Southwest Wisconsin Groundwater and Geology (SWIGG) Study

A multi-county effort to better understand private drinking water

WDNR Drinking Water Study Group
August 20, 2019

Background

- Jan. 2018 Moratorium & Manure Spreading Restriction requests
- Dr. Mark Borchardt & Dr. Madeline Gotkowitz Presented
- Invited Iowa & Lafayette Counties
- Grant County approved Groundwater study
- Grant, Iowa & Lafayette Counties discussed groundwater study

SWIGG Study Purpose:

To give counties and the state better information about how to ensure residents have safe water to drink

Goals:

- assess how widespread well contamination is
- identify sources of any contamination
- analyze risk factors associated with well contamination
- develop geological maps

Researchers:

- **Dr. Ken Bradbury**, Director and State Geologist, WI Geological & Natural History Survey
- **Dr. Mark Borchardt**, Research Microbiologist, USDA Agricultural Research Service
- **Joel Stokdyk**, Biologist, U.S. Geological Survey

- Land Conservation Committees & Departments were created in 1982 to provide local leadership in protecting Wisconsin's land & water resources
- Authorized to implement DATCP, DNR, & County Conservation Programs
  - Farmland Preservation
  - Conservation Reserve Enhancement Program
  - Soil & Water Resource Management Program
  - Nonpoint Source Pollution Control Program
  - Land & Water Resource Management Plan

Wisconsin Geological and Natural History Survey

We provide <u>objective scientific information</u> about the <u>geology</u>, <u>mineral resources</u>, and <u>water resources</u> of Wisconsin

- Hydrogeology
- Geologic mapping
- GIS

- Well construction analysis
- Project guidance
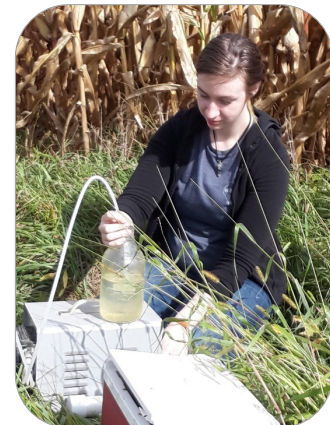
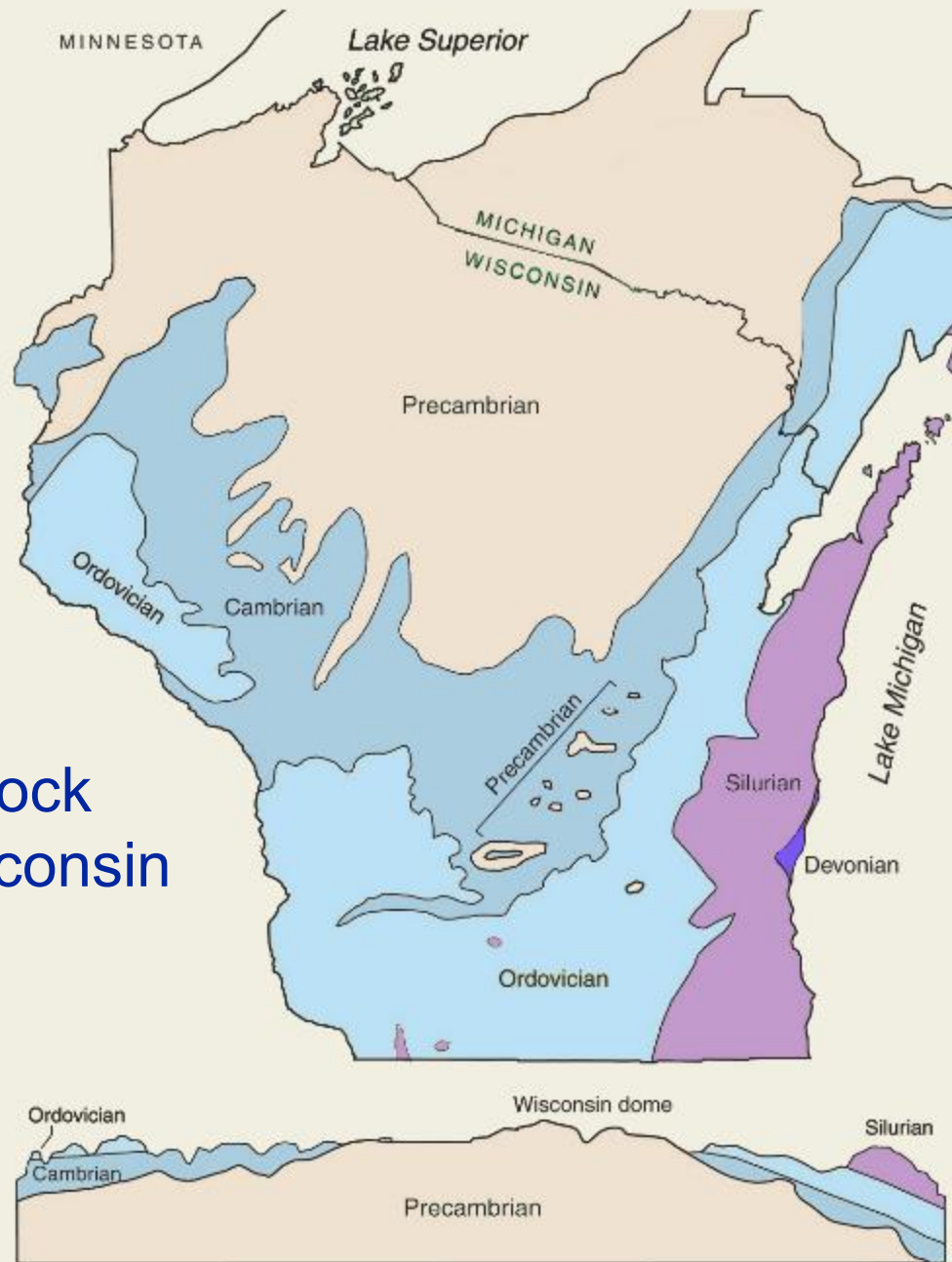# Laboratory for Infectious Disease and the Environment

