US EPA ARCHIVE DOCUMENT

Protecting Drinking Water by Reducing Uncertainties Associated with Geologic Carbon Sequestration in Deep Saline Aquifers

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Objective & Tasks

* Objective: We seek to protect groundwater quality by reducing hydrologic and geochemical uncertainties associated with geologic carbon sequestration in deep, saline reservoirs.

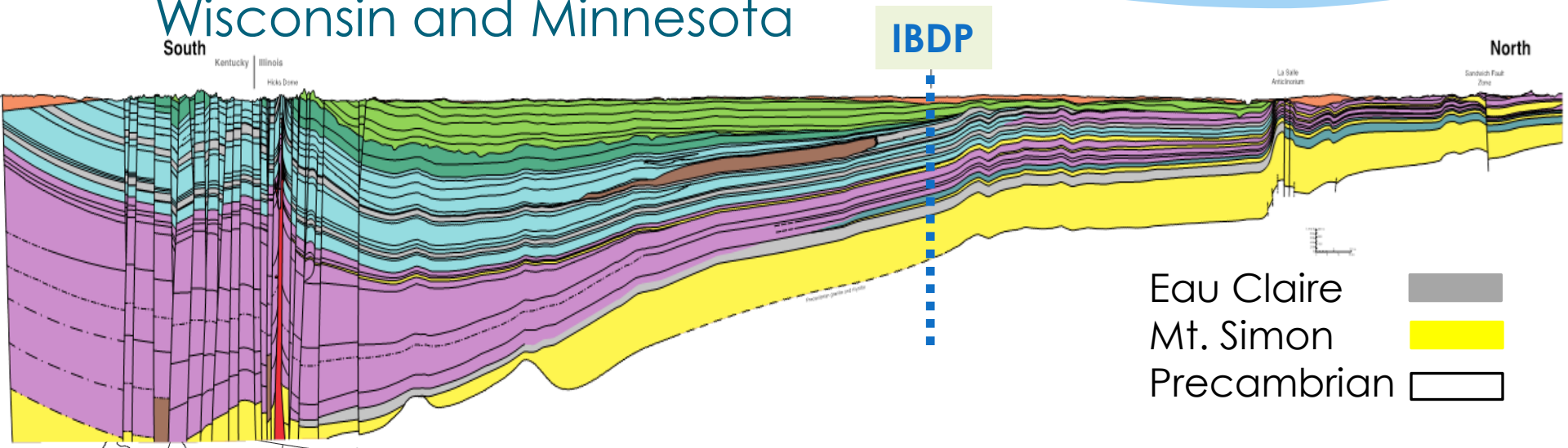
* Task 1: Data mining at natural gas storage sites (Mehnert)
* Task 2: Vertical pressure profiles for monitoring CO_2 and brine migration: research and validation of the Westbay system (Benson)
* Task 3: Enhancement of regional flow and transport models to reduce risk (Lin & Ray)
* Task 4: Geochemical Investigations (Roy, Berger & others)
* Task 5: Saline groundwater discharge from the Illinois Basin (Panno)

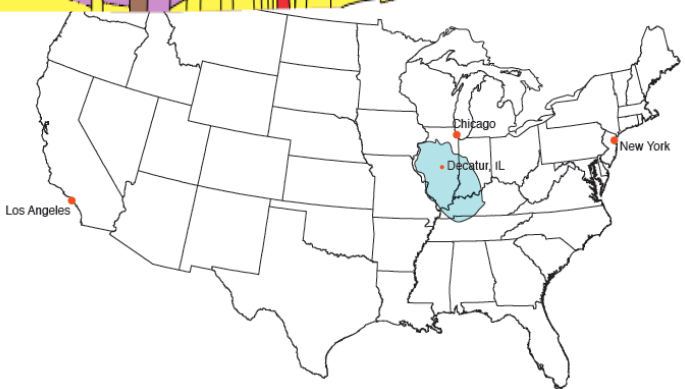
Background

* Mt. Simon Sandstone
  * Deep saline aquifer suitable for GCS
  * GCS feasibility evaluated by 2 USDOE Regional Partnerships (MGSC & MRGSC)

