A Play-Based Exploration of CO_2 Storage in the Illinois Basin

Nathan Webb

Principal Research Scientist, Geologist
Head – Subsurface Energy Resources Section

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Project Overview

- **Period of Performance:** 1/1/2024 to 12/31/2025
- **Funding:** $999,984 Federal Share; $251,992 Cost Share
- **Objective:** build a database using existing subsurface, surface, and societal data for entities screening areas of Illinois for commercial geologic CO_2 storage
  - Test the database using play-based exploration and analyses methods to create composite maps that clearly delineate areas in the state with the lowest risk for storage site development,
  - Share the database with DOE, the four existing RI projects, and the AOI 1 Recipients under this FOA, and
  - Provide the public with access to the database and resulting composite maps, specifically those screening Illinois for commercial storage sites or those potentially impacted by the development of such sites

Prime Contractor
Illinois State Geological Survey (ISGS)
PI: Mr. Nathan Webb
Co-PI: Mr. Carl Carman

Responsibilities of ISGS:
- Project management and planning
- Societal Considerations and Impacts Assessment and Plans
- Assemble Geospatial Database
- Define Play Elements and Criteria
- Perform Play-Based Exploration and Analysis
- Share Database, Play Maps, and Workflow

(Task 1, 2, 3, 4, 5, 6)

Subawardee
Visage Energy
(VE)

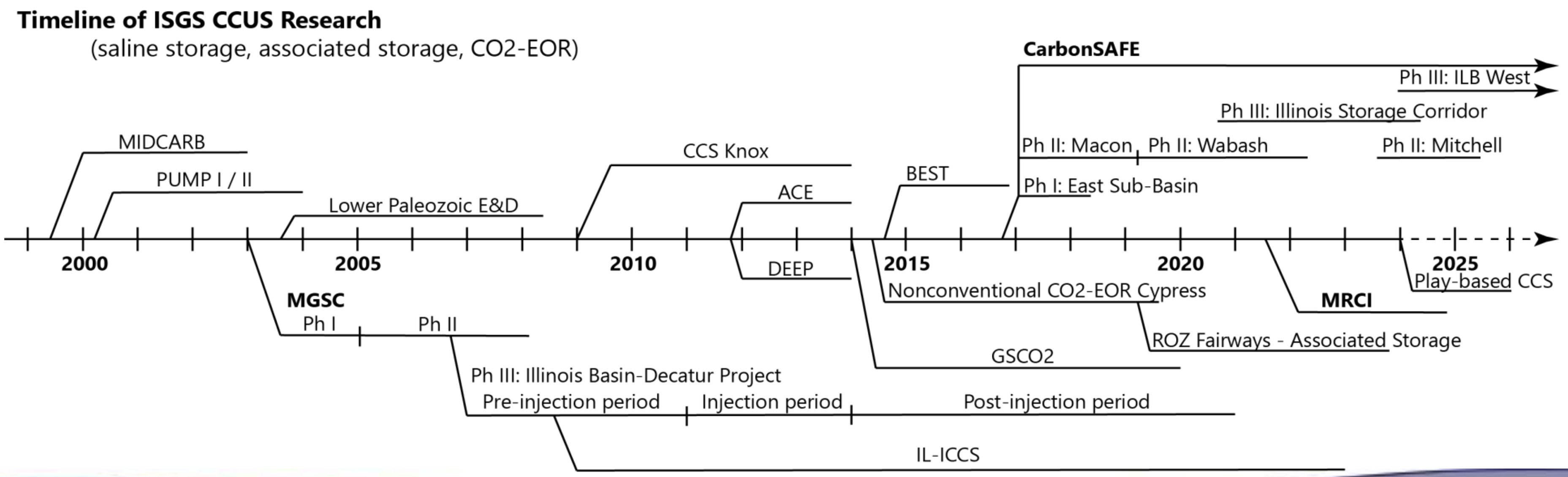
Visage CLEAN ENERGY CONSULTING

Responsibilities of VE:
- Societal Considerations and Impacts Assessment and Plans
- Assemble Geospatial Database
- Define Play Elements and Criteria
- Perform Play-Based Exploration and Analysis
- Share Database, Play Maps, and Workflow

(Tasks 2, 3, 4, 5, 6)

