Surface Water Availability in the East Central Illinois Planning Area:

Factors that Affect the Distribution and Availability of Surface Waters for Water Supply

H. Vernon Knapp, Senior Hydrologist
Center for Watershed Science
Illinois State Water Survey

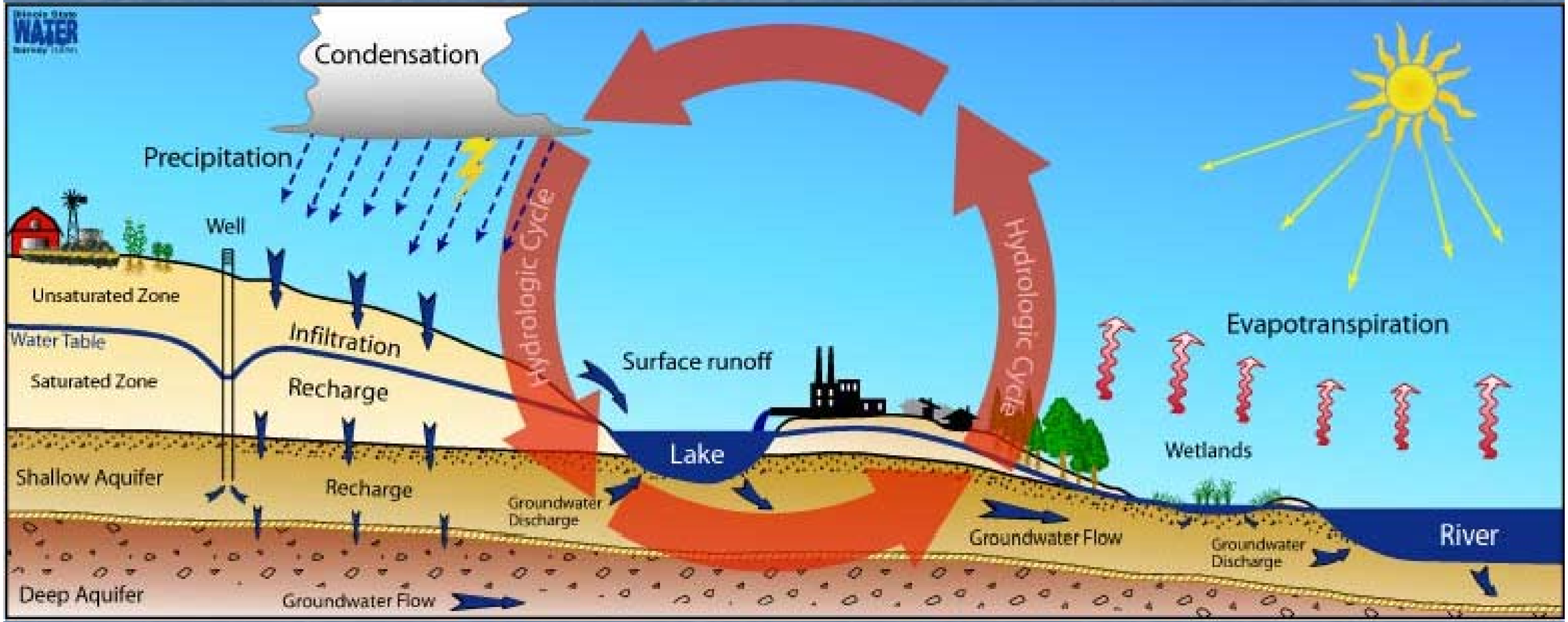
August 31, 2007

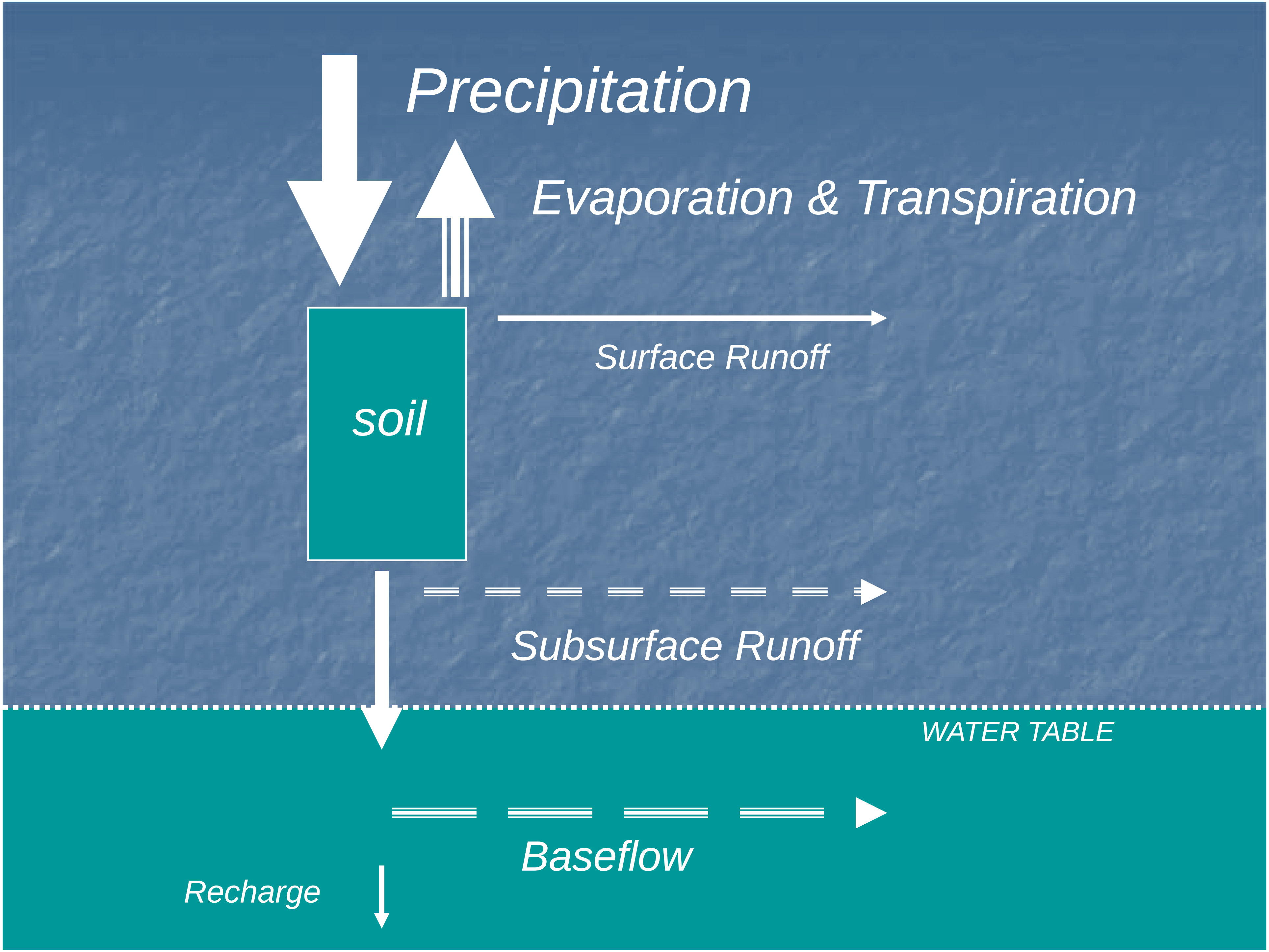
Presentation Outline

- **The Hydrologic Cycle**
  Sources of natural flow in rivers and streams
- **Surface Water Supply Sources**
  Statewide and East Central Illinois
- **Factors Affecting Surface Water Availability**
  Climate variability & change
  Water use (withdrawals and return flows)
  Reservoirs, diversions, navigation works
  Indirect impacts on baseflow (groundwater interactions)
- **Instream Flow and Water Supply**

