Hydrogeology of Wisconsin's National Forests

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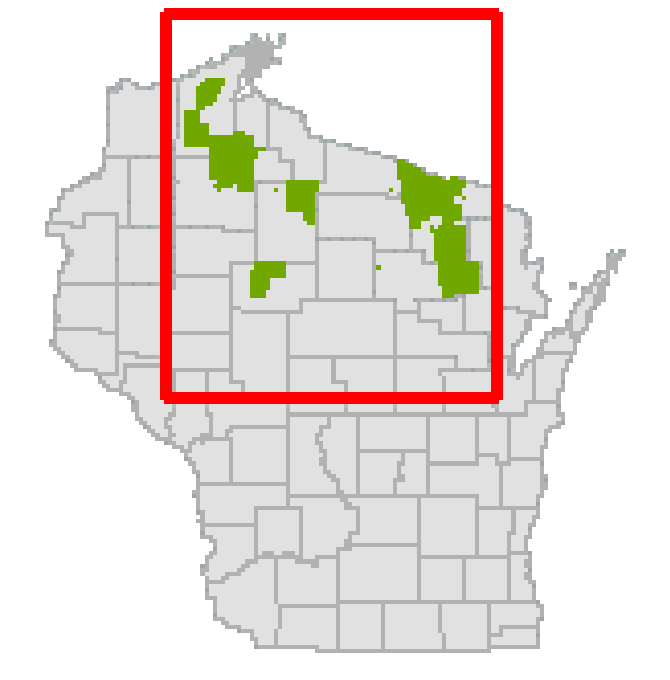
Wisconsin Geological and Natural History Survey

USGS
science for a changing world

Background

- First comprehensive groundwater study in Chequamegon-Nicolet National Forest (CNNF)
- Collaborators
  - Wisconsin Geological and Natural History Survey
  - U.S. Geological Survey
  - U.S. Forest Service



Chequamegon-Nicolet National Forest

Study drivers

- Groundwater important for USFS
  - Streams, springs, ecosystems
  - Water supply

One potential effect of climate change

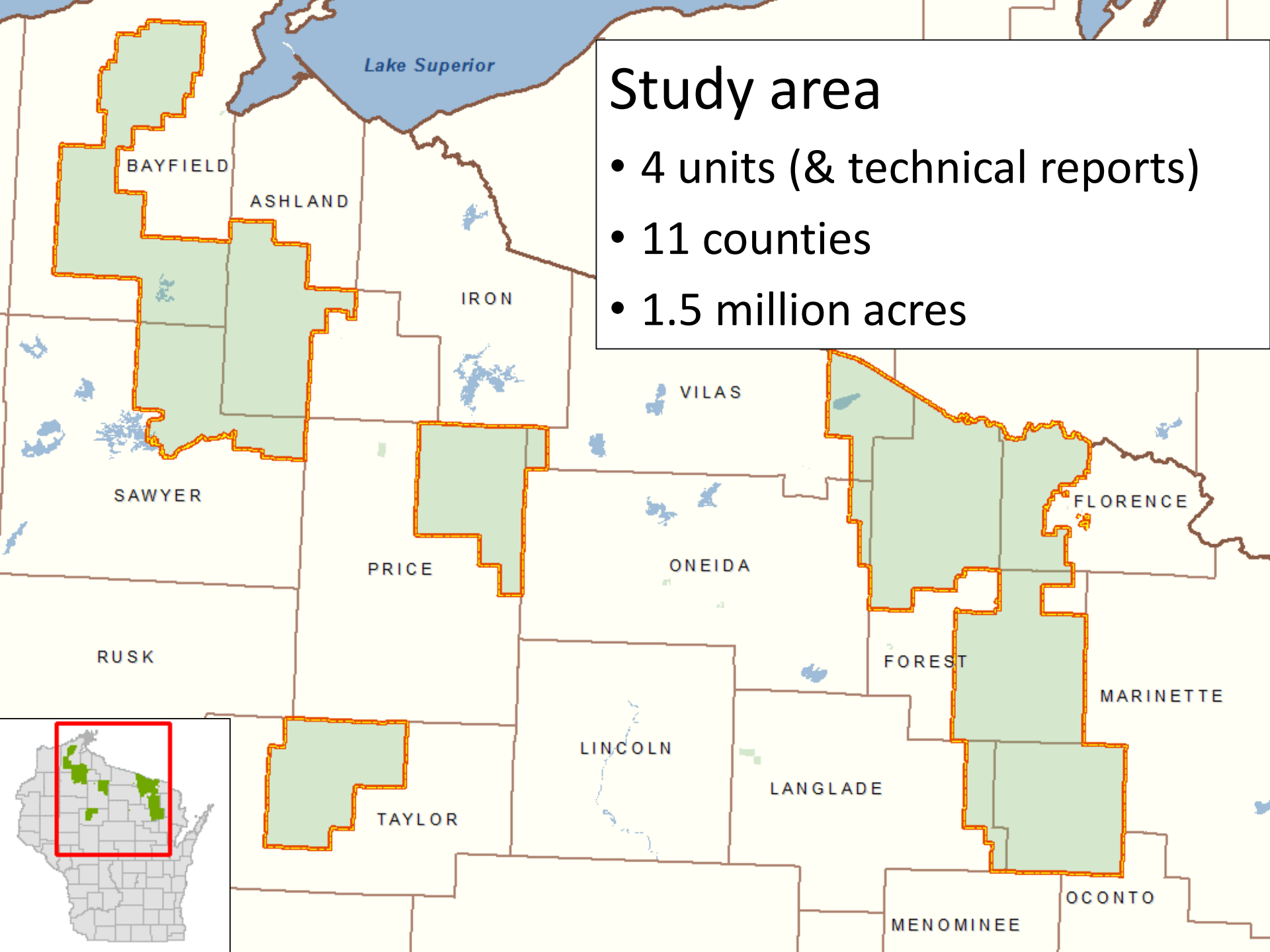
- Future stressors…
  - Climate change, high-capacity wells, mining, logging

Objectives

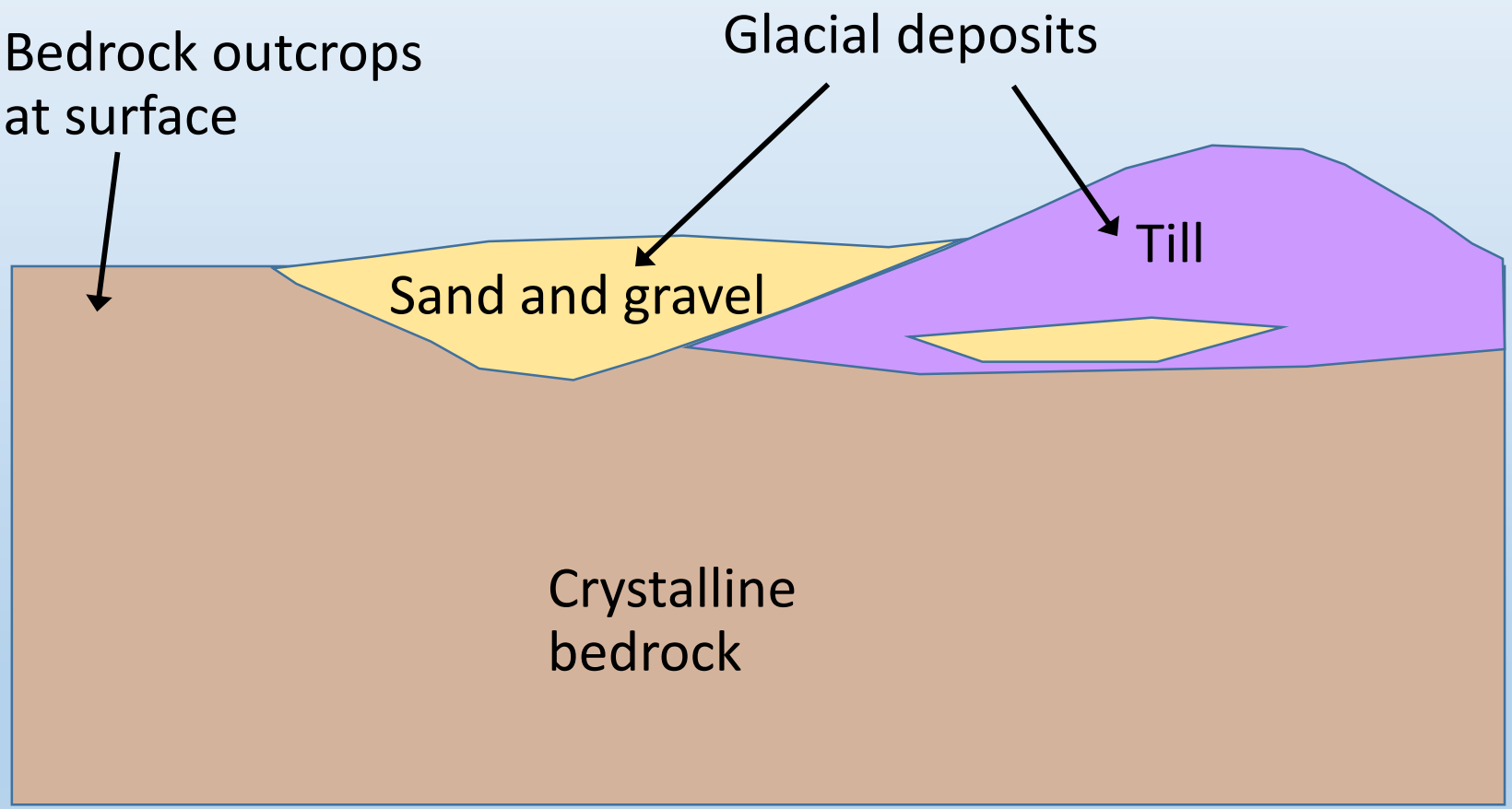
- Characterize groundwater system
- Products
  - Well geodatabase, aquifer & recharge maps, groundwater flow models
- Create framework for resource management & foundation for site-specific studies

