Meeting Water Demand in Northeastern Illinois

Summary of ISWS Modeling

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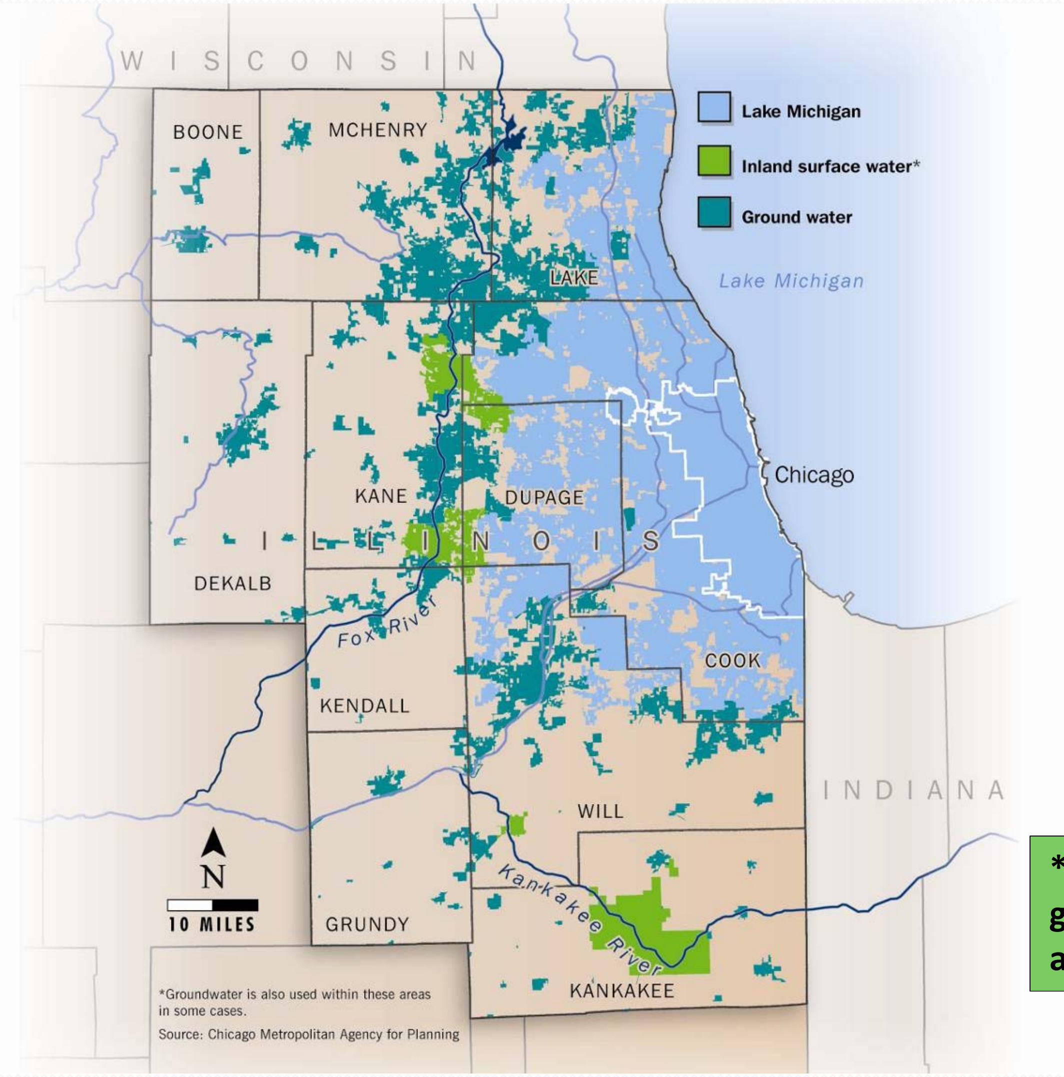
ILLINOIS

Overview

- Sources of water in northeastern Illinois
- Water demand in northeastern Illinois
- Assessment of resources
  - Lake Michigan
  - Fox River
  - Groundwater
- Summary

Sources of Water in Northeastern Illinois

Sources of Public Water Supply in Northeastern Illinois

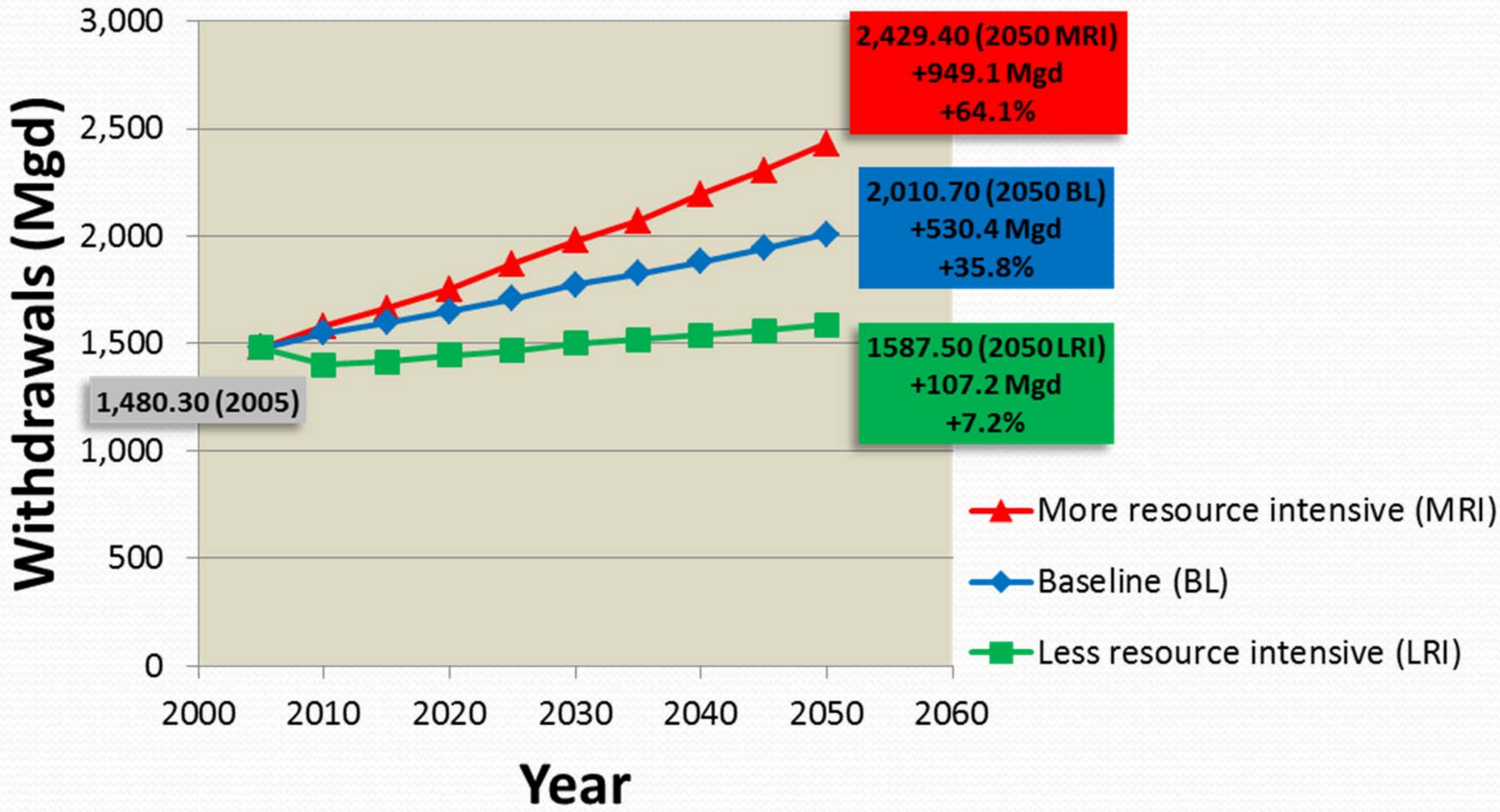


***Elgin and Aurora use groundwater as well as surface water**

CMAP

Water Withdrawals in Northeastern Illinois

Withdrawals in Northeastern Illinois, by Water Source (Excludes Through Flow for Power Generation)



2005 withdrawals adjusted to average 1971-2000 climate

Withdrawals in Northeastern Illinois, by Water Source (Excludes Through Flow for Power Generation)

Source	***2005****		***2050 (LRI)***		***2050 (BL)***		***2050 (MRI)***	
	Mgd	%	Mgd	%	Mgd	%	Mgd	%
Lake Michigan	1,018.0	69	952.9	60	1,222.7	61	1,396.9	57
Inland surface waters	212.2	14	275.3	17	327.1	16	445.0	18
Groundwater	250.1	17	359.1	23	461.0	23	587.6	24
TOTAL	**1,480.3**		**1,587.5**		**2010.7**		**2,429.4**	

