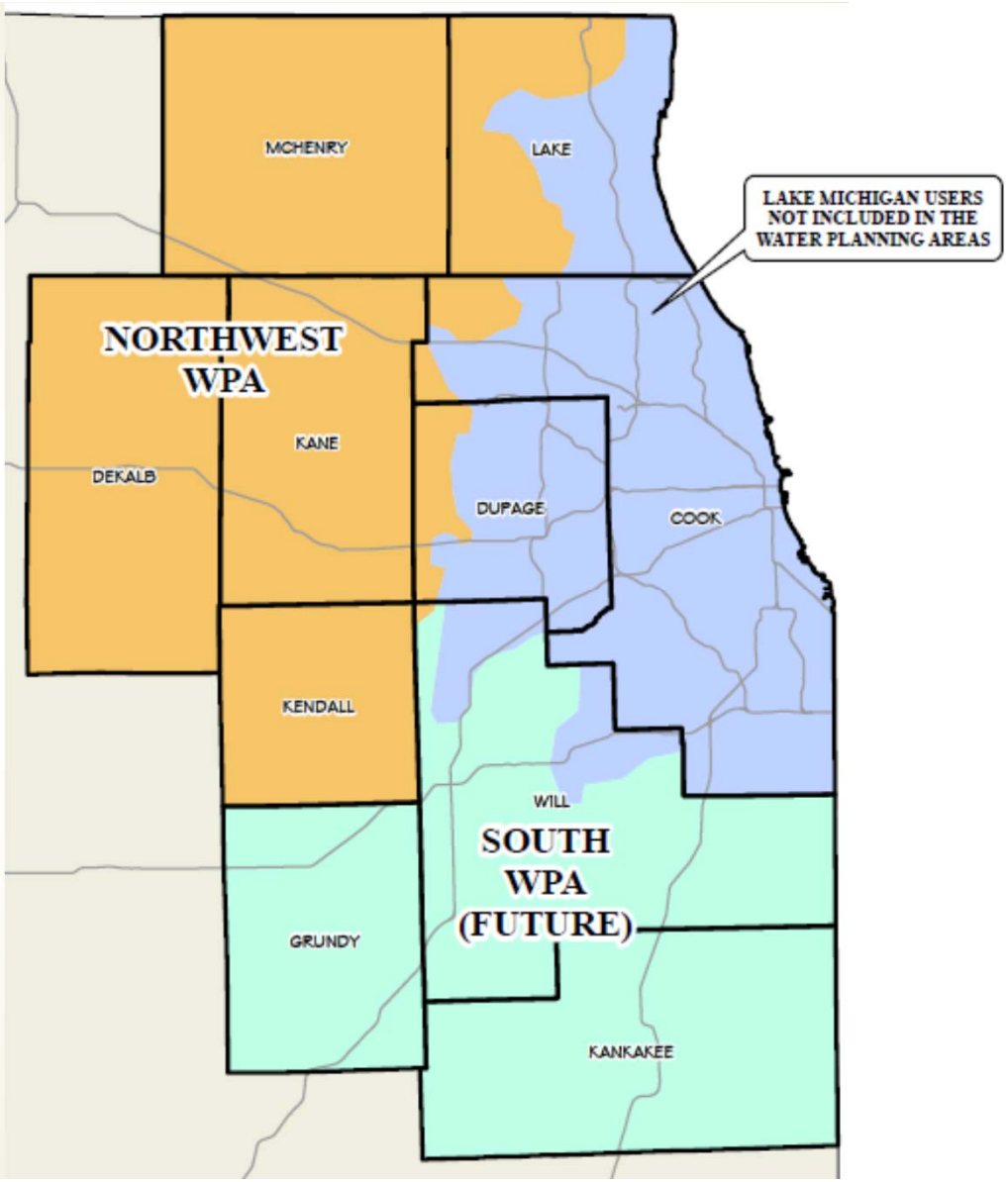
Insights from modeling in the NWPA region



Goal of this study

1 Best estimate of available water

At what rate would groundwater withdrawals be "sustainable" given the 2005 pumping well configuration?

Methodology

- Utilize a groundwater flow model of the NWPA and surrounding regions to assess the impacts of historical pumping data and future scenarios on:
  - Groundwater heads
    - "What is the available head above the deep bedrock units?"
  - Base flow in streams
    - "What is the reduction in base flow since pre-development?"

	HYDROSTRATIGRAPHIC UNIT	MODEL LAYER
QUATERNARY MATERIALS	Wadsworth Unit	1
	Haeger-Beverly Unit	2
	Yorkville-Batestown Unit	3
	Tiskilwa Unit	4
	Ashmore Unit	5
	Winnebago-Upper Glasford Unit	6
	Upper Glasford Sand Unit	7
	Lower Glasford Unit	8
	Lower Glasford Sand Unit	9
BEDROCK	Upper Bedrock Unit	10
	Silurian-Devonian Carbonate Unit	11
		12
		13
	Maquoketa Unit	14
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	Ironton-Galesville Unit	21
	Eau Claire Unit	22
	Mt. Simon Unit	23
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		25
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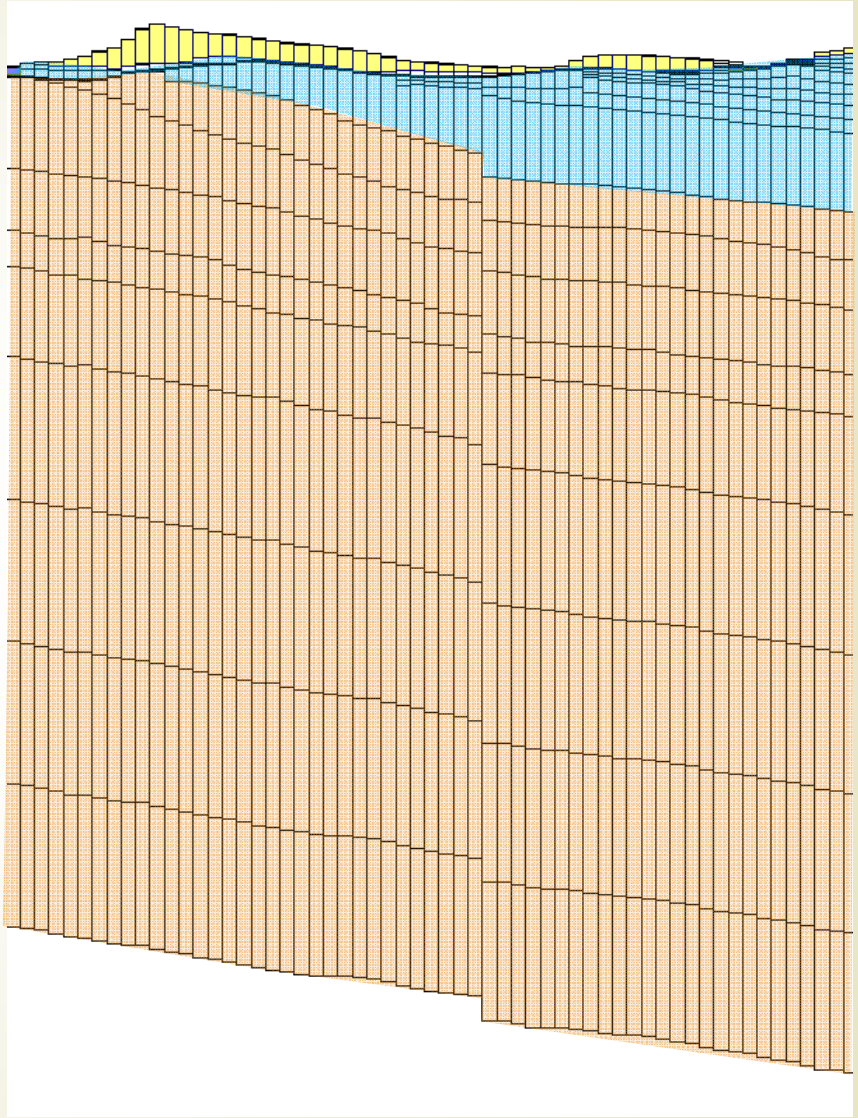


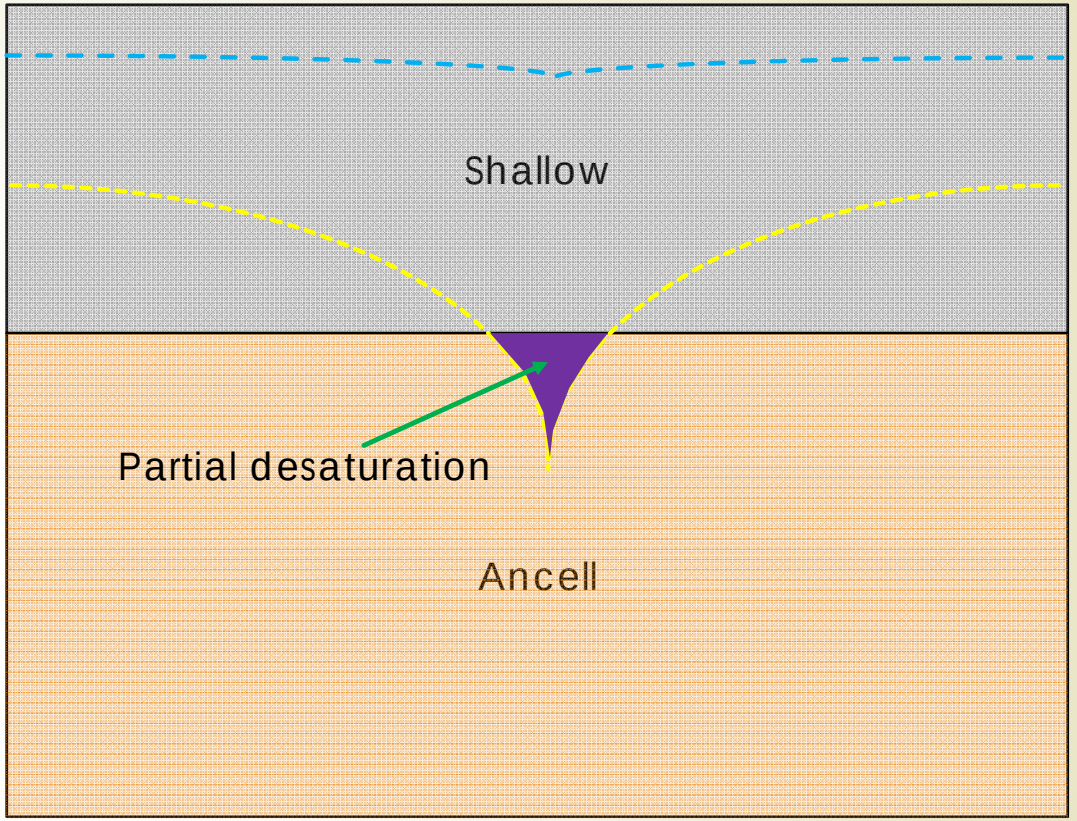
Part 1: Pumping in the deeper aquifer systems

Desaturation of the Ancell

What is the issue?

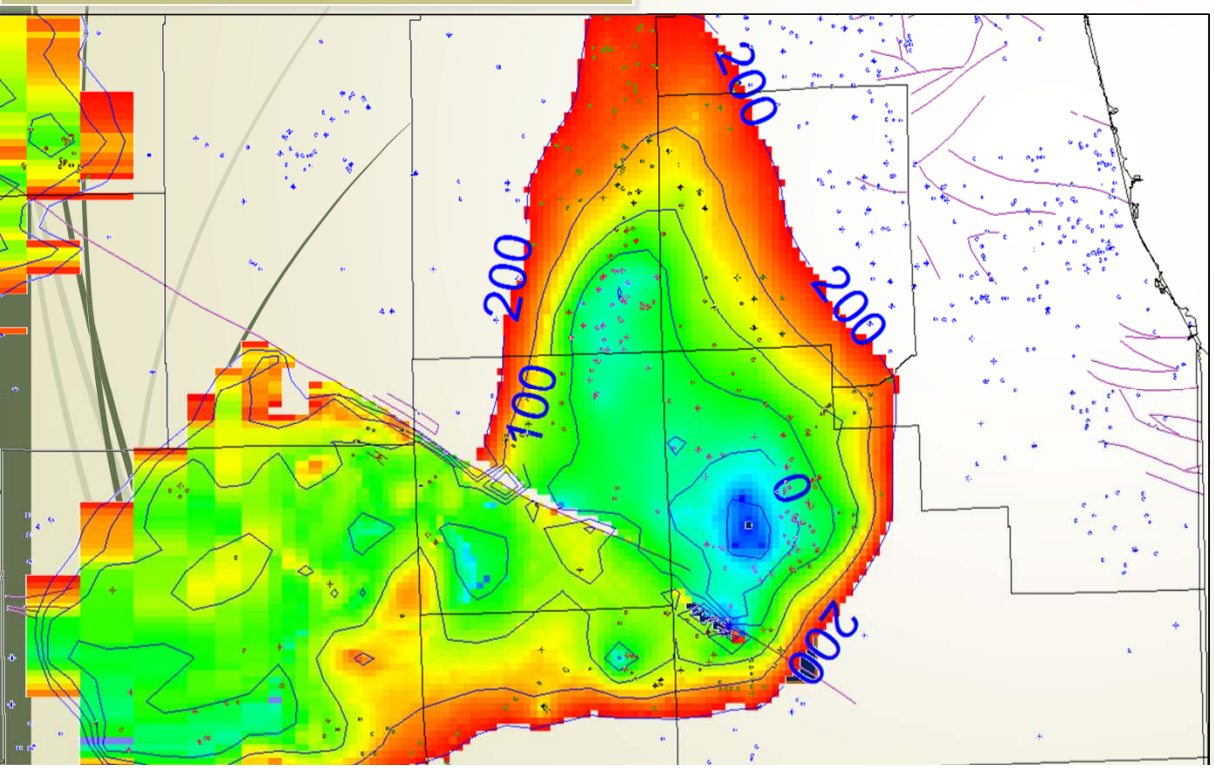
Partial Desaturation

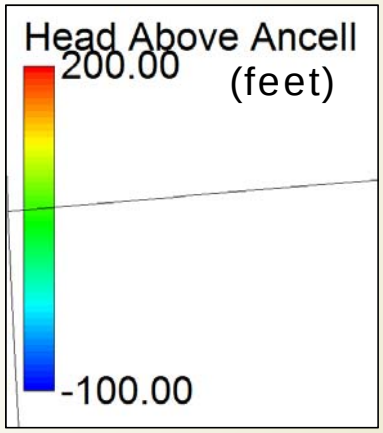
- Small capacity wells in the Ancell will be threatened
  - In 2013, observed decrease in productivity in Ancell wells in Montgomery, IL
- Potential to impact water quality



