Water and Environmental Issues Due to Oil Production in North Dakota

Presented By:

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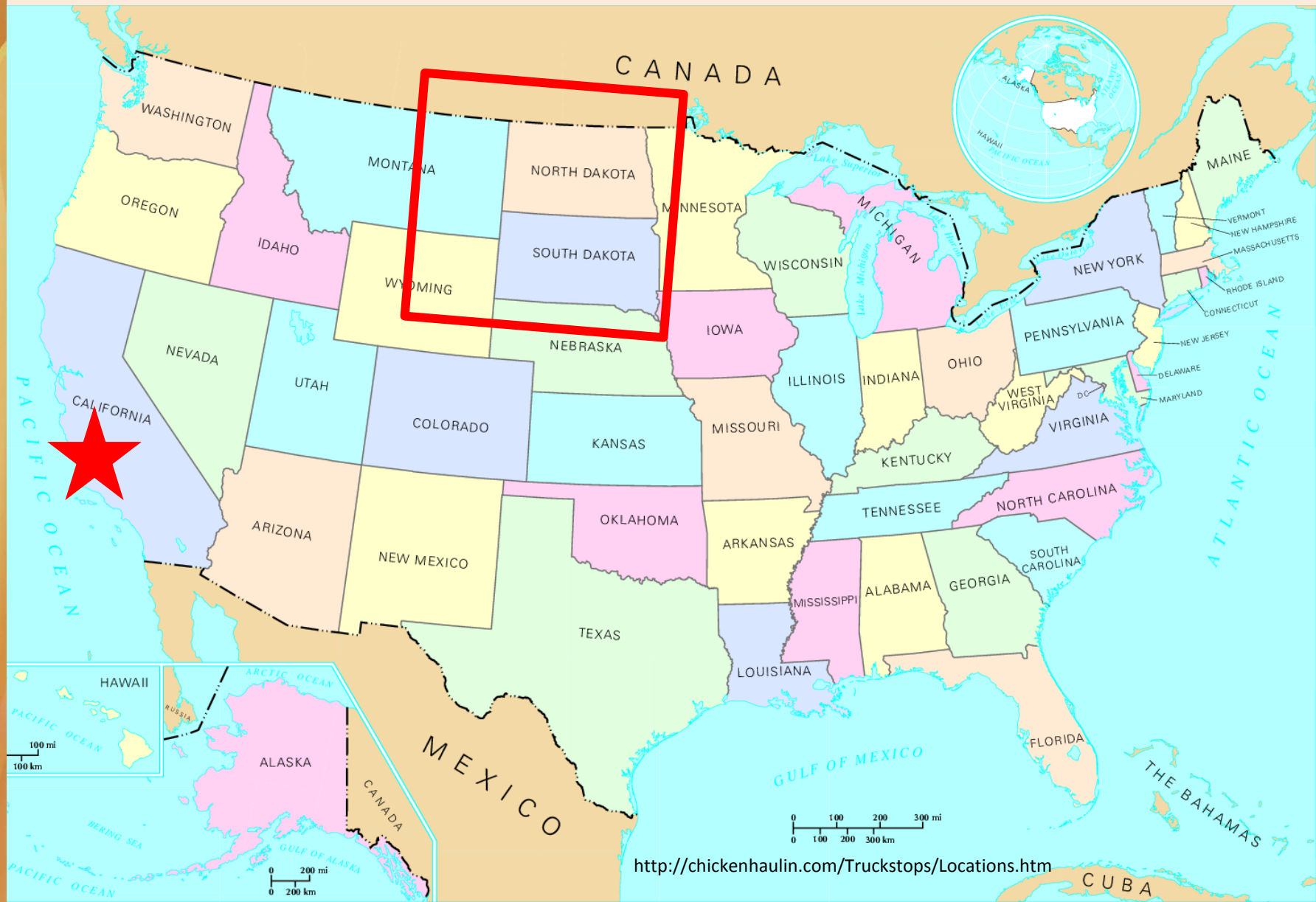
Introduction

- North Dakota Oil Industry
  - 1950's and 1980's Oil Boom
  - Technology did not allow for the recovery of enough oil
- New Technology
  - Hydraulic Fracturing
  - Horizontal Drilling
- Environmental Consequences
  - Solution that saves water and saves money

http://www.ndstudies.org/resources/IndianStudies/threeaffiliated/issues_economic.html

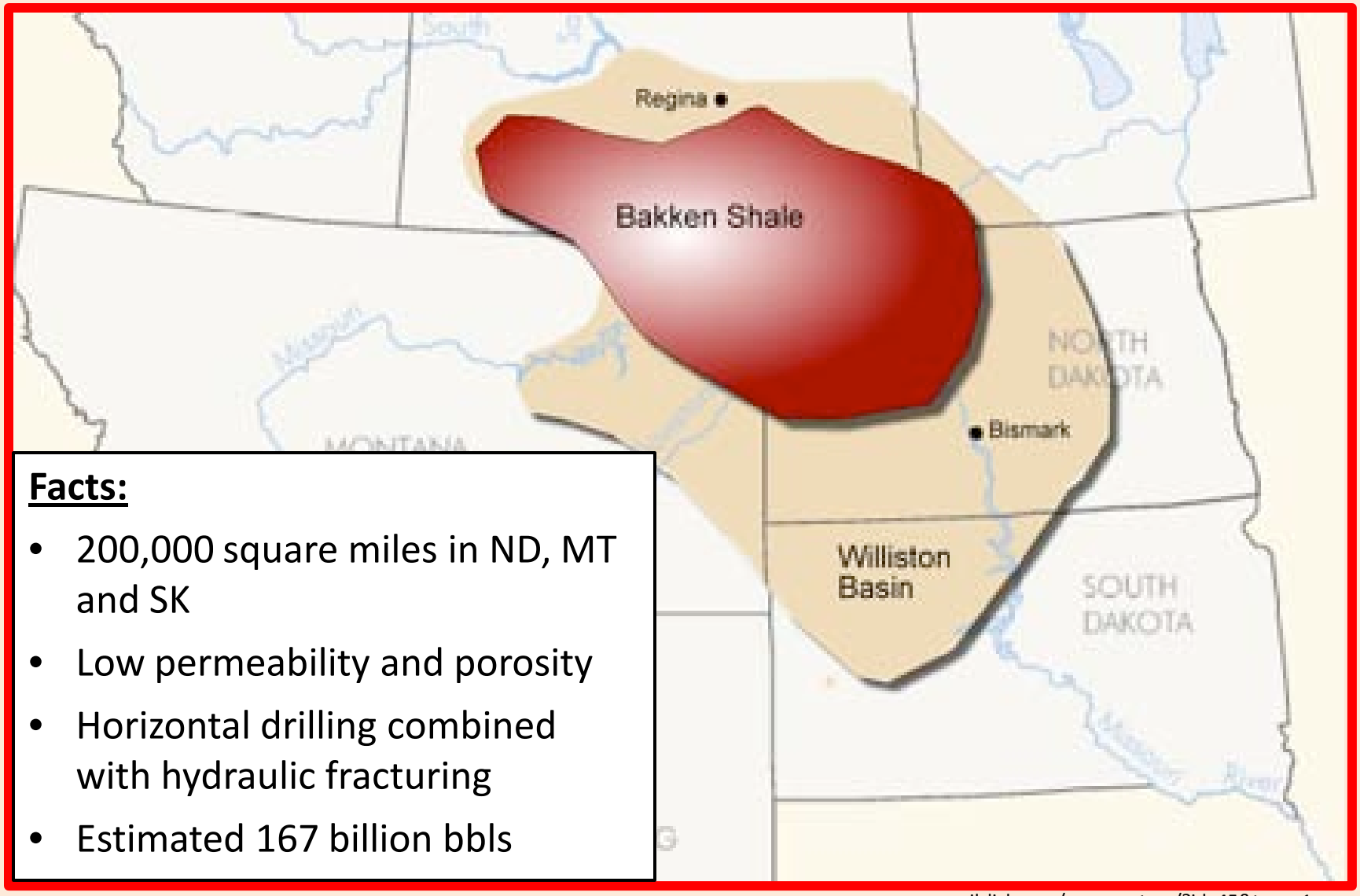
http://www.bizjournals.com/twincities/print-edition/2011/08/26/builder-finds-fertile-soil.html?page=all

