THE MARCELLUS SHALE GAS PLAY
Ground Water Impacts

James B. Campbell, Director
Pennsylvania Water Science Center
New Cumberland, PA

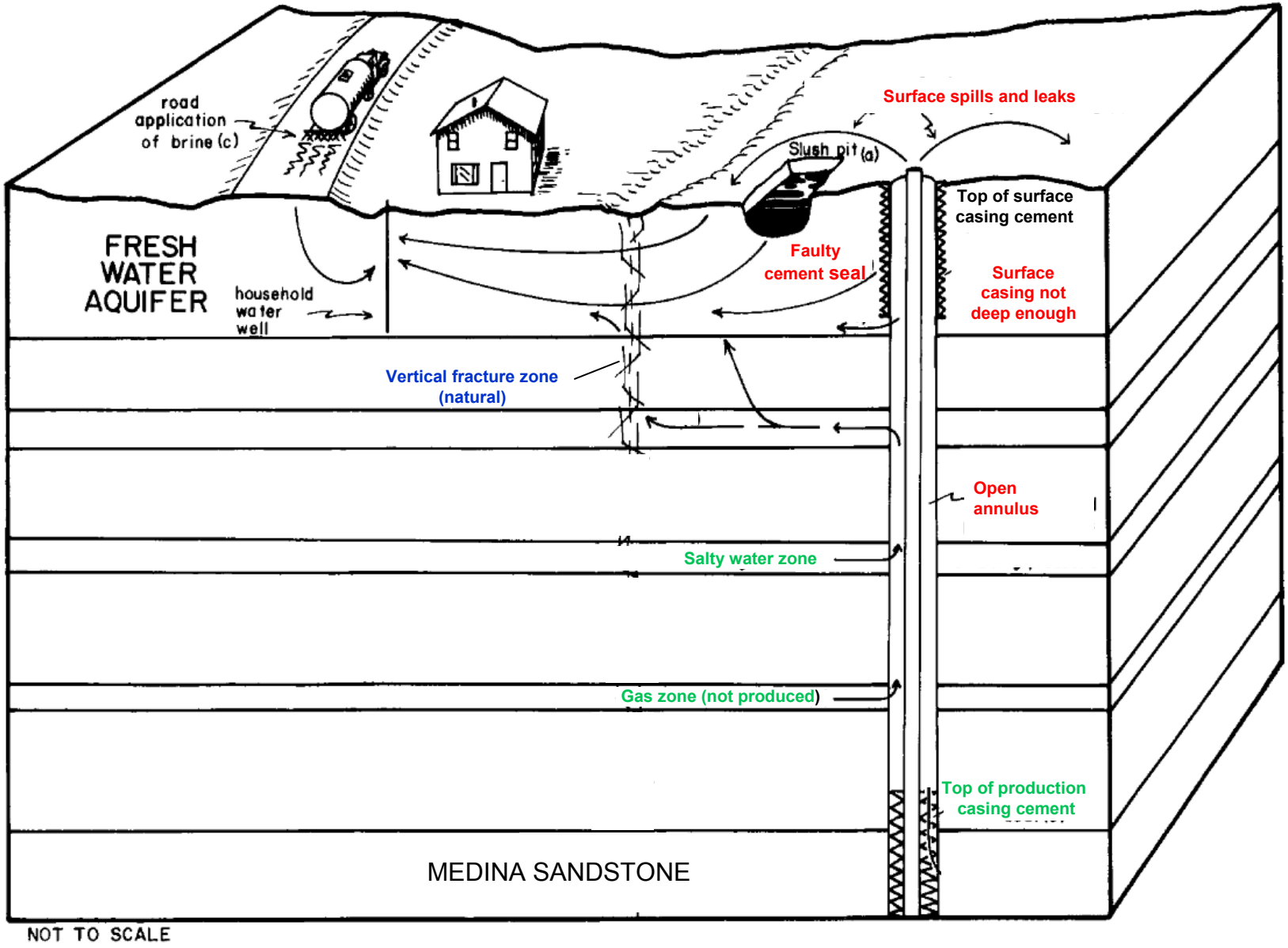
USGS

Marcellus Shale Gas - Ground Water Impacts

- Surface Operations
- Well Construction
- Hydraulic Fracturing
- Frac Barriers
- Fracing near Faults
- Deep Water Injection of Frac Fluids
- Abandonment of Wells

