



Energy & Environmental Research Center (EERC)

An Overview of Carbon Capture Utilization and Storage (CCUS)

2023 MACPZA Spring Conference

Alexandria, Minnesota

June 2, 2023

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**HIGH-BAY
TECHNOLOGY
DEMONSTRATION**

**FUEL
PROCESSING**

**MOBILE
LABORATORIES**

**WATER USE
MINIMIZATION
TECHNOLOGY**

FUELS OF THE FUTURE

**NATIONAL CENTER
FOR HYDROGEN
TECHNOLOGY**

CHEMICAL STORAGE

LABORATORIES

OFFICES

**IN-HOUSE
FABRICATION SHOP**

**TECHNOLOGY
DEMONSTRATION**

**DISCOVERY HALL
MEETING AREA**

OUR FACILITIES

254,000 SQ FT OF FACILITIES

CORE RESEARCH PRIORITIES

Coal Utilization & Emissions

Carbon Management

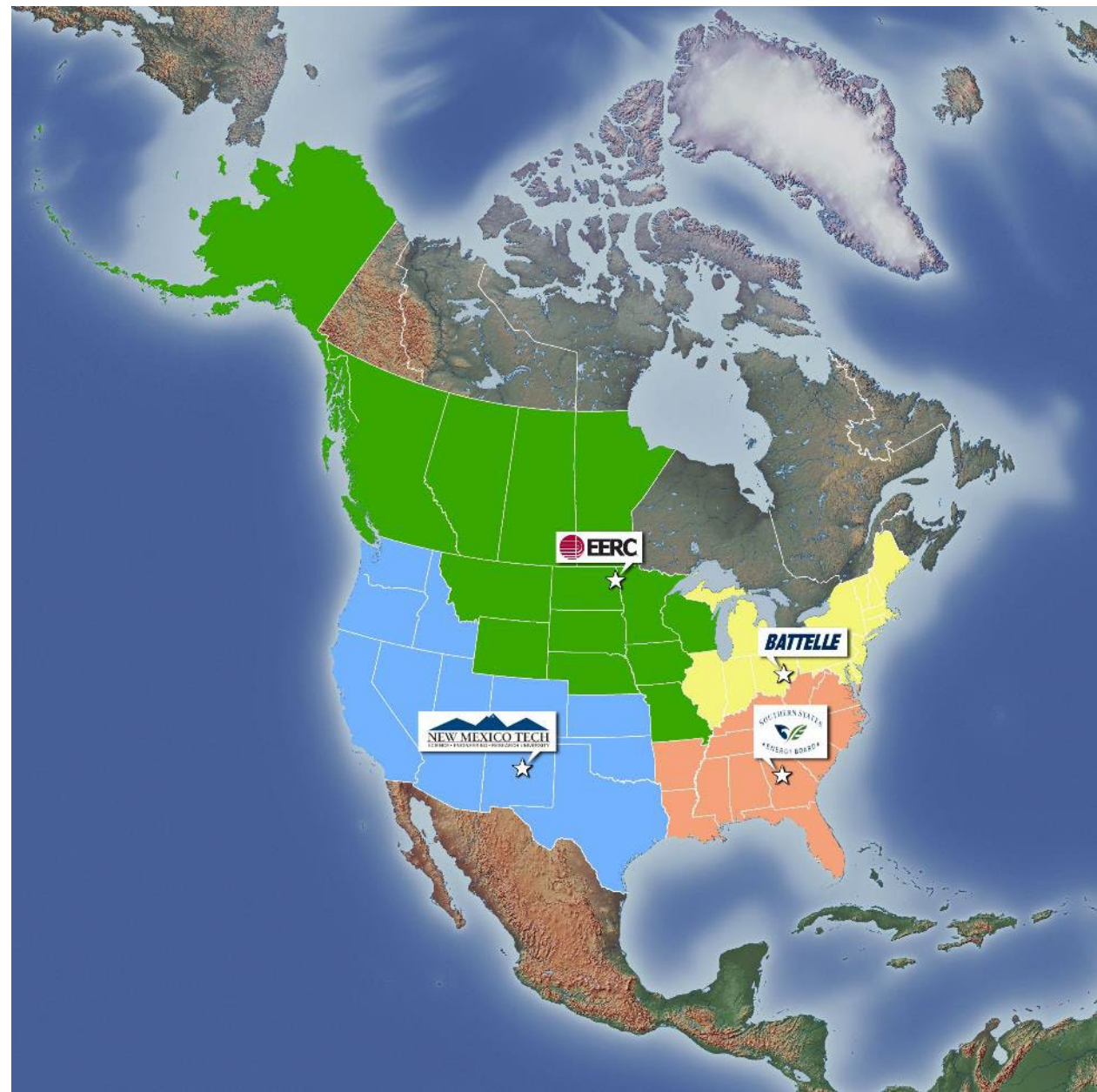
Oil & Gas

Alternative Fuels & Renewable Energy

Energy–Water



REGIONAL CARBON SEQUESTRATION PARTNERSHIP PROGRAM



Critical Challenges. Practical Solutions.

PCOR PARTNERSHIP

2003–2005 – PCOR Partnership: Characterization

2005–2008 – PCOR Partnership: Field Validation

2007–2019 – PCOR Partnership: Commercial Demonstration

2019–2024 – PCOR Partnership Initiative: Commercial Deployment



U.S. DEPARTMENT OF
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ENERGY
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LABORATORY



Institute of Northern Engineering
University of Alaska Fairbanks



UNIVERSITY
OF WYOMING
School of
Energy Resources



EERC



U.S. DEPARTMENT OF
ENERGY



NATIONAL
ENERGY
TECHNOLOGY
LABORATORY

Image credit – EERC

PCOR PARTNERSHIP

2003–PRESENT

The PCOR Partnership Initiative addresses regional capture, transport, use, and storage challenges facing commercial CCUS deployment. The Initiative focuses on:

- Strengthening the technical foundation for geologic CO₂ 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 policy makers.
- Enabling and advancing deployment of CCUS.



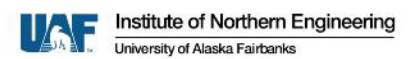
Our Partners inform our priorities.



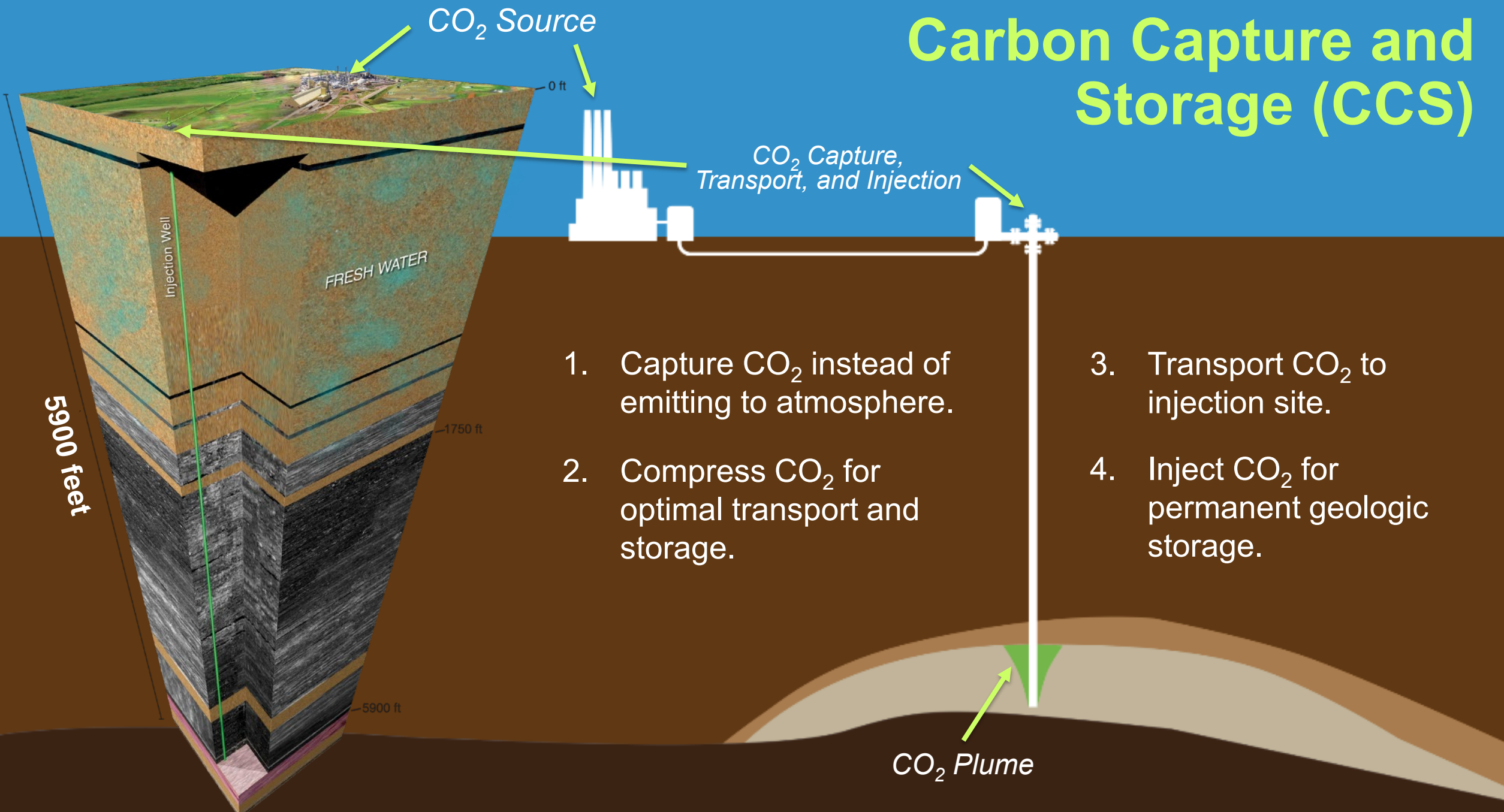
Critical Challenges. Practical Solutions.



