



Marcellus Shale Gas Extraction; Potential Public Health Impacts and CHEC Research and Outreach Initiatives

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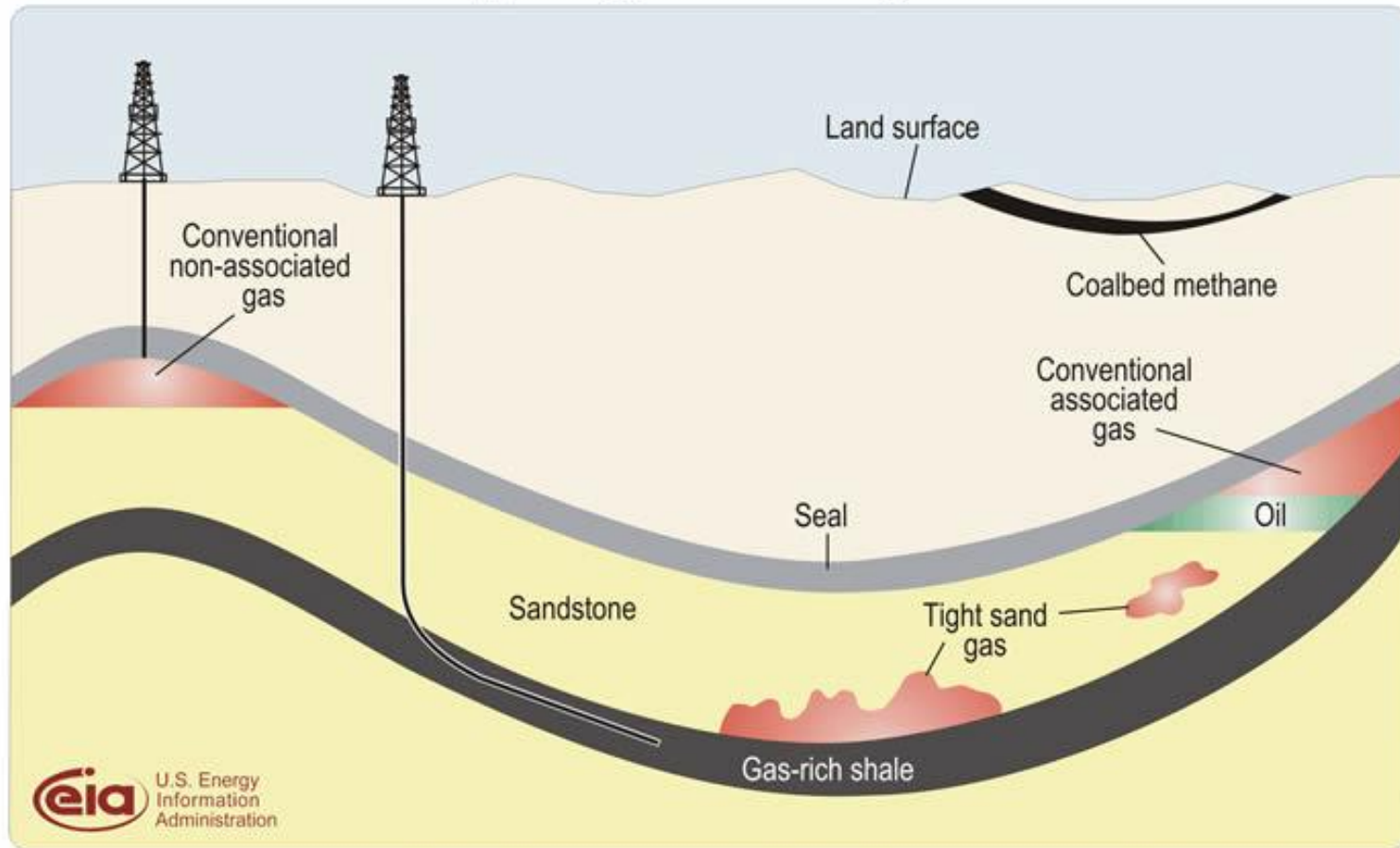


Non-Conventional Natural Gas Production Estimates

- The production of natural gas from unconventional reservoirs (i.e., tight gas sands, coalbed methane resources, and gas shales) has become commonplace within the U.S. energy industry in recent decades.
- Of the 17.2 trillion cubic feet (tcf) of natural gas produced in the U.S. in 1990, roughly 16 percent (2.8 tcf) was from unconventional sources (Kuuskraa and Stevens 1995).
- By 2006, the percentage of unconventional gas production to total domestic production increased to 43 percent (8.5 tcf of the total 18.6 tcf produced) (EIA 2008).
- Recent projections by the Energy Information Administration (EIA 2008), the statistical agency of the U.S. Department of Energy, suggest that onshore production of unconventional natural gas will increase to 9.6 tcf in 2018 and hold at or near that level for the next dozen years. In essence, unconventional natural gas will constitute roughly one-half of the projected 19.6 tcf onshore production by the year 2030 (EIA 2008).