*adjusted to average 1971-2000 climate

+107.2 Mgd
+7.2%

+530.4 Mgd
+35.8%

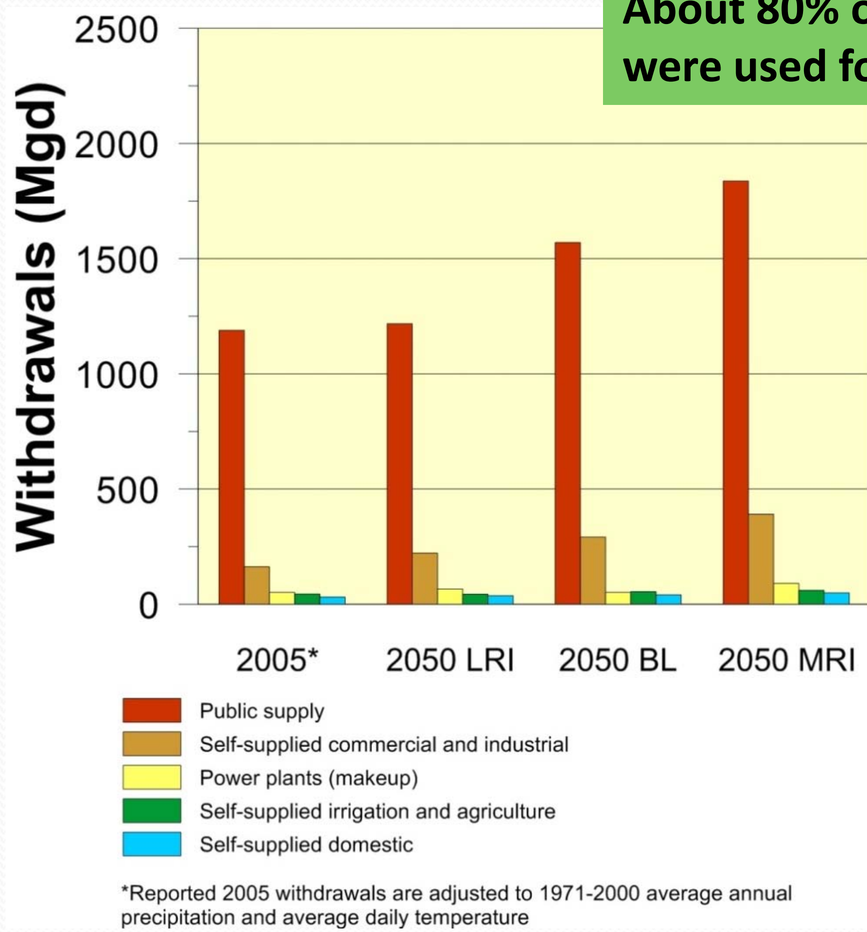
+949.1 Mgd
+64.1%

Dziegielewski and Chowdhury, 2008

Projected Withdrawals

(Excludes Through Flow for Power Generation)

About 80% of 2005* withdrawals were used for public supply



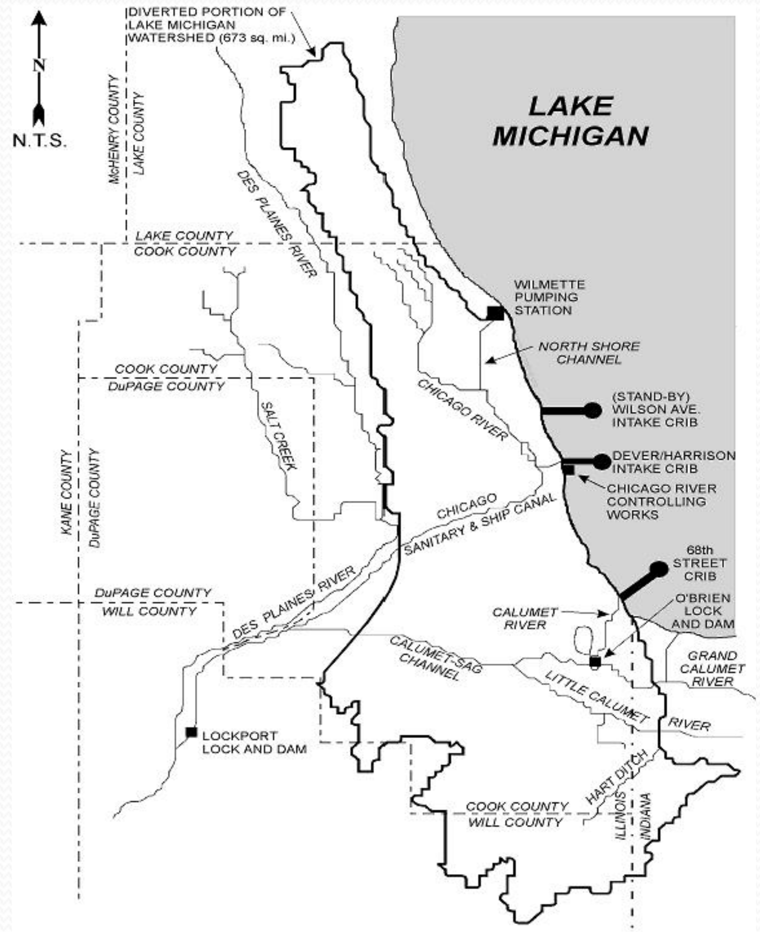
Dziegielewski and Chowdhury, 2008

Lake Michigan

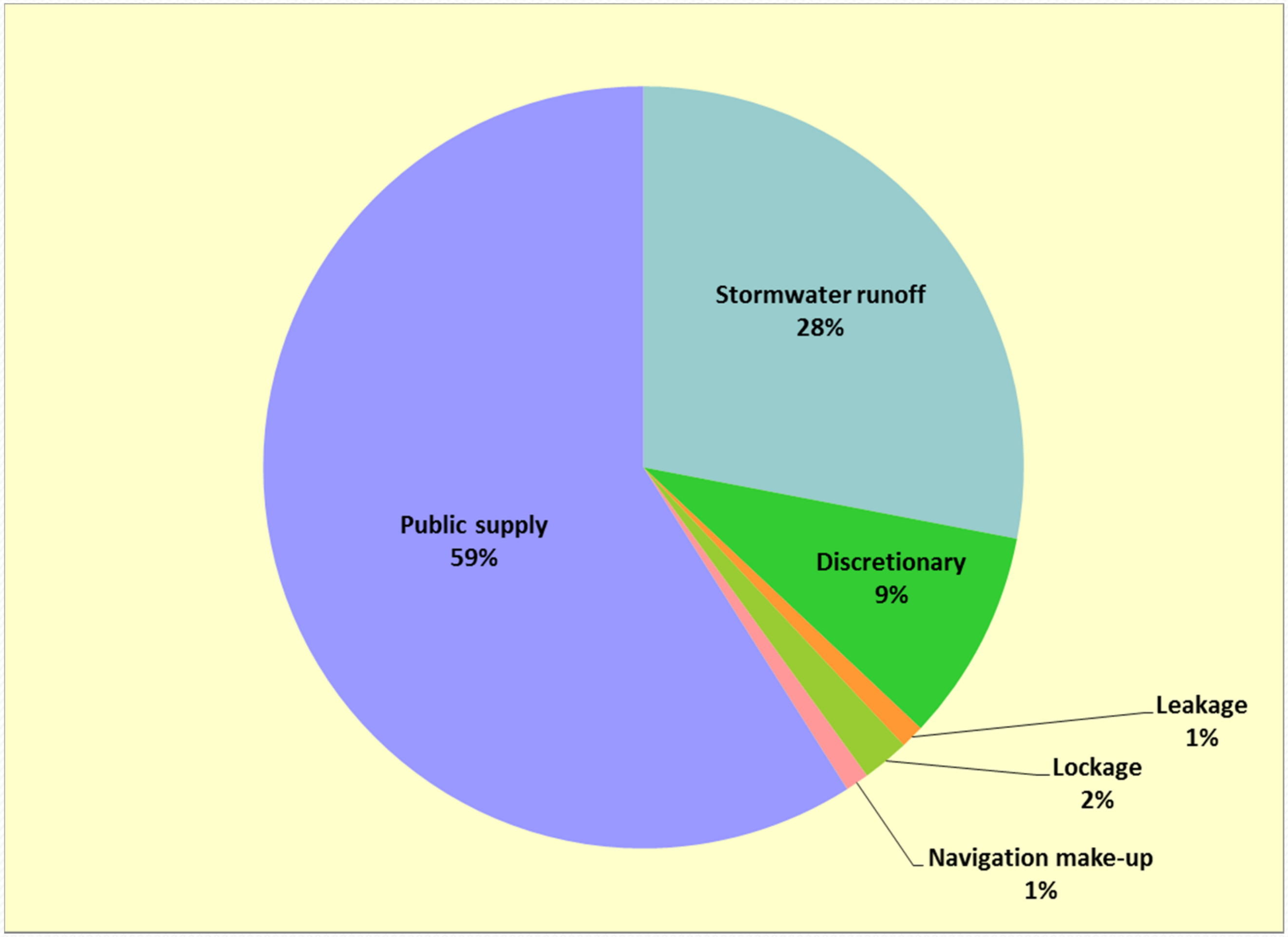
Lake Michigan Diversion

Components

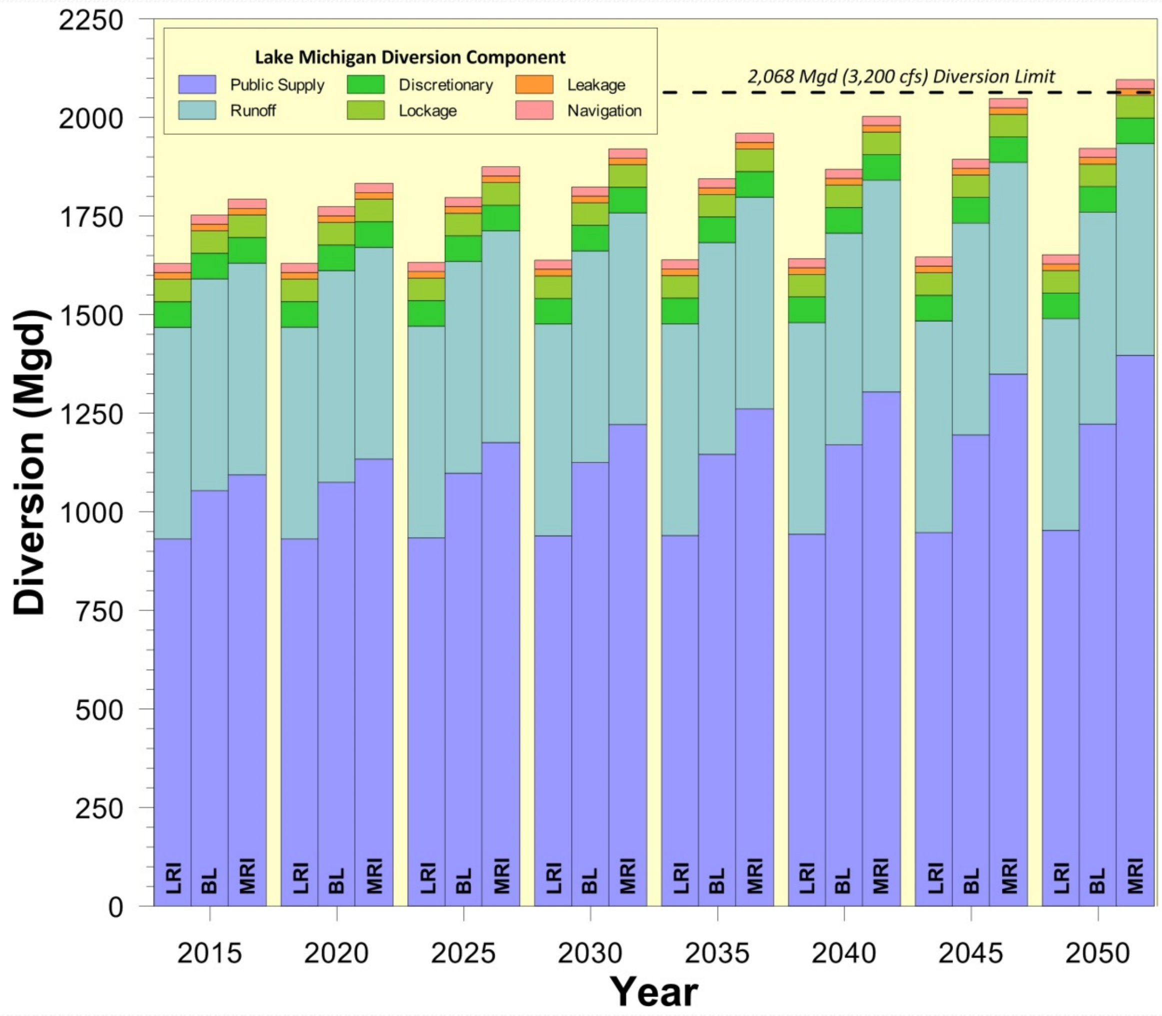
- Direct diversion
  - Lockage
  - Leakage
  - Navigation make-up
  - Discretionary diversion
- Stormwater runoff
- Public supply



