

ASSESSMENT OF PA REGULATORY SCHEME TO PROTECT WATER RESOURCES

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The “SRBC”

Brief Background

Susquehanna River Basin Commission

- **Federal-interstate compact commission established by the federal government and the states of New York, Pennsylvania, and Maryland.**
- **Responsible for managing the basin's water resources.**
- **Currently comprised of 47 full-time staff.**





Susquehanna River Basin

The Basin

- 27,510-square-mile watershed
- Comprises 43 percent of the Chesapeake Bay watershed
- 4.2 million population
- 60 percent forested
- 32,000+ miles of waterways

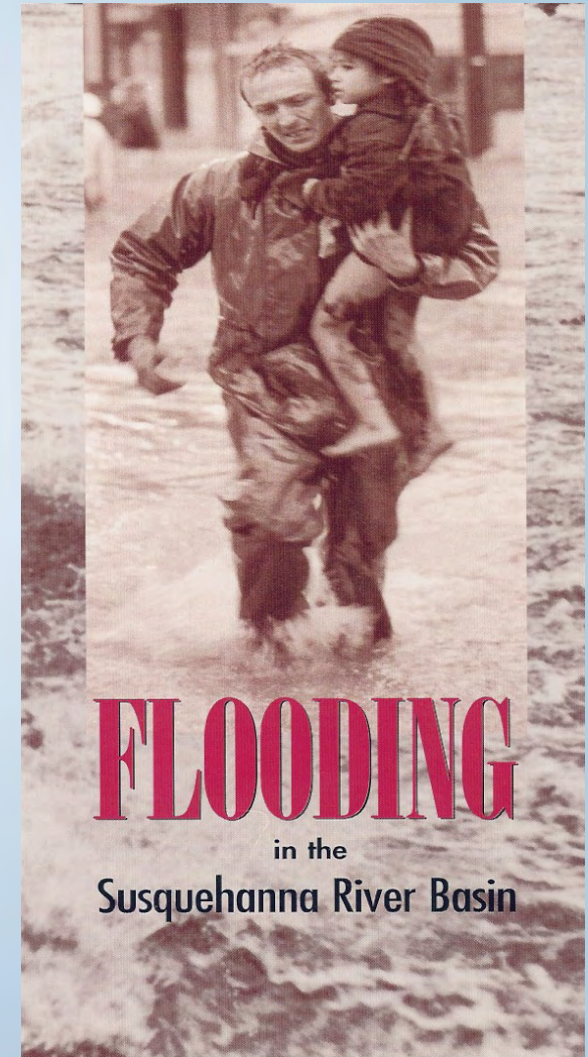


The Susquehanna River

- 444 miles, largest tributary to the Chesapeake Bay
- Supplies 18 million gallons a minute to the Bay

Commission Programs

- **Flood Forecast and Warning System**
- **Monitoring and Assessment**
- **Public Education and Outreach**
- **Water Resources Planning**
- **Drought Coordination**
- **Regulatory Program**



Marcellus Shale

- **What is it?**
- **Where is it?**

Amount of Natural Gas in Marcellus Shale

- **U.S. currently produces approx. 30 trillion cubic feet per year of natural gas.**
- **Estimates range from 200 to 1,000 trillion cubic feet contained in Marcellus Shale.**
- **Approx. 10% of that is recoverable.**
- **Approx. 20 to 50 trillion cubic feet available from Marcellus.**

Natural Gas from Marcellus Shale

Marcellus Shale

- **What is it?**



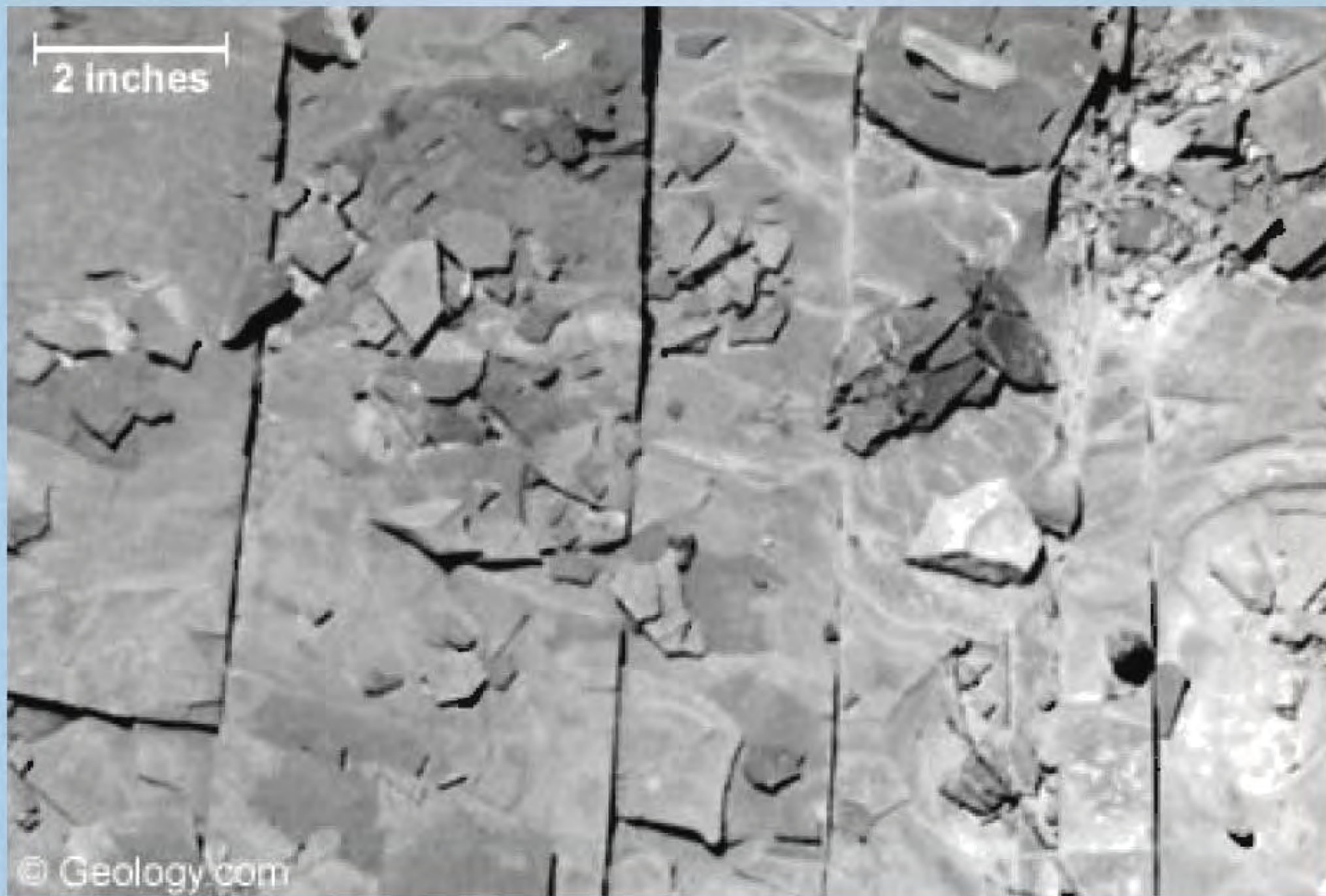
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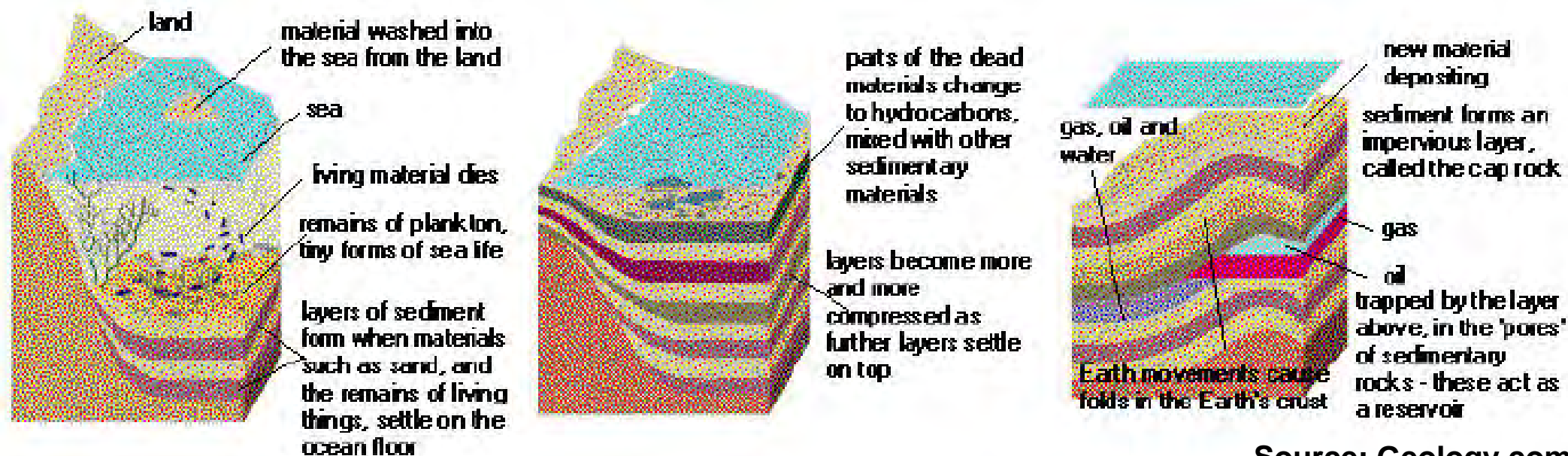
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Formation of Oil and Gas



