

**FINAL REPORT / ONE PAGE SUMMARY**

**CONTRACT #:** R-043-053  
**PROJECT NAME:** “Research in Support of Integrated Carbon Capture and Storage for North Dakota Ethanol Production”  
**PROJECT PERIOD:** 06/01/2020 – 11/30/2021  
**CONTRACTOR:** EERC  
**PRINCIPAL INVESTIGATOR:** Kerryanne M. Leroux  
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**PARTICIPANTS**

<b>Sponsors</b>	<b>Cost Share</b>
NDIC (cash)	\$500,000
Red Trail Energy (cash)	\$750,000
<b>Total</b>	<b>= \$1,200,000</b>

<b>Project Deliverables</b>	<b>Dates</b>	<b>Complete</b>
Quarterly Report	06/01/20 – 09/31/20	X
Quarterly Report	10/01/20 – 12/31/20	X
Quarterly Report	01/01/21 – 03/31/21	X
Quarterly Report	04/01/21 – 06/30/21	X
Quarterly Report	06/01/21 – 09/31/21	X
Final Report	06/01/2020 – 11/30/2021	X

<b>Project Schedule</b>	<b>Date</b>
Contract Date	06/01/2020
Start Date	06/01/2020
Completion Date	11/30/2021

**PURPOSE OF THE PROJECT:**

The Energy & Environmental Research Center, in partnership with Red Trail Energy, LLC (RTE), a North Dakota ethanol producer, and the North Dakota Industrial Commission Renewable Energy Program, continued investigation of carbon capture and storage (CCS) applicable to small-scale industrial CO<sub>2</sub> emitters (<1,000,000 tonnes of CO<sub>2</sub> emitted annually) considering CO<sub>2</sub> capture and permanent geologic storage. Using the RTE facility near Richardton, North Dakota, as a case study, this project was the fourth phase (Phase 4) of a multiphase research and development effort to create the first integrated CCS system in North Dakota for the reduction of carbon emissions from ethanol production and capitalize on evolving low-carbon fuel markets.

**WORK ACCOMPLISHED, PROJECT RESULTS:**

The objective for the research project was to collect the data necessary to advance the RTE case study for ultimate implementation of the first integrated ethanol and CCS facility in North Dakota. This resulted in a package that details effective approaches and lessons learned, including any public materials generated through the following deliverables: D1 – CO<sub>2</sub> Storage Characterization Methodologies Report, D2 – North Dakota CCS Regulatory-Incentives Crosswalk, D3 – North Dakota CO<sub>2</sub> Storage Facility Permit (SFP) Guide, and D4 – North Dakota CCS Outreach Tool Kit. These documents were developed to serve as standalone guides with detailed topic discussion, as well as together (i.e., combined in the D5 – Final Report) for a comprehensive package, for the reduction of carbon emissions from ethanol production and to capitalize on evolving CCS incentive programs.

**POTENTIAL APPLICATIONS OF THE PROJECT:**

Successful completion of Phase 4 work has positioned the North Dakota ethanol industry as a national leader in developing reduced-carbon ethanol with a strategic first-to-market advantage over other states. This supporting research helps to ensure secure injection and storage economic viability, regulatory compliance, public knowledge sharing, and generation of a North Dakota CO<sub>2</sub> SFP blueprint. The blueprint generated can, thus, be utilized by other North Dakota renewable energy or biofuel producers to implement CCS, enhancing overall North Dakota economics.



November 30, 2021

Ms. Karlene Fine  
Executive Director  
North Dakota Industrial Commission  
State Capitol, 10th Floor  
600 East Boulevard Avenue  
Bismarck, ND 58505-0310

Dear Ms. Fine:

Subject: Deliverable (D) 5 for Research in Support of Integrated Carbon Capture and Storage for North Dakota Ethanol Production; Contract No. R-043-053; EERC Fund 25204

Attached is the D5: Final Report for the subject project. If you have any questions, please contact me by phone at (701) 777-5013, by fax at (701) 777-5181, or by e-mail at [kleroux@undeerc.org](mailto:kleroux@undeerc.org).

Sincerely,

DocuSigned by:  
  
F93F81AE98DB40F...  
Kerryanne M. Leroux  
Principal Engineer

KML/rlo

Attachment



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# RESEARCH IN SUPPORT OF INTEGRATED CARBON CAPTURE AND STORAGE FOR NORTH DAKOTA ETHANOL PRODUCTION

## Final Report

### *Deliverable D5*

#### *Prepared for:*

Karlene Fine

North Dakota Industrial Commission  
State Capitol, 14th Floor  
600 East Boulevard Avenue, Department 405  
Bismarck, ND 58505-0840

Contract No. R-043-053

#### *Prepared by:*

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## LIST OF ACRONYMS AND NOMENCLATURE

AOR	area of review
CCS	carbon capture and storage
CMG	Computer Modelling Group Ltd.
DMR	[North Dakota] Department of Mineral Resources
DOE	U.S. Department of Energy
EERC	Energy & Environmental Research Center
EPA	U.S. Environmental Protection Agency
GEM	Generalized Equation-of-State Model
IRS	Internal Revenue Service
LCF	low-carbon fuel
LCFS	[California] Low Carbon Fuel Standard
MRV	monitoring, review, and verification
NDAC	North Dakota Administrative Code
NDCC	North Dakota Century Code
NDIC	North Dakota Industrial Commission
primacy	primary enforcement responsibility
REP	Renewable Energy Program
RTE	Red Trail Energy, LLC
SFP	storage facility permit
Section 45Q	Enhancement of Carbon Dioxide Sequestration Credit
UIC	underground injection control
USDWs	underground sources of drinking water

# RESEARCH IN SUPPORT OF INTEGRATED CARBON CAPTURE AND STORAGE FOR NORTH DAKOTA ETHANOL PRODUCTION

## EXECUTIVE SUMMARY

The Energy & Environmental Research Center (EERC), in partnership with the North Dakota Industrial Commission (NDIC) Renewable Energy Program and North Dakota ethanol producer Red Trail Energy, LLC (RTE), conducted the fourth phase (Phase 4) of a multiphase research and development effort that began in 2016 to create the first integrated carbon capture and storage (CCS) system in North Dakota. This latest research effort collected the remaining data necessary to advance the RTE case study for ultimate CCS implementation, resulting in a package that details effective approaches and lessons learned, including any public materials generated, through the following deliverables: 1) CO<sub>2</sub> Storage Characterization Methodologies Report, 2) North Dakota CO<sub>2</sub> Storage Facility Permit Guide, 3) North Dakota Carbon Capture and Storage Outreach Tool Kit, and 4) North Dakota CCS Regulatory-Incentives Crosswalk. These documents were developed to serve as standalone guides, with detailed topic discussion, as well as together (provided in the attached appendixes) for a comprehensive package for the reduction of carbon emissions from ethanol production and to capitalize on evolving CCS incentive programs.

The first geologic CO<sub>2</sub> storage facility in the state of North Dakota, Red Trail Richardton Ethanol Broom Creek Storage Facility No. 1, was established with formal approval of RTE's North Dakota CO<sub>2</sub> storage facility permit (SFP) on October 19, 2021. The formal approval of the RTE SFP by NDIC authorizes the geologic storage of CO<sub>2</sub> from the RTE ethanol facility in the amalgamated storage reservoir pore space of the Broom Creek Formation. The RTE CCS project is currently constructing a CO<sub>2</sub> capture facility adjacent to the RTE ethanol facility near Richardton, North Dakota, to ultimately inject about 180,000 tonnes of CO<sub>2</sub> annually more than a mile below RTE property for permanent storage.

Development of a North Dakota CO<sub>2</sub> SFP application is a lengthy process that presently requires significant investment of time and resources by the CCS operator, as well as applications for incentive certifications. Detailed planning that includes contingencies and frequent communication with North Dakota regulators is necessary for a successful effort. Although some efficiencies can be gained for the future CCS implementation, operators should plan on a roughly 5-year time frame for 1) general project feasibility, 2) site-specific data acquisition, 3) engineering designs, 4) permitting, and 5) construction before operations can start. Operators should also be aware of potential delays or bottlenecks due to availability of subcontractor crews, equipment delivery timelines, material supplies, schedules of regulators/officials, etc. Flexibility and creativity are essential for managing unforeseeable issues as well, such as the effect of a global pandemic on community outreach plans or material supplies.

Public science-based and community-focused outreach has been a major component to the RTE CCS project. Building on foundations developed during previous research phases, Phase 4 outreach began in June 2020—coincident with the COVID-19 pandemic. With the onset of the pandemic, lockdowns, and limitations on face-to-face contact, the established outreach, such as monthly city and county commission meetings, community open houses, and individual landowner

communication, gave way to traditional and social media and websites to convey information about project-specific activities and the overall RTE CCS status. Project status updates and related materials were sent to county and city commissioners via e-mail as the research progressed. In lieu of providing community open houses to announce project milestones, such as the intent to move forward with submission of a North Dakota CO<sub>2</sub> SFP application, a press release and summarizing article were disseminated to local and major newspapers in the state and posted on the EERC weblog (<https://blog.undeerc.org>). The ultimate outreach effort, scheduled after RTE's SFP was formally approved by NDIC, was a virtual open house held on November 10, 2021. Registrants also received a packet of information providing a project overview summarizing the project results, describing the permitting process, and explaining CO<sub>2</sub> capture and long-term monitoring. The project continues to benefit from local public acceptance; to date, feedback from the audiences has been neutral to positive and, overall, interactions have been constructive.

To maximize incentive opportunities, fuel producers implementing CCS can currently qualify for 1) a California Low Carbon Fuel Standard Pathway with approved CCS Permanence Certification (LCFS) and 2) U.S. Internal Revenue Service (IRS) Enhancement of Carbon Dioxide Sequestration Credit (a.k.a. Section 45Q) tax credits with an approved U.S. Environmental Protection Agency (EPA) Monitoring, Reporting, and Verification (MRV) Plan. In addition, developing application requirements for an EPA MRV plan (for IRS 45Q tax credit), as well as a California LCFS CCS certification, if applicable, simultaneously with the SFP application can provide efficiencies in document preparation and ensure consistency. Again, it is highly recommended to collaborate with all agency officials throughout project/plan development.

Much work still lies ahead for the RTE CCS project as it transitions to an operational phase as the first commercial CCS facility in North Dakota. Now that RTE has acquired a formally approved permit, RTE is confidently moving forward with implementation and operation. Completion of construction is anticipated in early 2022; thus start-up operations of CO<sub>2</sub> capture and injection are expected by Q2-2022. The start of decades of monitoring data collection and reporting will commence once systems are optimized and operating.

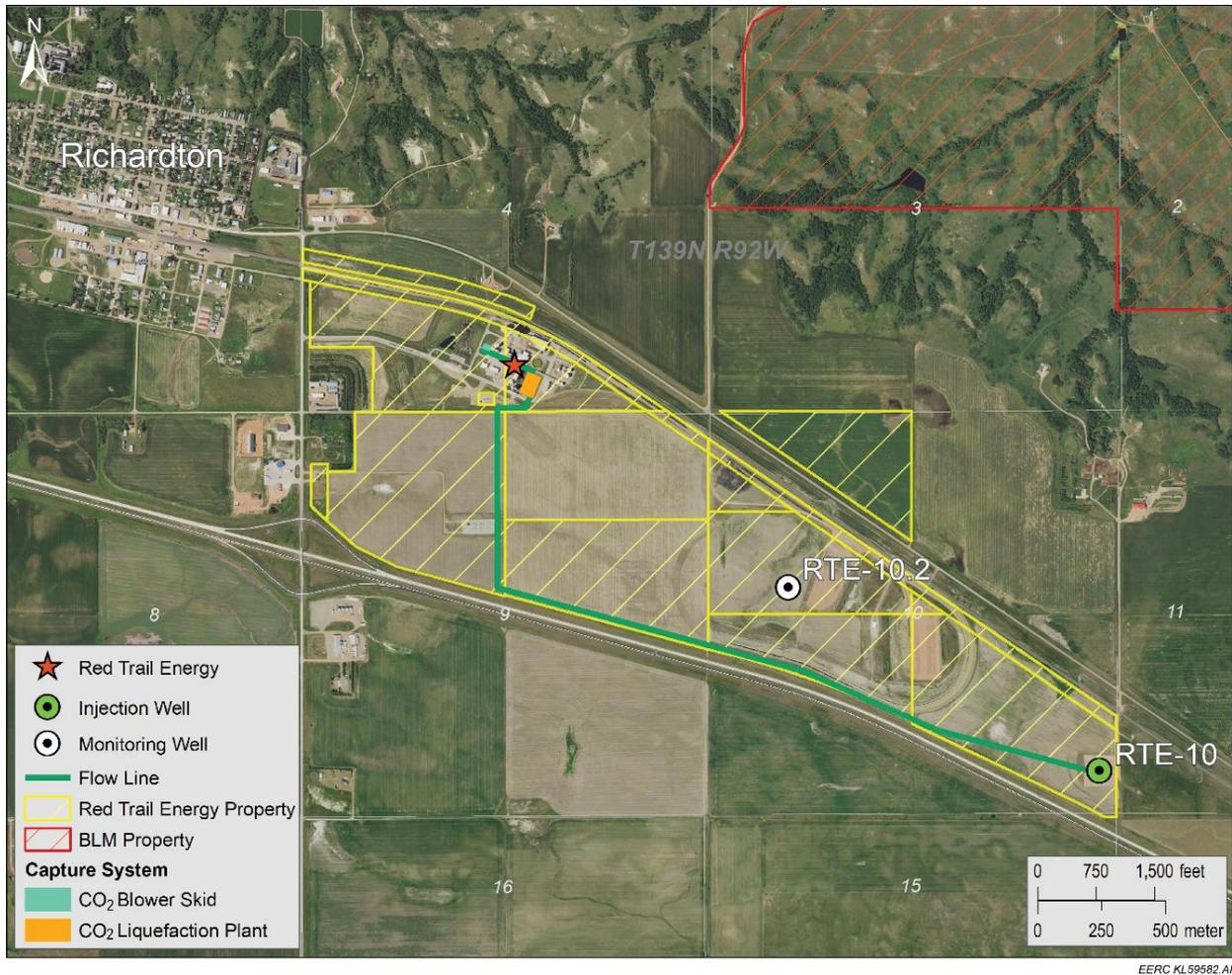
# RESEARCH IN SUPPORT OF INTEGRATED CARBON CAPTURE AND STORAGE FOR NORTH DAKOTA ETHANOL PRODUCTION

## INTRODUCTION

The Energy & Environmental Research Center (EERC), in partnership with Red Trail Energy, LLC (RTE), a North Dakota ethanol producer, and the North Dakota Industrial Commission (NDIC) Renewable Energy Program (REP), continued investigation of carbon capture and storage (CCS) applicable to small-scale industrial CO<sub>2</sub> emitters (<1,000,000 tonnes of CO<sub>2</sub> emitted annually) considering CO<sub>2</sub> capture and permanent geologic storage. The RTE ethanol facility is a North Dakota-based, investor-owned 64-million-gallon dry mill ethanol production plant, which has been in operation since January 2007. This research project collected the data necessary to advance the RTE case study for ultimate implementation of the first integrated ethanol and CCS facility in North Dakota, resulting in a carbon storage package that details effective approaches and lessons learned, including any public materials generated, as summarized in the following appendixes: CO<sub>2</sub> Storage Characterization Methodologies Report (Appendix A), North Dakota CO<sub>2</sub> Storage Facility Permit Guide (Appendix B, selected summary sections), North Dakota Carbon Capture and Storage Outreach Tool Kit (Appendix C), and North Dakota CCS Regulatory-Incentives Crosswalk (Appendix D).

RTE received formal approval on October 19, 2021, of the first North Dakota CO<sub>2</sub> storage facility permit (SFP). RTE, in partnership with the EERC, NDIC REP, and the U.S. Department of Energy (DOE), have been investigating CCS applicable to small-scale industrial CO<sub>2</sub> emitters over the past 5 years (Leroux and others, 2020). The RTE facility emits an average 180,000 metric tons of high-purity CO<sub>2</sub> annually from the fermentation process during ethanol production. RTE plans to commercially inject the CO<sub>2</sub> stream more than a mile below RTE property for permanent geologic CO<sub>2</sub> storage. North Dakota has the authority to regulate the geologic storage of CO<sub>2</sub> and primacy to administer the North Dakota Underground Injection Control (UIC) Class VI Program (83 Federal Register 17758, 40 Code of Federal Regulations [CFR] 147). The U.S. Environmental Protection Agency (EPA) UIC Class VI was created to solely regulate CO<sub>2</sub> geologic storage. The copious amounts of data collected, engineering conducted, evaluations performed, and regulatory processes engaged to achieve this permit are summarized in the sections below.

The RTE CCS project is currently constructing a CO<sub>2</sub> capture facility adjacent to the RTE ethanol facility near Richardton, North Dakota. Figure 1 shows the integration of major CCS components with the existing RTE ethanol facility, consisting of a blower to divert the CO<sub>2</sub> emissions to the capture (liquefaction) plant, from which the now liquid CO<sub>2</sub> stream will flow to the RTE-10 injection well for geologic storage into the Broom Creek Formation (a saline formation); an underground flowline (buried >6 ft in depth) was installed in September 2021 on RTE property to connect the capture plant to the RTE-10 injection well. A monitoring well (RTE-10.2) has also been installed on RTE property for compliance with the North Dakota CO<sub>2</sub> SFP requirements to directly monitor CO<sub>2</sub> injection in the Broom Creek Formation. Monitoring equipment installed in both the RTE-10 and RTE-10.2 wells includes pressure–temperature gauges in the Broom Creek and Inyan Kara Formations and a fiber-optic cable along the entire length of



EERC KL59582.AI

Figure 1. RTE ethanol facility and CCS site showing location of project infrastructure and location relative to the community of Richardton, North Dakota.

both wells and flowline for temperature and acoustic sensing. Additional near-surface monitoring equipment has also been recently installed at the RTE CCS site, including two water wells for monitoring the Fox Hills Formation (lowest freshwater source, ~1800 ft depth) and two soil gas stations (~15 ft depth), one set near each of the monitoring and injection wells; both water wells also contain fiber-optic cable.

## **CHARACTERIZING A GEOLOGIC STORAGE COMPLEX IN NORTH DAKOTA**

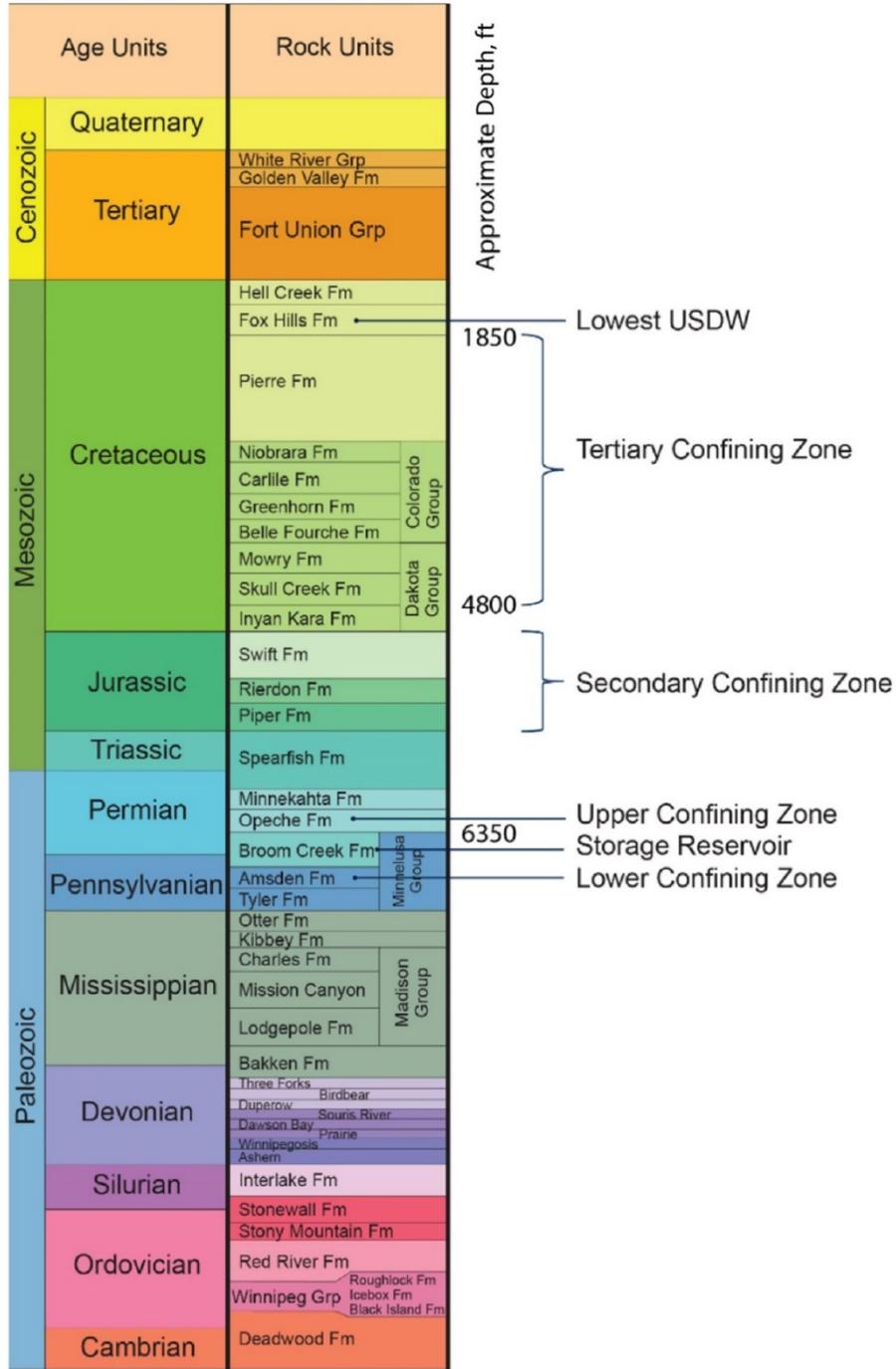
The CO<sub>2</sub> Storage Characterization Methodologies Report was developed as a guide for biofuel producers (and other interested parties) on the types of geologic evaluations needed to complete a North Dakota CO<sub>2</sub> SFP application, which includes the UIC Class VI well permitting for dedicated CO<sub>2</sub> storage. The five primary North Dakota CO<sub>2</sub> SFP application components are 1) pore space access, 2) geologic exhibits, 3) area of review, 4) supporting permit plans, and 5) injection well and storage operations, as detailed in the North Dakota Century Code (NDCC) (Chapter 38-22) and North Dakota Administrative Code (NDAC) (Chapter 45-05-01). Characterization strategies for developing the geologic exhibits are summarized below, with details provided in Appendix A (Klapperich and others, 2021).

### **Characterization Strategies for a North Dakota CO<sub>2</sub> SFP Application**

As mentioned previously, research investigations began in 2016 to characterize the geology and determine site feasibility to develop the first CCS facility in North Dakota (Leroux and others, 2020). This geologic characterization work resulted in RTE conducting a 3D seismic survey over the project area in March 2019 and drilling a stratigraphic test well (RTE-10) in March–April 2020 to acquire the geologic data required for a North Dakota CO<sub>2</sub> SFP application to implement commercial CCS at the RTE site located near Richardton, North Dakota (Figure 1).

The Broom Creek Formation directly below RTE property possesses excellent geologic properties (high porosity/permeability, tight seals) for CO<sub>2</sub> injection and permanent storage (Leroux and others, 2020). Shales and salts of the Opeche, Piper, and Swift Formations overlying the Broom Creek Formation create a sealing barrier over 1000 ft thick, providing a secure, permanent geologic storage reservoir for the planned geologic CO<sub>2</sub> storage. Further above, the Pierre Formation is an impermeable shale approximately 2000 ft thick, providing an additional seal for underground sources of drinking water (USDW) in the area to be permitted (Figure 2).

Properties of the targeted complex for CO<sub>2</sub> injection and storage at the RTE site, the geologic structure of the overall project area, and protections for USDWs must be determined for permit compliance. For example, the target for the RTE CCS project is the Broom Creek Formation, sealed by the Opeche (above) and Amsden (below) Formations, more than 6000 ft below the surface. Publicly existing regional well data were collected in addition to a site-specific geophysical (seismic) survey and core/testing/logging during drilling of the potential injection well. Porosity, permeability, mineralogy, and geomechanical properties were investigated through laboratory analyses of collected core samples as well as evaluation of downhole testing and logging results. Geochemical evaluation required use of the Computer Modelling Group Ltd. (CMG) compositional simulation software package GEM (Generalized Equation-of-State Model) and PHREEQC, a geochemical modeling software package developed by the U.S. Geological Survey, to investigate the potential for seal dissolution during injection and storage. Results from the seismic survey were evaluated for any faults or fractures throughout the project area. Existing publicly available data were also diligently investigated to identify and understand aquifer systems in the region to ensure USDWs would not be impacted by CO<sub>2</sub> injection and storage.



EERC KL59762.AI

Figure 2. Stratigraphic column identifying the storage reservoir and confining zones for the geology overlying the storage facility area (from RTE's SFP).

These properties were then utilized to estimate how the injected CO<sub>2</sub> will behave within the target complex over time, during injection operations and long after injections cease (postinjection), to determine the storage facility area to be permitted, pore space owners to be

amalgamated, and monitoring requirements for permit compliance. Industry-standard geologic software (Schlumberger's Petrel) was employed to generate a static model of the target complex. Industry-standard simulation software (CMG's GEM) incorporated the static geologic model with additional dynamic operational properties such as CO<sub>2</sub> flow rate, pressure, and temperature that interact with storage formation pressure and temperature. Simulations for the RTE site were run to ~100 years postinjection to estimate the direction and expanse of the stored CO<sub>2</sub>, denoted as the stabilized CO<sub>2</sub> plume. When depicted on the surface map, the areal extent of this plume determined the storage facility area to be permitted, the pore space ownership, and the area of review (AOR) for monitoring throughout the RTE CCS project duration.

### **Characterization Lessons Learned**

In addition to meeting the technical requirements, several administrative lessons were derived during the RTE SFP development process pertaining to 1) data management, 2) generation of permit figures, and 3) land use. As the RTE SFP application represents the first such permit submitted in North Dakota, there are undoubtedly gains that can be made in efficiency of resources used for development and efficiencies in how the results of the data analysis are communicated. For example, use of strong data management practices is a key element to developing a comprehensive and effective SFP application. A wide variety of data sources are combined in the effort, from publicly available legacy data, new data derived from regional samples to new data derived from site-specific samples, tests, and/or surveys. As these data sets are likely to not be in complete agreement with one another (or can be subject to any number of internal errors related to acquisition or processing), decisions made about how each data set is used for each development step need to be tracked and recorded. This becomes particularly important when these decisions about input data are revisited or reviewed in the context of the results developed from a model or analysis, which is a common occurrence on an iterative process, such as reservoir simulation. Maintaining a detailed record of data inputs also helps maintain a consistency of results and figures throughout the process and facilitates changes, if changes are determined to be needed. This record is also vital for communicating the final results to the regulatory body and describing why one data set may have been given preference or weighted more heavily over another.

Careful consideration also needs to be given to how figures, including maps, are created for a North Dakota CO<sub>2</sub> SFP application. The regulatory language prescribes the display of multiple data sets in map form for various sections of the permit application. However, maps can be created in a wide variety of forms, so a solid understanding of what a map needs to communicate to the regulatory body can help ensure the final product effectively conveys the required information. This understanding can also aid in determining which figure types or elements can be combined and which need to be retained independently. Developing a clear purpose for each figure can also speed up the revisions process during development and/or NDIC Department of Mineral Resources (DMR) evaluation of the application. It can also be tempting to try to combine many related data sets or results into a map or figure, as these combined products provide an efficiency in space. However, there is a point where this efficiency in space loses out to the complexity of the resulting figure, which may become confusing or "too busy." Thus there are situations where the use of multiple figures, each focused on a different data element, may be preferred over using a single combined figure.

Final estimations of the storage facility area and AOR can have major business and community implications. A factor that may not be necessary to consider immediately during AOR delineation is the distribution of surface landownership. However, this element can impact the final calculation of the size of an AOR or amalgamated pore space for storage, predominantly for landowners on the edges of these boundaries. For the sake of simplicity, RTE determined to not attempt to split or provide partial compensation for acreage at the edges of these boundaries, impacting the final shape of the AOR to include properties that extended beyond the boundary simulation. Therefore, an accurate accounting of landownership is not only a required element of an SFP application but can also impact determinations that are otherwise made from geologic and engineering perspectives. In addition, regional aspects, such as the proximity of the Richardton community to the RTE site, may be a factor in choosing locations of injection and monitoring wells for control of AOR positioning.

## **THE NORTH DAKOTA CO<sub>2</sub> STORAGE FACILITY PERMIT PROCESS**

The formal approval of the RTE SFP on October 19, 2021, by NDIC (Figure 3) authorizes the geologic storage of CO<sub>2</sub> from the RTE ethanol facility in the amalgamated storage reservoir pore space of the Broom Creek Formation. The North Dakota CO<sub>2</sub> Storage Facility Permit Guide was then developed to provide a successfully submitted, accepted, and approved North Dakota CO<sub>2</sub> SFP application for small-scale industrial CO<sub>2</sub> emitters in North Dakota considering geologic storage. The final document is 500+ pages, sent to NDIC REP for posting on its website ([www.nd.gov/ndic/renew-project.htm](http://www.nd.gov/ndic/renew-project.htm)); therefore, only select summary sections are provided Appendix B (Connors and others, 2021). A summary of each major section is also provided in the characterization report in Appendix A.

This final, approved permit guide incorporates all revisions required through the 8-month state review and evaluation process. Following formal submission to the NDIC DMR on February 9, 2021, the RTE SFP application underwent a thorough technical and regulatory assessment by the expert staff (e.g., professional geologists, engineers, technical/field staff) within the DMR and the Department of Environmental Quality. Clarifications and resulting revisions could be requested during this time frame. Once the application was considered complete, a public hearing was scheduled, as dictated by NDCC and NDAC (NDCC 38-22-06, NDAC 43-05-01-08), and held August 12, 2021. As required, the hearing was also publicly announced providing an opportunity for public comments to be submitted to the DMR for consideration. Because the hearing is part of the DMR evaluation, expert testimony from RTE (with legal and EERC teams) was encouraged to answer final questions of clarification and resulting revisions or additional information. When all additional information requested during the public hearing had been provided, the permit was then presented by the DMR Director during the monthly NDIC meeting to be formally approved via majority vote by NDIC members consisting of the state's Governor, Attorney General, and Agriculture Commissioner. The unanimous vote to approve RTE's SFP created The Red Trail Richardton Ethanol Broom Creek Storage Facility No. 1 as the first storage facility to be established in the state of North Dakota.



Figure 3. From left to right: Director of the North Dakota Department of Mineral Resources Lynn Helms, RTE CEO Gerald Bachmeier, Agriculture Commissioner Doug Goehring, Governor Doug Burgum, RTE COO Dustin Willett, Attorney General Wayne Stenehjem, EERC Principal Policy and Regulatory Strategist Kevin Connors, and NDIC Oil & Gas Division Petroleum Resource Geologic Analyst Stephen Fried.

## COMMUNITY OUTREACH DURING A GLOBAL PANDEMIC

Public science-based and community-focused outreach has been a major component to the RTE CCS project. Building on foundations developed during previous research phases, Phase 4 outreach began in June 2020—coincident with the COVID-19 pandemic. Therefore, a guide was compiled for other emerging CCS efforts, particularly in rural communities. General strategies for approaching outreach during a pandemic are summarized below, with details provided in Appendix C (Crocker and others, 2021).

With the onset of the COVID-19 pandemic, lockdowns, and limitations on face-to-face contact, the established outreach, such as monthly city and county commission meetings, community open houses, and individual landowner communication, gave way to traditional and social media and websites to convey information about project-specific activities and the overall RTE CCS status. Project status updates and related materials were sent to county and city commissioners via e-mail as the research progressed. In lieu of providing community open houses to announce project milestones, such as the intent to move forward with submission of a North Dakota CO<sub>2</sub> SFP application, a press release and summarizing article were disseminated to local and major newspapers in the state and posted on the EERC weblog (<https://blog.undeerc.org>). The ultimate outreach effort, scheduled after RTE's SFP was formally approved by NDIC, was a virtual open house held November 10, 2021. Select slides are shown in Figure 4. Registrants received a

# Red Trail Energy Virtual Open House

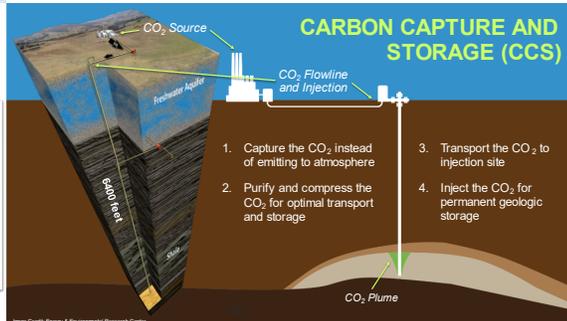
## Welcome to the Red Trail Energy virtual open house!



### Collecting Core

**AGENDA**

- Welcome/Tutorial
- Opening Remarks
- Timeline**
- Carbon Capture
- Process
- Permitting
- Monitoring
- Other Research



**AGENDA**

- Welcome/Tutorial
- Opening Remarks
- Timeline
- Carbon Capture
- Process
- Permitting**
- Monitoring
- Other Research

- Regulating authority is North Dakota Industrial Commission (NDIC)
- RTE received approval for permanent CO<sub>2</sub> storage on October 19, 2021
- First State to Acquire Primary Regulatory Authority (Class VI Primacy)
- Meets or exceeds all EPA Class VI requirements

### North Dakota CO<sub>2</sub> Storage Permitting

**AGENDA**

- Welcome/Tutorial
- Opening Remarks
- Timeline
- Carbon Capture
- Process
- Permitting**
- Monitoring
- Other Research

#### North Dakota CO<sub>2</sub> Storage Facility Permit (Class VI) Checklist

- ✓ Pore Space (Affidavit + Maps)
- ✓ Geologic Exhibits (a.k.a. Technical Evaluation)
- ✓ AOR Delineation (Maps + Corrective Action Plan)
- ✓ Emergency and Remedial Response Plan
- ✓ Worker Safety Plan
- ✓ Corrosion Monitoring and Prevention Plan
- ✓ Leak Detection and Reporting Plan
- ✓ Well Casing and Cementing Program
- ✓ Testing and Monitoring Plan
- ✓ Well-Plugging Plan
- ✓ Postinjection Site Care and Facility Closure Plan
- ✓ Injection Well and Storage Reservoir Information
- ✓ Financial Assurance Demonstration

✓ Approved on October 19, 2021

### Red Trail Energy Ethanol Facility

**AGENDA**

- Welcome/Tutorial
- Opening Remarks
- Timeline
- Carbon Capture
- Process
- Permitting
- Monitoring**
- Other Research

### Exploring New Monitoring Techniques

**AGENDA**

- Welcome/Tutorial
- Opening Remarks
- Timeline
- Carbon Capture
- Process
- Permitting
- Monitoring
- Other Research

Figure 4. Select slides created and discussed by the RTE and EERC team during the virtual open house conducted on November 10, 2021.

packet of information providing a project overview summarizing the project results, describing the permitting process, and explaining CO<sub>2</sub> capture and long-term monitoring. The project continues to benefit from local public acceptance. To date, feedback from the audiences has been neutral to positive and, overall, interactions have been constructive.

Public outreach activities scheduled throughout CCS implementation, particularly any time a project-related activity has potential for public contact or exposure, would further solidify local acceptance. Example opportunities to continue the positive interactions may include (certainly not limited to) ribbon cutting on the CCS facilities (i.e., start of operations) and monitoring activities for permit compliance, such as environmental sampling, geophysical surveys, etc. Increasing educational outreach would help teachers educate the future generation of decision-makers to engage in problem-solving in their backyard, in their state, in their region, to go beyond the focus on problem identification. Informal education opportunities using displays and demonstrations at county and state fairs, career fairs, STEM Night at the baseball game, etc., could be effective at informing and engaging learners of all ages. A documentary film showcasing how CCS research culminates into a commercial facility could bring value to the local economy and North Dakota. When North Dakota's lower-carbon ethanol is sold, the broader reach of video brings the story to a larger audience and provides context to help national viewers understand its significance.

## **MEETING QUALIFICATIONS FOR CCS INCENTIVES**

With additional partnership from DOE, the project team has been evaluating potential integration of North Dakota regulations with evolving out-of-state low-carbon fuel (LCF) markets and other evolving incentive programs over the past 5 years (Leroux and others, 2020). The ultimate goal of this effort is to implement a small-scale (<1,000,000 tonnes of CO<sub>2</sub> emitted annually) commercial CCS system at an industrial fuel production facility to generate a reduced-carbon ethanol fuel that qualifies for LCF programs. The California Air Resources Board and the U.S. Internal Revenue Service (IRS) have developed substantial economic opportunities for CCS implementation at small-scale fuel production facilities through the Low Carbon Fuel Standard (LCFS) and Enhancement of Carbon Dioxide Sequestration Credit (a.k.a. Section 45Q) CCS tax credit program, respectively. To maximize current incentive opportunities, fuel producers could qualify for 1) a California LCFS Pathway, with approved CCS Permanence Certification, and 2) IRS 45Q CCS tax credits, with an approved EPA Monitoring, Reporting, and Verification (MRV) Plan. A summary of findings is provided in this section, with details available in Appendix D (Leroux and others, 2021).

The California LCFS and IRS Section 45Q tax program are the most mature CCS incentive programs at this time for economic opportunities at small-scale fuel production facilities. Some complexities of the California LCFS CCS Permanence Certification requirements have become clearer, whereas others remain uncertain as the EERC and RTE navigate one of the first applications to this program. For example, LCFS staff have clarified that third-party reviewers selected to review a submitted CCS Permanence Certification application need to go through an LCFS CCS staff approval process as part of the application. These reviewers do not need to go through the accreditation process required for "third-party verification" of LCFS pathways (i.e., certified carbon intensity values). A majority of components required for the LCFS CCS certification that are not included in the North Dakota CO<sub>2</sub> SFP application are those related to the required site risk assessment, CO<sub>2</sub> capture and transport operations, and additional monitoring stipulations. Although an approved SFP is not required prior to submittal of the CCS certification, an entity applying should collaborate with LCFS staff while developing the SFP and certification applications to ensure compliance for both California and North Dakota programs.

An EPA Greenhouse Gas Reporting Program Subpart Resource Recovery MRV Plan is required for qualification of the IRS 45Q CCS tax credit. Capture and transport components make up most of the additional information required by the MRV Plan that is not included in a North Dakota CO<sub>2</sub> SFP application. Because these EPA and IRS programs have been established for many years, several examples of approved MRV Plans are publicly available, providing more certainty regarding development and approval of an MRV Plan for IRS qualification of 45Q credits.

Efficiencies can be gained by developing designs, plans, and applications simultaneously with North Dakota CO<sub>2</sub> SFP efforts and collaborating among program and regulatory authorities throughout the process. Figure 5 provides a summary of the SFP, LCFS, and EPA processes. Review of coring programs, well designs, and monitoring plans with program authorities (particularly California) is recommended to allow any of their specific requirements to be included in an SFP application prior to submittal. While awaiting North Dakota regulatory review following SFP submittal, the LCFS-required site risk assessment can be developed for CCS certification and supporting CO<sub>2</sub> capture and transport documentation can be packaged for both the LCFS CCS and EPA MRV applications.

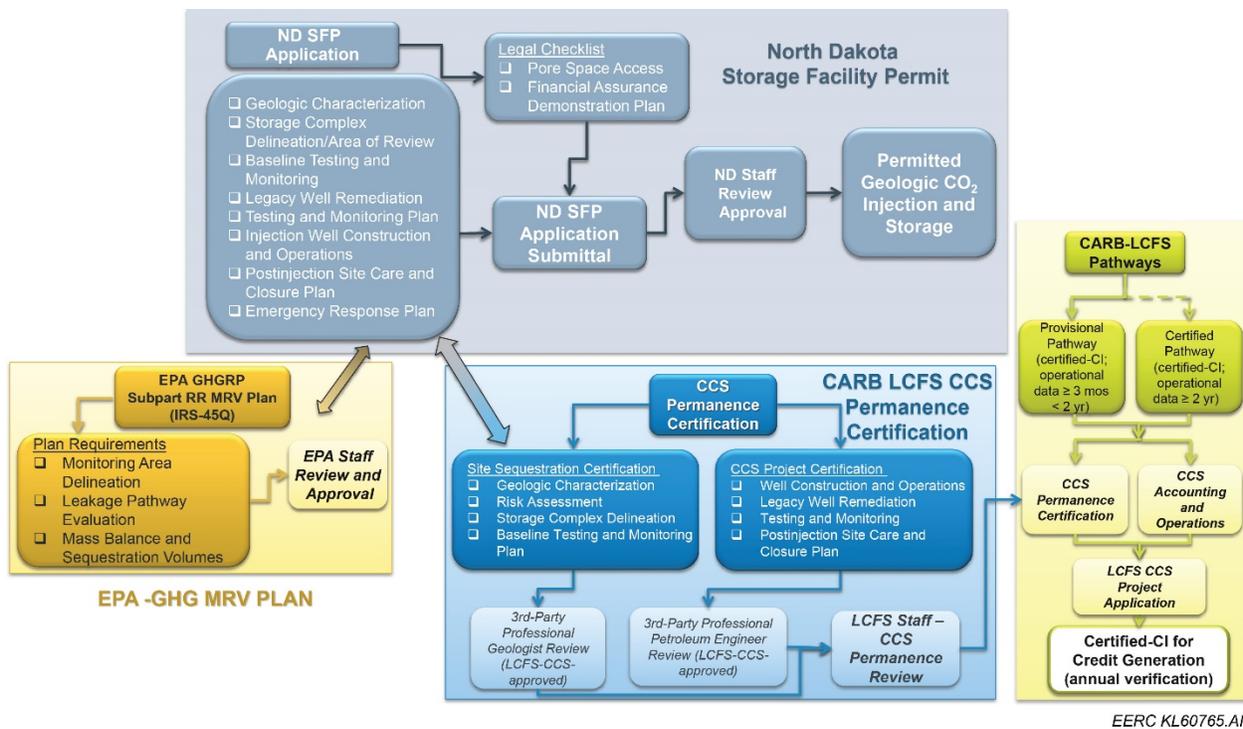


Figure 5. Illustration describing the relationship between the North Dakota CO<sub>2</sub> SFP application process and the California CCS certification required for a North Dakota ethanol-CCS product to qualify for LCFS carbon credits, as well as EPA MRV Plan approval requirements and the process to qualify for IRS 45Q CCS tax credits. For more details see Appendix D.

The number of states and regional entities considering low-carbon or clean-fuel incentive programs has been growing over the past few years, with over a dozen states creating investigative legislation to explore potential program frameworks. California, Oregon, and British Columbia have maintained their established LCF programs; however, California is the only program with official adoption of CCS certification. Other states investigating LCF programs include Colorado, Iowa, Washington, Illinois, Kansas, Minnesota, Nebraska, New Mexico, Utah, Wisconsin, Maine, Maryland, and Vermont. On the federal level, Canada and Brazil are the only identified countries currently considering nationwide LCF programs. As these programs evolve and mature, markets for LCFs are anticipated to increase, further supporting economic viability of integrating CCS with fuel production.

## **IMPLEMENTING THE FIRST CCS EFFORT IN NORTH DAKOTA**

Development of a North Dakota CO<sub>2</sub> SFP application is a lengthy process that presently requires significant investment of time and resources by the CCS operator, as well as applications for incentive certifications. Detailed planning that includes contingencies and frequent communication is necessary for a successful effort. Flexibility and creativity are also essential for unforeseeable issues, such as the effect of a global pandemic on community outreach plans. That said, much work still lies ahead for the RTE CCS project as it transitions to an operational phase.