Location



http://chickenhaulin.com/Truckstops/Locations.htm

Bakken Shale Formation



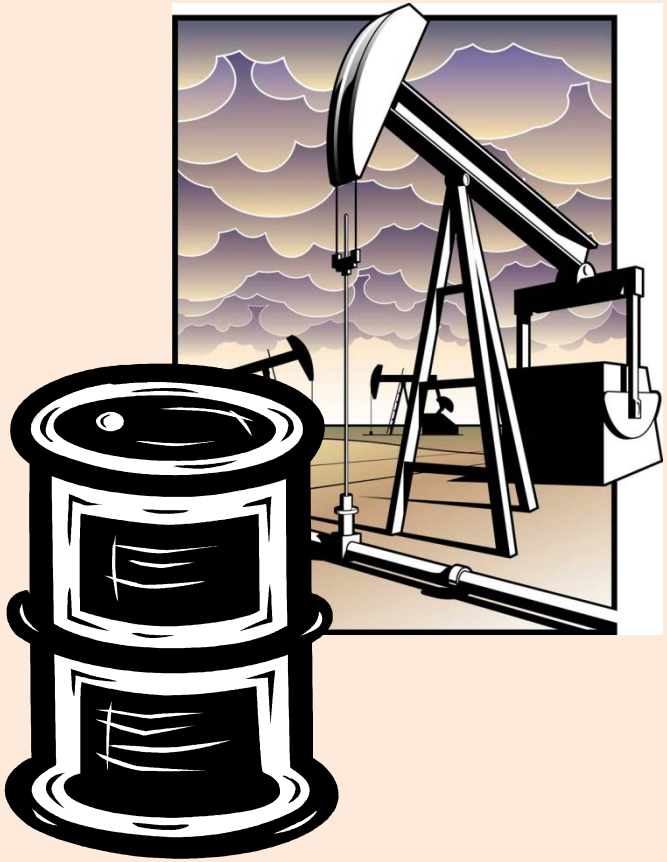
Facts:

- 200,000 square miles in ND, MT and SK
- Low permeability and porosity
- Horizontal drilling combined with hydraulic fracturing
- Estimated 167 billion bbls

www.oilslick.com/commentary/?id=45&type=1

Outline

- Hydraulic Fracturing
- Define the Problem
- Technology Options
- Comparison Analysis
- Recommendation



Hydraulic Fracturing

Definition:

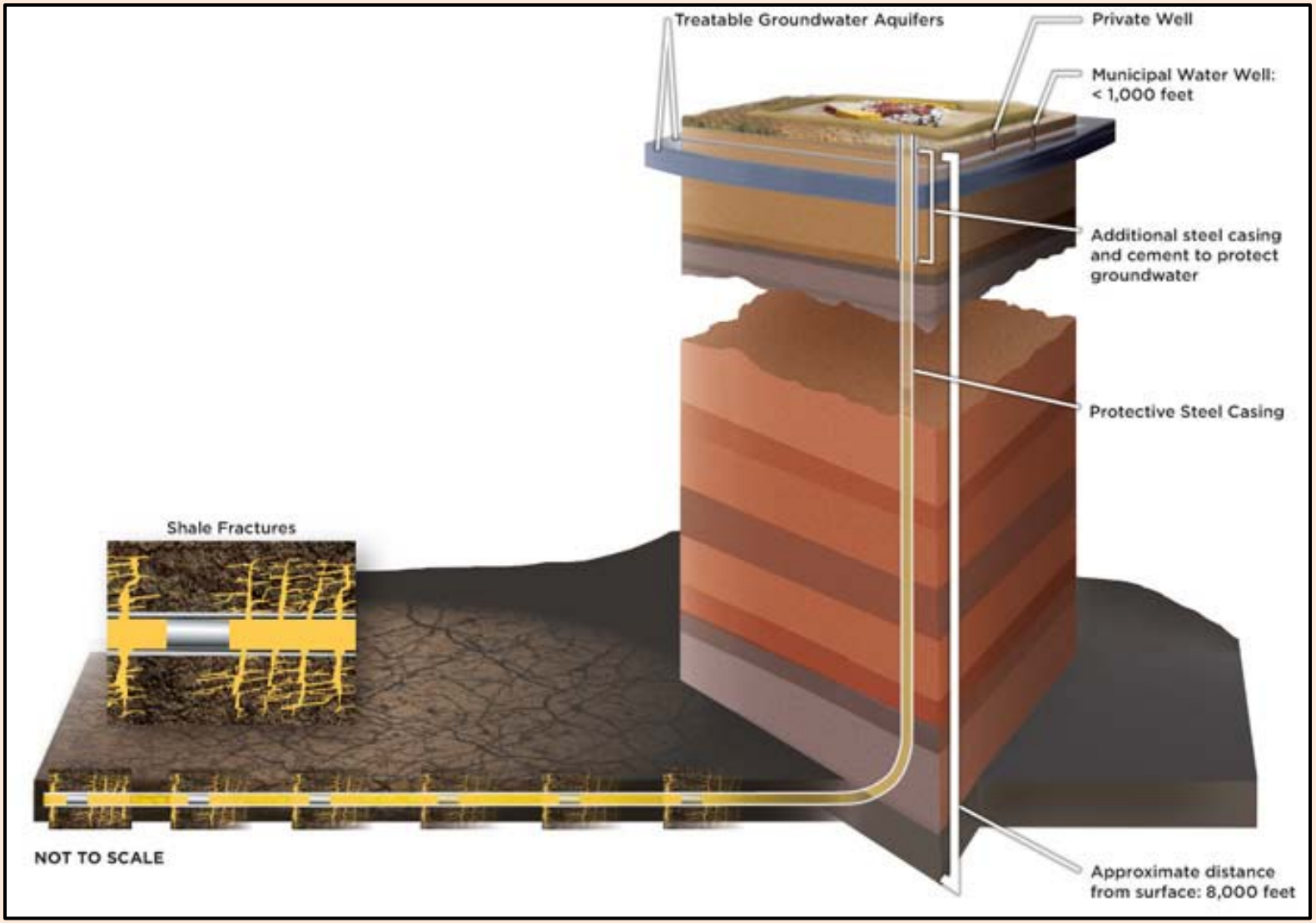
- Process by which oil and natural gas is extracted from oil shale rock formations

Method:

- Use of high pressure fracking fluid to release the oil locked in the rock formation and increase the oil production of the wells

