    

Managing the Risks of Shale Gas Development

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RESOURCES FOR THE FUTURE

EUCE Conference on Environment & Energy Comparison of US and EU Policies

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About RFF

- A nonprofit and nonpartisan organization that conducts independent research – rooted primarily in economics and other social sciences – on environmental, energy, natural resource and environmental health issues.
- Headquartered in Washington, DC.
- 30 Ph.D. environmental economists, 12 visiting and nonresident scholars, 10 research assistants
- Website: http://www.rff.org
- Blog: http://common-resources.org

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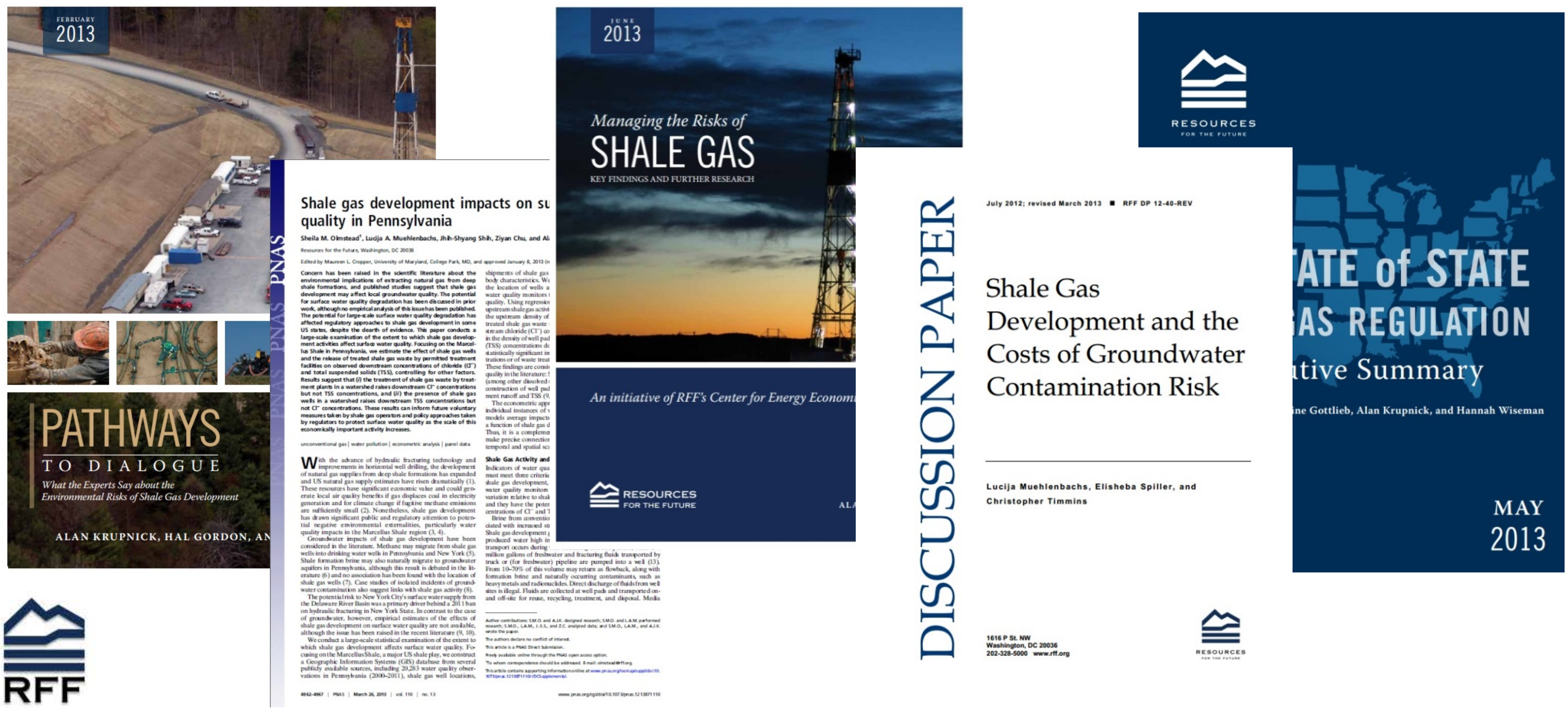
RFF Initiative: “Managing the Risks of Shale Gas Development”

- RFF’s Center for Energy Economics and Policy (CEEP)
- An independent, broad assessment of the key environmental risks associated with the shale gas development process.



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Surveying the Experts: Who & What?

215 experts:

- **NGOs** (35): Most national environmental groups, some local
- **Academics** (63): Universities/think tanks
- **Government** (42): Federal agencies; about half the relevant states; river basin commissions
- **Industry** (75): Operating and support companies, trade associations, consulting firms, law firms

Chose high priorities among 264 possible risks

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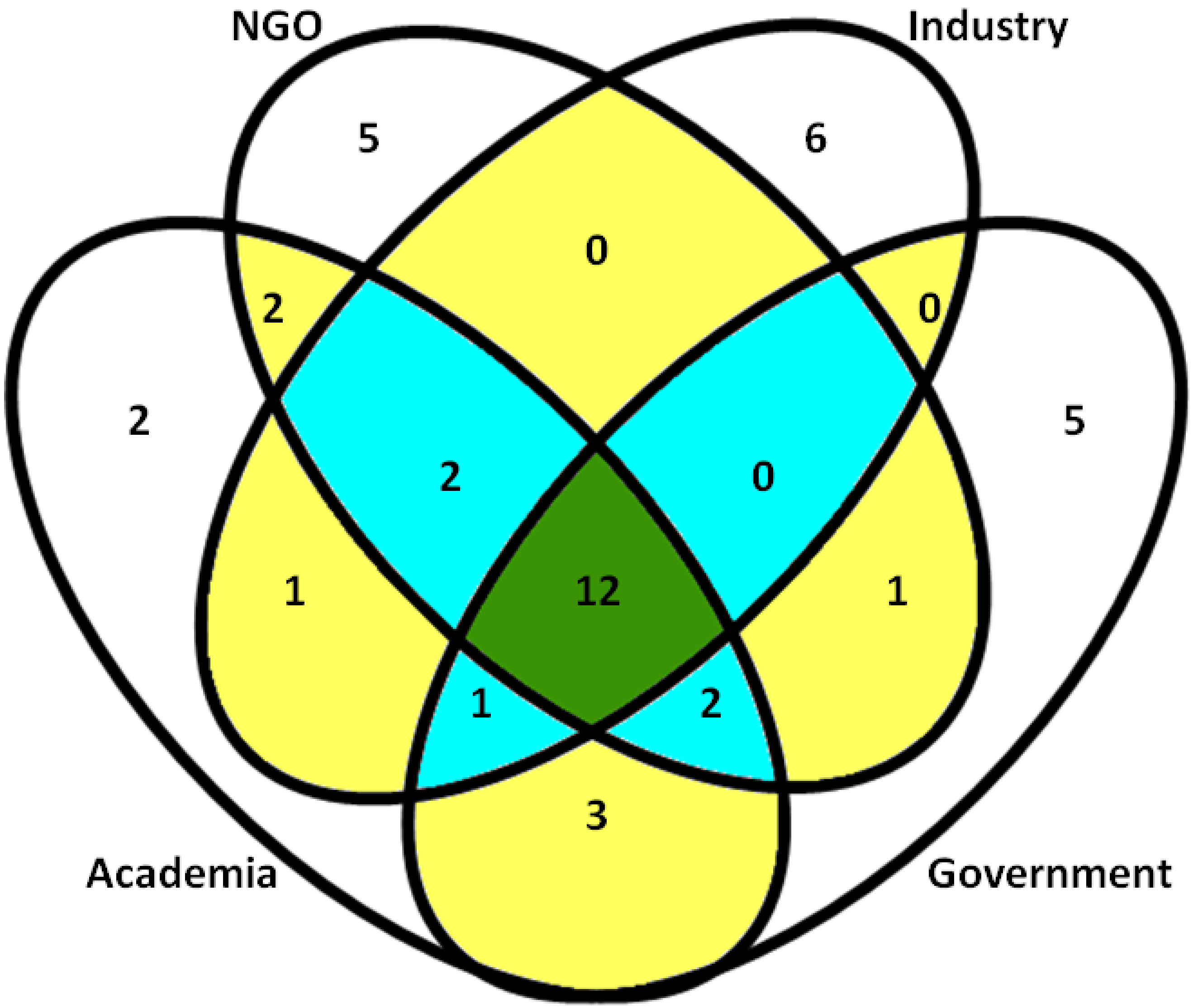
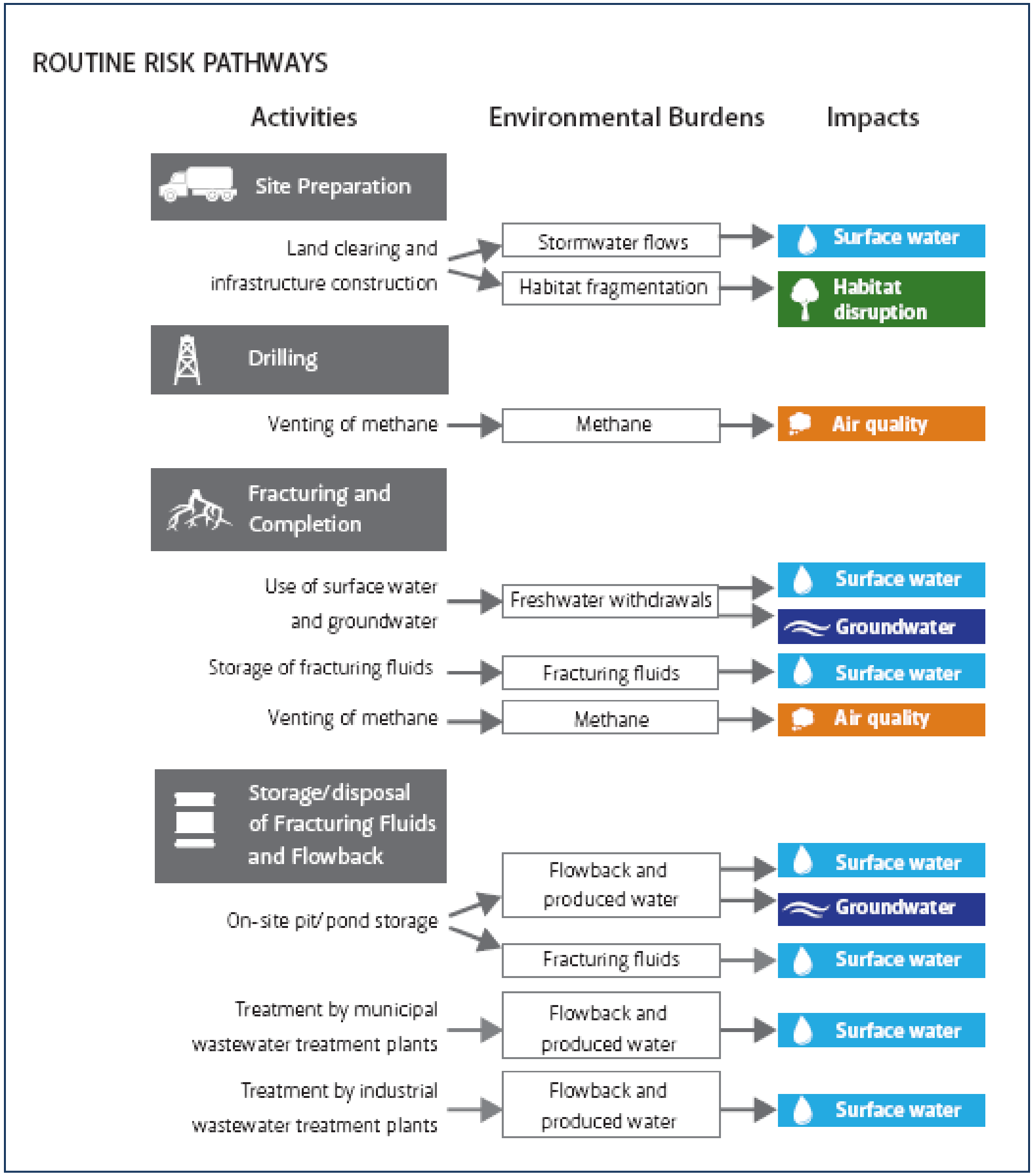
Overlap of each groups' high priority routine risk pathways

