

Emissions Inventory & Ambient Air Monitoring of Natural Gas Production in the Fayetteville Shale

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The Fayetteville Shale Air Quality study was performed by the Arkansas Department of Environmental Quality. David Lyon's current affiliation is with Environmental Defense Fund (EDF), which was not involved with this study. Consequently, this paper does not necessarily reflect the views of EDF.



Introduction

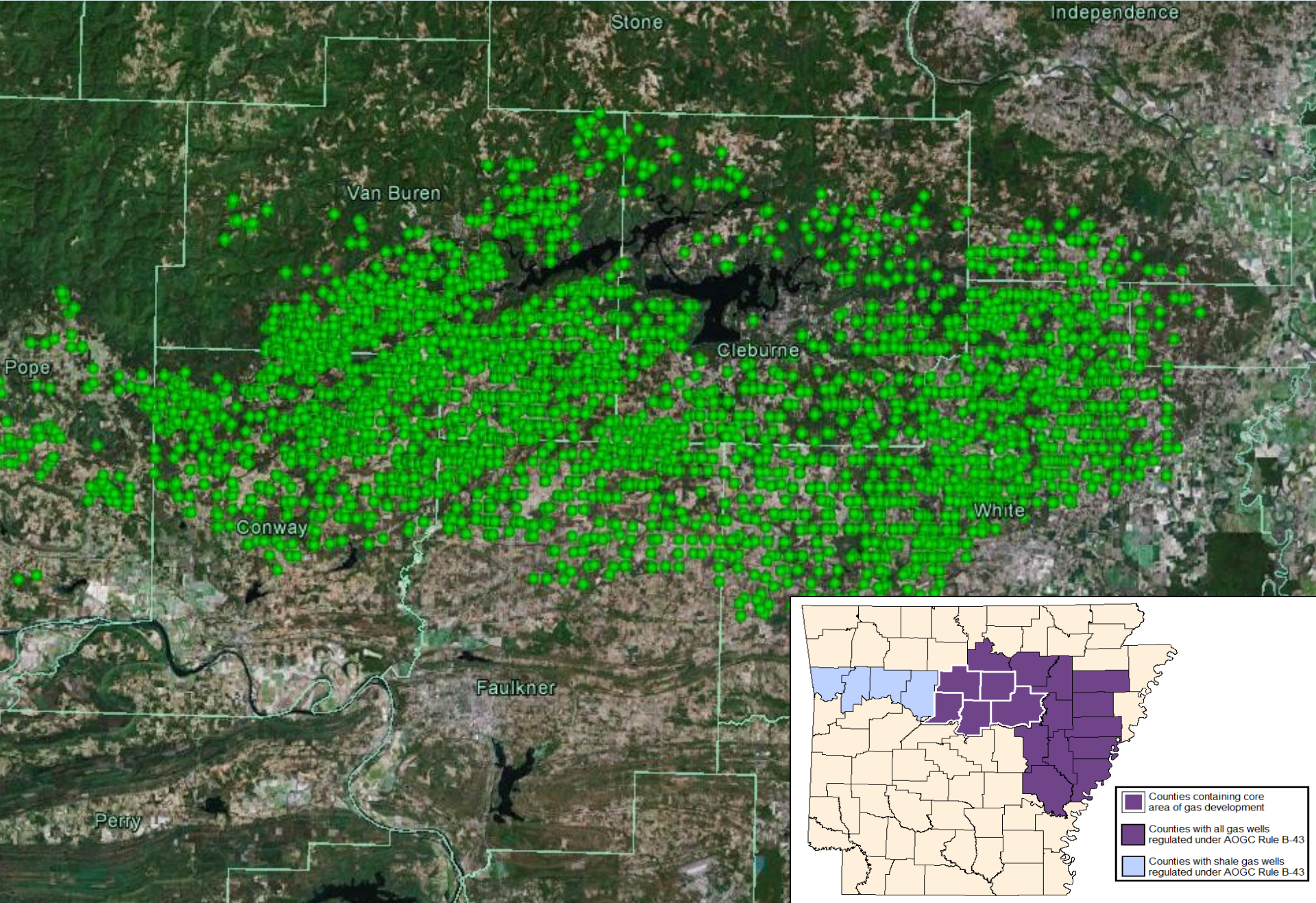
- EPA Region 6 awarded ADEQ an energy grant in 2010 to develop an emissions inventory and perform ambient air monitoring of natural gas production in the Fayetteville Shale region of Arkansas.
- An emissions inventory was developed to estimate annual county-level criteria pollutant and greenhouse gas emissions from Fayetteville Shale natural gas production activities for inclusion in the 2008 NEI.
- Ambient air monitoring was performed around the perimeter of 15 sites including compressor stations and new wells undergoing drilling or hydraulic fracturing.

