Neeraj Gupta- Battelle
Sallie Greenberg- University of Illinois

Midwest Regional Carbon Initiative - MRCI

(Regional Initiative to Accelerate CCUS Deployment in Midwestern and Northeastern USA)

DE-FE0031836

U.S. Department of Energy
National Energy Technology Laboratory
CO_2 Storage Project Review Meeting
August 15-19, 2022

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U.S. DEPARTMENT OF ENERGY | NATIONAL ENERGY TECHNOLOGY LABORATORY | BATTELLE | ILLINOIS

Outline

- Background and Program Goals
- Previous Efforts in the Region and Data Collaboration
- Addressing Key Technical Challenges for CO_2 Storage
- Enhancing Infrastructure Development
- Stakeholder Outreach
- Summary

MRCI Program Goals

- Implement a collaborative Regional Initiative to accelerate CCUS deployment in the Midwestern and Northeastern US.
- Build on more than 20 years of CCUS experience in the region by combining expertise of two RCSPs (MRCSP & MGSC).
- Engage national and international stakeholders, including state geological surveys, universities, industrial partners and advisors, fossil fuel production and utilization companies, and NGOs.
- Advanced CCUS research through four tasks:
  - Addressing key technical challenges.
  - Obtaining and sharing data to support CCUS.
  - Facilitating regional infrastructure planning.
  - Performing regional technology transfer.

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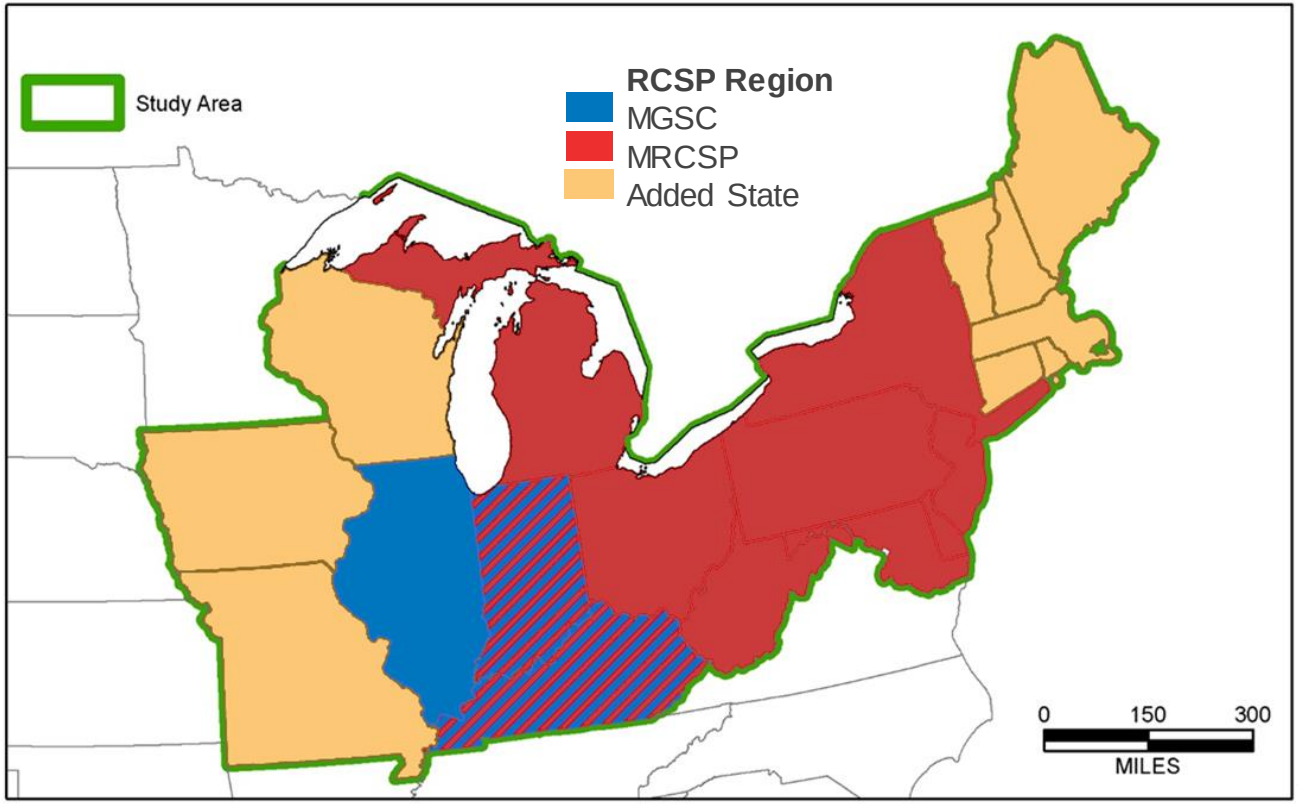
MRCI – Covering 20 States in Midwest and Northeast

- Battelle and Illinois State Geological Survey combine expertise from MRCSP and MGSC
- Working with State Geological Surveys and Universities across the Region to Accelerate deployment of CCUS



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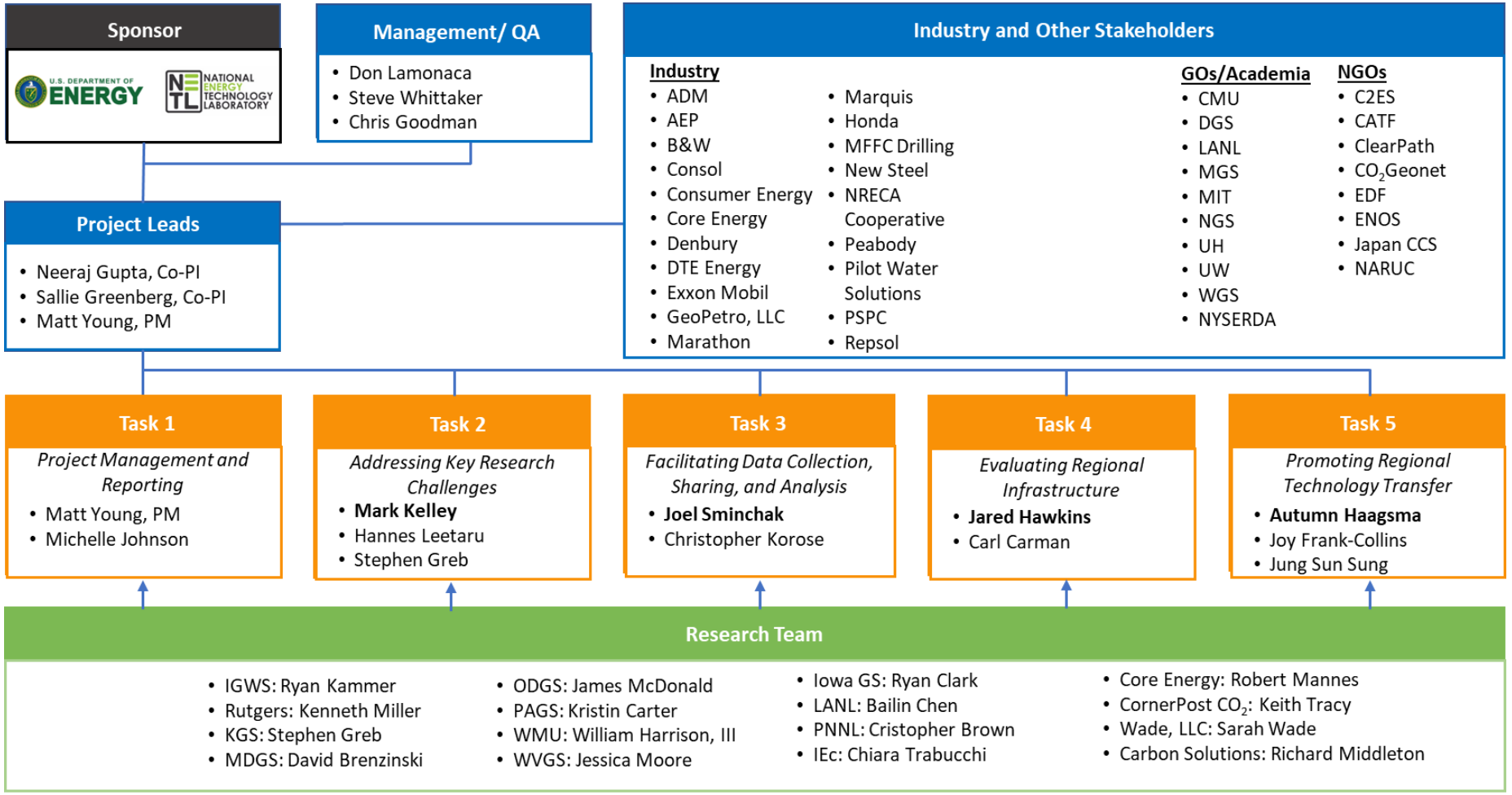
MRCI – Collaboration between Researchers, Industry, and Government, and non-Governmental Organizations



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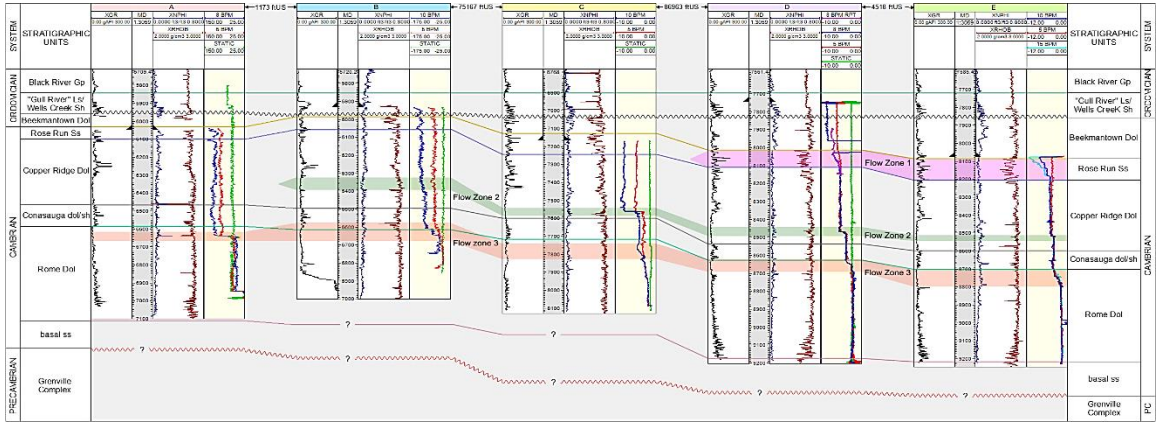
Industrial Collaborations to Enable Deployment and Scale-up

- MRCI is interacting with a range to industry to accelerate CCUS deployment
  - Regional oil and gas companies – obtain legacy seismic and wellbore data for regional mapping
  - Brine Disposal Companies – piggyback logging, monitoring, modeling of large-scale operations to evaluate CO_2 storage
  - Existing and future CO_2 sources – helping companies with site screening and regulatory roadmaps
    - Ethanol plants across the region
    - Planned ammonia plants
    - CoalFIRST in Pennsylvania and Indiana
    - CarbonSAFE Illinois
    - Support utilities and independent power producers
    - State agencies such as MD Energy Administration
    - CCS task forces across the region



