Energy & Environmental Research Center (EERC)

An Overview of Carbon Capture Utilization and Storage (CCUS)

2023 MACPZA Spring Conference

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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

20 YEARS PCOR Partnership | EERC | U.S. DEPARTMENT OF ENERGY | NETL NATIONAL ENERGY TECHNOLOGY LABORATORY

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

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 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 policy makers.
- Enabling and advancing deployment of CCUS.

Our Partners inform our priorities.

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PCOR Partnership PARTNERSHIP MEMBERS

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

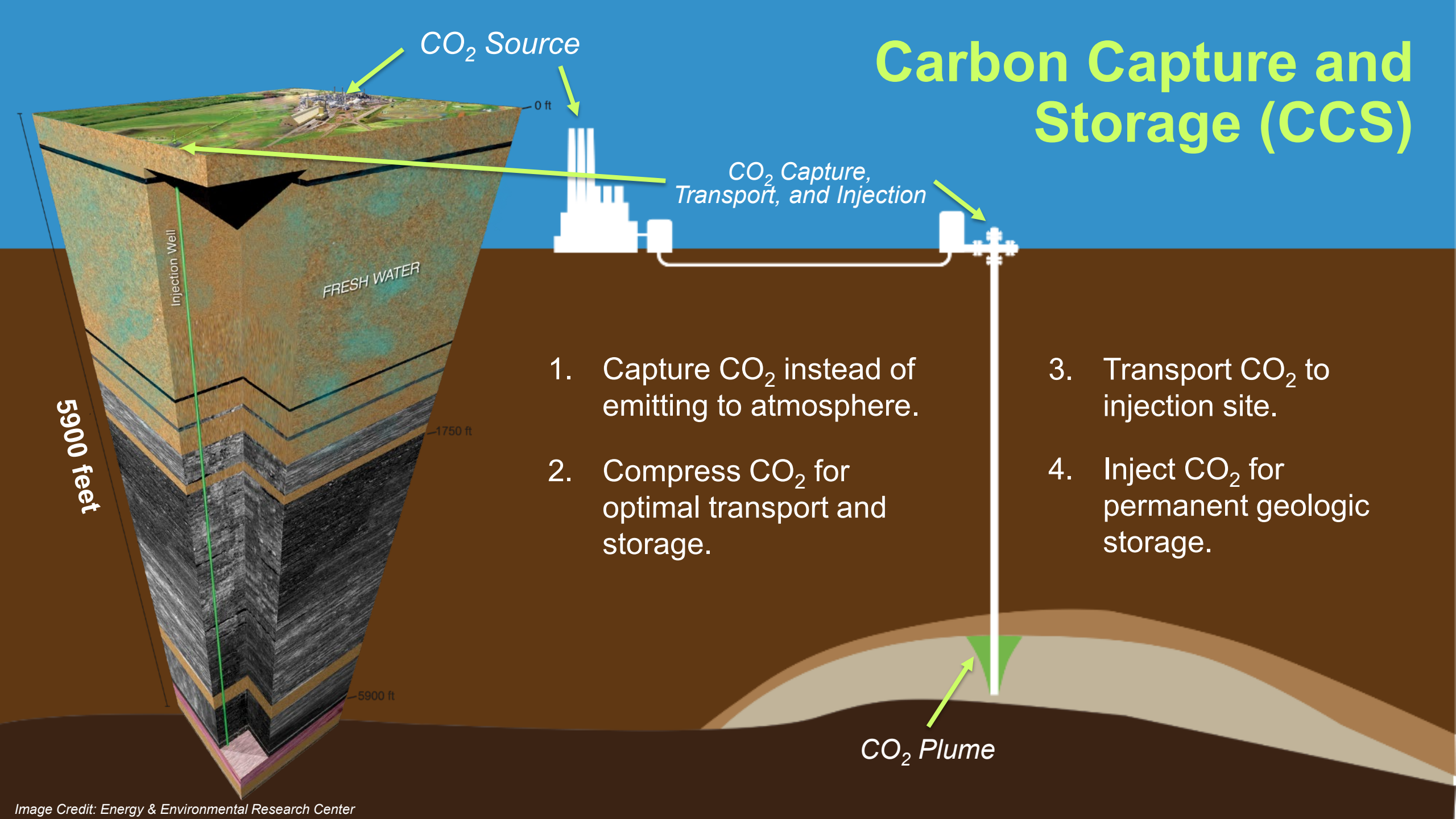
EERC — University of North Dakota

North Dakota Industrial Commission

UAF Institute of Northern Engineering — University of Alaska Fairbanks

University of Wyoming — School of Energy Resources

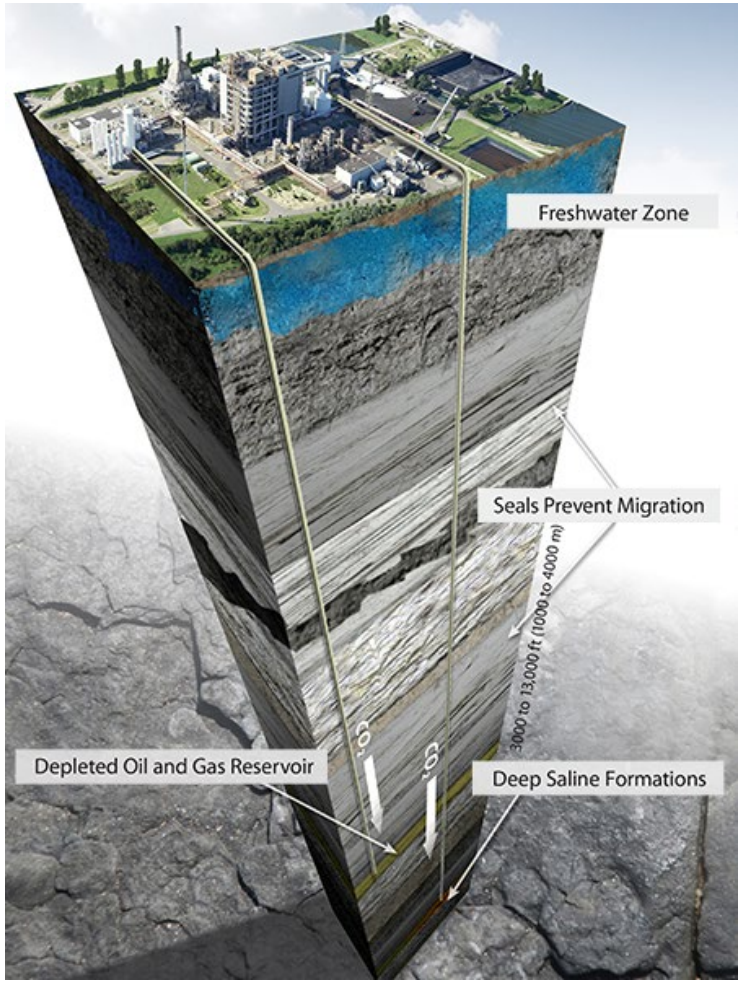
Carbon Capture and Storage (CCS)



1. Capture CO_2 instead of emitting to atmosphere.
2. Compress CO_2 for optimal transport and storage.
3. Transport CO_2 to injection site.
4. Inject CO_2 for permanent geologic storage.

