

Ground Water Protection Council Annual Conference

June 22, 2022

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Background on Great Plains Institute

An independent nongovernmental organization focused on energy policy and technology.

Mission

- *Transforming the energy system to benefit the economy and the environment.*

Objectives

- *Increase energy efficiency and productivity.*
- *Decarbonize electricity production.*
- *Electrify the economy and adopt zero and low-carbon fuels.*
- *Capture carbon for beneficial use and permanent storage.*



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Key GPI Carbon Management Objectives

- *Elevate carbon capture as a national priority for achieving midcentury climate goals, creating high-wage jobs and sustaining our domestic energy and industrial base.*
- *Provide comprehensive policy support for carbon capture equivalent to support already provided to other low and zero-emission technologies.*
- *Foster economywide deployment of carbon capture and the national buildout of critical CO₂ pipeline infrastructure.*

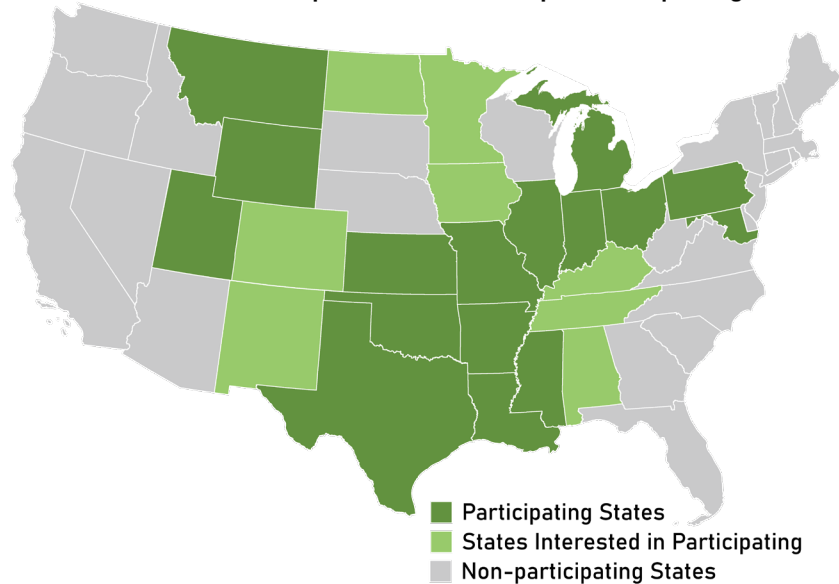


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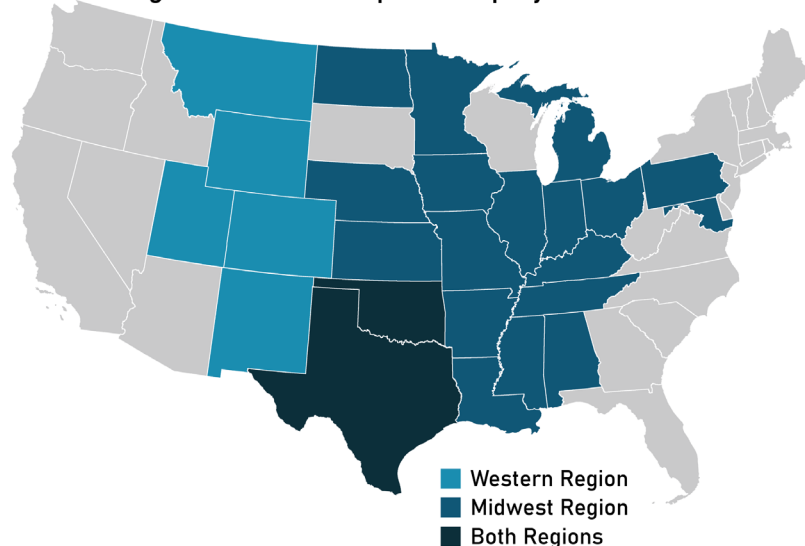
Helping States Become Carbon Capture Ready

State Carbon Capture Work Group: Participating States



- **State Carbon Capture Work Group:** Established in 2015, with state officials representing 16 states.
- **Regional Deployment Initiative:** Approximately 700 state officials, companies, NGOs, and unions from over two dozen states interested in supporting state and federal policy development
- Work Group and RDI coordinating state policymaker and stakeholder engagement, development of policy recommendations, and regional deployment modeling and jobs analysis.


Regional Carbon Capture Deployment Initiative



www.carboncaptureready.org

Analytical Report

Published June 30, 2020




Transport Infrastructure for Carbon Capture and Storage


WHITEPAPER ON REGIONAL INFRASTRUCTURE FOR MIDCENTURY DECARBONIZATION

Authored by
Elizabeth Abramson and Dane McFarlane
Great Plains Institute

Jeff Brown
University of Wyoming



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REGIONAL CARBON CAPTURE DEPLOYMENT INITIATIVE

JUNE 2020

Summary of Findings:

CO₂ Transport Infrastructure for Economy-Wide Deployment

As outlined in the sections above, and detailed in the methodological appendix of this paper, this analysis identified near- and medium-term opportunities for capture at industrial and power facilities along with likely geologic storage opportunities in deep saline formations and existing EOR operations. To maximize CO₂ capture and storage and approach the scale needed for US decarbonization targets and international temperature targets, shared regional CO₂ transport infrastructure will minimize investment requirements, transport costs, and land use. Los Alamos National Laboratory's SimCCS model was used to identify optimal regional scale transport networks that deliver CO₂ from capture facilities to storage locations identified by this analysis, resulting in Figure 8.

