Mitchell CarbonSAFE

DOE Project Number DE-FE0032268

Nate Grigsby- PI

Nathan Webb and Sherilyn Williams-Stroud- CoPIs

ILLINOIS
Illinois State Geological Survey
PRAIRIE RESEARCH INSTITUTE

U.S. Department of Energy

Fossil Energy and Carbon Management and National Energy Technology Laboratory

Carbon Management Research Project Review Meeting

Monday August 5th; 2024, 1:25 PM

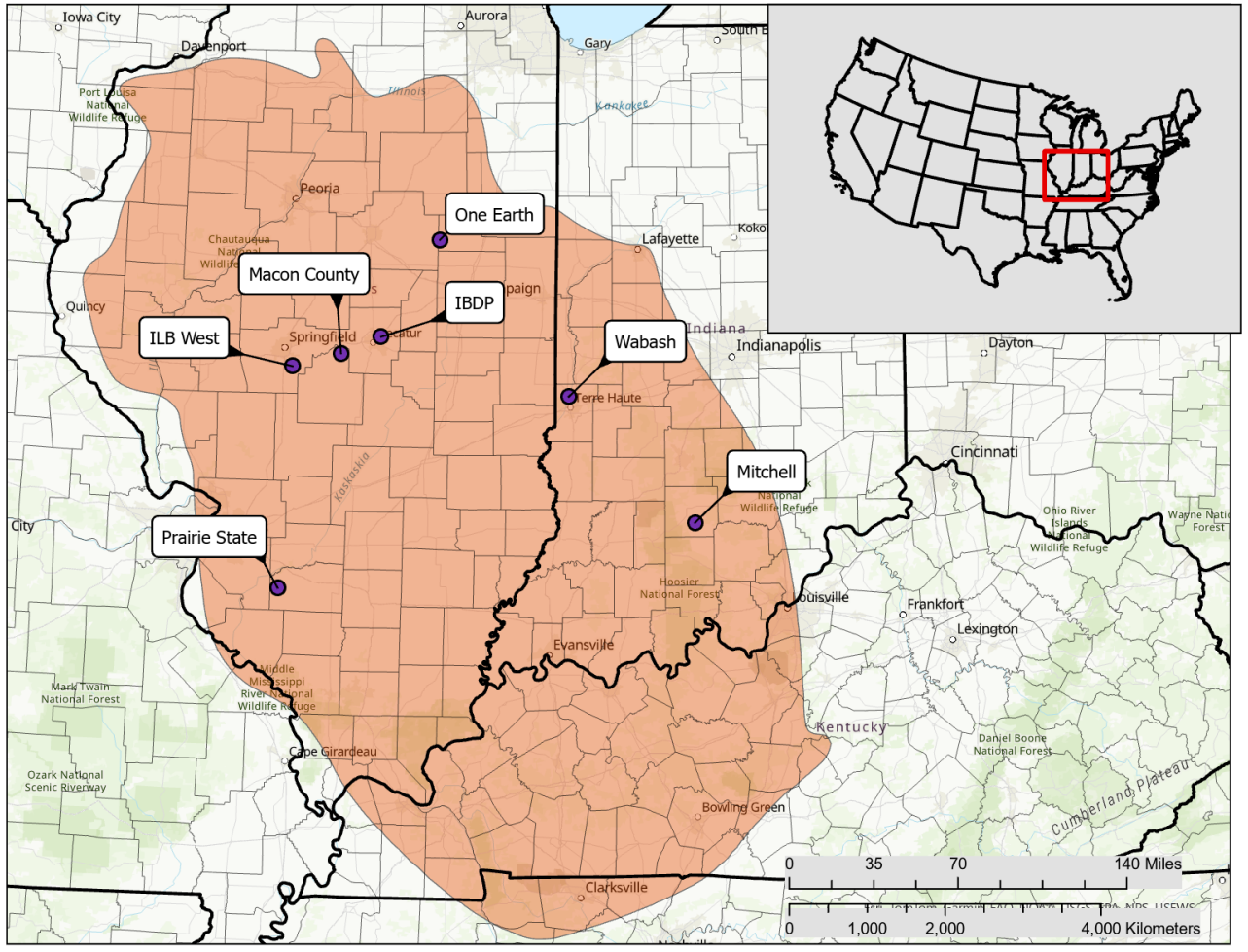
Acknowledgements

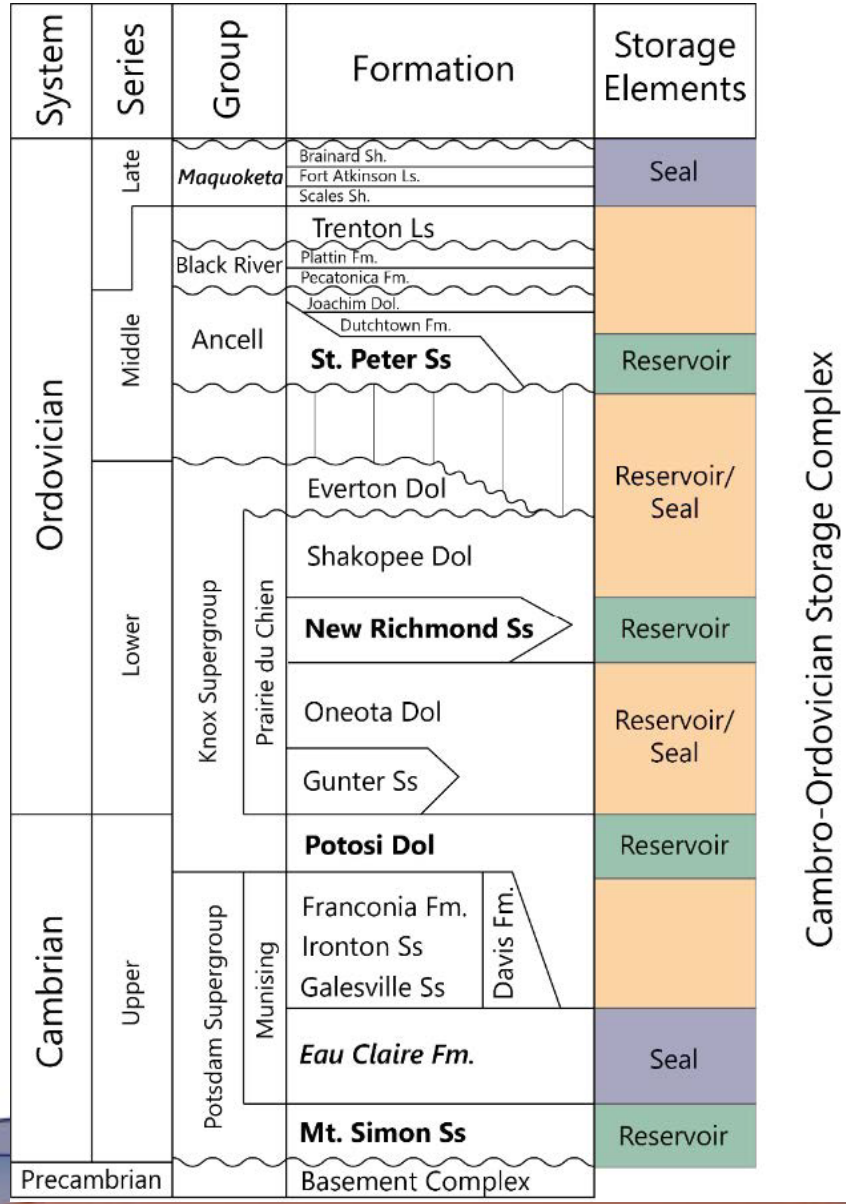
- This material is based on work supported by the Department of Energy Award Number DE-FE0032268
- Through a university grant program, IHS Petra and SLB Techlog software were used for the mapping and well log analysis work presented herein.

