Critical Challenges. Practical Solutions.

Energy & Environmental Research Center (EERC)

North Dakota Permitting Timelines: CCS and CO_2 EOR with Storage

CO_2 Conference

Midland, Texas

December 8, 2021

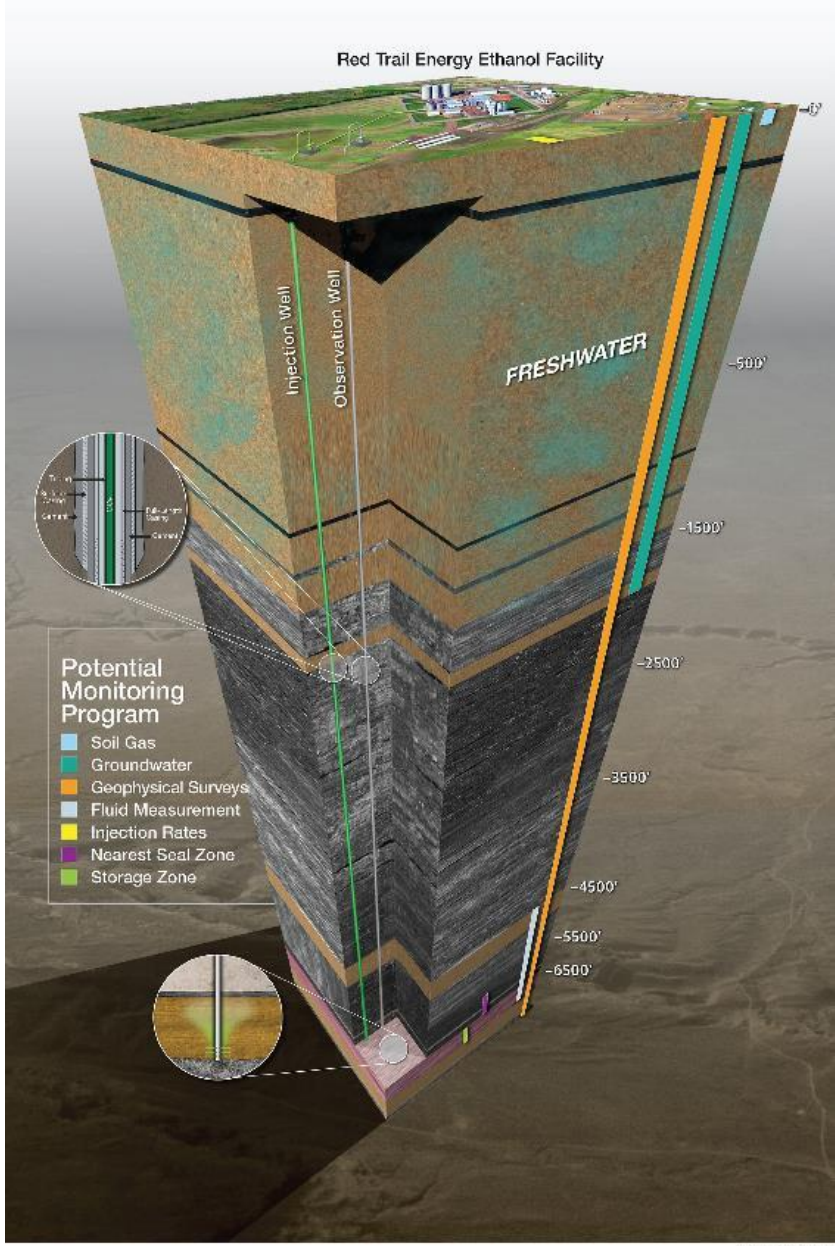
Kevin Connors

Assistant Director for Regulatory Compliance and Energy Policy

PCOR Partnership Project Manager

FIRST GEOLOGIC STORAGE PERMIT IN NORTH DAKOTA

Red Trail Richardton Ethanol Broom Creek Storage Facility #1 – Approved October 19, 2021



EERC | UND UNIVERSITY OF NORTH DAKOTA | U.S. DEPARTMENT OF ENERGY | NETL NATIONAL ENERGY TECHNOLOGY LABORATORY

RESOURCE MANAGEMENT FRAMEWORK

CONTROL OF GAS AND OIL RESOURCES
CHAPTER 38-08

38-08-01. DECLARATION OF POLICY. It is hereby declared to be in the public interest to foster, to encourage, and to promote the development, production, and utilization of natural resources of oil and gas in the state in such a manner as will prevent waste; to authorize and to provide for the operation and development of oil and gas properties in such a manner that a greater ultimate recovery of oil and gas be had and that the correlative rights of all owners be fully protected; and to encourage and to authorize cycling, recycling, pressure maintenance, and secondary recovery operations in order that the greatest possible economic recovery of oil and gas be obtained within the state to the end that the landowners, the royalty owners, the producers, and the general public realize and enjoy the greatest possible good from these vital natural resources.

Source: N.D. Century Code.

CARBON DIOXIDE UNDERGROUND STORAGE
CHAPTER 38-22

38-22-01. POLICY. It is in the public interest to promote the geologic storage of carbon dioxide. Doing so will benefit the state and the global environment by reducing greenhouse gas emissions. Doing so will help ensure the viability of the state's coal and power industries, to the economic benefit of North Dakota and its citizens. Further, geologic storage of carbon dioxide, a potentially valuable commodity, may allow for its ready availability if needed for commercial, industrial, or other uses, including enhanced recovery of oil, gas, and other minerals. Geologic storage, however, to be practical and effective requires cooperative use of surface and subsurface property interests and the collaboration of property owners. Obtaining consent from all owners may not be feasible, requiring procedures that promote, in a manner fair to all interests, cooperative management, thereby ensuring the maximum use of natural resources.

Source: N.D. Century Code.

- It is in the public interest to promote
- Benefits the state
- Prevent waste, maximize ultimate recovery of oil and gas, protect correlative rights
- CO_2 is valuable commodity

CO_2 STORAGE ASSOICATED WITH CO_2 EOR

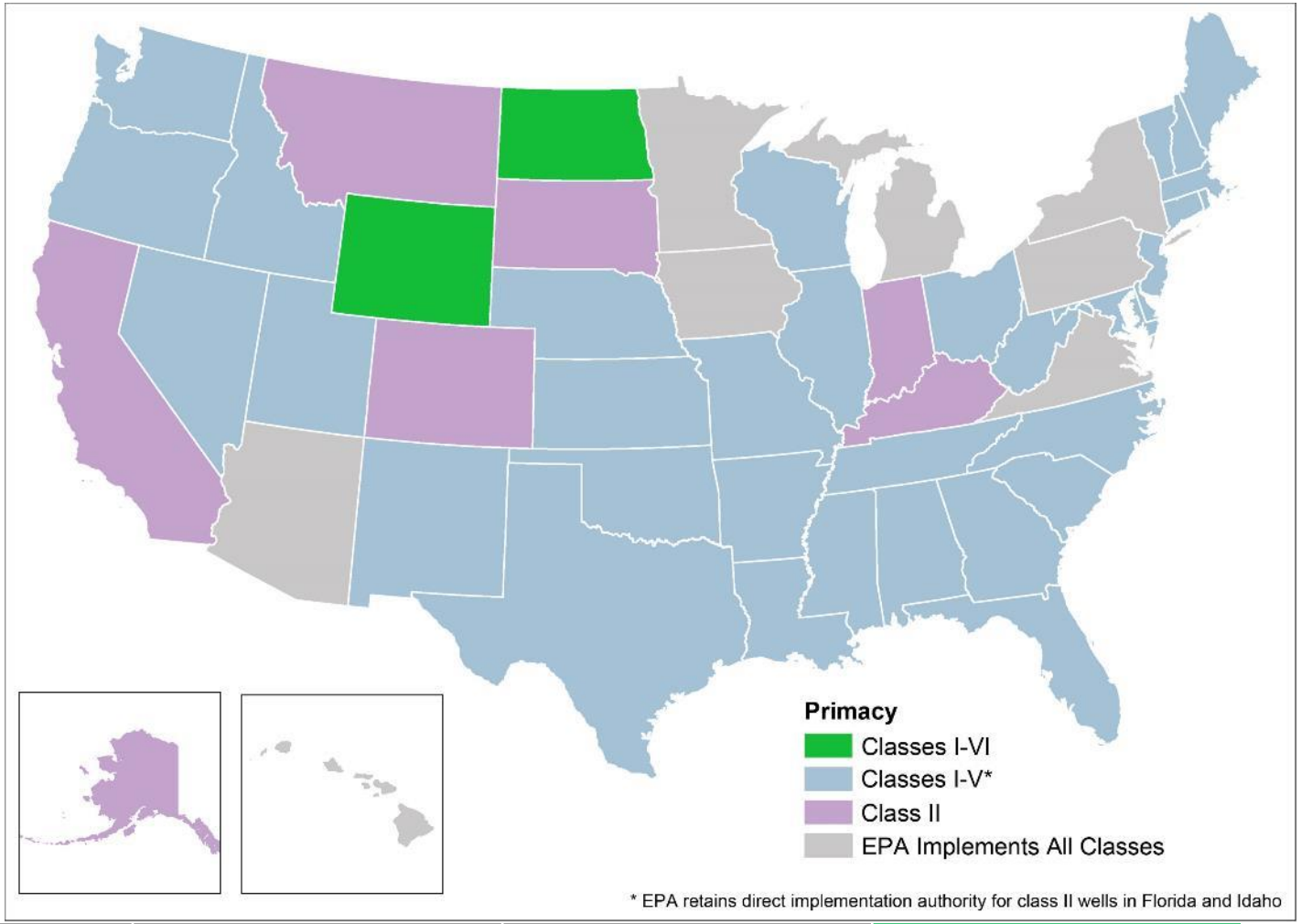
- CO_2 EOR is a project-centric approach that includes:
  - Mineral lease agreements.
  - Oil and gas unit operations.
  - Mineral extraction.
  - EOR through Class II underground injection.
- States are mandated by law to maximize ultimate recovery of oil and gas resources.
- Class II injection wells are permitted individually within the established units to ensure protection of underground drinking sources of water (USDW).
- Oil and gas operators have utilized Class II wells for CO_2 EOR for approximately 50 years without a single USDW contamination incident.

GEOLOGIC STORAGE OF CARBON DIOXIDE

- It is public interest to promote geologic storage of CO_2 in order to reduce anthropogenic emissions.
- CO_2 is a valuable commodity.
- The state's pore space should be regulated and managed as a resource under the resource management philosophy as opposed to a waste disposal regulatory framework.

Resource Management Framework	Waste Disposal Framework
A resource management framework allows for the regulatory complexities that accompany CO_2 storage to be integrated into a unified regulatory framework and proposes a "public and private sector partnership." 1) Environmental protection 2) Ownership and management of pore space 3) Maximize storage capacity 4) Long-term liability	• Sidesteps the public's role in both the creation of CO_2 and the mitigation of its release into the atmosphere. • Places the burden solely on Industry to rid itself of "waste" from which the public must be "protected." • Lacking citizen buy-in with respect to responsibility for the problem as well as the solution will have a negative impact on CO_2 storage as a viable methodology for reducing anthropogenic CO_2 emissions.

