Water Availability and Management in Shale Gas Operations

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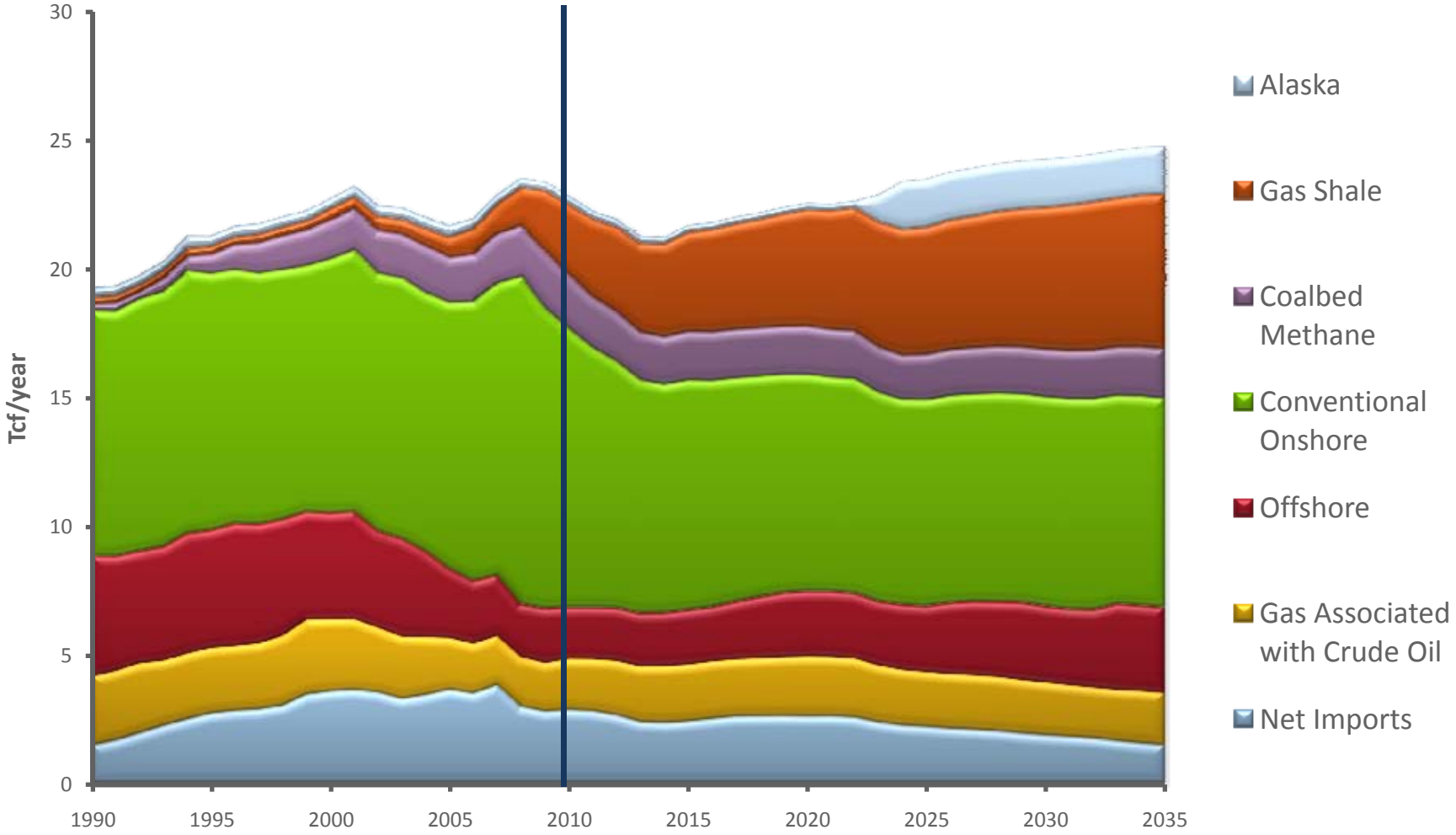
Acknowledgments

- DOE- Office of Fossil Energy
- DOE – Office of Policy and International Affairs
- NETL- Strategic Center for Natural Gas and Oil
- RPSEA (Research Partnership to Secure Energy for America)
  - Environmentally Friendly Drilling Program