Lake Michigan Diversion, 2005



Lake Michigan Diversion, 2015-2050



Lake Michigan Water Availability

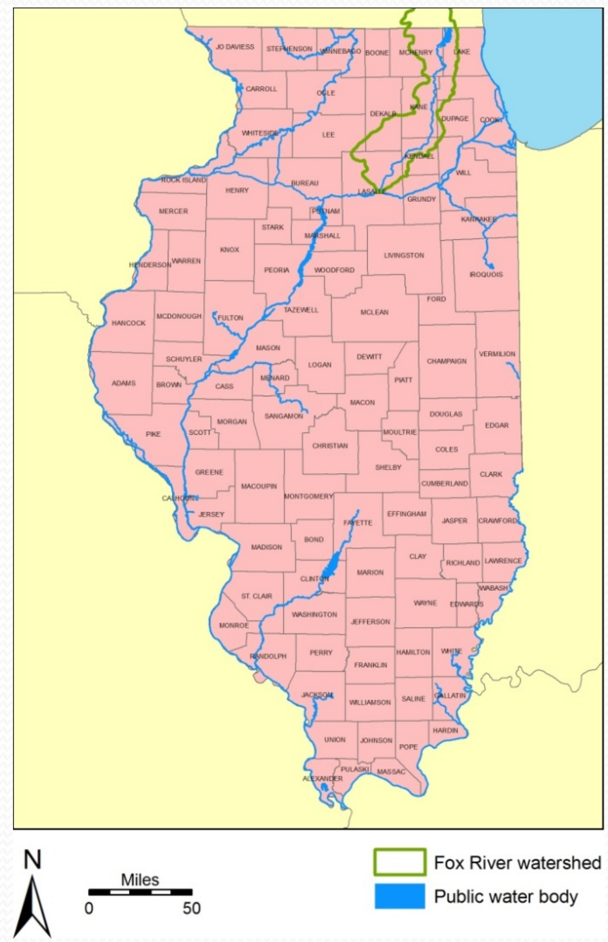
- Limitations of analysis
  - Assumed magnitude of diversion components
    - **Stormwater runoff** = 1984-2003 average
    - **Discretionary diversion** specified at IDNR constraint (effective 2015) that assumes TARP fully operational in 2025
    - **Lockage** = 25-year average
    - **Leakage** = 1997-2007 average
    - **Navigation make-up** = 1997-2007 average
  - Climate change
- Conclusion
  - Illinois can remain in compliance with the Court decree and still accommodate an increase of 50 to 75 Mgd in public supply demand(while continuing to accommodate growing water demand within the current Lake Michigan service area).

Fox River

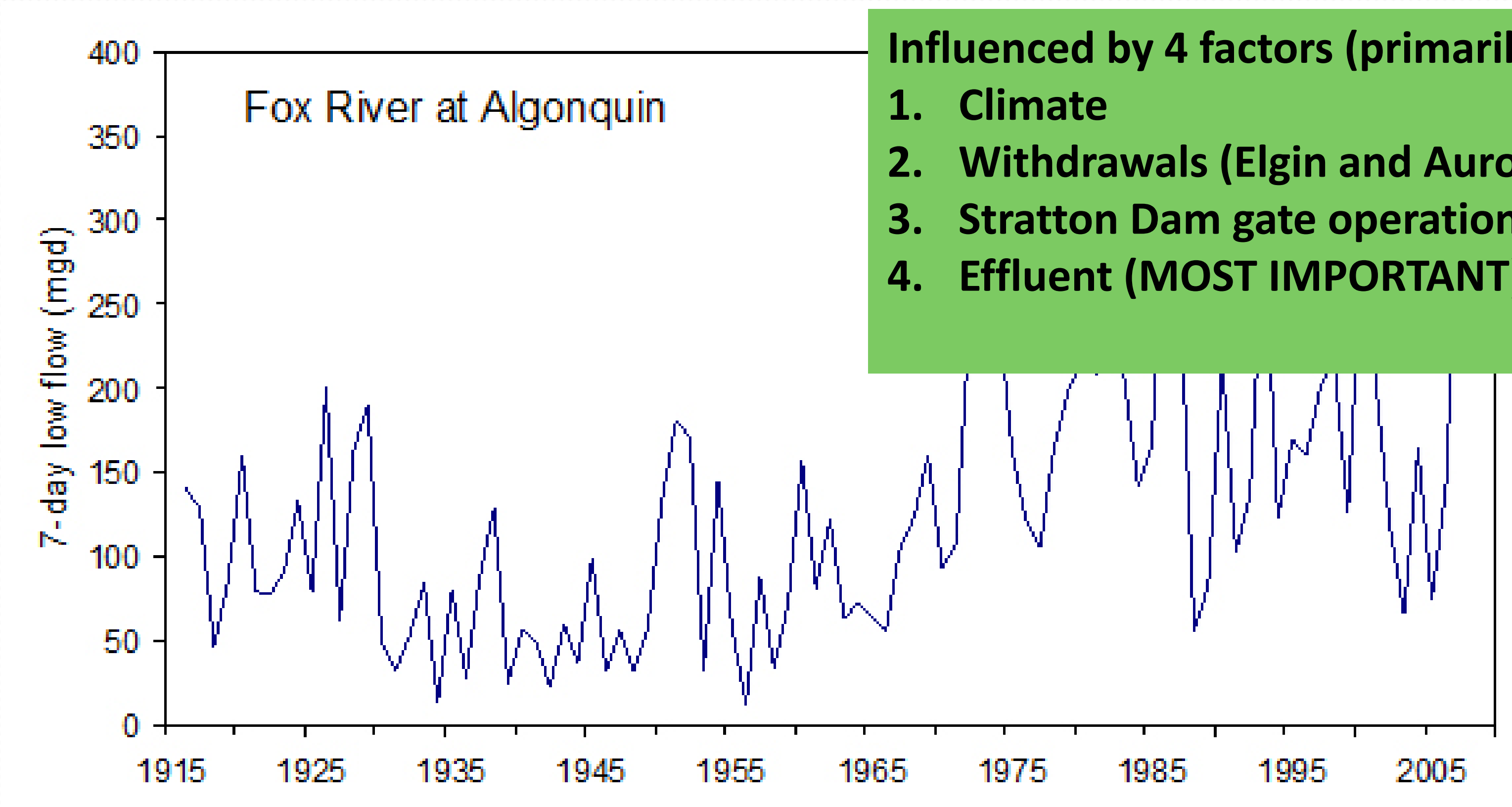
Public Waters of Illinois

Importance of low flow in modeling and regulation

- Low flow is a reasonable estimate of flow during drought conditions and the minimum flow available to satisfy instream flow needs.
- Instream flow needs are uses of water within the stream channel
  - aquatic habitat
  - assimilation of wastewater
  - water-based recreation
  - stream aesthetics
- IDNR commonly uses the 7-day 10-year low flow value ($Q_{7,10}$) as the protected minimum flow for Illinois' public waters, including the Fox River.



Annual low flows, Fox River at Algonquin



Influenced by 4 factors (primarily)