Study area

- 4 units (& technical reports)
- 11 counties
- 1.5 million acres



Regional geology - simplified



Approach: 4 study components

1. <u>Hydrogeologic data</u>

   Data inventory and aquifer characterization

2. <u>Groundwater potential recharge</u>

   Soil-water balance model

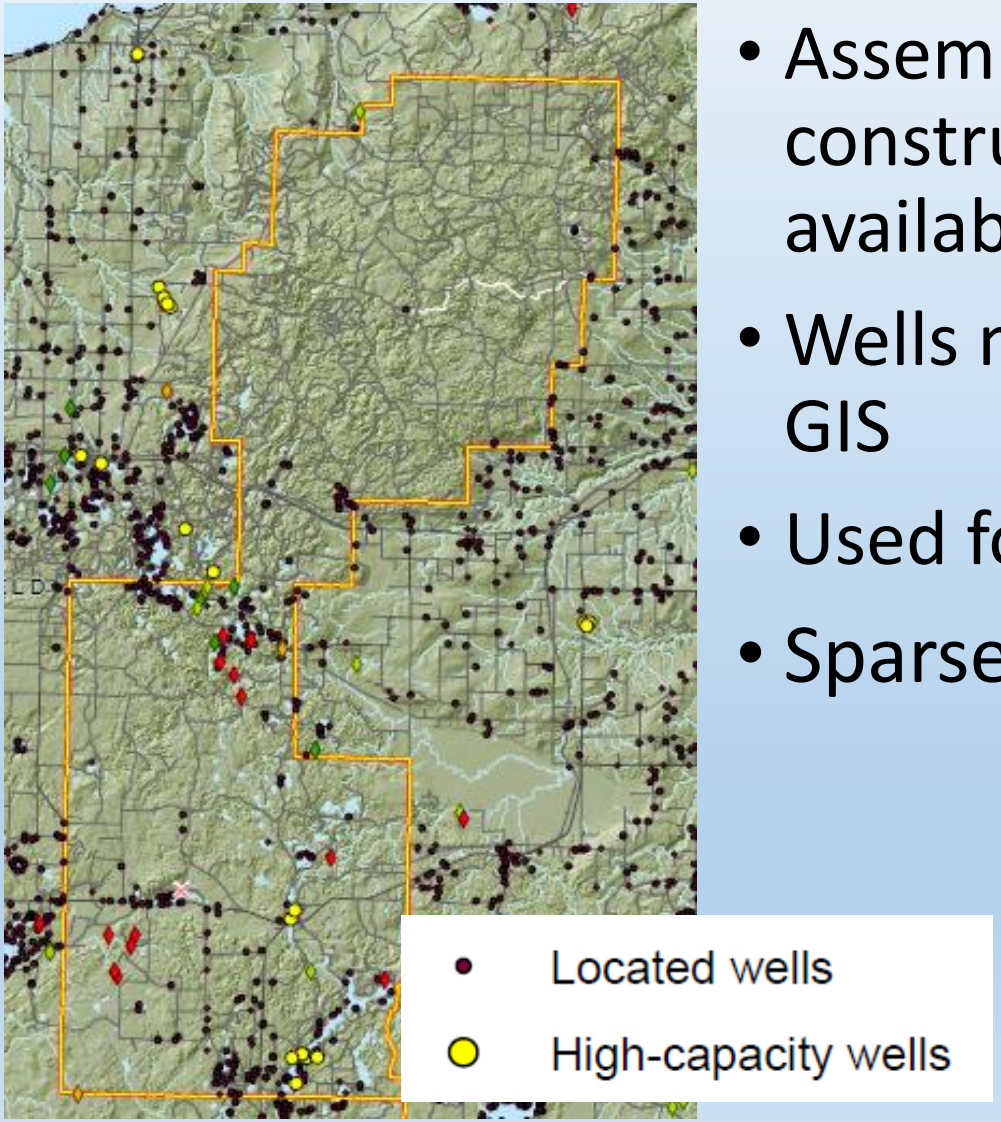
3. <u>Geochemistry</u>

   Water sampling