- Interagency research lab, USDA-ARS and USGS

- Study occurrence, transport, and health effects of human pathogens in the environment

- Special focus on water quality and waterborne infectious disease

- More than 150 research publications

L·I·D·E

LABORATORY FOR INFECTIOUS DISEASE AND THE ENVIRONMENT
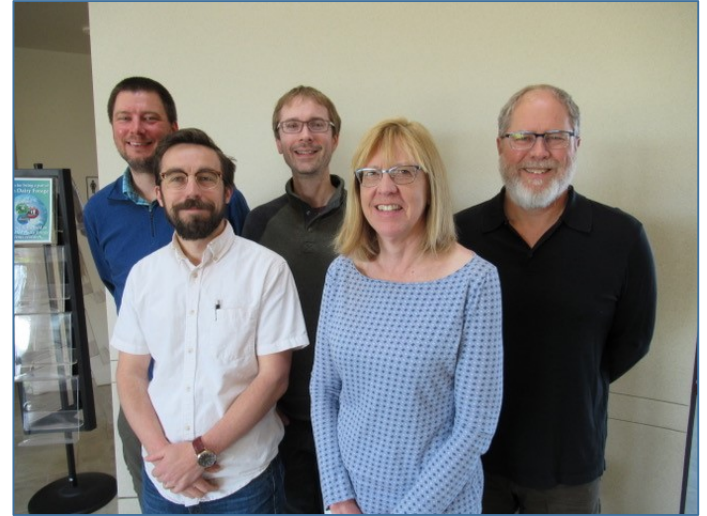
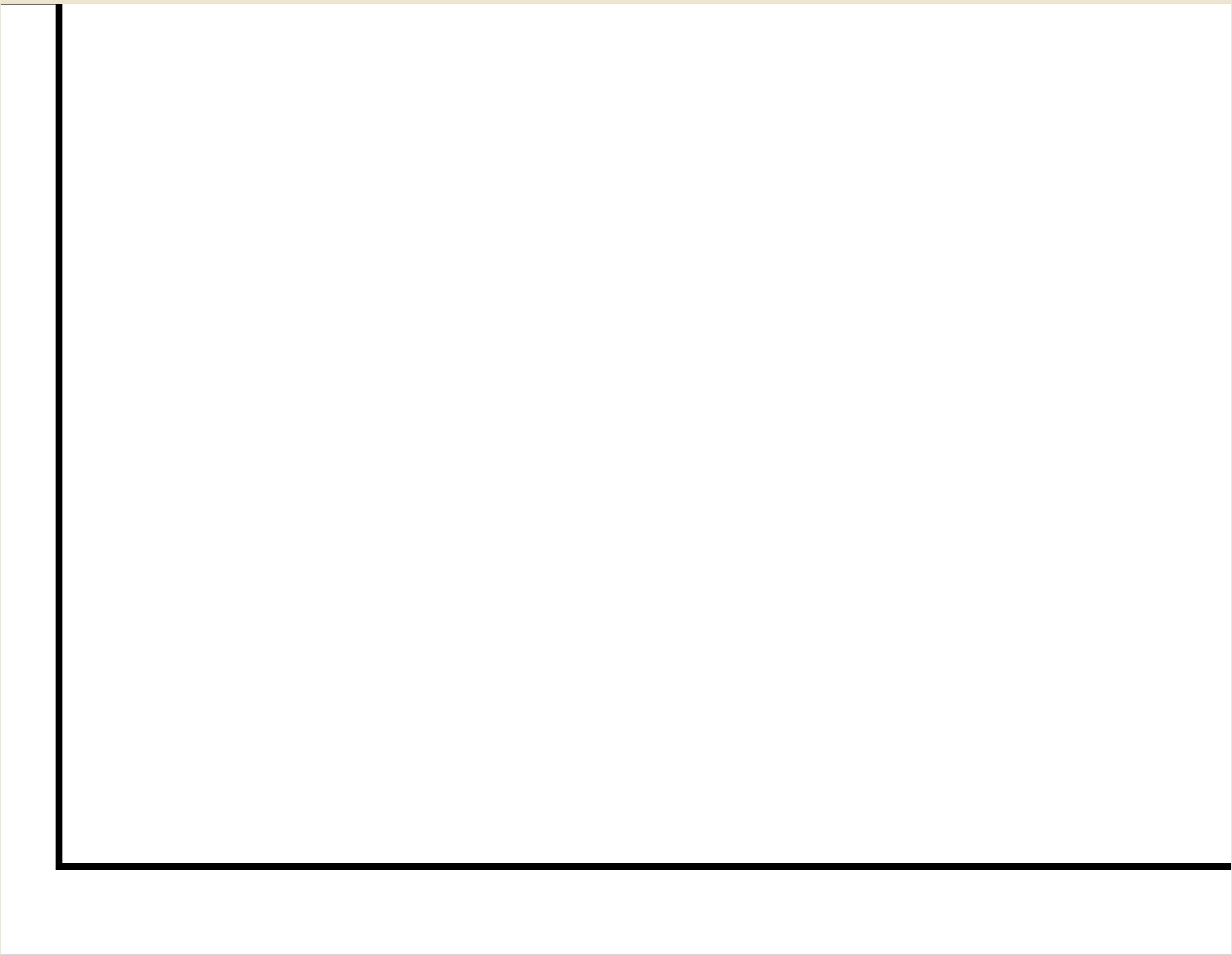# Water and Environmental Analysis Lab (WEAL)

- UW-Stevens Point Center for Watershed Science and Education

- Wisconsin DNR and DATCP certified

- Outreach services
  - Well water education
  - Lake/river monitoring
  - GIS (mapping/modeling)

- Analyses Offered
  - Bacteria
  - Nutrients
  - Nitrate
  - Metals
  - Water chemistry
  - Pesticides and metabolites; pharmaceuticals

College of Natural Resources
University of Wisconsin-Stevens Point

Extension
UNIVERSITY OF WISCONSIN–MADISON

Simplified bedrock geology of Wisconsin

Hydrogeology of Southwest Wisconsin

- Bedrock aquifers
- Carbonate rock near surface
- Groundwater moves through fractures and karst conduits
- Flow can be very rapid
- Sinkholes and karst features occur