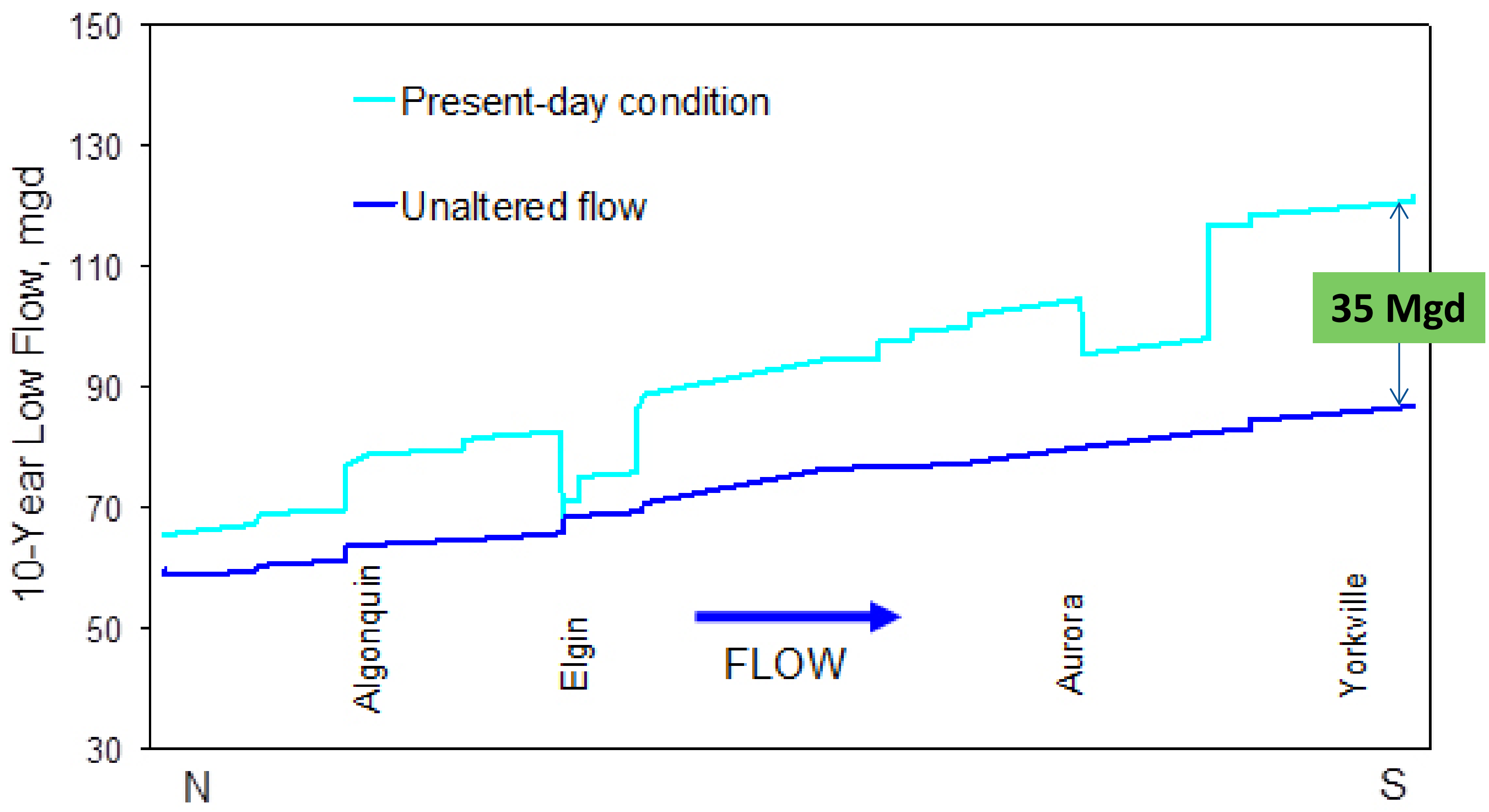
1. **Climate**
2. **Withdrawals (Elgin and Aurora)**
3. **Stratton Dam gate operations**
4. **Effluent (MOST IMPORTANT)**

Pre-1964: Summer low flow periodically <35 Mgd
1965-present: Summer low flow almost always >65 Mgd

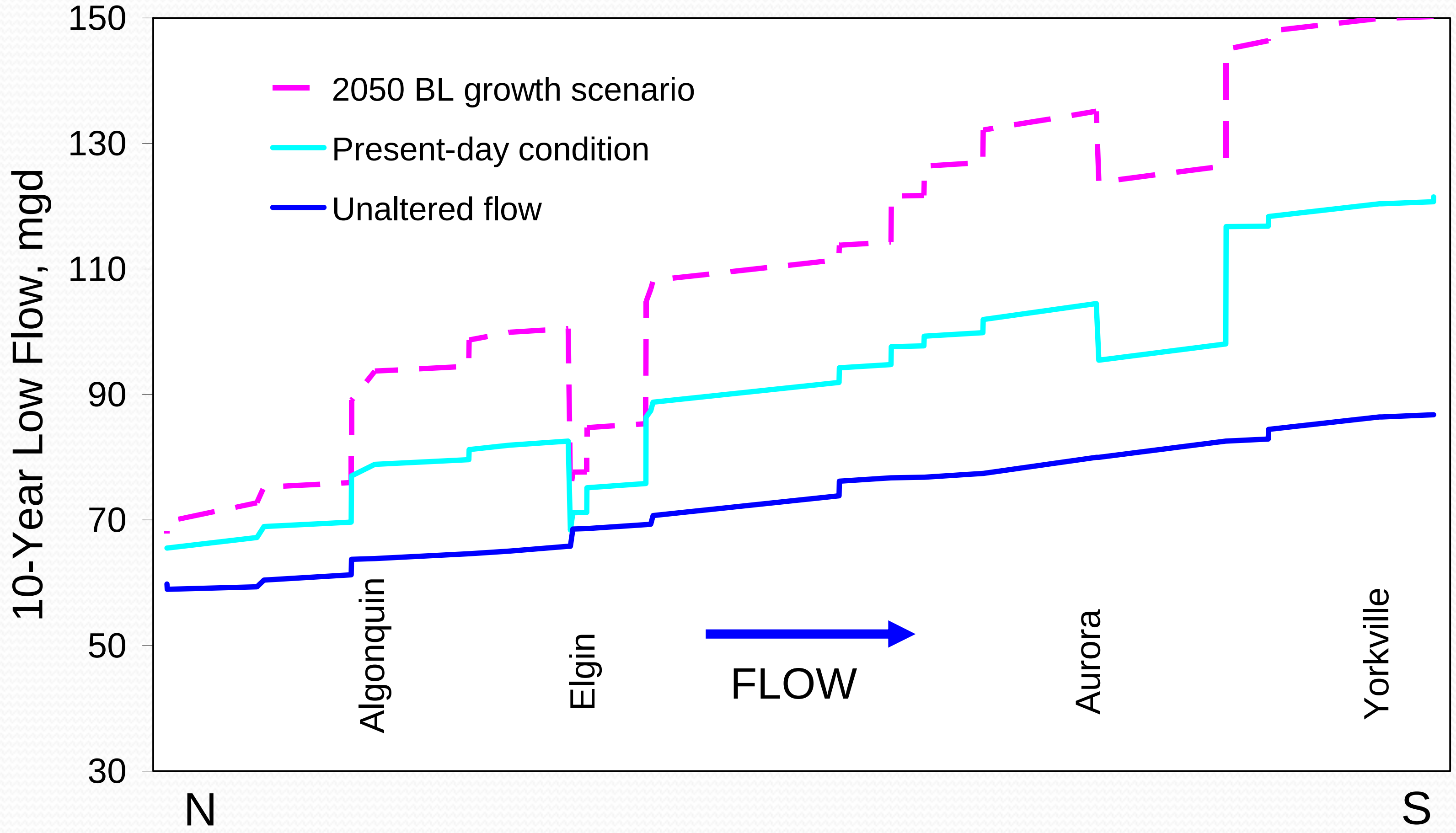
Effluent in the Fox River

- Averages 138 Mgd
- As much as 10% of average flow in many reaches
- Effluent discharge rate is closely linked to water use
- Effluent originating from groundwater-using communities increases low flow

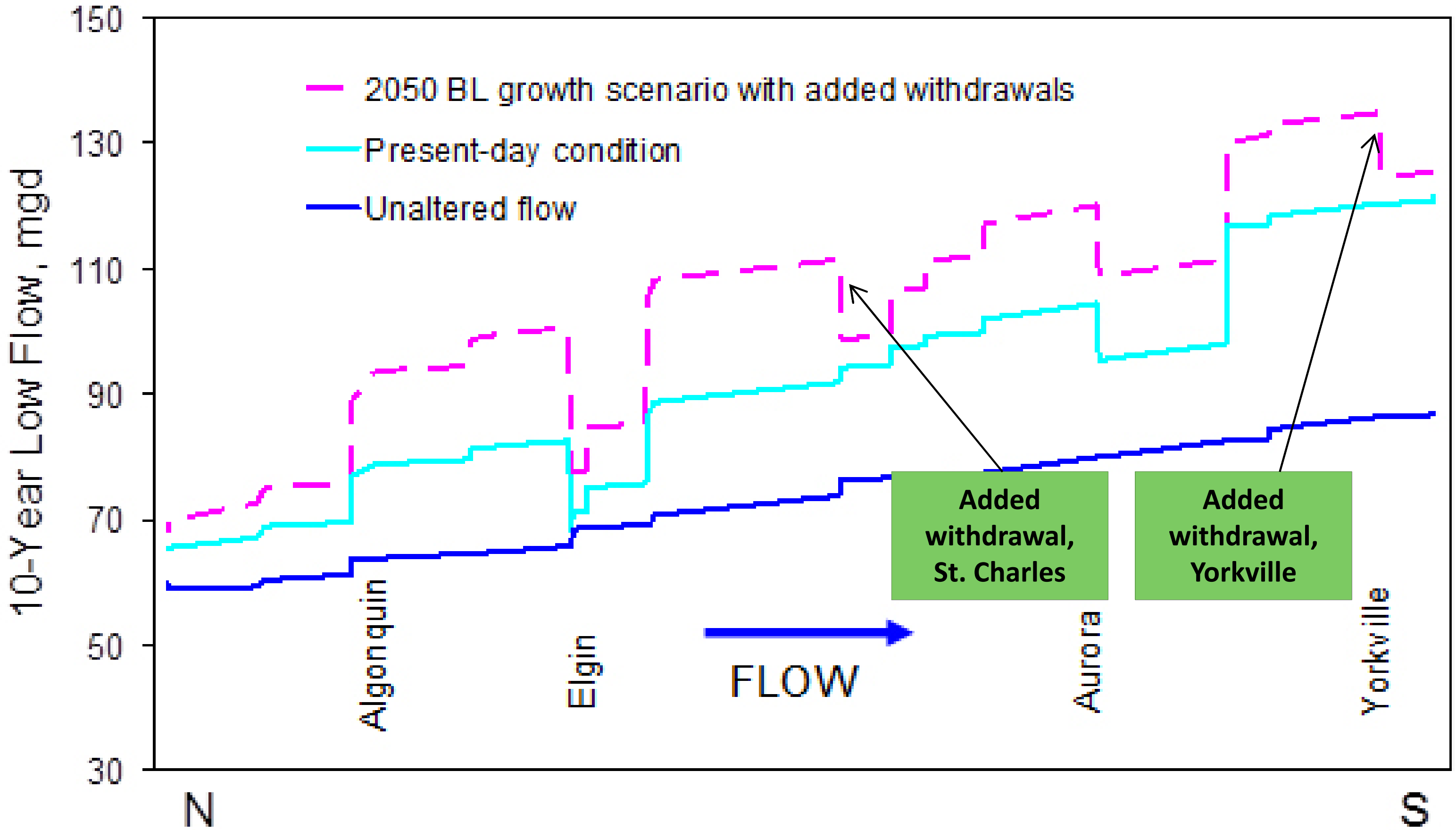
Ten-year low flow, Fox River from near Crystal Lake to Yorkville



