

# Primer on Natural Gas Development in Bradford County

Comparing and contrasting different data sources

## MARCELLUS SHALE FORMATION

The Marcellus Shale is a rock formation that underlies approximately 2/3 of the Commonwealth of Pennsylvania and portions of the states of New York and West Virginia. At a depth of 5,000 to 8,000 feet, the Marcellus Shale is believed to hold trillions of cubic feet of natural gas and has long been considered prohibitively expensive to access. Recent advances in drilling technology and rising natural gas prices have attracted new interest in this previously untapped formation. The geology of the Marcellus formation suggests that areas in the southwest, north central and northeastern regions of Pennsylvania that have not traditionally seen much gas well drilling may be especially productive.

### Drilling in the Marcellus Shale

Pennsylvania's Marcellus shale play began in 2003, when Range Resources-Appalachia, LLC (formerly Great Lakes Energy Partners, LLC) drilled a well to the Lower Silurian Rochester Shale in Washington County. The deep formations (such as the Oriskany Sandstone and the Lockport Dolomite) did not look favorable, but the Marcellus shale had some promise. Range drilled some additional wells, and through experimentation with drilling and hydraulic fracturing techniques borrowed and revised from those used on the Mississippian Barnett Shale gas play in Texas, began producing Marcellus gas in 2005. Since then, the company has permitted more than 150 Marcellus wells in Washington County alone. Other companies have joined the fray with permitting and drilling in many areas of the Appalachian Plateaus in Pennsylvania. As of the end of 2007, more than 375 suspected Marcellus wells had been permitted in Pennsylvania. An additional 78 had been permitted as of this writing (end of February, 2008). Therefore, it appears that the Marcellus gas play will continue unless gas prices fall dramatically.

The yields of these wells were often unimpressive upon completion. However, many of these older wells in the Marcellus have a sustained production that decreases slowly over time. Many of them continued to produce gas for decades. A patient investor might make a profit from these low yield wells with slowly declining production rates. For new wells drilled with the new horizontal drilling and hydraulic fracturing technologies the initial production can be much higher than what was seen in the old wells. Early production rates from some of the new wells has been over one million cubic feet of natural gas per day. The technology is so new that long term production data is not available. As with most gas wells, production rates will decline over time, however, a second hydraulic fracturing treatment could restimulate production.

### Economic Significance of the Marcellus Shale Gas Field

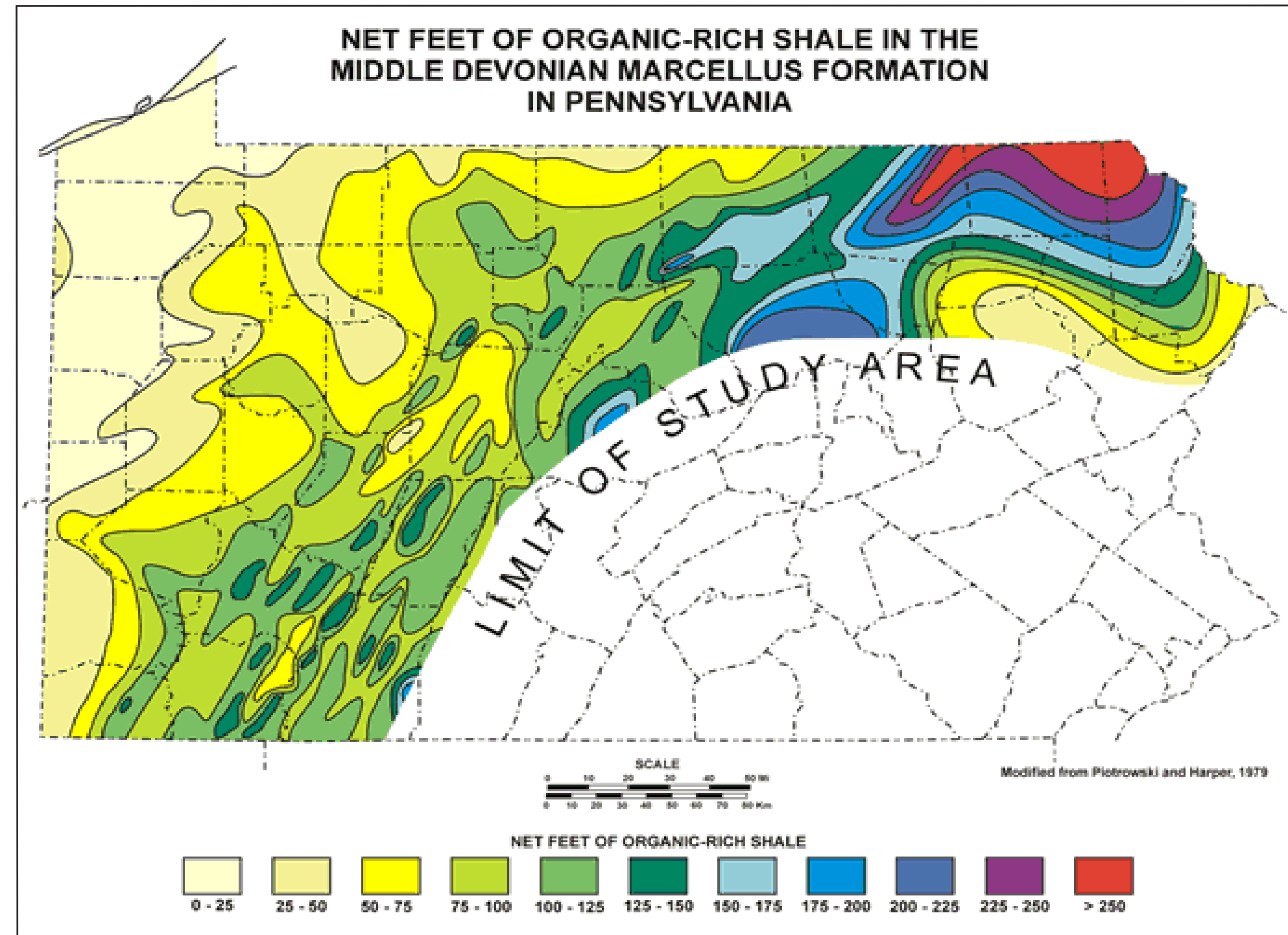
The presence of an enormous volume of potentially recoverable gas in the eastern United States has a great economic significance. This will be some of the closest natural gas to the high population areas of New Jersey, New York and New England. This transportation advantage will give Marcellus gas a distinct advantage in the marketplace.

Source: DCNR, PA Geologic Survey Publication VOL. 38 NO. 1, page nine.

