

Natural Gas Resources of the Marcellus Shale

**Pennsylvania House of Representatives
GOP Policy Committee**

April 7, 2010

**Testimony of
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Senior Vice President, Marcellus Shale
Range Resources – Appalachia, LLC**



RANGE RESOURCES

Range Resources

- Natural gas production company
- Included in S&P 500
- Committed to Pennsylvania
- Regional Headquarters in Washington County
- Pioneered Marcellus Shale, 2004
- Over \$1 Billion invested in Keystone State
- Employs more than 300 Pennsylvanians, support over 1,000 contractor jobs and many more indirect and induced jobs



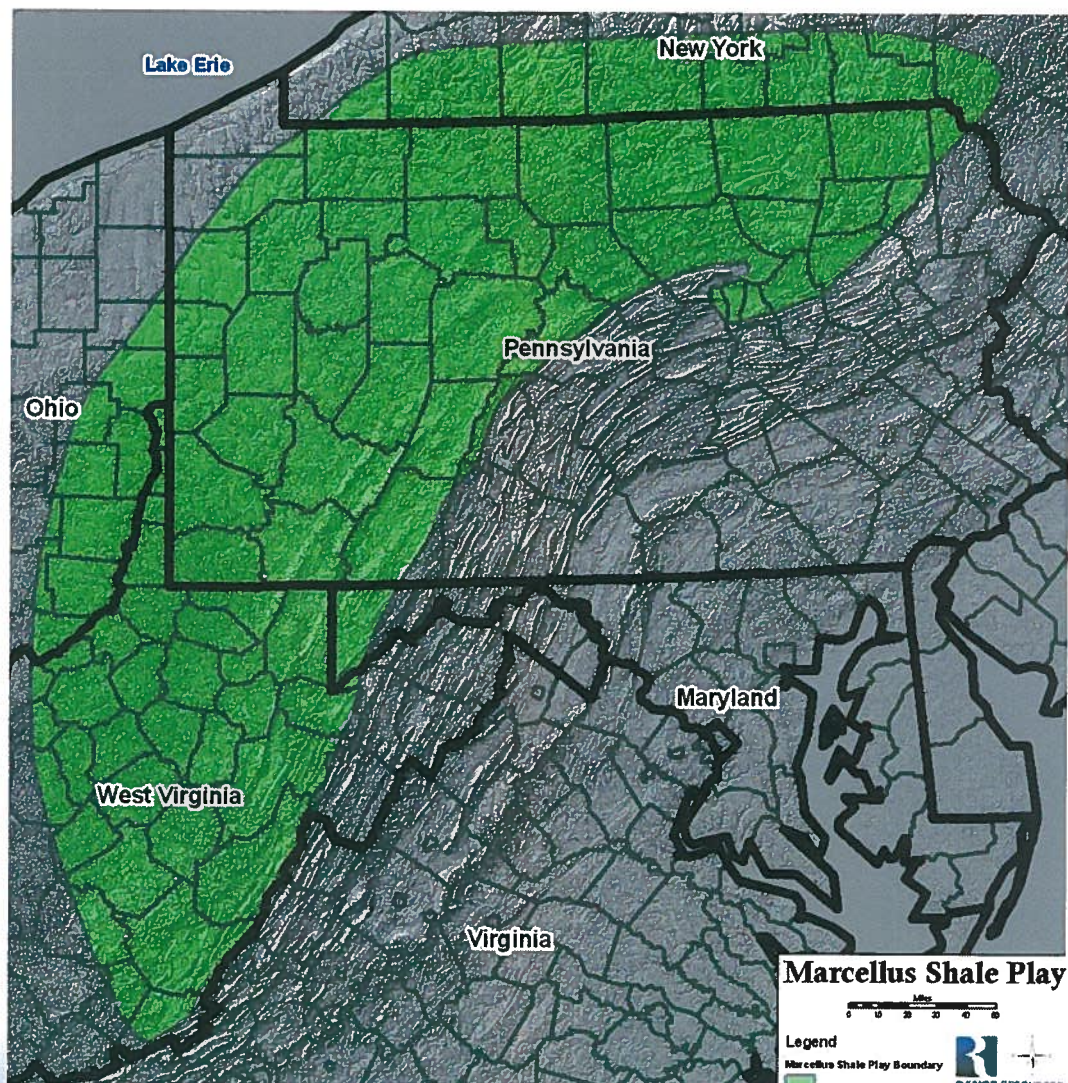


What is the Marcellus Shale?

- organic-rich, shale
- 5,000 – 9,000 foot depth
- Mud that settled on ocean floor 380 million years ago; turned to rock
- Natural gas and hydrocarbons are trapped in tiny micropores between grains of mud
- Extremely low permeability

Marcellus Shale is big

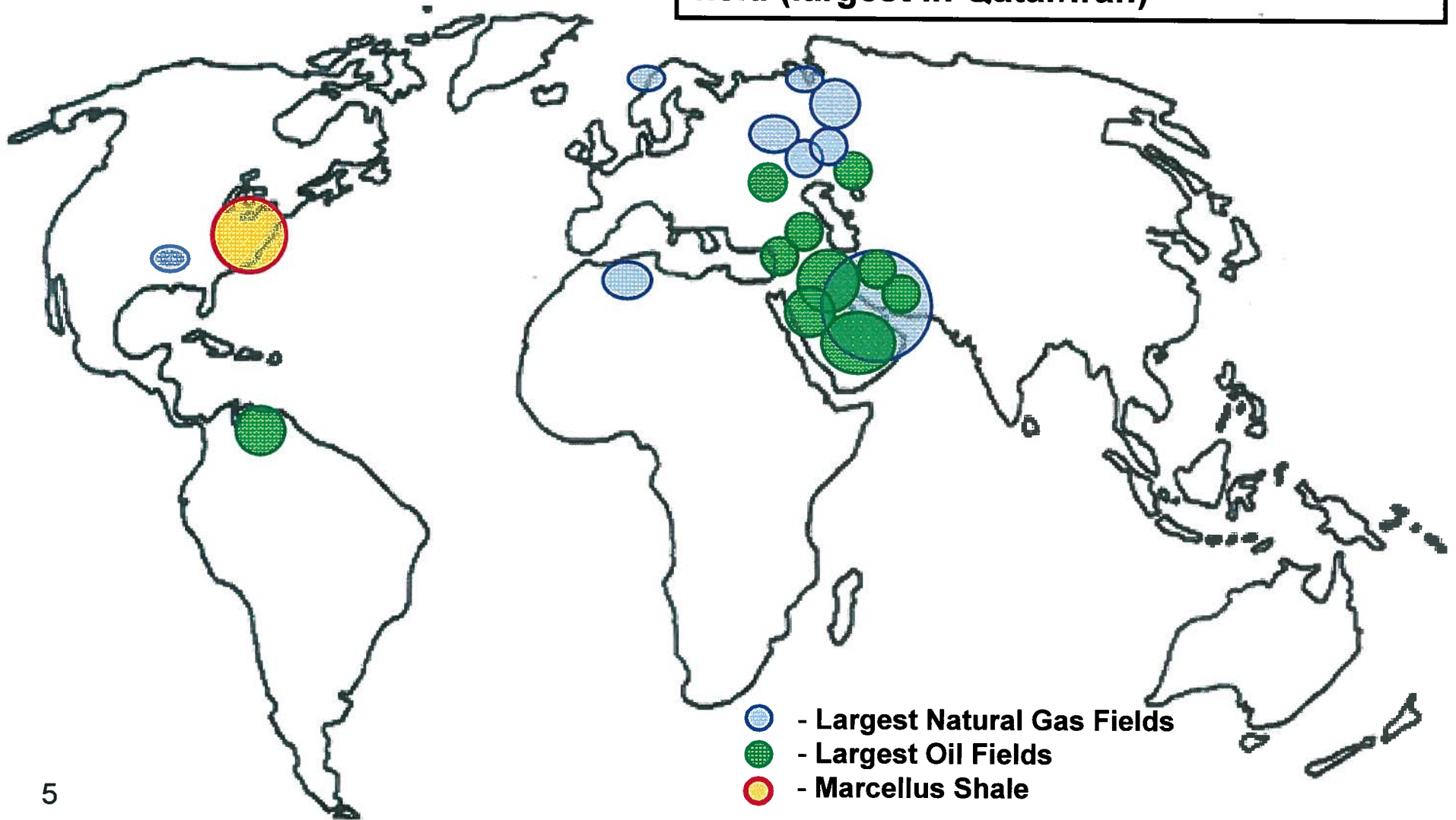
- Marcellus fairway is 40,000 – 50,000 square miles
- Estimates of recoverable reserves up to 500 tcf; current U.S. natural gas demand is 23 tcf per year