Lower 48 states shale plays



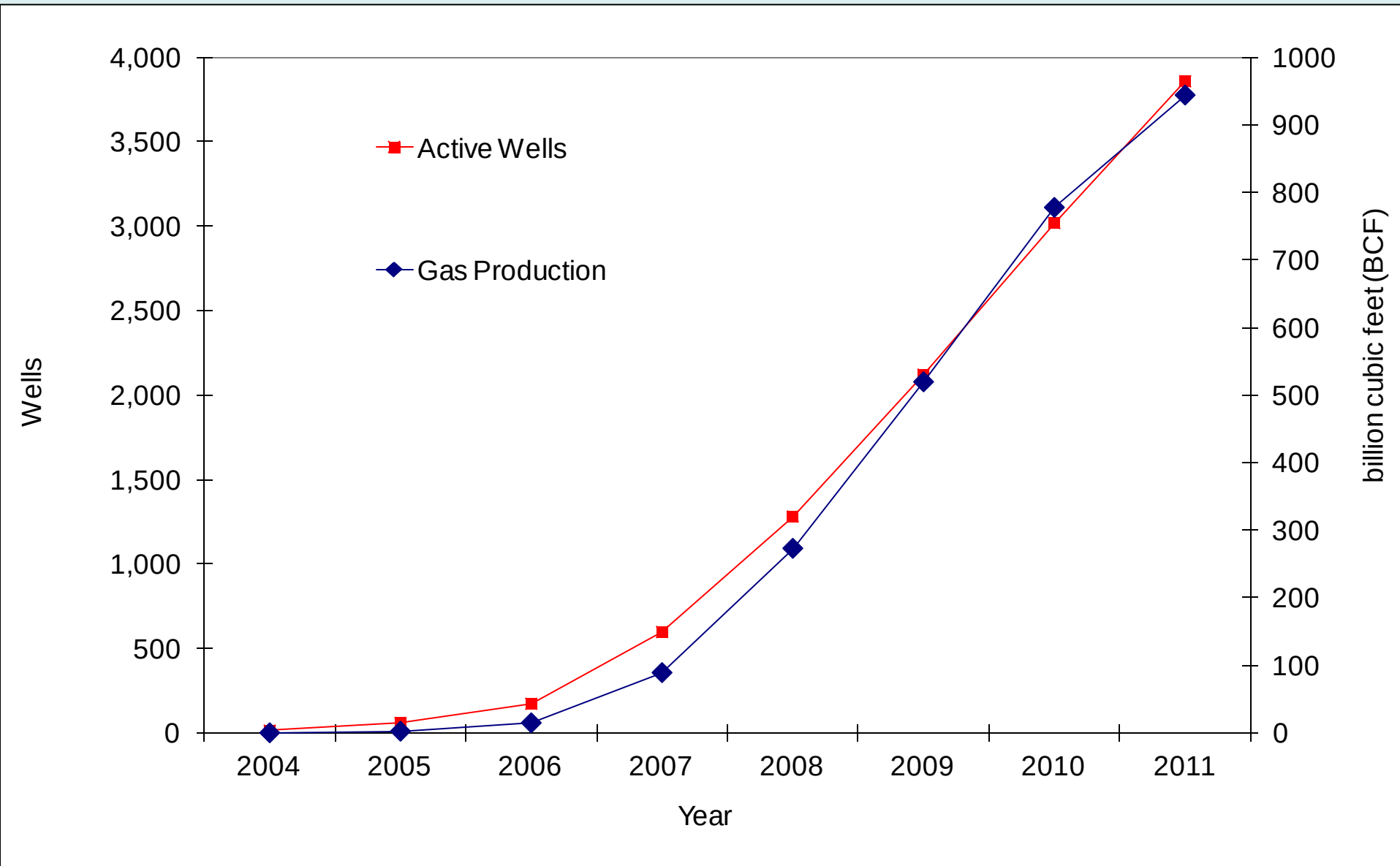
Fayetteville Shale





http://www.aogc.state.ar.us/Maps_GoogleEarth.htm

Fayetteville Shale Wells & Production



Emissions Inventory

- Annual emissions from 2008 were estimated at the county-level for the 10 counties with active wells.
 - Pollutants included NO_x , VOC, PM_{10} , CO, SO_2 , CH_4 , & CO_2
 - Emission sources included compressor engines, drilling rigs, hydraulic fracturing pumps, well venting, and fugitive emissions from production, processing, & transmission.
 - Data submitted to EPA for inclusion in 2008 NEI version 2.0



Emissions Inventory

- Compressor engine emissions were conservatively assumed to equal permitted limits adjusted by months operational in 2008.
 - <http://www.adeq.state.ar.us/home/pdssql/pds.asp>
- Drilling rig, hydraulic fracturing pump, well venting, and fugitive emissions were based on Armendariz 2009 and Bar-Ilan 2008.
 - http://www.edf.org/sites/default/files/9235_Barnett_Shale_Report.pdf
 - http://www.wrapair.org/forums/ogwg/documents/2008-11_CENRAP_O&G_Report_11-13.pdf
- Emission equation parameters were modified to reflect typical operating procedures and gas composition.
 - Data were provided by Southwestern Energy, the largest producer.
