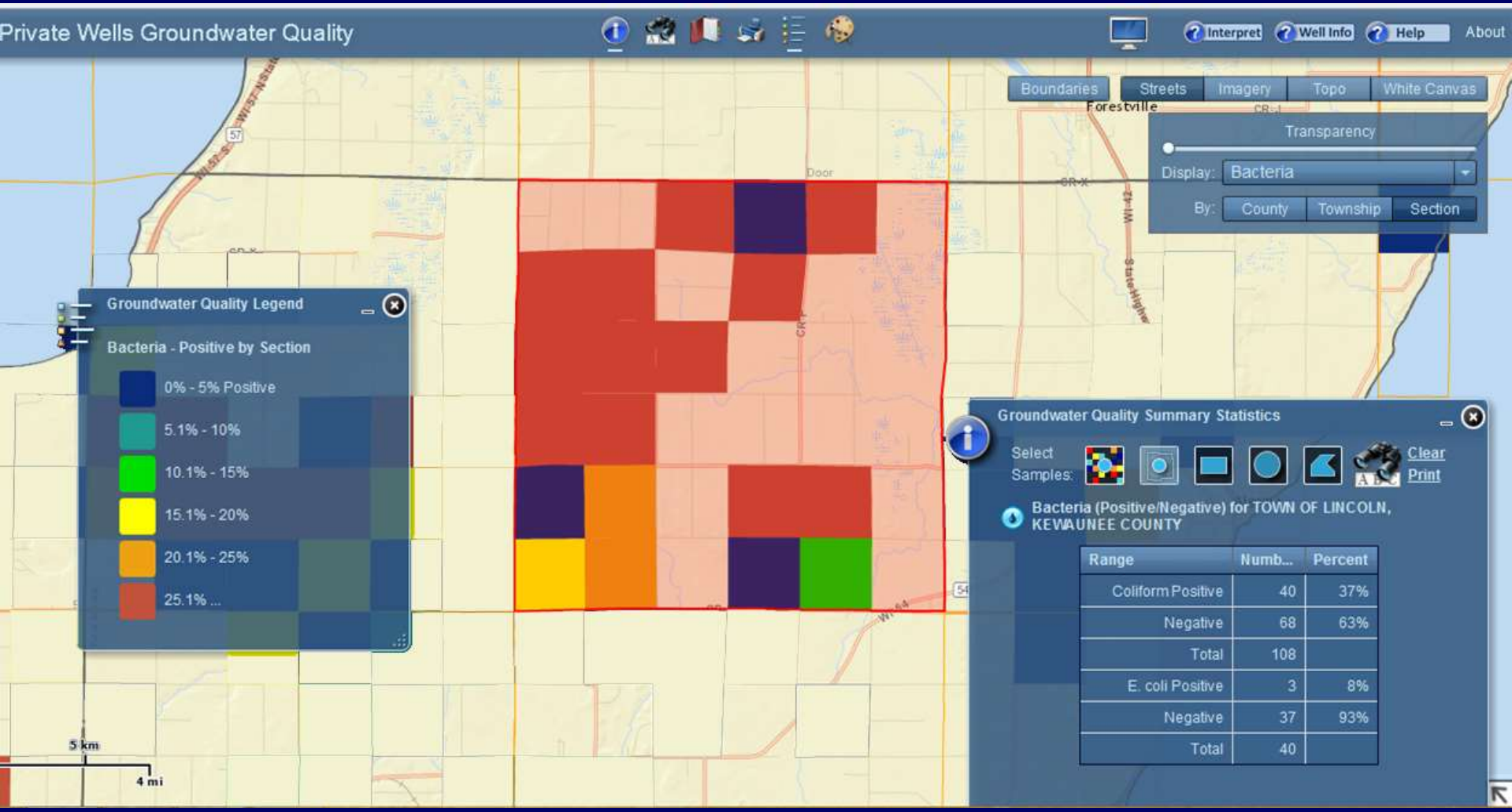
Kewaunee County Land Use



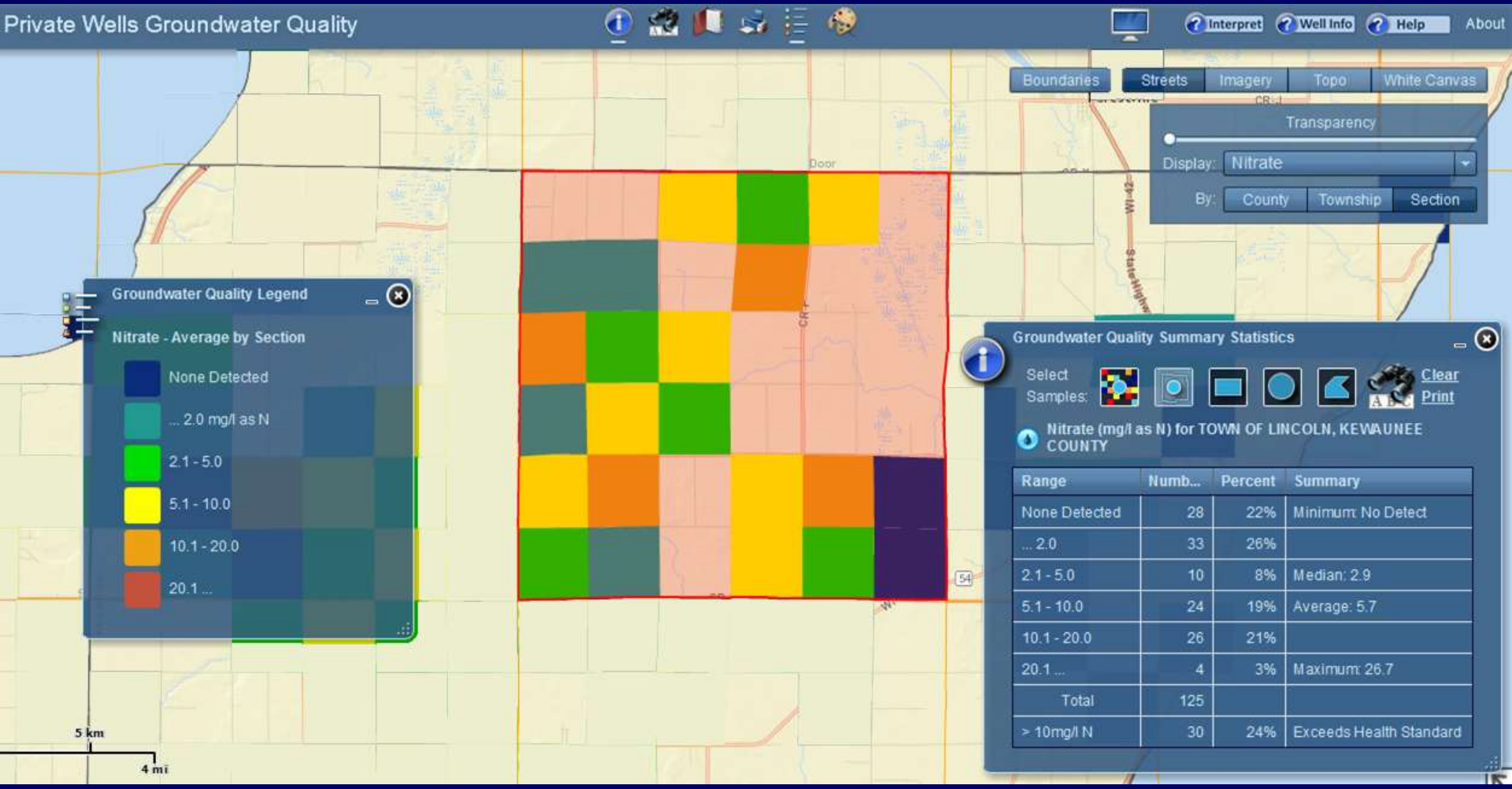
Kewaunee CAFOs

- In WI, Concentrated Animal Feeding Operations (CAFOs) are defined as those farms having > 1000 animal units
- Kewaunee County has 15 CAFOs (14 dairy and one beef operation)
- Town of Lincoln
  - Three CAFOs
  - ~13,500 cattle
  - 334 households