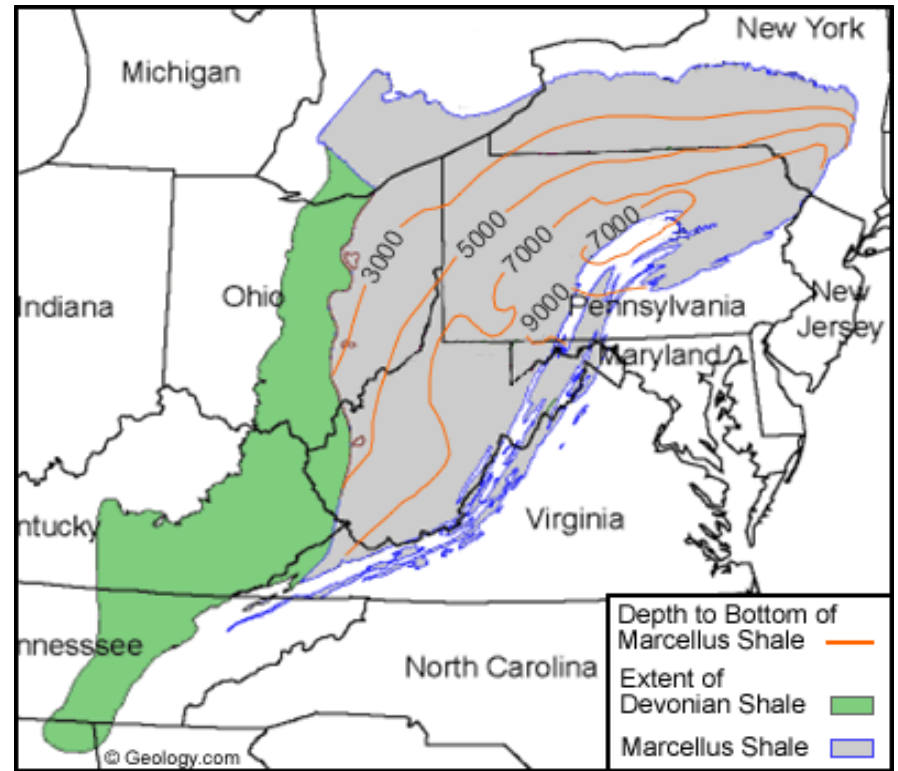
Conventional and Non-conventional Natural Gas Extraction Methodologies

Schematic geology of natural gas resources



Marcellus Shale Range and Production Estimates

- In 2008, Engelder and Lash, estimated that about 50 TCF (trillion cubic feet) of recoverable natural gas could be extracted from the Marcellus Shale.
- In November 2008, on the basis of production information from Chesapeake Energy Corporation, the estimate of recoverable gas from the Marcellus Shale was raised to more than 363 TCF (Esch, 2008).
- The United States uses about 23 TCF of natural gas per year (U.S. Energy Information Administration, 2009), so the Marcellus gas resource may be large enough to supply the needs of the entire Nation for roughly 15 years at the current rates of consumption.