Regional Injection Zones from Brine Disposal Wells

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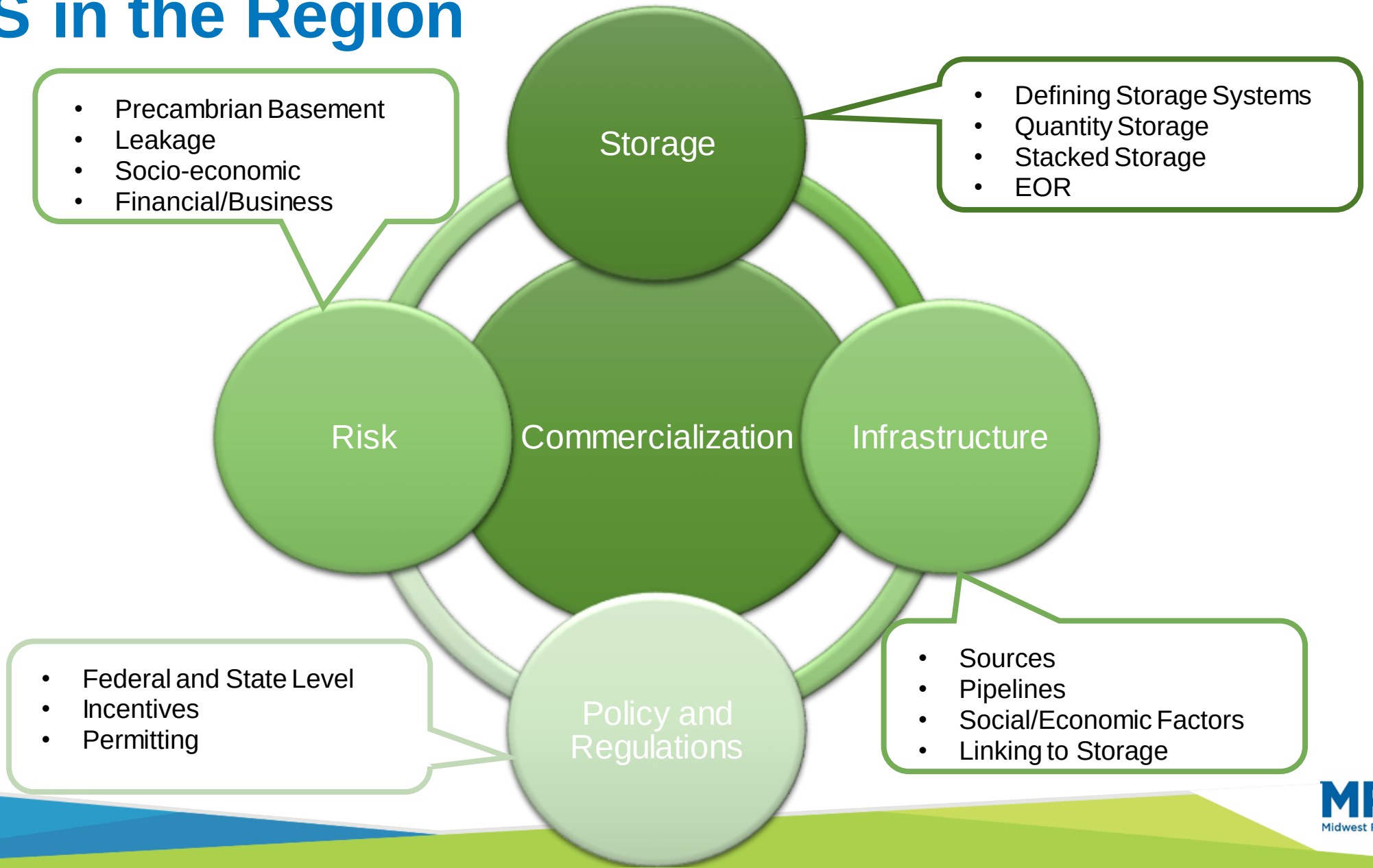
Project Aims to Tackle Challenges to Pave Way for CCUS in the Region



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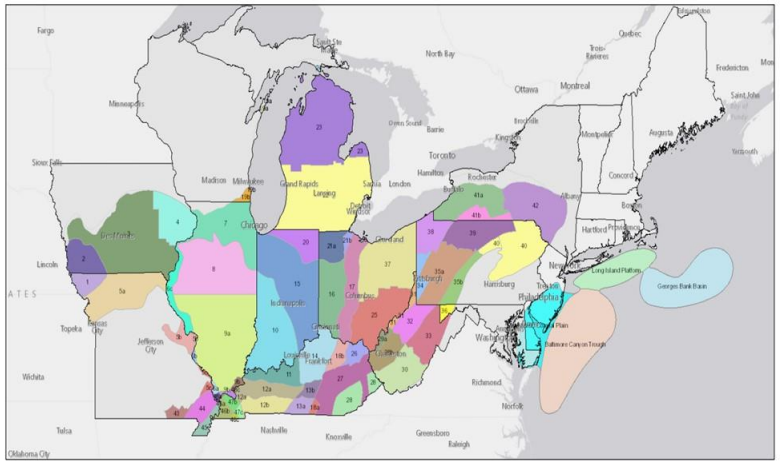
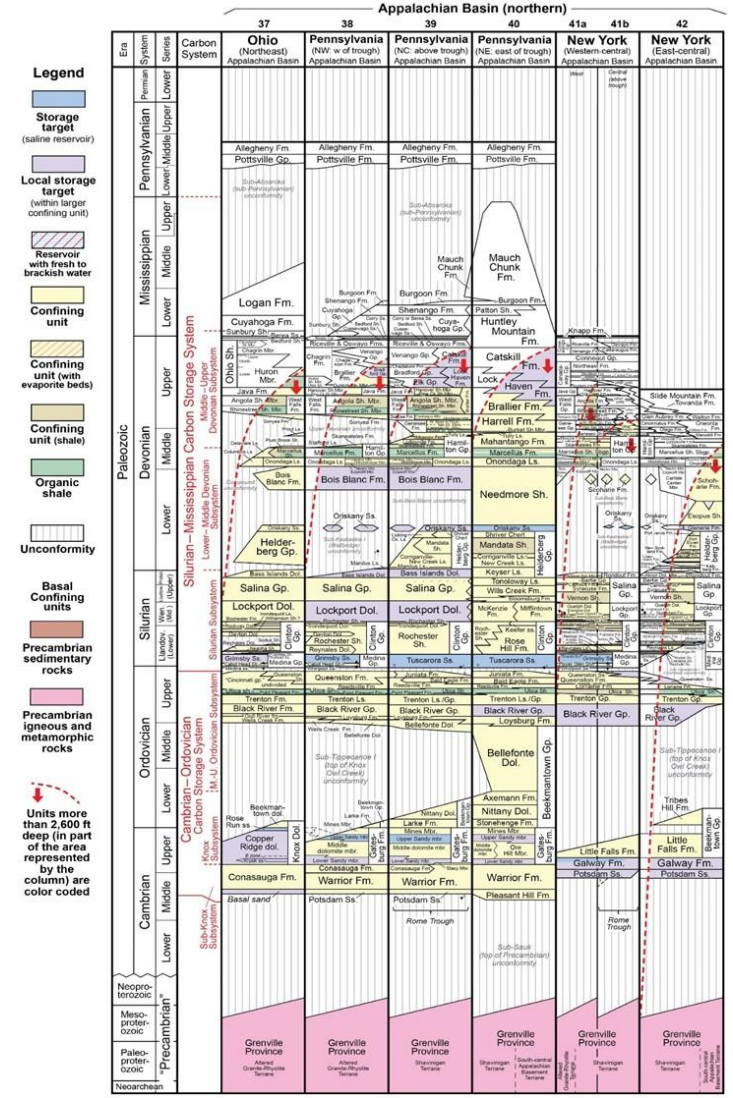
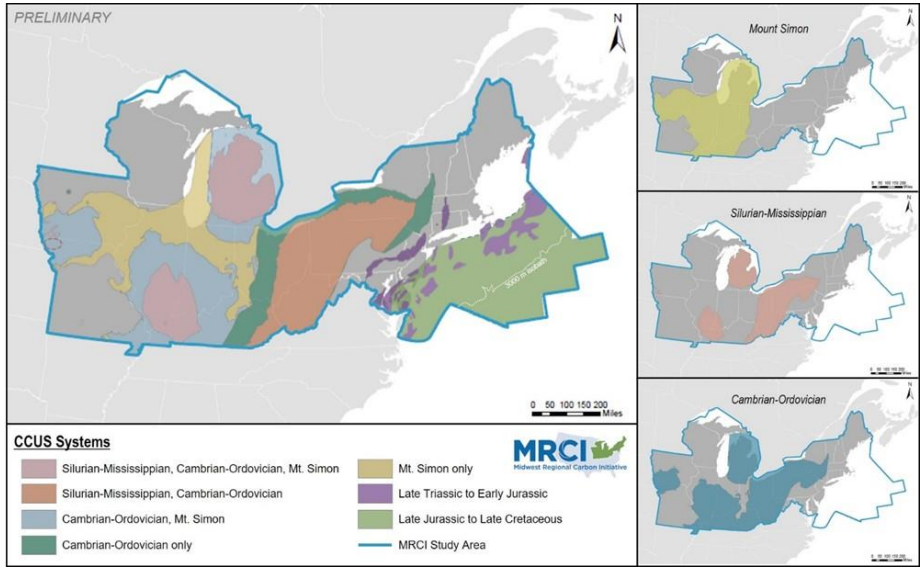
Defining Carbon Storage Systems and Resources with State Collaborators

Geologic provinces and basins were subdivided into geologic sub-regions on the basis of stratigraphy. Stratigraphic columns were developed for each sub-region and used to identify potential reservoirs and seals







Potential reservoirs and seals were grouped into five “mega” CS systems (Cambrian; Cambrian-Ordovician; Silurian-Mississippian; Late Triassic-Early Jurassic; and Late Jurassic-Cretaceous).