### Well Production Rates

Before 2000, many successful natural gas wells had been completed

Source: geology.com 5/4/2009

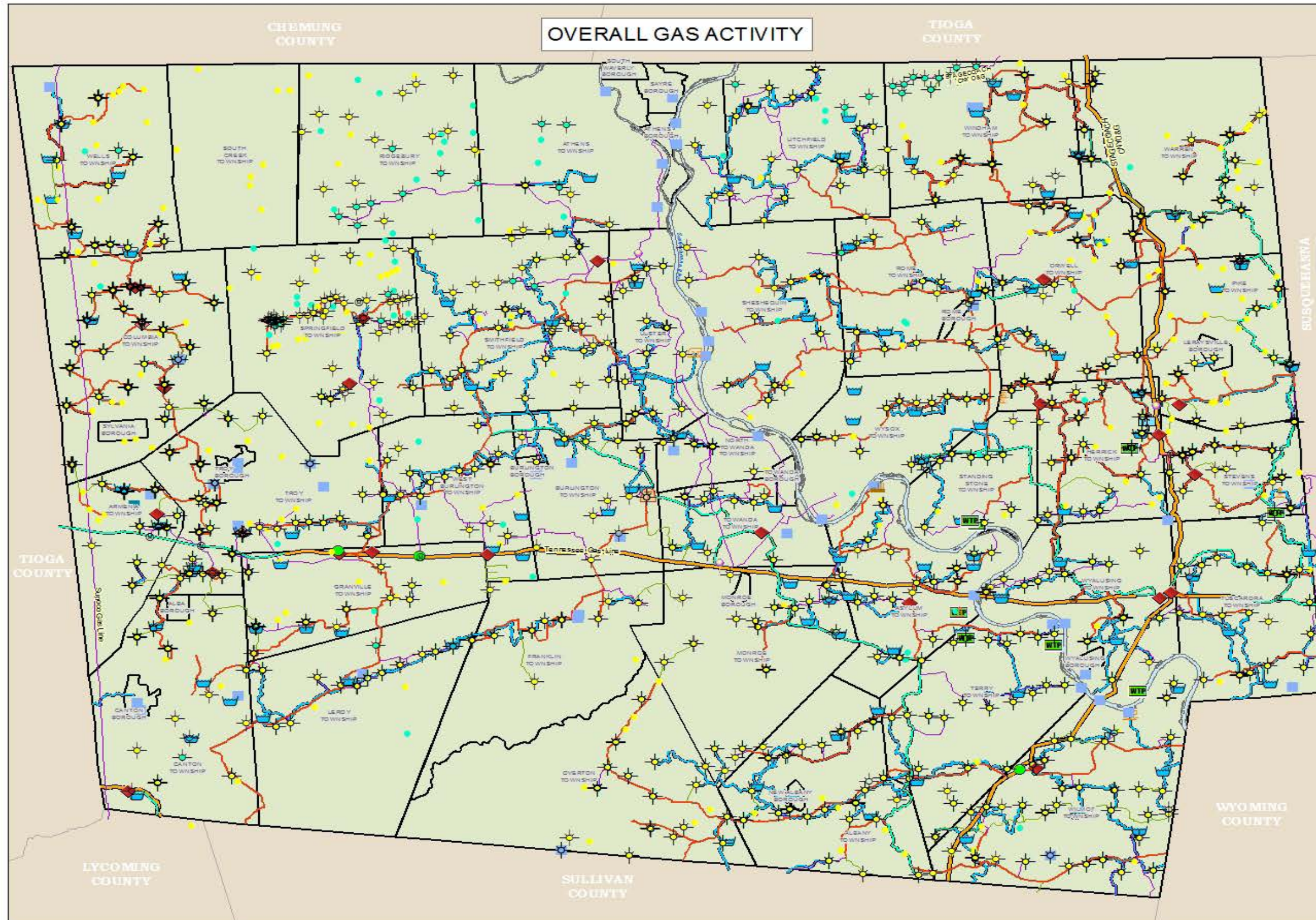


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**What should you glean from this map?**

That multiple sources, all supplying data on the same entity, list very different instances.



☼ Active DEP Wells - July 2013

**County Database**

**FEATURE TYPE**

- HORIZONTAL GAS WELL
- VERTICAL GAS WELL
- ▤ WATER IMPOUNDMENT
- ◆ COMPRESSOR STATION
- ▣ GROUNDWATER WITHDRAWAL
- DEHYDRATOR
- ⊙ METER STATION
- NATURAL GAS POWER PLANT
- SUBSTATION
- TAP LOCATION
- WATER PUMP STATION
- WATER TRANSFER PAD
- WATER TREATMENT FACILITY
- WATER WITHDRAWAL
- ◆ WATER/MUD STORAGE FACILITY
- COMMUNICATION TOWER

**Gas Lines**

**Pipe Size**

- Unknown
- 2" - 10"
- 12" - 19"
- 20" - 24"
- 30" - 36"
- Water Lines



July 11, 2013

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## Explanation of Data Sources

The map on the previous page illustrates the various activities associated with natural gas activity in Bradford County, according to the data we have received. This is merely scratching the surface of what we know to be a growing industry in Bradford County. There are multiple sources of data and each differs.

### DEP (Department of Environmental Protection)

All wells must be permitted with DEP. This data is downloaded from the Pennsylvania Spatial Data Access (PASDA) web site as a shapefile of Oil and Gas wells in PA. Once downloaded, the file is ready to be added to a GIS map. Each file consists of an attribute table which lists well names, company, and a unique identifier. The most recent download is from October, 2011 and is updated every three months.

### 911 Addressing Points

The most recent development of locational information is 911 Addressing points for Natural Gas Facilities. These facility sites need to be addressed for emergency response. These addresses are generated by the Planning Office for Bradford County 911. Ideally, a well site or gas facility is 911 addressed before the drilling, production, or building begins.

### Pipeline Permits

These are permits for the construction of feeder and other connecting pipelines. These are mapped only as accurately

as the permit map illustrates. Water pipelines are the latest addition to the infrastructure.

### Landmen Information

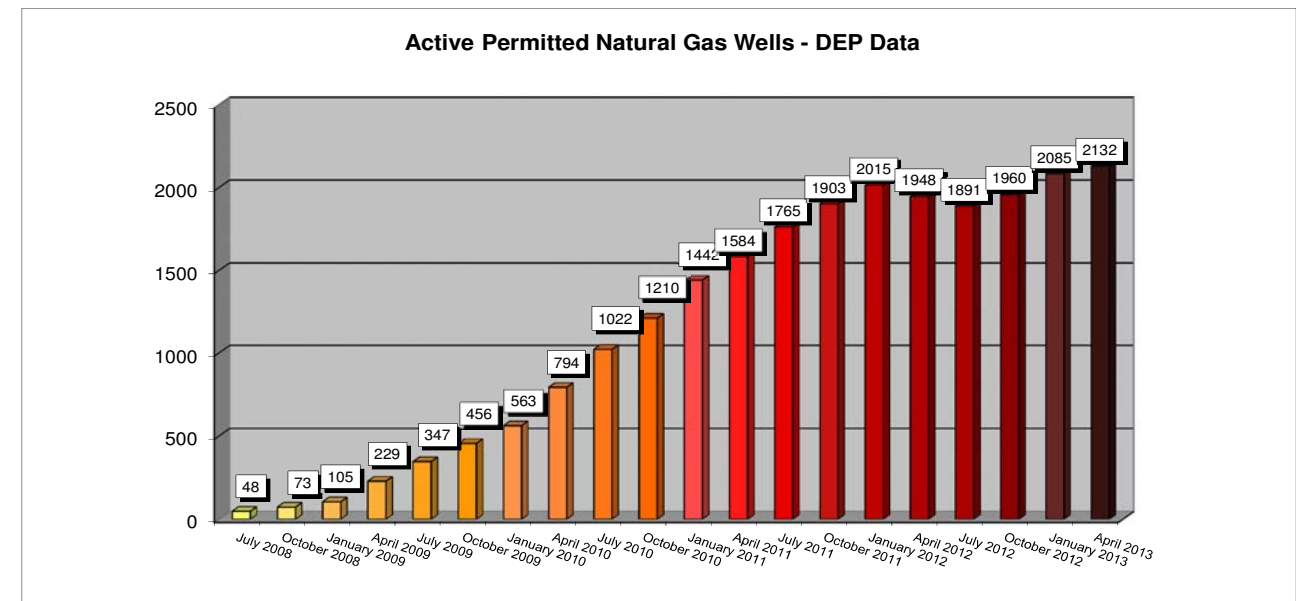
Landmen for the Gas Companies use the Planning Office to purchase parcel maps. Through these interactions we are able to glean new pipelines and gas wells from their maps. These are mapped as preliminary and eventually DEP data will reflect these developments if they happen.

### Conclusion

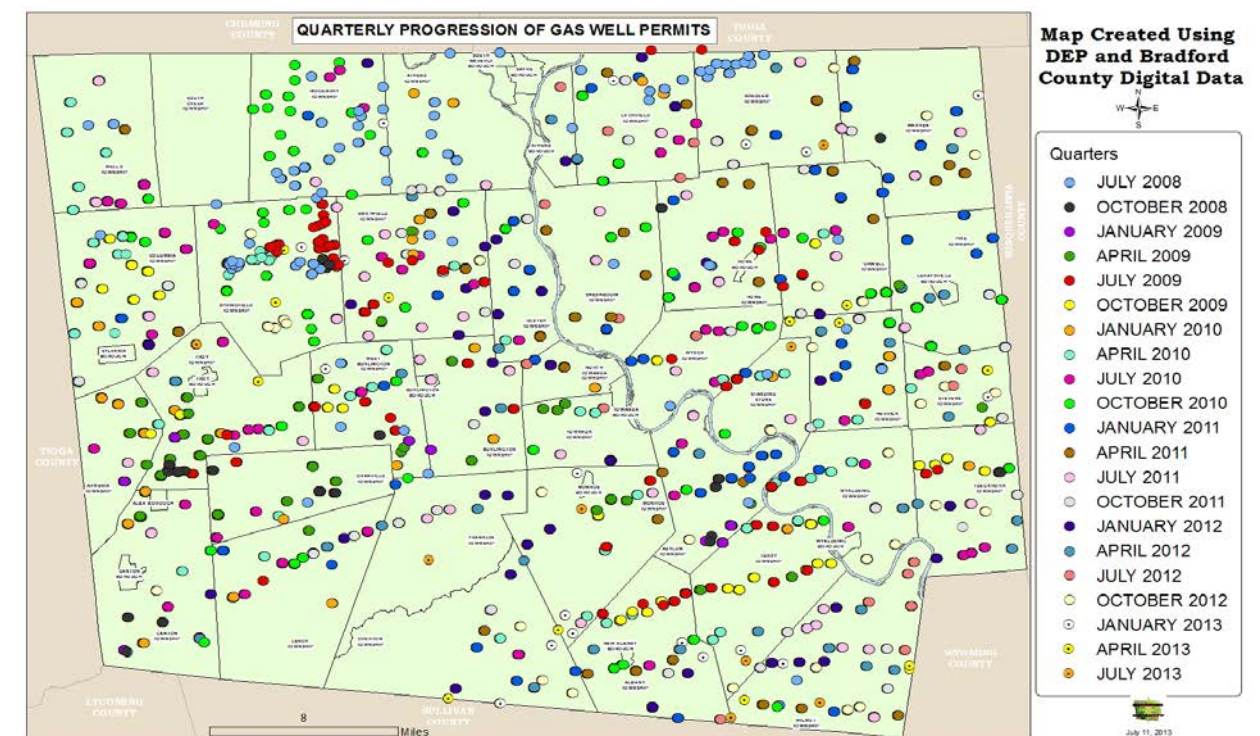
None of these sources, even when used together, are supplying a complete listing of the active well sites in Bradford County. This conclusion also leaves further questions about the accuracy and timeliness of the limited data currently being obtained and its effects on planning.

