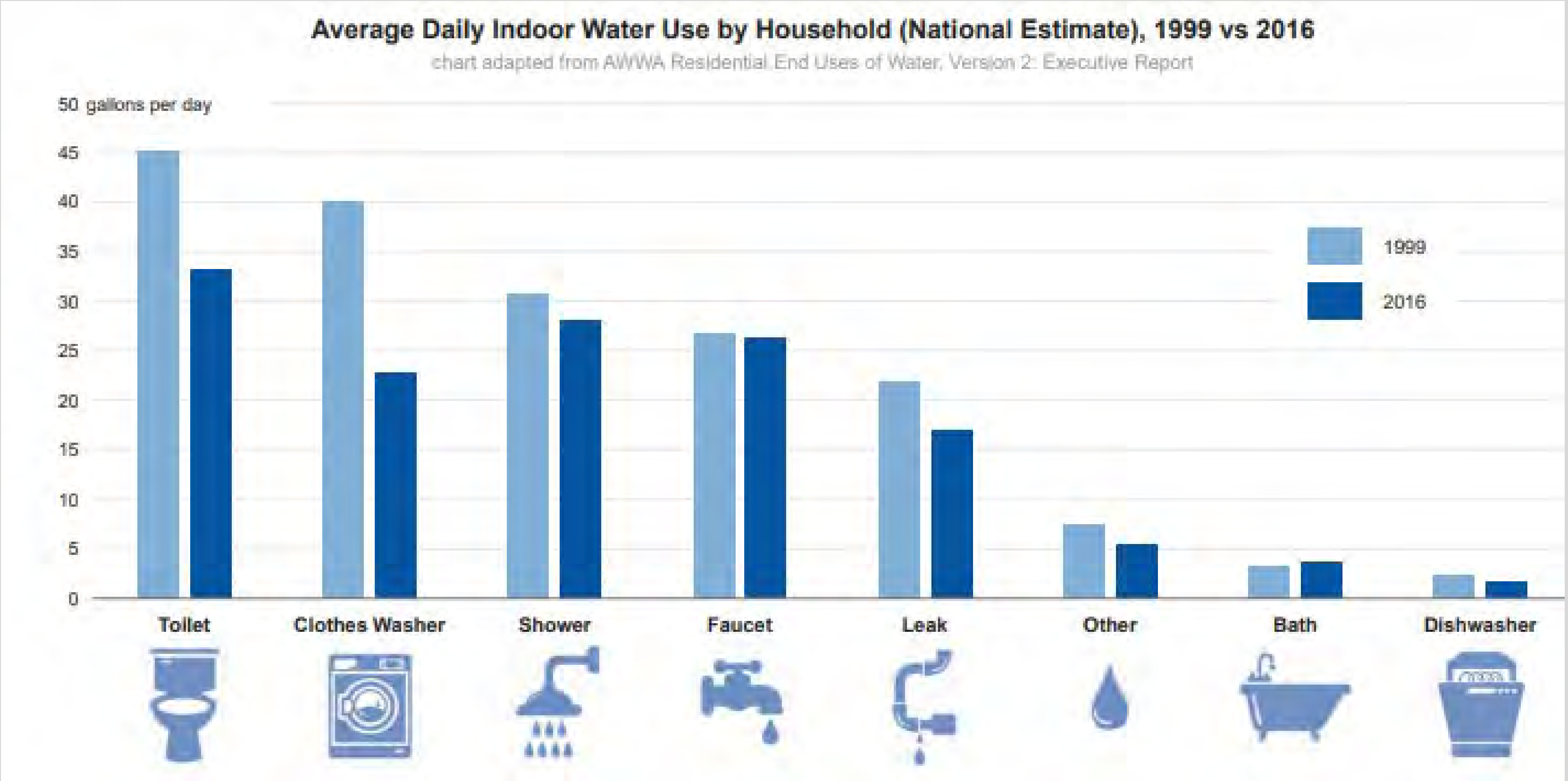
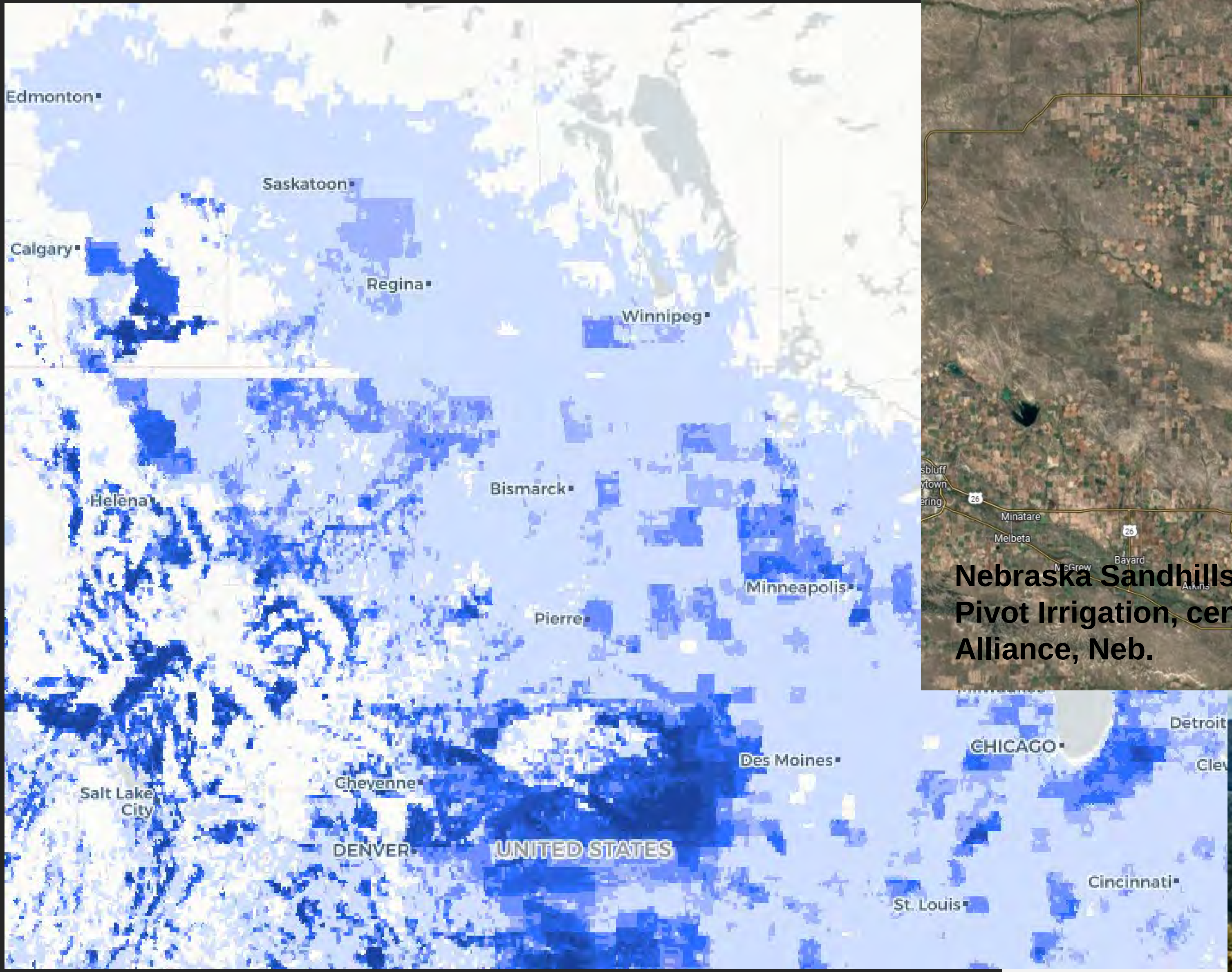
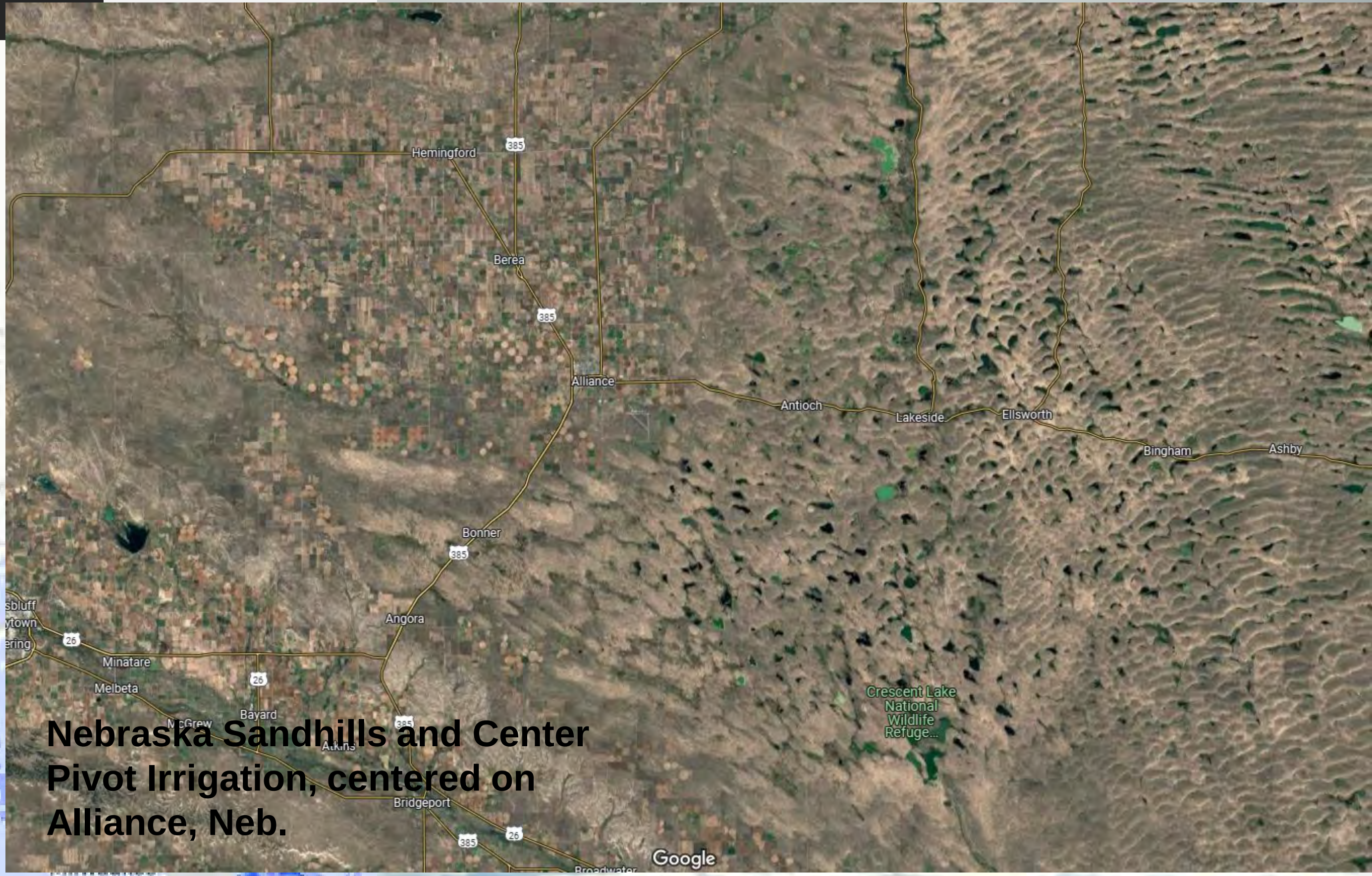