- A very vulnerable landscape

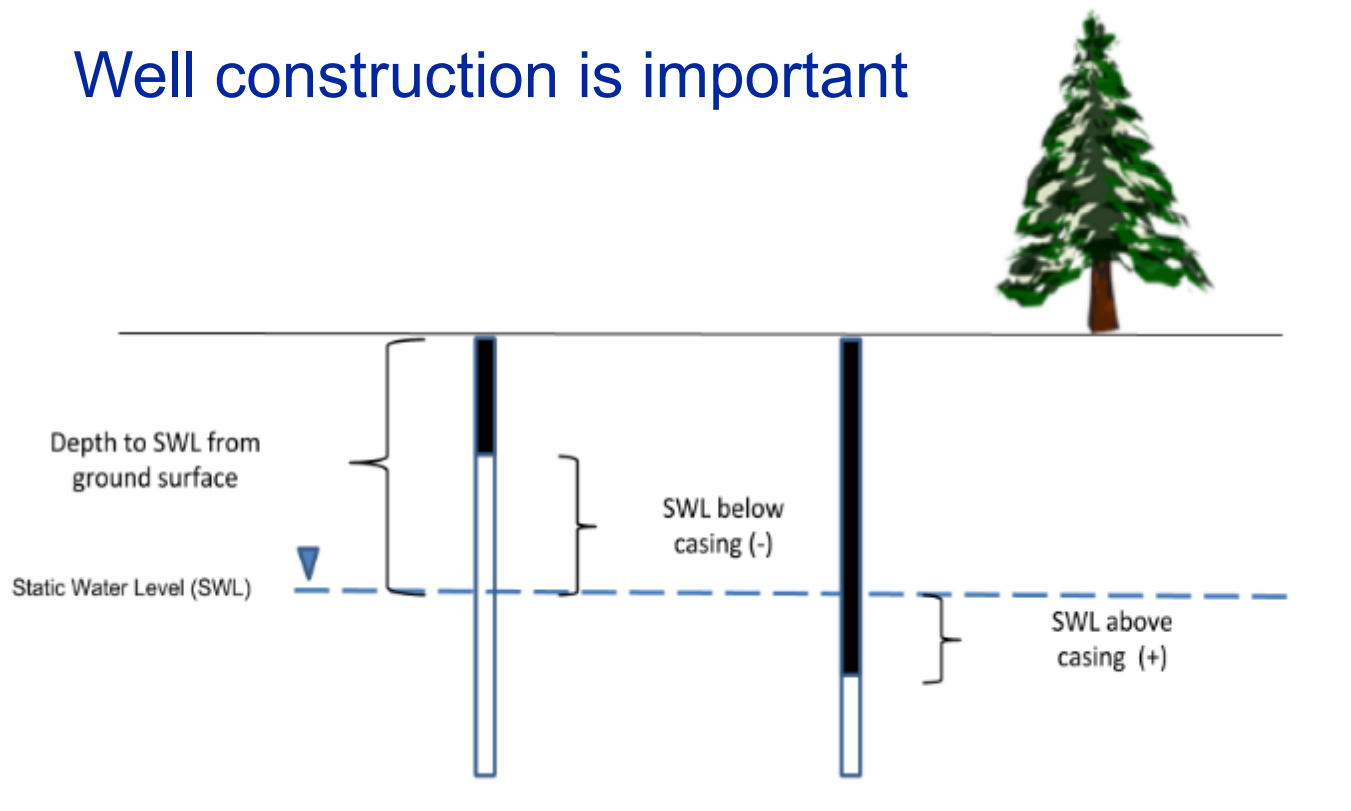Bedding plane fractures are common in dolomite