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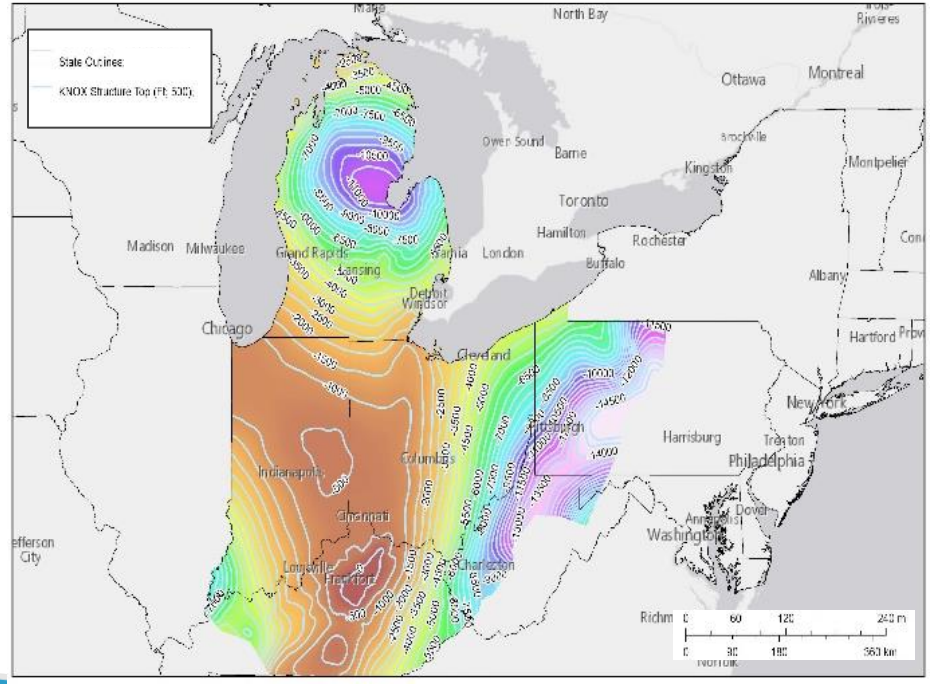
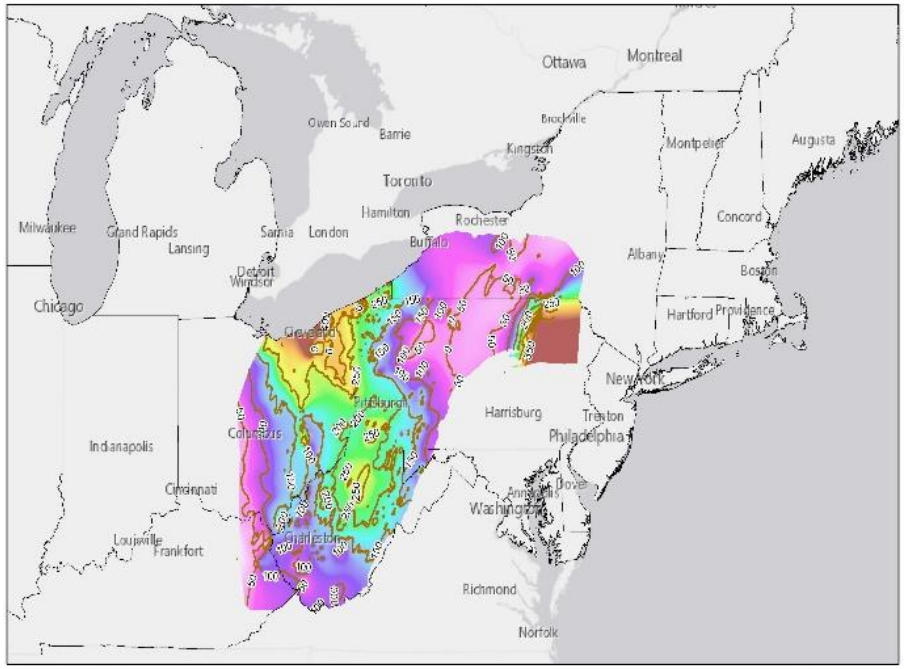
Developing a Geologic Maps Database for Site Assessment

Maps for key geologic units (depth, structure, thickness, available property data (porosity)) were compiled into an interactive ArcGIS map database containing over 600 maps.

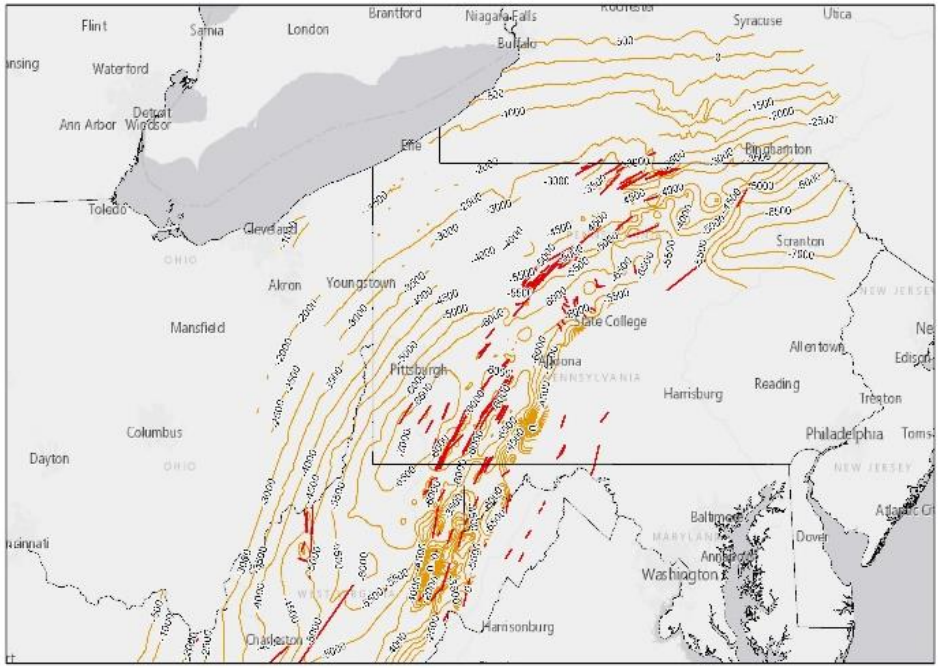
Knox Structure Top



Onondaga Thickness



Oriskany Structured Top and Faults



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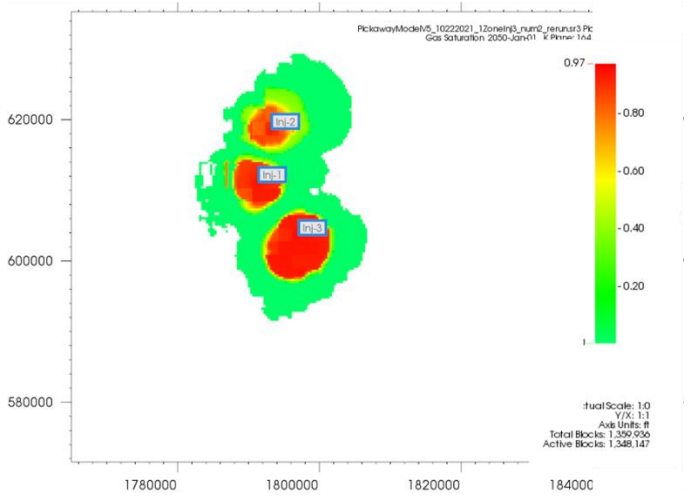
Modeling Commercial-Scale Injectivity of Different CS Systems – Moving up the SRMS Ladder

Models were developed for selected CS systems to evaluate their feasibility for hosting a commercial-scale storage project (assumed to be >1 MMT CO_2 per year >30 years).

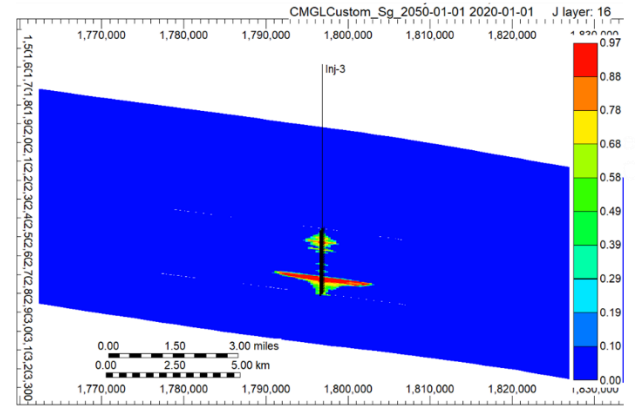
Modeling determined the number/spacing of injection wells and approximate Area of Review (AoR; i.e., CO_2 plume area and pressure-impacted area) required to accommodate the target injection rate/quantity of CO_2.

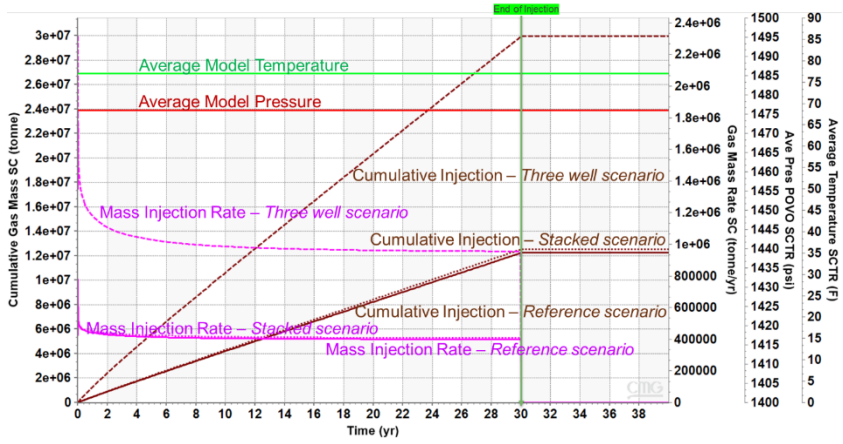
Pickaway County, Central Ohio - Model of Cambrian Ordovician Carbon Storage System – Results indicate that the Maryville formation in Pickaway County offers a *potentially viable* commercial-scale target for CO_2 sequestration if three or more injection wells are used.

End of Injection



End of Injection





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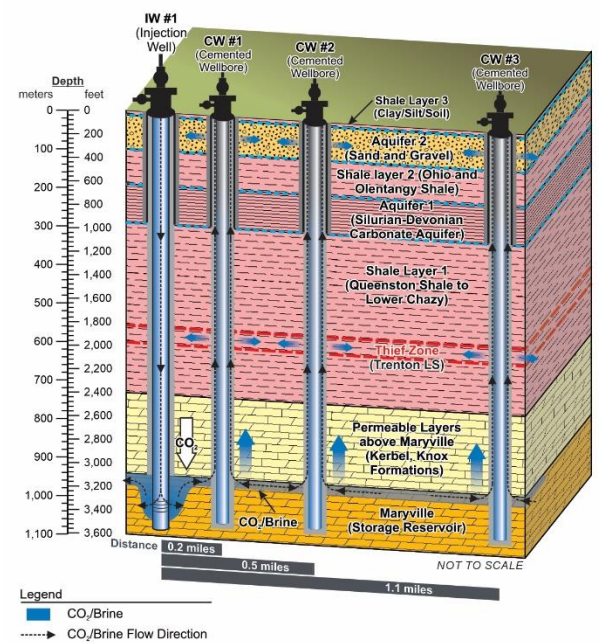
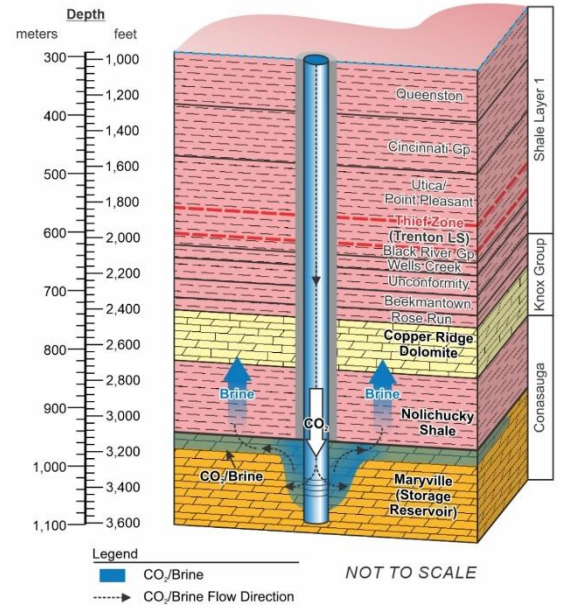
Modeling Containment Risks of Different CS Systems

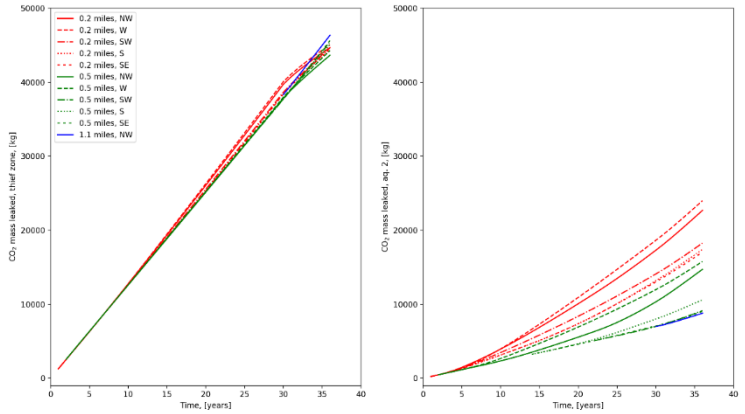
Generalized diagrams showing stratigraphy and cemented wellbore leakage pathway (left) and caprock leakage pathway (right) that were evaluated with the NRAP-Open-IAM Model and Seal Horizon Model.