The Hydrologic Cycle

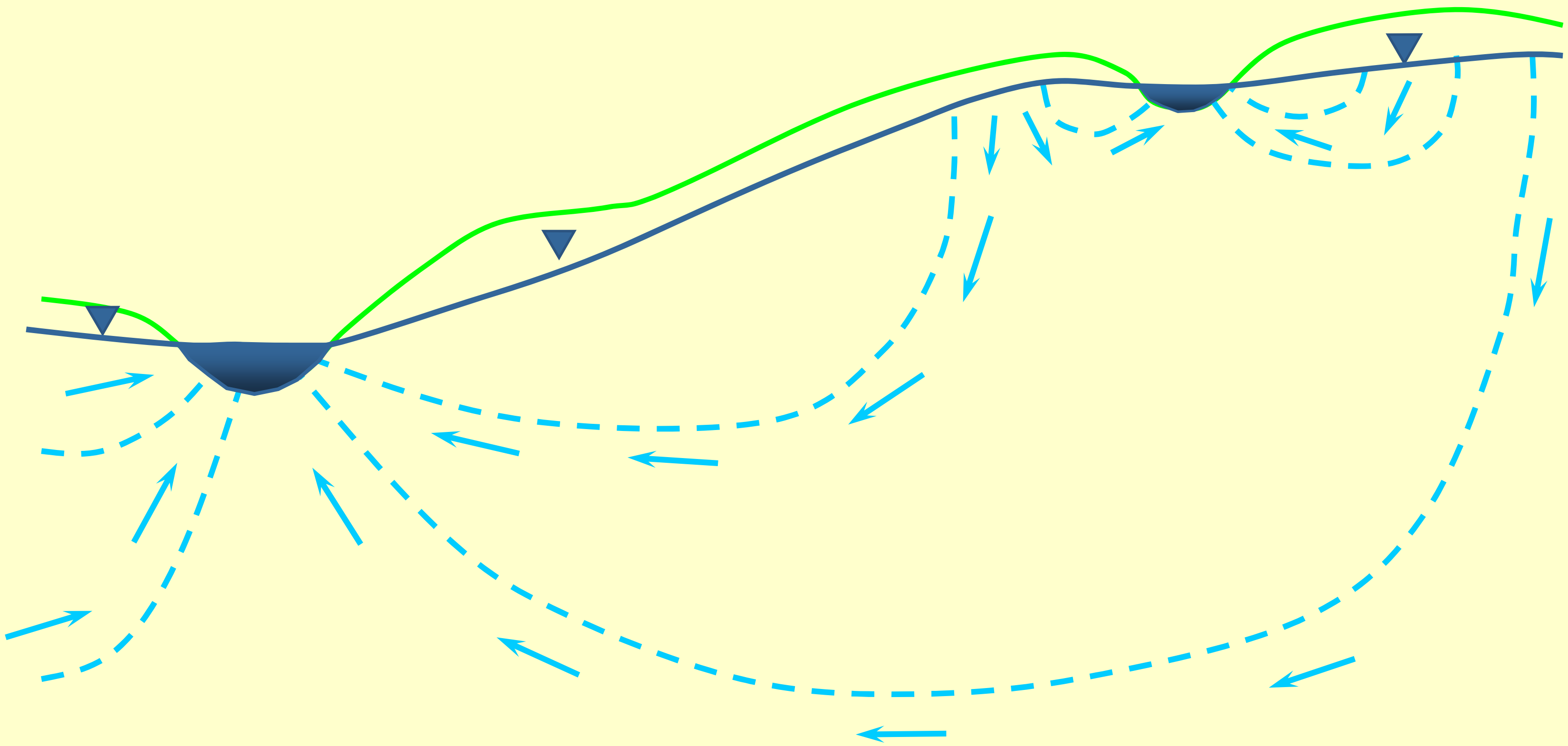
Climate, surface water, and groundwater are linked




Precipitation
Evaporation & Transpiration
Surface Runoff
soil
Subsurface Runoff
WATER TABLE
Baseflow
Recharge

Groundwater to Surface Flow Diagram:

Surface Water and Shallow Groundwater are a Common Resource



Regional variations in surface runoff and baseflow

- The amounts of baseflow in regional streams are directly related to the intersection of the stream with permeable groundwater resources – often these are areas with sand deposits – creating local and regional source areas of baseflow
- In east-central Illinois, some streams with the highest baseflow levels have a direct interface with the Mahomet Aquifer