Figure 8. Optimized transport network for economy-wide CO₂ capture and storage

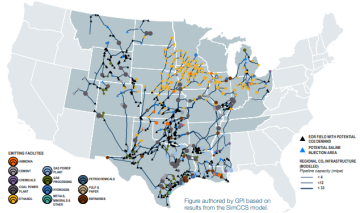


Table 7. Miles of CO₂ pipeline modeled, by diameter

Diameter	4"	6"	8"	12"	16"	20"	24"	30"
Length (miles)	4,712	6,063	8,560	5,834	2,675	1,700	59	16

The difference in build-out of CO₂ transport infrastructure in the Near- to Medium-Term Scenario and the High-Cost Sensitivity Scenario shows that there is still a gap in pure break-even economic equilibrium: a regional scale CO₂ transport network will require capital investment that will not necessarily be paid simply through the sale of CO₂ at \$20 per ton combined with the value of tax credits in the current 45Q program. The transport networks modeled here maximize the rate of CO₂ capture and storage across the power and industrial sectors while minimizing the cost and land use of transport infrastructure. In reality, CO₂ transport infrastructure may more likely be built out in a piecemeal fashion, linking single facilities or a small group of projects to a single storage location. This may result in CO₂ infrastructure that is not of sufficient capacity to meet the scale of CO₂ capture and storage required by midcentury decarbonization targets. This infrastructure would need to be replaced in the future or an abundance of additional infrastructure would need to be built, costing more and having a greater land use impact than a regional system built through coordinated planning.

This study has shown clear opportunities for wide-spread capture at low costs throughout the Midwest, Midcontinent, Rockies, Northern Plains, Gulf Coast, and Texas.

If the US is to significantly decarbonize the industrial and power sectors, as well as create a marketplace that allows for direct air capture facilities to help achieve net-zero or negative carbon emissions, then planning and coordination must occur in the near term to begin building regional-scale transport

Near-term planning and coordination of regional-scale infrastructure will enable significant decarbonization of the industrial and power sectors while creating a marketplace for direct air capture of CO₂ will require.

Economy-wide deployment of carbon capture and storage will help achieve net-zero or negative carbon emissions in the US.

networks for economy-wide deployment of carbon capture and storage. By midcentury, local, national, and international climate action and the need to drive down the societal costs of carbon emissions will likely create natural economic incentives that enable CO₂ capture at industrial and power facilities, in addition to direct air capture facilities, that today seem relatively expensive.

Developing solutions in the near term to address logistical issues such as inter-state CO₂ transportation corridors, interconnected pipeline networks operated or shared by multiple private entities, and state and federal support for future-proofing pipeline capacity through "super-sizing" will drastically reduce costs as well as land use and environmental impact of CO₂ transport infrastructure. Achieving national goals will require broad scale coordinated vision and action. This analysis provides a framework for coordinated regional infrastructure that can help define that vision.

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Download the paper at:

carboncaptureready.org/analysis



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CO₂ Capture Opportunities: Industrial and Power Facilities