 - Fayetteville Shale produces a dry gas with low VOC content (0.05%).

Emissions Inventory by County

County	Production	Active Wells	New Wells	2008 Emissions (tons)						
	MMCF	#	#	NO _x	VOC	PM ₁₀	CO	SO ₂	CH ₄	CO ₂
Cleburne	9,064	57	38	215	29	35	133	2	4,860	36,265
Conway	76,219	305	142	1,038	240	124	674	11	26,335	296,919
Faulkner	12,413	85	32	427	97	32	401	3	5,927	129,329
Franklin	169	9	0	0	0	0	0	0	25	2
Independence	292	7	7	23	5	6	8	0	640	2,378
Jackson	292	3	3	7	1	3	1	0	291	293
Johnson	22	1	0	0	0	0	0	0	3	0
Pope	1,823	22	14	107	10	12	52	1	1,526	10,961
Van Buren	98,794	453	271	1,973	373	244	1321	16	41,789	437,426
White	74,268	361	197	1,211	223	217	786	95	31,480	383,796
Total	273,355	1,303	704	5,002	977	674	3,377	128	112,877	1,297,371

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Emissions Inventory by Source

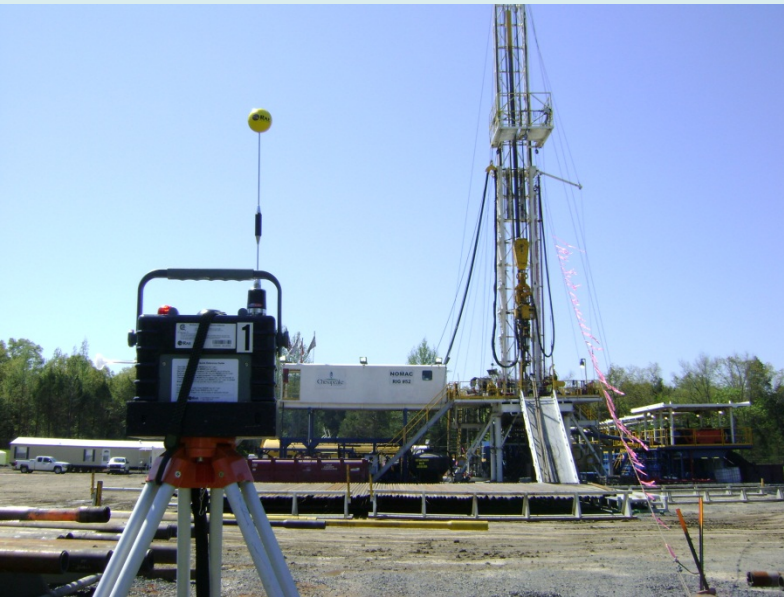
	2008 Emissions (tons)						
	NO _x	VOC	PM ₁₀	CO	SO ₂	CH ₄	CO ₂
Compressor Engines	3,381	787	79	3,258	106	13,833	1,225,643
Well Drilling	1,336	110	490	98	18	0	51,196
Hydraulic Fracturing	285	23	105	21	4	0	10,939
Well Venting	0	33	0	0	0	58,033	5,620
Production Fugitive	0	7	0	0	0	12,619	1,222
Processing Fugitive	0	4	0	0	0	6,309	611
Transmission Fugitive	0	12	0	0	0	22,083	2,139
Total Emissions	5,002	977	674	3,377	128	112,877	1,297,371