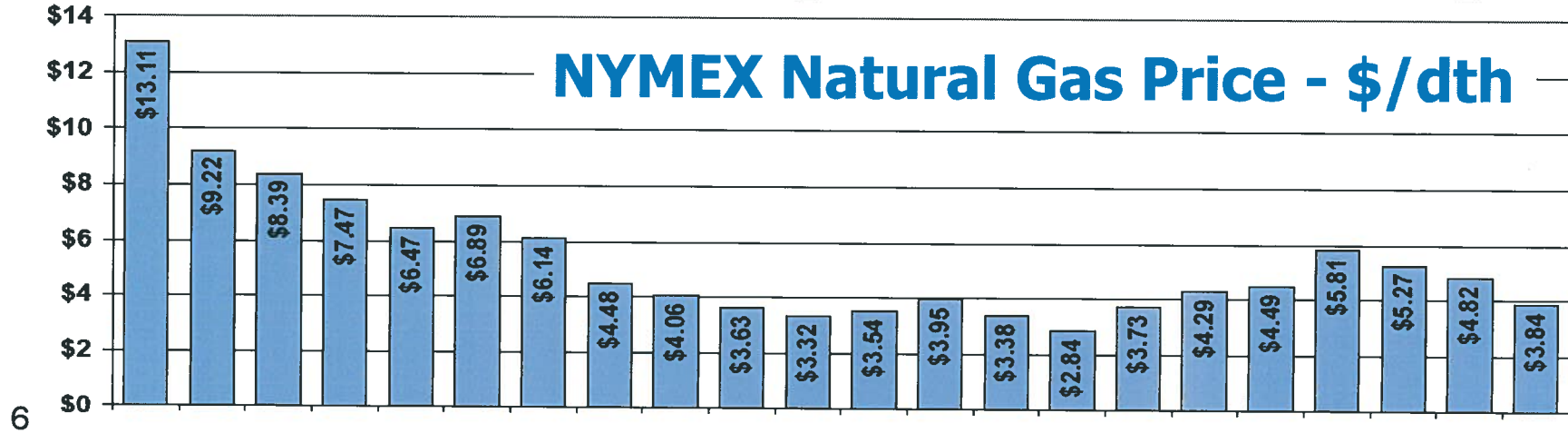
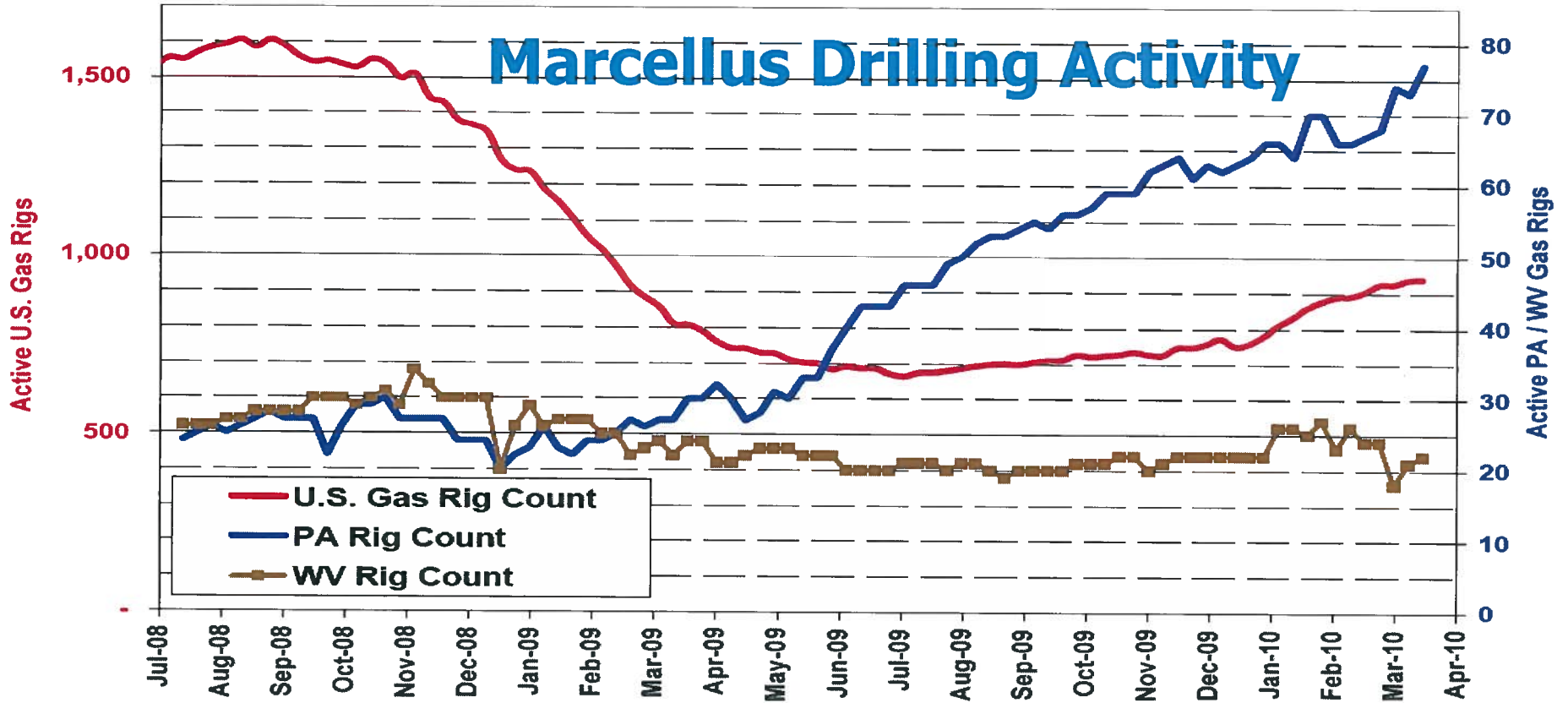
How the Marcellus compares to the largest oil and gas fields in the world

(Bubble size approximates reserves)

Marcellus reserves could exceed those of the largest oil field in the world (Saudi Arabia) and be the 2nd largest natural gas field (largest in Qatar/Iran)

