

The Environmentally Friendly Drilling Systems Program

Integrating advanced technologies into systems that significantly reduce the impact of petroleum drilling and production.

*Awarded
October 5, 2009*



Goal of EFD: Major Reduction in E&P Footprint

- **Low Footprint Rig Operations**
- **Produced and Frac Flow back Brine Management**
- **Lower Air Emissions**
- **Lessened Surface Footprint**
- **Public Stakeholder Involvement (Society Issues)**



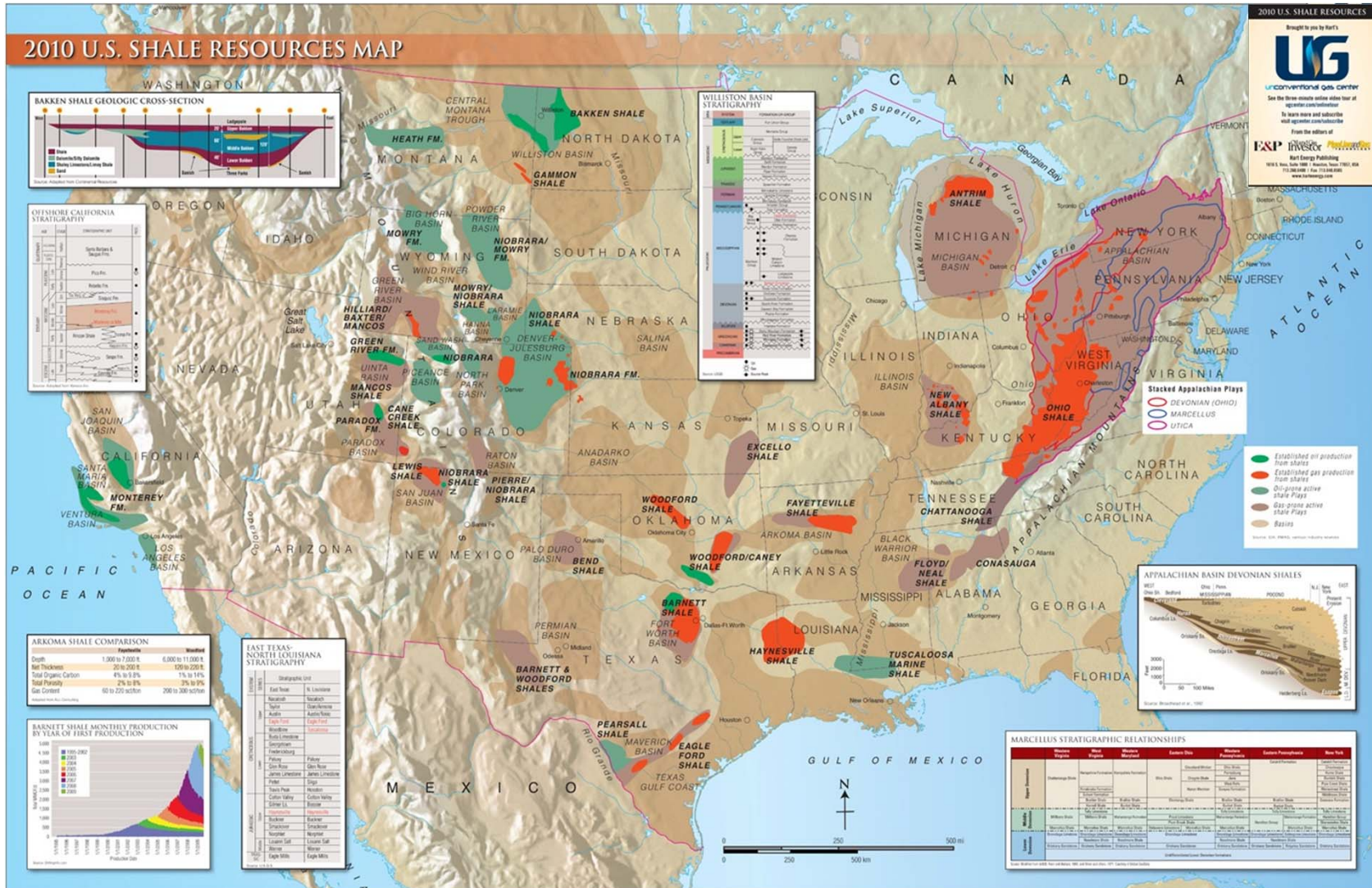
Thank you Sponsors!