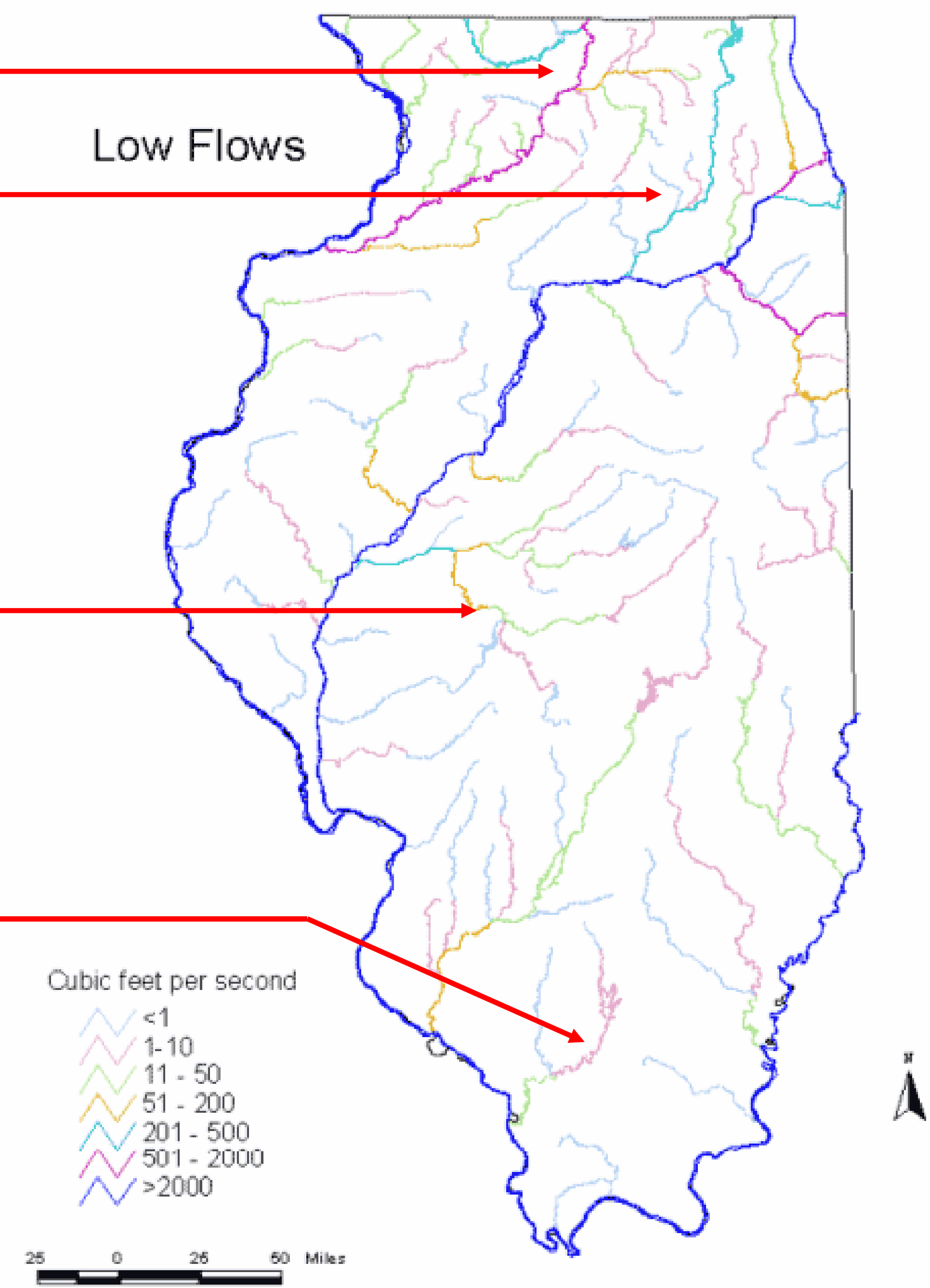
Rock River > 1000 cfs

Fox River 200 – 300 cfs

Sangamon River 30 – 50 cfs

Big Muddy River 1 – 10 cfs

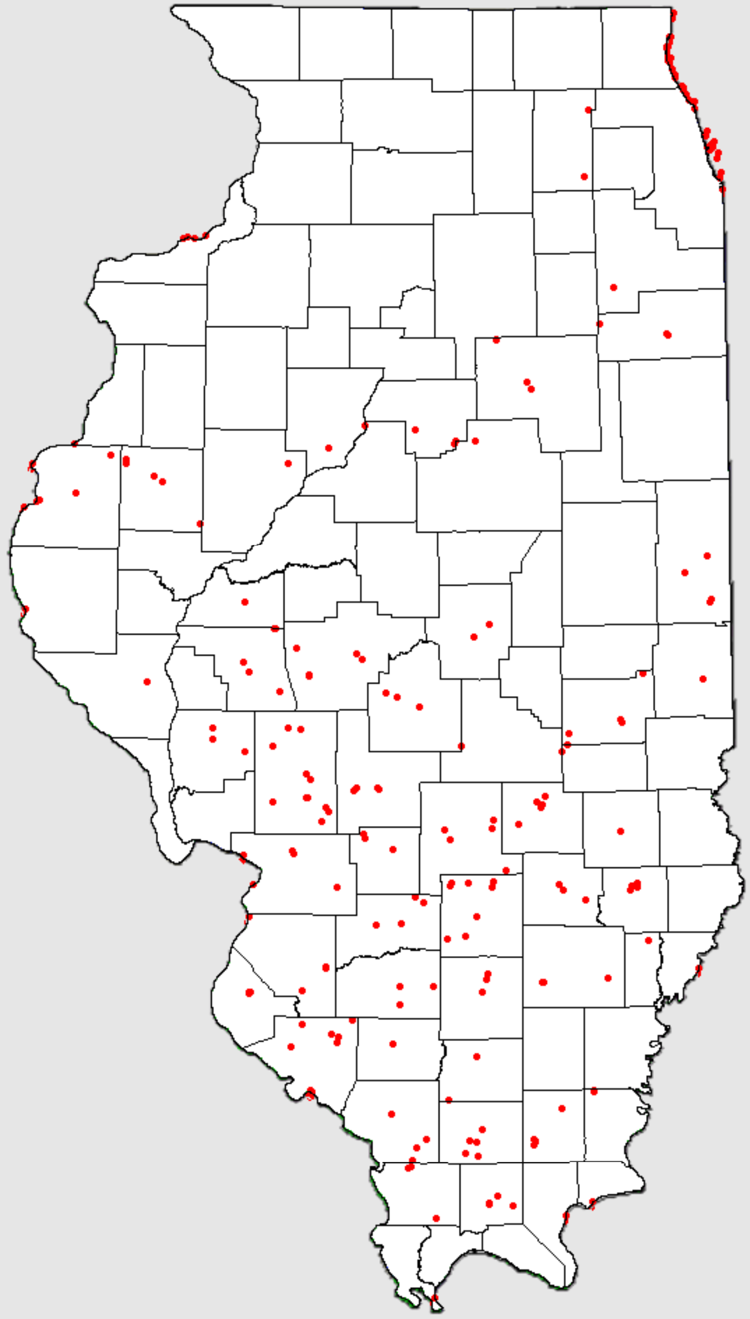
5-year low flows



Public Surface Water Supplies

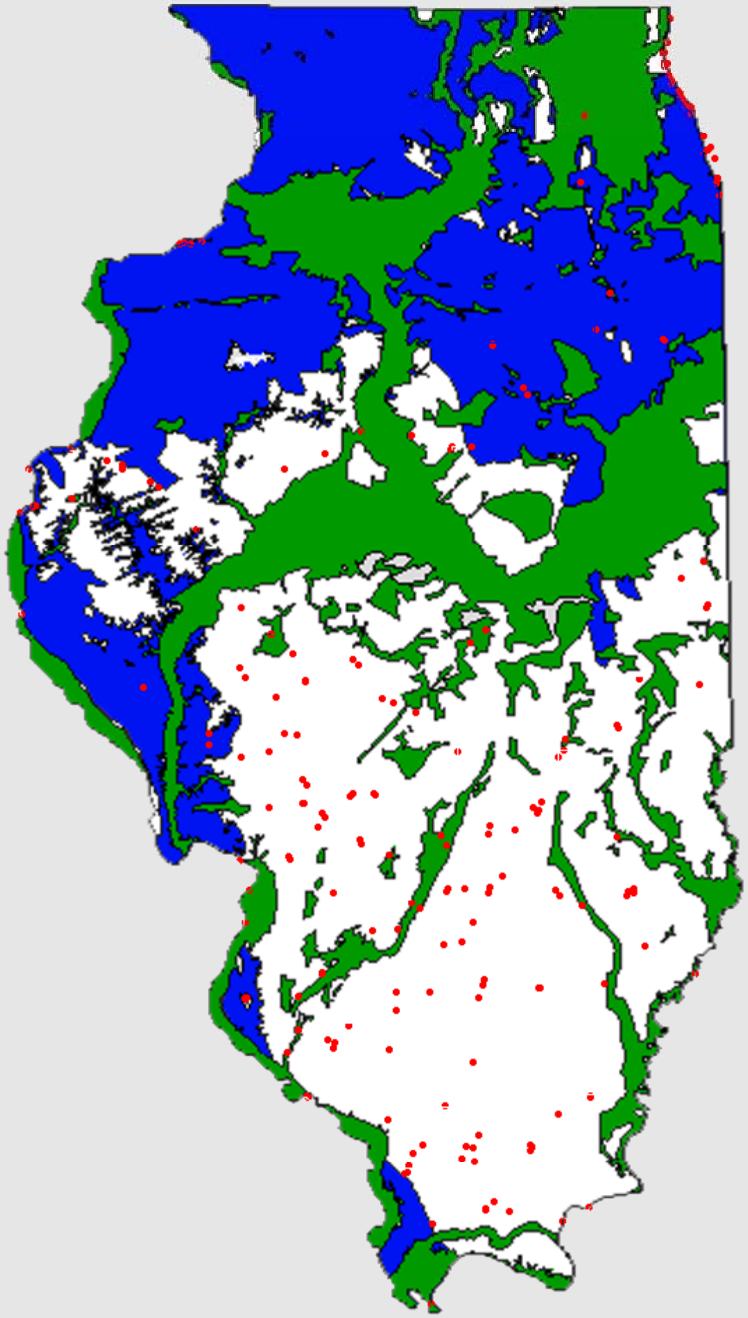
- Surface Water Intakes

  (public water supplies)