Average Daily Indoor Water Use by Household (National Estimate), 1999 vs 2016
chart adapted from AWWA Residential End Uses of Water, Version 2: Executive Report
50 gallons per day
45
40
35
30
25
20
15
10
5
0
1999
2016
Toilet
Clothes Washer
Shower
Faucet
Leak
Other
Bath
Dishwasher





Nebraska Sandhills and Center Pivot Irrigation, centered on Alliance, Neb.

Sandy glacial soils are irrigated

Irrigation Expansion

- Agriculture is expanding north with crop genetics and warmer temperatures.
- Irrigation increases with hotter temps and longer dry spells.

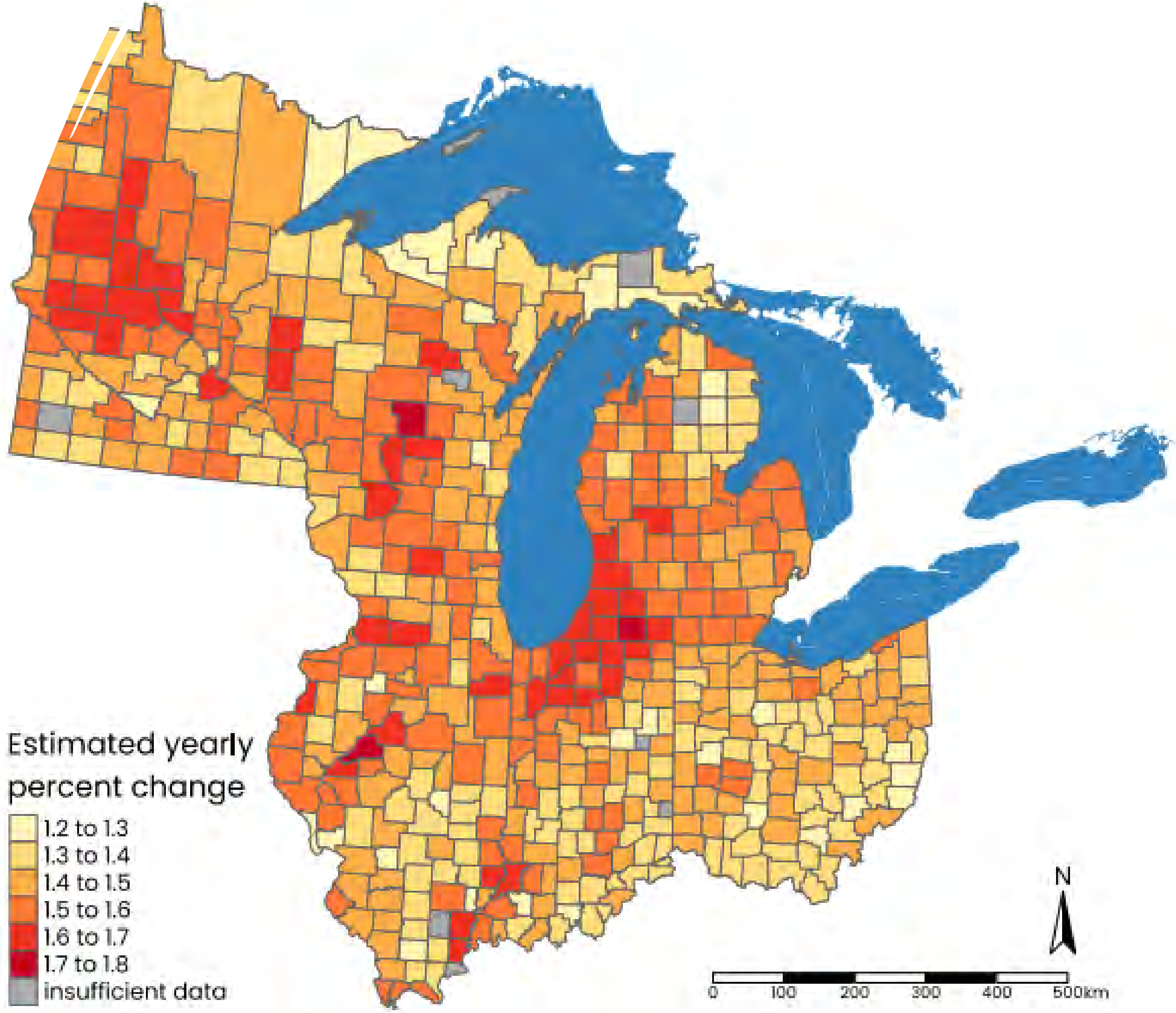


Figure 2: Hot spots in expansion of irrigated agriculture across EPA region 5.

Unlike west of the 100th meridian, agriculture in the wet midwestern U.S. has tended to rely more on seasonal rainfall irrigation. This is changing, however, and more so in some counties than others, as irrigation expands. Shown above our estimates of the relative growth in irrigated acreage by county. Counties with the strongest expansion have seen creage of irrigated cropland grow at 1.8% per year over the decade. In technical terms, the percent-change figures coefficients from a log-linear regression equation with county-specific time trends, estimated with data from the 2, 2007, 2012 and 2017 Census of Agriculture (USDA National Agricultural Statistics Service 2022).

What questions should be asked?

- What is the distribution of usable groundwater?
- Who is already using it and how much?
- Where is scarcity a concern / where is there extra capacity?
- What are the societal priorities for using groundwater?
- What are alternatives to groundwater?

Recharge Potential

An aquifer is like a bank account. Income is important.

Simulation of Potential Groundwater Recharge for the Glacial Aquifer System East of the Rocky Mountains, 1980–2011

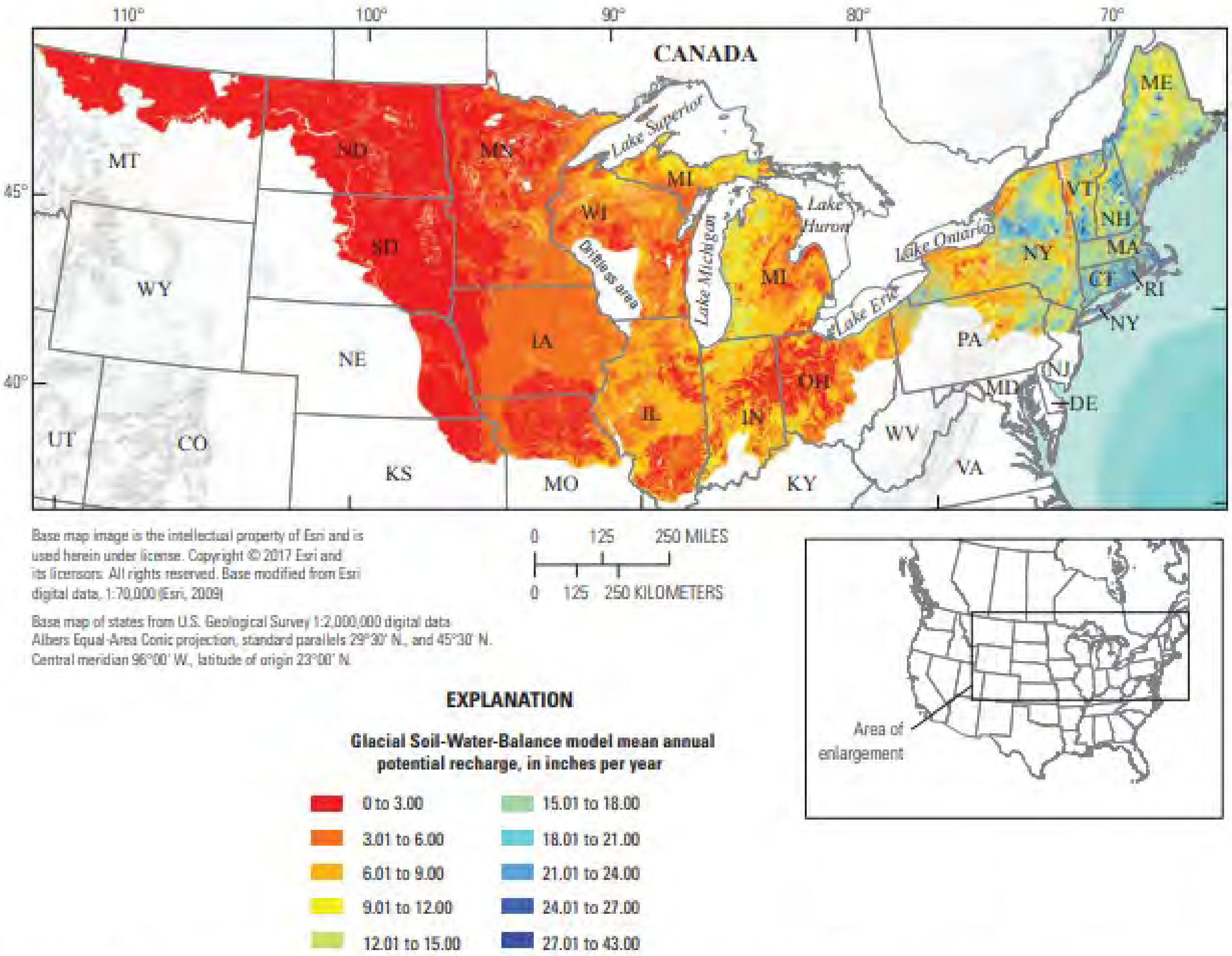


Figure 14. Mean annual potential recharge from 1980 to 2011 simulated with the glacial Soil-Water-Balance model.

