Alternative Energy-Driven Oilfield Wastewater Reclamation

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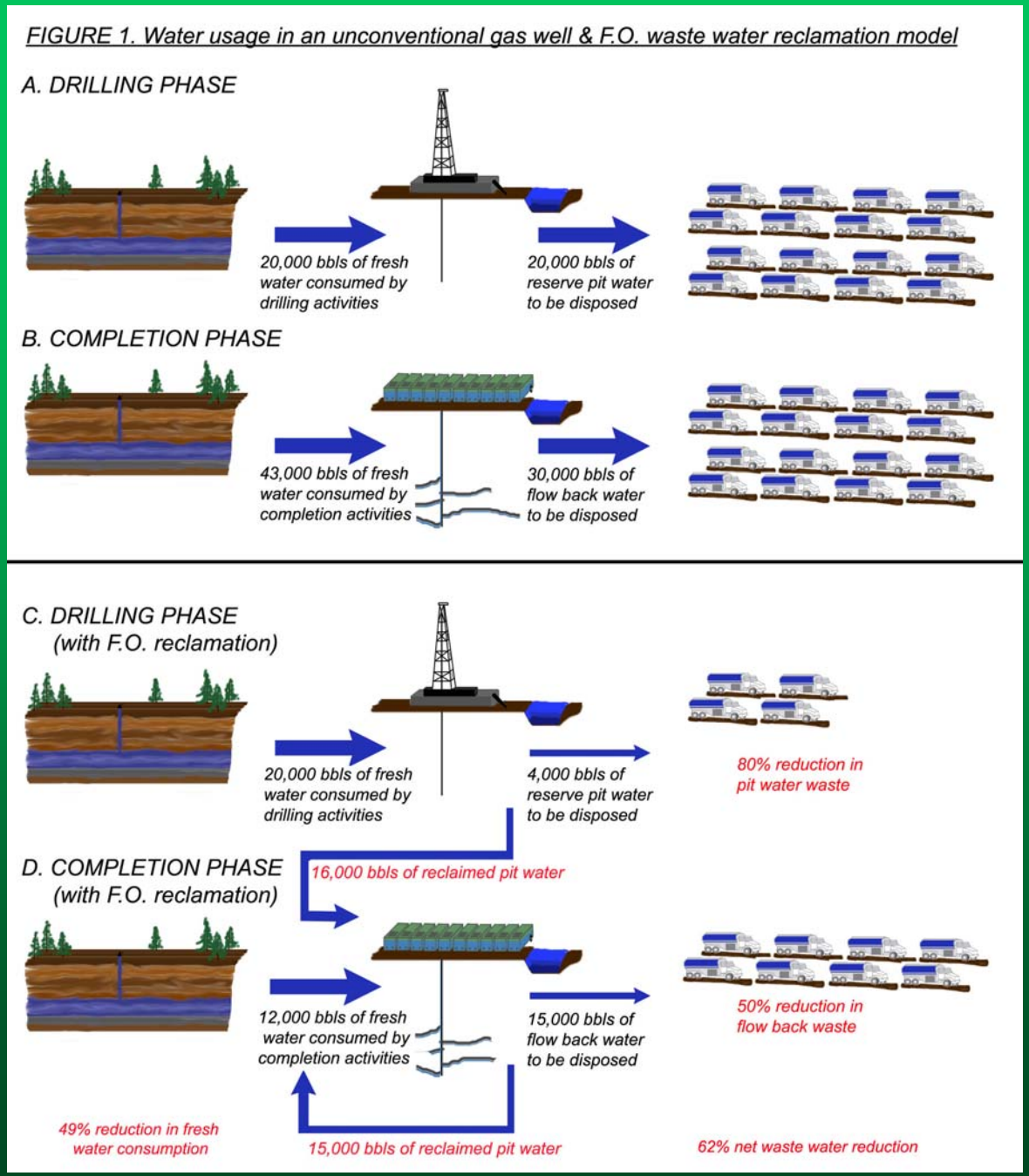
Acknowledgements

- Hydration Technologies Innovations (HTI):
  - Mr. Walt Schultz
  - Dr. Keith Lampi
  - Dr. Ed Beaudry

- Bear Creek Services:
  - Mr. William J. O'Brien III & the Bear Creek Board
  - Mr. Eric Appleton
  - Dr. Xingwen Chen
  - Mr. Ron Scott
  - Team Bear Creek



Three types of E&P water

- Drilling Fluids
  - Water-based mud
  - Rig Supply
- Completion Fluids
  - Stimulation fluid
  - Work-over fluid
- Production Fluids
  - Geological saltwater

Disposal options vary by region but typically include:

- Land farming (limited)
- Annular injection (limited)
- Private disposal well
- Commercial disposal well

