Surface Water Supply Planning Issues in the Southern Lake Michigan Region

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Illinois State Water Survey

Straddling the Divide Conference

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Wisconsin
Lake Michigan
Muskegon River
Michigan
Rock River
Milwaukee
Grand River
Grand Rapids
Kalamazoo River
Kalamazoo
Fox River
Chicago
St. Joseph River
South Bend
Ohio
Kankakee River
Indiana
Illinois

Regional use of surface waters

- Waters withdrawn from surface sources other than Lake Michigan currently supply 35 mgd in PWS, roughly 2 percent of the water use in the region.
- Groundwater is generally the first option for water supply. Surface waters will typically be developed in regions of limited GW or used to a greater extent when municipalities outgrow their local groundwater supply.
- As growth outside of the Lake Michigan watershed continues, there will be an increasing need for integrated planning/management of groundwater and surface water supplies.

Major surface water supply issues

1. Protecting Instream Flow Uses
2. Groundwater – Surface Water Interactions
3. Climate Change and Variability

Surface Water Uses

Off-stream uses

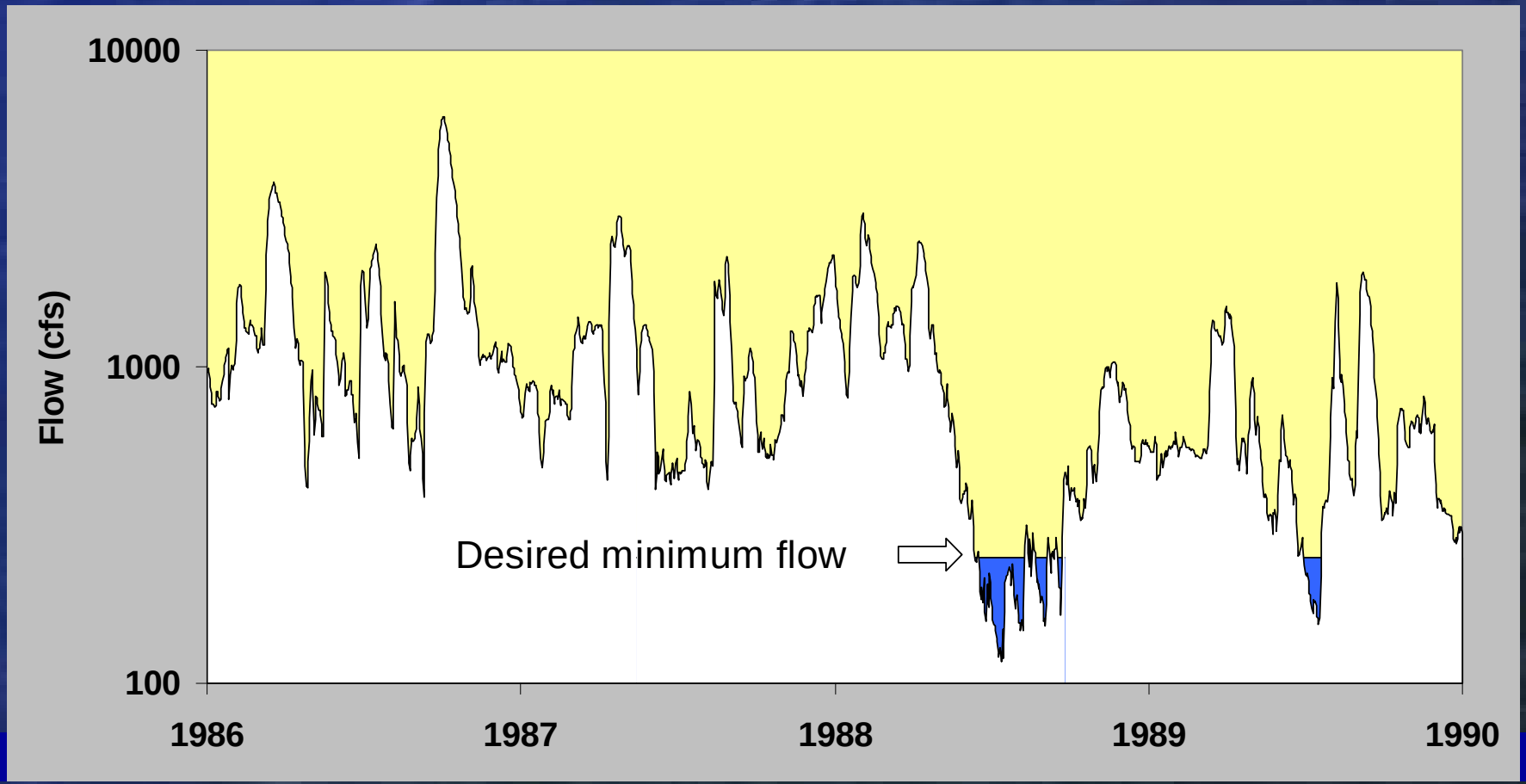
- Withdrawals for PWS, irrigation, industry
- Power generation (thermal)

Instream uses

- Assimilation of waste waters
- Recreation/Aesthetics
- Aquatic habitat / biological health
- Navigation (larger rivers)

Availability of flow in regional streams

Streamflow is usually abundant and its use for water supply is not a concern in most years. But during low flows, instream flow uses become a priority issue.



Some General Surface Water Comments

- In contrast to groundwater, available surface water yield is reasonably well quantified
- Alternative water supplies (off-channel storage, groundwater) need to be reserved for use low flow periods
- The need to better understand the chemistry and biological aspects of instream flow needs

Biggest concern with urban instream flows: Assimilation of waste waters

- Streams in urban areas are receptors of effluent discharges, and typically have considerable more low flow than under natural conditions

- The greatest conflict is typically not between off-stream withdrawals and instream uses, but between the use of the stream for wastewater assimilation versus other instream uses

Assimilation of wastewaters: Fox River example

Largest withdrawals:

Elgin, 13.5 mgd

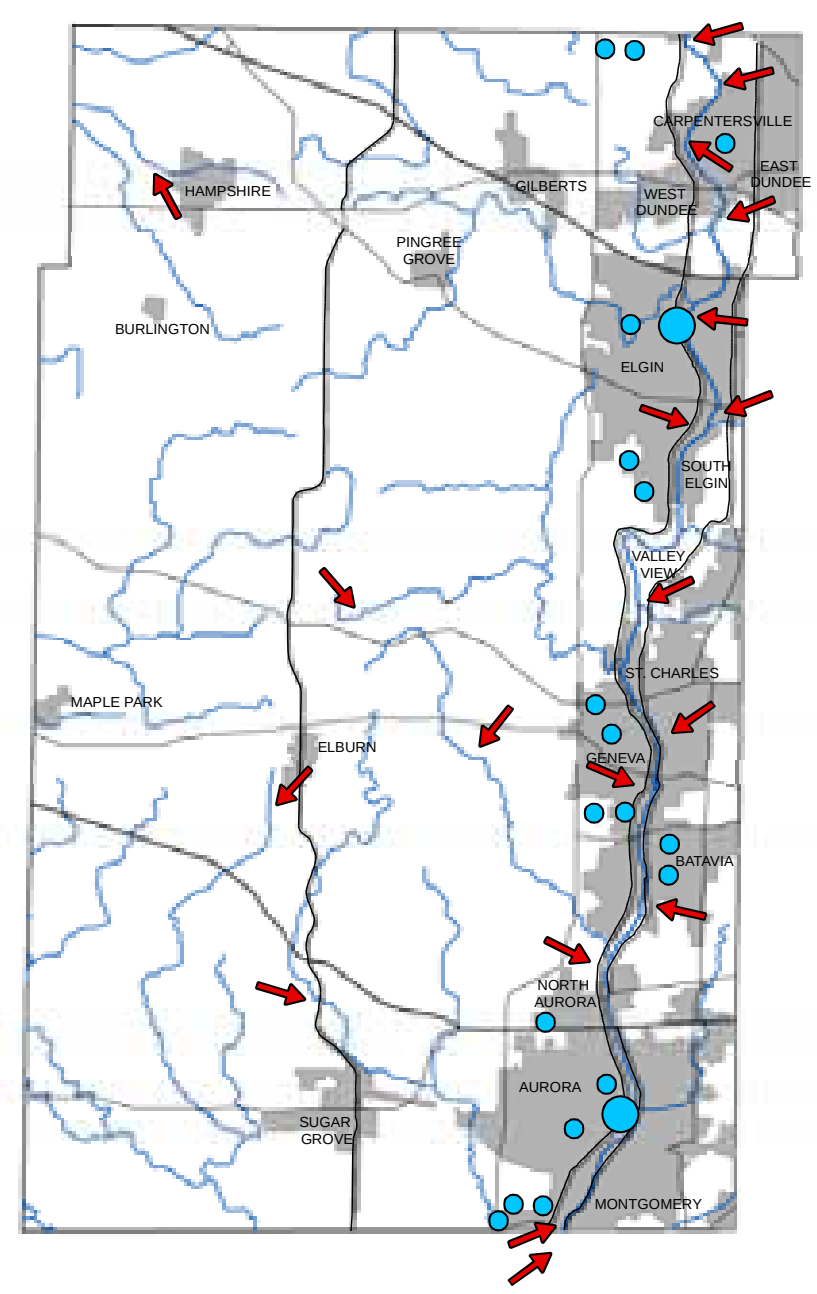
- 1.0 Groundwater
- 12.5 Fox River

Aurora, 17.7 mgd

- 7.5 Groundwater
- 10.2 Fox River

Major wastewater discharge sites

45 mgd during low flows

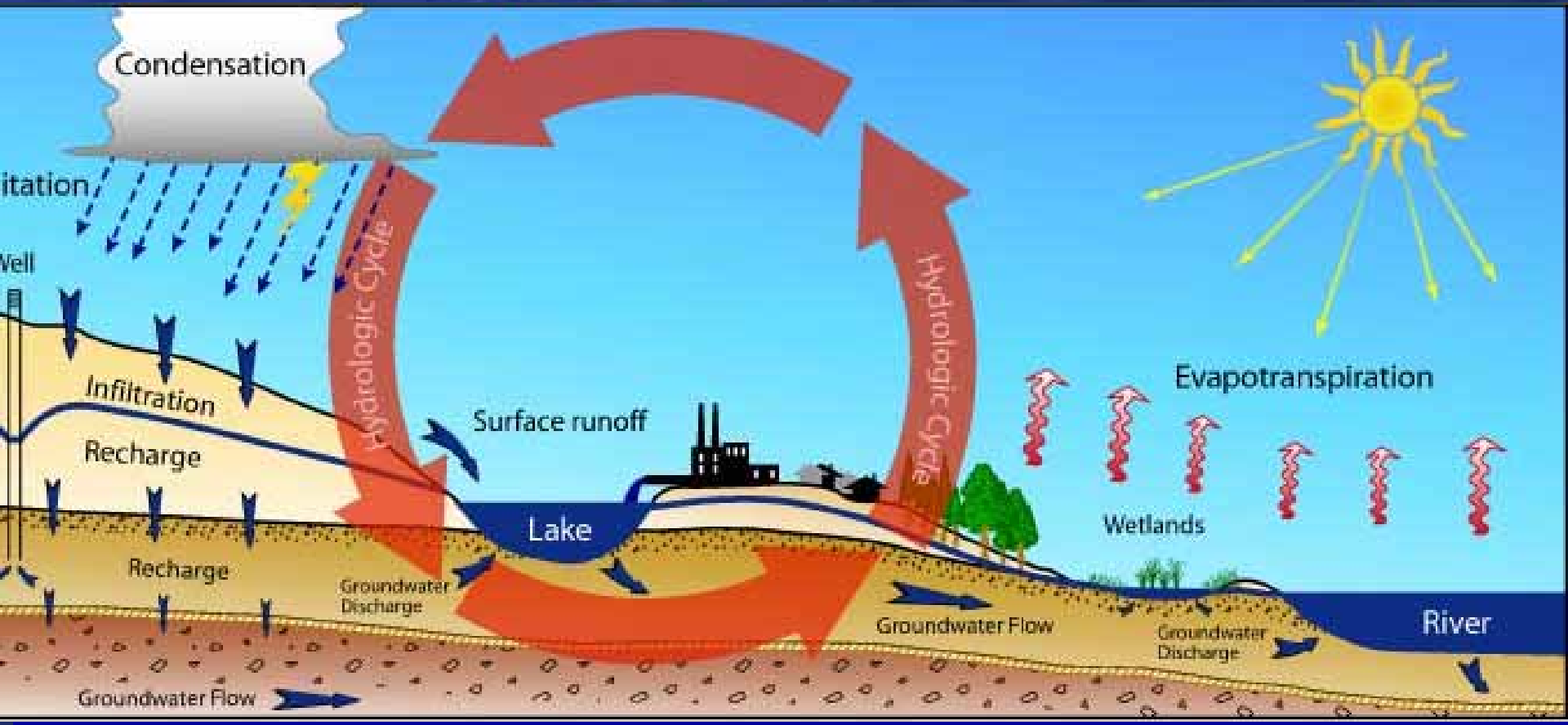


Scientific needs for Instream Flows

- We need to better understand the assimilative capacities of streams. This will require intensive monitoring schemes designed to identify specific water quality dynamics.
- Oxygen demand, nutrients, endocrine disrupters.
- Effects of low channel dams on assimilative capacity
- Need to understand the behavior and enhancement of aquatic ecosystems.
- Improving technologies for wastewater treatment.

Groundwater – Surface Water Interactions

The water that recharges shallow aquifers is the same as that discharging to streams as base flow



Groundwater-Surface Water Interactions

- If the aquifer is directly connected to the stream, pumping can induce water from stream into aquifer
- Even if not directly connected, lower groundwater levels can reduce base flow movement to streams
- Changes in base flow are good indicators of changes in groundwater recharge and other
- There are legitimate concerns about reduced recharge in urban areas; however, base flows in urban streams tend to be higher than their rural counterparts.
- The greatest threat to instream flow quantity may not come from surface water withdrawals, but from overuse of shallow aquifers.

Groundwater-Surface Water Interactions

- Shallow groundwater and surface water – A single resource needing integrated planning/management
- Pumping tests are needed to evaluate direct impacts between groundwater use & streamflows in areas of shallow groundwater development.
- Long-term streamflow gages are needed on tributaries that have high base flows to monitor long-term impacts of groundwater development on low flows.
- Trends in hydrologic systems are highly variable, complex, and may be difficult to verify unless monitoring is designed for maximum feedback.