Although some efficiencies can be gained for the future CCS implementation, operators should plan on a roughly 5-year time frame for 1) general project feasibility, 2) site-specific data acquisition, 3) engineering designs, 4) permitting, and 5) construction before operations can start. Operators should also be aware of potential delays or bottlenecks due to availability of subcontractor crews, equipment delivery timelines, materials availability, schedules of regulators/officials, etc. Because every site is unique, future operators should discuss potential SFP plans and procedures with North Dakota regulators before final documents are started; mid-development, if there are any significant changes; and prior to submission for consideration by the state to ensure permit elements are properly represented and interpreted. In addition, developing application requirements for an EPA MRV plan (for IRS 45Q tax credit), as well as a California LCFS CCS certification, if applicable, simultaneously with the SFP application can provide efficiencies in document preparation and ensure consistency. Again, it is highly recommended to collaborate with all agency officials throughout development.

Regardless of in-person or virtual approaches to outreach, messaging needs to help audiences understand how the technology can be implemented safely, and every encounter with the public—positive and negative—makes an impression. Encounters can occur anywhere, anytime, ranging from planned events (e.g., an open house) to casual conversation (e.g., local café, gas station, etc.). Given the rural close-knit communities near the RTE study region, encounters are shared among community members. Concerns to date have centered on human safety, groundwater and environmental protection, clarity and disclosure regarding the process, transparency as the process moves forward, and the trustworthiness of the project team and regulatory oversight. Outreach activities should provide an opportunity for community members to learn about the project and be heard and reveal important concerns to be addressed as this first-of-its-kind facility in this region comes to fruition.

Now that RTE has acquired a formally approved North Dakota CO<sub>2</sub> SFP, it is confidently moving forward with commercial implementation and operation of the first CCS facility in North Dakota (Figure 6). With completion of construction anticipated in early 2022, start-up operations of CO<sub>2</sub> capture and injection are expected by Q2-2022. Monitoring data collection and reporting will commence once systems are optimized and operational.



Figure 6. Construction of the CO<sub>2</sub> capture facility on the RTE CCS site (see Figure 1 for location).

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**APPENDIX A**  
**CO<sub>2</sub> STORAGE CHARACTERIZATION**  
**METHODOLOGIES REPORT**



September 30, 2021

Ms. Karlene Fine  
Executive Director  
North Dakota Industrial Commission  
State Capitol, 10th Floor  
600 East Boulevard Avenue  
Bismarck, ND 58505-0310

Dear Ms. Fine:

Subject: Deliverable (D) 1 for Research in Support of Integrated Carbon Capture and Storage for North Dakota Ethanol Production; Contract No. R-043-053; EERC Fund 25204

Attached is the D1: CO<sub>2</sub> Storage Characterization Methodologies Report for the subject project. If you have any questions, please contact me by phone at (701) 777-5013, by fax at (701) 777-5181, or by e-mail at [kleroux@undeerc.org](mailto:kleroux@undeerc.org).

Sincerely,

DocuSigned by:  
  
F93F81AE98DB40F...  
Kerryanne M. Leroux  
Principal Engineer

KML/kal

Attachment



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# CO<sub>2</sub> STORAGE CHARACTERIZATION METHODOLOGIES REPORT

## Research in Support of Integrated Carbon Capture and Storage for North Dakota Ethanol Production

### *Deliverable D1*

#### *Prepared for:*

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September 2021

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## CO<sub>2</sub> STORAGE CHARACTERIZATION METHODOLOGIES REPORT

### EXECUTIVE SUMMARY

The first North Dakota CO<sub>2</sub> storage facility permit (SFP) application was submitted in February 2021 for operating a Class VI CO<sub>2</sub> injection well for permanent geologic CO<sub>2</sub> storage in North Dakota by Red Trail Energy, LLC (RTE). RTE anticipates formal approval in October 2021. The RTE Carbon Capture and Storage (CCS) Project is constructing a CO<sub>2</sub> capture facility adjacent to the RTE ethanol facility near Richardton, North Dakota, to inject the CO<sub>2</sub> more than 1 mile below RTE property for geologic storage. Therefore, significant geologic characterization is required to support the operability and safety of such an effort for permit compliance. For the RTE site, this has involved technical support from the Energy & Environmental Research Center in partnership with the North Dakota Industrial Commission Renewable Energy Program for project data collection, followed by geologic modeling and predictive simulations of the target CO<sub>2</sub> storage complex. All of these are required by state regulations in the North Dakota Century Code (NDCC) (Chapter 38-22) and North Dakota Administrative Code (Chapter 45-05-01) for compliance with an SFP. This report contains a summary of the characterization approach taken for a successfully submitted, accepted, and soon-to-be approved North Dakota CO<sub>2</sub> SFP application.

Properties of the targeted complex for CO<sub>2</sub> injection and storage at the RTE site, the geologic structure of the overall project area, and protections for underground sources of drinking water (USDWs) must be determined for permit compliance. For example, the target for the RTE CCS Project is the Broom Creek Formation, sealed by the Opeche (above) and Amsden (below) Formations, more than 6000 ft below the surface. Publicly existing regional well data were collected in addition to a site-specific geophysical (seismic) survey and core/testing/logging during drilling of the potential injection well. Porosity, permeability, mineralogy, and geomechanical properties were investigated through laboratory analyses of collected core samples as well as evaluation of downhole testing and logging results. Geochemical evaluation required use of Computer Modelling Group Ltd. (CMG) compositional simulation software package GEM (Generalized Equation-of-State Model) and PHREEQC, a geochemical modeling software package developed by the U.S. Geological Survey, to investigate the potential for seal dissolution during injection and storage. Results from the seismic survey were evaluated for any faults or fractures throughout the project area. Existing publicly available data were also diligently investigated to identify and understand aquifer systems in the region to ensure USDWs would not be impacted by CO<sub>2</sub> injection and storage.

These properties were then utilized to estimate how the injected CO<sub>2</sub> will behave within the target complex over time, during injection operations and long after injections cease (postinjection), to determine the storage facility area to be permitted, pore space owners to be amalgamated, and monitoring requirements for permit compliance. Industry-standard geologic software (Schlumberger's Petrel) was employed to generate a static model of the target complex. Industry-standard simulation software (CMG's GEM) incorporated the static geologic model with additional dynamic operational properties such as CO<sub>2</sub> flow rate, pressure, and temperature that interact with storage formation pressure and temperature. Simulations for the RTE site were run

to ~100 years postinjection to estimate the direction and expanse of the stored CO<sub>2</sub>, denoted as the stabilized CO<sub>2</sub> plume. When depicted on the surface map, the areal extent of this plume determined the storage facility area to be permitted, the pore space ownership, and the area of review (AOR) for monitoring throughout the RTE CCS Project duration.

In addition to meeting the technical requirements of the North Dakota CO<sub>2</sub> SFP application, several administrative lessons were derived during this development process pertaining to 1) data management, 2) generation of permit figures, 3) land use, and 4) communication with regulators. Effective and reliable data management practices were a key element to conducting technical work between teams (laboratory, modeling, etc.) to ensure proper and consistent results were being used as well as reported in the application. Many figures and maps are directly prescribed by the regulations; therefore, a balance should be maintained to convey the required information in a clear and concise manner, which could mean one or multiple figures for a given topic (e.g., isopach of confining layers) depending on the nature of the content. Pore space ownership is tied to the surface owner in North Dakota (NDCC Chapter 47-31); therefore, final estimations of the storage facility area and AOR can have major business and community implications. For example, well locations for the RTE CCS Project were not only chosen for geologic operability but also where CO<sub>2</sub> movement would be away from the town of Richardton. In conclusion, because every site is unique, future operators should discuss potential SFP plans and procedures with North Dakota regulators before final documents are started, mid-development if there are any significant changes, and prior to submission for consideration by the state to ensure permit elements are properly represented and interpreted.

## CO<sub>2</sub> STORAGE CHARACTERIZATION METHODOLOGIES REPORT

### INTRODUCTION

Research efforts by Red Trail Energy, LLC (RTE) and the Energy & Environmental Research Center (EERC), with funding support from the North Dakota Industrial Commission (NDIC) Renewable Energy Program and the U.S. Department of Energy, began in 2016 to characterize the geology and determine site feasibility to develop the first carbon capture and storage (CCS) facility in North Dakota (Leroux and others, 2020). This geologic characterization work resulted in RTE conducting a 3D seismic survey over the project area in March 2019 and drilling a stratigraphic test well (RTE-10) in March–April 2020 to acquire the geologic data required for a North Dakota CO<sub>2</sub> storage facility permit (SFP) application to implement commercial CCS at the RTE site located near Richardton, North Dakota (Figure 1).

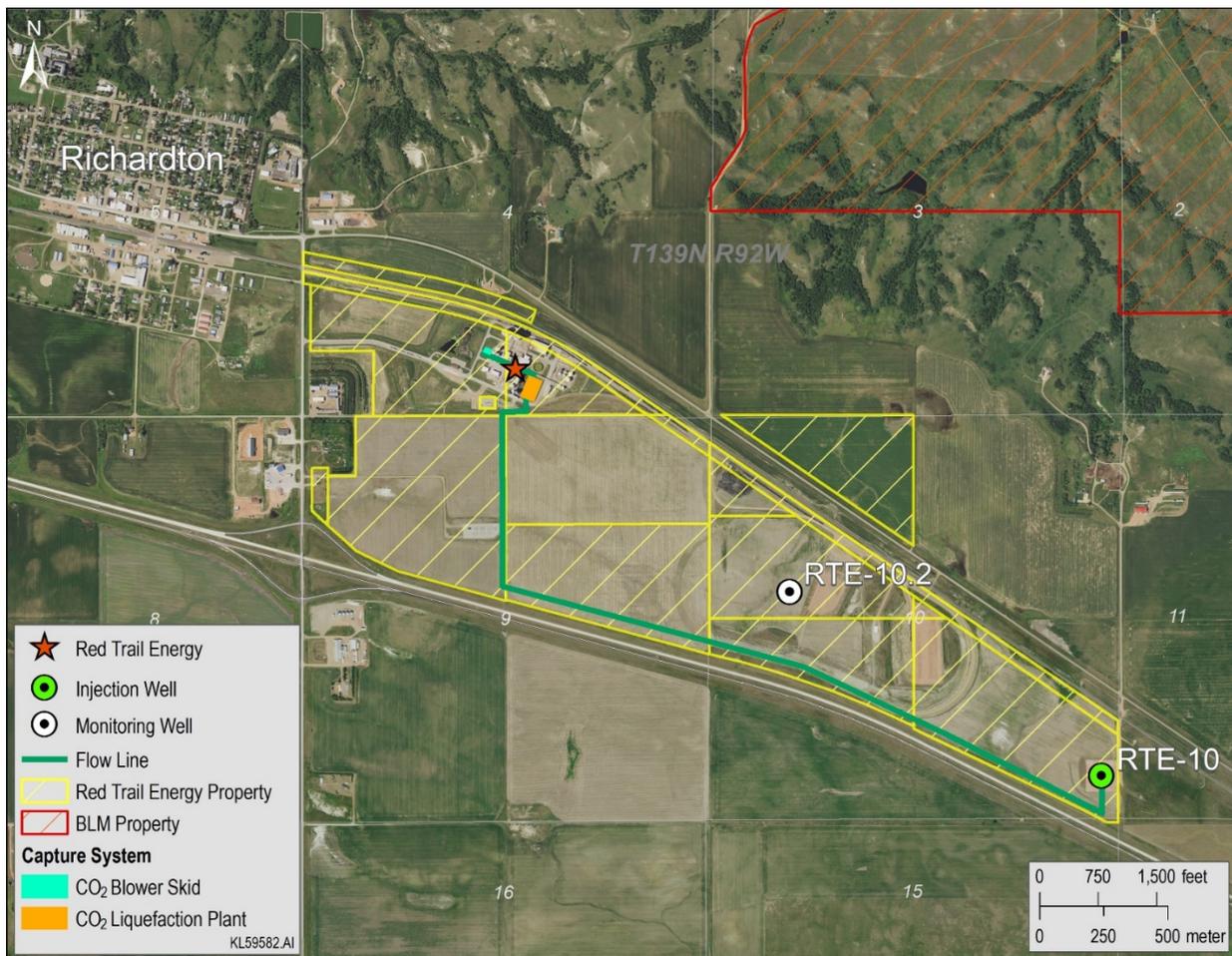


Figure 1. RTE geologic storage of CO<sub>2</sub> project map (from RTE's SFP application).

The RTE ethanol facility is a North Dakota-based, investor-owned 64-million-gallon dry mill ethanol production plant, which has been in operation since January 2007. The RTE facility emits an average 180,000 metric tons of high-purity CO<sub>2</sub> annually from the fermentation process during ethanol production. A CO<sub>2</sub> capture plant to dehydrate and compress the fermentation-generated CO<sub>2</sub> emissions at the RTE facility has been commissioned, providing the engineering support for the expected CO<sub>2</sub> output stream. RTE plans to commercially inject the 180,000-metric-ton-per-year CO<sub>2</sub> stream into the Broom Creek Formation on RTE property for permanent geologic CO<sub>2</sub> storage.

Figure 1 shows integration of major CCS components with the existing RTE ethanol facility consisting of a blower to divert the CO<sub>2</sub> emissions to the capture (liquefaction) plant, from which the now liquid CO<sub>2</sub> stream will flow to the RTE-10 injection well for geologic storage into the Broom Creek Formation (a saline formation); an underground flow line is being installed on RTE property to connect the capture plant to the RTE-10 injection well. A monitoring well (RTE-10.2) was also installed on RTE property in October 2020 for compliance with the North Dakota CO<sub>2</sub> SFP requirements to directly monitor CO<sub>2</sub> injection in the Broom Creek Formation. Monitoring equipment currently installed in both the RTE-10 and RTE-10.2 wells includes pressure–temperature gauges in the Broom Creek and Inyan Kara Formations and a fiber-optic cable along the entire length of the well and flow line for temperature and acoustic sensing.

The Broom Creek Formation directly below RTE property possesses excellent geologic properties (high porosity/permeability, tight seals) for CO<sub>2</sub> injection and permanent storage (Sorensen and others, 2009a; Glazewski and others, 2015; Leroux and others, 2020). Shales and salts of the Opeche, Piper, and Swift Formations overlying the Broom Creek Formation create a sealing barrier over 1000 ft thick, providing a secure, permanent geologic storage reservoir for the planned geologic CO<sub>2</sub> storage. Further above, the Pierre Formation is an impermeable shale approximately 2000 ft thick, providing an additional seal for underground sources of drinking water (USDW) in the area to be permitted.

This report provides a guide for biofuel producers (and other interested parties) on the types of geological evaluations needed to complete a North Dakota CO<sub>2</sub> SFP application, which includes the U.S. Environmental Protection Agency (EPA) Class VI well permitting for dedicated CO<sub>2</sub> storage. Occasionally in this report, references are made to sections of the RTE SFP application of which the final version can be found on the NDIC Oil and Gas Division website ([www.dmr.nd.gov/oilgas/](http://www.dmr.nd.gov/oilgas/)).

## **OVERVIEW OF NORTH DAKOTA CO<sub>2</sub> SFP APPLICATION COMPONENTS**

The North Dakota CO<sub>2</sub> SFP is the largest and first of three permits required to operate a CO<sub>2</sub> storage project in the state of North Dakota. The remaining two permits grant permission to drill and subsequently operate the CO<sub>2</sub> injection well or wells. In contrast, the SFP application provides the permitting agency the evidence that an operator has collected and evaluated all of the needed data sets, appropriately sited a CO<sub>2</sub> storage operation, gained a thorough understanding of the fate of CO<sub>2</sub> injected on the site, developed the appropriate operations plans (e.g., injection operations, site monitoring, or emergency response), gained access rights to the needed lands, and provided

evidence of financial viability for the project's duration. The SFP's many components are described in the North Dakota Century Code (NDCC) (Chapter 38-22) and North Dakota Administrative Code (Chapter 45-05-01) and were derived from the EPA Class VI injection well rules (40 Code of Federal Regulations [CFR] 146.81). The following is a brief summary of the major components as discerned by the EERC project team while developing RTE's application. These divisions are not required by the permit regulations, but rather serve to group related data components and elements together.

The Pore Space Ownership section provides evidence and documentation that the appropriate permissions and access rights have been acquired by the operator to conduct the planned CO<sub>2</sub> injection project. In North Dakota, pore space is owned by the land surface owner, and these rights cannot be severed from one another (NDCC Chapter 47-31 Subsurface Pore Space Policy). The storage operator is mandated by North Dakota statute for CO<sub>2</sub> geologic storage to obtain the consent of landowners who own at least 60% of the pore space of the storage reservoir. The statute also mandates that a good faith effort be made to obtain consent from all pore space owners and that all nonconsenting pore space owners are or will be equitably compensated. In addition, pore space owners within 0.5 miles outside of the project boundary are to be notified as well as any lessees and mineral owners/operators within the project boundary and this 0.5-mile buffer area.

The Geologic Exhibits section describes the geologic characterization data used to develop predictions of the ultimate disposition of injected CO<sub>2</sub> and address a variety of requirements designed to ensure the protection of groundwater and other resources. The geology of the targeted CO<sub>2</sub> injection formation (the storage formation), the upper and lower sealing formations (the cap rocks), intermediate formations, groundwater-bearing formations, and surface lands need to be thoroughly described and characterized. Aspects to be evaluated include mineralogy, geochemistry, geomechanics, structure, geophysics, hydrogeology, and seismic history of the formations within the area to be permitted for injection. This report primarily focuses on this section of the permit application package.

The Area of Review (AOR) section describes multiple project zones used to define and describe permitted injection activities. The largest of these areas is the AOR, which is the total land area potentially impacted by injected CO<sub>2</sub> and the associated increase in reservoir pressure, with an additional buffer area; an example illustration is provided in Figure 2. Depending on the volume and rate of CO<sub>2</sub> injection, the AOR can be several times larger than the area of the injected CO<sub>2</sub> plume because of the ability of increased reservoir pressure to be transmitted through a storage formation. The area occupied by the CO<sub>2</sub>, at its largest extent, defines the storage facility and amalgamated areas. These and other areas shown in Figure 2 are the products of the evaluations and predictions derived from the data presented in the Geologic Exhibits section. The hydrogeology and demonstration of protections of USDWs in the AOR are also described in this section.

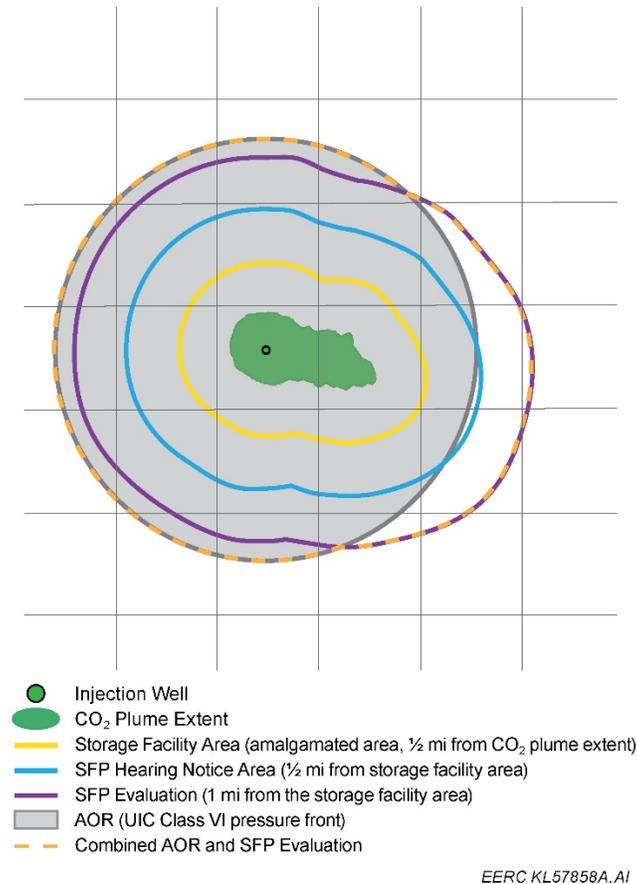


Figure 2. Project boundary terms (modified from the North Dakota Department of Mineral Resources) regarding SFP requirements (Connors and others, 2020).

The Supporting Permit Plans section contains multiple plans that describe how a site will be operated, managed, funded, closed, and monitored for CO<sub>2</sub> movement throughout the project's life cycle. The requirements for each of these plans described in North Dakota's regulations are listed in Table 1. These plans can be revised as a project progresses to respond to changing circumstances or technological improvements.

**Table 1. Supporting Plans for Permit Application**

Emergency and Remedial Response Plan
Financial Assurance Demonstration Plan
Worker Safety Plan
Testing and Monitoring Plan
Corrosion Monitoring and Prevention Plan
Surface Leak Detection and Monitoring Plan
Subsurface Leak Detection and Monitoring Plan
Well Casing and Cementing Plan
Plugging Plan
Postinjection Site Care and Facility Closure Plan

The Injection Well and Storage Operations section describes the engineering criteria, procedures, and plans for completing project wells and injecting CO<sub>2</sub> in a manner that protects USDWs. This section includes well construction schematics and procedures, along with operation plans and/or procedures for injection operations.

## **GEOLOGIC CHARACTERIZATION**

The Geologic Characterization section of RTE's SFP application consists of multiple components to describe the characteristics of the geologic formation to be used as the storage target, its associated cap rock(s), other overlying geology, and surface land features and use. This includes notable features within the storage horizon and/or cap rocks such as faults and fractures and potential mineral zones within the storage facility area. Additionally, a detailed description of any aquifers (including USDWs), surface land use, and features present within the project area are also required. Characteristics of the site geology need to be described in detail and include the source of data used to arrive at these conclusions.

The storage target can generally be assumed to consist of all or a portion of a geologic formation with appropriate porosity, permeability, depth, and cap rock association to contain injected CO<sub>2</sub>. In North Dakota, several formations within the Williston Basin may be suitable for this purpose (Sorensen and others, 2009b). The Williston Basin's geology is generally well studied, and the nature of these formations is generally known and understood. However, the specific characteristics of a formation can vary significantly from location to location, necessitating detailed study of the area targeted for injection. In most cases, study of the injection area consists of analysis of existing data resources, such as previous geologic investigations, existing well data, and any existing core samples as well as collection and analysis of new well data and rock and fluid samples from the storage target(s) and associated cap rocks.

The geologic formations that make up the storage target(s) and cap rocks will each need to be individually defined and characterized within the project area. Characterization will need to describe in detail the mineralogy, structure, flow properties, geophysical properties, geomechanical properties, and geochemical properties of each geologic unit to be used for storage or as a cap rock. At the RTE site, these various properties were evaluated both from existing data resources and from the study of new core, new geologic logs, and geophysical surveys collected specifically for these characterization activities. Core samples were subjected to a variety of laboratory analysis methods to determine their various properties (e.g., geologic properties, geomechanical properties, geochemical properties, etc.) and the distribution (or heterogeneity) of these properties and to identify any features of concern within the rock samples, such as evidence of faults or naturally occurring fracture systems.

Mineralogy of each rock unit of interest at the site was determined through direct examination of the core and well logs collected from the RTE site as well as laboratory studies of these samples, which included x-ray diffraction (XRD), x-ray fluorescence (XRF), and thin-section studies. These studies determined the mineralogic composition and distribution within the storage target and the cap rocks. They also provided information on porosity of the samples. The data on the mineralogy were also used to conduct geochemical studies of the impact of the injected CO<sub>2</sub>

on the storage target and the cap rocks. The geochemical studies showed a minimal geochemical impact of the injected CO<sub>2</sub> as the mineralogy of the storage target and cap rock were largely composed of minerals that are nonreactive with CO<sub>2</sub> (e.g., quartz, anhydrite, and feldspar). Additional information is available in Sections 2.3.1, 2.4.1, and 2.4.3 of RTE's SFP application ([www.dmr.nd.gov/oilgas/C28848.pdf](http://www.dmr.nd.gov/oilgas/C28848.pdf)).

Laboratory studies of porosity and permeability were also conducted on the core samples to describe the flow characteristics of the storage target and cap rocks. Standard lab procedures were used to evaluate total porosity, horizontal and vertical permeability, CO<sub>2</sub>-to-brine relative permeability, and CO<sub>2</sub> capillary entry pressure. The lab data were compiled and compared to log data measured when the test well was drilled to develop a more complete understanding of the flow properties at the RTE site (Figure 3 and Table 2). One of the critical aspects of permitting a CO<sub>2</sub> storage project is being able to accurately forecast how the injected CO<sub>2</sub> will behave in the storage target once it is injected and how the injected CO<sub>2</sub> will interact with the cap rocks. These behaviors are key contributors to the ultimate size of the stored CO<sub>2</sub> plume and the corresponding AOR. Each of these data types contribute to that understanding, reducing the uncertainty inherent in these predictions, and are ultimately incorporated into the modeling and simulation efforts necessary to predict the injected CO<sub>2</sub> behavior.

Geomechanical properties were tested both downhole during the drilling of the test well and on laboratory samples, predominately in the cap rocks. Cap rock samples were submitted to fracture analysis both in the laboratory and through the use of a borehole fracture finder log collected when the well was drilled. The fracture finder log provides the preferred orientation of fractures, if present, while laboratory analysis (combined with seismic results) can help define connectiveness of fractures, association of fractures with other geologic features, and other characteristics. For example, fractures in the RTE cores were found to be associated with stylolites, a diagenetic feature found in some carbonates.

Rock strength and stress testing were also conducted downhole and on core samples to determine the strength of the cap rocks and how they might respond to increased stress due to CO<sub>2</sub> injection. Schlumberger's wireline-deployed Modular Dynamics Tester (MDT) provides a means of conducting in situ measurements of rock strength and stress. The MDT was used at RTE to conduct minifracture tests, which measure how much pressure is needed to induce a fracture in a rock package. Detailed measurements provided by the tool can be used to calculate the in situ stresses present in a rock formation. At the RTE site, the minimum fracture pressure was measured at a value well in excess of the required injection pressure. Core samples were also tested for ductility and mechanical strength properties via triaxial testing to provide additional information for geomechanical modeling and establish the rock strength properties of the cap rocks. Additional information can be found in Section 2.4.4 of RTE's SFP application ([www.dmr.nd.gov/oilgas/C28848.pdf](http://www.dmr.nd.gov/oilgas/C28848.pdf)).

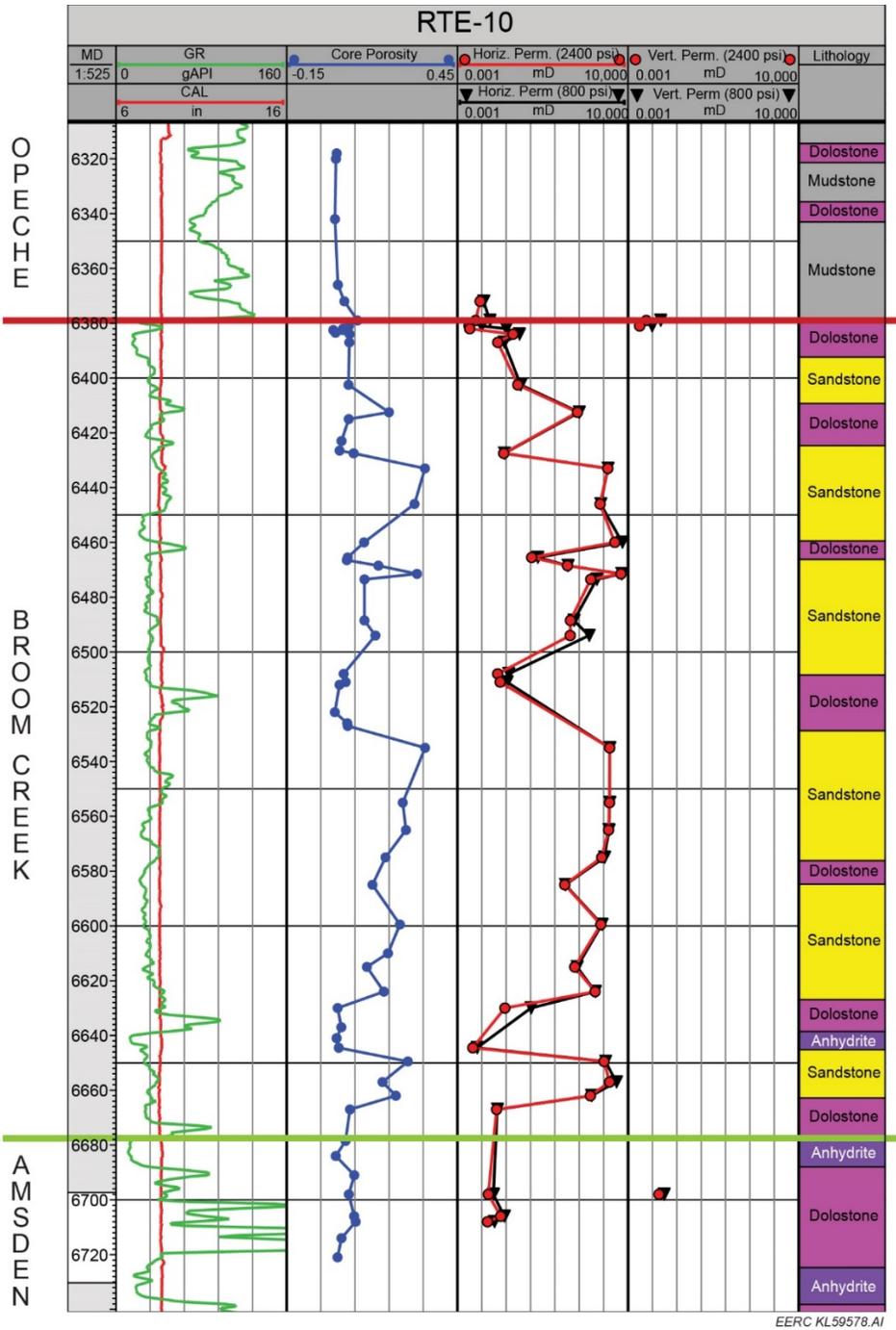


Figure 3. Example of vertical distribution of core-derived porosity and permeability values in the RTE CO<sub>2</sub> storage complex (from RTE's SFP application).

**Table 2. Example Description of CO<sub>2</sub> Storage Reservoir (injection zone) at the RTE-10 Well (from RTE's SFP application)**

<b>Injection Zone Properties</b>			
<b>Property</b>	<b>Description</b>		
Formation Name	Broom Creek		
Lithology	Sandstone, dolomite		
Formation Top Depth, ft	6379		
Thickness, ft	298 (sandstone 201; dolomite 97)		
Capillary Entry Pressure (GW), psi	1.1		
<b>Geologic Properties</b>			
<b>Formation</b>	<b>Property</b>	<b>Laboratory Analysis</b>	<b>Model Property Distribution</b>
Broom Creek (sandstone)	Porosity, %	21.68 (12.18–33.65)*	25.26 (1.01–32.14)*
	Permeability, mD	419.1 (25.35–5120)**	277.45 (20.202483.64)**
Broom Creek (dolomite)	Porosity, %	6 (2.91–8.54)*	15.24 (1.01–32.14)*
	Permeability, mD	0.08 (0.004–1.12)**	8.65 (0.01–2261.53)**

\* Porosity values are reported as the arithmetic mean followed by the range of values in parentheses.

\*\* Permeability values are reported as the geometric mean followed by the range of values in parentheses.

Geochemical simulations were performed to calculate the effects of introducing the CO<sub>2</sub> stream to the injection zone. The effects were found to be minimal and not threatening to the geologic integrity of the storage system. Mineralogical information collected from samples and downhole data, such as temperature, were used as inputs for these analyses.

The injection zone, the Broom Creek Formation, was investigated using the geochemical analysis option available in the Computer Modelling Group Ltd. (CMG) compositional simulation software package GEM (Generalized Equation-of-State Model). GEM is also the primary simulation software used for evaluation of the reservoir's dynamic behavior resulting from the expected CO<sub>2</sub> injection. The project's base case simulation (base case) was rerun with the geochemical analysis option included (geochemistry case), and results from the two cases were compared. Geochemical alteration effects were seen in the geochemistry case; however, these effects were not significant enough to cause observable change to storage reservoir performance or to mechanical integrity of the storage formation.

Results of the simulation show that geochemical processes will be at work in the Broom Creek during and after CO<sub>2</sub> injection. Mineral dissolution and some reprecipitation are expected to occur during the simulated time span of 45 years. Fluid pH will decrease in the area of the CO<sub>2</sub> accumulation, and there will be a slight net increase in system porosity. However, these changes are not significant enough to create observable change in reservoir performance parameters such as injection rate or wellhead injection pressure. Additional information is available in Section 2.3.3 of RTE's SFP application ([www.dmr.nd.gov/oilgas/C28848.pdf](http://www.dmr.nd.gov/oilgas/C28848.pdf)).

Similar geochemical studies were conducted on the cap rock, the overlying Opeche Formation. No geochemical studies were conducted on the Amsden Formation as reservoir simulation results demonstrated that neither free-phase nor dissolved CO<sub>2</sub> would contact the underlying Amsden Formation. Geochemical interactions of injected CO<sub>2</sub>, reservoir brine, and mineralogical makeup of the cap rock were simulated using PHREEQC, a free geochemical

modeling software package developed by the U.S. Geological Survey (USGS). Vertically oriented 1D simulations were created of the Broom Creek and Opeche boundary where the cap rock formation will be exposed to CO<sub>2</sub> at the boundary of the simulation and allowed to enter the system by diffusion processes. Results were monitored at 1-meter increments above the cap rock–CO<sub>2</sub> exposure boundary. Mineralogy of the formations and brine composition were input into the model based on laboratory analysis of cap rock material conducted as part of the RTE SFP application development, with CO<sub>2</sub> stream composition provided by RTE. Three different CO<sub>2</sub> exposure levels of the CO<sub>2</sub> stream to the cap rock (1.15, 2.3, and 4.5 moles/yr) were used; these values are considerably higher than the actual expected exposure levels. This was done to ensure that the degree and pace of modeled geochemical change would not be underestimated. These three simulations were run to represent 20 years of injection plus 25 years postinjection (45 years total). The simulations were performed at the reservoir pressure and temperature conditions measured during RTE-10 testing. Although results showed geochemical processes at work, even at extreme exposure levels these processes did not extend more than 10 ft up into the cap rock (which is >100 ft thick at RTE-10). It was also demonstrated during the simulation period that long-term exposure to CO<sub>2</sub>, even well above planned operating levels, will not cause deterioration of the Opeche and Amsden cap rocks. Additional information can be found in Sections 2.4.1 and 2.4.3 of RTE's SFP application ([www.dmr.nd.gov/oilgas/C28848.pdf](http://www.dmr.nd.gov/oilgas/C28848.pdf)).

Geophysical data (commonly referred to as seismic data) were collected and analyzed to identify any regional structural features, such as faults or fractures, with sufficient permeability and vertical extent to allow fluid movement between formations and assess the likelihood of impacts from future seismic events in or around the storage site. Publicly available seismic data was used in conjunction with new seismic data collected from the site to identify any structural features present in or around the project site. Historical earthquake records were also reviewed to evaluate the potential risk of future seismic activity. A regional fault system, the Heart River Fault, was known to be in the vicinity of the project site, but further analysis demonstrated that the fault system terminates much deeper than the proposed injection target and does not pose a risk to the project. The new seismic survey data identified “collapse” features in the strata above the target Broom Creek Formation that had potential to impact the ability of the cap rock to contain injected CO<sub>2</sub>. However, these features, which formed as a result of salt-bearing rock layers being dissolved during the deposition of sediments in the region, do not pose a significant risk. The features do not connect the Broom Creek to the next major permeable zone, the Inyan Kara Formation, and pressure data and water chemistry data collected from the site suggest that the Broom Creek and Inyan Kara Formations are hydraulically isolated. The features were interpreted as having a low risk of interfering with containment. Finally, the project site was shown to be of low risk to future seismic events due to the highly stable nature of the Williston Basin, which experiences very few naturally occurring seismic events as well as very few induced seismic events, despite extensive oil and gas extraction activity in other portions of the Williston Basin to the north and west of the project site.

Demonstration of protection of the lowest USDWs is another requirement for a North Dakota CO<sub>2</sub> SFP and is thus a key component of geologic characterization. Extensive evaluations of aquifer systems within the Williston Basin and the state of North Dakota have been conducted by USGS and various state entities over the years. These existing data provide a strong foundation from which to develop characterizations of the USDWs in a project site in North Dakota. At the

RTE site, the lowest USDW, the Fox Hills Formation, was identified and described, along with other aquifer systems in the project area. The aquifers were also characterized from water well data available from the state of North Dakota and existing water wells within the project area that were identified and described (Figure 4). The few wells that penetrated the Fox Hills Formation in the project area were also sampled and analyzed.

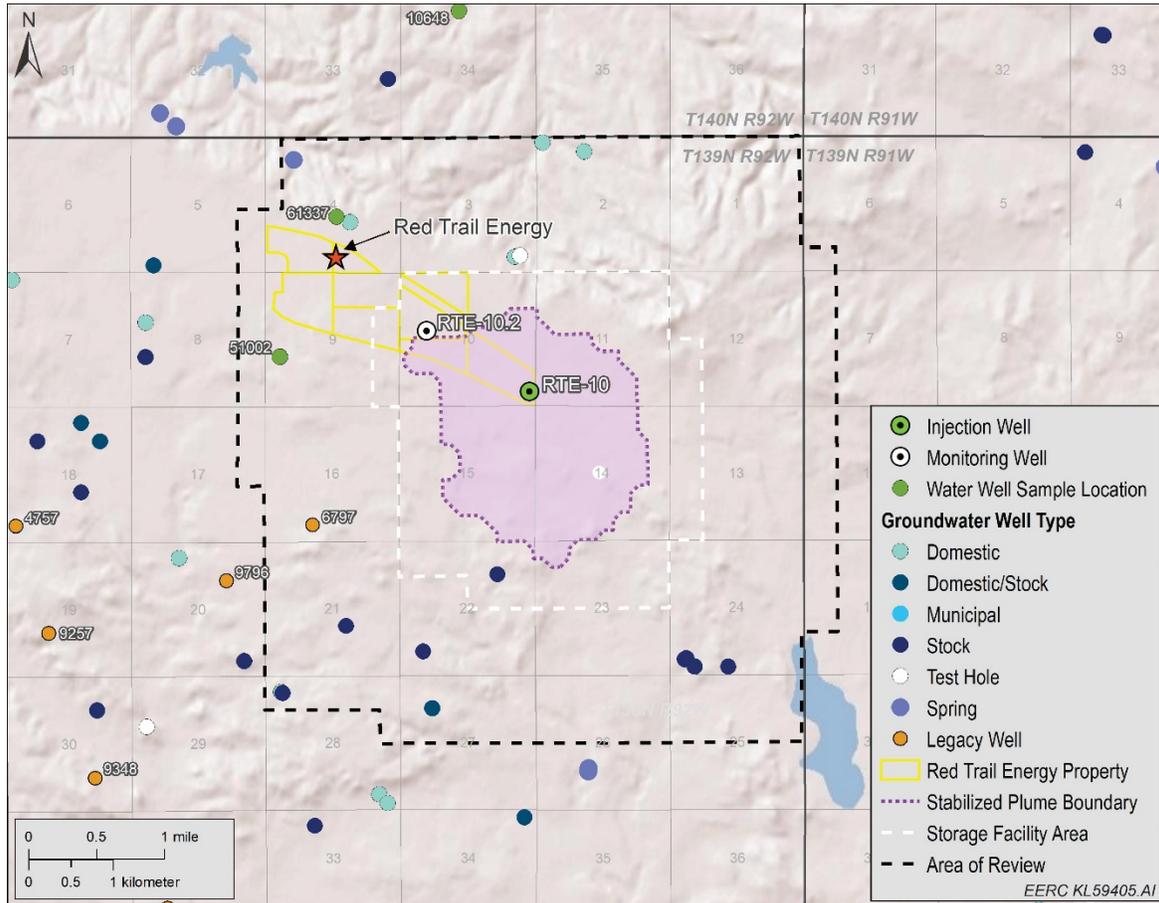


Figure 4. Example map of water wells in the project area in relation to the RTE facility, RTE-10 and RTE-10.2 wells, stabilized CO<sub>2</sub> plume extent, facility area, 1-mile AOR, and legacy oil and gas wells (from RTE's SFP application).

The Fox Hills Formation, and the overlying aquifer layers, were found to be of low risk of impact from CO<sub>2</sub> injection activities because of the presence of the Pierre Formation. The Pierre Formation is a thick and extensive impermeable rock layer that underlies much of North Dakota and provides a natural barrier between the relatively shallow freshwater aquifer systems, such as the Fox Hills Formation aquifers and the deeper saline aquifer systems, which also contain oil and gas deposits in other areas of the Williston Basin. Other impermeable layers between the Pierre Formation and the much deeper Broom Creek Formation provide additional protection and isolation of the USDWs from CO<sub>2</sub> injection activities.

## **SITE EVALUATION METHODOLOGIES**

The data collected from geologic characterization activities were ultimately incorporated into efforts to model the behavior of injected CO<sub>2</sub> into the RTE project site. Modeling involves multiple steps of data integration, interpretation, and evaluation to build a representative geologic model followed by additional evaluation and interpretation to develop predictions of plume behavior through numerical simulation of injection. The following is an overview of how this process was carried out to generate results for the RTE SFP application.

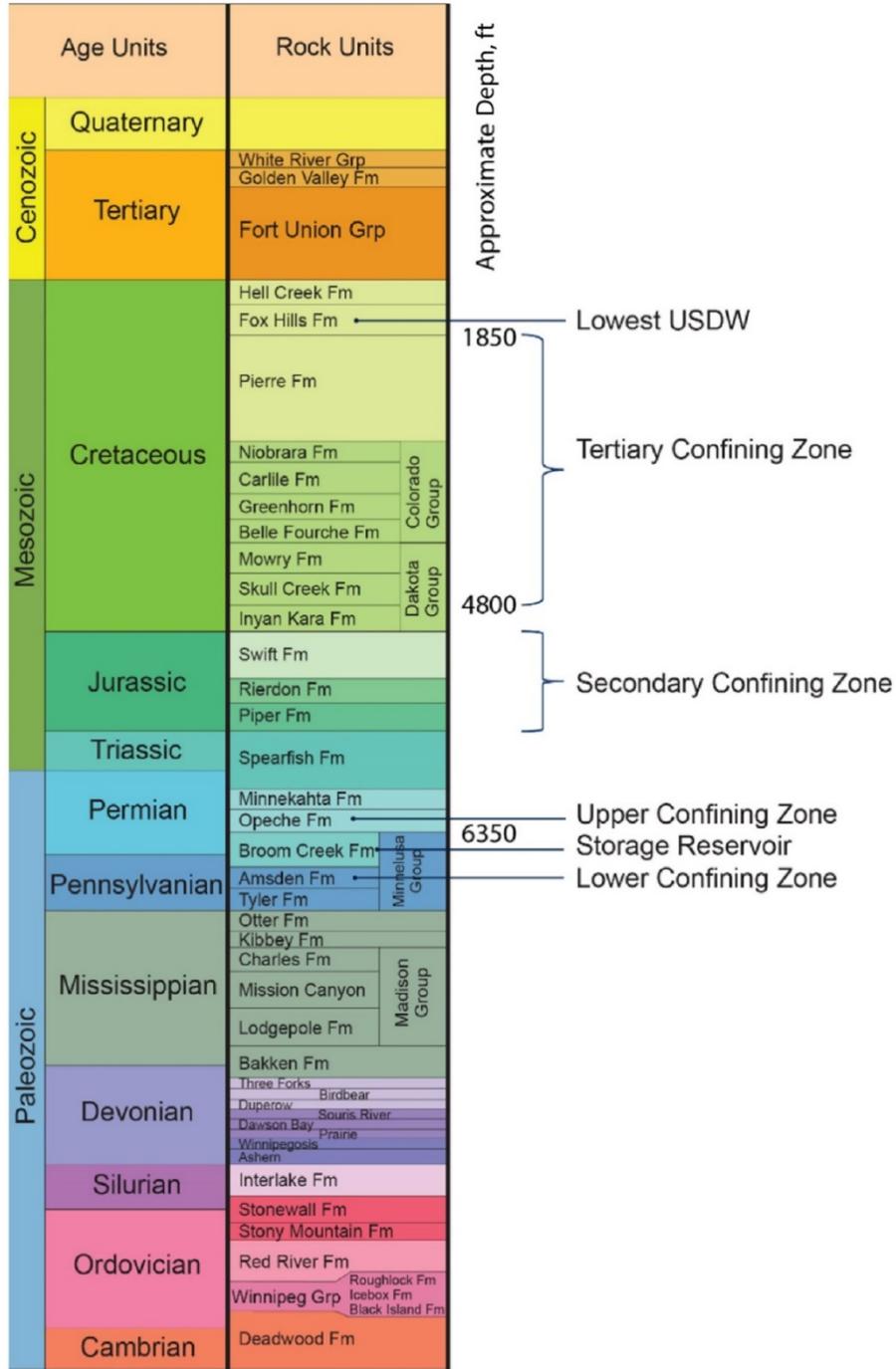
A detailed geologic model of the RTE site was built to provide the 3D basis and static initial conditions for the simulation of CO<sub>2</sub> injection for 20 years and assess the site's fitness for permanent geologic CO<sub>2</sub> storage. RTE plans to inject 180,000 metric tons of CO<sub>2</sub> annually into the sandstone of the underlying Broom Creek Formation. Data from offset wells, wells drilled on the site, analysis of samples collected from the site, and a geophysical survey of the site were incorporated into a geologic model of the Broom Creek Formation and the overlying and underlying cap rock formations. Simulated CO<sub>2</sub> injection studies were conducted to determine the wellhead and downhole pressure resulting from injection and how the injected CO<sub>2</sub> would distribute in the Broom Creek. Reservoir conditions observed from the stratigraphic test well were used to establish the initial conditions. Results of the injection studies were then used to determine the project's AOR pursuant to North Dakota's geologic CO<sub>2</sub> storage regulations.