Background/ Mt. Simon Sandstone

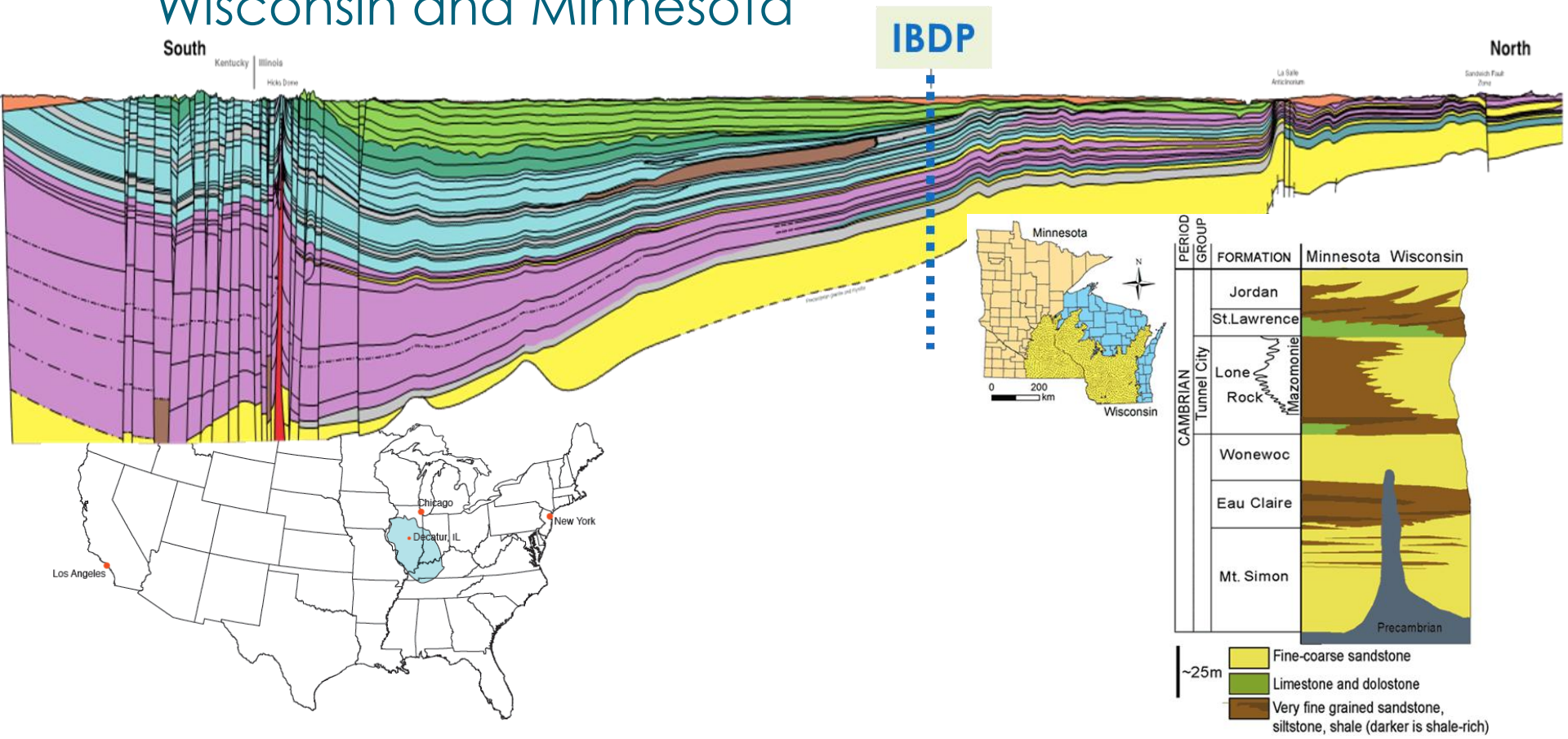
* Open reservoir with drinking water resources in Wisconsin and Minnesota