PARTNERSHIP MEMBERS

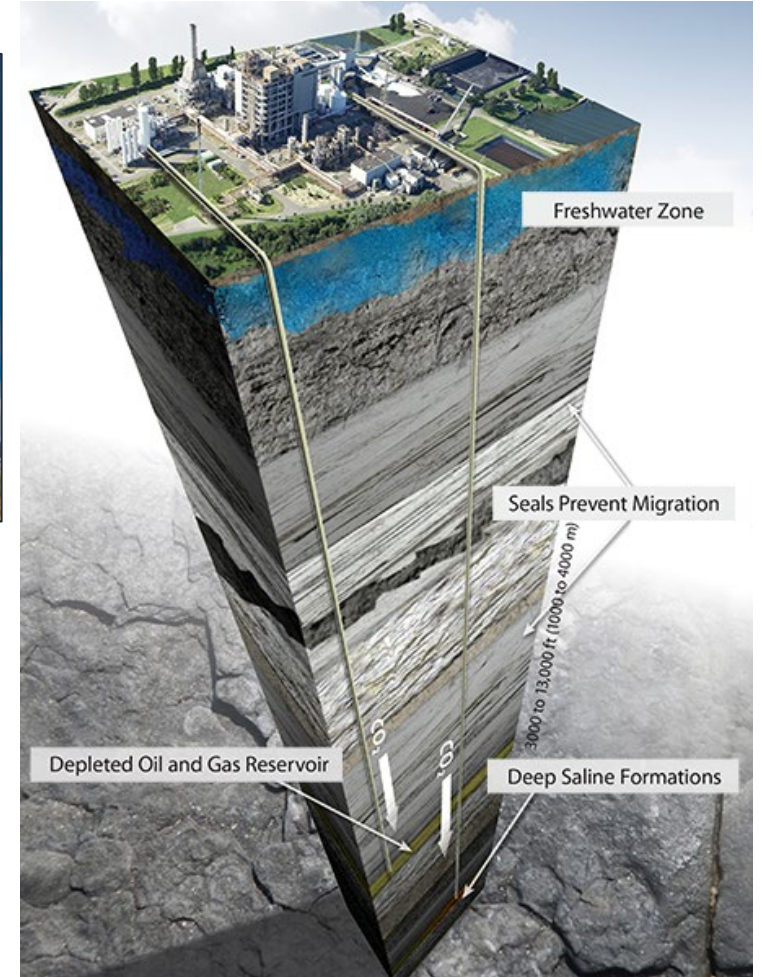


Carbon Capture and Storage (CCS)



1. Capture CO₂ instead of emitting to atmosphere.
2. Compress CO₂ for optimal transport and storage.
3. Transport CO₂ to injection site.
4. Inject CO₂ for permanent geologic storage.

CO₂ CAN BE MANAGED



A close-up photograph of a person's hands holding a large, rectangular, reddish-brown soil core sample. The soil has a porous, crumbly texture. The background is blurred, showing a person in a white lab coat. In the bottom right corner, there is white text on a dark background.

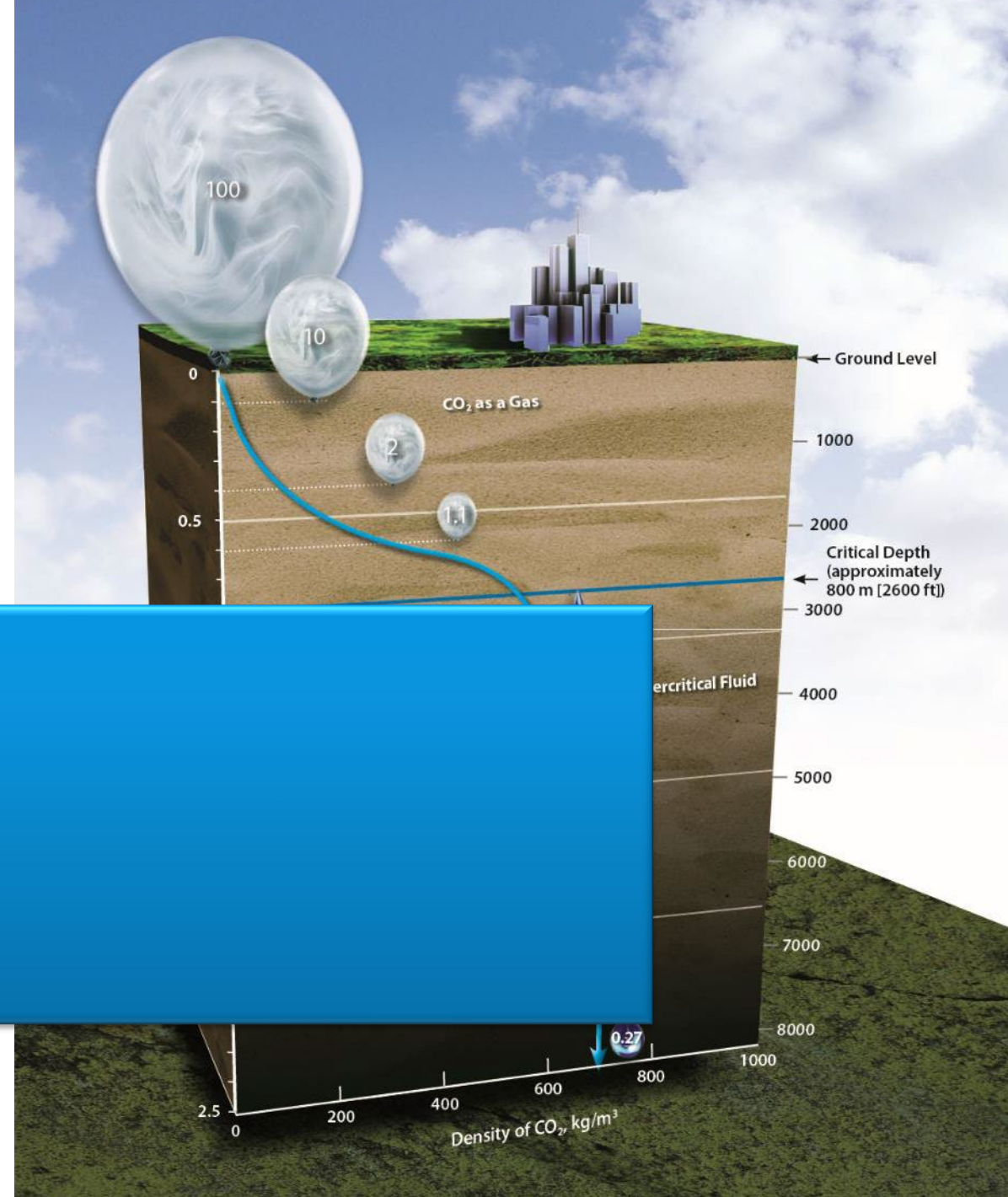
**GEOLOGIC
STORAGE OF
CARBON DIOXIDE**

CRITICAL SUBSURFACE CHARACTERISTICS

- Depth
- Porosity/permeability
- Good cap rock
- Appropriate salinity
- No natural leakage pathways