Image Credit: Energy & Environmental Research Center

CO_2 CAN BE MANAGED



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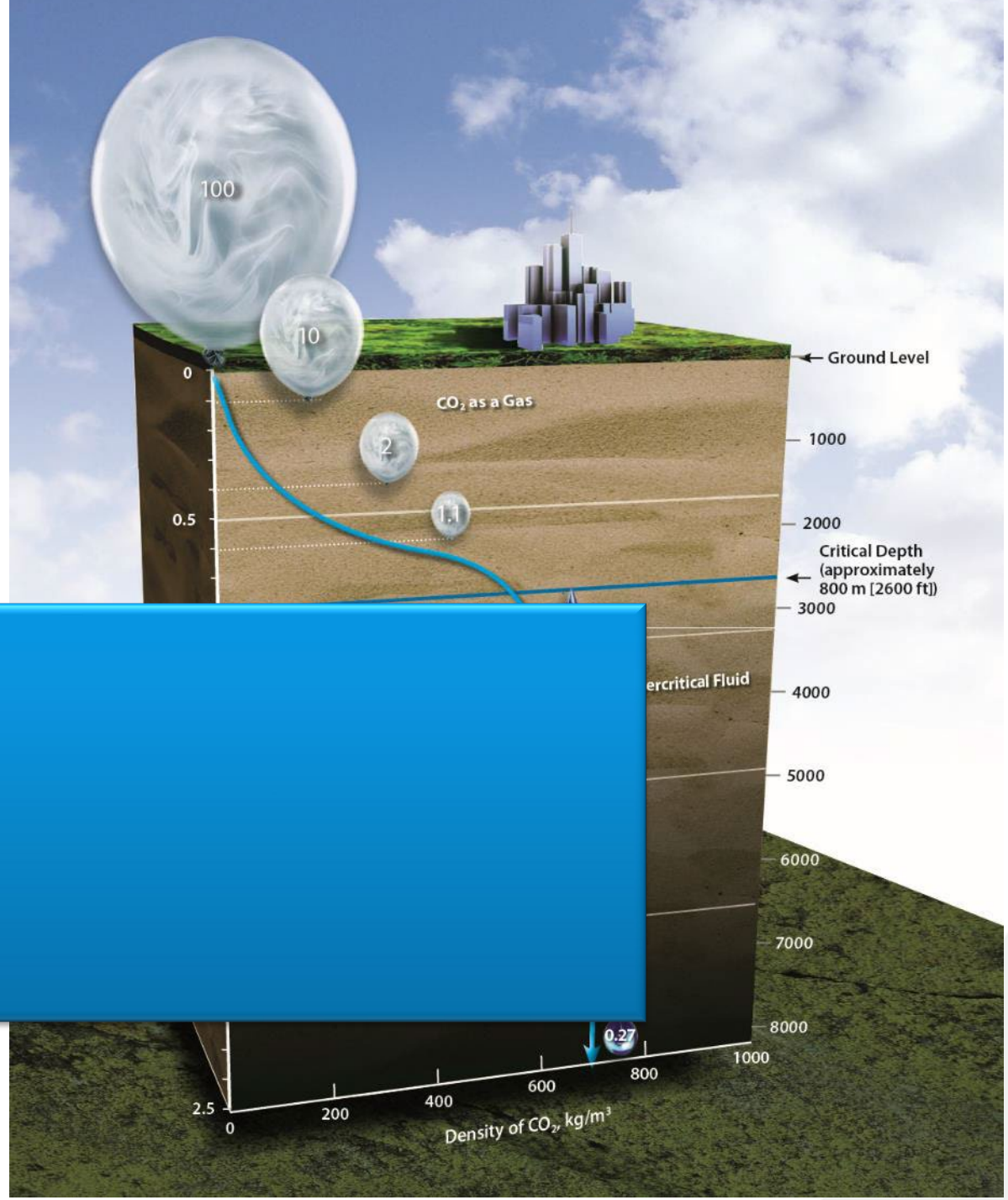
Critical Challenges. Practical Solutions.

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, CO_2 becomes a supercritical fluid.
- CO_2 will behave like a liquid.
- High density of the CO_2 allows for more storage in a given volume.

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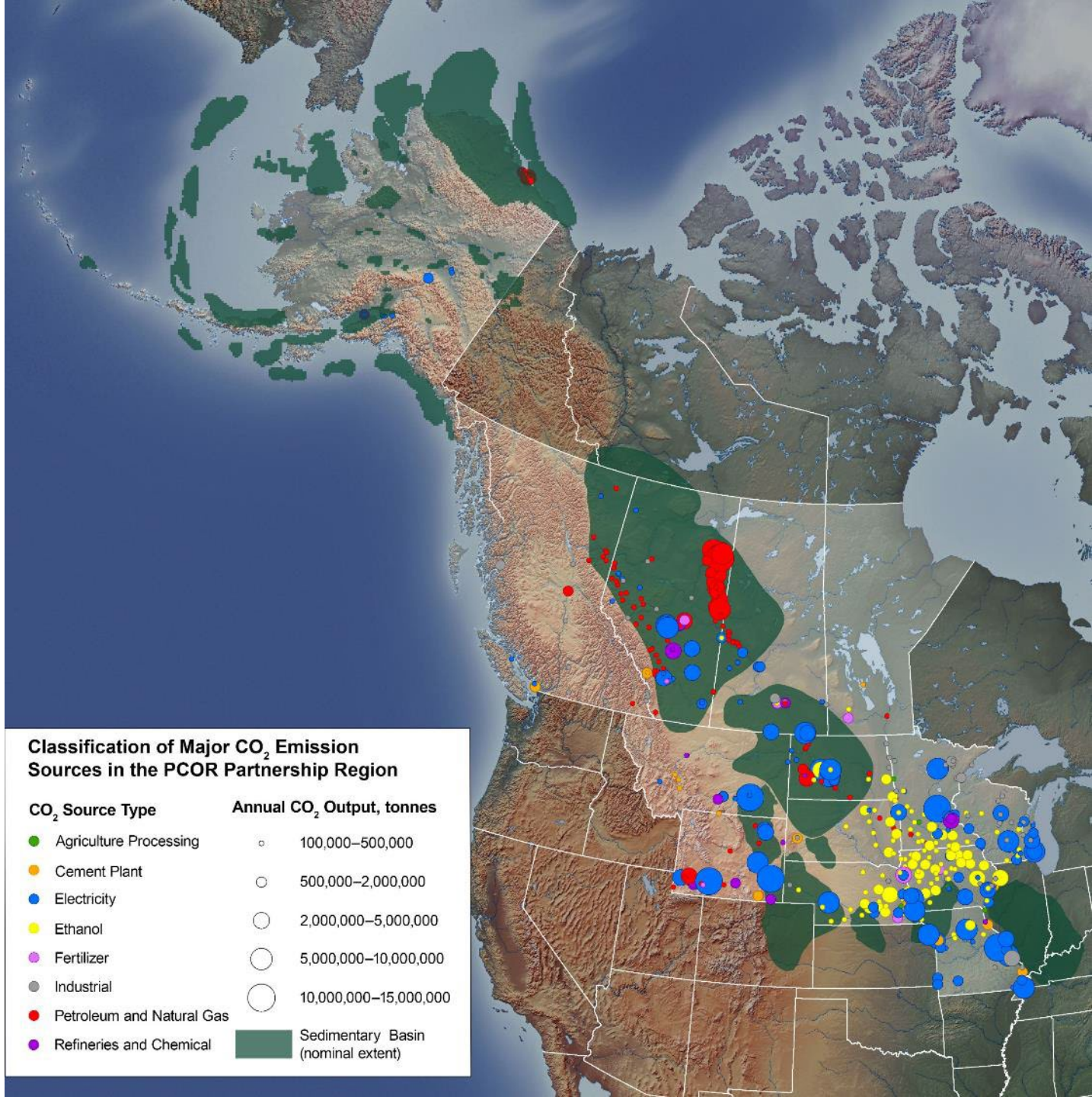
POROSITY AND PERMEABILITY

