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DEPARTMENT OF ENVIRONMENTAL PROTECTION

Oil and Gas Management

DEP Office of Oil and Gas Management

Bureau of Oil and Gas Planning and Program Management

Well Plugging and Subsurface Activities Division

Production Waste Trends and Management

May 19, 2017

2017 Shale Network Workshop

State College, PA

Presentation Outline

- Current Oil and Gas Waste Generation Trends
  - Unconventional Industry
  - Conventional Industry
- DEP Process for Permitting UIC Wells
- Review of Lawrence County Induced Seismic Event
- Regulatory Framework for Managing Induced Seismic Risks

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Current Oil and Gas Waste Generation Trends

Unconventional: 2016 Waste Streams

Volumes of waste in barrels or tons each year	2016 (Bbls)	2016 (Tons)	2016 (% Bbls)	2016 (% Tons)
Basic Sediment (in Barrels) RWC 807	1,191	NA	0.003%	NA
Drill Cuttings (in Tons) RWC 810	NA	442,295	NA	75.180%
Drilling Fluid Waste (in Barrels) RWC 803	529,676	NA	1.290%	NA
Filter Socks (in Tons) RWC 812	NA	45	NA	0
Fracturing Fluid Waste (in Barrels) RWC 805	NA	72,727	NA	12.362%
Fracturing Fluid Waste (in Tons) RWC 805	4,278,074	NA	10.415%	NA
General O&G waste not covered by other waste types	None Reported	None Reported	None Reported	None Reported
Other Oil & Gas Wastes (in Barrels) RWC 899	731,798	NA	1.782%	NA
Other Oil & Gas Wastes (in Tons) RWC 899	NA	1,582	NA	0.269%
Produced Fluid (in Barrels) RWC 802	35,464,252	NA	86.341%	NA
Servicing Fluid (in Barrels) RWC 808	69,364	NA	0.169%	NA
Servicing Fluid (in Tons) RWC 808	NA	9,062	NA	1.540%
Soil Contaminated by Oil & Gas Related Spills (in Tons) RWC 811	NA	6,238	NA	1.060%
Spent Lubricant Waste (in Barrels) RWC 809	391	NA	0.001%	NA
Synthetic Liner Materials (in Tons) RWC 806	NA	43,417	NA	7.380%
Waste Water Treatment Sludge (in Tons) RWC 804	NA	12,947	NA	2.201%
Grand Total	41,074,746	588,313	100%	100%

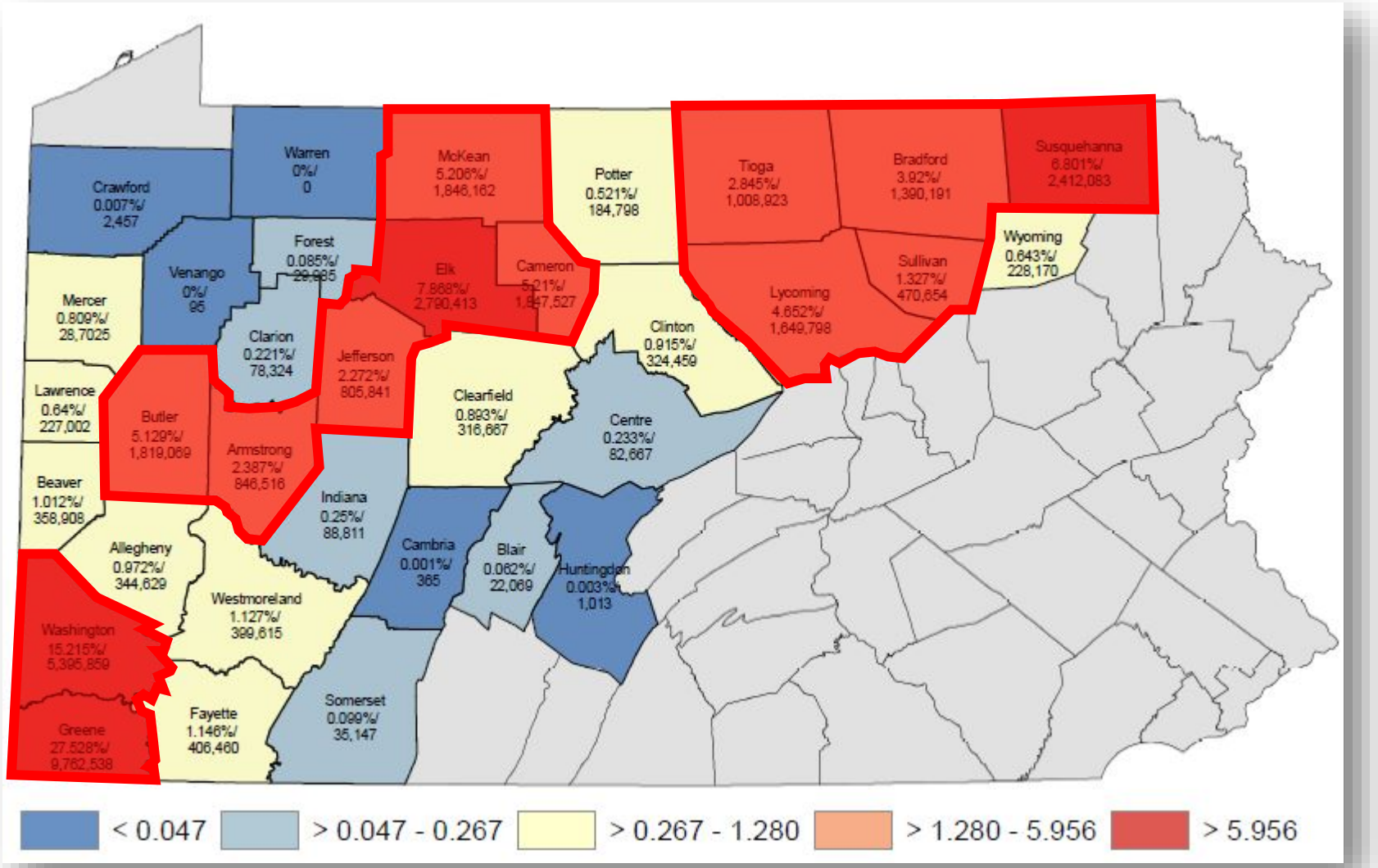
Current Oil and Gas Waste Generation Trends

Unconventional: 2016 Waste Management Trends

Volumes of waste in barrels or tons each year	2016 (Bbls)	2016 (Tons)	2016 (% Bbls)	2016 (% Tons)
CENT WASTE TRT FAC NPDES DISCHARGE	243,307	61	0.592%	0.010%
CENTRALIZED TREATMENT PLANT FOR RECYCLE	6,725,828	155	16.375%	0.026%
INJECTION DISPOSAL WELL	2,184,141	NA	5.317%	NA
LANDFILL	28,314	452,075	0.069%	76.843%
RESIDUAL WASTE PROC FAC (GENERAL PERMIT)	3,690,017	13,093	8.984%	2.225%
RESIDUAL WASTE PROCESSING FACILITY	4,013,049	11,305	9.770%	1.922%
RESIDUAL WASTE TRANSFER FACILITY	6,669	8,563	0.016%	1.455%
REUSE OTHER THAN ROAD SPREADING	24,152,007	66,975	58.800%	11.384%
STORAGE PENDING DISPOSAL OR REUSE	31,413	36,086	0.076%	6.134%
Grand Total	41,074,746	588,313	100%	100%