USGS

Gas-Development Related Contamination

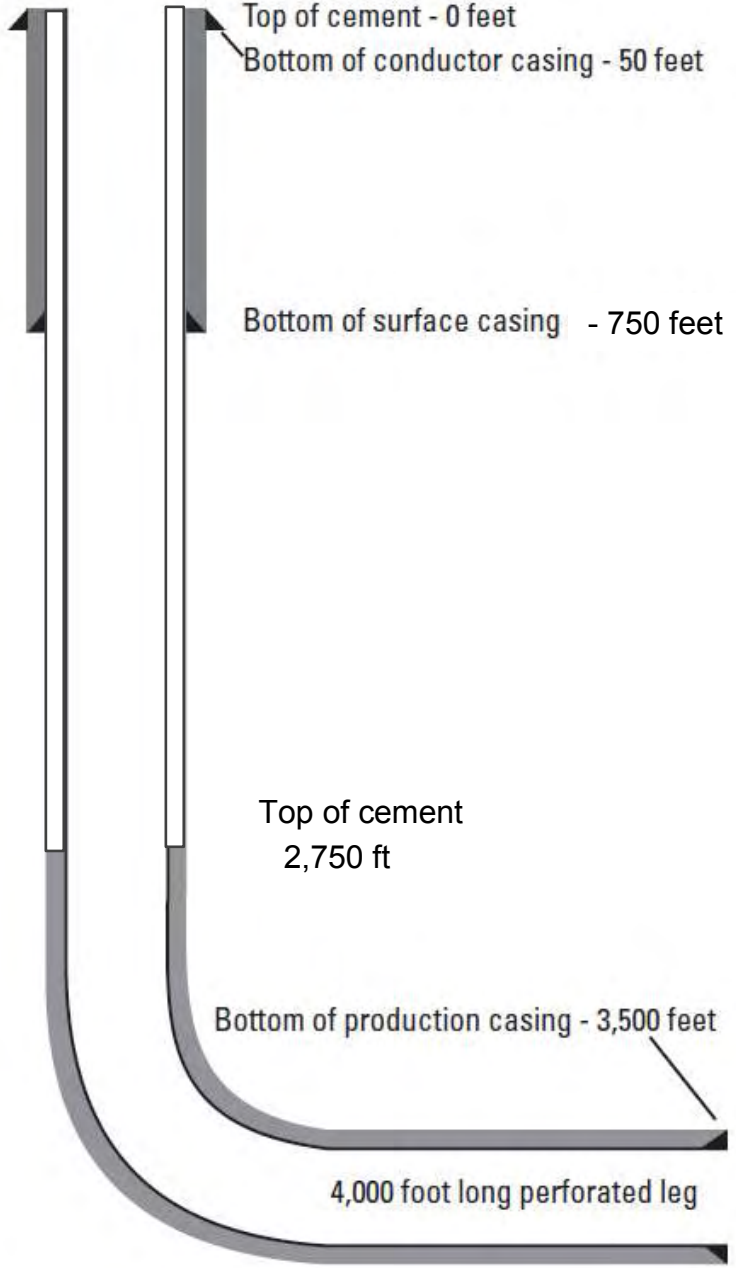


Harrison (1983)

Past Practices

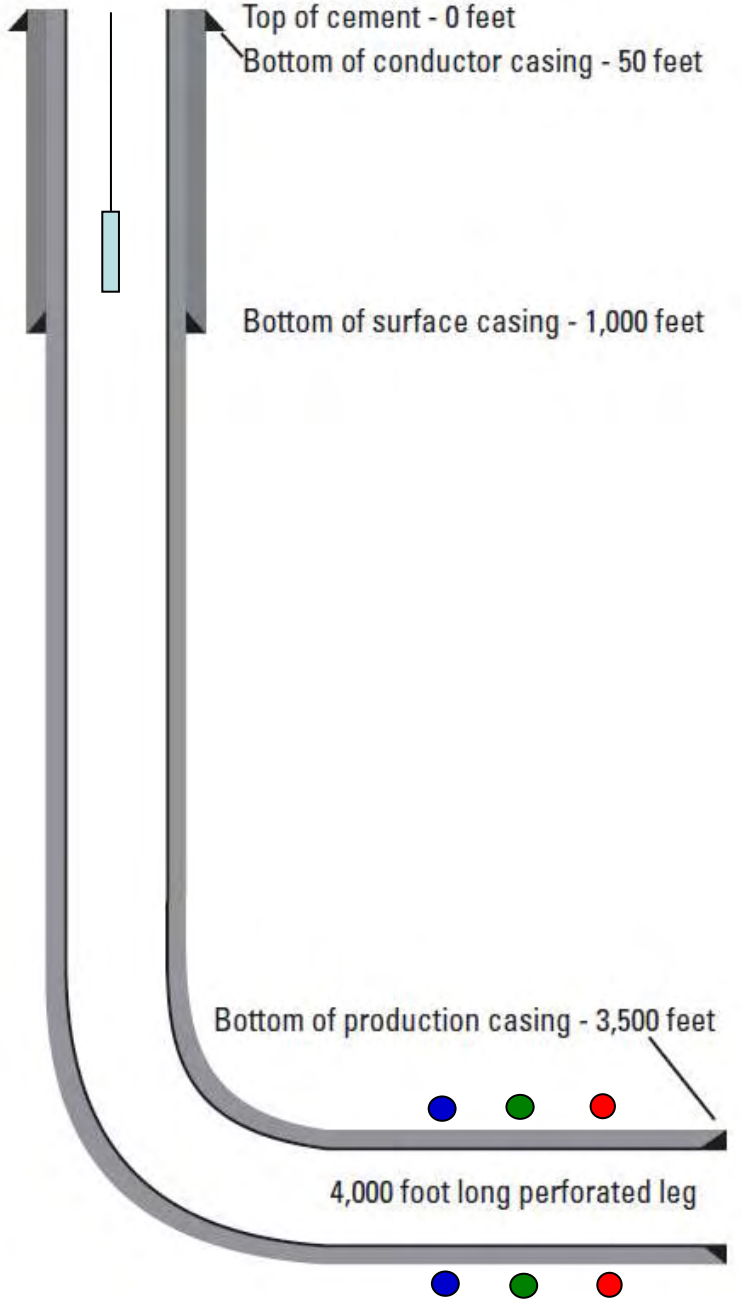
Shale Gas Development

- Cemented surface casing may not be deep enough to protect freshwater aquifer
- Open annulus interval between top of production casing cement to bottom of surface casing may allow upward migration of salty water and gas
- Drilling and frac fluid storage in surface impoundments and burial of drill cuttings onsite may contaminant shallow groundwater and surface water
- One-time use of frac fluid wasteful of freshwater resources and creates disposal issue
- Limited water-well sampling before drilling/hydraulic fracturing operation