Depth

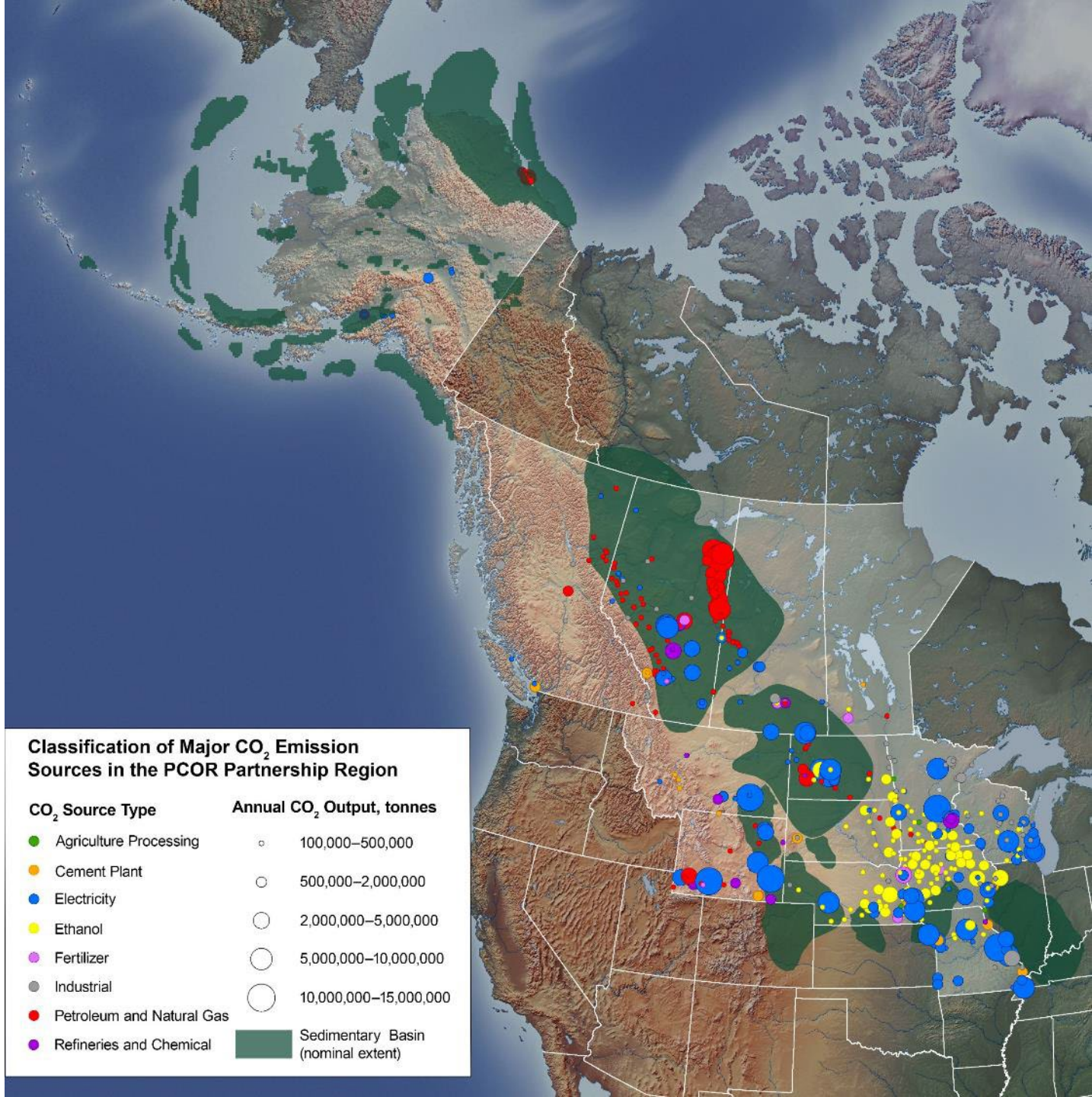
- Below approximately 2600 ft, CO₂ becomes a supercritical fluid.
- CO₂ will behave like a liquid.
- High density of the CO₂ allows for more storage in a given volume.



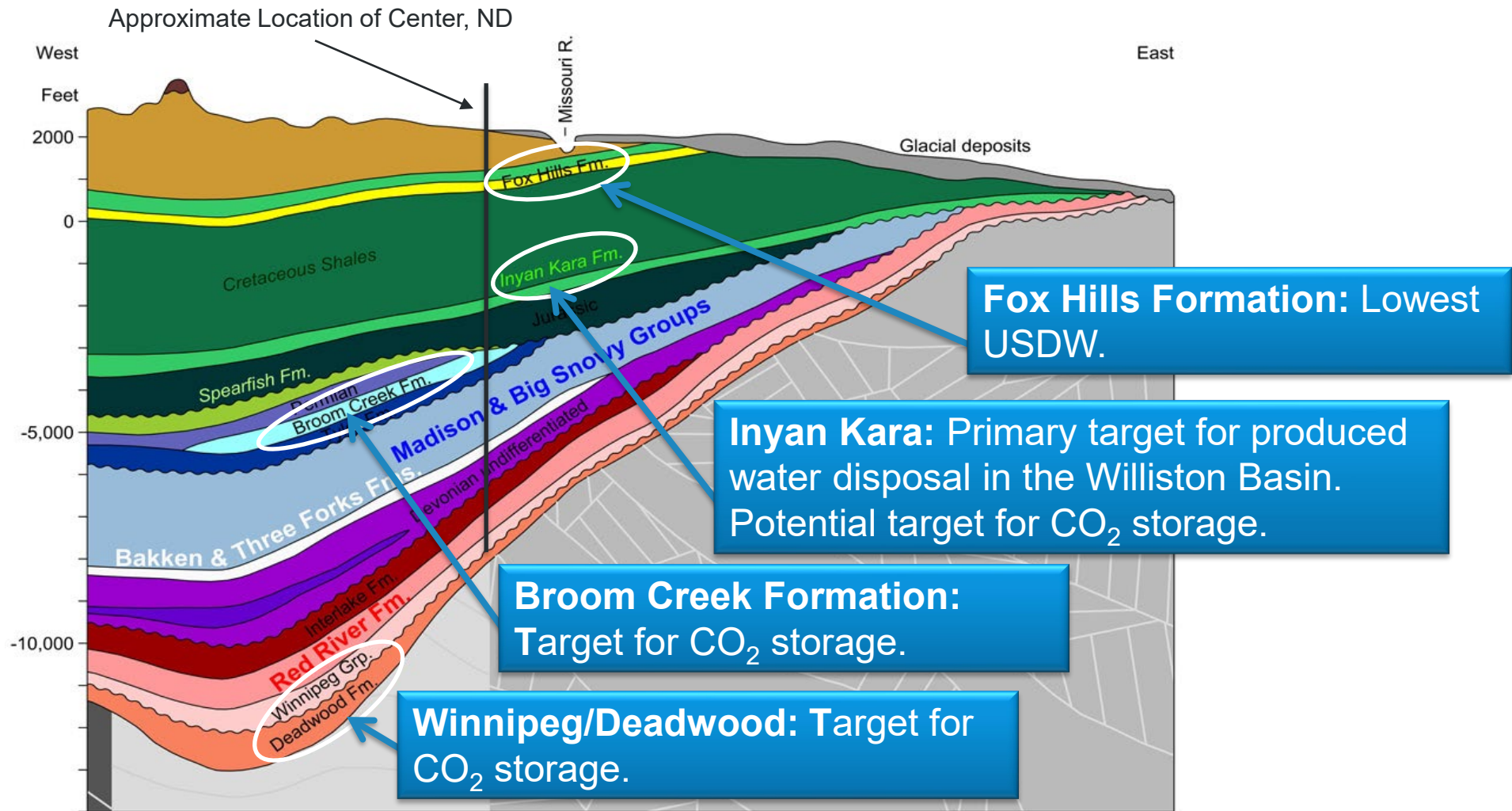
POROSITY AND PERMEABILITY



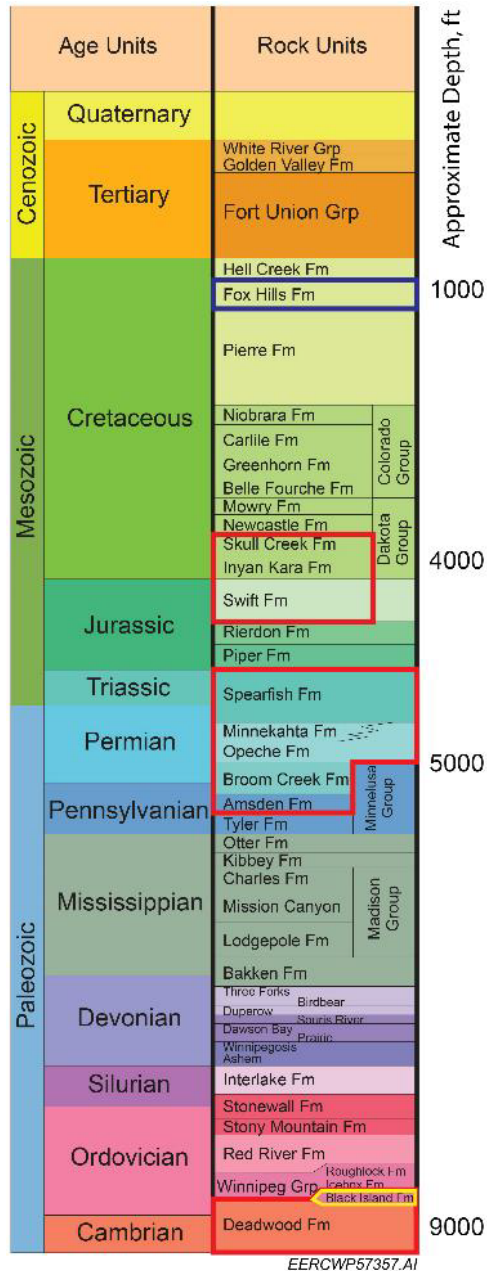
REGIONAL SOURCES AND SEDIMENTARY BASINS



WILLISTON BASIN SALINE STORAGE OPPORTUNITIES



North Dakota Stratigraphic Column



WILLISTON BASIN GEOLOGY OFFERS MULTIPLE OPTIONS FOR CCS AND CCUS

Inyan Kara Fm – Saline Storage

Broom Creek Fm – Saline Storage

Madison conventional reservoirs – EOR

Bakken and Three Forks unconventional reservoirs – EOR
Duperow conventional reservoirs – EOR