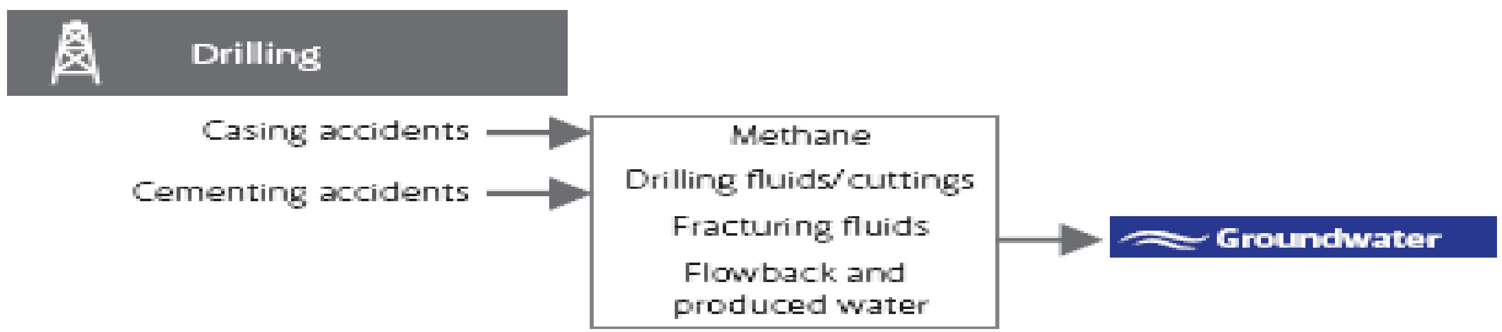


Consensus routine risk pathways



ADDITIONAL ROUTINE RISK PATHWAYS IDENTIFIED BY TOP EXPERTS

ACCIDENT RISKS PATHWAYS



Public Survey

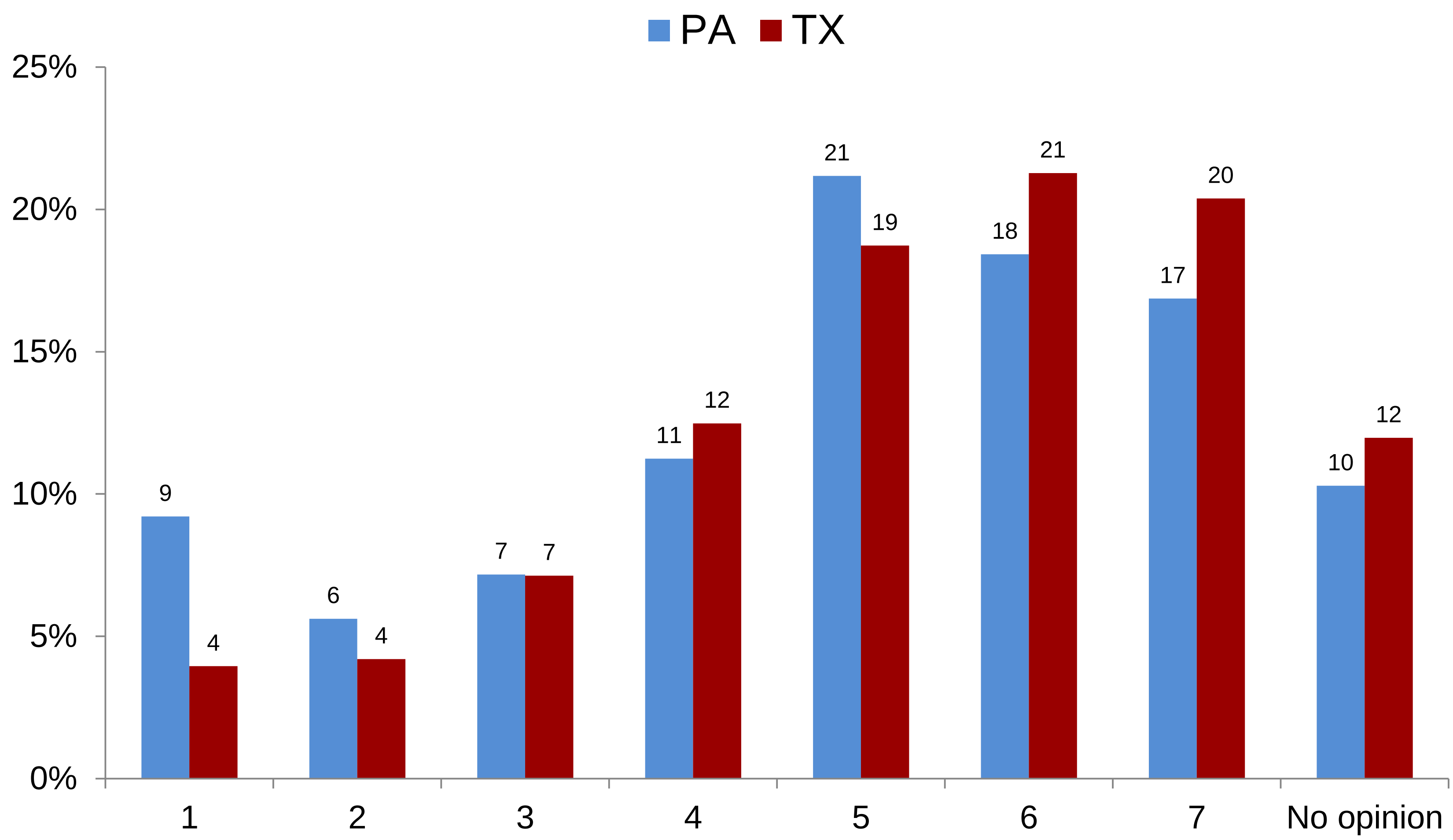
Public concerns for shale gas development well known, but no information currently available on

- Risk valuation
- Risk preference tradeoffs

We survey public in Texas and Pennsylvania to elicit attitudes and (monetary) preferences for five key risk attributes

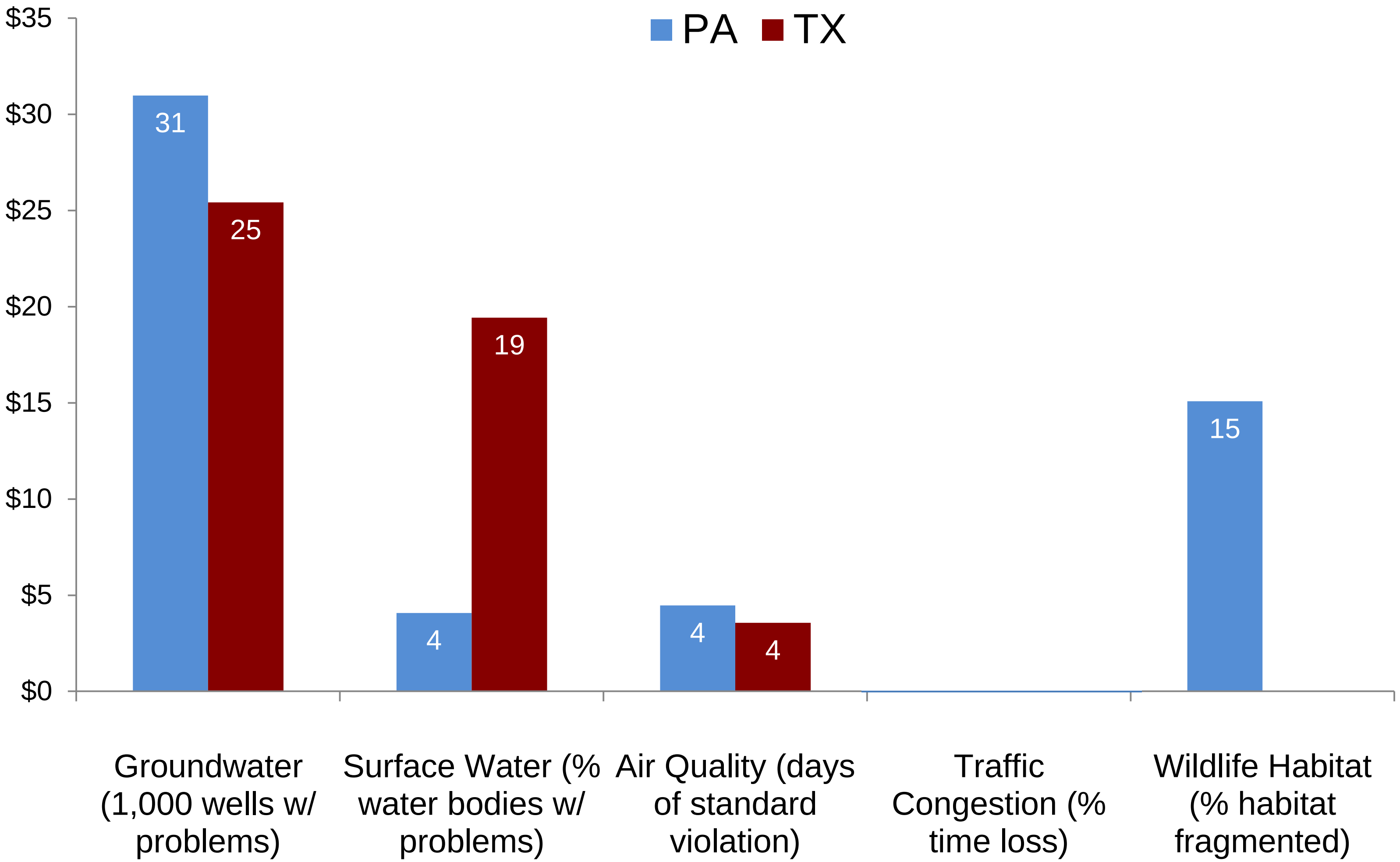
Three information "treatments" describing risks (industry, NGO, "neutral"):

Does the Public Support Shale Gas Development?



1=not supportive, 7=extremely supportive

How Much Are People WTP for Risk Reductions?
($/household/year)



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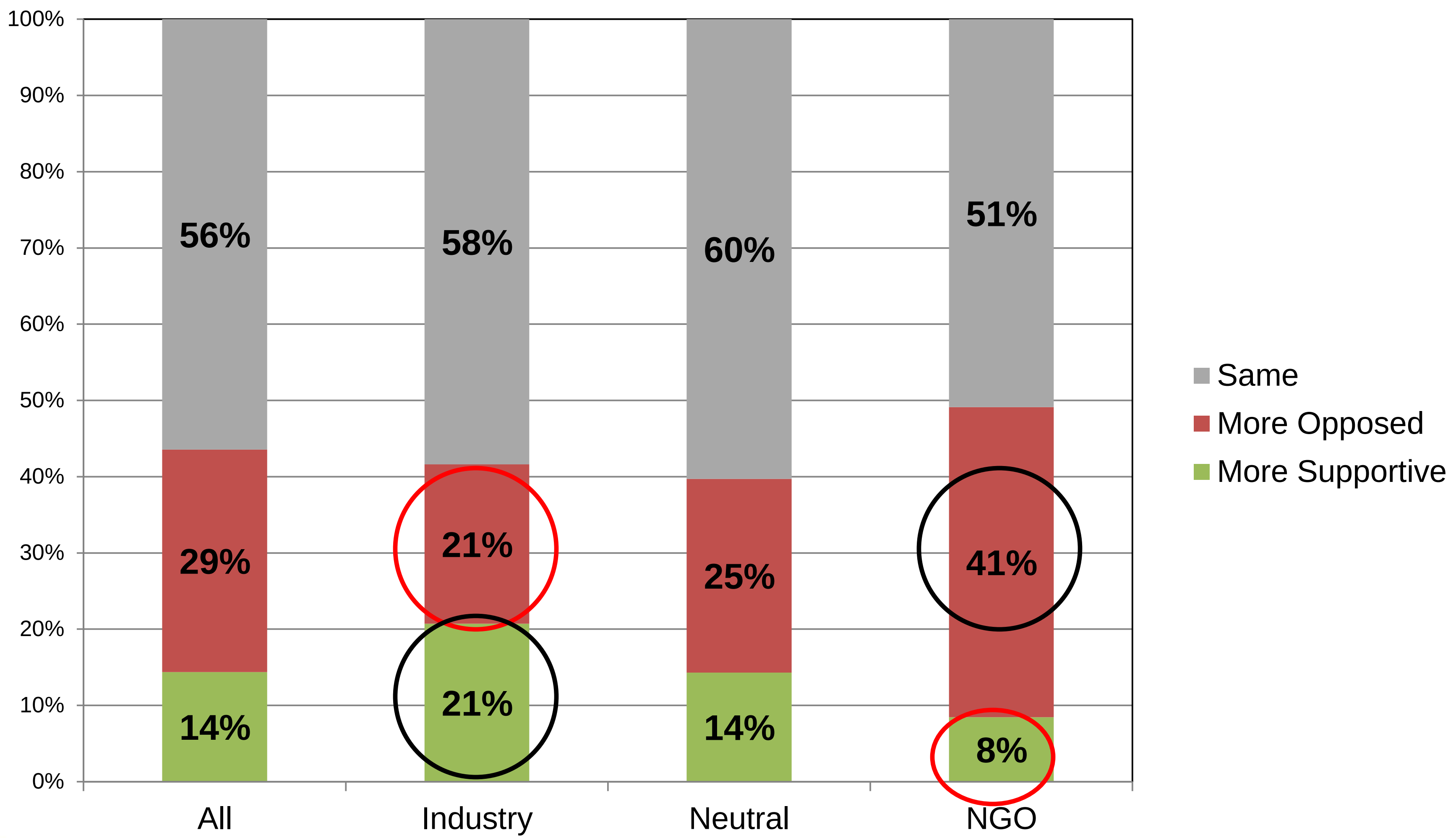
How Do Messages Affect Support?