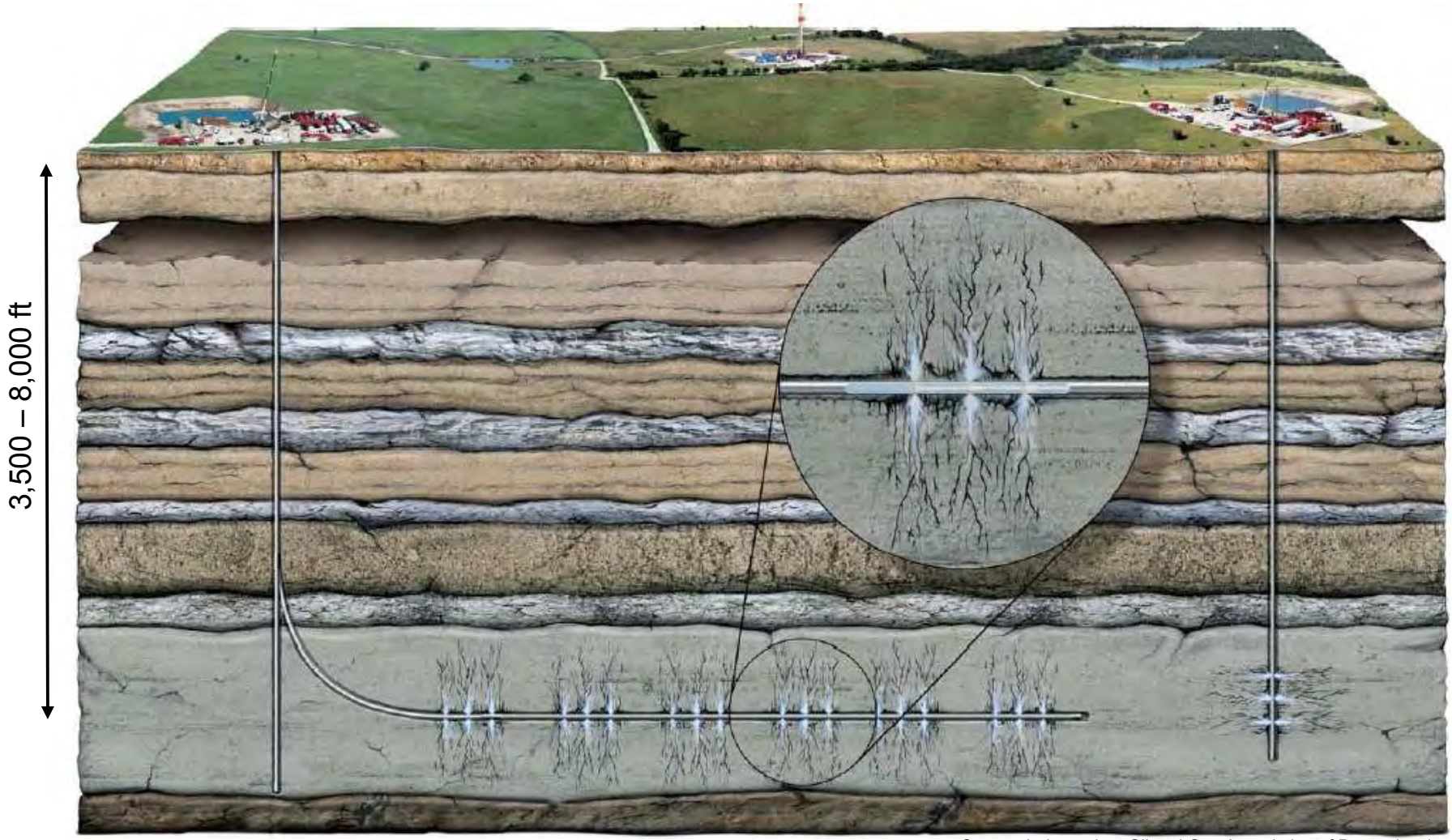
Best Practices
Shale Gas Development

- Geophysical logging to delineate base of freshwater aquifers
- Surface casing and cement/packers deep enough to protect freshwater aquifers
- Production casing/cement/packers (with intermediate string if needed) to prevent upward migration of salty water and gas
- Cement-bond logging and pressure testing to ensure good seals
- Drilling and frac fluid storage in tanks and offsite burial of drill cuttings
- Avoid hydraulic fracturing near structures
- Microseismic monitoring of hydraulic fracs
- Reuse of frac fluid reduces freshwater resource impacts and disposal issue
- Water-well sampling before and after drilling/hydraulic fracturing operation