REGIONAL SOURCES AND SEDIMENTARY BASINS



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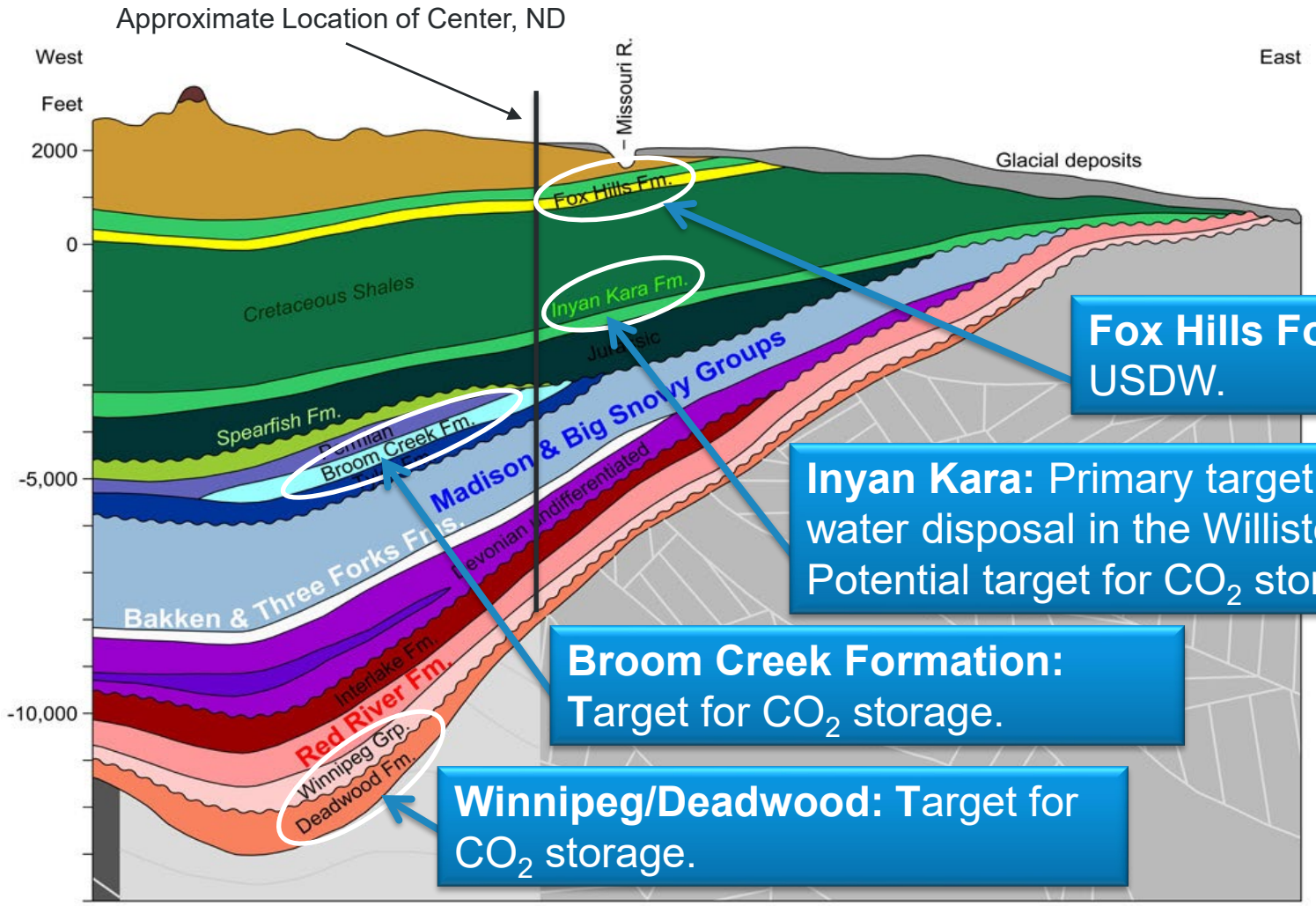
WILLISTON BASIN SALINE STORAGE OPPORTUNITIES



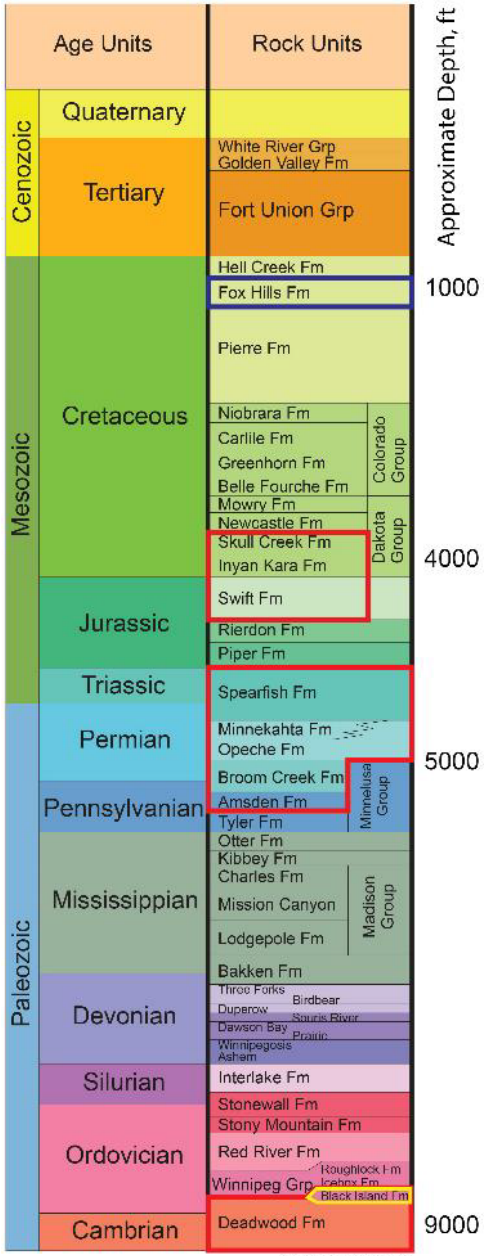
Fox Hills Formation: Lowest USDW.

Inyan Kara: Primary target for produced water disposal in the Williston Basin. Potential target for CO_2 storage.

Broom Creek Formation: Target for CO_2 storage.

Winnipeg/Deadwood: Target for CO_2 storage.

North Dakota
Stratigraphic Column



WILLISTON BASIN GEOLOGY OFFERS MULTIPLE OPTIONS FOR CCS AND CCUS

Image Credit: Energy & Environmental Research Center

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

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Critical Challenges. Practical Solutions.

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 CO_2 stored in a qualified EOR project: $60/tonne.
  - Tax credit from direct air capture (DAC): $130/tonne.
- Tax credit for CO_2 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 CO_2 sold for EOR.
- No sales tax on construction of pipeline.
- Property tax-exempt for 10 years (equipment).
- Coal conversion tax: tax reduction with CO_2 capture (up to 50%).
- No sales tax on CO_2 EOR infrastructure.
- 0% extraction tax for 20 years for CO_2 EOR.