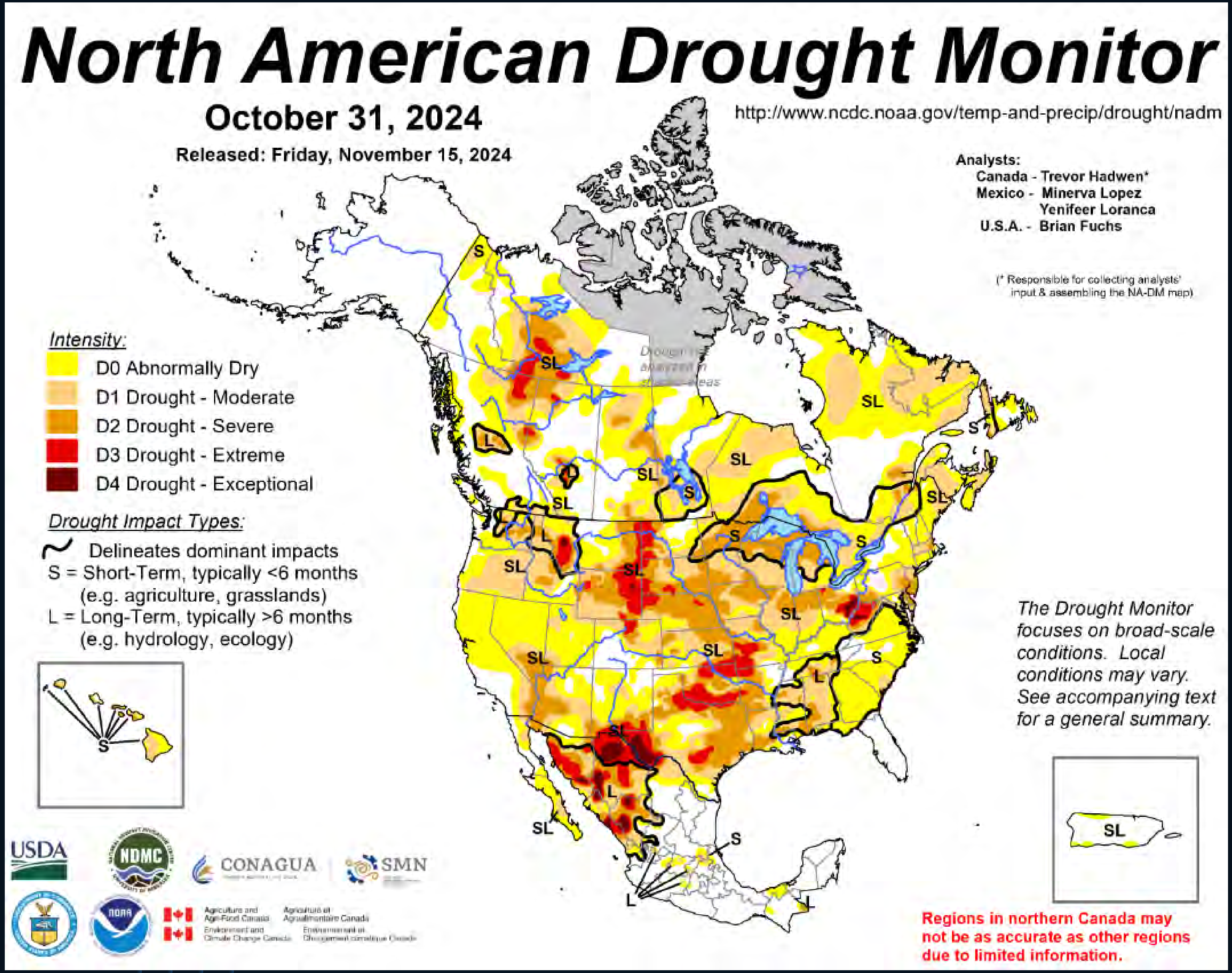
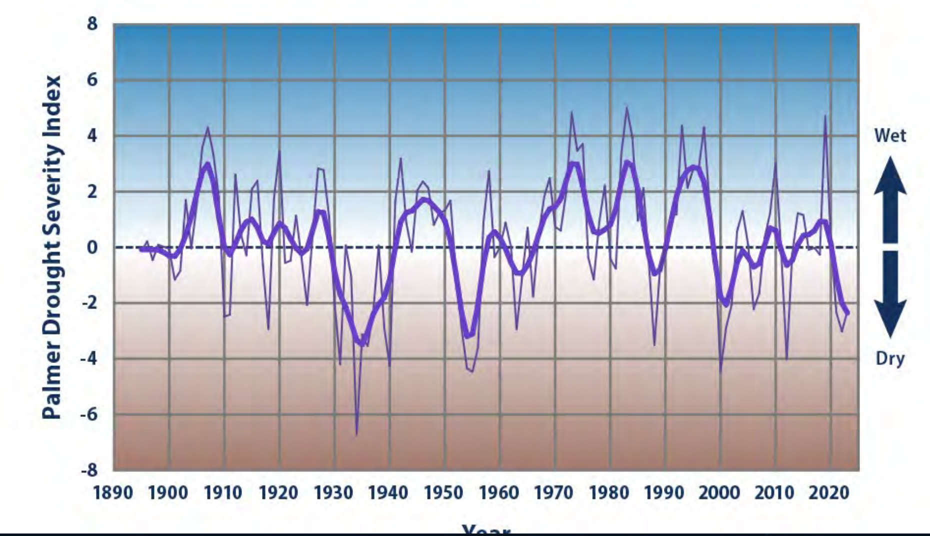


Figure 1. Average Drought Conditions in the Contiguous 48 States According to the Palmer Index, 1895–2023



- https://www.ncei.noaa.gov/access/monitoring/nadm/maps
- https://www.epa.gov/climate-indicators/climate-change-indicators-drought

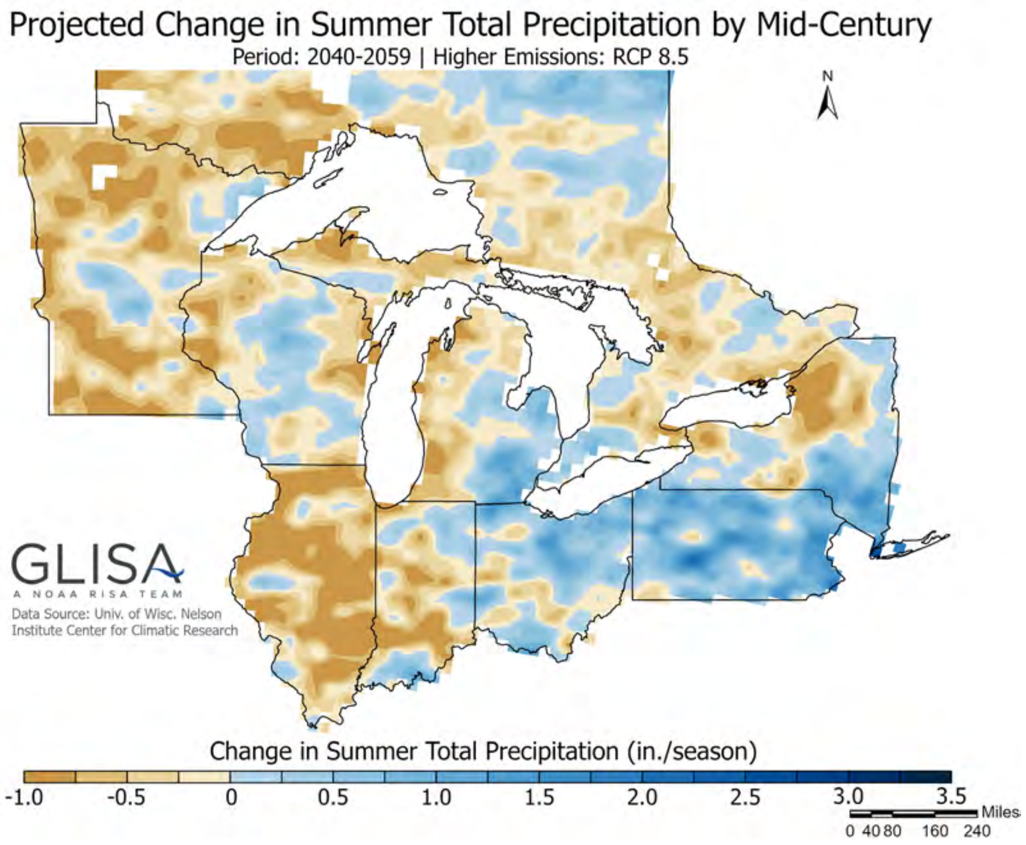
Climate Change in the Great Lakes Region