### **Geologic Modeling**

The geologic model was constructed using Schlumberger's Petrel software suite. Petrel is a software platform that allows for the development of geologic models using well and seismic data in combination with geostatistics. The geologic model represents the subsurface geology of the proposed CO<sub>2</sub> storage reservoir and its upper and lower confining zones, which are made up of the Opeche and Broom Creek Formations and the upper portion (i.e., 50 ft) of the Amsden Formation (Figure 5). Geologic properties were distributed within the 3D volume of the reservoir as inputs for numerical simulations of CO<sub>2</sub> injection to predict the migration of CO<sub>2</sub> and pressure effects throughout the storage reservoir. These geologic properties included 1) lithofacies/lithology (bodies of rock with similar geologic characteristics), which were used to assign relative permeability data; 2) porosity; 3) matrix permeability; 4) temperature; and 5) pressure.

Multiple sets of data were used to construct the geologic model. Publicly available data, which included well logs and formation top depths, were acquired from the online database of NDIC. Site-specific data that were collected as part of storage reservoir characterization efforts and included geophysical well logs, petrophysical analyses, formation fluid analyses, and a surface seismic survey were also used in the model construction.

The well logs acquired in the stratigraphic test well were used to pick formation top depths, interpret lithology, estimate petrophysical properties, and determine a time–depth shift for seismic data. Formation top depths were picked from the top of the Pierre Formation to the top of the Amsden Formation. Regional formation top depths from wellbores within a 25-mile radius of the



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Figure 5. Stratigraphic column identifying the storage reservoir and confining zones for the geology overlying the storage facility area (from RTE's SFP application).

study area were added to these existing site-specific data to understand the geologic extent, depth, and thickness of subsurface geologic strata. Lateral structure trends from the acquired seismic data were used to reinforce interpolation of the formation tops to create structural surfaces, which served as inputs for geologic model construction.

Core samples obtained from the RTE-10 wellbore were analyzed and added to existing Opeche, Broom Creek, and Amsden data sets that were obtained from the NDIC database. These analyses included XRF, XRD, thin sections, porosity, and flow measurements. Learnings from these site-specific core data analyses and well logs collected from the RTE-10 wellbore were used to determine Broom Creek Formation lithologies in legacy wellbores throughout the area for which no core data were collected. Lithologies assigned to each wellbore were then used to generate the facies properties of the Broom Creek Formation. Eleven offset wells with porosity logs were used to inform petrophysical property distributions in addition to the core data from RTE-10. The various data sets derived from RTE-10 showed good agreement with the limited offset well data available near the RTE-10 site.

### **Overview of Simulation Activities**

Numerical simulations of CO<sub>2</sub> injection into the Broom Creek Formation were conducted using the geologic model of the Opeche, Broom Creek, and Amsden Formations. Simulations were carried out using CMG's GEM, a compositional reservoir simulation module. The simulation used a grid of cells to cover the project area with a rectangle of dimensions 10 by 10 miles. For reference, the modeled CO<sub>2</sub> plume was approximately 2 miles in diameter at its maximum extent, and the final AOR was a polygon approximately 4.4 by 4.4 miles in size. The simulation model boundaries were assigned infinite-acting conditions to allow lateral water flux and pressure dispersion through the simulated-boundary aquifer. The reservoir was assumed to be 100% brine saturated with an initial formation salinity of 164,000-ppm total dissolved solids. The fluid model used Henry's solubility model, which allowed CO<sub>2</sub> to dissolve into the native formation brine. Both the relative permeability and the capillary pressure data for Broom Creek were analyzed and generated through the laboratory evaluation. Relative permeability curves were not upscaled or smoothed to avoid significantly altering the data and correlations determined from the laboratory evaluation. The injection well, RTE-10, was simulated as perforated from below installed wellbore-monitoring gauges to the bottom of the Broom Creek Formation interval with an assumed neutral completion condition, meaning the model assumes no damage has occurred to the formation permeability as a result of completing perforations in the well and that no artificial stimulation, such as fracturing or acidizing of the well, has occurred (as none of which are planned for RTE-10).

### ***Sensitivity Analysis***

Because the availability of data for this study included well logs, core data, and rock-fluid properties (such as relative permeability), the need to investigate influential parameters in typical sensitivity studies has been reduced. Wellhead temperature (WHT), tubing roughness, permeability/porosity reduction, and formation compressibility were the parameters that remained to be analyzed for larger influences on simulation results. A preliminary sensitivity analysis suggested that, at the given injection rate, WHT played the most prominent role in determining wellhead pressure (WHP) response. Because higher temperatures reduce the density of the CO<sub>2</sub>

injected, this reduces the hydraulic head in the wellbore, requiring a higher WHP to sustain the injection rate. Thus a higher WHT value was chosen as a conservative well constraint during the simulation study.

### ***Simulation Results***

Simulation with the given well constraints predicted that WHP will not exceed 1300 psi during injection operations, and the bottomhole pressure (BHP) is expected to rise to just above 3000 psi. The injection rate was held constant over the 20 years of injection. At the end of 20 years of simulated injection, a total of 3.7 million metric tons of CO<sub>2</sub> was injected into the Broom Creek Formation.

During and after injection, free-phase (supercritical) CO<sub>2</sub> accounts for the majority of CO<sub>2</sub> observed in the model's pore space, but the mass of free-phase CO<sub>2</sub> declines during the postinjection period. Throughout the injection operation, a portion of the free-phase CO<sub>2</sub> is trapped in the formation's pores through a process known as residual trapping. In residual trapping, a portion of the CO<sub>2</sub> that enters a pore clings to the pore wall and is unable to exit the pore. CO<sub>2</sub> also dissolves into the formation brine throughout injection operations (and continues afterwards), although the rate of dissolution slows over time. The relative portions of free-phase, trapped, and dissolved CO<sub>2</sub> is calculated by the model throughout the duration of the simulation.

Long-term CO<sub>2</sub> migration potential was also investigated through the numerical simulation efforts. The slow lateral migration of the plume is caused by the effects of buoyancy, where the free-phase CO<sub>2</sub> injected into the formation rises to the cap rock or lower-permeability layers present in the Broom Creek, then moves outward toward updip (i.e., the naturally rising slant of the cap rock). This process results in a higher concentration of CO<sub>2</sub> at the center of the accumulation, which gradually spreads out toward the model edges where the CO<sub>2</sub> saturation is lower. Figures 6 and 7 show the gas saturation changes between the end of injection (year 2041) and 100 years postinjection (year 2141) in the cross-sectional view.

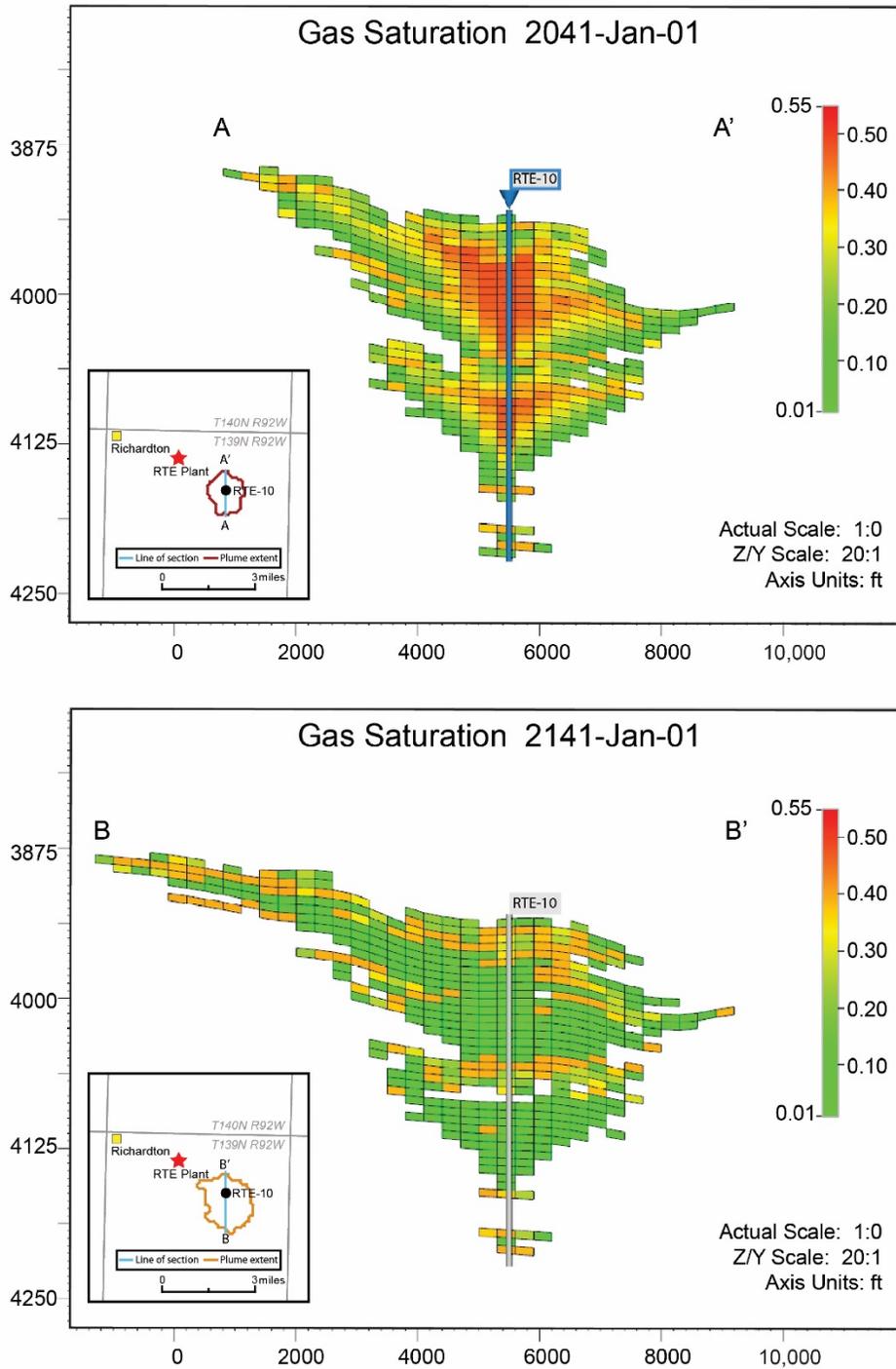


Figure 6. CO<sub>2</sub> plume cross section at the end of injection (top) and as a stabilized plume (bottom), displayed south to north through the RTE-10 well (from RTE’s SFP application). Elevation below sea level is displayed on the Y axis.

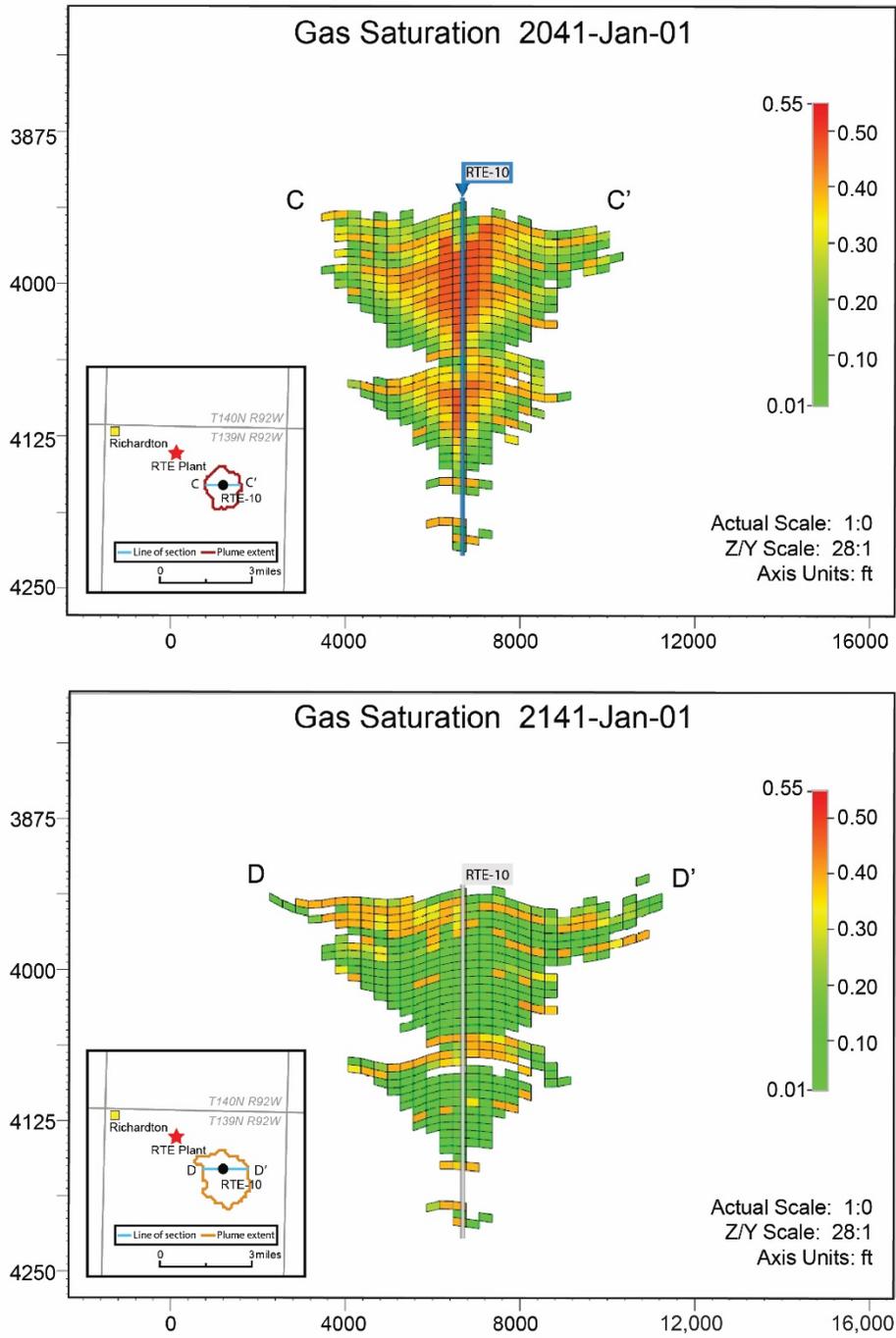


Figure 7. CO<sub>2</sub> plume cross section at the end of injection (top) and as a stabilized plume (bottom), displayed east to west through the RTE-10 well (from RTE's SFP application). Elevation below sea level is displayed on the Y axis.

### ***Maximum Surface Injection Pressure***

Additional cases were run to determine if the well would ultimately be limited by the maximum calculated surface injection pressure of 2250 psi (based on flow line rating) or by the maximum calculated downhole pressure of 4019 psi (90% of the formation fracture pressure). Other parameters were kept the same for the additional tests.

The maximum surface pressure was reached in the simulations before the maximum BHP was encountered. At the maximum surface pressure of 2250 psi, the predicted BHP response was observed with a peak of less than 3200 psi and an average pressure of less than 3100 psi. At this pressure, the well is able to accept injections of 2140 metric tons/day of CO<sub>2</sub> with 3.5-in.-diameter tubing. This rate far exceeds the project's expected daily average injection rate of ~500 metric tons/day. Simulations with 4.5-in.-diameter tubing showed that the well can achieve a higher injection rate of 4150 metric tons/day of CO<sub>2</sub>, but the BHP does not exceed 3360 psi, with an average BHP of 3240 psi. These values are all below the maximum calculated BHP of 4019 psi.

### ***Stabilized Plume***

During the postinjection period, movement of the injected CO<sub>2</sub> plume is driven by the potential energy found in the buoyant force of the injected CO<sub>2</sub>. As the plume spreads out within the reservoir and CO<sub>2</sub> is trapped residually through the effects of relative permeability and dissolution, the potential energy of the buoyant CO<sub>2</sub> is gradually lost. Eventually, the buoyant force of the CO<sub>2</sub> is no longer able to overcome capillary entry pressure of the surrounding reservoir rock. At this point, the CO<sub>2</sub> plume ceases to move within the subsurface and becomes stabilized. The extent of the stabilized plume is important for determining the project's AOR and the corresponding scale and scope of the project's monitoring and safety plans.

Plume stabilization can be visualized at the microscale as CO<sub>2</sub> being unable to exit its current pore space and enter the neighboring pore space, but at the macroscale these interactions cannot be measured. Instead, plume stabilization may be estimated using the simulation tools available to predict the CO<sub>2</sub> plume's extent. For the RTE project, stabilization was defined to occur at the time when CO<sub>2</sub> no longer migrates to adjacent cells within the simulation model. CO<sub>2</sub> may still experience gradual redistribution within the plume, but the geographic extents of the plume remain unchanged.

The CO<sub>2</sub> plume was simulated in 1-year time steps until the extent ceased to change in order to define the plume extent boundary and the associated buffers and boundaries (Figures 5 and 6). This estimate is anticipated to be regularly updated during the CO<sub>2</sub> storage operation as data collected from the site are used to update predictions made about the behavior of the injected CO<sub>2</sub>.

### ***Delineation of AOR***

The AOR is defined as the region surrounding the geologic storage project where USDWs may be potentially affected by CO<sub>2</sub> injection activity. The primary risk is due to the potential for vertical migration of CO<sub>2</sub> and/or formation fluids to a USDW from the storage reservoir. Therefore, the AOR encompasses the region overlying the extent of reservoir fluid pressure

increase sufficient to drive formation fluids (e.g., brine) into a USDW, assuming pathways for this migration (e.g., abandoned wells or fractures) are present. The minimum pressure increase in the reservoir that results in a sustained flow of brine upward into an overlying drinking water aquifer is referred to as the “critical threshold pressure increase” and the resultant pore pressure as the “critical threshold pressure.” EPA guidance for AOR delineation under the Underground Injection Control Program for Class VI wells provides several methods for estimating the critical threshold pressure increase and the resulting critical threshold pressure.

### ***Critical Threshold Pressure Increase Estimation at RTE-10***

For the purposes of delineating the change in reservoir pressure for the RTE study area, constant fluid densities for the lowermost USDW (the Fox Hills Formation) and the injection zone (the Broom Creek Formation) were used. A density of 1001 kg/m<sup>3</sup> was used to represent the USDW fluids, and a density of 1106 kg/m<sup>3</sup>, which is estimated based on the in situ brine salinity, temperature, and pressure, was used to represent injection zone fluids.

Critical pressure threshold increases were calculated for the proposed storage reservoir at a range of depths through the reservoir at the RTE-10 well, the depth of the bottom of the USDW, and fluid density values from the RTE-10 well (Table 3). Using this method, the threshold pressure increase at the top of the Broom Creek Formation at the RTE-10 well was determined to be 107.3 psi. Additional information can be found in Appendix A, Section 2.4.4, of RTE’s SFP application ([www.dmr.nd.gov/oilgas/C28848.pdf](http://www.dmr.nd.gov/oilgas/C28848.pdf)).

**Table 3. Critical Threshold Pressure Increase Calculated at the RTE-10 Wellbore Location. Chosen depths represent the top, middle, and base of the Broom Creek Formation (from RTE’s SFP application).**

Depth, ft MD	Depth Descriptor	Elevation, m AMSL*	pi, kg/m <sup>3</sup>	pu, kg/m <sup>3</sup>	zu, m	zi, m	ξ, coefficient	ΔPc, psi
1668	Fox Hills Base	785	–	–	–	–	–	–
6379	Broom Creek Top	–1197	1106	1001	239	–1197	0.0731	107.3
6529	Broom Creek Middle	–1242	1106	1001	239	–1242	0.0709	110.7
6678	Broom Creek Base	–1288	1110	1001	239	–1288	0.0688	114.1

\* Above mean sea level.

These estimates of critical threshold pressure increase were compared to potential pressure increases within the storage facility area that would result from CO<sub>2</sub> injection and the potential lateral extent of the injection fluid as determined by predictive simulations. Estimates of change in reservoir pressure for various depths within the Broom Creek Formation were then compared against the difference in pressure predicted for each cell in the simulation model at the end of injection, where the greatest increase in pressure was observed. Within the bounds of the modeled

area and throughout the entire storage facility area, the maximum pressure difference during the final year of injection is estimated to reach approximately 52 psi, which occurs in near proximity to the injection well. This pressure is below the calculated critical threshold pressure increase of 107.3 psi. Therefore, the critical pressure is not exceeded at the RTE injection site anywhere within or around the injected CO<sub>2</sub> plume, and critical pressure is not a deciding factor in determining the AOR extent.

At RTE, the maximum extent of injected CO<sub>2</sub> plus one-half mile is the storage facility area, as the critical pressure is not exceeded by injection of CO<sub>2</sub> in the “storage reservoir.” The AOR is then 1 mile beyond the storage facility area (Figure 8). As shown, the AOR is depicted by the black dotted line, which includes the simulated CO<sub>2</sub> extent (purple boundary and shaded area), storage facility area (dotted white boundary), and AOR (dotted black boundary).

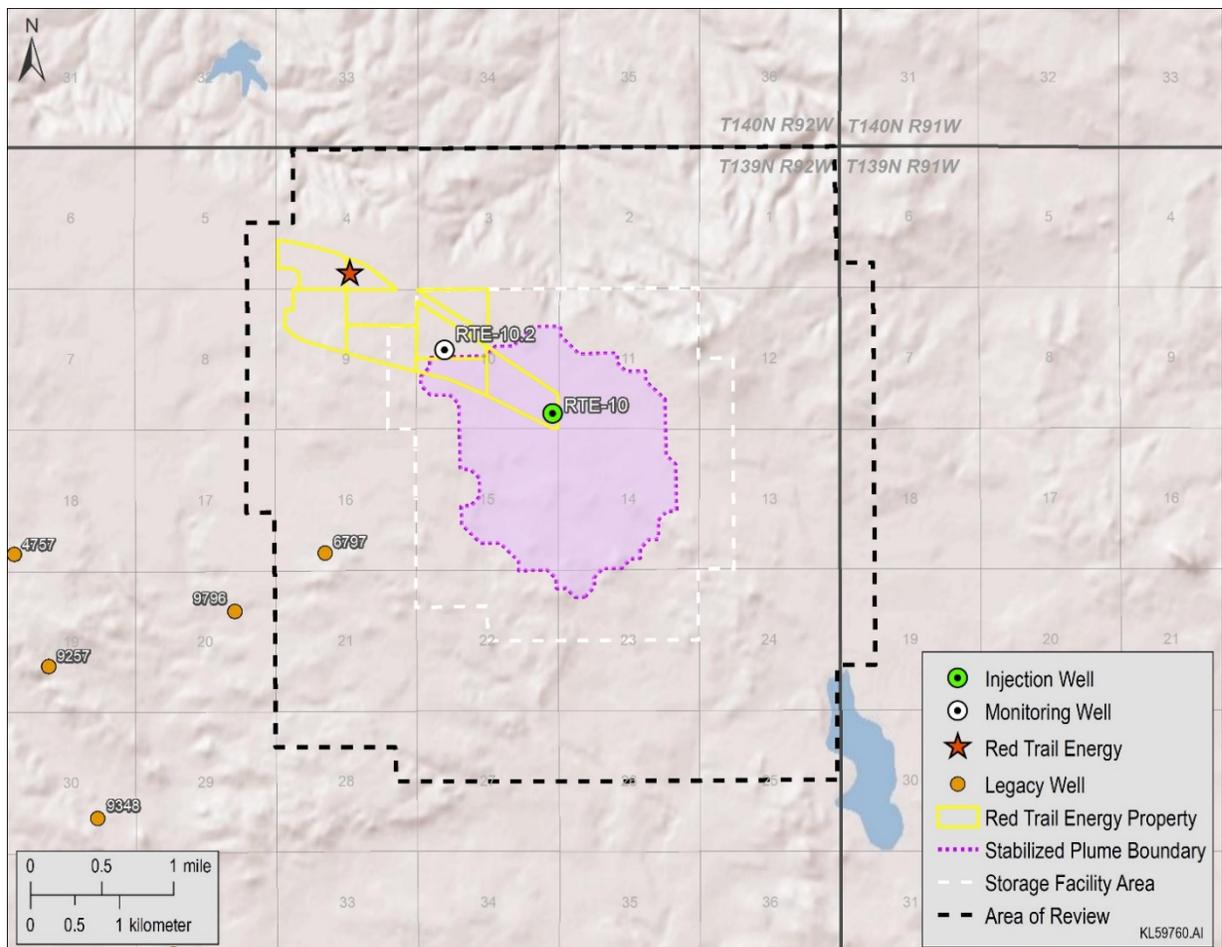


Figure 8. Final AOR estimations of the RTE-10 storage facility area in relation to nearby legacy wells. Shown are the simulated CO<sub>2</sub> extent (purple boundary and shaded area), storage facility area (dotted white boundary), and AOR (dotted black boundary). Orange circles represent nearby legacy wells near the storage facility area (from RTE’s SFP application).

## SUMMARY AND LESSONS LEARNED

Development of a North Dakota CO<sub>2</sub> SFP application is a lengthy process that presently requires significant investment of time and resources by the CCS operator. In addition to meeting the technical requirements, several administrative lessons were derived during the RTE SFP development process pertaining to 1) data management, 2) generation of permit figures, 3) land use, and 4) communication with regulators.

As the RTE SFP application represents the first such permit submitted in North Dakota, there are undoubtedly gains that can be made in efficiency of resources used for development and efficiencies in how the results of the data analysis are communicated. For example, use of strong data management practices is a key element to developing a strong and effective SFP application. A wide variety of data sources are combined in the effort, from publicly available legacy data, to new data derived from regional samples, to new data derived from site-specific samples, tests, or surveys. As these data sets are likely to not be in complete agreement with one another (or can be subject to any number of internal errors related to acquisition or processing), decisions made about how each data set is used for each development step need to be tracked and recorded. This becomes particularly important when these decisions about input data are revisited or reviewed in the context of the results developed from a model or analysis, which is a common occurrence on an iterative process such as reservoir simulation. Maintaining a detailed record of data inputs also helps maintain a consistency of results and figures throughout the process and facilitates changes if changes are determined to be needed. This record is also vital for communicating the final results to the regulatory body and describing why one data set may have been given preference or weighted more heavily over another.

Careful consideration also needs to be given to how figures, including maps, are created for a North Dakota CO<sub>2</sub> SFP application. The regulatory language prescribes the display of multiple data sets in map form for various sections of the permit application. However, maps can be created in a wide variety of forms, so a solid understanding of what a map needs to communicate to the regulatory body can help ensure the final product effectively conveys the required information. This understanding can also aid in determining which figure types or elements can be combined and which need to be retained independently. Developing a clear purpose for each figure can also speed up the revisions process during development and/or NDIC Department of Mineral Resources evaluation of the application. It can also be tempting to try to combine many related data sets or results into a map or figure, as these combined products provide an efficiency in space. However, there is a point where this efficiency in space loses out to the complexity of the resulting figure, which may become confusing or “too busy.” Thus there are situations where the use of multiple figures, each focused on a different data element, may be preferred over using a single combined figure.

Final estimations of the storage facility area and AOR can have major business and community implications. A factor that may not be necessary to consider immediately during AOR delineation is the distribution of surface landownership. However, this element can impact the final calculation of the size of an AOR or amalgamated pore space for storage, predominantly for landowners on the edges of these boundaries. For the sake of simplicity, RTE determined to not attempt to split or provide partial compensation for acreage at the edges of these boundaries,

impacting the final shape of the AOR to include properties that extended beyond the boundary simulation. Therefore, an accurate accounting of landownership is not only a required element of an SFP application but can also impact determinations that are otherwise made from geologic and engineering perspectives. In addition, regional aspects, such as the proximity of Richardton to the RTE site, may be a factor in choosing locations of injection and monitoring wells for control of AOR positioning.

Future operators are encouraged to discuss potential SFP application plans and procedures with North Dakota regulators before final documents are started, mid-development if there are any significant changes, and prior to submission for consideration by the state to ensure permit elements are properly represented and interpreted. RTE's SFP application was the first to be submitted for operating a Class VI CO<sub>2</sub> storage well in North Dakota. It has provided an example template for other operators to follow when developing their own SFP applications and has allowed North Dakota regulators to explore how the regulations are to be interpreted when applied to the complex issues inherent in developing a Class VI permit. That said, every CCS effort is unique, generating by nature individualized timelines, approaches, and implementation plans.

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**APPENDIX B**  
**NORTH DAKOTA CO<sub>2</sub> STORAGE FACILITY**  
**PERMIT GUIDE**



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# NORTH DAKOTA CO<sub>2</sub> STORAGE FACILITY PERMIT GUIDE

## Research in Support of Integrated CCS for North Dakota Ethanol Production

### *Deliverable D3*

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## **NORTH DAKOTA CO<sub>2</sub> STORAGE FACILITY PERMIT GUIDE**

### **EXECUTIVE SUMMARY**

Red Trail Energy, LLC (RTE) a North Dakota ethanol producer, received formal approval of its North Dakota CO<sub>2</sub> storage facility permit (SFP) on October 19, 2021. The RTE carbon capture and storage (CCS) project is currently constructing a CO<sub>2</sub> capture facility adjacent to the RTE ethanol plant near Richardton, North Dakota, to ultimately inject about 180,000 tonnes of CO<sub>2</sub> annually more than a mile below RTE property for permanent storage. This approval by the North Dakota Industrial Commission (NDIC) authorizes the geologic storage of CO<sub>2</sub> from the RTE ethanol facility in the amalgamated storage reservoir pore space of the Broom Creek Formation. The Red Trail Richardton Ethanol Broom Creek Storage Facility #1 is the first storage facility to be established in the state of North Dakota.

RTE, in partnership with the Energy & Environmental Research Center and the NDIC Renewable Energy Program, has been investigating CCS applicable to small-scale industrial CO<sub>2</sub> emitters (<1,000,000 tonnes of CO<sub>2</sub> emitted annually) over the past 5 years. This document therefore is a guide for a successfully submitted, accepted, and approved North Dakota CO<sub>2</sub> SFP application.

The five primary North Dakota CO<sub>2</sub> SFP application components are 1) pore space access, 2) geologic exhibits, 3) area of review, 4) supporting permit plans, and 5) injection well and storage operations, as detailed in the North Dakota Century Code (Chapter 38-22) and North Dakota Administrative Code (Chapter 45-05-01). This final, approved permit guide incorporates all revisions required through the 8-month state review and evaluation process, including all additional information requested during the public hearing on August 12, 2021.



# RED TRAIL ENERGY, LLC

“Our Farms, Our Fuel, Our Future”

---

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## RED TRAIL ENERGY – CARBON DIOXIDE GEOLOGIC STORAGE FACILITY PERMIT

North Dakota CO<sub>2</sub> Storage Facility Permit Application

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## **RED TRAIL ENERGY – CARBON DIOXIDE GEOLOGIC STORAGE FACILITY PERMIT APPLICATION**

### **PERMIT APPLICATION SUMMARY**

Red Trail Energy, LLC (RTE) is requesting consideration of this application for the geologic storage of carbon dioxide (CO<sub>2</sub>) from the RTE ethanol facility located near Richardton, North Dakota (Figure PS-1). The RTE ethanol facility is a North Dakota-based, investor-owned 64-million-gallon dry mill ethanol production plant (Table PS-1), which has been in operation since January 2007. The RTE facility emits an average 180,000 metric tons of high-purity CO<sub>2</sub> (>99% CO<sub>2</sub> dry) annually from the fermentation process during ethanol production. RTE plans to commercially capture (dehydrate and compress) and inject the 180,000-metric-ton-per-year CO<sub>2</sub> stream into the Broom Creek Formation on RTE property for permanent geologic CO<sub>2</sub> storage.

Research efforts by RTE and the Energy & Environmental Research Center, with funding support from the North Dakota Industrial Commission Renewable Energy Program and the U.S. Department of Energy, began in 2016 to characterize the geology and determine site feasibility to develop the first carbon capture and storage (CCS) facility in North Dakota (Leroux and others, 2020). The geologic characterization work resulted in RTE conducting a 3D seismic survey over the project area in March 2019 and drilling a stratigraphic test well (RTE-10) in March–April 2020 to acquire the geologic data required for this North Dakota CO<sub>2</sub> Storage Facility Permit (SFP) application to implement commercial CCS at the RTE site. In addition, detailed capture process design has been conducted for a liquefaction system to capture the fermentation-generated CO<sub>2</sub> emissions at the RTE facility, providing the engineering support for the expected CO<sub>2</sub> output stream and thus injection conditions.

As shown in Figure PS-1, integration of CCS technology with the existing RTE ethanol facility will consist of a CO<sub>2</sub> liquefaction system pumping the CO<sub>2</sub> stream to the RTE-10 injection well for geologic storage into the Broom Creek Formation (a saline formation). An underground flow line will be installed on RTE property to connect the liquefaction system to the RTE-10 injection well. A monitoring well (RTE-10.2) was also installed on RTE property in October 2020 for compliance with the North Dakota CO<sub>2</sub> SFP requirements to directly monitor CO<sub>2</sub> injection in the Broom Creek Formation. Monitoring equipment currently installed in both RTE-10 and RTE-10.2 wells includes pressure–temperature gauges in the Broom Creek Formation and a fiber optic cable along the entire length of the well and flow line. Additional monitoring equipment to be added includes (but is not limited to) CO<sub>2</sub> flowmeters at the capture facility, along the flow line, and at the wellhead as well as related SCADA (supervisory control and data acquisition) systems.

The Broom Creek Formation is situated directly below RTE property with excellent geologic properties (high porosity/permeability, tight seals) for CO<sub>2</sub> injection and permanent storage (Sorensen and others, 2009; Glazewski and others, 2015; Leroux and others, 2020). Shales and salts of the Opeche, Piper, and Swift Formations overlying the Broom Creek Formation create a sealing barrier of over 1,000 ft, providing a secure, permanent geologic storage reservoir for the planned geologic CO<sub>2</sub> storage. Further above, the Pierre Formation is an impermeable shale approximately 2,000 ft thick, providing an additional seal for underground sources of drinking water in the area to be permitted.

Therefore, the following North Dakota CO<sub>2</sub> SFP application provides detailed geologic exhibits generated from the seismic survey, core collection with subsequent laboratory analyses and downhole testing from the RTE-10 and RTE 10.2 wells, and successive modeling and simulation for predictive CO<sub>2</sub> movement forecasting and pore space access determination. These lay the foundation for area of review determination, which is the basis for the required supporting permit plans: emergency and remedial response, financial assurance demonstration, worker safety, testing and monitoring, well casing and cementing, plugging, and postinjection site and facility closure. In conclusion, injection well and storage operations provide detailed descriptions of the RTE-10 and RTE-10.2 wells and planned injection and storage/monitoring operations, included for a proposed permit to inject. An RTE Storage Facility Permit Regulatory Compliance Table (Appendix E) has been generated to provide a crosswalk of the specific RTE application components addressing each permit requirement.

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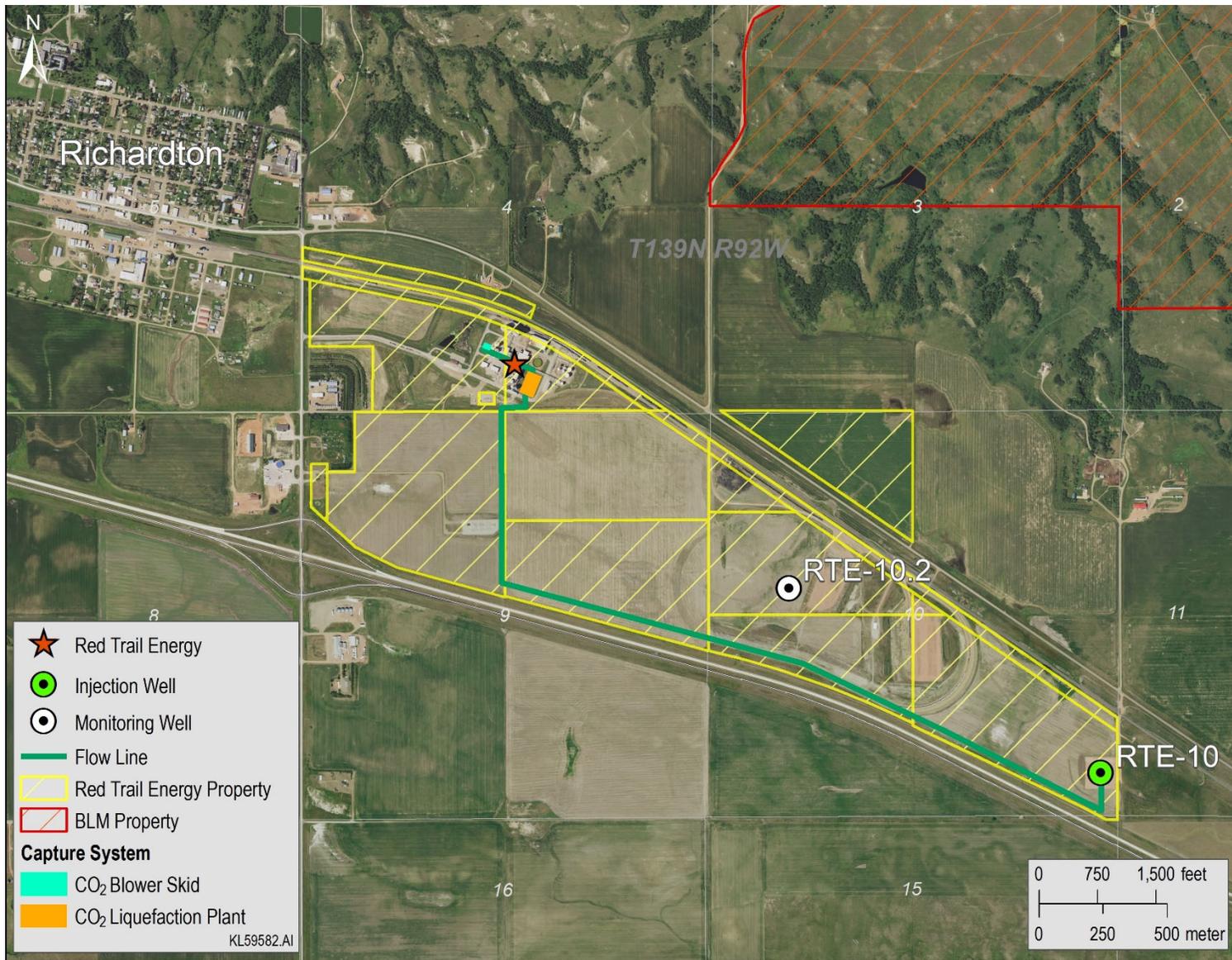


Figure PS-1. RTE geologic storage of CO<sub>2</sub> project map.

**Table PS-1. RTE Operator and Ethanol Facility Information**

**Operator Information Pursuant to NDAC § 43-05-01-07.1 Subsection 3a, c, and f**

<p><u>NDAC § 43-05-01-07.1 Subsection 3a</u> The activities conducted by the applicant which require it to obtain a storage facility permit or other federal, state, or local permits.</p>	<p>RTE is proposing geologic storage of CO<sub>2</sub>.</p> <p>Additional activities: drilling stratigraphic test wells RTE-10 (NDIC File No. 37229) and RTE-10.2 (NDIC File No. 37858), conversion of these wells to Class VI injection and monitoring wells (respectively), and the construction of a CO<sub>2</sub> liquefaction system and flow line.</p>							
<p><u>NDAC § 43-05-01-07.1 Subsection 3c</u> Up to four standard industrial classification codes which best reflect the principal products or services provided by the facility.</p>	<table border="1"> <thead> <tr> <th>Products</th> <th>Standard Industrial Classification (SIC) Code</th> </tr> </thead> <tbody> <tr> <td>Ethanol</td> <td>2869</td> </tr> <tr> <td>Corn Oil</td> <td>2046</td> </tr> </tbody> </table>	Products	Standard Industrial Classification (SIC) Code	Ethanol	2869	Corn Oil	2046	
Products	Standard Industrial Classification (SIC) Code							
Ethanol	2869							
Corn Oil	2046							
<p><u>NDAC § 43-05-01-07.1 Subsection 3f</u> A listing of all environmental permits, construction approvals, or any other relevant permit received or applied for from the commission or any other federal, state, or local regulatory agency.</p>	<p>Permits to Drill (state) and Richardton Special Use Permits (local) for wells RTE-10 (NDIC File No. 37229) and RTE-10.2 (NDIC File No. 37858), construction permits (local) for the CO<sub>2</sub> liquefaction system, and storm water permit (state) for the CO<sub>2</sub> liquefaction system and wellsite location.</p>							

**APPENDIX C**  
**NORTH DAKOTA CARBON CAPTURE AND**  
**STORAGE OUTREACH**  
**TOOL KIT**



November 30, 2021

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Dear Ms. Fine:

Subject: Deliverable (D) 4 for Research in Support of Integrated Carbon Capture and Storage for North Dakota Ethanol Production; Contract No. R-043-053; EERC Fund 25204

Attached is the D4: North Dakota Carbon Capture and Storage Outreach Tool Kit for the subject project. If you have any questions, please contact me by phone at (701) 777-5013, by fax at (701) 777-5181, or by e-mail at [kleroux@undeerc.org](mailto:kleroux@undeerc.org).