Source: Geology.com

1. Organic Matter
2. Deposition

3. Deep Burial
4. Entrapment

Typical Natural Gas Composition

- Methane (CH_4) - 70 to 90%
 - Ethane (C_2H_6)
 - Propane (C_3H_8)
 - Butane (C_4H_{10})
- } 0 to 20%
- Carbon dioxide (CO_2) - 0 to 8%
 - Nitrogen (N_2) - 0 to 5%
 - Hydrogen Sulfide (H_2S) - 0 to 5%
 - Oxygen (O_2) - 0 to 0.2%
 - Rare Gases (Ar, He, Ne, Xe) - Trace

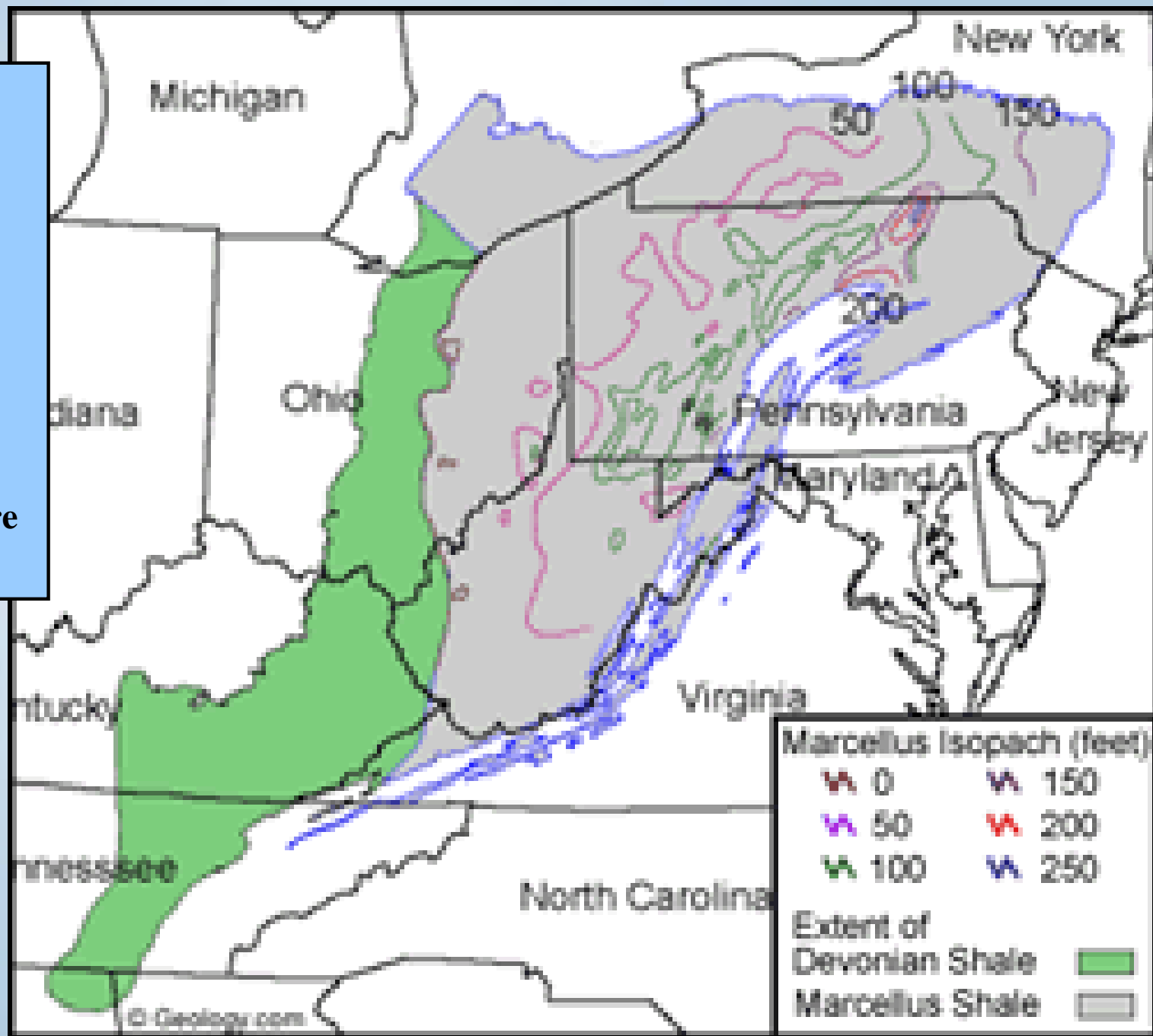
Source: NaturalGas.org

Marcellus Shale

- **Where is it?**

Appalachian Basin

- NY to PA, OH, MD, WV and VA
- Trending northeast,
- Spans a distance of approximately 600 linear miles,
- Area of 54,000 square miles.