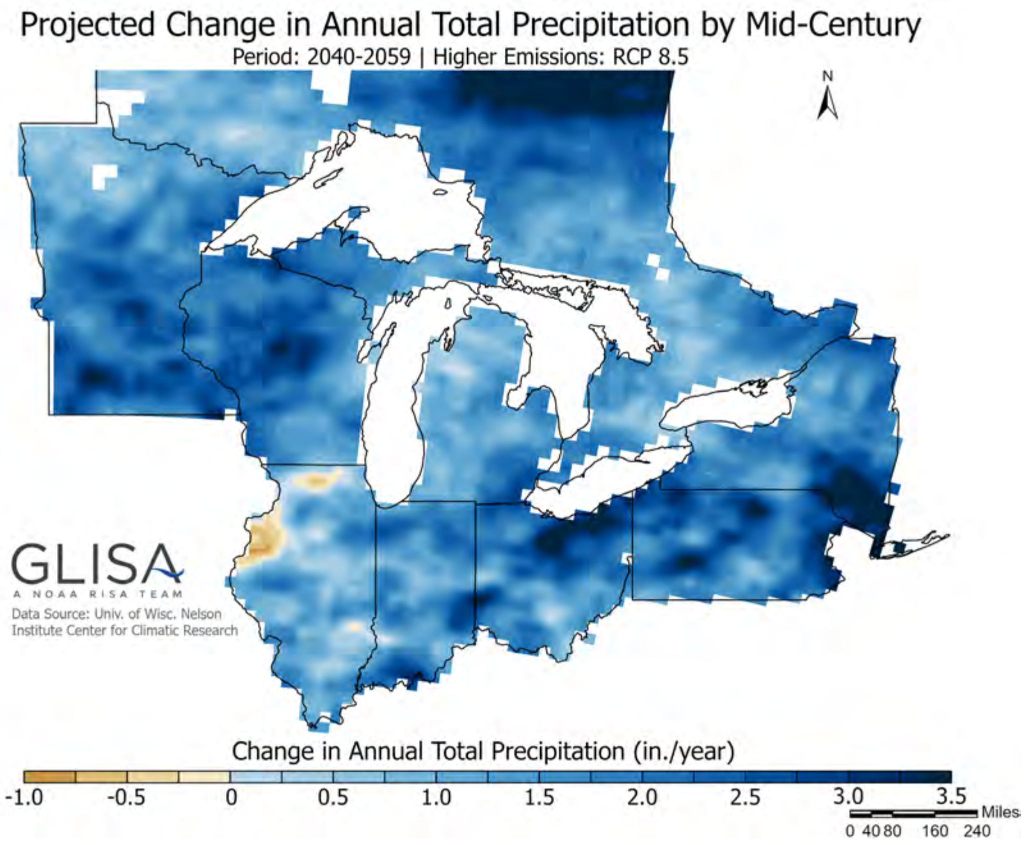
GLISA
A NOAA RISA TEAM

Average Temperature	Frost-free Season	Total Precipitation	Heavy Precipitation Events
2.3°F	16 Days	14%	35%
1951-2017	1951-2017	1951-2017	1951-2017

Precipitation Change

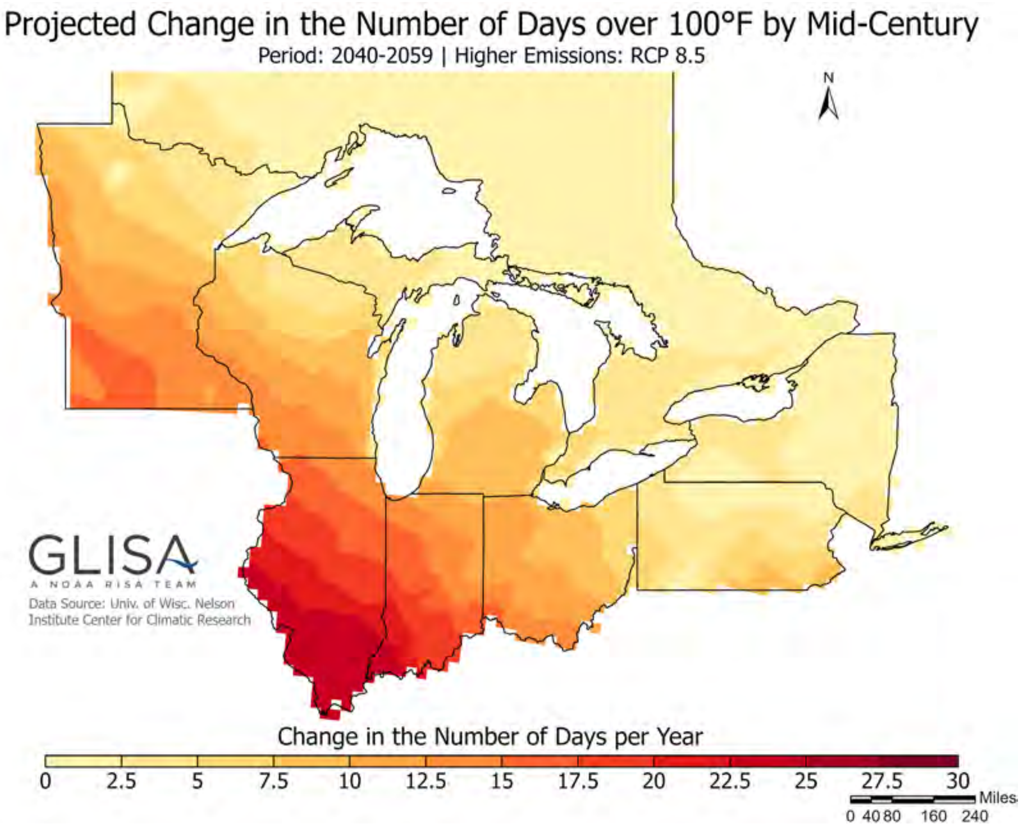
https://glisa.umich.edu/great-lakes-regional-climate-change-maps/

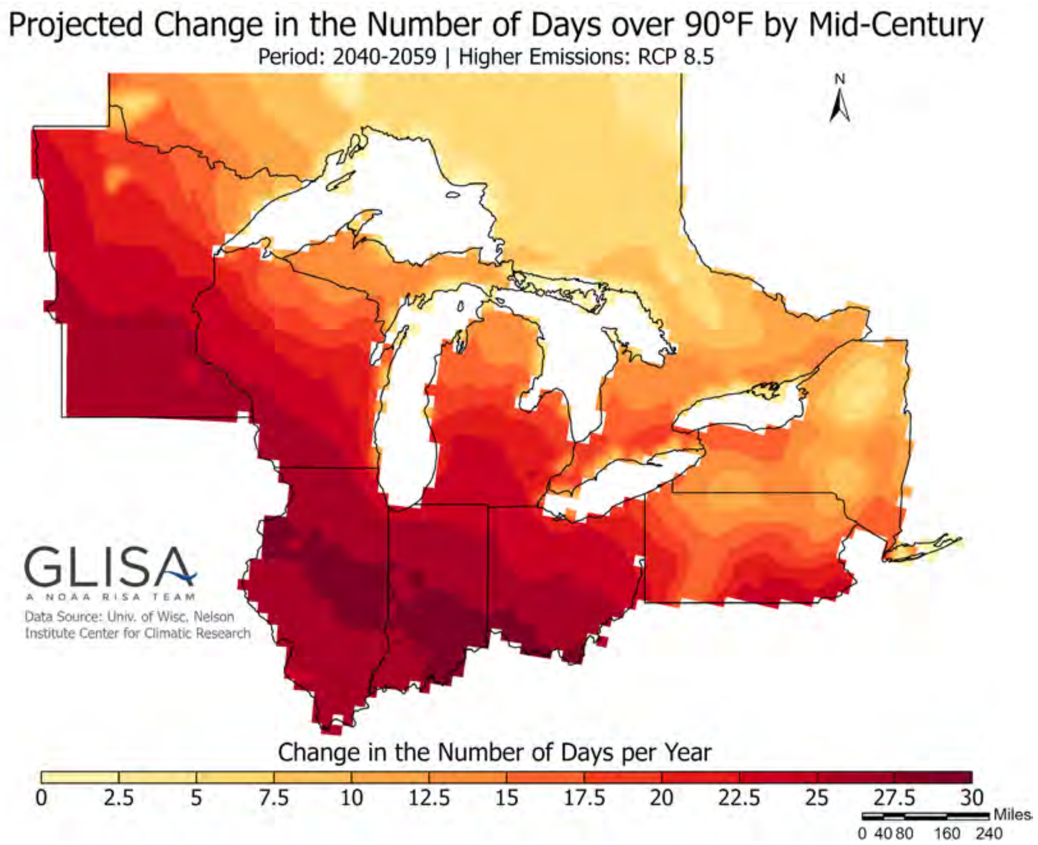




Change in Number of Hot Days

https://glisa.umich.edu/great-lakes-regional-climate-change-maps/





Water Withdrawals

- Is total volume being tracking?
- How are aquifers responding to pumping and climate and stress?

Table 5: Technical Details of Groundwater Withdrawal Control Institutions by State

	MN	WI	IL	MI	IN	OH
Threshold for withdrawal **registration**	≥ 10,000 gal/day or ≥ 1,000,000 gal/year	≥100,000 gal/day, excluding residential wells	≥70 gal/min (=100,800 gal/day)	≥ 100,000 gal/day (includes impact assessment)	≥100,000 gal/day, excluding residential wells	≥ 100,000 gallons per day
Threshold for withdrawal **permit**	Same as above	Same as above if within Great Lakes Basin, ≥1,000,000 gal/day otherwise	None	≥ 2,000,000 gal/day, or on appeal if site specific review leads to denial	Same as above if within "restricted use area", otherwise ≥1,000,000 gal/day	Same as above if within Great Lakes Basin, ≥ 2,000,000 gal/day otherwise
Meter requirement	Yes, flow meter (or comparable method) with 10% accuracy for new installations	Yes, type not specified	Yes, total withdrawals estimated	No	Yes, (for applicable facilities), but total withdrawals estimated	No
Statutes Consider Ecological Impacts?	Yes	Yes	No	Yes	Yes	No
Great Lakes basin-specific rules?	No	Yes	No, special case of Lake MI diversion	No, almost entirely within basin	No	Yes
Mechanisms for managing acute groundwater (GW) conflicts	GW Management Areas; Water Use Conflict Admin. Procedure	GW Protection Areas	GW Emergency Restrictions; Regulated Recharge Areas	GW Dispute Resolution Process	Restricted Use Area; Emergency Regulation of Groundwater Rights	GW Stress Areas Provision

Registration vs. Permitting

- Registration is notification only
- Permits may have construction specifications like:
  - Location (not within a building), separation distance, setbacks from contamination sources
  - Well testing and construction report
  - No multi-aquifer wells
  - Sealing of unused wells
- Environmental monitoring wells and exploratory borings may also require a permit
- Managed aquifer recharge (injection wells) may not be permitted.
  - Authority resides with EPA and must be assumed by the state.

