# Gas Well Drilling and Development
# Marcellus Shale


June 12, 2008 Commission Meeting
Elmira, New York

# Marcellus Shale – Why Now?

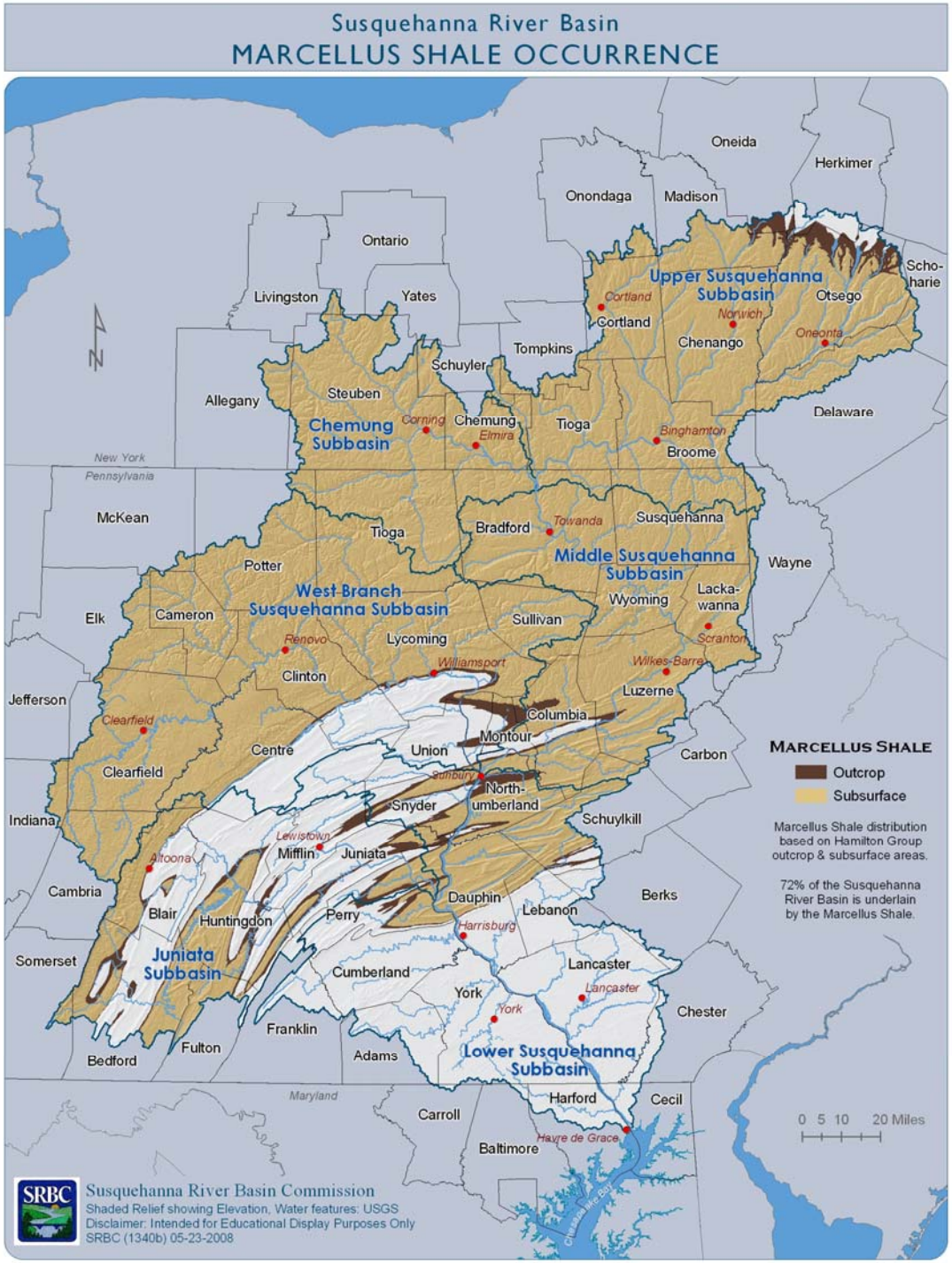
- For many years it has been known that natural gas exists in the Marcellus Shale
- Advances in horizontal drilling, hydraulic fracturing, and higher natural gas prices in recent years have made shale gas wells more profitable
- The success of the Barnett Shale in Texas has spurred the search for other sources of shale gas across the United States
- Estimates of recoverable natural gas reserves from the Marcellus Shale range from 50 – 200 trillion cubic feet (TCF)