Geographic Location

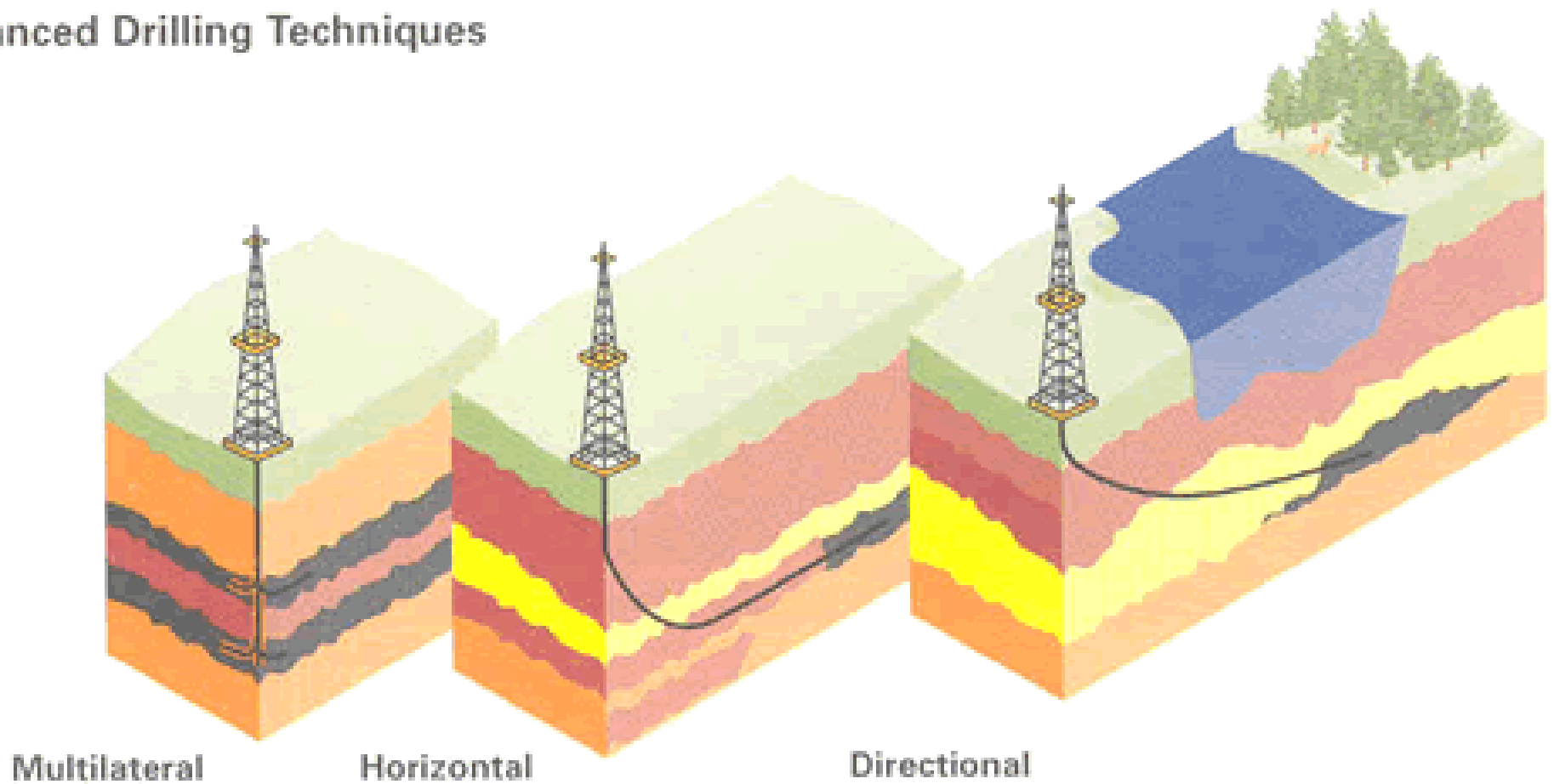
- **Appalachian Basin Province**
 - NY to PA, OH, MD, WV and VA
 - Trending northeast, spans a distance of approximately 600 linear miles, and 54,000 square miles
 - 72 percent of the Susquehanna River Basin is underlain by the Marcellus Shale



Marcellus Shale Play

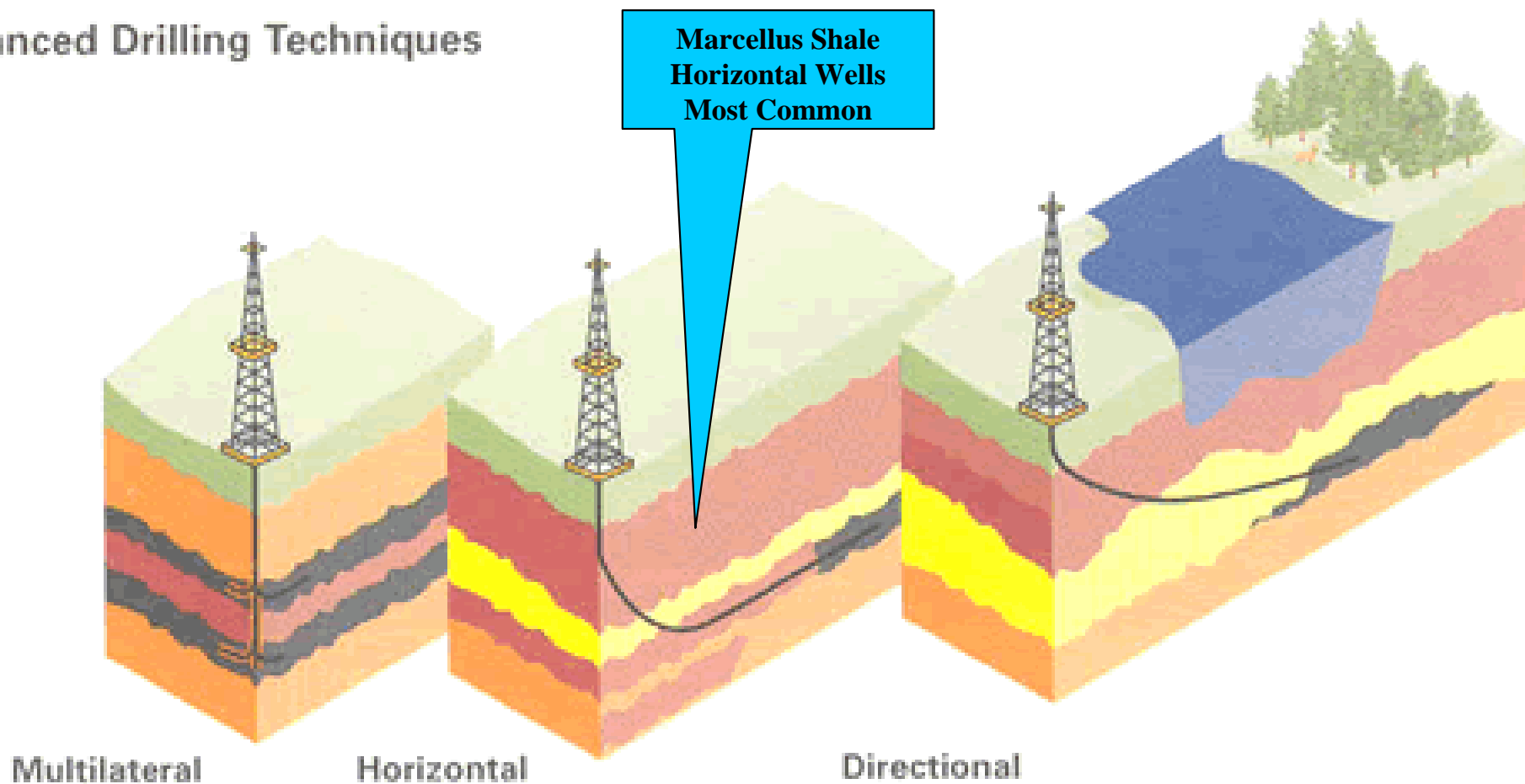
Why Now ???

