Methane in Well Water

- Evaluation of Methane Sources in Groundwater in Northeastern Pennsylvania
 - study examined over 1,700 water wells in gas-producing and non-gas producing areas, determining that "methane is ubiquitous in groundwater" in the region, and that it is unrelated to Marcellus Shale development.
 - over 78 percent of the sampled water wells exhibit detectable methane concentrations.
 - 3.4 % of the samples exceeded action levels recommended by the Pennsylvania Department of Environmental Protection.

Groundwater May 2013

Groundwater Contamination

- Shallow Groundwater Quality and Geochemistry in the Fayetteville Shale Gas-Production Area, North-Central Arkansas, 2011
 - examined the water quality of 127 shallow domestic wells
 - water-quality data focusing on
 - chloride concentrations
 - methane concentrations
 - carbon isotope ratios

—found no groundwater contamination associated with gas production

Groundwater Contamination

- several incidents in Colorado and Pennsylvania where gas drilling appears to have caused gas to get into drinking water. "Every one we identified was caused by a failure of the integrity of the well, and almost always it was the cement job," Mark Boling, executive vice president and general counsel of Southwestern Energy Co
- "The groundwater pollution incidents that have come to light to date have all been caused by well construction problems," A. Scott Anderson, a senior policy adviser with the Environmental Defense Fund

Potential Pathways for Hydraulic Fracturing Fluid and Formation Methane

- Abandoned Wells
- Surface Spills
- Well Casing Failure

Truth or Fiction? Hydraulic Fracturing uses Dangerous Chemicals





Chemicals Used

- Industry uses approximately 750 different chemicals in fracture stimulation
- Of these chemicals 29 chemicals are
 - (1) known or possible human carcinogens,
 - (2) regulated under the Safe Drinking Water Act
 - (3) listed as hazardous air pollutants under the Clean Air Act.
- Source: US House Committee Report on Chemicals Used in Hydraulic Fracturing, April 2011

Most Often Used Chemicals

		/
Table 1. Chemical Components Appearing Mos	t Often in	
Hydraulic Fracturing Products Used Between 20	005 and 2009	
Chemical Component		
Methanol (Methyl alcohol)		
Isopropanol (Isopropyl alcohol, Propan-2-ol)		
Crystalline silica - quartz (SiO2)		
Ethylene glycol monobutyl ether (2-		
butoxyethanol)		
Ethylene glycol (1,2-ethanediol)		
Hydrotreated light petroleum distillates		
Sodium hydroxide (Caustic soda)		

Hazardous Chemicals Used

Chemical Component Chemical Category	Category	# of Products
Methanol (Methyl alcohol)	НАР	342
Ethylene glycol (1,2-ethanediol)	НАР	119
Diesel	Carcinogen, SDWA, HAP	51
Naphthalene	Carcinogen, HAP	44
Xylene	SDWA,HAP	44
Hydrogen chloride (Hydrochloric acid)	НАР	42
Toluene	SDWA,HAP	29
Ethylbenzene	SDWA,HAP	28
Diethanolamine (2,2-iminodiethanol)	НАР	14
Formaldehyde	Carcinogen, HAP	12
Sulfuric acid	Carcinogen	9
Thiourea	Carcinogen	9
Benzyl chloride	Carcinogen, HAP	8
Cumene	НАР	6
Nitrilotriacetic acid	Carcinogen	6
Dimethyl formamide	НАР	5
Phenol	НАР	5
Benzene	Carcinogen, SDWA, HAP	3
Di (2-ethylhexyl) phthalate	Carcinogen, SDWA, HAP	3
Acrylamide	Carcinogen, SDWA, HAP	2
Hydrogen fluoride (Hydrofluoric acid)	НАР	2
Phthalic anhydride	НАР	2
Acetaldehyde	Carcinogen, HAP	1
Acetophenone	НАР	1
Copper	SDWA,HAP	1
Ethylene oxide	Carcinogen, HAP	1
Lead	Carcinogen, SDWA, HAP	1
Propylene oxide	Carcinogen, HAP	1
p-Xylene	НАР	1