# Marcellus Shale Geology

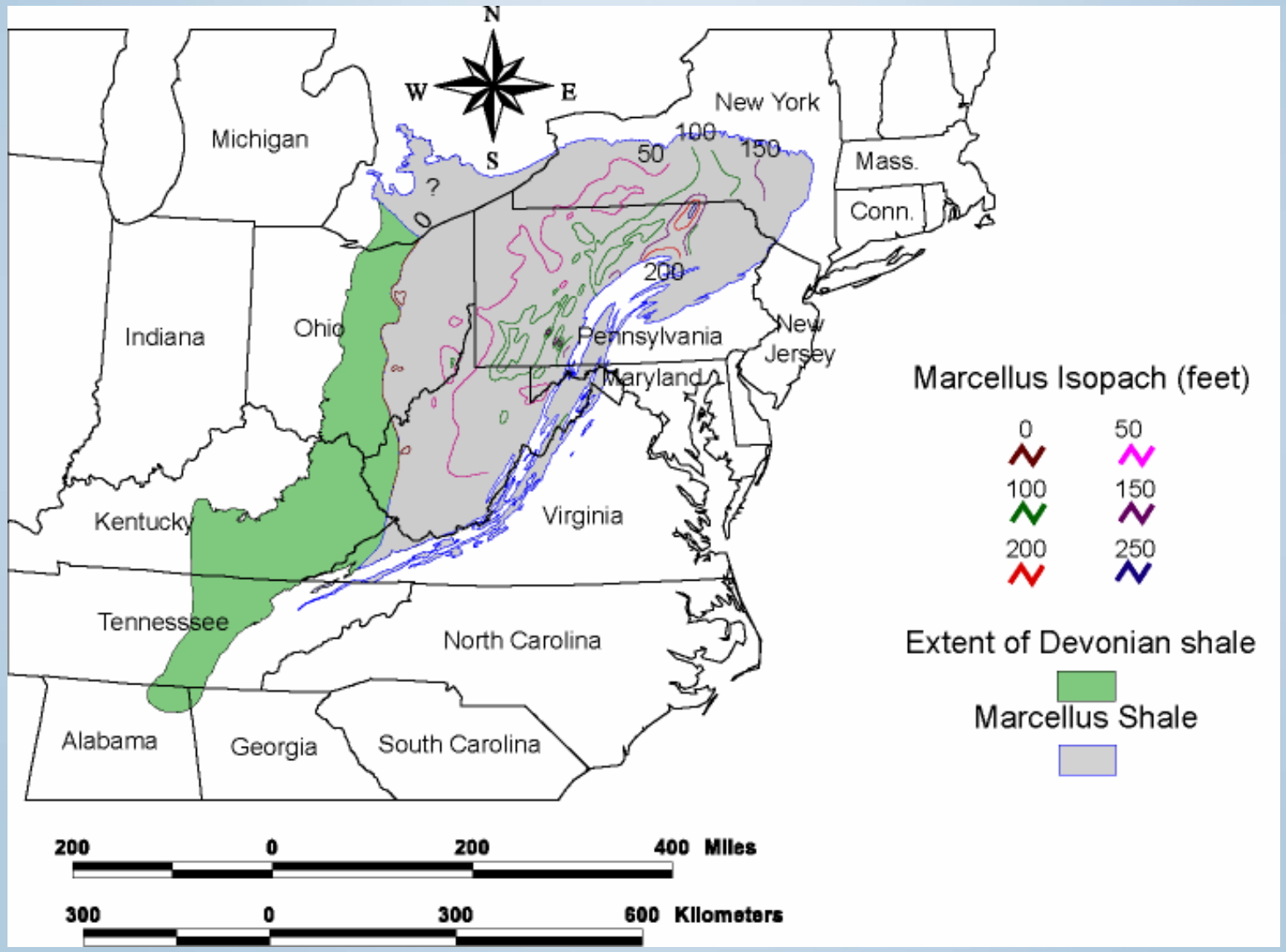
- Devonian Black Shale
  - Low density fissile shale
  - Carbonaceous (organic rich)
  - Vertical natural fractures
  - Low permeability
  - Slightly radioactive

