3042

May name is Ken Gayman, I am the President of the IWLA Shawnee/Cherokee Chapter of Washington Cty., I am a formal combat Marine, The reserch I have been doing is disturbing on the drilling in are area, with the water pollution, air pollution and health problems people are experiencing. Could we be No. 2 in the nation for air pollution. Possibility. The company that I worke for, I did alot of driving through, Virginia, West Virgina, maryland, Ohio and Pennsylvania I have noticed the roofs on the houses were turning Black, and the more I drove as the last 6 years, as the years went went by the more roofs on houses turning Black. Is this a indicater that the air quality has be inpacted. Possibility. Being in combat going on missions I would be scared but what is happening in Southwestern Pennsylvania. now I am terrorfied. I do own a small farm and I will protect it with my life. I didn't go to combat to fight for our rights and freedom and have them taken away by the gas industy and oil industry. I am educating Veterans on there property rights and the freedom of all Veterns. What I have seen a combat Veteran took his properity off

of him and put him in jail for running them off of his property (Pipe Line company.) They distroyed 300 acres of his 600 acre farm. Is this the American way. NO.

check the photos and reading materia that I sent to you. I am an American and I will fight for our dreams and the American way.

Thank you
Kenneth Gayman

P.S. Please excuse the hand writting, eye problems

Izaak Walton League of America
Shawnee/Cherokee Chapter, Washington Co.
Kenny Gayman
112 Oak Dr.
Jefferson, PA. 15344

NOTES

Hope these photos and other material sent to you to make the right decision to protect our air, water and pristine/protected site for this generation and generations to come according the the 4th constitution. Article I Section 27.

Thank You

Izaak Walton League of America
Shawnee Chapter of Washington County
Ken Gayman - President

I am the Chair Person of the Historic and Esthetic program for the Shawnee Chapter of Washington County and the Harry Enstrom Chapter of Greene County

I am also a member of the State of Pennsylvania Archaeology Society, member of the Mon-Yough Chapter 3 Archaeology and History Club meeting place California University and a member of Archaeological Conservancy from the State of New Mexco.

Propose changes to the Pennsylvania Oil and Gas Regulations.

All drillers make predrill available data to the public along with the placement of well pads, compressor Stations and where the pipe lines are going to be placed. Known as chapter 78 of Pennsylvania Code Act 13, The oil and gas law passed in 2012. There are no provisions in the oil and gas act to protect any Archaeological and

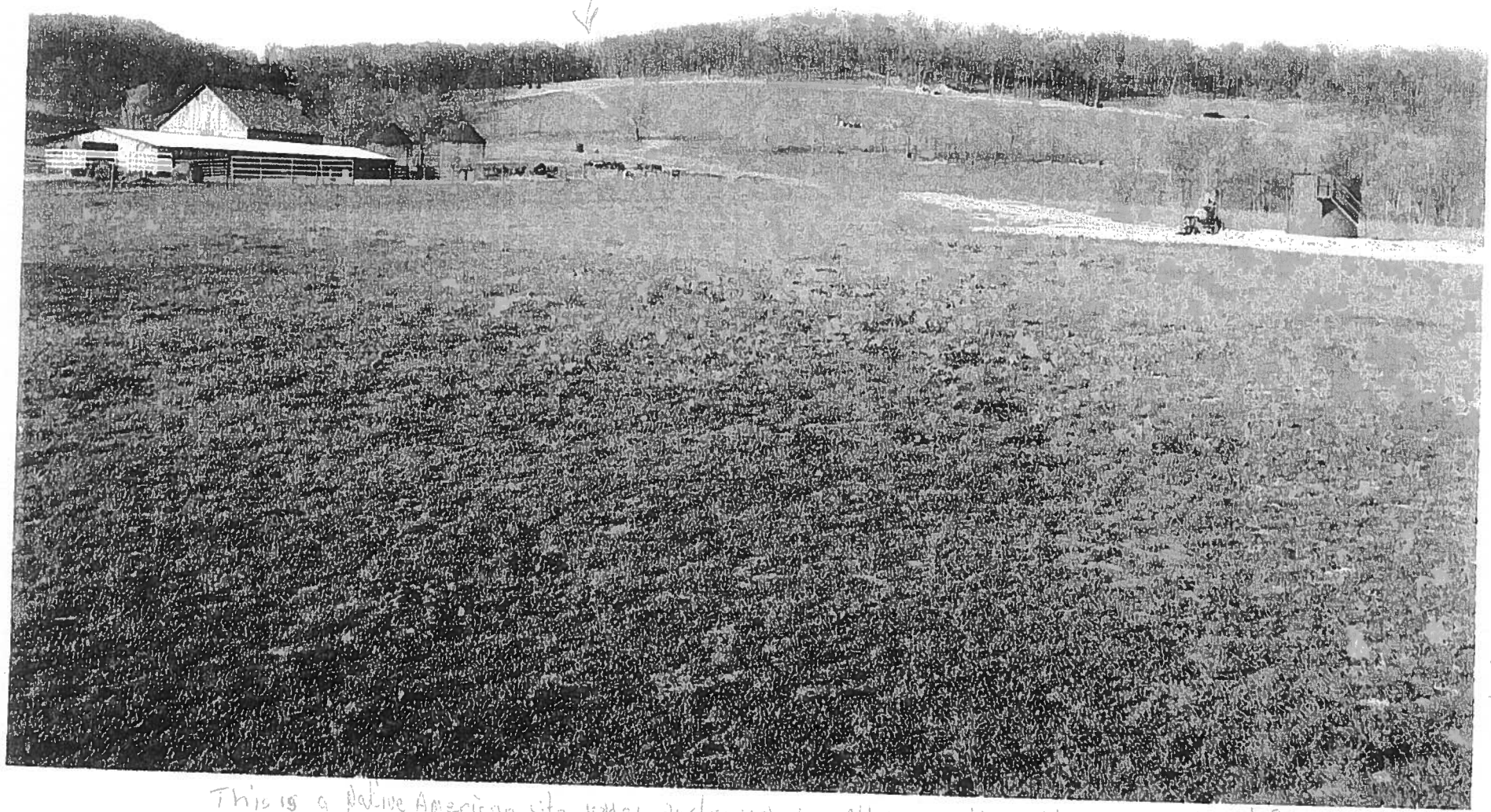
Historical sites. The drilling companies should have a certified Archaeologist to do surveying before any well pads compresser stations, impoundment pons, pipe lines and roads leading to well pads to determine that they are not destroying any archaeology site and historical sites.

There are several laws in place protecting all Archaeological and Historical sites. There are Federal laws, state laws, The national Historical Code section 106 of the law, grave protection act, Freedom of religion act, Burial protection act, House Bill 506 passed by the U.S. congress protecting archaeological sites in New Mexico and the Pennsylvania Constitution Article 1 section 27 protection of these sites for this generation and generation to come.

I recommend a provision be adopted in the oil and gas act to protect these site for myself and all the people in Pennsylvania. (A fine to enforce this act [illegible].) All well pads, compresser stations, impoundment ponds, pipe lines and roads leading to well pads be a minimum of 500 feet from sites.

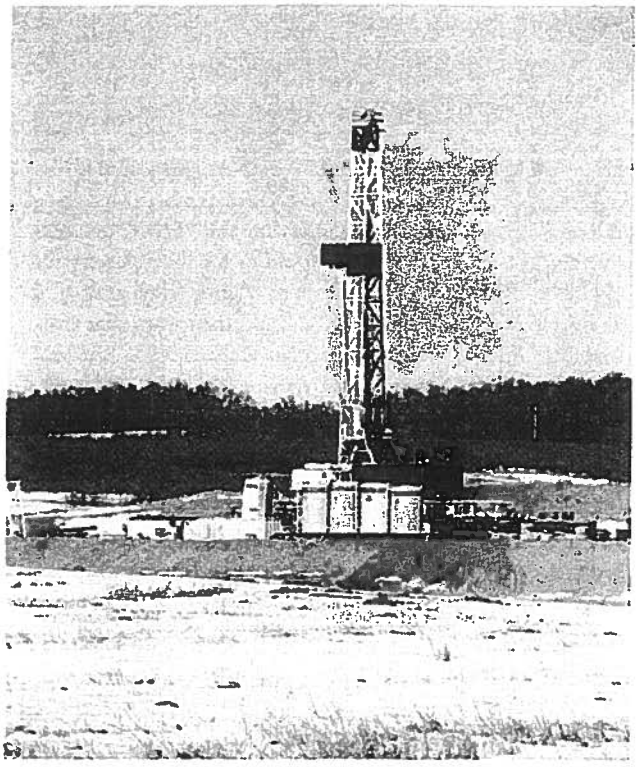
Thank You

Kenneth G. Gayman



This is a Native American site what destroyed by Atlas on the ridge were the old fort is in the

Does the Natural Gas Boom Endanger Archaeology?



On the North Branch of Pennsylvania's Susquehanna River, roughly an hour northwest of Scranton, sits Friedenshuetten. Meaning "tents of peace," the village was an eighteenth-century utopia founded by a Moravian missionary. There, both expats from what is now the eastern Czech Republic and Native Americans of the Eastern Delaware Nation coexisted in log cabins and wigwams from 1763 until 1772 when simmering distrust dissolved the settlement.

Archaeologists from Kings College in Wilkes-Barre began excavating the site in 1972, finding pieces of pipes, flints, and remains of a hearth, among other artifacts. The following year they uncovered the village's main core.

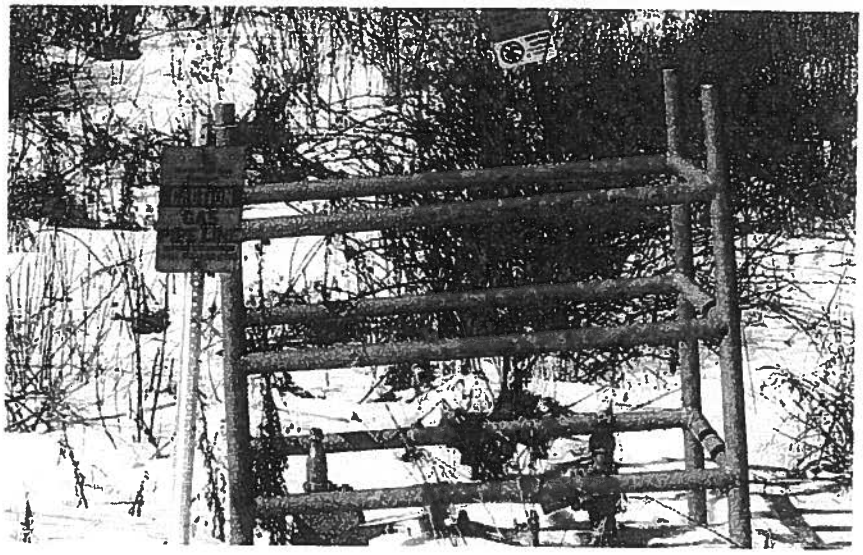
Today, situated amid the village's remains are two installations courtesy of Chesapeake Energy, the U.S.'s second largest producer of natural gas. One is a set of interpretive panels that explain the significance of the site. The other is a pipeline.

Back in the mid-1980s, Pennsylvania historical societies first identified the natural gas industry as a threat to archaeological sites. At the time, the warning just covered conventional well drilling. But, over the past five years, exploration of the Marcellus Shale formation, which extends from upstate New York to Tennessee, has ramped up. New developments in hydraulic fracturing, or "fracking"—the injection of millions of gallons of a fluid mixture made up primarily of water and sand into the shale—allow companies to extract greater quantities of methane trapped within the rock. The practice opens up areas where it was previously not feasible to retrieve natural gas. The resulting gas rush could further encroach on Pennsylvania's archaeological history thanks to minimal regulatory oversight from Harrisburg.

"It's a beautiful example of totally screwed up priorities," says Katherine Faull, a professor of German and the humanities at Bucknell University who uncovered a map of Friedenshuetten in a Moravian church in Germany, which she translated, annotated, and published in 2009. When she discusses Friedenshuetten today, her voice carries an air of exasperation. "There's nobody, it seems, who can say anything or stop the energy companies."

Faull's story echoes that of Bill Johnson, an independent archaeologist who, for 15 years, studied a southwestern Pennsylvania site where two different Monongahela villages (dating to A.D. 1300 and 1450, respectively) once stood. Unknown marauders in the early 1500s sacked the later settlement, burning its cache of corn and butchering several children—eating at least one of them. Johnson is still cataloging artifacts from the site, half of which, he discovered recently, has a drill rig on it. (The Archaeological Conservancy bought the other half in 2007.) "You assume," he says, "that the site is always going to be there."

Two energy industry–friendly provisions on Pennsylvania's books make that a dangerous assumption. The first is the so-called "10-acre rule," wherein if a company applies to the state's Department of Environmental Protection for a permit on a project that will take up 10 or fewer acres of land, the Pennsylvania Historical & Museum Commission (PHMC) is not required to review the proposal to ensure the protection of archaeological sites, nor does it have to be notified. When a project does exceed that acreage, the PHMC is notified. However, thanks to a 1995 amendment to the state's history code known as "Act 70," passed under heavy pressure from the gas lobby, the PHMC must fund, or itself undertake,



any excavations of previously recorded archaeological sites that exist where a permit is pending. "PHMC has a far smaller staff and fewer financial resources than in the past," says Doug McLearen, chief of the PHMC's Division of Archaeology & Protection. "We no longer conduct or fund such excavations."

Act 70 makes PHMC's stewardship of Pennsylvania archaeology an "unfunded mandate," says Jason Espino, president of the Society for Pennsylvania Archaeology's Allegheny Chapter. With worries about increased fracking of the Marcellus Shale, Espino has heard stories of the gas industry's impact on Paleoindian sites in western Pennsylvania and sites that likely contained multiple settlements over time and contain artifacts dating from the early Archaic period, 9,000 years ago, up to the turn of the seventeenth century.

Espino is currently working toward a master's degree in applied archaeology at Indiana University of Pennsylvania. For his thesis, he's tracking 3,000 previously recorded sites in Washington County, where fracking in Pennsylvania first began in 2005. He notes that fracking requires less actual drilling than conventional wells (the high-pressure method is combined with horizontal drilling to create clustered networks of cracks that open up more of the formation to extraction). But each fracking operation affects five times as much land (10 acres versus two). He says that nearly 17,000 acres of land statewide were at risk of disturbance in 2010, compared to 10,000 acres in 2008. Acknowledging a need to balance economic and archaeological interests, he suggests allowing the PHMC to cross-reference the locations for all proposed wells with the locations of known archaeological sites. "PHMC could then warn that wells might impact an archaeological site and recommend moving operations a couple hundred feet over to avoid them," he says. When presented with Espino's proposal, Travis Windle, a spokesperson for the Marcellus Shale Coalition, a trade group that represents more than 200 oil and gas companies, among them Chesapeake Energy, responded, "If that's not going to present any major operational heartburn, hiccups, issues, that's a no-brainer."

One approach that could mitigate harm to archaeological sites is to align the movement for their protection with the efforts of environmental groups. To date, concerns about groundwater contamination—by the chemicals used in and the methane released from fracking—have led to a moratorium on the process in both New York and New Jersey. Whereas some archaeologists worry that an alliance would lead to their interests being subjugated to environmentalists' concerns, Tim Murtha, an archaeologist at Penn State University, strongly disagrees. "Conservationists do a much better job at communicating the issues than we have," he explains. "We can't disentangle human history from natural history or environmental history, and it's that notion that should bring us together in terms of preservation."

—Nikhil Swaminathan

Historic and Pre-historic Preservation

We, the undersigned, are requesting that the historic and pre-historic sites of Southwestern Pennsylvania be preserved. Several colleges and historical organizations have a wealth of information on History, Native Americans and Euro-Americans, that are being lost forever due to the lack of concern for these sites by natural gas drilling companies. The drilling companies should be held accountable for the destruction of these sites as mandated by section 106 of the Historical Preservation Code, the state constitution section 27 and be prohibited from drilling until these sites can be examined by the Pennsylvania Archaeological Society Mon-Yough Chapter 3 or professional archaeologists

	NAME	ADDRESS
1.	Rachel Hunter	2354 Riverview Terrace, Pgh. PA 15218
2.	Barbara Grover	5526 Wilkins Ave, Pgh PA 15217
3.	Mary R Yaeger	7524 Graymore Rd Pgh 15221
4.	Bob Zilka	1147 East St. Wilkinsburg, PA 15221
5.	Mel Parker	623 Kennard St Pgh 15208
6.	Mel ORdway	513 Tuleyn St. Pgh, 15213
7.	Nicholas Fedorek	138 Stratford Ave, PGH, PA, 15206
8.	Michael Winkler	340 First St-2nd Flr Aspinwall, PA 15215
9.	Jennifer L. Petrus	1225 Richmond St. Pgh PA 15218
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	NAME	ADDRESS
1.	John Beabout	Carmichaels Pa
2.	Eben Williams	149 N. Woodland ave, WBG, PA
3.	Carla Franks	211 Sterling Ave, Masontown PA 15461
4.	Alberta Orndoff	Box 316 Millsboro, Pa 15348
5.	Margaret A. McCombs	509 E. George St. Carmichaels, PA 15320
6.	CATHERINE SALVATORE	526 PLATE STREET, CONNELLSVILLE, PA 15425
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	NAME	ADDRESS
1.	MICHAEL TOMLINSON	623 CHERRY ST. ERIE PA 16502
2.	David C. Dean	19143 Hare Creek Rd Corry PA 16407
3.	Richard Yanock	70 Stagecoach St. 15301
4.	Diane Nicholls	dlane330@aol.com
5.	Mary Butler	1601 W Crawford Ave Connellsville PA mbutlerrock@hotmail.com 15425
6.	Clare Swornik	218 E. 11th St. bethany hogsed2@neo.com
7.		
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	NAME	ADDRESS
1.	Linda Yanock	70 Strabane St Wash.
2.	Rich Yanock	70 Strabane St. Wash
3.	Rebecca Trojan	127 Valley View Rd
4.	[illegible]	231 Wilson Rd McDonald PA 15057
5.	[illegible]	109 Reservoir Hill Rd. Jefferson, PA 15344
6.	Sarah Vecenie	3608 Whitetail Lane PGH PA 15209
7.	Samantha Rickenbach	100 S. Arch St Connellsville, PA 15425
8.	[illegible]	100 S. Arch St. Connellsville PA 15425
9.	[illegible]	46 middle St CLARKSVILLE PA 15322
10.	D Winkler	POB 23 Jefferson PA 15344
11.	A. BARKIN	109 STEVENS RIDGE DR. 15005
12.	K. Lipinski	117 Hathaway Rd 15323
13.	Debbie Harter	184 S. MAIN ST, WASH 15301
14.	Charles E. Hammond	3282 OLD FOREST RD WBG, PA 15370
15.	Randi Chambers	153 Sylvest St Wbg PA 15370
16.	Stephen J Hahn	232 N Porter St Waynesburg PA 15370

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	NAME	ADDRESS
1.	Gilbert W. Grasse	5380 Rt 982 Derry Pa 15627
2.	Tony Kerin	343 Shirey Run Rd. Blairsville Pa 15717
3.	Roger Kerin	168 N. valley st Derry, PA 15627
4.	Lorraine Noel	15 LITTLE MINGO Rd FINLEYVILLE PA 15332
5.	Carrianne M. Kane	800 VALLEY VIEW DR KRAVOSBURG PA 15034
6.	Karen L. Nice	5449 Sunset View Dr. Monroeville PA
7.	Nina R. Lassen	4773 S. Pioneer Rd, Allison Park, PA 15101
8.	Genesis G. Hammond-Schrock	216 6th Street, California PA 15419
9.	Gary M Tucker	405 Richard St. Clearfield, Pa.
10.	Christine Kula	92 Rivulet Rd. Carlisle 17015
11.	Lucy Koelle	210 Idlewild Lane 19063
12.	David & Linda Headley	132 Volek Rd Smithfield PA. 15478 media PA
13.	HUGH McCARTNEY	11078 FREEPORT LN; NORTH EAST
14.	~~Keiko~~ Miller	452 Wilshire Rd., Erie, PA. 16509
15.	MAtthew Retkowski	313 Illinois Ave Erie PA 16505
16.	Anna McCartney	11078 Freeport Lane North East PA 16421

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	NAME	ADDRESS
1.	Emmett McKenzie	346 Nesmith Rd Box 303 CARMICHAELS, PA 15320
2.	Jordan Wilt	358 Gosling Rd RICESLANDING PA
3.	Cindy Lee Stockdale Computer	144 CUMBERLAND VILLAGE CARMICHAELS PA 15320
4.	Jadie Sarber	241 College St. New Salem Pa 15468
5.	Andrea Kinsinger	P.O Box 54 102E Drive Clarksville, Pa 15322
6.	Mark Simkovic	518 W. GREENE ST. CARMICHAELS PA. 15320
7.	Tom Simkovic	295 GLADE RUN RD, CARMICHAELS PA, 15320
8.	[illegible]	12 Col Smith Ridge Rd Smithpa 15311
9.	[illegible]	5 Spring Dr. Coal Center, PA. 15423
10.	Ella Ankrom	69 Rt 21 Mobile Park Carmichaels PA 15320
11.	Sean Ankrom	69 RT 21 Mobile Park Carmichaels, PA. 15320
12.	Dustin Martin	22 Rt 21 mHP Carmichaels PA, 15320
13.	John F Fulmer III	22 Rt 21 mHP Carmichaels, PA 15320
14.	Dawn L Wise	226 S Market St Carmichaels PA 15320
15.	Clarice McCann	450 Nemacolin RD Carmichaels PA 15320
16.	Ann R McE	1311 SOUTH BRANCH MUDDY CREEK ROAD CARMICHAELS PA. 15320

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	NAME	ADDRESS
1.	Pamela S Ukyel	404 S Market St Carmichaels Pa
2.	Rich Garrett	43 RT Mobile Home Park Carmichaels PA
3.		112 Nemacolin Road Carmichaels PA
4.		213 East St. Carmichaels, PA 15320
5.		160 Stone St Carmichaels PA 15320
6.	Stephen J Burkes	612 West Greene ST Carmichaels PA 15320
7.		380 Arsmart Rd Rices Landing PA 15357
8.	AJ Smith	540 old Waynesburg Road 15320
9.		130 Cumberland Village Carmichaels PA 15320
10.		119 Cumberland Village Carmichaels PA 15320
11.		311 Schoolbus Rd Mt. Morris Pa 15349
12.	Michael Boehm	311 School Bus Rd Mount Morris Pa 15349
13.		103 Ceadarwood Dr Carmichael PA 15320
14.	Delores Butcher	19 cumberland village Carmichaels PA 15320
15.	Kenneth Williams	19 cumberland village Carmichaels PA 15320
16.	Roy Huff	39 Cumberland Village Pa 15320

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	NAME	ADDRESS
1.	Fred Zeth	131 Higgins Country Rd Holbrook PA 15341
2.	Mike Dierkin	600 Enon Church Road West Finley, PA 15377
3.	Matthew Steiner	600 Enon Church Rd. W. Finley PA 15377
4.	Ken Hafalla	46 middle St Clarksville PA 15322
5.	Debbie Longood	404 Jones Rd Holbrook PA 15341
6.	Ralph Dawoni	333 Second Greensboro PA
7.	Cecilia Shumaker	169 McCullough Rd, Sycamore, Pa 15364
8.	Betty Zeth	131 Higgins Country Rd Holbrook PA 15341
9.	Charles Rimmel	404 Jones Road Holbrook, PA 15341
10.	JOHN R LOVINGWOOD @yahoo.com	404 JONES RD HOLBROOK PA 15341
11.	Emily Bloom	184 S. Main St Washington, Pa 15301
12.	James R. O'Connell	P.O. BOX 370, Bobtown, Pa. 15315
13.	Terry Greenwood	45 Berry Lane, Daisytown Pa 15427
14.	Charles E. Hummell	2242 Dry Forest Rd Waynesboro, Pa
15.	Ray M Rustan 1545 West	Roy Furman Hwy Waynesburg, PA 15370
16.		

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	NAME	ADDRESS
1.	John R. Price	173 Quarter House Clearville
2.	TOM DULZ	345 Cherokee Lane Artemas
3.	William B Williams	515 Bens Cove Rd Clearville PA
4.	PAUL & [illegible] PARKER	60 MORROW ROAD AVELLA, PA 15312
5.	LINDA M YANOCK	70 S Trabant St WASH. PA 1530
6.	Brenda Speigle	247 Looking Glass Lane Morrisdale, PA 16858
7.	Mary Ellen McConnell	2228 Raggedy Mtn. Rd Clearville, PA 15535
8.	Angel & Wayne Smith	814-784-0020 1316 Rock Hill Church Rd Clearville, PA 15535
9.	[illegible]	5298 River Drive York PA 17406
10.	[illegible]	191A Brandywine Road Wernersville, PA 19565
11.	[illegible]	252 N 5th St Indiana, PA 15701
12.	[illegible]	252 N 5th Indiana, PA 15701
13.	[illegible]	175 Chapel Ridge Rd Pittsburgh, Pa 15238
14.	[illegible]	905 Richard St Clearfield Pa 16830
15.	William E. Black	William E. Black 188 Nettles Ln. Franklin, Pa 16323
16.	[illegible]	1124 DOREY ST. CLEARFIELD, PA 16830

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	NAME	ADDRESS
1.	Mark A. Zutt	[redacted] P.O. Box 596 Fredericktown, PA 153
2.	[illegible]	384 Grant Ave Nemacolin PA 3
3.	Kathy Allen	2109 E. Nat'l Pike, Scenery Hill, PA 15360
4.	[illegible]	1065 Cracible Rd. Rices Landing PA 15357
5.	[illegible]	734 Jefferson Rd. Waynes 15370
6.	[illegible]	744 [illegible] Rd Waynesburg PA 15370
7.	Vickie Haywood	40 Haynes Rd Hackett PA 15481
8.	[illegible]	184 S. Main St. Washington PA 15301
9.	[illegible]	1888 Freeniff Rd, Rices Landing, PA 15357
10.	[illegible]	PDB 23 Jefferson PA, 15344.
11.	Marjorie Howard	149 Preachers Rd Waynesburg PA 15370
12.	Jerry Howard	149 Preachers Rd. Waynesburg PA 15370
13.	Donna Riggle	691 Valley View Rd 84 PA 15330
14.	[illegible]	196 Bill Georges Rd Waynesburg PA 15370
15.	Dawn Rinehart	710 Wine Alley, Waynesburg, PA 15370
16.	Joyce Cross	386 Crayne's Run Rd Waynesburg, Pa 15370
17.	Charles E. Hemmell	P.O. Box 548 Waynesburg Pa 15370

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	NAME	ADDRESS
1.	[illegible]	Claysville 15436 Pa
2.	[illegible]	W. Newton Pa 15089
3.	[illegible]	Pgh Pa 15241
4.	David Barno	WEST MIFFLIN, PA 15122
5.	Georgiann Barno	WEST MIFFLIN, PA 15122
6.	[illegible]	Greensburg PA 15601
7.	Robin Heese	Greensburg PA 15601
8.	Kendyll Heese	Greensburg PA 15601
9.	Ethan Heese	Greensburg PA 15601
10.	Marilyn Reagle	Ross Township Pa 15237
11.	Shaunda Reagle	Export Pa 15632
12.	Caden Mustick	Export Pa 15632
13.	William Ross	Export Pa 15632
14.	Mike Lastuka	Pittsburgh Pa 15210
15.	James J Barno	Elizabeth Pa. 15037
16.	James D Barno	Elizabeth Pa. 15037

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	NAME	ADDRESS
1.	Susan M. Stephenson	P.O. Box 272 Beallsville, PA
2.	Susan S Rick	113 Oak Drive Jefferson Pa 15344
3.	Susan mason	Rt. 88, Rices Landing, PA
4.	Kayla Motycki	917 Meadow Ave Charleroi Pa 150
5.	Patty Pierce	87 Yankosky RD Charleroi
6.	Ronald J Dulla	29 Gulla Lane, Hickory, PA 15340
7.	Emma L. Pushnik	37 Clearview Dr - Scenery Hill PA
8.	George G Pushnik	15360
9.	Sandra Mosley	55 Laurel Dr Wash, Pa
10.	Sean Wilson	401 Hazel St. Bentleyville, Pa 1531
11.	Pat Godla	81 Willow Dr. Monessen, PA 1506
12.	Brenda Wenecke	120 Greenwood Clarksville
13.	Nancy Moore	16 Fish Bot RD. Vestaburg Pa 1536
14.	Tracy Legatka	552 Lakeview D. Brownsville, Pa 15417
15.	Jud Morgan	526 4th ST. Marianna 1534
16.	Andrea Matusky	437 1st St. Vestaburg Pa. 1536

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	NAME	ADDRESS
1.	Lisa Soltys	221 cemetery rd, Gbg Pa 15601
2.	Jennifer Thomas	121 Elm St. Clarksville PA 15322
3.	Ray Slick	134 Desko Rd. McClellandtown PA 15458
4.	Don Patterson	113 Oak Drive Jefferson PA 15344
5.	Connie J. Smith	357 Highland Ridge Rd Marianna PA 15345
6.	Jerry L Lilley	RD #3 Box 440 A Moundsville W.Va
7.	Dianna Sakach	162 Oak Rd. Scenery Hill PA.
8.	[illegible]	PO Box 11 Cokeburg PA 15324
9.	[illegible]	Po Box 299 Beallsville, Pa 15313
10.	[illegible]	Po Box 299 Beallsville 15313
11.	[illegible]	210 Lee Hill Brownsville 1541
12.	[illegible]	602 N Pa B'ville 15417
13.	[illegible]	288A Brownsville, 15417
14.	[illegible]	685A National Pike ea Brownsville 15417
15.	[illegible]	PO Box 357 Richeyville PA 15358
16.	[illegible]	704 N 88 Rd Carmichaels Pa 15320

Historic and Pre-historic Preservation

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NAME	ADDRESS
1. LorRea Toler	627 summit Ave Monessen PA 15062
2. Jennifer Thomas	121 Elm St. Clarksville PA 15322
3. Ben Ville	1 Pike Run DaisyTown PA 15427
4. [illegible]	111 [illegible] Rd Rices Landing 15357
5. [illegible]	Box 387 Fredericktown PA
6. [illegible] Walters	Box 585 Clarksville Pa 15322
7. [illegible]	134 2nd Street Clarksville 15322
8. Kristin Mull	243 Rices Landing Rd. Rices Landing Pa 15357
9. [illegible]	169 Barneys Run [illegible]
10. [illegible]	168 Clarksville Pa
11. Jen [illegible]	P.O. Box 74 Rices Landing, PA 15357
12. [illegible]	521 [illegible] Rd 15320
13. Brenda R Hutchinson	89 Blackdog Hollow Rd Clarksville, PA 15322
14. [illegible]	PO Box 219 [illegible] PA 15351
15. Stephanie [illegible]	Box 1424 [illegible] Rd Jefferson PA 15344
16. Carol [illegible]	112 Oak Dr. Jefferson PA 15344

Historic and Pre-historic Preservation

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	NAME	ADDRESS
1.	Lori Gialone	111 Gane St Rices Landing Pa 15357
2.	Julie Gialone	111 Gane St. Rices Landing PA. 1535
3.	Maria Gialone	111 Gane st Rices Landing PA. 1535
4.	Federico Gialone	111 Gane St. Rices Landing PA. 15357
5.	Mary Johnson	9 Selena St. Bentleyville Pa 15314
6.	BETTY DYSON	42 COCTEZ DR WASHPA
7.	Tim Conti	14 BESCO ST, CLAYSVILLE, PA 15323
8.	Rocco A. Malach	9 ROCCO LANE, SCENERY HILL PA. 15360
9.	Bob Ward	216 Dorsey St Belle Vernon Pa 1501
10.	[illegible]	531 S. Main St. Washington PA 1530
11.	Jim Connor	113 TAYLOR [illegible]
12.	Frank Moore 3	14 Williams Lane [illegible]
13.	Terry Wright	16 Rock Hollow RD Claysville
14.	Michael P. Ward	60 NANNIE ST. WASH., PA 153
15.	Gary Mills	728 Redwood DR. McDonald, PA. 1505
16.	Walter R. Dorsheck	54 MADISON ST COKEBURG PA 1532

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	NAME	ADDRESS
1.	Carl J. Mauser	45 ACHESON AVE, WASHINGTON PA 15301
2.	JOHN M. ROBSON	1206 GANETOWN RD WASHINGTON, PA. 1530
3.	Raymond W McVay	1199 Brush Run Rd Washington 15301
4.	[illegible]	121 Springfield Ave Washington PA 15301
5.	Joyce D Hay	121 Springfield Ave Washington PA 15301
6.	RICH HORN	915 Lone Pine RD Amity PA 15311
7.	DEBBIE HORN	915 Lone Pine RD Amity PA 15311
8.	Paul Brider	150 C Prospect Ave Wash Pa.
9.	[illegible]	841 Bird View St Wash PA
10.	P Katherine Mauser	45 Acheson Ave. Wash. Pa 15301
11.	Nellwood Rapp	135 Park St Cecil PA 15319
12.	Richard A Gavorik	70 Strabane St Wash., PA
13.	Robert Deppen	348 Knob Rd Brownsville, PA
14.	[illegible]	184 woodland Rd PA
15.	Maria Weikel	988 Cross St. California, PA 15419
16.	Mayea Hyson	1067 Pine Run Dr. Coal Center PA 15423

Historic and Pre-historic Preservation

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	NAME	ADDRESS
1.	Gabe L Bry	28 Letherman, Scenery Hill, Pa. 15360
2.	Dawn Coleman	2188 East National Pike, Scenery Hill PA 15360
3.	Nicholas J. Demarco Sr.	194 Cookson Rd. Waynesburg Pa.
4.	Patricia L Shaw	134 Ridge Lane Spraggs PA 15362
5.	Vickie moon	855 Oak Forest Rd Brad PL 15314
6.	Patty Jo Duda	156 Duda Rd Mt. Morris PA 15349
7.	Felicia Riggle	331 Riggle Rd Aleppo PA 15310 (Waynesburg)
8.	Andrea M Ridely	41 Grandview Drive Wb, PA 15370
9.	RhiANNON Stone	525 East Lincoln Waynesburg PA 15370
10.	Patty Layton	Smithfield PA.
11.	Eli Patterson	661 Laynes Run Rd
12.	Dave Ress	Waynesburg, Pa.
13.	Amanda Welch	
14.	Cathy Jellots	Rices Landing, PA.
15.	Mike Ryan	Carmichaels, Pa.
16.	Sue Bell	Brownsville

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	NAME	ADDRESS
1.	James C. Woodhouse	218 Lake Front Dr. Dauphin, PA
2.	Eric Weaver	13829 S. Norristown Rd Meadville, PA 1633
3.	Melissa Diamanti	151 Panorama Drive State College PA 16801
4.	Matthew Cain	503 3rd Street New Cumberland PA
5.	Brooke S. Blasko	620 Pugh Rd Cumberland Stratford PA 19087 PA
6.	[illegible]	1722 LT 130 GARRETTSVILLE OH
7.	Tim Williams	wtimw@aol 814 547 2372 26913 Hwy 408 cambridge pa
8.	[illegible]	
9.	Nina Larsen	4773 S. Pioneer Rd, Allison Park Pa 15101
10.	Lisa Dugas	1246 High St. Pgh, PA 15212
11.	Angela Jaillet	693 N. Water St. Kittanning, PA 1656
12.	John Nagy	7500 National Pike Uniontown, PA 1540
13.	John Kelsey	1067 Lakeview Dr Latrobe 1562
14.	Dolores Motel	1019 Lloyd Ave., Latrobe, PA 15650
15.	Joyce Thomas	8-First Ave Latrobe
16.	Kim DeBone	6164 Old Wm. Penn Hwy

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	NAME	ADDRESS
1.	Vernon Baker	121 Big Shanty Rd RT Morgan
2.	Bobby Baker	304-825-6841
3.	Debby MEADOWS	Rt. 1, Box 233, FARMington WV 26571
4.	Jim Dillon	150 Pratts Rd. Carmichaels
5.	Jim Aikel	McClellandtown PA
6.	Brian A Mill	Holbrook PA.
7.	Elissa Gooden	1507 SMITHCREEK, WB6.
8.	Edward KENSIC	885 West Goode St Carmichaels Rt 523
9.	Brian Lilley	RD #3 Box 233 Cameron, WV
10.	Susan H Haines	242 Sayphillips Hill Rd Aleppo PA 15362
11.	Margaret Hopkins	217 Tin Can Hollow Rd Rices Landing 15357
12.	Ernest E Woodward	361 Markleysburg Pa
13.	Julia D. Tankard	361 Markleysburg, PA
14.	Marie Taylor	1821 O.D. DAIRY RD Dilliner PA
15.	Joe Gaughan	1821 O.D. DAIRY R. Dilliner PA
16.	Patty Lewis D. Lewis Sr.	P.O. Box 385 CLARKSVILLE, PA. 15322

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	NAME	ADDRESS
1.	Frank DeLuca	274 Dillinger PA. 15327
2.	Jean Mabel	314 Carters Rd, Carmichaels, PA 1532
3.	Linda Simpson	340 Nemes Rd Carm Pa 15320
4.	William Simpson	340 Nemes Rd. Carm. Pa. 15320
5.	Linda Gregory	609 Dividing Rd. ABG. 15321
6.	Doug Cline	1154 Garards Fort Rd Waynesburg 15320
7.	Jean Cline	199 Jordyce Hill Rd. Waynesburg Pa, 15370
8.	Kathy Morris Miller	3202 E. Lake Hartridge Dr. W. Haven Florida
9.	Sharon Lewis	P.O. Box 114 Sokol Hill Millsboro
10.	Jeff Lewis	P.O. Box 114 Sokol Hill Millsboro
11.	Sara Lewis	P.O. Box 114 Sokol Hill Millsboro
12.	Nancy Hughes	632 Windy Gap Rd Aleppo Pa.
13.	Brad Hughes	632 Windy Gap Rd Aleppo Pa.
14.	Liz Menhart	19 S. Washington St. Waynesburg
15.	Candace Tustin	19 S Washington St. Waynesburg
16.	Kenny IV Fike	25 Ash Rd, Uniontown PA 1540

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	NAME	ADDRESS
1.	Jeff McClelland	275 Third St. Brownsville, PA
2.	Chris Sigler	GRINDSTONE, PA
3.	[illegible]	346 Third St California, PA
4.	[illegible]	230 2nd Street Belle Vernon PA 150
5.	[illegible]	UNIONTOWN, PA
6.	Richard E Bowen Jr	Connellsville, PA
7.	Robert Myers	New Salem, PA
8.	arthur w Campbell	ORIENT PA 15420
9.	Linda Dunfee	511 Payne Hill Rd. Jefferson Hills, PA 1502
10.	Michael Bridenbaugh	1819 Third St Connellsville PA 15425
11.	[illegible]	251 Church St Ext Smithfield 15478
12.	Ron Kostbade	97 E. Main ST. UNIONTOWN PA 15401
13.	[illegible]	193 March Ave New Eagle PA 15351
14.	Diana Whitlatch	717 W Main, Monongahela, PA 15063
15.	Joan R. Whitlatch	717 W. Main Street, Monongahela PA 15063
16.	Larry Carr	Box 28 LAKE LYNN PA 1545

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	NAME	ADDRESS
1.	Brian Boadwater	27 Reesmans MHP Waynesburg PA
2.	Deirdra Bell	27 Reesmans MHP Wby PA
3.	Steven Cummings	618 Taylortown RD Dilliner PA.
4.	Becky Keck	PO Box 71 Greensburg PA 15338
5.	Carole McIntyre	248 Horseshoe Lane Waynesburg 15370
6.	Alice McMahan	1770 S 88 Rd Greensboro PA
7.	ELLEN WEEKLY 226 W	Roy Farmer Hwy Wind Ridge PA
8.	VALERIE GLISTER	424 Clarksville Road Clarksville Pa
9.	Jared McCullough	881 Little Shannon RD Mt. Morris Pa 15332
10.	Vicki Emerick	593 Maple town Rd Garards 15349
11.	Irene Smith	60008 Woodlands Bluff Rd, Morgantown WV 26508 for Pa
12.	Jeanette Trader	953 Washington RD Prosperity Pa 15329
13.	Ethel J. Vernon	143 Dillner Hill Rd Dilliner Pa 15327
14.	Nicholas J. White	712 Gladden, Crawfordsville 15370
15.	Mary Wenski	352 N. West St, Waynesburg PA
16.	Robert Wenski	352 N. West St Waynesburg PA

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	NAME	ADDRESS
1.	TRAVIS SMITH	PO Box 88 Bobtown
2.	GRACE ROUPE	P.O. BOX 82 BRAVE PA.
3.	CAROLINE ROUPE	1274 Jollytown Road Waynesburg PA
4.	Larry Conard	71 Carmichaels, PA
5.	Angel Conard	71 Carmichaels PA
6.	Luke Cyphert	7 Briar Patch Ln Morgantown WV
XXX 7.	Joe Lasko 627-3010 Lone Star Farms	1907 Kirby Rd
8.	Brandy Jaworek	534 Mt. Morris PA 15349
9.	GARY LACORTE	164 CREEK RD MT. MORRIS, PA
10.	Nadine Pratt	McHenry MD
11.	CHARLES W CORWIN	724-627-9300
12.	Dylan Martin	[illegible]
13.	Shawnie R. Smith	315 Ceylon Rd Carmichaels
14.	[illegible]	Bobtown PA 15315
15.	David R Johnson	123 N Richhill WBG PA 15370
16.	Linda Pardee	Carmichaels, PA 15320

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	NAME	ADDRESS
1.	Denise Decker	323 Achlegel Rd Grayswille, Pa 15337
2.	Julie E. Wells	210 Dorhame Greensboro PA 15338
3.	Jane Harrison	Wynhard, Greensboro PA
4.	Kathy Green	Greensboro, PA 15338
5.	John Ly. Yeasterday	GARARDS FORT PA 15334
6.	Vivian L. Bauer	2131 E NATIONAL Pike, Scenery Hill PA 15360
7.	Joann M. Bell	164 Oak Dr. Jefferson, PA 15344
8.	Emma Hurst	1725 Smith Crek Rd Waynesburg PA 15370
9.	TINA RIGGI	1 CUMBERLAND Village CARM. PA
10.	Debra RIGGI	1 CUMBERLAND Village CARM. PA 15320 15320
11.	DENA DANFORTH	11 ROCK ST BROWNSVILLE PA 15417
12.	PAT Ferguson	103 LOCUST ST BRAVE PA 15316
13.	Amy Hurst	203 Mountainview Gardens Waynesburg 15370
14.	Shelly Naylor	424 Glade Run Rd. CARMICHAELS PA 15320
15.	Evelyn Gabelotta	Box 357 Smithfield, Pa. 15478
16.	Ida Vescio	187 Deeker Rd Carmichaels PA 15320

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	NAME	ADDRESS
1.	Glenda Watson	PO Box1 Clarksville Pa 15322
2.	Donald Watson	PO Box1 Clarksville PA 1532
3.	Ellen Reynolds	789 Crucible Rd. Rices Landing PA, 15357
4.	Beth Smith	315 Ceylon Rd 15320
5.	Erwin Woody Wilson	312 [illegible] Station Rd 15338
6.	[illegible]	123 Milliken Rd New Freeport PA 15352
7.	[illegible]	120 Center Highlands Wbg 1537[illegible]
8.	Carole Main	255 LOG CABIN RD HOLBROOK PA 1534[illegible]
9.	C. W. Koochuck	306 Tanner Run Prosperity
10.	Dorothy Kennedy	157 Fieldsorg Rd Dilliner PA 15327
11.	Debra Tennant	71 Taylortown Rd Dilliner PA 15327
12.	Diana Smith	1426 [illegible] Run Rd Waynesburg 1537[illegible]
13.	Julia A Thomas	65 Princeton Ave Uniontown PA 154[illegible]
14.	Bronwyn Waid	402 clear st. Greensboro PA 15338
15.	Mary Aston-Richards	P.O. Box 265 Greensboro, PA
16.	Diane Blacker	298 Lough Rd Wind Ridge PA

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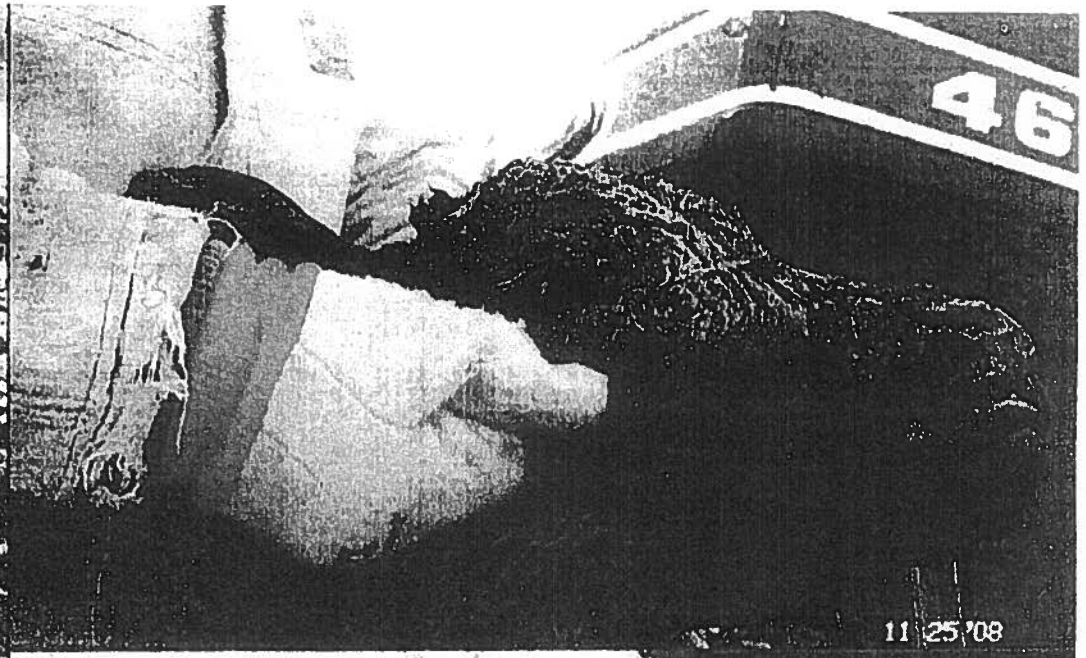
	NAME	ADDRESS
1.	Gary D Foster	Brownsville Pa.
2.	Reba Prinkey (southern Flower)	Brownsville Pa.
3.	[illegible]	408 Church St Brnville PA 15417
4.	Michelle Dent	806 Worthington Ave Clairton PA 15025
5.	Nancy J. Pepper	
6.	Cindy Lacey	619 River St W. Brownsville
7.	Melissa Barry	400 2nd St Brownsville
8.	Chas McClean	6018 N. Pike Brownsville, Pa
9.	Don Moore	454 Dunlap PA
10.	[illegible]	Po Box 36 [illegible] Pa 15[illegible]
11.	Emily Carr	PO Box 32 Lake Lynn PA 15451
12.	Rhonda Carr	P.O. Box 32 Lake Lynn pa. 15451
13.	Michael E. Long	216 Bell Drive, Dunbar, Pa. 15431
14.	Phyllis Carr	P.O Box 32 Lake Lynn Pa 15451
15.	[illegible] Carr	PO Box 32 Lake Lynn PA 15451
16.	[illegible]	1601 W. Crawford Ave Connellsville PA 15425

Grave with shirt marking spot of Grave in the back ground by tree is William Rice Tomb stone

William Rice-Tomb stone photo of busted up tomb stone a small town was named after him.