UNDERGROUND INJECTION CONTROL CLASS VI PRIMACY



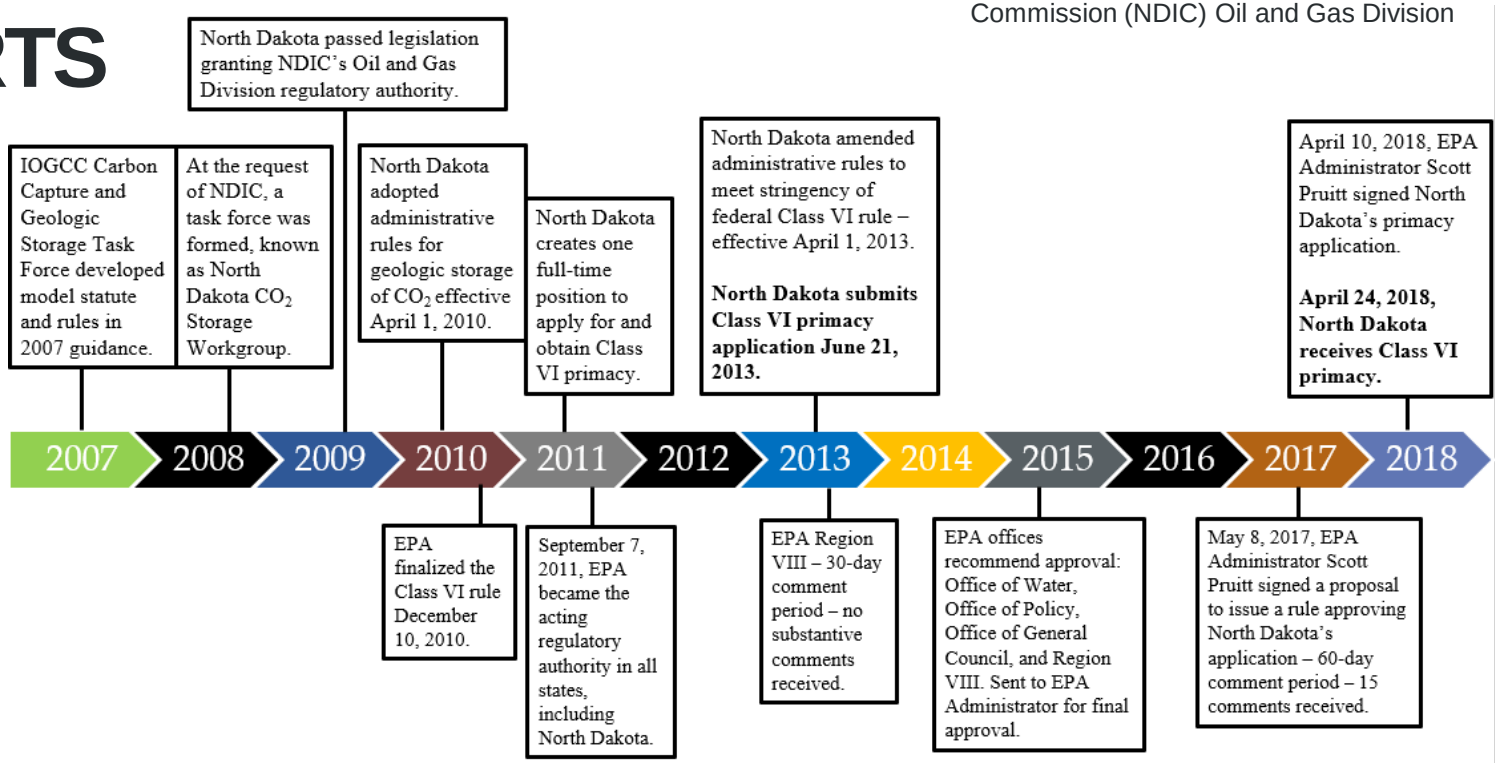
Class I	Class II	Class III	Class IV	Class V	Class VI
Hazardous and nonhazardous fluids (industrial and municipal wastes).	Brines and other fluids associated with oil and gas production, including CO_2 EOR.	Fluids associated with solution mining of minerals.	Hazardous or radioactive wastes. This class is banned by EPA.	Nonhazardous fluids into or above a USDW and are typically shallow.	Injection of CO_2 for long-term storage.

CLASS VI PRIMACY EFFORTS

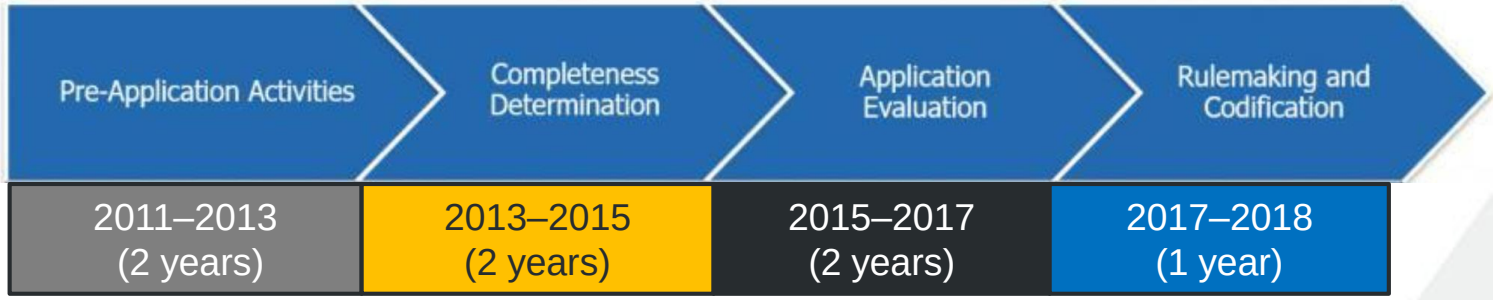
Establishment of State Authority

- **Geologic Storage of Carbon Dioxide**
  Multiyear effort to pass all-encompassing state legislation
- **Pre-Application Activities**
  Approximately 2 years (690 days)
    - Crosswalk stringency demonstration
    - State rulemaking 10–12 months
    - Primacy application package
- **Completeness Determination**
  Approximately 2 years
- **Application Evaluation**
  Approximately 2 years
- **Rulemaking and Codification**
  351 days
- **State Primacy Approval**
  Approximately 5 years (1768 days)

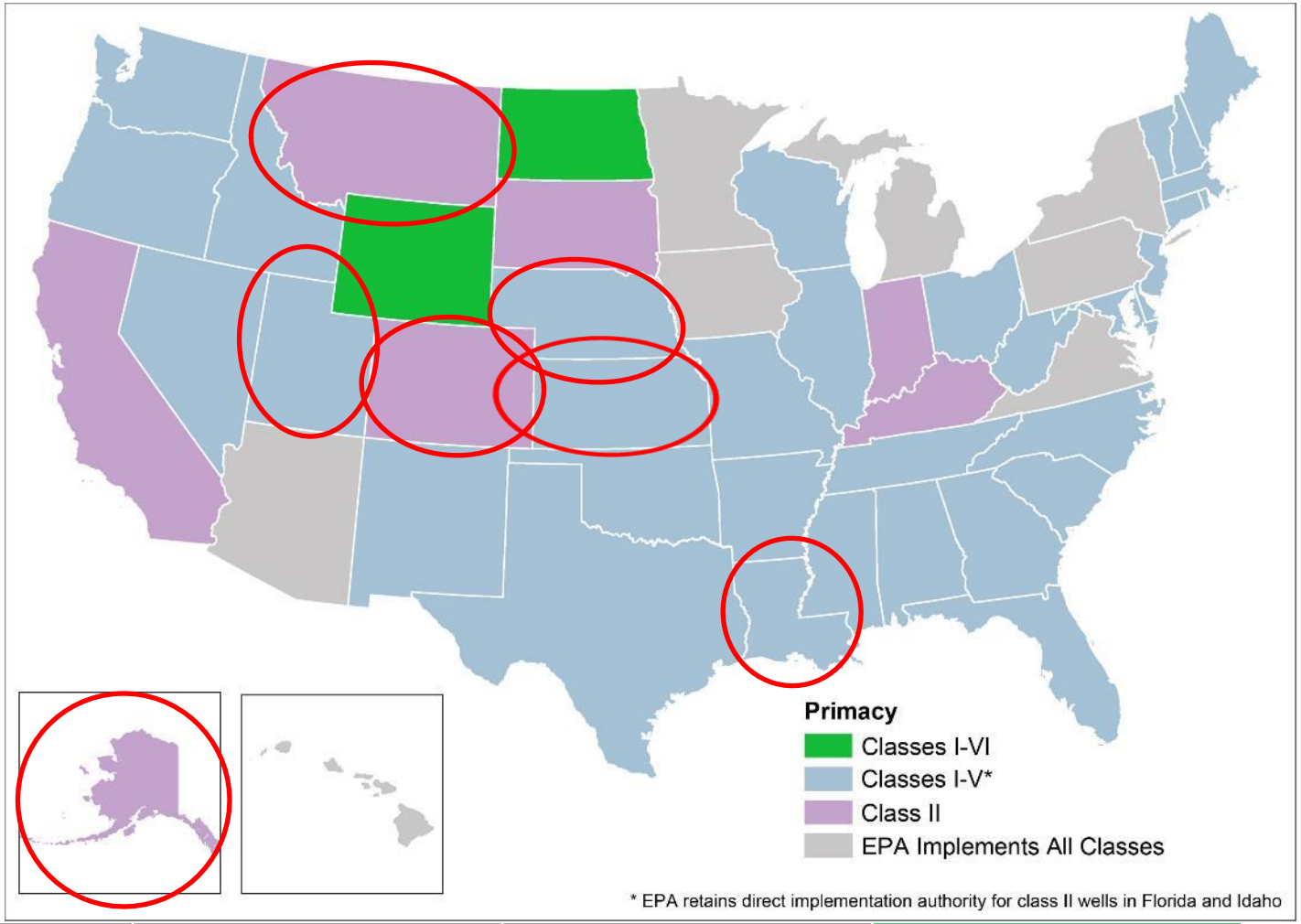
Created by the North Dakota Industrial Commission (NDIC) Oil and Gas Division