# 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

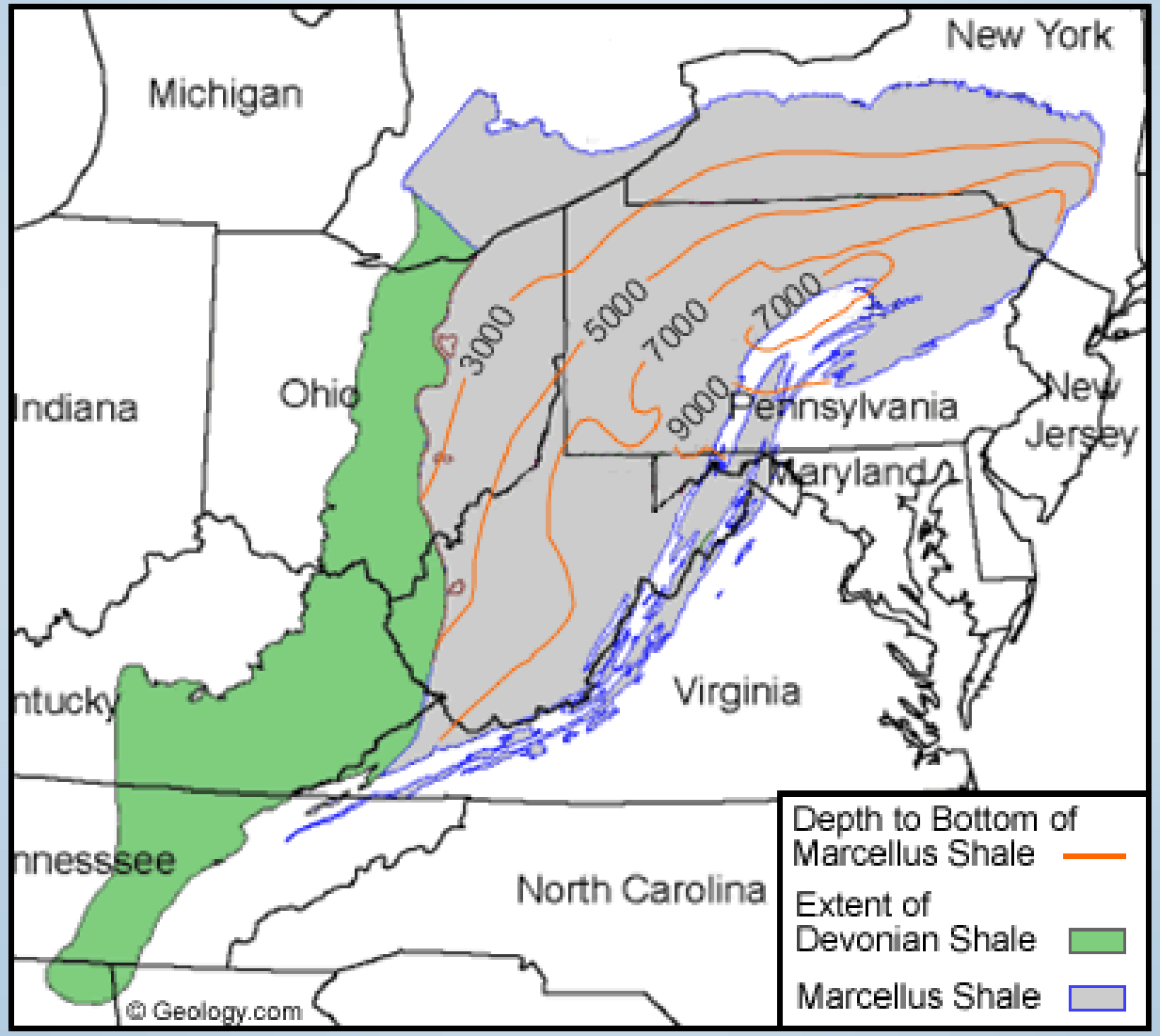


# Thickness Map of the Marcellus Shale




Map from the United States Geological Survey (USGS), Open-File Report 2006-1237, Milici and Swezey.

# Map of the Approximate Depth to the Base of the Marcellus Shale




Map retrieved from: geology.com/articles/marcellus-shale.

# Marcellus Shale Gas

- Large volume of entrapped natural gas approximately 5,000 – 8,000 feet below ground surface
- Regional stratigraphic (blanket-like) accumulations stored in a tight formation
- Requires “unconventional” means for extraction
  - Horizontal Drilling
  - Fracture Stimulation (Hydrofrac)

# Horizontal Gas Well Drilling

- Drill vertically to desired depth in the formation
- Drill rods are then turned (horizontal) in order to drill perpendicular to naturally occurring vertical fractures