- Fracking fluid is 90% water, 9.5% proppants and 0.5% additives

Hydraulic Fracturing



www.fe.doe.gov/programs/oligas/shalegas/hydraulicfracturing.html

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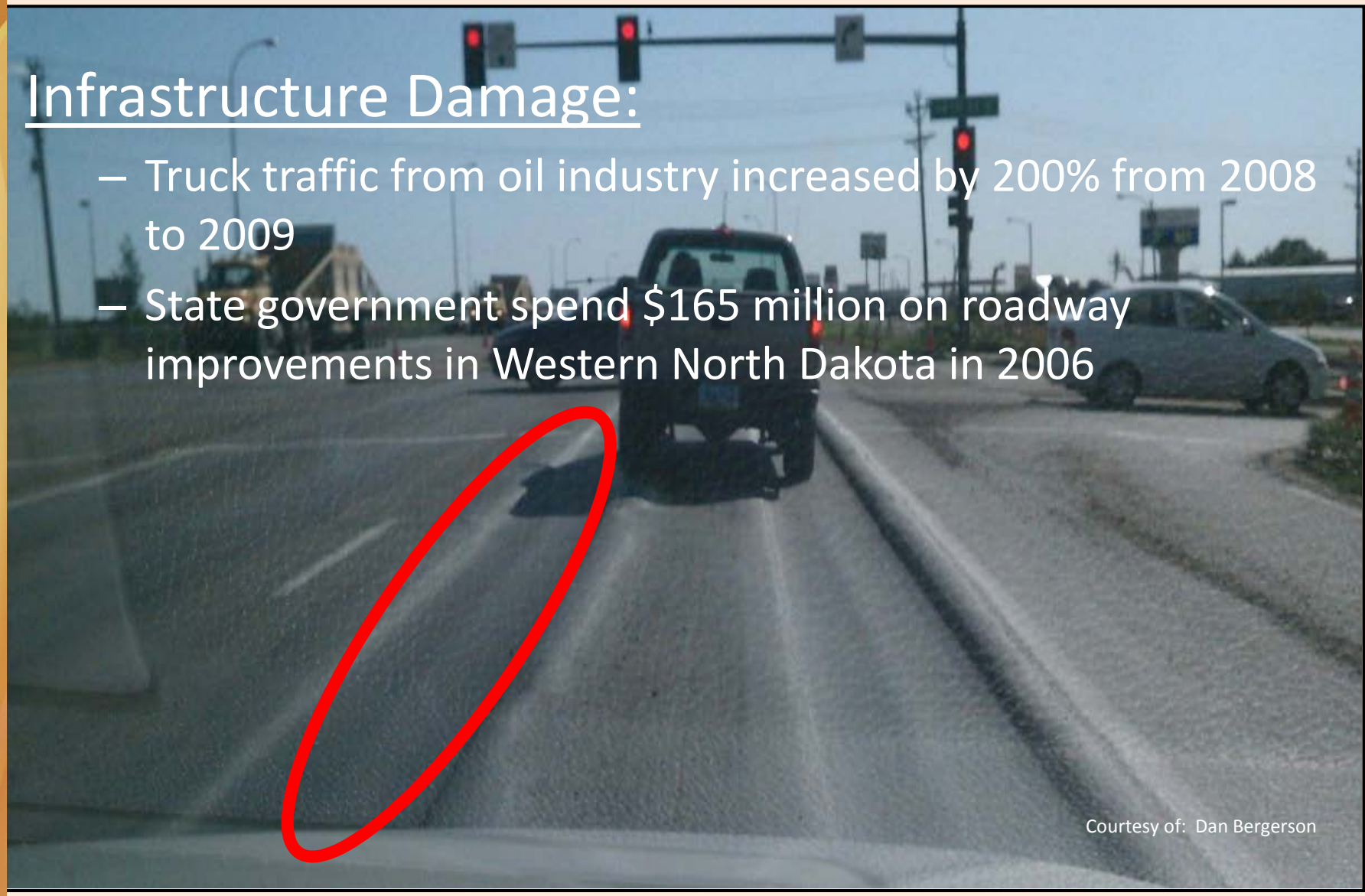
The Problem

1. Water Demand:
   - 1,000,000 gallons of water needed per frack
   - Multiple fracks can be applied to each well

2. Waste Disposal:
   - Deep well injection
     - Returning the used frack water to the empty well deep below the water tables
   - Others

Water Demand Consequences



Infrastructure Damage:

- Truck traffic from oil industry increased by 200% from 2008 to 2009
- State government spend $165 million on roadway improvements in Western North Dakota in 2006

Courtesy of: Dan Bergerson

Water Demand Consequences Cont.

Highway Safety:

- Cultural change to this area
- 25% of deaths in oil industry were traffic related

Environmental:

- Dust pollution affects crops and animals

Air Pollution:

- 6.5 grams of nitrogen oxide, 6.5 grams of carbon monoxide, and 2.1 grams of hydrocarbons are released per mile for each of the 300 to 1300 trucks used per well

Waste Disposal Consequences

Current Method:

- Deep well injection without treatment

Harmful Components:

- Proprietary chemicals
- High salinity
- TDS ranging from 60,000 mg/L to 200,000 mg/L

Possible Consequences:

- Groundwater/soil contamination

Objectives

1. Reduce Water Demand
   - Oil company initiative

2. Water Treatment
   - Reuse in hydraulic fracturing
   - Reduce amount of water wasted

3. Overall Cost and Water Savings

Technology Options

Membrane

Thermal

Chemical

http://img.directindustry.com/images_di/photo-g/chemical-water-treatment-machine-116677.jpg; http://www.aastropure.com/images/ceramic_membra.jpg; http://www.wastechcontrols.com/papers/vacuum_distillation.htm

Membrane Treatment

Electrodialysis(ED)/ED Reversal(EDR):

- Utilizes electricity and specifically charged membranes (cation-exchange and anion-exchange)

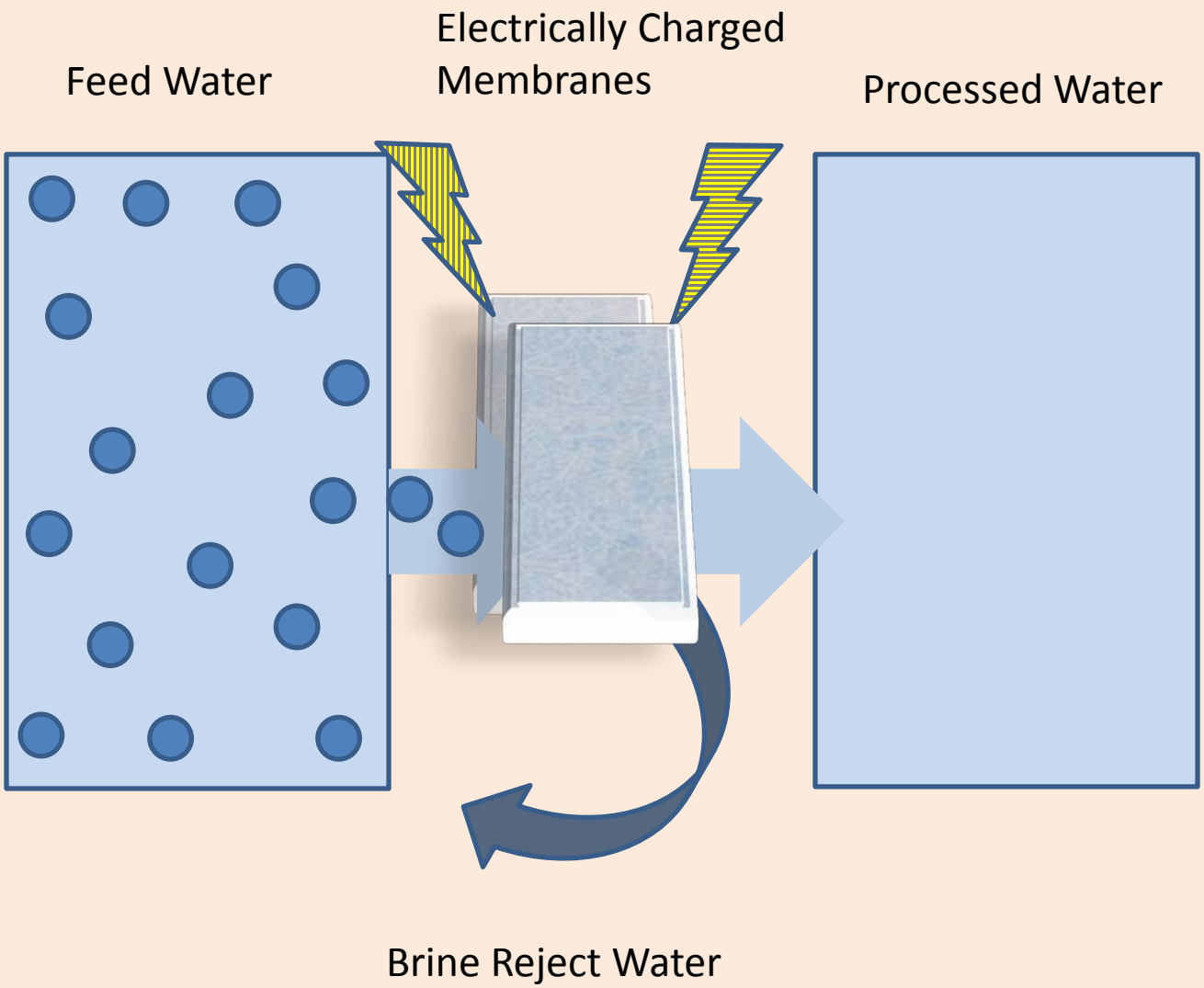
http://www.indiamart.com/aquatreat-sys-engineers/products.html

