



# Natural Gas Hydraulic Fracturing

## Issues USGS is Tracking

**Marcia McNutt, Director**

U.S. Geological Survey

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# Science to Support Decision Making

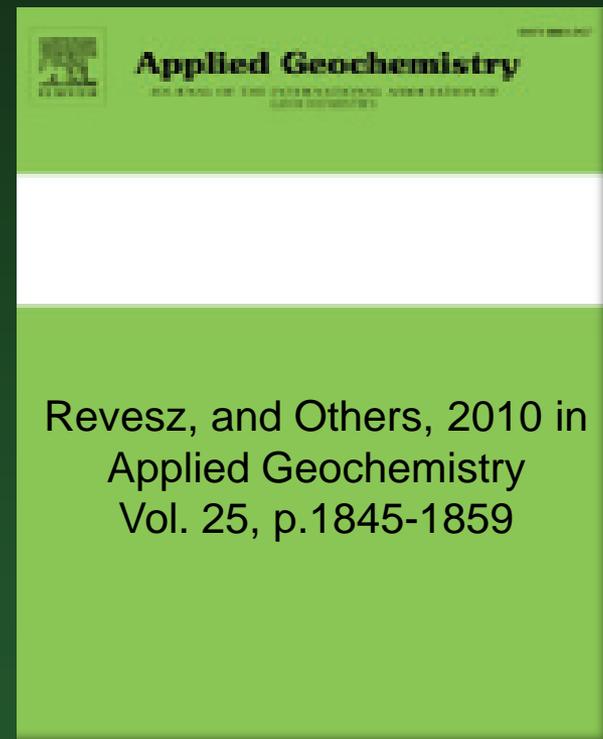
- **Water quality**
  - domestic water supply
  - impact on aquatic species
- **Induced seismicity**
  - evidence of cause/effect
- **Landscape modification**
  - degree of fragmentation
  - impacts on wildlife migration
- **Science of fluid flow at depths of injection**
  - long-term fate of 10's of millions of gallons of fluids
  - stress-strain-time history

# Domestic Water Supply

## Origin of Stray Gas in Groundwater

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Origin of combustible stray gas in groundwater was determined using isotopic evidence at Tioga Junction, PA.



# Direct Impact Water Availability

- Total water use for life of field may be large
- Fresh water is not returned to streams or aquifers (consumptive use)
- Impact may be larger on headwater streams, on local aquifers, or in arid regions
- Reduced stream flows may affect habitats and endangered species

# Direct Impact Surface Incidents

- Fluid and chemical transport to site
  - Spills
- On-site fluid handling mishaps
  - Spills
  - Leaking impoundments or pits

# Direct Impact Subsurface Incidents

- Loss of control during hydraulic fracturing, e.g. compromised annular cement
  - Groundwater contamination
  - Release to surface of gas and/or contaminated water
- Loss of control of flowback from well – release to surface
- Induced seismicity from brine disposal wells