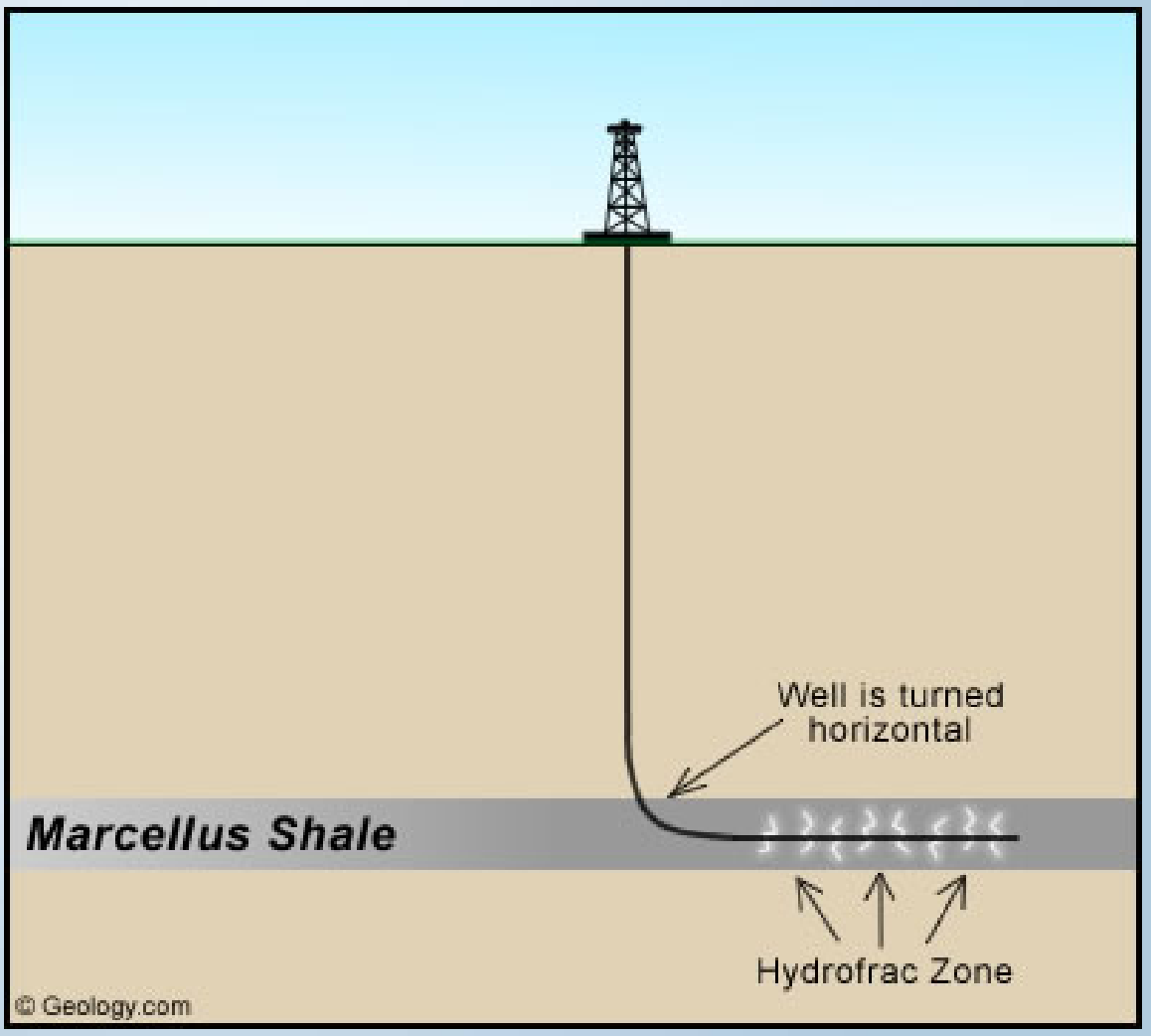



Illustration retrieved from: geology.com/articles/marcellus-shale.