4. <u>Groundwater flow model</u>

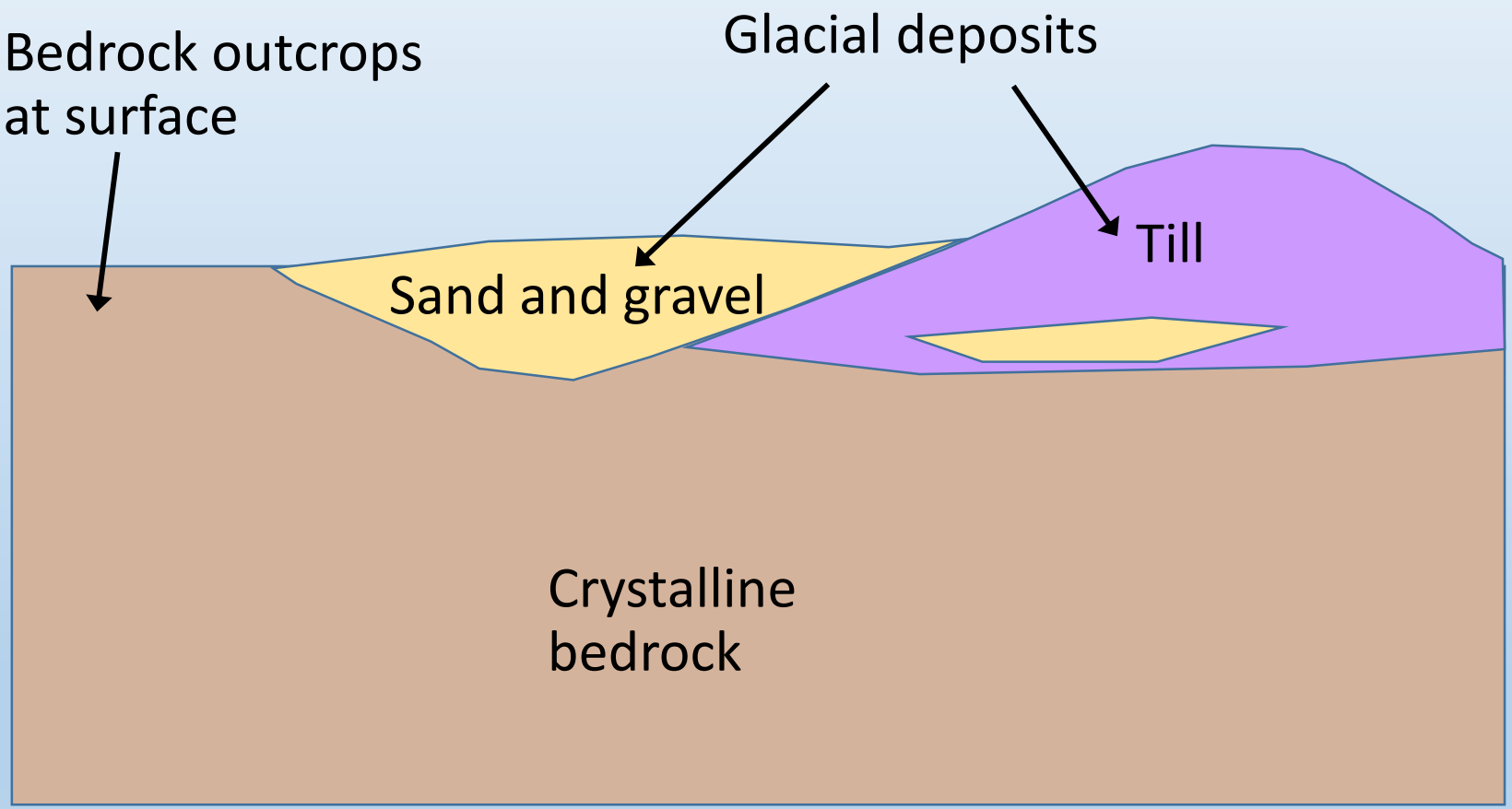
   GFLOW – 2D regional flow

1. Hydrogeologic data – inventory

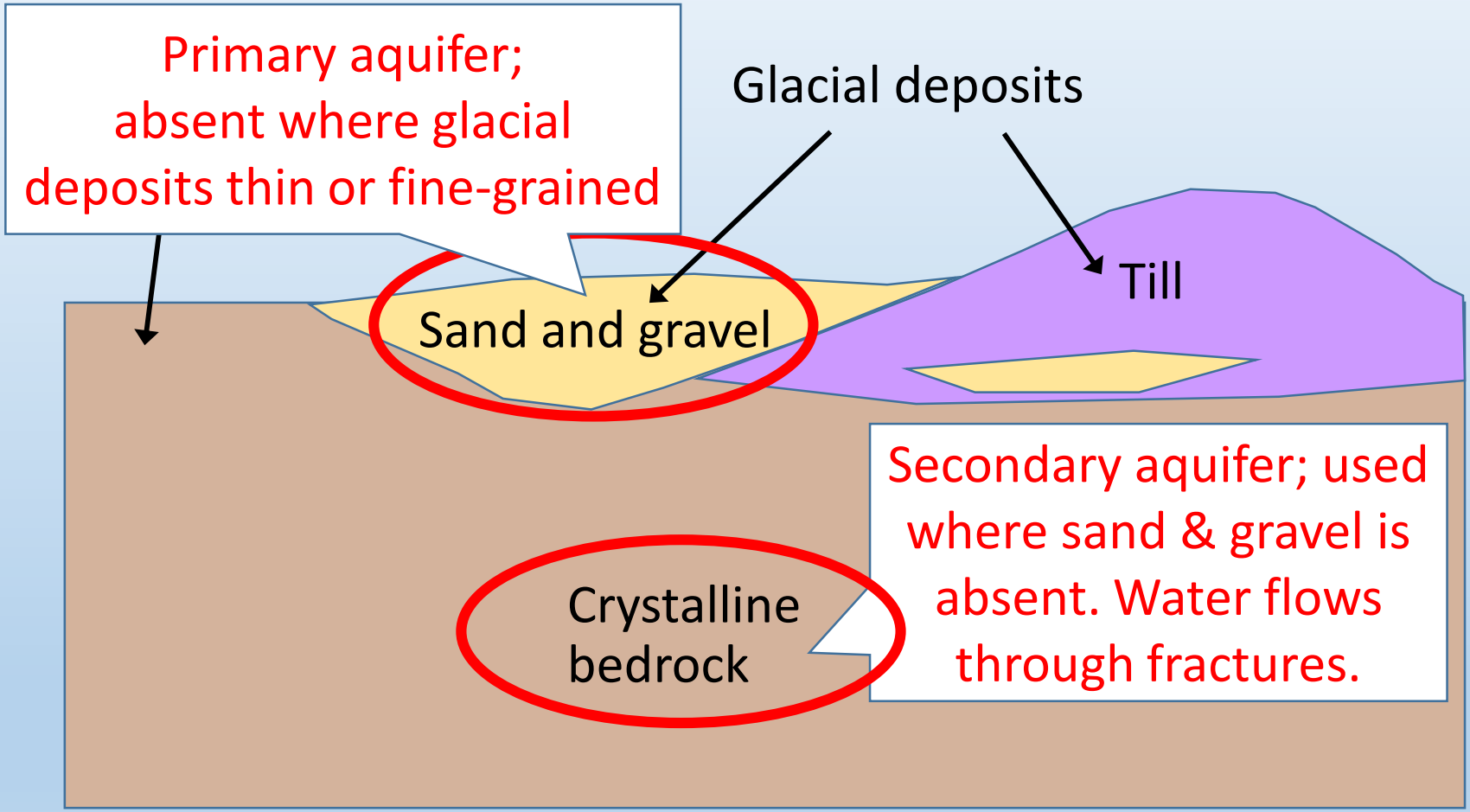


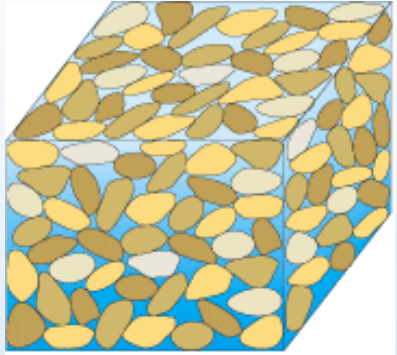
- Assembled geodatabase of well construction reports & other available data
- Wells moved to best location in GIS
- Used for analysis in rest of study
- Sparse in many areas!

