Letter Modified from June 6, 2001 to City Council and resent. Modifications reflect additional citations and improved statistics.

Dear Council Member,

I wish to respectively offer slightly revised comments on the proposed items before Council on the Marcellus. I believe that I have the technical background to offer factual information that can assist you in evaluation of the risk and economic impact of Marcellus and similar extractive technologies which are being applied to numerous reservoirs throughout our state and nation. First, I will state up front that I see the proposed resolutions before the City Council on the Marcellus as misguided at best, and will attempt to address in a factual basis why they should be rejected. I will provide a summary with references to the pertinent material, or provide elaboration of the technical analysis in the appendices. I am available at any time to discuss via email or phone any aspect of this issue.

1) **Safety –** Bottom line based on a standard risk analysis using all the reported spill data since 1 January, 2005 to 6 June 2011 (171 incidents), a period when the WV-DEP reports permitted operations at 15,928 wells (e.g., drilling, plugging, work-overs – Figure 1) one can estimate the risk of a major spill (~30,000 gallons) at a particular well of $1.07X10^{-4}$ (.000107 - Appendix 1 for the analytical details). The risk of the spill reaching the river is even lower given the closed-loop system and the secondary containment ponds at the well site. The probability of a spill reaching across the river is negligible given the volume and velocity of the river's flow. To put this in perspective, the risk of a major spill is less than the probability of a fatal automobile injury to any given individual in a year (1.78 *10-4 in 2009[1]). The risk of a spill is at risk factor that we deem “safe” enough to allow people to drive vehicles. Also, the recent dumping of 1.5 million gallons of raw sewage into the Monongahela River by MUB is a great test of the ability the river to act as a hydrologic barrier. This dumping is three times the maximum quantity of fluid used in a fracture stimulation of operation at a well.
2) **Suitability of the Location –** Given the relatively low risk, the Morgantown Industrial Park (MIP) is a reasonable location for the Northeast Natural Energy wells. The MIP has excellent road access that is used daily for heavy truck traffic, and given its past history as a superfund site it cannot be used for habitation or agriculture. The MIP contains two operations that deal with waste that is much more hazardous than either drilling fluids or flow-back water. The Chemtura site, which is right on the river, has a documented history of emissions (HCl and Phenols[2]). The AES site is used for a collection and transfer site for all types of hazardous waste. The MIP also contains existing producing gas wells. I believe that what could be characterized as a brownfield is one of the best sites in Monongalia County for a gas well.

[1] National Highway Traffic Safety Administration - http://www-nrd.nhtsa.dot.gov/departments/nrd-30/ncsa/STSI/54_WV/2009/Counties/West%20Virginia_Monongalia%20County_2009.PDF
[2] US EPA - http://www.epa-echo.gov/cgi-bin/get1cReport.cgi?tool=echo&IDNumber=WV0004740

3) **Local Tax Fiscal Impact –** Counties and municipalities in West Virginia receive a small portion of the revenue from the state severance tax based on production in the county and municipality. While declining with declining production and price over the last few years, in June 2010, Morgantown received $22,132.14, and Monongalia County received $92,590.55 based on price and production during calendar 2009[3]. In addition, the estimated 2010 property tax revenue in Monongalia County from oil and gas operations was $1,336,670[4]. This was based on production in the county and city that is from older wells at relatively low rates (For example there are several wells in the city including a gas well right across the bike path from the Seneca Center). In 2008, reported gas production in Monongalia County was 4.16 billion cubic feet. If successful (high probability), the two wells being proposed in the MIP could double gas production in the county and would double county and city tax revenues. The Council should consider the very significant fiscal impact of its actions on tax revenues. I do not wish to highlight the negative, but the banning of drilling in the city and in an area within one mile of the city boundary could be interpreted as a taking of property (the mineral estate) without compensation. On a very conservative basis, I would estimate a square mile to contain 3 billion cubic feet of recoverable gas. Given an average $4.00/mcf value and a 3/16 royalty discounted at 5%, I would estimate a value to the royalty estate of approximately $1.25 million per square mile. The Council should consider this as a contingency to compensate the mineral estate, and a moral necessity for the taking of property.

   As aside the extension of regulation by the city beyond its boundaries has some interesting implications. For while second hand smoke is dangerous (fatality rate of $1.3 * 10^{-4}$ as cited by the CDC in 2006[5]) and in my opinion should be banned from all public places, the logic state since second-hand smoke affect its citizens, Morgantown should extend its smoking ban beyond the city limits. Same could be stated for zoning to prevent sprawl and traffic fatalities.

