Overview of Chippewa County Groundwater Quality Inventory

Project update

March 6 & 7, 2017

University of Wisconsin-Stevens Point
College of Natural Resources

UW Extension
University of Wisconsin-Extension

Chippewa County
Land Conservation and Forest Management

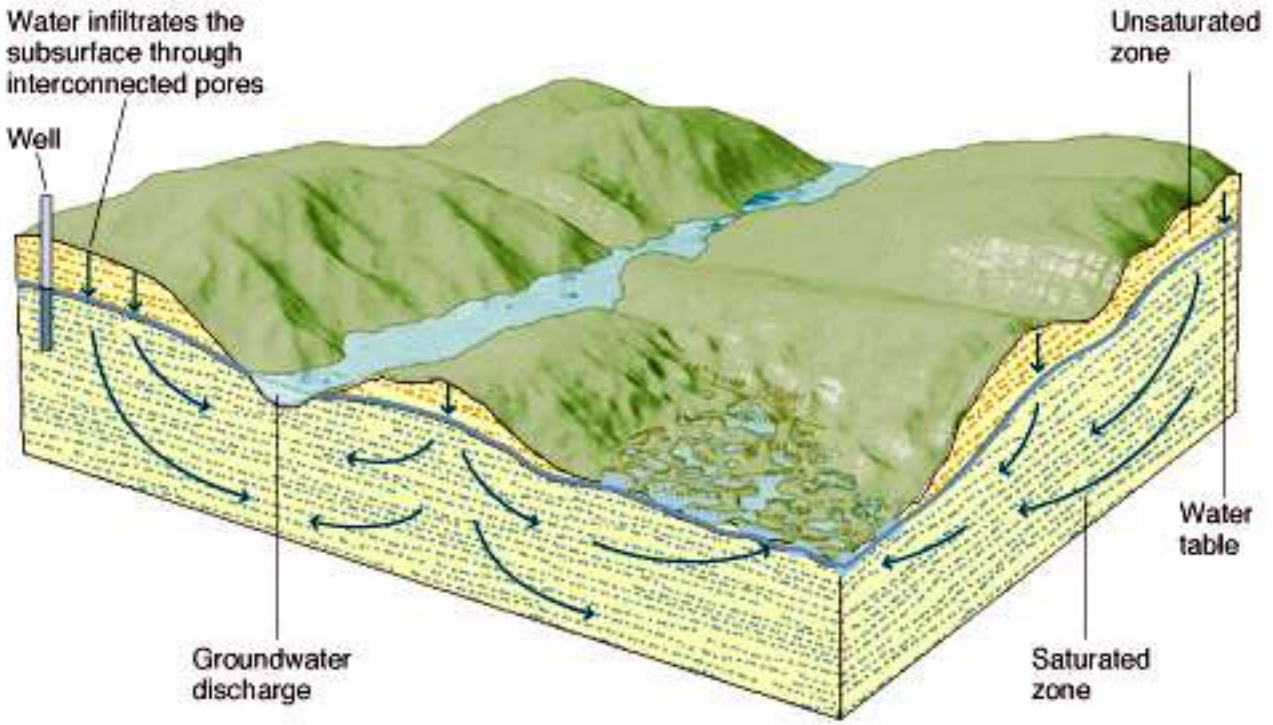
CHIPPEWA COUNTY
Public Health
Prevent · Promote · Protect

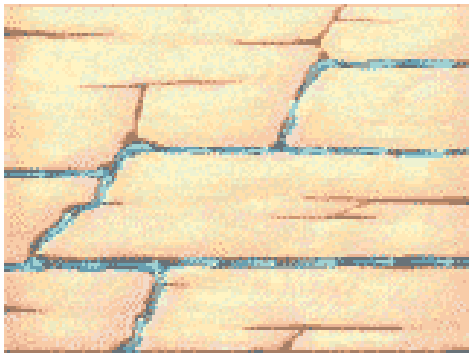
Through the University of Wisconsin-Extension, all Wisconsin people can access University resources and engage in lifelong learning, wherever they live and work.

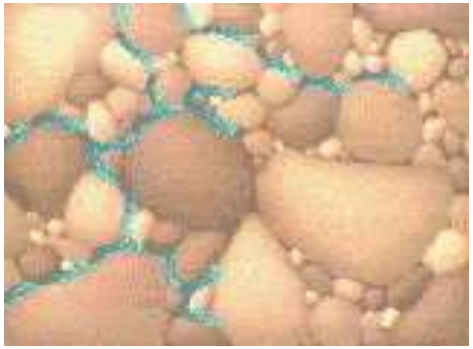
Today's presentation

- Groundwater Basics
- Well Construction
- What do my individual test results mean?
- General groundwater quality in Chippewa County
- Question & Answer

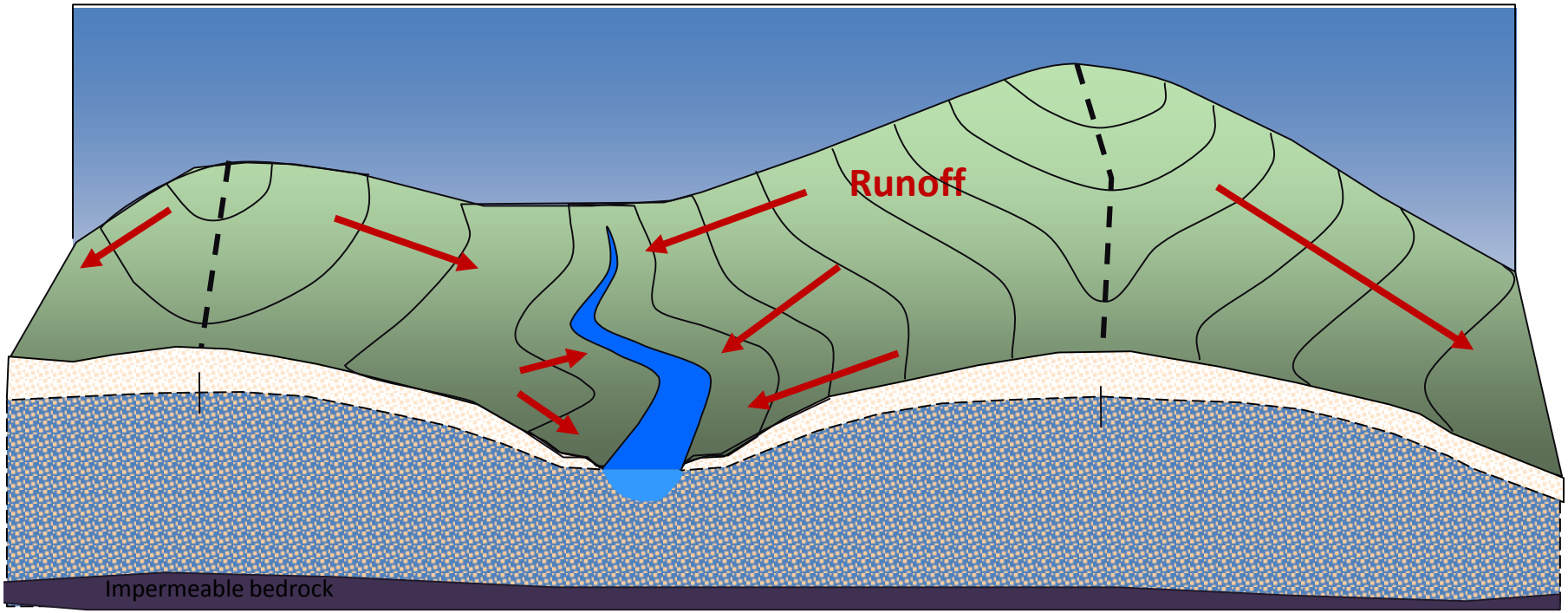
Groundwater Movement

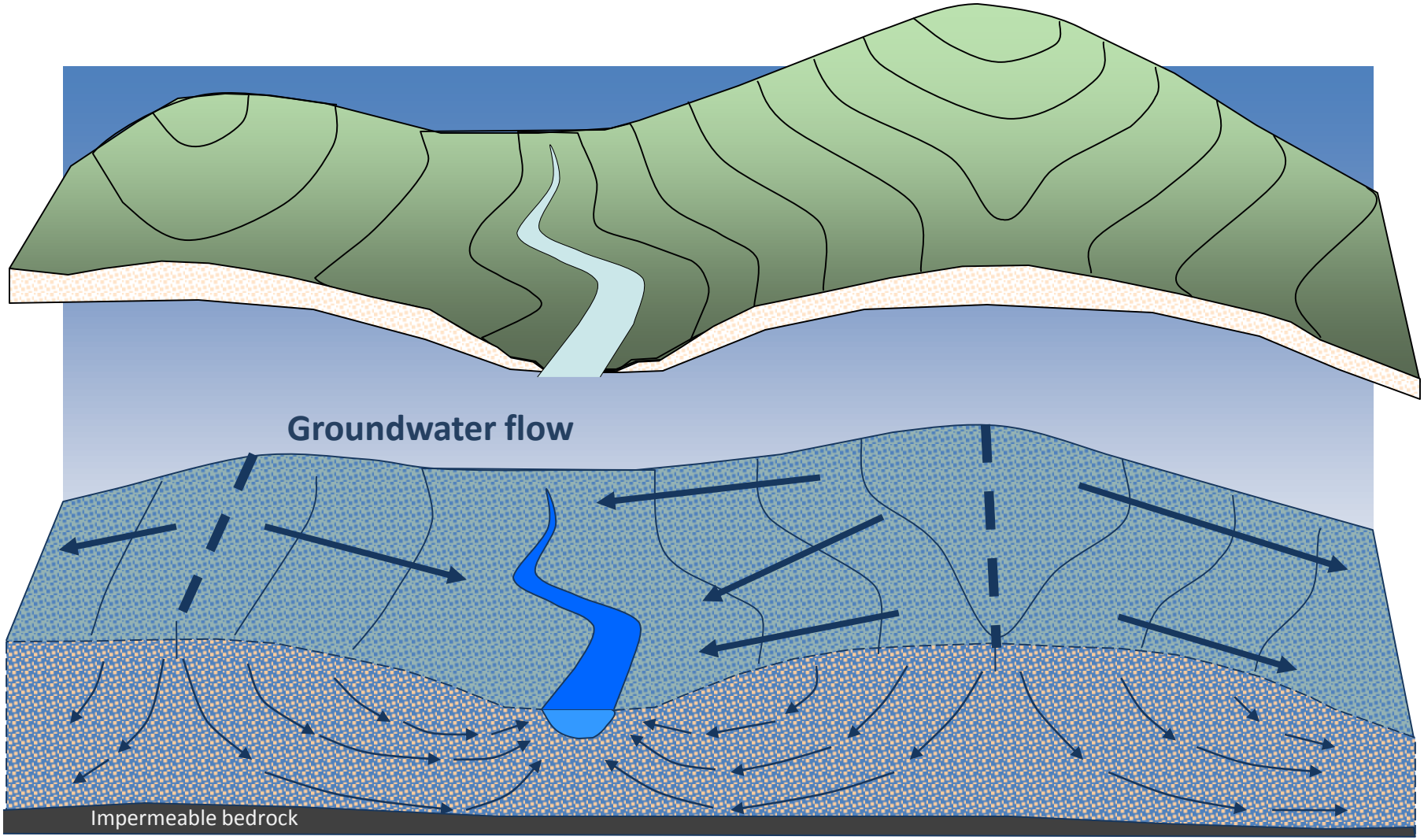




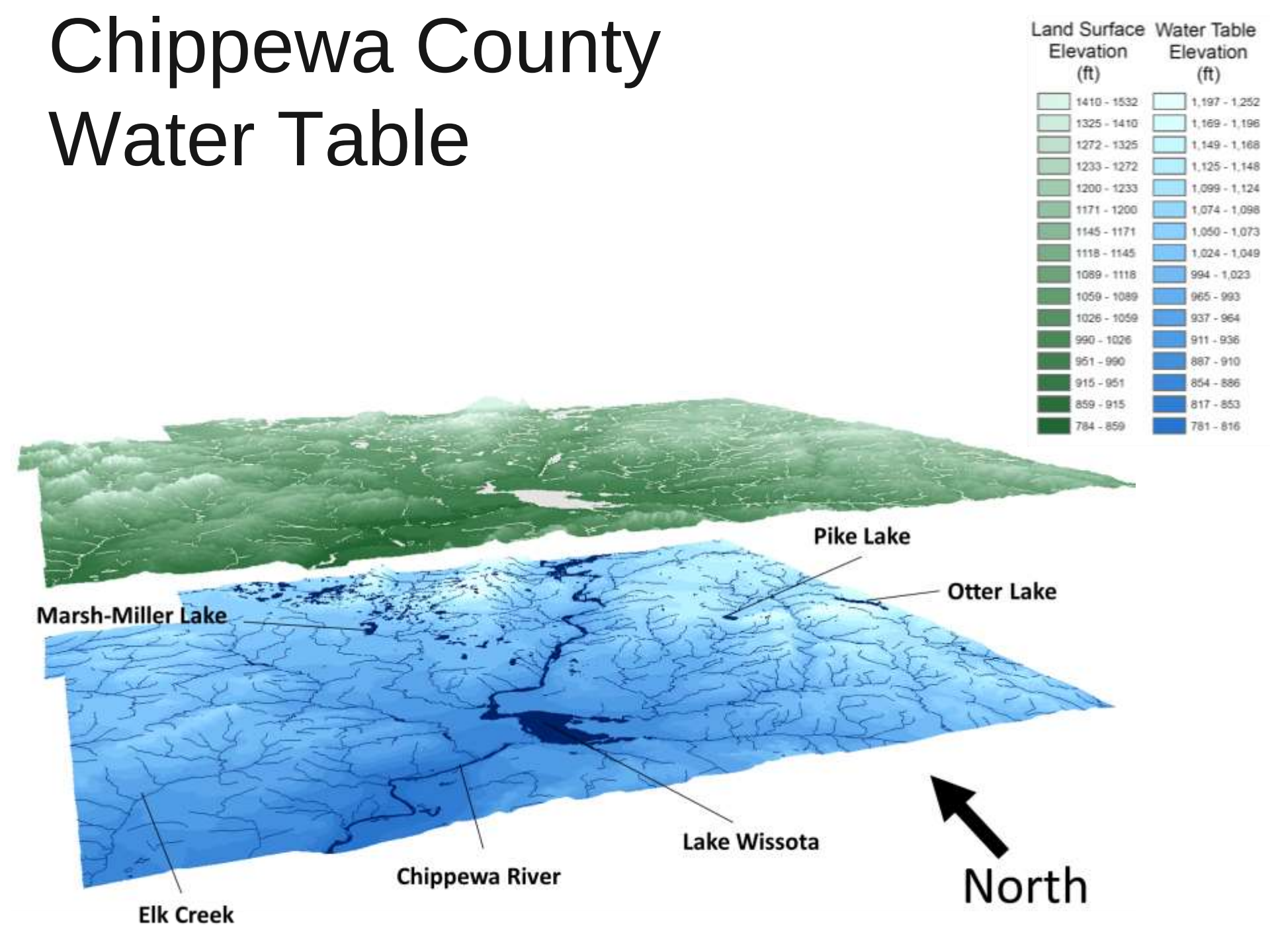


Watershed – the land area where water originates for lakes, rivers or streams. Water flows from high elevation to low elevation.




Groundwater flow
Impermeable bedrock

Chippewa County Water Table



General Groundwater Flow Direction

The black arrows show generalized groundwater flow direction in the area near your well. Groundwater flows perpendicular to the groundwater elevation lines and moves from high areas (hills) to low areas (streams,rivers). In general, residential wells impacted by land use are usually the result of those activities occuring within a roughly 1/2 mile distance from a well.

Disclaimer: This map is for educational purposes only. Groundwater flow is a best guess based on currently available information.

