The Environmental Challenge International

… a student team competition

Air & Waste Management Association Annual Conference & Exhibition, 2017

Fracademic Exercise

The Purpose

Students from near and far will be arriving in Pittsburgh, Pennsylvania for this year's Environmental Challenge International. This contest gives student teams experience with proposing effective solutions to a simulated environmental problem--a problem based on real-world site conditions and events. The teams will also get the chance to present their solution to a panel of environmental professionals at A&WMA's 2017 conference.

Although the challenge is somewhat quantitative, teams will be expected to address a wide range of concerns related to the environment, energy, and health. Teams will be evaluated based on a variety of issues, such as, how the problem is interpreted, how conclusions were determined, and how well the team can communicate its reasoning and judgements. So, in addition to the scientific and technical aspects of this competition, resolution of political and community issues along with appropriate regulatory approaches will be important.

As you work through the exercise, don't forget to have fun! This environmental challenge "gives everyone attending the conference a chance to participate and gets the professionals of tomorrow interacting with the professionals of today."

The Challenge

It seems that "energy independence" are the buzz words of politicians and pundits everywhere these days. Not surprising, since the United States, with its vast reservoirs of natural gas, oil, and coal, in addition to its advanced solar and wind technology, can certainly be independent of extra-national energy suppliers.

In a January 21, 2017 article titled "Producers Gear Up for Oil's Recovery" in *The Wall Street Journal*, reporter Erin Ailworth writes:

"U.S. oil producers, optimistic that higher crude prices are here to stay, have issued 2017 budgets that call for dramatically greater spending to tap new wells.

"Preliminary capital-spending plans released in recent weeks by more than a dozen American shale drillers… show an average 60% budget increase for the group."

FracKing Drilling Company is seeking to expand its hydraulic fracturing operations in southwestern Pennsylvania. According to a statement late in 2016 by Douglas "Rusty" Bitt, the president of FracKing Drilling, the company wants to get drilling by December 2019:

"The time is right for expansion of drilling in the Keystone State. We are looking to tap beyond the Marcellus shale play down into the Utica. Our drilling team is eager to get started," said Rusty Bitt, president of FracKing Drilling Company.

-EnergySpike Magazine

Southwestern PA has historically been one of America's leading manufacturing areas. Life-long residents are accustomed to heavy industry and the numerous manual labor opportunities such activity brings. In addition, oil and natural gas wells (conventional wells) are quite familiar to citizens. Recall that in 1859, the first oil well, Drake's Well, was drilled in Titusville, in western PA. Pittsburgh, PA, the largest city in southwestern PA, has a mix of light and heavy operations along with a substantial presence from academia including the University of Pittsburgh and Carnegie Mellon University.

Although the popularity of Pittsburgh's sports teams--the Steelers, Penguins, and Pirates--helps to solidify comradery in the region, tensions can run high when it comes to unconventional gas well proposals. After learning about FracKing's plans for drilling, one group has formed to stop the work. The group, Citizens Outraged that Fracking Found Us in Pennsylvania (COFFUP), made this statement in mid-January 2017:

"There is no good time to expand drilling in the Keystone State. We are outraged to learn that a known bad actor--FracKing Drilling--plans to expand their dirty business into the pristine farming communities of southwestern Pennsylvania," said Ida Knomore, chair of Citizens Outraged that Fracking Found Us in Pennsylvania.