Background: CO_2 Source

- Cement production accounts for ~8% of global CO_2 emissions
- Heidelberg Materials' Beyond 2020 Strategy
  - 2030: Reduce CO_2 to 50% of 1990 emissions
  - 2050: Net zero
- Mitchell Cement Plant
  - Established in 1897
  - $650M upgrade complete on June 15th 2023
  - 2nd largest in North America
- Projects selected for DOE awards
  - FE0032222---FECM FEED study: 2-2.6 Mt CO_2/year
  - FE0032268---CarbonSAFE Phase II (this study)
  - CD0000009---OCED CCS Demonstration project: Capture/transport FEED, Class VI Permit

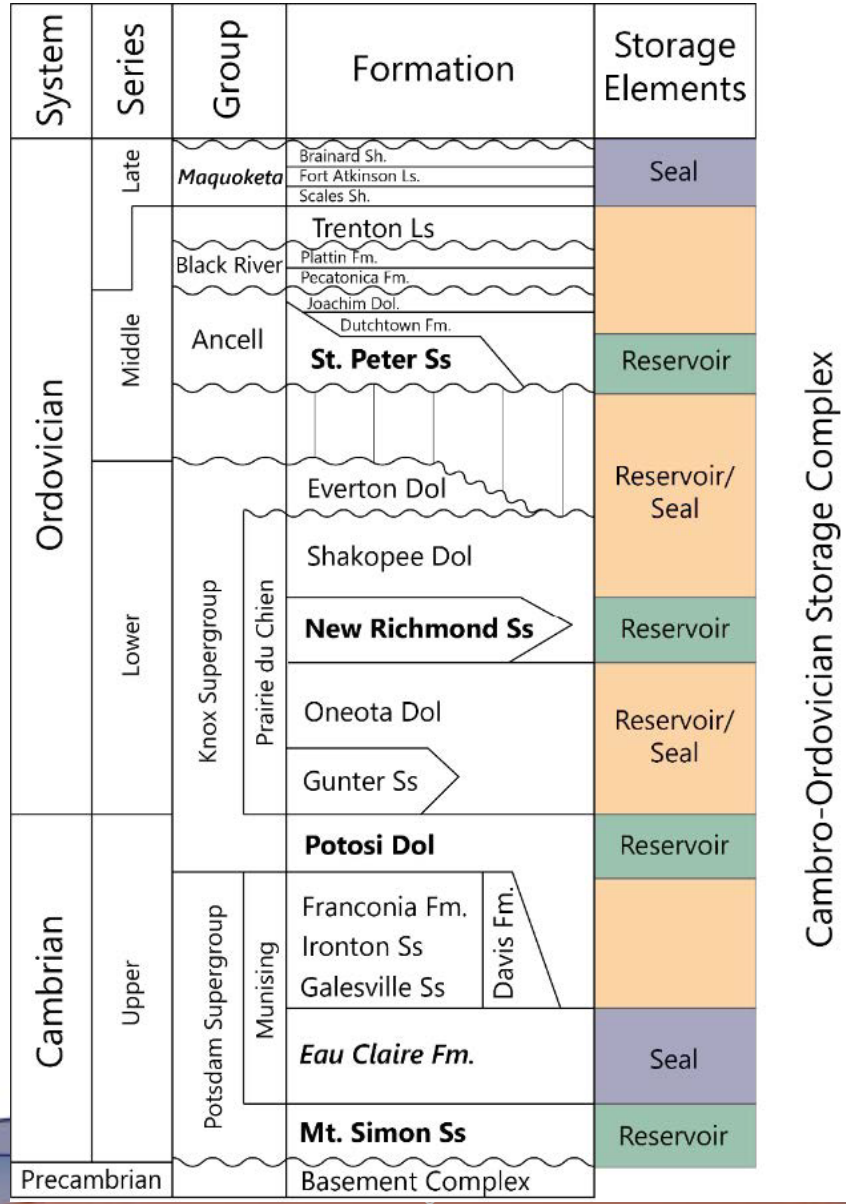
Background: Regional Setting





Background: Anticipated Local Geology

- New Richmond Sandstone; 2,800 ft deep; 400 ft thick (>200 ft net)
  - Several porous/permeable sandstone embedded in dolomite
- Potosi Dolomite (Vuggy Knox); 3,700 ft deep; 2,800 ft thick
  - Vugular dolomite can act as reservoir and seal
  - Unpredictable
  - Target at Wabash (75 miles NW)
- Mt. Simon Sandstone; 5,800 ft deep; 1,200 ft thick
  - Regional studies suggest low porosity but limited data
  - Target at Decatur (IBDP; 150 miles NW)
- Seals
  - Maquoketa and Eau Claire both thick and laterally extensive
  - Mt. Carmel Fault 12 miles east



Project Overview

- Prepare Mitchell for Class VI permit
  - Geologic characterization
    - Establish geologic suitability of the site for CCS
  - Develop Community Benefit Plan
  - Conduct risk assessment
  - Evaluate technical and economic feasibility of site

- Performance Dates
  - 10/2023 to 9/2025
- Funding summary
  - $8,898,036 federal funds
  - $2,224,760 cost share
  - **$11,122,796 total**

	Project Funding Profile Per Project Team Member					
	Budget Period 1					
	Year 1		Year 2		Total	
	DOE Funds	Cost Share	DOE Funds	Cost Share	DOE Funds	Cost Share
Applicant (ISGS/UIUC)	$1,820,986	$286,548	$1,744,316	$286,552	$3,565,302	$573,100
Heidelberg		$1,576,988				$1,576,988
Projeo Corporation	$5,011,752				$5,011,752	
Indiana Geological and Water Survey	$100,000	$25,336	$100,000	$25,336	$200,000	$50,672
Trimeric Corporation			$24,974		$24,974	
Gnarly Tree Sustainability Institute	$47,535	$11,884	$48,473	$12,116	$96,008	$24,000
Total ($)	$6,980,273	$1,900,756	$1,917,763	$324,005	$8,898,036	$2,224,760
Total Cost Share (%)						20%

Mitchell CarbonSAFE team

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Heidelberg Materials

Projeo

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INDIANA UNIVERSITY

GNARLY TREE SUSTAINABILITY INSTITUTE

TRIMERIC CORPORATION

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Gladly we learn and teach
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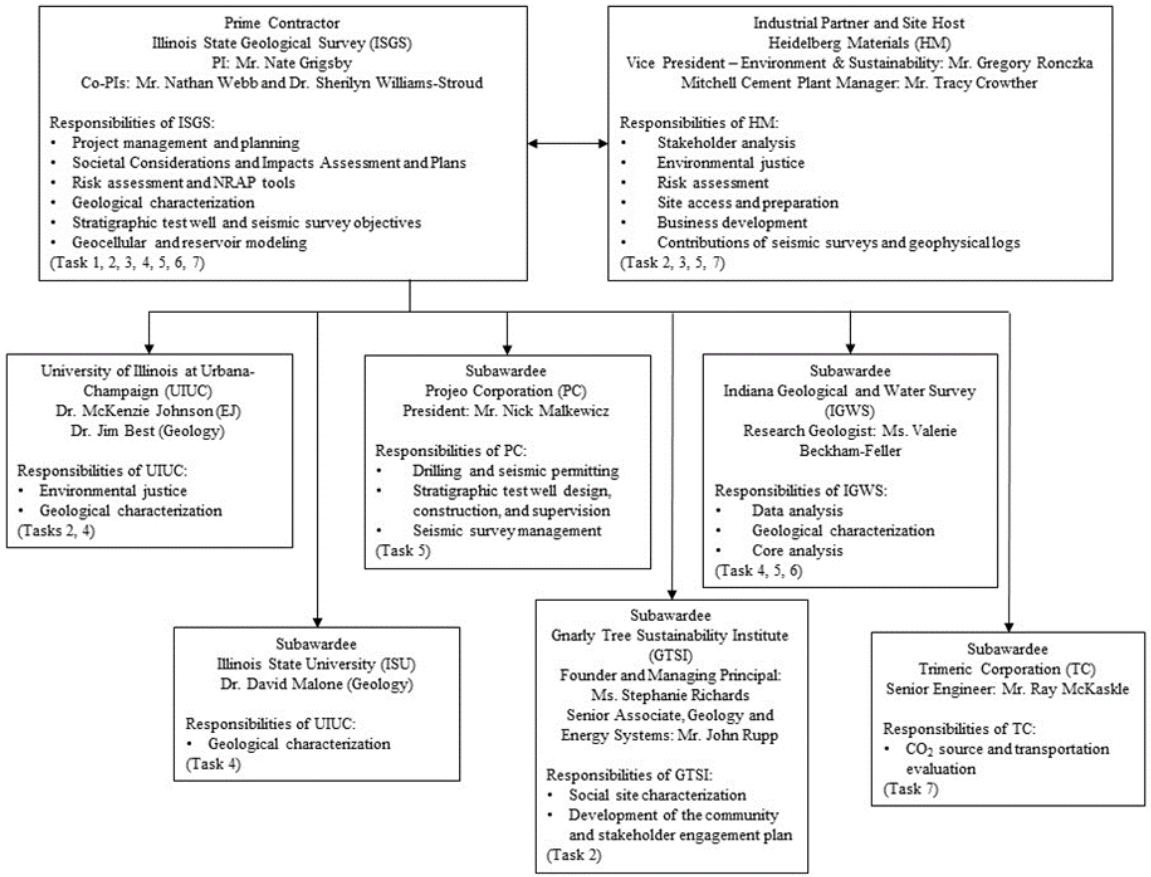

Project Execution Plan (Tasks)