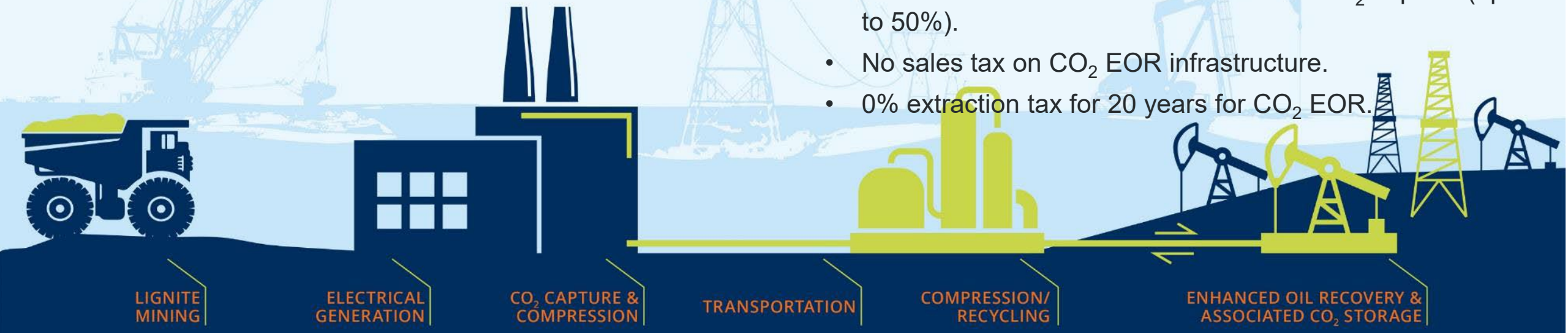

Image Credit – EERC

REGULATING GEOLOGIC STORAGE OF CARBON DIOXIDE

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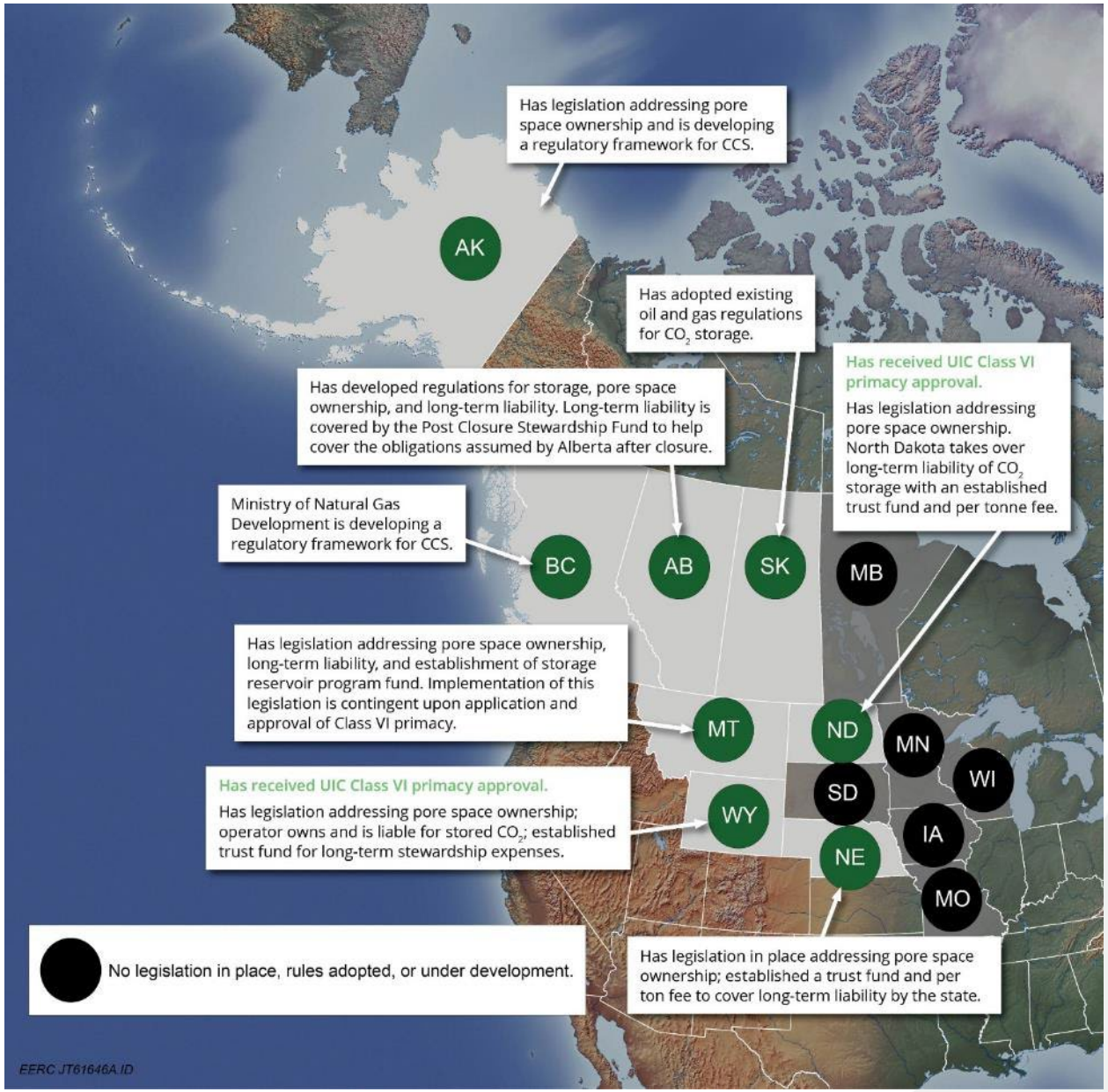
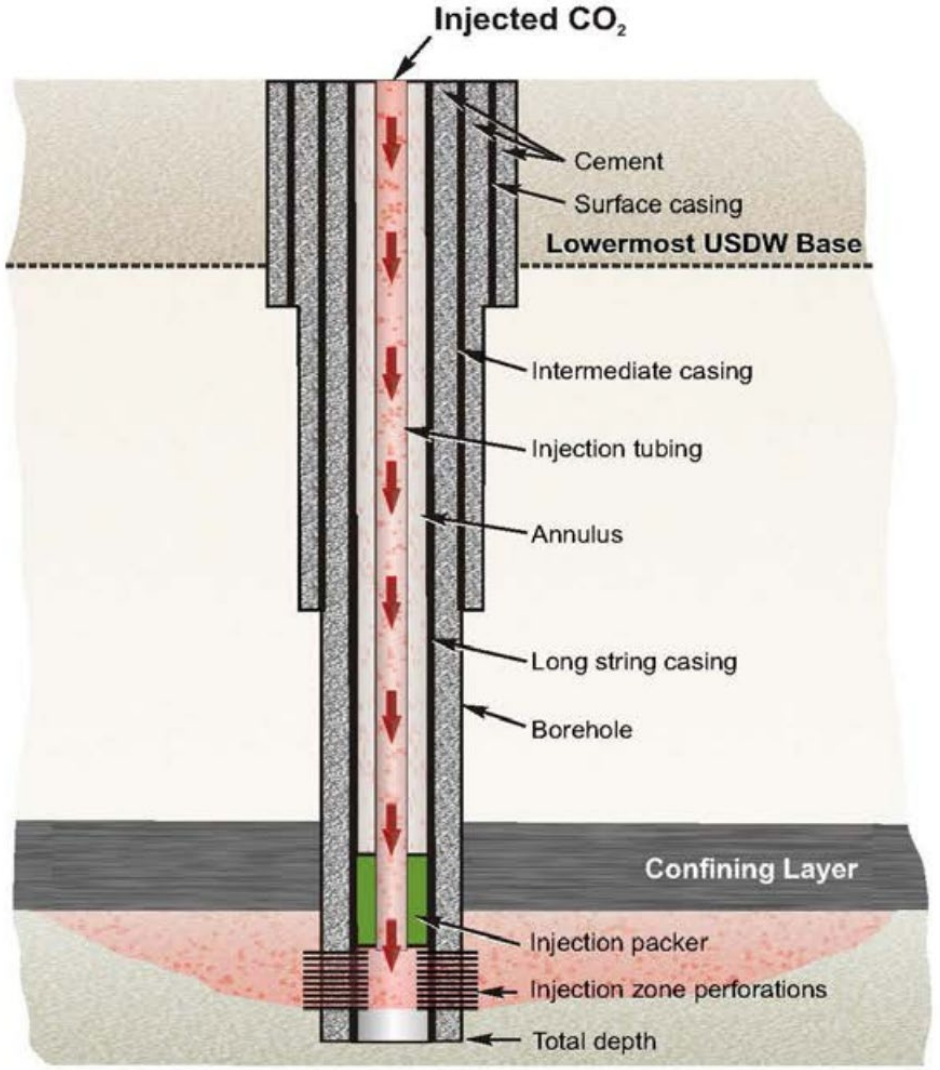
POLICY AND REGULATORY DEVELOPMENTS

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



CLASS VI INJECTION WELLS

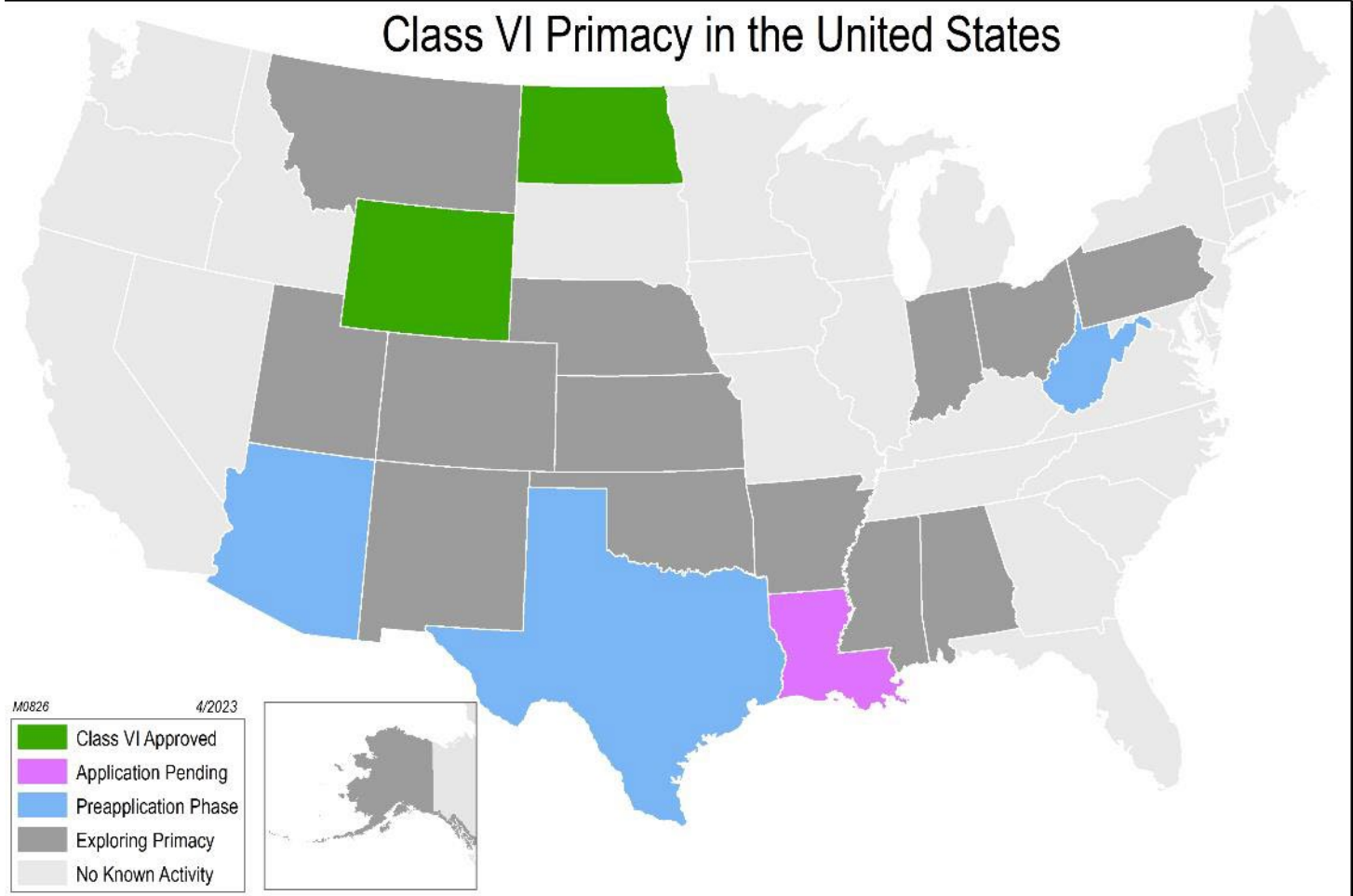
- Class designated for CO_2 injection wells as required by the U.S. Environmental Protection Agency (EPA) under the Safe Drinking Water Act.
- Material costs are increased over other well types (corrosion resistance, increased tensile/compressive strength, etc.).
- Injection target formation total dissolved solids (TDS) content cannot be less than 10,000 milligrams per liter.