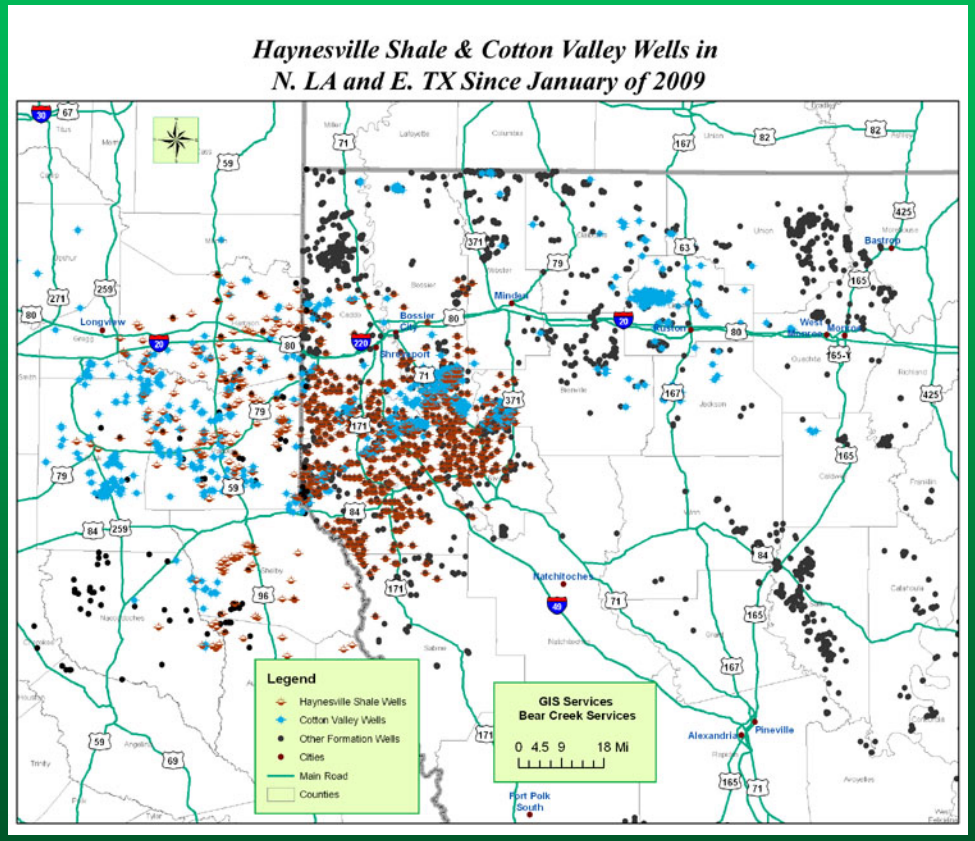
Once fresh water becomes E&P waste, the vast majority leaves the natural fresh water cycle, especially when deep (disposal) well injected

How Serious is the Fresh Water Draw-Down Situation?

- Haynesville Shale Well
  - Drilling Fluid — 20,000 bbls — 840,000 gal
  - Completion Fluid — 165,000 bbls — 6,500,000 gal
  - Flowback — 20,000 bbls — 840,000 gal
  - Produced Water — ~50 bpd — 2,100 gal
- Cotton Valley
  - Drilling Fluid — 20,000 bbls — 840,000 gal
  - Completion Fluid — 30,000 bbls — 1,260,000 gal
  - Flowback — 20,000 bbls — 840,000 gal
  - Produced Water — ~50 bpd — 2,100 gal

Well Count in N. LA / E. TX January 2009 - present

- Haynesville Shale Wells (Jan 2009 to present)
  - 526 (NLA) + 187 (ETX) = 713
  - 713 wells x 8MM gpw = 5,704,000,000 (5.7 billion gallons!)
- Cotton Valley Wells (Jan 2009 to present)
  - 708 (NLA) + 405 (ETX)
  - 1113 wells x 2MM gpw = 2,226,000,000 (2.25 billion gallons!)
- Projected to drill ***thousands*** of Haynesville wells in 2010
- Water resources in other areas are even more sensitive!



Well count and map compliments of Dr. Xingwen Chen, Director of GIS, Bear Creek Services

Recent articles on E&P wastewater reuse

- Recycling Water for Frac can reduce costs by >15%. “New Approach Maximizes Horizontal Fracturing Investment”. *E&P.* September 2009
- DNR pledges to do ‘everything humanly possible’ to ensure ground water does not suffer from because of Haynesville Shale Activity. *The Shreveport Times*. Thursday September 3, 2009.
- All of these approaches (RO, filtration, chemical, and thermal) will be applied in the effort to ensure that water is reused to the maximum extent, reducing costs as defined by financial, environmental, and social. “Water treatment processes make strides”. *E&P*. July 2009.
- There are significant cost benefits of water resuse and sound water resource management. “Pretreatment processes in a nutshell”. *Hydrocarbon Engineering*. June 2009.
- Recycling technologies work but are not currently economical in East Texas. “Oil and Gas Wastewater recycling continues to increase, but is affected by current economy”. *Fort Worth Basin Oil & Gas Magazine*. May 2009.
- One solution to the water supply problem is to use produced formation water or flowback water from prior stimulation operations. “The benefits of recycle-produced water for fracs”. *E&P.* March 2009.
- New, low cost, and readily implemented approaches are needed for management of water associated with development of conventional and unconventional oil and gas reserves. “Technology Status Assessment”. Castle and Rodgers. Clemson University. November, 2008.