Sincerely,

DocuSigned by:  
  
F93F81AE98DB40F...  
Kerryanne M. Leroux  
Principal Engineer

KML/rlo

Attachment

\



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# NORTH DAKOTA CARBON CAPTURE AND STORAGE OUTREACH TOOL KIT

**Research in Support of Integrated Carbon Capture and Storage for North Dakota Ethanol Production**

*Deliverable D4*

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# NORTH DAKOTA CARBON CAPTURE AND STORAGE OUTREACH TOOL KIT

## EXECUTIVE SUMMARY

Public science-based and community-focused outreach has been a major component to the Red Trail Energy (RTE) Carbon Capture and Storage (CCS) project into this fourth phase (Phase 4) of a multiphase research effort conducted by the Energy & Environmental Research Center (EERC), in partnership with RTE, a North Dakota ethanol producer, and the North Dakota Industrial Commission (NDIC) Renewable Energy Program. During Phase 4, the culmination of research resulted in the development of a North Dakota CO<sub>2</sub> storage facility permit (SFP) application and formal approval received on October 19, 2021. The RTE CCS project is currently constructing a CO<sub>2</sub> capture facility adjacent to the RTE ethanol facility near Richardton, North Dakota, to ultimately inject about 180,000 tonnes of CO<sub>2</sub> annually more than a mile below RTE property for permanent geologic storage. Building on the previously submitted Outreach Package,<sup>1</sup> this document covers the outreach conducted since June 2020—coincident with the COVID-19 pandemic—to serve as a guide for other emerging CCS efforts, particularly in rural communities.

Outreach engagement efforts in 2020–2021 continued practices and leveraged relationships established during Phases 2 and 3 (2017–2020). With the onset of the COVID-19 pandemic, lockdowns, and limitations on face-to-face contact, the established outreach, such as monthly city and county commission meetings, community open houses, and individual landowner communication, gave way to traditional and social media and websites to convey information about project-specific activities and overall RTE CCS status. Project status updates and related materials were sent to county and city commissioners via e-mail as the research progressed. In lieu of providing community open houses to announce project milestones, such as the intent to move forward with submission of a North Dakota CO<sub>2</sub> SFP application, a press release and summarizing article were disseminated to local and major newspapers in the state and posted on the EERC weblog. The ultimate outreach effort, scheduled after RTE’s SFP was formally approved by NDIC members (Governor, Attorney General, and Agriculture Commissioner), was a virtual open house held in early November 2021. Registrants received a packet of information providing a project overview, summarizing the project results, describing the permitting process, and explaining CO<sub>2</sub> capture and long-term monitoring. The project continues to benefit from local public acceptance. To date, feedback from the audiences has been neutral to positive and, overall, interactions have been constructive.

In general, messaging needs to help audiences understand how the technology can be implemented safely, and every encounter with the public—positive and negative—makes an impression. Encounters can occur anywhere, anytime, ranging from planned events (e.g., an open house) to casual conversation (e.g., local café, gas station, etc.). Given the rural close-knit communities near the RTE study region, encounters are shared among community members. Concerns to date have centered on human safety, groundwater and environmental protection,

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<sup>1</sup> Crocker, C.R., Leroux, K.M., Crossland, J.L., Massmann, N.M., Manthei, M.M., Glazewski, K.A., Daly, D.J., and Hamling, J.A., 2020, Public outreach package for carbon capture and storage in North Dakota: Prepared for North Dakota Industrial Commission, Grand Forks, North Dakota, Energy & Environmental Research Center, February.

clarity and disclosure regarding the process, transparency as the process moves forward, and the trustworthiness of the project team and regulatory oversight.

Public outreach activities scheduled throughout CCS implementation, particularly any time a project-related activity has potential for public contact or exposure, would further solidify local acceptance. Example opportunities to continue the positive interactions may include (certainly not limited to) ribbon cutting on the CCS facilities (i.e., start of operations); monitoring activities for permit compliance, such as environmental sampling; and geophysical surveys. Increasing educational outreach would help teachers educate the future generation of decision-makers to engage in problem-solving in their backyard, in their state, and in their region to go beyond the focus on problem identification. Informal education opportunities using displays and demonstrations at county and state fairs, career fairs, STEM Night at the baseball game, etc., could be effective at informing and engaging learners of all ages. A documentary film showcasing how CCS research culminates into a commercial facility could bring value to the local economy and North Dakota. When North Dakota's lower-carbon ethanol is sold, the broader reach of video brings the story to a larger audience and provides context to help national viewers understand its significance. In conclusion, outreach activities should provide an opportunity for community members to learn about the project, be heard, and reveal important concerns to be addressed as this first-of-its-kind facility in this region comes to fruition.

# NORTH DAKOTA CARBON CAPTURE AND STORAGE OUTREACH TOOL KIT

## INTRODUCTION

Early, proactive, and ongoing public outreach with stakeholders is a pillar in the success of first-of-its-kind infrastructure development. The Energy & Environmental Research Center (EERC), in partnership with Red Trail Energy, LLC (RTE), a North Dakota ethanol producer, and the North Dakota Industrial Commission (NDIC) Renewable Energy Program, has been conducting a feasibility and implementation case study for carbon capture and storage (CCS) since 2016. Outreach is considered an integral part of project-related activities that have public contact or exposure. During this fourth phase (Phase 4), the culmination of research resulted in the development of a North Dakota CO<sub>2</sub> storage facility permit (SFP) application and formal approval received on October 19, 2021. Outreach has a critical role in this effort as a North Dakota CO<sub>2</sub> SFP application and regulatory review process are subject to public review and comment.

Building on previously submitted information,<sup>1</sup> this document covers the outreach conducted since June 2020—coincident with the COVID-19 pandemic—to serve as a guide for other emerging CCS efforts, particularly in rural communities. The RTE CCS project is currently constructing a CO<sub>2</sub> capture facility adjacent to the RTE ethanol facility near Richardton, North Dakota, to ultimately inject about 180,000 tonnes of CO<sub>2</sub> annually more than a mile below RTE property for permanent geologic storage. The RTE facility is located approximately a half mile southeast of the town of Richardton in eastern Stark County (population<sup>2</sup>: 33,646), southwestern North Dakota (Figure 1).

The goal of project outreach is to engage stakeholders and create an environment that allows them to make informed community decisions regarding the project. Effective outreach plans create informed team members who can act as knowledgeable spokespeople for the project. Outreach is triggered by project-related activities that have public contact or exposure. This includes actions by the outreach team on behalf of the project, project management, the technical team, or partners. For the RTE CCS project, RTE acted as the public face for all events, with support from EERC technical and communications staff.

Outreach actions were geared to generate trust, a primary element in building good relationships, in the RTE CCS project among a variety of audiences through engagement, information sharing, and transparency. At the heart of these efforts was providing accurate information that responded to audience needs. The RTE CCS research effort required interaction with various stakeholders where value was provided through a dedicated and systematic outreach effort. Outreach and communication efforts were developed for research activities, coordinated with and supported by the field-based research teams, and provided informational and educational

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<sup>1</sup> Crocker, C., Leroux, K., Crossland, J., Massmann, N., Manthei, M., Glazewski, K., Daly, D., and Hamling, J., 2020, Public outreach package for carbon capture and storage in North Dakota: Prepared for North Dakota Industrial Commission, Grand Forks, North Dakota, Energy & Environmental Research Center, February.

<sup>2</sup> April 1, 2020, [www.census.gov/quickfacts/starkcountynorthdakota](http://www.census.gov/quickfacts/starkcountynorthdakota).

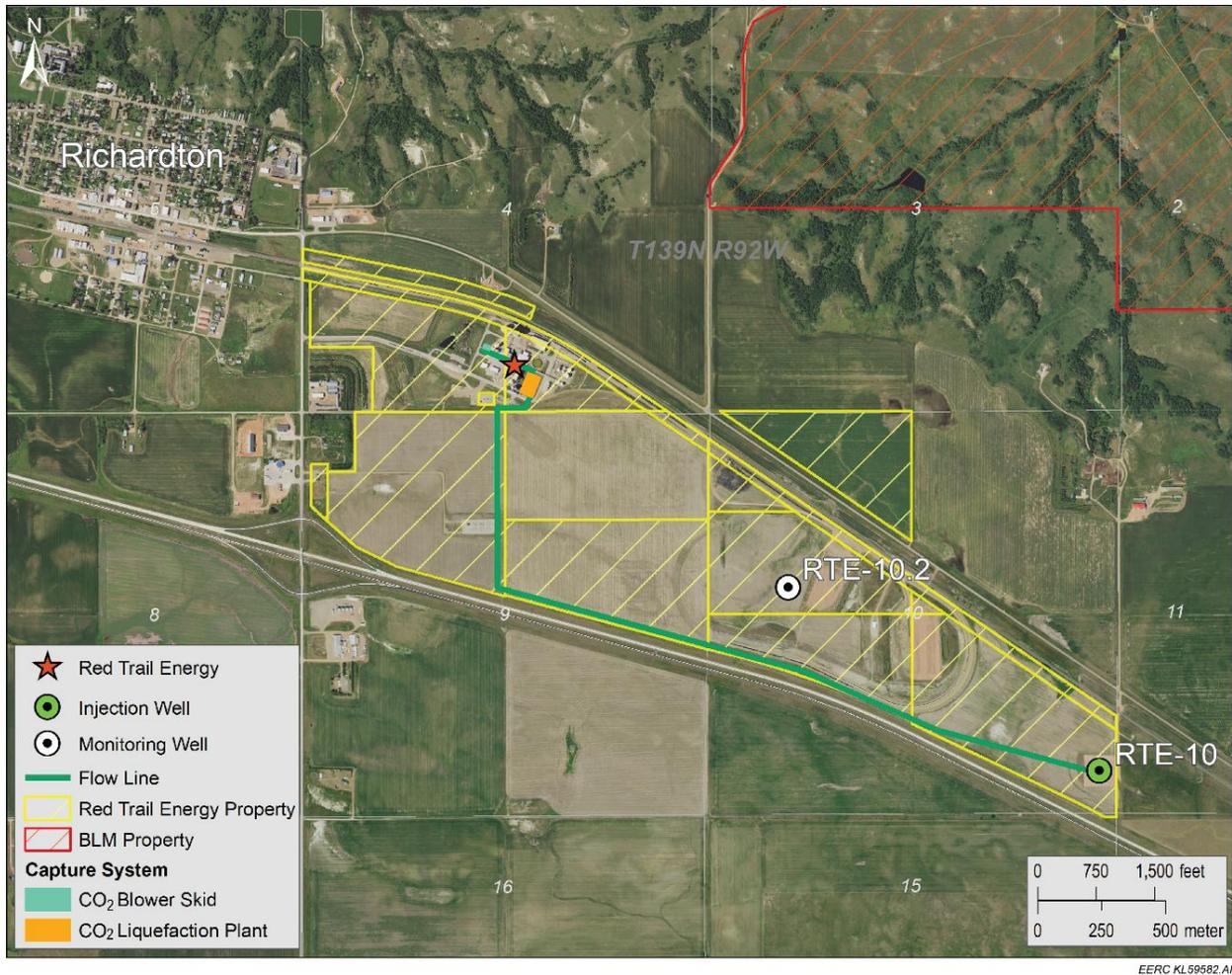


Figure 1. RTE ethanol facility and CCS site showing location of project infrastructure and location relative to the community of Richardton, North Dakota.

materials related to the proposed characterization and monitoring activities. Outreach activities during this phase of the project focused on engagement with target audiences, including local and regional officials, landowners, mineral rights owners, and the community.

Outreach activities were a coordinated effort that was fundamentally affected by COVID-19 restrictions and encompassed 1) the project technical team (e.g., RTE, its legal counsel, the EERC), 2) partner outreach beyond the technical team (e.g., RTE employees and board, EERC employees, and other project partners), and 3) external outreach (e.g., local/regional officials, landowners, etc.).

External outreach was triggered by project-related activities that had public contact or exposure. This included actions on behalf of the project by the outreach team, by project management, the technical team, or partners.

RTE CCS outreach was informed by prior expertise developed, in part, through the EERC’s Plains CO<sub>2</sub> Reduction (PCOR) Partnership Program, part of the U.S. Department of Energy’s (DOE’s) Regional Carbon Sequestration Partnerships (RCSP) Initiative (e.g., Daly and others, 2009, 2016, 2018), and the RCSP Outreach Best Practice Manual (DOE National Energy Technology Laboratory, 2017). These efforts built upon the collective outreach experience of the DOE RCSP Initiative; DOE Carbon Storage Assurance Facility Enterprise (CarbonSAFE) Initiative; outreach experiences for geologic CO<sub>2</sub> injection projects (e.g., Sacuta and others, 2016); and knowledge from commercial practices, such as the models for evaluating public relations actions developed by Jim Macnamara (2016).

## OUTREACH PLAN

An outreach plan provides details on target audiences, messages, and engagement strategies for key relationships and materials to support project development. Effective outreach addresses five key questions, shown in Table 1. The outreach plan answers these questions by defining goals, like identifying audiences and engagement strategies, and laying out the timeline for activities. This living document is frequently updated to respond to feedback and new information over the course of the project.

**Table 1. Relating Outreach Plan Content to Key Project Story Questions**

Outreach Development Questions		RTE CCS Outreach Plan
1	What are we trying to achieve, and how do we best work together to achieve it?	<ul style="list-style-type: none"> <li>• Goal, approach, and success measures</li> <li>• Partners’ roles</li> <li>• Audiences</li> <li>• Implementation considerations and guidelines</li> </ul>
2	What is our story?	<ul style="list-style-type: none"> <li>• Outreach narrative, themes, and messages</li> </ul>
3	How will audiences hear our story?	<ul style="list-style-type: none"> <li>• Engagement strategies</li> <li>• Outreach tool kit</li> </ul>
4	When do we need to tell the story?	<ul style="list-style-type: none"> <li>• Outreach timeline matched to technical timeline and partner considerations</li> </ul>
5	Who heard the story, and what do they think about it?	<ul style="list-style-type: none"> <li>• Success measures/tracking/review and assessment</li> </ul>

An outreach plan was developed in collaboration with RTE prior to initiating field activities (Leroux and others, 2018). The following is a summary of key elements.

### Social Characterization

Social characterization was undertaken as a baseline assessment of stakeholders for the RTE CCS project to help define, quantify, and provide context to the social picture in the RTE area; develop the outreach approach; and identify elements influencing the social feasibility of CCS in the region. Research focused on Stark County within the context of the surrounding counties and

state of North Dakota. Although natural energy resources (oil production and unmined coal) exist in western Stark County, the RTE CCS region comprises rural, agriculture-based communities.

### **Target Audiences**

Several target audience categories were identified for engagement, including project partners, media, elected officials and regulators, the education community, the general public, technical (peer-to-peer) personnel, and environmental nongovernment organizations. For the RTE CCS project, landowners—who are also pore-space owners by law in North Dakota—are a critical subgroup under general public.

### **Project Narrative, Themes, and Messages**

Generation of a single coherent story is essential for effective, informed team members to be knowledgeable spokespeople for the project. The story needs to be consistent whether presented as a one-sentence sound bite, a paragraph synopsis, or a project fact sheet. These messages provide a foundation for expansion and customization over the course of the project. Social characterization research, known concerns, and audience attitudes and perceptions were key inputs to message development. For example, the RTE CCS project one-sentence sound bite was derived as the following:

*The RTE CCS effort is looking to address environmental concerns and strengthen the local economy by investigating the feasibility of and business case for safe, secure, permanent, geologic storage of carbon dioxide from ethanol production.*

As the research project transitioned from feasibility to applying for the permit to sequester CO<sub>2</sub>, the message also transitioned from what and why investigate to when and how to implement—explaining the processes of determining technical efficacy and assuring human safety and environmental protection.

### **Tracking and Assessment Techniques**

Tracking and assessment practices were based on existing and practiced EERC outreach protocols (e.g., Daly and others, 2009, 2016, 2018). Outreach encounters, materials distribution, stories in the media, and web page visits were tracked. Assessment involved evaluation of quantitative data and qualitative feedback from outreach encounters. To date, feedback from the audiences has been generally neutral to positive and, overall, interactions have been constructive.

### **Engagement Strategies**

The engagement strategies used to reach target audiences comprise three categories: 1) in-person, one-on-one conversations and small group presentations; 2) mass communications via mailings, traditional print and broadcast media, social media, and Internet interactions; and 3) indirect engagement through RTE, the EERC, and other project partner (e.g., NDIC) communication activities. Within each category, strategies were customized for specific audiences and the objective of the communication. In the case of the RTE CCS project, the landowner

agreement discussions, board meeting setting, and interactions with governmental stakeholders facilitated one-on-one and small group engagement. With the onset of restrictions associated with the COVID-19 pandemic, electronic communications and media campaigns (e.g., newspapers, blogs, and social media outlets) became critical pathways for information dissemination. Details on the engagement strategies are included in the audience relations sections under General Approach.

### **Materials Development**

Outreach materials development involves preparing information necessary to understand the basics of CCS technologies and the RTE CCS project activities, particularly translating jargon and technical information into verbiage both familiar and relevant to the audience. These may include, but are not limited to, fact sheets (general project or activity-focused), posters, infographics, press releases, and bulleted talking points. With the message transition to describing results, newspaper and blog articles were added to the tool kit content as both target materials for media campaigns and future reference for Internet searches.

## **GENERAL APPROACH**

As a project conducts publicly visible activities, such as a stratigraphic test well drilling, environmental sampling, and submission of the North Dakota CO<sub>2</sub> SFP application, outreach should become more interactive by matching research event schedules with the sequence of outreach audiences, strategies, activities, and materials development that must precede them. For this segment of the effort, the RTE CCS project built on outreach efforts begun in February 2019 to introduce the project to key stakeholders. General nontechnical communication such as press releases, project fact sheets, and web pages gave numerous opportunities for a wide audience to learn the basics of the project in a short time frame.

### **CCS Outreach Materials**

Target audience and engagement strategy drove outreach materials development. Project materials were optimized through an iterative process of quality assurance/quality control reviews involving technical team members, project partners, and editing vetted through leadership teams. Content was developed from EERC technical materials, research and technical staff, social characterization, partner communications, and the experience of the outreach and graphic design teams. Example products developed since June 2020 for the RTE CCS effort are provided in Appendix A.

### **Local and Regional Official Relations**

Two of the target audiences of public outreach for project activities were the Stark County Commission and Richardton City Commission, which includes the mayor of Richardton. As these boards meet monthly and accept presentations, the county and city commission meetings provide an ideal venue to engage local officials, share project information, learn about any potential approval(s) needed, gather feedback, and show goodwill toward the community and region.

County and city administrative personnel attend the meetings, which allows each appearance to effectively inform and engage many county and city government departments, disseminating widespread information more effectively and efficiently into the communities.

RTE attended and presented at commission meetings in advance of the stratigraphic test well drilling in early March 2020—having already shared plans to submit a permit to drill application in 2019. Stark County and Richardton auditors were contacted 2 weeks in advance of published meeting dates (generally the first Tuesday and second Monday, respectively) to obtain a place on the meeting agenda. An overall provisional CCS timeline was presented at each meeting. At each appearance, commissioners received an informational packet containing a project fact sheet and relevant activity-specific frequently asked questions (FAQ) fact sheets, presenter(s) business card(s), and activity timeline. Similar packets with a press release were prepared for media. In advance of each appearance, the outreach team developed talking points highlighting current status and future activities, relevant dates, pertinent results, and any critical information to be conveyed. Commissioners expressed appreciation for information in advance of activities. Starting in April 2020, pandemic restrictions precluded the possibility of in-person presentations. Updates were supplied via e-mail, working through the county and city auditors. Each e-mailed packet included updates on the project along with a copy of the project fact sheet and any relevant activity FAQs, reports, and blog articles to serve as background information for the slate of new commissioners elected during the pandemic.

The NDIC Department of Mineral Resources (DMR) Oil and Gas Division, a crucial stakeholder for the RTE CCS project, also received copies of the informational packets following each meeting—a continuation of the practice established in 2019. As the state regulatory entity overseeing all subsurface activity in North Dakota, the DMR is the permitting authority for North Dakota’s geologic CO<sub>2</sub> injection and storage program (North Dakota Industrial Commission, 2013) and is recognized as a “go-to source” by media for information of this type. Supplying the DMR with up-to-date information regarding the project and public engagement 1) generated more efficient future meetings and 2) ensured the DMR was aware of project progress and information in advance of potential media inquiries. Therefore, not only were good relations maintained, the interaction provided effective dissemination of project progress and information.

### **Landowner Relations**

Positive relations with local landowners are a critical component to the success of any project field activities and, ultimately, the overall CCS effort. In North Dakota, surface landowners also hold the pore space rights needed for permanent geologic CO<sub>2</sub> storage; therefore, building and maintaining positive relations is important for potential CCS implementation.

The RTE CCS project field activities conducted since early 2020 involved RTE-owned land for stratigraphic test well drilling. As the project moved from establishing feasibility to submitting an SFP application, landowner and community communications focused on conveying the results of the research and describing the application process. (Note that the pursuit of pore-space agreements was outside the scope of this project, so the details of that contact are not included here.) RTE had already established good relations with landowners during previous business and research activities using direct contact, which has proven to be a most effective and efficient engagement strategy. Direct contact facilitated the following:

- Face-to-face communication for trust- and relationship-building
- Opportunities for landowners to express concerns, receive immediate answers to questions, and provide feedback
- Timely responses to requests

Unlike the previous phase, notification and cover letters were not required for the stratigraphic test well drilling. Still, an activity-specific fact sheet was developed for nontechnical audiences to provide reference information and concise details describing the steps and benefit of the geologic investigation, with clear statement of purpose, easy-to-follow structure, commonly used verbiage, invitation to learn more at the project website, and RTE contact information. The following were at the heart of landowner contact:

- Facilitating communication
- Keeping landowners informed
- Dealing fairly and equitably with neighbors
- Demonstrating trustworthiness, respect, and transparency
- Showing that RTE is part of the local community

Landowners also received personal written and verbal invitation to the virtual open house (discussed further in the following section) as part of a separate EERC–PCOR Partnership research effort initiated in October 2021 for a low-impact sparse-sensor geophysical monitoring study.

### **Community Relations**

Maintaining the trust of the community is crucial to project and/or activity success. RTE is a visible member of the Richardton community given its location between the Interstate 94 exit and the city of Richardton (Figure 1). The RTE ethanol facility depends on local farmers for its corn feedstock. Thus showing transparency and providing opportunities for community information-sharing is vital to RTE’s sustainability and the CCS effort.

The community was defined mainly as Richardton area residents. Nearby communities were also included in outreach efforts (via print and broadcast media) because of the rural nature of the area:

- Richardton, 692 population (U.S. Census Bureau, 2020 Decennial Census)<sup>3</sup>
- Dickinson, 25,679 population (Stark County seat, 26 miles west of Richardton)
- Hebron, 794 population (18 miles east of Richardton)

The last open house of the previous research phase occurred in December 2019, 4 months before the region started to address the growing COVID-19 pandemic. The research components continued, but as pandemic events unfolded, it became obvious that continuing the open communication effort with the community in the time of pandemic lockdown and exclusion of

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<sup>3</sup> [www.census.gov/search-results.html?searchType=web&cssp=SERP&q=population%20of%20Richardton%20city,%20North%20Dakota](https://www.census.gov/search-results.html?searchType=web&cssp=SERP&q=population%20of%20Richardton%20city,%20North%20Dakota) (accessed November 22, 2021).

face-to-face contact precluded holding an open house at the time the decision was made to move forward with the North Dakota CO<sub>2</sub> SFP application. Beginning in February 2021, the team opted to produce a series of press releases and public bulletins with an EERC blog-published news article to provide further information should media and/or individuals search for more information on the Internet. The first article detailed the results of the research, the decision to move forward, and the next step—SFP application. The second article announced the submission of the RTE SFP application on February 9, 2021, and its significance in mid-February 2021. The third, a bulletin released in mid-October 2021 after the SFP public hearing (held by the DMR on August 12, 2021) and DMR comments were addressed, provided an update to the project, and the fourth, a bulletin released at the end of October 2021 announced the receipt of formal RTE SFP approval by NDIC members (Governor, Attorney General, and Agriculture Commissioner) on October 19, 2021. The blog articles are included in Appendix A. The first two articles were attached to project updates sent to area and state officials and included in background material for the virtual open house described below. The bulletins included an invitation to the virtual open house.

The defined community was invited (in addition to landowners) to attend a virtual RTE CCS project open house held November 10, 2021, using the Zoom meeting platform to share general project information, results of the research, and next steps. As NDIC had recently granted RTE's SFP application, the event focused on an overview of the project, its value to the region, the process—CO<sub>2</sub> capture, flowline transport, and injection at the RTE ethanol facility—and monitoring components of the operation. Appendix A contains materials related to the open house, including the background materials and presentation.

The open house was advertised in regional newspapers in Richardton, Hebron, and Dickinson; on a digital sign at Richardton city limits; and by word of mouth. Community members within a half-mile of the low-impact geophysical survey boundaries received an invitation in their notification letters. Project information and an open house invitation were shared via e-mail with science teachers in the nearby school districts: Richardton–Taylor, Hebron, and Dickinson (public and private) as another means of getting information into the public should teachers decide to share information with their students. The procedure developed for coordinating and executing the open houses is provided in Appendix B. In order to gain a sense of the number of participants and to offer background materials, participants were asked to preregister on Eventbrite for the open house. The EERC's Eventbrite account hosted the meeting, which became visible to anyone searching for events on the site. As a result, registration for the event extended beyond the local community. Participation and meeting questions tended toward technical aspects of the process, either because the community attendees did not have questions or were intimidated by the setting, the technology, or the other participants.

## **Media Relations**

Developing relationships with local journalists and those within the energy “beat” is crucial to ensure that accurate information about the project gets to the public. Technical projects can be difficult to portray accurately in the media because they cannot be easily boiled down to a sound bite or short article. The communications and outreach team worked with all project partners to develop key messages about the RTE CCS project. Those messages were used in developing news releases and communicating with local media (including both television and radio interviews).

Each journalist assigned to report on the project has different needs in understanding the project based on their goals and experience. For example, an energy reporter for a trade publication may be well-versed in writing about CCS. A journalist for a general publication covering diverse topics may need more context to aid in understanding the topic. Proactively developing relationships with local journalists establishes a communication channel for media to get accurate information from the project team.

The communications team sought opportunities to be proactive in providing information and engage with area journalists, both directly for the project and indirectly as part of EERC-initiated media outreach, such as editorial boards with regional newspapers, fielding media inquiries promptly with useful information, and maintaining existing relationships. A general rule of thumb in media relations is that if they do not receive the information from the project contact, they will find it from somewhere else, and it may be inaccurate or outdated. In developing relationships with journalists, the project benefits most from a communications team that is helpful to media contacts in accomplishing their jobs.

Establishing relationships with influential media in the area facilitates dissemination of accurate information. Having relationships with media reduces the likelihood of misinformation because the reporters come to the source for clarification on key facts. In addition, having those relationships establishes a communication channel to address misinformation as soon as possible. Print and broadcast media in the project area included local, county-size, and statewide components.

Print media targeted for communications included the following:

- *Richardton Merchant*, 983 biweekly circulation
- *Hebron Herald*, 764 weekly circulation
- *Dickinson Free Press*, 4970 daily circulation
- *Bismarck Tribune*, 16,861 daily circulation

Major print media in the region included the following:

- *Fargo Forum*, 65,000 circulation
- *Grand Forks Herald*, 7500 circulation

Broadcast media included the following:

- TV station KFYZ serves Bismarck and western North Dakota, extending to eastern Montana and northern South Dakota, market share unavailable
- TV and virtual station KX News serves Bismarck and western North Dakota, market share unavailable

Both local newspapers, the *Hebron Herald* and *Richardton Merchant*, are run out of the same office. The editor was willing to cover the RTE CCS news articles and open house event in the publications. Because of the small staff, the rapport established during the initial phase of public outreach was easy to maintain, allowing accurate information to be provided during story/article development.

In addition to individual press releases, EERC news stories are filed as blog articles on the EERC website and included in a monthly newsletter, which increases blog views about 5–10 times the original posting. The circulation of the newsletter is about 13,000 people in related energy, agriculture, and government roles and includes media distribution to every newspaper in North Dakota. The blog articles are attached in Appendix A.

The RTE CCS project was featured in several regional media stories and online publications during the reporting period. North Dakota-based media stories were published by all of the targeted print and broadcast media listed above. In addition, stories ran in online publications by ethanolproducer.com, gasworld.com, and greencarcongress.com. Many of the stories posted subsequent to press releases by North Dakota Senator Hoeven, the California Air Resources Board, and the NDIC DMR, as well as EERC releases. Statewide exposure about the project elevates its importance and helps connect it to other CCS projects across North Dakota.

## **RECOMMENDATIONS**

Every outreach activity should be treated as an opportunity to assess and improve. The EERC continues to establish and strengthen connections with media outlets as an objective “go-to source” for project-specific questions as well as relevant geology and CCS concepts. E-mail-ready media packets are generated for each commission meeting, available to RTE staff, and provided to the DMR. Those indirect engagement strategies as well as weblogs, social media, etc. are very useful tools for disseminating science-based information, locally and across the continent.

Personal contact and communication led to measurable benefits in the earlier phases of this project, which likely carried over to this reporting period. Personal contact is also one of the easiest ways to measure effectiveness. The pandemic was the greatest obstacle to providing a similar-quality experience during this reporting period and limited the ability to gauge community sentiment directly. The virtual open house provided indication of interest. While participation at the open house was on a par with community-based, in-person open houses, the number of local residents participating was less than in the past, possibly because of the hurdle of unfamiliar technology. About 45 registrants received the information packet and about 30 logged on to the event. Of the 30 who attended, feedback during the event was positive.

Advanced planning and teamwork are essential. EERC field crews for field activities were briefed on the RTE CCS project and carried copies of the project fact sheet and activity FAQs to share with individuals curious about the activity, the RTE CCS project, or CCS in general. EERC field crews drove and worked from easily identifiable vehicles, were polite and friendly, were respectful of private property, and were conspicuous consumers of the local economy (e.g., took meals in the local café).

Sharing project and activity information, communicating to convey understanding, demonstrating transparency, and showing respect are critical elements to building the trust needed for community support of a CCS effort. Public perception is an aspect that can make or break any first-of-a-kind effort, regardless of how technically and environmentally sound. Key recommendations for the RTE CCS outreach efforts included the following:

- Keep messages consistent across all target audiences.
- Share information with all stakeholders in advance of any field activities; the greater the visibility, the more broadly the information should be shared.
- Provide opportunities for audience questions.
- Use multiple engagement strategies—virtual meetings can be very effective for a portion of the population, including stakeholders who live at a distance from the project.
- Anticipate questions and how they can be addressed.
- Review comments on other CCS-related activities to understand where community concerns lie and to anticipate the sorts of question to be addressed in developing materials (questions invariably tend toward high-level concerns of personal safety, drinking water aquifer protection, and land value).
- Address misinformation, and do so clearly and respectfully.
- Ensure all individuals engaged with project development understand anticipated concerns and how they are being addressed.
- Prepare press packets for every occasion.
- Develop good relationships with media.
- Consider multipurpose uses of outreach materials (provide resource conservation and message consistency).
- Treat every encounter as a chance to make a good impression.
- Provide regular updates on activity status and progress to landowners, local officials, and state regulators—it will be continually appreciated.

Messaging needs to help audiences understand how the technology can be implemented safely, and every encounter with the public—positive and negative—makes an impression. Encounters can occur anywhere, anytime, ranging from planned events (e.g., an open house) to casual conversation (e.g., local café, gas station, etc.). Given the rural close-knit communities near the RTE study region, all encounters will likely be shared among community members as well as the perceived attitudes that accompany them. Concerns to date have centered on human safety, groundwater and environmental protection, sequestration effects on land values, the relationship of CCS to mineral rights ownership, assurance of the permanence of CO<sub>2</sub> sequestration (vs. future extraction for EOR), clarity and full disclosure regarding the process, transparency as the process moves forward, and trustworthiness of the project team and regulatory oversight. Providing opportunities for community members to feel heard not only generates positive attitudes toward the project team but also reveals important concerns to be discussed as this first-of-its-kind facility in this region moves forward.

## **FUTURE OUTREACH OPPORTUNITIES**

Public outreach activities scheduled throughout CCS implementation, particularly any time a project-related activity has potential for public contact or exposure, would help solidify the local acceptance of the project. Opportunities to continue the positive interactions may include (certainly not limited to) the following:

- Construction of a CO<sub>2</sub> capture facility
- Ribbon cutting on the CCS facilities (i.e., start of operations)

- Monitoring activities for permit compliance, such as environmental sampling, geophysical surveys, etc.

Increasing educational outreach would help teachers educate the future generation of decision-makers to engage in problem-solving in their backyard, in their state, in their region and to go beyond the focus on problem identification. Informal education opportunities using displays and demonstrations at county and state fairs, career fairs, STEM Night at the baseball game, etc., could be effective at informing and engaging learners of all ages.

A documentary film showcasing how CCS research culminates into a commercial facility could bring value to the local economy and North Dakota. When North Dakota's lower-carbon ethanol is sold, the broader reach of video brings the story to a larger audience and provides context to help national viewers understand its significance.

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**APPENDIX A**

**RED TRAIL ENERGY CCS PROJECT  
2020–2021 OUTREACH MATERIALS**

## **RED TRAIL ENERGY CCS PROJECT 2020–21 OUTREACH MATERIALS**

### **FACT SHEETS**

CCS Project Fact Sheet, Red Trail Energy CCS Project (March 2021)  
CCS Project Fact Sheet, Red Trail Energy CCS Project (February 2019)  
Activity FAQs, Water and Soil Gas Sampling near Richardton, North Dakota (March 2021)  
Activity FAQs, Geology Study – Drilling Down at Red Trail Energy (completed: March 2021)  
Activity FAQs, Geology Study – Drilling Down at Red Trail Energy (upcoming: February 2020)  
Capturing Carbon Dioxide at Red Trail Energy (August 2021)

### **RTE CCS PROJECT OPEN HOUSE ADVERTISING AND COMMUNICATION MATERIALS**

Event invitation—print (mailed to landowners)  
Event invitation—e-mail (to commissioners)  
Event invitation—teachers (e-mailed to teachers)  
Richardton digital sign text  
Eventbrite registration details  
Zoom link e-mail  
Postevent blog

### **RTE CCS PROJECT VIRTUAL OPEN HOUSE – NOVEMBER 10, 2021**

Planning and timing spreadsheet  
Information packet containing the following:  
    Cover letter with information packet  
    North Dakota is a Great Place for CCUS infographic-style fact sheet  
    Keeping an Eye on Injected CO<sub>2</sub> – CCUS Monitoring infographic-style fact sheet  
    CCS project fact sheet, Red Trail Energy CCS project (March 2021) (see fact sheets above)  
    Capturing Carbon Dioxide at Red Trail Energy (see fact sheets above)  
    Science Says “Go!” at the Red Trail Energy Ethanol Plant, EERC Solutions article  
Full open house slideshow

### **RED TRAIL ENERGY CARBON CAPTURE AND STORAGE PROJECT: 2020–2021 COMMISSION MEETING TALKING POINTS**

Stark County March 3, 2020  
Stark County August 24, 2020  
Stark County April 14, 2021  
Stark County August 10, 2021

### **BLOGS AND PRESS RELEASES**

Red Trail Energy Hosts Open House in Richardton  
Science Says “Go!” at the Red Trail Energy Ethanol Plant

Red Trail Energy Submits North Dakota Carbon Dioxide Storage Facility Permit Application  
New Milestone for Carbon Capture and Storage (UND Today)  
Red Trail Energy and EERC to Host Virtual Open House  
Red Trail Energy Awarded the First CO<sub>2</sub> Storage Facility Permit in North Dakota  
Red Trail Energy Virtual Open House Outlines CCS Project's Promising Future (postevent blog)

**FACT SHEETS**

CCS Project Fact Sheet, Red Trail Energy CCS Project (March 2021)

CCS Project Fact Sheet, Red Trail Energy CCS Project (February 2019)

Activity FAQs, Water and Soil Gas Sampling near Richardton, North Dakota (March 2021)

Activity FAQs, Geology Study – Drilling Down at Red Trail Energy (completed: March 2021)

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Capturing Carbon Dioxide at Red Trail Energy (August 2021)

# RED TRAIL ENERGY CCS PROJECT

# PROJECT

FACT SHEET

INTEGRATED CARBON CAPTURE AND STORAGE FOR NORTH DAKOTA ETHANOL PRODUCTION

## RTE CCS Project

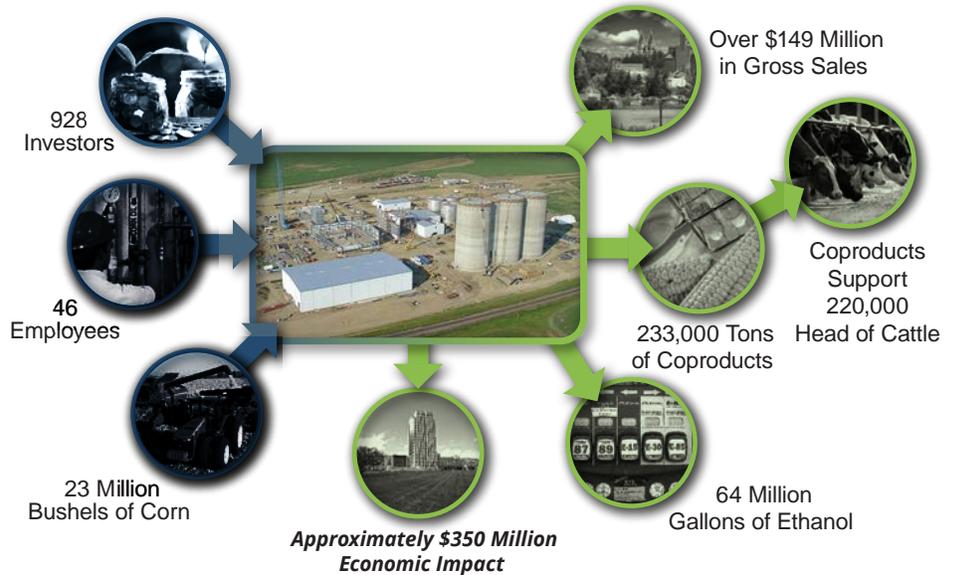
Red Trail Energy, an ethanol production plant in Richardton, North Dakota, is seeking to make its ethanol more valuable by integrating carbon capture and storage, or CCS, to reduce carbon dioxide emissions from ethanol production. Generating an ethanol fuel applicable for low-carbon fuel (LCF) programs in states such as California and Oregon will provide a long-term premium market for Red Trail Energy and stability for employees and local corn growers.

Keeping CO<sub>2</sub> out of the atmosphere could also qualify for federal tax credits to offset some of the cost of integrating and operating CCS.



## Building on Success

Since 2007, Red Trail Energy has been producing corn-based ethanol and distillers grains at its investor-owned plant. The ethanol plant provides an alternative market to farmers in 32 counties in the region and creates tax revenue in eastern Stark County. Integration of CO<sub>2</sub> capture and permanent geologic storage will position North Dakota as a national leader in developing reduced-carbon ethanol with a strategic first-to-market advantage over other states. The ability to command premium pricing and diversify product markets will help secure Red Trail Energy's future, providing stability in a volatile, commodity-driven market.



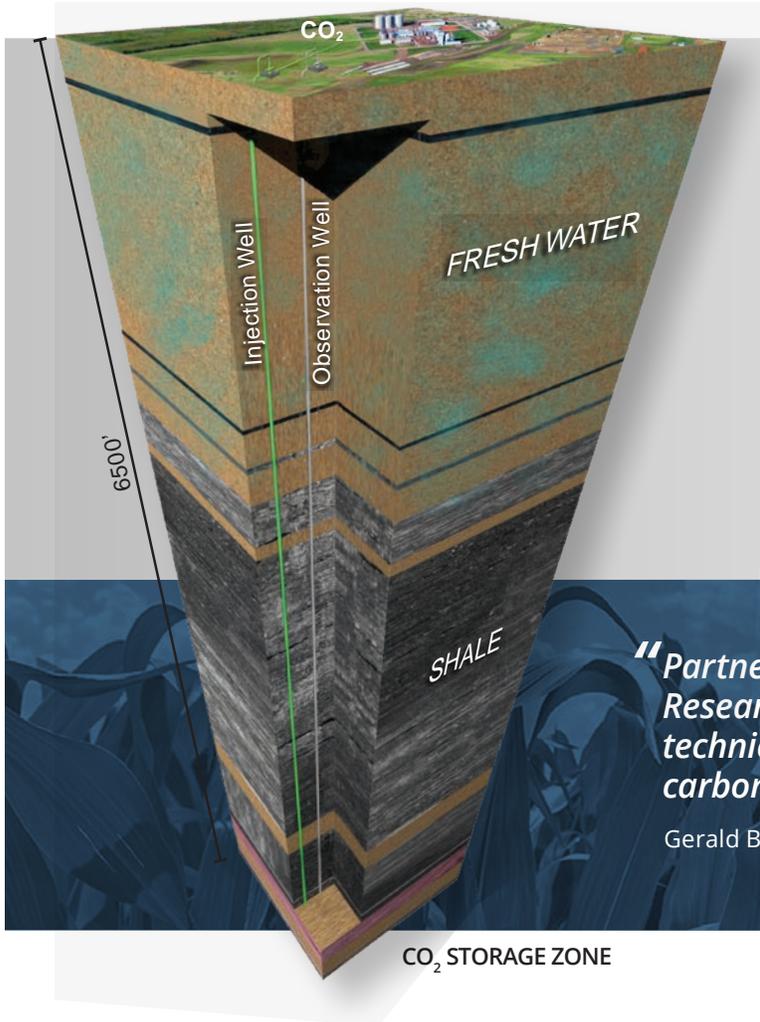
## Carbon Capture and Storage

CCS is the practice of capturing CO<sub>2</sub> emissions from an industrial facility instead of releasing the emissions to the atmosphere. Once captured, the CO<sub>2</sub> is transported to a site for injection and safe, permanent storage deep underground. CO<sub>2</sub> injection is currently practiced in over 100 locations in the United States, typically for extending the life of older oil fields.

*Integrating carbon capture and storage ensures the long-term viability of Red Trail Energy.*

## First of Its Kind

The integrated CCS project is a first of its kind in North Dakota. Incorporating CO<sub>2</sub> capture into the ethanol facility can be done with existing commercial technology. Captured CO<sub>2</sub> could then be injected deep underground and permanently stored. Red Trail Energy must ensure that the CO<sub>2</sub> is never emitted to the atmosphere in order to meet the low-carbon fuel requirement. North Dakota has well-suited geology for safe, permanent CO<sub>2</sub> storage; a regulatory framework to oversee all aspects of such projects; and authority from the federal government to do so.



## Collaboration with Experts

Geologic CO<sub>2</sub> storage requires a deep porous layer to hold CO<sub>2</sub> and overlying impermeable rock layers as seals to keep the CO<sub>2</sub> in place. Red Trail Energy is collaborating with the Energy & Environmental Research Center at the University of North Dakota, a global leader in CCS research. Researchers investigated every aspect of permanent geologic storage below the plant, the cost of CO<sub>2</sub> capture, and the likelihood of economic favorability. These steps were necessary before any permitting or CO<sub>2</sub> injection could take place. The EERC's proven approach features characterization, modeling, and simulations to ensure the efficacy and safety of injecting CO<sub>2</sub> into a suitable geologic container more than a mile deep.

*“Partnering with the Energy & Environmental Research Center has helped us to validate CCS as a technical and economical option for meeting low-carbon fuel program markets in other states.”*

Gerald Bachmeier, Red Trail Energy Chief Executive Officer

## Multiphase Path to a Commercial Venture

Investigation of CCS integration with the Red Trail Energy ethanol plant has been ongoing since 2016. Technical and economical feasibility has been successfully demonstrated. Recent activities include equipment contracting, public outreach, and development of the first North Dakota CO<sub>2</sub> Storage Facility Permit application, submitted in February 2021.