High Efficiency Electrodialysis (HEED®)

- Require 40% less membrane area in their stacks, and are 70% more energy efficient
- Mobile

http://www.hellotrade.com/eet-coropration/high-efficiency-electrodialysis.html

Electrodialysis

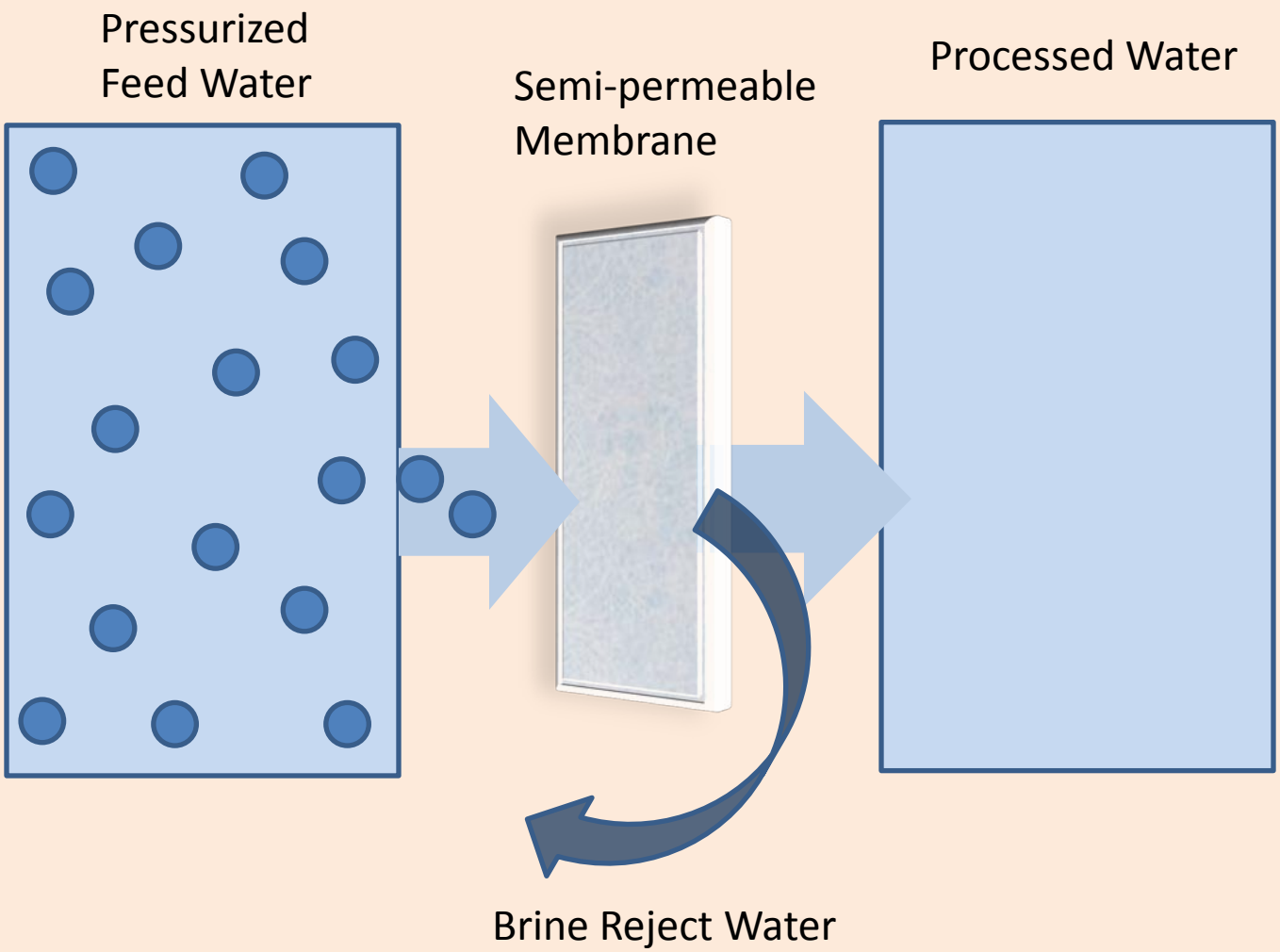


Reverse Osmosis (RO)

- Pressure forces a solution through a semi-permeable membrane resulting in separate streams of concentrated brine and pure water
- The process involves three streams: feedwater, treated water, and concentrated brine

http://www.veoliawaterst.com/desalator/en/

RO Diagram


Pressurized
Feed Water
Semi-permeable
Membrane
Processed Water
Brine Reject Water