Hydrogeologic data - aquifer characterization

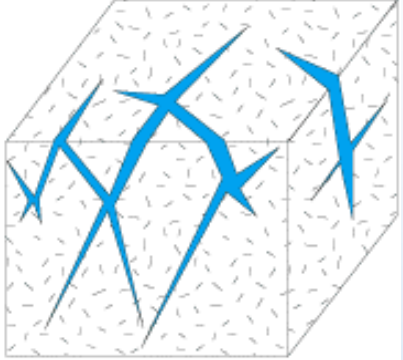


Hydrogeologic data - aquifer characterization





A. Well-sorted sand



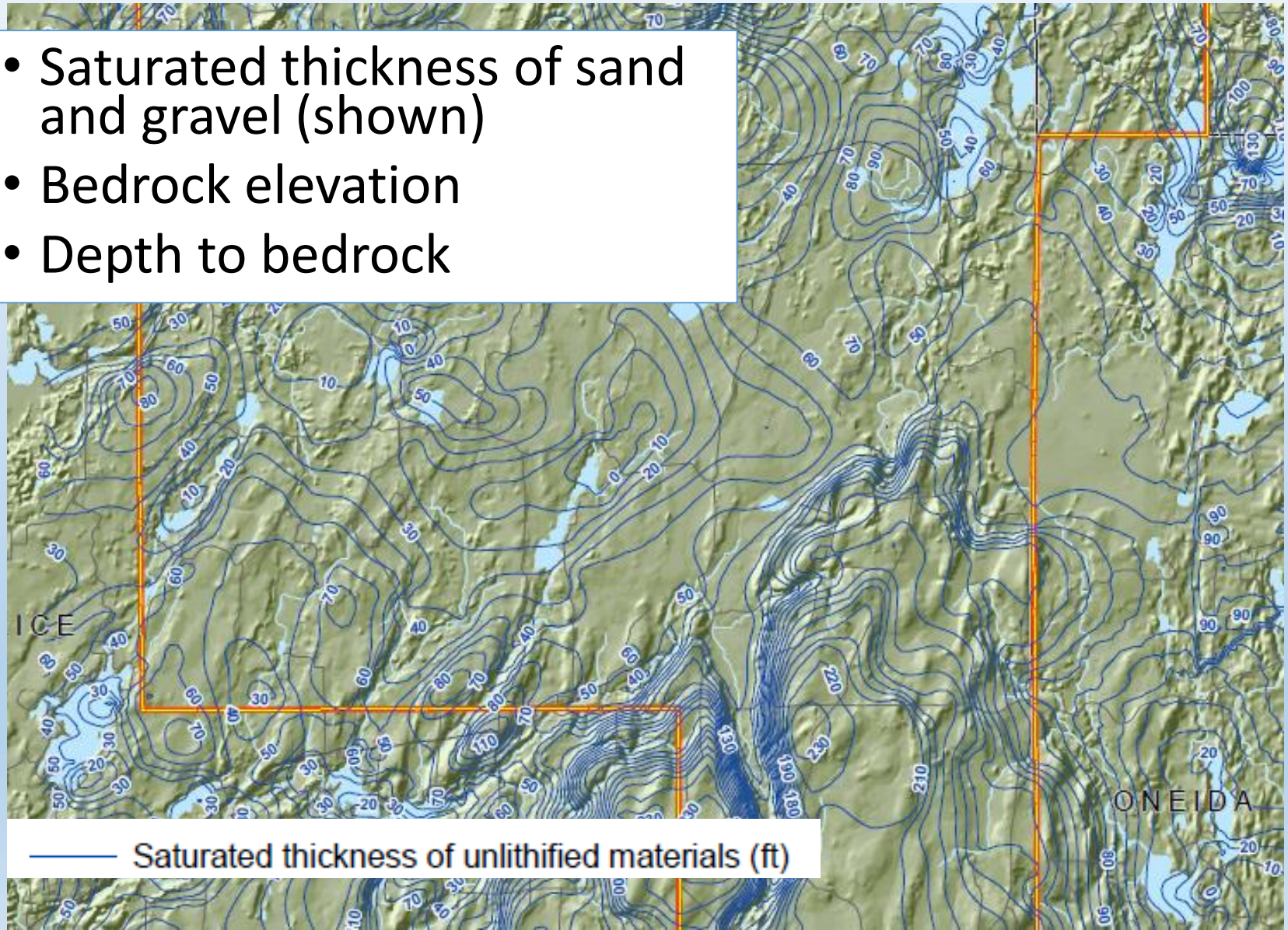
B. Fractures in granite

	Sand and gravel	Crystalline bedrock
Description	Surficial glacial deposits	Fractured rock below glacial deposits
Provides water supply for…	75% of wells	25% of wells
Mean hydraulic conductivity	30-40 ft/day	2-4 ft/day
Potential well yield	100-300 gpm	<20 gpm

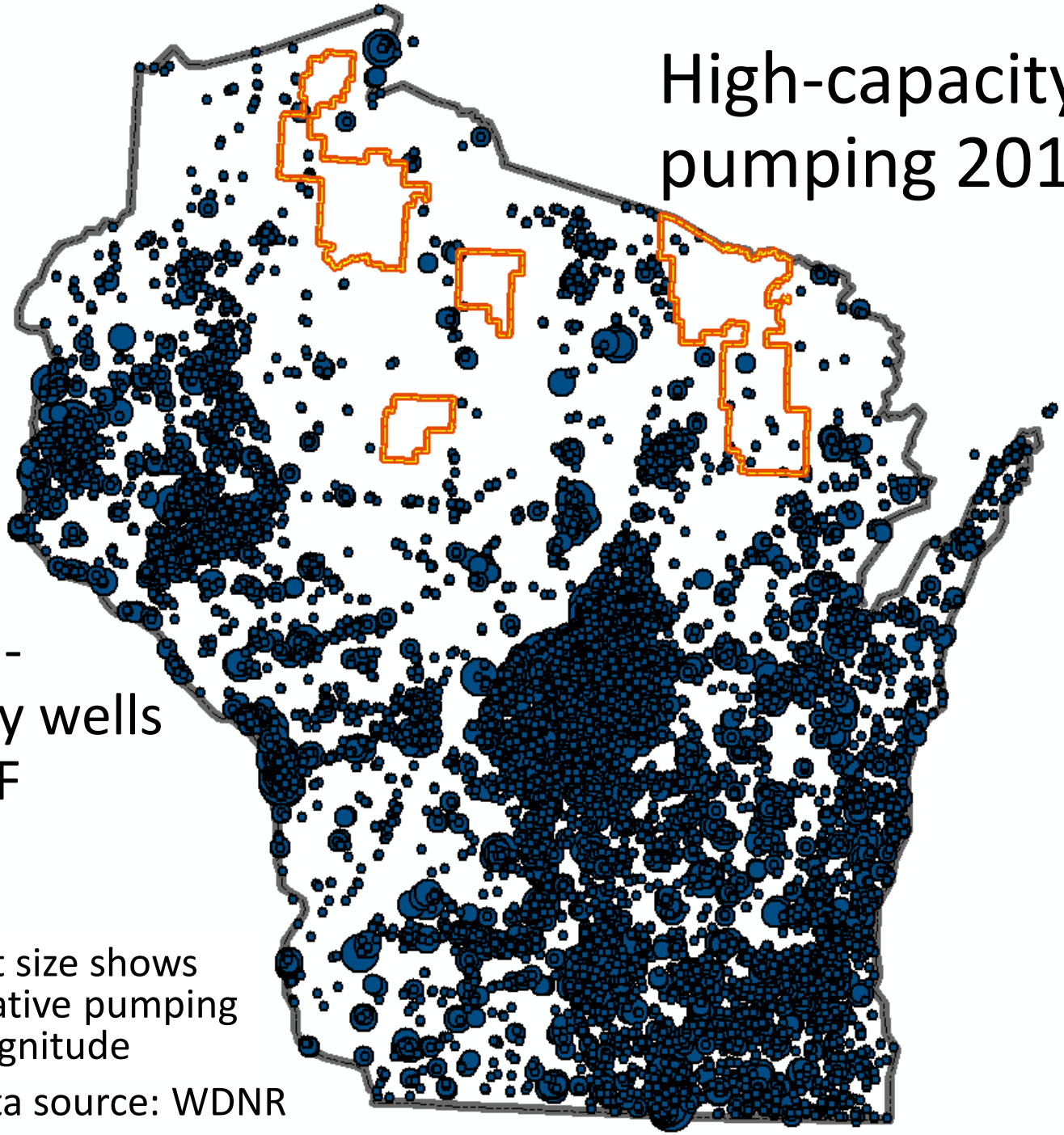
https://pubs.usgs.gov/circ/2003/circ1262/

Aquifer characterization maps

- Saturated thickness of sand and gravel (shown)
- Bedrock elevation
- Depth to bedrock



