

Potential Ecological Effects of Marcellus Shale Activities

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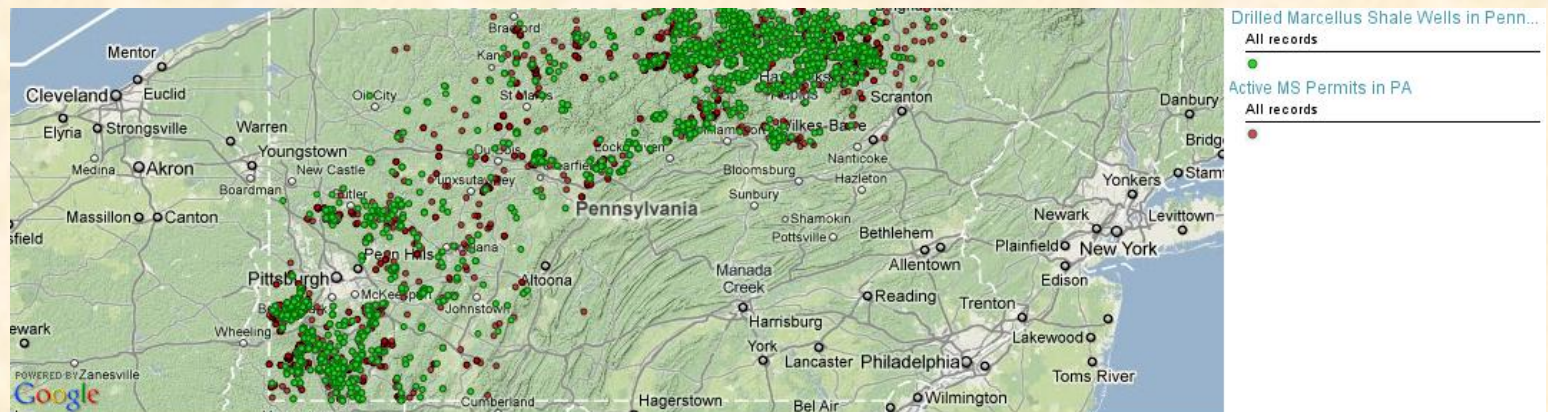
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The Ground Work..

- All extractive industries have environmental costs
- “Problem or not” is the wrong approach
- The degree to which we are willing to gamble is the question
- Prudence: the ability to govern and discipline by the use of reason or good judgment
 - In other words, “if you pursue one objective without regard to other consequences that the decision might have, you are likely to do something very bad” –Dr. Tony Ingrafea
- Precautionary principle of public health and classic sustainability
- Horizontal fracturing is still in an “I don’t know phase”
- Not a panacea, humans are terrible at foresight

Pennsylvania is a resource state and it shows!