Iowa County

Karst features…

Evidence of subsurface
dissolution and collapse

Geology is important

- Geology & soil depth affect groundwater vulnerability
- One objective is to develop **geological maps**
  - Depth to bedrock
  - Rountree formation
- Data will be included in the analysis of well contamination factors
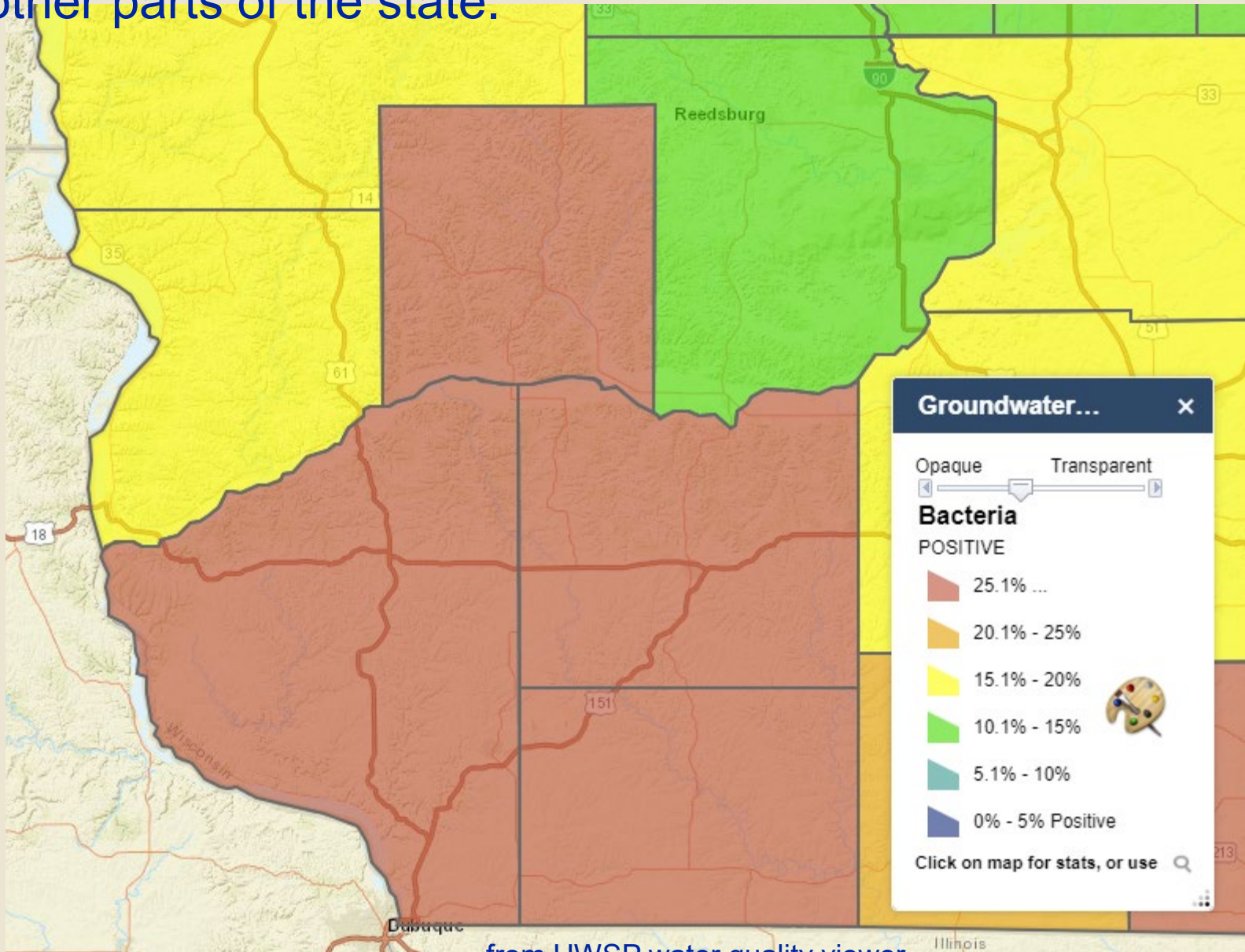- Maps are resources for uses beyond this study

Well construction is important

Depth to SWL from ground surface

SWL below casing (-)

Static Water Level (SWL)

SWL above casing (+)

