Critical Challenges. Practical Solutions.

Energy & Environmental Research Center (EERC)

# NORTH DAKOTA BRINE EXTRACTION AND STORAGE TEST

## DE-FE0026160

U.S. Department of Energy National Energy Technology Laboratory
Addressing the Nation's Energy Needs Through Technology Innovation – 2019 Carbon Capture, Utilization, Storage, and Oil and Gas Technologies Integrated Review Meeting
August 26–30, 2019

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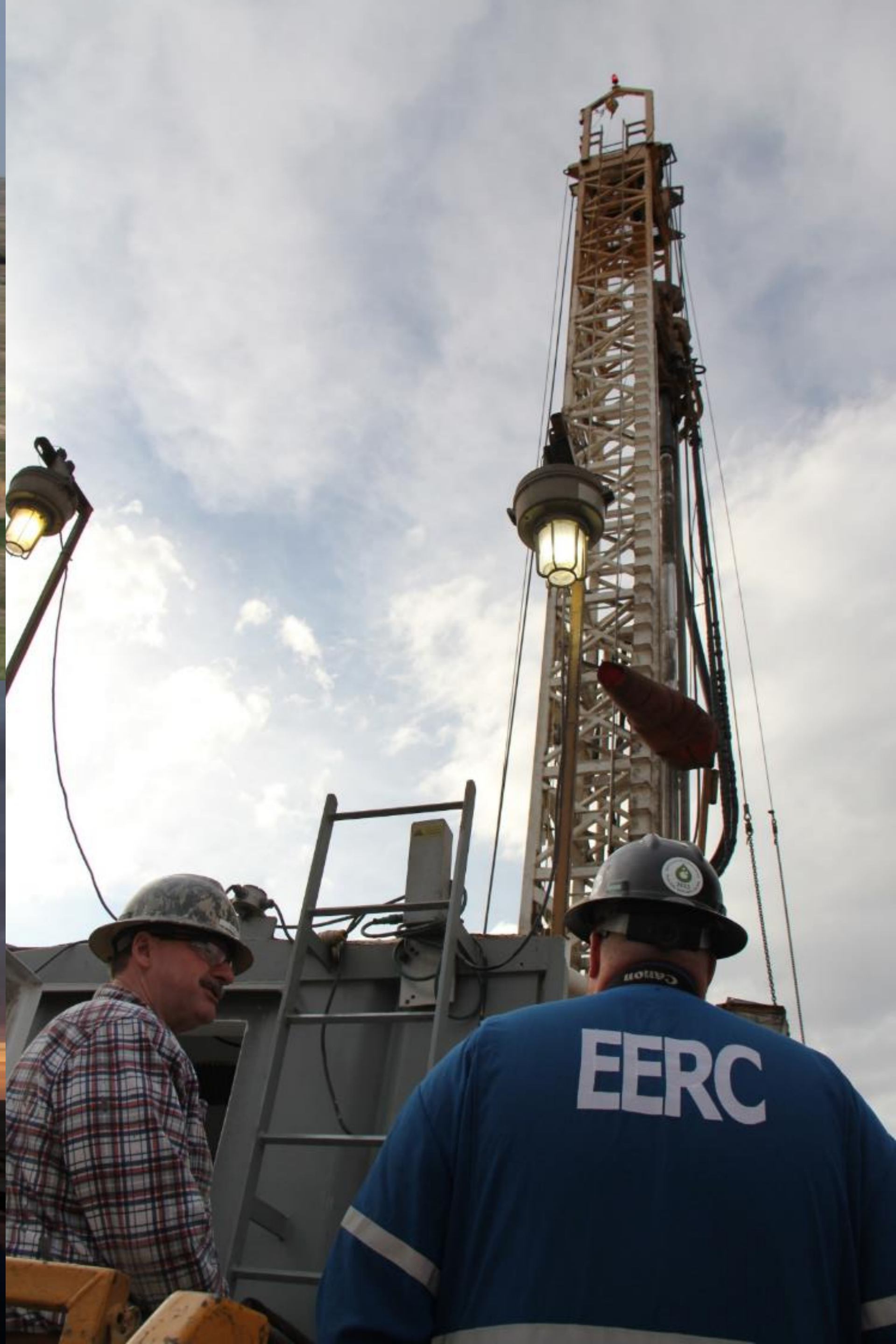
# NORTH DAKOTA

BRINE TREATMENT AND STORAGE TEST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UND UNIVERSITY OF NORTH DAKOTA

# GEOLOGIC $CO_2$ STORAGE

## CONSIDERATIONS FOR COMMERCIAL PROJECTS

- Buoyant fluid
- Large volumes = large footprint
- Access to pore space
  - Leasing, unitization/amalgamation, trespass
- Regulatory compliance
- Assuring permanence for incentives or credits
  - Conformance and storage efficiency


Because of a host of technical, social, regulatory, environmental, and economic factors, brine disposal tends to be more accessible and generally quicker, easier, and less costly to implement compared to dedicated $CO_2$ storage.

**Brine extraction can enable dedicated $CO_2$ storage and improve the geologic $CO_2$ storage potential of a site.**

# TWO COMPLEMENTARY COMPONENTS

Active Reservoir Management (ARM) Test

- Reduce stress on sealing formation
- Geosteer injected fluids
- Divert pressure from leakage pathways
- Reduce area of review (AOR)
- Improve injectivity, capacity, and storage efficiency
- Validate monitoring techniques, and forecast model capabilities

Brine Treatment Test Bed

- Alternate source of water
- Reduced disposal volumes
- Salable products for beneficial use

