Energy & Environmental Research Center (EERC)

NORTH DAKOTA BRINE TREATMENT TECHNOLOGY DEVELOPMENT AND TEST BED FACILITY

BRINE EXTRACTION AND STORAGE TEST (BEST)

DE-FE0026160

U.S. Department of Energy National Energy Technology Laboratory
Water Technologies Project Review Meeting
September 17, 2020 – 1:30 p.m. ET

John Hamling
Assistant Director, Integrated Projects

PROGRAM OVERVIEW

Objectives:

- Validate efficacy of brine extraction as a means of active reservoir management (ARM)
  - Applications that can enable the implementation and improve the operability of industrial carbon capture and storage (CCS) projects.
  - Manage injection performance and formation pressure.
  - Model, predict, monitor, and validate movement of fluids and pressure.
  - Provide data set to enable evaluation and design of ARM applications at compatible CCS sites.
  - Improve use and efficiency of geologic CO_2 storage resources
- Implement and operate a brine treatment technology development and test bed facility
  - Enable development of brine treatment technologies capable of treating high-total dissolved solids (TDS) brines associated with geologic CO_2 storage target.

Project Details:

- Phase II project: $21,323,604
  - DOE Share: $17,103,044
  - Cost Share: $4,220,560
    - ♦ Schlumberger: $2,800,000
    - ♦ CMG: $1,420,560
- Period of Performance:

  July 2016 – May 2022

PARTNERS

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

EERC

Nuverra Environmental Solutions

CMG

Schlumberger Carbon Services

MAJOR CONTRACTORS

AE2S CONSTRUCTION

AE2S INDUSTRIAL

HAM'S WELL SERVICE WESTHOPE, ND

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

TWO COMPLEMENTARY COMPONENTS

Active Reservoir Management (ARM) Test

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

Brine Treatment Test Bed

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

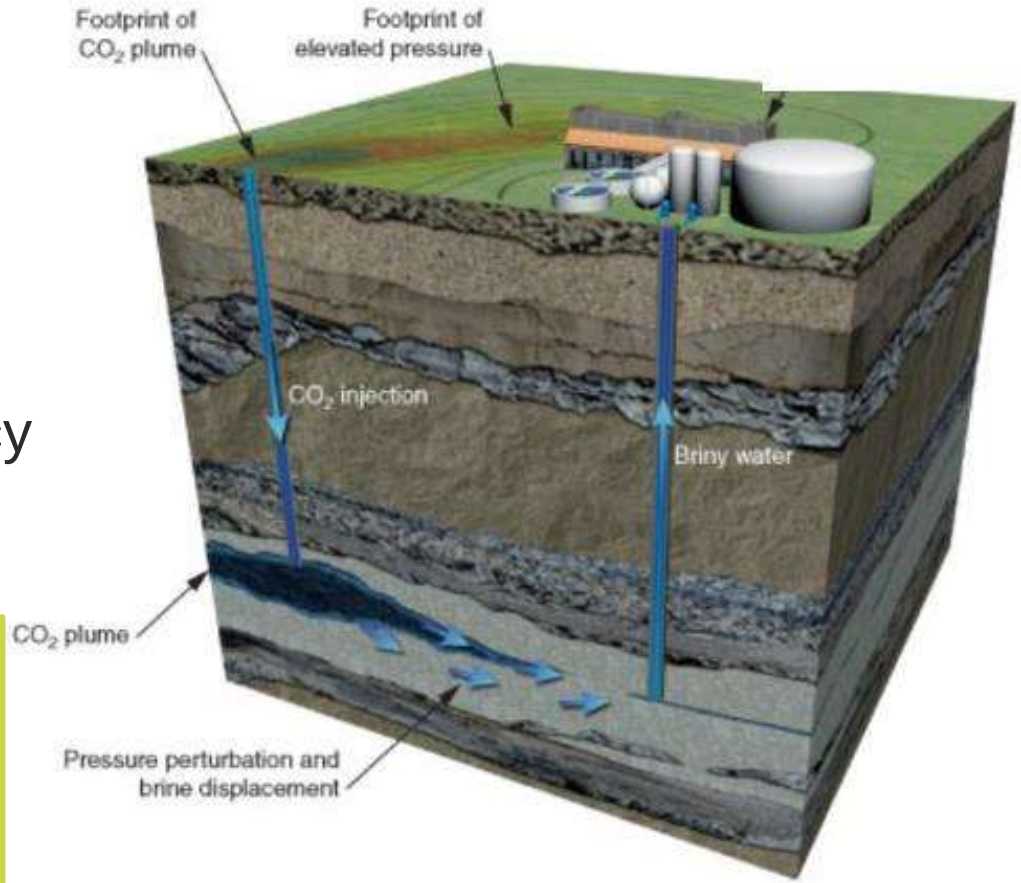
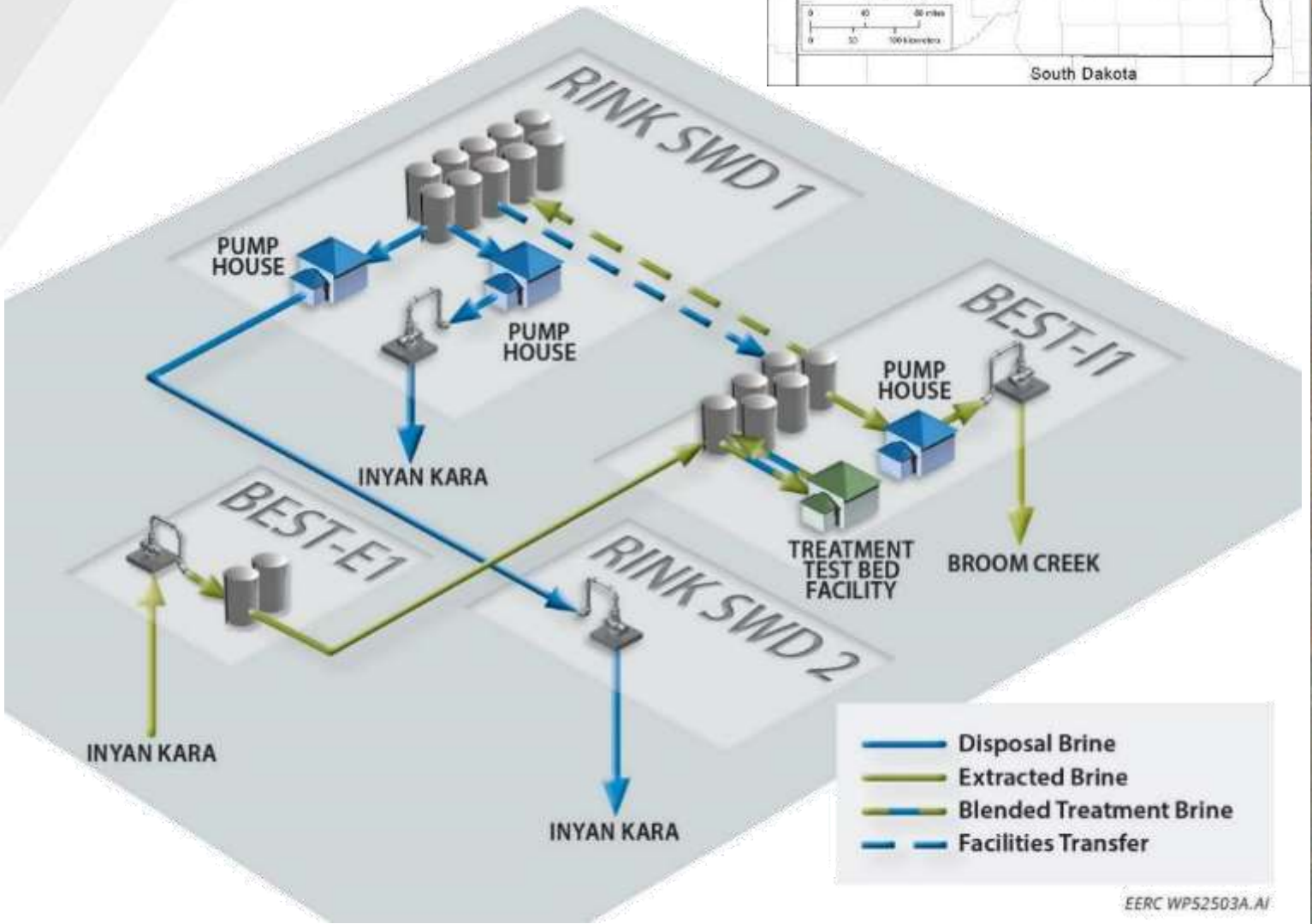