Available head above the Ancell in 2005

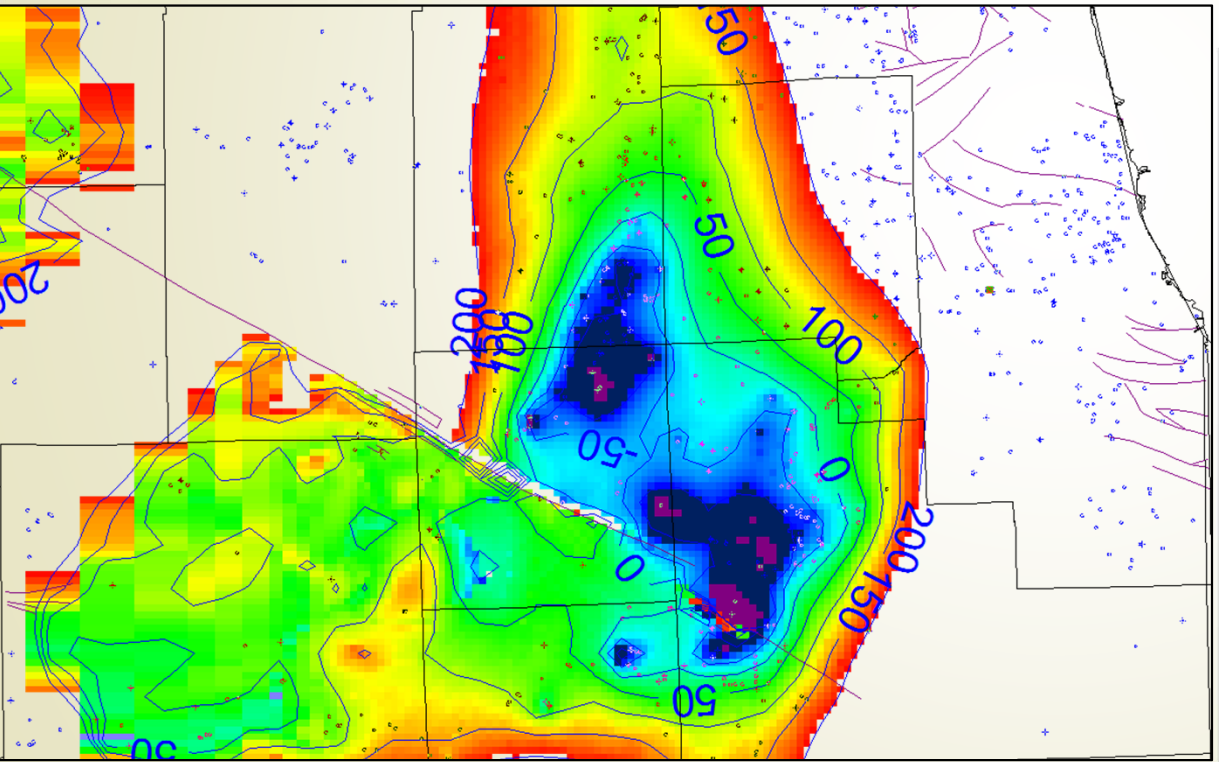
1 2005 Pumping Rates

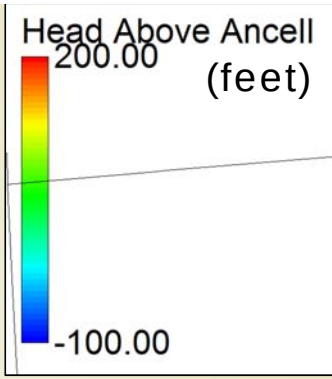


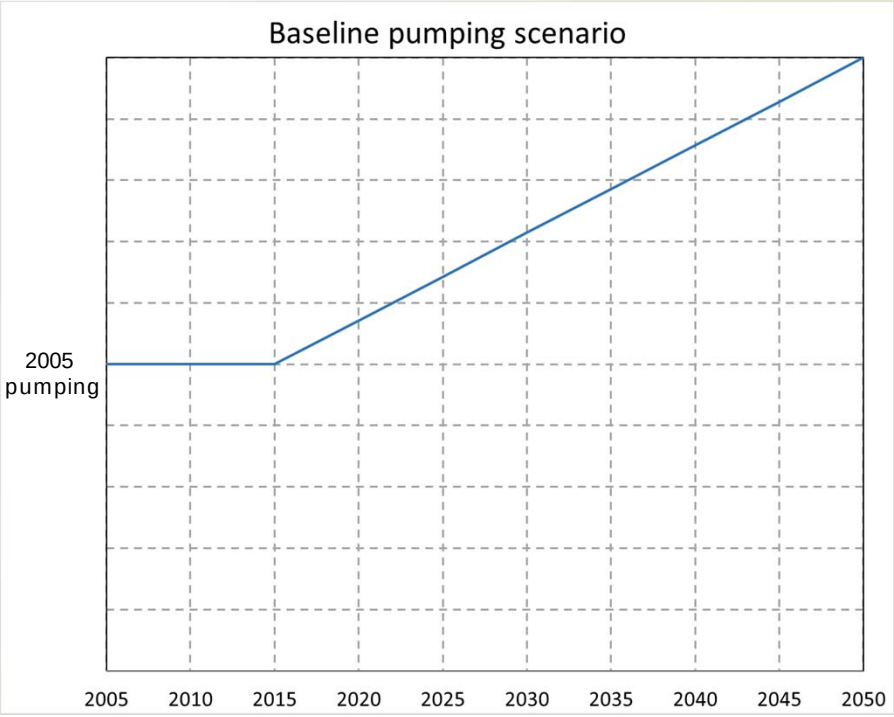


Available head above the Ancell in 2050

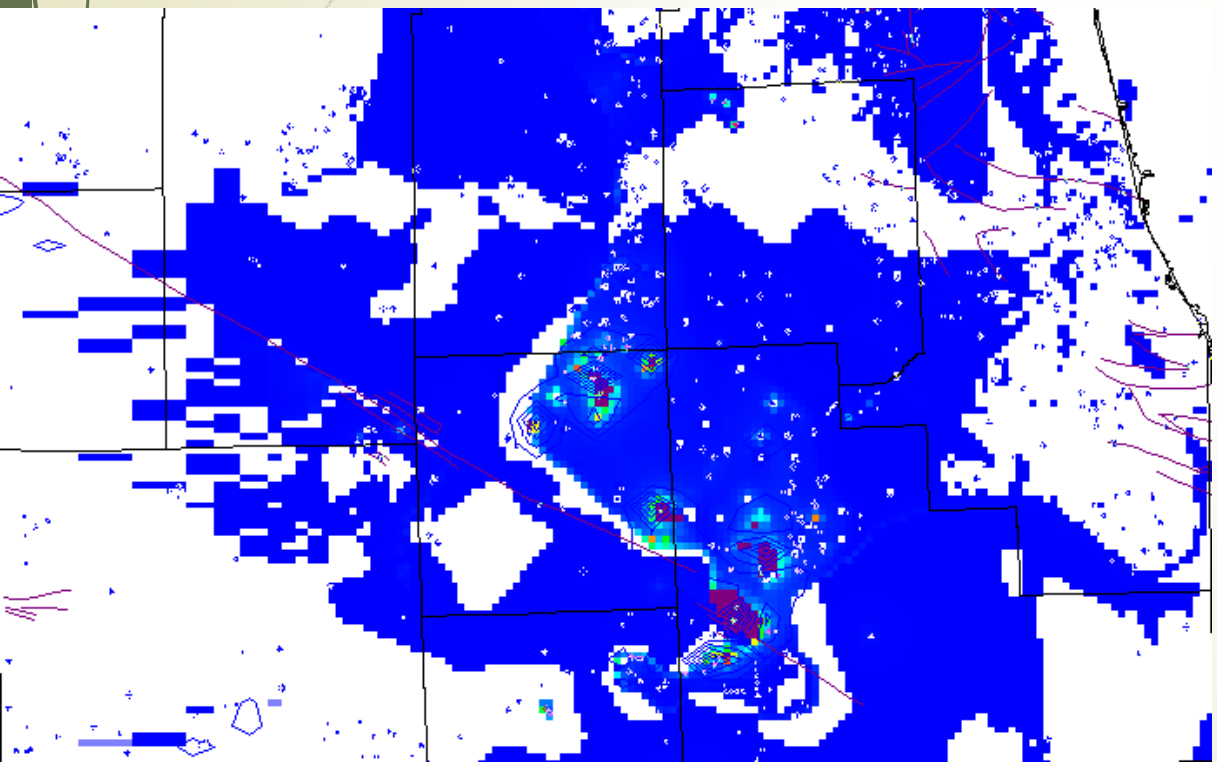
2 2050 Baseline Pumping Rates

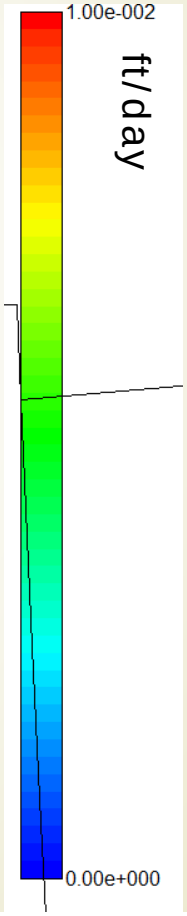






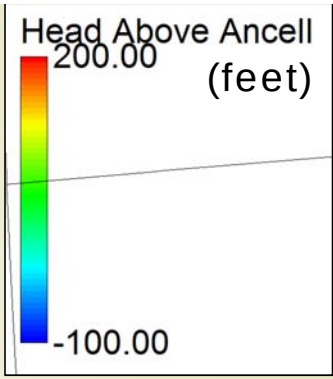
Change in leakage to the deep between 2005 and 2050 (colored areas represent zones where leakage to the deep increased)

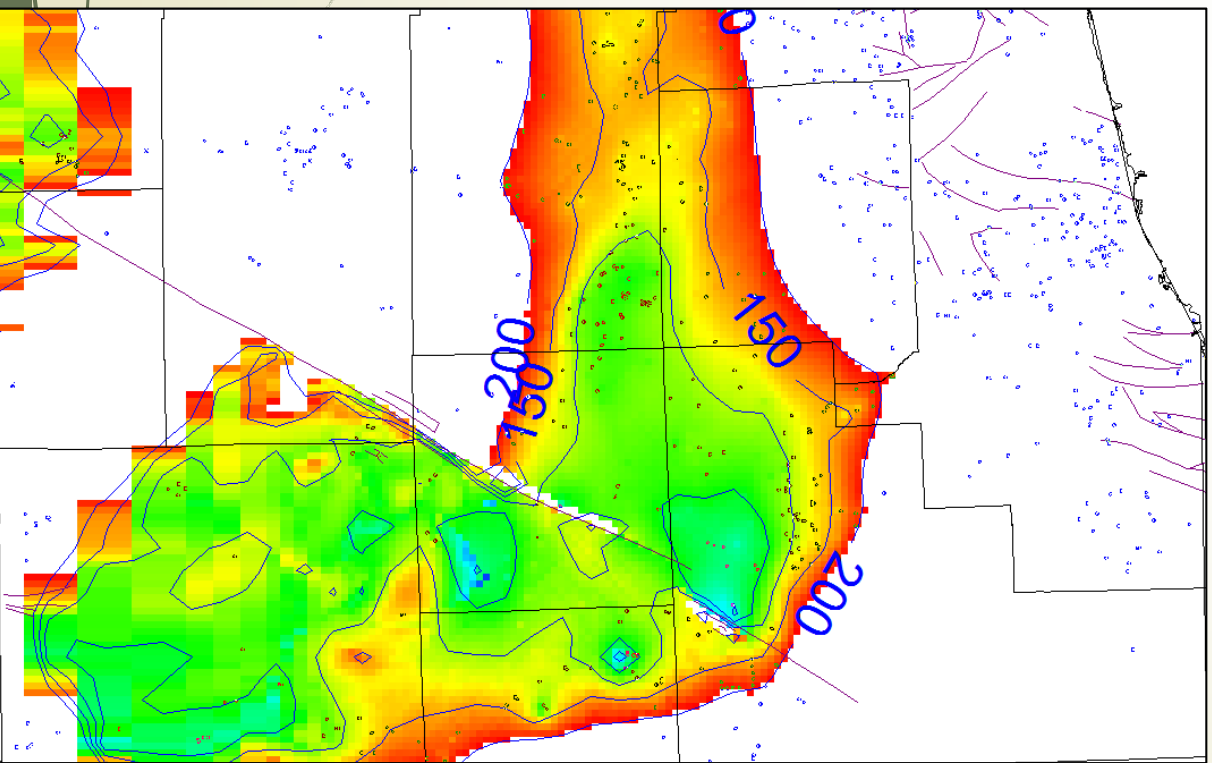


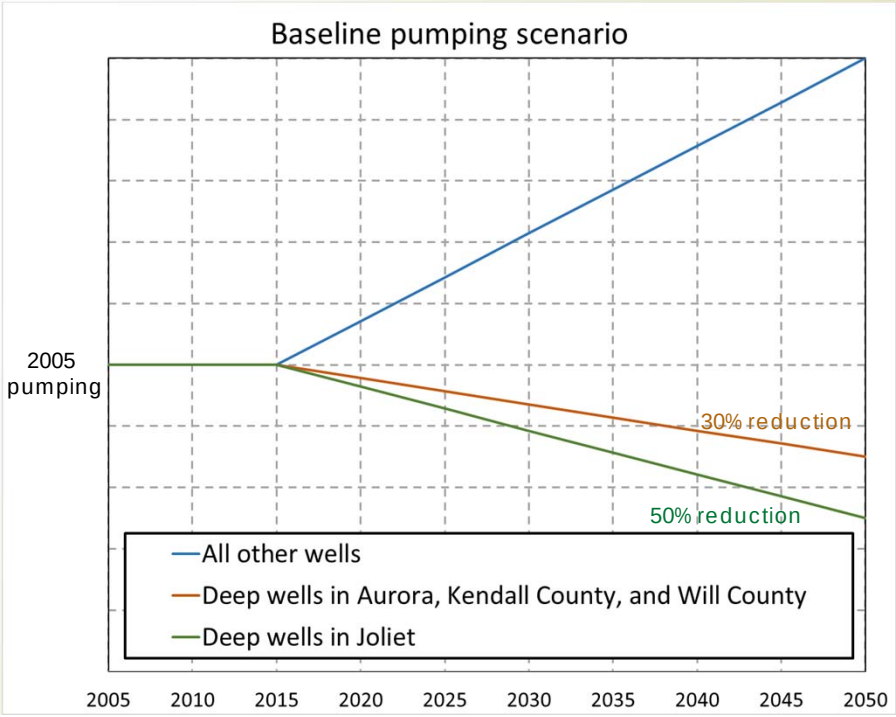


Available head above the Ancell in 2050

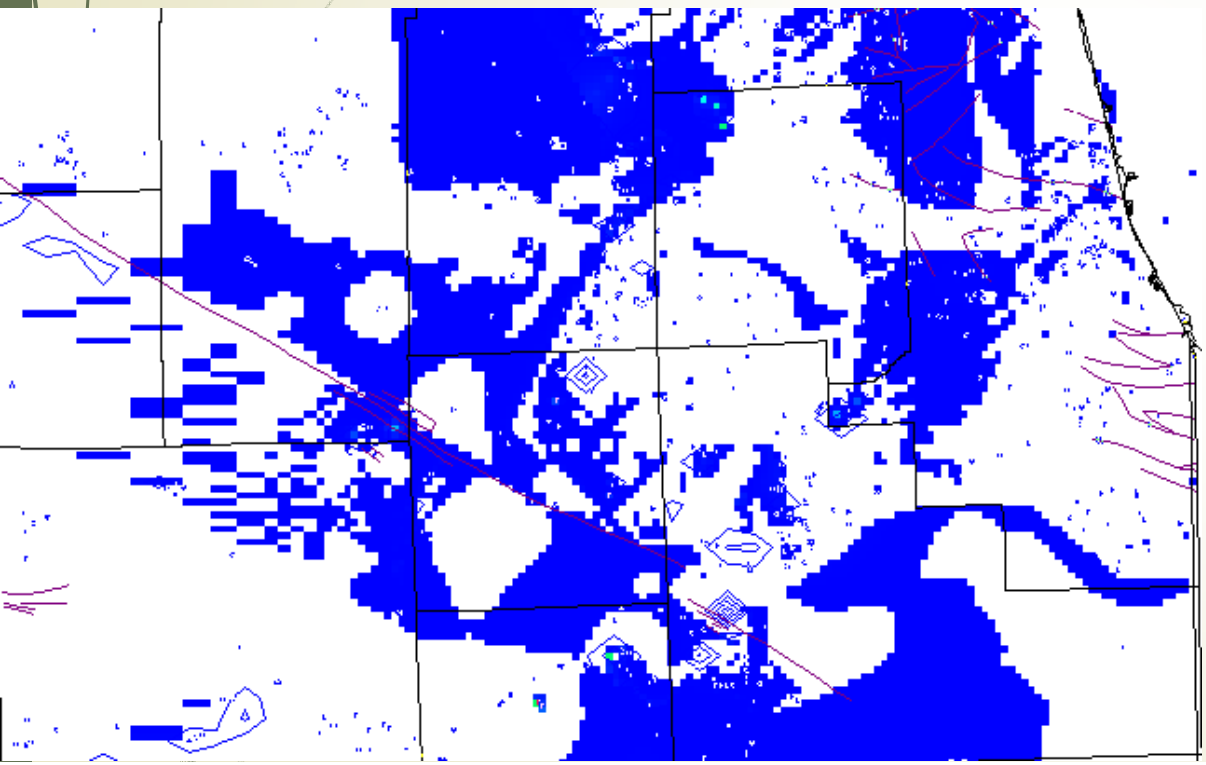
7 Reduce pumping in Aurora, Kendall County, and Will County; Reduce pumping further in Joliet