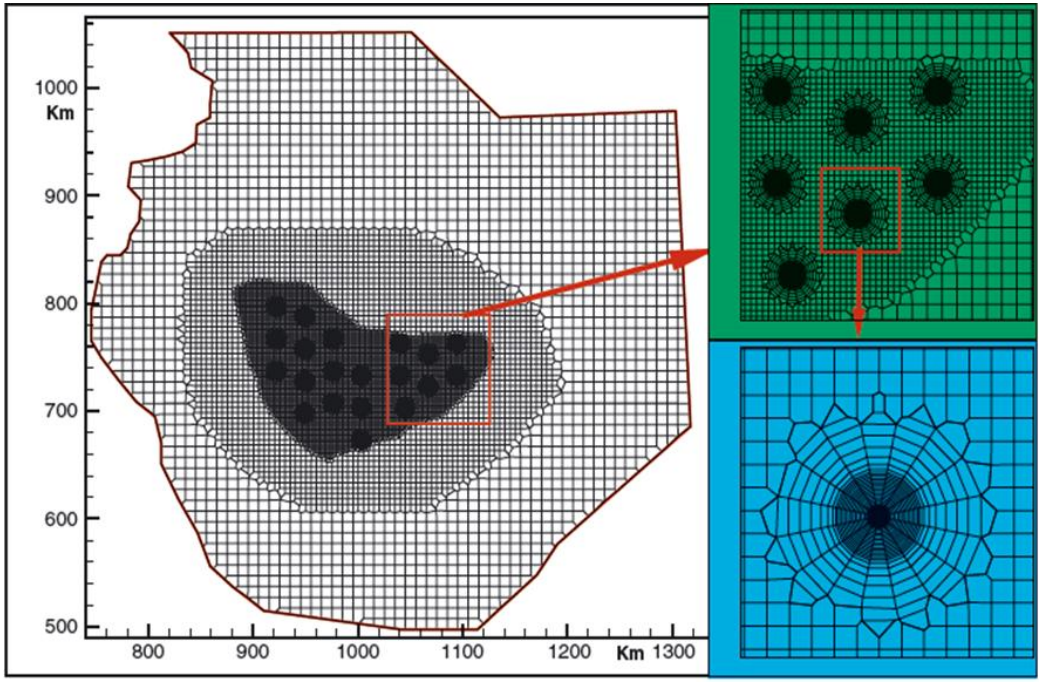
Background/ Mt. Simon Sandstone

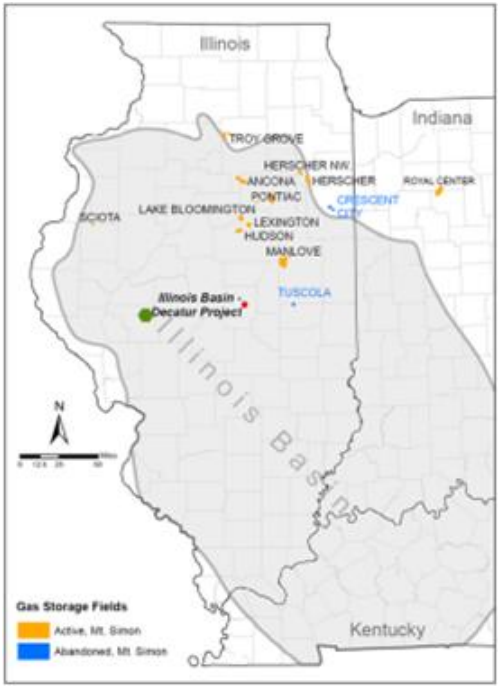
* Open reservoir with drinking water resources in Wisconsin and Minnesota



Background/ Mt. Simon

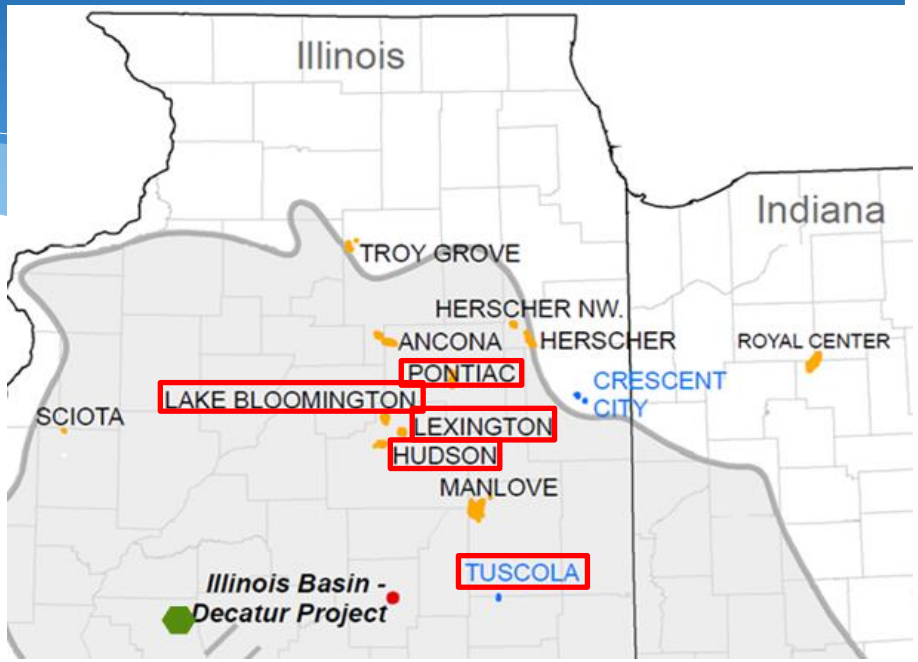
* Mt. Simon Sandstone
  * Basin-scale modeling to evaluate possible commercial scale development (TOUGH2-MP)
  * Used for natural gas storage since late 1950s
    (Herscher and Troy Grove opened in 1958)