Unconventional Petroleum Energy Resources are Plentiful

*Technology is available, but it will be the
environmental issues and society's acceptance
that slow
the development of shale gas resources in South
Texas*

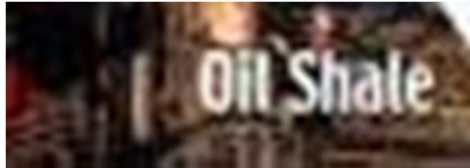
Today's Expanding Natural Gas Resource (Hart Publications)



The Way We Used to Look at Petroleum Resources



A New Vision of Fossil Energy



Exploration and Production in Environmentally Sensitive Areas

Sustainable Development

Best Cost/Benefit Decisions

Societal Decisioning

Best Environmental Decisions

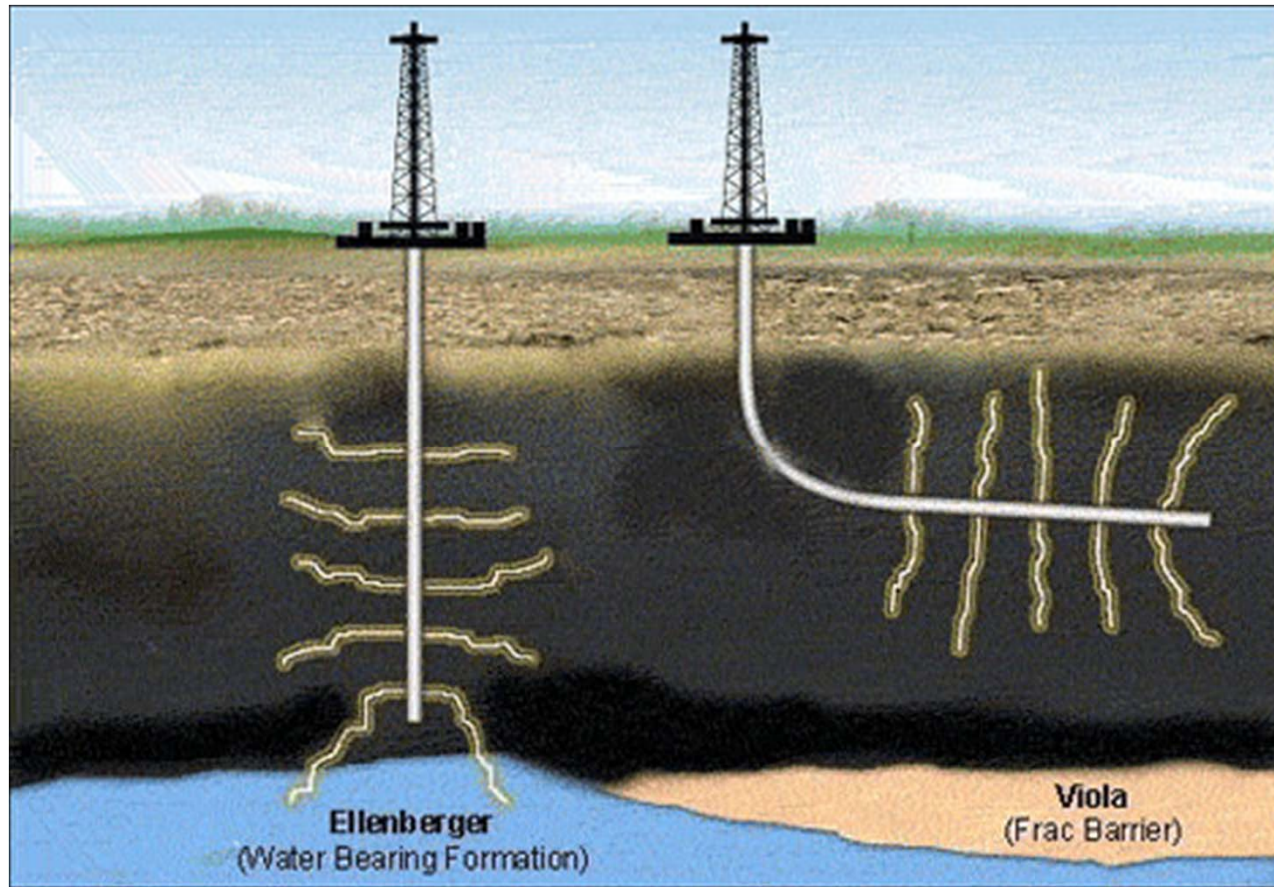
Description of Technology

One Gas Shale Well Equivalent to City of Cotulla, TX

Water Usage	Well Operations	City Operations(1)	Comments
Water Usage	5 to 10 million gal	18 million gal (3 mo.)	A 3 to 10 year supply for “typical” rural well
Power Use	7,500 HP	6 MW (8,000 Hp)	Avg. SCR rig
Solid Waste	200,000 lbs. (7,000 ft well, basement, road & pad +incidentals)	2,000,000 lbs (3 months)	3 mo. Ops.
Unit Budget	~\$ 3.2 MM	~\$1.7 MM	3 mo. Ops.

- (1) Based on comparison to Andrews TX city budget (pop.9,600) 2008 FY
(2) TCEQ Statistical Estimates for Individual water well, rural property

