

# **DRILLING IN ARID REGIONS: WATER LESSONS LEARNED FROM THE EAGLE FORD**



**Carl Vavra,**

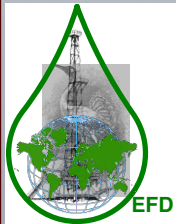
**Frank Platt &**

**David B. Burnett**

**Global Petroleum Research Institute**

**Texas A&M University**

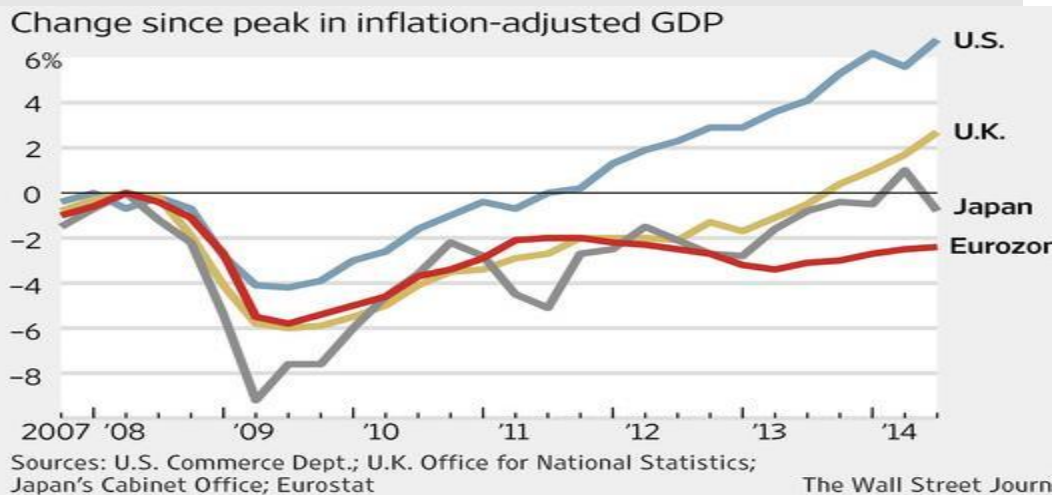
**November 2014**



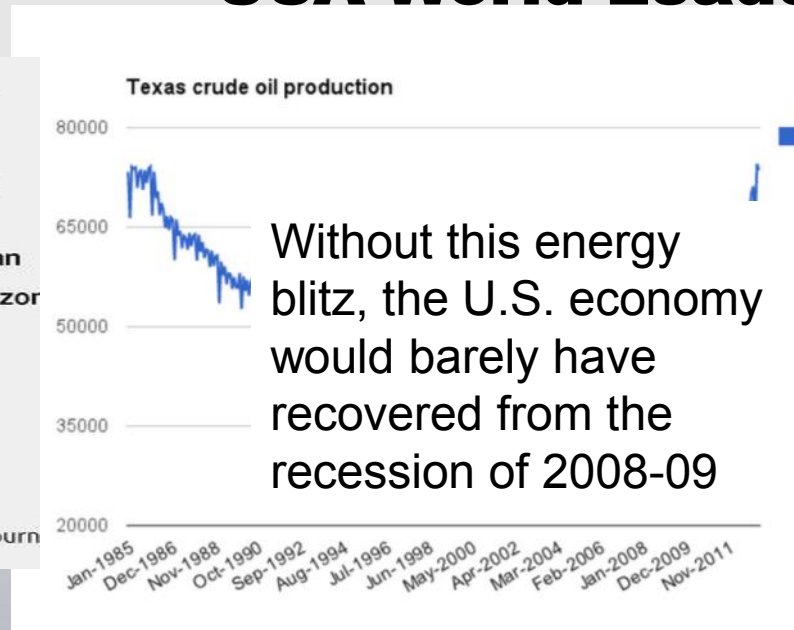
**GLOBAL PETROLEUM  
RESEARCH INSTITUTE**  
TEXAS A&M ENGINEERING EXPERIMENT STATION

# Unconventional Shale Gas Revolution has Saved America

## The EU Left Behind



## USA World Leader



*Shale Development Can Re-Energize Mexican Economy*

For more Info see:

<http://www.washingtontimes.com/news/2014/oct/18/moore-oil-the-real-economic-stimulus/#:~:ixzz3Gh561bVA>

# Planning Unconventional Oil & Gas Development in Arid Regions

## Key Issues

1. Lack of Infrastructure
2. Fresh Water Resource Uses
3. Public/policy Demands (**environmental & perception** Issues)
4. Potential for Water Contamination

# 1. Lack of Infrastructure



**Transport of equipment and support services across semi arid Rangelands becomes a major logistics issue**





# Site Access



## Main Components – Rollout Road

- Conformable



- Hinged board segments



***Every site needs a road to link it to the outside world. New technology promises to protect sensitive environments from the damage that putting in a conventional road causes.***

## 2. Water Use; Eagle Ford Shale Well & a City of 4,000 Population

<b>Operation Needs</b>	<b>Well Operations</b>	<b>City Operations<sup>(1)</sup></b>	<b>Comments</b>
<b>Water Usage</b>	<b>10 million gal</b>	<b>18 million gal (3 mo.)</b>	<b>5-6 mm gal frac. 1-2 mm gal well ops.</b>
<b>Power Use</b>	<b>7,500 HP</b>	<b>6 MW (8,000 Hp)</b>	<b>Avg. SCR rig</b>
<b>Solid Waste</b>	<b>100,000 lbs. (wbm, 10,000 ft well)</b>	<b>1,600,000 lbs (3 months)</b>	<b>3 mo. Ops. MSW highly variable</b>
<b>Unit Budget</b>	<b>\$2 to \$5 MM</b>	<b>~\$1.7 MM</b>	<b>3 mo. Ops.</b>

In 2003, 4.5 lbs. of waste generated per person per day. That's 1,600,000 lbs. for 4000 people over 3 months (90 days).

