Shale Gas and Tight Oil Development: An Adaptive Model Resulting from Real Long-term Solutions that Incorporate Water Resources Management and the Public Trust*

Gary Hanson[1]

Search and Discovery Article #80253 (2012)**
Posted September 17, 2012

*Adapted from oral presentation at Geosciences Technology Workshop, Hydraulic Fracturing, Golden, Colorado, August 13-16, 2012
**AAPG©2012 Serial rights given by author. For all other rights contact author directly.

[1]River River Watershed Management Insititute, Louisiana State University, Shreveport (ghanson@lsus.edu)

Summary

- Being proactive is critical about evaluating water resources prior to a gas shale play.
- If not in place, form a regional water resources committee and a water/energy group.
- Be flexible and adaptive as you work to protect public water resources and work with industry.
- Work with state authorities, but take action where they cannot.
- Relationships built above will really help if your community is faced with water shortages (drought).

Selected References

Davies, R.J., S. Mathias, J. Moss, S. Hustoft, and L. Newport, 2012, Hydraulic fractures: How far can they go?: Marine and Petroleum Geology, v. 37/1, p. 1-6. doi.org/10.1016/j.marpetgeo.2012.04.001.

Fisher, K., and N. Warpinski, 2012, Hydraulic fracture-height growth: Real data: SPE Production and Operations, v. 27/1, p. 8-19, SPE 145949-PA. doi.org/10.2118/145949-PA.

Hanson, G., and A. Lewis, 2010, Managing the "Shale Gale" within the goal of water resource sustainability: A case study of unconventional shale gas development and water resource management: 2012 Land Grant and Sea Grant National Water Conference, Portland, Oregon, 2010: Web accessed 11 September 2012. http://www.usawaterquality.org/conferences/2012/Posters/Hanson_poster.pdf

Holling, C.S., L.H. Gunderson, and D. Ludwig, 2002b, In quest of a theory of adaptive change, *in* L.H. Gunderson and C.S. Holling, (eds.),

Panarchy: understanding transformations in human and natural systems: Island Press, Washington, DC, 597 p.

Molofsky, L.I., J.A. Connor, S.K. Farhat, A.S. Wylie, Jr., and T. Wagner, 2011, Methane in Pennsylvania water wells unrelated to Marcellus shale fracturing: Oil and Gas Journal, December 5, 2011, p. 1-32.

Myers, T., 2012, Potential contaminant pathways from hydraulically fractured shale to aquifers: Ground Water, 17 April 2012. doi:10.1111/j.1745-6584.2012.00933.x

Osborn, S.G., A. Vengosh, N.R. Wamer, and R.B. Jackson, 2011, Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing: Proceedings of the National Academy of Sciences, USA, v. 108, p. 8172-8176

Warpinski, N.R., and L.W. Teufel, 1987, Influence of geologic discontinuities on hydraulic fracture propagation: Journal of Petroleum Technology, v. 39/2, p. 209-220.

EMD/DEG North America GTW
Hydraulic Fracturing:
New Controversies and Key Plays
13-15 August 2012 | Golden Colorado

Shale Gas and Tight Oil Development: An Adaptive Model Resulting from Real Long-term Solutions that Incorporate Water Resources Management and the Public Trust

Red River Watershed Management Institute
Louisiana State University Shreveport

Gary Hanson, Director

Amanda Lewis, Assistant to Director

LSU SHREVEPORT
RED RIVER WATERSHED MANAGEMENT INSTITUTE

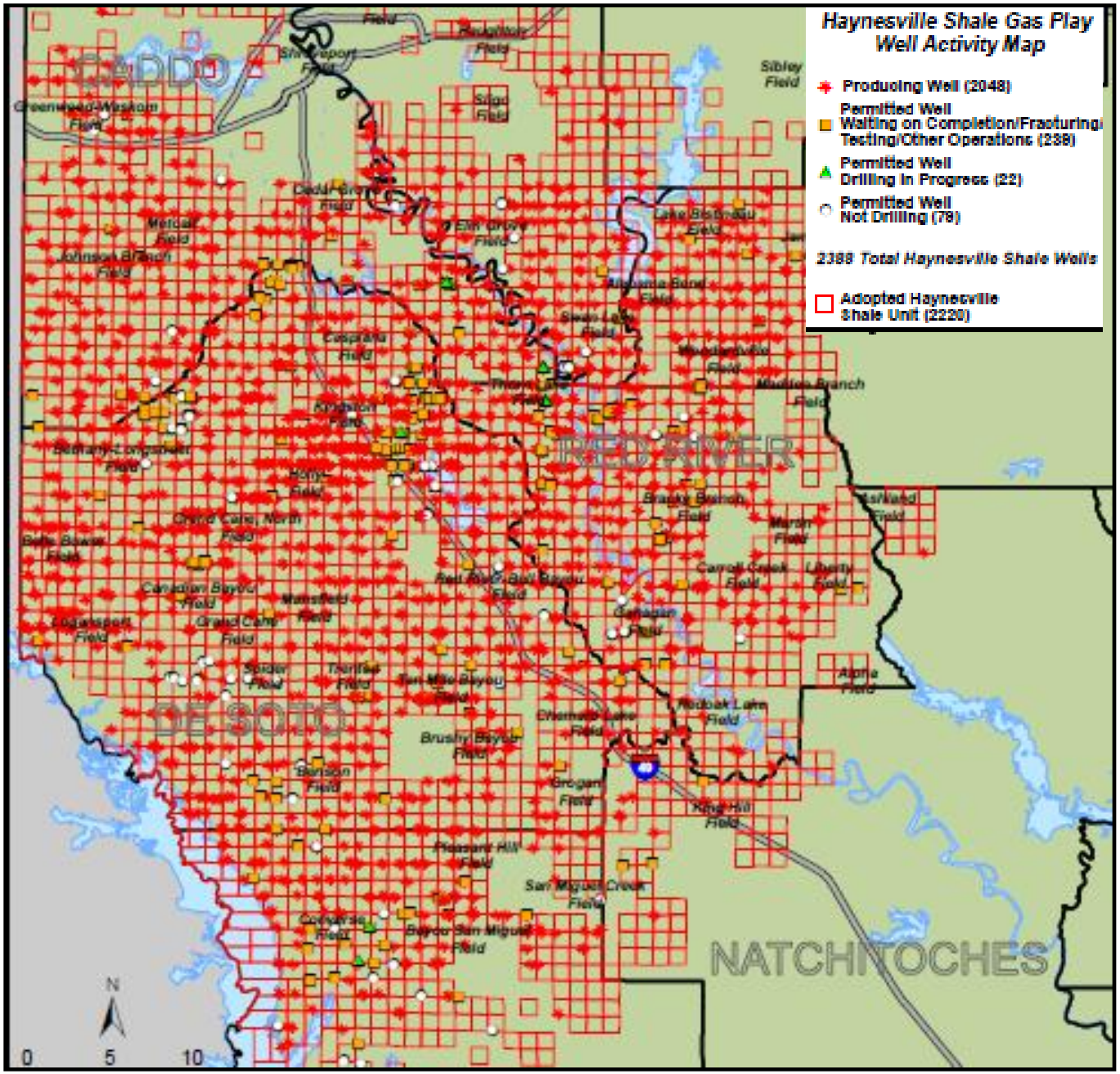
Introduction

- Oil and gas booms
- Haynesville shale gas boom
- Resilience and adaptive water management
- The Haynesville Model and results/resilience
- Tsunami of fear and ignorance
- Just the facts… Do we need a “new normal for peer review?”
- Is a “Rational Middle” possible?

Oil and Gas Booms – Public opinion of this natural resource was different in the past

Circa 1924

Louisiana Haynesville Shale Boom – 2007-2012

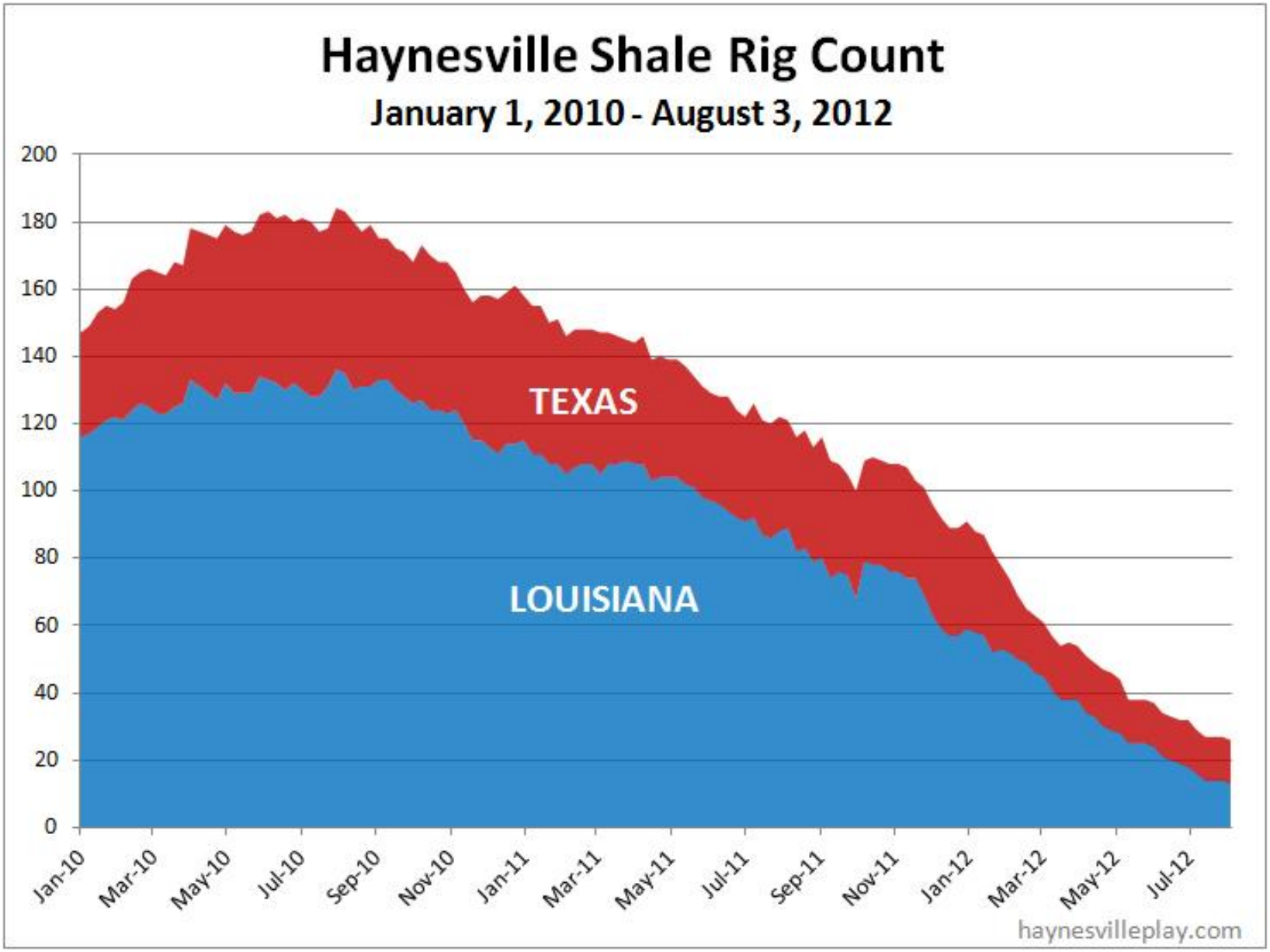


2042 Producing Wells

Estimated $26.6 Billion Well costs

Source: LADNR

Oil and Gas Boom Cycles



Natural Gas: 40 Rigs Can Maintain Haynesville Production Plateau

August 13, 2012
LA - 13 rigs
TX - 11 rigs

August 7, 2012 | Richard Zeits

The key argument often used by natural gas bulls is that the dramatic reduction in rig counts in the dry gas producing shales will translate into a rapid drop off in supply and lead to the price recovery toward the $5 level, and possibly higher. The Haynesville shale, where the rig count has declined from the peak of over 180 rigs two years ago to approximately 27 currently, is often presented as the most compelling evidence supporting that argument.

In less than four years since its discovery announcement, the Haynesville production went from zero to almost 7 Bcf per day, by some industry estimates, or over 10% of the total US natural gas production, demonstrating the exceptional productivity of this field as well as the scalability of the supporting operational infrastructure including oilfield services, gathering systems, and pipeline off-take. The rig count peaked at about 186 rigs during the summer of 2010 but has been in a steady decline ever since. There are currently approximately 27 rigs working in the play, about evenly split between the Louisiana and Texas portions of the play. Of these rigs, approximately 11 rigs, including 8 run by Anadarko are focusing on the liquids-rich part of the Haynesville, mostly in Panola County of Texas. The other approximately 16 rigs are targeting dry gas.

Resilience

"The capacity of a system
to experience shocks while retaining
essentially the same function,
structure, feedbacks, and therefore identity."

Adaptive Capacity

"is the capacity of a system to adapt if the environment where the system exists is changing."

Adaptive capacity is determined by :

- the ability of institutions and networks to learn, and store knowledge and experience
- creative flexibility in decision making and problem solving
- the existence of power structures that are responsive and consider the needs of all stakeholders.

Paradoxes of Management

"There have been many puzzling, paradoxical, failures of management of renewable resources"

- Sustainable designs driven by conservation interests can ignore the needs for a kind of economic development that emphasize synergy, human ingenuity, enterprise and flexibility.
- Those driven by economic and industrial interests can act as if the uncertainty of nature can be replaced with human engineering and management controls, or ignored altogether in deference to market dynamics.
- Those driven by social interests often presume that nature or a larger world present no limits to the imagination and initiative of local groups.

(adapted by P. Bunnell, 2002 from C. S. Holling, L. H. Gunderson and D. Ludwig, 2002)

Paradoxes of Management

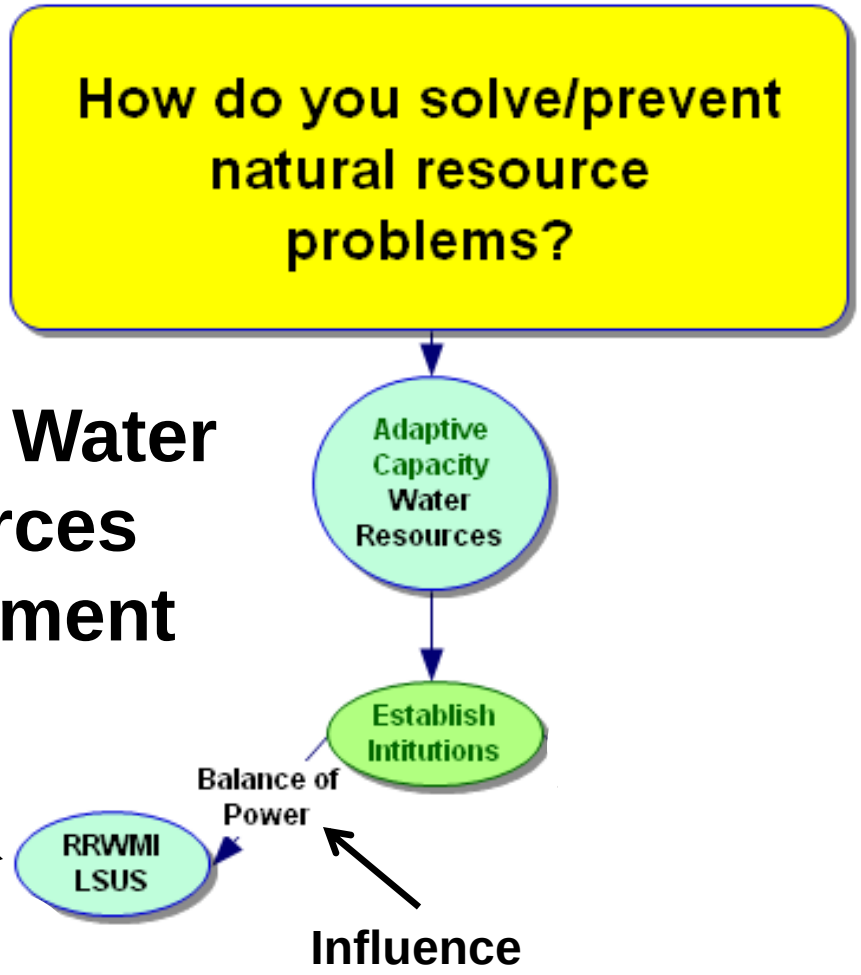
"There have been many puzzling, paradoxical, failures of management of natural resources"

- Sustainable designs driven by conservation interests can ignore the needs for a kind of economic development that emphasize synergy, human ingenuity, enterprise and flexibility.
- Those driven by economic and industrial interests can act as if the uncertainty of nature can be replaced with human engineering and management controls, or ignored altogether in deference to market dynamics.
- Those driven by social interests often presume that nature or a larger world present no limits to the imagination and initiative of local groups.

(adapted by P. Bunnell, 2002 from C. S. Holling, L. H. Gunderson and D. Ludwig, 2002)

The Haynesville Model

Adaptive Water Resources Management

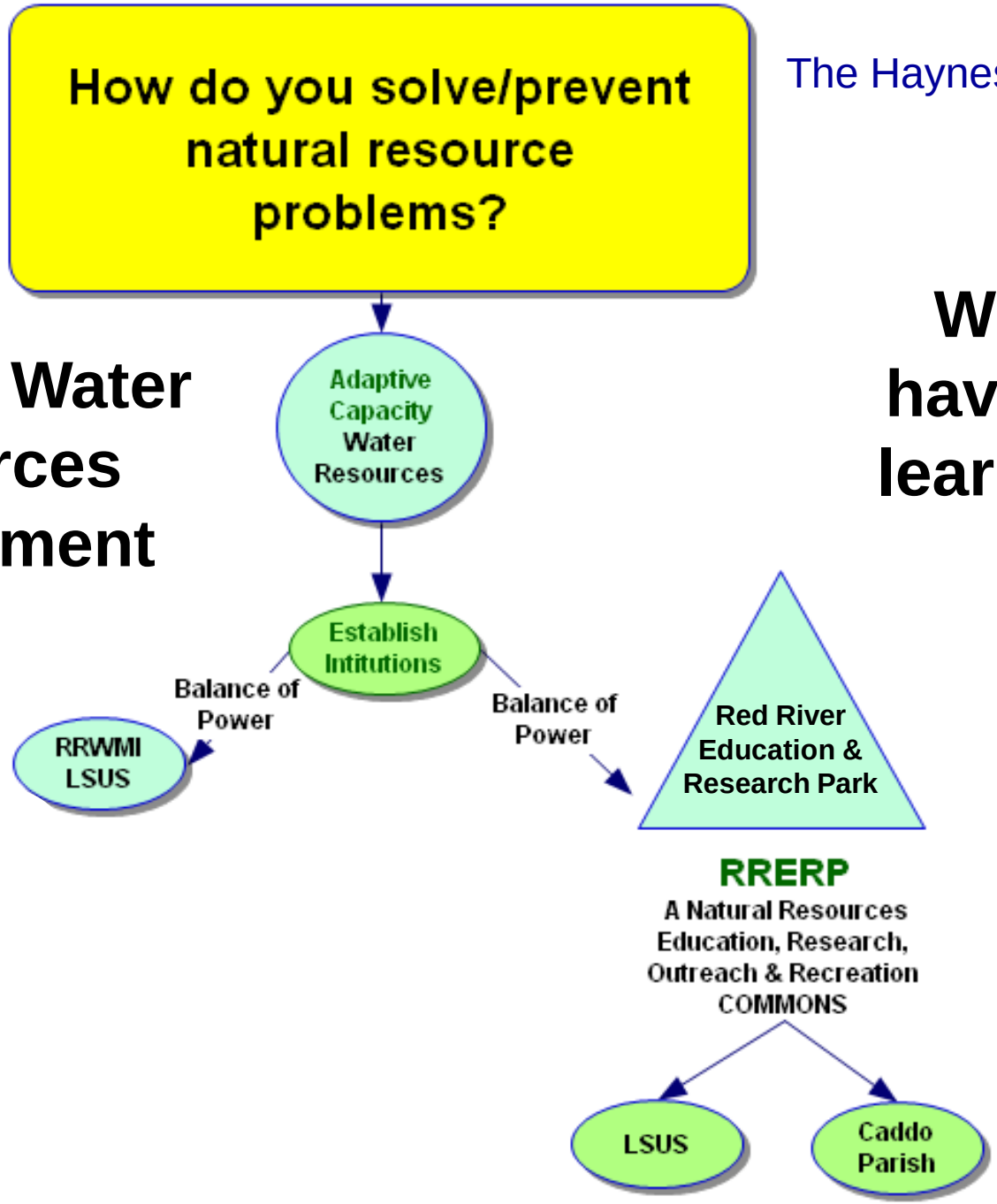


Red River Watershed Management Institute

What have we learned?