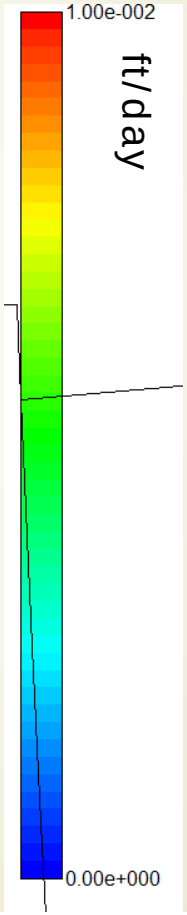




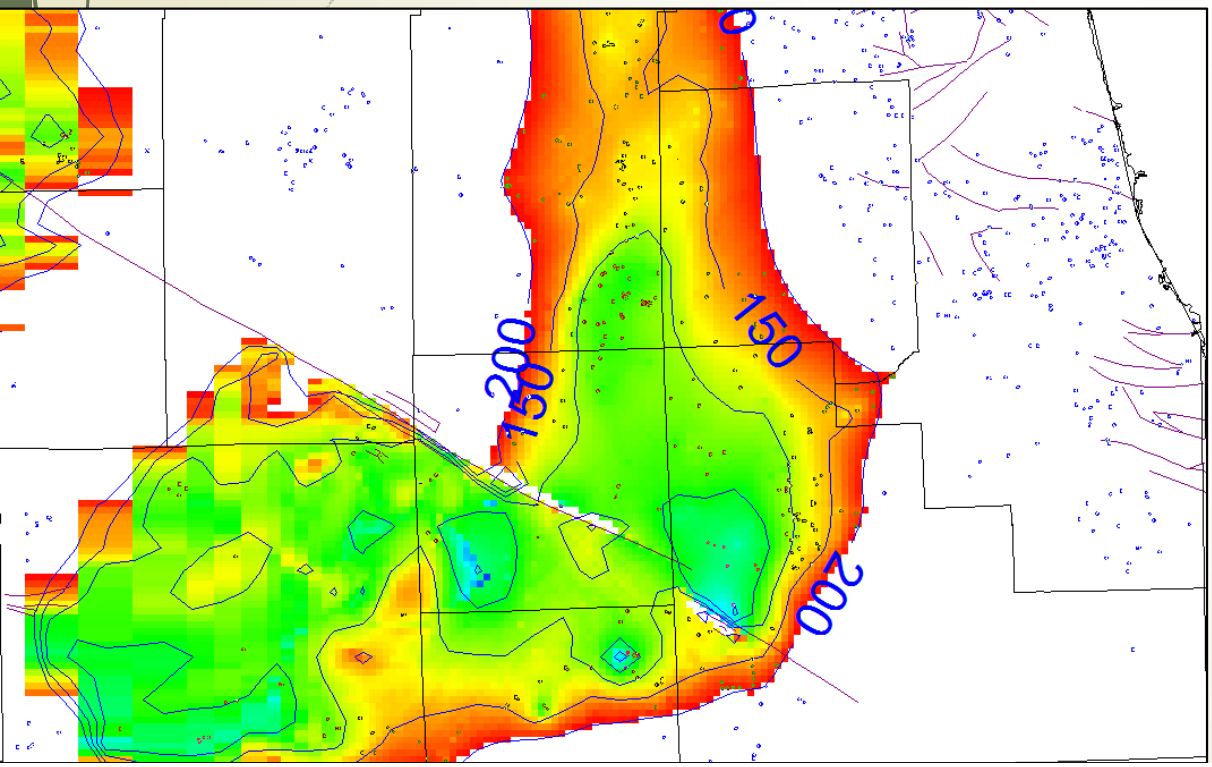


Change in leakage to the deep between 2005 and 2050 (colored areas represent zones where leakage to the deep increased)





Question: Where to relocate pumping?



- Option 1: Keep pumping in the deep
  - Decrease pumping in select areas
  - Distribute pumping more evenly
  - Requires cooperation from multiple counties, even outside the NWPA
- Option 2: More pumping into the shallow aquifer system
  - Will influence “natural groundwater discharge” to surface waters
- Other options: Surface water?

Part 2: Pumping in the shallow aquifer systems

Reduction in natural groundwater discharge

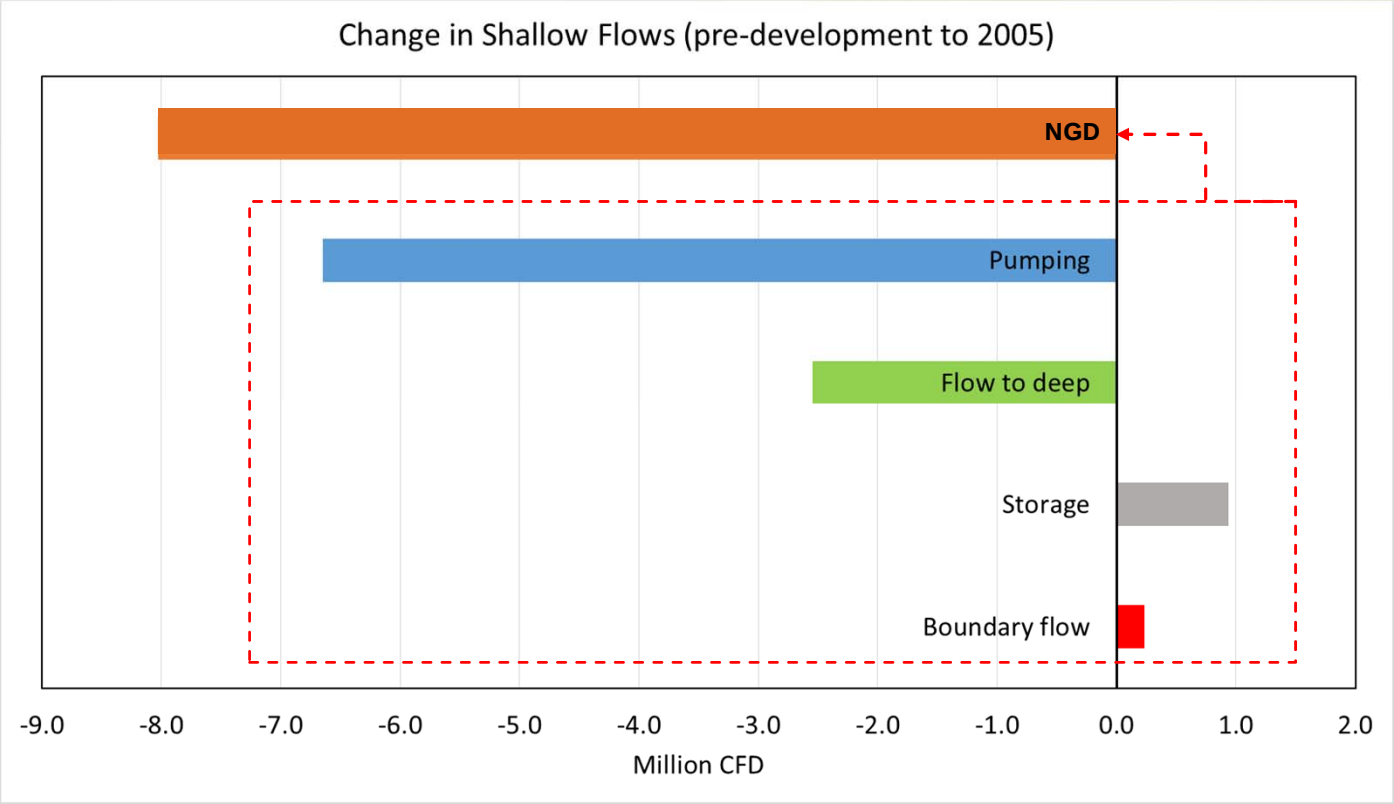
Fox River Watershed

Reduction in natural groundwater discharge (NGD)

- What is an allowable reduction in natural groundwater discharge from pre-pumping conditions?
  - In Michigan, a 10% reduction in natural groundwater discharge was found to adversely impact sensitive fish species (Zorn et al. 2008)
- Two open questions:
  - Is this value appropriate for the urban streams in the NWPA region?
  - If we have already passed the point of 10% reduction in NGD, is the ecological damage irreversible?

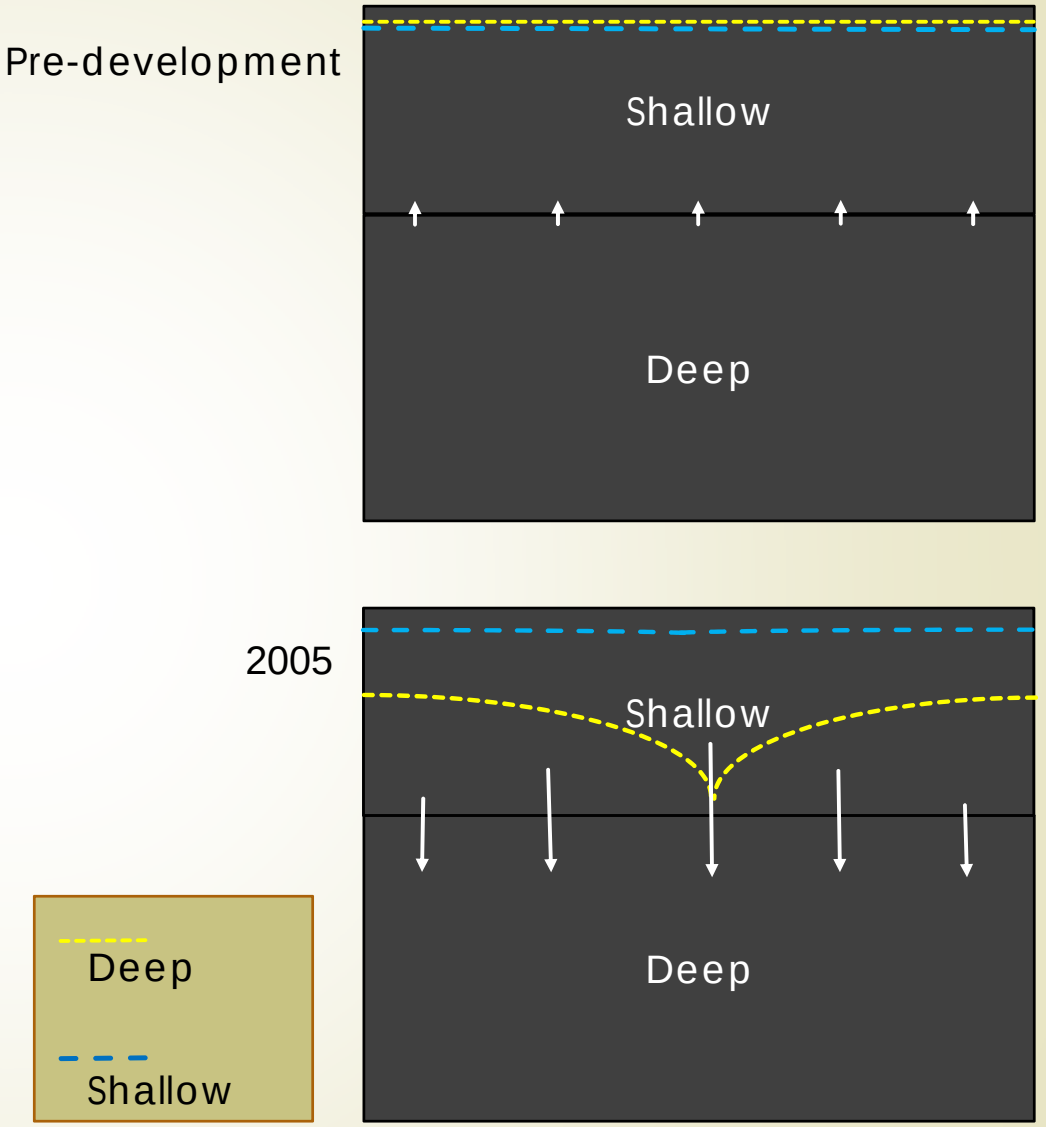
Reductions in natural groundwater discharge (NGD) in the Fox River Watershed

- 8 million CFD reduction in NGD
- Only a 6.7 million increase in shallow pumping!!!
- Reduction in NGD also a function of:
  - Flow to the deep aquifer
  - Change in storage
  - Change in groundwatershed size