4) **Employment –** In West Virginia over the last five years the industrial sector has seen a decrease of 6,686 employees, which have been partially offset by 2,027 new direct employees in the oil & gas sector[6]. Indirect employment related to the oil and gas sector must be many more thousands. These new oil and gas sector jobs pay on the average 75% more than a typical position in the industrial sector. Many of these people live in Morgantown. I have a fracture stimulation engineer living directly behind me, and I know of several geologists working in the industry living in the city. There are several operating

[3] West Virginia State Tax Office - http://www.wvsto.com/dept/Admin/Tax/Pages/OilandGas.aspx
[4] West Virginia Tax Department as stated on page 8 by WV Oil and Natural Gas Association in http://www.wvonga.com/LinkClick.aspx?fileticket=DlTtGbEQnLM%3d&tabid=159&mid=1084
[5] 50,000 deaths attributed to second –hand smoke and a population of 300,000,000 equals a morbidity rate of 1.3X10-4. See American Lung Association and references therein - http://www.lungusa.org/stop-smoking/about-smoking/health-effects/secondhand-smoke.html)
[6] Work Force West Virginia - http://www.workforcewv.org/LMI/cntyform2.cfm?SelectCnty=West%20Virginia

companies in the city. We should be promoting the continued growth of the industry in the city and county.

5) **Impact on Property Values –** I have heard it stated that gas wells will negatively impact our property values. This is a statement that I cannot understand. In the early 1980's I was involved in drilling a number of directional wells with large fracture stimulations in Ojai and Long Beach, California. I have also evaluated the Beverly Hills field. To my knowledge, property values in these posh neighborhoods have not been seriously decreased by oil and gas operations. The City of Long Beach has its own oil and gas department to promote development and production sharing provides significant revenue on City owned property. These are certainly nice places to live, if I could afford the real estate. The same could be stated for Tarrant County, Texas. Shale gas operations in the Barnett Shale exist on the campuses of TCU and University of Texas at Arlington and in several high-end country club/housing developments. It has certainly provided TCU and UT-A significant additional funds to attract and keep top scholars. I contacted one of my former bosses who has a high-end house over an area of active Barnett shale-gas exploration and production (I have attached his email and would be happy to provide his name and contact information for very limited use – Appendix 2). He is obviously very pleased with the results, which provide additional income for his golfing retirement. I see no reason that West Virginia should be different than these areas.

6) **Energy = Clean Water –** Energy is the one necessity for clean water. In the United States, 10% of **ALL** energy consumed in the US is used to process and move our water primarily for domestic consumption[7]. We have clean water to drink and bath, because we have the political desire and the energy to process and move it. Most of this energy used by local water utilities is in the form of natural gas and electricity (gas and coal). In most municipalities, the biggest purchaser of natural gas is the water utility and the energy consumption is approximately equal to that of all the households. You can see many examples of energy poor countries where one does not want to drink the water (India and China are good examples). Without energy there cannot be clean water.

7) **Impact to West Virginia –** One can see the impact of the Marcellus on the state with increased tax revenue. The revenue through May 2011 is above projections in part because from the 23% increase from last year in Severance Tax, which is running 47 million more than last year[8]. The increase in other tax components such as personal and corporate income can also be attributed to increased gas production resulting in increases

[7] For example see presentation by Michael E Webber and references therein especially Stillwell, 2009 - http://www.ncseonline.org/00/Batch/CEREL/N2010%20Meeting/Webber%20CEREL%20Energy%20and%20Water%205%20Nov%202010.pdf

[8] WV State Auditor's Office - http://www.budget.wv.gov/reportsandcharts/revenuereports/Documents/RGRmay11.pdf).

income to royalty owners and companies for quick marts to oil companies operating in West Virginia and Morgantown.

8) **Impact on our pocket books –** The world price of natural gas is approximately $14/mcf. Our domestic price is around $4/mcf. Previously, I have calculated that this price differential saved me $200 in January on my gas bill[9]. The price differential exists because as a country, we are self-sufficient in gas production. I calculate that this price differential saved the average consumer in the United States $736 over the past year. This saving is bigger than the federal tax stimulus, and I would be so bold as to speculate kept us afloat during the recession. It has directly contributed to a blossoming of the chemical industry, especially in West Virginia and the United States.