Conservation – a part of the solution

- Water use has declined over the past 30 years
- In the long run, conservation is usually cheaper than building new supplies and has many benefits
- Conservation increases the susceptibility of water supplies to drought (National Drought Study)
- Thus, conservation should be used in conjunction with development of additional supplies – there should always be sufficient reserve for public confidence
- As part of tactical responses to drought, conservation has had mixed success in Illinois. To be successful the process needs political/social will.

Climate Change and Variability

- Climate Change – Progressive long-term changes in climate related to increases in the concentration of greenhouse gases
- Climate Variability – Natural and periodic changes in the climate that may last several decades, but are a part of the overall long-term stable climate

Climate Change and Variability

- The existence of global warming is real. However, global climate models provide insufficient detail on what this will mean at regional scales, such as for the Midwest.
- The potential effect of human-induced climate change on precipitation is particularly not well-understood
- Different Global Climate Models show a wide range of potential changes in both temperature & precip.
- Potential climate change should be analyzed within the context of historical variability

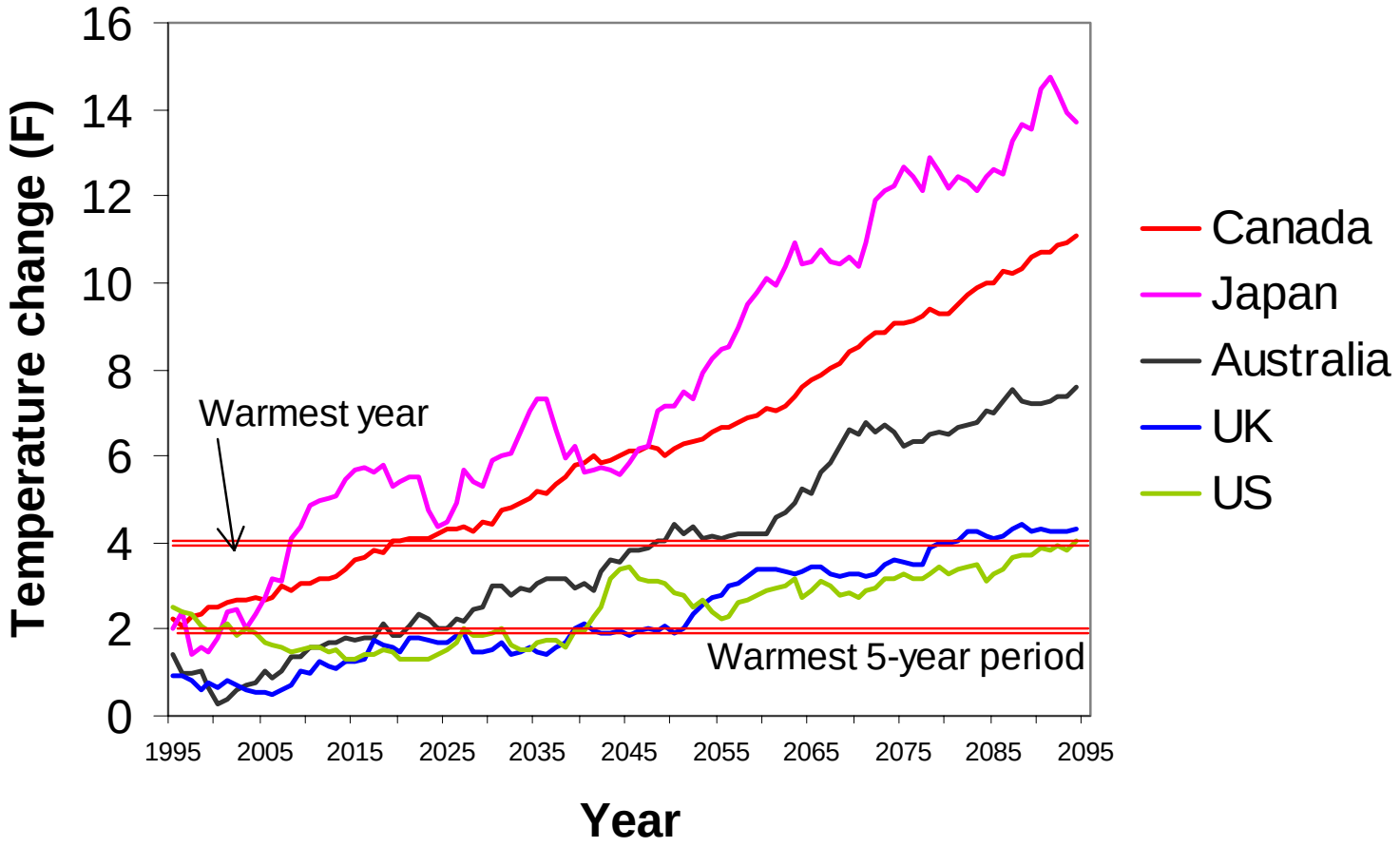
Climate Change Impacts on Water Resources

There is general expectation that:

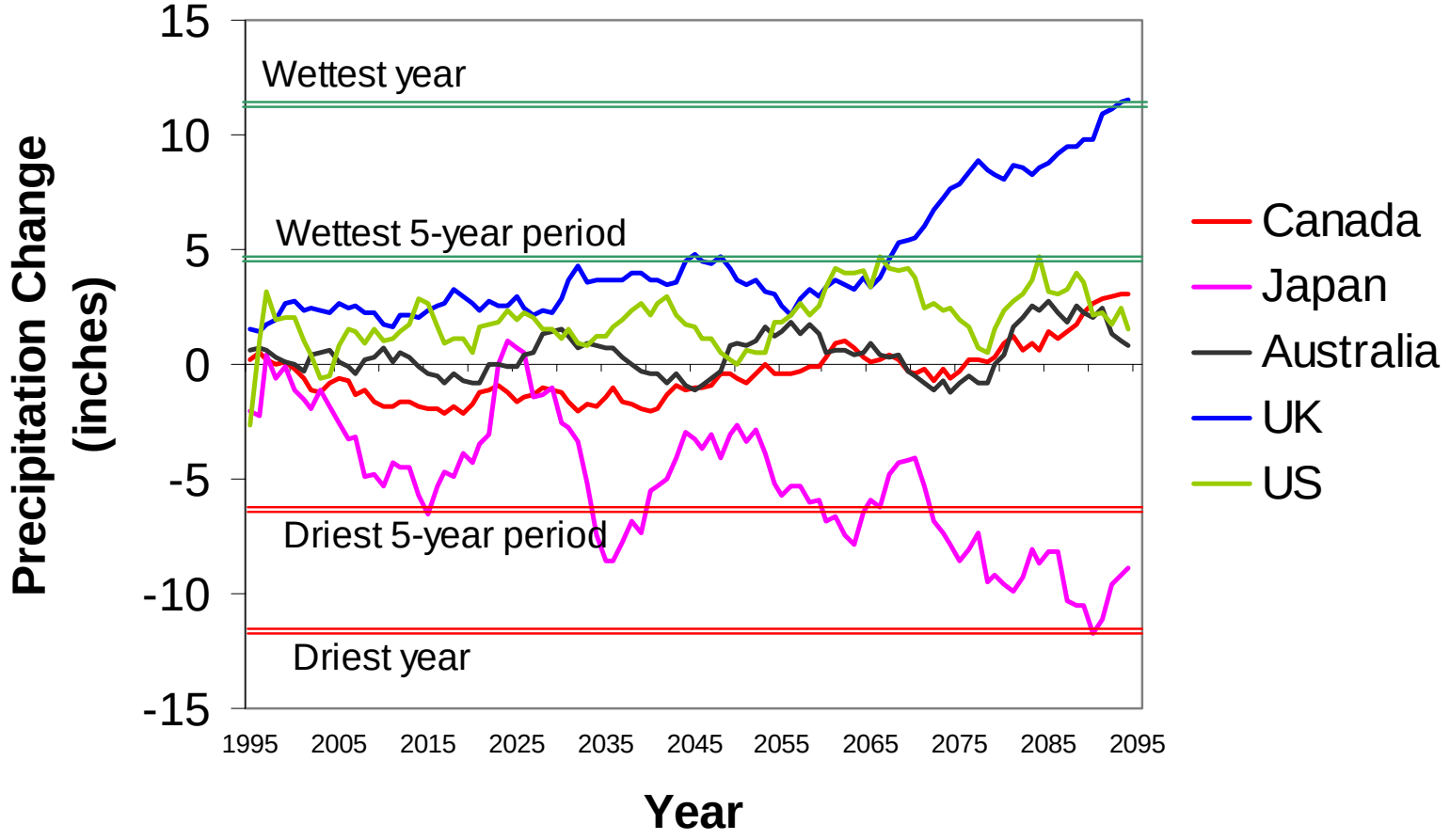
- Heavy precipitation events will increase in magnitude and frequency as part of climate change
- Overall precipitation could either increase moderately or decrease
- The hydrologic cycle will intensify, resulting in more extreme floods and droughts
- Water levels in streams and lakes will decrease.