Schematic of Massive Hydraulic Fracturing Stimulation of Shales



<http://www.freewebs.com/mana76016/gaswells1.jpg>

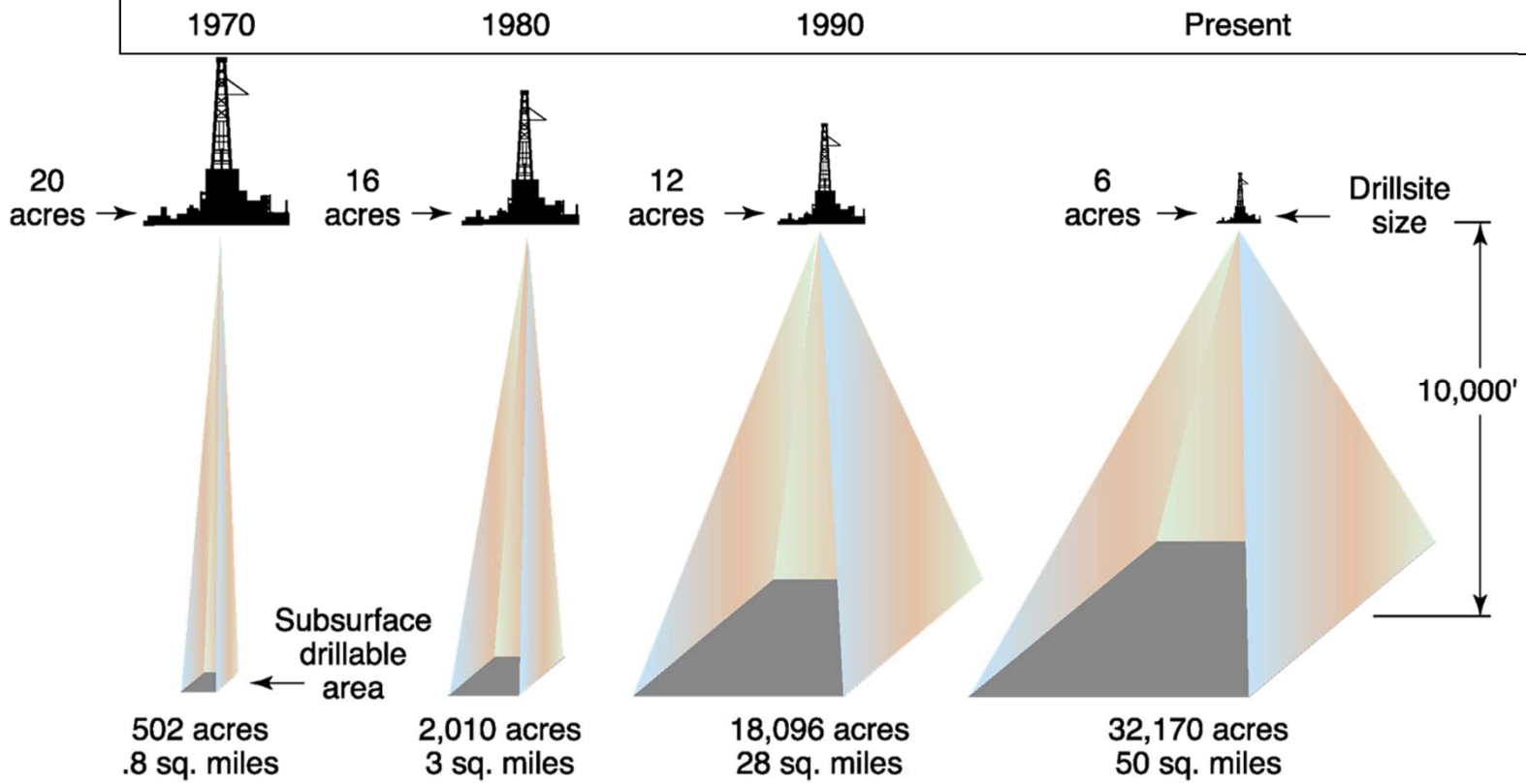
1.4 Platform/Rig Site Options

V

Access to Environmentally Sensitive

- How to access with minimal impact
- How to measure effect of low-impact practices

Questar using "Pod" drilling (1 acre per well.)



Source: William Harrison, Kansas Geological Survey

Barnett Shale Well Pad – Fort Worth Texas



The Technology Partners EFD Program 2010

EFD Alliance














- Navigation**
- [About the University/National Laboratories Alliance](#)
 - [Texas A&M University](#)
 - [Sam Houston State University](#)
 - [TerraPlatforms, L.L.C.](#)
 - [University of Arkansas](#)

About the University/National Laboratories Alliance

Task 4.0 University/National Laboratories Alliance

The EFD Program creates a partnership between National Laboratories and key University partners to develop and disseminate critical new technology to accelerate development of domestic reserves in a safe and environmentally friendly manner. Historically the national labs have provided beneficial technologies to increase oil and gas production, but have not focused in the past few years on basic research aimed at providing clean fossil energy to the public in cost effective environmentally acceptable manner. Universities have provided education, service, and research but primarily in regional areas and in most instances, specialized areas.

The following Universities/National Laboratories are members of the alliance. Click on the link to see what each me

Texas A&M University 	Sam Houston State University 	TerraPlatforms L.L.C 
University of Arkansas 	West Virginia University 	University of Colorado 
Utah State University 	University of Wyoming 	Arbonne National Laboratory 
HARC 	TAMU ERC 	Tx AgriLife Research 
Los Alamos National Laboratory 		

<http://sites.google.com/a/pe.tamu.edu/efd-alliance/Home>

Societal Acceptance

(Utah State Univ./Sam Houston State)



- **Develop understanding of the environmental and social impacts that gas development in the Uinta Basin.**
- **Identify opportunities and barriers to expanded use of EFD approaches in the Uinta Basin.**

Deliverables

- White paper summarizing needs/barriers for the region.
- Fact-sheets and other materials discussing EFD applications.
- Workshops will be held to ensure that the technologies are effectively transferred.