Illustration modified from Lawrence Livermore National Laboratory https://str.llnl.gov/Dec10/aines.html

THE SITE


Saskatchewan
Manitoba
CANADA
UNITED STATES
Williston
Minot
BEST Site
Montana
North Dakota
Grand Forks
Minnesota
Bismarck
Dickinson
Fargo
South Dakota


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 WPS2503A.AI


McKenzie County Rural Water System
23
N
Existing Disposal Facility
Existing Bermed Pad
BEST - I1
RINK SWD 1
Command Center
Brine Treatment Facility
1312 ft
2055 ft
Approximate Site Boundary
Proposed Well Pad
BEST - E1
Proposed Road
Existing Pipeline Route
1426 ft
Site Infrastructure:
Existing
Saltwater Disposal Well
Proposed
Wells
Tank Farm
Pipeline Route
Freshwater Supply
Overhead Electric Lines
Buried Electric Lines
Structures
RINK SWD 2
feet
0
250
500
1000

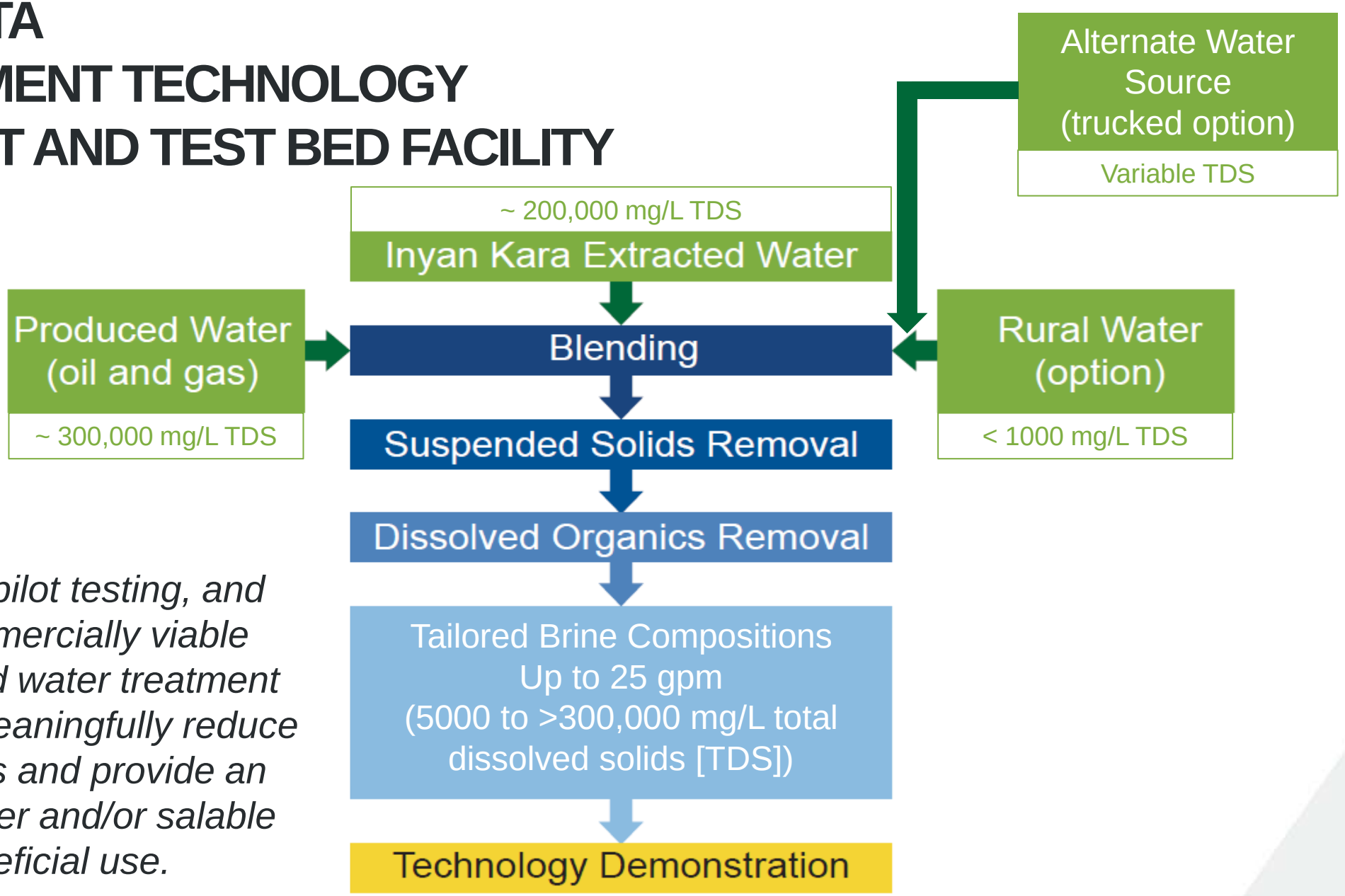
SUCCESS CRITERIA

Validate efficacy of ARM applications to industrial CO_2 storage projects (though a field test).

Demonstrate the steps necessary to design and implement ARM for industrial CCS projects.

Enable development of water treatment technologies with application to treating high-TDS brines associated with geologic CO_2 storage targets.

NORTH DAKOTA BRINE TREATMENT TECHNOLOGY DEVELOPMENT AND TEST BED FACILITY



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.

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

EERC
UND NORTH DAKOTA

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 60' building (16-ft walls)
- 32' 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 (3000-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.)
- Remote, real-time, secure access

ACKNOWLEDGMENT

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

Developing and Validating Pressure Management and Plume Control Strategies in the Williston Basin Through a Brine Extraction and Storage Test

John Harding, Marc Kurz, Ryan Klapperich, Lonny Jacobson, and Robert Jensen

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undeerc.org

EERC · Nuverra · U.S. DEPARTMENT OF ENERGY · NETL · CMG COMPUTER MODELLING GROUP LTD · Schlumberger

WATFORD CITY, NORTH DAKOTA

Oil & Gas Industrial Hub

- Population: ~15,000
- Lodging and restaurants
- 24-hour services

15 MILES EAST OF WATFORD CITY

ON HIGHWAY 23

WATER TREATMENT DEMONSTRATION FACILITY

- Permanent environmental enclosure (24/7/365 ready)
  - 60’ x 80’ (18’ wall height)
  - Air-handling and exchange
  - Class I Division 2-rated
- 53’ demonstration bay with concrete floor
- Two overhead doors
- Integrated with active reservoir management (ARM) and saltwater disposal (SWD) infrastructure
- Treatment rates up to 25 gpm (bench to pilot)

- Sized to accommodate up to a semi-tractor–trailer-sized demonstration
- 300 kW electric power
- Waste management
- Propane (5000-gal tank)*
- Noncontact cooling water (30 gpm)*

* Can be accommodated.

BLENDING AND PRETREATMENT

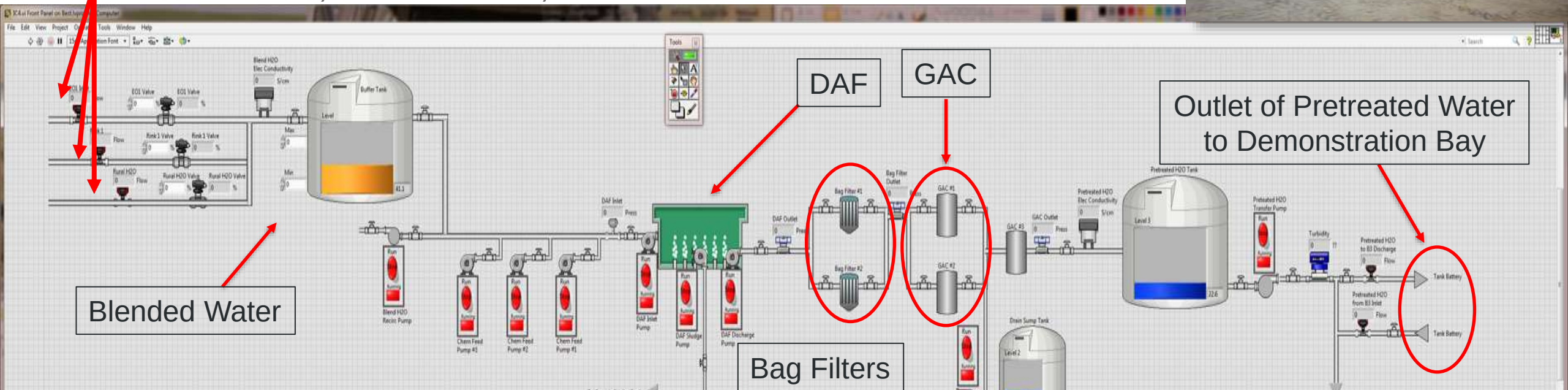
Blending of water to a target TDS level of 180,000 mg/L

