Changes in Ground-Water Conditions from Possible Changes in Climatic Conditions in the Great Lakes Basin

Impact of Climate Change on the Great Lakes Ecosystem

U.S. Department of the Interior
U.S. Geological Survey

Setting

- Eighteen percent of fresh surface water on earth
- Fresh ground-water in storage is about another Lake Michigan in volume
- Major cities rely on surface water from lakes for supply
- Most places in the basin rely on ground water for supply

USGS

Precipitation minus Potential ET

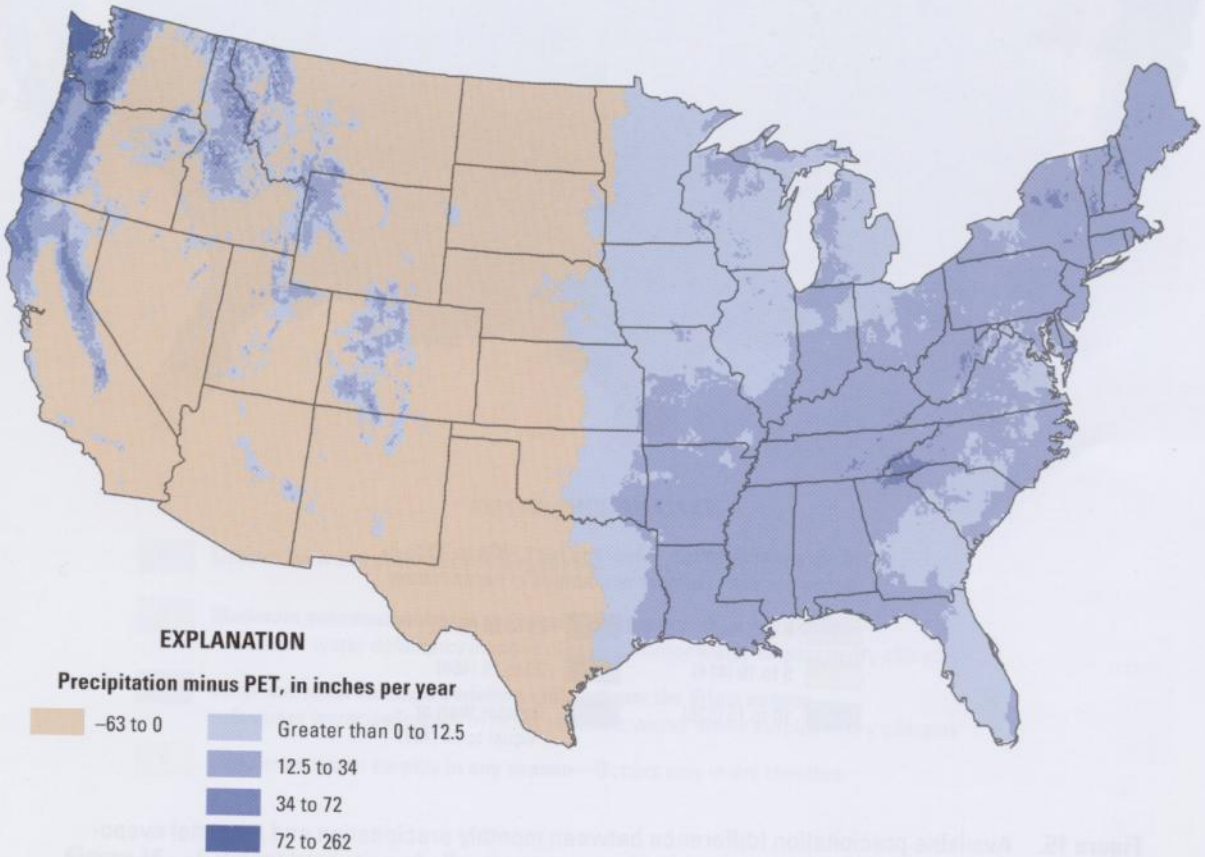
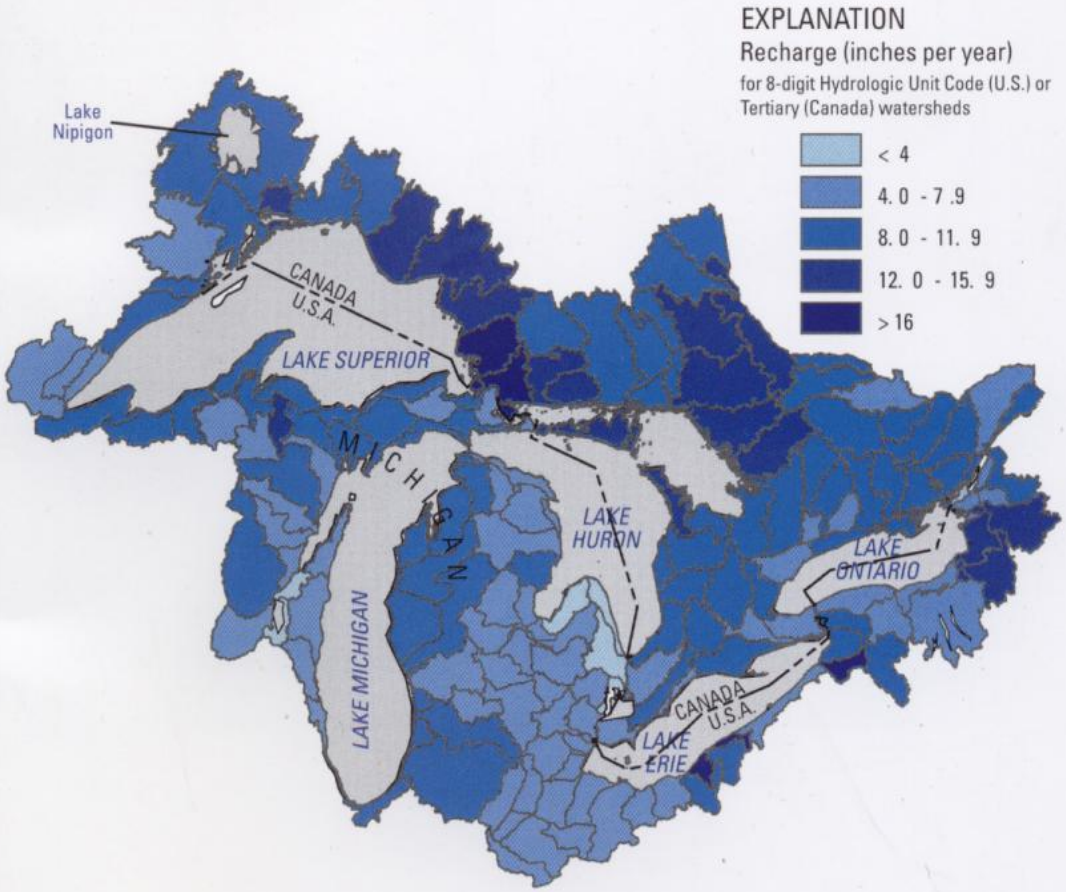
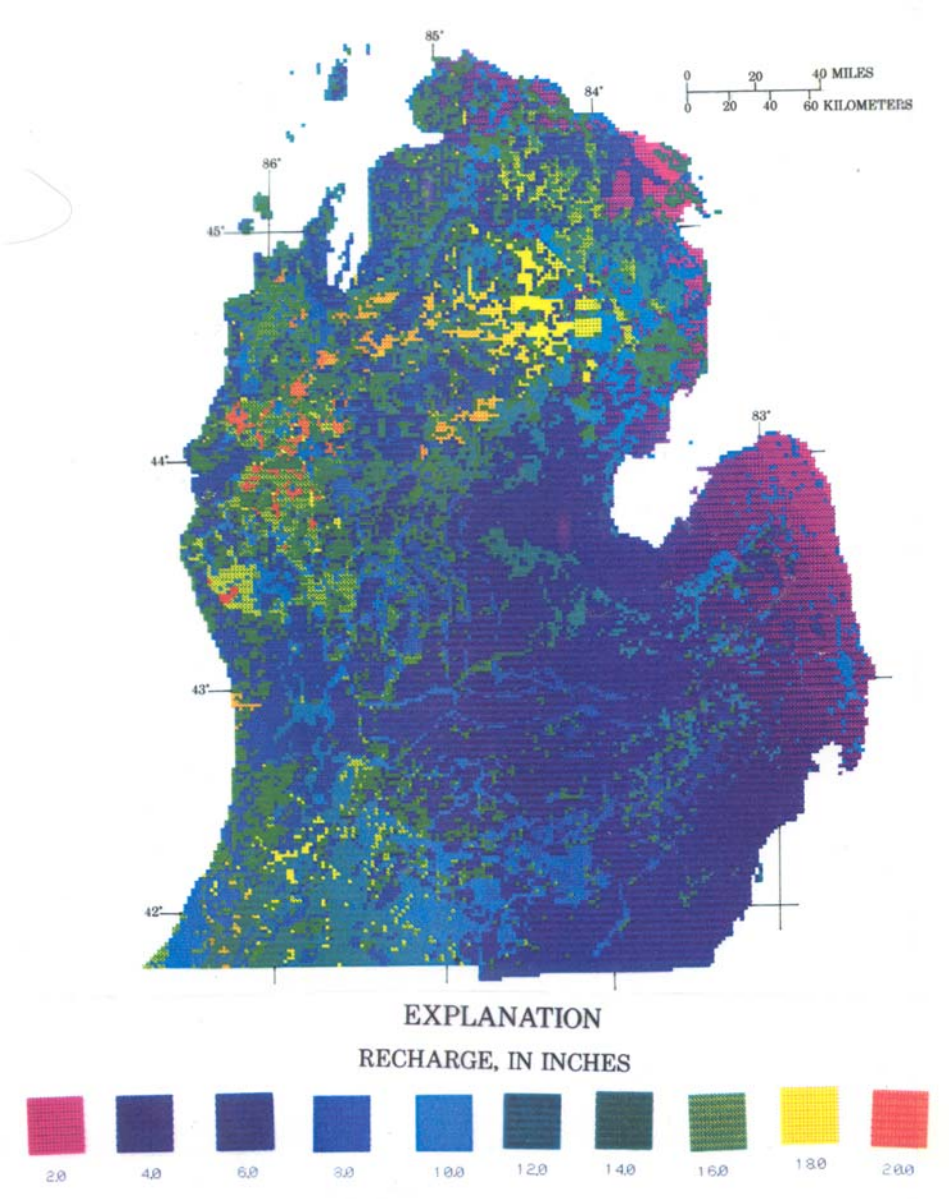