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redtrailenergy.com

### PROJECT PARTNERS



# RED TRAIL ENERGY

# CCS PROJECT FACT SHEET

INTEGRATED CARBON CAPTURE AND STORAGE FOR NORTH DAKOTA ETHANOL PRODUCTION

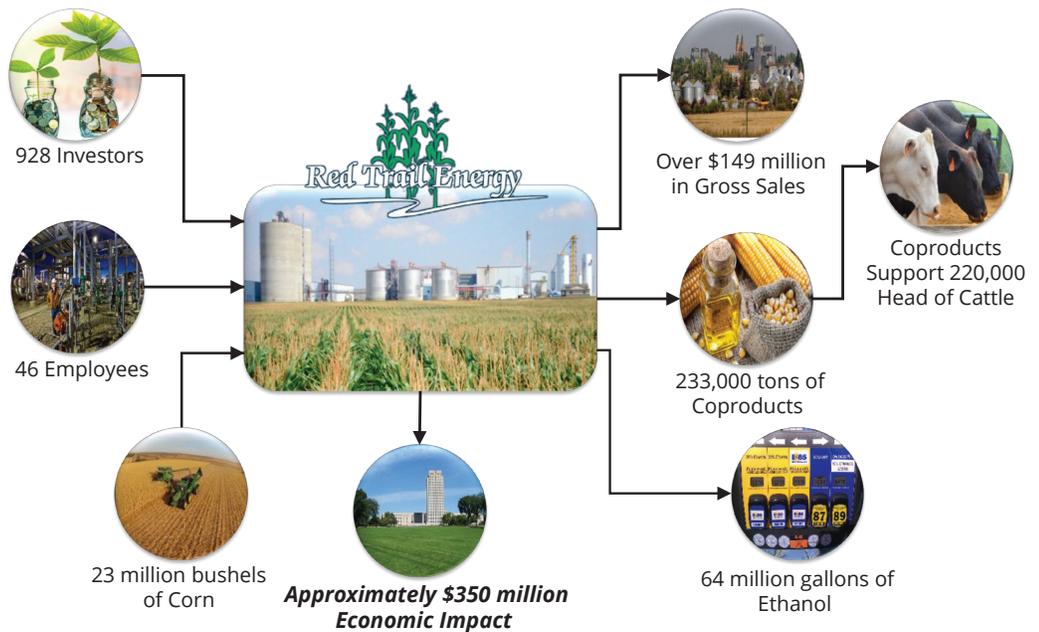
## Red Trail Energy CCS Project

Red Trail Energy, an ethanol plant in Richardton, North Dakota, is seeking to make its facility more sustainable by integrating carbon capture and storage, or CCS, to reduce carbon dioxide emissions from ethanol production. This reduction in CO<sub>2</sub> emissions will make Red Trail Energy's ethanol more valuable to states that have low-carbon fuel programs, such as California. Keeping CO<sub>2</sub> out of the atmosphere could also qualify for federal tax credits to offset some of the cost of integrating and operating CCS.



### Building on Success

Since 2007, Red Trail Energy has been producing corn-based ethanol and distillers grains at its investor-owned plant in Richardton, North Dakota. The ethanol plant provides an alternative market to farmers in 32 counties in the region and creates tax revenue in eastern Stark County. Integration of CO<sub>2</sub> capture and geologic storage will position North Dakota as a national leader in developing reduced-carbon ethanol. The ability to command premium pricing and diversify product markets will help secure Red Trail Energy's future, providing stability in a volatile, commodity-driven market.



### What Is Carbon Capture and Storage?

CCS is the practice of capturing CO<sub>2</sub> emissions from an industrial facility instead of releasing them to the atmosphere. Once captured, the CO<sub>2</sub> is transported to a site for injection and safe, permanent storage deep underground. Carbon dioxide injection is currently practiced in over 100 locations in the United States, typically for extending the life of older oil fields.

*"Integrating carbon capture and storage ensures the long-term viability of Red Trail Energy."*

Gerald Bachmeier, Red Trail Energy Chief Executive Officer

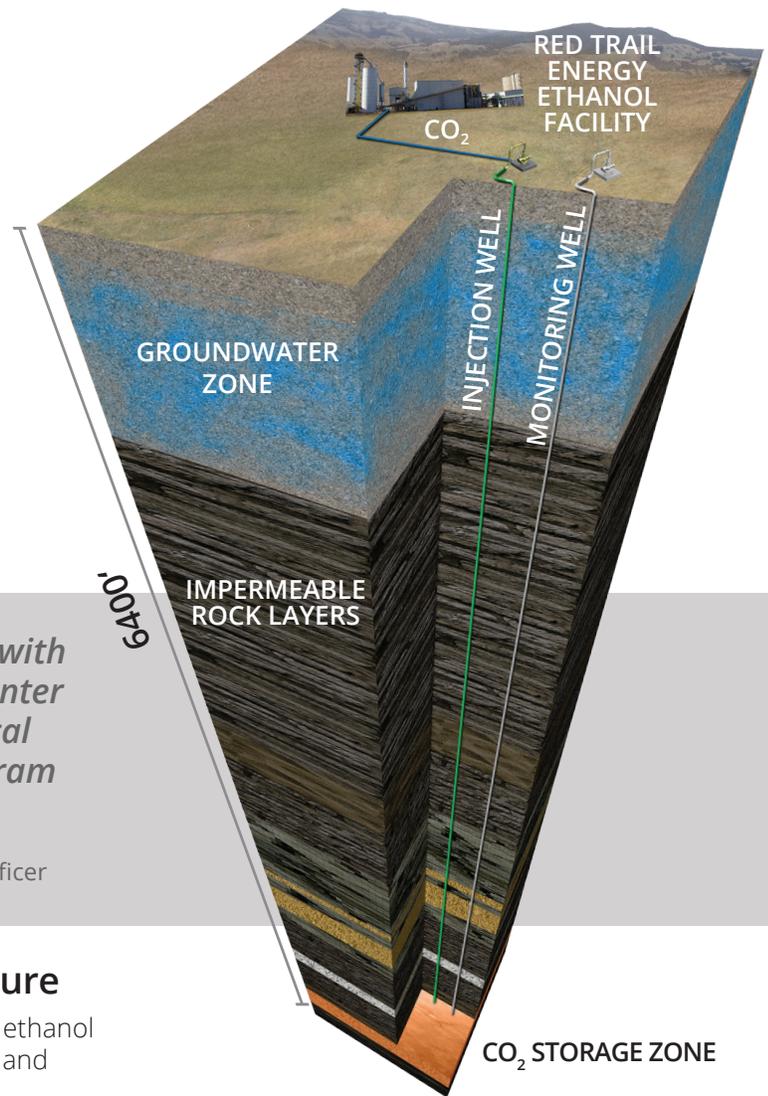
## First of Its Kind

The integrated CCS project is a first of its kind in North Dakota. Incorporating CO<sub>2</sub> capture into the ethanol facility can be done with existing technology. The next step is what to do with the CO<sub>2</sub> once it has been captured. Captured CO<sub>2</sub> could be injected deep underground and permanently stored or potentially sold as a commodity to oilfield operators to increase production in aging wells. Red Trail Energy must ensure that the CO<sub>2</sub> is never emitted to the atmosphere in order to meet new CCS qualifications for low-carbon fuel and tax credit programs. North Dakota has well-suited geology for safe, permanent CO<sub>2</sub> storage; a regulatory framework to oversee all aspects of such projects; and authority from the federal government to do so.



## Collaboration with Experts

Geologic CO<sub>2</sub> storage requires a deep porous layer to hold CO<sub>2</sub> and overlying impermeable rock layers as seals to keep the CO<sub>2</sub> in place. Red Trail Energy is collaborating with the EERC at the University of North Dakota, a global leader in CCS research. The EERC's proven approach features monitoring, characterization, modeling, and simulations to ensure the safety of injecting CO<sub>2</sub> into a suitable geologic container more than a mile deep.



*“We are very excited to continue working with the Energy & Environmental Research Center (EERC) to investigate CCS as an economical option for meeting low-carbon fuel program markets in other states.”*

Gerald Bachmeier, Red Trail Energy Chief Executive Officer

## Multiphase Path to a Commercial Venture

Investigation of CCS integration with the Red Trail Energy ethanol plant has been ongoing since 2016. Preliminary technical and economic feasibility has been successfully demonstrated. Current activities are focused on facility design, geologic characterization, and public outreach.

### For More Information, Contact:

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## PROJECT PARTNERS



## RED TRAIL ENERGY CCS PROJECT

# ACTIVITY FAQs

INTEGRATED CARBON CAPTURE AND STORAGE FOR NORTH DAKOTA ETHANOL PRODUCTION

## Water and Soil Gas Sampling near Richardton, North Dakota

In spring, summer, and fall 2019, field crews from the Energy & Environmental Research Center, (EERC) collected groundwater and soil gas samples near Richardton to learn about natural changes in levels of carbon dioxide and other related components. The data gathering is part of the Red Trail Energy carbon capture and storage (CCS) research effort, which is investigating the feasibility of safe, permanent, commercial-scale geologic storage of CO<sub>2</sub> integrated with ethanol production. The groundwater and soil gas samples provide regional data on natural cycles prior to potential CO<sub>2</sub> storage in the project area.

### Why Did We Sample?

Samples collected and analyzed before potential operations help determine the normal or natural environmental conditions within the project area. If the project advances, North Dakota regulations will require groundwater and soil gas monitoring as part of an extensive monitoring and safety program for sites where CO<sub>2</sub> may be permanently stored deep underground. These data would also help determine whether future changes in CO<sub>2</sub> levels come from natural seasonal cycles or further testing is needed.

For groundwater, the chemical makeup in freshwater aquifers depends on the rocks through which it moves and anything else that filters into the aquifer.

Soil gas comes from the biological activity of the soil's plant, animal, and microbial communities.

As part of the natural carbon cycle of these ecosystems, seasonal changes in CO<sub>2</sub> are being studied to define existing environmental conditions.



### What Is the Benefit of Water and Soil Gas Sampling?

Healthy soil and groundwater are vital, and ensuring that the environment is not negatively impacted by this project is a top priority for Red Trail Energy. Understanding CO<sub>2</sub> behavior in the natural environment before any development occurs helps the operators design an effective monitoring plan as required by the permits prior to potential CO<sub>2</sub> storage. Establishing the natural levels and seasonal changes in CO<sub>2</sub> is also helpful when assessing future monitoring results.

### What Was the Community Impact?

Safety and courtesy are top priorities. Care was taken to protect the environment during sampling activities. Three 2-day activities took place in spring, summer, and fall 2019. Crews used one pickup on existing roadways. Persons near sampling sites could hear a generator or hammer drill as soil gas samples were collected.

## What Do Landowners Need to Know?

Red Trail Energy appreciates the cooperation of landowners participating in this research effort. The 2019 sampling effort has been completed. Sample analysis is underway, and participating landowners will receive the results of the groundwater and soil gas analyses approximately 3 months after each sampling event.

## Where Did We Sample?

Conditions permitting, three water wells and 11 soil gas locations were sampled during each seasonal event. All locations were near the Red Trail Energy facility and Richardton.



*Technicians take some water measurements onsite before collecting groundwater to be analyzed in the laboratory.*

## How Was Sampling Carried Out?

Water samples were collected from existing wells using procedures that have no impact to the well or groundwater system. Soil gas sampling required placement of temporary flags to mark the location that was tested each season. Sample collection at each site took 30 minutes to an hour, with the entire event lasting approximately 2 days.



*Soil gas is collected with a probe driven into the ground 3.5 feet during each sampling event.*

## What Are the Next Steps?

Information on project progress and other potential field activities is available on the EERC's website. An open house showcasing results is planned for winter 2019. The final report will be available to the public in summer 2020.

The ultimate goal of the **Red Trail Energy Carbon Capture and Storage (RTE CCS) Project**, a multiphase research and development effort, is to create the first integrated CCS system in North Dakota. Led by the Energy & Environmental Research Center (EERC) at the University of North Dakota, with support from RTE, the Industrial Commission of North Dakota Renewable Energy Program, and the U.S. Department of Energy, technical partners in this research include Trimeric Corporation, Schlumberger Carbon Services, and Computer Modelling Group.

### For More Information Contact:

**Dustin Willett**, Chief Operating Officer, RTE, [dustin@redtrailenergy.com](mailto:dustin@redtrailenergy.com), (701) 974-3308

**Nikki Massmann**, Director of Communications, EERC, [nmassmann@undeerc.org](mailto:nmassmann@undeerc.org), (701) 777-5428

Learn more at <https://undeerc.org/RedTrailEnergy/>



## RED TRAIL ENERGY CCS PROJECT

## ACTIVITY FAQs

FACT SHEET

INTEGRATED CARBON CAPTURE AND STORAGE FOR NORTH DAKOTA ETHANOL PRODUCTION

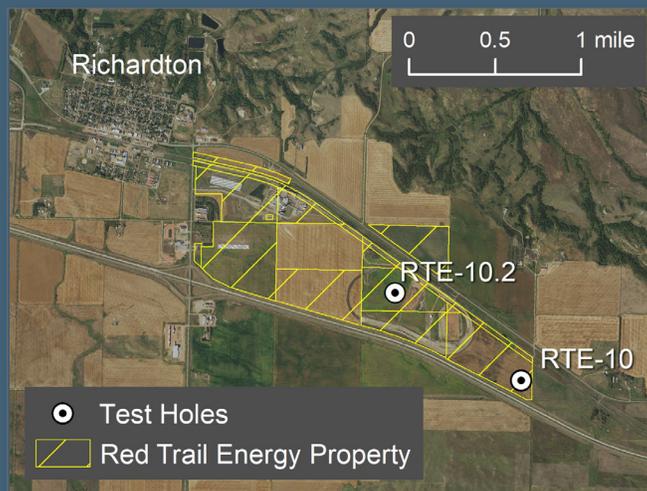
## Geology Study – Drilling Down at Red Trail Energy

Two test holes were drilled on Red Trail Energy property east of Richardton, North Dakota, to provide rock samples (called core) and geologic data as part of the Red Trail Energy carbon capture and storage (CCS) project. Field preparations began in December 2019 for the first hole, which was completed in April 2020. The second hole was completed in October 2020. No CO<sub>2</sub> was injected during either of these tests.

## What Was the Benefit of Drilling a Test Hole?

Information collected from this research activity was added to results from the geophysical survey and existing information to help scientists verify that the deep rock formations underlying the study area will safely and permanently store CO<sub>2</sub> from the local ethanol plant. In addition, this information was necessary to prepare the required state permits for CO<sub>2</sub> injection and storage.

*Two 1.3-mile-deep test holes drilled on Red Trail Energy property east of the ethanol plant provided samples and other data to help determine whether the potential storage zones are suitable for permanent CO<sub>2</sub> storage. Under this research activity, Red Trail Energy obtained permits from state, county, and local officials to perform the test.*



## What Precautions Were Taken?

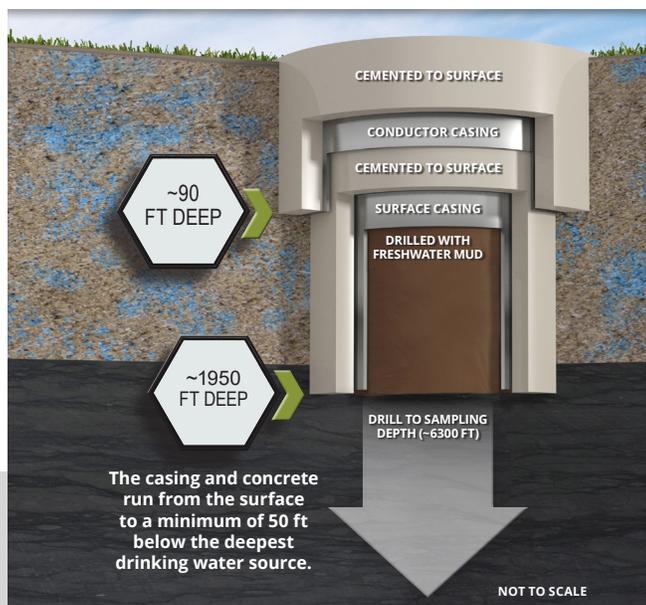
Land and groundwater resources were protected by impermeable barriers installed prior to and during drilling (illustrated at right).

## What Did Researchers Learn?

In the several months following the drilling activity, the rock cores, geologic fluids, and wireline logging data were analyzed and incorporated into the computer model of the subsurface developed with the geophysical survey. Using the results, geologists have determined that the rock layers meet the criteria for safe, permanent geologic storage of CO<sub>2</sub> from the ethanol plant.

## What Is Carbon Capture and Storage, or CCS?

CCS captures CO<sub>2</sub> from industrial processes before it is emitted by the plant, transports the CO<sub>2</sub> to an injection site, and injects the CO<sub>2</sub> deep underground for safe, permanent storage in a suitable rock layer. CCS is best-suited for large stationary facilities such as ethanol plants, coal-fired power plants, cement plants, oil and gas refineries, and agricultural processing plants.



*As required under the permit to drill, groundwater resources were protected during drilling by the use of freshwater drilling mud, then by layers of steel casing and concrete. The casing and cement remain as permanent protection for groundwater; see "Drill the Hole" on the back page for more details.*

## What Were the Basic Steps for This Activity?

Drilling, sampling, and data collection followed the same practices and procedures used to characterize the geology of hydrocarbons, coal, and water resources in North Dakota.

**Obtain Permits** – Drilling the holes for geologic research required permits from the North Dakota Industrial Commission Oil and Gas Division. The permits ensured that proper steps were taken to protect groundwater. The permit for drilling one hole was granted in December 2019. The second permit was granted in September 2020.

**Prepare Drill Site** – Pad preparation entailed leveling and laying aggregate on an area of land approximately 400 × 400 ft to make a flat, stable work area for drilling equipment. Each pad took 10–14 days to complete and created an impermeable barrier to protect the land and groundwater. These barriers remain in place.

**Drill the Hole** – Drilling was completed in four stages. Stage 1 involved digging a hole 90 ft deep, which was lined with steel pipe (conductor casing) and coated with concrete to the surface. Step 2 involved drilling a hole to 100 ft below the bottom of the freshwater zone (~1950 ft). Using freshwater drilling mud prevents groundwater contamination. The hole was fitted with steel pipe (surface casing), the outside of which was cemented from the bottom to the surface to protect drinking water during subsurface activities. Stage 3 continued drilling



*Wireline logging collected data about the rock layers, their fluids, and their pressures.*

to a depth of nearly 5000 ft (into the overlying shale seal above the potential zone for storage). Stage 4, the coring stage, involved collecting multiple cylinders of rock called cores, which were cut using a special hollowed-out drill bit. Stages 3 and 4 were repeated for the second target zone, yielding a total of about 930 ft of core.

**Gather Downhole Data** – After the core samples were removed, a truck with specialized instruments ran sensors into the hole, a technique called wireline logging. This standard drilling industry practice collected data about the rock layers, their fluids, and their pressures.

**Close the Hole** – After data collection was completed, the test hole was sealed temporarily to maintain integrity while data and rock core analysis were performed.



*Multiple cylindrical rock samples called cores were retrieved from the bottom 930 ft of the hole using a specialized coring drill bit.*

The ultimate goal of the **Red Trail Energy Carbon Capture and Storage (RTE CCS) Project**, a multiphase research and development effort, is to create the first integrated CCS system in North Dakota. Led by the Energy & Environmental Research Center at the University of North Dakota, with support from Red Trail Energy, the Industrial Commission of North Dakota Renewable Energy Program, and the U.S. Department of Energy, technical partners in this research include Trimeric Corporation, Schlumberger Carbon Services, and Computer Modelling Group.

### For More Information Contact:

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Learn more at [undeerc.org/RedTrailEnergy/](https://undeerc.org/RedTrailEnergy/)



# RED TRAIL ENERGY CCS PROJECT

# ACTIVITY FAQs

INTEGRATED CARBON CAPTURE AND STORAGE FOR NORTH DAKOTA ETHANOL PRODUCTION

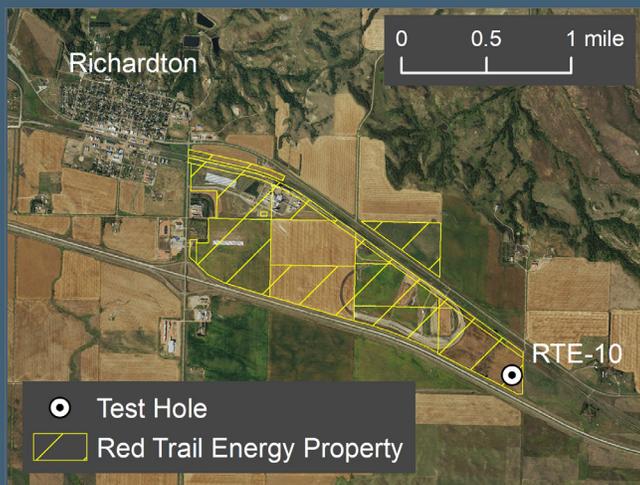
## Geology Study – Drilling Down at Red Trail Energy

A test hole drilled on Red Trail Energy property east of Richardton, North Dakota, will provide rock samples (called core) and geologic data as part of the Red Trail Energy carbon capture and storage (CCS) project. Field preparations began in December 2019, and drilling is expected to occur in early 2020, pending tool and rig availability.

### What Is the Benefit of Drilling a Test Hole?

Information collected from this research activity will be added to results from the geophysical survey and existing information to help scientists verify that the deep rock formations underlying the study area will safely and permanently store CO<sub>2</sub> from the local ethanol plant. In addition, this information is necessary to prepare the required state permits for CO<sub>2</sub> injection and storage.

*The next step in determining whether the potential storage zones are suitable for permanent CO<sub>2</sub> storage is drilling a 1.3-mile-deep test hole on Red Trail Energy property east of the ethanol plant. Under this research activity, permits were obtained from state, county, and local officials to perform the test.*



### What Are the Impacts to the Community?

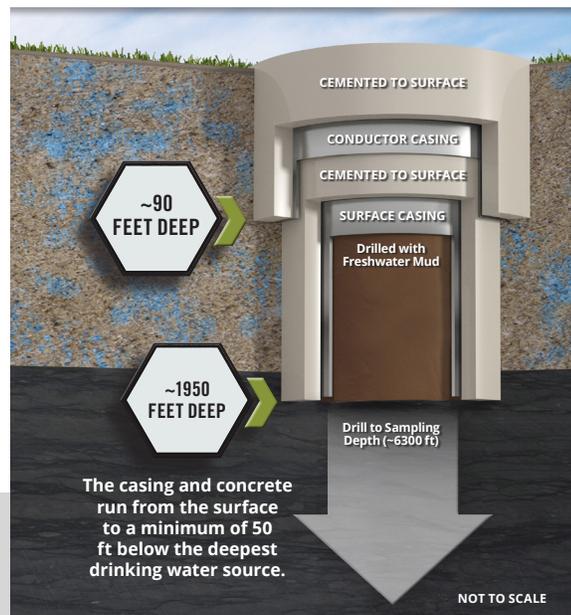
Safety and courtesy are top priorities. Business will increase for the month when drilling personnel travel to and from the job site for food, fuel, and other amenities. During drilling, the land and groundwater resources are protected by impermeable barriers (illustrated at right).

### What Are the Next Steps?

Over several months following the drilling activity, the rock cores, geologic fluids, and wireline logging data will be analyzed and incorporated into the computer model of the subsurface developed with the geophysical survey. Geologists will use the results to determine if the rock layers meet the criteria for safe, permanent geologic storage of CO<sub>2</sub> from the ethanol plant.

### What Is Carbon Capture and Storage or CCS?

CCS captures CO<sub>2</sub> from industrial processes before it is emitted by the plant, transports the CO<sub>2</sub> to an injection site, and injects the CO<sub>2</sub> deep underground for safe, permanent storage in a suitable rock layer. CCS is best-suited for large stationary facilities such as ethanol plants, coal-fired power plants, cement plants, oil and gas refineries, and agricultural processing plants.



*As required under the permit to drill, groundwater resources are protected during drilling by freshwater drilling mud, then isolated with layers of steel casing and concrete. The casing and cement remain as permanent protection for groundwater; see "Drill the Hole" on the back page for more details.*

## What Are the Basic Steps for This Activity?

Drilling, sampling, and data collection will follow the same practices and procedures used to characterize the geology of hydrocarbons, coal, and water resources in North Dakota.

**Obtain Permits** – Drilling a test hole for geologic research requires a permit from the North Dakota Industrial Commission (NDIC) Oil & Gas Division. The permit helps ensure that proper steps are taken to protect groundwater. The permit for drilling was granted in December 2019.

**Prepare Drill Site** – Pad preparation entails leveling and laying aggregate on an ~400- × 400-ft area of land to make a flat, stable work area for drilling equipment. The pad creates an impermeable barrier to protect the land and groundwater and takes about 5–7 days to complete.

**Drill the Hole** – Drilling takes place in four stages. Stage 1 involves digging a hole 90 ft deep, which is lined with steel pipe (conductor casing) and coated with concrete to the surface. Step 2 involves drilling a hole to 100 feet below the bottom of the freshwater zone (~1950 feet). Using freshwater drilling mud prevents groundwater contamination. The hole is fitted with steel pipe (surface casing), the outside of which is cemented from the bottom to the surface to isolate and protect drinking water during subsurface activities. Stage 3 continues drilling to a depth of nearly 5000 ft (into the overlying shale seal above the



*Wireline logging will collect data about the rock layers, their fluids, and their pressures.*

potential zone for storage). Stage 4, the coring stage, involves about 550 ft of the hole where multiple cylinders of rock called cores are cut using a special hollowed-out drill bit. Stages 3 and 4 are repeated for the second target zone, yielding a total of about 1000 feet of core.

**Gather Downhole Data** – After the core samples are removed, a truck with specialized instruments will run sensors into the hole, a technique called wireline logging. This standard drilling industry practice will collect data about the rock layers, their fluids, and their pressures.

**Close the Hole** – After data collection is completed, the test hole will be sealed temporarily to maintain integrity while awaiting data and rock core analysis.



*Multiple cylindrical rock samples called cores will be retrieved from the bottom 2000 ft of the hole using a specialized coring drill bit.*

The ultimate goal of the **Red Trail Energy Carbon Capture and Storage (RTE CCS) Project**, a multiphase research and development effort, is to create the first integrated CCS system in North Dakota. Led by the Energy & Environmental Research Center at the University of North Dakota, with support from Red Trail Energy, the Industrial Commission of North Dakota Renewable Energy Program, and the U.S. Department of Energy, technical partners in this research include Trimeric Corporation, Schlumberger Carbon Services, and Computer Modelling Group.

### For More Information Contact:

**Nicole Massmann**, Director of Communications, EERC, [nmassmann@undeerc.org](mailto:nmassmann@undeerc.org), 701.777.5428

**Dustin Willett**, Chief Operating Officer, RTE, [dustin@redtrailenergy.com](mailto:dustin@redtrailenergy.com), 701.974.3308

Learn more at <https://undeerc.org/RedTrailEnergy/>



**RED TRAIL ENERGY** CCS PROJECT**ACTIVITY FAQs**

FACT SHEET

INTEGRATED CARBON CAPTURE AND STORAGE FOR NORTH DAKOTA ETHANOL PRODUCTION

## Capturing Carbon Dioxide at Red Trail Energy

Red Trail Energy (RTE) is seeking to make its ethanol more valuable by integrating carbon capture and storage, or CCS, to reduce CO<sub>2</sub> emissions from its ethanol production.

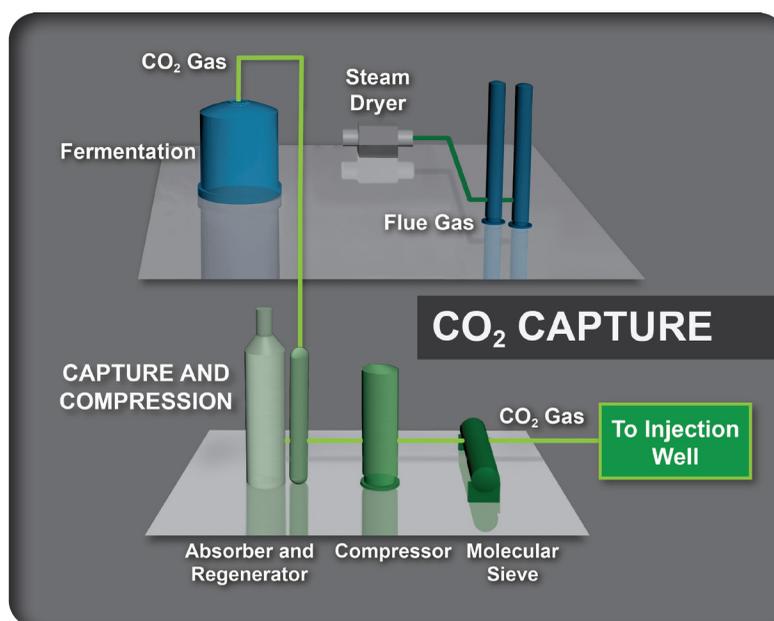
### Where Does CO<sub>2</sub> Come from During Ethanol Production?

CO<sub>2</sub> emissions are by-products of both fermentation and steam generation during ethanol production. During fermentation, yeast digests the starch in ground corn kernels to produce ethanol, with solids and CO<sub>2</sub> as by-products. Drying the leftover solids in natural gas-powered dryers produces a useful animal feed called “distillers grains” and CO<sub>2</sub> from burning the natural gas. The CO<sub>2</sub> from both of these processes is usually vented into the atmosphere.

### How Is the CO<sub>2</sub> Captured?

The CO<sub>2</sub> from fermentation is easy to capture and is currently the only target of the new RTE capture system. The exhaust from the fermentation vessel is mostly CO<sub>2</sub> saturated with water vapor and contains small amounts of oxygen, nitrogen, methane, and aldehydes. Pipes take the exhaust from the fermentation process to the capture facility next to the ethanol plant. The exhaust is compressed and dehydrated to purify the CO<sub>2</sub>. The rest of the exhaust, mainly water vapor and oxygen, is released into the atmosphere.

Water and oxygen are both corrosive to the metal components of the CO<sub>2</sub>-handling system: the flow line, wellhead tubing, fittings, and monitoring components. To enhance the integrity of the system, oxygen and water are minimized, and all metal components are made of noncorrosive materials, like stainless steel.



### What Happens to the Captured CO<sub>2</sub>?

Captured CO<sub>2</sub> will be injected deep underground on RTE property near the ethanol facility for safe, permanent geologic storage. The storage zone, called the Broom Creek Formation, is a sandstone layer more than a mile beneath the RTE plant. The Broom Creek Formation is sealed by several layers of impermeable shales more than half a mile thick that protect groundwater and prevent the CO<sub>2</sub> from escaping.

### How Does CO<sub>2</sub> Get from the Capture Plant into the Ground?

At the RTE capture plant, the CO<sub>2</sub> gas is compressed to 1500 psi to form liquid CO<sub>2</sub>, which flows like water and other liquids. The compressor acts like a water tower, providing the pressure (head) for “downhill” flow through the short flow line to the injection well and into the storage zone. The 4-in.-diameter high-pressure flow line will be buried on RTE property. The system will include shutoff valves to control flow and shut down injection, if needed. Real-time, continuous fiber optic monitoring along the entire path ensures rapid response to any unplanned changes in the system.

## What Is the RTE CCS Project?

RTE plans to capture carbon dioxide from its ethanol plant in Richardton, North Dakota, to permanently store the CO<sub>2</sub> more than a mile underground near the facility. The ultimate goal of this effort is to make a CCS fuel that qualifies for low-carbon-fuel (LCF) programs. Keeping CO<sub>2</sub> out of the atmosphere could also qualify for federal tax credits to offset some of the cost of integrating and operating CCS. Investigation of CCS integration with the RTE ethanol plant has been ongoing since 2016, and economic and technical feasibility has been successfully demonstrated. RTE is set to become the first facility to commercially implement and operate a CCS project in North Dakota.

## Why Capture CO<sub>2</sub>?

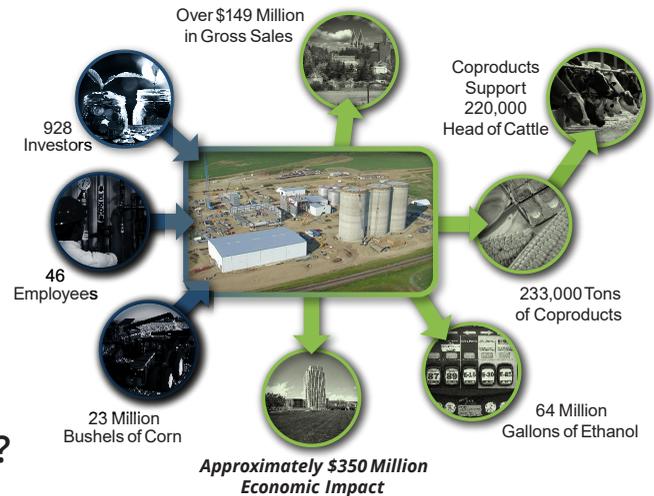
Generating an ethanol fuel applicable for LCF markets will deliver a long-term premium market for RTE, providing stability for the company, its employees, and regional corn growers. LCF programs (such as those in California and Oregon) provide credits for fuels that exhibit a lower carbon life cycle than petroleum, e.g., ethanol compared to gasoline, biodiesel compared to diesel, etc.

## What about Safety for CO<sub>2</sub> Capture?

Commercial technologies to capture CO<sub>2</sub> from the fermentation process already exist and have been in use for nearly 40 years. Guidelines for worker and community safety are well-established.

## How Much Is the Carbon Footprint Reduced?

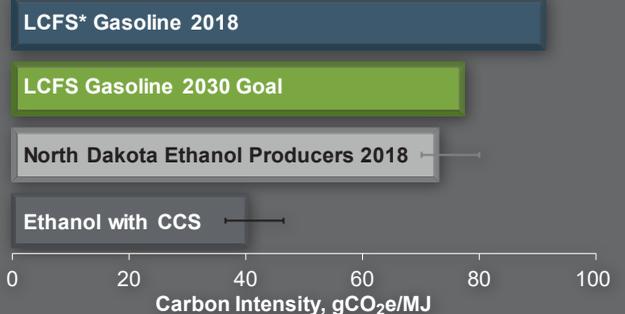
All of the CO<sub>2</sub> produced from the fermentation vessels at the ethanol plant will be captured and permanently stored deep underground. This equates to about half of the carbon footprint for RTE's ethanol.



## What Are LCF Programs?

The objective of LCF programs is to reduce the greenhouse gas emissions of transportation fuels. The details and standards for these state government programs are determined by the legislators and regulatory agencies that develop and design them. As of July 2021, California, Oregon, and British Columbia have active LCF programs. Other states looking to pass bills to establish LCF programs are Washington, Colorado, and several midwestern states. Canadian and Brazilian efforts are also making headway. The metric for LCF programs is the carbon intensity (CI) value. Capturing and permanently storing CO<sub>2</sub> would significantly lower RTE's ethanol CI value, thus generating more CO<sub>2</sub> credits per gallon sold.

## Carbon Intensity by Fuel Type



\*California's Low Carbon Fuel Standard

### For More Information, Contact:

**Dustin Willett**  
Chief Operating Officer, RTE  
dustin@redtrailenergy.com  
701.974.3308

**Red Trail Energy LLC**  
Richardton, ND 58652  
redtrailenergyllc.com

## PROJECT PARTNERS



**RTE CCS PROJECT OPEN HOUSE ADVERTISING AND COMMUNICATION  
MATERIALS**

Event invitation—print (mailed to landowners)  
Event invitation—e-mail (to commissioners)  
Event invitation—teachers (e-mailed to teachers)  
Richardton digital sign text  
Eventbrite registration details  
Zoom link e-mail  
Postevent blog



# RED TRAIL ENERGY, LLC

“Our Farms, Our Fuel, Our Future”

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PO Box 11 Richardton, ND 58652 (701) 974-3308 FAX (701) 974-3309

---

November 1, 2021

«Title» «Landowner\_Name»  
«FullStreet»  
«City», «FullState» «Zip»

Dear «Title» «LastName»:

**Subject: Virtual Open House Invitation**

Red Trail Energy (RTE) is using science to sustain our energy future. After nearly 5 years of research, including a geophysical survey, water and soil gas sampling, and diligent geology and engineering studies, we are approaching the final phases of carbon capture and storage (CCS) implementation. We are excited to share information on the next steps of the RTE CSS project and the positive impact it will have on the region.

Please join us on Zoom for information and updates on the RTE CCS project on Wednesday, November 10, at 6:00 p.m. MST. The event will last about an hour and will include remarks by RTE CEO Gerald Bachmeier and presentations by researchers from the Energy & Environmental Research Center at the University of North Dakota. The event includes time for questions, and a door prize will be given away.

An RSVP is required. Please go to [RedTrailEnergyVirtualOpenHouse.eventbrite.com](https://www.RedTrailEnergyVirtualOpenHouse.eventbrite.com) to register for the event. You can register all the way up to the time of the event. When you RSVP, you can submit questions in advance and elect to receive an information packet by mail to prep for the meeting.

Sincerely,

Dustin Willett  
Chief Operating Officer

DW/cc

Enclosure



# RED TRAIL ENERGY, LLC

“Our Farms, Our Fuel, Our Future”

PO Box 11 Richardton, ND 58652 (701) 974-3308 FAX (701) 974-3309

November 5, 2021

«Commissioner\_FULLNAME»  
«PERSONBUSINESS\_ADDRESSED»  
«ADDRESS»  
«CITY», «STATE» «ZIP\_CODE»

Dear Commissioner:

**Subject: Virtual Open House Invitation**

Red Trail Energy (RTE) is using science to sustain our energy future. After nearly 5 years of research, including a geophysical survey, water and soil gas sampling, and diligent geology and engineering studies, we are approaching the final phases of carbon capture and storage (CCS) implementation. We are excited to share information on the next steps of the RTE CSS project and the positive impact it will have on the region.

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Sincerely,

Dustin Willett  
Chief Operating Officer

DW/cc



# RED TRAIL ENERGY, LLC

“Our Farms, Our Fuel, Our Future”

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PO Box 11 Richardton, ND 58652 (701) 974-3308 FAX (701) 974-3309

---

November 3, 2021

«Faculty\_FULLNAME»  
«PERSONBUSINESS\_ADDRESSED»  
«ADDRESS»  
«CITY», «STATE» «ZIP\_CODE»

Dear Science Teacher:

**Subject: Virtual Open House Invitation**

Red Trail Energy (RTE) is using science to sustain our energy future. After nearly 5 years of research, including a geophysical survey, water and soil gas sampling, and diligent geology and engineering studies, we are approaching the final phases of carbon capture and storage (CCS) implementation. We are excited to share information on the next steps of the RTE CSS project and the positive impact it will have on the region.

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An RSVP is required. Please go to [RedTrailEnergyVirtualOpenHouse.eventbrite.com](https://www.eventbrite.com/e/red-trail-energy-virtual-open-house) to register for the event. You can register all the way up to the time of the event. When you RSVP, you can submit questions in advance and elect to receive an information packet by mail to prep for the meeting. Feel free to share this link with your students and their families.

Sincerely,

Dustin Willett  
Chief Operating Officer

DW

# Richardton Digital Sign Text

## Two Slides

Learn the latest news  
Red Trail Energy CCS Project  
Join RTE's Virtual Open House  
Wed., Nov. 10, 6:00 p.m. MST  
Register for Zoom event  
[undeerc.org/RedTrailEnergy](http://undeerc.org/RedTrailEnergy)

RTE Virtual Open House  
Information and door prizes  
Access by computer or phone  
Wed., Nov. 10, 6:00 p.m. MST  
Register for online event  
[undeerc.org/RedTrailEnergy](http://undeerc.org/RedTrailEnergy)

# Virtual Open House Eventbrite Registration Form

Event Title: Red Trail Energy CCS Project Virtual Open House

Organizer: UND EERC (University of North Dakota Energy & Environmental Research Center)

Categorization: Seminar or Talk, Science & Technology; no sub-category

Tags: carboncaptureandstorage, ccs, eerc, ethanol, northdakota, redtrailenergy, Richardton, virtualopenhouse

Location: Online event

Date and Time: Single event, November 10, 2021, 6:00 p.m.–8:00 p.m.

Main Event Image:



Summary: *Get the latest news on the carbon capture and storage (CCS) project at Red Trail Energy at this online event.*

Description:

Red Trail Energy (RTE) invites you to attend a virtual open house on Wednesday, November 10, 2021 at 6:00 p.m. MST for updates about the RTE CCS project.

The event agenda will include premeeting trivia, presentations by RTE leadership and scientists from the Energy & Environmental Research Center (EERC), time to ask questions, and a door prize drawing for those who register in advance.

A Zoom link will be provided by e-mail to all registrants.

This virtual open house is cohosted by the EERC.

Online Event Page: Turned off to protect meeting disruptions.

Tickets: Please register to receive the Zoom link.

Quantity available: 200

Registrants: 46 from the United States, Canada, and Turkey

## Virtual Open House Eventbrite Registration Form – 2

Order Form:

- (required) Prefix, first name, last name, suffix, e-mail, cell phone, home address
- (optional) Company/organization, information packet request

Attendees were not allowed to edit information after ordering.

Order confirmation (website):

Thank you for your interest in the Red Trail Energy Carbon Capture and Storage Project! Your registration was successful! You should also receive ticket confirmation by email.

Please email us at [info@undeerc.org](mailto:info@undeerc.org) if you have any questions or concerns.

Order confirmation (email): Custom message was added the week of the event:

*Thank you for registering for the Red Trail Energy Carbon Capture and Storage project virtual open house. As a reminder, the meeting starts at 6:00 p.m. MST (7:00 p.m. CST). Below is the direct link to the Zoom meeting.*

***Meeting URL:***

<https://und.zoom.us/j/93392163601?pwd=N01OcHRJOTBzSjE1Z2RscHBMN0VJUT09>

*You can also open the Zoom app or go to [zoom.us](https://zoom.us) and click Join a Meeting. When prompted, type in this information (you can omit the spaces from the Meeting ID):*

***Meeting ID:*** 933 9216 3601

***Passcode:*** energy

*You can test the meeting link at any time. If you test it today and see a message that the meeting hasn't started yet, you did everything correctly. On Wednesday night, the meeting will be live 15 minutes ahead of the scheduled start time, and you are welcome to try then as well. There will be trivia playing for 10 minutes prior to the start of the event. The trivia is just for fun, similar to the slides that play in a movie theater if you arrive early.*

*If you have difficulty logging into the meeting, please e-mail me (Dan) at [dblaufuss@undeerc.org](mailto:dblaufuss@undeerc.org). I will help you get into the meeting.*

*We look forward to updating you on the project. See you Wednesday.*

*Best regards,*

*Dan Blaufuss*

*EERC Outreach Coordinator*

## Zoom Link E-mail

Thank you for registering for the Red Trail Energy Carbon Capture and Storage project virtual open house. As a reminder, the meeting starts at 6:00 p.m. MST (7:00 p.m. CST). Below is the direct link to the Zoom meeting.

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We look forward to updating you on the project. See you Wednesday.

Best regards,

Dan Blaufuss  
Outreach Coordinator

## **Red Trail Energy Virtual Open House Outlines CCS Project's Promising Future**

On Wednesday, November 10, 2021, Red Trail Energy (RTE) gave an update on its carbon capture and storage (CCS) project. More than 50 people registered to hear the latest news at a virtual open house presented over Zoom by RTE and its research partner, the Energy & Environmental Research Center (EERC) at the University of North Dakota. Interested registrants in the project included local landowners and officials as well as industry professionals from the United States, Canada, and Turkey.

The biggest news was the approval of the storage facility permit by the North Dakota Industrial Commission on October 19, which brings the RTE CCS project one step closer to becoming the first of its kind in North Dakota. One of the evening's presentations offered a peek at a small part of the planning and documentation that went into the 600-plus-page storage facility permit.