### Mapping the Spread of Gas Wells

The map to the right illustrates the growth of Natural Gas wells in Bradford County from July, 2008 to July 2013. DEP data, released every three months, is layered with the oldest on top and the most recent as the bottom layer. This allows you to see older gas wells in the northern half of the county that pre-date the recent boom. Though there has been an increase in well permits every quarter from July, 2008, the greatest increase has been since January, 2010.

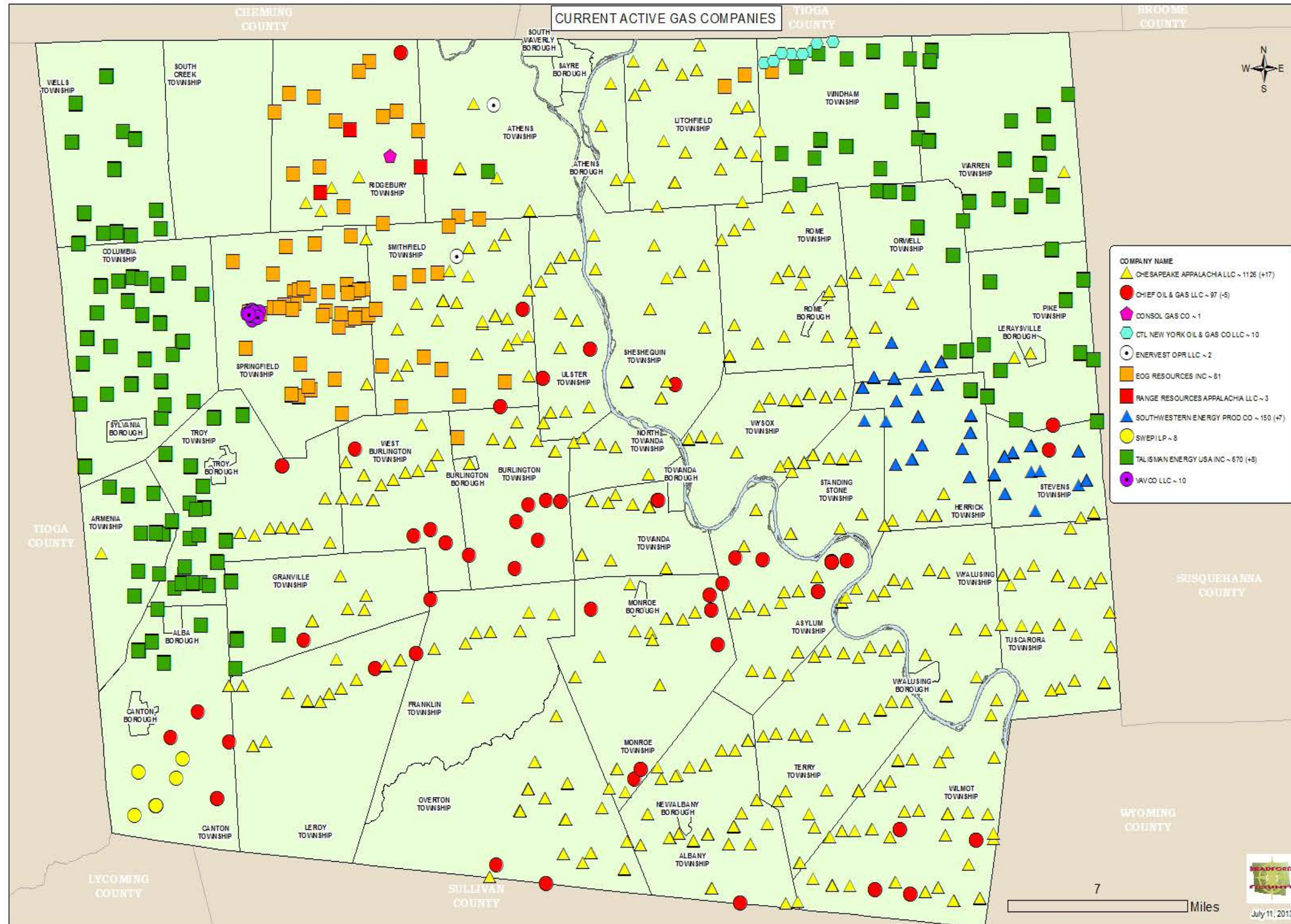


DEP shapefiles are used to chart the growth of Natural Gas Well Permits in Bradford County. Gas Well Permits have been significantly increasing in the County every quarter, with January, 2010 to present day making up greater than 70% of Active well permits issued. \*\*While DEP had reported a decrease in active wells for the July, 2012 update (most likely due to a well's status chnge) there is an increase for the October 2012 and January 2013 updates. (See site status map for more info.)



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Oil and Gas Companies

There are a variety of Oil and Gas companies operating in Bradford County. Some companies, such as Belden & Blake, have been working in the County for a number of years. The northern portion of Bradford County generally has the wells and companies that pre-date the recent boom. The gas well company data is from the DEP, July, 2013 file. The legend to the left shows how many active gas wells each company has in Bradford County following the same color and pattern marked in the map. The number of gas companies with active wells operating in Bradford County is currently at 11. A decrease in a company's total number of active wells is indicated by a negative number in parentheses ( - ) after the total. An increase is indicated by a (+).



7 Miles

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## Auxiliary uses of the Natural Gas Development

### Water Withdrawals and Trucking

Water Withdrawals are an important part of the drilling process. Water is needed constantly during the fracturing and drilling process. This means there will be a CONSTANT stream of water truck deliveries from the water withdrawal site to the drilling site during drilling and fracturing. This influx of heavy truck traffic will greatly change the driving climate of many roads.

Bradford County has seen moderate trucking in the past with the timber industry and with milk trucks. This trucking is not nearly as repetitive and continuous as water withdrawal to drill site trucking. A number of municipalities have been experiencing a deterioration of their roads. Townships and Boroughs can protect their roads through Posting and Bonding.

The Susquehanna River Basin Commission (SRBC) has been encouraging the increased use of Water Impoundments across Bradford County. This will hopefully result in less heavy truck traffic. Companies are also running water lines along newly laid gas lines to reduce traffic. Water withdrawal locations are mapped on the following page.

### Posting and Bonding

The goal of the Posting and Bonding program is to make heavy haulers pay for the road damages that they have created. To do this a municipality must do an engineering and traffic study. This can be very costly and is the reason many municipalities shy away from posting and bonding. The engineering study will determine the status of all roads and what they should be posted as. After the study, an Ordinance is adopted. Heavy hauling users of the roads are notified and signs posting the maximum weight allowed are installed. An equally difficult part of Posting and Bonding is enforcement. Local and/or State Police or a Code Enforcement Officer may be enlisted.

Agreements must also be made with heavy haulers using the posted roads. They must post a bond. The first bond has set limits (\$6,000 per mile for unpaved and \$12,000 per mile for paved) but once that bond is used up in damages to the road the following bond may be set at any limit. It is upon the municipality to watch the condition of the roads and collect bonds when the damage reaches their monetary value.

### Pipelines & Compressor Stations

Pipelines and compressor stations are imperative for the transportation of natural gas. There are many existing pipelines within Bradford County. New gathering lines and larger pipelines are actively being built. Along these pipelines compressor stations (photo, below) are needed. Concerns with the compressor stations usually stem from its humming noise.