98 Head of cattle did after fracking well. Paluted farm and contaminated six water well below Fayette. Had a fish kill in Pigeon Creek. DEP was a well aware of this and still yet nothing was done


11 25 '08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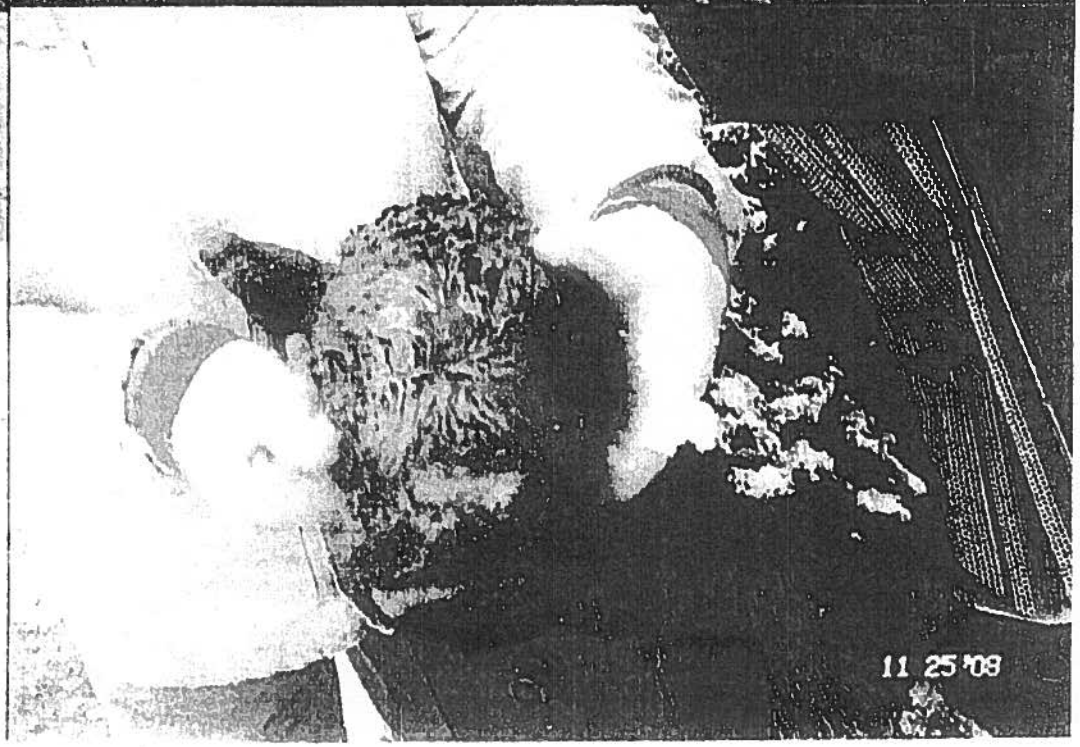
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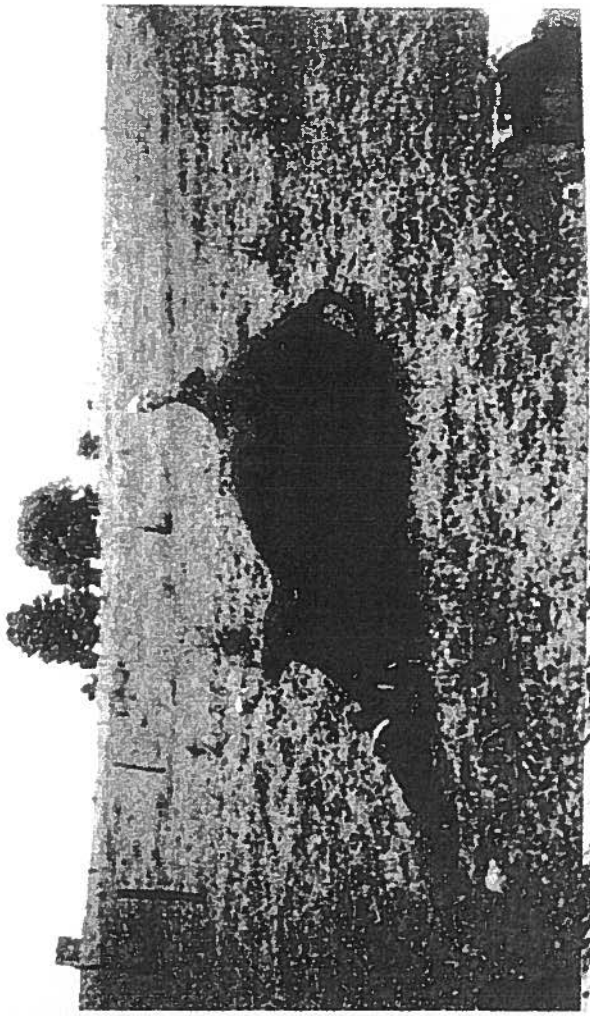
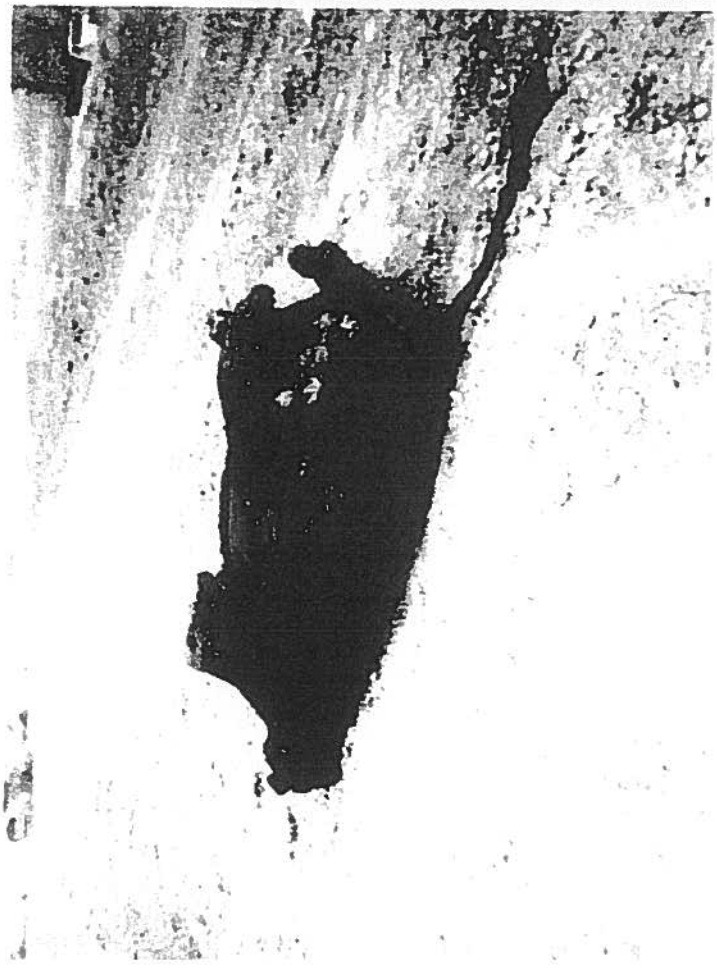
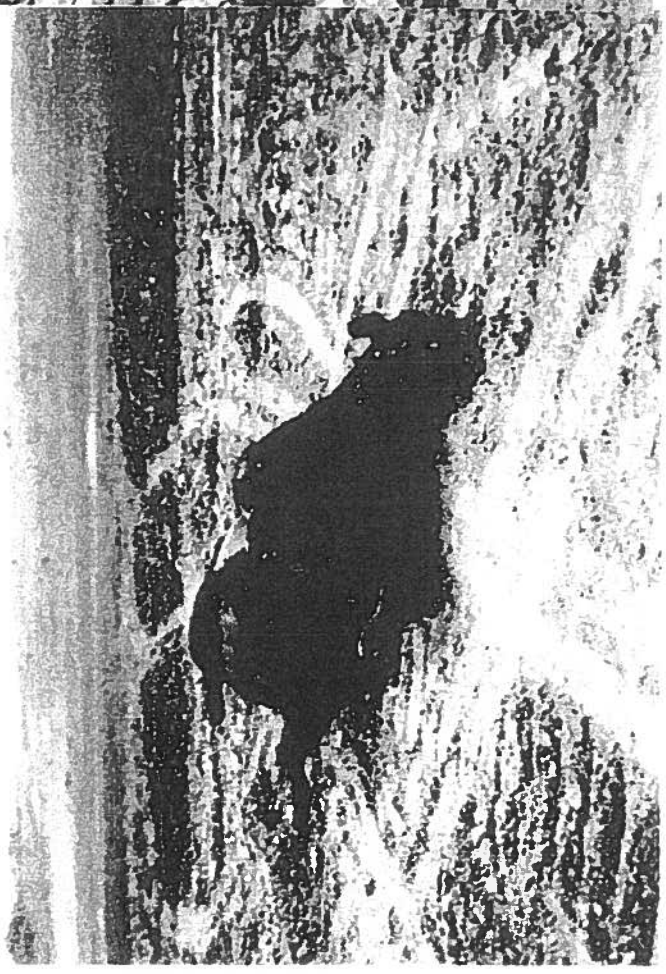
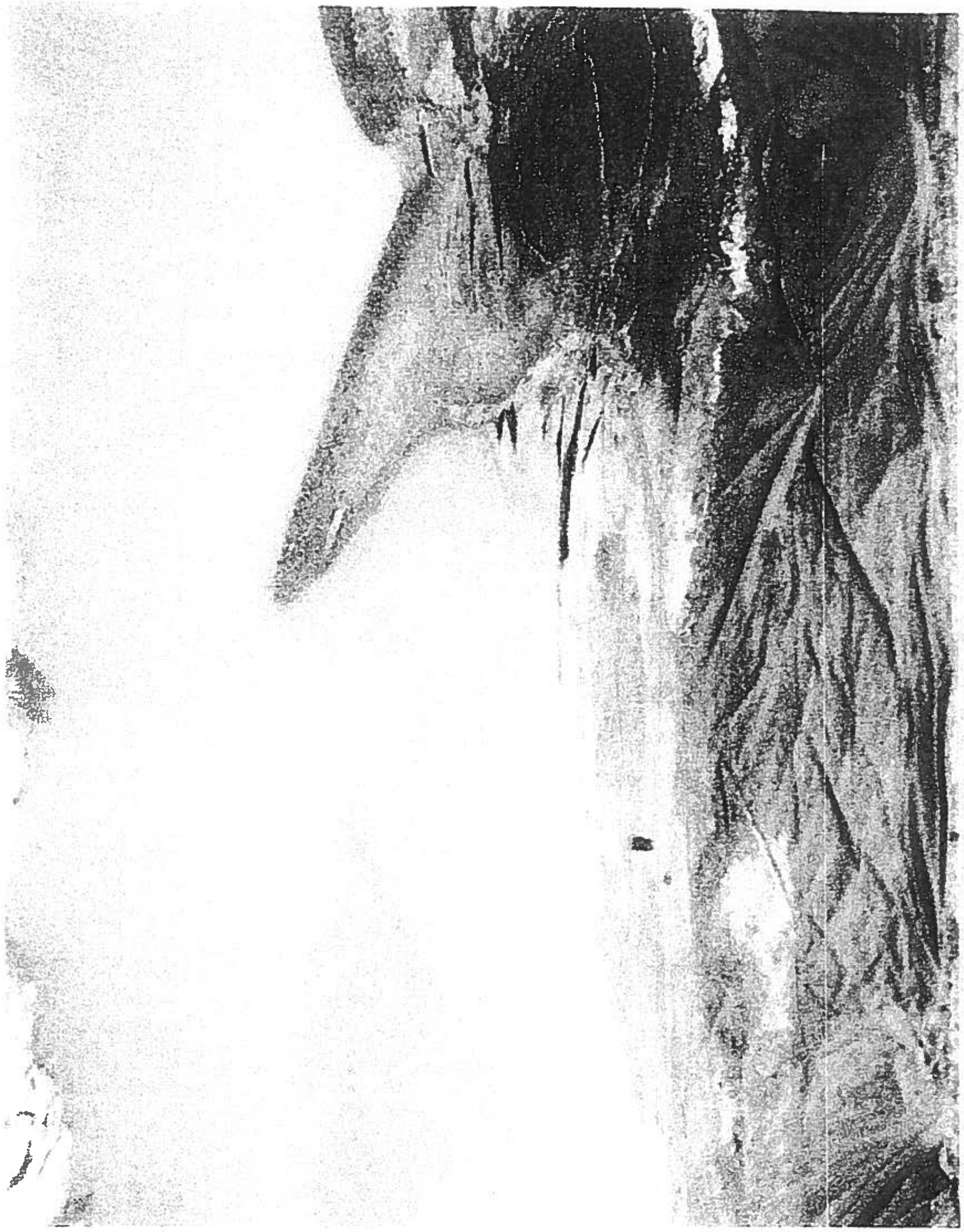
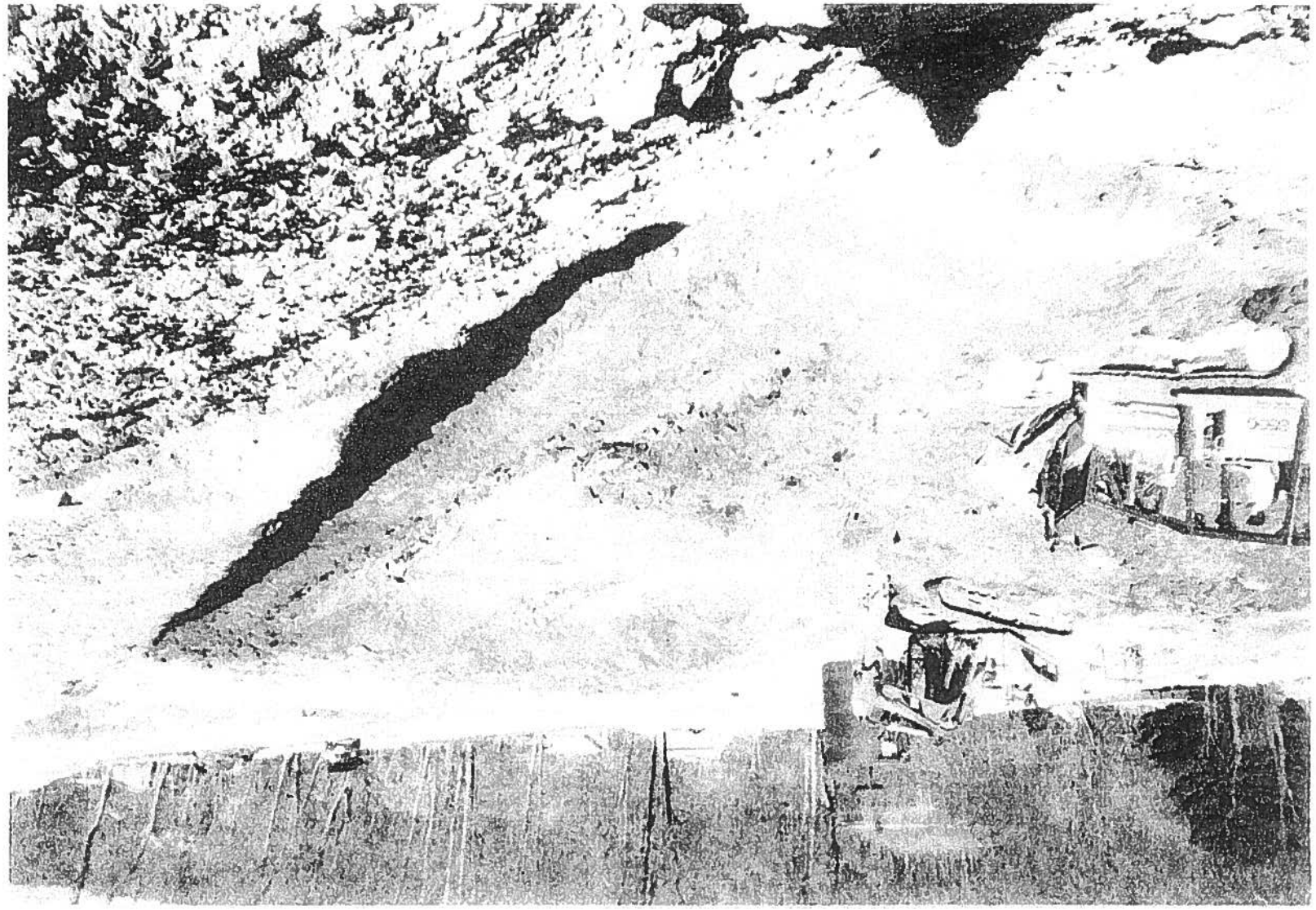






Sludge from Drilling buried on my cousins farm
Also Attached are some photos of dead cattle on farm.
Water was polluted by Frack fluids. He lost 31 head of cattle
and 14 calfs born still born. Some had no cleft palettes and some
had no irises. Some had white eyes. His whole farm is still polluted today
Is this a co[illegible] by the DEP who said that everything is fine

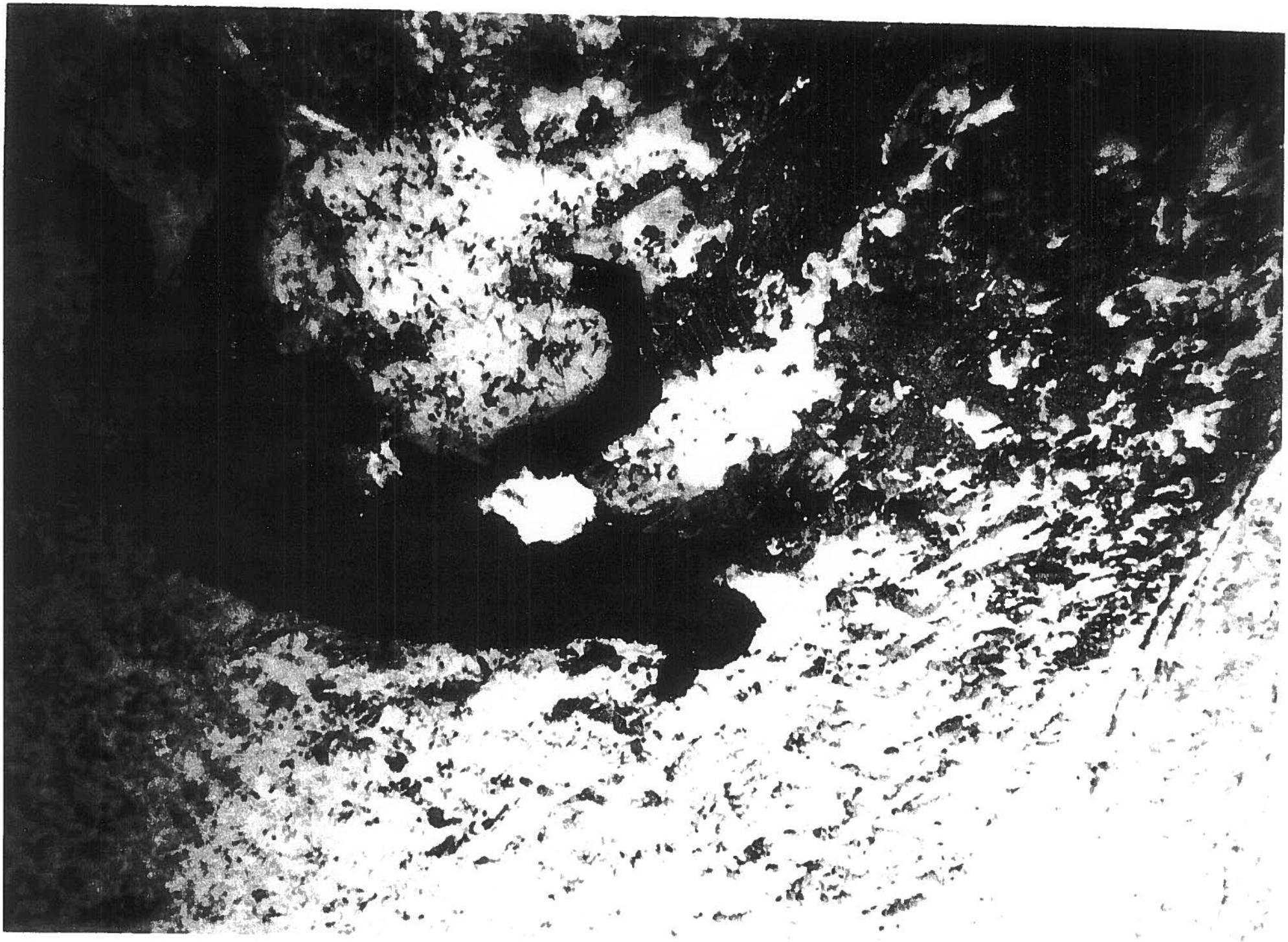




Road turn Red

Cows died after giving birth.

Calf has white
eyes



Endangered species bill clears committee

By Natasha Lindstrom
nlindstrom@calkins.com

HARRISBURG — A controversial bill that would change the way Pennsylvania designates endangered species and wild trout streams is headed for a vote on the House floor.

House Bill 1576, called the Endangered Species Coordination Act, cleared the Game and Fisheries Committee Wednesday on a 16-8 vote. House Majority Leader Mike Turzai told reporters Wednesday evening that the legislation has "significant bipartisan support" and he intends to run a vote on it next week.

The bill has pitted environmental and sportsmen groups against oil, gas and coal companies and the Pennsylvania Chamber of Business and Industry, with industry advocates voicing their support.

Under HB 1576, decisions by the state Game Commission and Fish and Boat Commission would now be subject to approval by the Independent Regulatory Review Commission, or IRRC, along with review by standing legislative committees.

The bill's author, Armstrong County Rep. Jeff Pyle, R-60, Ford City, said he aims to bring more openness, scrutiny and appeal options to an unchecked regulatory process that's been stifling economic development and penalizing landowners.

"I think the bill adds a consistency, I think it adds a transparency and it brings them into line with Pennsylvania's other rule-promulgating agencies," Pyle said. "What a lot of people don't know is Fish and Boat and Game commissions are the only ones not subject to IRRC. Everyone else is."

But opponents, including the Pennsylvania Federation of Sportsmen's Clubs and PennFuture, argue the legislation threatens the state's most vulnerable animals in an attempt to make it easier for private industry to expand. They oppose stripping the Game and Fish and Boat commission of their autonomy over the listing process.

"What they're trying to do is take the fate of wildlife in Pennsylvania out of the hands of scientists and put it in the hands of a regulatory board, which has never been done before," said Ann Pettigrew, a bird watcher from York who attended the committee meeting to protest the bill. "We feel what's going to happen is that they're going to open more and more lands up to fracking up and natural gas drilling so that more habitat is destroyed."

Pyle said that under his bill, the scientists employed by the existing commissions would continue to drive decisions on which species get added or removed. The IRRC would be an extra layer of checks and balances, he said, to help ensure the commissions follow the law and can back up their decisions with proof.

Pennsylvania lists 28 species of birds, bats and mammals as endangered and threatened, along with 62 fish, amphibians and invertebrates.

Pyle has questioned the need for the state to list species that may be low on population in Pennsylvania but thriving elsewhere.

"What most people are most familiar with is the federal endangered species list. What people don't know is the Game Commission and Fish and Boat maintain their own Pennsylvania-only lists," Pyle said. "So something that we find in one county here yet is in great, great abundance in other states is considered endangered here."

Keith Thomas, a Boy Scout leader from Mechanisburg, said he's worried about the precedent the bill sets when it comes to protecting Pennsylvania's wildlife. Anecdotally, he's observed a major drop in the bats living in his area.

"I'm shocked right now that I don't see the bats that I've seen all my life," Thomas said.

An amendment attached to the bill addressed some of the opposition's initial concerns, including removing a requirement that all listed species undergo a review every two years. The amendment also clarified that no licensing money can be transferred to another agency to implement the act — a change to help alleviate concerns over losing federal funds.

Fayette County Reps. Deberah Kula and Pam Snyder and Bucks County Rep. John Galloway voted in favor of HB 1576 in committee, while Fayette County Rep. Tim Mahoney and Beaver County Rep. Jesse White voted it down.

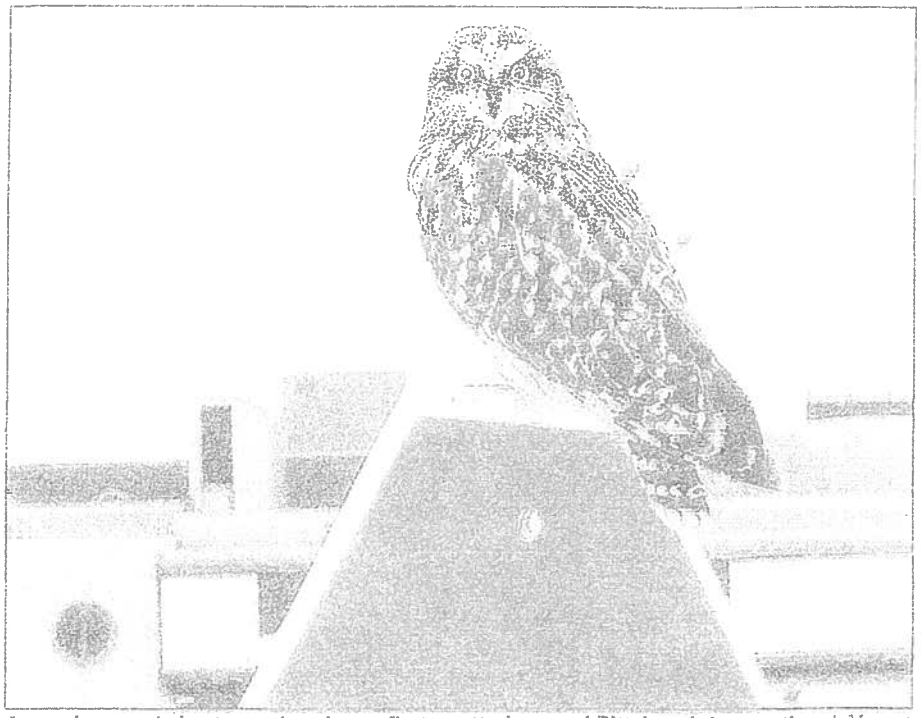
"The bill has not yet taken final form," Pyle noted. "I'm sure there will be amendments offered on the floor, and it still has to go through the Senate. I'm not sure what they're thinking."

Jefferson County Sen. Joe Scarnati, R-25, has introduced a similar bill in the state Senate.

Natasha Lindstrom may be reached at nlindstrom@calkins.com.

Endangered owl released in Washington Co.

By Katrine O. Warco
Staff writer
kwarco@observer-reporter.com



An endangered short-eared owl was first spotted around Pittsburgh International Airport in December.

An endangered short-eared owl has a new home in Washington County after it was captured earlier this month on the grounds of Pittsburgh International Airport.

The owl was spotted around the airfield, fairly close to the airport terminal, in late December, said Jeff Martinelli, public affairs manager for the airport.

The bird is endangered and protected under the state's Game and Wildlife Code. Short-eared owls are medium-sized owls with small ear tufts and round, beige facial disks similar to barn owls. They are most often seen in the late afternoon and at dawn or dusk.

Martinelli said they are considered a regionally endangered species. This area is the on the southern tier of their habitat.

"It is rare that they are this far south," Martinelli said.

After the bird was spotted, the Allegheny County Airport Authority wildlife team coordinated a plan to protect the bird while also ensuring airport safety. While finding wildlife at the airport is not unusual, endangered species like the owl have to be treated differently, Martinelli said. When the bird is endangered, the airport is required by the Federal Aviation Administration to comply with the Endangered Species Act.

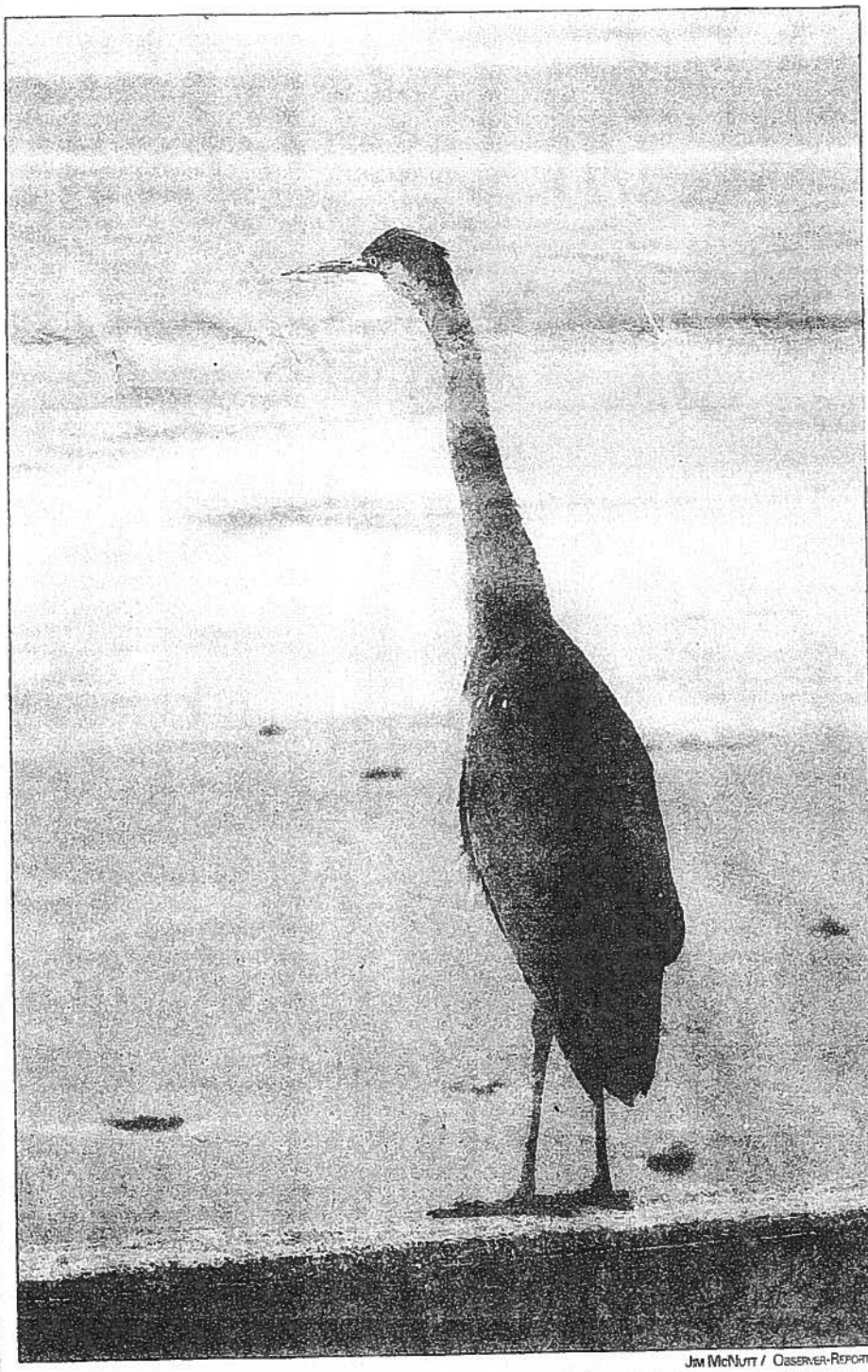
The authority team, along with the U.S. Department of Agriculture, contacted the National Aviary and state game commission. The game commission gave a trapping permit to capture and relocate the owl.

All four groups worked to remove the owl from airport property. Once captured, the owl was taken to a 500-acre, reclaimed strip mine in Washington County and released. The owls nest on reclaimed and replanted mines.

The airport has a comprehensive, integrated program in place to help minimize conflict between birds and aircraft.

"It is a continuous management program designed to minimize wildlife-related risks," said Bradley D. Penrod, president and chief strategy officer for the airport authority. "In addition to vigilance and watchfulness, our program implements innovative methods of monitoring and adaption of mitigation techniques."

On the lookout



Jim McNutt / Observer-Reporter

A great blue heron sits on a concrete wall, scanning Canonsburg Lake in search of fish to eat Monday. With the lake 90 percent frozen, it might have been a long wait.

U.S. Fish & Wildlife Service

Threatened and Endangered Species

Indiana Bat
(Myotis sodalis)

The Indiana bat is an endangered species. Endangered species are animals and plants that are in danger of becoming extinct. Threatened species are those that are likely to become endangered in the foreseeable future. Identifying, protecting, and restoring endangered and threatened species are primary objectives of the U.S. Fish and Wildlife Service's endangered species program.

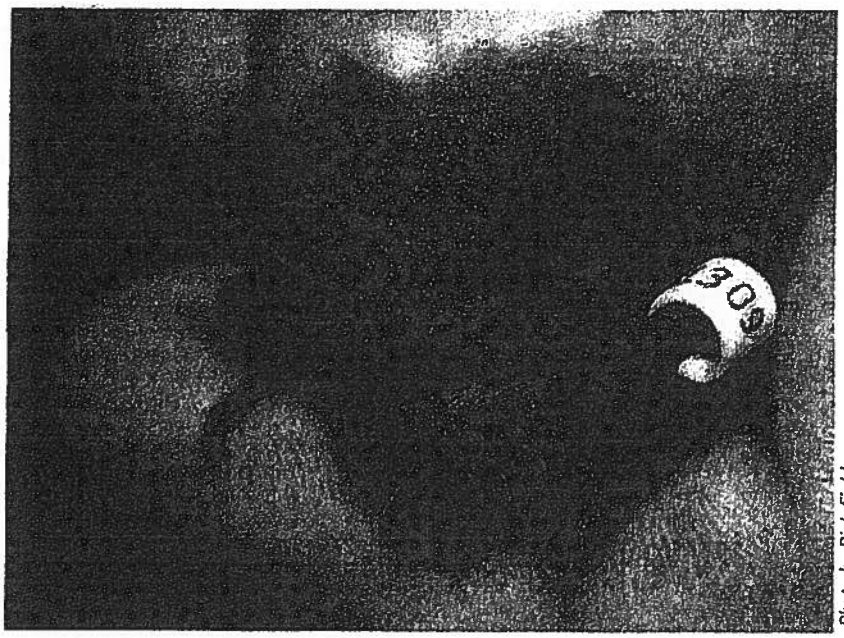


Photo by Rich Fields

Indiana bats eat up to half their body weight in insects each night.

What is the Indiana Bat?

Description

The scientific name of the Indiana bat is *Myotis sodalis* and it is an accurate description of the species. Myotis means "mouse ear" and refers to the relatively small, mouse-like ears of the bats in this group. Sodalis is the Latin word for "companion." The Indiana bat is a very social species; large numbers cluster together during hibernation. The species is called the Indiana bat because the first specimen described to science in 1928 was based on a specimen found in southern Indiana's Wyandotte Cave in 1904.

The Indiana bat is quite small, weighing only one-quarter of an ounce (about the weight of three pennies). In flight, it has a wingspan of 9 to 11 inches. The fur is dark-brown to black. The Indiana bat is similar in appearance to many other related species. Biologists can distinguish it from similar species by comparing characteristics such as the structure of the foot and color variations in the fur.

Habitat

Indiana bats hibernate during winter in caves or, occasionally, in abandoned mines. For hibernation, they require cool, humid caves with stable temperatures, under 50° F but above freezing. Very few caves within the range of the species have these conditions.

Hibernation is an adaptation for survival during the cold winter months when no insects are available for bats to eat. Bats must store energy in the form of fat before hibernating. During the six months of hibernation the stored fat is their only source of energy. If bats are disturbed or cave temperatures increase, more energy is needed and hibernating bats may starve.

After hibernation, Indiana bats migrate to their summer habitat in wooded areas where they usually roost under loose tree bark on dead or dying trees. During summer, males roost alone or in small groups, while females roost in larger groups of up to 100 bats or more. Indiana bats also forage in or along the edges of forested areas.

Reproduction

Indiana bats mate during fall before they enter caves to hibernate. Females store the sperm through winter and become pregnant in spring soon after they emerge from the caves.

After migrating to their summer areas females roost under the peeling bark o dead and dying trees in groups of up tc 100 or more. Such groups are called maternity colonies. Each female in the colony gives birth to only one pup per year. Young bats are nursed by the mother, who leaves the roost tree only to forage for food. The young stay witl the maternity colony throughout their first summer.

Feeding Habits

Indiana bats eat a variety of flying insects found along rivers or lakes and in uplands. Like all insect-eating bats, they benefit people by consuming insects that are considered pests or otherwise harmful to humans. Their role in insect control is not insignificant – Indiana bats eat up to half their body weight in insects each night.

Range

Indiana bats are found over most of the eastern half of the United States. Almost half of all Indiana bats (207,000

in 2005) hibernate in caves in southern Indiana. In 2005, other states which supported populations of over 40,000 included Missouri (65,000), Kentucky (62,000), Illinois (43,000) and New York (42,000). Other states within the current range of the Indiana bat include Alabama, Arkansas, Connecticut, Iowa, Maryland, Michigan, New Jersey, North Carolina, Ohio, Oklahoma, Pennsylvania, Tennessee, Vermont, Virginia, West Virginia. The 2005 population estimate is about 457,000 Indiana bats, half as many as when the species was listed as endangered in 1967.

Why is the Indiana Bat Endangered?

Human Disturbance

Indiana bats, because they hibernate in large numbers in only a few caves, are extremely vulnerable to disturbance. During hibernation, they cluster in groups of up to 500 per square foot. Since the largest hibernation caves support from 20,000 to 50,000 bats, it is easy to see how a large part of the total population can be affected by a single event. Episodes of large numbers of Indiana bat deaths have occurred due to human disturbance during hibernation.

Cave Commercialization and Improper Gating

The commercialization of caves – allowing visitors to tour caves during hibernation – drives bats away. Changes in the structure of caves, such as blocking an entrance, can change the temperature in a cave. A change of even a few degrees can make a cave unsuitable for hibernating bats. Some caves are fitted with gates to keep people out, but improper gating that prevents access by bats or alters air flow, temperature, or humidity can also be harmful. Properly constructed gates are beneficial because they keep people from disturbing hibernating bats while maintaining temperature and other requirements and allowing access for bats.

Summer Habitat Loss or Degradation

Indiana bats use trees as roosting and foraging sites during summer months. Loss and fragmentation of forested habitats can affect bat populations.

Pesticides and Environmental Contaminants

Insect-eating bats may seem to have an unlimited food supply, but in local areas, insects may not be plentiful because of pesticide use. This can also affect the quality of the bats' food supply. Many scientists believe that population declines occurring today might be due, in part, to pesticides and environmental contaminants. Bats may be affected by eating contaminated insects, drinking contaminated water, or absorbing the chemicals while feeding in areas that have been recently treated.

What is Being Done to Prevent Extinction of the Indiana Bat?

Listing

Prompted by declining populations caused by disturbance of bats during hibernation and modification of hibernacula, the Indiana bat was listed in 1967 as "in danger of extinction" under the Endangered Species Preservation Act of 1966. It is listed as "endangered" under the current Endangered Species Act of 1973. Listing under the Endangered Species Act protects the Indiana bat from take (harming, harassing, killing) and requires Federal agencies to work to conserve it.

Recovery Plan

The Endangered Species Act requires that recovery plans be prepared for all listed species. The U.S. Fish and Wildlife Service developed a recovery plan for the Indiana bat in 1983 and is now revising that Plan. The recovery plan describes actions needed to help the bat recover.

Habitat Protection

Public lands like National Wildlife Refuges, military areas, and U.S. Forest Service lands are managed for Indiana bats by protecting forests. This means ensuring that there are the size and species of trees needed by Indiana bats for roosting; and providing a supply of dead and dying trees that can be used as roost sites. In addition, caves used for hibernation are managed to maintain suitable conditions for hibernation and eliminate disturbance.

Education and Outreach

Understanding the important role played by Indiana bats is a key to conserving the species. Helping people learn more about the Indiana bat and other endangered species can lead to more effective recovery efforts.

U.S. Fish & Wildlife Service
1 Federal Drive
Fort Snelling, Minnesota 55111
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http://www.fws.gov/midwest/endangered

December 2006

Evaluating a groundwater supply contamination incident attributed to Marcellus Shale gas development

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Edited by Stephen Polasky, University of Minnesota, St. Paul, MN, and approved April 2, 2015 (received for review October 22, 2014)

High-volume hydraulic fracturing (HVHF) has revolutionized the oil and gas industry worldwide but has been accompanied by highly controversial incidents of reported water contamination. For example, groundwater contamination by stray natural gas and spillage of brine and other gas drilling-related fluids is known to occur. However, contamination of shallow potable aquifers by HVHF at depth has never been fully documented. We investigated a case where Marcellus Shale gas wells in Pennsylvania caused inundation of natural gas and foam in initially potable groundwater used by several households. With comprehensive 2D gas chromatography coupled to time-of-flight mass spectrometry (GCxGC-TOFMS), an unresolved complex mixture of organic compounds was identified in the aquifer. Similar signatures were also observed in flowback from Marcellus Shale gas wells. A compound identified in flowback, 2-n-Butoxyethanol, was also positively identified in one of the foaming drinking water wells at nanogram-per-liter concentrations. The most likely explanation of the incident is that stray natural gas and drilling or HF compounds were driven ~1–3 km along shallow to intermediate depth fractures to the aquifer used as a potable water source. Part of the problem may have been wastewaters from a pit leak reported at the nearest gas well pad—the only nearby pad where wells were hydraulically fractured before the contamination incident. If samples of drilling, pit, and HVHF fluids had been available, GCxGC-TOFMS might have fingerprinted the contamination source. Such evaluations would contribute significantly to better management practices as the shale gas industry expands worldwide.

high-volume hydraulic fracturing | shale gas | natural gas | water quality | Marcellus Shale

Horizontal drilling and high-volume hydraulic fracturing (HVHF) are used in combination to extract natural gas, condensate, and oil from shale reservoirs in the United States at rates affecting the world economy (1–4). In the shale gas-rich Marcellus Formation, such slick water HVHF began in 2004, leading to >8,000 Marcellus wells drilled in Pennsylvania (PA) alone as of October 2014. Nearly 70% of these have been hydraulically fractured using large volumes of water and sand with relatively small volumes of gels, acids, biocide, and other compounds (5, 6). The fast rate of such shale development in the northeastern United States has led to several cases of water resource impacts, including surface discharges of contaminants as well as subsurface gas migration (6–12). Although media reports of incidents are common, published reports are few (10).

The most useful evidence for incidents links contaminants directly to the source with a high degree of certainty. To evaluate impacts, a "multiple lines of evidence" approach (13–16) is generally necessary, including (*i*) time series analyses of natural gas and organic and inorganic compound concentrations, (*ii*) comparisons of natural gas isotopic compositions between gas well annular gas and groundwater, (*iii*) assessments of gas well construction, (*iv*), chronology of events, (*v*) hydrogeologic characterization, and (*vi*) geospatial relationships.

Here we provide data for a contamination incident from PA where the regulator (PA Department of Environmental Protection, PADEP) concluded that stray natural gas derived from nearby Marcellus Shale gas wells contaminated the aquifer used by at least three households in southeastern Bradford County, PA (Fig. 1). In addition to gas, the well waters were also observed to foam (Fig. 1*C*), but no cause was determined. To investigate this and other contaminants present, we demonstrate an investigative approach to identify unique organic unresolved complex mixtures (UCMs) and a target compound linked to shale gas-related contamination (2-n-Butoxyethanol, 2-BE).

History

Between 2009 and 2010, five gas well pads, known as Welles 1 through 5, were constructed about 1–2.25 km north of a small valley along the north branch tributary of Sugar Run where several private homes used groundwater for drinking (Fig. 1 *A* and *B* and). On each well pad, two wells with horizontal sections at depth were drilled and surface casing was emplaced to about 300 meters below ground surface (m-bgs) on the vertical section. The vertical casing consists of steel pipe surrounded by cement. At intermediate depths, no casing was installed. Production casing was used through the zone of gas production in the Marcellus Shale at depths between 2,100 m-bgs and 2,300 m-bgs (horizontal section).

By the end of September 2009 after both gas wells on the Welles 1 well pad were drilled, no construction problems associated with gas migration (6) were noted; however, a drilling fluid

Author contributions: G.T.L., F.D., D.Y., and S.L.B. designed research; G.T.L., F.D., J.L.W., D.Y., P.G., T.S., and S.L.B. performed research; F.D. contributed new reagents/analytic tools; G.T.L., F.D., J.L.W., D.Y., P.G., T.S., E.H.-F., and S.L.B. analyzed data; and G.T.L. and S.L.B. wrote the paper.

Conflict of interest statement: G.T.L. and Appalachia Consulting provided litigation support and environmental consulting services to the impacted households.

This article is a PNAS Direct Submission.

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This article contains supporting information online at

away in Susquehanna County, and (*v*) several potable water wells near the pollution incident that represent natural background. These background wells include a well from one of the relocated households, three non-impacted households located within 5 km of the impacted homes, and a private house near Salt Springs. We also obtained and analyzed one common drilling additive (Airfoam HD). Sampling methodologies are described in .

Subsets of these samples were analyzed via gas chromatographic separation, specifically using GCxGC-TOFMS, isotope ratio mass spectrometry, and inductively coupled plasma atomic emission spectrometry (ICP-AES) (see and). GCxGC-TOFMS has previously been successful in identifying hydrocarbons in crude oil forensics (13). Here, TOFMS was used to detect analytes as they eluted from the second column. Concentrations were quantified, when possible, by running samples with known compounds injected in tandem with the sample. Additionally, surrogate standards were added to all samples before extraction to account for sample extraction efficiency.

Available natural gas analyses completed during investigations before settlement (and and) and completed on a subset of the samples we collected in November 2012 ( ) are reported in .

Aquifer testing was also conducted using household Well 4 as a pumping well and the other original and replacement wells as monitoring wells to investigate shallow aquifer characteristics ( ).

Results

Dissolved Organic Analysis. Every flowback/produced water sample we analyzed had a similar UCM of hydrocarbons when evaluated with GCxGC-TOFMS (Fig. 3). All groundwater samples from impacted sites (Wells 1, 3, and 6; see Fig. 1) that were analyzed with GCxGC-TOFMS showed UCMs similar to those detected in the flowback/production waters (e.g., Fig. 4*A* and –). Well 1 was analyzed both before and after purging (at which time the water no longer foamed). Peak intensities for the UCM were generally greater after purging (compare Fig. 4*A* and).

Classes of analytes in GCxGC-TOFMS, such as aliphatic hydrocarbons or organic acids, align along a diagonal of the 2D cross-plot chromatograms. For the specific conditions used here, aliphatic hydrocarbons cluster near the origin, while compounds with increasing heteratomic substitution or unsaturation lie further along the *y* axis. With the exception of the surrogate compounds ( ), only general classifications were determined from mass spectra. The detected molecules elute showing molecular weights <1,000 atomic mass units, and mass-to-charge ratios (*m*/*z*) of 50–550. Each flowback/production water sample had a similar but distinct pattern of saturated versus branched chain alkanes (compare Fig. 3 *A* and *C*).

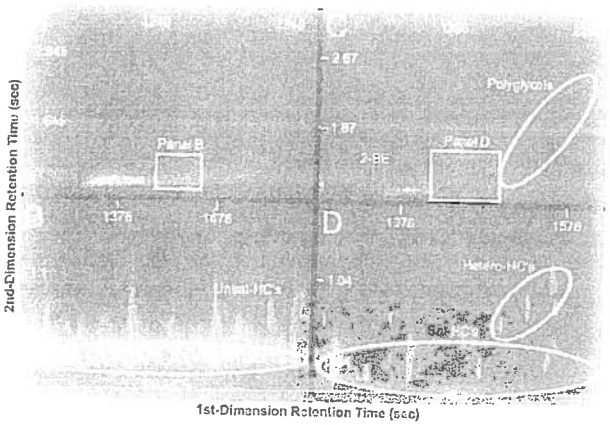

Fig. 3. GCxGC-TOFMS chromatograms of flowback water. (*A*) Example from a gas well in Connelsville, PA. (*B*) Magnified portion of *A* as indicated by white rectangle. (*C*) Example from a gas well in Kittanning, PA. (*D*) Magnified portion of *C* as indicated by white rectangle. General compound classes are illustrated in panels. Unresolved complex mixture (UCM) concentrations are relative to each panel, but increase in concentration from cool (e.g., blue) to bright (e.g., red) color.

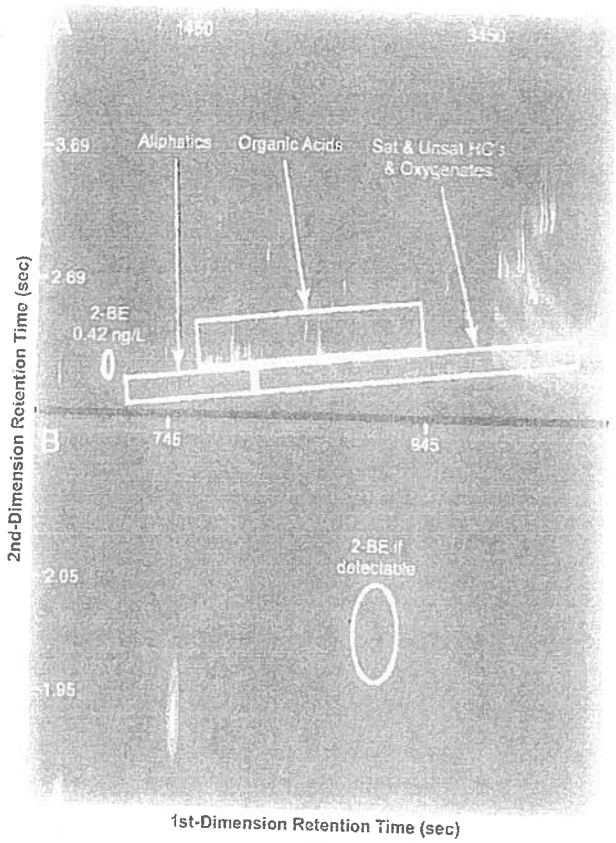

Fig. 4. GCxGC-TOFMS chromatograms for (*A*) Well 1 (PLG-12-67A) before purging and (*B*) background Well B1 (PLG-13-7A) that was not impacted by gas drilling activities. The hydrocarbon UCM observed in Well 1 is similar to that observed in flowback samples (e.g., Fig. 3). The 2-BE was positively identified in Well 1 (impacted by gas drilling activities), but not as part of background water quality. *B* is magnified to illustrate the absence of 2-BE.

A few of the ~30 flowback/production water samples were positively identified as containing 2-BE (Chemical Abstracts Service (CAS) number 111-76-2) and glycols—compounds commonly used during drilling and HVHF (Fig. 3*C*). For example, 2-BE was the only compound identified using GCxGC-TOFMS in the drilling additive and surfactant Airfoam HD (Fig. 5). The groundwater well analyzed before and after purging (Well 1) also contained detectable 2-BE. In contrast to the UCM, which increased in peak intensity with purging, concentrations of 2-BE decreased after purging: Sample PLG-12-67A before purge (Fig. 4*A*) contained ~0.42 ng/L 2-BE versus sample PLG-12-68A (after purging,) contained ~0.086 ng/L 2 BE (concentrations on as-received basis). No 2-BE was detected in the other two groundwater wells, although they contained the UCM [no 2-BE was detected in Well 3 ( ) or Well 6 ( )].

To confirm the presence of 2-BE, sample extracts were reanalyzed using GCxGC with a high-resolution TOFMS (GCxGC-HR-TOFMS) at Leco Corporation. For example, the presence of 2-BE was confirmed in the accurate mass spectra for prepurge sample PLG-12-67A from Well 1 (e.g., one of the replacement wells) by comparison with the 2-BE standard ( ). Only 2-BE matched the molecular ion determined by the GCxGC-HR-TOFMS within 5 ppm. None of the field blanks or preparatory blanks contained

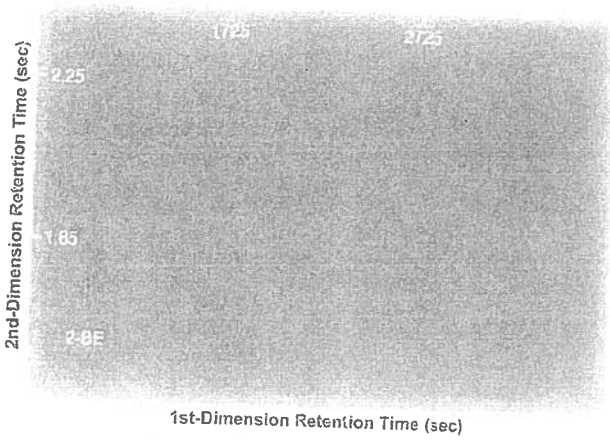

Fig. 5. GCxGC-TOFMS chromatogram for Airfoam illustrating 2-BE as the sole detectable component.

2-BE above detection (~0.01 ng/L). Likewise, neither UCM nor 2-BE were detected from groundwater (e.g., Fig. 4*B* and) sampled from three household wells (e.g., B1, B2, and B3 illustrated in Fig. 1) located outside of the impacted area and used to evaluate background conditions.

Inorganic Analysis. Conservative inorganic constituents (e.g., Cl and Br) can be used to determine if flowback or production waters have contaminated groundwater because these wastewaters can contain total dissolved solids in concentrations greater than 300,000 mg/L (6, 18). Further, if upward migration of HVHF fluids occurred after mixing with formation waters, dissolved Cl/Br mass ratios are more likely to be useful as effective fingerprints than the HVHF fluid components themselves, due to their more conservative behavior in groundwater (6, 10). Crossplots of Cl/Br (mass ratio) versus Cl concentration (Fig. 6) can help elucidate the source of Cl. For example, the natural water quality data for Salt Spring in Susquehanna County, PA, documents that Appalachian Basin brine (ABB) up-wells naturally into groundwater and surface water in Susquehanna County in that location as well as others (18). Although diluted, this spring water has a similar composition to flowback/production waters throughout PA and a few other brine springs and deep formation waters in the state (18–26) (Fig. 6 and). Conversely, Fig. 6 illustrates that the Cl concentrations and Cl:Br ratios of the impacted household waters from Bradford County are more likely gaining dissolved salts from sources with higher Cl:Br mass ratios than ABB.

Dissolved Gas and Isotopic Analyses. The dissolved methane concentrations measured in the impacted wells reached as high as 46.6 mg/L between 2010 and 2012 (Fig. 2 and). Such a high value is similar to methane concentrations we measured in three samples from Salt Springs State Park, where ABB is emitting naturally (Susquehanna County, 35.2 ± 1.53 mg/L,). In contrast, the predrill concentration in Well 2 was reported as <0.02 mg/L (e.g., plotting at the origin in Fig. 2). Likewise, the 1,701 drinking water wells collected by gas companies before drilling in adjacent Susquehanna County between 2008 and 2011 and analyzed in commercial laboratories (27) varied from a high (90th percentile) of 1.8 mg/L for valleys to a low of 0.017 mg/L for uplands. A steady decrease in dissolved methane was observed for at least one impacted household well (Well 1) with ample time series data, subsequent to the remediation of the Welles 3, 4, and 5 series gas wells (Fig. 2). An anomalous concentration spike was observed for all sampled wells in May 2012; however, differences in well purging and sampling protocols from that event complicate comparison with those that preceded it.

A plot of δD versus $\delta^{13}C$ data for methane is illustrated in for the (*i*) impacted household wells, (*ii*) annular space of Welles 2, 3, 4, and 5 gas wells, and (*iii*) predrill private household wells from the region (16). Notably, methane isotopic characteristics are consistent between gas sampled from the annular spaces of Welles 2, 3, 4, and 5 gas wells and groundwater sampled from the impacted homeowner wells. In contrast, methane characterized from predrill water wells in the region (16) illustrate generally different isotopic characteristics ( ). In addition, illustrates that $\delta^{13}C$ for methane and ethane are also consistent among gas samples from Welles 3, 4, and 5 wells' annuli and the impacted groundwater wells.

Hydrogeologic Considerations. The impacted homeowner wells lie along the north branch of Sugar Run valley between the axes of two east–west aligned structural folds (Fig. 1 and). The concave Barclay fold (syncline), is located 1–3 km to the north of Welles 1–5 pads; the convex Wilmot fold (anticline) lies to the south at a distance of 5–7 km ( ). Under the impacted valley (between the folds), bedrock strata dip ~5–10 degrees downward to the northwest toward the Welles series gas wells.

In September 2010, significant gas bubbling commenced in the Susquehanna River near the community of Sugar Run southeast of the impacted homeowner wells (Fig. 1 and). When projected back to the Welles gas wells, bedding planes that outcrop near the river (and that presumably facilitate methane migration) intersect the boreholes at ~400–600 m-bgs ( ). In comparison, the gas wells were cased to ~300 m-bgs ( ).

Well-developed vertical to near-vertical fractures (joints) are observed in outcrop to trend NNW–SSE in the study area. A second, lesser-developed set is aligned E–W. Many stream valleys, such as the impacted north branch of Sugar Run, lie parallel to the NNW–SSE joints, consistent with joint-controlled valley development (Fig. 1). In addition to jointing, Fig. 1 and also illustrate the surficial trace of a thrust fault identified from seismic reflection data. The fault plane dips ~16 degrees downward to the south. This dip intersects the Welles 1–5 series gas wells at depths between ~180 m-bgs and 580 m-bgs (and). Thus, the thrust fault structural plane likely intersects some uncased portions of boreholes at the Welles 1, 2, and 3 pads. Of

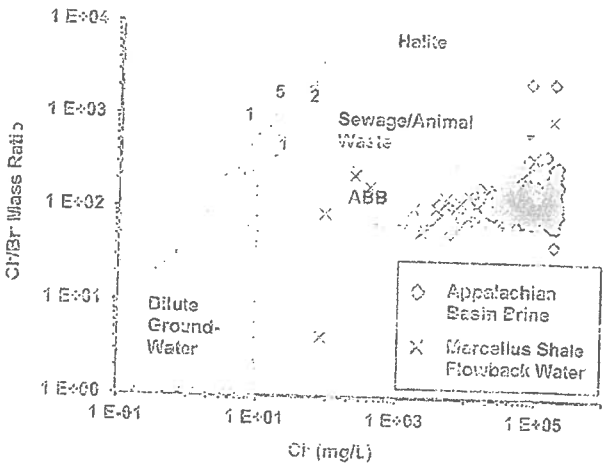

Fig. 6. Crossplot of Cl/Br mass ratio vs. Cl concentrations for samples collected from Wells 1, 2, and 5 (labeled) with bounding upper and lower conservative mixing curves for various endmembers (e.g., Appalachian Basin brine, sewage and animal waste, and halite sources). Appalachian Basin brine samples (20–22, 24) and Marcellus Shale flowback samples (23, 25, 26) are also plotted for comparison.

these three series, the Welles 1 and 2 wells did not reveal excessive, sustained annular gas pressures; however, elevated annular pressures of ~64 atm and ~48 atm were detected for Welles 3-2H and 3-5H, respectively. In response to the PADEP's COA with the gas company, cement was squeezed into boreholes for the Welles 3, 4, and 5 series (and), with subsequent decreases in gas well annular pressure.