UNDERGROUND INJECTION CONTROL (UIC) PROGRAM

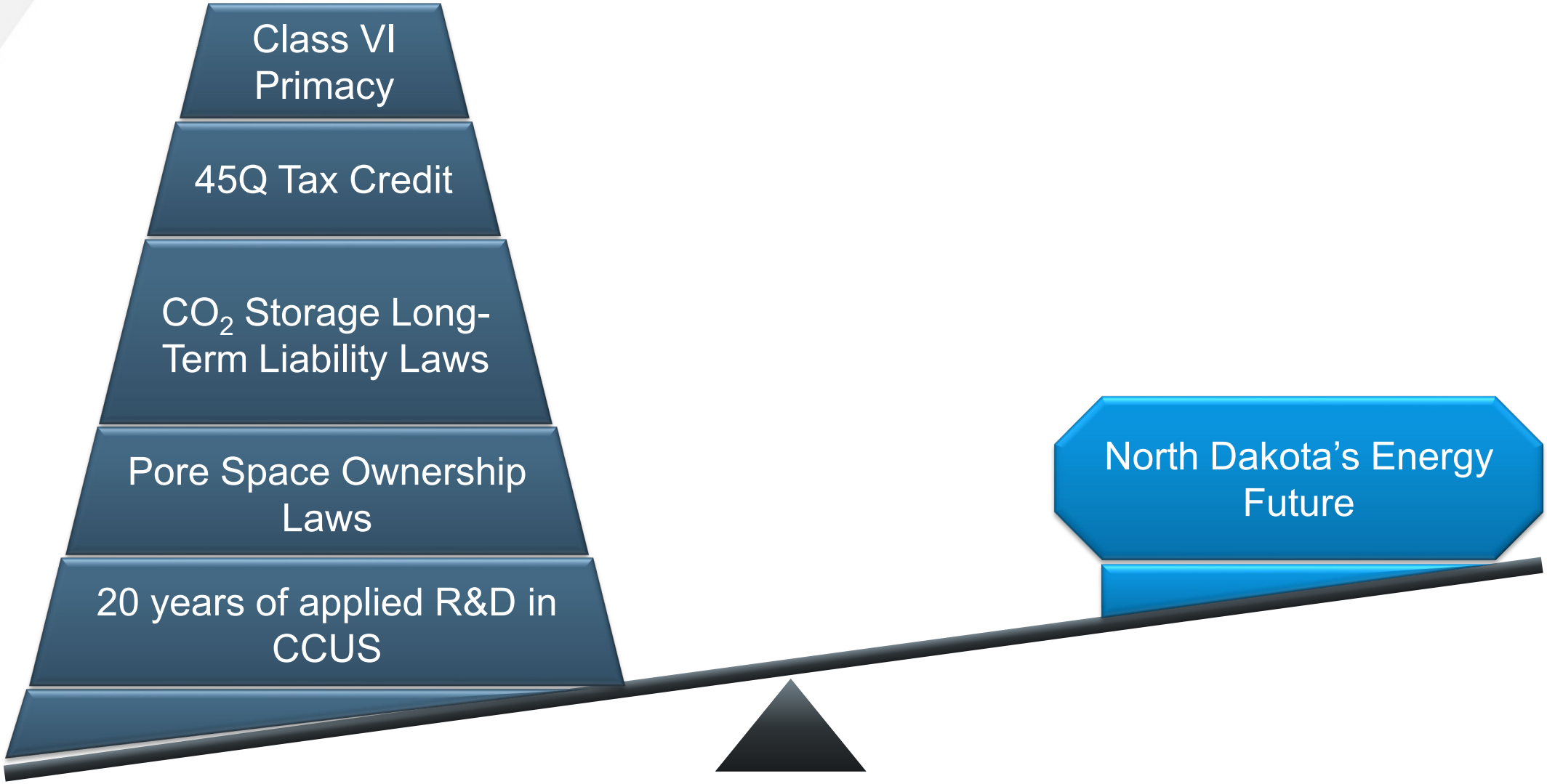
UIC Program Standards:

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



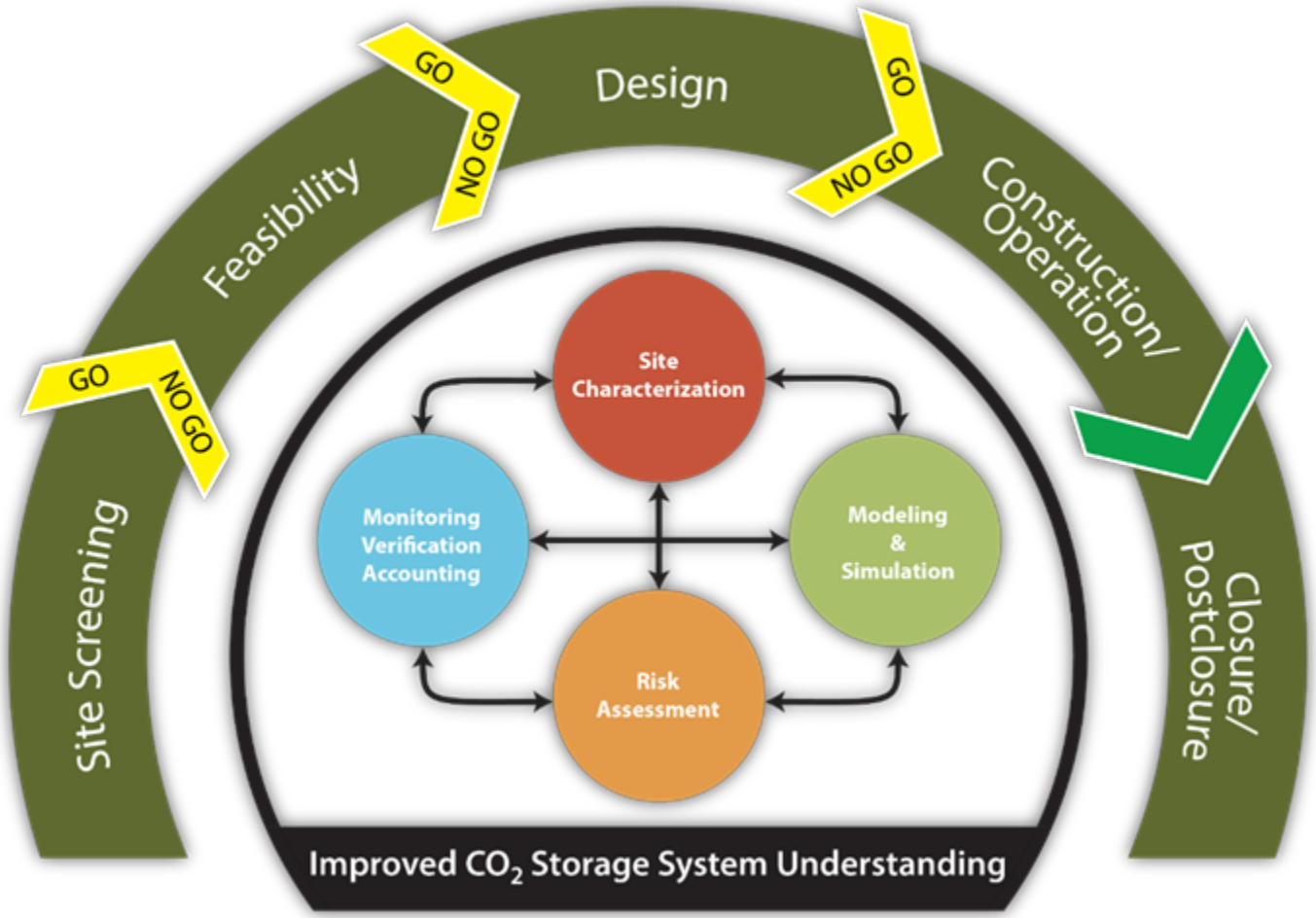
Class I	Class II	Class III	Class IV	Class V	Class VI
Hazardous and nonhazardous fluids (industrial and municipal wastes).	Brines and other fluids associated with oil and gas production, including CO_2 EOR.	Fluids associated with solution mining of minerals.	Hazardous or radioactive wastes. This class 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

