EERC | UND UNIVERSITY OF NORTH DAKOTA

Critical Challenges. Practical Solutions.

Energy & Environmental Research Center (EERC)

Plains CO_2 Reduction (PCOR) Initiative to Accelerate Carbon Capture, Utilization, and Storage Deployment (FE0031838)

U.S. Department of Energy
National Energy Technology Laboratory
Carbon Management Research Project Review Meeting
August 28, 2023

Kevin C. Connors
PCOR Partnership Project Manager

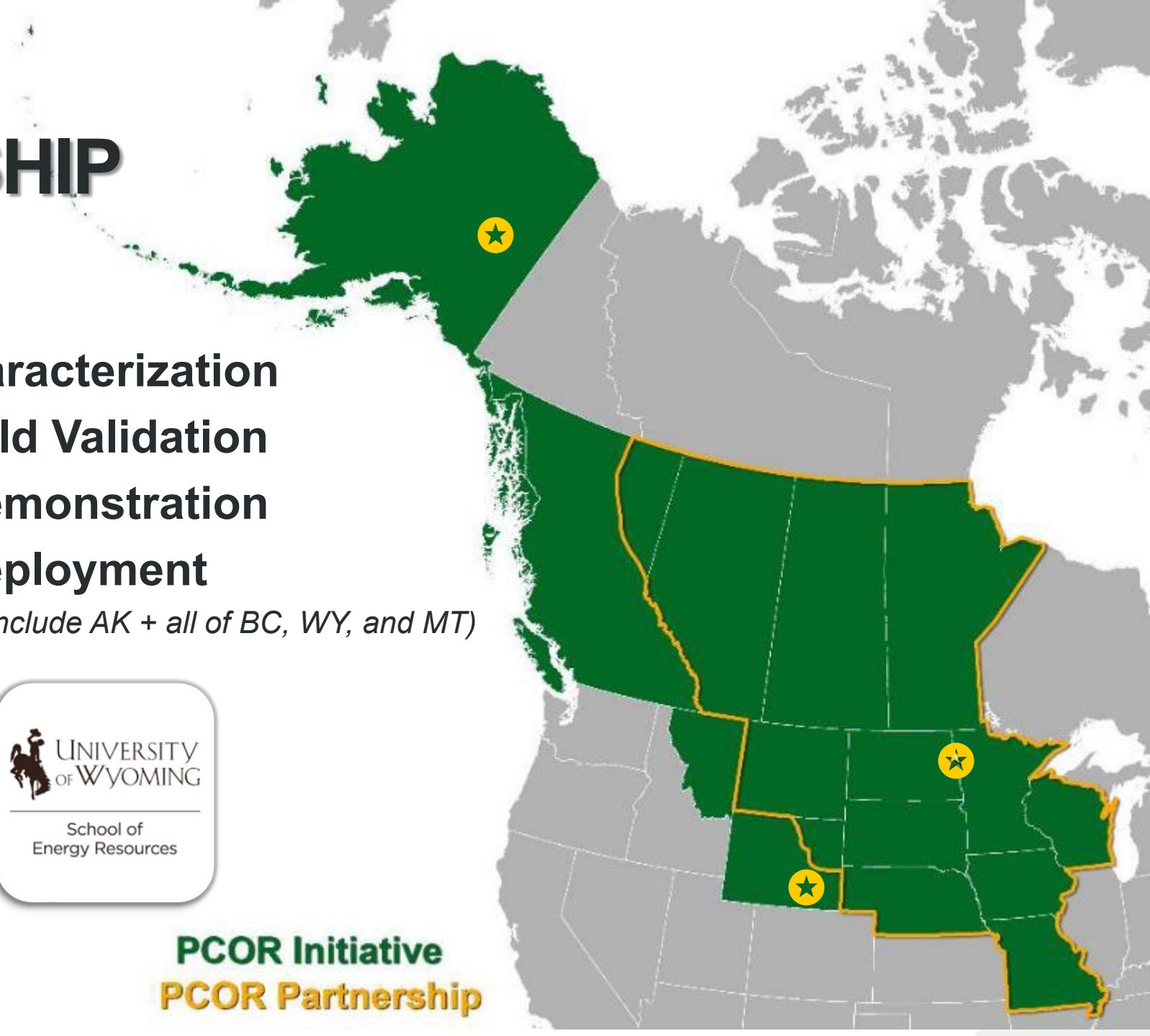
20 YEARS PCO2R Partnership

REGIONAL INITIATIVE

PCOR PARTNERSHIP

- 2003–2005: **Phase I** – **Characterization**
- 2005–2009: **Phase II** – **Field Validation**
- 2007–2018: **Phase III** – **Demonstration**
- 2019–2024: **Initiative** – **Deployment**

(PCOR Partnership region expanded to include AK + all of BC, WY, and MT)



PCOR Initiative
PCOR Partnership

20 YEARS PCOR Partnership

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PCOR PARTNERSHIP

The PCOR Partnership addresses regional capture, transport, use, and storage challenges facing commercial carbon capture and storage (CCS)/carbon capture, utilization, and storage (CCUS) deployment. The PCOR Partnership focuses on:

- Strengthening the technical foundation for geologic CO_2 storage and enhanced oil recovery (EOR).
- Advancing capture technology.
- Improving application of monitoring technologies.
- Promoting integration between capture, transportation, use, and storage industries.
- Facilitating regulatory frameworks.
- Providing scientific support to policymakers.
- Engaging the public through outreach and education.

Our partners inform our priorities.