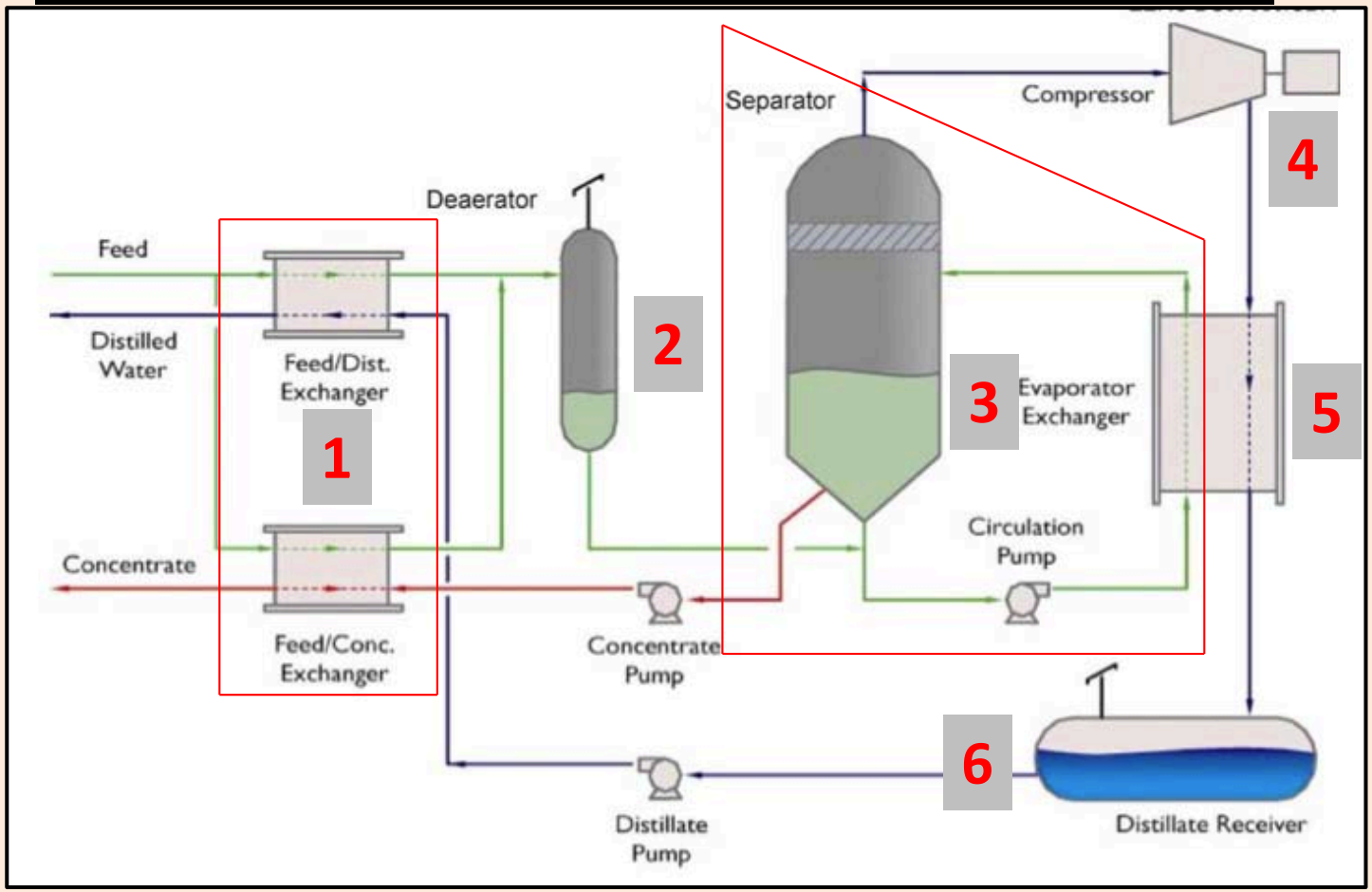
Thermal Treatment

Involves treating brine waste using distillation to produce clean, distilled water

Vendors:

- AltelaRain
- Aqua-Pure (NOMAD)
- 212 Resources
- General Electric (GE)

Mechanical Vapor Recompression (MVR) NOMAD 2000 - Process



Patrick Horner: Aqua-Pure

1. Heat Exchangers
2. Deaerator
3. Circulation Loop
4. Compressor
5. Evaporator Exchanger
6. Distillate/Effluent

Aqua-Pure

Patrick Horner: Aqua-Pure

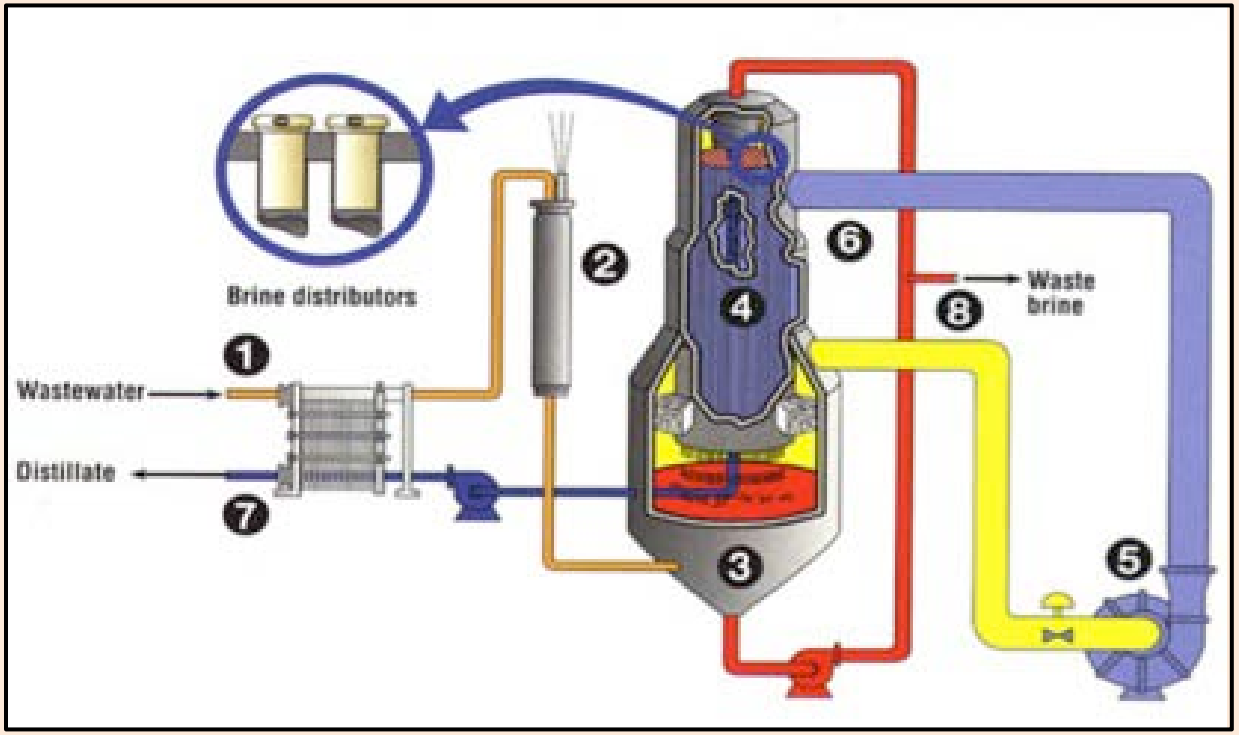
General Electric (GE)
Brine Concentrators & Evaporators

http://www.ge-energy.com/products_and_services/products/surface_wellhead/heavy_oil_sagd_solutions.jsp

Brine Concentrator & Evaporator

Process:

1. Heat Exchanger
2. Deaerator
3. Brine Slurry
4. Evaporator
5. Compressor
6. Distillate Stream
7. Heat Exchanger
8. Brine Stream



http://www.gewater.com/products/equipment/thermal_evaporative/brine_concentration.jsp

Chemical Treatment

Used as a pretreatment process

Precipitation (Hart Resource Technology)

- Chemical flocculation and pH adjusted precipitation
- Solids produced are filtered out and sent to a landfill
- Treated brine can be sold for deicing purposes

Emulsion (Nanozox™ process)

- Peroxide coated bubbles are negatively-charged
- Organics are oxidized to carbon and oxygen while metals are precipitated and filtered for disposal
- Concentrated solids are used for granular salt production, road de-icing application, or deep well disposal

Water Recovery (%)

1. HEEPM- 98
2. HEED - 95
2. NOMAD- 95
4. BCE - 85
5. RO - 75

TDS Limits

1. BCE - >100,000
2. NOMAD -100,000
3. HEEPM - 50,000
4. RO - 40,000
5. HEED - 27,000

Potential Options

BCE

NOMAD

RO

HEED

Capacity (MGD)