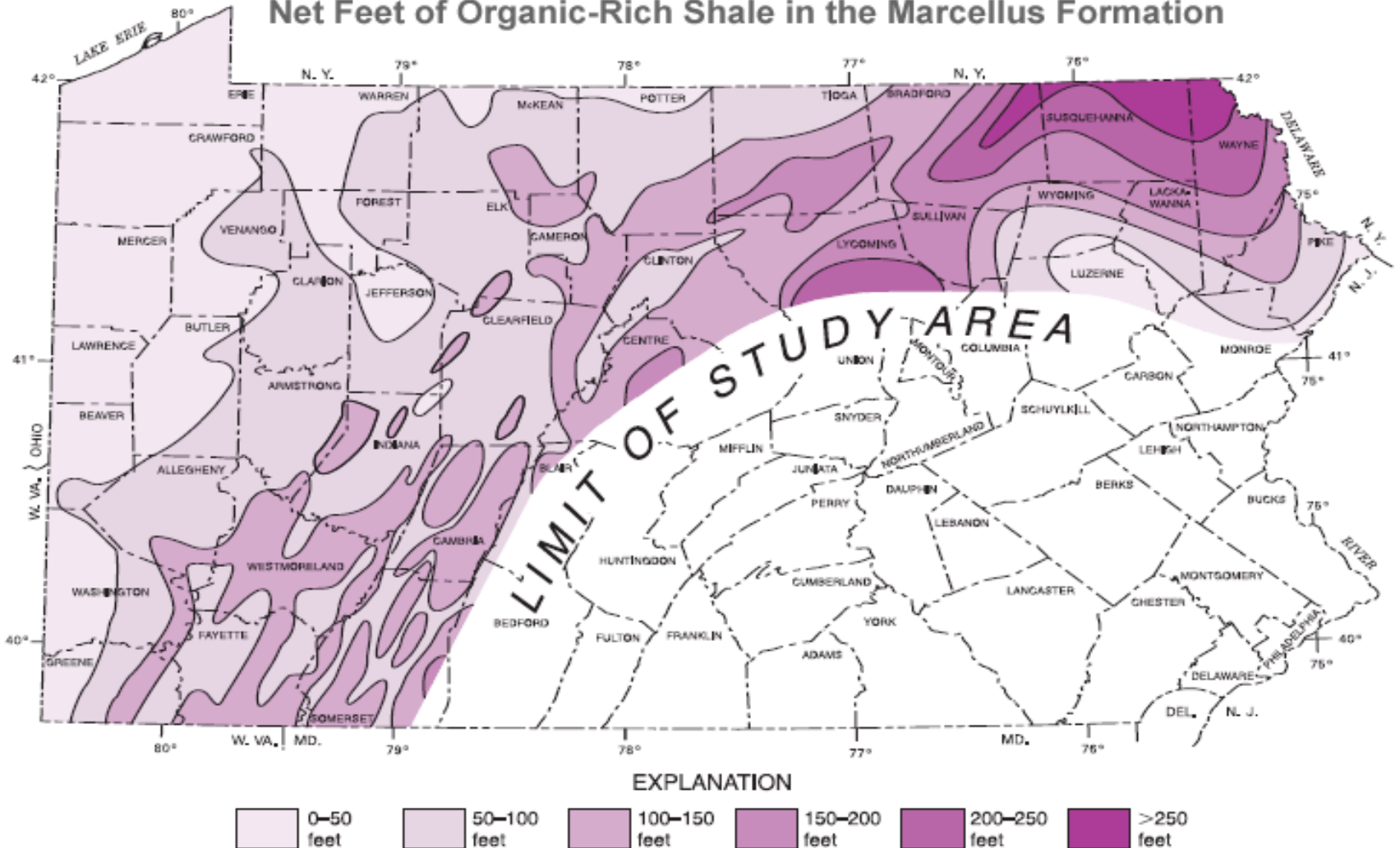


de Witt, Wallace et al. (1993) Principal Oil and Gas Plays in the Appalachian Basin (Province 131). U.S. Geological Survey Bulletin 1839-I, 37 p.

Water Resources and Natural Gas Production from the Marcellus Shale

By Daniel J. Soeder and William M. Kappel, USGS - - From USGS Fact Sheet 2009-3032

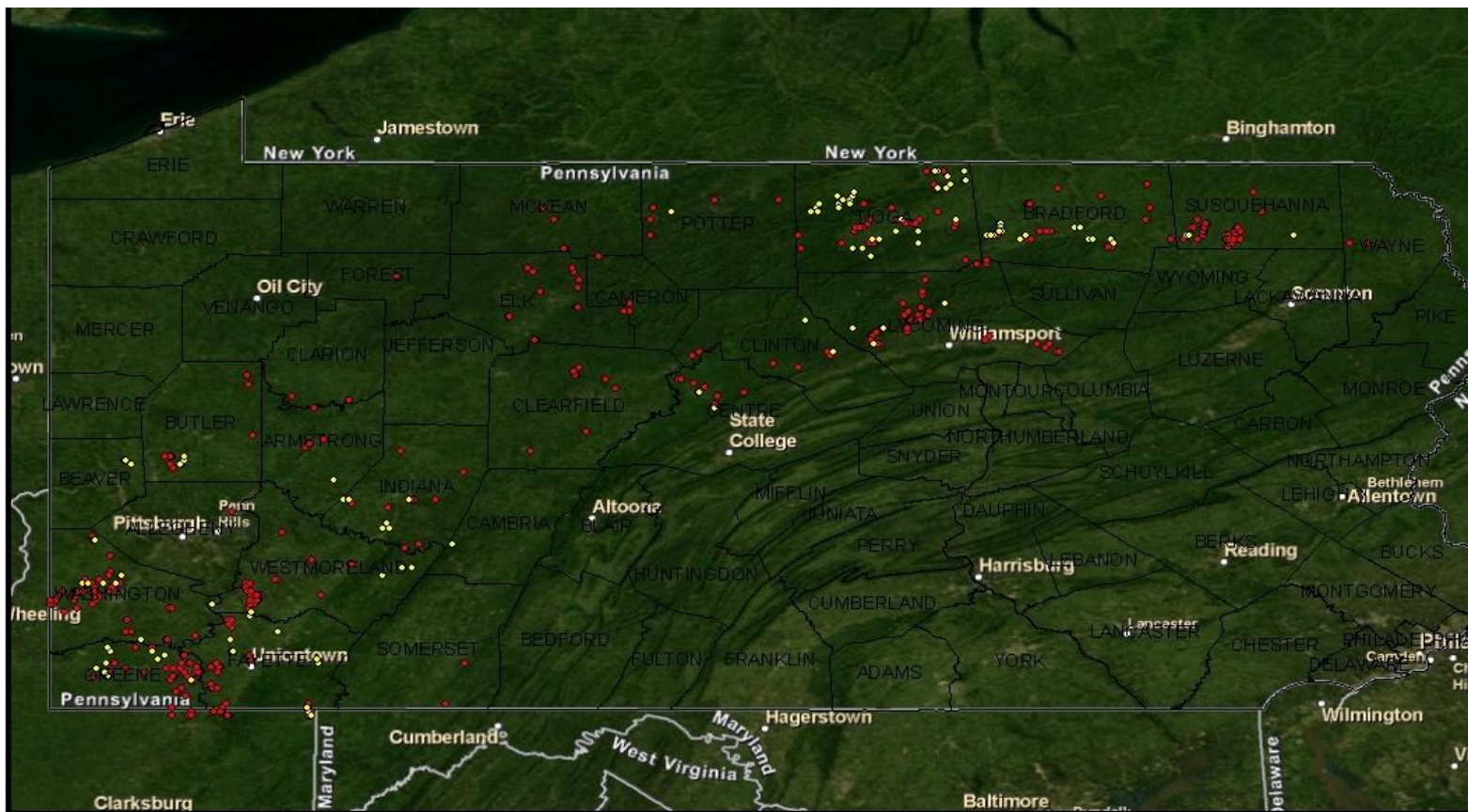
Net Feet of Organic-Rich Shale in the Marcellus Formation



Harper, John A. (2008). The Marcellus Shale - An Old "New" Gas Reservoir in Pennsylvania. Pennsylvania Geology, Volume 38, Number 1. Pennsylvania Bureau of Topographic and Geologic Survey.