To evaluate the local bedrock aquifer used by the three impacted households, aquifer testing was conducted for 7 h in November 2012, using Well 4 as a pumping well (25.8 L/min). Static groundwater elevations near the three impacted households ranged from 303.5 m above mean sea level (m-msl) to 308.9 m-msl, with flow converging toward the north branch of Sugar Run ( ). The aquifer test results indicated preferential drawdown parallel to the valley alignment, suggesting aquifer anisotropy and/or heterogeneity. Additional aquifer characterization is provided in .

Discussion

Even though drinking water consistently foamed in three households in Bradford County (e.g., Fig. 1*C*), commercial laboratories reported no compounds other than natural gas present at concentrations above regulatory recommended action levels, and no constituents were detected above regulatory drinking water standards. However, commercial laboratory analyses did sporadically detect ethylene and propylene glycol and surfactants near microgram-per-liter detection limits ( ). When we analyzed a subset of the household waters with GCxGC-TOFMS in 2012, we detected very low concentrations of 2-BE. This compound is of special interest because the US Environmental Protection Agency (USEPA) has suggested that 2-BE could be an indicator of contamination from HVHF activities (29). Additional information on 2-BE is provided in . GCxGC-TOFMS also documented a UCM of organic contaminants in all three water wells analyzed. Background groundwater outside of the affected area had no such contamination (Fig. 4*B* and). It is not possible to prove unambiguously that the UCM and 2-BE were derived from shale gas-related activities. However, the timing (Fig. 2 and) and the presence of UCMs and 2-BE in flowback/production waters in PA (Fig. 3) are consistent with shale gas activity as the most probable source.

We also conclude that the foam identified from the homeowner wells was likely derived from either the UCM hydrocarbons (28) or 2-BE (a known surfactant). Methane degassing is exacerbated during the onset of household well pumping due to rapid water level drawdown and drop in hydrostatic pressure. The resulting effervescence and groundwater agitation then aids as a foaming facilitator. Given that 2-BE was only found in Well 1, despite foaming observed in all water wells, it might be reasonable to conclude that the UCM aided by gas effervescence was the most probable cause. Further, foaming and concentrations of 2-BE decreased with increasing well purging, unlike the UCM. On the other hand, 2-BE is a known surfactant, making it a more probable cause of foaming at low concentrations. Detection of 2-BE is difficult at these low concentrations in the presence of other organic compounds. Therefore, the compound may have been present in the foaming drinking waters even though we could not detect it in all wells.

There are no reports of 2-BE as a natural constituent in waters from shale (30). However, the common drilling additive Airfoam HD contains 2-BE as the only detectable organic component from our analyses (Fig. 5). Although we have no evidence that Airfoam HD was used in the Welles series gas wells in drilling fluids, this substance has been commonly used in northern and central PA. Indeed, it was cited by the PADEP as the cause of foam from a spring discharging to the canyon wall above Pine Creek in Lycoming County (PA) that began 15 March 2010. Further, a more recent PADEP contamination determination letter, dated 14 May 2014, identified at least one private water well in Springville Township, Susquehanna County, PA, that was impacted by drilling fluids using Airfoam HD as a surfactant. Here, 2-BE in addition to volatile organic compounds and ethyl glycol were detected at microgram-per-liter concentrations in that household well and were deemed responsible for the foaming groundwater in the household well. This contamination was attributed to drilling fluid additives and not HVHF by the PADEP.

Notably, the Welles 1 gas well pad was the location of a drilling fluid pit leak in August 2009 ( ). Further, well construction issues required remedial efforts in the Welles 3–5 series gas wells. Therefore, drilling fluids used in their installation could reasonably account for the observed foam impacts to household Wells 1–6 (Fig. 1*C*). Since 2-BE and the UCM were identified together, drilling fluids might be the source of both.

Alternately, since the UCMs are similar in the well waters and flowback/production waters and 2-BE was only observed with the UCM, another scenario is that the UCM and 2-BE are derived from HVHF fluids. In fact, HVHF was initiated in February 2010 at the Welles 1 pad—5 mo before the turbidity and natural gas problems in the homeowner wells (and Fig. 2). This well pad was also one of the two closest pads to the aquifer contamination incident. Notably, gas wells situated on the Welles 2–5 pads were hydraulically fractured in 2012 using fluids containing 2-BE (; see). Although no data were reported online ( ) regarding the compounds used during HVHF of Welles 1 pad wells, it is reasonable that the same nonemulsifier agent (which contained 2-BE) was likely used. Therefore, we conclude that it is possible that HVHF fluids used at the Welles 1 pad contaminated the drinking water aquifer.

If HVHF fluids did contaminate the water wells, it would be surprising if such contamination were due to fluids returning upward from deep strata, given that (*i*) this has never been reported (6), (*ii*) the time required to travel 2 km up from the Marcellus along natural fractures is likely to be thousands to millions of years (31), and (*iii*) Fig. 6 shows that the Cl:Br ratios in the drinking waters indicate the absence of salts that would be diagnostic of fluids from the Marcellus Shale (e.g., flowback/production waters). The most likely way for HVHF fluids to contaminate the shallow aquifers would therefore be through surface spillage of HVHF fluids before injection or by shallow subsurface leakage during injection.

It is possible that the provenance of the UCM and 2-BE was different from that of the stray gas. Indeed, the most reasonable explanation for the natural gas impacts to water wells is that gas migrated from Welles 3-2H or possibly from multiple gas wells drilled on the Welles 3–5 pads due to excessive annular pressures and lack of competent annular cement that allowed gas to move vertically upward along the wellbore and into shallow uncased portions of bedrock fractures, including an identified fault zone (, Fig. 1, and and). Induced fracture propagation below the surface casing of Welles 3-2H is also possible given the recorded gas well annular pressures (see). In addition to potentially opening fracture pathways, excessive annular pressures and natural gas buoyancy likely drove gas up-dip along bedding-plane partings to the southeast, intermittently stair-stepping upward along near-vertical joints to Sugar Run (Fig. 1 and , , and). Well water turbidity was likely due to the entrainment of fine-grained sediment as a result of off-gassing and groundwater effervescence (32). The lower hydrostatic pressure of the shallow aquifer beneath the impacted valley, exacerbated by household pumping, likely drew in the contaminating fluids (and).

Conclusions

We used comprehensive GCxGC-TOFMS to document that organic compounds derived from one or more shale gas wells in

PA were the likely cause of foaming and a complex suite of UCMs in three homeowner wells. In one well, 2-BE was positively identified and is a common constituent of both HVHF and drilling fluids. These impacts were likely caused by drilling or HVHF fluids used in the gas wells. Two of the closest shale gas wells were hydraulically fractured by the time of the impact, and the well pad was cited by the PADEP for a pit leak. Despite noticeable white foaming of groundwater, reported concentrations for dissolved organics were below applicable regulatory standards when investigated by both environmental consultants and the PADEP. Only natural gas was previously reported as a confirmed contaminant. If contaminants entered groundwater during HVHF or drilling, then they persisted 2.5 y in the subsurface, i.e., until the November 2012 sampling.

Importantly, the techniques we needed to identify the impacts, GCxGC-TOFMS and GCxGC-HR-TOFMS, are not readily available in most commercial laboratories. Investigating gas drilling impacts with these analytical methods may be more effective than using target compound lists that may or may not include appropriate analytes and appropriate laboratory detection limits.

Although much of the concern shown by the public focuses on the possibility that some of the 1,000 compounds (29, 33) used in HVHF could migrate upward from the target shale, such upward leakage has never been documented. This is probably because HVHF fluids remain trapped in deep rock strata. However, the public cannot ascertain the cause of most shale gas-related problems (10) because the full datasets are often not released publicly and explained.

The data released here do not implicate upward flowing fluids along fractures from the target shale as the source of contaminants but rather implicate fluids flowing vertically along gas well boreholes and through intersecting shallow to intermediate flow paths via bedrock fractures. Flow along such pathways is likely when fluids are driven by high annular gas pressure or possibly by high pressures during HVHF injection. Such shallow- to intermediate-depth contaminant flow paths are not limited to HVHF but rather have been previously observed with conventional oil and gas wells. As shale gas development expands worldwide, problems such as those that occurred in northeastern PA will only be avoided by using conservative well construction practices, such as intermediate casing strings, proper cementation, and mitigating overpressured gas well annuli.

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1. MIT (2011) *The Future of Natural Gas* (MIT, Cambridge, MA).
2. Engelder T (2011) Should fracking stop? No, it's too valuable. *Nature* 477:272–275.
3. Arthur MA, Cole DR (2014) Unconventional hydrocarbon resources: Prospects and problems. *Elements* 10(4):257–264.
4. Blumsack S (2014) Dash for gas, 21st-century style! *Elements* 10(4):265–270.
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6. Vidic RD, Brantley SL, Vandenbossche JM, Yoxtheimer D, Abad JD (2013) Impact of shale gas development on regional water quality. *Science* 340(6134):1235009.
7. Entrekin S, Evans-White M, Johnson B, Hagenbuch E (2011) Rapid expansion of natural gas development poses a threat to surface waters. *Front Ecol Environ* 9(9): 503–511.
8. Wilson JM, VanBriesen JM (2012) Oil and gas produced water management and surface drinking water sources in Pennsylvania. *Environ Pract* 14(4):288–300.
9. Osborn SG, Vengosh A, Warner NR, Jackson RB (2011) Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing. *Proc Natl Acad Sci USA* 108(20):8172–8176.
10. Brantley SL, et al. (2014) Water resource impacts during unconventional shale gas development: The Pennsylvania experience. *Int J Coal Geol* 126:140–156.
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12. Jackson RB, et al. (2014) The environmental costs and benefits of fracking. *Annu Rev Environ Resour* 12(18):327–362.
13. Breen KJ, Revesz K, Baldassare FJ, McAuley SD (2007) *Natural Gases in Ground Water near Tioga Junction, Tioga County, North-Central Pennsylvania--Occurrence and Use of Isotopes to Determine Origins, 2005* (US Geol Surv, Reston, VA) Sci Invest Rep 2007-5085.
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17. General provision for well construction and operation, The Pennsylvania Code, Chapter 25, Sect. 78.73(c) (1989).
18. Llewellyn G (2014) Evidence and mechanisms for Appalachian Basin brine migration into shallow aquifers in NE Pennsylvania, U.S.A. *Hydrogeol J* 22(5):1055–1066.
19. Warner NR, et al. (2012) Geochemical evidence for possible natural migration of Marcellus Formation brine to shallow aquifers in Pennsylvania. *Proc Natl Acad Sci USA* 109(30):11961–11966
20. Poth CW (1962) The occurrence of brine in western Pennsylvania. *Pa Geol Surv Bull* M47:1–53.
21. Dresel E (1985) The geochemistry of oilfield brines from western Pennsylvania, MSc thesis (Pennsylvania State University, University Park, PA).
22. Osborn SG, McIntosh JC (2010) Chemical and isotopic tracers of the contributions of microbial gas in Devonian organic-rich shales and reservoir sandstones, northern Appalachian Basin. *Appl Geochem* 25(20):456–471.
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24. Kelley D, DeBor D, Malanchak J, Anderson D (1973) *Subsurface brine analyses of Pennsylvania from deep formations, OFR 73-02* (Pa Bur Topogr Geol Surv, Harrisburg, PA).
25. Haluszczak LO, Rose AW, Kump LR (2013) Geochemical evaluation of flowback brine from Marcellus gas wells in Pennsylvania, USA. *Applied Geochemistry* 28(2013):55–61.
26. Pennsylvania Department of Environmental Protection (2010) *Frac and flowback water analyses* (Pa Dep Environ Prot, Harrisburg, PA). Available at www.shalenetwork.org.
27. Molofsky LJ, Connor JA, Wylie AS, Wagner T, Farhat SK (2013) Evaluation of methane sources in groundwater in northeastern Pennsylvania. *Ground Water* 51(3):333–349.
28. Lea JF, Nickens HV, Wells M (2008) *Gas Well Deliquification* (Elsevier, New York).
29. US Environmental Protection Agency (2012) *Study of the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources: Progress Report* (US Environ Prot Agency, Washington, DC), EPA 601/R-12/011.
30. Leenheer JA, Noyes TI, Stuber HA (1982) Determination of polar organic solutes in oil-shale retort water. *Environ Sci Technol* 16(10):714–723.
31. Engelder T (2012) Capillary tension and imbibition sequester frack fluid in Marcellus gas shale. *Proc Natl Acad Sci USA* 109(52):E3625, and author reply (2012) 109(52):E3626.
32. Gorody AW (2012) Factors affecting the variability of stray gas concentration and composition in groundwater. *Environ Geosci* 19(1):17–31.
33. US House of Representatives Committee of Energy and Commerce Minority Staff (2011) *Chemicals Used in Hydraulic Fracturing* (US House Rep, Washington, DC).

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4. Blumsack S (2014) Dash for gas, 21st-century style! *Elements* 10(4):265–270.
5. King GE (2012) *Hydraulic Fracturing 101: What Every Representative, Environmentalist, Regulator, Reporter, Investor, University Researcher, Neighbor and Engineer Should Know About Estimating Frac Risk and Improving Frac Performance in Unconventional Gas and Oil Wells* (Soc Petrol Eng, Richardson, TX), Pap 152596.
6. Vidic RD, Brantley SL, Vandenbossche JM, Yoxtheimer D, Abad JD (2013) Impact of shale gas development on regional water quality. *Science* 340(6134):1235009.
7. Entrekin S, Evans-White M, Johnson B, Hagenbuch E (2011) Rapid expansion of natural gas development poses a threat to surface waters. *Front Ecol Environ* 9(9): 503–511.
8. Wilson JM, VanBriesen JM (2012) Oil and gas produced water management and surface drinking water sources in Pennsylvania. *Environ Pract* 14(4):288–300.
9. Osborn SG, Vengosh A, Warner NR, Jackson RB (2011) Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing. *Proc Natl Acad Sci USA* 108(20):8172–8176.
10. Brantley SL, et al. (2014) Water resource impacts during unconventional shale gas development: the Pennsylvania experience. *Int J Coal Geol* 126:140–156.
11. Darrah TH, Vengosh A, Jackson RB, Warner NR, Poreda RJ (2014) Noble gases identify the mechanisms of fugitive gas contamination in drinking-water wells overlying the Marcellus and Barnett Shales. *Proc Natl Acad Sci USA* 111(39):14076–14081.
12. Jackson RB, et al. (2014) The environmental costs and benefits of fracking. *Annu Rev Environ Resour* 12(18):327–362.
13. Breen KJ, Revesz K, Baldassare FJ, McAuley SD (2007) *Natural Gases in Ground Water near Tioga Junction, Tioga County, North-Central Pennsylvania-Occurrence and Use of Isotopes to Determine Origins, 2005* (US Geol Surv, Reston, VA) Sci Invest Rep 2007-5085.
14. Revesz KM, Breen KJ, Baldassare FJ, Burruss RC (2010) Carbon and hydrogen isotopic evidence for the origin of combustible gases in water-supply wells in north-central Pennsylvania. *Appl Geochem* 25:1845–1859.
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16. Baldassare FJ, McCaffrey MA, Harper JA (2014) A geochemical context for stray gas investigations in the northern Appalachian Basin: Implications of analyses of natural gases from Neogene- through Devonian-age strata. *AAPG Bull* 98(2):341–372.
17. General provision for well construction and operation, The Pennsylvania Code, Chapter 25, Sect. 78.73(c) (1989).
18. Llewellyn G (2014) Evidence and mechanisms for Appalachian Basin brine migration into shallow aquifers in NE Pennsylvania, U.S.A. *Hydrogeol J* 22(5):1055–1066.
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20. Poth CW (1962) The occurrence of brine in western Pennsylvania. *Pa Geol Surv Bull* M47:1–53.
21. Dresel E (1985) The geochemistry of oilfield brines from western Pennsylvania, MSc thesis (Pennsylvania State University, University Park, PA).
22. Osborn SG, McIntosh JC (2010) Chemical and isotopic tracers of the contributions of microbial gas in Devonian organic-rich shales and reservoir sandstones, northern Appalachian Basin. *Appl Geochem* 25(20):456–471.
23. Hayes TD (2009) *Sampling and Analysis of Water Streams Associated with the Development of Marcellus Shale Gas. Final Report Prepared for the Marcellus Shale Coalition* (Gas Technol Inst, Des Plaines, IL).
24. Kelley D, DeBor D, Malanchak J, Anderson D (1973) *Subsurface brine analyses of Pennsylvania from deep formations, OFR 73-02* (Pa Bur Topogr Geol Surv, Harrisburg, PA).
25. Haluszczak LO, Rose AW, Kump LR (2013) Geochemical evaluation of flowback brine from Marcellus gas wells in Pennsylvania, USA. *Applied Geochemistry* 28(2013):55–61.
26. Pennsylvania Department of Environmental Protection (2010) *Frac and flowback water analyses* (Pa Dep Environ Prot, Harrisburg, PA). Available at www.shalenetwork.org.
27. Molofsky LJ, Connor JA, Wylie AS, Wagner T, Farhat SK (2013) Evaluation of methane sources in groundwater in northeastern Pennsylvania. *Ground Water* 51(3):333–349.
28. Lea JF, Nickens HV, Wells M (2008) *Gas Well Deliquification* (Elsevier, New York).
29. US Environmental Protection Agency (2012) *Study of the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources: Progress Report* (US Environ Prot Agency, Washington, DC), EPA 601/R-12/011.
30. Leenheer JA, Noyes TI, Stuber HA (1982) Determination of polar organic solutes in oil-shale retort water. *Environ Sci Technol* 16(10):714–723.
31. Engelder T (2012) Capillary tension and imbibition sequester frack fluid in Marcellus gas shale. *Proc Natl Acad Sci USA* 109(52):E3625, and author reply (2012) 109(52):E2626.
32. Gorody AW (2012) Factors affecting the variability of stray gas concentration and composition in groundwater. *Environ Geosci* 19(1):17–31.
33. US House of Representatives Committee of Energy and Commerce Minority Staff (2011) *Chemicals Used in Hydraulic Fracturing* (US House Rep, Washington, DC).

Supporting Information

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SI Text

SI History

Given the early groundwater problems reported, venting of the annular spaces in the gas wells commenced in July 2010. Casings were perforated and cement was injected into the annular space (cement squeezing) from August to September 2010 to bolster the gas wells' integrity and reduce annular pressures in the Welles 3, 4, and 5 series gas wells (Table S1 and Fig. S10). The remedial cement squeezes were coincident with reports of natural gas bubbling in the Susquehanna River near the town of Sugar Run, ~3.5 km southeast of the Welles series gas wells (Fig. 1 and Fig. S9). The Welles series wells were the closest associated gas drilling activity at that time.

With commercial laboratory analyses, more than 250 target compounds were analyzed on at least one occasion (inorganics, volatile organics, semivolatile organics, glycols, radiologicals, and surfactants, among others). Despite visible foaming during initial purging, no analyte concentrations exceeded PADEP primary drinking water maximum contaminant levels or medium-specific concentrations as regulated under PA Act 2. Almost no targeted volatile or semivolatile organic compounds were detected, except for carbon disulfide in household Wells 2 (0.45 μg/L) and 5 (0.96 μg/L). This compound is not uncommonly found in such analyses and is not uniquely linked to gas drilling. Although not reported by the commercial laboratory, our evaluation of the laboratory reports (Method 8270C for Well 1 for semivolatile organics) revealed various nontargeted compounds with ~10–36 carbon atoms (estimated total concentration of ~25–50 μg/L) that were present in at least one groundwater sample collected. Surfactants (methylene blue active substances) were also detected at the detection limit (0.12 mg/L) by a commercial laboratory in one sample from Well 1 on 26 March 2012. Ethylene glycol was detected in Wells 1 and 5 on 26 March 2012 and 14 May 2012 at concentrations of 5,100 and 3,200 μg/L, respectively. Propylene glycol was also detected in Well 5 on 14 May 2012 at a concentration of 960 μg/L. All of these analytes and corresponding low concentrations were detected sporadically with intermittent "nondetections" when analyzed for. The civil case focused on the most obvious contamination–natural gas impacts.

SI Methods

Sampling. The new analyses reported here were measured on samples collected from outside spigots using pumps and infrastructure already in place and from a sample from Salt Springs. Before sampling, water was purged for the amount of time indicated in Table S4 with field water quality parameters noted (e.g., pH, conductivity, temperature). All samples were preserved on ice for transport, and were subsequently refrigerated.

Samples for dissolved gases were collected using two types of vessels: 125-mL glass serum bottles and 1-L sample bottles designed by Isotech, Inc. for natural gas isotopic analysis. In all cases, water was allowed to enter the bottles gently using vinyl tubing attached to an outside spigot (to minimize agitation and off-gasing). Isotech bottles (which contain biocide in a specially designed cap) were filled following Isotech protocol for collecting dissolved gas samples ( ). The bottles were filled with water, inverted, and submerged in a water-filled 5-gallon bucket. The source of water was allowed to keep flowing into the sample bottle until another two volumes of water had been displaced.

For the serum bottles, a slight headspace was left so the bottles could be capped with a 20-mm butyl rubber stopper. Then 1.25 mL of benzylkonium chloride (or, for some test bottles, sodium azide) were added, using a syringe, to kill microbiota. As the biocide was added, a second syringe was inserted into the septa cap and used to evacuate headspace. The water emitting at Salt Springs in Salt Springs Park (Susquehanna County, PA) was sampled by submerging three 125-mL glass serum bottles into the spring water, allowing the bottles to fill, and then capping them with a 20-mm blue butyl rubber stopper under water. Two syringes were then used to add 1.25 mL of sodium azide and to evacuate the remaining headspace.

Samples of almost 30 flowback or production waters were shared with us from natural gas wells drilled in the PA Marcellus before treatment at a brine wastewater remediation plant. Additionally, a sample of drilling foam (M-I SWACO Platinum AirFoam) was obtained.

GCxGC Analysis. An extended organic analysis was completed on the flowback/production waters and samples from three of the potable wells (one original and two replacement wells, bottles labeled PLG-12-60A, PLG-12-68A, and PLG-12-64A). In addition, one of the replacement wells that was sampled after purging (PLG 12-68A) was compared with water before purging (PLG-12-67A). Three background potable water samples were also analyzed from houses outside of the impacted area, but within 5 km of the incident: bottles PLG 13-5B, PLG 13-6A, and PLG 13-7A.

Samples were prepared using separatory funnel-based liquid/liquid extraction under both acidic and basic pH by extraction in dichloromethane following a modification of USEPA Method 3510C ( ). Many of the flowback samples formed emulsions, especially during the first sample extraction, and were therefore separated using centrifugation. Samples were also spiked with control "surrogate" compounds to measure extraction efficiency (see Table S7).

Sample extracts from flowback and production waters were first characterized by GC-TOFMS. Spectra were very complex, resulting in large UCMs in every sample. To further identify compounds in the UCMs, analysis by GCxGC-TOFMS was used. The GCxGC-TOFMS was a Pegasus-4D system (Leco Corporation).

The sample of Airfoam HD was also analyzed with GCxGC-TOFMS. Additional preparatory blanks and a trip blank taken with the samples were also prepared and analyzed.

The potable waters were compared with the data from flowback/produced waters as well as reference standards. These standards, chosen from among the compounds used in hydraulic fracturing in PA ( ), were run under identical conditions at a concentration of 200 pg/uL as a single-point calibration. When these compounds were detected in the potable water samples, concentrations were estimated from the area under the peak for a given fragment and mass/charge ratio.

Dissolved Gases. Samples were analyzed for dissolved hydrocarbons including methane and ethane within 1 wk of collection. To analyze the 1-L bottles for dissolved gases, ultra-high-purity helium was introduced to create headspace (10% by volume standard temperature and pressure) (1). Headspace hydrocarbons were then analyzed using an HP 5890 Series II Gas Chromatograph with a flame ionization detector and a custom vacuum inlet system. Daily standard curves were generated using 1.83 ppm,

14.9 ppm, and 1,000 ppm methane standards from Scott Specialty Gases. Analytical precision for measurement of these standards was better than ±2%.

When headspace is created, gas in the water equilibrates between the aqueous phase and the gases in the headspace, and the concentration can be determined from

$$TC = C_{AH} + C_A,$$

where TC is the total concentration (in milligrams per liter) of the original aqueous sample. C_{AH} is the measured concentration in the gas phase (in milligrams per liter), and C_A is the concentration (in milligrams per liter) that has remained in the aqueous phase, as indicated by the Henry's Law constant at 21 °C.

To analyze $\delta^{13}C$ in methane and ethane, ~5 nmols of analyte were injected into a helium carrier stream and purified using a modified PreCon peripheral device before analysis on a MAT 252 mass spectrometer. Precision of measurements of daily standards (1.84 ppm) is ±0.3‰, with daily standards providing the means of accurately reporting data directly on the Vienna Pee Dee Belemnite scale.

A few samples were also sent to Isotech for analysis of $\delta^{13}C$ (in CH_4 and C_2H_6) and δD in CH_4. Samples analyzed at Pennsylvania State University and Isotech varied between 0‰ and 0.7‰.

Inorganic Analysis. Anions were analyzed using a Dionex ICS 2500 ion chromatograph (IC) on filtered unacidified samples using an IonPac AS18 anion exchange column (4 × 250 mm) and IonPac AG18 guard column (4 × 50 mm) at Pennsylvania State University. Major elements were analyzed on a Perkin-Elmer Optima 5300 ICP-AES on filtered, acidified samples. Analytical precision on the ICP-AES is estimated to be ±3% for all major elements and ±10% for minor elements. Detection limits for the IC data were calculated as the concentration of the lowest standard used during analysis minus the relative SD for multiple analyses of that standard.

Hydrogeology. The impacted area (Fig. 1) lies within the Glaciated Low Plateau section of the Appalachian Plateau province. Bedrock consists of gently folded sandstone, siltstone, and shale overlain by glacial drift. In the study area, sandstone of the Upper Devonian Catskill Formation dominates the uppermost stratigraphic section, with siltstone and shale of the Lock Haven Formation outcropping infrequently in low-lying areas to the north (Fig. 1). Average elevation drop from ridge to valley is ~125 m. Drift and alluvial sediments vary in thickness from a thin veneer on hill slopes to 60 m in major valleys. Fig. S11 illustrates approximate bedrock elevations in meters above mean sea level. Groundwater discharges into the valley along the north branch of Sugar Run where the affected houses are located (Fig. 1 and Fig. S3*A*).

Two principal aquifers are present. Shallow unconfined outwash acts as an aquifer in the major valleys, while confined bedrock units act as aquifers in the uplands. Groundwater flows from hilltops to valley discharge zones. Groundwater is largely of the $Ca–HCO_3^-$ type; however, Na–Cl type groundwater, which occurs in some major valleys, has been attributed to upward seepage of ABB (2–4). For example, Cl–Br ratios are consistent with transport of ABB upward into shallow aquifers along permeable faults and topographic lineaments (3). Thermogenic natural gas is also common in shallow groundwater throughout the region (5–7).

In response to the groundwater quality problems, the gas company installed a replacement potable well for each household in September 2010. However, these replacement wells exhibited elevated natural gas concentrations. Water wells 1–6 are cased to ~6.5 m-bgs and are completed as open rock wells to a maximum depth of ~60 m-bgs. We completed a pumping test in November 2012 to evaluate aquifer characteristics. Well 4 (a replacement well) was pumped for 7 h at a constant pumping rate of 25.8 L/min while evaluating the hydraulic responses of the original and replacement potable wells (Fig. S3). Water level monitoring revealed a maximum drawdown of 15.2 m in the pumping well, and the drawdown ellipse was aligned NNW–SSE along the dominant set of fractures (joints) and the valley orientation (Fig. 1 and Figs. S3 and S11), indicating aquifer anisotropy and/or heterogeneity.

Asymmetric drawdown observed could be due to the dominant vertical joints oriented NNW–SSE as observed in local bedrock outcrops. Alternately, asymmetric drawdown could be due to openings between bedding planes that terminate in the valley wall (e.g., stress relief fracturing). Consistent with bedrock heterogeneity, the steep hydraulic gradient observed east of the pumping well (e.g., into the bedrock valley wall) suggests lower permeability in the more upland areas away from the incised valley. Shallow valley aquifer parameters were estimated: storativity (S) ~1.6×10^{-5}, maximum transmissivity tensor (Tss) ~5.9 m^2/d, and minimum transmissivity tensor (Tnn) ~2.6 m^2/d with a NNW–SSE major axis orientation. The geometric mean of principal transmissivities was estimated at 3.9 m^2/d; given a saturated well thickness of 23 m for Well 4, the hydraulic conductivity (K) is estimated at 2×10^{-6} m/s.

Welles 3-2H pressures and fracturing potential. Based upon the observed annular pressures recorded at gas well Welles 3-2H (~64 atm), it is possible that fracturing was induced near the well's surface casing shoe (base of surface casing), providing an additional migration pathway for contaminants. Although fracture gradients vary regionally, 0.16 atm/m is used as a guideline to avoid potential fracture propagation in PA injection wells (8). For gas well Welles 3-2H, the approximate threshold for fracture propagation would be an approximate pressure of 51 atm at the surface casing shoe—surface casing extends 320 m-bgs. Given the maximum recorded annular pressure of 64 atm in connection with Welles 3-2H, it is indeed possible that fracture propagation was induced, providing a pathway for contaminant migration. Notably, 196 bbl of cement (~31,100 L) was reportedly squeezed at a relatively shallow depth interval (~500–600 m-bgs) at Welles 3-2H as part of its remediation (Fig. S10).

Uses and sources of 2-BE. In addition to being used in gas drilling and HVHF fluids, 2-BE is used in industry as a solvent for paints and surface coatings and as an ingredient for paint thinners, herbicides, degreasers, dyes, soaps, and cosmetics. It is a fully miscible, clear liquid with an ether-like odor at thresholds of 0.10–0.40 ppm in air. Domestic US production of 2-BE has steadily increased—reported amounts include 59 million kilograms, 123 million kilograms, 136 million kilograms, and 185 million kilograms for years 1975, 1984, 1986, and 1995, respectively, by producers such as Dow Chemical, Eastman Chemical Co., Occidental Petroleum Corp., and Shell Chemical Co., among others. Besides areas undergoing gas drilling development, areas most prone to water resource discharges of 2-BE include those near manufacturing or processing facilities that use 2-BE, municipal landfills, hazardous waste sites, and areas treated with herbicides that contain 2-BE. Although not expected to be significant, release of 2-BE could also result from consumer product use, such as outdoor use of liquid cleaners and paints (9).

1. Kampbell DH, Vandegrift SA (1998) Analysis of dissolved methane, ethane, and ethylene in ground water by a standard gas chromatographic technique. *J Chromatogr Sci* 36(5):253–256

2. Llewellyn G (2011) Structural and topographic assessment of shallow bedrock permeability variations throughout Susquehanna County, PA: A focus of Marcellus Shale gas development. *Geol Soc Am Abstr Prog* 43:567.

3. Llewellyn G (2014) Evidence and mechanisms for Appalachian Basin brine migration into shallow aquifers in NE Pennsylvania, U.S.A. *Hydrogeol J* 22(5):1055–1066.
4. Warner NR, et al. (2012) Geochemical evidence for possible natural migration of Marcellus Formation brine to shallow aquifers in Pennsylvania. *Proc Natl Acad Sci USA* 109(30):11961–11966.
5. Molofsky LJ, Connor JA, Farhat SK, Wylie AS, Jr, Wagner T (2011) Methane in Pennsylvania water wells unrelated to Marcellus shale fracturing. *Oil Gas Dev* 109(19):54–67.
6. Molofsky LJ, Connor JA, Wylie AS, Wagner T, Farhat SK (2013) Evaluation of methane sources in groundwater in northeastern Pennsylvania. *Ground Water* 51(3):333–349.
7. Baldassare FJ, McCaffrey MA, Harper JA (2014) A geochemical context for stray gas investigations in the northern Appalachian Basin: Implications of analyses of natural gases from Neogene- through Devonian-age strata. *AAPG Bull* 98(2):341–372.
8. US Environmental Protection Agency (1984) *Operators Compliance Manual for Class II Injection Wells in Pennsylvania* (US Environ Prot Agency, Washington, DC).
9. US Department of Health and Human Services (1998) *Toxicological Profile for 2-Butoxyethanol and 2-Butoxyethanol Acetate* (US Dep Health Human Serv, Washington, DC).
10. Coleman DD, Liu CL, Hackley KC, Benson LJ (1993) Identification of landfill methane using carbon and hydrogen isotope analysis. *Proceedings of the Sixteenth International Madison Waste Conference* (Univ Wisconsin, Madison WI), pp 303–314.
11. Hsieh PA, Neuman SP, Stiles GK, Simpson ES (1985) Field determination of the three-dimensional hydraulic conductivity tensor of anisotropic media: 2. Methodology and application to fractured rocks. *Water Resour Res* 21(11):1667–1676.
12. Maslia ML, Randolph RB (1987) Methods and computer program documentation for determining anisotropic transmissivity tensor compoents of two-dimensional groundwater flow. *US Geol Surv Water Supply Pap* 2308:1–46.

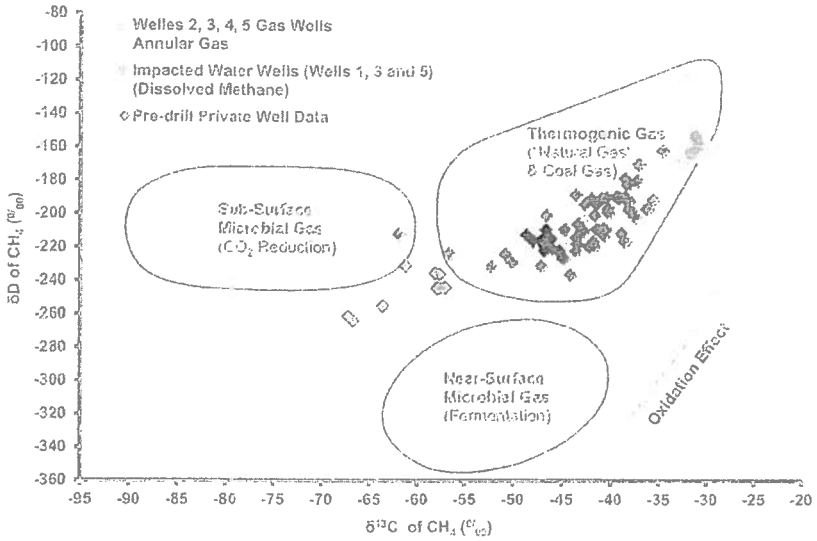

Fig. S1. Crossplot of δD of CH_4 vs. δ^{13}C of CH_4 (per mil) illustrating isotopic similarity between natural gas sampled from the annuli of gas wells (Welles 2, 3, 4 and 5 series) and impacted water wells (Wells 1, 3, and 5). Isotopic data were not available for other impacted water wells. Predrill private well data were collected throughout Bradford, Sullivan, Susquehanna, and Tioga counties in NE Pennsylvania (7). Regions for different types of microbial and thermogenic gas are illustrated (10).

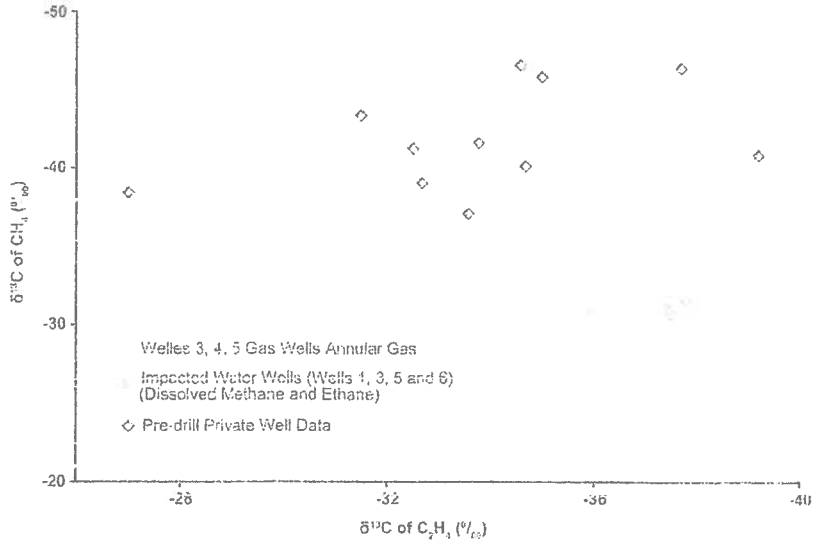

Fig. S2. Crossplot of δ^{13}C of CH_4 vs. δ^{13}C of C_2H_6 (per mil) illustrating isotopic similarity between natural gas sampled from annuli of gas wells (Welles 3, 4, and 5 series) and impacted water wells (Wells 1, 3, 5, and 6). Isotopic data were not available for other impacted water wells. Predrill private well data collected throughout Bradford, Sullivan, Susquehanna, and Tioga counties in NE Pennsylvania (7).

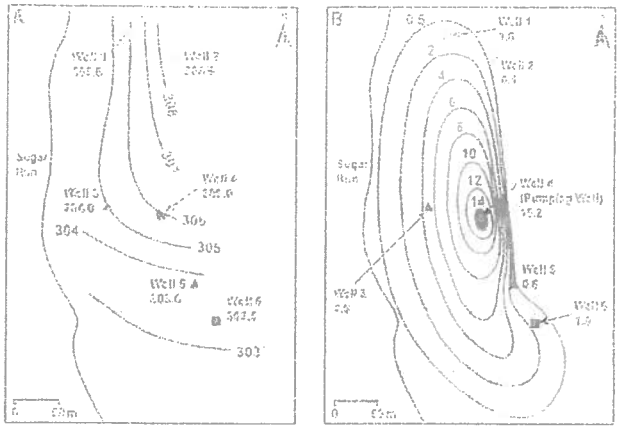

Fig. S3. (*A*) Groundwater elevation contours (meters above mean sea level) under ambient conditions illustrate groundwater convergence toward the valley center (Sugar Run tributary). (*B*) Drawdown (meters) induced by constant rate (25.8 L/min) 7-h aquifer test of Well 4. Using analysis methods outlined previously (11, 12), the maximum (T_{max}) and minimum (T_{min}) transmissivity components were estimated at 5.9 m^2/d and 2.6 m^2/d, respectively. The storage coefficient was estimated at 1.6×10^{-5}.

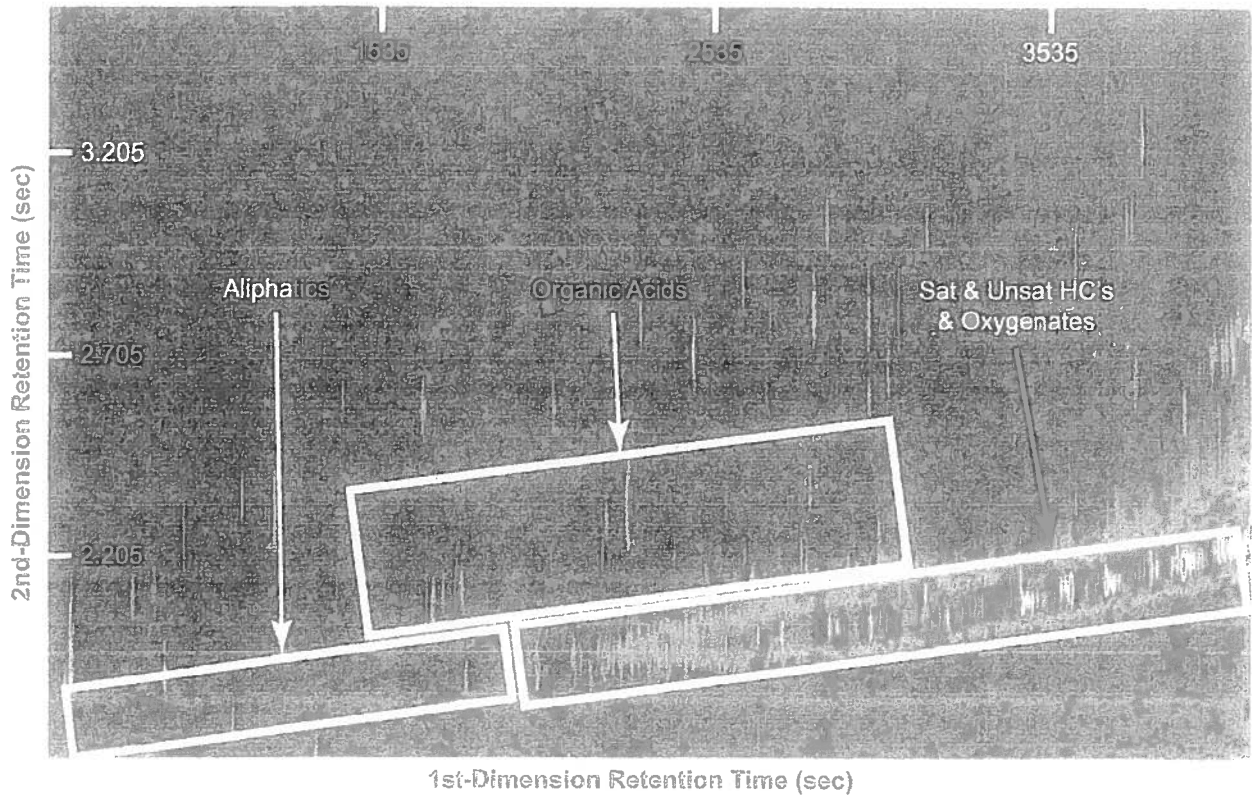

Fig. S4. GCxGC-TOFMS chromatogram illustrating UCM from Well 3 (PIG-12-60A), one of the original impacted household water wells. Compound classes are illustrated. Color variations indicate relative compound concentrations, with blue being the lowest and red being the highest.

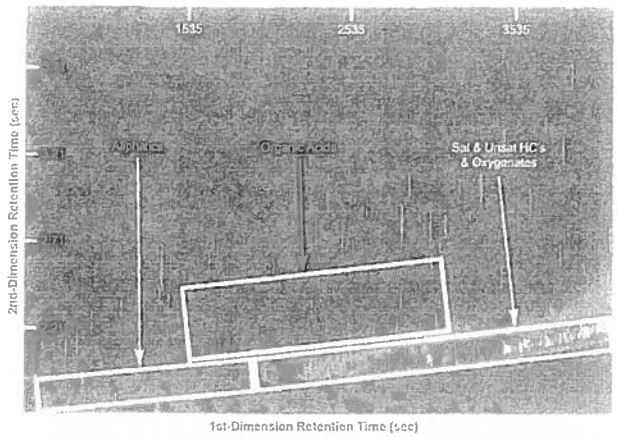

Fig. S5. GCxGC-TOFMS chromatogram illustrating UCM from Well 6 (PLG-12-64A), which was installed as a replacement for Well 5 by the gas company in August/September 2010 and exhibits impacts. Compound classes are illustrated. Color variations indicate relative compound concentrations, with blue being the lowest and red being the highest.

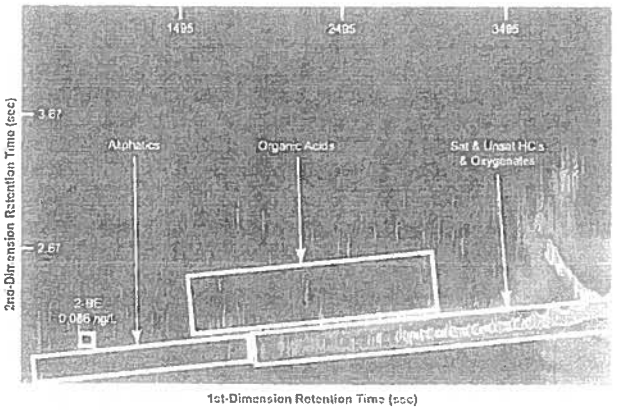

Fig. S6. GCxGC-TOFMS chromatogram illustrating UCM from Well 1 (PLG-12-68A) after purging, which was installed as a replacement for Well 2 by the gas company in August/September 2010 and exhibits impacts. The presence of 2-BE is still identified but at a lower concentration than prepurge Well 1 sample (compare Fig. 4A).

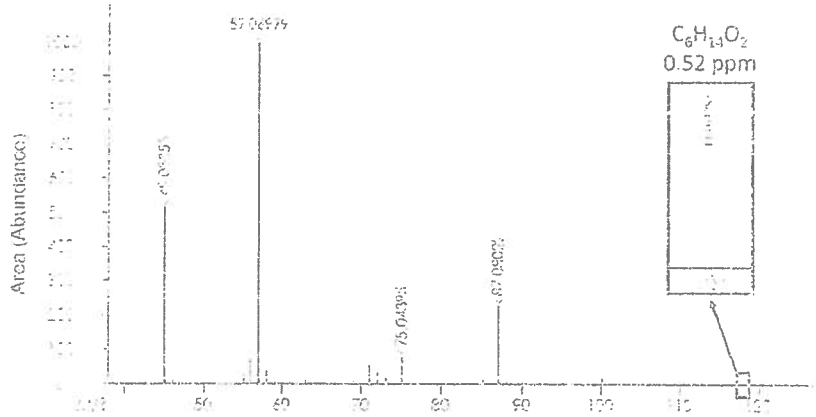

Fig. S7. The accurate high resolution mass spectrometer mass spectrum indicating presence of 2-BE in Well 1 (PLG-12-67A) before purging.

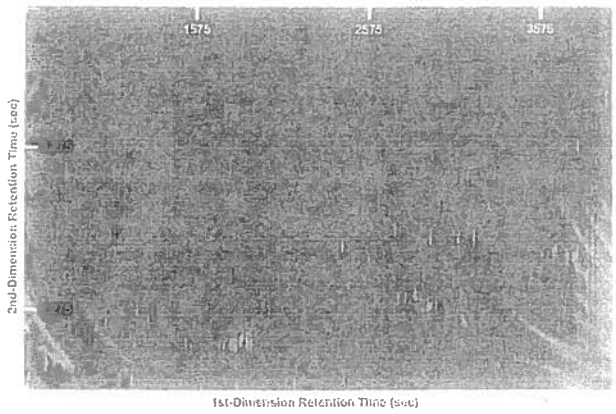

Fig. S8. GCxGC-TOFMS chromatogram illustrating absent UCM from background well B1 (bottle PLG-13-7A) that was not impacted by gas drilling activities. Other background wells (B2 and B3) produced similar GCxGC-TOFMS chromatograms, indicating the same.

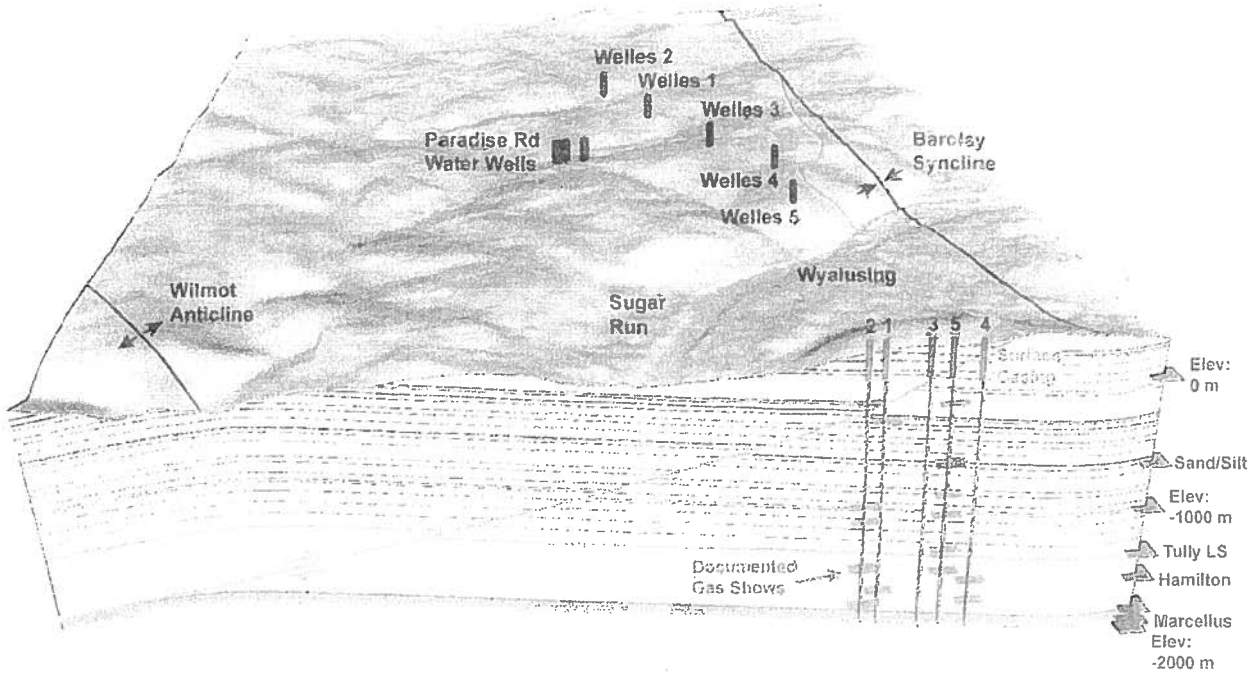

Fig. S9. Block diagram illustrating a shallow angle thrust fault (red line), Barclay and Wilmot structural fold surficial traces (surficial black lines), and bedding planes (subsurface black lines). Stratigraphic units and markers are illustrated on the right side. Viewpoint is toward the west. A light detection and ranging (LIDAR) digital elevation model (DEM) was used to construct the land surface. Water well positions (Wells 1 through 6) are illustrated. Generalized gas well depictions (Welles 1–5 series) are illustrated and projected to the front of the block for comparison with the thrust fault, bedding planes, and documented gas shows overlying the Marcellus Shale (see Fig. S10). In September 2010, gas was observed bubbling from the Susquehanna River in numerous locations between the communities of Sugar Run and Wyalusing. Gas bubbling ceased following gas well remedial activities conducted at the Welles 3, 4, and 5 well pads.

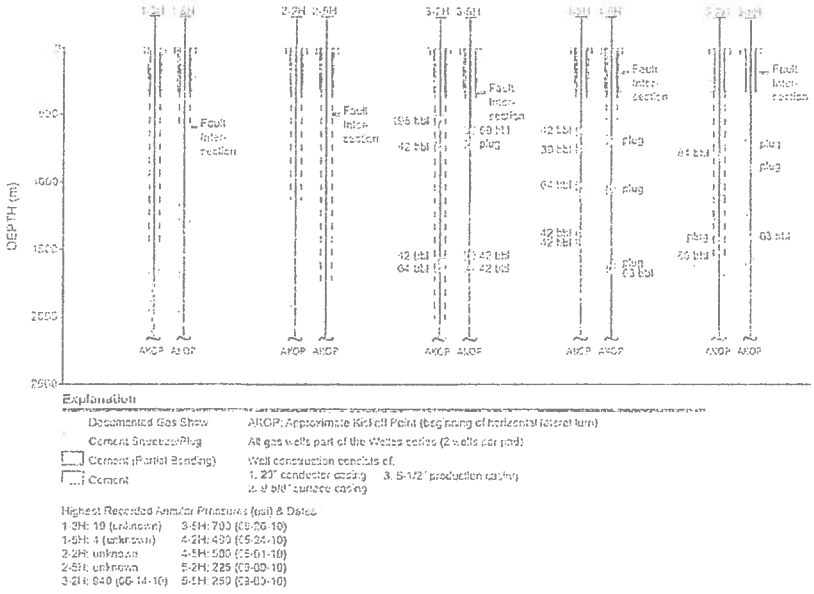

Fig. S10. Schematic illustrating construction of Welles 1–5 series gas wells. Depth intervals of gas shows are illustrated in yellow, as documented in gas well logs. Intervals illustrated in red indicate remedial activities, including cement squeezes and plugs with known quantities of cement used. Originally emplaced cement is illustrated in dark gray, and "partially bonded" cement is illustrated in light gray. Highest recorded gas well annular pressures (pounds per square inch) are provided with record date.