- 1: Project Management and Planning
- 2: Community Benefit Plan
  - Community outreach programming
- 3: Risk Assessment and Monitoring
  - Identification of project risks
  - Development of mitigation and monitoring strategies
- 7: Storage Complex Development Planning
  - Conceptual level design study

Expected Outcomes

- 1: Effective project management
- 2: Updated CBP
  - DEIA Implementation
  - Community engagement strategy
  - EEJ assessment and J40 Initiatives
- 3: Site specific risks and mitigation strategies
- 7: Technical and economic feasibility of site

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Project Execution Plan (Tasks)

- 4: Subsurface Characterization
  - Develop and update conceptual geologic models of reservoirs and seals
  - Data evaluation
- 5: Drilling and Field Data Acquisition
  - Stratigraphic test well
    - ~7,200 ft (through Mt Simon)
    - Sophisticated logs, ~600ft core, ~100 sidewall, 3 DSTs
  - 2D Seismic Survey
    - 54 miles to evaluate structure and formation continuity
- 6: Storage Complex Modeling
  - Geocellular Modeling
  - Reservoir Simulations

Expected Outcomes

- 4: Refined characterizations
  - Conceptual geologic models for targets and seals
  - Local fluid properties (USDW)
- 5: Site specific data to inform Tasks 4 and 6
- 6: Constrain reservoir injectivity, containment, capacity
  - Area of Review

Project schedule and key milestones

Table 4. Project Milestones

Task / Subtask	ID	Milestone Title & Description	Planned Completion Month	Verification Method
1 / 1.1	A	Project Kickoff Meeting	2	Attend Meeting, Presentation File provided to DOE
1 / 1.2	B	Updated Project Management Plan	2	File provided to DOE
2 / 2.1	C	Updated Community and Stakeholder Engagement effort	3	File provided to DOE
2 / 2.0	D	CBP Mid Project Update Meeting	12	Attend Meeting, Presentation File provided to DOE
2 / 2.1	E	DEIA SMART (per DEIA Plan)	12 & 24	Mid project review and End of project report
2 / 2.3	F	Energy and Environmental Justice Assessment	24	Included in end of project report
3 / 3.2	G	Risk Mitigation Plan	23	File provided to DOE
4 / 4.1	H	Obtain Stratigraphic Well Drilling and Seismic Permits	6	Summary in quarterly report
5 / 5.2	I	Complete Stratigraphic Test Well	10	Summary in quarterly report
5 / 5.4	J	Complete 2D Seismic Survey	14	Summary in quarterly report
6 / 6.2	K	Storage complex characterization and assessment report	20	File provided to DOE
6 / 6.3	L	Detailed Site Characterization Plan	23	File provided to DOE
7 / 7.1	M	Preliminary CO_2 management & monitoring plan, including coverage for transport of CO_2	24	File provided to DOE
7 / 7.2	N	Technical and economic feasibility evaluation of a proposed CO_2 storage project	24	File provided to DOE

Table 7: Gantt Chart with Team Responsibilities by Task. Letters refer to milestones in Table 4.

#	Task Name	Start Month	End Month	Budget Period 1																								Organization							
				10/23	11/23	12/23	01/24	02/24	03/24	04/24	05/24	06/24	07/24	08/24	09/24	10/24	11/24	12/24	01/25	02/25	03/25	04/25	05/25	06/25	07/25	08/25	09/25	ISGS	HM	UIUC	PC	ICWS	TC	GTSI	ISU
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24								
1.0	Project Management and Planning																																		
1.1	Manage all project activities, objectives, & milestones	1	24	A																								X							
1.2	Project management plan	1	2		B																							X							
1.3	Data management	1	24																									X	X	X	X	X	X	X	X
1.4	Access to geologic materials / samples	1	24																									X							
2.0	Community Benefits Plan																																		
2.1	Community and labor engagement	1	19			C									D													X	X	X				X	
2.2	Investing in job quality and a skilled workforce continuity	2	8																									X	X	X				X	
2.3	Diversity, equity, inclusion, and accessibility	1	19											E	D											E		X	X	X	X	X	X	X	X
2.4	Justice40 Initiative	1	19												D							F						X	X	X				X	
3.0	Risk Assessment and Monitoring																																		
3.1	Conduct risk assessment	2	23																									X	X						
3.2	Develop risk mitigation & monitoring strategies	2	23																							G		X	X						
4.0	Subsurface Characterization																																		
4.1	Conduct pre-drilling site assessment & obtain drilling & seismic acquisition permits	1	6						H																			X		X	X	X			X
4.2	Develop conceptual geological model	3	21																									X		X	X	X			X
4.3	Analyze well data	9	21																									X		X		X			X
5.0	Drilling and Data Acquisition																																		
5.1	Design seismic acquisition & well drilling program	1	6																									X	X	X	X	X			X
5.2	Drill & construct stratigraphic test well	8	10										I															X	X	X	X	X			X
5.3	Collect well data	11	14																									X	X	X	X	X			X
5.4	Conduct regional 2D seismic survey	11	14														J											X			X	X			
6.0	Storage Complex Modeling																																		
6.1	Develop geocellular models	2	20																									X		X		X			X
6.2	Develop reservoir models	2	20																				K					X							
6.3	Identify future data requirements	11	23																							L		X		X		X			X
7.0	Storage Complex Development Planning																																		
7.1	Develop conceptual level design study	4	24																								M	X	X				X		
7.2	Assess technical & economic feasibility of storage complex	4	24																								N	X	X						

Current Status

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Task / Subtask	ID	Milestone Title & Description	Planned Completion Month	Status
1 / 1.1	A	Project Kickoff Meeting	2	Complete
1 / 1.2	B	Updated Project Management Plan	2	Complete
2 / 2.1	C	Updated Community and Stakeholder Engagement effort	3	Complete
2 / 2.0	D	CBP Mid Project Update Meeting	12	Ongoing
2 / 2.1	E	DEIA SMART (per DEIA Plan)	12 & 24	Ongoing
2 / 2.3	F	Energy and Environmental Justice Assessment	24	Ongoing
3 / 3.2	G	Risk Mitigation Plan	23	Ongoing
4 / 4.1	H	Obtain Stratigraphic Well Drilling and Seismic Permits	6	Complete
5 / 5.2	I	Complete Stratigraphic Test Well	10	Delayed
5 / 5.4	J	Complete 2D Seismic Survey	14	Complete
6 / 6.2	K	Storage complex characterization and assessment report	20	Ongoing
6 / 6.3	L	Detailed Site Characterization Plan	23	Ongoing
7 / 7.1	M	Preliminary CO_2 management & monitoring plan, including coverage for transport of CO_2	24	Ongoing
7 / 7.2	N	Technical and economic feasibility evaluation of a proposed CO_2 storage project	24	Ongoing

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2.2	Investing in job quality and a skilled workforce continuity	2	8																									X	X	X				X	
2.3	Diversity, equity, inclusion, and accessibility	1	19											E	D											E		X	X	X	X	X	X	X	X
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5.2	Drill & construct stratigraphic test well	8	10										I	→	→	→												X	X	X	X	X			X
5.3	Collect well data	11	14														→	→	→	→								X	X	X	X	X			X
5.4	Conduct regional 2D seismic survey	11	14	←	←	←	←	←	←	←	←	←					J											X			X	X			
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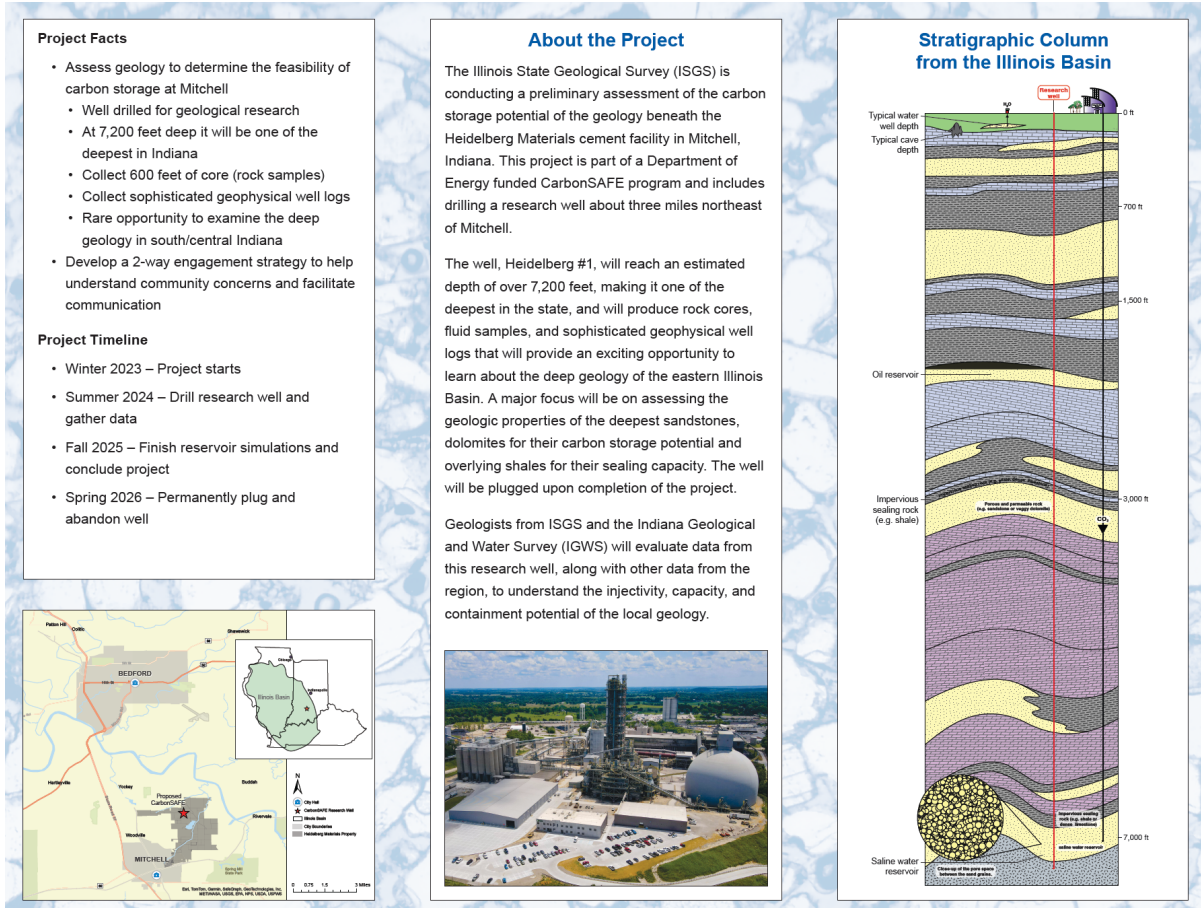
Task 2: Community Benefits Plan