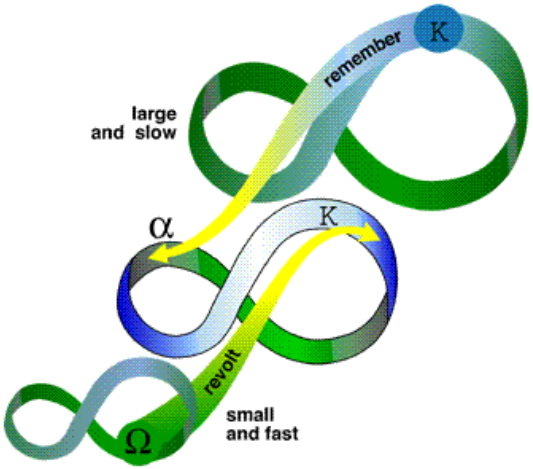
The Haynesville Model

Adaptive Water Resources Management

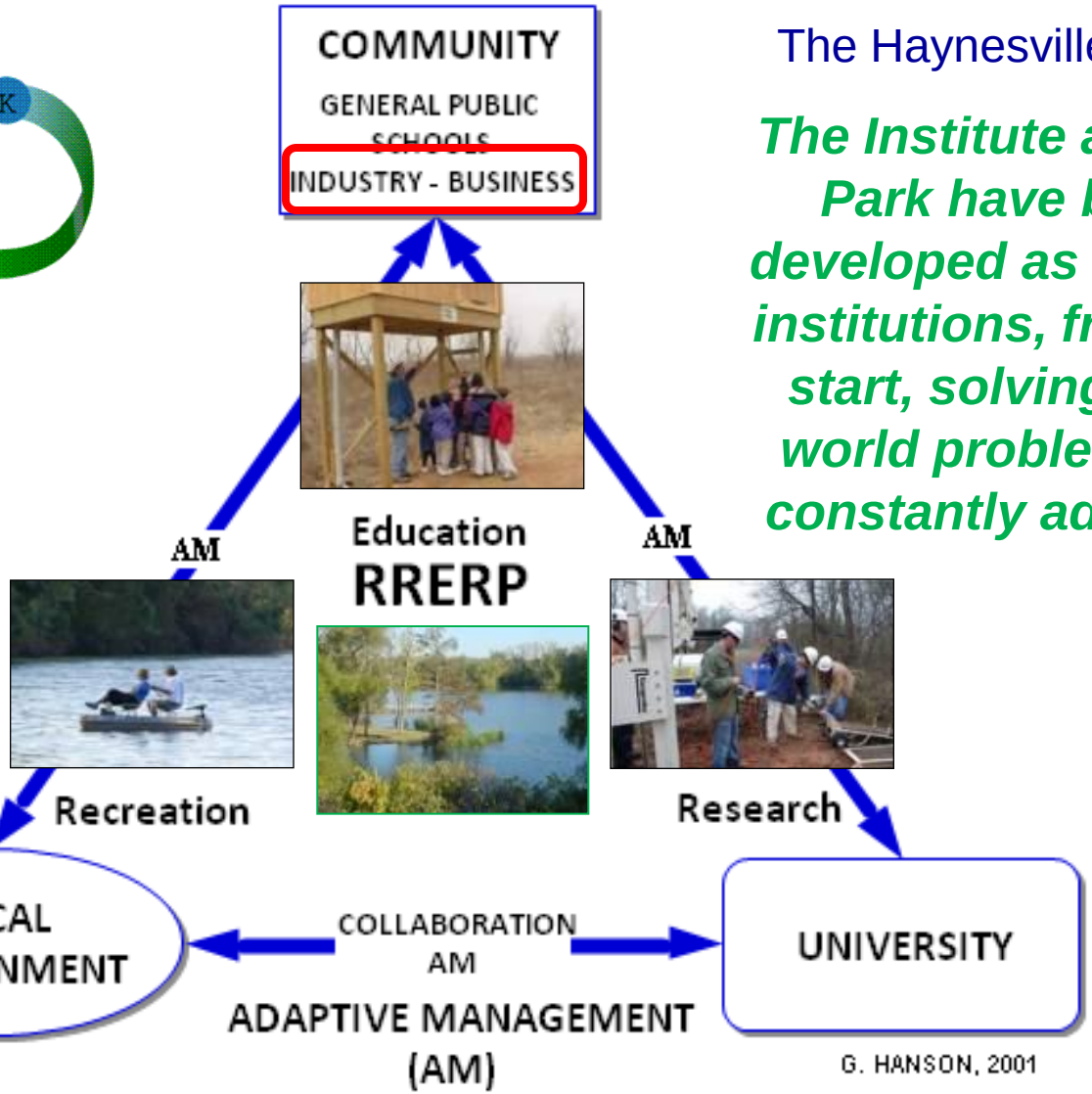


What have we learned?

Evolving Community-based Nature Education & Research Park Model (Red River Education & Research Park)



Hollings Adaptive cycles

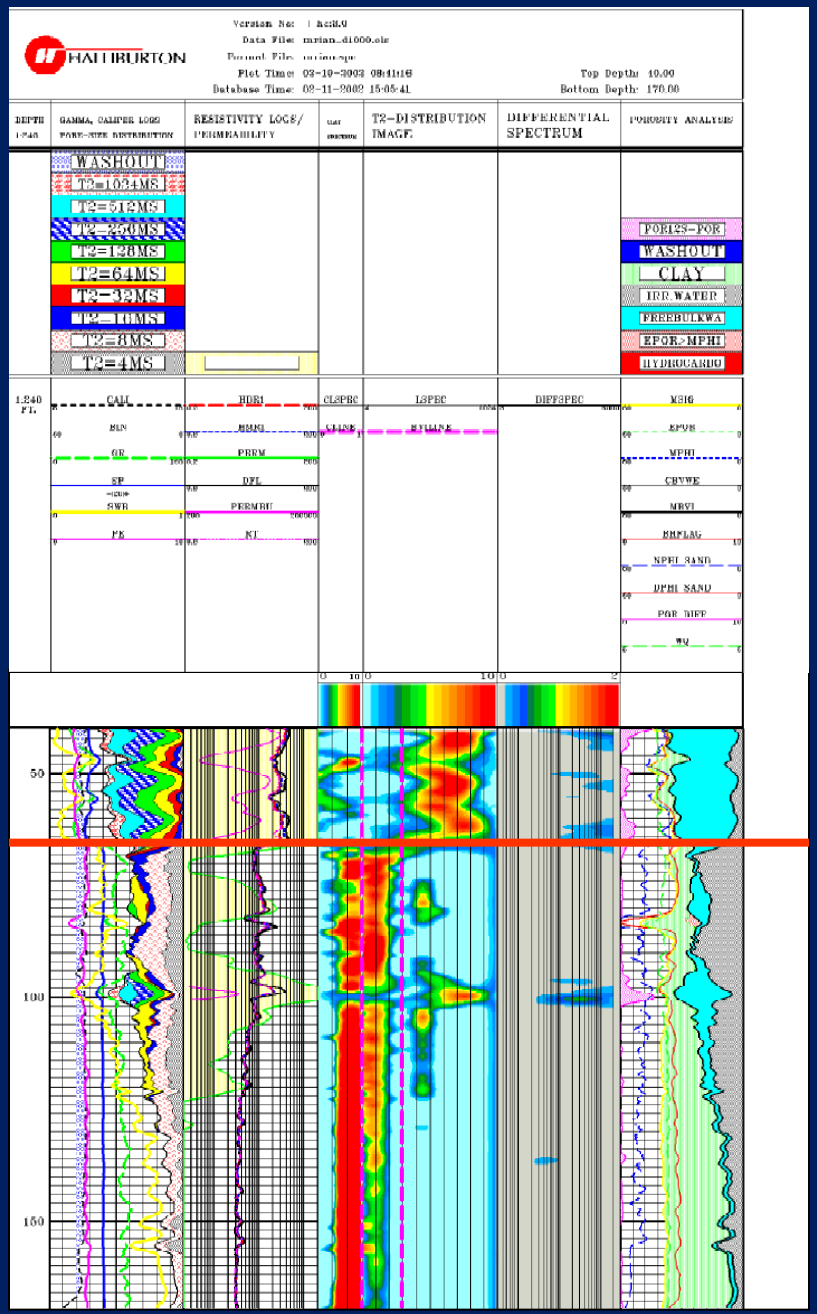


The Haynesville Model

The Institute and the Park have been developed as flexible institutions, from the start, solving real-world problems by constantly adapting

An adaptive model - Based on "Sense of Place" institution building

LSUS 001 Monitoring Well Project - Wilcox/Alluvial Aquifer



Research

Magnetic Resonance Imaging Log (MRIL)

Red River Alluvial Aquifer

Wilcox Aquifer

Industry/University Partnership

LSUS Research Park

Halliburton Logging Well

LSUS Red River Watershed Management Institute

Red River Education & Research Park

"Not scared of dirt, willing to work"

Using a suite of borehole logs to evaluate Red River Alluvial Aquifer & Carrizo-Wilcox Aquifer (Dan Buller, Halliburton Global Advisory Unconventional Reservoir Optimization)

LSUS students using Geoprobe to develop monitoring well in Red River Alluvial Aquifer

LSUS Red River Watershed Management Institute

Red River Education & Research Park

Phase I – Basic Water Sampling & Monitoring Instrumentation is Complete

Using [illegible]ogs to evaluate Red River Alluvial Aquifer & Carrizo-Wilcox Aquifer (Dan Buller, Halliburton Global Advisory Unconventional Reservoir Optimization)

LSUS students using Geoprobe to develop monitoring well in Red River Alluvial Aquifer

"Not scared of dirt, willing to work"

***SHELF**: **S**urface water, **H**ydrogeology, **E**nergy, **L**aboratory **F**ield site*

A Water- Energy Floodplain Field Laboratory

Phase 2 Involves the installation of additional monitoring equipment across transects of wells in the park. The placement of Aqua Troll Data loggers and Level Troll data loggers will allow us to collect water level and with the Aqua Trolls water quality data as well. This will provide a more complete profile of the Red River Alluvial Aquifer by allowing data collection at timed intervals and river to riparian wetlands to “upland.” Support and advice from Shell Oil.

***SHELF**: **S**urface water, **H**ydrogeology, **E**nergy, **L**aboratory **F**ield site*

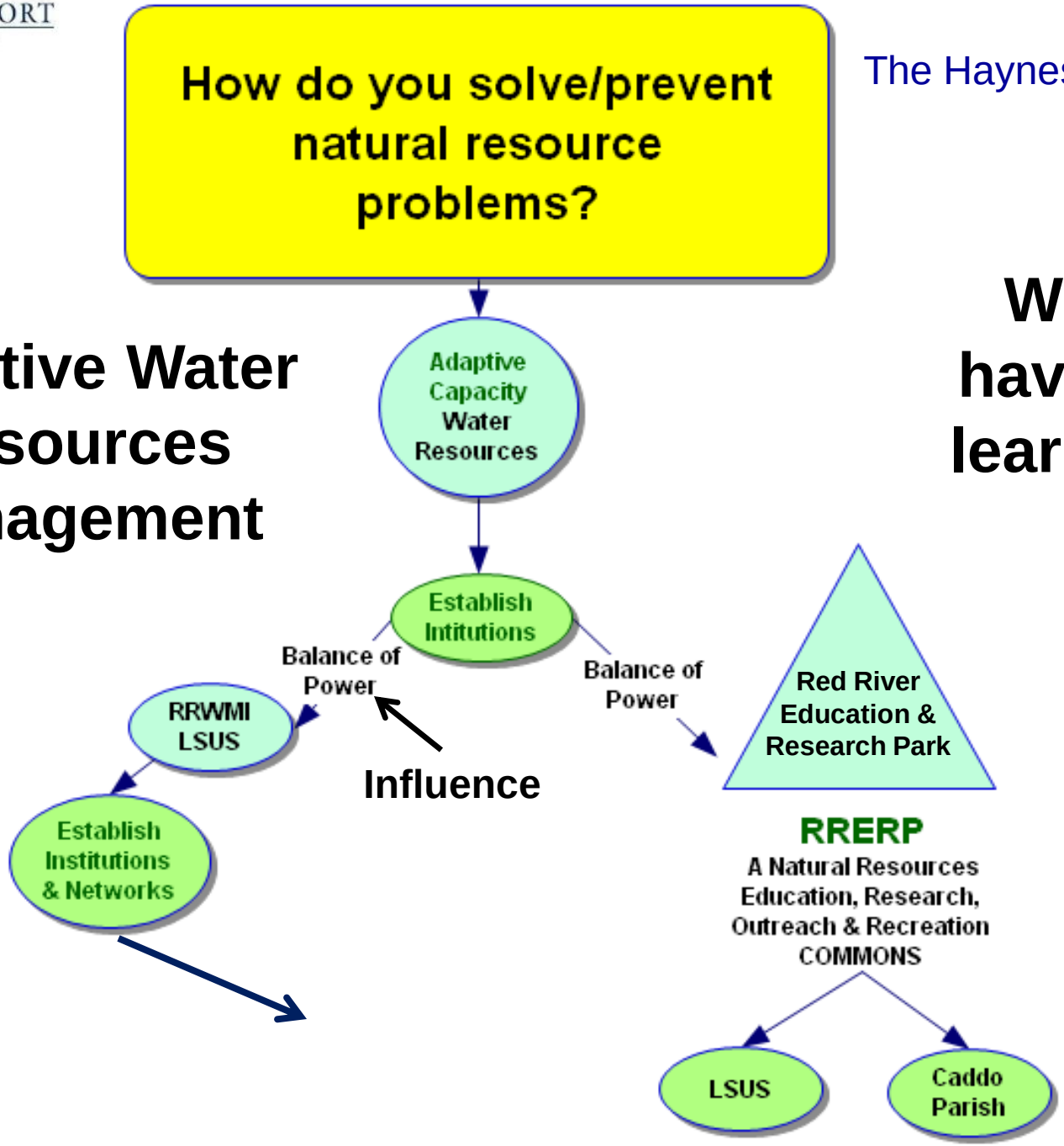
A Water- Er *aboratory*

Phase 2 Involv ditional monitoring eq cts of wells in the park. The ll Data loggers and L will allow us to collect wate ua Trolls water quality rovide a more complet er Alluvial Aquifer by allo timed intervals and s to “upland.” Support and advice from Shell Oil.

The Haynesville Model

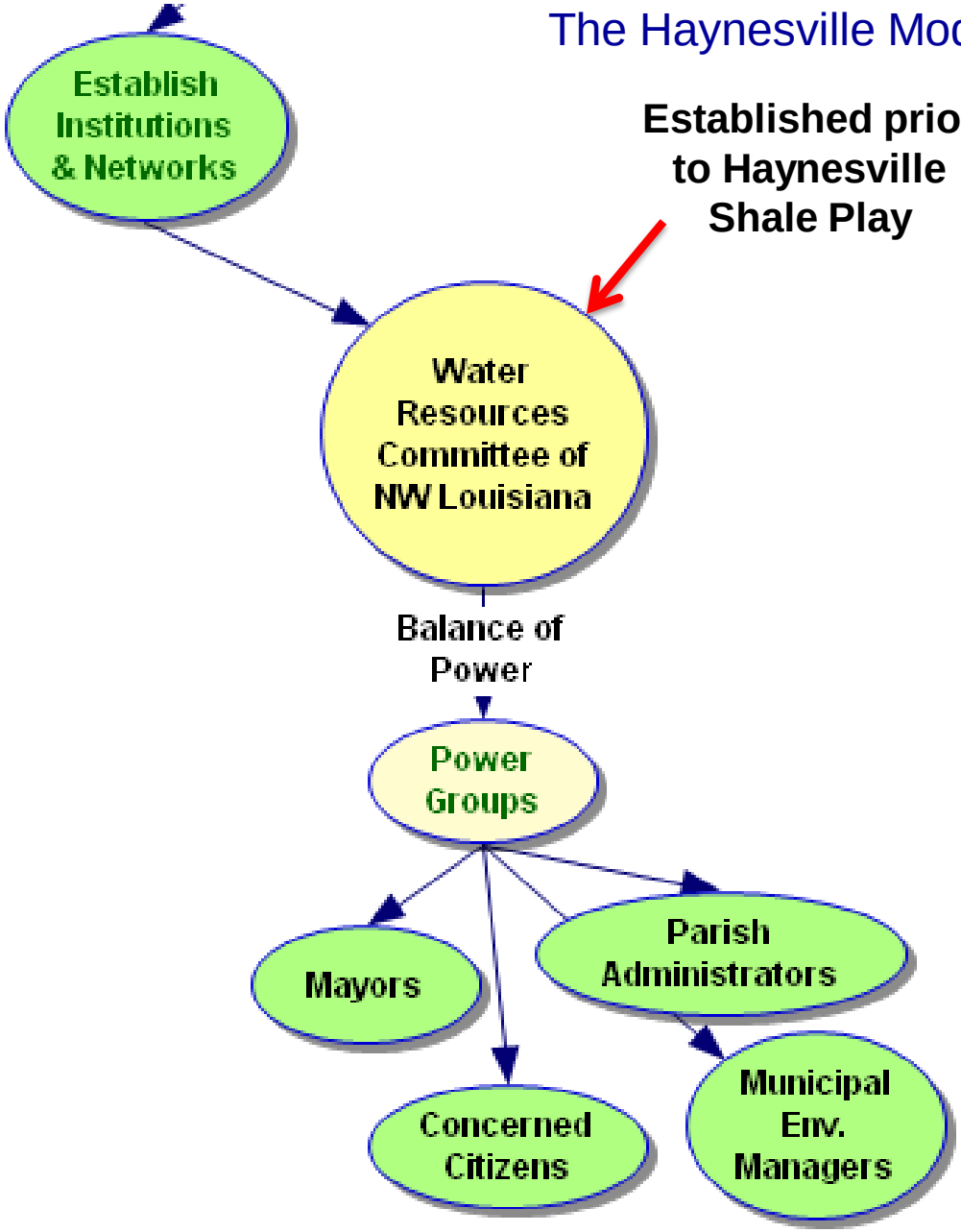
Adaptive Water Resources Management

What have we learned?