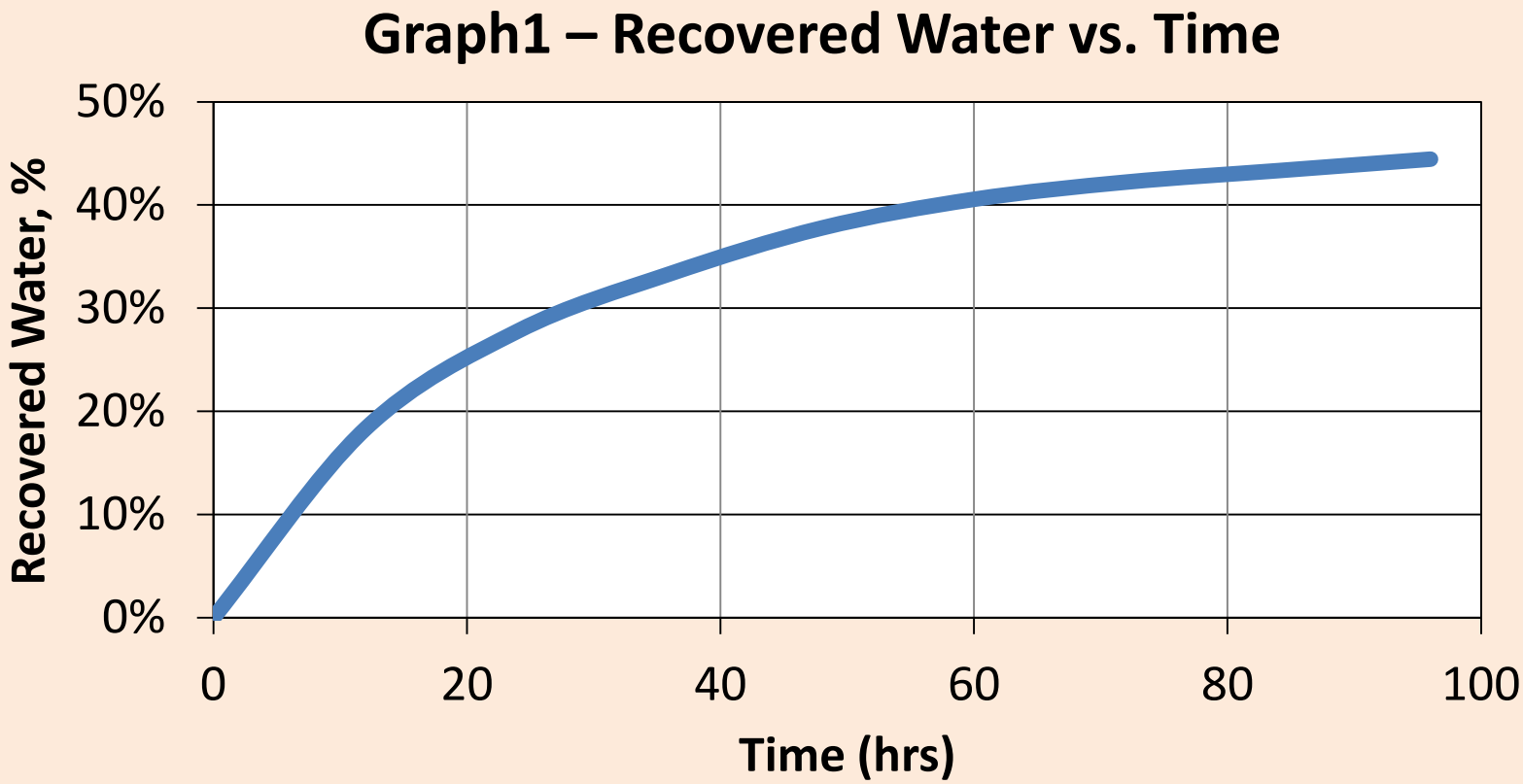
1. BCE - 1.7
2. RO - 1.1
3. NOMAD - 0.096
4. AtelaRain - 0.004

Mobility

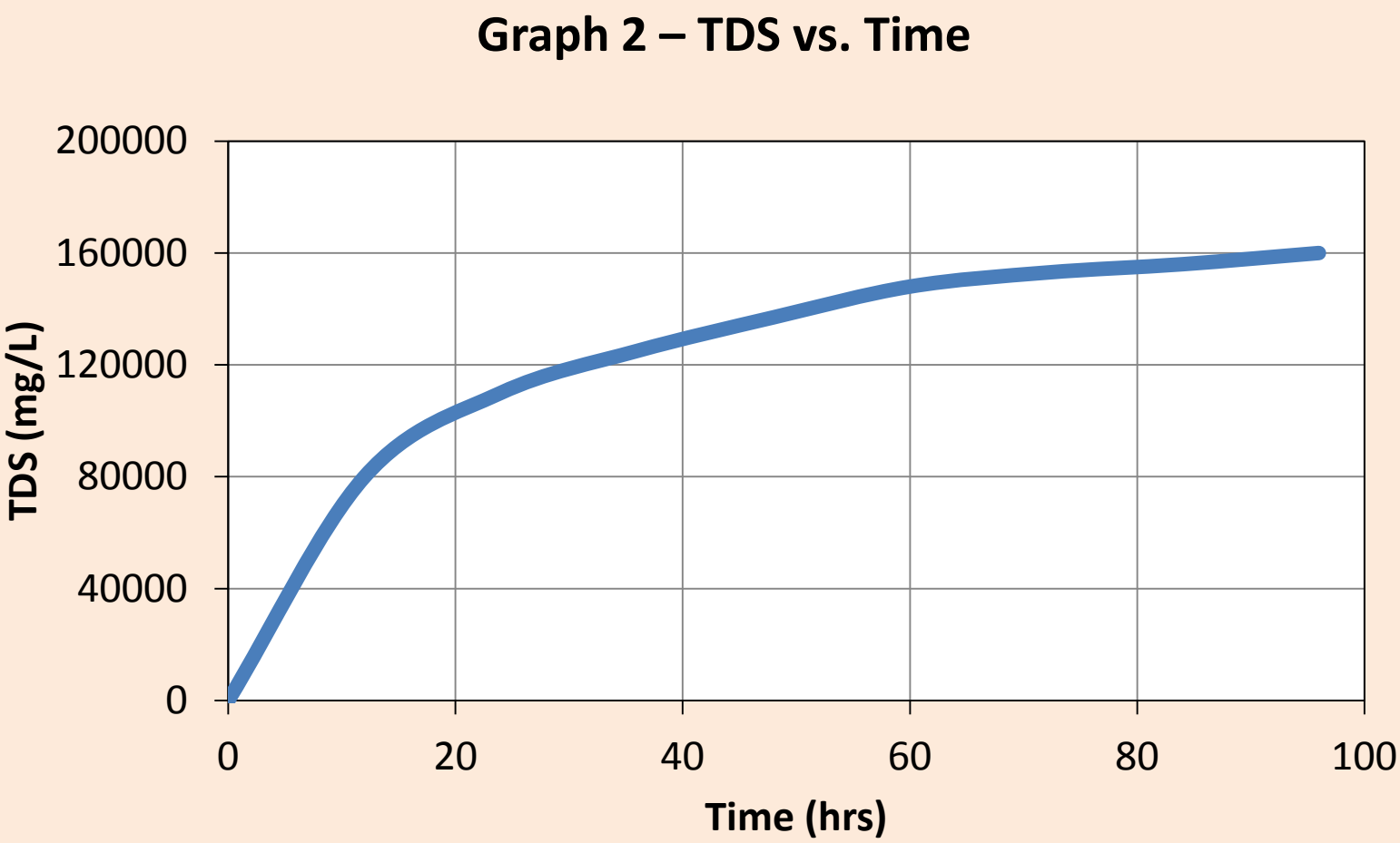
RO
HEED
HEEPM
NOMAD

Comparison Criteria

- Total water injected 4 million gallon per well
- 44 % of water retrieved = 1.8 million gallons