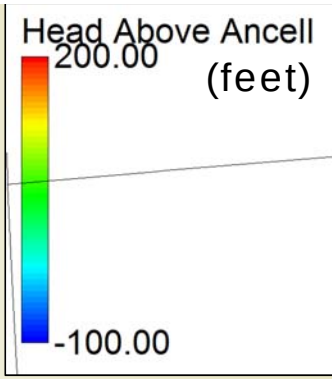


Interactions between the shallow and deep systems

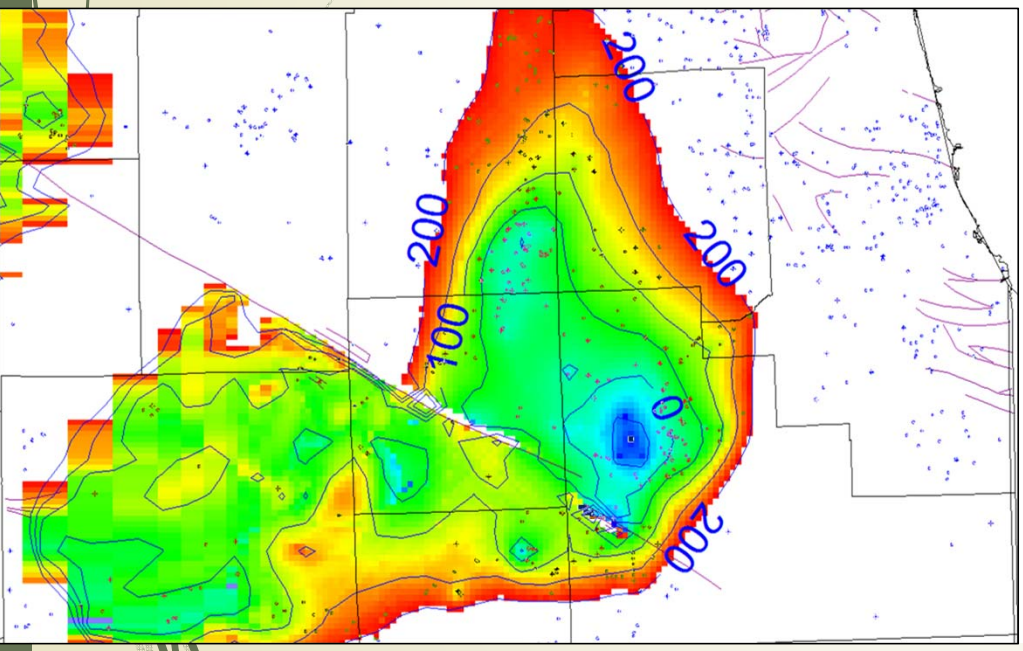
- Implication
  - In pre-development, water entered the shallow aquifer from the deep aquifer in the Fox River Watershed
  - In 2005, water entered the deep aquifer from the shallow aquifer in the Fox River Watershed



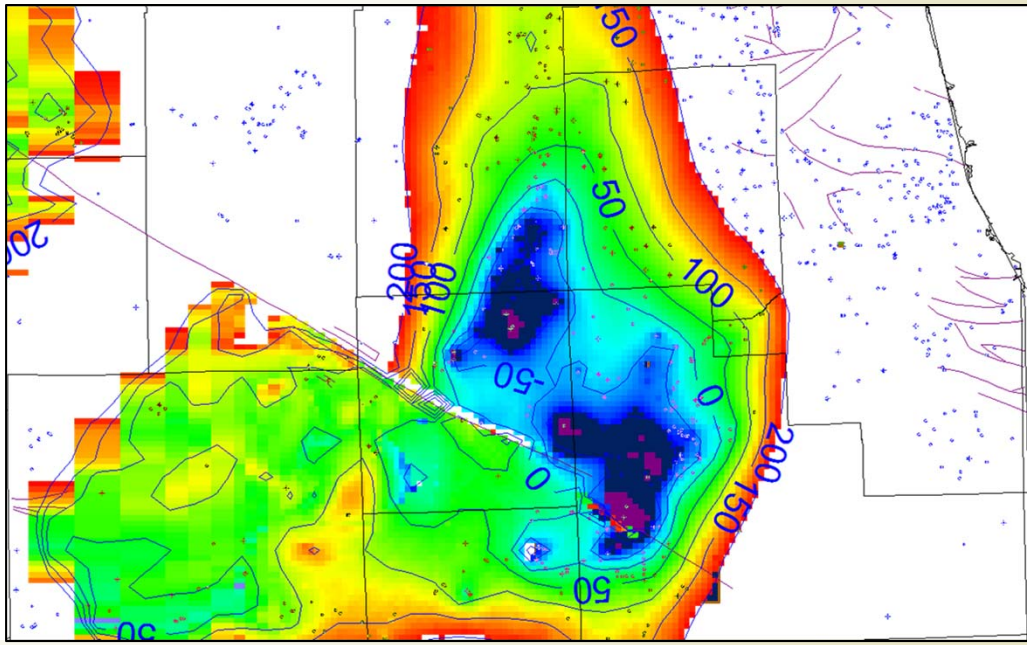
Available head above the Ancell in 2050



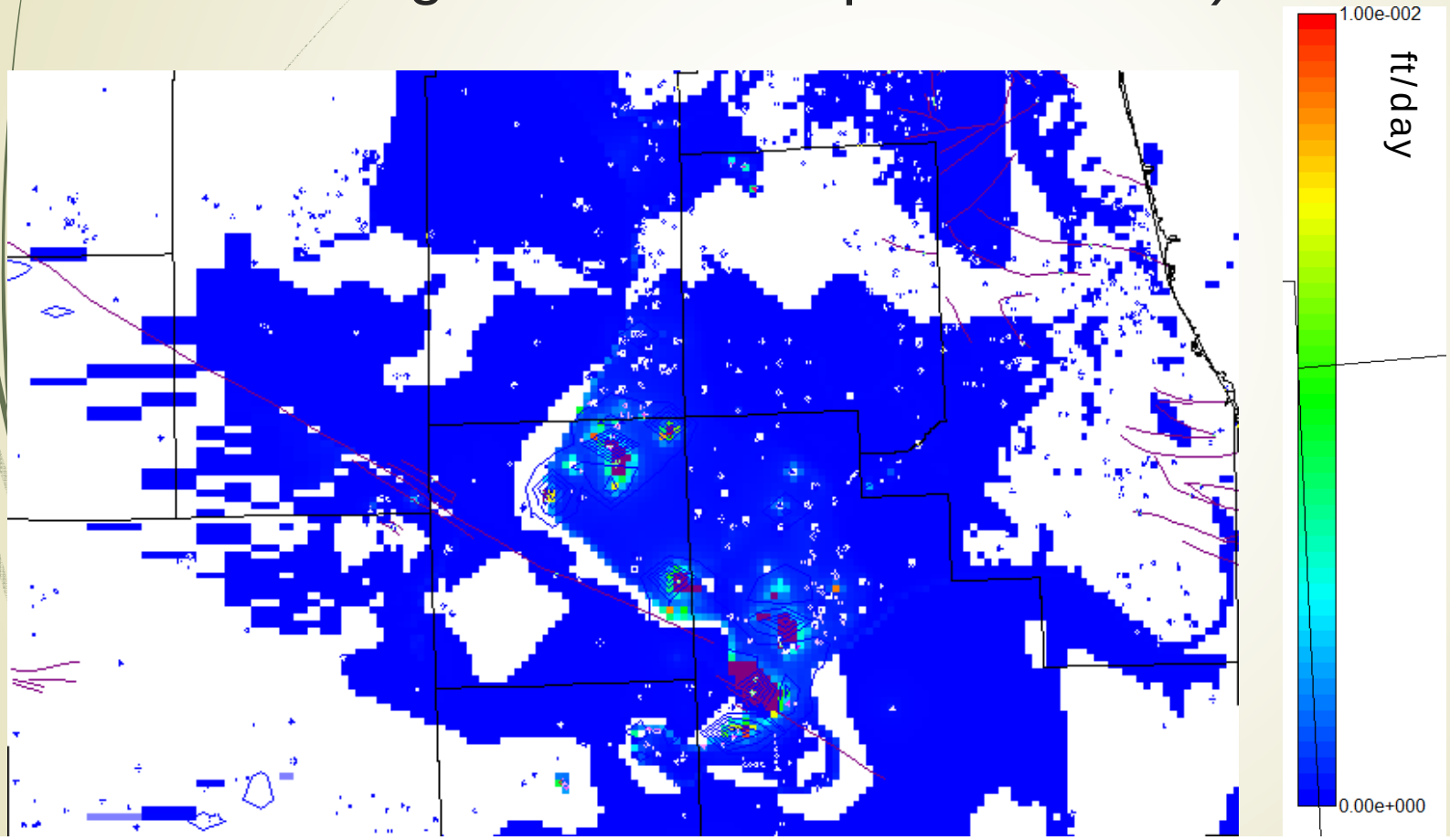
2005



2050 baseline

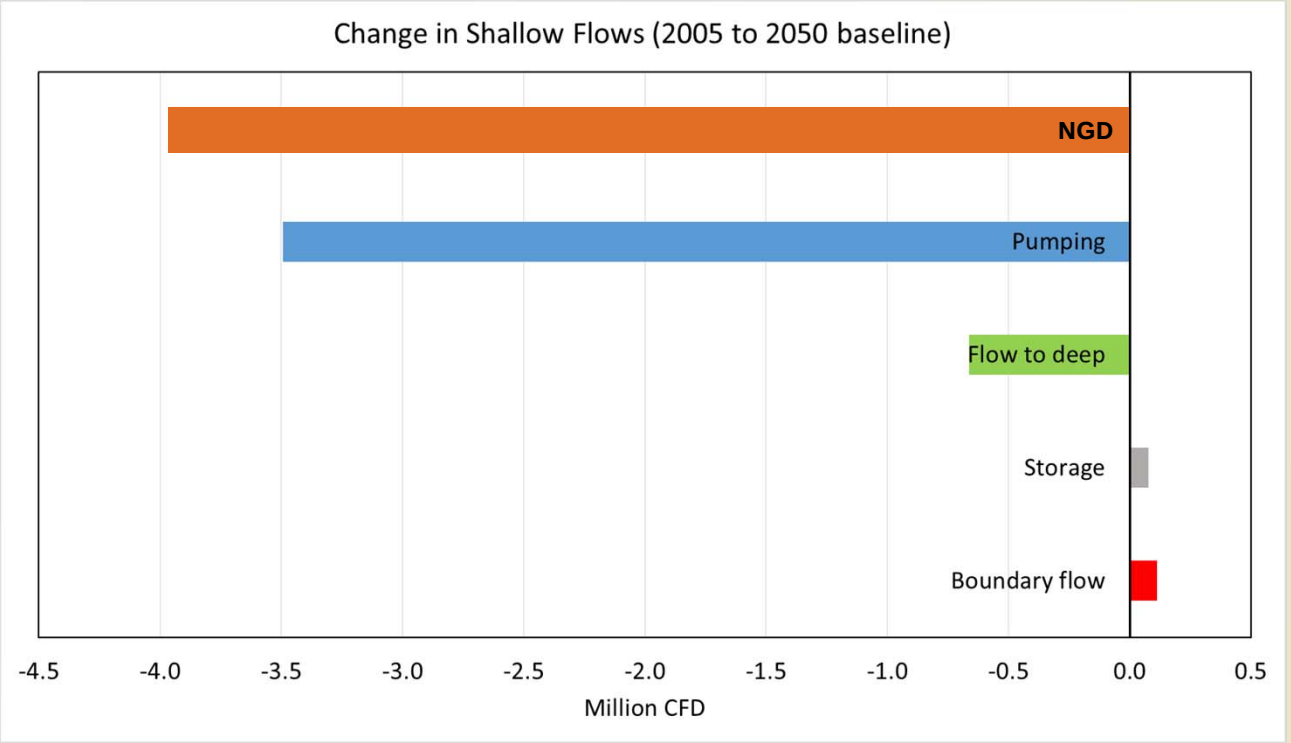


Change in leakage to the deep between 2005 and 2050 (colored areas represent zones where leakage to the deep increased)

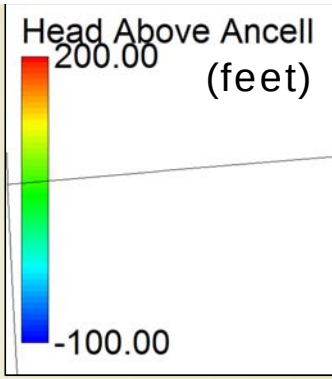


Future reductions in NGD- Baseline

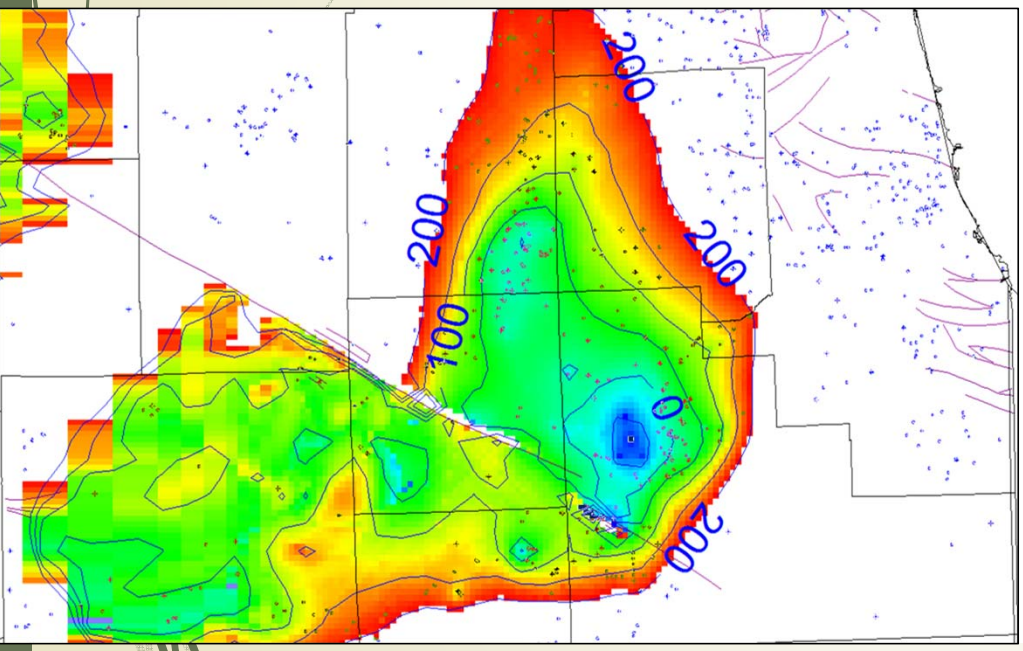
- Per baseline in the Fox River Watershed
  - Shallow pumping of 3.5 million CFD would result in a reduction of 4 million CFD in NGD
  - Note that this is contingent on deep pumping developing per baseline!!!



