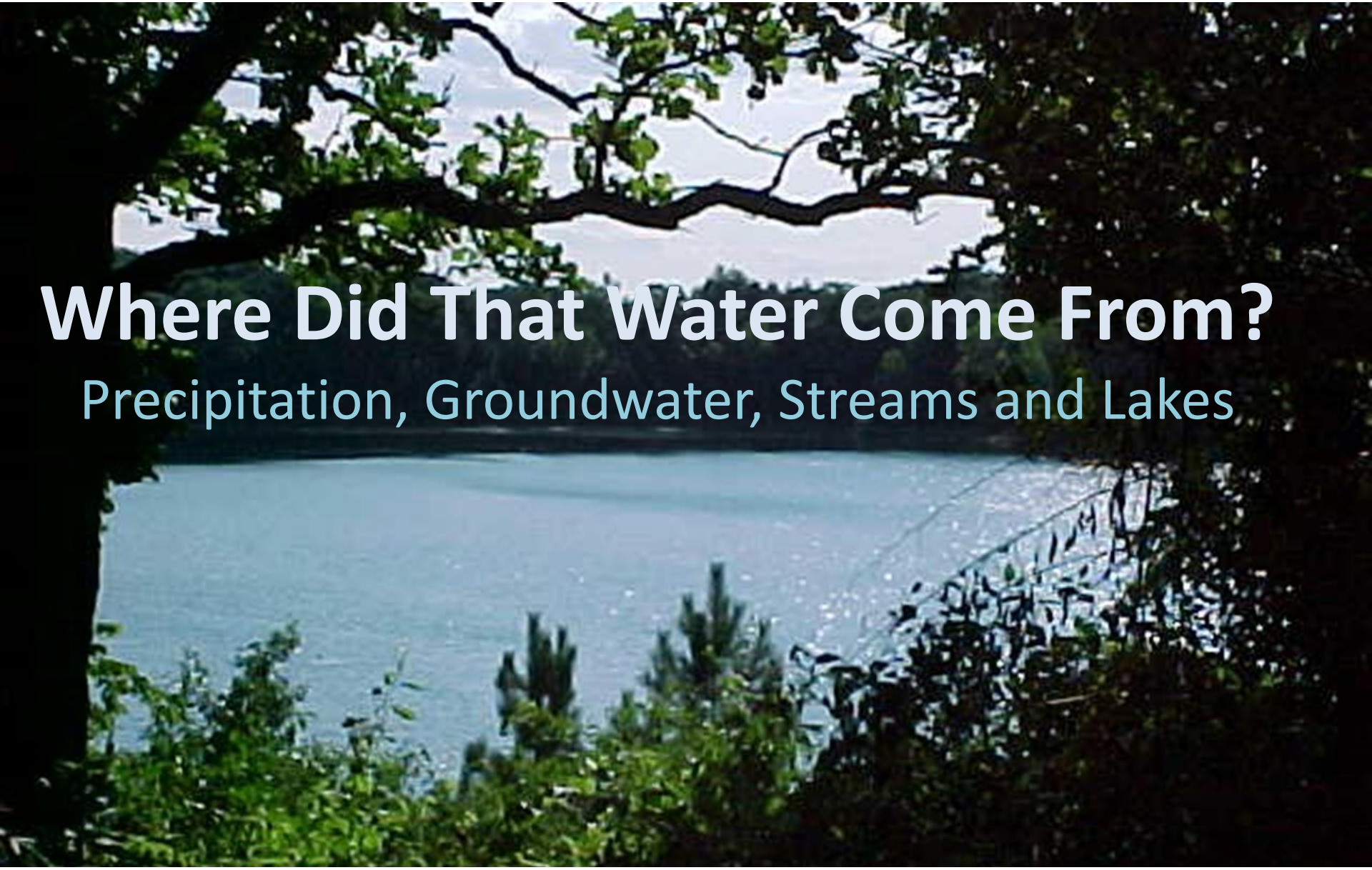

Where Did That Water Come From?

Precipitation, Groundwater, Streams and Lakes

Center for Watershed Science and Education
College of Natural Resources
University of Wisconsin-Stevens Point

Extension
UNIVERSITY OF WISCONSIN-MADISON

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Following the Water!

Overview

- Digging into the Water Cycle
  - Where is the water?
  - What is “groundwater”?
  - Where does all this water come from?
  - Where does it go?
  - What does that tell us about lakes & streams

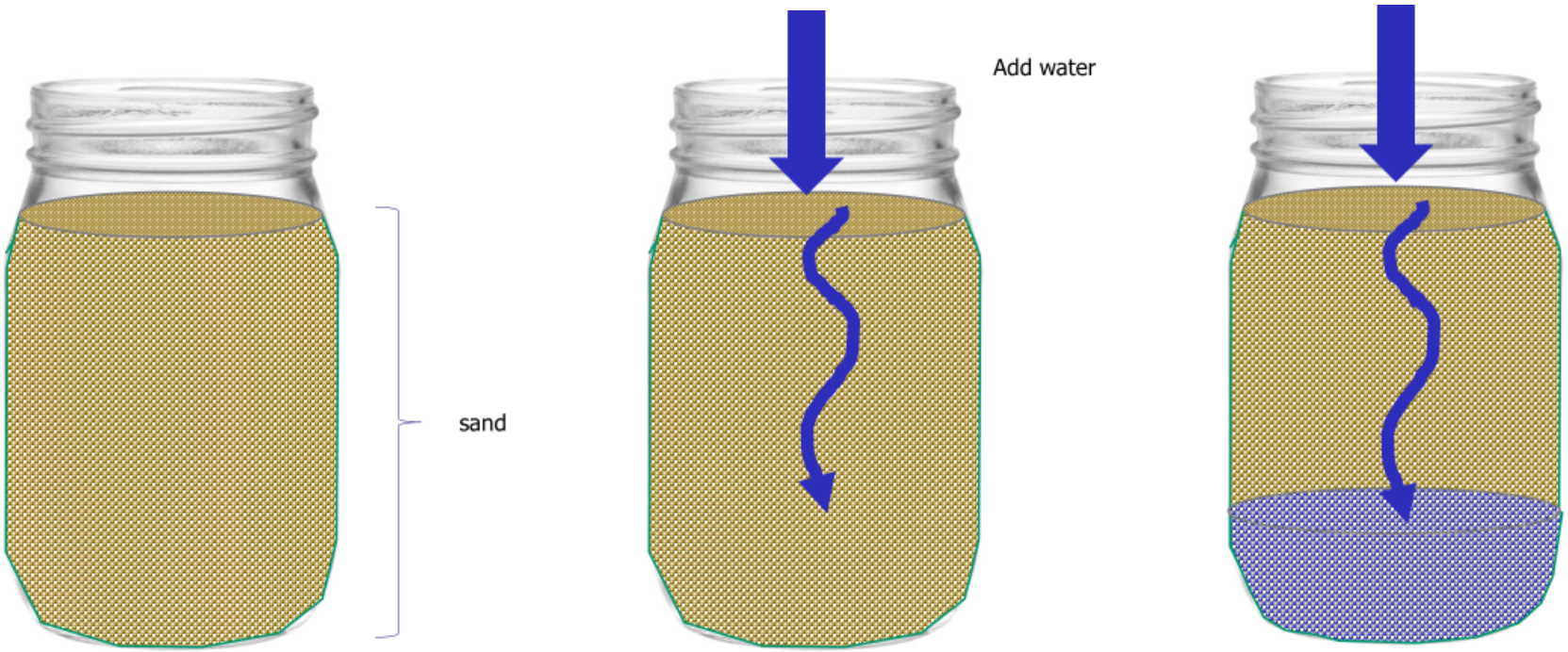
Streams

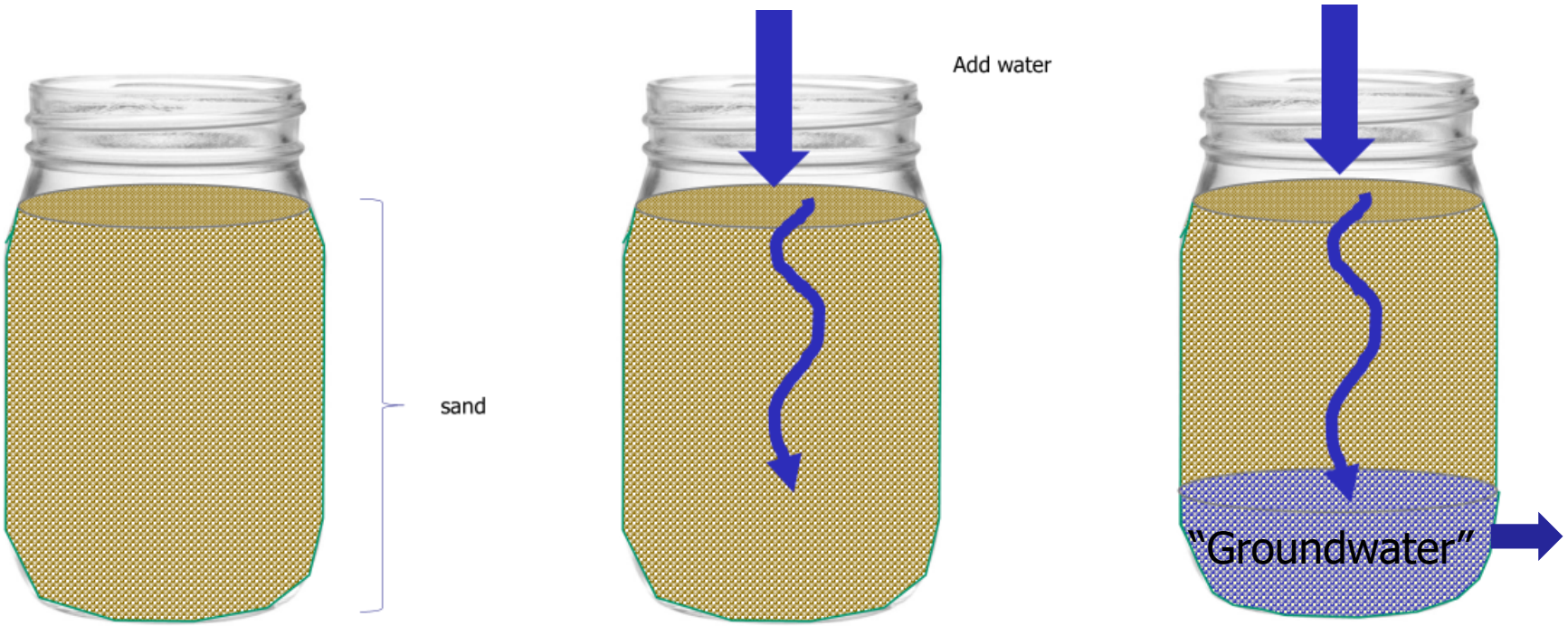
Lakes

Wetlands

Groundwater

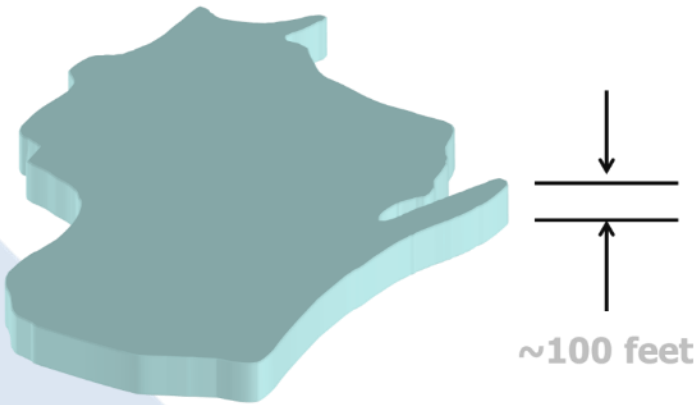
Let's spend just a little more time on "Groundwater"




sand
Add water
"Groundwater"

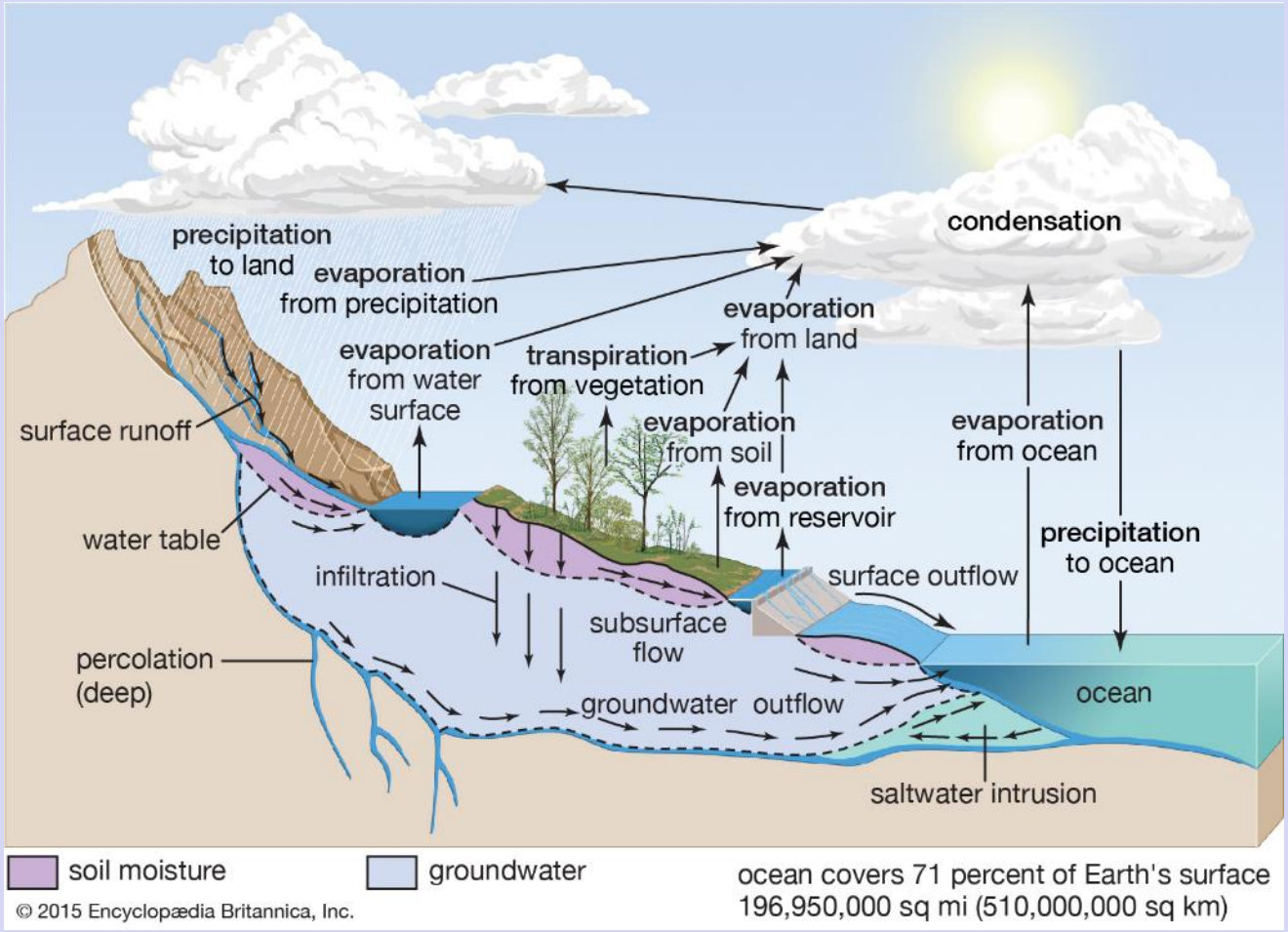
Where is the water?

- Focus on Wisconsin
  - 15,000 lakes (1,500 square miles total area .. that's about 1,000,000 acres or 3% of Wisconsin)
  - 13,500 miles of streams (<1% of Wisconsin)
  - 8,300 square miles of wetlands (15% of Wisconsin)
  - 56,000 square miles of groundwater (100% of Wisconsin)

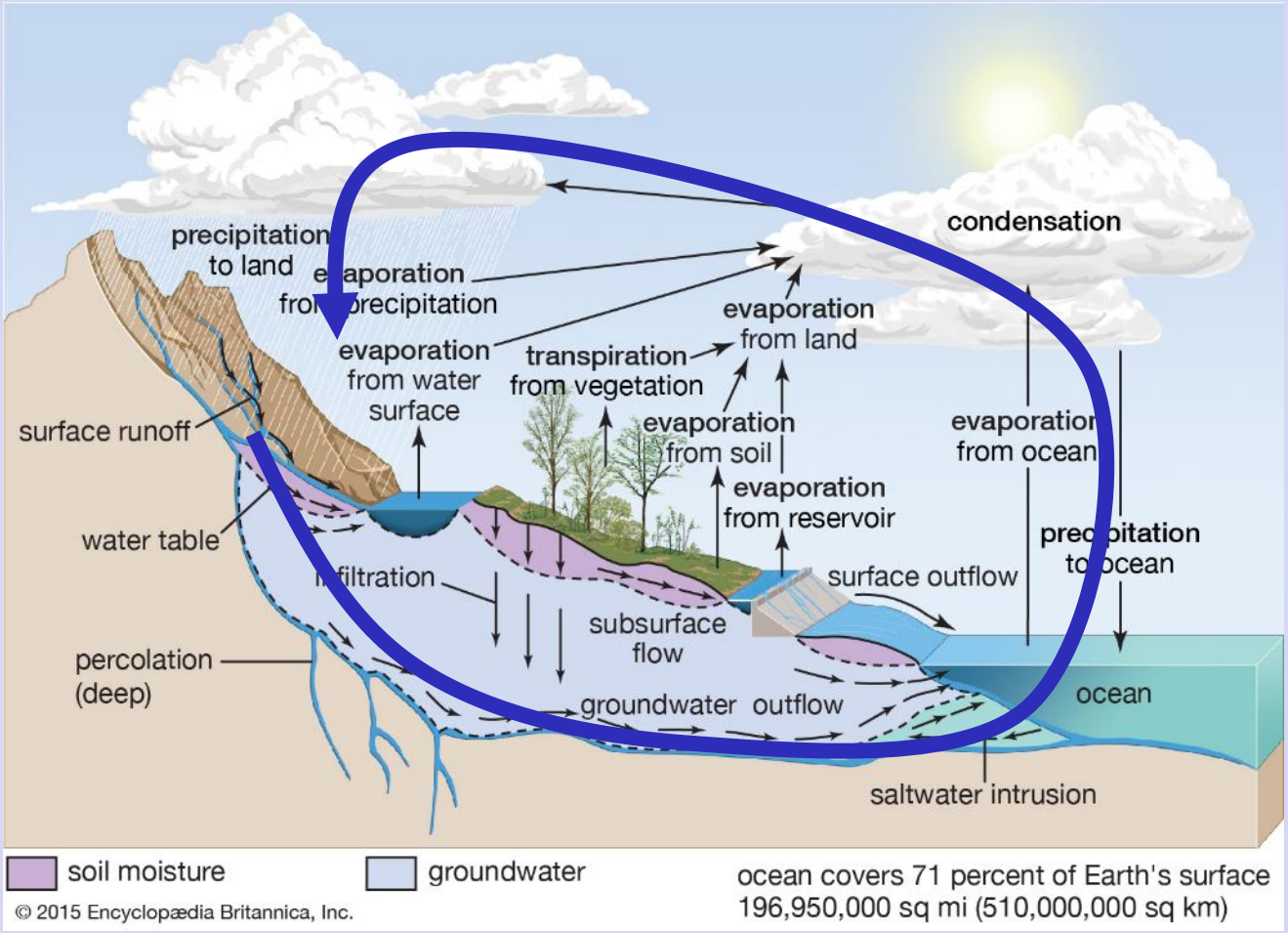


Based on a few assumptions and information in https://waterlibrary.aqua.wisc.edu/water-facts/

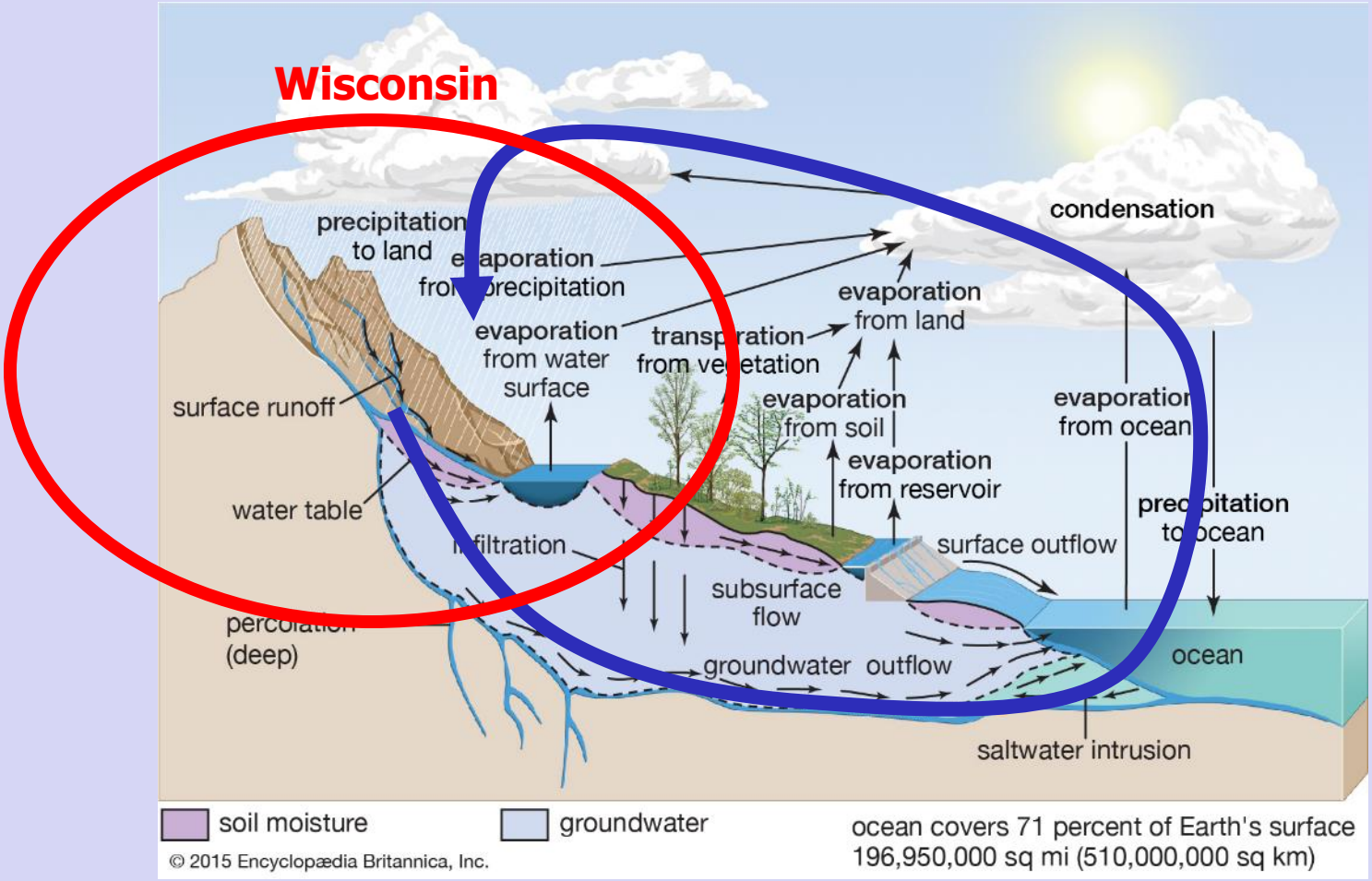
These water features are part of the water cycle



All of these water features are part of the water cycle



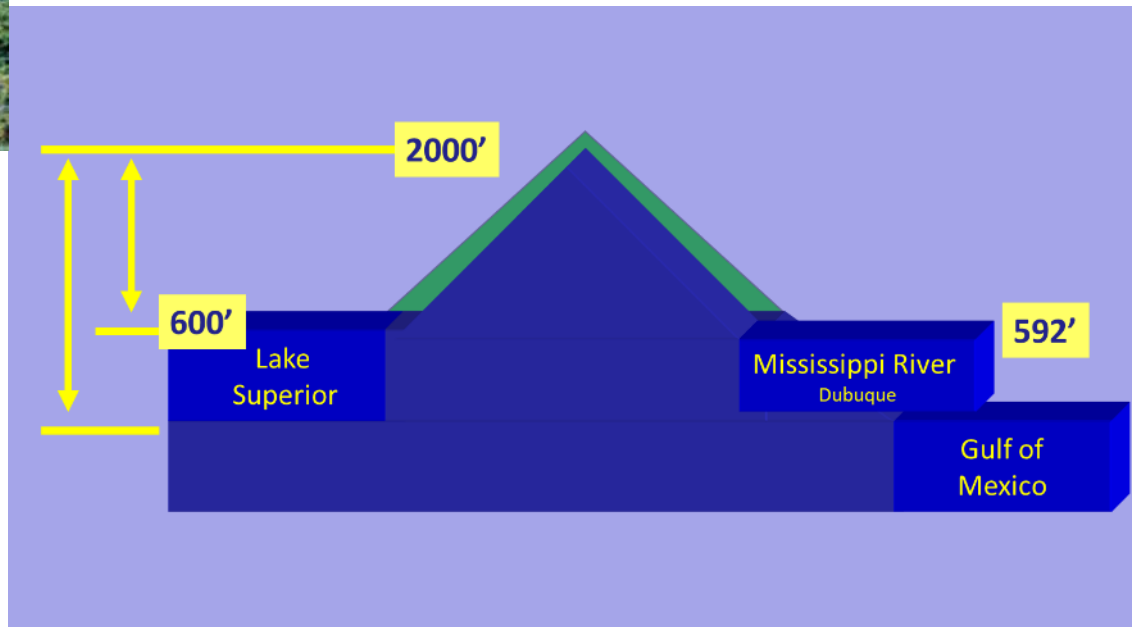
All of these water features are part of the water cycle