Marcellus Shale Permits by County

2008-2009



0 20 40 80 Miles

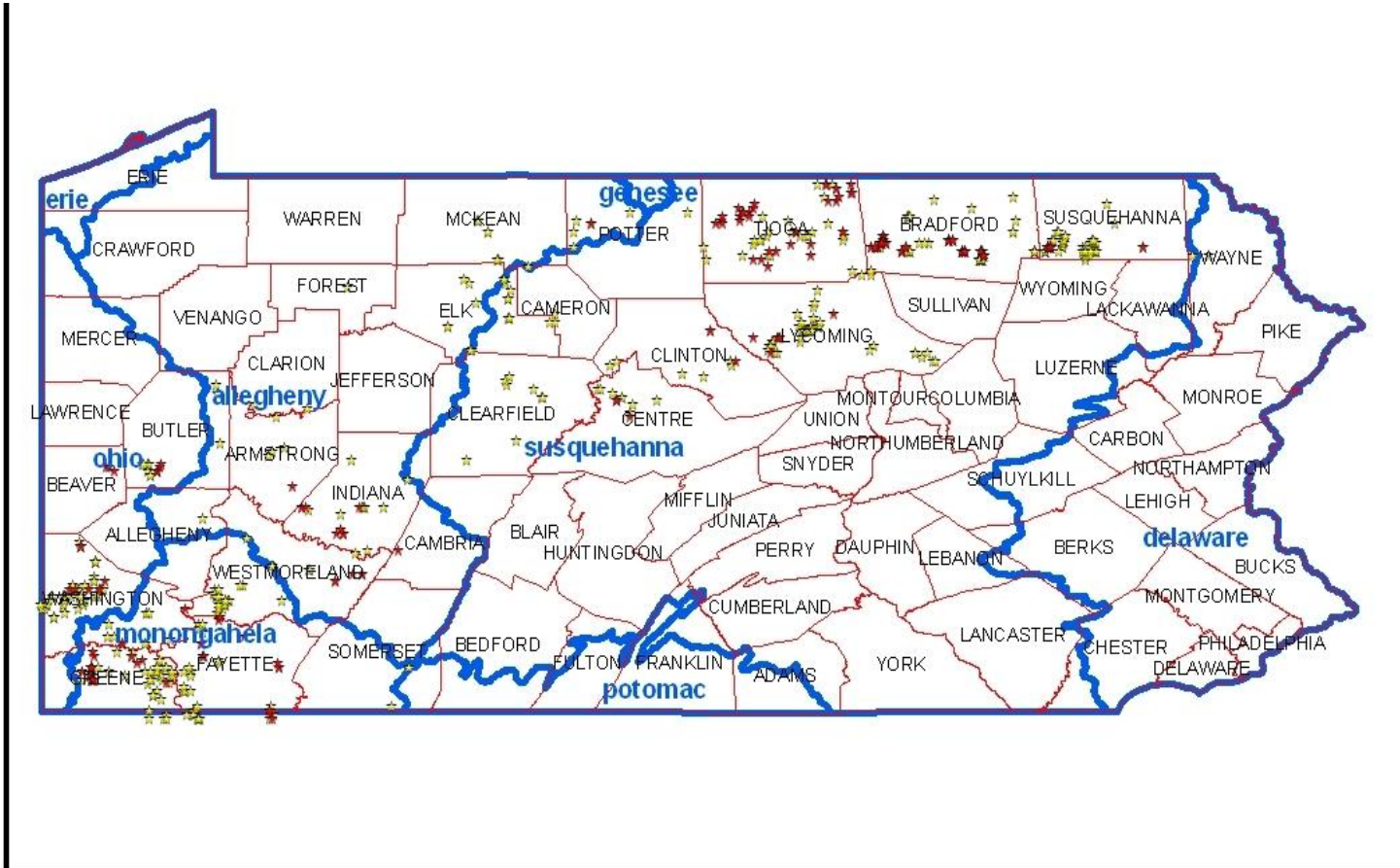


- ◆ 2009 Marcellus Drilling Permits
- ◆ 2008 Marcellus Drilling Permits
- PaCounty



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Marcellus Shale Permits by Watershed 2008-2009



0 20 40 80 Miles



- ☆ 2008 Marcellus Drilling Permits
- ★ 2009 Marcellus Drilling Permits
- PaCounty
- ▭ Major Drainage Basin



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What is Hydrofracturing-hydrofracking—fracking- fracing