Figure 14. Difference between annual precipitation and potential evapotranspiration (PET) rates across the conterminous United States (modified from Healy and others, 2007).

Estimation of Shallow Ground-Water Recharge in the Great Lakes Basin



Ground-Water Recharge



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Ground-Water Level Declines Greater than 40 feet

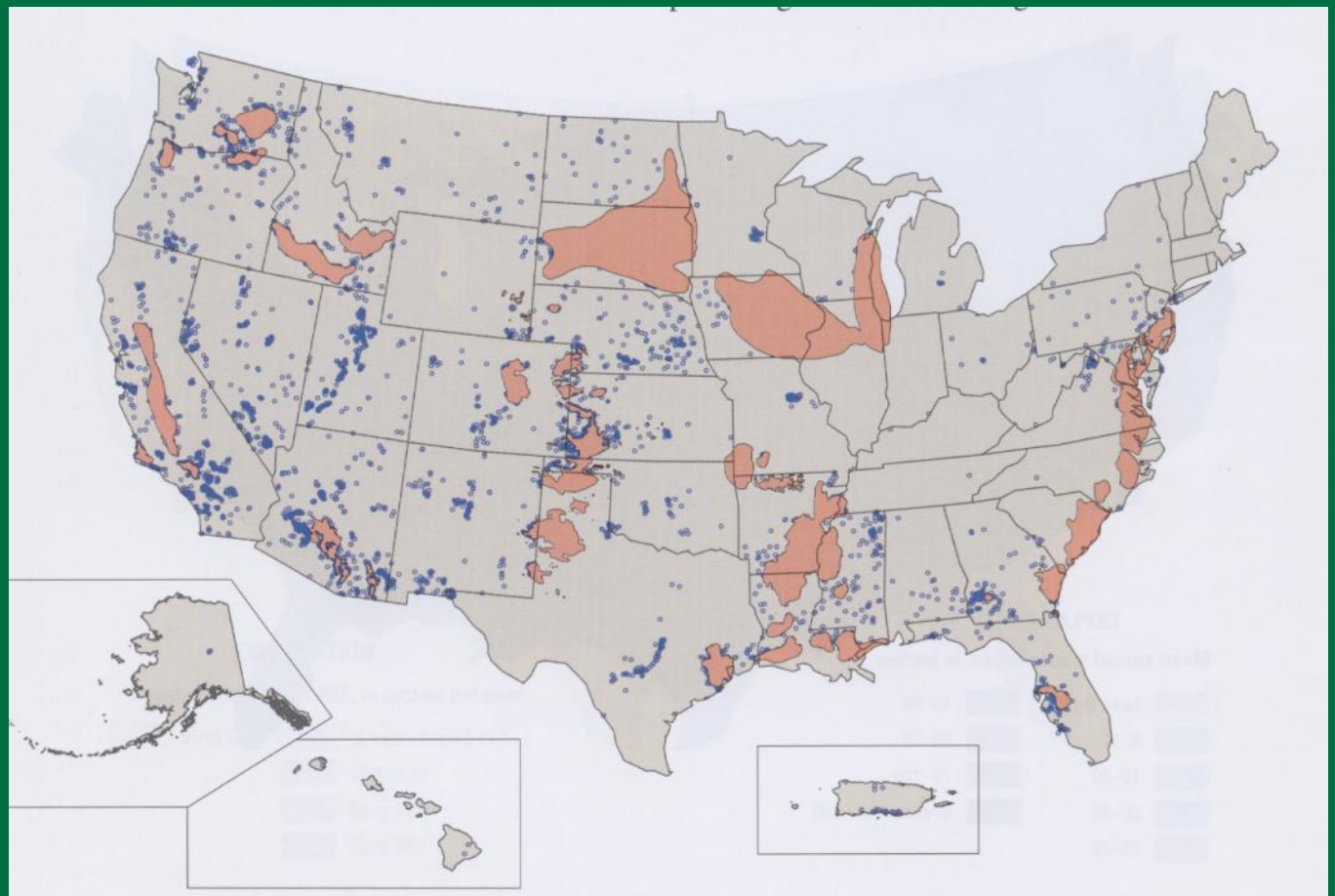
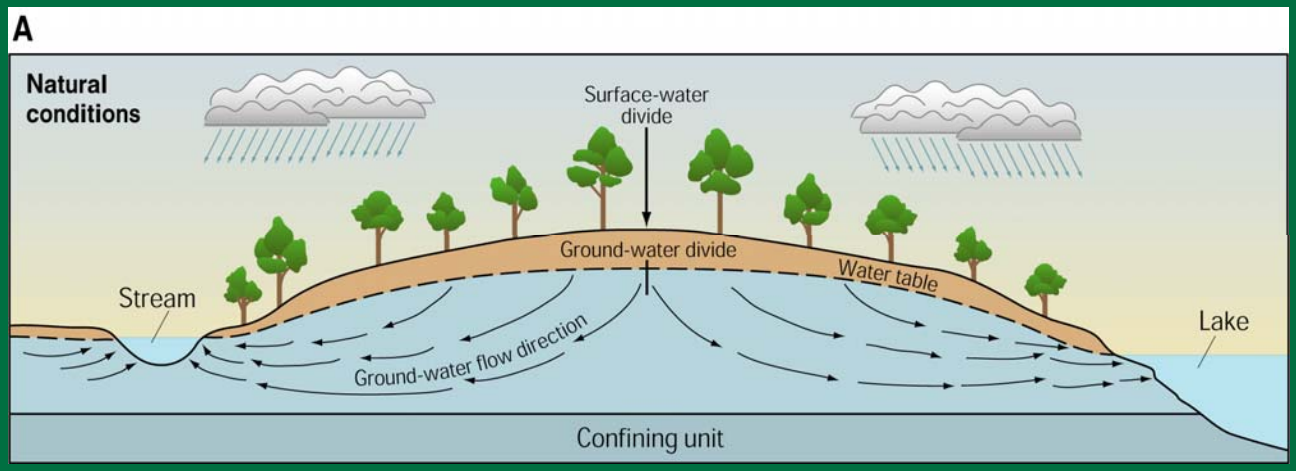
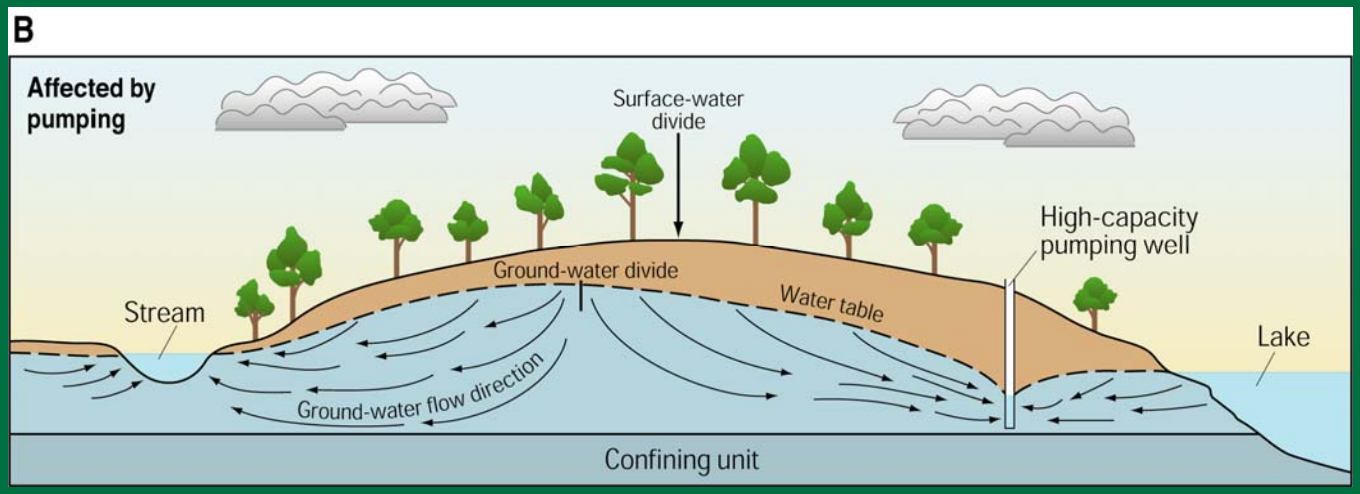