Red River conventional reservoirs – EOR

Deadwood Fm – Saline Storage



Image Credit: Energy & Environmental Research Center

INCENTIVES

45Q Tax Credits

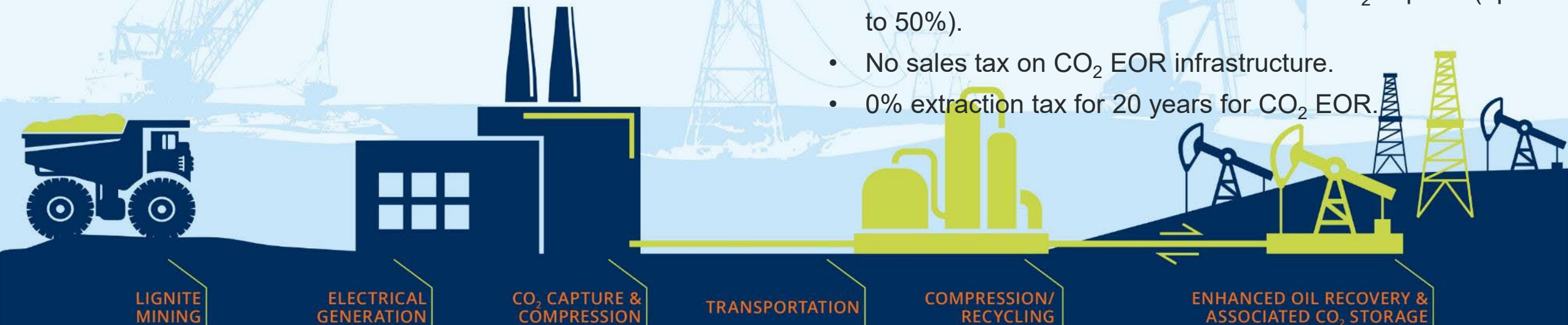
- Projects beginning construction before January 1, 2033, can claim credits for 12 years after operations begin.
- Provides for direct payment for 45Q credits.
- Tax credit for CO₂ stored in a qualified EOR project: \$60/tonne.
 - Tax credit from direct air capture (DAC): \$130/tonne.
- Tax credit for CO₂ stored in a saline formation: \$85/tonne.
 - Tax credit from DAC: \$180/tonne.

West Coast LCFS Markets

- Credits trading up to \$80–\$220 per ton (June 2021–2022).
- Stacked with 45Q.

North Dakota Incentives

- No sales tax on capture-related infrastructure.
- No sales tax on CO₂ sold for EOR.
- No sales tax on construction of pipeline.
- Property tax-exempt for 10 years (equipment).
- Coal conversion tax: tax reduction with CO₂ capture (up to 50%).
- No sales tax on CO₂ EOR infrastructure.
- 0% extraction tax for 20 years for CO₂ EOR.



REGULATING GEOLOGIC STORAGE OF CARBON DIOXIDE



7. "Storage facility" means a wellbore, cavern, or other formation, and a wellbore, cavern, or other formation used for storing carbon dioxide and equipment used for injecting and recovering carbon dioxide.
 8. "Storage operator" means a person who is responsible for the safe and sound operation of a storage facility.
 9. "Storage reservoir" means a wellbore, cavern, or other formation used for storing carbon dioxide.
- 38-22-03. Commission authority.**
The commission has authority:
Over all persons and property necessary to administer and enforce this act;
To regulate activities relating to a storage facility, including construction, operation, maintenance, and investigation of a storage facility;
To require, in a reasonable time and manner, a storage facility operator to provide assurance of financial responsibility for the facility;
To require storage facility operators to provide assurance of financial responsibility for the facility;
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Critical Challenges. Practical Solutions.

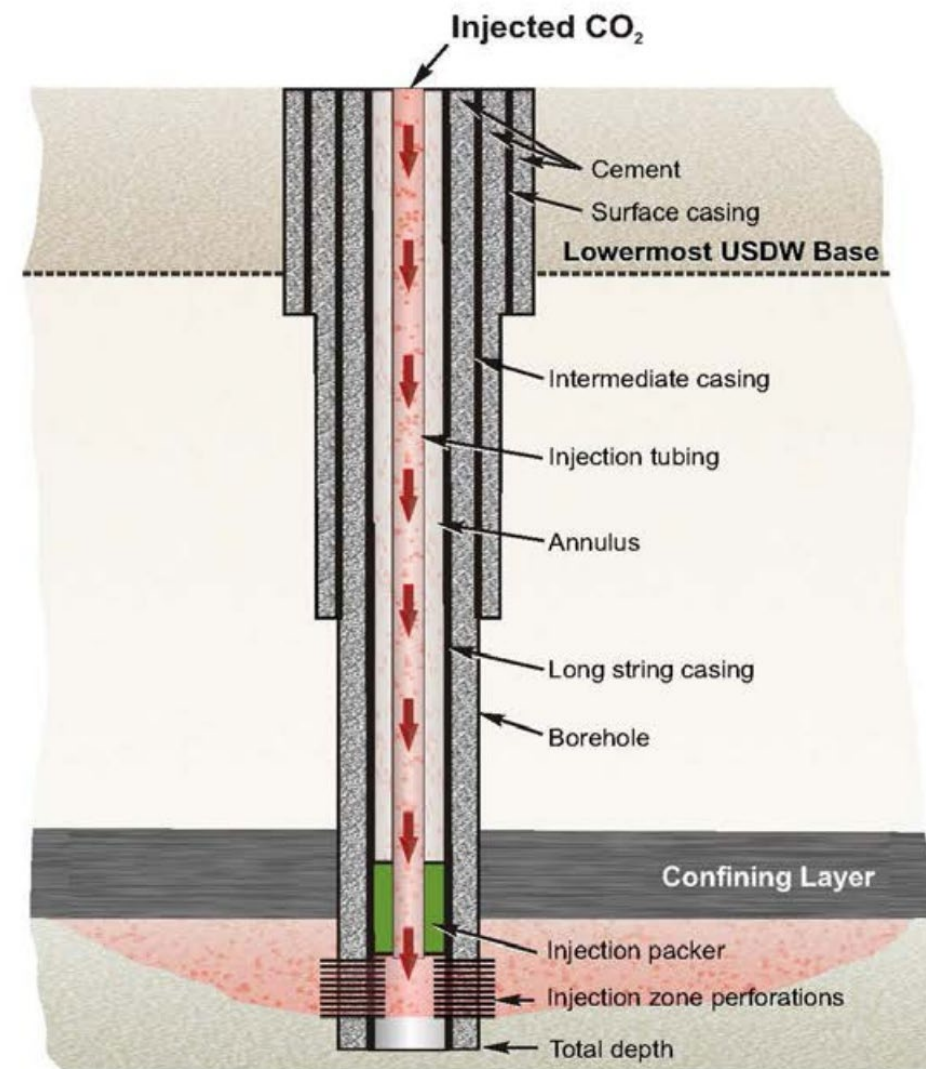
POLICY AND REGULATORY DEVELOPMENTS

- Pore space Law
- Long-term responsibility
- Class VI primacy
- Regulatory program implementation
- Pathways to permit approval
- Policy/regulatory barriers



CLASS VI INJECTION WELLS

- Class designated for CO₂ injection wells as required by the U.S. Environmental Protection Agency (EPA) under the Safe Drinking Water Act.
- Material costs are increased over other well types (corrosion resistance, increased tensile/compressive strength, etc.).
- Injection target formation total dissolved solids (TDS) content cannot be less than 10,000 milligrams per liter.



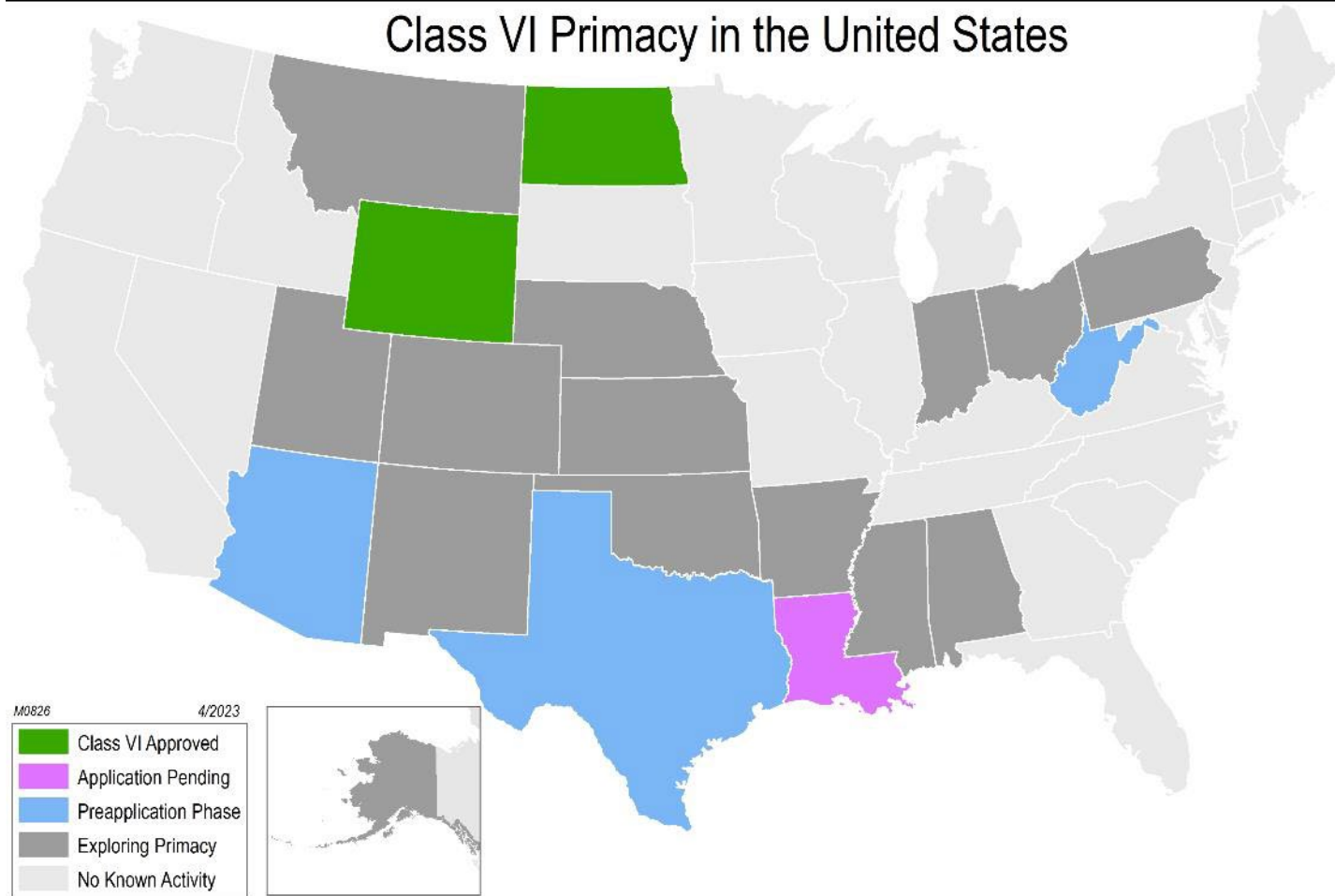
Critical Challenges. Practical Solutions.