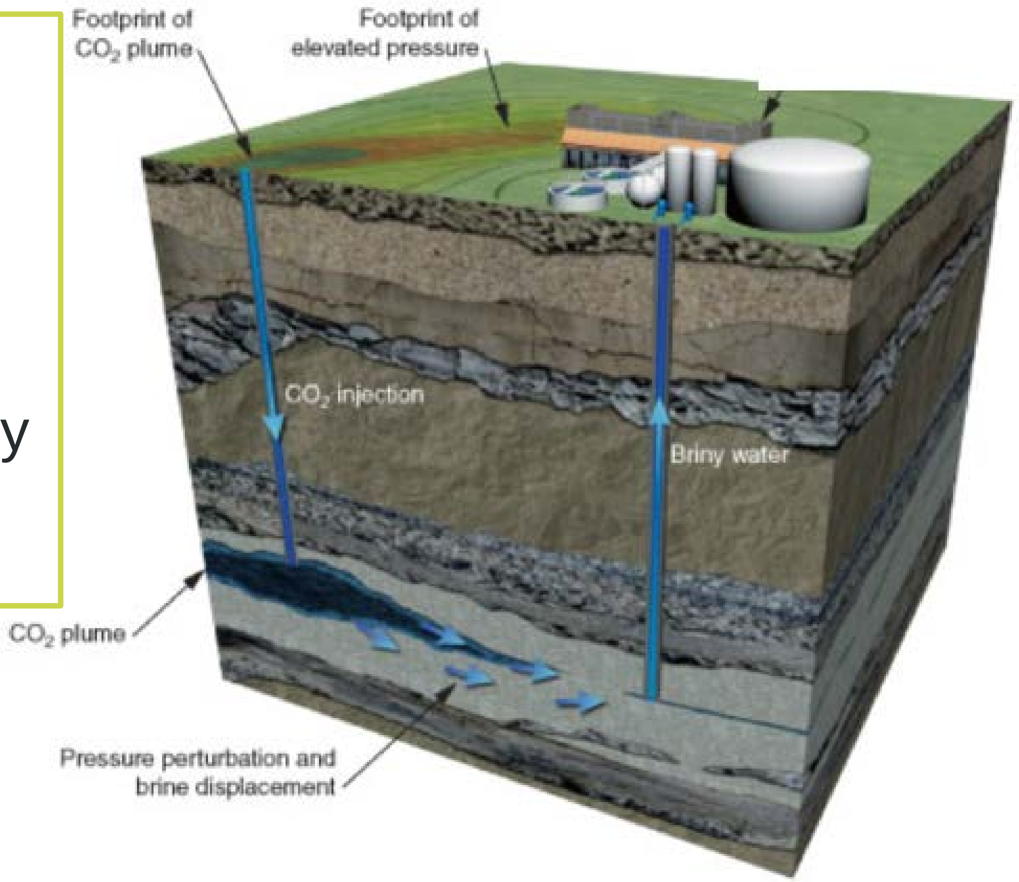
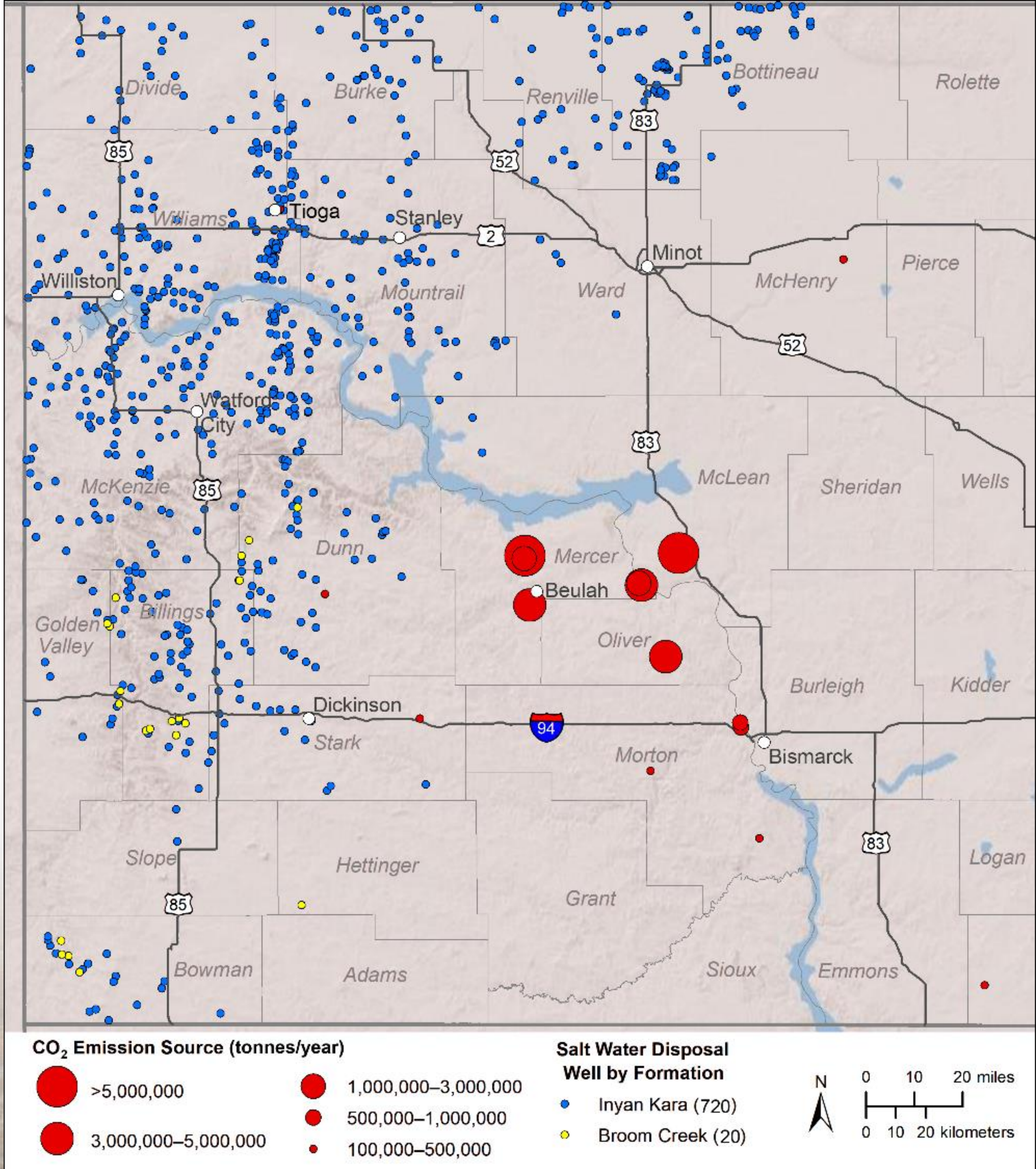
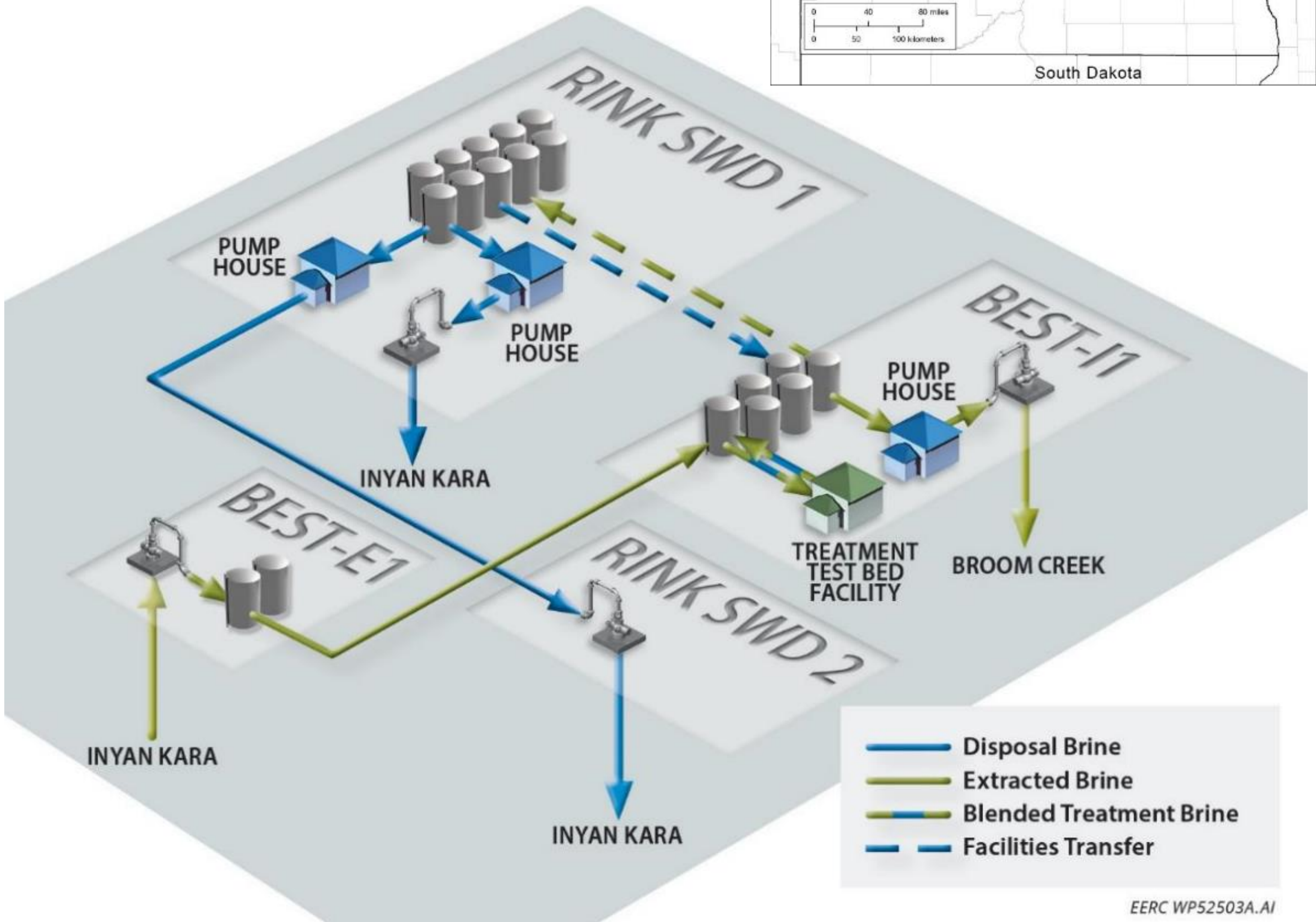



*Illustration modified from Lawrence Livermore National Laboratory https://str.llnl.gov/Dec10/aines.html*