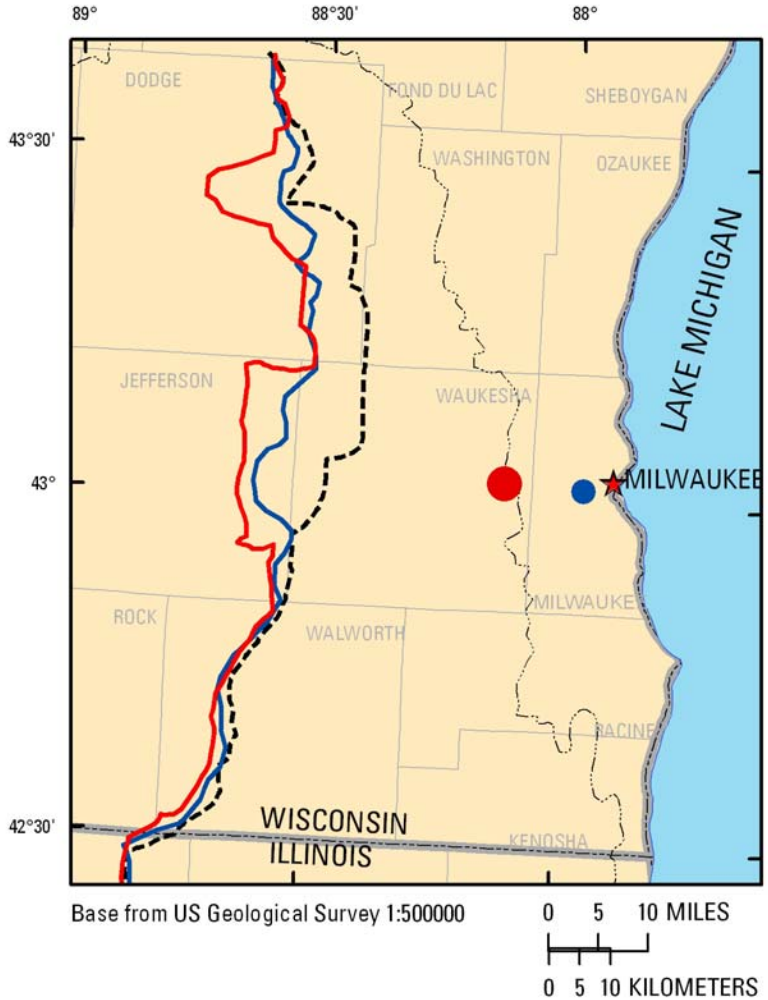
Figure 12. Water-level declines. Red regions indicate areas in excess of 500 square miles that have water-level decline in excess of 40 feet in at least one confined aquifer since predevelopment, or in excess of 25 feet of decline in unconfined aquifers since predevelopment. Blue dots are wells in the USGS National Water Information System database where the measured water-level difference over time is equal to or greater than 40 feet.