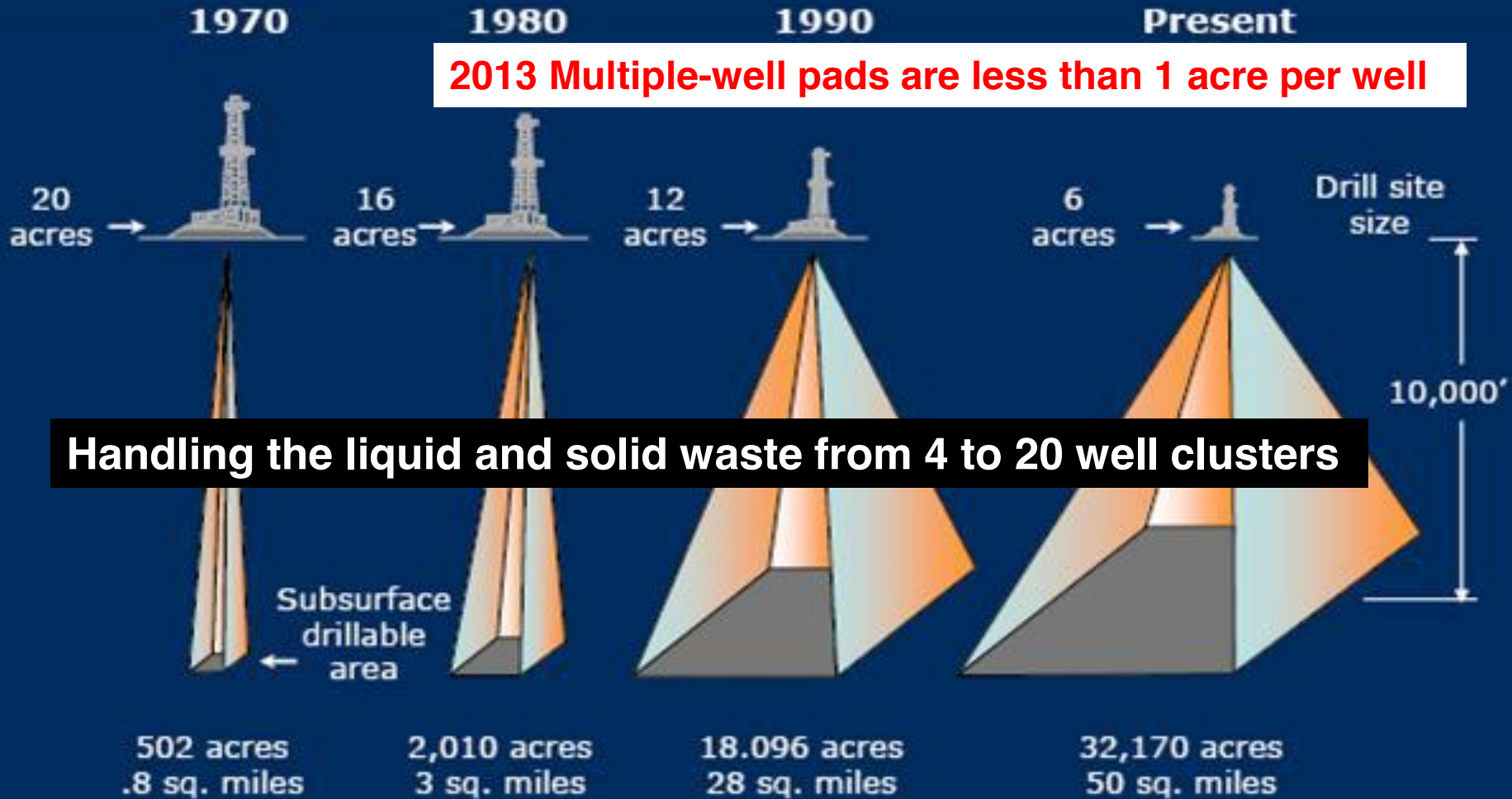
(1) Comparison to Andrews TX city budget (pop.9,600) 2008 FY