The Tennessee Gasline is the main interstate gas transmission line that traverses Bradford County. Currently, there is a plan to initiate the "300 Line Expansion" that includes the "looping" or installation of additional pipe adjacent to the existing pipeline to increase capacity of segments of 30-inch diameter pipeline. Additional compressor stations will be included with the project and increase delivery capacity in the region by 300,000 dekatherms per day .



### Seismic Testing

Seismic testing is used to determine the geometry of subsurface layers such as the Marcellus shale formation. Geokinetics is a company that is actively performing seismic testing in much of Bradford and Sullivan County. Survey lines are laid with geophones. Thumper trucks or small charges are used to create shock waves. The geophones will detect the returning waves and use that information to determine the formation of the layers below. They are used to find faults (cracks) and other features in the subsurface layers.

Seismic surveys are very expensive and cost more than other types of geophysical surveys and they are not done without due cause.

#### **Thumper Truck**

Photo:<http://www.sonicsampling.com/WebPage/WebPage.asp?Ref=5599>



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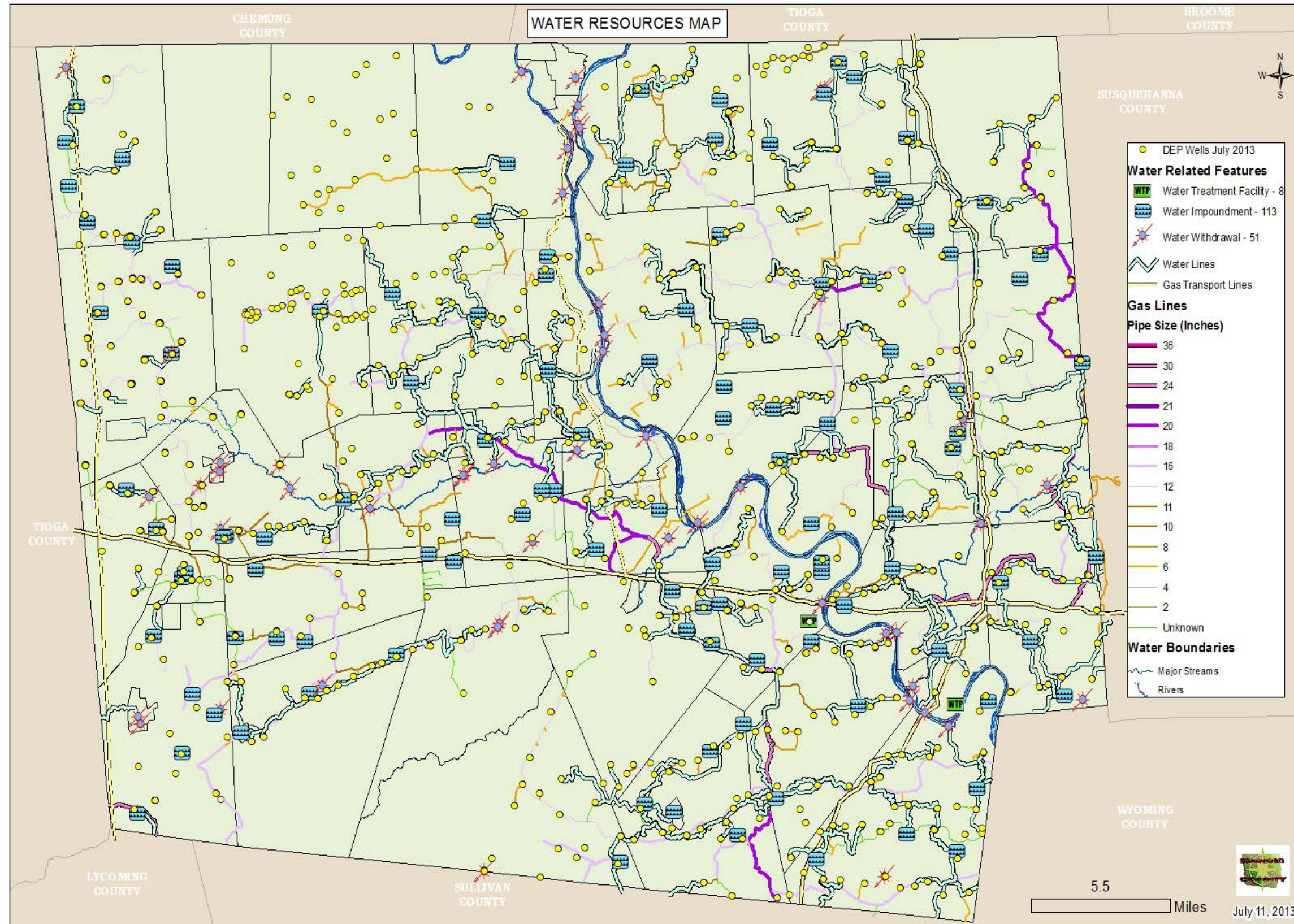


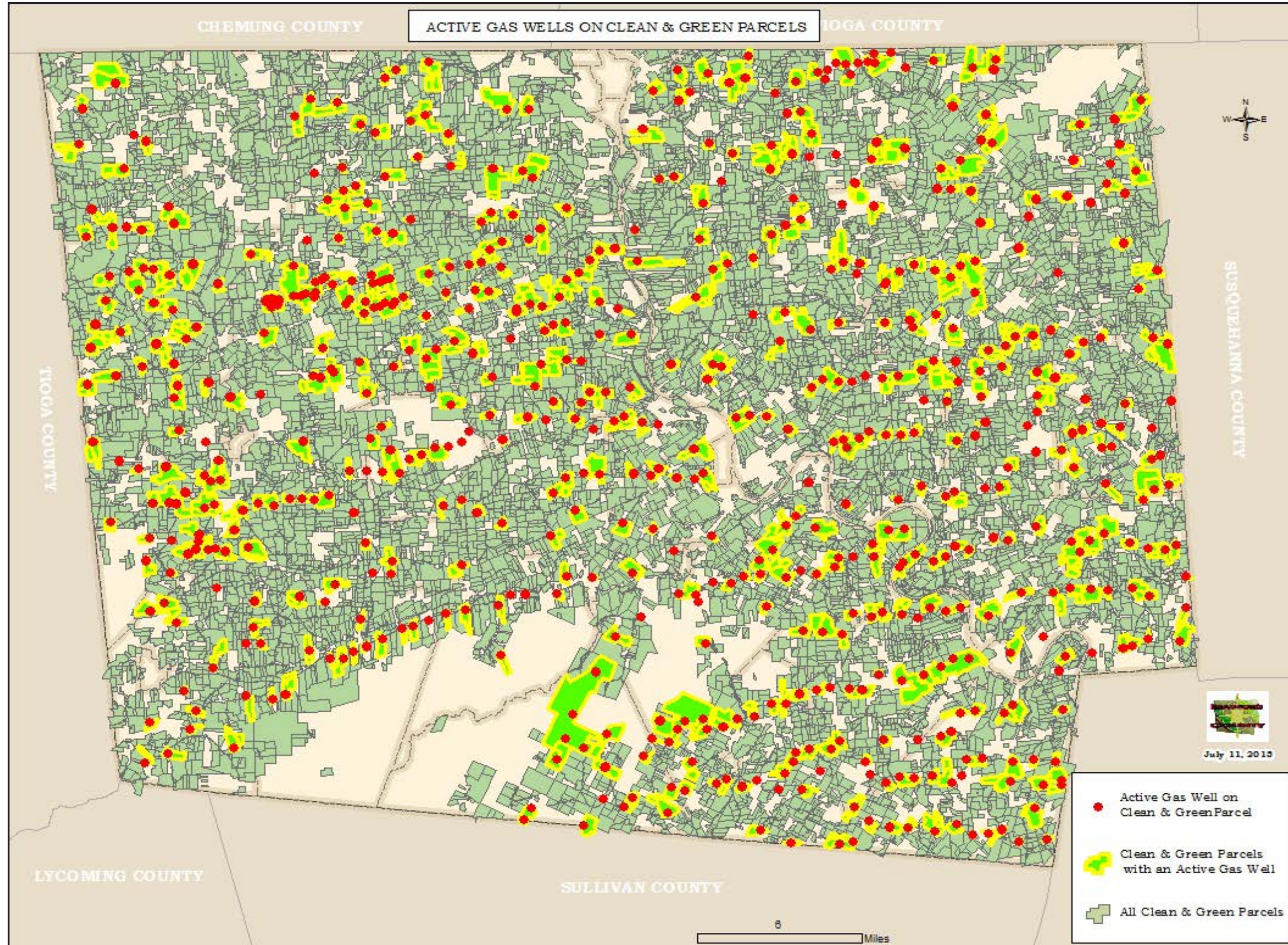
Photo taken 5/2/2009, Ellen Crowley

## Water Withdrawal

Above is a water withdrawal site in Sheshequin Township, operated by Talisman Energy. There are four hook-ups on a large gravel parking area to fill four trucks at once. The hook-ups tap into the Susquehanna River (The Ulster Bridge can be seen behind the hook-ups in the photo above). Typical water withdrawal sites, especially on major tributaries and along the Susquehanna River, contain a submerged suction line from the tributary to multiple hydrants, pumps, water main and water storage tanks for storing water on a temporary basis that is later intended to be transferred by vehicle to a natural gas well pad for the purpose of hydraulic fracturing. In addition, a site also includes truck loading and staging area for trucks that can carry in excess of 6,700 gallons of water to a well pad.