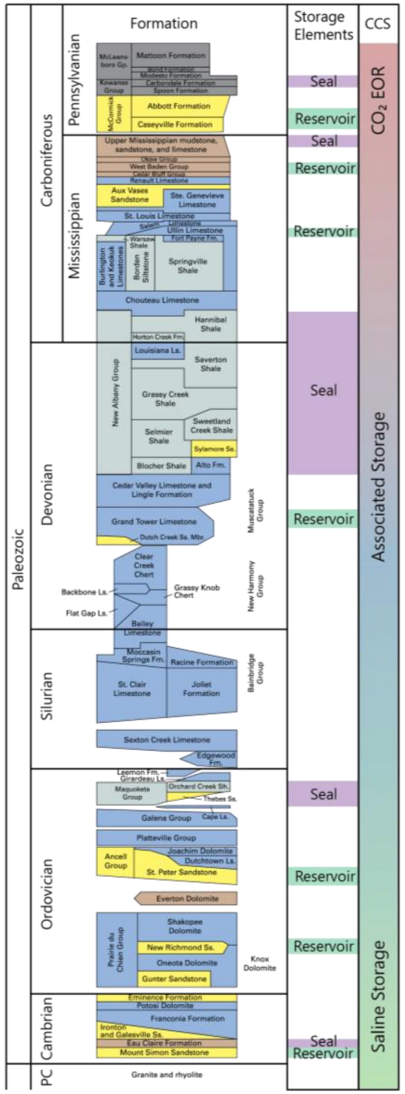
Project Background

- ISGS has been conducting CCS research for over 20 years
  - Improving understanding of ILB geology
  - Reducing uncertainty in CCS development
- Regional studies (e.g., MGSC, MRCI)
  - Data synthesis
  - Resource assessment
- Site specific studies (e.g., Illinois Basin-Decatur Project, CarbonSAFE)
  - Detailed characterization

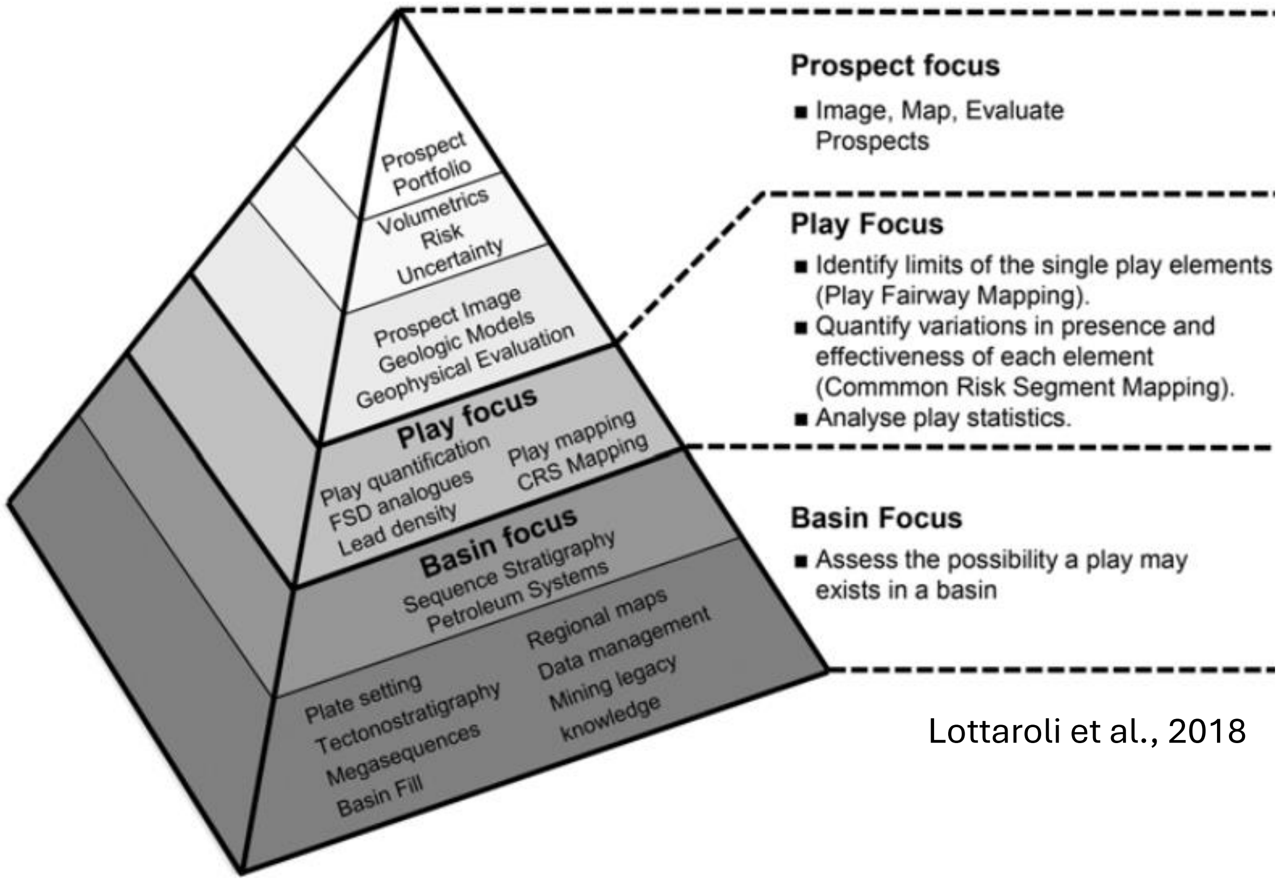


Where do we go from here?