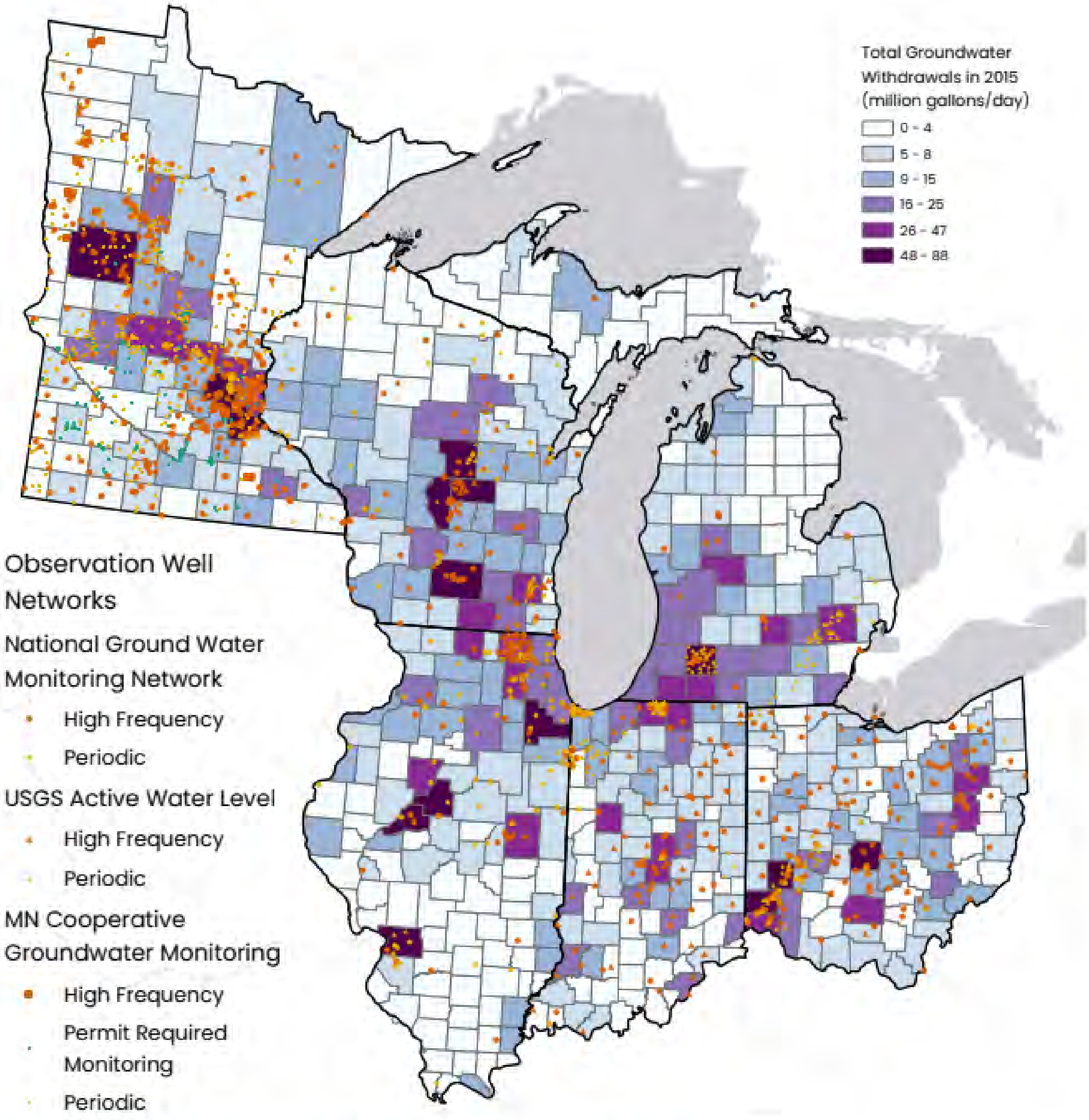
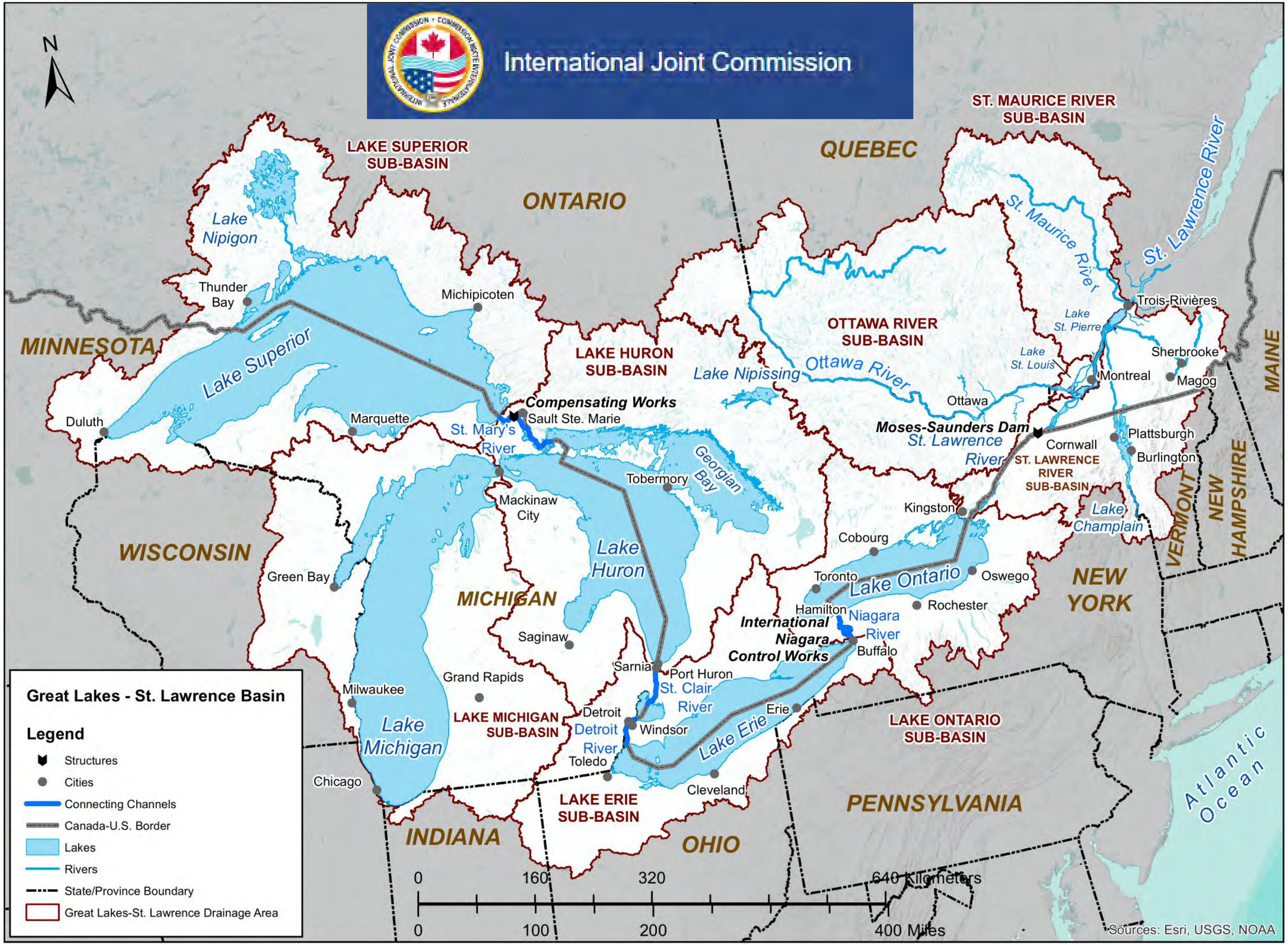
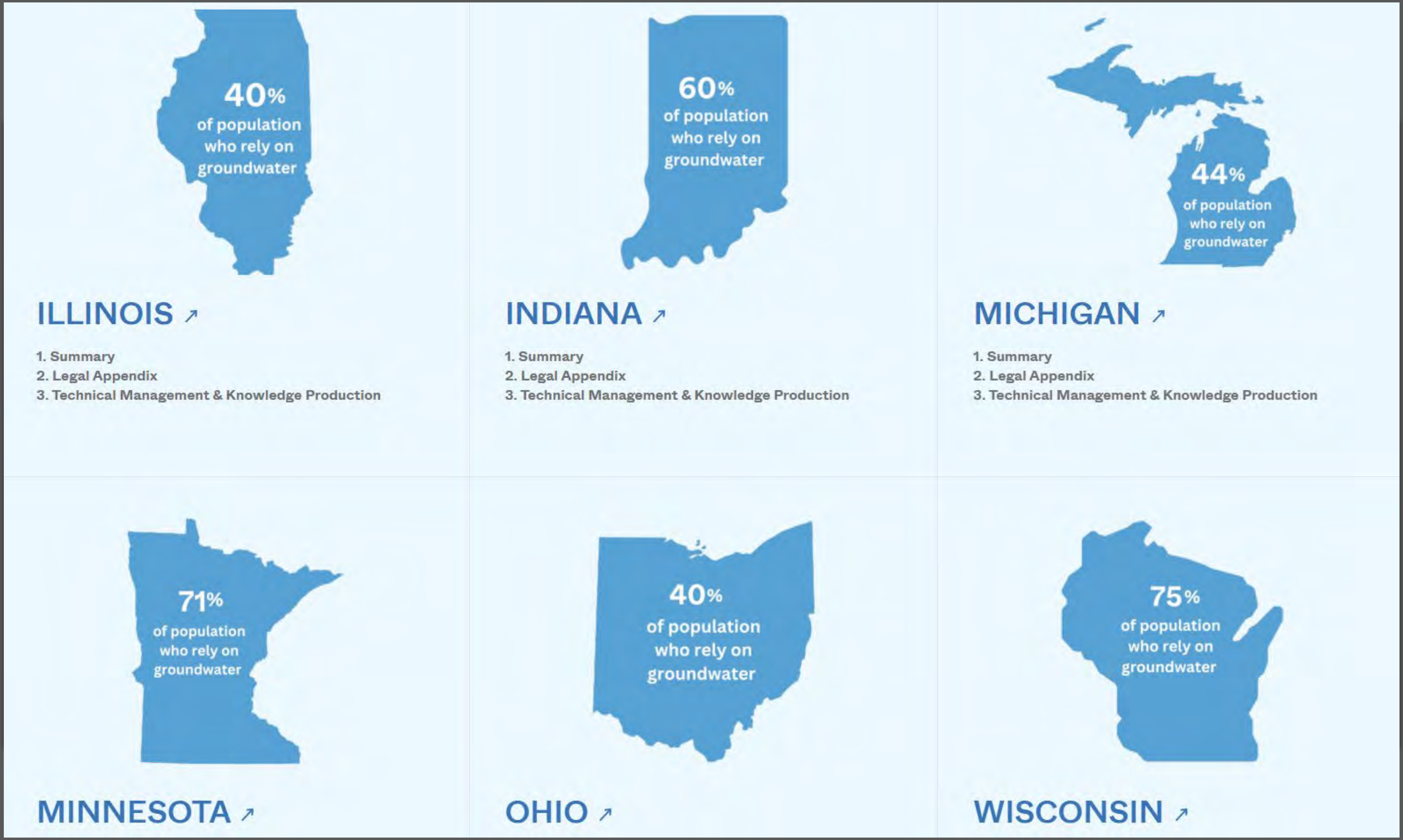