-Pittsburgh Post Press

Your Assignment

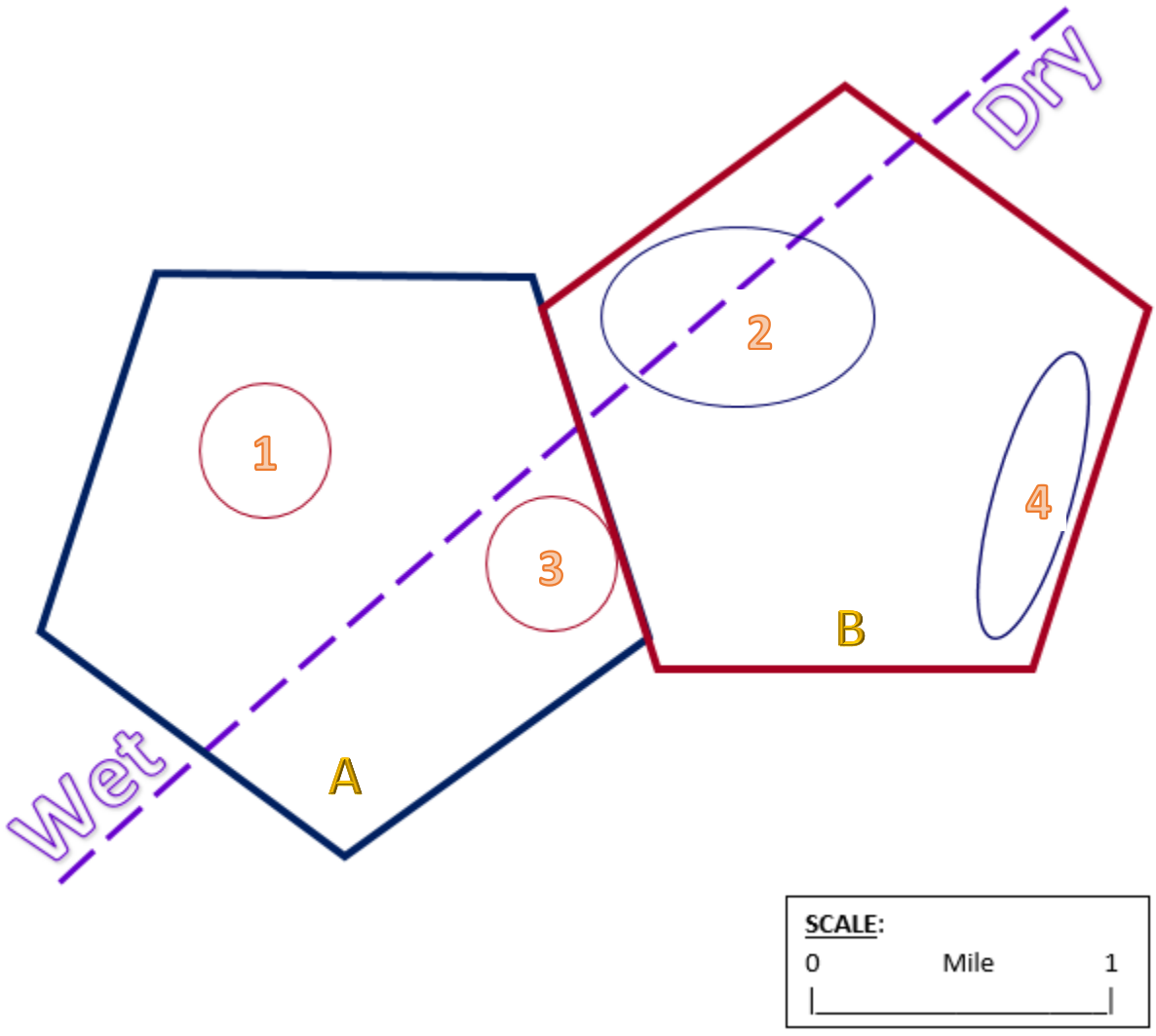
A consortium of SW PA government planning organizations named SWPA-PO has hired you, a team of renowned and unbiased environmental consultants, to create a proposal that addresses *how*, *who*, *what* and some *whys* regarding the regulatory and public concerns in construction of the drilling operations which are proposed by FracKing Drilling in one of several areas of SW PA (see Figure 1). This plan will be a proposal that will guide decision making as FracKing pushes the project forward in negotiations with the SW PA Department of Environmental Protection and the Allegheny County Health Department. To be successful in your presentation, you must tactfully and eloquently articulate issues, knowns, unknowns, and recommendations for the completion or rejection of this project.

There is no easy answer that will please everyone completely. You must do your best to build public support and articulate how to address the concerns of community groups like COFFUP and ensure the project, if approved, provides the most tangible environmental, economic, and social benefits.

At a minimum, you should consider two or three alternative solutions that weigh environmental, social, and economic interests. You should have a preferred solution to present to interested parties. In addition, keep the following questions in mind and address them in your solution:

1. Can drilling be conducted safely while protecting the environment in the proposed area?
2. What types of permits are needed for the proposed operation?
3. What types of contamination may be present in the potential sites for drilling?
4. What efforts will be made to mitigate pollution and contamination from all potential sources?
5. What are possible impacts to the residents nearby from site preparation, drilling, and operation of the completed wells?
6. What will be done to reclaim any reclaimable land after the wells go into operation?
7. How will all impacts be mitigated?