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Potential Public Health Problems Associated with Intense Marcellus Shale Gas Production

1. Community and behavioral health impacts.
2. Excessive groundwater and surface water usage, lowering freshwater aquifers and surface water sources. (Each fracked well uses about 5 million gallons of water)
3. Exposure to fracking chemicals from leaks, spills, accidents, off gassing from frac-water pits.
4. Groundwater contamination from flowback and produced water that contain toxic metals/elements, organic compounds (BTEX), and elevated levels of radionuclides from the shale formation itself.
5. Inadequate treatment and inappropriate disposal of brine water into surface water, which adds toxic anions and cations and increases TDS levels in drinking water supplies.
6. Inhalation exposure from volatile organic compounds in frac water, and air contaminants from diesel usage, compressor stations and gas drying facilities.
7. Methane gas in air and water and explosion potential.



Radon Activities in Homes over the Marcellus Shale Formation- Indicates the Intrinsic Activity of the Shale Layer Itself

Formation is enriched in Uranium-decays to Radium and then to Radon

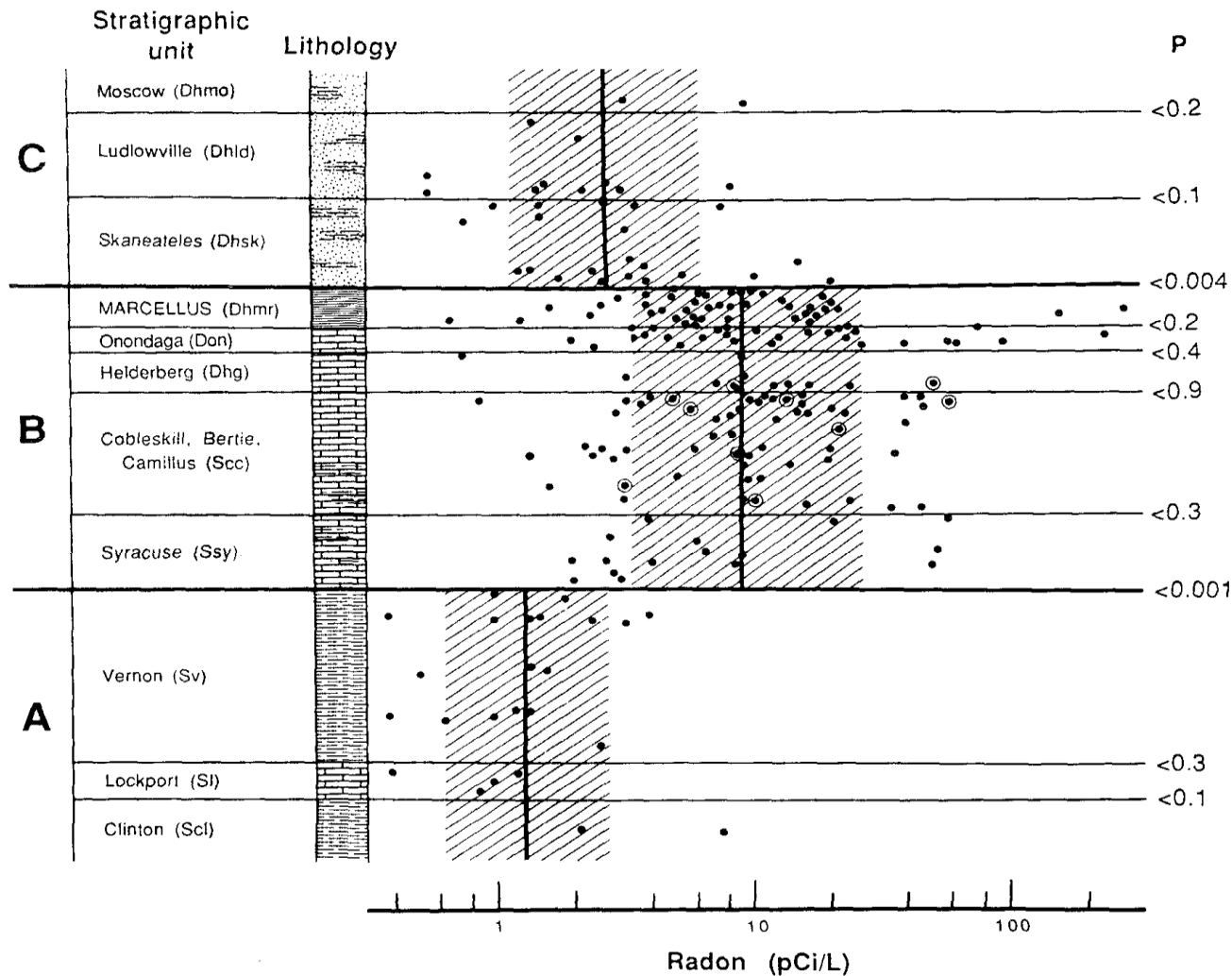
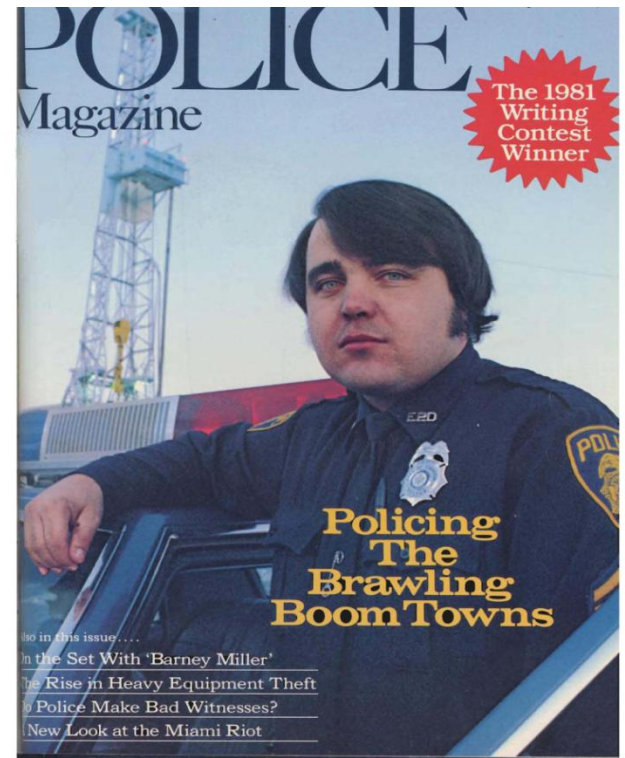