Created by the USEPA



UNDERGROUND INJECTION CONTROL CLASS VI PRIMACY



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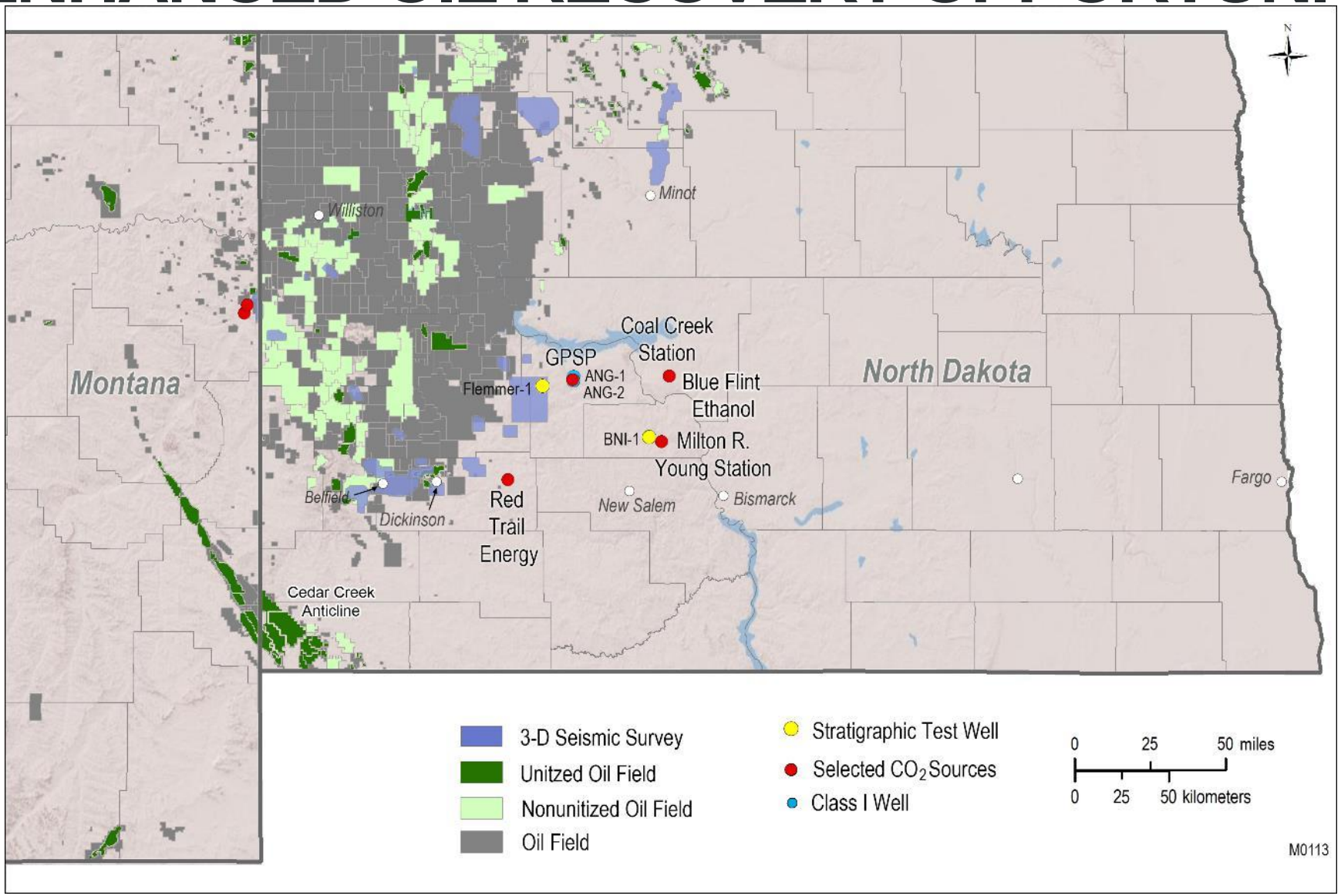
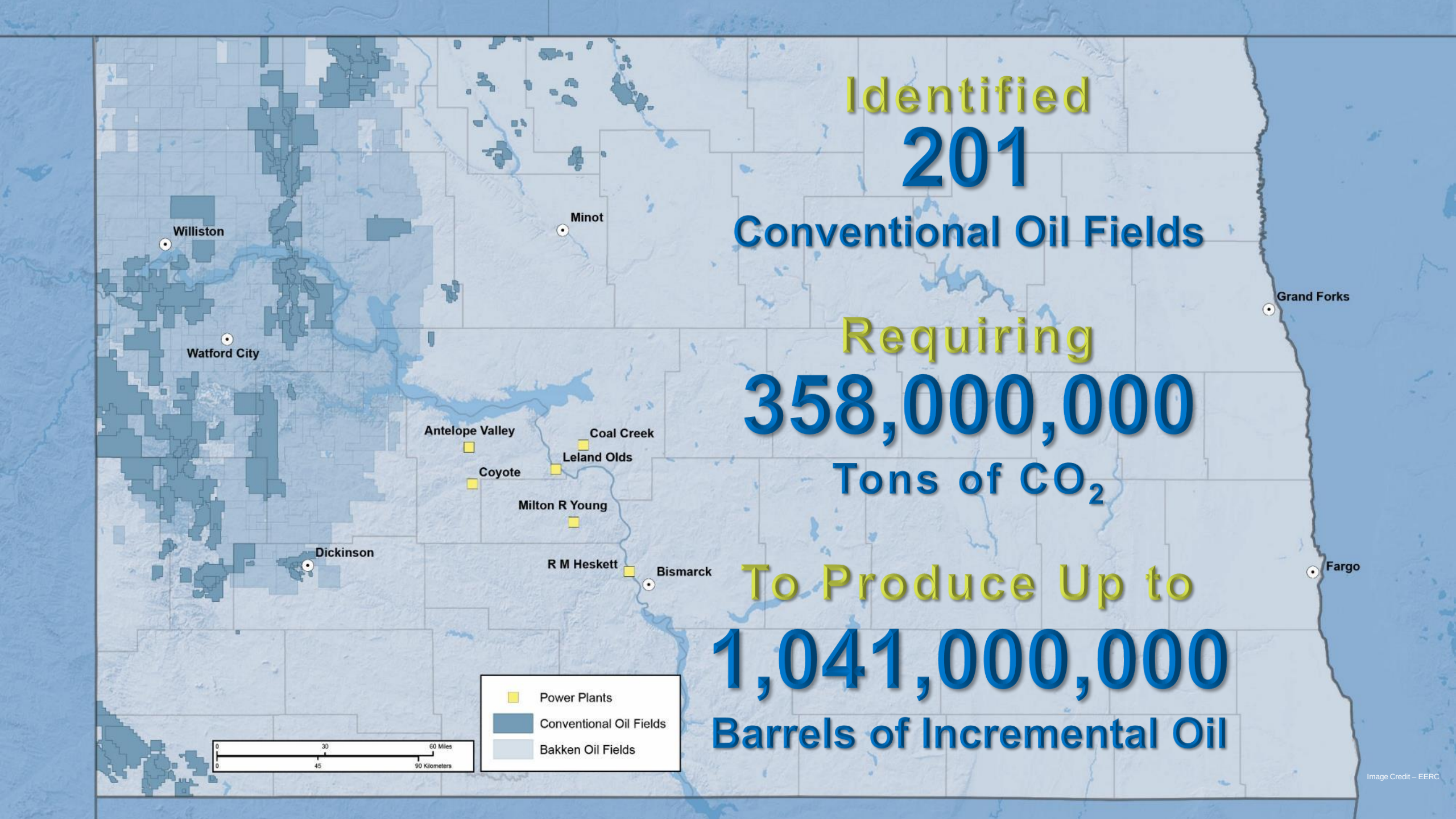
COMPARE AND CONTRAST PERMITTING GEOLOGIC CO_2 STORAGE AND CO_2 EOR

PORE SPACE AMALGAMATION COMPARED TO OIL AND GAS UNITIZATION

Pore Space Amalgamation	Oil and Gas Unitization
Amalgamation • Surface owners own the pore space (2009) • Severance of pore space prohibited • 60% pore space access obtained • Good-faith effort • All nonconsenting pore space owners are or will be equitably compensated. • Surface acreage compensation formula • Ratifications prior to approval	Unitization • Mineral ownership • Surface estate and mineral estate can be severed • Pore volume/oil in place with phased in formula • 55% mineral access obtained • Ratifications follow approval

CO_2 ENHANCED OIL RECOVERY OPPORTUNITIES




Identified
201
Conventional Oil Fields
Requiring
358,000,000
Tons of CO_2
To Produce Up to
1,041,000,000
Barrels of Incremental Oil
Williston
Minot
Watford City
Grand Forks
Antelope Valley
Coal Creek
Leland Olds
Coyote
Milton R Young
Dickinson
R M Heskett
Bismarck
Fargo
Power Plants
Conventional Oil Fields
Bakken Oil Fields
0 30 60 Miles
0 45 90 Kilometers
Image Credit – EERC

NORTH DAKOTA 6-MONTH PERMITTING PROCESS: OIL AND GAS UNITIZATION

Month 1: Operator applies to Unitize field.

Preliminary regulatory review (proposed formula).

Month 2: Schedule docket date in Month 4.

Month 3: NDIC gives public notice of hearing date and time.

Month 4: Oil and Gas Unitization hearing.

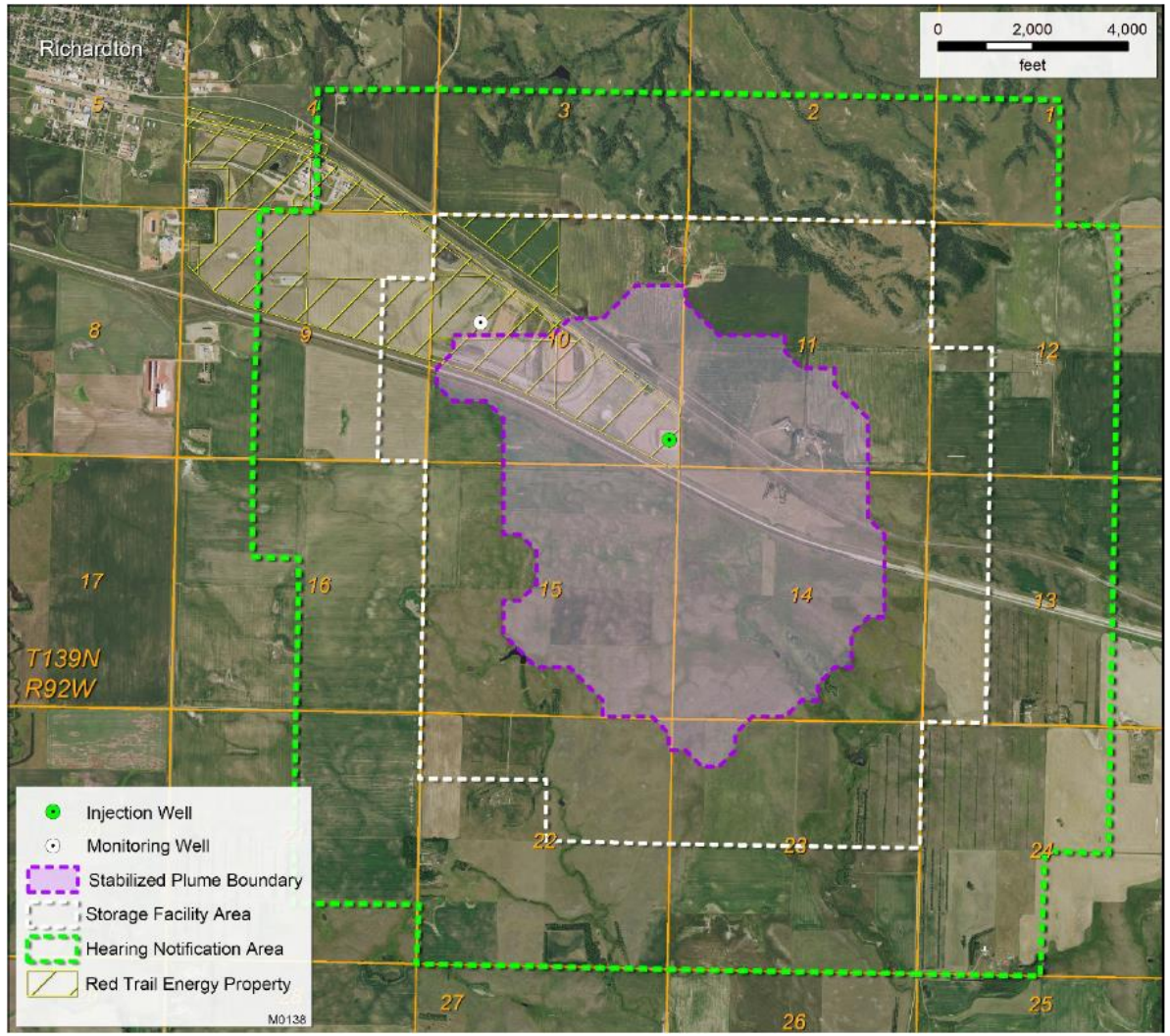
Month 6: Order signed by NDIC.