Advanced Drilling Techniques



Source: DOE

Advanced Drilling Techniques



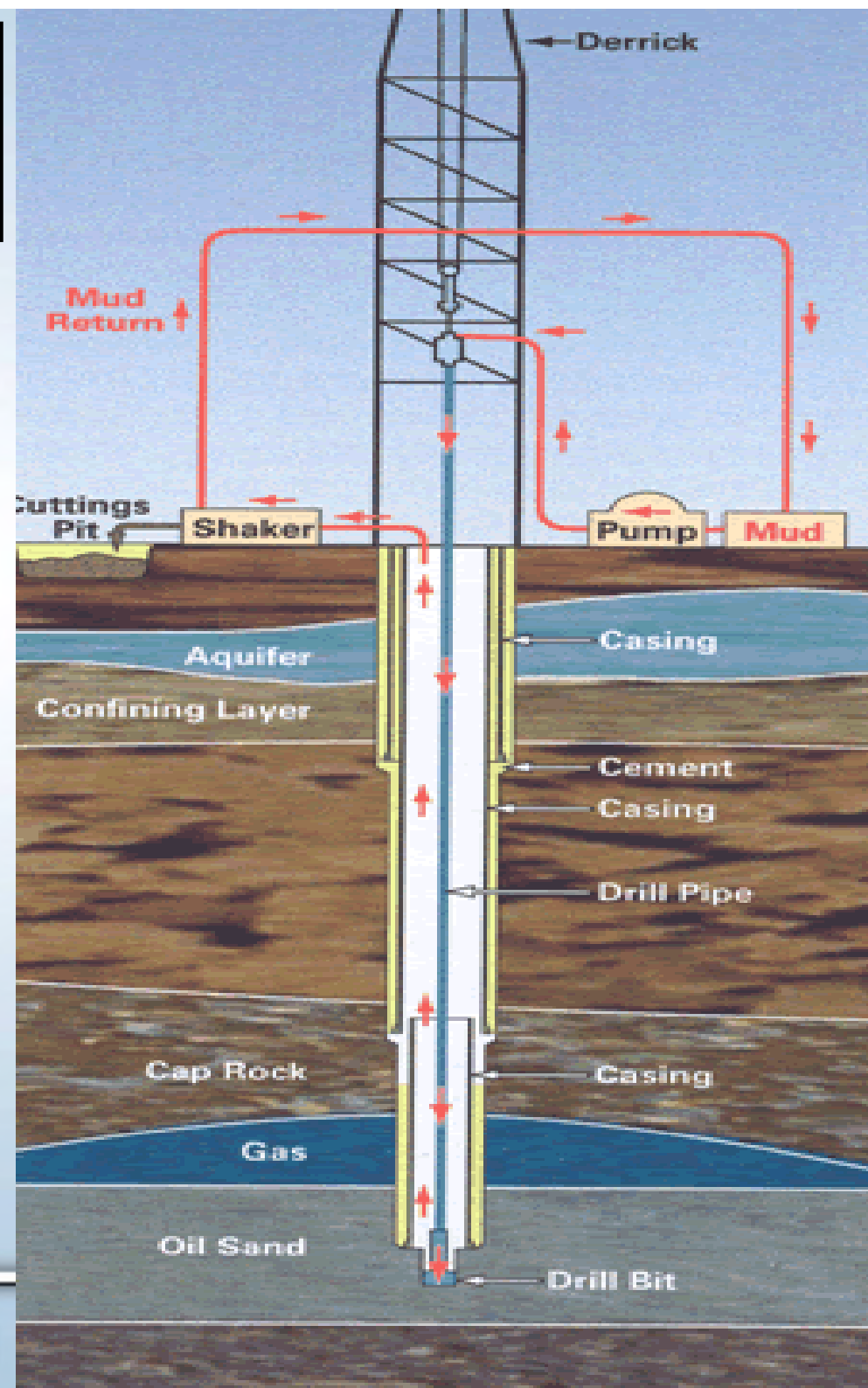
Source: DOE



How Wells Are Drilled

- Drill Hole
- Advance Casing
- Grout Annulus
- Advance Hole
- Advance Casing
- Grout Hole
- Advance Hole into Shale
- Advance Perforated Casing
- Hydro-Fracture Formation
- Remove Gas

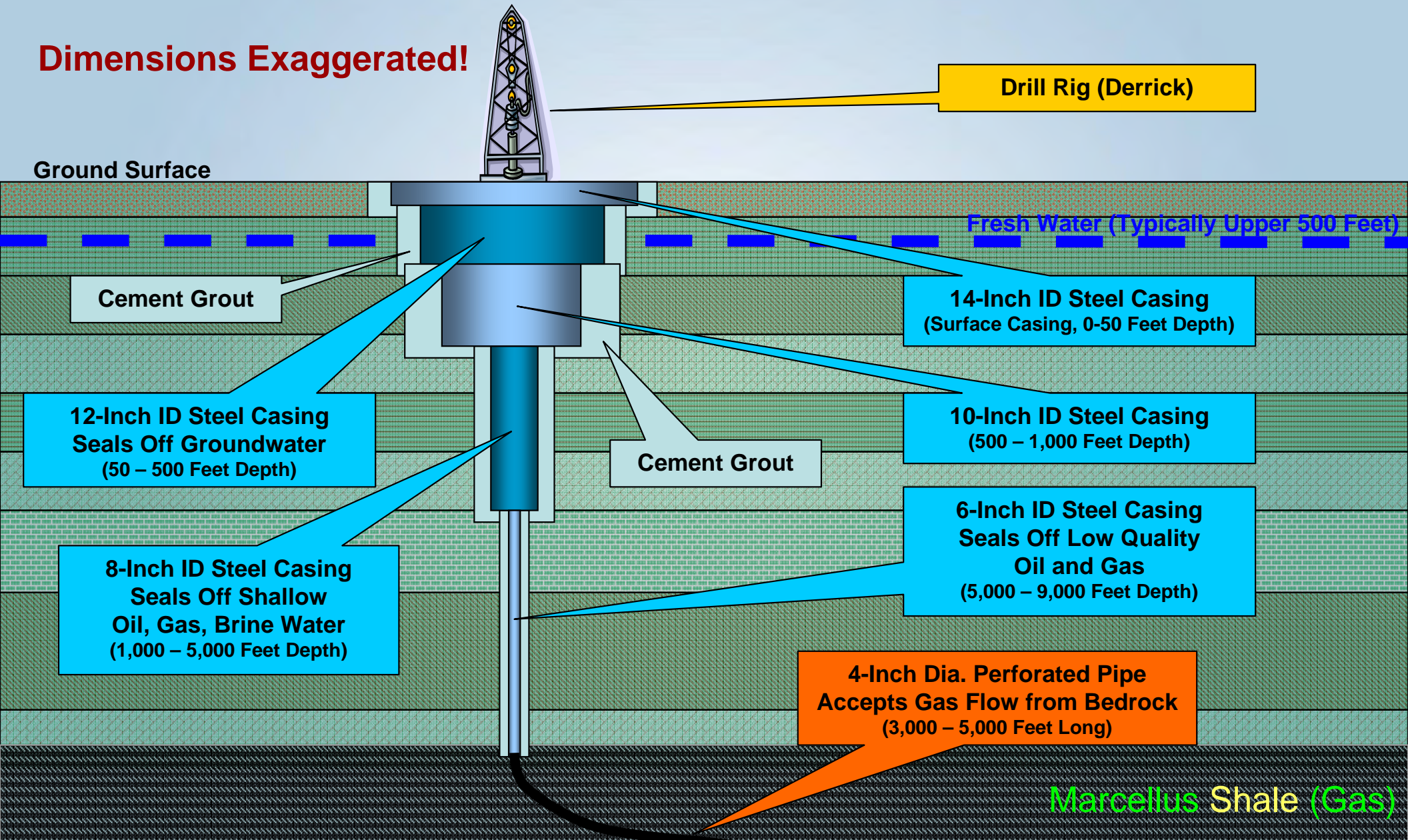
Source: Modified from DOE



Types of Drilling Fluids (Muds)

- **Oil-Based Muds (OBM)**
 - Contain diesel oil or mineral oil, perform best in reactive shales and horizontal wells, but contain toxic ingredients that make disposal difficult.
- **Water-Based Muds (WBM)**
 - Inexpensive, easily disposed, but do not provide good results in horizontal wells.
- **Synthetic-Based Muds (SBM)**
 - More expensive than WBM or OBM; but less toxic and more biodegradable than OBM.