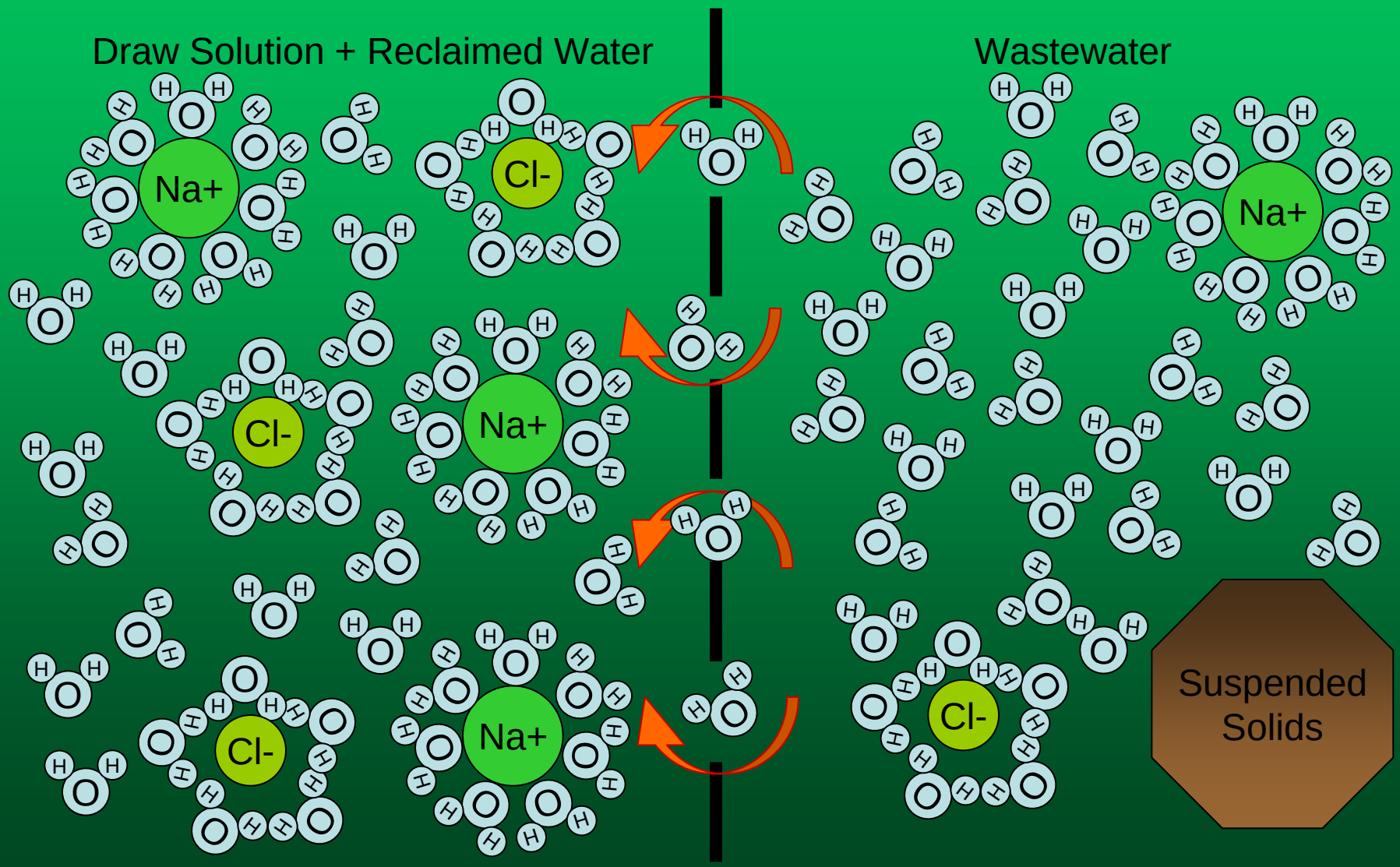
Water reclamation technologies

- Reverse Osmosis
- Evaporative - Distillation
- Course Filtration
- Electro-chemical flocculation
- Chemical precipitation
- Combinations
- Bear Creek’s Green Machine