Comparison Criteria



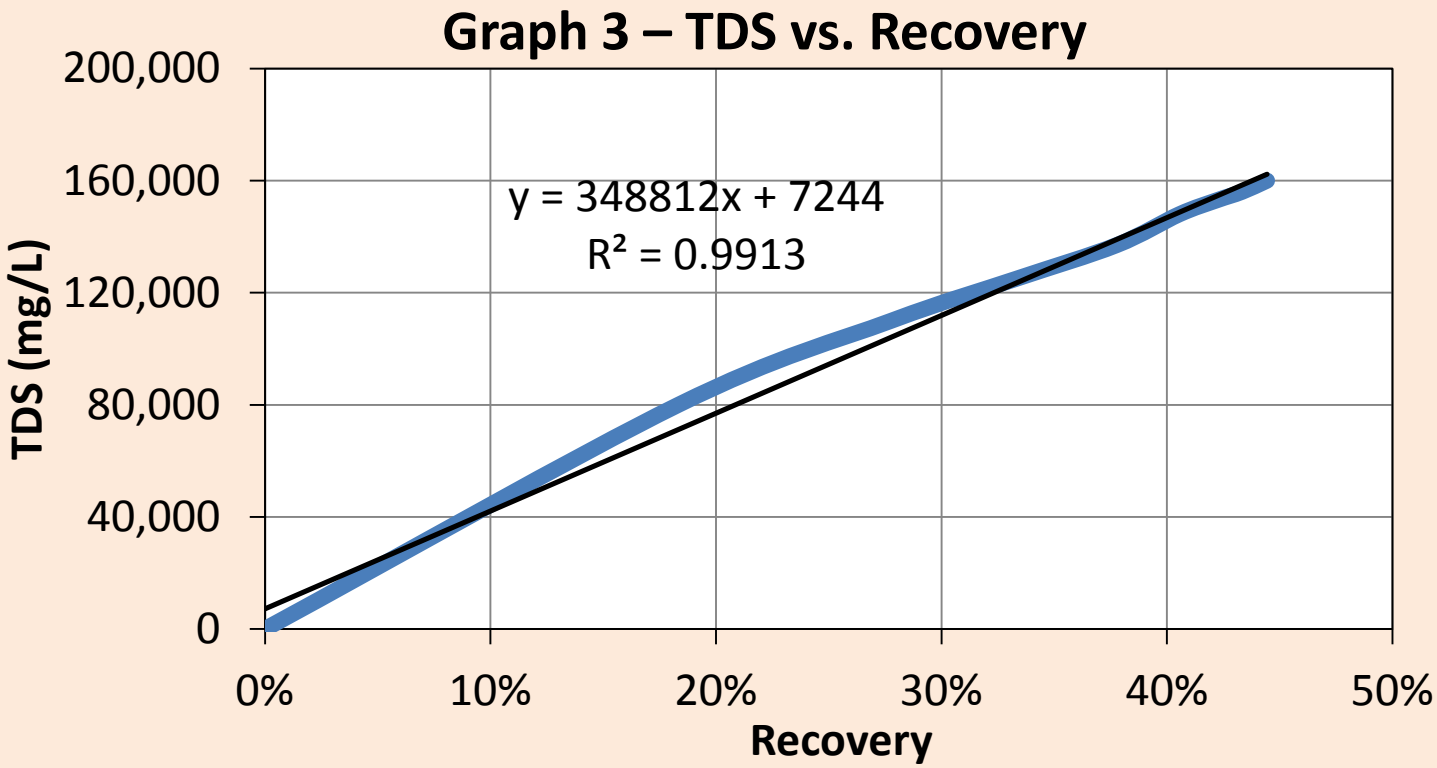


Table 1: TDS Concentrations	
Recovery (%)	**TDS (mg/L)**
5	18,774.95
20	75,099.80
40	150,199.60

Comparison Criteria

- Treatment Comparison (Table 2)

Table 2: Treatment Comparisons				
Technology	**HEED**	**RO**	**MVR**	**Brine Concentrator**
Operating Cost $/bbl	0.21	0.5	3.5-6.0	1.55
TDS, mg/L	27,000	40,000	100,000	>100,000
Water Recovery, %	95	50-75	75-95	75-85
Maintenance	High	High	Low	Low
Mobility	Yes	Yes	Yes	No

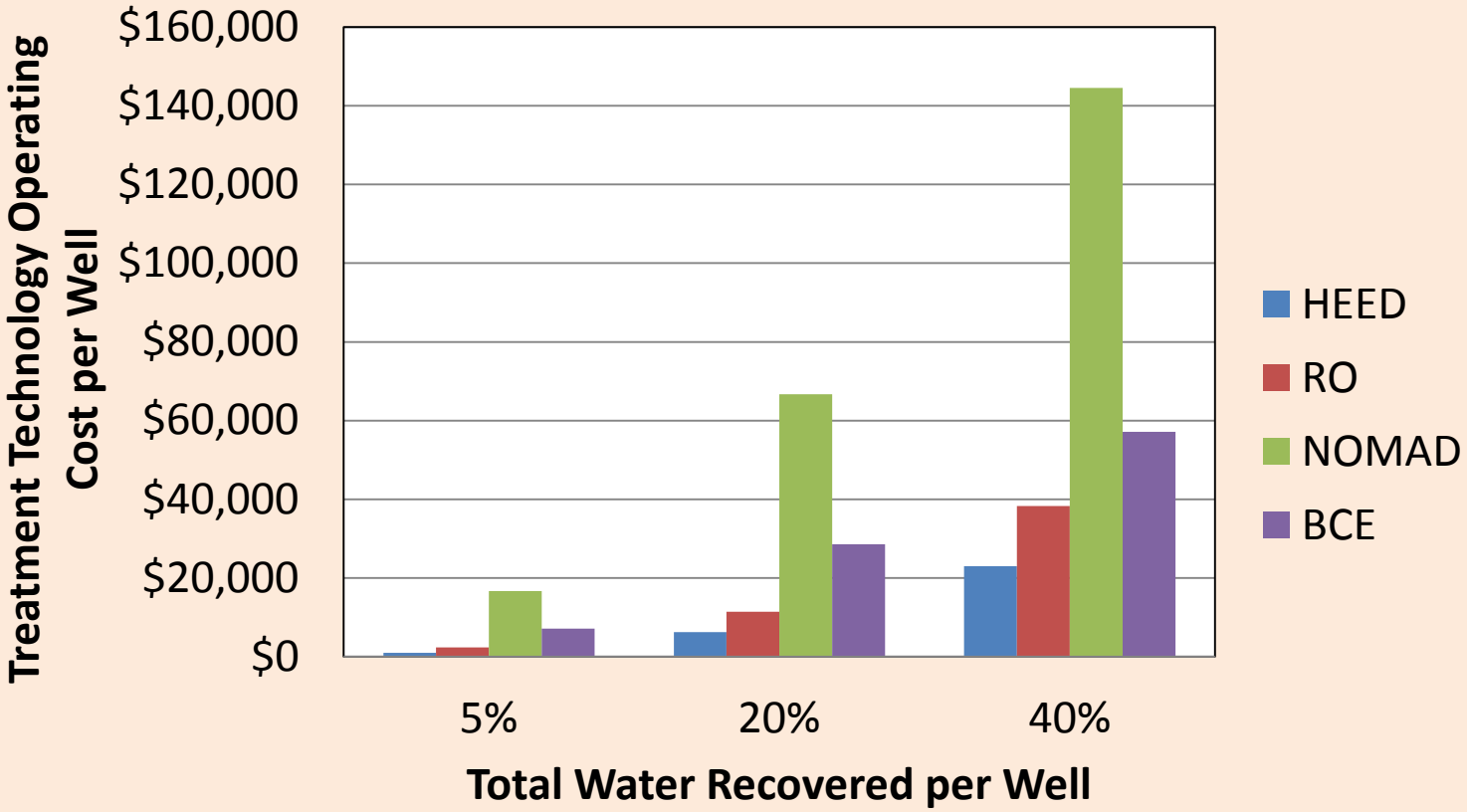
Comparison Criteria Cont.

- Each technology needs dilution at different percentages of retrieval (Table 3)
- None require dilution prior to 5%

Table 3: Volume of Dilution Water (bbl)			
Technology	Percentage of Injected Water Recovered		
	5%	20%	40%
HEED	0	10,866	71,290
RO	0	3,906	38,500
NOMAD	0	0	3,196
BCE	0	0	0

Treatment Cost Analysis

- The operating cost for each technology was applied to the volume of water being treated at each percentage