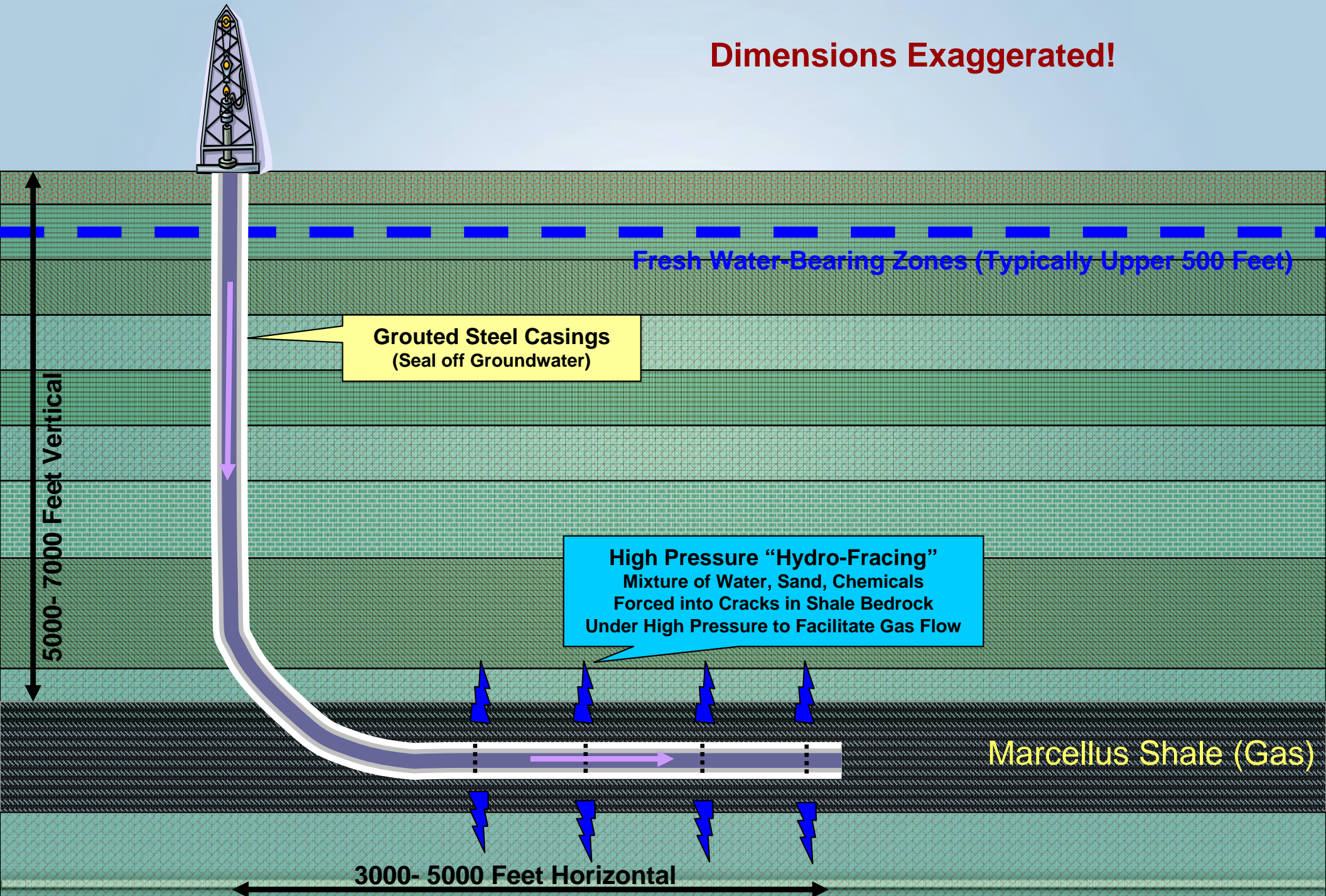
Dimensions Exaggerated!



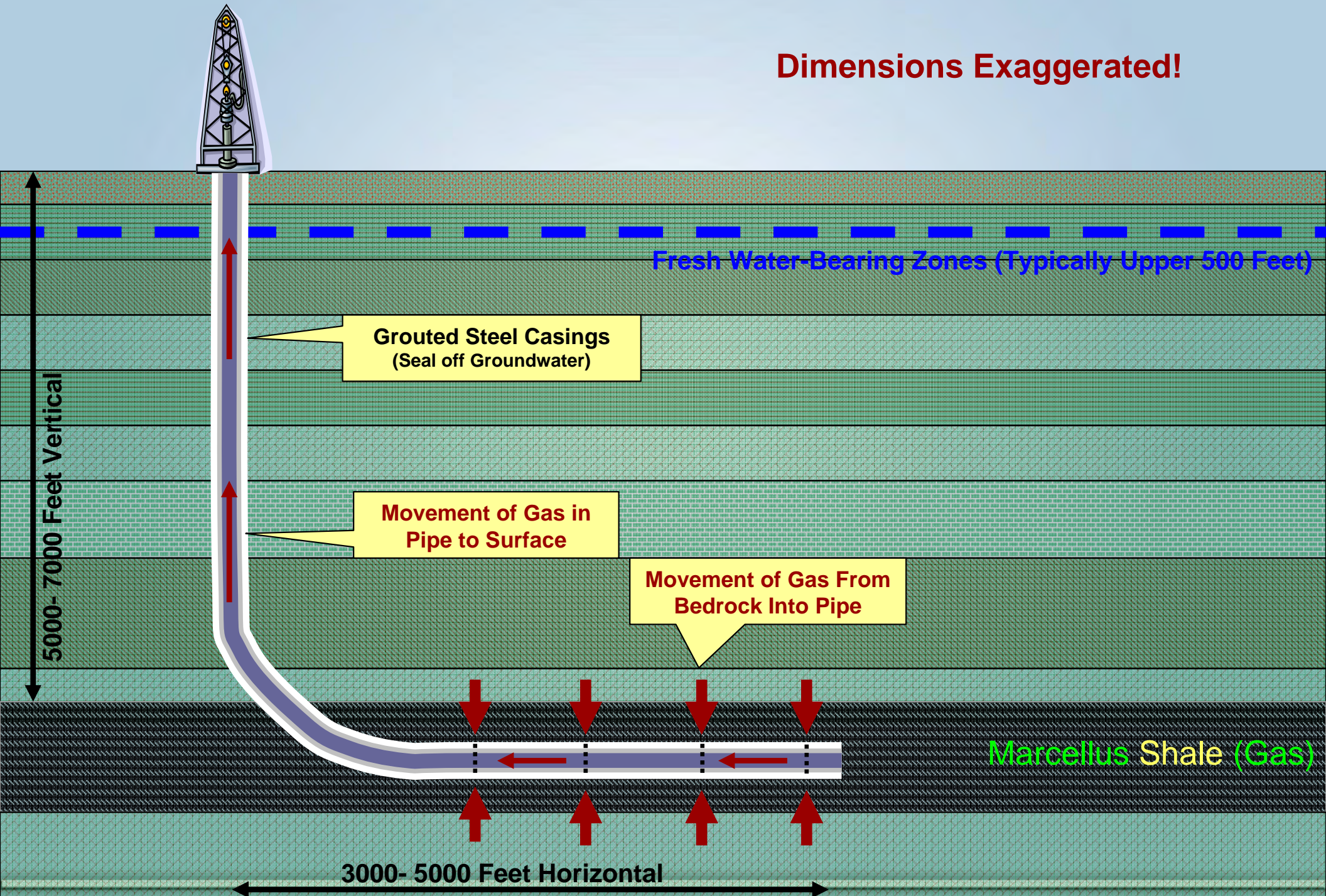
Hydro-Fracturing Process

- **Mixture of water, sand, chemicals (<1%): chemicals for bacteria control and friction.**
- **Injected (pumped) under high pressure (600-1,000 psi) into well.**
- **Pressure forces mixture out into cracks and fractures in shale bedrock.**
- **Provides avenue for gas to move into well.**
- **Increases (stimulates) well production.**
- **Source of flow-back water, disposed off-site.**

Dimensions Exaggerated!



Dimensions Exaggerated!