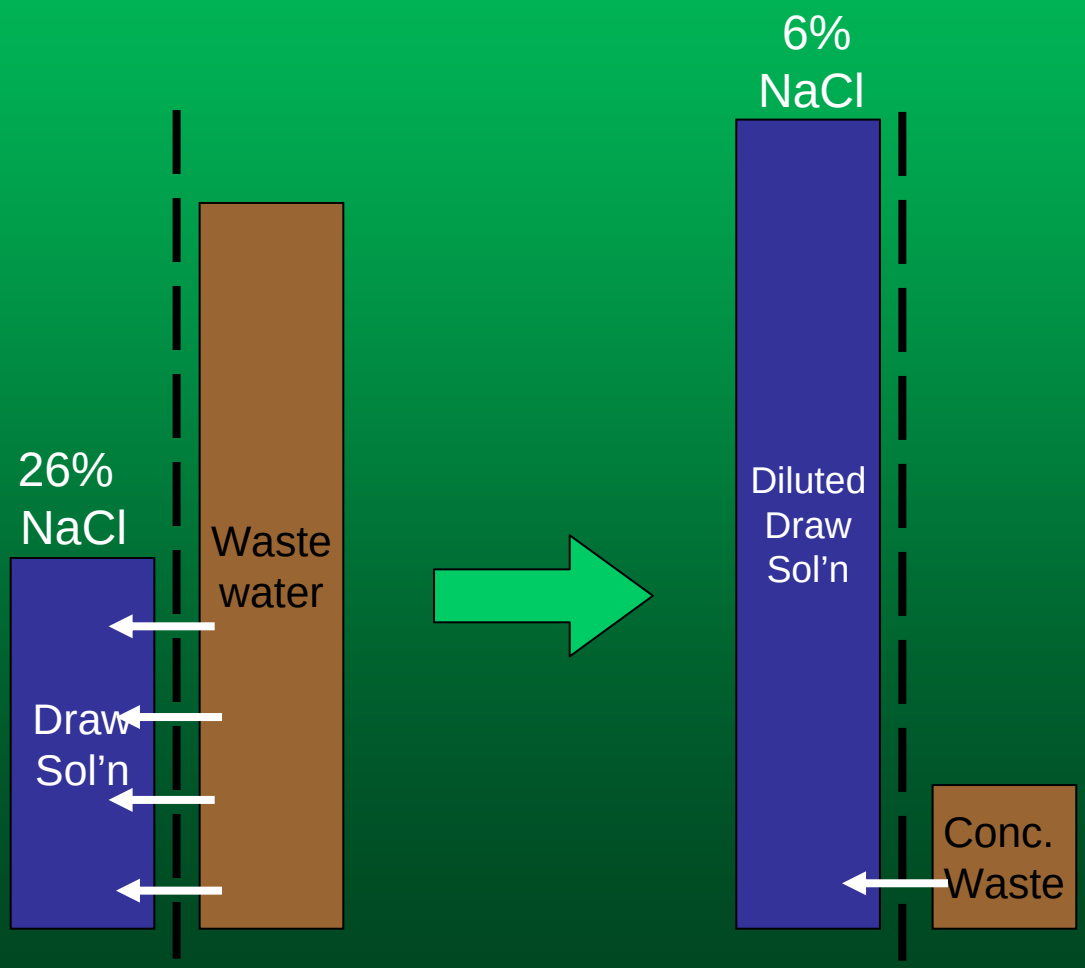
Why is ‘Bear Creek’s Green Machine’ Different?

- Primary reclamation process is driven by alternative energy (osmotic gradient-drive)
- Entire system is low pressure and safe to operate
- Selective filtration (forward osmosis membrane technology) rejects unwanted solutes and solids from the waste stream without complicated pre-treatments or fouling
- Economically competitive with conventional disposal

What is Forward Osmosis?



The FO Premise: Dilution of the Draw Solution, Concentration of Wastewater



Bear Creek's
Green Machine*

1/16th and 1/4th Scale Field Trials

June 15, 2009 - Present

* Patent Pending – USPTO Application # (61, 223,128)