High-capacity well pumping 2014



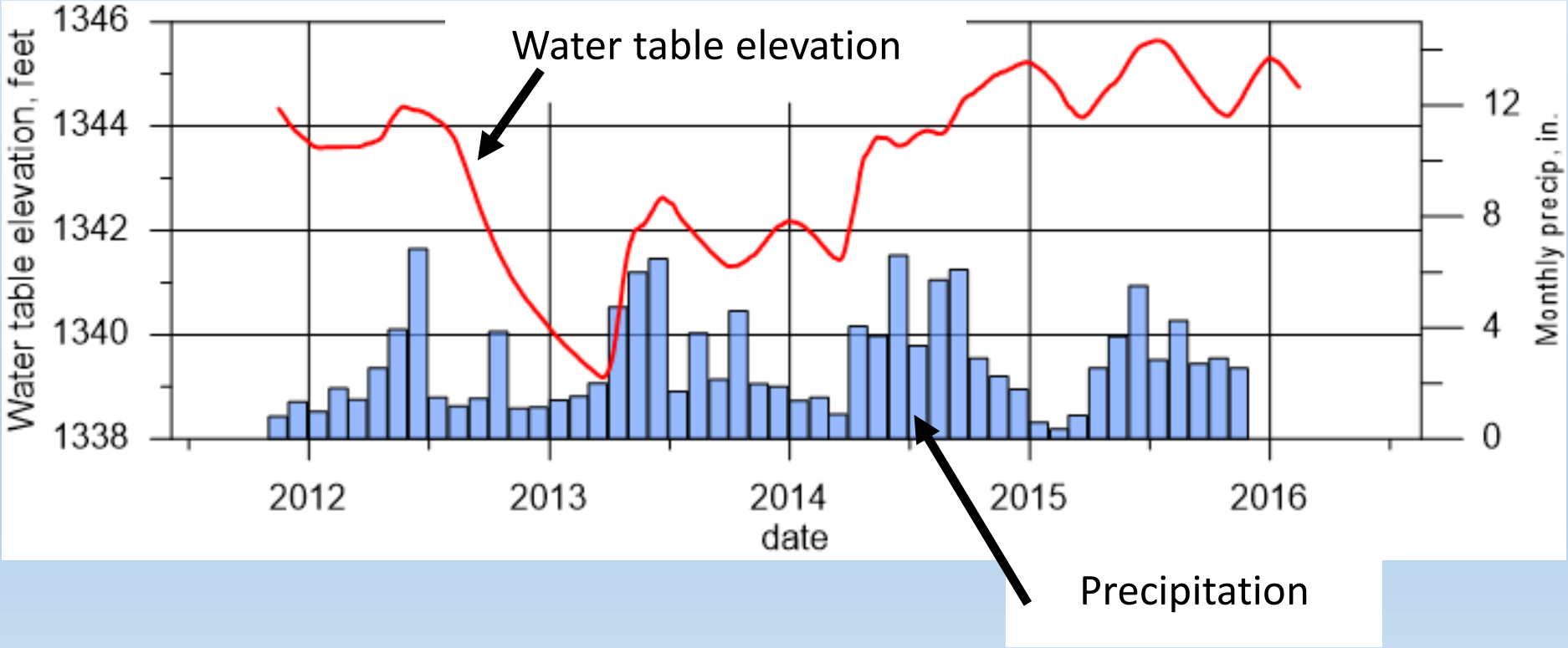
- 40 high-capacity wells in CNNF

Dot size shows relative pumping magnitude

Data source: WDNR

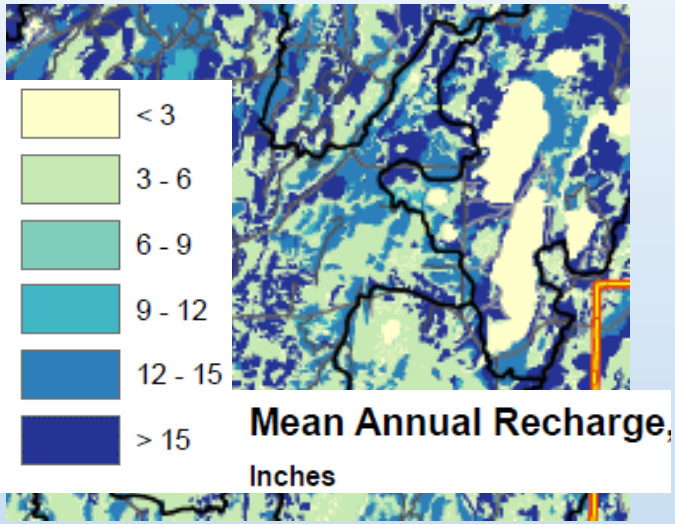
Monitoring groundwater levels

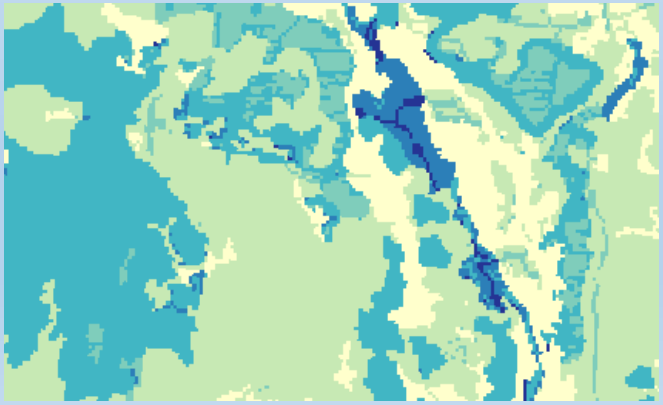
- Baseline conditions to evaluate future impacts
- Interpret changes: low water levels from regional drought or local pumping or…?



2. Groundwater potential recharge

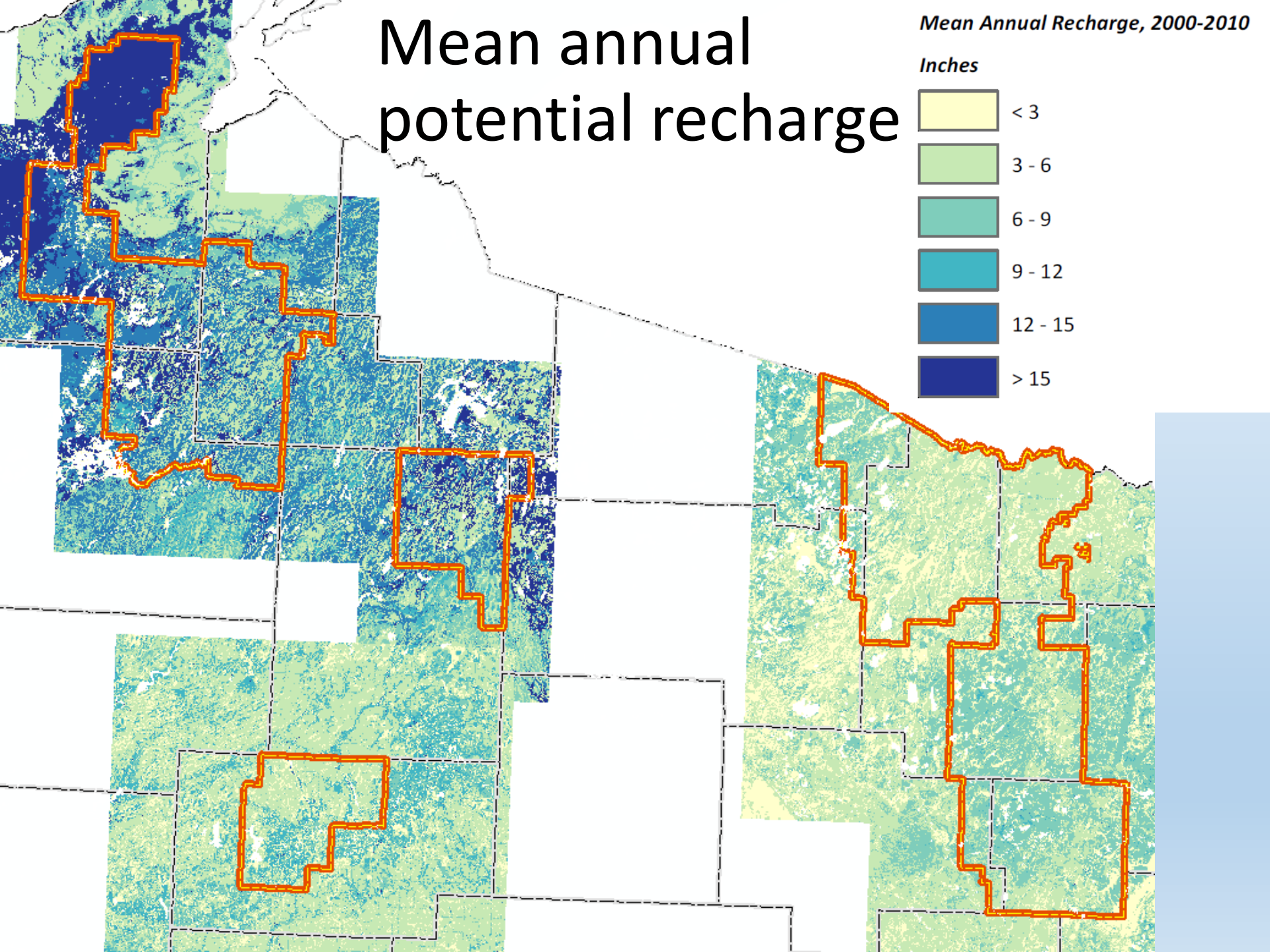
- Soil-water balance (SWB) model
- Produces a grid of potential recharge
- Varies with space and time