Section 45Q Tax Credit for CO₂ Storage

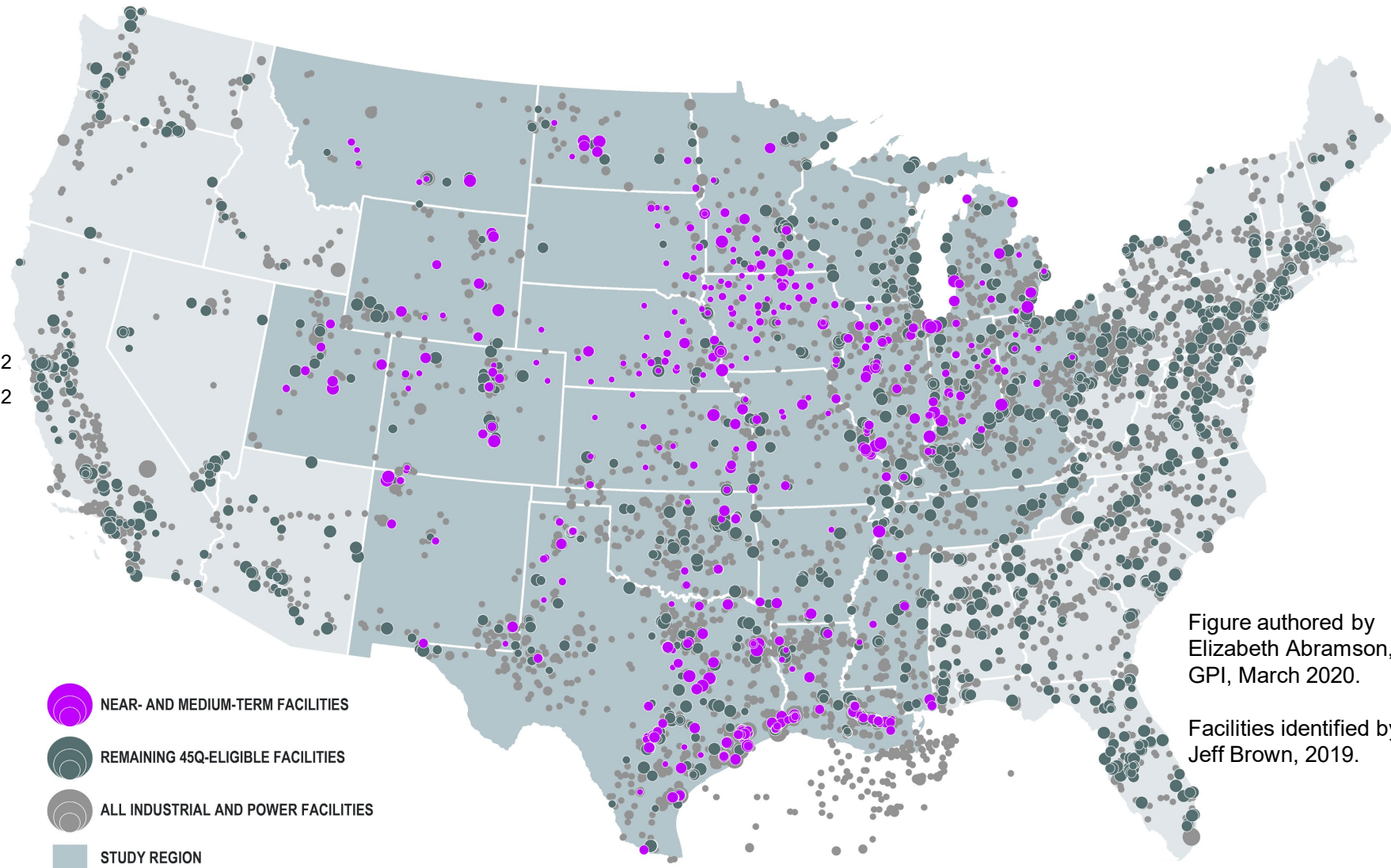
Geologic Saline: \$50 / ton
EOR Storage: \$35 / ton

Minimum Capture Thresholds

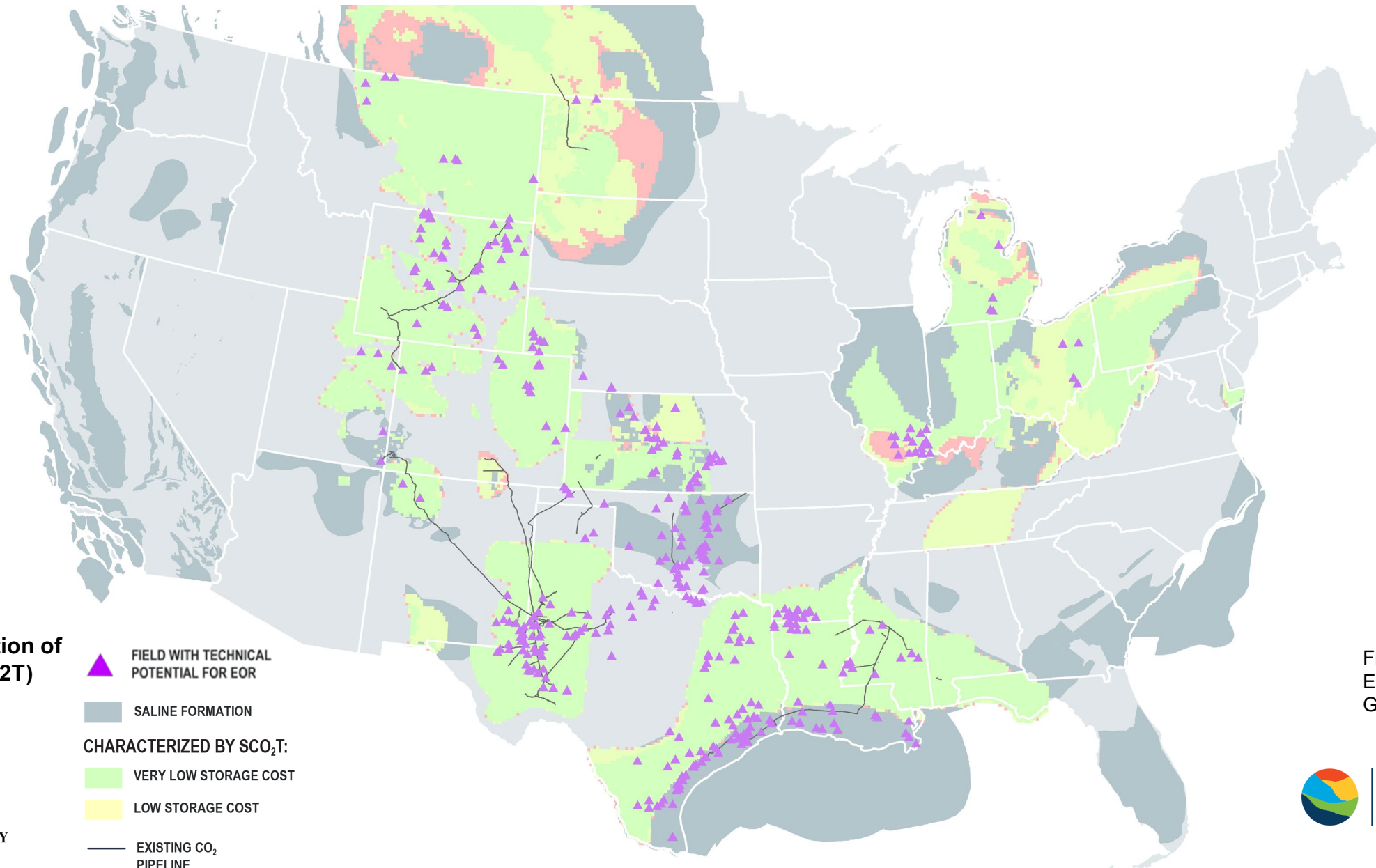
Industrial Facility: 100 thousand tons CO₂
Power Plants: 500 thousand tons CO₂