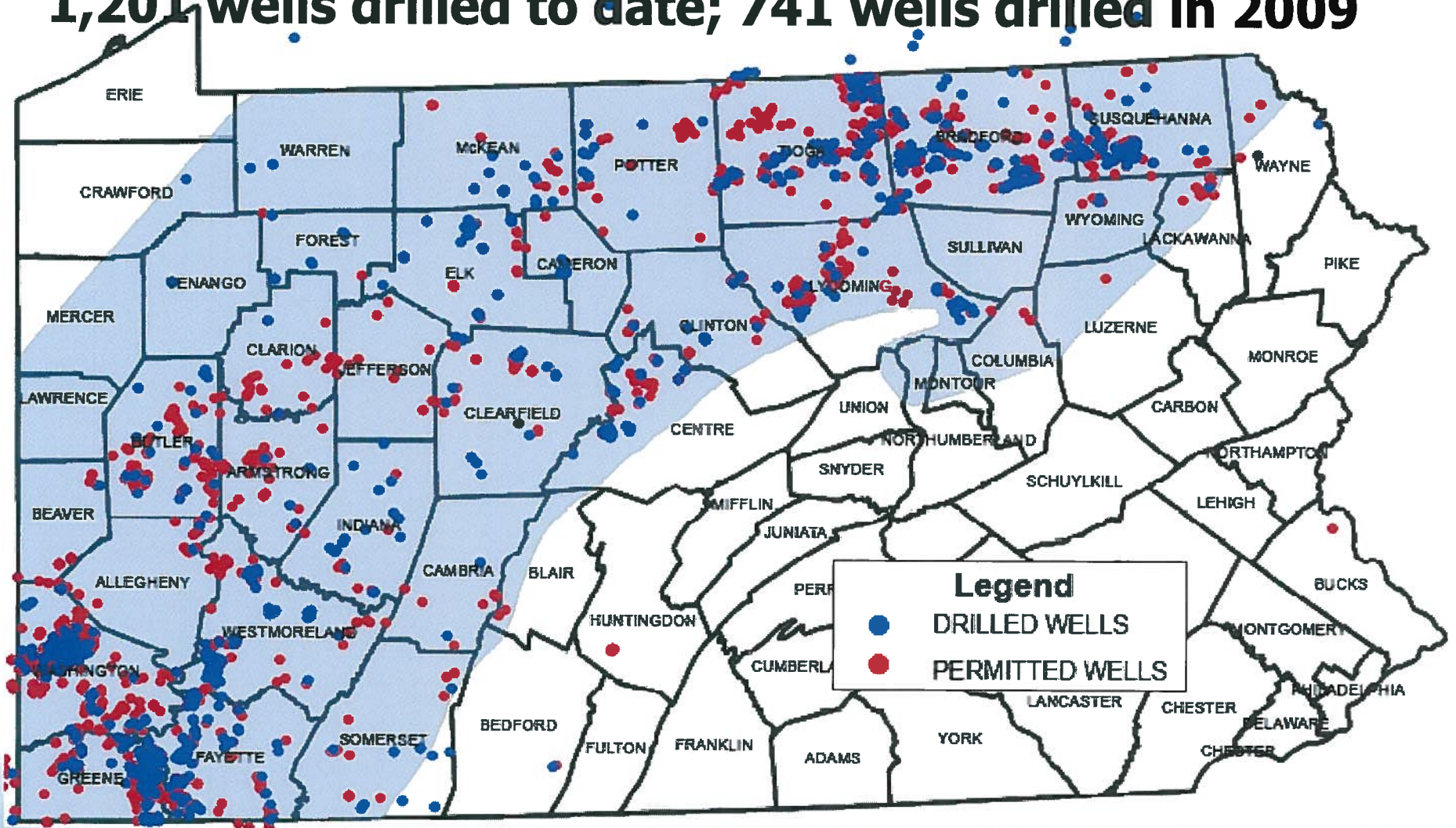


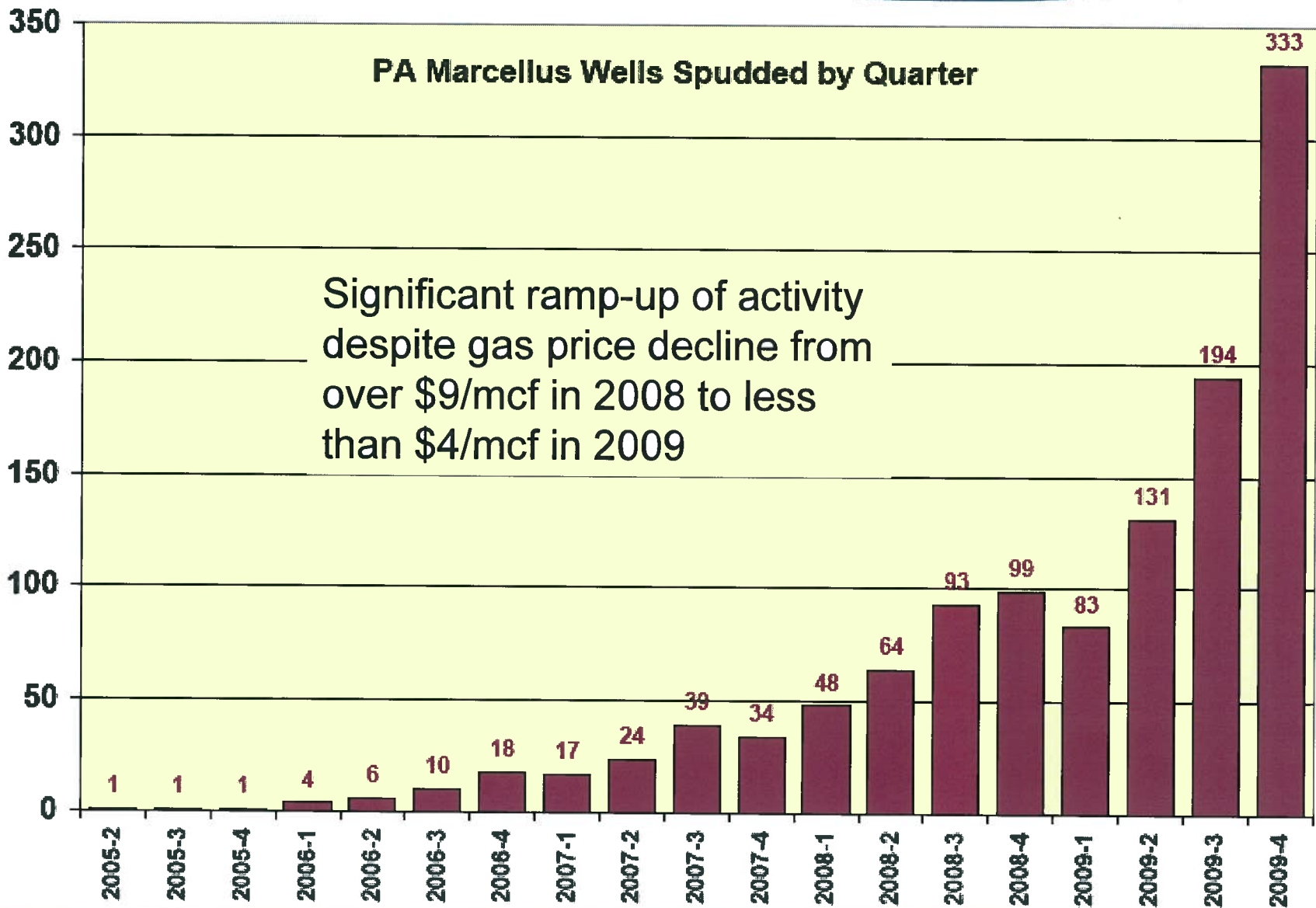
**U.S. Natural Gas Drilling Activity vs.
 Pennsylvania Drilling Activity**
 Source: Baker Hughes North American Rig Count 3/26/2010



Marcellus Drilling Activity - 12/31/2009

1,201 wells drilled to date; 741 wells drilled in 2009





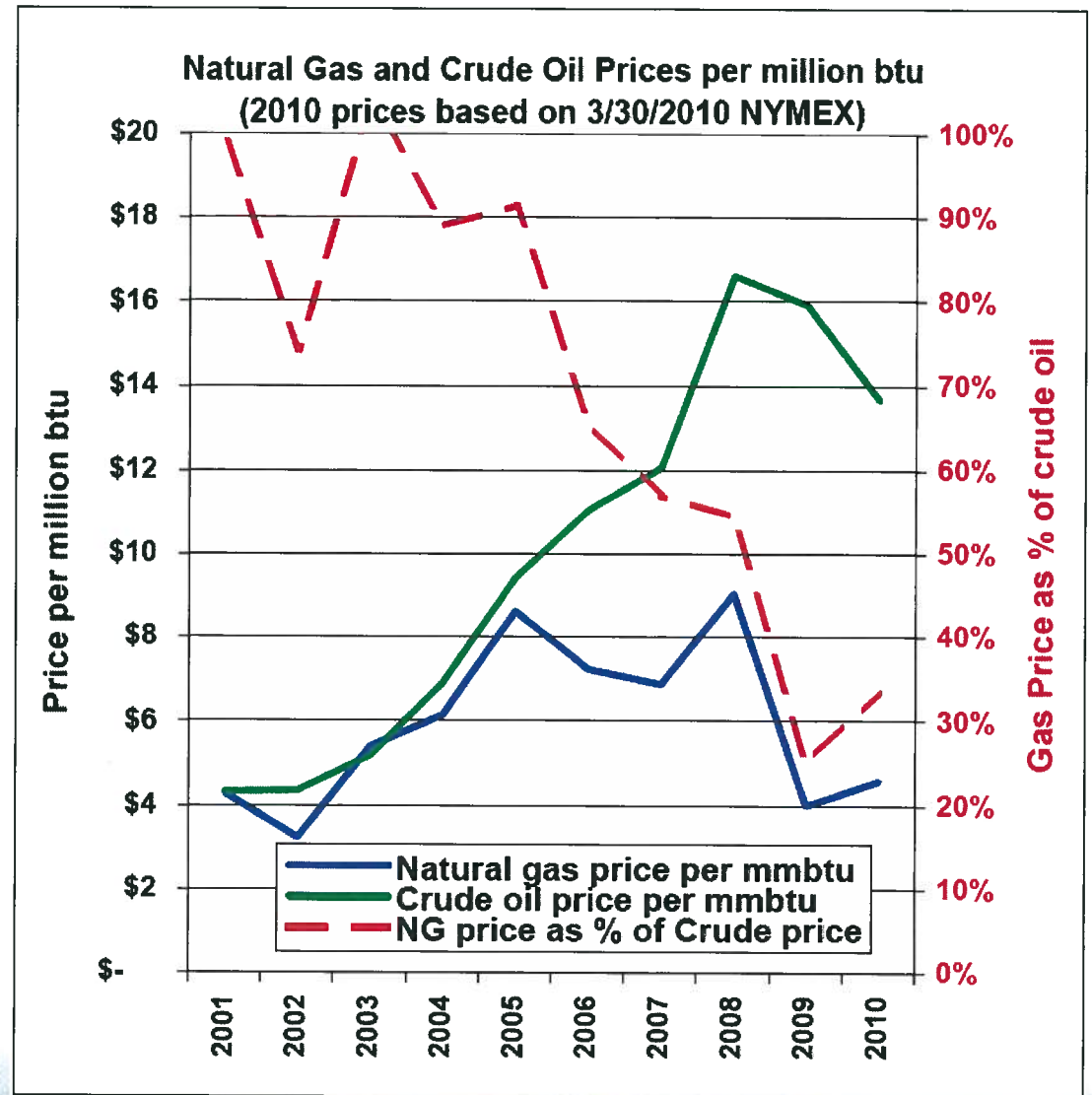
Economic Impact Study by economists and industry experts at Penn State University July, 2009



	2008	2009	2010	2015	2020
Jobs created - thousands	29	49	107	161	175
Expenditures (leasing, drilling, pipelines) - \$billions	3,095	4,415	9,468	13,260	14,034
Gross Output - \$millions	4,179	6,251	14,166	23,463	25,430
Value added - \$millions	2,263	3,755	8,272	12,409	13,500
State & Local taxes - \$millions	239	396	872	1,308	1,423
Production rate - bcf/d	0.04	0.17	0.55	2.91	3.99
Gas price/mcf	\$ 8.90	\$ 5.39	\$ 6.72	\$ 7.24	\$ 7.53
Wells drilled	364	621	1,200	2,534	2,814
Landowner royalty - \$billions	\$ 0.02	\$ 0.05	\$ 0.22	\$ 1.23	\$ 1.75