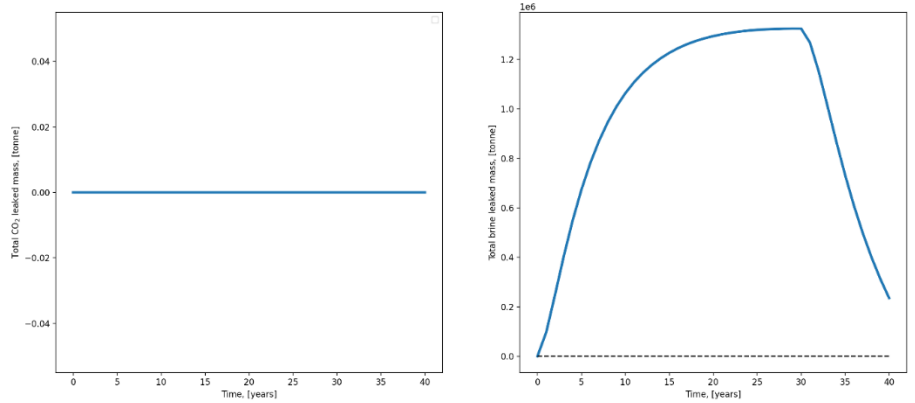
Cemented Wellbore Leakage: mass of CO_2 leaked into Thief Zone (left plot) and Aquifer 2 (right plot) via hypothetical cemented wells at various distances from the injection well.

Caprock Leakage: Cumulative CO_2 mass (left plot) and Brine mass flux (right plot) over time across the Nolichucky Seal









Cemented Wellbore Leakage Scenario

Caprock Leakage Scenario

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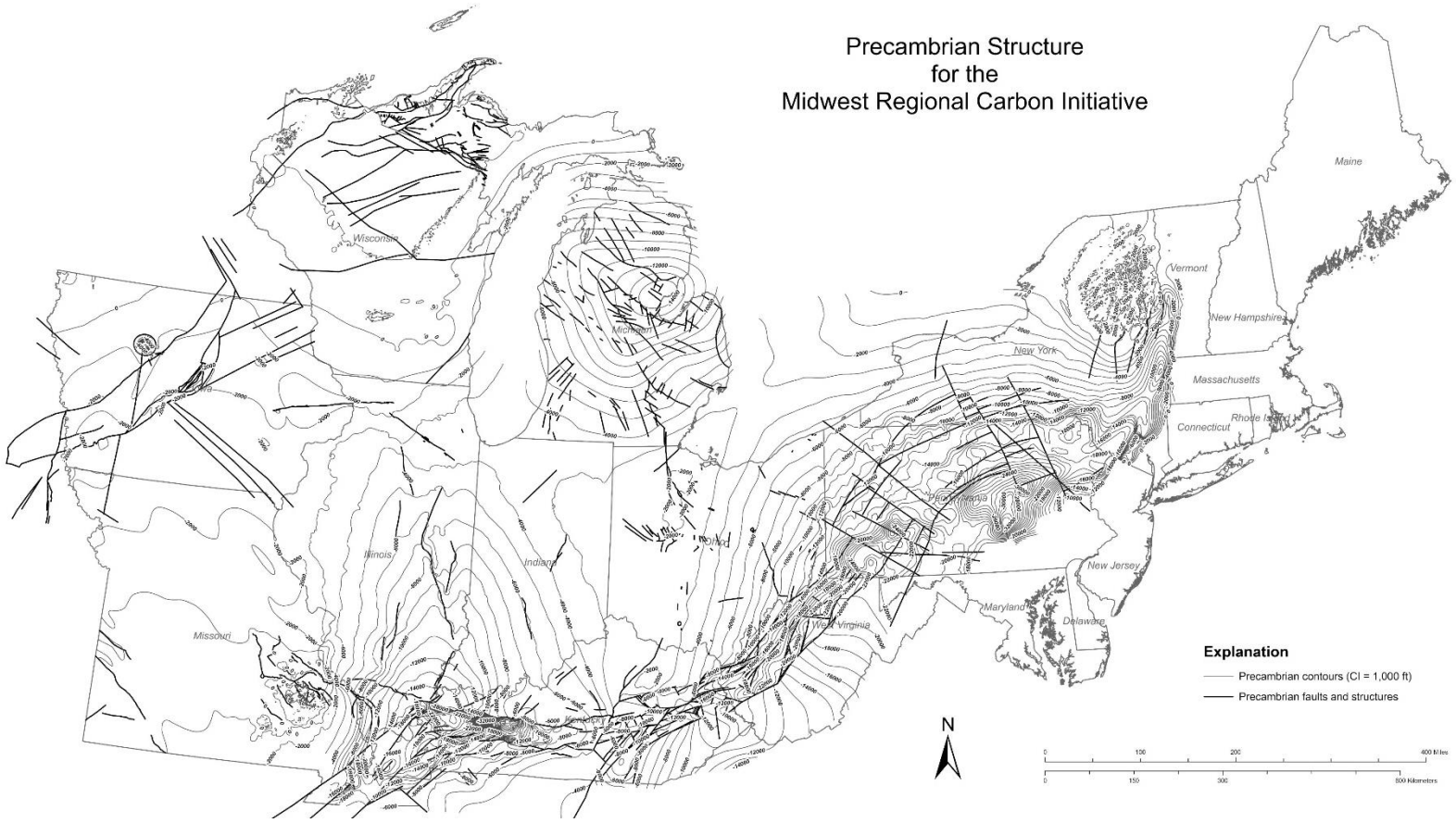
Precambrian Structure, Faults and Stress

- A regional Precambrian structure surface was compiled from multiple sources
- Regional faulting at the Precambrian surface was included
- Precambrian sedimentary and igneous rift fill locations were added to the map
- In the coastal plain and Atlantic offshore, Triassic rift basins were added
- A Precambrian crystalline (metamorphic-igneous) province and terrane map was made for the surface

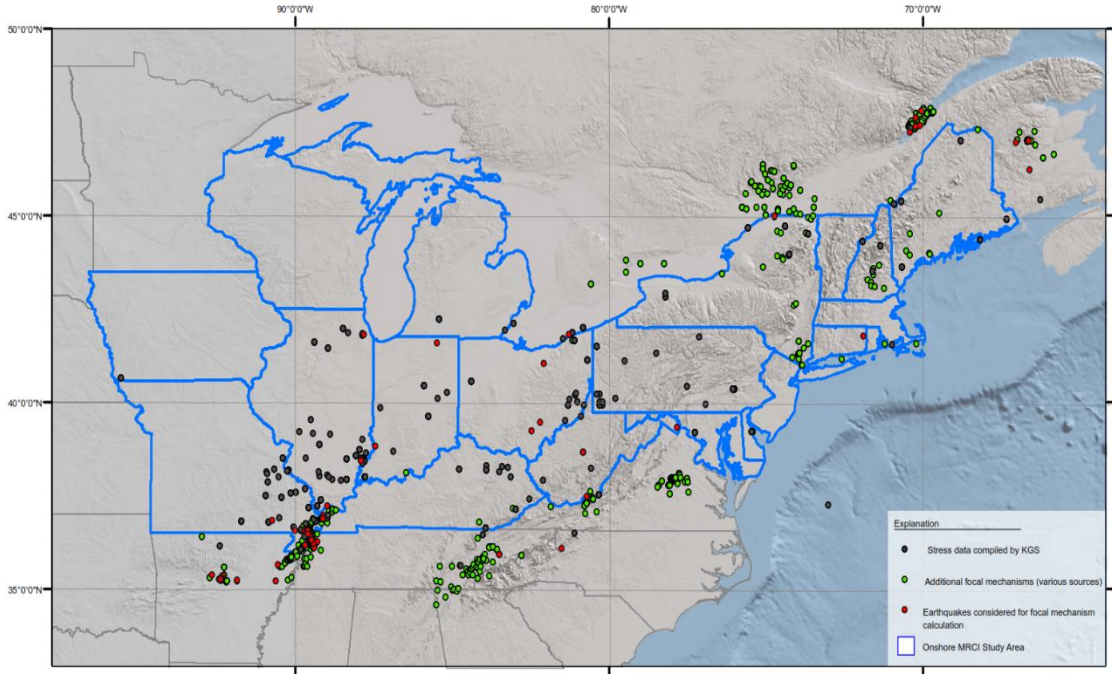


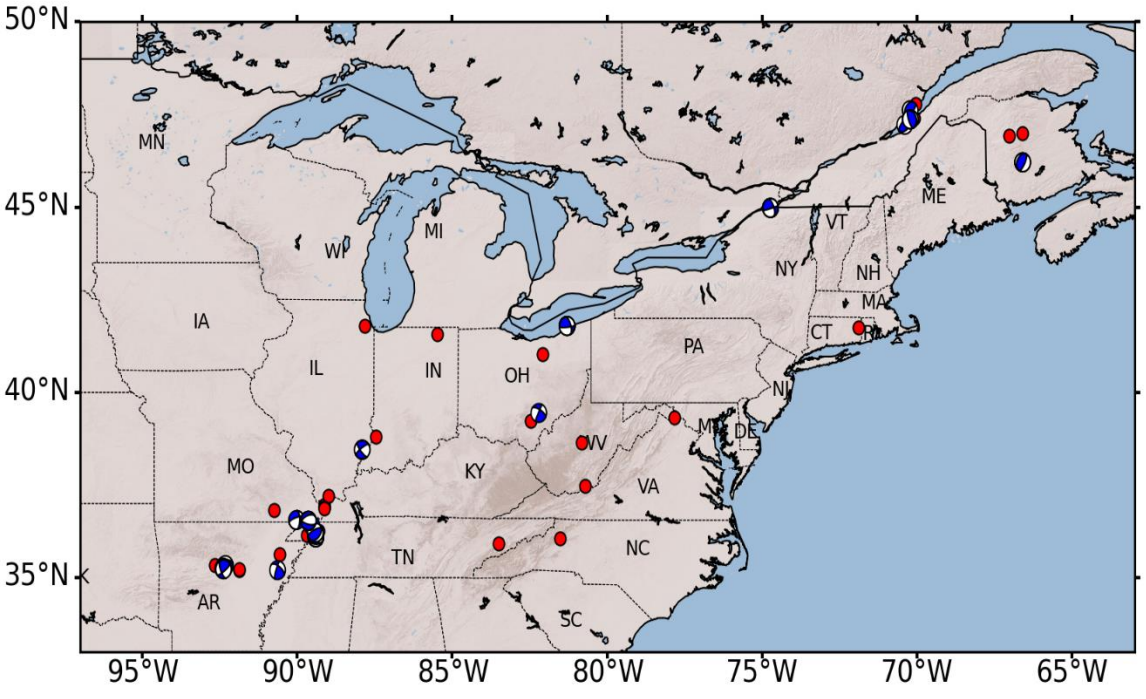
Additional Crustal Stress Data from Earthquake Focal Mechanisms (FM)

- New Stress Data Complied by KGS
- Additional FMs from Existing Catalogs
- Earthquakes Considered for FM Calculation (63 events)

New focal mechanisms determined for magnitude 3 and greater earthquakes identified in the MRCI catalog