Figure 3. Radon activities plotted against stratigraphic position. Vertical lines indicate geometric means; diagonal rule pattern = area within 1 standard deviation of mean. A, B, C correspond to regions in Figure 1. Circled data points are homes north of Rock Cut, now inaccessible to ground water that has passed through Marcellus Shale. P is probability (based on Student's t test) that data from adjacent formations might represent single population. Parenthetical symbols designate units differentiated on Geologic Map of New York (Fisher et al., 1971).

Psycho-Social and Behavioral Health Effects

1. Disproportionate increases in mental health case loads, crime, divorce, suicide, and alcoholism in impacted community as compared to nearby non-impacted communities (Kohrs, E.V., 1974. *Social Consequences of Boom Growth in Wyoming*).
2. While Kohrs' work has been criticized as unscientific, later research has determined that in many boom communities such social problems did indeed occur at disproportionate rates when compared to non-booming communities. Social service case loads can skyrocket, in many cases at rates faster than even the population increase.
3. Most studies have found that impacts in these areas cannot be attributed exclusively to either old-timers or newcomers, and the reasons for these increases have not been concretely determined. The stresses of social change, uncertainty, isolation, inadequate housing and infrastructure, and substandard services are generically blamed.



Extracted from: **From-Energy Boomtowns & Natural Gas: Implications for Marcellus Shale Local Governments & Rural Communities**
NERCRD Rural Development Paper No. 43
January 2009, 63 pp. Jeffrey Jacquet , The Northeast Regional Center for Rural Development , The Pennsylvania State University

Creation of Significant Challenges for Local Government

Jurisdictional unevenness: The energy development prompting population growth takes place in a political jurisdiction different from the one which bears the cost.

New Comers vs. Old Timers: Rapid growth frequently requires major new infrastructure expenditures to accommodate new residents and older residents may oppose subsidizing such expenditures under uniform taxation arrangements.

Insufficient control of land use: decisions about disposition of land as in federal coal or offshore leasing prevents the local government from using zoning or siting arrangements to ease adjustment.

Severity of growth: Sheer numbers of people entering to work, despite adequate housing, may be unassimilatable without significant declines in quality of public services and community life.

Creation of Significant Challenges for Local Government: Continued

Volatile production patterns: The boom-bust cycle associated with energy development presents the local government with an uneven future path of public service demand.

Monopoly of information: the industry or regulatory agency exercises tremendous power over the pace of development and the amount of information that is available to planners; sometimes, an incentive to misinform exists.

Risk. The uncertainty surrounding the future of many energy activities raises the risk premium, often so high that the financial sector is unwilling to lend funds to or buy bonds of local governments.

Impacts on Community Safety and Roads in Wetzel County, West Virginia (Courtesy of Wetzel County Action Group)

Below: Trucks parked along blind bend in road.



Above: Slip below drill site closes road to ambulance.



Above : Road Disintegration from Truck Traffic

The Center for Healthy Environments and Communities (CHEC); Community Research and Outreach Activities Targeting Gas Extraction Activities and Impacts

Overall Strategy

1. Engage Key Community Informants to establish trusted links to community residents (Washington County, Fayette, and Bedford County)
2. Establish and Maintain a Steering Committee of Key Environmental Organizations in order to coordinate activities connected to gas drilling impacts such as development of citizen surveillance groups, education and state wide coordination and information sharing
3. Develop and maintain sophisticated web-based information commons in conjunction with Rhiza Labs
4. Establish and Facilitate Workshops to Empower Individual Community members to host community information meetings on Gas Drilling and its related impacts.
5. Provide technical assistance in the development of a pilot citizen surveillance project with Youghiogheny River Keeper.