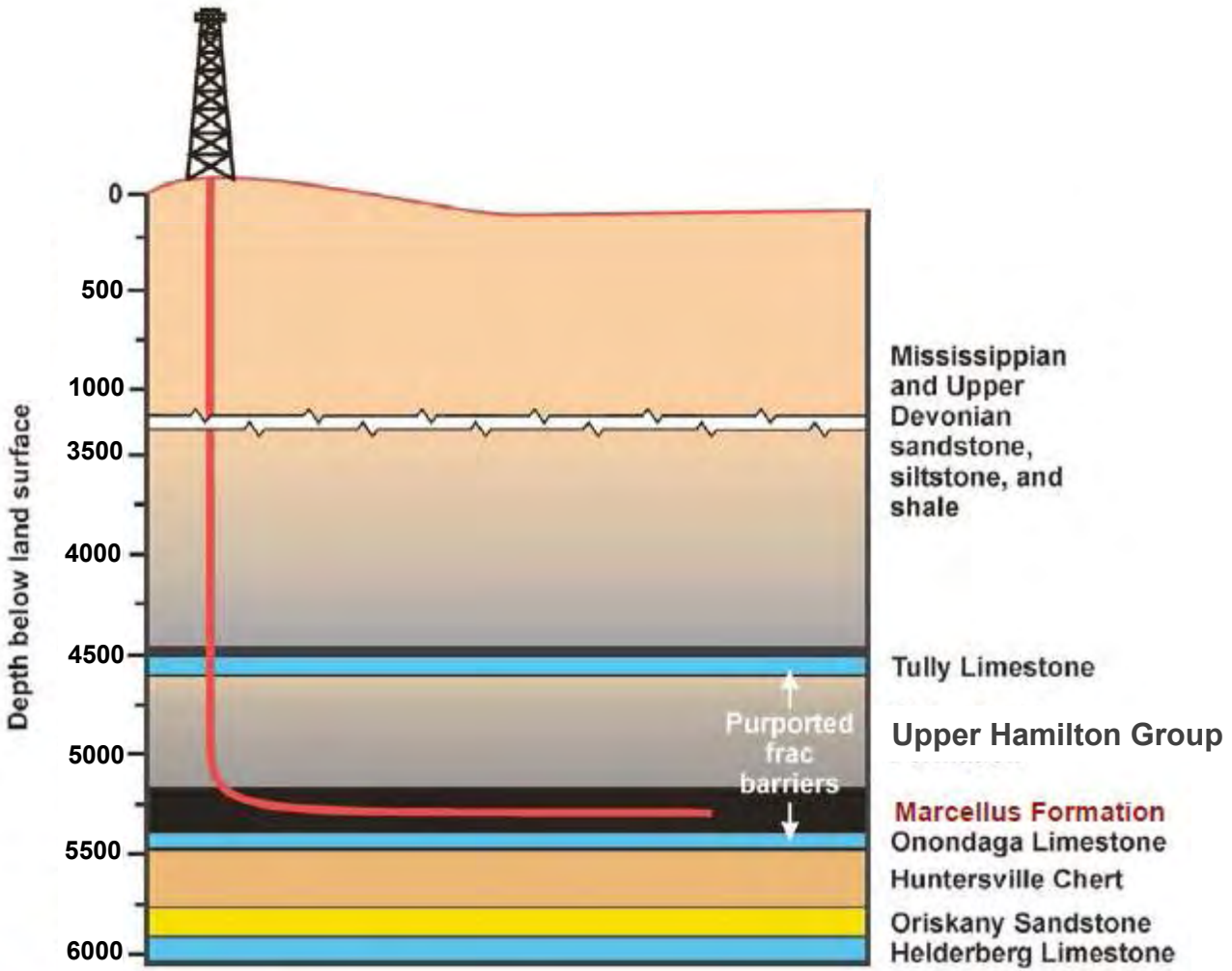
Marcellus Shale Gas Development

Hydraulic Fracturing and Horizontal Drilling

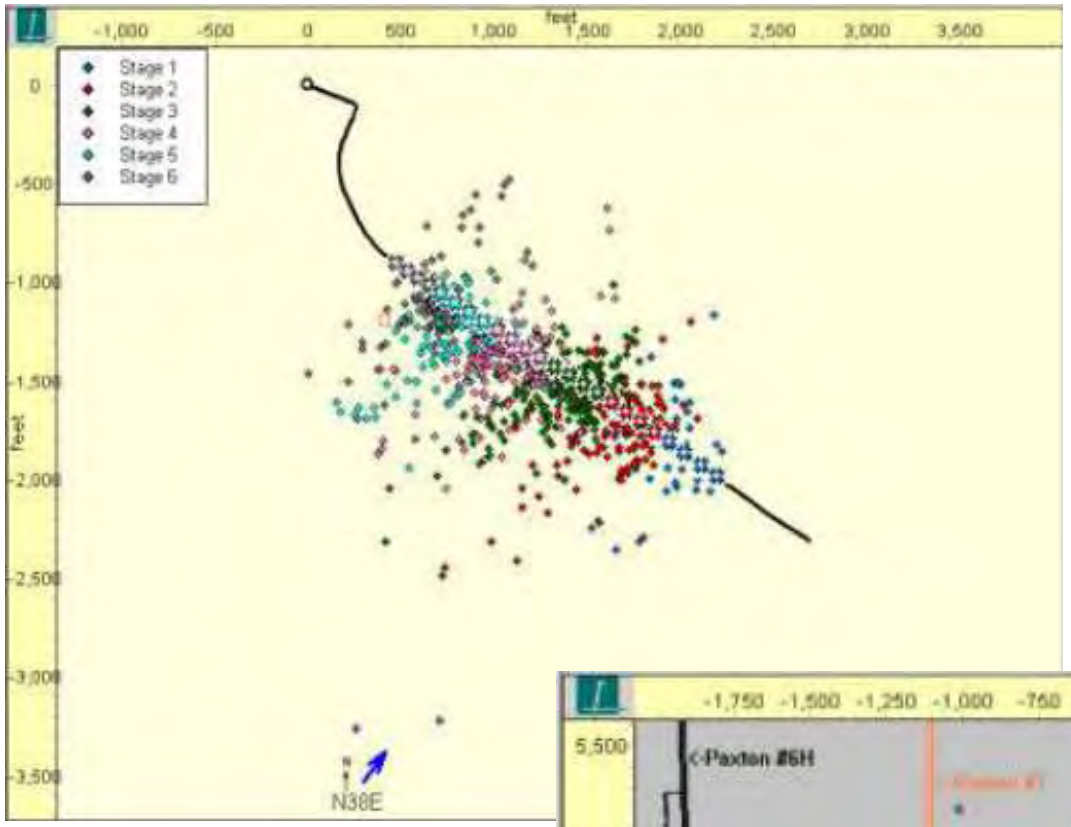


Source: Independent Oil and Gas Association of Pennsylvania

Stratigraphy and Frac Barriers

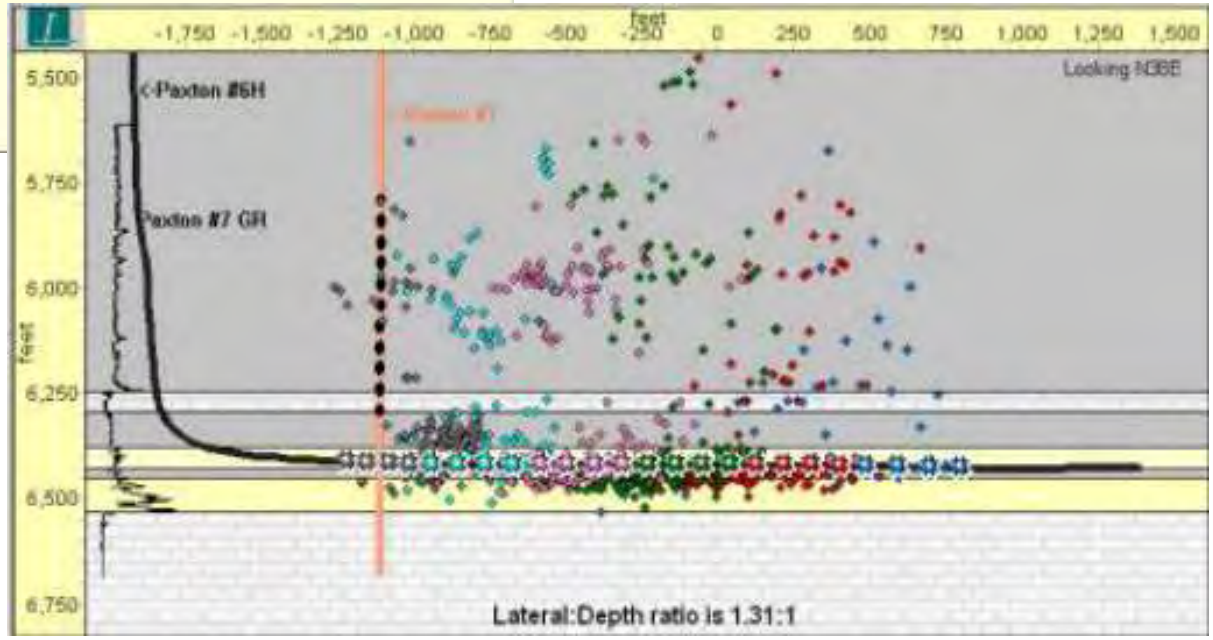


Modified from Kostelnick (2010)