Status

- Completed interviews with reps from industry, state agency and nonprofit sectors.
- Gathered documentation about regulatory rules & procedures at state, tribal and federal level.

University of Arkansas: Fayetteville Shale

Probabilistic Risk-Based Decision Support for Oil and Gas Exploration and Production Facilities in Sensitive Ecosystems

Fayetteville Shale Natural Gas: Reducing Environmental Impacts

Search Go

Drilling Locations and Status

The interactive Map below shows the location of currently operating wells. By pressing the Ctrl button and dragging the mouse on the map, you can zoom to various areas of the Fayetteville Shale. You can turn information on and off using the legend on the side of the map. You can display information about a particular feature by moving your mouse over it.

2D 3D | Road Aerial Hybrid

Active Natural Gas Wells
 Drilling Permits
 1 week ago
 2 weeks ago
 3 weeks ago
 Compressor Stations
 Sections
 Monthly Production Output

Open a full screen map window

Information on pop. To change Monthly (put layer red on), select Month from ul. Natural Gas Wells Compressor Stations Permit

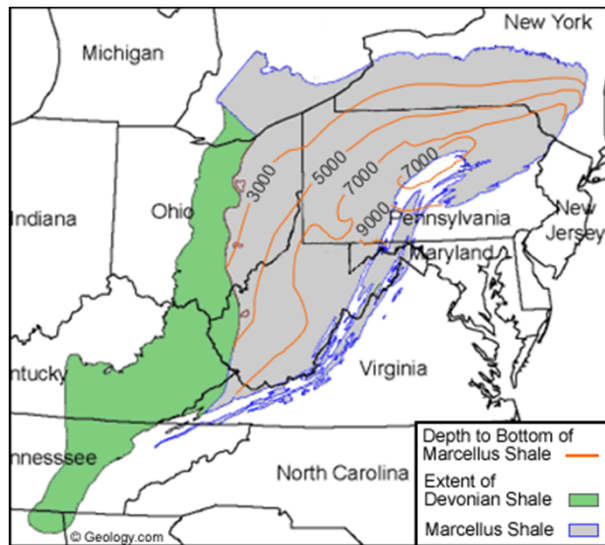
Permit #: 39373 -
OBJECTID: 315215
API: 03145101030000
Well Permit: 39373
STATUS: Producing
STATUSSYM: Active
WL_TYPE: Natural Gas
Section_T_R: 34.17N R10W
Latitude: 34.41872
Longitude: -92.06406
FIELD: B-43
ZONE:
DT_MDD: 3/12/2007 12:00:00 AM
FAYSHALE: True

Input your address or well section # to zoom
Examples:

- Lat, Long: 35.187278, -92.304382
- Address: 800 N College Ave, Fayetteville AR, 72701
- Section: 10S-7N-15W

<http://lindo.cast.uark.edu/LINGOPUBL>

Eastern Mountain States Studies (West Virginia University)



Initiate an environmentally friendly E&P systems program for the Marcellus Shale Basin.

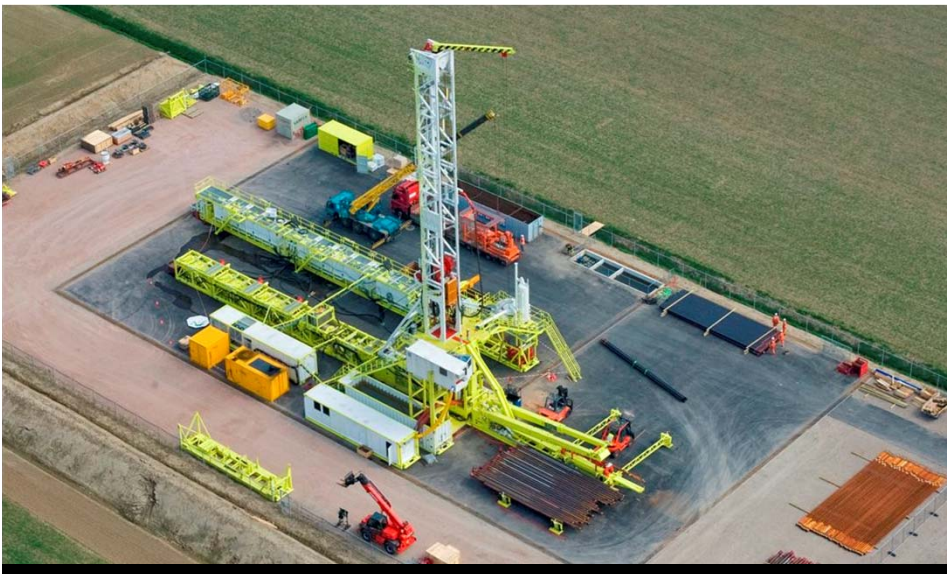
Deliverables

- White paper summarizing the needs and barriers associated with developing the Marcellus play.
- Series of workshops to transfer new EFD technology for developing the Marcellus play.