Emissions Inventory Summary

- Compressor engines were the primary source of most pollutants, with the exception of CH₄, which was emitted mainly from well venting and fugitive sources.
- VOC emissions were relatively lower than regions such as the Barnett Shale due to the low VOC content of gas.
- Fayetteville Shale gas production activities in 2008 contributed < 1% of statewide emissions from stationary, mobile, & area sources for all pollutants except NO_x (2.6%).
- Emissions in 2011 were likely greater than 2008 since both the number of active wells & production was ≈3X higher.

Ambient Air Monitoring

- Air quality was monitored for ≈ 8 hours around the perimeter of 15 sites including compressor stations & new well pads.
- Measurements included VOC, NO, & NO₂ concentrations and temperature, wind speed, & wind direction.
- Data were collected from November 2010 – June 2011.
 - Analysis included general linear model of pollutant concentrations.



Sites Studied

Hydraulic Fracturing Sites (3)



Drilling Sites (6)



Compressor Stations (4)

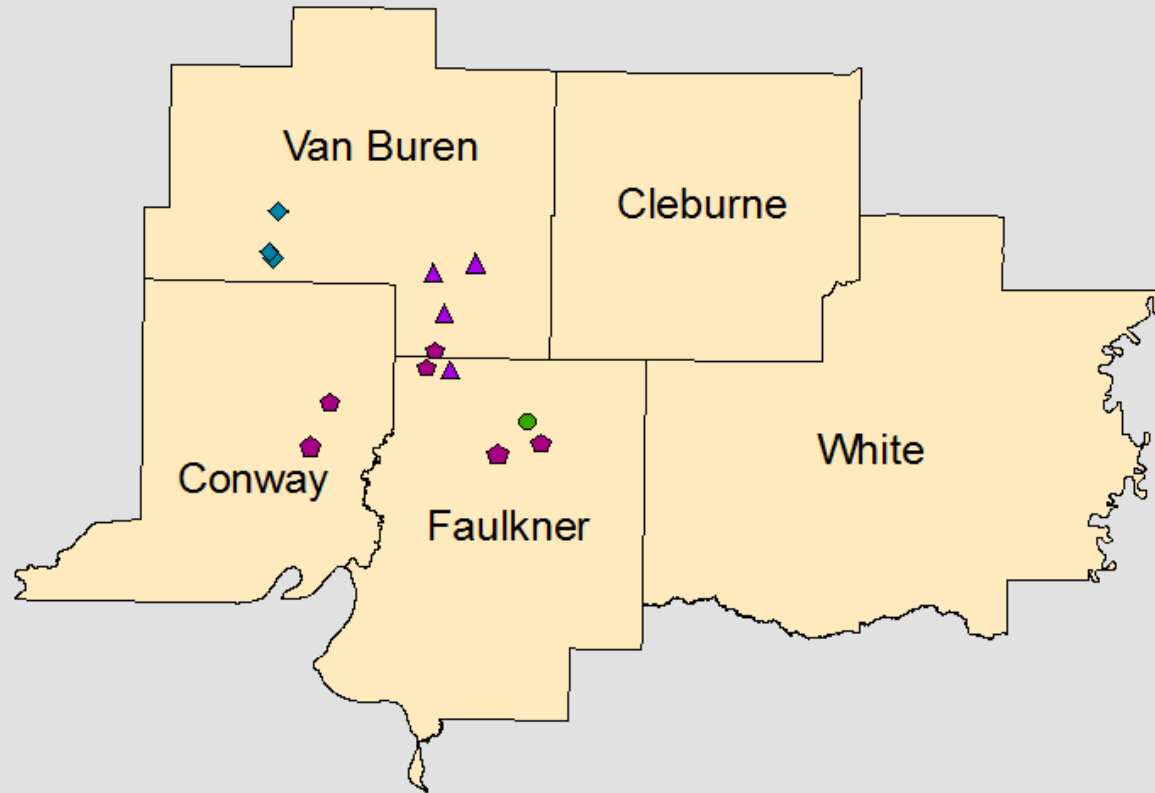


Control Site (1)



