



April 25, 2023

Mr. Reice Haase
Deputy Executive Director
North Dakota Industrial Commission
600 East Boulevard Avenue, Department 405
State Capitol, 14th Floor
Bismarck, ND 58505-0840

Dear Mr. Haase:

Subject: Quarterly Status Report for the Period of January 1 – March 31, 2023, “Field Study to Determine the Feasibility of Developing Salt Caverns for Hydrocarbon Storage in Western North Dakota”; Contract No. G-054-104

Attached please find the Energy & Environmental Research Center (EERC) Quarterly Status Report for the subject project. If you have any questions, please contact me by phone at (701) 777-5108 or by email at ssmith@undeerc.org.

Sincerely,

DocuSigned by:

Steve Smith

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Steven A. Smith

Assistant Director, Integrated Analytical Solutions

SAS/rlo

Attachment

c/att: Brent Brannan, North Dakota Industrial Commission
Karen Tyler, North Dakota Industrial Commission



FIELD STUDY TO DETERMINE THE FEASIBILITY OF DEVELOPING SALT CAVERNS FOR HYDROCARBON STORAGE IN WESTERN NORTH DAKOTA

Quarterly Project Status Report

(for the period January 1 – March 31, 2023)

Prepared for:

Reice Haase

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

Contract No. G-054-104

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**FIELD STUDY TO DETERMINE THE FEASIBILITY OF DEVELOPING SALT
CAVERNS FOR HYDROCARBON STORAGE IN WESTERN NORTH DAKOTA**
Quarterly Progress Report
January 1 – March 31, 2023

EXECUTIVE SUMMARY

The Energy & Environmental Research Center (EERC) was awarded a contract by the North Dakota Industrial Commission (NDIC) Oil and Gas Research Program (OGRP), NDIC No. G-054-104, to conduct a study on the feasibility of developing salt caverns in geologic formations in North Dakota for underground storage of energy resources, including natural gas, liquified natural gas, and hydrogen, as directed by Section 14 of North Dakota Senate Bill 2014. The EERC, in partnership with Bakken Energy, Neset Consulting Services, and the University of North Dakota Department of Petroleum Engineering, will validate the suitability of salt formations for cavern development and provide stakeholders with information needed to assess the techno-economic viability of storing hydrocarbons and/or hydrogen in engineered salt caverns in North Dakota. This update is for January 1 – March 31, 2023.

In December 2022, RESPEC completed the analysis of the core collected in the stratigraphic test well (HALITE 1). This quarter, RESPEC shared the final data, core, and core testing and interpretation report. The EERC completed additional analyses on selected core samples for model calibration.

The geomodeling team incorporated site-specific data from HALITE 1 into the geologic model and handed the model off to the geomechanics team. The geomodeling team is now focused on completing regional prospectivity mapping for salt cavern locations. The geomechanical modeling team began running simulations to determine potential cavern dimensions and operational stability.

WSP was selected as the consultant to assist in the engineering analysis and design work. Following a kickoff meeting, WSP began providing preliminary process flow diagrams. WSP will also provide a cost estimate for total cavern development. WSP's work is anticipated to be completed by the end of April. The EERC engineering team began compiling economic data for economic analysis models for different stored commodities and a list of surface facility decision factors important to the feasibility of salt cavern storage for inclusion in the final report.

**FIELD STUDY TO DETERMINE THE FEASIBILITY OF DEVELOPING SALT
CAVERNS FOR HYDROCARBON STORAGE IN WESTERN NORTH DAKOTA**
Quarterly Progress Report
January 1 – March 31, 2023

INTRODUCTION

The Energy & Environmental Research Center (EERC) was awarded a contract by the North Dakota Industrial Commission (NDIC) Oil and Gas Research Program (OGRP), NDIC No. G-054-104, to conduct a study of the feasibility of developing salt caverns in geologic formations in North Dakota for underground storage of energy resources, including natural gas, liquified natural gas, and hydrogen, as directed by Section 14 of North Dakota Senate Bill 2014. The EERC, in partnership with Bakken Energy, Neset Consulting Services (Neset), and the University of North Dakota (UND) Department of Petroleum Engineering, will validate the suitability of salt formations for cavern development and provide stakeholders with information needed to assess the techno-economic viability of storing hydrocarbons and hydrogen in engineered salt caverns in North Dakota.