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## Clean and Green

The Clean and Green Act, as it is commonly known, is more formally known as ACT 319. The purpose of ACT 319 is to provide a real estate tax benefit to owners of agricultural or forest land by taxing that land on the basis of its "use value" rather than its "Market Value." This act provides preferential assessment to any individuals who agree to maintain their land solely devoted to agricultural use, agricultural reserve, or forest reserve use.

Source:  
Clinton County,  
<http://www.clintoncountypa.com/clean&green.htm>  
5/4/2009

Bradford County is a largely rural and agricultural county which is seen in the number of Clean and Green Parcels in the map to the left. A natural gas well is a violation of Clean and Green. Roll back taxes for the prior seven (7) years would have to be paid. In this largely rural area with many Clean and Green properties within the County it seems almost inevitable that many gas wells will be located on a Clean and Green Property.

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In Bradford County there are 8,536 parcels currently enrolled in Clean and Green. Of these eight thousand plus parcels, 512 have at least one natural gas well permit associated with them. This relationship is illustrated in the bar graph on the left.

Bradford County currently has 2,150 permits for active

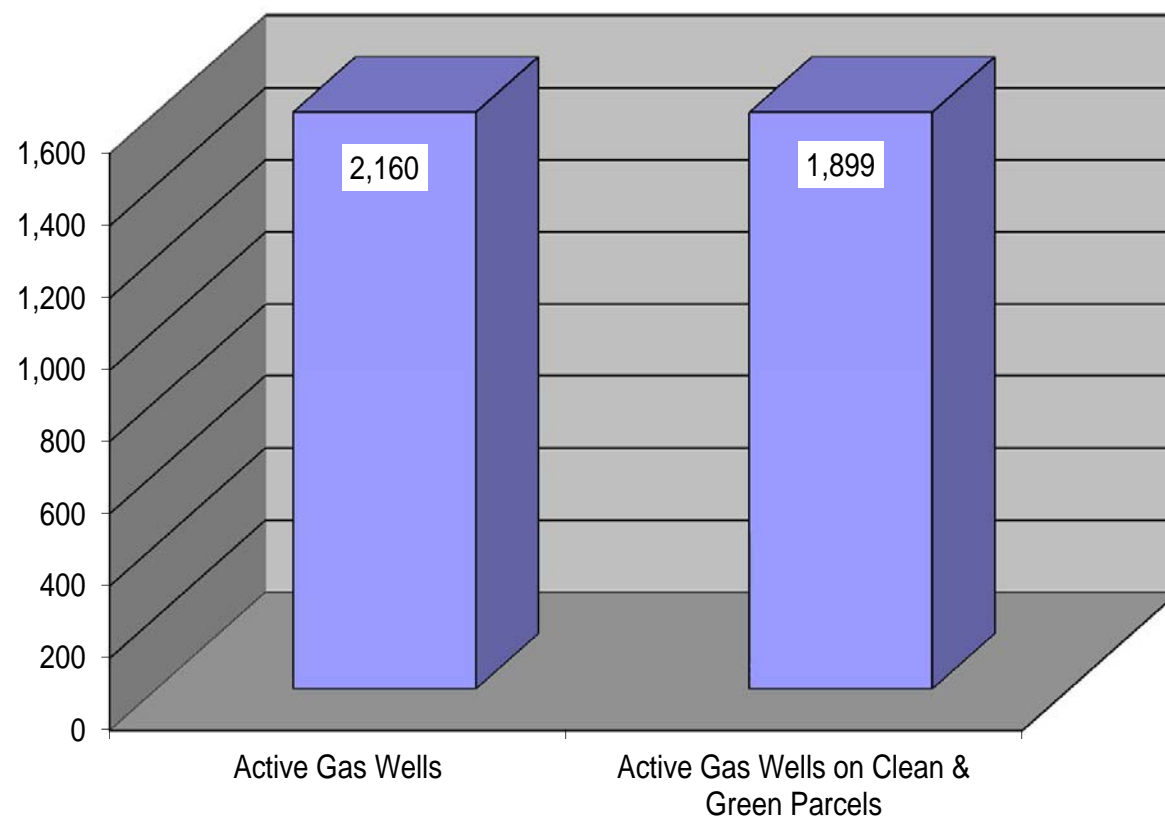
natural gas wells. Of these well permits, 1,899 are located on Clean and Green parcels. This relationship is illustrated in the bar graph on the right. While there is potential for 1,899 wells to be placed on Clean and Green parcels, only 512 Clean and Green parcels would currently be affected. This is due to multiple

horizontal wells being drilled on the same well pad, and also due to well clustering. Essentially, a change in use of a Clean and Green parcel will result from not only one well on the property but multiple wells.

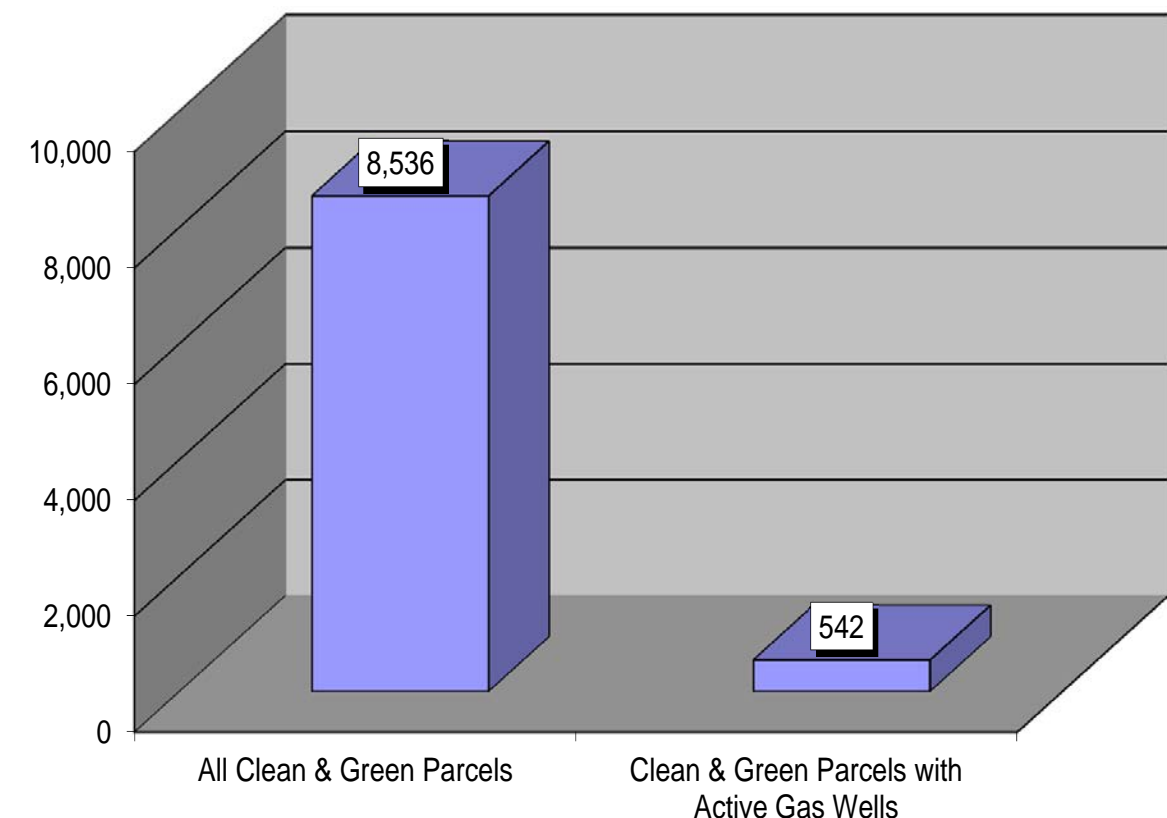
In some cases, property owners make arrangements with the leasing company to pay the roll

back taxes and deduct that from the parcel owner's royalties. This alternative could help to save many of the property owners from facing high tax bills directly.