9) **Impact on our Country –** West Virginia and the United States has received an incredible gift with the Marcellus Shale. With estimated reserves of more than 500 trillion cubic feet, it is one of the largest natural gas fields in the world. Those of us who live above this tremendous resource have two choices. We can play the NIMBY card, employing scare tactics and using poorly documented "facts" to fight attempts to drill for that gas. Or we can embrace the idea that our country requires energy from the Marcellus Shale, accept the temporary inconvenience that the drilling brings, but insist that it be done properly. If we choose this latter path, we will be helping to move the country to a fuel that will support us for the next 60 years, while diminishing the strategic importance of unstable areas such as Iraq, Bahrain and other parts of the Middle East, where our children will continue to die.

Every morning as I wake up to the alarm on my cell-phone, tune to NPR and turn on the tap for clean water for my morning coffee, I give thanks to the men and women who work every day and night to provide the energy that I need to live a healthy life. I would hope that the City Council would think how their actions either discourages or encourages the production of the energy that the nation, West Virginia, Morgantown and I need.

Again, I am available to discuss these issues as necessary.

Respectively,

Tim Carr
Morgantown, West Virginia
tim.carr51@gmail.com

[9] See General Overview of Natural Gas Industry - WVU Extension, Monongalia County especially slide 33 at http://anr.ext.wvu.edu/r/download/93425

PS: I have copied Northeast Natural Energy, since I have mentioned their wells, and felt it appropriate. I have copied the County Commission since the City's actions have impact on our county. Also, it is time to provide the public with additional information that they can weigh into their decisions. Copied to Dominion Post. Circulate as desired.

Disclaimer: *In the past I have been involved in the oil and gas business and have been directly involved in drilling wells internationally and domestically in Alaska, California, Texas, and Kansas. I am currently a professor at West Virginia University. The views and opinions that I express are my own and do not represent the University. I receive no personal remuneration from any oil and gas company operating in West Virginia or the Appalachian basin.*