Surface Water Quality Risk Study (PNAS, 2013)

We exploit spatial and temporal variation in the proximity of shale gas wells, waste treatment facilities, and surface water quality monitors in Pennsylvania to estimate:

1. the impact of *shale gas wells* on downstream chloride and TSS concentrations; and

2. the impact of *shale gas waste treatment* and release to surface water on downstream chloride and TSS concentrations.

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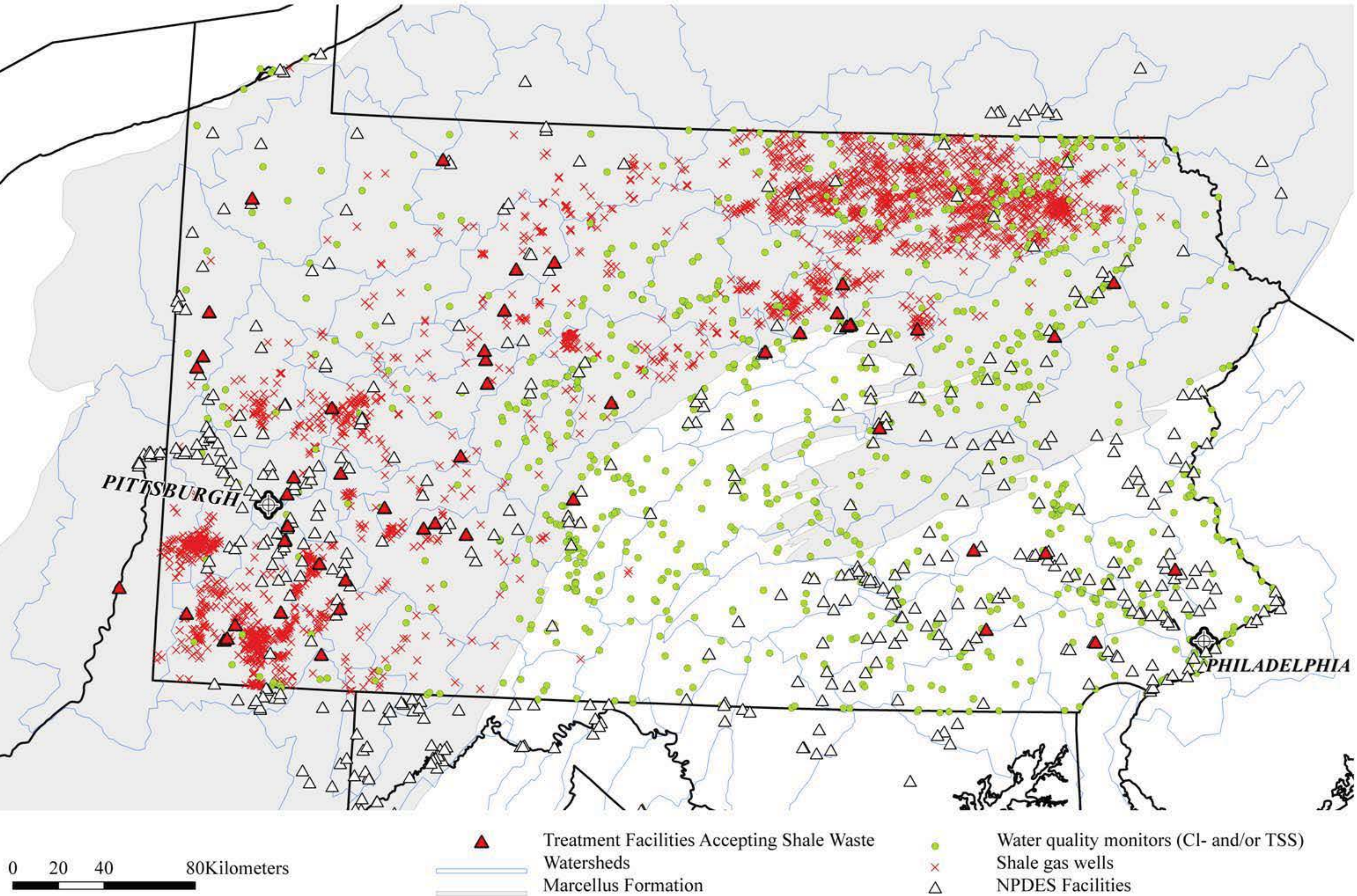
PITTSBURGH
PHILADELPHIA
0 20 40 80Kilometers
Treatment Facilities Accepting Shale Waste
Watersheds
Marcellus Formation
Water quality monitors (Cl- and/or TSS)
Shale gas wells
NPDES Facilities

Conclusions

- No statistically significant impact of shale gas wells on downstream chloride concentrations.
  - A positive result here would have been consistent with contamination problems from spills, dumping, etc.

- Release of treated shale gas waste to surface water by permitted waste facilities appears to increase downstream chloride concentrations.
  - Effect is significant only for POTWs, not CWTs.

- Shale gas wells appear to increase downstream TSS concentrations.

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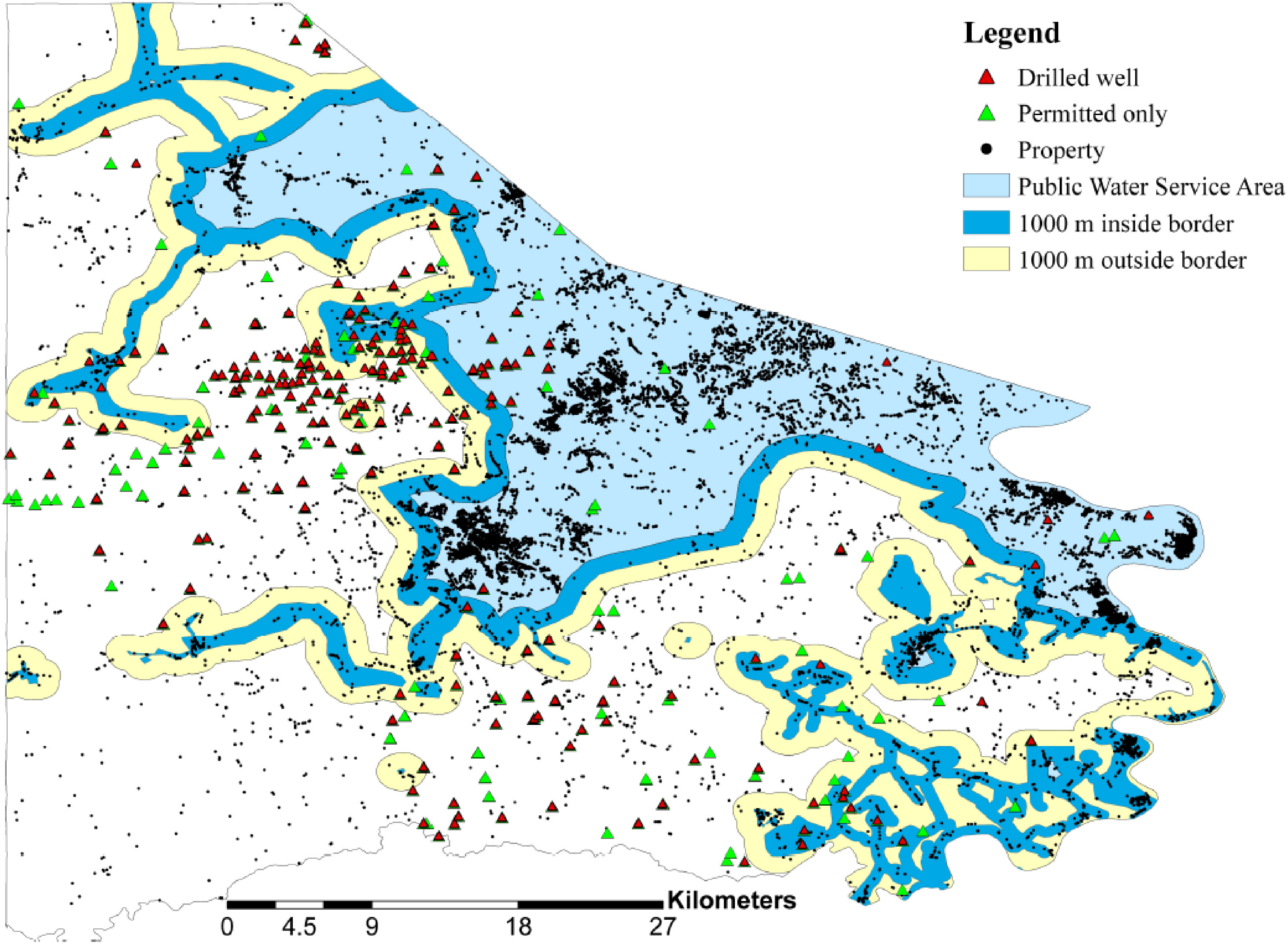

Legend
Drilled well
Permitted only
Property
Public Water Service Area
1000 m inside border
1000 m outside border
Kilometers
0
4.5
9
18
27

Findings from Washington County property value study

Properties closer than 2 km to a well pad:

- 10% increase
- Unless the property depends on groundwater: 16% decrease
  - Groundwater concerns cost 26% of property value

Wastewater characteristics from Marcellus shale gas development in PA

- Researchers: J. Shih, S. Olmstead, J. Chu, L. Muehlenbachs, J. Saiers (Yale), S. Anisfeld (Yale).
- Statistically analyzes characteristics of flowback, produced water, and drilling fluid waste sent to wastewater treatment facilities in PA, 2008-2011.
- Data Source: Form 26R, submitted to PADEP by "residual waste" generators.
- 432 different analytes were identified in the data, in the following categories:
    1. General chemicals
    2. Organics
    3. Pesticides
    4. Metals
    5. Radioactive Materials

2540-PM-BWM0347 Rev. 1/2011

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WASTE MANAGEMENT

FORM 26R
CHEMICAL ANALYSIS OF RESIDUAL WASTE
ANNUAL REPORT BY THE GENERATOR

This form must be fully and accurately completed. All required information must be typed or legibly printed in the spaces provided. If additional space is necessary, identify each attached sheet as Form 26R, reference the item number and identify the date prepared. The date on attached sheets needs to match the date noted below.

General Reference 287.54

Date Prepared/Revised

DEP USE ONLY
Date Received & General Notes

SECTION A. CLIENT (GENERATOR OF THE WASTE) INFORMATION

Company Name

If a Subsidiary, Name of Parent Company | EPA Generator ID#

Company Mailing Address Line 1 | Company Mailing Address Line 2

Company Address Last Line – City | State | Zip+4 | Phone | Ext

Company Contact Last Name | First Name | MI | Suffix

Municipality | County

Contact Phone | Ext | Contact Email Address

Is the waste generated at the Company Mailing Address (noted above)? ☐ Yes ☐ No
If 'No', describe location of waste generation and storage.

Municipality | County | State

SECTION B. WASTE DESCRIPTION

Residual Waste Code	Residual Waste Code Description	Amount	Unit of Measure	Time Frame
			☐ cu yd ☐ gal	
			☐ lb ☐ ton	☐ One Time

1. GENERAL PROPERTIES

a. pH Range to (based on analyses or knowledge)

b. Physical State
☐ Liquid Waste (EPA Method 9095)
☐ Solid (EPA Method 9095)
☐ Gas (ambient temperature & pressure)

c. Physical Appearance Color Odor
Number of Solid or Liquid Phases of Separation
Describe each phase of separation.