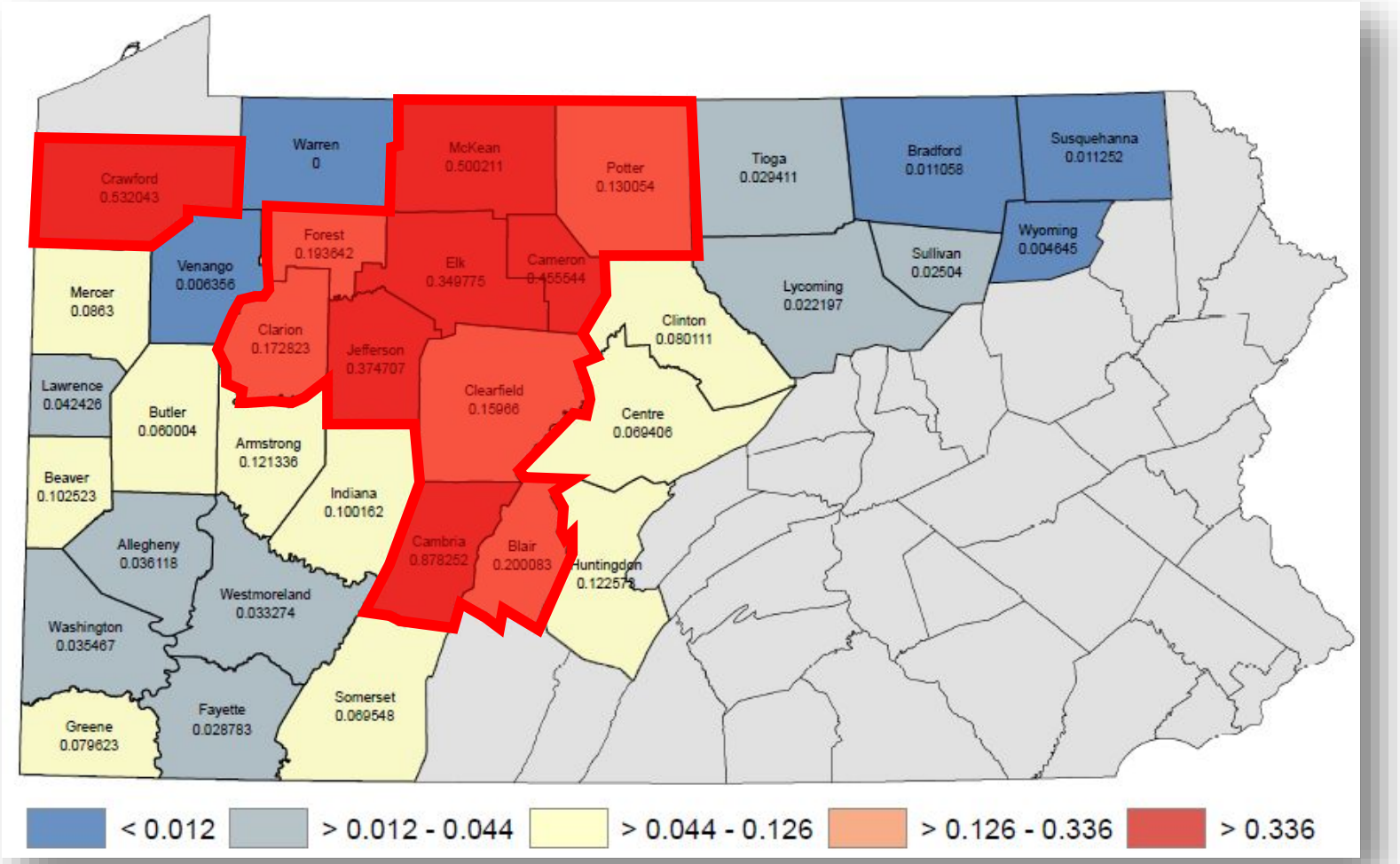
Current Oil and Gas Waste Generation Trends

Unconventional: 2016 Percentage and Bbls by County



Current Oil and Gas Waste Generation Trends

Unconventional: 2016 Brine-to-BOE Ratio by County



Current Oil and Gas Waste Generation Trends

Unconventional: 2016 Summary

- 35.4 MM Bbls of brine produced
- 75.2% of liquid waste is being recycled
- 4.7 MM Bbls of oil and condensate produced
- 5 Tcf (1 B BOE) of gas produced
- Limitation: our data system only captures the first stop for waste, e.g., if waste goes from well → pre-treatment → UIC well, we only have information for well and pre-treatment facility

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Current Oil and Gas Waste Generation Trends

Conventional: 2016 Waste Streams

Volumes of waste in barrels or tons each year	2016 (Bbls)	2016 (Tons)	2016 (% Bbls)	2016 (% Tons)
Basic Sediment (in Barrels) RWC 807	166	NA	0.004%	NA
Drilling Fluid Waste (in Barrels) RWC 803	1,665	NA	0.041%	NA
Fracturing Fluid Waste (in Barrels) RWC 805	1,719	NA	0.043%	NA
Fracturing Fluid Waste (in Tons) RWC 805	NA	43	NA	1.019%
Other Oil & Gas Wastes (in Barrels) RWC 899	6,360	NA	0.158%	NA
Other Oil & Gas Wastes (in Tons) RWC 899	NA	579	NA	13.724%
Produced Fluid (in Barrels) RWC 802	3,998,821	NA	99.340%	NA
Servicing Fluid (in Barrels) RWC 808	18,371	NA	0.456%	NA
Servicing Fluid (in Tons) RWC 808	NA	1,184	NA	28.064%
Soil Contaminated by Oil & Gas Related Spills (in Tons) RWC 811	NA	2,190	NA	51.908%
Synthetic Liner Materials (in Tons) RWC 806	NA	13	NA	0.308%
Waste Water Treatment Sludge (in Tons) RWC 804	NA	210	NA	4.977%
Grand Total	4,025,383	4,219	100%	100%