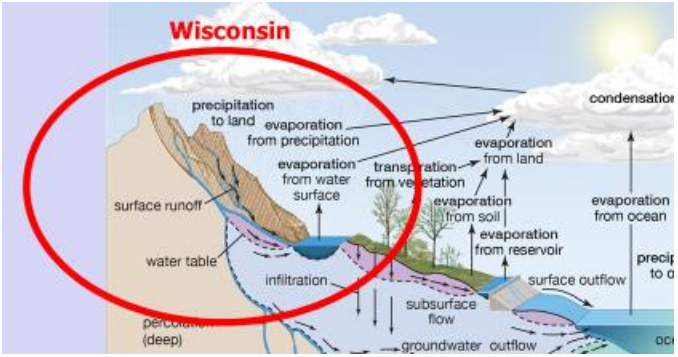


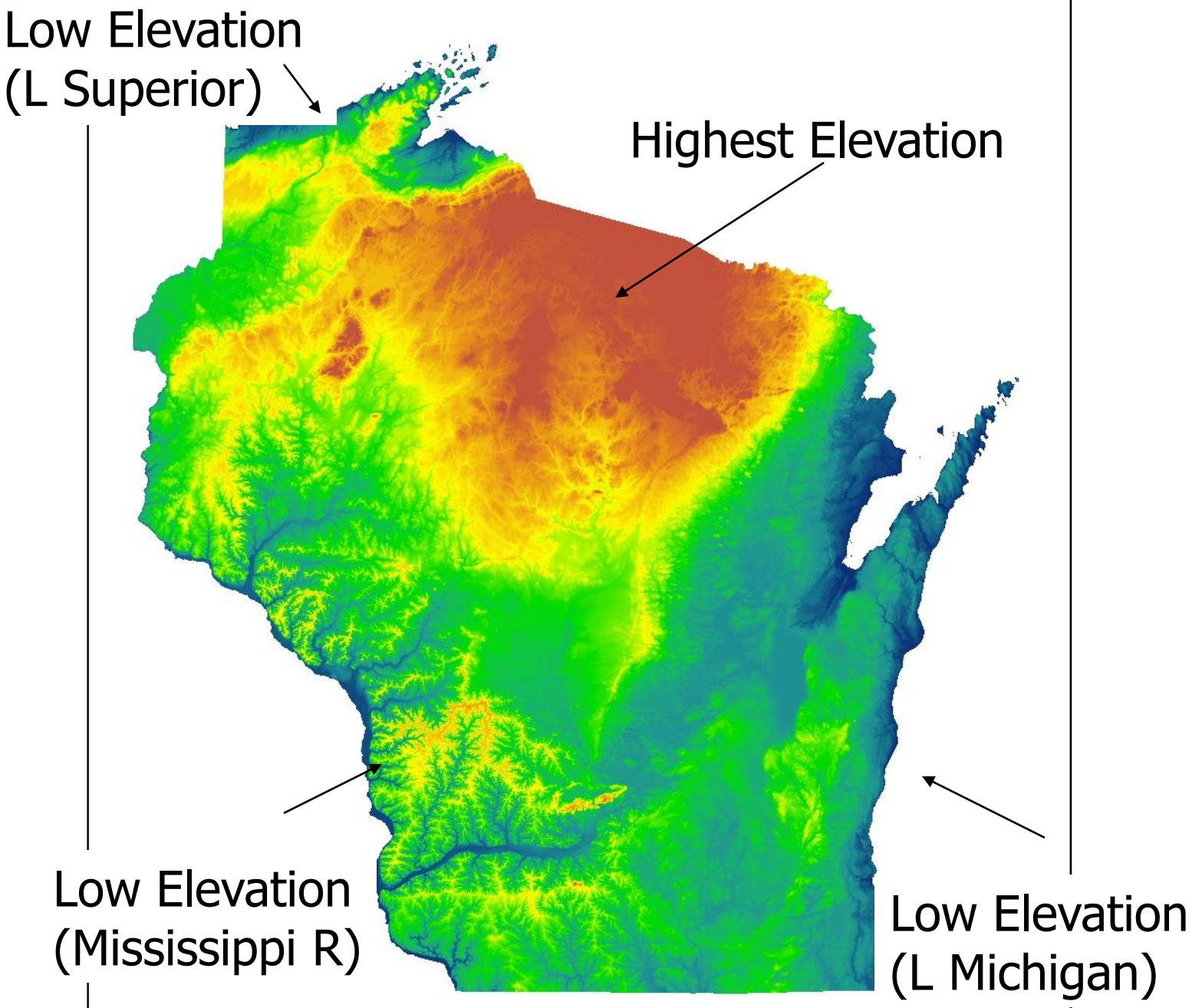
…Not this

Wisconsin

But this…

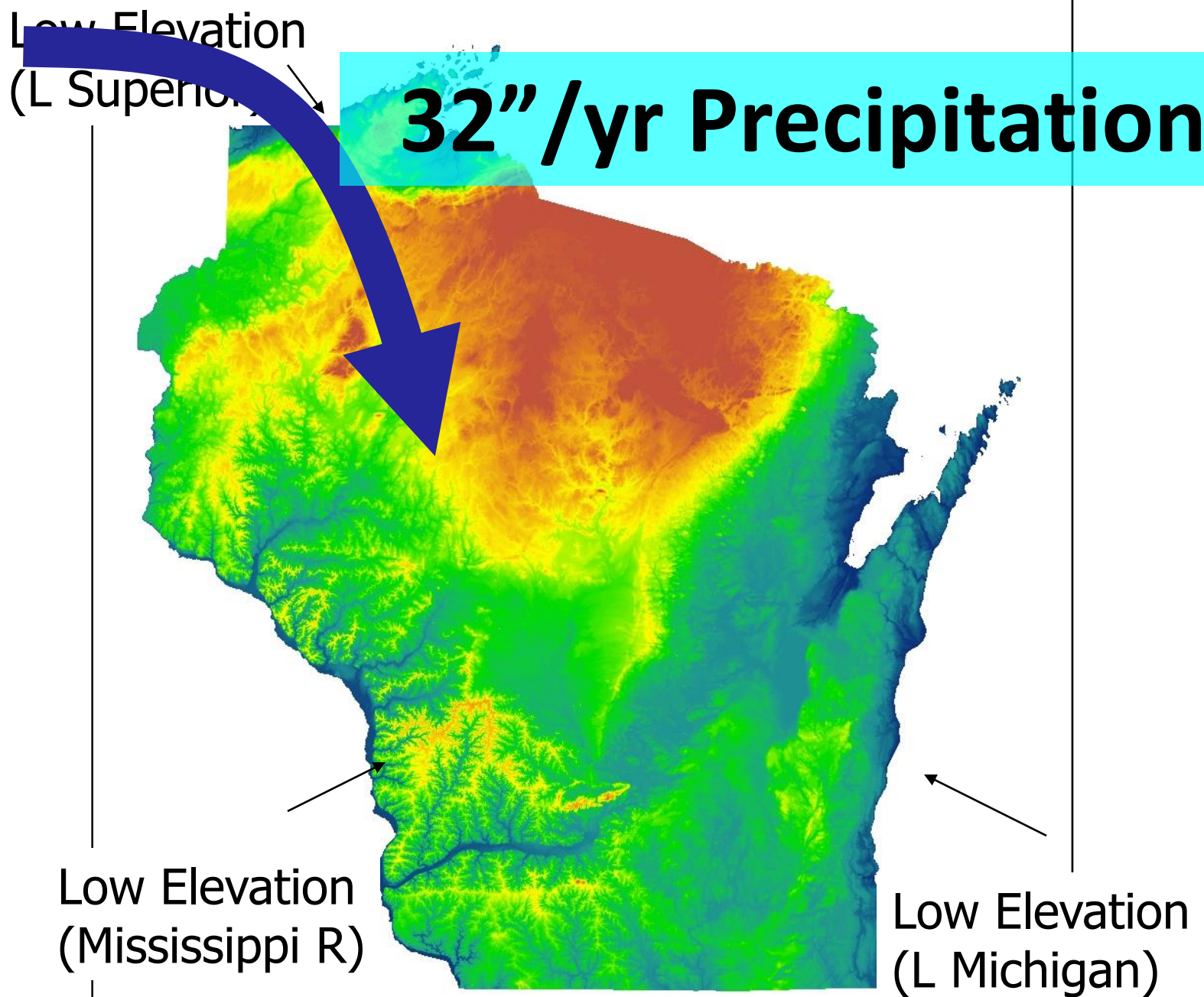





Low Elevation
(L Superior)
Highest Elevation
Low Elevation
(Mississippi R)
Low Elevation
(L Michigan)

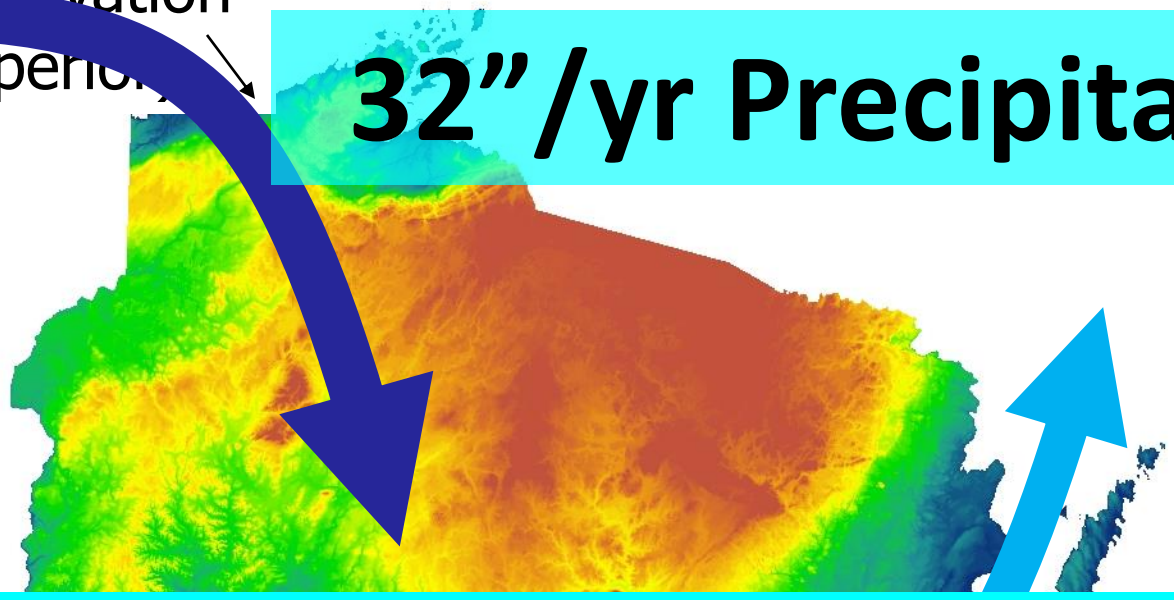
Let's Add Water

- **Precipitation**
  - Rain, Snow, Sleet
  - ~500 hours /year
  - 100 storms /year (most small, a few large)
  - 32 inches / year average

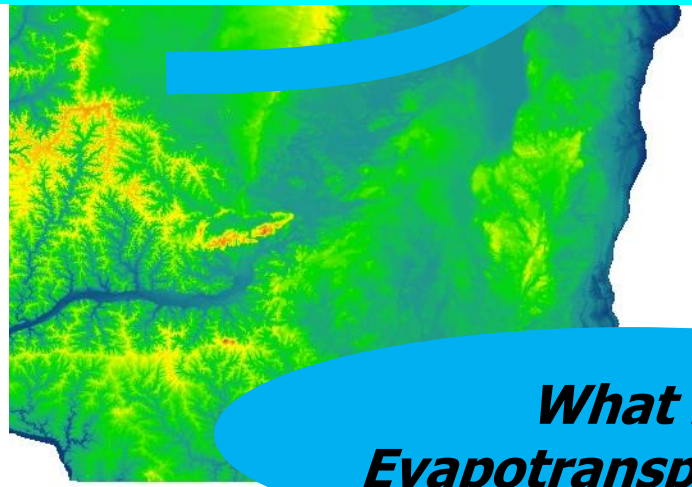

Low Elevation
(L Superior)
32”/yr Precipitation
Low Elevation
(Mississippi R)
Low Elevation
(L Michigan)

Low Elevation
(L Superior)

32”/yr Precipitation



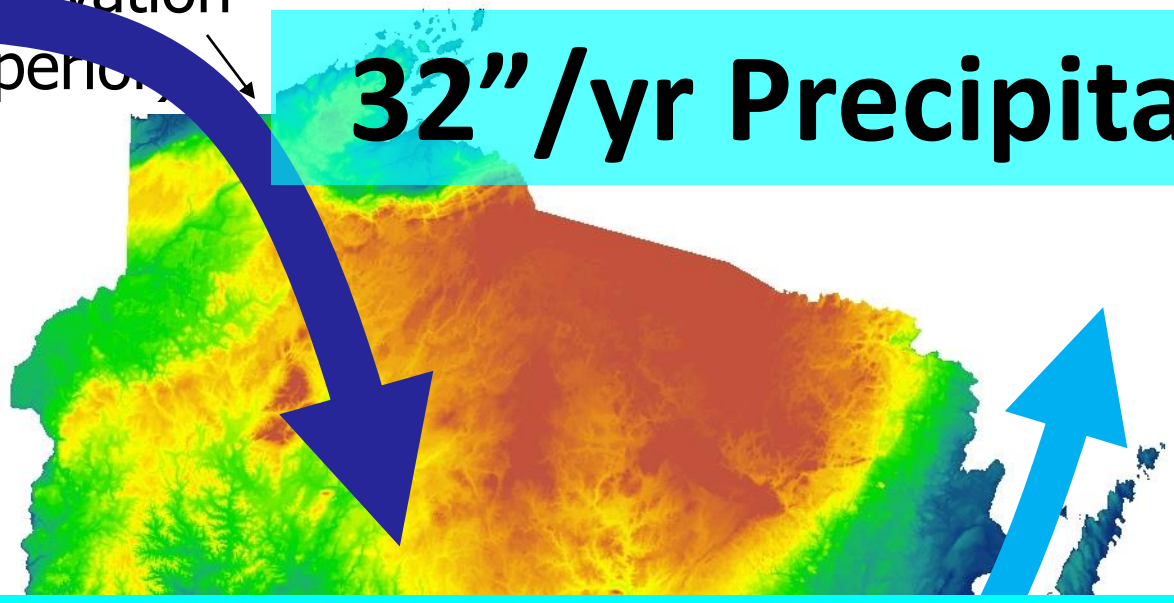
____” EvapoTranspiration



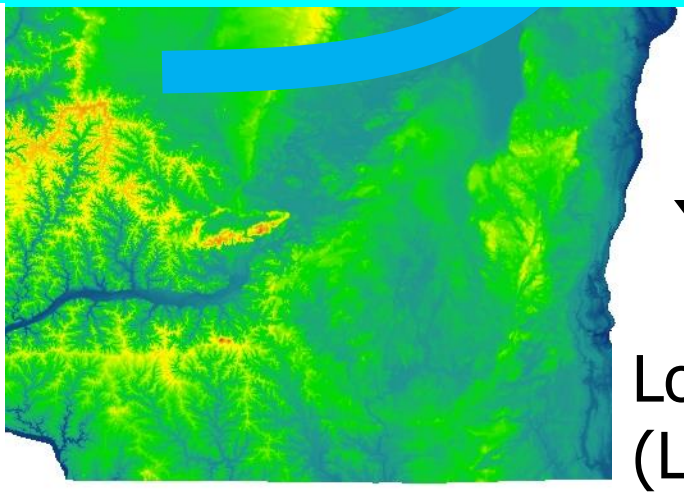
What is Evapotranspiration?

Low Elevation
(L Superior)

32”/yr Precipitation

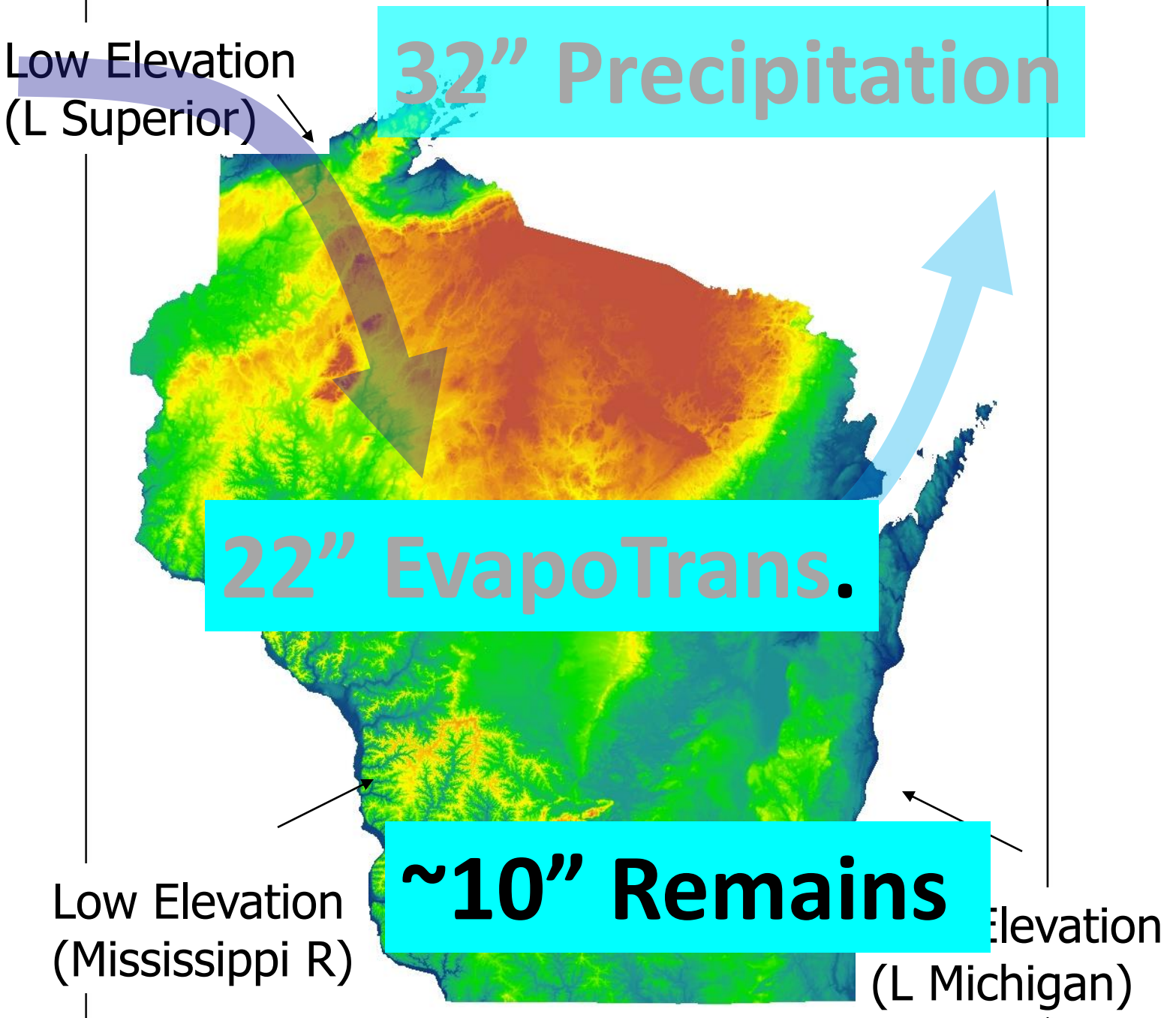


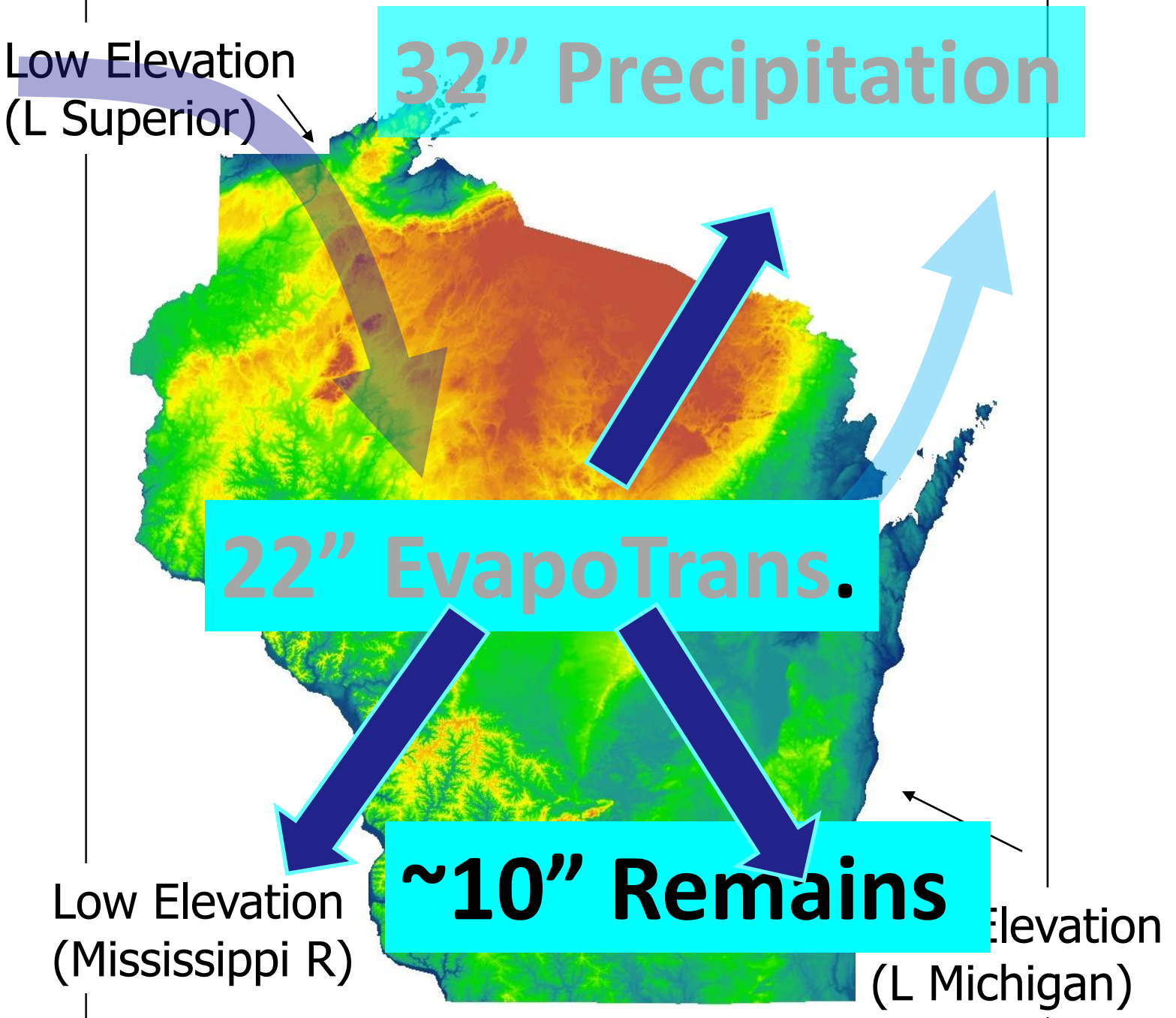
22” EvapoTranspiration



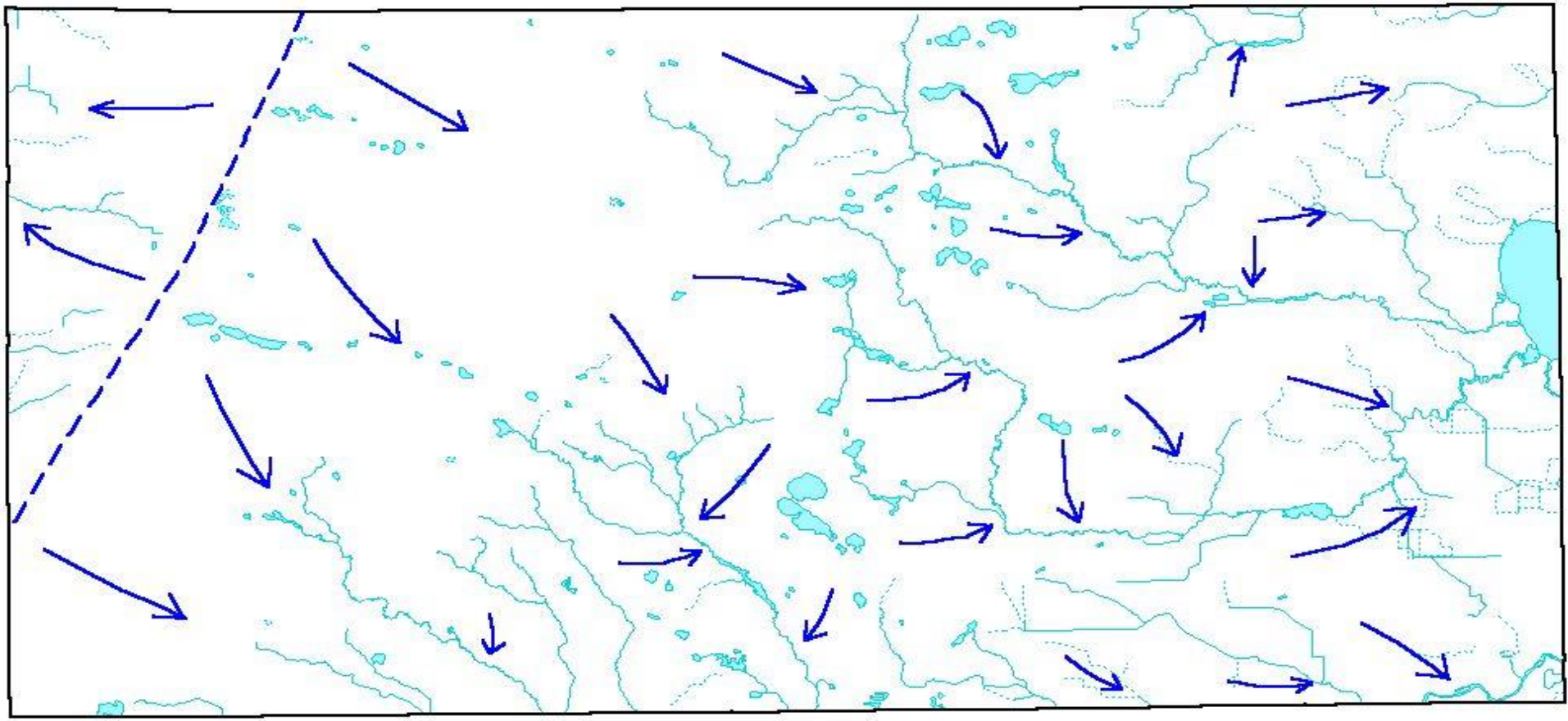
Low Elevation
(L Michigan)