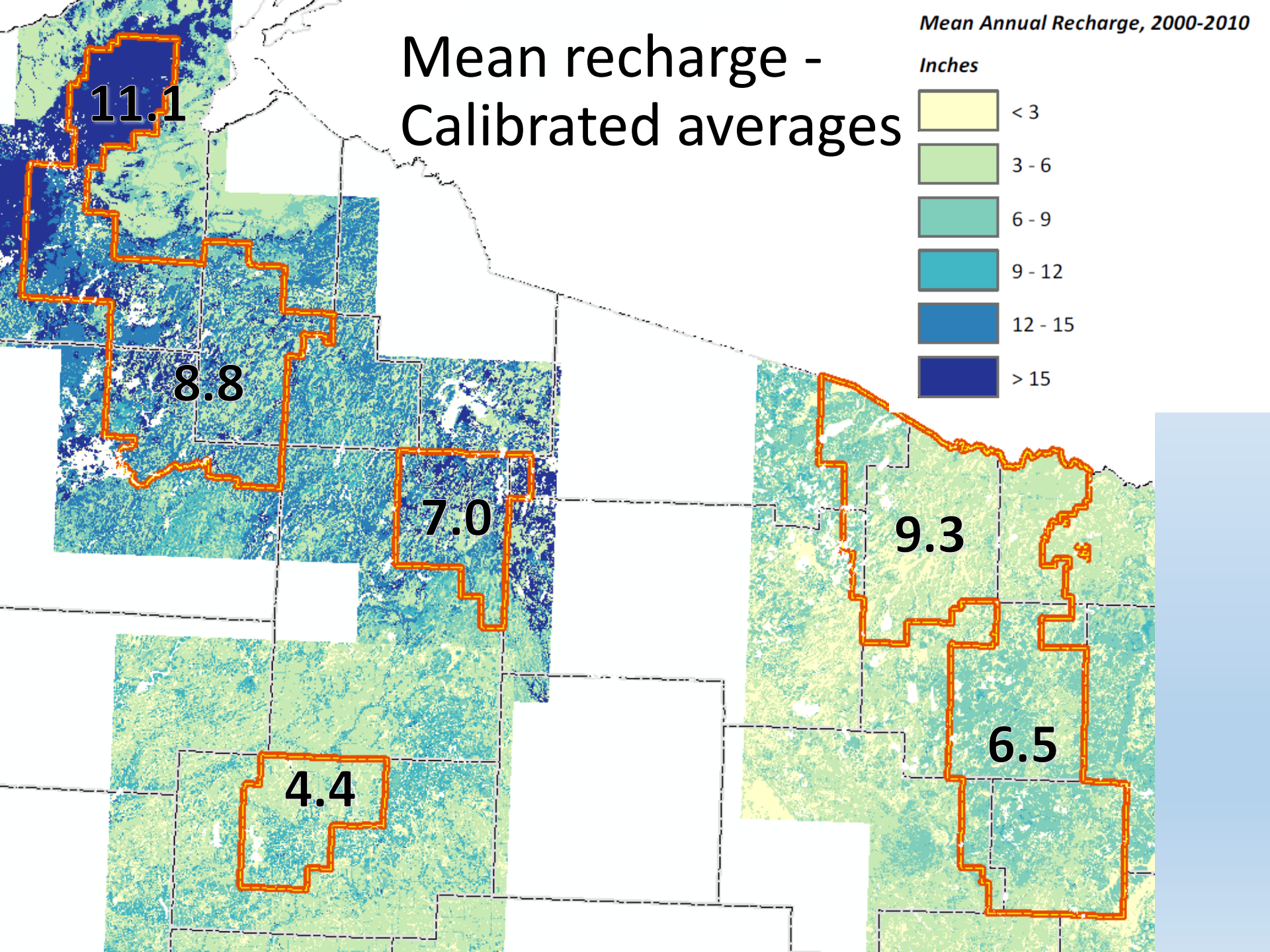


- Grid input to groundwater flow model & calibrated using a multiplier of the grid