Near- and Medium-Term Screening Criteria:

- 45Q Eligibility
- Operational patterns
- Expected life
- Right-size capture equipment to specific units within each facility



Saline: SCO2T & NATCARB 10km Grid Cells



Saline data via
**The Sequestration of
CO₂ Tool (SCO₂T)**

▲ FIELD WITH TECHNICAL
POTENTIAL FOR EOR

■ SALINE FORMATION

CHARACTERIZED BY SCO₂T:

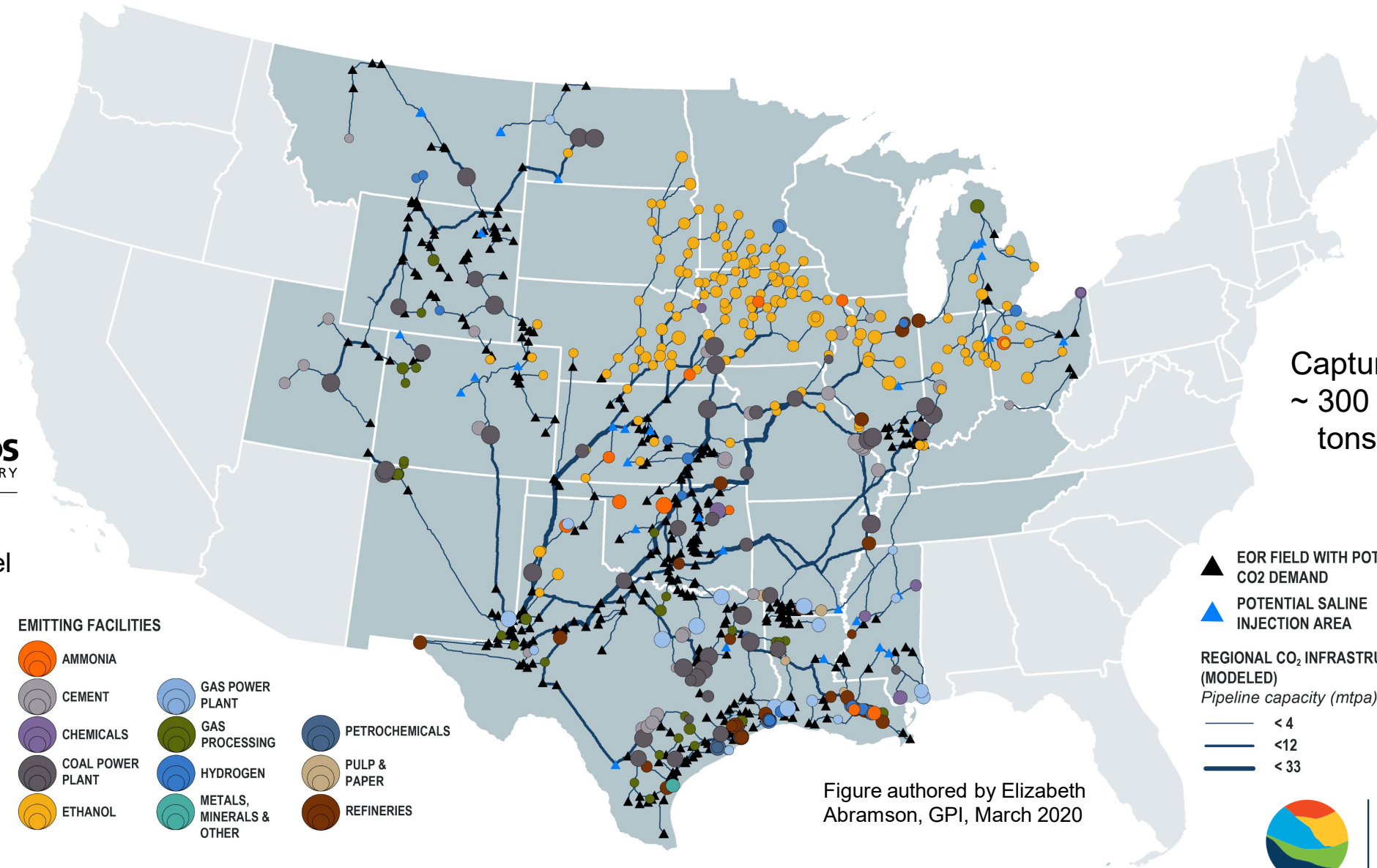
■ VERY LOW STORAGE COST

■ LOW STORAGE COST

— EXISTING CO₂
PIPELINE

Figure authored by
Elizabeth Abramson,
GPI, March 2020

Near- and Medium-Term Scenario: Optimized transport network for CO₂ capture and storage under 45Q