Ten-year low flow in 2050 (BL scenario), Fox River from near Crystal Lake to Yorkville



Ten-year low flow in 2050 (BL scenario), Fox River from near Crystal Lake to Yorkville



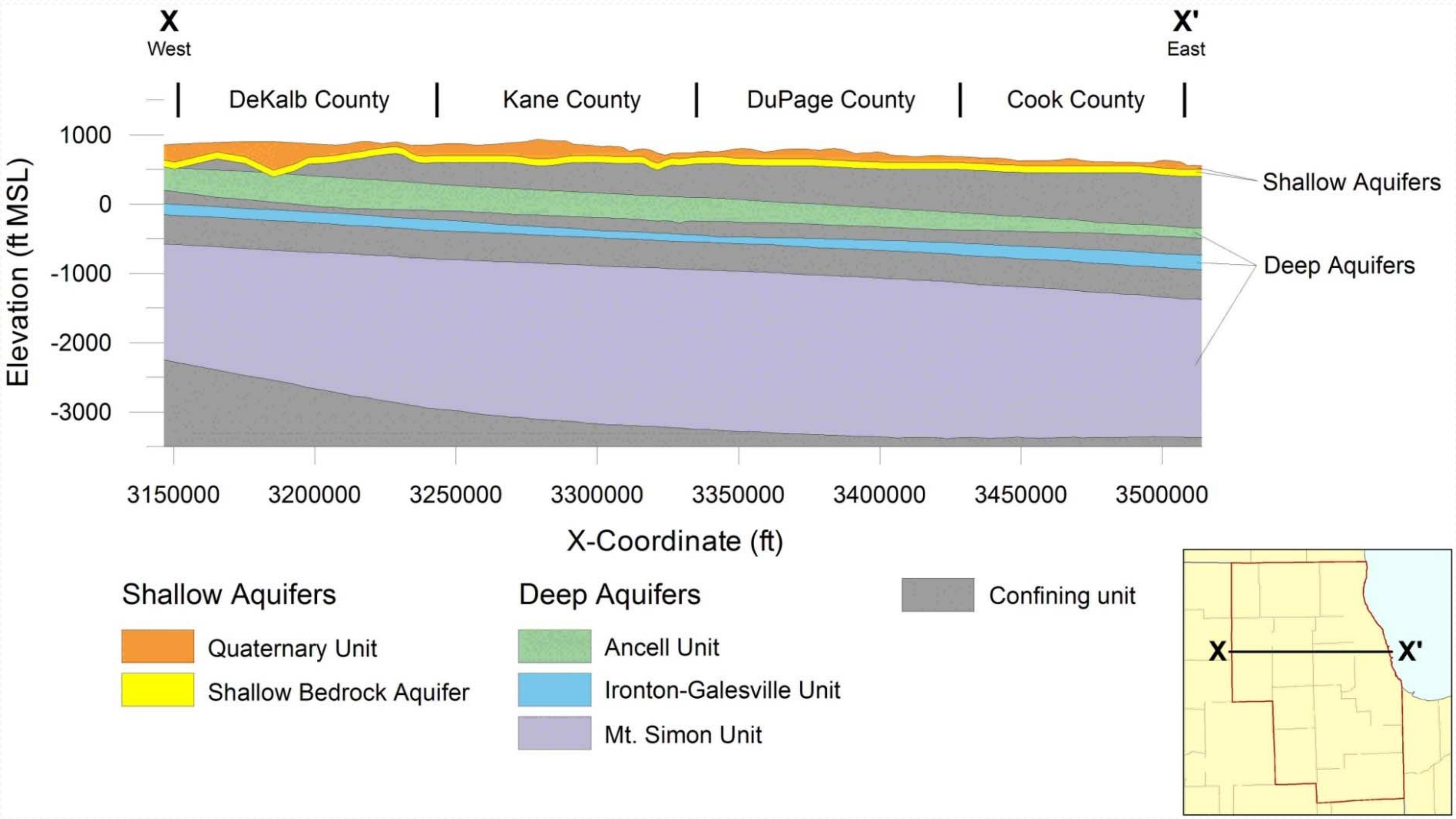
Added withdrawals in this example total 25 Mgd

Fox River: Conclusion

- Depending on the demand scenario, the Fox River can accommodate projected 2050 demand by Elgin and Aurora as well as 14 to 58 Mgd in additional withdrawals, assuming that IDNR fixes the protected low-flow level at approximately its current value so that it does not continue to increase with increasing effluent.

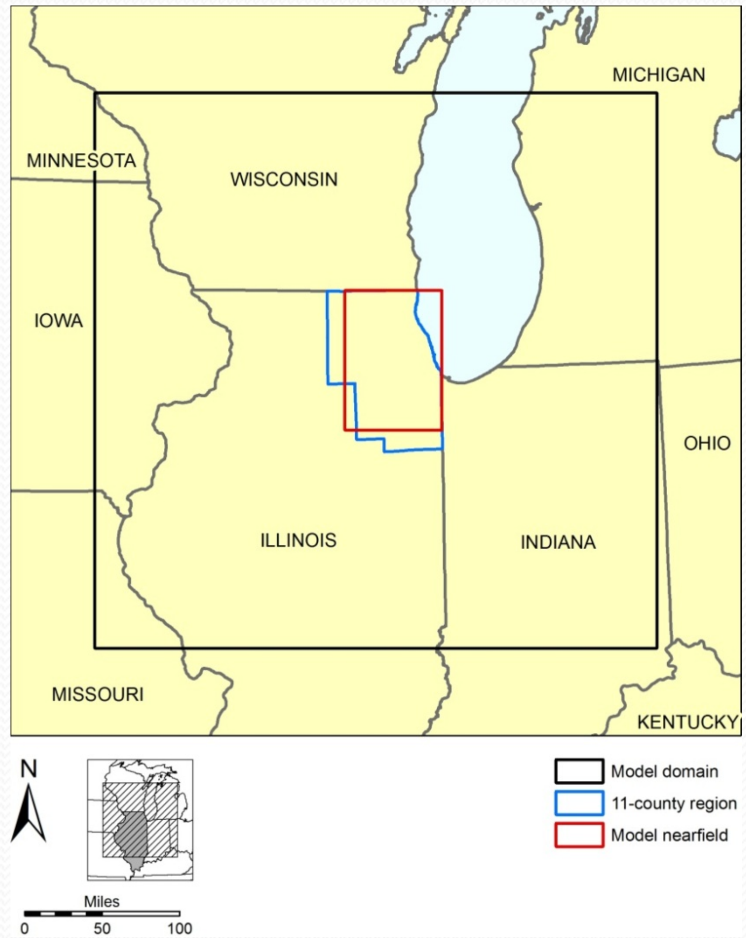
Groundwater

Aquifers of Northeastern Illinois



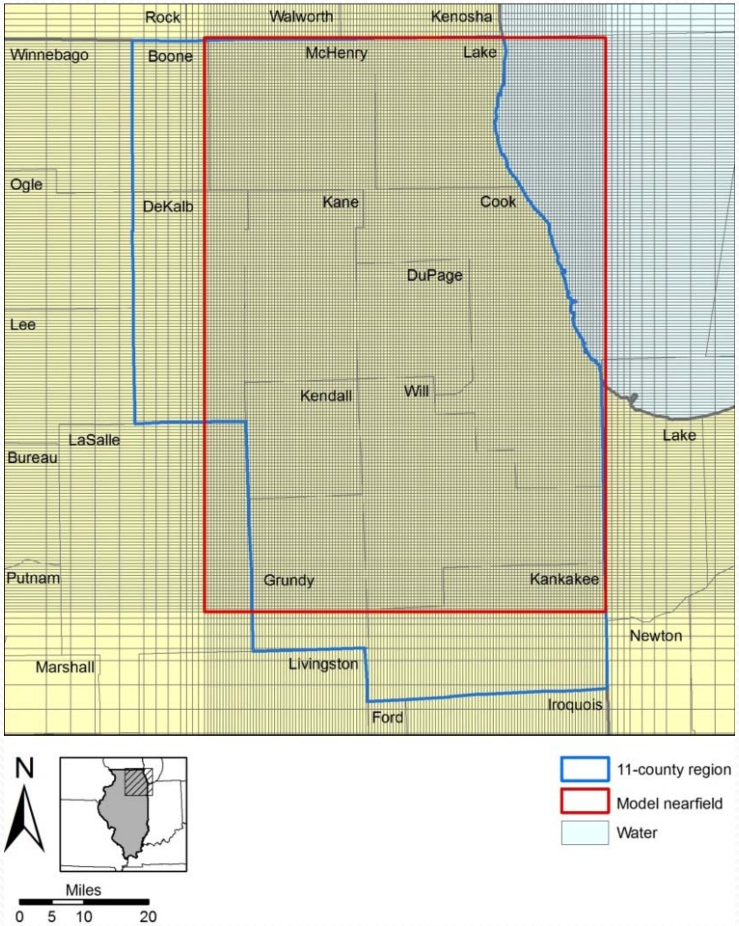
Groundwater Flow Model

- Multiple-state area
- Finite-difference
- MODFLOW 2000
- Maximum horizontal resolution in northeastern Illinois
- 22 layers
- Simulates historical pumping from 1864-2005
- Simulates future pumping from 2006-2050 (BL, LRI, MRI)



Groundwater Flow Model

Nearfield showing model grid



Groundwater Flow Model Uncertainty

Origins

- *Parameter uncertainty* is uncertainty in the input parameters of the model (hydraulic conductivity, recharge, pumping rates, aquifer geometry, etc.) and the variables the model simulates (hydraulic heads and flow rates).
- *Conceptual uncertainty* arises from our imperfect knowledge of the processes governing the modeled system, which forces us to make assumptions regarding what processes to include in the model.