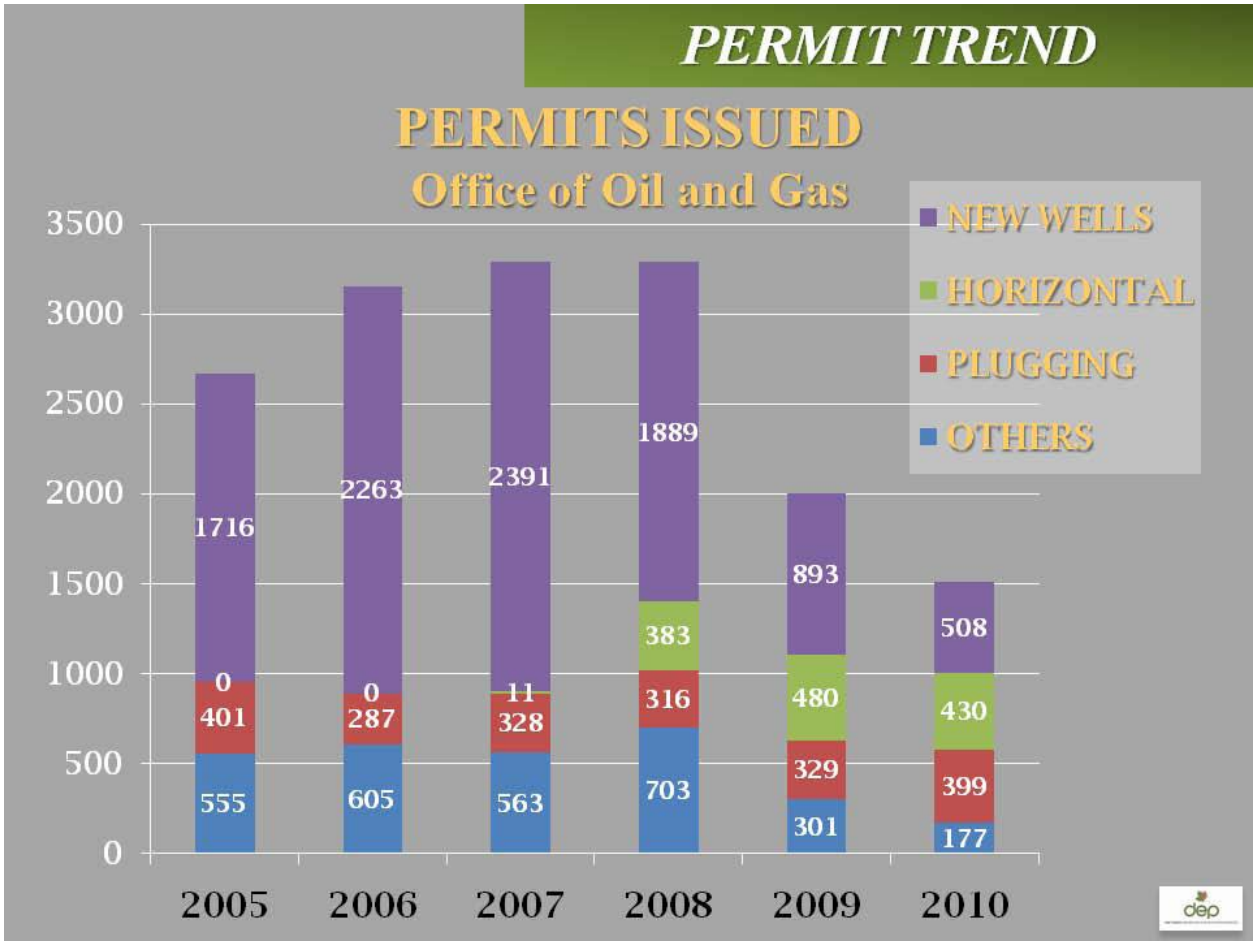

Figure 1 - Presentation by David Belcher from the Oil and Gas office of the WV Department of Environmental Protection (Dated February 9, 2011) showing well operations over the last 6 years.