- Deep saline reservoirs (especially the Mt. Simon Sandstone) represent the largest component in a **portfolio of CCS targets**
- Consider Illinois Basin more systematically
- Build a framework to integrate new data and rapidly re-evaluate CCS suitability anywhere in the Basin
- Sharpen focus on reducing uncertainty around CCS for developers and the public



Play-based exploration: Concept



Lottaroli et al., 2018

Strengths:

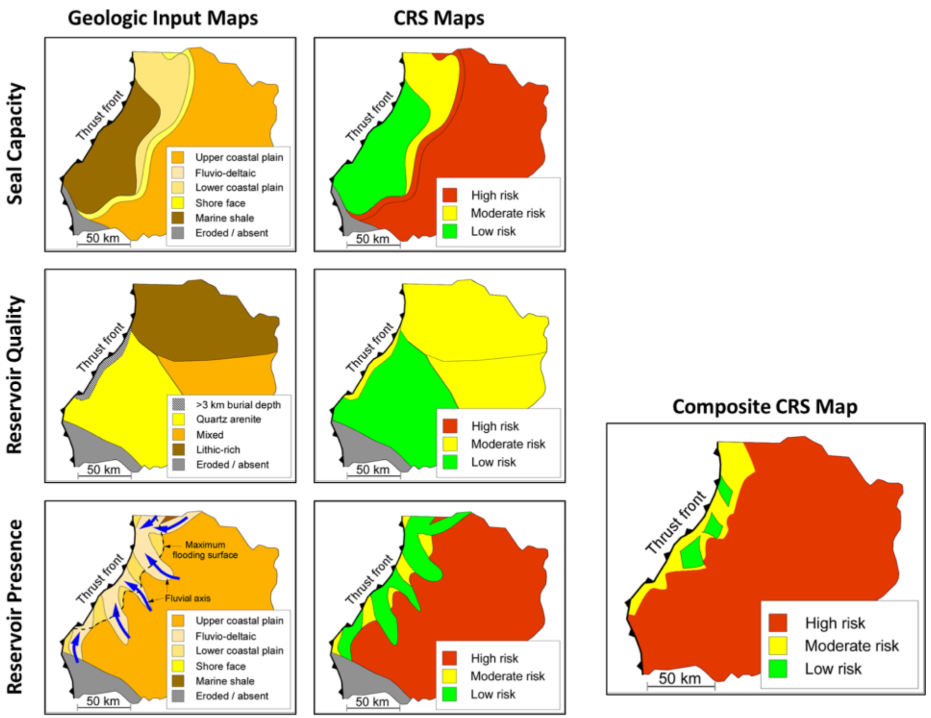
- Screening regional opportunities
- Selecting new exploration areas
- Management of complex exploration portfolios

Re-focus technique on CCS

- Basin focus reveals carbon sequestration systems
- Play focus identifies areas of high and low potential within the basin
- Prospect focus allows CCS projects to be identified, classified, and analyzed in the context of the play

Play-based exploration workflow:

- Define Play elements and suitability criteria
- Develop Play element maps
- Apply suitability criteria to Play element maps to create CRS maps
- Convolve CRS maps into composite maps to identify “sweet spots”
  - Verify composite maps reflect conceptual geologic model of the Illinois Basin



Rules of Addition

Inputs	Output
All green	Green
Any yellow but no red	Yellow
Any red	Red

Bump et al., 2021

Project Background

- Create CCS Play maps
  - Reduce exploration risk and expense
  - Create investment assurance
  - Focus future studies on the most promising sites
- Develop public website with annotated story maps
  - Facilitate communication of site selection rationale without the need for a keen understanding of CCS
- Build framework for future resource use
  - CRS maps can be redefined based on the preferred injectant (e.g., natural gas, hydrogen)
  - Play maps can be regenerated to show prospects for a range of energy storage scenarios that may compete for available pore space
  - Data synthesis is a step toward developing robust 3D models of the Illinois Basin