Status

- Continued planning for workshop – wk of 8/23.
- Will have a field trip to well locations in NY that are implementing research results/best practices.

Huisman Small Footprint Drilling Rig



Small footprint drilling rig to investigate reduction in environmental impact

EFD Activities

- Documenting prototype test of low impact rig.

Partners

- ***Huisman Rig***
 - ***Zero Spill Technologies***
 - ***Waste Heat – Electricity***
- LOC 400 movie uploaded to EFD web site.

Texas A&M Disappearing Roads



**How do you
make this
road
disappear?**

Disappearing Roads Competition.
<http://www.DisappearingRoads.com>

\$10,000 1st Place
\$7,000 2nd Place

NOx Air Emissions Studies



Develop guidelines concerning the measurement of oxides of nitrogen (NOx) for a drilling site and work with operating company personnel to plan an investigation at a location.

Deliverables

- Plans for an emissions study.
- Guidelines for emissions reduction of large engines.

Status

- Kicked off effort to develop guidelines.
- Guidelines incorporated into Scorecard Reference Guide.

Reduced Fracturing Footprints



Identify alternatives to reduce the footprint including offsite operations and innovative fracturing technologies such as a novel process involving: minimal pumping equipment, low volumes of frac fluid and materials that are environmentally green and non-damaging.

Deliverables

- Report documenting alternatives to reduce the footprint of hydraulic fracturing operations.

Status

- *Will hold workshop to identify Hydraulic Fracturing Scorecard parameters.*

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

Reverse Osmosis Definitions (RO)

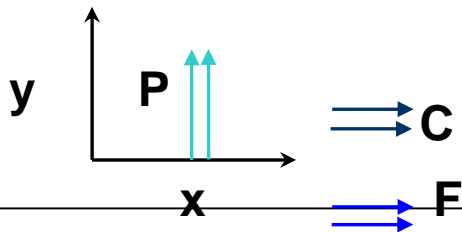
$$R = 1 - C_P / C_F \text{ Salt rejection}$$

Transmembrane pressure

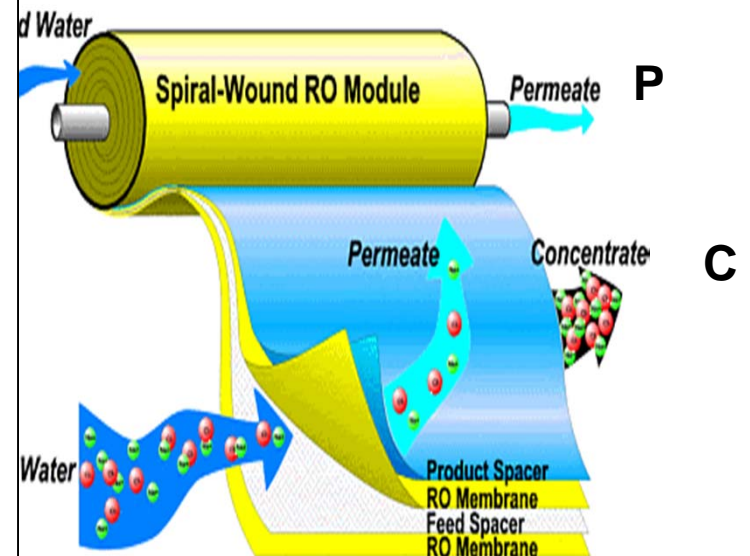
Feed, permeate, reject or
concentrate rates

Fluxes (volumetric rate/area)^F

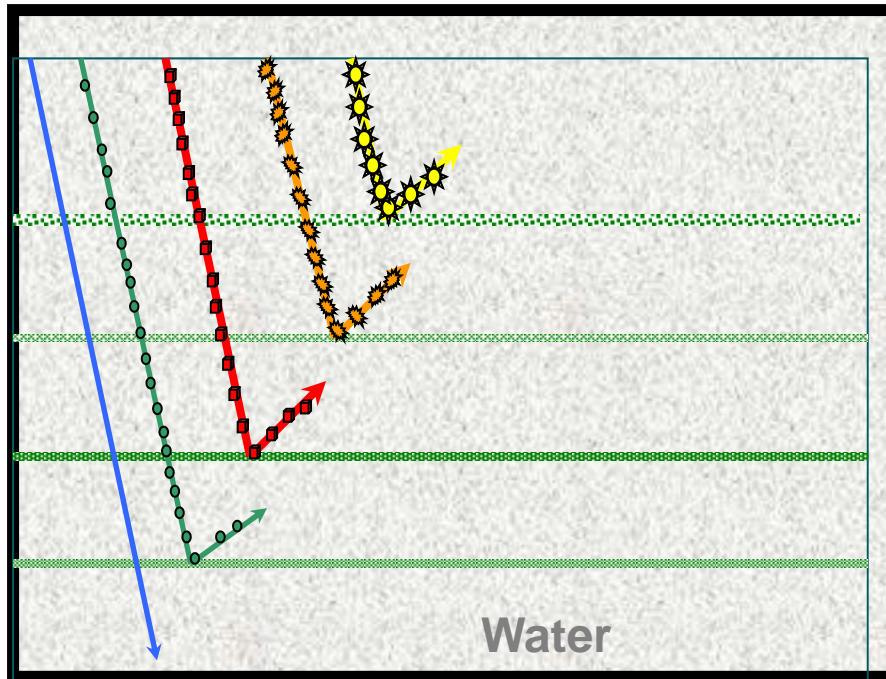
$$\text{Feed Flux: } J_F = Q_F / A$$



$$TMP = \left[\frac{P_F + P_R}{2} \right] - P_P$$



Identifying Key Technology Components



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



Comparison of Desalinated Produced Water with
Municipal Water from College Station. TX