Task 1: Data Mining at Natural Gas Storage Sites

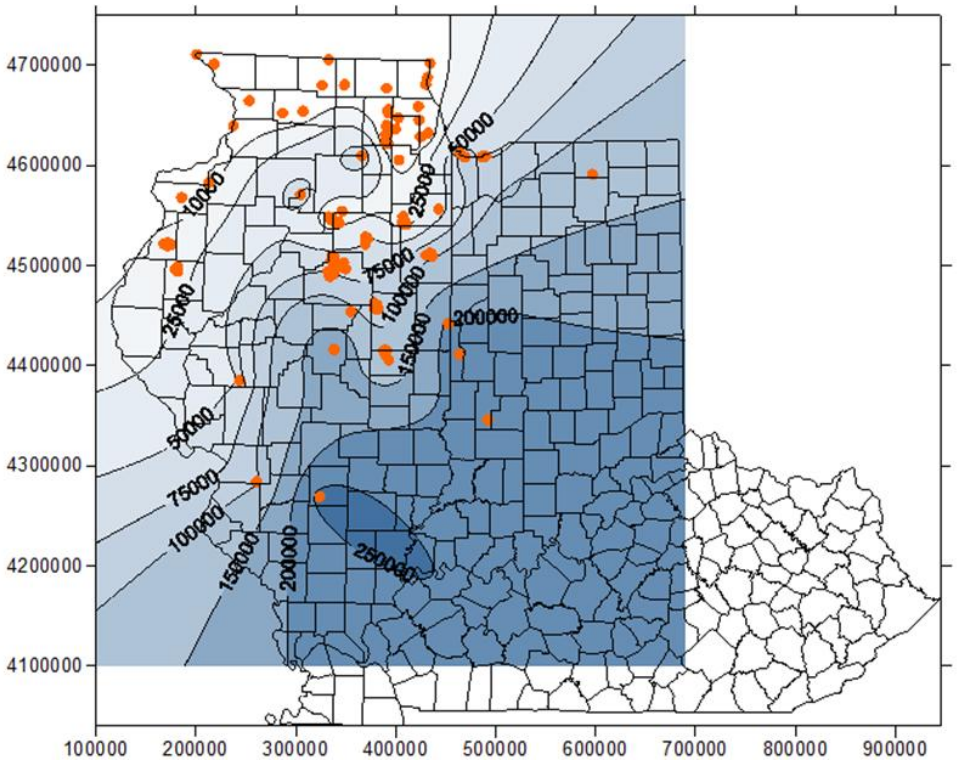
- Data mining
  - Emphasize porosity and permeability data, aquifer tests, static pressure data, geochemical data, & saturation data
- Past year (red boxes)
  - 4,043 porosity & perm values from core data
  - 5 aquifer tests compiled and analyzed.
  - Hudson test– >2,500 ft of drawdown in pumped well

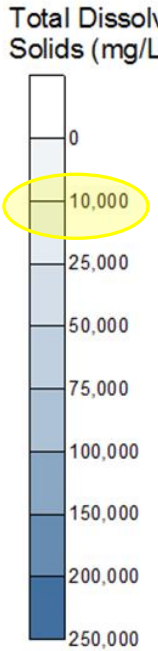


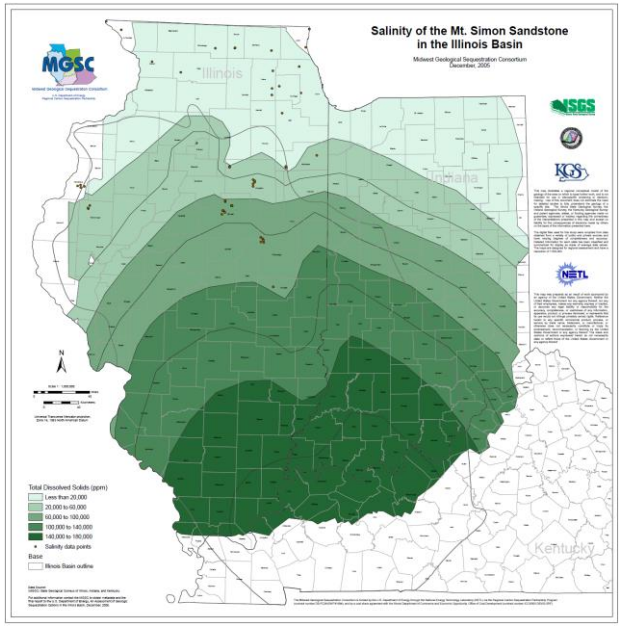
Field	Test duration (days)	Pumping rate (gpm)	Formations monitored		
			Mt. Simon	Eau Claire	Galesville
Hudson	19	55	X	X	x
Lake Bloomington	8	84	X	X	X
Lexington	2	10	X		X
Pontiac	41	45	X		
Tuscola	50	105	x	X	