Cartography by Sean Piette

General Groundwater Flow Direction

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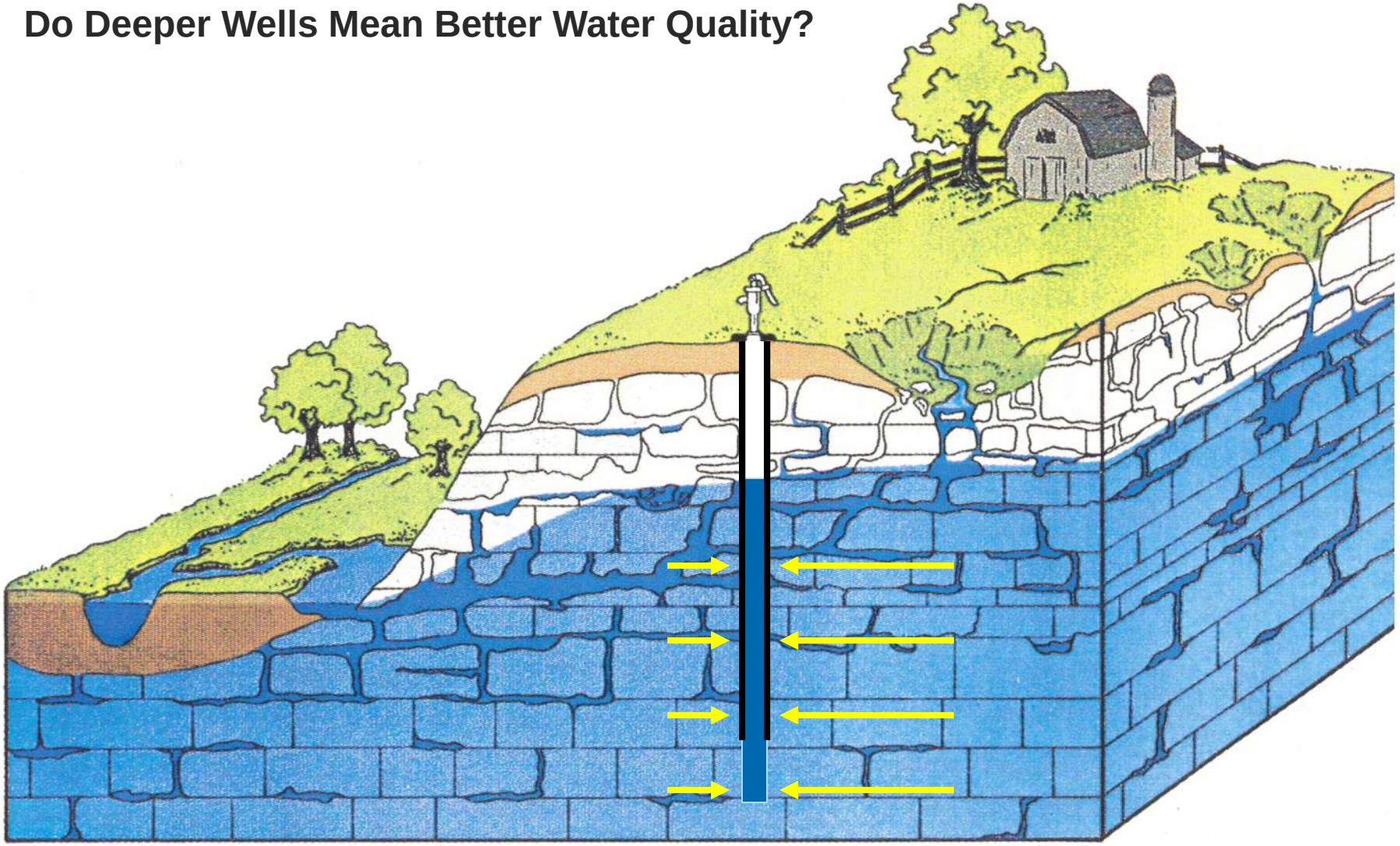
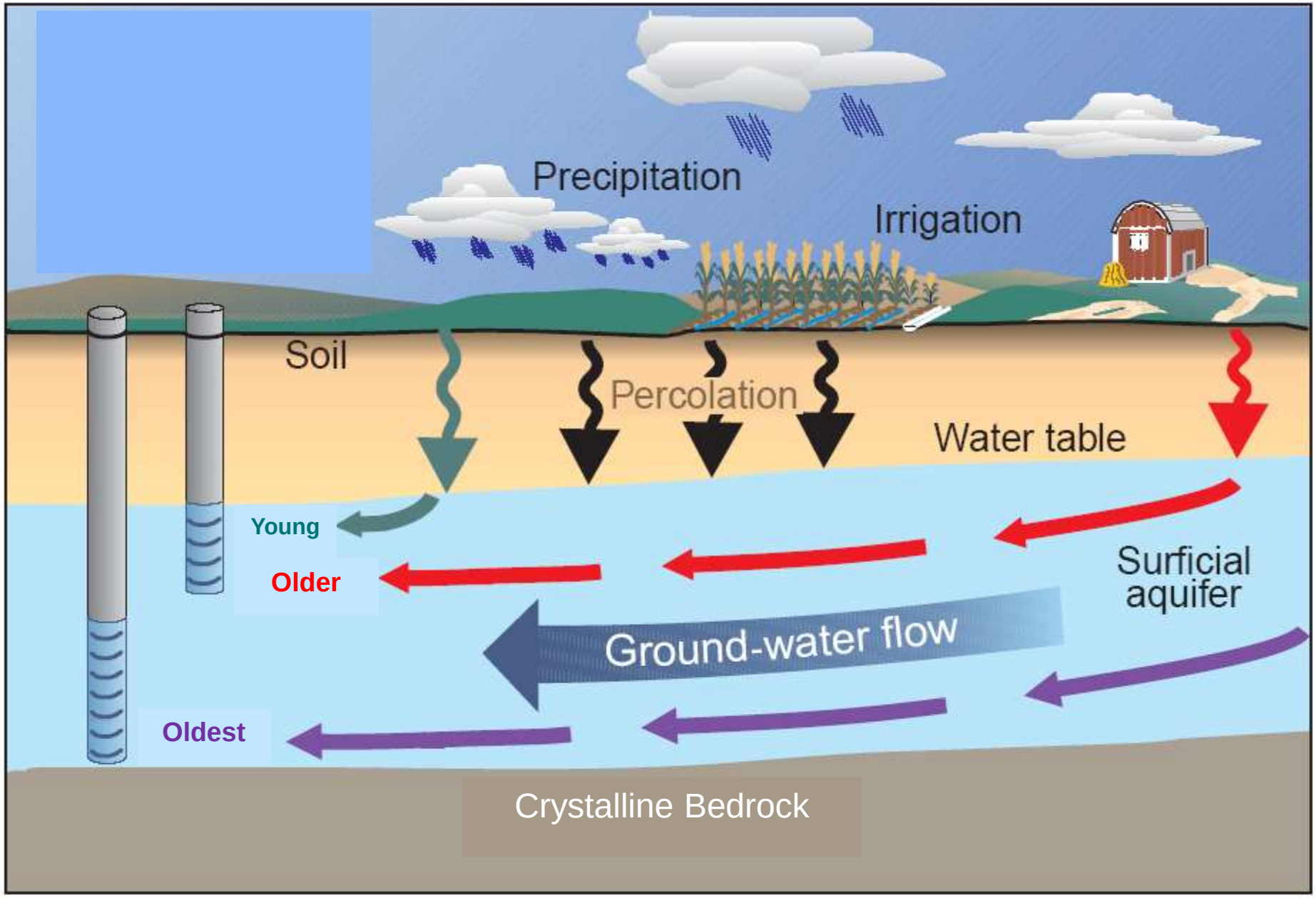
Do Deeper Wells Mean Better Water Quality?

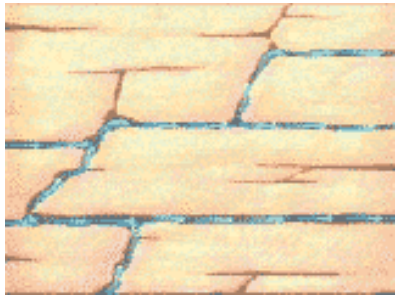



Precipitation
Irrigation
Soil
Percolation
Water table
Young
Older
Surficial aquifer
Ground-water flow
Oldest
Crystalline Bedrock

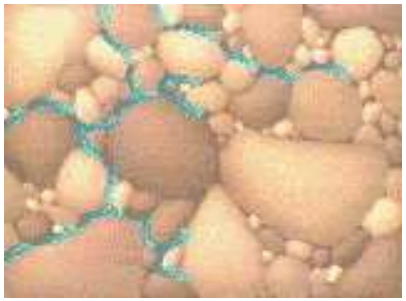
Aquifers: Our groundwater storage units

Aquifers are geologic formations that store and transmit groundwater.

The aquifer properties determine how quickly groundwater flows, how much water an aquifer can hold and how easily groundwater can become contaminated. Some aquifers may also contain naturally occurring elements that make water unsafe.



Water and contaminants can move quickly through cracks and fractures.



Water moving through tiny spaces in between sand particles or sandstone moves slower and allows for filtration of some contaminants.

Wisconsin's geology is like a layered cake. Underneath all of Wisconsin lies the Crystalline bedrock which does not hold much water. Think of this layer like the foundation of your house. All groundwater sits on top of this foundation. Groundwater is stored in the various **sandstone**, **dolomite** and **sand/gravel** aquifers above the **crystalline bedrock** layer. The layers are arranged in the order which they formed, oldest on the bottom and youngest on top.

Learn more about Wisconsin's geologic past by clicking the aquifer names

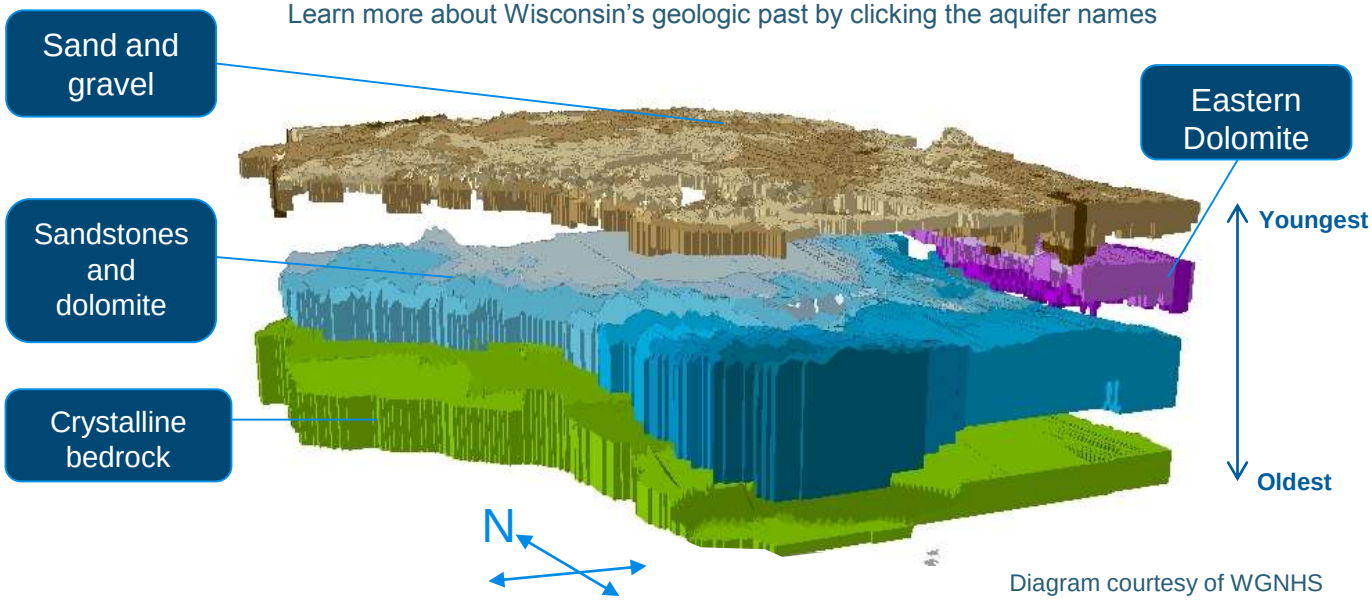


Diagram courtesy of WGNHS

BEDROCK GEOLOGY OF WISCONSIN

UNIVERSITY OF WISCONSIN–EXTENSION
Geological and Natural History Survey

APRIL 1981
REVISED 2005

EXPLANATION

DEVONIAN
- D — dolomite and shale

SILURIAN
- Sd — dolomite

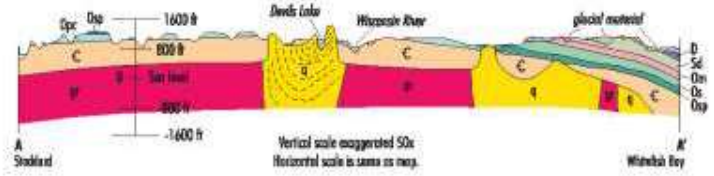
ORDOVICIAN
- Om — Maquoketa Formation—shale and dolomite
- Os — Sinnipee Group—dolomite with some limestone and shale
- Ostp — St. Peter Formation—sandstone with some limestone, shale and conglomerate
- Opc — Prairie du Chien Group—dolomite with some sandstone and shale

CAMBRIAN
- C — sandstone with some dolomite and shale

MIDDLE PROTEROZOIC
- Keweenawan rock—
  - ss, sandstone
  - v, basaltic to rhyolitic lava flows
  - i, gabbroic, anorthositic and granitic rock
- Wolf River rock—
  - g, rapakivi granite, granite, and syenite
  - a, anorthosite and gabbro

LOWER PROTEROZOIC
- q — quartzite
- gr — granite, diorite, and gneiss
- s, metasedimentary rock, argillite, siltstone, quartzite, greywacke, and iron formation
- vo, basaltic to rhyolitic metavolcanic rock with some metasedimentary rock
- ga, meta-gabbro and hornblende diorite

LOWER PROTEROZOIC OR UPPER ARCHEAN
- mv, metavolcanic rock
- gn, granite, gneiss, and amphibolite



Private vs. Public Water Supplies

Public Water Supplies

- Regularly tested and regulated by drinking water standards.

Private Wells

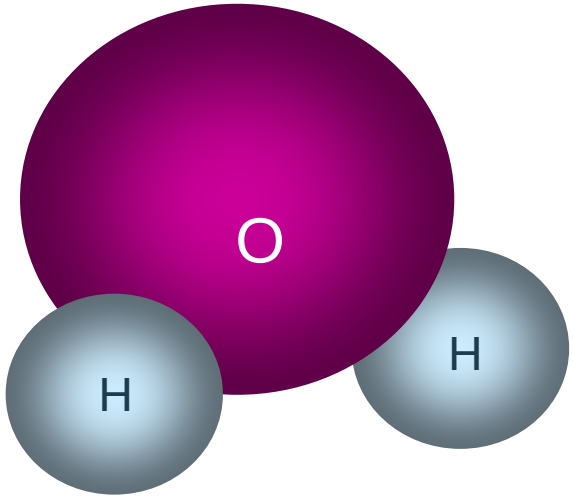
- Not required to be regularly tested.
- Not required to take corrective action
- Owners must take special precautions to ensure safe drinking water.

Is Your Water Well?

Photos courtesy of: Matt Zoschke

water basics

- "Universal Solvent"
- Naturally has "stuff" dissolved in it.
  - Impurities depend on rocks, minerals, land-use, plumbing, packaging, and other materials that water comes in contact with.
- Can also treat water to take "stuff" out



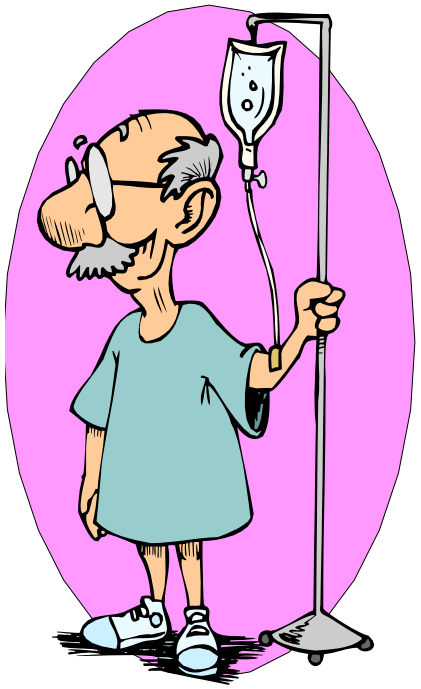
What are the Health Concerns?