Approximate, based on Gebert et al 1987


Low Elevation
(L Superior)
32” Precipitation
22” EvapoTrans.
~10” Remains
Low Elevation
(Mississippi R)
Elevation
(L Michigan)

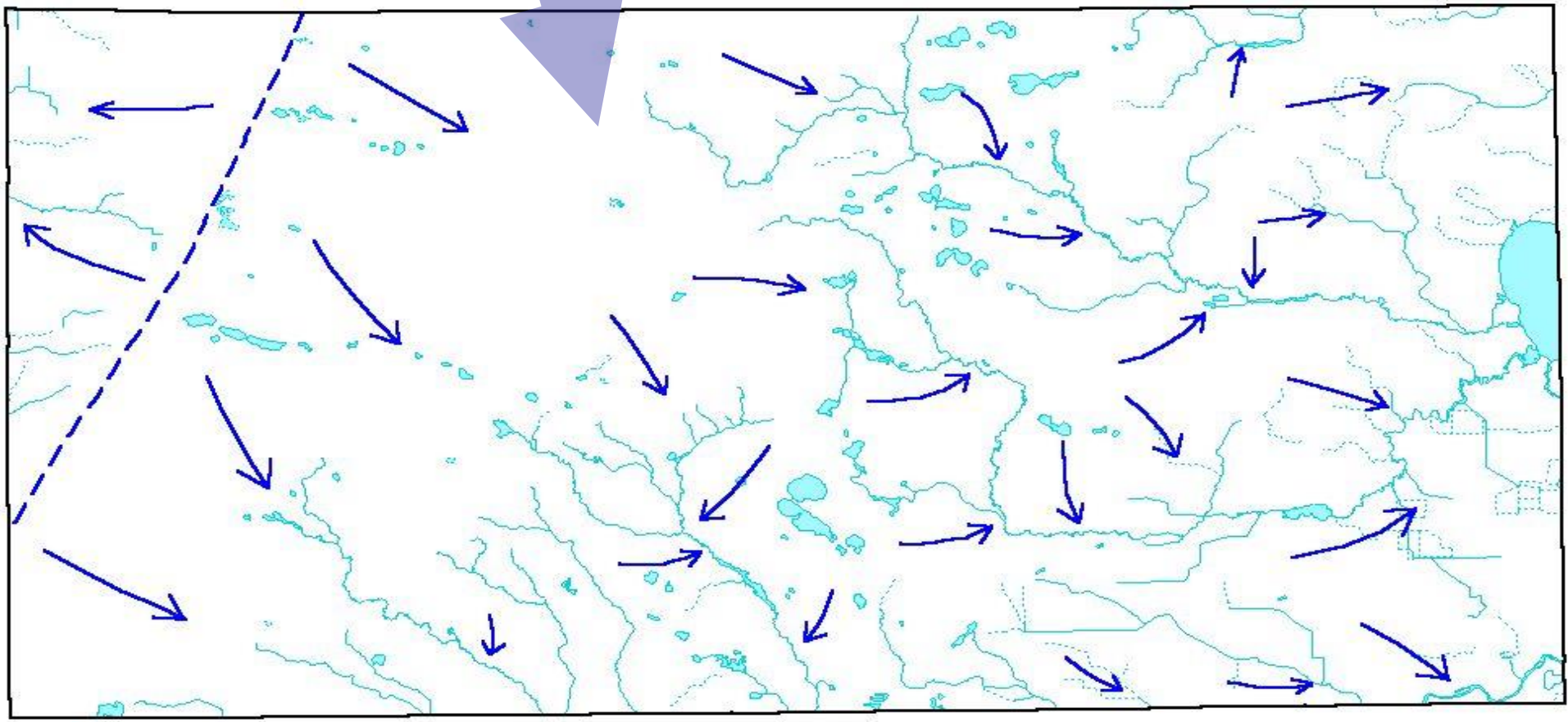

Low Elevation
(L Superior)
32” Precipitation
22” EvapoTrans.
~10” Remains
Low Elevation
(Mississippi R)
Elevation
(L Michigan)

Let's look at this another way…
"Map View"



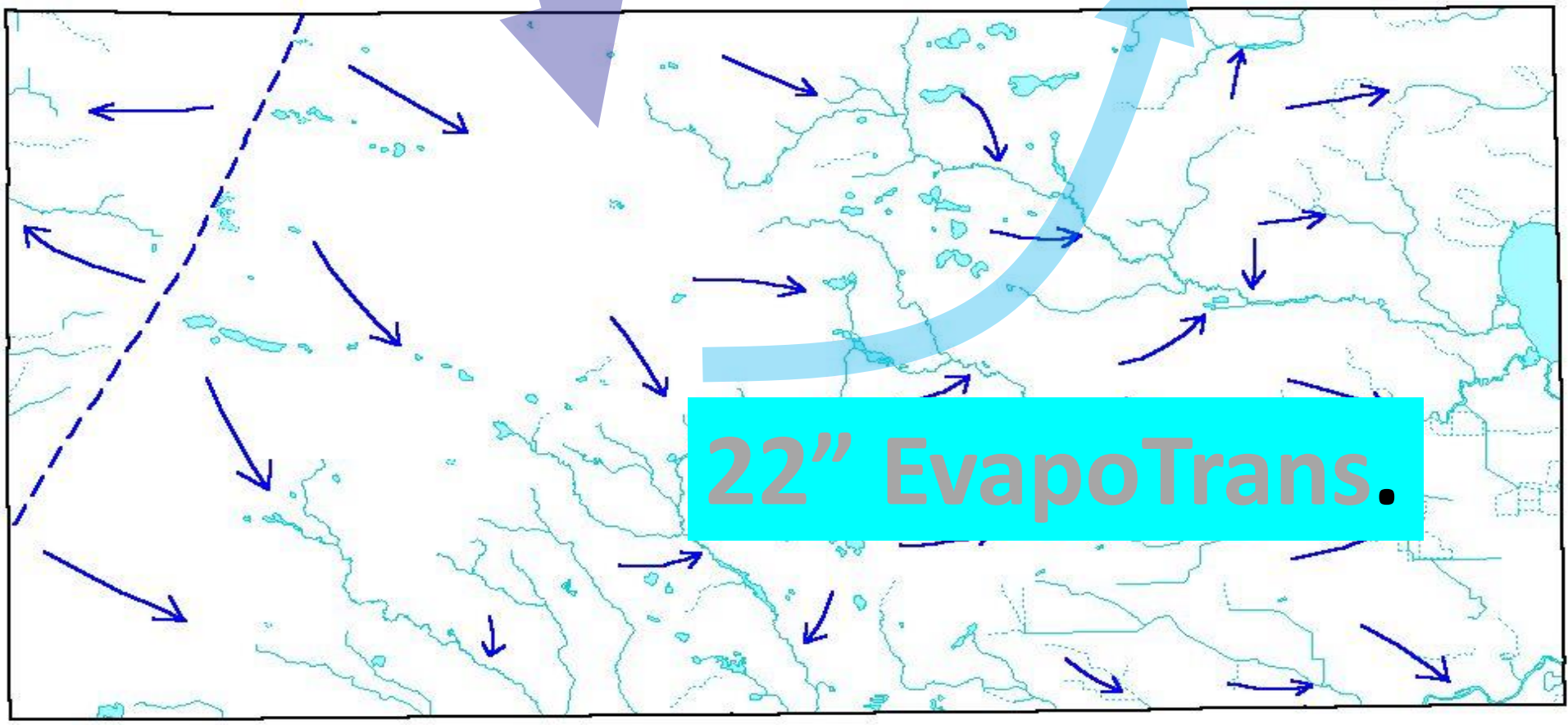
32” Precipitation

And add some water



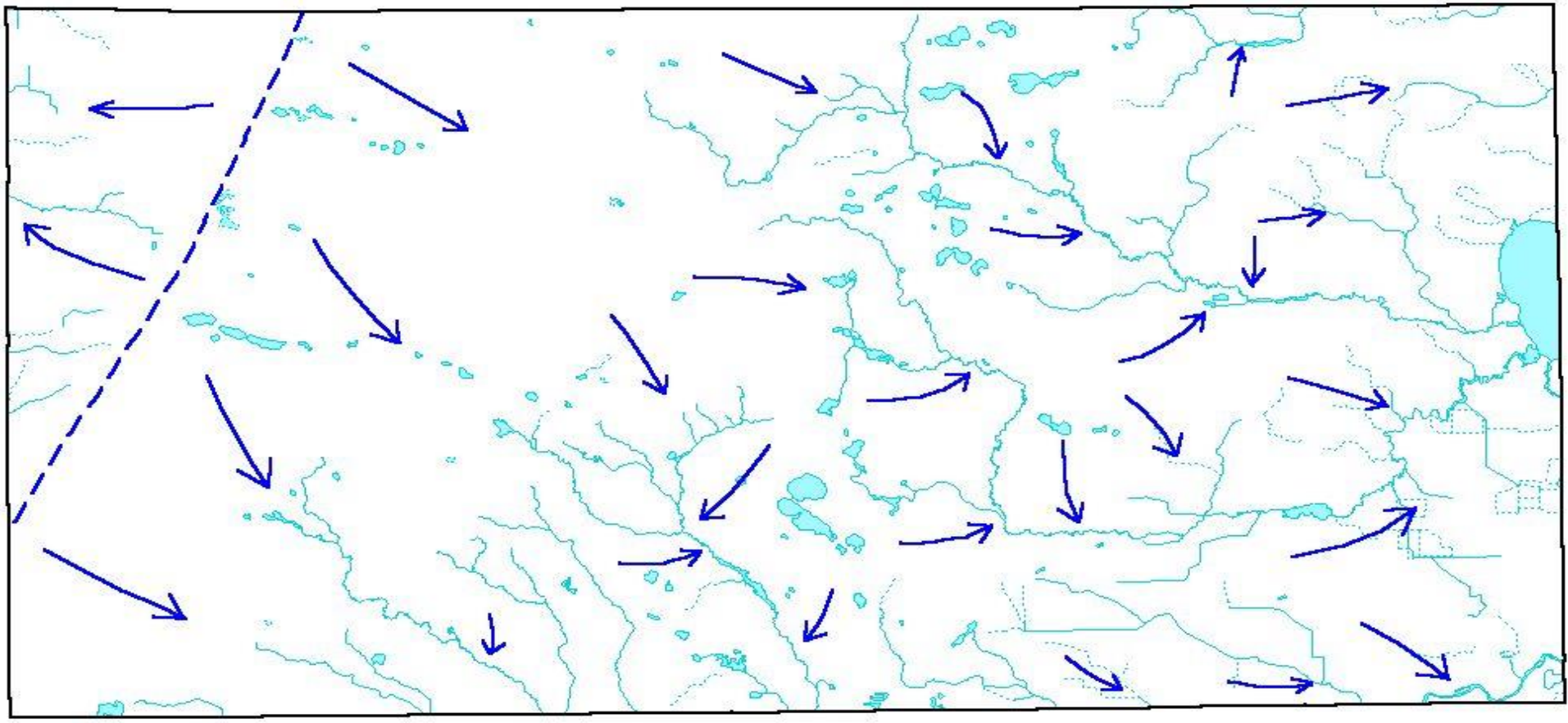
32” Precipitation

And add some water

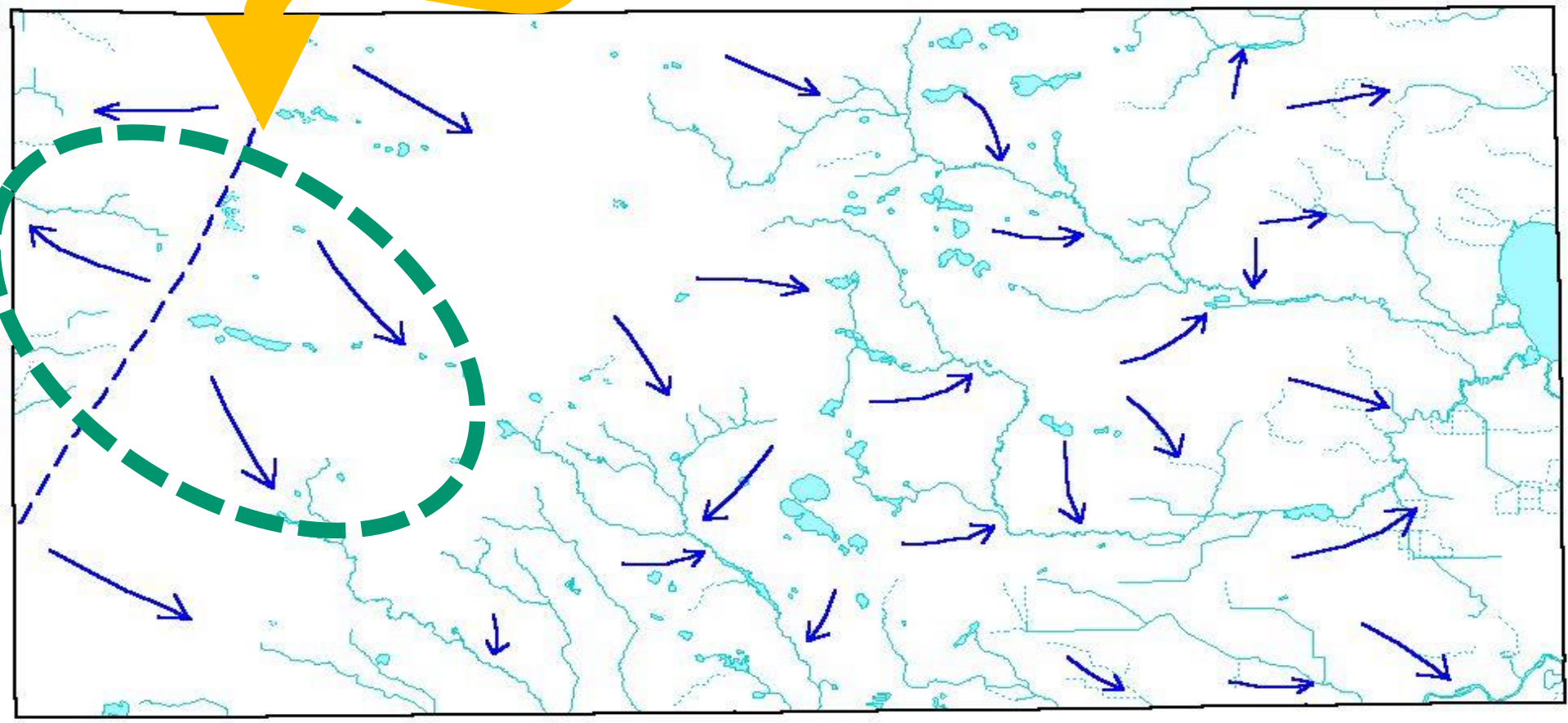


22” EvapoTrans.

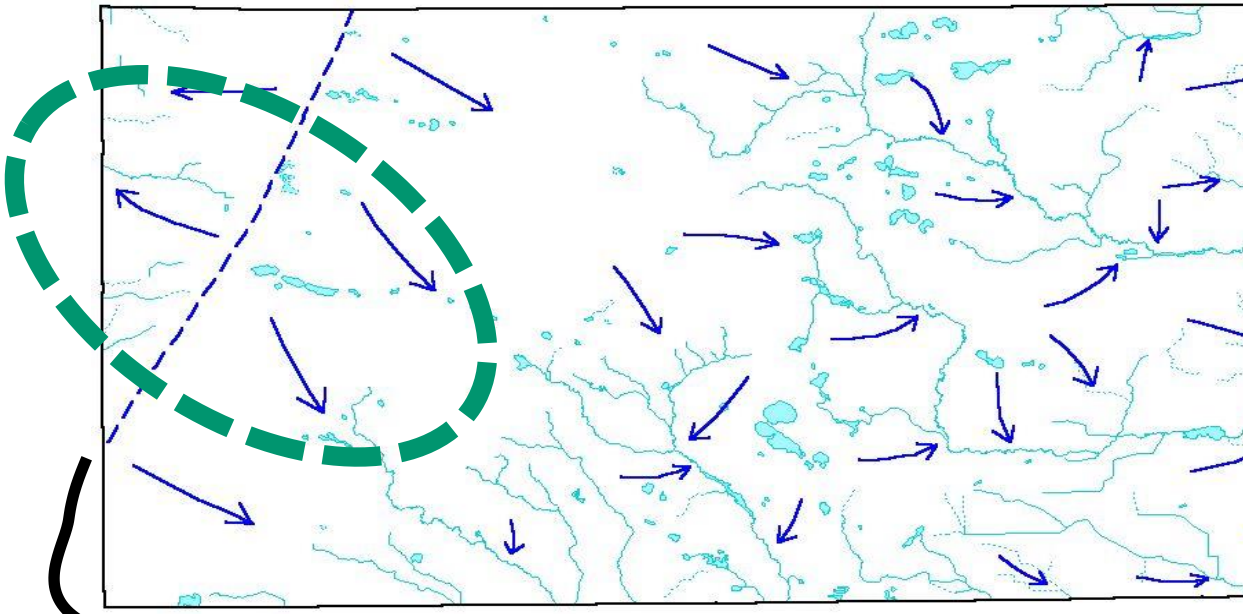
Arrows showing how the remaining water moves, eventually discharges to streams, which then drain to the edges of the state
… but how is it moving?



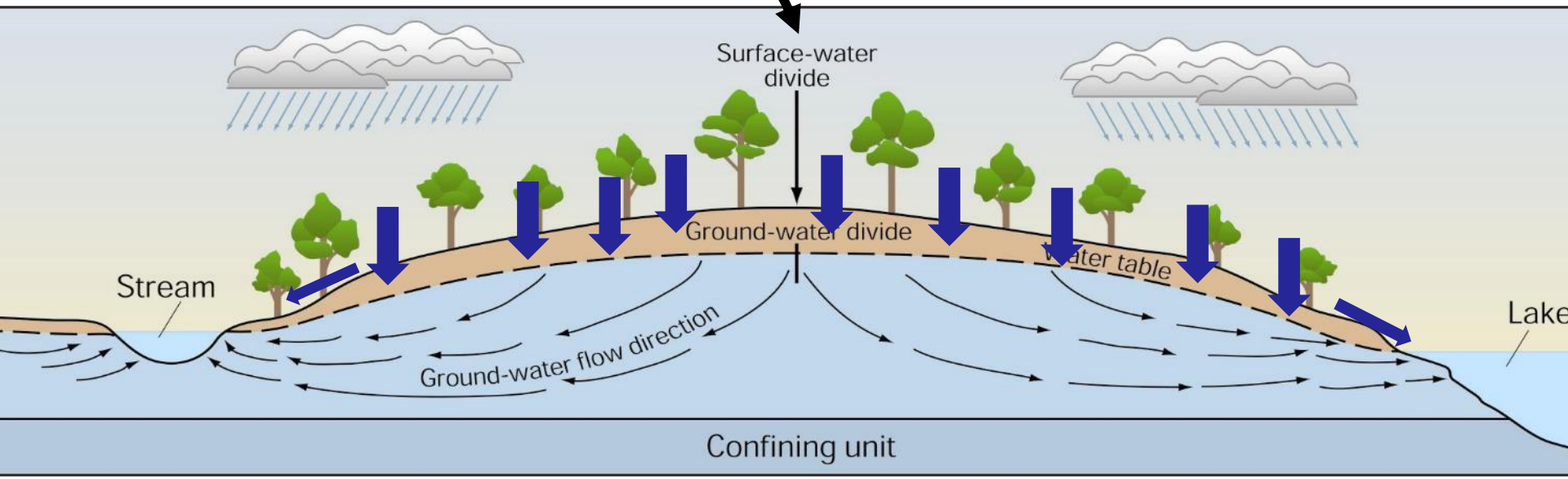
Let's zoom in on one part of this figure, where arrows suggest water going in opposite directions



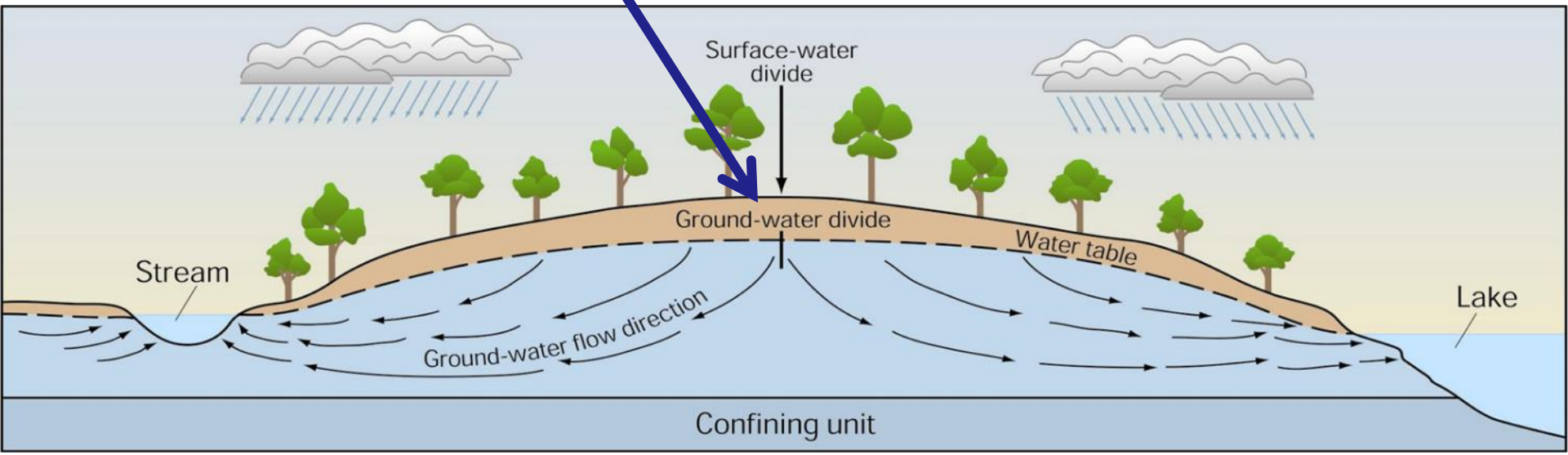
The dashed line is a "watershed divide"



Consider a "Side View" and when we add water

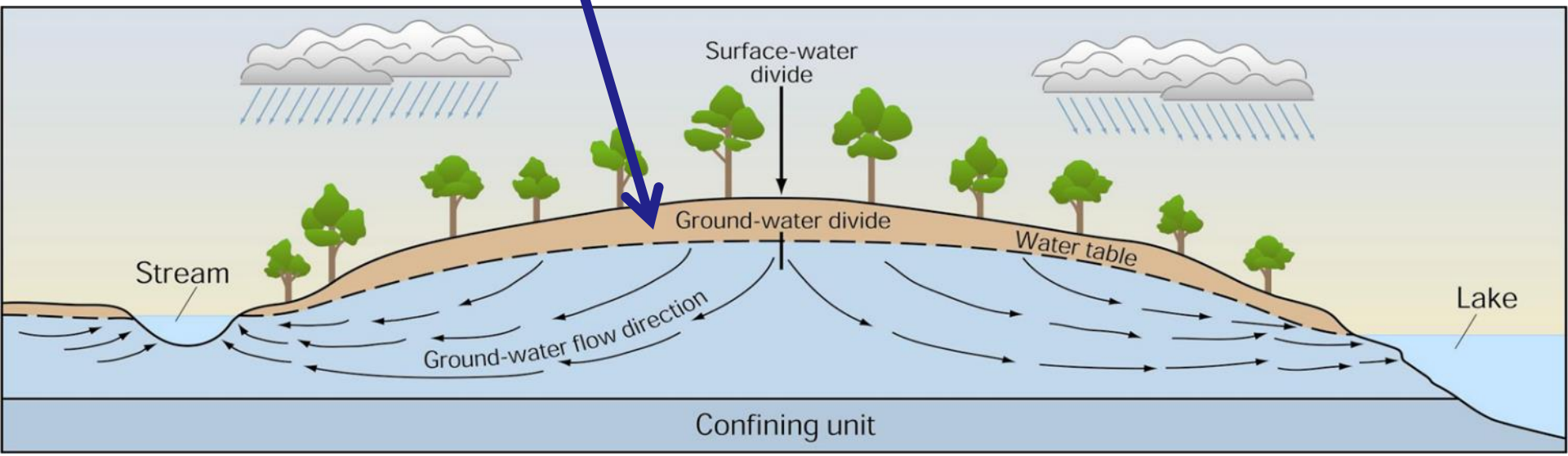


Let's work through some ideas
1) Watershed Divide



- **On one side of the divide it flows one direction, on the other, another direction**

