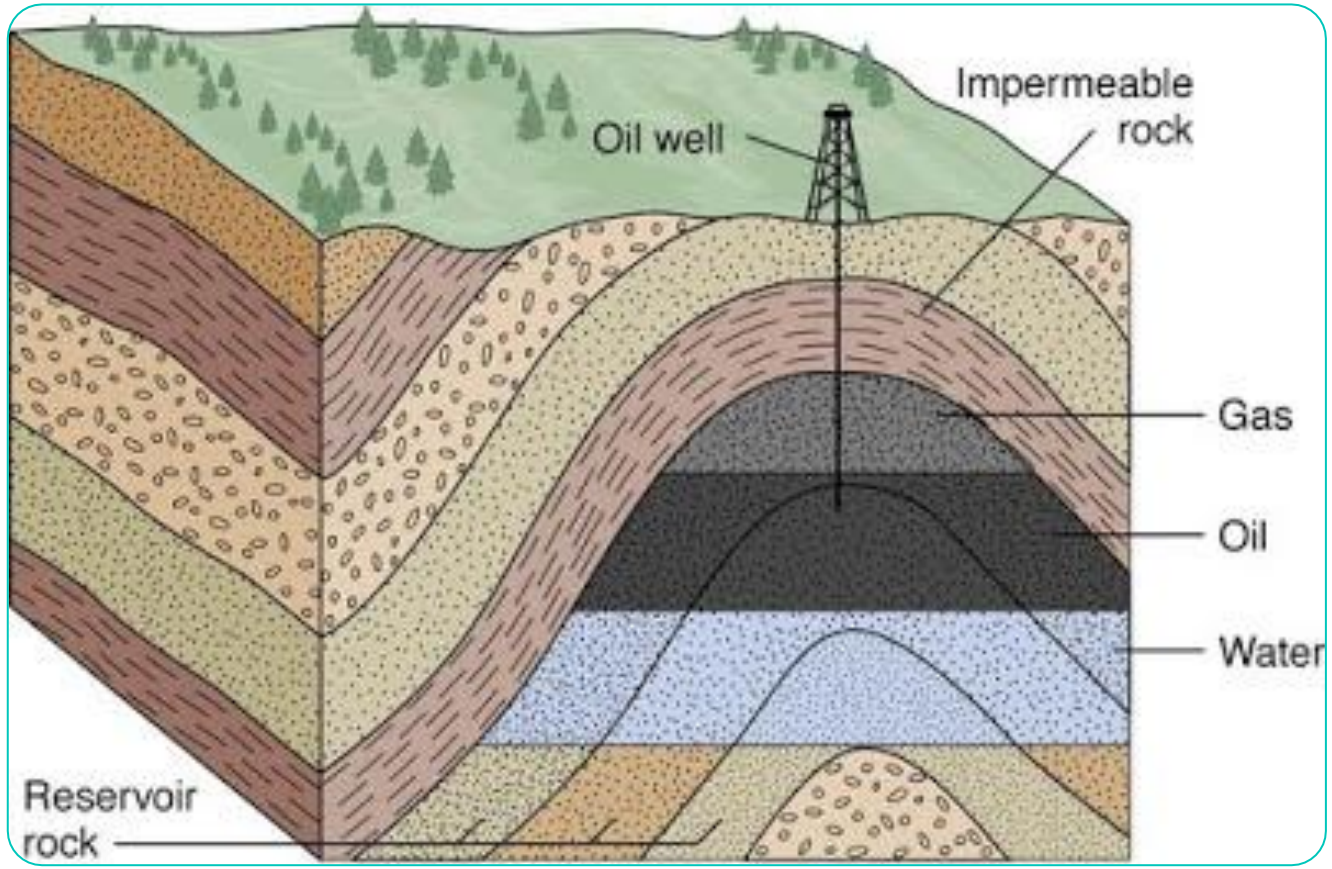
Efficient Industrial Scale Desalination and Economization of Permian Basin Produced Water