(2) R. T. Wright "Environmental Science 10 ed. 2008 Pearson Prentice Hall

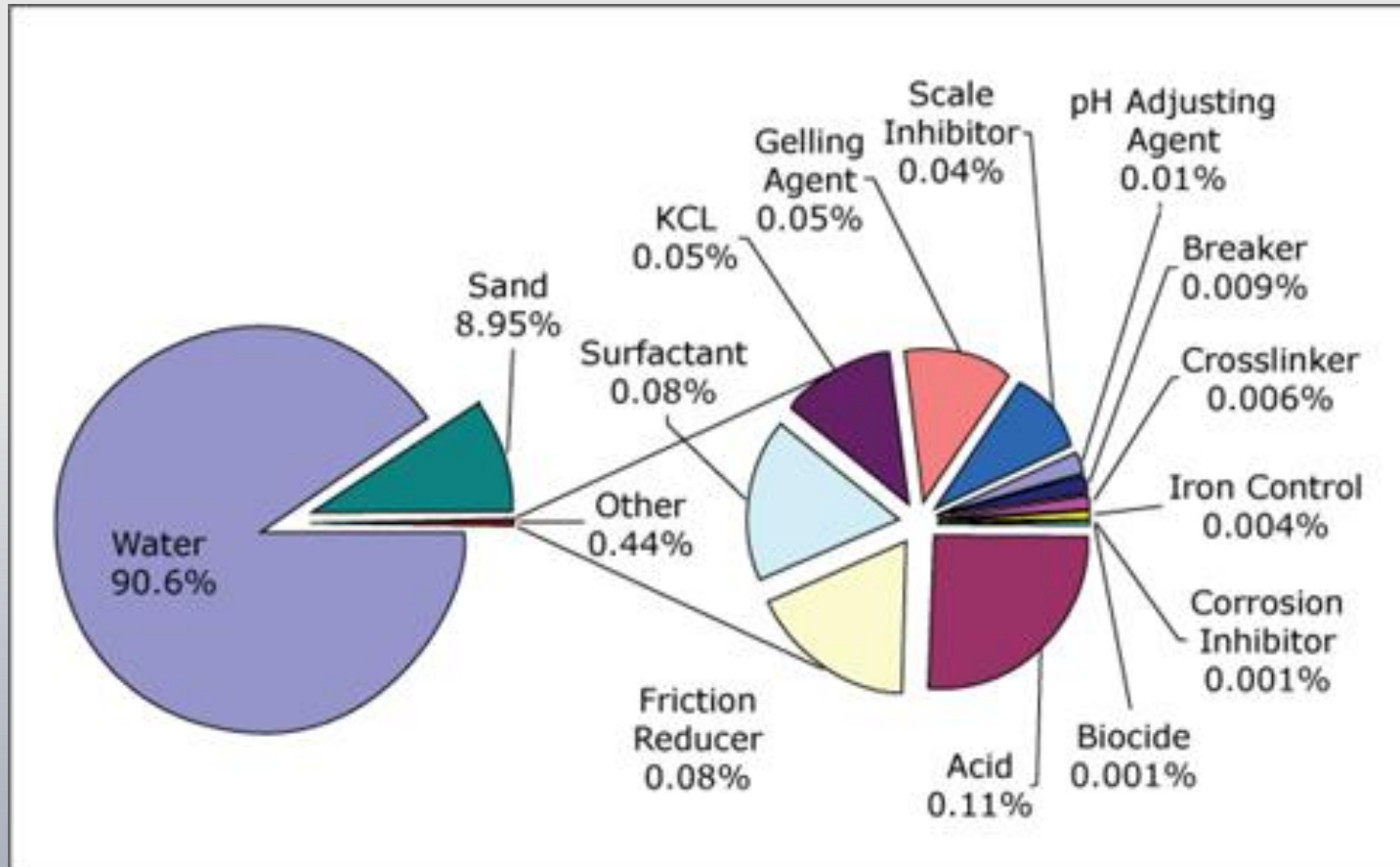


## 2. Water Re-Use and Surface Ops in O&G– Waste Management

2013 Multiple-well pads are less than 1 acre per well



## Composition of Fracturing Fluid - Generic

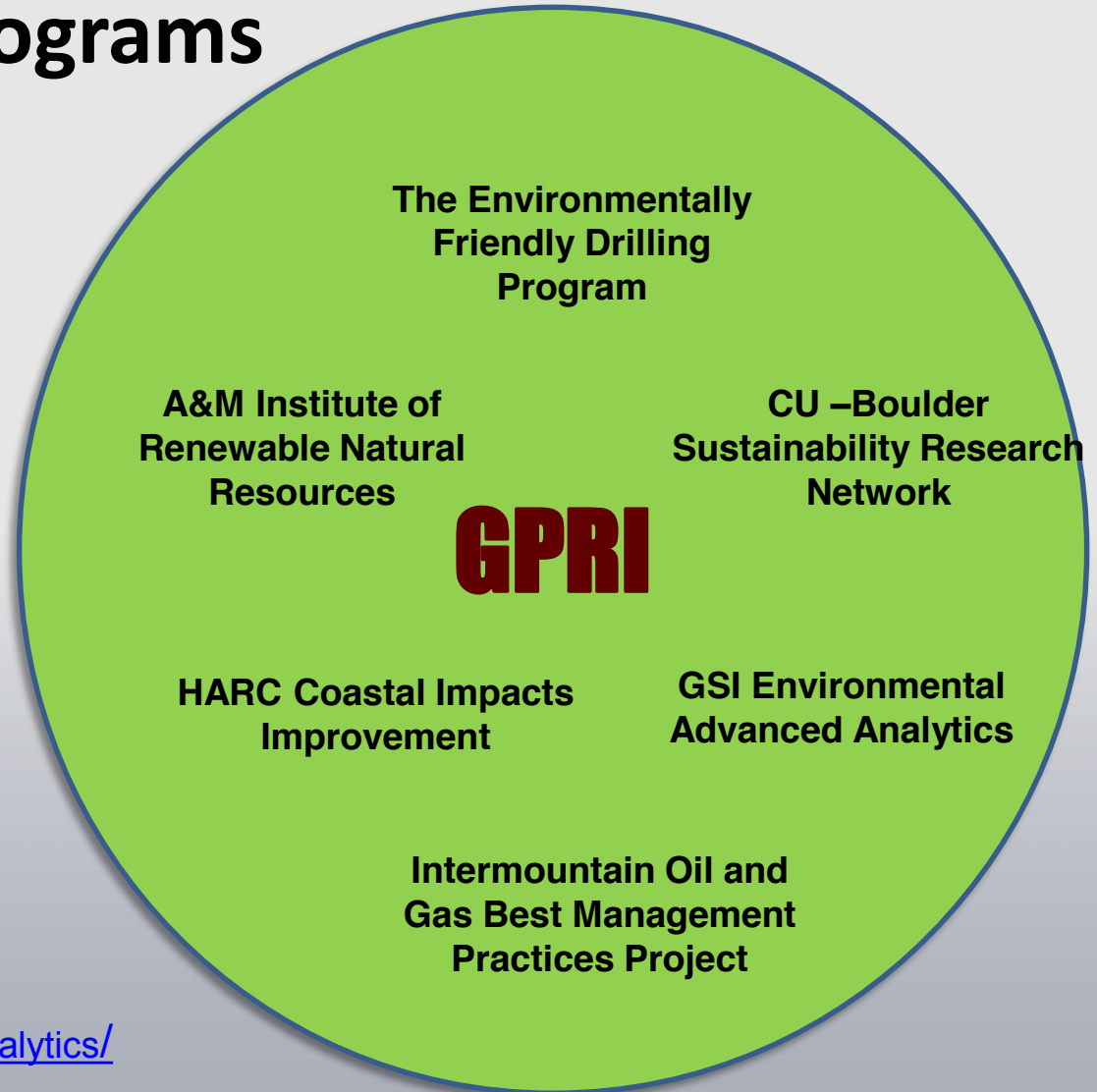


For more Info see:



## 3. GPRI and Key Environmental Programs

The **Global Petroleum Research Institute** within the Department of Petroleum Engineering at Texas A&M University has collaboration programs both within the University and with External Research Centers.



For more Info see:

[www.efdsystems.org](http://www.efdsystems.org)

<http://irn.r.tamu.edu/about/>

<http://www.colorado.edu/news/releases>

<https://sites.google.com/site/amadvancedanalytics/>

<http://efdsystems.org/index.php/coastal-impacts-technology-program-citp>

<http://outreach.colorado.edu/programs/details/id/359>

## 4. There is either not enough water or too much water



**Arid land is unable to soak up large amounts of sudden rainfall**



**As a result erosion from water run off is a major issue for site access roads**

# **Recycling & Re-Using Flowback and Produced Water**



## Waste constituent



### Produced water:

- Water
- Chemicals (and heavy metals)
- Low-solids percentage and distribution
- hydrocarbons
- Varies by location
- Some sort of separation from oil is usually done



### Drilling Wastes

- Water
- High solids (~ 5-8% by volume)
- Chemicals (mud additives)
- Lower Hydrocarbons concentration
- Miscellaneous