Economic Benefits

- Discovery of 100+ years of gas supply from U.S. gas shales since 2005 has caused a divergence of oil and natural gas markets since 2005
- Natural gas prices were \$12/mmbtu lower than oil in 2009 and projected to be \$9/mmbtu lower in 2010
- PA natural gas consumers will save nearly \$7 billion in 2010; U.S. will save over \$200 billion
- Natural gas is a bargain

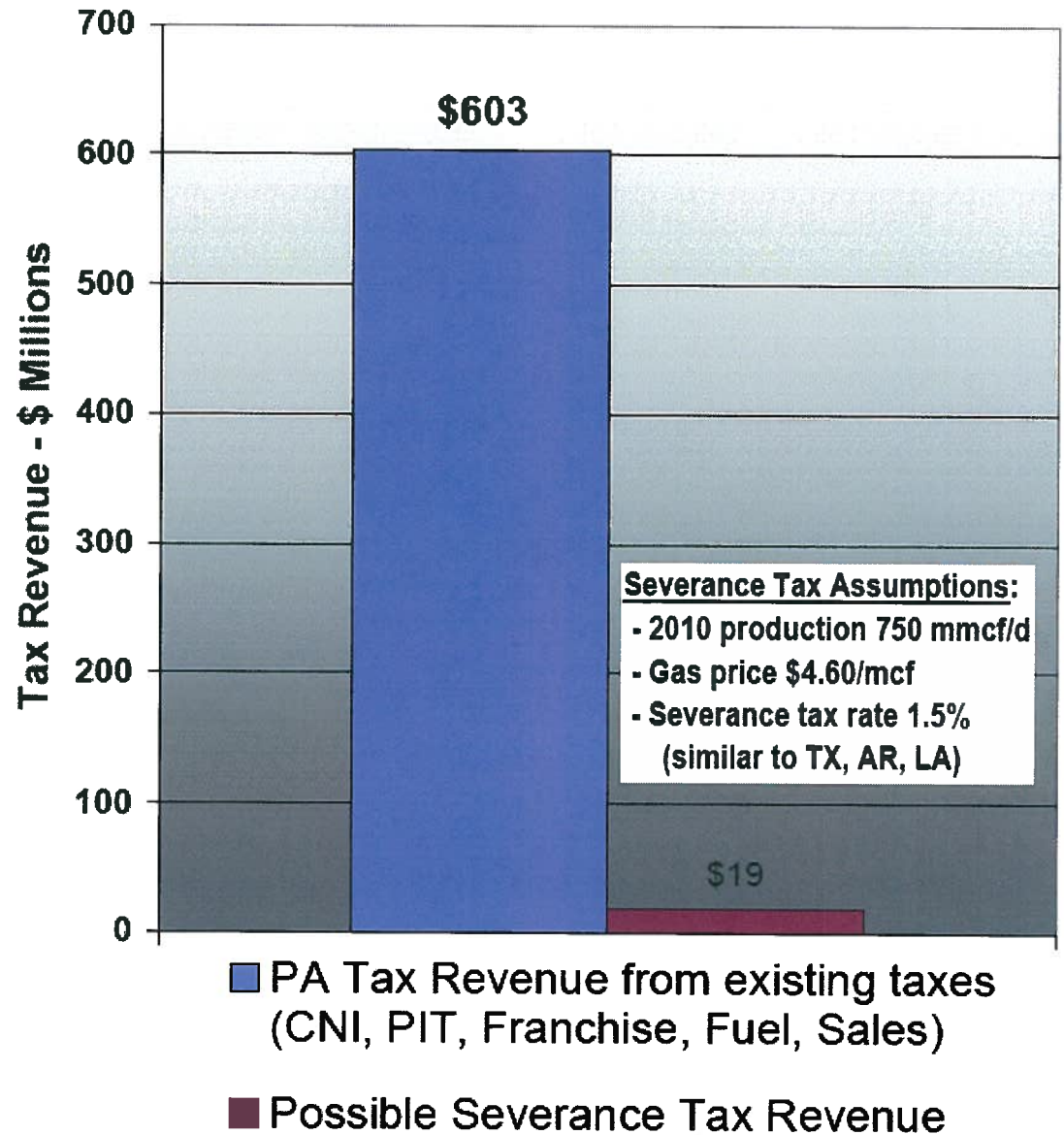


Economic Benefits

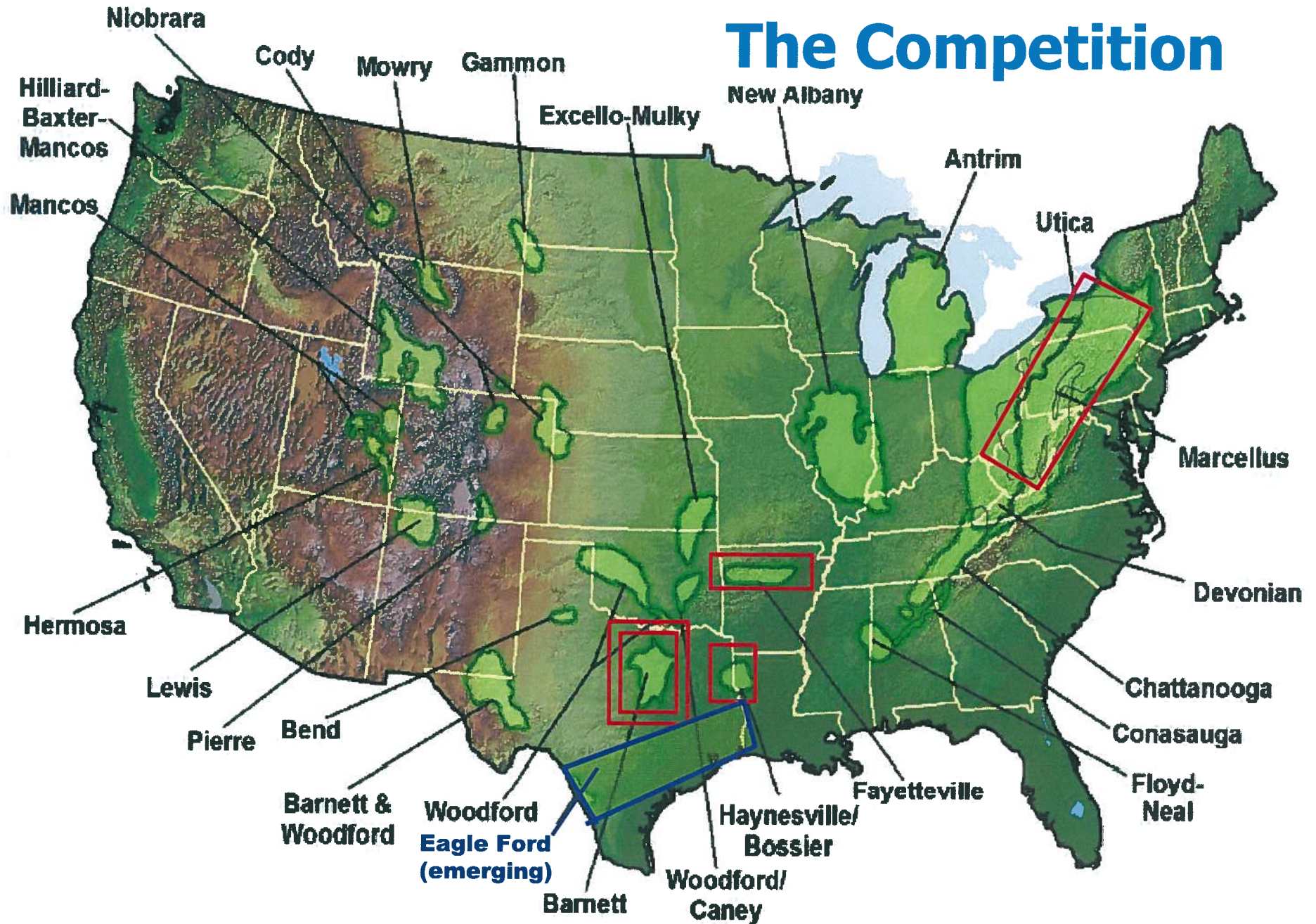
Marcellus Shale development activity during 2010 is expected to generate \$603 million in tax revenue to the Commonwealth and an additional \$269 million in tax revenue to local municipalities, primarily cities and boroughs.

Clearing roadblocks to Marcellus Shale development and growing revenue from existing taxes will bring much more revenue to Pennsylvania than imposing a punitive severance tax that can only limit growth.