Marcellus Gas Wells

- **Where Are They?**



Anticipated Activities within New York



**Gas and Oil Wells
Pre-Marcellus Gas Rush
South of Renovo, PA**

Issues & Challenges

- Gas Well Development -

- **Environmental, Public Health and Safety Concerns**
- **Casing of Wells Critically Important**
- **Flow-Back Water Requires Off-Site Treatment**



Flow-Back Water and Brine

Violations Include:

- **Poorly constructed water impoundments.**
- **Inadequate erosion and sediment controls.**
- **Improper waste and fluid disposal.**
- **Improper and unregistered withdrawals of water from streams.**

Interesting Facts Typical Gas Wells

- **Gas well drilling time; 20 to 60 days.**
- **Fracture stimulation time; 4 to 10 days.**
- **Flowback time; approx. 21 days**
- **Gas production (well-life); approx. 10-20 years**

Water Use – Gas Wells

- **Vertical wells use approx. 1 millions gallons during drilling and hydro-fracing.**
- **Horizontal wells use approx. 5 million gallons during drilling and hydro-fracing**
- **(approx. 1 million gal per 1,000 horiz. feet).**
- **Flow-back period approx. 21 days.**
- **Trucks haul flow-back water off-site to treatment facility.**

Sources of Water for Gas Well Drilling (Current Relative Amounts)

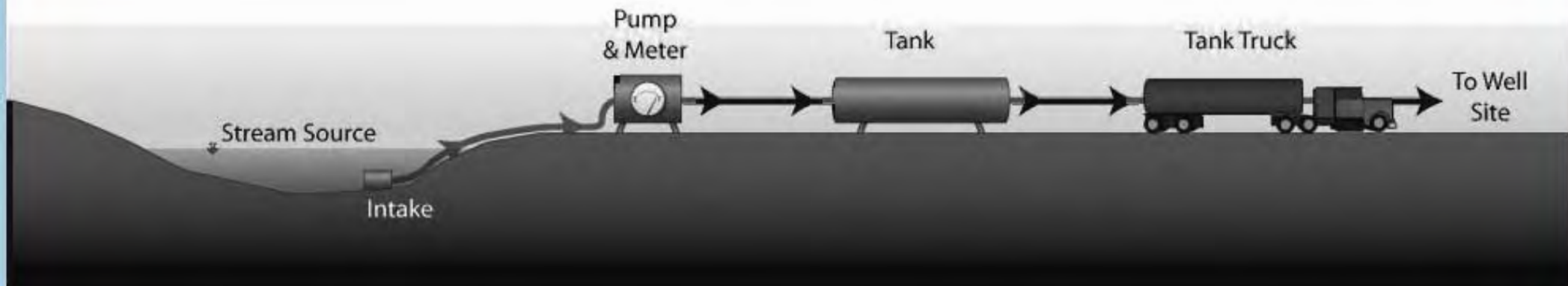
- **Surface Water Intakes (~80%)**
- **Public Water Supplies (~15%)**
- **Mine Drainage (<1%)**
- **Treated Municipal Wastewater (<1%)**
- **Treated Industrial Wastewater (<1%)**
- **Groundwater Wells (<1%)**

Sources of Water for Gas Well Drilling (Future Relative Amounts)

- **Surface Water Intakes (Decreasing)**
- **Public Water Supplies (Decreasing)**
- **Mine Drainage (Increasing)**
- **Treated Municipal Wastewater (Increasing)**
- **Treated Industrial Wastewater (Increasing)**
- **Groundwater Wells (Increasing, w/ Stringent Guidelines)**
- **Planning and Surface Storage (Increasing)**

Generic Schematic of Withdrawal Point

(the configurations will vary from case to case)



Water would be withdrawn from the stream source to a meter with recording device.

Tanks would temporarily store water for loading into tank trucks.

The exact configuration will vary depending on site conditions, contractor, and landowner requirements

Regulations Controlling Gas Wells

- **Pennsylvania Dept. of Environ. Protection (PADEP) permits individual gas wells (addresses environ. impacts).**
- **New York Dept. of Environ. Conservation (NYDEC) currently modifying their existing regulatory programs for gas well industry.**
- **Maryland Dept. of Environment (MDE) has gas well regulations, but none addressing high pressure, high volume gas wells.**
- **SRBC regulates consumptive use and water withdrawals at point-of-taking.**

What Constitutes Consumptive Use?

- Definition: A loss of water transferred through man-made conveyance or any integral part thereof (including such water purveyed through public water supply or wastewater system), due to transpiration by vegetation, incorporation into products during their manufacture, evaporation, **injection of water or wastewater into a subsurface formation from which it would not reasonably be available for future use in the basin**, diversion from the basin, or any other process by which water is not returned to the waters of the basin undiminished in quantity.

How SRBC Regulates Water Use Related to Gas Wells

- **Regulates consumptive water use on a “per pad” basis.**
- **Regulates individual water sources at point-of-taking; whether from surface water sources, public water supplies, groundwater wells, or other.**

SRBC Regulatory Authorities

(Not Specific to Gas Wells)

806.4 & 806.23—Groundwater Withdrawal and Surface Water Withdrawal

100,000 gallons per day (gpd) or more

806.4(a)(1) & 806.22—Consumptive Use of Water

20,000 gpd or more

806.4(a)(3) – Diversions In/Out of Basin

20,000 gpd out of basin, and any quantity in to basin

SRBC Regulatory Authorities

(Specific to Gas Wells)

§806.3, §806.4 – Projects Requiring Approval

§806.4(a)(1) & §806.22(f) - Consumptive Use of Water

All consumptive use, regardless of amount, all sources

§806.23—Groundwater Withdrawal and Surface Water Withdrawal

All water withdrawn, regardless of amount

§806.4(a)(3) – Diversions In/Out of Basin

All diversions, regardless of amount

SRBC Focuses on Low Flows at Surface Water Points-of-Taking

- **Want to protect aquatic ecosystems.**
- **Want to protect existing users.**
- **Determine “safe” amounts of withdrawals based on low flow characteristics and cumulative impacts on streams.**
- **Average Daily Flow (ADF) and Q_{7-10} .**

Low Flow Statistics

- **Average Daily Flow (ADF) is defined as the arithmetic average of all daily flows measured over entire period of record.**
- **Q_{7-10} is defined as the lowest consecutive seven-day flow occurring, on average, once every ten years.**

Low Flow Statistics (Cont.)

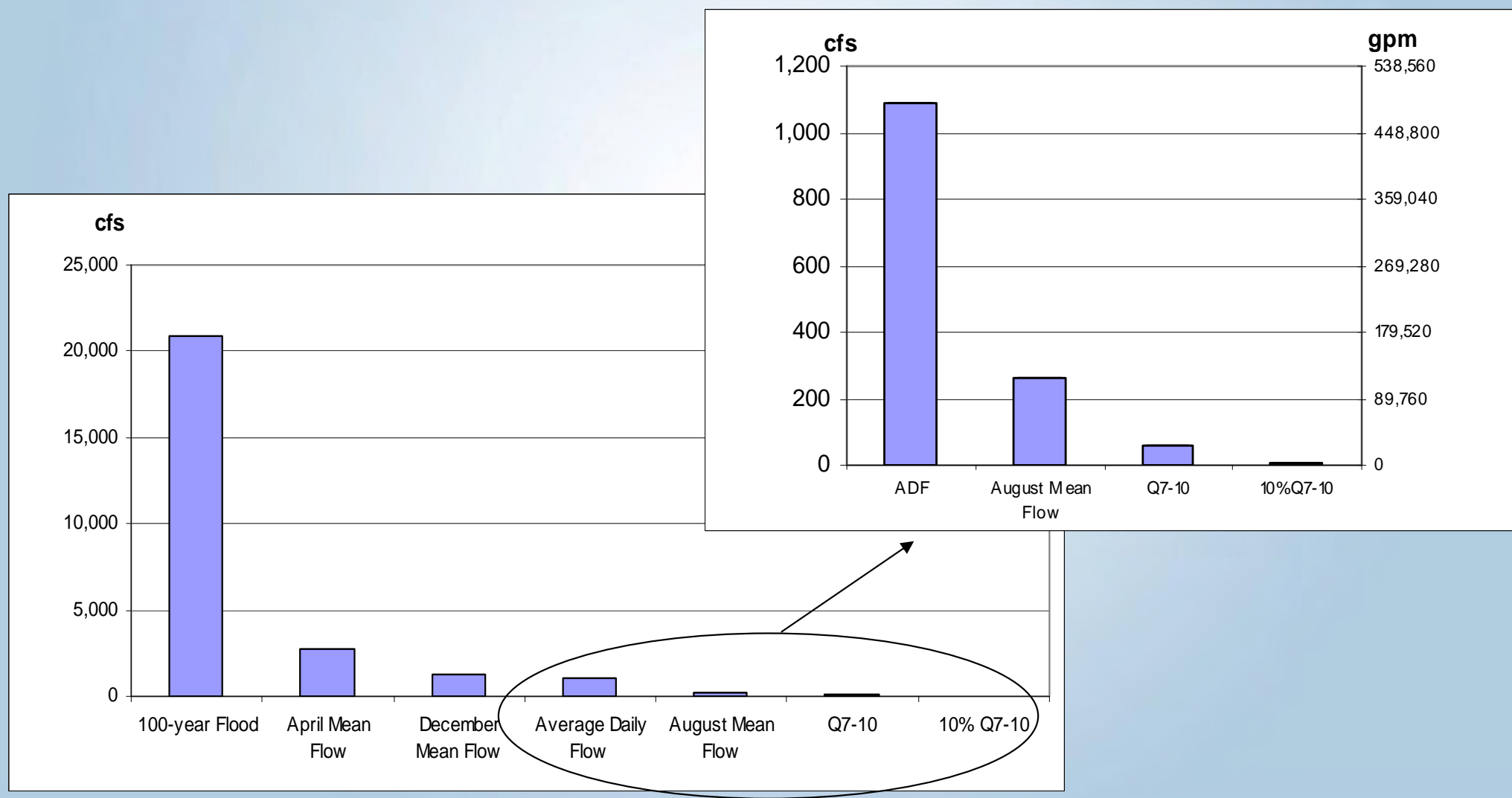
- **If proposed withdrawal is less than 10% of Q_{7-10} , no passby requirements.**
- **If proposed withdrawal is greater than 10% of Q_{7-10} , passby will be required.**
- **Passby is a minimum flow requirement set by SRBC; no withdrawals can occur if flows in given stream are below set passby value.**