… or tailored blends
<5000 mg/L TDS
to
>300,000 mg/L TDS

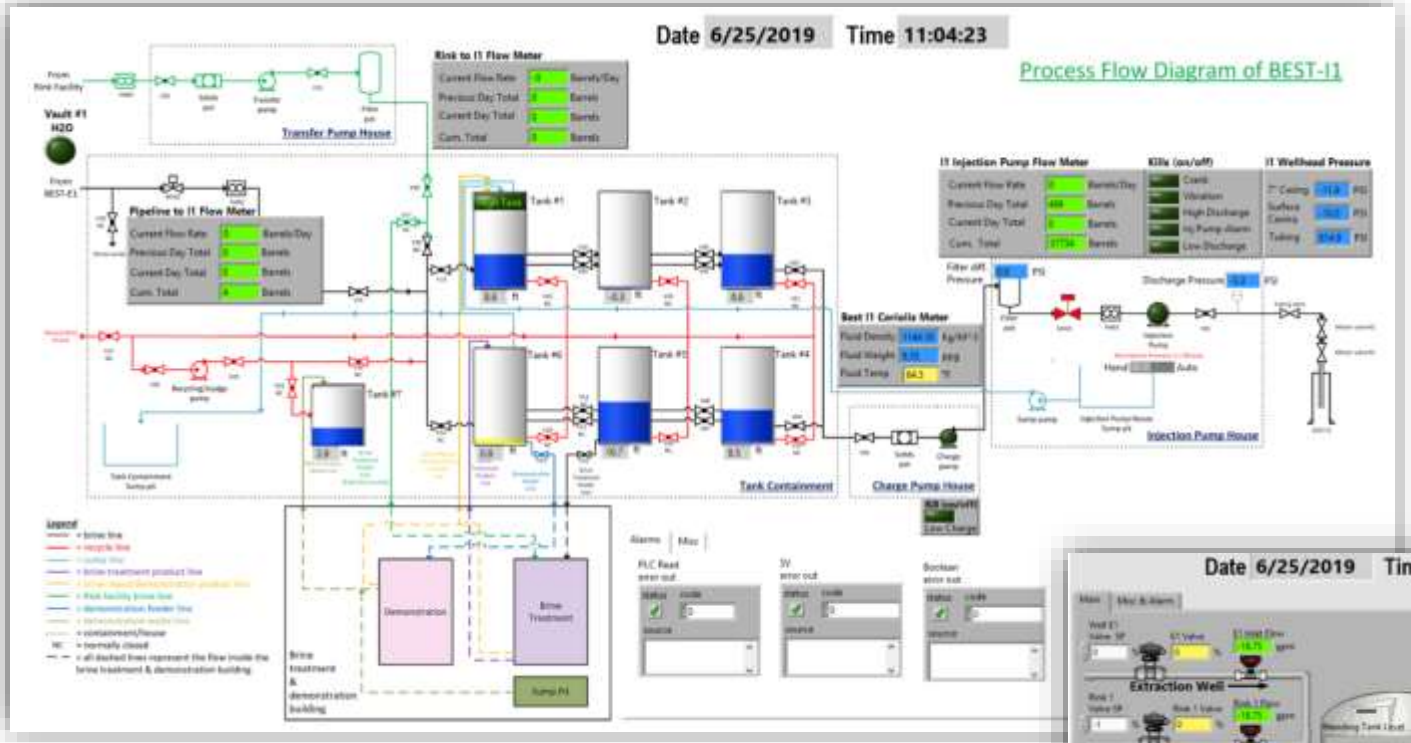
to suit capabilities and/or limitations of selected technologies.

- Suspended solids removal (dissolved air flotation [DAF]).
- Filter bags.
- Dissolved organics removal (granular activated carbon [GAC]).
- Facility can be adapted for use with alternate fluid compositions and treatment/pretreatment processes.

EXTRACTED, PRODUCED, AND FRESHWATER SOURCE



SCADA, REMOTE MONITORING AND CONTROLS



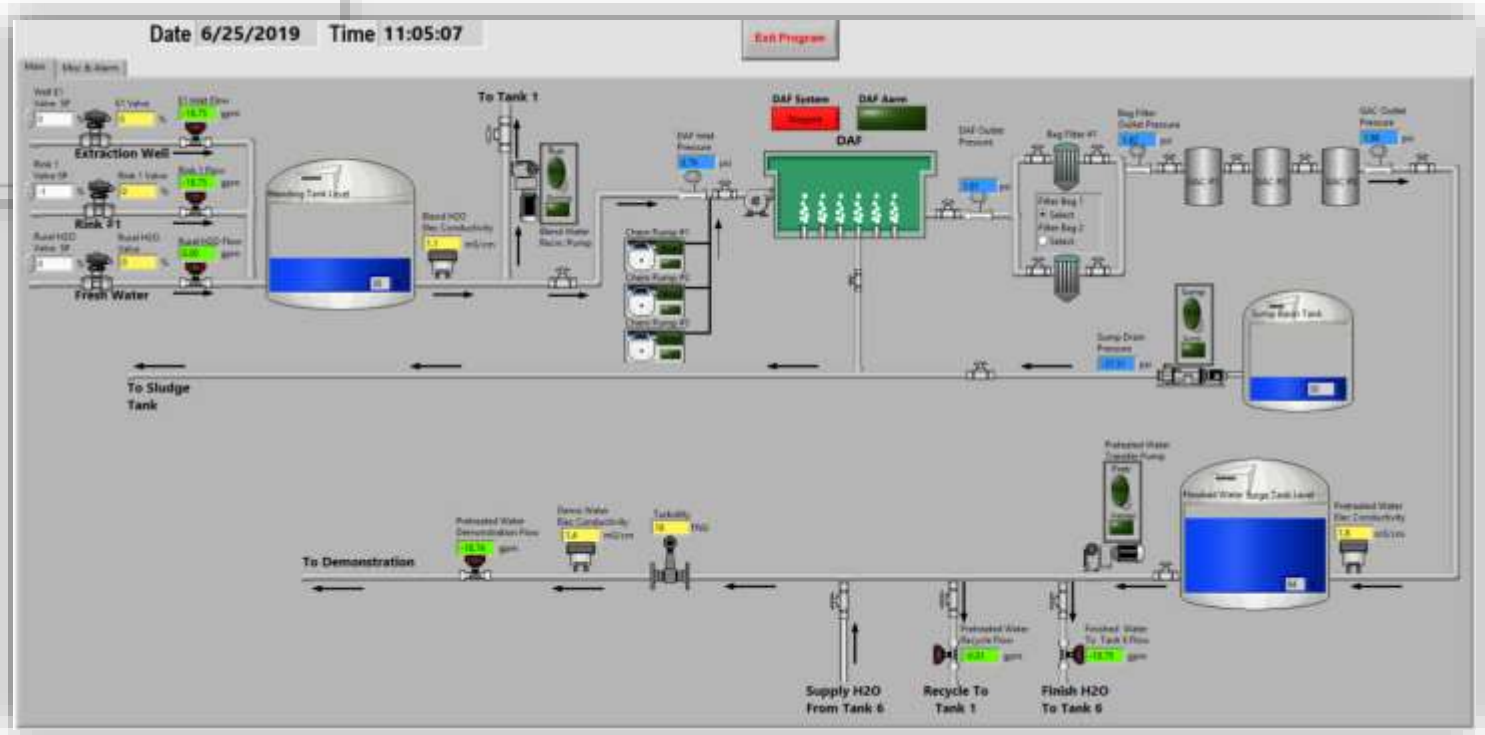
FACILITIES

- Influent and effluent flow rates and composition
- Chemical usage
- Energy and thermal use/load
- HSE and operability systems (e.g., pretreatment systems, hazardous environmental monitoring…)
- Remote, real-time, secure access