- Coal
- Timber
- Agriculture
- Oil & Gas
- Iron
- Limestone
- Water



Conceptual Model with Pathways

Water/Air/Land/Infrastructure

Fresh water usage

Land/Air/Noise/Infrastructure

Transportation

Land/Air/Noise/Light

The Drilling

Air/ Land use

Pipelines

Land/Infrastructure

Waste Stream

Condensate

Air/Land

Surface Impoundments

Water/Infrastructure

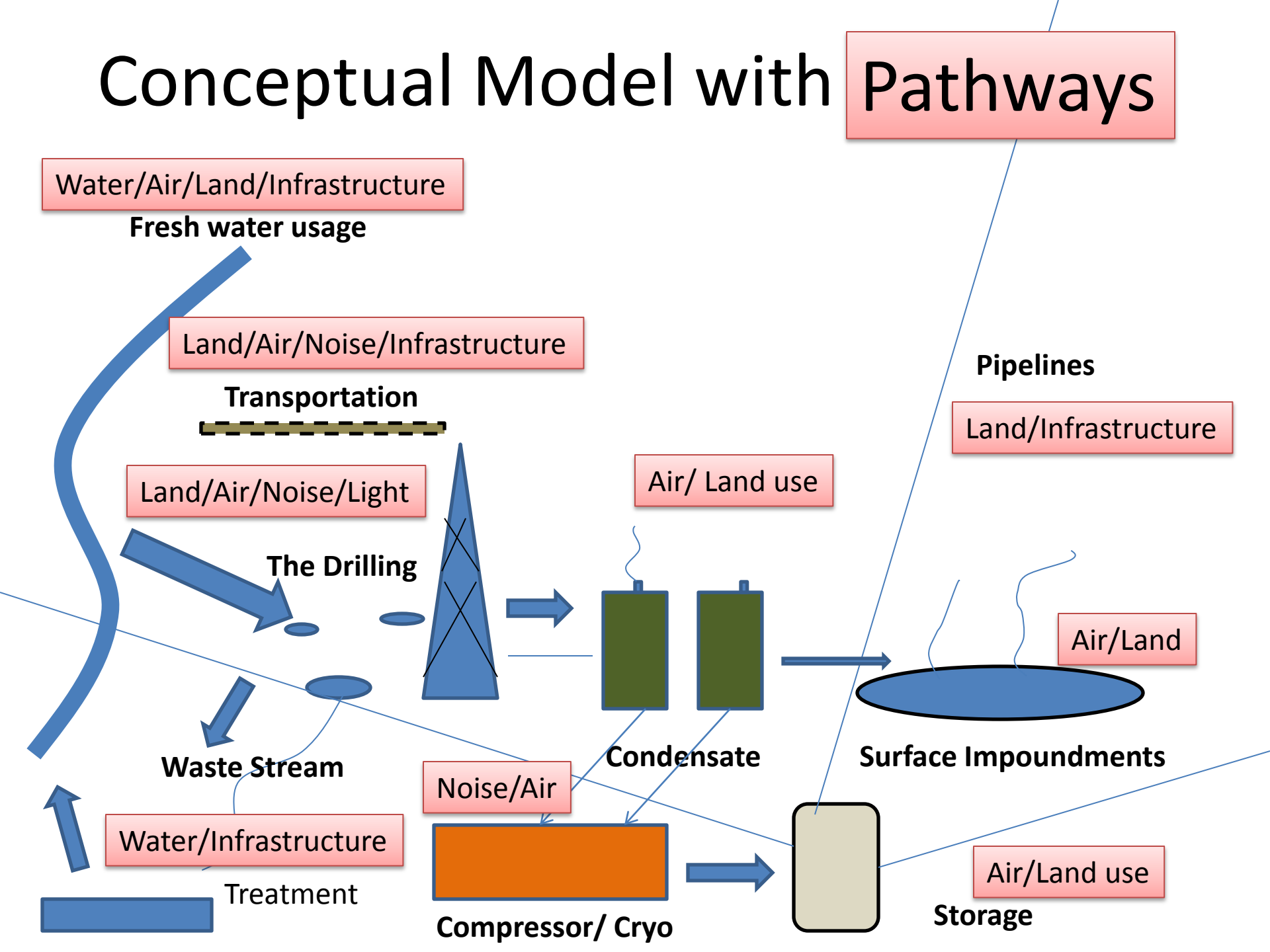
Noise/Air

Air/Land use

Treatment

Compressor/ Cryo

Storage



Environmental/Ecological Summary

- Environment: aggregate of things, conditions or influences; surroundings
- Ecology: air, water, minerals, organisms, and all other external factors effecting a receptor at a given time
- Water use, reuse, management, recycling
- Air fugitive emissions, diesel engines, gas is cleaner as fuel compared to coal & oil
- Land use, landscapes
- Noise
- Light
- Social environment
- Economical
- Inputs vs. Outputs (e.g., benefits and sustainability)

Ecological Impacts - Water

- Amount of water needed ~ 3-5 million gallons per fracture process
 - Average tanker holds 4,625 gallons ~ 200 trucks/million gallons
- Loss of well (aquifer) water through disruption or contamination
- Gas migration leading to methane contamination
- Fate of flowback and produced waters (POTWs)
- Water quality of local hydrography

Ecological Impacts – Land Use

- Large amount of acreage needed for well pads, impoundments and pipelines
- Visual, property values, other industries (e.g., tourism)
- Leased areas - former private and public lands become restricted areas
- Flattening of landscapes
- Removal of forest lands – erosion
- 4-6 acres per well pad, up to 16 wells per pad



Ecological Impacts – Air

- Increased vehicle and machinery emissions
- Well flaring
- VOCs from well installations
 - Condensation tanks openly vented by design
- Compressor stations
- Offgasing from
- condensate and
- storage tanks
- Vs. oil and coal



Ecological Impacts – Chemical Use

- Fracking fluids (How many carcinogens?)
- Produced water contaminated with organics, salts, heavy metals and NORMs
- Improper casing/cements
- Spills, illegal dumping
- Proprietary nature



Environmental Impacts - Infrastructure

- Significant increase in heavy truck traffic on secondary and township roadways and bridges
- Trucks may exceed weight and height limits
- Temporary roadway construction
- Rapid social change (e.g., services demanded)
- Pittsburgh has some of the worst infrastructure in the US