Joseph Alexander PhD PE
Circle Verde Water

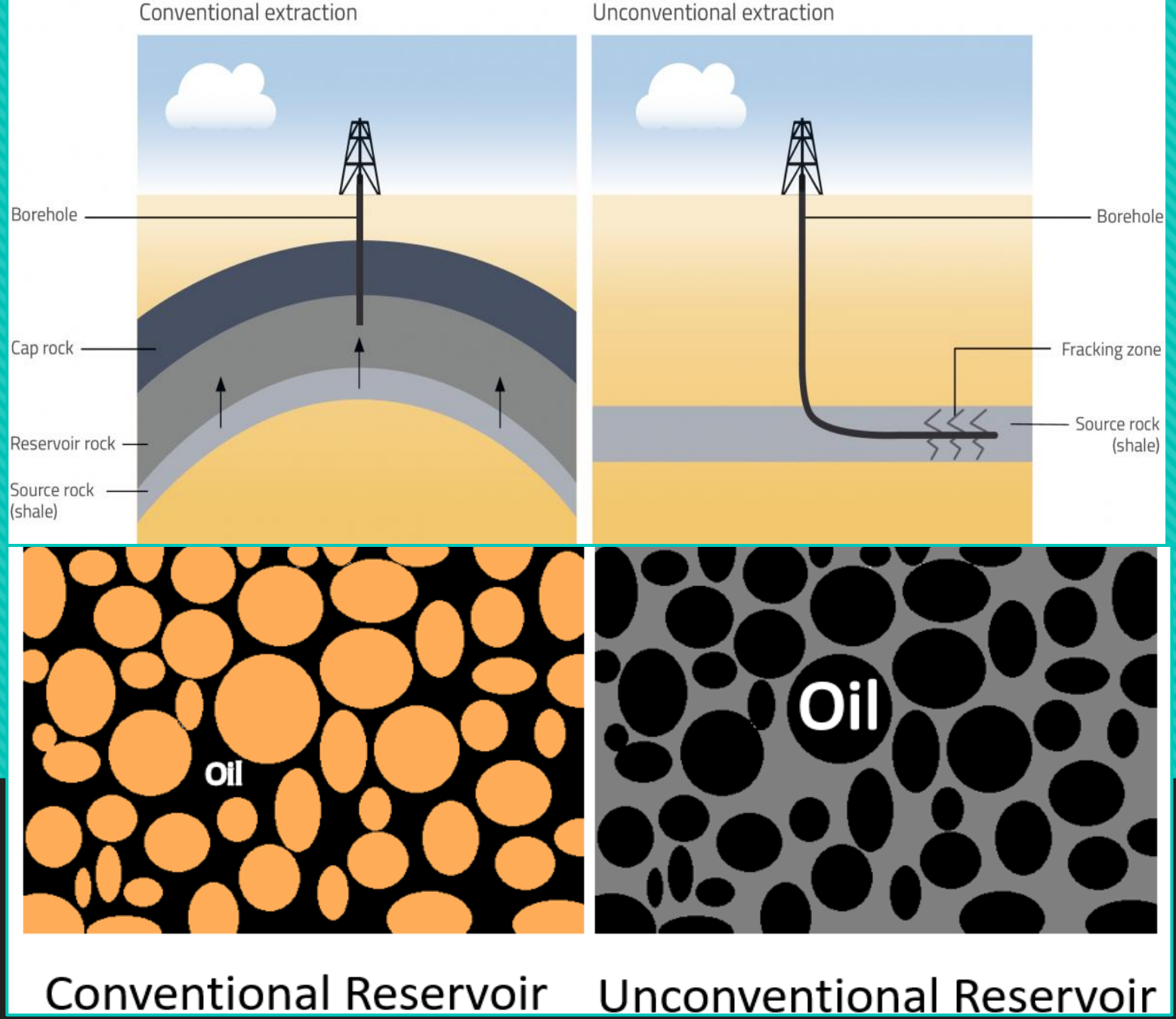
CIRCLE VERDE
Zero Waste Petroleum

Produced Water Disposal



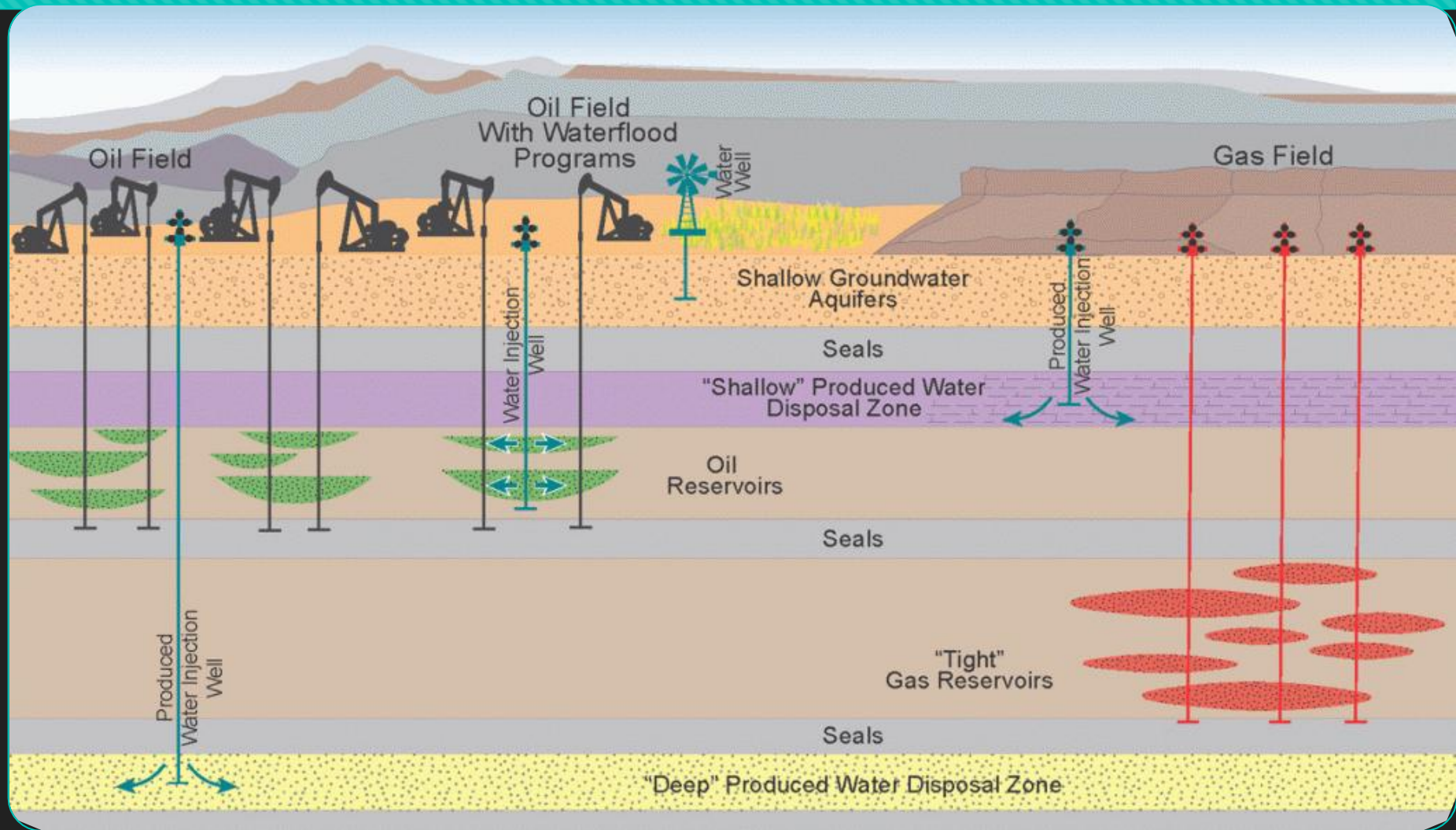
Water Disposal Not an Issue for Conventional Wells, I.e. Those Drilled Before Modern Hydraulic Fracturing as It Was Reinjected to Maintain Reservoir Pressure.

Fracking Revolution



Produced Water Disposal

- Deep: Below Oil Producing Zone
- Shallow: Above Oil Producing Zone



Produced Water Disposal - Issues

- Deep: Below Oil Producing Zone
- Linked to Earthquakes and Seismic Activity
- Severely Restricted Within Past 2-4 Years

- Shallow: Above Oil Producing Zone
- Causing Abandoned Wells to Discharge to Surface
- Emerging Issue

Produced Water Disposal - Seismicity

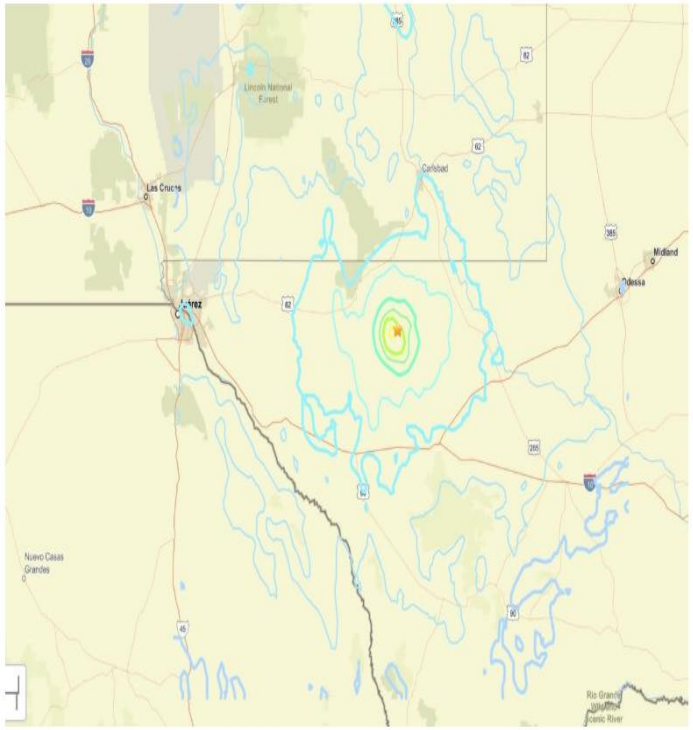
Strong 5.3 magnitude earthquake hits remote area of Texas

INDEPENDENT

MICHELLE DEL REY

May 4, 2025

0



A map of the earthquake from the U.S. Geological Survey (U.S. Geological Survey)

Biggest Earthquakes Near Western Texas

Sorted: Biggest ▾ | Nearby Places ▾

Western Texas has had: *(M1.5 or greater)*

17 earthquakes in the past 24 hours

86 earthquakes in the past 7 days

370 earthquakes in the past 30 days

4,748 earthquakes in the past 365 days

The largest earthquake in Western Texas:

today: 2.8 in Stanton, Texas, United States

this week: 3.7 in Carlsbad, New Mexico, United States

this month: 4.3 in Snyder, Texas, United States

this year: 5.4 in Loving, New Mexico, United States

Recent Earthquakes Near San Francisco, California, United States

Sorted: Recent ▾ | Filter By Magnitude ▾ | Nearby Places ▾

San Francisco has had: *(M1.5 or greater)*

1 earthquake in the past 24 hours

21 earthquakes in the past 7 days

151 earthquakes in the past 30 days

795 earthquakes in the past 365 days

The largest earthquake in San Francisco:

today: 1.6 in San Ramon, California, United States

this week: 3.7 in Cobb, California, United States

this month: 4.4 in Willits, California, United States

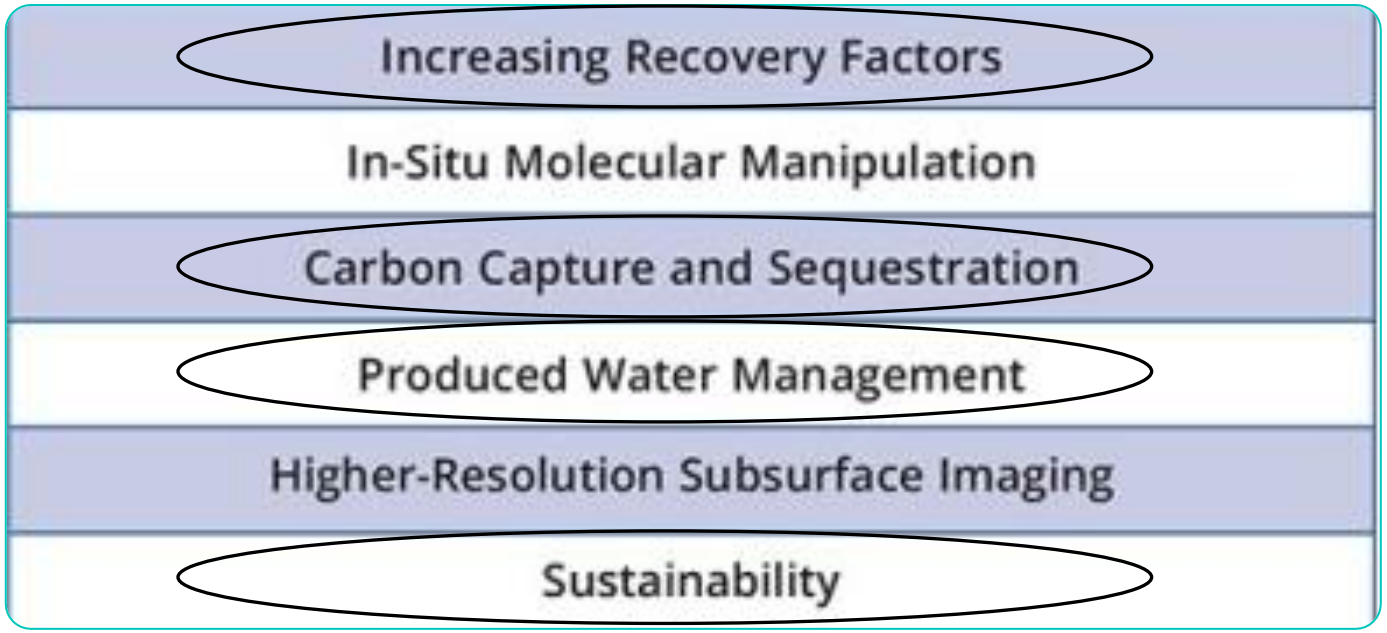
this year: 4.4 in Willits, California, United States

Produced Water Disposal – Surface Discharge Of Abandoned Wells.

Society of Petroleum Engineers – Grand Challenges

Increasing Recovery Factors
In-Situ Molecular Manipulation
Carbon Capture and Sequestration
Produced Water Management
Higher-Resolution Subsurface Imaging
Sustainability

Society of Petroleum Engineers – Grand Challenges



Solution: Desalinate and Treat Produced Water To A Level of Cleanliness Suitable For Surface Use and Discharge

200 BBL/Day Pilot System

Performance – Freshwater Effluent

Conductivity – Less than 200 uSiemens/cm

- 3rd Party Analysis – 98 to 170 uSiemens/cm

Turbidity of Freshwater: 1.4 NTU

- Inlet Raw Produced Water: 169 NTU

TSS of Freshwater Effluent: Below Detection Limit

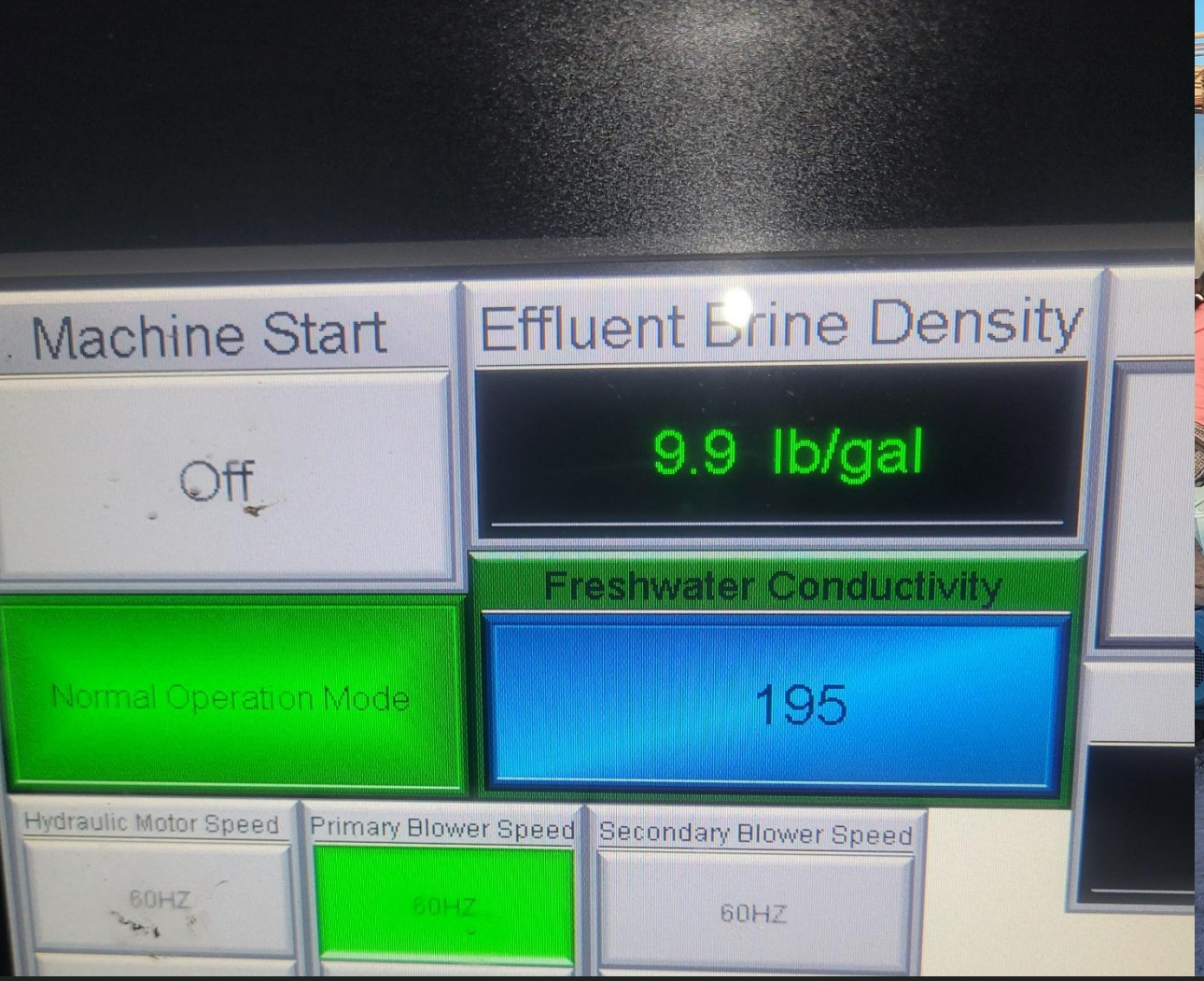
- Inlet Raw Produced Water: 600 mg/l

TDS of Freshwater Effluent: 78 mg/l

- Inlet Raw Produced Water: 151,490 mg/l

Freshwater NH3 Concentration: 12.5 mg/l

TOC of Freshwater Effluent: Typically, Less than 10 mg/l



Pilot System – Demonstration and 3rd Party Evaluation

- Passed EPA WET Testing After Post-Treatment
- Processed Flowback During 3rd Party Evaluation

Freshwater Effluent Passed Multiple 3rd Party WET Testing After Post-Treatment

- Freshwater Post Treated
  - Activated Carbon
  - Ammonia Absorbents
- All 5 Organisms Showed **Zero Mortality** in 100% Freshwater Effluent After 96 Hours
- No Genetic Mutations/Damage Detected
- Results Confirmed By Second Laboratory