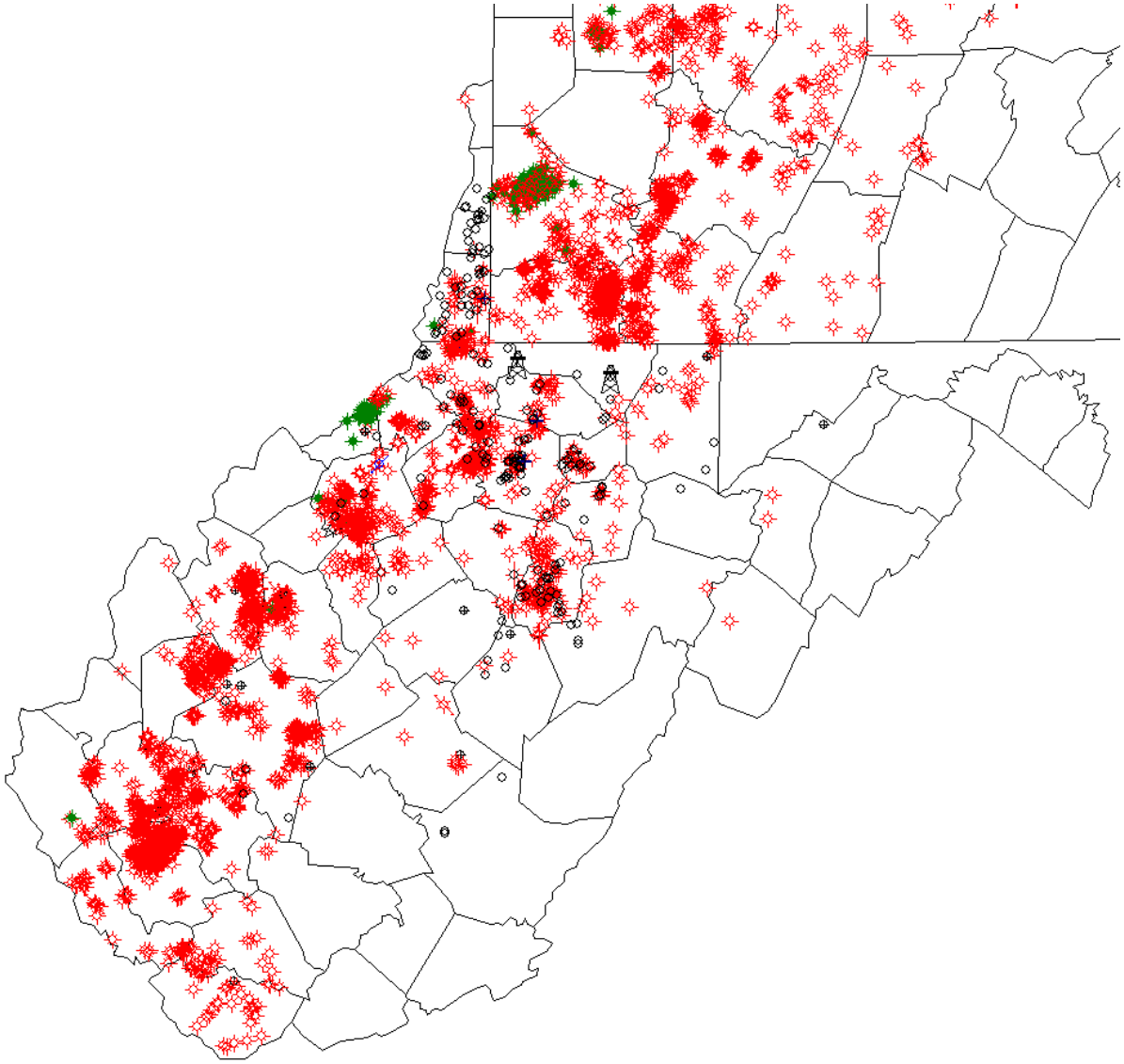

Figure 3 - Map of the distribution of Marcellus wells in West Virginia and adjoining Pennsylvania. There are a total of 2,376 wells targeting the Marcellus in the West Virginia. Red wells produce only methane, while green wells produce methane along with natural gas liquids. Open circles are permitted well locations and the two derricks show wells that are actively drilling in Monongalia County. Well locations and status from the West Virginia Department of Environment and the Pennsylvania Department of Environment.

Appendix 1 – Risk analysis of a spill affecting the MUB water treatment plant

Given all the angst concerning the wells in the Morgantown Industrial Park, I attempted to quantify the risk of an uncontained liquid spill of sufficient volume that could cause significant risk.

First- Given that the river is moving water at >100,000 gallons per second, I have no idea how to calculate or see how for a "reasonable" absolute maximum liquid spill volume could make its way across the river before moving well down-stream and subjected to dilution. This is the rational that MUB is using as it dumps 150 million gallons of raw sewage into the Monongahela. Given the current, I would assume the travel vectors would be in the meter per second range in the downstream direction and the millimeter per second range across the river due to dispersion/mixing. Also, I would assume since the Marcellus is a dry formation that the absolute maximum liquid volume that could be blown out under any scenario would be the maximum used in a single stage of a fracture stimulation operation. This would be ~500,000 gallons. Maybe someone could enlighten me, but the Mon looks to be a fine hydrologic barrier. I would be more concerned if the well was upstream on this side of the river.

I discuss the probability of spill risk in terms of documented frequency and size of past spill. This is a standard operation using cumulative frequency plots. I have data on the frequency of oilfield operations (i.e. drilling, workover and plugging of wells) from 2005 through 2010 (Figure 1). The total number of operations is 15,928 of which 2,376 wells targeted the Marcellus.

Searching the DEP database of spills for the period 1/1/2005 to 6/2/2011, I come up with 171 incidents for oil & gas operations with a reported volume of liquids for 64 incidents[10]. I have eliminated refinery and pipeline operations. These incidents range from 1 gallon of crude oil (DOMINION TRANSMISSION on 7/15/2008) to 10,000 gallons of biodegradable drilling soap (CABOT OIL & GAS CO WV on 4/26/2005). Plotting these on a cumulative probability plot (Figure 4) I come up with a P10 (90% chance) for a spill size of ~1 gallon, a P50 for a spill size of ~30 gallons and a P99 (1% chance) for a spill size at the maximum of 30,000 gallons. Now there have been more than 15,928 well operations with 171 spills so simple probability of an event independent of magnitude is $1.07X10^{-2}$, the probability of a major spill event (P99), which I have defined as 30,000 gallons or greater is $1.07X10^{-4}$. Now the probability of a spill breaking site containment, rolling down the hill and reaching the river is got to be small, but I cannot calculate it. In any case we can use the $1.07X10^{-4}$ risk and assume the impossible 100% probability of the spill reaching and crossing the river.