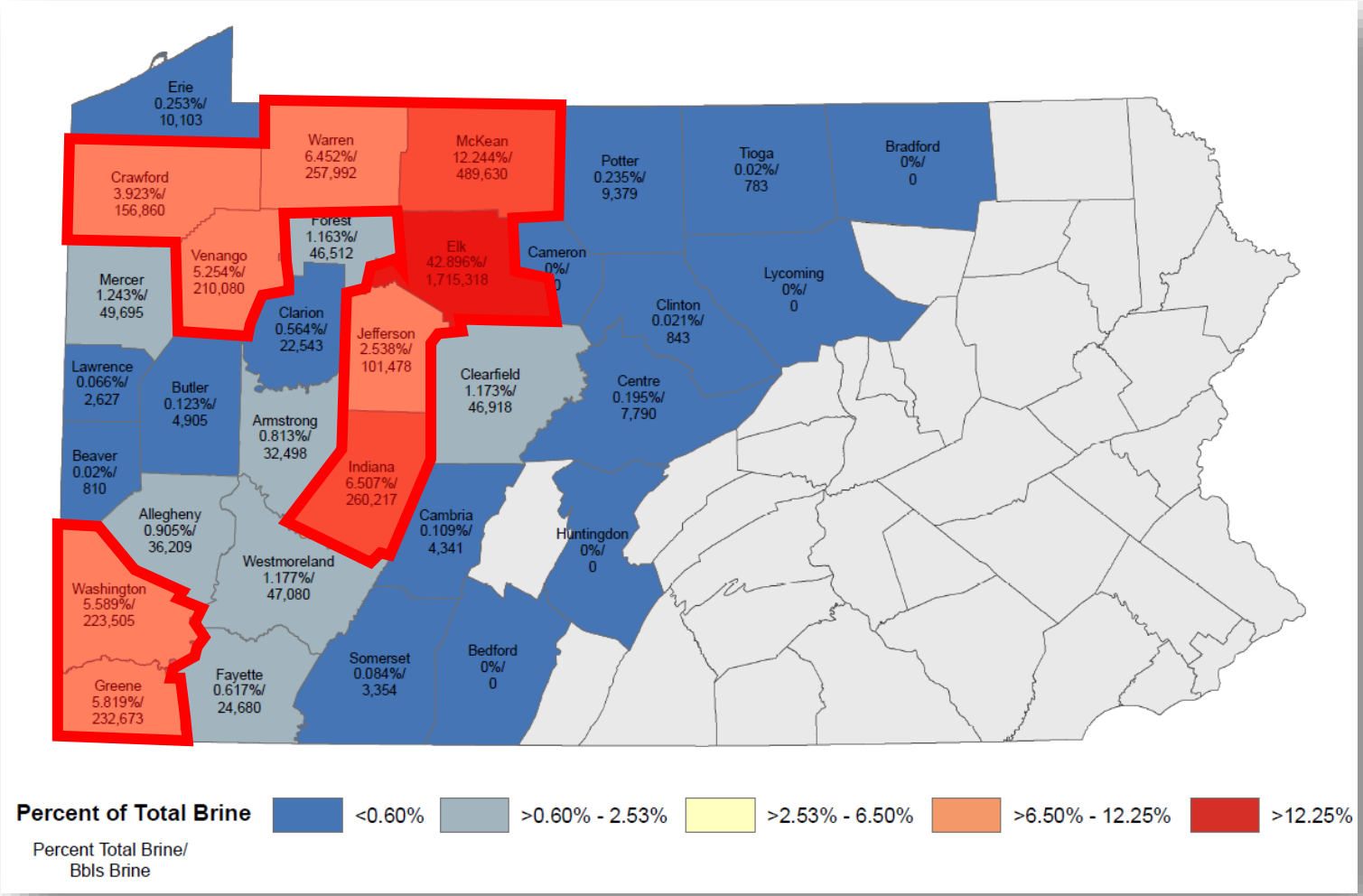
Current Oil and Gas Waste Generation Trends

Conventional: 2016 Waste Management Trends

Volumes of waste in barrels or tons each year	2016 (Bbls)	2016 (Tons)	2016 (% Bbls)	2016 (% Tons)
CENT WASTE TRT FAC NPDES DISCHARGE	634,216	807	15.740%	39.745%
CENTRALIZED TREATMENT PLANT FOR RECYCLE	33,529	64	0.832%	3.159%
INJECTION DISPOSAL WELL	238,949	NA	5.930%	NA
LAND APPLICATION	380	None Reported	0.009%	None Reported
LANDFILL	1,870	980	0.046%	48.284%
PUBLIC SEWAGE TREATMENT PLANT	517,079	NA	12.833%	NA
RESIDUAL WASTE PROC FAC (GENERAL PERMIT)	67	None Reported	0.002%	None Reported
RESIDUAL WASTE PROCESSING FACILITY	150,937	73	3.746%	3.585%
RESIDUAL WASTE TRANSFER FACILITY	6,036	106	0.150%	5.227%
REUSE OTHER THAN ROAD SPREADING	2,143,999	NA	53.210%	NA
ROAD SPREADING	271,926	NA	6.749%	NA
STORAGE PENDING DISPOSAL OR REUSE	30,307	None Reported	0.752%	None Reported
Grand Total	4,029,294	2,029	100.000%	100%

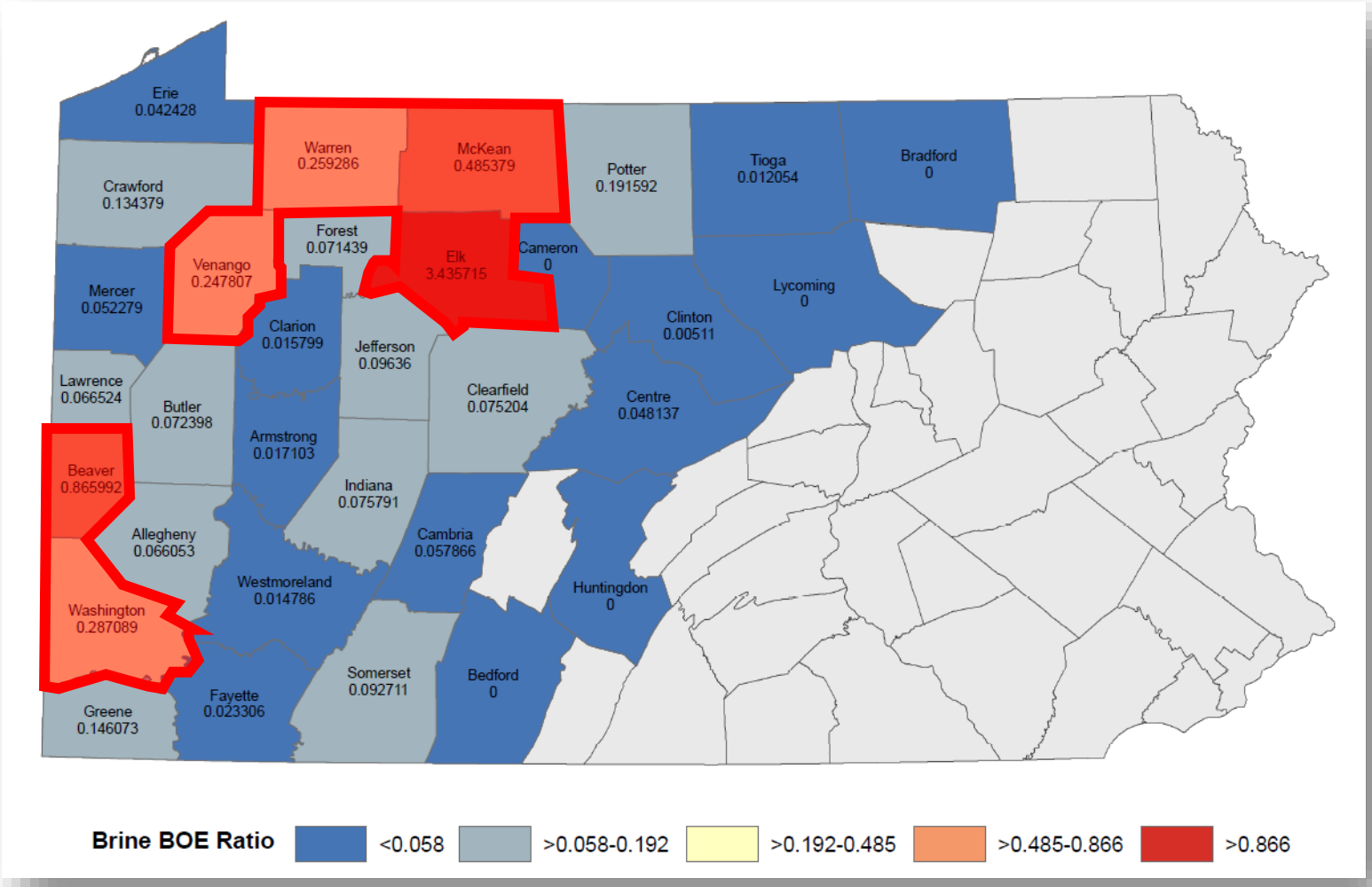
Current Oil and Gas Waste Generation Trends