Hardness (Ca, Mg)	54	706	1
Chloride	9	3	ND
Sulfate (SO ₄), K, Na, B	203	94 ppm	1.3
Dissolved Solids			
Organics (TOC, etc)	2 ug/L	0.9 mg/L	ND
Pharmaceuticals			
Endocrine Disruptors (EDCs)	14 ug/L	3.4 ug/L	85 ug/L

Facilities: Separation Sciences Laboratory





*Mobile Pre-Treatment and
Desalination Unit at
Boonville Texas Site. (2009)*

All Weather Mobile Unit for Site Treatments (2011)



- **A view of the mobile testing laboratory.**

Mobile Unit Interior (2011)



- *The mobile training unit capabilities:*
 - *bench top membrane efficacy tests,*
 - *Oil removal testing*
 - *TSS Removal*
 - *TDS Removal*
 - *Membrane Cleaning*
 - *Analytical monitoring*

Dissemination and Decisions Support (University of Arkansas)

Fayetteville Shale Natural Gas: Reducing Environmental Impacts

Search Go

Home
About Fayetteville Shale
Drilling Locations and Status
Natural Gas Production
Minimizing Environmental Impacts
Regulatory Requirements
Announcements

Drilling Locations and Status

The interactive Map below shows the location of currently operating wells. By pressing the Ctrl button and dragging the mouse on the map, you can zoom to various areas of the Fayetteville Shale. You can turn information on and off using the legend on the side of the map. You can display information about a particular feature by moving your mouse over it.

Open a full screen map window

- Active Natural Gas Wells
- Drilling Permits
- 1 week ago
- 2 weeks ago
- 3 weeks ago
- Compressor Stations
- Sections
- Monthly Production Output

You can turn information on and off at the top.

Develop a website for the Haynesville Shale that describes the natural gas resources available and their development and provides information about the state and federal regulatory requirements that developers must follow.

Deliverables

- Work with stakeholders from at least one other play to deploy an information site using this framework and document the process so that it could more easily be deployed elsewhere.

Status

- ***Presentation to be given.***

Best Practices Database (University of Colorado)



Develop a free-access, searchable, database and supporting website for best management practices (BMPs).

Deliverables

- Take the beta version to a broader community of partners to refine and expand its functionality, add BMP data, and develop additional website support materials. Materials featured on the website will include projects of the EFD team and its alliance partners.

Status

- Summer staff (6 undergrad, 2 interns, 2 law students) hired to expand website and database
- Summer emphasis will include case studies, BMP efficacy, cost/benefit analysis, and law materials
- New promotional flier
- Pre-proposal submitted to foundation for funding of companion human health laws project

Reduced Surface Footprint

**Texas A&M University Disappearing Roads
University Competition**

**Scott Environmental Services – Recycle – Reuse
Newpark Integrated Mats**

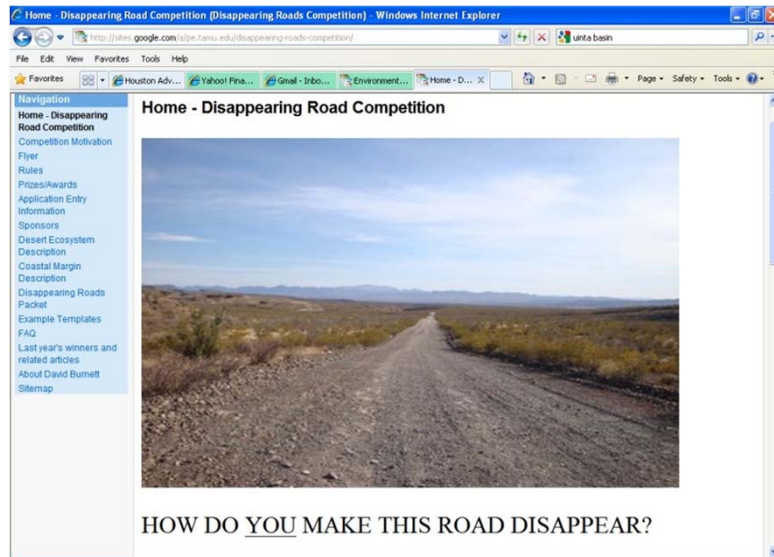
**Heartland Biocomposites – U of Wyoming Roll
out Roads**

Pecos Desert Test Center



←—————→
Approximately ½ mile

Disappearing Roads



Support the Disappearing Roads Competition.

Deliverables

- Support to the competition.