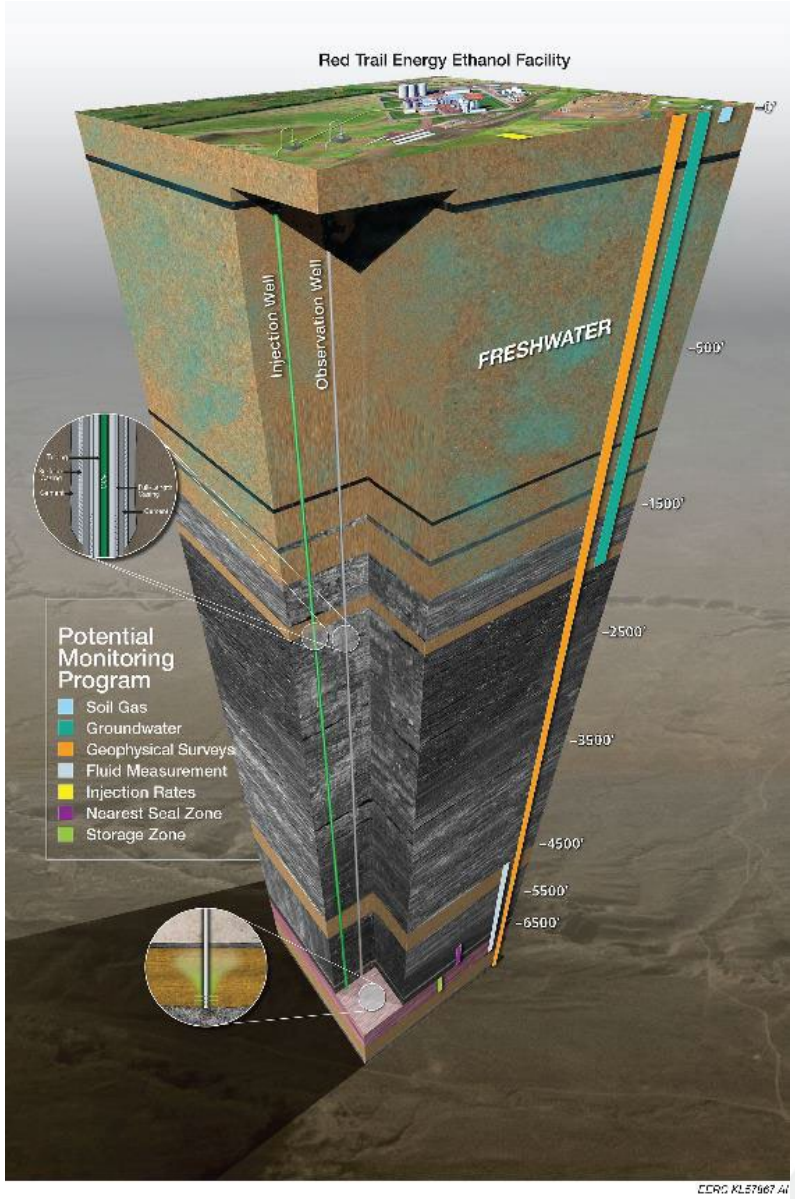
ADAPTIVE MANAGEMENT APPROACH



STORAGE FACILITY PERMIT

North Dakota CO_2 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

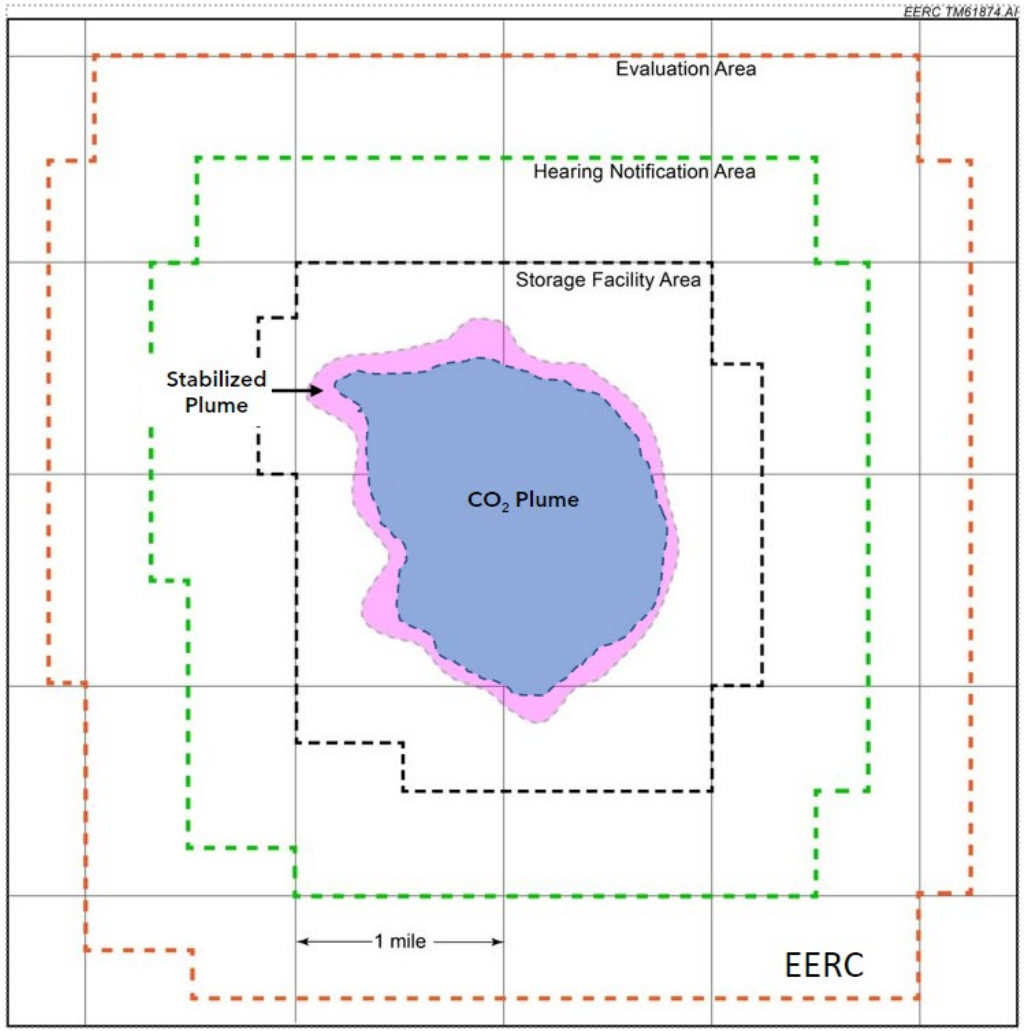


STORAGE FACILITY PROJECT BOUNDARIES

North Dakota UIC Class VI

- **CO_2 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).