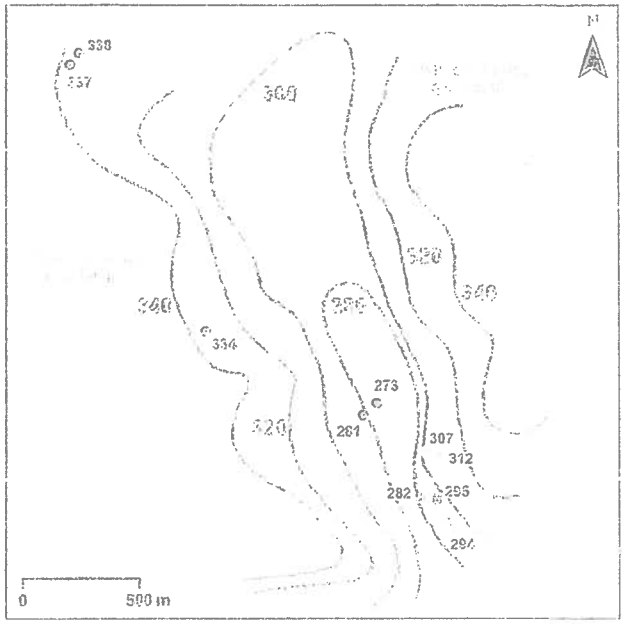

Fig. S11. LIDAR hillshade digital elevation map illustrating land surface with bedrock elevation contours in meters above mean sea level (brown lines). Dashed lines indicate uncertainty. Welles 1 and 3 series gas wells are illustrated as red asterisks. Control points and corresponding bedrock elevations are illustrated for Wells 1 and 2 (red), Wells 3 and 4 (green), Wells 5 and 6 (blue), and additional domestic well records obtained from the Pennsylvania Topographic and Geologic Survey's PaGWIS database (black circles). Squares and triangles represent replacement and original household wells, respectively. Like colors represent each household.

Table S1. Generalized timeline of events

Date, m/d/y	Event
04/23/2009	Welles 1 Pad constructed
05/15/2009	Welles 2 Pad constructed
06/15/2009	2 wells set on Welles 1 pad using 45 feet of conductor casing
06/28/2009	First spud of Welles 1-3H and 1-5H
08/07/2009	Leak out of a pit at Welles 1-3H, 1-5H
08/23/2009	Welles 3 Pad constructed
09/02/2009	Welles 1-3H, 1-5H cited by PADEP for discharge of contaminated fluids (from drilling or well) to ground
09/23/2009	Rig release from Welles pad 1
09/28/2009	First spud of Welles 2-2H and 2-5H
10/23/2009	Completion of Welles 2-2H
10/30/2009	First spud of Welles 3-2H and 3-5H
11/04/2009	Welles 4 Pad constructed
12/17/2009	Welles 5 Pad constructed
01/08/2010	First spud of Welles 4-2H and 4-5H
02/01/2010	Fracture stimulation (i.e., hydraulic fracturing), 20 stages, at Welles 1-3H and 1-5H
03/21/2010	Spud of Welles 5-2H and 5-5H
04/2/2010	1-3H initial annular gas pressure, 0 psi; 5-5H initial annular pressure, 0 psi; homeowner first notifies company of silt in a spring
04/14/2010	Drilling commences on Welles 5-2H
05/2/21010	Drilling finishes on Welles 5-2H
Early 05/2010	Homeowner notices sediment in water from well 3 (Fig. 1)
05/08/2010	Drilling completed for Welles 3-2H
05/12/2010	Rig release from Welles 3 pad
05/24/2010	Initial annular pressure on 3-2H, 950 psi, and for 3-5H, 700 psi
06/13/2010	Water pump has sediment in it at well 3
07/12/2010	Gas company notified of turbid water well 2 (Fig. 1); gas company observes sediment on filters in homeowner wells; registered water driller requested to investigate
07/12/2010	Homeowner at well 2 contacts gas company about turbidity; also turbidity issue at well 3
07/13/2010	Homeowner of well 2 notifies PA Department of Environmental Protection (DEP); company delivers water to both residences; homeowner tells gas company that their water from well 5 (Fig. 1) can be ignited, but gas company visits and ignition is not achieved; gas company delivers water for homeowners with wells 2 and 3
07/14/2010	DEP finds methane in well 3 but none in well 2
07/15/2010	DEP worker measures 3 vol.% methane in well 3 and none in well 2
07/17/2010	Water well driller retained by gas company notifies gas company that the water wells are bubbling at wells 3 and 2; gas company visits and observes the same
07/17/2010	Bubbling reported in well waters; well evacuated to allow recharge; lower explosive limit reported at 3% in well 3 and 68% in 2
07/19/2010	Letter sent to gas company by owner of well 3; gas company visits and sees no problems
07/20/2010	Welles 5-2H and 5-5Htreated by gas company
07/21/2010	Inspection of well 5 reveals no issues although some effervescence was observed, but no turbidity; gas company notifies DEP of the complaints and waits for DEP to indicate path forward
07/22/2010	Gas company is informed that a natural spring has dried up; gas company visits well 5 where the homeowner has been advised by a physician to not drink, cook, or bathe in the water
07/24/2010	Diagnostic tests run on Welles 3-5H and 3-2H to find problems (includes cement logging)
07/25/2010	Backhoe used to dig out cellar of Welles 3-2H to correct eccentric wellhead; unable to dig past big rock
07/26/2010	Four residents experiencing gas in water at faucets
07/30/2010	Another resident notifies gas company of turbidity in water
07/31/2010	Environmental teams for gas company collect samples of groundwater from residences in a screening sweep within 1-mile radius of Welles 1 and 3 pads
08/02/2010	Gas company installs methane monitor in well 3 (Fig. 1)
08/04/2010	Methane monitor sounds off at well 3 (Fig. 1); gas company responds to secure safety of residence and notify emergency responders
08/05/2010	Gas company makes an offer to replace water wells
08/06/2010	Four residences are set up by gas company with water tanks
08/06/2010	Track hoe used at Welles 3-2H to excavate cellar and repair eccentric wellhead; perforated shallow casing and squeezed with cement
08/10/2010	Shallow squeeze job on Welles 3-2H
08/13/2010	Squeeze job at two shallow depths on Welles 3-2H
08/17/2010	Gas company initiated drilling of replacement water well for a homeowner
08/19/2010	Perforated Welles-3-5H at shallow depth and pumped in 10 bbls of Na silicate, but unable to place cement; perforated shallow casing and squeezed in cement
08/20/2010	Installed methane monitors
08/26/2010	Completed water well for a homeowner

Table S1. Cont.

Date, m/d/y	Event
08/31/2010	Replacement water well started for a homeowner
09/01/2010	Another replacement water well started for a homeowner
09/02/2010	Second replacement water well finished for a homeowner
09/03/2010	Squeeze job at two shallow depths of Welles 3-5H with Na silicate and cement
09/03/1010	Ran temperature and audio log and performed squeeze job at an intermediate depth with cement (Welles 3-2H)
09/03/2010	Bubbles reported in Susquehanna River near Sugar Run, PA
09/04/2010	Ran temperature and audio log and did a cement squeeze job at intermediate depth at Welles 4-2H
09/04/2010	Ran temperature and audio log and did a cement squeeze job at intermediate depth at Welles 5-2H
09/07/2010	Replacement water well started for a homeowner
09/08/2010	Ran temperature and audio log and completed cement squeeze job at intermediate depth in Welles 5-5H
09/08/2010	Replacement water wells for two homeowners were completed
09/10/2010	Replacement water well completed for a homeowner
09/10/2010	Gas sensor and data logger installed in a residence
05/11/2011	PADEP cited gas company for violation of PA Oil and Gas Act and Clean Streams Law for allowing natural gas to enter aquifers; company had to identify, evaluate, and rehabilitate gas wells
09/29/2011	Welles 1-3H cited by PADEP for "failure to control residual waste to prevent water pollution"
11/29/2012	Welles 2-2H cited by PADEP for spill of high conductivity water on well pad
Fall 2012	Pumping test completed (Fig. S3)
11/11/2012 to 09/15/2013	Wells on Welles 2–5 well pads were hydraulically stimulated
10/18/2013	Spill on Welles 4–2H
11/04/2013	On PA DEP website under Welles 2-2H, Consent Agreements of Civil Penalty noted, $35,862 fine
10/18/2013	Spill on Welles 4-2H noted
10/25/2013	Spill associated with flowback fluids (10–15 gallons) noted on PA DEP website for Welles 5-6H

Table S2. Methane data used in initial investigation

	Analyst	Date, m/d/y	Methane µg/L
Well 1	Unknown	9/14/2010	10,900
	Unknown	10/6/2010	24,500
	Unknown	10/13/2010	20,600
	Unknown	10/20/2010	8,820
	Unknown	3/1/2011	17,100
	Unknown	4/7/2011	14,200
	Unknown	5/23/2011	9,210
	Property owners' consultant	5/26/2011	7,000
	Unknown	6/8/2011	9,890
	Unknown	6/22/2011	10,400
	Unknown	7/6/2011	10,800
	Unknown	7/20/2011	6,650
	Unknown	8/3/2011	10,400
	Unknown	8/17/2011	8,880
	Unknown	9/2/2011	6,230
	Unknown	9/14/2011	9,870
	Unknown	9/29/2011	9,620
	Unknown	10/12/2011	4,100
	Unknown	10/31/2011	6,090
	Unknown	10/31/2011	10,000
	Unknown	11/9/2011	4,940
	Unknown	11/22/2011	5,510
	Property owners' consultant	11/29/2011	6,300
	Unknown	12/7/2011	3,600
	Unknown	12/27/2011	6,120
	Unknown	1/4/2012	5,020
	Unknown	1/18/2012	5,060
	Unknown	2/1/2012	6,100
	Property owners' consultant	3/26/2012	3,400
	Unknown	3/28/2012	6,460
	Gas company's consultant	5/9/2012	11,850
	Property owner's consultant	5/30/2012	7,300
	Property owner's consultant	5/31/2012	6,900
Well 2	Property owner's initial laboratory baseline	4/8/2010	<20
	Unknown	7/15/2010	2,690
	Unknown	7/21/2010	9,480
	Unknown	8/3/2010	95.7
	Unknown	9/15/2010	1,410
	Unknown	10/6/2010	2,780
	Unknown	10/13/2010	4,580
	Unknown	10/20/2010	1,780
	Unknown	10/31/2010	ND
	Gas company's consultant	5/8/2012	630
	Property owners' consultant	5/15/2012	15
Well 3	Unknown	7/15/2010	19,500
	Unknown	7/21/2010	29,700
	Unknown	8/4/2010	8,360
	Unknown	8/2/2010	5,020
	Gas company's consultant	8/19/2010	17,510
	Gas company's consultant	5/9/2012	34,520
	Property owners' consultant	5/16/2012	4,300
	Property owner' consultant	5/30/2012	14,000
Well 4	Unknown	9/13/2010	5,070
	Unknown	10/7/2010	4,620
	Unknown	10/14/2010	4,810
	Unknown	10/21/2010	3,710
	Unknown	2/17/2011	3,270
	Unknown	4/7/2011	7,290
	Unknown	5/23/2011	8,860
	Unknown	6/8/2011	8,790
	Unknown	6/22/2011	10,400

Table S2. Cont.

	Analyst	Date, m/d/y	Methane, µg/L
	Unknown	7/6/2011	6,240
	Unknown	7/22/2011	5,920
	Unknown	8/3/2011	5,490
	Unknown	8/17/2011	5,390
	Unknown	8/31/2011	2,330
	Unknown	9/16/2011	10,100
	Unknown	10/3/2011	9,670
	Unknown	10/12/2011	9,760
	Unknown	10/28/2011	10,800
	Unknown	11/9/2011	5,190
	Gas company's consultant	5/9/2012	32,060
	Property owners' consultant	5/30/2012	14,000
	Property owners' consultant	5/31/2012	11,000
Well 5	Unknown	7/21/2010	25,800
	Unknown	8/3/2010	10,700
	Unknown	9/15/2010	17,000
	Unknown	10/12/2010	14,900
	Unknown	10/19/2010	16,200
	Gas company's consultant	8/19/2010	16,000
	Gas company's consultant	5/7/2012	27,280
	Property owners' consultant	5/14/2012	12,000
Well 6	Unknown	9/13/2010	9,230
	Unknown	10/5/2010	10,200
	Unknown	10/12/2010	8,480
	Unknown	10/19/2010	9,820
	Unknown	2/17/2011	2,290
	Unknown	4/7/2011	10,000
	Unknown	5/23/2011	8,630
	Unknown	6/8/2011	7,710
	Unknown	6/22/2011	11,300
	Unknown	7/6/2011	9,310
	Unknown	7/22/2011	7,850
	Unknown	8/3/2011	5,330
	Unknown	8/17/2011	8,380
	Unknown	8/31/2011	2,210
	Unknown	9/16/2011	10,800
	Unknown	10/4/2011	14,500
	Unknown	10/12/2011	13,700
	Unknown	10/28/2011	13,800
	Unknown	11/9/2011	8,020
	Gas company's consultant	5/9/2012	46,640
	Property owners' consultant	5/30/2012	14,000
	Property owners' consultant	5/31/2012	20,000

ND, not determined.

Table S3. GCxGC-TOFMS instrument parameters

	Parameter
GC instrument	
Carrier gas	helium
mode	split 10:1
Flow	1.00 mL/min
Septum purge flow	3.00 mL/min
Injection volume	1 µL
Injector temperature	250 °C
Transfer line temperature	300 °C
Oven equilibration time	0.5 min
First dimension oven*	
Initial temperature	40 °C
Hold time	0.20 min
Rate	1.60 °C/min
Final temperature	315 °C
Modulator	
Temperature offset	15 °C
Modulator period	5.00 s
Hot pulse time	0.6 s
Cool time	1.9 s
Second dimension oven†	
Initial temperature	55 °C
Hold time	0.20 min
Rate	1.60 °C/min
Final temperature	330 °C
Mass spectrometer	
Acquisition delay	320 s
Mass range	45–550 u
Acquisition rate	200 spectra/s
Detector voltage	2,000 V
Ionization energy	70 eV
Mass defect	0 mu/100 u
Ion source temperature	200 °C

*Rtx-Dioxin2, 60 m × 0.25 mm ID × 0.25 µm df.
†Rxi-17SilMS, 1.9 m × 0.15 mm ID × 0.15 µm df.

Table S4. Site descriptions for PSU analyses

Site names	Sample site	Sample site	Latitude	Longitude	GCxGC-TOFMS bottle ID	Sample date, m/d/y	Sampling protocol
		Analyzed with GCxGC: impacted houses					
Well 3 (PLG 12-60)	Fig. 1*B*	original well	41.642	−76.295	PLG-12-60 A	11/7/2012	sampled before purging
Well 6 (PLG 12-65)	Fig. 1*B*	replacement well	41.641	−76.294	PLG-12-64 A	11/7/2012	after purging ~5 min
Well 1 (PLG 12-69)	Fig. 1*B*	replacement well	41.643	−76.294	PLG 12-67 A	11/7/2012	before purging
					PLG 12-68 A	11/7/2012	after purging ~10 min
		Analyzed with GCxGC: nonimpacted houses					
Well B1 (PLG 13-7)	5 km from incident	nonimpacted household well	41.646	−76.286	PLG 13-7 A	3/16/2013	water purged
Well B2 (PLG-13-5)	5 km from incident	nonimpacted household well	41.628	−76.324	PLG 13-5B	3/16/2013	water purged
Well B3 (PLG-13-6)	5 km from incident	nonimpacted household well	41.671	−76.332	PLG 13-6A	3/16/2013	water purged
		Analyzed for inorganic solutes and/or dissolved gases					
PLG-12-33	on Route 29 near Salt Spring Park	private home, Susquehanna County	41.964	−75.819	NA	7/12/2012	water purged
PLG-12-34	Salt Spring State Park	Salt Springs, Susquehanna County	41.964	−75.819	NA	7/12/2012	see *Methods*
PLG-12-70	Wyalusing, PA	new house	41.708	−76.261	NA	11/7/2012	water purged
PLG-13-2	within 5 km of impacted valley	nonimpacted household well	41.643	−76.278	NA	3/16/2013	water purged
PLG-13-4	within 5 km of impacted valley	nonimpacted household well	41.648	−76.292	NA	3/2/2013	water purged

NA, not analyzed with GCxGC-TOFMS

Table S5. Hydrocarbon analyses (Pennsylvania State University and Isotech)

Site ID	Bottle ID*	Sample date, m/d/y	Location of analysis	Bottle	Biocide	CH_4 mg/L	STD%	C_2H_6, mg/L	STD%	$\delta^{13}CH_4$	$\delta^{13}C_2H_6$
Well 6 on Fig. 1 (replacement well)	1	11/7/2012	Penn State	Isotech	benzyl Cl	14.88	17.06	0.21	2.91	−31.9	—
	2	11/7/2012	Isotech	Isotech	benzyl Cl	20.00	—	0.36	—	−30.9	−35.6
	2	11/7/2012	PSU	Isotech	benzyl Cl	16.48	12.40	0.25	3.24	−30.8	—
Well 1 on Fig. 1 (replacement well)	1	11/7/2012	PSU	Isotech	benzyl Cl	6.76	19.28	0.11	8.53	−33.3	—
	2	11/7/2012	Isotech	Isotech	benzyl Cl	4.50	—	0.15	—	−31.5	−37.8
	2	11/7/2012	PSU	Isotech	benzyl Cl	5.00	19.34	0.13	5.27	−32.8	—
PLG 12-70 (new house)	70	11/7/2012	PSU	125 mL serum	benzyl Cl	0.80	0.21	—	—	−67.9	—
	70NB	11/7/2012	PSU	125 mL serum	no biocide	0.90	0.89	—	—	−64.0	—
PLG-12-34 (Salt Springs)	PLG-12-34A	7/12/2012	PSU	125 mL serum	Na azide	35.27	5.89	0.37	0.36		—
	PLG-12-34B	7/12/2012	PSU	125 mL serum	Na azide	36.66	5.19	0.36	7.22		—
	PLG-12-34C	7/12/2012	PSU	125 mL serum	Na azide	33.61	2.9	0.3	1.16		—

*Where a 1 or 2 are indicated, two bottles were collected at the site: one sent to Isotech (2) and then back to Pennsylvania State University (PSU) for analysis, the other (1) only analyzed at PSU.

Table S6. Inorganic analyses, mg/l

Site ID	Date, m/d/y	Ba (0.005)	Ca (0.01)	Fe (0.01)	K (0.01)	Mg (0.01)	Na (0.01)	P (0.01)	Si (0.01)	Sr (0.005)	Cl	SO_4	NO_3	Br
PLG 12-60	11/7/2012	0.2	26.1	0.18	1.46	4.40	31.3	0.02	4.59	0.49	6.6	9.4	<0.7	<0.1
PLG 12-65	11/7/2012	0.2	36.7	0.20	3.85	6.30	18.6	<0.01	4.52	0.95	19	11	4.9	<0.1
PLG 12-70	11/7/2012	0.1	43.3	<0.01	1.06	11.0	17.4	<0.01	4.88	0.25	0.98	19	<0.7	<0.1
PLG-12-33	7/12/2012	0.2	25.5	0.22	1.45	8.40	50.5	0.02	5.53	0.52	5.3	18	<0.4	<0.1
PLG-12-34	7/12/2012	110	367	1.61	13.5	55.0	1,800	0.70	3.75	65.8	2,680	<1.9	<0.4	48.1
PLG-12-69*	7/12/2012	0.2	28.8	0.04	1.62	4.20	30.3	0.06	4.77	1.33	14	6.8	<0.4	<0.1
PLG-12-69†	7/12/2012	0.2	28.1	<0.01	1.68	4.10	30.1	0.20	4.69	1.31	13	7.5	<0.4	<0.1
PLG 13-2	3/2/2013	0.3	40.1	<0.01	2.03	5.22	20.4	0.01	5.35	2.06	5.7	14	0.3	0.01
PLG 13-4	3/2/2013	0.5	28.5	<0.01	2.72	3.02	28.2	<0.01	4.96	1.80	9.9	7.4	<0.4	0.02
PLG 13-5	3/2/2013	0.2	63.6	<0.01	1.13	9.26	12.1	<0.01	4.59	0.20	28	20	2.7	<0.01
PLG 13-7	3/16/2013	0.3	54.5	<0.01	1.41	7.53	9.1	<0.01	5.15	0.85	34	15	0.3	<0.01
PLG-13-6	3/2/2013	0.2	46.6	<0.01	1.20	6.48	8.2	0.06	4.87	0.41	8.3	16	1.3	<0.01

Detection limits are given in parentheses next to element, if applicable.
*Prepurge.
†Postpurge.

Table S7. List of surrogate compounds used in analyses

Compound name	CAS no.	Concentration in final extract, pg/uL
2-Fluorobiphenyl	321-60-8	200
Nitrobenzene-d5	4165-60-0	200
p-Terphenyl-d14	1718-51-0	200
2-Chlorophenol-d4	93951-73-6	200
2-Fluorophenol	367-12-4	200
Phenol-d6	13127-88-3	200
2,4,6-Tribromophenol	118-79-6	200
PCB 18	37680-65-2	200
PCB 28	7012-37-5	200
PCB 52	35693-99-3	200
Triphenylmethane	519-73-3	40
Triphenylphosphate	115-86-6	80
Tris-(1,3-dichloroisopropyl)phosphate	13674-87-8	200

Table S8. Reported hydrofracturing compounds used in Welles 2-5H

Compound	Maximum concentration in hydraulic fracturing fluid, % by mass
Hydrochloric acid	0.03543
Trisodium nitrilotriacetate	0.00056
Sodium sulfate	0.00003
Sodium hydroxide	0.00001
Methanol (methy alcohol)	0.00021
Ethoxylated alcohols (C14–15)	0.00011
Modified thiourea polymer	0.00011
Propargyl alcohol (2-propynol)	0.00004
Alkenes	0.00002
2-butoxyethanol (ethylene glycol monobutyl ether)	0.00006
Methanol (methyl alcohol)	0.00006
Diethanolamine	0.00001
Petroleum distillate hydrotreated light	0.01532
Ammonium acetate	0.00263
Sodium polyacrylate	0.00881
Glutararaldehyde	0.00719
Didecyl dimethyl ammonium chloride	0.00213
Quaternary ammonium compound	0.00147
Ethanol	0.00107
Petroleum distillate lydrotreated Light	0.00025
Quaternary ammonium chlorids (ammonium chloride)	0.00011
Alcohol ethoxylated C12–C16	0.00004
Ethoxylated alcohols	0.00004
Alchohol ethoxylate	0.00004
Alcohols, C12–C14—secondary, ethoxylated	Not available
Ethoxylated oleylamine	Not available
Polyacrylamide (acrylamide, ammonium acrylate copolymer)	Not available
Polyethylene glycol monnleate	Not available
Sobitan monooleate	Not available
Sorbitol tetraoleate	Not available

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Radioactive Wastewater From Fracking Is Found in a Pennsylvania Stream

New testing shows that high levels of radium are being released into the watershed that supplies Pittsburgh's drinking water

By Joseph Stromberg
smithsonian.com
October 2, 2013

New testing of treated wastewater from fracking shows that it contains high levels of radioactive radium, along with chloride and bromide, [image via Environmental Science and Technology/Warner et. al.

Editor's Note, Oct. 9: Based on several comments that mentioned that the Josephine Brine Treatment Facility stopped treating fracking wastewater in 2011, we did a bit of digging and found that the treated water downstream from the plant still showed signatures that fracking water had run through it, according to the study's authors. The post has been revised with this information, along with the fact that treatment does remove a good bit of contamination.

In the state of Pennsylvania, home to the lucrative Marcellus Shale formation, 34 facilities treat wastewater from the process of hydraulic fracturing (a.k.a. "fracking") for natural gas and release it into streams. There's no national set of standards that guides this treatment process—the EPA notes that the Clean Water Act's guidelines were developed before fracking even existed, and that many of the processing plants "are not properly equipped to treat this type of wastewater"—and scientists have conducted relatively little assessment of the wastewater to ensure it's safe after being treated.

Recently, a group of Duke University scientists decided to do some testing. They contacted the owners of one treatment plant, the Josephine Brine Treatment Facility on Blacklick Creek in Indiana County, Pennsylvania, but, "when we tried to work with them, it was very difficult getting ahold of the right person," says Avner Vengosh, an Earth scientist from Duke. "Eventually, we just went and tested water right from a public area downstream."

Their analyses, made on water and sediment samples collected repeatedly over the course of two years, were even more concerning than we'd feared. As published today in the journal *Environmental Science and Technology*, they found elevated concentrations of the element radium, a highly radioactive substance. The concentrations within sediments in particular were roughly 200 times higher than background levels. In addition, amounts of chloride and bromide in the water were two to ten times greater than normal.

This is despite the fact that treatment actually removes most of the contaminants from the wastewater –including 90 percent of the radium. "Even if, today, you completely stopped disposal of the wastewater," Vengosh says, there's enough contamination built up in sediments that "you'd still end up with a place that the U.S. would consider a radioactive waste site."

In recent years, the use of fracking to extract natural gas from shale formations has boomed in several areas, most notably Pennsylvania's Marcellus Shale, which has been called "the Saudi Arabia of natural gas." The process involves injecting mix of water, sand and proprietary chemicals deep into rock at high pressure, causing the rock to fracture and allowing methane gas to seep upward for extraction.

Much of the concern over fracking has related to the seepage of these chemicals or methane from drilling wells into groundwater or the fact that high-pressure injection can trigger earthquakes, but the wastewater recently tested presents a separate, largely overlooked problem.

Between 10 and 40 percent of fluid sent down during fracking resurfaces, carrying contaminants with it. Some of these contaminants may be present in the fracking water to begin with. But others are leached into the fracking water from groundwater trapped in the rock it fractures.

Greene County wells show 7.2 million gallons of potentially toxic fluid

By Susy Kelly, for the Greene County Messenger | Posted: Friday, November 28, 2014 2:15 am

7,273,480.

That's the estimated number of gallons of kerosene, a variety of toxic diesel fuel, being legally used in fracking fluid in Greene County, according to chemical disclosure registry FracFocus.

Greene gas well sign

Greene gas well sign

Compared to Fayette County, which saw the use of 230,171 of the same chemical over three years, Greene County's figure is staggering.

A single well, Sandrock 1H in Gilmore Township, reported over half its frack fluid was kerosene. In the majority of wells, a fraction of a percent of the total fluid is listed as kerosene.

Vantage alone reports using 6,645,700 of it in the 28 wells it submitted information about to FracFocus. A single well, Sandrock 1H in Gilmore Township, reported over half its frack fluid was kerosene.

On average, non-Vantage wells in Greene County use 2,226 gallons of CAS number 64742-47-8 per frack job, for a total of 627,780 gallons in 282 wells.

The chemicals have left some to question the potential health impact.

Release into the environment

In Greene County, discharge to the environment has not been avoided, as evidenced by violation notices issued to wells by the state Department of Environmental Protection (DEP).

Two wells have received notices of violation (NOV) for discharge of pollutional waters to waters of the commonwealth, seven were cited for failure to properly control or dispose of industrial or residual waste to prevent pollution to the waters,

and two wells received NOVs for failure to properly store, transport, process or dispose of a residual waste. Those are just a fraction of all the NOVs issued in Greene County.

Scott Perry, deputy secretary of DEP's oil and gas division, explained that NOVs are an important tool for enforcing the parameters of drilling permits. Companies which have received NOVs must provide specific plans for preventing similar problems and cleaning up any damage, or ultimately risk losing their permits.

While the EPA has outlined potential pathways for toxic flowback to find its way into groundwater, and Ken Dufalla of the Greene County chapter of the Izaak Walton League of America reports finding evidence of flowback in the region's waterways, researchers have concerns for air quality as well.

The air we breathe

Southwest Pennsylvania Environmental Health Project (EHP) has been monitoring health complaints in the region since 2010, with funding from the Heinz Endowments and the Claneil Foundation.

Dr. Michael Kelly, media liaison for the Washington County-based nonprofit, said researchers began conducting a case study in 2012 to try to identify a common source for health complaints. EHP followed 27 families in the region who live in close proximity to extraction sites, Kelly said, and expects to publish the peer-reviewed data in the next few months.

"When you're dealing with chemicals, it can be very difficult to prove that it's a particular chemical that's causing the problem," Kelly said.

While no single chemical can be singled out as a cause for health problems, the source can.

Kelly said, "We can't prove these symptoms are caused by fracking, but we can't prove they came from anywhere else."

At first, Kelly said, EHP advised consumers to be cautious about the drinking water. Then they began looking at the air quality surrounding fracking activities, from the exhaust of various machinery to compressor stations to water impoundments containing flowback or process water.

Kelly said the EPA and industry representatives continued to claim no pollution was coming from fracking operations, so EHP took a look at how regulatory agencies were conducting their research. When residents lodged complaints, he

said, DEP would bring a 24-hour air quality monitoring canister to collect data and average the pollution emissions over that period.

"We went to a different way of measuring," Kelly said. "We discovered people were getting spikes of exposure. There would be nothing for several hours and then, bang! Off the charts."

Kelly said, "We've proven there's a public health problem. There are toxic-level spikes of exposure."

According to Kelly, the industry has kept a pace ahead of regulatory agencies, leaving the consequences related to health and the environment to be determined later.

"We're using the American people as guinea pigs in a huge chemical experiment."

FracFocus flaws

While fracking fluid contains a host of chemicals, some of them known to be particularly hazardous, the Energy Policy Act of 2005 exempts chemicals used in hydraulic fracturing from federal regulation. Colloquially, this is known as the "Halliburton Loophole."

In February, the US Environmental Protection Agency (EPA) clarified its position on the use of diesel fuel, saying that no diesel fuel may be used in fracking fluid without a permit from the federal government. The EPA specifically outlined five additives according to CAS number that require permits, and all are variants of diesel fuel.

In 2012, the state legislature passed Act 13, which, among other things, required gas companies to report chemicals used in the fracking process to FracFocus.

According to Harvard Law School's Environmental Law Program, the registry has holes. It does not review the submissions, nor do states themselves. Although FracFocus has been criticized for its imperfections, it remains the only such registry available for laypeople trying to understand the chemicals used in fracking.

In Pennsylvania, companies are required to report to FracFocus within 60 days of fracking a well. However, they don't always meet that requirement. For example, Vantage's Lamar Trust 1H well, just east of I79 outside Waynesburg has no report, though they've been cited by DEP seven times between 2009 and 2010.

In some FracFocus reports from Greene County wells, the listed information can cause confusion.

Five reports from EQT wells that used CAS number 64742-47-8, list it as a friction reducer purchased from Halliburton, which describes the substance as "non-diesel, BTEX-free".

There are 31 Consol wells that list a friction reducer with no CAS number, just the description "long chain polyacrylamide".

FracFocus, managed jointly by the Groundwater Protection Water Council and the Interstate Oil and Gas Compact Commission, provides information about how each of the chemicals can be used. CAS number 64742-47-8, it states, can be used as a carrier fluid for borate or zirconate crosslinker, a carrier fluid for guar gum gelling agents, and as a carrier fluid for polyacrylamide friction reducer.

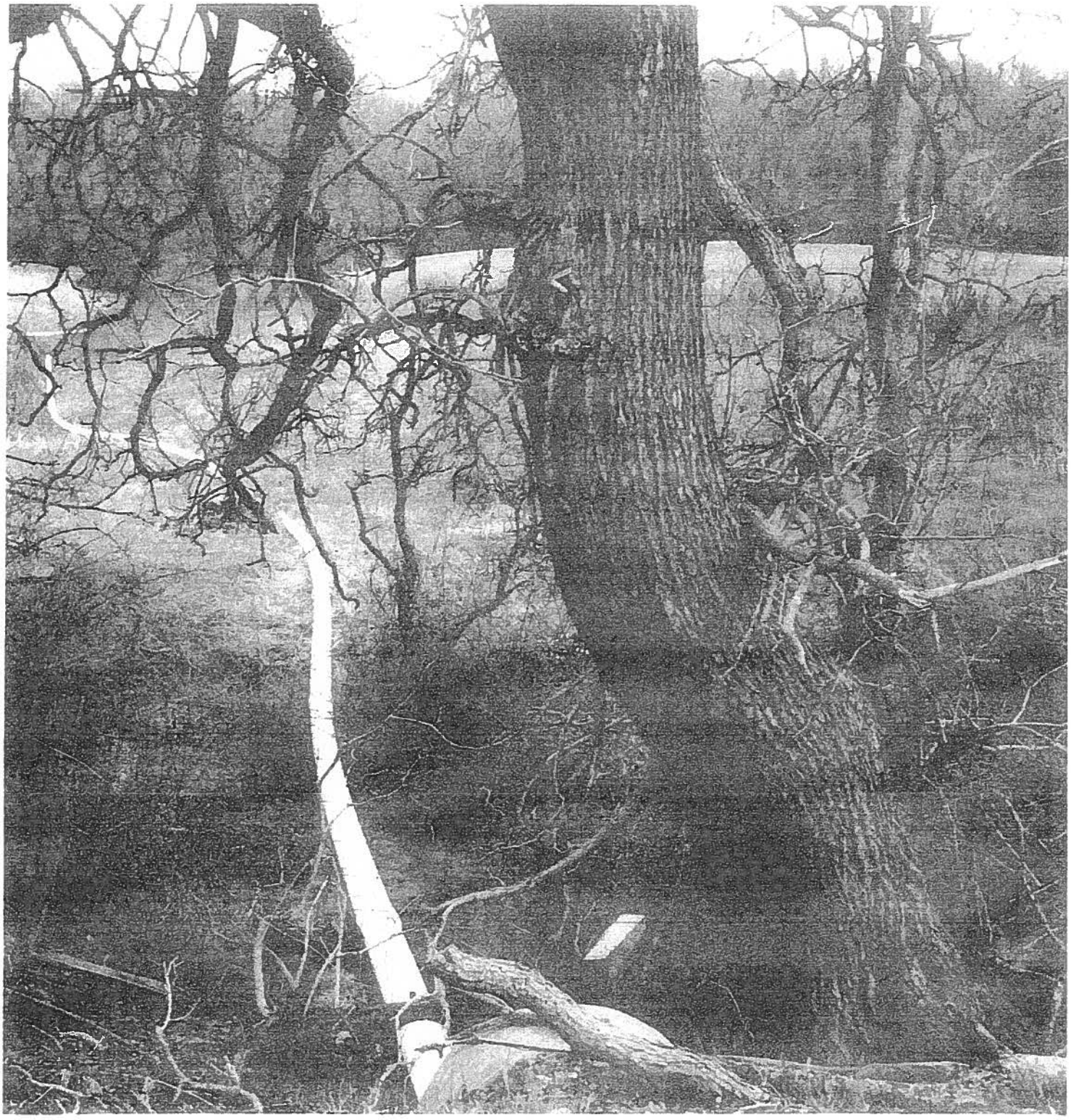
Material Safety Data Sheets (MSDS) describe a substance's toxicity and emergency procedures, and information from the MSDS supplied by Sigma Aldrich, one company that sells CAS number 64742-47-8 to frackers, says it is "toxic to aquatic life." It advises customers not to let the product enter drains.

"Discharge into the environment must be avoided," the MSDS says.

SITUATION NORMAL ALL FRACKED UP

By ELIZA GRISWOLD

Water wells contaminated with chemicals from drilling and leaking Impoundment ponds. According to studies and court records.



PHOTOGRAPHS BY SEAMUS MURPHY *Temporary plastic pipeline, used in the drilling process, near Mayo, Ireland*

Amwell Township is a 34-square-mile plot of sheep pastures and grassy pasturelands planted with alfalfa, orchard and timothy, in the southwestern corner of Pennsylvania. It's home to some 4,000 people, most of whom live in villages named Amity, Lone Pine and Prosperity. From some views, this diamond-shaped cut of land looks like the hardscrabble farmland it has been since the 18th century, when English and Scottish settlers successfully drove away the members of a Native American village called Annawanna, or "the path of the water." Arrowheads still line the streambeds. Hickory trees march out along its high, dry ridges. Box elders ring the lower, wetter gullies. The air smells of sweet grass. Cows moo. Horses whinny.

From other vantages, it looks like an American natural-gas field, home to 10 gas wells, a compressor station — which feeds fresh gas into pipelines leading to homes hundreds of miles away — and what was, until late this summer, an open five-acre water-impoundment chemical pond. Trucks rev engines over fresh earth. Backhoes grind stubborn stones. Pipeline snakes beneath clear-cut hillsides.

The township sits atop the Marcellus Shale Deposit, one of the largest fields of natural gas in the world, a formation that stretches beneath 575 miles of West Virginia, Pennsylvania, Ohio and New York. Shale gas, even its fiercest critics concede, presents an opportunity for the United States to be less dependent on foreign oil. According to Wood Mackenzie, an energy-consulting firm, the Marcellus formation will supply 6 percent of America's gas this year, a figure expected to more than double by 2020.

About five years ago, leases began to appear in the mailboxes of residents of Amwell Township from Range Resources, a Texas-based oil company seeking to harvest gas through hydraulic fracturing. "Fracking," as it is known, is a process of natural-gas drilling that involves pumping vast quantities of water, sand and chemicals thousands of feet into the earth to crack the deep shale deposits and free bubbles of gas from the ancient, porous rock. Harvesting this gas promises either to provide Americans with a clean domestic energy source or to despoil rural areas and poison our air and drinking water, depending on whom you ask.

On Nov. 21, the Delaware River Basin Commission, which involves four states — Pennsylvania, New Jersey, New York and Delaware — will vote on rules governing fracking in the river's watershed, which supplies some 15 million people with drinking water. The states most affected will be New York and Pennsylvania, which sit on the Marcellus Shale, where the gas is closest to the surface.

This summer, Gov. Andrew Cuomo of New York moved to lift the state's yearlong moratorium on fracking against vocal opposition from environmentalists and many local residents. Following a series of hearings this month, New York will decide whether to allow fracking early next year. In the meantime, New Yorkers are looking to Pennsylvania, the first neighbor to welcome fracking, as a model.

There are more than 4,000 Marcellus wells in Pennsylvania, with projections ranging from 2,500 new wells a year to a total of more than 100,000 over the next few decades; 458 of those wells are in Washington County and 60 are in Amwell Township, to which fracking has given an injection of new income and business; it has also spurred one of the first E.P.A. investigations into fracking's effects on rivers, streams, drinking water and human health.

Just before Christmas in 2006, a handful of neighbors gathered in the township's municipal building to sign leases granting Range Resources the right to drill for natural gas below their homes and, potentially, in any direction. Signing leases here is nothing new. Over the years, one industry after another has extracted minerals from the land. In the 1600s, it was coal; in the 1900s it was glass, coke and steel and manufacturing. "Sooner or later, somebody wants to go around, under or through you," one farmer and gun-shop proprietor told me. "You make your best deal and you talk to a lawyer. At least these companies pay something up front."

What these companies paid was more than many people in Amwell Township, where the per capita income in the 2000 census was $16,285, were accustomed to seeing in their lifetimes, even if the windfall wasn't the same for everyone. Next-door neighbors made, upon signing, between $1,500 and more than $500,000 for the same amount of land. Curiously, though, the huge gap in payments didn't cause much trouble among neighbors, at least at first. Most, if they express a political viewpoint at all, are old-school libertarians who believe each man has the right to live by his will and abilities.

The conflict instead is between "country folk and city people," Bill Hartley, 63, a barber and a cattle farmer told me. "The country folk want the drilling and have mineral rights. The city folk don't want the drilling and have no rights to sell."

At Hartley's Styling Shop, the barbershop Hartley has run out of a rented trailer on his great-great-grandfather's farm for the past 16 years, the gas boom is all anyone talks about. There's a barber pole spinning outside and a Jacuzzi in the bathroom. A John Deere clock tells time according to a tractor. When I met Hartley there early last spring, he was alone, reclining in his barber's chair and chain-smoking, as he had been for hours, or maybe years. The trailer's air and Naugahyde chairs were saturated with stale smoke.

"Do you mind if I smoke?" he asked. I didn't. "Good, because I would have told you, 'Tough.'" Hartley, who has the long, hollow face of an Appalachian Marlboro Man, keeps 35 cows on 110 acres of rocky fields of fescue. Until recently, like most farmers he knows, he needed a second job to pay for the cows. Raising cows costs more than $300 a head per year. It takes a good year for Hartley to break even. Now he has more money than he ever imagined. Signing his gas lease at "a little more" than $1,000 an acre net-

RUNOFF *Haney's children have shown signs of exposure to arsenic, and some of their animals got sick or died.*

'SOONER OR LATER,

SOMEBODY WANTS TO GO

AROUND, UNDER OR

THROUGH YOU. YOU MAKE

YOUR BEST DEAL AND

YOU TALK TO A LAWYER.'

ted him in excess of $110,000 upon signing, plus 12.5 percent of the royalties from gas produced on his land. Hartley prefers not to discuss exact amounts. "That's nobody's business," he said. But after the first couple of years, production tends to drop off precipitously, and the royalty checks will dwindle. So Hartley still cuts hair. "And I like people," he said.

As Hartley sees it, the gas industry has helped him to preserve his farm, cows and way of life. "I don't want to say you have to be born into it," he said. "But it has to be in your blood."

The Marcellus boom has brought a host of economic benefits to Western Pennsylvania — new jobs, booked motel rooms, busy food franchises and newly paved roads — and promises to bring more. According to a recent study by Pennsylvania State University, the industry has created 23,000 jobs, including employment for roustabouts, construction workers, helicopter pilots, sign makers, Laundromat workers, electricians, caterers, chambermaids, office workers, water haulers and land surveyors. Not to mention that leaseholders are saving, on average, 55 percent of the money they make upon signing leases and 66 percent of their royalties, according to the Pennsylvania State University study.

Hartley's cousin Stacey Haney lives two and a half miles from Hartley's farm. A brown-haired, blue-eyed former beautician, Haney, 42, is a nurse at the nearby Washington Hospital. Hartley and Haney share a kind of tough self-reliance, as well as a quick, dark wit.

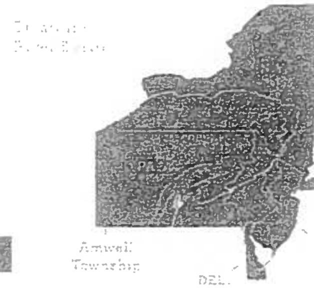
"We came into this world poor, and we'll go out of this world poor," Haney says. This is her family's motto. Haney — a single mother who wears her hair in a shag — works full time and is raising her two children, Paige, 12, and Harley, 15, along with an ark of 4-H animals. Her father, Larry, whom everyone calls Pappy, is a steelworker. He has had long stints of unemployment, beginning when Stacey was in second grade. He's also a sometime farmer whose butternuts have won first place so often at the Washington County Fair that no one else bothers to enter anymore. The fair is the highlight of the Haneys' year: beribboned photos of their award-winning rabbits, goats and pigs line the walls of their immaculate three-bedroom home, which Haney has hand-stenciled with deer tracks.

When the natural-gas industry came to town, Haney saw an opportunity to pay off farm bills and make a profit from the land. Word had it that the companies were interested in signing up large parcels, so in the winter of 2008, Haney, who owned only eight acres, persuaded two of her neighbors to pool their land on a lease for which she was paid, in installments, $1,000 dollars per acre and 15 percent royalties.

The money would help to pay the taxes [illegible] man who came to the Haneys' home [illegible] the lease [illegible] of a farm and pasture with [illegible] garbage [illegible] Haney said, which she found reassuring. And it didn't seem as if the drilling would affect their lives much. Range Resources was involved in the community in small ways too. For the past several years, it operated a booth at the Washington County Fair. In 2010, the company offered kids an extra $100 for the farm animals they auctioned. That was the year Stacey Haney's son, Harley, took his breeding goat, Boots, all the way to grand champion.

At the fair, Haney ran into her next-door neighbor, Beth Voyles, 5[illegible], a horse trainer and dog breeder, who signed the lease with Haney in 2008. She told Haney that her 1½-year-old boxer, Cummins, had just died. Voyles thought that he was poisoned. She saw the dog drinking repeatedly from a puddle of road runoff, and she thought that the water the gas company used to wet down the roads probably had antifreeze in it. "We do not use ethylene glycol in the fracking process," Matt Pitzarella of Range Resources told me. He also said that the dog's veterinarian couldn't confirm the dog had been poisoned and that another possible cause of death was cancer.

A month later, Haney's dog, Hunter, also died suddenly. Soon after, Voyles called Haney to tell her that her barrel horse, Jody, was dead. Lab results revealed a high level of toxicity in her liver. Voyles sent her animals' test results to Range Resources. In response, Range Resources wrote to Voyles to say that, as the veterinarian indicated, the horse died of toxicity of the liver, not antifreeze poisoning. The company did acknowledge that the vet suspected the horse died of poisoning by heavy metals. Subsequent tests of the Voyleses' water supply by Range Resources revealed no heavy metals.

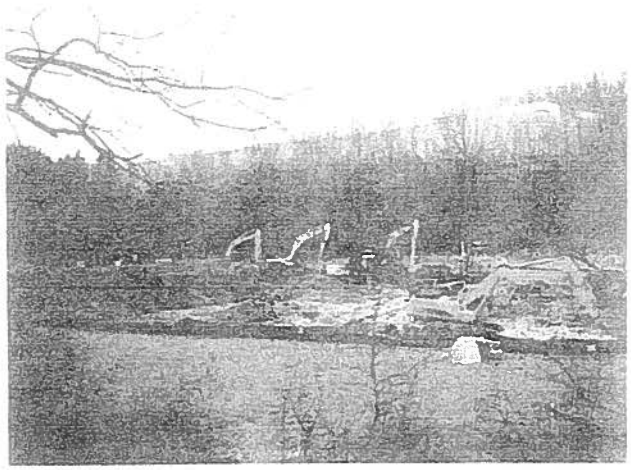


Voyles's boxers began to abort litters of puppies; six were born with cleft palates. They died within hours. Others were born dead or without legs or hair. Unsure what to do, Voyles stored 15 of the puppies in her freezer. (Range Resources says it was never notified about the puppies.) By December, Boots, the grand-champion goat, aborted two babies. Haney had to put her down the day after Christmas.

What was going on with the animals? Where were the toxic chemicals in their blood coming from? Haney feared that the arrival of the gas industry and the drilling that had begun less than 1,000 feet from her home might have something to do with it.

In Amwell Township, your opinion of fracking tends to correspond with how much money you're making and with how close you live to the gas wells, chemical ponds, pipelines and compressor stations springing up in the area. Many of those who live nearby fear that a leak in the plastic liner of a chemical pond could drip into a watershed or that a truck spill could send carcinogens into a field of beef cattle. (According to the Pennsylvania Department of Environmental Protection, 65 Marcellus wells drilled this year have been cited for faulty cement casings, which could result in leaks.) But for many other residents, including Haney's neighbors, the risks seem small, and the benefits — clean fuel, economic development — far outweigh them.

On a Saturday morning in July 2011, Bill Hartley's Styling Shop bustled with clients — a truck driver, a leaseholder, a landowner — all of whom profited from the gas boom. One was Ray Day, 64, a ginger-haired farm-



THE DRILL *Excavation near the Haneys' farm (top and bottom); treatment plant discharge headed for Black Lick Creek in Indiana County, Pa.*

Day drove me next to the well pad, a football field of cement and a few condensate tanks that painters were rendering forest green. Long before the recent drillers came, this was named the Well Field, after an oil well locals said was drilled here in the 1920s. Like some of his neighbors, Day signed a gas lease in part to protect his land from what he saw as a far more rapacious industry headed his way: long-wall coal mining, a process that takes a ribbon of coal out of a seam over miles. "Long-wall mining is so much more destructive than this, the way I see it," he said. "Hopefully with these pipes they wouldn't want to mine coal underneath us."

The fracturing was now over, the major pieces of equipment were gone and the field was replanted with medium red clover. Day wasn't concerned about the impact of drilling. "Nothing I've seen would indicate an adverse effect," he said, "except the odor coming off the compressor station." (Range Resources told Day that the smell comes from anaerobic bacteria that are more prevalent in this tracking process but that they are harmless. Investigating air quality around compressor stations is part of the E.P.A.'s ongoing study.) Day, like most of his neighbors, trusted the companies to use best practices. A man's word means a lot here. After all, without regulation or oversight, he and other farmers worked together to do things like fence streams to keep cattle out of them.

We drove back through an alfalfa field to the farm. "You haven't asked me what my profession is," Day said. "I'd assumed he was a farmer." "No one here could survive on farming," he replied. "I taught science in local schools for 35 years."

For Day and others, allowing the gas company to drill on their land is simply a matter of cash. They also firmly believe that natural gas should be used as a bridge between foreign oil and sustainable energy sources like

solar and wind. "Natural gas is the most eco-friendly fuel source that we have," said Rick Baker, 59, a plane tuner who lives on 91 acres located between Bill Hartley and Stacey Haney. "Some people will argue with me on this, but it burns clean." He's such a proponent of drilling that he even agreed to star in a commercial for Range Resources, for which he was paid $200.

About a year before Haney's dog died, in the summer of 2009, she began to notice that sometimes her water was black and that it seemed to be eating away at her faucets, washing machine, hot-water heater and dishwasher. When she took a shower, the smell was terrible — like rotten eggs and diarrhea. Haney started buying bottled water for drinking and cooking, but she couldn't afford to do the same for her animals.

Later that summer, her son, Harley, was stricken with mysterious stomach pains and periods of extreme fatigue, which sent him to the emergency room and to Pittsburgh's Children's Hospital a half-dozen times. "He couldn't lift his head out of my lap," Haney said. Early in November of the following year, after the animals died, Haney decided to have Harley tested for heavy metals and ethylene glycol. While she waited for the results, Haney called Range Resources and asked that it supply her with drinking water. The company tested her water and found nothing wrong with it. Haney's father began to haul water to her barn.

A week later, on Haney's 41st birthday, Harley's test results came back. Harley had elevated levels of arsenic. Haney called Range Resources again. The company delivered a 5,100-gallon tank of drinking water, called a water buffalo, the next day. "Our policy is if you have a complaint or a concern, we'll supply you with a water source within 24 hours," Pitzarella of Range Resources said. He added that the company has "never seen any evidence that anyone in that household has arsenic issues."

Although she was able to work 40 hours as a nurse and care for two kids and a small farm, Haney wasn't feeling great, either. So a few months later, she had herself and Paige tested too. Their tests results showed they had small amounts of heavy metals like arsenic and industrial solvents like benzene and toluene in their blood. Dr. Philip Landrigan of Mount Sinai said that the results show evidence of exposure, but that it was difficult to determine potential health effects at the levels found. But he added: "These people are exposed to arsenic and benzene, known human carcinogens. There's considered to be no safe levels of these chemicals." Pitzarella says that Range Resources was never shown these reports and that arsenic has nothing to do with fracking. Pitzarella cited a study by the Center for Rural Pennsylvania that found that 40 percent of Pennsylvania's water wells had at least one pre-existing water-quality problem, and that there was no obvious influence on private water-well quality from fracking. In a previous study, 2 percent of the state's wells had arsenic levels that exceeded health standards.

Soon Haney and her kids began to notice that even outdoors it smelled a lot like the shower — a combination of sweet metal, rotten eggs and raw sewage. Talking to neighbors, Haney learned that atop a hill, about 1,500 feet from her home and less than 800 feet from that of her neighbor, Beth Voyles, there was an open, five-acre chemical impoundment filled with chemically treated water.

Haney figured out how to navigate Google Earth on her son's computer. (She doesn't own one, nor does she have an e-mail address.) There was her gravel driveway and her house hidden under the canopy of maple trees. And there was the six-football-field-square black pond that dwarfed her neighbor's silver-roofed house. The grass surrounding the pond looked dead.

Popular concerns about natural-gas drilling have centered on what chemicals companies are putting into the earth, not least because this list is a proprietary secret. In 2005, Vice President Dick Cheney spearheaded an amendment to the energy bill, which critics call the Halliburton Loophole. This legislation exempts hydraulic fracturing from the Safe Drinking Water Act and protects companies like Halliburton, of which Cheney was once the C.E.O., from disclosing what chemicals are going into the ground.

But the problem, it turns out, lies also in the dissolved substances coming out, namely salts (bromides, chlorides), radionuclides like strontium and barium, as well as what are commonly called BTEX (benzene, toluene, ethylbenzene), volatile organic compounds that can be noxious to human health.