Unit ratifications required.

UIC permit application Form 14 to convert wells to injection (3 months, unless area permit is established in the unit).

PORE SPACE AMALGAMATION

Red Trail Richardton
Ethanol Broom Creek
Storage Facility #1



NORTH DAKOTA 8-MONTH PERMITTING PROCESS: CO_2 GEOLOGIC STORAGE PORE SPACE AMALGAMATION

Month 1: Complete storage facility permit received.
Regulatory review of application and begin draft permit.

Review and draft permit complete.
Submit application and draft permit to Department of Environmental Quality (DEQ) for consultation period.
Notify operator of DEQ consult period.
Operator begins preparing their notifications.

Month 3: DEQ 2-month consultation period ends.

Month 4: Schedule docket date in Month 6.
Operator gives 45-day advance notices outlined in North Dakota Administrative Code (NDAC) 43-05-01-08, subsections 1 and 2 (storage facility permit hearing).

Operator submits, to NDIC, affidavits of notification with associated ownership maps showing NDAC 43-05-01-08 notifications are met.

NDIC gives 30-day public notice outlined in NDAC 43-05-01-08 subsections 3, 4, and 5.
Public comment period for draft storage facility permit and storage facility permit application.

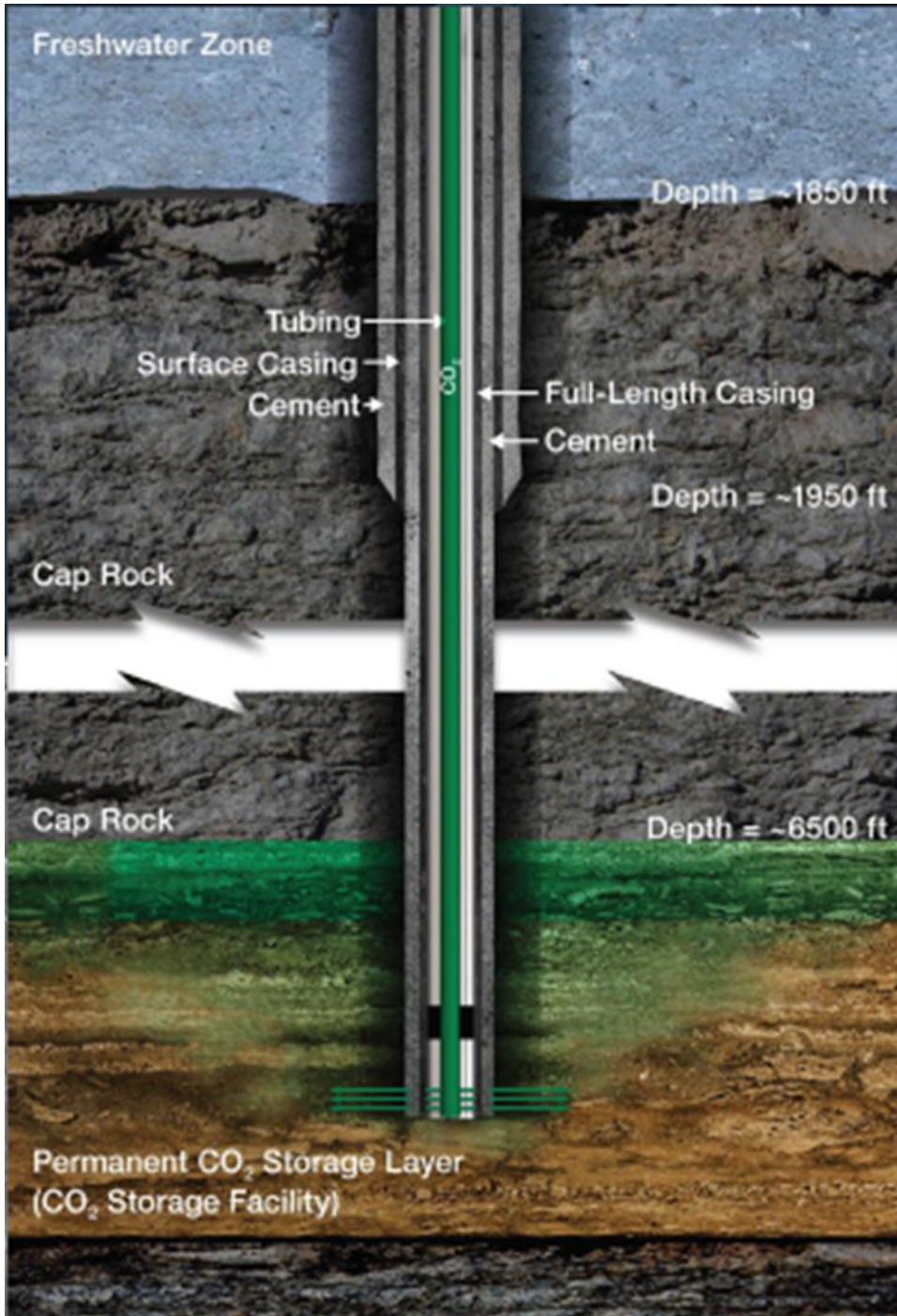
Month 6: Storage facility permit hearing.

Month 8: Order signed by NDIC.

Storage facility permit approved.
Form 25 to convert stratigraphic test or monitor well for Class VI approved.

COMPARING REGULATIONS

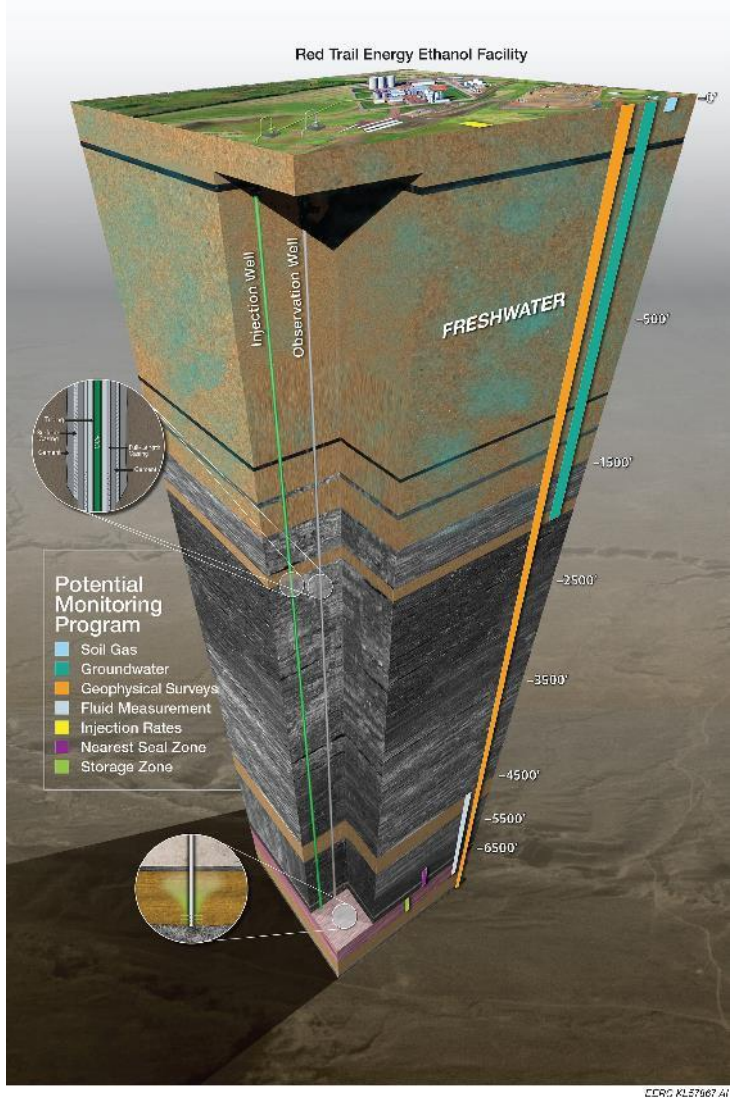
Geologic CO_2 Storage	CO_2 EOR
Class VI UIC Program • Section 1422 Safe Drinking Water Act (SDWA) • As stringent in protecting USDWs	Class II UIC Program • Section 1425 SDWA • As effective in protecting USDW
Injection Well Construction • CO_2 resistant materials • Cement to surface • Coring and logging	Injection Well Construction • Standard materials • Cement to base of surface casing
Area of Review • Delineate using Geologic Model and Computational simulations • CO_2 plume + pressure front	Area of Review • Fixed radius delineation
Monitoring • Continuous well monitoring • Internal and external mechanical integrity • Direct (dedicated monitoring well) and indirect methods (e.g. 3D Seismic)	Monitoring • Injection pressures, rates, etc. • Internal mechanical integrity • Production • Passive Seismic
Supporting Plans Financial Responsibility	Unit Blanket Bond



STORAGE FACILITY PERMIT

North Dakota CO_2 Storage Facility Permit [Class VI] Checklist

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



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GEOLOGIC EXHIBITS

North Dakota CO_2 Storage Facility Permit [Class VI] Checklist

- ❑ Storage Reservoir
  - ❑ Minerology
  - ❑ Mechanisms of Geologic Confinement
  - ❑ Geochemical Information of the Injection Zone
- ❑ Confining Zones
  - ❑ Upper Confining Zone
  - ❑ Additional Overlying Confining Zones
  - ❑ Lower Confining Zone
  - ❑ Geomechanical Information of Confining Zone
- ❑ Faults, Fractures, and Seismic Activity
- ❑ Potential Mineral Zones