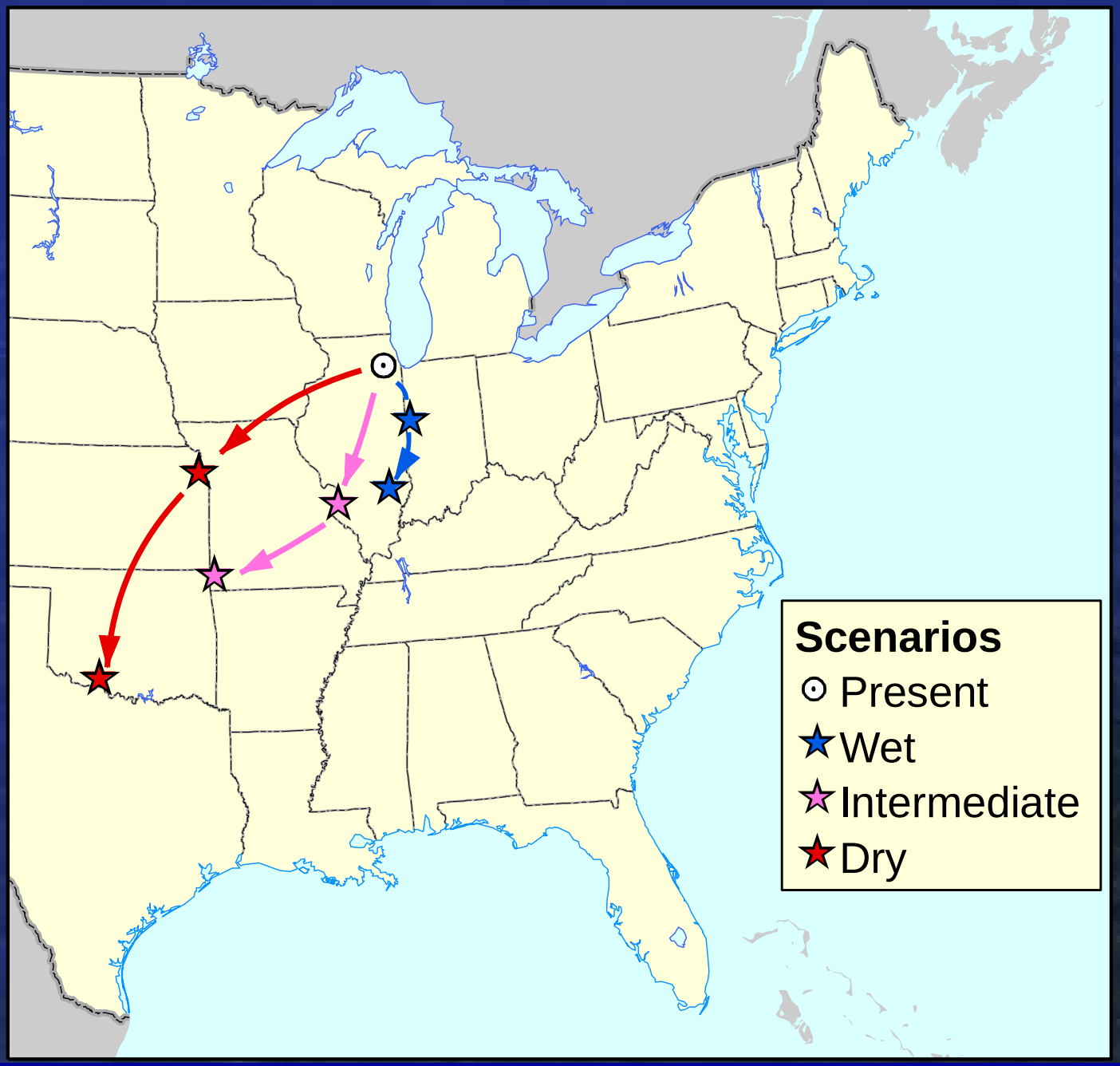
These conclusions depend substantially on which global climate model is used as the basis of the projection. Not all GCM scenarios would result in these changes.