Major Project Tasks

- 1.0 - Project Management and Planning
- 2.0 - Community Benefits Plan
- 3.0 - Assemble Geospatial Database
- 4.0 - Define Play Elements and Criteria
- 5.0 - Perform Play-Based Exploration and Analysis
- 6.0 - Share Database, Play Maps, and Workflow

Table of Deliverables

Task Number	Deliverable Title	Due Date
~~1 / 1.2~~	~~Updated Project Management Plan~~	~~January 31, 2024~~
3 / 3.4	Geospatial Database	December 31, 2024
5 / 5.0	Annotated and Contextualized Carbon Storage Play Maps for the State of Illinois	November 30, 2025
6 / 6.1	Project Website with Story Maps	December 31, 2025
6 / 6.2	Play Based Exploration and Analysis for CCS Topical Report	December 31, 2025

Gantt Chart with Team Responsibilities by Task. Letters refer to milestones.				Budget Period 1																								Organization	
#	Task Name	Start Month	End Month	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	10/25	11/25	12/25	ISGS	VE
				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	Project activities, objectives, and milestones	1	24	A																								X	
1.2	Project management plan	1	2		B																							X	
1.3	Data management	1	24																									X	
2.0	Community Benefits Plan																												
2.1	Community and stakeholder engagement	1	24												C												C	X	X
2.2	Investing in job quality and a skilled workforce	2	8																									X	X
2.3	Diversity, equity, inclusion, and accessibility	1	24																									X	X
2.4	Justice40	1	24																									X	X
3.0	Assemble Geospatial Database																												
3.1	Subsurface dataset	1	9									D																X	
3.2	Surface dataset	1	9									D																X	
3.3	Social dataset	1	9									D																X	X
3.4	Geospatial database	8	12																									X	
4.0	Define Play Elements and Criteria																												
4.1	Play elements	1	6																									X	
4.2	Subsurface, surface, and social criteria	5	12												E													X	X
5.0	Perform Play-Based Exploration and Analysis																												
5.1	Play element maps	11	16																F									X	
5.2	Common risk segment maps	14	19																									X	X
5.3	Composite play maps	17	22																						G			X	
5.4	Volumetric analysis	20	23																									X	
6.0	Share Database, Play Maps, and Workflow																												
6.1	Share	17	24																									X	
6.2	Document workflow	19	24																									X	X

Table of Milestones		
Task	Milestone	Date
3	Complete Subsurface, Surface and Social Datasets	10/1/24
4	Define Subsurface, Surface and Social Criteria	1/1/25
5	Complete Play Element Maps	4/1/25
5	Complete Composite Play Maps	11/1/25

Task 2.0 - Community Benefits Plan

- Developed the Subsurface Energy Resources Summer Experience Program (SERSEP) to run concurrently with the ISGS Paul Edwin Potter Internship Program
  - Used “A Play-Based Exploration of Carbon Capture and Storage (CCS) of the Illinois Basin” as the foundation
  - Mentors:
    - Participated in NAGT mentorship workshop
    - Developed a curriculum that incorporated DEIA inclusive mentorship components as supported by the National Academy of Science
    - Provided skill development workshops for SERSEP participants:
      - Intro to CSS; CCS community engagement; Intro to GIS for CCS; Geospatial data collection, processing, analysis, and reporting; Intro to Story Maps in GIS; Common Risk Segment Mapping; CCS Risk Assessment; Scientific Writing Skills; and How to Compose a Literature Review