Class VI Primacy in the United States

UNDERGROUND INJECTION CONTROL (UIC) PROGRAM

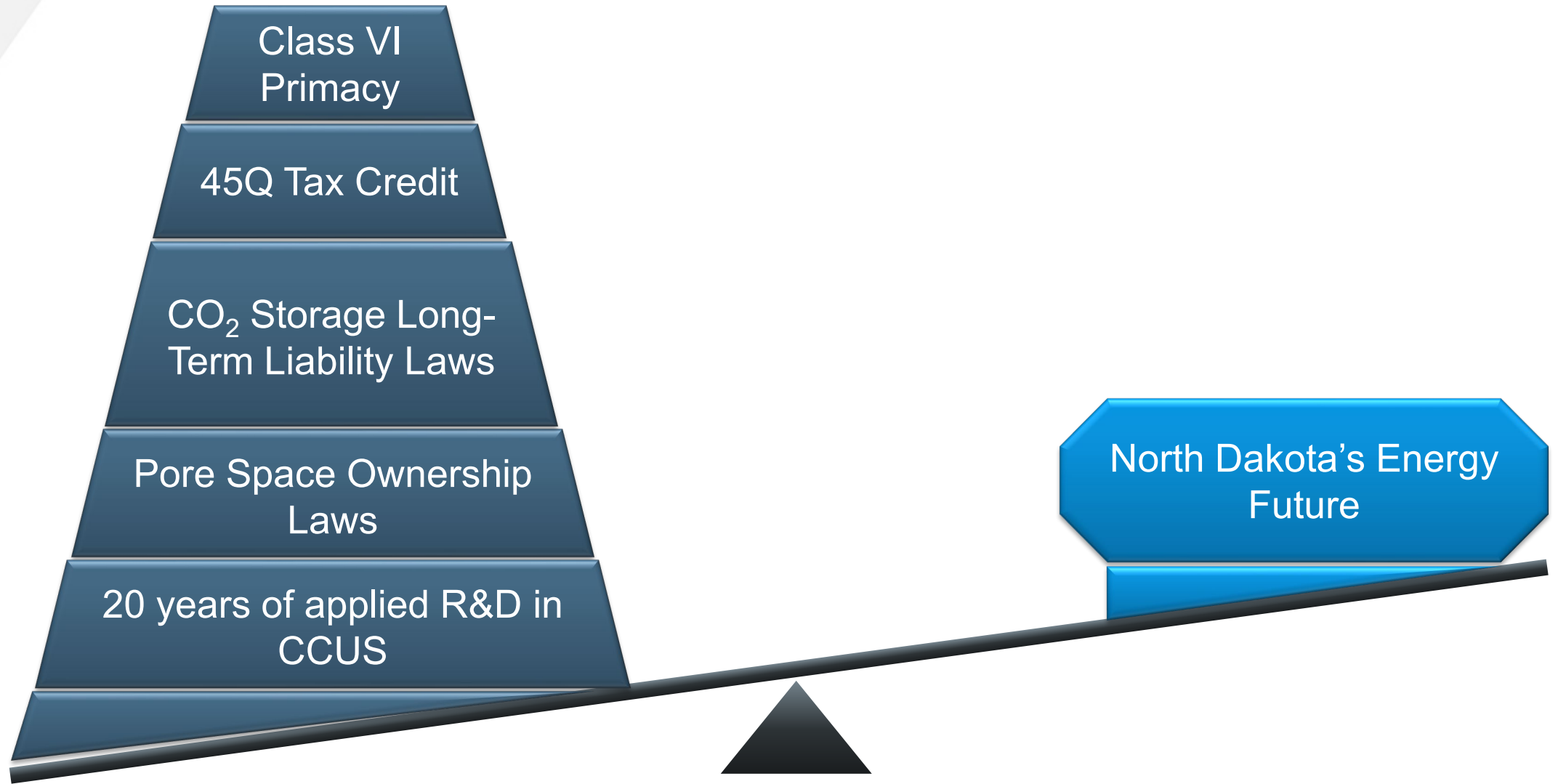
UIC Program Standards:

- 1) Protection of underground sources of drinking water (USDWs)
- 2) Injection zone
- 3) Confining zones (upper and lower)
- 4) AOR and corrective action
- 5) Wellbore integrity demonstration



Class I	Class II	Class III	Class IV	Class V	Class VI
Hazardous and nonhazardous fluids (industrial and municipal wastes).	Brines and other fluids associated with oil and gas production, including CO ₂ EOR.	Fluids associated with solution mining of minerals.	Hazardous or radioactive wastes. This class is banned by EPA.	Nonhazardous fluids into or above a USDW and are typically shallow.	Injection of CO ₂ for long-term storage.

NORTH DAKOTA'S LEVERAGE

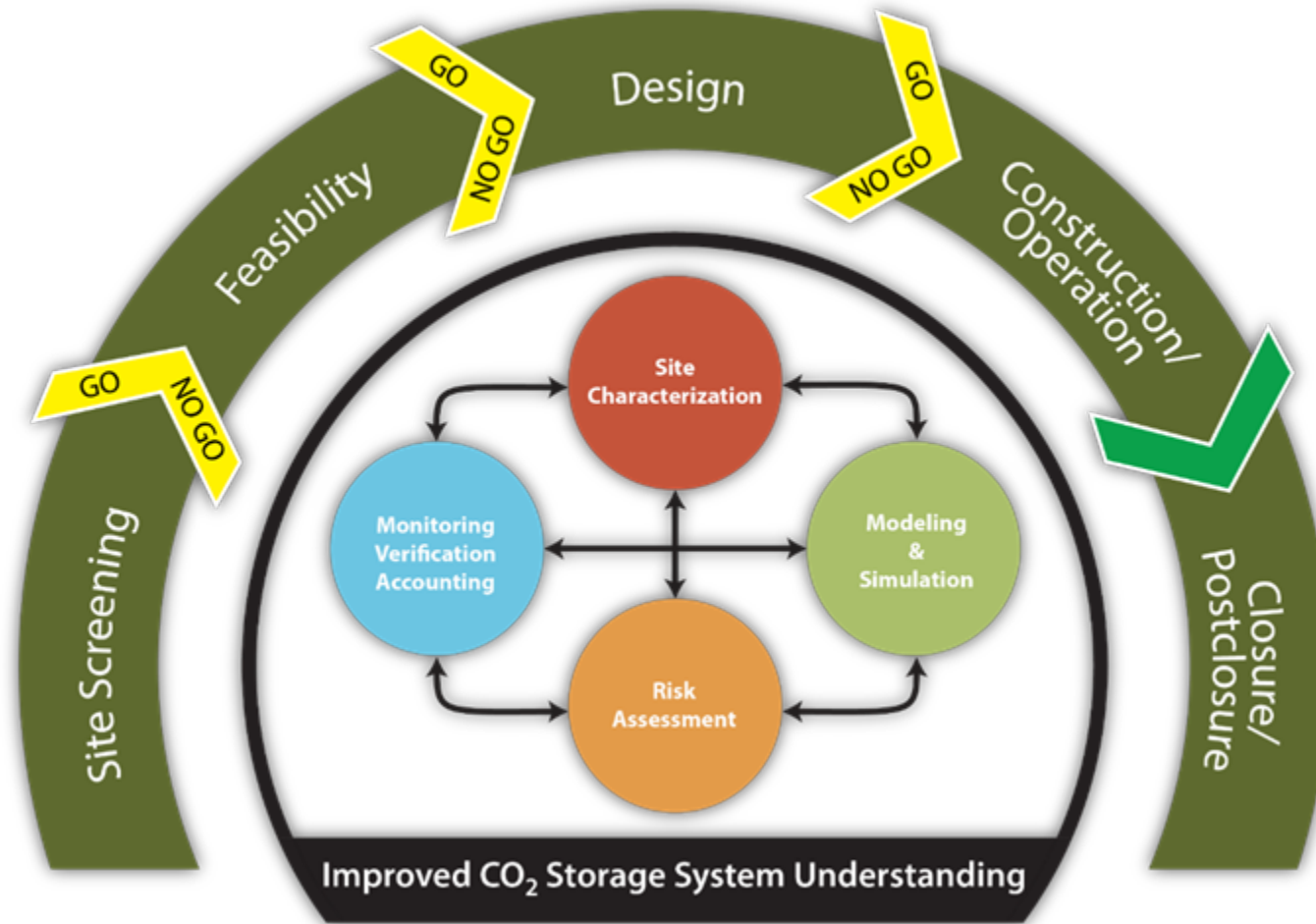


DEVELOPING A PROJECT



Critical Challenges. Practical Solutions.