Cost Saving Analysis

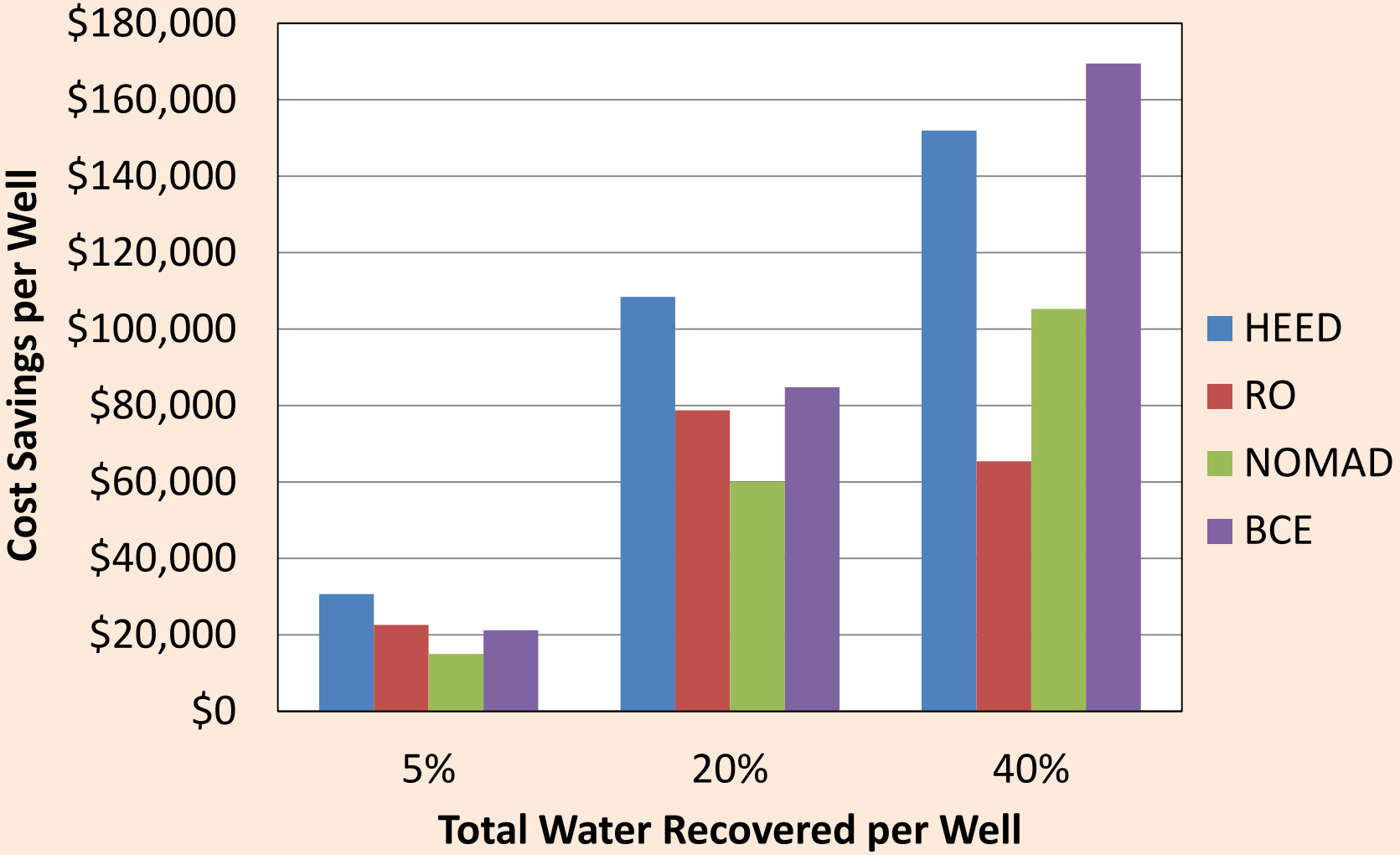
Waste without Treatment Cost:

- Initial costs for treatment
- Transportation of injection water
- Transportation and reinjection of flowback

Treating flowback Cost:

- Transportation (to and from the well site)
- Dilution
- Disposal costs
- Operating costs

Cost Savings Analysis Results



Water Savings Analysis

Which technology saves the most water per well?

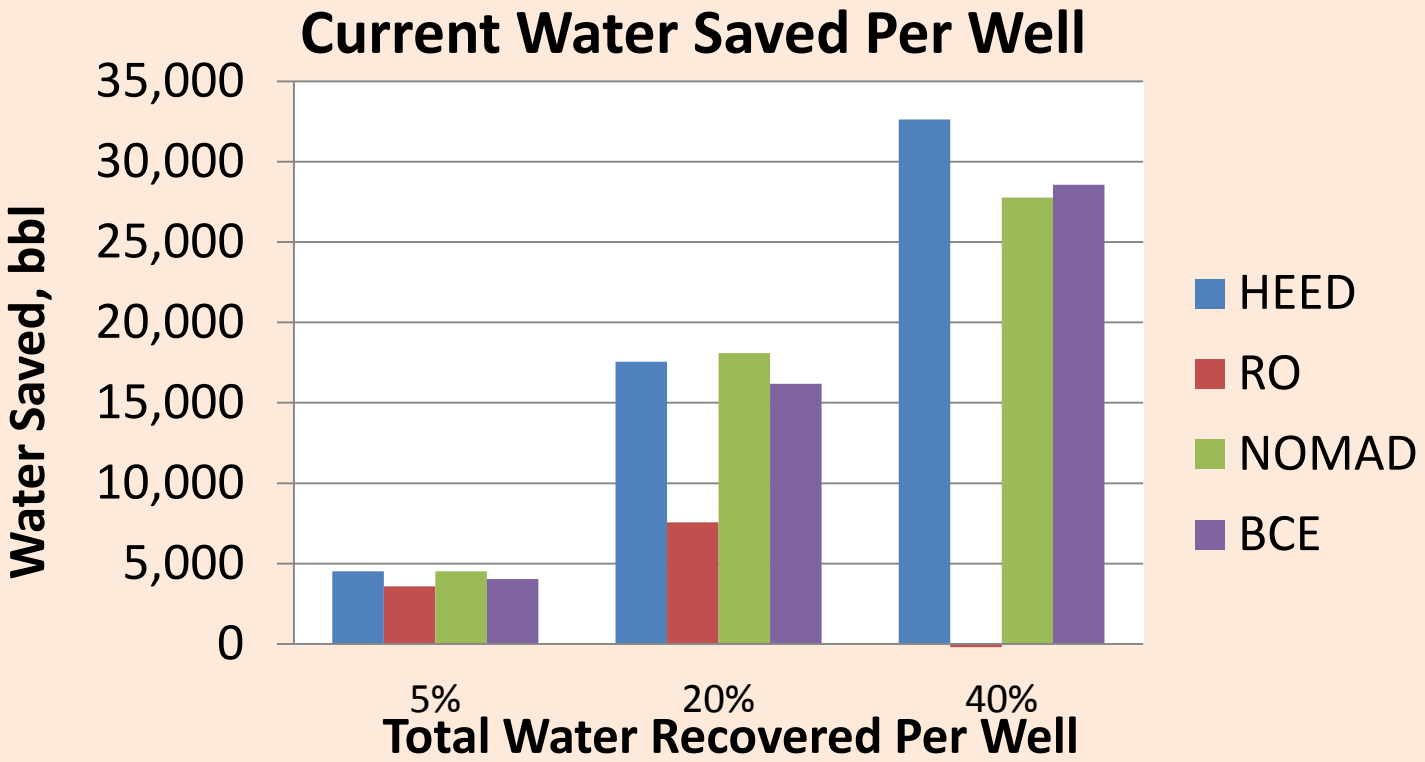
- Water Recycled – Dilution Water = Water Saved

Has that technology proven itself in the field?

- Contacted companies to determine their recovery rates and overall success treating flowback

Water Savings Analysis

Total Water Saved per Well, bbl			
	5%	20%	40%
HEED	4,524	17,552	32,626
RO	3,571	7,571	-203
NOMAD	4,524	18,095	27,772
BCE	4,048	16,190	28,571



Recommendations

- BCE - Not mobile
- HEED - Not tested on a large scale
- RO - requires excessive dilution
- NOMAD was chosen

Conclusions

Aqua-Pure's NOMAD 2000 would be the best choice for ND's oil fields because:

- Wells are spread out, so a centralized brine concentrator treatment facility isn't feasible
- the NOMAD's mobility allows it to be hauled from site to site
- Saves water
- And economical

Impact

- If NOMAD is used throughout Bakken Shale:
  - Based on 1,322 wells drilled per year
    - about 37 million bbl of water saved per year
    - $140 million saved
  - Based on 2,140 wells drilled per year
    - about 60 million bbl of water saved
    - $225 million saved

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Questions?

Thank you!