- **Raw Inlet Water Prior to Plant Contained**
  - Flowback/Frac Fluids
  - Explosive Residues
  - Corrosion Inhibitors

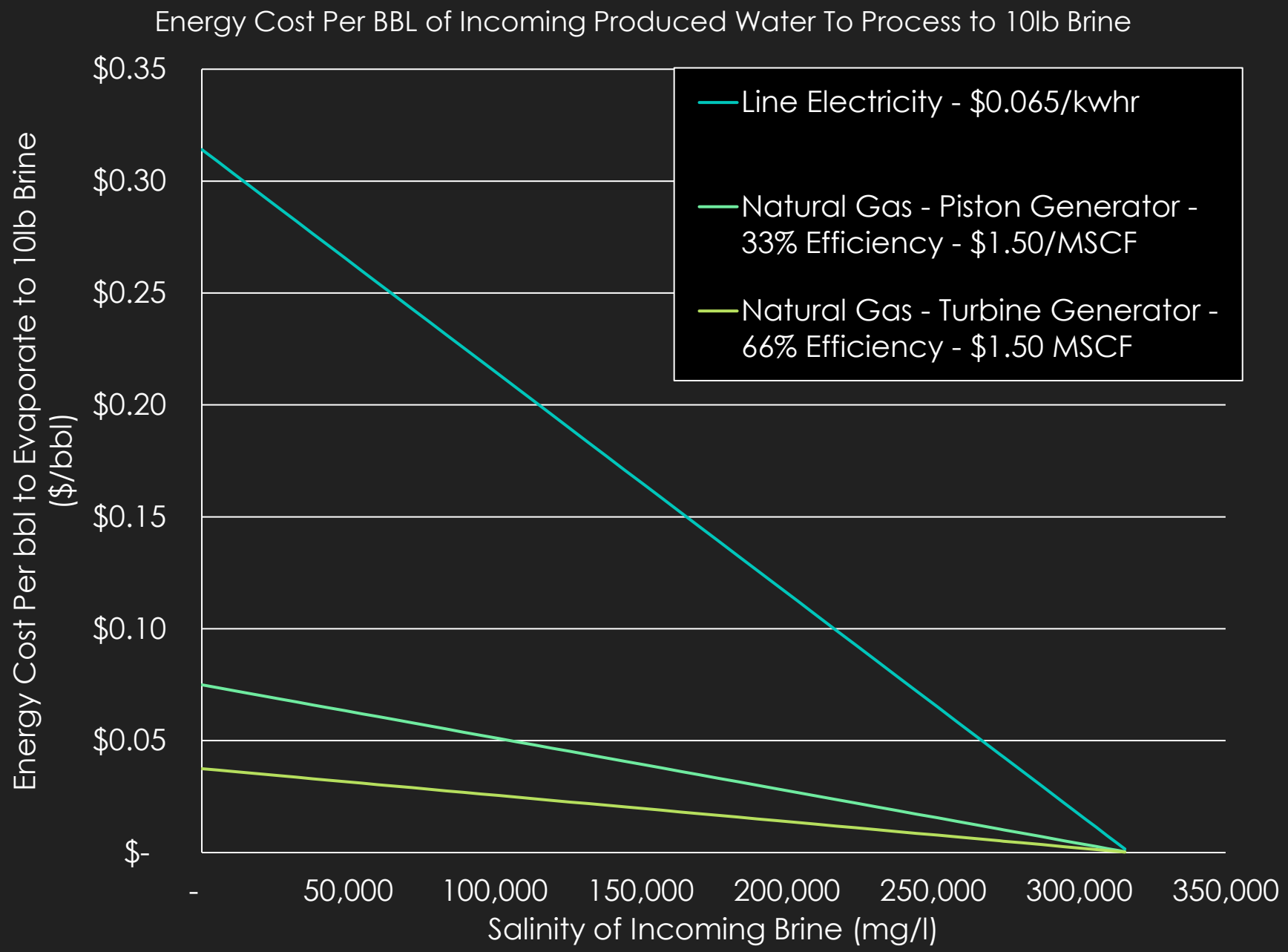
Maximum Contaminant Levels Observed

Inorganic Contaminants	Units	Max Allowable	Las Cruces	Midland	Santa Fe	Albuquerque	Circle Verde - Polished Fresh
Copper	ppm	1.3	0.2	0.258	0.37	0.15	ND
Lead	ppb	15	9	1.4	1.8	4	ND
Arsenic	ppb	10	8.1	8.29	1.9	9	8.2*
Barium	ppm	2	0.084	0.25	0.6	2	0.0017
Chromium	ppb	100	2	2.4	0.2	2	ND
Cyanide	ppb	200	6	146	0	0	8
Fluoride	ppm	4	1.13	0.5	0.39	0.73	ND
Nitrate	ppm	10	4.57	1.36	6.7	0.72	0.343**
Sodium	ppm	NA	590				28.9***
Selenium	ppb	50	3.7	0	21	0	12.5
Radioactive Contaminants							
Alpha Emitters	pCi/L	15	14	31	0.9	1.6	0.827*
Beta/Photon Emitters	pCi/L	50	21.6	31	3.9	0	1.25*
Radium	pCi/L	5	2.23	0	0.8	0.5	0.669*
Uranium	ug/l	30	38	26.8	2	6	0.000289*

*Concentration Below Detection Limit in Freshwater Effluent Stream Prior to Post-Treatment
**Concentration of 0.0871 mg/l In Freshwater Effluent Prior to Post-Treatment
***Concentration of 0.928 mg/l in Freshwater Effluent Prior to Post-Treatment

Normalized Energy Consumption

- Saturated Brine Production
- -Based on Pilot Experience/Outside Engineering Analysis
- - Energy Use per BBL of Incoming Raw Produced Water



Dry Salt Production

- Switch Between Concentrated Brine and Dry Salt Effluent Quickly
  - Salt Leaves Through Centralized Port, Falls Into Hopper, Auger/Belt Transports Away
  - Salt Effluent – Oily Consistency
    - Brief Processing Through Kiln –Dry/Free Flowing
  - Tests on Mentone Produced Water Showed No Increase in Hydrocarbon Levels in Freshwater Discharge

Dry Salt Production

Normalized Energy Costs ($/bbl Inlet Brine)

- Grid Electricity: $0.31/bbl[1]
- Natural Gas-Powered Piston Generator: $0.075/bbl[2]
- Combined Cycle Turbine Generator: $0.037/bbl[2]

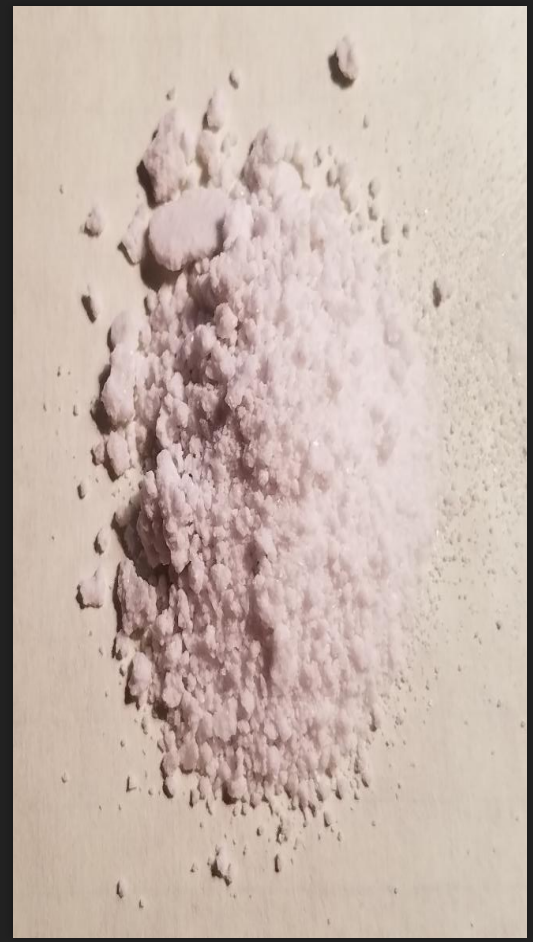
Efficient Mineral Extraction

- Lithium
- Potassium (Potash)