Wells with shallow casings (cased above water table) are more vulnerable to contaminants originating at the land surface than more deeply-cased wells.
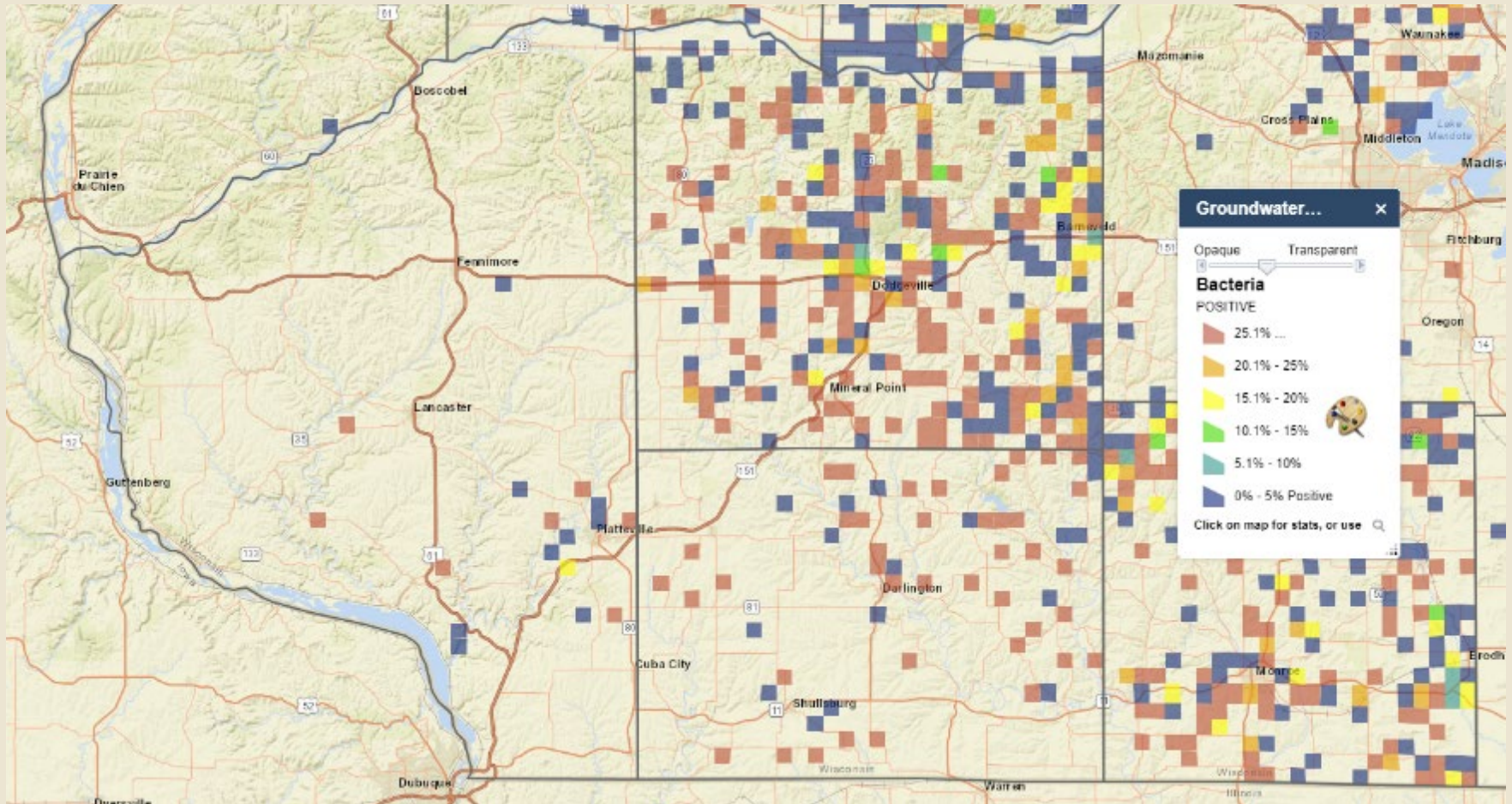
A preliminary review of well constriction identified over 900 such wells in Grant County alone.

Based on historical water sampling, southwest Wisconsin has a higher incidence of bacterial presence in wells than many other parts of the state.

Reedsburg

Groundwater... ✕

Opaque — Transparent

Bacteria
POSITIVE

25.1% ...

20.1% - 25%

15.1% - 20%

10.1% - 15%

5.1% - 10%

0% - 5% Positive

Click on map for stats, or use 🔍

from UWSP water quality viewer

Illinois

Prior to this study, well sampling was relatively sparse.

from UWSP water quality viewer

What we've done so far:

- ➢ Completed two rounds round of randomized sampling (November, 2018 and April 2019).
  - ➢ Homeowners collected samples
  - ➢ Samples analyzed for total coliform, *E. coli, &* nitrate by WEAL (UW-Stevens Point)
  - ➢ Results reported to individual home owners.

- ➢ Completed first round of sampling and lab analyses to determine fecal sources of contamination (April, 2019).
  - ➢ Results reported to individual home owners.

- ➢ Completed second round of fecal source sampling in early August 2019.
  - ➢ Lab analyses will be completed in November.