USGS

Ground-Water Divides







EXPLANATION

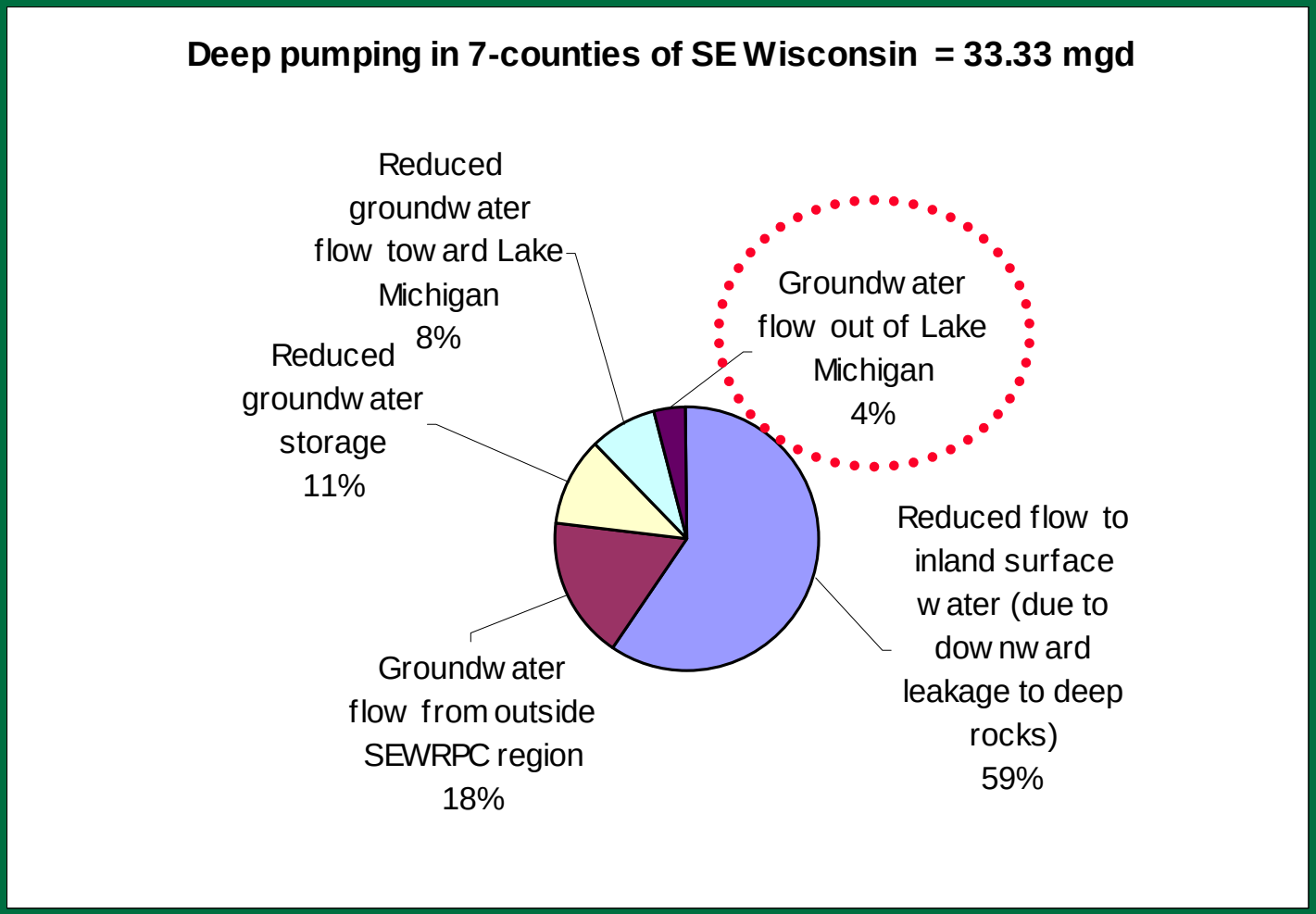
- Center of pumping, 1950 (16.9 million gallons per day)
- Center of pumping, 2000 (33.5 million gallons per day)

Regional surface-water divide

Deep sandstone aquifer ground-water divide

- 1860 (Predevelopment)
- 1950
- 2002

How much of the water that flows into the cone of depression to replenish water discharged by deep regional pumping (including discharge from Waukesha's deep wells) is flowing out of Lake Michigan itself?



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UW Extension WISCONSIN GEOLOGICAL AND NATURAL HISTORY SURVEY

Generalized Stratigraphy – Michigan Basin

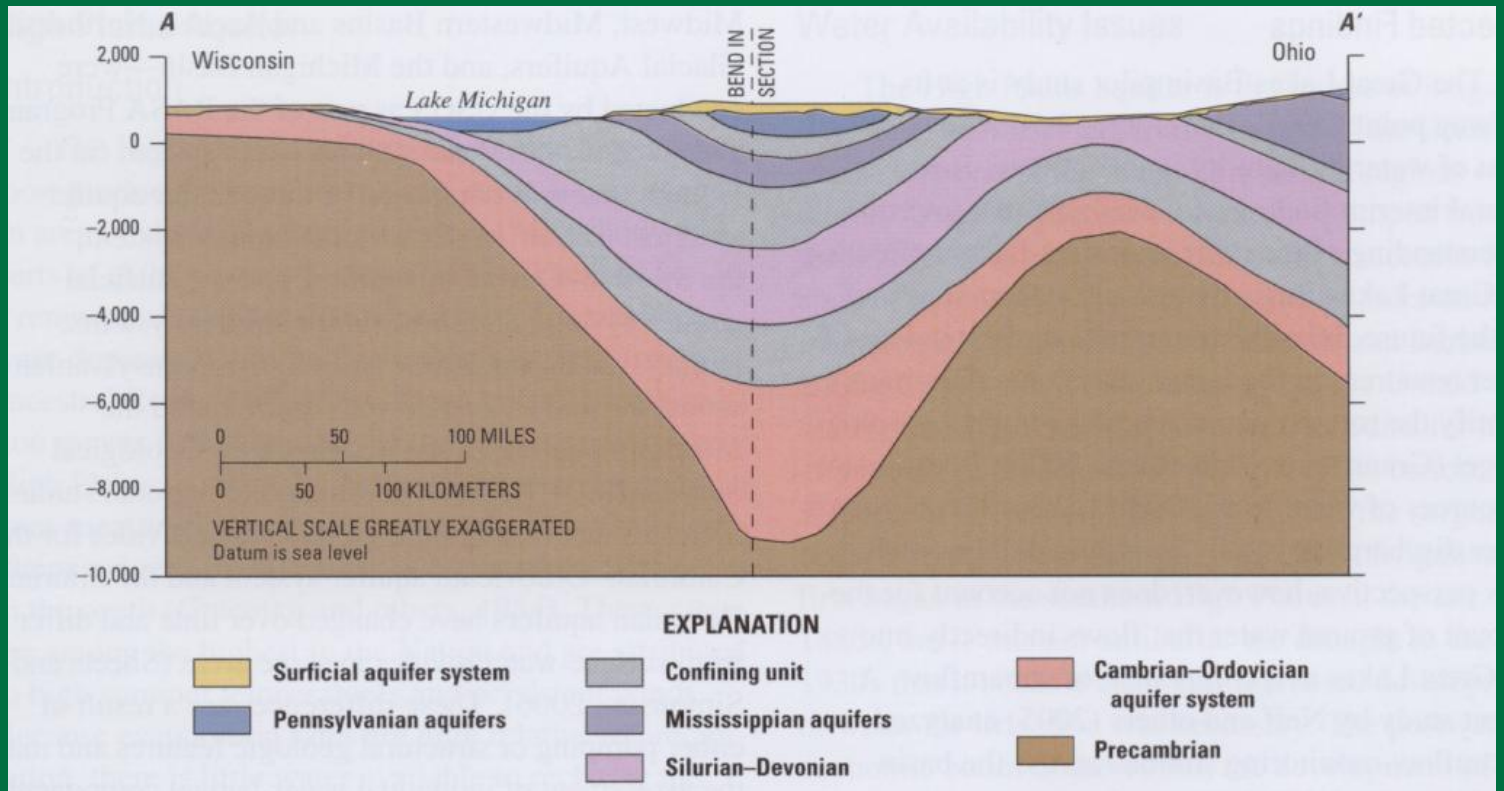

Figure 36. Generalized hydrostratigraphic section through the central part of the Great Lakes Basin, United States (from Sheets and Simonson, 2006). Line of section shown in figure 35.