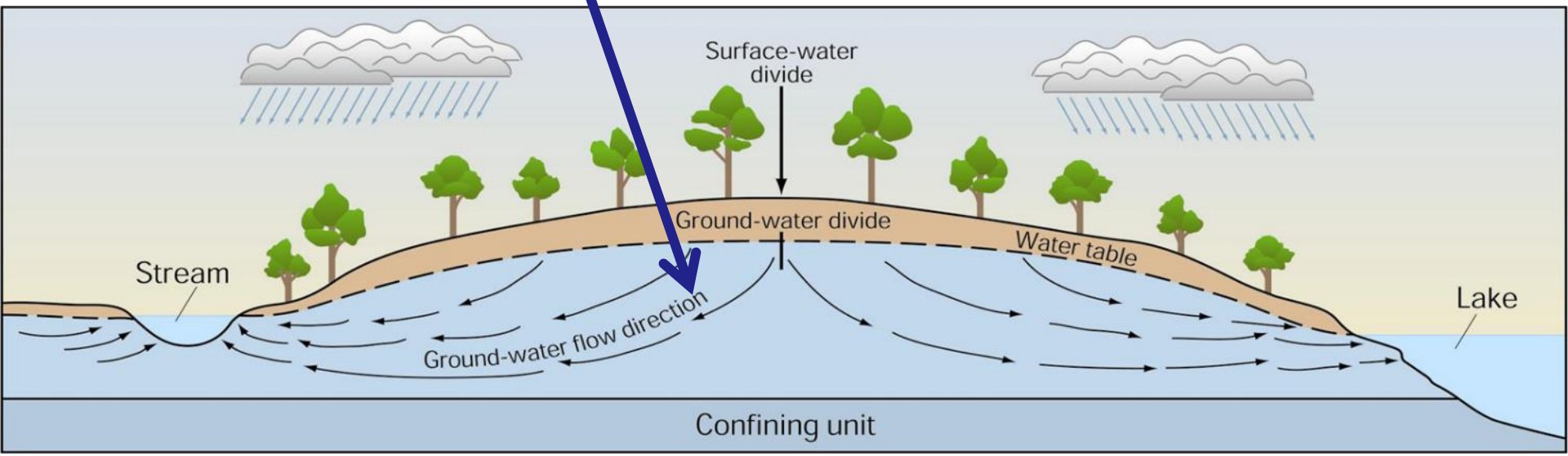
Let's work through some ideas
2) Water Table



- **Remember this groundwater is water in the pores of the sand or rock– but it is continuous water**

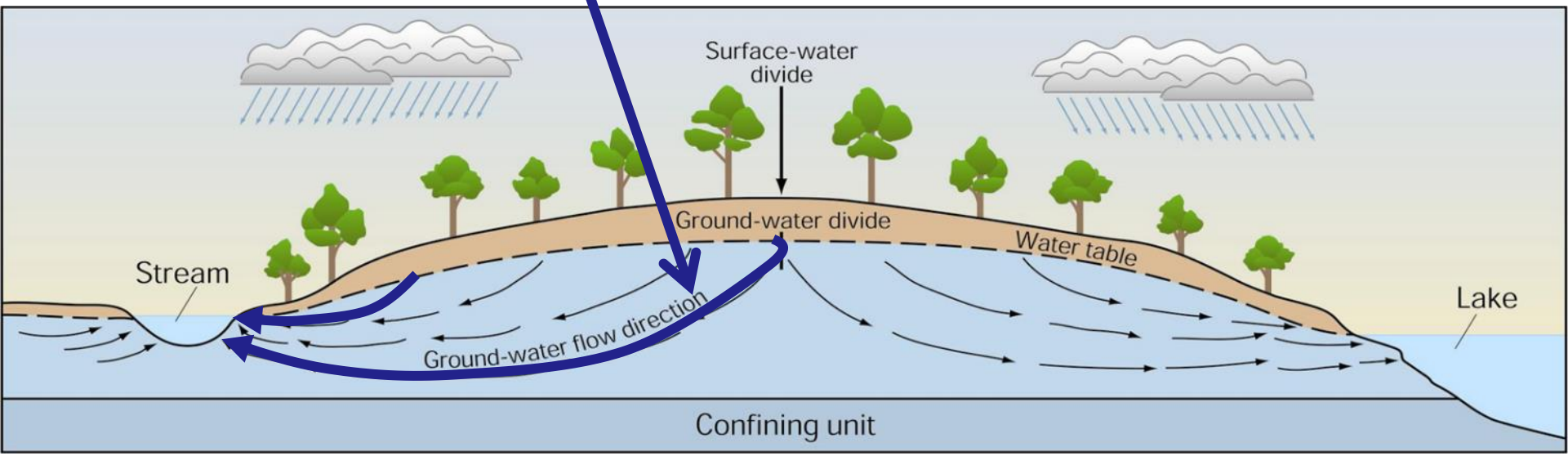
- **The surface of continuous water is the "water table"**

Let's work through some ideas
3) Flow Lines



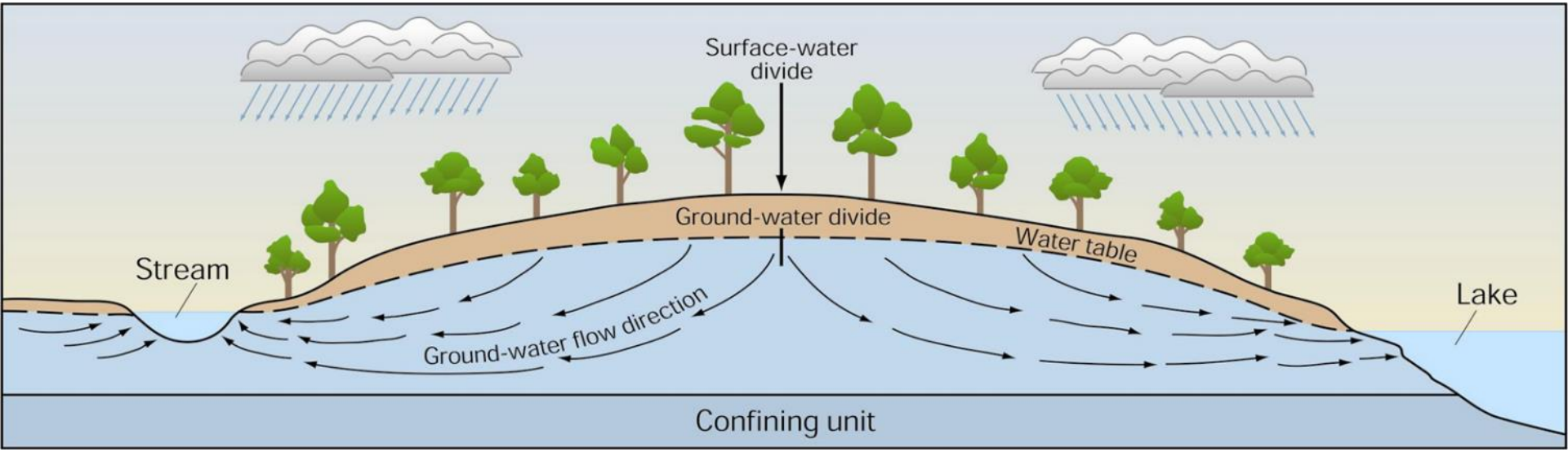
- **The path the groundwater takes is shown along "flow lines"**
- **In the groundwater, the speed of the water may be inches/day to feet/day**
- **(Compare to the stream where it is miles/day)**

Let's work through some ideas
3) Flow Lines



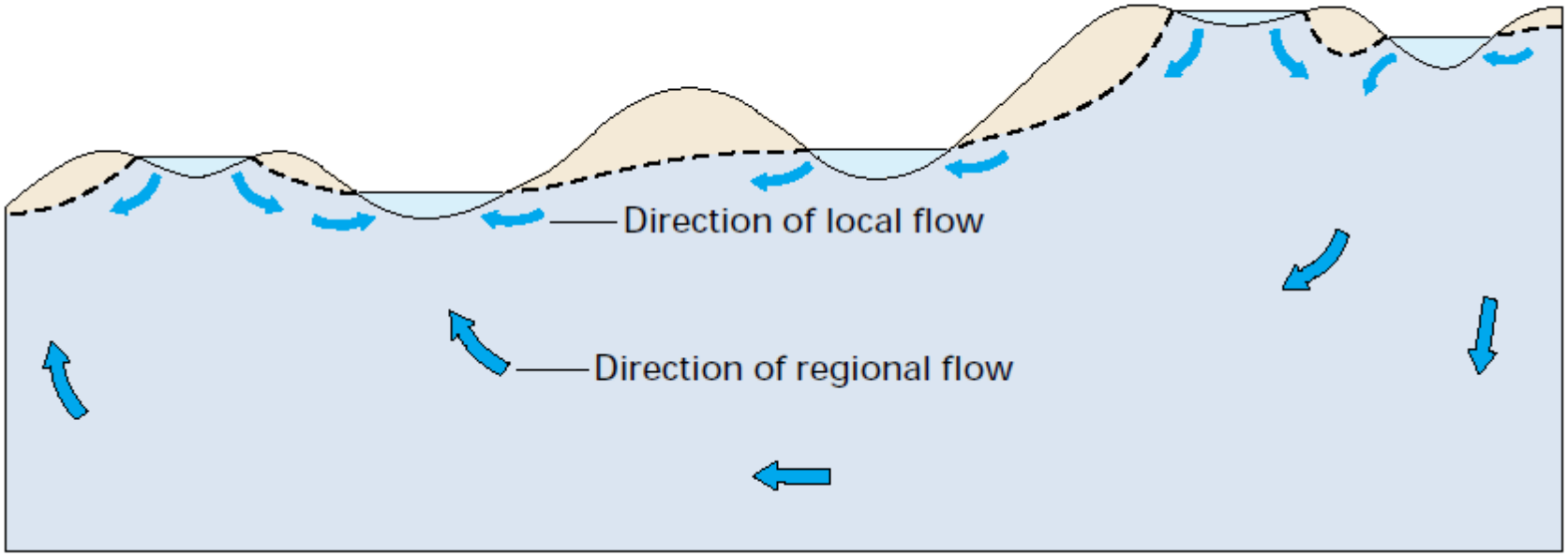
- **Some of the water may spend decades in the ground**
- **Other water may spend a few years (or less)**

And Finally,
4) Connecting with Streams & Lakes



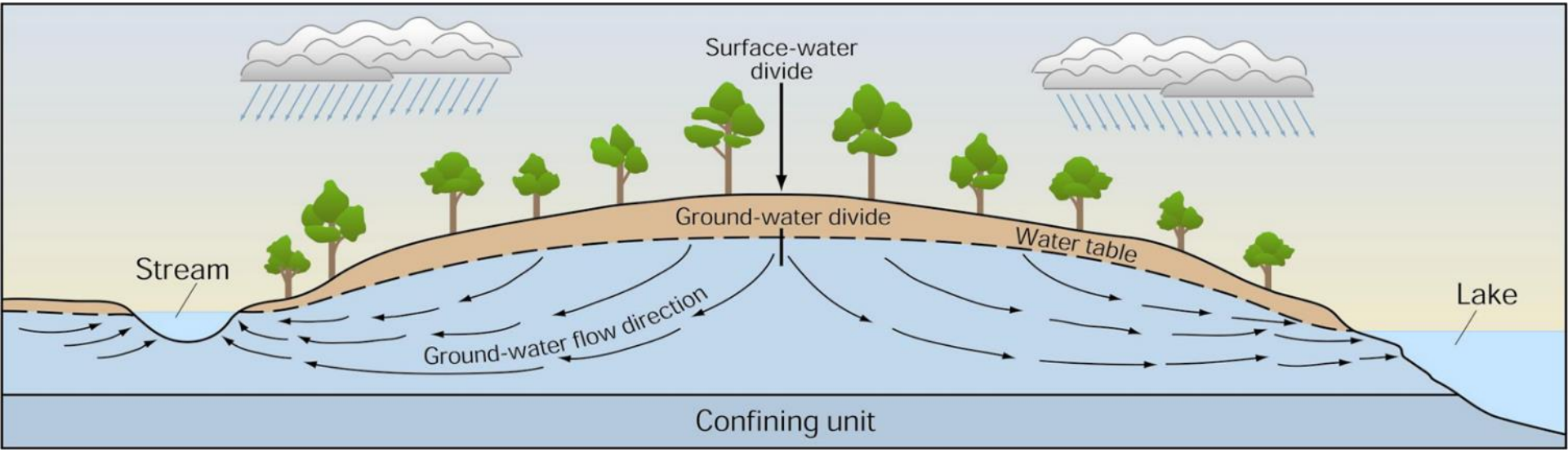
- **Viewing the streams, lakes and wetlands as connected through groundwater**
- **How could we include other examples: seepage lake, marsh in this figure?**

For example, a figure from USGS Publication 1139 (page 46)



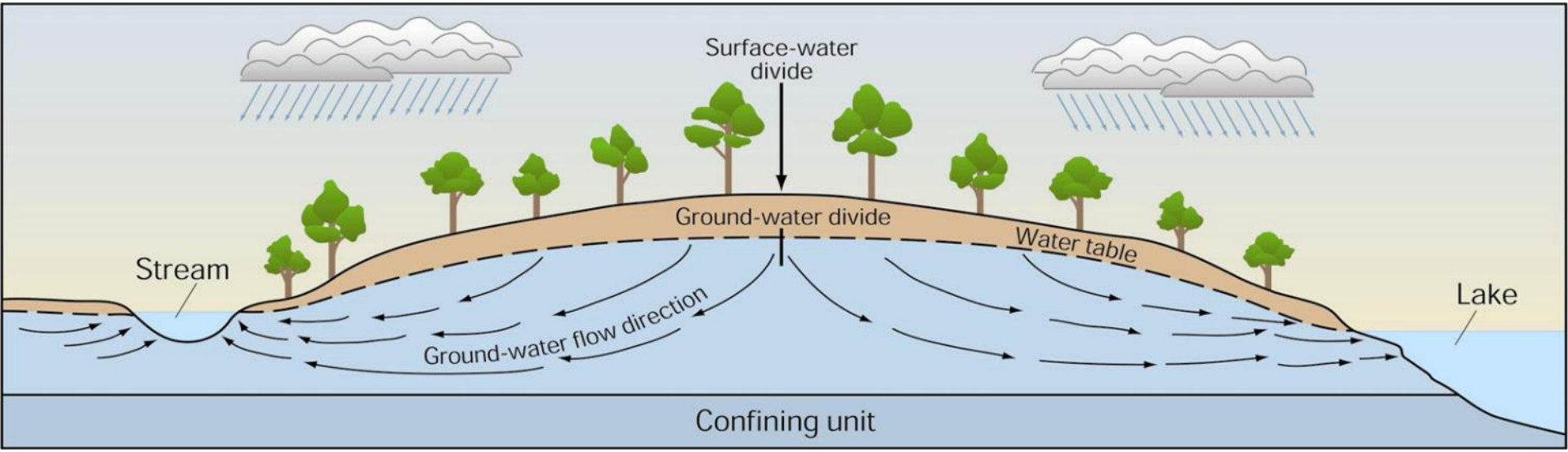
- **Showing a more complex topography and groundwater pathway network**

Let's Review



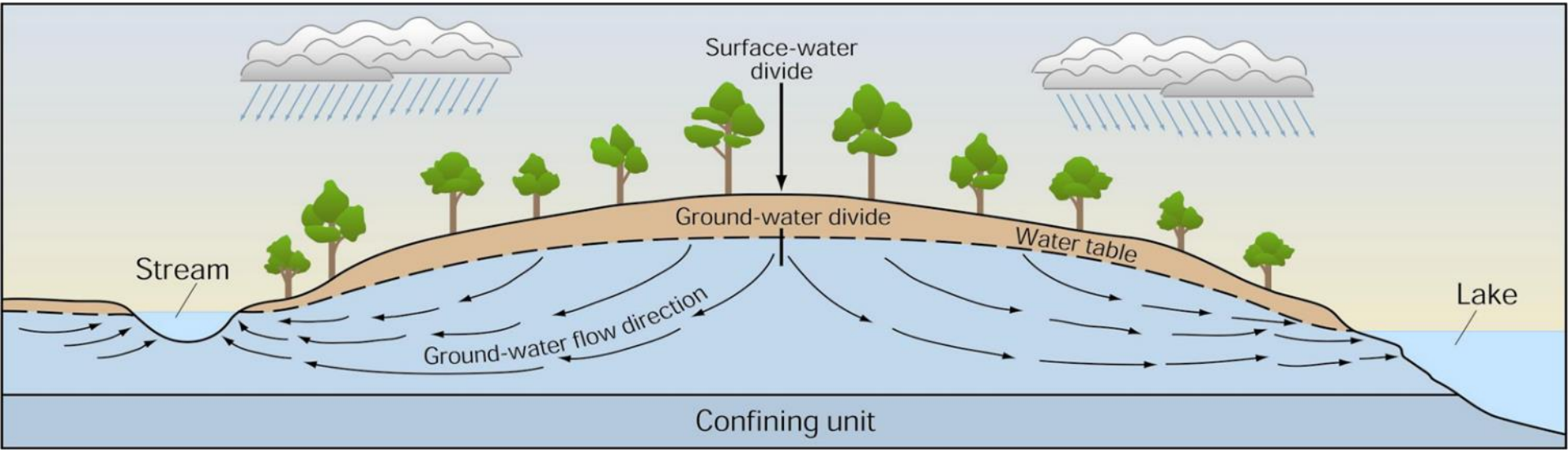
- **The topography and addition of water create a flowing groundwater system and a connected network of surface waters**

Let's map the "water table"



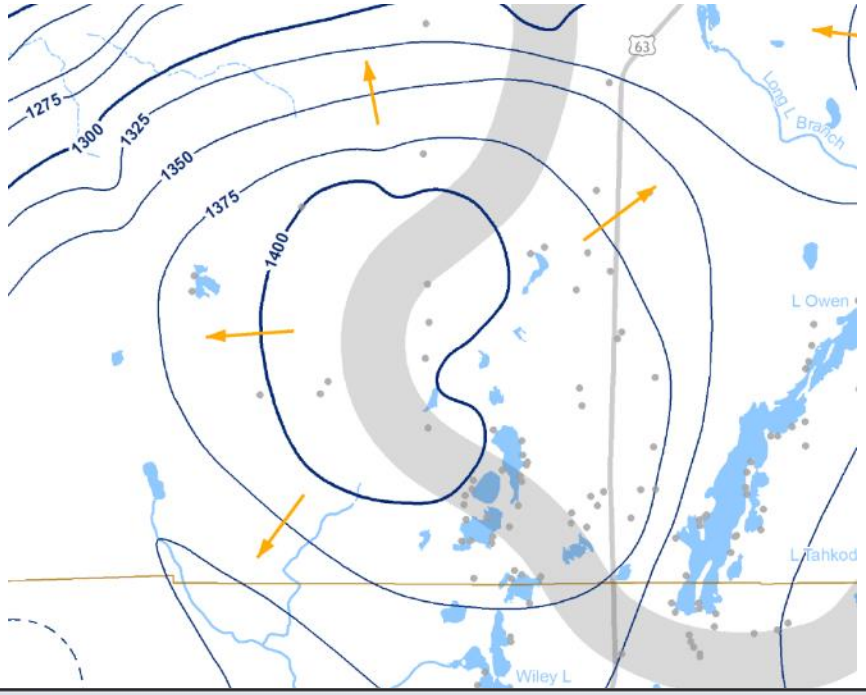
- **If the water input is somewhat similar year-to-year, and the flow out is roughly balanced with the flow in– the system is at a "steady-state"**

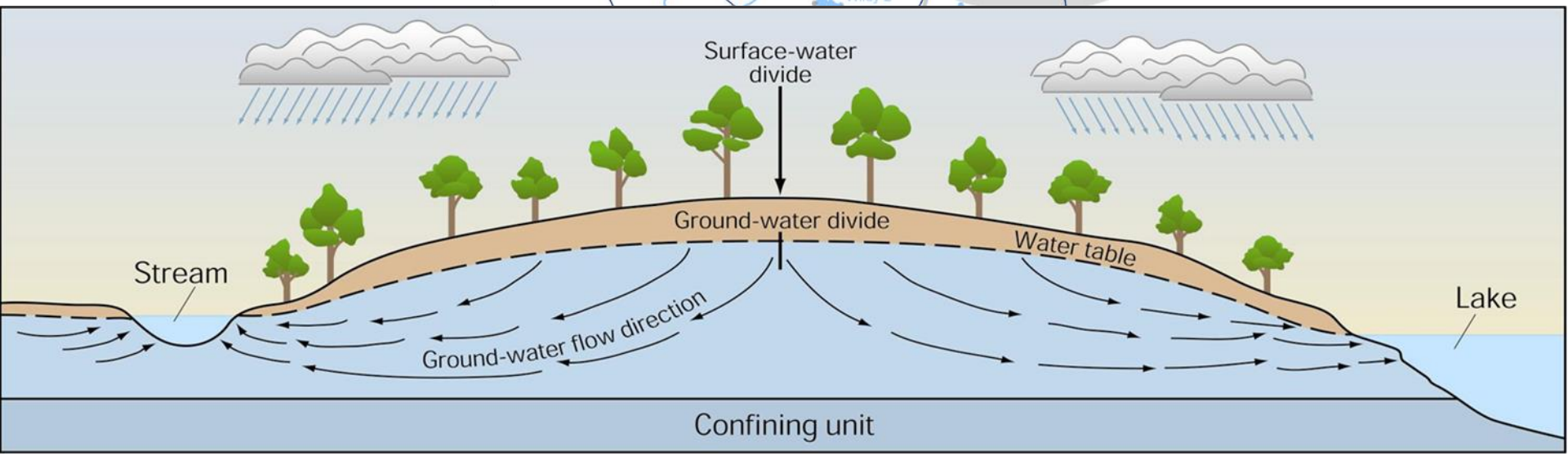
6) Water Table Mapping



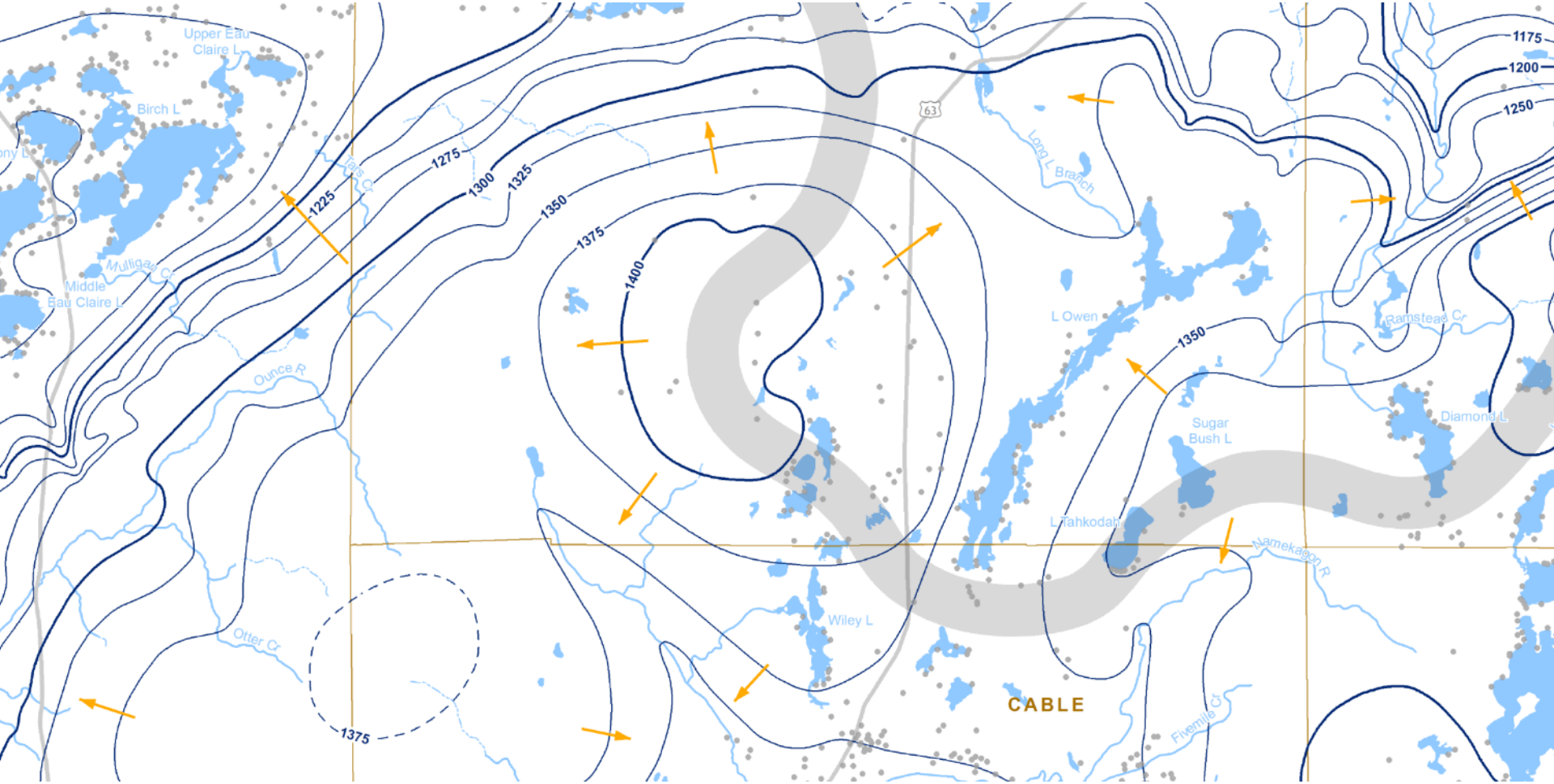
- **Could we create a map showing the water table surface just like we map elevation of the land?**