Conventional: 2016 Percentage and Bbls by County



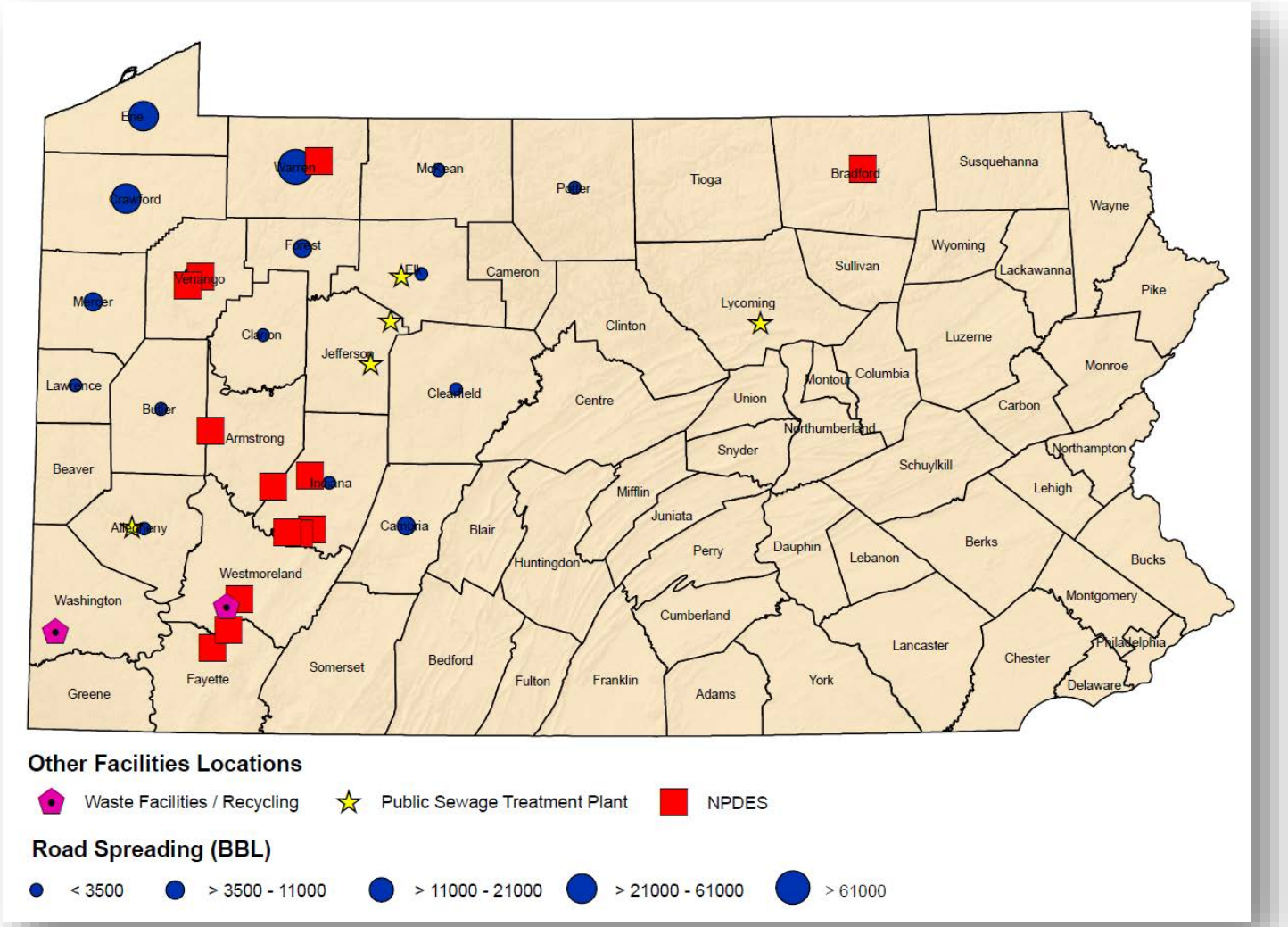
Current Oil and Gas Waste Generation Trends

Conventional: 2016 Brine-to-BOE Ratio by County



Current Oil and Gas Waste Generation Trends

Conventional: 2016 Treatment Facility Inventory



Current Oil and Gas Waste Generation Trends

Conventional: 2016 Summary

- 4 MM Bbls of brine produced
- Only half of liquid waste is being recycled
- 1.5 MM Bbls of oil and condensate produced
- 120 Bcf (21 MM BOE) of gas produced
- DEP's database is not comprehensive
  - Only 65% of total wells are represented in 2016 report
- Conventional industry is facing significant challenges relating to brine management

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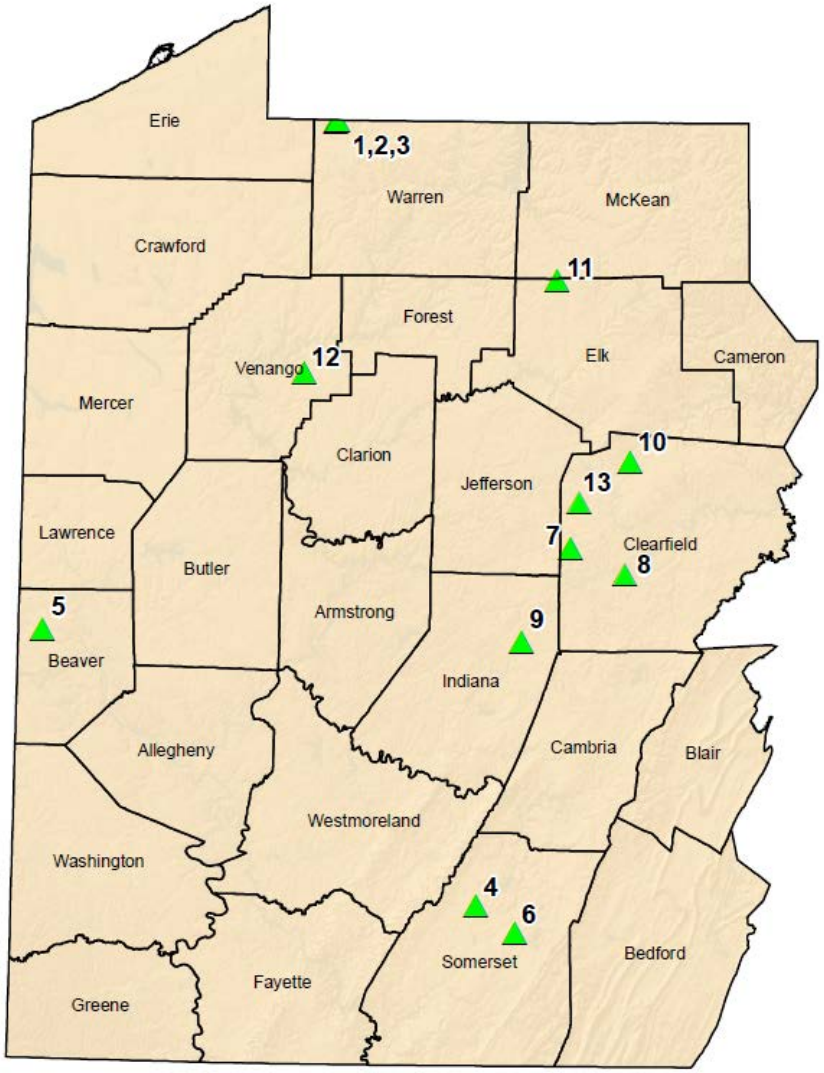
DEP Process for Permitting UIC Wells