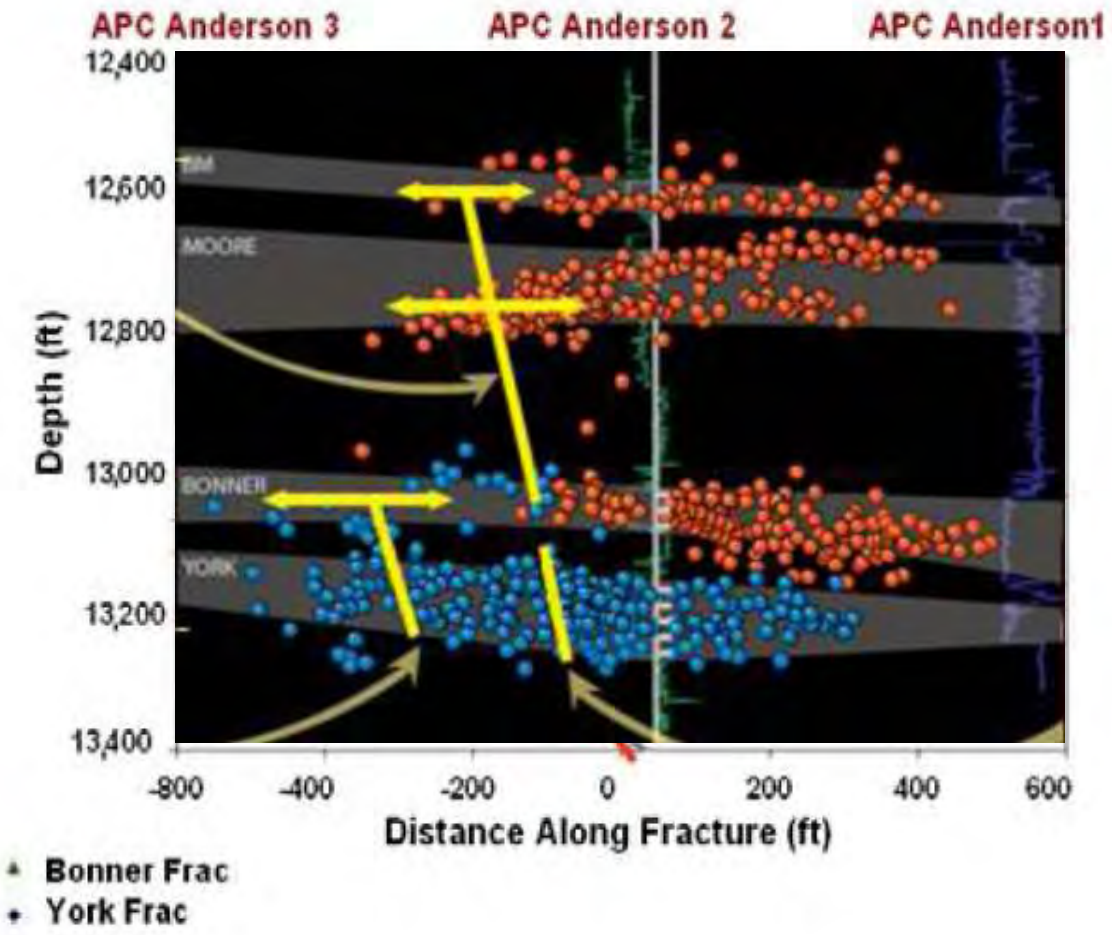


Microseismic Monitoring of Marcellus Fracs

(Marcellus SPE 131783)