PCO2R Partnership — PARTNERSHIP MEMBERS

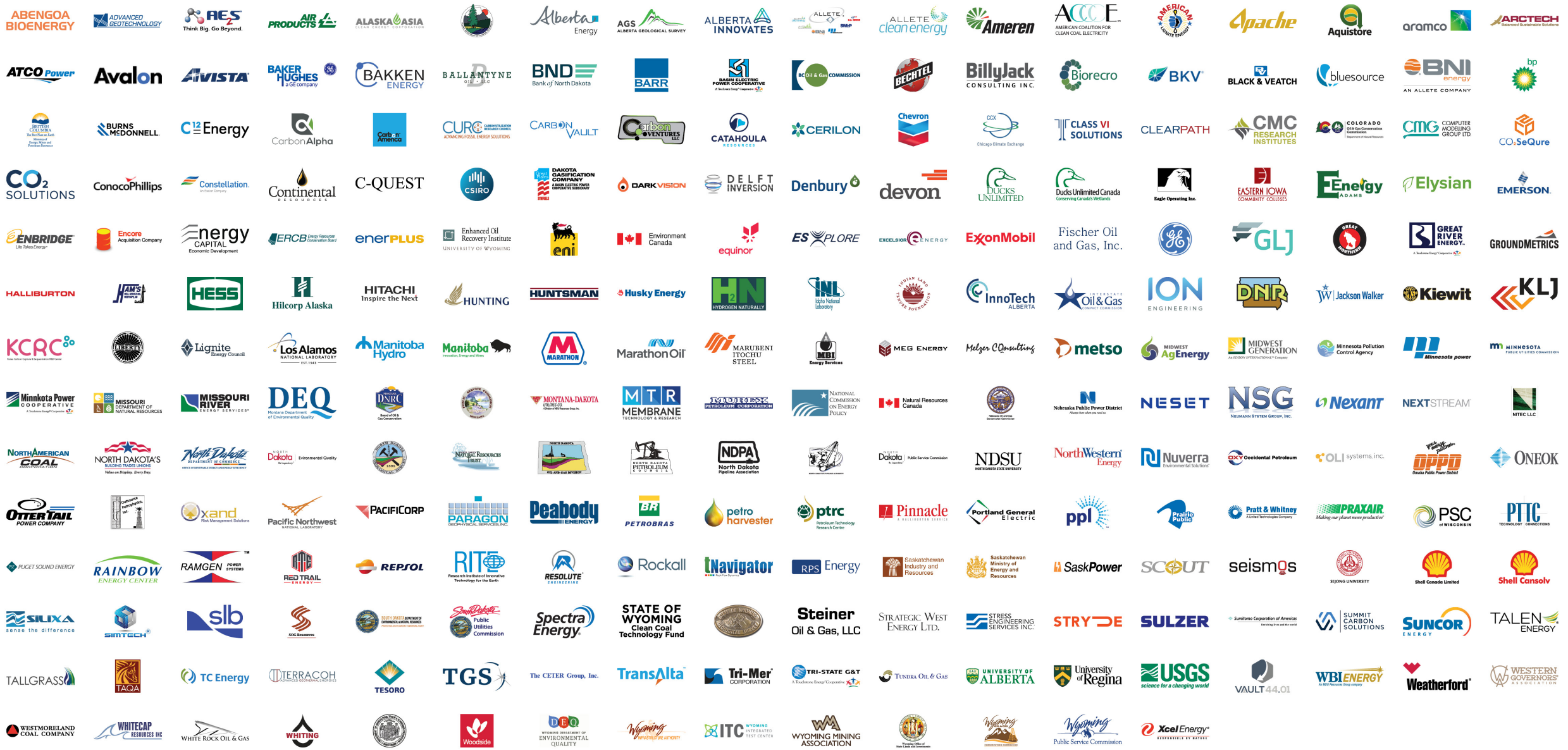
U.S. DEPARTMENT OF ENERGY | NETL NATIONAL ENERGY TECHNOLOGY LABORATORY

EERC UNIVERSITY OF NORTH DAKOTA

North Dakota Industrial Commission

UAF Institute of Northern Engineering, University of Alaska Fairbanks

University of Wyoming, School of Energy Resources



07/23

2022 AND 2023 HIGHLIGHTS

- PCOR Partnership annual meeting held in Anchorage, AK (2022) and upcoming in Grand Forks, ND (2023).
- Regulatory Roundup meetings held in Deadwood, SD (2022 and 2023).
- Technical Advisory Board (TAB) meetings held in Houston, TX and Anchorage, AK (2022) and Washington, DC (2023).
- Continued collaboration with University of Alaska Fairbanks (UAF) and University of Wyoming (UW).
- Field efforts continued at the Red Trail Energy (RTE) CCS site.
- *PCOR Pioneer* newsletter.
- Several products (deliverables and white papers) published.
- Additional white papers in development.

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PRODUCTS, PRESENTATIONS, AND PROGRESS

- Over 45 papers, abstracts, and posters have been developed under the PCOR Partnership Initiative on topics like:
  - Risk-based area of review
  - Storage optimization
  - Regional business model assessments
  - MVA strategies
  - Permitting guidance
  - Plume stability
  - Well testing for CO_2 storage sites
  - Technical and legal considerations for pore space
- Over 60 presentations and panel discussions have been given.
- Over 14 workshops and meetings were held.
- Over 60 collaborations and discussions have been held with project developers!

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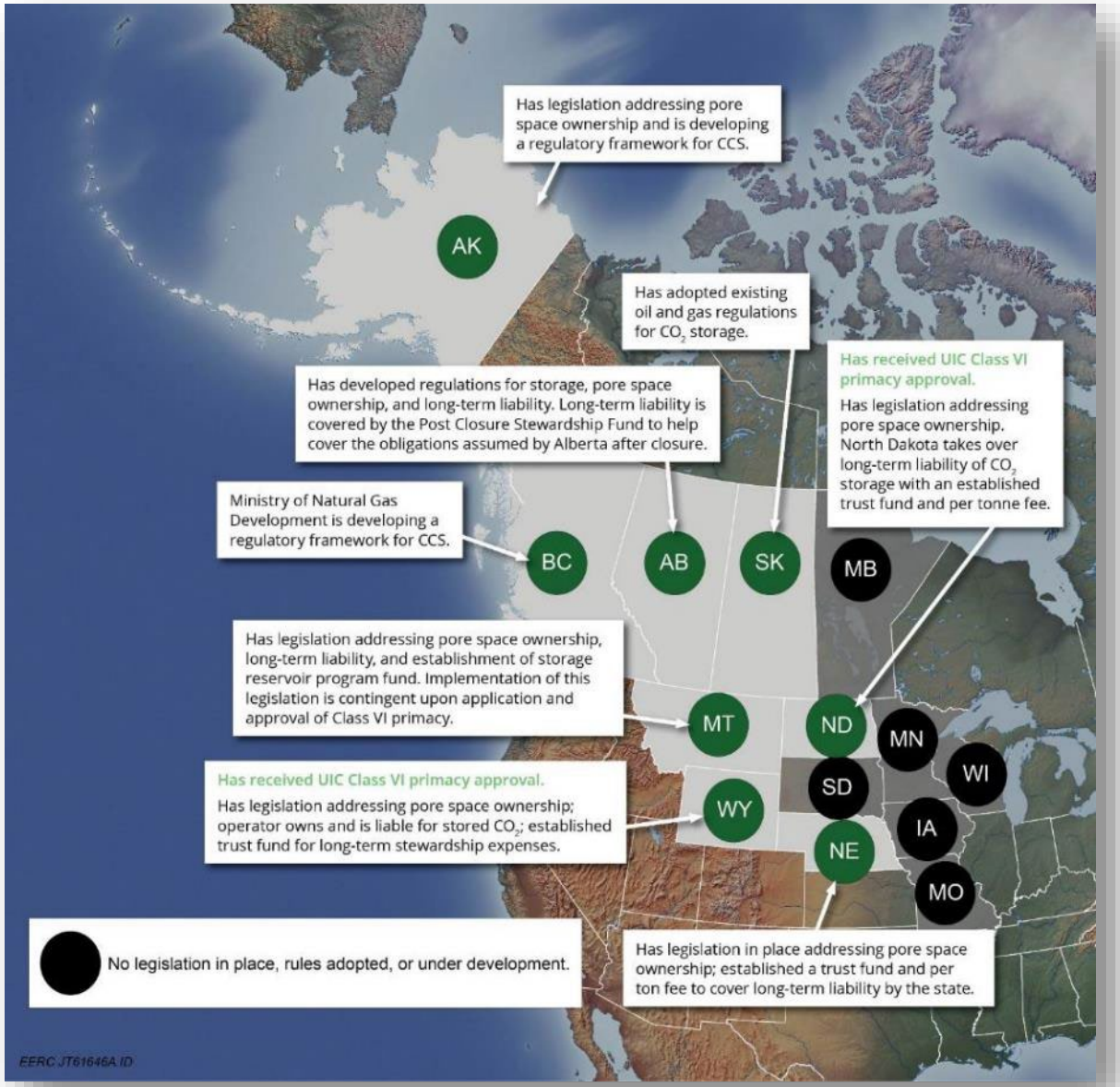
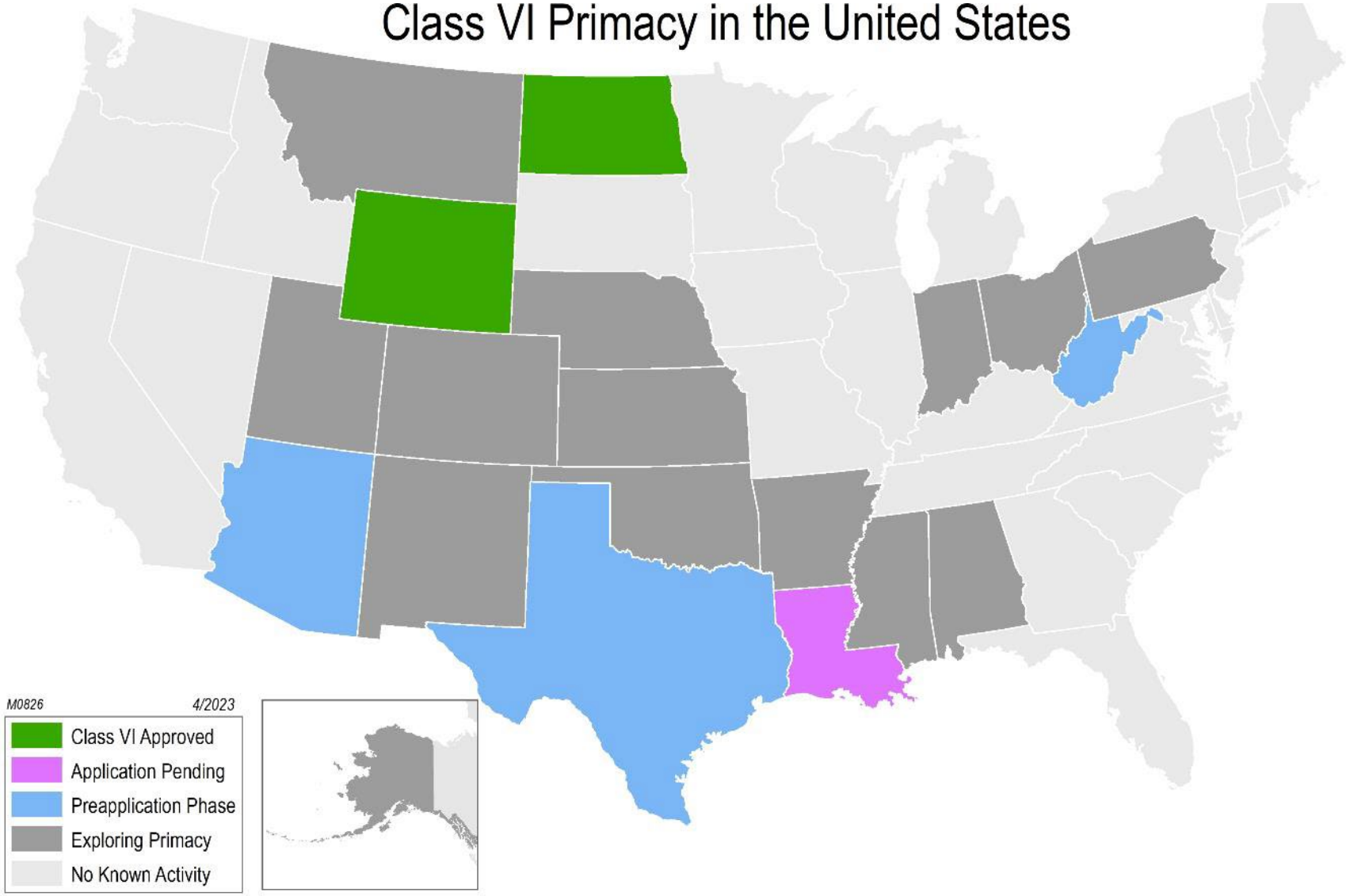
POLICY AND REGULATORY DEVELOPMENTS