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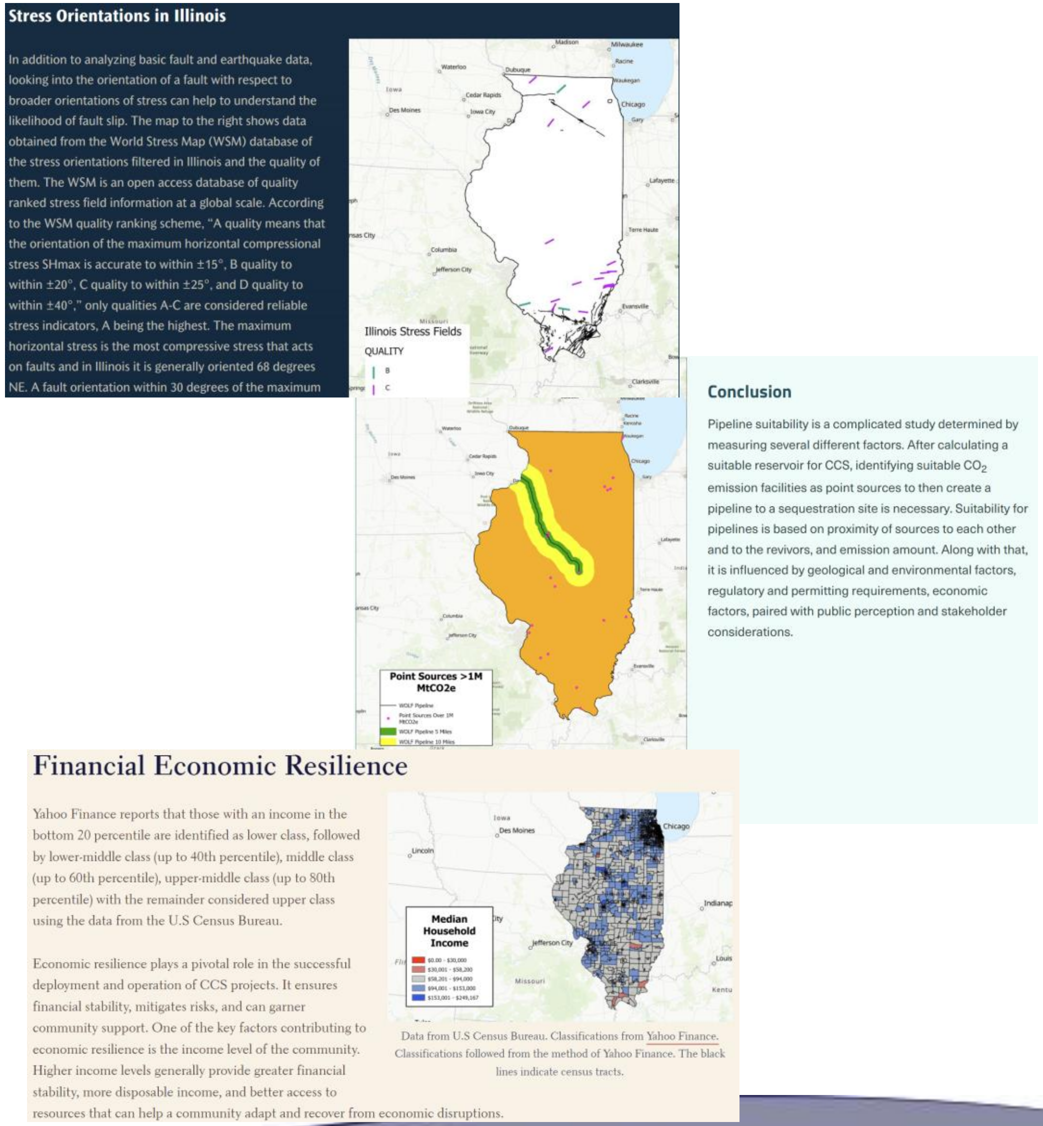
Recently, the talented Paul Edwin Potter Interns at the Illinois State Geological Survey had the incredible opportunity to visit the National Sequestration Education Center with ADM at Richland Community College!

During the tour, the Potter interns learned about ADM's groundbreaking work, including their achievement as the first American company to be granted a Class VI #CCS well permit by the US Environmental Protection Agency (EPA). ADM's CCS wells in Decatur have been successfully operating for over a decade.

The Paul Edwin Potter Internship Program immerses students in projects that address geologic issues in #Illinois. For 10 weeks during the summer, student interns work with and learn from professional geologists at ISGS.
#summerinternship #geology #carboncapture

Task 2.0 - Community Benefits Plan

- Developed the Subsurface Energy Resources Summer Experience Program (SERSEP) to run concurrently with the ISGS Paul Edwin Potter Internship Program
  - Three participants undertook a 10-week project with each focused on a single Play element
  - Stepped through Play analysis workflow:
    - Reviewed literature
    - Compiled GIS data
    - Explored mapping of Play elements to develop appropriate suitability classifications
    - Worked towards a common RAM
    - Created story maps
  - Opportunity for ISGS staff to test the Play analysis workflow and GIS tools