**Active Gas Wells and Clean and Green Parcels**



**All Clean and Green Parcels and Gas Wells**

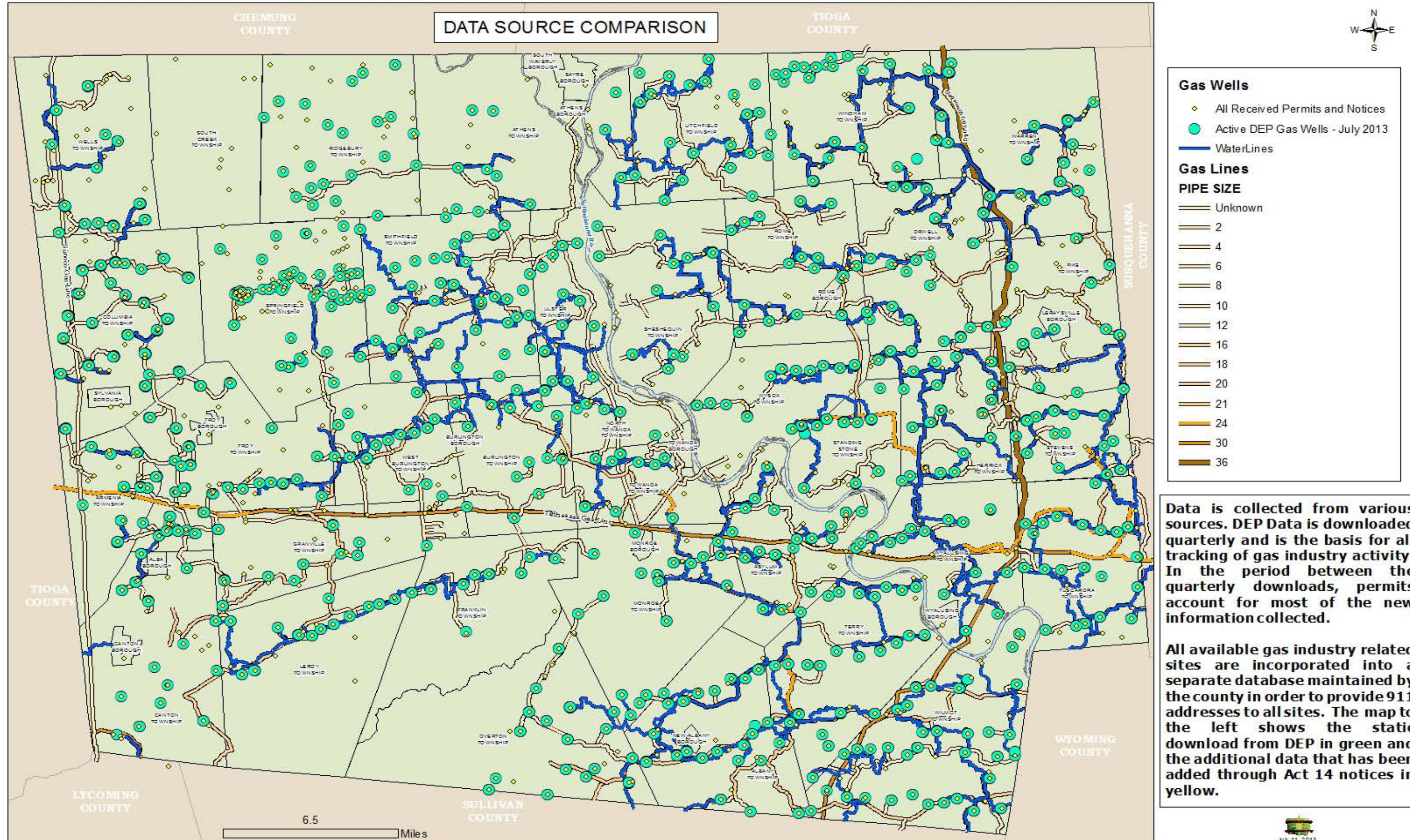






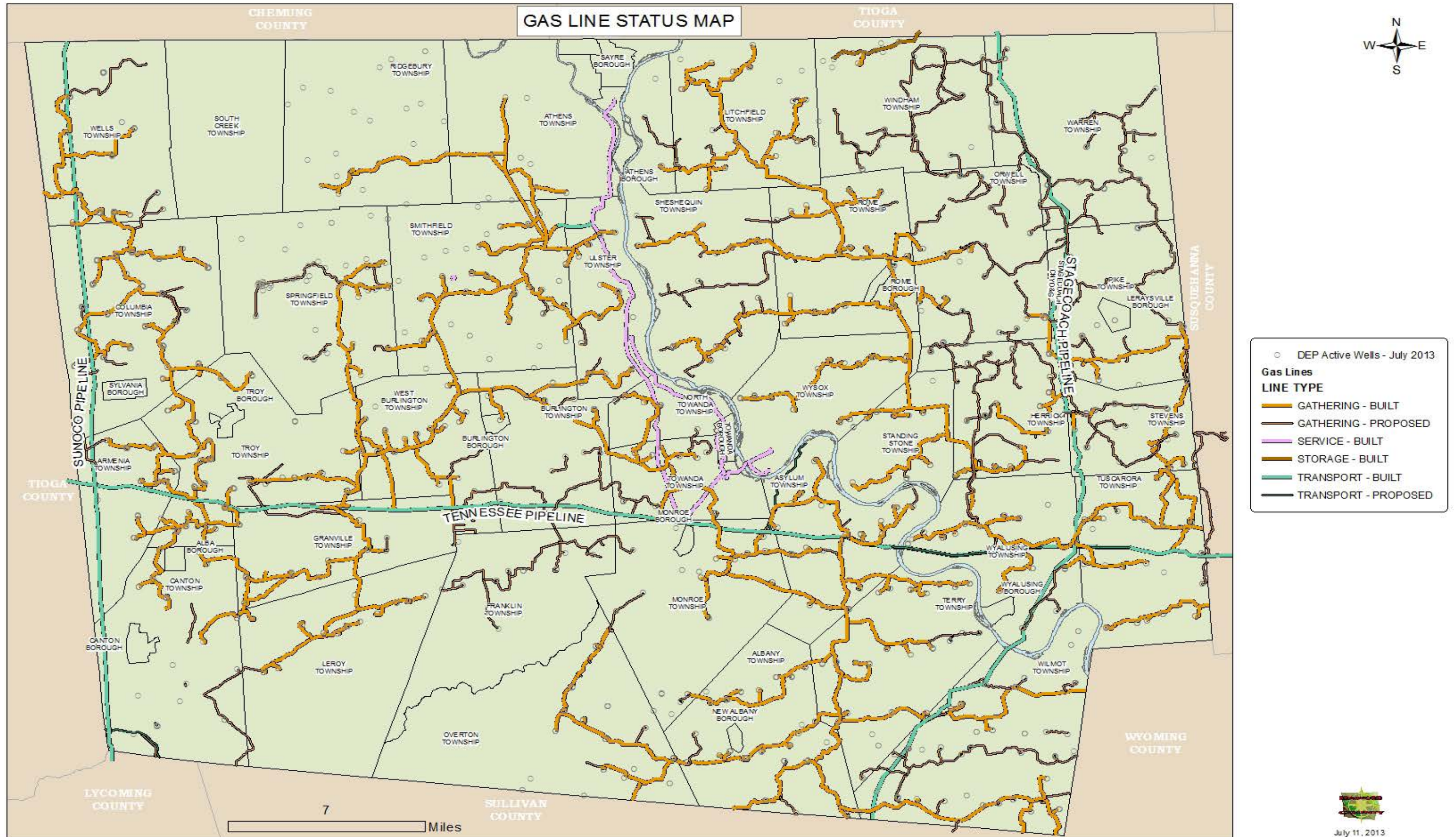
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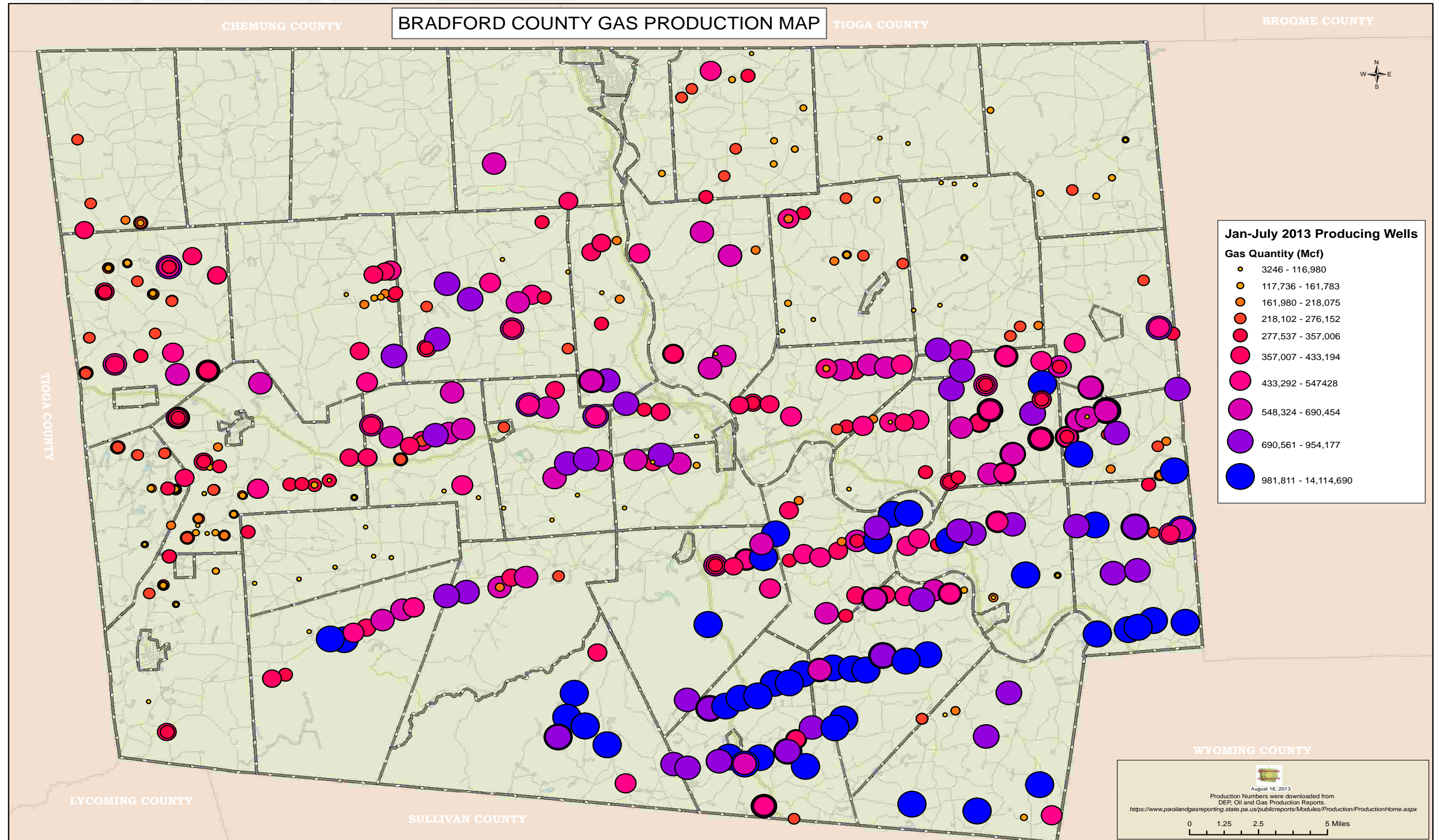
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## Comparing and contrasting different data sources