- Acute Effects – Usually seen within a short time after exposure to a substance.

  (ex. Bacteria or viral contamination which may cause intestinal disease)

- Chronic Effects – Results from exposure to a substance over a long period of time.

  (ex. Arsenic or pesticides can increase the chance of developing certain types of cancer)



Understanding Risk…?

Dying from a lightning strike.	0.013 in 1,000 chance.
0.010 mg/L of arsenic in drinking water.	3 out of 1,000 people expected to develop cancer.
2 pCi of indoor radon level.	4 out of 1,000 people expected to develop lung cancer.[1]
Dying in a car accident.	4 in 1,000 chance.
2 pCi of indoor radon combined with smoking.	32 out of 1,000 people expected to develop lung cancer.[1]

What did we test for?

Health Related

- Nitrate
- Arsenic
- Copper
- Lead
- Manganese
- Sulfate
- Sodium
- Zinc

Aesthetic

(taste, color, odor)

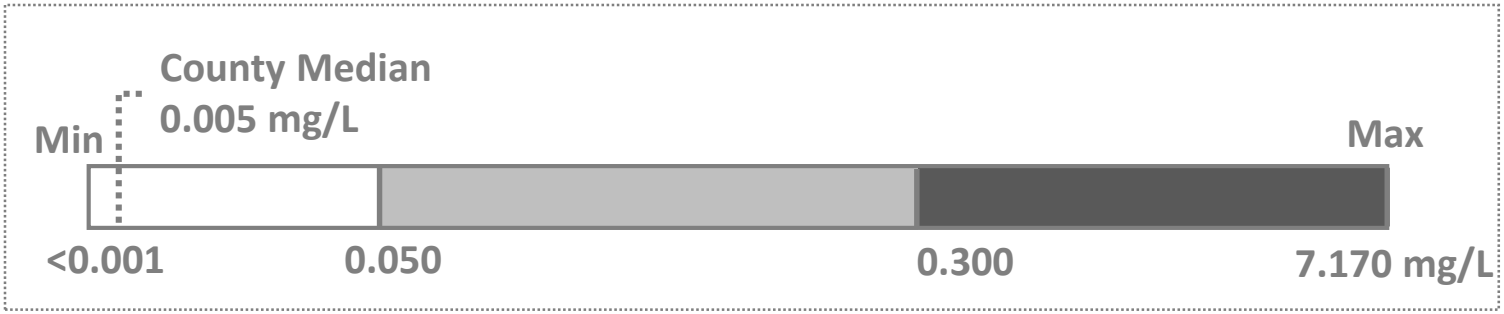
- Hardness
- Iron
- Manganese
- Chloride

Overall Water Quality

- pH
- Conductivity
- Alkalinity
- Calcium
- Magnesium
- Phosphorus

Manganese

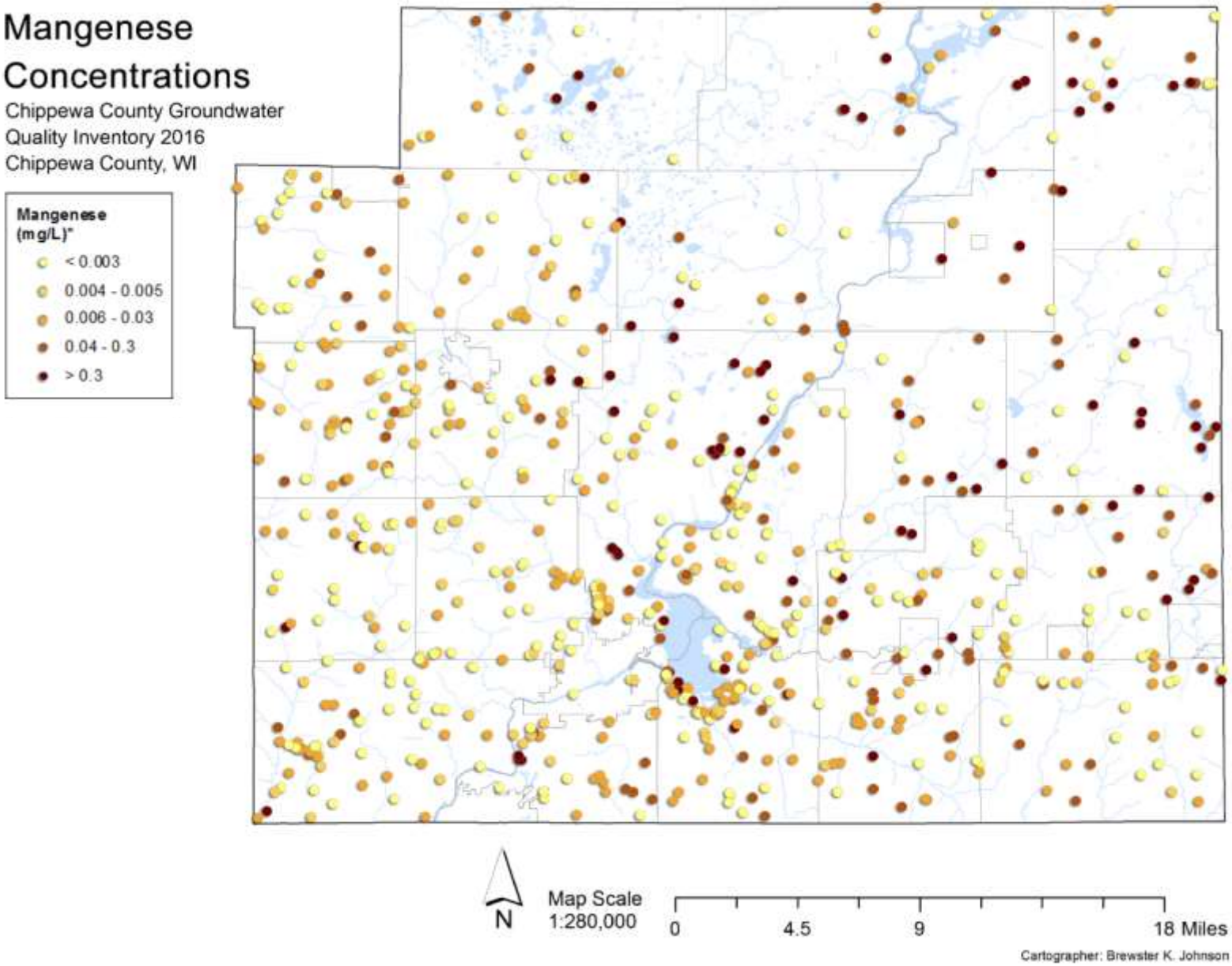
- Naturally occurring
- Aesthetic Level: 0.050 mg/L
  - Causes black/brown precipitate and possible staining on fixtures
- Health Advisory Level: 0.300 mg/L
  - Long-term exposure may harm the nervous system
- Treatment: Oxidation or Iron Filters



Health considerations | Aesthetic concerns | Likely land use impacts | No health or aesthetic concerns

Mangenese Concentrations

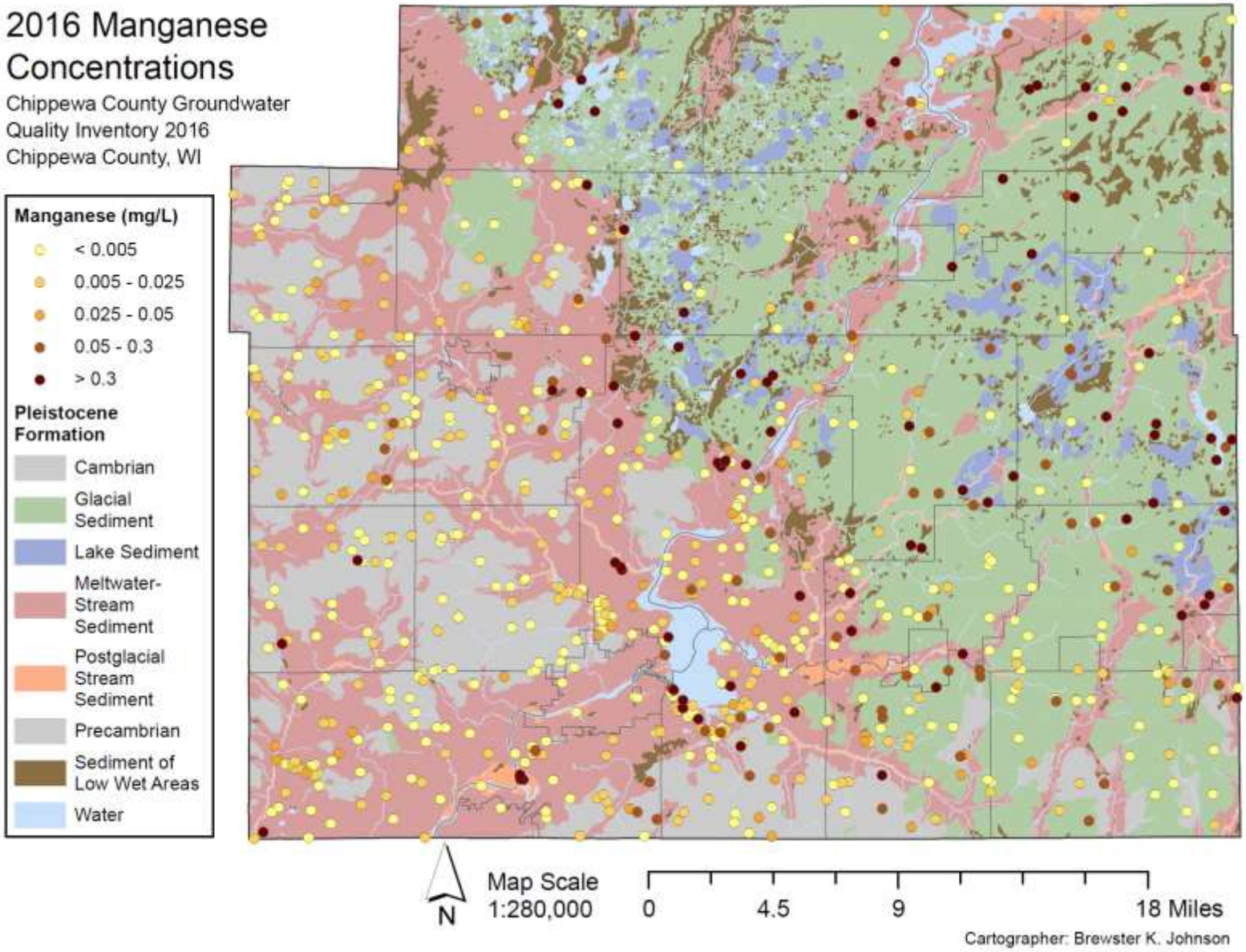
Chippewa County Groundwater Quality Inventory 2016
Chippewa County, WI



Cartographer: Brewster K. Johnson

2016 Manganese Concentrations

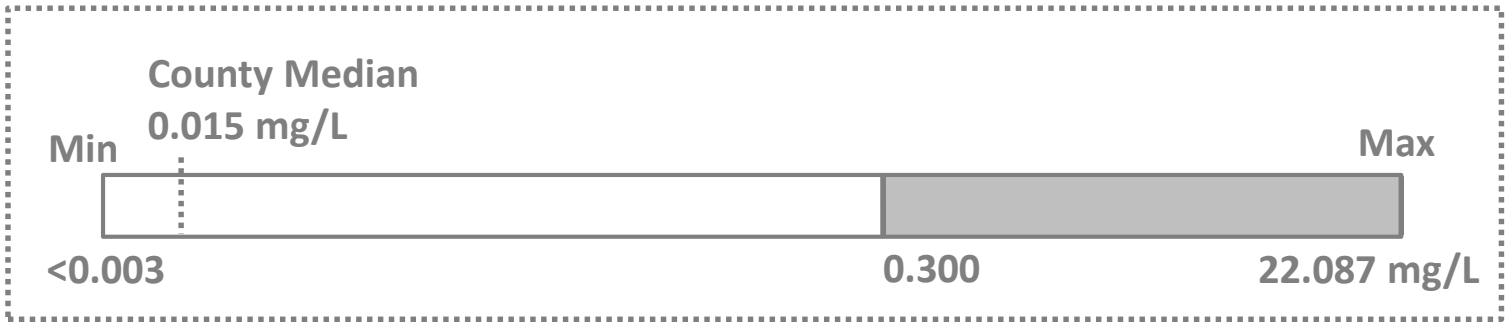
Chippewa County Groundwater Quality Inventory 2016
Chippewa County, WI



Cartographer: Brewster K. Johnson

Iron

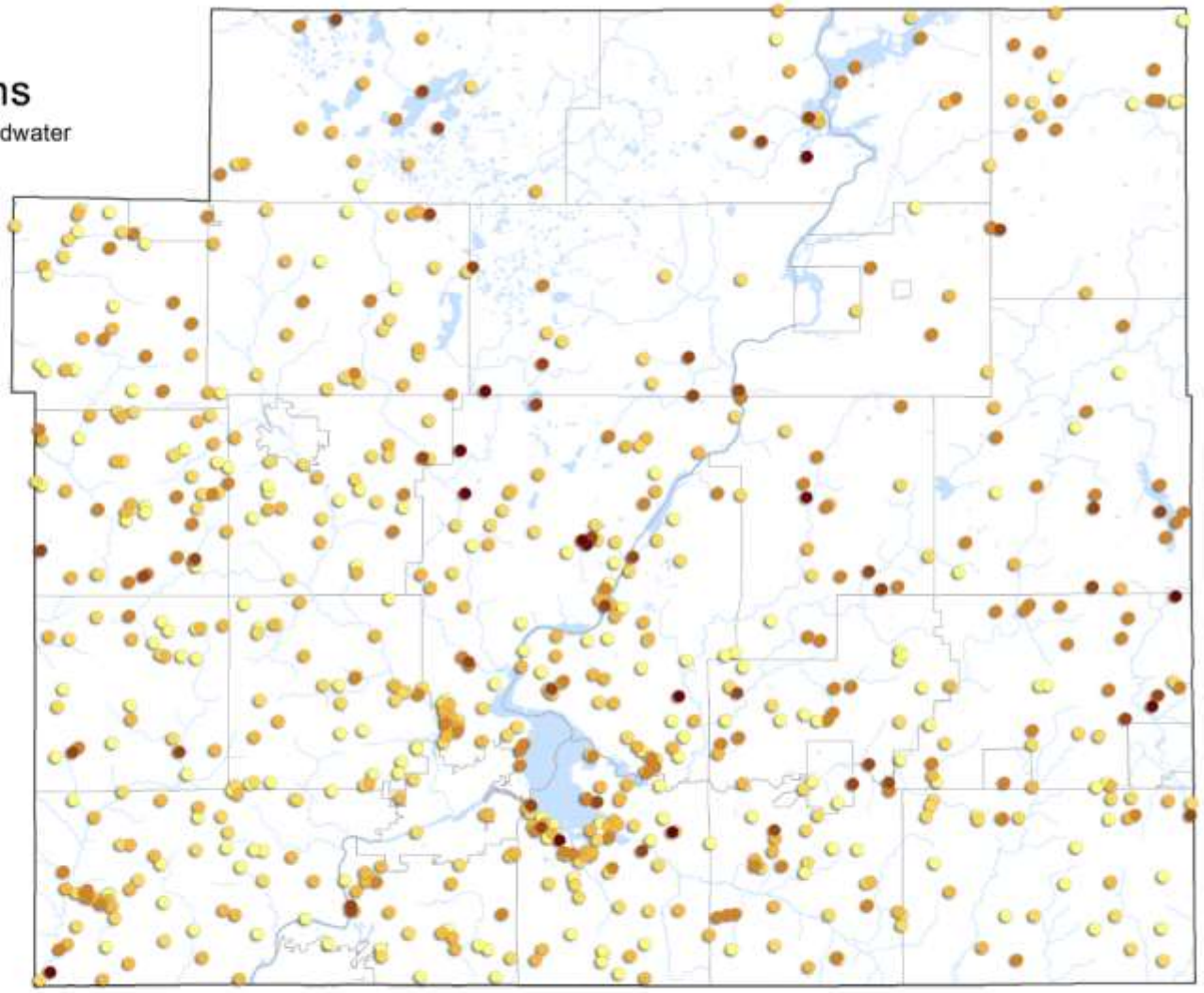
- Naturally occurring in soils and rock
- Aesthetic Level: 0.300 mg/L
  - Taste
  - Reddish-brown staining of sinks, showers, toilets and laundry
- Treatment:
  - Oxidation or Iron Filters
  - Water softeners