USGS

Ground-Water Withdrawal for Irrigation

- Ground-water withdrawal for irrigation has stabilized in western states
- Ground-water withdrawal for irrigation is increasing in eastern states

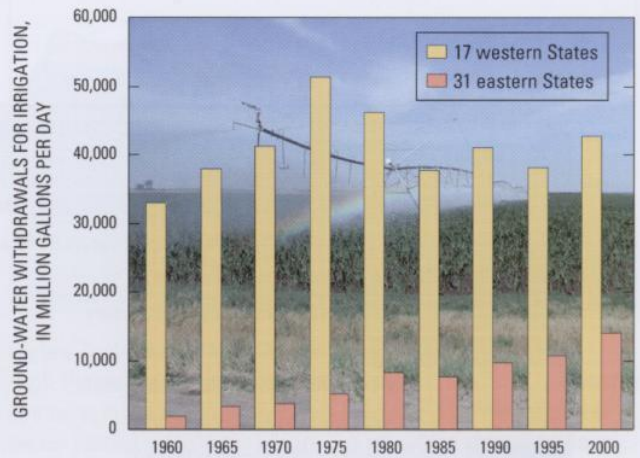

Figure 4. Ground-water withdrawals for irrigation in the western and eastern conterminous United States. Ground-water withdrawals for irrigation decreased in the western States in recent decades as a result of expanding urban areas, an increase in dryland farming, and increased efficiencies of application. In contrast, ground-water withdrawals for irrigation in the eastern half of the country increased steadily over the same period, in part, as a supplemental source of water to protect against dry periods. (Data compiled from U.S. Geological Survey Circulars titled "Estimated use of water in the United States," published in 5-year intervals for the years 1960 to 2000.)

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Growing Demands and Competition for Water

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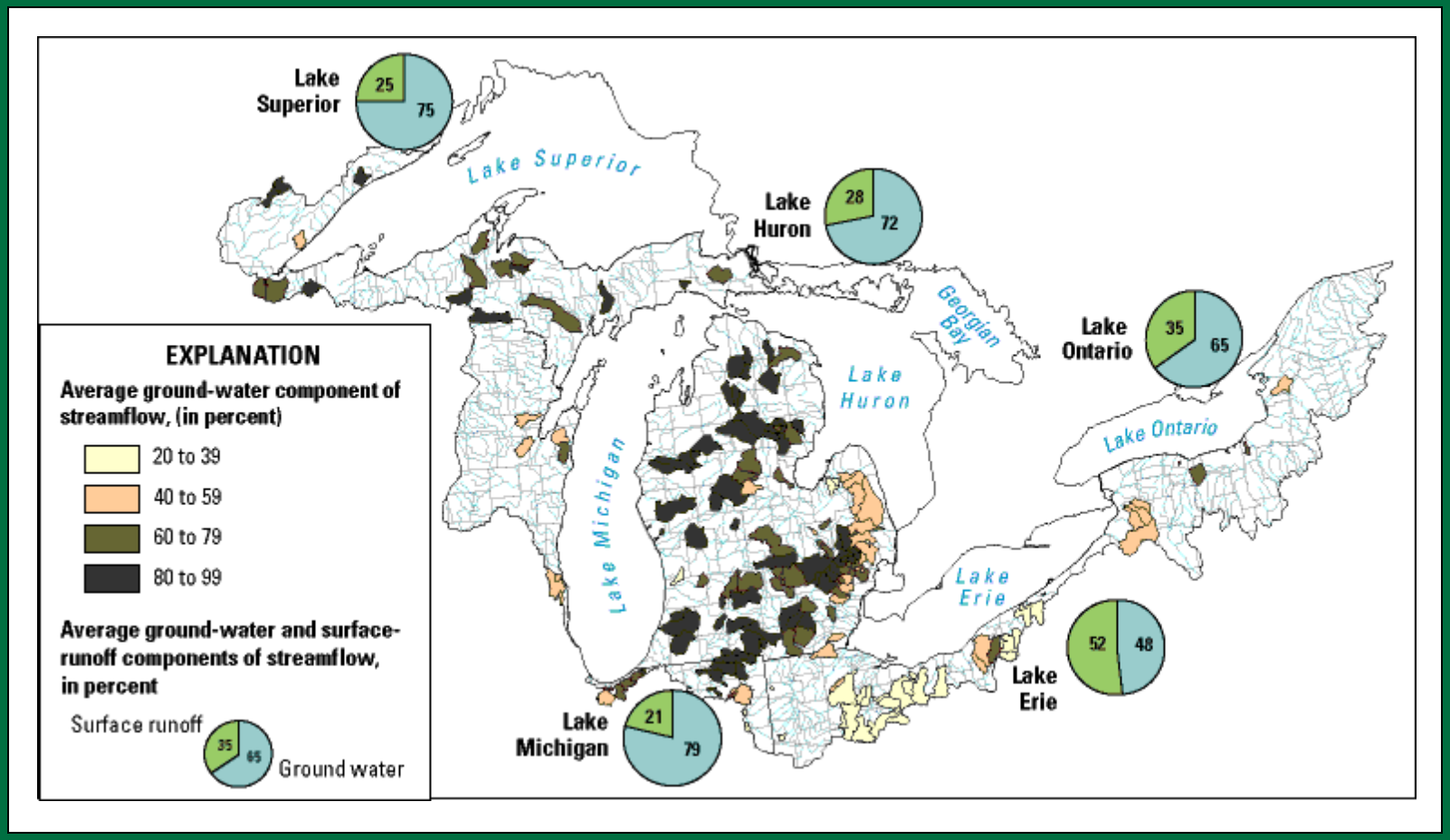
Ground-Water Discharge to Streams in the Great Lakes Basin



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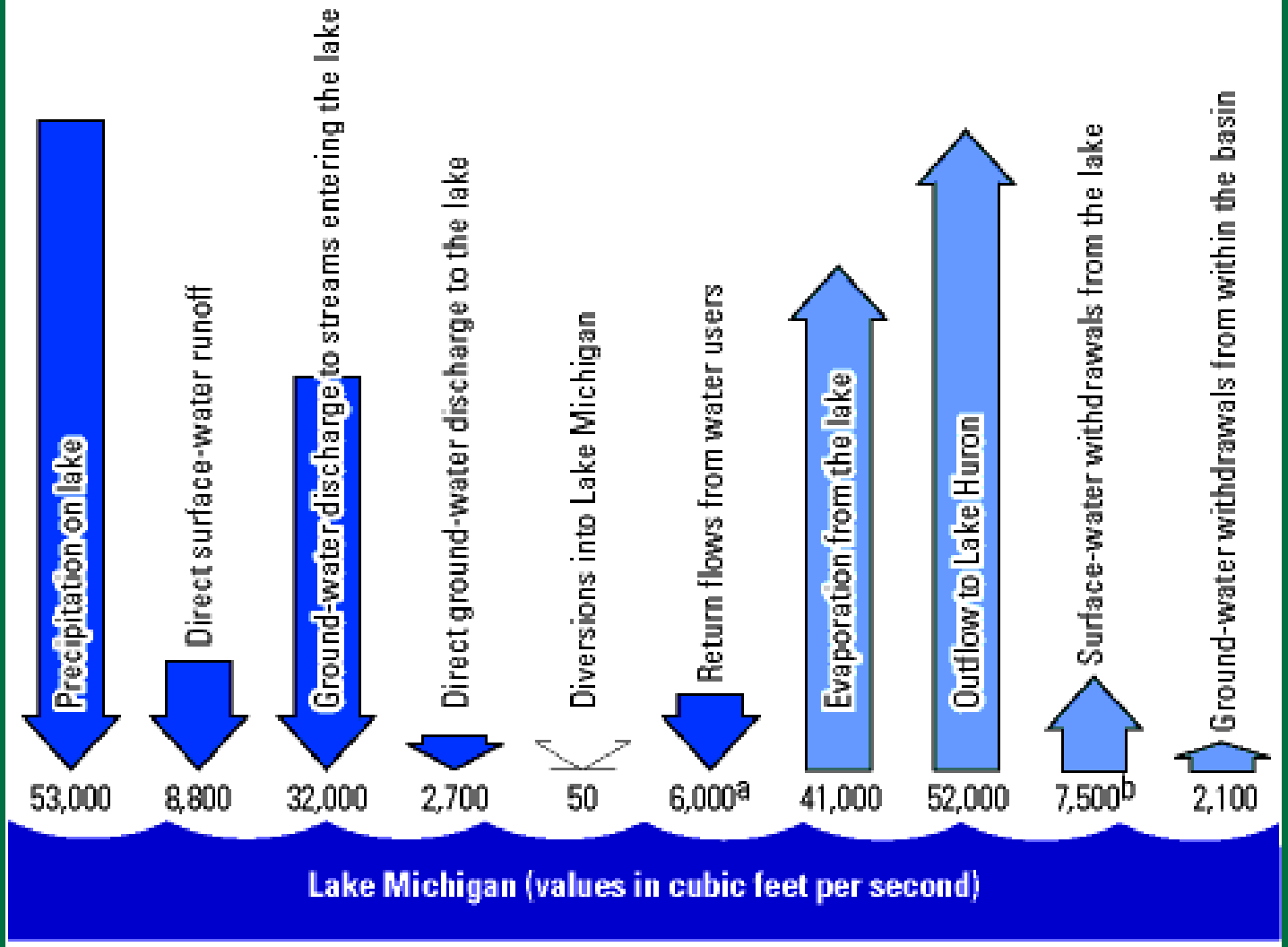