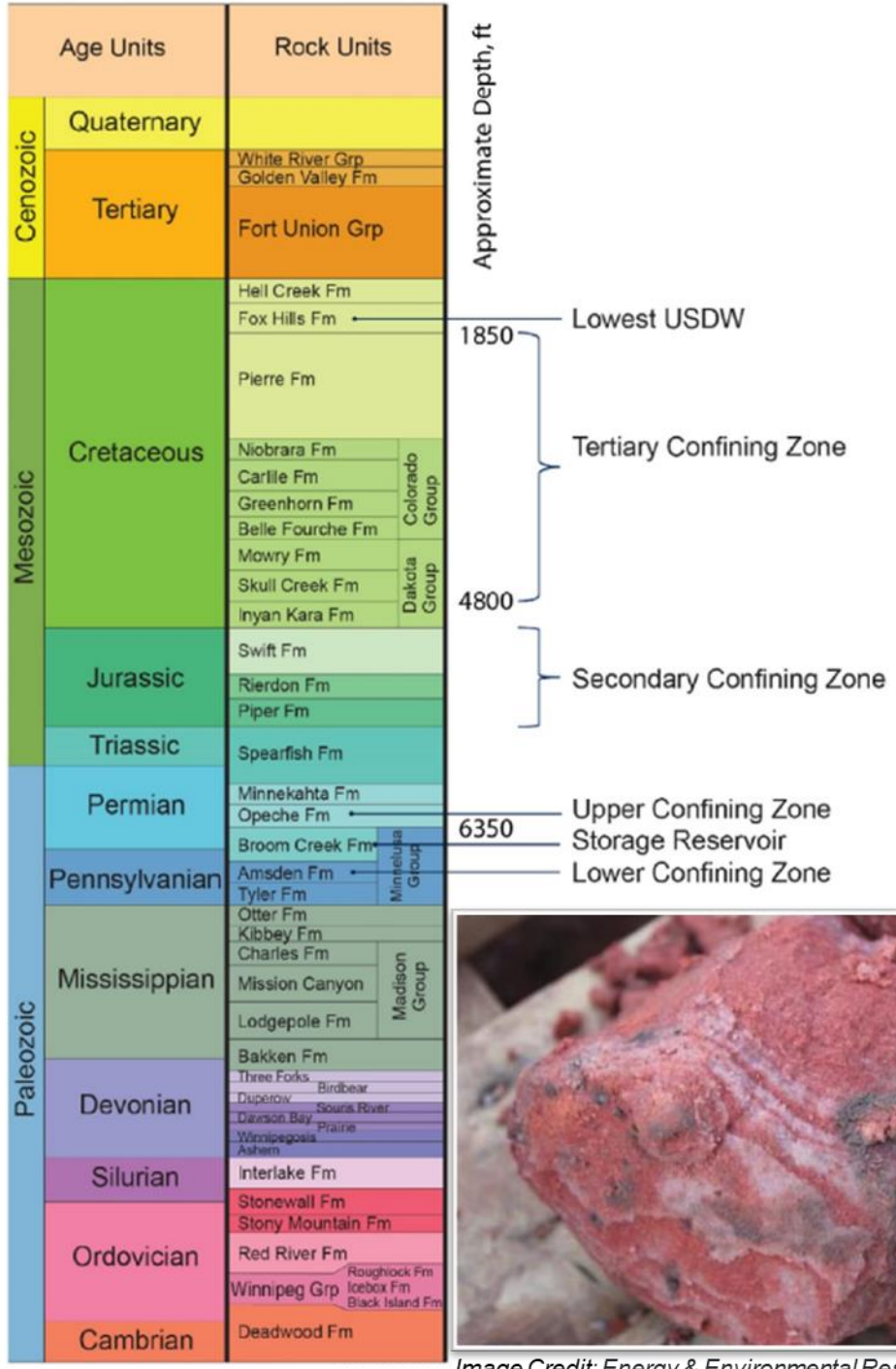
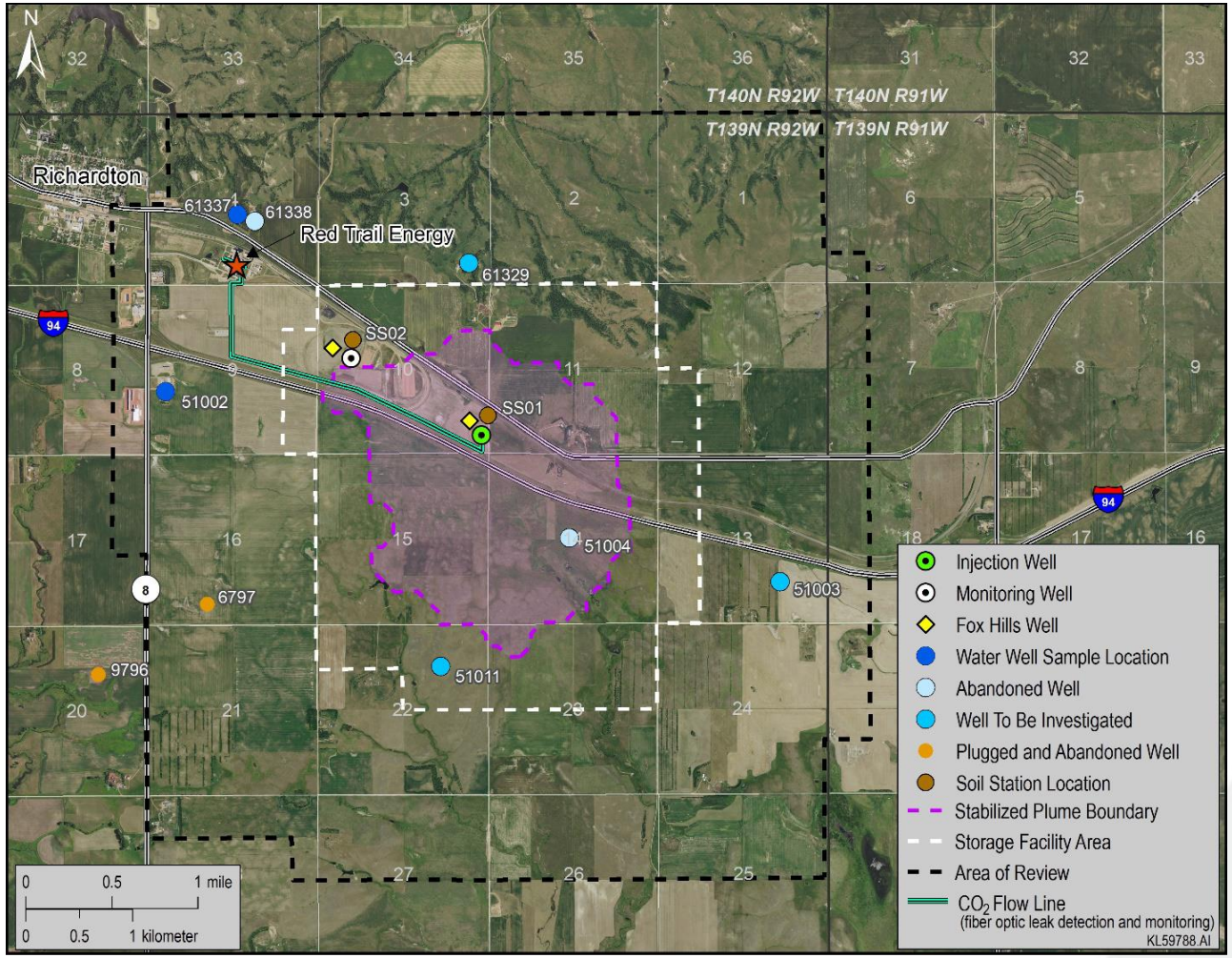


Image Credit: Energy & Environmental Research Center

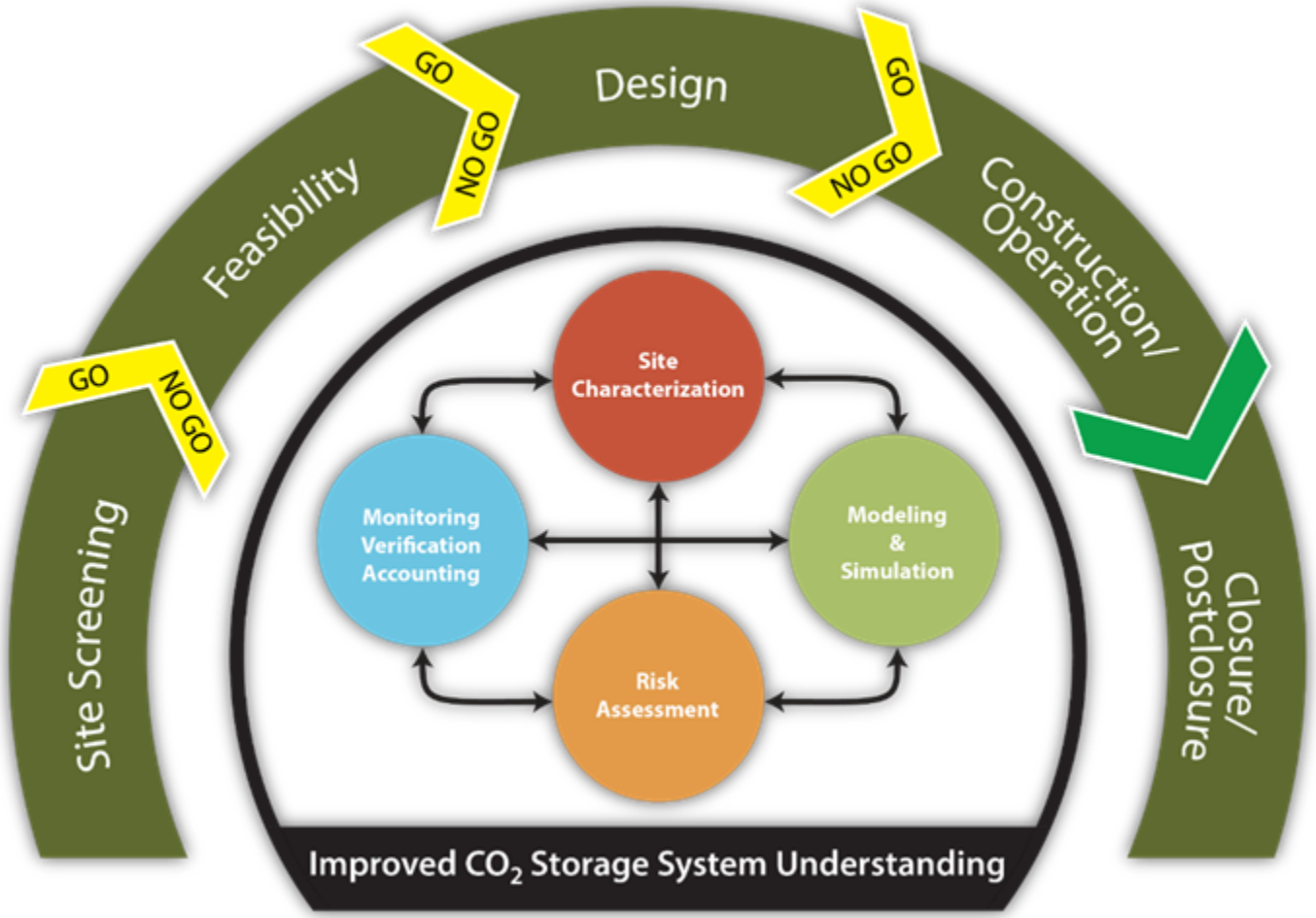
Testing and Monitoring Plans

- Analysis of Injected CO_2 and Injection Well Testing
- Corrosion Monitoring and Prevention Plan
- Surface Leak Detection and Monitoring Plan
- Subsurface Leak Detection and Monitoring Plan
- Near-Surface Groundwater and Soil Gas Sampling and Monitoring
- Completed Baseline Sampling Program
- Near-Surface (Groundwater and Soil Gas)-Monitoring Plan
- Deep Subsurface Monitoring of Free-Phase CO_2 Plume and Pressure Front
- Quality Assurance and Surveillance Plan