Health considerations | Aesthetic concerns | Likely land use impacts | No health or aesthetic concerns

Iron Concentrations

Chippewa County Groundwater Quality Inventory 2016
Chippewa County, WI

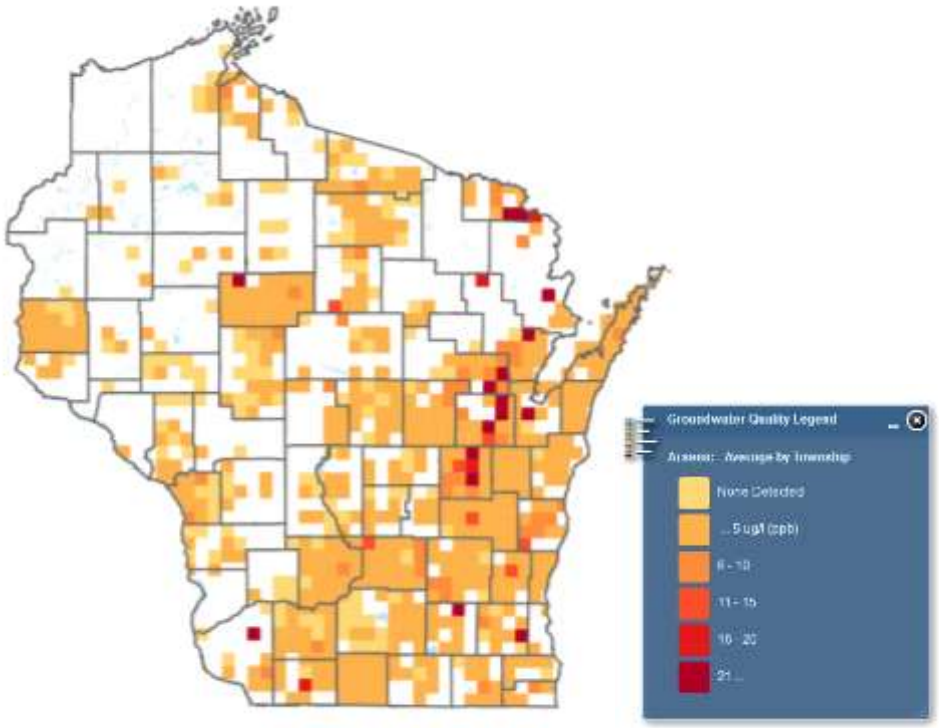


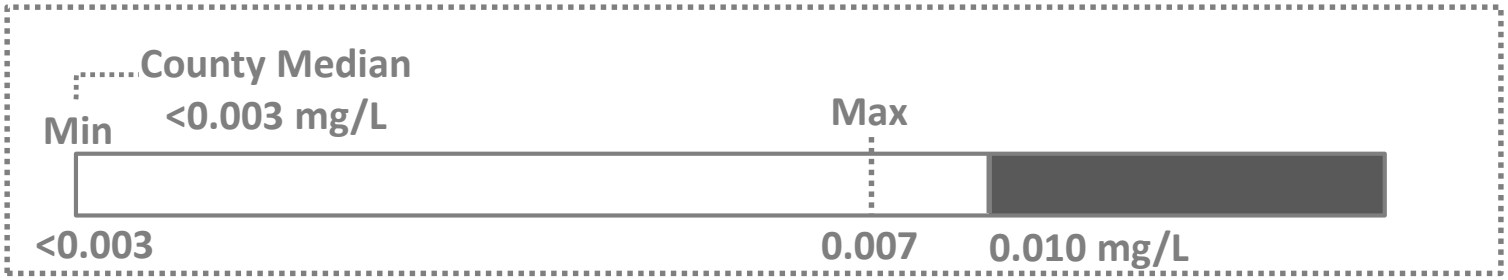
Statistics	
Min	<0.003
Max	22.087
Median	81.7
Mean	0.383

Cartographer: Brewster K. Johnson

Arsenic

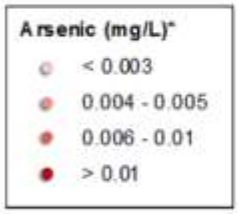
- Naturally occurring in soils or other geologic materials
- Health Standard: 0.010 mg/L
  - Long-term consumption may increase the risk of certain cancers
- Treatment: Reverse osmosis, distillation (drinking water)

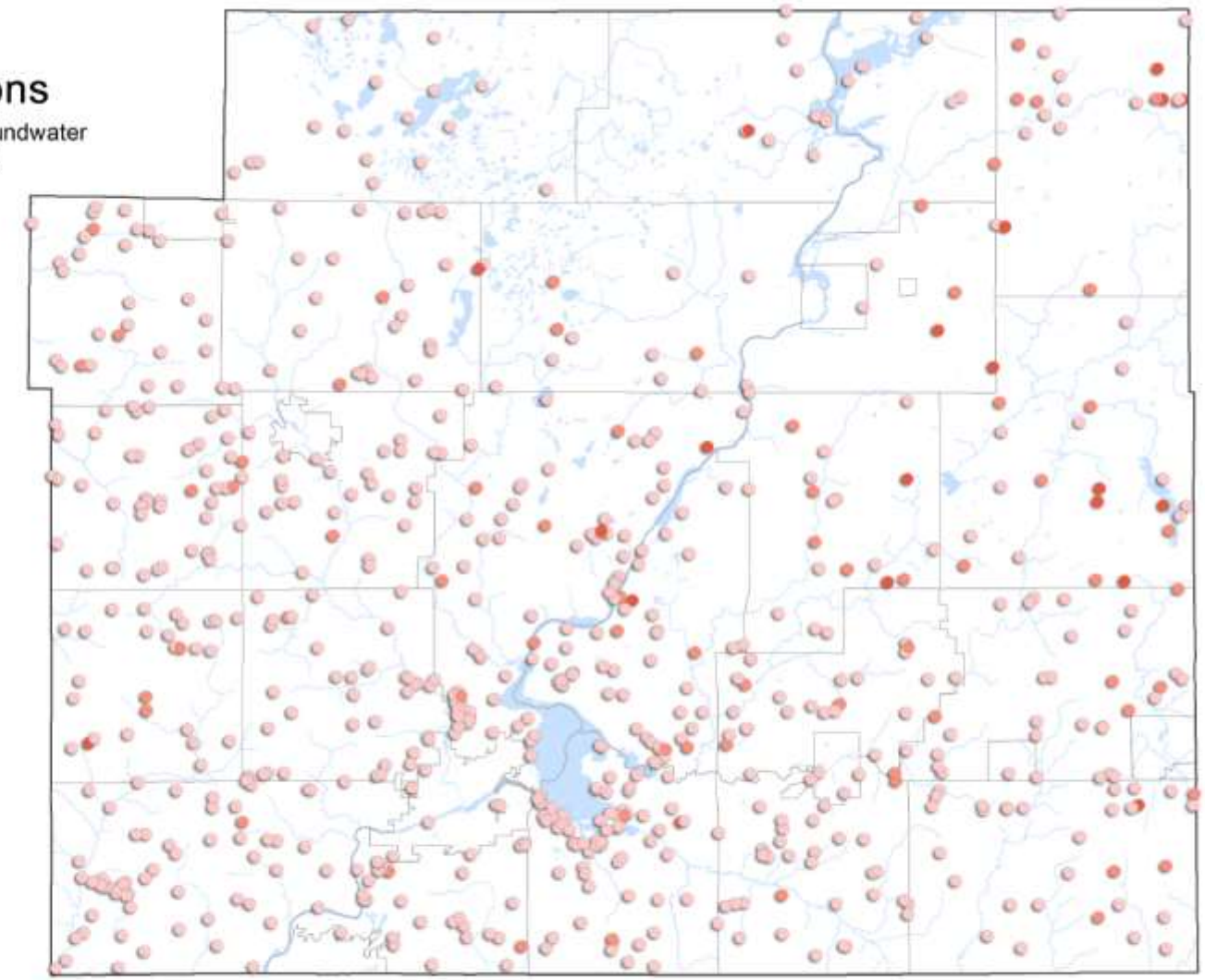




Arsenic Concentrations

Chippewa County Groundwater Quality Inventory 2016
Chippewa County, WI





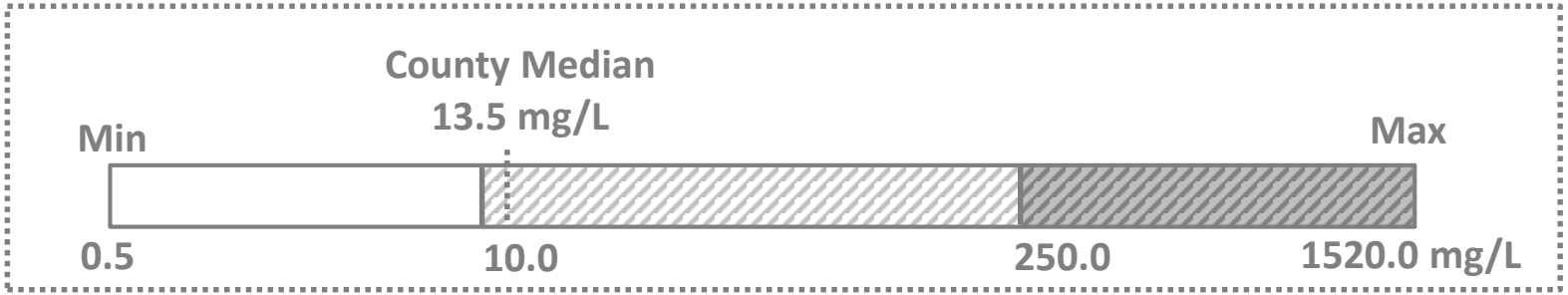
Map Scale
1:280,000

0 4.5 9 18 Miles

Cartographer: Brewster K. Johnson

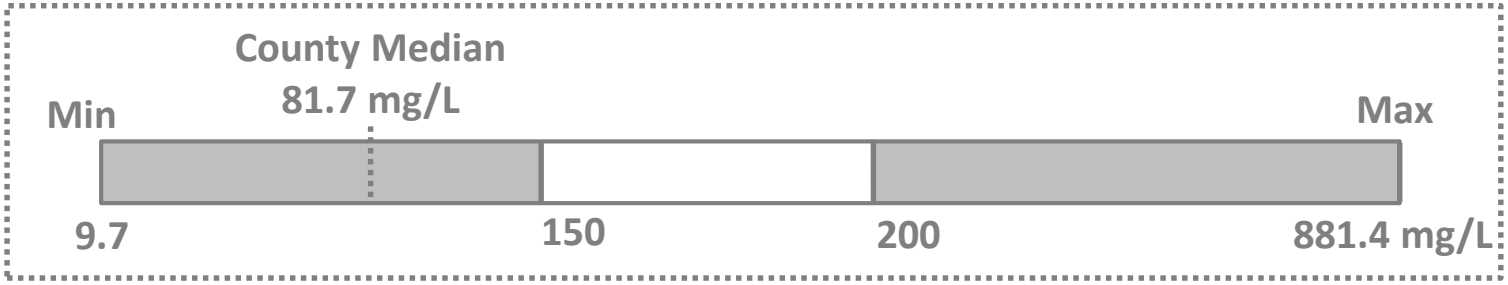
Chloride

- Natural levels generally <10 mg/L
- Elevated levels associated with:
  - Fertilizers, septic system effluent, road salt
- Aesthetic Level: 250 mg/L
  - Salty taste
  - Corrosion of some metals



Hardness

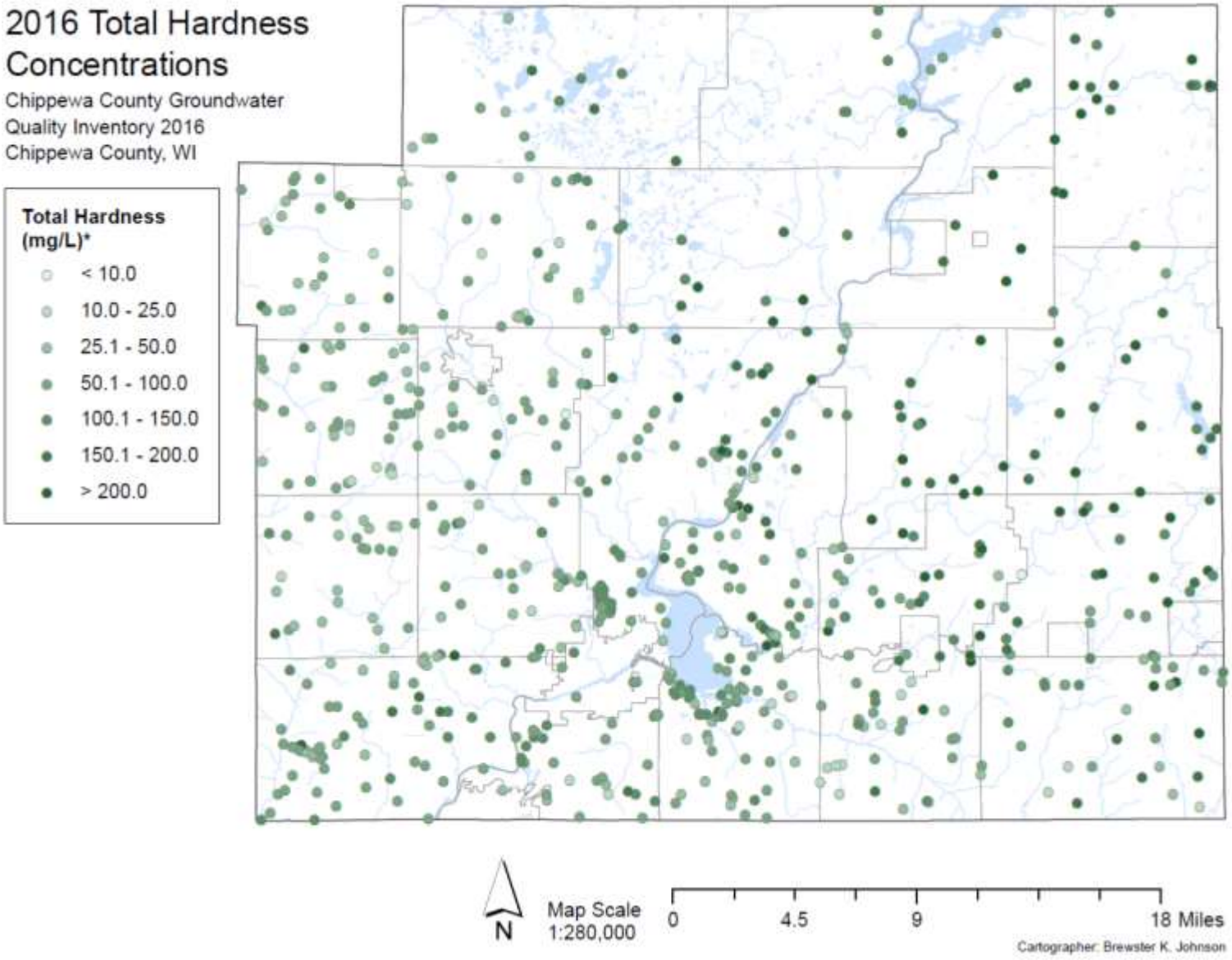
- Measure of calcium and magnesium
- Naturally occurring from dissolution of limestone or dolomite in rocks/soil
- Aesthetic Problems:
  - Greater than 200 mg/L
    - Scale deposits on fixtures/pipes/water heaters
    - Treatment: Water softener
  - Less than 150 mg/L
    - Soft water that tends to be more corrosive
    - Treatment: Acid-neutralizer