Global Climate Model Projections
Annual Temperatures - Illinois

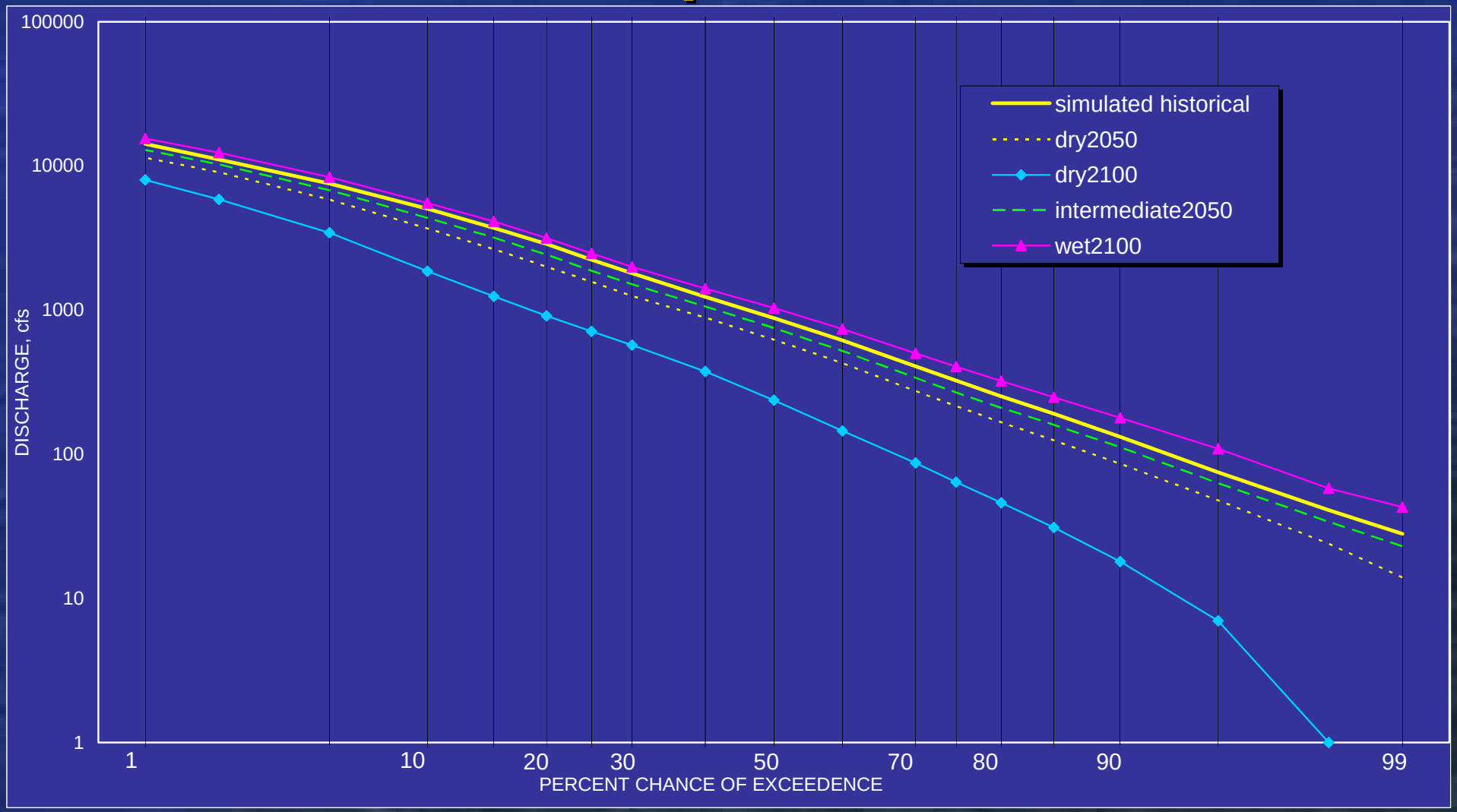


Global Climate Model Projections
Annual Precipitation - Illinois




Scenarios
Present
Wet
Intermediate
Dry

Hydrologic simulation of climate change impacts



Use of Climate Scenarios in Hydrologic Simulation Modeling

- The “wet” scenario predicts a moderate (< 15%) increase in all types of streamflow conditions. If this occurs, the changes in streamflow may be difficult to detect within the normal range of climate variability.
- The “intermediate” scenario indicates a moderate decrease in most flows, but a noticeable decrease (30%) in flows during extended drought conditions.
- The reduction in all flow conditions associated with the “dry” scenario would be substantial, and such a climate change would result in widespread socioeconomic impacts.

Looking at Historic Variability in Climate and Streamflow in the Midwest

- There is a need to understand potential climate changes within the context of historical climate variability.
- Given the significant uncertainties in climate change projections, scenarios of potential future changes should be balanced with observed changes in the hydrology of the Midwest.

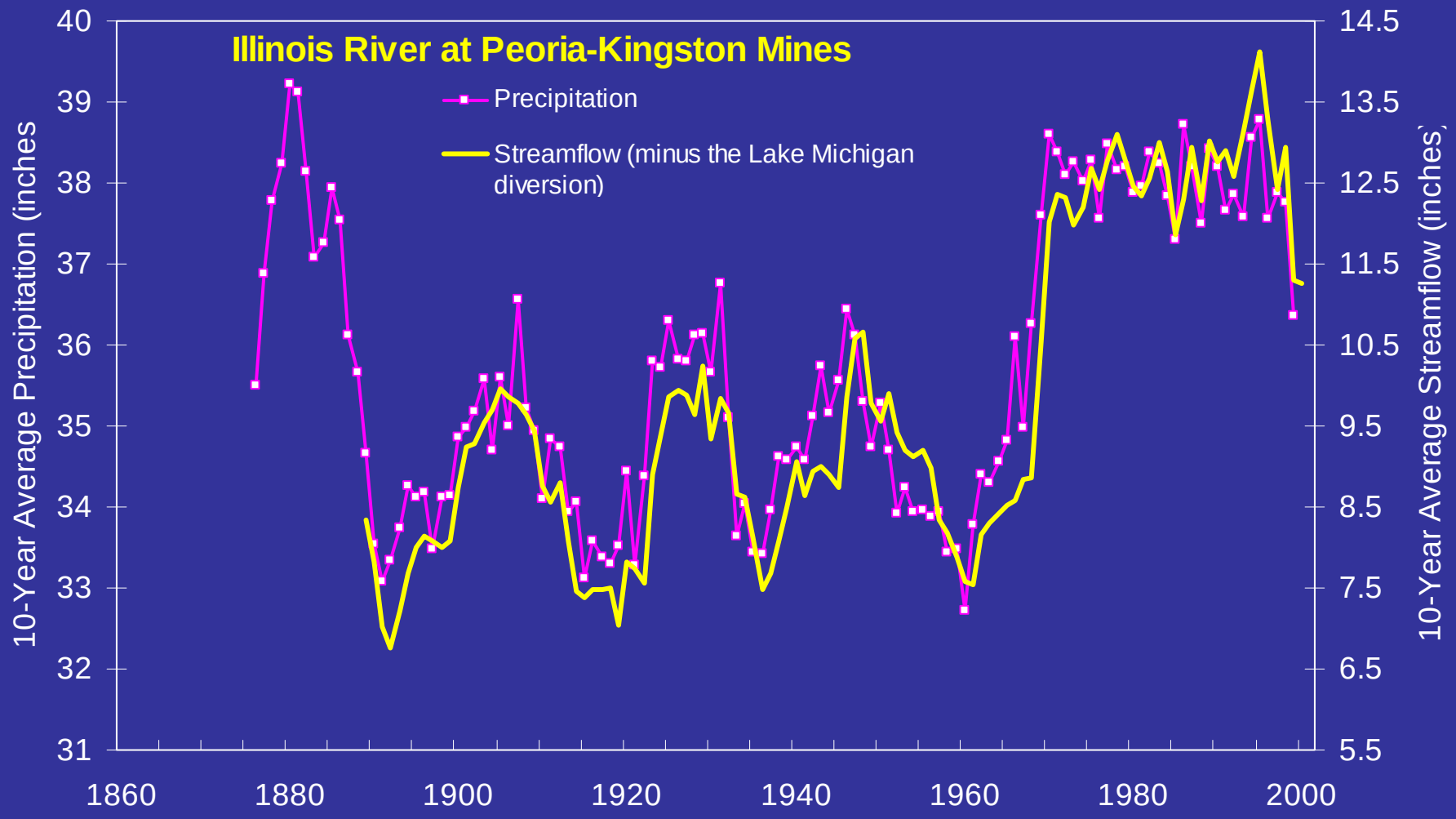
Historic Variability in Climate and Streamflow

- The Midwest shows little evidence of warming.
- Since about 1970, there has been a considerable increase in the average precipitation in the Southern Lake Michigan region (precipitation increases of 3-4 inches per year).
- This is part of a larger regional increase that has affected much of the Upper Midwest, although much of Wisconsin has generally seen smaller increases.
- Increases in the frequency of heavy rainfall events account for much of the additional precipitation.