The industry acknowledges that the question of how to handle the wastewater that comes from fracking is one of its most pressing problems. In Pennsylvania this problem is particularly acute. Pennsylvania's geological formations, unlike those of other states where natural-gas drilling has occurred, don't allow for the usual method of disposal: injection wells that store flowback deep below the earth's surface. Disposing of the chemical water has meant trucking it to another state or paying local treatment facilities to process it. The facilities, which are not equipped to remove salts, have often sent the frack water back into local rivers. In 2008, a United States Steel plant in Clairton, Pa., complained that the water from the Monongahela River was unfit for use. Loaded with salts, the water tasted and smelled odd and was corroding not only industrial equipment but also dishwashers and kitchen faucets. For several months, the Monongahela River, which provides most people in the Pittsburgh area with drinking water, no longer met state and federal standards. Following a request from the State of Pennsylvania, the U.S. Army Corps of Engineers found it would require five times the amount of water in their reservoirs to dilute the river. It took five months to clean it up.

"Salt is a serious problem," Rose Reilly, a water biologist for the Army Corps of Engineers, said. It has to be managed like any other pollutant. "It isn't biodegradable."

This past spring, in response to public outcry, Pennsylvania's Department of Environmental Protection asked gas companies to stop sending flowback to treatment plants. But it was a request — not a regulation. And enacting such measures is expensive. Shale gas is different from other kinds of oil exploration because there's no eureka moment. If you drill, you're sure to hit it. "This is a widget business," says Bobby Vagt, president of the Heinz Endowment, a Pittsburgh-based nonprofit that supports development in southwestern Pennsylvania; he ran gas and oil companies in Texas for 15 years. "The lower you can keep the costs — of every step of the process, including pipelines and road building — the more money you're going to make."

The challenge, as Tim Kelsey, a professor of agricultural economics at Pennsylvania State, points out, "is making sure that the community isn't left holding the bag." This is an economic issue as much as an environmental one. Banks have expressed reluctance to back home mortgages within up to three miles of a well. Whole towns could become brown fields, and home values would drop precipitously. Currently, companies operating in Pennsylvania pay no tax to extract gas. (Gov. Tom Corbett reportedly received at least $1 million in campaign donations from gas interests.) Corbett recently introduced legislation that would levy fees that critics say would amount to a tax of 1 percent per well on gas extraction, significantly lower than Arkansas (3.54 percent) and Texas (5.4 percent). Pennsylvania Democrats call the measure, which they see as friendly to oil and gas interests, "Drill, baby, drill."

But for men like Bill Hartley and others who welcome the arrival of fracking in the state, it's not the politics of deep drilling that matter. What matters is preserving common resources. "My one concern is our water," Hartley said. "My grandfather taught me water is life."

On Sunday, May 8, 2011, Mother's Day, when Haney and her kids were returning from dinner at a nearby Cracker Barrel restaurant, they turned onto McAdams Road, and the smell of raw sewage was "enough to make you gag," Haney's daughter, Paige, told me. They weren't the only ones to smell it. Beth Voyles, Haney's neighbor, called the Department of *Continued on Page 52*

(Continued from Page [illegible])

Environmental Protection to register her informal complaint about the stench. The D.E.P. sent out a water specialist, John Carson. His field notes, made public following a subpoena, indicate that he, too, smelled a "strong odor" at the impoundment but not on her property. Voyles claims that Carson refused to take her complaint. When asked for comment, a D.E.P. spokesman, Kevin Sunday, said in an e-mail that the "D.E.P. responds promptly to any and all complaints. There is an ongoing investigation into the impoundment. This is a matter of active litigation and cannot be discussed further." Range Resources says that the D.E.P. visited the area on 24 separate occasions and found no malodor.

Range Resources did have an explanation: the power had failed at the impoundment, shutting down the aerators that move oxygen into the water to prevent bacteria from growing. Range Resources maintains that a D.E.P. study from 2010 indicates no air pollution of any kind at the pond next door to the Haneys and the Voyleses, or anywhere else, for that matter. Critics of this study say the effect of fracking on air quality remains underinvestigated.

That same day, when Voyles told Range Resources she had developed blisters in her nose, it offered to put her up in a hotel, as it does for all nuisance complaints, but she didn't want to leave her dogs and horses behind. (Range later said that it had no record of the complaint.) Next door, on McAdams Road, Haney and her kids began to have intense periods of dizziness and nosebleeds. Of the three, Harley was the worst off. Haney took him to their family physician, [illegible], in the nearby town of Washington. Like most local doctors, he had never seen such symptoms before.

Haney says that the doctor's advice to her was unequivocal: "Get Harley out of that house right away. I don't want him anywhere near there, even driving by, for 30 days." So Haney took Harley to a friend's house in Eighty-Four, a town named for the lumber company. She took her daughter to her parents' house in Amity. Each day, she spent about four hours in the car shuttling the kids from school, to and from friends' homes and driving to the farm to feed the animals, which were O.K. some days and vomiting or collapsing on others. Haney found a cousin willing to take her pigs, but she had nowhere to house the other animals, so they remained at the farm. She stayed home for less than an hour at a time, long enough to put a load of laundry into the washer. Every two days, she spent $50 on gas. Their farmhouse stood abandoned. "Our home has become a $300,000 cat mansion," Haney said when I visited her in July.

Haney is no left-leaning environmentalist; she is a self-proclaimed redneck who is proud to trace her roots here back at least 150 years. This is not the kind of fight she usually takes on. "I'm not going to sit back and let them make my kids sick," she says. "People ask me why I don't just move out, [illegible]

[illegible]

mouth. Voyles filed suit against the Department of Environmental Protection in May. Range Resources chose to join the case, because its rights are also at stake. Documents from industry sources and the D.E.P. — now a matter of public record — support the suit's allegations of a series of structural violations and hazardous incidents surrounding the pond. They include half a dozen tears in the pond's plastic liner (at least one caused by a deer — its carcass had to be dragged out); at least four cracks in a temporary plastic transfer pipeline leading to an open field; two truck spills, one of which contaminated a cattle pasture; and a leak in an adjacent pond that held drill cuttings. Range admits that after this leak the level of total dissolved solids, or salts, spiked in the water. Of all these violations, the D.E.P. issued a citation for only the last. The D.E.P. declined to comment, citing the ongoing case.

In mid-July, Voyles's 25-year-old daughter, Ashley, was riding her paint gelding, [illegible], behind the chemical pond. Ashley could hear a hissing and bubbling sound in the stream. There were pools of red foamy oil slick. "It was rainbow water," Ashley said. The next morning, Haney and Voyles called (Continued on Page [illegible])

in the alphabet soup of government agencies they've contacted over the past year to test the water in the ponds: the D.E.P., the E.P.A., the Fish and Boat Commission. They also called Range Resources. Sunday, the D.E.P. spokesman, said that it was most likely decayed vegetation that gave off gas. Later, test results of the area commissioned by Range Resources revealed the presence of acetone, toluene, benzene, phenol, arsenic, barium, heavy metals and methane. The company maintains that none of these were found in drinking water.

Bill Hartley, Rick Baker, Beth Voyles and Stacey Haney received their first royalty checks this summer from the nine gas wells that lie on the square mile between them. Stacey used most of her $9,000 check to pay off the bills she incurred: $4,500 went to co-pays and deductibles for doctors' visits; $1,150 went to pay for gas. She set $2,700 aside to pay taxes on the earnings. The remaining $750 she used as a down payment on a camper. Haney finally moved the kids to live behind her parents' home in Amwell. Subsequently, the benzene and toluene levels in each of her children's urine dropped precipitously. For Haney, who continues to return to the farm to feed the animals every evening, the benzene and toluene levels remain higher. Haney still suffers from acute nausea, for which his doctor has prescribed Zofran, a medication frequently given to chemotherapy patients. "They've ruined our lives," Haney said. "I have to worry every day if my kids are going to have cancer. I will worry for the rest of my life about them with the amount of carcinogens we now have in our blood. We've lost everything — our pets, the value of our house. No amount of money that we'd ever get from royalties would ever replace my children's health."

The people of Amwell are no strangers to the price of development — the loss of a farm's spring, the sinking of a family home when the coal mine burrows beneath it — or the price of its absence — shuttered mills and lost jobs. But given our energy needs, the use of fracking and the number of wells are likely to grow. The question is whether regulations to address environmental and health issues can keep pace with a booming industry.

Haney's neighbors have heard about Harley's illness. "I don't know what to make of it," his cousin Bill Hartley says. "It could very well be there's a leak in the pond." Haney's daughter, Rick Baker's dog, aware of what the problem is. "I don't claim there's something going on more," he said. "It concerns me." He called Range Resources after it first delivered the water buffalo to say he was glad the company was trying to correct the problem. Baker stands by the positive impact the industry has had on Amwell and thousands of other townships. "This is definitely the right thing for Western Pennsylvania," he says. "We're sitting on one of the largest natural-gas reserves in the world. We need this natural gas to keep functioning." And the economic benefits were essential, he adds. "There are still people sitting in bars waiting for the steel mills to reopen." Yet Baker says he feels different from the way he did six months ago, when we first spoke. "The safety and environmental issues have to be addressed," he says. The future scares him. With big oil — Chevron, BP, among others — looking to get involved in the industry, Baker fears that it won't be accountable to individuals like himself and Haney.

Haney still made it to this year's Washington County Fair, where her daughter, Paige, lost the Spam bake-off. Paige's goat, Crunch, won first place, and her rabbit, Phantom, almost took best in show. As usual, Pappy's butternuts placed first. In the fair's main hall at the craft division, a glossy ribbon hung from a child's three-foot high Lego Patterson rig, a model of a gas well. It won first prize. ◆

ADDITIONAL PHOTOGRAPH CREDITS, PAGE 11
The Big Profile, Mike Coppola/Getty. What the Kids Are Doing These Days, www.dothelure.com. Fashion column: Joe Fresh. They're Famous on the Internet: Mike Haverstead. Dust Bowl the Sequel: Three Lions/Getty. How to Discuss Books You've Never Read: David Levenson/Getty.

Marcellus gas well activity in Washington County, Pennsylvania

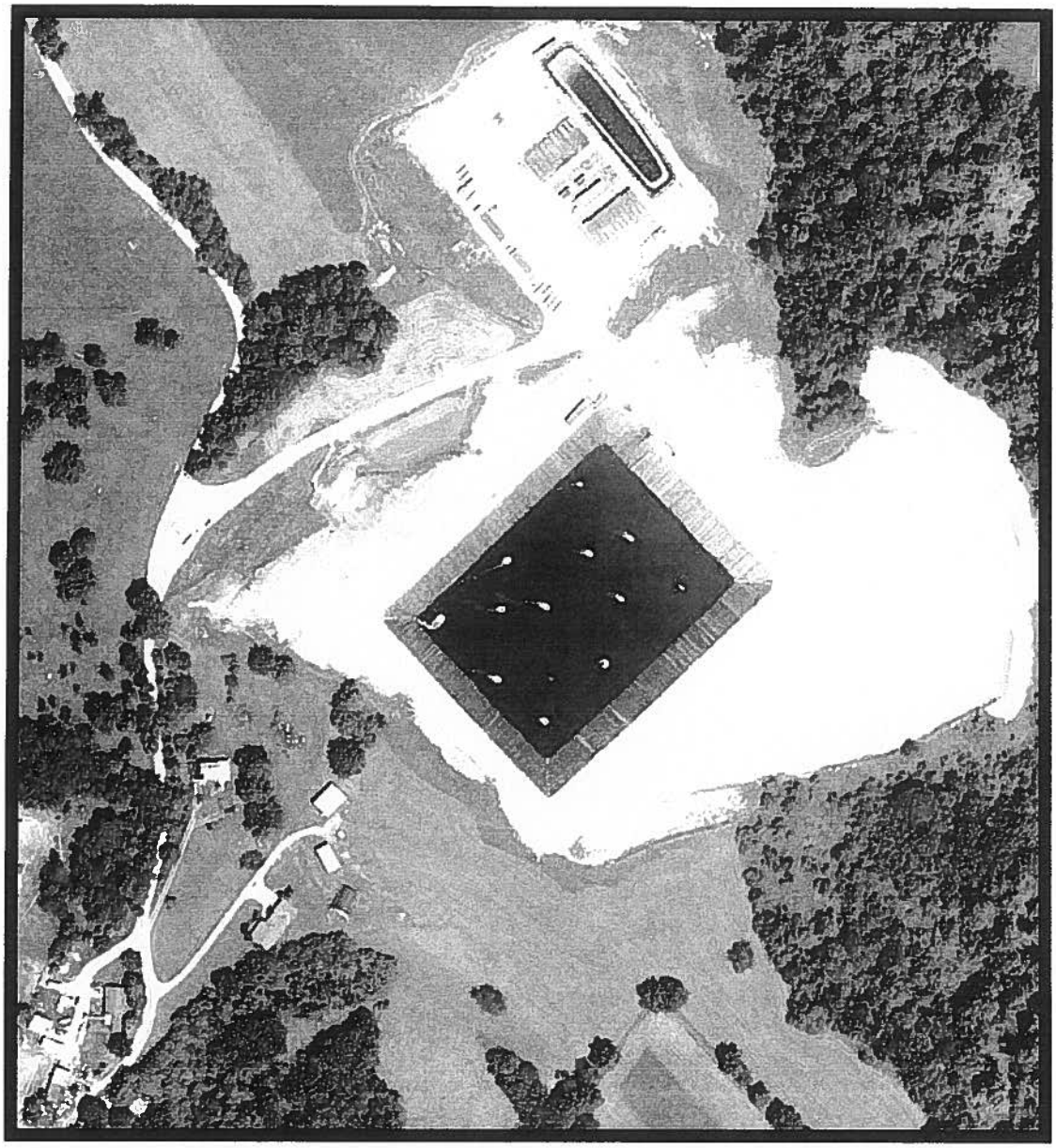


Photo 1: A "Super Misting" pit location as seen from Google Earth.

I am a concerned citizen of Pennsylvania. I am not a scientist, and I do not claim to be "in the know" about the procedures of the gas drilling industry. I am struggling to understand the bigger picture: I want to know the intentions of Marcellus Shale drilling companies; I want to know the possible impact that Marcellus Shale drilling will have on my life, my land, and my neighborhood. The purpose and spirit of this document is to present what I have learned, voice my concerns, and ask some questions. I hope that this photo essay inspires you to ask some questions of your own about what I call the "Super

Misting" pits, and about the public's right to know what's happening in their own back yards.

The gas extraction industry is not saying much about their presence here, and many of the people that live in the affected areas do not seem to know a whole lot about this issue.

How I Learned About Marcellus Shale Drilling

Late last year (2009) it first came to my attention that the Marcellus Shale well-drilling industry was possibly coming to our area in Westmoreland County. The town criers were trumpeting prosperity and "riches beyond belief," encouraging us and the land owners around us to get on board and sign a lease with the gas company. The only thing I knew about gas wells at that time was what I had seen all over our area—but those were not Marcellus Shale wells. I guess they call them "surface" gas wells. They are small green tanks with some piping around them. They are usually tucked neatly away in a field with grass and flowers around them; you might even see a bird of prey sitting on top of one. I did not see much of an issue with them.

So I started to do some research on the Internet about gas wells, and I found many articles about people that are having problems living around Marcellus Shale wells; people who claim that the drilling procedures ruined their land and water (Do a Google search for the name **Ron Gulla,** or the town of **Dimock, Pa.**, for more information).

It was at about this same time that I also heard people talking about a Marcellus well being set up in our area close by, so I went to have a look. As I drove over the hill and looked down on the area, my first impression was that it looked like they were putting in a Wal-Mart. Until then, I had no idea that this type of gas well took up so much acreage, and all I could think of on the way home was the size. That was my first "wake up call" about the fact that there is a big difference between the small "surface" gas wells that have dotted Pennsylvania farms for ages and the new Marcellus wells. I could see that I needed to find out more.

Over the next several months, I did research on the subject, and I came across many concerns voiced by other citizens about the Marcellus Shale gas extraction industry, as well as information about the extraction process. The millions of gallons of water used to extract the gas, the gas companies' lack of disclosure of toxic fracking chemicals used in the process, "trade secrets," the fact that Marcellus extraction companies get exemptions from federal laws that oversee the safety of our clean water and air, and the many complaints from families affected by drilling who complain of a loss of quality of life. I started to realize that this whole issue was really massive and complex. I think the information that bothered me the most was from Penn State's Web site on the subject, which says that according to current projections, gas companies plan to drill 30,000 Marcellus wells in the next ten years throughout central Pennsylvania, with more to come later.

Google Earth

For my home research project on this issue, I had been using the Internet, and Google Earth in particular, to get familiar with the counties of Pennsylvania, the surrounding landscape, and the rivers. Google Earth is a free satellite image viewing program that you

can use on the Internet (www.earth.google.com). Early in the project, I noticed that the satellite images (tiles) that were used were very outdated (roughly eight to ten years old) and were extremely low resolution. There was no visual record of Marcellus well drilling.

But in September 2010, I was on Google Earth and I noticed that the satellite images had changed in our area; they had been upgraded. Based on known changes in our area, the new satellite images were from around the first of June, 2010 and were available on the Internet by sometime in late August 2010. Also, the updated images are very high resolution. So I started to look to other areas to see if I could find Marcellus drilling sites. By this time, I had seen many photos of the Marcellus gas well drilling process on the Internet, so I knew what to look for. It was not difficult to find Marcellus drilling sites as I scanned over parts of Washington County. Newly cleared pads with rectangular dark waste pits, trucks lined up, piping and entry roads—they all have a familiar look, and they're available for everyone to see on Google Earth (See photo 2).

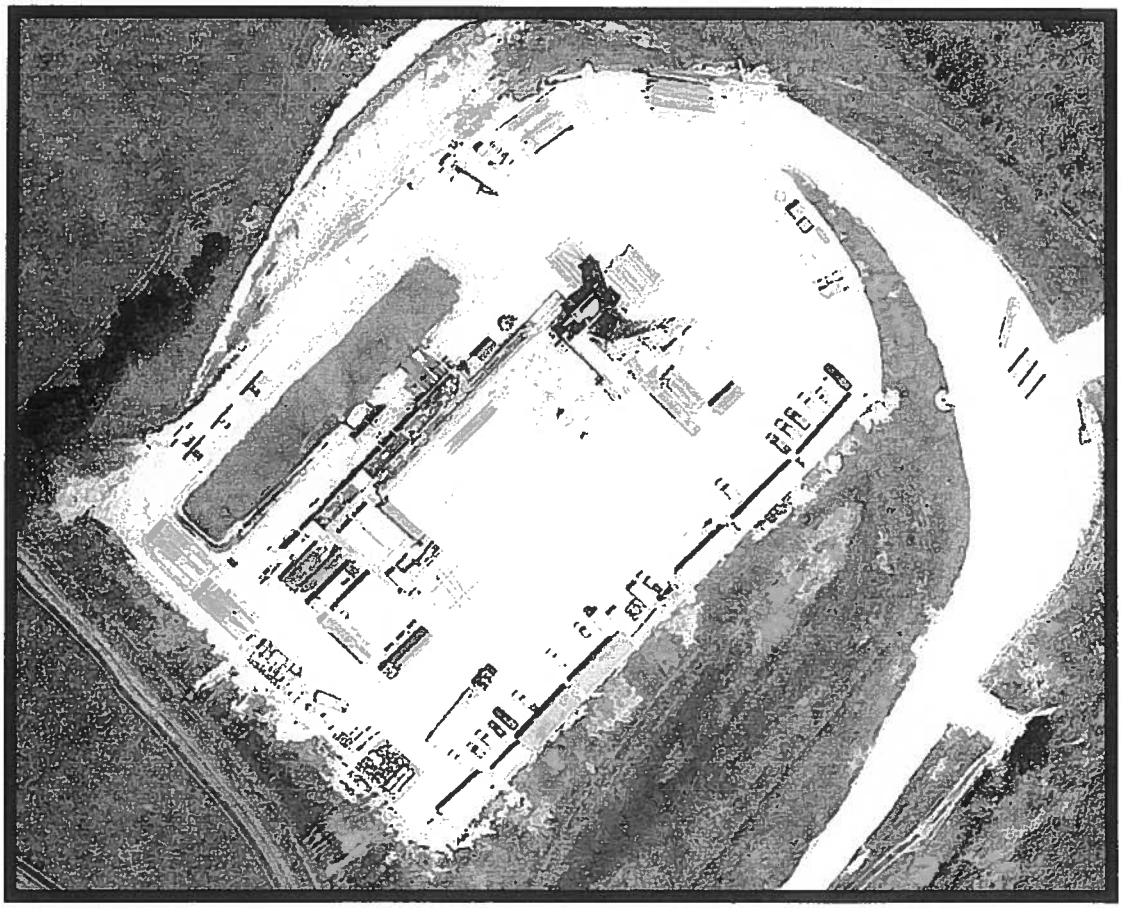


Photo 2

I found that Google Earth's satellite images of much of Washington County and Westmoreland County have been updated; I assume other new county images will follow. So now we have a satellite snap shot from around June 2010 of Marcellus well activity in these areas for all to inspect.

The Super Misting Pit on Google Earth

The thing that caught my attention the most as I scanned around Washington County on Google Earth was what I saw in photos 1 and 3. I have seen photos of small waste pits before, and some had small misting heads on them. The purpose of the misting heads, I have been told, is to help get the waste water to evaporate. When I saw the size of this pit, and the size of the misting heads, I knew I had found something significant. It took me several days of looking at this image to realize just how big it is. Notice the house and car in the lower left of the photo. Notice the size of the twelve large misting heads in relation to the houses. I would estimate the pit is six to seven acres (see photos 1 and 3).

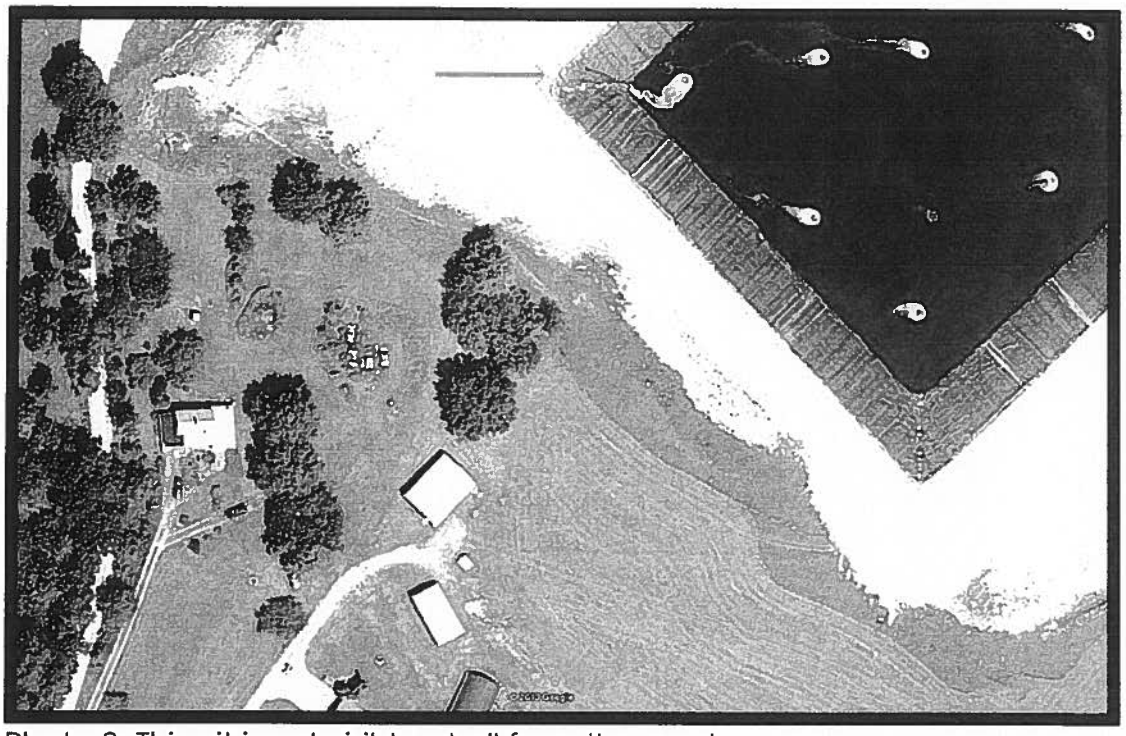


Photo 3: This pit is not visible at all from the road.

Photo 3b: Compare the size of the misting head on the right to the size of the cars and trucks on the left.

A Tour of Mcadams Road In Washington County, Pa.

After several days of looking at this image I decided to go to the area to see for myself what this thing looked like from ground level. The location of this particular misting pit is about five miles south of the town of Washington, just off Interstate 79 on Mcadams Road (See photo 4).

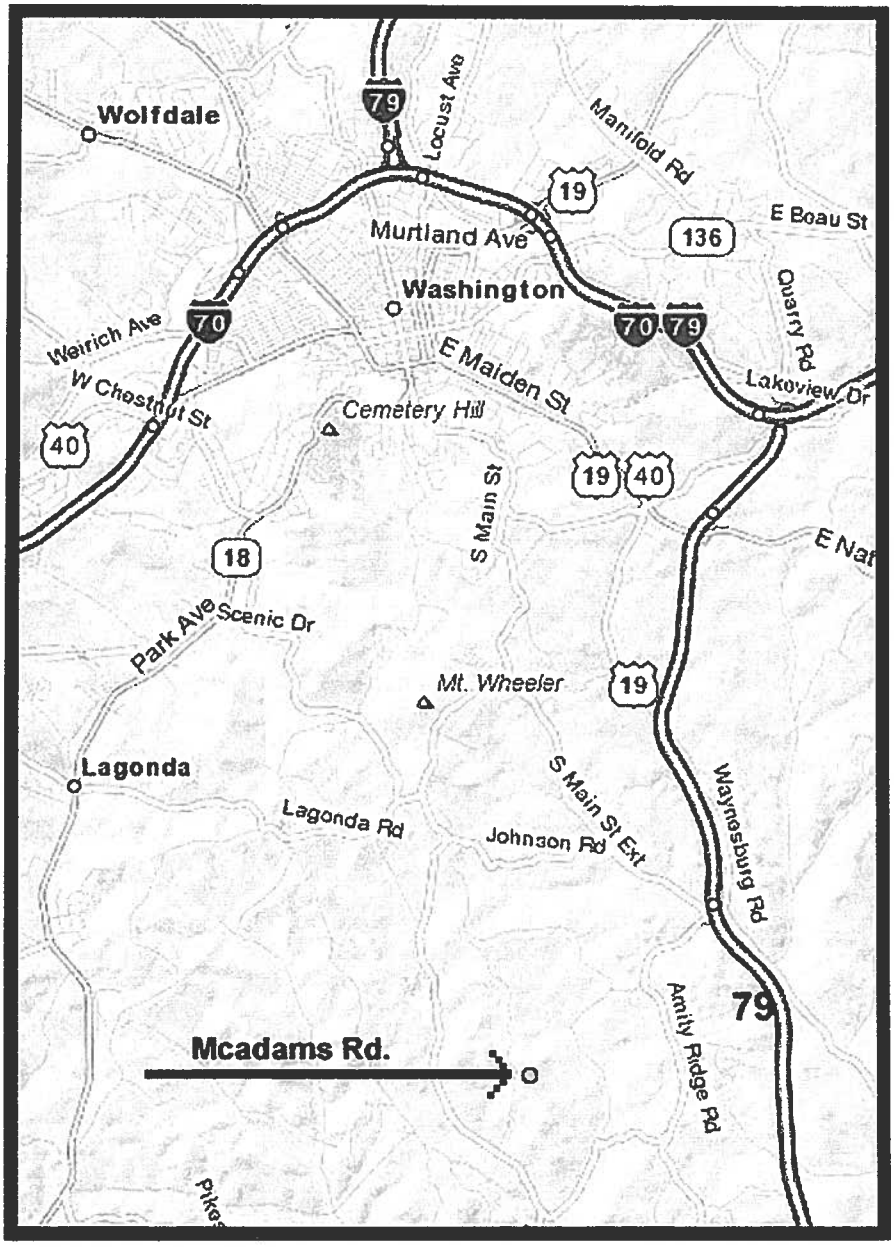


Photo 4

As I drove on Mcadams Road, the first thing I noticed was the amount of water that was on this road. This was September 3, 2010, at around noon. We had just had a long spell with no rain—several weeks—and on this day, the temperature was in the 90s. It was hot and hadn't rained, but most of the road was saturated with water.

Photo 5

I also noticed a large amount of "gray splash" on the bushes and grass that lined the road. Everything had a gray look to it (see photos 6 and 7).

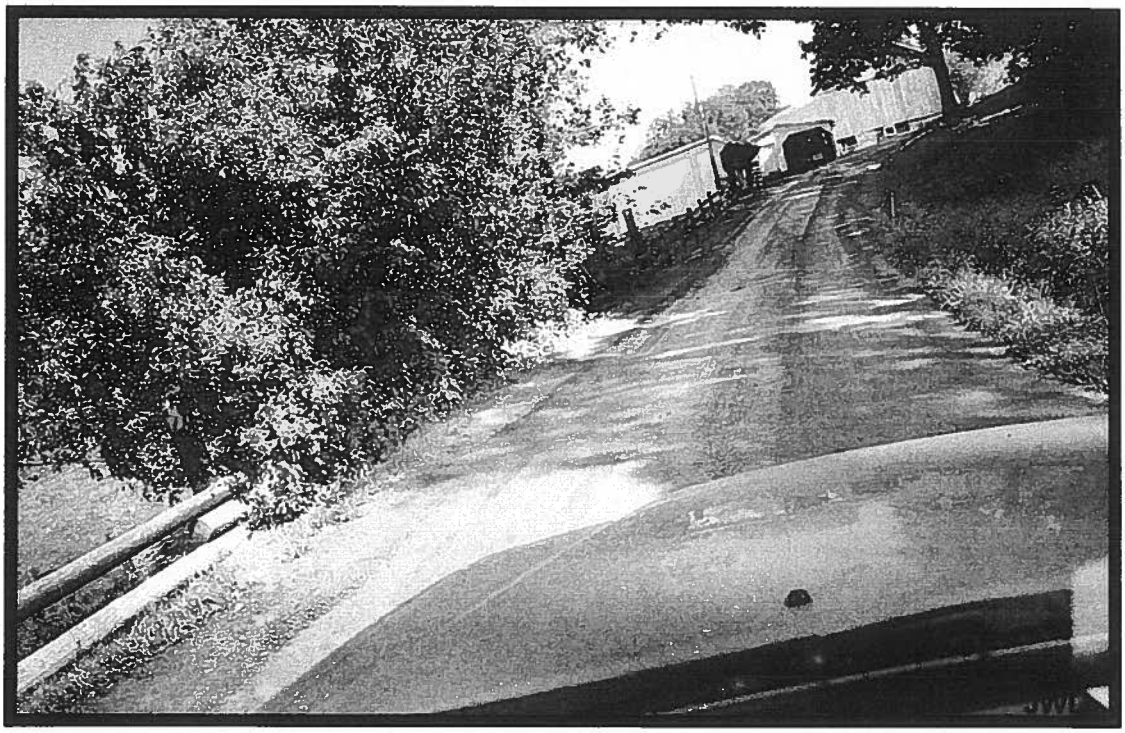


Photo 6

Photo 7

I did not see any waste water trucks on this visit; I have no direct knowledge of how this water got here. But I do suspect that it is directly related to the massive waste pit nearby.

Photo 8

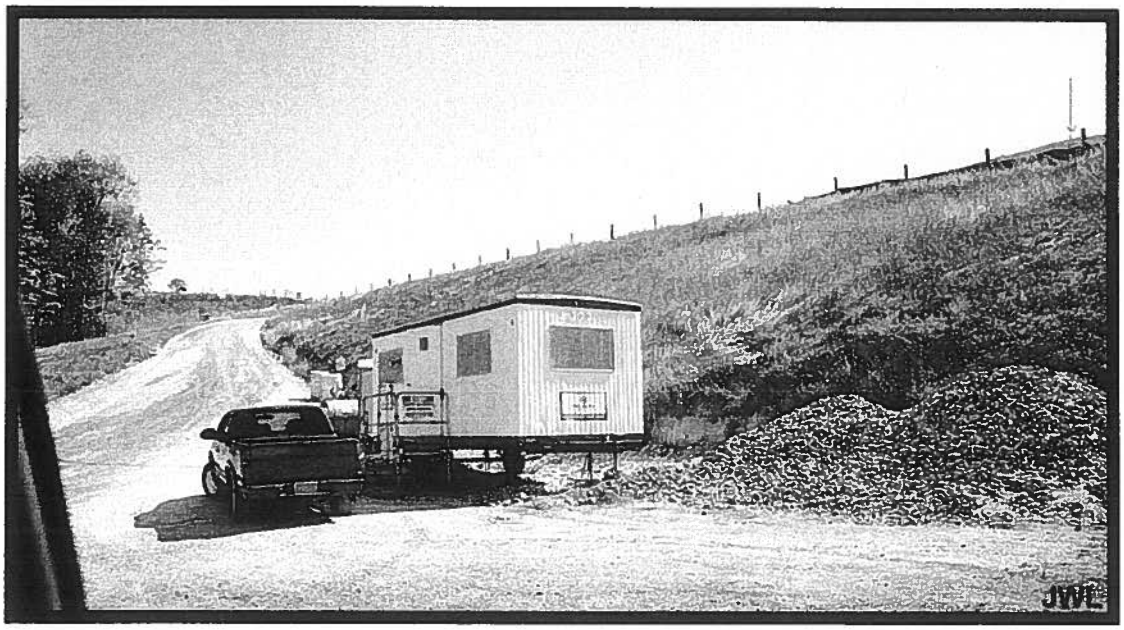


Photo 9

Further up the road, I came to the guard shack entrance of the "Super Mister" (Photo 9). If I had not seen this massive pit on Google Earth's newly updated images, I never would have known it was here. Photo 9 shows what you can see from the road. I can see why the neighbors that I talked to in this area were not aware that it was there. The red arrow

points to the faint distant fence pole at the very top corner of the misting pit (the red arrow in photo 3 points to the same post).

Photo 10

There were two yellow containers just above the guard shack with a sign that reads, "Spill Control Kits and Disposal."

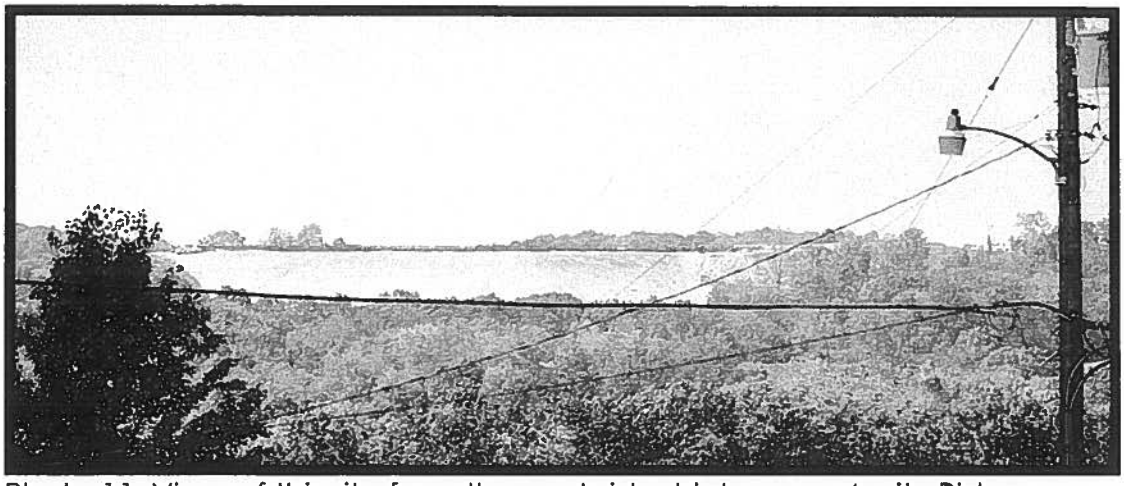


Photo 11: View of this site from the east side, high up on Amity Ridge Road, looking to the southwest. The misting heads are not visible from this vantage either.

Photo 12

Photo 13

Some of the area water pits and gas wells are connected with a network of piping. The company used existing road culverts to run the pipes along and to get the pipes under intersecting roads and driveways. It looks like the well's delivery pipes almost completely block the pre-existing road culverts (see photo 12). Does this not block the water runoff flow? Where will the water go when it rains hard?

Comments From Area Residents I Interviewed

"This has been going on for two and a half years, day and night, twenty-four/seven. The trucks; the noise—I have trouble sleeping at night."

"I have not received any royalties for two and a half years, and they say it will probably be another year and a half before we do. The gas company says that the wells are on standby, no production."

"I wish we would have had the township put operating time restriction on the activity."

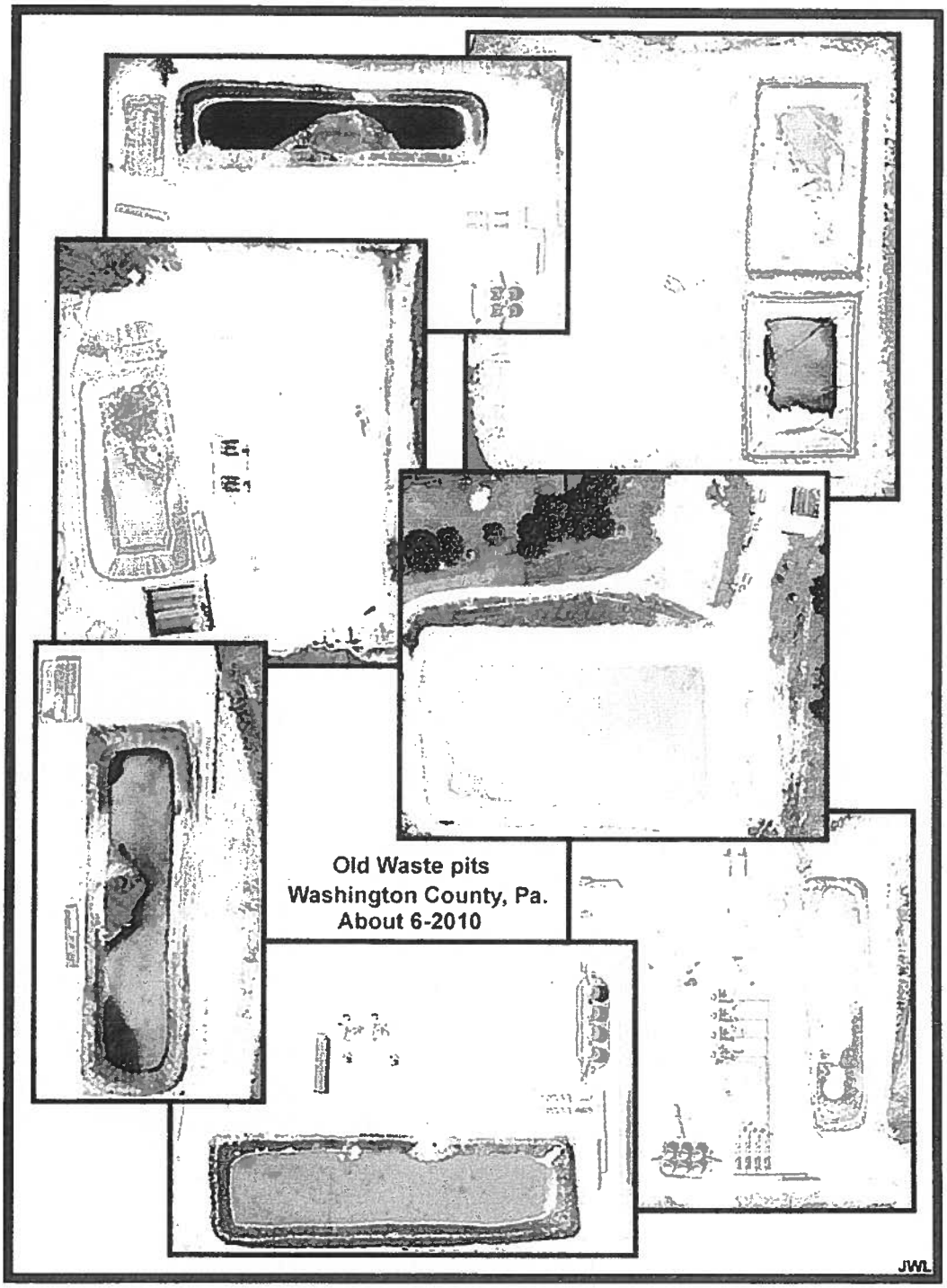


Photo 14

Another thing that I noticed while touring Google Earth was the number of old waste pits. In the **1984** Pennsylvania Oil & Gas Act 223, Chapter 2, the section on "well site restoration" states that: "**(c) Within nine months after completion of drilling of any well, the owner or operator shall restore, remove or fill all pits used to contain produced fluids or industrial waste and remove all drilling supplies and equipment not needed for production.**" Why are there so many of these old waste pits left open and not restored?

Some of my questions, concerns and comments

1) What is in the water that is being misted?

There seems to be an ongoing debate concerning the waste sludge that comes out of the drilled well and fracking process as processed waste. Industry representatives keep saying that it is only water, sand, and foaming agent. But third-party researchers say this is far from the truth. Dr. Theo Colburn, resident of Colorado, has done extensive research with collected samples reclaimed from large spills that have occurred. Dr. Colburn, in her presentation, says air quality is also an issue: "Drilling may produce a number of airborne pollutants as well. These pollutants may include heavy metals such as arsenic and mercury, and radioactive materials. Fugitive methane and volatile organic chemicals may be released directly into the air around a well site. In addition to methane, these chemicals may contain the "BTEX" complex (benzene, toluene, ethylbenzene and xylene)..." This seems to be a hard issue to pin down, especially when the gas extraction industries will not tell researchers or the public all the chemicals that they are putting into the ground, claiming that they are "trade secrets." And, the companies are exempt from some of the regulations in the federal Clean Air Act, the Clean Water Act, and other environmental legislation. If it is the case that this waste water sludge is heavily carcinogenic, misting it into the air in such high quantities would seem criminal. Are these private corporations really that powerful that they can dismantle environmental safeguards that our government has put into place to protect our air and water?

The misting pits are being used to help get rid of the waste water. If it is bad to dump the waste water in the Monongahela River, or to pave the roads with it, and if the sewage plants cannot process it properly, why is it OK to mist it into the atmosphere? Are these not issues that the public has a right to know about? Or is the public just in the way?

2) Where, exactly, is all this gray road water coming from?

3) What is the actual size and volume of this misting pit?

4) How much waste water does this misting pit actually mist to the atmosphere? What is the chemical make-up of the mist?

5) How many more of these misting pits are there? (I have found others.) And how many more will be built?

6) Is this industry allowed to clog existing road runoff drains?

7) Why must the neighbors suffer through the round-the-clock noise and commotion of the operation year after year?

8) Why are there so many old waste pits left open and not restored as required by law?

9) The DEP (Department of Environmental Protection) of Pennsylvania is going through some of the biggest budget cuts it has ever seen. In the last ten years, there have been budget cuts of almost 60 percent. Can the DEP do its job in light of these numbers? Is this not a prescription for a "Perfect Storm" to an accumulative, environmental disaster? Are we really so desperate that we need to fast-track this gas extraction at the expense of our health, environment, and future generations?

10) Over the past year, I have heard a lot of very aggressive and vociferous land owners pronouncing their "rights" to make money off of their property without some neighbor hindering them or getting in their way. I basically agree with this "right" that they talk about, except when it interferes with the Constitution of the Commonwealth of Pennsylvania, Article 1, Section 27, which states: **"The people have a right to clean air, pure water, and to the preservation of the natural, scenic, historic and esthetic values of the environment. Pennsylvania's public natural resources are the common property of all the people, including generations yet to come. As trustee of these resources, the Commonwealth shall conserve and maintain them for the benefit of all people."**

The apparent zeal our state and local representatives (trustees) have demonstrated to fast-track the extraction of Marcellus gas, leads me to wonder whether they are taking into account this constitutional right of the people of Pennsylvania when they make their decisions. That right should trump corporate and private profits. I guess it comes down to a question of values.

11) In 1984 the State of Pennsylvania specifically created the Oil and Gas Act 223 for this purpose:

Oil and Gas Act 223
Chapter 1
Sec. 601.102. Declaration of purpose

The purposes of this act are to:
(1) Permit the optimal development of the oil and gas resources of Pennsylvania consistent with the protection of the health, safety, environment and property of the citizens of the Commonwealth.
(2) Protect the safety of personnel and facilities employed in the exploration, development, storage and production of natural gas or oil or the mining of coal.
(3) Protect the safety and property rights of persons residing in areas where such exploration, development, storage or production occurs.
(4) Protect the natural resources, environmental rights and values secured by the Pennsylvania Constitution.

Do we now have a healthy sustainable balance between "optimal development…" **and** "protection; health; safety; environment; property rights; and values secured by the Pennsylvania Constitution"? Or, are we suffering from an epidemic of a very contagious psychological condition called, "Gold Fever"?

A repeated pattern of disasters

It seems that just about every month or so you hear on the news of another environmental disaster caused by industrial and fossil fuel corporations:

2009—Water contamination in the town of Dimock, Pa. The Associated Press wrote in October 2010 that "John Hanger (DEP) blames the methane contamination of the Dimock aquifer on faulty Marcellus Shale gas wells drilled by Cabot. The company vigorously denies responsibility for the pollution. It took out a newspaper ad and released a 29-page rebuttal document this week in which Cabot's chief executive officer, Dan Dinges, lambasted Hanger and his agency for 'political pandering' and abuse of authority."

April 2010—BP's Deepwater Horizon drill rig explodes, killing eleven people and causing the largest marine oil spill in industry history, discharging 185 million gallons of oil into the Gulf of Mexico, almost 20 times more than the Exxon Valdez spill in 1989.

June 2010—Well blowout in Clearfield, Pa. Workers lost control of the well on the Punxsutawney Hunting Club grounds, and it unleashed a combustible 75-foot fountain of natural gas and toxic wastewater. The gusher spewed for 16 hours before containment.

July 2010—Shallow gas well explodes in Indiana Township, Pa., killing two people.

September 2010—In San Francisco, an aging gas pipe explodes in a rural neighborhood, killing eight people and destroying 37 homes. The plans and location of the pipe were kept from the public. Most people did not even know a 30-inch gas main ran under their neighborhood.

October 2010—A toxic pond collapses in Hungary, killing four people and spilling 180 million gallons and threatening the Danube River. The Associated Press reported that Kolontar Mayor Karoly Tili noted that the disaster occurred only a week after Hungarian environmental authorities had declared the reservoir safe. "People are scared," he told the AP. "People no longer trust or believe what is said about the reservoir." MAL Rt., the Hungarian Aluminum Production and Trade Company, which owns the Ajkai Timfoldgyar plant where the spill occurred, insist the sludge is not considered hazardous waste according to European Union standards.

Hope springs eternal

It is my hope that this photo essay will encourage others to ask important questions about the pressing issue of Marcellus Shale drilling in their area. Be informed.

Please spend some time on Google Earth. Take a look at the satellite images of Washington County and see the Marcellus gas well activity that has been going on there for the past four years. And keep in mind that activity is going to double next year (2011), and that an estimated 30,000 wells will be put in place throughout central Pennsylvania in the next ten years.

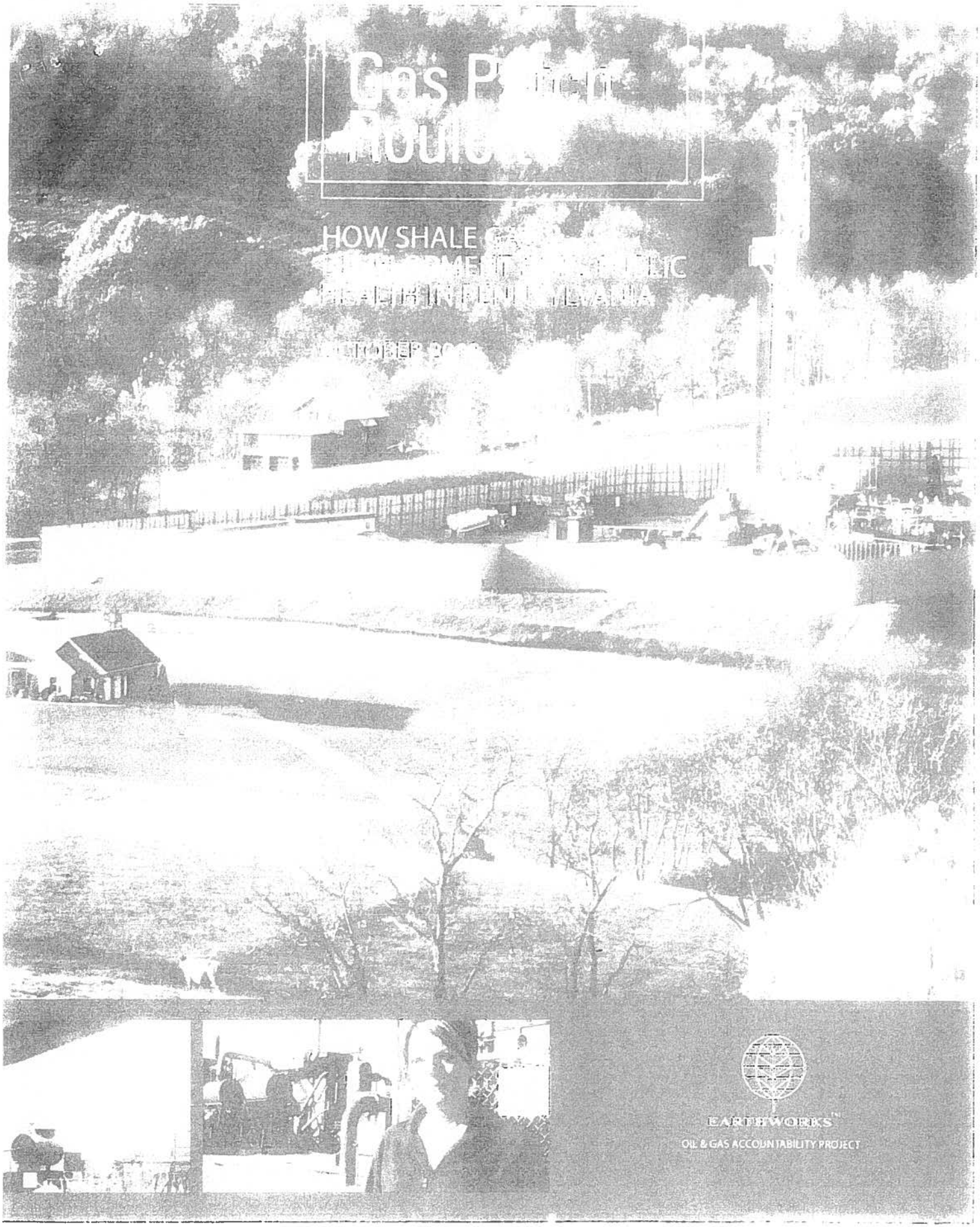
Jay Langham
10-5-2010

Credits and Additional Information:

- I would like to thank the courageous people from all states that are coming forward and telling the other side of the story about the Marcellus Shale gas extraction process, and giving their first-hand accounts of what it is like to live around a Marcellus well.
- Satellite images from Google Earth: www.earth.google.com
- Map from MapQuest: www.mapquest.com
- Dr. Theo Colburn: www.endocrinedisruption.com.
- All images are in Washington County, Pennsylvania.
- Book resource: *Toxic Sludge Is Good For You: Lies, Damn Lies and The Public Relations Industry* by John Stauber and Sheldon Rampton
- Ground photos by Jay Langham
- Super Misting pit location:
  40° 05'22.39" N
  80° 13'40.04" W

- Release statement:

VER 1.6



Gas P[illegible]
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HOW SHALE [illegible]

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EARTHWORKS
OIL & GAS ACCOUNTABILITY PROJECT

A goal of this research project has been to give voice to the many people in Pennsylvania and beyond who already bear the costs of the nation's dependence on fossil fuels.

This report reflects the tremendous concern, caring and openness of the project participants. Thank you for giving your time, sharing what are often difficult and personal experiences, and inviting us to write about them.

We are [illegible] for the work [illegible] local communities and grassroots organizations [illegible] goes to the Southwest Pennsylvania Environmental Health Project, which provided advice early on in the research process and [illegible]

Finally, many thanks to the Colcom Foundation for its generous support of this project and commitment to protecting the environment and public health.

Photo by Robert Donnan

Gas Patch Roulette

HOW SHALE GAS DEVELOPMENT RISKS PUBLIC HEALTH IN PENNSYLVANIA

OCTOBER 2011

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Introduction

Where oil and gas development goes, health problems often follow.