Task 1: Data Mining at Natural Gas Storage Sites

* Developed new TDS map to replace 2005 map (right)
  * 163 vs 55 data points, better geographic distribution, better IC







Task 1: Data Mining at Natural Gas Storage Sites

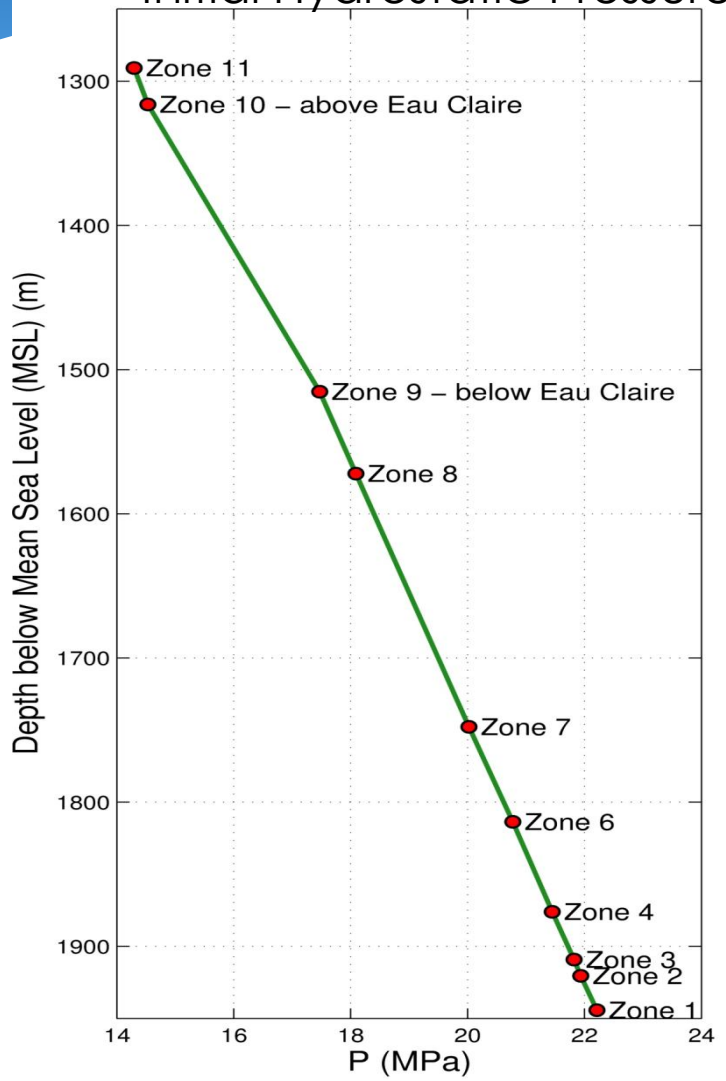
* Developed a list of 66 Mt. Simon wells
  * Most are public or industrial supply wells
  * Date back to 1891
  * If improperly plugged could be conduits for higher TDS water

Task 2: Vertical pressure profiles

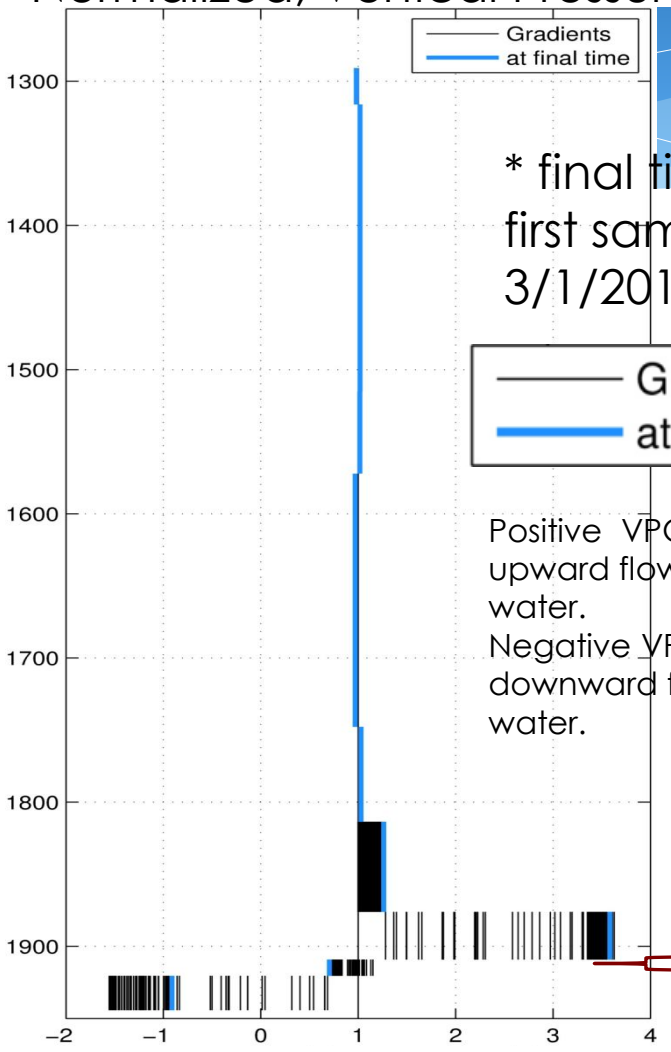
* Objective: evaluate leakage detection strategies using pressure data in overlying aquifer
* Develop pressure monitoring methods and protocals using modeling results and field data (Westbay system)
* Westbay system--
  * Deployed in verfication well at IBDP, 400 ft from CCS#1
  * Pressure monitoring and sampling ports at 9 depths in Mt. Simon (injection reservoir) and 2 depths in Ironton-Galesville (overyling aquifer), 4,917 to 7,061 ft