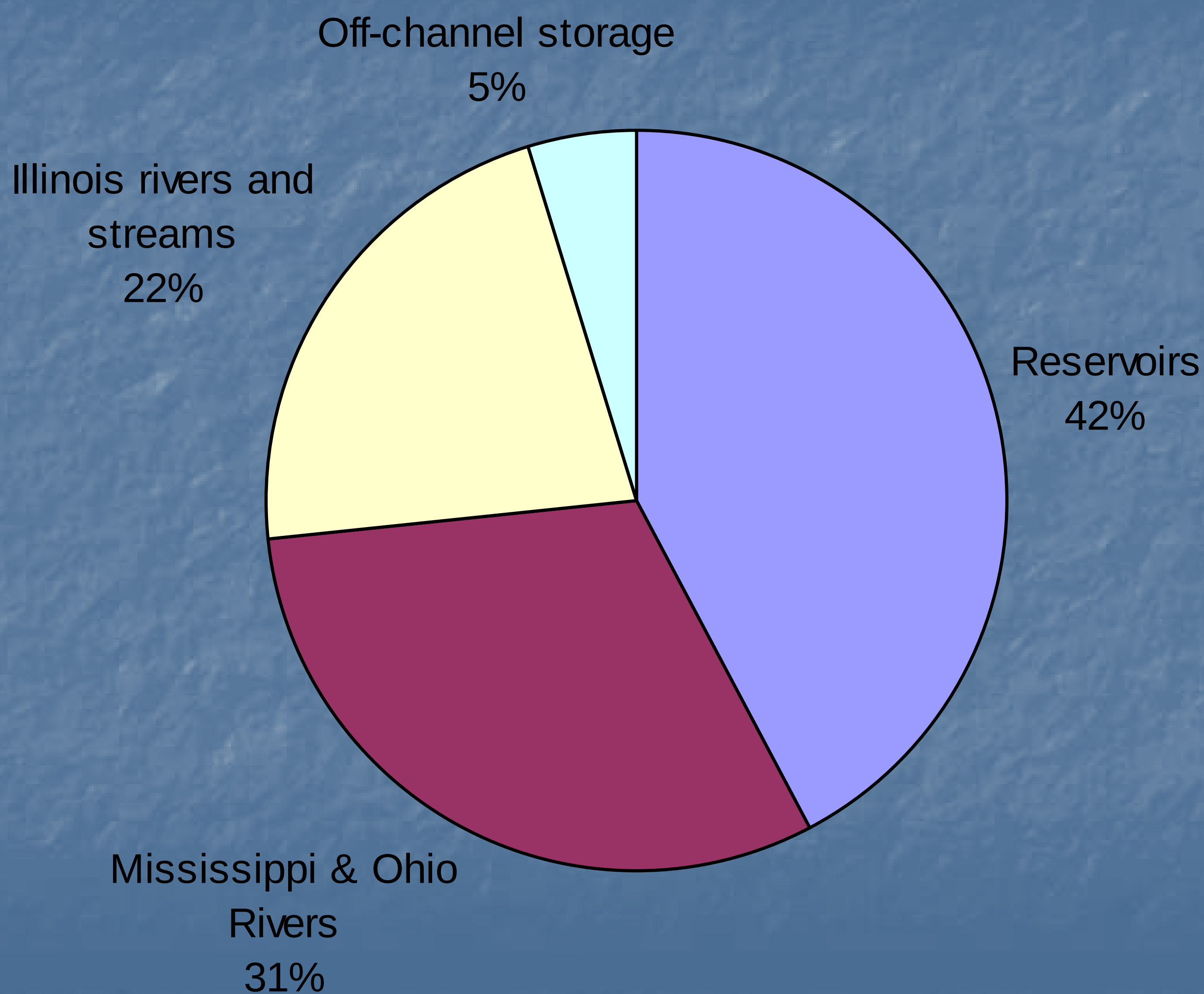


Surface and Ground-Water Resources

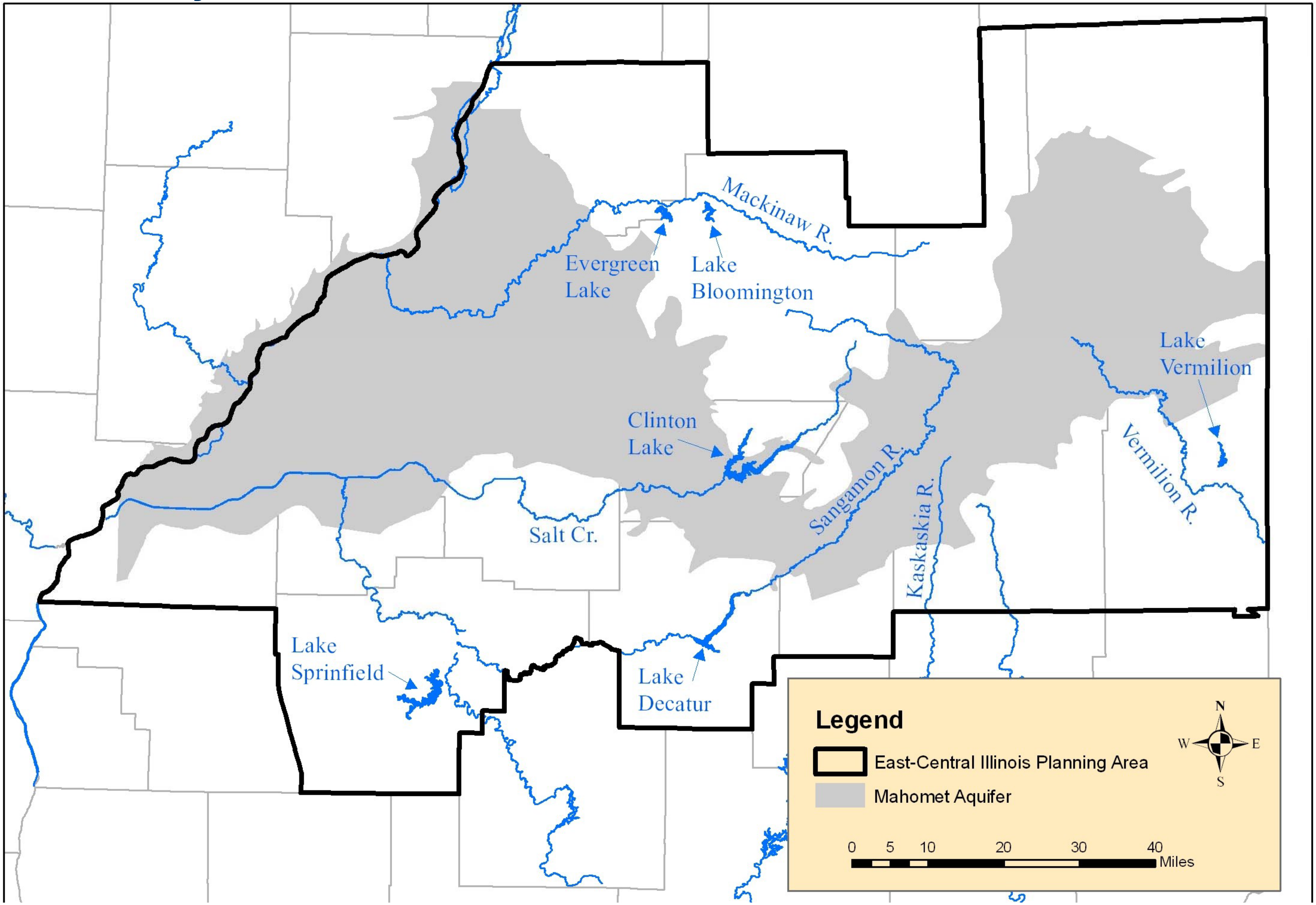
- Surface Water Intakes *(public water supply)*
- Major sand/gravel aquifers
- Bedrock aquifers (<500 feet deep)



Surface water sources other than Lake Michigan



Major Surface Water Sources in East Central IL

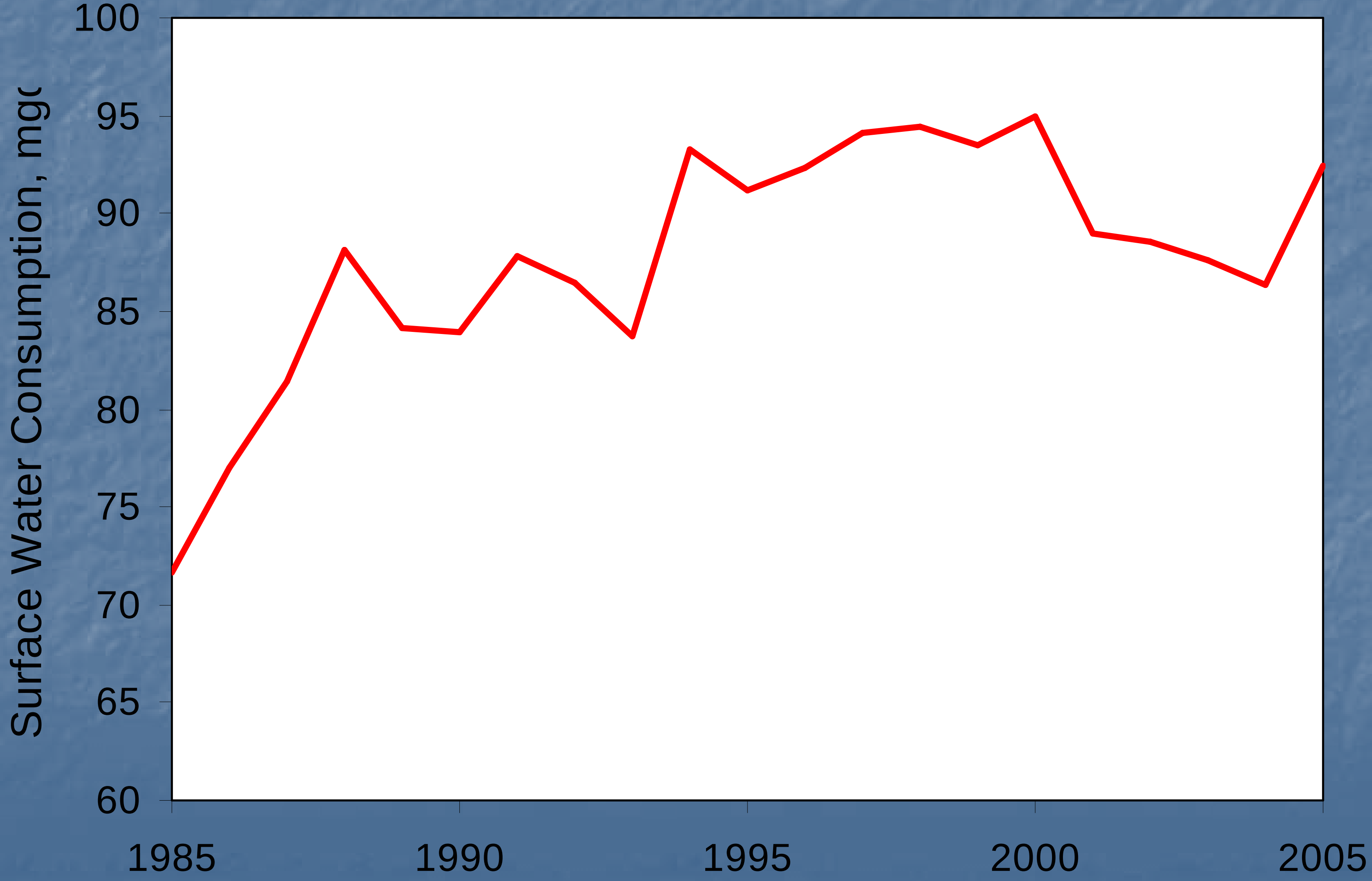


Community Surface Water Uses in East Central IL (2005 Data/Estimates)

- Bloomington = 11.5 mgd
- Decatur = 38 mgd in 2005 (includes industries that withdraw from Lake Decatur)
- Springfield = 33.5 mgd (includes power plant use)
- Danville = 8.5 mgd

Total Use from Community Lakes = 91.5 mgd

Trends in Surface Water Use of the Region's Communities, 1985-2005



Comparison of Surface Water System Use to Rough Yield Estimates

SPRINGFIELD

- SW Yield (50-yr drought) = 30 mgd
- Average PWS Use = 23 mgd
- Power Plant Use = 10.5 mgd

DECATUR

- SW Yield (50-yr drought) = 28-31 mgd
  (DeWitt well field effective yield = 7 mgd ??)
- Average PWS Use = 24 mgd
- Self-supplied industry = 14 mgd

BLOOMINGTON

- SW Yield (50-yr drought) = 13 mgd
- Average PWS Use = 11.5 mgd

Ongoing studies on SW system adequacy analyzing uncertainties in yield estimates

Errors in estimating:

- Flows at stream gages
- Frequency of drought flows
- Regional flow equations for ungaged locations
  - 30-60% error depending on drought duration and watershed size
- Reservoir volume
  - % of yield coming from reservoir capacity = 60-80 percent for reservoirs in the planning area
  - Overestimation bias
- Net evaporation over the drought duration
  - Typically accounts for 10-15% loss in the yield

Not all water supply reservoirs are the same - drought vulnerability varies by duration

Critical durations for reservoir yield – a function of watershed size, capacity versus inflow ratio, and differences in drought climatology across Illinois

- Decatur = 7-8 months (July – February)
- Danville = 7-8 months
- Springfield = 18 months (July – December)
- Bloomington = 20 months (June – January)
- Otter Lake, Pana, and other lakes = 54 months