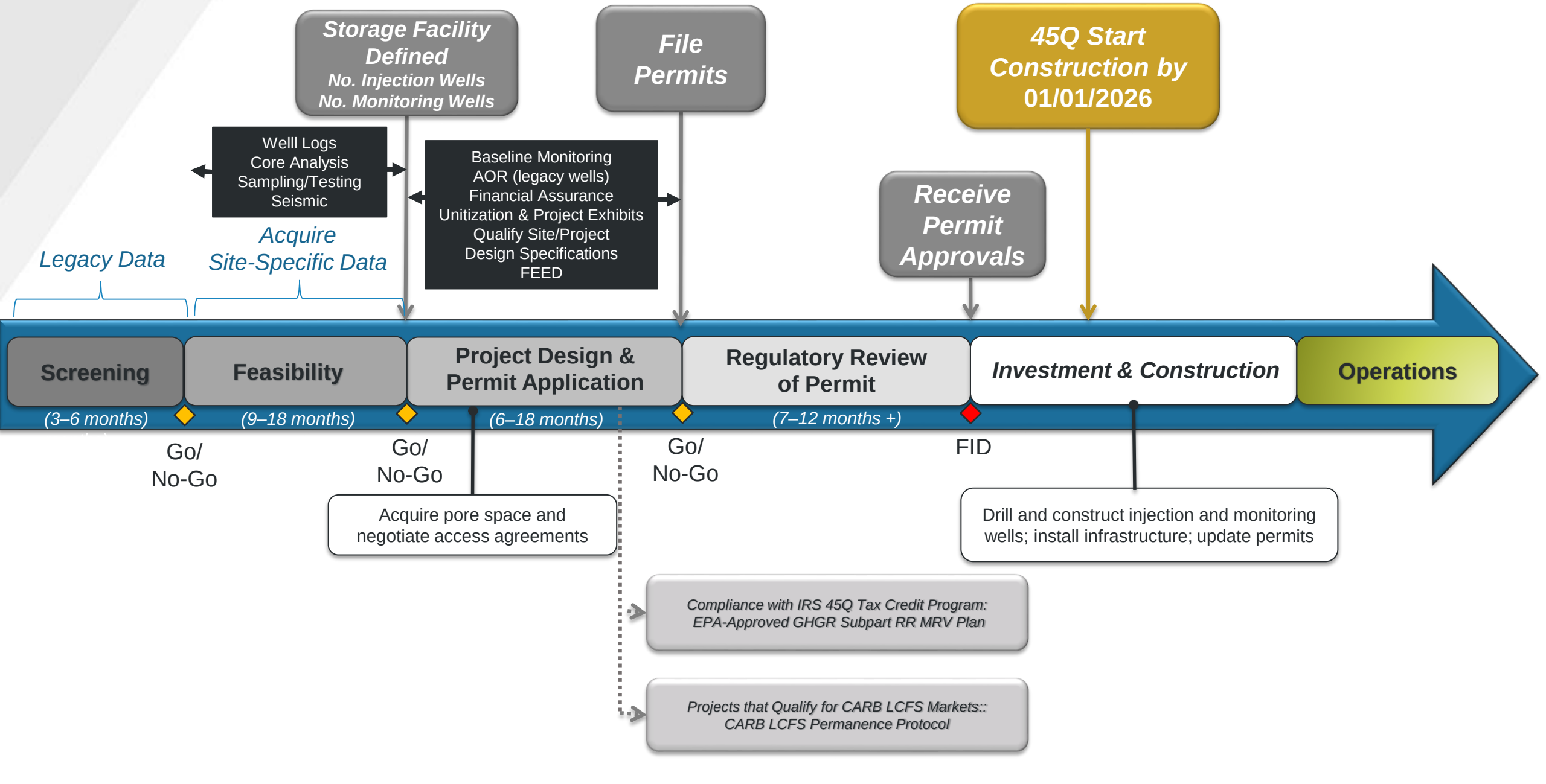


ADAPTIVE MANAGEMENT APPROACH TO PROJECT IMPLEMENTATION

- Staged approach to manage uncertainty and inform investment strategy.
- Implementation can be accelerated.
  - Higher investment needed at lower levels of confidence.
  - Concurrent vs. sequential development.
  - Balance financial and technical risk.
    - Site qualification
    - Permitting
    - Investment
    - 45Q start of construction



GENERALIZED TIMELINE TO IMPLEMENT GEOLOGIC CO_2 STORAGE



SUMMARY

- It starts with primacy and states taking the lead in regulating all aspects of the activity.
  - Overlays such as forced pooling, release of long-term liability, and title transfer incentivizes and enables storage projects.

- Oil and gas mineral resource policy is the most logical approach for CCS. (i.e., resource management regulatory philosophy).

- CCS and CO_2 EOR can follow a very similar permitting process in primacy states.

- Uncertainty around permitting and associated timelines on federal and state land untested for CO_2 storage (associated and dedicated).

- CO_2 EOR provides an efficient option for storage of CO_2.

- CO_2 EOR is key to the future of carbon management.

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Critical Challenges. Practical Solutions.

ACKNOWLEDGMENT

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DISCLAIMER

INCENTIVES

45Q Tax Credits

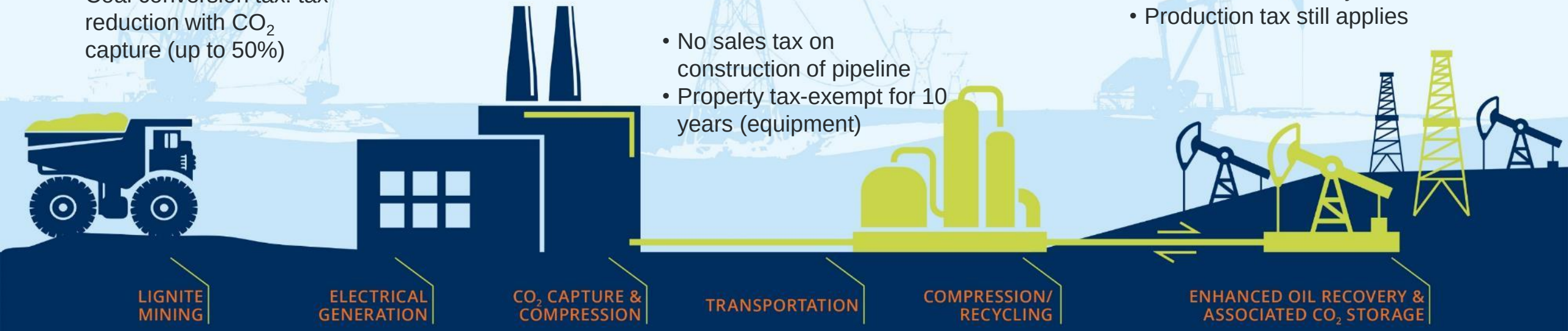
- Projects beginning construction before January 1, 2026, can claim credits for **12 years** after operations begin.
- Tax credits claimed by the taxpayer capturing the emissions or transferred to operators of CO_2 EOR projects.
- Tax credit for CO_2 stored in a qualified EOR project (10-year ramp-up to a maximum of **$35/tonne** in 2026).
- Tax credit for CO_2 stored in a saline formation (10-year ramp-up to a maximum of **$50/tonne** in 2026).

West Coast LCFS Markets

- Credits trading price range $167 to $213 per ton (March 2021)
- Stacked with 45Q

North Dakota CCUS Incentives

- Coal conversion tax: tax reduction with CO_2 capture (up to 50%)
- 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)
- No sales tax on CO_2 EOR infrastructure
- 0% extraction tax for 20 years for tertiary incremental recovery
- Production tax still applies



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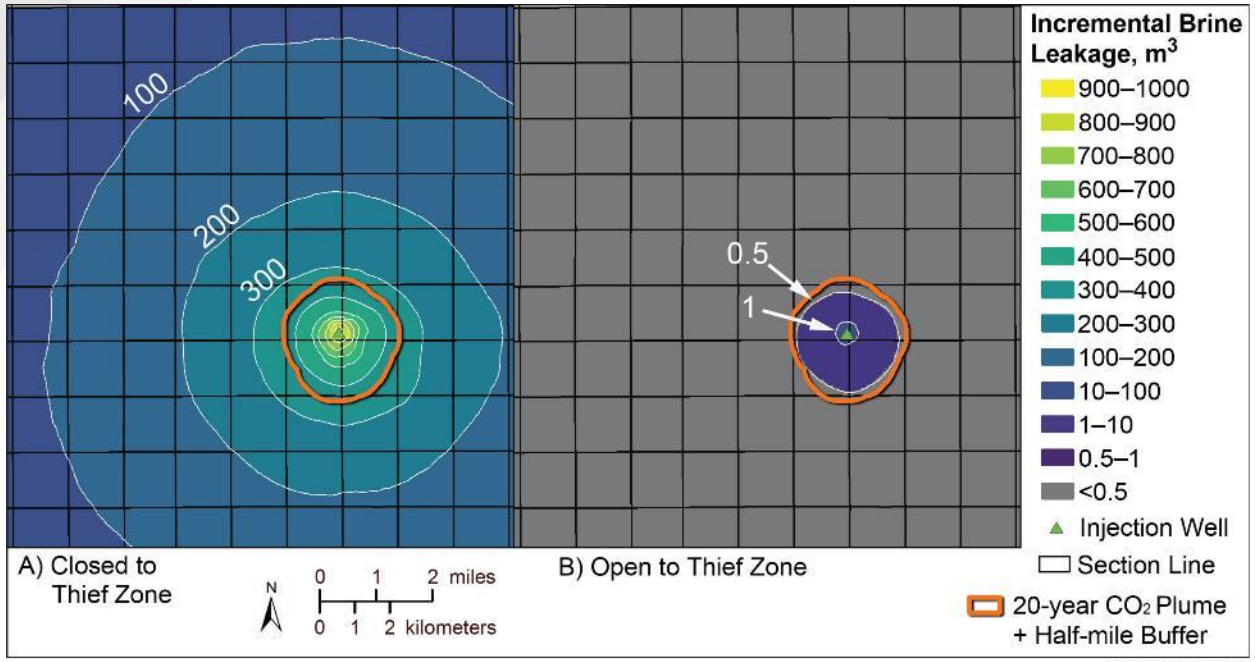
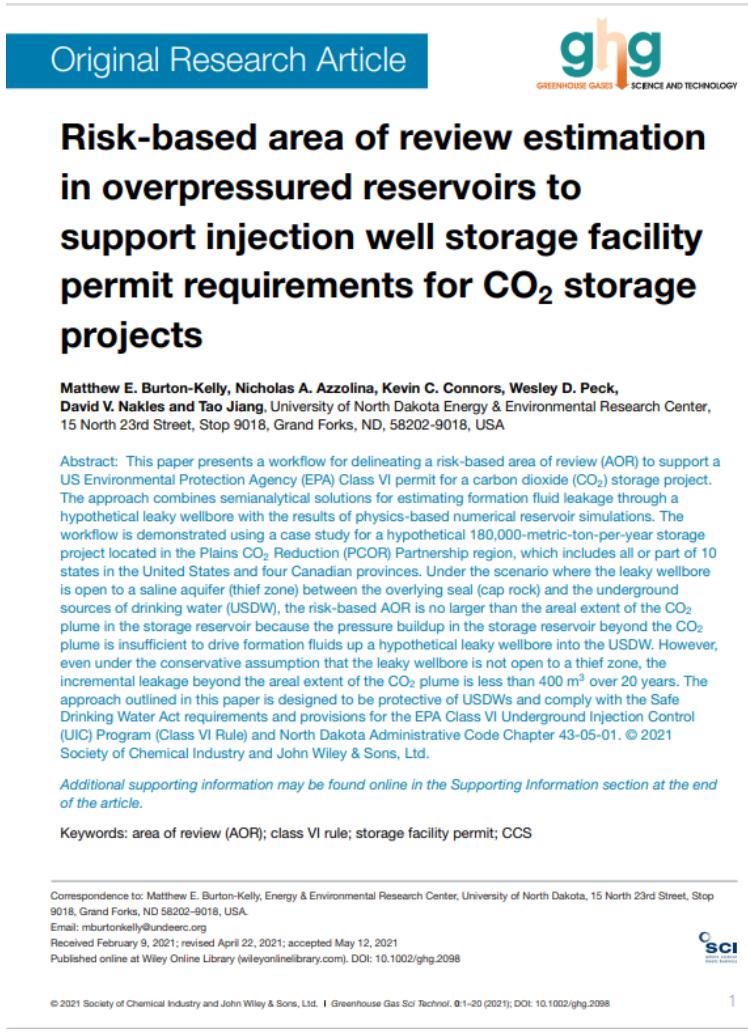
RISK-BASED AREA OF REVIEW