Current UIC Disposal Well Inventory



Map ID	OPERATOR	API	Permit Status	BBLS Per Month
1	BEAR LAKE PROP LLC	123-33914	Permitted	30,000
2	BEAR LAKE PROP LLC	123-39874	Permitted	30,000
3	BEAR LAKE PROP LLC	123-33944	Under DEP Review	30,000
4	CNX GAS CO LLC	111-20006	Permitted	30,000
5	COLUMBIA GAS OF PA INC	007-20027	Permitted	21,000
6	COTTONWOOD OPR CORP	111-20059	Permitted	27,375
7	EXCO RESOURCES PA LLC	033-00053	Permitted	4,260
8	EXCO RESOURCES PA LLC	033-22059	Permitted	9,000
9	PA GEN ENERGY CO LLC	063-31807	Permitted	30,000
10	SAMMY-MAR LLC	033-27257	Under DEP Review	30,000
11	SENECA RESOURCES CORP	047-23835	Permitted	45,000
12	STONEHAVEN ENERGY MGT CO LLC	121-44484	Permitted but not online	4,500
13	WINDFALL OIL & GAS INC	033-27255	Under DEP Review	30,000

Comments

- Note that Stonehaven Energy Mgt Co LLC well is now online
- Only commercial facility is Bear Lake Prop LLC

DEP Process for Permitting UIC Wells

UIC Permitting

DEP's Oil and Gas Program completes an independent geological and well integrity assessment for every new UIC permit application:

- Area of Review (AOR) analysis for "seismic risk" that includes 3- and 6-mile radii around historic earthquake epicenters
- Rigorous analysis of geologic conditions at and adjacent to the well site
- A mechanical integrity evaluation of the proposed injection well
- Additional consideration for monitoring at offset wells

In addition to these criteria, the Oil and Gas Program also considers several enhancements that are discussed in subsequent slides

Surface permitting activities are also still conducted: Control and Disposal Plan and Erosion and Sedimentation Controls

DEP Process for Permitting UIC Wells

UIC Permitting

1) Geologic analysis
   - Geological review of the area around the well, including the structural geologic framework

2) Detailed review of stratigraphy associated with UIC well
   - Review of geophysical logging suites available to understand fully how well brines will be contained
   - Confirmation of lower confinement whenever possible – this is particularly critical in situations where offset from basement rock is minimal

DEP Process for Permitting UIC Wells

UIC Permitting

3) Seismic event monitoring and shut-down protocol

- Operator development of a seismic monitoring and mitigation plan (SMMP) which includes active event monitoring
  - One seismometer on site or a local seismic network tied to the state's monitoring network (PASeis)

- As part of SMMP, the operator shall discontinue injection operations if a measured induced seismic event great than 2 M_L occurs within a 3-mile radius of the injection well – operations may not recommence until it has been definitively demonstrated that the seismic event is not associated with injection activities or some other approved mitigation strategy has been implemented

DEP Process for Permitting UIC Wells

UIC Permitting

4) Continuous pressure monitoring on outer strings and continuous casing pressure monitoring associated with long string (i.e., casing that houses the injection tubing)
   - Recommend that additional gauges/valves be installed on outer casing strings to detect and address potential well integrity issues in real-time

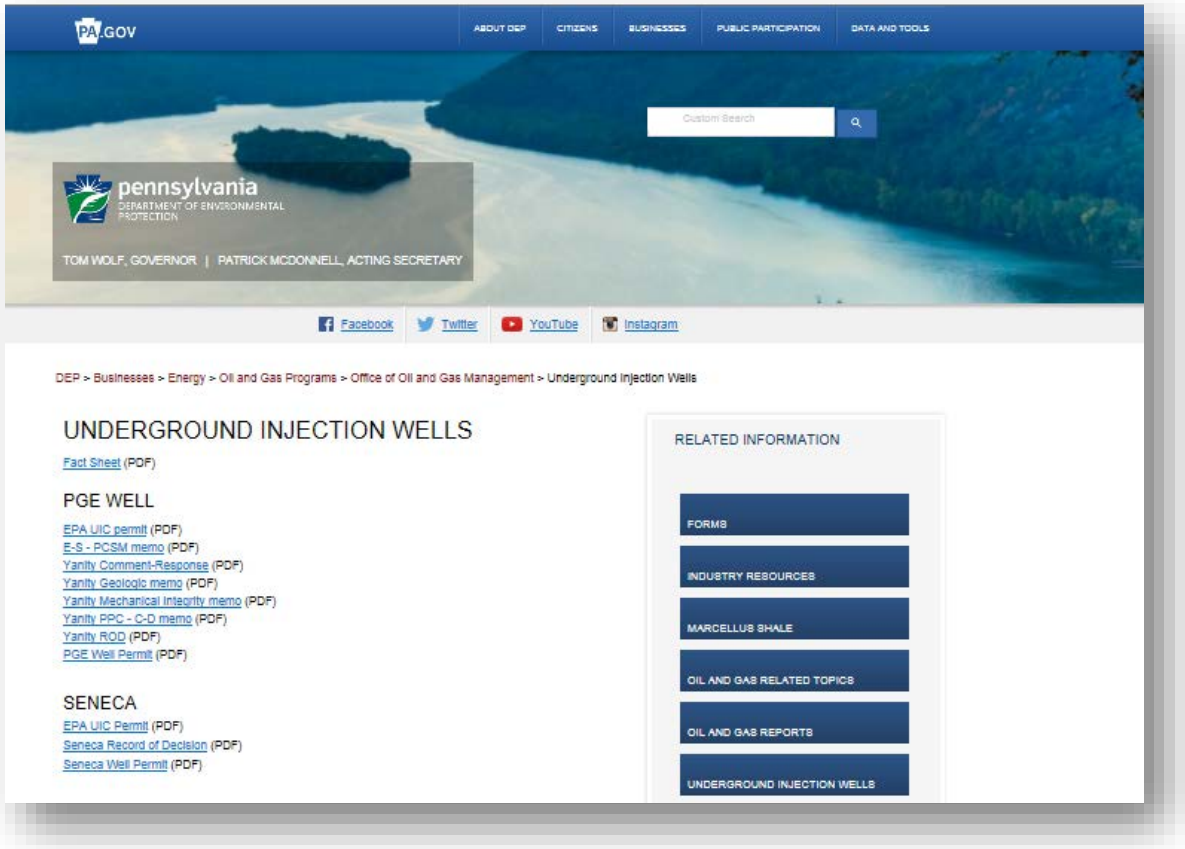
5) Installation of pressure alarm and pump shut-down device
   - Recommend installation of a pressure alarm and pump shut-down device outside the long string to safely keep any pressure leaks significantly below the pressure rating of the casing