Town of Lincoln Water Quality

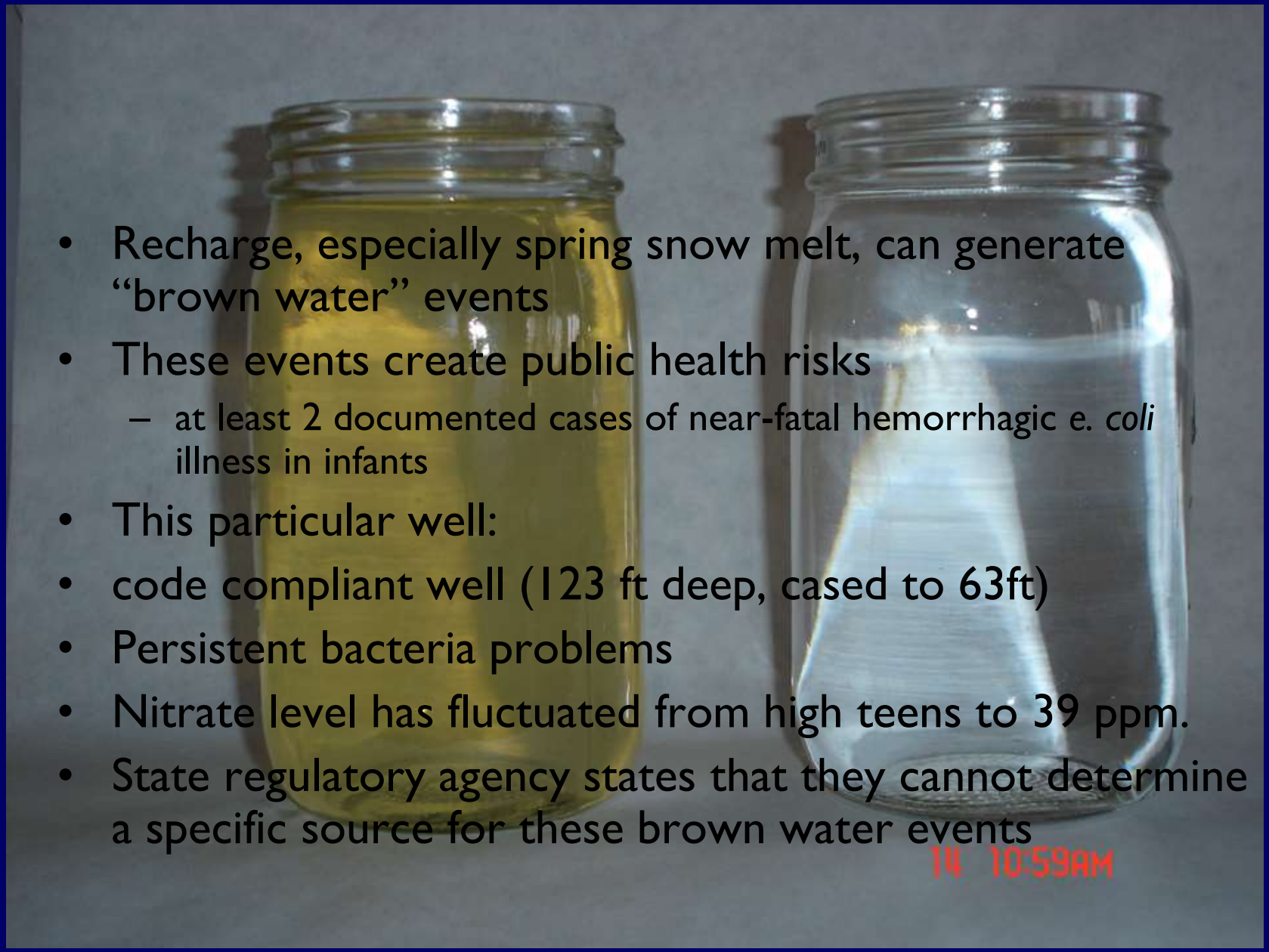


Town of Lincoln Water Quality



Range	Numb...	Percent	Summary
None Detected	28	22%	Minimum: No Detect
... 2.0	33	26%	
2.1 - 5.0	10	8%	Median: 2.9
5.1 - 10.0	24	19%	Average: 5.7
10.1 - 20.0	26	21%	
20.1 ...	4	3%	Maximum: 26.7
Total	125		
> 10mg/l N	30	24%	Exceeds Health Standard

Brown Water



- Recharge, especially spring snow melt, can generate "brown water" events
- These events create public health risks
  - at least 2 documented cases of near-fatal hemorrhagic e. *coli* illness in infants
- This particular well:
- code compliant well (123 ft deep, cased to 63ft)
- Persistent bacteria problems
- Nitrate level has fluctuated from high teens to 39 ppm.
- State regulatory agency states that they cannot determine a specific source for these brown water events

Virus Sampling (May 2014)

- Sampled 10 household wells in Kewaunee County
  - bovine-specific viruses,
  - human-specific viruses,
  - pepper mild mottled virus,
  - bovine bacteroides, and zoonotic pathogenic bacteria that are indicative of fecal waste:
    - enterohemorrhagic *E. coli*,
    - *Salmonella* species,
    - *Campylobacter jejuni*.