2010 PA Tax Revenue Analysis from Marcellus Shale Development



The Competition



Water Issues Related to Marcellus Shale Development



Preparation



Drilling



Completion & Production



Reclamation

Site Preparation

- Engineered site design
- ESCGP-1 Permits required
- E&S controls prevent sediment contamination of streams from runoff



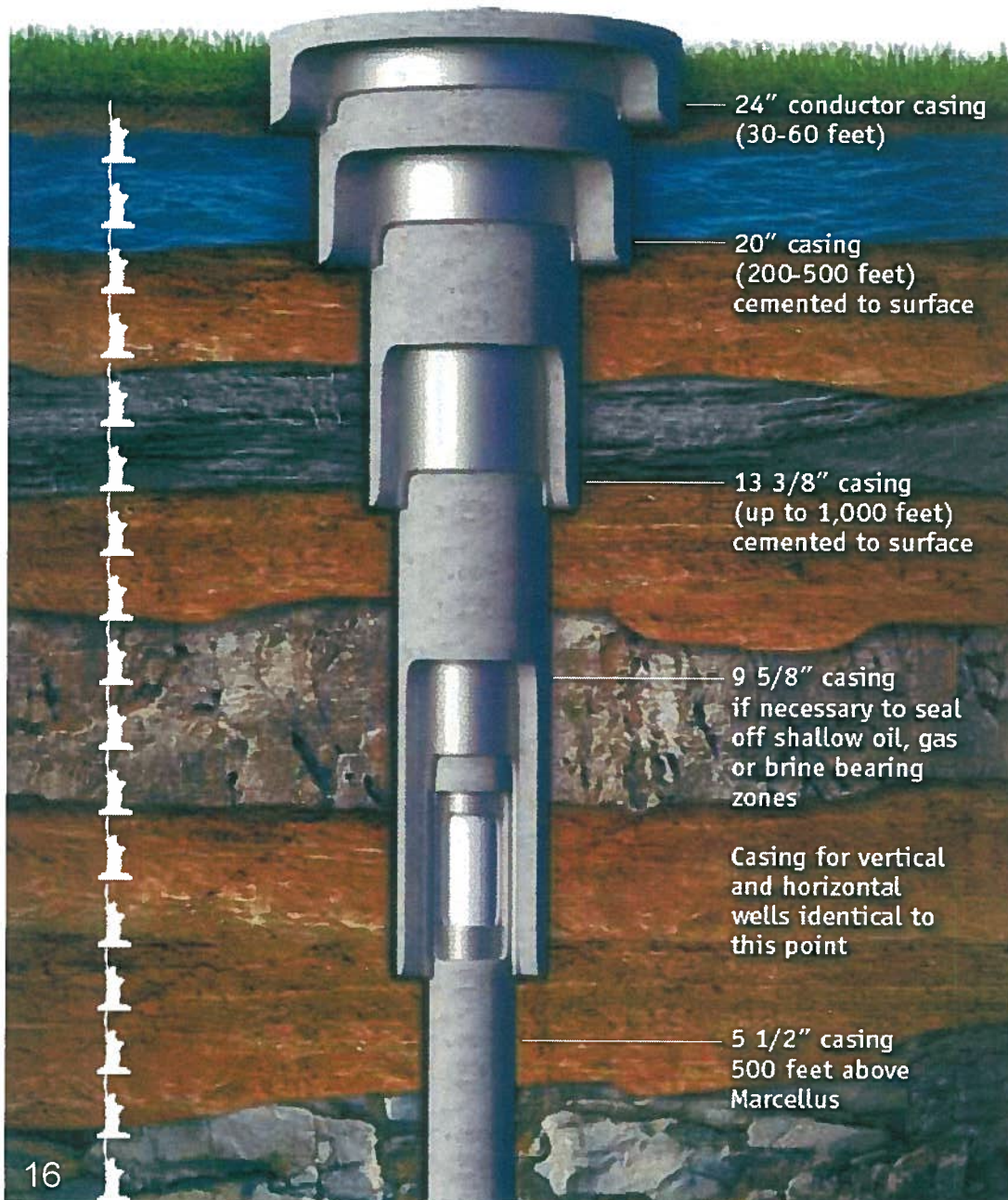


Drilling

- Access road and drilling pad are stabilized with crushed rock
- Slopes are stabilized with vegetation and appropriate erosion and sedimentation controls

General Casing Design for a Marcellus Shale Well

The Marcellus Shale is more than a mile below the Earth's surface.
It would take 17 Statues of Liberty on top of one another to reach the formation.



Ground Water Protection

- Fresh water is generally less than 500-foot depth; below that, water is salty
- Each casing string is cemented by pumping cement down pipe and circulating back up between the outside of pipe and the wellbore

Ground Water Protection

- PA casing and cementing regulations among toughest in the U.S. DEP has recently proposed additional regulations to specifically address shale drilling.
- 1,000' rebuttable presumption rule; DEP aggressively investigates all claims
- DEP issued only 80 orders to repair or replace water supplies impacted by drilling in past 15 years; 32,000 oil and gas wells drilled; 0.25% incident rate; all impacted water supplies replaced by drillers
- By comparison, Penn State 2009 study indicates over 40% of PA's 1.2 million private water wells and springs do not meet safe drinking water standards; common causes of contamination are on lot septic systems, agricultural practices, poor well construction

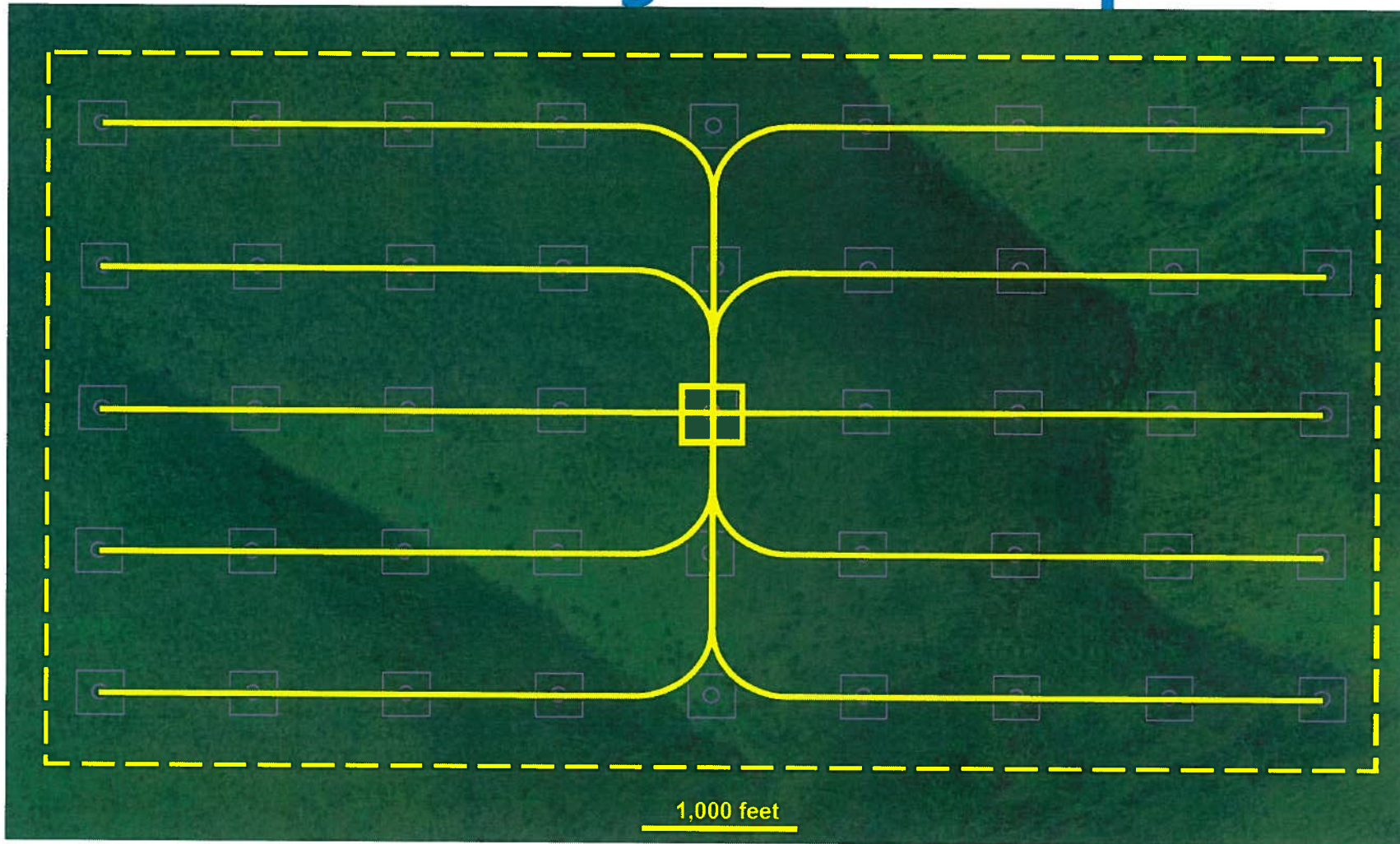


Horizontal Technology

John Perez Graphics

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Horizontal Drilling – small footprint



Total surface disturbance during drilling, including access road, drilling pad and required pipeline infrastructure:

- Horizontal (yellow) develop 1,000 acres per pad with 1% surface disturbance
- Vertical (purple) on 1,000-foot spacing develop 23 acres per well with 19% total surface disturbance



Fracing

Water Requirements for Marcellus

- Fracing a typical horizontal well requires 3-5 million gallons
- Is that a lot of water?
 - 4 million gallons is 1.8 inches of water over an area of 80 acres, the approximate drainage area of a well
 - PA receives about 40 inches of rainfall per year
 - If the productive area of the Marcellus takes 50 years to drill, annual water use over the productive area would be 0.04 inches of water per year or 1/10th of 1% of annual rainfall