DEP Process for Permitting UIC Wells

UIC Permitting

For more information:

http://www.dep.pa.gov/Business/Energy/OilandGasPrograms/OilandGasMgmt/Pages/Underground-Injection-Wells.aspx



Review of Lawrence County Event

- **Timing:** Several low-magnitude earthquakes occurred in Lawrence County during the morning hours of April 25, 2016
- **Locations:** Mahoning, North Beaver, and Union Townships, just west of New Castle
- **Magnitude:** 1.8 - 2.3 on the Richter Scale – since the seismic events were recorded and felt only by seismometers, they're considered "microseismic"
- **DEP Analysis:** These events correlated with operator activity

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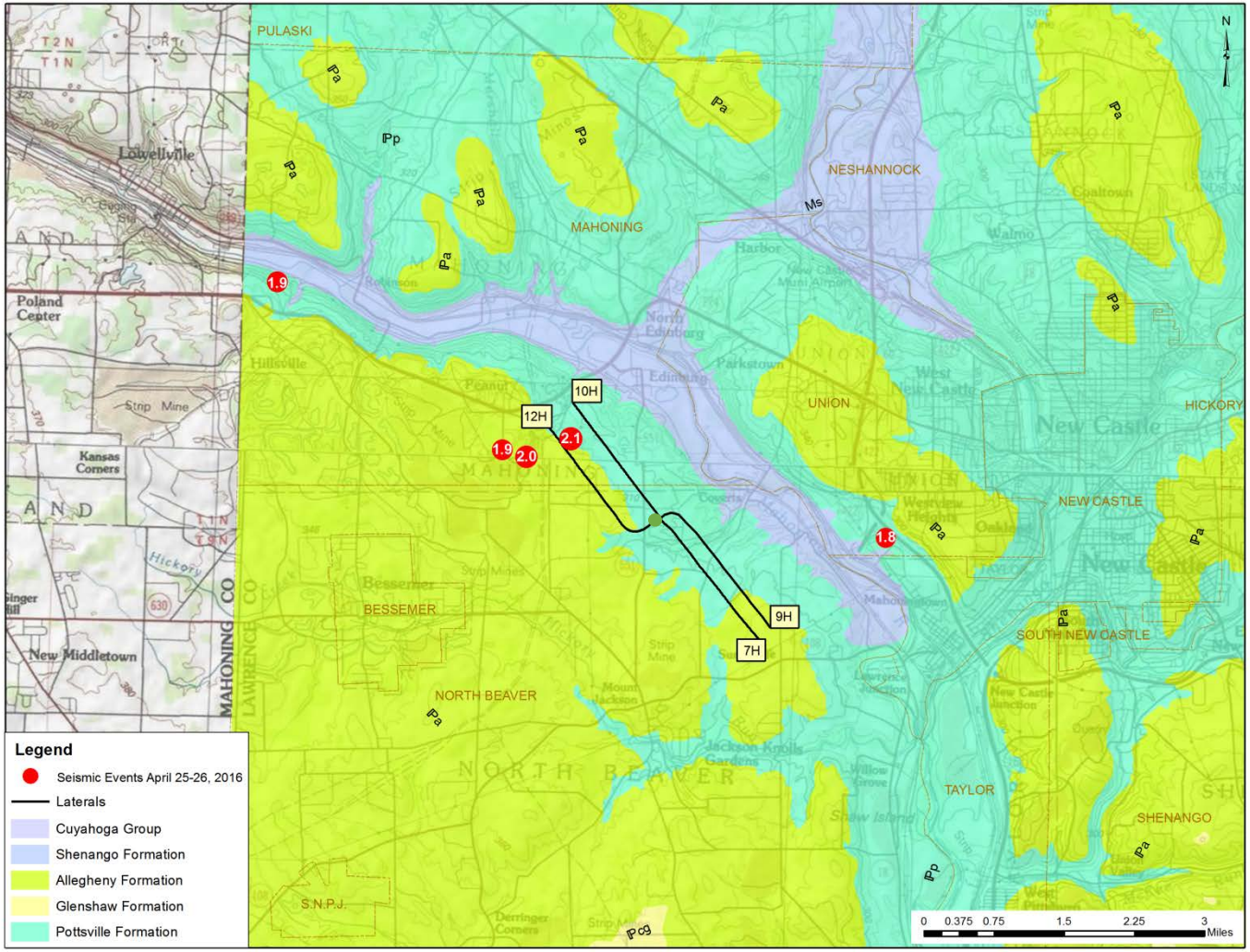
Review of Lawrence County Event

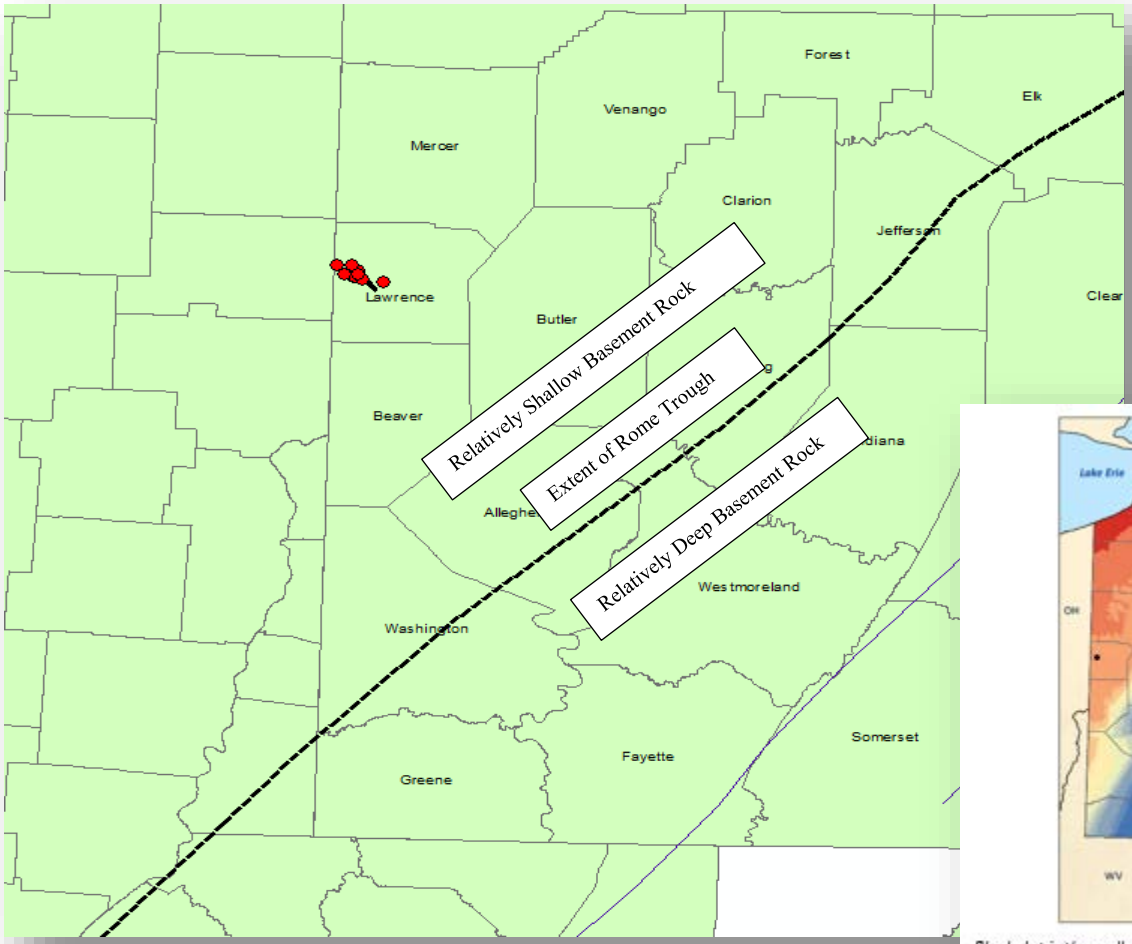
Lateral Locations, Epicenters per Lamont Doherty Network, and Geology