# Vertical vs. Horizontal Drilling

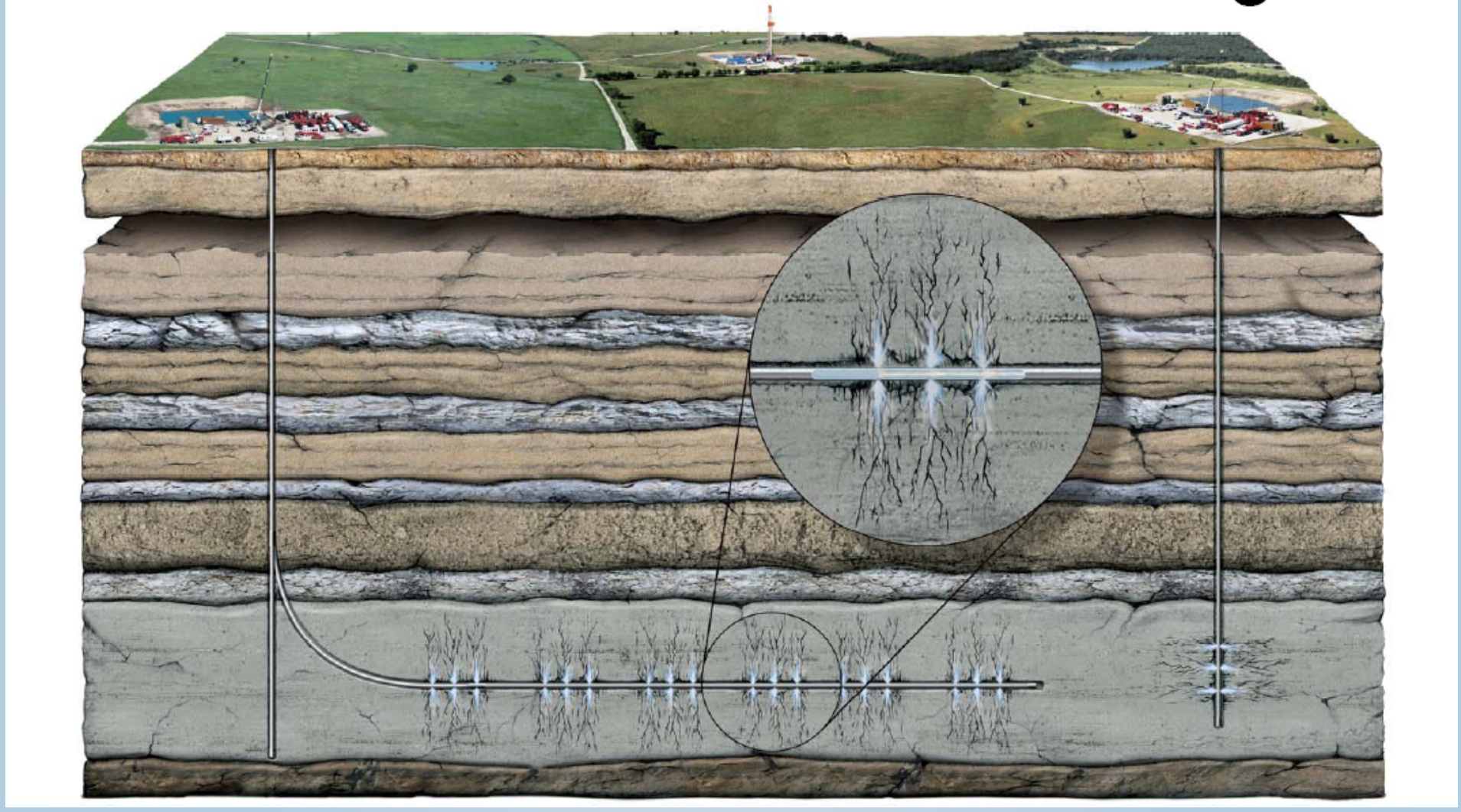


Illustration retrieved from: Independent Oil and Gas Association of Pennsylvania's *Drilling & Developing the Marcellus Shale*

# Horizontal Drilling

- Can provide greater access with a smaller footprint
- Multiple horizontal wells from a single drilling pad could drain 200 – 400 acres