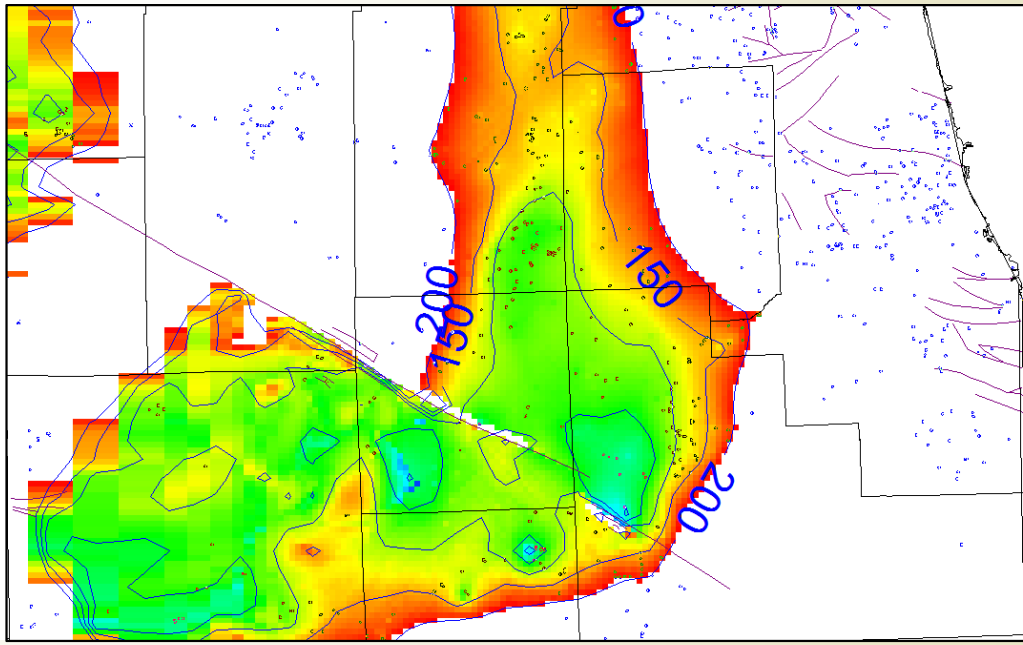
Available head above the Ancell in 2050



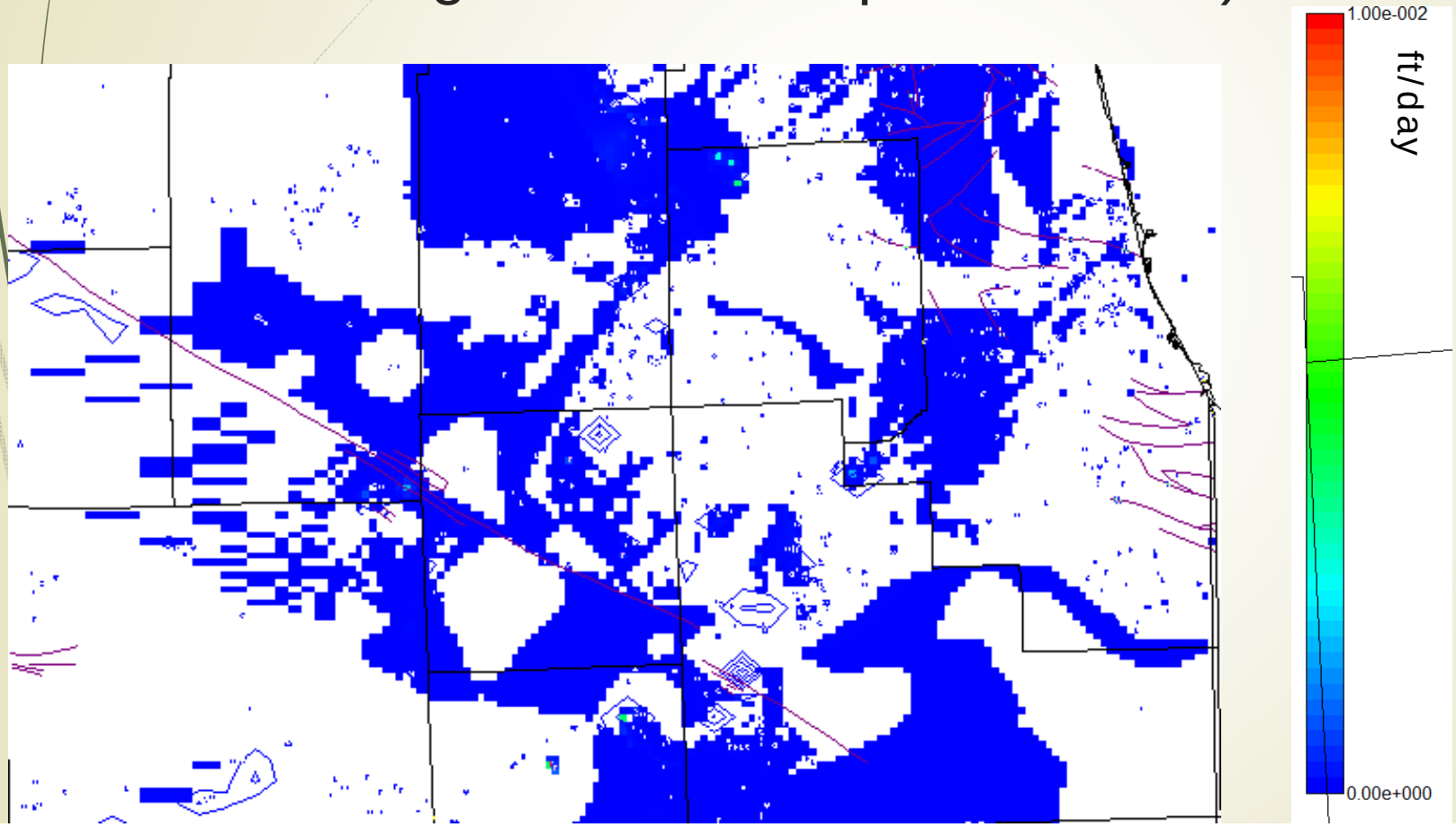
2005



2050 reduced

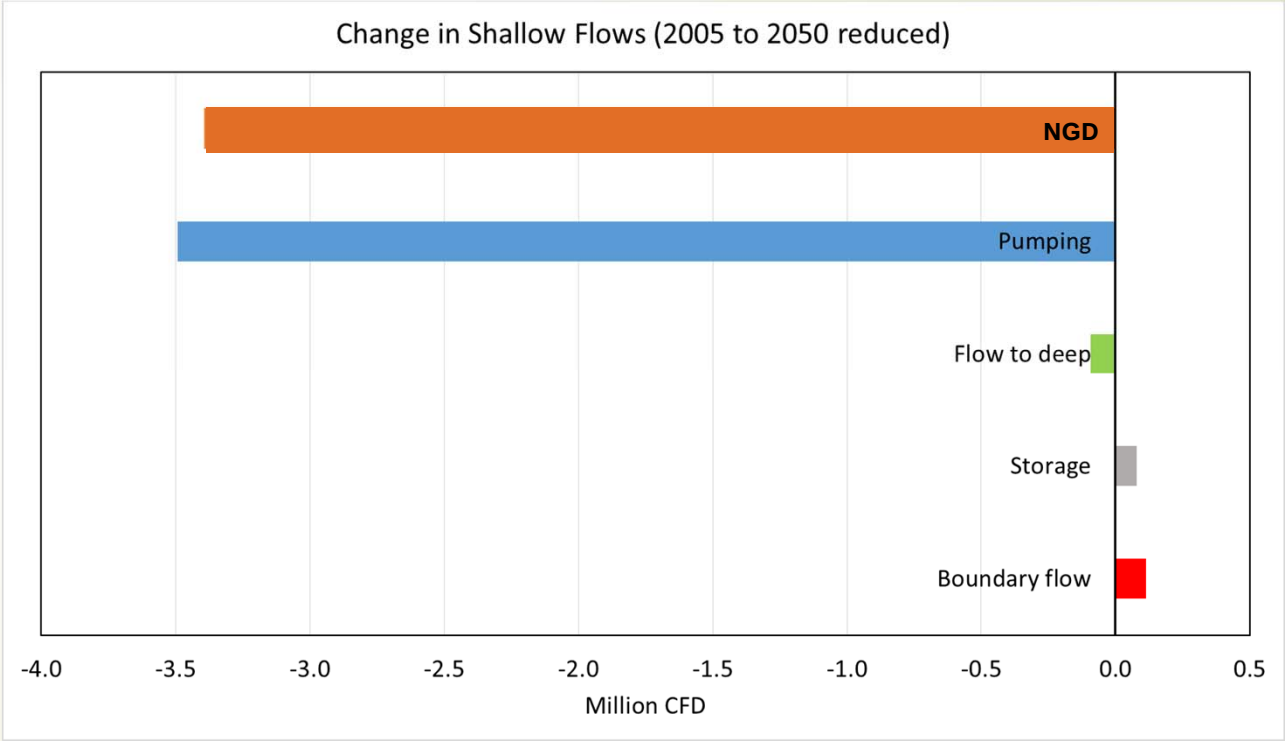


Change in leakage to the deep between 2005 and 2050 (colored areas represent zones where leakage to the deep increased)



Future reductions in NGD- 2050 Reduced

- Flow to the deep is less in 2050 than in 2005 for the Fox River Watershed
  - Reduction in natural groundwater discharge is less than pumping in the shallow



So how much water is available?

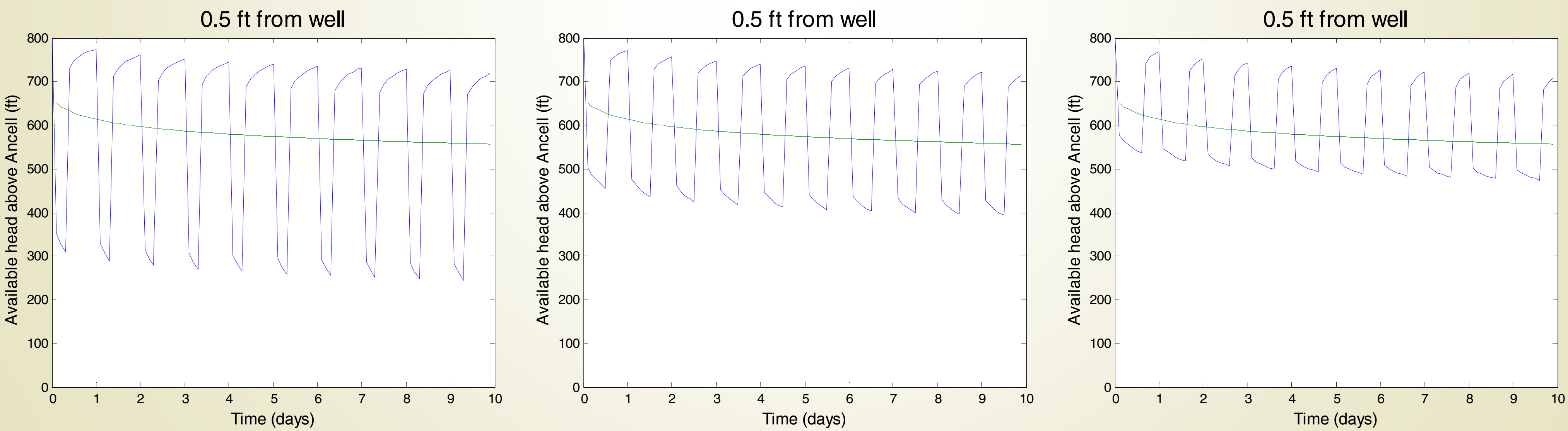
- In the deep:
  - The available water for deep pumping is contingent on the leakage from the shallow to deep aquifer
    - Leakage is contingent on pumping in the deep
  - Do we have to maintain saturation in all deep aquifers at every location at all times?
- In the shallow:
  - Reduction of natural groundwater discharge is contingent on pumping in both the shallow and the deep aquifers
  - What criterion will we use?
    - What percentage reduction is acceptable?
    - What is our “initial condition”: pre-pumping, present day, or other?
  - Low flow = effluent + natural groundwater discharge
    - Do we accept increases in effluent as a replacement for reductions in natural groundwater discharge

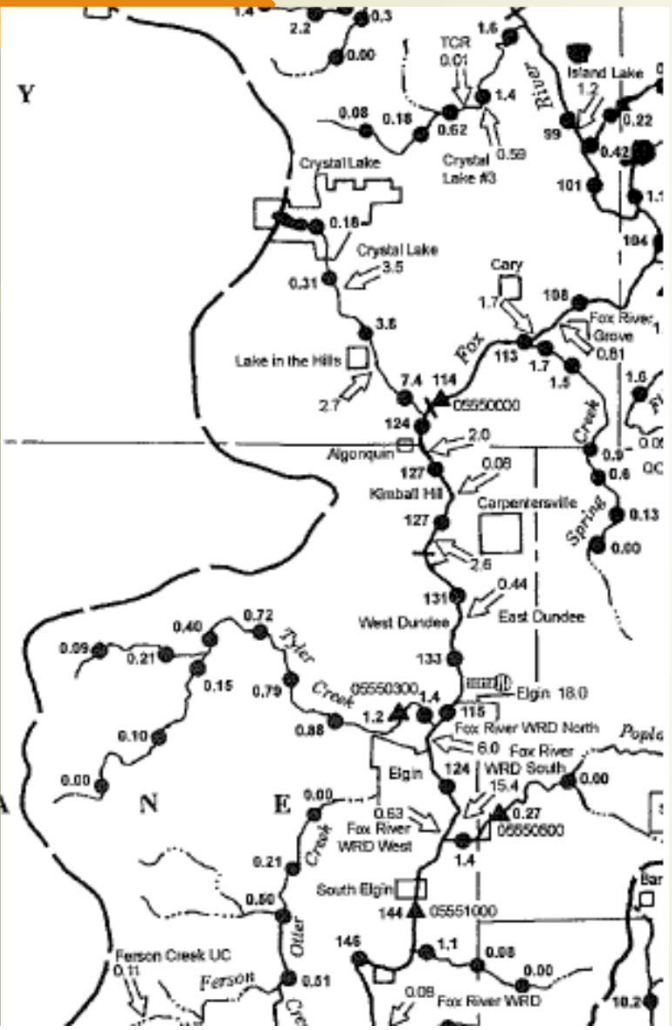
ISWS models

- Better spatial representation of the entire NWPA
  - Combine Kane, Kendall, and McHenry models
- Better understanding of future pumping plans
- Investigate interformational transfers via boreholes
- Improve estimates of recharge rates through time
- Improve temporal resolution
  - Changes in the daily pumping cycle
- Improve on understanding of the influence of effluent (necessary for model calibration to base flows)

Caveat: Pumping cycles

- Our model assumes an average pumping rate over a time interval of 1-5 years
  - Daily cycles in pumping will impact the local drawdowns
  - These local drawdowns will be more severe in confined aquifers such as the Ancell
- Hypothetical simulation: Each well pumps an average of 133,000 cfd
  - Scenario 1- pump for 1/3 of the day at a rate of 400,000 cfd
  - Scenario 2- pump for 1/2 of the day at a rate of 267,000 cfd
  - Scenario 3- pump for 2/3 of the day at a rate of 200,000 cfd