1. Grid Electricity Price: $0.065/kwhr
2. Natural Gas Price: $1.50/MMBTU

Oily Effluent

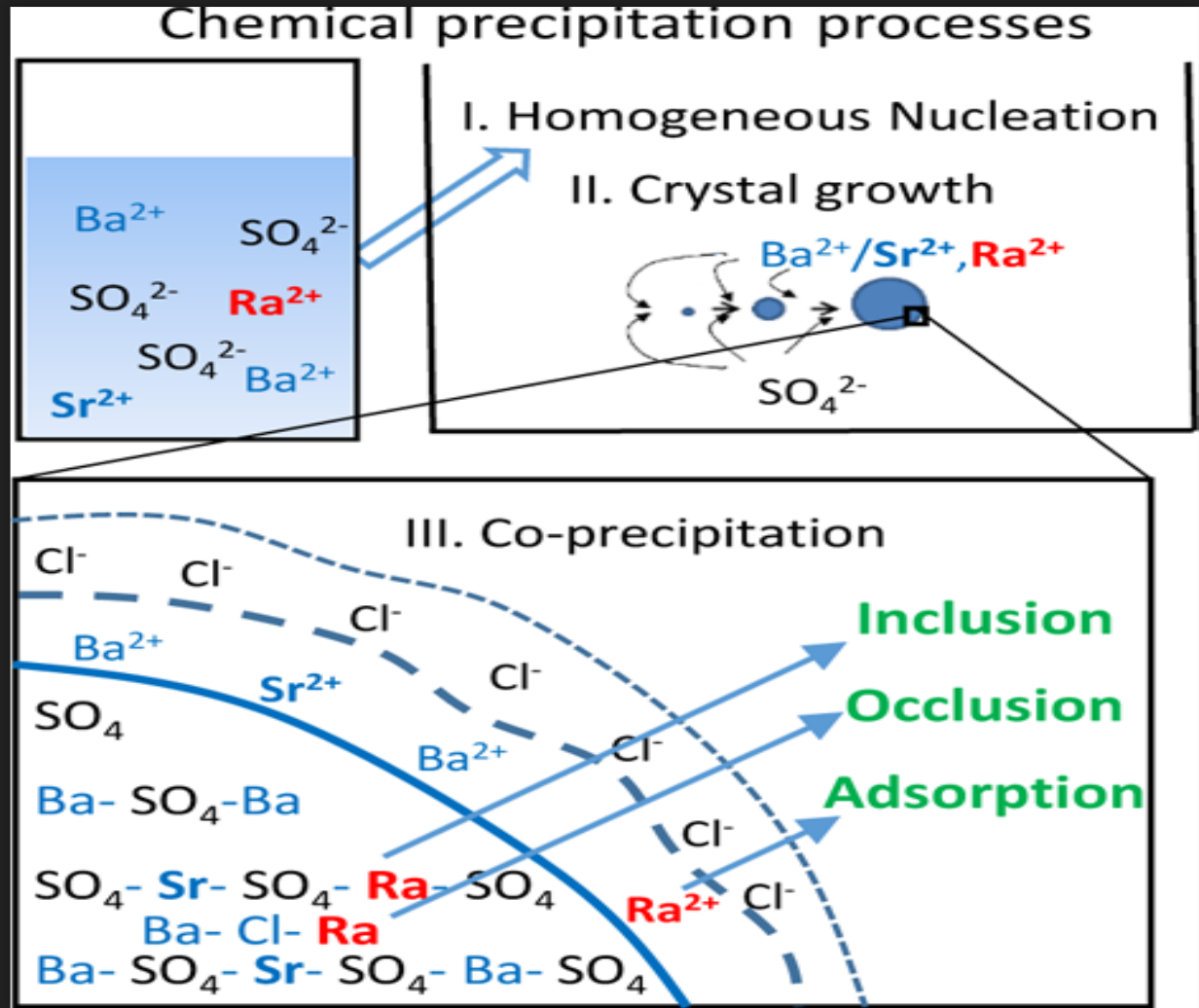
After Kiln



Radium Removal – Barite Precipitation

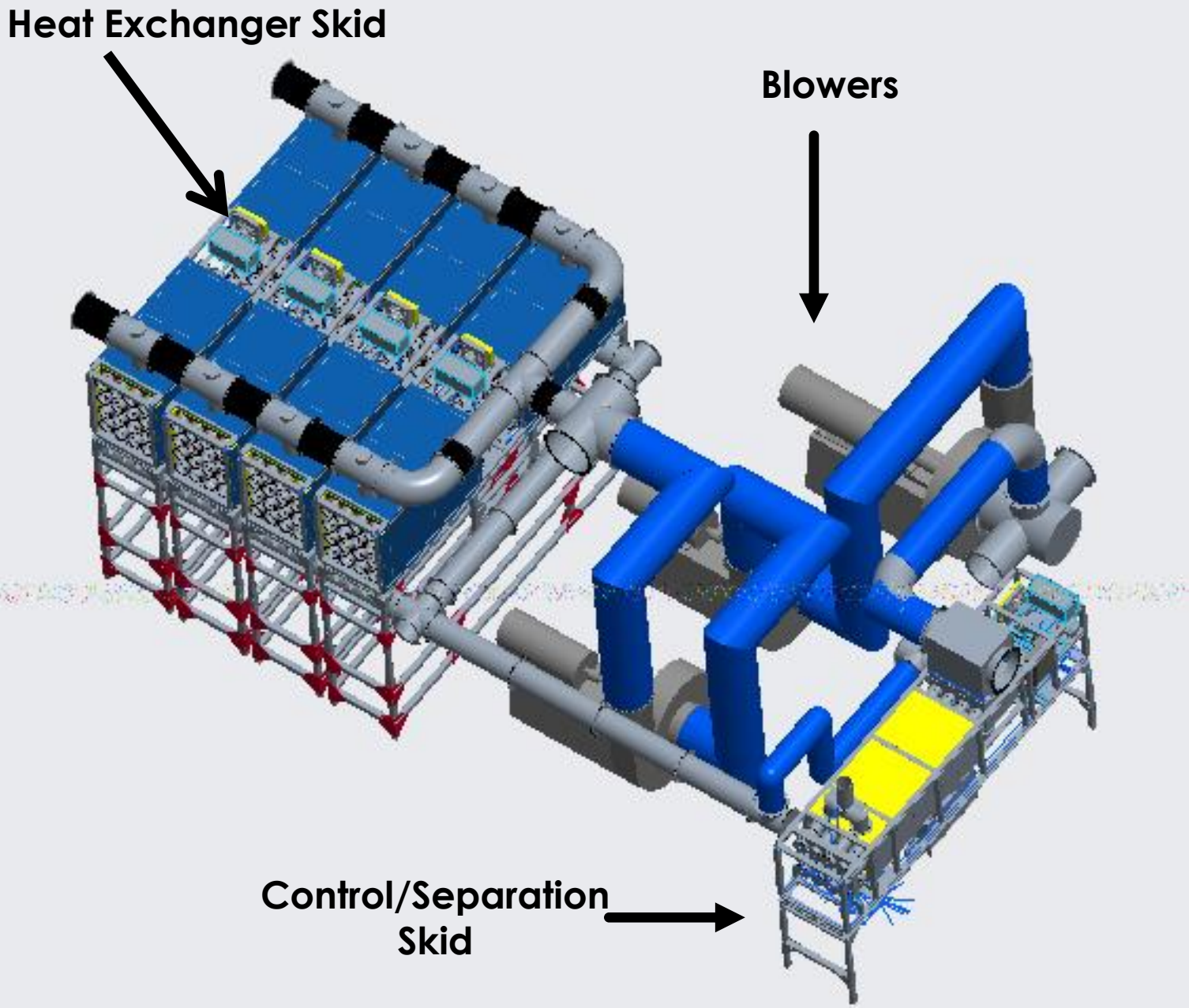
Tieyuan Zhang, Kelvin Gregory, Richard W. Hammack, and Radisav D. Vidic
Environmental Science & Technology **2014** *48* (8), 4596-4603
DOI: 10.1021/es405168b

- Effective
  - 99.99% Removal
- Inexpensive
  - Less than $0.03/bbl
- Safe
  - Precipitated Sludge Is Not Classified As Radioactive – Permian Water
  - Radium Locked Into Insoluble Form
- Accepted
  - Widely Used to Treat Wastewater From Uranium Mining
- Conducive To Desalination
  - Radium Removal Prior To Desalination Eliminates it in Brine/Salt Effluent.