Environmental Impacts - Noise

- Heavy drilling equipment noise
- Increase heavy truck traffic
- Chronic noise from compressor stations and further processing plants
- Drilling is a 24/7 operation, and it doesn't end there



Environmental Impacts – Climate Change

- Methane is over 20 times more effective in trapping heat in the atmosphere compared to CO₂
- Deforested areas minimizing carbon sink
- Better than coal and oil we think

Other Environmental Impacts

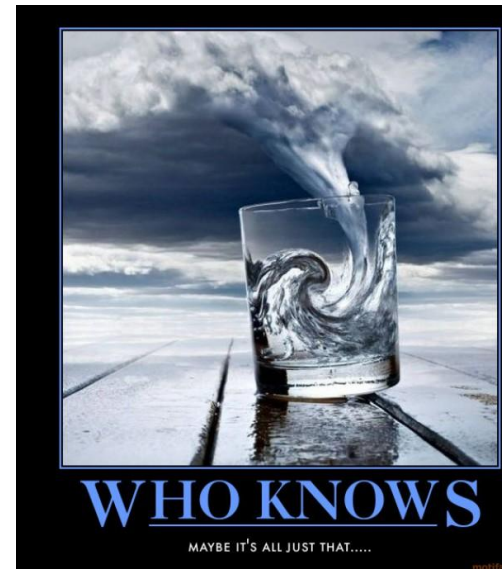
- Light pollution
 - Drilling is a 24/7 process until fracturing
- Mortgages and home equity loans jeopardized by presence of wells
- Property value
- Mine subsidence insurance compromised
- Adequate emergency response?
- *Unknown* exposures? (e.g., proprietary mixtures)

There will be Unknowns

- “During the first eight months of 2011, 65 Marcellus wells were cited for faulty casing and cementing practices - one more than was recorded in all of 2010¹.”
- Best practice to predict impacts prospectively rather than retrospectively
- PennDOT reported about 400 miles of road damage from Marcellus shale activity in 2010, only 10 miles in 2011²
- Fish kills, contamination, disease clusters, lawsuits
- And who really knows?

¹Read more: <http://thetimes-tribune.com/news/dep-inspections-show-more-shale-well-cement-problems-1.1205108#ixzz1YPQdC0A6>

²<http://online.wsj.com/article/AP0c211167e30b46baba29a0b154e9389f.html>



Cumulative Impacts over Time

- 300,000 oil and gas wells in PA
- PADEP does not know the location of about 100,000
- As of 9/8/2011 there have been 3,656 Marcellus wells drilled in PA
- The first 6 months yielded 34 million barrels of MS waste as reported by the PADEP
- “intense development”
 - Immediately says industry
 - Industry – developing 70% of every square mile of NY where extraction is feasible
 - 8 pads every square mile
 - 10s of thousands of wells
 - Cumulative impact not just over space, but over time
 - Over period of 5 – 10 years

Intensity & Cumulative Effects

- 10s of thousands of wells in PA – 44,000??
- “400,000 Marcellus wells in 3 state area”
 - Dr. Tony Ingraffea
- Billions of gallons of waste fluid
- Violations – over 1,000 in 2009 (PADEP 2011)
- Likelihood of risk increases with each individual
 - Basic probability

Water Research

- Water withdrawals in a single watershed, surface contamination, treatment/ disposal³
- Slickwater (injected), mixes with oil field brine (natural), these two combine to equal frac or flowback water
- Flowback (5 flowback samples, 26R waste reports)⁴
 - pH 5-8
 - Na/Ca/Cl dominated brines - extremely salty
 - Distinguishable from seawater (signature)
 - TDS: 1,850 to 345,000 mg/L
 - Ba and Sr concentrations as high as 26,800 and 5,230 mg/L respectively

³Soeder, D.J. & Kappel, W.M. (2009). Water resources and natural gas production from the Marcellus gas. Retrieved from <http://www.geology.com/usgs/marcellus-shale/>

⁴Kirby, S. C., Inorganic Geochemistry of Marcellus Shale Hydrofracturing Waters., Presented at the University of Pittsburgh GSPH Conference on Health Effects of Shale Gas Extraction: What is Known and What can We Predict

Fluid Waste

- In the first 6 month of 2011:
 - 34 million barrels barrels of MS waste in PA alone
 - 8x more than 2nd half of 2010
 - Brine, frac fluid, drill cuttings, sediment
 - Landfilled, numerous waste management companies, POTW, reuse and recycled
 - 29 million barrels recycled or reused
 - 3 million barrels taken to 15 treatment plants (stopped since May)
 - 800,000 deep well injected into wells in Ohio
 - State reporting requirements changing
 - Transportation of wastes – open rail cars and barges