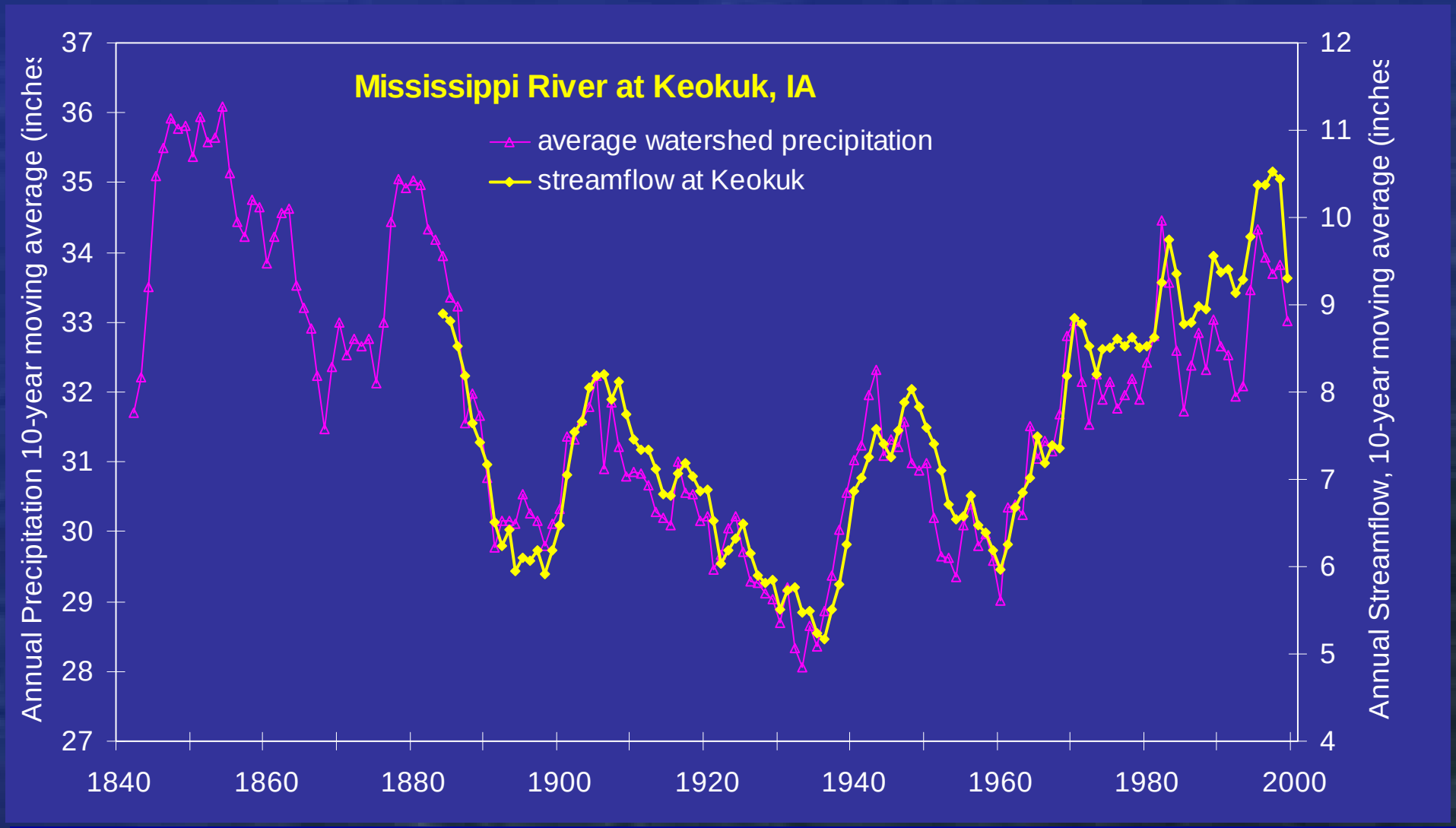
Historic Variability in Climate and Streamflow in the Midwest

- With the increase in precipitation, there has been a corresponding increase in average annual streamflow, with much of the UMRB experiencing flow increases of 30% or more.
- We don’t know if this is part of climate change or normal climate variability of a combination thereof.
- It does appear to be within the range (although at the extreme end) of conditions that have been experienced in the previous 150 years.