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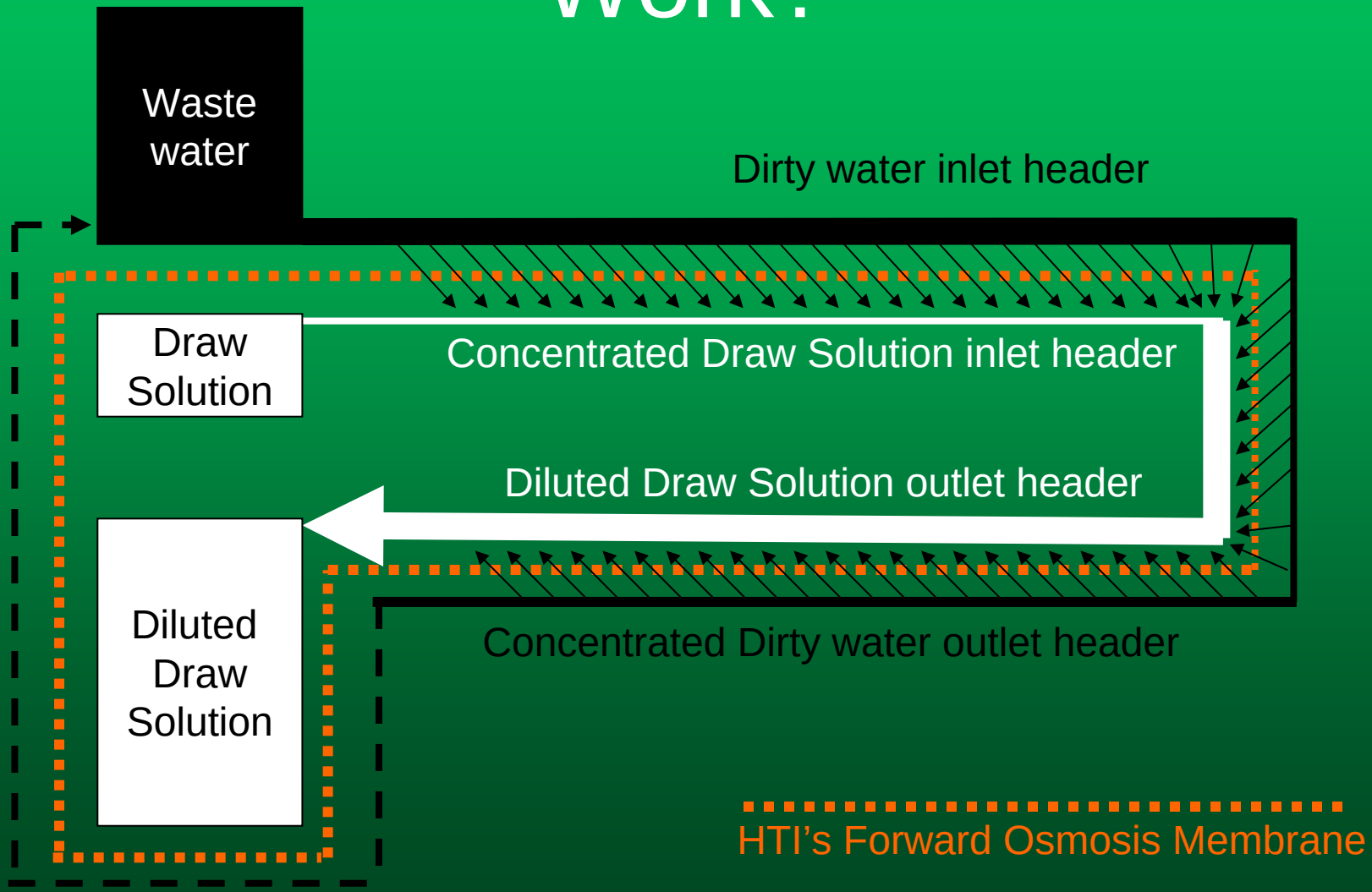
How does the Green Machine Work?



1/16th Scale Pilot Tests, Experimental Conditions

- Location – Oilfield near Logansport, TX
- Source water – Reserve pit water hauled to BCSWD for disposal
- Draw Solution – 23% NaCl
- Pump's Power source – 5 Kw gasoline powered generator
- Pumps – 50 gpm centrifugal, 50 gpm sump, 15 gpm gear pump
- FO System
  - 20, 40" x 8" cartridges, in one 300 gallon tote
  - 4 headers (waste-in, brine-in, waste-out, brine-out)
  - 4 frac tanks (waste water, brine water, produced water, fresh water)


23% brine inlet header
Produced brine outlet header
Waste water inlet header
Waste water outlet header
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Produced water return lines

Waste water supply lines

Waste water in FO vessels


Produced water
stream @ 6 gpm in
1/16th –scale unit


Pit water
Before
Reclaimed
water
After
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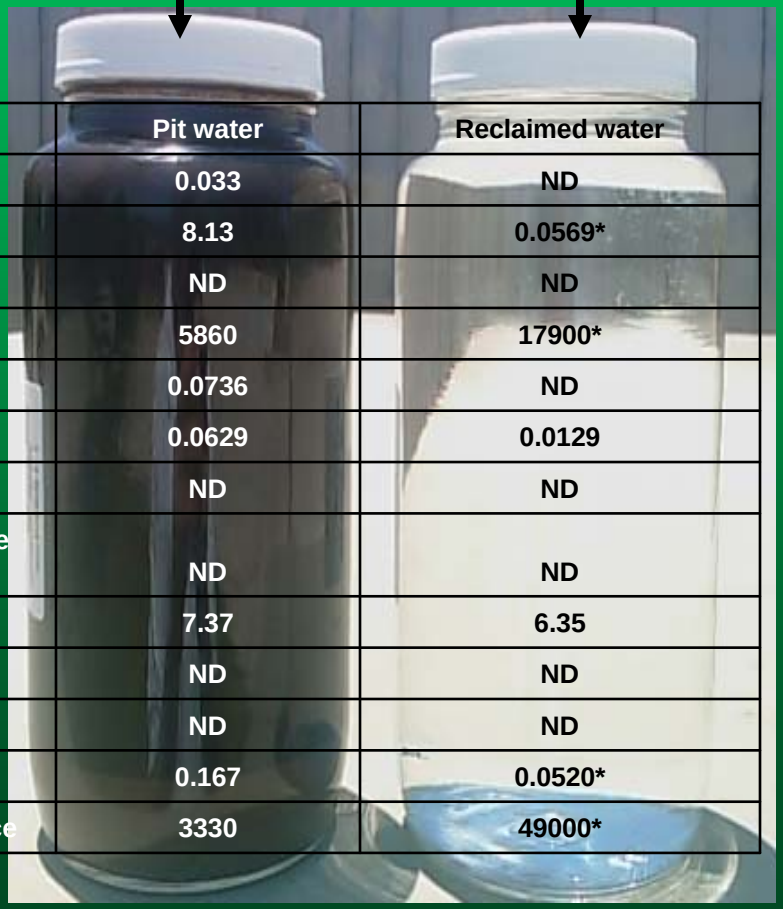
Analytical Data