Groundwater Flow Model Uncertainty

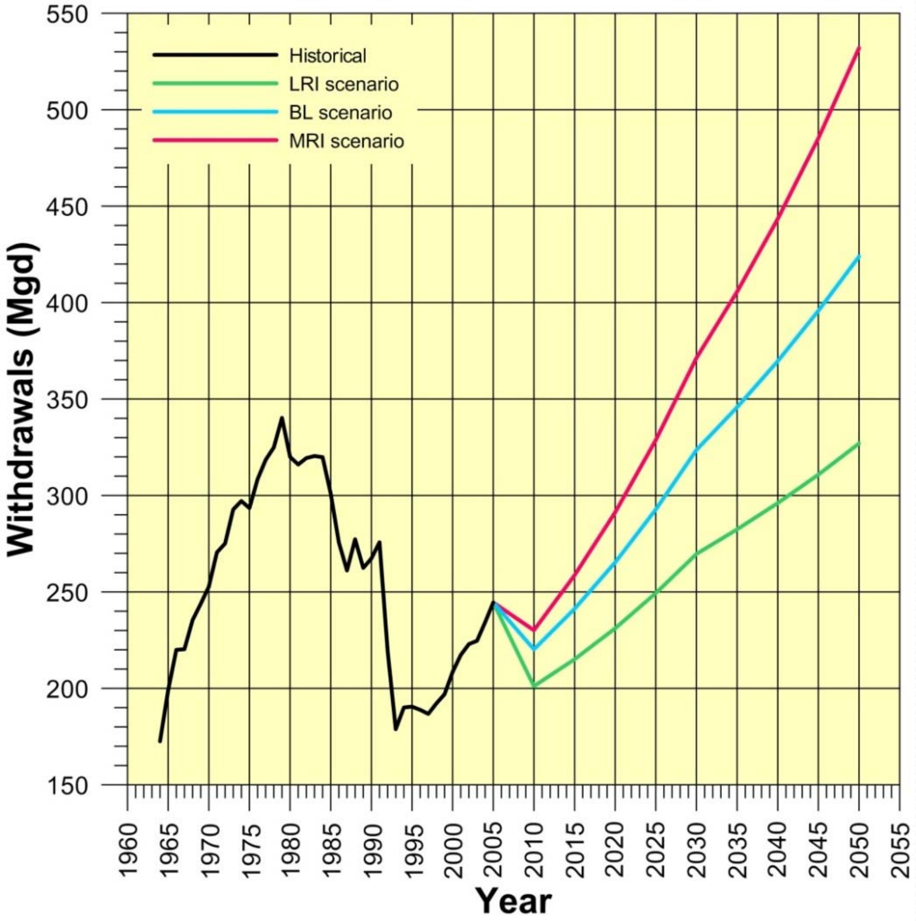
- The model results are highly uncertain
- The model results are best used as a screening tool to provide a sense of the locations and magnitudes of groundwater pumping impacts
- The model can be improved by acquiring more and better observations
- The model may be used to guide acquisition of new observations

Groundwater Flow Model Uncertainty

Conceptual Uncertainty Implicit in MODFLOW-2000

- Termination of withdrawals when model layer desaturates
- No interformational transfer of groundwater via open boreholes
- Resaturation of desaturated cells problematic

Simulated Groundwater Withdrawals in Northeastern Illinois (1964–2050)

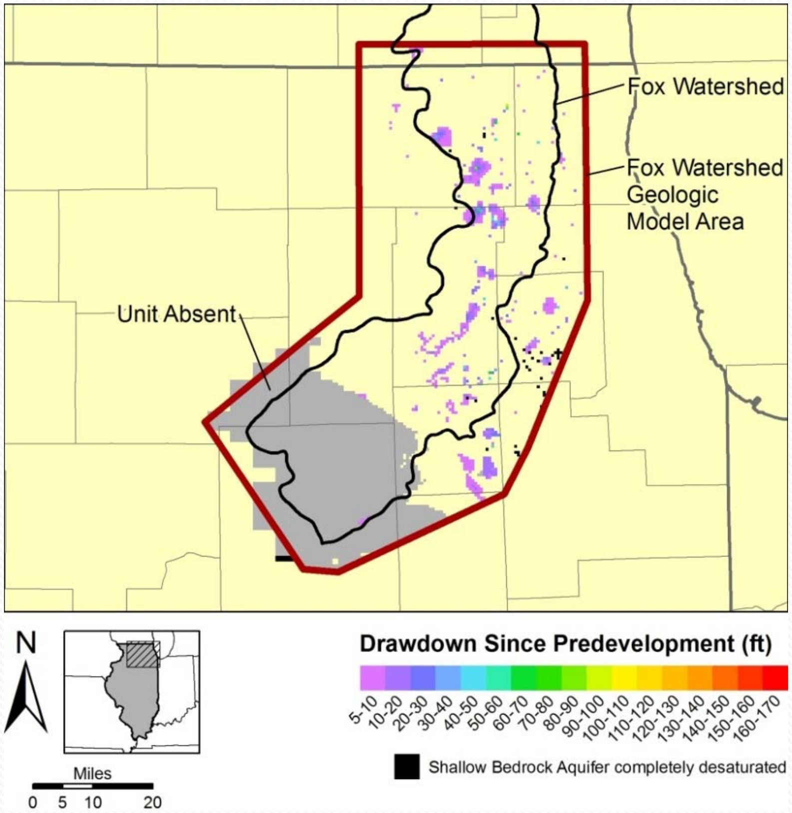


Drawdown

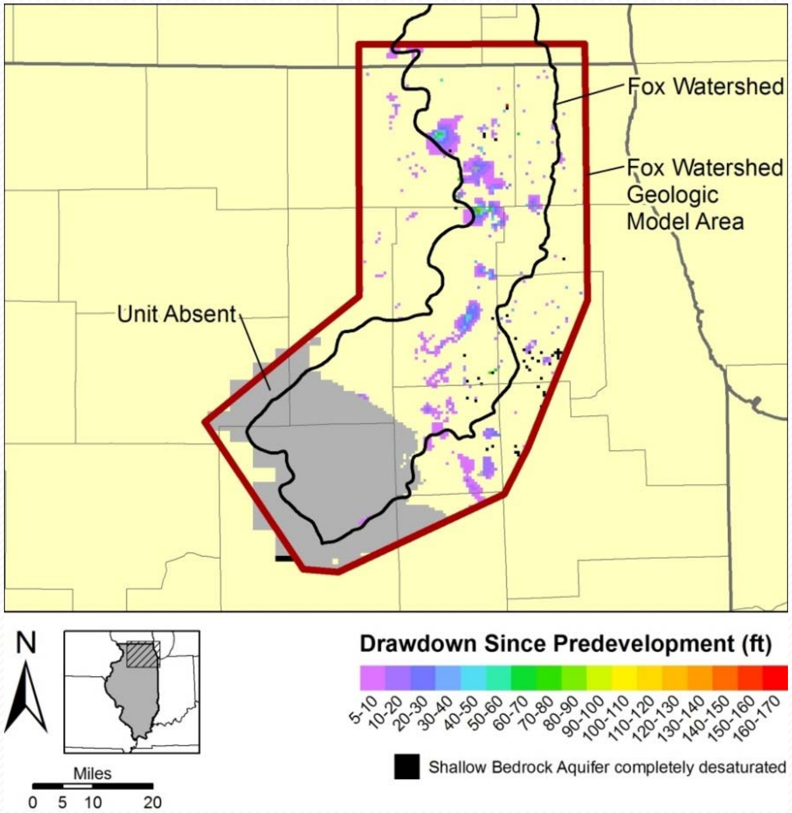
- Definition: reduction in head caused by pumping of a well or wells
- Problems
  - Decreases well yields
  - Increases pumping expenses
  - Water-supply interruptions
  - Reduction in natural groundwater discharge
  - Reduction in groundwater quality

Simulated Drawdown Since Predevelopment, Shallow Bedrock Aquifer

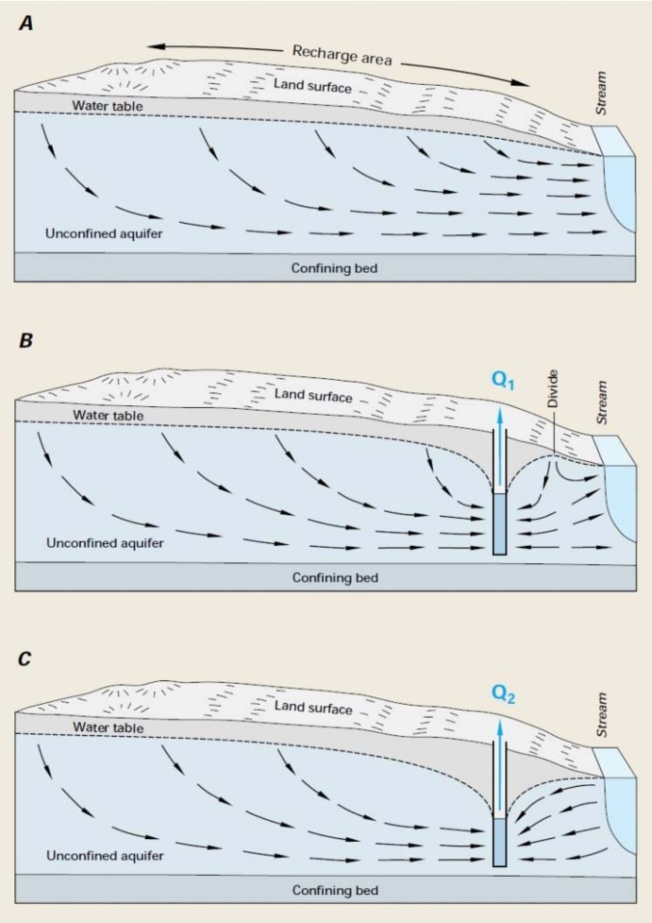
2005



2050 (BL)