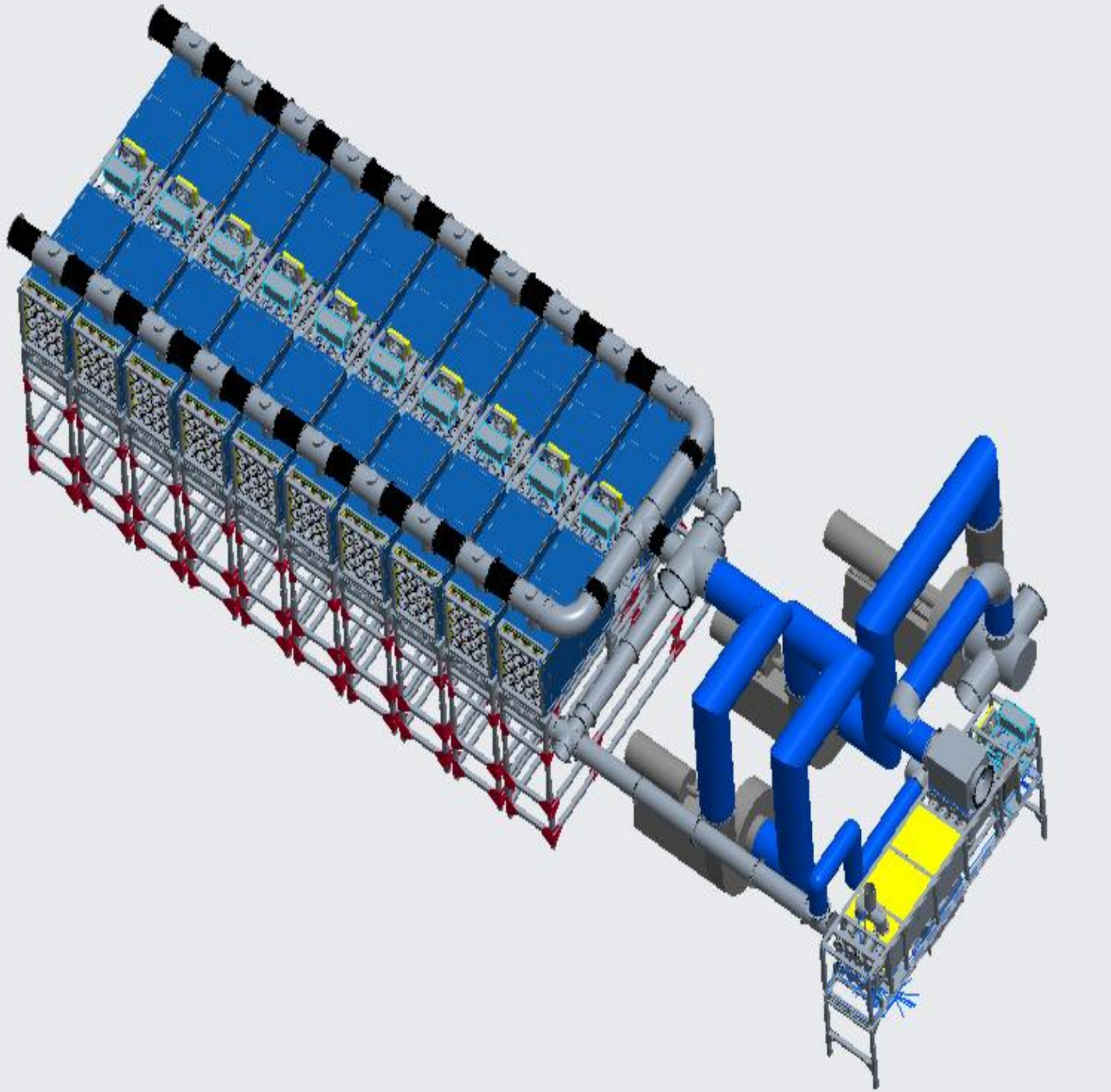
5,000 bbl/Plant

Commercial Facilities



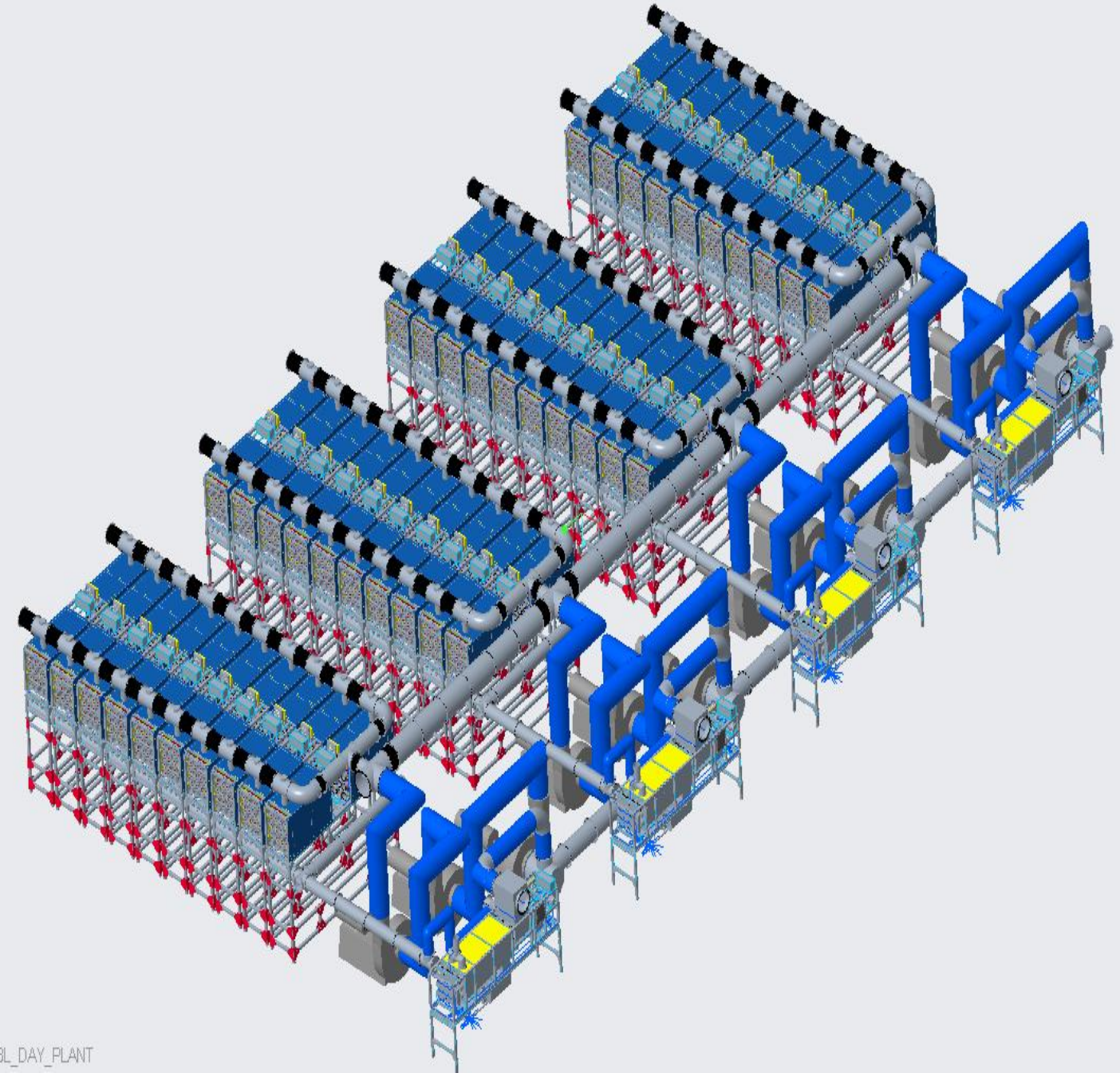
10,000 bbl/Plant

Commercial Facilities



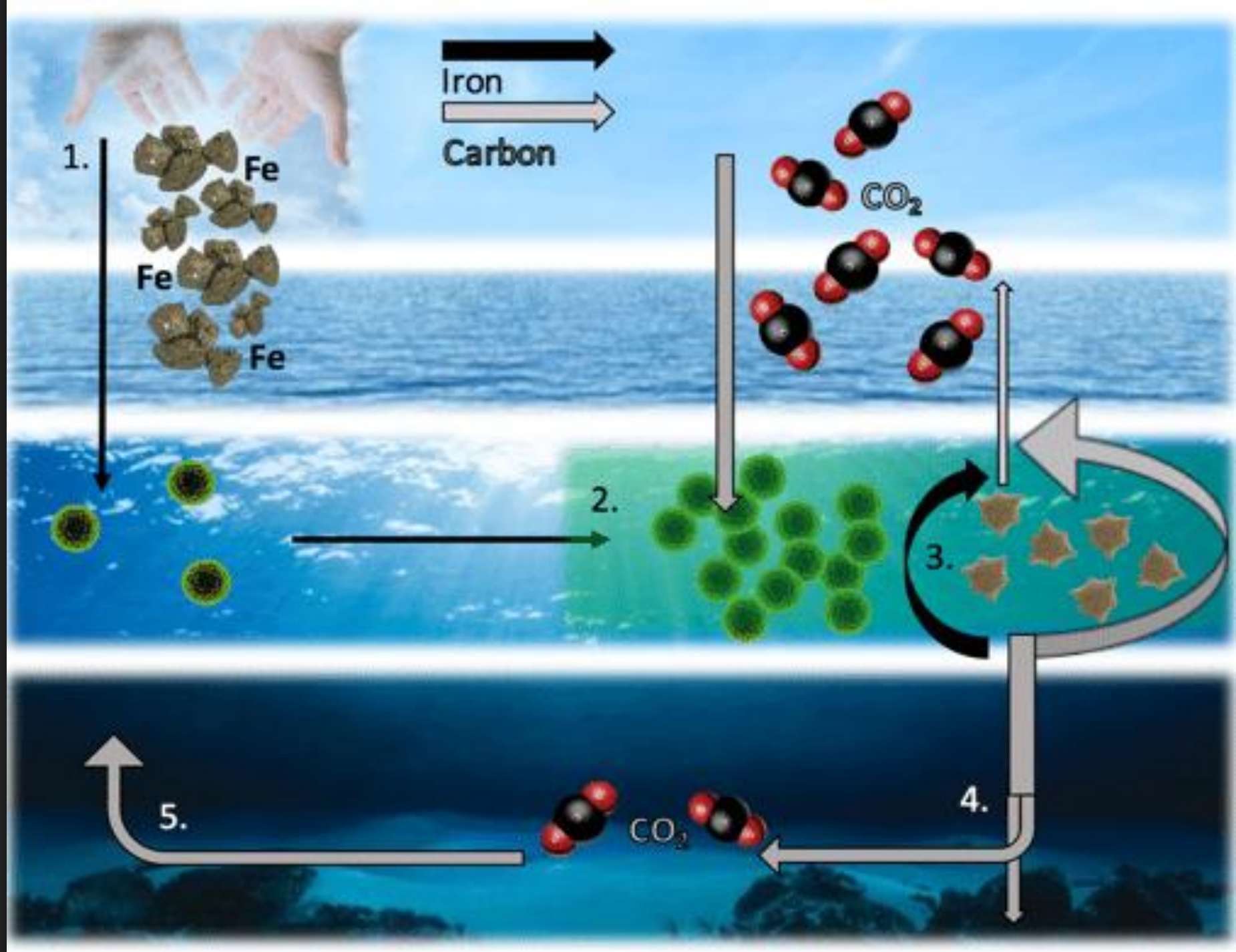
60,000 bbl/Plant

Commercial Facilities



Oceanic Iron Fertilization

- Iron is Missing Micronutrient in Offshore Oceans
- Dry Salt From Complete Evaporation of Produced Water – Ideal Fertilizer