Engage Key Community Informants to Establish Trusted Links to Community Residents

- Work with Key Informants to Document Experiences of poor health outcomes, environmental impacts and psycho-social issues related to gas drilling operations. (Washington County, Fayette, and Bedford County)
- Develop Superfund P42 pilot project uniting community outreach with innovative monitoring and remediation technology
- Maintain contact lists of community contacts for the purpose of providing ongoing and new information

Establish and Maintain A Steering Committee of Key Environmental Organizations

- An initial collaboration has been developed between Carnegie Mellon University, Clean Water Action, Duquense University, G.A.S.P., Three Rivers Water Keepers, Youghiogheny Water Keeper, Penn Environment and CHEC.
- This collaborative has been called the Well Tender Steering Committee. The next phase is adding new collaborators.
- This mission of this collaborative is to assist in the development of development of citizen surveillance groups targeting gas drilling operations as well as establish information sharing with groups throughout the state.

Develop and Maintain Web-Based Information Commons

- Rhiza Labs in conjunction with Maya Design has developed a community access and very user friendly web based information commons which is able to manage and process data from many sources. This platform will be implemented through the CHEC for use by community groups and individuals throughout the state.
- Citizen Surveillance groups will upload photos, videos, journals, documents of their experiences of the impacts of gas drilling in their area
- Citizen groups will be apprised of a very simple training on the use of the web based information platform.

Establish and Facilitate Workshops to Empower Individual Community members

- Create a workshop to inform and empower concerned citizens to create and facilitate their own presentations and community meetings focused on gas drilling impacts.
- Establish contacts with key environmental and recreational groups to advertise the workshops; such as: Trout Unlimited, Sierra Club, League of Women Voters, Rod and Gun Clubs
- Gather contacts of volunteers who will advocate and gather information on impacts related to gas drilling

Baseline TDS, Anion and Cation Monitoring at Select Locations on the Monongahela River

Sampling will be done along transects up-river, immediately downstream of mouth entry, and downstream from Dunkard Creek, Ronco Brine Treatment Facility (proposed) and 10 mile Creek.

Cation Analysis- Ca, Na, Mg, K, Fe, Ba, Sr, Mn, As, B, Co, Li, Se and U-minimally.

Anion Analysis- Cl, Br, and Sulfate

Ten-Mile Creek

Ronco Brine Treatment Facility

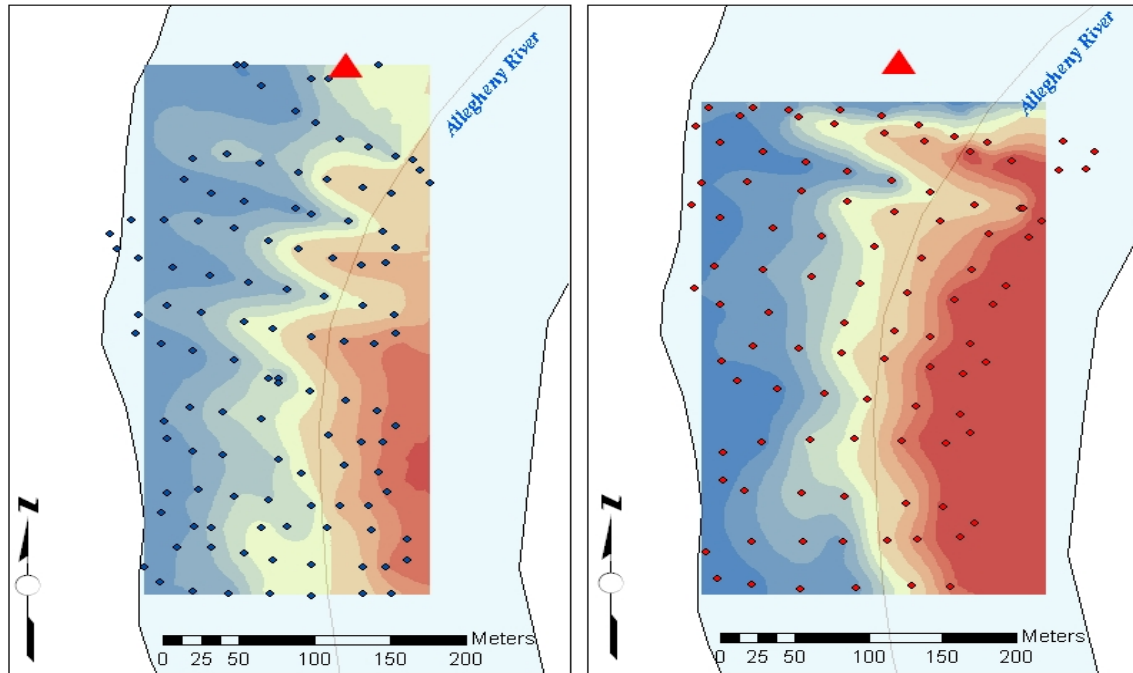
Dunkard Creek



Watershed Atlas of the Monongahela River, PEC,
<http://www.watershedatlas.org/>

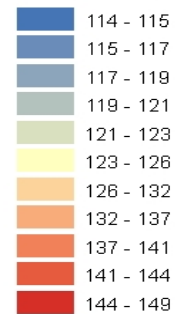
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Ordinary Kriging TDS Data Depiction- Based on River Mining Study; Same methodology will be used to Depict TDS from Tributaries into the Monongahela River



- ▲ Gravel Mining Extraction
- Allegheny River
- Hydrography Boundary
- ◆ Before River Mining Locations
- ◆ After River Mining Locations

Total Dissolved Solids (ppm)



TDS levels will be correlated with results of cation and anion analysis to determine underlying elemental/species composition.