Health considerations | Aesthetic concerns | Likely land use impacts | No health or aesthetic concerns

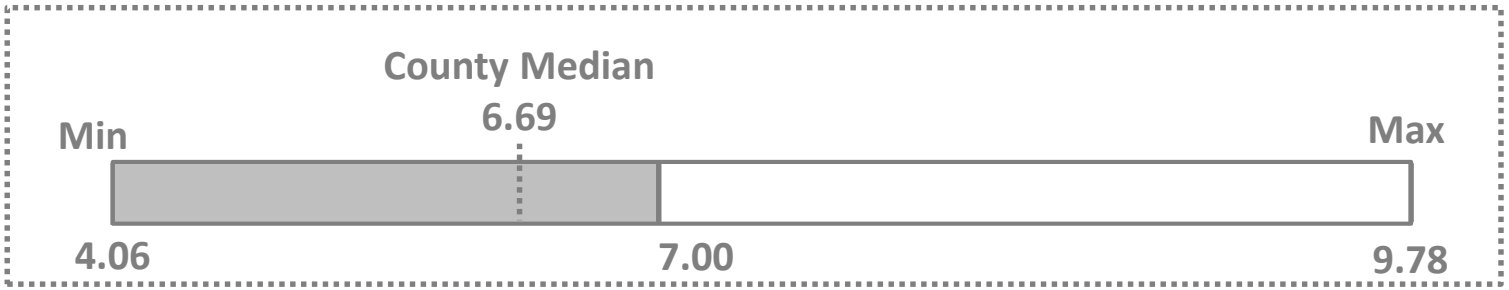
2016 Total Hardness Concentrations

Chippewa County Groundwater Quality Inventory 2016
Chippewa County, WI



pH

- Measure of acidity
- Levels less than 7.0 are:
  - More likely to cause corrosion
  - More likely to result in elevated levels of lead/copper if found in plumbing system
- Treatment: Acid-neutralizer



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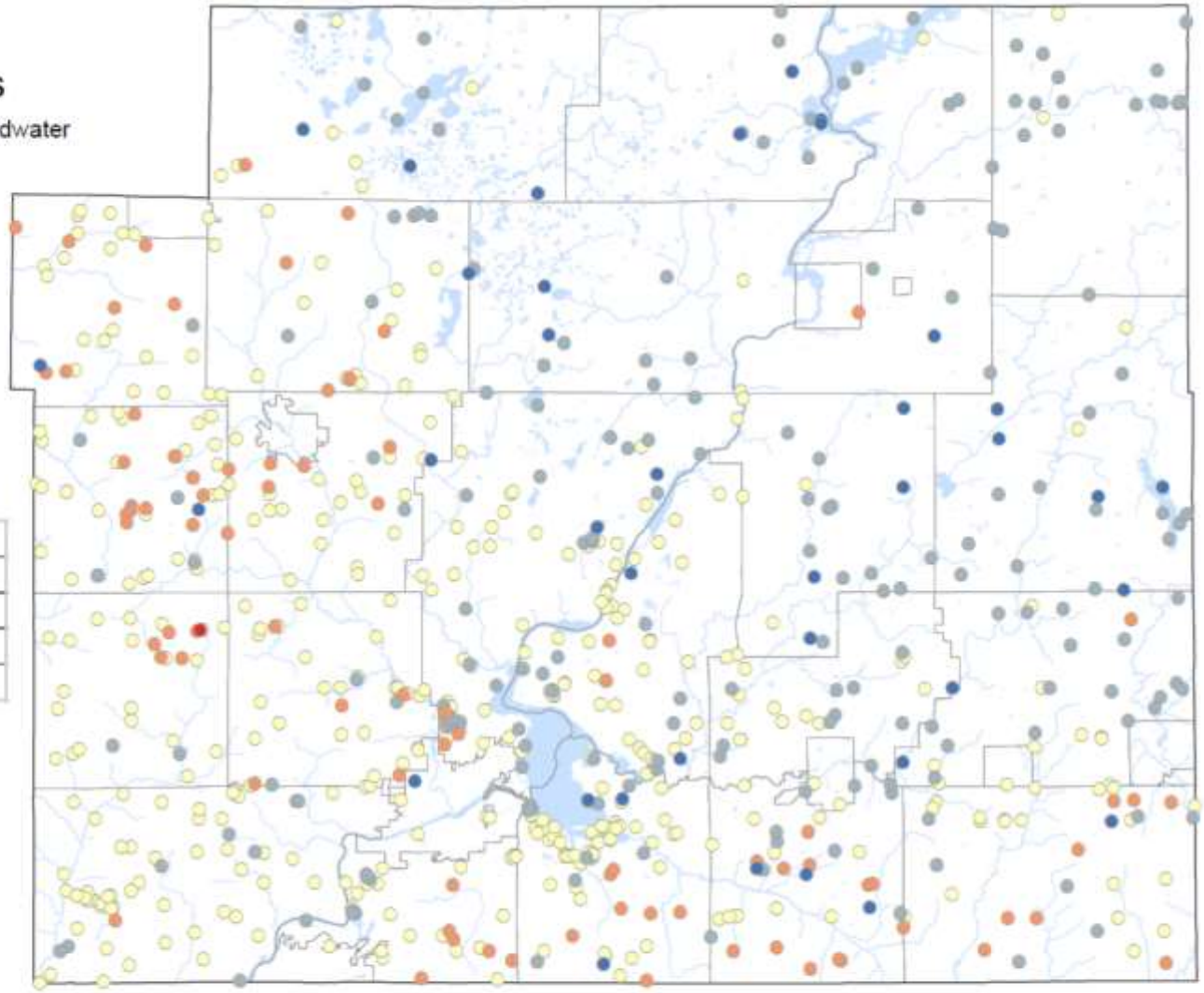
2016 pH Concentrations

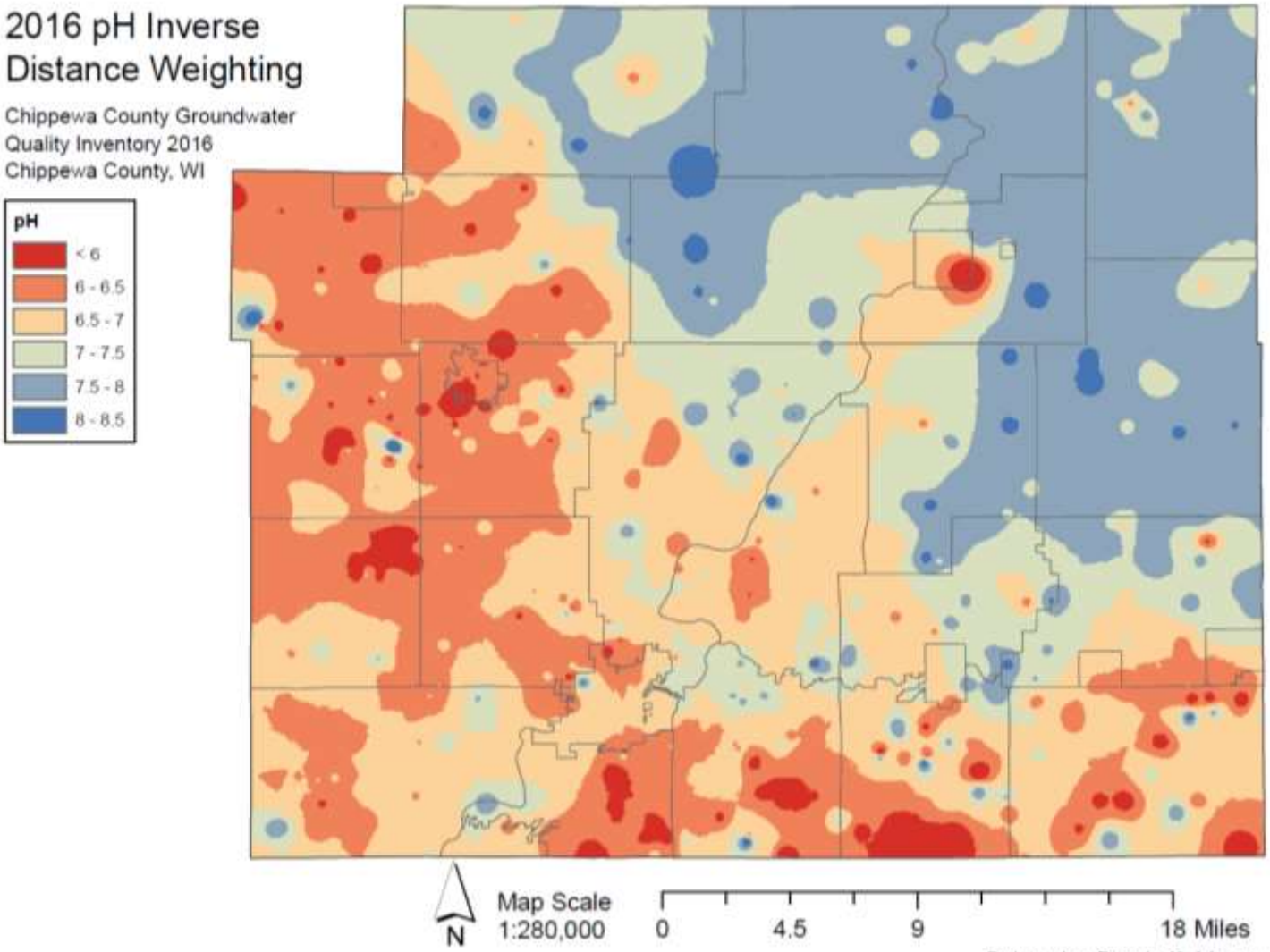
Chippewa County Groundwater Quality Inventory 2016
Chippewa County, WI



Statistics	
Min	4.06
Max	9.78
Median	6.69
Mean	6.78

2016 pH Inverse Distance Weighting

Chippewa County Groundwater Quality Inventory 2016
Chippewa County, WI



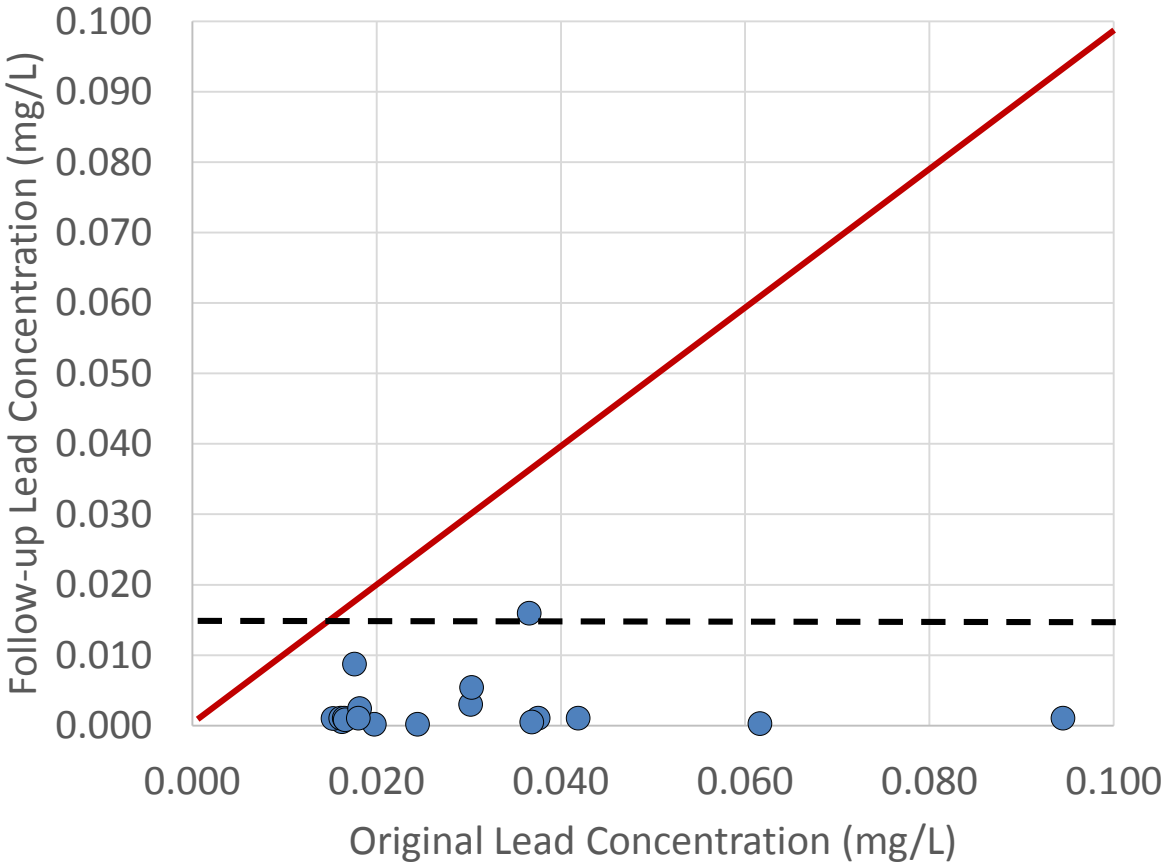
Cartographer: Brewster K. Johnson

Lead

- Sources: Lead solder, lead pipes, brass fixtures, stabilizer in materials used to make some hoses.
- Health Standard: 0.015 mg/L
  - Lead may damage the brain, kidneys, nervous system, red blood cells, reproductive system.
- Treatment: Run water for 1-2 minutes prior to using for drinking or cooking

Retesting of elevated lead samples

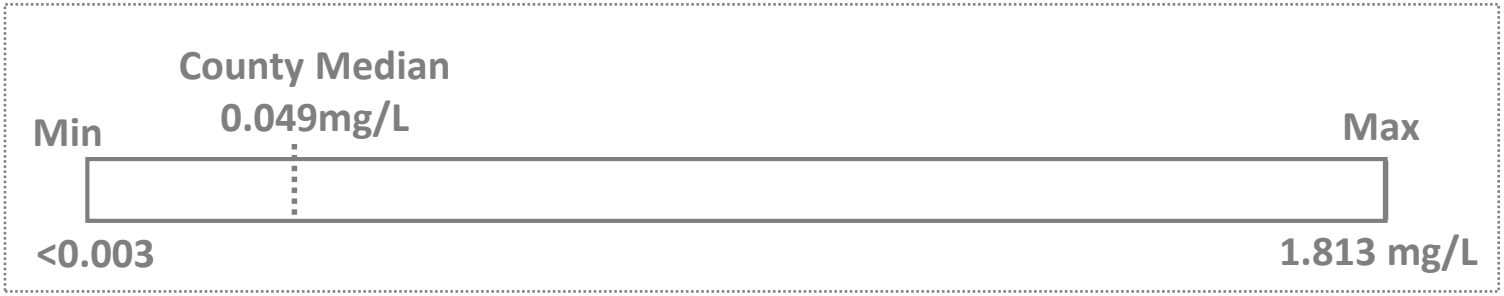
Original	Follow-Up
0.042	<0.002
0.016	<0.002
0.485	0.004
0.015	<0.002
0.016	<0.002
0.018	0.009
0.095	<0.002
0.354	<0.002
0.020	<0.002
0.030	0.003
0.017	<0.002
0.038	<0.002
0.062	<0.002
0.017	<0.002
0.024	<0.002
0.661	<0.002
0.018	0.002
0.018	<0.002
0.037	<0.002
0.037	0.016
0.030	0.005