Pit water Before

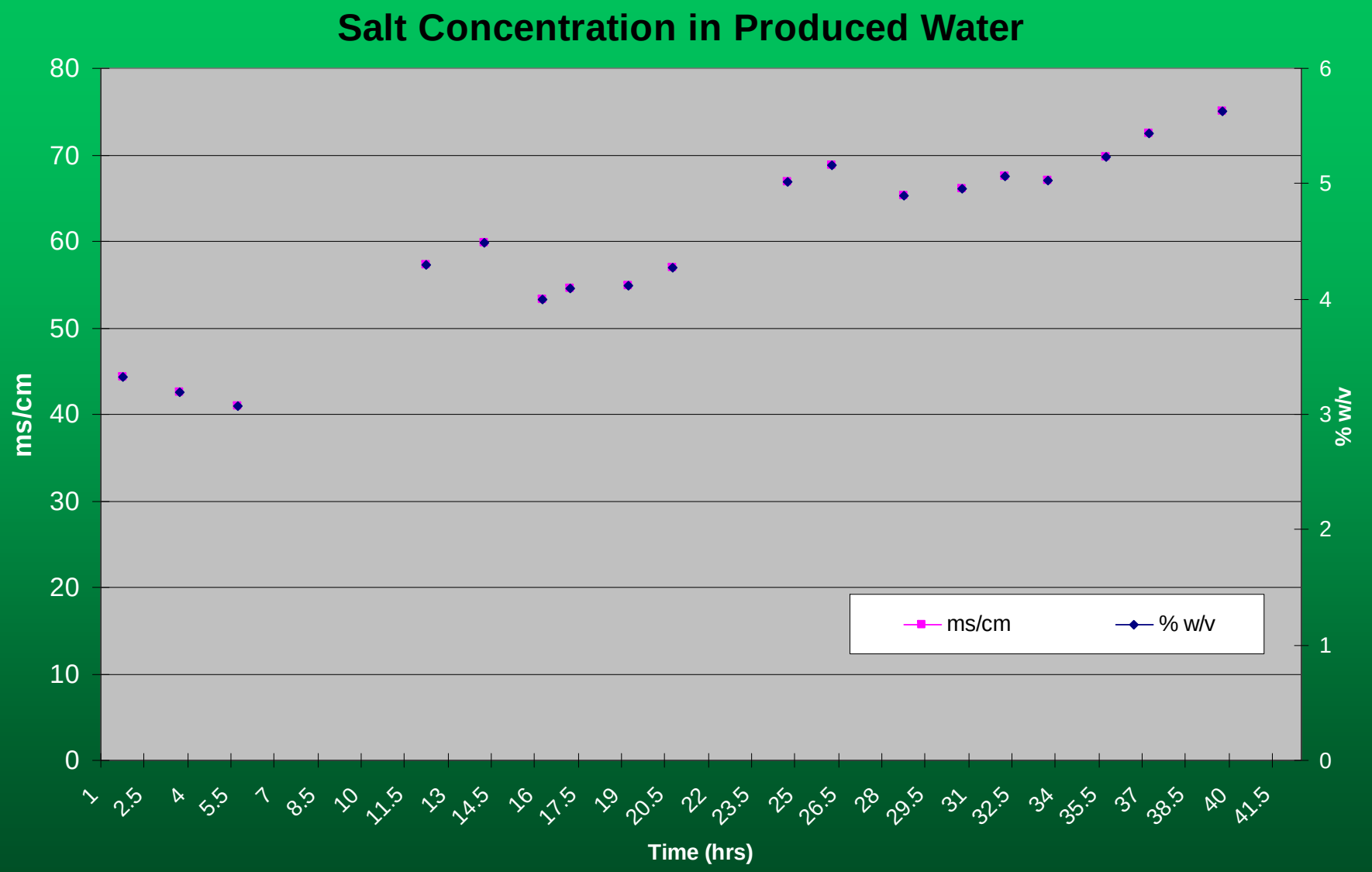
Reclaimed water After



	Pit water	Reclaimed water
Arsenic	0.033	ND
Barium	8.13	0.0569*
Cadmium	ND	ND
Chloride	5860	17900*
Chromium	0.0736	ND
Lead	0.0629	0.0129
Mercury	ND	ND
n-Hexane Extractable Material	ND	ND
pH	7.37	6.35
Selenium	ND	ND
Silver	ND	ND
Zinc	0.167	0.0520*
Specific Conductance	3330	49000*