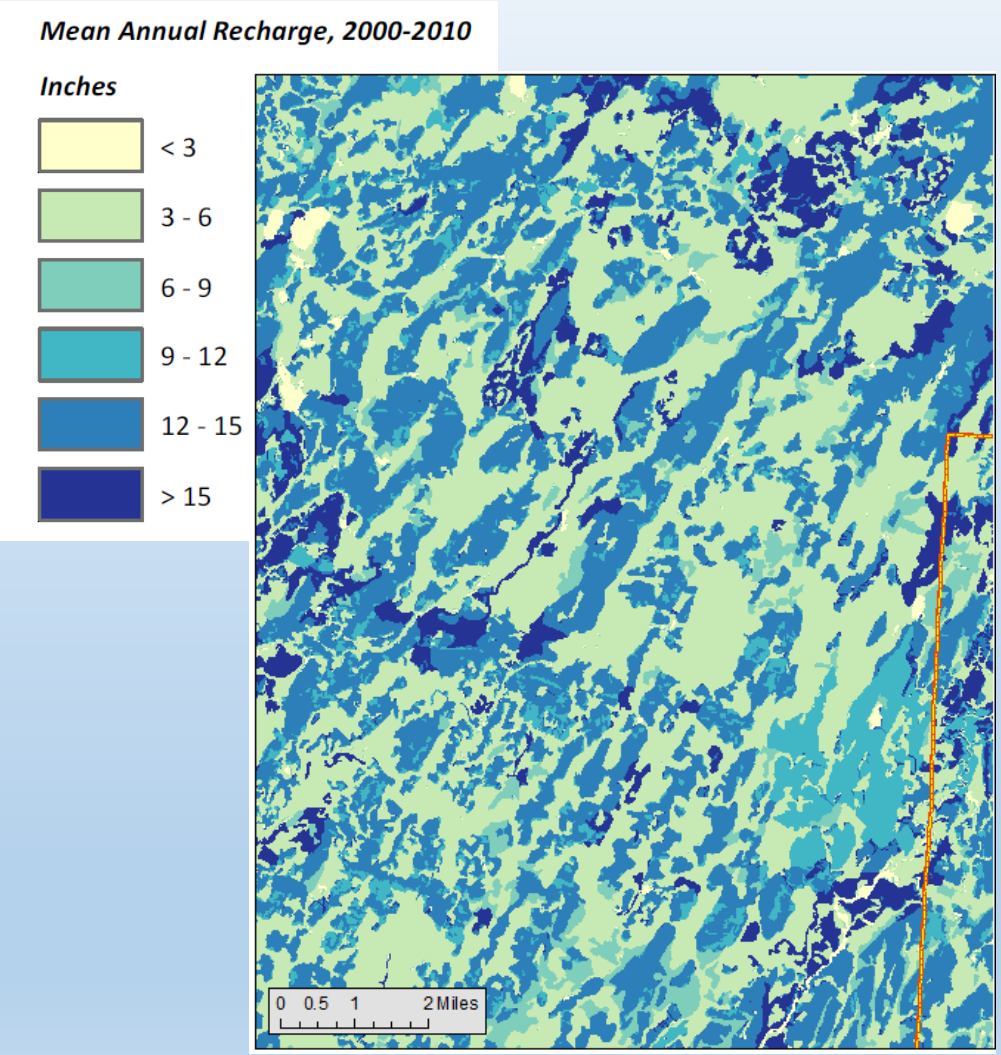
Mean annual potential recharge

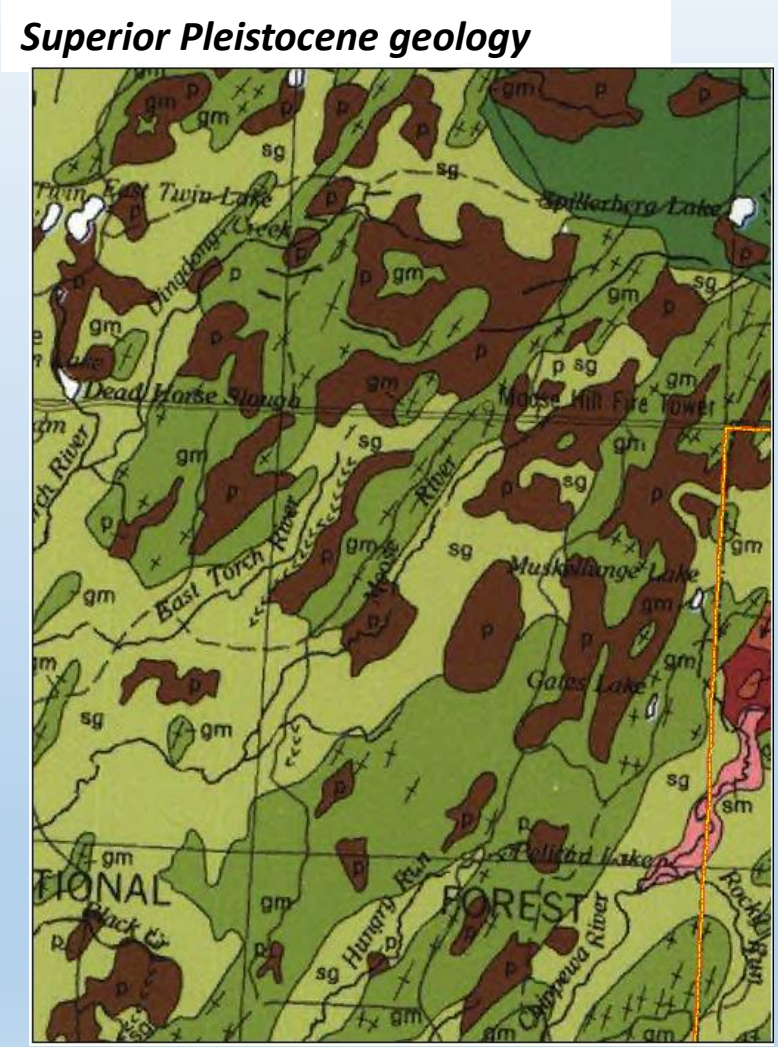


Mean recharge - Calibrated averages



Potential recharge vs. surficial geology/soil





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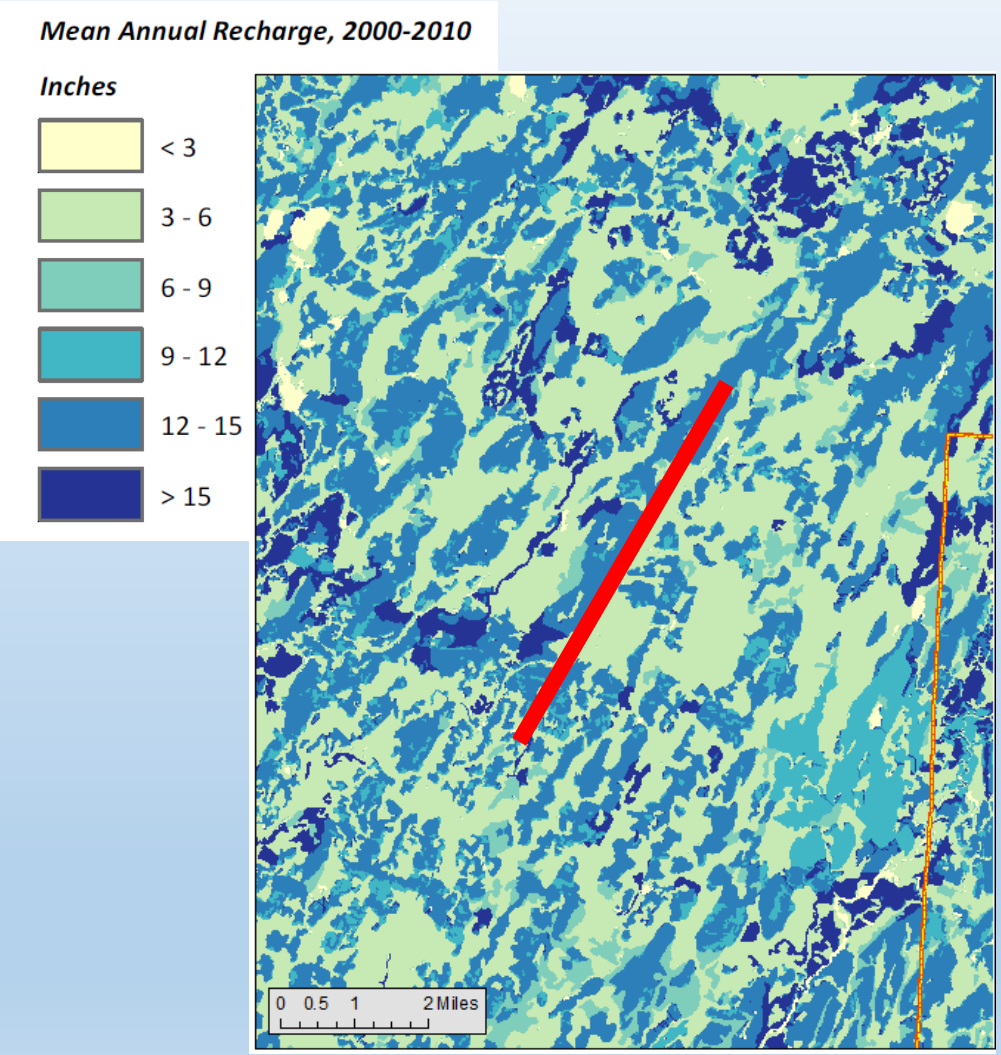

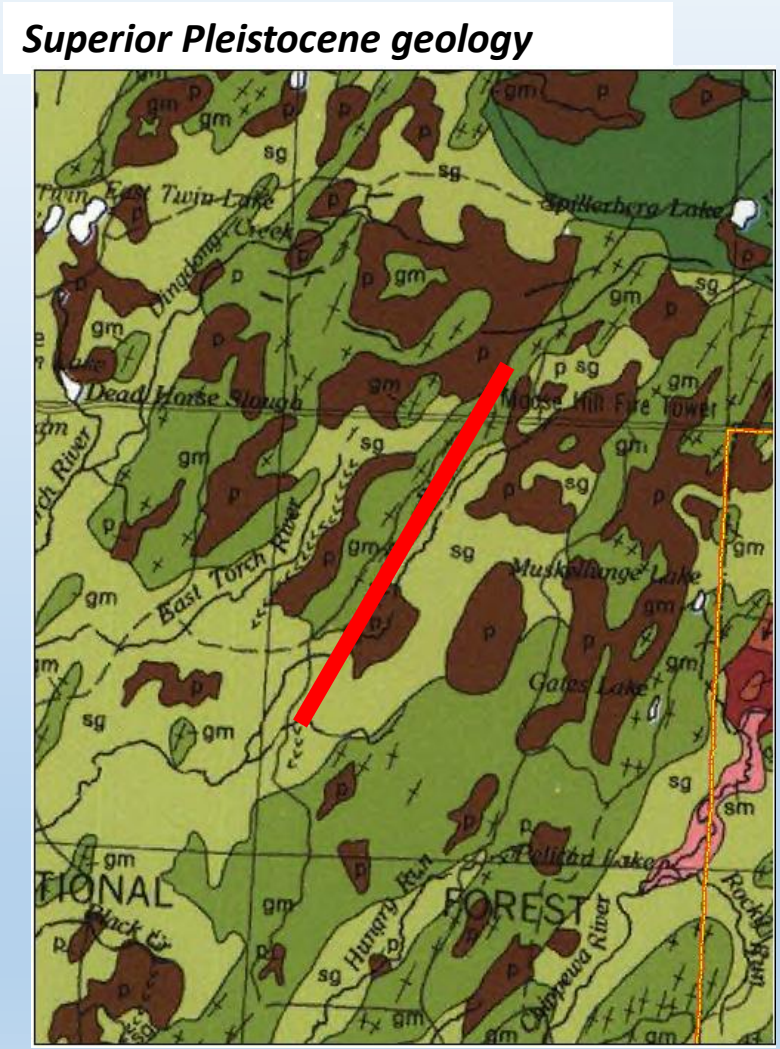

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3. Geochemistry – water quality

- Sampled wells, lakes, streams, springs
  - Ions, isotopes, alkalinity, pH
- Water quality generally unimpaired by humans - some places affected by road salt