2. CHEMICAL ANALYSIS ATTACHMENTS

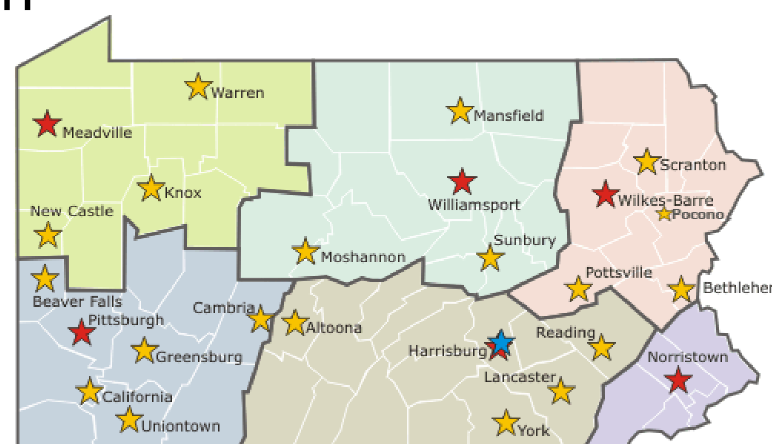
a. The results of a detailed chemical characterization of the waste, as described in the instructions, is attached. ☐ Yes ☐ No

b. A detailed description of the waste sampling method is attached. ☐ Yes ☐ No

c. The quality assurance/quality control procedures employed by the laboratory(ies) is attached. ☐ Yes ☐ No

d. The results of the hazardous waste determination is attached. ☐ Yes ☐ No

e. If applicable, a detailed explanation supporting use of generator knowledge in lieu of actual chemical analysis is attached. ☐ Yes ☐ No ☐ N/A



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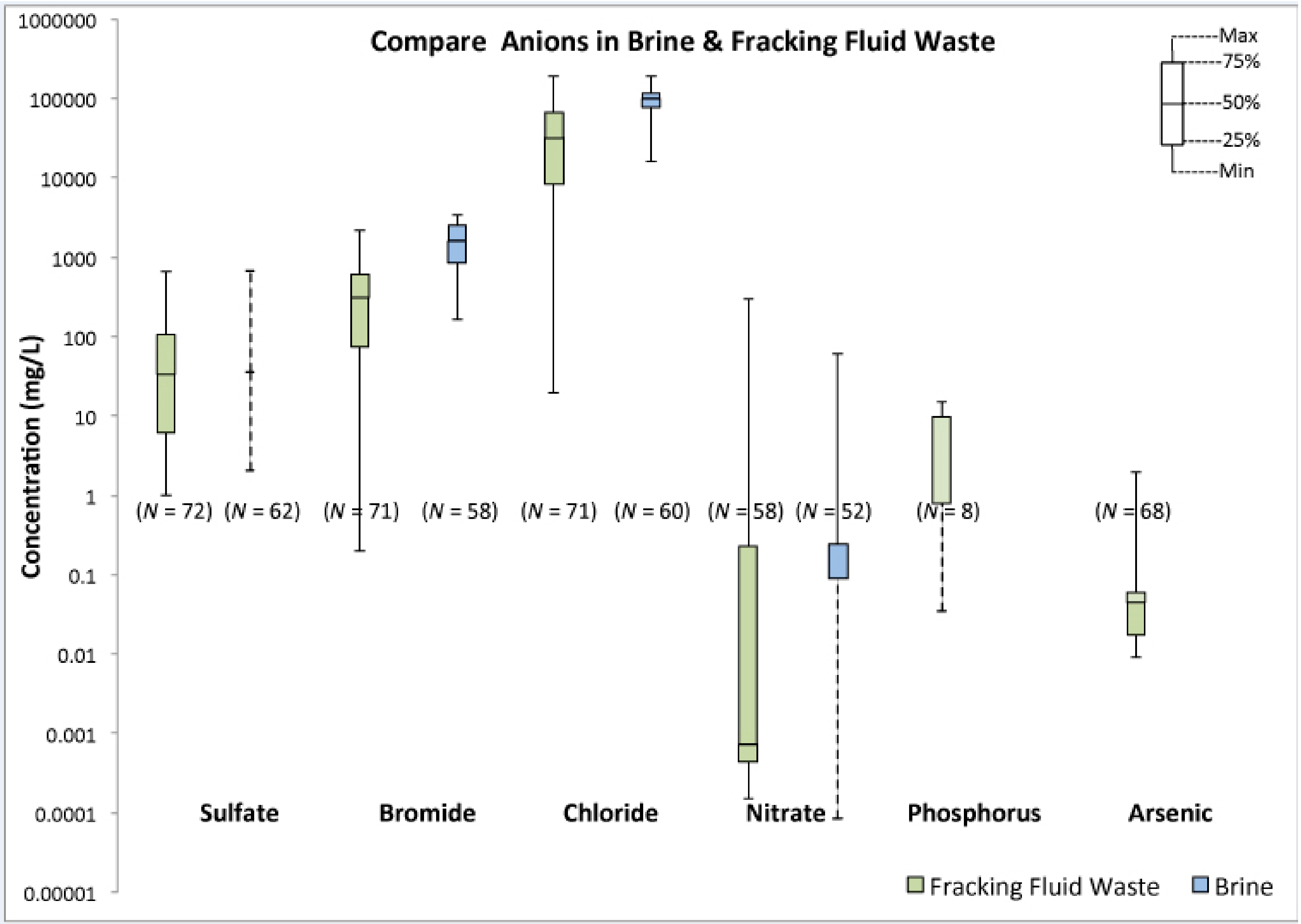
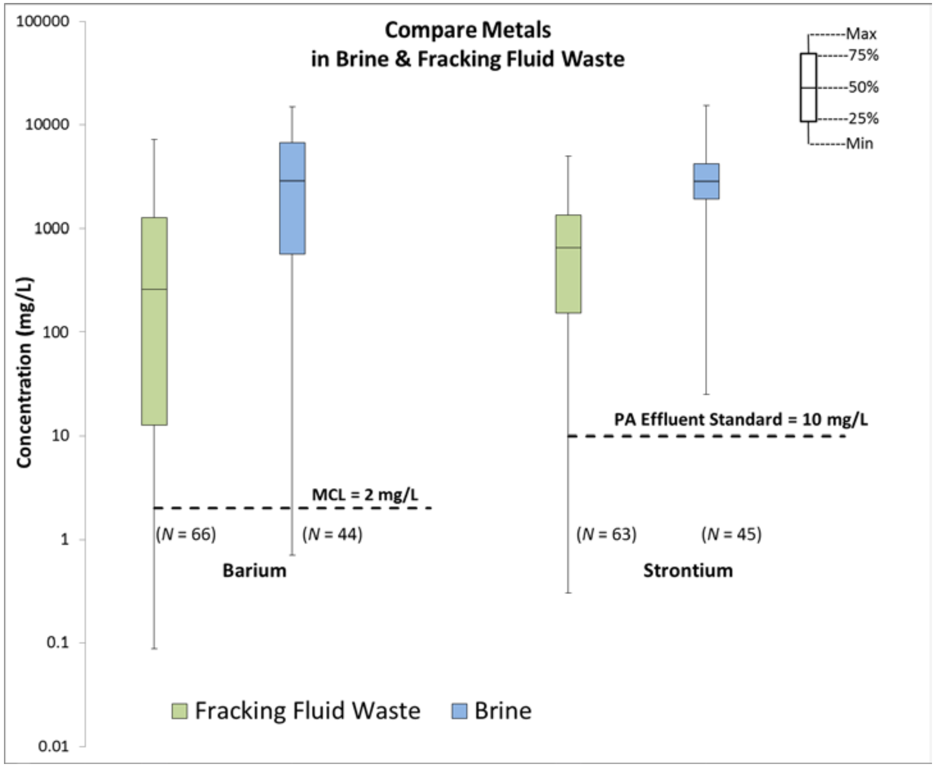
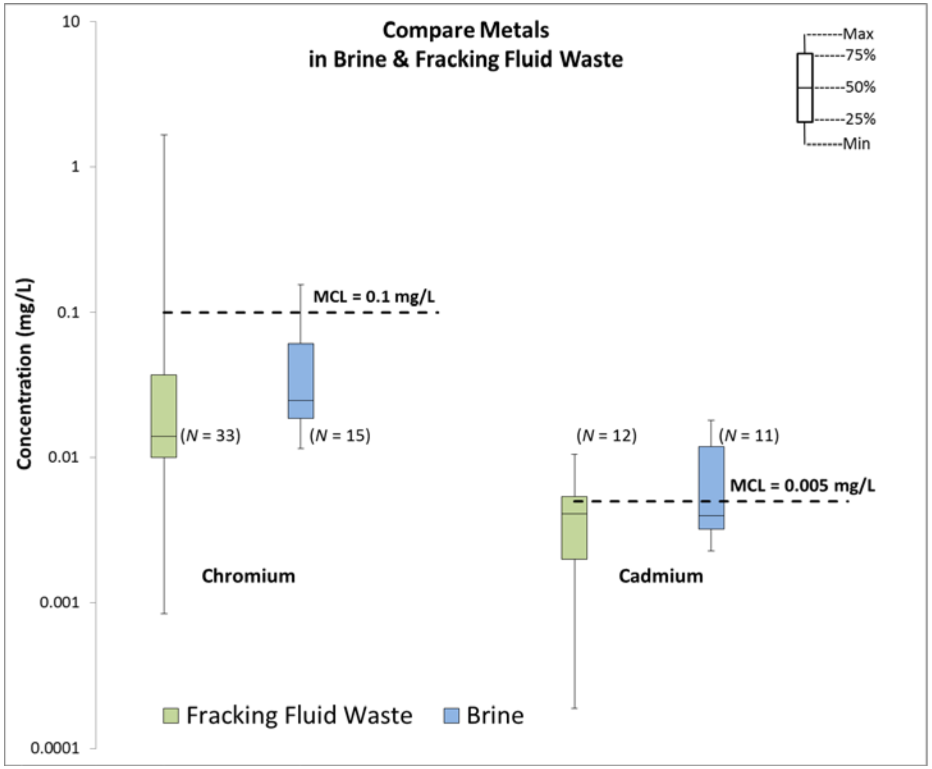


Compare Anions in Brine & Fracking Fluid Waste
Concentration (mg/L)
1000000
100000
10000
1000
100
10
1
0.1
0.01
0.001
0.0001
0.00001
Max
75%
50%
25%
Min
(N = 72)
(N = 62)
(N = 71)
(N = 58)
(N = 71)
(N = 60)
(N = 58)
(N = 52)
(N = 8)
(N = 68)
Sulfate
Bromide
Chloride
Nitrate
Phosphorus
Arsenic
Fracking Fluid Waste
Brine

Comparison of metals in brine and fracking fluid waste





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Findings from analysis of wastewater characteristics

- High chemical concentrations are observed pre-treatment.
  - When Ba is detected (92% of samples), median concentration is > 40 times PA's wastewater effluent standard and > 200 times the SDWA maximum contaminant level.
  - Concentrations of Cl^-, TDS, bromide, ^{228}Ra and Sr in pre-treatment wastewater are also far higher than either wastewater effluent standards or drinking water standards.
- Wastewater composition is highly variable over the course of the shale gas extraction process.
  - A challenge for effective treatment and management.
  - Form26 filed once/year/waste type/generating location.
- Produced water has very different composition than flowback, typically having higher Cl^-, TDS and ^{228}Ra concentrations.
- Many constituents may be effectively removed by chemical waste treatment facilities currently treating this waste (e.g., metals); others may not (e.g., salts).