*analytes were also present in small quantities in the concentrated draw solution (data not show, but available upon request)

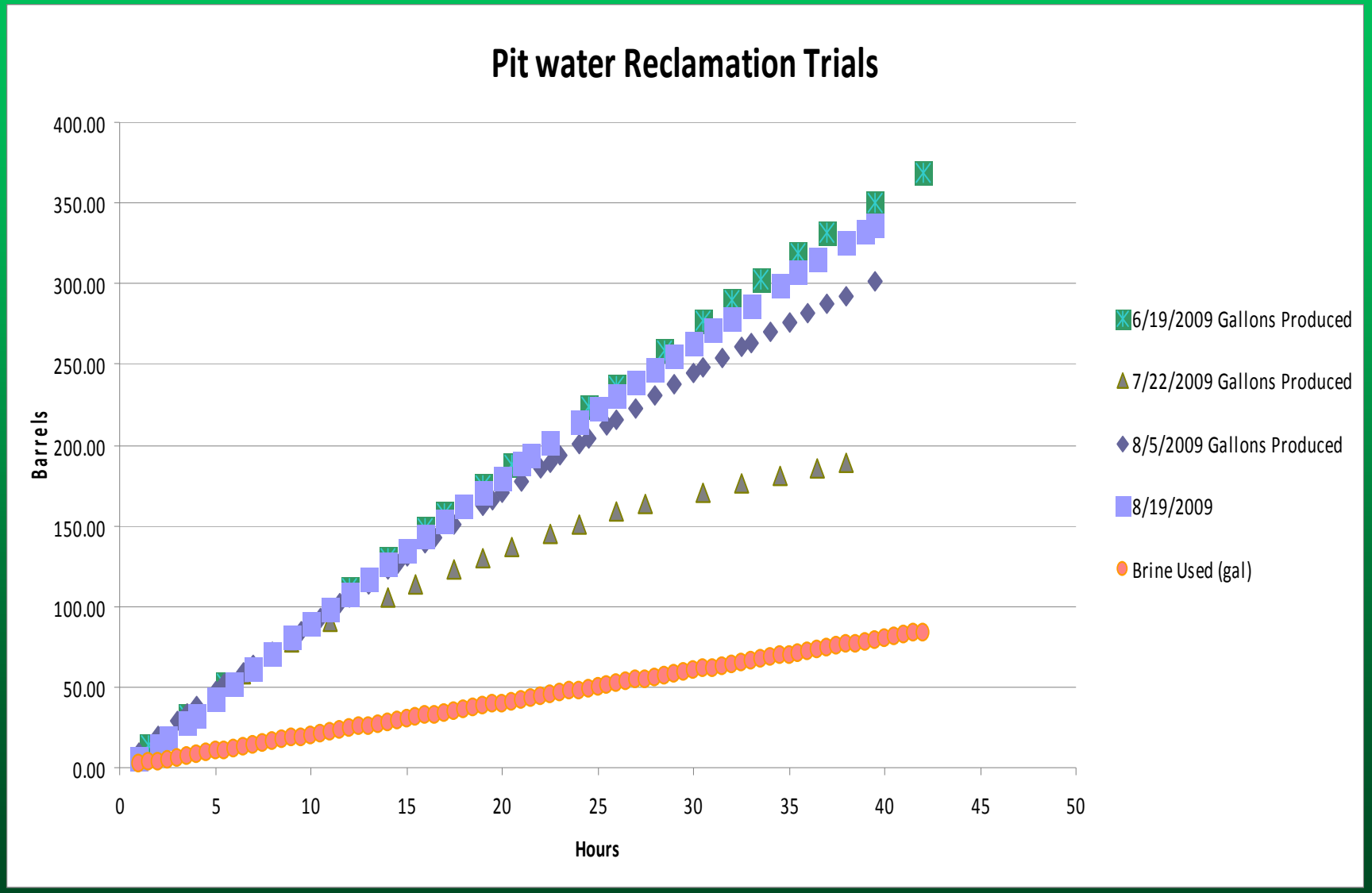
Fluid Production: Green Machine Field Trial, June 18, 2009


Salt Concentration in Produced Water
ms/cm
% w/v
Time (hrs)
ms/cm
% w/v
0
10
20
30
40
50
60
70
80
0
1
2
3
4
5
6
1
2.5
4
5.5
7
8.5
10
11.5
13
14.5
16
17.5
19
20.5
22
23.5
25
26.5
28
29.5
31
32.5
34
35.5
37
38.5
40
41.5