# ACTIVE WATER DISPOSAL SITE AS A PROXY FOR DEDICATED $CO_2$ STORAGE

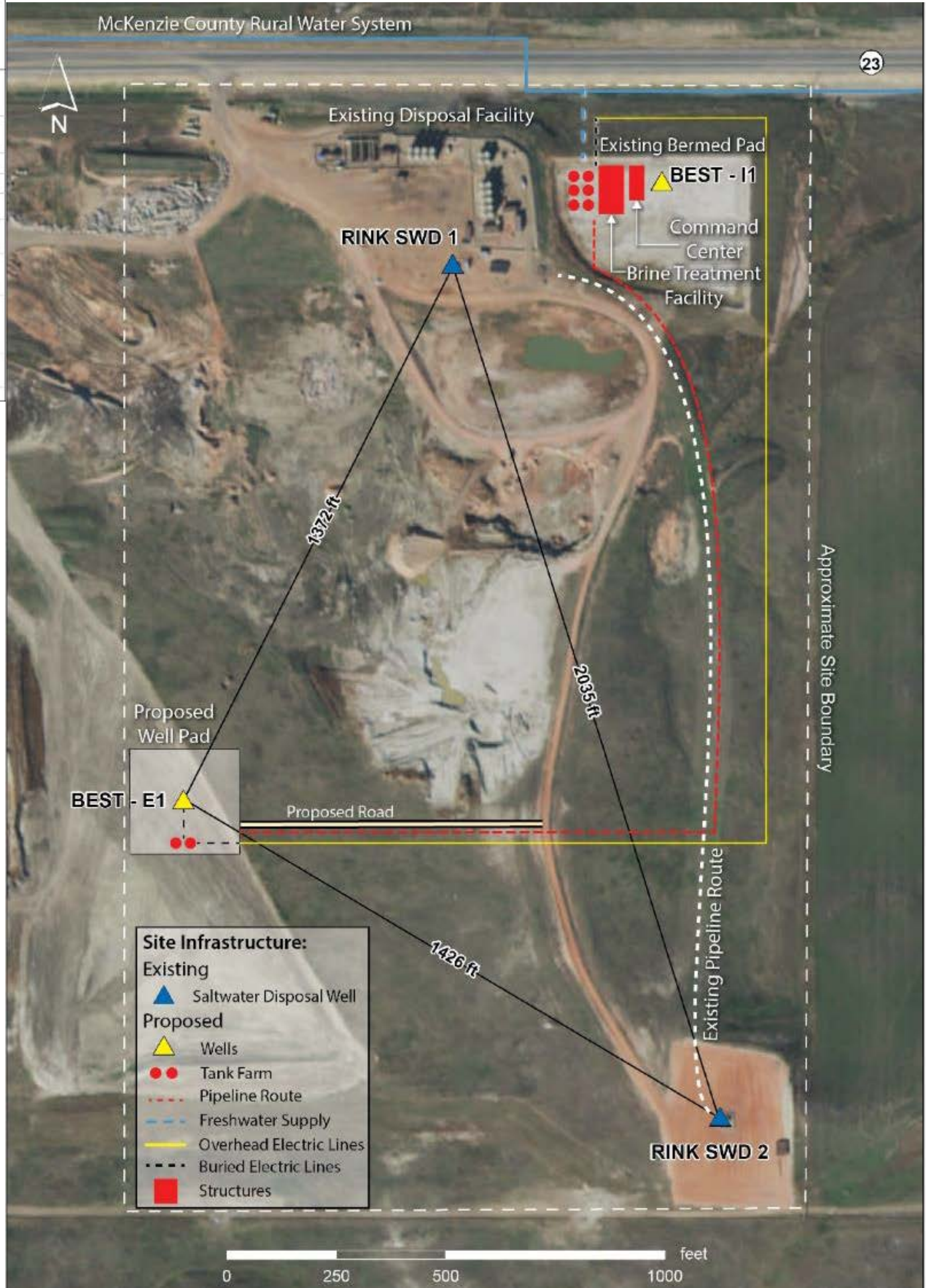


# THE SITE



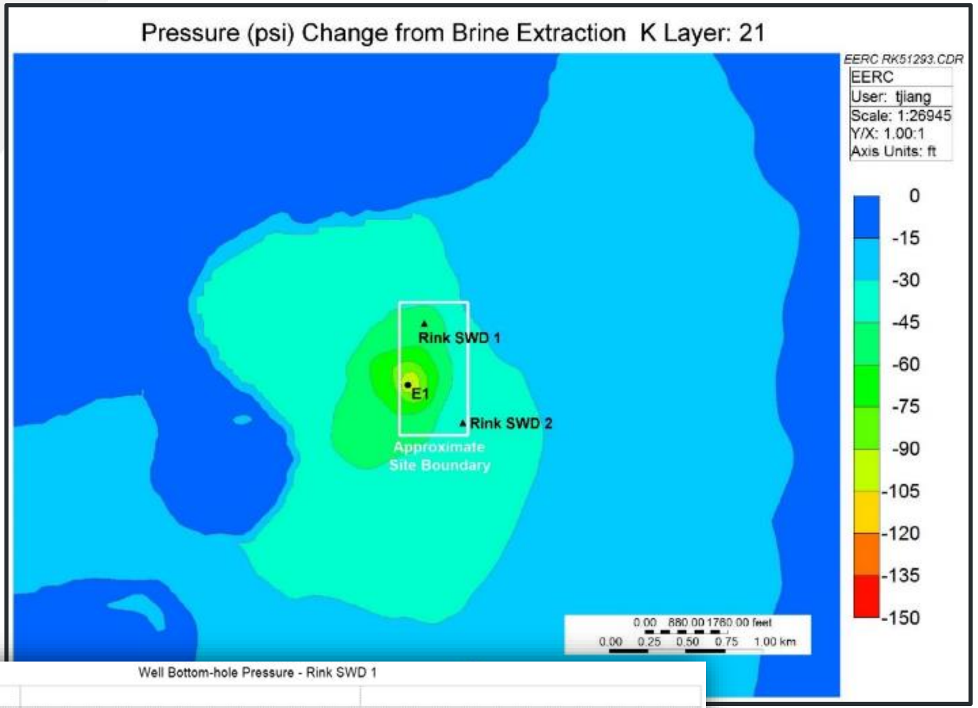
RINK SWD 1
PUMP HOUSE
PUMP HOUSE
INYAN KARA
BEST-I1
PUMP HOUSE
TREATMENT TEST BED FACILITY
BROOM CREEK
BEST-E1
RINK SWD 2
INYAN KARA
INYAN KARA
Disposal Brine
Extracted Brine
Blended Treatment Brine
Facilities Transfer
EERC WP52503A.AI


Saskatchewan
Manitoba
CANADA
UNITED STATES
Williston
Minot
BEST Site
North Dakota
Montana
Grand Forks
Minnesota
Bismarck
Dickinson
Fargo
0 40 80 miles
0 50 100 kilometers
South Dakota