Adaptive Water Resources Management

The Haynesville Model



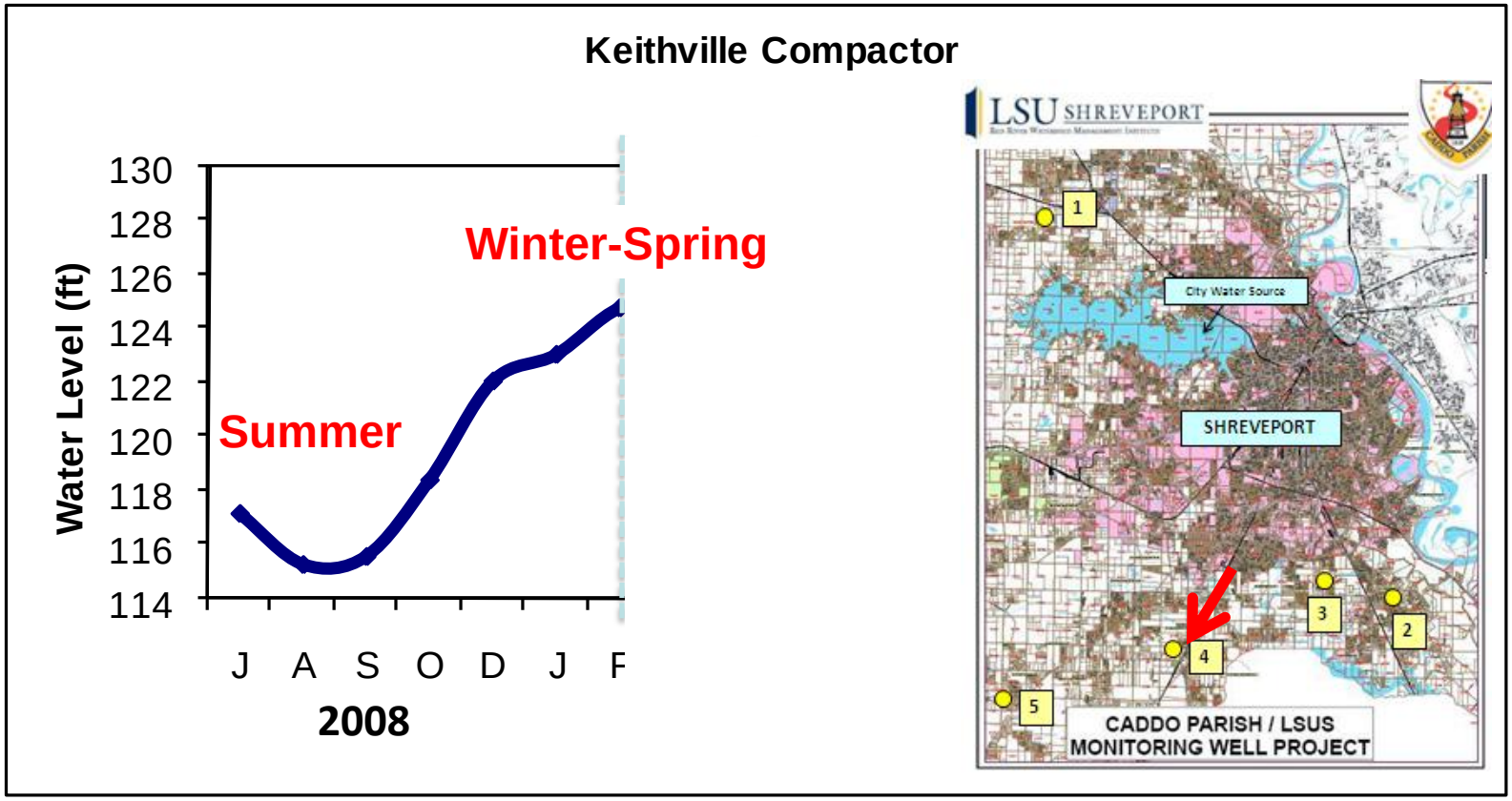
LSU SHREVEPORT
RED RIVER WATERSHED MANAGEMENT INSTITUTE

The Haynesville Model

Water Resources Committee of Northwest Louisiana Watershed Based Volunteer Committee

The Committee was formed by the Caddo Parish President, a concerned citizen & Director of the RRWMI. As WRCNL evolved, more issues arose, & it became more flexible & adapted to solve new challenges.

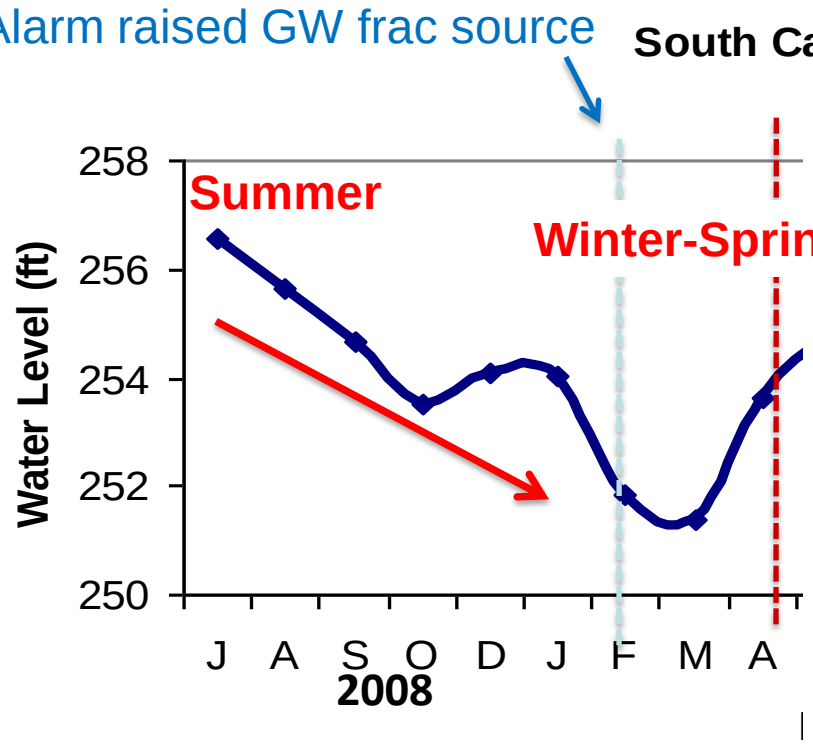
Caddo Parish/LSUS GW Monitoring



Typical Carrizo-Wilcox seasonally influenced water level curve (higher withdrawals in Summer)

Hanson and Lewis , 2010

Caddo Parish/LSUS GW Monitoring



This monitoring well was located near the early Haynesville producers.

The Parish, Office of Conservation and the Operators were shown the groundwater monitoring well levels

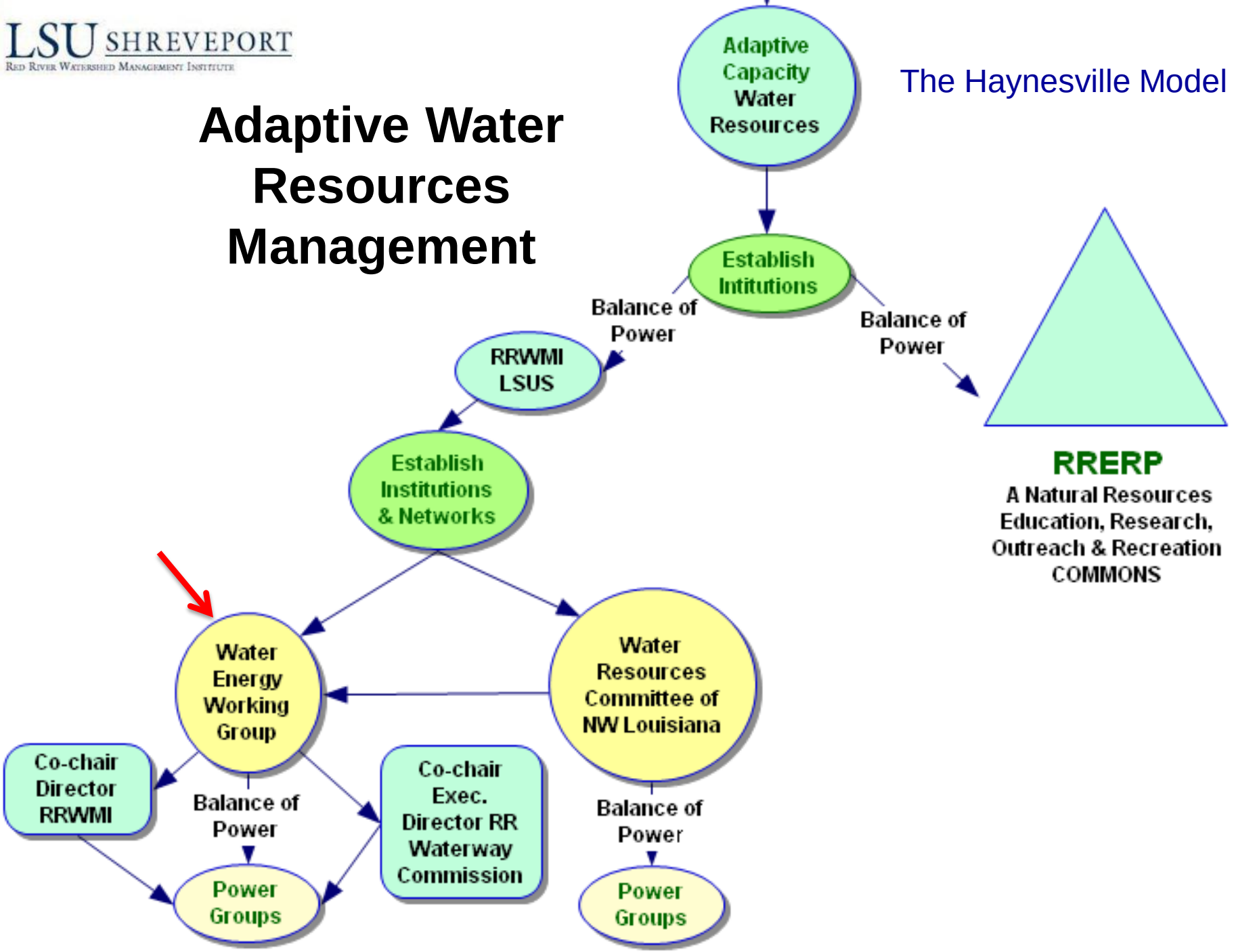
After drastic drop, water level appeared to be rebounding as operators voluntarily began to switch to mostly surface water for hydraulic fracturing

Hanson and Lewis , 2010

LSU SHREVEPORT
Red River Watershed Management Institute

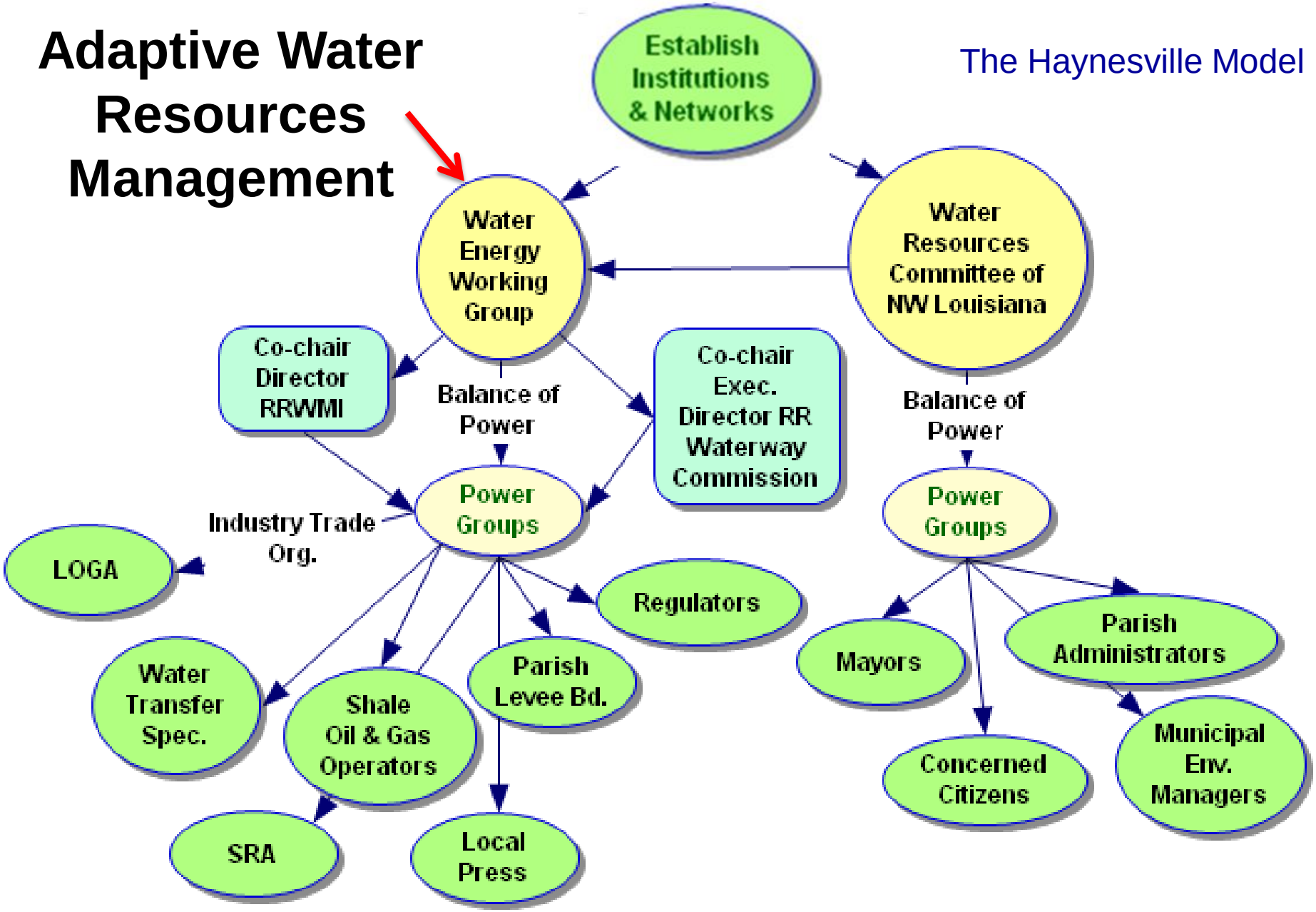
The Haynesville Model

Adaptive Water Resources Management



Adaptive Water Resources Management

The Haynesville Model



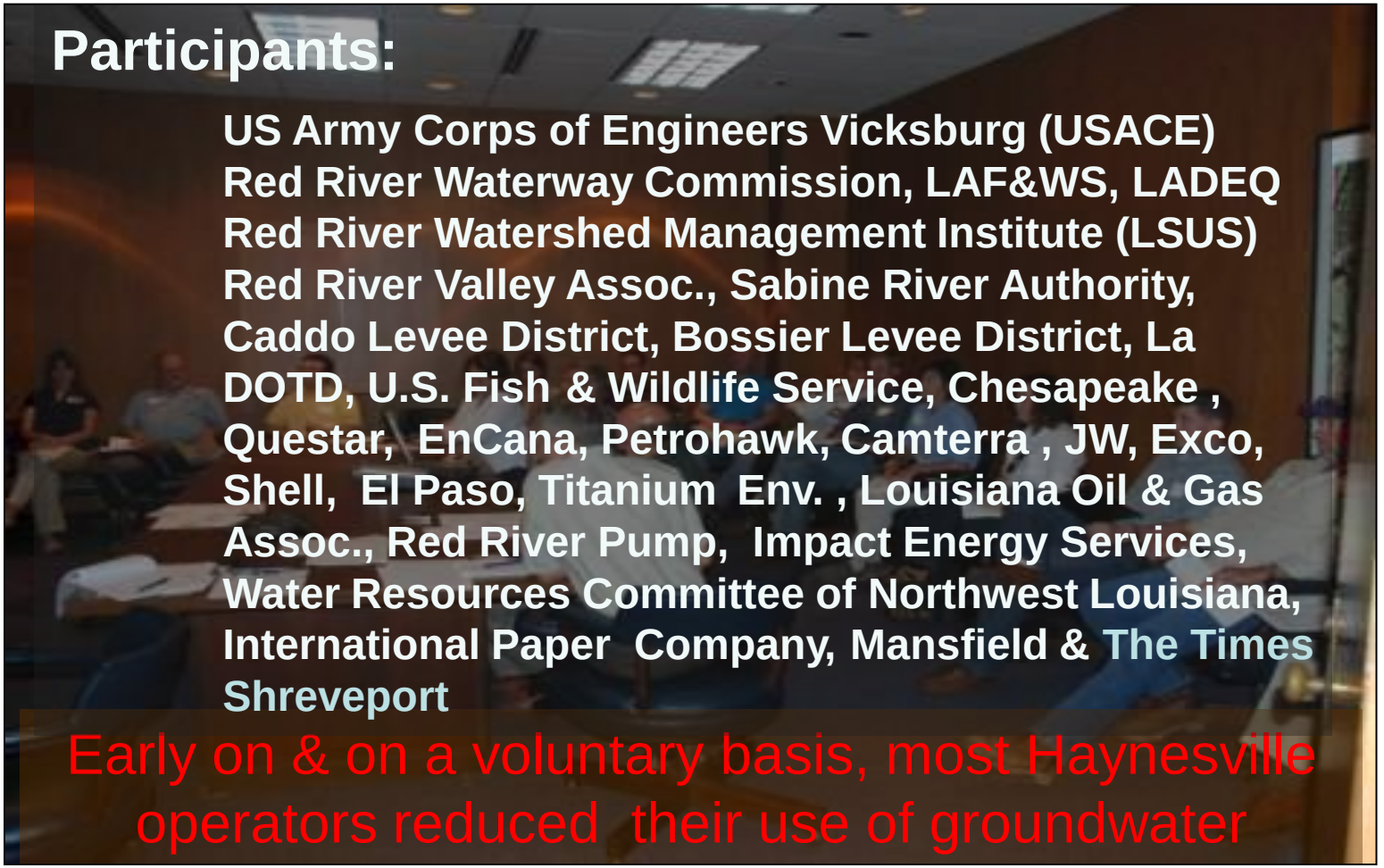
Water Energy Working Group – Meeting at LSU Shreveport

WG became more flexible & adapted to issues before or as they arose

Co-chairs: Directors of Red River Watershed Management Institute & Red River Waterway Commission

Water Energy Working Group – Meeting at LSU Shreveport

WG became more flexible & adapted to issues before or as they arose



Co-chairs: Directors of Red River Watershed Management Institute & Red River Waterway Commission