Such a map might look something like this…





Here's an example… just north of Hayward

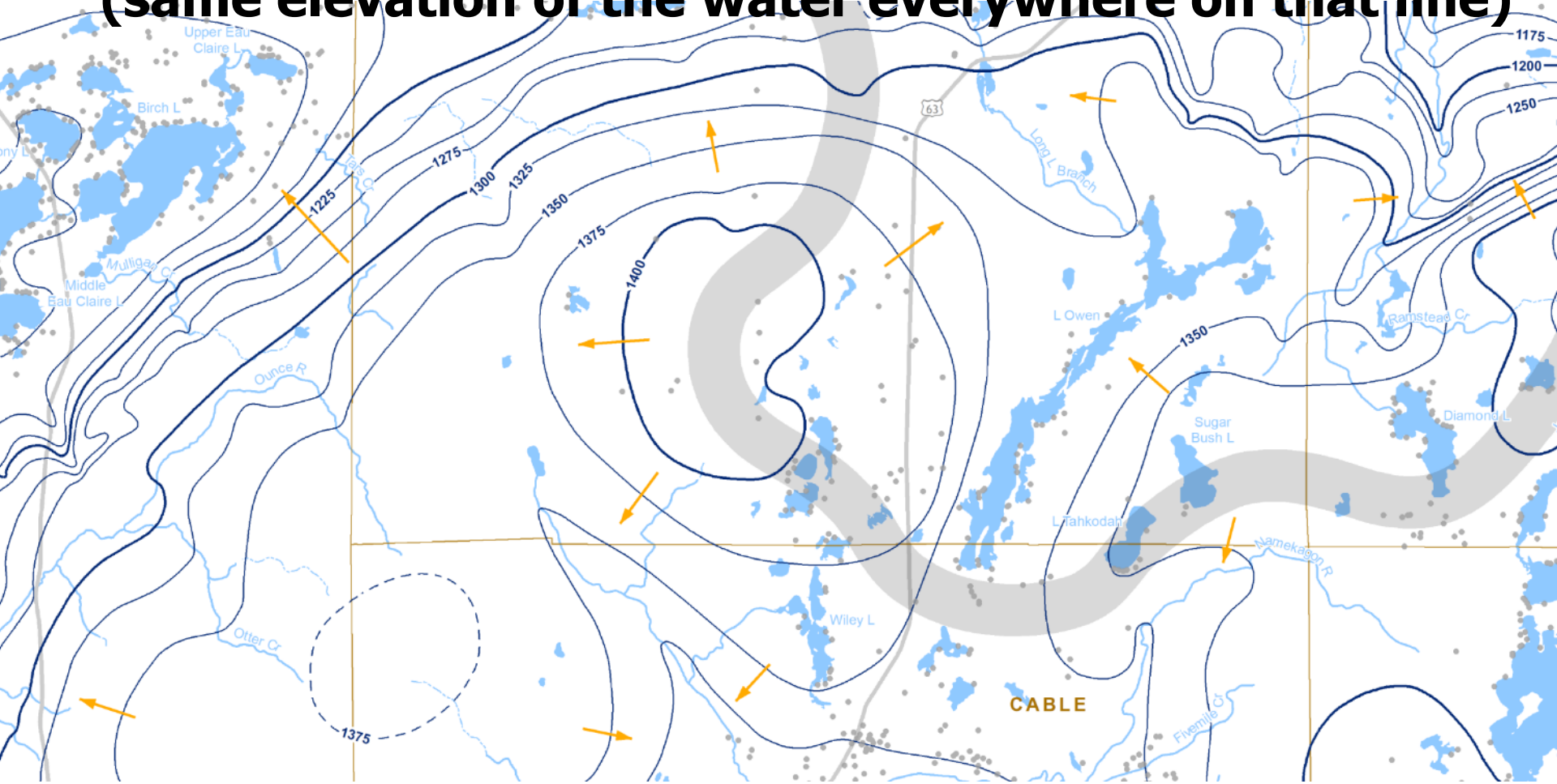


Generalized water-table elevation map for Bayfield County, Wisconsin

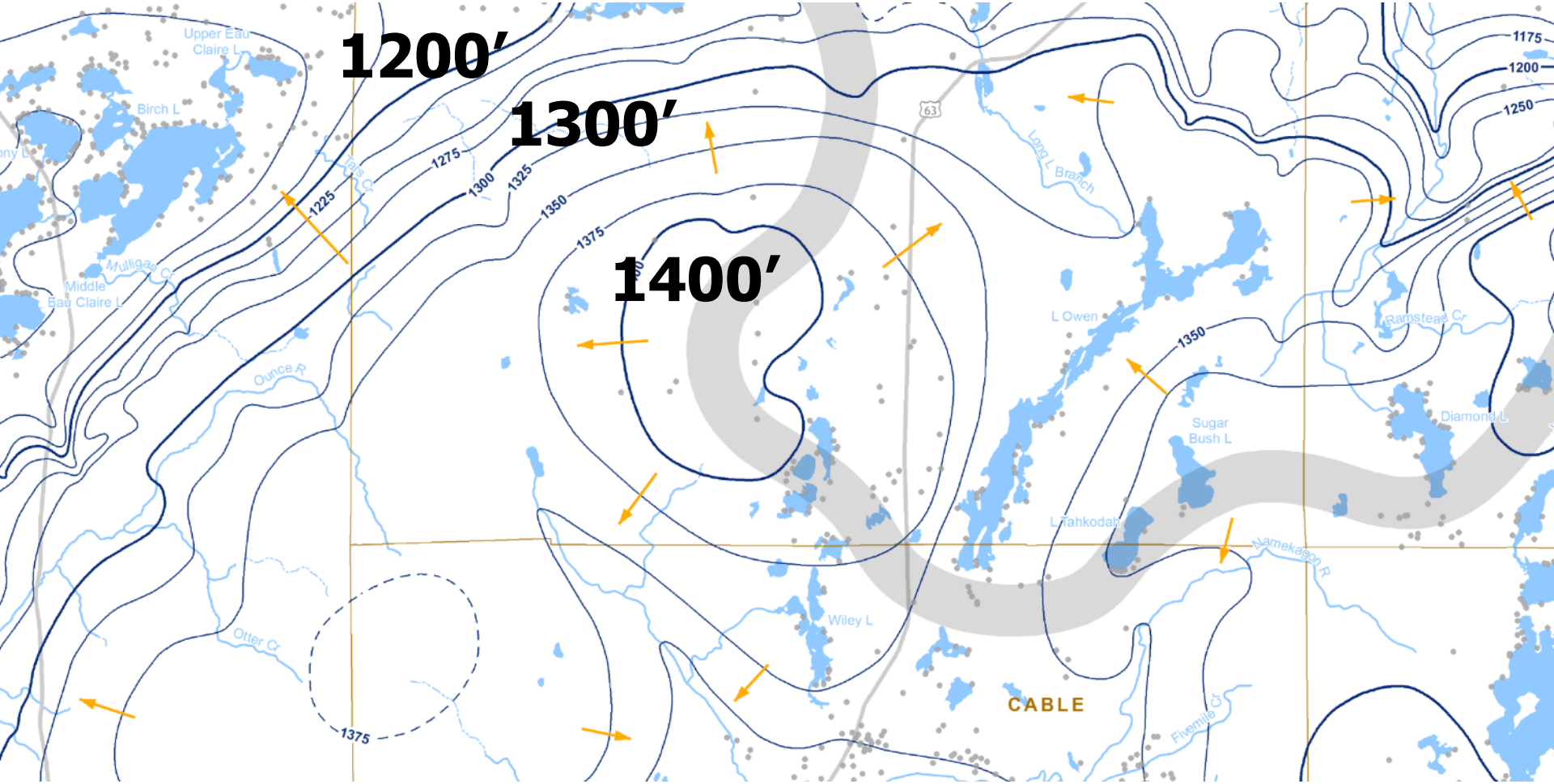
Anna C. Fehling and Madeline B. Gotkowitz
Open-File Report 2017-02, Plate 1, 2017

(this is available from the Wisconsin Geologic & Natural History Survey https://wgnhs.wisc.edu/pubs/wofr201702plate01/)

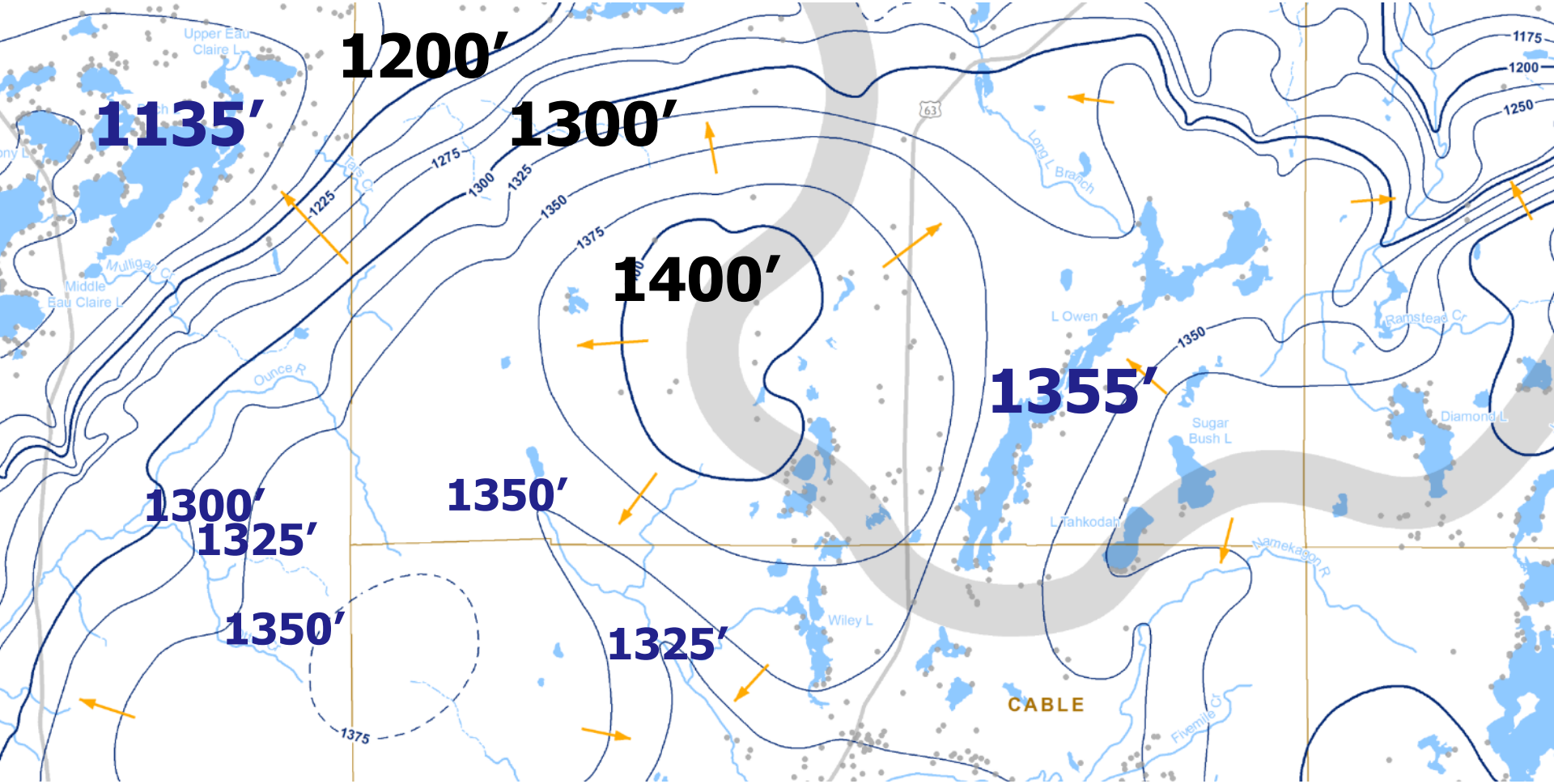
Groundwater Contours
(same elevation of the water everywhere on that line)



Water table elevations

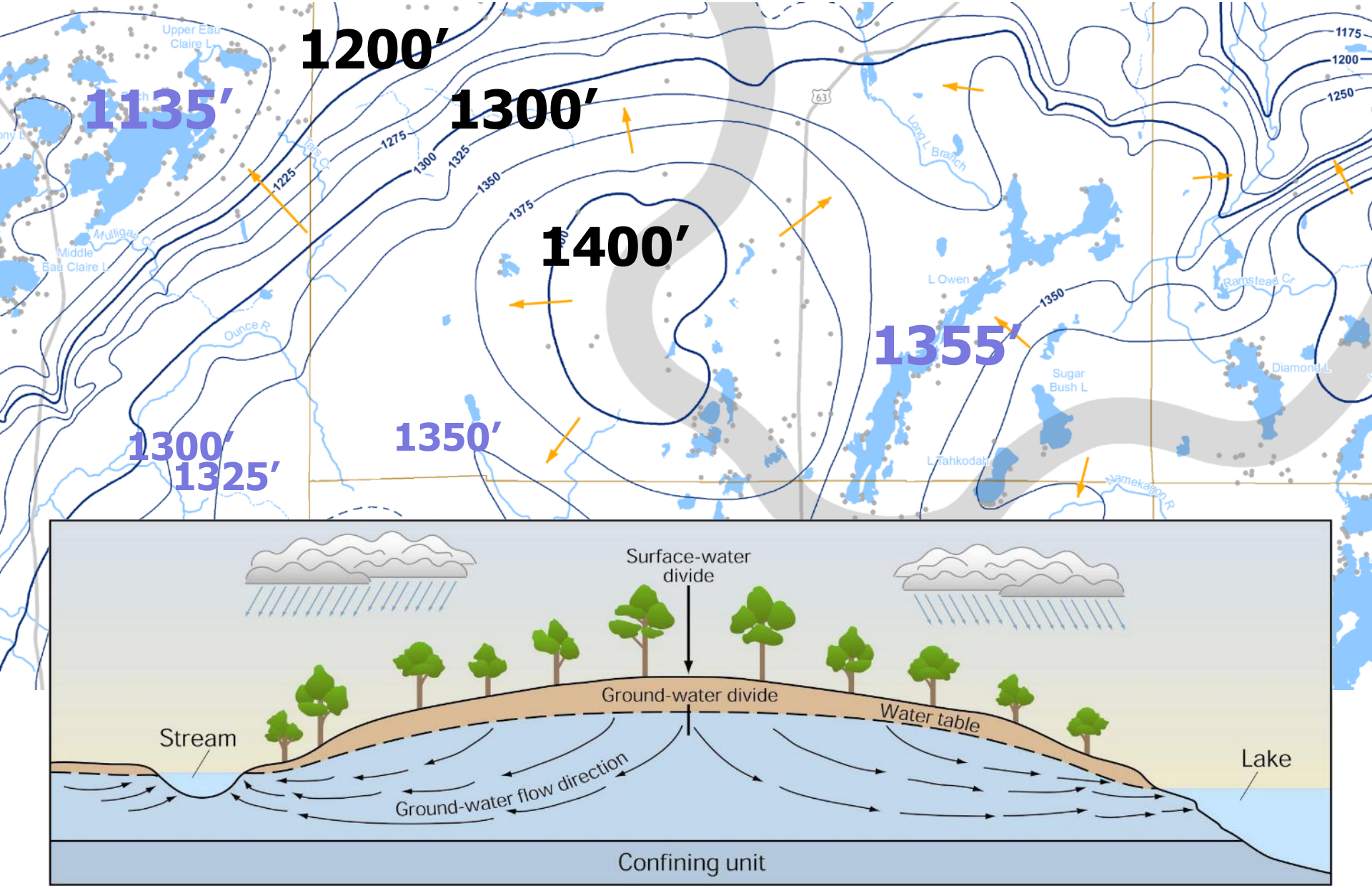


Water table elevations



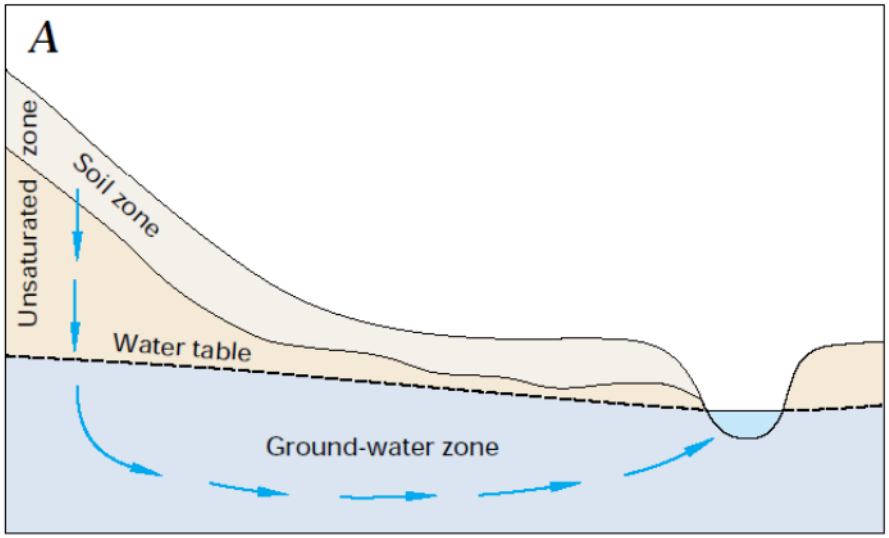
Water Surface Elevations

Water table elevations



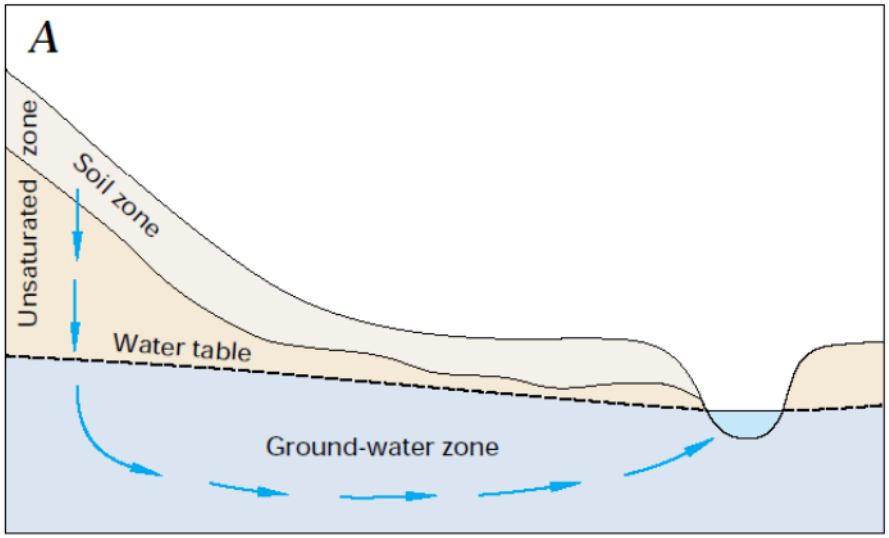
Let’s Get In the Stream!

Let's Get In the Stream!

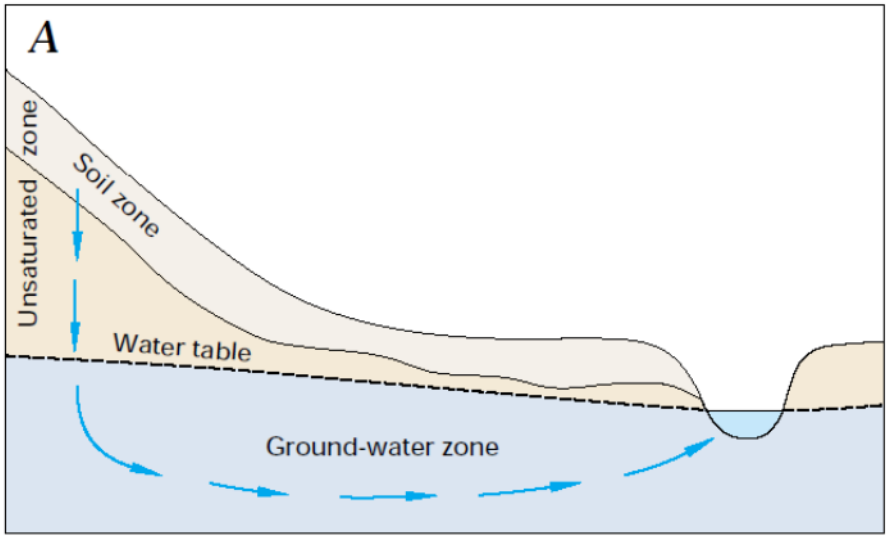


- **Groundwater discharges to wetlands, lakes and streams**
- **Provides a "base" flow to these resources**

- In the groundwater
  - Short paths and long paths
  - Years (or less) to Decades (or more)
  - This provides the “base” flow in a stream

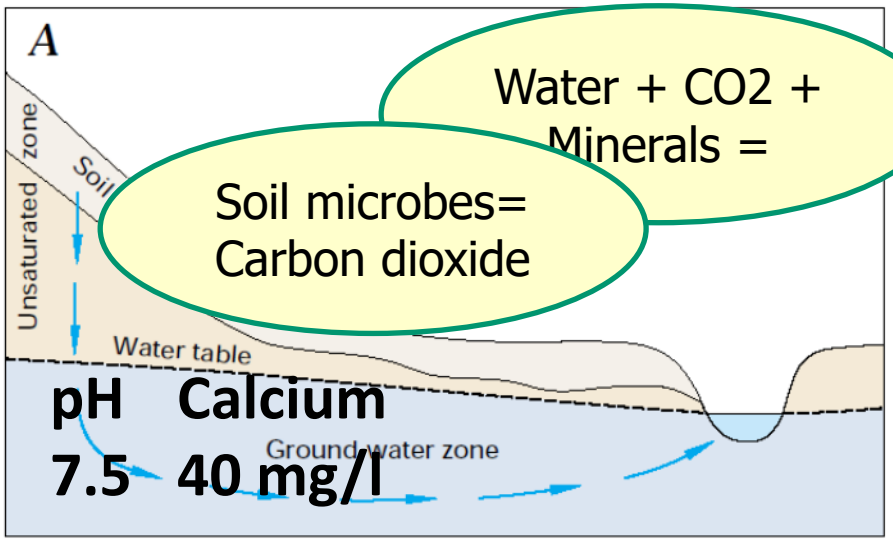


- Can see this connection in water composition
  - Groundwater chemistry reflects the geology of its pathway