Figure 8: Density and type of observation wells vary by state.

What questions should be asked?

- What is the distribution of usable groundwater?
- Who is already using it and how much?
- Where is scarcity a concern / where is there extra capacity?
- What are the societal priorities for using groundwater?
- What are alternatives to groundwater?


International Joint Commission
N
LAKE SUPERIOR SUB-BASIN
ONTARIO
QUEBEC
ST. MAURICE RIVER SUB-BASIN
Lake Nipigon
Thunder Bay
Michipicoten
MINNESOTA
Lake Superior
LAKE HURON SUB-BASIN
OTTAWA RIVER SUB-BASIN
St. Maurice River
St. Lawrence River
Trois-Rivières
Lake St. Pierre
Lake St. Louis
Sherbrooke
Montreal
Magog
MAINE
Lake Nipissing
Ottawa River
Ottawa
Compensating Works
Sault Ste. Marie
Duluth
Marquette
St. Mary's River
Moses-Saunders Dam
St. Lawrence River
Cornwall
Plattsburgh
Burlington
ST. LAWRENCE RIVER SUB-BASIN
Georgian Bay
Tobermory
Mackinaw City
Kingston
Lake Champlain
VERMONT
NEW HAMPSHIRE
WISCONSIN
Lake Huron
Cobourg
Green Bay
MICHIGAN
Toronto
Lake Ontario
Oswego
NEW YORK
Hamilton
Niagara River
Rochester
International Niagara Control Works
Buffalo
Saginaw
Sarnia
Port Huron
St. Clair River
Grand Rapids
Milwaukee
Lake Michigan
LAKE MICHIGAN SUB-BASIN
Detroit
Detroit River
Windsor
Erie
Lake Erie
LAKE ONTARIO SUB-BASIN
Toledo
Chicago
Cleveland
LAKE ERIE SUB-BASIN
PENNSYLVANIA
INDIANA
OHIO
Atlantic Ocean
Great Lakes - St. Lawrence Basin
Legend
Structures
Cities
Connecting Channels
Canada-U.S. Border
Lakes
Rivers
State/Province Boundary
Great Lakes-St. Lawrence Drainage Area
0 160 320 640 Kilometers
0 100 200 400 Miles
Sources: Esri, USGS, NOAA



https://assets.joycefdn.org/content/uploads/MINNESOTA-SHORT-FORM-SUMMARY-MAY-2024.pdf

State agencies with water authority

Table 2: State Agency organization around common areas of concern by state

	MN	WI	IL	MI	IN	OH
Groundwater appropriation registration or permitting Groundwater Availability and Ecological Impacts	Minnesota Dept. of Natural Resources (MN DNR)	Wisconsin Dept. of Natural Resources (WI DNR), diversion role accomplished via "Border Community" provisions of Great Lakes Compact	None	Michigan Dept. of Environment, Great Lakes, and Energy (EGLE)	Indiana Dept. of Natural Resources (IN DNR)	Ohio Dept. of Natural Resources (ODNR)
Industrial Contamination	Minnesota Pollution Control Agency (MPCA)		Illinois Environ. Protection Agency (IEPA)		Indiana Dept. of Environ. Mgmt. (IDEM)	Ohio Environ. Protection Agency (Ohio EPA)
Drinking Water Supply	Minnesota Dept. of Health (MDH)			EGLE and Michigan Dept. of Health & Human Services (MDHHS)	Indiana Dept. of Environ. Mgmt. (IDEM)	
Great Lakes Diversion appropriation	None		U.S. Army Corps of Engineers (USACE) & Illinois Dept. of Natural Resources (IL DNR)	None	None	None
Agricultural pesticide and fertilizer contamination	Minnesota Dept. of Ag. (MDA)	Wisconsin Dept. of Ag., Trade, and Consumer Protection (DATCP)	Illinois Dept. of Ag. (IDA)	Michigan Dept. of Ag. And Rural Develop-ment (MDARD)	IDEM with Office of the Indiana State Chemist (OISA)	Ohio Dept. of Ag. (ODA)

Legal Instruments — Priority of Use (Minn.)

(1) domestic water supplies and power producers which have approved contingency plans;

(2) uses of less than 10,000 gallons per day;

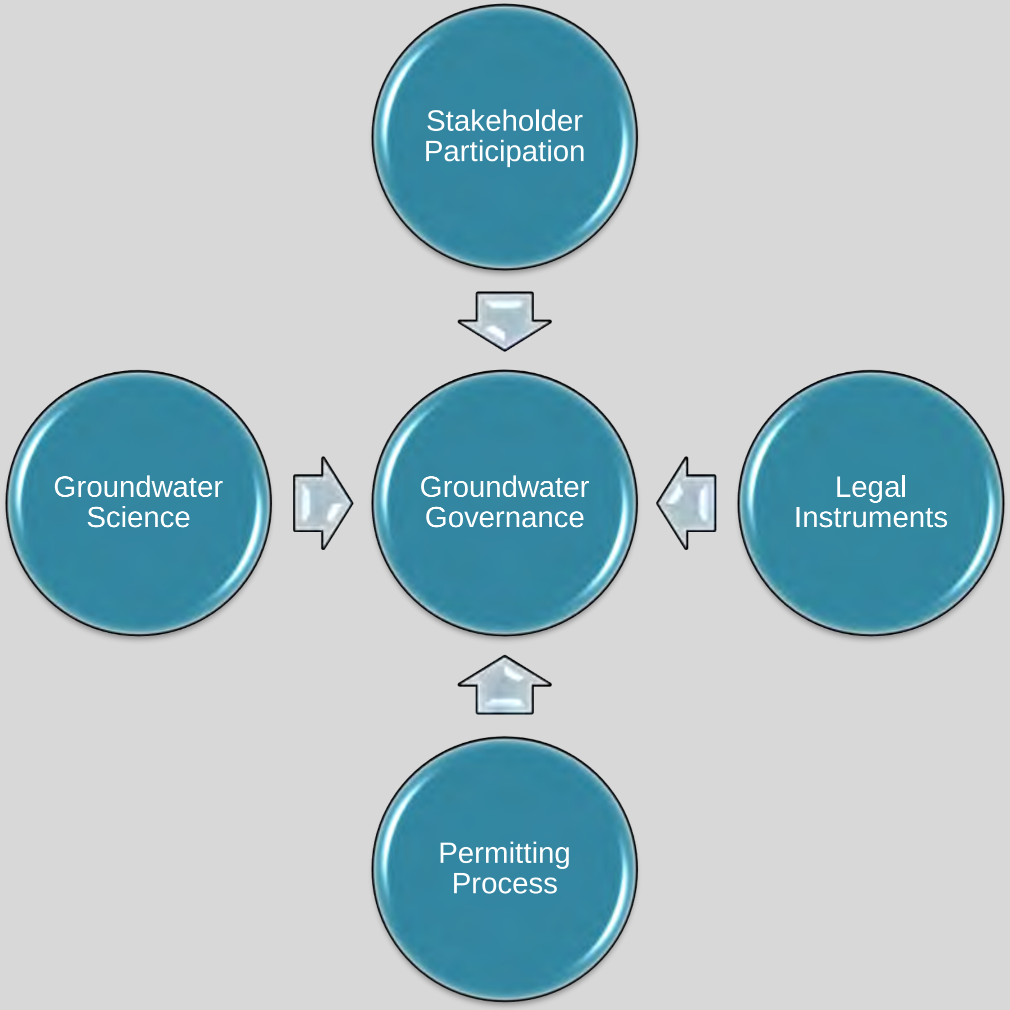
(3) agricultural irrigation and processing of agricultural products consuming in excess of 10,000 gallons per day;

(4) power production without approved contingency plans;

(5) other uses in excess of 10,000 gallons per day; and

(6) nonessential uses of water.