LSU SHREVEPORT
Red River Watershed Management Institute

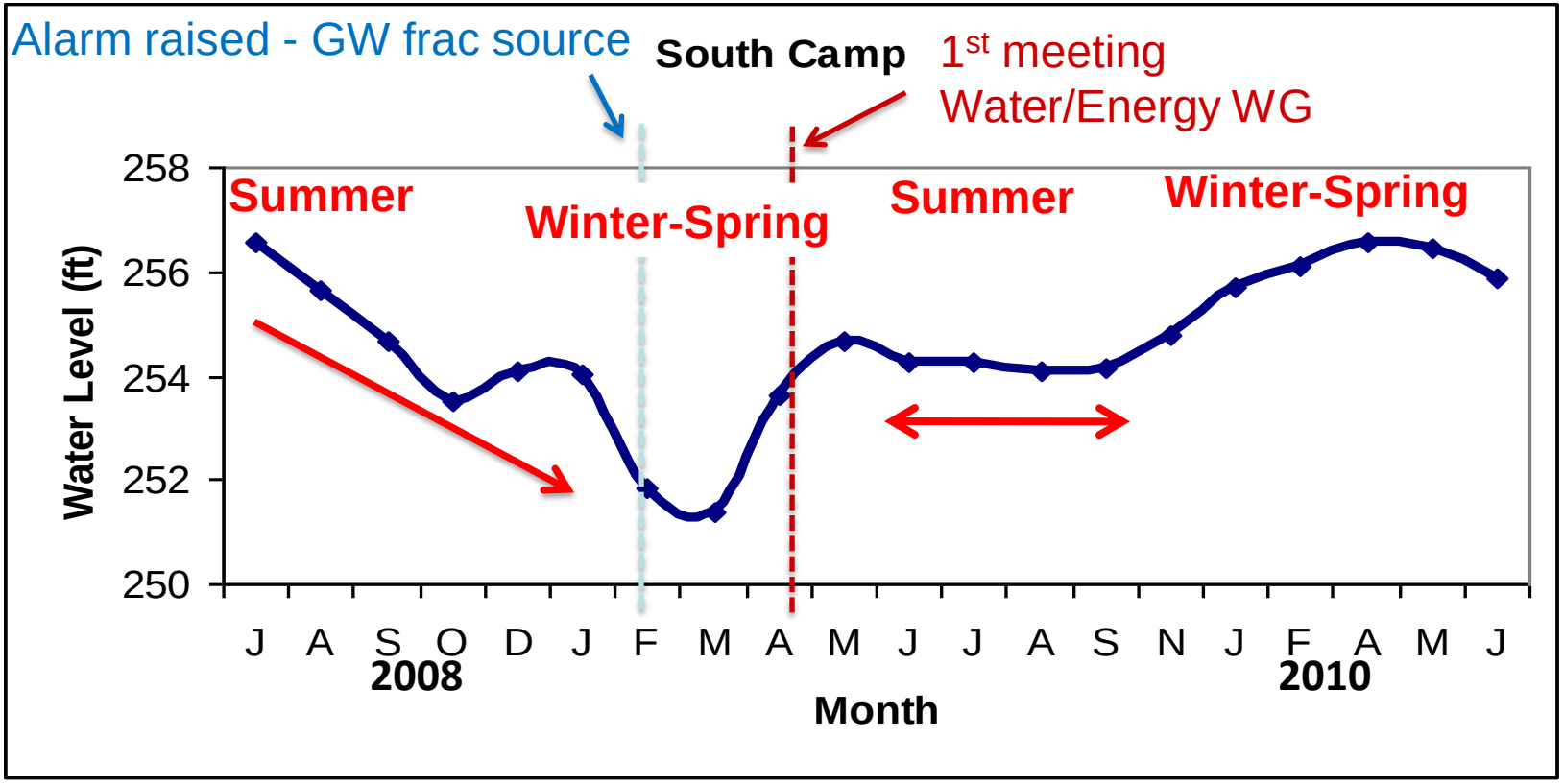
Water Energy Working Group

Critical Solutions to protect our water resources

BMP's must be utilized throughout the Life Cycle of the well

- Building location, roads
- Drilling
- Completion
- Production
- Reclamation

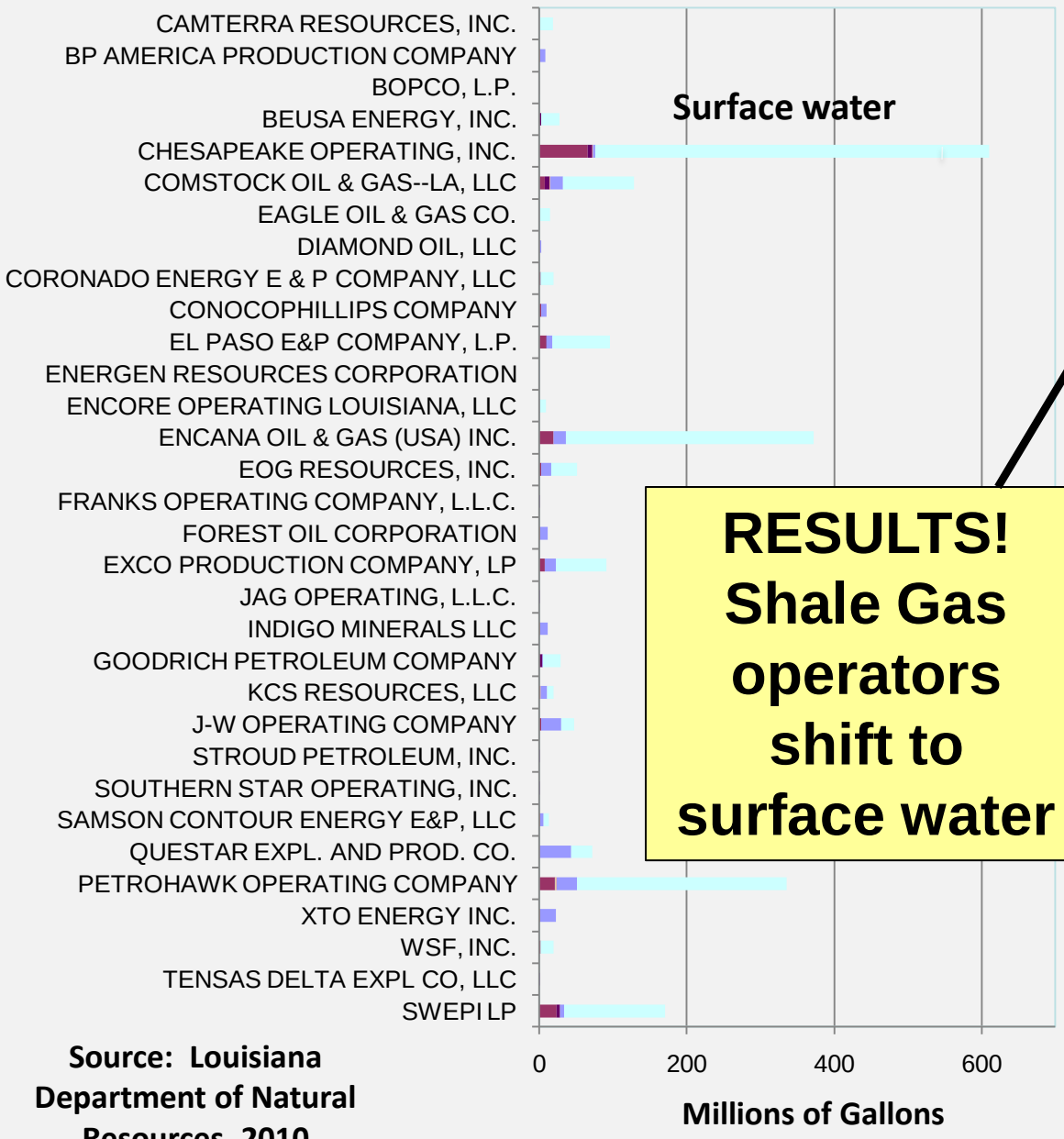
Caddo Parish/LSUS GW Monitoring

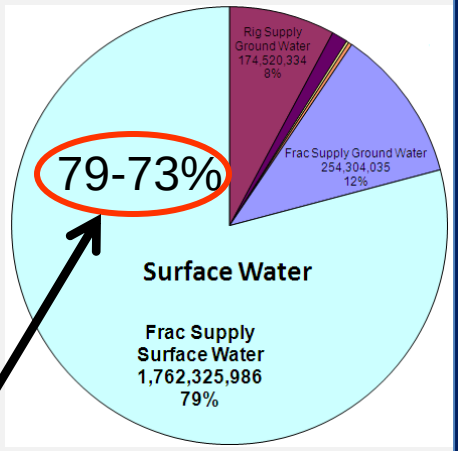


Water level flattened during summer 2009 and hydrograph appeared to return to a normal level with peak in Winter-Spring 2010 in this area of heavy drilling & hydraulic fracturing

Hanson and Lewis , 2010

Haynesville WH-1 Form - Water Volumes by Company





RESULTS! Shale Gas operators shift to surface water

- Rig Supply Ground Water
- Rig Supply Surface Water
- Other Ground Water
- Other Surface Water
- Frac Supply Ground Water
- Frac Supply Surface Water

Source: Louisiana Department of Natural Resources, 2010

Since Oct. 2009

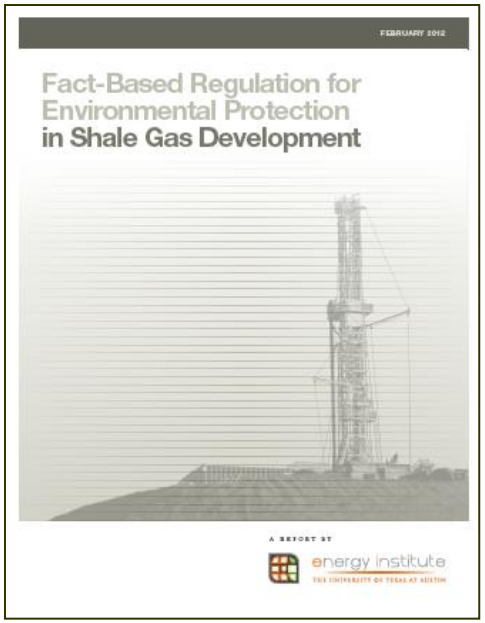
The Energy Institute, University of Texas Report

For the nation as a whole, the attitudes were found to be uniformly about two-thirds negative.

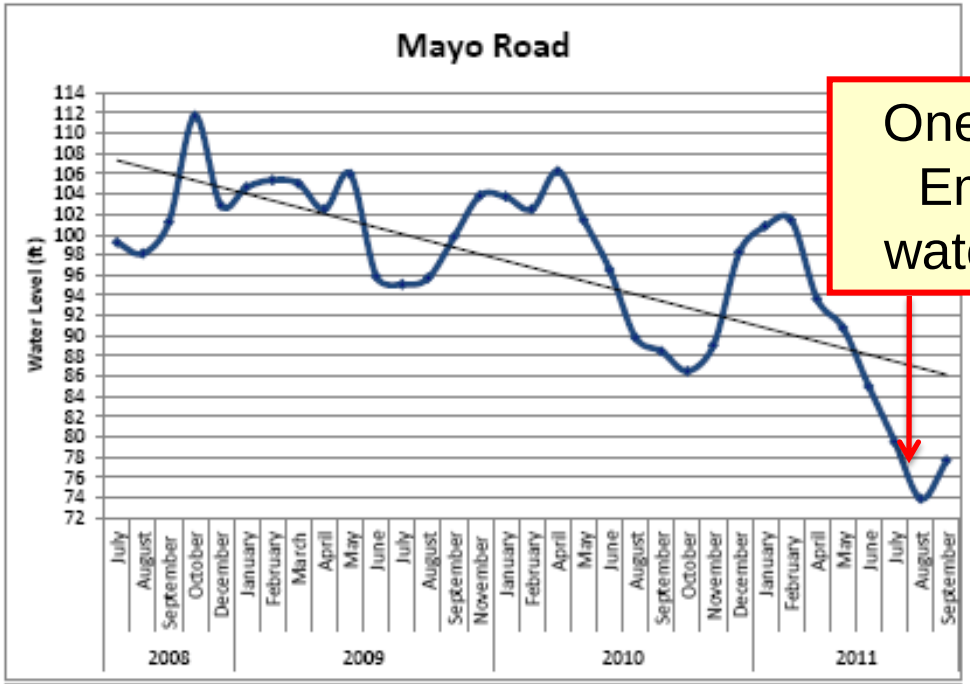
	Negative	Neutral	Positive
National Newspapers (3)	64%	25%	12%
Metropolitan Newspapers (10)	65%	23%	12%
National Television & Radio (7)	64%	19%	18%
Metropolitan Television (18)	70%	27%	3%
Online News (1)	63%	30%	7%

The local media coverage for each of the shale areas shows similarity to the national results for the Barnett and Marcellus shale areas; the Haynesville area may be anomalous because only one newspaper and one television source were available.

	Negative	Neutral	Positive
Barnett Shale Area			
Newspapers (3)	79%	6%	16%
Television (6)	70%	30%	0%
Marcellus Shale Area			
Newspapers (6)	67%	25%	8%
Television (11)	74%	20%	6%
Haynesville Shale Area			
Newspapers (1)	8%	46%	46%
Television (1)	0%	100%	0%



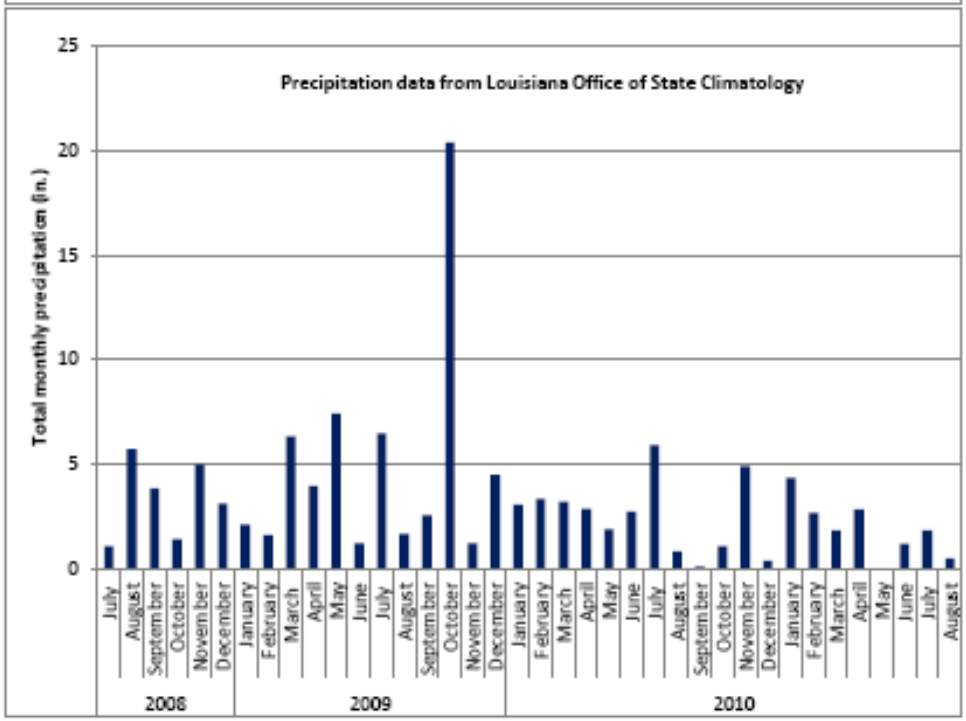
2011 Drought



One week before a Groundwater Emergency was declared, the water levels were checked again

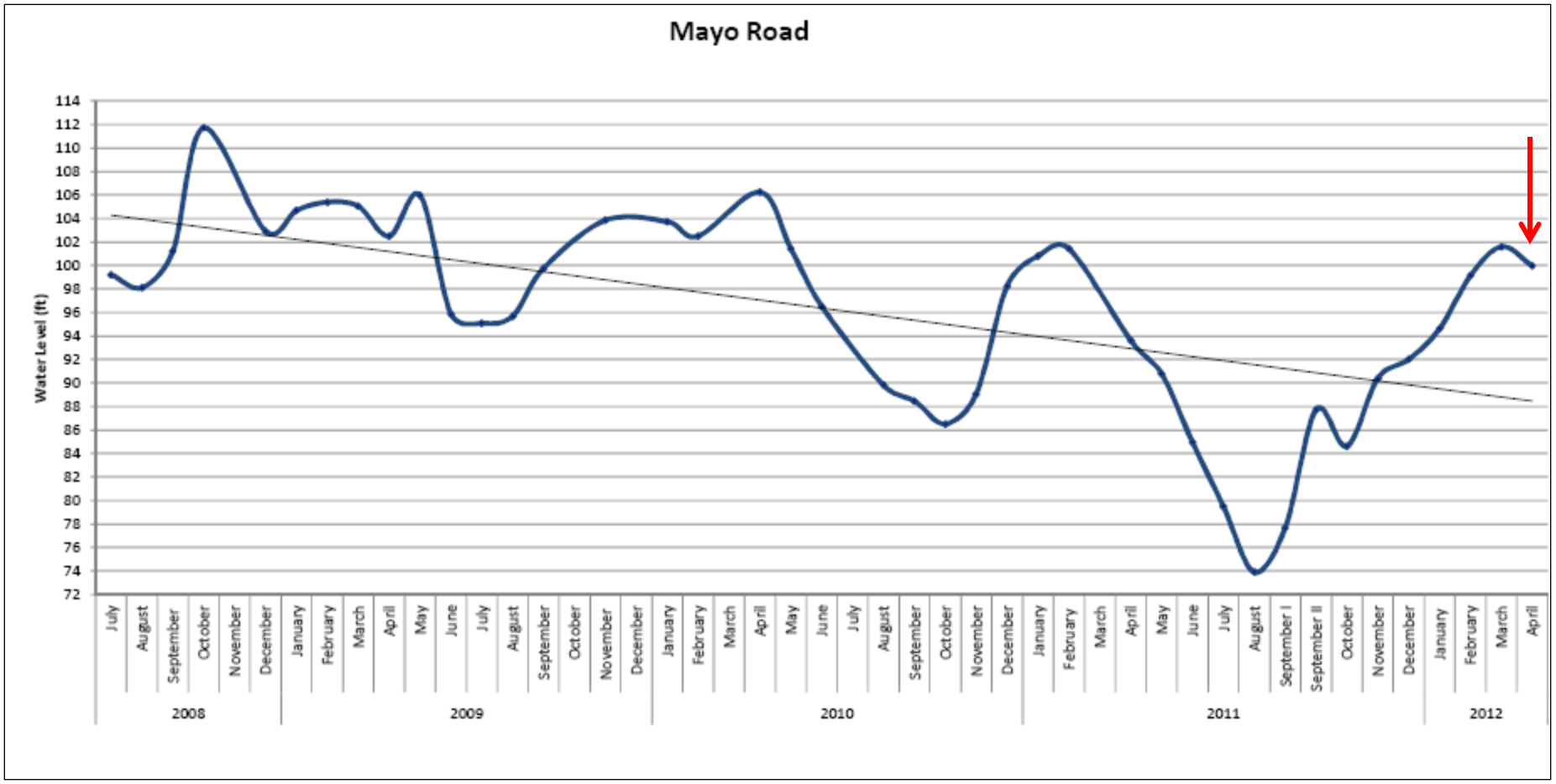
Mayo Road well had declined another 5.6 feet

After Groundwater Emergency Declaration was in place for 3 weeks, water levels were checked again. The Mayo Road well water level had risen 3.7 feet!



Water level dropped 34 ft. in 3 yrs.

April 29, 2012 Water Level



The Louisiana DNR Groundwater Emergency Declaration is still in place (May 2012)

Potential Groundwater Contamination
(Reality vs Perception)

Activists & some scientists are asserting that there has been groundwater contamination…

- Caused by shale gas Hydraulic Fracturing?
- Could the problem be landscape change? NIMBY?
- The desire to stop the use of fossil fuels? GHG's?
  - Slow development of alternate energy sources?
- Industry has a bad reputation?
- The public deserves the facts!