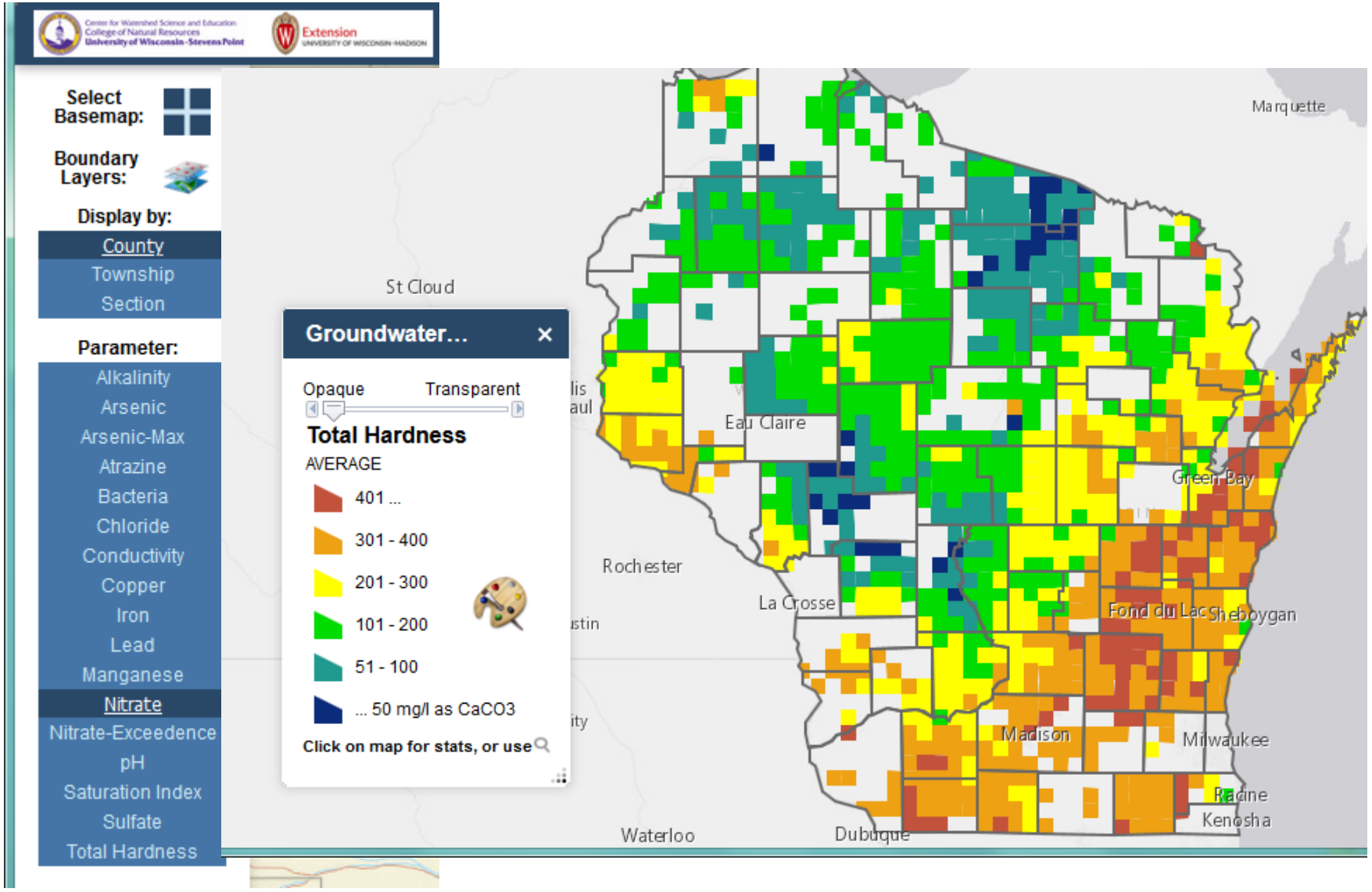
Calcium
0.3 mg/l

pH
5.5



(As a result of geology and nature of the flow paths,
the chemistry of streams (and lakes, and wetlands) will vary across Wisconsin)

- Clues to this can be found in the Wisconsin Well Water Viewer (https://www.uwsp.edu/cnr-ap/watershed)



Might be a good time to talk about a "Watershed"

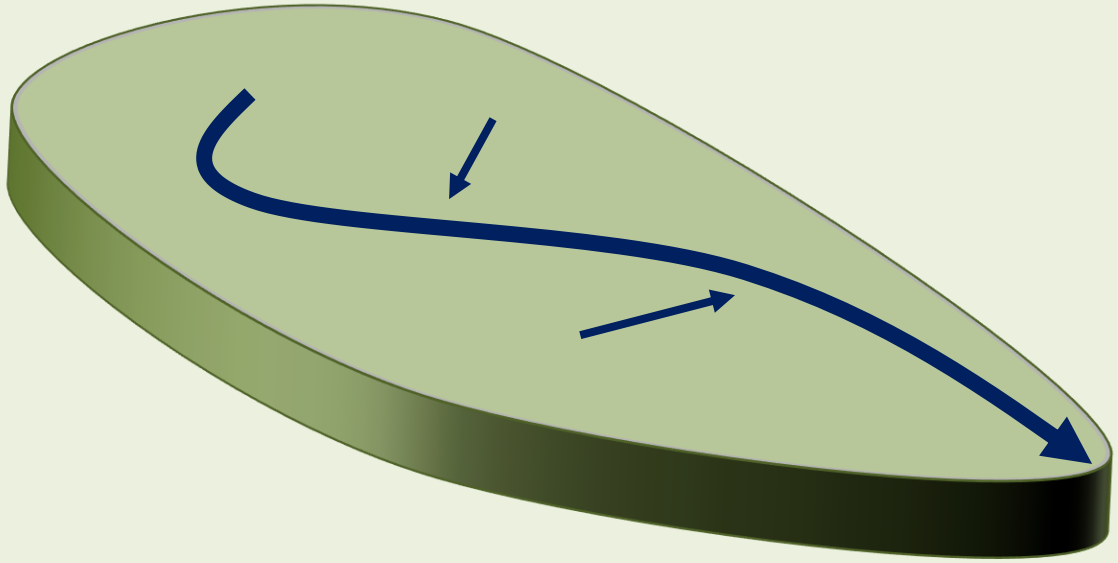
Land area where the water drains to the outlet point

Land area where the water drains to the outlet point

Land area where the water drains to the outlet point

Last revised: Thursday December 19 2019

The further upstream the outlet point, the smaller the watershed

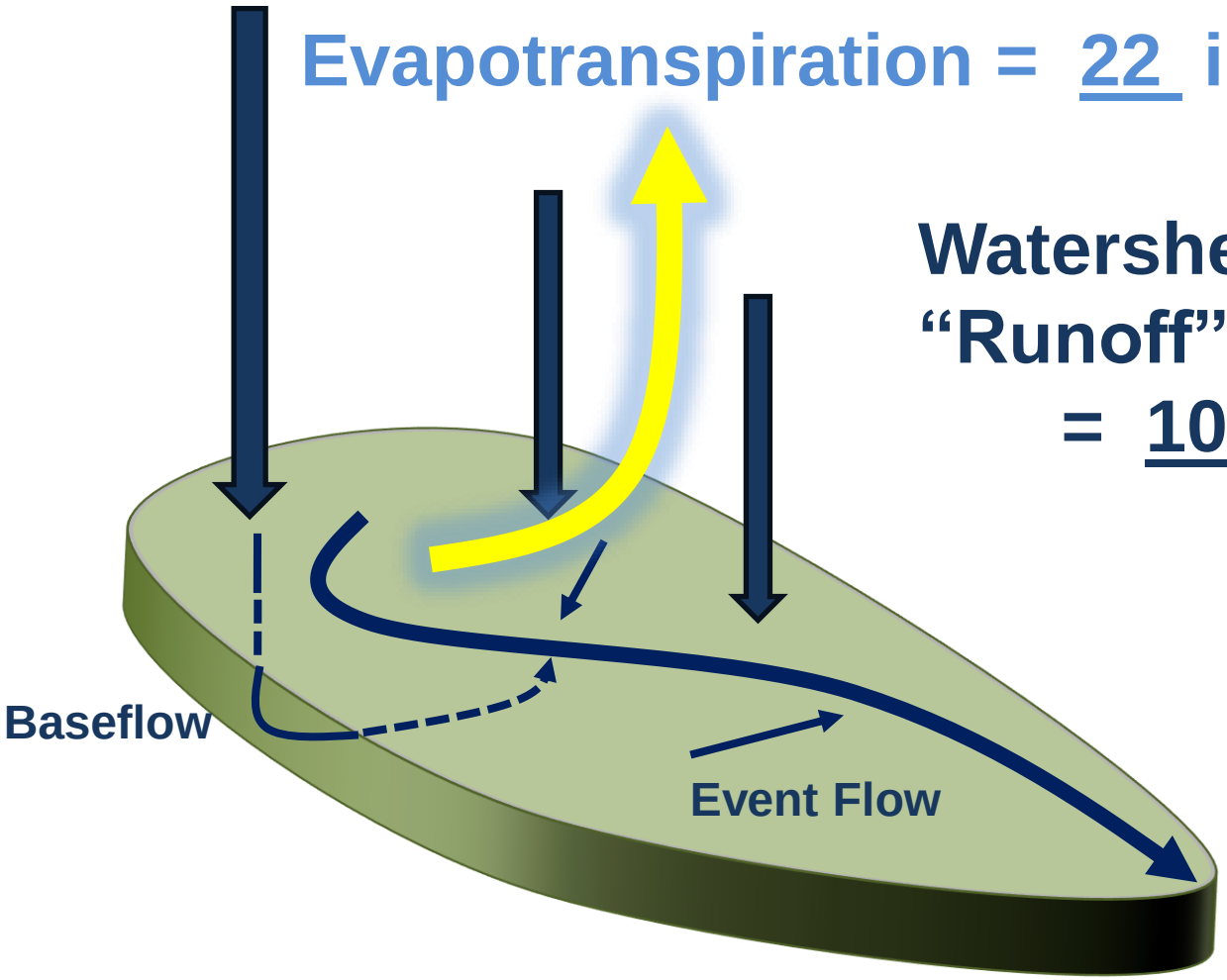


Land area where the water drains to the outlet point of interest

Precipitation = 32 inches/yr

Evapotranspiration = 22 inches/yr

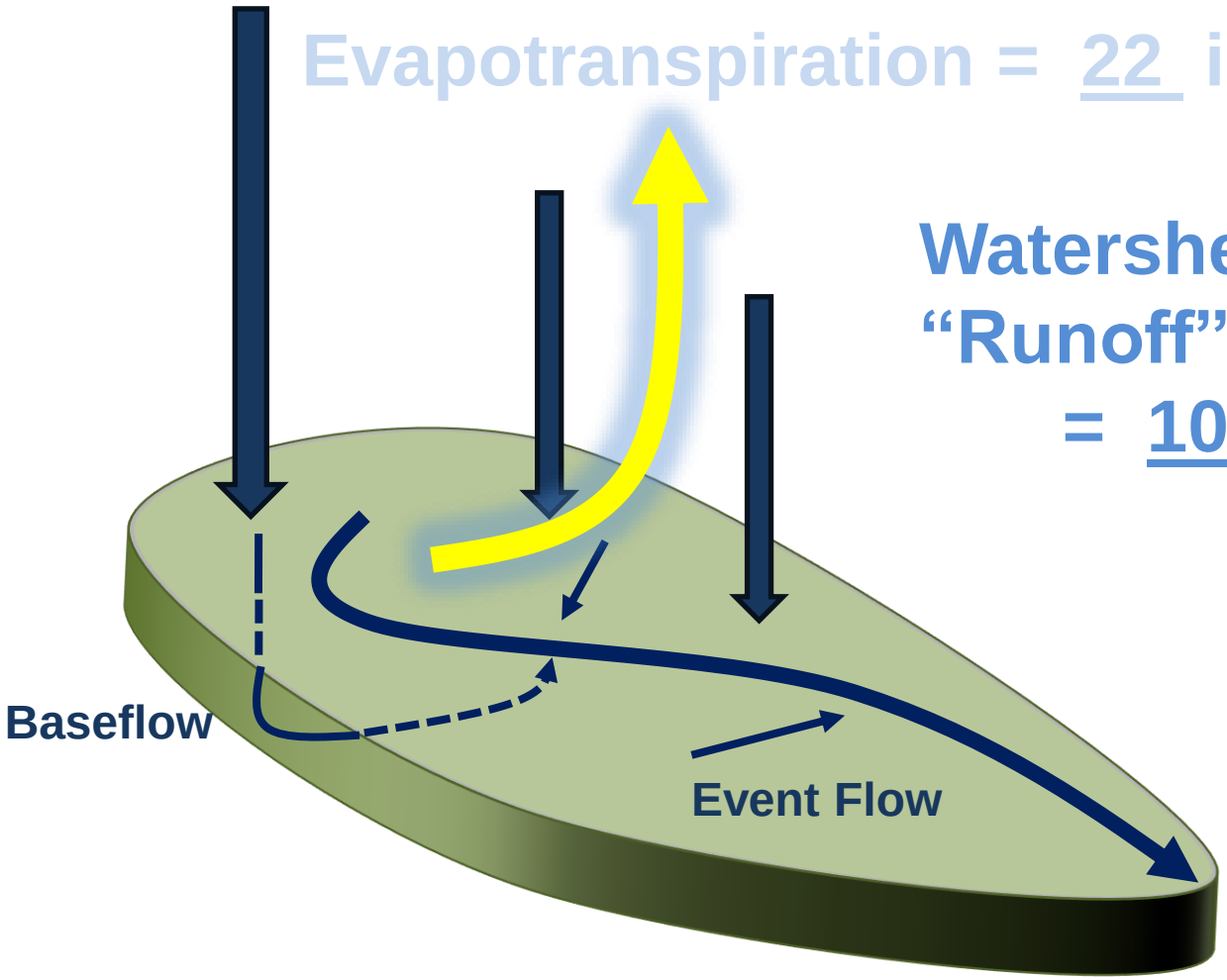
Watershed "Runoff" = 10 inches/yr



And each watershed has rain, evapotranspiration etc

Precipitation = 32 inches/yr

Evapotranspiration = 22 inches/yr



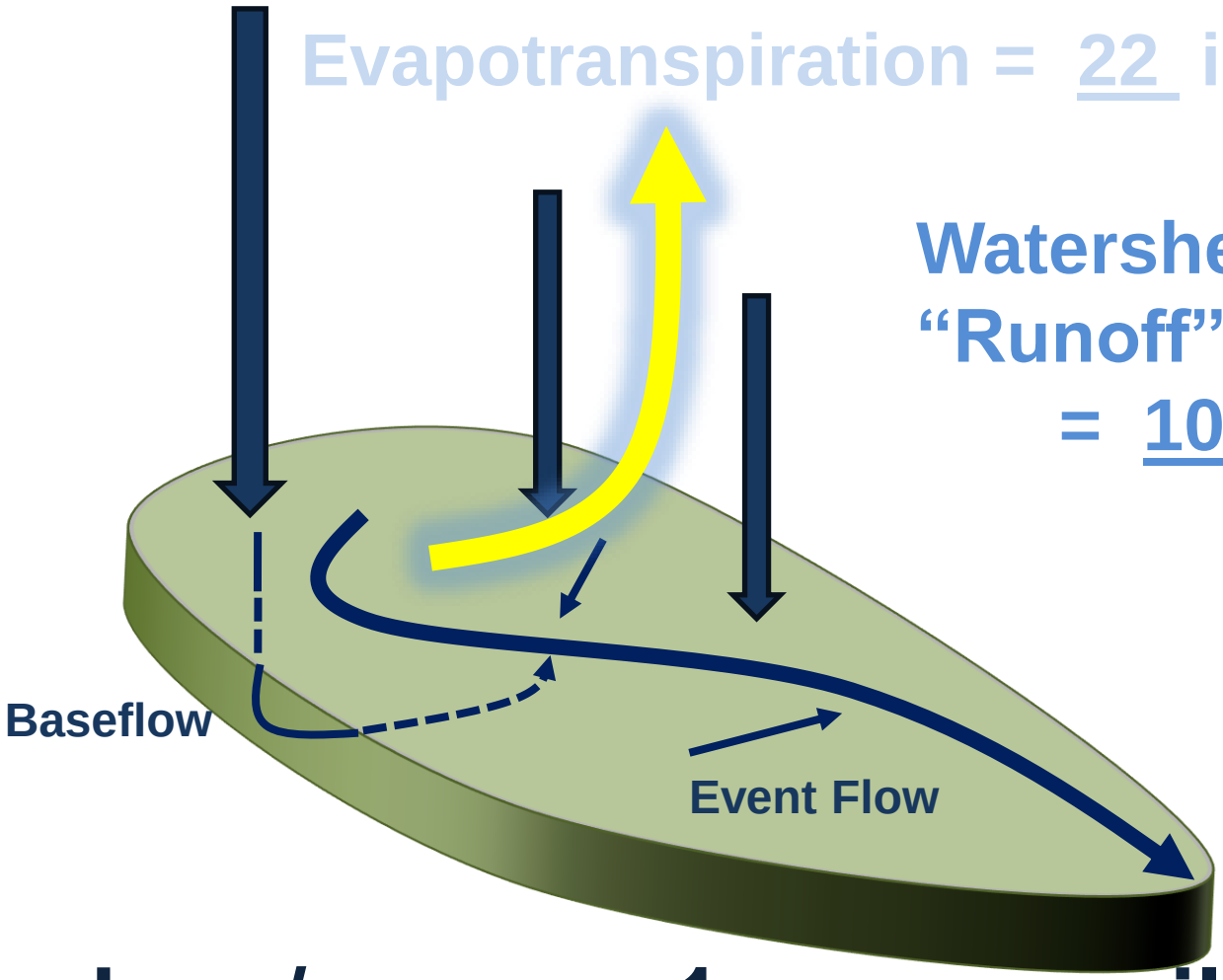
Watershed "Runoff" = 10 inches/yr

10 inches /year on 1 square mile…

= 23,000,000 cubic feet /year!

Precipitation = 32 inches/yr

Evapotranspiration = 22 inches/yr



Watershed "Runoff" = 10 inches/yr

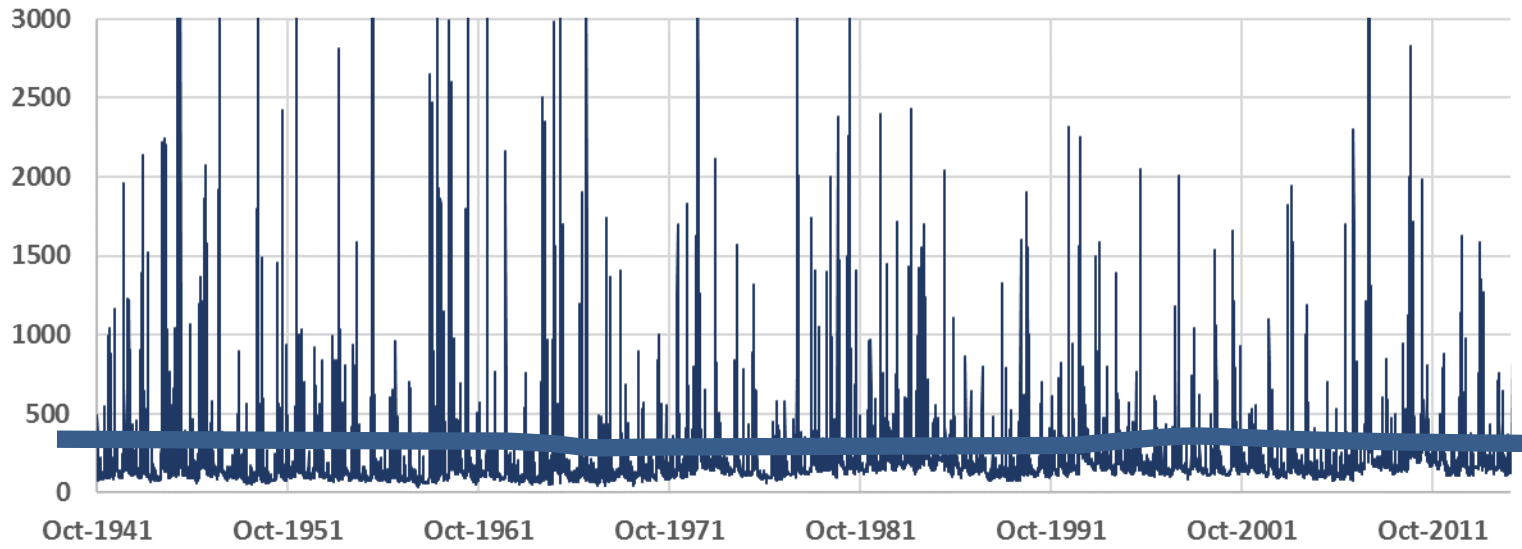
10 inches /year on 1 square mile…

= 23,000,000 cubic feet /year!

= 0.7 cubic foot every second!

Let’s look at some watersheds

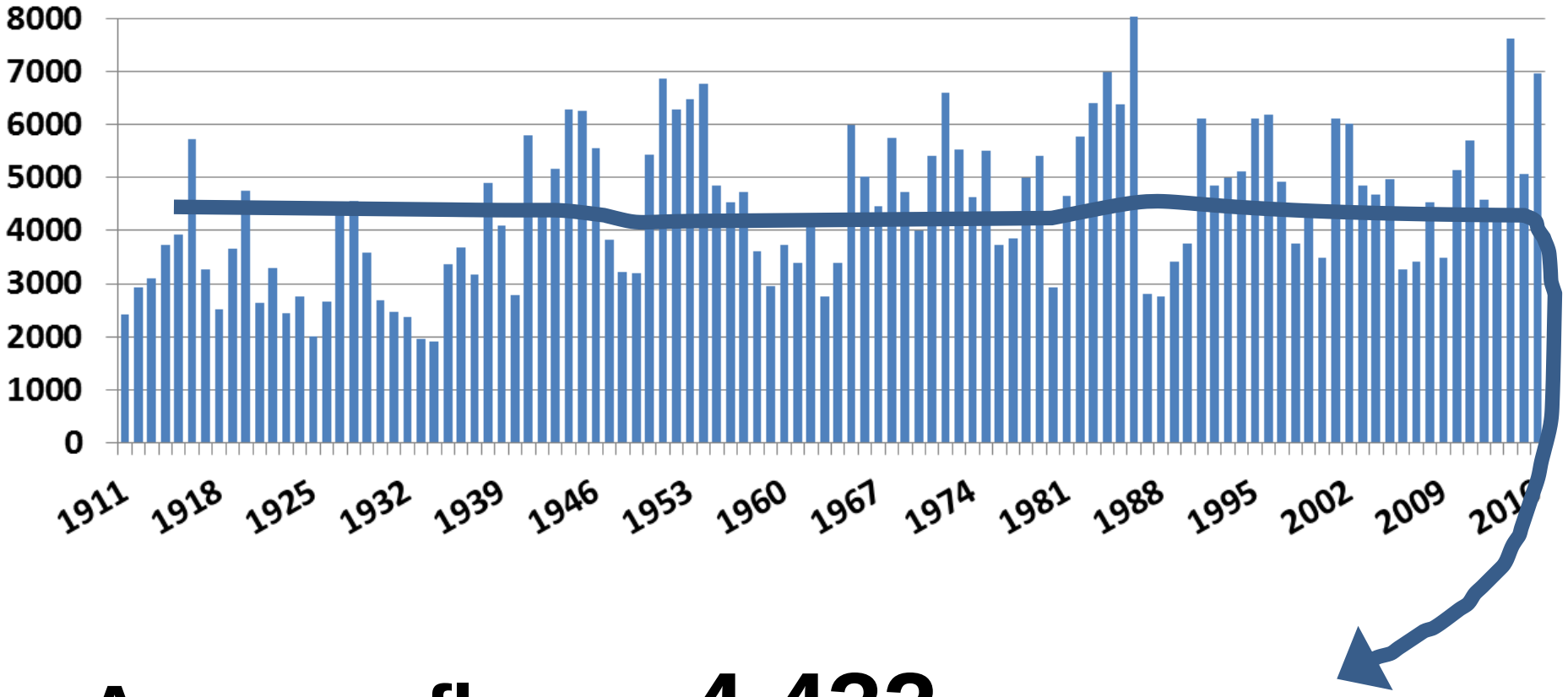
- **USGS KICKAPOO R AT LA FARGE, WI**
- **WATERSHED AREA**.--266 square miles.



Average flow ~186 cubic feet per second

Or...

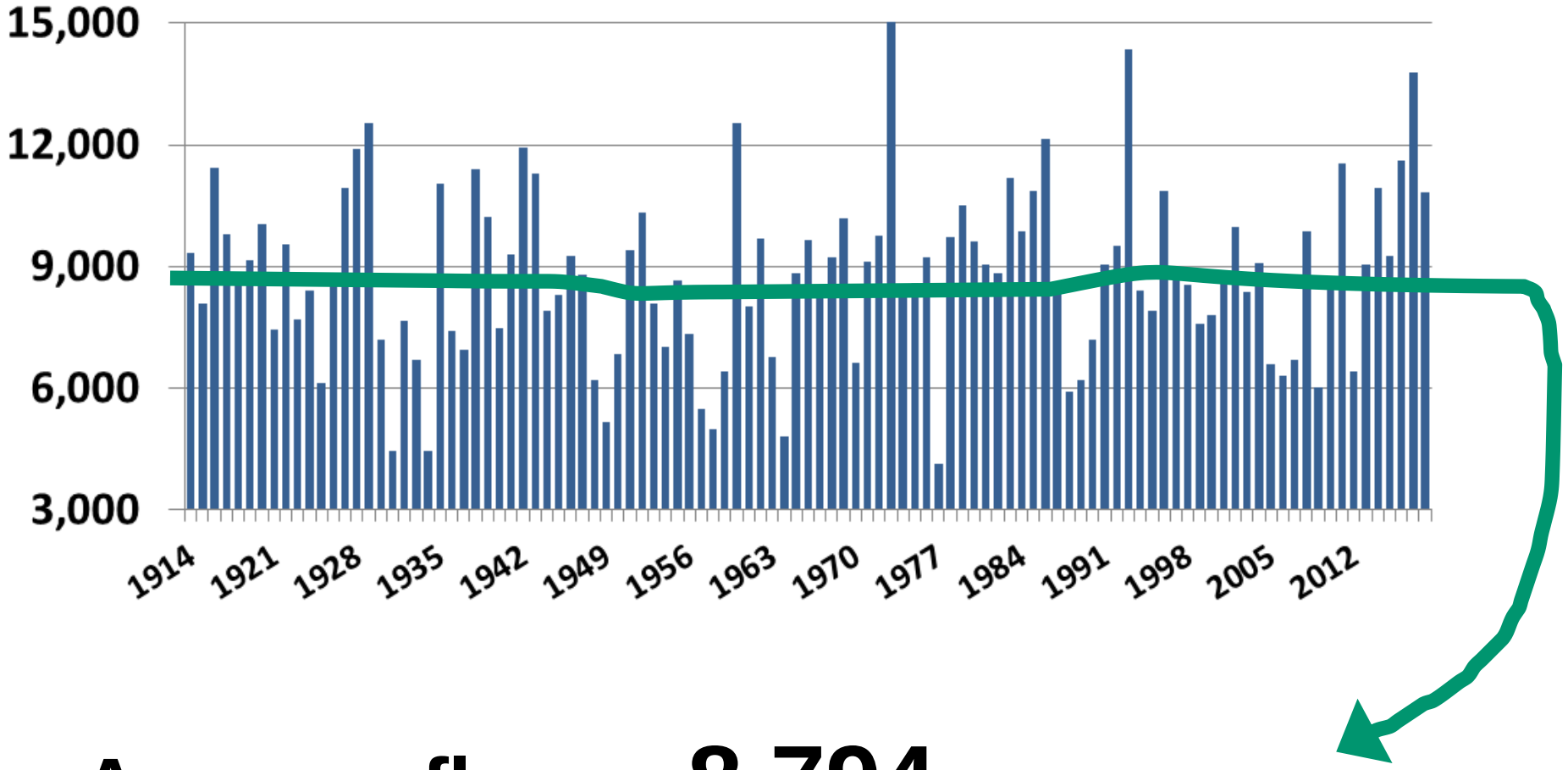
- **USGS 05340500 ST. CROIX RIVER AT ST. CROIX FALLS, WI**
- **WATERSHED AREA**.—6,240 square miles.