Water Blending and Pretreatment

Finished Water Supply for Demonstrations

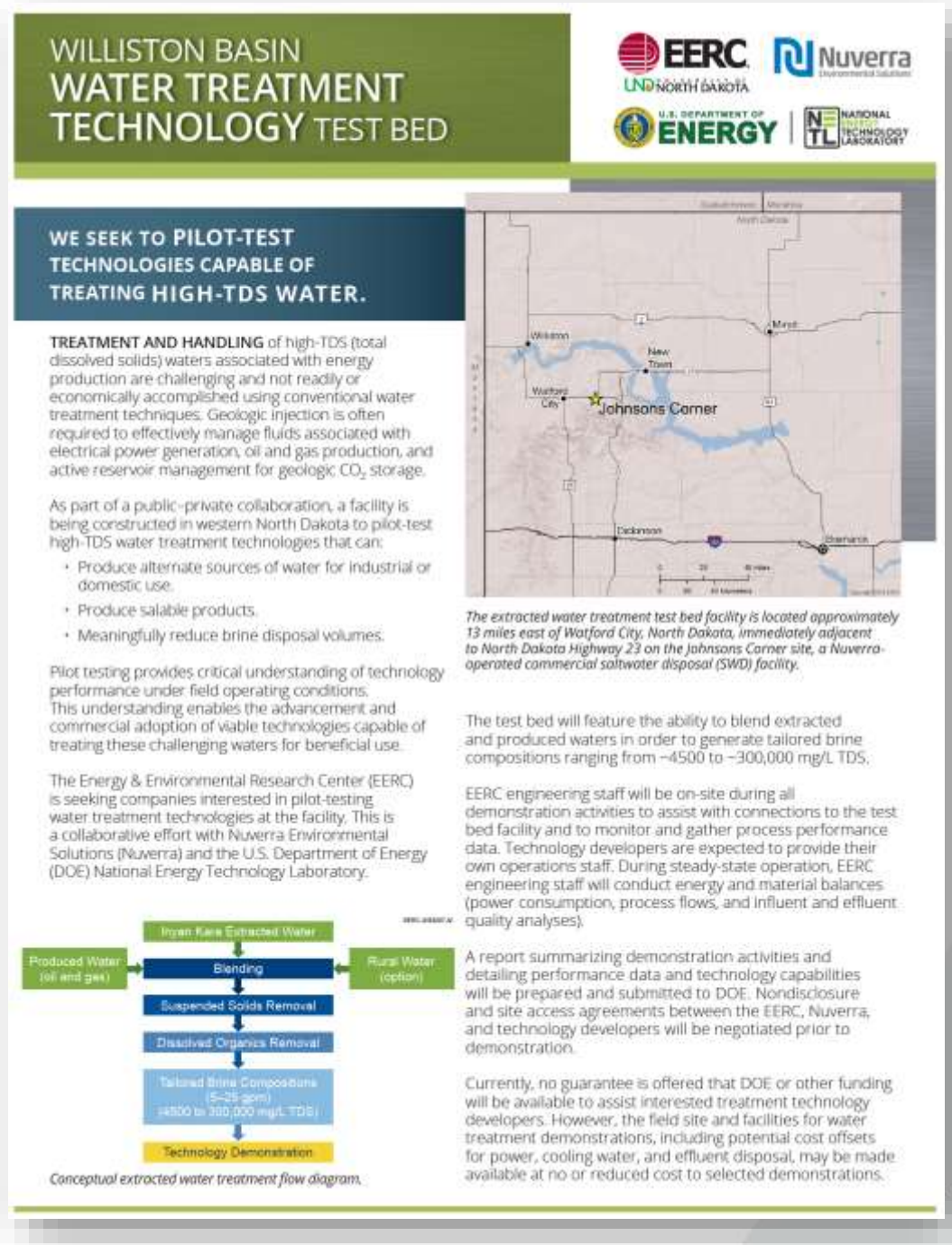
BLENDING AND PRETREATMENT



MOBILE WORKSHOP AND COMMAND CENTER

MULTIUSE OFFICE, MEETING AND WORKSPACE

- Seeking to develop and test two or more brine treatment technologies at the North Dakota brine treatment technology development and test bed facility.
- Enable development of brine treatment technologies capable of treating high-TDS brines associated with geologic CO_2 storage targets. (~**180,000** mg/L TDS).
  - Alternate source of water
  - Reduced disposal volumes
  - Salable products for beneficial use
- Cost offsets may be made available for highly qualified technologies.



WILLISTON BASIN
WATER TREATMENT
TECHNOLOGY TEST BED

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

WE SEEK TO PILOT-TEST TECHNOLOGIES CAPABLE OF TREATING HIGH-TDS WATER.

TREATMENT AND HANDLING of high-TDS (total dissolved solids) waters associated with energy production are challenging and not readily or economically accomplished using conventional water treatment techniques. Geologic injection is often required to effectively manage fluids associated with electrical power generation, oil and gas production, and active reservoir management for geologic CO_2 storage.

As part of a public-private collaboration, a facility is being constructed in western North Dakota to pilot-test high-TDS water treatment technologies that can:

- Produce alternate sources of water for industrial or domestic use.
- Produce salable products.
- Meaningfully reduce brine disposal volumes.

Pilot testing provides critical understanding of technology performance under field operating conditions. This understanding enables the advancement and commercial adoption of viable technologies capable of treating these challenging waters for beneficial use.

The Energy & Environmental Research Center (EERC) is seeking companies interested in pilot-testing water treatment technologies at the facility. This is a collaborative effort with Nuverra Environmental Solutions (Nuverra) and the U.S. Department of Energy (DOE) National Energy Technology Laboratory.

The extracted water treatment test bed facility is located approximately 13 miles east of Watford City, North Dakota, immediately adjacent to North Dakota Highway 23 on the Johnsons Corner site, a Nuverra-operated commercial saltwater disposal (SWD) facility.

The test bed will feature the ability to blend extracted and produced waters in order to generate tailored brine compositions ranging from ~4500 to ~300,000 mg/L TDS.

EERC engineering staff will be on-site during all demonstration activities to assist with connections to the test bed facility and to monitor and gather process performance data. Technology developers are expected to provide their own operations staff. During steady-state operation, EERC engineering staff will conduct energy and material balances (power consumption, process flows, and influent and effluent quality analyses).

A report summarizing demonstration activities and detailing performance data and technology capabilities will be prepared and submitted to DOE. Nondisclosure and site access agreements between the EERC, Nuverra, and technology developers will be negotiated prior to demonstration.

Currently, no guarantee is offered that DOE or other funding will be available to assist interested treatment technology developers. However, the field site and facilities for water treatment demonstrations, including potential cost offsets for power, cooling water, and effluent disposal, may be made available at no or reduced cost to selected demonstrations.

Conceptual extracted water treatment flow diagram.

TECHNOLOGY TESTING

BRINE TREATMENT DEVELOPMENT FACLITY

- Declaration of desire/intent to demonstrate.
- Conversation with EERC technical representative.
- Technology questionnaire screening.
- Technology selection.
- Negotiate site access agreement and contracting for technology demonstration.
- Hazard and operability assessment.
- Scheduled demonstration and test conditions.
  - Consideration for site operability and technology provider needs
  - Preferentially scheduled to coincide with appropriate periods of Inyan Kara water extraction and/or other efficient operating windows when possible
- Prepare test bed and staffing schedule, receive consumables.
- Shake down pretreatment equipment prior to demonstration.
- Mobilization of technology to site.
- Selected technologies connected to the test bed facility – electric, instrumentation, (accommodations for propane and/or cooling water as necessary), with EERC assistance to ensure operability and HSE requirements are satisfied.
  - Technology providers to provide operations staff, with assistance by EERC staff.
  - Technology providers operate their technology under EERC supervision.
  - EERC operates test bed facility to accommodate technology demonstration needs.
- During steady-state operation, EERC staff will conduct energy and material balances (power consumption, process flows, influent and effluent quality analyses).
- Extended operating periods (30 to 60 days), with consideration for operational and maintenance requirements.
- Effluent and treated water will be blended and reinjected where possible; streams unable to be reinjected will be disposed of at an authorized facility.
- Demobilization and reporting.