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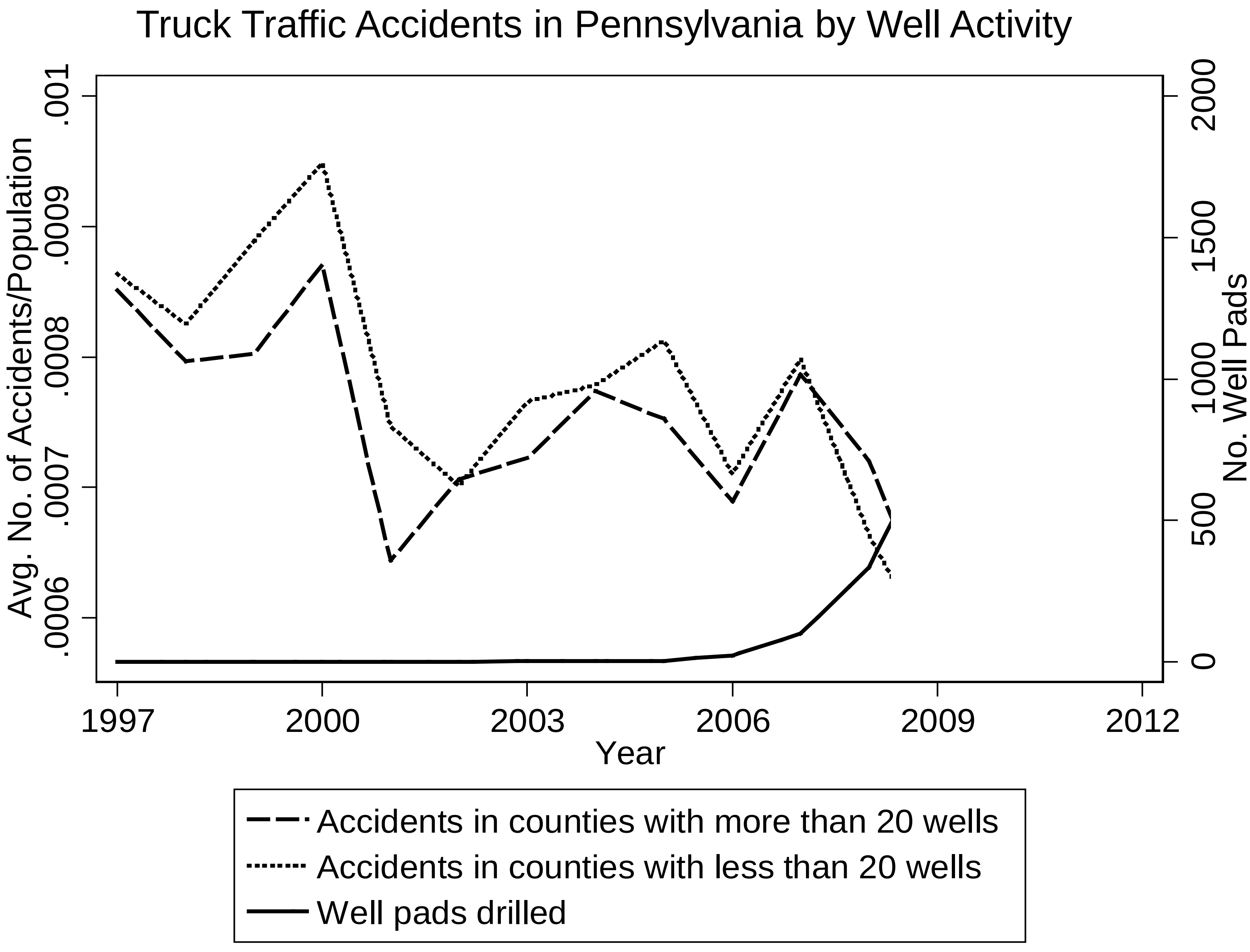
Truck Traffic Accidents in Pennsylvania by Well Activity
Avg. No. of Accidents/Population
.0006
.0007
.0008
.0009
.001
No. Well Pads
0
500
1000
1500
2000
1997
2000
2003
2006
2009
2012
Year
Accidents in counties with more than 20 wells
Accidents in counties with less than 20 wells
Well pads drilled

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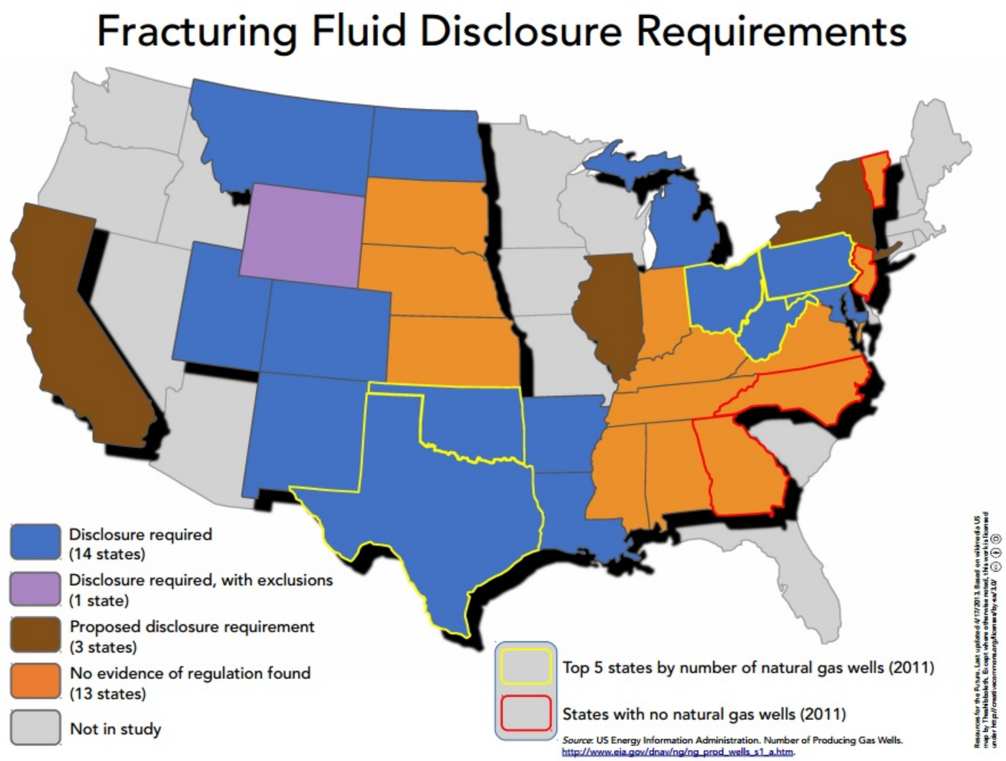
The state of state shale gas regulation

- Researchers: N. Richardson, M. Gottlieb, A. Krupnick, H. Wiseman
- 25 regulatory elements common to shale gas development across 31 states with current or potential development.



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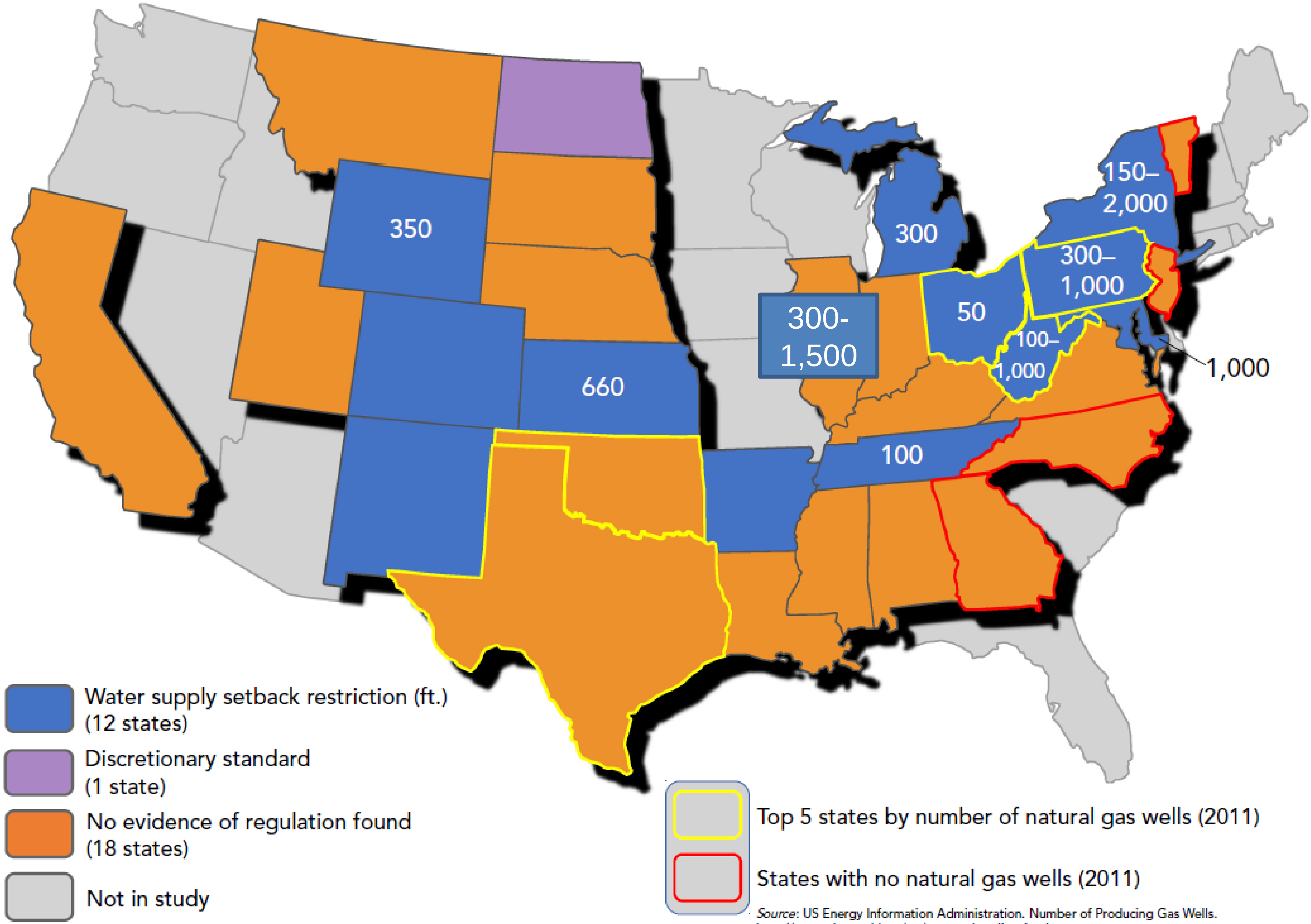
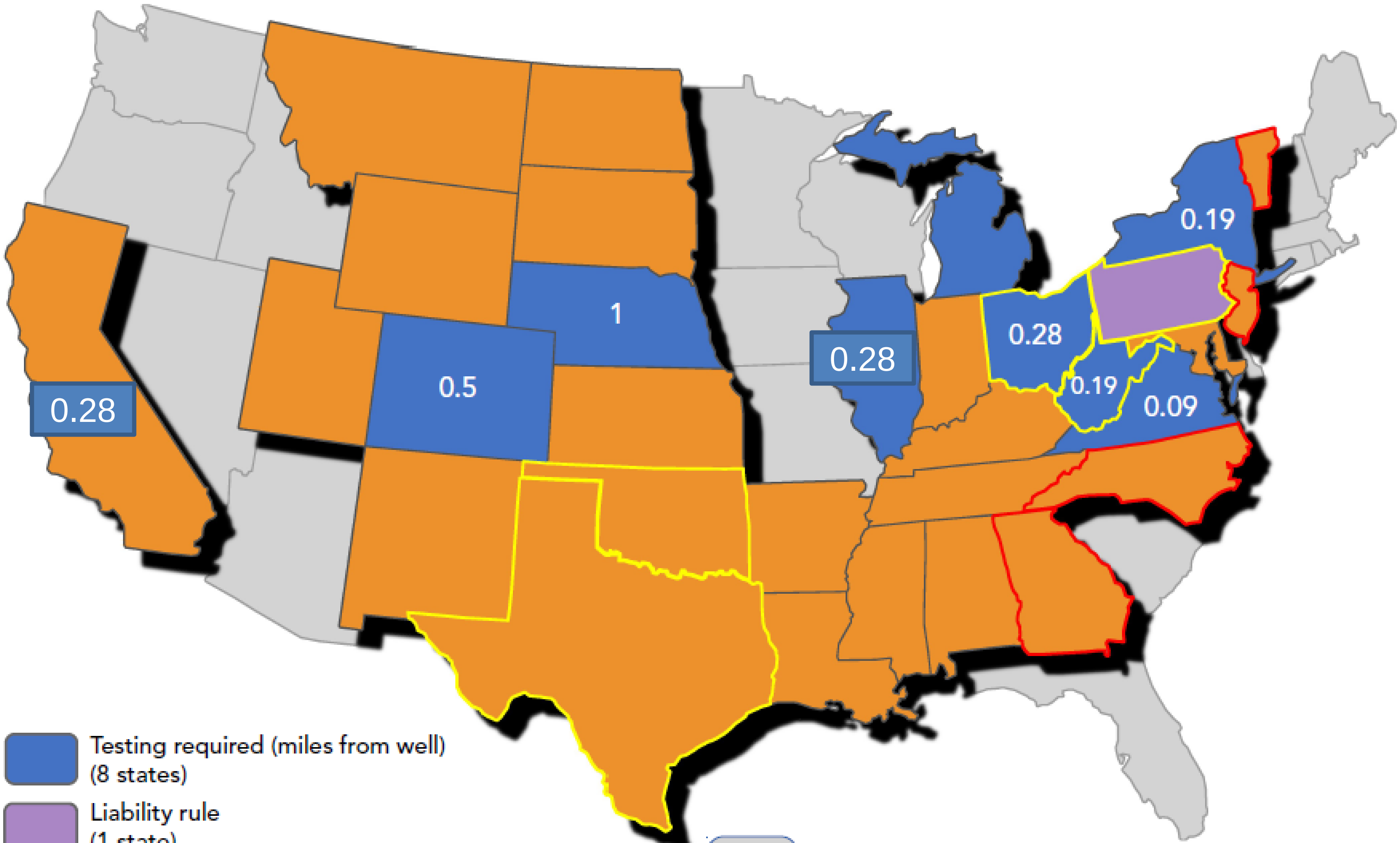
Setback Restrictions from Water Sources



Source: US Energy Information Administration. Number of Producing Gas Wells. http://www.eia.gov/dnav/ng/ng_prod_wells_s1_a.htm.