- Planned/undertaken community engagement
  - **To occur after CarbonSAFE phase II**
  - Tri-fold flyers developed and distributed
  - Coordination with Heidelberg Materials to prepare for future phases
  - Potential interviews with HM staff, policy makers, community advisory panel
- Progress towards SMART milestones
  - Year 1: Assess state of DEIA within project team:
    - DEIA assessment survey developed and distributed. To be analyzed next month.
  - Year 2: Summarize and quantify participation of interns and student researchers from groups underrepresented in STEM:
    - List of interns and student researchers compiled. To be tracked throughout project.



Task 2: Community Benefits Plan

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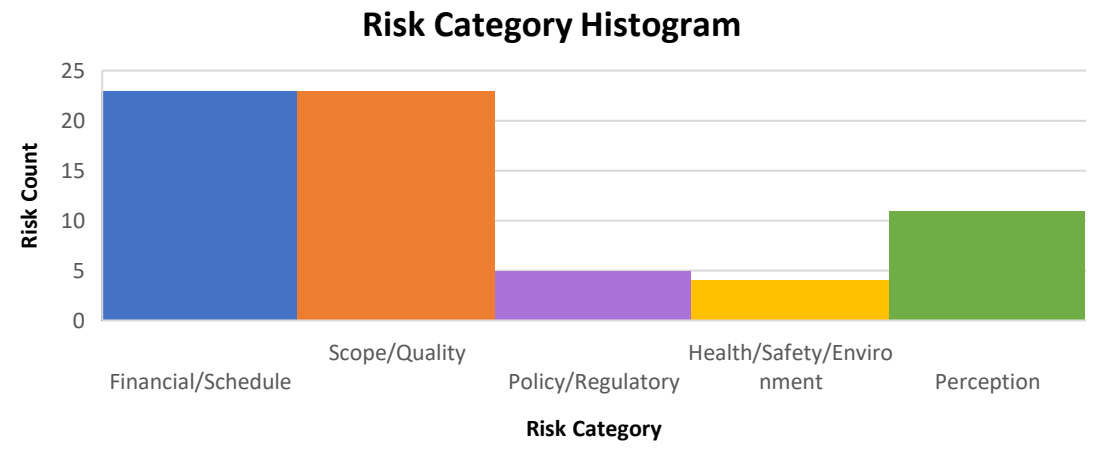
- **Background**
  - Developed annotated bibliographies referencing academic journal articles, professional reports, and case studies on **best practices in public engagement around CCUS** and **public perceptions of CCS**
  - Generated preliminary list of stakeholders common to CCUS projects
- **Site-Specific**
  - Developing social site characterization (PESTEL and Ejscreen) of 10-mile radius around Mitchell site
  - Stakeholder analyses & mapping of Mitchell to reflect best practices in public engagement around CCUS

Political	Economic	Social	Technological	Environmental	Legal
• State legislation supportive of CCS • State elected officials supportive of CCS • Need to better understand local politicians' opinions of CCS	• Economy recovering from pandemic • Inflation expected to increase project costs • Significant financial incentive for CCS with 45Q • Importance of Heidelberg Materials to local economy • Need to model economic benefits of project	• Need for stable employment and investment • Concerns regarding population with less than HS education, low life expectancy, prevalence of heart disease, number of residents with disability, access to broadband Internet, food insecurity • Need to better understand public opinions of CCS, Heidelberg Materials, and climate change	• Storage potential of saline aquifers • Relative safety of process • Need for local expertise • Need to determine spread of CO_2 in saline aquifers and to assess salinity of brine and porosity of rocks	• Concerns about number of impaired waters, brownfields, leaking underground storage tanks, emissions reductions • Need to ensure injection sites are below aquifers	• Legal rights to pore space are well-defined to property owner • CCUS project developers can use eminent domain • Responsibility for injection site passes to state after 12 years or when injection stops • Need to identify spread of plume and impacted property owners

Task 3: Risk Assessment and Monitoring

Initial Risk Register → Risk Workshop 1 → Additions & Revisions → Risk Workshop 2 → Final Risk Register

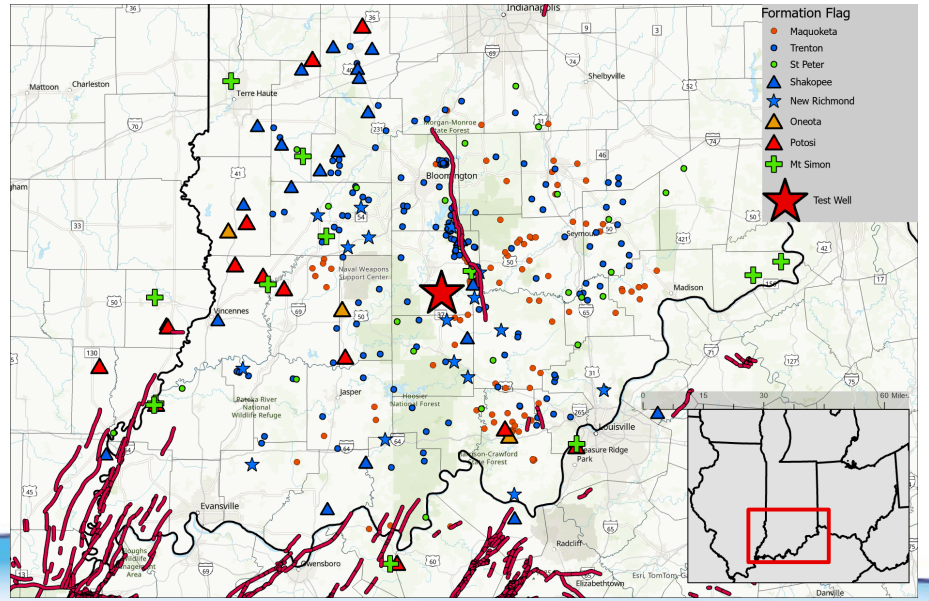
- Initial risk registry and Risk Assessment Matrix (RAM) complete
  - 66 total risks
  - Assigning severity, likelihood, consequence, mitigation
- Risk workshop 1
  - Evaluate risk definitions and categories
  - Provide feedback and edits