Task 3.0 Assemble Geospatial Database

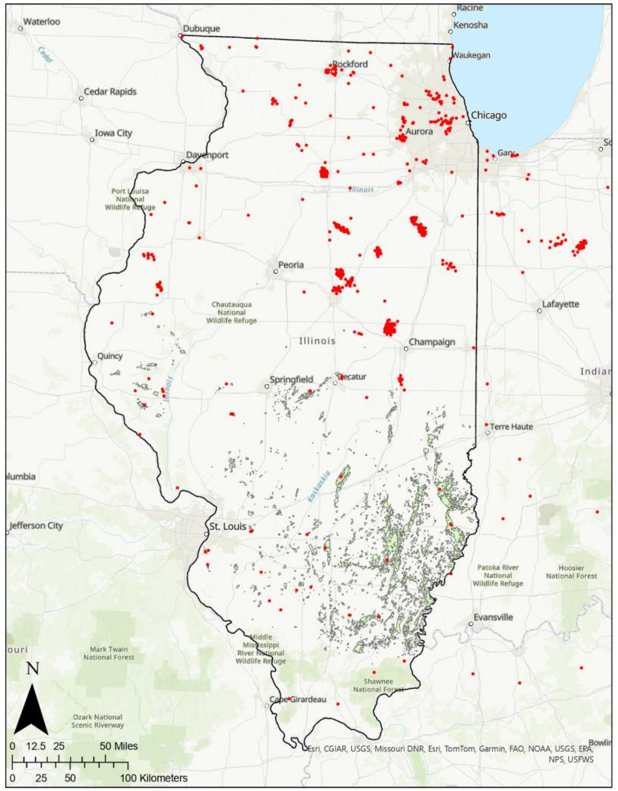
Subsurface Data

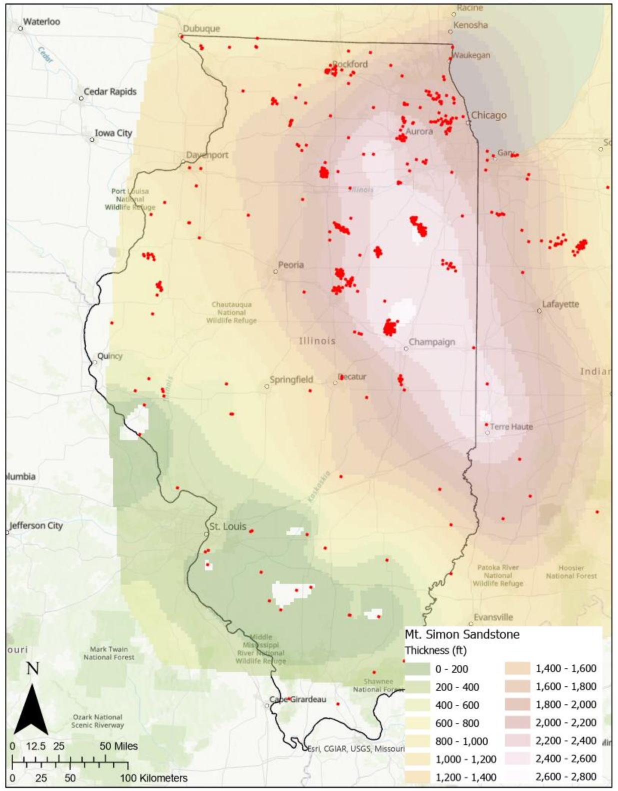
- Organized and classified 2D seismic survey data
- Worked with ISGS geoscientists to combine their stratigraphic formation tops from wells in Illinois that penetrate the Cambro-Ordovician Storage complex to build a database of control wells
- Collaborated with the DOE CATALOG team on the development and implementation of their Oil and Gas Regulatory Record digitizEr (OGRRE) tool to digitize well construction data from existing regulatory well records in Illinois

Surface and Societal Data

- Collected, reprojected, transformed and organized:
  - Surface infrastructure data, including railways and roads, and digitized proposed pipeline routes
  - EPA FLIGHT tabular data on point sources of CO2
  - Social data, including CEJST and EJScreen
  - US Census tabular data for multiple social and economic Play elements