RTE CEO Gerald Bachmeier shared the history of RTE and gave an overview of the project, with EERC researchers providing detail on carbon capture, the suitability of the storage zone, the storage process, and the extensive monitoring systems that will safeguard human health and ensure environmental protection. The presentations concluded with a look at an EERC research project getting under way at RTE for improved novel monitoring techniques with Japan-based partner, RITE (Research Institute of Innovative Technology for the Earth). Several key takeaways from the presentations include:

- The CO<sub>2</sub> to be injected underground will remain there permanently.
- The rock layers under RTE are well suited for CCS. A highly porous and permeable sandstone layer starting about 6400 feet below the surface has thick shale layers both above and below it that will trap the CO<sub>2</sub> where it is injected.
- The sandstone layer—called the Broom Creek Formation, into which RTE will be injecting CO<sub>2</sub>—can hold at least 1000 times more CO<sub>2</sub> than RTE will inject over the life of the project.
- In a worst-case scenario of damage to the flowline, which is at least 6 feet underground for its entire length, the capture system is specifically designed to revert to venting CO<sub>2</sub> gas into the atmosphere, exactly as happens currently under RTE's air quality permit (and at every ethanol plant without a CCS system).

The evening was widely regarded as educational and interesting and concluded with many questions and answers about a range of topics, including the salt water in the Broom Creek Formation, the concentration of CO<sub>2</sub> from the plant, and the extensive planning and engineering that will prevent blockage of the injection well. The question of whether the CO<sub>2</sub> might be retrieved for use elsewhere (such as oil production) was answered with assurance that the CO<sub>2</sub> will not be retrieved—doing so would be contrary to the agreement under which RTE will receive compensation for sequestration and would force RTE to pay back that compensation.

In his concluding remarks, Bachmeier made clear that the years of research and planning that have gone into the project showed that it would be safe, effective, and a boon to the economic impact RTE has on the region. “We want to be good neighbors,” said Bachmeier, encouraging anyone who had further questions or was interested in learning more about the project to contact RTE directly. Questions can also be sent to EERC researchers by e-mailing [info@undeerc.org](mailto:info@undeerc.org).

**RTE CCS PROJECT VIRTUAL OPEN HOUSE – NOVEMBER 10, 2021**

Planning and timing spreadsheet

Information packet containing the following:

- Cover letter with information packet

- North Dakota is a Great Place for CCUS infographic-style fact sheet

- Keeping an Eye on Injected CO<sub>2</sub> – CCUS Monitoring infographic-style fact sheet

- CCS project fact sheet, Red Trail Energy CCS project (March 2021) (see fact sheets above)

- Capturing Carbon Dioxide at Red Trail Energy (see fact sheets above)

- Science Says “Go!” at the Red Trail Energy Ethanol Plant, EERC Solutions article

Full open house slideshow

# Planning and Timing

Time (Minutes)	Event	Topic	Comments	Speaker	Priority Items/Graphics	Takeaway Message
10:00–2:00	Slideshow Welcome and Chat Tutorial	Agenda, chat usage, trivia	Have a banner at the top making it obvious that this is the RTE open house.	Charlene		This is thoroughly researched and approved and ready to go. This has been a long time coming; we've worked hard/checked with all the groups. Due diligence. This is where we're at.
5:00-7:00	Opening Remarks, Presentation 1	An introduction to RTE and overview of the project timeline.	What's next, and will this change anything in the community?	Gerald	RTE bubble graphic, timeline, pic of RTE property, core pic.	Capturing the CO <sub>2</sub> /CCS (whole package) helps ensure the long-term viability of RTE for its stakeholders and the community.
3:00-5:00	Presentation 2	Carbon Capture	Overview and status.	Kerryanne	Graphics of flowline: one showing source-to-container path and one focused on above-ground path.	The process will capture the CO <sub>2</sub> from the fermentation process—or roughly half the CO <sub>2</sub> emissions from the plant. g g g processes that have already confined salt water to the storage zone, protecting fresh water from what's below. We will monitor from start to finish and have contingencies for any anomalies that might come up. The are no identified fluid migration pathways.
5:00-7:00	Presentation 3	The Storage Process	How do you know it's safe. Geology focus.	Ryan	Two- and three-dimensional columns.	The state has a robust regulatory system requires a lot of characterization (developing an understanding that are the rocks suitable and in the right order) and a lot of monitoring to ensure it's safe, and they have approved our plans.
3:00-5:00	Presentation 4	Permitting	Process, status. Overview, DMR. Take in-depth questions (about mineral rights, etc.) at the end of the night.	Josh R.	Regulation authority map, well class graphic, permitting checklist.	Monitoring tracks the CO <sub>2</sub> and catches and addresses anomalies before any issues arise by enacting mitigation plans that have been developed
3:00-5:00	Presentation 5	Monitoring	Overview and status.	Ryan	Two- and three-dimensional columns, wa	and approved for such scenarios.
3:00-5:00 As Needed	Presentation 6 Post-Meeting Q & A	Other EERC Research at RTE	SASSA.	Kerryanne Charlene	Sources and sensors.	Ongoing research at RTE is focused on capturing even more of the CO <sub>2</sub> from the plant and developing less invasive, lower-cost monitoring techniques.
1:00	Door Prize		We will mail it to whomever wins. Make sure we have an address or way to contact them.	Michelle		
<b>Total Time</b>						
25:00-37:00 plus Q & A						



# RED TRAIL ENERGY, LLC

“Our Farms, Our Fuel, Our Future”

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PO Box 11 Richardton, ND 58652 (701) 974-3308 FAX (701) 974-3309

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November 1, 2021

Thank you for registering for the Red Trail Energy (RTE) virtual open house! Enclosed is the information packet you requested. Included in the packet are the following information sheets:

- RTE CCS Project
- Capturing Carbon Dioxide at Red Trail Energy
- North Dakota is a Great Place for CCUS
- Keeping an Eye on Injected CO<sub>2</sub>: CCUS Monitoring
- Science Says “Go!” at the Red Trail Energy Ethanol Plant

If, after reading through the material, you have questions, you can either e-mail them to [info@undeerc.org](mailto:info@undeerc.org) or ask them during the open house. There will be time for questions between presentations and at the end of the event.

As a reminder, the event takes place on Wednesday, November 10, at 6:00 p.m. MST. The link to the Zoom meeting will be e-mailed to you a couple of days in advance. If it doesn't appear in your inbox, check your junk e-mail folder.

Sincerely,

DocuSigned by:

*Dustin Willett*

E089F55131F44F9...

Dustin Willett

Chief Operating Officer

DW

# NORTH DAKOTA IS A GREAT PLACE FOR CCUS

## CARBON CAPTURE, UTILIZATION, AND STORAGE (CCUS) ADDRESS AN ENVIRONMENTAL CHALLENGE, AND NORTH DAKOTA IS A GREAT PLACE TO DO IT.

Scientists are concerned that increased greenhouse gases from human activities are contributing to climate change.



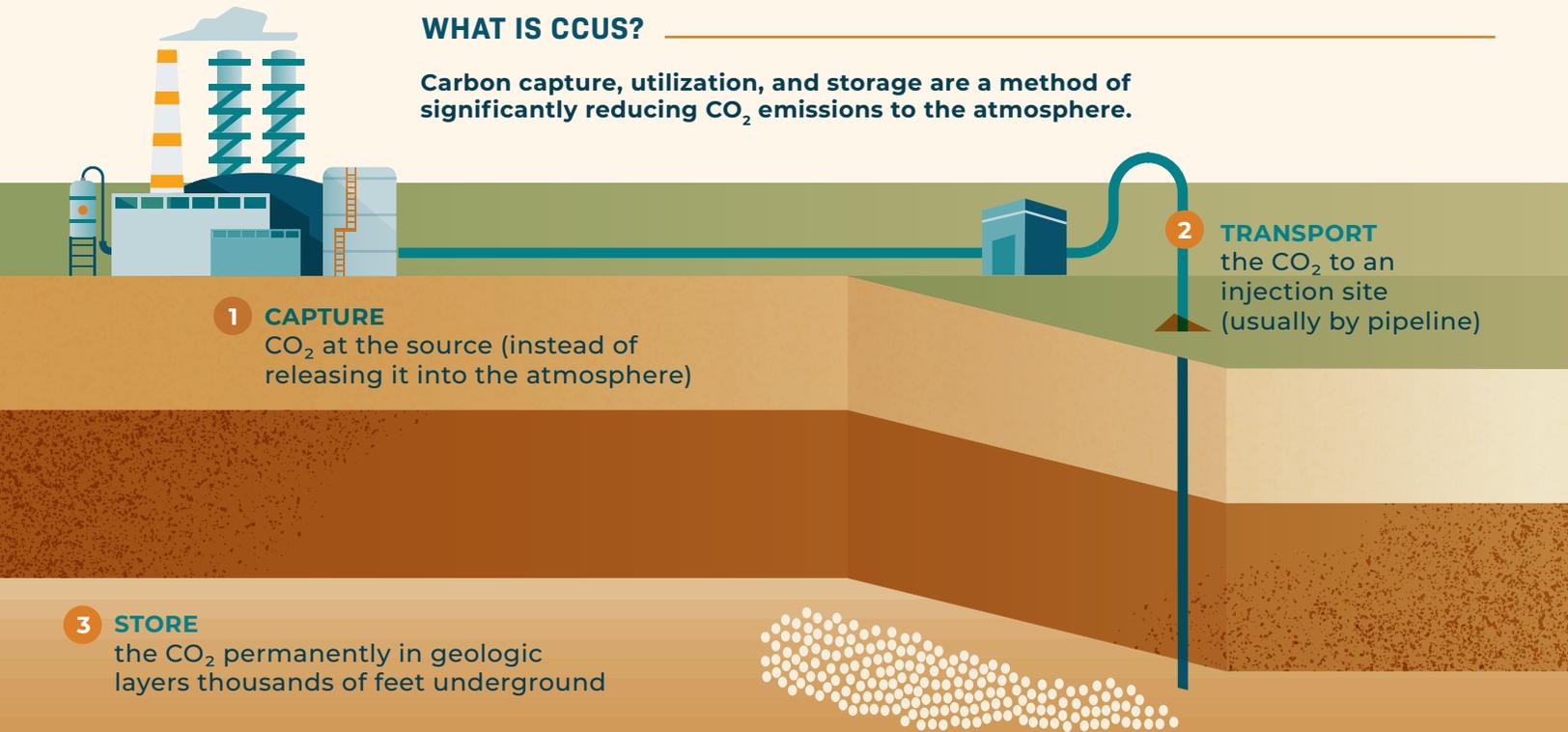
Carbon dioxide from North Dakota's energy development and consumption is one of those greenhouse gases.



CCUS reduces CO<sub>2</sub> emissions from large, stationary sources.

## WHAT IS CCUS?

Carbon capture, utilization, and storage are a method of significantly reducing CO<sub>2</sub> emissions to the atmosphere.



## WHY NORTH DAKOTA IS A GREAT PLACE FOR CCUS!



MULTIPLE LARGE SOURCES OF CARBON DIOXIDE EMISSIONS THAT ARE IMPORTANT TO THE ECONOMY AND QUALITY OF LIFE IN A VARIETY OF WAYS

These CO<sub>2</sub> sources include various industrial plants:



Agricultural processing (ethanol)



Produce energy



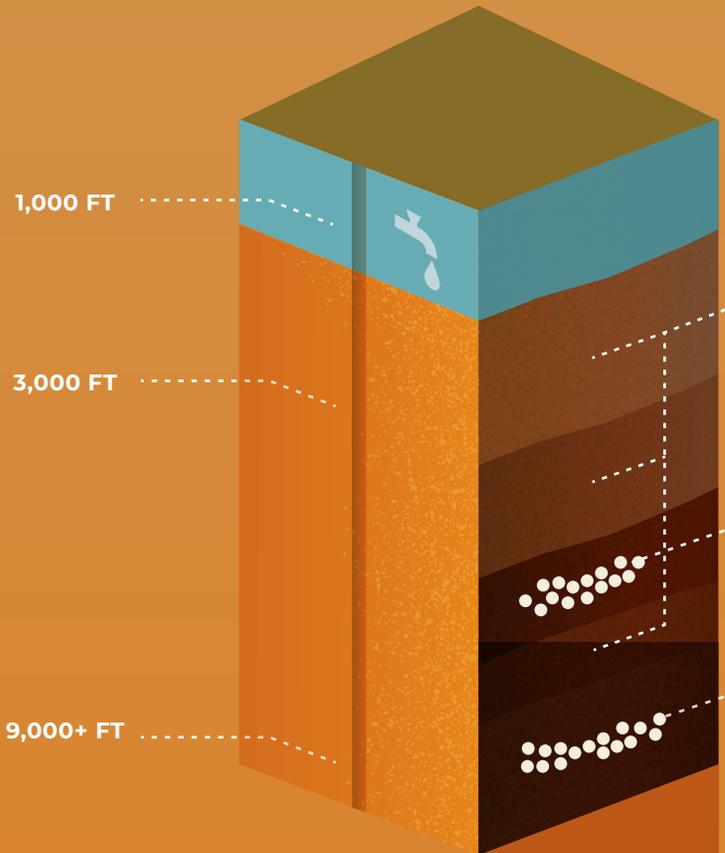
Provide economic benefits like jobs



Coal-based facilities (electrical generation, gasification)



## THE RIGHT GEOLOGY FOR SAFE, PERMANENT STORAGE IN DEEP, DEEP ROCK LAYERS



### STABLE GEOLOGY

- ✓ Very low risk for seismic events

### CAP ROCKS

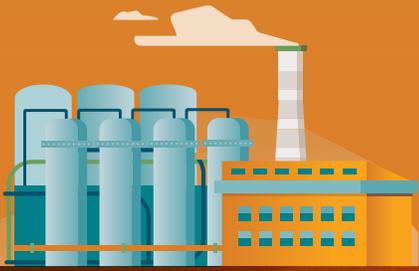
- ✓ Impermeable rocks prevent salty water and CO<sub>2</sub> from leaving the injection zone

### INJECTION ZONES

- ✓ Porous rocks containing salty water
- ✓ Older oil fields that might use CO<sub>2</sub> to produce more oil while permanently storing CO<sub>2</sub>
- ✓ North Dakota's potential injection zones are large enough to hold all the CO<sub>2</sub> from North Dakota's energy facilities



## CO<sub>2</sub> SOURCES LOCATED NEAR POTENTIAL PERMANENT STORAGE SITES



## THE RIGHT REGULATORY, INDUSTRY, AND POLICY ENVIRONMENT



- ✓ Structure to oversee safe, permanent CO<sub>2</sub> injection and storage
- ✓ Authority to regulate CO<sub>2</sub> injection wells
- ✓ Long-term liability laws for the permanently stored CO<sub>2</sub>
- ✓ State regulatory agencies familiar with the state's subsurface geology
- ✓ Experience with CO<sub>2</sub> pipelines

**SUPPORT THE DEVELOPMENT OF CCUS IN NORTH DAKOTA AS A CLEAN ENERGY STRATEGY.**

LEARN MORE AT [UNDEERC.ORG](http://UNDEERC.ORG)



U.S. DEPARTMENT OF ENERGY



# Keeping an Eye on Injected CO<sub>2</sub> CCUS MONITORING

Permanently storing CO<sub>2</sub> captured from industrial sources can help address climate change concerns.

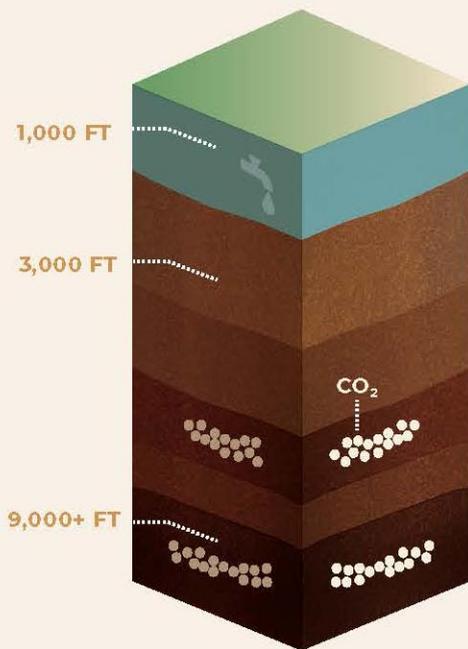
## HOW DO WE KNOW THE PROCESS IS SAFE?

CO<sub>2</sub> capture, utilization, and storage (CCUS) projects are designed to be safe for humans and the environment. Plans and operations throughout the CCUS project ensure the CO<sub>2</sub> will stay within the geologic rock layer into which it's injected.

## BEFORE THE PROJECT BEGINS:



CCUS professionals select only the best sites for safe, permanent CO<sub>2</sub> storage



### CONTAINMENT

Sealed container (sealing or cap rocks above the storage zone)

### CAPACITY

More than enough space to hold all the injected CO<sub>2</sub>

### STABILITY

No geologic faults in the surrounding rock

### DEPTH

Ample barriers between the storage zone and sources of drinking water

### CHEMISTRY

Rock compatible with CO<sub>2</sub> injection

### PRESSURE

Injection pressure won't break rock layers



Predict lateral movement of CO<sub>2</sub> in the storage zone



How far will the CO<sub>2</sub> move over time?



How fast?



Seek project approval from North Dakota regulatory authority to operate storage facilities and inject CO<sub>2</sub>

- ✓ Provide proof that the permanent storage container is safe
- ✓ Provide plans for:



Safe injection and monitoring



Leak detection and reporting

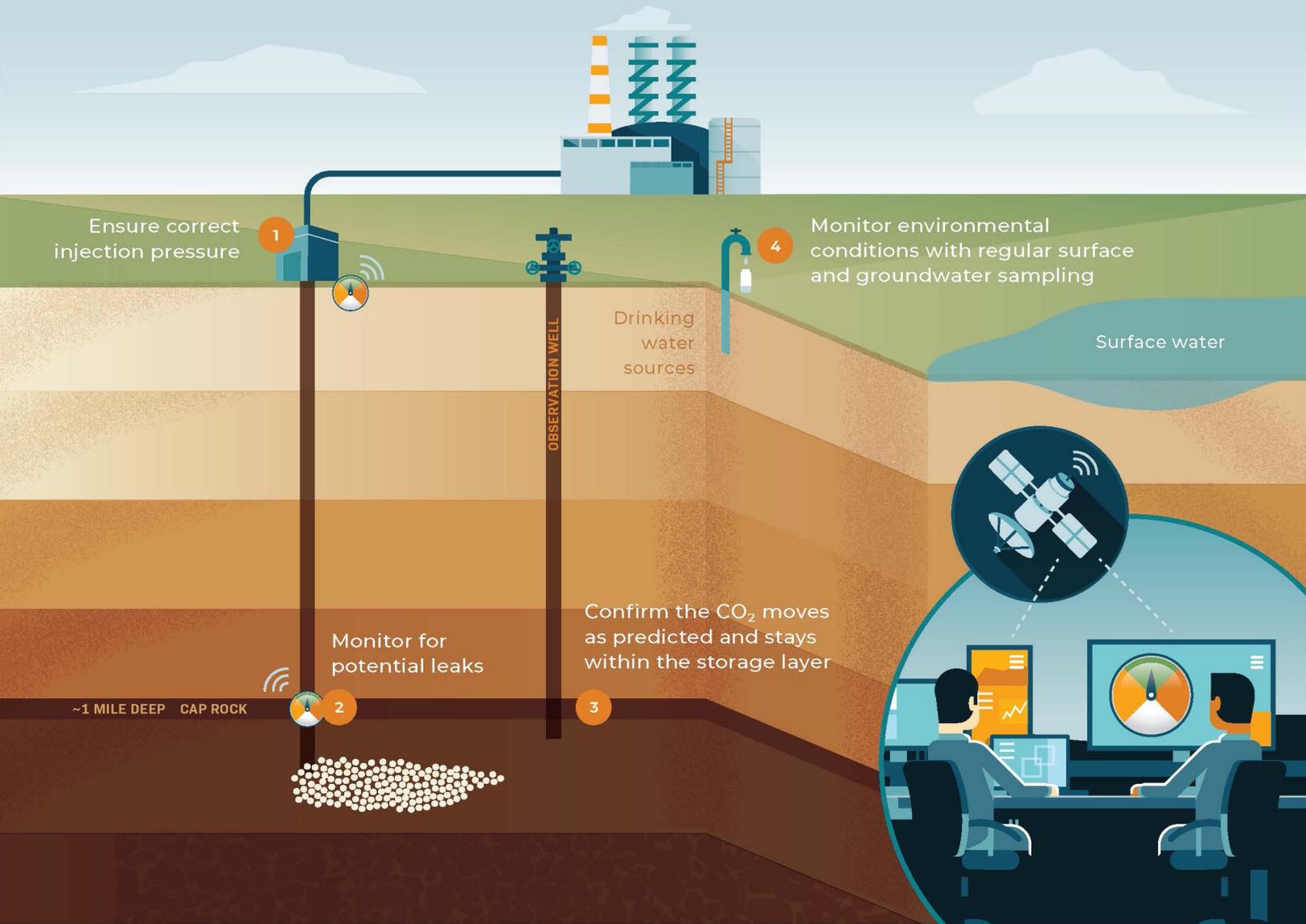


Risk assessment and mitigation



Post-injection site care and closure

## DURING THE CO<sub>2</sub> INJECTION PHASE:



## AFTER THE CO<sub>2</sub> INJECTION PHASE HAS ENDED:

Continue monitoring according to permit plan until the CO<sub>2</sub> stops moving (at least 10 years)



Support the development of CCUS  
in North Dakota as a clean energy strategy.

LEARN MORE AT [UNDEERC.ORG](http://UNDEERC.ORG)

**RED TRAIL ENERGY** CCS PROJECT

## Science Says “Go!” at the Red Trail Energy Ethanol Plant

Thursday, February 4, 2021

<https://blog.undeerc.org/2021/02/04/science-says-go-at-the-red-trail-energy-ethanol-plant/>

RICHARDTON, N.D.—Science says “Go!” on a carbon capture and storage (CCS) project in Richardton. CCS addresses environmental concerns and strengthens the local economy by reducing carbon dioxide emissions, which also increases the value of the ethanol.

Red Trail Energy, LLC (RTE) and its research partner, the Energy & Environmental Research Center (EERC), investigated every aspect of the permanent geologic storage potential deep below the plant, the cost of CO<sub>2</sub> capture, and the likelihood that low-carbon fuel (LCF) markets and regulations would line up to make North Dakota’s first-ever commercial CCS project safe and cost-effective.

The positive outcomes bring the implementation of a commercial-scale CCS system at the RTE facility one giant leap forward. Generating an ethanol fuel applicable for LCF programs will provide a long-term premium market for RTE, providing stability for employees and local corn growers. The results also provide a path forward for other North Dakota renewable energy or biofuel producers in the region to add value to their products with LCF programs, such as California and Oregon.

Years of research went into that conclusion. The thorough analysis of geology more than a mile underground required innovative sleuthing and a variety of techniques. In addition to gathering existing drilling data, RTE drilled two holes more than 6400 feet deep to collect geologic data, rock, and fluid samples. Over 950 ft of rock as well as fluid samples were collected and analyzed by researchers to develop a model of the subsurface and evaluate its ability to accept and contain CO<sub>2</sub> captured from RTE’s ethanol processing. EERC researchers also used a geophysical survey to project sound waves from the surface into the subsurface and analyze the reflected signal.

The myriad analyses fed the creation of computer models of the subsurface in the RTE study area. Improved and refined with each new set of data, these models provided a geologic template for CO<sub>2</sub> injection simulations to predict CO<sub>2</sub> movement during storage. The target storage layer below the RTE plant is called

the Broom Creek Formation. It is a thick, porous sandstone layer pressed between thick layers of tightly sealed shale. EERC researchers used the model to predict the effects of CO<sub>2</sub> injection on those geologic seals, including safe injection pressures for maintaining those confining layers.



*Drilling exploratory holes allows researchers to collect rock samples deep below ground, cutting core that arrives at the surface encased in long metal sleeves. The sleeves are measured, labeled, and cut to 3-foot lengths for shipment to the lab.*

They evaluated the entire geologic structure of the area around Richardton, looking for faults, fractures, seismic activity, and potential mineral resource zones. In the end, the results show that the Broom Creek and its shale seals do indeed have the ability to safely and permanently store the nearly 200,000 tons of CO<sub>2</sub> to be captured and injected annually by RTE through decades of operation. The results of these efforts are needed to prepare

the required North Dakota permit application for commercial CO<sub>2</sub> injection and storage, called a CO<sub>2</sub> storage facility permit.

The immediate economic driver is the LCF markets in states like California that are looking for ways to reduce the carbon footprint of transportation fueled by the internal combustion engine. The RTE CCS team has been working with West Coast regulators to ensure that the delivered ethanol will meet the requirements of California’s Low Carbon Fuel Standard, a program



*A rock core cut from the target CO<sub>2</sub> storage layer 6400 feet below ground shows the pink sandstone of the Broom Creek Formation. It has the consistency of playground sand.*

that includes monitoring to ensure that the CO<sub>2</sub> stays permanently trapped in its storage layer. Other states with LCF programs are expected to adopt those standards in the future. Ensuring a market share is critical to survival in the shifting energy market.

In addition to economics, technology is a major limiting factor in the rate at which innovative concepts become reality. Are the materials, processes, and technologies needed to carry out CCS on an ethanol plant available?

Separating and capturing CO<sub>2</sub> from ethanol fermentation gases have become established processes in the last 10 years and require site-specific engineering and not-quite off-the-shelf equipment. The compression, transport, and injection of CO<sub>2</sub> have been effectively developed over 40 years of enhanced oil recovery (EOR). The novel technological challenge for dedicated CO<sub>2</sub> storage (a challenge not faced by EOR) is proving that it stays put—and does so affordably and thus sustainably. Innovations by researchers and private companies continue to expand the toolbox and bring down the cost of monitoring CO<sub>2</sub> deep underground.

The RTE CCS project work included creating a monitoring plan that accounted for technical, economic, and regulatory components. For example, elements of the plan are focused on tracking CO<sub>2</sub> during injection and in the storage zone using real-time pressure and temperature data, as well as repeating monitoring well testing and geophysical surveys at specified intervals. Other elements include monitoring groundwater and soil gas as assurance of environmental protection.

North Dakota legislators and regulators recognized the potential for CCS to play a critical role in the state's energy production and made key decisions to regulate geologic storage projects within the state. In April 2018, the U.S. Environmental Protection Agency formally recognized the framework and procedures established by the North Dakota Department of Mineral Resources (DMR) by granting DMR's application for Class VI primacy.

Class VI refers to the EPA well classification established to regulate wells dedicated to permanent CO<sub>2</sub> storage. North Dakota's proactive request for primacy from EPA maintains the safe implementation established by federal regulations, facilitates communication, and incorporates local geology expertise.



*Once the permits are approved, the exploratory hole drilled in spring 2020 will be converted into the CO<sub>2</sub> injection well. The second test site, drilled in October, will be converted into a monitoring well for the CCS project.*

The next steps, as laid out in DMR regulations, require the submission of a complete North Dakota carbon storage permit application. All of the research results must be compiled into a five-part package of evidence making the case for safe, permanent geologic storage beneath the RTE ethanol plant.

The DMR, in consultation with the North Dakota Department of Environmental Quality, will evaluate the permit application to determine whether approval should be granted. This first-time regulatory process is estimated to take 8–12 months and includes a public comment period and hearing. Approval would bring RTE one step closer to becoming the first facility in North Dakota to commercially capture and permanently store CO<sub>2</sub>.

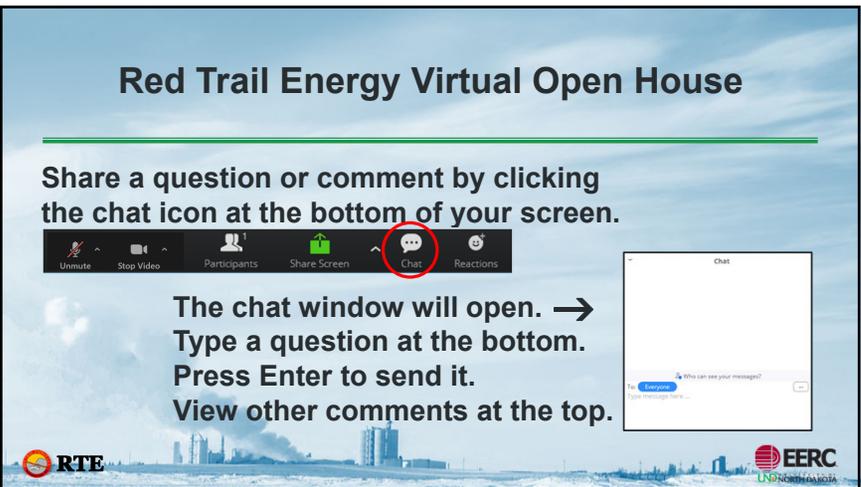
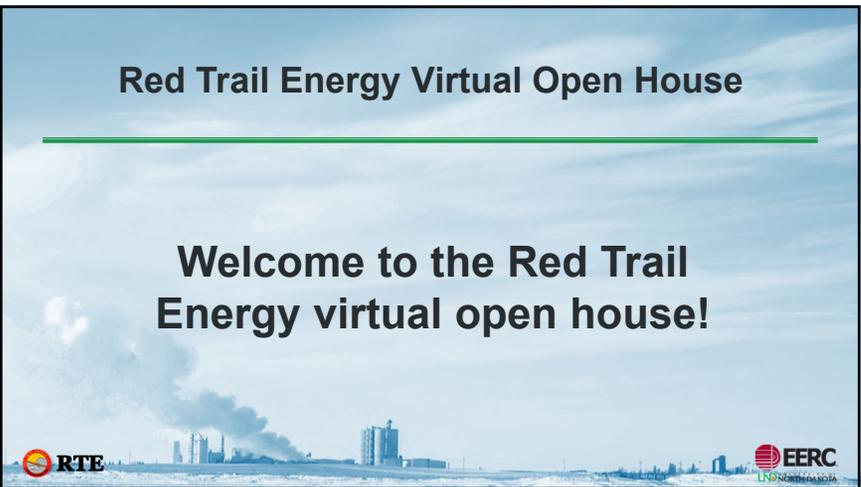
#### For More Information, Contact:

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701.974.3308

**Red Trail Energy LLC**  
Richardton, ND 58652  
redtrailenergyllc.com

#### PROJECT PARTNERS

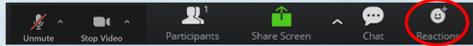




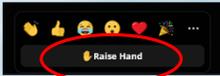
## Red Trail Energy Virtual Open House

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Raise your hand to ask a question by clicking on the Reactions icon



and then clicking on the Raise Hand button.





## Red Trail Energy Virtual Open House

### Enjoy Pre-Event Trivia

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Scottish physicist and chemist Joseph Black studied the properties of carbon dioxide in the 1750s. By what name did he know CO<sub>2</sub>?

- A. Ether
- B. Fixed Air
- C. Phlogistia




## Red Trail Energy Virtual Open House

### Enjoy Pre-Event Trivia

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B. Fixed Air

Joseph Black called it this because it was different from “common elastic air” (his name for the atmosphere) and reasoned it must have been “fixed” by the basic magnesium carbonate he had heated up.




## Red Trail Energy Virtual Open House

### Enjoy Pre-Event Trivia

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What percent of Earth’s atmosphere is carbon dioxide?

- A. 4%
- B. 0.4%
- C. 0.04%



Image credit: NASA




## Red Trail Energy Virtual Open House Enjoy Pre-Event Trivia

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C. 0.04%

Earth's atmosphere is approximately 78% nitrogen, 20% oxygen, and 0.9% argon. Water vapor can make up anywhere from 0%–3% of the atmosphere, and there are only trace amounts of everything else.



## Red Trail Energy Virtual Open House Enjoy Pre-Event Trivia

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The word *gas* likely originates from which Greek word?

- A. Chaos (meaning disorder)
- B. Gaster (meaning stomach)
- C. Kinesis (meaning movement)



## Red Trail Energy Virtual Open House Enjoy Pre-Event Trivia

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A. Chaos (meaning disorder)

The word *gas* was coined by Flemish chemist Jan Baptist van Helmont in about 1640 to describe the substance given off by burning charcoal. Helmont was the first person to realize there are gases different than atmospheric air.



## Red Trail Energy Virtual Open House Enjoy Pre-Event Trivia

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After nitrogen and oxygen, the next four most abundant substances in Earth's atmosphere are argon, water vapor, carbon dioxide, and neon. Which of these are considered greenhouse gases?

- A. Carbon dioxide
- B. Carbon dioxide and water vapor
- C. Carbon dioxide, water vapor, argon, and neon



## Red Trail Energy Virtual Open House

### Enjoy Pre-Event Trivia

**B. Carbon dioxide and water vapor**

Argon and neon are noble gases, which rarely react with anything. Argon's primary use is in making nonreactive atmospheres for activities like arc welding. Neon's primary use is in advertising signs.



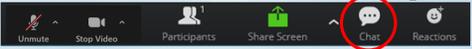
## Red Trail Energy Virtual Open House

# Welcome to the Red Trail Energy virtual open house!

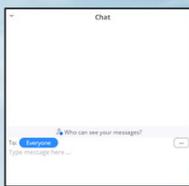


## Red Trail Energy Virtual Open House

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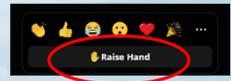


## Red Trail Energy Virtual Open House

Raise your hand to ask a question by clicking on the Reactions icon



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Red Trail Energy Virtual Open House  
*Enjoy Pre-Event Trivia*

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How thick, on average, is the Earth's crust under North America?

- A. 5 miles
- B. 10 miles
- C. More than 20 miles



Red Trail Energy Virtual Open House  
*Enjoy Pre-Event Trivia*

---

C. More than 20 miles

On average, the Earth's crust under North America is 22.8 miles thick. The crust under North Dakota is thicker than this average and in some places might be as much as 31 miles thick.



Red Trail Energy Virtual Open House  
*Enjoy Pre-Event Trivia*

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Ethanol coproducts produced by Red Trail Energy support how many head of cattle?

- A. 50,000
- B. 100,000
- C. 220,000



Image credit: Kari Suedel, Energy & Environmental Research Center



Red Trail Energy Virtual Open House  
*Enjoy Pre-Event Trivia*

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C. 220,000

That many dairy cows would produce 1.65 million gallons of milk per day. That many cattle could also produce 96.8 million pounds of beef.



Red Trail Energy Virtual Open House  
*Enjoy Pre-Event Trivia*

---

The word *carbon* comes directly from which language?

- A. Dutch
- B. French
- C. German



Red Trail Energy Virtual Open House  
*Enjoy Pre-Event Trivia*

---

B. French

Carbon comes from the French *charbon*, which itself comes from the Latin *carbō*, meaning charcoal. It is believed that the Latin is derived from the Proto-Indo-European word *\*ker*, a root meaning *heat* or *fire*.



Red Trail Energy Virtual Open House  
*Enjoy Pre-Event Trivia*

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Approximately how far below the surface will Red Trail Energy be injecting carbon dioxide?

- A. 1000 feet
- B. 2800 feet
- C. 6400 feet



Red Trail Energy Virtual Open House  
*Enjoy Pre-Event Trivia*

---

C. 6400 feet

This is 1.2 miles below the surface, where the sandstone of the Broom Creek Formation is.



## Red Trail Energy Virtual Open House

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# Welcome to the Red Trail Energy virtual open house!



The slide features a background image of an industrial facility with smokestacks emitting plumes of smoke against a cloudy sky. The RTE logo is on the left and the EERC logo is on the right.

## Red Trail Energy Virtual Open House

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### Agenda

- Welcome
- Remarks from Gerald Bachmeier
- Timeline
- Carbon Capture Process
- Permitting
- Monitoring
- Other EERC Research at RTE
- Door Prize

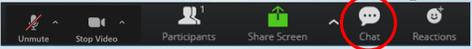


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## Red Trail Energy Virtual Open House

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Share a question or comment by clicking the chat icon at the bottom of your screen.



The chat icon (two speech bubbles) in the Zoom control bar is circled in red.

The chat window will open. →  
Type a question at the bottom.  
Press Enter to send it.  
View other comments at the top.



The screenshot shows a chat window with a text input field at the bottom and a list of messages at the top.



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## Red Trail Energy Virtual Open House

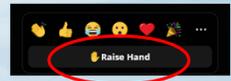
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Raise your hand to ask a question by clicking on the Reactions icon



The reactions icon (a face with a plus sign) in the Zoom control bar is circled in red.

and then clicking on the Raise Hand button.



The 'Raise Hand' button in the reactions bar is circled in red.



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Red Trail Energy Virtual Open House  
Enjoy Pre-Event Trivia

What does CCS stand for?

- A. Carbon capture in sandstone
- B. Carbon capture and storage
- C. Commandeering carbon safely



Red Trail Energy Virtual Open House  
Enjoy Pre-Event Trivia

B. Carbon capture and storage

A related acronym is CCUS, which stands for carbon capture, utilization, and storage.



Red Trail Energy Virtual Open House  
Enjoy Pre-Event Trivia

What percent of Venus's atmosphere is carbon dioxide?

- A. 25%
- B. 67%
- C. 96%



Image credit: NASA/JPL-Caltech



Red Trail Energy Virtual Open House  
Enjoy Pre-Event Trivia

C. 96%

The CO<sub>2</sub>-induced greenhouse effect on Venus makes its surface temperature even hotter than the daylight side of Mercury, although Venus is, on average, 186% farther from the sun.



Red Trail Energy Virtual Open House  
*Enjoy Pre-Event Trivia*

---

What year was carbon dioxide first liquefied?

- A. 1823
- B. 1875
- C. 1912



Red Trail Energy Virtual Open House  
*Enjoy Pre-Event Trivia*

---

A. 1823

Carbon dioxide requires high pressure (at least 75 psi) and a certain temperature range (between -69.9° and 88°F) to become a liquid. At normal atmospheric pressure, it will turn directly from a gas to a solid.



Red Trail Energy Virtual Open House  
*Enjoy Pre-Event Trivia*

---

How many gallons of ethanol does Red Trail Energy produce per year?

- A. 10 million
- B. 32 million
- C. 64 million



Red Trail Energy Virtual Open House  
*Enjoy Pre-Event Trivia*

---

C. 64 million

Adding carbon capture and storage to the process makes this ethanol desirable to the low-carbon fuel programs in California, Oregon, and British Columbia, providing a long-term premium market for Red Trail Energy and stability for employees and local corn growers.



Red Trail Energy Virtual Open House

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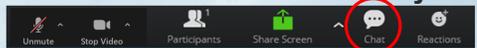
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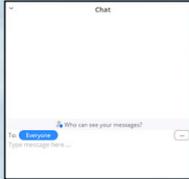
Red Trail Energy Virtual Open House

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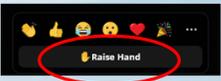

Red Trail Energy Virtual Open House

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Raise your hand to ask a question by clicking on the Reactions icon



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Red Trail Energy Virtual Open House

---

*Enjoy Pre-Event Trivia*

The word *oxygen* comes from the French word *oxygène*, which is a corruption of a Greek phrase meaning what?

- A. I bring forth acid
- B. Vitality to the kidneys
- C. Fire weather



Red Trail Energy Virtual Open House  
*Enjoy Pre-Event Trivia*

---

A. I bring forth acid

In the late 1700s, oxygen was falsely believed to be a key to forming acids.



Red Trail Energy Virtual Open House  
*Enjoy Pre-Event Trivia*

---

What is solid carbon dioxide called?

- A. Dry ice
- B.  $\text{SCO}_2$  (solid carbon dioxide)
- C.  $\text{SSCO}_2$  (solid state carbon dioxide)



Red Trail Energy Virtual Open House  
*Enjoy Pre-Event Trivia*

---

A. Dry ice

The earliest description of dry ice came in 1835, from Adrien-Jean-Pierre Thilorier, who didn't realize he had produced solid carbon dioxide until scientists from the French Academy of Sciences explained it to him.



Red Trail Energy Virtual Open House  
*Enjoy Pre-Event Trivia*

---

Approximately how much economic impact does Red Trail Energy have on the region?

- A. \$75 million
- B. \$150 million
- C. \$350 million



**Red Trail Energy Virtual Open House**  
*Enjoy Pre-Event Trivia*

---

C. \$350 million

This includes 928 investors, 46 employees, 23 million bushels of corn, and more than \$149 million in gross sales.



The slide features a background image of an industrial facility with smokestacks emitting plumes of smoke. At the bottom, there are logos for RTE (Red Trail Energy) on the left and EERC (Energy Efficiency Research Center) on the right, with 'UN NORTH DAKOTA' written below the EERC logo.

**Red Trail Energy Virtual Open House**  
*Enjoy Pre-Event Trivia*

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What makes North Dakota an ideal place for safe, permanent CO<sub>2</sub> storage?

- A. Well-suited geology
- B. The regulatory framework to oversee all aspects of such projects
- C. Authority from the federal government to do so
- D. All of the above



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**Red Trail Energy Virtual Open House**  
*Enjoy Pre-Event Trivia*

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D. All of the above.

The science says “Go,” the permits are approved, and the future is full of promise!



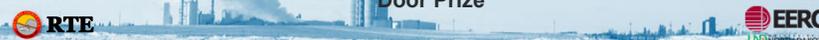
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**Red Trail Energy Virtual Open House**

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Agenda

- Welcome
- Remarks from Gerald Bachmeier
- Timeline
- Carbon Capture
- Process
- Permitting
- Monitoring
- Other EERC Research at RTE
- Door Prize



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## Red Trail Energy Virtual Open House

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**Welcome!**

**Thank you for joining us!**



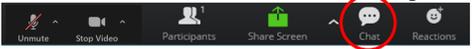
### AGENDA

- *Welcome/Tutorial*
- *Opening Remarks*
- *Timeline*
- *Carbon Capture*
- *Process*
- *Permitting*
- *Monitoring*
- *Other Research*

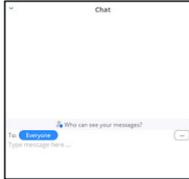
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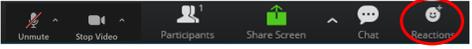

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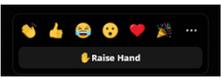
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### Raising Your Virtual Hand

Raise your hand to ask a question by clicking on the Reactions icon



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### AGENDA

- *Welcome/Tutorial*
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### List of Topics

Remarks from Gerald Bachmeier  
 Timeline  
 Carbon Capture  
 Process  
 Permitting  
 Monitoring  
 Other EERC Research at RTE  
 Door Prize



# Opening Remarks

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**Gerald Bachmeier**  
CEO of Red Trail Energy




## Red Trail Energy, LLC Richardton, North Dakota

**AGENDA**

- Welcome/Tutorial
- Opening Remarks
- Timeline
- Carbon Capture
- Process
- Permitting





928 Investors



46 Employees



23 million bushels of Corn



Red Trail Energy



Over \$149 million in Gross Sales



233,000 tons of Coproducts



64 million gallons of Ethanol



Coproducts Support 220,000 head of Cattle

Approximately \$350 million of Economic Impact






## Project Timeline

**AGENDA**

- Welcome/Tutorial
- Opening Remarks
- Timeline
- Carbon Capture
- Process
- Permitting
- Monitoring
- Other Research

2016	2017	2018	2019	2020	2021
Phase I: Prefeasibility		Phase II: Feasibility		Phase III: Design	
Determined Techno-Economic Viability		Initiate Monitoring and Characterization		Drill Stratigraphic Test Well	
Section 45Q Tax Credit Passed		Addressed Knowledge Gaps; Outreach Plan		Attain Formal CO <sub>2</sub> Capture Quotes	
ND Class VI Primacy Granted		Finalize Geologic Characterization		Contract and Order Equipment	
Permitting and Outreach		Start CCS Operations!			

Image credit: Energy & Environmental Research Center




### Everything Stays Safe On RTE Property

**AGENDA**

- Welcome/Tutorial
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The map displays the Red Trail Energy (RTE) property layout. Key features include the 'Capture System' area, a 'Fiber Optic along entire Flow Line (underground > 6ft)', a 'Monitoring Well', and an 'Injection Well'. Specific wells are labeled RTE-10-2 and RTE-10. A legend identifies symbols for Red Trail Energy, Injection Well, Monitoring Well, Flow Line, Red Trail Energy Property, BLM Property, Capture System, CO<sub>2</sub> Blower Skid, and CO<sub>2</sub> Liquefaction Plant. A scale bar shows 0, 750, and 1,500 feet.