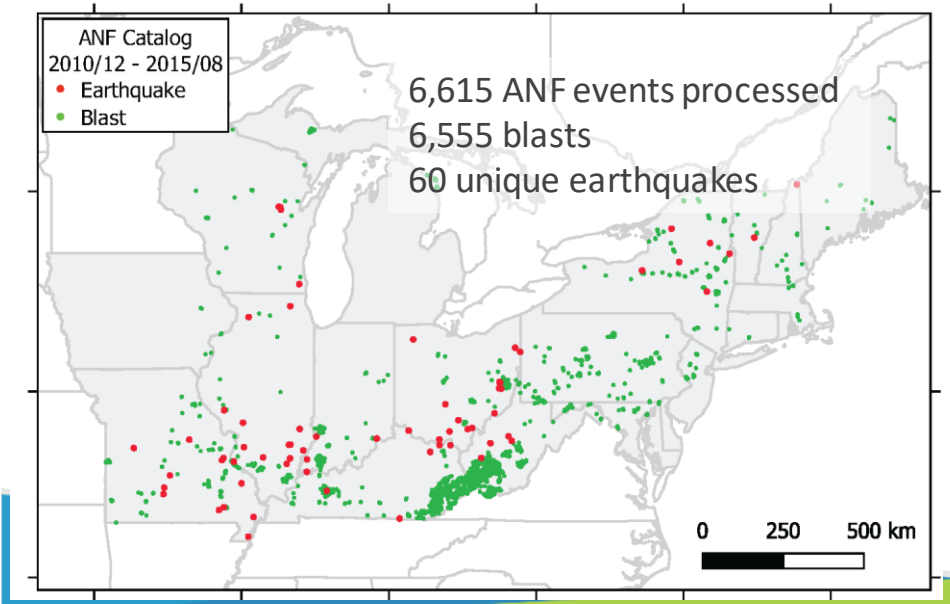
- FM not Constrained by Data
- Well-Constrained FM (25 of 63 events)

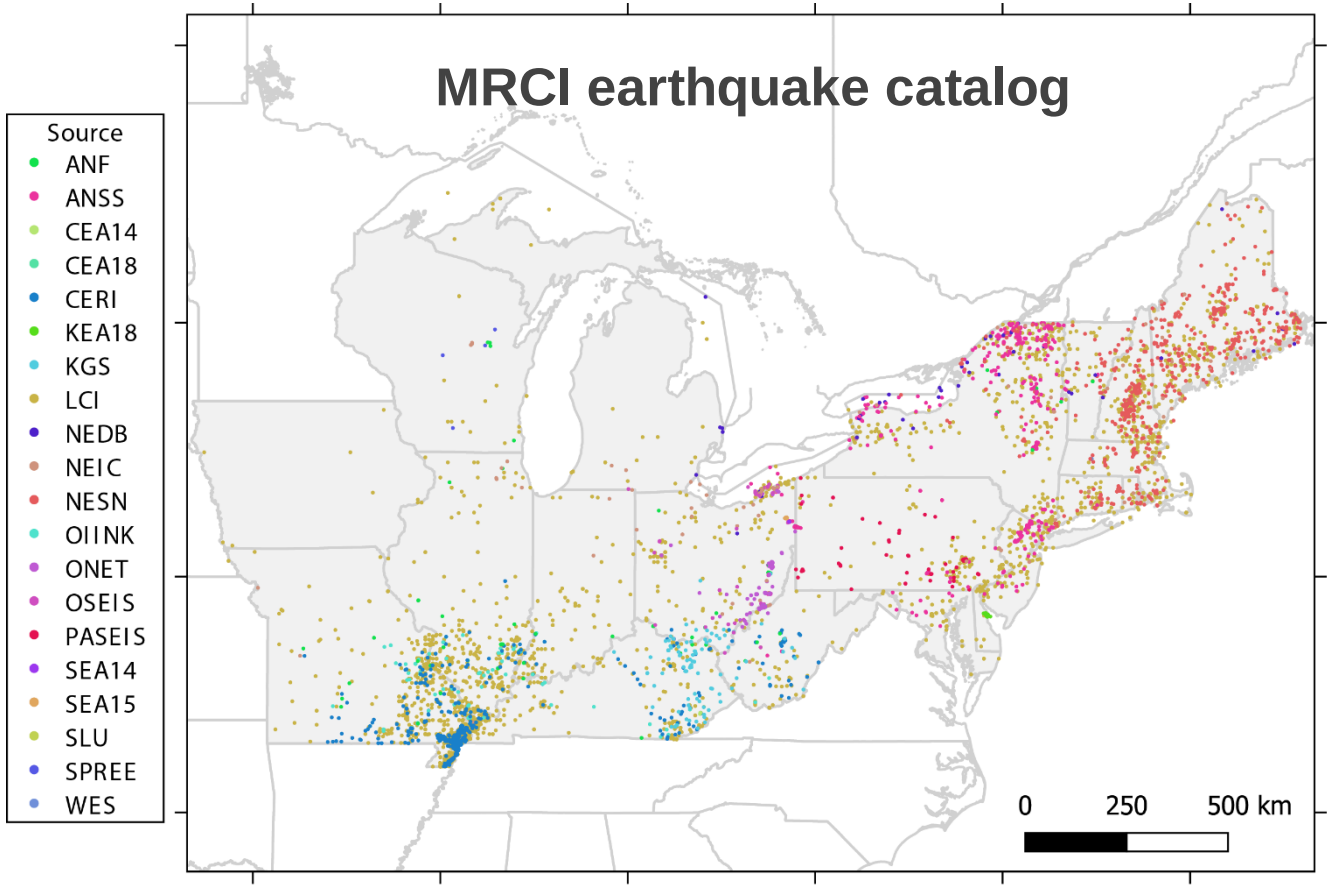




Induced Seismicity Potential

- Compiled lists of earthquakes from 1568-2020
- 20 sources:
  - national and state geological surveys
  - monitoring networks
  - published compilations
  - research papers
  - personal communications
  - EarthScope (ANF)
- 8,122 unique earthquakes
- Common magnitude scale calculated





Source	Count
ANF	61
ANSS	414
CEA14	8
CEA18	73
CERI	1846
KEA18	13
KGS	93
LCI	3551
NEDB	46
NEIC	103
NESN	592
OIINK	105
ONET	868
OSEIS	74
PASEIS	61
SEA14	140
SEA15	69
SPREE	4
WES	

The ANF database:

- Developed by nearly uniform monitoring by EarthScope's Transportable Array
- Composed of mostly blasts
- Machine-learning-base classifier identified 60 previously unknown earthquakes.

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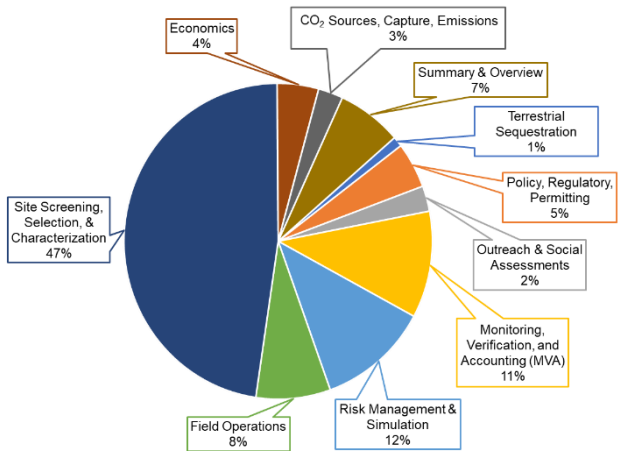
MRCI Research, Projects, Datasets

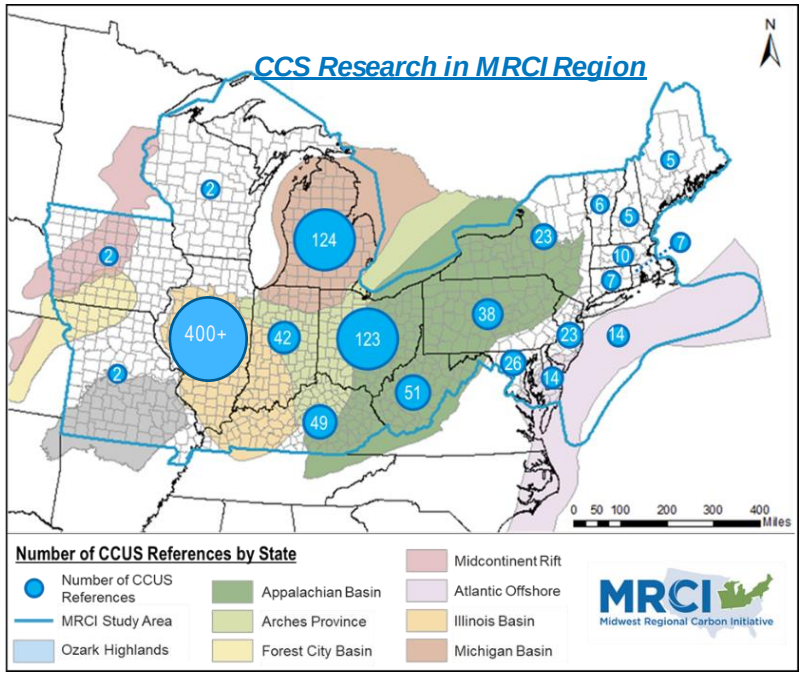
Facilitating Data Collection, Sharing, and Analysis

Over 930 reports, presentations, posters, technical papers, datasets inventoried from previous research on carbon storage in MRCI region

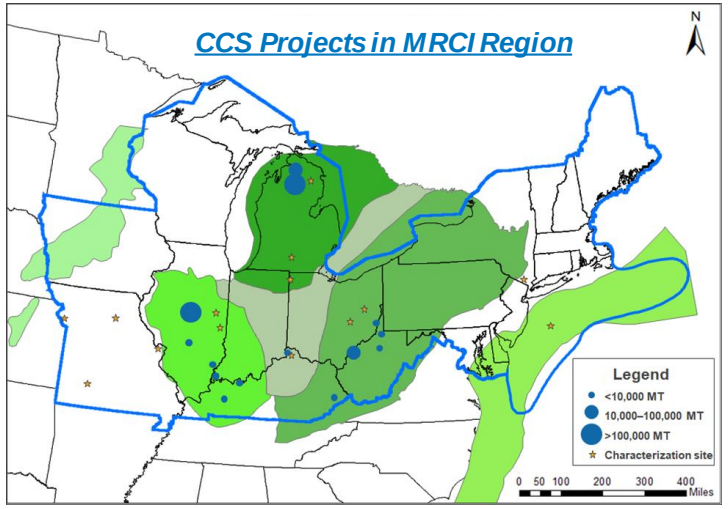
CCS Research Categories in MRCI Region



CCS Research in MRCI Region



CCS Projects in MRCI Region



Technology Development in MRCI Region

Applied Research: TRL 2–4
- Proof-of-concept testing
- Lab/bench-scale
- Integration of components
- Short duration, low–moderate cost
- Simulated conditions

Development: TRL 5–6
- Evaluation of performance
- Pilot field testing
- Small-scale CO_2 injection
- Longer duration, higher cost
- In situ operating conditions
- Relevant to a project lifecycle