Topics for Discussion

- Background on shale gas
- Water issues
  - Water supply needs
  - Hydraulic fracturing
  - Wastewater management
- Statistics on water requirements
- Research funded by DOE
- Other IPEC presentations relating to shale gas

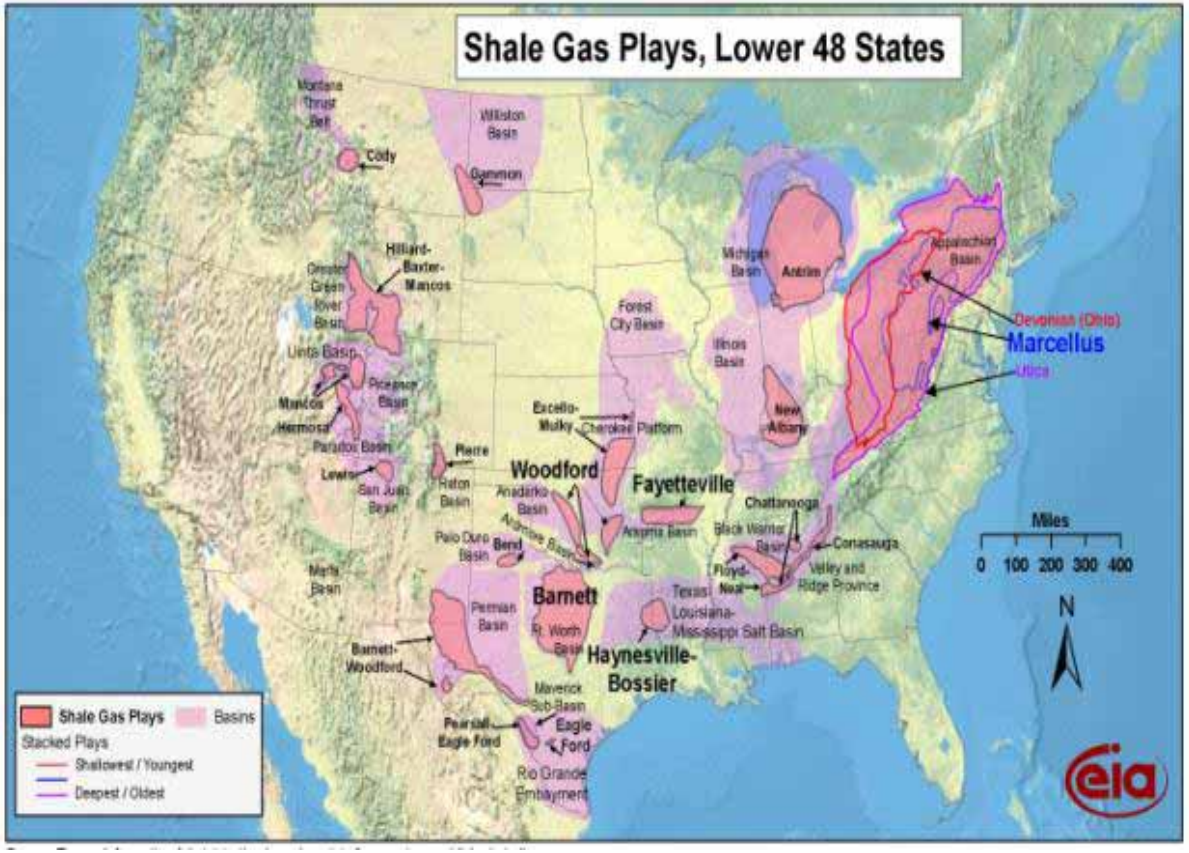
Importance of Shale Gas



Source: DOE/EIA Annual Energy Outlook 2010 (EIA 2010). Note that Tcf refers to trillion cubic feet

Shale Gas Plays

- The most active U.S. shale plays to date are:
  - the Barnett Shale,
  - the Fayetteville Shale in Arkansas,
  - the Antrim Shale in Michigan,
  - the Haynesville Shale in Louisiana,
  - the Marcellus Shale in Pennsylvania, New York, and West Virginia, and
  - the Woodford Shale in Oklahoma
- Two important Canadian shale plays:
  - the Horn River Shale in British Columbia, and
  - the Montney Shale in British Colombia and Alberta