[a]Return flow is reduced by 3,200 ft^3/s that is diverted out of the basin at Chicago, Ill.

[b]Withdrawals for power plant cooling not included

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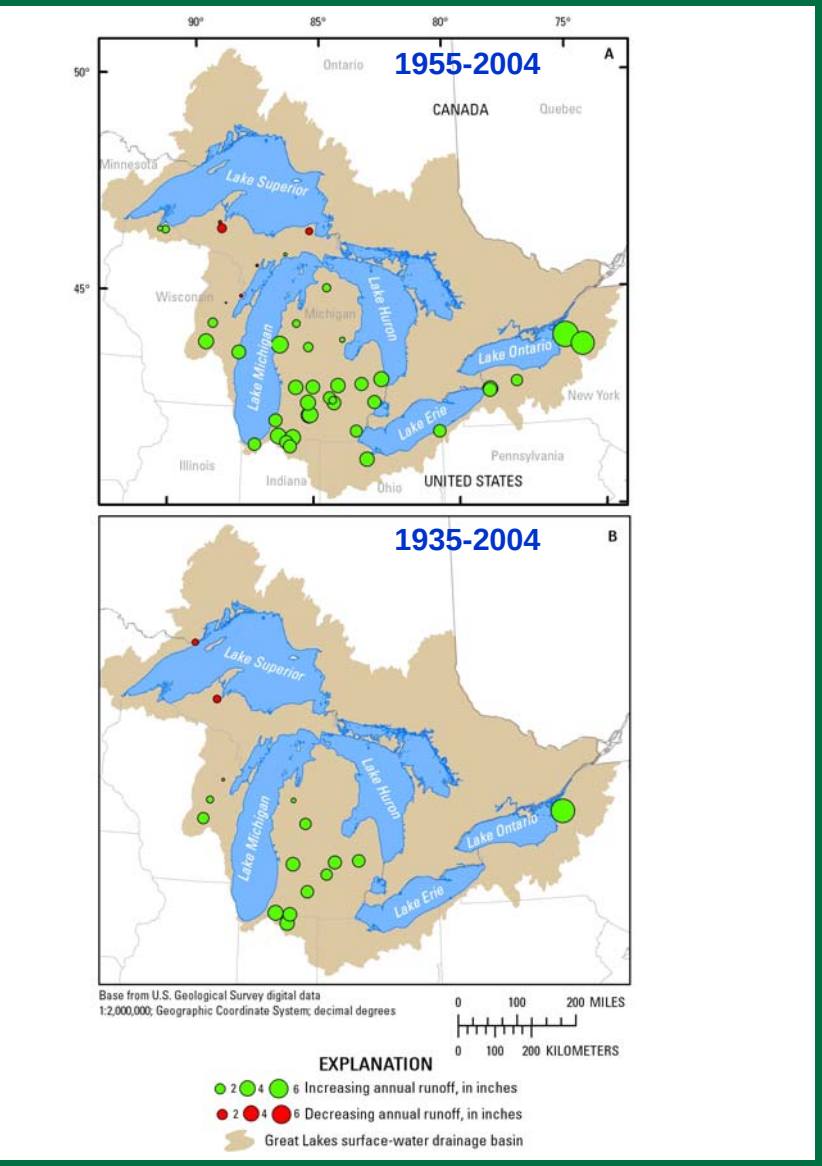
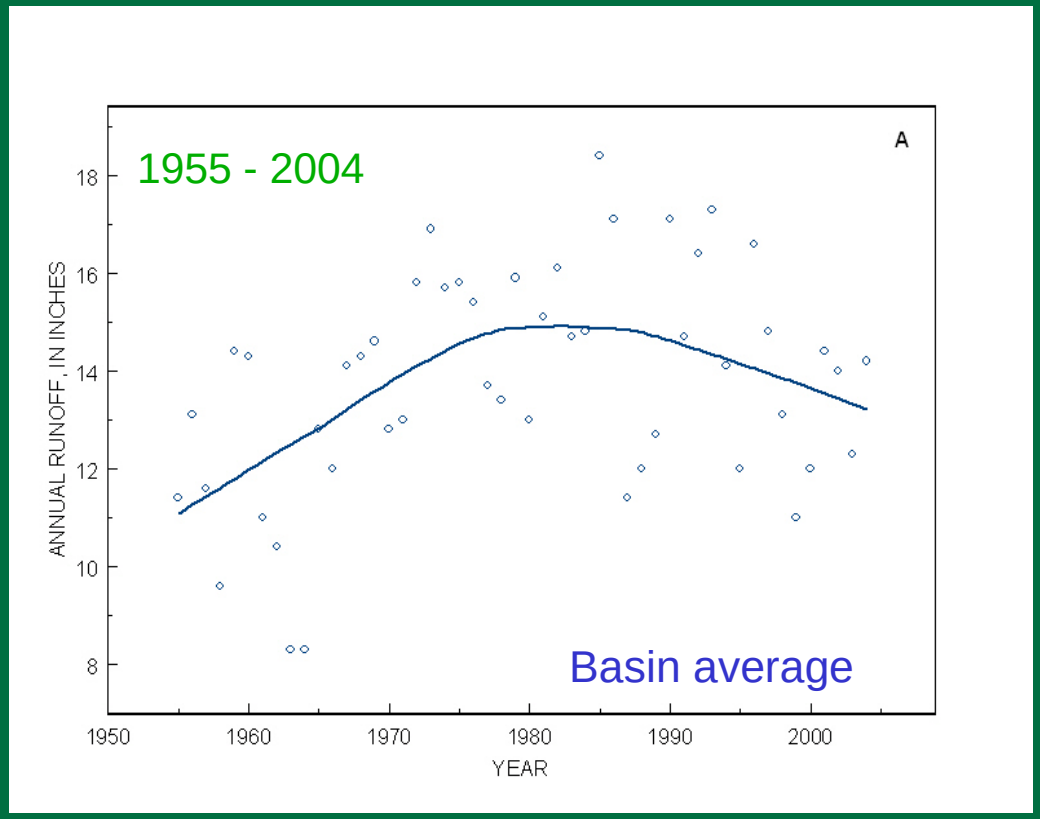
CHANGES IN MEAN ANNUAL RUNOFF