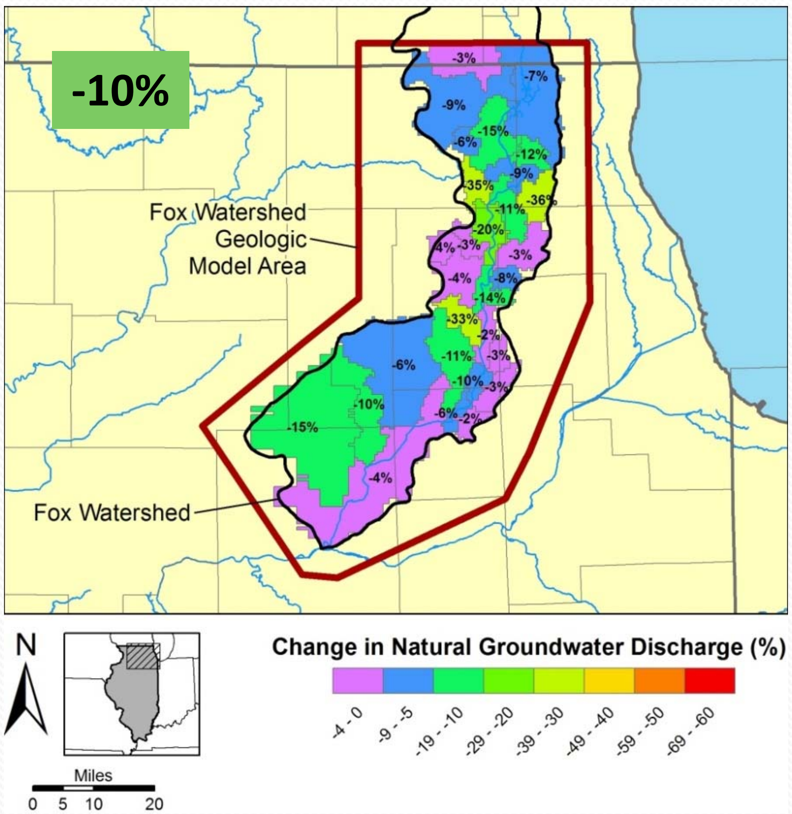


Effects of Shallow Pumping on Streamflow

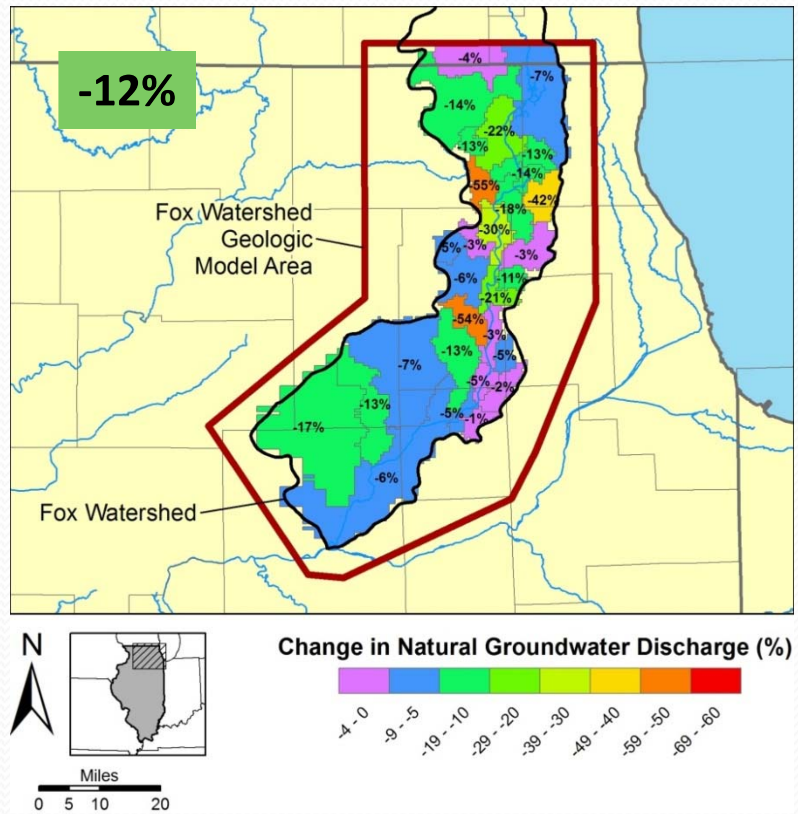


Simulated Change in Natural Groundwater Discharge Since Predevelopment

2005

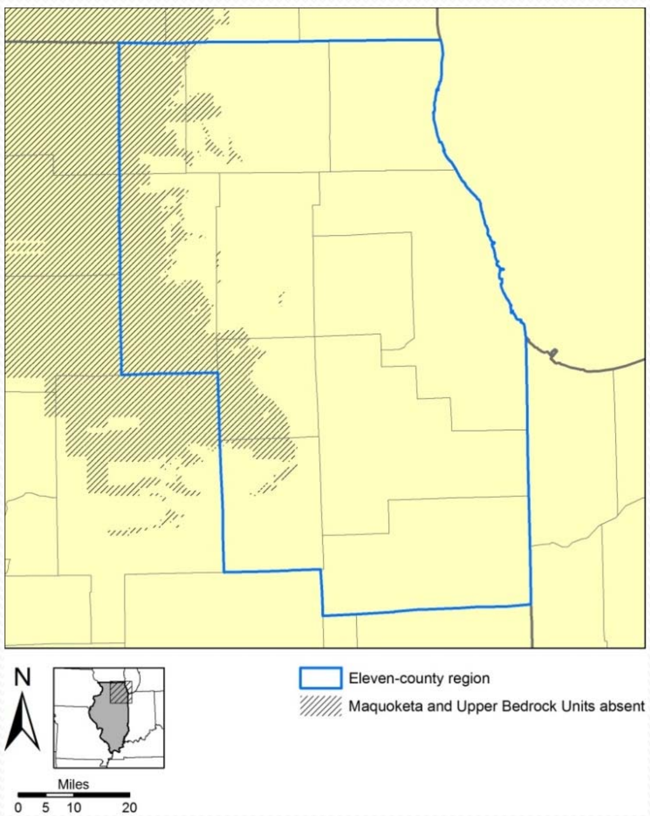


2050 (BL)

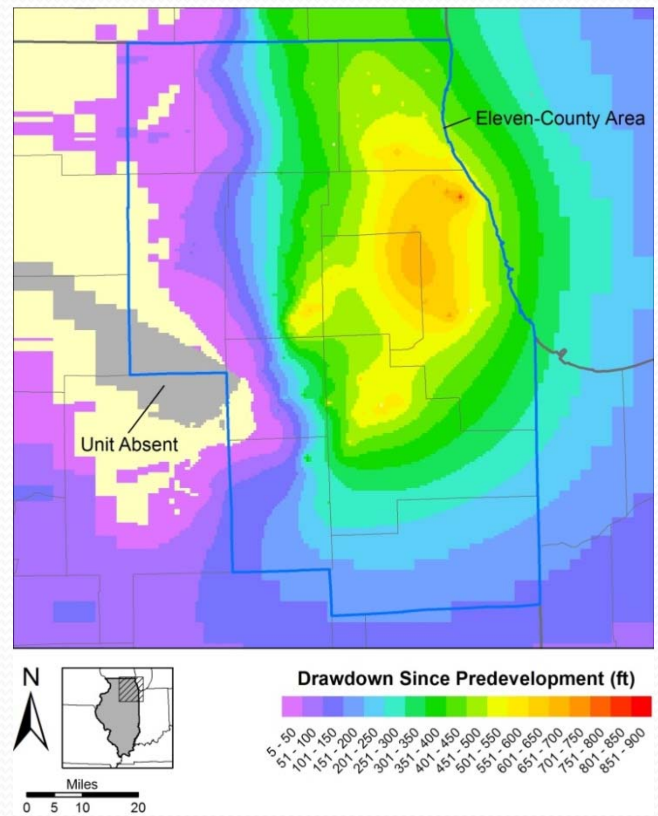


Simulated Drawdown Since Predevelopment, Deep Aquifers

Impermeable Cover Absent

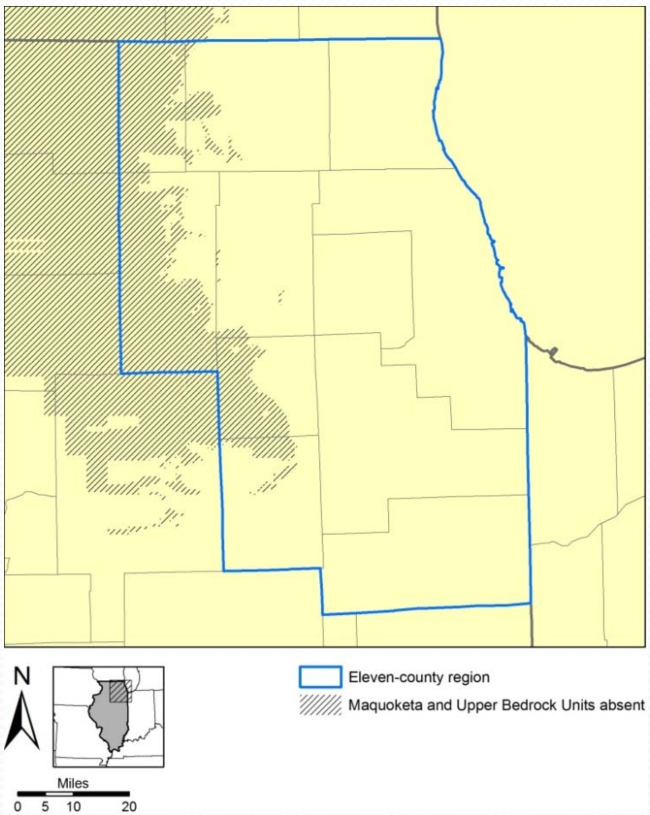


Ancell Unit (2005)