So to place the well risk in perspective, here are some sample risks of fatal accidents from Avena et al. 2007 via Ian Duncan at the Texas Bureau[11]. Population death rate for second hand smoke is from the CDC

[10] WV Division of Environmental Protection - http://apps.dep.wv.gov/oog/svsearch_new.cfm
[11] Ian Duncan Presentation - http://www.sseb.org/wp-content/uploads/2011/03/IanDuncan.pdf

Risks
Population Death Rates (PDR)

Second-Hand Smoke $1.3X10^{-4}$
Driving an Automobile $1X10^{-4}$ per year
Flying $5X10^{-5}$ per year
Mountain Climbing $1X10^{-3}$ per year
North Sea Offshore $1*10^{-3}$ per year
30 Fatal Accidents per 10^{8} exposure hours

It appears that a major event (≥30,000 gallons) is on the order of probability of my death in an automobile ($1X10^{-4}$) during the coming year. It is certainly better than mountain climbing and a little worse than flying. While a P50 incident is more likely, I can't image a 30 gallon or less spill breaking containment and causing any harm.

By the way have you been to the Morgantown industrial park, it is an experience. The "park" includes a Chemtura chemical plant with annual releases of HCL and Phenol[12], and hazardous waste transfer facility (AES). Both facilities are located right on the river. Not to mention two nice superfund sites. Some of the buildings look like they could be used in horror movie. It is worth a visit. On the upside the EPA maintains a large number of monitoring wells that could track the impact of any spill, if one could see through the previously existing contaminants. All of this is below the well site.

While on the EPA site take a look at MUB sewage disposal plant. They have been out of compliance for 12 out of last 12 quarters[13]. A truly great record. I would assume that MUB will have a violation this quarter, given the current operations to dump raw sewage.

[12] US EPA - http://www.epa-echo.gov/cgi-bin/get1cReport.cgi?tool=echo&IDNumber=WV0004740
[13] US EPA - http://www.epa-echo.gov/cgi-bin/get1cReport.cgi?tool=echo&IDNumber=WVL023124