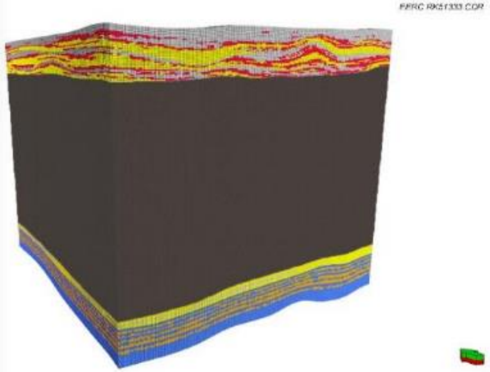



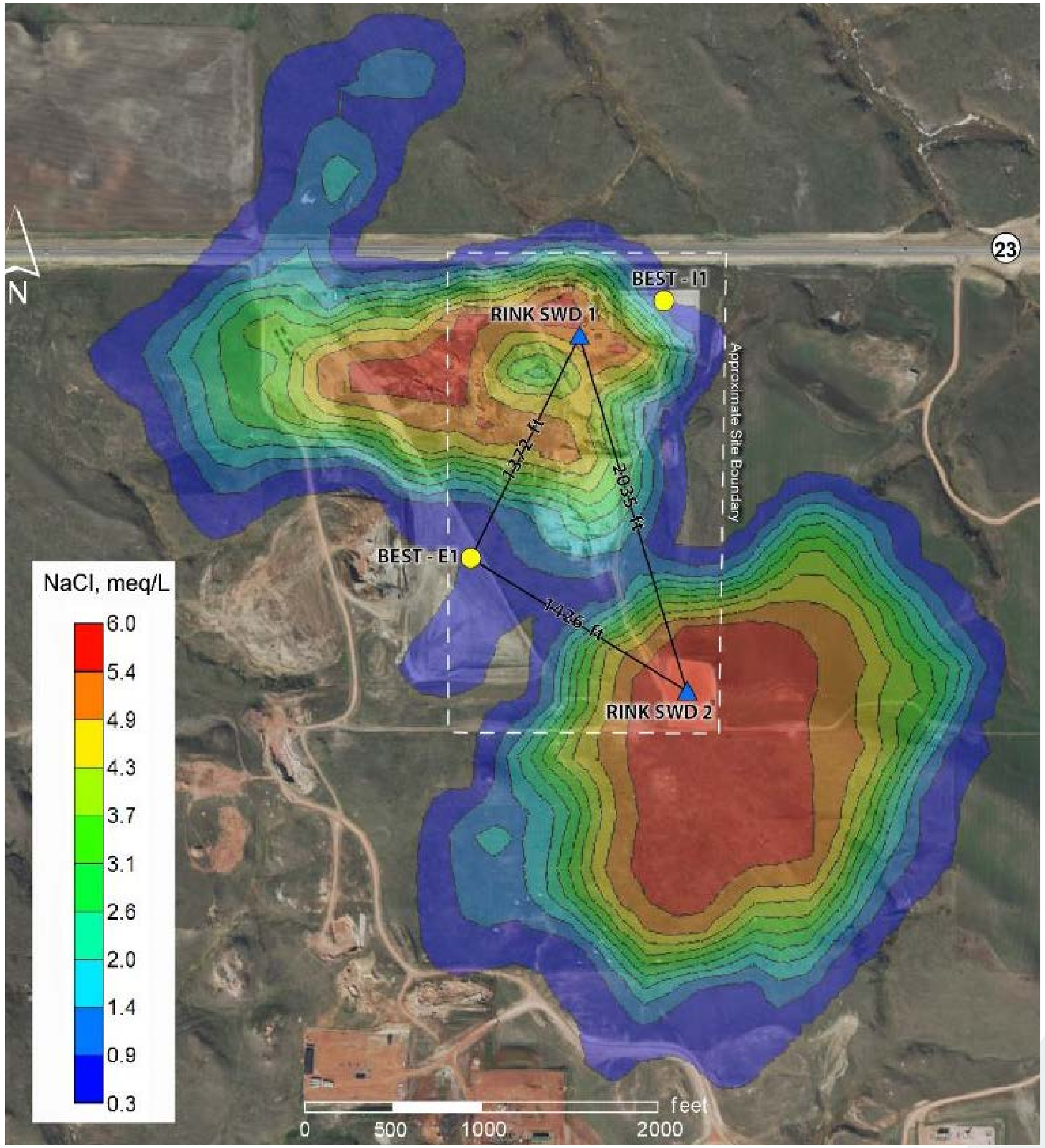
McKenzie County Rural Water System
23
N
Existing Disposal Facility
Existing Bermed Pad
BEST - I1
Command Center
Brine Treatment Facility
RINK SWD 1
1372 ft
2035 ft
Proposed Well Pad
BEST - E1
Proposed Road
Approximate Site Boundary
1426 ft
Existing Pipeline Route
RINK SWD 2
Site Infrastructure:
Existing
Saltwater Disposal Well
Proposed
Wells
Tank Farm
Pipeline Route
Freshwater Supply
Overhead Electric Lines
Buried Electric Lines
Structures
feet
0 250 500 1000

# THE DESIGN (BALANCE)





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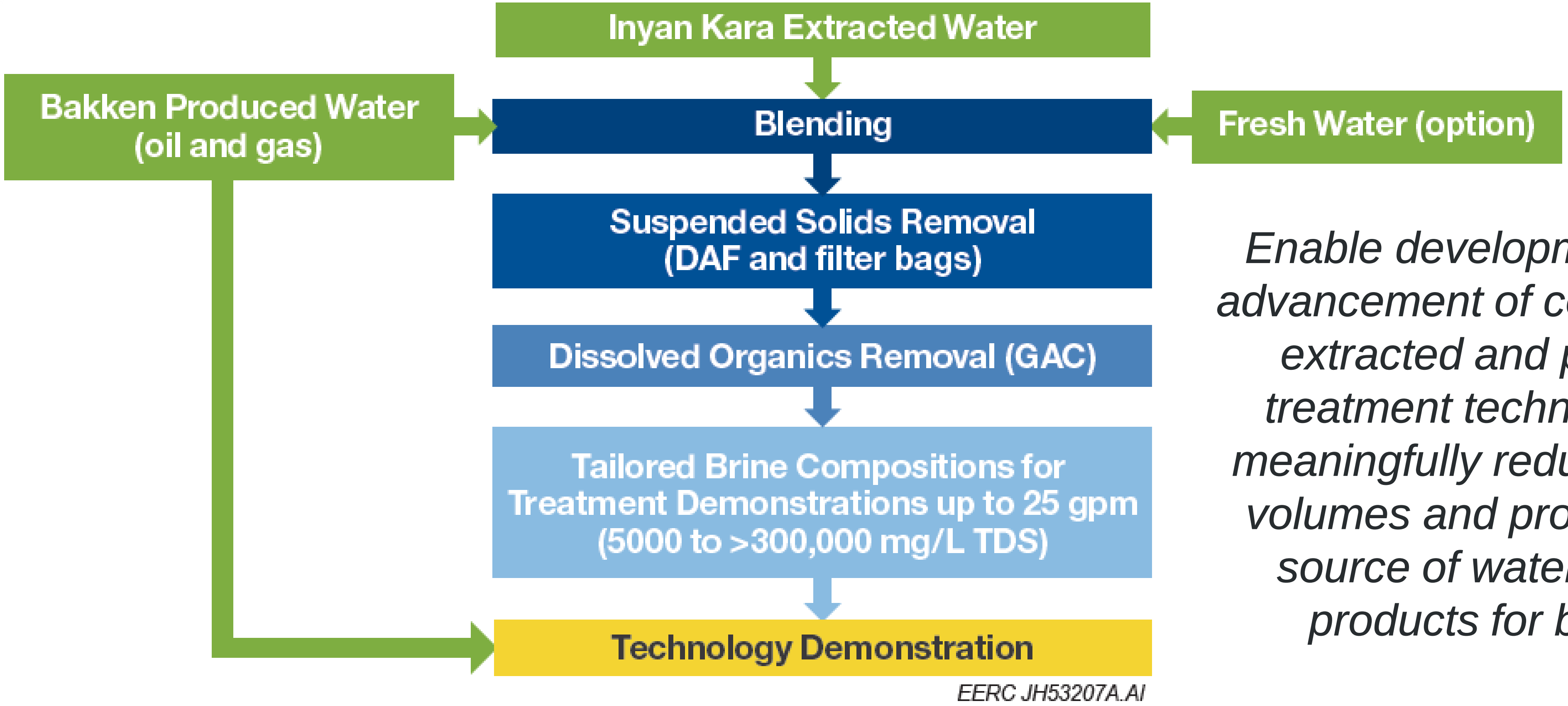
# BRINE TREATMENT TECHNOLOGY DEVELOPMENT AND TEST FACILITY




*Enable development, testing, and advancement of commercially viable extracted and produced water treatment technologies that can meaningfully reduce brine disposal volumes and provide an alternate source of water and/or salable products for beneficial use.*

- Permanent environmental enclosure
- Demonstration bay with concrete floor
- Integrated with ARM and SWD infrastructure
- Treatment rates up to 25 gpm (bench to pilot)
- Blending and pretreatment
- SCADA, energy/material and operability controls