Task 2: Vertical Pressure Profiles

Initial Hydrostatic Pressure



Normalized, Vertical Pressure Gradients



* final time before first sampling on 3/1/2012

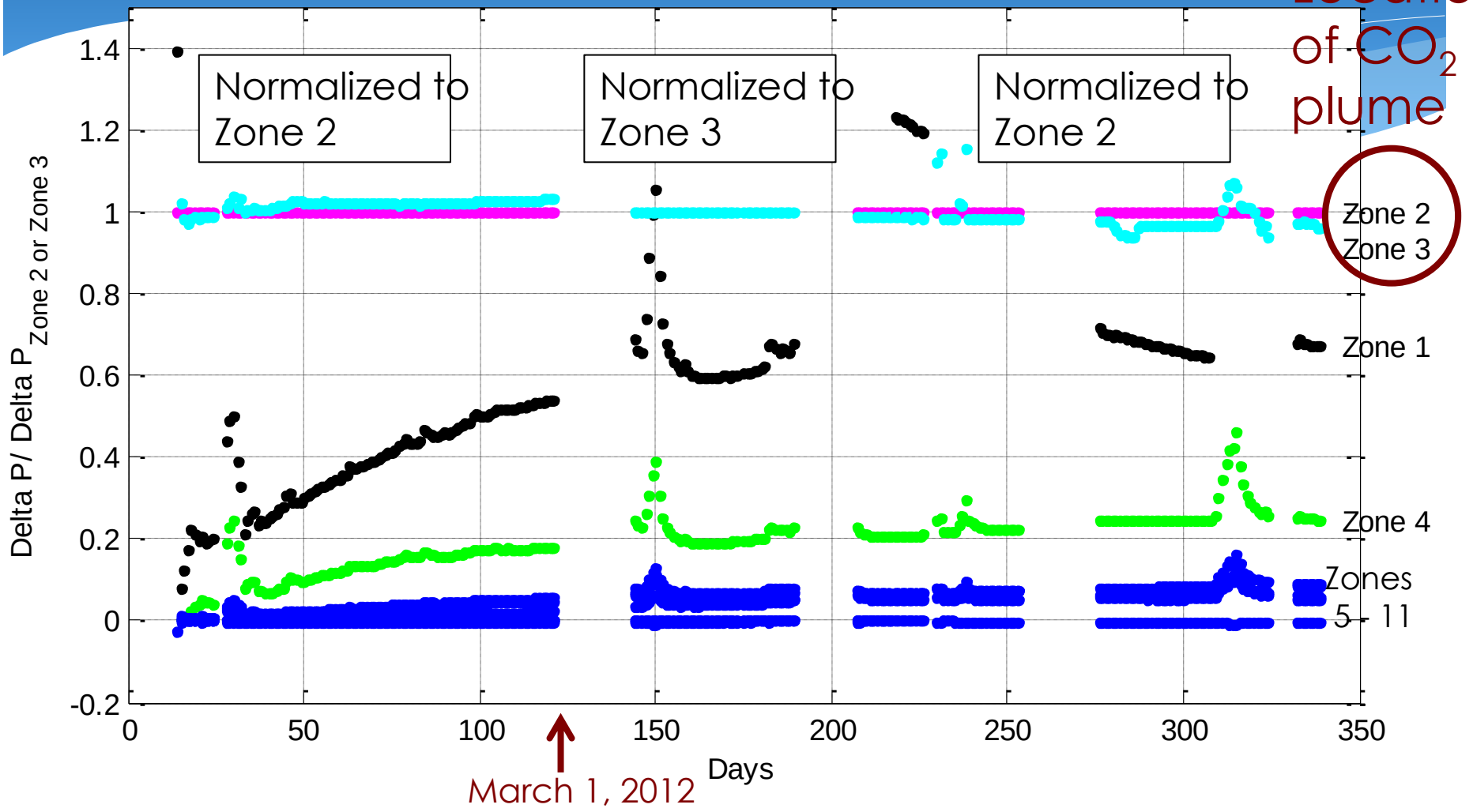
Gradients
at final time

Positive VPG indicates upward flow of displaced water.
Negative VPG indicates downward flow of displaced water.

CO_2 plume is here!

Normalized Pressure Buildup

(wrt injection zone pressure)