6/18/09 Pilot Experiment Results

- Elapsed Time of Experiment
  - 42 hours of continuous run-time
- Flow rate
  - 5-6.5 gpm total,
  - 4.2 – 6.2 gpm reclaimed,
  - 0.8 – 1.2 gpm brine concentrate
- Produced water
  - 4 to 4.5% NaCl (average)
  - 15,000 – 17,000 gallons produced
  - 360 – 420 barrels produced
- Scale extrapolation to 16X (full size unit)
  - 2.47 bpm produced water
  - 3565 bpd produced water in 42 hours

Low TDS Pit water, 4 trials



¼ Scale Green Machine

- 4 modules, 20 vessels / module
- Portable, self-contained on 32’ trailer
- Production rate = 0.5 to 0.75 bpm

- Available for field use, September, 2009

- Full scale (320 vessel) Unit, Anticipated production date, 11/30/09

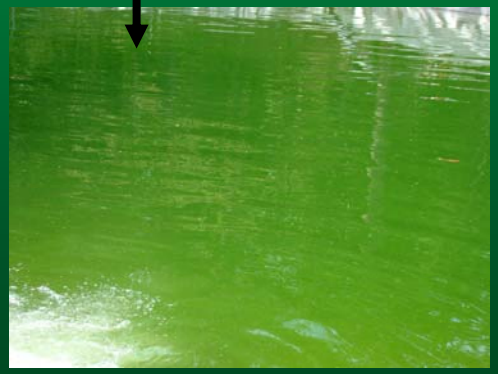
¼ Scale Green Machine

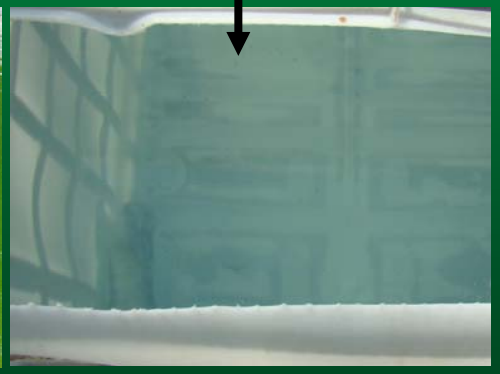
Bear Creek's ¼ Scale Green Machine

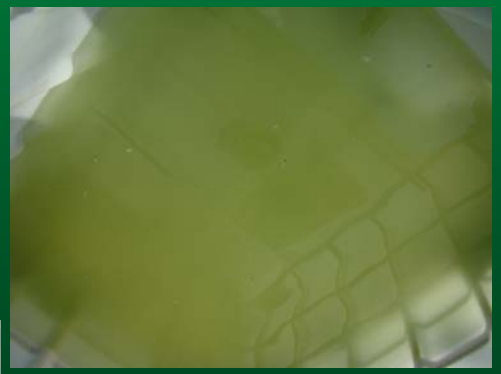
Pit water in

Reclaimed Pit water (4% NaCl) @ 30 GPM

Concentrated Pit water out







*can be weighted up to 26%

Why is it "GREEN"?

- Utilizes very little carbon-based energy (entire unit runs on a 25 KW generator and which uses less than 25 gallons of fuel per day)
- Harnesses the potential energy in the completion fluid to drive the filtration process
- Reclaims E&P waste water for re-use (reduces drawn-down on fresh water resources)
- Reduces the carbon footprint and road damage associated with trucking-related expenses

How does it compare to other technologies

- Truly Green (small carbon footprint & alternative energy-driven)
- Portable, Scalable, Modular (easy set up, take down, and can be ‘right-sized’ for the job)
- Economical (comparable to conventional disposal costs)
- Conducive to combinations of treatment media (course, affinity, phase, chemo)
- Highest water quality (rejects 100% of virus, bacteria, solids, >90% of undesirable solutes including iron, calcium, metals, barium, etc)
- Safe (entire unit runs on less than 10 psi, has no moving parts other than the self-contained pumps, and uses little electricity)

Limitations and Considerations

- Current commercial unit does not produce fresh water (makes a weak brine designed for completion or workover fluid or a concentrated brine for completion)
- Works most effectively on low TDS waste water (<3% TDS)
- Timing of the reclamation job falls between drilling and completion (ideally just before completion to reduce fluid storage costs)
- Local regulations vary

Is it economical?

- Based on our field trial data and the North Louisiana/ East Texas Summer 2009 existing industry-related cost structure, Bear Creek's Green Machine should, in most cases, show the operator a net cost savings when comparing the traditional cost of waste fluid disposal & transportation and subsequent completion fluid cost & transportation.

- Bear Creek's service model includes consultation analyses to help our clients determine how to minimize their fluid-related expenses and maximize their cost savings based on their specific operational structure, regulatory factors, geographical limitations, and preferences.

To schedule a consultation and/or field demonstration:

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