EERC EH59909.AI

- Risk-based area of review estimation in overpressured reservoirs to support injection well storage facility permit requirements for CO_2 storage projects
- Published in *Greenhouse Gases: Science and Technology*



Original Research Article

ghg GREENHOUSE GASES SCIENCE AND TECHNOLOGY

Risk-based area of review estimation in overpressured reservoirs to support injection well storage facility permit requirements for CO_2 storage projects

Matthew E. Burton-Kelly, Nicholas A. Azzolina, Kevin C. Connors, Wesley D. Peck, David V. Nakles and Tao Jiang, University of North Dakota Energy & Environmental Research Center, 15 North 23rd Street, Stop 9018, Grand Forks, ND, 58202-9018, USA

Abstract: This paper presents a workflow for delineating a risk-based area of review (AOR) to support a US Environmental Protection Agency (EPA) Class VI permit for a carbon dioxide (CO_2) storage project. The approach combines semianalytical solutions for estimating formation fluid leakage through a hypothetical leaky wellbore with the results of physics-based numerical reservoir simulations. The workflow is demonstrated using a case study for a hypothetical 180,000-metric-ton-per-year storage project located in the Plains CO_2 Reduction (PCOR) Partnership region, which includes all or part of 10 states in the United States and four Canadian provinces. Under the scenario where the leaky wellbore is open to a saline aquifer (thief zone) between the overlying seal (cap rock) and the underground sources of drinking water (USDW), the risk-based AOR is no larger than the areal extent of the CO_2 plume in the storage reservoir because the pressure buildup in the storage reservoir beyond the CO_2 plume is insufficient to drive formation fluids up a hypothetical leaky wellbore into the USDW. However, even under the conservative assumption that the leaky wellbore is not open to a thief zone, the incremental leakage beyond the areal extent of the CO_2 plume is less than 400 m^3 over 20 years. The approach outlined in this paper is designed to be protective of USDWs and comply with the Safe Drinking Water Act requirements and provisions for the EPA Class VI Underground Injection Control (UIC) Program (Class VI Rule) and North Dakota Administrative Code Chapter 43-05-01. © 2021 Society of Chemical Industry and John Wiley & Sons, Ltd.

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Keywords: area of review (AOR); class VI rule; storage facility permit; CCS

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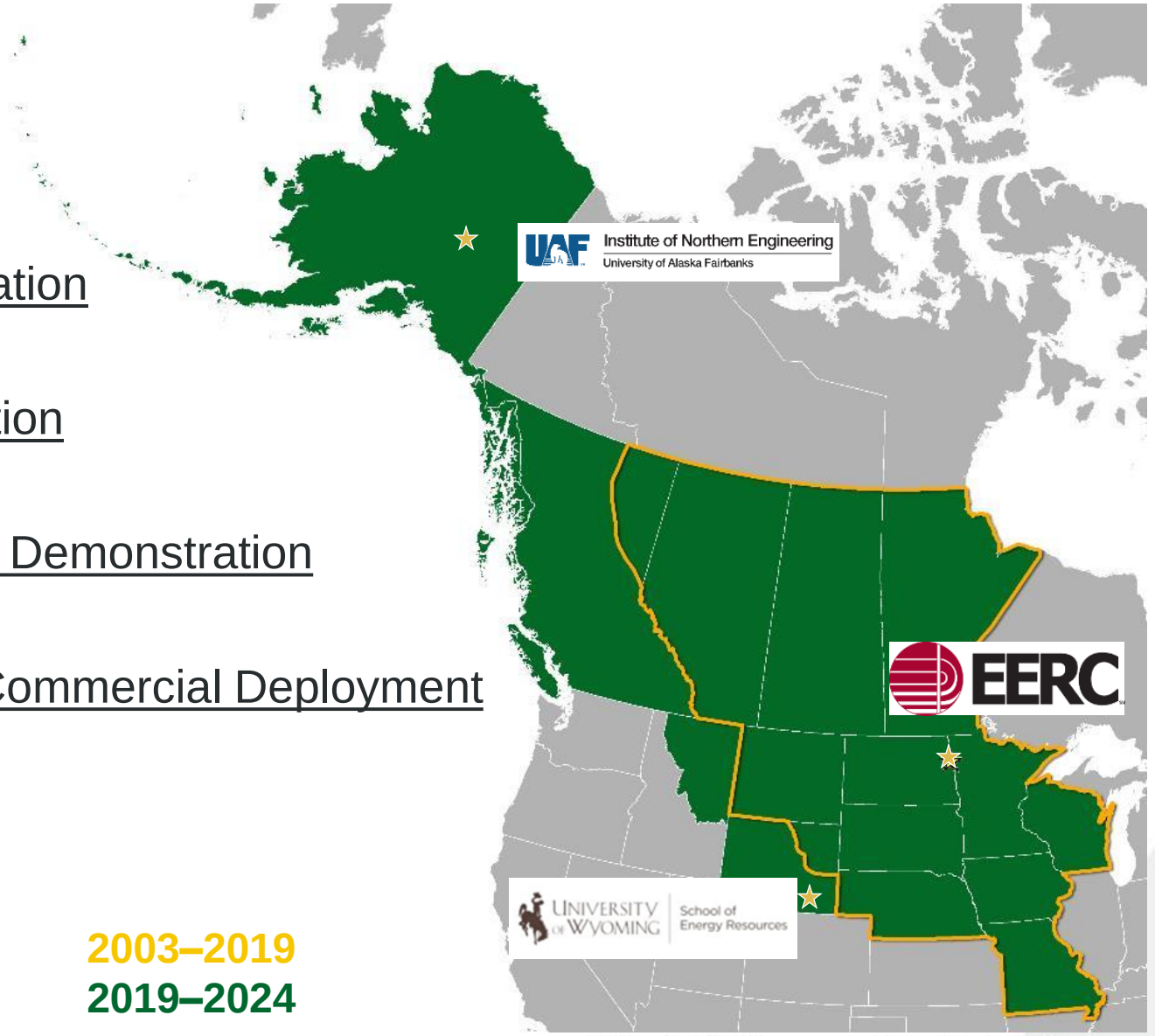
PCOR PARTNERSHIP

2003–2005 – PCOR Partnership: Characterization

2005–2008 – PCOR Partnership: Field Validation

2007–2019 – PCOR Partnership: Commercial Demonstration

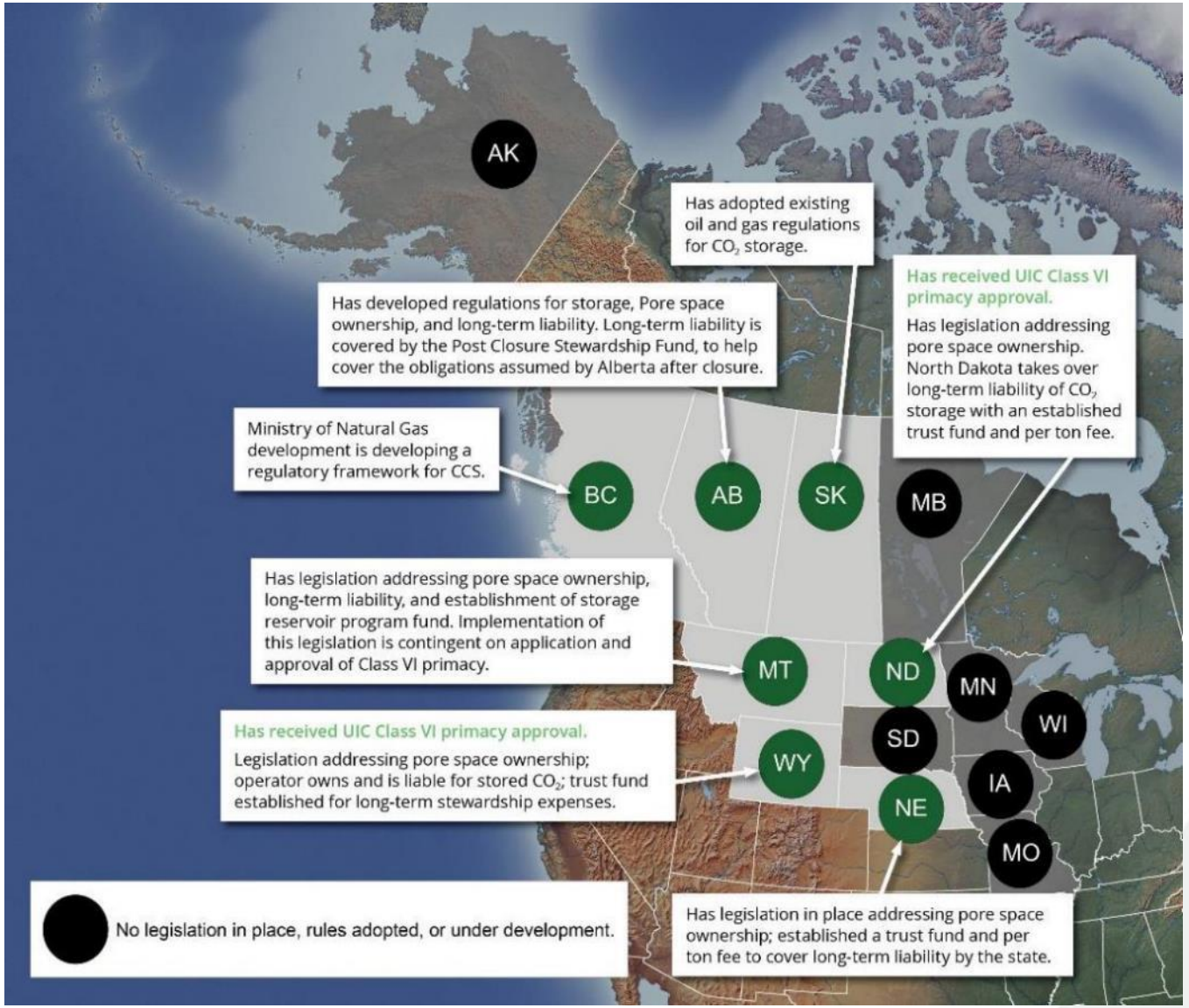
2019–2024 – PCOR Partnership Initiative: Commercial Deployment