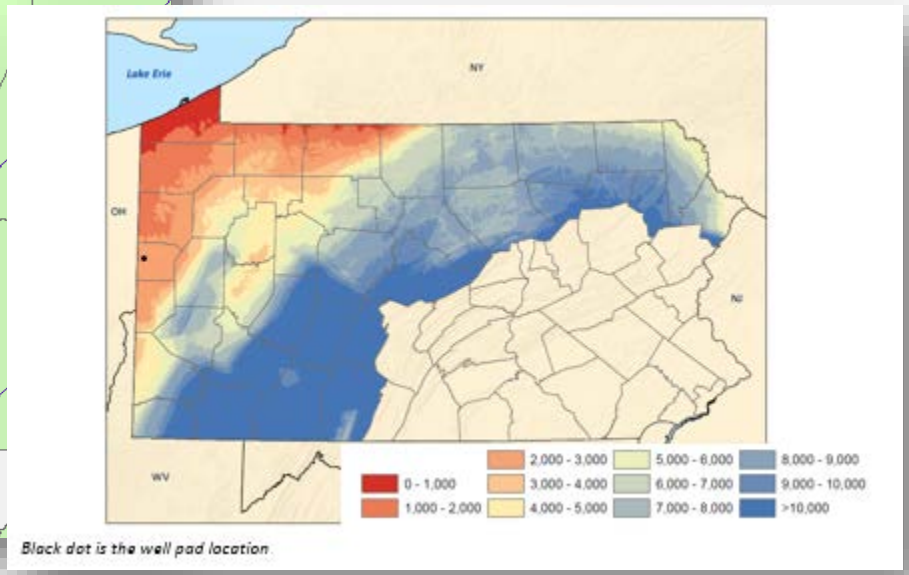


Orange dot is well pad location

Review of Lawrence County Event

Well Site Area and Regional Geologic Structure

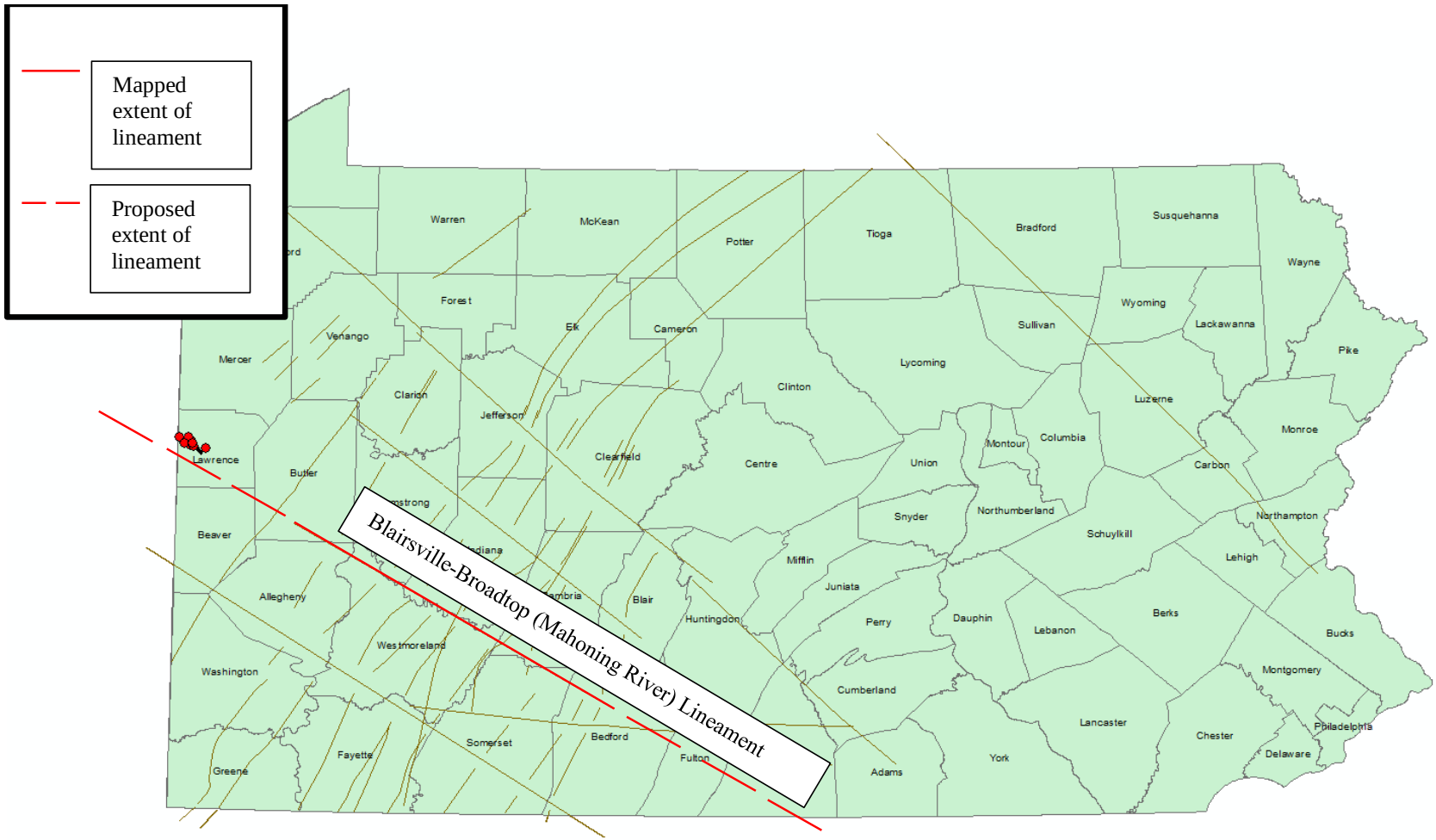




The Rome Trough is associated with thickening sediments and greater offset to crystalline basement rock