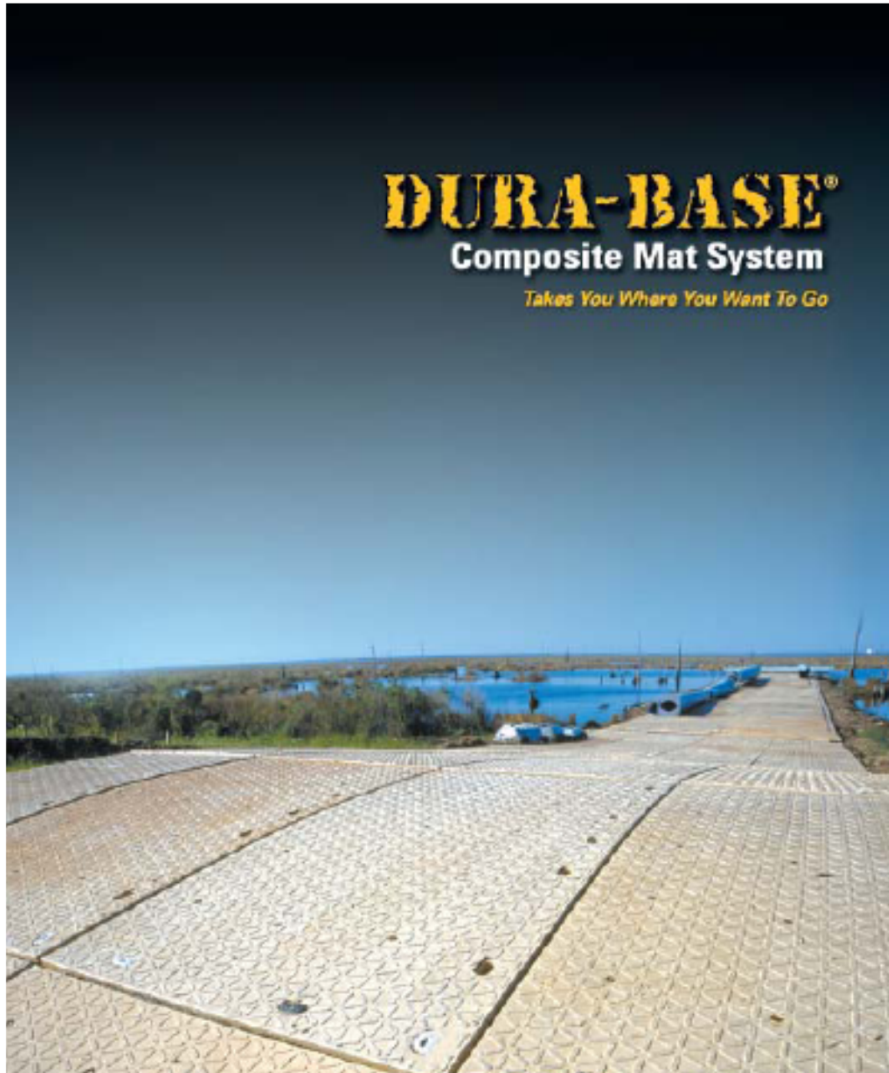
Status

- Finals held on May 26th.
- ***Separate presentation to be made.***
- ***PTTC will institutionalize program!***

Scott Environmental Services Recycled Drill Cuttings Road Base



DURA-BASE® COMPOSITE MAT SYSTEM



DURA-BASE® Features & Accessories

Large Mat Size: 8' x 14' (2.44 m x 4.27 m)
Small Mat Size: 8' x 7.5' (2.44 m x 2.29 m)

Each large mat has a nominal weight of 1,690 lbs. (677 kg)

The overlapping lip, 16 bolts and fasteners provide a solid interlocking system to reduce slippage and movement.

Tread pattern for improved traction for load-bearing vehicles and heavy equipment.

The overlapping joint provides a superior connection between mats.

4 1/4" (113 mm) thickness provides a solid barrier between the ground and work area.

Contact DURA-BASE® for additional information on DURA-BASE® accessories and bolts such as locking fasteners, mud cap, trench, ramp & transition assembly, pry bar, pin removal, and base application with the DURA-BASE® Composite Mat System.

All published dimensions are in inches.

Extractor

Mud Cap

Pry Bar

Locking Fastener

Ramp & Transition Assembly

Heavy Duty Clamping Fastener

Operator positions each mat, aligning the holes in the overlapping joints. A fastener is inserted and a quarter turn of the wrench quickly interlocks the system.

Locking Wrench

Mat system follows surface contours for terrain flexibility.

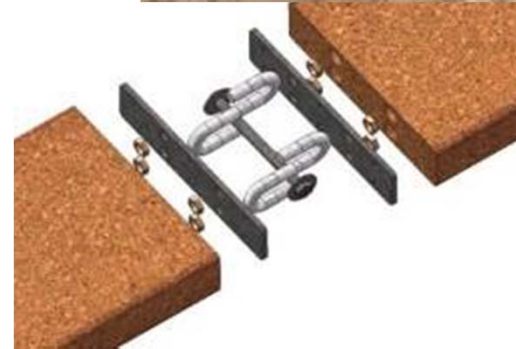
Laying Down Composite Mats



U of Wyoming – Heartland Biocomposites Rollout Road



- Main Components
 - Conformable
 - Hinged board segments



- Field Test



The Environmentally Friendly Drilling Technology Integration Program

Reducing Impacts of Oil & Gas Development
on Rangelands in Western U.S.