- Pore space law
- Long-term liability
- Class VI primacy
- Regulatory program implementation
- Pathways to permit approval
- Policy/regulatory challenges



Class VI Primacy in the United States



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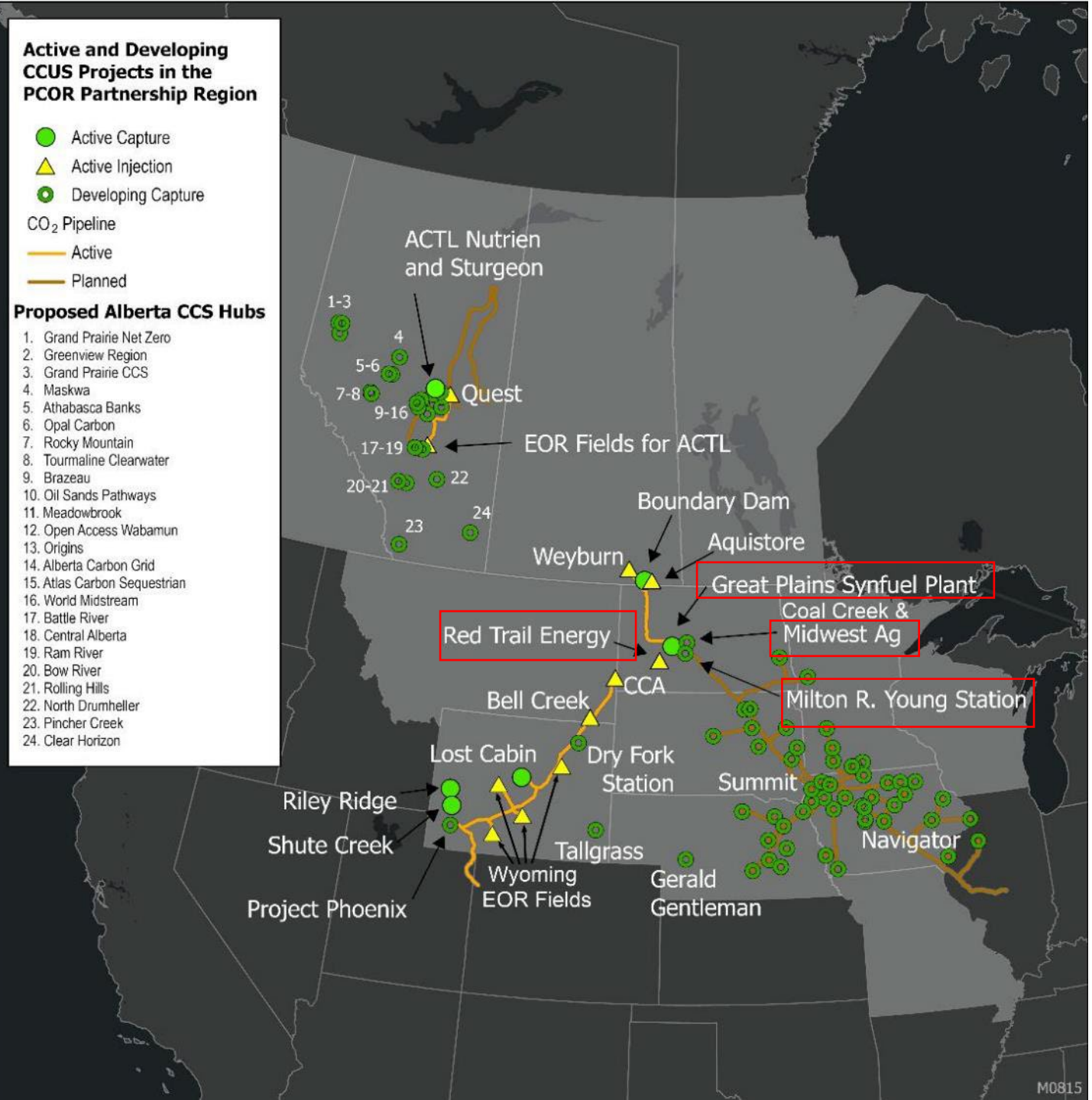
2023 REGULATORY ROUNDUP

From PCOR Region:
Alaska
Alberta
Montana
Nebraska
North Dakota
Saskatchewan
Wyoming

Outside PCOR Region:
Alabama
Arkansas
Colorado
Kansas
Louisiana
Mississippi
Utah
West Virginia

Unprecedented attendance:
- 13 states
- 2 Canadian provinces



ND STORAGE FACILITY PERMITS

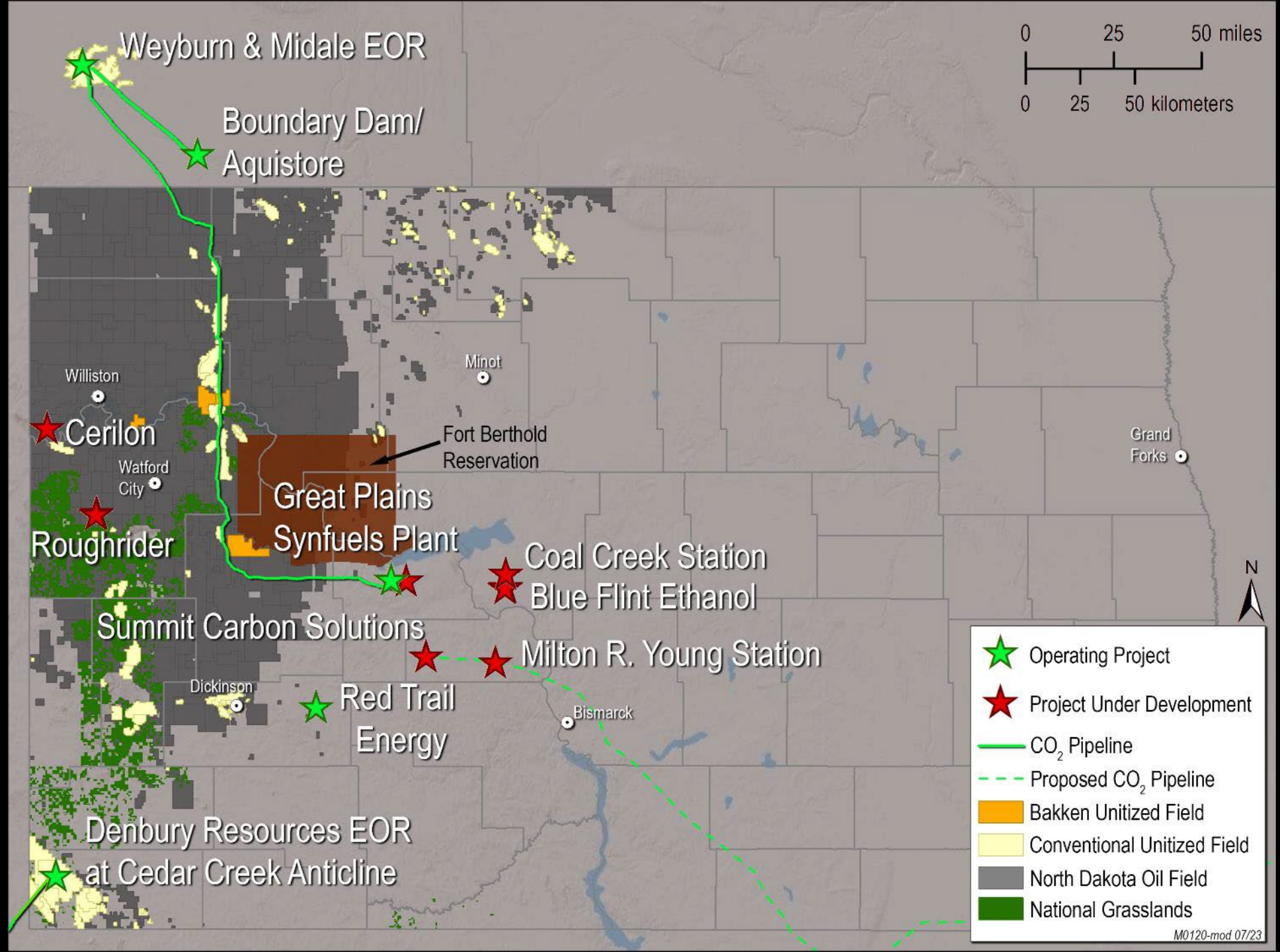
1. **Red Trail Energy**
   - Ethanol
   - Actively Injecting