Water Requirements for Marcellus

Water use per million btu of energy:

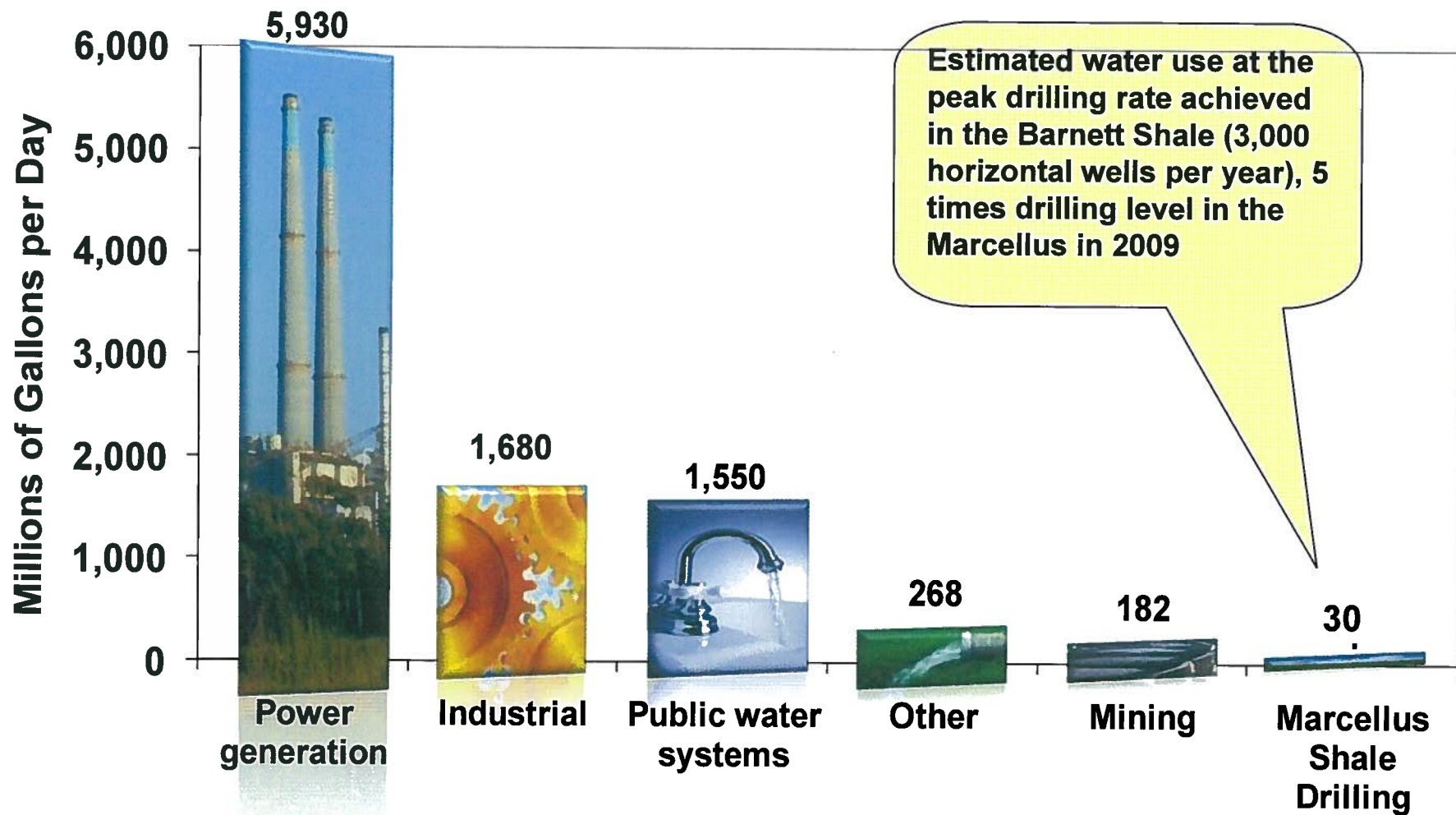
- Deep shale natural gas 0.60-5.80 gallons
- **Marcellus Shale gas – avg 1 gallon**
- Nuclear (uranium ready to use in a power plant) 8-14 gallons
- Conventional oil 8-20 gallons
- Synfuel-coal gasification 11-26 gallons
- Coal (delivered power plant) 13-32 gallons
- Oil shale 22-56 gallons
- Tar sands/oil sands 27-68 gallons
- Fuel ethanol from corn 2,510-29,100 gallons (irrigation)
- Biodiesel from soy 14,000-75,000 gallons (irrigation)

Shale gas production uses less water than any other significant energy source

Source: U.S. Department of Energy

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How Our Water Usage Stacks Up



Source: USGS, Pennsylvania Water Consumption



Water Impoundments

- Engineered design
- DEP construction standards
- ESCGP-1 Permits required
- Enhanced permit requirements with leak detection or groundwater monitoring if used to contain flow back water



Water Transfer

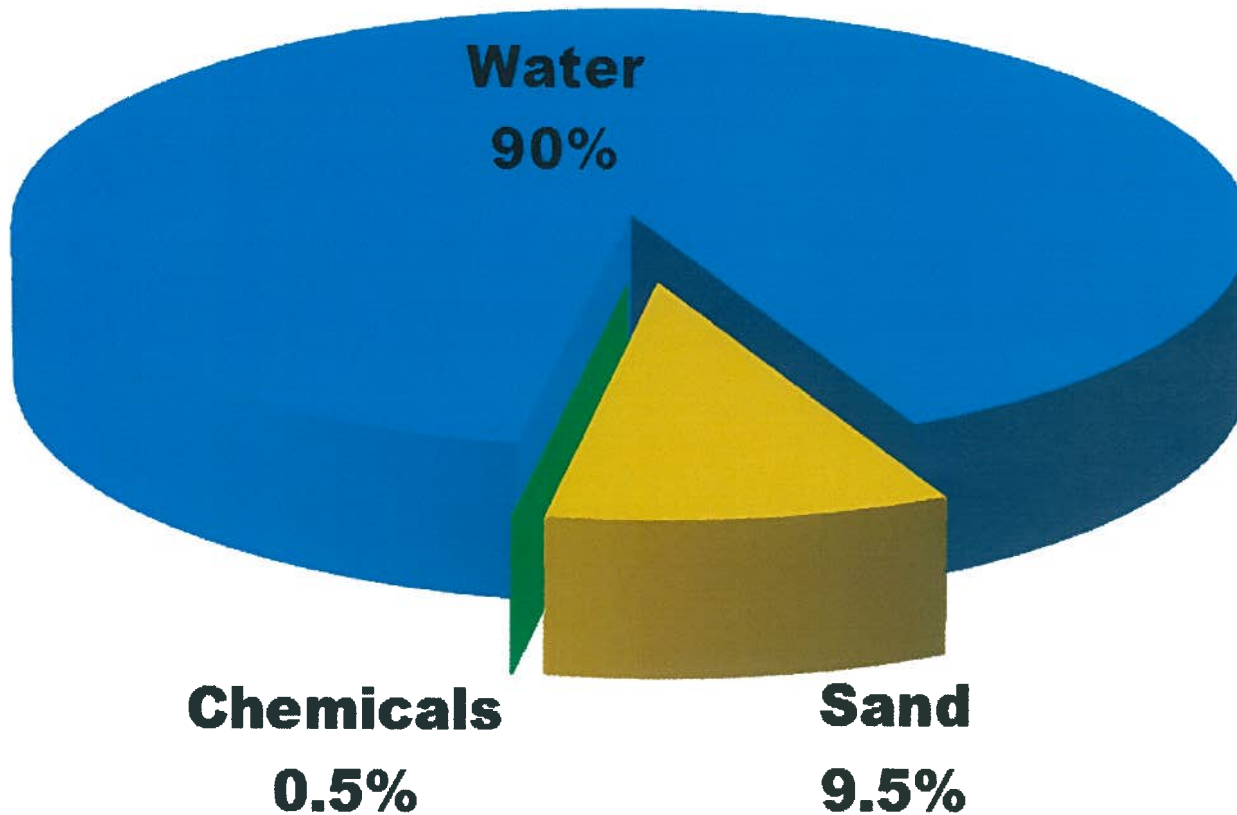
- Saves thousands of trucks on highways
- Can pump water several miles from impoundment to well during fracturing operation
- Aluminum irrigation pipe for fresh water
- HD Polyethylene or PVC for pumping recycled water

Water supply sources

- Larger streams and rivers
 - Pennsylvania has abundant water supplies
 - Water can be safely withdrawn at reasonable rates during all but the very driest periods
 - Susquehanna and Delaware River Basin Commissions have regulated water withdrawal for many years; no such regulation presently exists in the Ohio River basin
 - Industry and DEP have agreed to adopt SRBC rules; DEP is approving all water management plans
 - Protection of downstream uses
- Municipal water supplies
- Acid mine drainage – suitable for use with proper treatment

Frac Mixture

What goes into the well?