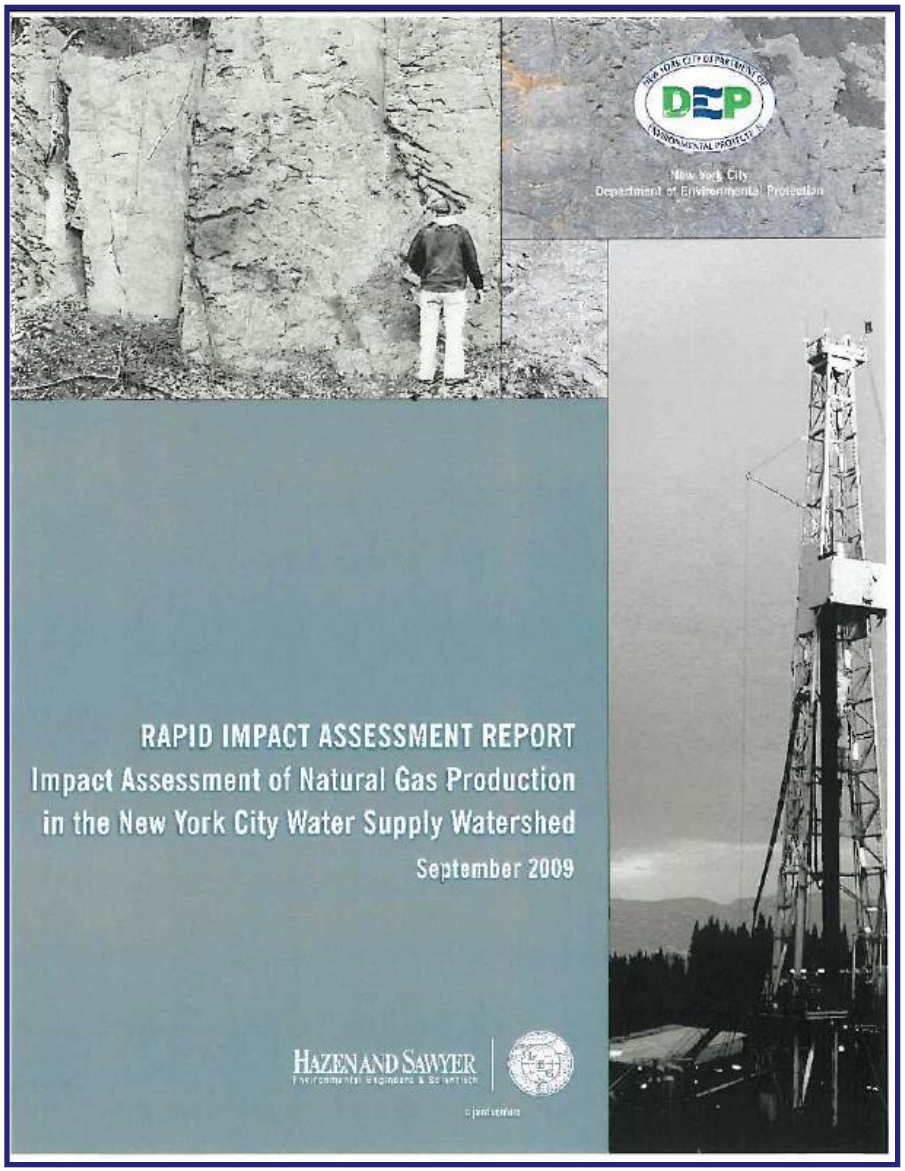
Workshop - Baltimore, Maryland (Fall 2010)

16 Expert Participants

Water Research Foundation (WaterRF)
Workshop on Natural Gas Development Issues for Drinking Water Utilities
Participant List

Name	Organization Name	Type of Organization
Technical Experts		
Scott Anderson	Environmental Defense Fund	NGO - Environmental advocacy
J. Daniel Arthur	ALL Consulting	Consultant / service provider
Tzahi Cath	Colorado School of Mines	University research
Kevin Fisher	Pinnacle Technologies	Consultant / service provider
Seth Guikema	Johns Hopkins, formerly of Texas A&M	University research
Gary Hanson	Red River Watershed Management Institute, Louisiana	NGO - Watershed management
Tom Hayes	Gas Technology Institute	Private sector research
Bill Kappel	U.S. Geological Survey	Federal research
Joe Lee	Pennsylvania Dept of Environmental Protection	Regulator - State
Matt Mantell	Chesapeake	Gas development company
J.P. Nicot	University of Texas Austin	University research
Chad Pindar	Delaware River Basin Commission	Regulator - Regional
Robert Puls	USEPA	Regulator - Federal
Dan Soeder	USDOE NETL	Federal research
John Veil	Argonne National Lab	Federal research
Lori Wrotenbery	Oklahoma Corporation Commission	Regulator - State

Water Research Foundation Hydraulic Fracturing Expert Workshop, Baltimore, Maryland



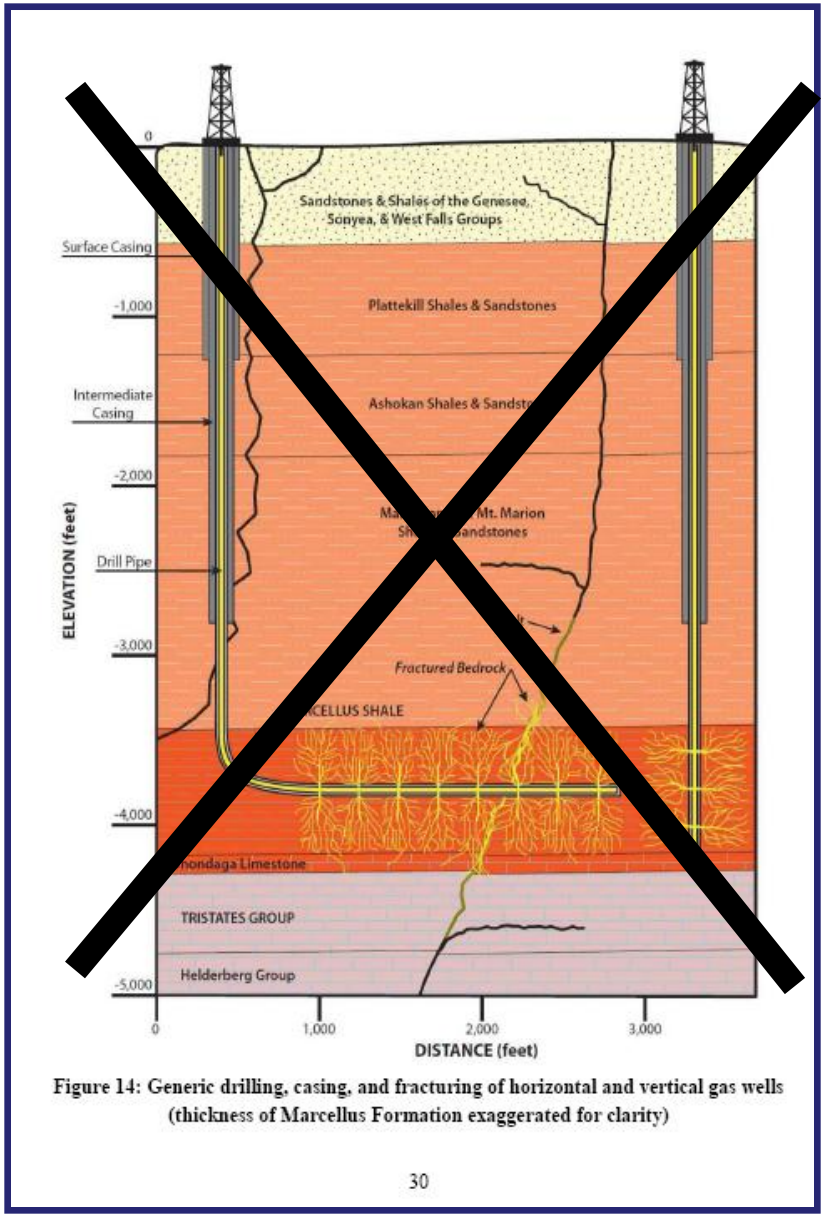


Figure 14: Generic drilling, casing, and fracturing of horizontal and vertical gas wells (thickness of Marcellus Formation exaggerated for clarity)

Water Research Foundation Hydraulic Fracturing Expert Workshop, Baltimore, Maryland

All Sides of the Hydraulic Fracturing Issue Must Recognize & Utilize The Best Science & Technology Available

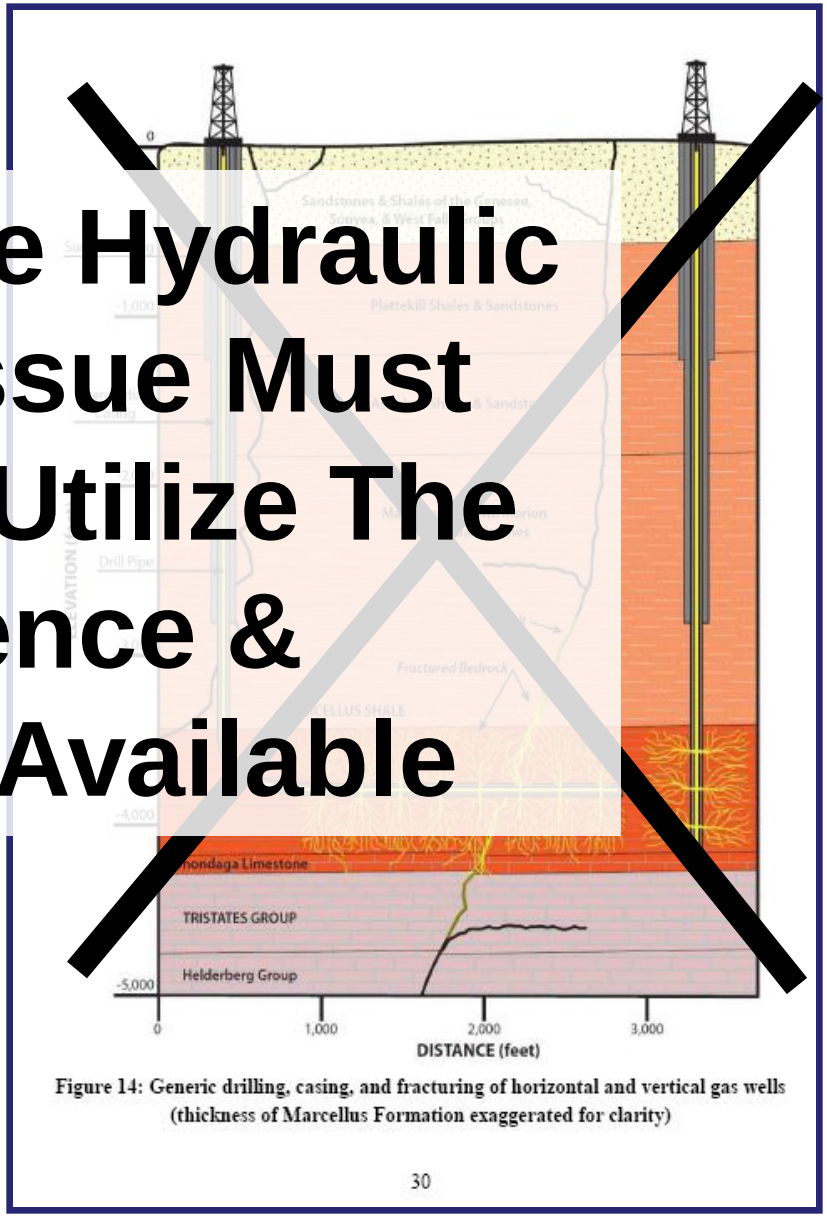


Figure 14: Generic drilling, casing, and fracturing of horizontal and vertical gas wells (thickness of Marcellus Formation exaggerated for clarity)

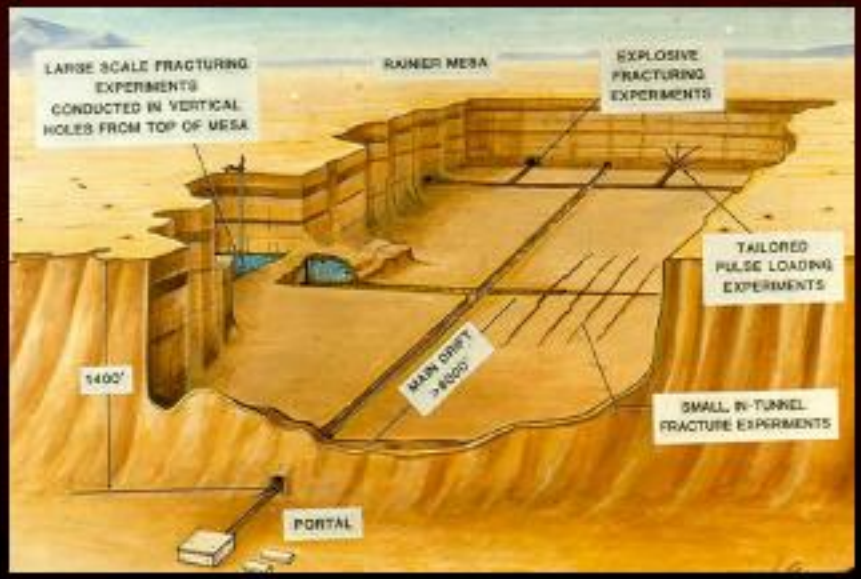
30

Water Research Foundation Hydraulic Fracturing Expert Workshop

Subsurface Session - Kevin Fisher (seated) now with Flotek, Dr. Seth Guikema standing (Johns Hopkins Risk Engineering)

Experiments to See and Touch Hydraulic Fractures

- **Minebacks**
  - Nevada Test Site
  - Coalbed Methane in AL
- **Fracture core-throughs**
  - Multi-well experiment (MWX)
  - M-Site
  - Mounds

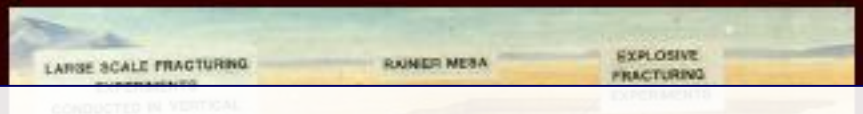


Mineback - Physical excavation of the rock to observe the fracture directly)

Geologic discontinuities, such as joints, faults, and bedding planes, can significantly affect the overall geometry of hydraulic planes, can significantly affect the overall geometry of hydraulic fractures. This can occur by arresting the growth of the fracture, increasing fluid leakoff, hindering proppant transport, and enhancing the creation of multiple fractures.

Warpinski & Teufell, 1987

Experiments to See and Touch Hydraulic Fractures



- Minebacks
  - Nevada Test Site
  - Colorado School of Mines
- Multiwell experiment (MWX)
  - M-Site
  - Mounds

This DOE Research is an Excellent Educational Tool to Inform the Public, Local Officials, NGO's and the Ever-Growing List of Government Committees/Studies Investigating Hydraulic Fracturing Operations

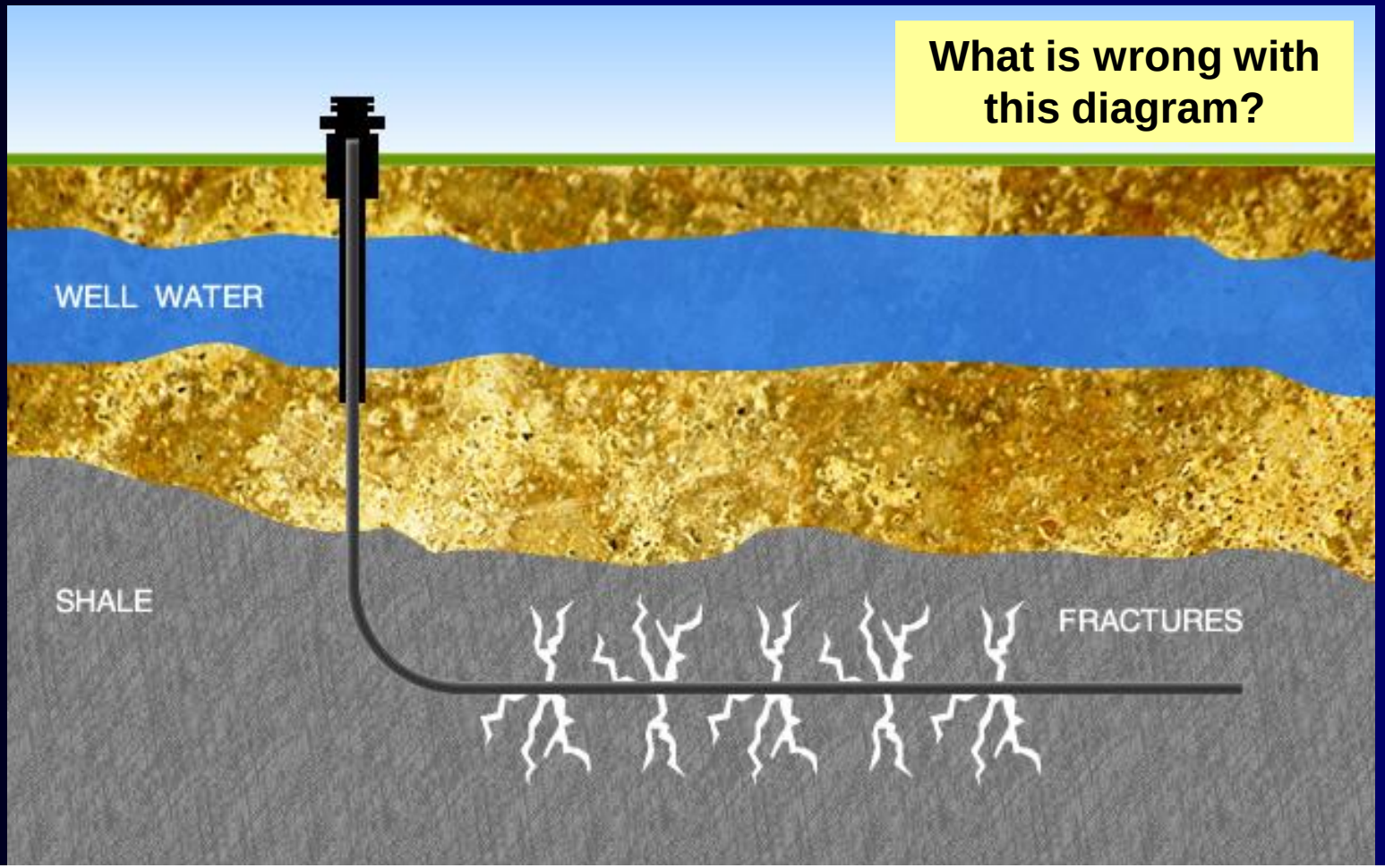
to observe the fracture directly)

Geologic discontinuities, such as joints, faults, and bedding planes, can significantly affect the overall geometry of hydraulic fractures. This can occur by arresting the growth of a propagating fracture, offsetting the fracture, changing the dominant transport, and enhancing the creation of multiple fractures.