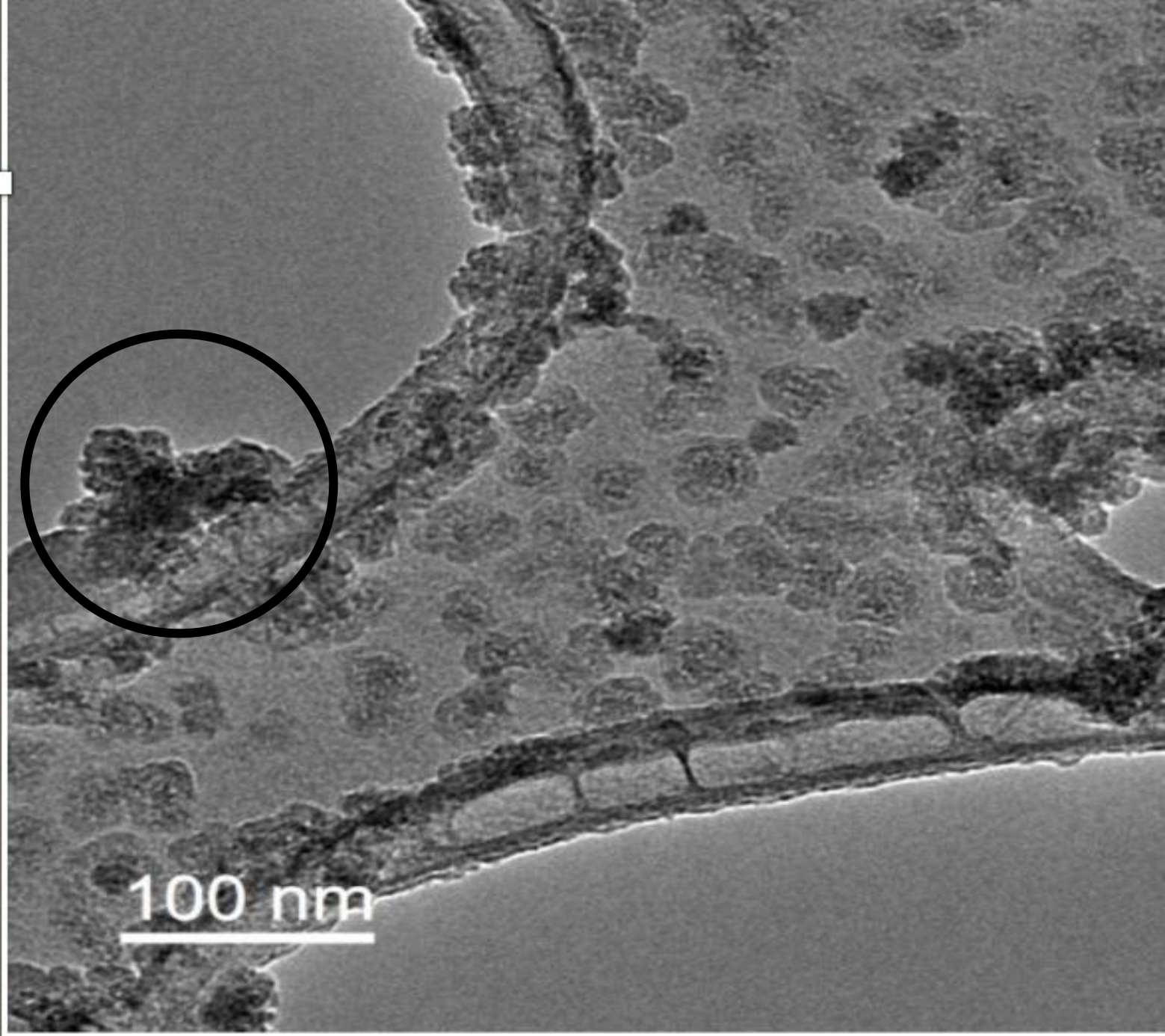
Iron Content of Produced Water

Filtration Alone

After Addition of Oxidants to Filtered Produced Water

NanoEarth Results

- Iron Found to Be Amorphous Nanoparticles by Hochella Team



Large Scale Experiments Conducted

- 300 to 10,000 Square Miles of Ocean
- Each Gram of Iron Sequesters 1K to 100K Grams of Carbon