Pre-drilling Water Well Testing Requirements



Testing required (miles from well) (8 states)

Liability rule (1 state)

No evidence of regulation found (22 states)

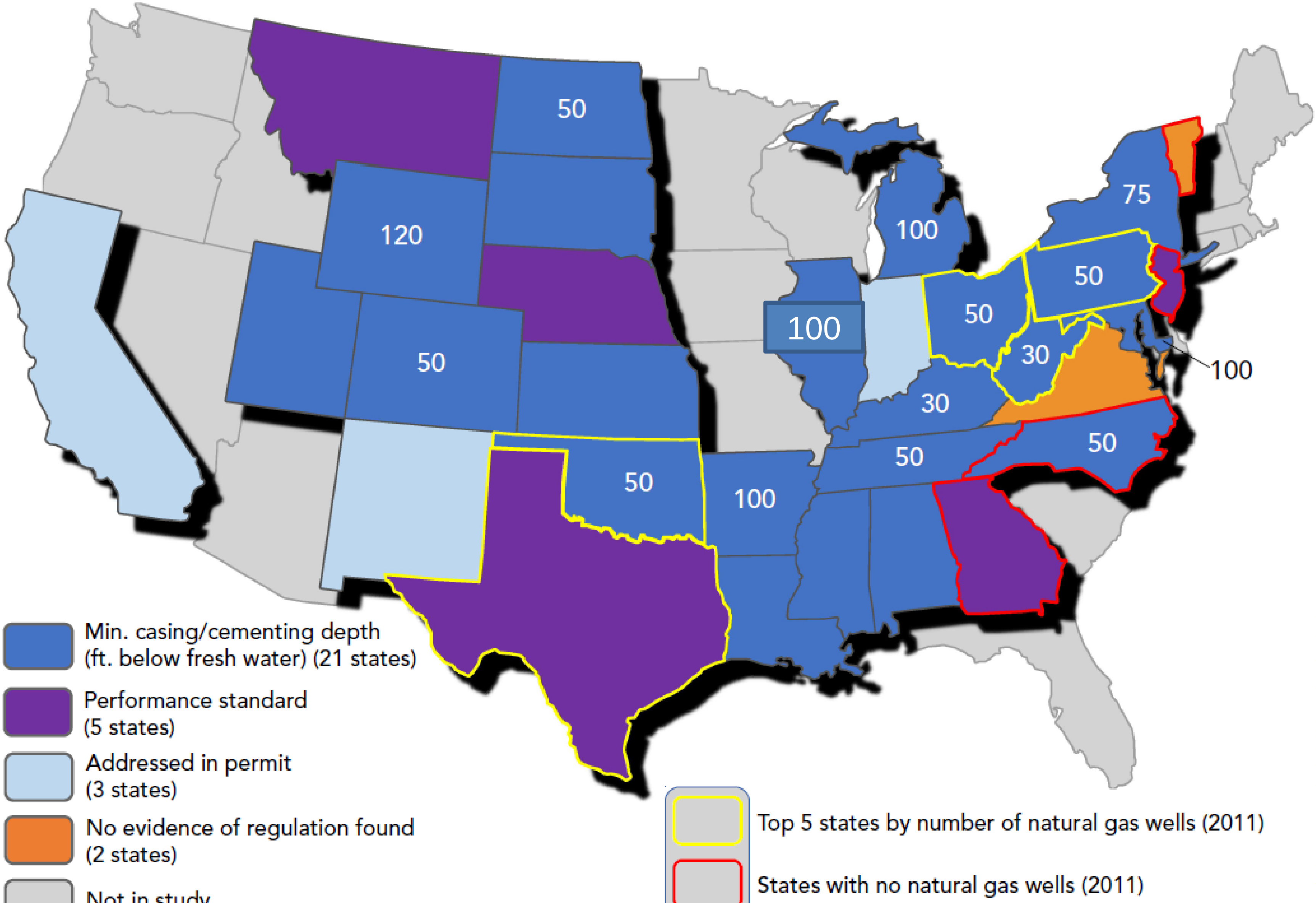
Not in study

Top 5 states by number of natural gas wells (2011)

States with no natural gas wells (2011)

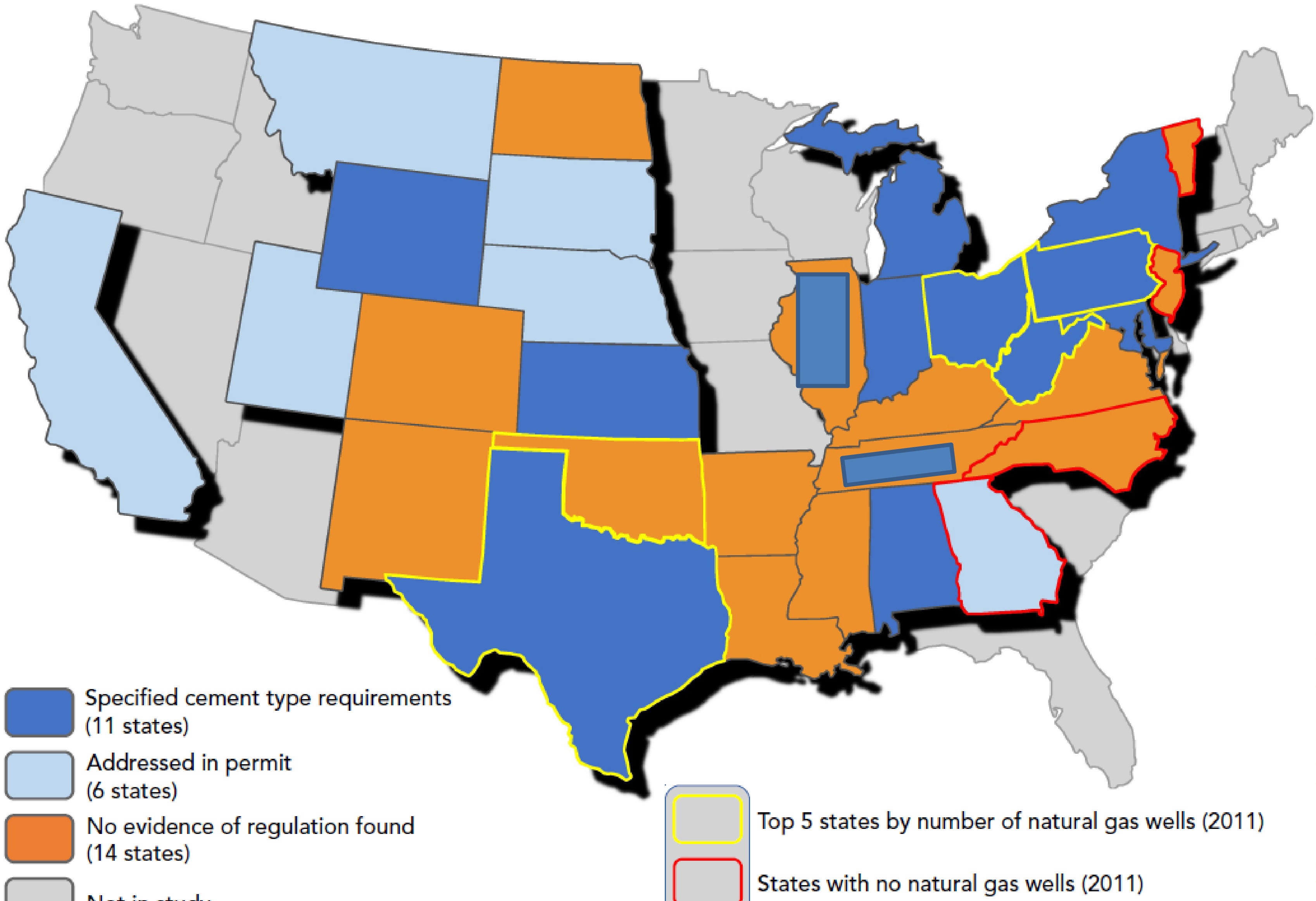
Source: US Energy Information Administration. Number of Producing Gas Wells. http://www.eia.gov/dnav/ng/ng_prod_wells_s1_a.htm.

Casing and Cementing Depth Regulations



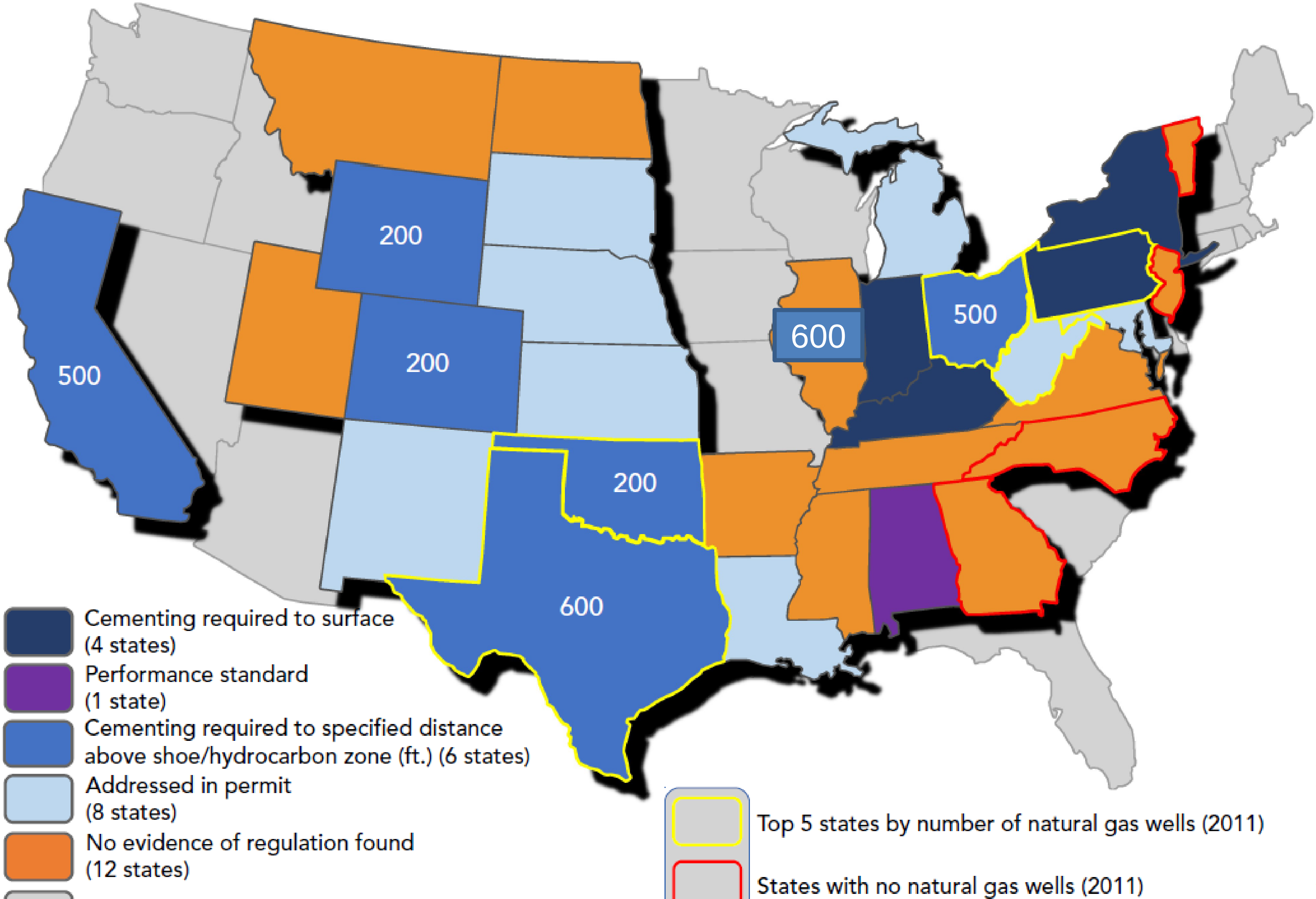
Source: US Energy Information Administration. Number of Producing Gas Wells. http://www.eia.gov/dnav/ng/ng_prod_wells_s1_a.htm.

Cement Type Regulations



Source: US Energy Information Administration. Number of Producing Gas Wells. http://www.eia.gov/dnav/ng/ng_prod_wells_s1_a.htm.