2, 3. **Minnkota Power Cooperative, Inc.** (2)
   - Lignite; Power Plant

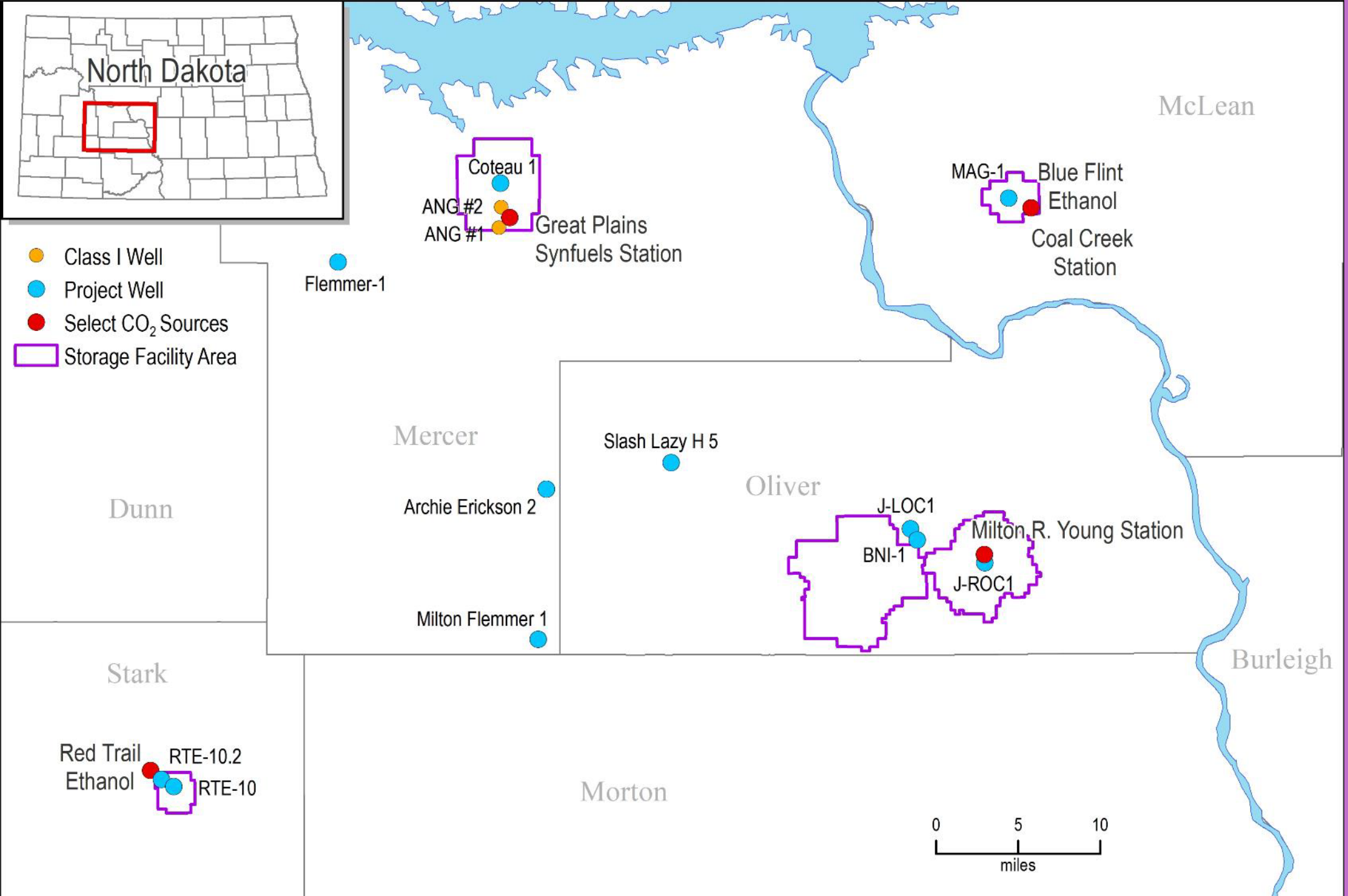
4. **Dakota Gasification Company**
   - Lignite; Synfuels

5. **Blue Flint Sequester Company, LLC**
   - Ethanol
   - Injection Permit Issued

6. ***DCC West Project LLC***
   1. Lignite
   2. Hearing held


Weyburn & Midale EOR
Boundary Dam/
Aquistore
0 25 50 miles
0 25 50 kilometers
Williston
Minot
Cerilon
Fort Berthold
Reservation
Watford
City
Grand
Forks
Great Plains
Synfuels Plant
Roughrider
Coal Creek Station
Blue Flint Ethanol
Summit Carbon Solutions
Milton R. Young Station
Dickinson
Red Trail
Energy
Bismarck
Denbury Resources EOR
at Cedar Creek Anticline
N
Operating Project
Project Under Development
CO_2 Pipeline
Proposed CO_2 Pipeline
Bakken Unitized Field
Conventional Unitized Field
North Dakota Oil Field
National Grasslands
M0120-mod 07/23

STORAGE FACILITIES



PCOR PARTNERSHIP

- Building on over 20 years of applied research in CCUS.
- Active region developing commercial CCUS projects.
- Engaged and motivated partners.
- Engaged regulators.
- PCOR Partnership is a catalyst for CCUS projects in the region.
- Focused on infrastructure development strategies.
- Ethanol industry in the region accelerating CCUS.
- Expanding CO_2 EOR opportunities in the region.

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THANK YOU

Critical Challenges. Practical Solutions.