# Why Treat Brine before Re-Use?

Initial Sampling & Treatment



Un-Treated    Treated

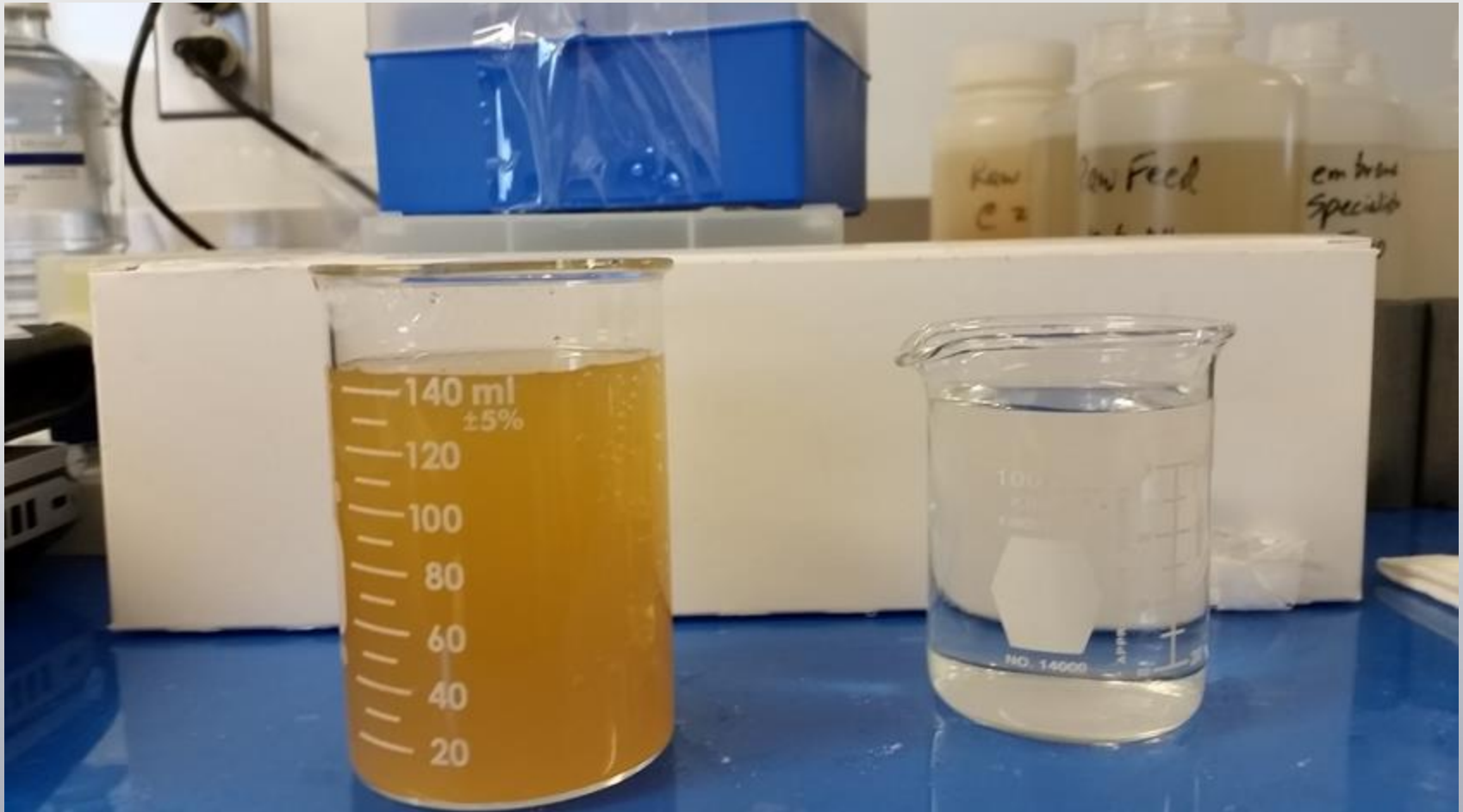
**Eagle Ford Field  
Frac Pond Brine**

After Three Weeks



Treated    Un-Treated

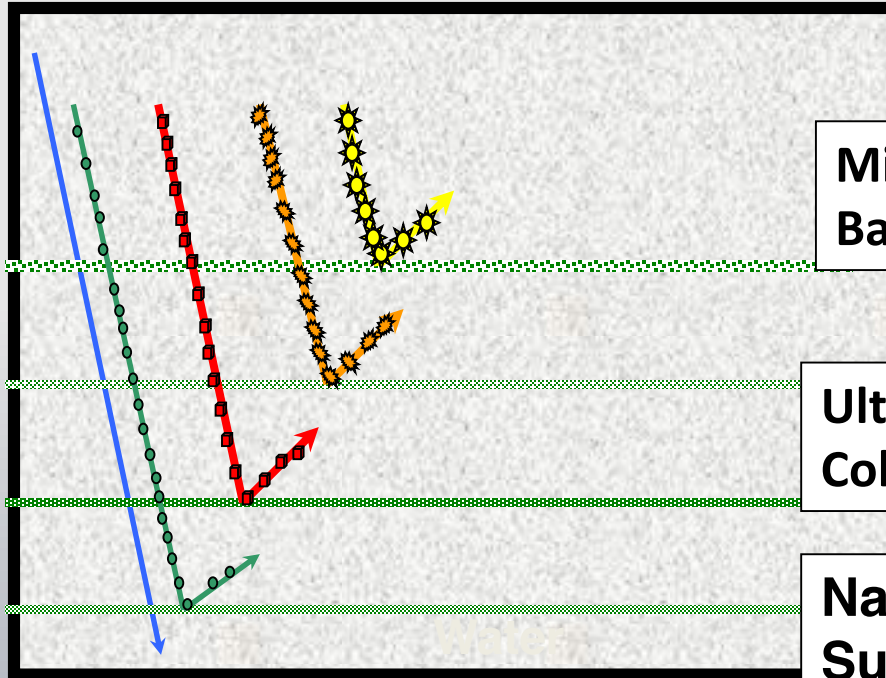
# West, Texas Permian Basin Field Trial



Feed

Permeate

# Membranes are More than RO



**Micro Filtration (MF) ( $10-0.1\mu\text{m}$ )**  
**Bacteria, suspended particles**



**Ultrafiltration (UF) ( $0.05-0.005\mu\text{m}$ )**  
**Colloids, macromolecules**



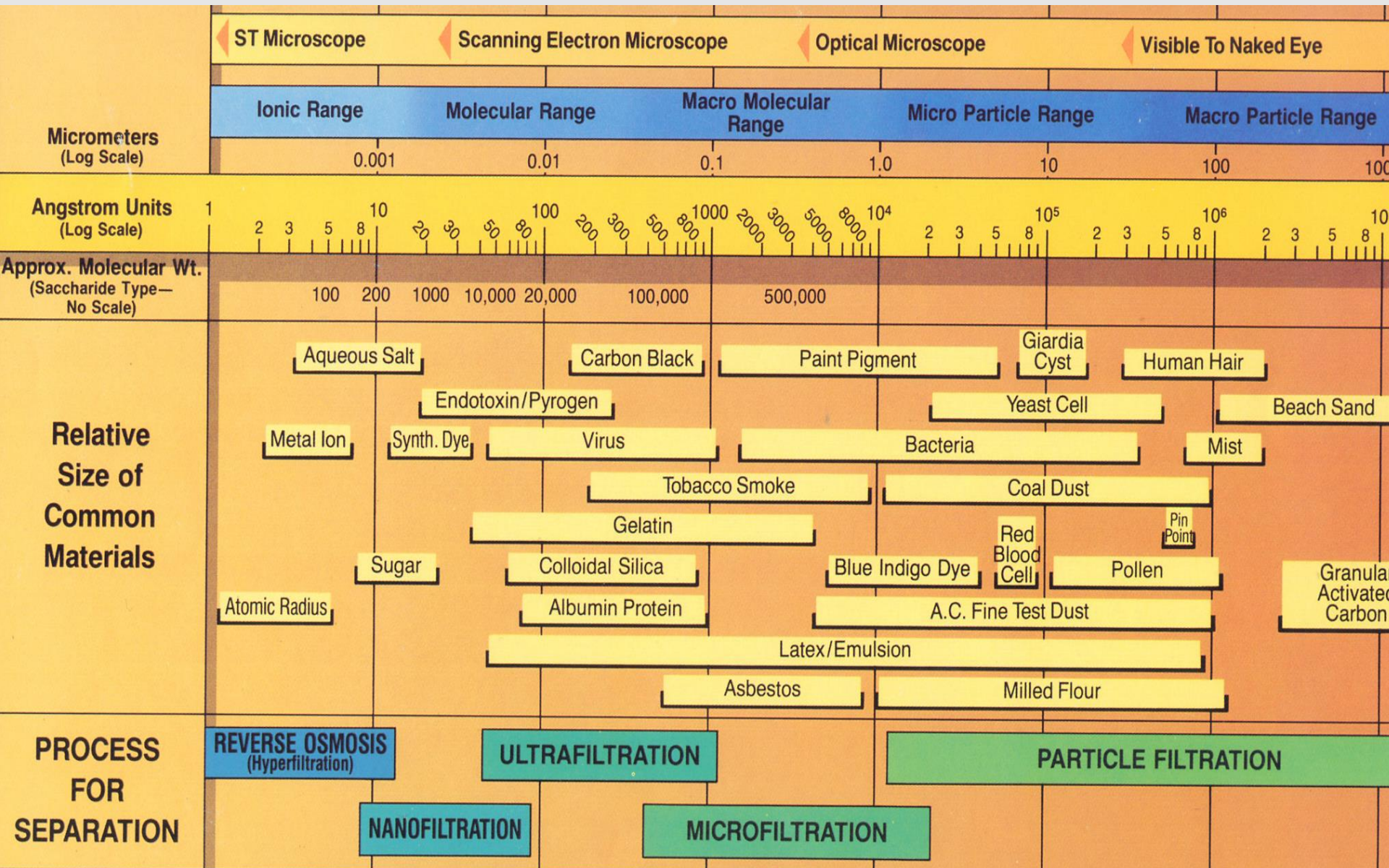
**Nanofiltration (NF) ( $5e^{-3}-5.e^{-4} \mu\text{m}$ )**  
**Sugars, dyes, divalent salt ppts.**



**Reverse Osmosis (RO) ( $1.e^{-4}-1e^{-5} \mu\text{m}$ )**  
**Monovalent salts, ionic metals**



# Size of Common Materials





# Pre-Treatment of Liquids Before Membrane Applications

## Gravity

- Settling Tanks
- Hydrocyclones
- Centrifuges

## Dead End Filtration

- Strainers
- Stainless Steel Screens
- Cartridge Filters
- Bag Filters
- Mycelx & Polymer Ventures – oil removal



# Low Pressure Media Filtration to Remove Oil & Grease



# Oil & Grease Removal



# Membrane Types

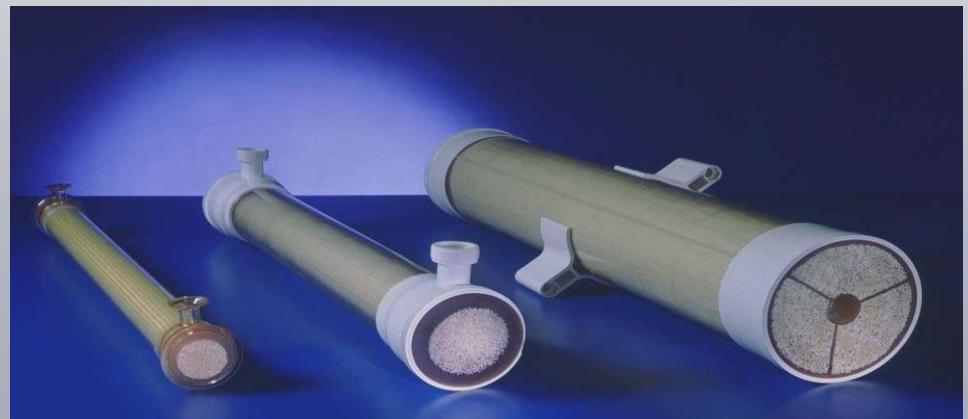
- Tubular
- Hollow Fibers
- Plates
- Spiral Wound
- Pleated Sheet