Nested Study of Impacted and Non-Impacted Segments of Tenmile Creek

Study Parameters –

Setup gauging stations to obtain hydrograph and **model streambed characteristics** (Jorge Abad, PhD, Pitt Engineering)

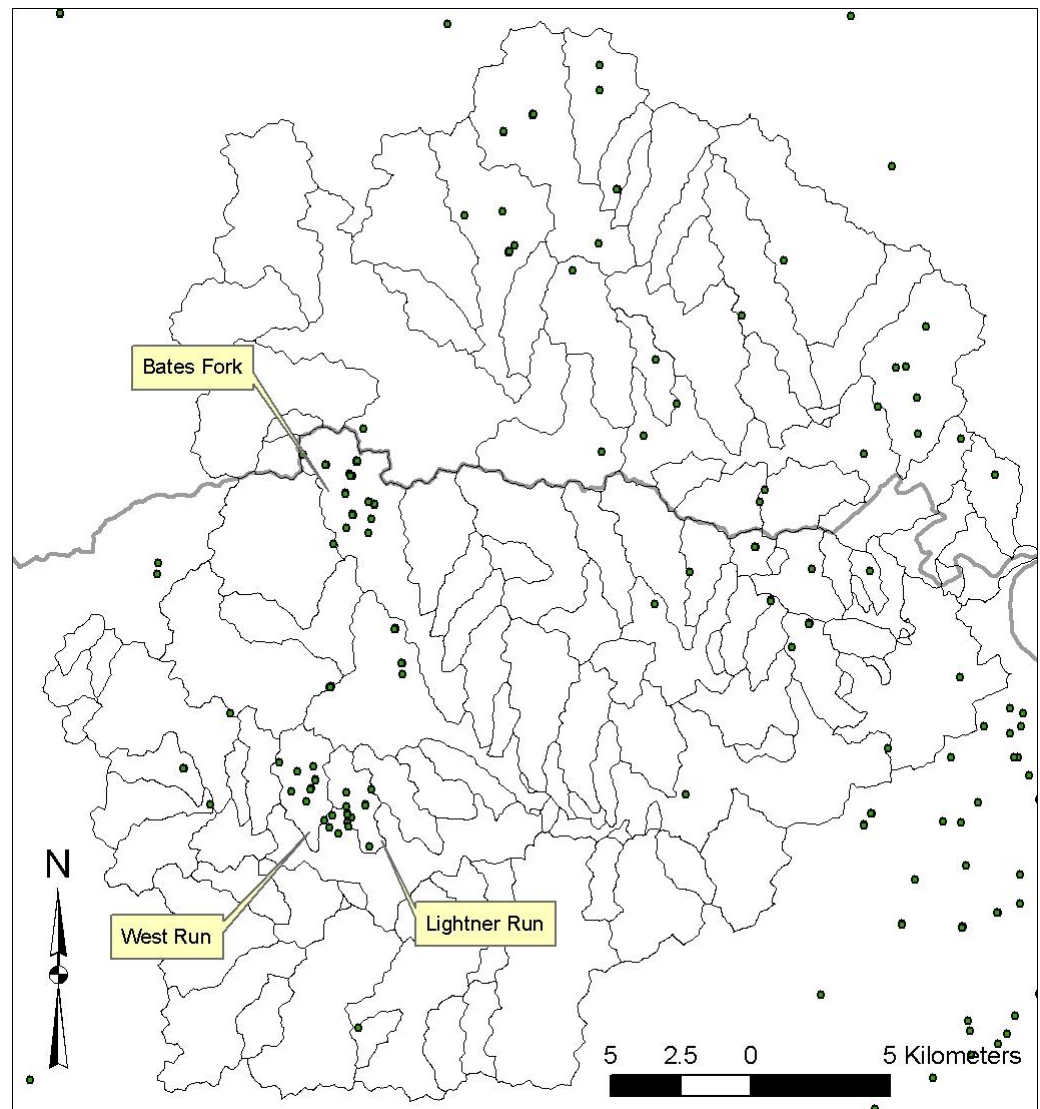
Collect and analyze samples for major cations and anions, monthly and during high and low flow periods. (Dan Bain, PhD, Pitt Geology)

Profile microbial communities at each sampling site using light and fluorescence microscopy and ARISA techniques. Perform microcosms and enrichment culture experiments to simulate expected changes in brine effects on communities using microscopy and phylotypic identification. (John Stoltz PhD, Duquesne University)

Survey of the salamander populations in the area of the two sites. (Kyle Selcer, PhD, Duquesne University)

Perform fish surveys following EPA and PFBC protocols, to monitor species diversity and abundance. Focus on three darter species which are predicted to be sensitive indicator species to pollution. (Brady Porter, PhD, Duquesne University)

Perform human risk analysis for identified contaminants (Conrad Volz, DrPH, GSPH)



Map by Dan Bain, PhD - Tenmile Creek drains 875 sq. km of eastern Washington and Greene Counties in Pennsylvania. Between 2007 and 2009, 124 Marcellus Shale drilling permits were issued within the watershed