NORTH DAKOTA BRINE TREATMENT FACILITY

POTENTIAL ADAPTATION FOR EXPANDED APPLICATIONS

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

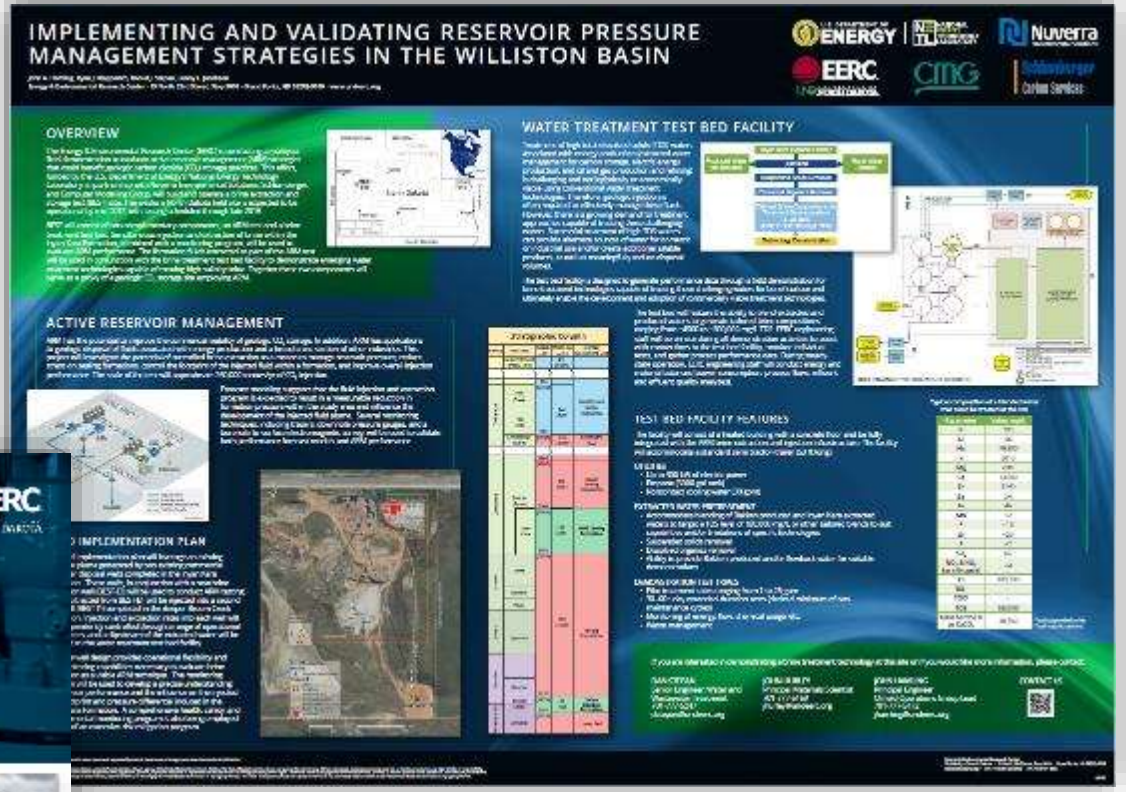
- Alternate water sources trucked and offloaded at site.
- Pretreatment and conditioning can be modified to replicate broader influent specifications.
- Blending of additives to replicate target fluid chemistries.
- Application of cascade technologies (e.g., power/thermal supply, pretreatment/conditioning…).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

NORTH DAKOTA BRINE TREATMENT FACILITY

POTENTIAL ADAPTATION FOR EXPANDED APPLICATIONS

- 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

INFORMATION AND OUTREACH



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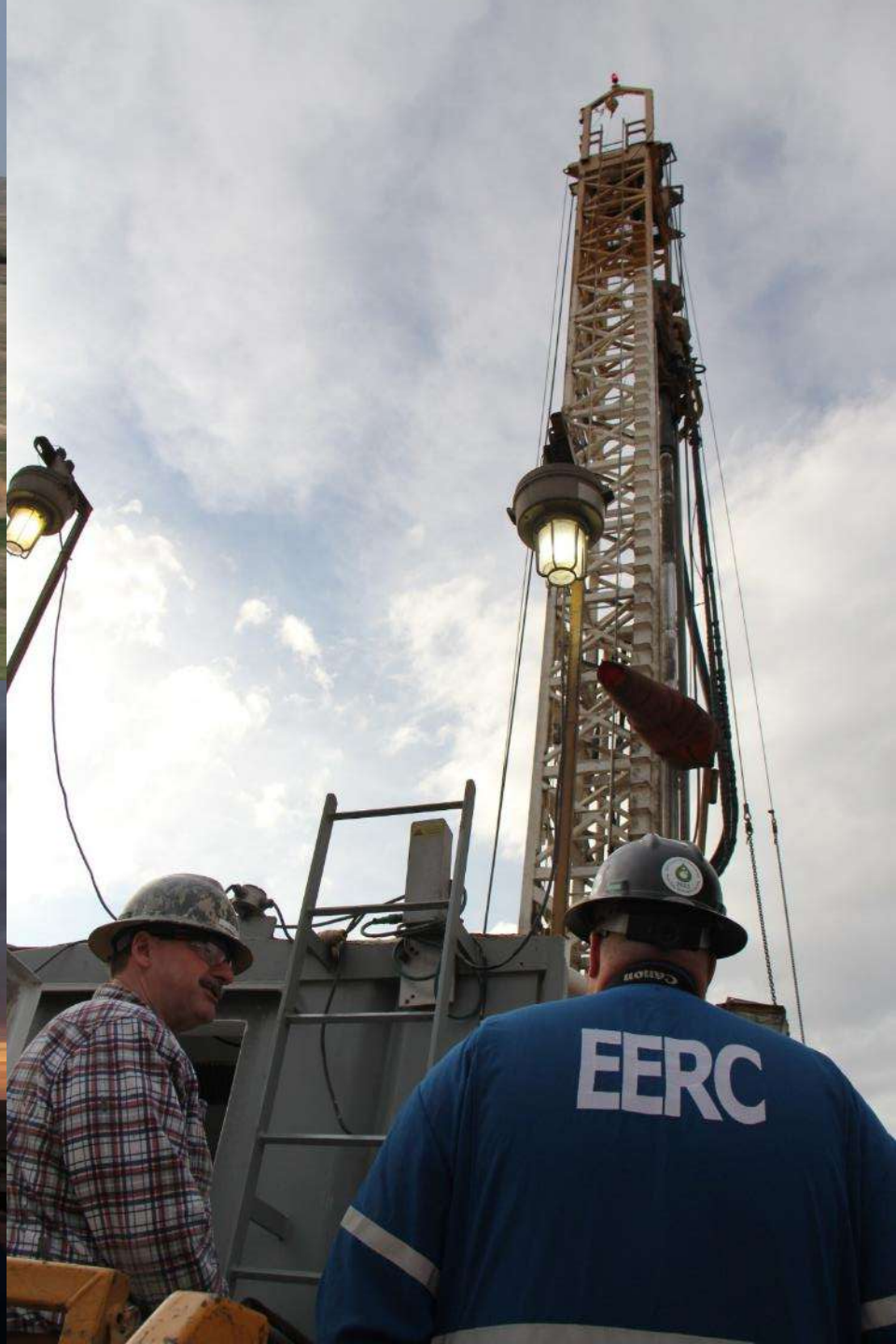
THANK YOU

Critical Challenges. Practical Solutions.

SUPPLEMENTAL INFORMATION

NORTH DAKOTA

BRINE TREATMENT USER FACILITY



EERC

UNIVERSITY OF NORTH DAKOTA

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THE SITE


Saskatchewan
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Minot
BEST Site
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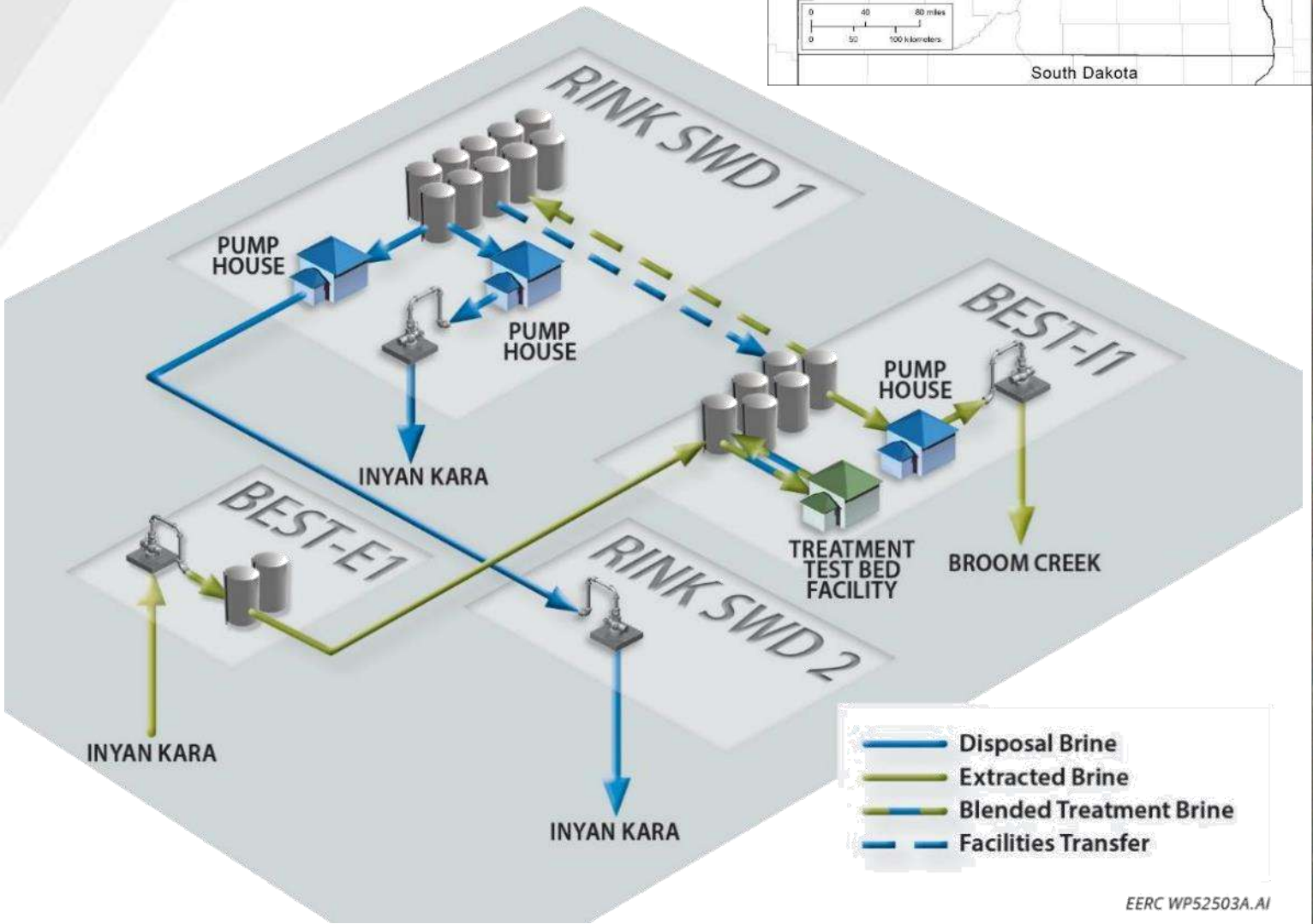
North Dakota
Grand Forks
Minnesota
Bismarck
Dickinson
Fargo
South Dakota