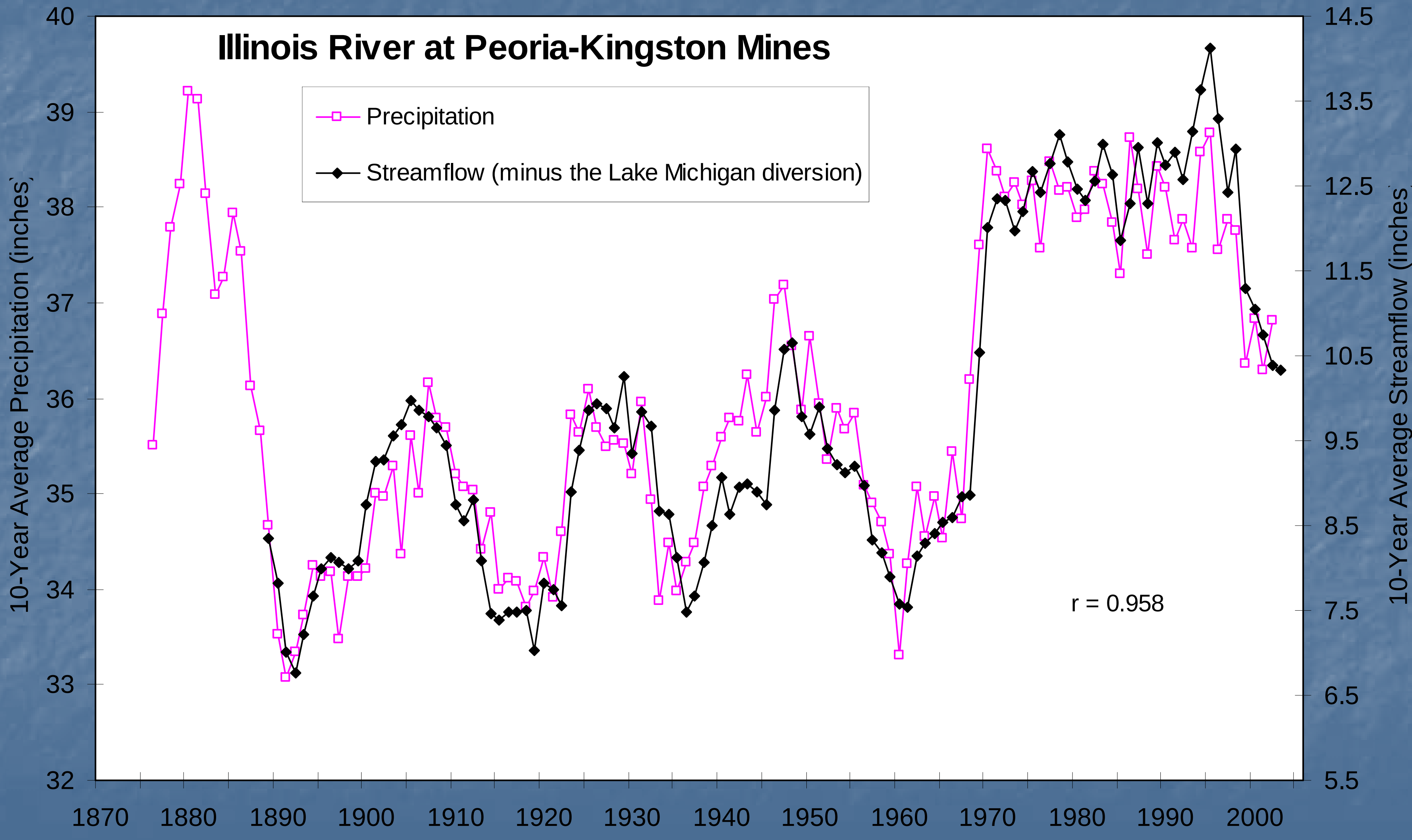
For what drought frequency should SW systems plan?

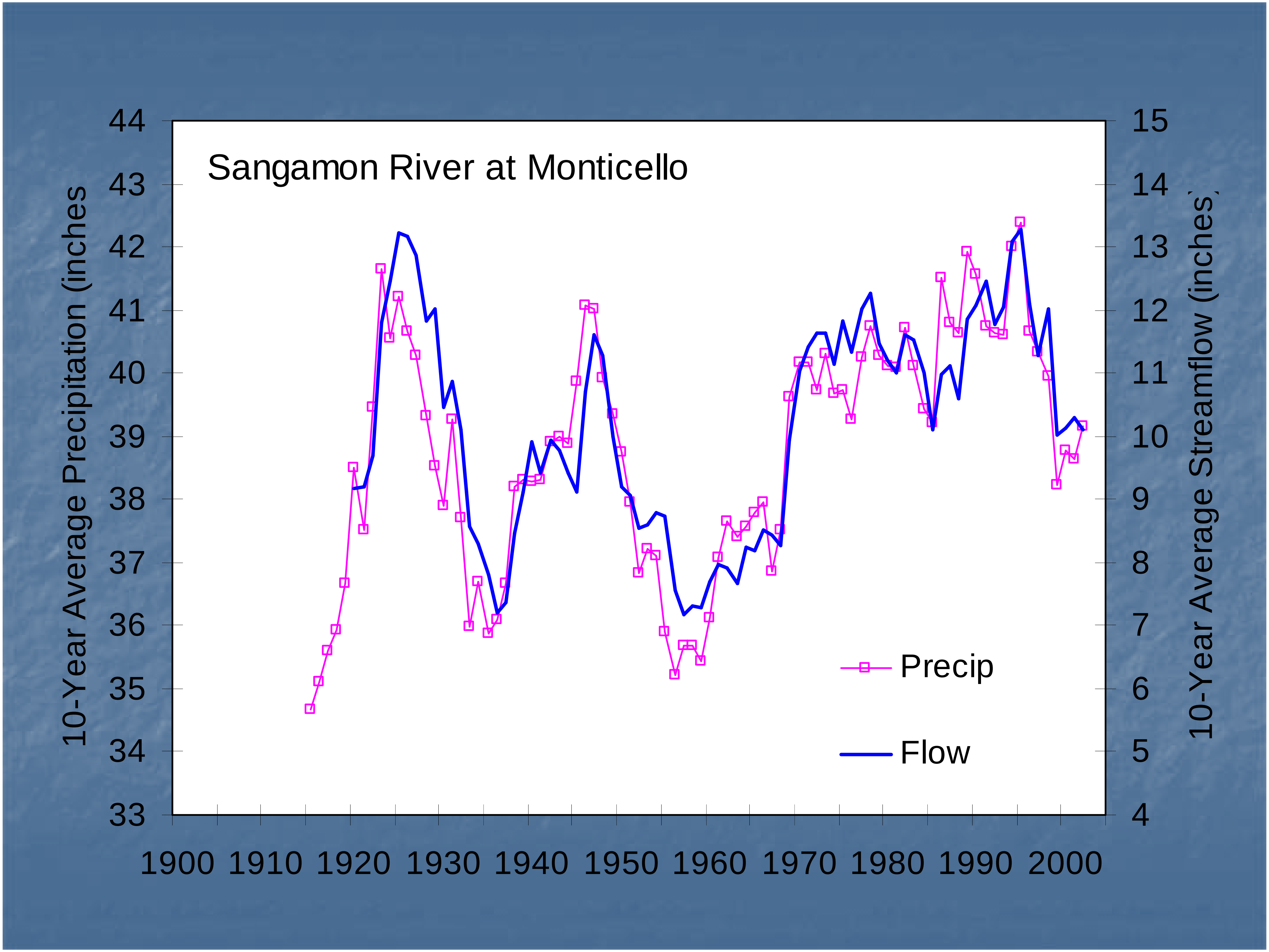
- Illinois SW supplies have usually been considered adequate if they can provide water demand over a 40-50 year drought without shortages
- In Missouri, the State recommends planning for the drought of record (1953-1956 drought)
- In practical terms, the level of acceptable risk may depend on the expected impacts of shortages. For very small communities that can haul water, it may not be economically justifiable to increase the size of their supply for a drought that occurs only once in 50 years
- For large communities lacking a sizable emergency source, shortage impacts could be extensive, it may be advisable to plan for the most severe droughts

Factors affecting low flows and surface water availability for the future

1. Climate variability & change
2. Water use (withdrawals and wastewater effluents)
3. Reservoirs, diversions
4. Indirect impacts on baseflow (land use, (groundwater-surface interactions)
5. Instream flow considerations

1. Effects of Climate Variability




Sangamon River at Monticello
10-Year Average Precipitation (inches)
10-Year Average Streamflow (inches)
44
43
42
41
40
39
38
37
36
35
34
33
15
14
13
12
11
10
9
8
7
6
5
4
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
Precip
Flow