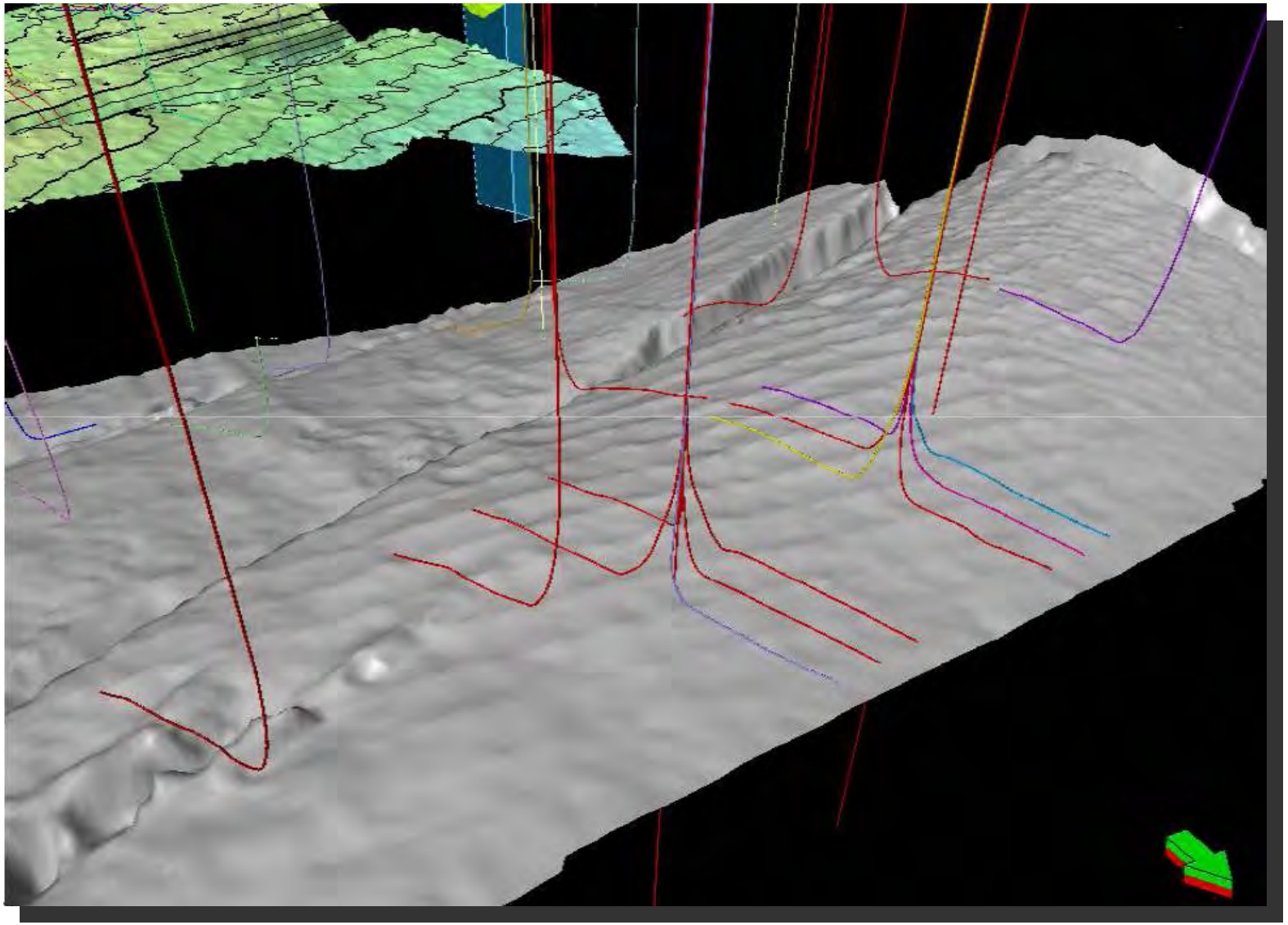


Fracing near faults



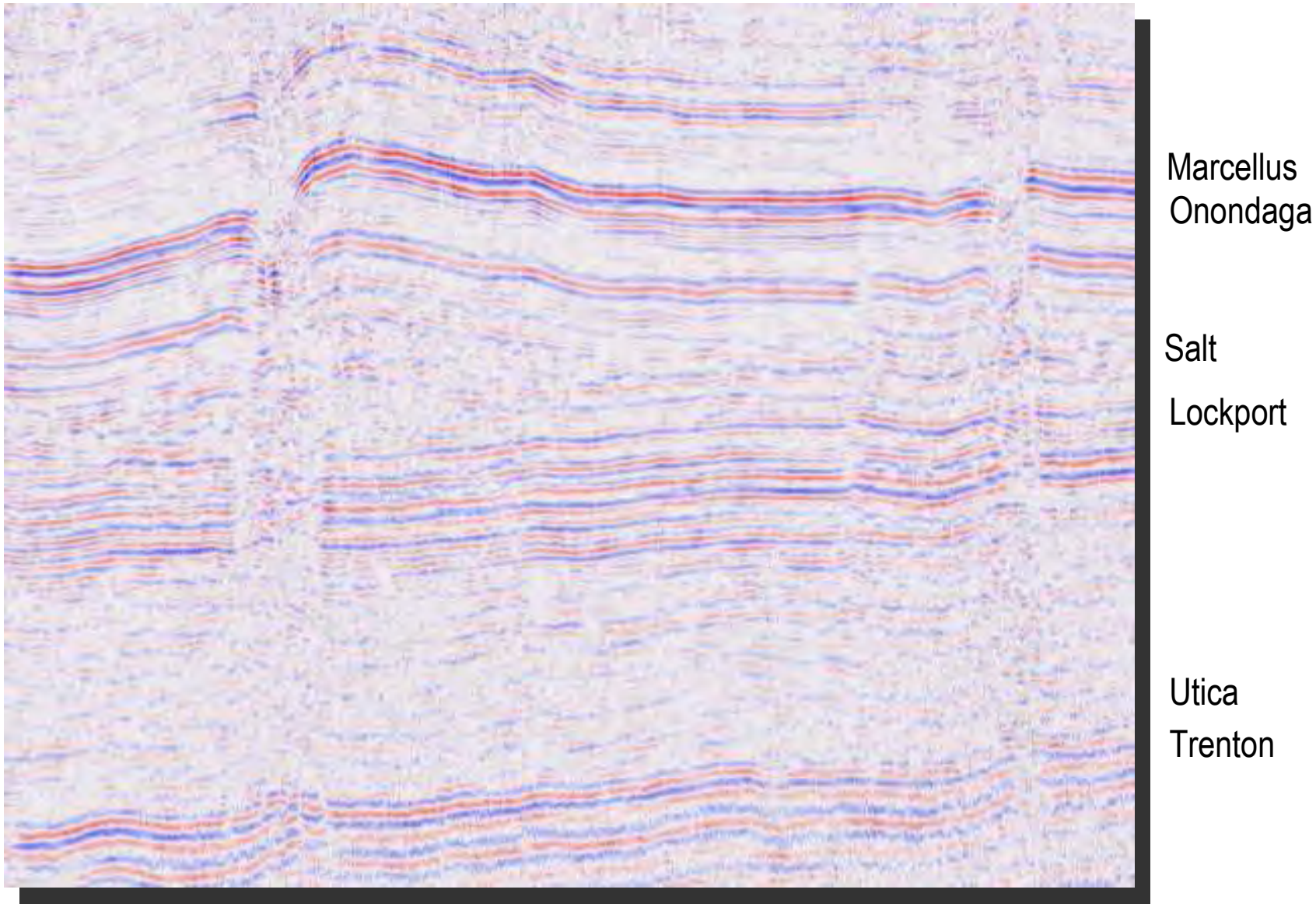
Sharma and others (2003)