David Burnett – Texas A&M University

Richard C. Haut – Houston Advanced Research Center

Tom Williams – AFS Solutions Inc.

Gene Theodori - Sam Houston State University

John Veil – Argonne National Laboratory

Texas A&M Vernal Utah

October 14, 2010



Texas A&M University



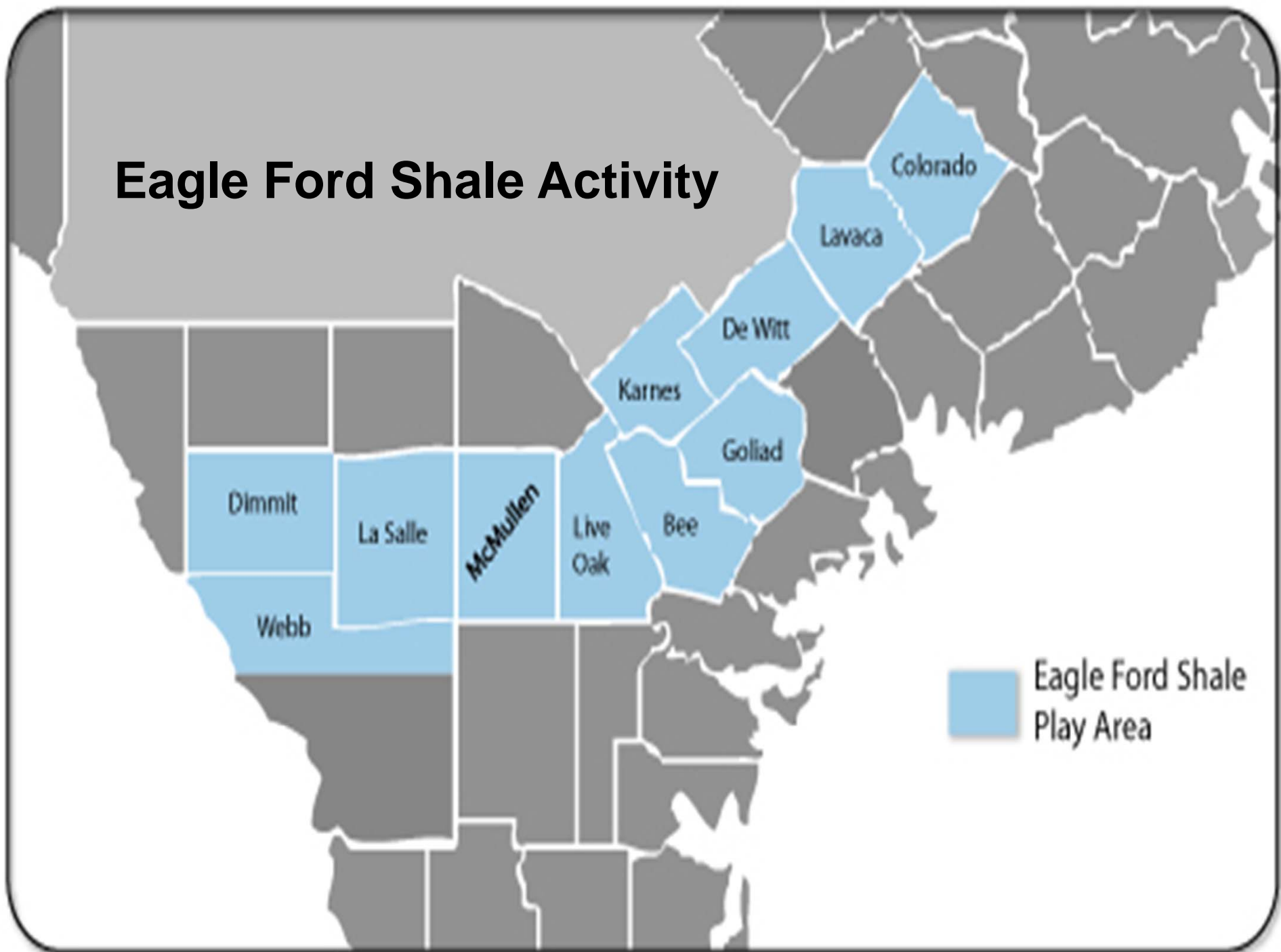
The EFD TIP in the Eagle Ford Shale

Objectives: *The Technology Integration Program is an integrated approach for applying new technologies in the production of unconventional natural gas.*

Target Proving Ground: *The Eagle Ford Shale*

The Goal: *To create a program that would speed the commercial development of technology developed through RPSEA programs.*

Eagle Ford Shale Activity



Recent Eagle Ford Activity

TEXAS



<http://efdsystems.org>

<http://www.GPRI.org>

<http://sites.google.com/a/pe.tamu.edu/efd-alliance/Home>

<http://www.TAMUEagleFordShale.com>

**Thanks –
Questions?**