Average flow ~4,432 cubic feet per second

Finally…

- **WISCONSIN RIVER**
- **DRAINAGE AREA**.—10,400 square miles.



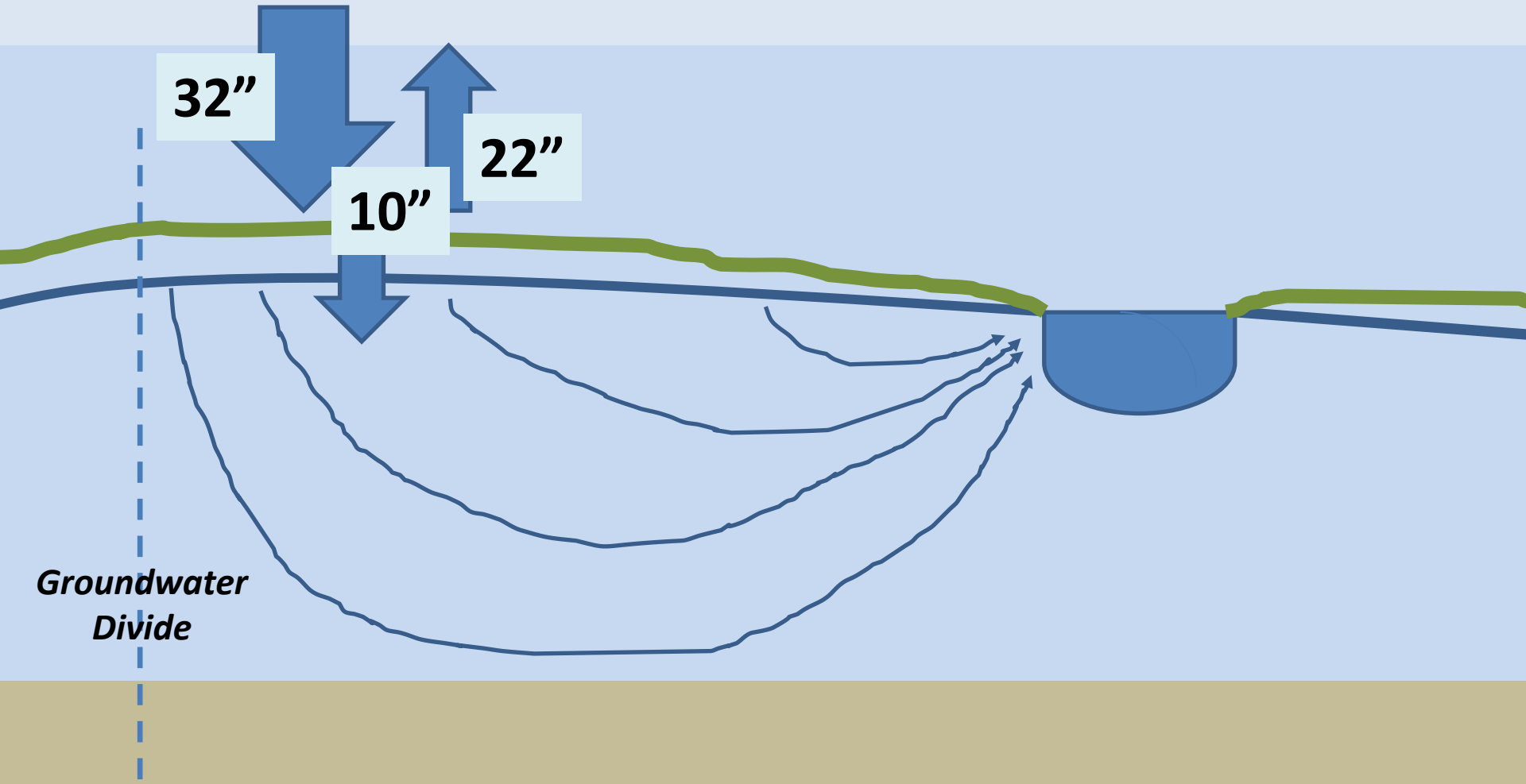
Average flow ~8,794 cubic feet per second

Wisconsin River (10,400 mi^2)

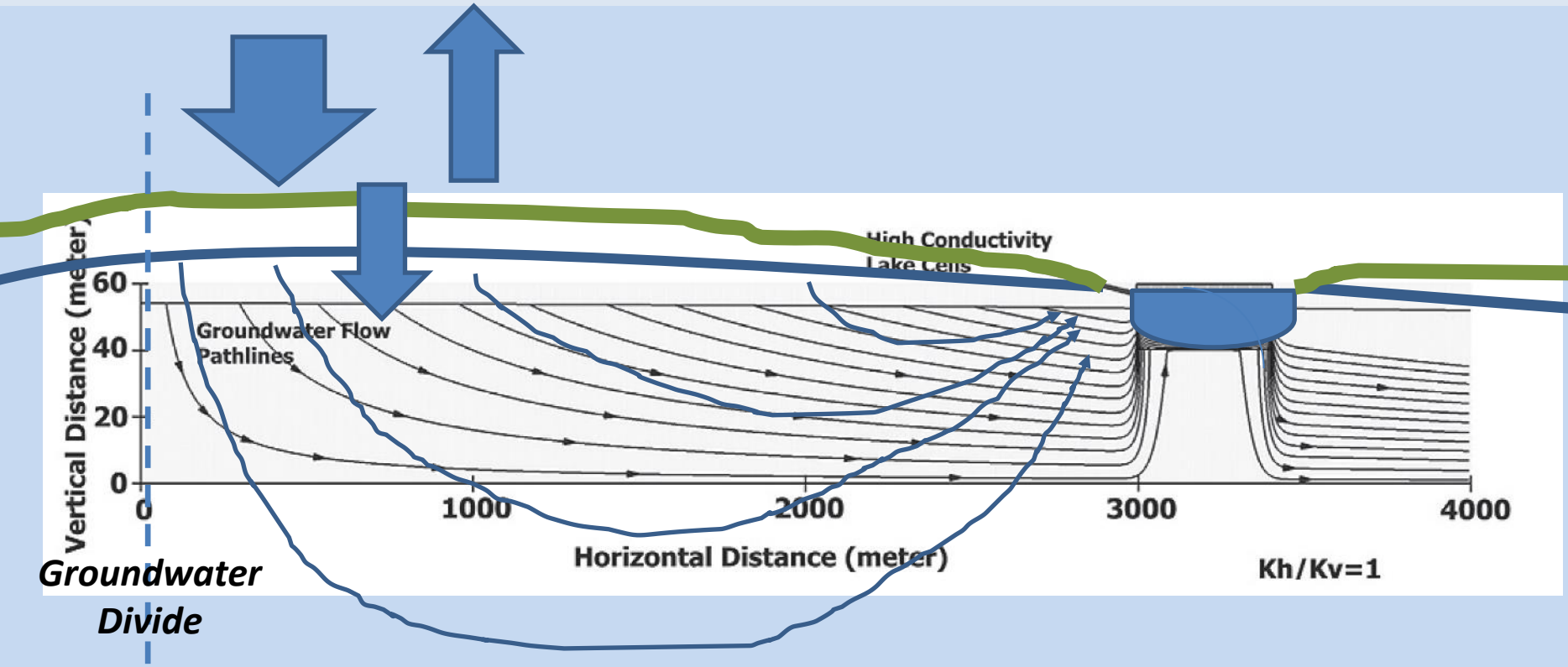
How about a Lake?

- Groundwater moves into the lakes
  - Directly on the edge of the lake
  - In streams that drain to the lake

Groundwater



Groundwater



Groundwater Divide

TOWN ROAD

PUBLIC ACCESS

DAM

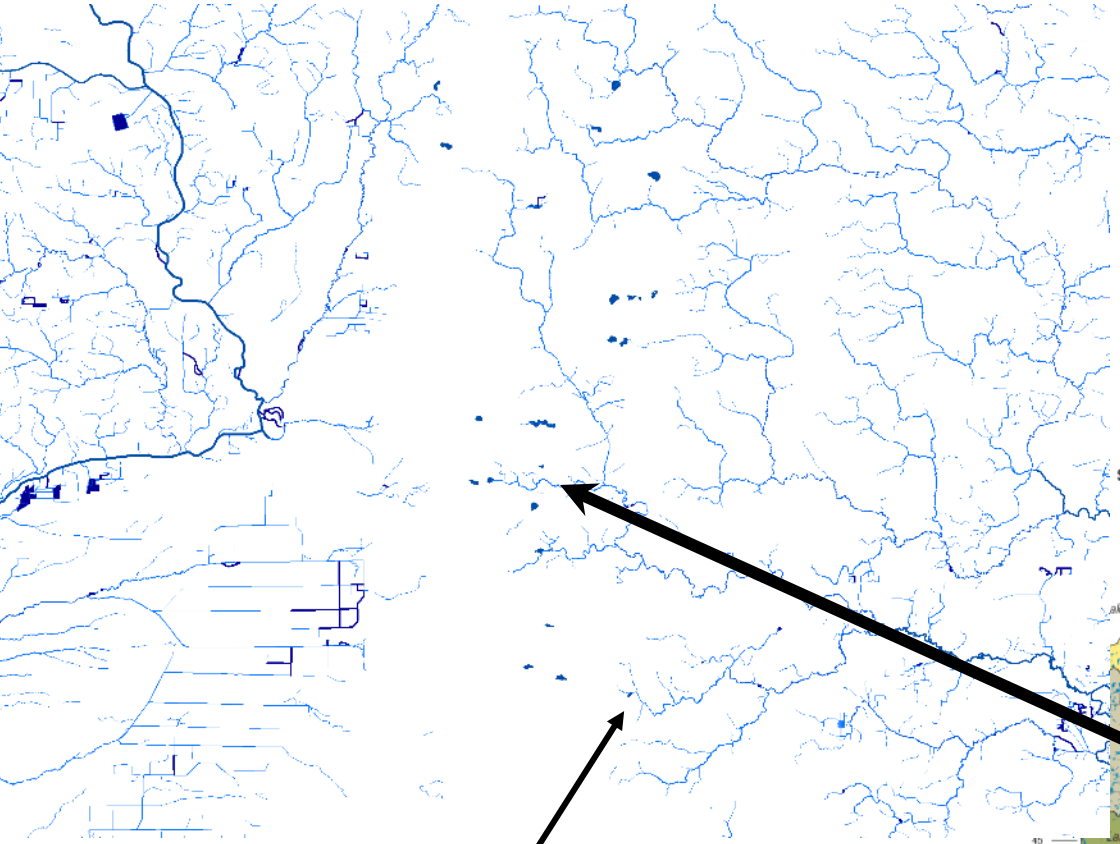
EMMONS CREEK

5'
10'
15'
20'
X23'

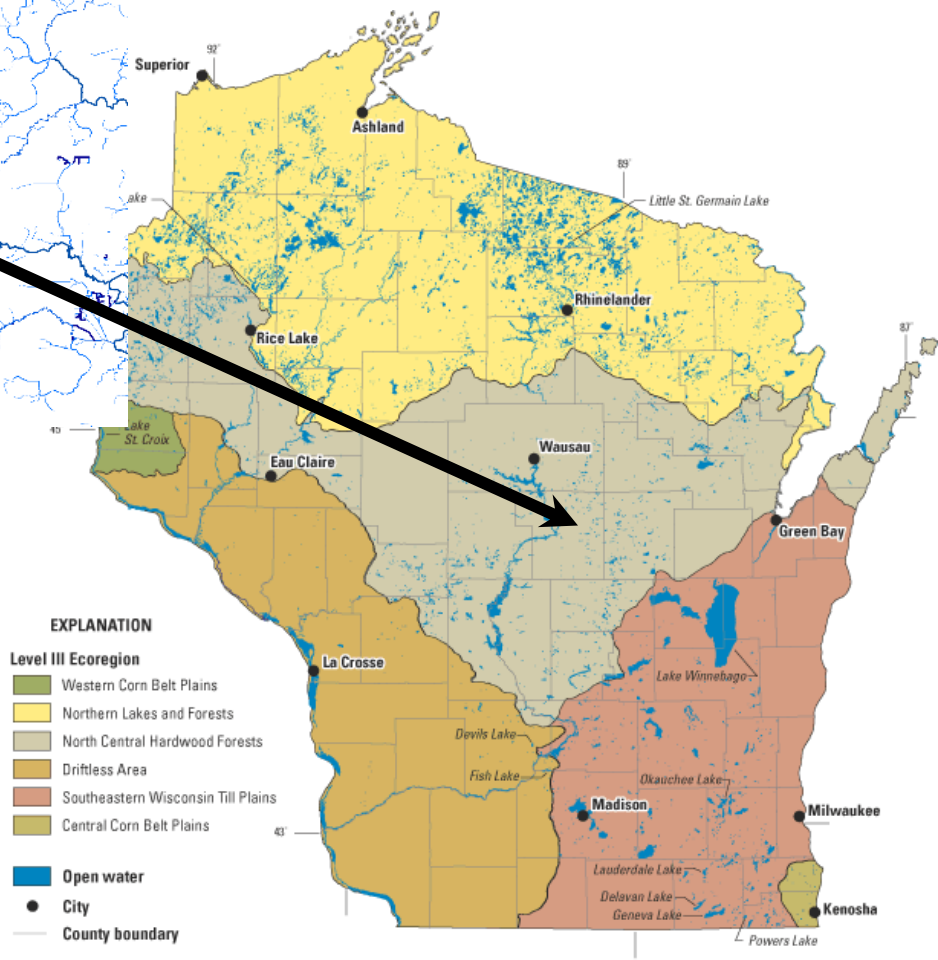
FOUNTAIN LAKE

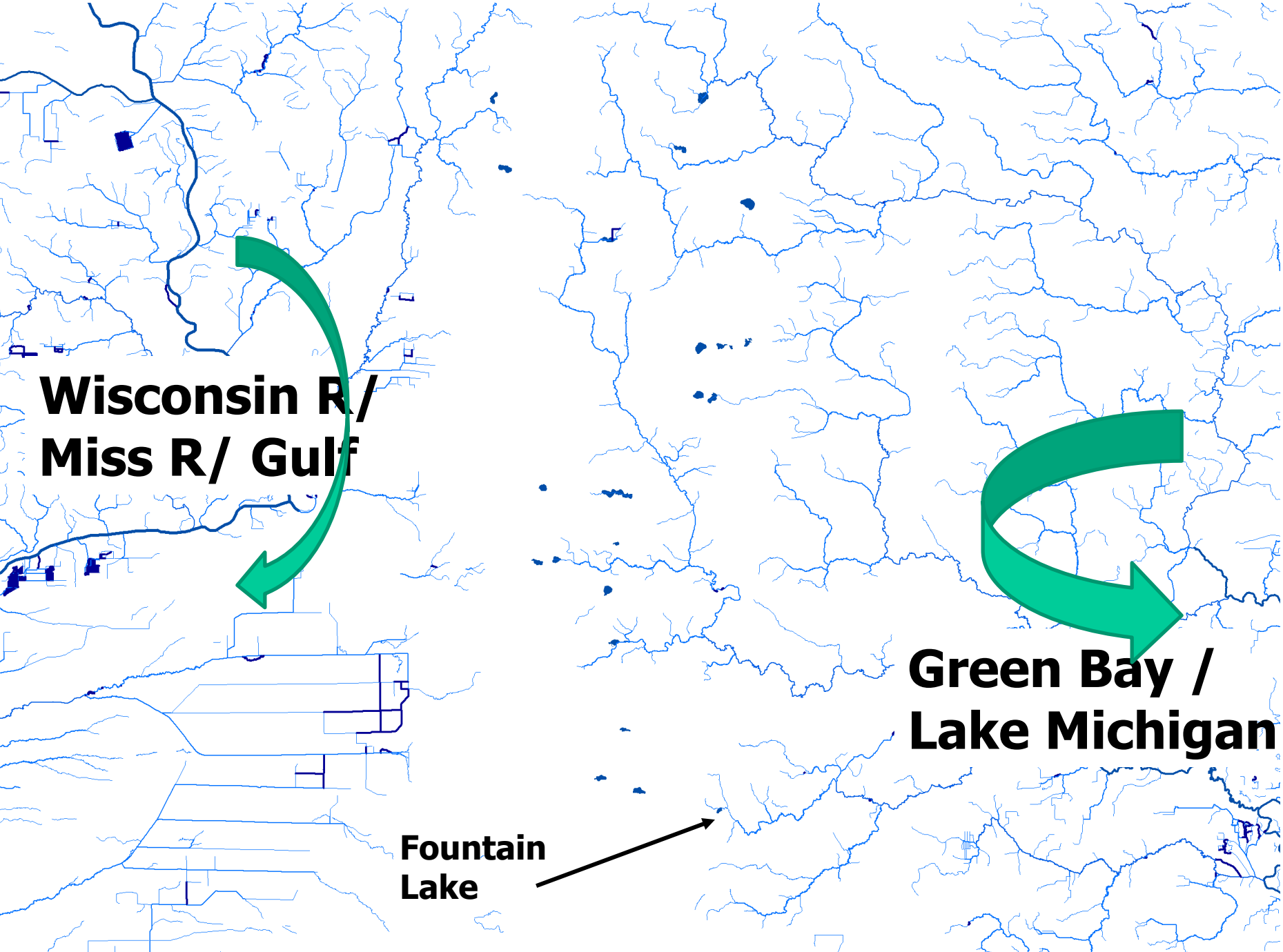
PORTAGE COUNTY
TOWN OF BELMONT
SECTIONS 10-11
T-21-N R-10-E