Source: DOE/EIA website

Steps in the Shale Gas Process

- Steps involving water are shaded

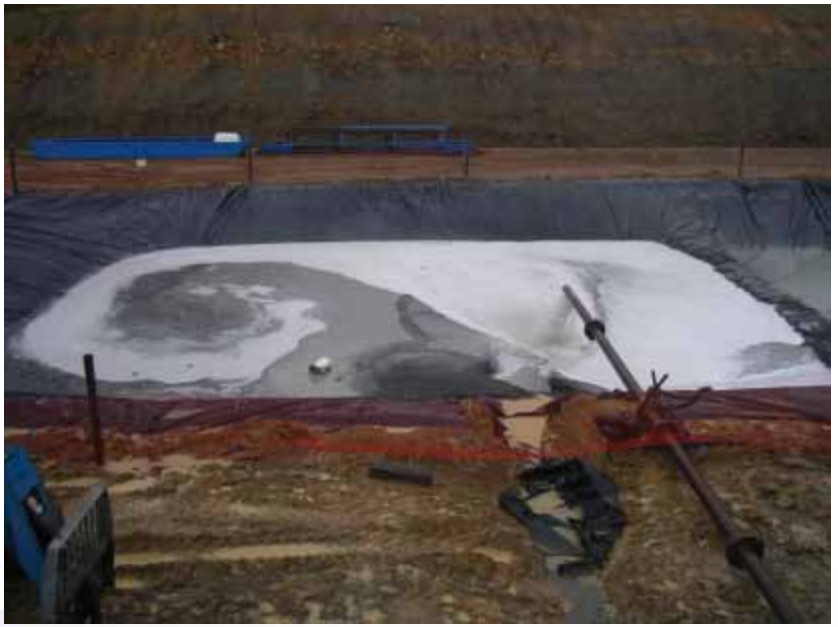
Gaining Access to the Gas (Leasing)
Searching for Natural Gas
Preparing a Site
Drilling the Well
Preparing a Well for Production (Hydraulic Fracturing)
Gas Production and Water Management
Moving Natural Gas to Market
Well Closure and Reclamation

Water Issues in Site Preparation

- Need to consider stormwater runoff from all land areas disturbed during construction
  - Follow proper sediment control practices
  - Stabilize exposed surfaces

Water Issues in Drilling

- Water is needed to make up drilling fluids
  - Ranges from 1 MG in the Haynesville Shale to 60,000 gallons in the Fayetteville Shale
  - Depends on the types of drilling fluids used and the depth and horizontal extent of the wells
  - The Marcellus Shale drilling volume falls near the lower end of this range at 80,000 gallons per well.
- Disposal of liquid components of drilling waste pits



Water Needed for Frac Jobs

- A single well may require 1 to 5 million gallons
  - Individual volume is not critical, but collectively can be important within a region
- Source of water:
  - Stream, river, or lake
  - Well
  - Impoundment created by producer
  - Public water supply
- Piped to site vs. delivery in tank trucks

Water Handling Onsite

Hydraulic Fracturing (Frac Job) Is Equipment-Intensive

Management of Frac Flowback Water (1)

- Large volume of flowback returns to the surface in first few hours to few days
  - Typically collect in pits/ponds
- Over time, smaller volume returns
  - Collect in tank

Management of Frac Flowback Water (2)

- Collected water must be removed from site
- Typically is collected by tank trucks and hauled offsite to:
  - Commercial disposal wells
  - Wastewater treatment plants
  - Treatment and reuse facilities
- Producers may install their own injection wells or reuse the flowback water

Natural Gas Wastewater Management Facilities in Pennsylvania

- PA DEP maintains a list of wastewater management facilities.
- As of June 2010, 27 commercial wastewater treatment facilities are permitted by the PADEP to treat flowback and produced water and then discharge the treated water to surface water bodies.
  - Some are in-house facilities, others accept outside wastewater
- 4 other commercial facilities treat the water and then discharge it to municipal sewers that flow to POTWs.
- The PADEP list also includes 25 other commercial wastewater treatment facilities that have applied for permits but have not yet received permission to operate and discharge

Commercial Disposal Sites in Pennsylvania Visited by Author in May 2010

- Facilities provide treatment for pH and metals but do not treat TDS
  - Eureka Resources installed additional thermal distillation units in June 2010
- Existing facilities grandfathered under new PA rules
  - New facilities will need to meet limit of 500 mg/L TDS