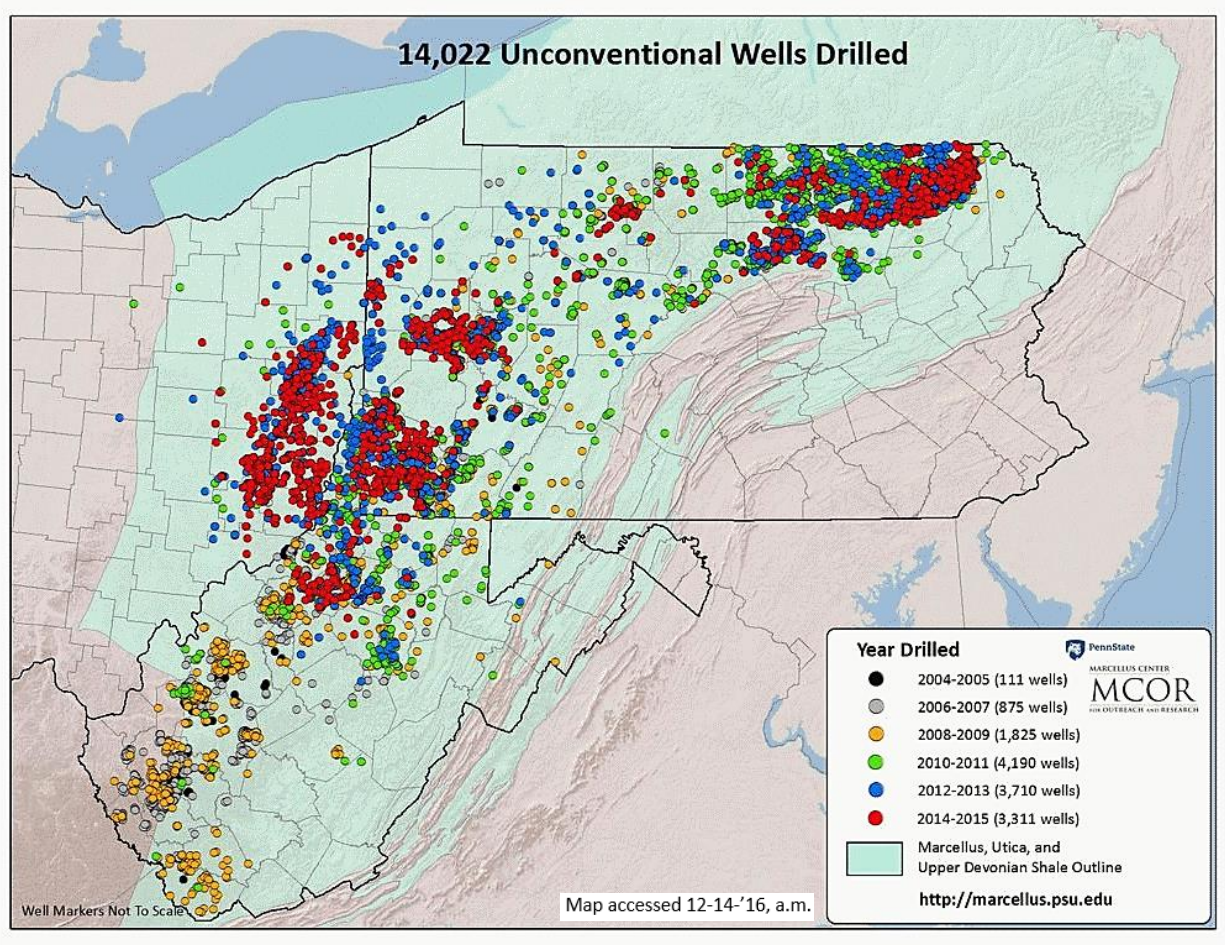
Figure 1. Potential Fracking Sites in SW PA. The pentagon-shaped boundaries represent two general conditions. The red boundary outlines a more urban setting while the blue boundary marks a more rural setting. Each numbered area identifies possible drilling sites being considered by FracKing. The "Dry" and "Wet" sides of the boundaries refer to the type of gas available.