Limiting Factor – Other Nutrients Are Consumed

- Phosphorous
- Potassium
- Calcium
- Silicon
- High Levels of All In Produced Water Dissolved Solids

Potential - Dry Salt Production - Permian

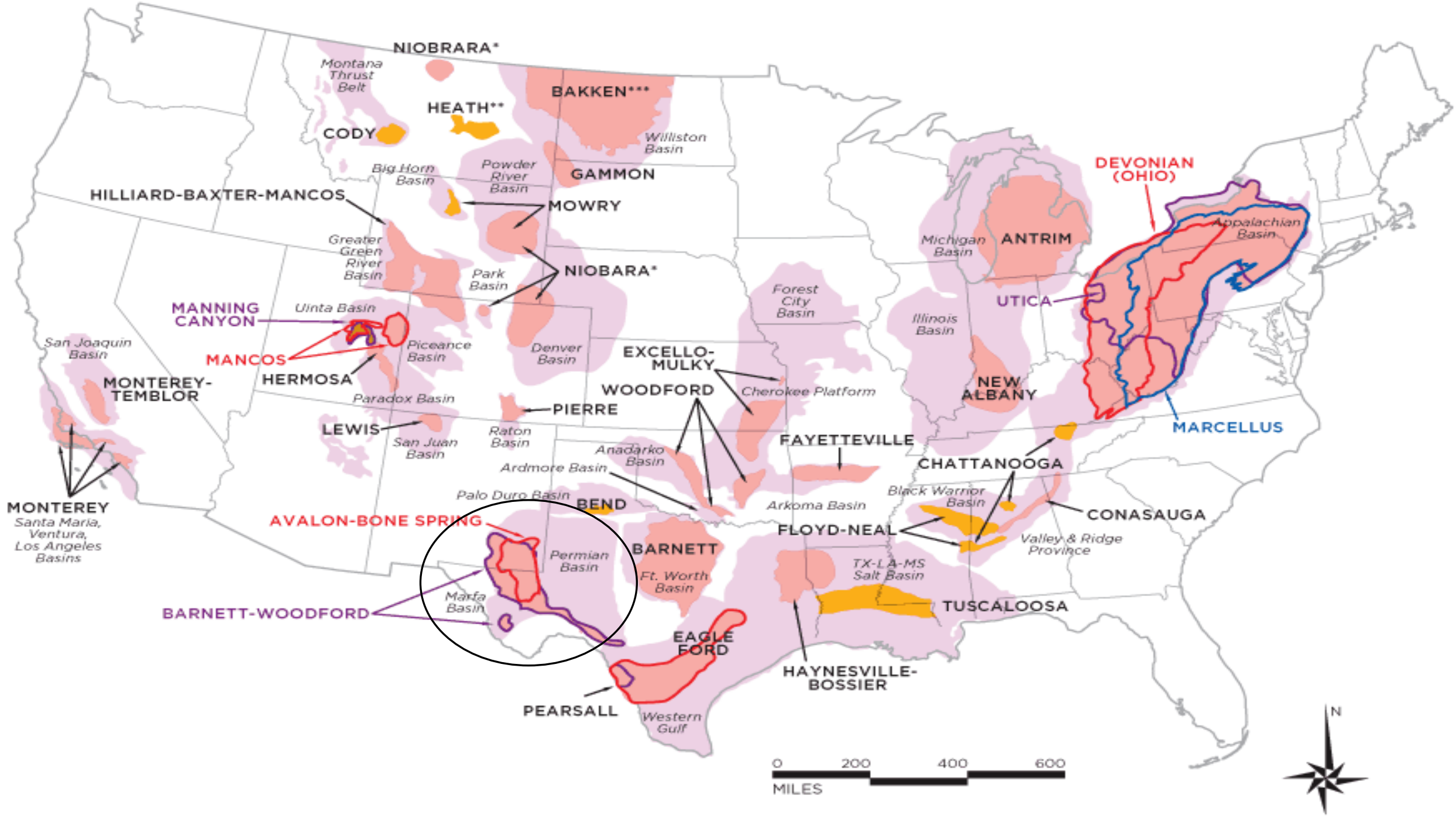
- 426,000 yd3/day of Salt
- 6,000 Rail Hopper Cars/day
- 1.35 Ore Carrier Ships/day

Permian Basin – Water Production

- 200 mg Fe/liter with 20MM bbl/day Production
- Potential to Sequester Above 20 Gigaton Carbon/year

100,000 gram CO_2 Sequestered/Gram Iron

Fertilizer


NIOBRARA*
Montana Thrust Belt
HEATH**
BAKKEN***
CODY
Williston Basin
Big Horn Basin
Powder River Basin
GAMMON
HILLIARD-BAXTER-MANCOS
MOWRY
Greater Green River Basin
Park Basin
NIOBARA*
MANNING CANYON
Uinta Basin
San Joaquin Basin
Piceance Basin
Denver Basin
MANCOS
HERMOSA
MONTEREY-TEMBLOR
Paradox Basin
PIERRE
LEWIS
San Juan Basin
Raton Basin
Anadarko Basin
Ardmore Basin
Palo Duro Basin
BEND
AVALON-BONE SPRING
Permian Basin
BARNETT
Ft. Worth Basin
Marfa Basin
BARNETT-WOODFORD
EAGLE FORD
PEARSALL
Western Gulf
MONTEREY
Santa Maria, Ventura, Los Angeles Basins
Forest City Basin
EXCELLO-MULKY
WOODFORD
Cherokee Platform
FAYETTEVILLE
Arkoma Basin
Michigan Basin
ANTRIM
Illinois Basin
NEW ALBANY
DEVONIAN (OHIO)
Appalachian Basin
UTICA
MARCELLUS
CHATTANOOGA
Black Warrior Basin
CONASAUGA
Valley & Ridge Province
FLOYD-NEAL
TX-LA-MS Salt Basin
TUSCALOOSA
HAYNESVILLE-BOSSIER
0 200 400 600
MILES
N

Available Infrastructure

- Extensive Rail Networks in Oilfield
  - Equipped for Loading of Free-Flowing Solids
  - Direct Access to Coastal Ports
  - Often Return Empty After Delivery of Sand
  - Would Allow Whole Trainloads on Reoccurring Basis
- Bulk Ore Carrying Ships Routinely Transport Cargo To US.
  - Often Return Empty

Available Capital

- Eligible for DOE LPO
  - Minimum of $1 billion
  - Typical Size: $2 Billion+
  - Eligible Expenses: Infrastructure, Equipment
- Support From Administration – Wants Desalination Plant Operational ASAP

Obvious Precautions

- Research Necessary
  - Oceanic Iron Fertilization in General
  - Determine if Salt Remaining From Produced Water is Safe/Effective Fertilizer
    - What Components Need to Be Added/Removed
    - Appropriate Processing Required

Precaution: Imbalanced Ecosystem/ Food Chain

Profound Realization

Contact Us

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