# BRINE TREATMENT DEVELOPMENT FACILITY

# ACCOMPLISHMENTS

## ACTIVE RESERVOIR MANAGEMENT

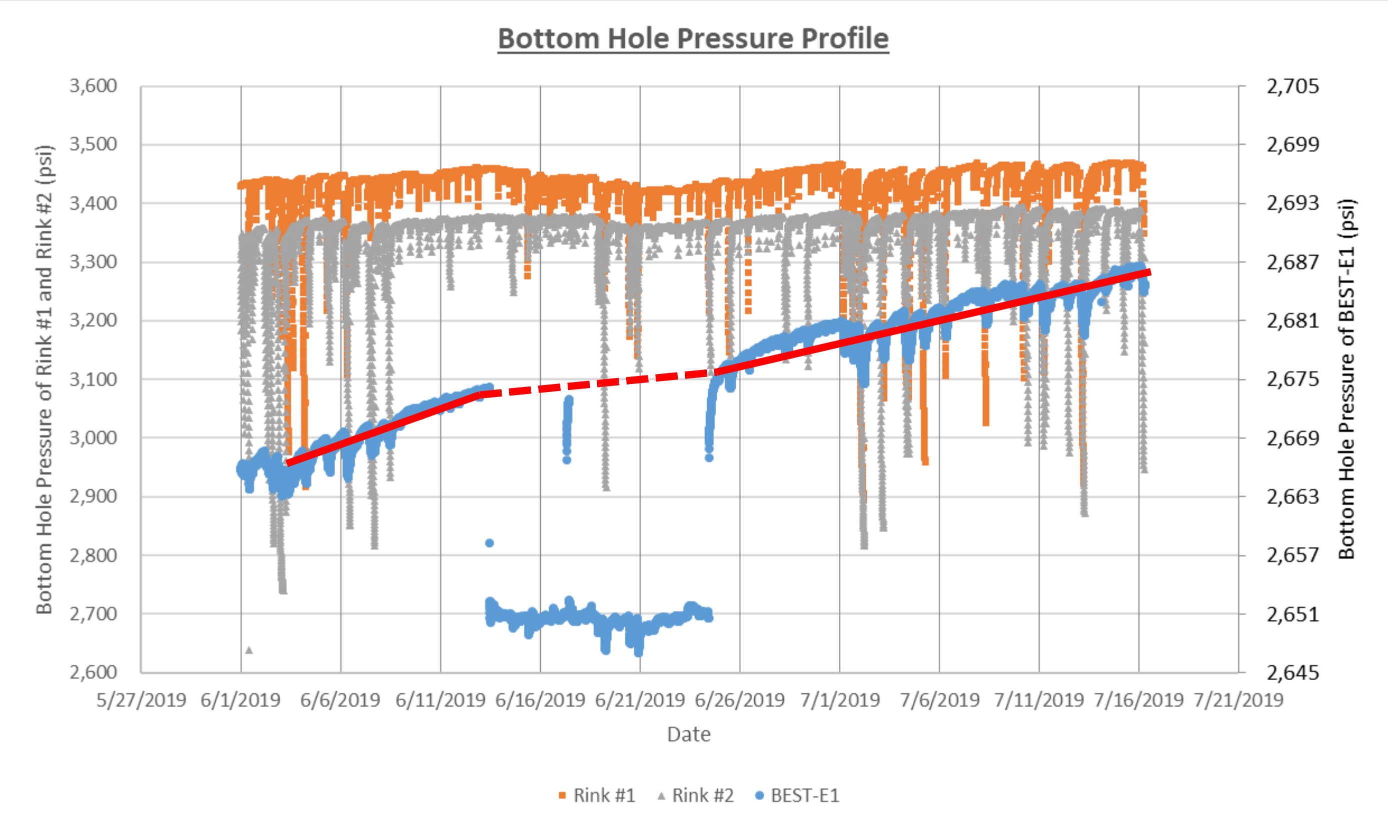
# ACCOMPLISHMENTS

## ACTIVE RESERVOIR MANAGEMENT

- Drilling and completion (BEST-I1,BEST-E1)
- Tie in with SWD infrastructure
- SCADA, HSE, and operability systems installed/tested; fixes and modifications incorporated; full integration and shakedown
- Achieved target rate of 5000 bbl/day
- **<u>Site is fully operational</u>**
- Updated performance models
- Updated and initiated field implementation plan (FIP)


# ACTIVE RESERVOIR MANAGEMENT

## RESPONSE




- Pressure communication between the extraction well and two injection wells
  - Connectivity confirmed
  - Measurable and significant response
  - Pressure buildup in reservoir due to injection
  - Brine extraction slows pressure buildup.

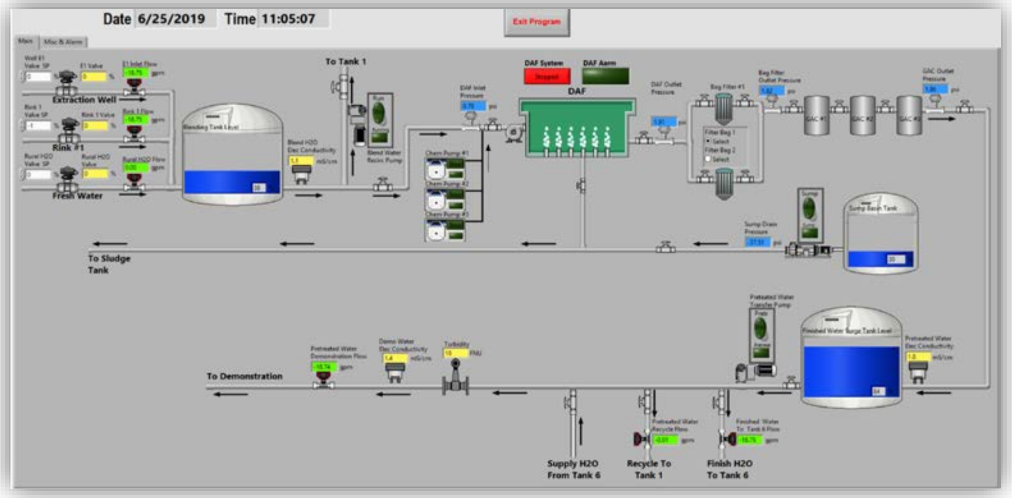
# ACCOMPLISHMENTS TO DATE

## BRINE TREATMENT DEVELOPMENT FACLITY

# ACCOMPLISHMENTS TO DATE

## BRINE TREATMENT DEVELOPMENT FACLITY

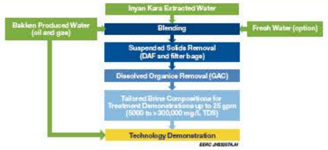
- Design and build complete
- SCADA, HSE, and operability systems installed/tested; fixes and modifications incorporated; shakedown complete
- **<u>Facility is fully operational.</u>**
- First demonstration completed
  - MVR, August 2019




# North Dakota water treatment test bed facility available for demonstration of produced water treatment technologies.

Enable development, pilot testing, and advancement of commercially viable extracted and produced water treatment technologies that can meaningfully reduce brine disposal volumes and provide an alternate source of water and/or salable products for beneficial use.

## TEST BED FACILITY CAN REPLICATE EXTRACTED WATERS THAT ARE REPRESENTATIVE OF LOCATIONS/ SOURCES THROUGHOUT THE UNITED STATES




## SITE SPECS

- 60' x 80' building (18-ft walls)
- 53' demonstration bay (accommodates semi tractor-trailer)
- 300 kW electric power
- Two overhead doors
- Demonstration bay, water pretreatment area, and control room
- Heated and insulated
- Air handling/exchange
- Hazardous environment detection and alarm
- Temporary water storage tanks for demonstration supply
- Waste handling and disposal on-site
- Pilot treatment rates ranging up to 25 gpm
- 30–60+ day extended-duration tests
- Capable of 24/7/365 operations

## FACILITY CAN BE READILY ADAPTED FOR USE WITH ALTERNATE FLUID COMPOSITIONS OR TREATMENT PROCESSES

- Alternate water sources trucked and offloaded at site
- Pretreatment and conditioning can be modified to replicate broader influent specifications
- Blending of alternate fluid chemistries for demonstration of water or chemical treatment processes
- Test beds for enabling technologies (e.g., power/thermal supply, pretreatment/conditioning...)
- On-site SWD (saltwater disposal) and waste handling
- Can accommodate propane (5000-gal tank) and/or noncontact cooling water (30 gpm)

## CONTROL ROOM

- Influent and effluent flow rates and composition
- Chemical usage
- Energy and thermal use/load
- EHS (environment, health, and safety) and operability systems (e.g., pretreatment systems, hazardous environment monitoring, etc.)

This is a collaborative effort with Nuverra Environmental Solutions and the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL).