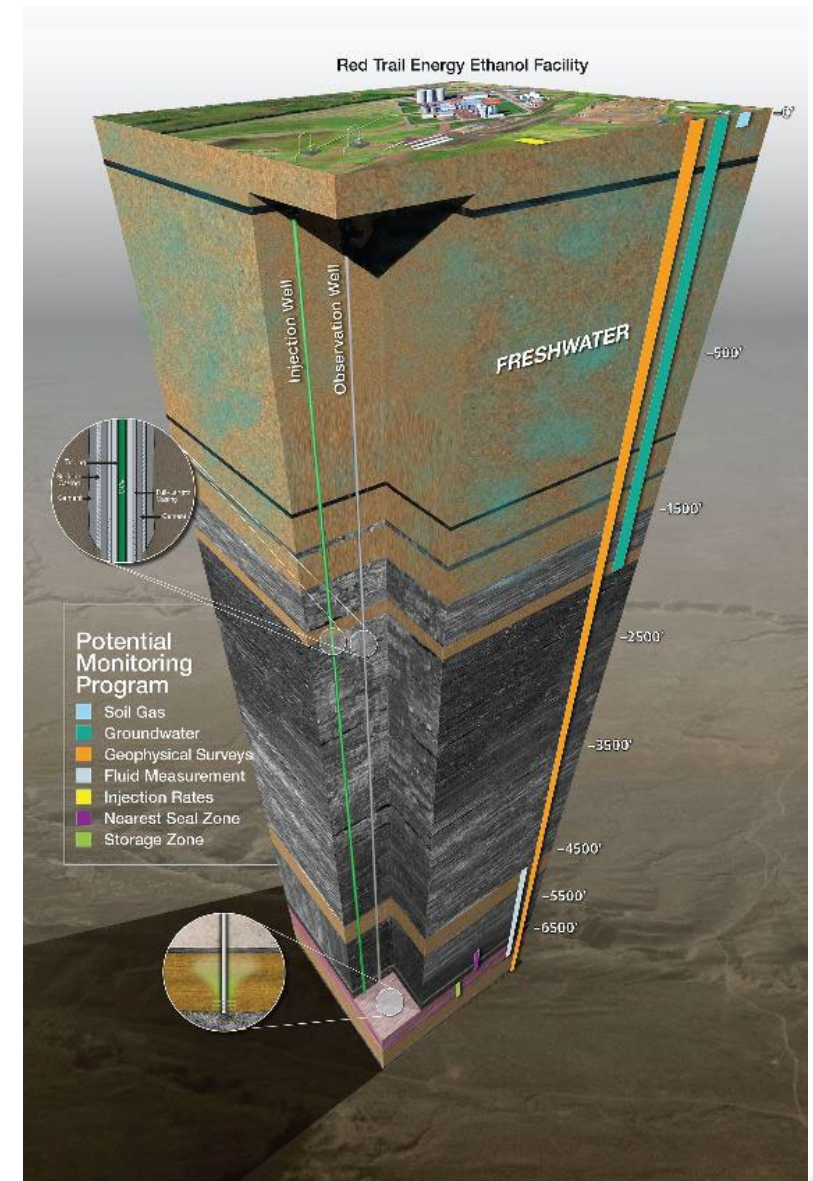
ADAPTIVE MANAGEMENT APPROACH



STORAGE FACILITY PERMIT

North Dakota CO₂ Storage Facility Permit (Class VI) Checklist

- Pore Space Access
- Geologic Exhibits
- Geologic Model and Simulations
- Area of Review (AOR)
 - Supporting Plans
 - Testing and Monitoring Plan
 - Postinjection Site and Facility Closure Plan
 - Emergency and Remedial Response Plan
 - Worker Safety Plan
 - Well Casing and Cementing Program
 - Plugging Plan
 - Financial Assurance Demonstration Plan
- Injection Well and Storage Reservoir Information

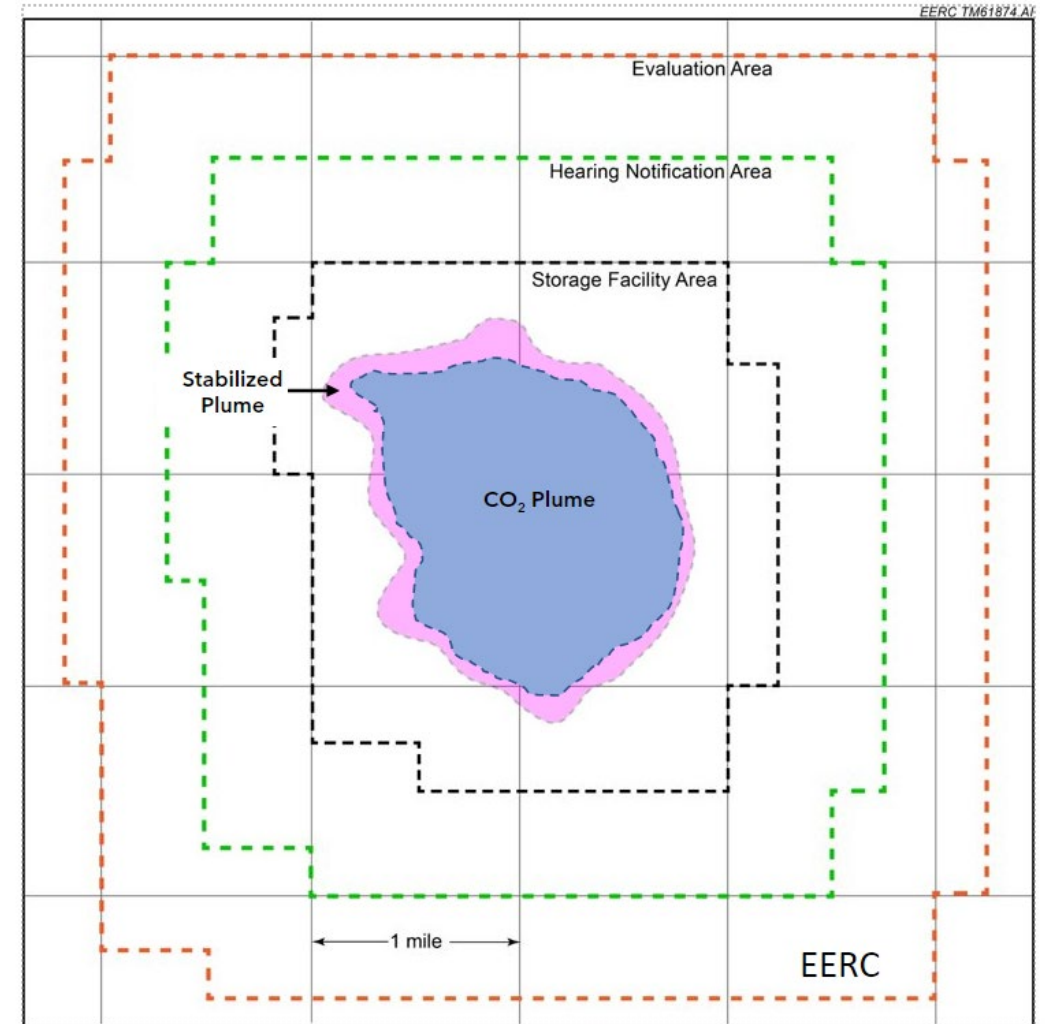


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STORAGE FACILITY PROJECT BOUNDARIES

North Dakota UIC Class VI

- **CO₂ Plume** – Simulated boundary at end of injection.
- **Stabilized Plume** – Simulated boundary at postinjection stabilization.
- **Storage Facility Area** – Boundary + Buffer
[pore space lease and amalgamation area]
- **Hearing Notification Area** – ½ mile from the storage facility area boundary (mineral estate and surface estate).
- **Area of Review (AOR)** – Not shown; calculated with simulation.
- **Evaluation Area** – 1 mile from the storage facility area boundary (default minimum AOR).