- **1955-2004: Increased by 2.6 in.** (average of 43 stations not substantially affected by regulation or urbanization)

- **1935-2004: Increases similar to 1955-2004 changes** (16 stations available)



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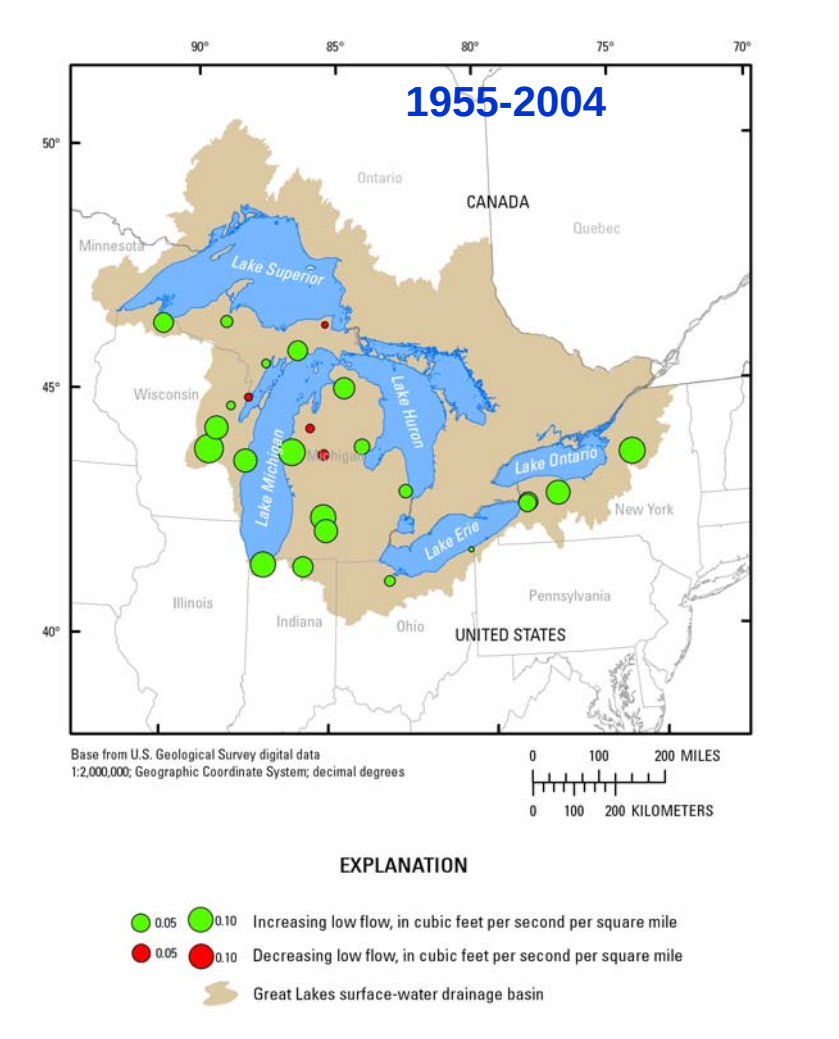
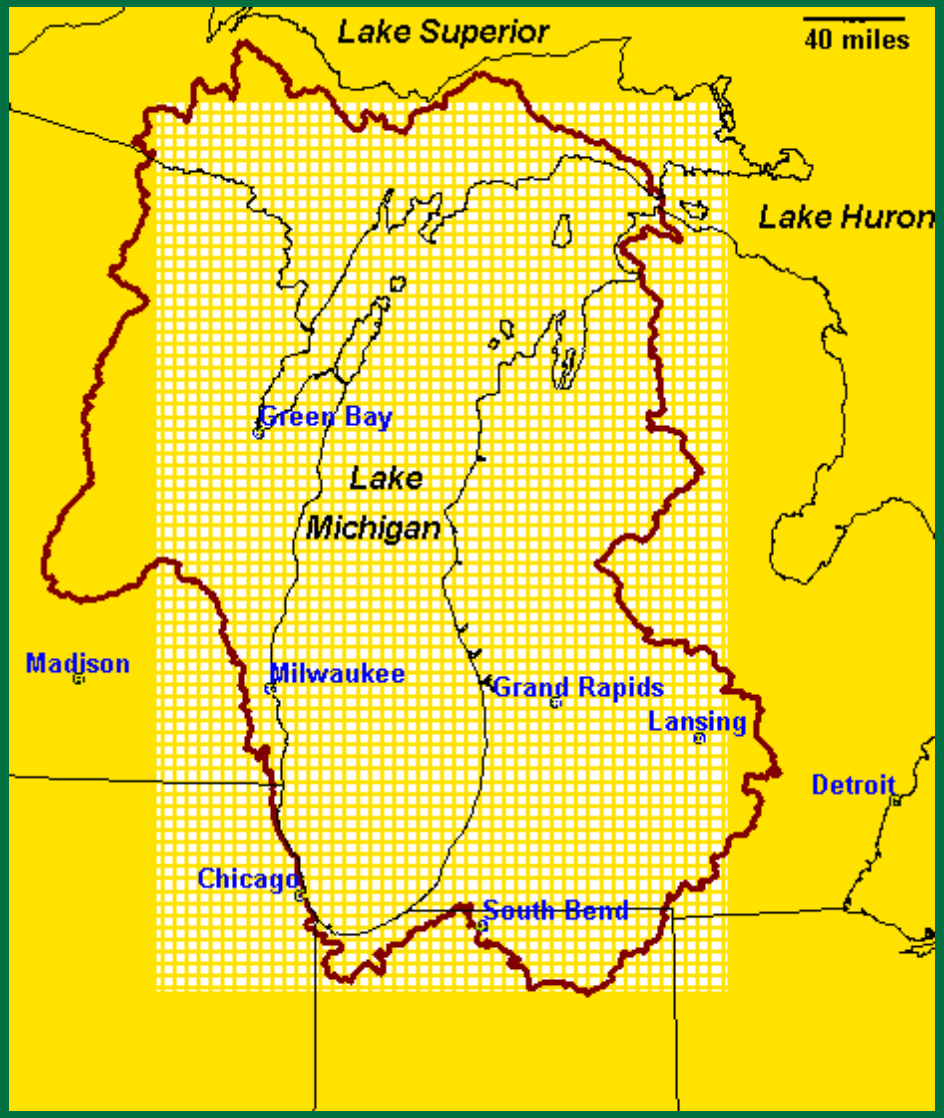
CHANGES IN MEAN ANNUAL 7-DAY LOW RUNOFF