Subsurface Data Improvement – Legacy Wells

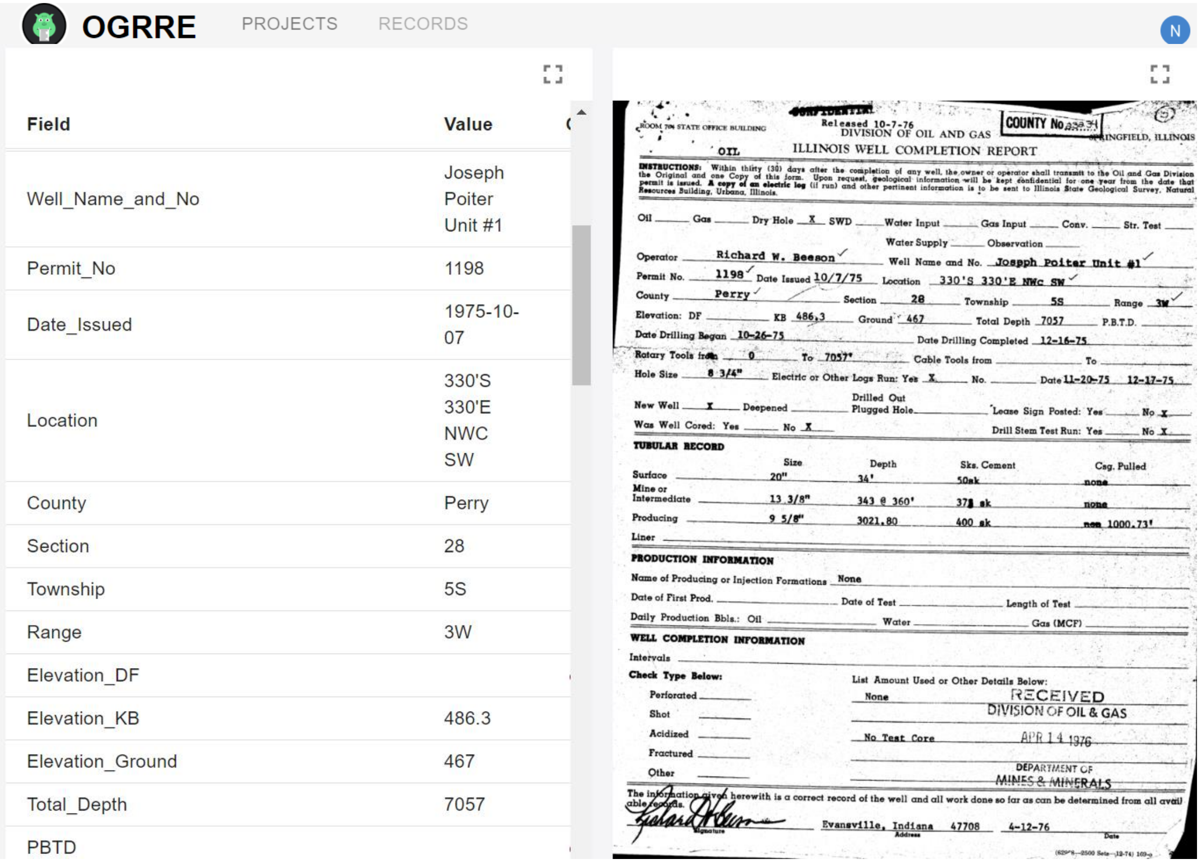




Red dots represent Mt. Simon SS legacy well penetrations

Oil fields (green polygons) approximate counties where ISGS has scanned well construction and other records

Mt. Simon Thickness approximates where there is significant interest in CCS development and where legacy well data is critical



OGRRE digitization is allowing significant improvements:

- Location
- Tubular record
- Completion intervals

Task 4.0 - Define Play Elements and Criteria

- Defined 35 play elements that will be included in the study
  - Developed a justification for each Play element based on the interpretation of possible impact on CCS suitability
- Each Play group was subdivided into subcategories (e.g., containment, storage, and groundwater for the subsurface group)
- Began developing an approach to classify suitability for CCS development using a CCS-specific RAM

				Likelihood of Impact on CCS Project				
Impact Categories			Severity of Impact on CCS Project	1-Highly Improbable	2-Improbable	3-Possible	4-Likely	5-Certain
$	HSE	⧖						
Up to $1k	No Injury; No Leakage	Delay of up to 2 weeks	1-Negligible	1	2	3	4	5
$1k to $10k	Injury: first aid; Leakage: no contamination of water supply or surface environment damage	Delay of 2 weeks to 6 months	2-Mild	2	4	6	8	10
$10k - $100k	Injury: medical procedure; Leakage: localized contamination of water supply or surface environment; additional monitoring required	Delay of 6 to 12 months	3-Moderate	3	6	9	12	15
$100k - $1,000k	Injury: permanent; Leakage: reversible contamination of water supply or surface environment, remediation required	Delay of 1 to 2 years	4-Severe	4	8	12	16	20
> $1,000k	Injury: fatality; Leakage: irreversible contamination of water supply or surface environment	Delay of 2 or more years	5-Catastrophic	5	10	15	20	25

Task 4.0 - Define Play Elements and Criteria

Play Element: Subsurface Examples →

- Data from:
  - Wells (e.g., construction records, geophysical logs, core, brine composition)
  - 2D seismic surveys
  - Maps
  - Models

Containment	**Seal Geometry**	Structural position, thickness, and areal extent of caprocks
	Seal Integrity	Caprock geomechanical properties in the context of ambient stress fields that may be modified by CO2 injection.
	Saline springs	Natural geological formations where groundwater containing high concentrations of dissolved salts emerges at the Earth's surface.
	Legacy wells	Abandoned or inactive oil, gas, or water wells that were drilled in the past for resource extraction purposes but are no longer in use or have been improperly sealed or plugged.