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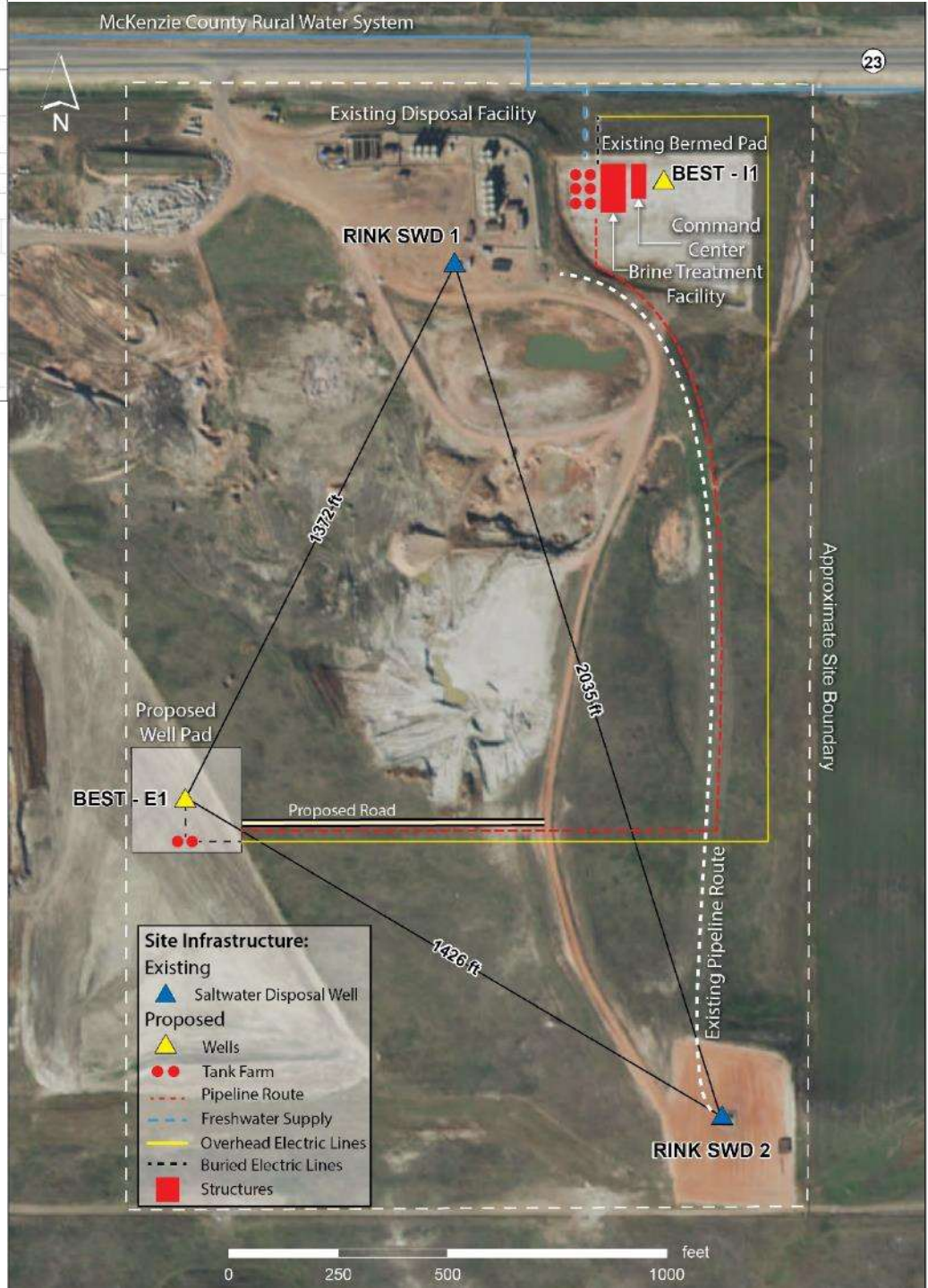
EERC WP52503A.AI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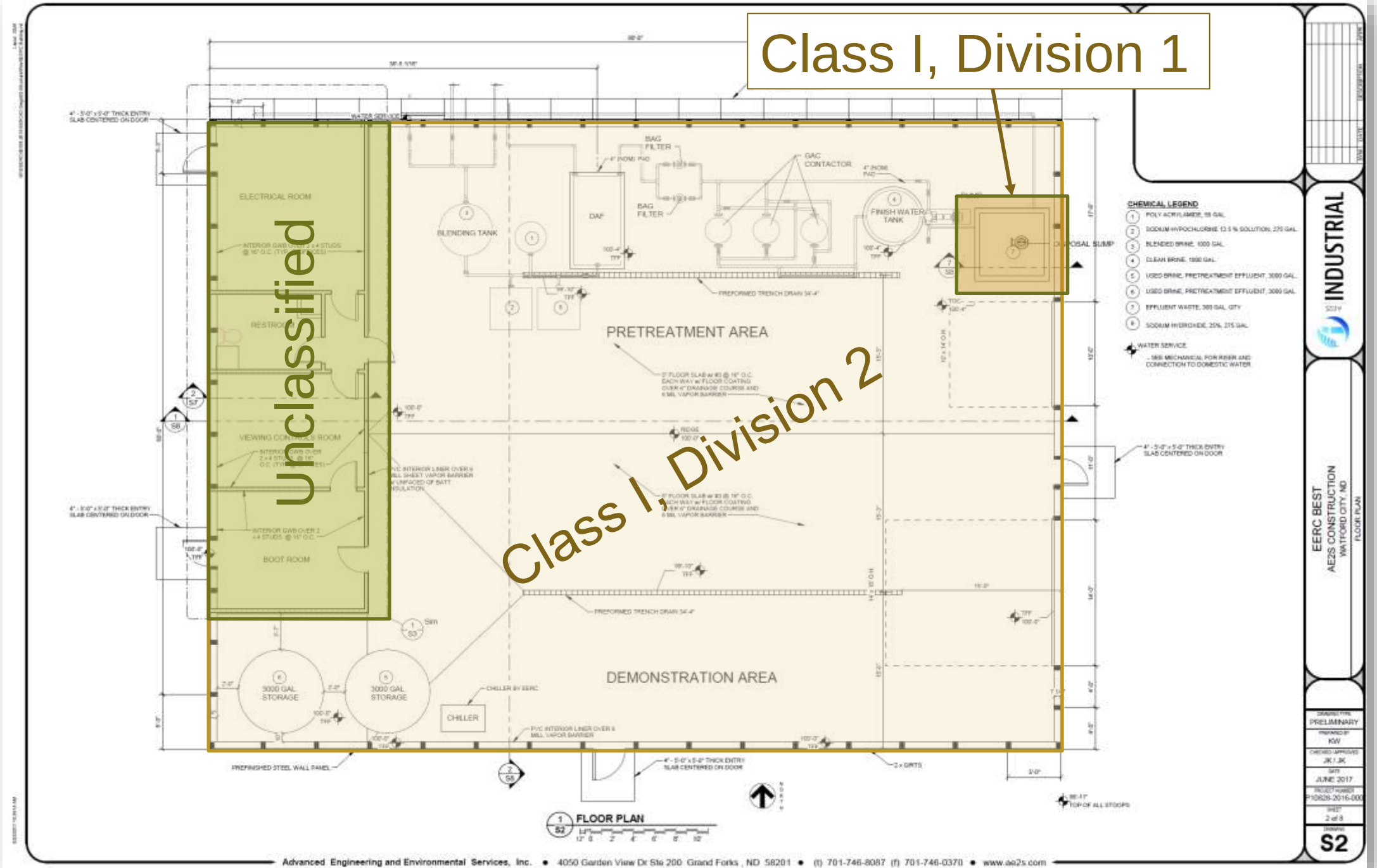
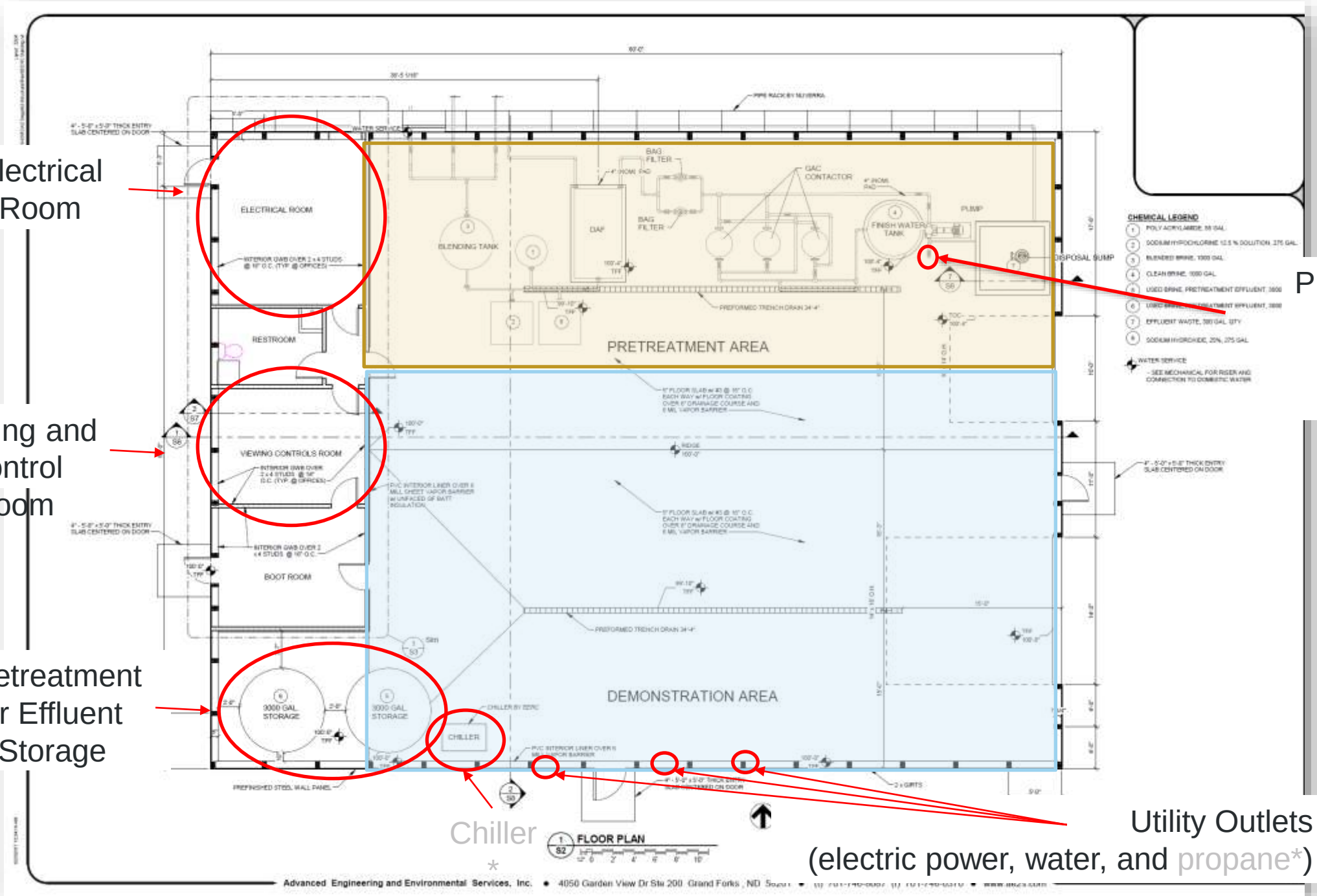