Groundwater policy to support inclusive prosperity and ecological health has these components:



Recommendations from first report

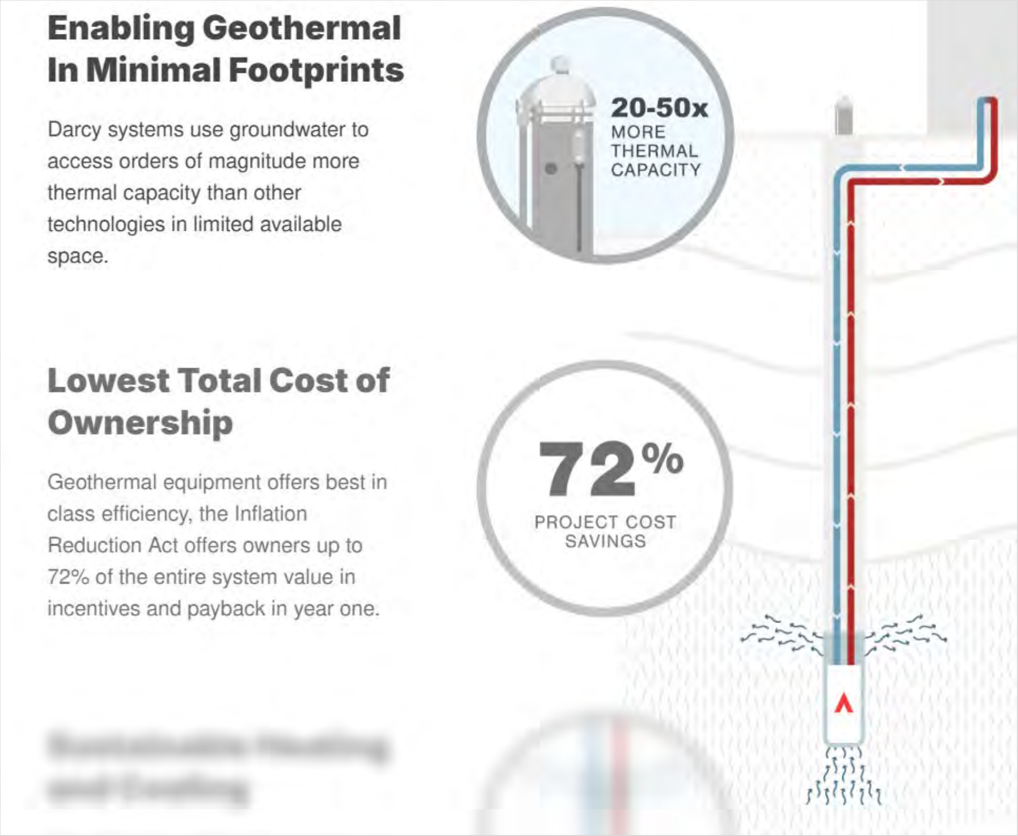
- Elevate groundwater sustainability in regional planning.
- Make groundwater goals specific, measurable, actionable, realistic, and time-delimited.
- Encourage inclusive groundwater management at the aquifer-level.
- Establish the knowledge necessary to define management boundaries within aquifers across political boundaries.

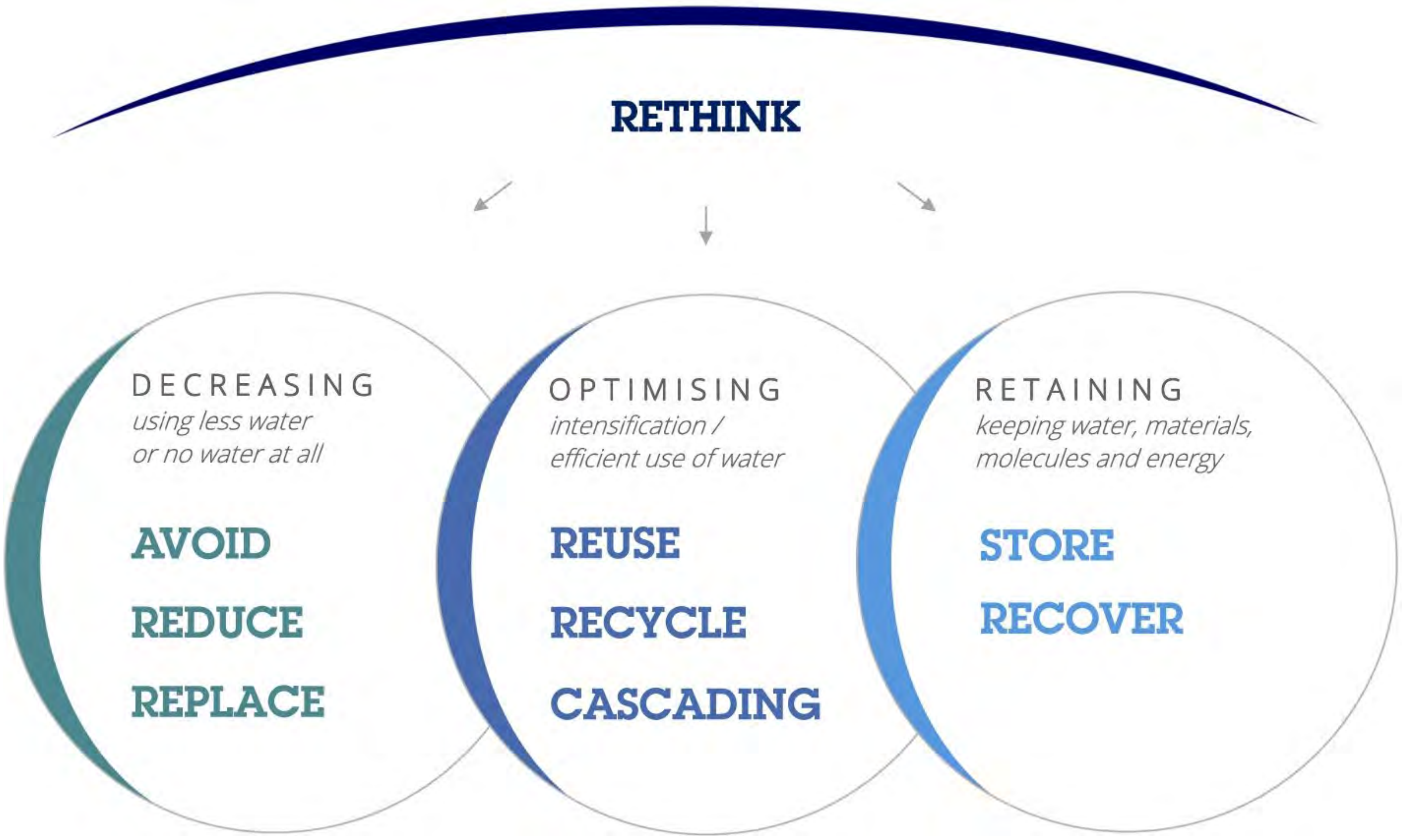
What questions should be asked?

- What is the distribution of usable groundwater?
- Who is already using it and how much?
- Where is scarcity a concern / where is there extra capacity?
- What are the societal priorities for using groundwater?
- What are alternatives to groundwater?

Cooling with Groundwater

- “Pump and Dump”
  - Take advantage of ~ 47 degree temperature by running through facility
  - Illegal in some states
- Pump, cycle a few times, treat and discharge
  - More common
  - Number of cycles depends on chemistry (scaling inside plant, meeting discharge water quality standards)
- Closed loop geothermal systems





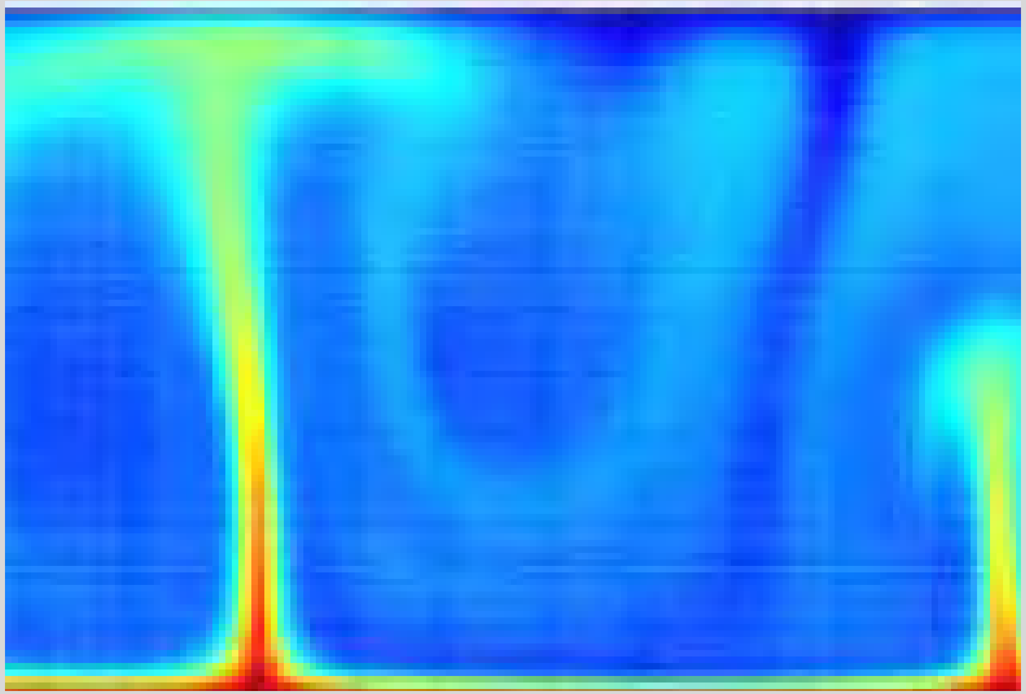
Morseletto, P., Mooren, C.E. & Munaretto, S. Circular Economy of Water: Definition, Strategies and Challenges. *Circ.Econ.Sust.* **2**, 1463–1477 (2022). https://doi.org/10.1007/s43615-022-00165-x