Initial Background Data

The exploration, development, and production of gas from the Marcellus Shale formation are expected to result in substantial increases in air pollutants. Attached is a report that was produced several years ago that estimates air emissions in southwestern PA. Note that information in this report will need to be substantiated; however, this report may give you some ideas for data analysis and preparation for this Fracademic Exercise.

A helpful website for current information about natural gas wells can be accessed here: www.marcellus.psu.edu. The following map was taken from this site in mid-December 2016.



Attachment ("Marcellus Shale 2014 Air Emission Estimates for Select SW PA Counties")

Marcellus Shale 2014 Air Emission Estimates for Select SW PA Counties

July 27, 2012

Background

The exploration, development, and production of gas from the Marcellus Shale formation are expected to result in substantial increases in air pollutants in the region. This memo provides an explanation of the methodology taken to estimate several of those pollutants for the Allegheny County Health Department (ACHD) 2014 emissions inventory prepared for the county's $PM_{2.5}$ State Implementation Plan (SIP) modeling work. The SIP modeling base year was 2007, which was assumed to have insignificant levels of emissions from Marcellus Shale wells.

Estimate of Wells Drilled in 2014

Estimates of the total number of wells expected in Washington, Greene, Fayette, and Westmoreland counties in 2014 were derived from projections given in a June 2011 Penn State Cooperative Extension report.[1] Table 1 of this report gives a total of 892 projected Marcellus Shale wells drilled in 2014 for southwest Pennsylvania. This total was distributed to the individual southwestern PA counties by assuming that the proportion in each county would be the same as reported by the PA DEP for 2011.[2] For example, 31.2% of total wells in southwest PA were in Washington County (159 in Washington County versus a total of 509 in southwest PA). Assuming this same percentage will hold through 2014, the expectation for Washington County is for **278** wells to be drilled in 2014 (31.2% of 892 projected wells). Similar calculations were carried out for the other counties (Greene was 24.0% or **214** wells; Fayette, 10.6% or **95** wells; and Westmoreland, 11.8% or **105** wells).

Estimate of Existing Wells in Operation in 2014

Besides the 2014 new well totals, we must determine the total number of wells expected to already be operating in each county in 2014. Thus, for example, according to PA DEP,[2] 560 wells were drilled in Washington County from January 1, 2005 through December 31, 2011. And projections provided in the Penn State Cooperative Extension report[1] for wells drilled in 2012 and 2013 show 430 wells are expected. So, a total of **990** wells are anticipated to be operating in Washington County in 2014. (Similarly, for Greene County, **740** total wells are expected; for Fayette, **332**; and for Westmoreland, **349**.)

Wet Versus Dry Wells

Based on the geology of the counties,[3] we have assumed that 40% of the wells are producing dry gas and 60% wet gas for Washington County, 70% dry gas / 30% wet gas for Greene County wells, and 100% dry gas for Fayette and Westmoreland wells.

Air Emission Factors

The "Emissions Per Well" provided in the table below are based on a Marcellus Shale operations analysis found in "An emissions inventory for the development and production of Marcellus Shale" by Anirban A. Roy, Peter J. Adams, and Allen L. Robinson of Carnegie Mellon University, 2012.[4] In this draft report, mean values are given for 2009 and 2020. A number that is roughly the average of the two annual mean values was selected for the estimates given here. Furthermore, for the midstream (processing) emissions, a typical gas flow of 5 million cubic feet per day (mmcf/day) from new wells was assumed (a magnitude derived from a statement made by Penn State geologist Terry Engelder[5] and from a PA DCNR presentation titled "The

Marcellus Shale Play in Pennsylvania" by John A. Harper and Jaime Kostelnik.[6] Therefore, for example, the yearly flow for new wells will be:

Annual Flow = (5 mmcf/day/new well) (365 days/yr) = 1.825 billion cubic feet (Bcf)/new well/yr.

Furthermore, the midstream NO_x emissions per new well will be:

Midstream NO_x Emissions = (2.4 tons NO_x/Bcf/new well) (1.825 Bcf/yr) = 4.39 tons NO_x/new well/yr.

It was assumed that midstream (and production) emissions during the start-up year (2014) would only be one-half, assuming that site preparation and initial production will be distributed rather evenly throughout the year. Thus, for example, midstream NO_x emissions per new well would be **2.20 TPY**.