Spiral Elements



Tubular Modules



Hollow Fiber  
Cartridges



# Ceramic Membrane Elements and Modules

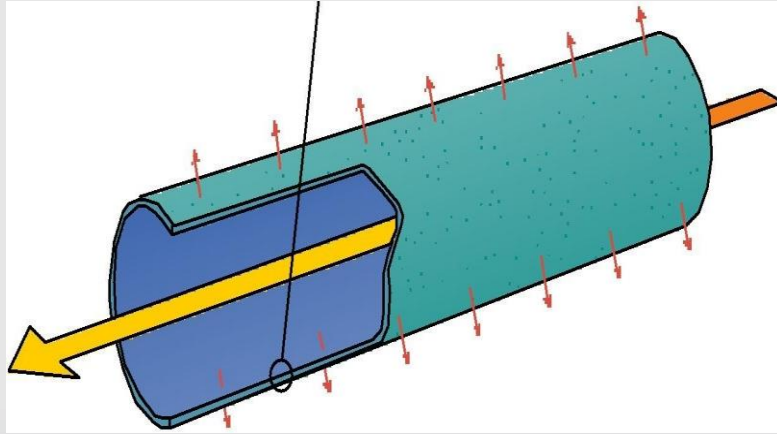


- Expensive
- Long life: >15 years

Applications:

- Dairy, CIP solutions, Process water, Catalyst recovery

# Scepter Membrane Elements and Modules



- Applications:
  - Chemical clarification, Oil / Water separation, Starch recovery, Catalyst recovery

- Expensive
- Long life: >15 years
- MF pore sizes only

# Membrane Systems

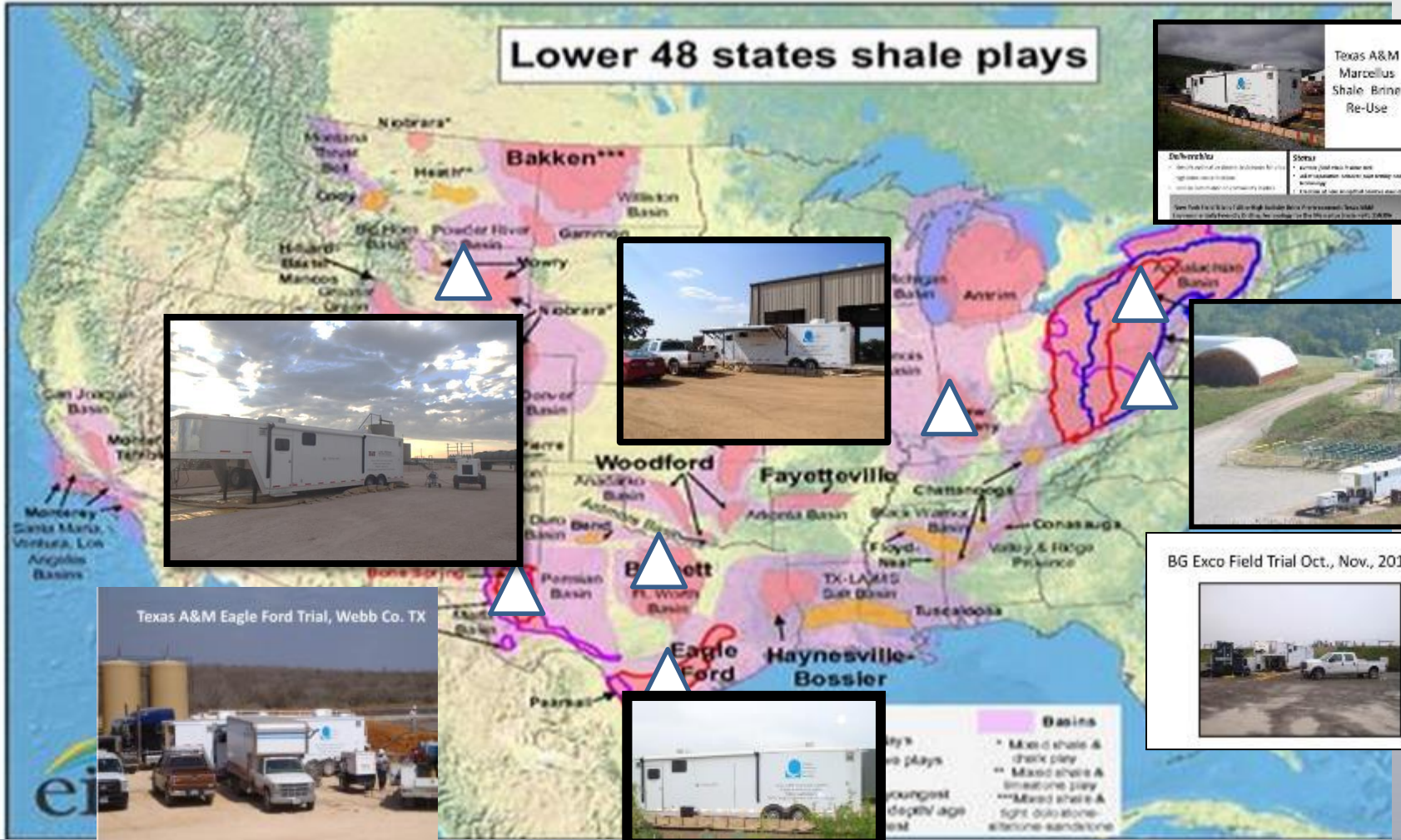


**UF Skids and Piping**

(Source GE Water)



## EFD Field Trials





# Produced Water Treatment – New York – Utica



Figure 2A shows a satellite view of the mobile unit in Chenango Co. NY

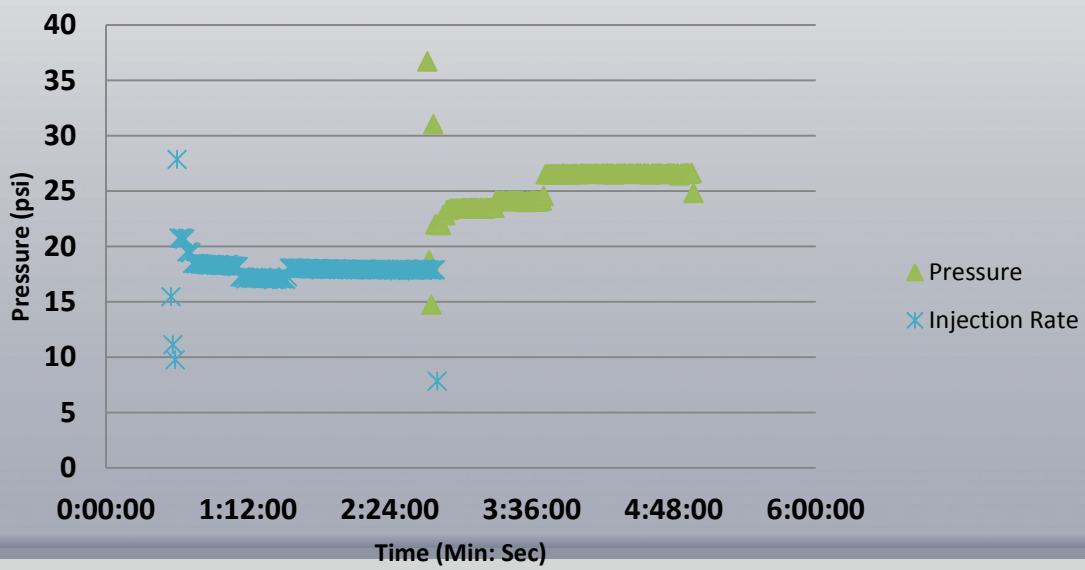


Figure 2B shows the mobile laboratory on its environmental protection apron at the field site. The large black poly tank contains waste fluids