Warpinski & Teufell, 1987

To be absolutely clear, I am in no way making light of the horrendous earthquake and tsunami that occurred in Japan on March 21st 2011

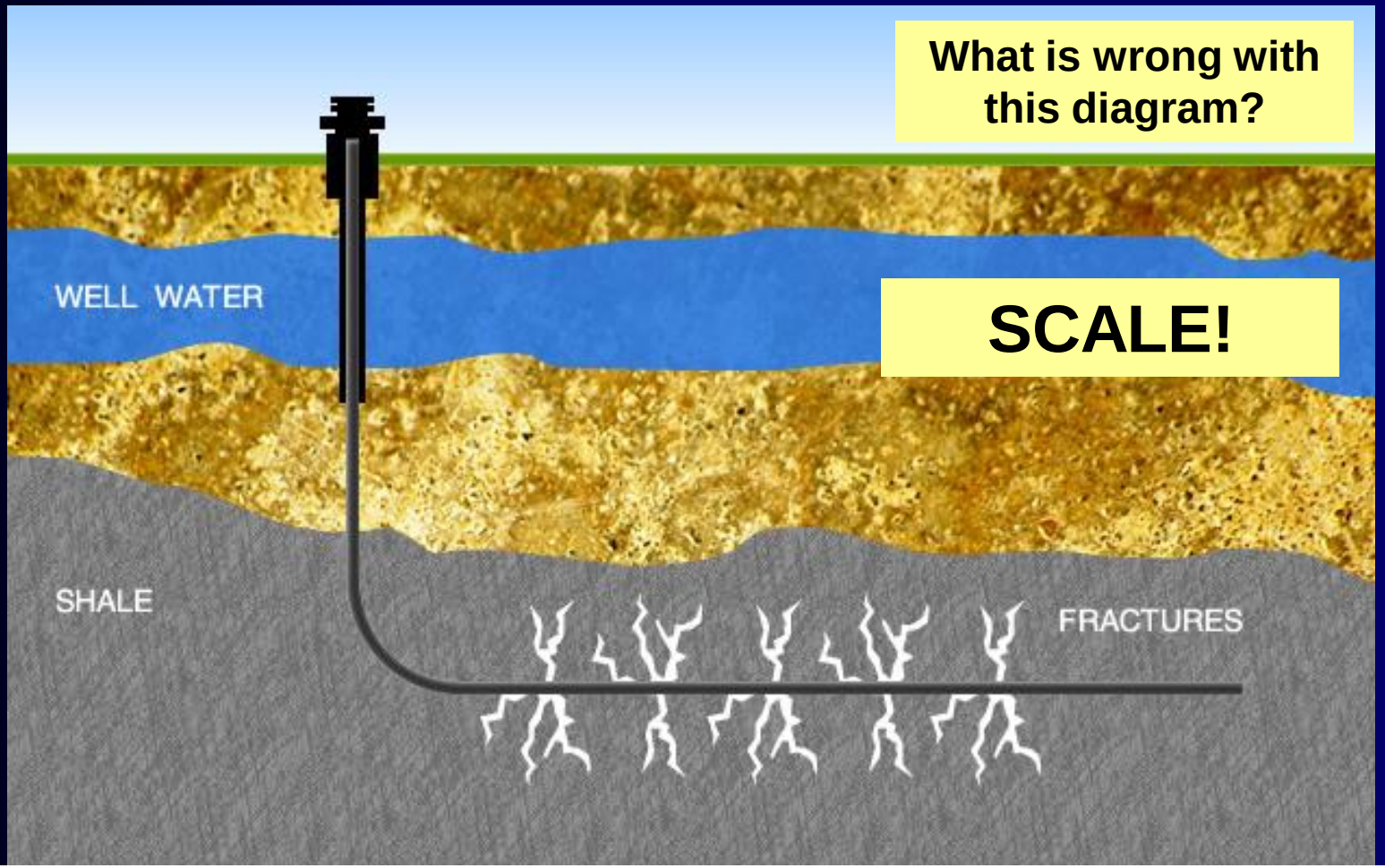
Inaccurate Representations of Hydraulic Fracturing (HF) and Groundwater



Idealized cross section of horizontal drilling and creation of fractures (fracing) for increasing oil and gas recovery.

http://today.uconn.edu/wp-content/uploads/2011/12/fracking.jpg

Inaccurate Representations of Hydraulic Fracturing (HF) and Groundwater



Idealized cross section of horizontal drilling and creation of fractures (fracking) for increasing oil and gas recovery.

http://today.uconn.edu/wp-content/uploads/2011/12/fracking.jpg

Landscape Change – Gas Field in East Texas

Most of these well pads are not Haynesville Shale horizontal wells, but are shallower Cotton Valley wells drilled vertically. Horizontal Haynesville wells typically need only a 7-11 acre pad sites to drill and complete multiple wells.

Unfortunately many anti-fracing blog sites show images of these older high-density drilled fields as a bad example of what shale drilling (low density) will look like in their area.

AP

THE BIG STORY

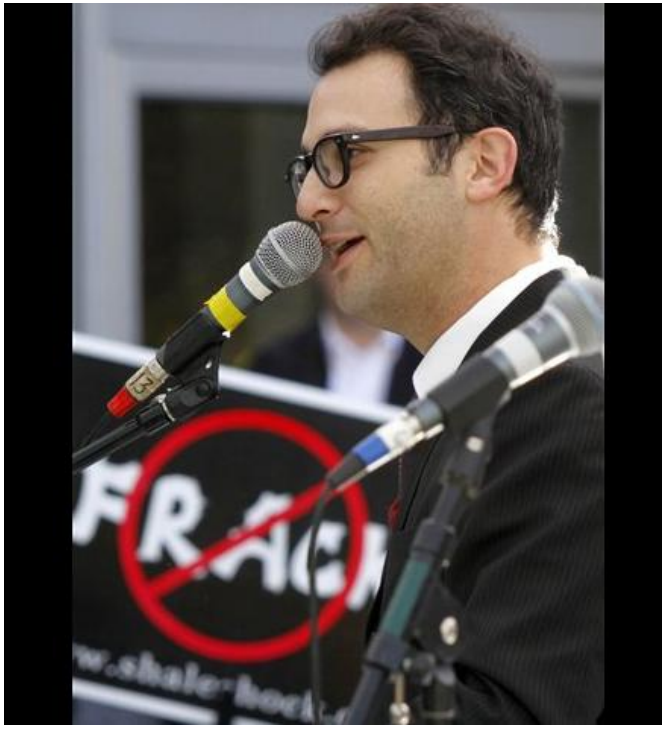
EXPERTS: SOME FRACKING CRITICS USE BAD SCIENCE

By KEVIN BEGOS — Jul. 22 6:44 PM EDT

The Fear

"breast cancer rates rose in a region with heavy gas drilling"

Josh Fox, The Sky is Pink



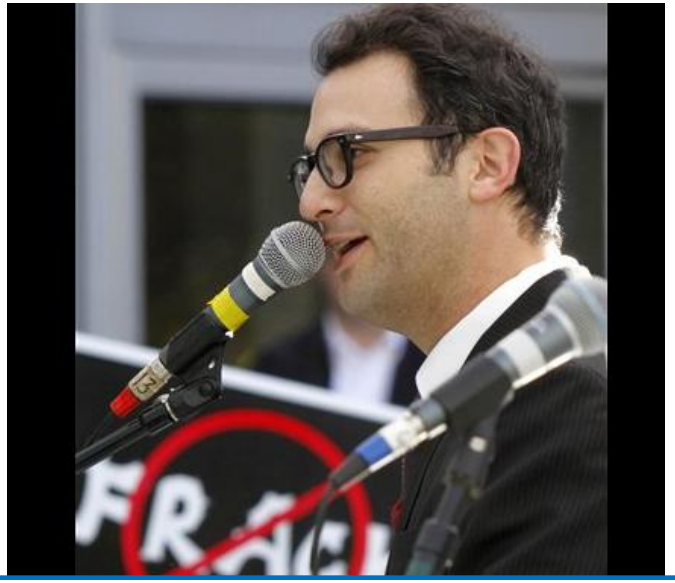
AP

THE BIG STORY

EXPERTS: SOME FRACKING CRITICS USE BAD SCIENCE

By KEVIN BEGOS — Jul. 22 6:44 PM EDT

The Facts



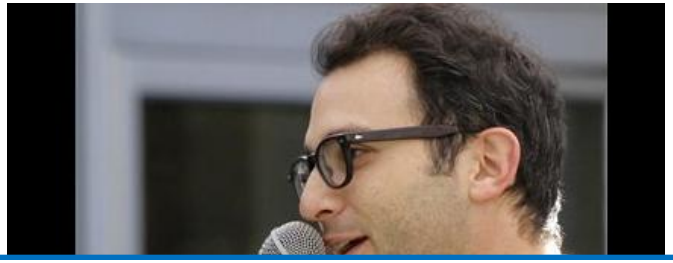
FILE - In this file photo from Nov. 3, 2010, documentary filmmaker Josh Fox speaks at a rally of protestors against Marcellus Shale drilling and hydraulic fracturing in Pittsburgh. Researchers say the claim that fracking has been linked to increased cancer rates in Texas is simply wrong. Fox, an Oscar-nominated filmmaker who uses the claim in a new film, declined to acknowledge the error when told of researchers who say he's doing a disservice to people with cancer by misrepresenting health data. (AP Photo/Keith Srakocic, File)

AP

THE BIG STORY

EXPERTS: SOME FRACKING CRITICS USE BAD SCIENCE

By KEVIN BEGOS — Jul. 22 6:44 PM EDT



The Facts

But researchers haven't seen a spike in breast cancer rates in the area, said Simon Craddock Lee, a professor of medical anthropology at the University of Texas Southwestern Medical Center in Dallas.

David Risser, an epidemiologist with the Texas Cancer Registry, said in an email that researchers checked state health data and found no evidence of an increase in the counties where the spike supposedly occurred.

And Susan G. Komen for the Cure, a major cancer advocacy group based in Dallas, said it sees no evidence of a spike, either.

Responsibility of scientists to accurately inform the public – Facts not Fear

PNAS PNAS PNAS

Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing

Stephen G. Osborn[a], Avner Vengosh[b], Nathaniel R. Warner[b], and Robert B. Jackson[a,b,c,1]

[a]Center on Global Change, Nicholas School of the Environment, [b]Division of Earth and Ocean Sciences, Nicholas School of the Environment, and [c]Biology Department, Duke University, Durham, NC 27708

Edited* by William H. Schlesinger, Cary Institute of Ecosystem Studies, Millbrook, NY, and approved April 14, 2011 (received for review January 13, 2011)

Directional drilling and hydraulic-fracturing technologies are dramatically increasing natural-gas extraction. In aquifers overlying the Marcellus and Utica shale formations of northeastern Pennsylvania and upstate New York, we document systematic evidence for methane contamination of drinking water associated with shale-gas extraction. In active gas-extraction areas (one or more gas wells within 1 km), average and maximum methane concentrations in drinking-water wells increased with proximity to the nearest gas well and were 19.2 and 64 mg CH_4 L^{-1} ($n = 26$), a potential explosion hazard; in contrast, dissolved methane samples in neighboring nonextraction sites (no gas wells within 1 km) within similar geologic formations and hydrogeologic regimes averaged only 1.1 mg L^{-1} ($P < 0.05$; $n = 34$). Average $\delta^{13}C$-CH_4 values of dissolved methane in shallow groundwater were significantly less negative for active than for nonactive sites ($-37 \pm 7‰$ and $-54 \pm 11‰$, respectively; $P < 0.0001$). These $\delta^{13}C$-CH_4 data, coupled with the ratios of methane-to-higher-chain hydrocarbons, and δ^2H-CH_4 values, are consistent with deeper thermogenic methane sources such as the Marcellus and Utica shales at the active sites and matched gas geochemistry from gas wells nearby. In contrast, lower-concentration samples from shallow groundwater at nonactive sites had isotopic signatures reflecting a more biogenic or mixed biogenic/thermogenic methane source. We found no evidence for contamination of drinking-water samples with deep saline brines or fracturing fluids. We conclude that greater stewardship, data, and—possibly—regulation are needed to ensure the sustainable future of shale-gas extraction and to improve public confidence in its use.

groundwater | organic-rich shale | isotopes | formation waters | water chemistry

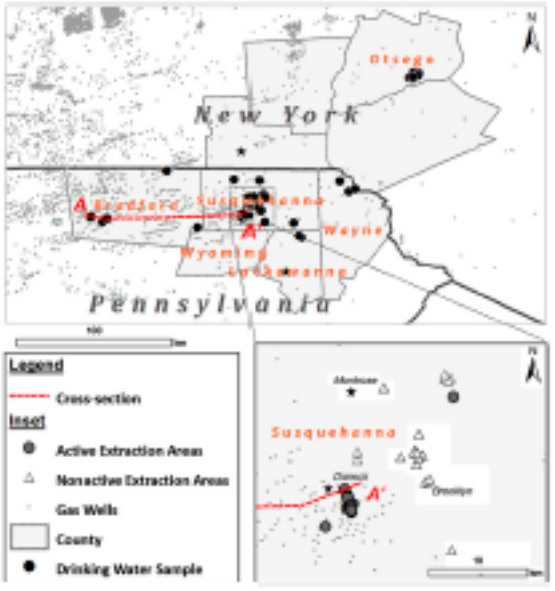


Fig. 1. Map of drilling operations and well-water sampling locations in Pennsylvania and New York. The star represents the location of Binghamton, New York. (*Inset*) A close-up in Susquehanna County, Pennsylvania, showing areas of active (closed circles) or nonactive (open triangles) extraction. A drinking-water well is classified as being in an active extraction area if a gas well is within 1 km (see *Methods*). Note that drilling has already spread to the area around Brooklyn, Pennsylvania, primarily a nonactive location at the time of our sampling (see inset). The stars in the inset represent the towns of Dimock, Brooklyn, and Montrose, Pennsylvania.

Responsibility of scientists to accurately inform the public – Facts not Fear

OIL&GAS JOURNAL

Methane in Pennsylvania water wells unrelated to Marcellus shale fracturing

Lisa J. Molofsky
John A. Connor
Shahla K. Farhat
GSI Environmental Inc.
Houston

Albert S. Wylie Jr.
Tom Wagner
Cabot Oil & Gas Corp.
Pittsburgh

Results from more than 1,700 water wells sampled and tested prior to proposed gas drilling in Susquehanna County, Pa., show methane to be ubiquitous in shallow groundwater, with a clear correlation of methane concentrations with surface topography.

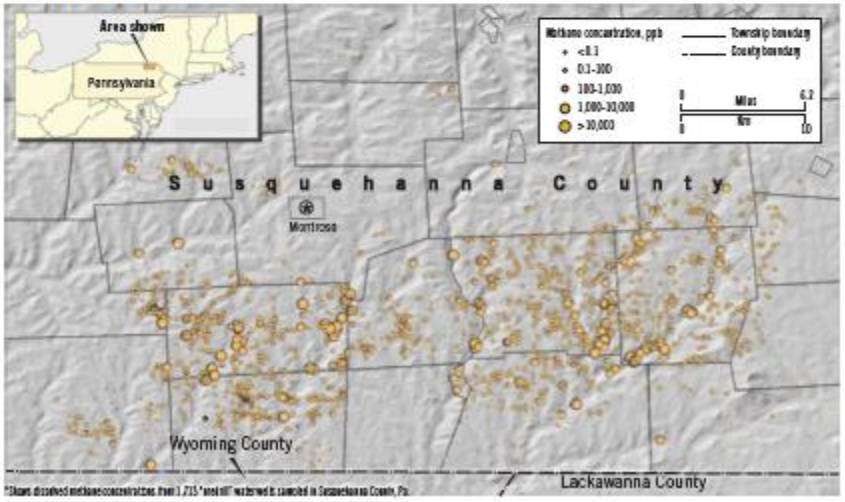
Specifically, water wells located in lowland valley areas exhibit significantly higher dissolved methane levels than water wells in upland areas, with no relation to proximity of existing gas wells. The correlation of methane concentrations with elevation indicates that, on a regional level, elevated methane concentrations in groundwater are a function of geologic features, rather than shale gas development.

Technical literature and historical publications confirm the presence of methane gas in natural seeps and water wells in this region for many decades, long before shale gas drilling operations were initiated in 2006.

Potential sources of this naturally occurring methane include thermogenic gas-charged sandstones in the Catskill formation, which are tapped by most water wells in this region. These sandstones exhibit an extensive network of fractures, joints, and faults that serve as principle conduits of groundwater flow and potential pathways for the movement of shallow-sourced dissolved methane.

Biogenic methane, which is produced by the natural decomposition of organic material within thick valley alluvium and glacial drift deposits in the area, may also be found in water wells that draw water from shallower sediment deposits.

LIDAR BARE-EARTH ELEVATION MAP* FIG. 1



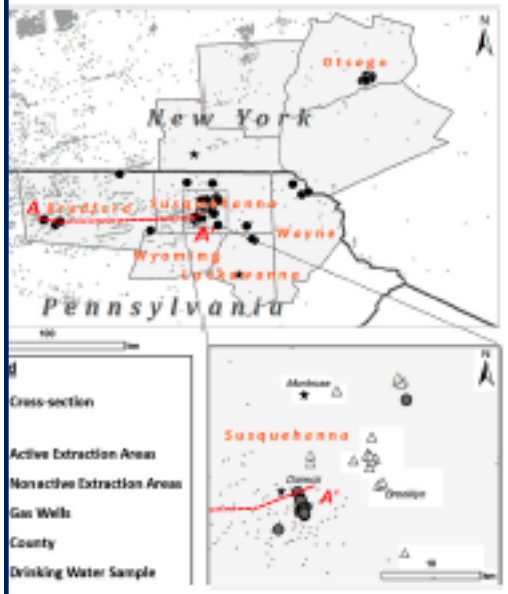
*Shows dissolved methane concentrations from 1,715 "wet-till" wells drilled & sampled in Susquehanna County, Pa.

ing water
and

t B. Jackson[a,b,c,1]

n Sciences, Nicholas School of the Environment, and

pproved April 14, 2011 (received for review January 13, 2011)



of drilling operations and well-water sampling locations in and New York. The star represents the location of Binghamton, set) A close-up in Susquehanna County, Pennsylvania, showing ve (closed circles) or nonactive (open triangles) extraction. A er well is classified as being in an active extraction area if a thin 1 km (see *Methods*). Note that drilling has already spread round Brooklyn, Pennsylvania, primarily a nonactive location at ur sampling (see inset). The stars in the inset represent the towns rooklyn, and Montrose, Pennsylvania.

Responsibility of scientists to accurately inform the public – Facts not Fear

None of Duke water samples were indicative of a Marcellus shale gas source

OIL&GAS JOURNAL

ing water
nd

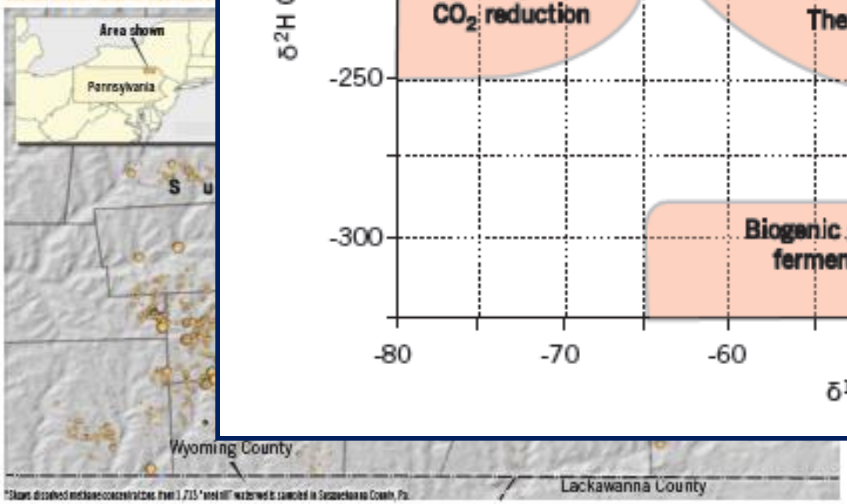
Methane in F
unrelated to

Lisa J. Molofsky
John A. Connor
Shahla K. Farhat
GSI Environmental Inc.
Houston

Albert S. Wylie Jr.
Tom Wagner
Cabot Oil & Gas Corp.
Pittsburgh

Results from more than 1,700 w
ed prior to proposed gas drillin
Pa., show methane to be ubiquit
with a clear correlation of metha
face topography.
Specifically, water wells loca
exhibit significantly higher dis
water wells in upland areas, w

LIDAR BARE-EARTH ELEVATIO



DUKE 2010 STUDY IN SUSQUEHANNA COUNTY

FIG. 9

round Brooklyn, Pennsylvania, primarily a nonactive location at
ur sampling (see inset). The stars in the inset represent the towns
rooklyn, and Montrose, Pennsylvania.

July 28, 2012

HUFF POST GREEN

THE INTERNET NEWSPAPER: NEWS BLOGS VIDEO COMMUNITY

Marcellus Shale Study Claims Gas Drilling Did Not Contaminate Drinking Water Wells

AP | By KEVIN BEGOS Posted: 07/10/2012 8:50 am

PITTSBURGH (AP) — New research on Marcellus Shale gas drilling in Pennsylvania may only add fuel to the debate over whether the industry poses long-term threats to drinking water.

A paper published on Monday by Duke University researchers found that gas drilling in northeastern Pennsylvania did not contaminate nearby drinking water wells with salty water, which is a byproduct of the drilling.