**RTE** **EERC**  
UND NORTH DAKOTA

### Collecting Core

**AGENDA**

- Welcome/Tutorial
- Opening Remarks
- **Timeline**
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- Process
- Permitting
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- Other Research

The left photo shows workers in safety gear at night, handling equipment. The right photo shows a large industrial pipe with a reddish-brown core sample being collected.

**RTE** **EERC**  
UND NORTH DAKOTA

### Share Questions and Comments in Chat

**AGENDA**

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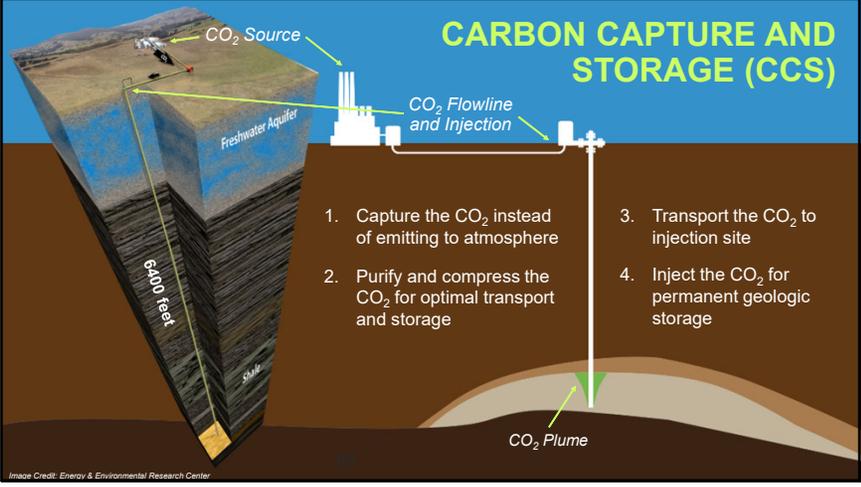
# Carbon Capture

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## Kerryanne Leroux

EERC Project Manager, Principal Engineer

**RTE** **EERC**  
UND NORTH DAKOTA



### Capture System

**AGENDA**

- Welcome/Tutorial
- Opening Remarks
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- Other Research

# Process

---

**Ryan Klapperich**  
EERC Geologist, Monitoring Team Lead

### Focus on Geology

**AGENDA**

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# Permitting

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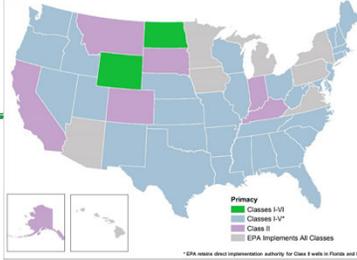
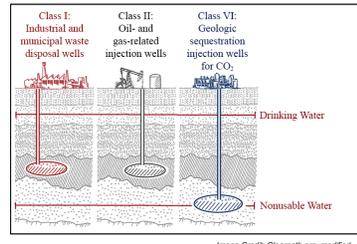
## Josh Regorrah

EERC Regulatory Specialist, Geologist




### AGENDA

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- Regulating authority is North Dakota Industrial Commission (NDIC)
- RTE received approval for permanent CO<sub>2</sub> storage on October 19, 2021
- **First State to Acquire Primary Regulatory Authority (Class VI Primacy!)**
- Meets or exceeds all EPA Class VI requirements

### AGENDA

## North Dakota CO<sub>2</sub> Storage Permitting

- Welcome/Tutorial
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- **Permitting**
- Timeline
- Monitoring
- Carbon Capture
- Other Research

### North Dakota CO<sub>2</sub> Storage Facility Permit (Class VI) Checklist

- ✓ Approved on **October 19, 2021**

- ✓ Pore Space (Affidavit + Maps)
- ✓ Geologic Exhibits (a.k.a. Technical Evaluation)
- ✓ AOR Delineation (Maps + Corrective Action Plan)
- ✓ Emergency and Remedial Response Plan
- ✓ Worker Safety Plan
- ✓ Corrosion Monitoring and Prevention Plan
- ✓ Leak Detection and Reporting Plan
- ✓ Well Casing and Cementing Program
- ✓ Testing and Monitoring Plan
- ✓ Well-Plugging Plan
- ✓ Postinjection Site Care and Facility Closure Plan
- ✓ Injection Well and Storage Reservoir Information
- ✓ Financial Assurance Demonstration

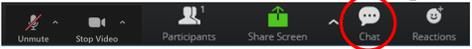



### AGENDA

## Share Questions and Comments in Chat

- Welcome/Tutorial
- Process
- Opening Remarks
- **Permitting**
- Timeline
- Monitoring
- Carbon Capture
- Other Research

Share a question or comment by clicking the chat icon at the bottom of your screen.



The chat window will open. ➔  
Type a question at the bottom.  
Press Enter to send it.  
View other comments at the top.





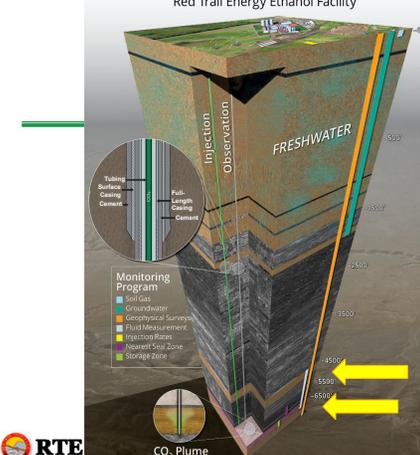

# Monitoring

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## Ryan Klapperich

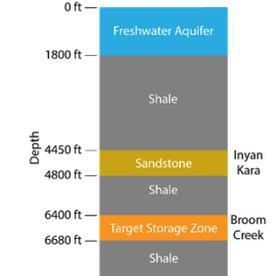
EERC Geologist, Monitoring Team Lead



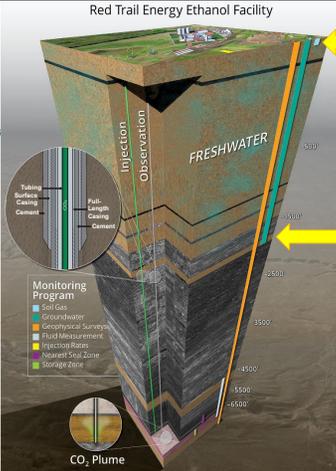



### AGENDA

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- Opening Remarks
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### AGENDA

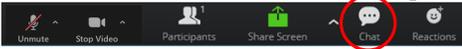
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The chat window will open. →  
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 Press Enter to send it.  
 View other comments at the top.






# Complementary Research

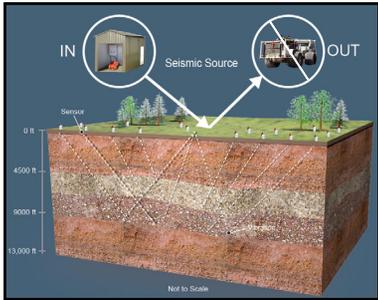
**Kerryanne Leroux**  
EERC Project Manager, Principal Engineer



### AGENDA

- Welcome/Tutorial
- Opening Remarks
- Timeline
- Carbon Capture
- Process
- Permitting
- Monitoring
- **Other Research**

## Exploring New Monitoring Techniques



### AGENDA

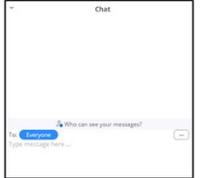
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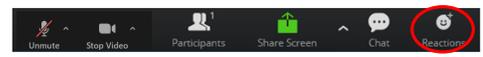


### AGENDA

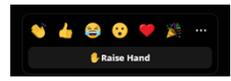
## Raising Your Virtual Hand

- Welcome/Tutorial
- Opening Remarks
- Timeline
- Carbon Capture
- Process
- Permitting
- Monitoring
- **Other Research**

Raise your hand to ask a question by clicking on the Reactions icon



and then clicking on the Raise Hand button.



## Questions?

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Image Credit: Energy & Environmental Research Center



## Door Prizes

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**RED TRAIL ENERGY CARBON CAPTURE AND STORAGE PROJECT: 2020–2021  
COMMISSION MEETING TALKING POINTS**

Stark County March 3, 2020

Stark County August 24, 2020

Stark County April 14, 2021

Stark County August 10, 2021

**Red Trail Energy Carbon Capture and Storage Project: Phase III Talking Points**  
**March 3, 2020, Stark County Commission Meeting**

**Red Trail Energy:**

- Is looking for ways to ensure the sustainability of the company and the market for its ethanol into the future (*see fact sheet in the packet*).
- Is working with the Energy & Environmental Research Center (EERC) at the University of North Dakota to determine whether carbon capture and storage at the Richardton facility would be safe and economically feasible.
- Successfully completed the geophysical survey and data analysis.

**The next step in determining whether the potential storage zones are suited for permanent CO<sub>2</sub> storage is to drill a test well to collect rock samples (cores), pressure information, and other data.**

- RTE finalized the test hole location on RTE property and plans to drill through the Broom Creek Formation, 1.3 miles deep.
- The Richardton City Planner was notified of the test hole location by RTE via a Special Use permit application submitted on November 21, 2019.
- We submitted a permit application to drill to the North Dakota Industrial Commission (NDIC), Department of Mineral Resources (DMR) Division of Oil & Gas on November 25.
- NDIC DMR approved our test hole application by awarding a permit on Monday, December 2, 2019.
- The well pad was completed by year's end (2019). It will protect groundwater and soils from fluids associated with the drilling and prevent precipitation runoff.
- The drill rig is expected this week. The start date for drilling the test hole is March 6, pending rig availability.
- The drilling activities involve a drill rig on-site for about 1 month. The sequence is:
  - Protect drinking water resources by drilling to ~1950 ft, lining the hole with steel pipe and concrete.
  - Drill to about 5000 ft, top of the rock core collection point.
  - Use a hollow bit (core bit) to drill through and pull up ~550 ft of potential seal and storage zone rocks (cores) (Inyan Kara Formation).
  - Drill to about 5800 ft, top of the second rock core collection point.
  - Use the core bit to collect another ~450 ft of core from a second seal/storage zone (Broom Creek Formation). The total depth will be about 6300 ft.
  - Run measuring tools down the hole to collect more geologic data and fluid samples (wireline logging). This involves a large enclosed truck with a crane and spooled cable.
  - Close the hole temporarily while the cores and other data are evaluated.
- Analysis of the rock, fluids, and other data is anticipated to take about 6 to 8 months.

- We will keep you informed as the effort progresses.
- We invited the community to an open house Wednesday, December 11, at the American Legion in Richardton to provide details to the community. Gerald Bachmeier, RTE's CEO, spoke about the project. EERC Geophysicist Amanda Livers shared the results of the geophysical survey. The open house was well attended, with about 30 community members participating. We appreciated the interest and opportunity to engage with the community.

**The groundwater- and soil gas-sampling activities wrapped up for the year.**

- Landowners have received the results of the May and August 2019 water and soil gas sampling. November results were compiled and are being sent out this week.
  - a. If asked: Later than originally anticipated owing to a delay in receipt of results.

**The EERC will do the following:**

- During the drilling activity, provide technical advisory support for rock collection, fluid sampling, and downhole testing.
- Following the drilling activity, perform laboratory analysis on the collected rock and fluid samples and add those results with other drilling activity and geophysical survey data to evaluate the ability of the deep rock layers to safely and permanent store CO<sub>2</sub> at rates generated from the RTE plant..
- For the work to date, prepare a report discussing the geophysical survey and sampling project results (available to the public in spring 2020).

**Public Engagement *[or Public Outreach]*:**

- We held a community open house on March 6 in Richardton, introducing the project and 2019 activities.
- We contacted landowners to obtain permission for sampling access permissions (April 2019) and let them know ahead of each sampling event.
- We will continue to provide periodic updates to you and city officials as the project progresses.
- Periodic updates will also be available through the EERC's Web page, social media, and print media (May–December 2019).
- We held a community open house on December 11 in Richardton, sharing the 2019 research results and introducing the 2020 drilling activity to collect geologic data.

For more information, contact me (see my card in the packet).

**For reference:**

Items in the packets:

- *RTE fact sheet*
- Drilling FAQs
- Dustin's card
- For the media packet: Press release, March 3, 2020: *RTE CCS project drilling begins this month*

**Details of the geophysical survey:**

- Completed the geophysical survey over about 8 square miles east of Richardton as an early step in investigating safe, permanent geologic storage of carbon dioxide.
  - The survey was successfully completed, accessing only lands where permission was granted—including limited access to county road ditches.
  - The geophysical data were processed and evaluated. The results were reported to landowners individually (*see Geophysical Survey Results in the packet*).
  - The survey and data collection were a success!
  - The survey company, Breckenridge, submitted the completion report to the North Dakota Industrial Commission. The company's surety bond with the state will stay in place for several more years.
  - RTE worked with landowners and the state inspector to complete reclamation work for damages to private gravel roadways and cropland related to the geophysical exploration survey. The state inspector has since been to the site to check how crops are growing and has commented that he did not observe any negative impact to crop growth in the areas where the trucks drove for the survey.
  - The data from the survey helped evaluate the rock layers more than a mile below the surface around the RTE facility. We learned that:
    - Two layers might serve as permanent CO<sub>2</sub> storage zones: the Inyan Kara Formation at just under a mile deep, and the Broom Creek Formation at 6400 ft deep—our original target layer.
    - Both layers are sealed by more than 1000 ft of cap rock, through which gases and liquid do not flow.
    - About 3000 ft of impermeable sealing rock isolates these saltwater layers from the deepest drinking water aquifer.

#### Details of the Groundwater and Soil Gas Sampling

- Healthy soil and groundwater are vital. Ensuring that the environment is not negatively impacted by this project is a top priority for Red Trail Energy.
- Three 2-day sampling events were completed in May, August, and November 2019.
- Groundwater samples were drawn from existing wells with landowner permission. Three wells were sampled, all from the well spigot.
- Soil gas samples were collected from about 3.5 feet below the surface using a temporary probe and battery-operated pump. A pickup-mounted generator and rotary hammer drive the probe into the ground. Weather permitting, we collected soil gas at 11 locations accessed with landowner permission and near existing roads and field crossings. Six are on RTE property.
- All sites are near the Red Trail Energy ethanol facility and Richardton, North Dakota, study area.
- Landowners have received the results of the May and August 2019 water and soil gas sampling events. November results were compiled and sent out in early March 2020.

**E-Mail Content**

**Date: August 24, 2020**

**From: Dustin Willett**

**To: Kay Haag, Auditor, Stark County, ND**

**Subject: Red Trail Energy Carbon Capture and Storage Project Update for the Stark County Commissioners**

Ms. Haag,

Thank you for accommodating our request during these unusual times and allowing Red Trail Energy, or RTE, to provide an update to the Stark County Commissioners via e-mail. Please share the following information and attached materials. Note that I would be happy to provide additional information as needed.

**Red Trail Energy wishes to keep you updated on the Carbon Capture and Storage (CCS) Project in a safe fashion as we self-isolate for health and safety. As you know, RTE:**

- Is looking to ensure the sustainability of the company and the market for its ethanol into the future (*see CCS Project fact sheet in the packet*).
- Is working with the Energy & Environmental Research Center (EERC) at the University of North Dakota to determine whether CCS at the Richardton facility would be safe and economically feasible.

We successfully completed drilling the first test hole in April 2020 to collect rock samples (cores), pressure information, and other data. We anticipate rock and data analysis to take about 6 to 8 months.

The next step is to finalize a second test hole location on RTE property with plans to drill through the Broom Creek Formation, 1.3 miles deep (*see Drilling Activity FAQs in the packet*):

- Richardton Mayor Frank Kirschenheiter has been notified of the test hole location by RTE via several discussions throughout August.
- We are submitting a permit to drill application to the North Dakota Industrial Commission (NDIC) Department of Mineral Resources (DMR) Division of Oil & Gas on August 24, 2020.
- The well pad is currently being designed. It will protect groundwater and soils from fluids associated with the drilling and will prevent precipitation runoff.
- The drill rig and start date for drilling the test hole is expected in October 2020, pending rig availability.
- We will keep you informed as the effort progresses.

Feel free to contact me with any questions (*see contact information on the fact sheets*).

Regards,  
Dustin Willett

For reference, the items in the attachment packet include the following:

- *Red Trail Energy CCS Project* fact sheet
- *RTE CCS Drilling Activity FAQs* fact sheet

## **Red Trail Energy Carbon Capture and Storage Project: Summary and Next Steps Timeline April 14, 2021, Stark County Commissioners**

### **Red Trail Energy (RTE):**

- Is looking for ways to ensure the sustainability of the company and the market for its ethanol into the future (*see fact sheet in the packet*).
- Is working with the Energy & Environmental Research Center (EERC) at the University of North Dakota to validate carbon capture and storage (CCS) at RTE's Richardton facility as safe and economically feasible.
- With the EERC, has investigated every aspect of commercially available CCS technology as a way to reduce the carbon dioxide emissions associated with ethanol production.
  - Successfully completed the geophysical survey and data analysis, drilling and data analysis for two geologic characterization holes on RTE's property, and computer modeling and CO<sub>2</sub> injection and permanent storage simulations.
  - Evaluated the entire geologic structure of the area around Richardton, looking for faults, fractures, seismic activity, and potential mineral resource zones.
  - Verified that the 6400-ft-deep Broom Creek Formation and its shale seals do indeed have the ability to safely and permanently store the nearly 200,000 tons of CO<sub>2</sub> to be captured and injected annually by RTE through decades of operation.
- Has therefore continued on to the next steps of the CCS project, obtaining permits and commissioning equipment, based on the findings.

### **The next step is obtaining permission from the state for the project.**

- Obtaining a permit for CO<sub>2</sub> injection requires submitting an application to the North Dakota Industrial Commission (NDIC) Department of Mineral Resources (DMR), the primary regulatory authority to issue permits for wells for dedicated CO<sub>2</sub> storage (also called Class VI wells).
- RTE submitted an application to inject and permanently store CO<sub>2</sub>, called a Storage Facility Permit, to DMR on February 9, 2021. The permit application:
  - Must show that the planned operation is safe and that the target formation (or storage facility) will hold and contain the amount of CO<sub>2</sub> to be injected and permanently stored.
  - Package included geologic evidence organized by the five categories: 1) data and information sources; 2) storage reservoir; 3) confining zones; 4) faults, fractures, and seismic activity; and 5) potential mineral zones.
  - Package also included determined pore space and mineral ownership within the proposed storage facility; supporting plans such as emergency mitigation, worker safety, long-term CO<sub>2</sub> monitoring, etc.; and planned operations.

- DMR, in consultation with the North Dakota Department of Environmental Quality, has completed its initial review of the application.
- The next step is for DMR to prepare a draft permit. Once the draft permit is prepared, DMR will set a public hearing date.
- The draft permit will be available from DMR.
- We expect to be notified of the public hearing date by mid-April and expect the hearing to occur between the end of May and July.
- We are obligated by North Dakota Century Code 43-05-01-08 to notify pore space and mineral rights owners within a half-mile of the storage facility area of the time and place of public hearing 45 days in advance.
- The same code requires DMR to notify the public 30 days ahead of the public hearing. Local as well as state authorities with jurisdiction of the storage facility area are included in this notice. Also, the notice will be posted in the Bismarck area newspaper and “in a newspaper of general circulation in the county where the land affected or some part thereof is situated.”
- We will keep you informed as the effort progresses.
- We anticipate inviting the community to a third open house sometime in late summer or early fall. We always appreciate the interest from and opportunity to engage with the community.

For more information, contact  
Dustin Willett  
Chief Operating Officer, RTE  
dustin@redtrailenergy.com  
701.974.3308

## **Red Trail Energy Carbon Capture and Storage Project: Summary and Next Steps Timeline August 10, 2021, Stark County Commissioners**

### **Red Trail Energy (RTE):**

- Is looking for ways to ensure the sustainability of the company and the market for its ethanol into the future (*see fact sheet in the packet*).
- Is working with the Energy & Environmental Research Center (EERC) at the University of North Dakota to validate carbon capture and storage (CCS) at RTE's Richardton facility as safe and economically feasible.
- With the EERC, has investigated every aspect of commercially available CCS technology as a way to reduce the carbon dioxide emissions associated with ethanol production.
  - Successfully completed the geophysical survey and data analysis, drilling and data analysis for two geologic characterization holes on RTE's property, and computer modeling and CO<sub>2</sub> injection and permanent storage simulations.
  - Evaluated the entire geologic structure of the area around Richardton, looking for faults, fractures, seismic activity, and potential mineral resource zones.
  - Verified that the 6400-ft-deep Broom Creek Formation and its shale seals do indeed have the ability to safely and permanently store the nearly 200,000 tons of CO<sub>2</sub> to be captured and injected annually by RTE through decades of operation.
- Has therefore continued on to the next steps of the CCS project, obtaining permits and commissioning equipment, based on the findings.

### **The next step is obtaining permission from the state for the project.**

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  - Must show that the planned operation is safe and that the target formation (or storage facility) will hold and contain the amount of CO<sub>2</sub> to be injected and permanently stored.
  - Package included geologic evidence organized by the five categories: 1) data and information sources; 2) storage reservoir; 3) confining zones; 4) faults, fractures, and seismic activity; and 5) potential mineral zones.
  - Package also included determined pore space and mineral ownership within the proposed storage facility; supporting plans such as emergency mitigation, worker safety, long-term CO<sub>2</sub> monitoring, etc.; and planned operations.

- DMR, in consultation with the North Dakota Department of Environmental Quality, has completed its review of the application.
- DMR has prepared the draft permit and set a public hearing date August 12, 2021.
- The draft permit will be available from DMR.
- We expect to be notified of the public hearing date by mid-April and expect the hearing to occur between the end of May and July.
- We are obligated by North Dakota Century Code 43-05-01-08 to notify pore space and mineral rights owners within a half-mile of the storage facility area of the time and place of public hearing 45 days in advance.
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For more information, contact  
Dustin Willett  
Chief Operating Officer, RTE  
dustin@redtrailenergy.com  
701.974.3308

## **BLOGS AND PRESS RELEASES**

Red Trail Energy Hosts Open House in Richardton

Science Says “Go!” at the Red Trail Energy Ethanol Plant

Red Trail Energy Submits North Dakota Carbon Dioxide Storage Facility Permit Application

New Milestone for Carbon Capture and Storage (UND Today)

Red Trail Energy and EERC to Host Virtual Open House

Red Trail Energy Awarded the First CO<sub>2</sub> Storage Facility Permit in North Dakota

Red Trail Energy Virtual Open House Outlines CCS Project’s Promising Future (postevent blog)

# Red Trail Energy Hosts Open House in Richardton



RICHARDTON, N.D. – Red Trail Energy, LLC (RTE) recently hosted an open house event at the American Legion in Richardton. Approximately 40 community members attended to hear about the latest developments on a local carbon capture and storage (CCS) project.

With the support of the North Dakota Industrial Commission (NDIC) and the U.S. Department of Energy (DOE), RTE is investigating CCS technology as a way to reduce the carbon dioxide emissions associated with ethanol production. Reducing emissions enables ethanol producers to be more competitive in states that have low-carbon fuel programs, such as California. CCS technology captures and permanently stores carbon dioxide emissions.

RTE CEO Gerald Bachmeier gave a presentation about the project and answered questions from community members. Scientists and engineers from the University of North Dakota (UND) Energy & Environmental Research Center (EERC) provided information about RTE's seismic survey results and the suitability of the geology at the site to permanently store carbon dioxide.

**“Using CCS to reduce the carbon dioxide emissions of our ethanol ensures the long-term viability of RTE in a highly competitive global market. We are excited to continue our**

## Red Trail Energy Hosts Open House in Richardton – 2

partnership with the EERC in this investigation, and we are very appreciative of the community support thus far.” – *Gerald Bachmeier*

Next steps for the RTE CCS Project involve further studying the deep rock layers at the RTE site and obtaining necessary permits and regulatory compliance for safe and permanent carbon dioxide storage.



Questions about the project can be directed to:

Dustin Willett, RTE Chief Operating Officer  
(701) 974-3308, [dustin@redtrailenergy.com](mailto:dustin@redtrailenergy.com)

Nikki Massmann, EERC Communications Director  
(701) 777-5428, [nmassmann@undeerc.org](mailto:nmassmann@undeerc.org)

**RED TRAIL ENERGY** CCS PROJECT

## Science Says “Go!” at the Red Trail Energy Ethanol Plant

Thursday, February 4, 2021

<https://blog.undeerc.org/2021/02/04/science-says-go-at-the-red-trail-energy-ethanol-plant/>

RICHARDTON, N.D.—Science says “Go!” on a carbon capture and storage (CCS) project in Richardton. CCS addresses environmental concerns and strengthens the local economy by reducing carbon dioxide emissions, which also increases the value of the ethanol.

Red Trail Energy, LLC (RTE) and its research partner, the Energy & Environmental Research Center (EERC), investigated every aspect of the permanent geologic storage potential deep below the plant, the cost of CO<sub>2</sub> capture, and the likelihood that low-carbon fuel (LCF) markets and regulations would line up to make North Dakota’s first-ever commercial CCS project safe and cost-effective.

The positive outcomes bring the implementation of a commercial-scale CCS system at the RTE facility one giant leap forward. Generating an ethanol fuel applicable for LCF programs will provide a long-term premium market for RTE, providing stability for employees and local corn growers. The results also provide a path forward for other North Dakota renewable energy or biofuel producers in the region to add value to their products with LCF programs, such as California and Oregon.

Years of research went into that conclusion. The thorough analysis of geology more than a mile underground required innovative sleuthing and a variety of techniques. In addition to gathering existing drilling data, RTE drilled two holes more than 6400 feet deep to collect geologic data, rock, and fluid samples. Over 950 ft of rock as well as fluid samples were collected and analyzed by researchers to develop a model of the subsurface and evaluate its ability to accept and contain CO<sub>2</sub> captured from RTE’s ethanol processing. EERC researchers also used a geophysical survey to project sound waves from the surface into the subsurface and analyze the reflected signal.

The myriad analyses fed the creation of computer models of the subsurface in the RTE study area. Improved and refined with each new set of data, these models provided a geologic template for CO<sub>2</sub> injection simulations to predict CO<sub>2</sub> movement during storage. The target storage layer below the RTE plant is called

the Broom Creek Formation. It is a thick, porous sandstone layer pressed between thick layers of tightly sealed shale. EERC researchers used the model to predict the effects of CO<sub>2</sub> injection on those geologic seals, including safe injection pressures for maintaining those confining layers.



*Drilling exploratory holes allows researchers to collect rock samples deep below ground, cutting core that arrives at the surface encased in long metal sleeves. The sleeves are measured, labeled, and cut to 3-foot lengths for shipment to the lab.*

They evaluated the entire geologic structure of the area around Richardton, looking for faults, fractures, seismic activity, and potential mineral resource zones. In the end, the results show that the Broom Creek and its shale seals do indeed have the ability to safely and permanently store the nearly 200,000 tons of CO<sub>2</sub> to be captured and injected annually by RTE through decades of operation. The results of these efforts are needed to prepare

the required North Dakota permit application for commercial CO<sub>2</sub> injection and storage, called a CO<sub>2</sub> storage facility permit.

The immediate economic driver is the LCF markets in states like California that are looking for ways to reduce the carbon footprint of transportation fueled by the internal combustion engine. The RTE CCS team has been working with West Coast regulators to ensure that the delivered ethanol will meet the requirements of California’s Low Carbon Fuel Standard, a program



*A rock core cut from the target CO<sub>2</sub> storage layer 6400 feet below ground shows the pink sandstone of the Broom Creek Formation. It has the consistency of playground sand.*

that includes monitoring to ensure that the CO<sub>2</sub> stays permanently trapped in its storage layer. Other states with LCF programs are expected to adopt those standards in the future. Ensuring a market share is critical to survival in the shifting energy market.

In addition to economics, technology is a major limiting factor in the rate at which innovative concepts become reality. Are the materials, processes, and technologies needed to carry out CCS on an ethanol plant available?

Separating and capturing CO<sub>2</sub> from ethanol fermentation gases have become established processes in the last 10 years and require site-specific engineering and not-quite off-the-shelf equipment. The compression, transport, and injection of CO<sub>2</sub> have been effectively developed over 40 years of enhanced oil recovery (EOR). The novel technological challenge for dedicated CO<sub>2</sub> storage (a challenge not faced by EOR) is proving that it stays put—and does so affordably and thus sustainably. Innovations by researchers and private companies continue to expand the toolbox and bring down the cost of monitoring CO<sub>2</sub> deep underground.

The RTE CCS project work included creating a monitoring plan that accounted for technical, economic, and regulatory components. For example, elements of the plan are focused on tracking CO<sub>2</sub> during injection and in the storage zone using real-time pressure and temperature data, as well as repeating monitoring well testing and geophysical surveys at specified intervals. Other elements include monitoring groundwater and soil gas as assurance of environmental protection.

North Dakota legislators and regulators recognized the potential for CCS to play a critical role in the state's energy production and made key decisions to regulate geologic storage projects within the state. In April 2018, the U.S. Environmental Protection Agency formally recognized the framework and procedures established by the North Dakota Department of Mineral Resources (DMR) by granting DMR's application for Class VI primacy.

Class VI refers to the EPA well classification established to regulate wells dedicated to permanent CO<sub>2</sub> storage. North Dakota's proactive request for primacy from EPA maintains the safe implementation established by federal regulations, facilitates communication, and incorporates local geology expertise.



*Once the permits are approved, the exploratory hole drilled in spring 2020 will be converted into the CO<sub>2</sub> injection well. The second test site, drilled in October, will be converted into a monitoring well for the CCS project.*

The next steps, as laid out in DMR regulations, require the submission of a complete North Dakota carbon storage permit application. All of the research results must be compiled into a five-part package of evidence making the case for safe, permanent geologic storage beneath the RTE ethanol plant.

The DMR, in consultation with the North Dakota Department of Environmental Quality, will evaluate the permit application to determine whether approval should be granted. This first-time regulatory process is estimated to take 8–12 months and includes a public comment period and hearing. Approval would bring RTE one step closer to becoming the first facility in North Dakota to commercially capture and permanently store CO<sub>2</sub>.

#### For More Information, Contact:

**Dustin Willett**  
Chief Operating Officer, RTE  
dustin@redtrailenergy.com  
701.974.3308

**Red Trail Energy LLC**  
Richardton, ND 58652  
redtrailenergyllc.com

#### PROJECT PARTNERS



RICHARDTON, N.D. – Red Trail Energy, LLC (RTE) submitted a North Dakota CO<sub>2</sub> Storage Facility permit application to the North Dakota Department of Mineral Resources (DMR). The permit will allow RTE the capability of permanently storing captured carbon dioxide in deep underground rock layers. If approved, the carbon capture and storage (CCS) effort would be the first of its kind in the state, located on RTE's property.

With the support of the North Dakota Industrial Commission (NDIC) and the U.S. Department of Energy (DOE), RTE and its research partner, the University of North Dakota Energy & Environmental Research Center (EERC), has investigated every aspect of commercially available CCS technology as a way to reduce the carbon dioxide emissions associated with ethanol production. Reducing emissions enables ethanol producers to be more competitive in states that have low-carbon fuel (LCF) programs, such as California. CCS technology coupled with LCF program benefits allows for permanently stored carbon dioxide emissions in a safe and cost-effective manner.

“Using CCS to reduce the carbon dioxide emissions of our ethanol ensures the long-term viability of RTE in a highly competitive global market,” said RTE CEO Gerald Bachmeier. “We are excited to move to the next phase of this project being a reality, and we are very appreciative of the community support.”

Questions about the project can be directed to:

Dustin Willett, RTE Chief Operating Officer  
(701) 974-3308, [dustin@redtrailenergy.com](mailto:dustin@redtrailenergy.com)

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# New milestone for carbon capture and storage

**Red Trail Energy and EERC near commercialization of CO<sub>2</sub> storage technology**

By Patrick C. Miller



*Red Trail Energy's ethanol plant at Richardton, N.D., is on track to become the first facility in North Dakota to commercially employ carbon capture and storage to help mitigate the impact of climate change. The company has been working with the UND Energy & Environmental Research Center as its research partner on the project. Photo courtesy Red Trail Energy.*

After nearly 20 years of researching and developing carbon capture and storage (CCS) technologies as a means of mitigating climate change, the UND Energy & Environmental Research Center (EERC) is on the verge of seeing the science put to commercial use in North Dakota.

An ethanol plant in Richardton operated by Red Trail Energy (RTE) LLC could become the first facility in North Dakota to commercially capture and permanently store carbon dioxide (CO<sub>2</sub>) underground. It came a step closer to reality last month when RTE submitted a permit application to the state's Department of Mineral Resources (DMR).



*Charles Gorecki*

“Going forward with this Red Trail Energy project and working all the way through the feasibility, design and now permit submission, we have set up a framework other companies could follow,” said EERC CEO Charlie Gorecki. “In addition, North Dakota has the policy framework in place to facilitate CCS and the authority to regulate the injection of carbon dioxide.”

Reducing CO<sub>2</sub> emissions enables ethanol producers to be more competitive in states that have low-carbon fuel (LCF) programs. CCS technology, coupled with LCF program benefits, allows for permanently stored CO<sub>2</sub> in a safe and cost-effective manner because it provides a means to reduce the carbon intensity of ethanol.

RTE CEO Gerald Bachmeier said, “We’re excited to submit the first application in the state for safe, permanent, geologic storage of carbon dioxide. Using CCS to reduce the carbon dioxide emissions of our ethanol ensures the long-term viability of RTE in a highly competitive global market.”

The DMR, in consultation with the state’s Department of Environmental Quality, will evaluate the permit application to determine whether approval should be granted. This first-time regulatory process is estimated to take 8–12 months and includes a public comment period and hearing.

Work on CCS technology began in 2003 with the EERC’s Plains CO<sub>2</sub> Reduction (PCOR) Partnership program.

“It really laid the groundwork for where we are with CO<sub>2</sub> storage opportunities in the PCOR region, which now includes 10 states and four Canadian provinces,” Gorecki said. “We looked at where you could store CO<sub>2</sub> based on the geology.”

### **Keeping ethanol competitive**

With the support of the North Dakota Industrial Commission (NDIC) and the U.S. Department of Energy (DOE), RTE and EERC have investigated many aspects of commercially available CCS

technology to reduce CO<sub>2</sub> emissions associated with ethanol production. Reducing these emissions enables ethanol producers to be more competitive in states with alternative fuels mandates or low-carbon fuel (LCF) programs, such as California and Oregon.



*Kerryanne Leroux, an EERC principal engineer, is the project manager of the Red Trail Energy carbon capture and storage project. UND archival photo.*

“The California Low-Carbon Fuels Standard provides a benefit or incentive for proving that your fuel has a lower carbon footprint or, as they call it, carbon intensity,” explained Kerryanne, an EERC principal engineer and project manager of the RTE project. “There’s also the IRS tax incentive program – section 45Q – that provides a tax credit for carbon capture and storage.”

CCS technology – coupled with LCF program benefits – allows for permanently stored CO<sub>2</sub> emissions in a safe and cost-effective manner.

“For CCS to be a commercial reality or at least make economic sense, these fuel standard programs, tax credits or sale of carbon dioxide for enhanced oil recovery are what is going to make carbon capture projects a reality,” Gorecki noted.

Much of the EERC’s research has focused on identifying geologic formations to serve as permanent underground storage for CO<sub>2</sub>. The Willison Basin in western North Dakota features permeable sandstone sandwiched between layers of dense shale, making it an ideal area in which

to inject CO<sub>2</sub> for underground storage. In addition to gathering existing drilling data, RTE drilled two holes more than 6,400 feet deep to collect geologic data, rock and fluid samples.

More than 950 feet of rock, as well as fluid samples, were collected and analyzed by researchers to develop a model of the subsurface and evaluate its ability to accept and contain CO<sub>2</sub> captured from RTE's ethanol processing. EERC researchers also used a geophysical survey to project sound waves from the surface into the subsurface to analyze the reflected signal.

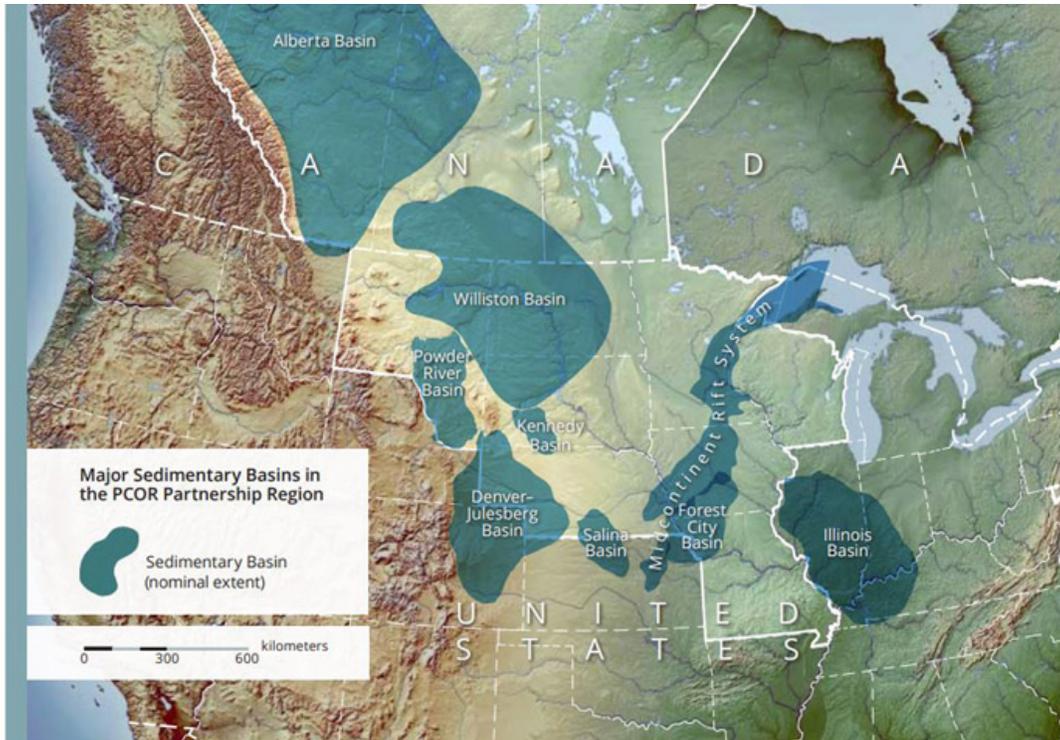
The analyses led to the creation of computer models of the subsurface in the RTE study area, providing a geologic template for CO<sub>2</sub> injection simulations that predict movement during storage. The target storage layer below the RTE plant is called the Broom Creek Formation.

### **Getting the site right**

EERC researchers evaluated the geologic structure of the area around Richardton, looking for faults, fractures, seismic activity and potential mineral resource zones. The results showed that the Broom Creek and its shale seals have the ability to safely and permanently store nearly 200,000 tons of CO<sub>2</sub> captured and injected annually by RTE during decades of operation.

“With a point source such as Red Trail's ethanol facility, we had already characterized the region in a broad sense, and we knew it sat on top of some of the best storage opportunities,” Gorecki said. “It made sense when Red Trail contacted us six or seven years ago. We already knew a lot about their site and its promise for CCS.”

The results of these efforts were used to prepare the required North Dakota permit application for commercial CO<sub>2</sub> injection and storage. Another advantage for the project in North Dakota is that the state has the regulatory structure in place for CCS.



One of the objectives of the EERC’s Plains CO<sub>2</sub> Reduction Partnership Program launched in 2003 was to identify geologic formations in which carbon storage could occur. Red Trail Energy’s ethanol plant at Richardton, N.D. is located above the Broom Creek Formation in the Williston Basin. EERC researchers have characterized it as an ideal area for CCS technology. Image courtesy of UND Energy & Environmental Research Center.

“The EERC and all of our industrial partners have the technical and commercial knowledge with the state and with other states,” Gorecki said. “North Dakota has the policy framework laid out and primacy to regulate the injections. We have the pieces all together.”

EERC researchers are continuing to improve and refine CO<sub>2</sub> injection and storage strategies, and are continuing to develop reservoir surveillance technologies to monitor, verify and account for injected CO<sub>2</sub> storage as close to real time as possible.

“We’re currently involved in several projects to study ways to reduce the cost of long-term monitoring on the site,” Leroux said. “It’s validating that the CO<sub>2</sub> has stayed put. We’re trying to make monitoring more economical and more time responsive.”

North Dakota’s CCS developments have attracted attention in other states. Gorecki has testified before legislatures in North Dakota, Minnesota and Nebraska. The possibility of a CO<sub>2</sub> pipeline connecting ethanol production facilities in Minnesota and Iowa to underground storage in North Dakota has also sparked interest, he said. In addition, there are also potential CCS opportunities in other states with similar geologic formations.

## New milestone for carbon capture and storage – 6

“Reducing carbon intensity and reducing carbon emissions to the atmosphere is certainly in focus right now in the media and politics,” Gorecki noted. “It’s become a big hot-button issue with a lot of interest One of the best ways to reduce these emissions is through carbon capture, utilization and storage.”

## **Red Trail Energy and UND's Energy & Environmental Research Center to Host Virtual Open House**

RICHARDTON, N.D. – Mark your calendars for a virtual open house hosted by Red Trail Energy (RTE) and the Energy & Environmental Research Center (EERC) over Zoom on Wednesday, November 10, at 6:00 p.m. MT (7:00 p.m. CT). This is your opportunity to hear updates about the RTE Carbon Capture and Storage (CCS) project, learn more about the science behind it, and ask questions.

The RTE CCS project is on track to be the first commercial-scale CCS project in North Dakota, capturing and storing nearly 200,000 tons of CO<sub>2</sub> annually, while also producing ethanol applicable to low-carbon fuel markets in California, Oregon, and British Columbia. Access to premium pricing in these markets—and those likely to be established in other states in the future—will provide increased stability to regional corn growers and the RTE ethanol facility, located near Richardton, ND.

RTE and its research partner, the EERC, have been investigating the safe, permanent storage of captured CO<sub>2</sub> in deep underground rock layers. Recent activities from this 5-year effort have included drilling two holes about 6500 feet deep, conducting detailed geologic evaluation, and researching incentive programs for commercially viable CCS at the RTE site. The next phase of the project, which is located on RTE's property, includes constructing the CO<sub>2</sub> capture plant, starting CCS operations, and executing monitoring plans.

All are welcome to join by registering at [RedTrailEnergyVirtualOpenHouse.eventbrite.com](https://www.eventbrite.com/e/red-trail-energy-virtual-open-house). There will be opportunities to ask questions during the open house; email [info@undeerc.org](mailto:info@undeerc.org) to request an informational packet ahead of the meeting. Project questions can also be submitted in advance to [info@undeerc.org](mailto:info@undeerc.org); these questions will be answered in a future bulletin as well.



## **Red Trail Energy Virtual Open House Outlines CCS Project's Promising Future**

On Wednesday, November 10, 2021, Red Trail Energy (RTE) gave an update on its carbon capture and storage (CCS) project. More than 50 people registered to hear the latest news at a virtual open house presented over Zoom by RTE and its research partner, the Energy & Environmental Research Center (EERC) at the University of North Dakota. Interested registrants in the project included local landowners and officials as well as industry professionals from the United States, Canada, and Turkey.

The biggest news was the approval of the storage facility permit by the North Dakota Industrial Commission on October 19, which brings the RTE CCS project one step closer to becoming the first of its kind in North Dakota. One of the evening's presentations offered a peek at a small part of the planning and documentation that went into the 600-plus-page storage facility permit.