Capture and storage:
~ 300 million metric
tons per year



SimCCS CO₂
transport model

EMITTING FACILITIES

- AMMONIA
- CEMENT
- CHEMICALS
- COAL POWER PLANT
- ETHANOL
- GAS POWER PLANT
- GAS PROCESSING
- HYDROGEN
- METALS, MINERALS & OTHER
- PETROCHEMICALS
- PULP & PAPER
- REFINERIES

- EOR FIELD WITH POTENTIAL CO₂ DEMAND
- POTENTIAL SALINE INJECTION AREA

REGIONAL CO₂ INFRASTRUCTURE (MODELED)

- Pipeline capacity (mtpa)*
- < 4
 - < 12
 - < 33

Figure authored by Elizabeth Abramson, GPI, March 2020



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Carbon Capture Ready Website

RDI Homepage

- State fact sheets
- Jobs fact sheets
- Analytical white paper
- Policy briefs
- Resources on carbon capture

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JOBS AND ECONOMIC IMPACT OF CARBON CAPTURE DEPLOYMENT Texas

TOTAL JOBS POTENTIAL

Project Jobs	Operations Jobs	Infrastructure Jobs
15,010	9,230	2,850

Texas has the opportunity to create an annual average of up to 17,860 project jobs over a 15-year period and 9,230 ongoing operations jobs through the deployment of carbon capture at 95 industrial and power facilities. The retrofit of equipment at these facilities has the potential to capture nearly 161 million metric tons of carbon dioxide (CO₂) per year. Along with the development of CO₂ transport infrastructure, this would generate up to over \$69 billion in private investment.

CREATING JOBS & CAPTURING CARBON

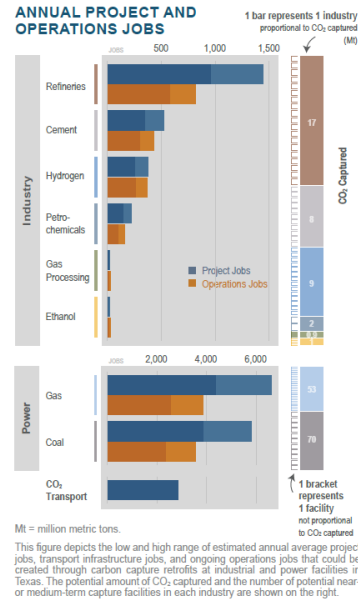
Carbon capture is essential to meeting mid-century emissions reduction goals while retaining and growing a domestic base of high-wage energy, industrial, and manufacturing jobs. Carbon capture retrofits require facilities to be outfitted with capture technologies such as amine scrubbers to remove CO₂ from exhaust gas and compressors to make the CO₂ transport-ready, that are dependent upon the type of industrial plant and vary across industries and facilities. There are jobs associated with the equipment, materials (e.g. cement and steel), engineering, and labor required to install the capture technology, as well as ongoing jobs to operate and maintain the retrofits. These are referred to as project jobs and operations jobs.

Rhodium Group performed an economic analysis based on the Regional Carbon Capture Deployment Initiative's near- and medium-term capture potential scenario. The Rhodium analysis quantifies the economic impact and employment opportunities of carbon capture retrofit projects by deploying state-specific data in the IMPLAN economic model. The analytical results measure the impact of project investment and operation costs through expected annual jobs. Average annual project jobs were calculated assuming deployment of all projects within the 15-year period from 2021-2035. The jobs reported are in-state jobs, directly associated with carbon capture retrofits. They do not include other jobs at the facilities, nor indirect and induced jobs.

CARBON CAPTURE JOBS AND ECONOMIC IMPACT SUMMARY

Industry	Number of Facilities	Total Capture Target Metric Tons	Private Investment Million Dollars	Annual Average Project Jobs 2021-2035	Annual Operations Jobs
Cement	11	8,000,000	\$1,200 - \$1,800	350 - 520	310 - 430
Coal Power	11	70,000,000	\$14,000 - \$20,000	3,870 - 5,800	2,360 - 3,540
Ethanol	4	1,000,000	\$60 - \$90	15 - 25	20 - 30
Gas Power	28	53,000,000	\$15,000 - \$25,000	4,400 - 6,600	2,570 - 3,850
Gas Processing	6	900,000	\$70 - \$100	20 - 25	20 - 30
Hydrogen	14	9,000,000	\$900 - \$1,300	260 - 380	270 - 370
Petrochemicals	2	2,000,000	\$500 - \$700	150 - 220	110 - 160
Refineries	19	17,000,000	\$2,600 - \$3,900	960 - 1,440	590 - 820
CO ₂ Transport Infrastructure	-	-	\$7,000,000,000	2,850	-

1 Rhodium Group analytical results: rhg.com/research/ For more information, visit carboncaptureready.org



carboncaptureready.org

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Carbon Capture and Storage Infrastructure for Midcentury Decarbonization

This report provides data sources, details the analytical methodology, and identifies potential capture facilities throughout the Western and Midwestern regions, as well as primary modeling scenarios and conclusions on regional CO₂/front capture, transport, and storage opportunities.