Lawrence County Event Details

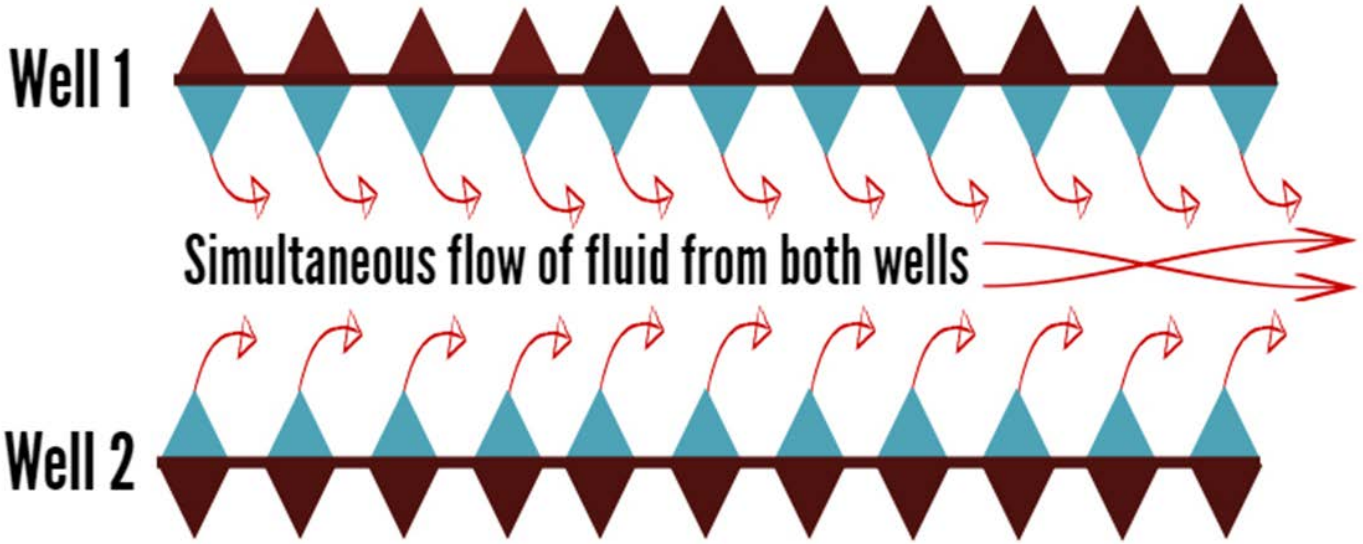
Seismic Event Locations with Regional Geologic Structure



Review of Lawrence County Event

What is zipper fracturing?

Zipper fracturing is defined as fracturing operations to be carried out concurrently at two horizontal wellbores which are parallel to each other and not very far from each other.



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Review of Lawrence County Event

Key Geologic Factors Tied to Seismicity and Forward Actions

- Structural geologic features in the area result in Precambrian crystalline "basement" rock being closer to the surface than in other areas of the basin: the depth in the area of the well pad is approximately 9,500 to 10,000 feet
- The Utica Shale is approximately 2,500 to 3,000 feet shallower than basement rock
- Literature proposes that the Blairsville-Broadtop Lineament extends through Lawrence County, but currently the mapped extent ends in Butler County
- DEP is currently assigning special permit conditions to future permits issued Mahoning, North Beaver, and Union Townships; Lawrence County – over the longer term, an "Area of Alternative Methods" will be the primary mechanism for regulating this issue

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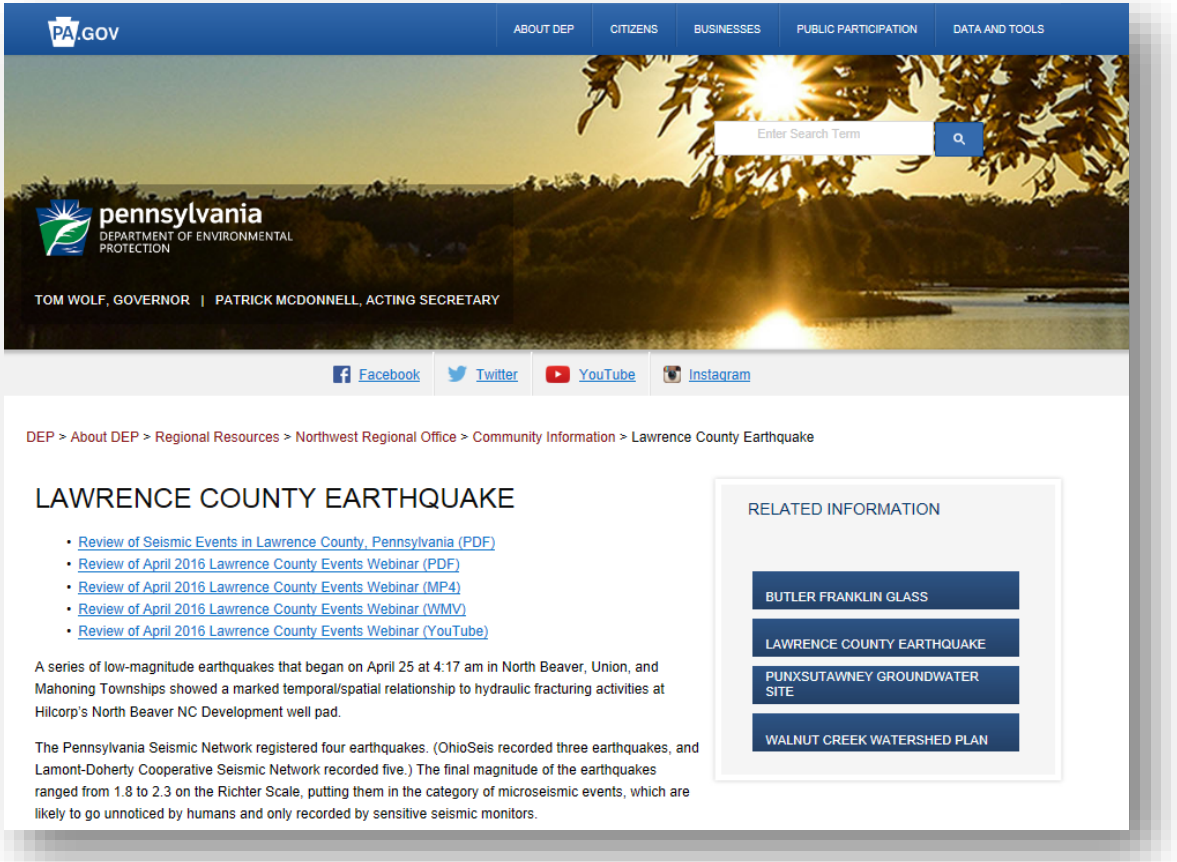
Review of Lawrence County Event

Lawrence County Induced Seismic Event

For more information:

http://www.dep.pa.gov/About/Regional/NorthwestRegion/Community-Information/Pages/Lawrence-County-Earthquake.aspx



Regulatory Framework for Managing Induced Seismic Risks

Area of Alternative Methods

- Stakeholder workgroup is being assembled
- Rulemaking will focus on Utica Shale development in areas where the formation is closer to crystalline basement rock and/or portions of the state where measurable seismic events have occurred historically
- During interim period, DEP will continue to rely on permit conditions for certain parts of Lawrence County and PASeis/internal SOPs for response in the remainder of the state

Regulatory Framework for Managing Induced Seismic Risks

Summary

- Geologic and engineering reviews to develop permit conditions will be used as the primary mechanism for regulating induced seismicity associated with UIC operations
- An “Area of Alternative Methods” will be developed to regulate induced seismicity associated with hydraulic fracturing
- DEP will continue to actively discuss research findings relating to induced seismicity with all groups performing research to better understand potential triggering mechanisms

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Thank You! Questions?

Seth Pelepko, P.G.
Program Manager, Well Plugging and Subsurface Activities Division
Bureau of Oil & Gas Planning & Program Mgmt
717.772.2199
mipelepko@pa.gov

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