Task 4.0 - Define Play Elements and Criteria

Play Element: Surface Examples →

- Data from:
  - PRI databases and publications
  - Public sources

Play Element: Societal Examples →

- Data from:
  - Public sources (national atlas, census, CEJST, EJ Screen)

Environmental	**Wetlands**	areas that are covered (often intermittently) with shallow water or have soil saturated with mositure.
	Karst terrain	Irregular limestone topography with sinkholes, underground streams, and caverns.
	Sole-source aquifer	An aquifer that supplies at least 50% of the drinking water for its service area and there are no reasonably available alternative drinking water sources should the aquifer become contaiminated.
Societal Land Use	**City limits**	Defined boundary of a city.
	Parks	Areas of land set aside and managed fro public recreation, conservation, and enjoyment.
	Historic places	Places of historical significance that are worthy of preservation.
	Federally owned land	Land that is owned and managed by the federal governement.
	Tribal lands	Areas of land set aside for Native American tribes as part of agreements between the federal government and tribal nations.

Next Steps (Year 2)

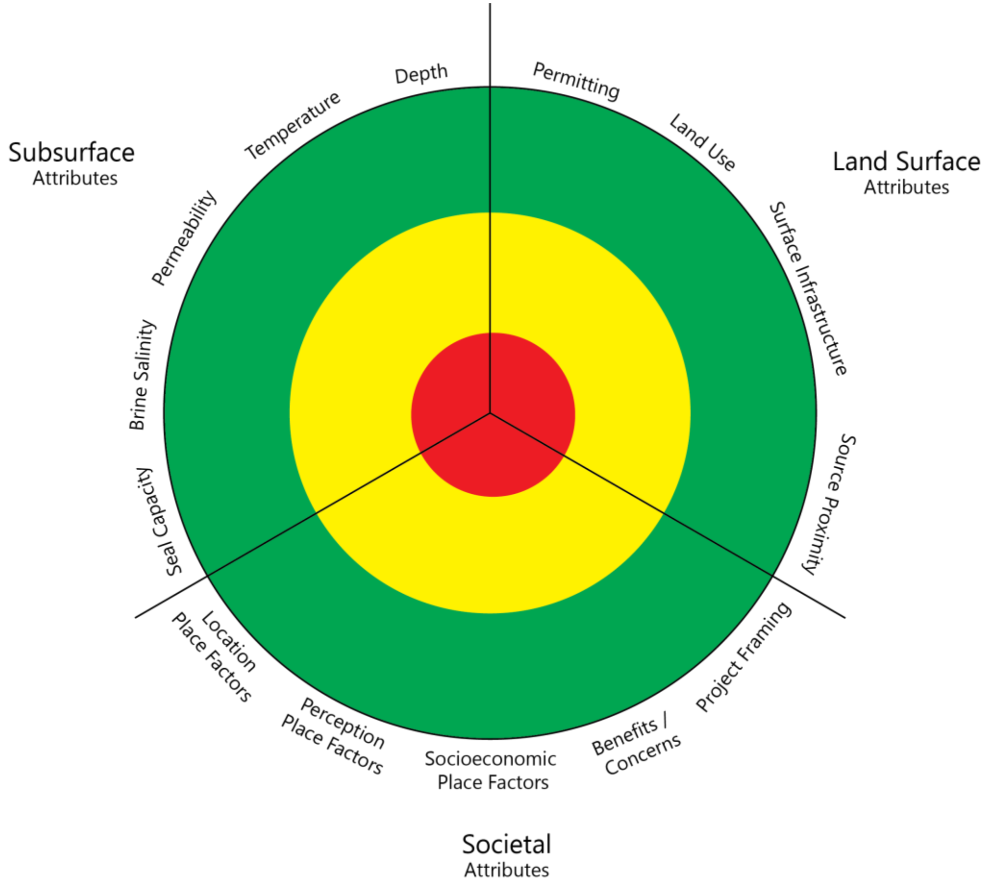
Task 5.0 - Play Element Convolution

- Create CRS maps and define suitability and classify as prospective (green), conditional (yellow), and critical (red)

Task 6.0 - Project Website & Story Mapping

- Develop Annotated and Contextualized Carbon Storage Play Maps for the State of Illinois
- Setting expectations: Suitability criteria will vary
  - ISGS will develop and apply suitability criteria as an exercise; *our criteria and maps will be interesting, not definitive*

Task 6.0 - Play Based Exploration and Analysis for CCS Topical Report



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- Thanks to Greg Lackey and the DOE CATALOG team for collaboration on OGRRE well construction record digitization

References

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