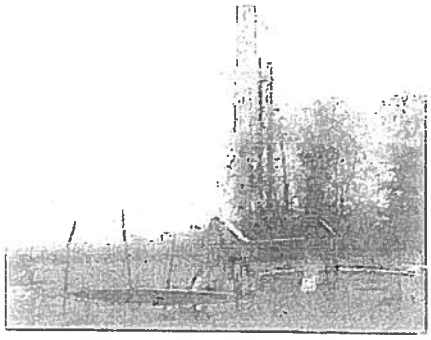
For many people across the United States, this statement has rung painfully true for a long time. As the drilling boom picks up speed and reaches more places, it is now resonating in new communities. From a growing number of stories told by individuals nationwide[1] to conferences held by academics and public agencies,[2] the "dots" between health symptoms and gas facilities are very slowly but surely being connected.

The health survey and environmental testing project described in the following pages is part of this critical process. Between August 2011 and July 2012, Earthworks' Oil & Gas Accountability Project (OGAP) investigated the extent, types, and possible causes of health symptoms experienced by people living in the gas patches of Pennsylvania.

Founded in 1988, Earthworks is dedicated to protecting communities and the environment from the impacts of irresponsible mineral and energy development while seeking sustainable solutions. We reform government policies, improve corporate practices, and work with landowners, organizations, agencies, and elected officials to adopt policies to protect public health and the environment and hold industry accountable for its practices.

Though knowledge of impacts evolves slowly, gas and oil extraction and production continue to accelerate rapidly—allowing industry to put still-emerging technologies to use without first establishing their safety.

The findings of this study stand in strong contrast to statements—often made by industry representatives and policymakers seeking to expand drilling—dismissing claims of health impacts as "personal anecdotes" and isolated incidents. Directly impacted people are frequently told that what they experience is a random occurrence and that some other source—traffic, lifestyle choices, family disease history, household products—is to blame.



Drilling directly behind the play yard.

Photo by: Nadia Steinzor

We know that the gas and oil industry uses toxic substances that harm human health. For example, of about 300 compounds identified as being used in hydraulic fracturing to extract gas, 65 are listed as hazardous by the federal government.[3] In turn, this creates a real potential for negative health effects in any area where gas development occurs.[4] While general scientific links regarding the effects of such exposure have been established,[5] research on the direct relationship between health problems and gas and oil activities has been limited and inconsistent.[6]

Even as knowledge of impacts evolves slowly, gas and oil extraction and production continue to accelerate rapidly—allowing industry to put still-emerging technologies to use without first establishing their safety. State regulations remain too lax and outdated to prevent the impacts of modern-day energy development, and regulatory agencies are often unable to conduct the

oversight and enforcement needed to protect air and water quality and, in turn, health and communities. Magnifying the consequences of this situation are special exemptions in provisions of the nation's bedrock environmental laws, which allow the industry to stifle key information and pursue risky practices.[7]

The overall result is that the burden of proof remains heaviest for impacted individuals and communities themselves. Companies can continue to avoid responsibility and downplay health-related concerns. Decisionmakers can continue to sidestep the need to recognize the damage and hold companies accountable.

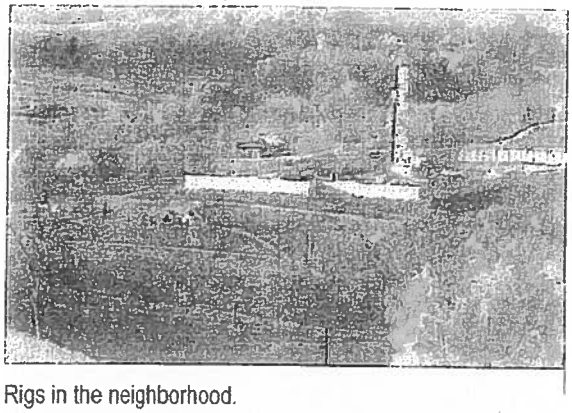
Yet the realities, including those described in this report, can be documented—and when they are, they can no longer be denied. When many people in many places where gas development is occurring have similar health complaints, something is clearly wrong. OGAP believes that when health problems occur, action to solve and prevent them must follow.

1 Background: The Marcellus Shale Boom

The Marcellus Shale spans a distance of approximately 600 miles from central New York through much of Pennsylvania and into the eastern half of Ohio and western parts of West Virginia; small sections are also found in Maryland and Virginia.[8] The formation covers an area of about 54,000 square miles (slightly larger than Florida) and varies greatly in depth, from outcroppings above ground to some areas to 9,000 or more feet below the surface.[9]

For a long time, extracting and producing deep shale gas from formations across the United States was considered economically and technologically unfeasible. But recent advances in hydraulic fracturing methods and its combination with horizontal drilling have made it possible to drill much deeper and further than ever before and, bolstered by political pressure to expand domestic energy production, have spurred a boom in shale gas (and shale oil) production nationwide.

The Marcellus Shale, considered a "gas super giant," has been at the center of this activity, particularly in Pennsylvania, an estimated 60 percent of which is underlain by the formation.[10] As of September 2012, nearly 5,900 unconventional oil and gas wells, primarily in the Marcellus Shale, had been drilled in the state and over 11,500 had been permitted; the pace of expansion has been stunning, with 75 percent of all unconventional wells having been drilled just since 2010.[11]



Rigs in the neighborhood.

Photo by: Mark Schmerling

Impoundment pits, which often contain contaminated waste, can leak and give off emissions.

Photo by: Robert Donnan

Gas and oil development is occurring in Pennsylvania and nearby states today more rapidly and with more extensive impacts than in the past. Current development uses a tremendous amount of water, chemicals, and land; requires heavy equipment; and produces large volumes of both wastewater and solid waste. The gas industry has plans for tens of thousands of additional wells across the Marcellus and Utica Shale regions and in other formations nationwide.

The complexity and intensity of this type of energy development opens up pathways of exposure that impact human health, including air and water pollution, traffic, noise, and soil contamination. Although no industrial process is harm-free, these problems can be particularly severe when operators act irresponsibly and are not required to take measures to prevent, minimize, or mitigate problems such as chemical and waste spills, emission releases, or equipment failure.

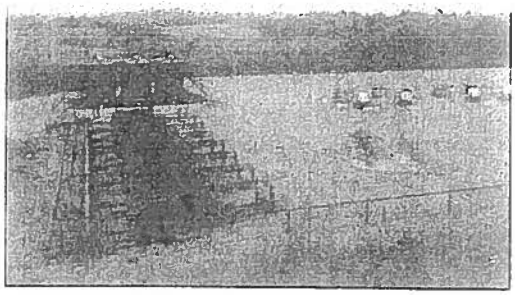
2 The Study

2.1. OVERVIEW

This research project had two central components, health surveys and air and water testing, and was undertaken in order to:

- Investigate the extent and types of health symptoms experienced by people living in the gas patches of Pennsylvania.
- Consider links between health symptoms and proximity to gas extraction and production facilities.
- Provide air and water quality testing to households in need of such information.
- Provide useful information to impacted residents, researchers, public officials, and partner organizations.
- Put forth common-sense recommendations for regulatory and policy changes to prevent negative health and environmental impacts.

This project represents a scaling-up (in terms of both the number of participants and geographic area covered) of community-based projects previously conducted by Earthworks' OGAP. We conducted health surveys with local residents and analyzed results in relation to contaminants identified through water quality investigations (Pavillion, Wyoming, 2010) and prior air quality monitoring (DISH, Texas, 2009).[12] In addition, in 2011 OGAP developed case studies of residents who reported health problems while living in close proximity to gas facilities in several counties in Texas.[13]



Separators split off heavy hydrocarbons from gas, and often vent methane and volatile organic compounds into the air.

Photo by: Nadia Steinzor

2.2. METHODOLOGY

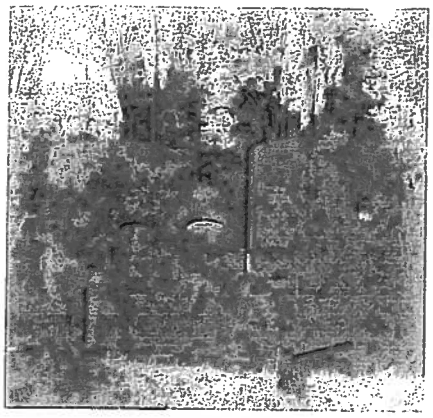
The health survey instrument used in this project was designed by Wilma Subra, President of Subra Company, and air and water quality testing was managed by the non-profit organization ShaleTest based in Denton, Texas. Data from the surveys and associations with testing results were obtained by tabulating responses and calculating percentages of both symptom categories and individual symptoms.

The survey focused on a range of exposures, health symptoms, and disease history. Responses were gathered to identify patterns that occur across locations and improve understanding of the experiences of participants. All the symptoms included in the survey could potentially be caused by exposure to substances known to be associated with gas and oil facilities.

It should be noted that this project did not investigate additional factors that can influence health conditions or cause symptoms (e.g., through structured control groups in non-impacted areas and in-depth comparative health history research). Such work, while important and currently lacking, was beyond the scope of this particular project. In addition, we did not seek to link single facilities with particular health problems experienced by specific participants.

The survey was completed by 108 individuals living in 55 households in 14 counties. The largest number of surveys (85 percent) was collected in Bedford, Bradford, Butler, Fayette, and Washington Counties. Taken together, all the counties represent a geographical range across the state (i.e., northeast to southwest) and have had gas development long enough for reports of health impacts and declining air and water quality to surface.

Respondents answered questions on their own or provided them to a relative or friend. In some cases, members of the same household, including spouses and parents, completed surveys for participants, and a few participants chose to provide answers to OGAP staff in person or over the phone. Due to expressed concerns about confidentiality, participants were given the option of completing the surveys anonymously, which some chose to do.[14]



Condensate tanks pull off water from gas and can produce fumes and emissions.

Photo by: Nadia Steinzor

Survey distribution was initiated through existing contacts in the target counties. These individuals then chose to participate in the project themselves and/or recommended other possible participants, who in turn provided additional contacts. The survey was also distributed to individuals who expressed interest in participating directly to OGAP at public events.

Placing an air canister at a test site for collecting emissions data.

Photo by: Nadia Steinzor

Air and water are the primary pathways of exposure to chemicals and other harmful substances, which are inhaled, ingested, and absorbed through the skin. With this in mind, environmental testing was conducted on the properties of a subset of survey participants (70 people in total) in order to identify the presence of pollutants that might be linked to both gas development and health symptoms. Test locations were selected based on household interest, the severity of symptoms reported, and proximity to gas facilities and activities. Because the need for testing in such places far exceeded the resources available, we also considered whether households had already received other environmental testing and been provided with the results.

In total, 34 air tests and 9 water tests were conducted at 35 households in 9 counties. The air tests were conducted using Summa Canisters put out for 24-hours by trained members of ShaleTest. The samples were analyzed by three certified laboratories using U.S. Environmental Protection Agency-approved TO-14 and TO-15 methods, which test for a wide range of Volatile Organic Compounds (VOCs) such as benzene, toluene, ethylbenzene, and xylene (BTEX chemicals). The water tests used samples drawn directly from household sinks or water wells by technicians employed by licensed laboratories and covered the standard Tier 1, Tier 2, and Tier 3 (including VOCs/BTEX) and in one case, Gross Alpha/Beta, Radon, and Radium as well.

2.3. FINDINGS

PARTICIPANT OVERVIEW

Among participants, 45 percent were male from 18 months to 79 years of age and 55 percent were female from 7 to 77 years of age. The closest a participant lived to gas facilities was 350 feet and the furthest away was 5 miles.

Participants had a wide range of occupational backgrounds, including animal breeding and training, beautician, child care, construction, domestic work, farming, management, mechanic, medical professional, office work, painter, retail, teaching, and welding. About 20 percent of participants reported occupational-related chemical exposure (for example, to cleaning products, fertilizers, pesticides, and solvents). At the time of survey completion, 80 percent of participants did not smoke and 20 percent did. While some of the non-smokers had smoked in the past, more than 60 percent never had.

Table 1: Survey location

County surveyed	Number of surveys collected	Percent of surveys
Washington	24	22
Fayette	20	18
Bedford	20	18
Bradford	17	16
Butler	12	11
Jefferson	3	3
Sullivan	2	2
Greene	2	2
Warren	2	2
Elk	2	2
Clearfield	1	1
Erie	1	1
Susquehanna	1	1
Westmoreland	1	1
TOTAL	108	100%

A COMPARATIVE LOOK:

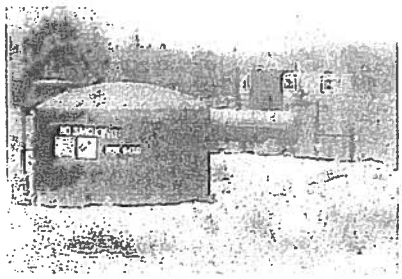
We established an informal comparison group of 5 individuals in 5 households in and around the city of Sayre in north-central Bradford County and in Waverly, New York, just over the state border from Sayre. This group generally lived further away from gas facilities than the main survey group, between 1.5 - 9 miles from gas wells and (in one case) 8 miles from a compressor station. None of the participants smoked and all reported being healthy. Taken together, these participants reported a total of 24 health symptoms, including some in the categories of skin, respiratory, digestive, muscles/joints, neurological, ear/nose/mouth, behavioral, and lymphatic. Only one or two participants reported each symptom or smelling odors of any kind—reflecting a lower level of impact than was generally documented among survey participants overall. While much smaller than the main survey group, the comparison group results indicate the possibility that fewer health symptoms exist at longer distances from facilities, an aspect indicated by the project findings overall that warrants further investigation and analysis.

HEALTH SYMPTOMS

Almost half of the survey participants answered the question of whether they had any health problems prior to shale gas development. About half of those responses indicated no health conditions before the development began and about half reported having had one or just a few, in particular allergies, asthma, arthritis, cancer, high blood pressure, and heart, kidney, pulmonary, and thyroid conditions.

In addition, 5 individuals volunteered (verbally or in writing) that their existing health symptoms became worse after shale gas development started and 15 that their symptoms lessened or disappeared when they were away from home. Members of four households also reported that they'd moved to new locations due to gas drilling and several others told OGAP staff that they would if their finances and jobs allowed it. Also of note is that participants in 22 households reported that pets and livestock began to have unexplained symptoms (such as seizures or losing hair) or suddenly fell ill and died after gas development began nearby.

22 households reported that pets and livestock began to have symptoms (such as seizures or losing hair) or suddenly fell ill and died after gas development began nearby.



Industrial equipment containing combustible products, very close to home.

Photo by: Nadia Steinzor

The specific symptoms reported within each of the top reported categories varied.[15] (To see which specific symptoms were included in all the categories, see the full survey at http://health.earthworksaction.org.) However, the primary categories of health problems reported by participants were quite consistent across counties. For example, sinus/respiratory problems was the top complaint category for all participants, as well as in four of the five main counties and the other counties group; the second top complaint category, behavioral/mood/energy, was the first in one county, second in three and in the other counties group, and third and fourth in one each.

Table 2: Ranking of top 8 categories of symptoms, by county

Symptom Category	All	Bedford	Bradford	Butler	Fayette	Washington	Others*
Sinus/respiratory	1	1	2	1	1	1	1
Behavioral/mood/energy	2	2	1	3	2	4	2
Neurological	3	5	5	8	7	3	3
Muscles/joints	4	3	3	4	8	5	6
Ear/nose/mouth	5	7	8	7	5	6	5
Digestive/stomach	6	4	7	5	4	8	7
Skin reactions	7	6	4	2	3	7	8
Vision/eyes	8	8	6	6	6	2	4

Table 3: Most prevalent categories of symptoms

	Percent of individuals reporting conditions in category						
Symptom category	All	Bedford	Bradford	Butler	Fayette	Washington	Others*
Sinus/respiratory	88	80	82	75	85	95	87
Behavioral/mood/energy	80	60	88	67	85	74	67
Neurological	74	45	71	50	70	79	60
Muscles/joints	70	55	82	67	70	74	47
Digestive/stomach	64	55	65	58	75	63	33
Ear/nose/mouth	66	40	59	50	75	68	47
Skin reactions	64	45	70	67	75	63	27
Vision/eyes	63	40	65	50	70	79	53

* Includes Clearfield, Elk, Erie, Jefferson, Greene, Sullivan, Susquehanna, Warren, and Westmoreland Counties. The surveys from these counties (15) were analyzed together to create a group comparable in number to each of the counties where more surveys were collected.

The 25 most prevalent symptoms among all participants were increased fatigue (62%), nasal irritation (61%), throat irritation (60%), sinus problems (58%), eyes burning (53%), shortness of breath (52%), joint pain (52%), feeling weak and tired (52%), severe headaches (51%), sleep disturbance (51%), lumbar pain (49%), forgetfulness (48%), muscle aches and pains (44%), difficulty breathing (41%), sleep disorders (41%), frequent irritation (39%), weakness (39%), frequent nausea (39%), skin irritation (38%), skin rashes (37%); depression (37%), memory problems (36%), severe anxiety (35%), tension (35%), and dizziness (34%).

The survey asked questions designed to identify if there might be associations between symptoms and living near particular types of facilities (wells, waste impoundment pits, and compressor stations). However, because it turned out that most survey participants actually live in close proximity to more than one type of facility, it was difficult to determine connections with a specific type of facility. Instead, we examined whether the distance from any type of oil and gas facility had a bearing on the number of types of symptoms reported in the survey.

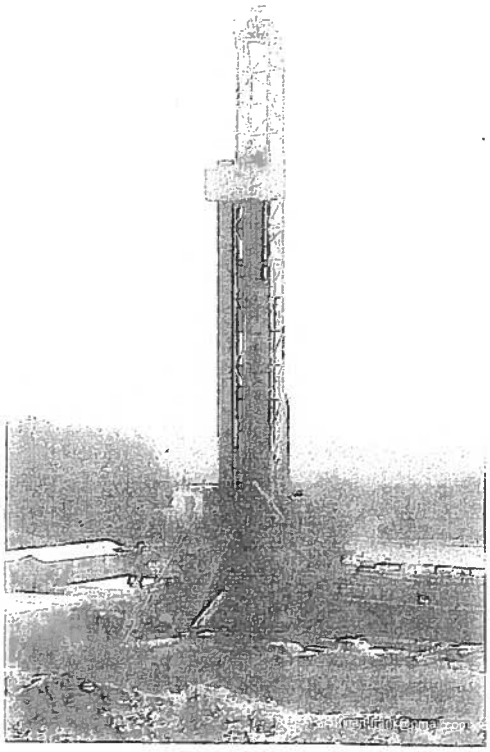
As seen in Table 4, many symptoms were commonly reported regardless of the distance from the facility (in particular sinus problems, nasal irritation, increased fatigue, feeling weak and tired, joint pain, and shortness of breath).

In general, as the distance from facilities decreases, the percentage of respondents reporting the symptoms increases. For example, when facilities were 1500-4000 feet away, 27 percent reported throat irritation; this increased to 63 percent at 501-1500 feet, and 74 percent at less than 500 feet. For severe headaches, 30 percent reported them at the longer distance, but about 60 percent at the middle and short distances.

However, when facilities were further away than 4001 feet, some percentages jumped back up. The data showed higher percentages of respondents experiencing certain symptoms at the longer than mid-range distances with regard to several other symptoms (e.g., throat irritation, sinus problems, nasal irritation, eye burning, and joint pain). It is possible that the chemicals that bring on these types of symptoms travel over much longer distances than would normally be expected, or that other factors were at play related to the landscape, weather conditions, participant reporting, and type of production.[16]

When the most prevalent symptoms are broken out by age and distance from facility, some differences are notable. In most age groups, symptoms are more prevalent in those living closer to facilities than those living further away. In sum, while the data presented in Figure 1 below do not prove that living closer to an oil and gas facility causes health problems, they do suggest a strong association.

In general, the closer to gas facilities respondents lived, the higher the rates of symptoms they reported.



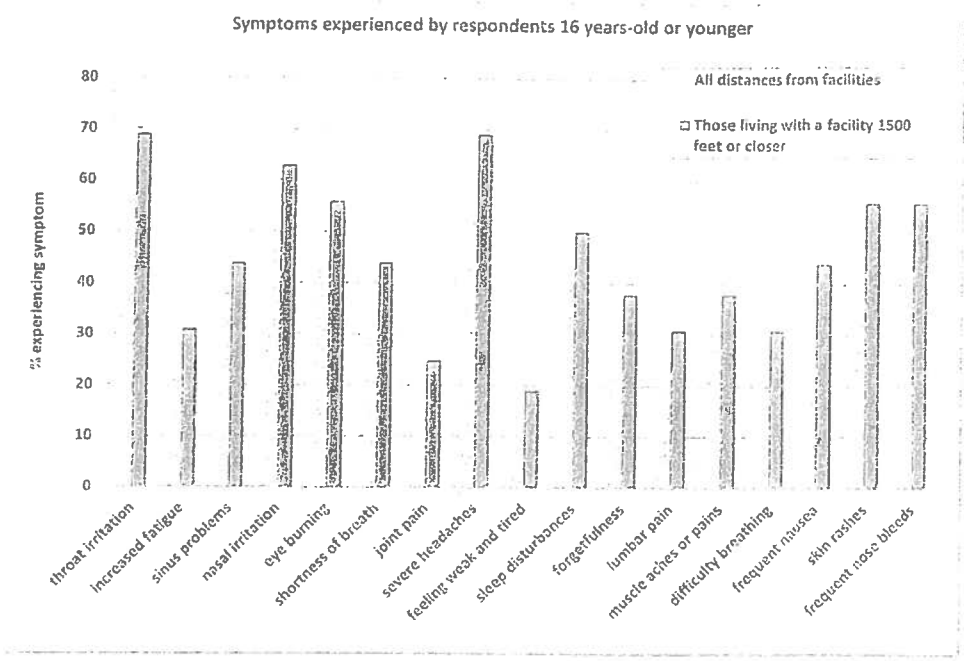
Drilling rig onsite.

Photo by: Frank Finan

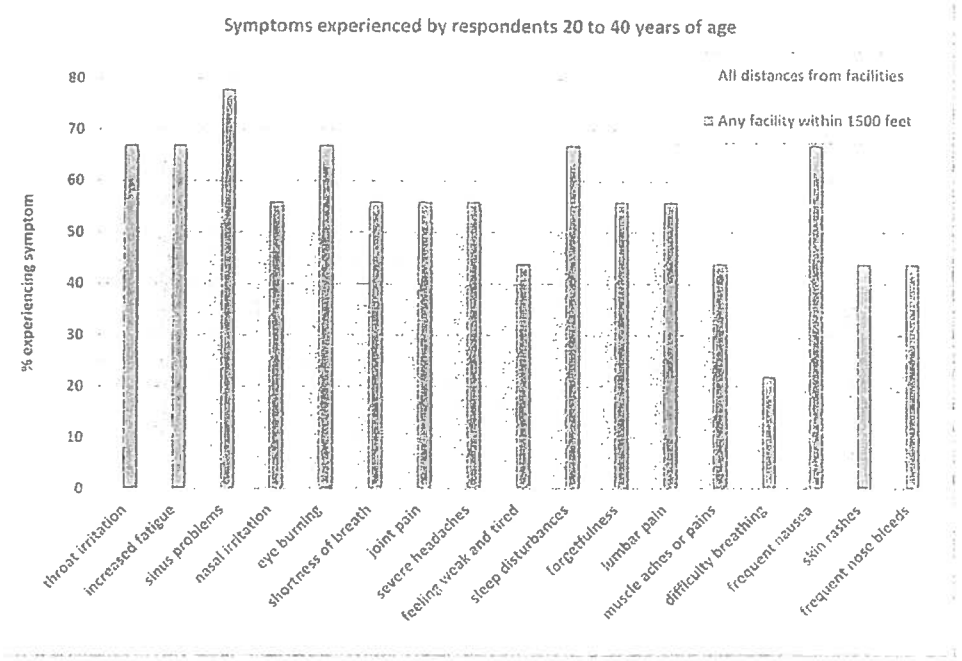
Table 4. Differences in symptoms by distance from an oil/gas facility

Distance	Number of surveys in this category	Age range	Number of smokers	Average number of symptoms per person	Number of symptoms experienced by 50% or more respondents	Top 15 symptoms (the / means the same percentage of respondents had the symptom – bringing the total to more than 15 symptoms in some cases)
Within 500 feet of any facility	27	1.5 to 76 (1 had no age data)	2	31	9	Throat irritation (74%), sinus problems (70%), nasal irritation/ eye burning/ joint pain/ severe headaches/ sleep disturbances (59%), skin rashes (56%), shortness of breath (52%), loss of sense of smell/ persistent cough/forgetfulness/ sleep disorders/ frequent nosebleeds/ swollen painful joints/ increased fatigue/ feeling weak and tired (44%)
501 - 1500 feet from a facility	40	3 to 79	12	30	11	Increased fatigue (68%), nasal irritation(65%), throat irritation (63%), eye burning/ severe headaches (60%), shortness of breath (55%), sleep disturbances/ sinus problems/ lumbar pain (53%), feeling weak and tired/ forgetfulness (50%), joint pain/ muscular pain/ memory problems/ weakness (48%)
1501 - 4000 feet from a facility	30	6 to 77 (1 had no age data)	9	27	1	Increased fatigue (57%), feeling weak and tired (47%), joint pain (43%), shortness of breath/ difficulty breathing (40%), sinus problems/ lumbar pain/ forgetfulness/ tension/ weakness of hands (37%), nasal irritation/ frequent nausea/ reduced muscles strength/ persistent skin problems (33%)
Greater than 4001 feet from a facility	11	34 to 76	2	29	8	Throat irritation/ nasal irritation/ feeling weak and tired (64%), sinus problems/ eye burning/ joint pain/ muscle aches or pains/ ringing in ears (55%), increased fatigue/ severe headaches/ shortness of breath/ sleep disturbances/ lumbar pain/ muscular pain/ weakness/ depression/ persistent hoarseness/ blurred vision (45%)

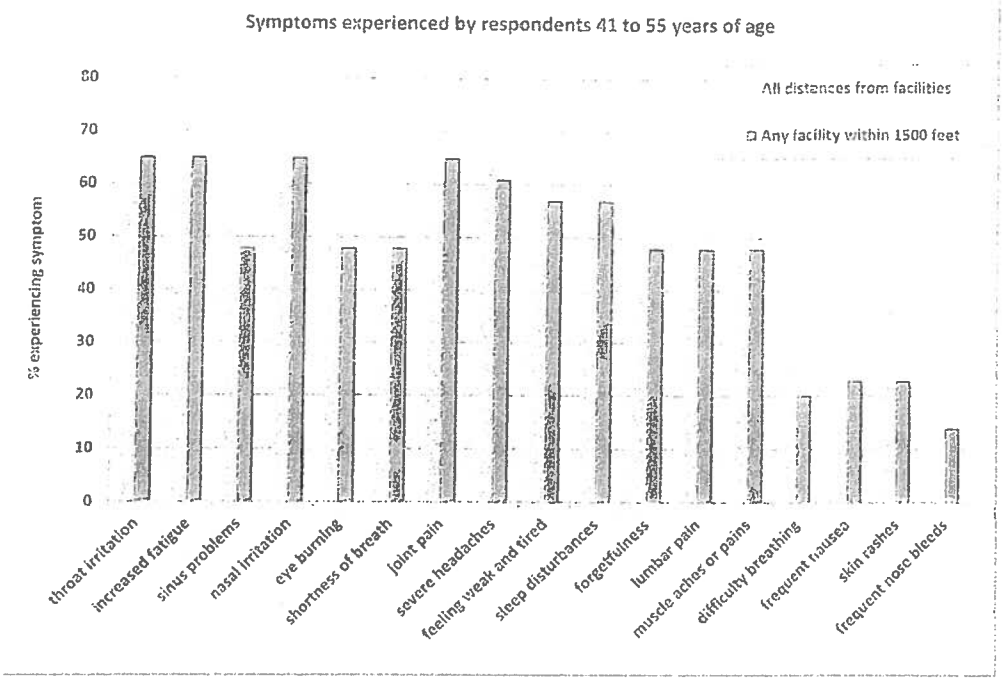
Figure 1. Association of symptoms and distance from facilities, by age group



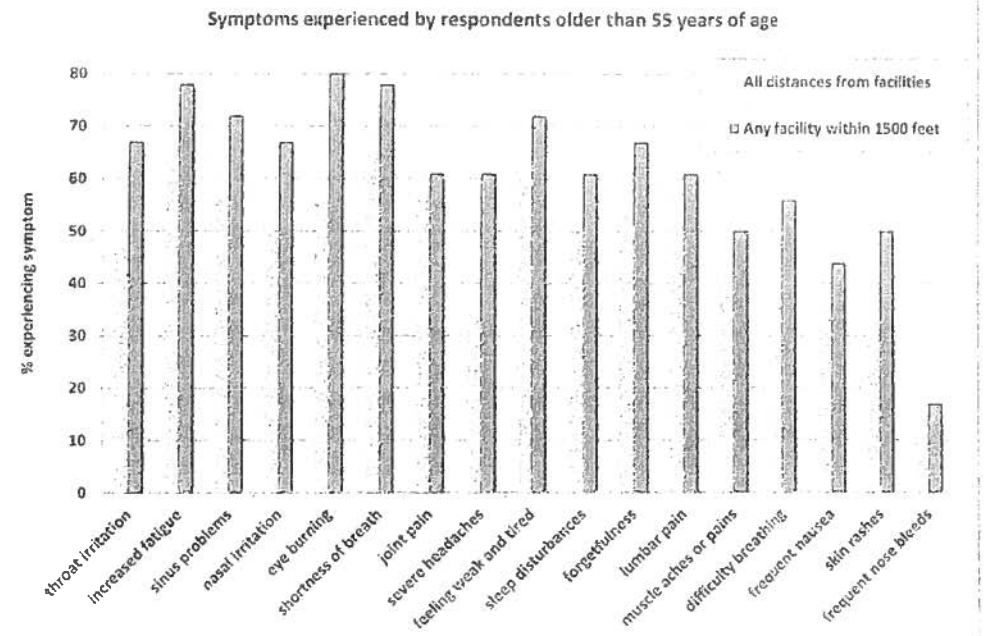
In the youngest age group (1.5-16 years old), the most common symptoms were related to sensitive mucous membranes (throat, eyes, nose) and skin. **Even these youngest respondents had conditions not typically associated with children (e.g., severe headaches, joint pain, lumbar pain, and forgetfulness).[17]** In the subset of this young age group living 1500 feet or closer to a facility, the percentage of respondents with symptoms increased. For example, the number of respondents experiencing throat irritation jumped from 57 to 69 percent, and severe headaches increased from 52 to 69 percent. **Of all age groups, this group had the highest occurrence of frequent nosebleeds within 1500 feet of facilities (56%).[18]**



In the next age group (20-40 years old), there was a high occurrence of symptoms related to the throat, eye, and nose; fatigue, nausea, and severe headaches were also common symptoms. For those living 1500 feet or closer to a facility, the percentage of respondents with symptoms increased for all symptoms except one (headaches). In some cases, the percentage reporting symptoms was considerably higher (e.g., for sinus problems, eye burning, shortness of breath, and sleep disturbances). 44 **percent of 20 to 40-year-olds living within 1500 feet of facilities complained of frequent nosebleeds, compared to 29 percent of all participants of this age.**



Approximately 60 percent of participants in the third age group (41-55 years old) reported throat irritation, increased fatigue, nasal irritation, joint pain, and severe headaches. Although the occurrence of some symptoms (e.g., throat irritation, joint pain, and sleep disturbances) increased in the subset of this group living closer to facilities, the increases were not as dramatic as those experienced in other age groups. In some cases, the percentages actually went down in the subgroup of those living closer to facilities.



In the oldest age group (56-79 years old) the symptoms most frequently experienced were increased fatigue, shortness of breath, and feeling weak and tired. For some symptoms (e.g., throat irritation, sinus problems, nasal irritation, eye burning, shortness of breath, severe headaches and skin rashes) **there were large increases in the subset of this age group who lived closest to facilities.**

The survey also asked respondents to indicate whether or not they were smokers. Table 5 shows that while smokers had, on average, more symptoms than non-smokers, and more symptoms in common with each other, the most frequently reported symptoms were very similar to non-smokers (including forgetfulness, increased fatigue, lumbar pain, joint pain, eye burning, nasal irritation, sinus problems, sleep disturbances, severe headaches, throat irritation, shortness of breath, frequent nausea, muscle aches or pains, and weakness).

The fact that the non-smokers reported symptoms that are commonly considered to be side effects of smoking (e.g., persistent hoarseness, throat irritation, sinus problems, nasal irritation, shortness of breath, and sleep disturbances) suggests that there are likely factors other than smoking that contribute to these symptoms.

Table 5. Comparison of symptoms in smoking and non-smoking subgroups of similar ages [19]

	Number in this category	Age range	Average number of symptoms per person	Number of symptoms experienced by 50% or more of respondents	Top 15 symptoms (in order of highest percentage reporting symptom)
Non-smokers	54	23 - 70	27	6	Forgetfulness (59%), lumbar pain/ joint pain (57%), increased fatigue (56%), eye burning/ nasal irritation (54%), sinus problems/ sleep disturbances (48%), severe headaches/ throat irritation (44%), shortness of breath (43%), frequent nausea/ muscular pain/ persistent hoarseness (41%), weakness (39%)
Smokers	27	24 - 70	38	13	Increased fatigue (70%), eye burning/ lumbar pain (59%), sinus problems/ nasal irritation/ joint pain/ forgetfulness/ severe headaches/ sleep disturbances (56%), shortness of breath/ throat irritation/ frequent nausea/ muscular pain (52%), feeling weak and tired/ weakness (48%)

Breaking down the data further, as shown in Table 6, **it appears that the symptoms most frequently reported by smokers and non-smokers were remarkably similar within each age group.** For example, in the age group 20-40, increased fatigue, sinus problems, throat irritation, frequent nausea, and sleep problems were among the top symptoms for smokers and non-smokers. In the 41-55-year-old group, increased fatigue, throat irritation, eye burning, severe headaches, and feeling weak and tired were among the top symptoms in both groups, and in the over-56 age group, eye burning, sinus problems, increased fatigue, joint pain, and forgetfulness were among the top symptoms of smokers and non-smokers.

Furthermore, the data from smokers did not greatly affect the results in the "all respondents" category. When compared to the non-smoking subgroup, the only notable difference was in the 41-55-year-old age group, where the average number of symptoms in the "all respondents" was 30, versus 22 in the non-smoking subgroup. The top symptoms, however, were very similar.

Table 6. Symptoms by age group, and by smoking or non-smoking status

Age category	Sub-category	Number in sub-category	Average number of symptoms per person	Number of symptoms in 50% or more respondents	Top 15 symptoms (in order of highest percentage reporting the symptom)
16 and under	All respondents (None were smokers)	21	19	2	Throat irritation (57%), severe headaches (52%), nasal irritation (48%), skin rashes/ abdominal pain/ eye burning/ frequent nose bleeds/ sleep disturbances (43%), sinus problems/ persistent cough (38%), shortness of breath/ frequent nausea (33%), skin irritation/ asthma/ difficulty breathing/ allergies/ diarrhea/ dry eyes/ muscle aches or pains/ forgetfulness/ behavioral changes/ frequent irritation (29%)
20 - 40	All respondents	14	29	12	Increased fatigue (64%), severe headaches/ sinus problems/ throat irritation/ frequent nausea (57%) abdominal pain/ nasal irritation/ eye burning/ muscular pain/ lumbar pain/ weakness/ sleep disturbances/ depression (50%), dry/cracked red skin/ feeling weak and tired/ sleep disorders/ allergies/ sores or ulcers in mouth/ forgetfulness/ joint pain/ severe anxiety (43%)
	Non-smokers	10	29	10	Increased fatigue/ severe headaches/ abdominal pain, (60%), sinus problems/ throat irritation/ frequent nausea/ nasal irritation/ dry, cracked red skin/ feeling weak and tired/ sleep disorders (50%), eye burning/ muscular pain/ lumbar pain/ sleep disturbances/ depression/ allergies/ sores or ulcers in mouth/ forgetfulness/ skin rashes/ shortness of breath/ diarrhea/ extreme drowsiness/ tension/ persistent skin problems/ loss of sense of smell/ lumps or swelling neck (40%)
	Smokers	4	28	28	Weakness (100%), increased fatigue (75%), sinus problems (75%), throat irritation (75%), frequent nausea (75%), eye burning (75%), muscular pain (75%), lumbar pain (75%), sleep disturbances (75%), depression (75%), joint pain (75%), severe anxiety (75%), frequent irritation (75%), severe headaches/ nasal irritation/ allergies/ sores or ulcers in mouth/ forgetfulness/ swollen painful joints/ muscle aches or pains/ loss of sex drive/ irregular or rapid heart beat/ persistent hoarseness/ reduced muscle strength/ difficulty concentrating/ severe pain in eyes/ compulsive behavior/ weight loss (50%)

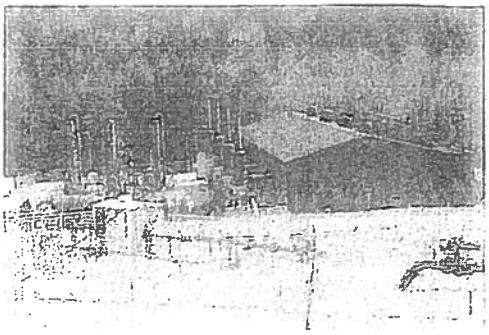
41 - 55	All respondents	33	30	8	Severe headaches/ nasal irritation/ increased fatigue (63%), joint pain/ throat irritation (60%), feeling weak and tired (57%), sinus problems/ eye burning (60%), shortness of breath/ sleep disturbances/ depression, muscles aches or pains (49%), lumbar pain/forgetfulness (46%), memory problems (43%)
	Non-smokers	22	22	8	Joint pain (68%), nasal irritation (64%), throat irritation (59%), severe headaches/ increased fatigue/ feeling weak and tired (55%), sinus problems/ depression (50%), eye burning/ muscle aches or pains (45%), shortness of breath/ memory problems/ lumbar pain/ skin rashes (41%)
	Smokers	13	44	18	Severe headaches/increased fatigue (77%), sleep disturbances (69%), nasal irritation/ throat irritation / feeling weak and tired/ eye burning/ shortness of breath/ forgetfulness/ sleep disorders/ loss of sex drive (62%), sinus problems/ muscle aches or pains/ lumbar pain/ skin irritation/ muscular pain/ persistent hoarseness/ agitation (54%)
56 - 79	All respondents	36	32	11	Increased fatigue (67%), shortness of breath/ feeling weak and tired (64%), sinus problems/ eye burning, joint pain (56%), forgetfulness (53%), difficulty breathing/ nasal irritation/ lumbar pain/ sleep disturbances (50%), throat irritation (47%), weakness/ reduced muscle strength/ memory problems (44%)
	Non-smokers	28	32	9	Feeling weak and tired (68%), increased fatigue/ shortness of breath (64%), sinus problems/ eye burning/ sleep disturbances (54%), joint pain/ forgetfulness/ throat irritation (50%), difficulty breathing/ nasal irritation/ weakness/ memory problems/ sleep disorders/ frequent urination (46%)
	Smokers	8	35	18	Increased fatigue/ joint pain/ lumbar pain (75%), shortness of breath/ sinus problems/ eye burning, forgetfulness/ difficulty breathing/ nasal irritation/ tension/ frequent nausea (63%), feeling weak and tired/ reduced muscle strength/ arthritis/ muscular pain/ persistent skin problems/ diarrhea/ skin rashes 50%)

ODOR EVENTS

Bad and unusual odors are an indication of the presence of a substance or chemical, and are a common complaint of people living near gas facilities. Among survey participants, 81 percent reported experiencing bad odors sometimes or constantly. The frequency ranged from 1 to 7 days per week and from several times per day to all day long; 18 percent said they could smell odors every day.

81% reported experiencing bad odors sometimes or constantly. The frequency ranged from 1 to 7 days per week and from several times per day to all day long.

Participants were asked to describe the suspected source of the odors. Nearly all responses related odors to gas facilities and events, including drilling; gas wells; well pads; fracturing; compressor stations; condensate tanks; drinking contaminated water; flaring; waste pits; retention ponds; diesel engines; truck traffic; pipelines and pipeline stations; spills and leaks; subsurface events; seismic testing; and blue-colored particles in air (possibly a sign of catalytic compounds or particulate matter).



Centralized compressor stations move large volumes of gas to and through pipelines. Emissions can include volatile organic compounds such as benzene and toluene, nitrogen oxides, and formaldehyde.

Photo by: Nadia Steinzor

When asked in the survey whether health symptoms occurred in conjunction with odor events, participants reported the associations listed below. Most indicated that symptoms would last from a few hours to a few days and, in some cases, a few weeks.

- **Nausea:** ammonia, chlorine, gas, propane, ozone, rotten gas.
- **Dizziness:** chemical burning, chlorine, diesel, ozone, petrochemical smell, rotten/sour gas, sulfur.
- **Headache:** chemical smell, chlorine, diesel, gasoline, ozone, petrochemical smell, propane, rotten/sour gas, sweet smell.
- **Eye/vision problems:** chemical burning, chlorine, exhaust.
- **Respiratory problems:** ammonia, chemical burning, chlorine, diesel, perfume smell, rotten gas, sulfur.
- **Nose/throat problems:** chemical smell, chlorine, exhaust, gas, ozone, petrochemical smell, rotten gas, sulfur, sweet smell.
- **Nosebleeds:** kerosene, petrochemical smell, propane, sour gas.
- **Skin irritation:** chemical smell, chlorine, ozone, sulfur.
- **Decreased energy/alertness:** chemical gas, ozone, rotten/sour gas, sweet smell.
- **Metallic/bad taste in mouth:** chemical burning, chlorine, turpentine.

2.4. ENVIRONMENTAL TESTING

AIR

As seen in Table 7, the 34 Summa canister air tests, taken together, detected a total of 19 VOCs. In sum, there was considerable consistency in the chemicals present in many of the samples, although concentrations varied. This could in part be due to differences in the reporting limits and suite of chemicals analyzed by the three labs used in this project. It is possible, for example, that more VOCs were present in more locations, but Pace Analytical had much higher reporting limits than Columbia and Con-Test so the Pace results showed "non-detect" for many substances.[20]

Table 7. VOCs in ambient air, sorted by highest percent detection; concentrations are in micrograms per cubic meter, µg/m³ (n = total number of canister samples that were analyzed for a particular chemical; NA = VOC not included in the analysis)

Volatile Organic Compound (VOC)	n	Number of samples detecting VOC	Percent of n detecting VOC	Min.	Max.	Mean*	Chemical reporting limits for the three labs used		
							Columbia	Con-Test	Pace **
2-Butanone	17	16	94	0.95	2.9	1.52	0.85 - 1.3	NA	NA
Acetone	17	15	88	8.0	19	11.85	6.5 - 10	NA	NA
Chloromethane	34	27	79	1.0	1.66	1.21	0.59 - 0.90	0.1	1.39 1.53
1,1,2-Trichloro-1,2,2-trifluoroethane	34	26	76	0.54	0.73	0.64	0.22 - 0.34	0.38	5.13 - 5.67
Carbon tetrachloride	34	26	76	0.46	0.76	0.62	0.091 -	0.31	4.21 - 4.65
Trichlorofluoromethane	34	26	76	0.6	1.8	1.48	0.81 -1.2	0.28	3.32 - 3.66
Toluene	34	22	65	0.68	7.9	1.83	0.53 – 0.82	0.19	2.52 - 2.79
Dichlorodifluoromethane	17	9	53	1.9	2.8	2.41	NA	0.25	3.32 - 3.66
n-Hexane	8	3	38	3.03	7.04	5.23	NA	NA	2.37 - 2.61
Benzene	34	11	32	0.31	1.5	0.85	0.46 - 0.67	0.16	2.14 - 2.36
Methylene Chloride	34	10	29	1.9	32.62	7.93	0.49 – 0.76	1.7	2.33 - 2.57
Total Hydrocarbons (gas) * **	8	2	25	49.8	146	97.9	NA	NA	46.9 - 52.2
Tetrachloroethylene	34	8	24	0.12	10.85	1.68	0.10 – 0.16	0.34	4.54 - 5.02
1,2,4-Trimethylbenzene	17	4	24	0.38	0.61	0.48	NA	0.25	3.30 - 3.64
Ethylbenzene	34	6	18	0.27	1.5	0.54	1.4 – 1.9	0.22	2.91 - 3.21
Trichloroethylene	34	6	18	0.17	5.37	2.71	0.08 - 0.12	0.27	3.60 - 3.98
Xylene (m&p)	34	5	15	0.92	5.2	1.98	2.5 – 3.8	0.43	2.82 - 3.12
Xylene (o)	34	5	15	0.39	1.9	0.76	1.2 – 1.9	0.22	2.91 - 3.21
1,2-Dichloroethane	34	1	3	0.64	0.64	0.64	0.59 - 0.90	0.2	2.71 - 2.99

* Mean of samples detecting chemical.[21]

** Pace reporting limits were in ppbv. We converted to µg/m³.[22]

*** Total hydrocarbons reported as parts per billion volume (ppbv).

Breaking out the air data by county, the highest number of VOCs were detected in samples from Washington County (15), Butler County (15), Bradford County (11), and Fayette County (9). Washington County also had the highest measured concentration of five and the second highest concentration of 11 VOCs.[23] Samples from Butler and Bradford Counties had the highest concentrations of five and three VOCs, respectively. Five chemicals were detected in all nine of the samples from Washington County and in the six samples from Butler County: 1,1,2-Trichloro-1,2,2-trifluoroethane; carbon tetrachloride; chloromethane; toluene; and trichlorofluoromethane. (Detailed data for all the counties where air testing occurred are available at http://health.earthworksaction.org.)

In 2010, the Pennsylvania Department of Environmental Protection (DEP) conducted air testing around natural gas wells and facilities in three regions across the state, in part using the same canister sampling methods as in this project.[24] When compared to the DEP's results, OGAP's results showed some similarities in both the chemicals detected and concentrations.

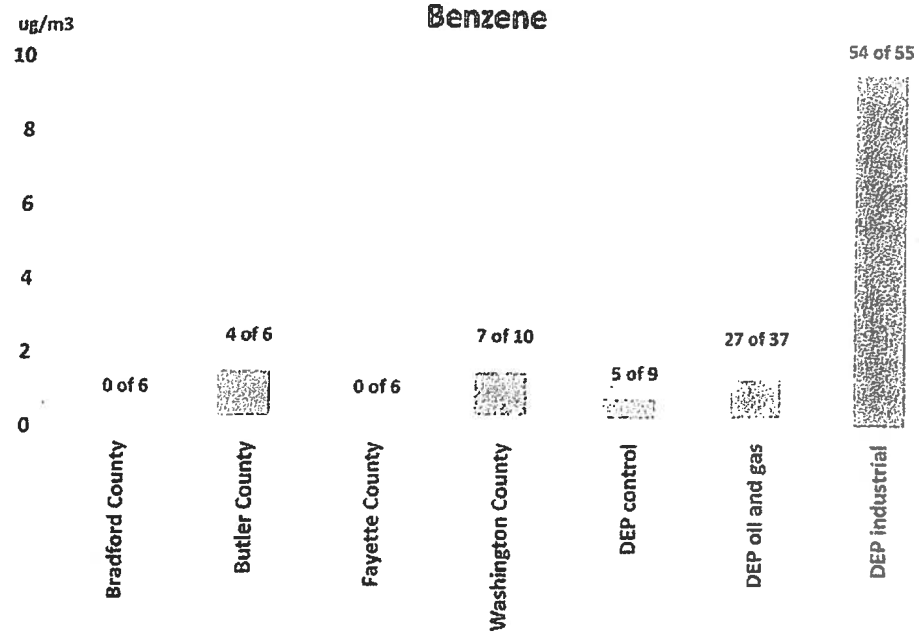
Figure 2 shows benzene, toluene, ethylbenzene, and m&p-xylenes (o-xylenes not included) broken down by county from our project, as well as samples taken by DEP at control sites (rural, forested areas with no nearby gas development), oil and gas sites (including some nearby residences), and an industrial site (the Marcus Hook monitoring site, which is close to two oil refineries in an industrialized area of the state[25]). Also shown in the chart are the number of detections and the number of samples in each category (e.g., benzene was detected in four of six air samples in Butler county).

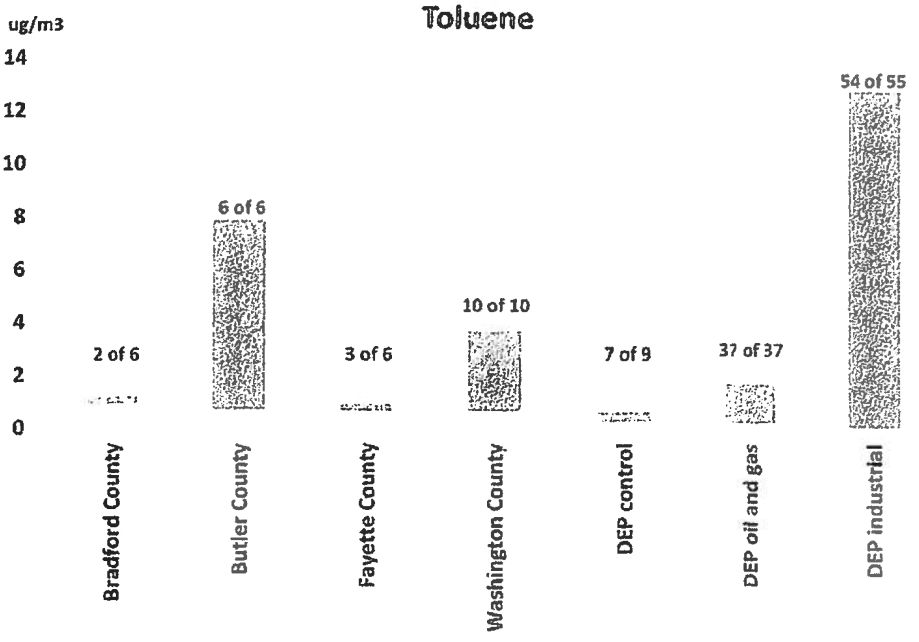
As seen in these charts, BTEX chemicals measured in our project in Butler and Washington counties were consistently higher than concentrations found at DEP control sites (ethylbenzene and m&p-xylenes were not detected at any of the control sites). When compared to the sampling done by DEP around oil and gas facilities the concentrations in Butler and Washington counties were in the same range for benzene, but were considerably higher for toluene, ethylbenzene, and m&p-xylenes. It is also striking that some of the concentrations of ethylbenzene and xylene measured at homes in Butler and Washington counties were higher than any concentration detected by the DEP at the Marcus Hook industrial site. Again, while factors such as topography, type of gas, and emission control technologies can influence air results, it is highly possible that air quality at the sites where we tested—all in rural and residential areas—was worse overall because of the proximity of gas facilities.

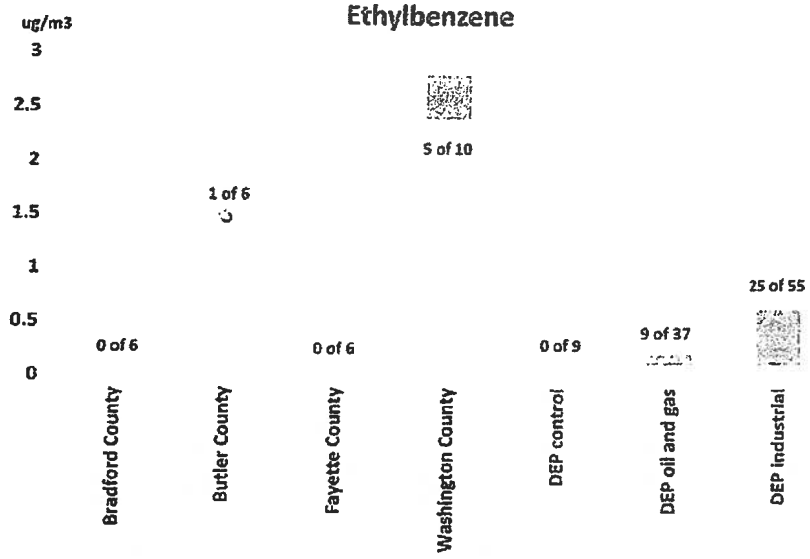
Concentrations of ethylbenzene and xylene measured at homes in Butler and Washington Counties for this project were higher than in air tests done by the DEP at the Marcus Hook industrial site.