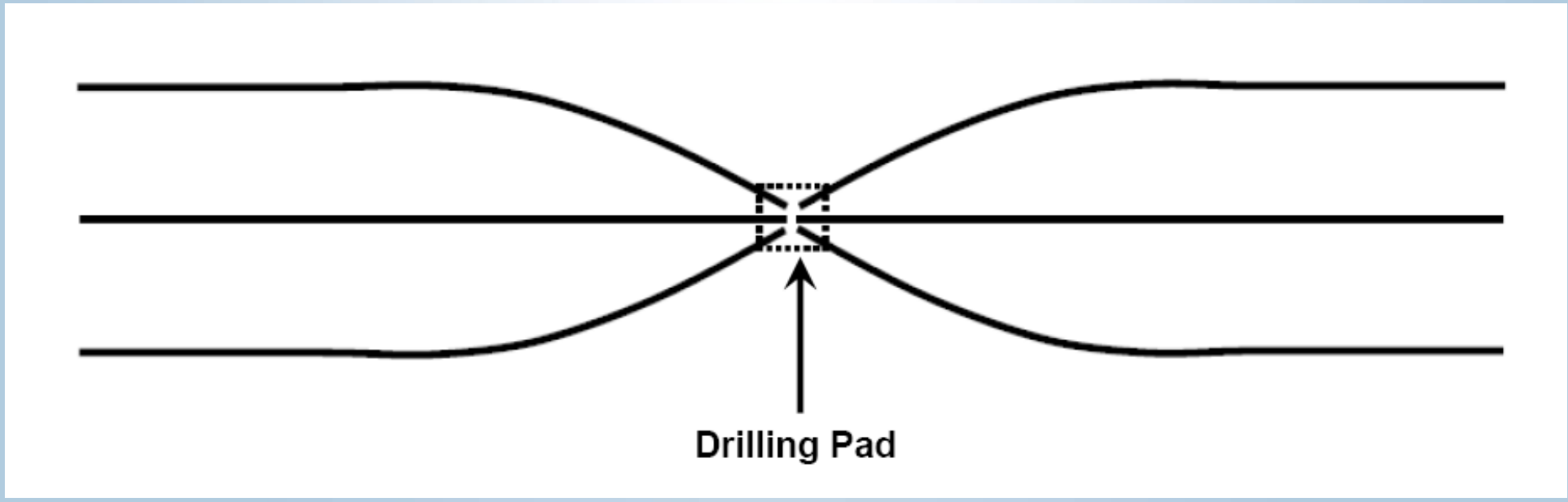



Illustration retrieved from: Independent Oil and Gas Association of Pennsylvania's *Drilling & Developing the Marcellus Shale*

# Fracture Stimulation (frac or hydrofrac)

- Increases the permeability of the shale
- Increases the rate which gas can be produced and recovered from the reservoir formation

# Hydraulic Fracturing (Hydrofracing)

- Force a fracturing fluid (primarily water) into a sealed off portion of the borehole under high pressure
- The applied pressure causes the formation to fracture, allowing the fracturing fluid to enter further into the formation and extending the cracks
- Solid proppant (usually sand) is added to the fracture fluid to keep fractures open after the injection stops

# Hydrofracing (cont'd)

- Hydrofracing typically requires millions of gallons of water

- Flowback water requires off-site treatment
  - Brine
  - Hydrocarbons
  - Metals
  - May be slightly radioactive