Intermediate Casing Cement Circulation Regulations



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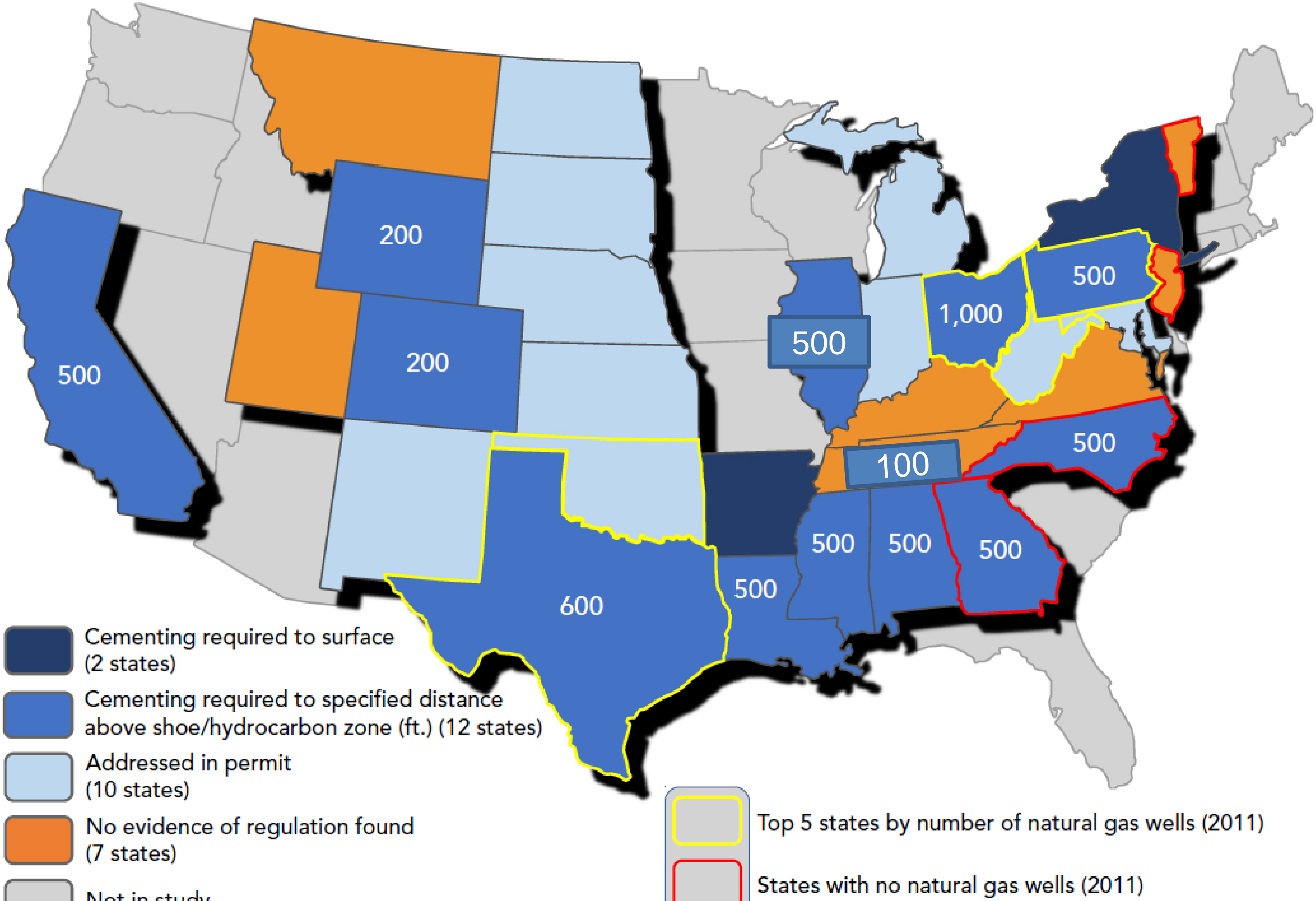
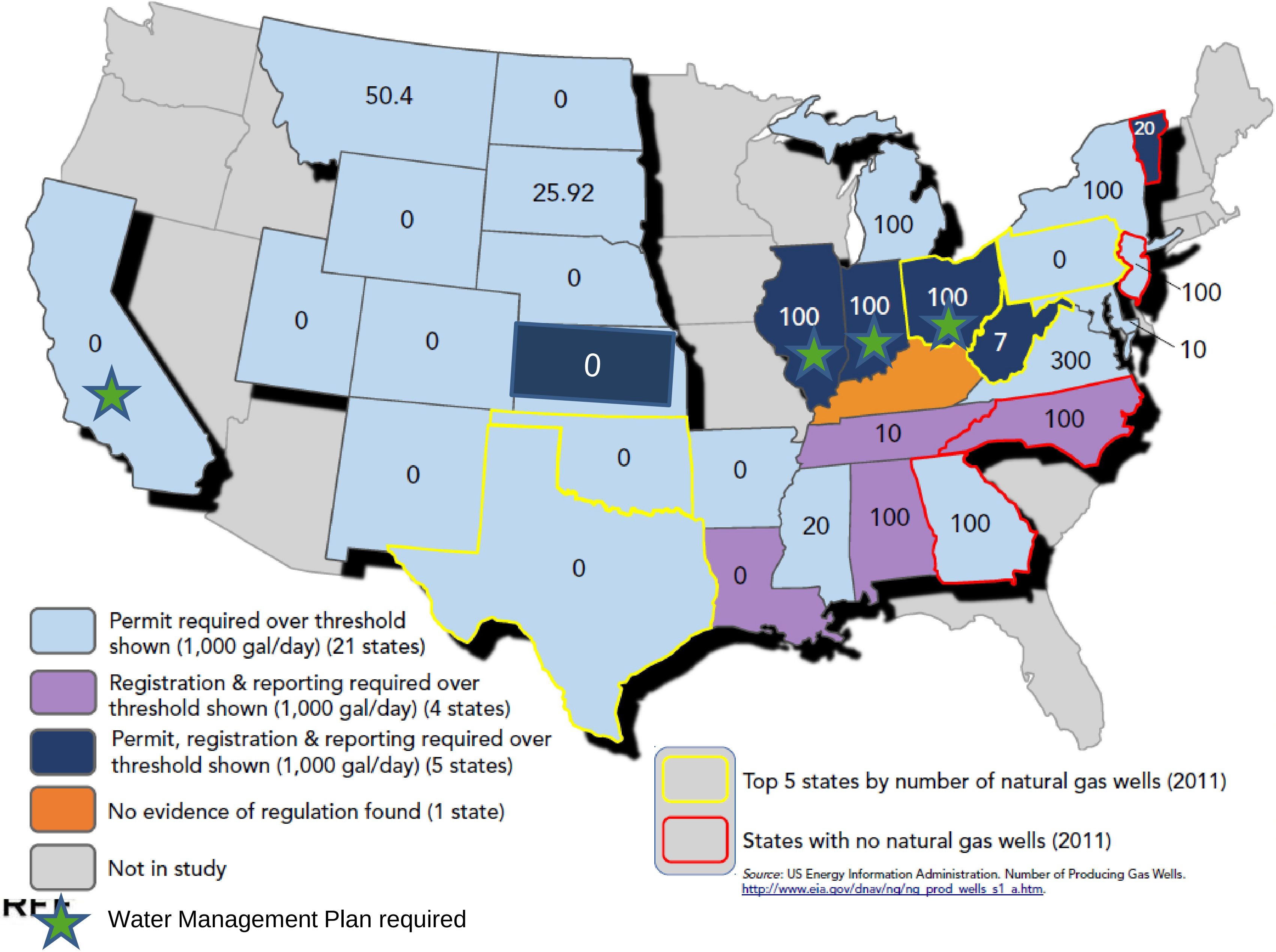
Production Casing Cement Circulation Regulations



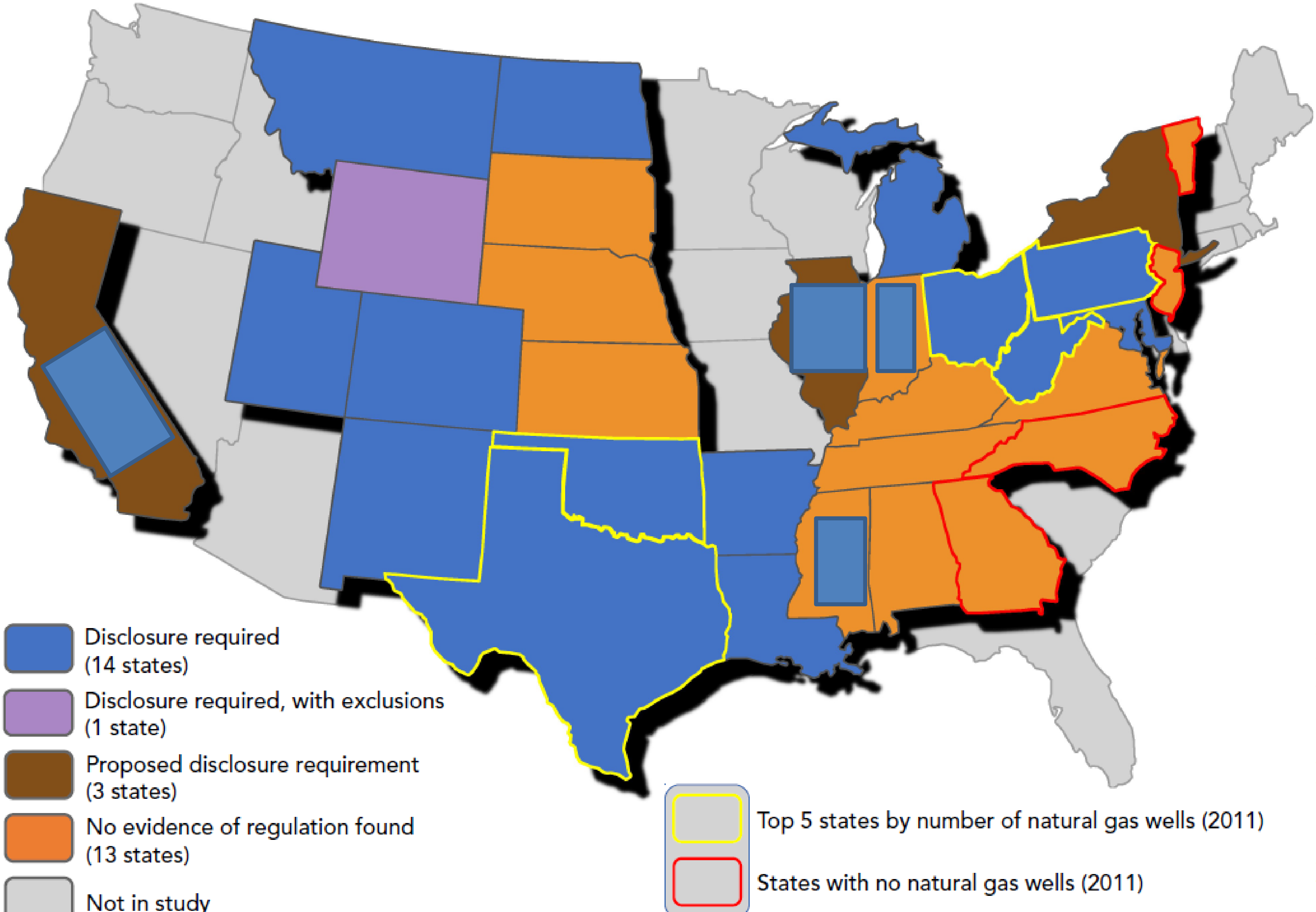
Source: US Energy Information Administration. Number of Producing Gas Wells. http://www.eia.gov/dnav/ng/ng_prod_wells_s1_a.htm.