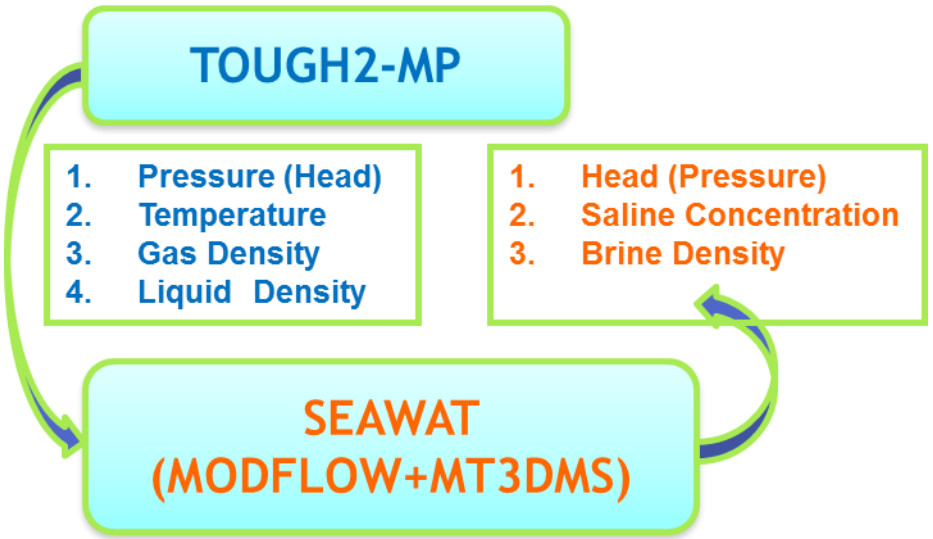


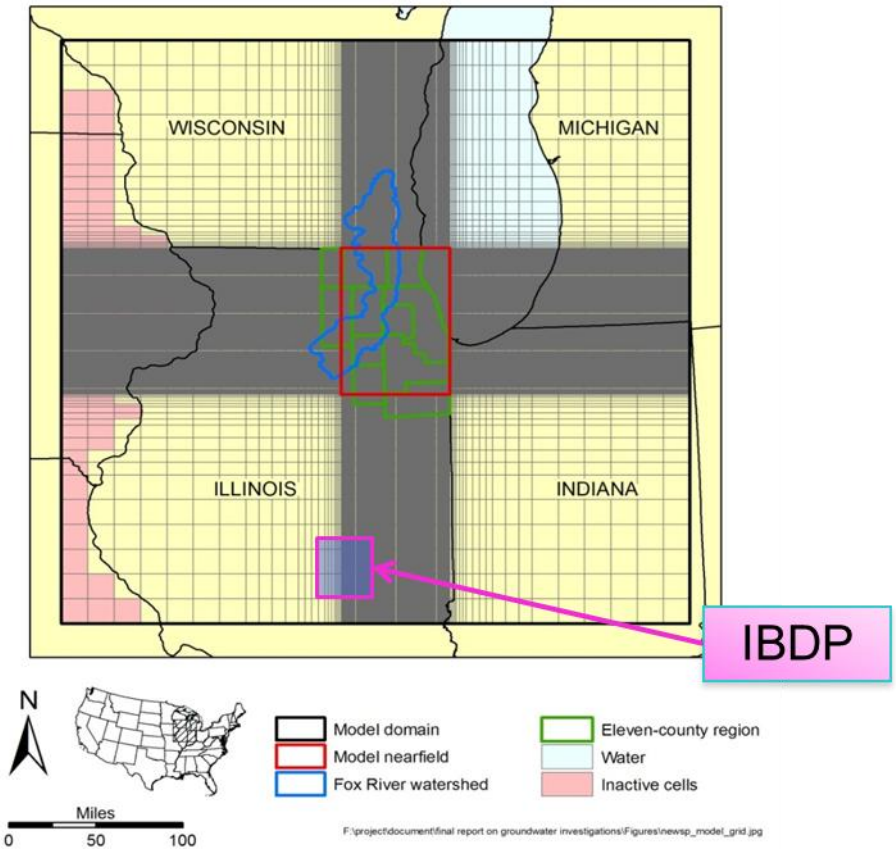
Task2 : IBDP Multilevel Pressure Data

- **Vertical pressure gradients:** Height of CO_2 plume has reached zone 3 but is below zone 4
- **Pressure buildup:** CO_2 is present in zones 2 & 3, but has not reached zone 4.
- **Sampling data:** consistent with these conclusions
- Multilevel pressure measurements alone are indicative of the height of the CO_2 plume, even before the plume reaches the monitoring well.

Task 3: Link & enhance models

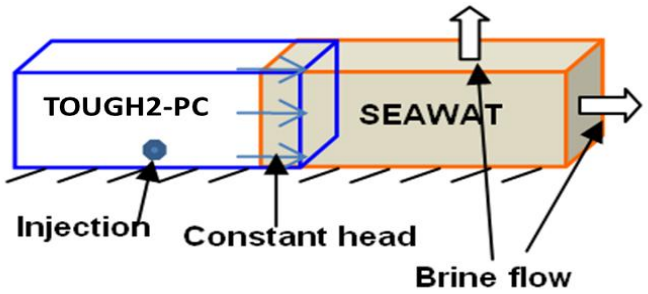
* link between ISWS Bedrock Aquifer model & ISGS GCS Basin-scale model

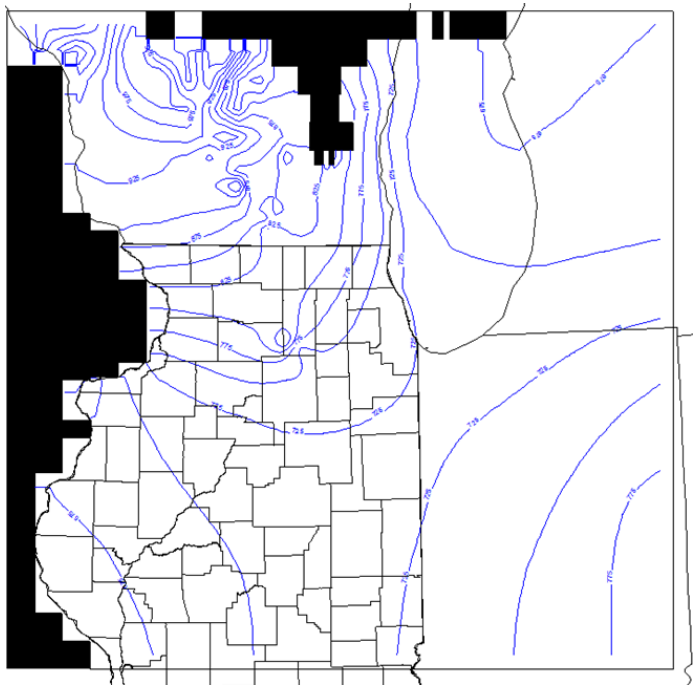




Task 3: Link & enhance models