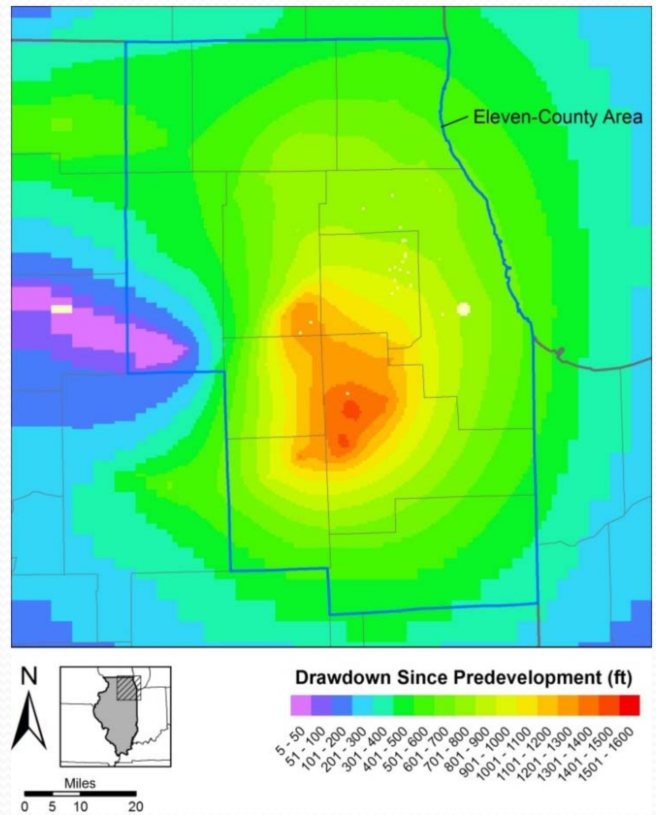


Simulated Drawdown Since Predevelopment, Deep Aquifers

Impermeable Cover Absent

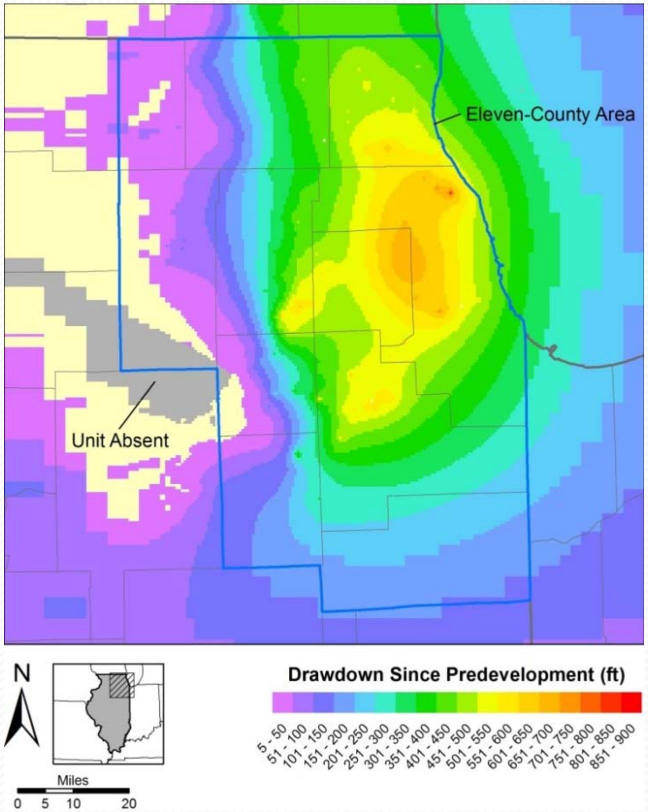


Ironton-Galesville Unit (2005)

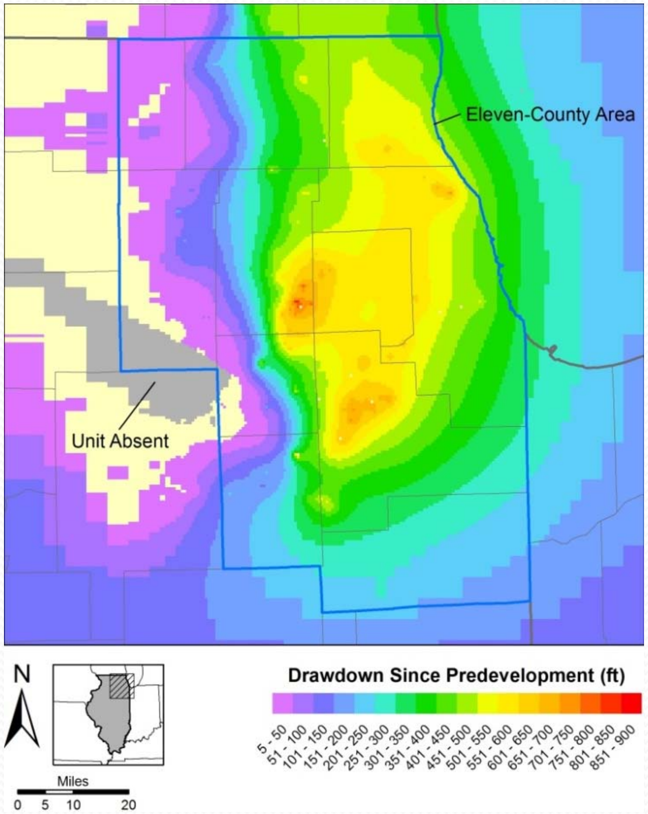


Simulated Drawdown Since Predevelopment, Deep Aquifers

Ancell Unit (2005)

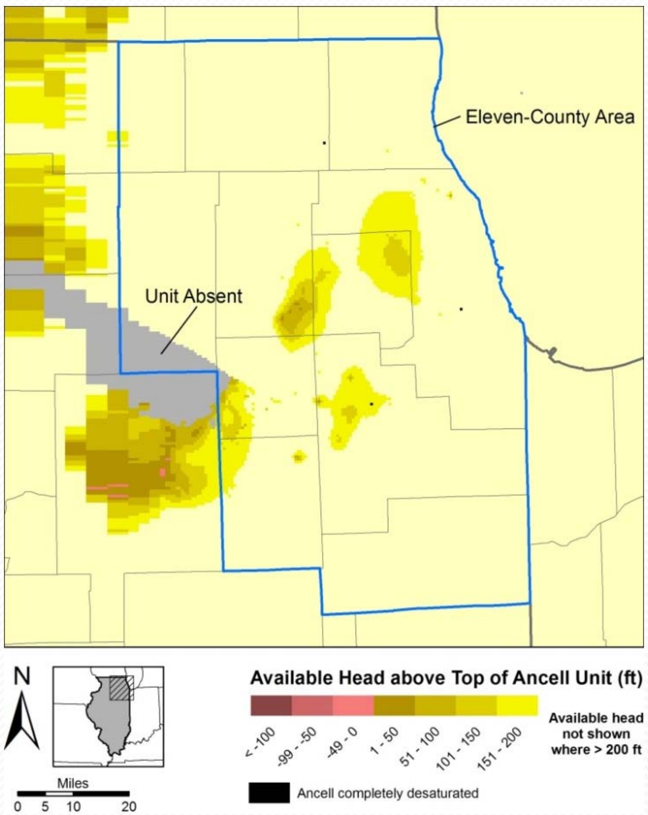


Ancell Unit (2050, BL)

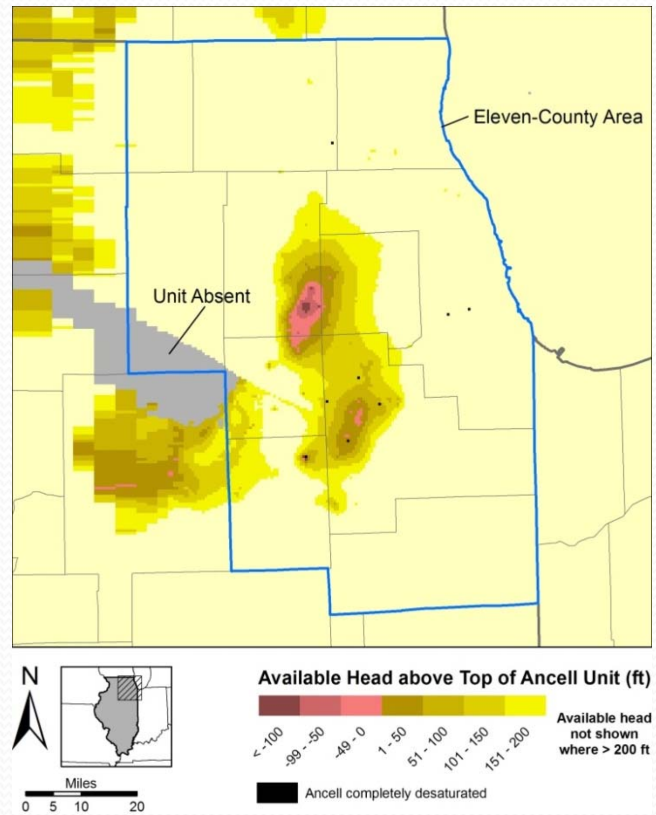


Simulated Available Head, Deep Aquifers

Ancell Unit (2005)



Ancell Unit (2050, BL)



Summary

- **Water Demand** Excluding once-through flows for electric power generation, the region may require 1,588 to 2,429 Mgd in 2050, an increase of 107 to 949 Mgd (7 to 64 percent) from the estimated 2005 withdrawal, corrected to 1971-2000 average climate, of 1,480 Mgd.
- **Scope of Study** Sources of water investigated include Lake Michigan, the Fox River, shallow aquifers within the Fox River basin, and deep aquifers underlying the entire region.
- **Lake Michigan** Illinois' Lake Michigan water allocation program can accommodate growing demand in the existing Lake Michigan service area as well as additional demand of 50 to 75 Mgd and *probably* remain in compliance with Supreme Court decreed limit .

Summary

- **Fox River** Depending on the demand scenario, the Fox River can accommodate projected 2050 demand by Elgin and Aurora as well as 14 to 58 Mgd in additional withdrawals, assuming that IDNR fixes the protected low-flow level at approximately its current value so that it does not continue to increase with increasing effluent.
- **Groundwater** Computer simulation of plausible scenarios of future groundwater demand, using existing well locations, suggests that additional drawdown, reduction in stream base flow, and changes in the quality of groundwater withdrawn from deep wells are all possible in parts of the 11-county study area before 2050.

Summary

- **Groundwater** Limited areas of partial to complete desaturation (draining of pore spaces) of the Ancell Unit will develop by 2050.
- **Groundwater** Model simulations suggest that, in 2005, pumping had reduced natural groundwater discharge within the Illinois portion of the Fox River watershed by about 10 percent. Simulation of future pumping scenarios suggests that natural groundwater discharge in the Illinois portion of the Fox River basin could be reduced to rates that are 10 to 14 percent less than predevelopment rates in 2050.

Summary

- **Future Work** Surface water and groundwater models can be used for further analysis.
- **Future Work** Models can be improved with new observations , revision of pumping forecasts, and adaptation to continually improving modeling codes.
- **Future Work** Monitoring is key.

Contact Information

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