1. Eureka Resources
2. Pennsylvania Brine – Franklin
3. Tunnelton Liquids
4. Hart Resource Technologies

Ohio Counties with Commercial Disposal Wells

- In most shale gas plays, wastewater is disposed of through injection wells
- Marcellus region has very few permitted wells
- Some operators haul wastewater to Ohio

Statistics on Water Requirements for Marcellus Shale

- Make estimate of maximum volume of water needed to meet Marcellus Shale fraccing needs
  - Estimate volume of water per well
  - Estimate maximum number of wells in a year

Pennsylvania Drilling Permits and Wells Drilled

Year	Marcellus Shale Drilling Permits Issued	Marcellus Shale Wells Drilled
2007	99	18 (July – December)
2008	519	196
2009	1,985	763
2010	1,398 (January – June)	564 (January - June)

Source: PA DEP website

- the number of wells actually drilled during the first six months of 2010 can be doubled to estimate a full year (1,128).
- The ratio of 2010 extrapolated drilled wells to 2009 drilled wells (1,128 to 763) = 1.48.
- Assuming the same 48% increase over the 2010 estimate for future growth, a hypothetical maximum is 1,128 x 1.48 = 1 ,669 wells.

West Virginia Drilling Permits and Wells Drilled

Year	Marcellus Shale Drilling Permits Issued	Marcellus Shale Wells Drilled
2007	152	143
2008	400	274
2009	424	47
2010	176 (January – June)	1 (January – June)

Source: WV DEP website

- The ratio of drilled wells to drilling permits was 95% in 2007 and 69% in 2008.
- Applying the 2008 ratio to the total number of drilling permits in 2009 (0.69 x 424) gives an estimated hypothetical maximum of 293 wells.

New York Drilling Permits and Wells Drilled

Year	Total Drilling Permits Issued (not necessarily Marcellus Shale)	Total Wells Drilled
2008	744	??
2009	552	??
2010	302 (January – August)	??

Source: presentation made by Jack Dahl, NY DEC, August 24, 2010

- New York has moratorium on Marcellus Shale wells
- No good way to predict maximum number of wells
- Chose to estimate maximum New York wells to be the same as maximum West Virginia wells = 293

Hypothetical Maximum Water Demand for Marcellus

State	Hypothetical Maximum Number of Wells Drilled in a Year	Annual Volume under Scenario 1: 1 MG of water needed per well	Annual Volume under Scenario 2: 2.8 MG of water needed per well	Annual Volume under Scenario 3: 3.9 MG of water needed per well	Annual Volume under Scenario 4: 5 MG of water needed per well
PA	1,669	1,669 MG	4,673 MG	6,509 MG	8,345 MG
WV	293	293 MG	820 MG	1,142 MG	1,465 MG
NY	293	293 MG	820 MG	1,142 MG	1,465 MG
Total	2,255	2,255 MG	6,314 MG	8,795 MG	11,275 MG

- Caveats
  - estimates of maximum wells drilled could significantly overestimate or underestimate the actual quantity
  - assumed maximum number in one state will not necessarily correspond to the maximum in each of the other states
  - As gas companies refine and improve their efforts to recycle and reuse flowback and produced water from wells already fracced, the water needed per well may decrease
  - if operators drill longer horizontal wells with more frac stages, the volume per well could increase

Actual Water Withdrawals for 2005 (in MGD)

Category	New York	Pennsylvania	West Virginia	Total
Public Supply	2,530	1,420	189	4,139
Domestic	140	152	34	326
Irrigation	51	24	<1	75
Livestock	30	62	5	97
Aquaculture	63	524	53	640
Industrial	301	770	966	2,037
Mining	33	96	14	143
Thermoelectric	7,140	6,430	3,550	17,120
Total	10,288	9,478	4,811	24,577