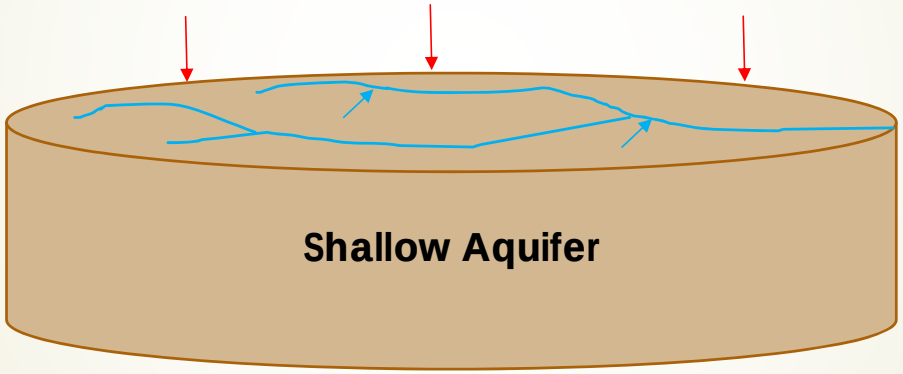




Unresolved issue regarding NGD

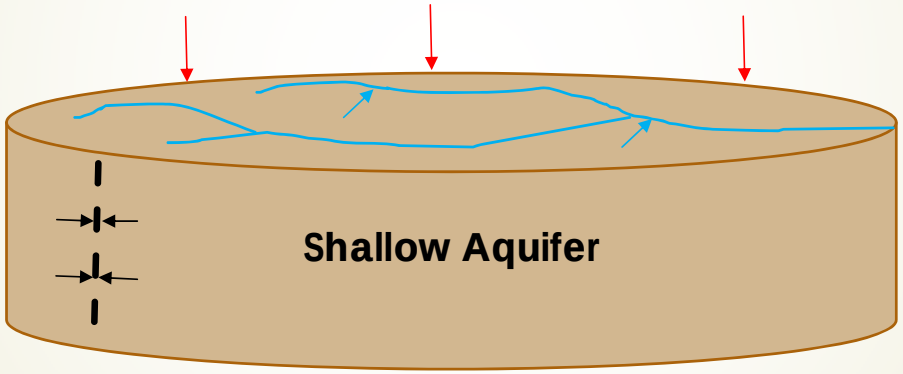
- Complication: Low flow (base flow) is not equivalent to natural groundwater discharge in the Fox River Watershed
  - Shallow pumping has reduced natural groundwater discharge
  - Effluent discharges have increased
  - Low flow is a combination of groundwater and effluent
    - Hence, low flows (base flows) have not decreased in many of the NWPA watersheds, although natural groundwater discharge has

Shallow pumping: pre-development



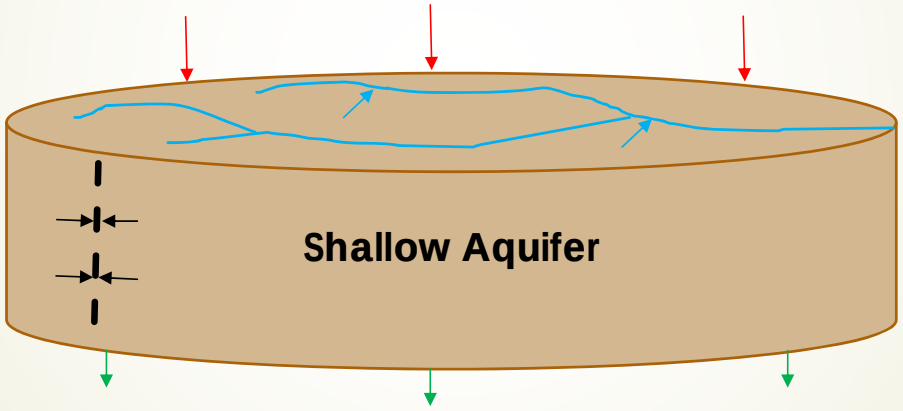
Natural Groundwater Discharge = Recharge

Shallow pumping: current



Natural Groundwater Discharge = Recharge - Pumping

Shallow pumping: current

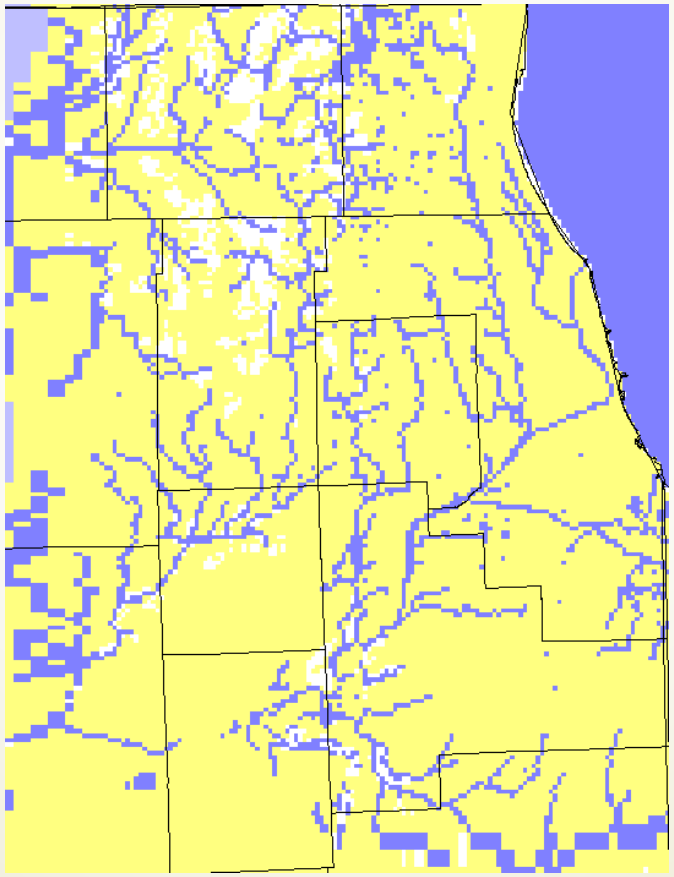


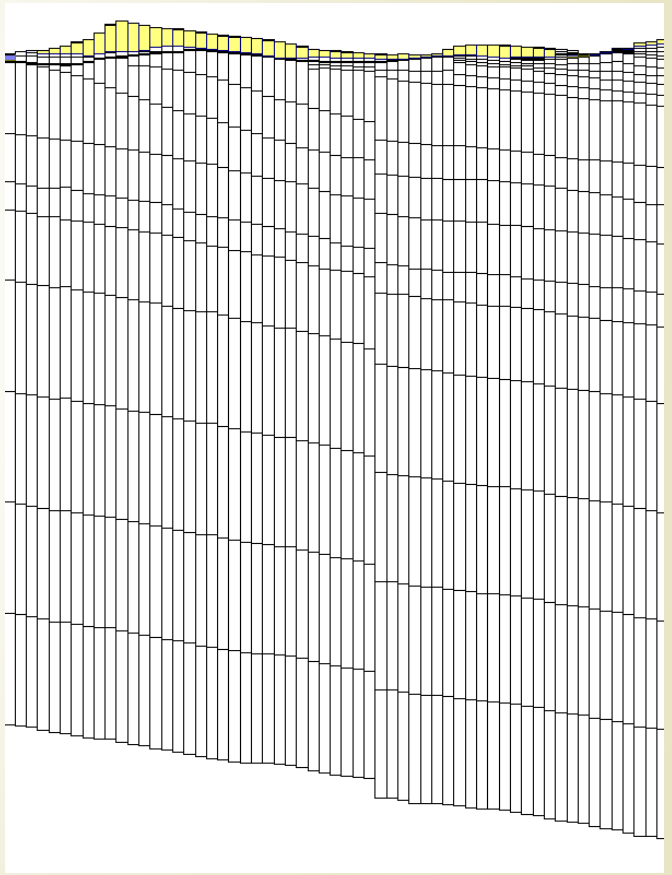
Natural Groundwater Discharge = Recharge – Pumping – Flow to the deep
+ Water from storage

Groundwater Flow Model

MODFLOW

- MODFLOW is a finite difference model developed by the USGS.
- Used to simulate groundwater heads and the groundwater contribution to streams.





Shallow vs. Deep Aquifer Systems

MODFLOW model layers

- "Shallow" aquifer consists of everything from the Galena-Platteville up (blue area)
- "Deep" aquifer consists of everything from the Ancell Unit down (orange area)

	HYDROSTRATIGRAPHIC UNIT	MODEL LAYER
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	Eau Claire Unit	22
	Mt. Simon Unit	23
		24
		25
		26

Implications

- From pre-development to 2005, there was a 14% reduction of natural groundwater discharge in the Fox River Watershed (north of the Sandwich Fault in Kendall County)
- If pumping continues per baseline, in 2050, NGD will be reduced by 8.3% from 2005 rates

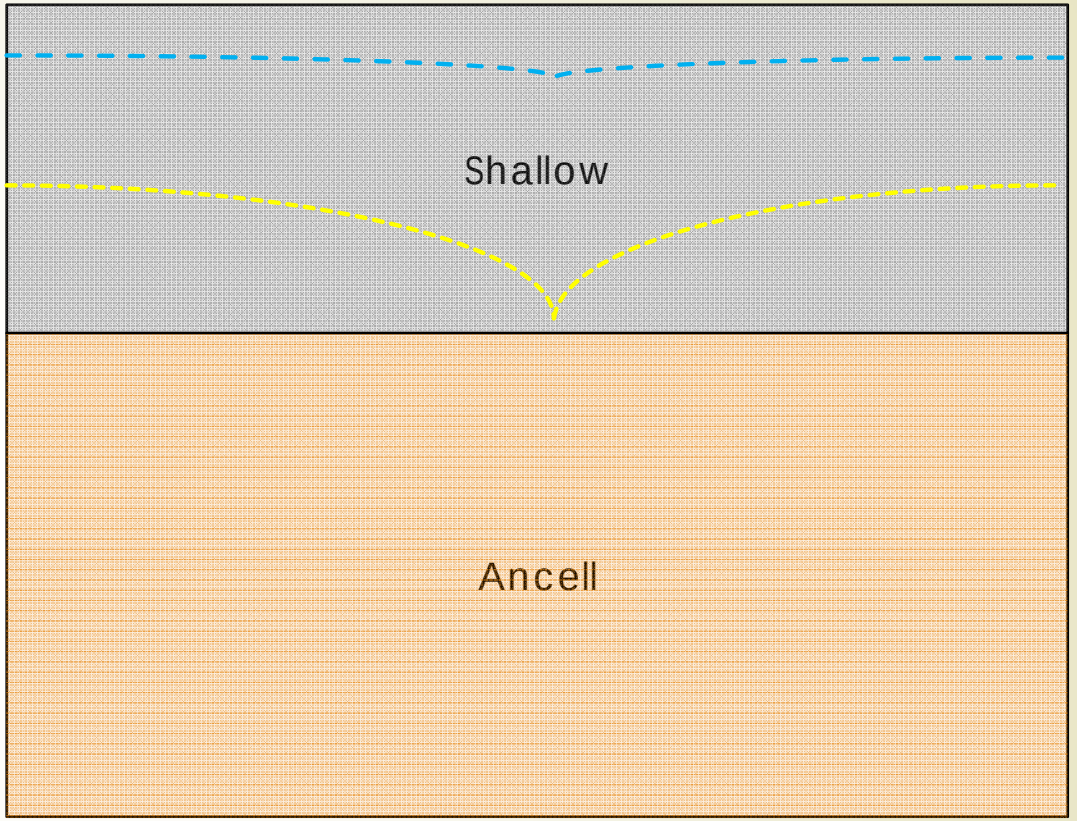
- Caveat: We are currently improving our estimates of natural groundwater discharge, which may change the above values

- What issues are coming out of the model results
  - What can we do today and in the near future?
  - What information do we need to improve our models?

Best estimate of available water

1 Available head in the deep aquifers

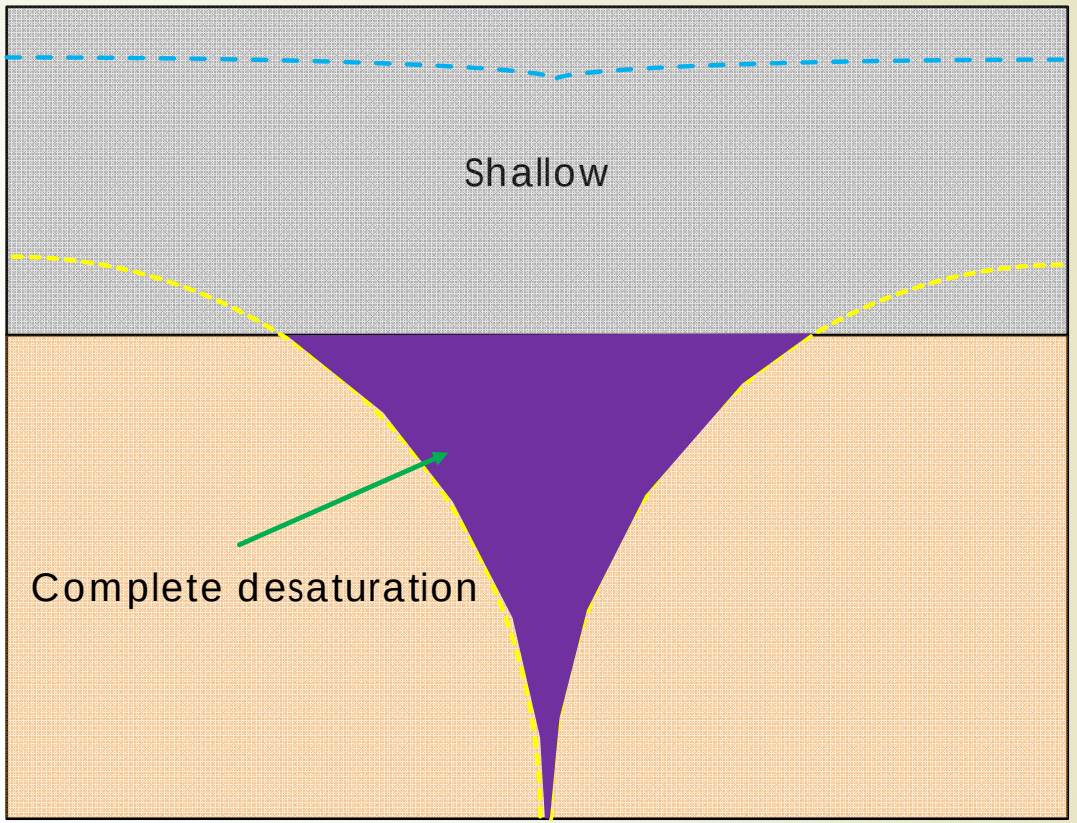
How much pumping can occur given the 2005 well configuration to maintain saturation above the Ancell Unit?



What is the issue?

Complete Desaturation

- All wells pumped dry locally
- Desaturation of the Ancell may extend beyond political boundaries.



How to prevent partial desaturation in the future?