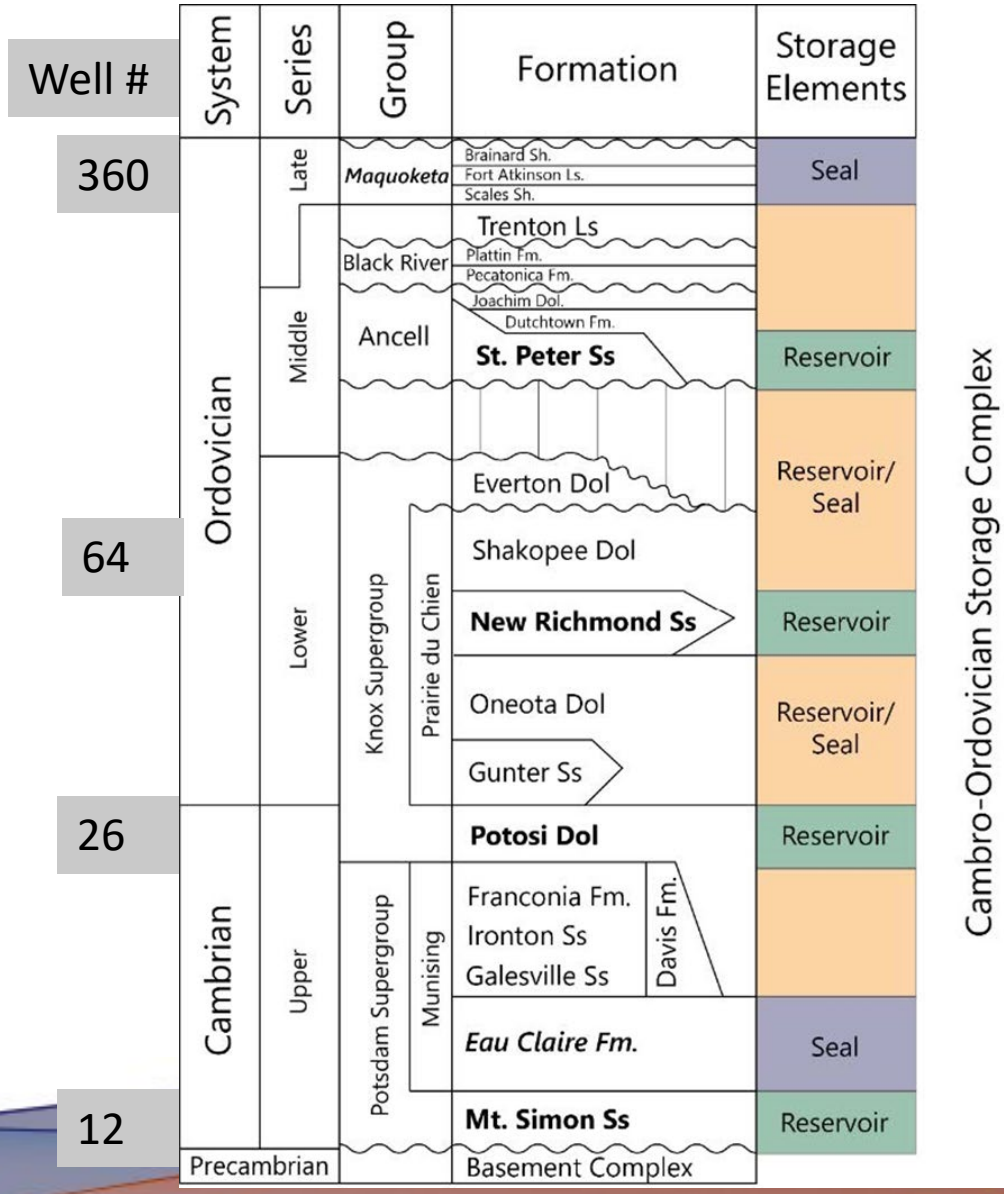


Risk	Likelihood	Severity	Mitigation
CarbonSAFE Phase II			
Potosi lost circulation	High	High	LCM, cement plugs if necessary
Budget overruns	High	High	Effective and thorough planning and project management
Subsequent Phases			
Community Resistance	Medium	High	Effective engagement
Unsuitable Geology	Low	High	Alternative injection plans
Project activities put drinking water at risk	Low	High	Safe drilling practices, effective planning and project management

Task 4: Subsurface Characterization

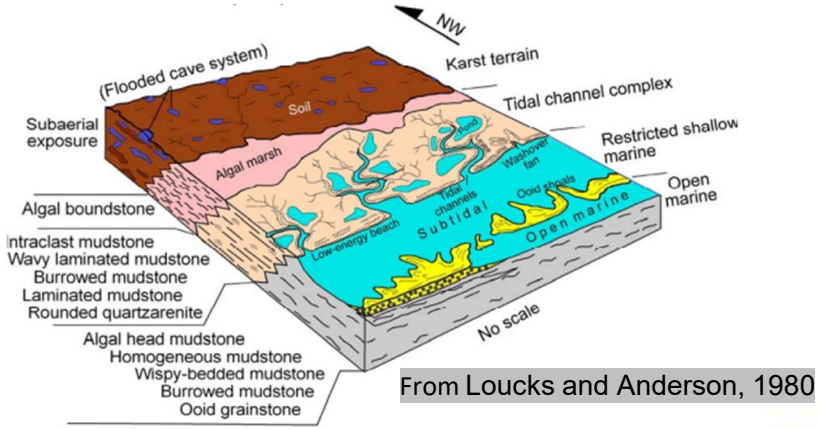
- Conceptual: Literature review, analogues
  - Set expectations, provide context for data
- Site Specific: Analyze local data
  - 50-mile radius
  - Compile data, constrain local properties



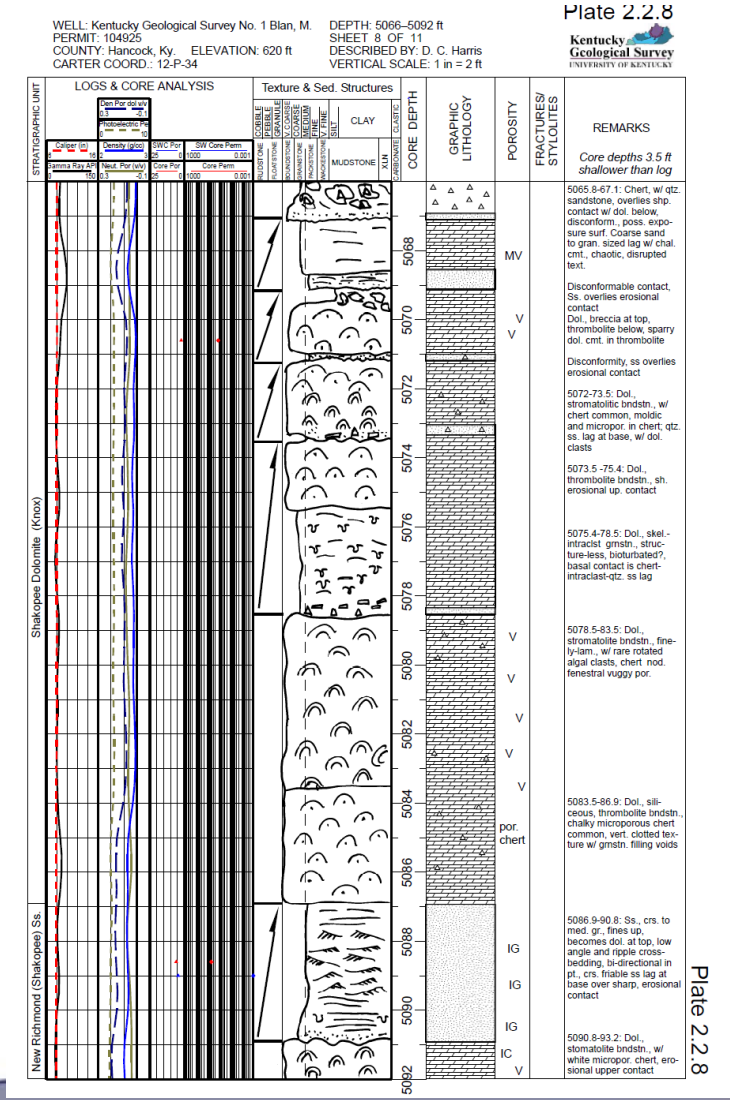


New Richmond-Conceptual Model

- Western Kentucky carbon storage test @ Marvin Blan (70 miles south)
  - Core = Tidal channel complex with cyclic depositional cycles
    - Sandstone has consistently high porosity/permeability
    - Variability in dolomite
- Analogues: Ellenburger, Arbuckle, Roubodoix
  - Characterization techniques
  - Flow unit geometry
  - Pitfalls
  - Uncertainties