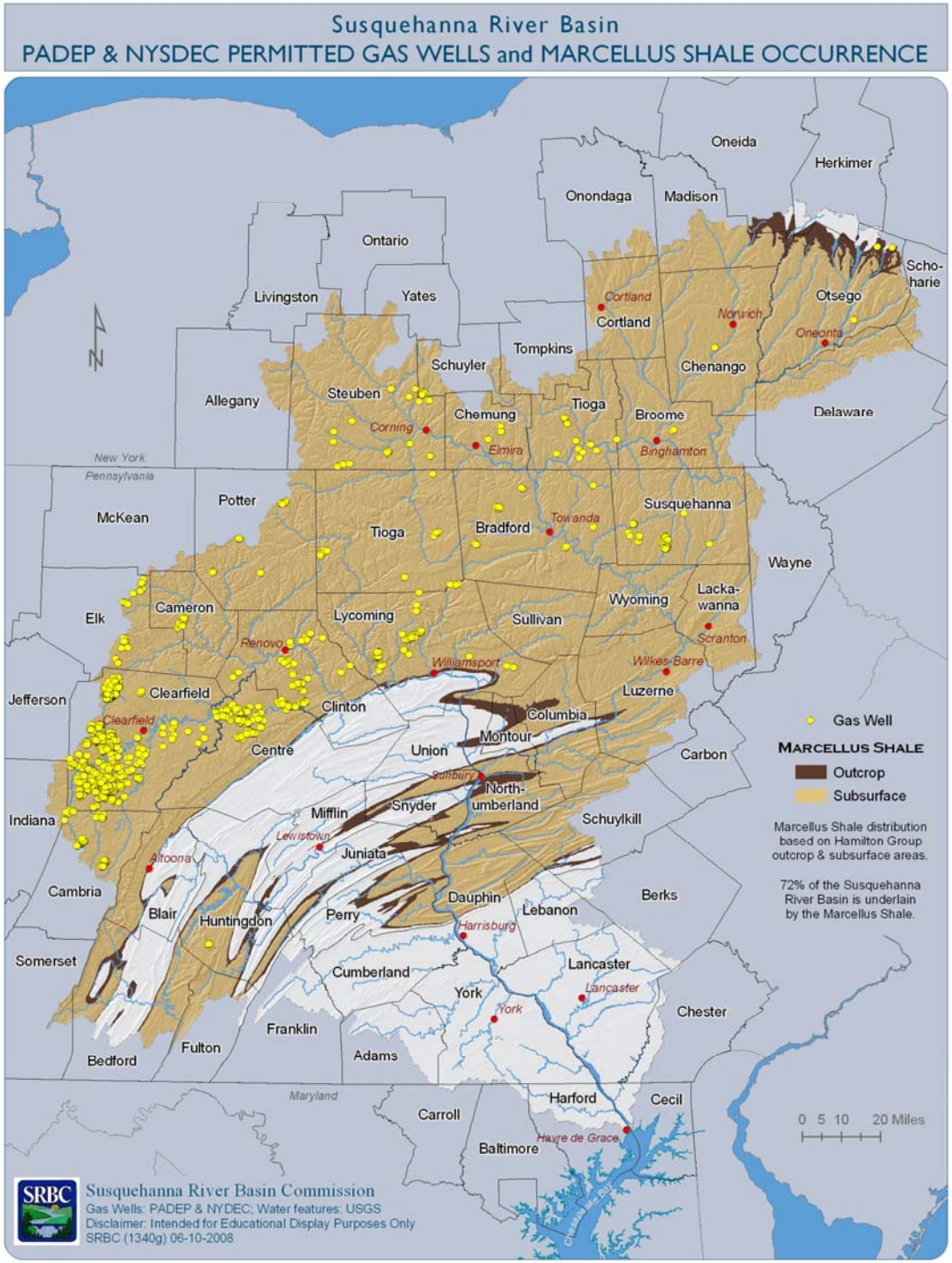
# Commission Regulation

- Consumptive water use definition (§806.3)
  - The loss of water transferred through a manmade conveyance system or any integral part thereof (including such water that is purveyed through a public water supply 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 other process by which the water is not returned to the waters of the basin undiminished in quantity.

# Commission Regulation (cont'd)

- Projects requiring review and approval
  - Consumptive water use §806.4(a)(1)
    - 20,000 gpd/30-day average (600,000 gallons)
  - Water withdrawals §806.4(a)(2)(iii)
    - 100,000 gpd/30-day average (3,000,000 gallons)
    - Any project which involves a withdrawal from a groundwater or surface water source and which is subject to the requirements of §806.4(a)(1) regarding consumptive use.

# Location of PADEP and NYSDEC Permitted Gas Wells in the Susquehanna River Basin



# Typical Gas Well Site

Image retrieved from: Independent Oil and Gas Association of Pennsylvania's, Drilling & Developing the Marcellus Shale

# Frac tanks are typically used to store water on-site for drilling and hydrofracing

# Brine Treatment Facilities

- The fracturing process uses an average of 2 to 9 million gallons of fresh water per well
- Currently no brine treatment facilities operate within the basin

# Potential Impacts/Approval Challenges

- Consumptive Use/Surface Water Withdrawal
  - Sites are located in headwater areas
  - Streams are typically high quality
  - Operations continue during low flow periods
  - Passby considerations/streams encroachment
  - Cumulative impacts of multiple projects

- Potential Local Infrastructure Issues
  - Increased traffic
  - Dust control

# Recent Commission Actions

**<u>May 30, 2008</u> – Cease and desist Orders were issued to two gas well drilling companies**

**<u>June 6, 2008</u> - Letter to 23 gas well companies operating within the Susquehanna River Basin clarifying that water used for developing natural gas wells in the Susquehanna River Basin needs Commission approval**

# Moving Forward

- Gas well site inspections are currently ongoing
- Numerous additional gas well drilling companies will be notified
- Notice of Intent for Approval by Rule
  - Pursuant to 18 CFR Section 806.22(e)
- Staff is expecting applications for consumptive use and surface water withdrawal

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