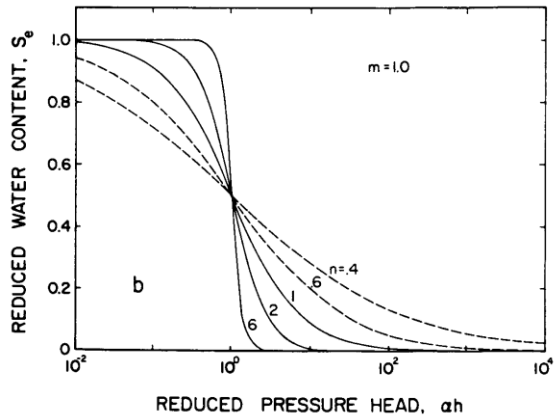
* Using basic TOUGH2 model
  * Includes 3 layers– Mt. Simon, Eau Claire & Ironton-Galesville
  * Single injection well
* Data passed to SEAWAT using Python scripts
* Future improvements
  * Better IC for pressure & TDS
  * More realistic grid for TOUGH2
  * Automate linking





Task 3: Link & enhance models

* Literature review of van Genuchten (1980) saturation/relative permeability
* Confirmed it to be a fitting technique, no assumptions to restrict its use for rock
* Compiled parameter estimates for sandstones



$$S_e = \frac{1}{[1 + (\alpha h)^n]^m}$$

$$S_e = \frac{S_l - Slr}{S_{ls} - Slr}$$

Acknowledgments

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