Circular Water Solutions can provide potential savings of 50-70%

- closed-loop systems
- wastewater recycling
- rainwater harvesting
- groundwater recharge

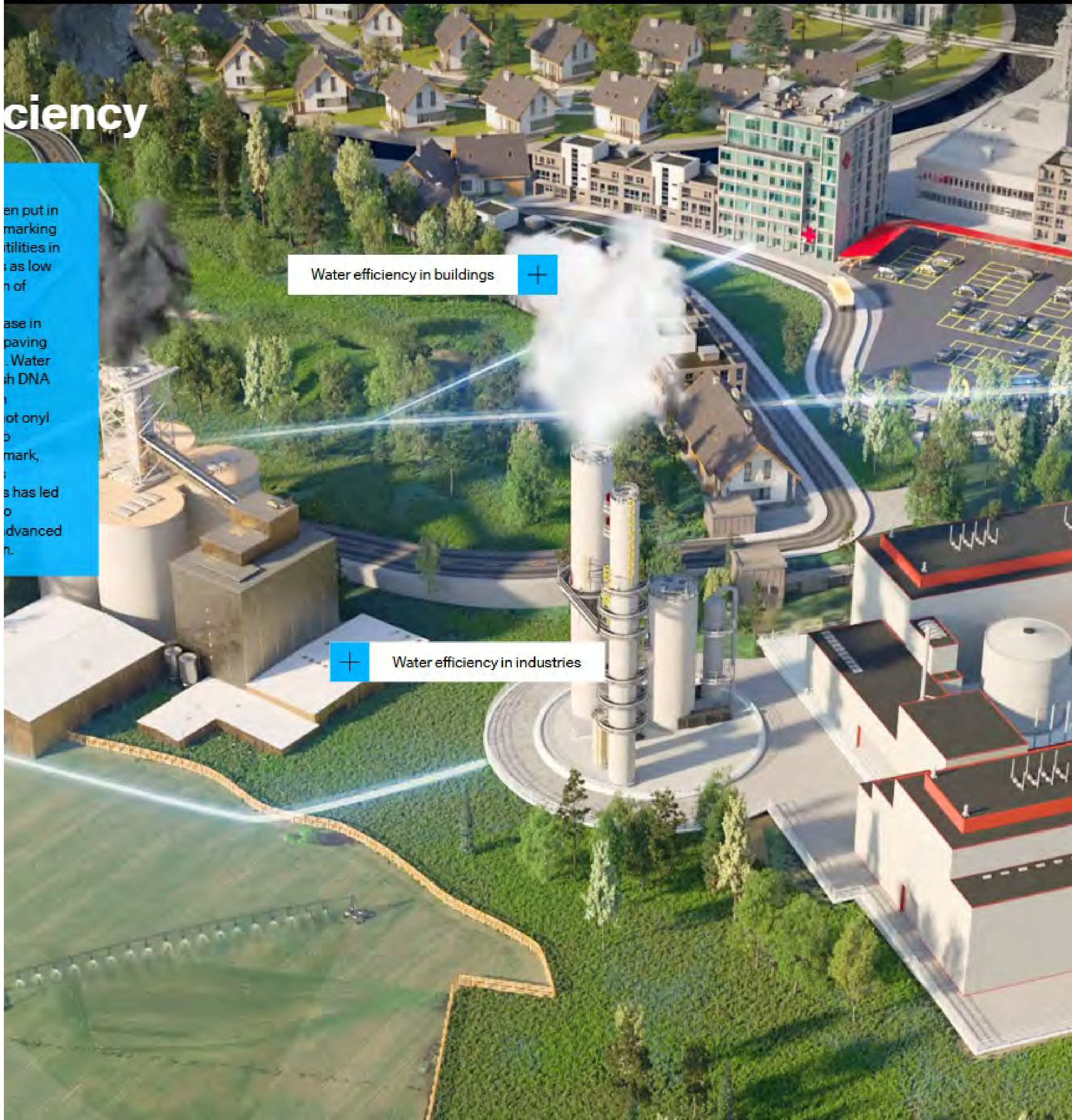
Move Heat through Passive Cooling Strategies

- building design optimization
- natural ventilation
- cool roofs
- high-volume low-speed (HVLS) fans
- advanced cooling towers



Denmark sets a good example for water circularity, in similar geologic terrain and land use.

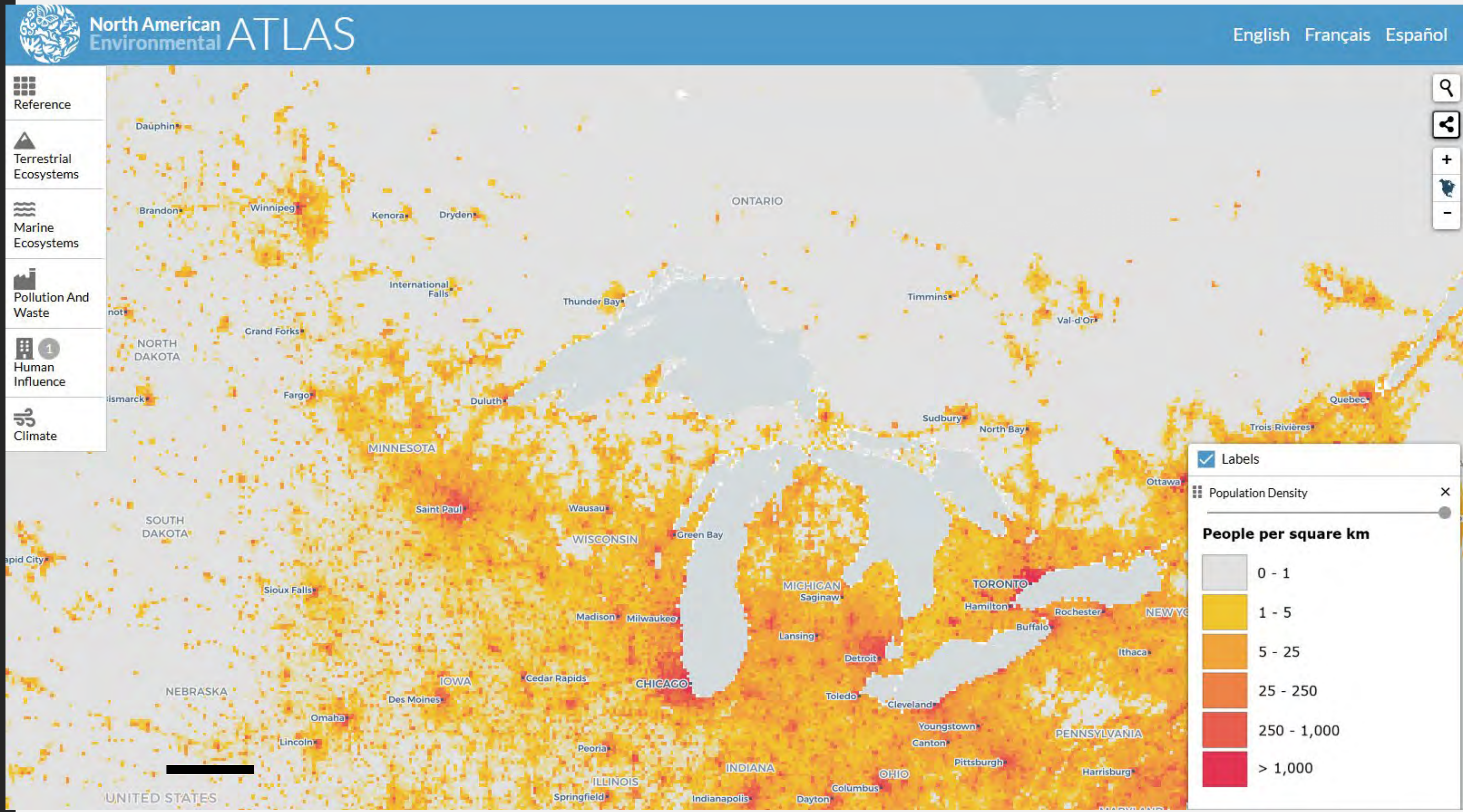
- State of Green newsletter
- Their consultants are available globally
- Encourage visits



Summary of Freshwater's Data Center Conversations

- Power and water are the biggest issues to site a facility and water supply is a risk to their operations
- Most data centers have a 'water neutral' or a 'water positive' goal
- Water needs to be high purity water, usually goes through reverse osmosis for recirculation
- Water may need to be cooled and treated before discharged
- They use either direct evaporative cooling (wet) or air cooling (dry) but cannot easily switch between them
  - Wet : less $, quieter, more water
- State legislation and tax incentives are working
- It would be helpful to have statewide planning on water availability, power availability, and water reuse options.

Where Can a State or Province Safely Add Water Demands Equivalent to a Medium City?



- **Caution:** the urban fringe
    - mix of private and municipal wells has the potential for well interference
    - far from surface water sources like the Great Lakes or major rivers
- **Caution:** areas with only glacial sediment aquifers
- **Caution:** areas with seasonal water scarcity
    - irrigated
    - drought-prone

The Midwest can expect more data centers and other large water users

- Make scientifically robust groundwater data available in a timely, relevant, and accessible way.
- Engage with Tribal and First Nations and other jurisdictions sharing groundwater.
- Consult stakeholders to identify trade-offs and prioritize choices across sectors and non-human and human users.
- Use results to guide regional policy and planning.
- Require circular water design.
- Look for surface water or other cooling alternatives; some areas are already experiencing groundwater scarcity.

https://en.wiktionary.org/wiki/divining_rod

Siting Data Centers with Groundwater in Mind

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