- pump ~800 L through hemodialysis filters
- (RT-qPCR) methods were used to determine the virus genome concentrations

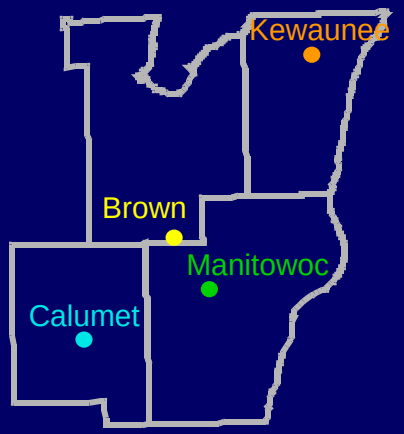
Results

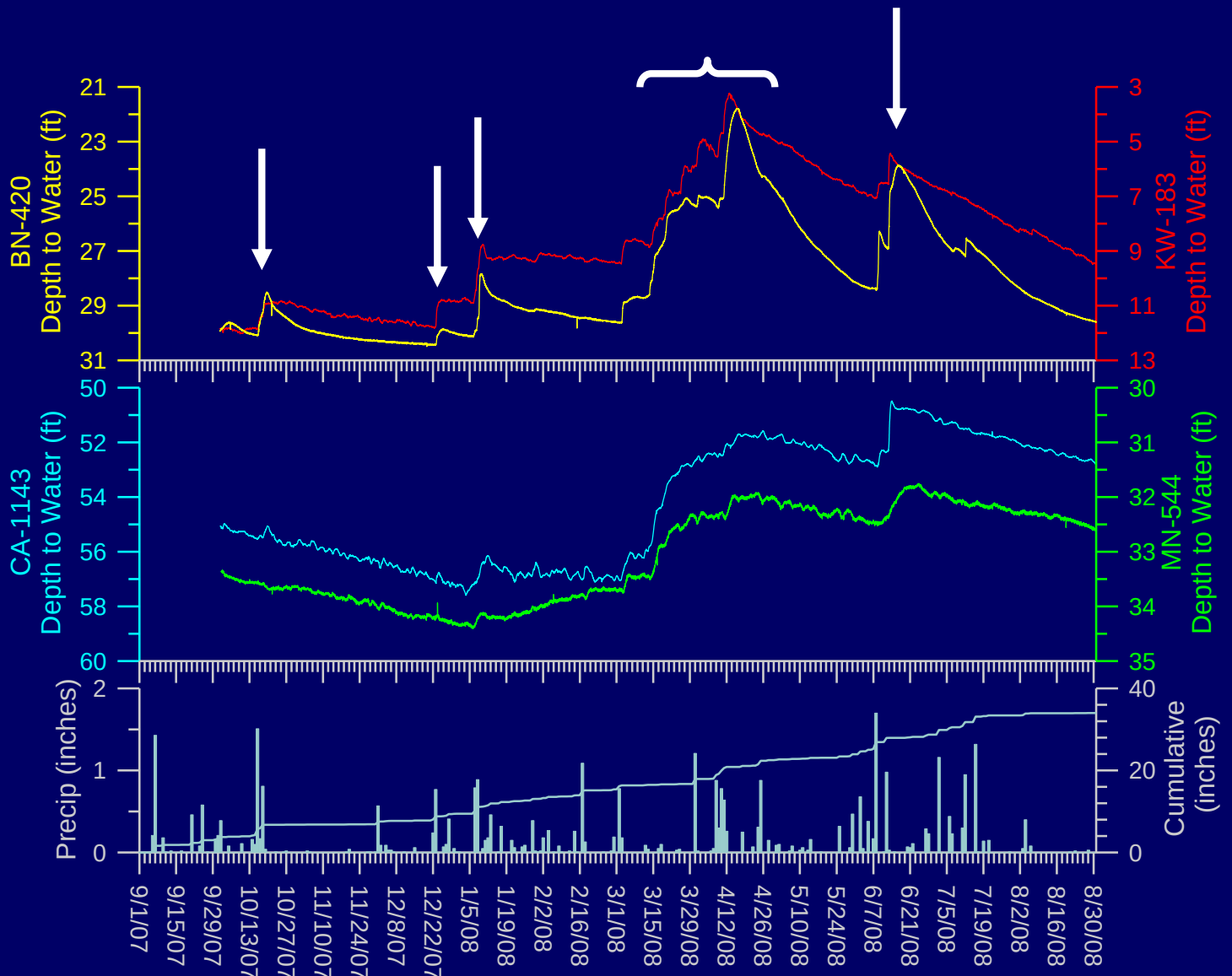
- 7 of 10 wells were positive for fecal contamination
  - 2 wells contained human-specific viruses
  - 1 well contained bovine-specific viruses
  - 1 well contained both virus types
  - 1 well was positive for bovine bacteroides.
- 5 of the wells contained either *Salmonella* or *C. jejuni*