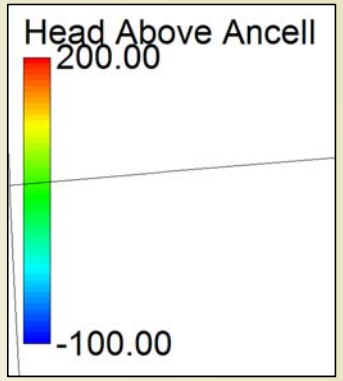
Reductions in pumping from 2005 rates

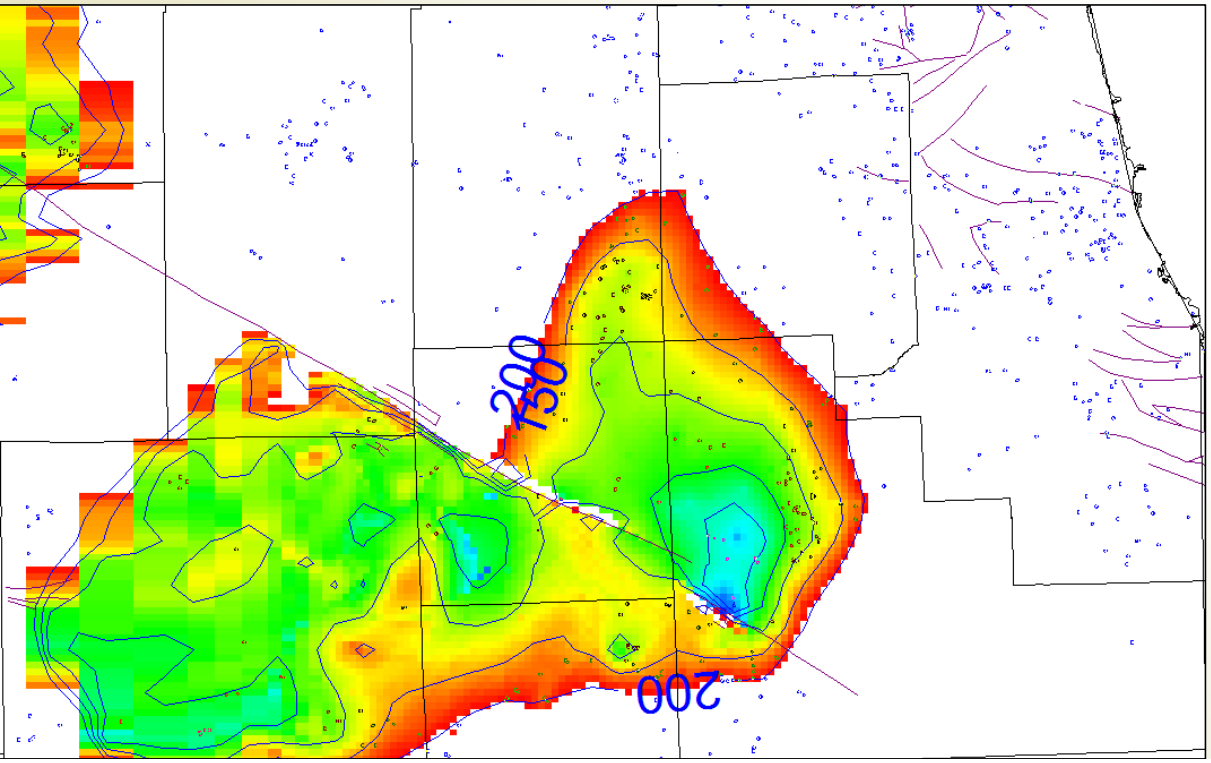
Pumping rates in the model will be reduced linearly to some percentage of 2005 rates.

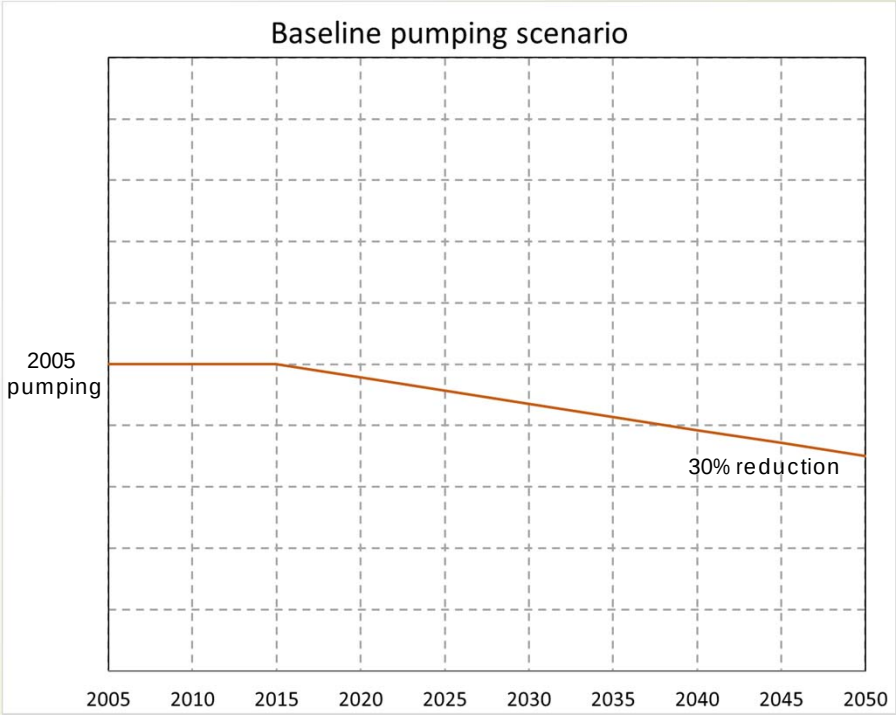
First, reductions will be everywhere, then only for portion of the model.