Common Uses for Chemicals

Product	Purpose	Other Common Uses*
Water	Expand the fracture and deliver sand	Landscaping, manufacturing
Sand (Proppant)	Allows the fractures to remain open so that the natural gas and oil can escape	Drinking water filtration, play sand, concrete and brick mortar
Acid	Helps dissolve minerals and initiate cracks in the rock	Swimming pool and chemical and cleaner
Anti-bacterial Agent	Eliminates bacteria in the water that produces corrosive byproducts	Disinfectant; sterilizer for medical and dental equipment
Breaker	Allows a delayed breakdown of the gel	Used in hair coloring, as a disinfectant, and in the manufacture of common household plastics
Clay stabilizer	Prevents formation clays from swelling	Used in low-sodium table salt substitute, medicines, and <u>IV fluids</u>

Common Uses for Chemicals

Product	Durnose	Other Common Uses*
Corrosion		Used in pharmaceuticals, acrylic fibers
inhibitor	Prevents corrosion of the pipe	and plastics
Crosslinker	Maintains fluid viscosity as temperature increases	Used in laundry detergents, hand soaps and cosmetics
Friction reducer	Slicks the water to minimize friction	Used in cosmetics including hair, make- up, nail and skin products
Gelling agent	Thickens the water in order to suspend the sand	Cosmetics, baked goods, ice cream, toothpaste, sauces and salad dressings
Iron control	Prevents precipitation of metal in the pipe	Food additive; food and beverages; lemon juice
pH Adjusting Agent	Maintains the effectiveness of other components, such as crosslinkers	Laundry detergents, soap, water softener and dishwasher detergents
Scale inhibitor	Prevents scale deposits downhole and in surface equipment	Used in household cleansers, deicer, paints and caulk
Surfactant	Used to increase the viscosity of the fracture fluid	Glass cleaner, multi-surface cleansers, antiperspirant, deodorants and hair-color

Truth or Fiction? Hydraulic Fracturing Releases Methane to the Atmosphere



• Allegation-

 hydraulic fractured wells leak 40 to 60 % more methane than conventional wells¹

• Fact-

 hydraulic fracturing accounts for only 3.6% of released methane from drilling operations²

Climatic Change (2011) 106;679-690
Environmental Research Letters 7(4):044030,2012

American Petroleum Institute (API) and America's Natural Gas Alliance (ANGA)

- Methane emissions are 50 percent lower than EPA's estimates.
- Venting of methane into the atmosphere during liquids unloading is 86 percent lower than EPA's estimates.
 - Emissions from well re-fracturing are 72 percent lower than EPA estimates, and well re-fracture rates are significantly lower than EPA estimated.
- EPA estimated the re-fracture rate at 10 percent of active wells, but the actual rate ranged from 0.7 percent to 2.3 percent.

Massachusetts Institute of Technology

 "It is incorrect to suggest that shale gas-related hydraulic fracturing has substantially altered the overall [greenhouse gas] intensity of natural gas production."

Different Studies Different Answers



Truth or Fiction? We Need More Regulation at the Federal Level

Regulatory Oversight

- Responsibility for regulating flowback fluid lies with one or more state regulatory agencies, depending on the state.
- In 9 states, jurisdiction over waste management for oil and gas exploration and production activity involves more than one agency.