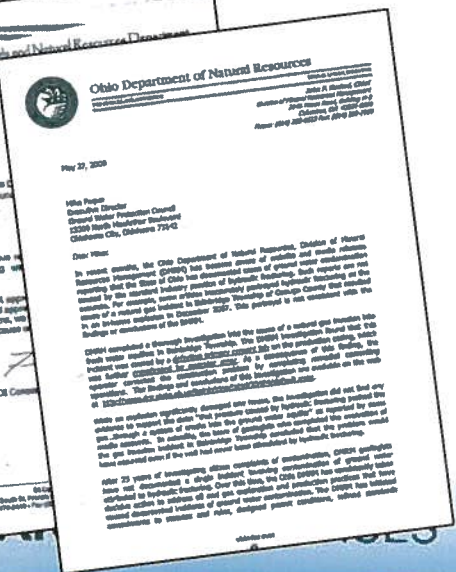
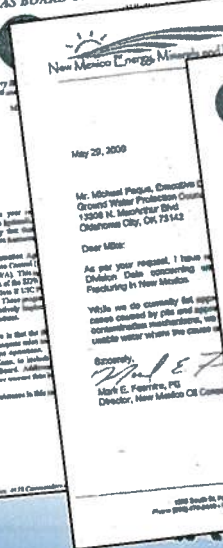
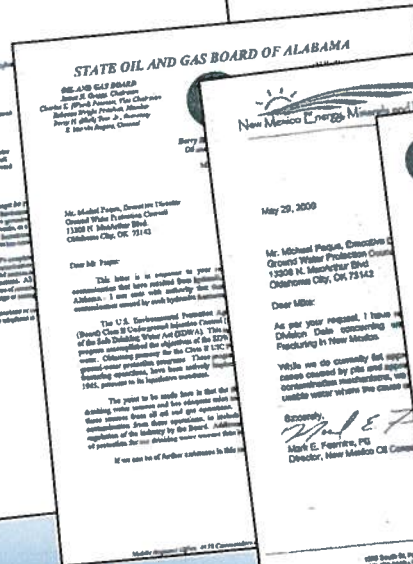
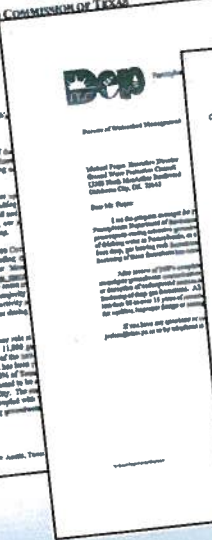
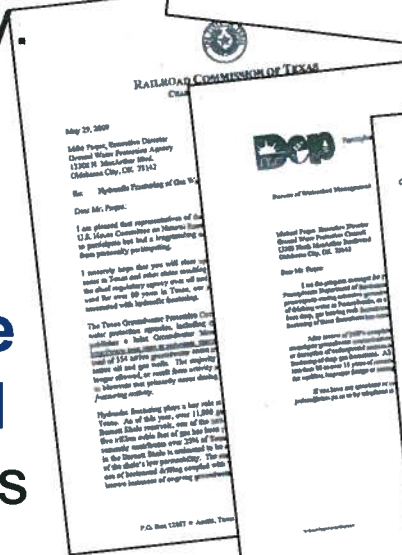
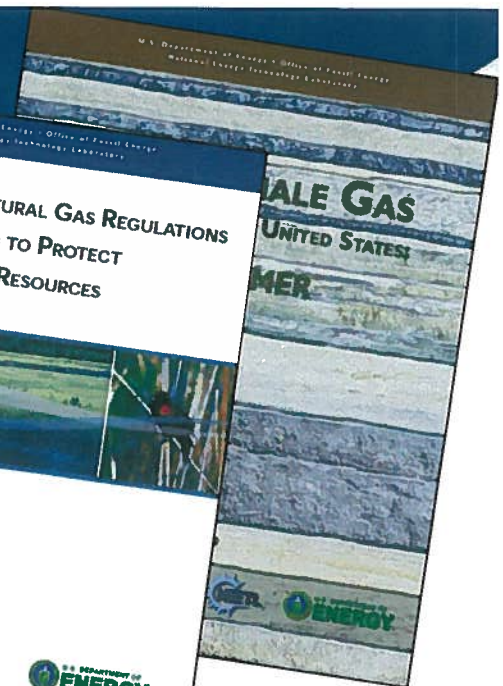
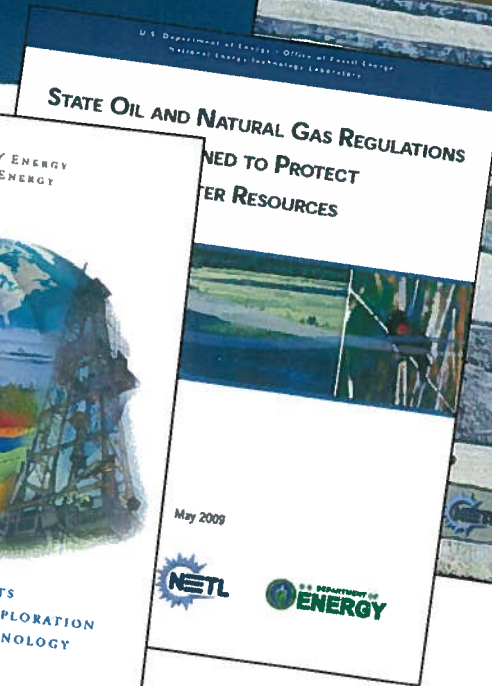
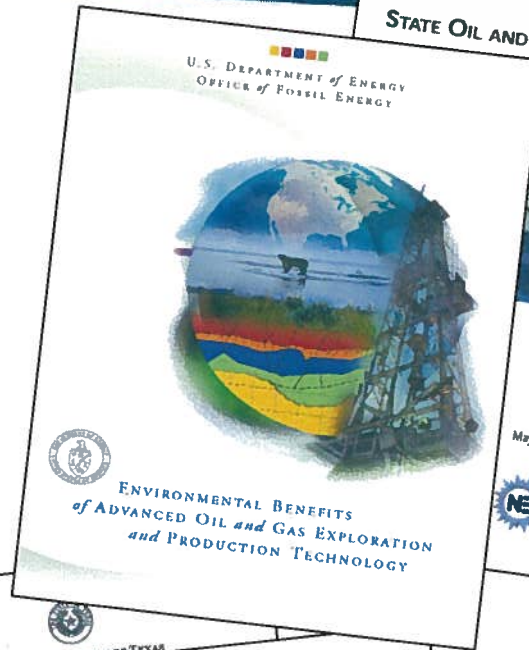
Primarily fresh water, with some sand, and a very small proportion of common chemicals, representing 0.5% of the mix. The chemicals are in very small quantities, low concentrations, used in highly supervised environments, and injected through multiple layers of cemented steel casings

Typical additives used in frac water

Additive type	Main compound	Purpose	Common use
Friction reducer	Polyacrylamide	Reduces friction between fluid and pipe	Water treatment; soil conditioner; some children's toys
Biocide	Glutaraldehyde	Eliminates bacteria in the water that produce corrosive byproducts	Disinfectant; sterilize medical and dental equipment and surfaces
Scale inhibitor	Ethylene glycol	Prevents scale deposit in the pipe	Automotive anti-freeze, household cleaners, de-icing agent
Oxygen scavenger	Ammonium bisulfite	Removes oxygen from the water to protect the pipe from corrosion	Cosmetics, food and beverage processing, water treatment
Diluted Acid	Hydrochloric Acid	Help dissolve cement and minerals and help initiate fractures	Swimming pool chemical and cleaner

Safe and Proven

More than 30 state and federal regulatory agencies have extensively studied hydraulic fracturing technology. There are **zero** confirmed cases of groundwater contamination in **one million wells fraced** over the last 60 years



Water Treatment and Disposal

- Water flowed back after frac contains salt and other naturally occurring dissolved solids present in ancient sea water
- Water is gathered and removed from site by either truck or pipeline
- Traditional treatment of natural gas wastewater in PA:
 - Removal of heavy metal constituents, then discharge to large streams or rivers where safely diluted
 - Deep well injection (limited)
- DEP and Industry are aware and prepared for Marcellus waste water

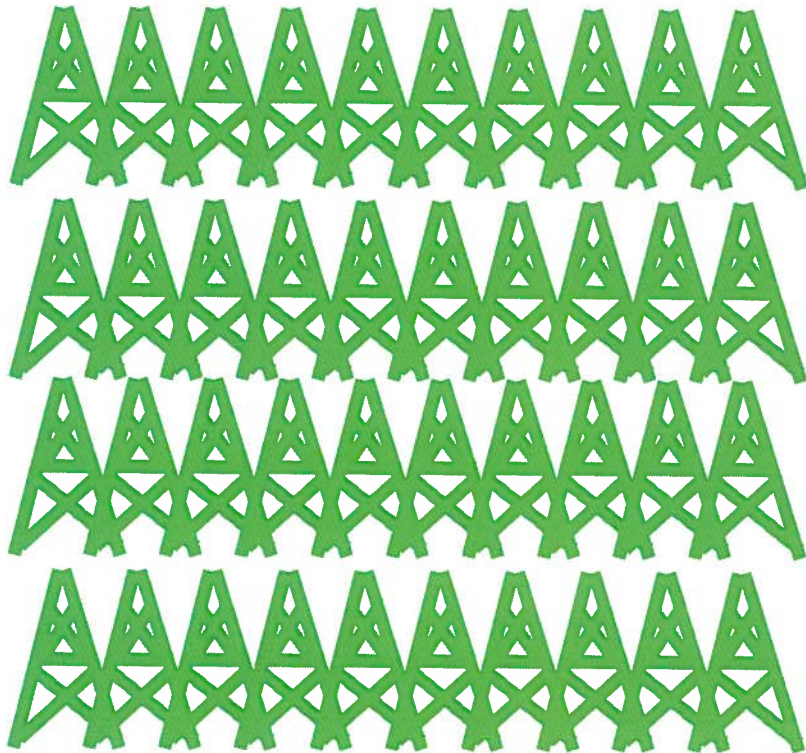


How much water?