Phosphorus

- Naturally low in groundwater
- Elevated levels may result from dissolution of phosphorus rich minerals
- Not a common test for well or drinking water
- Concern for surface water quality- contributes to eutrophication
  - soil & P fertilizer runoff

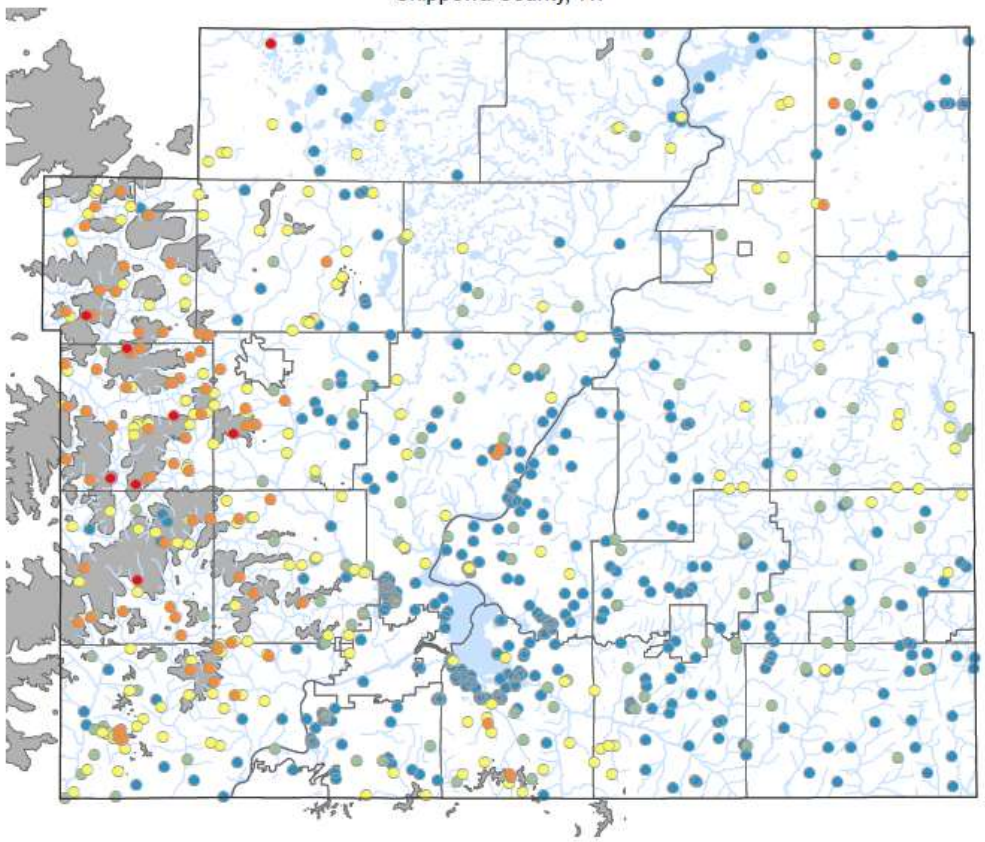
Algae bloom on Wisconsin's Lake Tainter.
(photo: Peg McAloon)

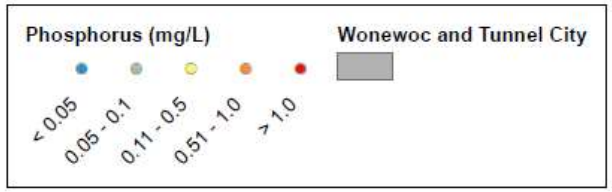


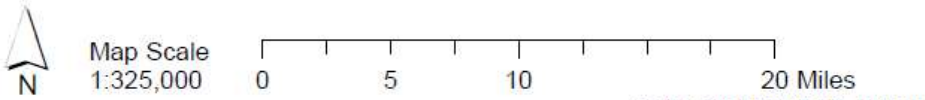
Health considerations | Aesthetic concerns | Likely land use impacts | No health or aesthetic concerns

2016 Phosphorous & Intersection with Wonewoc and Tunnel City

Chippewa County Groundwater Quality Inventory 2016
Chippewa County, WI



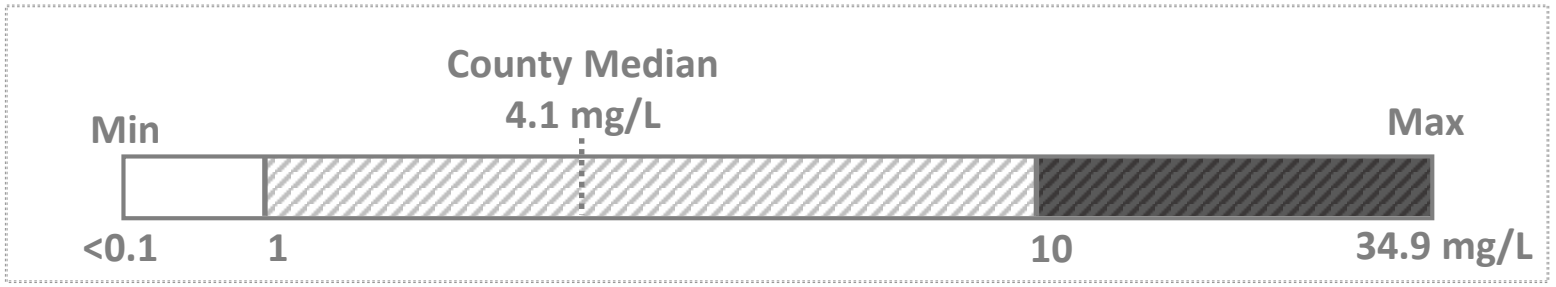




Cartographer: Brewster K. Johnson

Nitrate

- Natural levels in groundwater < 1 mg/L
- Elevated levels associated with:
  - Fertilizers, manure/bio-solid applications, septic system effluent
- Health Standard: 10 mg/L
  - Methemoglobinemia, birth defects, miscarriages, thyroid function
  - Greater than 10 mg/L should not be used by infants, pregnant women or those trying to become pregnant. Everyone else avoid long-term consumption.
- Treatment: Reverse osmosis, distillation, or anion exchange (drinking water only)



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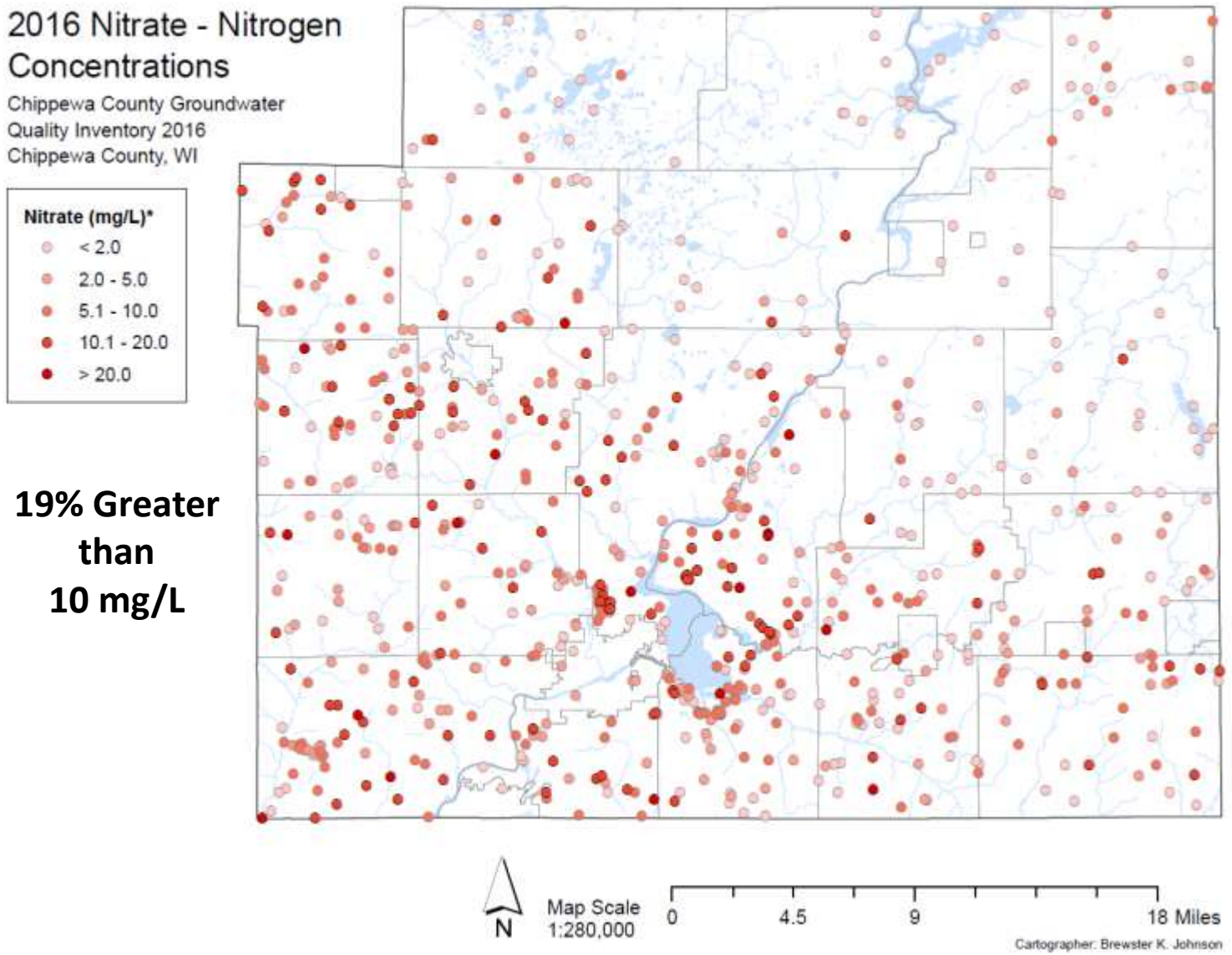

19% Greater than 10 mg/L

2016 Nitrate - N Inverse Distance Weighting

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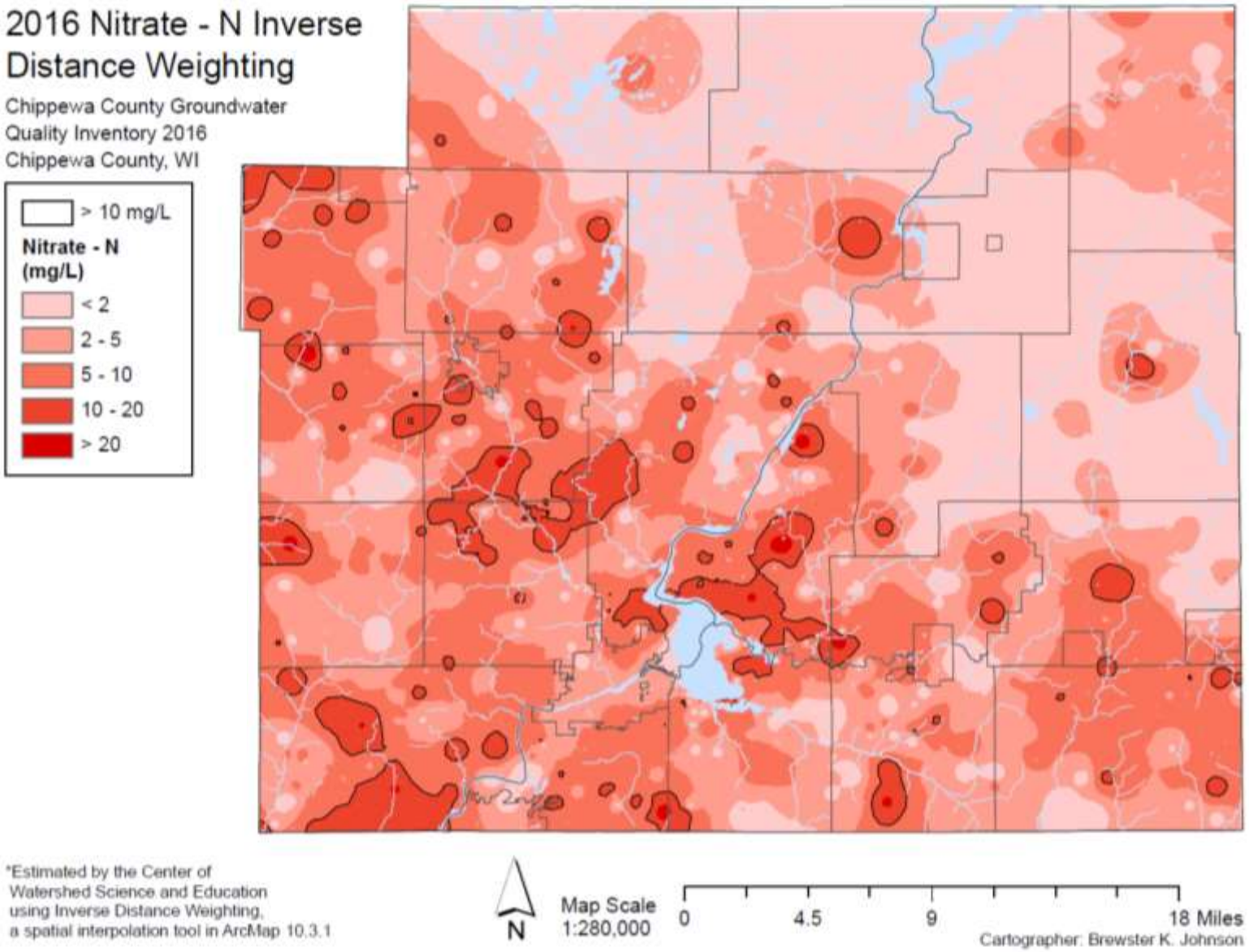

*Estimated by the Center of Watershed Science and Education using Inverse Distance Weighting, a spatial interpolation tool in ArcMap 10.3.1