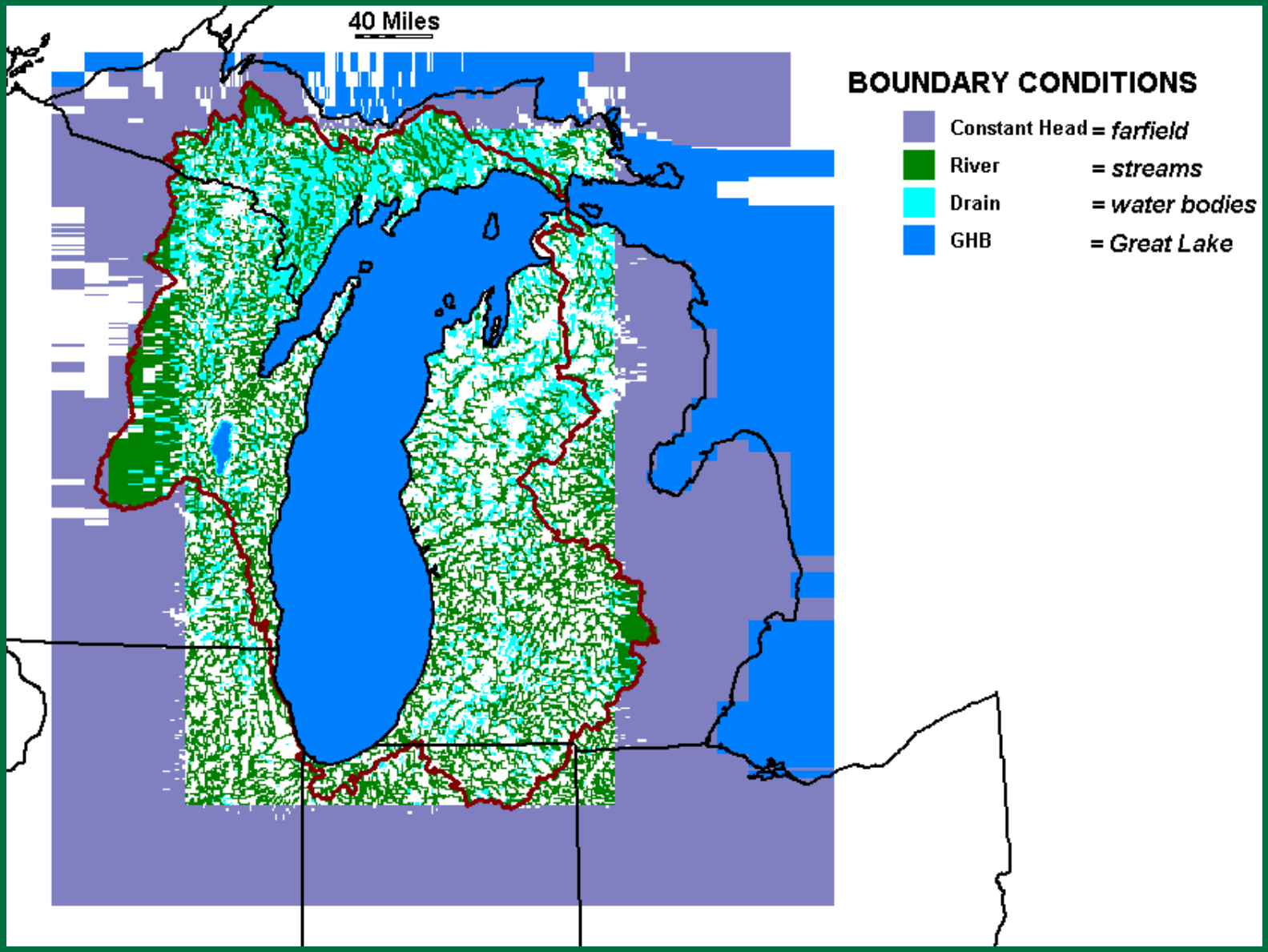
- **Increased by 0.048 (ft³/s)/mi²** (average of 27 stations not substantially affected by regulation or urbanization)

- Increases larger for some of the few highly urbanized and highly regulated stations analyzed than any of the 27 stations not substantially impacted by urbanization or regulation

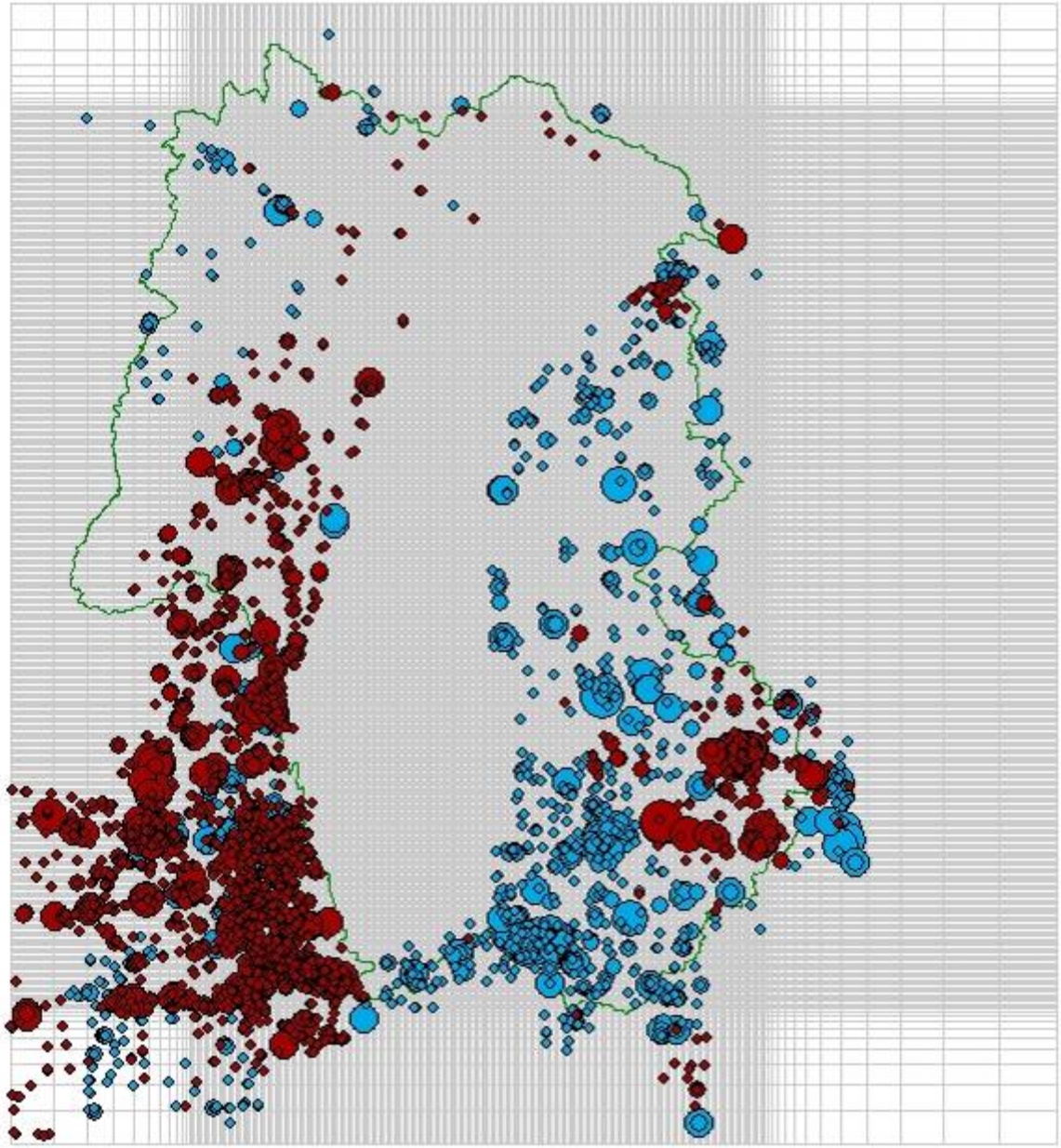
USGS



Lake Michigan Basin Model Domain


40 Miles
BOUNDARY CONDITIONS
Constant Head = farfield
River = streams
Drain = water bodies
GHB = Great Lake

USGS



Public Supply, 2001 - 2004 Stress Period,
Blue -glacial wells, Brown - bedrock wells, 7600 total

Center Pivot Irrigation Using GW Source