Water Withdrawal Regulations



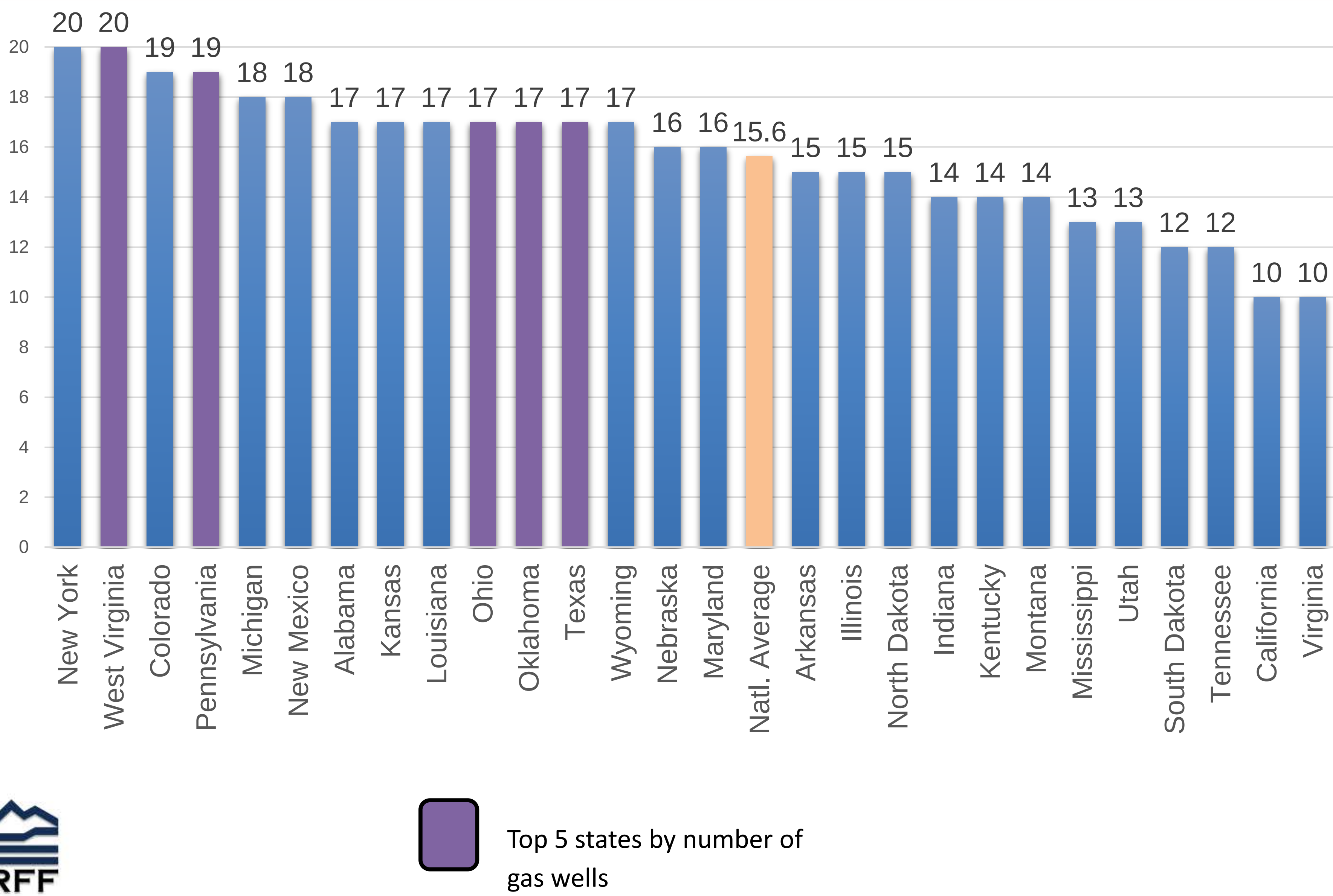
Source: US Energy Information Administration. Number of Producing Gas Wells. http://www.eia.gov/dnav/ng/ng_prod_wells_s1_a.htm.

Fracturing Fluid Disclosure Requirements



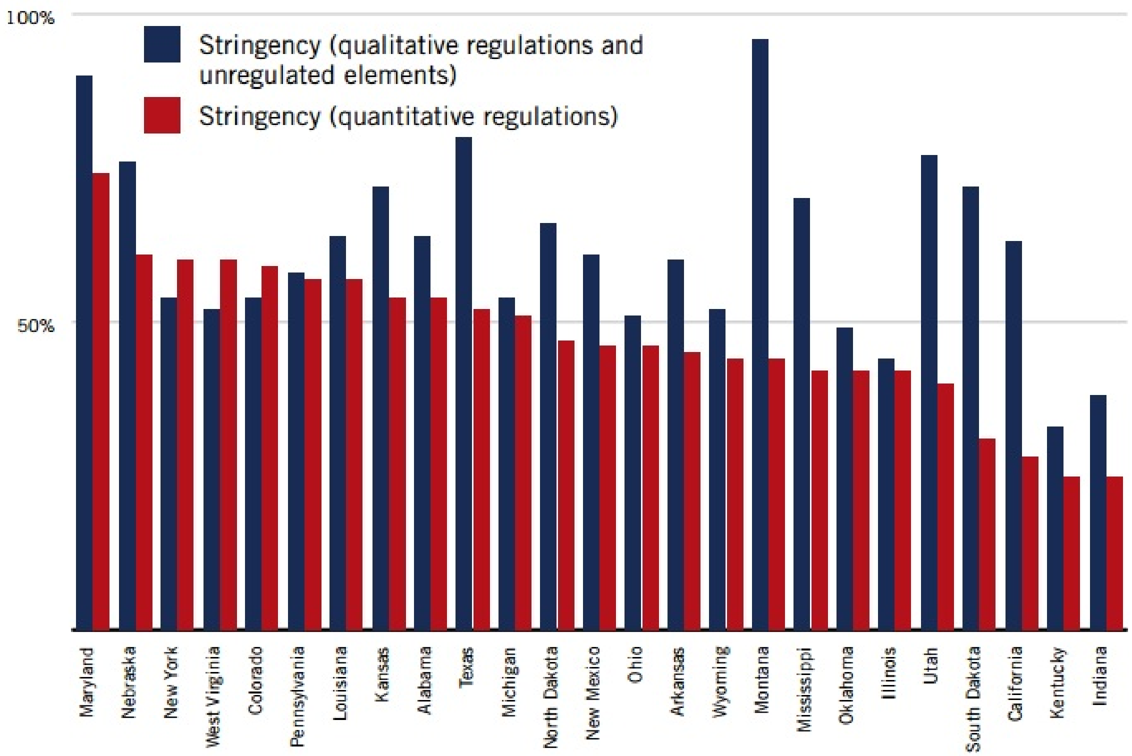
Source: US Energy Information Administration. Number of Producing Gas Wells. http://www.eia.gov/dnav/ng/ng_prod_wells_s1_a.htm.

Elements Regulated



Findings from state regulatory analysis

- High degree of heterogeneity among states in:
- Most elements regulated: NY, WV.
- Fewest elements regulated: CA, VA.
- The five states with the most gas wells regulate more elements than the national average.



Other points

- The States First initiative
- Federal: BLM weakened first set of proposed rules, opportunity to model best regs missed.
- Other federal: EPA's significant green completion rule helps address methane, but still a long way to go, as shown by the recent ICF/EDF report. Methane not that important anyway
- Need greater attention to local control. Bans and Act 13 repeal.
- Impact of regulations on the energy industry and local communities.
    - Impact on power sector;
    - obviously not impeding SGD. Leading to lots of pipeline construction and plans.
    - Impact on communities ➔ traffic, property value studies, NGI report.

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Thank you!

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Risk Matrix

Site Development and Drilling Preparation
After locating a site for shale gas development, the area must be excavated and prepared for drilling. Preparation activity also often includes leveling of the site.

Activity	Intermediate Impacts					
	Groundwater	Surface Water	Soil Quality	Air Quality	Habitat Disruption	Community Disruption
Clearing of land/construction of roads, well pads, pipelines, other infrastructure		Stormwater flows Invasive species	Stormwater flows	Conventional air pollutants and CO_2	Habitat fragmentation Invasive species	Industrial landscape Light pollution Noise pollution
On-road vehicle activity		Stormwater flows		Conventional air pollutants and CO_2	Other	Noise pollution Road congestion/accidents
Off-road vehicle activity		Stormwater flows		Conventional air pollutants and CO_2	Other	Noise pollution

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Drilling Activities
Drilling begins by boring a single well shaft vertically into the desired formation. One or more lateral wells are then drilled from the end of the vertical wellbore, angling to run horizontally through the shale formation.

Activity	Intermediate Impacts					
	Groundwater	Surface Water	Soil Quality	Air Quality	Habitat Disruption	Community Disruption
Drilling equipment operation at surface	Drilling fluids/cuttings	Drilling fluids/cuttings	Drilling fluids/cuttings	Conventional air pollutants and CO_2		Industrial landscape Light pollution Noise pollution
Drilling of vertical and lateral wellbore	Methane Drilling fluids/cuttings Intrusion of saline-formation water into fresh groundwater	Drilling fluids/cuttings		Methane		

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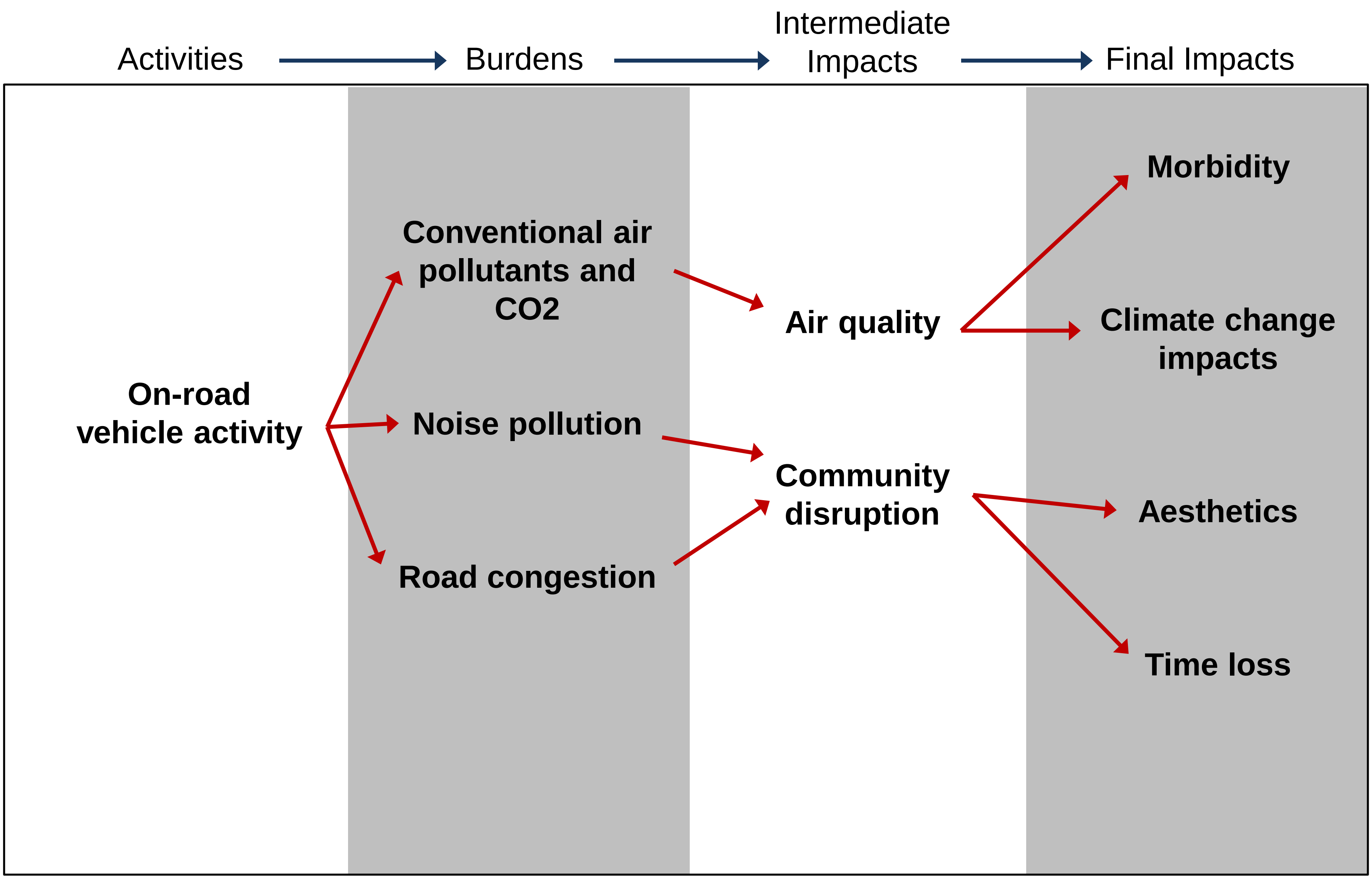
Example of Impact Pathways



Research on Environmental Risks

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Drilling of vertical and lateral wellbore	Methane Drilling fluids/cuttings Intrusion of saline-formation water into fresh groundwater	Drilling fluids/cuttings		Methane		

1. Expert survey of shale gas development risks

2. Statistical analysis:
   a) Effects of shale gas activity on surface water quality in Pennsylvania
   b) On property values
   c) Truck traffic on accidents
   d) Analysis of chemical assays of flowback/produced water

3. State-by-state regulatory analysis

4. Public Survey

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Surveying the Experts: Responsibility

Who should be responsible for managing risks?

	NGO	Industry	Academic	Gov't	All experts
Government	93.8%	49.4%	74.9%	74.8%	69.4%
Industry	6.2%	50.6%	25.1%	25.2%	30.6%

- All groups prefer shared responsibility
- For consensus pathways, majority of industry supports government responsibility

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