RTE CEO Gerald Bachmeier shared the history of RTE and gave an overview of the project, with EERC researchers providing detail on carbon capture, the suitability of the storage zone, the storage process, and the extensive monitoring systems that will safeguard human health and ensure environmental protection. The presentations concluded with a look at an EERC research project getting under way at RTE for improved novel monitoring techniques with Japan-based partner, RITE (Research Institute of Innovative Technology for the Earth). Several key takeaways from the presentations include:

- The CO<sub>2</sub> to be injected underground will remain there permanently.
- The rock layers under RTE are well suited for CCS. A highly porous and permeable sandstone layer starting about 6400 feet below the surface has thick shale layers both above and below it that will trap the CO<sub>2</sub> where it is injected.
- The sandstone layer—called the Broom Creek Formation, into which RTE will be injecting CO<sub>2</sub>—can hold at least 1000 times more CO<sub>2</sub> than RTE will inject over the life of the project.
- In a worst-case scenario of damage to the flowline, which is at least 6 feet underground for its entire length, the capture system is specifically designed to revert to venting CO<sub>2</sub> gas into the atmosphere, exactly as happens currently under RTE's air quality permit (and at every ethanol plant without a CCS system).

The evening was widely regarded as educational and interesting and concluded with many questions and answers about a range of topics, including the salt water in the Broom Creek Formation, the concentration of CO<sub>2</sub> from the plant, and the extensive planning and engineering that will prevent blockage of the injection well. The question of whether the CO<sub>2</sub> might be retrieved for use elsewhere (such as oil production) was answered with assurance that the CO<sub>2</sub> will not be retrieved—doing so would be contrary to the agreement under which RTE will receive compensation for sequestration and would force RTE to pay back that compensation.

In his concluding remarks, Bachmeier made clear that the years of research and planning that have gone into the project showed that it would be safe, effective, and a boon to the economic impact RTE has on the region. “We want to be good neighbors,” said Bachmeier, encouraging anyone who had further questions or was interested in learning more about the project to contact RTE directly. Questions can also be sent to EERC researchers by e-mailing [info@undeerc.org](mailto:info@undeerc.org).

**APPENDIX B**

**VIRTUAL OPEN HOUSE COMPONENTS AND  
PLANNER**

## OPEN HOUSE COMPONENTS AND PLANNER

### Open House Planner with Timeline in Relation to Planned Event Date

Timeline	Action	Instruction	Outcome/Product/Notes
10 weeks Prior	Request for open house assistance.		Requested by client leadership or suggested by the EERC before a new stage of project begins
10 weeks Prior	Establish open house working team.	<ul style="list-style-type: none"> <li>Consisting of project lead, researchers, outreach and communications team members, and an administrative assistant (AA)</li> </ul>	<ul style="list-style-type: none"> <li>EERC: Project Manager, Outreach Lead, Outreach Coordinator, Geophysicist Lead, Regulatory Lead, Geoscientist Lead, AA, Communications Director, Communications Coordinator</li> <li>Client: Provided messaging assistance and approval, as needed</li> </ul>
Weekly Thereafter	Meet as necessary to discuss details and deliver updates to team.	<ul style="list-style-type: none"> <li>Choose teleconferencing service, date, and time.</li> </ul>	<p><i>Examples:</i></p> <ul style="list-style-type: none"> <li>Wednesday, November 10, 2021, 6:00–7:00 p.m.</li> <li>Zoom</li> <li>Checked sports schedules, holidays, and community meeting schedules</li> </ul>
8 weeks Prior	Create message, plan presentations, and establish engagement strategies for intended audience.	<ul style="list-style-type: none"> <li>Discuss major point to emphasize.</li> <li>Establish presentation topics.</li> <li>Plan news bulletin topics and information dissemination.</li> </ul>	<ul style="list-style-type: none"> <li><i>Example:</i> The research project has been going on for 5 years; the project is carefully thought out and duly researched front to back. The CCS process is safe.</li> <li>Presentations on the project timeline, permitting, carbon capture, monitoring, further research</li> <li>Information packet to contain three fact sheets and two infographics, each chosen</li> </ul>
7 weeks Prior	Plan event schedule.	<ul style="list-style-type: none"> <li>Designate emcee.</li> <li>Set presentation order.</li> <li>Discuss PowerPoint slide formatting.</li> </ul>	<ul style="list-style-type: none"> <li>Outreach Lead will emcee</li> <li>Order: Welcome, Zoom chat tutorial, opening remarks, project timeline, carbon capture, storage process, permitting, monitoring, further research</li> </ul>
5 weeks Prior	Plan takeaway messages for each presentation.	<ul style="list-style-type: none"> <li>Finalize wording of main topic for presentations.</li> </ul>	<p><i>Examples:</i></p> <ul style="list-style-type: none"> <li>Storage process: CCS/storage takes advantage of natural geologic processes that have already confined salt water to the storage zone, protecting fresh water from what's below. We will monitor from start to finish and have contingencies for any anomalies that might come up. There are no identified fluid migration pathways.</li> </ul>

B-1

Continued . . .

**Open House Planner with Timeline in Relation to Planned Event Date (continued)**

<b>Timeline</b>	<b>Action</b>	<b>Instruction</b>	<b>Outcome/Product/Notes</b>
4 weeks Prior	Release first news bulletin, prepare pre-event slideshow, set up online registration.	<ul style="list-style-type: none"> <li>• Send news bulletin to newspapers.</li> <li>• Write trivia questions for slideshow.</li> <li>• Create Eventbrite page for registration.</li> </ul>	<ul style="list-style-type: none"> <li>• Sixteen trivia questions created and incorporated into slideshow</li> <li>• Begin submitting to media sources at least 3 weeks before event to guarantee best visibility to target audience</li> <li>• <i>Examples: Richardton Merchant, Hebron Herald, and Dickinson Press</i> were chosen for their reach to the target audience</li> <li>• Distribution frequencies range from daily to biweekly, and submission dates vary for each</li> <li>• Bulletin released on October 15, 2021</li> </ul>
3 weeks Prior	Create visual aids.	<ul style="list-style-type: none"> <li>• Create PowerPoint presentation slides that include helpful visual diagrams based on established takeaway messages.</li> </ul>	
2 weeks Prior	Create invitations and invitation lists, and distribute.	<ul style="list-style-type: none"> <li>• Send to landowners, local and state officials, town and regional community, dependent on who is impacted most by new stage of project.</li> <li>• Engage by mail, e-mail, digital signage (where available), social media.</li> <li>• Release second news bulletin to same newspapers.</li> </ul>	<ul style="list-style-type: none"> <li>• Digital sign in Richardton is handled by school employee Adam Bohn</li> </ul>
1 week Prior	Virtual open house dry run, and mail info packets.	<ul style="list-style-type: none"> <li>• Time each presentation.</li> <li>• Mail info packets with letter and five fact sheets to those who requested it.</li> </ul>	<ul style="list-style-type: none"> <li>• Review PowerPoint slides and assign adjustments</li> </ul>
2 days Prior	E-mail link to registrants.	<ul style="list-style-type: none"> <li>• E-mail Zoom link through Eventbrite.</li> <li>• E-mail Zoom link from Outreach Coordinator’s e-mail account, as insurance.</li> <li>• Alter Eventbrite landing pages and registration confirmations to automatically give Zoom link to late registrants.</li> </ul>	<ul style="list-style-type: none"> <li>• A couple e-mail addresses had typos. These were researched, corrected, and resent</li> </ul>
1 day Prior	Final dry run with RTE and EERC staff.	<ul style="list-style-type: none"> <li>• Straight run-through of all presentations with minimal chatter between.</li> </ul>	<ul style="list-style-type: none"> <li>• Make final adjustments to PowerPoint slides</li> </ul>
Day of Event	Execute open house.	<ul style="list-style-type: none"> <li>• Follow timeline for scheduled presentations, circulating to speak with researchers, and final questions.</li> <li>• Discuss event outcomes with internal attendees and client leadership to determine successfulness and follow-up needs.</li> <li>• Watch Eventbrite registration and contact e-mail accounts to assist late registrants with gaining access.</li> </ul>	

B-2

Continued . . .

**Open House Planner with Timeline in Relation to Planned Event Date (continued)**

Timeline	Action	Instruction	Outcome/Product/Notes
1 week Post	Write and share postevent news release.	<ul style="list-style-type: none"> <li>• Write news release; news release has historically been written at the EERC and sent to client leadership for quotes and approvals.</li> <li>• Share on the EERC Solutions blog and sent as a news release to North Dakota news outlets.</li> </ul>	<ul style="list-style-type: none"> <li>• Increases visibility/reach and support of client and efforts to inform the community about project events.</li> </ul>
1–2 weeks Post	Track and record engagement through event registration, news items, etc.	<ul style="list-style-type: none"> <li>• Note number of attendees, overall attitude of attendees, questions asked, any concerns to address moving forward.</li> </ul>	
As Needed	Report on open house to necessary parties.	<ul style="list-style-type: none"> <li>• Collect utilized materials for demonstrative of efforts.</li> <li>• Compile responses to determine success level and necessary next stage efforts.</li> </ul>	<ul style="list-style-type: none"> <li>• Dependent on project specifications</li> </ul>

**APPENDIX D**

**NORTH DAKOTA CARBON CAPTURE AND  
STORAGE REGULATORY-  
INCENTIVES CROSSWALK**



October 29, 2021

Ms. Karlene Fine  
Executive Director  
North Dakota Industrial Commission  
State Capitol, 10th Floor  
600 East Boulevard Avenue  
Bismarck, ND 58505-0310

Dear Ms. Fine:

Subject: Deliverable (D) 2 for Research in Support of Integrated Carbon Capture and Storage (CCS) for North Dakota Ethanol Production; Contract No. R-043-053  
EERC Fund 25204

Attached is the D2: North Dakota Carbon Capture and Storage (CCS) Regulatory-Incentives Crosswalk for the subject project. If you have any questions, please contact me by phone at (701) 777-5013, by fax at (701) 777-5181, or by e-mail at [kleroux@undeerc.org](mailto:kleroux@undeerc.org).

Sincerely,

DocuSigned by:  
  
F93F81AE98DB40F...  
Kerryanne M. Leroux  
Principal Engineer

KML/kal

Attachment



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# **NORTH DAKOTA CARBON CAPTURE AND STORAGE (CCS) REGULATORY-INCENTIVES CROSSWALK**

## **Research in Support of Integrated CCS for North Dakota Ethanol Production**

### *Deliverable 2*

#### *Prepared for:*

Karlene Fine

North Dakota Industrial Commission  
State Capitol, 14th Floor  
600 East Boulevard Avenue, Department 405  
Bismarck, ND 58505-0840

Contract No. R-043-053

#### *Prepared by:*

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October 2021

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## **NORTH DAKOTA CARBON CAPTURE AND STORAGE (CCS) REGULATORY- INCENTIVES CROSSWALK**

### **EXECUTIVE SUMMARY**

Carbon capture and storage (CCS) incentive programs create opportunities to achieve economically viable CCS implementation for industrial facilities; however, navigating qualification requirements for these programs can be challenging. The Energy & Environmental Research Center (EERC), in partnership with Red Trail Energy, LLC (RTE), a North Dakota ethanol producer, and the North Dakota Industrial Commission (NDIC) Renewable Energy Program (REP), investigated CCS incentive programs applicable to small-scale industrial CO<sub>2</sub> emitters (<1,000,000 tonnes of CO<sub>2</sub> emitted annually) considering CO<sub>2</sub> capture and permanent geologic storage. The RTE CCS Project is currently constructing a CO<sub>2</sub> capture facility adjacent to the RTE ethanol facility near Richardton, North Dakota, to ultimately inject the CO<sub>2</sub> more than a mile below RTE property for permanent storage. RTE received formal approval on October 19, 2021, of the first North Dakota CO<sub>2</sub> storage facility permit (SFP). Therefore, as RTE approaches the start of CCS operations, an in-depth understanding of incentive certifications and qualifications is necessary for economic sustainability of the project. Current interpretations of out-of-state low-carbon fuel markets and/or other incentive program requirements, verified by program authorities, and lessons learned are provided in this report.

The California Low Carbon Fuel Standard (LCFS) and the Enhancement of Carbon Dioxide Sequestration Credit (a.k.a. Section 45Q) tax program under the Internal Revenue Service (IRS) provide the most mature incentive programs at this time for economic opportunities to implement CCS at small-scale fuel production facilities. Some complexities of the California LCFS CCS Permanence Certification requirements have become clearer, whereas others remain uncertain as the EERC and RTE navigate one of the first applications to this program. For example, clarification has been provided that third-party reviewers, a requirement for LCFS CCS certification, need to go through an approval process instead of the accreditation process required for verification of LCFS pathways (i.e., certified carbon intensity values). A majority of components required for the LCFS CCS certification and not included in the North Dakota CO<sub>2</sub> SFP application are related to the required site risk assessment, CO<sub>2</sub> capture and transport operations, and additional monitoring stipulations. Although an approved SFP is not required prior to submittal of the CCS certification, an entity applying should collaborate with LCFS staff while developing the SFP and certification applications to ensure compliance for both California and North Dakota programs.

A U.S. Environmental Protection Agency (EPA) Greenhouse Gas Reporting Program (GHGRP) Subpart Resource Recovery (RR) Monitoring, Reporting, and Verification (MRV) Plan is required for qualification of the IRS Section 45Q CCS tax credit. Capture and transport components make up most of the additional information required by the MRV Plan that is not included in a North Dakota CO<sub>2</sub> SFP application. Because these EPA and IRS programs have been established for many years, several examples of approved MRV Plans are publicly available, providing more certainty regarding development and approval of an MRV Plan for IRS qualification of 45Q credits.

The number of states and regional entities considering low carbon or clean fuel incentive programs has been growing over the past few years, with over a dozen states creating investigative legislation to explore potential program frameworks. California, Oregon, and British Columbia have maintained their established LCF programs; however, California is the only program with official adoption of CCS certification. Other states investigating LCF programs include Colorado, Iowa, Washington, Illinois, Kansas, Minnesota, Nebraska, New Mexico, Utah, Wisconsin, Maine, Maryland, and Vermont. On the federal level, Canada and Brazil are the only identified countries currently considering nationwide LCF programs. As these programs evolve and mature, markets for LCFs are anticipated to increase, further supporting economic viability of integrating CCS with fuel production.

To maximize current incentive opportunities, small emitters should qualify for 1) a California LCFS pathway with approved CCS Permanence Certification and 2) IRS 45Q CCS tax credits with an approved EPA MRV Plan. Satisfying the requirements for LCFS CCS certification simultaneously with an MRV Plan can provide efficiencies in document preparation and ensure consistency. Because of the prescriptive nature of the LCF CCS certification requirements for attaining approved certification, operational and monitoring compliance will likely be compatible with evolving programs should a transition be desired in the future. As qualifications for CCS incentives emerge in other regions, market evaluations will likely be necessary to optimize economic opportunities.

## **NORTH DAKOTA CARBON CAPTURE AND STORAGE (CCS) REGULATORY- INCENTIVES CROSSWALK**

### **BACKGROUND**

The Energy & Environmental Research Center (EERC) at the University of North Dakota (UND), in partnership with the North Dakota Industrial Commission (NDIC) and North Dakota ethanol producer Red Trail Energy (RTE), is conducting the fourth phase (Phase 4) of a multiphase research and development effort to create the first integrated carbon capture and storage (CCS) system in North Dakota for the reduction of carbon emissions from ethanol production and capitalize on evolving low-carbon-fuel (LCF) markets. The ultimate goal of this effort is to implement a small-scale (<1,000,000 tonnes of CO<sub>2</sub> emitted annually) commercial CCS system at an industrial fuel production facility to generate a reduced-carbon ethanol fuel that qualifies for LCF programs.

With additional partnership from the U.S. Department of Energy (DOE), the project team has been evaluating potential integration of North Dakota regulations with out-of-state LCF markets and other evolving incentive programs over the past 5 years (Leroux and others, 2020). The California Air Resources Board (CARB) and the U.S. Internal Revenue Service (IRS) have developed substantial economic opportunities for CCS implementation at small-scale fuel production facilities through the Low Carbon Fuel Standard (LCFS) and Enhancement of Carbon Dioxide Sequestration Credit (a.k.a. Section 45Q) CCS tax credit program, respectively. Oregon and British Columbia have maintained existing LCF programs, albeit not yet incorporating specific CCS policy. A few other states (Washington, Colorado) and countries (Canada, Brazil) had proposed legislation or feasibility studies to inform potential development of LCF programs for their jurisdictions.

The RTE CCS Project is currently constructing a CO<sub>2</sub> capture facility adjacent to the RTE ethanol facility near Richardton, North Dakota, to ultimately inject about 180,000 tonnes of CO<sub>2</sub> annually more than a mile below RTE property for permanent storage. North Dakota has the authority to regulate the geologic storage of CO<sub>2</sub> and primacy to administer the North Dakota Underground Injection Control (UIC) Class VI Program (83 Federal Register 17758, 40 Code of Federal Regulations [CFR] 147). The U.S. Environmental Protection Agency (EPA) UIC Class VI was created to solely regulate CO<sub>2</sub> geologic storage. RTE received formal approval on October 19, 2021, of the first North Dakota CO<sub>2</sub> storage facility permit (SFP). Therefore, as RTE approaches the start of CCS operations, an in-depth understanding of incentive certifications and qualifications is necessary for economic sustainability of the project.

### **CALIFORNIA LCFS CCS CERTIFICATION**

In January 2019, CARB adopted the CCS protocol under LCFS to include CCS processes within “pathway certification” of carbon intensity (CI) values, i.e., the means for acquiring credits through the LCFS carbon market (Leroux and others, 2020). Figure 1 summarizes the

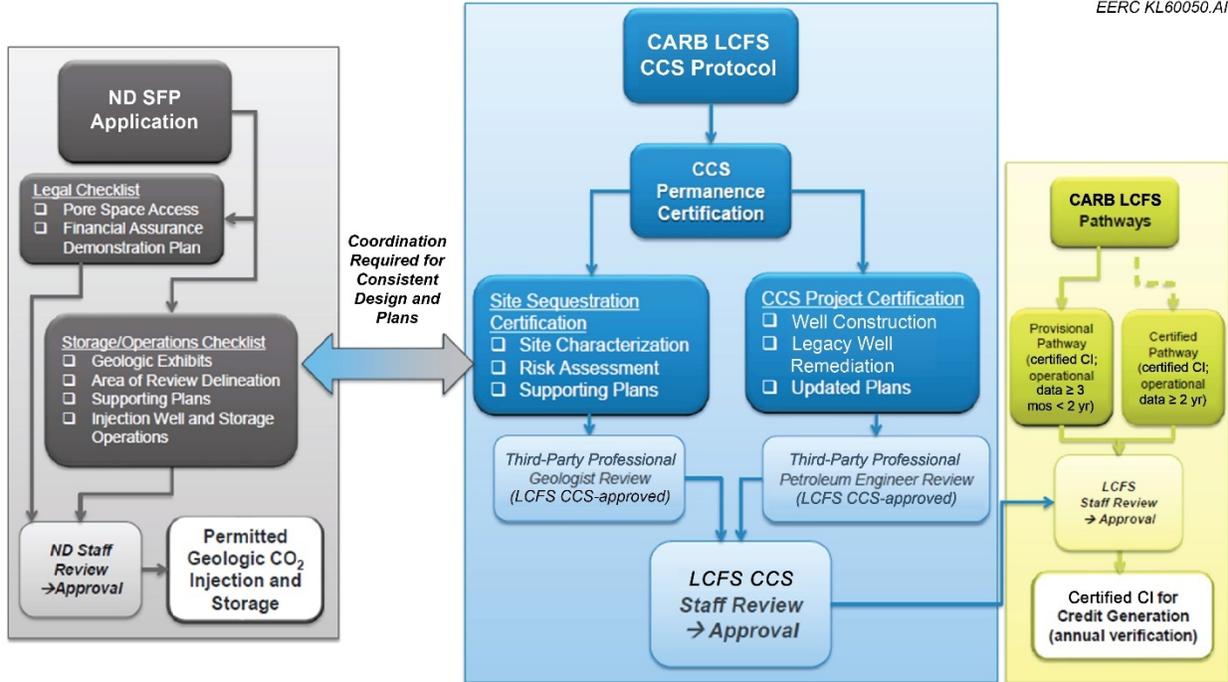


Figure 1. Illustration describing the relationship between the North Dakota CO<sub>2</sub> SFP application process and the California CCS certification required for a North Dakota ethanol-CCS product to qualify for LCFS carbon credits.

overall process for attaining CCS Permanence Certification through the California LCFS program for incorporation into a certified LCFS pathway for carbon credits. Note that although design-based pathways (DBP) for a temporary (not certified) CI value were also adopted concurrently with adoption of the CCS protocol (Leroux and others, 2020), DBPs are not required to start the CCS certification process. In fact, LCFS staff will now only consider new ethanol-CCS applications if significantly different from RTE's process or if explicitly needed by investors, as they have deemed RTE's accepted DBP application as the benchmark model for estimating CI values for ethanol-CCS.

Therefore, the first step in obtaining a CCS-inclusive pathway is CCS Permanence Certification, as detailed in the LCFS CCS protocol ([https://ww2.arb.ca.gov/sites/default/files/2020-03/CCS\\_Protocol\\_Under\\_LCFS\\_8-13-18\\_ada.pdf](https://ww2.arb.ca.gov/sites/default/files/2020-03/CCS_Protocol_Under_LCFS_8-13-18_ada.pdf)). The certification resembles the North Dakota CO<sub>2</sub> SFP, as both adhere to the foundation of the EPA UIC Class VI regulations, yet with significant additions. The process involves the following components: 1) approval of third-party reviewers, 2) development of application documentation, 3) third-party review and certification of the completed application, 4) LCFS evaluation of the certified application package, and 5) LCFS Tier 2 pathway application for unconventional fuel production. Some of the LCFS CCS Permanence Certification requirements differ from the requirements of the North Dakota CO<sub>2</sub> SFP regulations. Appendix A summarizes the primary differences with additional detail provided below.

**Third-Party Reviewers:** At minimum, a licensed professional geologist and a licensed professional petroleum engineer are required for the third-party review team. Other professionals/experts may be included in the review team to cover all expertise required for certifications. All review team members require formal approval by an LCFS CCS executive officer, which could take 1 to 2 months following submission of criteria documentation. For example, criteria include a 5-year conflict-of-interest project list, i.e., proof that the review team has not collaborated with the applicant within the last 5 years. Details are provided in Section H of the application template, available on the CARB website ([https://ww2.arb.ca.gov/sites/default/files/2020-06/ISD\\_OGGMB\\_152\\_Carbon\\_and\\_sequestration\\_project\\_application\\_form\\_0.pdf](https://ww2.arb.ca.gov/sites/default/files/2020-06/ISD_OGGMB_152_Carbon_and_sequestration_project_application_form_0.pdf)).

**Application Package:** Sections A–G of the application template collect background information about the applicant(s) and CCS project; the last two sections (I and J) address the qualifications for Site Sequestration Certification and CCS Project Certification, respectively. In general, the Site Sequestration Certification section contains the bulk of the application, housing similar geologic characterization and supporting plans as required for a North Dakota CO<sub>2</sub> SFP. The CCS Project Certification section houses reports of required well testing and baseline monitoring results, a majority of which are also required for a North Dakota CO<sub>2</sub> SFP. Although CO<sub>2</sub> capture and transport operation detail is not required by a North Dakota CO<sub>2</sub> SFP, these requirements are a straightforward addition to the application. The potential conflicts with a North Dakota CO<sub>2</sub> SFP are within the subsections of the Site Sequestration Certification regarding the required site risk assessment, testing and monitoring, and compliance via state approvals.

The most significant difference from North Dakota requirements is the inclusion of a Site-Based Risk Assessment Plan, the results of which are used to calculate the Buffer Account detailed in the LCFS CCS Protocol. The Buffer Account is to be retained through the first 50 years' postinjection as insurance against leakage and, thus, LCFS carbon credit losses. Risk probabilities must be scored within categories of <1% (low), 1%–5% (medium), and >5% (high), with a mandate that any rated “high” risks be mitigated to “medium” or “low” risks prior to application submittal. The estimated quantification of CO<sub>2</sub> storage must have > 90% probability that > 99% of the CO<sub>2</sub> is retained over a 100-year postinjection period. Specific risk tools are not listed, which CARB staff have explained is intentional. Their priorities during review will be the inputs and assumptions used to generate results.

Several monitoring requirements are mandated in addition to North Dakota stipulations, such as ecosystem stress, downhole microseismic, and a 100-year postinjection period. Ecosystem (vegetation) stress monitoring is required from preinjection (baseline) with annual operational measurements through postinjection. This can be challenging for a North Dakota CCS site where a majority of land use is agricultural (i.e., frequent vegetation changes) or covered in snow. CARB staff have concurred that remote sensing, such as satellite or areal surveys, are compliant and preferred. A permanent downhole seismic monitoring system must also be in place to detect any potentially induced microseismic activity in the storage zone. Microseismic monitoring is not a North Dakota CO<sub>2</sub> SFP requirement. It was determined through previous communications with CARB staff (Leroux and others, 2020) that fiber optic cable with DAS (distributed acoustic sensing) capability along the length of the injection wellbore would be compliant; alternatives may be applicable but were not discussed. Finally, the postinjection site care and monitoring period is

defined as “the time between the date of injection completion and 100 years after injection completion.” The North Dakota program may be of particular benefit in this case, as it allows for a transfer of title and monitoring activities to the State once all requirements for project completion as defined by North Dakota regulations have been met (Leroux and others, 2020).

CARB staff have stated that approval alone from other state entities is not sufficient justification for compliance; rather, it is the engineering and supportive technical documentation that will be evaluated for compliance. For example, RTE has sufficiently complied with North Dakota’s requirements for financial demonstration, which included a surety bond with the State of North Dakota for well plugging and site reclamation and a third-party pollution liability insurance policy to cover 1) postinjection site care and facility closure activities and 2) emergency and remedial response actions, if warranted. To determine compliance with their program, CARB will conduct an independent review of the calculations and assumptions used to estimate emergency funds presented in the SFP documentation. Another example is the maximum operating injection pressure, which must not exceed 90% of the storage fracture pressure per North Dakota CO<sub>2</sub> SFP requirements. The LCFS CCS Protocol requirement is 80% for the maximum. Again, North Dakota approval alone is not considered sufficient by CARB, and they will review the engineering and supportive technical documentation to evaluate for compliance with their program.

**Third-Party Certification:** Site Sequestration Certification requires review by the LCFS-approved geologist for Section I of the application template that contains site characterization, risk assessment, and supporting plan documentation. CCS Project Certification requires review by the LCFS-approved petroleum engineer for Section J of the application template that encompasses Well Construction and Legacy Well Remediation. This certification also requires the engineer to review and certify the Supporting Plans following the geologist review (and thus any changes incurred). Once third-party certification is complete, the application package is ready for formal submittal to the LCFS CCS staff for evaluation and approval of CCS Permanence Certification.

**LCFS Evaluation:** Once the application package has been submitted, the CARB review process includes 1) completeness check, 2) technical review, and 3) online posting of a redacted version for 30-day public review, only addressing “substantive comments that are technical.” Currently, LCFS CCS staff estimate the review process time frame to be about 12 months. This time frame does not include any discussion or informal review with CARB staff prior to third-party certification to ensure application completeness.

**Ethanol-CCS Pathway:** LCFS Tier 2 Pathways for certified CI values accounting for carbon credits are approved through a third-party verification process, separate from the CCS Permanence Certification process. These third-parties must be LCFS-accredited. The process for any pathway approval is defined by the overarching LCFS policy through CARB and includes operational data for the entire production of the fuel being certified and sold to California. Therefore, a minimum of 3 months of operational data is required for a “Provisional Pathway” to be considered for certification. The CI value generated and certified under this pathway is subject to change significantly with updated operational data, which can also affect credits acquired and have financial ramifications. The “Certified Pathway” thus requires a minimum of 2 years of operational data for a more risk-adverse CI value certification. Regardless of a Provisional or Certified

Pathway, CARB staff also stated that credits cannot be acquired before formal approval of CCS Permanence with no retroactive options.

## **MONITORING, REPORTING, AND VERIFICATION (MRV) PLAN FOR CCS TAX CREDITS**

To qualify for the Section 45Q CCS tax credit, the IRS requires an approved Monitoring, Reporting, and Verification (MRV) Plan under the EPA Greenhouse Gas Reporting Program (GHGRP) Subpart Resource Recovery (RR). MRV Plan requirements are provided in Title 40 Chapter I Subchapter C Part 98.448. This program has been established for over a decade with numerous approved plans available for reference on EPA's website ([www.epa.gov/ghgreporting/subpart-rr-geologic-sequestration-carbon-dioxide](http://www.epa.gov/ghgreporting/subpart-rr-geologic-sequestration-carbon-dioxide)). For example, Archer Daniels Midland Company had an MRV Plan approved in January 2017 for dedicated CO<sub>2</sub> storage.

A proposed MRV Plan must be submitted within 180 days of a CCS operator receiving formal approval for a North Dakota CO<sub>2</sub> SFP. A one-time filing extension of up to an additional 180 days is allowed with formal request. To submit an MRV Plan, operators must first establish a Certificate of Representation through the GHGRP's Electronic Greenhouse Gas Reporting Tool (e-GGRT, <https://ghgreporting.epa.gov>) at least 60 days prior to submitting an MRV Plan or filing an extension. All MRV Plans, extensions, and annual reports must be submitted electronically through e-GGRT.

The proposed MRV Plan must include 1) delineation of the maximum and active monitoring areas, 2) identification of potential surface leakage pathways within the maximum monitoring area, 3) strategy for detecting and quantifying any surface leakage of CO<sub>2</sub> as well as establishing baselines for monitoring CO<sub>2</sub> surface leakage, and 4) summary of how site-specific variables will be calculated using the mass balance equation. Figure 2 provides an illustrated summary, and Appendix A compares these EPA guidelines to North Dakota CO<sub>2</sub> SFP requirements. Because the North Dakota program was required to be equivalent or more stringent than the EPA Class VI Program to be granted primary enforcement authority (primacy), a majority of geologic characterization and monitoring requirements between the two are identical. CO<sub>2</sub> capture facility detail is an additional requirement for an MRV Plan and is similar to the information needed for LCFS CCS certification.

Once the proposed MRV Plan is submitted, EPA will send a notification of receipt and initiate a completeness check. If EPA determines the submitted MRV Plan is incomplete, the operator will have up to 45 days to submit an updated plan. Once determined to be complete, EPA will initiate a 60-day technical review of the MRV Plan, after which EPA may request additional information from the operator. If EPA requests additional information, the operator will be given a timeline to fulfill the request.

Formal approval of the submitted MRV Plan occurs when the technical review is satisfactory and EPA issues a final decision to the operator. The operator must implement the approved MRV Plan on the day or day after it becomes finalized. If an operator is dissatisfied with EPA's final decision, an appeal may be made to the Environmental Appeals Board.

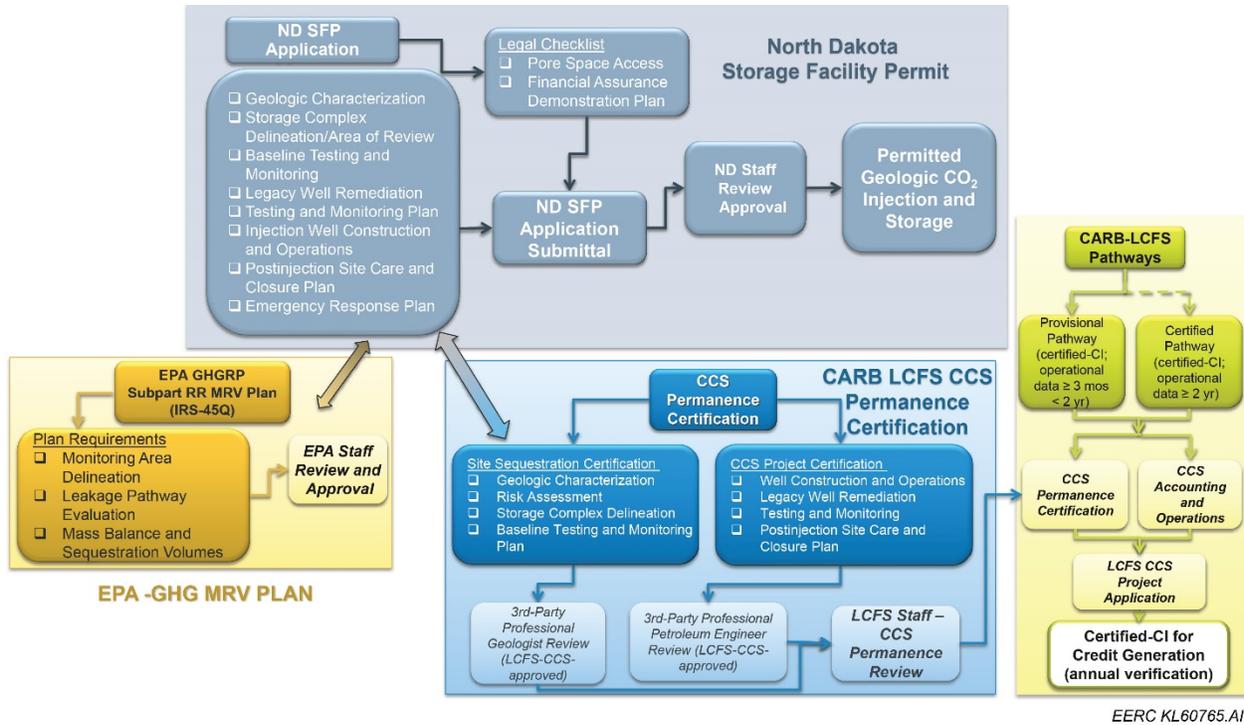


Figure 2. Addition of EPA MRV Plan approval requirements and process to the North Dakota regulations and California certifications shown in Figure 1.

If revisions to the approved MRV Plan are needed, then the operator must submit an updated MRV Plan to EPA for approval within 180 days of the proposed start for the new plan. Examples for plan modifications included but are not limited to changes to the monitoring and/or operations not originally anticipated, a change in the permit class of the injection well, or a notification by the EPA of substantive errors in the existing MRV Plan. While the revised MRV Plan is pending approval, the operator must continue to report under the most recently approved plan.

## MARKET GROWTH

The number of states and regional entities considering low carbon or clean fuel incentive programs has grown over the past year, with over a dozen states creating investigative legislation to explore potential program frameworks. States investigating LCF programs include Colorado, Iowa, Washington, Illinois, Kansas, Minnesota, Nebraska, New Mexico, Utah, Wisconsin, Maine, Maryland, and Vermont. At the federal level, Canada and Brazil remain the only countries currently considering nationwide LCF programs.

Investigated jurisdictions are in various stages of low carbon or clean fuel incentive development. Appendix B summarizes the current status of each incentive program by region and state. In general, California, Oregon, and British Columbia have maintained their established LCF programs, with California remaining the only program with official adoption of CCS certification. In December 2019, Oregon's Clean Fuels Program (CFP) incorporated CCS verbiage in its

proposed draft rule changes; however potential adoption appears to have stalled during the global pandemic. As programs evolve and mature, markets for LCFs are anticipated to increase, further supporting economic viability for CCS integration with fuel production.

## CONCLUSIONS

To maximize current incentive opportunities, small emitters should qualify for 1) a California LCFS Pathway with approved CCS Permanence Certification and 2) IRS-45Q CCS tax credits with an approved EPA MRV Plan. Developing application requirements for LCFS CCS certification simultaneously with an MRV plan can provide efficiencies in document preparation and ensure consistency.

Efficiencies can be gained by developing designs, plans, and applications simultaneously with North Dakota CO<sub>2</sub> SFP efforts and collaborating among program and regulatory authorities throughout the process. Review of coring programs, well designs, and monitoring plans with program authorities (particularly California) is recommended to allow any of their specific requirements to be included in an SFP application prior to submittal. While awaiting North Dakota regulatory review following SFP submittal, the LCFS-required site risk assessment can be developed for CCS certification, and supporting CO<sub>2</sub> capture and transport documentation can be packaged for both the LCFS CCS and EPA MRV applications.

Since California is the only state to date with formal CCS certification within its LCFS program, approved CCS certification plans may be compatible with other or evolving programs due to the prescriptive nature of the LCFS CCS Protocol requirements. For example, Oregon's CFP historically accepts California LCFS approvals while maintaining independent CI values. Continued assessment of evolving programs is recommended to evaluate optimal economic opportunities as CCS incentive qualifications emerge in other regions.

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**APPENDIX A**

**CCS INCENTIVES – REGULATORY CROSSWALK**

**CCS Incentives – Regulatory Crosswalk**

<b>Category</b>	<b>LCFS CCS Protocol</b>	<b>ND CO<sub>2</sub> SFP</b>	<b>EPA Class VI/ MRV (IRC-45Q)</b>
Minimum Injection Depth	2600 ft (800m)	Below lowermost USDW (Foxhills)	Below lowermost USDW
Site Characterization: Confining Zones Specifics	Primary, secondary & dissipation zone	Primary zone	Primary zone
Maximum Injection Pressure of Injection Horizon	80% of fracture gradient of the sequestration zone*	90% of fracture gradient of injection zone	90% of fracture gradient of injection zone
Annulus Pressure*	>Tubing pressure during injection	>Tubing pressure during injection	>Tubing pressure during injection
Area of Review	Based on the CO <sub>2</sub> plume migration	Based on larger of the CO <sub>2</sub> plume/pressure front or 1-mile buffer	Based on larger of the CO <sub>2</sub> plume and pressure front/zone of endangerment MRV: active/maximum area for delineation
<b><i>Modeling</i></b>			
History Matching Required	Required within 5-year review	Not specified	Not Specified
Reevaluate Plume Extent	< 5 years, with third-party review	Operator proposal, not > 5years	Operator proposal, not > 5years
Modeling Encompass	Injection period + 100-yr postinjection	Injection period + time frame for plume cessation (max 50 years)	Injection period + time frame for plume cessation (50 years)
Third-Party Review	Approved professional geologist/engineer	Not required	Not required

Continued . . .

**CCS Incentives – Regulatory Crosswalk (continued)**

<b>Category</b>	<b>LCFS CCS Protocol</b>	<b>ND CO<sub>2</sub> SFP</b>	<b>EPA Class VI/ MRV (IRC-45Q)</b>
<b>Risk Management Plan</b>			
Occurrence Period	100-year PISC	Through plume stabilization or 50 years	Through plume stabilization or 50 years
Risk of CO <sub>2</sub> Leakage	>90% probability that >99% of the CO <sub>2</sub> is retained over a 100-year period post injection.	Prevent migration into USDWs	Prevent migration into USDWs
Facilities	Process and operations of capture facility and pipeline with valves	Not specified	MRV: diagram/description of capture facility and process
<b>Testing and Monitoring</b>			
Ecosystem Stress Monitoring	Required annually	Not specified	Not specified
History Matching	Required within 5-year review	Not specified	Not specified
Emissions Monitoring for CO <sub>2</sub> Stream Analysis	Measure all energy inputs; continuous measurement of rate/composition/density (every 15 minutes); validate sampling points	Operator proposed with sufficient frequency to represent chemical/physical characteristics	Measure all energy inputs; semiannual to represent chemical/physical characteristics of oxides; sampling points at flowmeter
Post Injection Site Care Period	Minimum of 100 yr following cessation of injection*	Through plume stabilization or 50 years	Minimum of 50 years following cessation of injection*

\* Variance requests permissible.



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## **APPENDIX B**

# **STATUS OF LOW CARBON AND CLEAN FUEL INCENTIVE PROGRAMS ACROSS THE UNITED STATES AND ABROAD**

## STATUS OF LOW CARBON AND CLEAN FUEL INCENTIVE PROGRAMS ACROSS THE UNITED STATES AND ABROAD

States with Active Incentive Policies				
State Participation	Program Title	Status	Carbon Capture Storage (CCS) Inclusion	Regulatory Agency
California	Low Carbon Fuel Standard (LCFS)	Active	CCS Protocol	California Air Resources Board (CARB)
Oregon	Clean Fuels Program	Fuel Pathway – Active CCS – not active (June 2021)	CCS Protocol plans to mirror CARB	Environmental Quality (DEQ) & Environmental Commission

States Developing Incentive Policies				
State Participation	Program Title	Status	CCS Inclusion	Regulatory Department
Colorado	Climate Action Plan	Feasibility study – GHG Roadmap Final Report (Jan 2021)	Enact a task force for CCUS policy (mid-2021)  Regulatory Incentives	Colorado Energy Office
Illinois	Renewable Gas and Low Carbon Fuels Act Midwestern Clean Fuels Policy Initiative (1)	Introduced at Legislative General Assembly Feb 2021 (5)	State Tax and Regulatory Incentives	Illinois Commerce Commission
Iowa	Midwestern Clean Fuels Policy Initiative (1)	Study in 2009  In state legislature 2021 (2)	[none published]	
Kansas	Midwestern Clean Fuels Policy Initiative (1)	In state legislature	State tax incentives	[none published]
Minnesota	Future Fuels Act (Midwestern Clean Fuels Policy Initiative [1])	Legislative hearing in House March 2021 (4)	[none published]	

<b>States Developing Incentive Policies</b>				
<b>State Participation</b>	<b>Program Title</b>	<b>Status</b>	<b>CCS Inclusion</b>	<b>Regulatory Department</b>
Nebraska	Renewable Fuels Standard	In state legislature	[none published]	
Nevada	State Climate Strategy	Initial steps taken for 2030 goal (1)	[none published]	
New Mexico	Clean Fuel Standard Act	(Senate 2021/House 2022)	State tax incentives	[none published]
South Dakota	Great Plains Institute	Enacting Clean Diesel Program	[none published]	
Texas	Advanced Clean Energy Project	Policy in state legislature	State tax incentives	[none published]
Utah	Tier 3 Standards	Roadmap built to assist legislature – Alternative Fuel Credits established	State tax incentives	[none published]
Washington/ Puget Sound	Clean Fuels Program (by Jan. 1, 2023)	Preliminary (Legislative House Bill, 5/17/21. In State Senate) (2)	CCS via carbon credit generation proposed	[none published]
Wisconsin	Midwestern Clean Fuels Policy Initiative (1)	Task Force recommends to governor – plan to address summer 2021 (1)	[none published]	
Kentucky Louisiana Montana Michigan Mississippi North Dakota Oklahoma Wyoming	No LCFS Programs engaged	[none published]	State tax incentives	[none published]
<b>Northeast/Regional Programs</b>				
Connecticut	[none published]	Governor commits to Transportation and Climate Initiative Program (12/2020)	[none published]	
Delaware	[none published]	Climate Action Plan (8/2020)	[none published]	
Maine	[none published]	Program proposal	[none published]	
Maryland	[none published]	Program proposal (11/2019)	[none published]	

<b>States Developing Incentive Policies</b>				
<b>State Participation</b>	<b>Program Title</b>	<b>Status</b>	<b>CCS Inclusion</b>	<b>Regulatory Department</b>
Massachusetts	[none published]	Governor commits to transportation & climate initiative program (12/2020)	[none published]	
New Hampshire	[none published]	Legislative approval to engage in regional and national discussions (6)	[none published]	DEQ
New Jersey	[none published]	Proposal of Advanced Clean Trucks to Dept. Env. Protection (6/2021)	[none published]	
New York	[none published]	State legislative proposal for 2022 (failed 2021) (3)	[none published]	Environmental conservation
Pennsylvania	Plans to join the Regional GHG Initiative	Start date for Transportation & Climate Initiative Program in 2022	[none published]	
Rhode Island	[none published]	Governor commits to Transportation & Climate Initiative Program (12/2020)	[none published]	
Vermont	[none published]	Program study (2009)	[none published]	

Outside Countries Participation	Program Title	Status	CCS Inclusion	Regulatory Department
Canada	Clean Fuel Standard (includes any type of liquid fuels, not just transport fuels)	Published final regulations (Dec. 2021) Enact by Dec. 2022	Quantification method (similar to CCS Protocol)	By province
British Columbia	GHG Reduction Act (Renewable & Low Carbon Fuel Requirements)	Active in Transportation Credits CCS credits not established yet	Implementation in progress for proposed regulatory policy for CCS (7)	Ministry of Natural Gas Development
Brazil	RenovaBio	Established Dec. 2019 (Voluntary Carbon Credit market)	Under discussion	[none published]

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