ACKNOWLEDGMENT

DOE Disclaimer

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# REGIONAL CHALLENGES

Technological:

- Very high salinity brines (100,000 to >300,000 mg/L TDS).
- Potential for fluid interactions, scaling, TENORM (technologically enhanced naturally occurring radioactive material) or biogenic gas in treated concentrate streams.

Logistical:

- Environmental conditions … **Winter!**

Economic:

- Geologic injection is cost-efficient and convenient.
- Freshwater is inexpensive and abundant.
- Limited demand for brine treatment (ahead of market).

# CHALLENGES

Maintain an up-to-date risk register, mitigate risks where prudent, incorporate flexibility where possible, robust designs and contingency plans, be adaptive as conditions change.

- Extracted fluid temperature
- Injection rates/volumes in offset wells.
- Lessons from peers

Results from ARM field tests carry far reaching benefits that can positively impact commercial CCS implementation.

Large field tests have elevated risks and challenges.

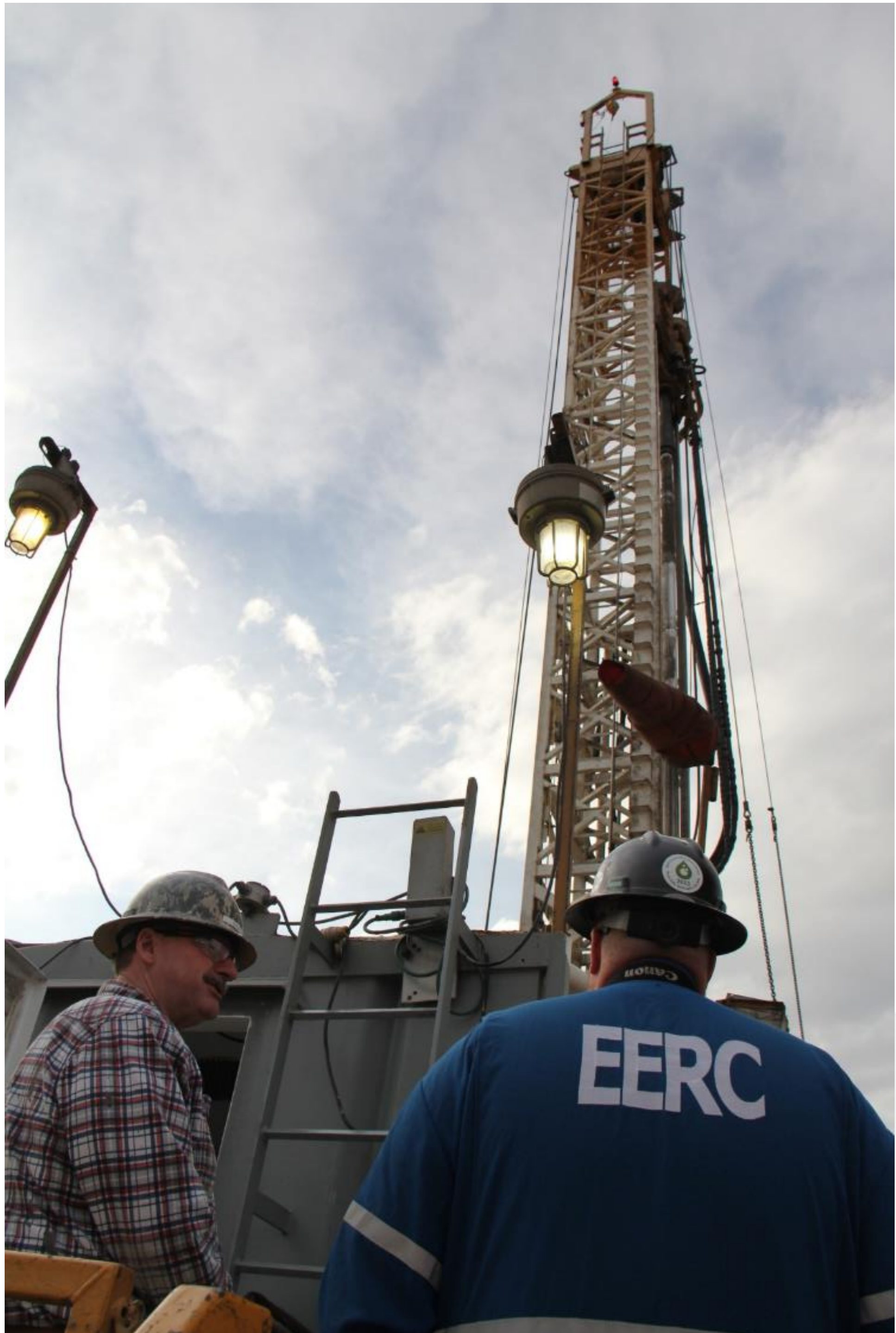
Risk, cost, and objectives must be managed together.

**Public/Private partnership is key**

Committed partners, strong relationships, and full roster of experts.

Design phase provides opportunity to develop robust design that incorporates flexibility.

Communication is crucial.



# SYNERGY OPPORTUNITIES

## MONDAY

## SUBSURFACE PLENARY

### PLAINS AND NORTHWEST 2

| | |
|---|---|
| 1:30 PM | North Dakota Integrated Carbon Storage Complex Feasibility Study (FE0029488)<br>• Wesley Peck, University of North Dakota Energy and Environmental Research Center (O'Dowd) |
| 2:00 PM | Integrated Midcontinent Stacked Carbon Storage Hub (FE0031623)<br>• Andrew Duguid, Battelle Memorial Institute (McNemar) |
| 2:30 PM | Commercial-Scale Carbon Storage Complex Feasibility Study at Dry Fork Station, Wyoming (FE0031624)<br>• Scott Quillinan, University of Wyoming (O'Dowd) |
| 3:00 PM | Developing and Validating Pressure Management and Plume Control Strategies in the Williston Basin Through a Brine Extraction and Storage Test (FE0026160)<br>• John Hamling, University of North Dakota Energy and Environmental Research Center (McNemar) |

## WEDNESDAY

## SUBSURFACE BREAKOUT

### GEOLOGIC STORAGE

| | |
|---|---|
| 3:50 PM | Task 4: Active Reservoir Management (FEW-0191)<br>• Thomas Buscheck, Lawrence Livermore National Laboratory (McNemar) |

## TUESDAY

## SUBSURFACE PLENARY

| | |
|---|---|
| 2:00 PM | Gulf Coast Field Demonstration at a Flagship Power Plant to Assess Optimal Reservoir Pressure Control, Plume Management and Produced Water Strategies (FE0026140)<br>• Robert Trautz, Electric Power Research Institute Inc. (Hull) |

# NORTH DAKOTA BRINE TREATMENT FACILITY

## SYNERGY

Facility can be readily adapted for use with alternate fluid compositions or treatment processes.

- Alternate water sources trucked and offloaded at site.
- Pretreatment and conditioning can be modified to replicate broader influent specifications.
- Blending of additives to replicate target fluid chemistries.
- Application of cascade technologies (e.g., power/thermal supply, pretreatment/conditioning…).
- On-site SWD and waste handling.