Effect of Climate Variability on Streamflow

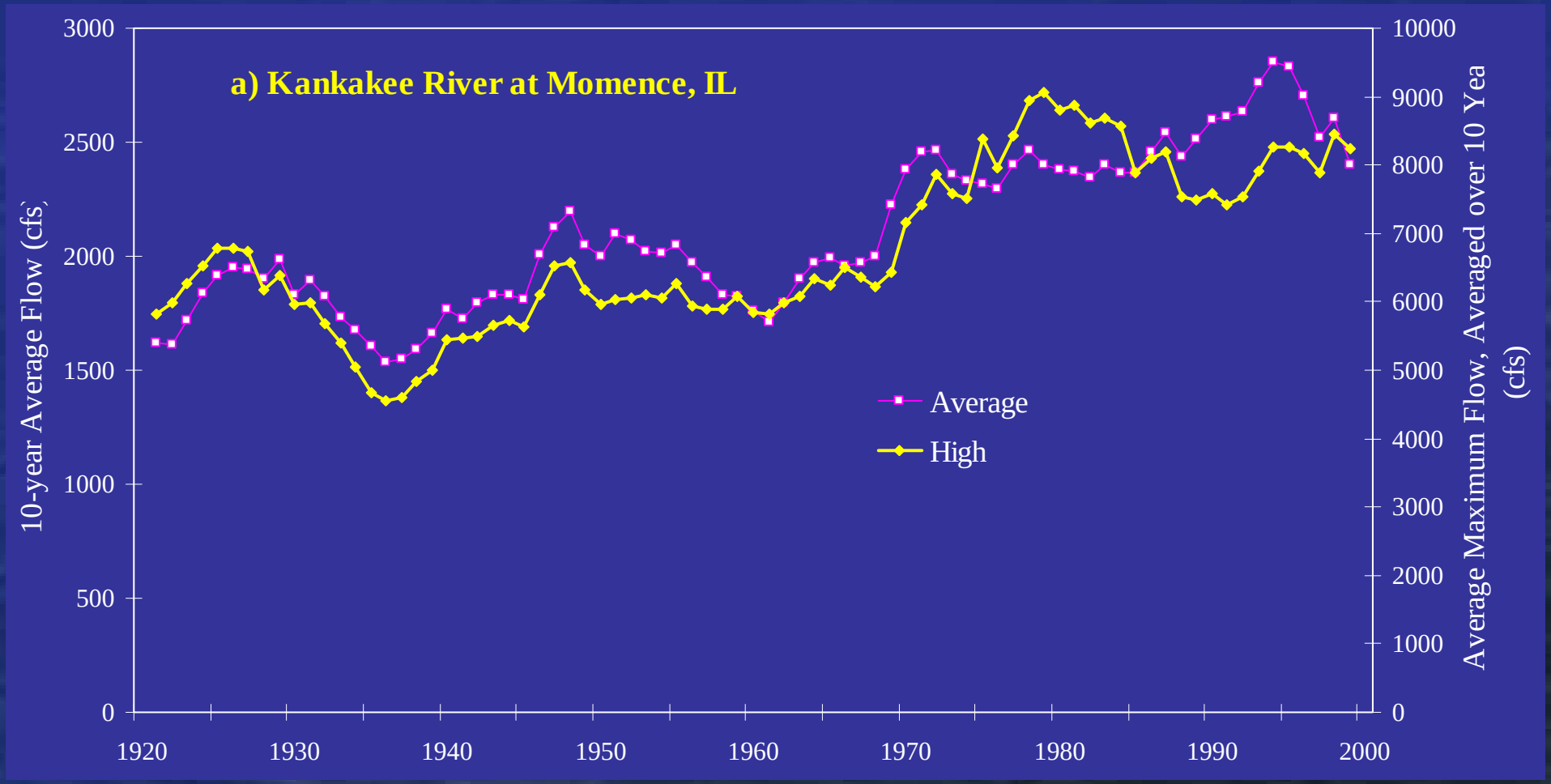


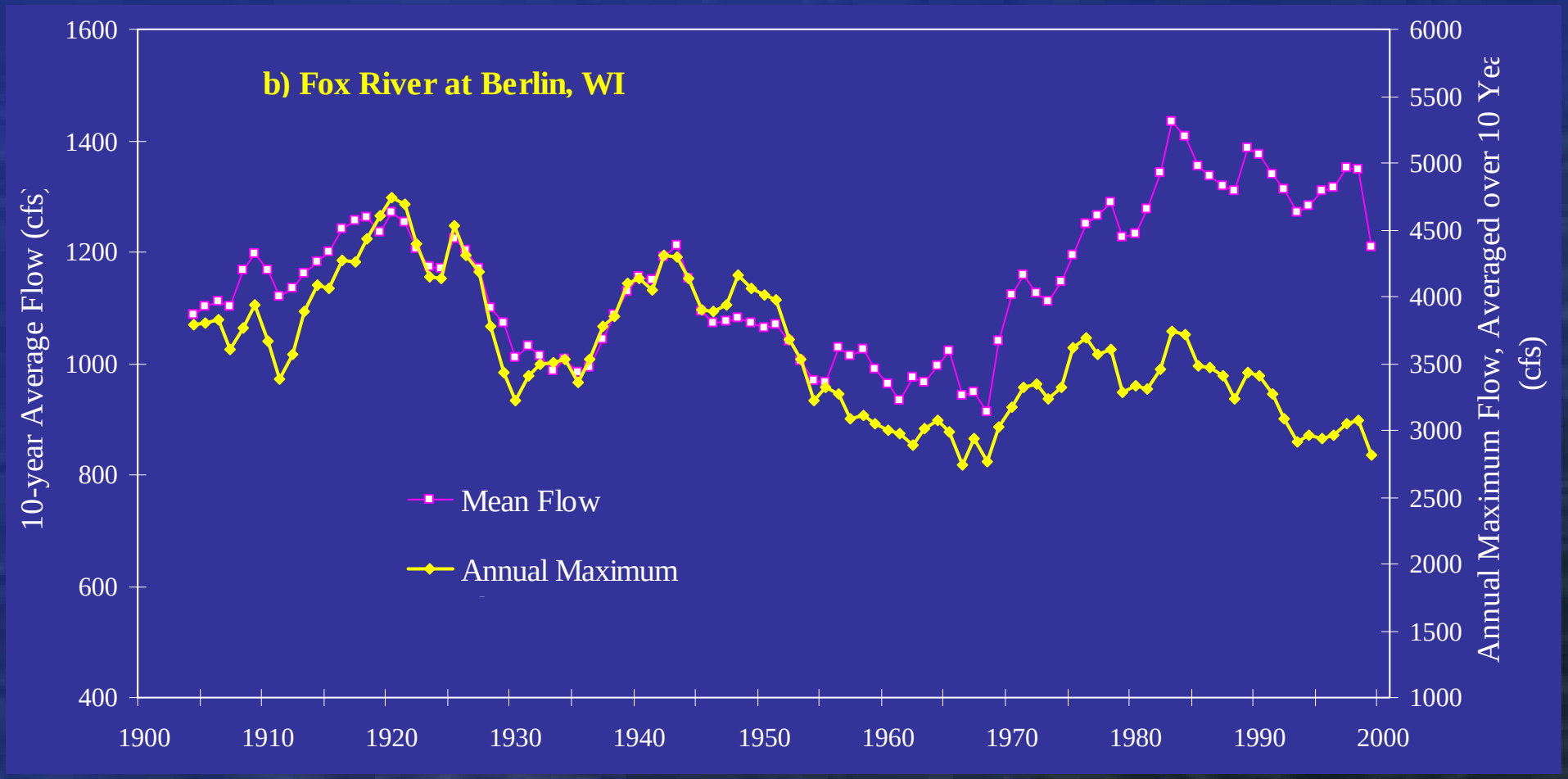
Effect of Climate Variability on Streamflow