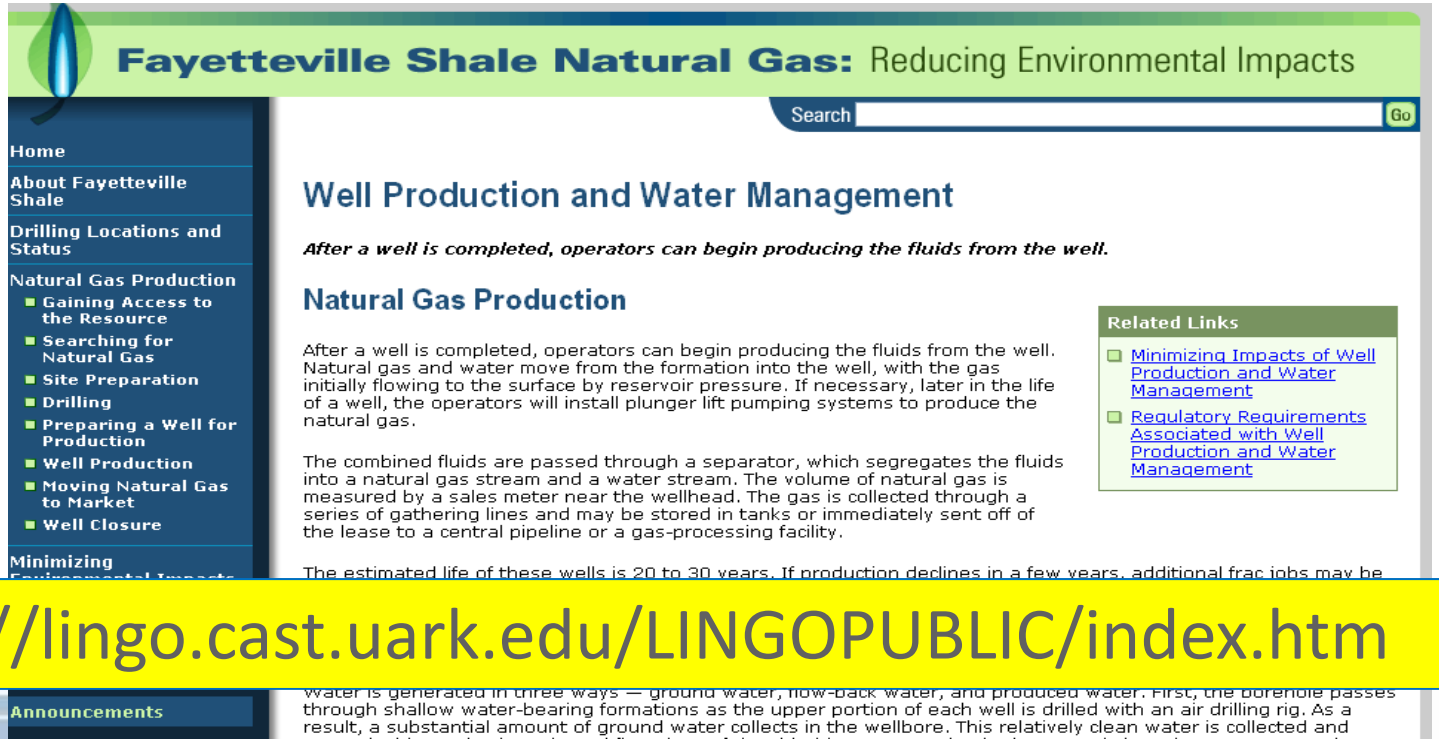
Source: USGS report (Kenny et al. 2009)

Comparison of Marcellus Shale Water Needs with Actual Withdrawal

	Volume	Percentage Water Required for Shale Gas Production Compared to Total Withdrawal
Water needed for shale gas	6.2 – 31 MGD	100%
Total water withdrawal	24,577 MGD	0.03% – 0.13%
Total water withdrawal excluding thermoelectric uses	7,457 MGD	0.08% – 0.42%

Shale Gas Research Funded by DOE-NETL (1)

- In 2006, DOE funded a project with Univ. of Arkansas and Argonne to develop the Fayetteville Shale Information website that includes technologies and practices that can be used to minimize environmental impacts during natural gas development
- The Univ. of Arkansas created an additional online Infrastructure Placement Analysis System tool that allows natural gas developers to select specific well sites so that they minimize interactions with sensitive and endangered populations and sites with special historical preservation status



http://lingo.cast.uark.edu/LINGOPUBLIC/index.htm

Shale Gas Research Funded by DOE-NETL (2)

- In September 2009 , DOE made 7 funding awards for shale gas water projects
  - Most related to Marcellus Shale
  - 1 was an expansion of the earlier Fayetteville Shale work
- Work began in late 2009 and will run for several years