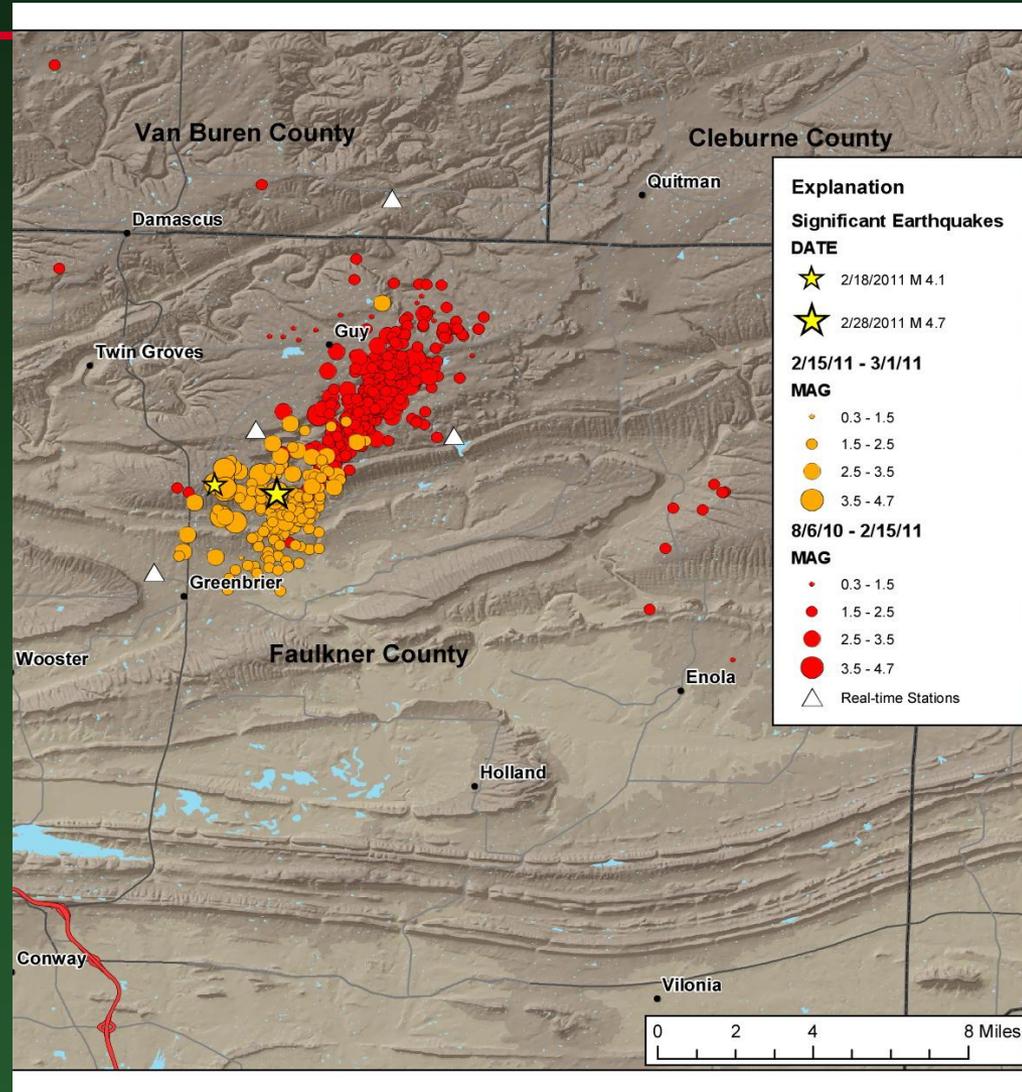
# Induced Seismicity and Enhanced Recovery

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- Below a few kilometers depth, Earth's crust is close to failure on pervasive set of fractures and faults.
- Injection activity lowers confining stress, making triggered earthquakes more likely.
- Formation of new fractures – the hydrofrac itself – doesn't release much energy compared to the triggered quakes.
- The USGS addresses induced seismicity from a hazards perspective and conducts research to better understand the complex connection to subsurface fluid production and injection.

# The Arkansas Example

- As part of an enhance recovery operation (shale gas play), large volumes of wastewater are being injected at depths of 2-4 km.
- Hundreds of shallow earthquakes at same depths as injection have been triggered. The largest, M4.7, caused damage in nearby towns.
- In April, the Arkansas oil and gas commission halted injection activities at two main disposal wells. Earthquakes were dramatically reduced in number and magnitude.



# Secondary Impacts: Landscapes

- Land disturbance and habitat fragmentation
- Pads, roads, and pipelines
  - Runoff from precipitation
  - Stream sedimentation and water quality
- Wildlife and fisheries
- Dust, viewshed, traffic, air quality
- Socioeconomic changes to communities

# Landscape Impacts, Elk County, PA



(images from GoogleEarth, 2009)

(from Coleman and others, 2009)