# Produced Water Treatment – New York – Utica

Samples	Date	Test Description	Duration	KW Used	Cost per bbl
S-62, S-63	Sept. 2	Running Dow NF (B)	3.35	0.2	\$0.84
S-58, S-59	Sept. 2	Koch UF			\$0.0275
S-84, S-85	Sept. 20	Media	325 (gal)	0.3	\$0.0039
		Koch UF	63.63	2.1	\$0.14
				Total of cells 1,3&4 = \$0.98	

**Pressure and Rate Koch Hollow Fiber August 25, 2011**

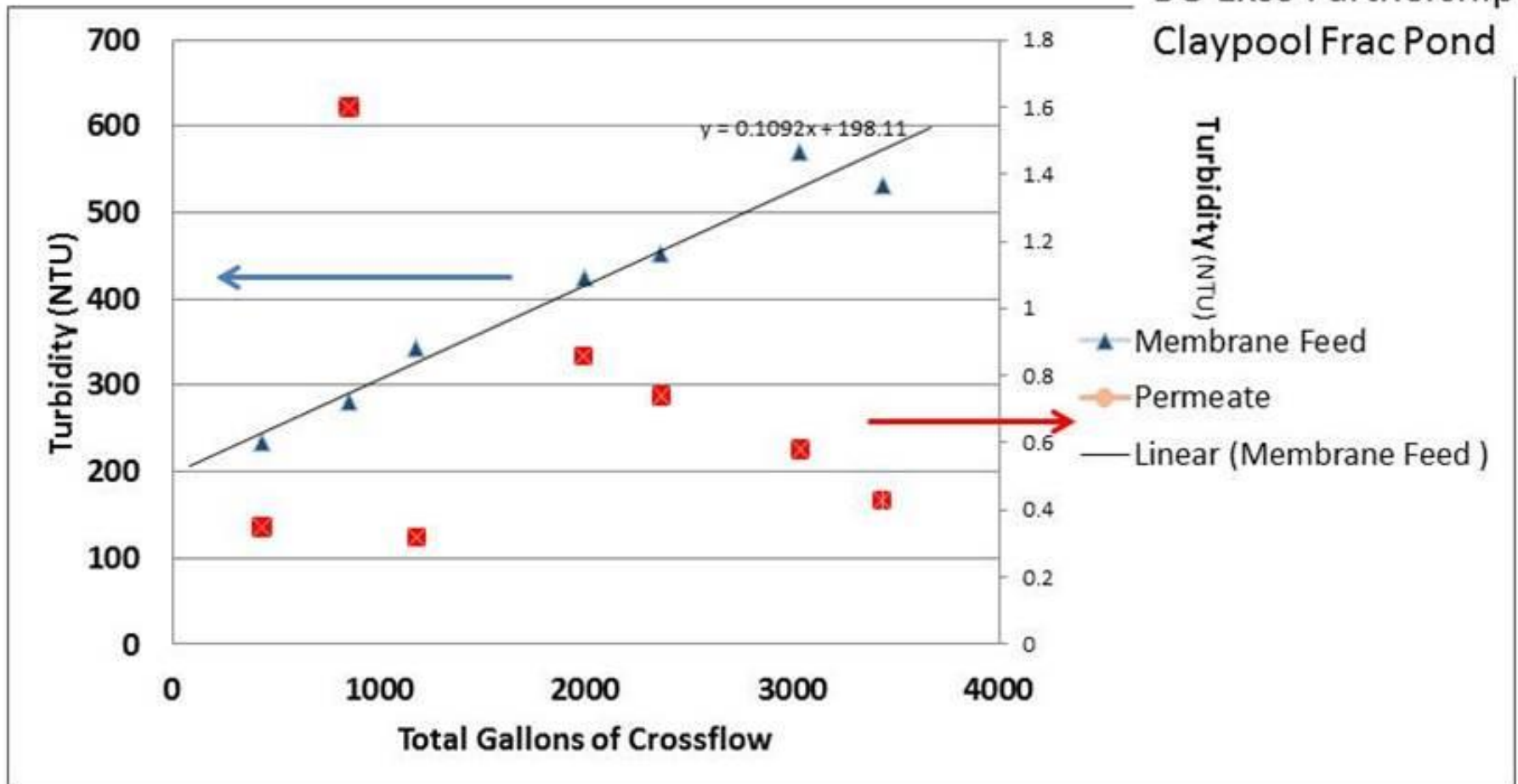


## New York Field Trial

Sample Number	Filtration Description	Turbidity (ntu)	Total Iron	TDS (ppm)	Conductivity (ms/cm)	pH	TOC
S-1	Raw Water	60	270	220,000		5.7	90
S-1	After Media	21	222				73
S-60	After Micro	3.6	55				28
S-61	After Nano	0.4	22				22

## Experimental Ultra Filter Solids Removal Efficiency

Test:  
Nov 2, 2012  
BG Exco Partnership  
Claypool Frac Pond







**Water Treatment Research in the Eagle Ford;  
LaSalle Co. Texas**

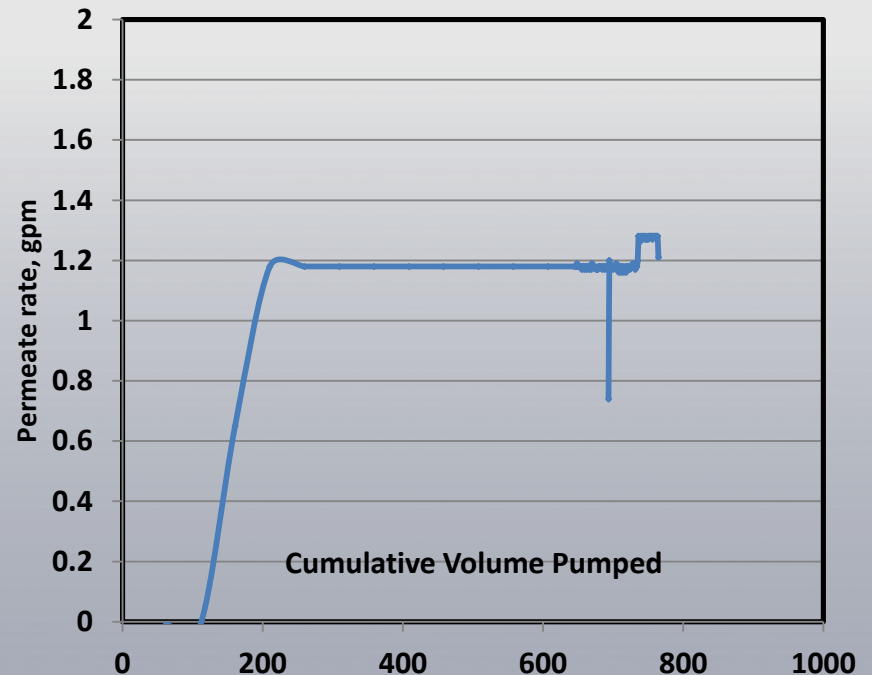
# GPRI Designs Mobile Water Treatment Unit on site in South Texas