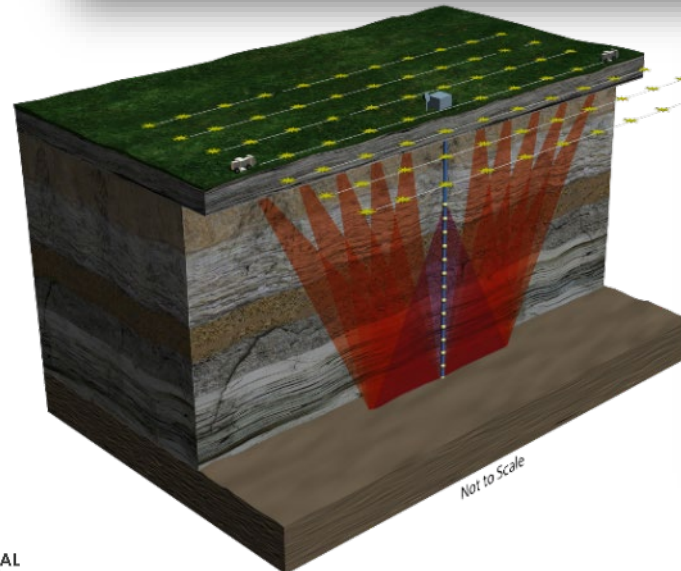
CO₂ IS MONITORED EVERY STEP OF THE WAY



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SUBSURFACE MONITORING IS DONE TO ENSURE CONTAINMENT

Regulations require periodic subsurface monitoring.



SOIL GAS MONITORING



Critical Challenges. Practical Solutions.

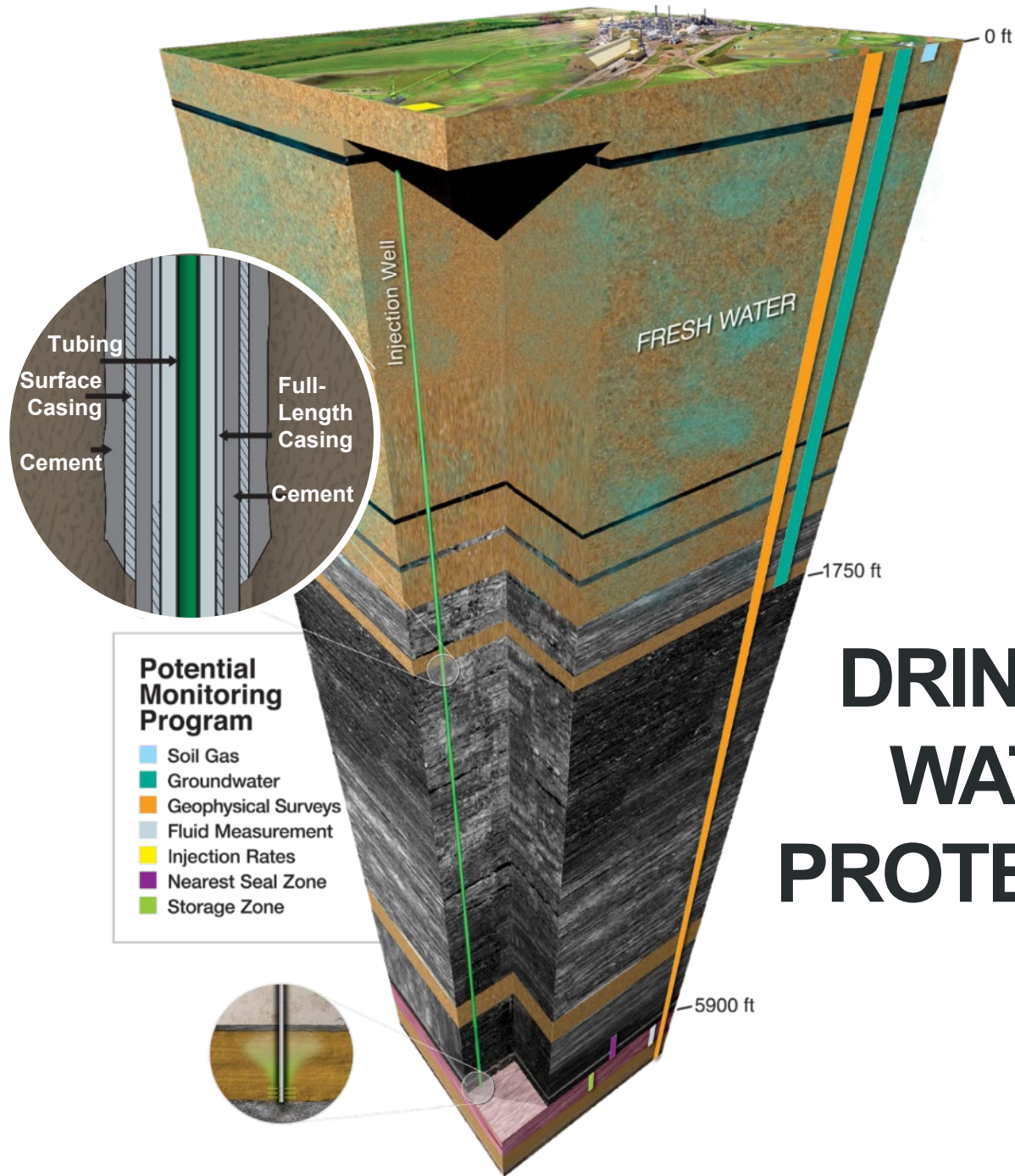
WATER MONITORING

Is done to confirm that current CO₂ levels match baselines taken before injection started.