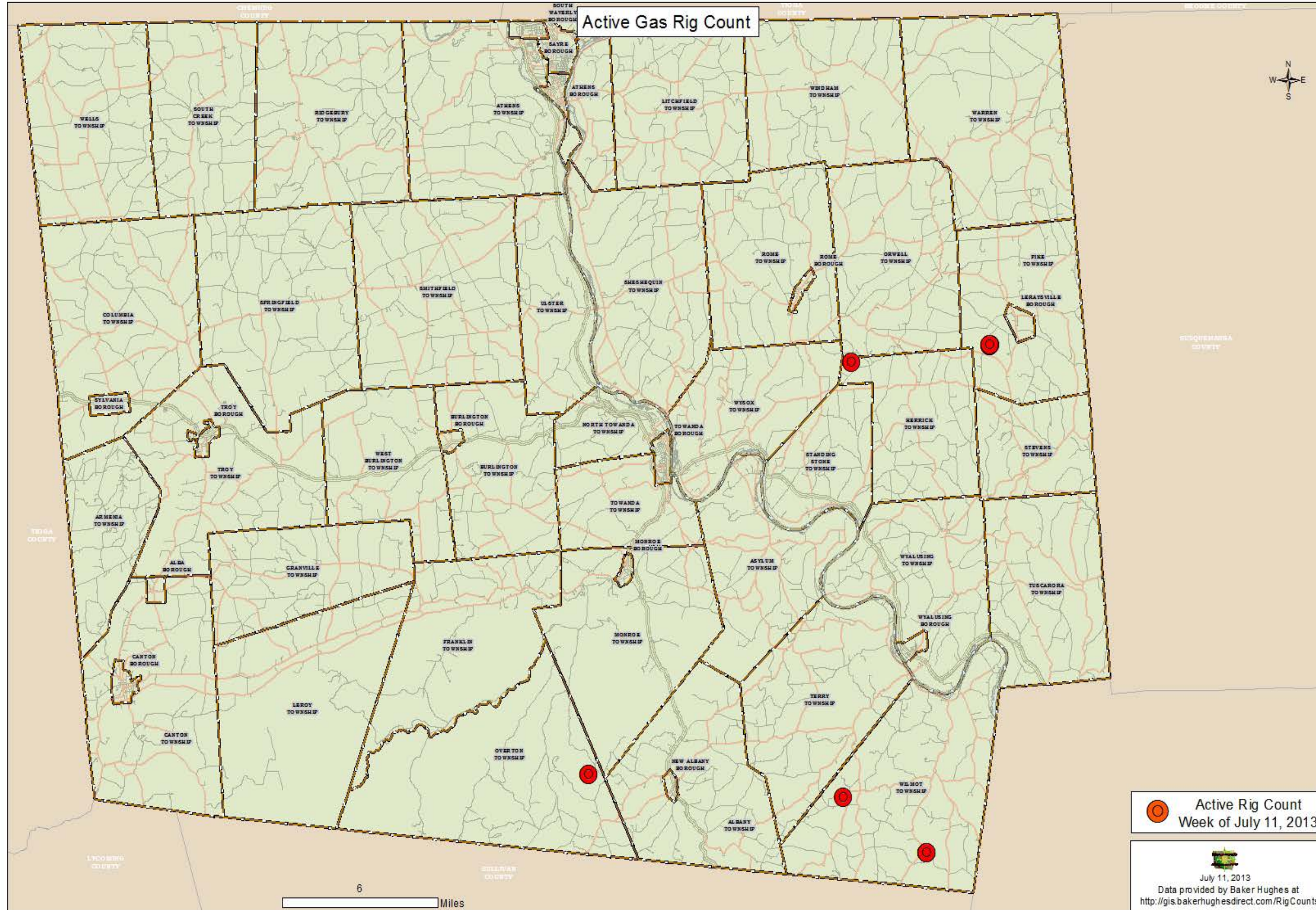
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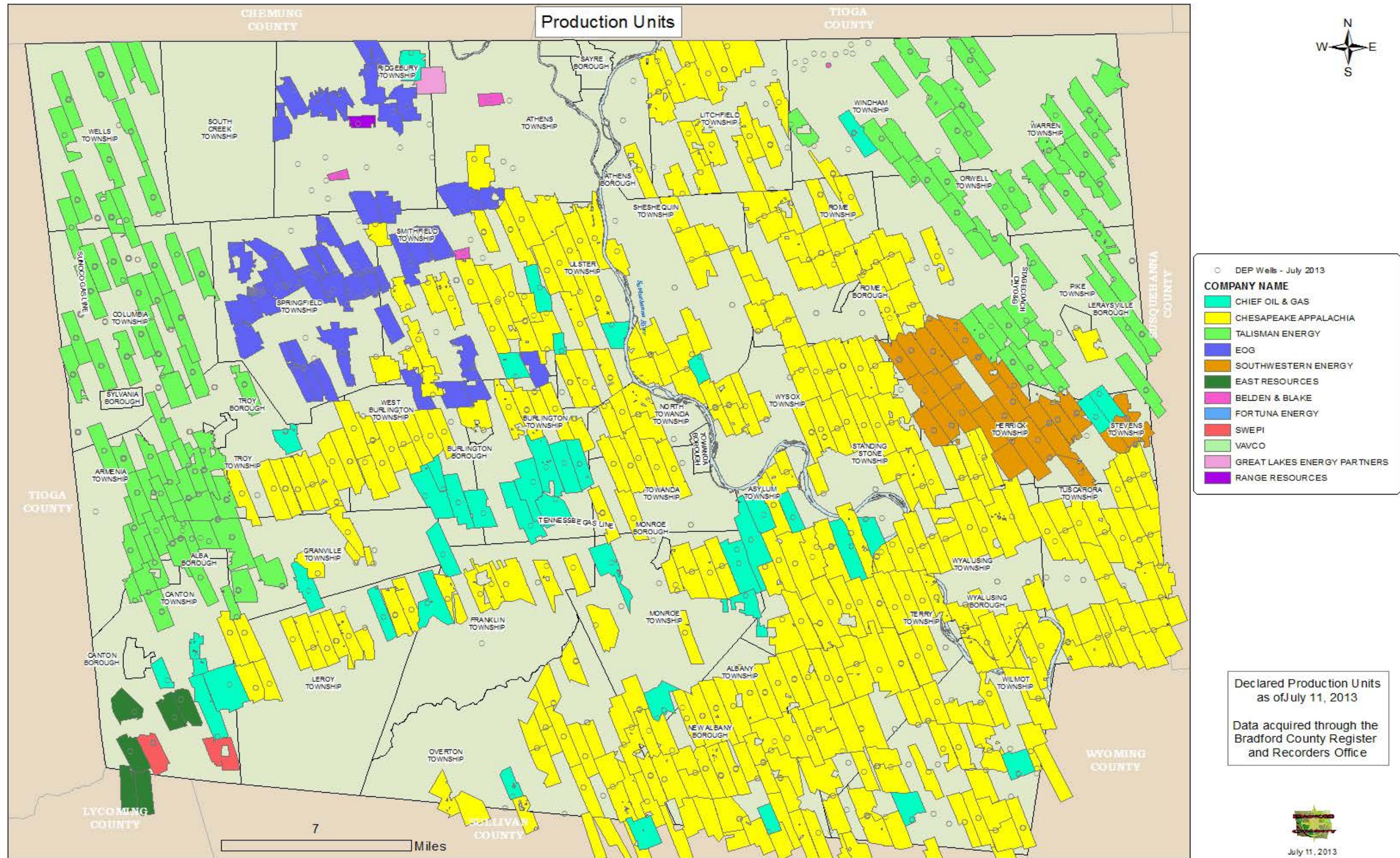
## Comparing and contrasting different data sources