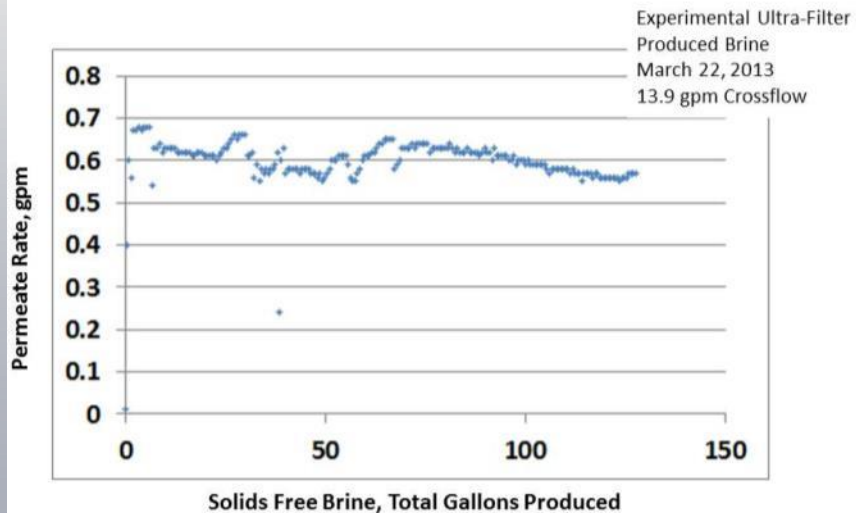
# South Texas Eagle Ford Trial 2013



Ultrafilter Permeate vs. Total Volume



## Storey Ranch Field Trial





# On Site Analytical Measurement.



## BG Trial September 2012

### Media Pre-Treatment

Sample Number	Sample Identification	Turbidity (ntu)	Total Iron	TDS (ppm)	Conductivity (ms/cm)	pH	TOC
SP-1	Pre-treatment	307				6.7	92
SP-2	Post-treatment						61
SP-3	Pre-treatment	357					98
SP-4	Post-treatment	264					63
		254 (After ABS)					

Pre-treatment consists of 10µm screen then oil and grease removal step followed by BTEX removal

Microbac Laboratories, Inc.

Pittsburgh Division

100 Marshall Drive Warrendale, PA 15088 Phone:724-772-0610 Fax:724-772-1686

www.microbac.com



## CERTIFICATE OF ANALYSIS

Work Order Number:

**Ultra-Filter Results**

**Before >5700E cfu per ml**

**After 1E cfu per ml**

\*WALK - IN CLIENT  
TAMV-GPRI  
RM407 RICHARDS  
COLLEGE STATION

Drinking Water Potable

Sample#: 2101705-02  
Description: DRAFT: Feed Water  
Date and Time Sampled: 10/25/2012 15:00  
Analysis Performed by: Microbac Laboratories Inc., Pittsburgh Division

Analysis Performed by: Microbac Laboratories Inc., Pittsburgh Division

DRAFT: Miscellaneous Analysis	DRAFT: Miscellaneous Analysis	Method	Qualifier	Result	Units	D
Water Meets USEPA Standard?	Water Meets USEPA Standard?	-		See below	No Units	10/2
DRAFT: Microbiology Analysis	DRAFT: Microbiology Analysis	Method	Qualifier	Result	Units	D
Coliform	Coliform	SM 9223 B		See below	per 100 mL	10/2
E. coli	E. coli	SM 9223 B		See below	per 100 mL	10/2
Heterotrophic Plate Count	Heterotrophic Plate Count	SM 9215 B		> 5700E	cfu per mL	10/2

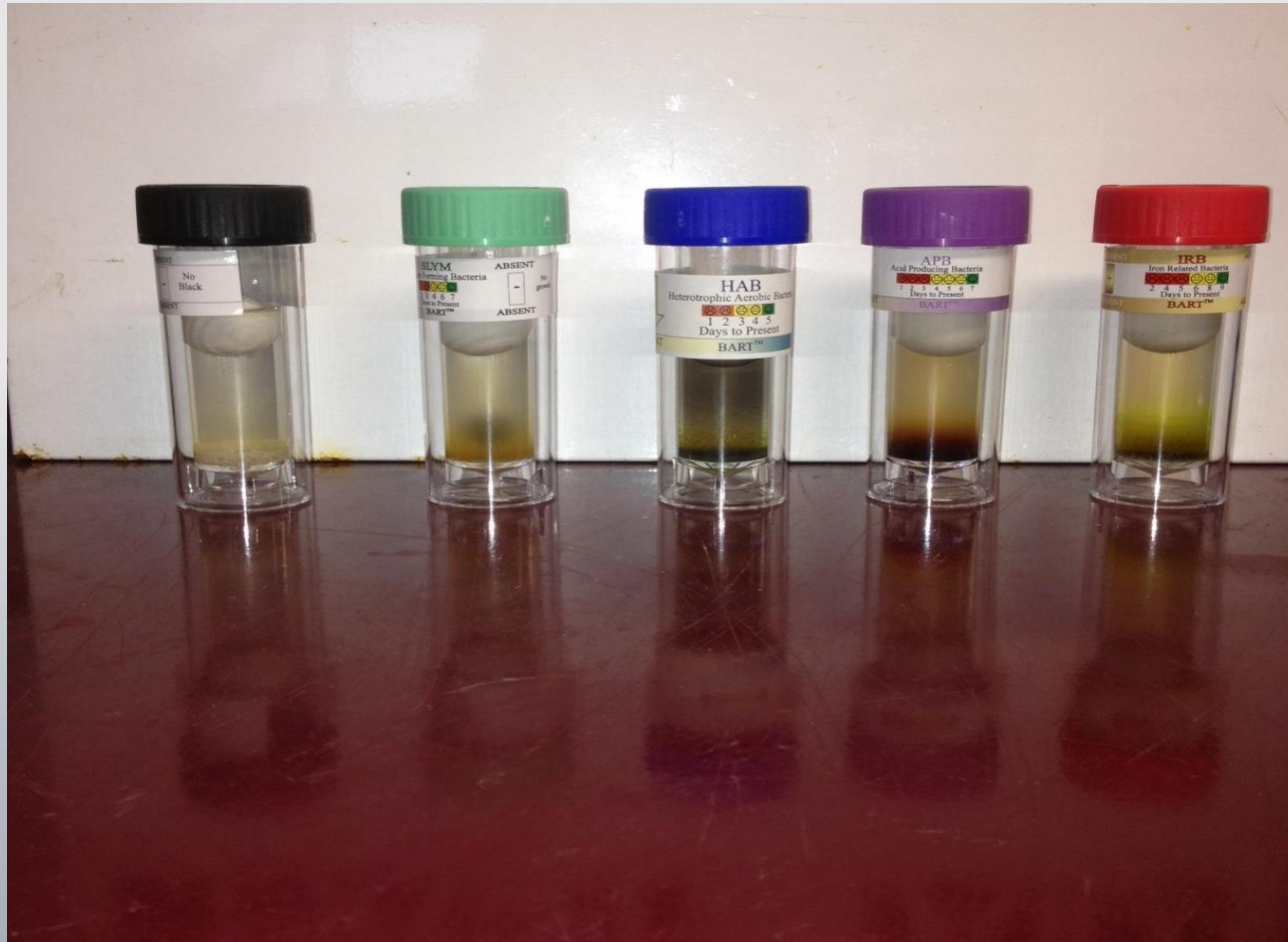
Sample#: 2101705-02  
Description: DRAFT: Feed Water  
Date and Time Sampled: 10/25/2012 15:00  
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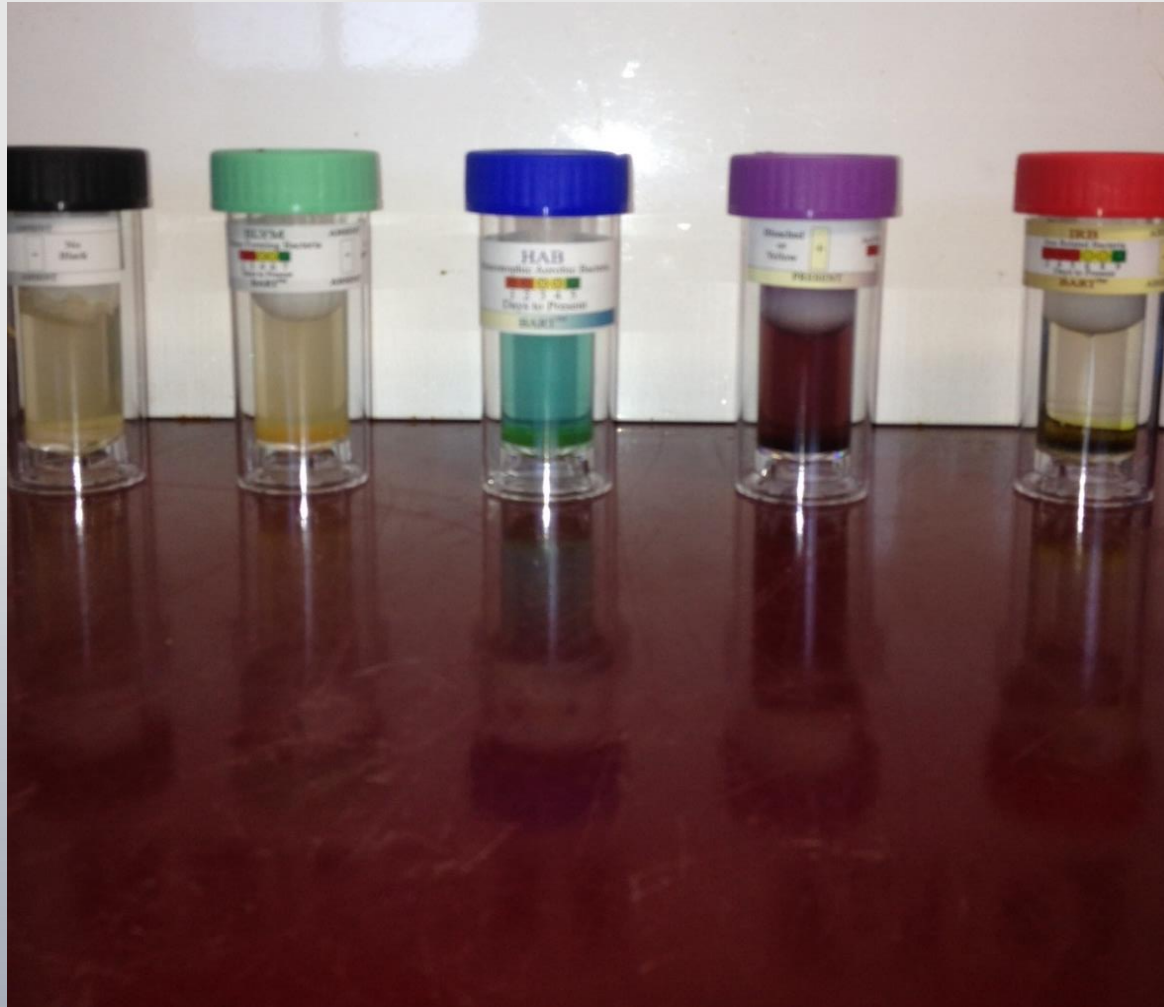
DRAFT: Miscellaneous Analysis	DRAFT: Miscellaneous Analysis	Method	Qualifier	Result	Units	D
Water Meets USEPA Standard?	Water Meets USEPA Standard?	-		See below	No Units	10/2
DRAFT: Microbiology Analysis	DRAFT: Microbiology Analysis	Method	Qualifier	Result	Units	D
Coliform	SM 9223 B	SM 9223 B	See below	per 100 mL	10/26/12 15:00	LMZ
E. coli	SM 9223 B	SM 9223 B	See below	per 100 mL	10/26/12 15:00	LMZ
Heterotrophic Plate Count	SM 9215 B	SM 9215 B	> 5700E	cfu per mL	10/26/12 15:00	LMZ