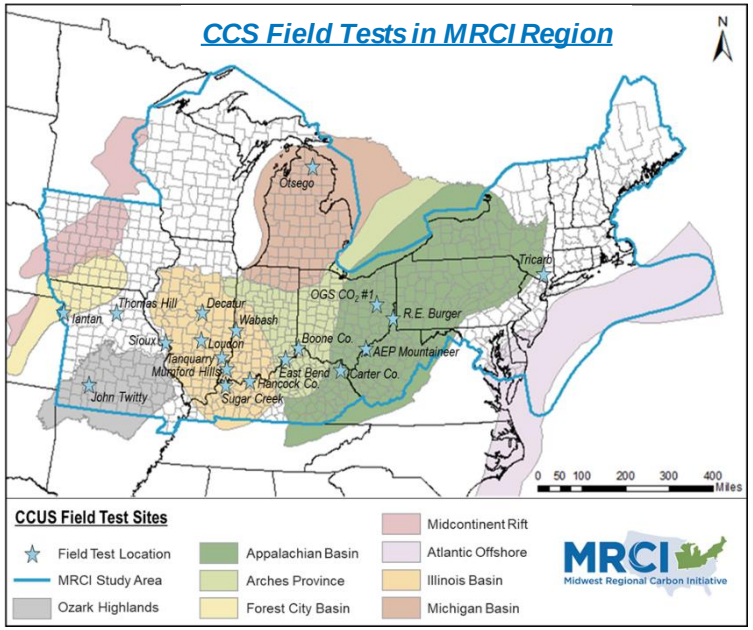
Demonstration: TRL 7–9
- Full-scale commercial application
- Large-scale CO_2 Injection
- Extended duration, major costs
- Variable operating conditions
- Relevant to all phases of a project's full lifecycle

Characterization & Feasibility CCS Projects
- MGSC Phase I
- MRCSP Phase I
- Mid-Atlantic Offshore
- OCDO
- CarbonSAFE Phase I

Pilot-Scale CCS Projects
- MGSC Phase II Tests
- MRCSP Phase II Tests
- AEP Mountaineer
- Southern MI Advanced CO_2-EOR

Large-Scale CCS Projects
- MGSC Phase III Illinois Basin Decatur Project
- MRCSP Phase III Michigan Basin
- CarbonSAFE IL Phase III

CCS Field Tests in MRCI Region



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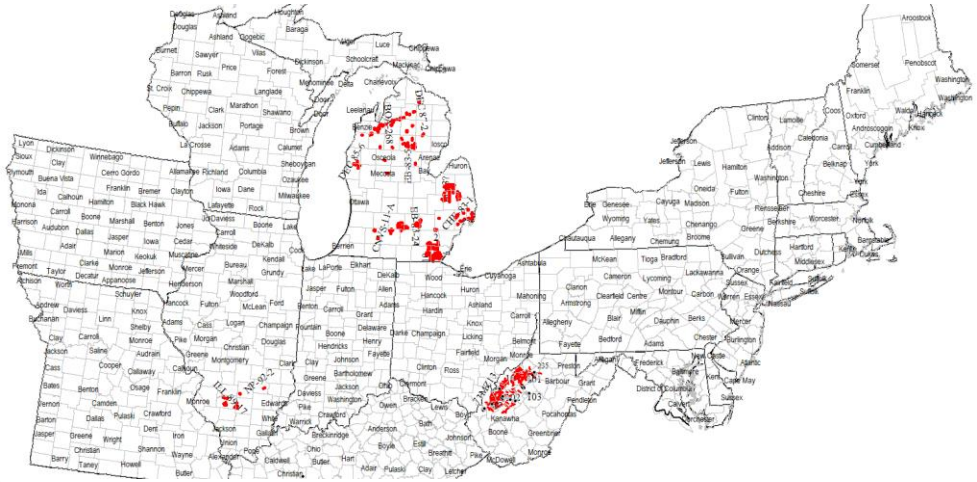
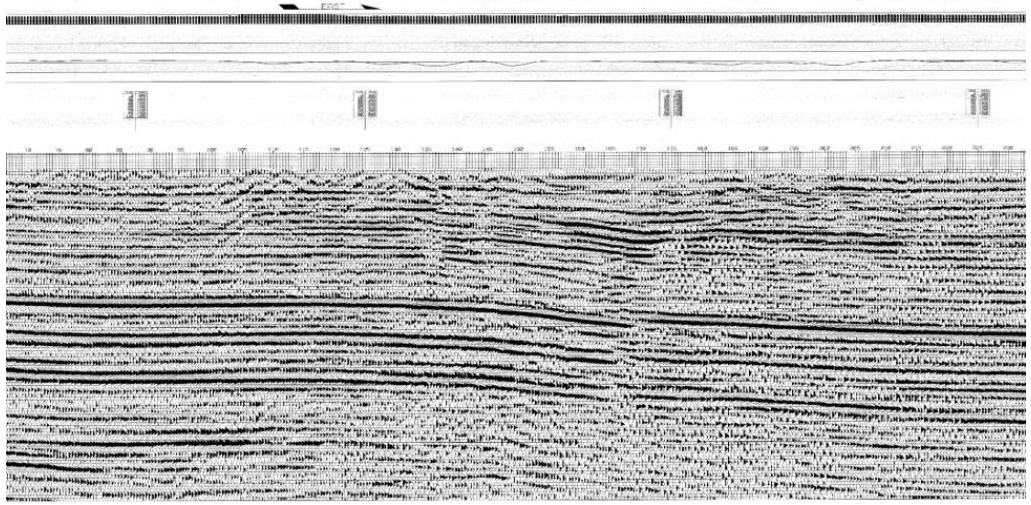
Leveraging Legacy Seismic Datasets

Legacy seismic data was obtained ,organized, summarized, and digitized so that it may support CCS in the MRCI region:

- 832 linear miles of 2D seismic data
- 43 square miles of 3D seismic data
- 57 boxes containing CD's, cassettes, reels, field data, and paper seismic
- Six oil & gas operating companies with data from Illinois, Michigan, and Appalachian Basins

The seismic lines were cataloged in terms of acquisition parameters, vintage, quality, location, and resolution.





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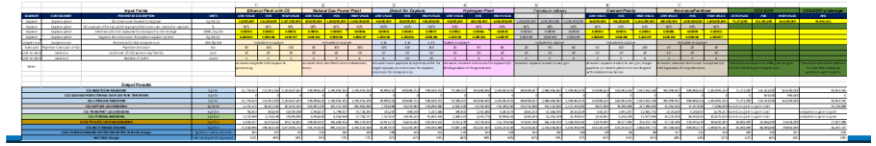
Additional Data Analyses

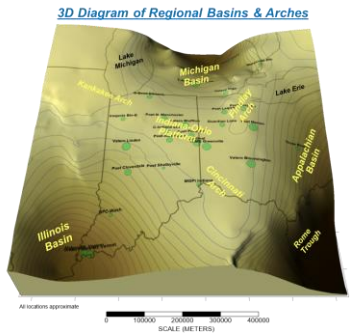
- **Planning and Executing Additional Data Analyses**
- *Additional analysis completed with existing CCS datasets for MRCI:*
- *Class I & II Underground Injection Control well injectivity analysis*
- *Central MRCI Ethanol Plant CCS Screening Study*
- *Greenhouse Gas Emissions Life Cycle Analysis for MRCI Sources*
- *ACT collaboration for micro-seismicity*
- *Machine learning for downhole pressure/temperature prediction*
- *CT scan for carbonate porosity zones*
- *NRAP tool validation with field data in MRCI*

GHG LCA Net CO_2 Storage

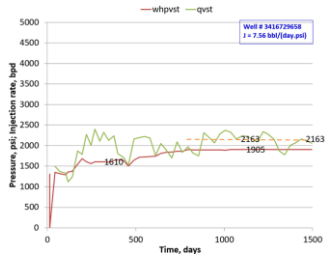
- Ethanol Plant with CS (82-90%)
- Direct Air Capture Plant (59-90%) (depending on energy source for capture)
- Petroleum refinery (NA)
- Fertilizer/Ammonia Plant (87-88%)
- Natural Gas Power Plant (71-76%) (accounting for displaced electricity)
- Hydrogen Plant (88-90%)
- Cement Plant (90-91%) (new facility)
- CO2-EOR (59-66%) (not including downstream combustion of fuel products)



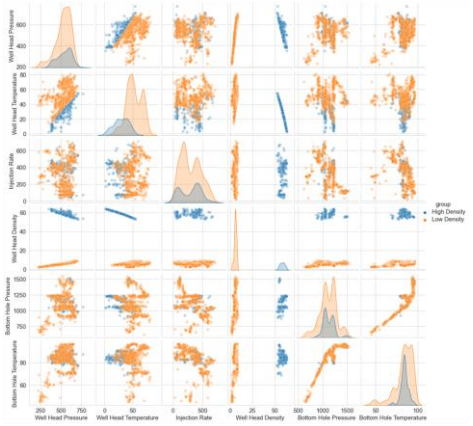
Central MRCI Ethanol Plant CCS Screening



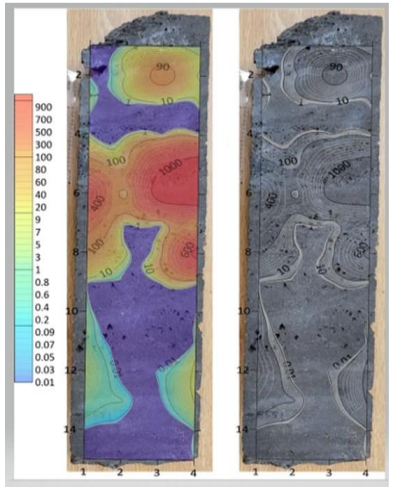
Class II UIC Well Injectivity Analysis

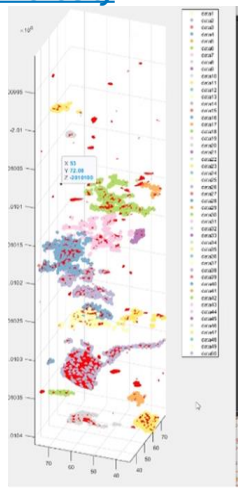


Machine Learning for Bottomhole Pressure/Temp



CT Scan of Carbonate Porosity





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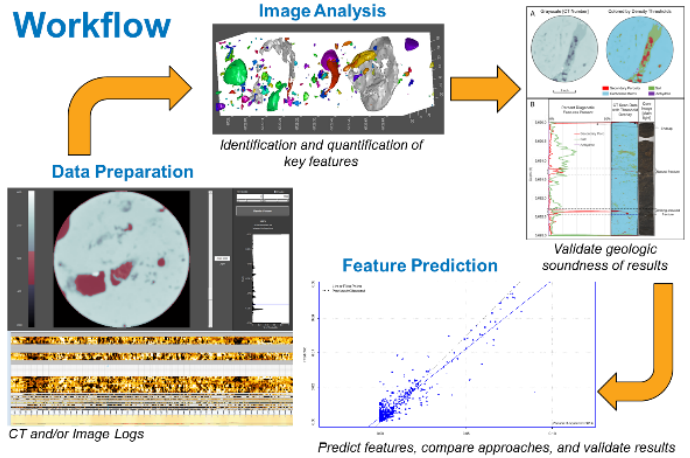
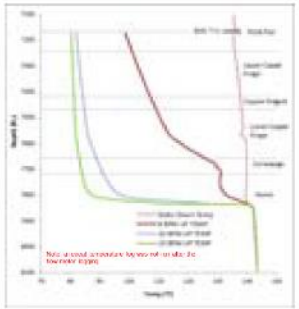
SMART Initiative

- Machine Learning
  - Topic areas identified for ML analysis
    - BHP/BHT Prediction from Wellhead Data Using Machine Learning
    - Carbonate Characterization using 2D and 3D Images to Predict Reservoir Properties
    - DTS/DAS processing and interpretation
  - Preliminary work plans were developed for these ML topics.
  - The project team discussed integrating data from the MGSC, MRCSP, and other portions of the MRCI into the ML efforts. These data included items like injection operational pressure/temperature data, geophysical log data, core CT scans, geophysical logs, and CO_2 storage monitoring data.