What we Know: Silurian Aquifer

- Dense and ubiquitous fracture network
  - little surface runoff
  - water easily infiltrates to subsurface
- Recharge
  - exceedingly rapid
  - carries surface contaminants to the water table
- Flow within the aquifer occurs primarily along bedding plane fractures
  - Little to no attenuation of contaminants within the aquifer
- Flow rates vary from 10's to 100's of ft/day

What We Know: Recharge

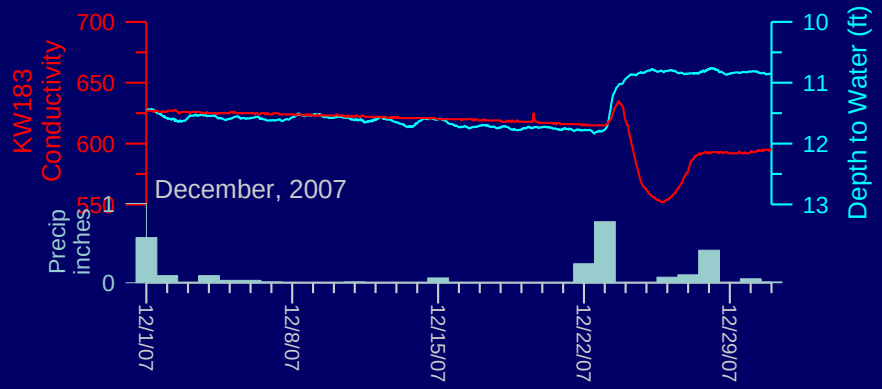




What We Know: Recharge

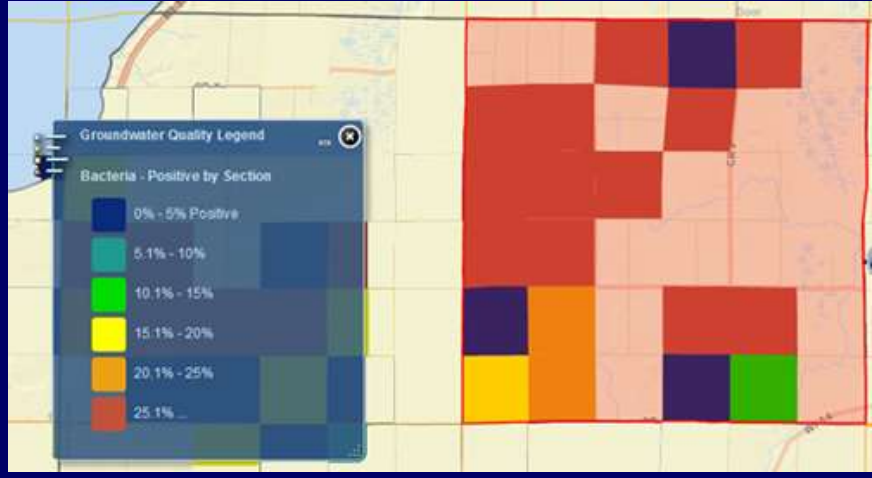
- Sharp change in conductivity within 24 hrs of recharge event
  - Rise in conductivity as vadose water drains
  - Drop in conductivity as low-conductivity recharge enters saturated zone

Research Question Year 1



- What is the timing of enteric pathogen contamination in relation to groundwater recharge?
  - Measure recharge indicators and soil temperature at two monitoring sites
  - Use automated samplers at three domestic wells to collect samples during recharge events (4 to 6 events)
  - Samples will be analyzed by qPCR for 25 microbial targets divided into three fecal-source groups: 1) Human-specific microbes; 2) Bovine-specific microbes; and 3) Non-specific microbes found in fecal wastes
  - Determine optimal time for pathogen sampling

Research Question Year 2



- What is the extent of enteric pathogen contamination in domestic wells in NE Wisconsin?
  - Use WCR databases to identify domestic wells in two townships.
  - Randomly select 250 wells and invite to be part of study
  - Determine optimal sampling time for pathogens based on year 1 results
  - When a sampling alert is received, randomly sample 10 wells
  - Total sample set will consist of 5 sets of samples collected under optimal conditions and 5 sets of samples under sub-optimal conditions
  - Statistical analysis to assess extent of fecal contamination