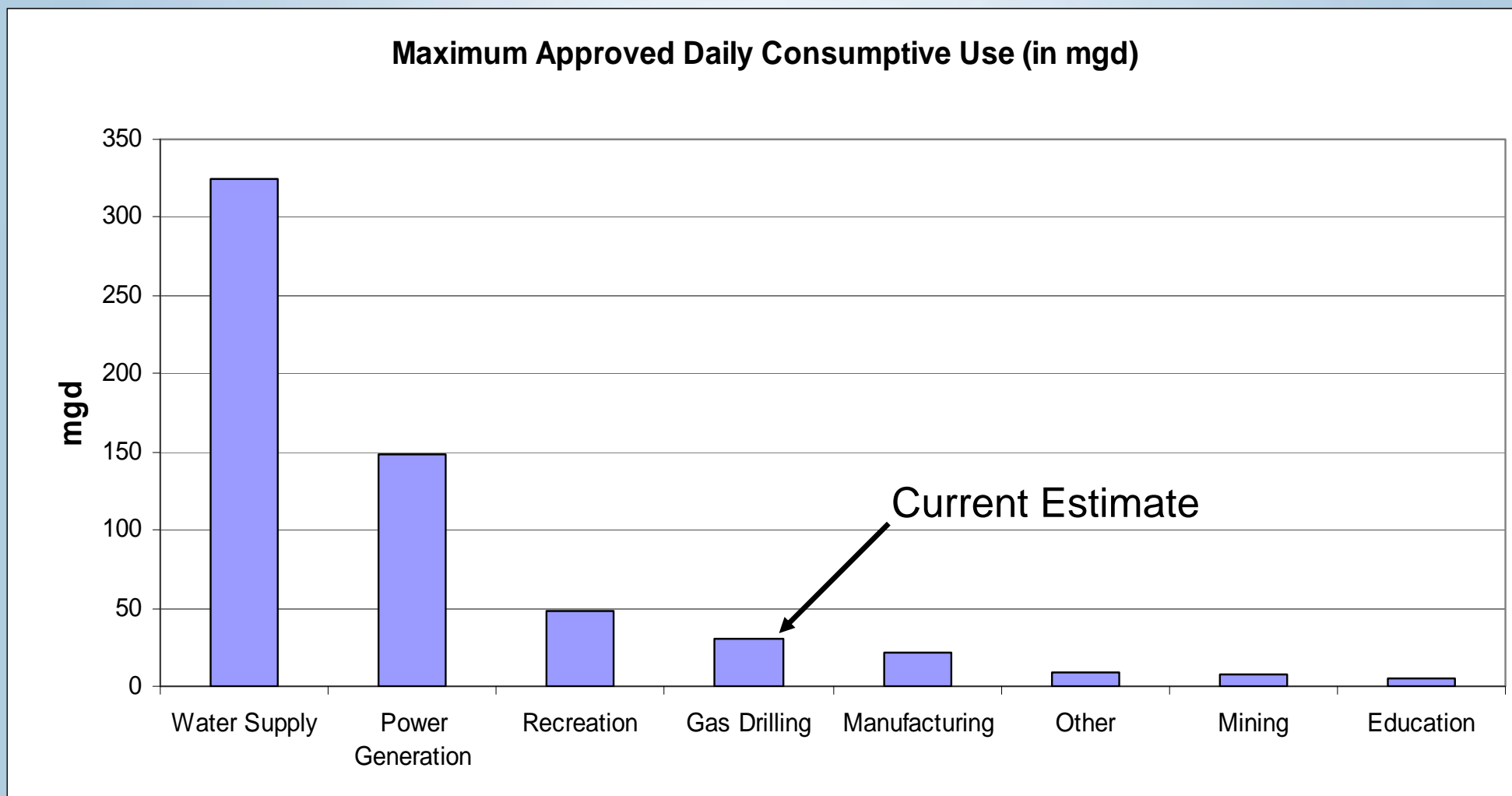




Low Flow Statistics of Perennial or Intermittent Streams



Maximum Approved Daily Consumptive Use for Gas Wells vs Other Uses



Gas Well Economics

Well Statistics - Economics

- **Drilling cost per well:**
 - \$800,000 (vertical)
 - \$3,000,000 to \$5,000,000 (horizontal)
- **Daily production per well:**
 - Can reach 1 million cubic feet per day
- **Life expectancy per well:**
 - 10 to 20 years
- **Gross revenues per well-life:**
 - 1,000,000 ft³/day x 10 yrs x \$6/1000 ft³
 - \$6,000 per day, well-life \$22 million possible

Tax Revenues Generated by Marcellus Shale Play

- **Various taxes paid to local municipality**
 - ?
 - ?
- **Various taxes paid to host state**
 - ?
 - ?

Landowner Leasing & Royalty Fees

- Terms can vary widely, so hire good lawyer!
- Leasing Fees (\$):
 - Few hundred \$ to over \$2,000 per acre
- Royalty Fees:
 - Typically 12.5% of well production
- Pipeline Right-of-Way Fees:
 - Few \$/foot (rural) to \$+100/foot (urban)

Representative Listing of Companies Actively Drilling or Leasing Marcellus Shale Properties

- **Range Resources Appalachia, LLC**
- **North Coast Energy**
- **Chesapeake Appalachia**
- **Chief Oil & Gas, LLC**
- **East Resources, Inc.**
- **Rex Energy Corp.**
- **Anadarko E&P Company LP**
- **EOG Resources, Inc.**
- **Alta Operating Company**
- **Fortuna Energy, Inc.**
- **Cabot Oil & Gas Corp.**
- **Southwestern Energy**
- **Citrus Energy**
- **Exco North Coast Energy, Inc.**
- **J-W Operating Co.**
- **Ultra Resources, Inc.**
- **Turn Oil, Inc.**