Cartographer: Brewster K. Johnson

2016 Nitrate - Nitrogen & 2015 Land Cover

Chippewa County Groundwater Quality Inventory 2016
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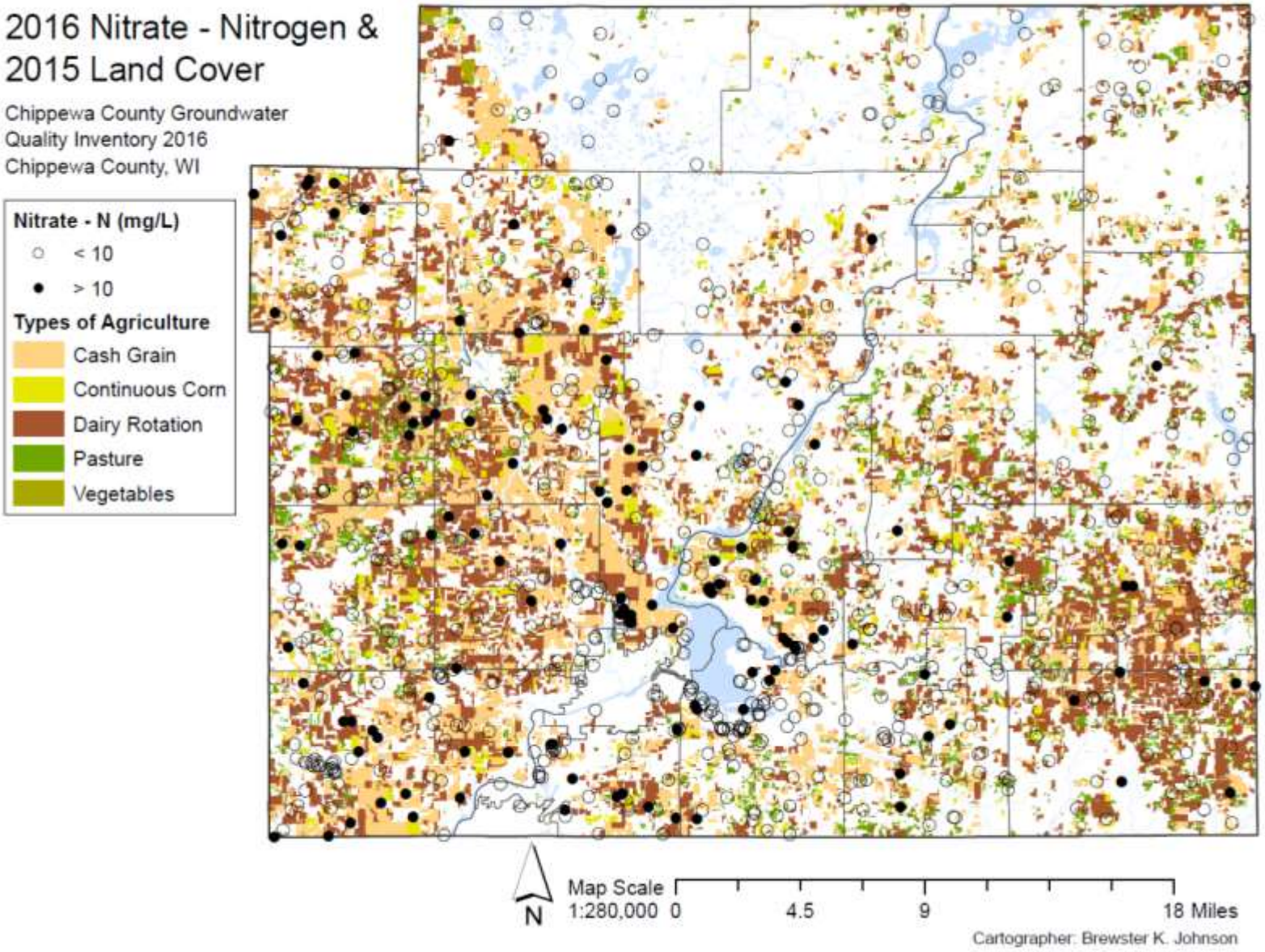
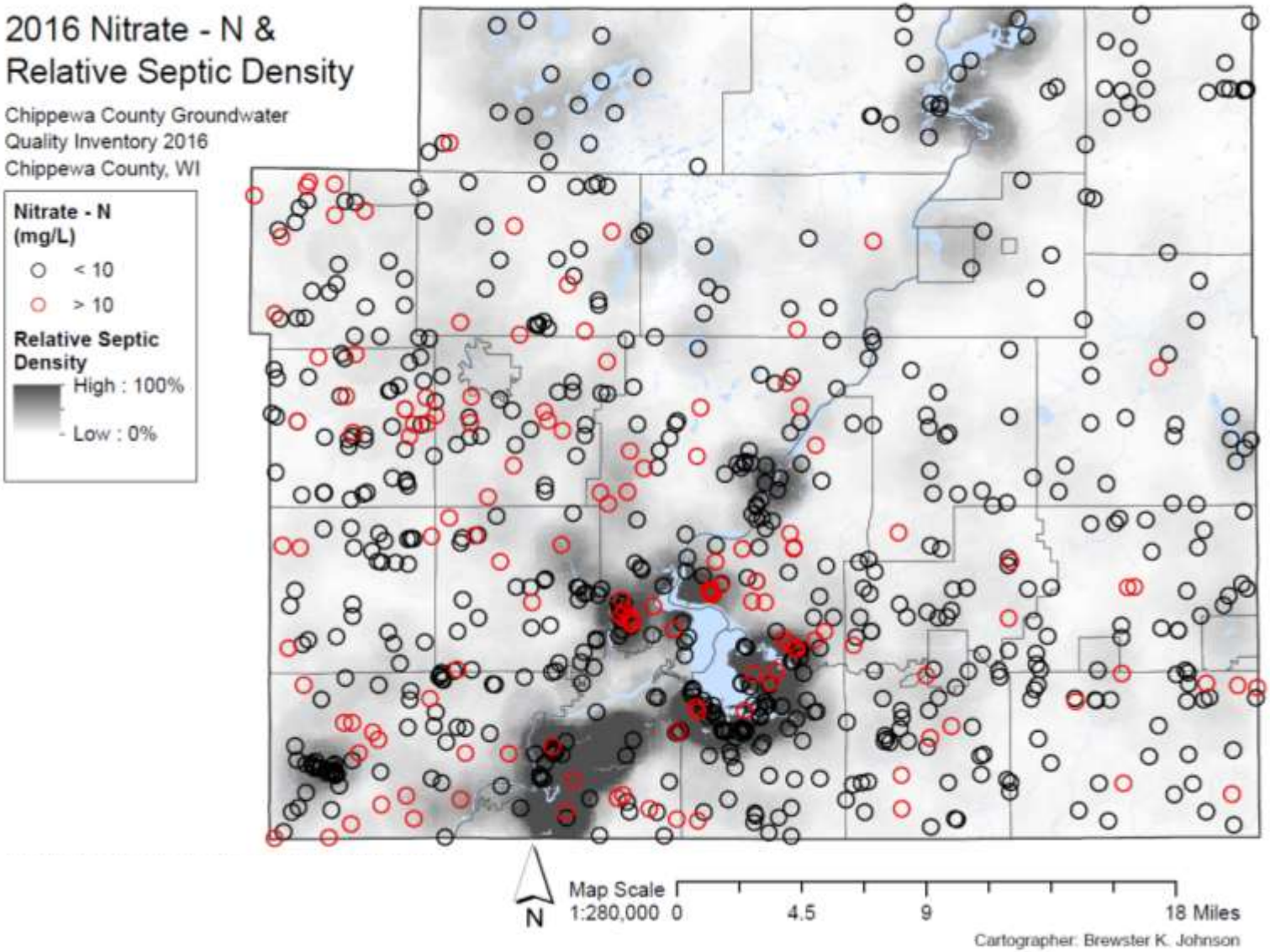


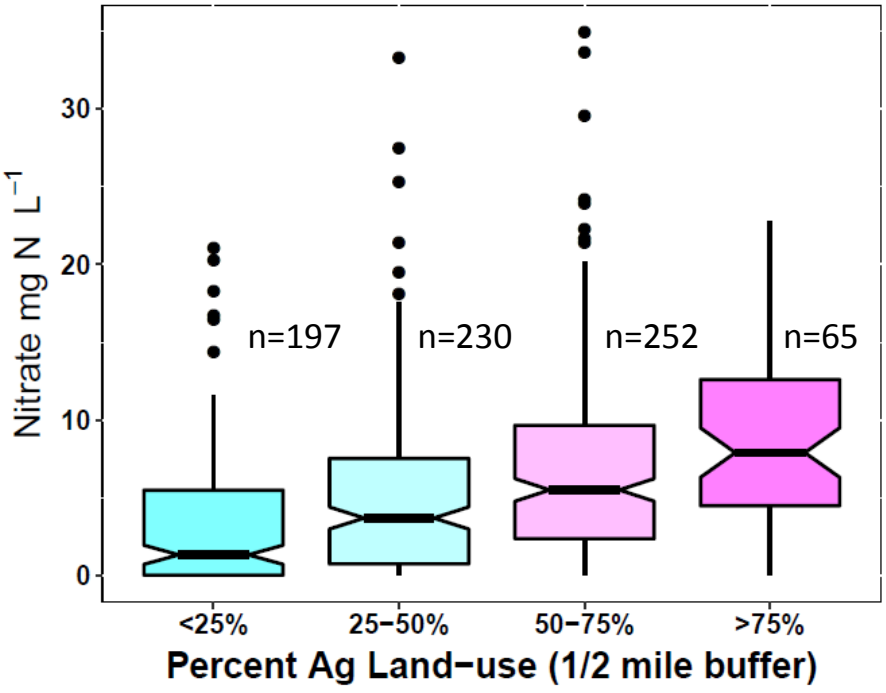
Cartographer: Brewster K. Johnson

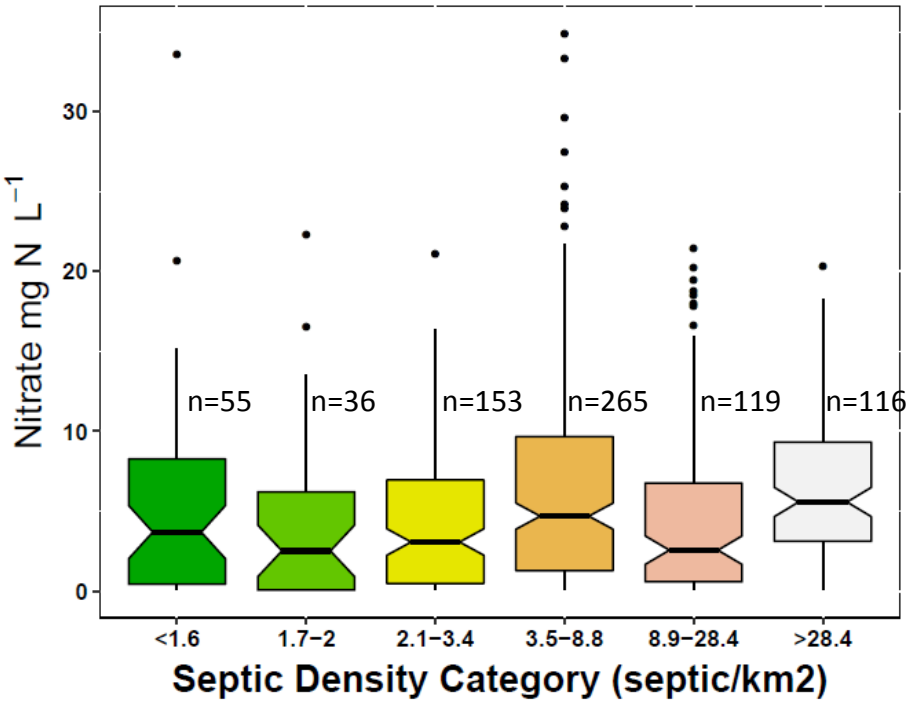
2016 Nitrate - N & Relative Septic Density