From Loucks and Anderson, 1980



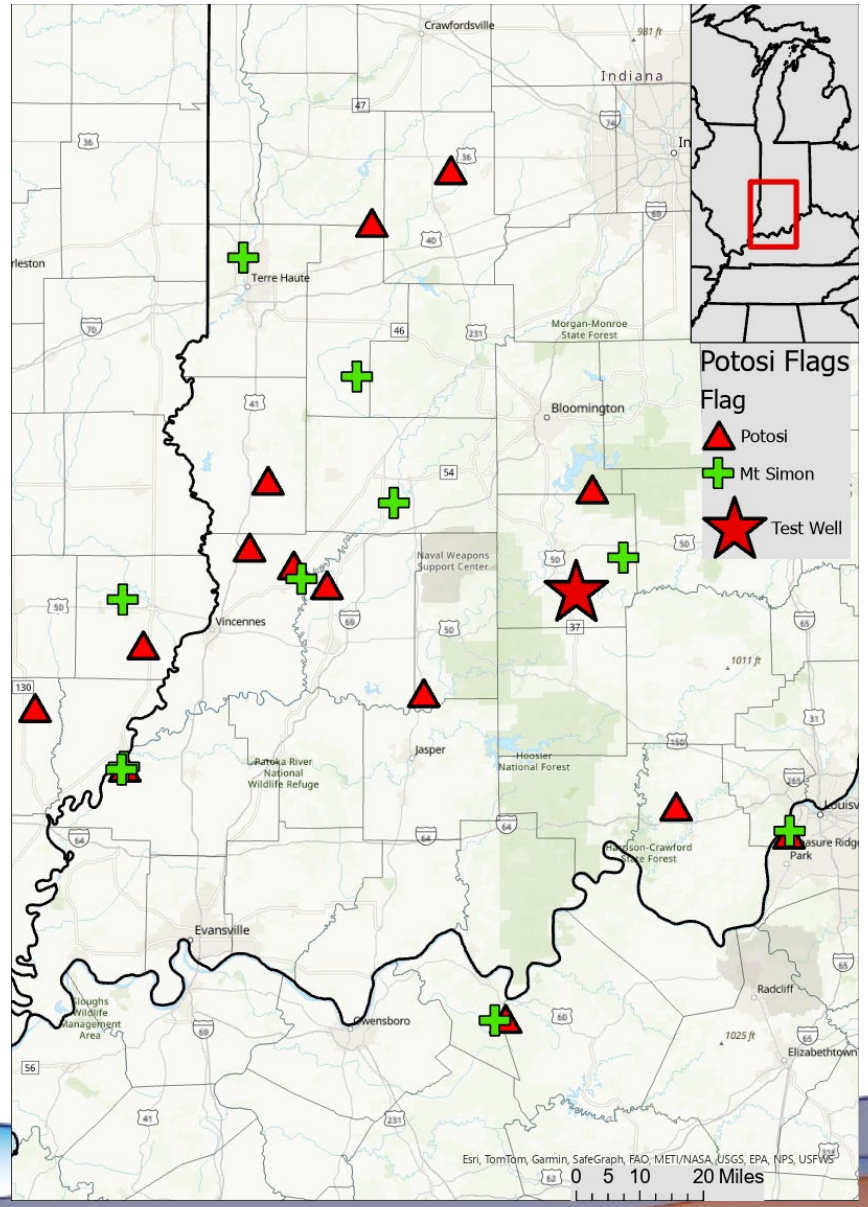
From Harris et al., 2014

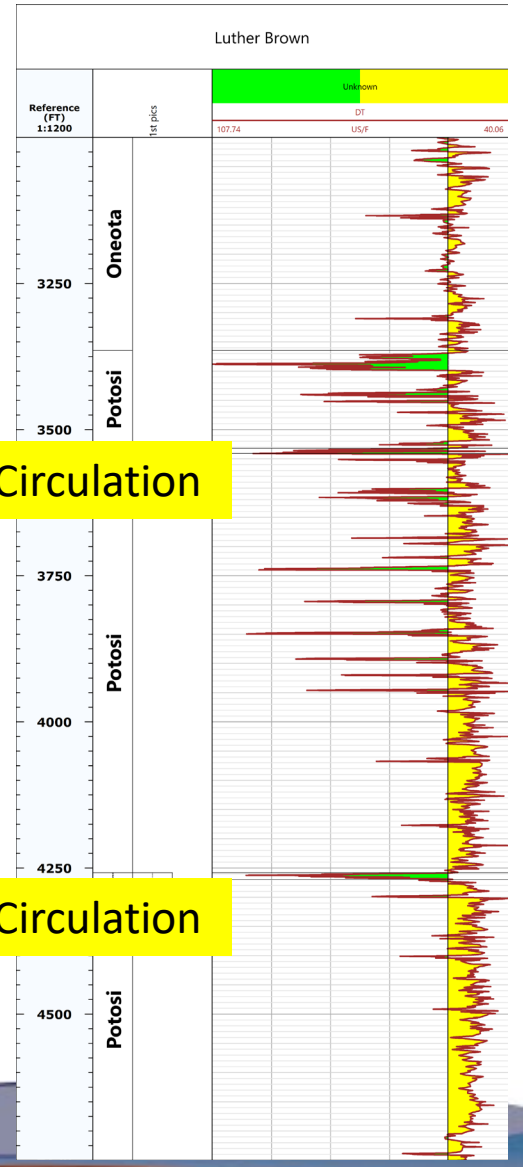
New Richmond: Site Specific

- Pre-project expectations based on closest well (Bailey) and Harris et al., (2014)
  - 250-300 feet New Richmond, 50% net
- Developed methods to calculate %Quartz/Dolomite based on Pe or NPHI + RHOB logs
- Several laterally continuous sand units in study area that stack to the south
  - **Bailey and Harris et al., (2014) underestimate thickness**

Potosi

- Only a few wells encounter Potosi
  - Can't correlate vuggy intervals over long distances
- Luther Brown well
  - 9 miles NE
  - Drilled in 1959 (poor logs)
  - Lost circulation twice
  - Dt log suggests vugular intervals over 1,000-foot interval





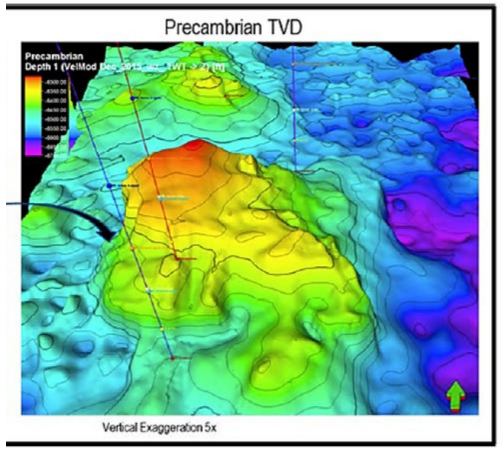
Lost Circulation

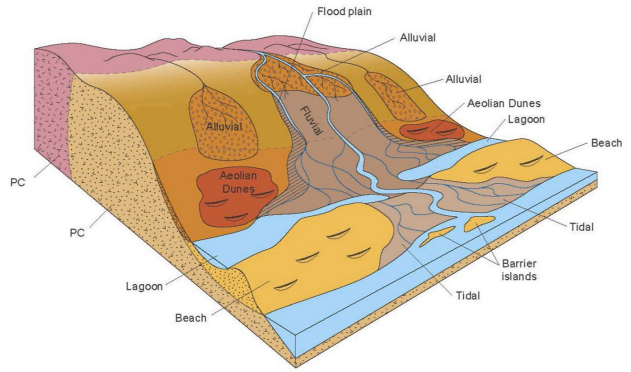
Lost Circulation

Mt. Simon

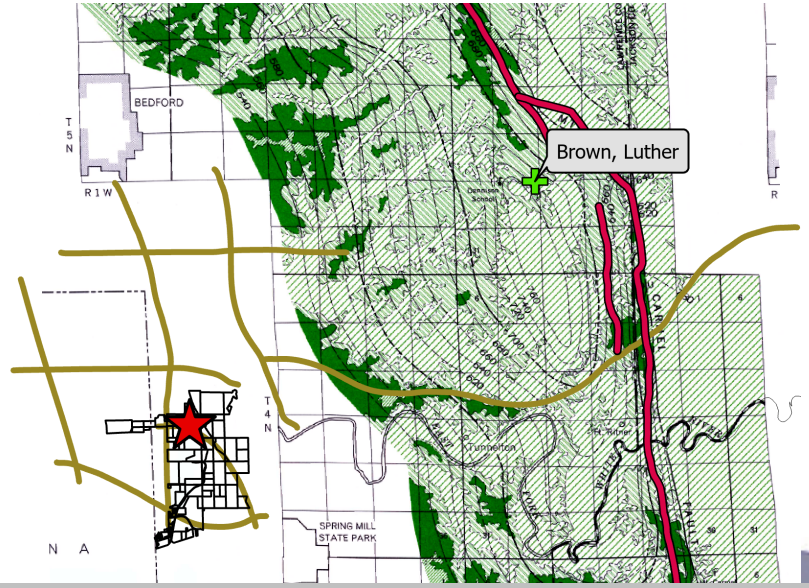
- Luther Brown well (9 miles NE)
  - Only well within 30 miles that encounters Mt. Simon (40 to lower Mt. Simon)
  - Sample descriptions available:
    - 450 ft of reddish, medium-coarse grained, poorly consolidated sandstone is present at the base of the Mt. Simon Sandstone
  - Logs suggest some permeability
- IBDP and ensuing studies found porosity preservation due to weathering of Precambrian highs
- Proximity to Leesville Anticline may improve Arkosic zone potential