EXHIBIT 39: CURRENT PRODUCED WATER MANAGEMENT BY SHALE GAS BASIN.			
Shale Gas Basin	Water Management Technology	Availability	Comments
Barnett Shale	Class II Injection Wells	Commercial and non- commercial	Disposal into the Barnett and underling Ellenberger Group
	Recycling	On-site treatment and recycling	For re-use in subsequent fracturing jobs
Fayetteville Shale	Class II Injection Wells	Non-commercial	Water is transported to two injection wells owned and operated by a single producing company
	Recycling	On-site recycling	For re-use in subsequent fracturing jobs
Haynsville Shale	Class II Injection Wells	Commercial and non- commercial	
Marcellus Shale	Class II Injection Wells	Commercial and non- commercial	Limited use of Class II injection wells
	Treatment and discharge	Municipal waste water treatment facilities, commercial facilities reportedly contemplated	Primarily in Pennsylvania
	Recycling	On-site recycling	For re-use in subsequent fracturing jobs
Woodford Shale	Class II Injection Wells	Commercial and non- commercial	Disposal into multiple confining formations
	Land Application		Permit required through the Oklahoma Corporation Commissio9n
	Recycling	Non-commercial	Water recycling and storage facilities at a central locations
Antrim Shale	Class II Injection Wells	Commercial and non- commercial	
New Albany Shale	Class II Injection Wells	Commercial and non- commercial	

From Modern Shale Gas Development in the United States: A Primer

Federal Laws Applicable to Drilling

- The Clean Water Act (CWA) regulates discharges of pollutants to surface water and storm water runoff.
- The Safe Drinking Water Act (SDWA) regulates injection of fluid wastes (produced water) under the ground.
- The Clean Air Act (CAA) sets rules for
 - air emissions from engines, gas processing equipment, tanks and other sources associated with production and drilling activities.
- The National Environmental Policy Act (NEPA) requires environmental impact assessments
- for development of federal lands.
- Occupational Safety and Health Act –, sets safety standards, requires Material Safety Data Sheets for chemicals used on locations for employee use.
- Emergency Planning & Community Right-to-Know Act (EPCRA) requires storage of regulated chemicals above certain quantities be reported to local and state emergency responders on an annual basis.

Truth or Fiction? Hydraulic Fracturing Causes Earth Quakes (induced seismicity)



Induced Seismicity

- What is Induced Seismicity?
 - Seismic activity that is related to human activities
- What is a micro Seismic event?
 - magnitude less than 2.0



Studies

- U.S. Geological Survey (USGS)
 - "no evidence to suggest that hydraulic fracturing itself is the cause of the increased rate of earthquakes" (Hayes, 2012).
- (Zoback, 2012).
 - "the pressurization during hydraulic fracturing affects only limited volumes of rock (typically several hundred meters in extent) and pressurization typically lasts only a few hours"
 - Induced Seismicity Potential in Energy Technologies, National Academy of Sciences

Induced Seismicity

- No instances of induced seismicity(M >3.0)has been detected
- 2 instances have been attributed to Hydraulic Fracturing
 - Cuadrilla Resources in the UK (2.3 magnitude)
 - Eola Field, Oklahoma (2.8 magnitude)
- In both cases the fracture stimulations affected existing fault lines

Observations of Induced Seismicity

	Global	United States
Waste water injection	11	(9)
Oil and gas extraction (withdrawal)	38	(20)
Secondary recovery (water flooding)	27	(18)
Geothermal energy	25	(3)
Hydraulic fracturing (shale gas)	2	(1)
Surface water reservoirs:	44	(6)
Other (e.g. coal and solution mining)	8	(3)

Induced Seismicity Potential in Energy Technologies (2012), National Academy of Sciences

Truth or Fiction? Hydraulic Fracturing Squanders Water Resources



Statistics

- 2-4 million gallons to hydraulically fracture a single well,
 - 30-70 percent of that water is lost
 - » Kansas Geological Survey, Public Information Circular (PIC) 32



What Does 4 Million Gallons of Equal?

- Texas golf course every eight days during the summer. Source: hillcountrywater.org
- irrigate enough cornfields to produce 5,100 gallons of ethanol. Source: USDA Farm and Ranch Irrigation Survey
- 64 tons of steel. Source: U.S. Geological Survey
- Used annually by 40 American households for indoor uses only. Source: Sustainable Asset Management
- Used annually for outdoor watering by 90 typical American households. Source: U.S. Environmental Protection Agency
- Used by New York City every six minutes. Source: New York City Department of Environmental Protection