# Research Issue: Fate of Water

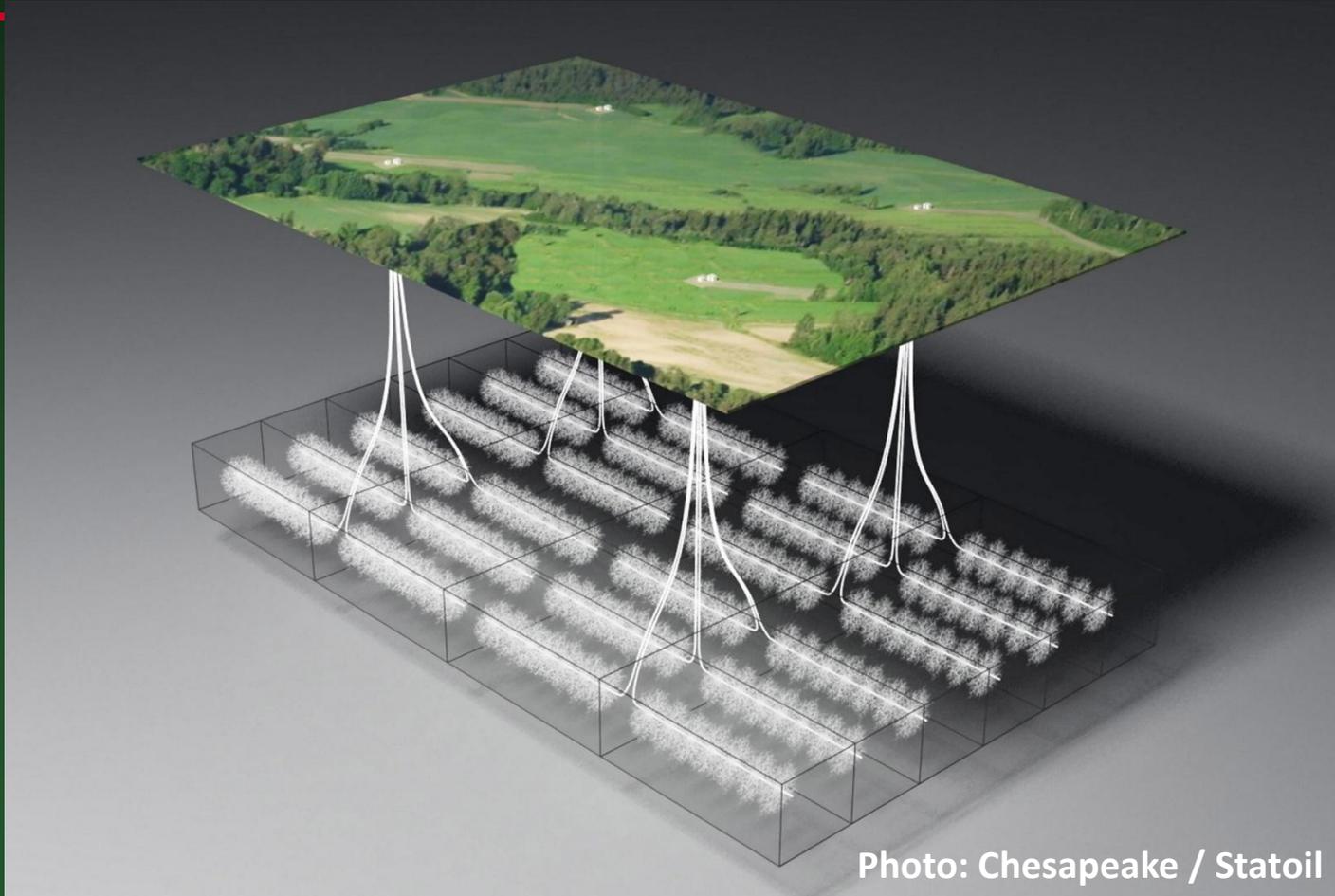
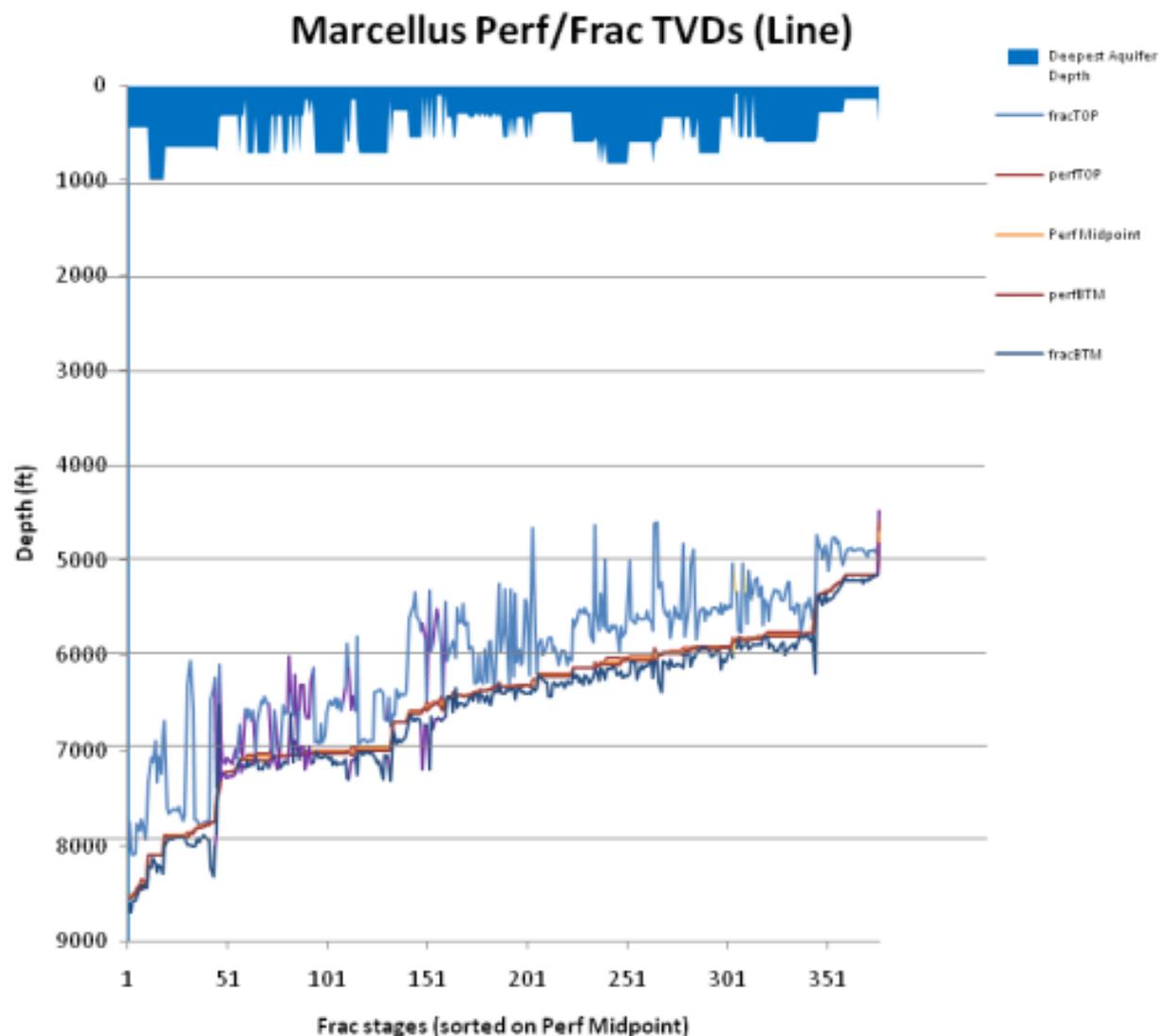


Photo: Chesapeake / Statoil

# Hydraulic fracturing vs the environment: what do diagnostics say?

- Marcellus issues?
  - More height growth than Barnett
  - Far from mapped aquifers



# USGS Activities

- **Natural gas resource assessments complete or underway – gas sands, shale gas, coalbed methane**
- **Surface water flow – nationwide ongoing stream gaging and water availability studies**
- **National produced water database – 58,000 entries**
- **Water quality sampling and monitoring – tailoring existing networks on streams, initiating limited flowback water sampling**

# USGS Activities (continued)

- **Production and basin water budget assessment pilot study**
- **Initiating groundwater flow modeling to predict fate of injected fluids**
- **Saline water resource evaluations – potential for beneficial use**
- **Status and trends of endangered species**
- **Regional long-term baseline of groundwater and surface water**

# Conclusions

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- **Direct and indirect impacts result from hydraulic fracturing**
- **Monitoring data and science can inform decision making**
- **Coordination through federal – state – industry partnerships are important**