SWIGG Study Results

	Wells sampled	Total coliform	*E. coli*	High nitrate*	Total coliform or high nitrate
SWIGG November 2018	301	34%	4%	16%	42%
SWIGG April 2019	539	16%	2%	15%	27%
Statewide 1997[a]	534	23%	3%	7%	-
Statewide 2013[b]	3838	18%	-	10%	-
Statewide 2017[c]	401	-	-	8%	

*High nitrate is $NO_3^--N > 10$ mg/L

[a] US General Accounting Office. Information on the quality of water found at community water systems and private wells. United States GAO/RCED-97-123, June 1997.

[b] Knobeloch L., Gorski P., Christenson M., and Anderson H. 2013. Private drinking water quality in rural Wisconsin. Journal of Environmental Health 75:16-20.

[c] Agricultural chemicals in Wisconsin groundwater. Wisconsin Department of Agriculture, Trade, and Consumer Protection, ARM-PUB-264.indd, April 2017.

Percent private wells positive for coliforms, *E. coli*, or nitrate-N > 10 mg/L by county and sample date

County and Sample Date	Total coliform	E. coli	Nitrate-N > 10 mg/L	Coliform or Nitrate-N > 10 mg/L
Grant - November (n = 122)	38%	7%	12%	43%
Grant - April (n = 250)	14%	1%	14%	25%
Iowa - November (n = 117)	26%	3%	13%	33%
Iowa - April (n = 187)	14%	1%	13%	25%
Lafayette - Nov (n = 62)	40%	3%	27%	55%
Lafayette - April (n = 102)	23%	4%	21%	36%

Nitrate & indicator bacteria: Standard water quality tests

Nitrate
- Source: manure, human wastewater, & fertilizer
- Maximum contaminant level goal: 10 ppm NO_3^- -N

Total coliform
- Source: fecal & non-fecal
- Maximum contaminant level goal: 0

E. coli
- Source: fecal
- Maximum contaminant level goal: 0

All three: Indicate contamination but not the fecal source

Fecal Sources of Contamination

Where's it coming from?
What factors are involved?

Potential fecal sources
- Septic systems: 16,092
- Septage-applied fields: ?
- Hogs & pigs: 71,983
- Cattle & calves: 373,411

Other factors
- Well characteristics
- Rainfall
- Geology

Data from county records & 2012 USDA Census of Agriculture

Study Sampling and Analyses

- Randomized sampling from 126 wells positive for total coliform, *E. coli*, or (nitrate-N > 10 ppm)

- Pump ~800 L through hemodialysis filters

- qPCR for microbial genetic targets

  - Human-specific microbes

  - Bovine-specific microbes

  - Swine-specific microbes

  - Non-specific microbes (pathogens of both people and cattle)

Microbes: Identifying the Fecal Source
(n = 35 wells) (red font indicates pathogenic)

Host	Microorganism	Wells
	Adenovirus A-F	2
	Bacteroidales-like Hum M2	6
Human-specific	Human *Bacteroides*	29
	Cryptosporidium hominis	1
	Enterovirus	1
	Any human microbe	**30**

Microbes: Identifying the Fecal Source

(n = 35 wells) (red font indicates pathogenic)

Host	Microorganism	Wells
Bovine or ruminant-specific	Ruminant *Bacteroides*	16
	Bovine polyomavirus	1
	Any bovine microbe	**17**

Microbes: Identifying the Fecal Source
(n = 35 wells) (red font indicates pathogenic)

Host	Microorganism	Wells
Swine-specific	Pig-1-*Bacteroidales*	3
	Pig-2-*Bacteroidales*	3
	Any swine microbe	**5**

Other Fecal Microbes (red font indicates pathogenic)

Host	Microorganism	Wells
	Cryptosporidium parvum	2
	Cryptosporidium spp.	4
	Rotavirus A (*NSP3* gene)	3
Non-specific	Rotavirus A (*VP7* gene)	1
	Salmonella (*invA* gene)	7
	Salmonella (*ttr* gene)	5
	Any pathogenic microbe	**13**
	Total fecal positive wells	**32**

Salmonella was cultured from 4 out of the 7 wells positive for *Salmonella* by qPCR