Drilling pads with multiple horizontal laterals



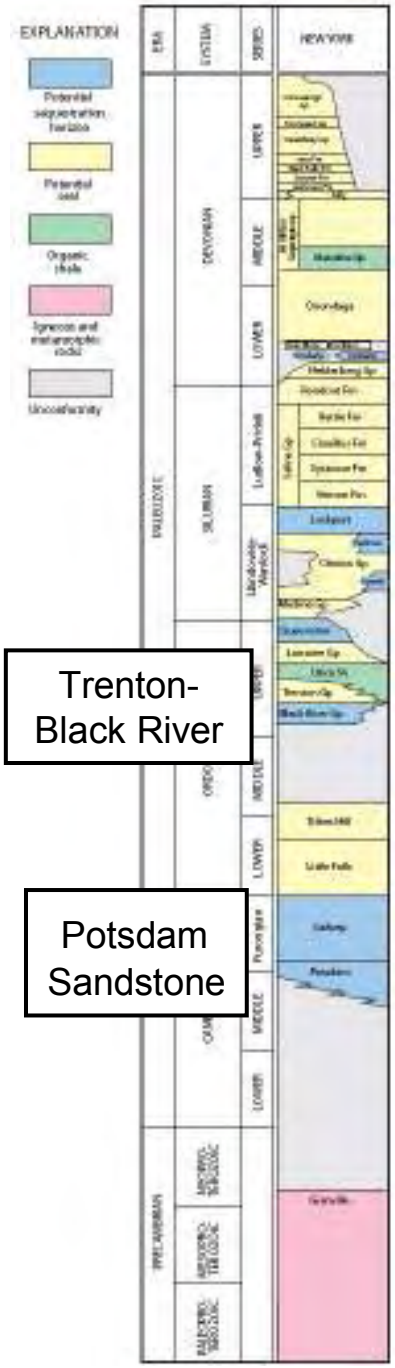
Teff (2011)

Structure (folds and faults)



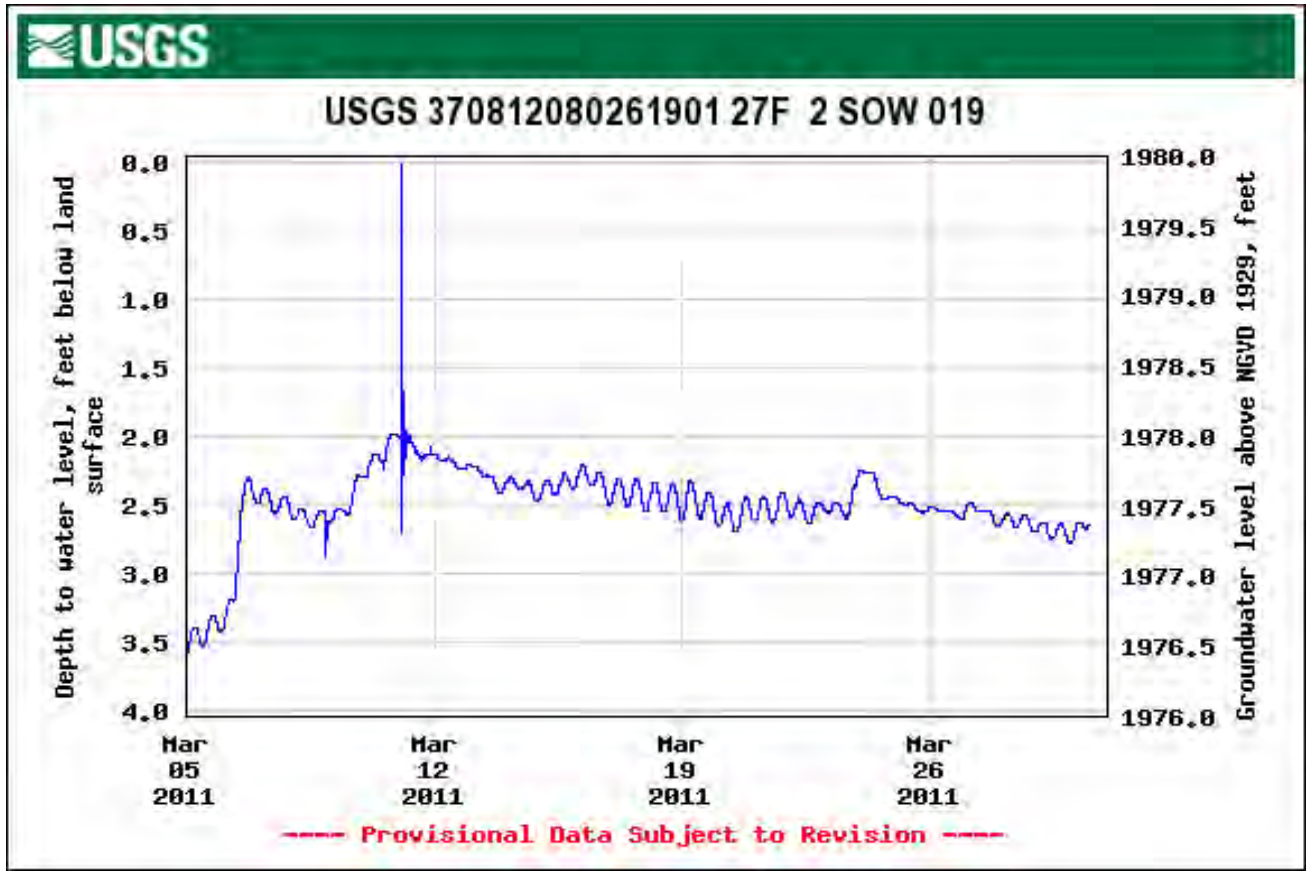
Seismic survey

Smith and Leone (2010)