"These results reinforce our earlier work showing no evidence of brine contamination from shale gas exploration," said Robert Jackson, director of Duke's Center on Global Change and a co-author of the paper, which appeared online in the Proceedings of the National Academy of Sciences. The team evaluated 426 samples from groundwater aquifers in six counties.

The findings are noteworthy because last year the same Duke team found evidence that methane from gas wells had contaminated drinking water in Pennsylvania. That prompted harsh criticism from the top official at the state Department of Environmental Protection, who accused the researchers of bias and shoddy science.

We need a “new normal” in peer review – Oil & Gas industry professionals must be in the mix

Industry presents more facts to show HF does not reach groundwater zones.

SPE 145949

Hydraulic Fracture-Height Growth: Real Data

Kevin Fisher and Norm Warpinski, SPE, Pinnacle—A Halliburton Service

Copyright 2011, Society of Petroleum Engineers

This paper was prepared for presentation at the SPE Annual Technical Conference and Exhibition held in Denver, Colorado, USA, 30 October–2 November 2011.

This paper was selected for presentation by an SPE program committee following review of information contained in an abstract submitted by the author(s). Contents of the paper have not been reviewed by the Society of Petroleum Engineers and are subject to correction by the author(s). The material does not necessarily reflect any position of the Society of Petroleum Engineers, its officers, or members. Electronic reproduction, distribution, or storage of any part of this paper without the written consent of the Society of Petroleum Engineers is prohibited. Permission to reproduce in print is restricted to an abstract of not more than 300 words; illustrations may not be copied. The abstract must contain conspicuous acknowledgment of SPE copyright.

Abstract

Much public discourse has taken place regarding hydraulic-fracture growth in unconventional reservoirs and whether fractures could potentially grow up to the surface and create communication pathways for frac fluids or produced hydrocarbons to pollute groundwater supplies. Real fracture-growth data mapped during thousands of fracturing treatments in unconventional reservoirs are presented along with the reported aquifer depths in the vicinity of the fractured wells. These data are supplemented with an in-depth discussion of fracture-growth limiting mechanisms augmented by mineback tests and other studies performed to visually examine hydraulic fractures. These height-growth limiting mechanisms, which are supported by the mapping data, provide insight into why hydraulic fractures are longer laterally and more constrained vertically. This information can be used to improve models, optimize fracturing, and provide definitive data for regulators and interest groups.

Industry presents more facts to show HF does not reach groundwater zones. More Research…

ARTICLE IN PRESS JMPG1575_proof ■ 21 April 2012 ■ 1/6

Marine and Petroleum Geology xxx (2012) 1–6

Contents lists available at SciVerse ScienceDirect

Marine and Petroleum Geology

journal homepage: www.elsevier.com/locate/marpetgeo

Review article

Hydraulic fractures: How far can they go?

Richard J. Davies [a,*], Simon Mathias [a], Jennifer Moss [b], Steinar Hustoft [c], Leo Newport [a]

[a] Durham Energy Institute, Department of Earth Sciences, Durham University, Science Labs, Durham DH1 3LE, UK
[b] 3DLab, School of Earth, Ocean and Planetary Sciences, Main Building, Park Place, Cardiff University, Cardiff CF10 3YE, UK
[c] University of Tromsø, Department of Geology, Dramsveien 201, N-9037 Tromsø, Norway

ARTICLE INFO

Article history:
Received 14 February 2012
Received in revised form
5 April 2012
Accepted 7 April 2012
Available online xxx

Keywords:
Fracture
Pressure
Shale
Natural
Stimulated

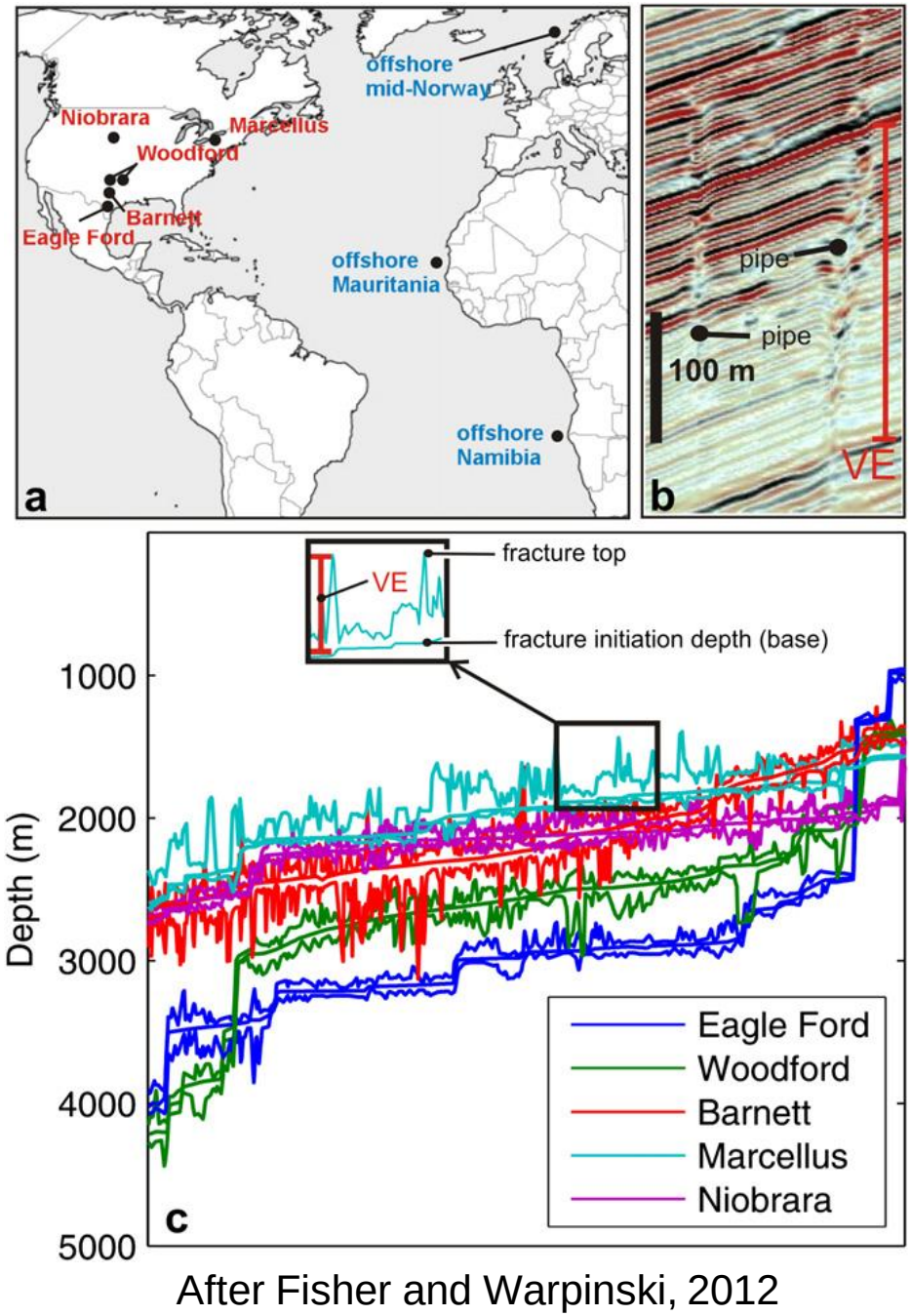
ABSTRACT

The maximum reported height of an upward propagating hydraulic fracture from several thousand fracturing operations in the Marcellus, Barnett, Woodford, Eagleford and Niobrara shale (USA) is ~588 m. Of the 1170 natural hydraulic fracture pipes imaged with three-dimensional seismic data offshore of West Africa and mid-Norway it is ~1106 m. Based on these empirical data, the probability of a stimulated and natural hydraulic fracture extending vertically >350 m is ~1% and ~33% respectively. Constraining the probability of stimulating unusually tall hydraulic fractures in sedimentary rocks is extremely important as an evidence base for decisions on the safe vertical separation between the depth of stimulation and rock strata not intended for penetration.

© 2012 Published by Elsevier Ltd.

Hydraulic Fracturing : How Far Can They Go

"Based on these empirical data, the probability of a stimulated and a natural fracture extending > 350 m is ~1% and ~33% respectively"



After Fisher and Warpinski, 2012

Figure 3. (a) Map of the globe showing location of the eight datasets. Red font – datasets for stimulated hydraulic fractures, blue font – datasets for natural hydraulic fractures (pipes). (b) Seismic line from offshore Mauritania showing a representative vertical pipe imaged on 3D seismic reflection data and its vertical extent. (c) Graph of stimulated hydraulic fractures in the Marcellus, Barnett, Woodford and Eagleford shales (after Fisher and Warpinski, 2011) and including unpublished data provided by Halliburton for the Niobrara shale. Inset – extract of the graph showing how the vertical extents of fractures were measured. All depths are in true vertical depth (TVD). The black dashed line – depth of the stimulation of the hydraulic fractures. Coloured spikes – separate hydraulic fractures propagating upwards and downwards from the depth of stimulation.

Richard Davies et al, 2012

Again, We need a “new normal” in peer review – Oil & Gas industry professionals must be in the mix

ground water

Potential Contaminant Pathways from Hydraulically Fractured Shale to Aquifers

by Tom Myers

Abstract

Hydraulic fracturing of deep shale beds to develop natural gas has caused concern regarding the potential for various forms of water pollution. Two potential pathways—advective transport through bulk media and preferential flow through fractures—could allow the transport of contaminants from the fractured shale to aquifers. There is substantial geologic evidence that natural vertical flow drives contaminants, mostly brine, to near the surface from deep evaporite sources. Interpretative modeling shows that advective transport could require up to tens of thousands of years to move contaminants to the surface, but also that fracking the shale could reduce that transport time to tens or hundreds of years. Conductive faults or fracture zones, as found throughout the Marcellus shale region, could reduce the travel time further. Injection of up to 15,000,000 L of fluid into the shale generates high pressure at the well, which decreases with distance from the well and with time after injection as the fluid advects through the shale. The advection displaces native fluids, mostly brine, and fractures the bulk media widening existing fractures. Simulated pressure returns to pre-injection levels in about 300 d. The overall system requires from 3 to 6 years to reach a new equilibrium reflecting the significant changes caused by fracking the shale, which could allow advective transport to aquifers in less than 10 years. The rapid expansion of hydraulic fracturing requires that monitoring systems be employed to track the movement of contaminants and that gas wells have a reasonable offset from faults.

Ground Water©2012,National GroundWater Association.
doi: 10.1111/j.1745-6584.2012.00933.x

DiscoveryNews ... wants to find life here.

EARTH | SPACE | TECH & GADGETS | ANIMALS | HISTORY | ADVENTURE | HUMAN

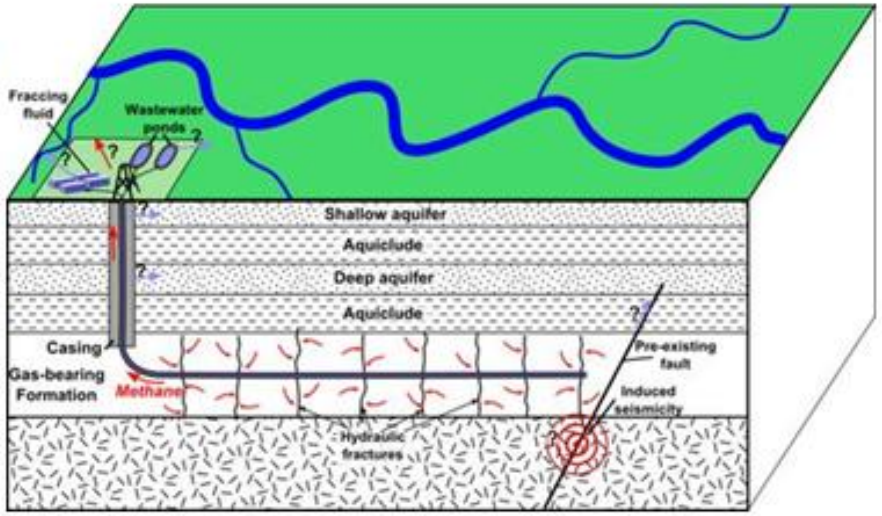
GROUNDWATER FOULED BY FRACKING

Analysis by Tim Wall
Wed May 9, 2012

Clean-burning natural gas may not be all it is fracked-up to be.

Groundwater in the eastern United States could be contaminated by the natural gas extraction process known as hydraulic fracturing, or fracking, after a decade or less, far less time than the thousands of years proponents of the mining technique claim.

The Marcellus shale, a rock formation running from New York to Pennsylvania and parts of Ohio and Virginia, contains large amounts of natural gas and is located close to the energy hungry East Coast. To release the gas engineers have to shatter the rock with millions of gallons of high pressure water, sand and toxic chemicals like benzene.



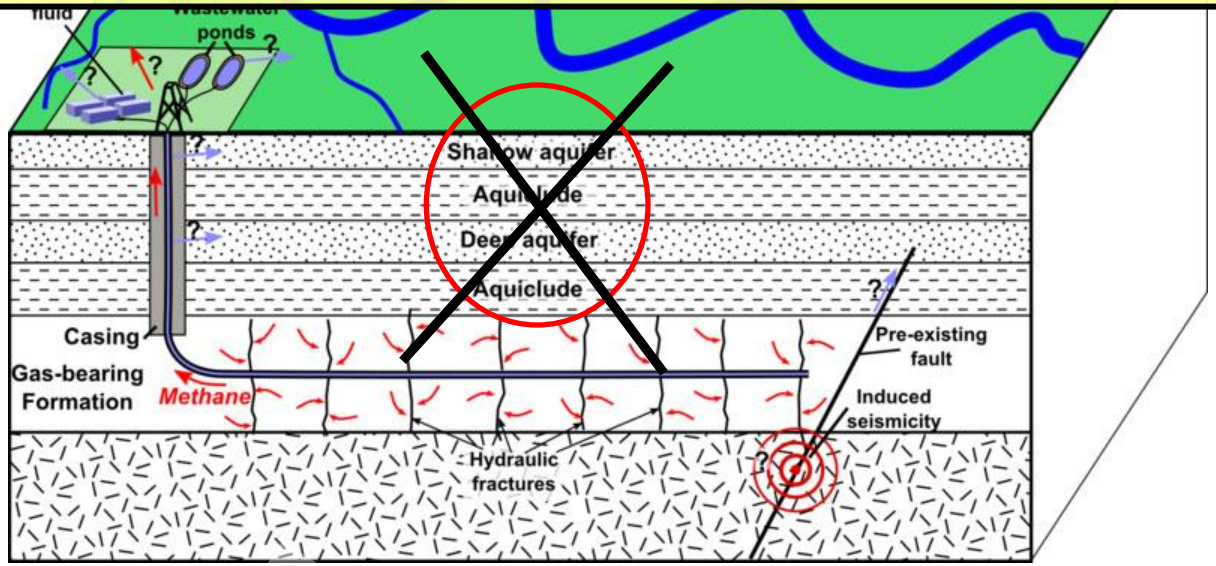
In a controversial computer simulation, however, hydrologist Tom Myers suggested that the rock is more permeable than earlier studies predicted and that, once fractured, the rock allows the toxic fracking liquid to percolate upwards.

Groundwater above natural gas deposits in other areas could be even more susceptible to pollution from fracking.

"One would have to say that the possible travel times for a similar thing in Arkansas or Northeast Texas is probably faster than what I've come up with," Myers told ProPublica.

Assertions from article by T. Meyers paper published in **Ground Water**

Huge Knowledge Gap!



"Groundwater in the eastern United States could be contaminated by the natural gas extraction process known as hydraulic fracturing, or fracking, after a decade or less, far less time than the thousands of years proponents of the mining technique claim.

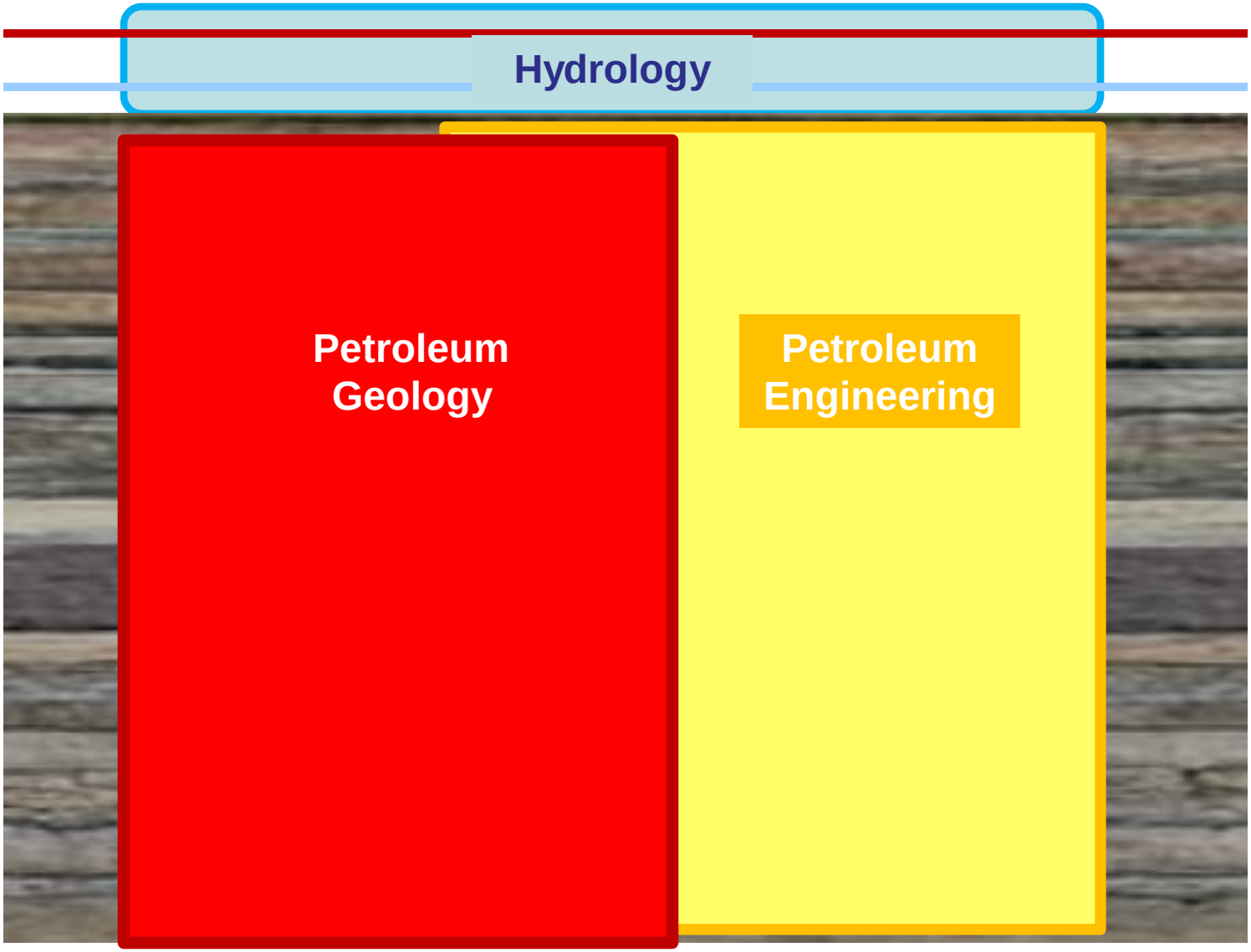
WRONG!

The Marcellus shale, a rock formation running from New York to Pennsylvania and parts of Ohio and Virginia, contains large amounts of natural gas and is located close to the energy hungry East Coast. To release the gas engineers have to shatter the rock with millions of gallons of high pressure water, sand and **toxic chemicals like benzene**.