# NORTH DAKOTA BRINE TREATMENT FACILITY

## POTENTIAL ADAPTATION FOR EXPANDED APPLICATION

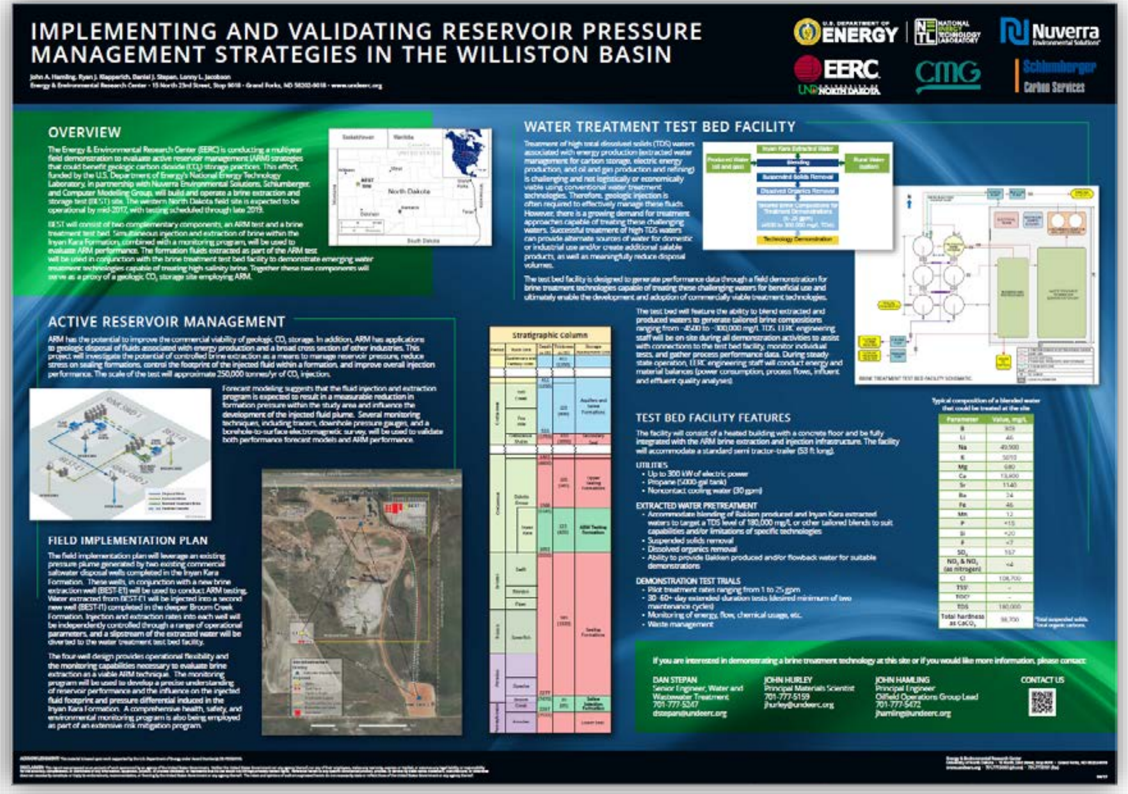
- Oil and gas fluid conditioning (e.g., emulsion breaking, corrosion, scale inhibitors, fluid compatibility testing, etc.)
- Produced water treatment
- Electric power generation wastewater treatment
- Industrial and municipal waste and water treatment
- Mineral resource recovery
- Agricultural water treatment
- Geologic conditioning and homogenization as a means of water pretreatment
- Benchmarking the economic and technical limits of water treatment technologies (e.g., MVR)
- Collaboration with other federal, state, or industry groups

## PARTNERS

## MAJOR CONTRACTORS

This material is based upon work supported by the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL) under Award No. DE-FE0026160.

# INFORMATION AND OUTREACH



# SITE EVENTS

## STAKEHOLDER ENGAGEMENT AND COMMISSIONING
## IEAGHG RISK AND MODELING NETWORK MEETING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# THANK YOU

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# APPENDIX

# BENEFIT TO THE PROGRAM

This project is expected to result in the development of engineering strategies/approaches to quantitatively affect changes in differential formation pressure and to monitor, predict, and manage differential pressure plume movement in the subsurface for future $CO_2$ saline storage projects. Additionally, the brine treatment technology evaluation is expected to provide valuable information on the ability to produce water for beneficial use. The results derived from implementation of the project will provide a significant contribution to the U.S. Department of Energy's (DOE's) Carbon Storage Program goals. Specifically, this project will support **Goals 1 and 2** by validating technologies that will improve reservoir storage efficiency, ensure containment effectiveness, and/or ensure storage permanence by controlling injected fluid plumes in a representative $CO_2$ storage target. Geologic characterization of the target horizons will provide fundamental data to improve storage coefficients related to the respective depositional environments investigated, directly contributing to **Goal 3**. In addition, this project will support **Goal 4** by producing information that will be useful for inclusion in DOE best practices manuals.

# PROJECT OVERVIEW

## GOALS AND OBJECTIVES

- Confirm efficacy of ARM for commercial scale CCUS
  - Managing injection performance and formation pressure
  - Model, predict, monitor and validate movement of fluids and pressure
  - Generate results that enable evaluation and adoption of concept at compatible CCUS sites.

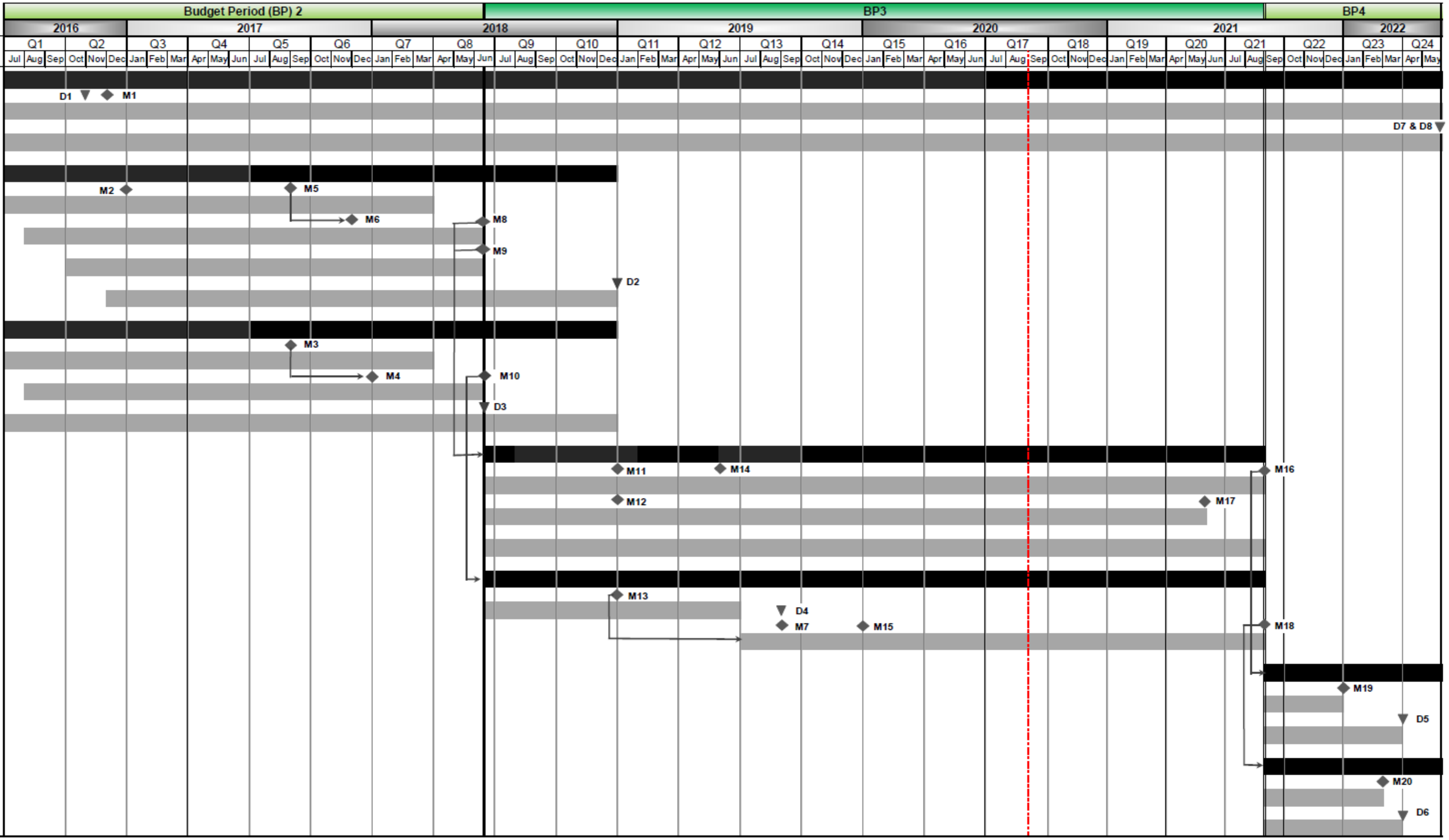
- Implement and operate a development facility for brine treatment technologies applicable to ARM for CCUS

Three development stages over 71 months

1. Site preparation and construction
2. Site operations for ARM and brine treatment technology testing and development
3. Project closeout/decommissioning and data processing/reporting