This study follows a preliminary evaluation of the potential of salt cavern development completed by the EERC in December 2020. The 2020 study identified three salt formations deemed worthy of further investigation for characterization activities to inform future cavern development studies.

The goal of this field study is to validate the depth, thickness, and geologic and geomechanical suitability of the North Dakota salt formations for salt cavern development. The anticipated outcome is key information needed by the state, the oil and gas industry, and other interested parties to assess the techno-economic viability of storing hydrocarbon gases and hydrogen in engineered salt caverns.

This project will incorporate field, laboratory, modeling/simulation, and engineering analysis and design to determine the potential for salt cavern development in North Dakota. The work will be conducted in seven tasks.

ACCOMPLISHMENTS DURING REPORTING PERIOD

Project Management

This task includes the necessary activities to direct the project to meet all technical, schedule, and budget requirements. Work under this task will ensure that project plans, results, and decisions are appropriately documented and project reporting and briefing requirements are satisfied.

Significant accomplishments during the reporting period include the following:

- The sixth quarterly report was submitted on January 26, 2023.
- The Industry Advisory Board (IAB) reconvened. A meeting was held on January 25 with 14 members of the advisory board to review project progress since the last IAB meeting.
- The EERC participated in and provided information for legislative hearings pertaining to the project as requested, fulfilling Milestone (M)11.
- A final report template was shared with the project team. Summarizing completed tasks is in progress.

Site Screening and Characterization

In this task, potential locations with amenable salt formations will be identified and targeted for screening and characterization. Screening criteria will be based on the interpretation of publicly available wireline logs, thickness, confinement, and depth. Several potential site locations will be identified, and some small-scale, localized geologic modeling will be performed to inform decision-making.

Significant accomplishments during this reporting period include the following:

- This task is complete.

Site Selection/Land Permitting

In this task, the potential project locations identified in the Site Screening and Characterization task will be evaluated with project partners. Surface and subsurface rights will be secured. Permits will be secured in preparation for drilling.

Significant accomplishments during this reporting period include the following:

- This task is complete.

Drilling and Core Collection

As part of this task, a stratigraphic test well will be drilled at the selected site. The well will be logged, and core will be collected through the target salt formations. Neset will provide general contracting services and work closely with the EERC throughout the process from planning to site closure.

Significant accomplishments during this reporting period include the following:

- This task is complete.

Core Testing and Interpretation

This task includes all core testing and interpretation. Tests will be performed to identify bulk characteristics of the formation, including lithology, thickness, porosity, permeability, mineralogy, geomechanical competency of the overlying and underlying sealing formations, geomechanical properties of the salts, and dissolution properties of the salts.

Significant accomplishments during this reporting period include the following:

- The final data and the core testing interpretation report were received from RESPEC in early February 2023. Data included core lithology descriptions, gamma logging results, and results of geomechanical and geochemical testing of salt and non-salt core samples of the cored intervals.
- The EERC received the core from RESPEC. Seven more samples were selected and analyzed for porosity, permeability, and crystallographic structure using x-ray diffraction (XRD) and x-ray fluorescence analysis (XRFA) techniques. Results from these analyses were used to calibrate the mineralogical model that was based on petrophysical well logs.

Geologic and Geomechanical Modeling

As part of this task, modeling will be performed based on site-specific data generated through the drilling and core testing. Geologic models will be developed to inform the subsurface geologic regime and evaluate the regional structural and stratigraphic trends. Geomechanical modeling will incorporate information derived from the geologic models and the site-specific data and will inform the overall cavern dimensions and operational stability.