Zero Discharge Water Management for Horizontal Shale Gas Well Development	West Virginia University
Sustainable Management of Flowback Water during Hydraulic Fracturing of Marcellus Shale for Natural Gas Production	University of Pittsburgh
Pilot Testing: Pretreatment Options to Allow Re-Use of Frac Flowback and Produced Brine for Gas Shale Resource Development	Texas A&M University, Argonne, Los Alamos
An Integrated Water Treatment Technology Solution for Sustainable Water Resource Management in the Marcellus Shale	Altela, Inc., Argonne
Integration Of Water Resource Models With Fayetteville Shale Decision and Support Systems	University of Arkansas, Argonne
Comprehensive Lifecycle Planning and Management System for Addressing Water Issues Associated With Shale Gas Development in New York, Pennsylvania and West Virginia	ALL Consulting
Cost Effective Recovery of Low-TDS Frac Flowback Water for Re-use	GE Global Research

Texas A&M Project

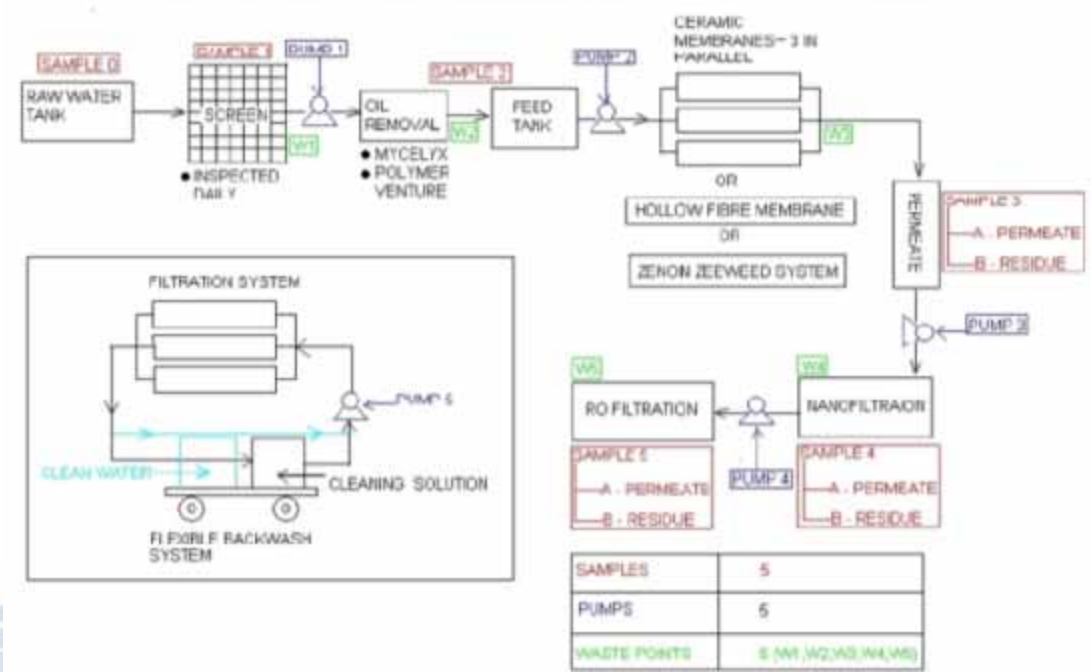
- Specific Objectives
  - Develop a mobile, multifunctional field water treatment system for “pretreatment" of oil field waste brine
  - Conduct field demonstrations of specific technology, and
  - Create a communication and outreach network to provide reliable information to regulatory agencies and to the public on industry efforts to develop unconventional resources.