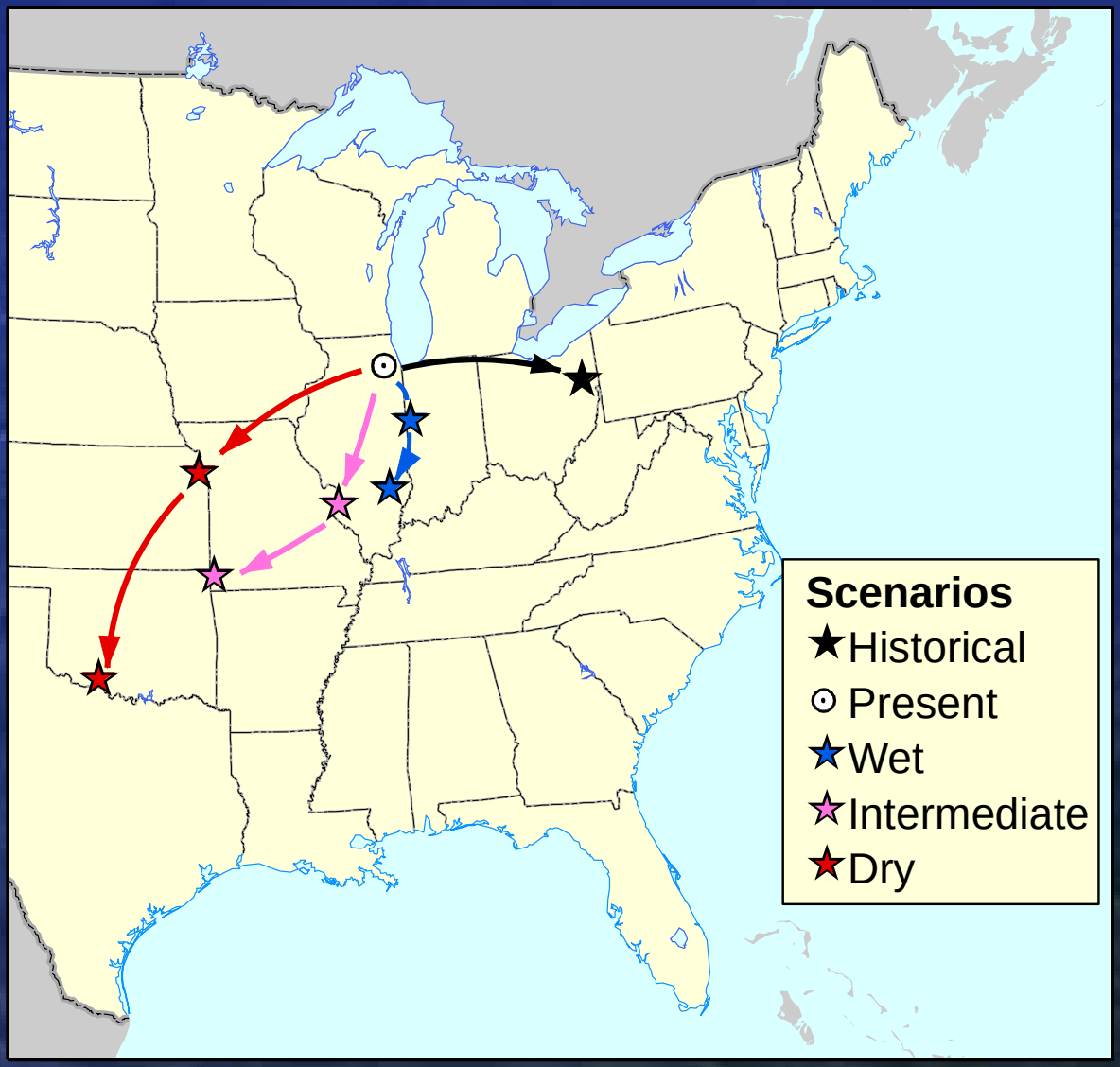


Historic Variability in Climate and Streamflow in the Midwest

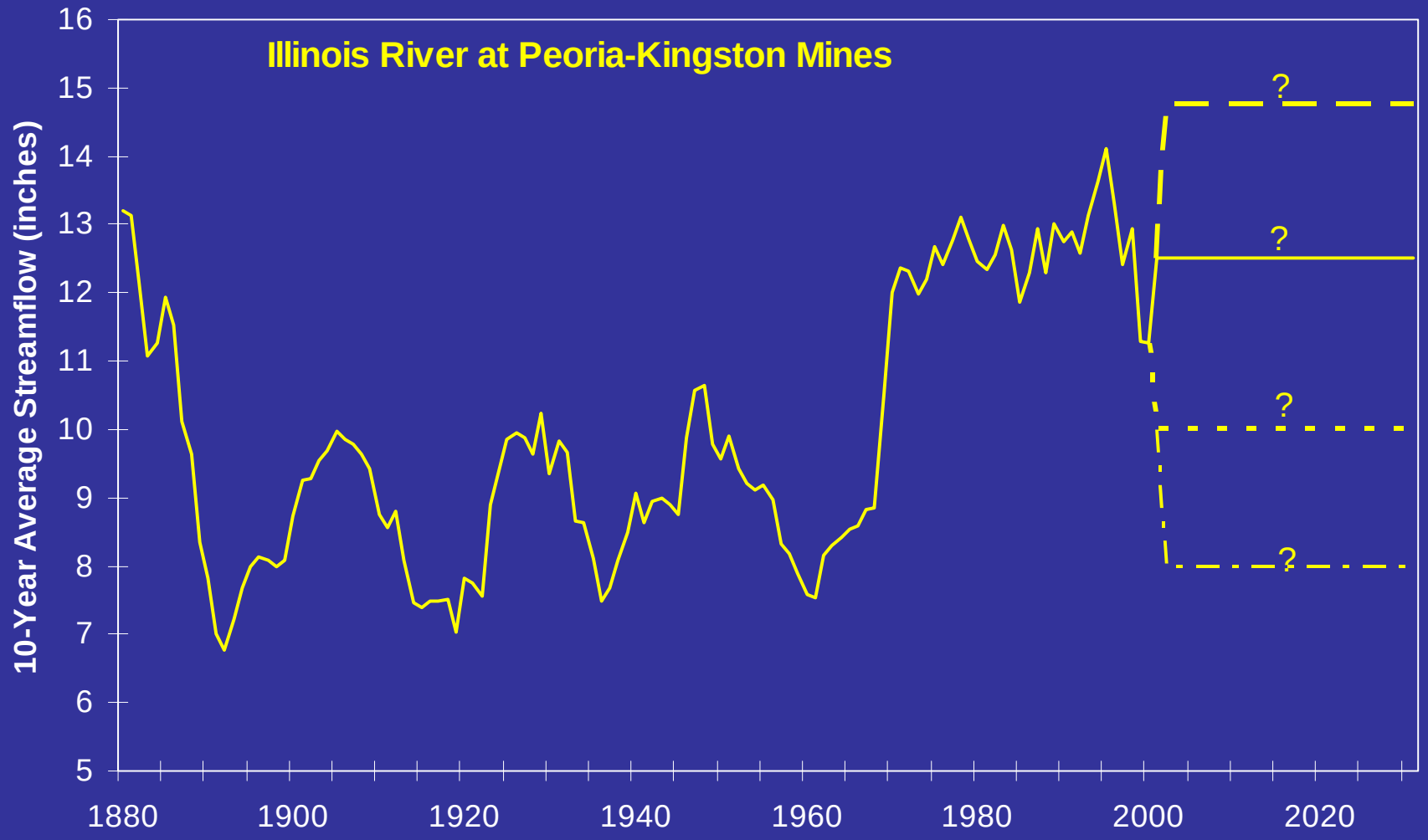
- Low flows and medium flows are increasing; their increases is proportional to the increase in mean flows
- There has been a decrease in the frequency and severity of drought conditions
- The response to high flows are mixed. For much of the region, high flows have increased in proportion to average flows, but in some areas statistical tests show a significant reduction in high flows relative to average flows.


a) Kankakee River at Momence, IL
10-year Average Flow (cfs)
Average Maximum Flow, Averaged over 10 Yea
(cfs)
Average
High
3000
2500
2000
1500
1000
500
0
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
1920
1930
1940
1950
1960
1970
1980
1990
2000


b) Fox River at Berlin, WI
10-year Average Flow (cfs)
Annual Maximum Flow, Averaged over 10 Yea
(cfs)
Mean Flow
Annual Maximum
1600
1400
1200
1000
800
600
400
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000


Scenarios
Historical
Present
Wet
Intermediate
Dry

Climate Variability:
What's in store for the next 30 years?



Climate Change Effects on Water Resources

- Currently the climate conditions are very favorable towards water resource availability and maintaining healthy streams.
- This could change with a major shift related to either climate variability or change.
- At a minimum, yield/recharge estimates must consider the extremes of historical climate variability
- If the drier or intermediate GCM projections come true, there will be some difficult choices related to water resource priorities
- Commercial navigation could especially be impacted

In summary

- We cannot separate surface water issues from groundwater issues. Integrated planning approaches are needed.
- Wastewater assimilation and biological health of streams must be understood as part of surface water supply development.
- The potential effect of climate change on precipitation, and thus on water resources, is still uncertain. Perspectives should be balanced with historical trends.