THE MAP TO THE LEFT SHOWS WELLS THAT ARE CURRENTLY BEING DRILLED. THE STATUS OF THIS INFORMATION CHANGES FROM WEEK TO WEEK. THE INFORMATION COMES FROM THE BAKER HUGHES WEBSITE, <http://gis.bakerhughesdirect.com/>. INFORMATION IS CURRENT TO THE DATE LOCATED ON THE MAP

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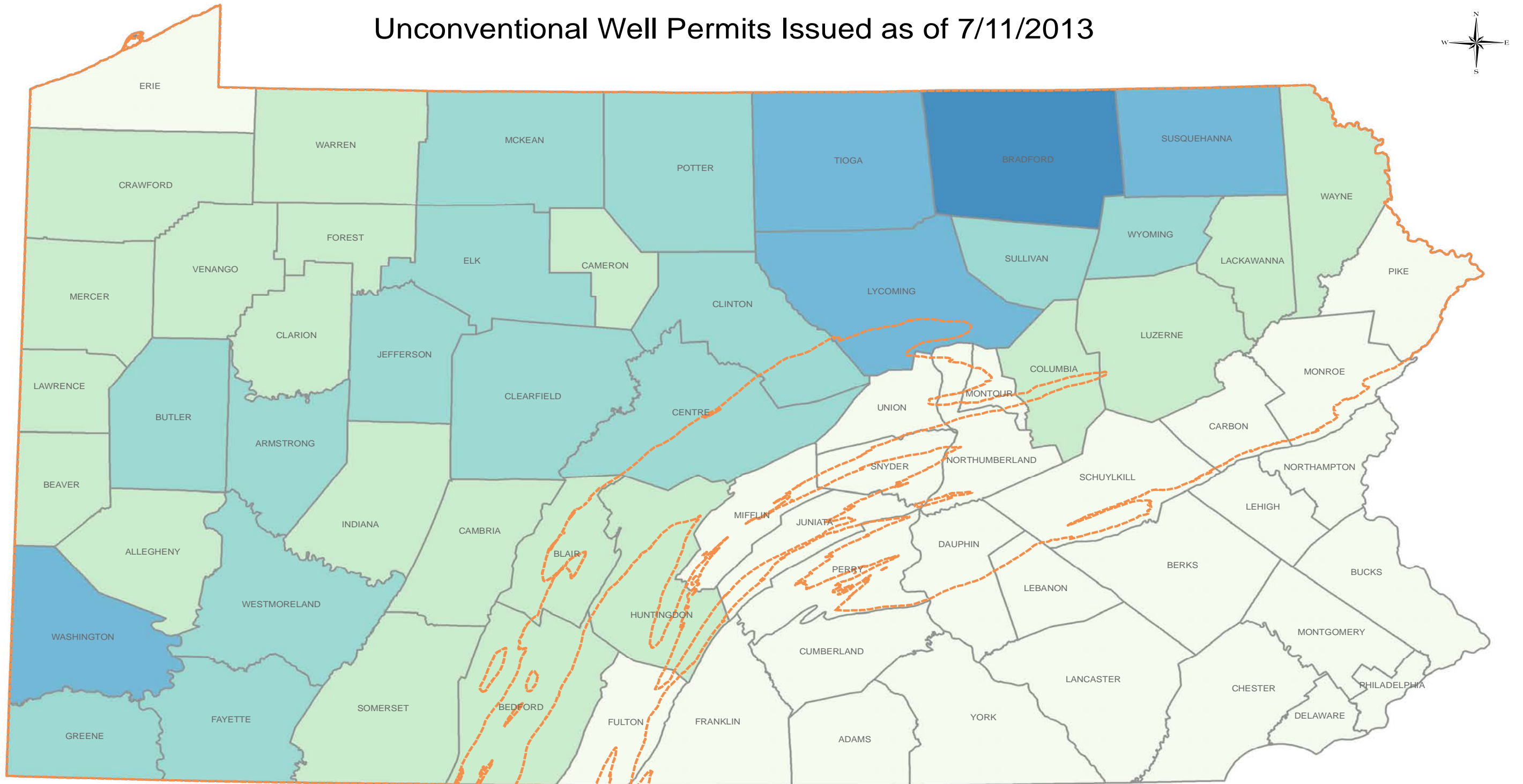





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## Unconventional Well Permits Issued as of 7/11/2013



40 Miles

  
 July 11, 2013  
 Data provided by DEP's Oil and Gas Reports  
[http://www.portal.state.pa.us/portal/server.pt/community/oil\\_and\\_gas\\_reports/20297](http://www.portal.state.pa.us/portal/server.pt/community/oil_and_gas_reports/20297)

**Number of Well Permits Issued**

0
1 - 500
501 - 1000
1001 - 2000
2001 - 3000
Marcellus Shale Boundary

**Number of Well Permits by County**

2787, BRADFORD	205, ELK	24, CAMBRIA	0, CARBON	0, MONTGOMERY
1640, TIOGA	186, CENTRE	21, WAYNE	0, CHESTER	0, MONTOUR
1403, SUSQUEHANNA	171, CLINTON	19, MERCER	0, CUMBERLAND	0, NORTHAMPTON
1387, WASHINGTON	169, MCKEAN	16, COLUMBIA	0, DELAWARE	0, NORTHUMBERLAND
1302, LYCOMING	119, JEFFERSON	15, LUZERNE	0, DAUPHIN	0, PERRY
944, GREENE	99, BEAVER	12, VENANGO	0, ERIE	0, PHILADELPHIA
483, BUTLER	97, INDIANA	10, WARREN	0, FRANKLIN	0, PIKE
453, WESTMORELAND	90, CLARION	9, BLAIR	0, FULTON	0, SCHUYLKILL
409, CLEARFIELD	55, ALLEGHENY	5, CRAWFORD	0, JUNIATA	0, SNYDER
372, FAYETTE	53, SOMERSET	2, HUNTINGDON	0, LANCASTER	0, UNION
310, WYOMING	50, LAWRENCE	2, BEDFORD	0, LEBANON	0, YORK
276, ARMSTRONG	43, CAMERON	0, ADAMS	0, LEHIGH	
235, POTTER	39, FOREST	0, BERKS	0, MIFFLIN	
224, SULLIVAN	29, LACKAWANNA	0, BUCKS	0, MONROE	