All Weather Mobile Unit for Site Treatments

- **Shown in the photograph at left is the mobile training unit used by Texas A&M TEES for water and waste water training for municipal water facility operators.**
- **A similar unit is being constructed for oil field well site brine treatment.**

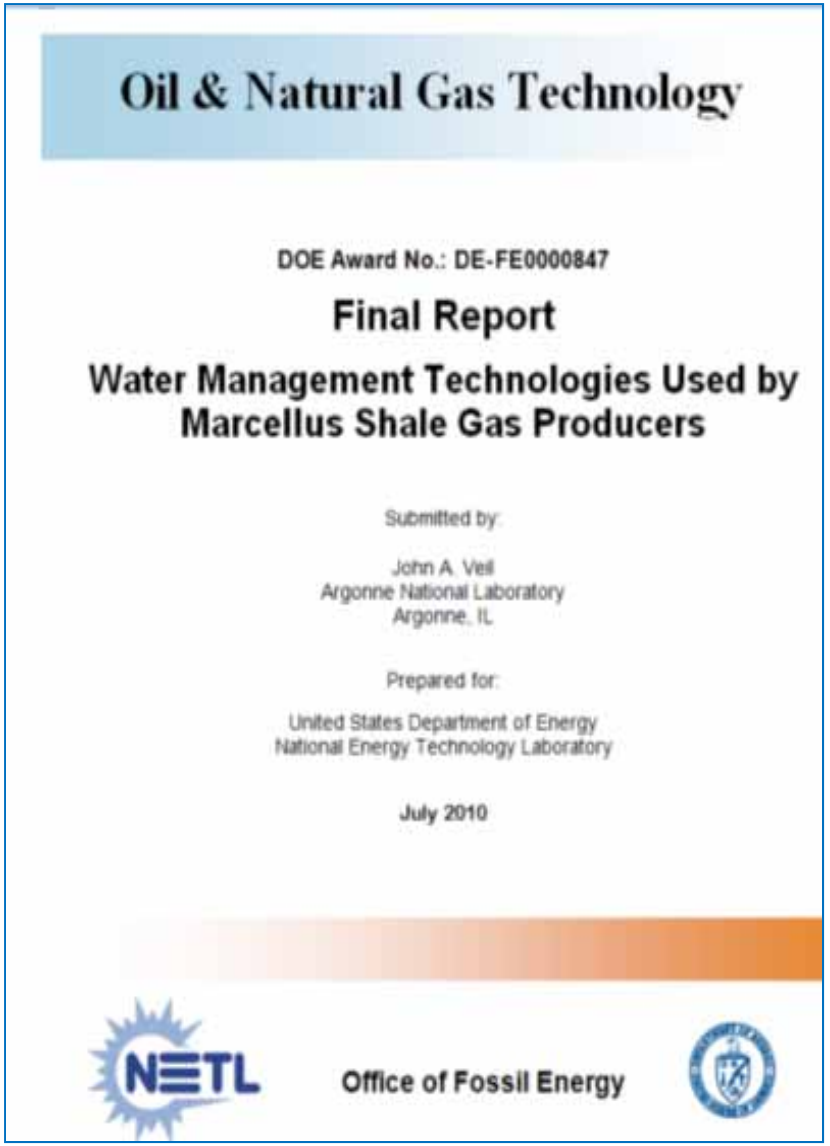
Schematic for Mobile Unit

Task 3



New NETL-Funded Report by Argonne

- July 2010 deliverable from Texas A&M and Argonne project


Oil & Natural Gas Technology

DOE Award No.: DE-FE0000847

Final Report

Water Management Technologies Used by Marcellus Shale Gas Producers

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Prepared for:

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National Energy Technology Laboratory

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NETL

Office of Fossil Energy

Available at

http://www.ead.anl.gov/pub/dsp_detail.cfm?PubID=2537

Altela Project

- Flowback water and produced water collected in lined pit
- AltelaRain treatment unit is in operation
- Matt Bruff will describe the results in his talk this afternoon

Source: Altela Inc.

University of Arkansas Project

- Develop a water management decision support system by modifying and integrating a state-of-the art water resource simulation model with a modern enterprise geographic information system
- Argonne compiled additional Arkansas and federal requirements relating to water withdrawal and other water resources
  - Updated the Fayetteville Shale Information website to include references for these regulations
- Jackson Cothren will describe the results in his talk this afternoon

IPEC Presentations Relating to Shale Gas or Other Upstream Water Issues

- Tues PM – full session **PTTC/DOE: Environmental Technologies for Water & Resource Management for Shale Gas & Coalbed Methane Plays**
- Wed AM – full session **Treatment & Beneficial Use of Produced Water**
- Wed PM – full session **Water Management Issues in Exploration & Production**
- Thurs AM – full session **Water Management Issues in Exploration & Production**

Plenty of Challenges Ahead

Source: C.B. Veil – taken in Ithaca, NY, June 2010