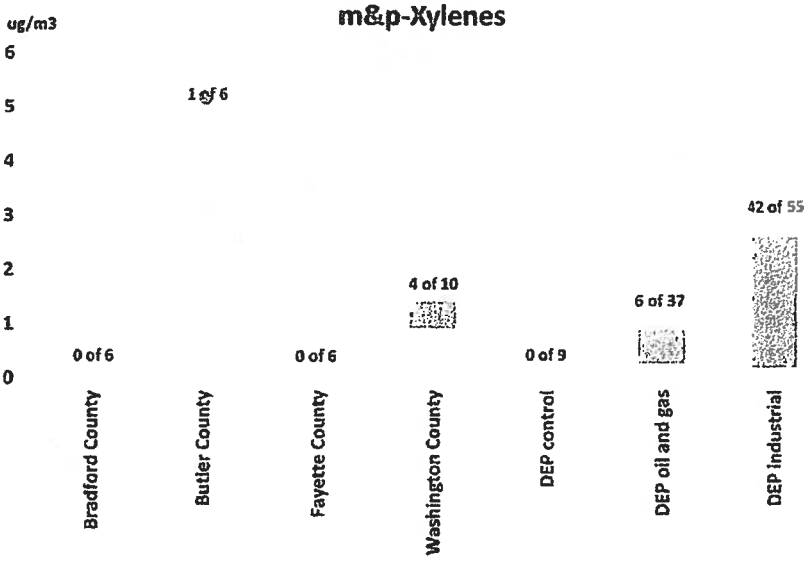
According to the DEP, some of the VOCs found in our study are present in ambient air because they were once widely used and persist in the atmosphere.[26] The DEP indicates that acetone and the BTEX chemicals, however, may be attributed to gas development.[27] (In addition, the presence of VOCs clearly influences air quality overall.)

Figure 2. The four charts that make up Figure 2 show comparisons of BTEX concentrations where they were detected in project samples (Bradford, Butler, Fayette, and Washington Counties only) and DEP samples (control, oil and gas facility, and an industrial site).









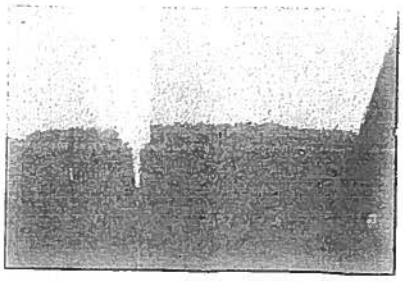
To provide some perspective on benzene concentrations found in our results, we examined data on national benzene concentrations in the U.S. (based on annual average concentrations at 22 urban sampling locations). Between 1994 and 2009, benzene in ambient air declined.[28]

In 2009, 80 percent of the urban sites had average annual benzene concentrations between 0.4 and 1.5 micrograms per cubic meter (µg /m^3), with the average and median concentrations for the 22 sites being less than 1 µg /m^3. Five of our air canister tests had benzene above the national (urban) average, and two had concentrations equal to the maximum average annual concentration measured by EPA in U.S. urban areas in 2009 (i.e., 1.5 µg /m^3).[29]

As mentioned previously, the current project's sampling locations were in rural areas of Pennsylvania. While local traffic may have contributed some benzene, the most likely primary sources of benzene in these areas are oil and gas facilities; increased truck traffic associated with these sites could also be a contributing factor.

It is important to note that the concentrations found in our study were one-time samples, while the EPA concentrations represent an average of many samples taken over the course of a year. So there may have been some individual samples in urban areas that were higher than 1.5 µg /m³. It is also possible, however, that benzene concentrations at the sampling locations in our project could have exceeded 1.5 µg /m³ if numerous samples were taken over the course of several months or a year.

Finally, the chemicals sampled in our project were limited to a selection of VOCs. The analytical methods used did not test for some chemicals known to be associated with oil and gas facilities such as formaldehyde, which is commonly emitted from compressor stations. According to the U.S. EPA, the major toxic effects caused by acute formaldehyde exposure via inhalation are eye, nose, and throat irritation and effects on the nasal cavity.[30] These were symptoms experienced by high percentages of survey respondents. In addition, hydrogen sulfide, a known toxic compound with many of the health effects documented in this project, is often associated with oil and gas development. Testing for such chemicals would have required different types of air sampling methods than applied here.



Operators flare gas that's uneconomical to process or to burn off certain compounds. Flaring emits a host of air pollutants determined by the chemical composition of the gas and the temperature of the flare.

Photo by: Frank Finan

WATER

The nine water samples taken for this project were sent to laboratories that analyzed for dozens of substances. Table 8 shows the 26 parameters that were detected in at least one sample (including water temperature and pH). Several of the chemicals found in samples are known to be associated with oil and gas drilling operations. For example, barium, bromide, calcium, chloride, iron, manganese, magnesium, potassium, sodium, sulfate, strontium, and Total Dissolved Solids (TDS) have been measured in effluent from a Pennsylvania wastewater plant that only treats oil and gas industry brine and hydraulic fracturing flowback.[31]

Drinking water standards do not even exist for some contaminants, such as methane, bromide, sodium, strontium, or Total Suspended Solids (TSS).

Table 8. Water quality results from nine private water wells in Bradford and Butler Counties, Pennsylvania (Note: not all parameters were analyzed in every sample)

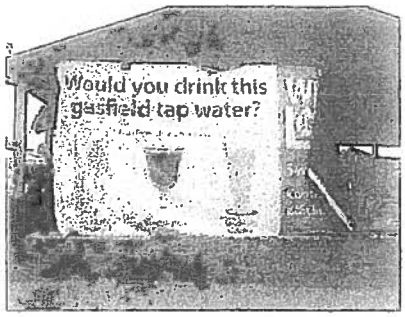
Parameter	Units	Number of samples	Number above detection limit	Min[a]	Max	Mean[b]	PA DEP MCL[c]	Number of samples above MCL
Barium	mg/L	9	9	0.029	0.5	0.25	2	0
Calcium	mg/L	9	9	33	66.2	43.7	None	
Magnesium	mg/L	9	9	4.5	16.8	9.1	None	
Sodium	mg/L	9	9	9.2	64.1	20.9	None	
Strontium	mg/L	9	9	0.126	1.7	0.5	None	
Hardness (Total as CaCO3)	mg/L	9	9	120	234	147	None	
pH	Std Units	9	9	6	7.9	6.5	6.5 - 8.5	2 below
Alkalinity (Total as CaCO3)	mg/L	9	9	38	285	130	None	
Total Dissolved Solids	mg/L	9	9	138	392	218	500	0
Sulfate	mg/L	9	9	6.7	231	33	250	0
Manganese	mg/L	9	7	<0.005	6.44	1.04	0.05	7
Chloride	mg/L	9	7	<5.0	84.3	24.1	250	0
Iron	mg/L	9	6	<0.04	153	19.5	0.3	5
Potassium	mg/L	6	6	1.14	1.57	1.1	None	
Specific Conductance	µmhos/cm	6	6	287	552	326	None	
Methane	µg/L	9	5	1.06	57.4	10	None	
Arsenic	mg/L	9	4	<0.001	0.0282	0.005	0.010	1
Lead	mg/L	9	4	<0.001	0.113	0.01	0.005*	3
Total Coliform	per 100 mL	9	4	Absent	Present		None	
Total Suspended Solids	mg/L	6	4	<5	448	118	None	
Temp, water	Deg. Celsius	3	3	25	29	28	None	
Turbidity	NTU	3	3	0.22	5.7	2.3	None	
Nitrate	mg/L	3	3	0.076	0.71	0.46	10	0
E. coli	per 100 mL	9	2	Absent	Present		None	
Sulfur	µg/L	1	1	<1,000	7,550	2,850	None	
Bromide	mg/L	1	1	0.26	0.26	0.26	None	

[a] **Minimum values:** If reports included non-detects of a particular chemical, the minimum value in the table was shown as being less than (<) the lowest laboratory detection limit.
[b] **Mean values:** Non-detected chemicals were assigned a concentration equal to half of the detection limit *only if* there were other samples that detected the chemical.
[c] **MCL:** Maximum Contaminant Levels published by the Pennsylvania Department of Environmental Protection Division of Drinking Water Management.

Two of the water samples, both from Butler County, were more acidic than the recommended pH for drinking water. Iron, manganese, arsenic, and lead were detected in water well samples from Bradford and Butler Counties at levels higher than the Maximum Contaminant Levels (MCLs) set by DEP's Division of Drinking Water Management.[32]

It is important to note that while laboratory tests may not show exceeded levels for some of the other substances, drinking water standards on which to base such determinations often do not exist, including for methane, bromide, sodium, strontium, or Total Suspended Solids (TSS).

More than half of the project water samples contained methane. Although some groundwater can contain low concentrations of methane under normal conditions, its presence could also indicate natural gas migration from improperly cased or damaged gas wells. In addition, a recent analysis of U.S. Geological Survey water monitoring data for an aquifer near Pavillion, Wyoming found that thermogenic gas (which likely comes from shale formations), as well as chemicals associated with hydraulic fracturing, are present—evidence that strongly suggests that these substances can seep into water supplies following fracturing.[33]



Drinking water wells have been contaminated with methane, chemicals, and other substances.

Photo by: Nadia Steinzor

Concentrations of some metals such as manganese and iron may be elevated in Pennsylvania surface waters and soils either naturally or due to past industrial activities, and levels can vary regionally and seasonally.[34] In 2012, Pennsylvania State University (PSU) researchers found that some drinking water wells in the state contained elevated concentrations of certain contaminants prior to any drilling in the area.[35] For example, PSU researchers found that 27 percent of pre-drilling water samples had manganese above the DEP drinking water standard.[36] In this project, 7 out of the 9 water supplies sampled (78 percent) had manganese levels above the state MCL; this is a much higher percentage than the PSU study. If there was no impact from drilling, one would expect that fewer than three of our project samples would have had manganese above the MCL.

Even when metals in ground water are naturally occurring or pre-date gas development, drilling and hydraulic fracturing have the potential to mobilize substances in formations such as Marcellus Shale, which is enriched with barium, uranium, chromium, and zinc and other metals.[37] Also, drilling can cause physical and chemical changes to groundwater aquifers that may result in elevated metals and sediment concentrations in drinking water.[38] In the PSU study, there were three cases where wells within within 3,000 feet of the nearest Marcellus gas well experienced changes in manganese, iron and sediment after drilling occurred. For example, each water well had pre-drilling manganese concentrations near or below the drinking water standard (0.05 mg/L) that increased far above the standard following drilling.[39]

SYMPTOM AND TESTING ASSOCIATIONS

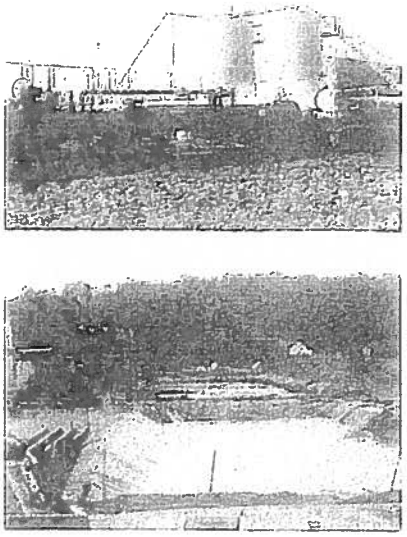
More research would be required to state "cause and effect" connections between the chemicals present in air and water in specific locations and symptoms reported by particular residents. Nonetheless, associations can be made, as many of the chemicals detected through testing are known to be linked to both oil and gas operations and with the health symptoms reported in the surveys.[40]

Many of the chemicals detected through testing are known to be linked to both oil and gas operations and with the health symptoms reported in the surveys.

The air tests together detected 19 chemicals that may cause sinus, skin, ear/nose/mouth, and neurological symptoms, 17 chemicals that may affect vision/eyes, 16 that may induce behavioral effects, 11 that have been associated with liver damage, 9 with kidney damage, and 8 associated with digestive/stomach problems. In addition, the brain and nervous system may be affected by 5 chemicals that were detected, the cardiological system by 5, muscles by 2, and blood cells by 2.[41]

More specifically, benzene, toluene, ethylbenzene, xylene, chloromethane, trichloroethene, and acetone were detected at project sites where residents reported associated symptoms in health surveys, including in the categories of sinus/respiratory, skin, vision/eyes, ear/nose/mouth, and neurological. Some of these chemicals, as well as others (such as carbon tetrachloride and tetrachloroethylene), were found at sites where survey participants reported associated symptoms in the categories of digestion, kidney and liver damage, and muscles. (For a full list of health symptoms associated with the chemicals detected, see http://health.earthworksaction.org.)

As shown in Table 9, 68 percent of the respondents at households where chemicals were detected reported symptoms known to be associated with those chemicals. Fayette and Washington Counties had the highest rate of association, followed by Greene, Bedford, and Butler. **The total number of symptoms reported by individual participants ranged from 2-111, but more than half of participants reported having over 20 symptoms and nearly one-quarter reported over 50.** The highest number of number of symptoms in households where we conducted air testing were reported by a 26 year-old female in Fayette County (90 symptoms) and a 51 year-old female in Bradford County (94 symptoms).



The many stages of gas development create multiple pathways for exposure to air and water pollution, such as emissions, spills, leaks from compressors, impoundments, and other facilities.

Photos by: Nadia Steinzor (top); Frank Finan (bottom)

Table 9. Match between health symptoms reported by individuals at air testing sites and known effects of chemicals detected

County	Number of individuals surveyed at homes where testing was conducted	Association between known effects of chemicals detected and symptoms reported	
		Average	Range
Overall	65	68%	33 - 100%
Fayette	17	73%	33 - 100%
Washington	15	73%	33 - 100%
Bradford	10	58%	16 - 100%
Butler	12	63%	56 - 68%
Bedford	6	69%	63-100%
Elk	2	64%	53 - 74%
Clearfield	1	None	None
Greene	1	70%	70%
Susquehanna	1	50%	50%

In addition, as shown in Table 10, the percent of individuals reporting particular types of symptoms that are associated with chemicals detected in the air testing was generally consistent across counties.

Table 10. Percent of individuals at air testing sites reporting symptoms associated with chemicals detected at those sites, by symptom category

Symptom Category	All	Bedford	Bradford	Butler	Fayette	Washington	Others *
Sinus/respiratory	83	100	88	100	81	73	80
Vision/eyes	73	--	100	63	69	67	60
Digestive/stomach	69	50	63	88	75	80	--
Skin reactions	63	50	63	88	69	53	40
Neurological	60	50	88	75	44	53	60
Behavioral/mood/energy	54	67	50	63	63	47	40
Ear/nose/mouth	33	50	--	38	44	33	20
Muscle problems	--	--	--	--	--	40	--

* This includes air samples from Clearfield, Elk, Greene, and Susquehanna Counties

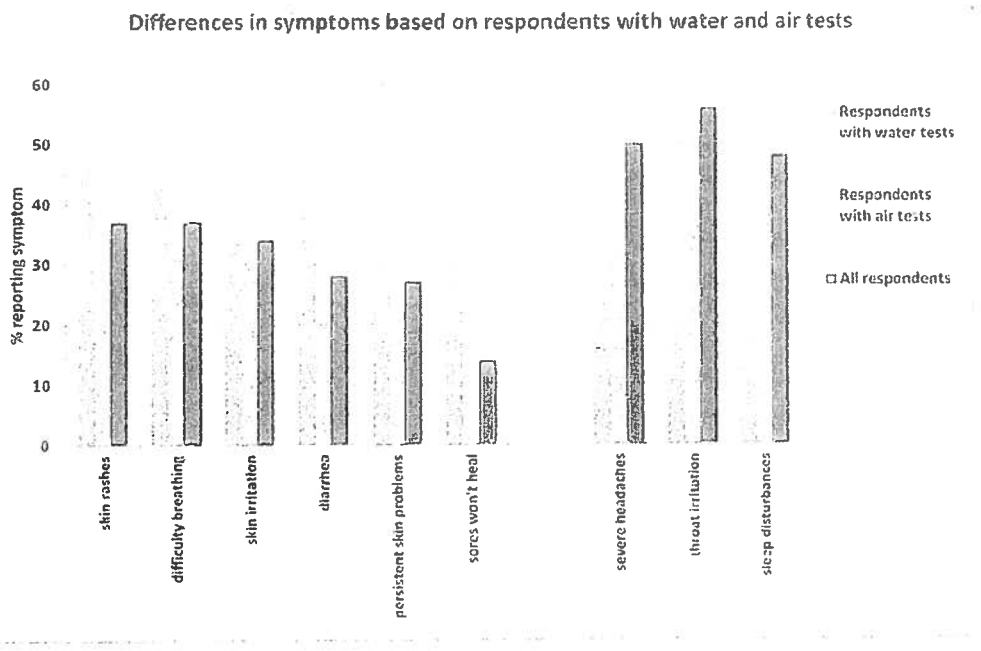
As mentioned above, iron, manganese, arsenic, and lead were detected in water samples at levels above Pennsylvania drinking water standards. These substances are known to be associated with

numerous symptoms reported by individuals living in the homes where those tests were conducted, including in the categories of sinus/respiratory, skin reactions, digestive/stomach, vision/eyes, ear/nose/mouth, neurological, muscle/joint, behavioral/mood/energy, and liver and kidney damage. In addition, survey participants in the homes where water test results showed the presence of methane reported health symptoms known to be associated with the gas, including in the categories of sinus/respiratory, digestive/stomach, neurological, and behavioral/mood/energy.

Where water test results showed the presence of methane, participants reported health symptoms known to be associated with the gas.

Even though many participants indicated they had concerns with both water and air, the different types of testing conducted at different households provides a way to explore whether there might be particular symptoms more commonly associated with one type of exposure. As indicated in Figure 4, there were notable differences in several of the top symptoms reported at households where water versus air was tested, and among survey participants as a whole. Participants with water tests had a higher occurrence of skin rashes, difficulty breathing, skin irritation, diarrhea, persistent skin problems and sores that wouldn't heal, as well as a lower occurrence of severe headaches, throat irritation, and sleep disturbances, than those with air tests and all respondents.

Figure 4: Differences in symptoms based on respondents with water and air tests



2.5. CONCLUSIONS

The data gathered through this project point to three central conclusions: (1) contaminants that are associated with oil and gas development are present in air and water in areas where residents are experiencing health symptoms consistent with such exposures; (2) there is a strong likelihood that residents who are experiencing a range of health problems would not be if widespread gas development were not occurring; and (3) by permitting widespread gas development without fully understanding its impacts to public health—and using that lack of knowledge to justify regulatory inaction—Pennsylvania and other states are risking the public's health.

This project documented health symptoms and the presence of air contaminants at longer distances from gas facilities than in other locations where similar projects have been conducted.[42] This could be because the previous air testing was conducted in a limited geographical area very close to facilities, while the surveys and testing in Pennsylvania took place in areas where wells and facilities are more spread out. This could also help to explain why Pennsylvania residents who don't have gas facilities located on their own properties often report health problems and indicates that air contaminants and odors can travel further than might have previously been assumed.

Because of the short-term nature of the air canister testing (24 hours) and the single water tests conducted at households, our results reflect conditions at particular "moments in time." Factors such as the stage of drilling, weather conditions, wind speeds, topography, geology, and whether facilities are in operation or shut down may have an impact on the testing results. In addition, some chemicals may have been present in water or air below detection limits or prior to when the tests were conducted, meaning that other exposures may have also occurred that caused the reported symptoms. Given this, more continuous testing over longer periods of time and at additional locations would likely reveal different chemicals, chemical concentrations, and associations with health impacts.

More continuous testing over longer periods of time and at additional locations would likely reveal different chemicals, chemical concentrations, and associations with health impacts.

A related consideration for future research is the wide variation of results, and therefore conclusions about the presence and levels of chemicals, that occur depending on the laboratory used. This project used three laboratories to supply canisters and analyze samples (a step taken to compare the capacity and protocols of labs and to have "back up" should one of the labs have proven inadequate). However, while all the labs tested for the same core suite of chemicals, testing for other chemicals and the reporting limits for detection varied. In addition, the labs did not all analyze the samples for the same VOCs. For example, only Columbia Analytical analyzed for Acetone and 2-Butanone, while only Pace Analytical analyzed for n-Hexane and Total Hydrocarbons as gas.

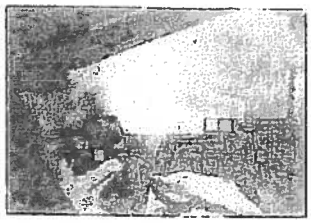


Photo by: Frank Finan

More research is warranted to establish connections between reported health problems and particular events related to gas operations, such as chemical spills, leaking waste pits, and flaring and venting. This could include, for example, examination of case files compiled by regulatory agencies, interviews with residents near the facilities where problems occurred, and daily odor and symptom logs kept by residents.

3 Missing pieces

Public health was not brought into discussions about shale gas extraction at earlier stages; in consequence, the health system finds itself lacking critical information about environmental and public health impacts of the technologies and unable to address concerns by regulators at the federal and state levels, communities, and workers..

–Institute of Medicine at the National Academies of Science[43]

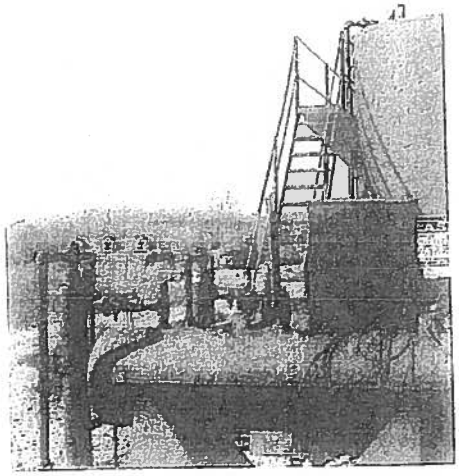
3.1. SCIENCE AND TESTING

Simply put, scientific investigation has not been able to keep pace with the rapid expansion of potential pathways of exposure and associated risks of gas development. Widespread interest by the health, medical, and environmental research community in examining the impacts of oil and gas development is relatively recent, perhaps coincident with the geographic expansion of activities and increased risk of impacts.

In addition, environmental testing and monitoring has long been primarily conducted for a limited number of air contaminants and in areas of high population density,[44] while testing at oil and gas facilities in states like Pennsylvania began only recently.[45] The result is a lack of data on which to base health-related research or for use by agencies charged with protecting health and air and water quality. Further, only a few states require any kind of baseline water testing before drilling begins, and this information is largely not accessible to the general public.[46] This makes it difficult for researchers, regulators, and communities to establish clear connections after gas operations begin.

People living in oil and gas development areas and workers are exposed to multiple toxic substances from a number of facilities. Yet this experience is often not reflected in the standards used to determine the safety or risk of exposure.

People living in oil and gas development areas day in and day out—as well as workers at job sites where hazardous substances are continuously used—are subjected to chronic, long-term exposure to multiple toxic substances from a number of facilities. Yet this experience is often not reflected in the standards used to determine the impacts of chemicals and the relative safety or risk of exposure to them through both air and water.[47] In turn, this calls into question reference to these standards (including by the gas industry and regulators) as a basis on which to judge the "risk" and "safety" of operations or to claim that evidence of harm does not exist. As summarized by the Agency for Toxic Substances and Disease Registry, "...most toxicological testing is performed on single chemicals, but human exposure is rarely limited to single chemicals...A particular issue is whether a mixture of components, each of which is present at less than guidance concentrations, may be hazardous due to additivity, interactions, or both."[48]



Well equipment close to home.

Photo by: Nadia Steinzor

Similarly, risk assessments for many chemicals use a high dose

as the starting point for calculating levels at which negative effects can be observed—potentially minimizing the exposure risks of low doses of many chemicals.[49] A recent paper, for example, showed that endocrine disrupting chemicals can have different but still harmful effects at low doses than at high ones, concluding that fundamental changes in chemical testing and safety protocols are needed to protect human health.[50] In addition, many chemicals have not yet been studied with regard to their health impacts. For example, as stated in a study on air toxics by the University of California-Berkeley School of Public Health, "Of the 188 hazardous air pollutants (HAPs) listed in the Clean Air Act, only a handful have information on human health effects. Lack of consistent monitoring data…makes it difficult to assess the extent of low-level, chronic, ambient exposures to HAPs that could affect human health."[51]

Finally, many areas of the country already have compromised air and water quality from various sources, such as traffic, agriculture, industry, and even previous mining and fossil fuel development. Today's oil and gas operations add even more chemicals and pollutants to the environment. For individuals with underlying conditions (e.g., asthma, heart conditions, or cancer), this can potentially cause a "trigger effect" and result in both new and the worsening of old health problems.

EMERGING KNOWLEDGE

Recent research has begun to establish links between oil and gas operations and health, including:

- A 2011 review of over 600 known chemicals used in natural gas operations concluded that many could have long-term health impacts, including on skin, eyes, and kidneys and respiratory, gastrointestinal, brain/nervous, immune, endocrine, and cardiovascular systems, as well as causing cancer and mutations.[52]

- A 2012 study in Colorado based on air sampling data showed that due to the toxicity of air emissions near natural gas sites, residents living closer to the sites had a greater risk of health-related impacts than those living further away.[53]

- A 2012 paper documented cases in which animals (both livestock and pets) exposed to natural gas operations and related toxic substances suffered negative health impacts and even death.[54]

3.2. POLICY AND REGULATION

Public health has not been a priority for policymakers making decisions about gas development. In just the last year, Maryland, Pennsylvania, and the U.S. Secretary of Energy established commissions to study the impacts of shale gas development, but none of the more than 50 members on these official bodies had health expertise.[55] In addition, New York's multi-year review of Marcellus Shale drilling has to date failed to analyze health impacts.[56]

Regulators do not require companies to provide information on potential health impacts in energy proposals and permit applications. Some associated concerns (such as traffic and noise) are often included in federal Environmental Assessments and Environmental Impact Statements, or when laws in 17 states spur similar analyses.[57] But only a few Health Impact Assessments (HIAs) have been conducted in the United States specifically on oil and gas development.[58]

Special exemptions for the oil and gas industry in sections of seven federal environmental laws compound the neglect of public health impacts in decisionmaking. Most notable is the ability of operators to keep secret the chemicals and chemical concentrations used in hydraulic fracturing (Safe Drinking Water Act); to measure air emissions based on single facilities, even if several make up a single operation (Clean Air Act); and to avoid classification (and thereby stringent transport and disposal requirements) of produced solid waste and wastewater as hazardous (Resource Conservation and Recovery Act).[59] These loopholes are replicated on the state level, where regulations developed for limited conventional drilling—in particular with regard to setbacks and waste disposal—are inadequate to address the complexity and intensity of shale gas development.

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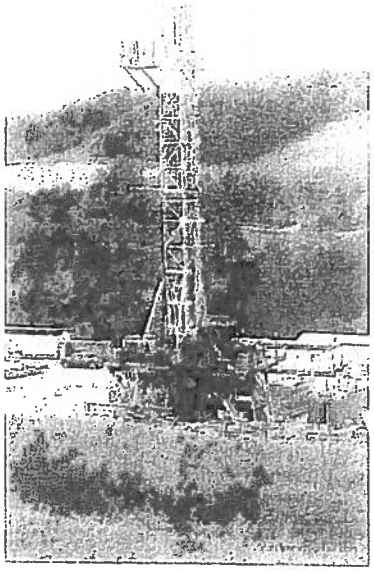


Photo by: Frank Finan

In addition, a crisis is underway in oil and gas industry monitoring and enforcement, likely adding to the pathways of pollution that are left undocumented and unaddressed. In a comprehensive analysis of programs in six states (Colorado, New Mexico, New York, Ohio, Pennsylvania, and Texas), Earthworks' OGAP found that regulatory agencies have been unable to keep up with oversight of existing wells, let alone the boom in shale gas development.[60] In Pennsylvania specifically, OGAP found that 86 percent of active wells were not inspected in 2011; violations by many operators are getting worse with time; the rate of enforcement has been declining; and penalties are too weak and inconsistent to have a deterrent effect.[61]

4 Recommendations

The shale gas boom reflects a glaring mismatch in timing: knowledge about health and environmental impacts—and changes in policies and regulations to address them—are evolving slowly, while development is rapid and widespread.

Because of this, our primary recommendation is that Pennsylvania (and other states) should put public health first and refuse to permit new gas development until they can assure affected communities that they (a) fully understand the associated public health risks and (b) have taken all necessary steps to prevent those health risks.

To this end, the following measures can help prevent the further degradation of public health and air and water quality.

GIVE PUBLIC HEALTH A CENTRAL ROLE IN GAS DEVELOPMENT DECISIONS. States should conduct HIAs to analyze both problems that could arise over time and existing health and environmental risks that could be exacerbated by industrial activities.[62] Because HIAs help identify measures related to toxic exposure, air and water pollution, emergency response, and other aspects, their conclusions can (if adopted) help prevent problems from occurring in the first place.[63]

INVOLVE STATE AND COUNTY DEPARTMENTS OF HEALTH. These agencies should have the resources necessary to track reports of health problems near gas facilities and to respond to citizen complaints (e.g., through a database and online and telephone systems). Health departments could also train health and medical professionals on exposure pathways and symptoms related to gas operations, so that residents can receive informed advice and appropriate testing and care referrals.[64] The DEP and the Pennsylvania Department of Health (DOH) should establish an agreement to document and respond to spills of chemicals and waste, the underground migration of fracturing fluids, leaks, and other problems that could give rise to health problems. Financial assistance should be available for low-income residents whose health may be affected by gas operations to receive blood and urine tests for chemical exposure.

PLAN AND PACE PERMITS. Regulatory agencies like the DEP should have a long-term, comprehensive plan for the scope and pace of permits issued for wells and other facilities, rather than simply reviewing and approving them on a one-by-one basis. As part of this process, vital information on air and water quality concerns and pollution sources should be considered and, in turn, be factored into decisions on where wells and facilities can be built—particularly in relation to places where health would be most at risk, such as homes, schools, hospitals, and agricultural areas.

STRENGTHEN REGULATIONS. Among the most critical measures for Pennsylvania (as well as other states) to consider are significant increases in setback distances from facilities; requirements for operators to install and use advanced technologies to reduce emissions, odors, and noise; the replacement of open impoundment pits with closed-loop systems to store waste and drilling fluids; and required "green completions" to eliminate flaring and venting of methane gas and other pollutants.

CLOSE THE ENFORCEMENT GAP. Inadequate oversight of gas operations means that risks and damage to air and water quality are frequently not documented and measures not taken to ensure accountability, deter offenders, and prevent problems from occurring. Key steps include binding,

effective inspection protocols, inspection schedules, and wells-to-inspector ratios; significantly higher fines and penalties for violations; and more timely, thorough responses to citizen reports of problems.

REVERSE SPECIAL EXEMPTIONS IN KEY PROVISIONS OF U.S. ENVIRONMENTAL LAWS. These loopholes allow oil and gas operators to avoid rules that every other industry must follow and make it difficult to fully identify and calculate impacts to air and water quality and health. In turn, this skews information on the relative costs and benefits of gas development and slows action to prevent impacts. Closing them would increase the availability and transparency of information on contaminants and exposures and make it possible to resolve remaining questions about health impacts.

CONDUCT BASELINE WATER TESTING AND CONTINUOUS AIR MONITORING. Baselines should be done for both private wells and public drinking water supplies prior to drilling and (for air) at or near facilities during all phases of operations. Tests should cover a full suite of chemicals and results should be available to the public.[65] Air quality testing should be conducted at a range of facilities (e.g., well heads, compressor stations, and impoundment pits) that cause emissions and at distances both close to and further away from homes, schools, and other locations. The DEP or the DOH could jointly oversee the testing using independent laboratories.

DEVELOP NEW TESTING MEASUREMENTS. Federal agencies (in particular the Centers for Disease Control and Prevention, the Environmental Protection Agency, and the Occupational Safety and Health Administration) should develop guidelines for interpreting air and water tests that take into account simultaneous exposure to multiple chemicals. Drinking water and air standards should be developed for those chemicals for which none currently exist. Public agencies should advocate for giving low-level, chronic exposure greater prominence in policy decisions. The public health research community can help improve understanding of current types of exposure and advance data and protocols that better reflect conditions in gas development areas.

PROHIBIT NON-DISCLOSURE AGREEMENTS (NDAS). Often used in legal settlements involving business activities and intellectual property protection, NDAs have in recent years become widespread in oil and gas damages cases as part of negotiations over such aspects as monetary compensation and medical expenses.[66] As a result, documentation, testimony, and information critical to understanding and preventing health and environmental impacts are often not available. A possible solution would be public policies that preclude NDAs from covering factual statements and data in court filings and during discovery, or to require parties to present reasons why facts related to health and safety should be concealed before an NDA can be entered into.

5 Final words

While we realize that human activities may involve hazards, people must proceed more carefully than has been the case in recent history. Corporations, government entities, organizations, communities, scientists and other individuals must adopt a precautionary approach to all human endeavors...When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically.

–Wingspread Consensus Statement on the Precautionary Principle [67]

Across the oil and gas patches of the United States, people experiencing health problems voice the simple wish to be believed. Numerous participants in this project—and others in similar situations nationwide—report that their health has declined since gas development began nearby. Despite frequent statements by policymakers and regulators about the "potential" of "future" impacts, problems are happening right now, in Pennsylvania and across the gas patches of the United States. For many people, the situation has grown dire and urgent.

Social, economic, and political pressures often mean that industrial activities are allowed to happen long before their impact on health and safety is fully understood. Without a doubt, more research on the environmental and health dimensions of shale gas development is needed and can play a central role in ongoing decisions about complex and controversial energy issues. Yet an equally valid concern is the need for response even in the face of unanswered questions. To date, reports of health impacts and the situations of individuals—despite continually growing more widespread and serious—have not been defined as evidence or taken seriously enough to spur action and change.

For many proponents of unfettered gas development, the absence of incontrovertible evidence of direct links between gas facilities and specific health impacts amounts to proof that no harm exists. But for the individuals whose lives, families, and homes are at risk—as well as many others who believe health and the environment always deserve protection—what we don't yet know only strengthens the need for caution.

The precautionary principle is warranted when it comes to both current and future gas and oil development. In particular, this means shifting the burden of proof of whether harm is being caused to those proposing the action—the gas industry and promoters of gas development at all levels of policymaking—rather than it continuing to be borne by those directly, and negatively, affected.

Policymakers and regulators often speak of the "potential" of "future" impacts—but problems are happening right now in Pennsylvania, and across gas patches of the United States. For many people, the situation has grown dire and urgent.

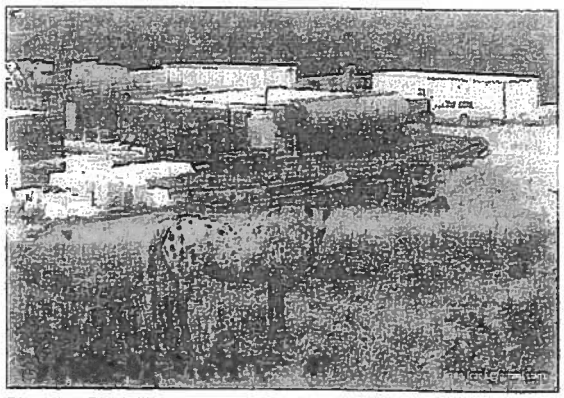


Photo by: Frank Finan

Earthworks' OGAP believes that corporations should be allowed to extract and process gas and other mineral fuels *only* if they can do so without harming human health or contaminating the air, water, and soil—with an eye to impacts at the local, regional, and global levels. This means:

1. **No Water Pollution:** protect public health, the environment, and the climate from toxic, hazardous, and carcinogenic chemicals used in the extraction of fossil fuel energy resources.
2. **Low Emissions:** protect public health, the environment, and the global climate from pollutants emitted during drilling and ongoing production of energy resources.
3. **No-Go Zones:** protect sacred areas, fragile ecosystems, neighborhoods, drinking watersheds, and densely populated areas targeted for energy development.
4. **Landowner and Community Consent:** continue to develop and then implement laws and policies making surface and mineral estates co-equal and ensuring that landowners have the right to negotiate and say "no" to energy development, and that communities wishing to restrict or prohibit development have the ability to do so.
5. **Prioritize Renewable Energy:** a comprehensive energy policy should work towards a long-term phase-out of fossil fuels in favor of energy efficiency and renewable sources like solar and wind.

These goals are achievable if decisionmakers are willing to slow the rush to drill, and if industry stops denying the serious problems left in its wake and instead invests the resources and time needed to fix and prevent them. The findings of this health survey and environmental testing project—coupled with similar patterns reported elsewhere and an emerging body of scientific and community-based research—provide a sufficient basis for strong action without further delay. Only then will the residents of Pennsylvania, and every other gas and oil producing state, be reassured that their health is not an acceptable casualty of fossil fuel use, but instead a basic and vital need deserving of protection.

6 Real people, real lives

This section profiles some of the people who participated in this study. There are many similar stories being told in Pennsylvania and other states that have been widely reported elsewhere. Some participants in this project requested anonymity and said they fear reprisals or legal problems if they speak out.

ANGEL AND WAYNE SMITH, BEDFORD COUNTY

If proof is ever needed that gas development comes in many forms, it can be found on the Smith farm. Old gas wells drilled decades ago into the Oriskany Sandstone are now being used to store more recently produced gas. But the results of this process haven't stayed underground, and a well and compressor station were recently built nearby.

Angel and Wayne Smith at their farmhouse.

Photo by: Nadia Steinzor

By 2007, Angel and Wayne knew something was changing, and very wrong. First their well water turned brown. Then water started bubbling up through their barn floor and an oily sheen and foam appeared on their pond. A strong propane odor laced the air. Headaches, nosebleeds, fatigue, sinus problems, throat and eye irritation, and shortness of breath soon set in. In the space of several months, a horse and three cows died and twelve calves were either miscarried or stillborn—a loss of animals unprecedented in the Smiths' many years of farming. Angel and Wayne's own health problems multiplied and trips to doctors are now routine.

"I'm often told to stop fighting what's happening because we get some royalties from the gas storage, but it hasn't been about the money in a really long time," says Angel. "It's about operators doing the right thing for people who have been harmed. We just want our lives, our land, and our health back."

"It's about operators doing the right thing for people who have been harmed. We just want our lives, our land, and our health back."

JANET AND FRED MCINTYRE, BUTLER COUNTY

For several months, the McIntyres hadn't been happy about the heavy traffic, intense odors, and the waste pits and rigs dotting surrounding farmland. But the turning point came when the entire family became sick after a meal that included glasses of tap water. Then the water in the kitchen and bathroom turned soapy and foamy and a dog suddenly died.

For Janet and Fred and many of their neighbors with similar problems, the quest for answers and help has been long, hard, and frustrating—and is far from over. Thanks to a weekly water drive supported by organizations, local residents, and churches, the McIntyres and their neighbors have bottled water to drink, but still have to bathe and do laundry in water that could be contaminated. While some ailments have abated, Janet, Fred, and their young daughter continue to have rashes, breathing problems, fatigue, eye and throat irritation, and headaches. Some previous health conditions have also grown worse.

"I had good water before, but now everyone around here has an issue with their well or health. Something's clearly not right," says Janet. "Can I put my finger on it and prove the precise cause beyond a doubt? No, but the only thing that's changed around here is gas drilling."

Janet helps coordinate the ongoing water drive for families in her community whose drinking water went bad after drilling began.

Photo by: Jason Bell

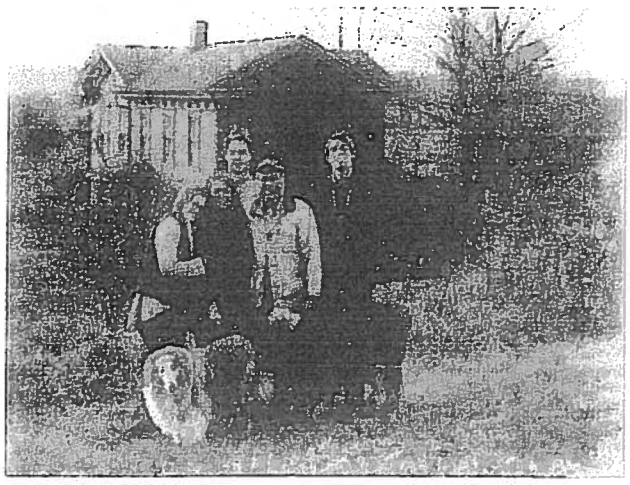
"Now everyone around here has an issue with their well or health."

JENNY AND TOM LISAK, JEFFERSON COUNTY

On a warm summer day nearly 30 years ago, Jenny and Tom claimed their slice of heaven, purchasing a historic farmhouse surrounded by fields. Over the years, their hard work and determination paid off and Ladybug Farm, a certified organic produce farm, was born. So were three children, who grew up loving nature.

A few years ago, the Lisaks came face-to-face with an unexpected and unwelcome change to their environment, as Marcellus Shale operations got underway. First there was constant truck traffic, then wells were drilled not far from their house and crops. The Lisaks began to wake up to the strong smell of diesel and would experience frequent headaches, fatigue, sore throats, and eye and nose irritation whenever they were near gas facilities in the area. When a permit was issued for an impoundment pit and gas well on the property adjacent to their farm, stress, irritation, anxiety, and sleeping problems also set in.

"When living in the country, your time is marked by nature and each season comes with its own smells, sounds, and colors. But those colors have faded and our well-being, livelihood, and dreams are now threatened," says Jenny. "I strongly object to being forced to breathe toxic fumes and other unhealthy conditions, and to my family facing the possibility of one day becoming refugees from our own home."



Lisak family on their farm.

Photo by: Jason Bell

"We are facing the possibility of one day becoming refugees from our own home."

PAM JUDY, GREENE COUNTY

When Pam Judy and her husband built their dream house in 2006, they truly came home—settling on property that once belonged to her great grandparents and remained part of the family farm. Country life was going great until an unwelcome neighbor moved in just 800 feet away: a large gas compressor station.

At first, the resulting noise, odors, and emissions took away peace and quiet—and then also the entire family's health. Both parents and children became extremely tired and began to have severe headaches, runny noses, sore throats, and muscle aches. Pam has also experienced dizziness and vomiting. Everyone noticed that they felt better when they were away from home, and started avoiding being outside in their yard or on their porch.

Air testing (including by the Pennsylvania Department of Environmental Protection) in the Judy's yard and around the compressor station revealed the presence of a cocktail of chemicals, including known carcinogens like benzene, toluene, and xylene, and several others linked to symptoms the family was experiencing.

"It's bad enough feeling sick so much of the time, but we also have to worry about the serious health problems, like cancer, that prolonged exposure to emissions could cause," says Pam. "State and federal officials must take the complaints of residents seriously and demand that industry change its practices. By the time the dangers become completely clear, it will be too late for many people."

Pam at the compressor station near her home.

Photo by: Mark Schmerling

"By the time the dangers become completely clear, it will be too late for many people."

PAT KLOTZ, BRADFORD COUNTY

Fresh air and the outdoors have always been important to Pat Klotz, who for many years had a large garden and kept horses. Even after moving, she's stayed active caring for rescued dogs, renovating her home, and working as a home health aide. Which is why it felt so strange to get bad headaches and feel exhausted much of the time.

Then Pat started keeping track of what happened when—and concluded that her health began to decline soon after a gas well went in upslope behind her house. Every once in awhile, the air would smell like sulfur, and soon after she'd start having trouble breathing, get dizzy, or feel intense burning in her eyes and throat. Sometimes she'd get a strange metallic taste in her mouth or sudden leg cramps.

Relatives who live near gas facilities several miles away told Pat they were having the same symptoms, including sudden dental problems. Both households had dogs that would suddenly become lethargic and have seizures. When they all stopped drinking the tap water—which began to sometimes run fizzy and turn black in 2010—both people and animals felt better.

"Doctors don't know what to do and elected officials don't take our complaints seriously."

"Living in the country is supposed to be good for you, but our sense of peace and tranquility ended when drilling started," says Pat. "The doctors don't know what to do, even though more and more people have the same symptoms. Elected officials don't take our complaints seriously. So we're still here waiting for help."

JANET AND CHRIS LAUFF, WASHINGTON COUNTY

To Janet and Chris Lauff, the property was perfect, with a rolling meadow ringed by forest and a stream. They bought it, built a house, and raised their young children. But nearly 15 years later, they're thinking about moving—that is, if anyone will buy the place (which isn't leased) with two well pads and a wastewater impoundment next door.

"I just want to get my family out of here to a better place."

This shift has been rather sudden, with quality of life affected in just the last few years, and conditions deteriorating rapidly in the last several months. The Lauffs date the start of their problems to when an access road to the well pads and the impoundment went in upslope behind their house. Now the impoundment is used 24/7 and truck traffic has become constant.

These events have brought bad odors, nose and throat irritation, and headaches. One of the Lauff's sons has asthma, raising concerns of how exposure to chemicals is affecting his health. At times, the odors have been so severe that the family has left home, and in 2010, the water from their well stopped running entirely. They've also found dead raccoons, fox, and deer near their stream. Both Janet and Chris—who holds degrees in biology and chemistry and has worked in the chemical and gas industry for 30 years—know such events can signal deeper health and environmental problems.

"It's impossible to know how much we're affected day-to-day and what that means for the future," says Janet. "Gas development changes your whole life. Your privacy is gone. Your peace of mind and sense of security are gone. I've been pretty calm until now, but after dealing with the odors, noise, dust, water, and air issues for almost three years, I just want to get my family out of here to a better place."

LINDA AND DAVID HEADLEY, FAYETTE COUNTY

In rural Fayette County, big changes usually come slowly. After nearly 30 years in the area, Linda and David Headley were accustomed to a quiet, serene way of life, and the farm they bought seven years ago was the perfect place to settle with their two sons.

But just weeks after moving in, the Headleys were hit hard by the reality of not owning the oil and gas rights on their property. First it was the truck traffic and heavy equipment; then came the gas wells, separator tanks, and impoundment pit; and more recently a pipeline cutting across hayfields. Along with all this have been fuel spills, noise, bad odors, and a spring that started bubbling and can be lit on fire.

It wasn't only the Headley's property that was transformed—their health also changed. Linda has constant sore throats and coughing spells. Grant and Adam have bouts of intense stomach pain and nosebleeds. Everyone gets headaches and red, itchy skin after spending time outdoors. Even the Headley's horses have been affected, with brittle hooves and sore feet. And as Linda and David began talking to neighbors about the changes sweeping the community, it became clear that such symptoms were widespread.

"Our once peaceful existence has forever changed. We aren't getting answers about why our land is being damaged and so many people are sick," says Linda. "The industry is a loose cannon and regulators seem to be helpless in the face of all the development. If we could put a man on the moon decades ago, we can surely find a better, safer, healthier way to fuel our future."

Linda and David watch pipeline construction across their hayfields.

Photo by: Roberto M. Esquivel / Herald-Standard

"If we could put a man on the moon decades ago, we can surely find a better, safer, healthier way to fuel our future."

CAROL FRENCH, BRADFORD COUNTY

As lifelong farmers, Carol French and her significant other Claude Arnold know what it's like to be tired at the end of a hard day's work. So they didn't think twice about how fatigued they were and how their bones ached. But then they began to wonder if it might be connected to the rashes, shortness of breath, and headaches they also were experiencing..

Fortunately, Carol knew what questions to ask and where to look for answers. A co-founder of Pennsylvania Landowner Group for Awareness and Solutions, she was spending every free moment learning about the impacts of gas development and sharing that knowledge with others. She also kept track of problems that arose with leases—including her own—and on properties where drilling was taking place.

Yet nothing could prepare Carol and Claude for when their own water went bad in 2011. Carol started tracking the timing of when it would run white, settle with a mossy substance on top of sand, or become like gelatin, and when nearby drilling activities and the family's health symptoms occurred. Her daughter Lynsey—who has an autoimmune disease that the family doctor said could make her more susceptible to chemical exposure—was hospitalized with a high fever, severe weight loss, and intense abdominal pain, and was found to have an enlarged liver and spleen and fluid retention. Once she recovered, she moved away and hasn't been sick since. In the meantime, several dairy cows have developed rashes and sores, and Carol and Claude continue to have skin and respiratory problems.

"Gas proponents dismiss and deny stories like ours, and some even say that developing the resource is so important that it's worth 'necessary sacrifice,'" says Carol. "But what gives them the right to decide whose health, family, property, and livelihood should be sacrificed?"

Carol French

Photo by: Nadia Steinzor

"What gives gas proponents the right to decide whose health, family, property, and livelihood should be sacrificed?"

CAROL JEAN MOTEN AND DEBBIE PEEPLES, WASHINGTON COUNTY

The neighborhood where sisters Carol Jean Moten and Debbie Peeples have lived nearly their whole lives is tight-knit, with modest houses along a few streets where everyone knows and helps each other. Residents also long appreciated the quiet and fresh air that comes from living next to a county park—that is, until much of the park was leased for gas drilling and several well pads went in where trees once stood.

Soon after gas development began, the water in Carol, Debbie, and their mother Edna's homes turned odd colors. A neighbor found sand coming through pipes into the sink. Periodically, often at night, the air would get hazy and gas and chemical smells would blow downhill from the park.

For Carol and Debbie, these episodes meant the onset of symptoms like headaches, shortness of breath, burning eyes and throat, dizziness, and disorientation. Carol, an artist, started having difficulty painting. Over time, both sisters developed skin lesions and often felt weak and tired. And they began to wonder if illnesses among cats and dogs in the neighborhood could be related.

"My family drank the water for a long time and now we're breathing bad air. But the exposure is low-dose and doesn't fit the criteria to gauge harm," says Carol Jean. "Even a toxicology doctor told me that the only thing I can do is leave my home and move away. When it comes to hydrofracturing, there is no justice."

Carol Jean Moten (right) with her mother Edna.

Photo by: Martha Rial

"Even a toxicology doctor told me that the only thing I can do is leave my home and move away."

7 Endotes

[1] "List of the Harmed" compiled by the Pennsylvania Alliance for Clean Water and Air, http://pennsylvaniaallianceforcleanwaterandair.wordpress.com/the-list/ (accessed September 25, 2012) and Humes, Edward, "Fractured Lives: Detritus of Pennsylvania's Shale Gas Boom." Sierra Magazine, July/August 2012.

[2] "Second Annual Conference on Health Effects of Shale Gas Extraction." Center for Healthy Environments and Communities, University of Pittsburgh. November 2011; presentations at http://shalegas.pitt.edu and "Epidemiologic and Public Health Considerations of Shale Gas Production: The Missing Link." Physicians, Scientists, and Engineers for Healthy Energy. January 2012; presentations at www.psehealthyenergy.org/site/view/971.

[3] A. Lustgarten, "Drill for natural gas, pollute water." *Scientific American*, November 17, 2008.

[4] R. Witter et al., *Potential Exposure-Related Human Health Effects of Oil and Gas Development: A White Paper*, Colorado School of Public Health, University of Colorado, and Colorado State University Department of Psychology, 2008.

[5] Colborn, T., Kwiatkowski, C., Schultz, K., and Bachran, M. "Natural gas operations from a public health perspective." 2011. *Human & Ecological Risk Assessment* 17(5):1039-1056.

[6] Witter, R., Stinson K., Sackett H., et al. Potential Exposure-Related Human Health Effects of Oil and Gas Development: A Literature Review (2003-2008). Colorado School of Public Health, 2008.

[7] "Loopholes for Polluters: The oil and gas industry's exemptions to major environmental laws." Earthworks, 2011. http://www.earthworksaction.org/library/detail/loopholes_for_polluters

[8] Durham, L.S. March, 2008. "Appalachian Basin's Marcellus–the new target." *Explorer*. American Association of Petroleum Geologists.

[9] "Marcellus Shale—Appalachian Basin Natural Gas Play." Geology.com: http://geology.com/articles/marcellus-shale.shtml (accessed June 19, 2012).

[10] "Learn about the Marcellus Shale." Pennsylvania Independent Oil and Gas Association. http://www.pioga.org/marcellus-shale/, (accessed June 19, 2012).

[11] Based on data from "Oil and Gas Reports." Pennsylvania Department of Environmental Protection. www.portal.state.pa.us/portal/server.pt/community/oil_and_gas_reports/20297#InteractiveReports (accessed September 10, 2012).

[12] "Community Health Survey of Current and Former Residents of DISH, Texas." Earthworks OGAP, 2009. http://earthworksaction.org/publications.cfm?pubID=438; and "Community Health Survey Results of Pavillion, Wyoming." Earthworks OGAP, 2010. http://earthworksaction.org/PR_PavillionHealthSurvey.cfm

[13] *Natural Gas Flowback: How the Texas gas boom affects community health and safety*. Earthworks' OGAP, 2011. http://www.earthworksaction.org/library/detail/natural_gas_flowback

[14] All survey participants were assured by OGAP that their identifying information (e.g., name and address) would be kept confidential and not used for any other purposes than this project, including to follow up with additional questions, respond to requests for assistance, or to provide additional resources.