Precambrian structure at IBDP based on 3D seismic. From Greenberg, 2021





Depositional model of the Mt. Simon from Freidberg et al., 2022



Leesville Anticline in relation to Mitchell site. Modified from Melhorn and Smith, 1959

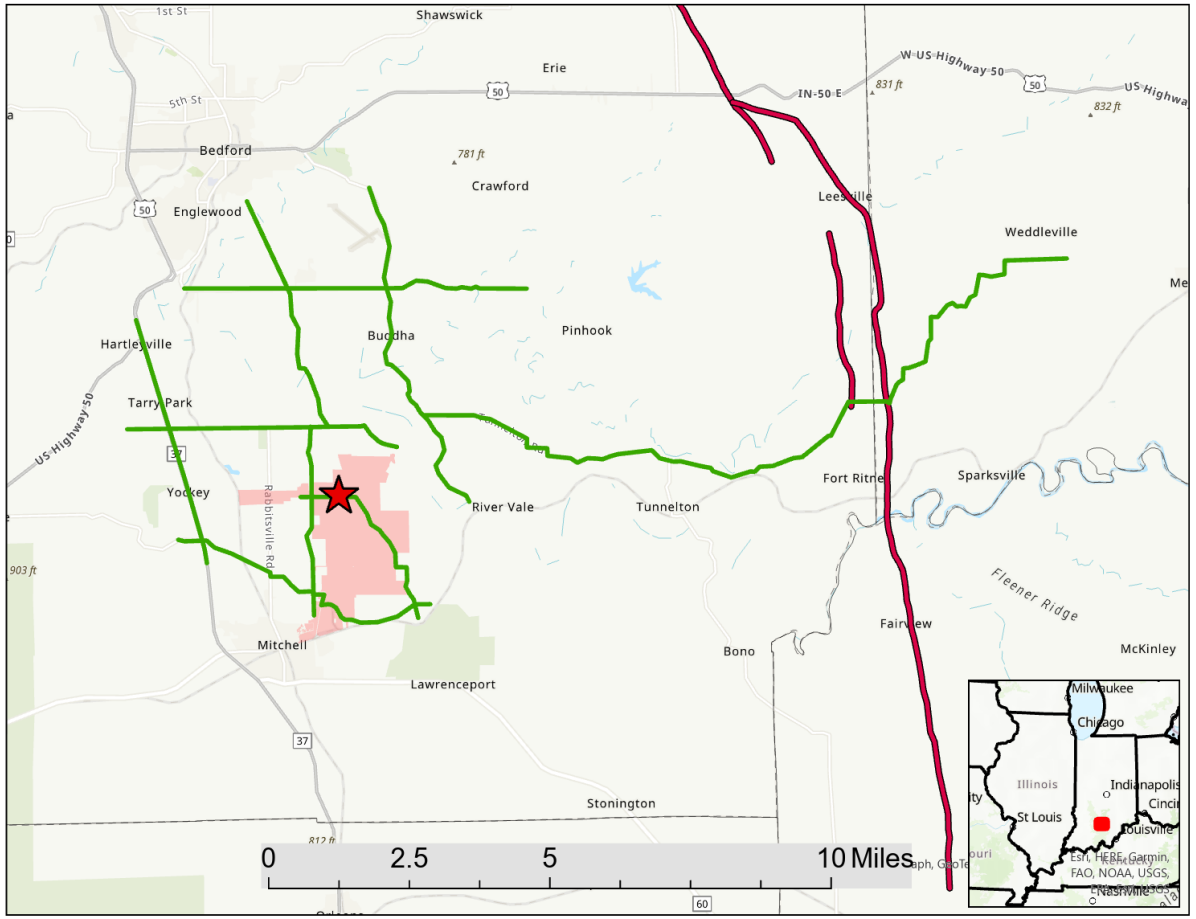
Task 5: Field work

Seismic

- 54 linear miles acquired in June 2023. Processed in October 2023
- Captured Mt. Carmel Fault
- Some faulting observed in Pre Cambrian and Lower/Middle Mt. Simon, but none in Knox or seals

Stratigraphic test well

- Permit acquired
- Vetting drilling contractors



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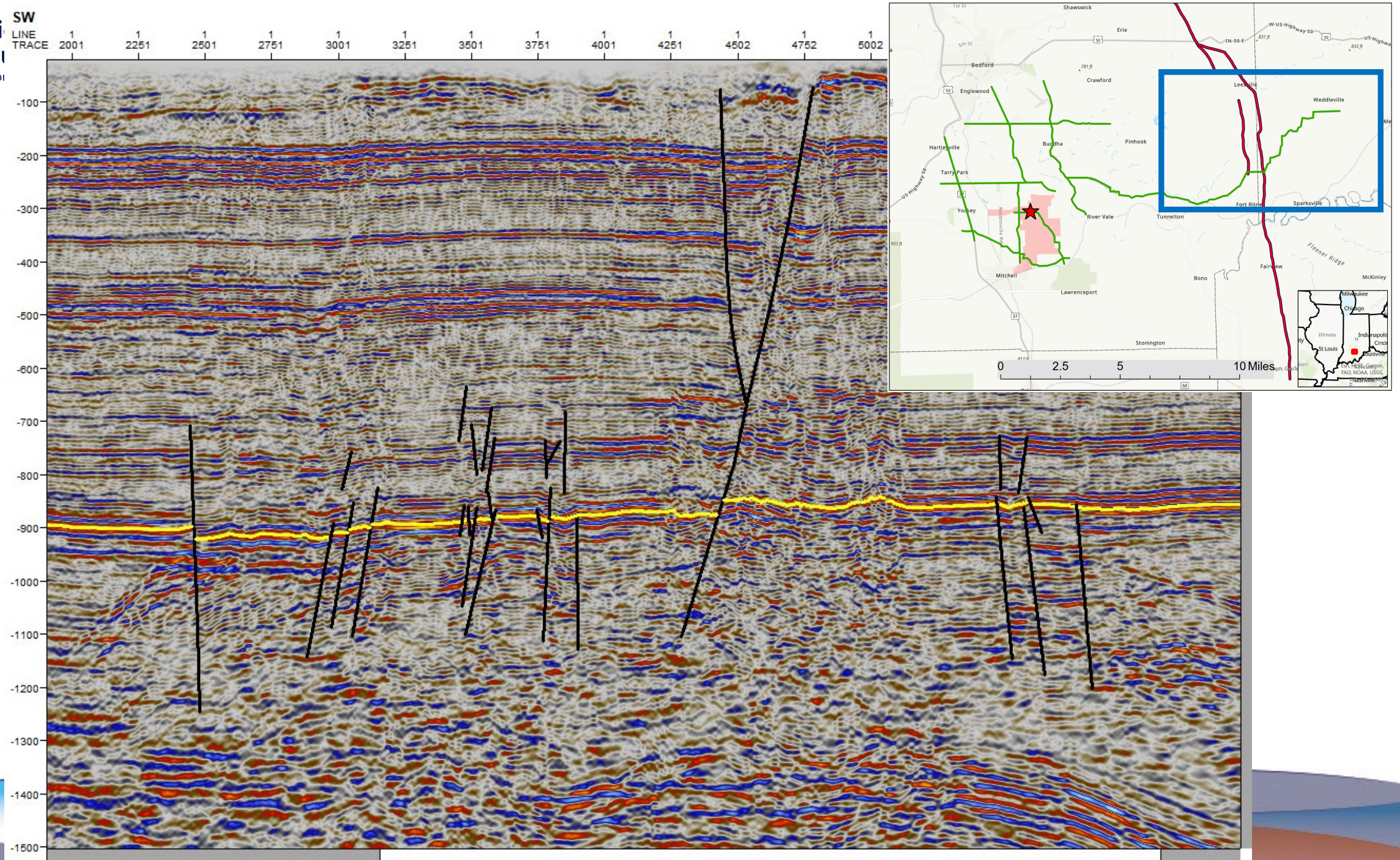
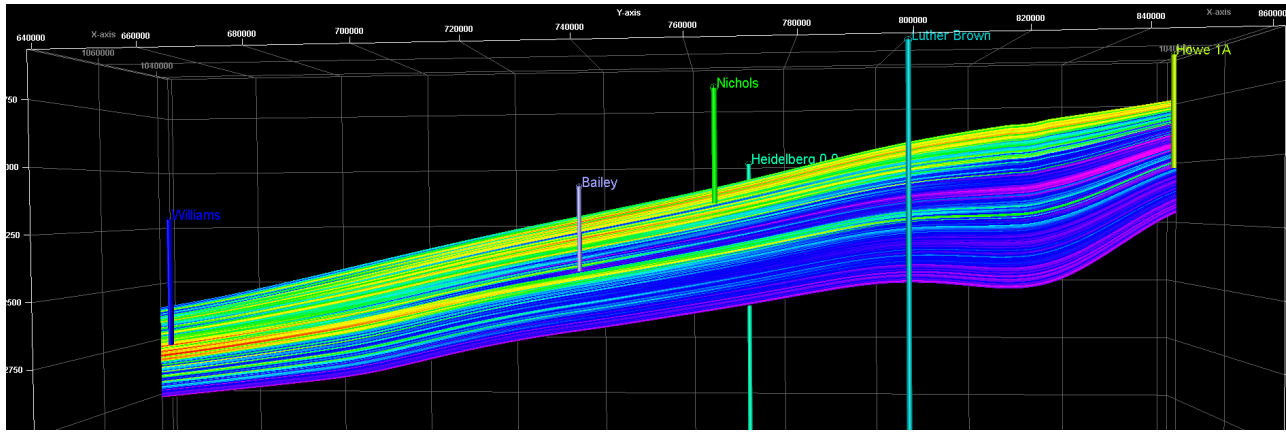
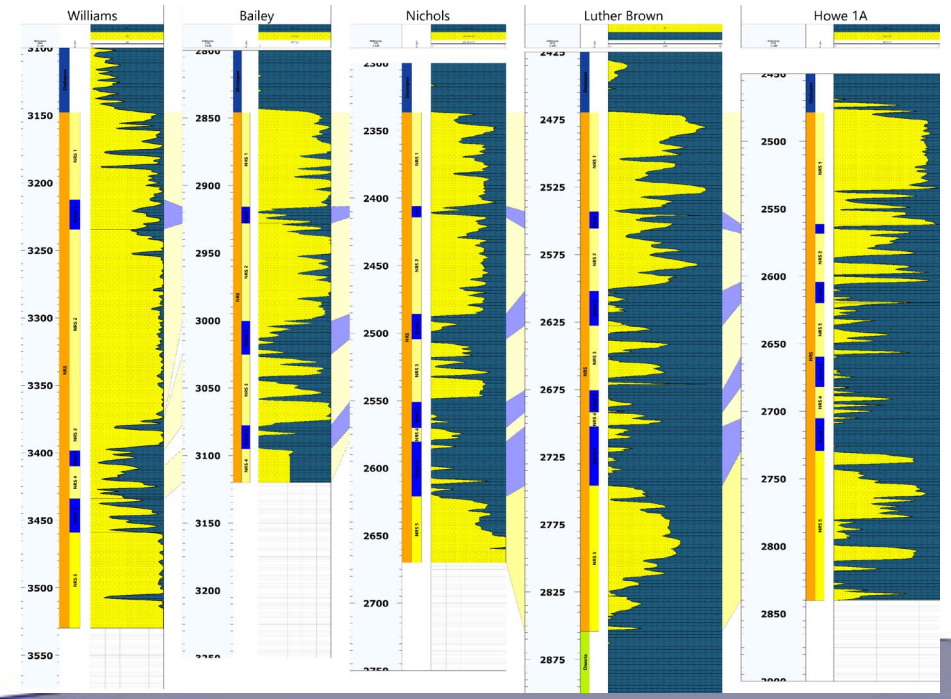