CO_2 IS MONITORED EVERY STEP OF THE WAY

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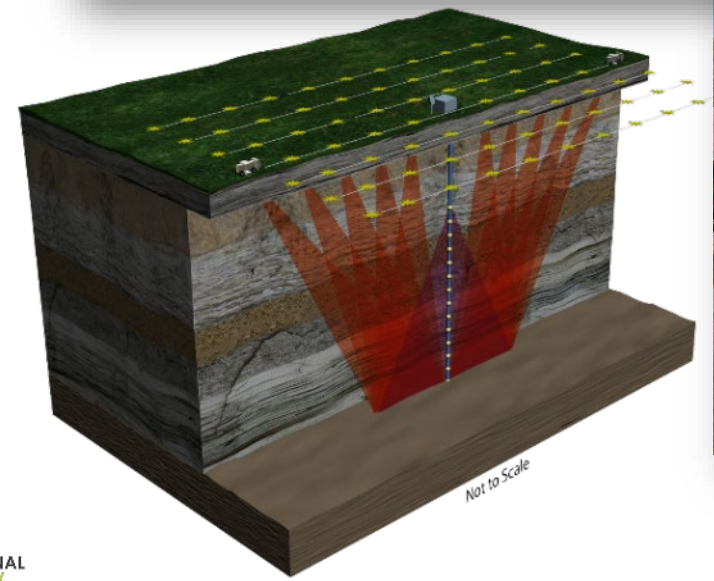
SUBSURFACE MONITORING IS DONE TO ENSURE CONTAINMENT

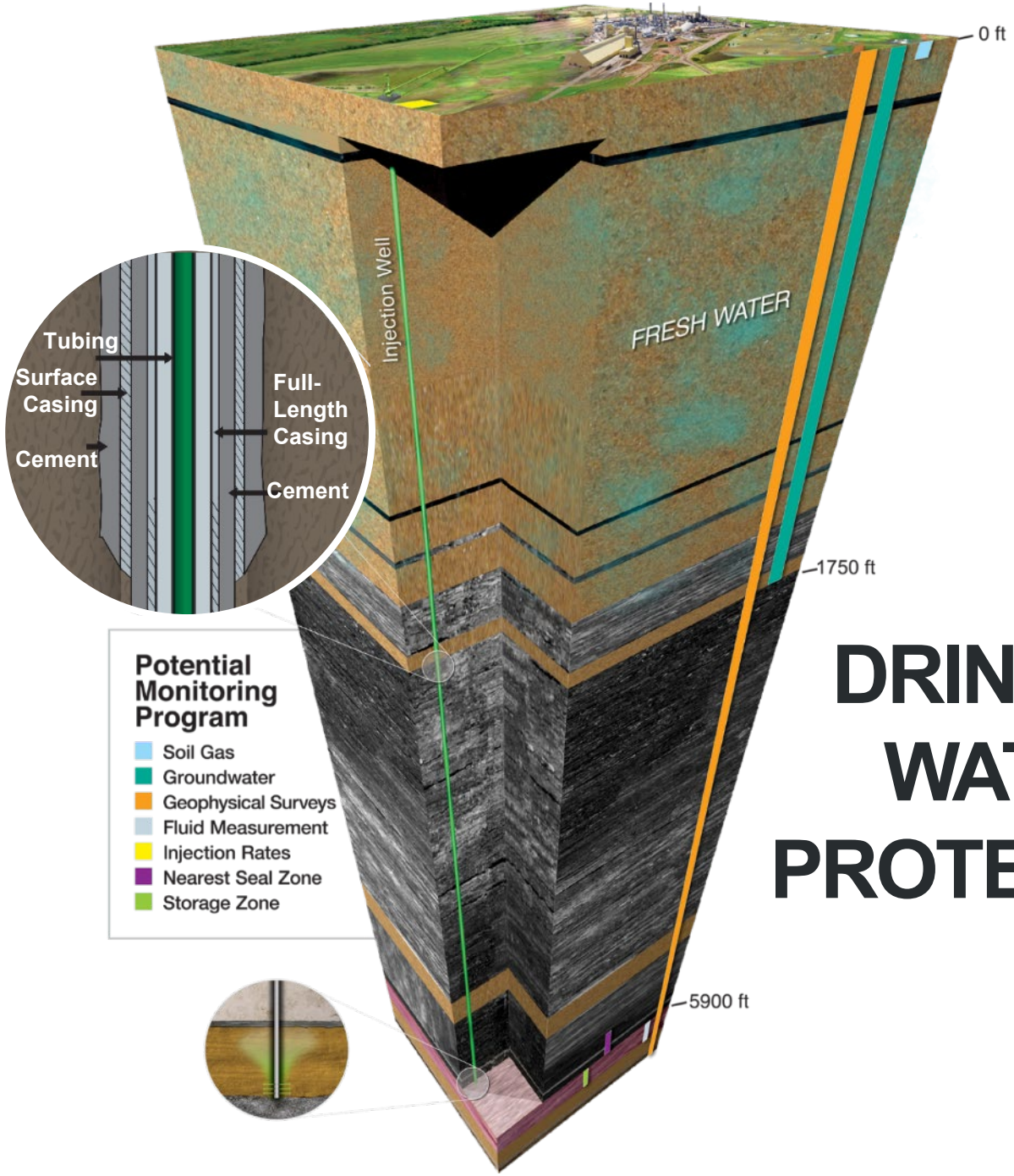
Regulations require periodic subsurface monitoring.