In a **controversial computer simulation**, however, hydrologist Tom Myers suggested that the rock is more permeable than earlier studies predicted and that, once fractured, the rock allows the toxic fracking liquid to percolate upwards."

Realms of Expertise Today – When it comes to drilling & completing an oil & gas well…

Multidisciplinary



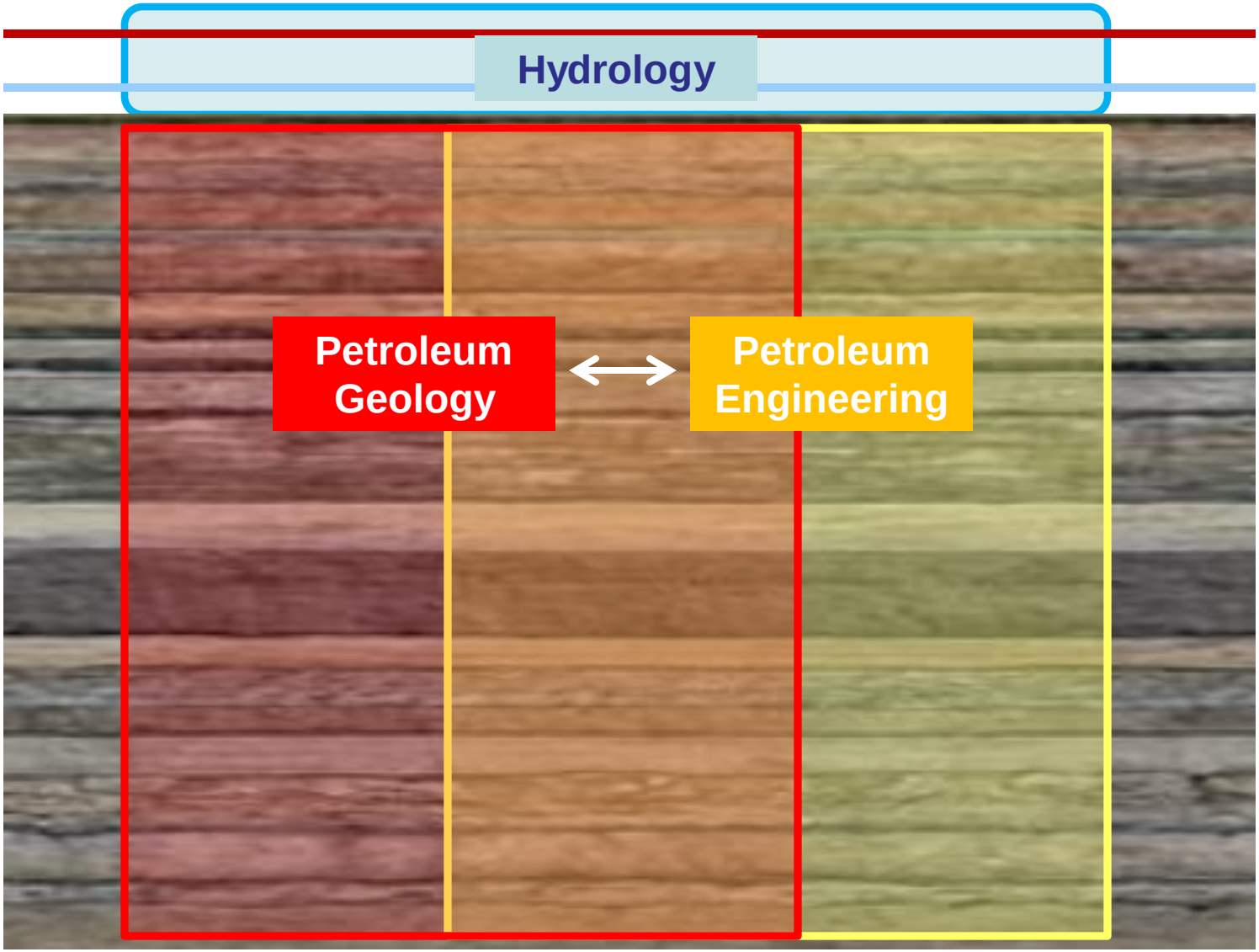
Surface

Groundwater
(Few hundreds to 1000 feet)

Subsurface
(thousands of feet)

Realms of Expertise Today – When it comes to drilling & completing an oil & gas well…

Interdisciplinary (Petroleum Geologists & Engineers)



Surface

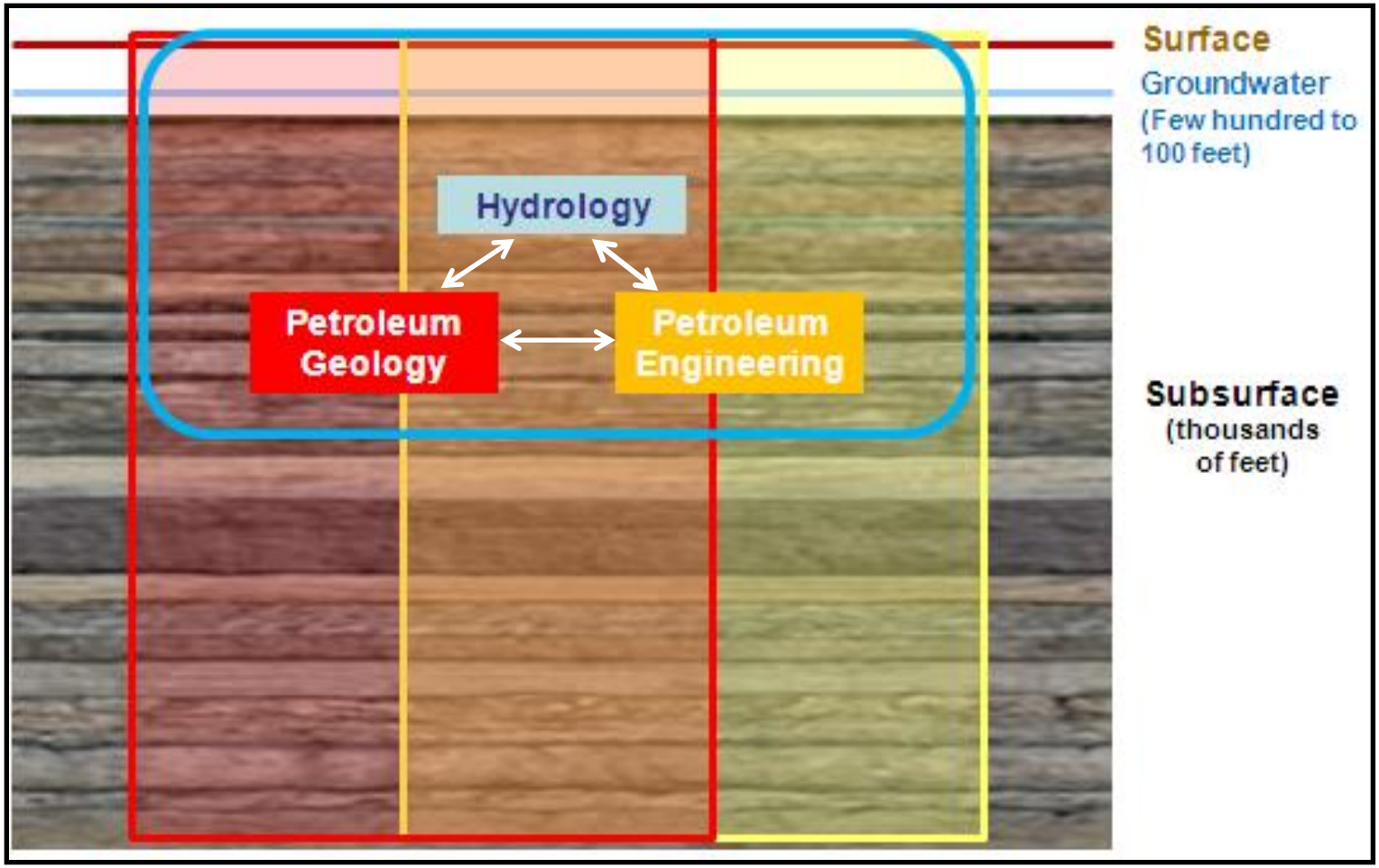
Groundwater
(Few hundreds to 1000 feet)

Subsurface
(thousands of feet)

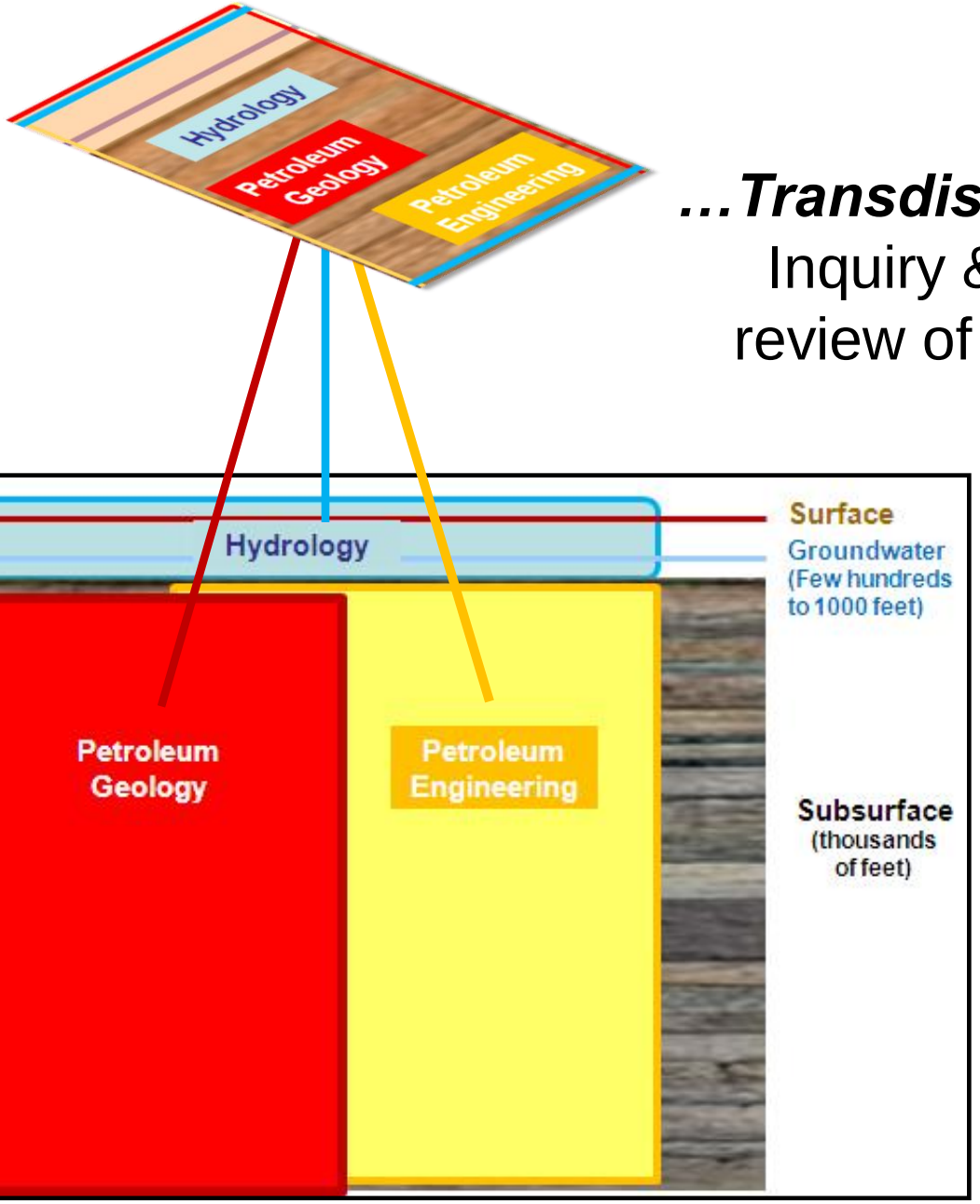
Gary Hanson, 2011

Realms of Expertise – Where we need to get to!

To solve these issues pertaining to potential drinking water risks & petroleum drilling & completion we need not just ***interdisciplinary*** but…



Gary Hanson, 2011



…Transdisciplinary
Inquiry & peer review of papers

Gary Hanson & Sam Chan, 2012

TRUTHLAND MOVIE

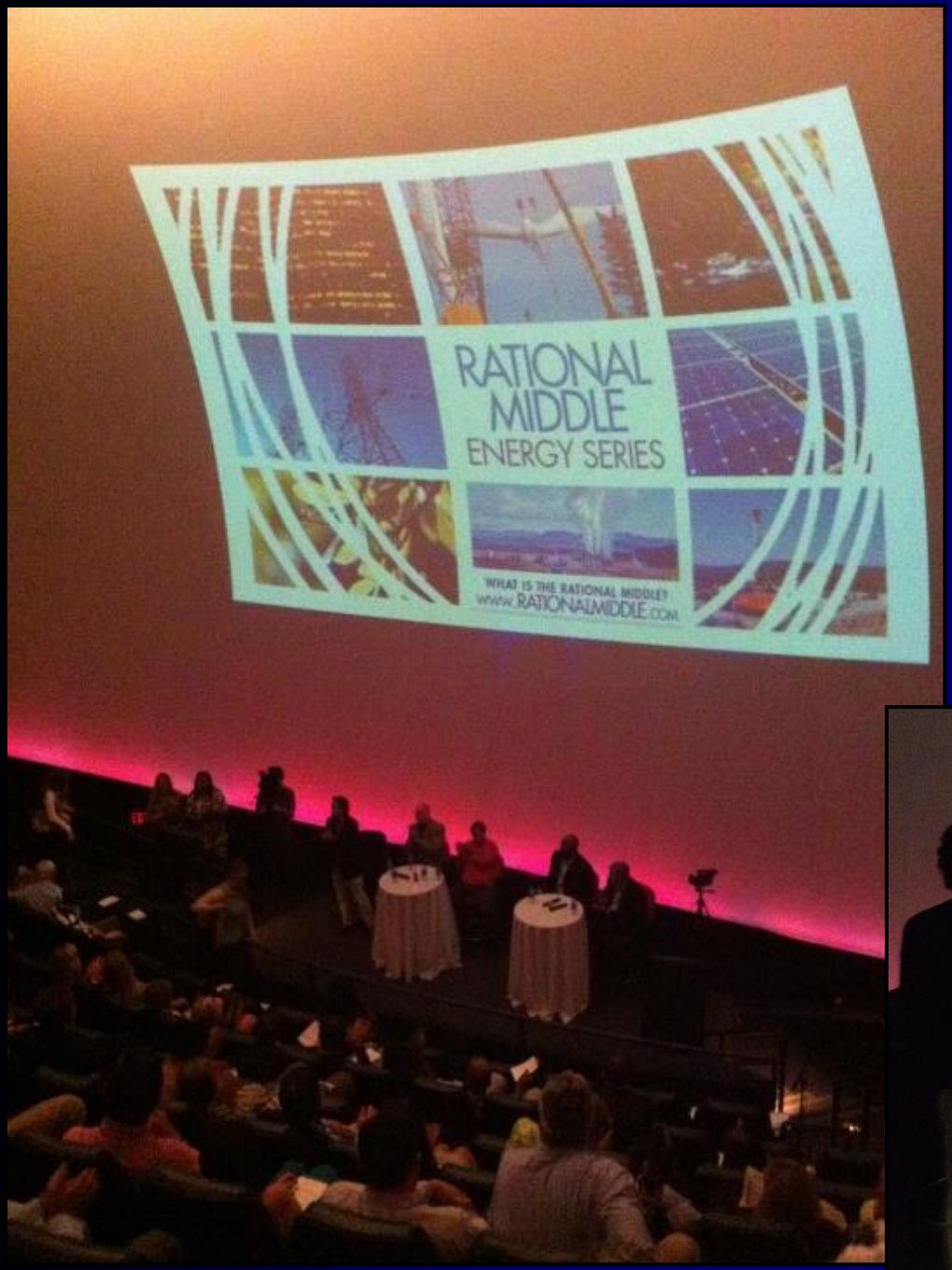
ENERGYINDEPTH

IPAA
INDEPENDENT PETROLEUM ASSOCIATION OF AMERICA

twitter facebook YouTube tumblr.

TRUTH LAND

Copyright Energy In Depth, a project of the Independent Petroleum Association of America © 2012 Movie Site. All rights reserved.



Gregory Kallenberg (Acclaimed Haynesville Documentary) & Shell Oil

First panel discussion, Shreveport, Louisiana

Gregory Kallenberg (Acclaimed Haynesville Documentary) & Shell Oil

Rational Middle

@rationalmiddle

In order to create an energy future that is environmentally sound, economically viable, and ensures energy security, we need to work together. Join the movement

http://www.rationalmiddle.com

First panel discussion, Shreveport, Louisiana

The desire to stop the use of fossil fuels? GHG's?

Scott Tinker

The movie
SWITCH

THE GLOBAL ENERGY TRANSITION: WHAT WILL IT TAKE TO MAKE THE SWITCH

- Energy underpins modern economies and when the economy struggles, investment in the environment falters
- Coal is globally abundant and, unless a price is set on carbon, relatively cheap
- Conventional oil production is beginning to plateau, but not because of resource limits
- Natural gas is globally abundant, versatile, and cleaner than coal
- Uranium (nuclear) is globally abundant, reliable, and clean
- Carbon Capture and Storage is unlikely to happen at any scale that will have an impact on climate
- "Renewables" produce intermittent electricity and require significant advances in electricity storage and transmission
- Energy efficiency is vital and can be improved across all consumption sectors
- Energy security – available, affordable, reliable and sensible – requires a government, industry, academic partnership

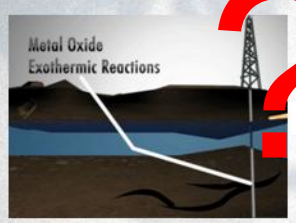
Scott Tinker Texas State Geologist, 2012

The need to develop water efficient and disruptive energy technologies

GASFRAC ENERGY SERVICES INC.

WaterLess Fracturing Technology

CHIMERA ENERGY CORPORATION



REVOLUTIONARY EXOTHERMIC NON-HYDRAULIC EXTRACTION

Hybrid Air Transport

Remote Locations – Unique, low cost & green transportation

(Rigs, equipment, proppant, fluids & tubulars)

Road Damage

Surface Transport Limitations

BAKER HUGHES

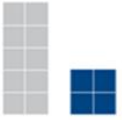
VaporFrac Fracturing Fluid

Improve production in water-sensitive, low-pressure reservoirs

Schlumberger

HiWAY Flow-Channel Hydraulic Fracturing Increases Production Using Less Water and Proppant

Compared to slickwater treatments, the HiWAY service **uses up to 60% less water.**



WATER

↓60%

DECREASE

LSU SHREVEPORT
RED RIVER WATERSHED MANAGEMENT INSTITUTE

Summary

Community Leaders & Neutral Entity

- Being proactive about evaluating water resources prior to a gas shale play is critical
- If not in place, form a regional water resources committee & a water/energy group
- Be flexible and adaptive as you work to protect public water resources and work with industry
- Work with state authorities, but take action where they cannot
- Relationships built above will really help if your community is faced with water shortages (drought)

Acknowledgements:

US EPA Region 6
City of Shreveport
Anderson Family
EXCO Resources
Shell, Chesapeake, EnCana, Petrohawk
AEP SWEPCO
Halliburton, Pinnacle
Louisiana Dept. of Natural Resources
The Parishes of Caddo, DeSoto, Bossier & Webster, Sabine River Authority & Red River Waterway Commission
Members of the Water Energy Working Group
LSU Shreveport & LSU System
Environmental Dynamics Program UARK

Questions?