For wells already in operation in 2014, assuming a steady average production rate of 1 mmcf/day per well based on production decline curves reported in "The Marcellus Shale Play in Pennsylvania,"[6] the total gas flow from Washington County existing wells during 2014 will be 0.365 Bcf, and the corresponding midstream NO_x emissions per existing well in 2014 is estimated to be about **0.90 TPY**.

Caveats on This Estimation Approach

Development is frequently seasonal and refracking of existing locations can occur. Neither of these two conditions were considered in the emission estimates.

Results

Marcellus Shale air emission estimates for Washington, Greene, Fayette, and Westmoreland Counties in southwestern Pennsylvania are given in Table 1 in tons per year (TPY) for 2014.

References

1. "Pennsylvania Marcellus Shale Economic Impact Study" by the Marcellus Shale Education & Training Center, a collaboration of the Pennsylvania College of Technology and the Penn State Cooperative Extension, June 2011. (See Figure 4 and Table 1 in study at http://marcelluscoalition.org/wp-content/uploads/2011/08/PennsylvaniaStatewideWorkforceAssessmentv1_Final_for_web.pdf.)
2. PA DEP Office of Oil and Gas Management Wells Drilled by County accessed June 28, 2012 (see http://www.depreportingservices.state.pa.us/ReportServer/Pages/ReportViewer.aspx?/Oil_Gas/Wells_Drilled_By_County).
3. Derived by Jason Maranche of ACHD from geological map of Marcellus Shale dry/wet gas demarcation and distribution of wells drilled in 2007 through 3/19/2012 from Marcellus Center for Outreach and Research (see www.marcellus.psu.edu).
4. "An emissions inventory for the development and production of Marcellus Shale" by Anirban A. Roy, Peter J. Adams, and Allen L. Robinson of Carnegie Mellon University, 2012 – DRAFT.
5. Penn State University geologist Terry Engelder online interview, June 2010 (see http://www.youtube.com/watch?v=0uNzwFkrcqg&feature=relmfu.)
6. PA DCNR presentation titled "The Marcellus Shale Play in Pennsylvania" by John A. Harper and Jaime Kostelnik (www.marcellus.psu.edu/resources/PDFs/DCNR.pdf, see slide 64, et al.).

Table 1. Estimated Marcellus Shale 2014 Air Emissions (TPY)

DRILLED IN 2014 (i.e., NEW WELLS)			Wash Dry (40%)	Wash Wet (60%)	Greene Dry (70%)	Greene Wet (30%)	Fayette Dry	Westm Dry
	Number of wells ->		111	167	150	64	95	105
	Emissions per Well * (TPY)							
Development	NOx	6.00	666	1002	900	384	570	630
	PM2.5	0.30	33	50	45	19	29	32
	VOC dry	3.00	333		450		285	315
	VOC wet	14.00		2338		896		
Production	NOx	0.45	50	75	68	29	43	47
(Assumed at 50%)	PM2.5	0.01	1	1	1	0	0	1
	VOC dry	0.26	29		39		25	27
	VOC wet	1.25		209		80		
Midstream*	NOx	2.20	244	367	330	141	209	231
(Assumed at 50%)	PM2.5	0.05	6	8	8	3	5	5
	VOC	4.75	527	793	713	304	451	499
EXISTING IN 2014 (i.e., 2007-2013)			**Wash Dry (40%)**	**Wash Wet (60%)**	**Greene Dry (70%)**	**Greene Wet (30%)**	**Fayette Dry**	**Westm Dry**
	Number of wells ->		396	594	518	222	332	349
	Emissions per well * (TPY)							
Production	NOx	0.90	356	535	466	200	299	314
	PM2.5	0.01	4	6	5	2	3	3
	VOC dry	0.53	210		275		176	185
	VOC wet	2.50		1485		555		
Midstream*	NOx	0.90	356	535	466	200	299	314
	PM2.5	0.01	4	6	5	2	3	3
	VOC	1.90	752	1129	984	422	631	663

TOTALS		Wash	Greene	Fayette	Westm
	NOx	**4187**	**3183**	**1419**	**1536**
	PM2.5	**118**	**91**	**40**	**44**
	VOC	**7805**	**4717**	**1568**	**1689**

***** Midstream emission factors, based on Reference 4, are: NOx = 2.4 tons/Bcf, $PM_{2.5}$ = 0.03 tons/Bcf, and VOCs = 5.2 tons/Bcf.