Chippewa County Groundwater Quality Inventory 2016
Chippewa County, WI

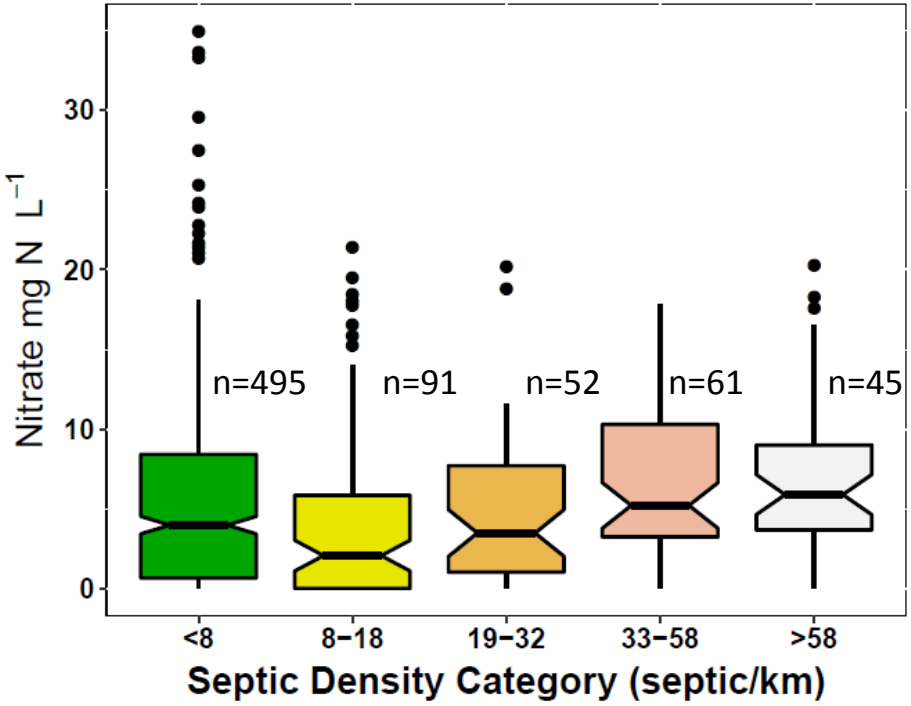


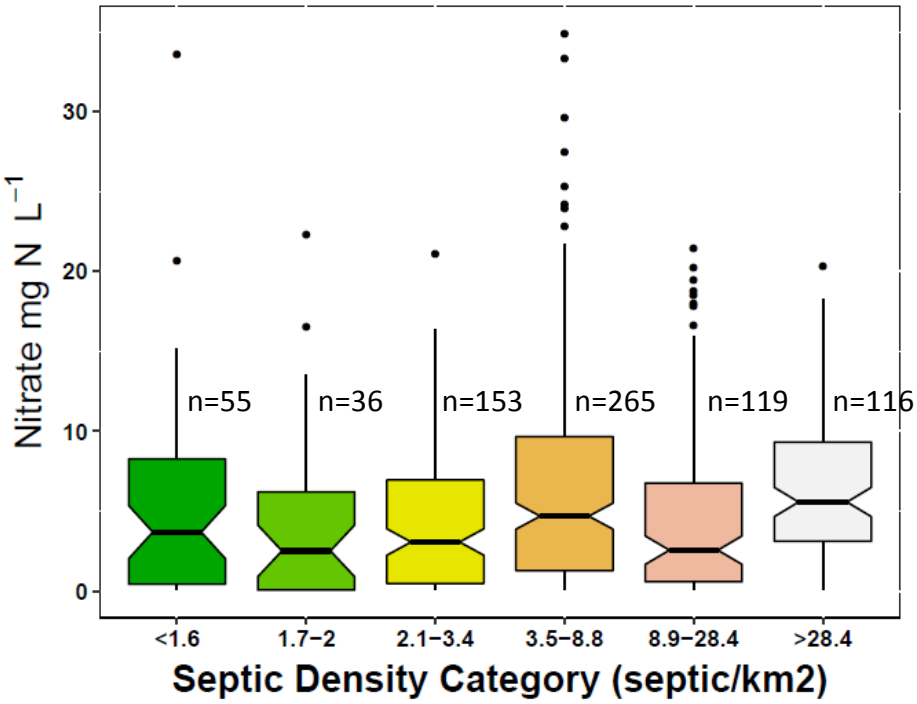
Agriculture, septic systems and nitrate



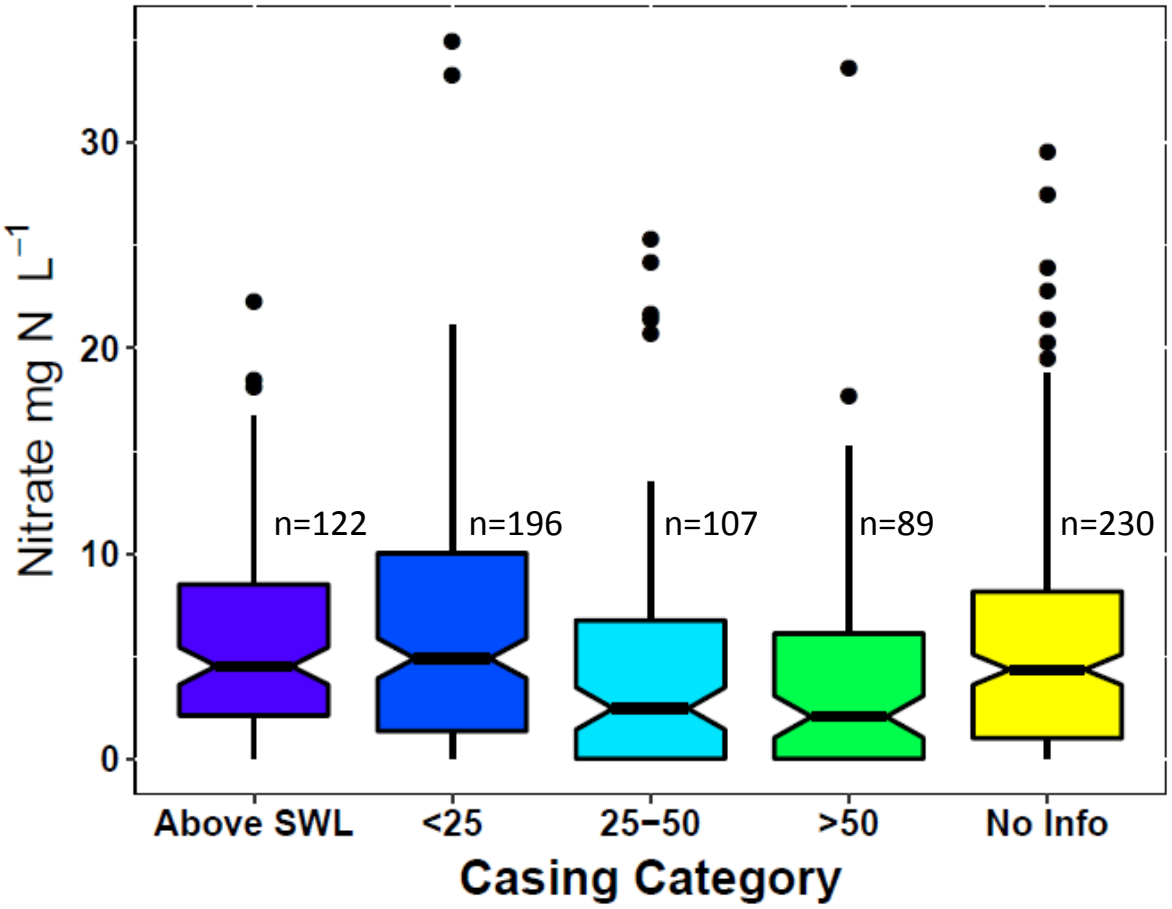


Septic systems and nitrate

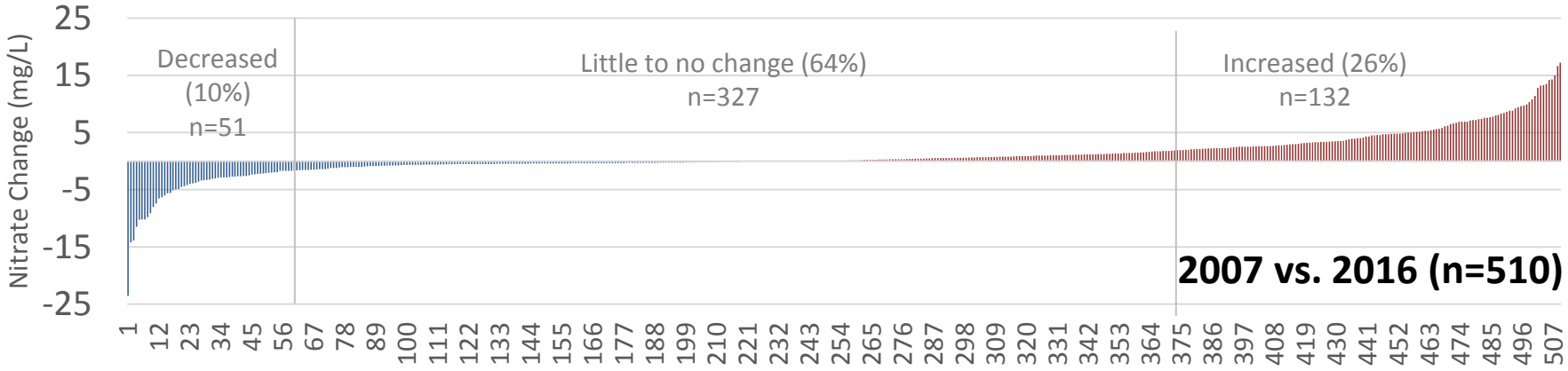


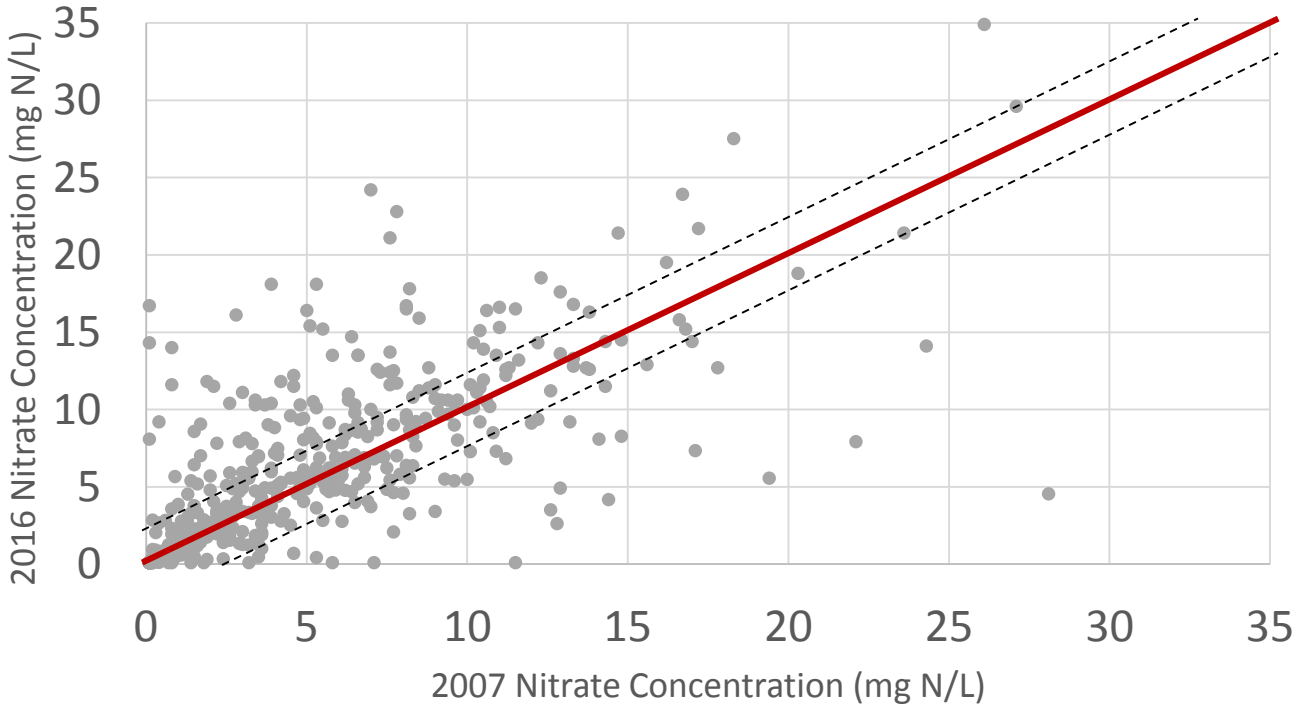


Casing depth and nitrate



Comparing 2007 to 2016





Year	Nitrate Average (mg N/L)	Greater than 10 mg/L
2007	4.7[a]	13.3%
2016	5.7[b]	20.6%

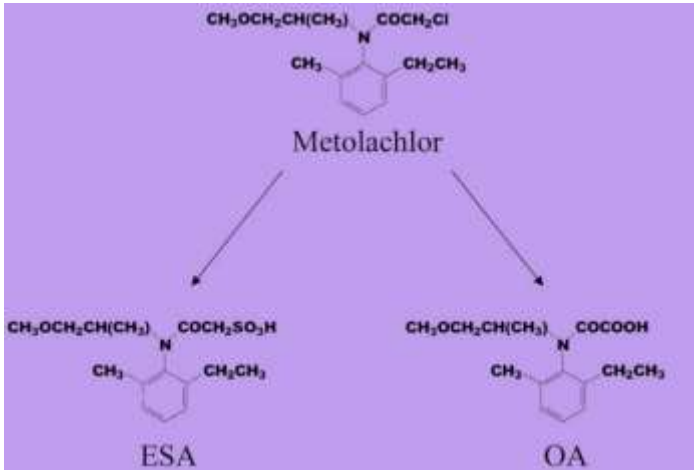
Nitrate Source Analysis

- Nitrate was a primary focus of this groundwater quality inventory.
- Sixty wells were chosen for additional testing to determine the source(s) of nitrate.

What did we look for?

- Two major sources of nitrate contamination:
  - Agricultural Practices
  - On-site waste treatment systems (septic)

What did we look for?



- Agricultural Practices
  - Pesticide Metabolites (breakdown products)
  - Metolacholor, alachlor and acetochlor metabolites
    - Mobile in groundwater
    - Unique to agricultural practices
    - Established testing method
  - Wisconsin Department of Agriculture Trade and Consumer Protection – Groundwater Exceedance Survey:

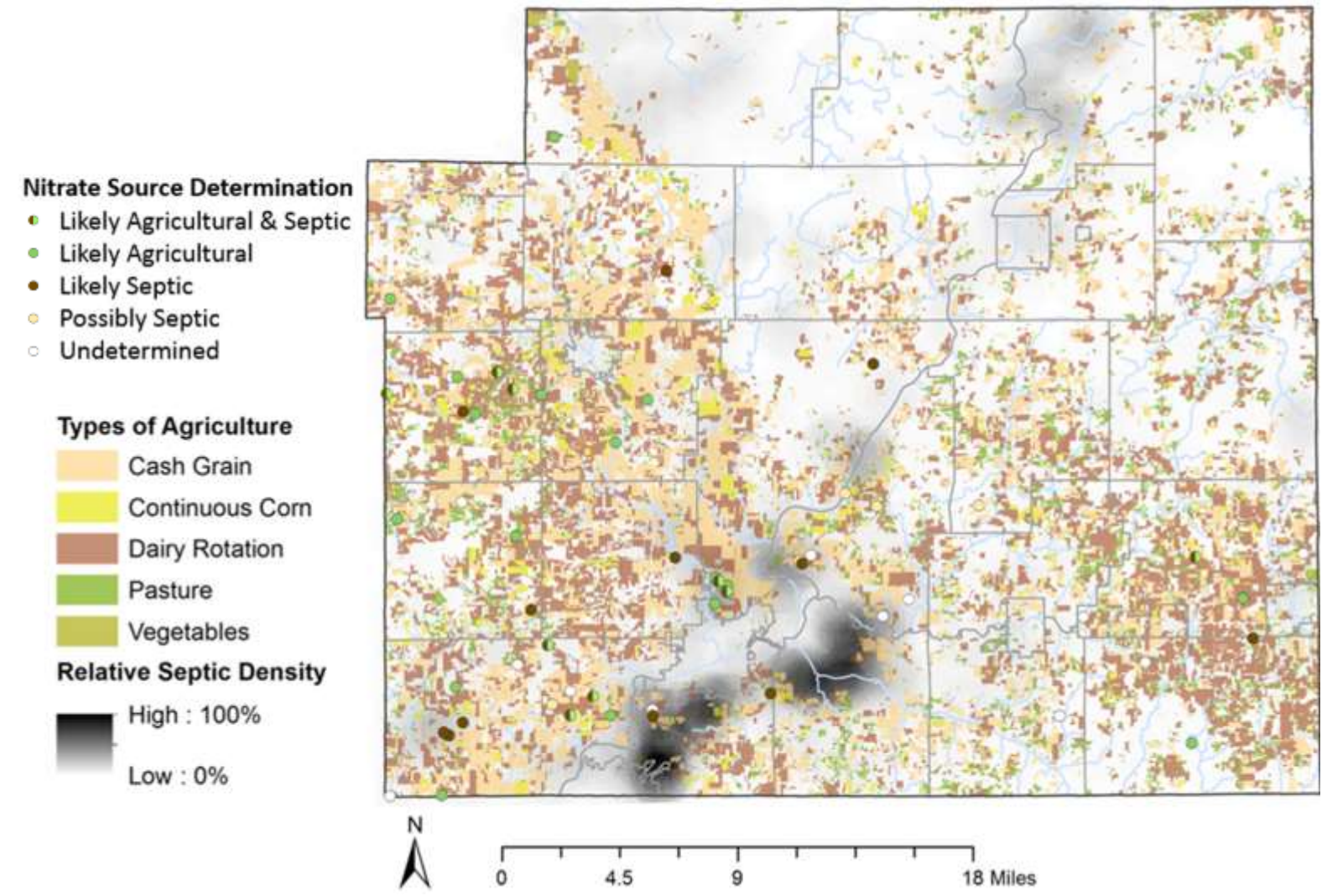
    "The <u>two most commonly detected pesticide metabolites</u> in the 2012 Targeted Sampling project were **metolachlor ethanesulfonic acid** (ESA) and **alachlor ESA**, which were detected in over 50 percent of the wells sampled. Metolachlor ESA and alachlor ESA were also the most common pesticide metabolites in the 2007 statewide survey, with approximately 21.6 percent of the wells having detectible concentrations."

What did we look for?

- On-site waste treatment systems (septic)
  - Unique to human use
    - Food products (caffeine, artificial sweeteners)
    - Pharmaceuticals
  - Reported in literature
  - Stable, mobile in subsurface environment
  - Good instrumental response

Well Selection

- Wells for follow-up nitrate source analysis (NSA) were selected based on these criteria:
  - Only wells with a Wisconsin Unique Well Number were considered.
  - Wells with nitrate-N concentrations less than 2 mg/L are near background levels of nitrate and therefore not considered for NSA.
  - An Inverse Distance Weighting tool in ESRI ArcMap was used to assign density values categorizing septic density criteria.
  - 32 had concentrations between 2 and 10 mg/L.
  - 28 wells had nitrate-N concentrations higher than 10 mg/L.
    - Two of these had nitrate–N concentrations greater than 20 mg/L.


Nitrate Source Determination
Likely Agricultural & Septic
Likely Agricultural
Likely Septic
Possibly Septic
Undetermined
Types of Agriculture
Cash Grain
Continuous Corn
Dairy Rotation
Pasture
Vegetables
Relative Septic Density
High : 100%
Low : 0%
N
0
4.5
9
18 Miles

Results of Nitrate Source Analysis

Tracers Detected	Nitrate-N (mg/L)			N
	Mean	Median	Range	
Both agricultural & septic tracers	11.8	12.2	3.6 – 32.4	15
At least one agricultural	10.3	9.1	4.9 – 17.8	13
More than one septic	8.3	8.4	2.2 – 15.3	13
Only one septic tracer	8.8	8.4	3.4 – 14.7	6
No tracers detected	7.9	5.2	2.1 – 21.7	13

Comparing nitrate concentrations and the detection of chemical indicators:

- The greatest mean, median and overall nitrate concentrations were detected in wells with both tracers.
- The mean nitrate concentration for wells with at least one agricultural tracer but no septic tracers was above the drinking water standard of 10 mg/L.
- Four wells without detects of either tracers had nitrate above 10 mg/L. Further investigation is needed to determine the source of contamination in these areas.

What does this mean?

- There are established WI Public Health Standards for Alachlor ESA and Metolachlor ESA + OA.

Analyte	WI Public Health Standard (parts per billion)	Highest Concentration in Chippewa County Study (ppb)
Alachlor ESA	20	2.62
Alachlor OA	No standard	Not detected
Metolachlor ESA	1300	4.10
Metolachlor OA		0.21

What does this mean?

- There are NO established Public Health Standards for pharmaceuticals. The WI Division of Public Health has determined a Health Advisory Level for the antibiotic sulfamethoxazole.

Analyte	WI Public Health Standard (parts per billion)	Highest Concentration in Chippewa County Study (ppb)
Acesulfame	No standard	3.209
Sucralose	No standard	2.053
Caffeine	No standard	0.021
Paraxanthine	No standard	0.020
Sulfamethoxazole	100	0.251

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