ACKNOWLEDGMENT

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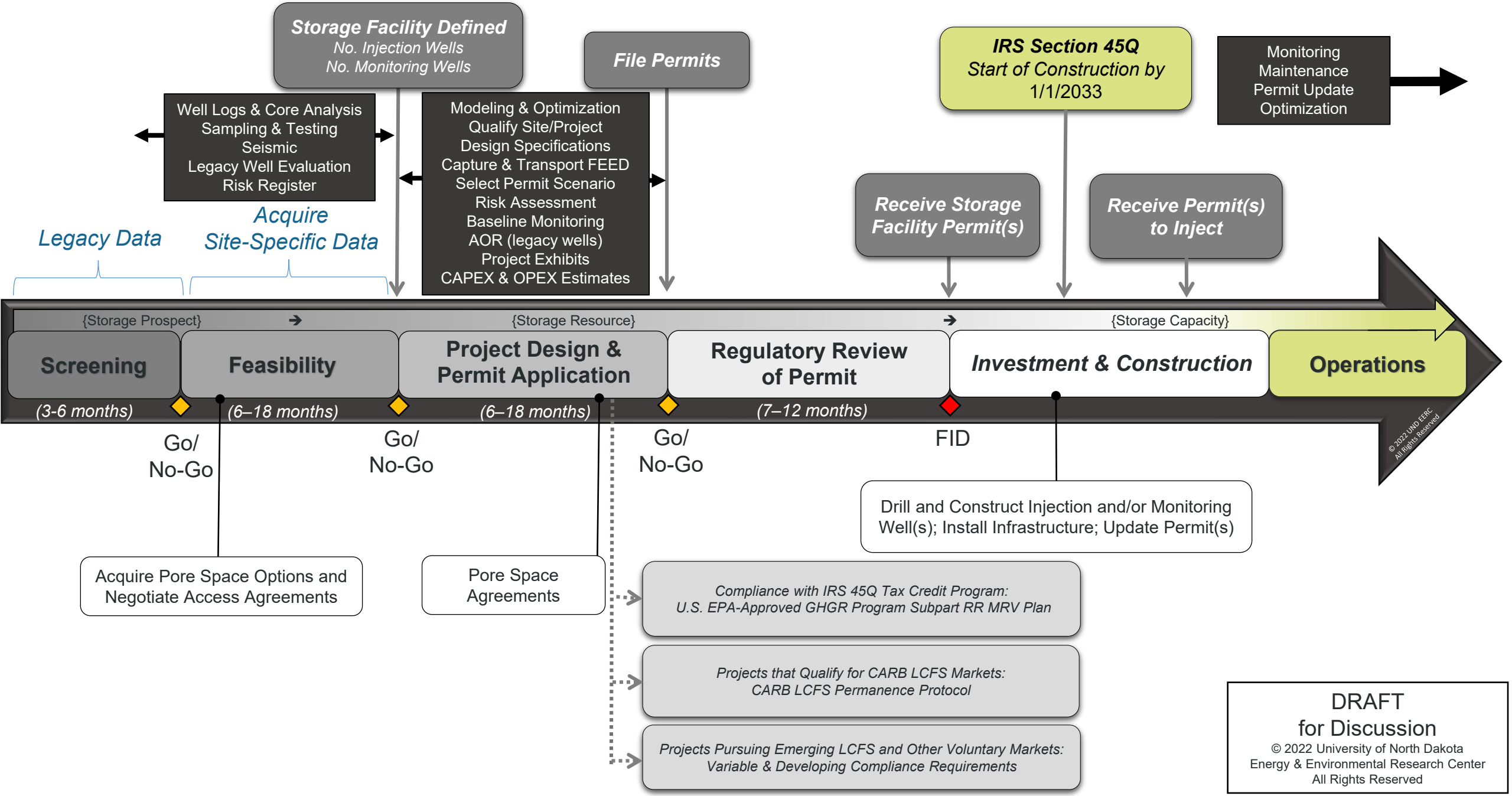
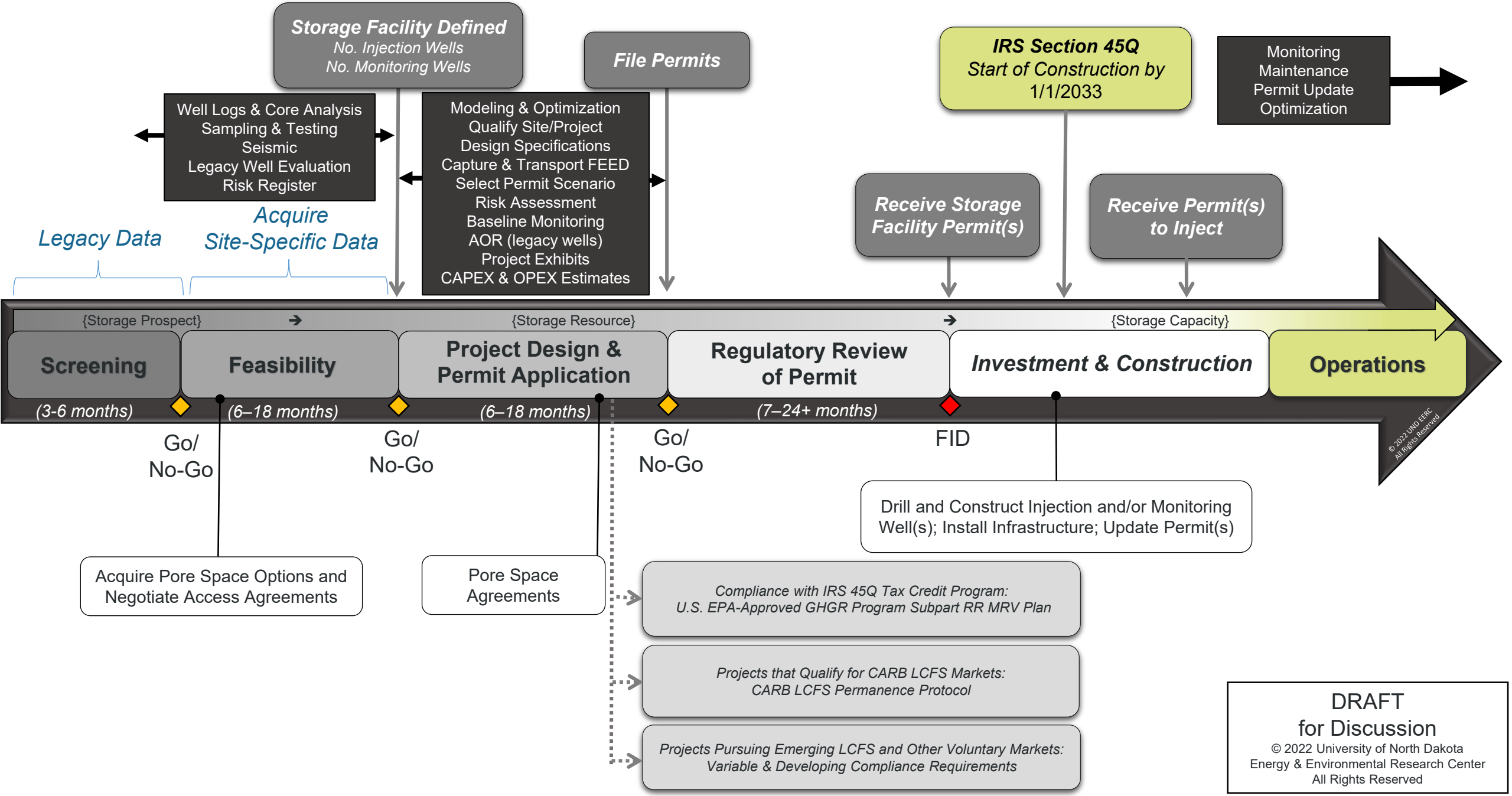
DISCLAIMER