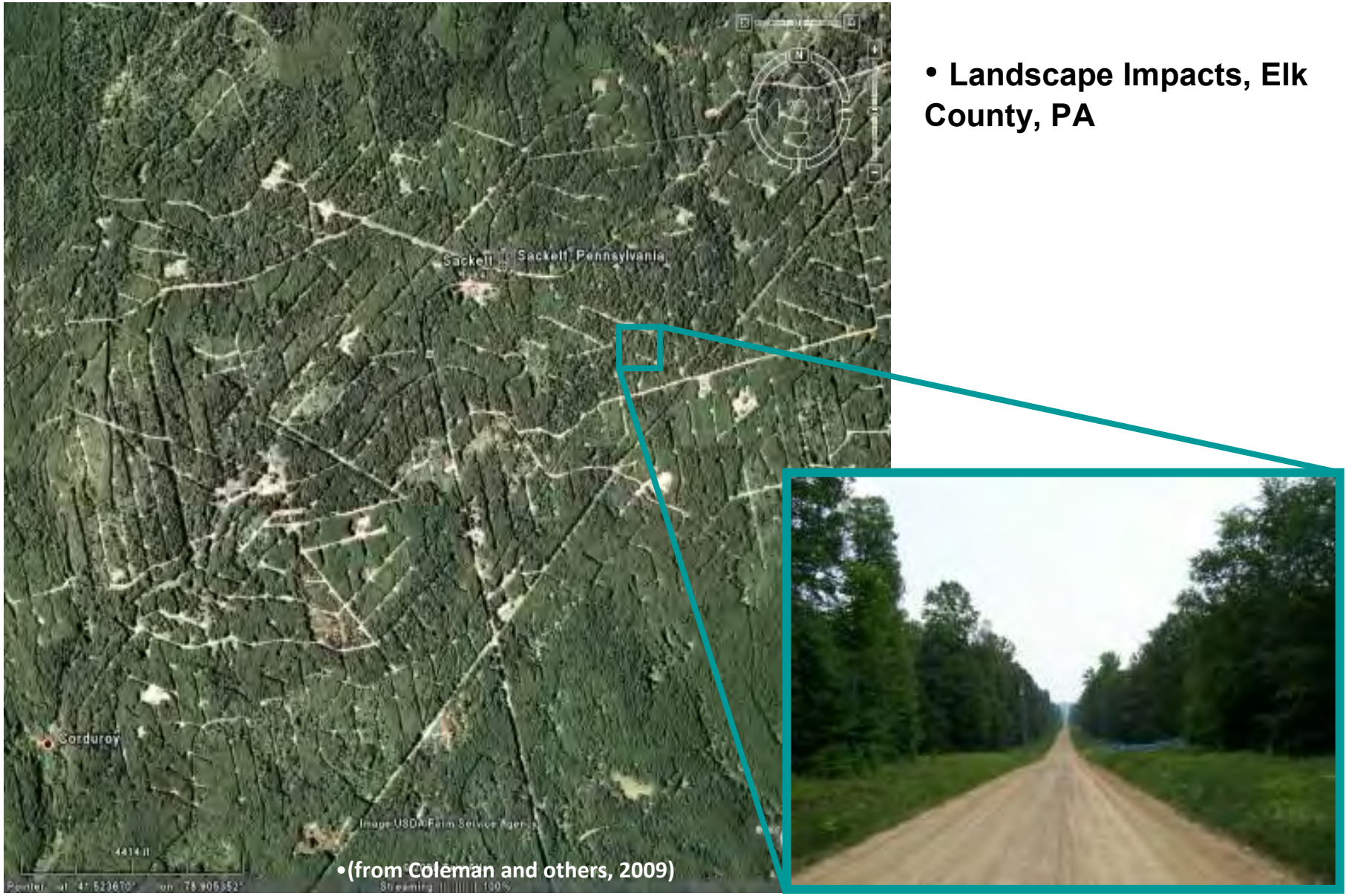


Deep Water Injection

- **Disposal of frac water into saline formations by deep-well injection (currently operating injection wells in Ohio)**
- **Potential Increased Seismic Activity**



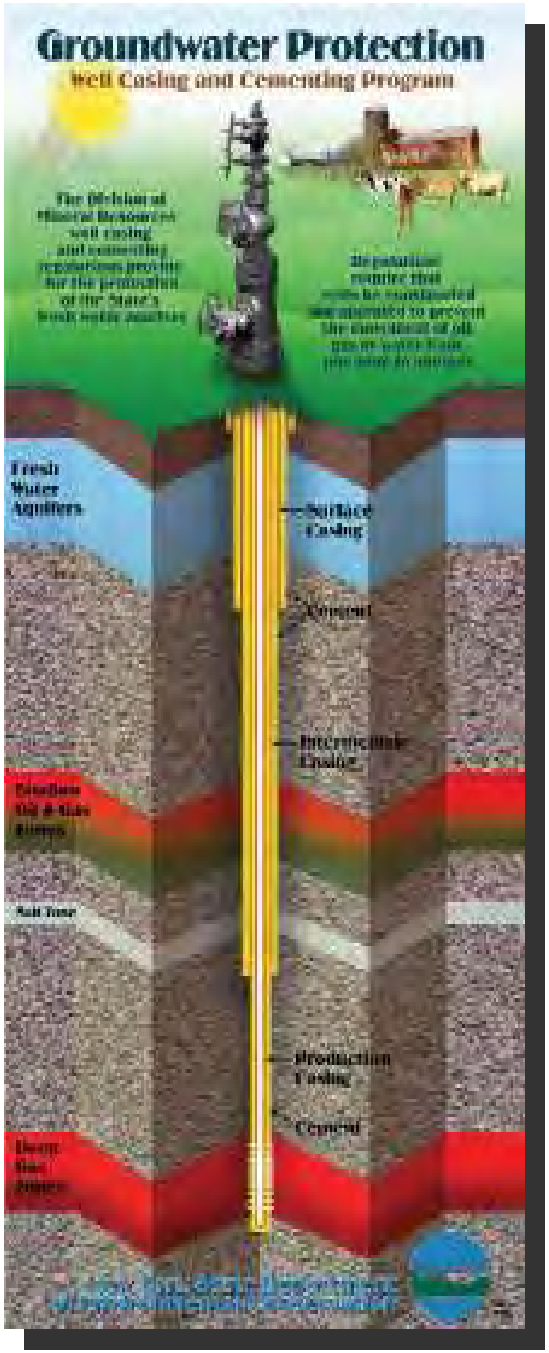
Well Abandonment



- **Landscape Impacts, Elk County, PA**

- **(from Coleman and others, 2009)**


USGS
science for a changing world
http://energy.usgs.gov



Well Casing and Protection of Freshwater Aquifers

- Saltwater and gas present in Devonian bedrock above Marcellus Shale
- Potential upward migration of saltwater and gas that may contaminate freshwater aquifers
- Conductor casing to competent bedrock
- Surface casing with annulus cemented to land surface to protect freshwater aquifers
- Intermediate casing if dictated by drilling conditions
- Production casing with cemented annulus to isolate gas-producing zone