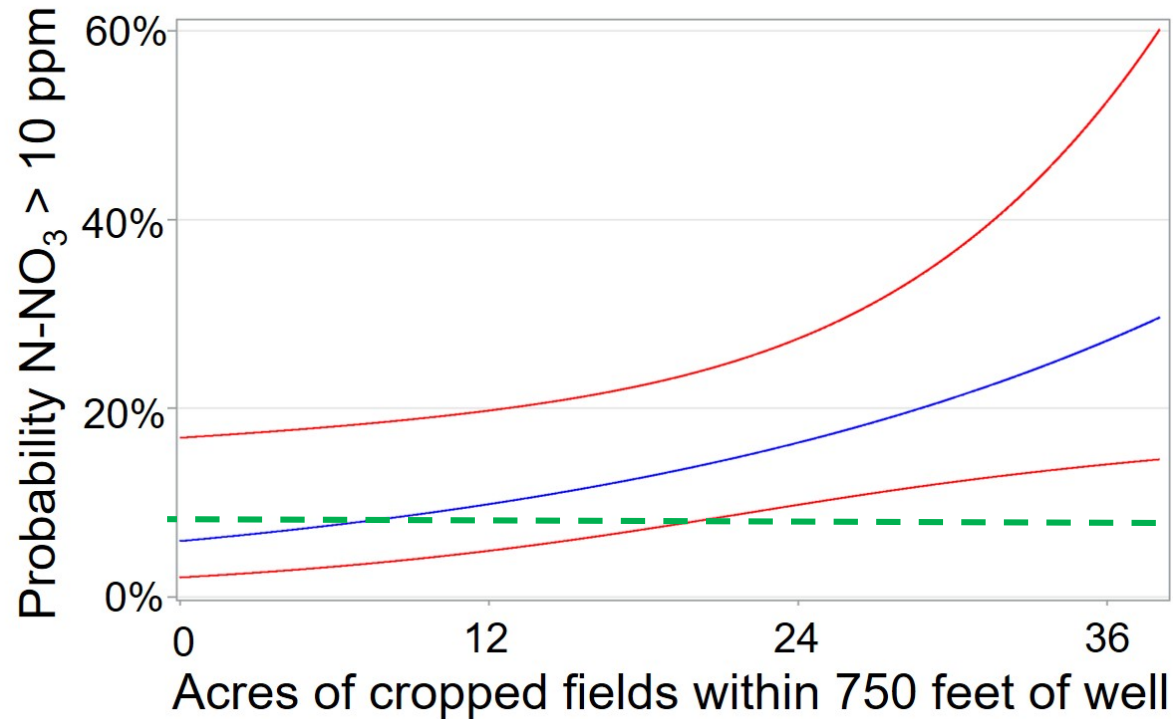# Which factors affect contamination?

Approach: Evaluate relationship between contamination & well characteristics

- Well & casing depth
- Age
- Depth to bedrock
- Others

Outcome: Statistical assessment of factors that are related to contamination

Kewaunee County: More crop land around a well means greater risk for contamination by high nitrate

Model accounts for the effects of:
Distance to nearest cropped field

Distance to manure lagoon

Depth to bedrock

Probability of detection
95% confidence interval
State-wide average (7%)

SWIGG Study Outcomes

1. Percentage of wells contaminated using standard nitrate & bacteria tests

2. Determination of the contamination source (human, bovine, swine) for a subset of wells

3. Evaluation of well characteristics factors associated with contamination

4. Geologic maps for bedrock depth & Rountree formation

SWIGG Study: Local Funding

County	Portion of SWIGG region
Grant	56%
Iowa	26%
Lafayette	18%

- Estimated total project cost: $203,000
- Grant: Some 2018 dollars available
- Iowa: Work it into plan for 2019 & 2020 budgets
- Lafayette: Work it into the normal budget process
    - Lafayette Co. for 2019: $15,470
    - Lafayette Ag Stewardship Alliance: $7,000
    - Private donations: $7,910

Southwest Wisconsin Groundwater and Geology Study Team

Lynda Schweikert, Grant County Conservation, Sanitation and Zoning Dept
Katie Abbott, Iowa County Land Conservation Department
Terry Loeffelholz, Lafayette County Land Conservation, Planning & Zoning Dept
Ken Bradbury, Director & State Geologist, WI Geological & Natural History Survey
Joel Stokdyk, Biologist, U.S. Geological Survey
Mark Borchardt, Research Microbiologist, USDA Agricultural Research Service
Scott Laeser, Clean Wisconsin
Barry Hottmann, Community Educator, UW Extension-Iowa County
Lafayette Ag Stewardship Alliance
Iowa County Uplands Watershed Group
Water & Environmental Analysis Laboratory, UW-Stevens Point