Temperature Logging (Well C)



- The temperature logs run with the dynamic logging passes show that the borehole above ~7,850 ft. underwent cooling – i.e., there is no injectivity below ~7,850 ft.
- A repeat temperature log was not run after the spinner-meter logging runs.

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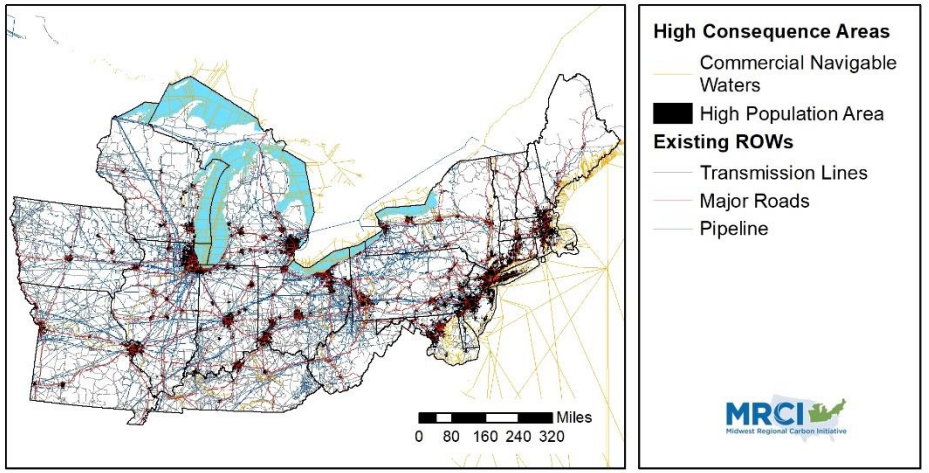
Rethinking infrastructure for Carbon Capture, Utilization, and Storage (CCUS)

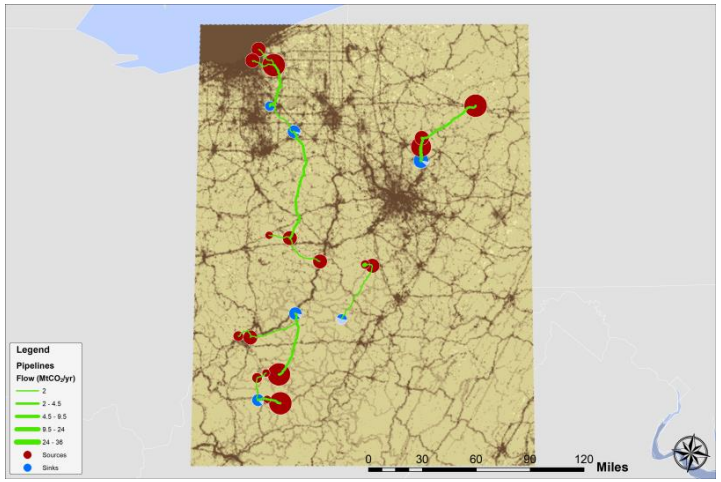
Researching the infrastructure of CCUS is more than just the physical equipment that enables CCUS; it also includes the policy, economics, and people that make CCUS work.

Evaluating Regional Infrastructure

GOAL: Evaluate current infrastructure and future needs to accelerate CCUS deployment

- Conduct a screening level assessment of surface and subsurface infrastructure
- Assess **site readiness** to rank areas
- Conduct analysis of **social, economic, and workforce development** factors
- Analyze current **regulatory, pore space issues**, gaps, policy, and tax incentives





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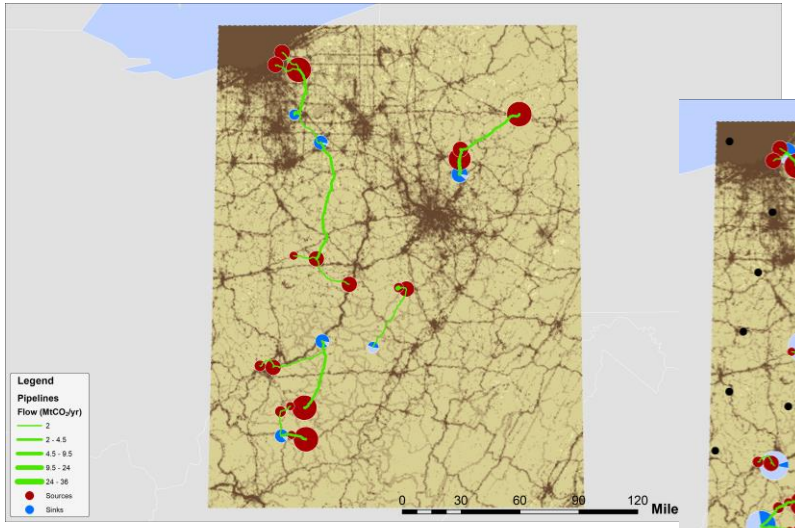
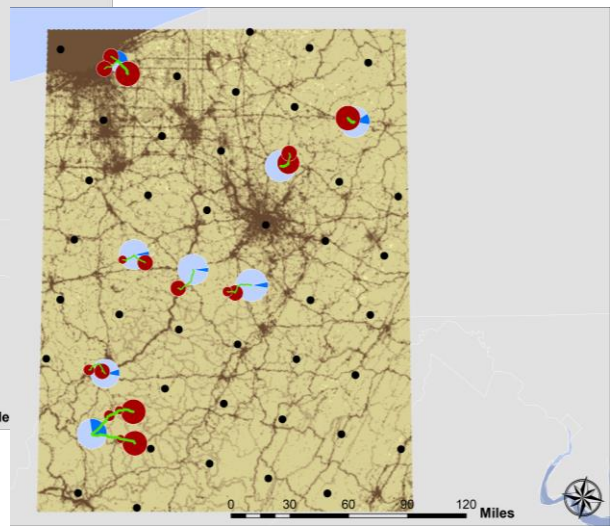
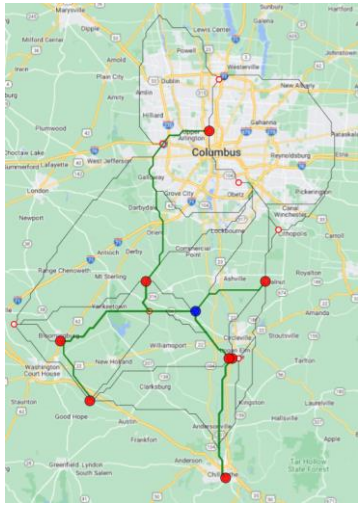
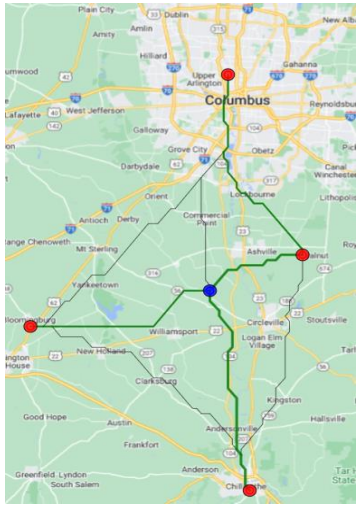
Infrastructure Development Strategies

- Investigate infrastructure development strategies for distinct MRCI projects:
  - (1) Distributive–Ohio/Pennsylvania/West Virginia
  - (2) Hub–Northern Michigan,
  - (3) Hub–Indiana,
  - (4) Local–Central Ohio, and
  - (5) Offshore–Mid-Atlantic/Northeast
- Emerging technologies: Blue Hydrogen, BioEnergy with CCS (BECCS), and Direct Air Capture (DAC).









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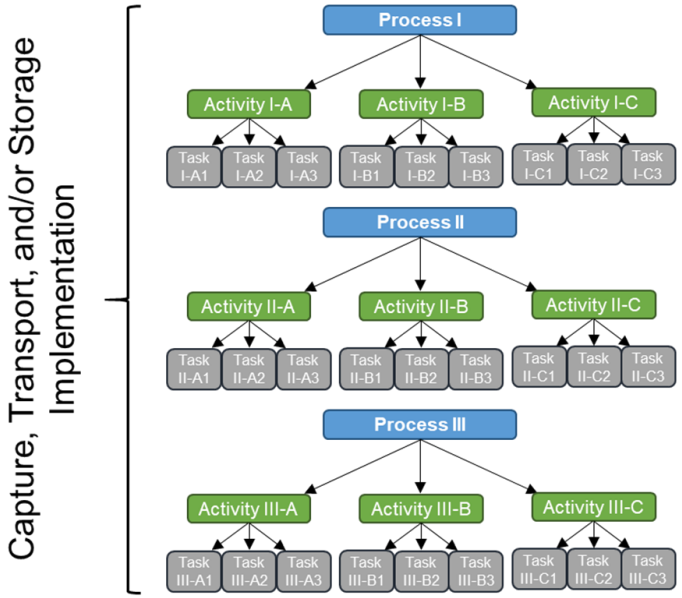
Evaluating Regional Infrastructure Progress



United States® Census Bureau

2020 Census Results

United States® Census Bureau

Quarterly Workforce Indicators

EPA United States Environmental Protection Agency

EJScreen

NCES National Center for Education Statistics

CIP THE CLASSIFICATION OF INSTRUCTIONAL PROGRAMS

-Evaluating jobs using input-output models.
-Calculating projects expenses, benefits, and tax.

Jobs and Economic Impact

-Conducting community characterization.
-Researching environmental justice and sustainability.
-Working with outreach task.

Social Characteristics

-Determining workforce characteristics.
-Outlining workforce needs.
-Identifying training institutions.

Workforce Development

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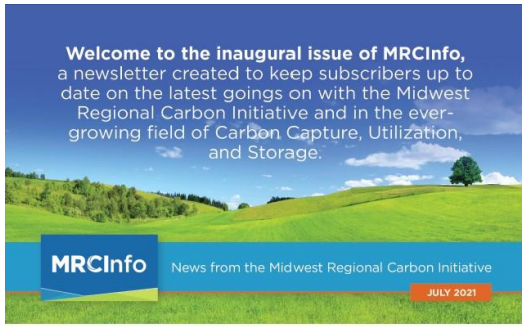
Promoting Regional Technology Transfer

GOAL: Leverage existing and new relationships with critical CCUS stakeholders within the RI and globally and become a key resource for CCUS development.