Year	2009	2010	2011	2012	2013	2014	units
Est. % of flowback water recycled	50%	70%	80%	80%	80%	80%	
New wells drilled	700	1,200	1,700	2,200	2,700	3,000	wells
Fresh water requirement	6.7	10.8	14.9	19.3	23.7	26.3	M Gals/day
Fresh water requirement - % of annual PA rainfall	0.015%	0.024%	0.032%	0.042%	0.052%	0.057%	
Fresh water requirement - % of total PA water use	0.070%	0.113%	0.155%	0.201%	0.246%	0.274%	
Waste water generated	1.0	1.0	0.9	1.2	1.5	1.6	M Gals/day

Assumes drilling levels forecasted by PSU economic impact study (7/2009) and recycling at the percentages indicated above

How Much Salt?



8 million gallons per day
of flow back water



salt dumped on only state
roads annually (750,000 tons)

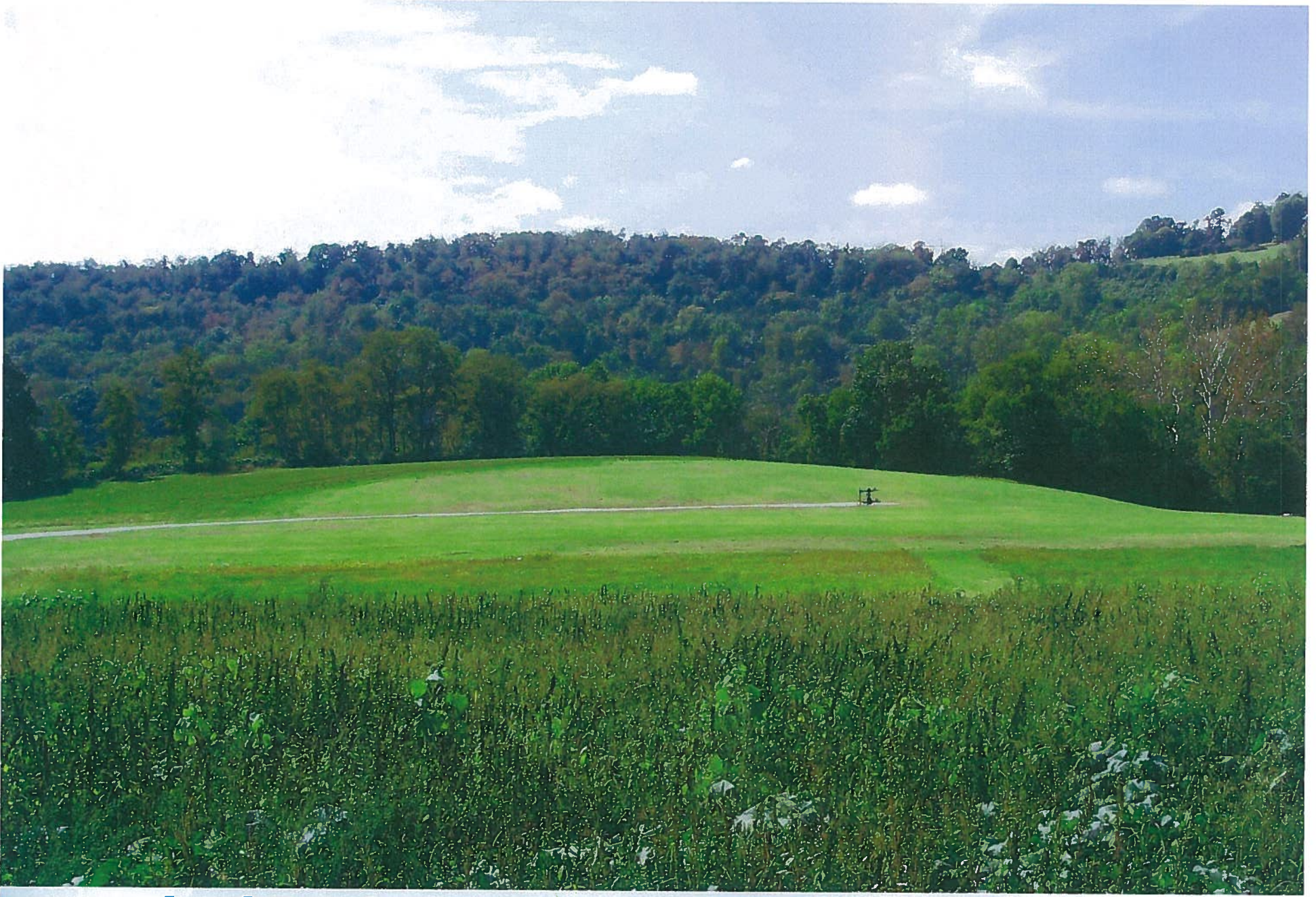
With proper management and recycling, estimates of waste water from Marcellus drilling are expected to be less than 2 million gallons per day at peak drilling levels

Water Disposal Solution

There won't be a "silver bullet" or single technology, the solution will consist of a portfolio of disposal options, many of which are already being utilized including:

- Traditional disposal methods
- recycling of flow back water (very promising - from zero to 60% in 6 mo.)
- deep well injection
- zero liquid evaporation, crystallization, and land filling





Final Reclamation



Production

- Site is reclaimed to a small fraction of its original size during drilling
- Production equipment will remain for life of the well
- Produced fluids will be removed and safely disposed



Production

Is there adequate regulation?

Act 223 - The Oil & Gas Act of 1984

- **Primary statute regulating oil and gas drilling activity**
- **Details permitting and operations requirements for the following:**
 - **Well drilling permits**
 - **Well registration and identification**
 - **Inactive status of wells**
 - **Well location restrictions**
 - **Well site restoration**
 - **Site restoration requirements**
 - **Casing and cementing requirements – Protection of fresh groundwater**
 - **Plugging requirements**
 - **Protection of water supplies**
 - **Reporting requirements**
 - **Bonding**
 - **Enforcement and remedies**

PA Code 25, Chapter 78

- Detailed regulations promulgated under Act 223.

Act 214 - Coal and Gas Resources Coordination Act of 1984

- This Act covers governs placement of wells and special regulations in areas containing active coal mines and unmined coal seams.

Act 359 - Oil and Gas Conservation Law of 1961

- Governs spacing of deep wells which penetrate the Onondaga Formation (directly beneath the Marcellus Shale).

PA Code 25, Chapter 102

- Regulations with respect to erosion and sedimentation control for earth disturbance activities.
- Basis for Erosion and Sedimentation Control Manual for oil & gas development (well pads, pipelines, impoundments).
- Requires ESCGP-1 for earth disturbance over 5 acres; applies to all Marcellus wells, pipelines and water impoundments.

PA Code 25, Chapter 105

- **Requires permits for stream and wetland crossings.**
- **Requires permits for stream and wetland encroachments.**
- **Requirements for dam permits for impoundments if the impoundment is to be used for collection/storage of flowback and/or produced water.**
- **Construction Guidelines for the construction of impoundments**

Federal Clean Water Act and Pennsylvania Clean Streams Law

- **These are the laws that allow Pennsylvania to enact the permitting requirements described above associated with Chapter 102 and Chapter 105.**

PA Code 25, Chapter 287, Residual Waste

- **regulates disposal of wastes from drilling or completion operations**
- **regulates transportation of wastes from drilling or completion operations and the record keeping**
- **annual chemical analysis of the waste stream.**

Act 220 - Water Resources Planning Act Of 2002

- **Under Act 220, the PADEP has mandated that operators submit a comprehensive Water Management Plan for all Marcellus Shale wells prior to conducting hydro-fracturing operations on wells.**

Title 40 of the Code of Federal Regulations, Part 112

- **Mandates Oil Pollution Prevention and regulates by requiring Spill Prevention Control and Contingency Plans**

SRBC - Susquehanna River Basin Commission

- **Interstate Compact Commission that regulates all water usage within the Susquehanna River Basin in PA (and other states).**
- **Requires reports, plans and procedures to be filed and followed prior to any activity on a wellsite in the SRBC area. Also includes significant fees for water consumptive use.**

US Army Corp of Engineers

- **ACOE performs a review of the stream/wetland crossing General Permit applications submitted to the PADEP when impacts from the crossings exceed thresholds defined by the ACOE.**



Thank You

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MyRangeResources.com

PaMarcellus.com

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