Available head above the Ancell in 2050

3 Reduce pumping in all wells

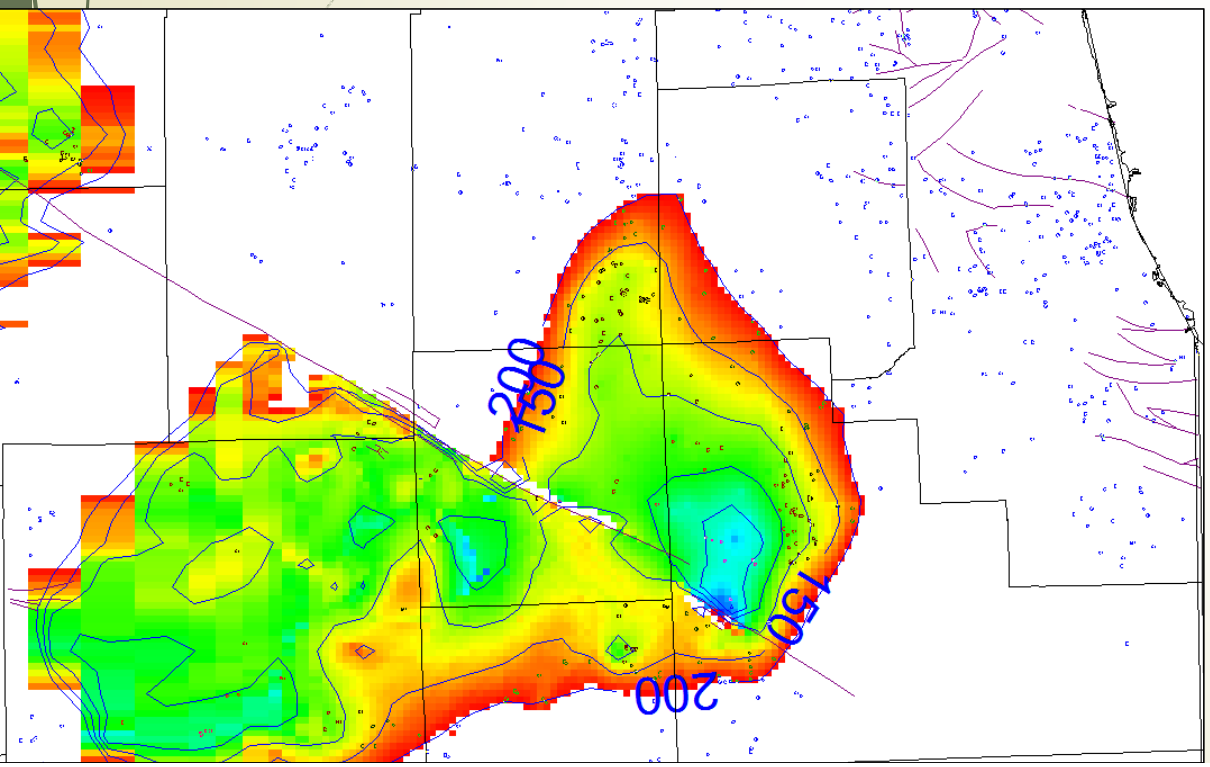


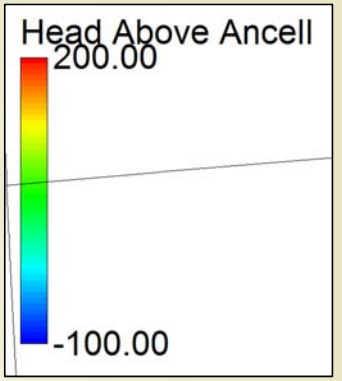


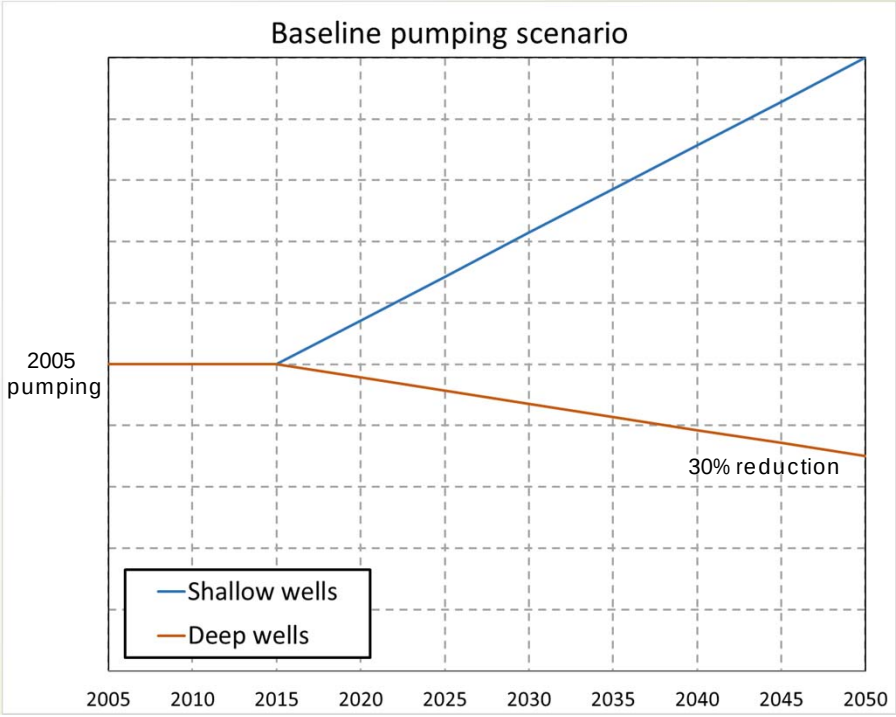


Available head above the Ancell in 2050

4 Reduce pumping in deep wells

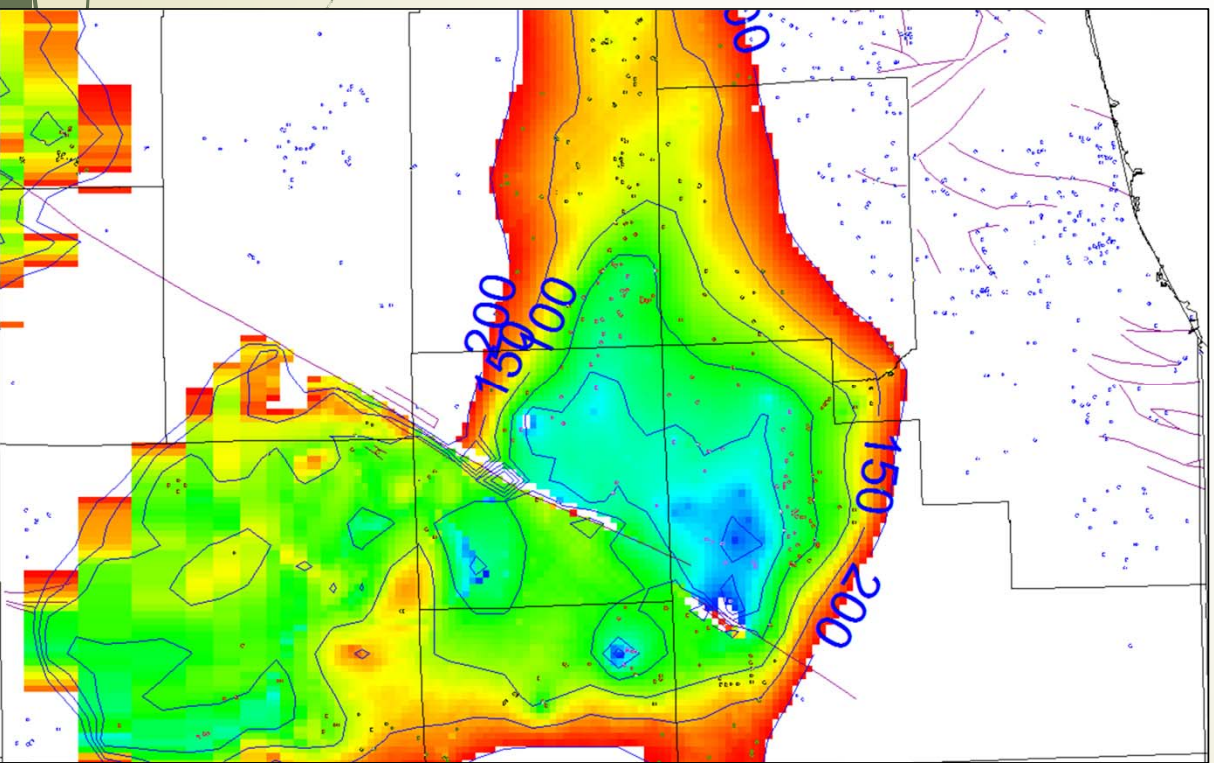


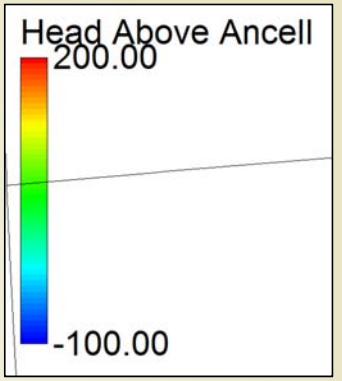


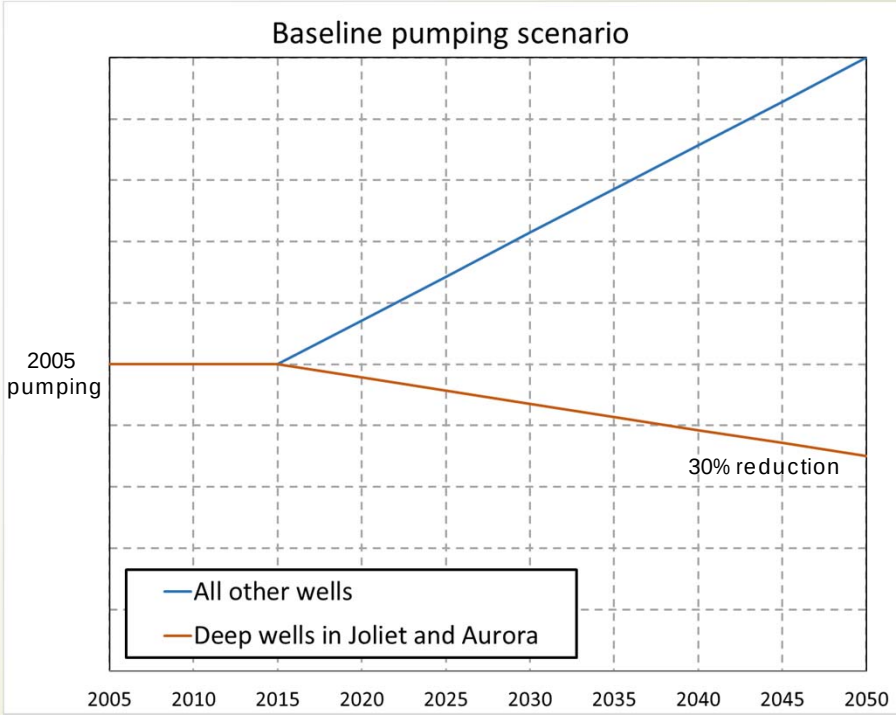


Available head above the Ancell in 2050

5 Reduce pumping in Joliet and Aurora

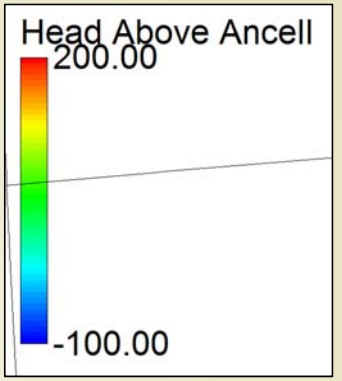


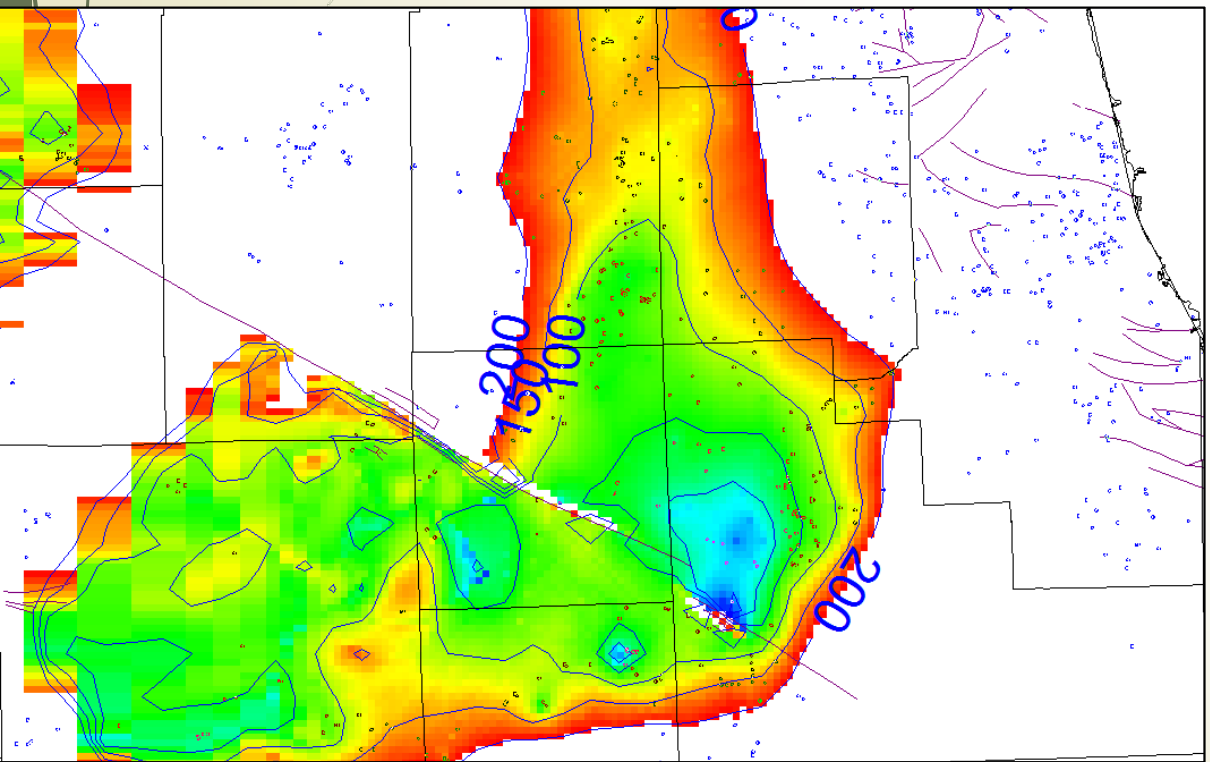


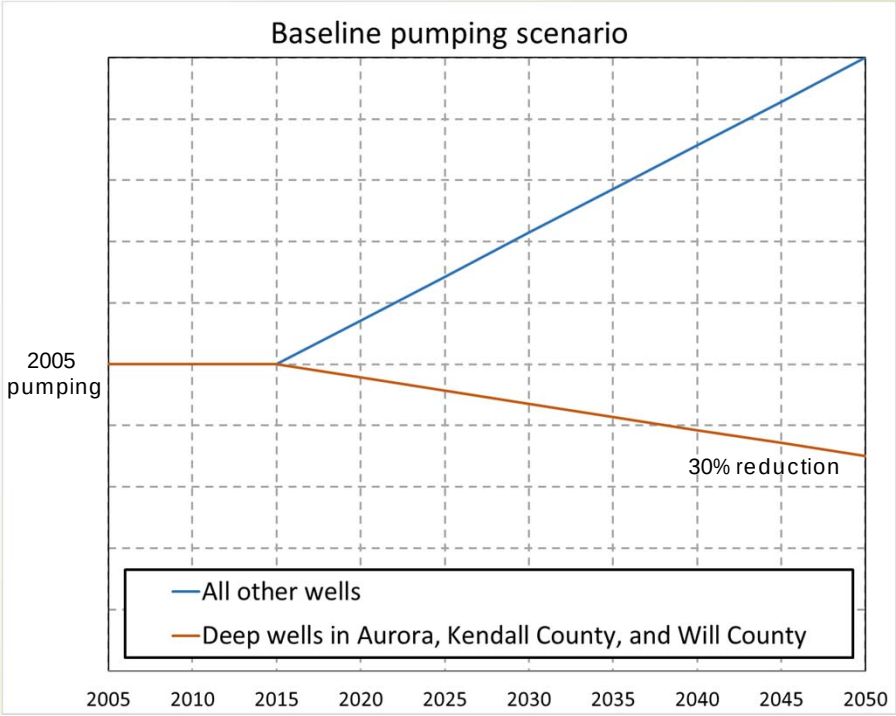


Available head above the Ancell in 2050

6 Reduce pumping in Aurora, Kendall County, and Will County



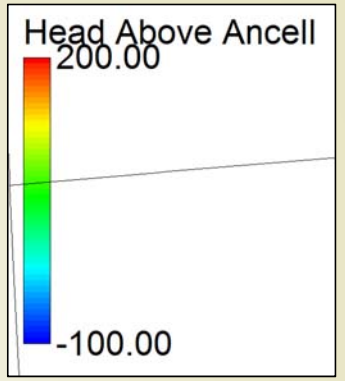


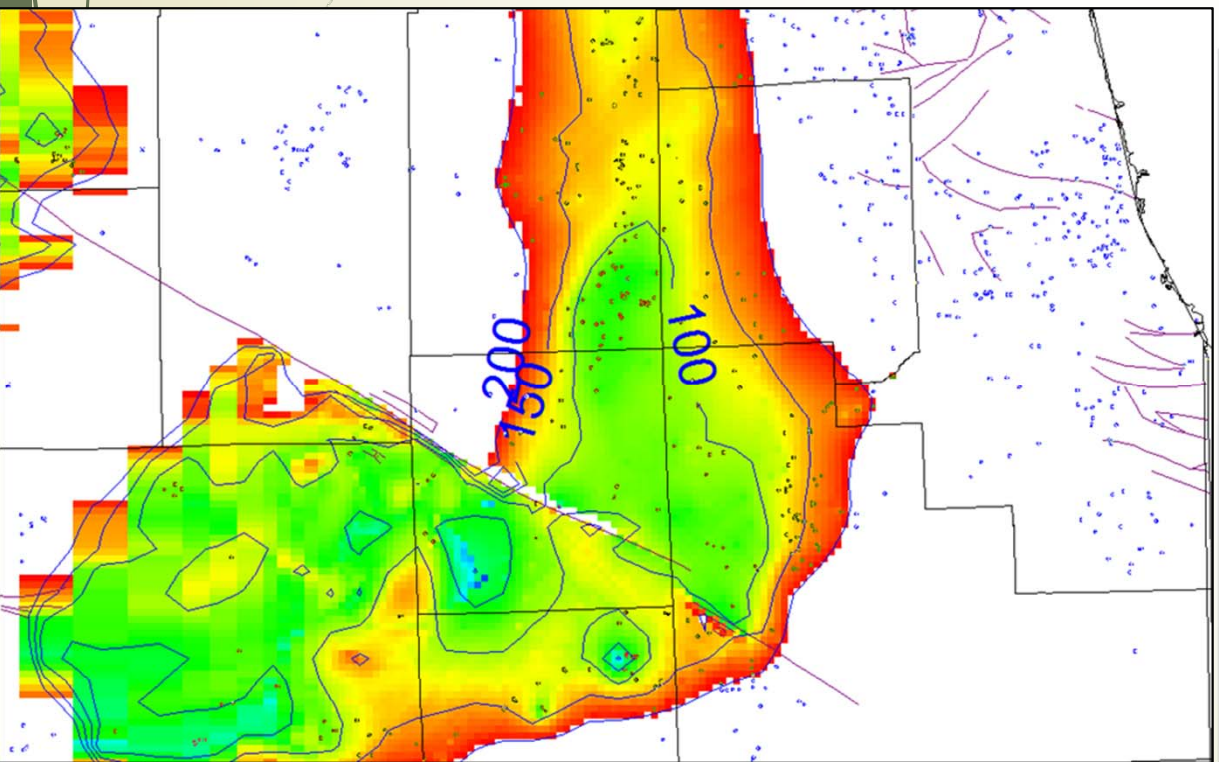


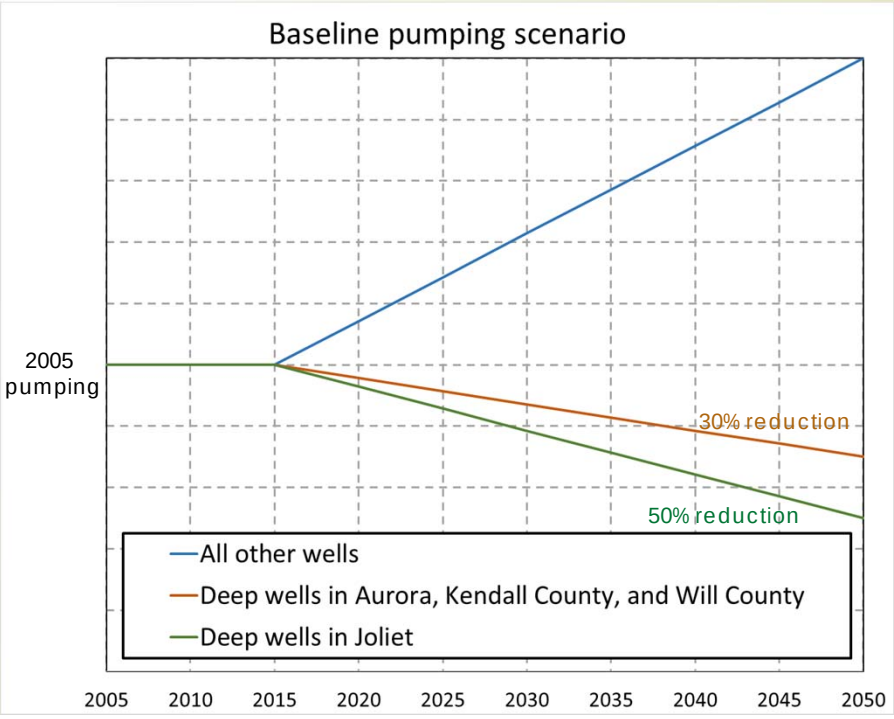
Available head above the Ancell in 2050

8

Reduce pumping in Aurora, Kendall County, and Will County;
Reduce pumping further in Joliet
Run to steady state



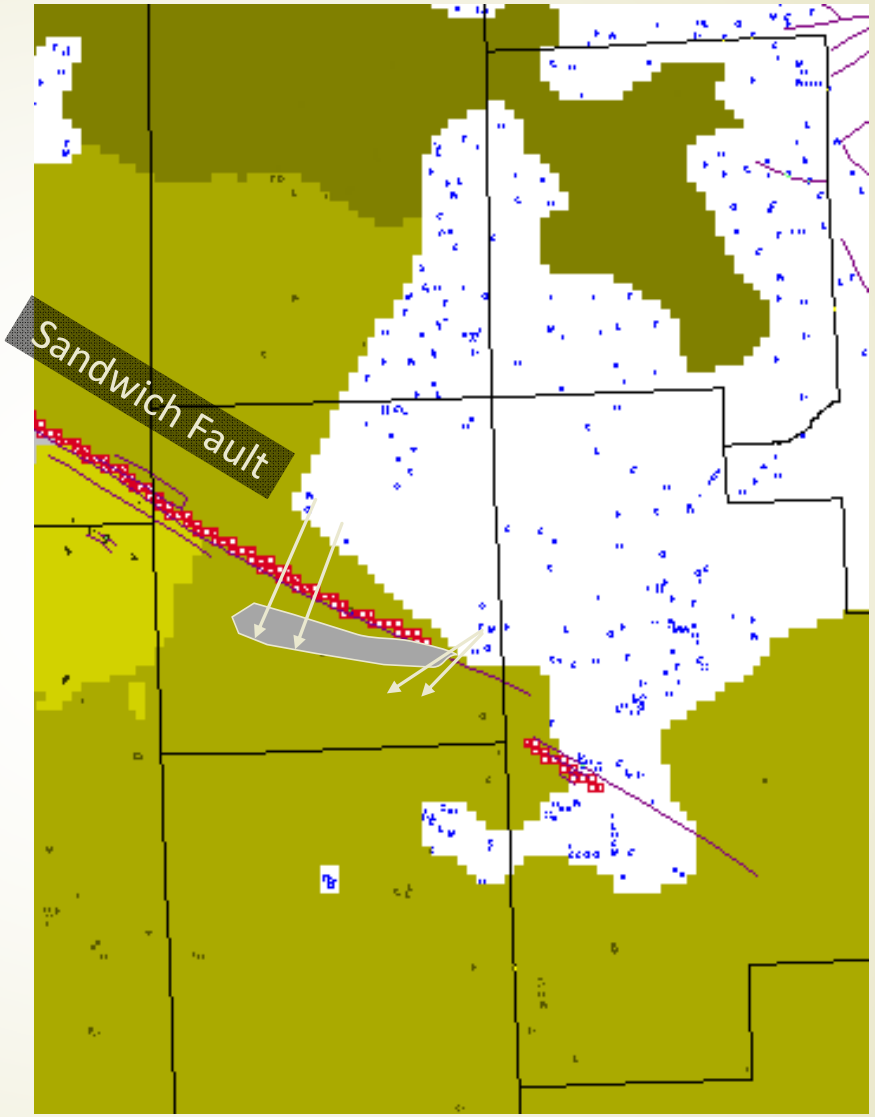




Scenario With Moved Yorkville and Joliet Wells

Expanded interconnection between the Ancell and Ironton- Galesville Sandstones

Blue dots represent deep wells



Groundwater Levels at Yorkville