Climate Variability Impacts on Sangamon River Streamflows

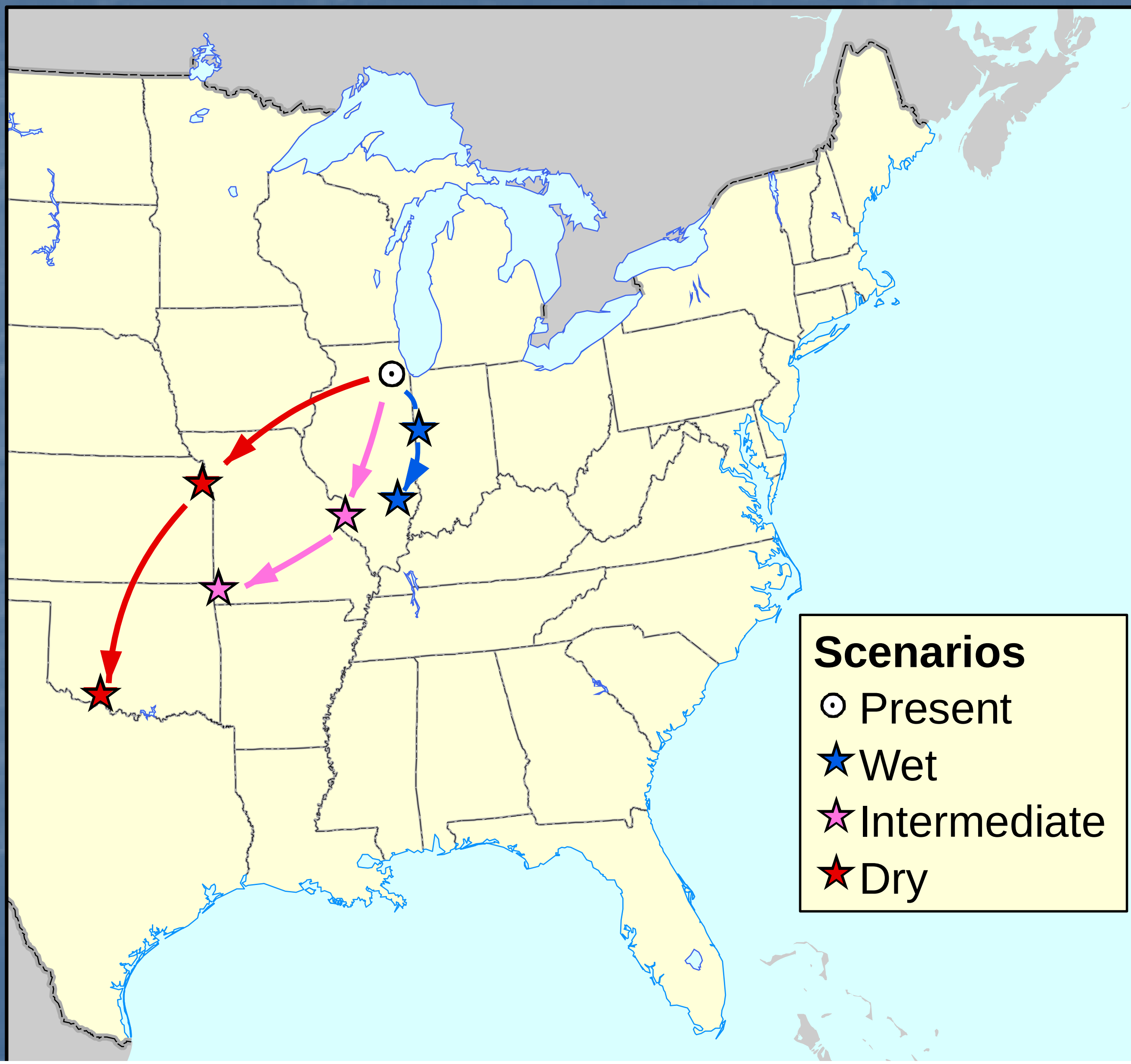
- A 5% increase in average precipitation since 1970 has produced a 20% increase in average streamflow amount.
- There has been a decrease in the frequency and duration of drought conditions
- Low and medium flows have generally increased; however specific droughts (1988) have produced very low flows
- The cause(s) of the observed increase in total precipitation are not known. However, observed trends exhibit considerable regional variability that likely arise at least in part due to chance (natural variability).

Future Climate Change and Potential Impacts on Water Resources?

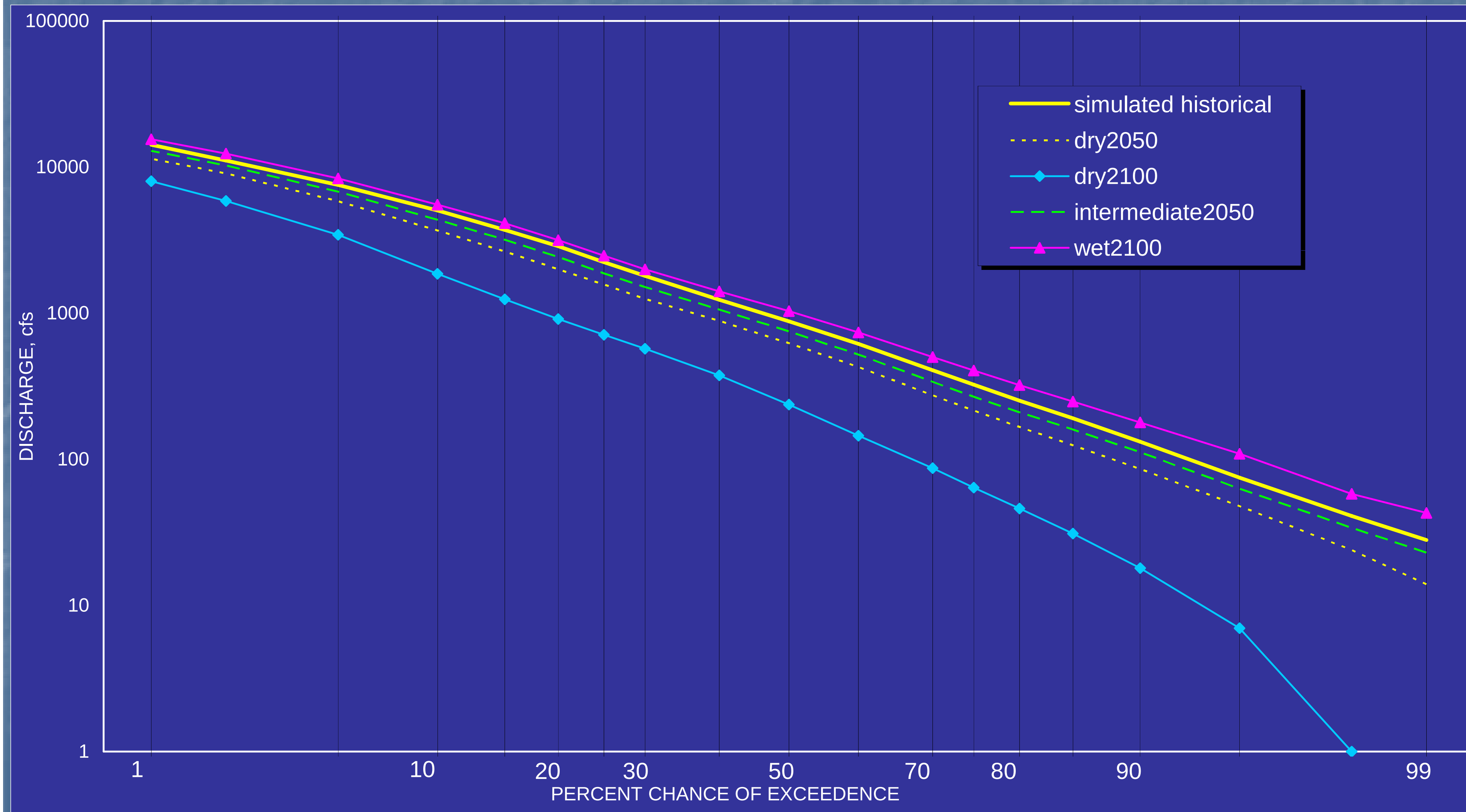
- There is the expectation that average temperature will increase over the 21st Century

- Future trends in precipitation resulting from climate change, however, are uncertain. The ISWS is examining SW impacts of potential scenarios in which average annual precipitation may either increase or decrease by up to 5 inches.