Download the report below.

[Download Whitepaper](#)

Jobs and Economic Growth Fact Sheets

The Regional Deployment Initiative has released a series of state fact sheets on potential jobs creation and economic impact of carbon capture deployment, based on collaborative analysis by Rhodium Group. The Rhodium analysis quantifies the economic impact and employment opportunities of carbon capture retrofit projects by deploying state-specific data in the IMPLAN economic model.

Download each state fact sheet below:

Midcontinent Region →

Arkansas	Louisiana	Montana	Oklahoma
Colorado	Michigan	North Dakota	South Dakota
Iowa	Minnesota	Nebraska	Texas
Illinois	Missouri	New Mexico	Utah
Indiana	Mississippi	Ohio	Wisconsin

An Atlas of Carbon and Hydrogen Hubs for United States Decarbonization

February 2022



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The screenshot shows a web browser window with the URL <https://carboncaptureready.betterenergy.org/analysis/>. The page header includes the Great Plains Institute logo and navigation links: "Who We Are", "Our Work", and "Become a Donor". A blue navigation bar contains the following menu items: "CARBON CAPTURE READY", "REGIONS", "ANALYSIS", "RESOURCES", and "CONTACT". The main content area features the title "GPI's Carbon and Hydrogen Hubs Atlas" and a paragraph explaining that the atlas was published in February 2022, based on an analysis of United States industrial activity, emissions, and fuel combustion. It lists factors considered, such as geologic storage potential and current hydrogen production. A prominent blue button labeled "Download the Hubs Atlas" is centered below the text. Underneath, a link states "Or, click below to view a hubs fact sheet for each region:" followed by a grid of regional links: Houston, Michigan & Ohio, Pacific Northwest, Texas: Permian, Illinois, North Dakota, Pennsylvania, Utah, Kansas, Northern California, Rockies: Denver, Louisiana, Oklahoma, and Southern California.

Download the atlas at:
carboncaptureready.org

Potential US Carbon and Hydrogen Hubs

Guiding Criteria

- High concentration of large industrial emitters
- High quantities of fossil fuel use for on-site industrial energy production
- Presence of 45Q tax credit qualifying facilities for carbon capture retrofit, as well as identified near- and medium-term capture opportunities
- Current reported production of hydrogen and ammonia (optional)
- Large geologic saline and fossil formations for permanent CO₂ storage
- Existing multi-modal commodity distribution infrastructure such as freight railroads, barge waterways and ports, and freight truck interstate highway routes
- Existing conventional fossil fuel distribution infrastructure for hydrogen blending and established right-of-way that minimizes impact of CO₂ transport infrastructure