Mike Keckhaver

Survey of Monitored Shale Sites



Drilling Site



Hydraulic Fracturing Site



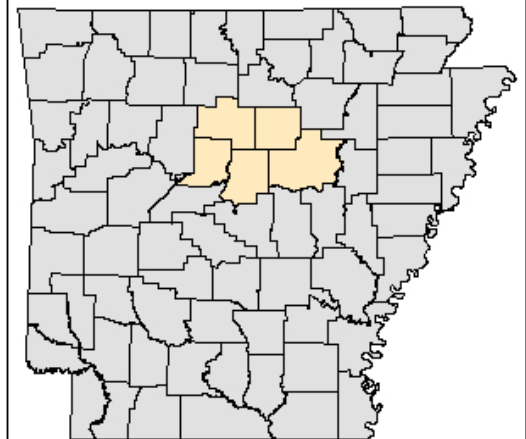
Control Site



Compressor Station



Most productive counties



Air Monitoring Equipment

RAE Systems

AreaRAEs

MDLs =

2 ppm NO

0.3 ppm NO₂

0.1 ppm VOC

RAE Systems

ppbRAE PID

MDL =

20 ppb VOC

Coastal Environmental Weatherpak



Monitoring Method



Monitoring Method



Air Monitoring Summary

- NO & NO₂ were below detection limits at all sites.
- Average VOC concentrations were below 100 ppb at compressor station & hydraulic fracturing sites.
- VOC at drilling sites was typically elevated with 8 hr & 15 min averages reaching 0.7 & 5.3 ppm, respectively.
 - GLMs showed statistically significant relationships between VOC concentration, location, & wind direction.
 - Open tanks of oil-based drilling mud & cuttings were the likely source of elevated VOC concentrations.
- Detailed presentation on air monitoring results given by Toby Chu at 2012 National Air Quality Conference.
 - <http://www.epa.gov/ttnamti1/files/2012conference/3A01Chu.pdf>



Conclusions

- Fayetteville Shale gas production activities emit large quantities of air pollutants, primarily NO_x , CH_4 , & CO_2 .
 - Dry gas & lack of condensate tanks result in low VOC emissions.
 - Fugitive emission estimates were based on gas leakage rates from 1996 EPA/GRI study and have high uncertainty.
 - Well venting emissions may be lower with green completions.
- There were no apparent serious ambient air quality issues.
 - Mud tanks probably contributed to elevated VOC concentrations.
 - VOC was not speciated; therefore hazardous air pollutants such as benzene may be present at harmful concentrations.
 - NO_x emissions may contribute to regional ozone formation.

Acknowledgements

- EPA Region 6
- Southwestern Energy
- Chesapeake Energy
- BHP Billiton
- Scot Stinson
- Jay Justice



References

- Armendariz, A. 2009. Emissions from Natural Gas Production in the Barnett Shale Area and Opportunities for Cost-Effective Improvements. Environment Defense Fund.
 - http://www.edf.org/documents/9235_Barnett_Shale_Report.pdf
- Bar-Ilan, A., R. Parikh, J. Grant, T. Shah, and A. Pollack. 2008. Recommendations for Improvements to the CENRAP States' Oil and Gas Emissions Inventories. ENVIRON.
 - http://www.wrapair.org/forums/ogwg/documents/2008-11_CENRAP_O&G_Report_11-13.pdf

Questions?

- Full report available for download on ADEQ website:
 - http://www.adeq.state.ar.us/air/pdfs/fayetteville_shale_air_quality_report.pdf
- For questions about the report, contact:
 - Mike Bates, Arkansas DEQ, Air Division Chief,
bates@adeq.state.ar.us
- For technical questions, contact:
 - David Lyon, Environmental Defense Fund, Research Analyst
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