Class I, Division 1
Unclassified
Class I, Division 2
ELECTRICAL ROOM
VIEWING CONTROL ROOM
BOOT ROOM
PRETREATMENT AREA
DEMONSTRATION AREA
BLENDING TANK
DAF
BAG FILTER
BAG FILTER
GAC CONTACTOR
FINISH WATER TANK
3000 GAL STORAGE
3000 GAL STORAGE
CHILLER
PREFORMED TRENCH DRAIN
PREFINISHED STEEL WALL PANEL
CHEMICAL LEGEND
FLOOR PLAN
INDUSTRIAL
EERC BEST
AE2S CONSTRUCTION
WATFORD CITY, ND
FLOOR PLAN
PRELIMINARY
JUNE 2017
S2
Advanced Engineering and Environmental Services, Inc. • 4050 Garden View Dr Ste 200 Grand Forks , ND 58201 • (t) 701-746-8087 (f) 701-746-0370 • www.ae2s.com


Electrical Room
Viewing and Control Room
Pretreatment or Effluent Storage
Pretreated Water Supply Outlet
Chiller *
Utility Outlets (electric power, water, and propane*)
* Can be accommodated
ELECTRICAL ROOM
RESTROOM
VIEWING CONTROLS ROOM
BOOT ROOM
PRETREATMENT AREA
DEMONSTRATION AREA
BLENDING TANK
DAF
BAG FILTER
GAC CONTACTOR
FINISH WATER TANK
PUMP
DISPOSAL SUMP
CHEMICAL LEGEND
3000 GAL STORAGE
3000 GAL STORAGE
CHILLER
PREFORMED TRENCH DRAIN 24'-4"
PREFINISHED STEEL WALL PANEL
FLOOR PLAN
Advanced Engineering and Environmental Services, Inc.

Example of Produced Water Chemistry [high-TDS blend source]

Sample	Parameter	Result	
53809-01	**Produced Water (1/21/16)**		
	Alkalinity, as Bicarbonate (HCO3-)	272	mg/L
	Alkalinity, as Carbonate (CO3=)	0	mg/L
	Alkalinity, as Hydroxide (OH-)	0	mg/L
	Alkalinity, Total as CaCO3	223	mg/L
	Bromide	1080	mg/L
	Calcium	22800	mg/L
	Chemical Oxygen Demand	13000	mg/L
	Chloride	200000	mg/L
	Magnesium	1420	mg/L
	pH	5.71	
	Potassium	9030	mg/L
	Sodium	92600	mg/L
	Strontium	1830	mg/L
	Sulfate	200	mg/L
	Total Dissolved Solids	335000	mg/L
	Total Organic Carbon	305	mg/L