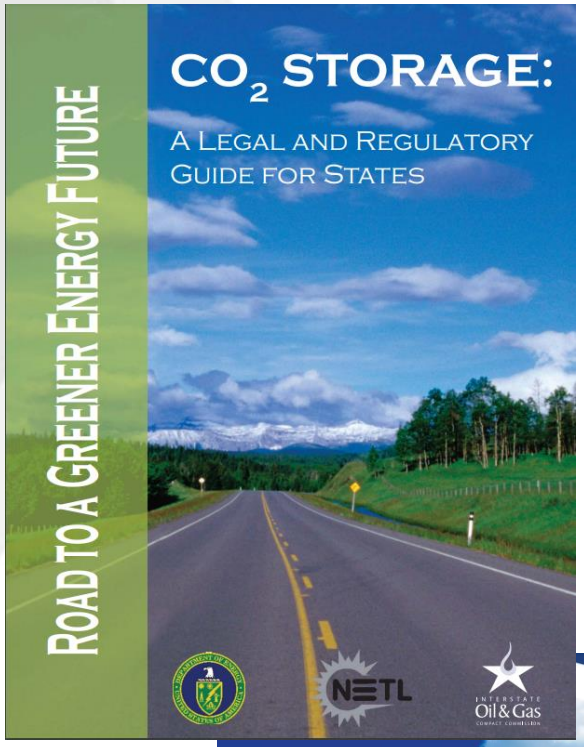
POLICY AND REGULATORY DEVELOPMENTS

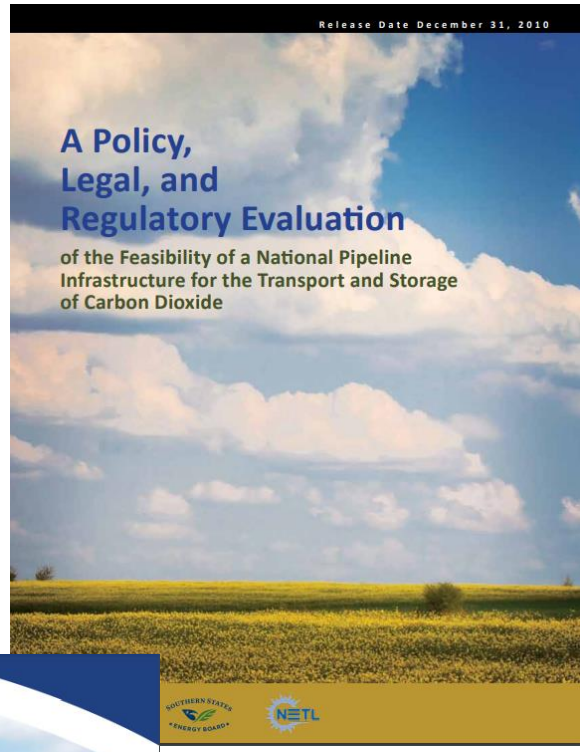
- Pore space
- Long-term liability
- Class VI primacy
- Regulatory program implementation
- Pathways to permit approval

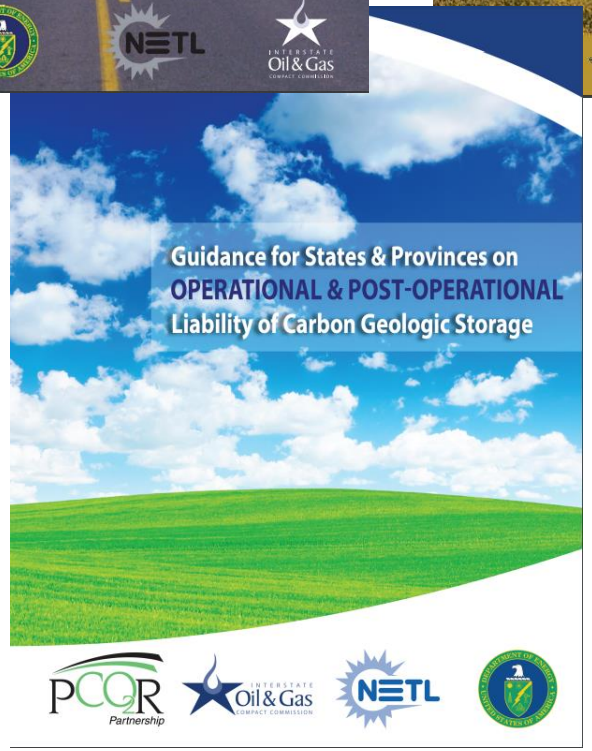
Regulatory Roundup Meeting August 17–18, 2021



IOGCC CARBON GEOLOGIC STORAGE TASK FORCE







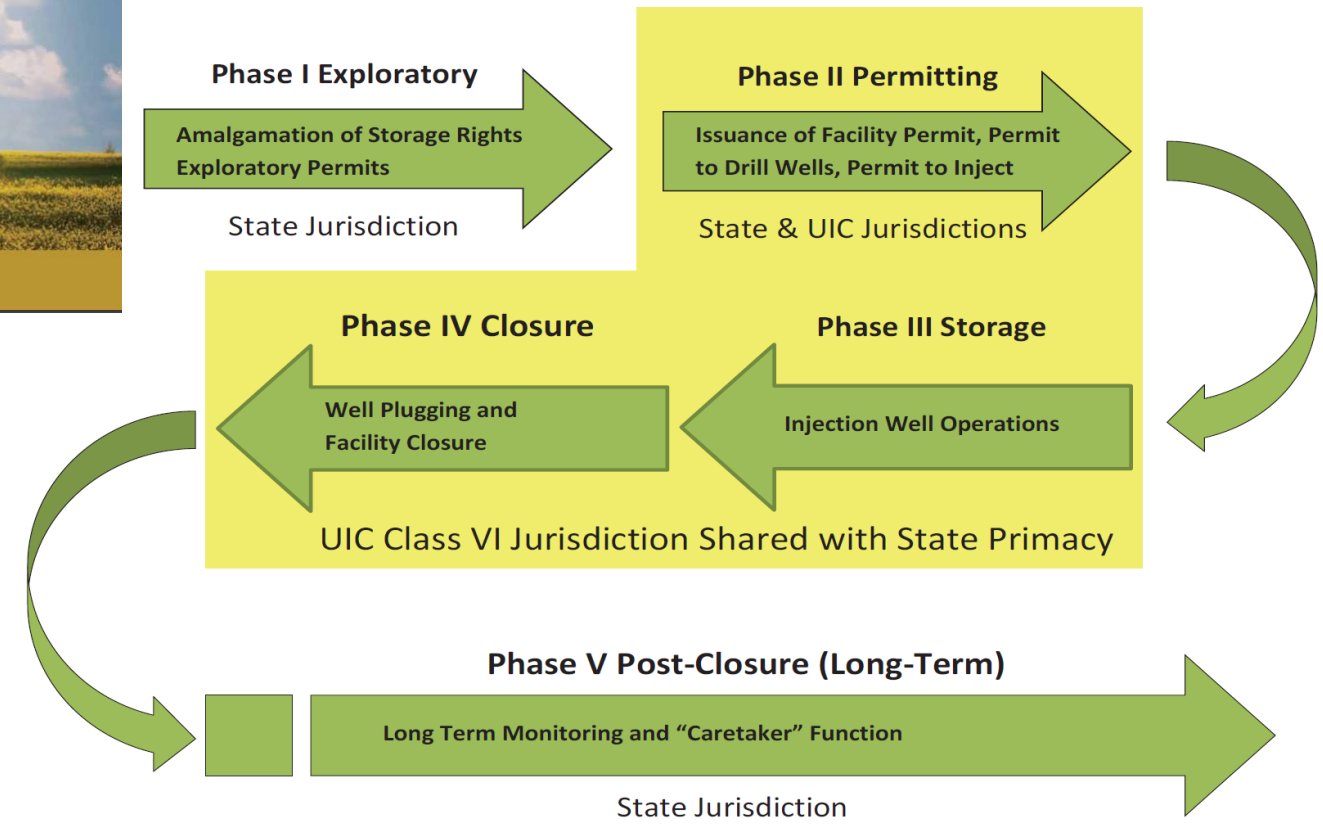
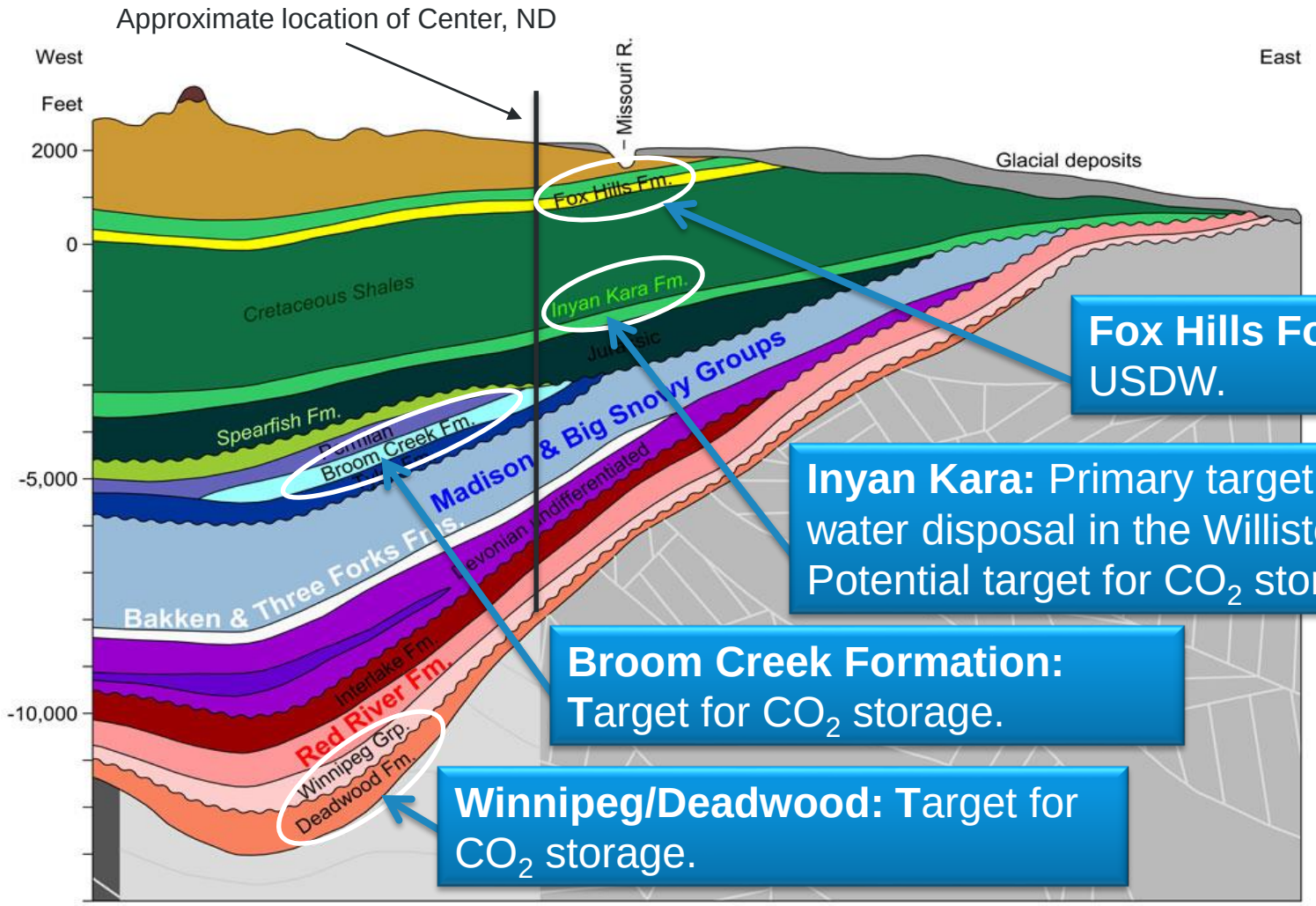


Figure 1-1 CGS Project Flow Diagram
(Yellow boxes show concurrent state and UIC Class VI jurisdiction in Phases II, III, IV. Phase I and V show exclusive state jurisdiction.)

Created by the IOGCC Task Force

WILLISTON BASIN SALINE STORAGE



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.