Geocellular Models

- Mt. Simon/Potosi
  - Waiting on test well
- New Richmond
  - %Q model (Sand/Dolomite) matches expectations

South North

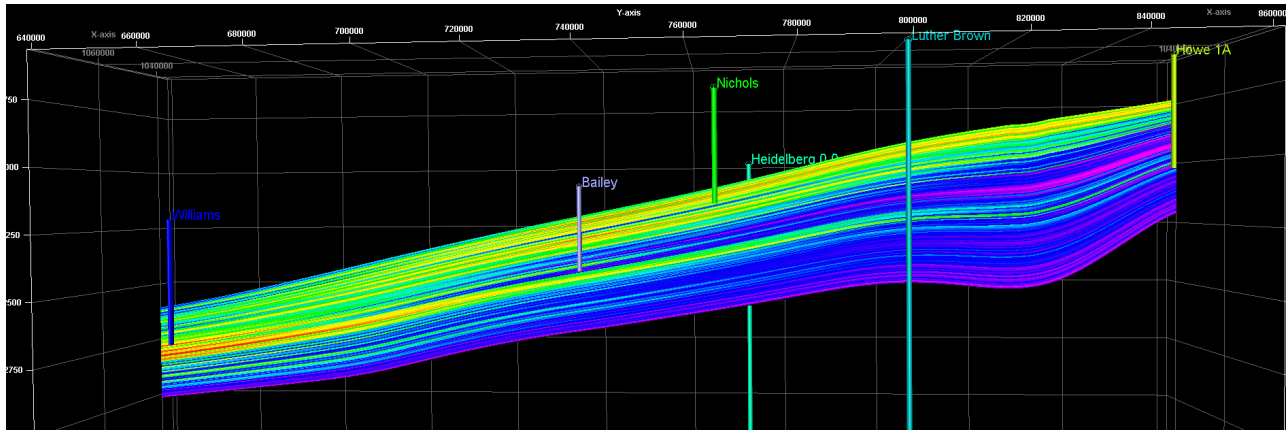


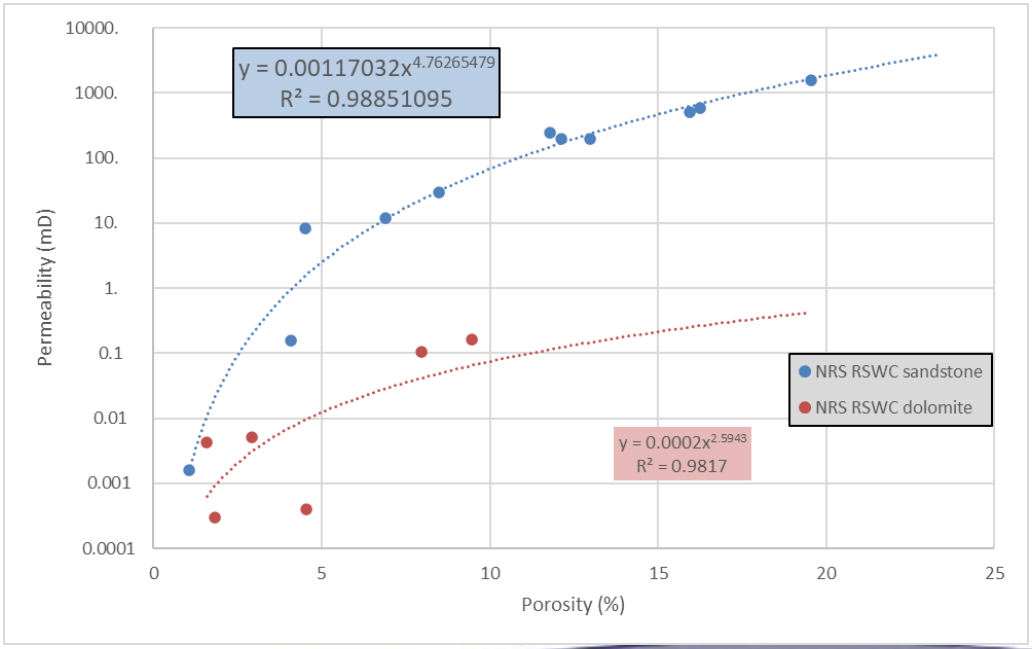


Geocellular Models

- Mt. Simon/Potosi
  - Waiting on test well
- New Richmond
  - %Q model (Sand/Dolomite) matches expectations
  - Density porosity matrix density scaled to %Q
    - $DPHI = \frac{\rho_{mixed} - RHOB\ (welllog)}{(\rho_{mixed}) - 1}$
    - $\rho_{mixed} = 2.87 - (\%Q(2.87 - 2.65)$
  - Porosity to permeability transforms based on Marvin Blan core

South North





Accomplishments

- CBP
  - Initial A&V meeting
  - DEIA survey developed and distributed
  - Preliminary PESTLE analysis complete
- Preliminary risk register complete
  - 1st workshop scheduled for September
- Pre-drill geologic characterization complete
  - New Richmond has better potential than anticipated
- Preliminary geocellular model for NRS complete
- Field work
  - 2D seismic survey complete
  - Test well to be drilled this year

Next Steps

- **Drill well**
- Incorporate well data
  - Conceptual geologic model
  - Geocellular models
    - Petrophysical properties
    - Well tie
  - Input parameters for reservoir simulations
- CBP
  - SMART 1 milestone
  - Mid project A&V meeting

Thank you

Questions?