- Promote acceleration of CCUS deployment by providing general support for commercialization and technology transfer
- Compile and communicate information from previous tasks to interested stakeholders
- Engage with federal and state governments, industry consortia and NGOs
- Engage with global institutions



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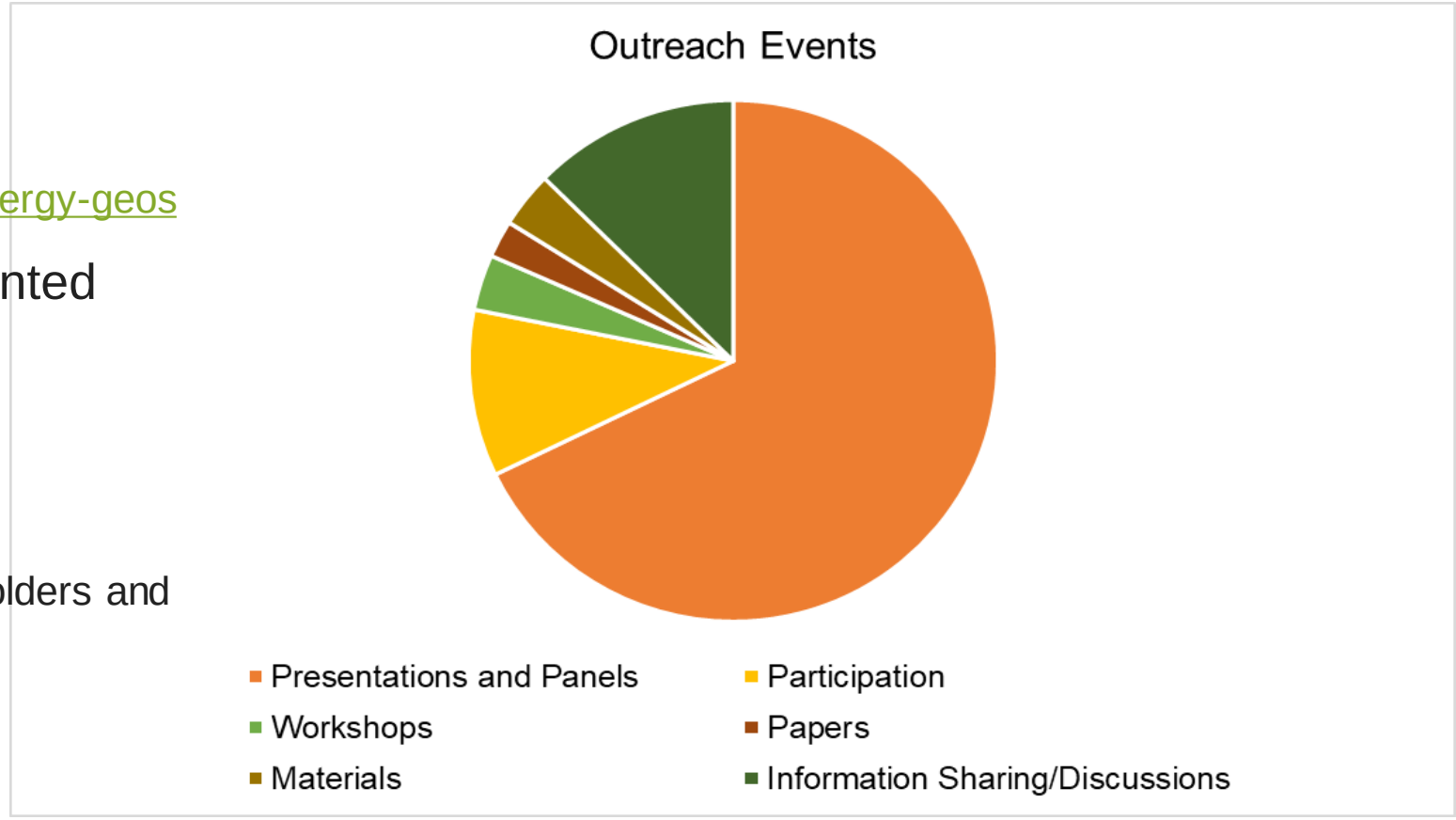
Promoting Regional Technology Transfer

- Website development is ongoing
  - www.midwestccus.org
- Bi-monthly newsletters
- CCUS Podcast - https://soundcloud.com/energy-geos
- Numerous outreach activities documented
  - Technical presentations and panels
  - Workshops
  - Event participation
  - Information sharing, discussions with stakeholders and interested parties
  - Papers
  - Materials – Fact sheets, Infographics



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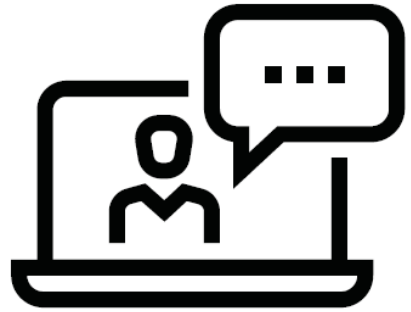
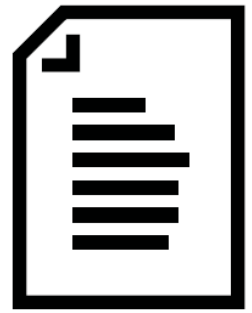
Focus on Environmental Justice

Learning, Connecting, and Informing

- Formed MRCI EJ Working Group to explore the topic, learn about its roots, and how it intersects with CCUS
- Compile and communicate information about Justice40 Initiative, Energy Communities, etc. with stakeholders
- Hosting EJ Workshop at Annual Stakeholders Meeting Sept. 27-28, 2022
- Engaging with other Initiatives on EJ in late 2022, early 2023





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Aligning Outreach Strategy with Targeted Audiences

General Public	Technical	Academic/Educators/ Students	Industry	Policy/Regulators
• Annual Meetings • Website • Newsletter • Fact sheets • Educational Videos • Podcast • Story Maps	• Annual Meetings • Newsletter • Website • Webinars • Podcast • Story Maps • Conferences and papers • Short courses	• Annual Meetings • Newsletter • Website • Fact Sheets • Educational Videos • Story Maps • Short courses • Hands-on learning opportunities	• Annual Meetings • Newsletter • Website • Fact Sheets • Podcast • Story Maps	• Annual Meetings • Newsletter • Website • Fact Sheets • Informational meetings • Story Maps • CURC engagement

- 2020-2021 considered "passive" phase, will be moving into an "active phase"
- 2022- big things planned and more engagement on state and federal levels!

Summary and Expected Outcome

- Establishment of a broad-based consortium of researchers and stakeholders
- Collection, compilation, sharing, and utilization of CCUS related data from across the region
- Assessment and analyses to improve certainty of geologic characterization underway
- Identification of viable storage reserves, including stacked storage.
- Identification of available information and methods useful for Basement characterization
- Outline source-sink scenarios and pipeline routes for CCUS
- Application of a Risk-Based Probabilistic Model to value potential risks of CCS
- Assessment of policy, economic, and social issues, including knowledge sharing materials and workforce development plans
- **MRCI Stakeholder Meeting – Columbus, September 27-28**


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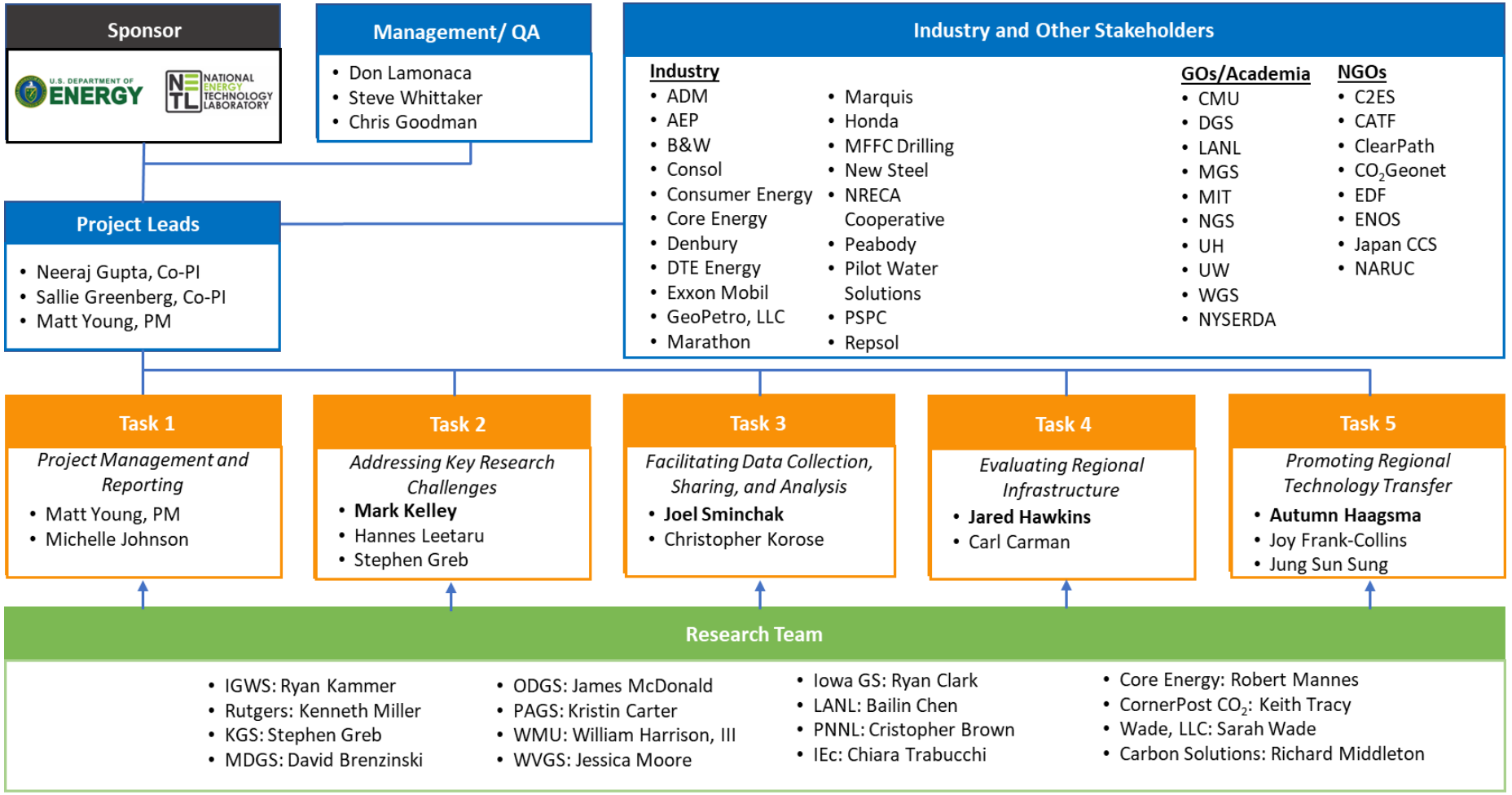
MRCI – Collaboration between Researchers, Industry, and Government, and non-Governmental Organizations



MRCI Midwest Regional Carbon Initiative

Gantt Chart

Task	Description	FY2020				FY2021				FY2022				FY2023				FY2024			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1.0	**Task Management and Planning**	1	2																		12
2.0	**Addressing Key Technical Challenges**							5		6						10					
2.1	Assessing regional/subregional framework and expanding CO_2 stacked storage characterization																				
2.2	Analyzing Precambrian Basement faulting/stress																				
2.3	Developing industrial partnership and regional technical collaboration																				
2.4	Conducting regional/subregional analysis																				
2.5	Assessing and managing risks																				
3.0	**Facilitating data collection, sharing, analysis**													9							
3.1	Inventorying of available data and analyses																				
3.2	Facilitating data sharing																				
3.3	Planning and executing additional data analyses																				
3.4	Engaging the National Laboratories' efforts																				
3.5	Engaging NRAP																				
3.6	Advising machine learning for CCUS efforts																				
3.7	Participation in DOE SMART Initiative																				
4.0	**Evaluating Regional Infrastructure**												8								
4.1	Evaluating infrastructure																				
4.2	Assessing site readiness																				
4.3	Conducting social, economic, and jobs analysis																				
4.4	Promoting commercialization and policy																				
4.5	Convening regional stakeholders for infra-structure evaluation																				
5.0	**Promoting Regional Technology Transfer**					3	4			7								11			
5.1	Facilitating regional efforts to address non-technical, permitting, and infrastructure																				
5.2	Engaging global efforts																				
5.3	Supporting policy, incentives, and business cases																				
5.4	Engaging CCUS stakeholders																				

Task POP Subtask POP Deliverable Milestone* Subtask Dependence

*Values correspond to Table 2.

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