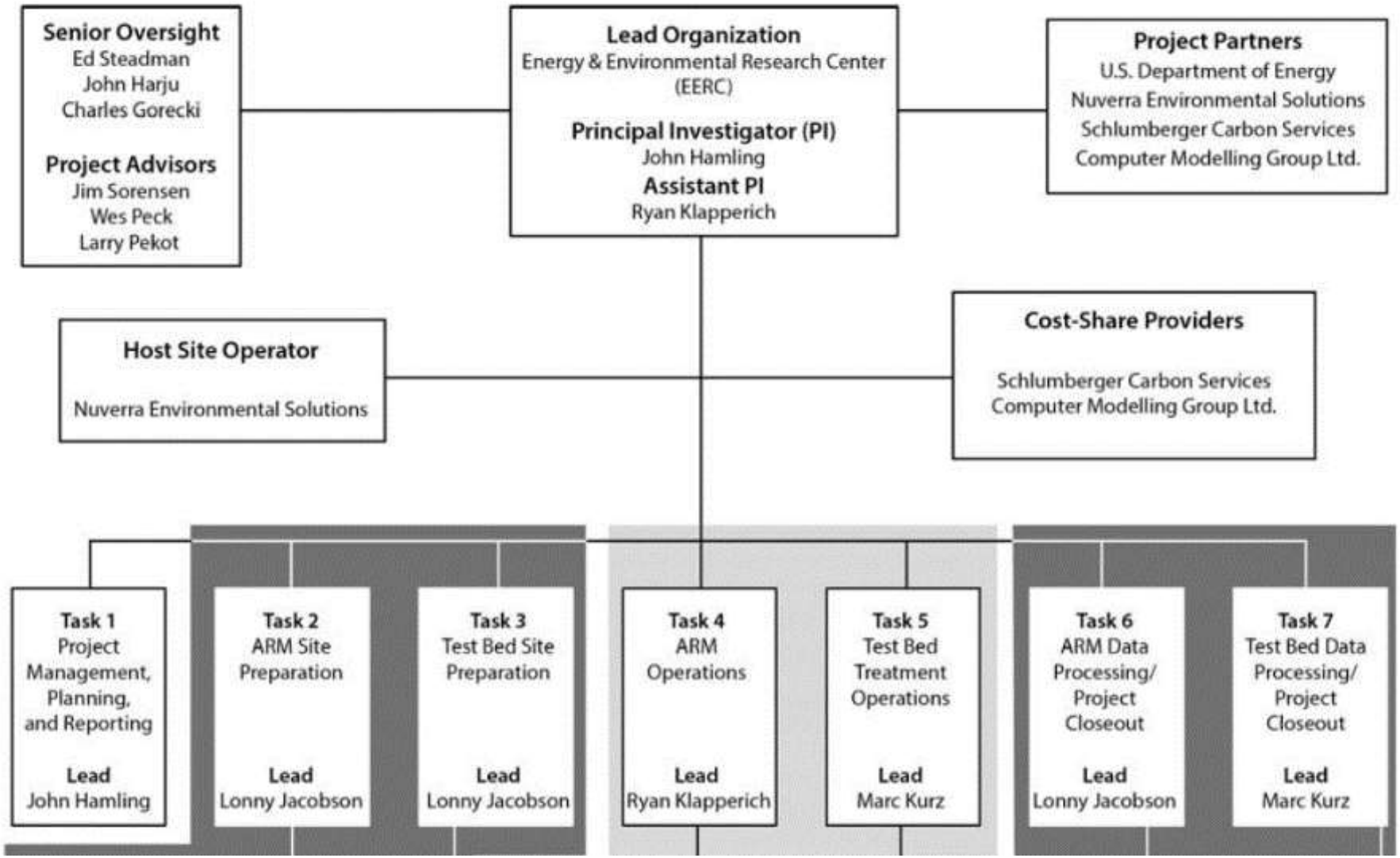
Sample	Parameter	Result	
53837-01	**Johnson Disposal Water (Rink #1) 3/1/16 1055**		
	Alkalinity, as Bicarbonate (HCO3-)	150	mg/L
	Alkalinity, as Carbonate (CO3=)	0	mg/L
	Alkalinity, as Hydroxide (OH-)	0	mg/L
	Alkalinity, Total as CaCO3	123	mg/L
	Bromide	865	mg/L
	Calcium	18800	mg/L
	Chemical Oxygen Demand	16000	mg/L
	Chloride	147000	mg/L
	Magnesium	1030	mg/L
	pH	5.84	
	Potassium	7260	mg/L
	Sodium	78700	mg/L
	Strontium	1450	mg/L
	Sulfate	265	mg/L
	Total Dissolved Solids	278000	mg/L
	Total Organic Carbon	300	mg/L

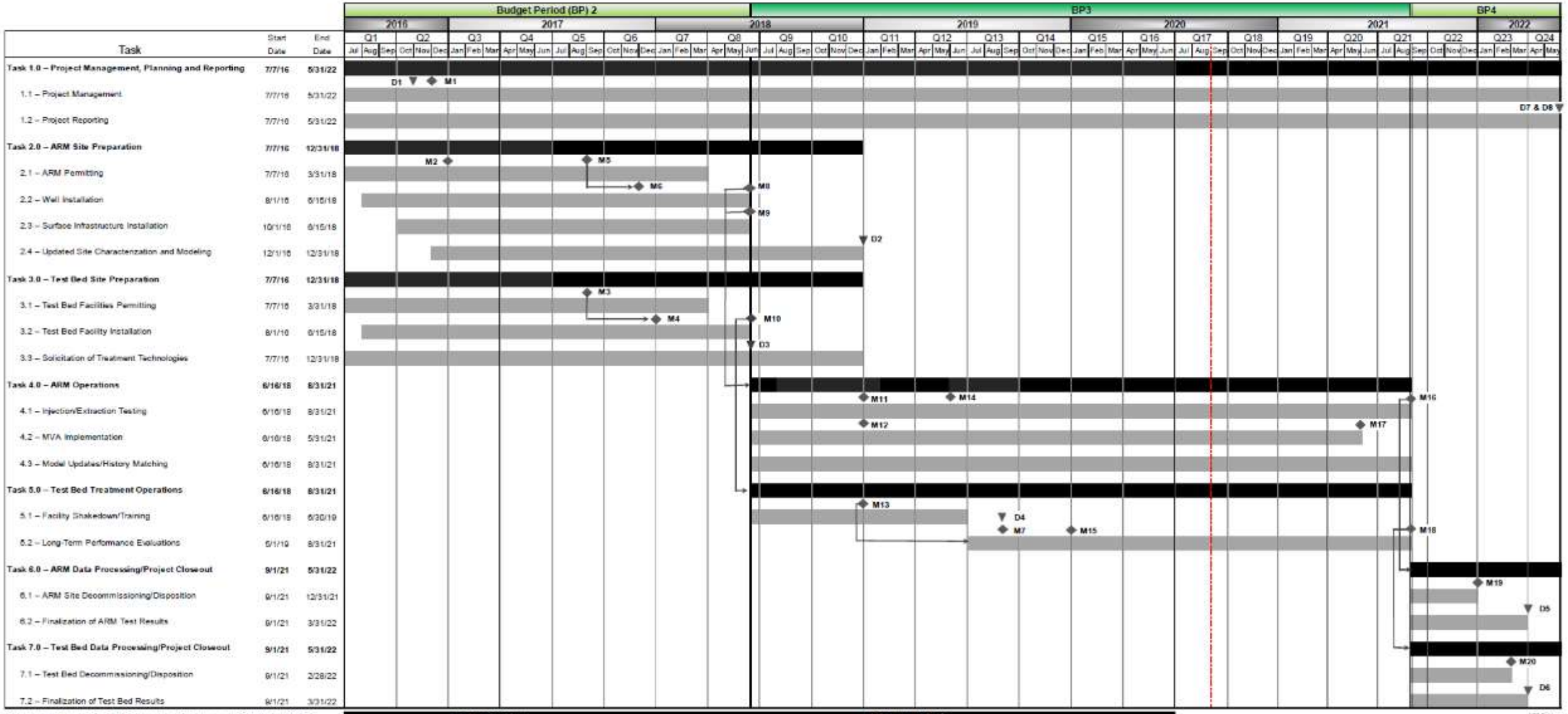
Example of Inyan Kara Extracted Water Chemistry [medium-TDS blend source]

Sample	Parameter	Result	
54622-01	**E-1 Produced Brine (3/24/20)**		
	Alkalinity, as Bicarbonate (HCO3-)	112	mg/L
	Alkalinity, as Carbonate (CO3=)	0	mg/L
	Alkalinity, as Hydroxide (OH-)	0	mg/L
	Alkalinity, Total as CaCO3	91.6	mg/L
	Aluminum	< 10	mg/L
	Barium	12.8	mg/L
	Boron	351	mg/L
	Bromide	758	mg/L
	Calcium	14900	mg/L
	Chloride	148000	mg/L
	Conductivity at 25°C	217000	µS/cm
	Density	1.15	g/mL
	Iron	102	mg/L
	Lithium	50.9	mg/L
	Magnesium	903	mg/L
	Manganese	14.3	mg/L
	pH	5.37	
	Phosphorus	< 20	mg/L
	Potassium	5730	mg/L
	Silicon	< 20	mg/L
	Sodium	59400	mg/L
	Strontium	1240	mg/L
	Sulfate	283	mg/L
	Total Dissolved Solids	232000	mg/L
	Total Organic Carbon	1080	mg/L
	Total Suspended Solids	150	mg/L
	Zinc	< 1	mg/L

APPENDIX

ORGANIZATION CHART





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

Red line indicates the end of the 6 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

Gantt Chart, Deliverables, and Milestones