# Gantt Chart, Deliverables, and Milestones

| Task | Start Date | End Date |
|---|---|---|
| **Task 1.0 – Project Management, Planning and Reporting** | **7/7/16** | **5/31/22** |
| 1.1 – Project Management | 7/7/16 | 5/31/22 |
| 1.2 – Project Reporting | 7/7/16 | 5/31/22 |
| **Task 2.0 – ARM Site Preparation** | **7/7/16** | **12/31/18** |
| 2.1 – ARM Permitting | 7/7/16 | 3/31/18 |
| 2.2 – Well Installation | 8/1/16 | 6/15/18 |
| 2.3 – Surface Infrastructure Installation | 10/1/16 | 6/15/18 |
| 2.4 – Updated Site Characterization and Modeling | 12/1/16 | 12/31/18 |
| **Task 3.0 – Test Bed Site Preparation** | **7/7/16** | **12/31/18** |
| 3.1 – Test Bed Facilities Permitting | 7/7/16 | 3/31/18 |
| 3.2 – Test Bed Facility Installation | 8/1/16 | 6/15/18 |
| 3.3 – Solicitation of Treatment Technologies | 7/7/16 | 12/31/18 |
| **Task 4.0 – ARM Operations** | **6/16/18** | **8/31/21** |
| 4.1 – Injection/Extraction Testing | 6/16/18 | 8/31/21 |
| 4.2 – MVA Implementation | 6/16/18 | 5/31/21 |
| 4.3 – Model Updates/History Matching | 6/16/18 | 8/31/21 |
| **Task 5.0 – Test Bed Treatment Operations** | **6/16/18** | **8/31/21** |
| 5.1 – Facility Shakedown/Training | 6/16/18 | 6/30/19 |
| 5.2 – Long-Term Performance Evaluations | 5/1/19 | 8/31/21 |
| **Task 6.0 – ARM Data Processing/Project Closeout** | **9/1/21** | **5/31/22** |
| 6.1 – ARM Site Decommissioning/Disposition | 9/1/21 | 12/31/21 |
| 6.2 – Finalization of ARM Test Results | 9/1/21 | 3/31/22 |
| **Task 7.0 – Test Bed Data Processing/Project Closeout** | **9/1/21** | **5/31/22** |
| 7.1 – Test Bed Decommissioning/Disposition | 9/1/21 | 2/28/22 |
| 7.2 – Finalization of Test Bed Results | 9/1/21 | 3/31/22 |




Note: The contract modification for Phase II was fully executed on September 9, 2016.

Red line indicates the end of the 5 year program.

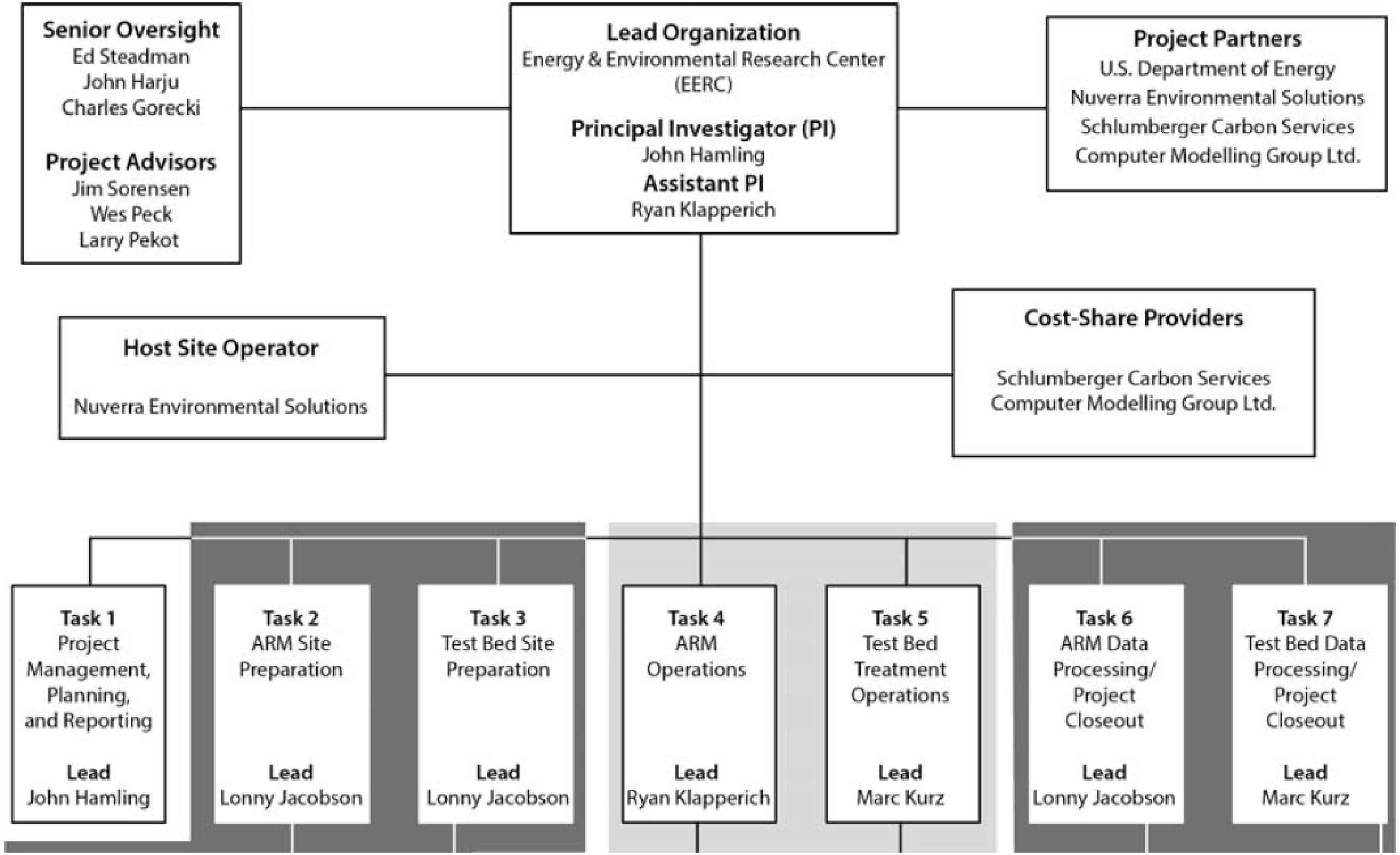
**Deliverables ▼**

- D1 – Updated PMP
- D2 – Field Implementation Plan (FIP) Finalized
- D3 – Water Treatment Technology Selection Process Summary
- D4 – Preliminary Schedule of Technologies
- D5 – Vol. 1 – ARM Engineering and Evaluation Summary
- D6 – Vol. 2 – Technology Evaluation Report
- D7 – Data Submission to EDX
- D8 – Lessons Learned Document

**Milestones (M) ◆**

- M1 – Project Kickoff Meeting
- M2 – Permit to Drill Submitted
- M3 – Water Treatment Test Bed Permit Received
- M4 – Start Water Treatment Facilities Construction
- M5 – Permit to Drill Received
- M6 – Start Site Preparation
- M7 – First Treatment Technology Selected
- M8 – Well Installation Complete
- M9 – Surface Installation Complete
- M10 – Water Treatment Facilities Complete
- M11 – Initiate Stage 1 of Experimental Scenario
- M12 – Initiate Collection of Operational Data
- M13 – Water Treatment Test Bed Fully Operational
- M14 – Initiate Stage 2 of Experimental Scenario
- M15 – First Treatment Technology Evaluated
- M16 – Completion of ARM Operations
- M17 – Conduct Repeat BSEM Survey
- M18 – Completion of Water Treatment Technology Demonstration
- M19 – ARM Site Decommissioning/Disposition Completed
- M20 – Water Treatment Test Bed Decommissioning/Disposition Completed

# ORGANIZATION CHART



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# PROJECT SUMMARY

## 2019

- Test bed operational June 2019
- ARM FIP Initiated
- Seeking technologies for testing at ND Brine Treatment Test Bed User Facility.
- First technology selected and scheduled for testing

## 2020

- Seek and schedule technologies for testing at ND Brine Treatment Test Bed User Facility.
- Preferred operations in spring, summer, or fall
- Update and continue ARM FIP, data collection, and interpretation

## 2021

- Operations currently planned through September 2021
- Generate results that enable evaluation and adoption of concept at compatible CCUS sites

North Dakota Brine Treatment Facility and ARM Test Operating Time Frame