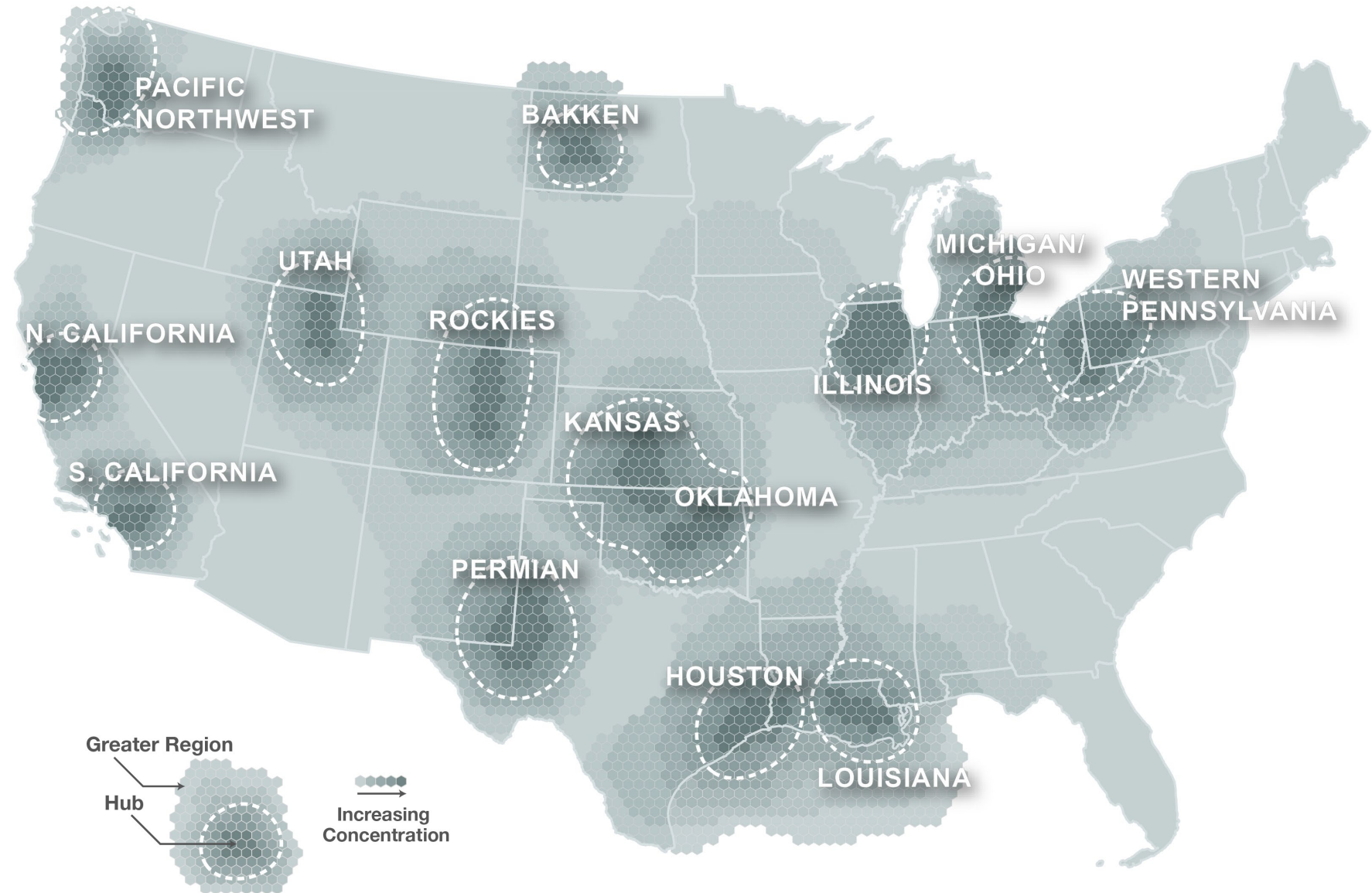


Figure authored by Elizabeth Abramson, GPI, 2021
Source: Carbon and Hydrogen Hubs Atlas, GPI 2022



Decision Support Tool

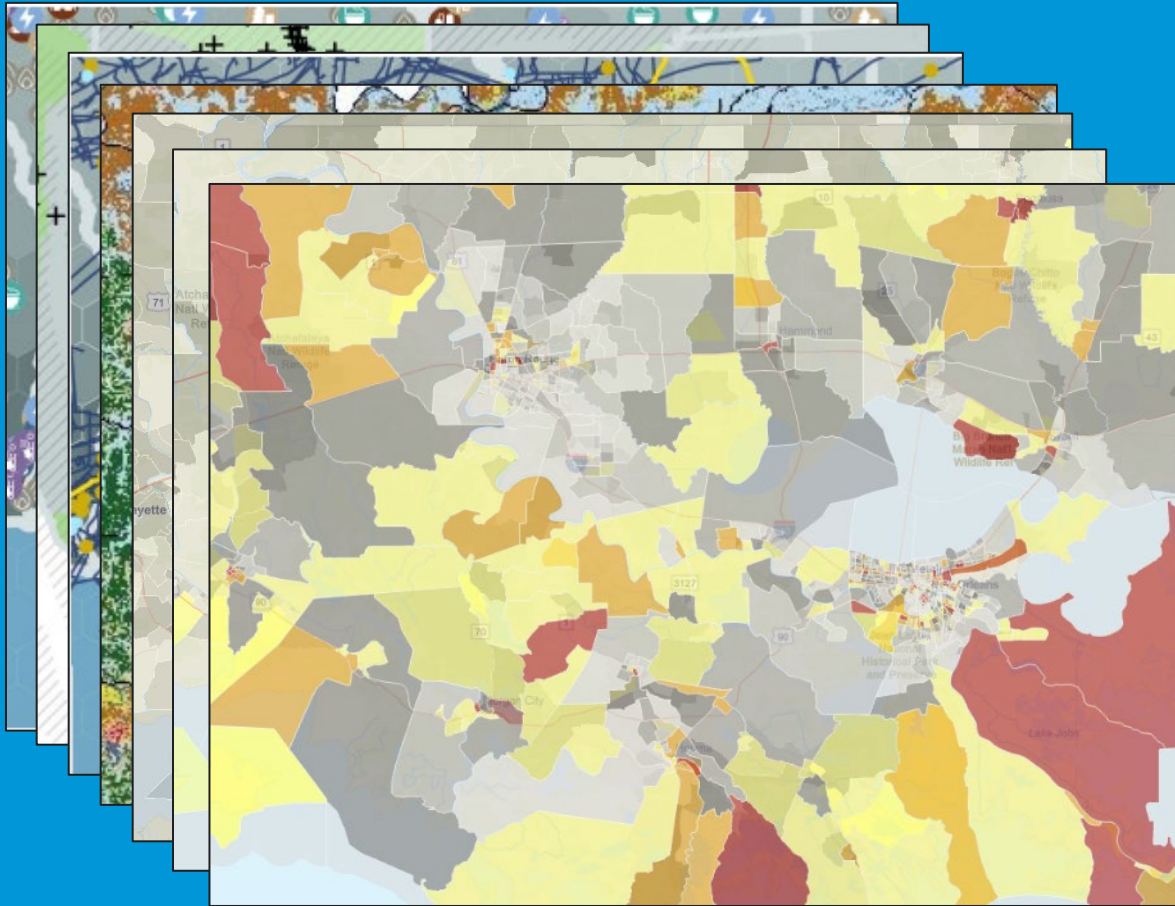
- Geospatial Analysis
- Environmental, Natural Resource, Legal Constraints
- Environmental Justice
 - Demographic Data
 - Stakeholder Engagement