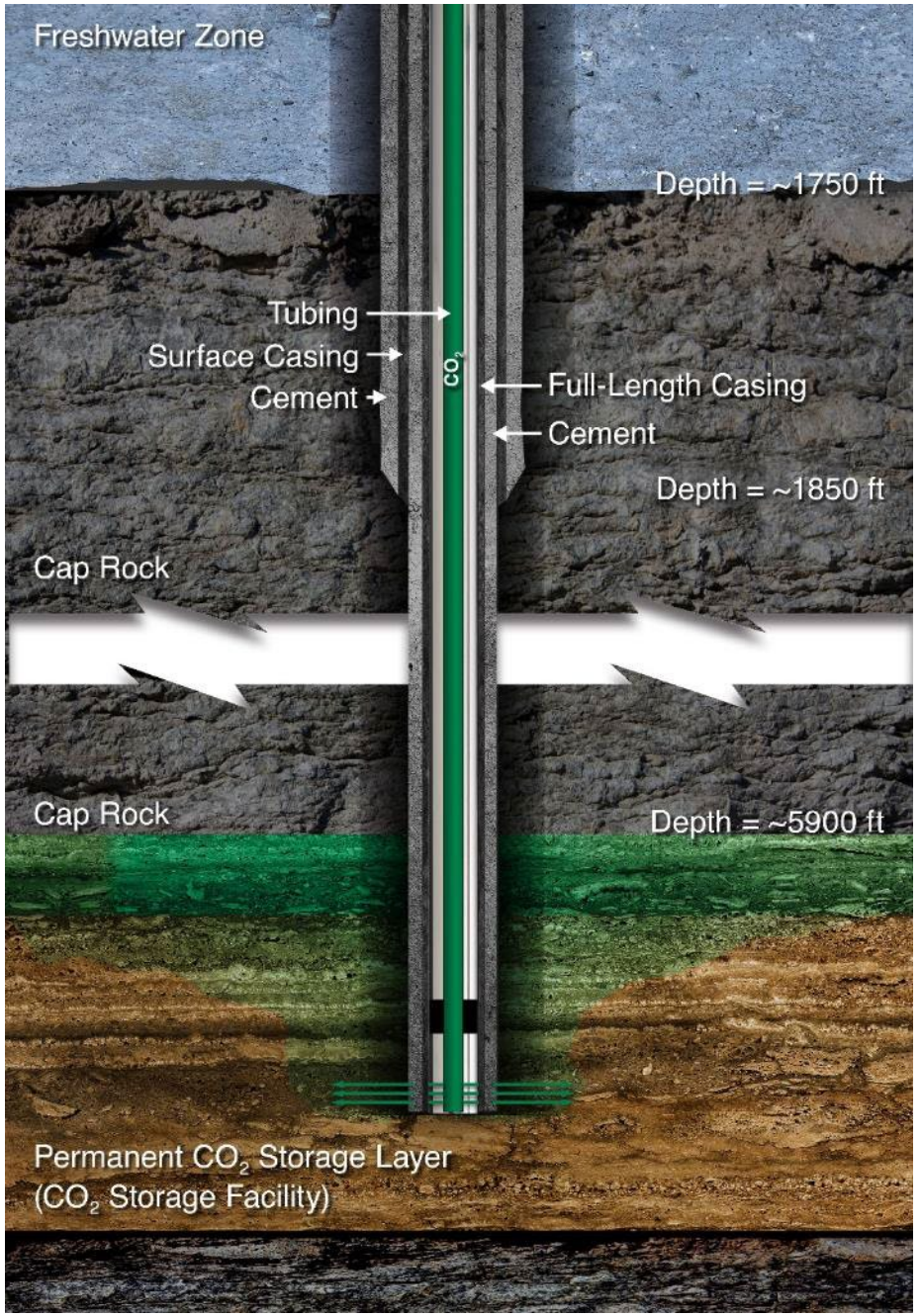
SOIL GAS MONITORING

WATER MONITORING

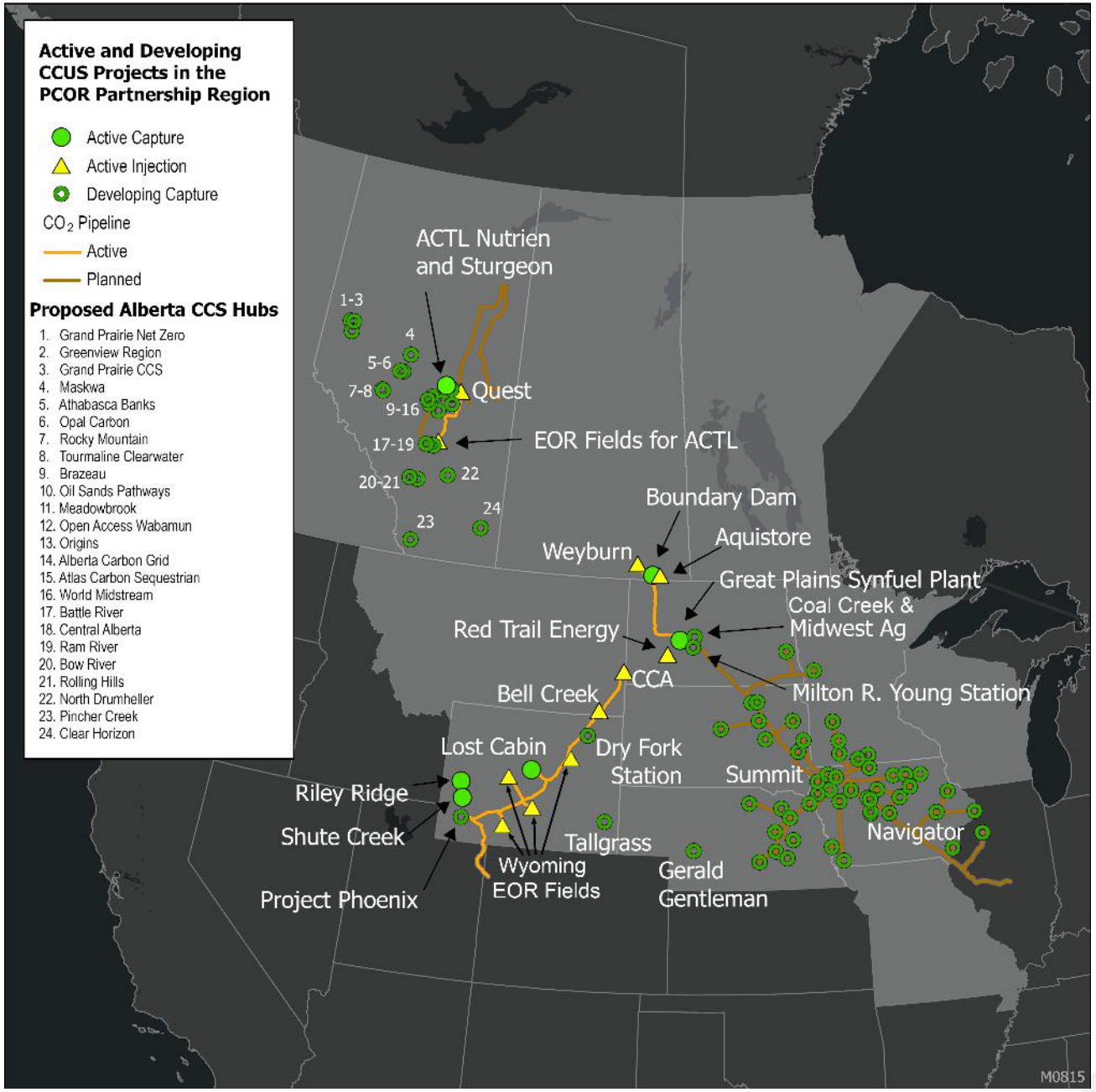
Is done to confirm that current CO_2 levels match baselines taken before injection started.



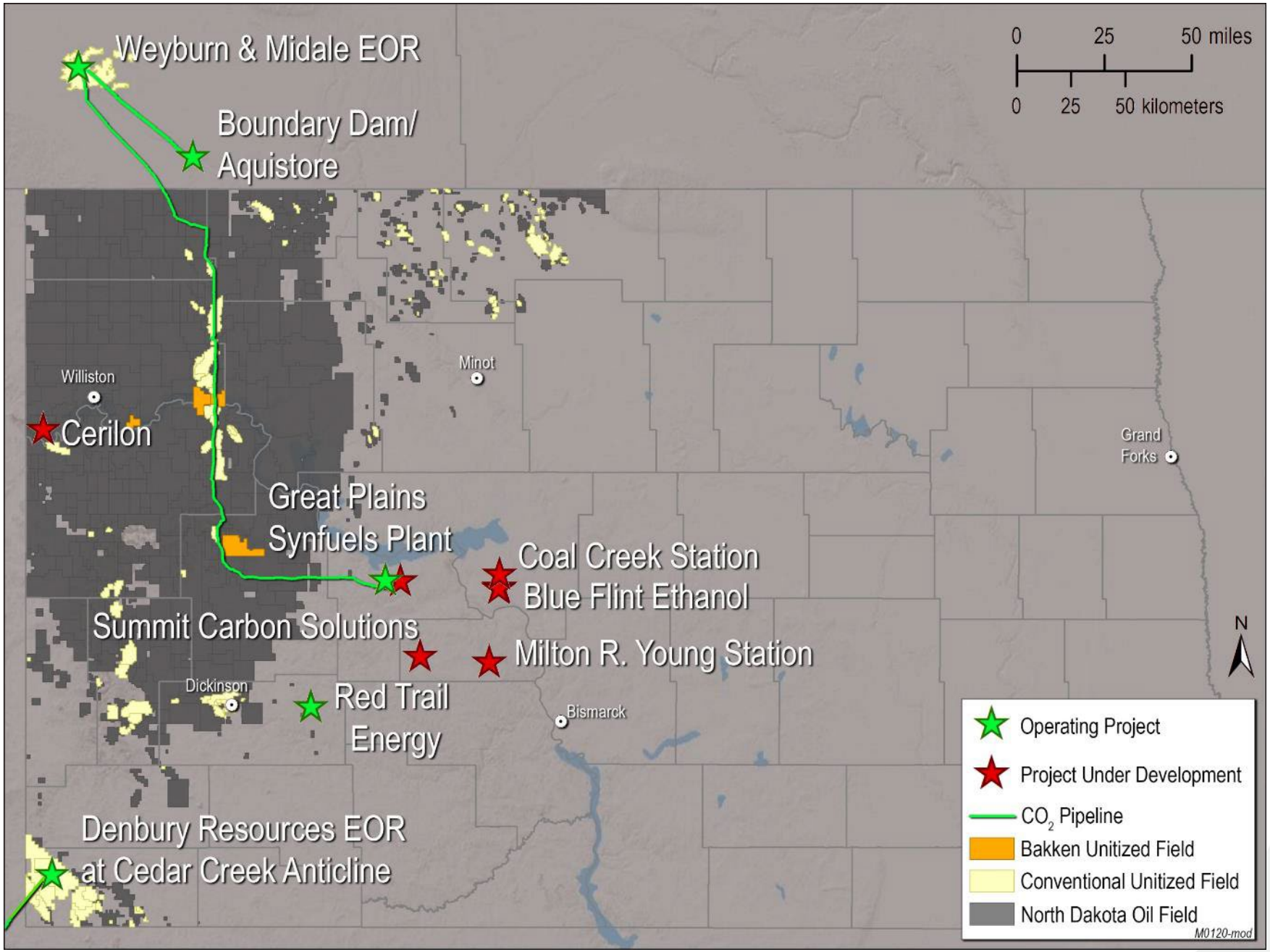
DRINKING WATER PROTECTION



CCUS DEVELOPMENT ACROSS THE PCOR PARTNERSHIP REGION



NORTH DAKOTA CCUS ACTIVITY



GEOLOGIC STORAGE PERMITS IN NORTH DAKOTA

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

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

Image: Dakota Gasification Company

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

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

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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

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DISCLAIMER

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THANK YOU

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