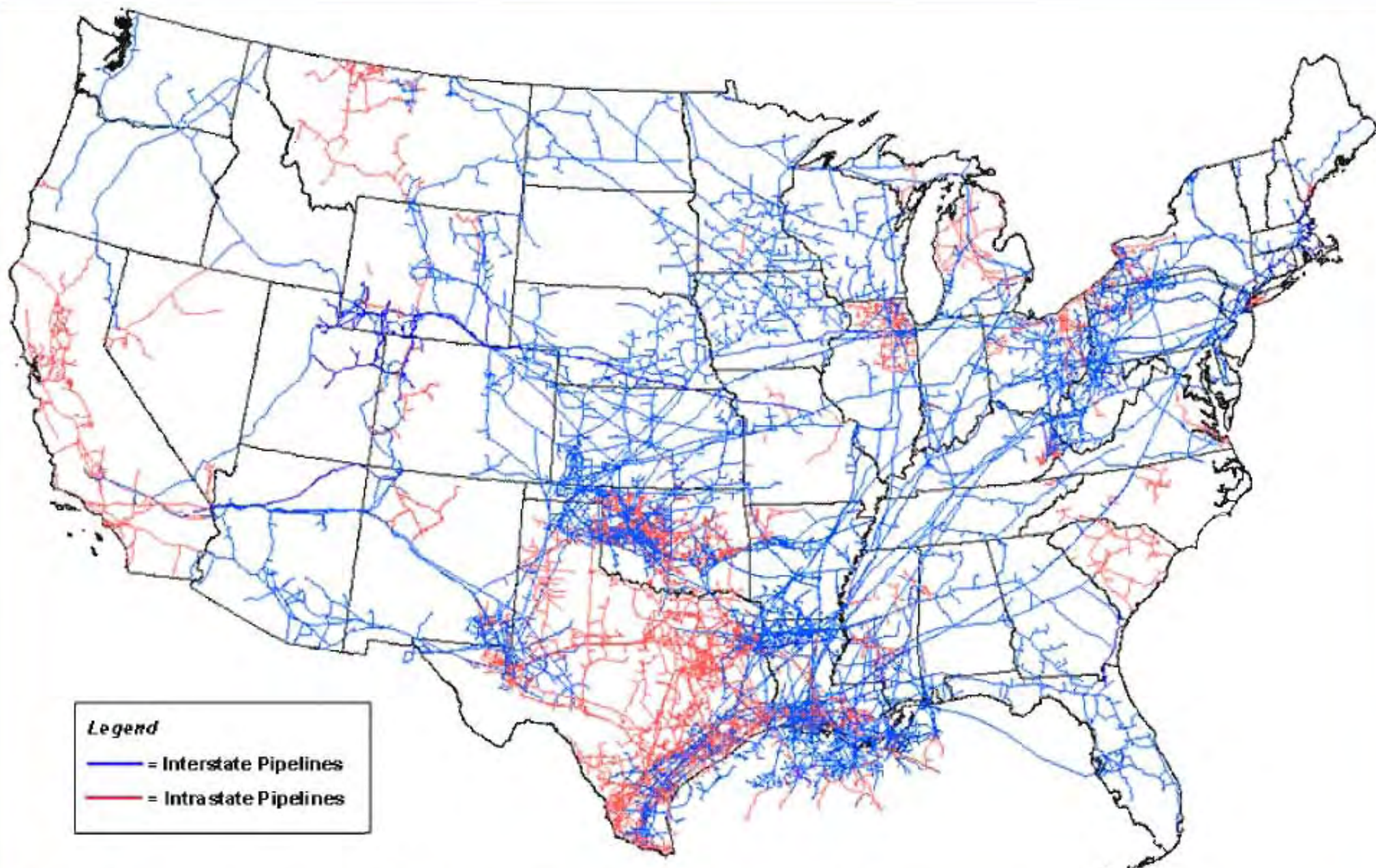
Natural Gas Price Trends

Estimated Average Wellhead Price

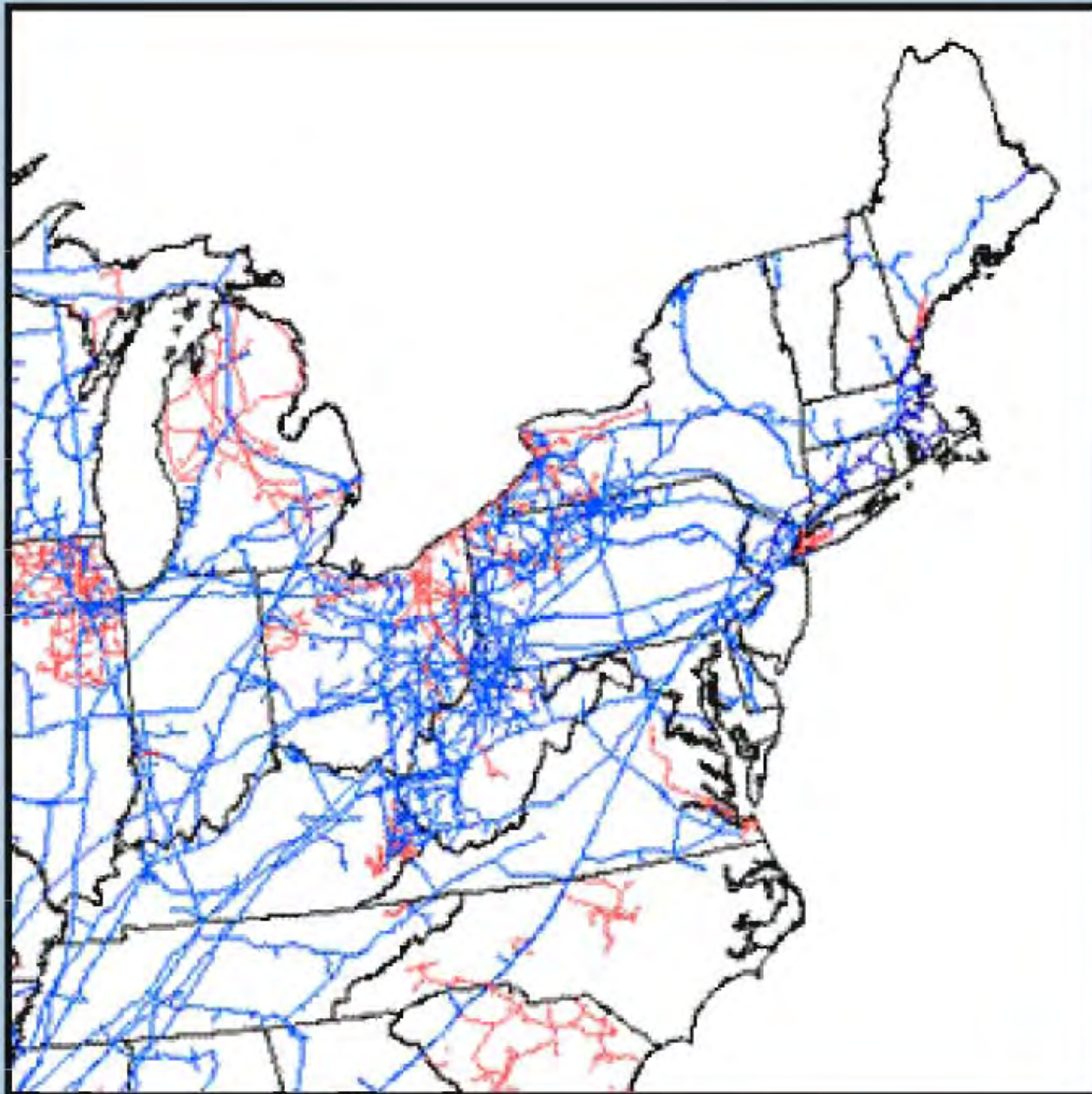
	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09
Price (\$ per Mcf)	8.32	7.27	6.36	5.97	5.87	5.15
Price (\$ per MMBtu)	8.09	7.07	6.18	5.80	5.70	5.00

Note: Prices were converted from \$ per Mcf to \$ per MMBtu using an average heat content of 1,029 Btu per cubic foot as published in Table A4 of the [Annual Energy Review 2006](#). Source: Energy Information Administration, Office of Oil and Gas.

\$ per Mcf = Dollars per Thousand Cubic Feet



Source: Energy Information Administration, Office of Oil & Gas, Natural Gas Division, Gas Transportation Information System





Typical Gas Well Drill Pads





































































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