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TOOL ARCHITECTURE



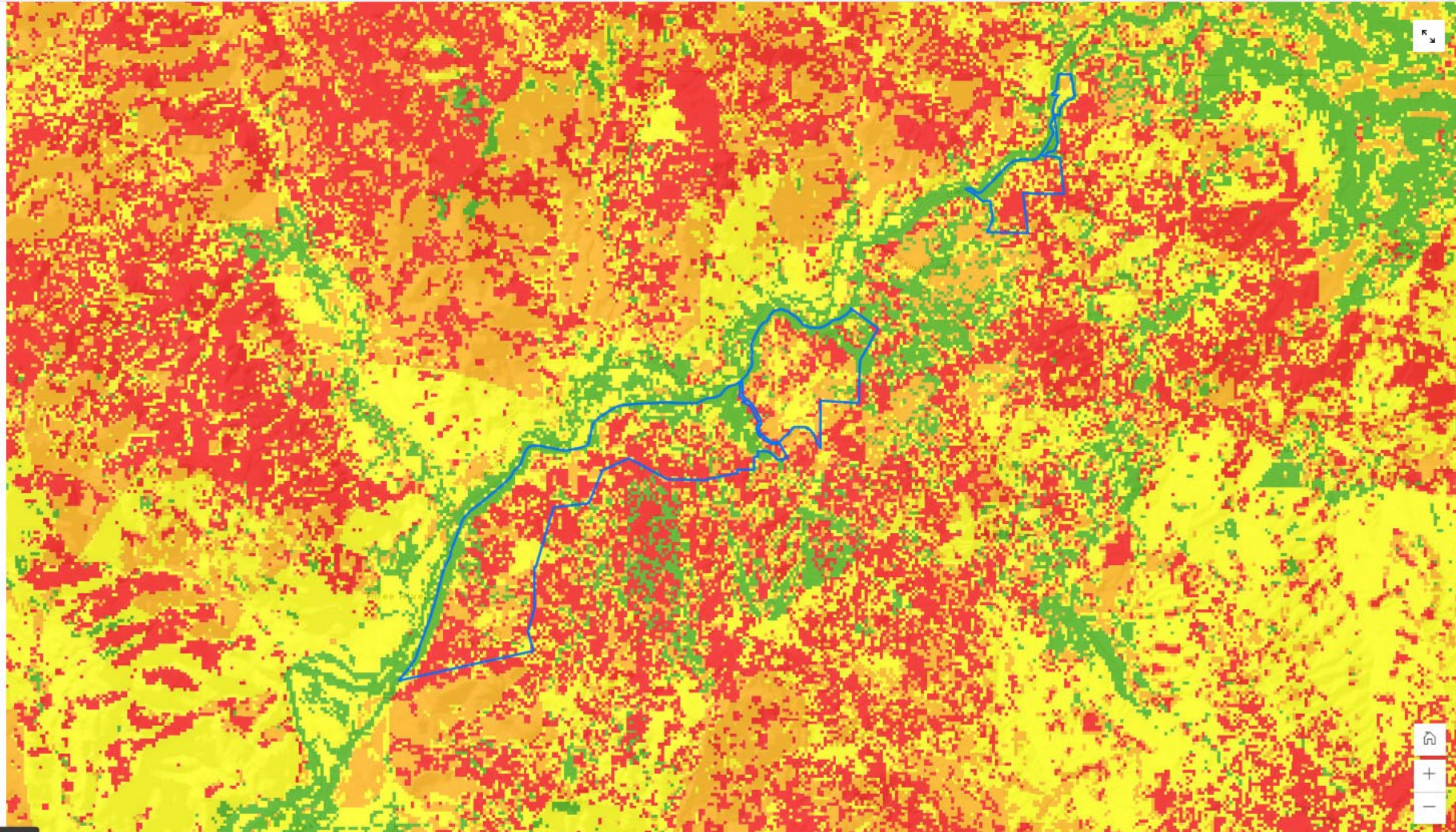
Infrastructure
+ Environmental
+ EJ/Community =

TOOL TO SUPPORT
STAKEHOLDER
OUTREACH AND
ENGAGEMENT

Main Corridor - South



POSITIVE	NEGATIVE
✓ Visible and reflective street signs	✗ Ingress/egress: one major road, steep and narrow
✓ Low previous fire occurrence	✗ Limited turnarounds
✓ Nearby fire station	✗ Heavy fuel loading
✓ Road conditions: short driveways	✗ Defensible space: limited, small lots
	✗ Building construction: mixed, largely combustible
	✗ Limited water sources
	✗ Utility placement: propane and electric are aboveground
	✗ Problematic topography
	✗ Roofing materials: vary widely



RECOMMENDATIONS



- *STATE DRIVERS*

- *Supportive Statutory Framework*

- *Financial Incentives*

- *Siting Assistance*



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Supportive Statutory Framework

- *Pore Space Ownership*
- *CO₂ Ownership*
- *Unitization/Amalgamation*
- *Stewardship Requirements*
- *Regulatory Regime and Appropriations*



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Financial Incentives

- *Reduced Royalties/Severance*
- *Sales Tax Waivers*
- *Reduced Property Taxes*
- *Loans and Grants*



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Siting Assistance

- *Pipeline Siting*
- *Geologic Characterization*
- *Public Outreach*



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Thank You

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