Air Research

- Can PA handle additional burden to air quality?
- PADEP preliminary sampling in SWPA
 - 48 VOCs, CO, NO_x sampled at all major process points
 - Methane, ethane, propane and some benzene (compressor stations predominately)
 - “Air near Marcellus drilling sites is safe⁵”
 - Sampling was no longer than 4 days at each location at 8 hour and 24 hour times frames
- Work by Robert Field, et al has recorded ozone and methane levels above NAAQS in Wyoming and has attributed spatial and temporal variability to local oil and gas activity⁶

⁵WBNG, DEP Says Air Near Marcellus Drilling Sites Is Safe (Jan. 31, 2011) available at:

<http://www.wbng.com/news/local/DEP-Says-Air-Near-Marcellus-Drilling-Sites-Is-Safe-114951289.htm>

⁶Field, Robert, Air Monitoring Strategies. Presented at the University of Pittsburgh GSPH Health Effects of Shale Gas Extraction: What is Known and What can we Predict, University Club, 123 University Place, Pgh, PA November 19, 2010

Air Impacts in Other Areas

- In Dallas-Fort Worth area (Barnett Shale), annual emissions from oil and gas sector exceed emissions from motor vehicles
- 2008 analysis by Colorado Department of Health and Environment concluded that smog-forming emissions exceed motor vehicle emissions for entire state
- Wyoming recently failed to meet NAAQS for Ozone for the first time in the state's history. Oil and gas sector to blame claims WDEQ

Air Caveats

- Numerous point sources or area sources?
- Monitoring based on ambient air not emission sources
- Texas – continuous chromatography
 - Heavy resources
- Lifecycle analysis is necessary
 - Extraction
 - Refinement/processing
 - Transportation
 - Combustion
 - Waste disposal
- Natural gas can be a benefit to areas that burn oil for instance
 - 2,600 NYC Housing Authority buildings are switching to natural gas

Land Use/Landscapes

- Disruption of habitats - 4-6 acres per pad
- Agricultural areas
- Forested areas (Allegheny National Forest)
- Scenic viewsheds
- Local site planning needed
- Road use agreements with authorities
- Numerous legacy contamination in PA

- 88,350 sq. ft.
- Pad size: 15,450 sq. feet



⁷Upaddhay, R., S, Bu, M. Visual Impacts of Natural Gas Drilling in the Marcellus Shale Region, Cornell U. Dept. of City and Regional Planning: CRP 3072 Land Use, Environmental Planning And Urban Design Workshop, Fall 2010

Learn from PA?

- 3,656 MS wells, 7,222 active permits (end of August 2011)
- Without adequate environmental research and regulatory oversight, PA will be making the same choice as the gas boom of the mid 1880s – leaving environmental damages to the next generation.

Is it Safe?

- “Is driving a car safe” – Carl S. Kirby PhD
- For more information:
 - Fractracker.org
 - CHEC.pitt.edu
 - Pipeline PG (twitter)
 - PADEP Oil and Gas
 - GASP.org

References

1. Read more: <http://thetimes-tribune.com/news/dep-inspections-show-more-shale-well-cement-problems-1.1205108#ixzz1YPQdC0A6>
2. <http://online.wsj.com/article/AP0c211167e30b46baba29a0b154e9389f.html>
3. Soeder, D.J. & Kappel, W.M. (2009). Water resources and natural gas production from the Marcellus gas. Retrieved from <http://www.geology.com/usgs/marcellus-shale/>
4. Kirby, S. C., Inorganic Geochemistry of Marcellus Shale Hydrofracturing Waters., Presented at the University of Pittsburgh GSPH Conference on Health Effects of Shale Gas Extraction: What is Known and What can We Predict
5. WBNG, DEP Says Air Near Marcellus Drilling Sites Is Safe (Jan. 31, 2011) available at:
6. <http://www.wbng.com/news/local/DEP-Says-Air-Near-Marcellus-Drilling-Sites-Is-Safe-114951289.htm>
7. Field, Robert, Air Monitoring Strategies. Presented at the University of Pittsburgh GSPH Health Effects of Shale Gas Extraction: What is Known and What can we Predict, University Club, 123 University Place, Pgh, PA November 19, 2010
8. Upaddhay, R., S, Bu, M. Visual Impacts of Natural Gas Drilling in the Marcellus Shale Region, Cornell U. Dept. of City and Regional Planning: CRP 3072 Land Use, Environmental Planning And Urban Design Workshop, Fall 2010
9. Group Against Smog and Pollution: <http://gasp-pgh.org/>