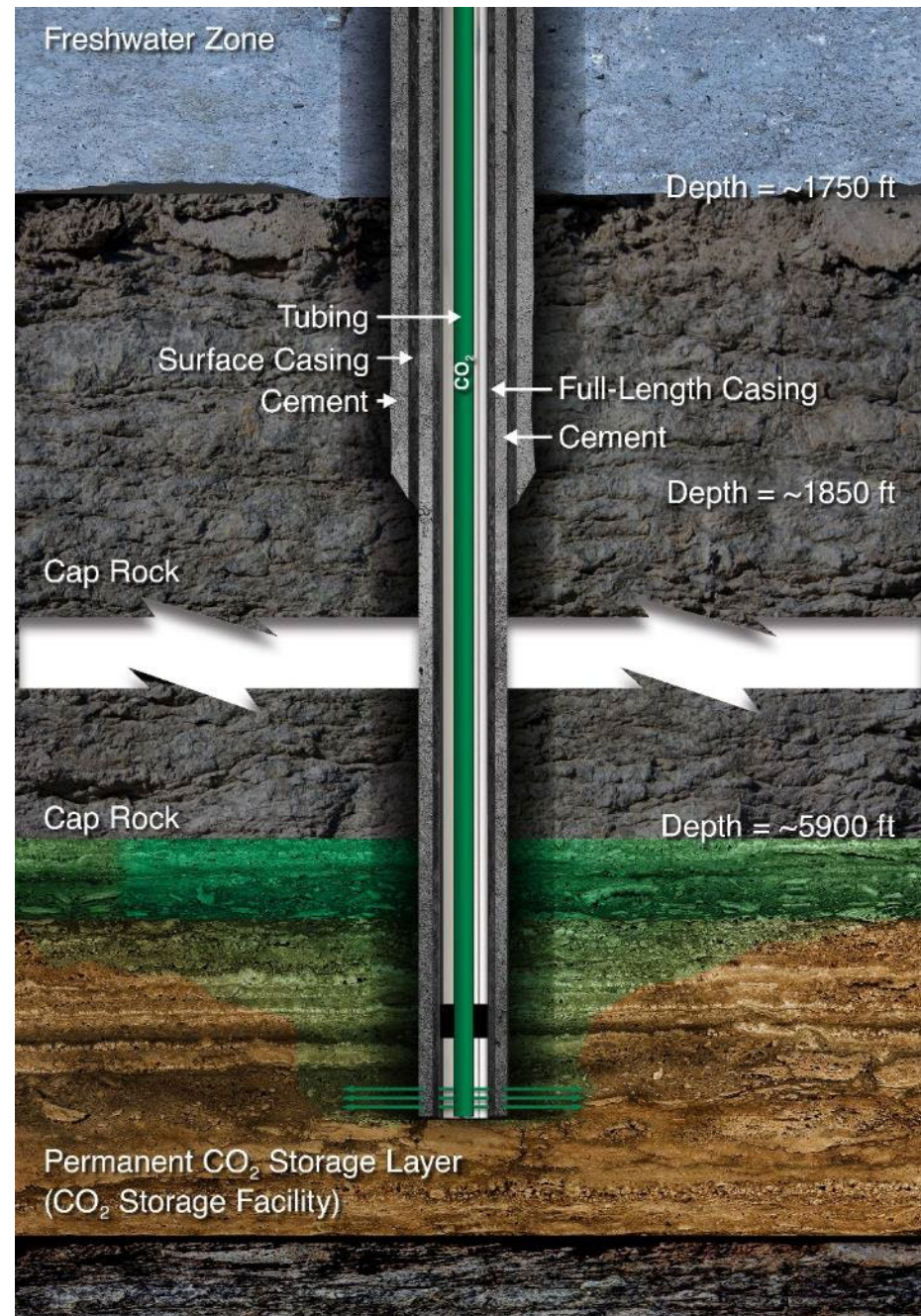


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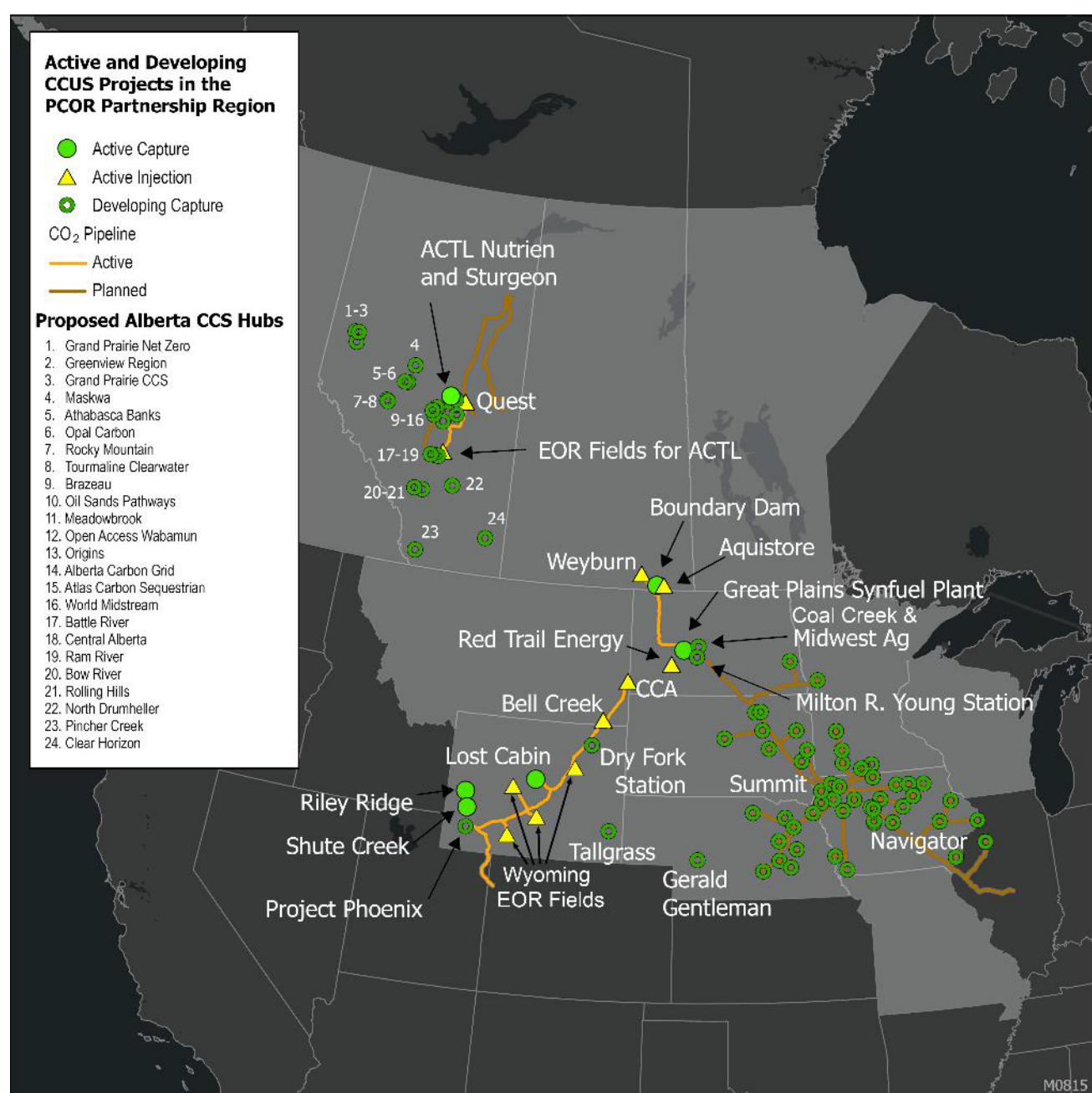




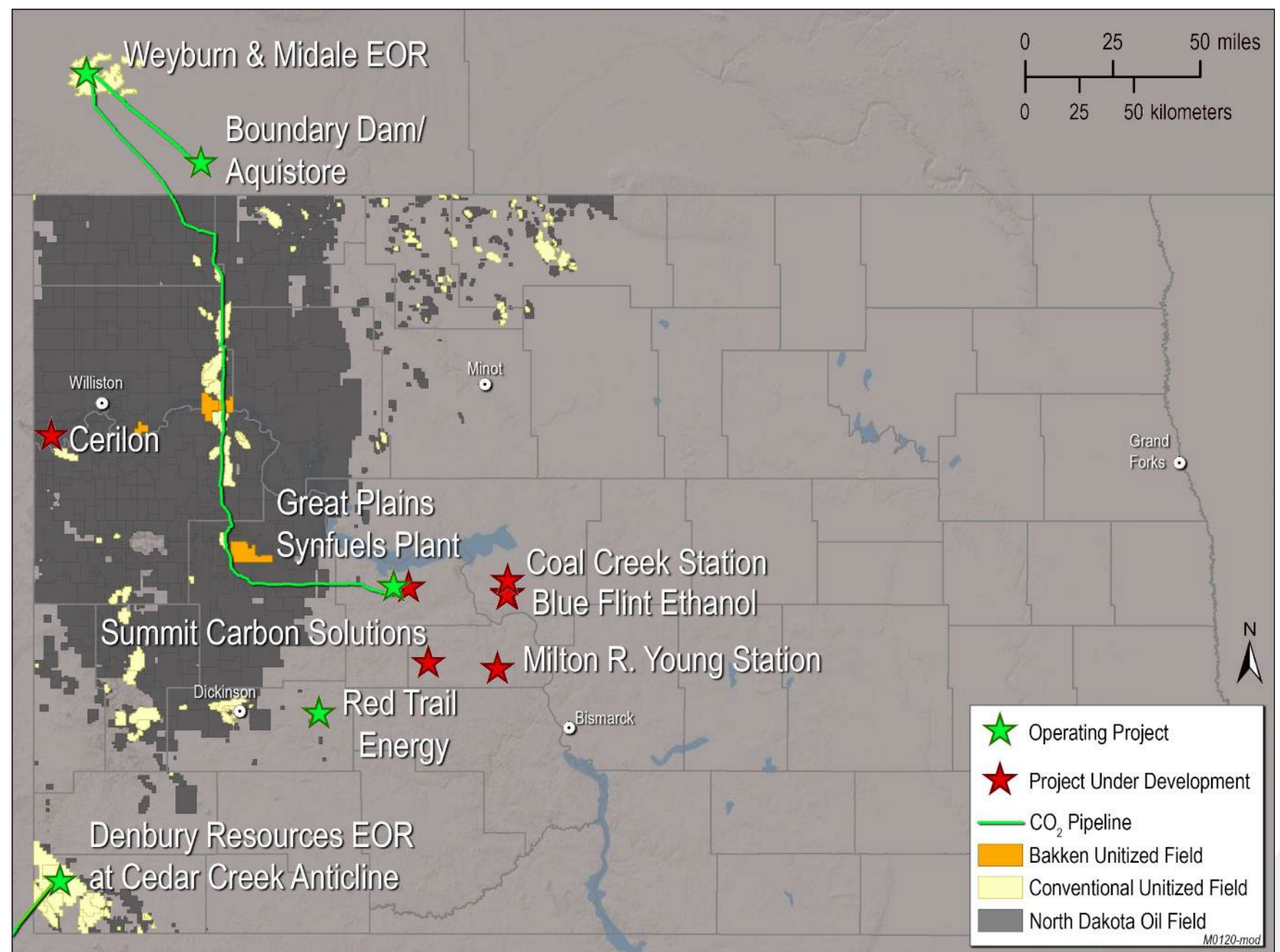
DRINKING WATER PROTECTION



CCUS DEVELOPMENT ACROSS THE PCOR PARTNERSHIP REGION



NORTH DAKOTA CCUS ACTIVITY



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GEOLOGIC STORAGE PERMITS IN NORTH DAKOTA

Blue Flint Underwood Broom Creek Storage Facility #1 – Approved May 25, 2023



Red Trail Richardton Ethanol Broom Creek Storage Facility No. 1 – Approved October 19, 2021



DGC Beulah Broom Creek Storage Facility #1 – Approved January 24, 2023



Image: Dakota Gasification Company

Minnkota Center MRYS Broom Creek Storage Facility No. 1
Minnkota Center MRYS Deadwood Storage Facility No. 1
Approved January 21, 2022



CONCLUSIONS

- Two decades of research into demonstrating safety and efficacy of CCUS.
 - Demonstrated success of monitoring techniques.
- Regulatory environment continues to develop in support of deploying CCUS.
- Incentive programs are driving current development.
 - Companies and their investors are driven to meet their own emission reduction goals.
- CCUS technology represents a key opportunity to decarbonize industry.

ACKNOWLEDGMENT

This material is based upon work supported by the U.S. Department of Energy National Energy Technology Laboratory under Award No. DE-FE0031838.

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A wide-angle photograph of a university campus at sunset. The sun is low on the horizon, casting a warm glow over the scene. In the foreground, there are large trees with some yellowing leaves. In the background, several multi-story brick buildings and a parking lot with many cars are visible under a clear sky.

THANK YOU

Critical Challenges. Practical Solutions.