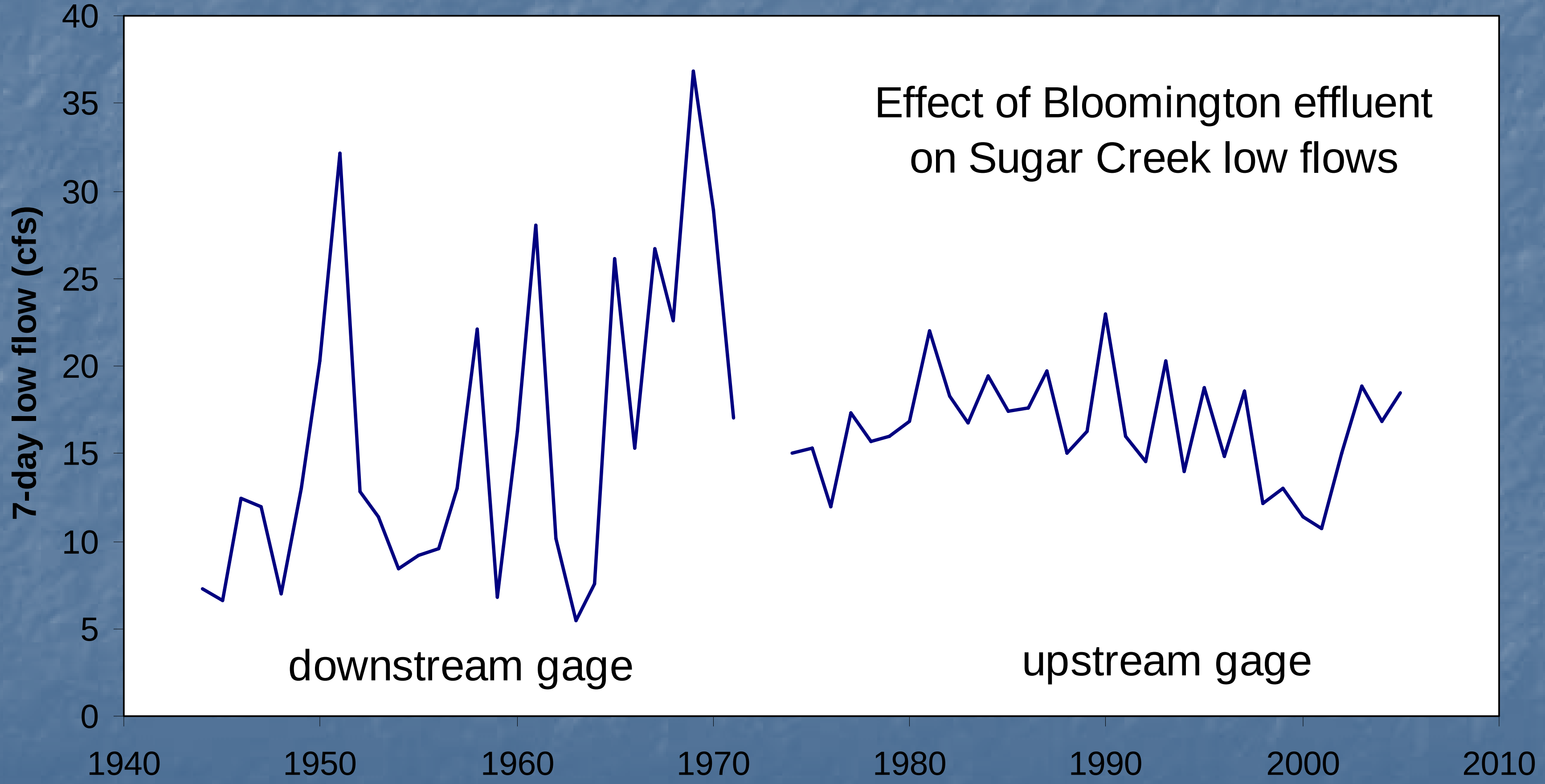
Climate Change Scenarios

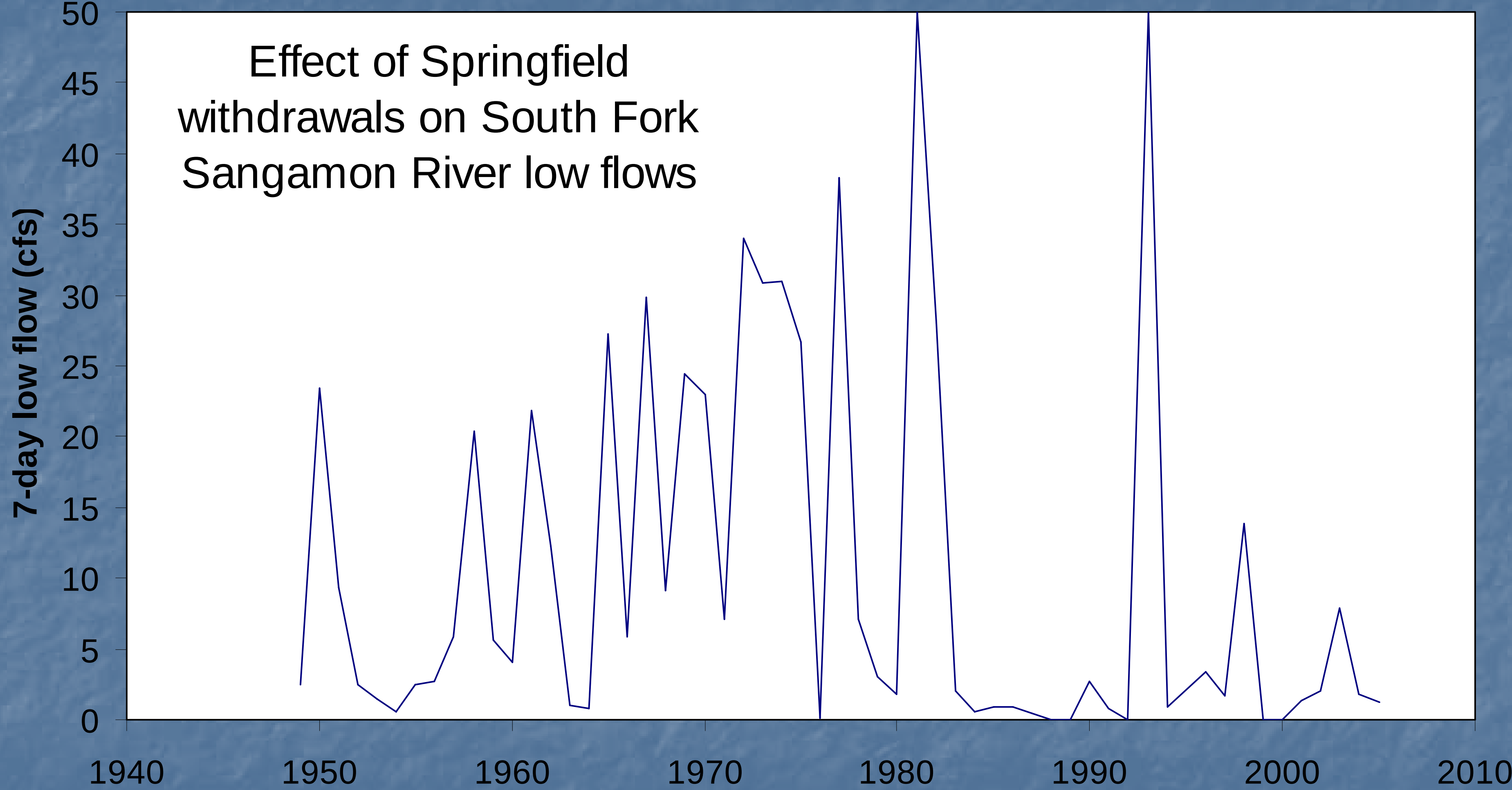


Hydrologic modeling for simulation of climate change impacts

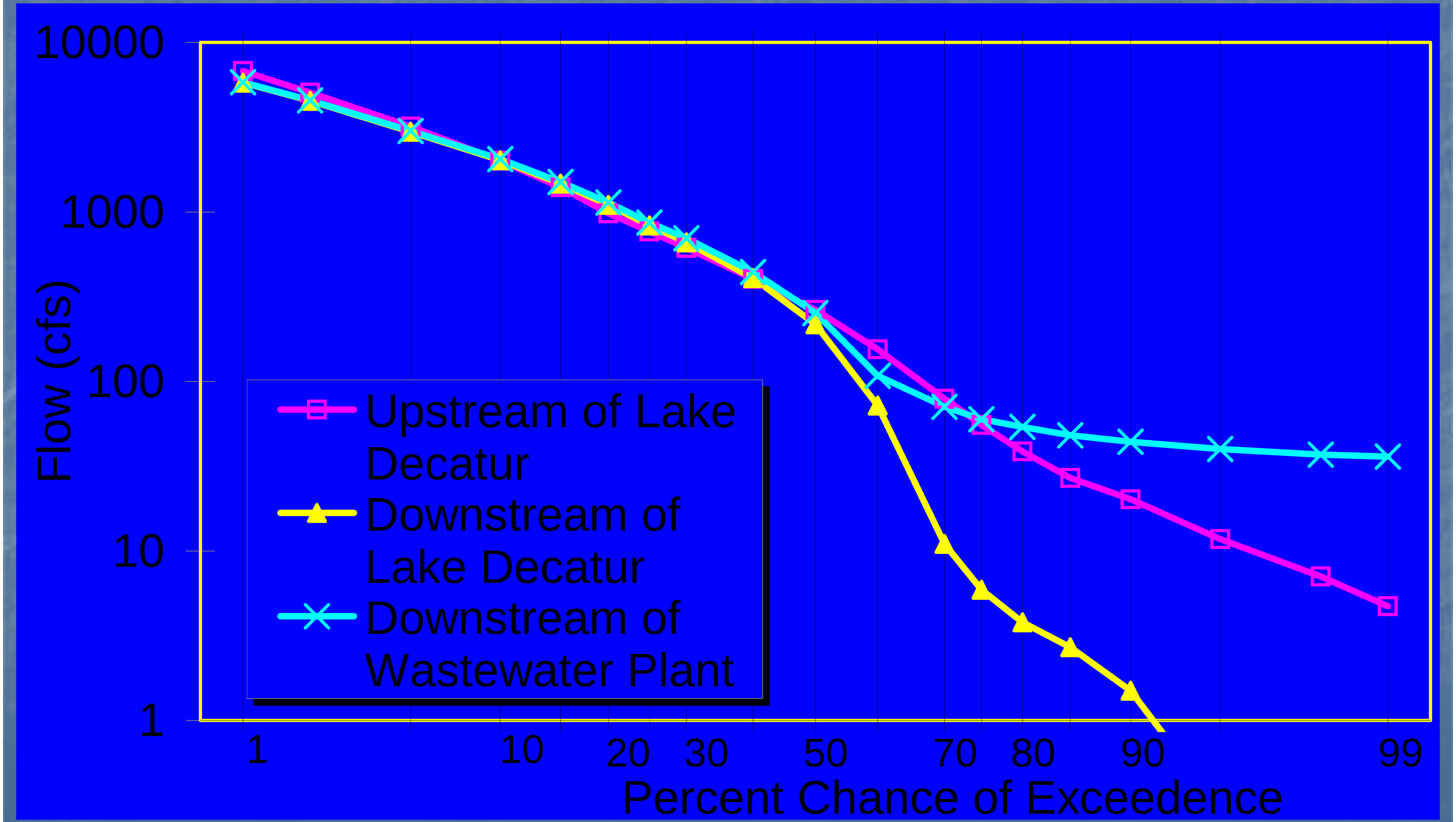


2. Effects of water use on streamflow (withdrawals and wastewater discharges)




Effect of Springfield
withdrawals on South Fork
Sangamon River low flows
7-day low flow (cfs)
0
5
10
15
20
25
30
35
40
45
50
1940
1950
1960
1970
1980
1990
2000
2010

3. Effects of Reservoirs on Downstream Flows



4. Indirect impacts on baseflows

- Potential changes in baseflows caused by urbanization or other land use factors – conceptual basis, but Illinois examples show little if any change

- Reduction in low flows caused by pumping from nearby shallow aquifers – As the regional use of groundwater increases, there is a potential for low flows to be impacted by GW-SW interactions in certain locations