INDICATIVE TIMELINE TO IMPLEMENT CARBON CAPTURE AND GEOLOGIC CO_2 STORAGE IN ND

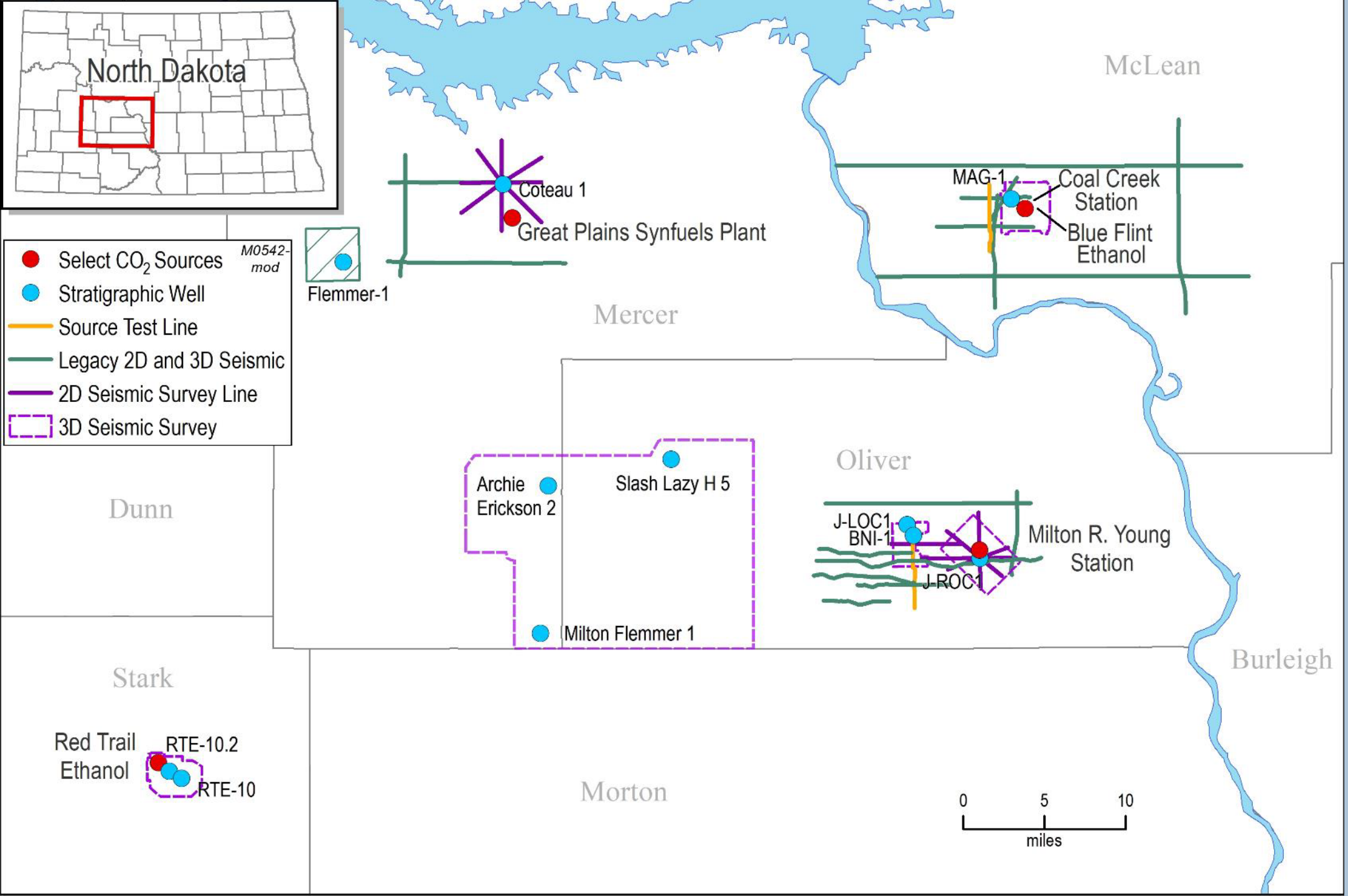


DRAFT
for Discussion

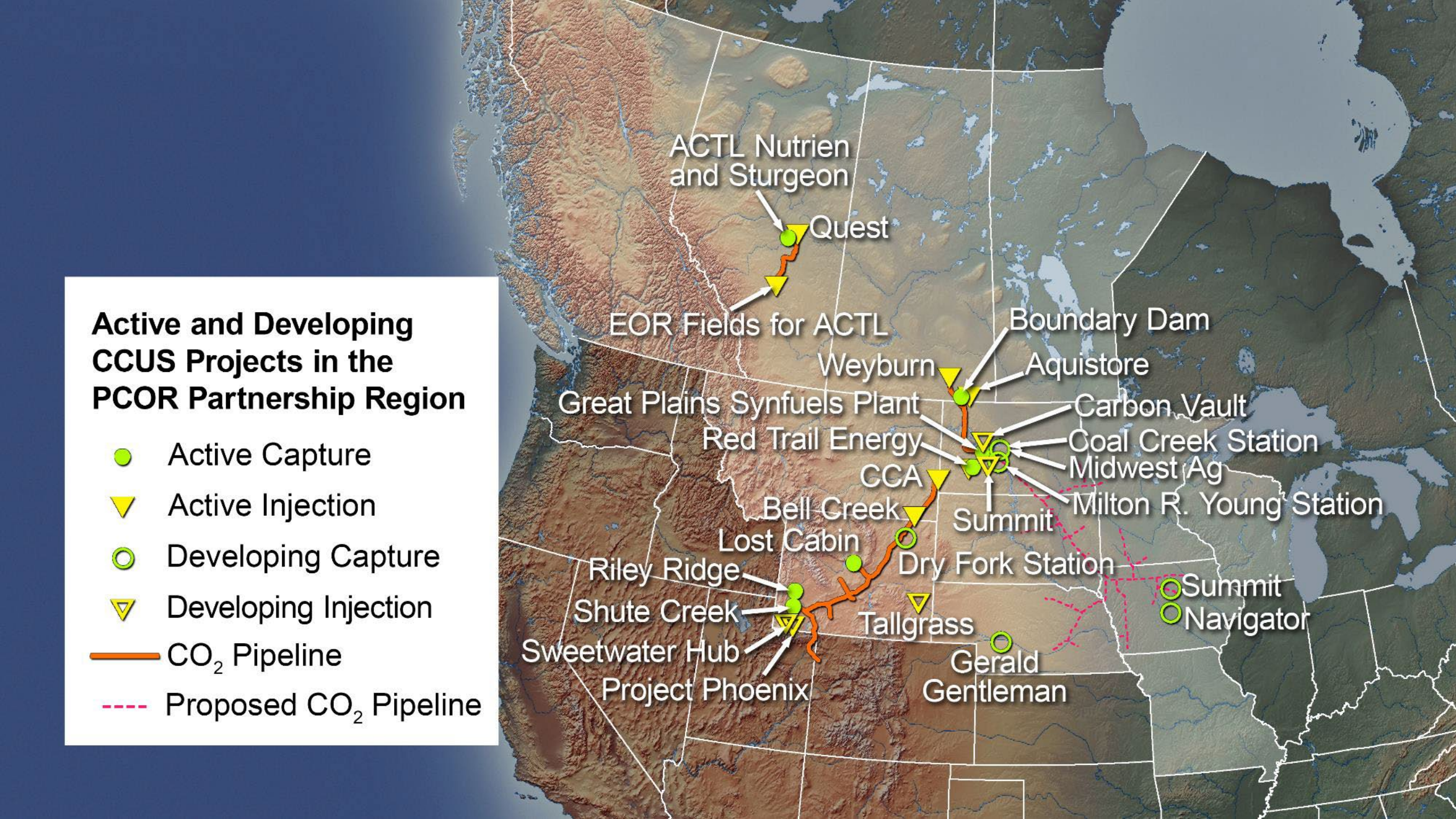
INDICATIVE TIMELINE TO IMPLEMENT CARBON CAPTURE AND GEOLOGIC CO_2 STORAGE



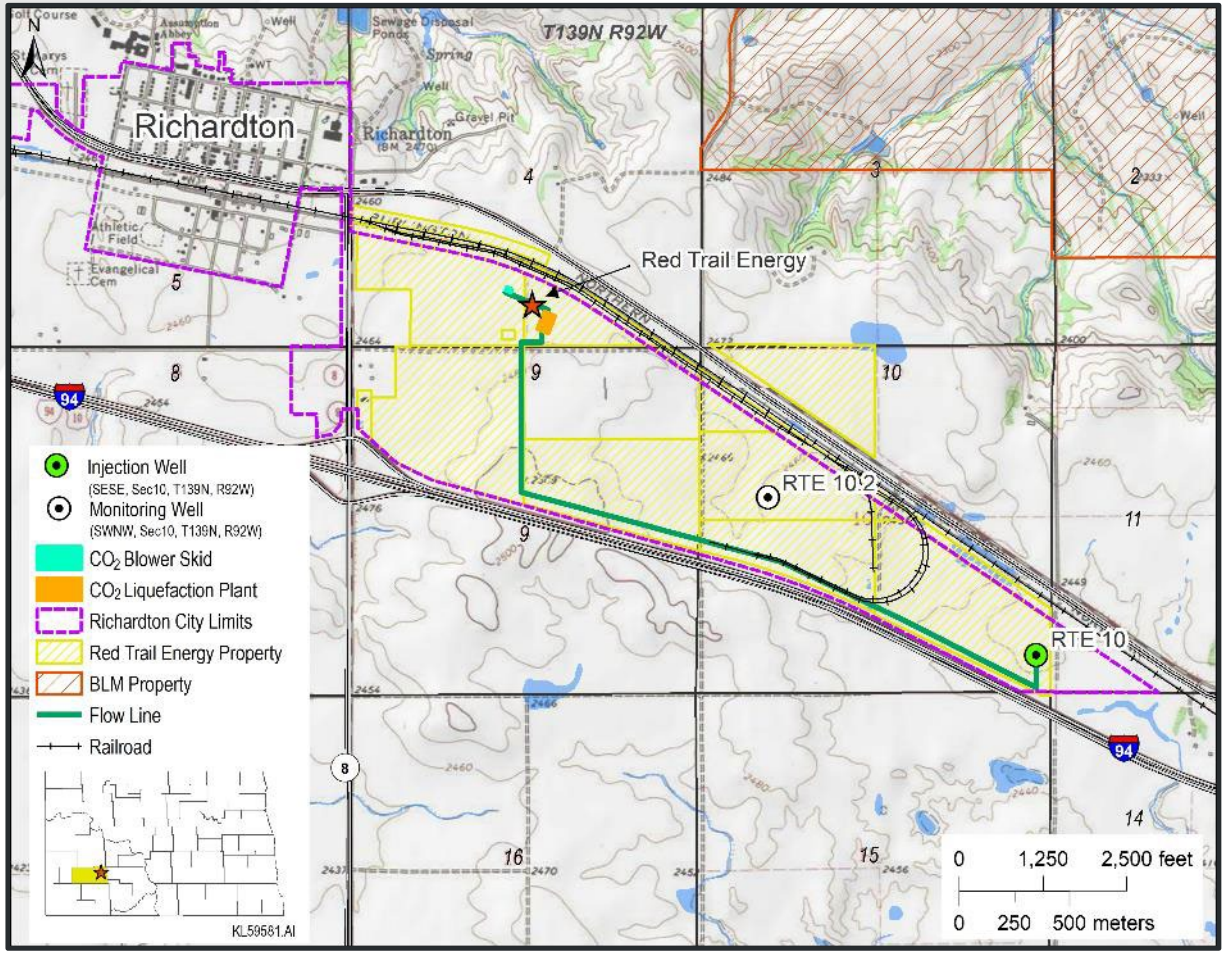
DRAFT
for Discussion



DATA ACQUISITION


Active and Developing CCUS Projects in the PCOR Partnership Region
Active Capture
Active Injection
Developing Capture
Developing Injection
CO_2 Pipeline
Proposed CO_2 Pipeline
ACTL Nutrien and Sturgeon
Quest
EOR Fields for ACTL
Boundary Dam
Weyburn
Aquistore
Great Plains Synfuels Plant
Carbon Vault
Red Trail Energy
Coal Creek Station
Midwest Ag
CCA
Milton R. Young Station
Bell Creek
Summit
Lost Cabin
Dry Fork Station
Riley Ridge
Summit
Navigator
Shute Creek
Tallgrass
Sweetwater Hub
Gerald Gentleman
Project Phoenix

PCOR HIGHLIGHT – RED TRAIL ENERGY CCS PROJECT



Red Trail Energy NDIC Storage Facility Permit

Facility	64-million-gallon dry mill ethanol production plant	
Tonnage	180,000 tonnes per annum	
Injector Design	One CO_2 injector into single storage reservoir	
Regulatory Status	NDIC	Class VI permit approved Permit to Inject approved
Other	Support from US DOE, NDIC Renewable Energy Program, DOE-funded EERC-PCOR for storage site development and novel sustainable monitoring	

CO_2 PRESSURE PLUME AND SATURATION PLUME MONITORING

The Players:

- Research Institute of Innovative Technology for the Earth (RITE)
- RTE
- EERC
- PCOR Partnership
- DOE National Energy Technology Laboratory (NETL)