Photo credit: https://www.pca.state.mn.us/water/road-salt-and-water-quality

Water chemistry – distinguishing source

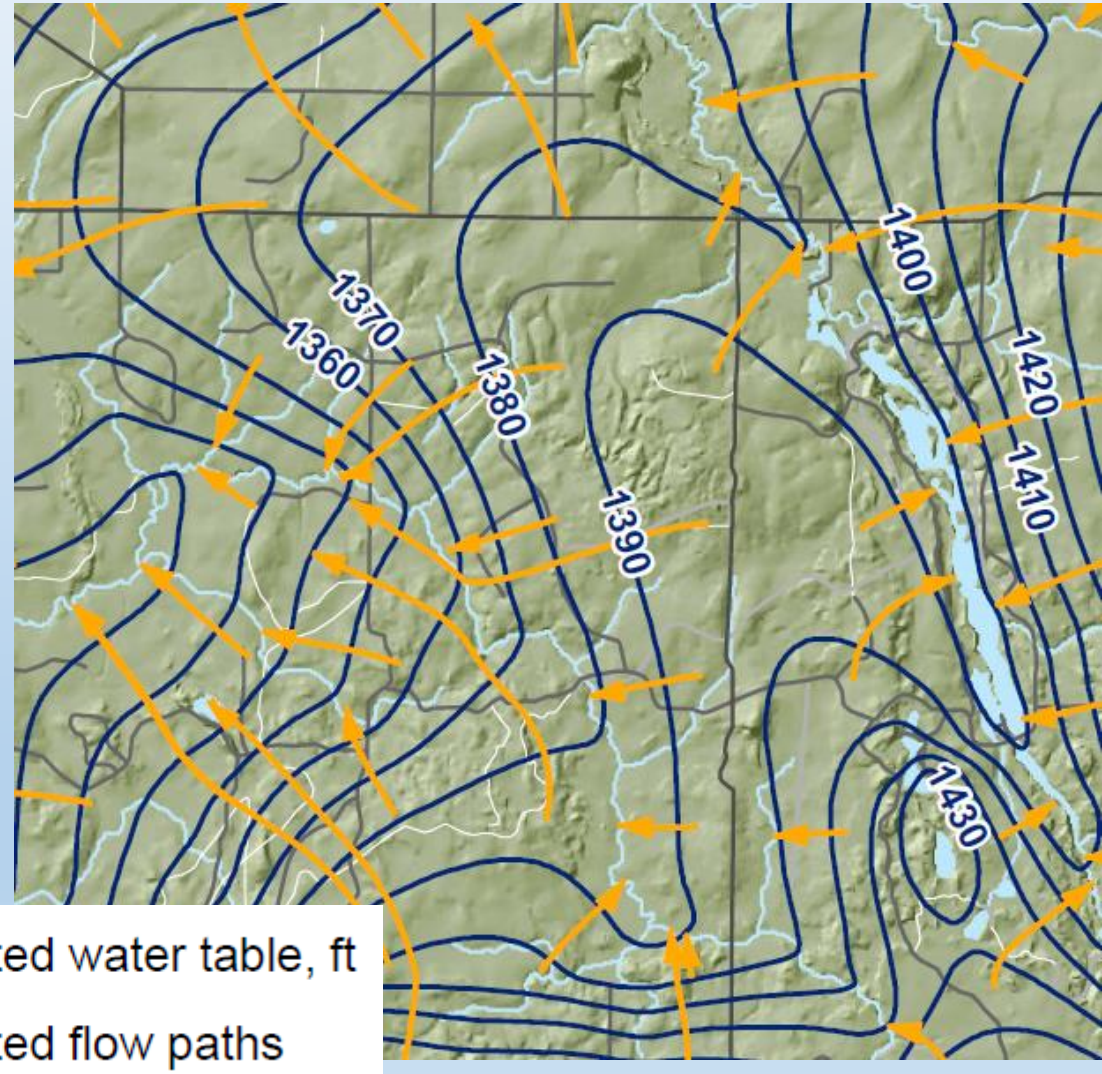
- Chemistry of groundwater vs. surface water
- Use this to answer:
  - Is a well drawing water from a lake?
  - Is a stream fed by groundwater?
- Alkalinity, electrical conductivity typically higher in groundwater

	Ground-water	Surface water
Electrical conductivity, µs/cm	161-249	31-63
Alkalinity, as mg/L $CaCO_3$	83-132	8-28

*Mean values from each unit for samples interpreted as groundwater-dominated or surface-water dominated.

4. Groundwater flow model

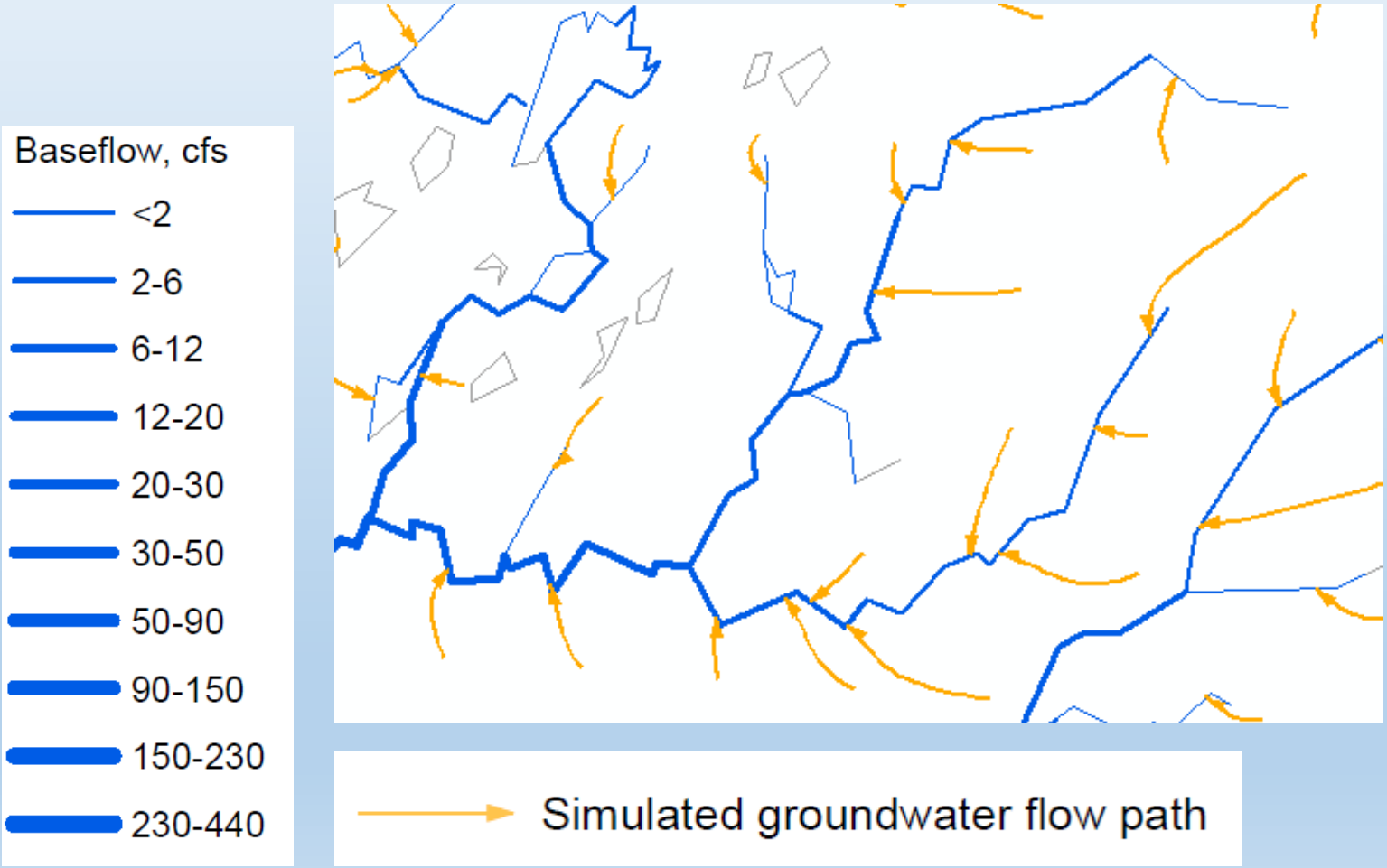
- Simulate regional flow system using GFLOW
  - 6 total models (1-2 per unit)
- Water table map
  - GFLOW vs. point interpolation



Simulated water table, ft

Simulated flow paths

Groundwater flow model: Simulated baseflow



Groundwater flow model as a tool

- Simulate changes in baseflow or water levels (e.g. from new well)
- Identify areas contributing groundwater to a stream or wetland
- Ideal for extracting inset model -- use regional results as boundary conditions for smaller model

Summary

- Products of this study create a framework for future work in northern WI.
- Geodatabase, maps, and models will be made publicly available. Reports in peer review.

- Continuing work…
  - Use report to guide data collection – water table, streamflow measurements, geology, etc.
  - Local studies in areas of interest

Thank you!
Questions?

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