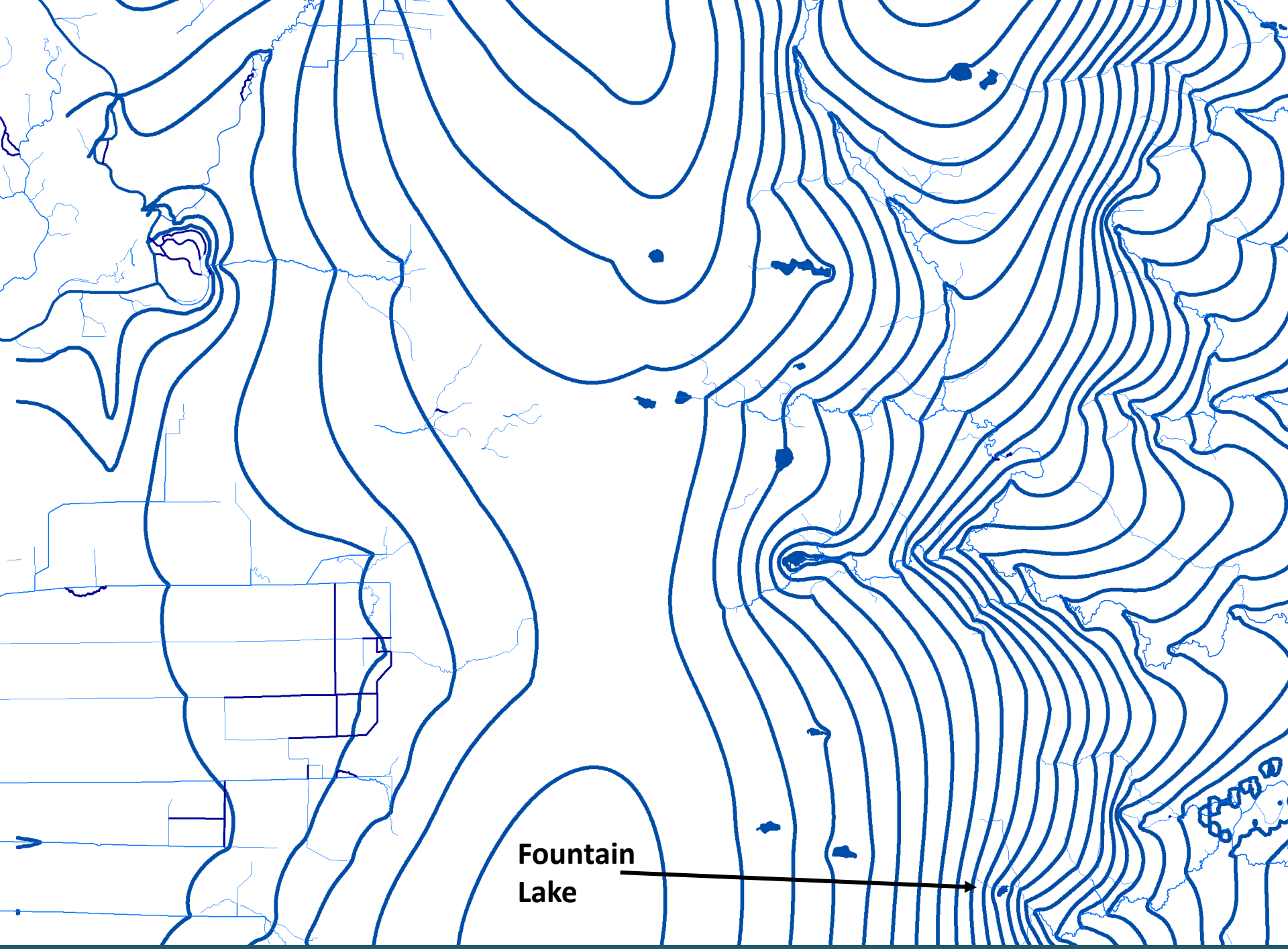
SCALE 20" = 1 MILE
AREA 16 ACRES

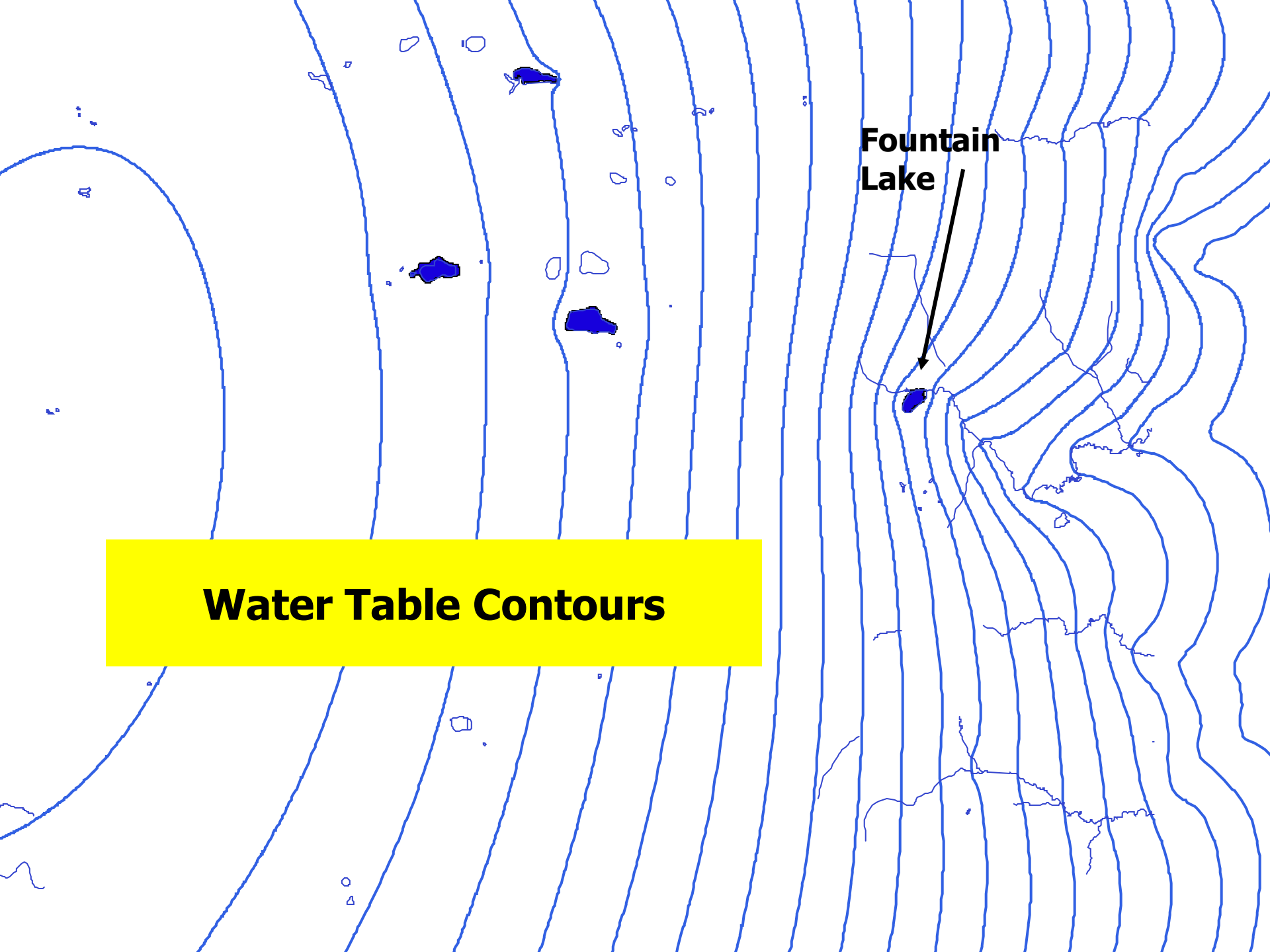


Fountain Lake

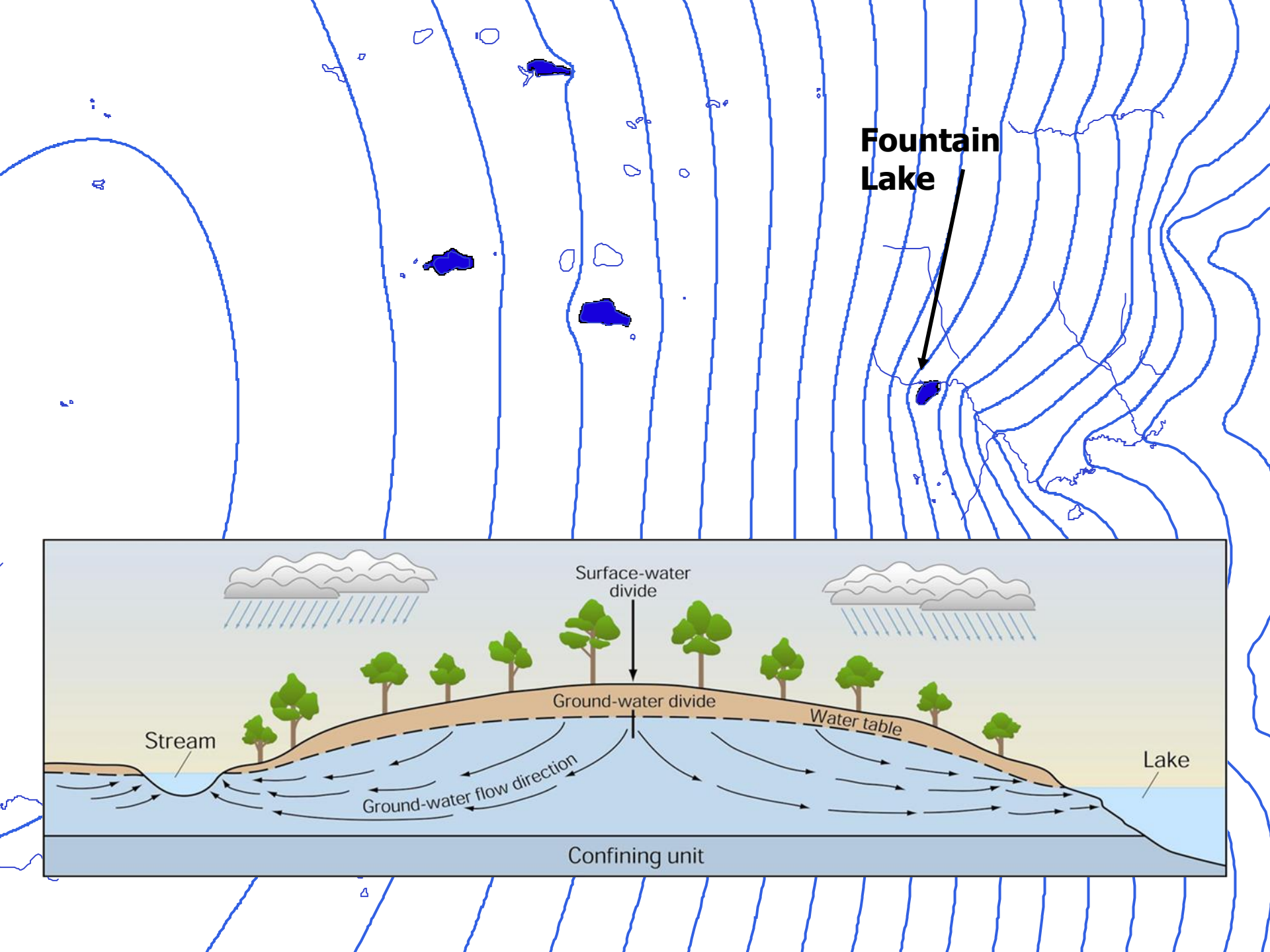


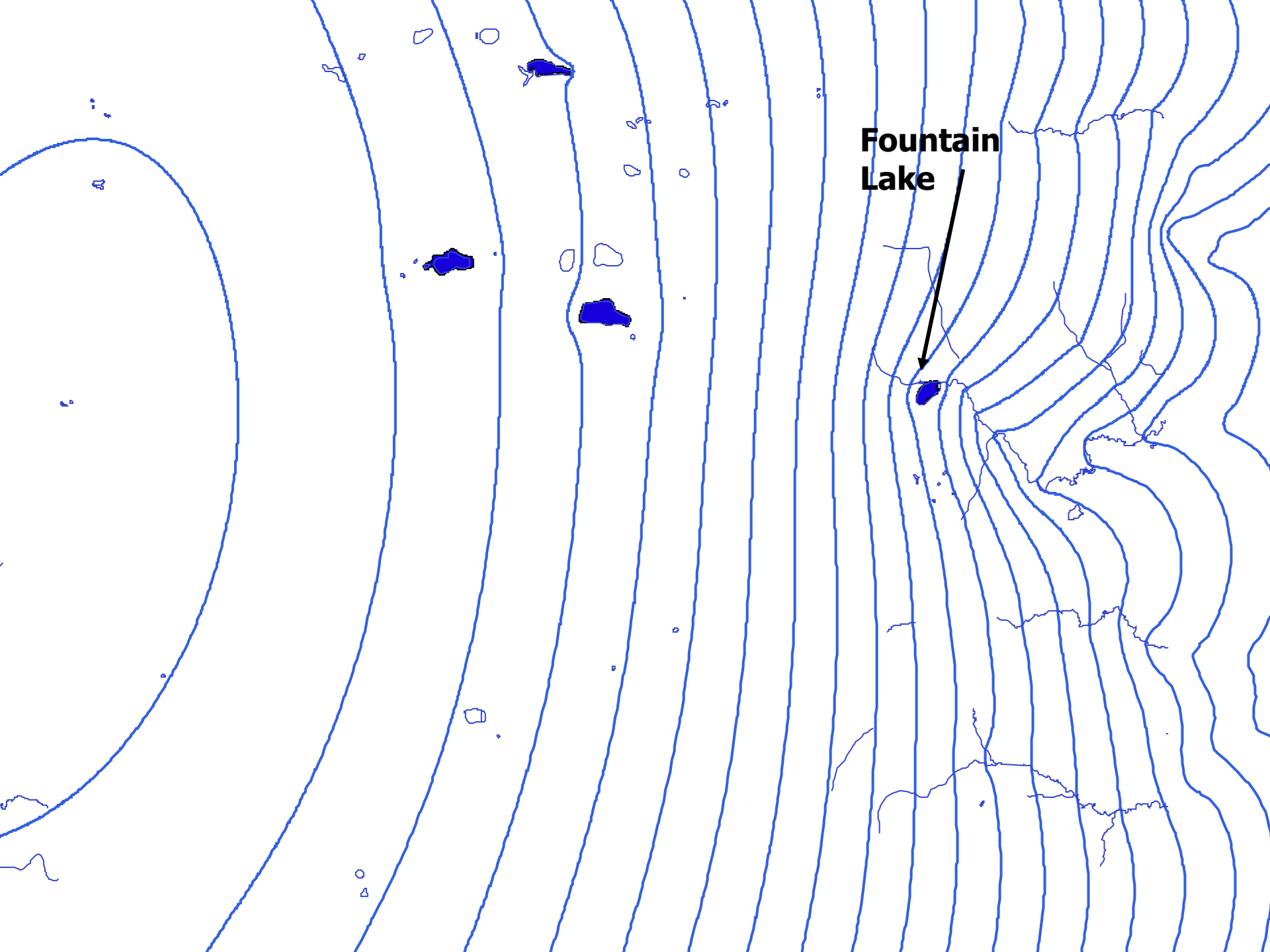

Wisconsin R/
Miss R/ Gulf
Green Bay /
Lake Michigan
Fountain
Lake

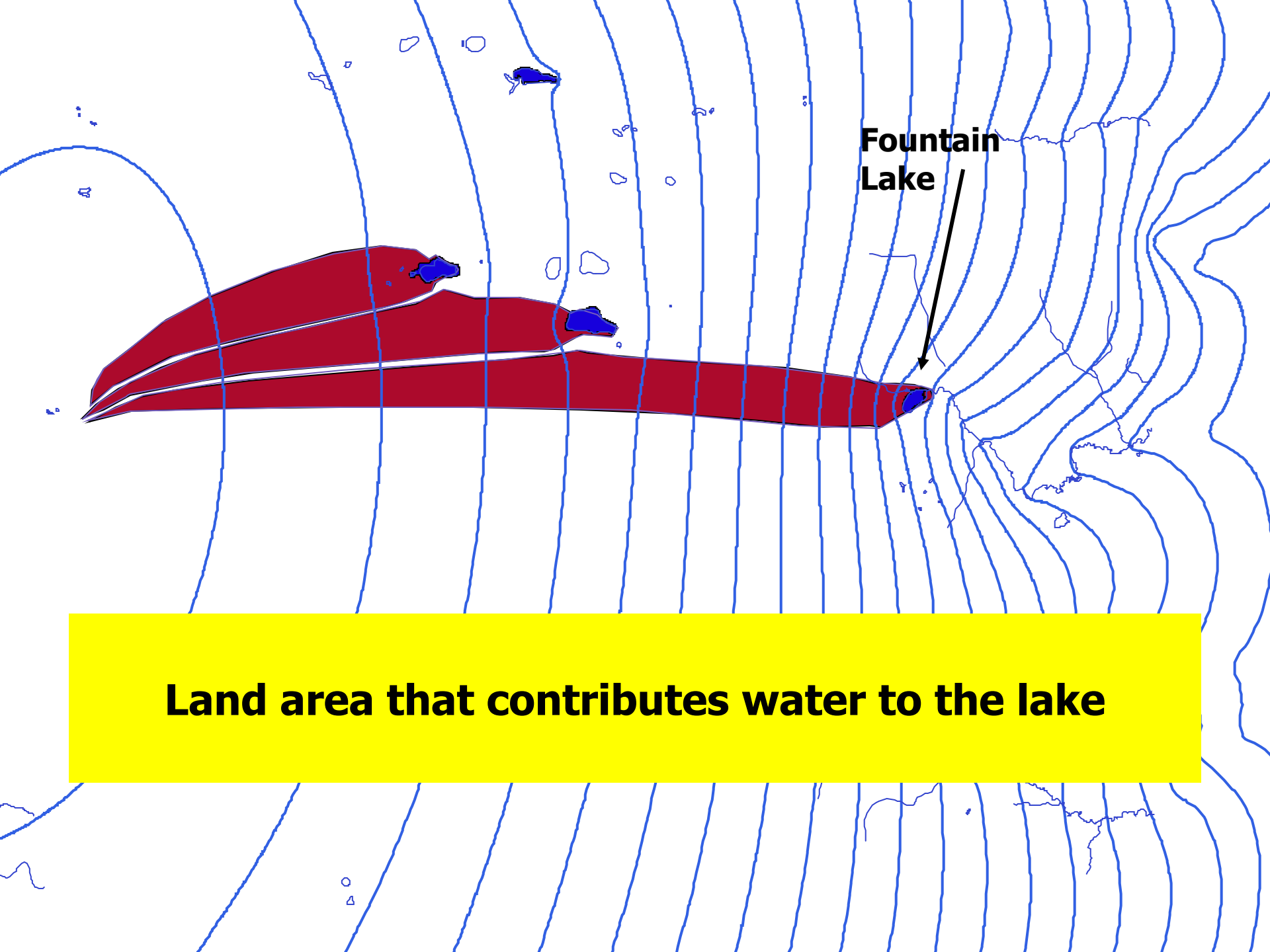

Fountain
Lake



Water Table Contours

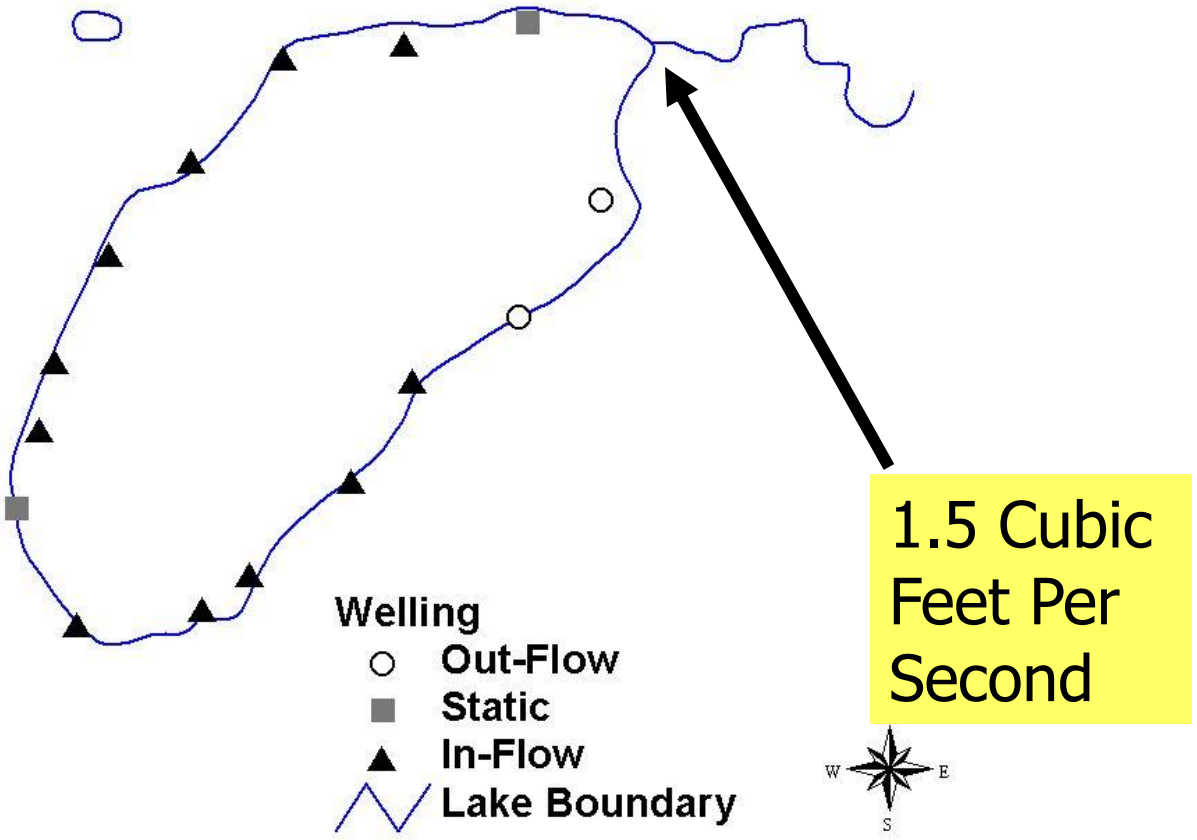

Fountain Lake
Surface-water divide
Ground-water divide
Water table
Stream
Lake
Ground-water flow direction
Confining unit


Fountain
Lake



Land area that contributes water to the lake

Fountain Lake



Interesting sidebar: In this lake, calcium from the land forms marl in the lake

Soil

- $CaMg(CO_3)_2$ + Water & Carbon Dioxide = $Ca^{2+} + Mg^{2+} + 4\ HCO_3^-$

Lake

- $Ca^{2+} + CO_3^{2-} = CaCO_3$

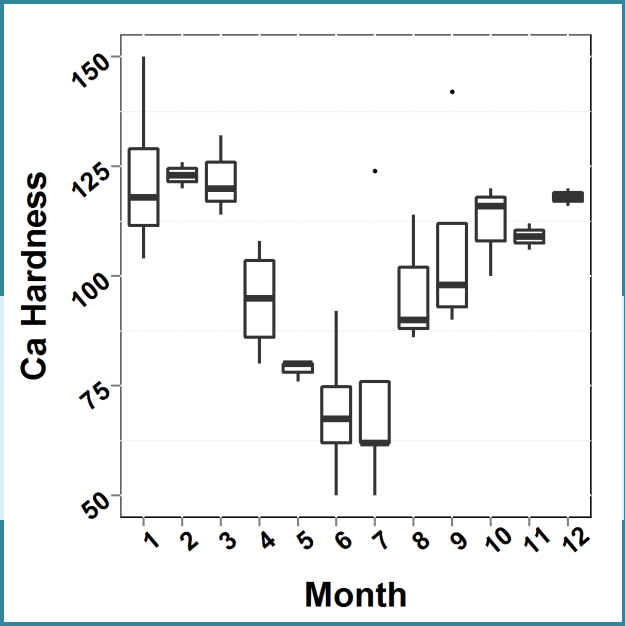
Interesting sidebar: In this lake, calcium from the land forms marl in the lake

Soil

- $CaMg(CO_3)_2$ + Carbon Dioxide + Water & = $Ca^{2+} + Mg^{2+} + 4\ HCO_3^-$

Lake

- $Ca^{2+} + CO_3^{2-} = CaCO_3$



This can get more complicated!

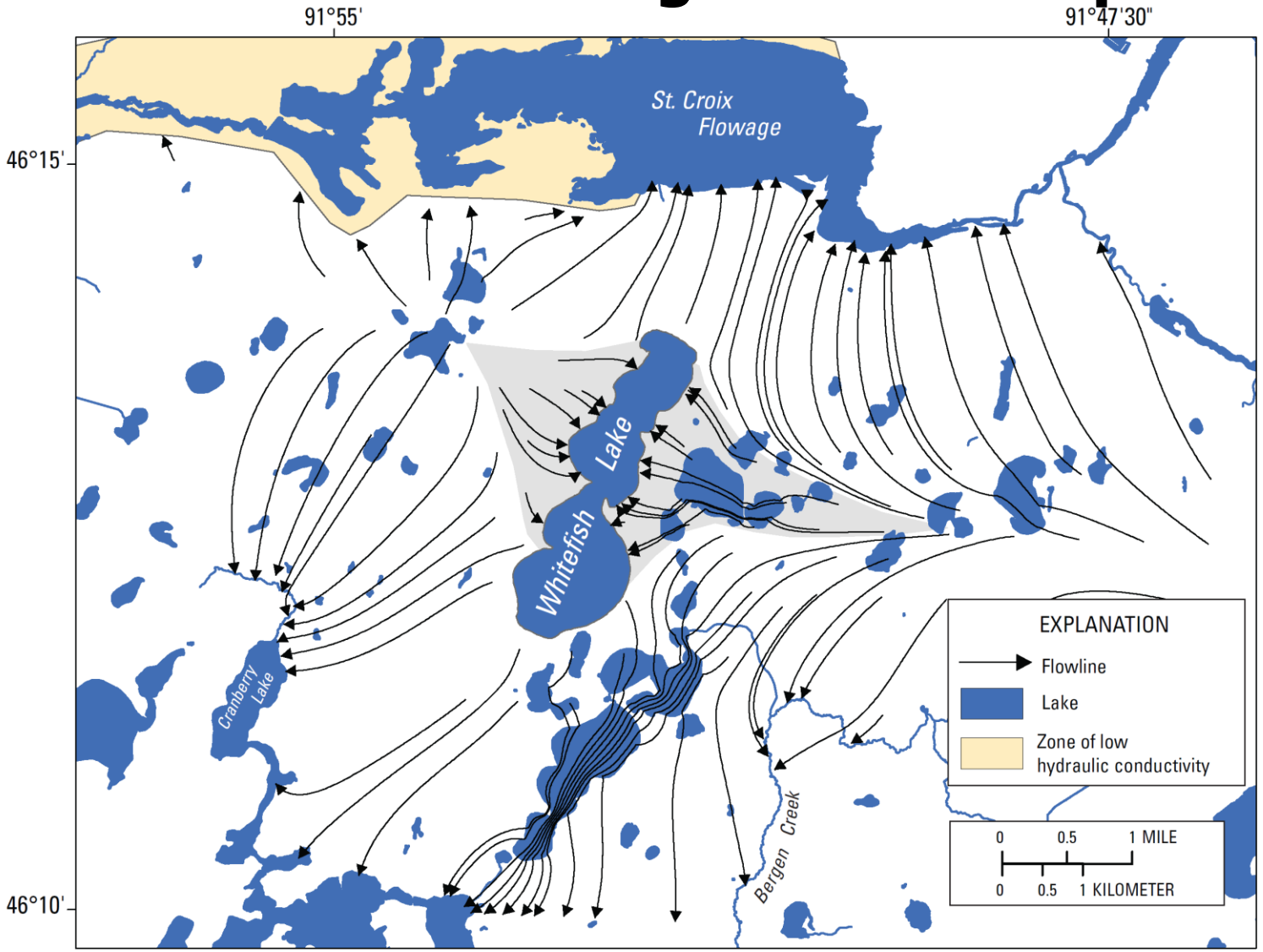
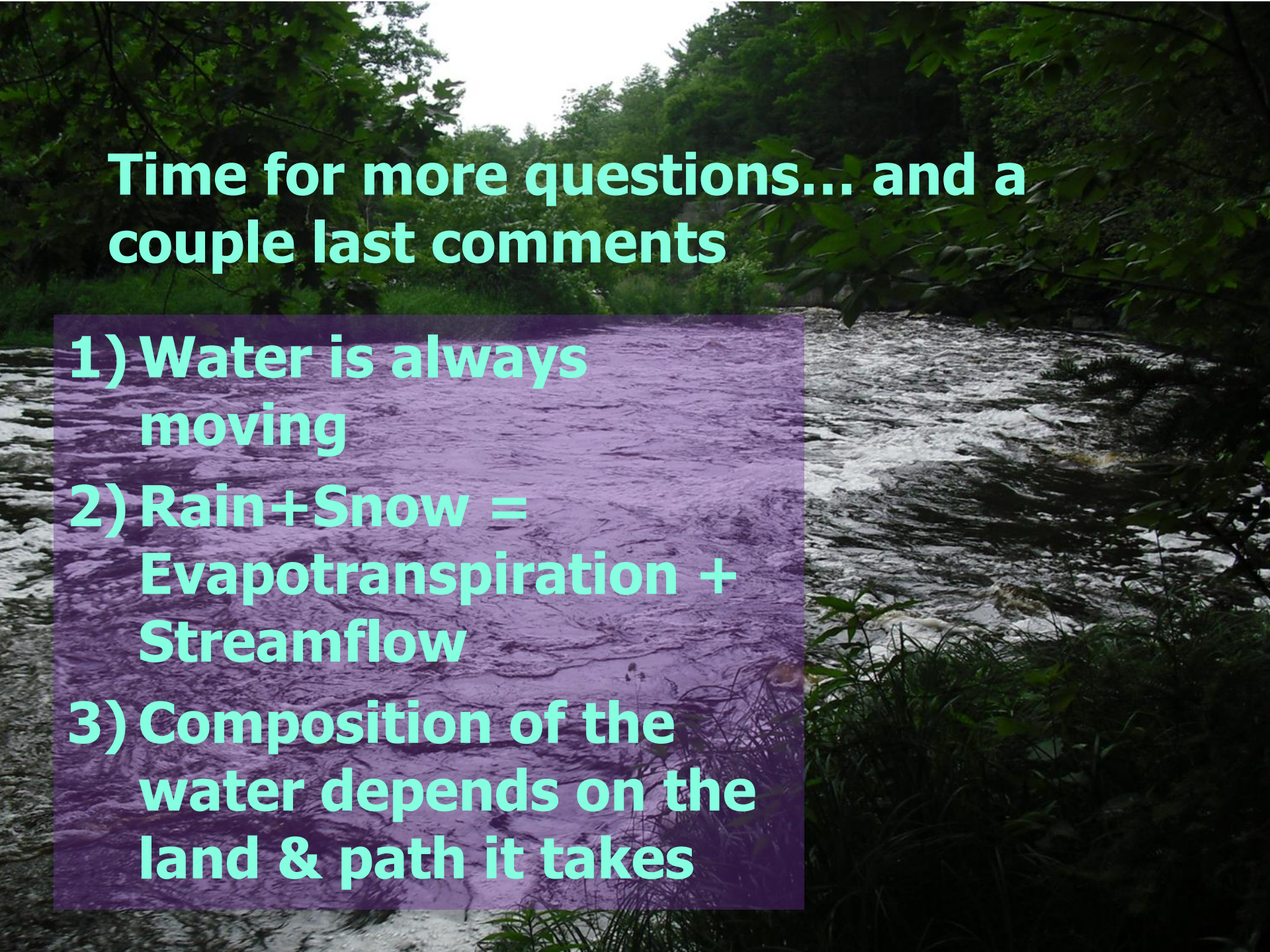


Figure 13. Simulated groundwater contributing area and flow directions near Whitefish Lake, Douglas County, Wis., from the GFLOW groundwater-flow model.



Time for more questions… and a couple last comments

1) Water is always moving
2) Rain+Snow = Evapotranspiration + Streamflow
3) Composition of the water depends on the land & path it takes

For More Information contact me!

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