Surface Water Accounting Models for Water Supply Planning

- To account for streamflow frequency and existing and potential flow additions/subtractions caused by human factors
- Provides the ability to examine the impacts of future water use scenarios on streamflows on any location (gaged or ungaged) in a watershed.
- Future applications might include additional impacts from stream–groundwater interactions as they become better understood.
- The accounting model will become available for the Sangamon and Mackinaw watersheds by the end of the year

Sources of low flow in regional streams
(10-year low flows in million gallons per day)

	Baseflow	Wastewater	Withdrawals/ reservoirs
Sangamon River Springfield	10	+40	-5 net
Salt Creek Lincoln downstream	15 40	+ 1 +12	+3 +3
Sugar Creek	3	+10	0
Mackinaw River upstream downstream	<1 15	0 +2	0 0

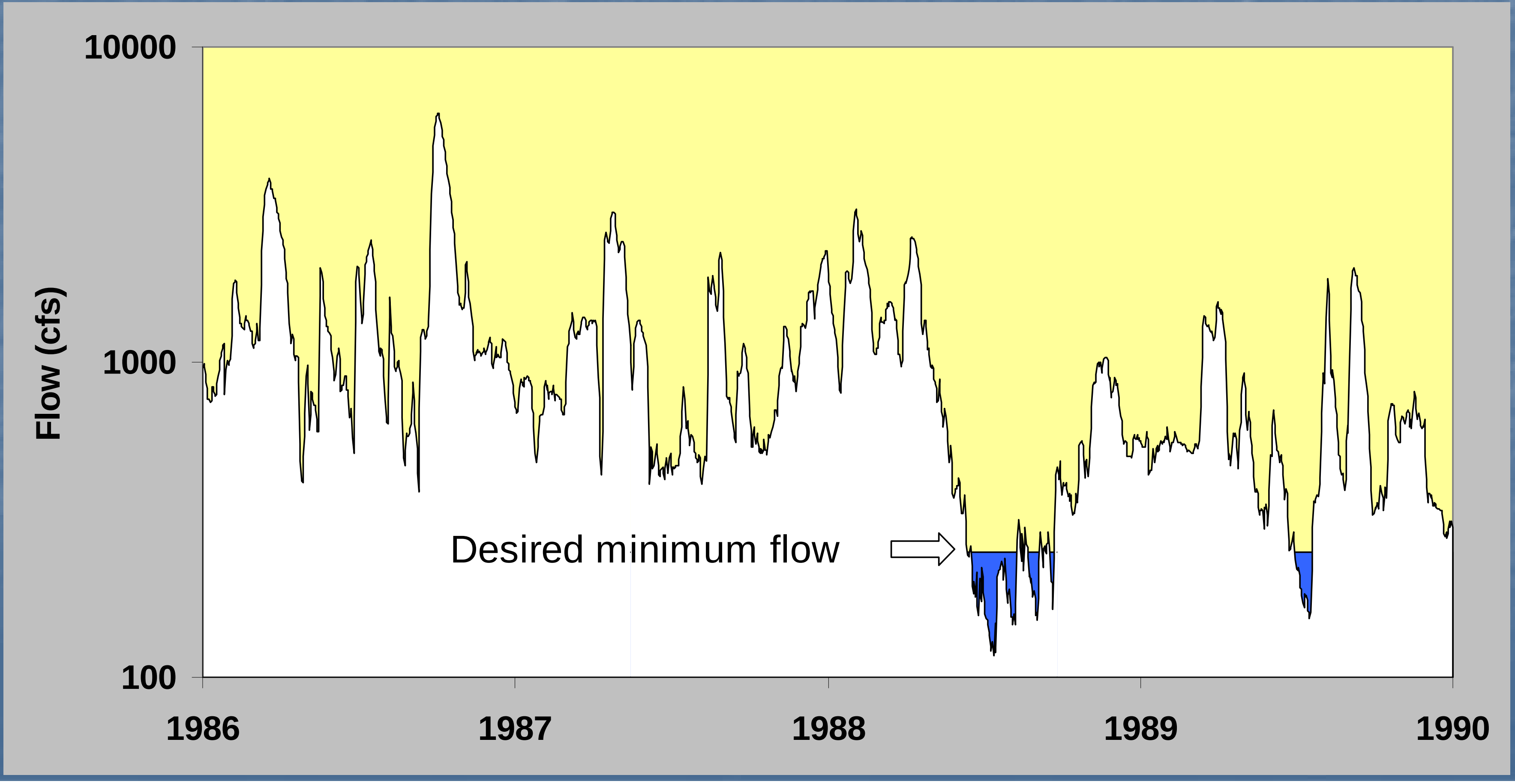
Water Supply and Instream Flow Needs

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

Note that there can be conflicts between different uses of instream flow

Protecting instream flows

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.

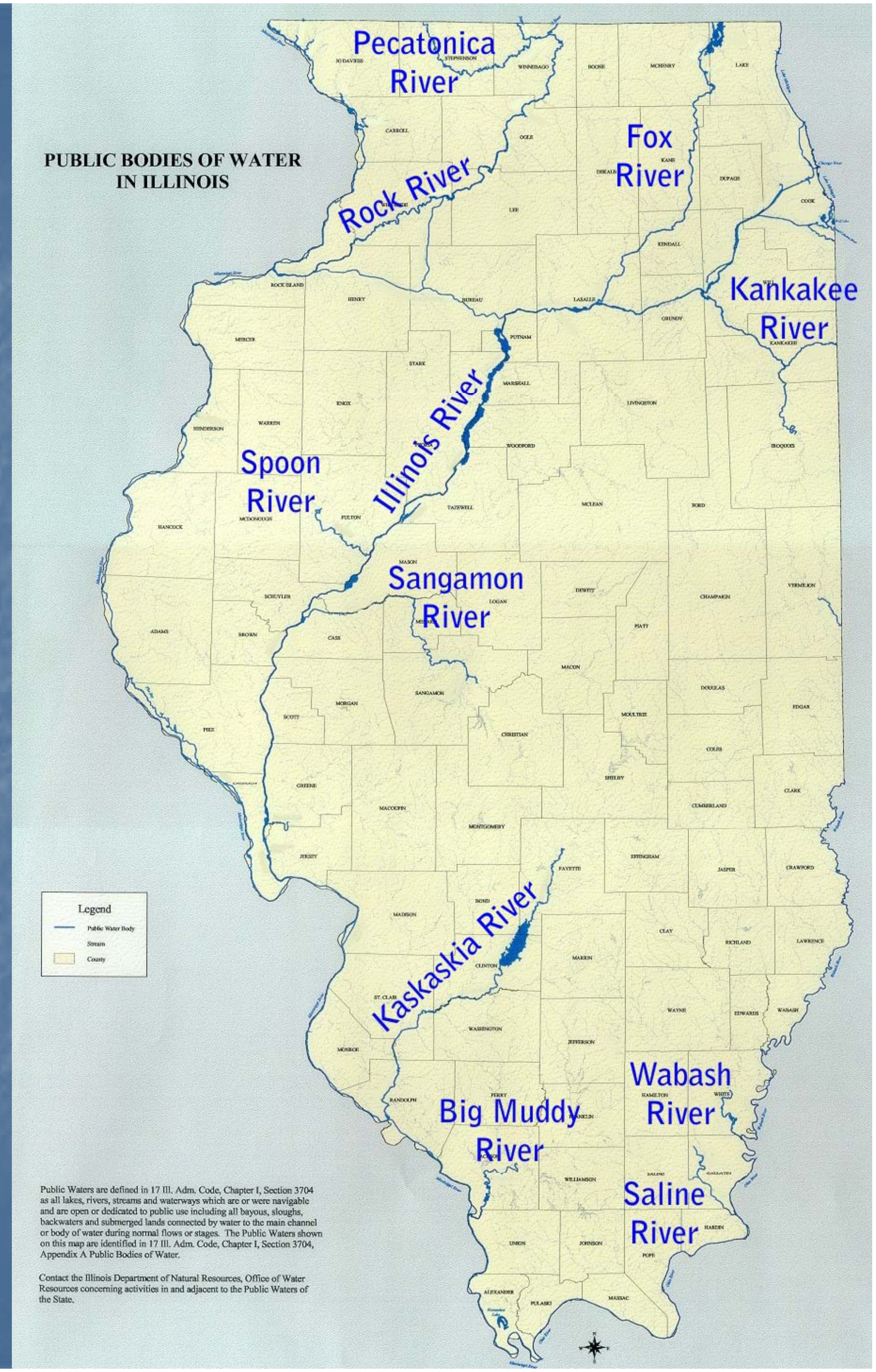


Protected flow level

- In 1984 IDNR adopted the use of the 7-day 10-year low flow (Q7,10) as a protected flow level for Public Waters of the State.
- The Q7,10 protected flow is considered an interim surrogate value where there is insufficient information to define instream flow needs.

Public Bodies of Water in Illinois

The State's authority to protect low flows extends only to these rivers



How do instream flow considerations affect water supply plans?

- Having a minimum instream flow essentially requires an alternative source of supply during low flow periods in drought
- Off-channel storage is the most practical alternative source
- Return flows of a similar quantity immediately downstream of a new withdrawal could potentially be considered as “no net reduction”

* Having communities be fully prepared for severe droughts would reduce the chance that streams would be the supply source of last resort

Thank you!

Look for more information and updates:

http://www.sws.uiuc.edu/wsp

E-mail me with questions:

vknapp@uiuc.edu