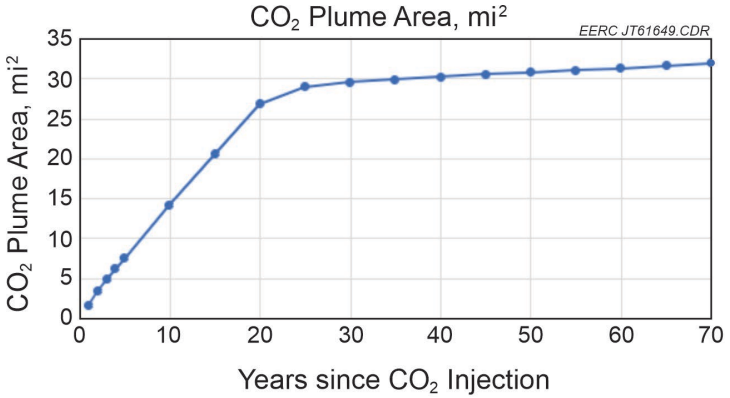
The Challenge: Monitoring requirements for geologic CO_2 storage projects are substantial.

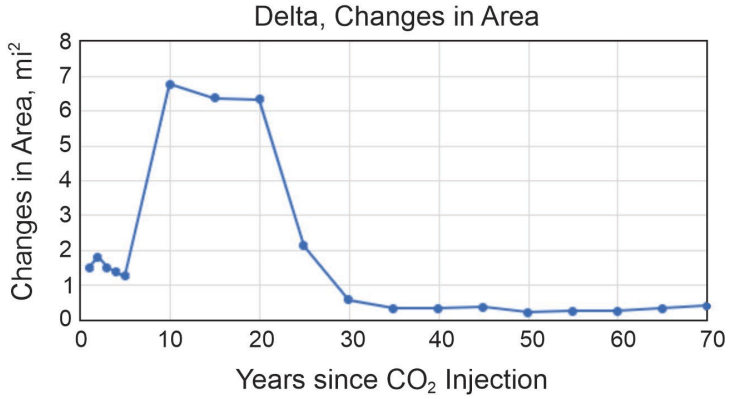
The Objective: Develop the next generation of cost-efficient, long-term monitoring tools and validate them against established methods for monitoring CCS. Develop an approach for more frequent data acquisition and processing while maintaining a reduced surface impact.

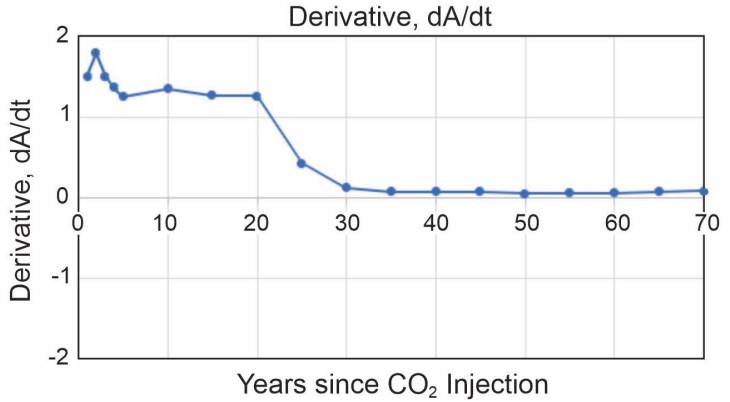
Desired Result: New monitoring tools that are qualified with CCS regulatory and incentive programs and are available for use by CCS projects that can incorporate them into their monitoring strategies.

PCOR HIGHLIGHT – PLUME STABILIZATION

- The EERC, through the PCOR Partnership, conducted a study to evaluate a quantitative approach to demonstrate plume stabilization, with a theoretical case study of a CCS project in North Dakota.
- Plume stabilization is not explicitly defined by EPA rules and regulations.
  - Individual states such as North Dakota may have more rigorously defined plume stability expectations.
- Plume stabilization must be defined by the operator via multiple approaches, including risk assessment, numerical simulations, and monitoring data.
- The EERC conducted a study applying a simplified methodology by Harp and others (2019) to calculate the time at which plume stabilization occurs.
- Plume stabilization can be found when the change in area over time slows to near zero, displaying asymptotic behavior.
  - dA/dt