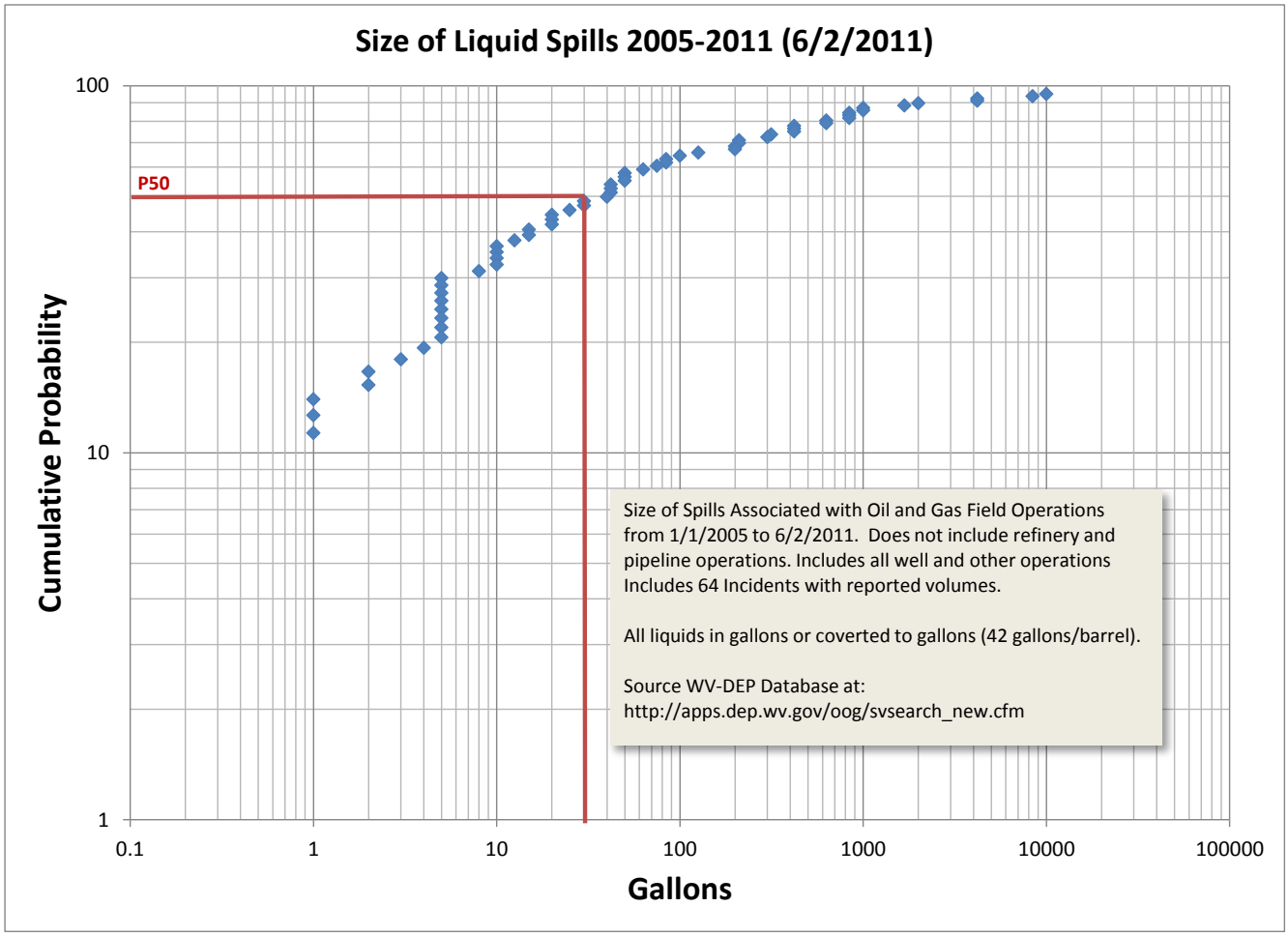

Figure 4 – Cumulative probability of liquid spill size. Data on spills was obtained from http://apps.dep.wv.gov/oog/svsearch_new.cfm

Appendix 2 – Email from JR Concerning the Barnett Shale in Tarrant County, Texas

>>> "[redacted]" <[redacted]@sbcglobal.net> 06/04/11 10:21 AM >>>

Hi Tim,

Good to hear from you, and I do plan to make it to Madison for the fall meeting.

With respect to my neighborhood in southwest Fort Worth, you are correct that I do live in a community of about 600 homes surrounding a golf course. It is a Fort Worth equivalent of the Bent Tree, Brookhaven or Gleneagles developments in Plano and North Dallas that you may remember. In the middle of 2008, the homeowners, working collectively through our Homeowners Association, leased the mineral rights on all the individual lots plus the development's common areas (roads, streams, median strips, etc) to XTO Energy. The golf club, which is a separate legal entity, leased to XTO at the same time as a coordinated effort, so XTO basically picked up six or seven hundred contiguous acres in one deal. A provision of the agreement is that XTO would not put a rig inside the development, but would drill horizontal wells underneath from drill sites outside the development. We have farmland south of us and Trinity River floodplain to the west where there is space for drill sites. XTO completed its first horizontal Barnett well under the development in the summer of 2010. The drilling and fracing had no impact on the homeowners; in fact, many of the homeowners did not even realize the well had been drilled until they received their first royalty check. Over the last few years, we have seen rigs come and go from a drillsite about half a mile up the road from the front gate of the development as XTO has drilled out in various directions. Aside from some truck traffic occasionally on the main road, the drilling has not affected us.

The homeowners have been getting regular royalty checks since XTO put the well on production (about $50 per month for an average half-acre lot). The upfront bonus was very nice (about $12,000 for a half-acre lot), of course representative of the higher gas prices in mid-2008 rather than current prices. Basically, all the homeowners are very satisfied with the whole process of leasing and drilling, and the value of homes has in fact increased by what is now the added value of the producing mineral leases. I don't know of anyone who has left the neighborhood because of the Barnett activity. The homeowners are not only happy to be getting individual checks, but also pleased that the Homeowners Association is getting some royalty income on the common areas, so that is helping to keep down homeowner dues.

Hope the Marcellus works out as well for the West Virginia folks.

See you in September.

----- Original Message -----
From: Tim Carr
To: [redacted]
Sent: Friday, June 03, 2011 2:46 PM
Subject: Question on Barnett

[redacted],

We having loads of fun on the Marcellus up in WV. One of the criticisms is that the wells will have an extreme negative impact on property values. Having worked on wells in Ojai and Long Beach, CA, I don't think this is the case. I remember that you mentioned that your neighborhood with the golf course was looking to lease for the Barnett. Did anything come of it? If so was the result favorable, or has everyone sold and fled the neighborhood?

Hope to make it to Madison for the fall. Hope to see you there.

Cheers,

Tim