# HACH Bacteria Test Vials



# HACH Bacteria Test Vials



## Med. - High Pressure Membranes and On-Line Sensors



Nanofiltration for Divalent Ion Removal – creates stable solids free brines for fracturing fluids



# Analytes: Non Purgeable Organics



Figure 5. GE Analytical equipment for TOC analysis-

Figure 6 Samples Analysis in Mobile Laboratory

For more Info see:

<http://www.geinstruments.com/products-and-services/toc-analyzers>

# Portable Oil in Water Analytic



For more Info see:

<http://www.advancedsensors.co.uk/products/side-stream-slip-stream/sa100>



# The EFD Team

*Co-funded by RPSEA, U.S. Fish & Wildlife, Industry, Environmental Organizations*

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- FLY7 NORTH Nature Center Conservancy
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- OU
- TCAT Texas Center for Applied Technology
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For more Info see:

<http://www.efdsystems.org>

## Membrane (Physical removal)

# Representative power costs of desalination of oil field brine

Salinity of Feed Brine, tds (ppm)	Power Costs Kw Hr per 1,000 gal. Permeate			
	Pre- treatment	RO desalination	Operating Cost, \$ per 1,000 gal.	Operating Cost, \$ per bbl
<b>Contaminated Surface water ~1,500 tds.</b>	\$0.65	\$1.25	\$1.90	\$0.08
<b>Gas well produced brine ~ 3,600 tds.</b>	\$2.50	\$2.00	\$4.50	\$0.19
<b>Oil well produced brine ~50,000 tds</b>	\$2.20	\$6.00	\$8.20	\$0.34
<b>Gas well produced brine ~ 35,000 tds</b>	\$2.00 (est.)	\$4.20 (est.)	\$6.20 (est.)	\$0.26

Sc

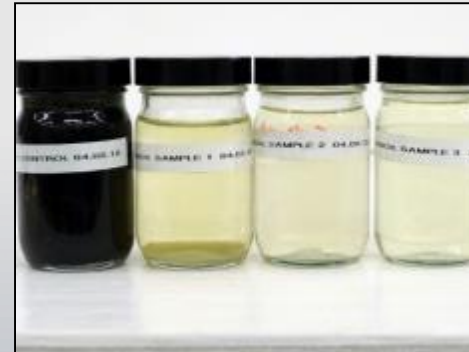


# Looking Ahead - Advanced Analytics

Air Emissions from Produced Water  
Open Impoundments



Frac flowback Water  
Sampling



Stray Methane Gas  
Sampling



For more Info see:

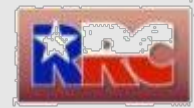
<http://epicphotogear.com/tip/panos>

# EFD Coastal Impacts Technology Program

## 2012 – 2014 Comprehensive Program

- Implements technologies along the Texas Gulf Coast
- Measures effectiveness of technologies to conserve, protect or restore the coastal environment
- Will inform and educate a needed workforce.

*Selected by the Texas Coastal  
Advisory Board for funding.*



For more Info see:

<http://efdsystems.org/index.php/coastal-impacts-technology-program-city>

# Government Partners; South Texas



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## Eagle Ford News

Posted on: November 4, 2013

### Energy infrastructure, transport and finance highlight 20th U.S.-Mexico Border Energy Forum

AUSTIN —Top corporate executives and government officials — including Gary Doer, Canada's Ambassador to the United States— will meet to discuss energy infrastructure, transport and finance at the 20th annual U.S.-Mexico Border Energy Forum, Nov. 6-8 at the Embassy Suites San Antonio Riverwalk-Downtown.

\*The Border Energy Forum has worked to establish partnerships and encourage cross-

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# Thank you

## Links to More Information

Videos and Panorama Shots

[Water Treatment Video Link](#)

<http://www.youtube.com/watch?v=hdoiWXDU6ek>

<http://www.efdsystems.org>

<https://sites.google.com/site/amefdtipprogram2013/page-3>



<http://epicphotogear.com/tip/panos/>