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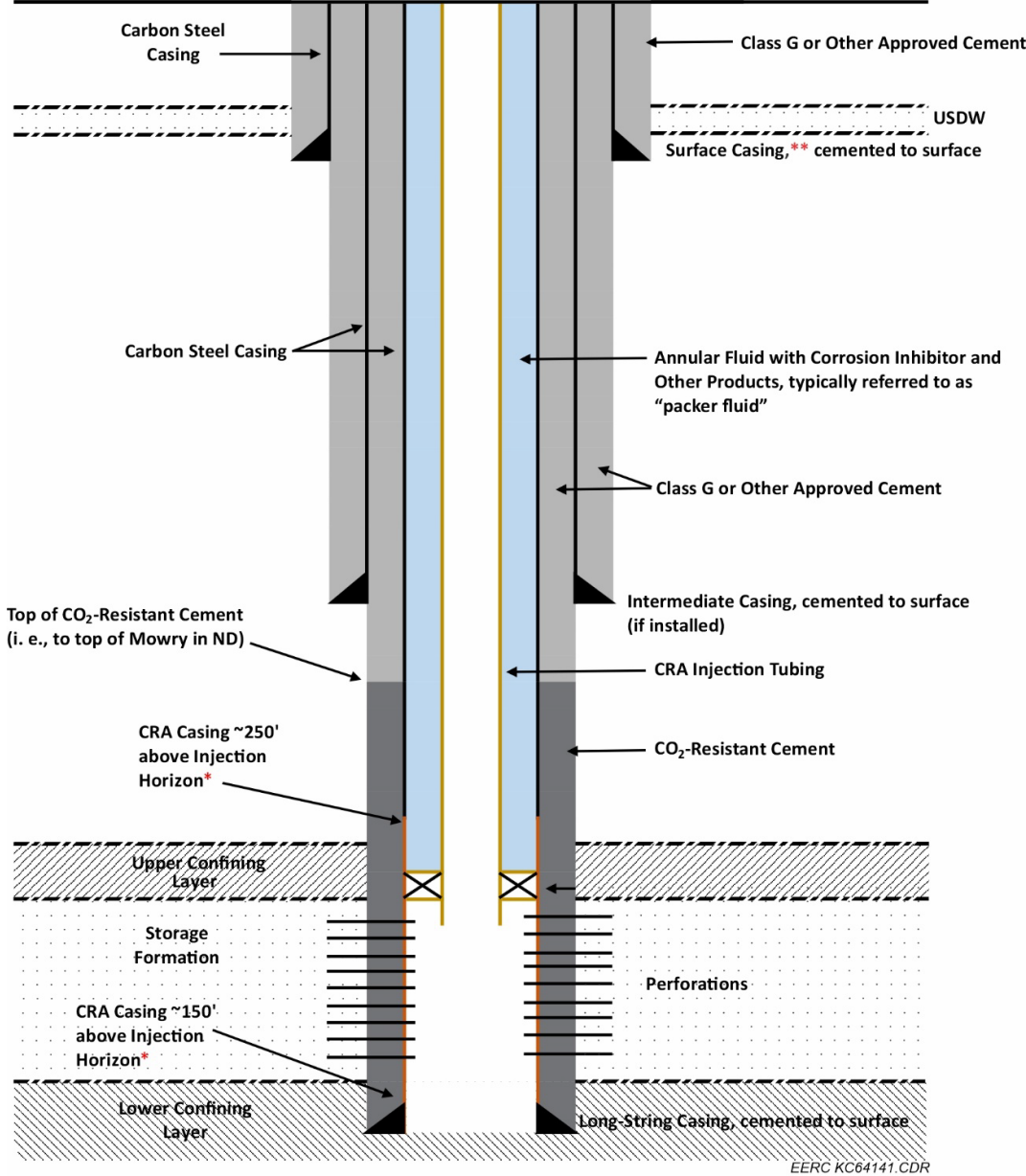
PCOR HIGHLIGHT – PARTNERING WITH STRESS ENGINEERING

- Stress Engineering Services, Inc., is working as a subcontractor to provide the PCOR Partnership with basic guidelines and white papers on considerations for:
  1. Selecting corrosion-resistant alloy material for use in CO_2 storage and utilization applications.
  2. Use of carbon steel (CS) pipelines with CO_2 streams containing hydrogen sulfide (H_2S).
- The EERC is preparing these white papers and guideline documents for publication.

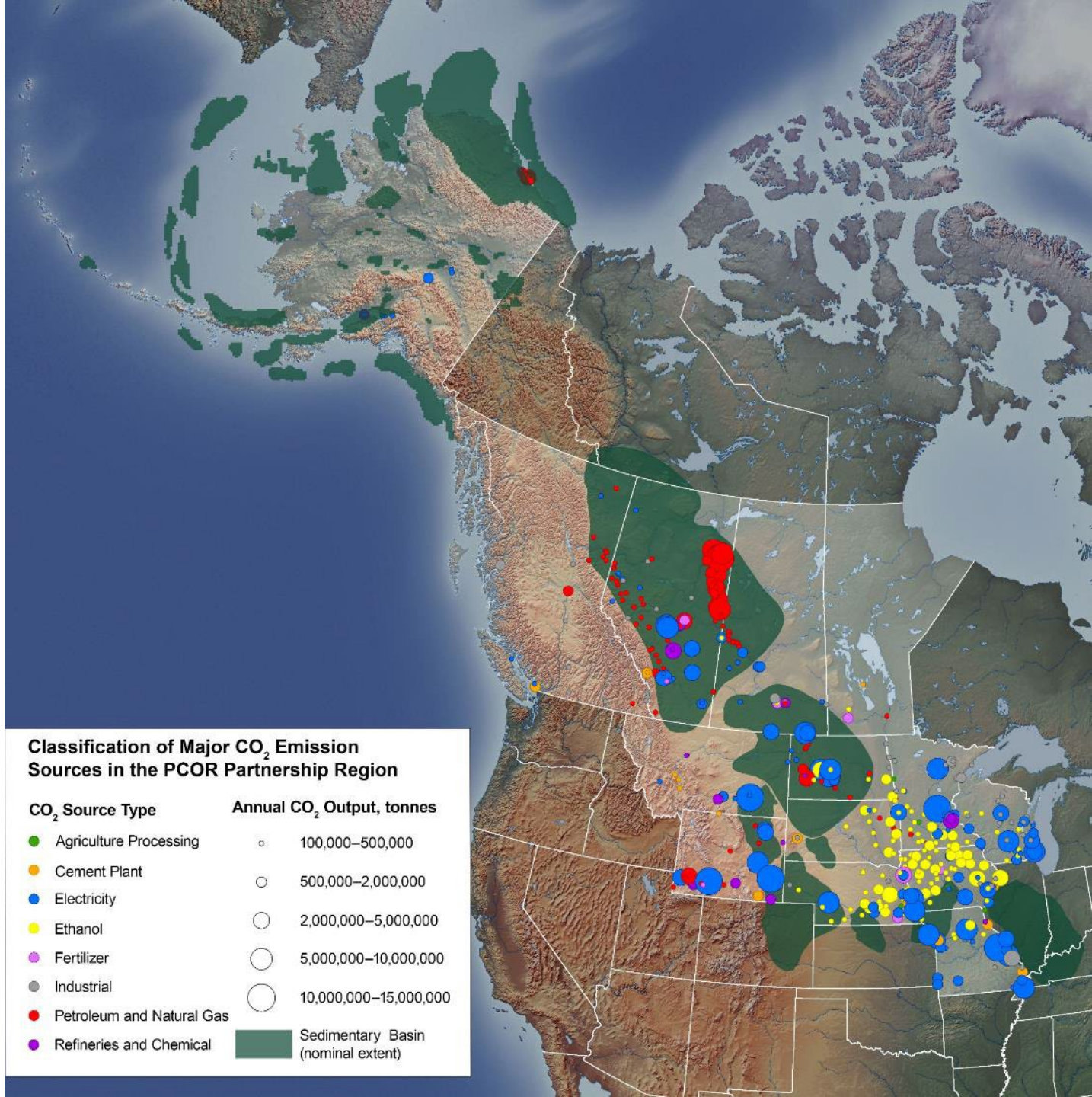


NOTES:

1. Drawing is not to scale but to provide a representation for the construction of a CCS injection well.
2. CRA = corrosion-resistant alloy
3. Injection packer is to be installed within 50' of the top perforation.

*Indicated lengths are provided as a reference and would be defined on a project-by-project basis.
**Surface casing is required to be set 50' below lowermost source of drinking water.

REGIONAL SOURCES AND SEDIMENTARY BASINS



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PCOR PARTNERSHIP – NEW PARTNERS

2022 New Partners

- Air Products
- Alaska Asia
- Alaska DNR
- Aramco Americas
- Bakken Energy
- Barr Engineering
- BKV Corporation
- Carbon Alpha
- Cerilon (ND Ventures)
- CO2SeQure
- Dark Vision Technologies Inc.
- Devon Energy
- Enbridge
- Enerplus
- GLJ Ltd.
- Halliburton
- Hess
- Hydrogen Naturally
- Liberty Media
- Marathon Petroleum Corporation
- Neset Consulting
- Paragon Geophysical Services
- Rainbow Energy
- RITE
- SimTech
- Stryde Limited
- Tallgrass Energy
- TERRACOH, inc.
- White Rock Oil and Gas

2023 New Partners

- Avalon International Corporation
- Bank of North Dakota
- ConocoPhillips
- Emerson
- Frontier Carbon Solutions
- Hitachi Industrial Equipment & Solutions America, LLC
- Hunting Energy Services
- Marubeni-Itochu Tubulars America Inc.
- OLI Systems, Inc.
- Retract
- Rock Flow Dynamics
- Stress Engineering
- Sumitomo Corporation
- WOGCC