Significant accomplishments during this reporting period include the following:

- The geomodeling team incorporated site-specific data from HALITE 1 into the geologic model and handed off the model to the geomechanics team.
- The geomodeling team began compiling regional parameters of Dunham and Pine salts for screening based on geomechanical and salt composition results into a well log data cluster analysis for regional prospectivity mapping. Formation top picking started for 700+ additional wells.
- The geomodeling team began identifying the minimum well log data necessary to predict the presence of evaporite minerals (e.g., thenardite and halite) or well log patterns associated with depositional indicators of salt deposition for inclusion in the regional salt cavern prospectivity.

- Plans for completing 1D, 3D, and near-wellbore geomechanical modeling were elaborated, and additional personnel were onboarded.
- The geomechanical modeling team began running simulations to determine potential cavern dimensions and operational stability. Background stresses, deformation, and boundary conditions are included in the modeling.

Engineering Analysis and Design

This task includes the detailed engineering design and analysis that will be performed to identify surface equipment needs to include design specifications; brine-handling, use, and disposal practices; and monitoring needs. The EERC will also seek advisement from external engineering teams with expertise in developing and operating salt caverns used for hydrocarbon storage. Site-specific implementation plans for future cavern development will be developed.

Significant accomplishments during this reporting period include the following:

- Conversations with potential consultants were finalized, and revised quotes were received and reviewed. WSP was selected to assist with the engineering analysis and design.
- Following a kickoff meeting with WSP, process flow diagram (PFD) development and cost estimations began in mid-February and are anticipated to be complete by the end of April.
 - Preliminary PFDs for leaching, gas compression, and brine compensated storage facilities were received from WSP.
 - A request was submitted to WSP for a total cavern development cost estimation.
- Additional team members were onboarded.
- The engineering team began implementing specific case scenarios for process simulations in Aspen software.
- The engineering team began compiling economic data for development of the economic analysis models for different stored commodities and their unique facilities.
- The engineering team began compiling a list of surface facility decision factors and variables important to the feasibility of salt cavern storage for the final report.
- A member of the engineering team trained on SALGAS, a solution mining simulation software from the Solution Mining Research Institute (SMRI), to model leaching of caverns. The software simulates cavern development size, shape, duration, and water and power requirements.

FINANCIAL INFORMATION

This study is sponsored by NDIC OGRP. Table 1 presents the expected budget and expenses to date for the study.

Table 1. Salt Cavern Study – Expected Budget and Expenses to Date

Sponsors	Expected Budget	Actual	
		Expenses as of 3/31/2023	Balance
NDIC Share – Cash	\$12,986,200	\$11,085,443	\$1,900,757
Bakken Energy – In-Kind*	\$500,000	\$0	\$500,000
Total	\$13,486,200	\$11,085,443	\$2,400,757

* The Bakken Energy in-kind cost share was for securing land options and surface and subsurface rights for drilling the stratigraphic test well. By using a preexisting well pad for siting the stratigraphic test well, this need no longer exists. A contract modification is in progress.

PLANNED FUTURE ACTIVITIES

The following activities are planned for the next quarter.

Project Management

- Complete final report.

Site Screening and Characterization

- This task is complete.

Site Selection/Land Permitting

- This task is complete.

Drilling and Core Collection

- This task is complete.

Core Testing and Interpretation

- Incorporate findings in final report.

Geologic and Geomechanical Modeling

- Complete regional prospectivity mapping for salt cavern locations.
- Share geologic screening results with the engineering team.
- Complete 1D, 3D, and near-wellbore geomechanical modeling.
- Share geomechanics cavern modeling results with the engineering team for incorporating into engineering design.
- Summarize geologic and geomechanical modeling results in final report.

Engineering Analysis and Design

- Receive final project report from WSP.
- Complete main case scenarios in Aspen.
- Build economic analysis/model framework for each simulation scenario.
- Perform economic sensitivity analysis.
- Populate economic framework with outputs from Aspen.
- Complete leaching models for the Dunham, Pine, and Charles salts in SALGAS.
- Summarize engineering results for final report.