[15] Specific symptoms within each of the main categories included: SINUS/RESPIRATORY (loss of sense of smell, shortness of breath, hoarseness, asthma, sinus problems, abnormal lung function, difficulty breathing, persistent cough, wheezing, allergies, nasal irritation, throat irritation, coughing up blood/sputum). BEHAVIOR/MOOD/ENERGY (increased fatigue, feeling weak & tired, extreme drowsiness, sleep disorders, sleep disturbances, depression, loss of sexual drive, fainting, judgment problems, behavioral changes, suicidal thoughts, personality changes, severe anxiety, tension, compulsive behavior, agitation, difficulty with activities, appetite disturbances, frequent irritation). NEUROLOGICAL (memory loss, amnesia, forgetfulness, spelling difficulties, decreased motor problems, difficulty drawing, staggering/stumbling, falling nerve damage, tremors, seizures, weakness of hands, trembling of hands, tingling of hands, disorientation, hallucination, dizziness, balance difficulty, slurring of speech, difficulty concentrating). MUSCLES/JOINTS (swollen or painful joints, arthritis, muscular pain, muscle aches, lumbar pain, weakness, reduced strength). EAR/NOSE/MOUTH (deafness, hearing loss, ringing in ears, difficulty hearing, frequent nosebleeds, noises in ears, loss of sense of taste, discoloration of teeth, metallic taste on cough, gingivitis, redness/swelling/discoloration of gums, severe salivation, mouth sores or ulcers). DIGESTIVE/STOMACH (abdominal pain, rectal bleeding, change in bowel habits, black stool, red blood in stool, diarrhea, persistent indigestion, frequent nausea, vomiting, vomiting blood, loss of appetite, weight loss. SKIN (persistent problems; rashes, irritation, hives, boils, changes in color, sores, discolored areas, dry/cracked/red areas, pinpoint dots, burns, contact dermatitis, eczema, peeling hands and arms, thickening, yellowing). VISION/EYES (eyes burning, burns on eyes, conjunctivitis, blurred vision, dry eyes, blindness in either eye, severe eye pain, chronic eye irritation, vision difficulty, vision decrease, frequent tearing of eyes, swelling of eyes, uncontrolled eye movement, loss of ability to see colors, trembling of eyelids, yellowing of eyes).

[16] A possible explanation is that, given the topography and forest cover in many parts of rural Pennsylvania, distances to facilities (which were largely reported by survey participants and, where possible using publicly available data, verified by the project coordinator) were not exact because they were not visually apparent. In addition, natural features, wind speed, and other factors can also determine how far chemicals can travel at any given point in time. It is also possible that those living farther away from facilities may have certain symptoms because they are more directly downwind and therefore have more consistent, longer-term exposure to airborne contaminants than those living even closer to facilities. Or, facilities closer to some of the survey respondents may have had better

pollution control technologies or were processing different qualities of gas (e.g., wet gas contains higher concentrations of liquid hydrocarbons than dry gas) and therefore were emitting fewer of the chemicals that could cause these symptoms.

[17] Not only the respiratory tract, but other organs as well are affected by air pollution. Thus volatile hydrocarbons and carbon monoxide are transported to the brain and heart via the blood. Symptoms such as headaches, giddiness, nausea and pounding of the heart are the first indications of excessive exposure. In addition, according to the Swiss National Air Pollution Monitoring network, headaches can be an early indicator of excessive exposure to air pollutants such as volatile organic compounds. http://www.bafu.admin.ch/publikationen/publikation/00652/index.html?lang=en&download=NHzLpZig7t,lnp6I0NTU042l2Z6ln1ad1lZn4Z2qZpnO2Yuq2Z6qpJCGdn99fGym162dpYbUzd,Gpd6emK2Oz9aGodetmqaN19XI2!dvoaCVZ,s-.pdf

[18] For example, frequent nosebleeds are more common among children because their mucousal membranes are less developed. If there are toxic chemicals in the air, nosebleeds in children may be an early-warning sign of an excessive exposure. This symptom has been experienced by other children in oil and gas producing areas and reported in previous reports by Earthworks OGAP.

[19] Table includes all smokers. There were 27 smokers between the ages of 24 and 70. The table compares the results from the smoking sub-group to the sub-group of non-smokers who were between similar ages (23-70 years old). Not included in this calculation were 22 non-smokers who were either younger or older.

[20] Eight of the samples (23.5%) were analyzed by Pace Analytical Services, nine (26.5%) by Con-Test Analytical Laboratory, and seventeen (50%) by Columbia Laboratories.

[21] Some studies calculate the average/mean by including all samples, and for non-detects a value equal to 1/2 of the minimum reporting limit (MRL)/detection limit is used. (For example, see: Pennsylvania DEP. Southern Delaware County Report. http://www.dep.state.pa.us/dep/deputate/airwaste/aq/toxics/projects/sdel/sdelrpt3.pdf We did not do that because the one laboratory, Pace Analytical, had MRLs that were often much higher than the values actually detected by the other two laboratories. So the means would have been skewed (i.e., most likely higher than actual ambient concentrations).

[22] Pace Analytical reporting limits were reported in parts per billion volume (ppbv). We converted ppbv to micrograms per cubic meters (µg/m3). To convert values we used equations from "Air Unit Conversion Table" (Torrent Labs) http://www.torrentlab.com/torrent/Home/ResourceCenter.html and EnviroGroup http://www.envirogroup.com/IA%20Unit%20Conversion%20Table.xls.

[23] Even though we found more VOCs and higher concentrations of the chemicals in Washington County than other counties, this does not necessarily mean that Washington County has worse air quality than other counties in this study. More research would be needed to confirm that, especially given that more samples were taken in Washington than in other counties in our study, thus increasing the chances for detection of VOCs. It is also possible that in some places, sampling did not occur when facilities were emitting high concentrations of chemicals or precisely when the wind was blowing contaminants toward canisters.

[24] Ibid.

[25] According to DEP, the Marcus Hook ambient air sampling site was chosen because it is "close to several industrial facilities and near roads with high traffic volumes." *PA DEP. 2003. Southern Delaware County Air Monitoring Project. Third Interim Report.* p. 4. www.dep.state.pa.us/dep/deputate/airwaste/aq/toxics/projects/sdel/sdelrpt3.pdf Data are for the 2010 monitoring year and were downloaded from DEP's website: www.dep.state.pa.us/dep/deputate/airwaste/aq/toxics/sites/sdc.htm (both accessed September 20, 2012).

[26] For example, 1,1,2-trichloro-1,2,2-trifluoroethane, dichlorodifluoromethane, trichlorofluoromethane and chloromethane were once used as refrigerants and propellants but have been phased out due to destruction of the ozone layer. Carbon tetrachloride was used to produce these refrigerants but its production declined as use of the other chemicals was banned.

[27] See Pennsylvania Department of Environmental Protection, Northeastern Pennsylvania Marcellus Shale Short-Term Ambient Air Sampling Report; Northcentral Pennsylvania Marcellus Shale Short-Term Ambient Air Sampling Report, 2011; and Southwestern Pennsylvania Marcellus Shale Short-Term Ambient Air Sampling Report, 2010.

[28] U.S. Environmental Protection Agency. Ambient Air Concentrations of Benzene. In the "Metadata" section EPA explains that this does not necessarily represent a national trend because the data come from just 22 urban sites. http://cfpub.epa.gov/eroe/index.cfm?fuseaction=detail.viewInd&lv=list.listbyalpha&r=231333&subtop=341 (accessed September 20, 2012).

[29] The five highest concentrations from our study were found in Butler: 1.5, 1.0 µg /m3; and Washington: 1.5, 1.4, 1.2 µg/m3.

[30] U.S. Environmental Protection Agency. "Technology Transfer Network Air Toxics Site: Formaldehyde." http://www.epa.gov/ttn/atw/hlthef/formalde.html (accessed September 20, 2012).

[31] C.D. Volz et al., Contaminant Characterization of Effluent from Pennsylvania Brine Treatment Inc., Josephine Facility Being Released into Blacklick Creek, Indiana County, Pennsylvania. Department of Environmental and Occupational Health, University of Pittsburgh, 2011.

[32] Pennsylvania Department of Environmental Protection, Division of Drinking Water Management, "Maximum Contaminant Levels," www.portal.state.pa.us/portal/server.pt?open=18&objID=437830&mode=2 (accessed July 20, 2012).

[33] Tom Myers, PhD. "Assessment of Groundwater Sampling Results Completed by the USGS." (Technical memo prepared for Earthworks, Natural Resources Defense Council, and Sierra Club. September, 2012.

[34] For example, according to the National Science Foundation, "Pennsylvania's air, water and soils retain the signature of the steel industry and of coal-burning over the last century in their low-level manganese contamination." National Science Foundation. Sidney Draggan, PhD (Topic Editor), "Can Marcellus Shale Development and Healthy Waterways Co-exist?" Last revised August 8, 2012 (accessed October 2, 2012). http://www.eoearth.org/article/Marcellus_Shale_Gas_Development_and_Healthy_Waterways?topic=49463

[35] Boyer, E., Swistock, B., Clark, J., Madden, M. and Rizzo, D. (Pennsylvania State University). 2011. *The Impact of Marcellus Gas Drilling on Rural Drinking Water Supplies.* The Center for Rural Pennsylvania. http://www.rural.palegislature.us/documents/reports/Marcellus_and_drinking_water_2012.pdf

[36] ibid. p. 12.

[37] Banks, T. Jan. 2011. "Fluid Rock Interactions Associated with Hydraulic Fracturing and Natural Gas Development." *Global Water Program Magazine.* (Johns Hopkins University) http://globalwater.jhu.edu/magazine/article/fluid_rock_interactions_associated_with_hydraulic_fracturing_and_natural_ga/

[38] ProChemTech International, Inc. "Marcellus Gas Well Hydrofracture Wastewater Disposal by Recycle Treatment Process." www.prochemtech.com/Literature/TAB/PDF_TAB_Marcellus_Hydrofracture_Disposal_by_Recycle_1009.pdf (accessed September 20, 2012).

[39] Boyer, E., Swistock, B., Clark, J., Madden, M. and Rizzo, D. (Pennsylvania State University). 2011. The Impact of Marcellus Gas Drilling on Rural Drinking Water Supplies. The Center for Rural Pennsylvania. http://www.rural.palegislature.us/documents/reports/Marcellus_and_drinking_water_2012.pdf

[40] R. Witter et al., *Potential Exposure-Related Human Health Effects of Oil and Gas Development: A Literature Review (2003-2008).* Colorado School of Public Health, 2008; and T. Colborn et al., "Natural gas operations from a public health perspective," *Human & Ecological Risk Assessment* 17(5) (2011): 1039-1056.

[41] Agency for Toxic Substances and Disease Registry (ATSDR), "Toxicological Profiles," http://www.atsdr.cdc.gov/toxprofiles/index.asp (accessed July 30, 2012); and New Jersey Department of Health, "Right to Know Hazardous Substance Fact Sheets," http://web.doh.state.nj.us/rtkhsfs/indexfs.aspx (accessed July 30, 2012).

[42] "Community Health Survey of Current and Former Residents of DISH, Texas." Earthworks OGAP, 2009. http://earthworksaction.org/publications.cfm?publID=438; and Lisa Sumi, Earthworks' Oil & Gas Accountability Project, "Air Sampling Conducted in Monroe, Conecuh, and Escambia Counties, Alabama," 2007.

[43] "The Health Impact Assessment of New Energy Sources: Shale Gas Extraction." Announcement and summary of meeting at the Institute of Medicine, April 30-May 1, 2012. See www.iom.edu/Activities/Environment/EnvironmentalHealthRT/2012-APR-30.aspx, (accessed June 27, 2012).

[44] U.S. Environmental Protection Agency. "Ambient Air Monitoring Program." http://www.epa.gov/airquality/qa/monprog.html (accessed September 20, 2012).

[45] Clean Air Council. "PA DEP launches long-term air sampling." http://cleanair.org/program/outdoor_air_pollution/marcellus_shale/pa_dep_launches_long_term_air_sampling (accessed September 20, 2012).

[46] Pennsylvania law is unique in establishing a "zone of presumption," by which operators of unconventional (i.e., shale) wells are responsible for pollution of a water supply if it is up to 2,500 feet away and the pollution occurred within 12 months of completion, drilling, stimulation, or alteration of the well. Operators are required to share this baseline information with homeowners. However, they can rebut the presumption under certain conditions. See "Act 13 Frequently Asked Questions," Pennsylvania Department of Environmental Protection: www.portal.state.pa.us/portal/server.pt/community/act_13/20789/act_13_faq/1127392, (accessed July 3, 2012). Colorado requires baseline surface water sampling in particular sensitive areas, downgradient of wells before and three months after drilling, operations, and completion; nearby landowners are provided with the test results: "COGA Baseline Groundwater Quality Sampling Program," www.coga.org/index.php/BaselineWaterSampling/FAQ (accessed August 15, 2012). Ohio requires permit applicants to conduct water sampling prior to drilling, at distances from wells of 300 feet in urban areas and 1,500 feet anywhere if horizontal drilling occurs. See summary of Senate Bill 315 by Ohio Department of Natural Resources: www.ohiodnr.com/tabid/23947/Default.aspx (accessed July 6, 2012).

[47] See, for example, NIOSH Pocket Guide to Chemical Exposures (including recommended exposure limits), Centers for Disease Control and Prevention. www.cdc.gov/niosh/npg/; "National Primary Drinking Water Regulations" (including maximum contaminant levels), U.S. Environmental Protection Agency. http://water.epa.gov/drink/contaminants/index.cfm; "Permissable Exposure Limits," U.S. Occupational Safety and Health Administration. www.osha.gov/SLTC/pel/ (all accessed July 20, 2012).

[48] Assessment of Joint Toxic Action of Chemical Mixtures. Guidance Manual. Agency for Toxic Substances and Disease Registry. 2004. Available at www.atsdr.cdc.gov/interactionprofiles/ipga.html (accessed July 20, 2012).

[49] Birnbaum, L.S. "Environmental Chemicals: Evaluating Low-Dose Effects." *Environmental Health Perspectives*, 120(4)A143-144, 2012.

[50] Vandenberg, L.N., Colborn, T., Hayes, T.B., et al. "Hormones and Endocrine-Disrupting Chemicals: Low-Dose Effects and Nonmonotonic Dose Responses." *Endocrine Reviews* 33: 0000–0000, 2012.

[51] Morello-Frosch, R.A., Woodruff, T.J., Axelrad, D.A., and Caldwell, J.C. "Air toxics and health risks in California: the public health implications of outdoor concentrations." *Risk Analysis*, 20(2):273-91, 2000.

[52] Colborn; T., Kwiatkowski, C., Schultz, K., and Bachran, M. "Natural gas operations from a public health perspective." 2011. *Human & Ecological Risk Assessment* 17(5):1039-1056.

[53] McKenzie, LM., Witter, R.Z., Newman L.S., Adgate J.L.. "Human Health Risk Assessment of Air Emissions from Development of Unconventional Natural Gas Resources." *Science of the Total Environment.* 2012 May 1;424:79-87.

[54] Bamberger, M. and Oswald, Robert E. "Impacts of Gas Drilling on Human and Animal Health." *New Solutions: A Journal of Environmental and Occupational Health Policy.* Vol 22(1)51-77, 2012.

[55] Goldstein, B., Kriesky, J., Pavliakova, B. "Missing from the Table: Role of the Environmental Public Health Community in Governmental Advisory Commissions Related to Marcellus Shale Drilling." *Environmental Health Perspectives.* Vol 120(4)483-486, 2012.

[56] Comments on New York's draft Supplemental Generic Environmental Impact Statement. Earthworks' OGAP. December 2011. www.earthworksaction.org/library/detail/earthworks_new_york_sgeis_comments

[57] "States with NEPA-like Environmental Planning Requirements." Council on Environmental Quality, National Environmental Policy Act website. http://ceq.hss.doe.gov/state_information/states.html (accessed June 27, 2012).

[58] The most notable examples are the North Slope of Alaska and Garfield County, Colorado. Health Impact Project, "HIA in the United States," www.healthimpactproject.org/hia/us, (accessed June 27, 2012).

59 Earthworks. "Loopholes for Polluters: The oil and gas industry's exemptions to major environmental laws." 2011. While some states have begun to adopt and strengthen disclosure laws, and industry has a website for limited, voluntary disclosure (see www.FracFocus.org), operators are still largely able to keep secret the types, mixtures, and concentrations of chemicals used and to claim proprietary "trade secret" privileges. See "Disclosure of toxic oil and gas chemicals," www.earthworksaction.org/issues/detail/disclosure_of_oil_and_gas_hazardous_chemicals. On air emissions, see "The BREATHE Act," www.earthworksaction.org/issues/detail/the_breathe_act (accessed July 3, 2012).

[60] Earthworks' Oil & Gas Accountability Project. Breaking All the Rules: the crisis in oil and gas regulatory enforcement. 2012.

[61] Earthworks' Oil & Gas Accountability Project. Enforcement Report: Pennsylvania Department of Environmental Protection. 2012.

[62] A. Wernham, "Health Impact Assessment for Shale Gas Extraction," www.healthimpactproject.org/resources/health-impact-assessment-for-shale-gas-extraction (accessed July 10, 2012).

[63] Garfield County, Colorado, "Battlement Mesa Health Impact Assessment," www.garfield-county.com/environmental-health/battlement-mesa-health-impact-assessment-ehms.aspx (accessed July 10, 2012).

[64] The Southwest Pennsylvania Environmental Health Project has prepared useful materials and presentations in this regard. See "Health concerns in the era of gas drilling—a basic toolkit for health care providers." www.environmentalhealthproject.org/resources/medical-resources (accessed September 15, 2012).

[65] Replacement water supplies should also be provided when changes in the quality and safety of drinking water occur following nearby gas operations—as required by Pennsylvania law but rarely enforced. See Pennsylvania Code, Oil and Gas Wells, Chapter 78, Section 51, "Protection of Water Supplies." http://www.pacode.com/secure/data/025/chapter78/chap78toc.html (accessed July 20, 2012).

[66] Earthjustice, "Fracking Damage Cases and Industry Secrecy," http://earthjustice.org/features/campaigns/fracking-damage-cases-and-industry-secrecy (accessed July 10, 2012).

[67] Science and Environmental Health Network, "Wingspread Consensus Statement on the Precautionary Principle," 1998, www.sehn.org/wing.html (accessed July 18, 2012).

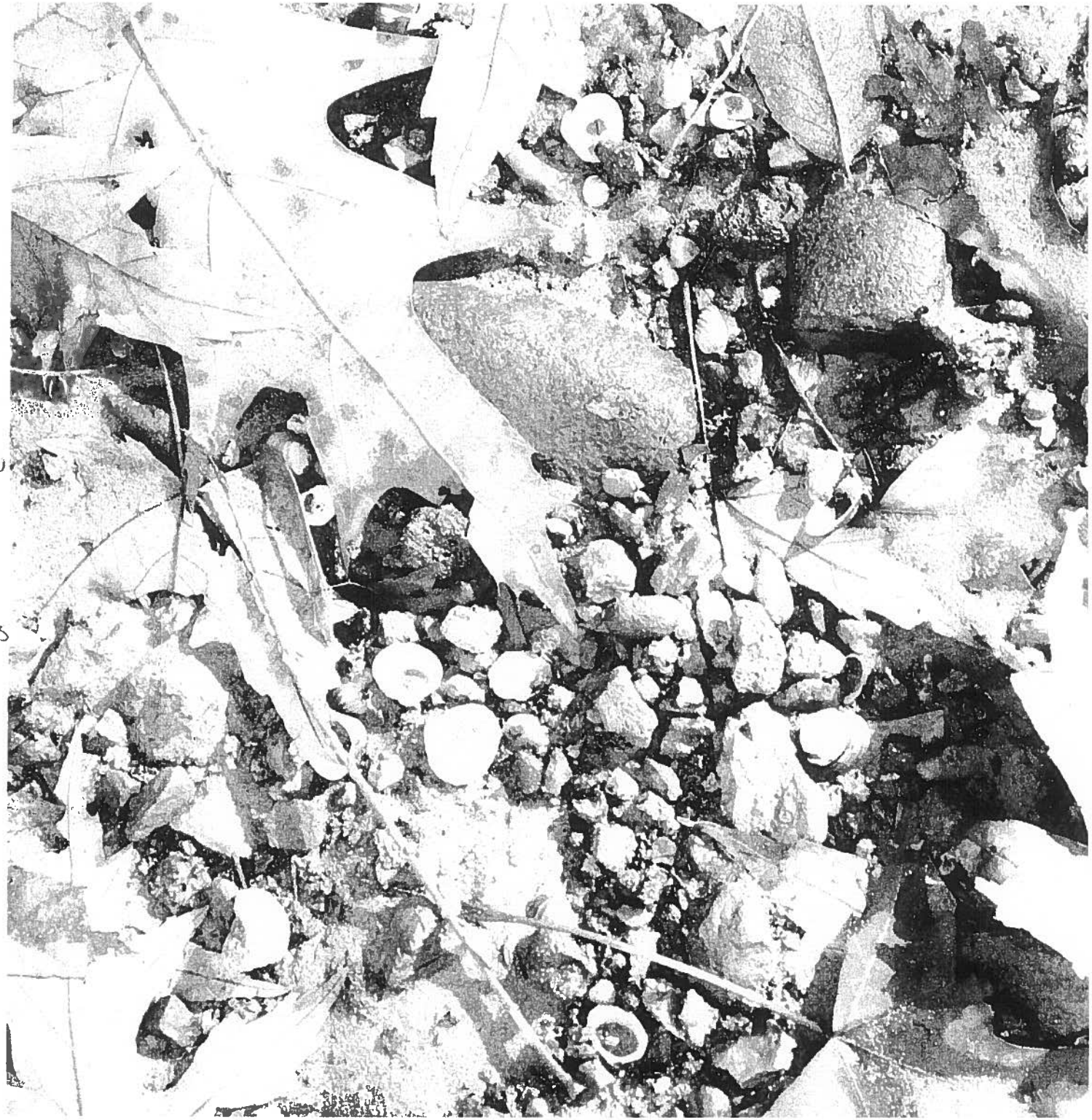

OGAP

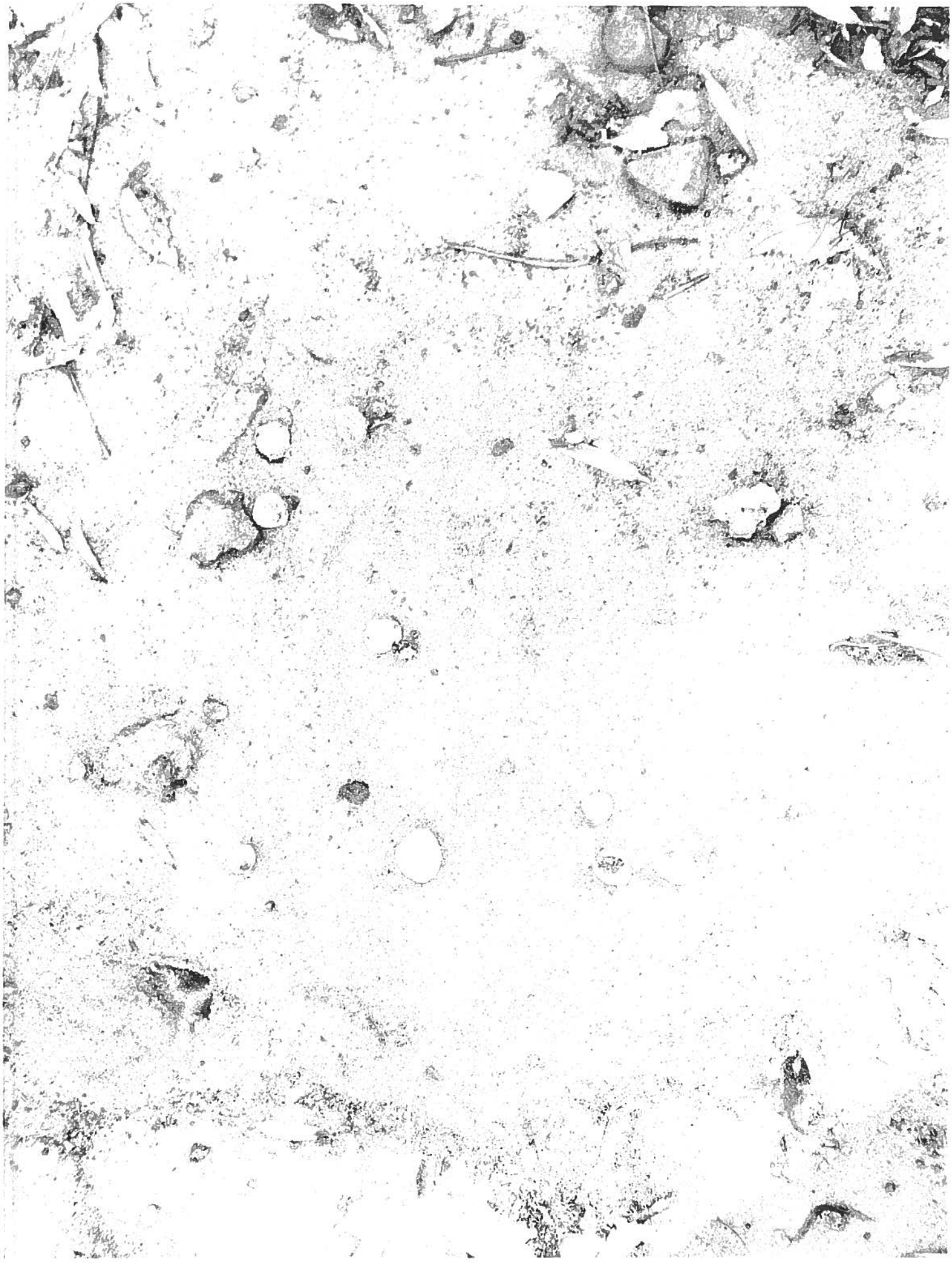
photos of 2 condensate Tanks on well pads. What types of V.O.C. being omitted into the air people are having health problems

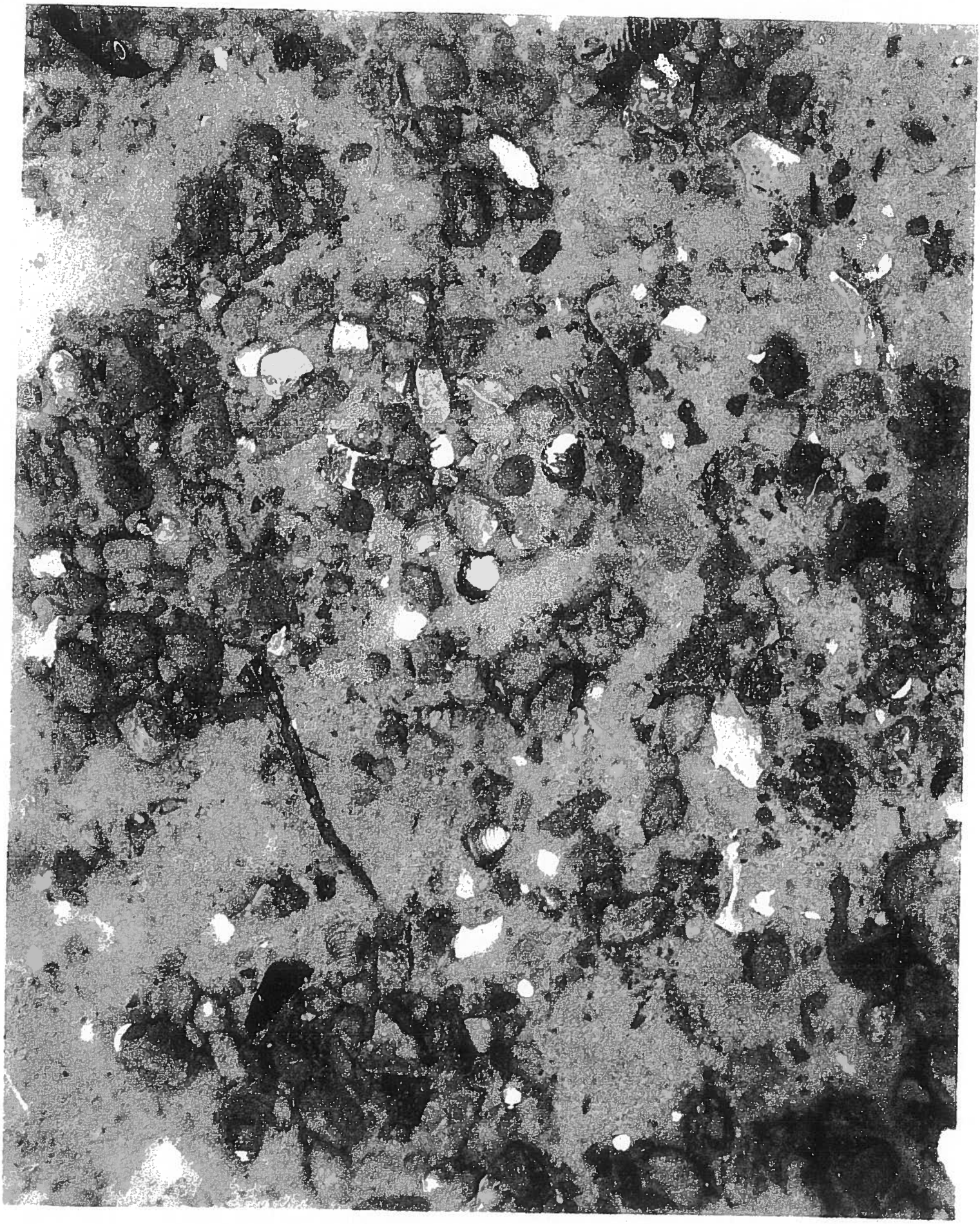
Photos of dead clam shells all along the Mon River and streams of water that run into the mon-river

The clams shells dead, that are in the small streams are an indicator that fresh water in these streams has been impacted with bromides and other chemicals from the drilling.

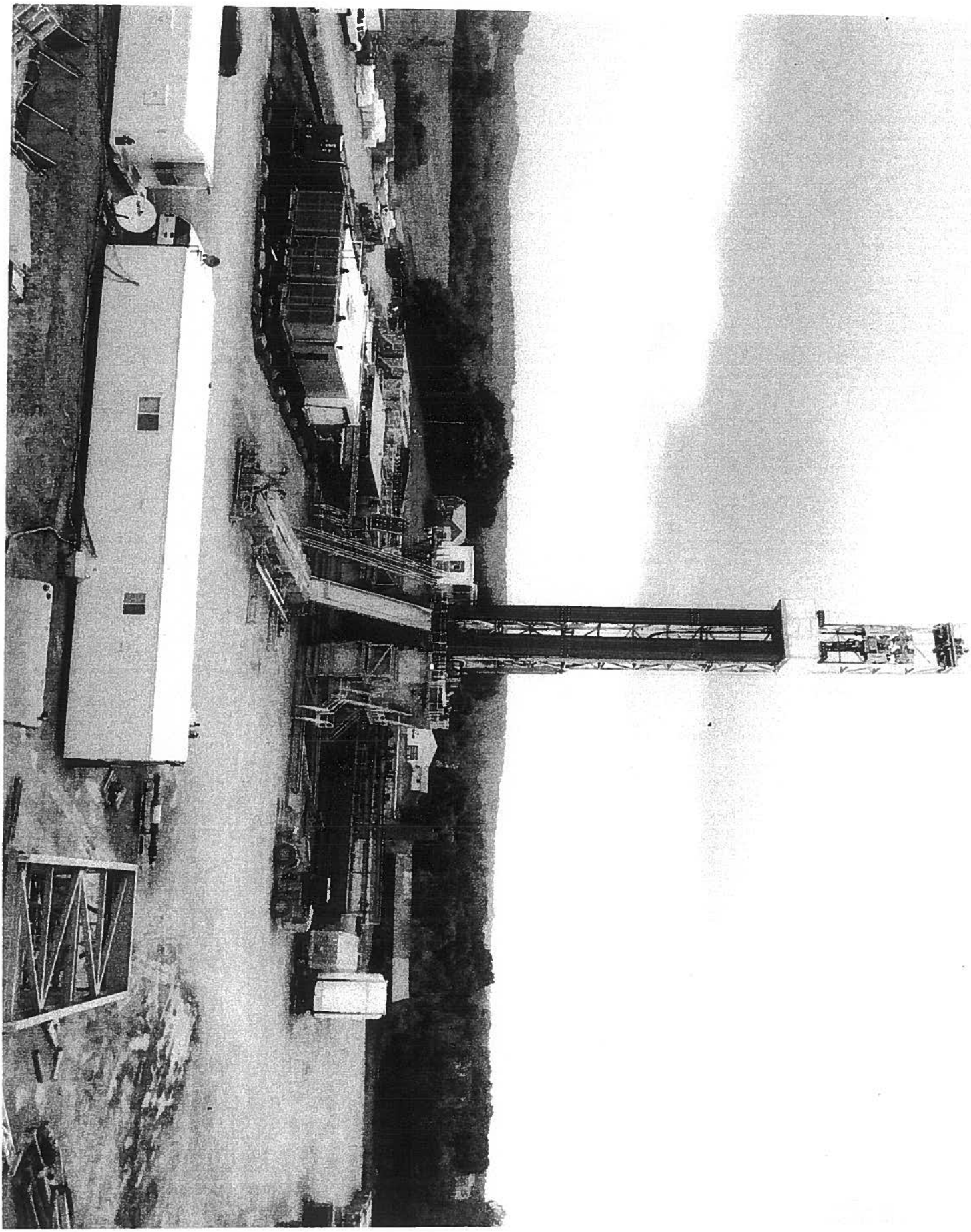
Same as a coal miner years ago used canary bird to monitor the air in the mines to warn the coal miners that the methane was high







Well pad 600ft from a trailer park. People were getting sick.



Take with a night camera. What type of chemicals are in the air bubbles. (UEP was
Why are alot of people sick with cancers in these bodies from compressor station. Notified

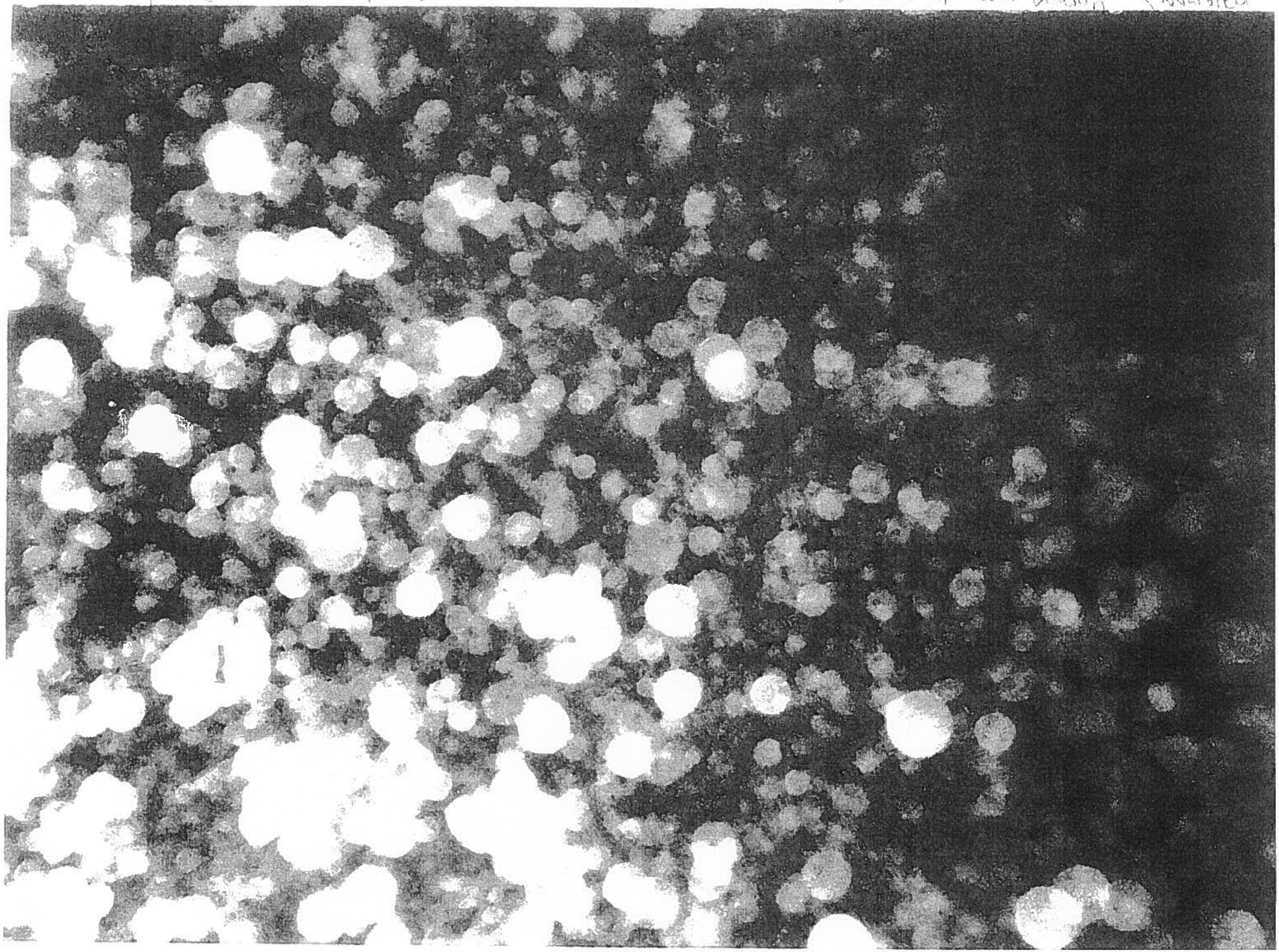
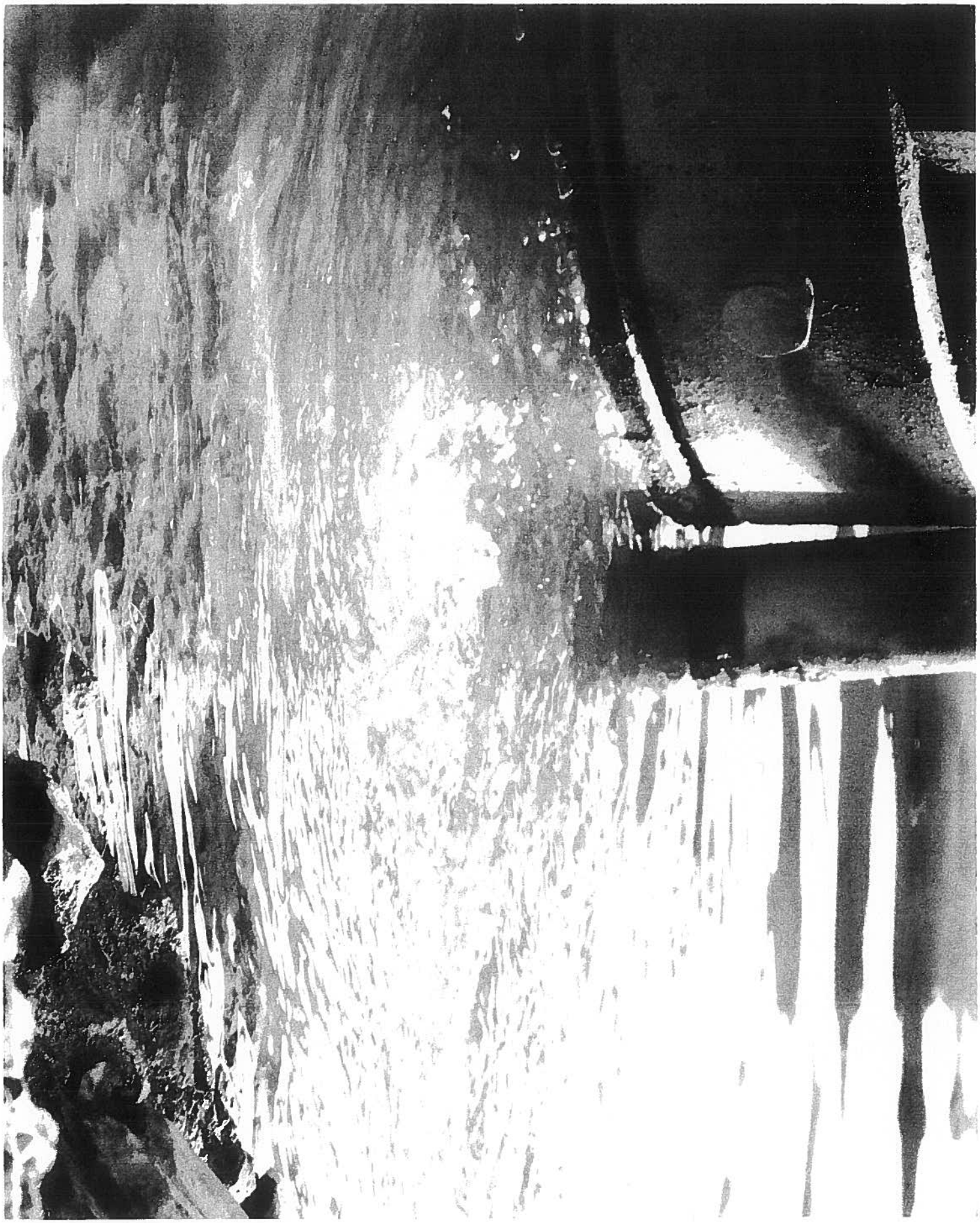


Photo of marcellus well leaking methane and other V.O.C.
Methane is 25 to 30% more pollutent than C.O.2 From coal Fired PowerPlants



Gas well leaking methane gas

Methane gas that we lit on fire after the fracked a well. Water is coming from ~~A~~ spring water that cattle drank from cattle will no long drink this water from spring

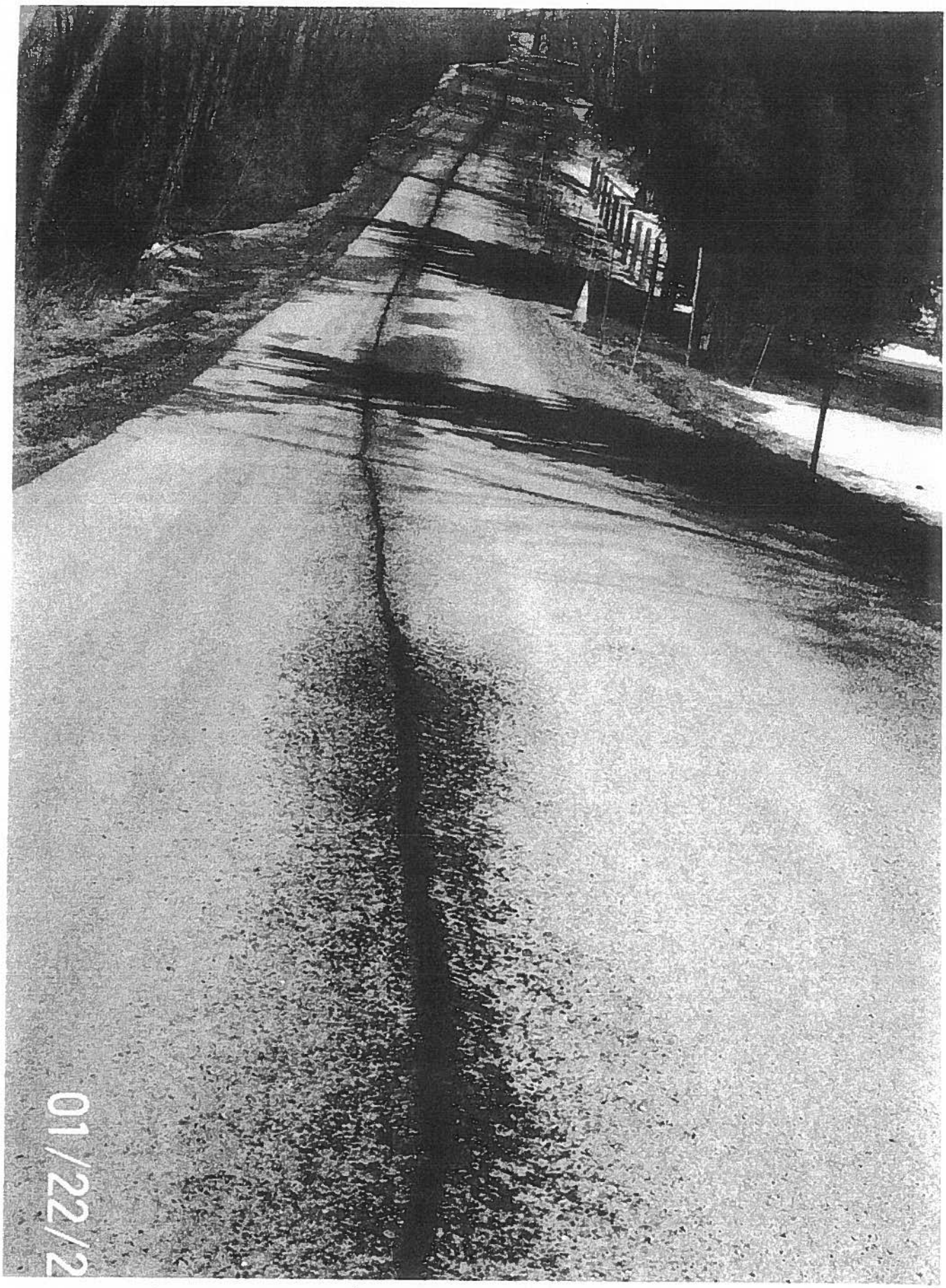
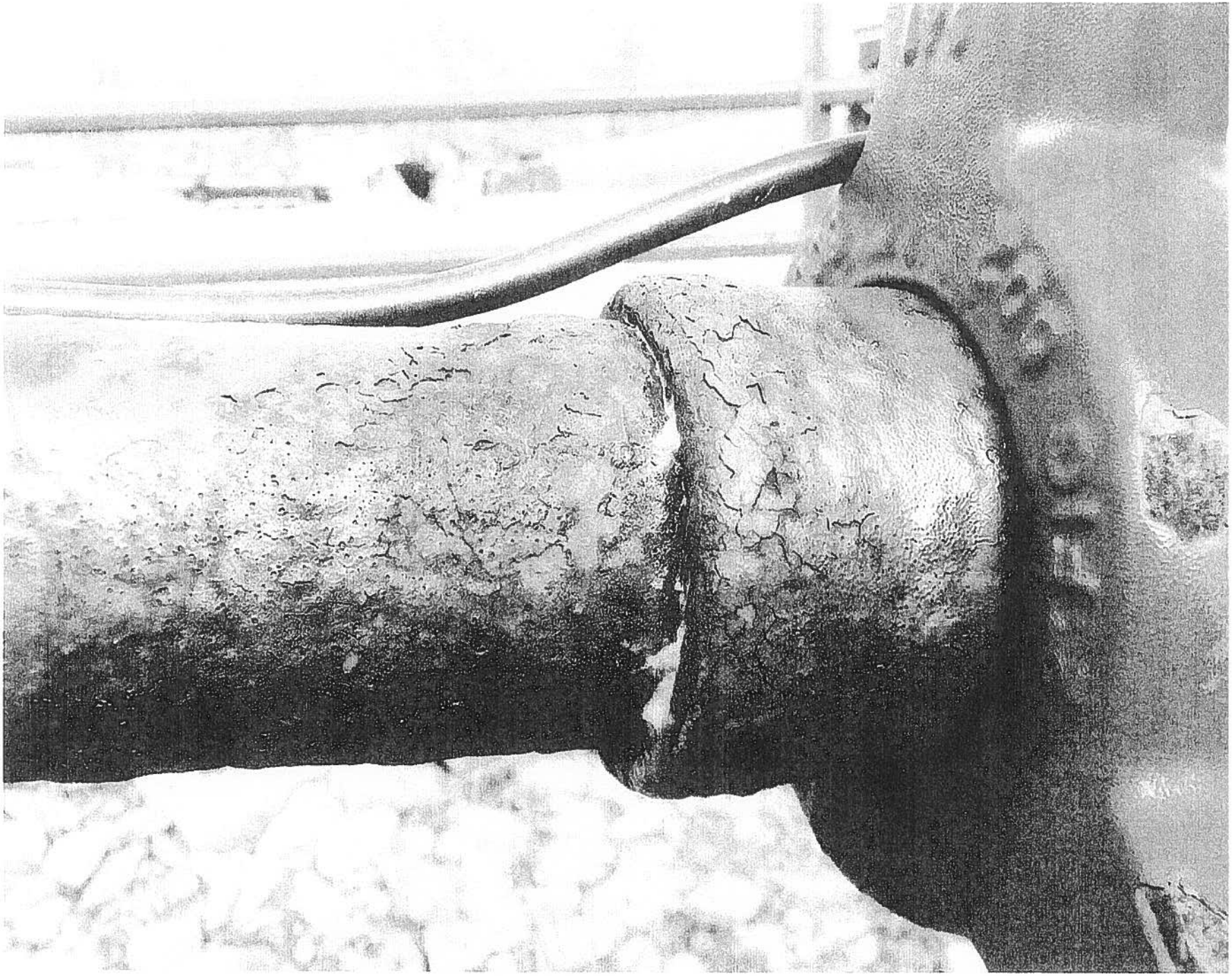


Photo of truck that left well pad and dumped flow back water onto road and drove 9 miles. This is happening every where

I have been meeting w/ foreign delegates from all over the world and to educate them on what the drilling companies are doing to use this is a photo of 26 different nations

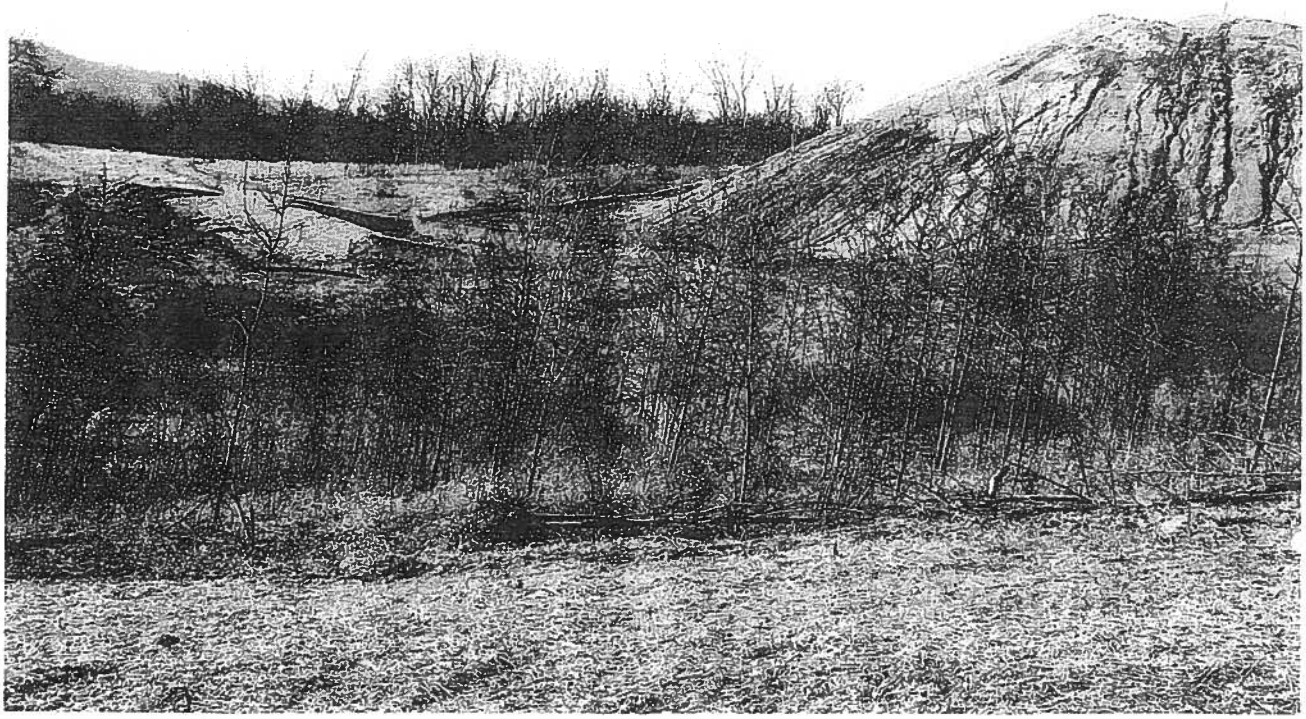
July 2013 Photo #2

1. SERGE BLUDS DC CELO
2. MAXWELL OZONOH — NIGERIA
3. WILFRED NIWAGABA — UGANDA
4. Rachel Cheeseborough MD (ELO)
5. DESIRÉ ZINGA — ANGOLA
6. Ganchua PUREVJAV — Mongolia
7. Gail Shott — Pittsburgh PA
8. Yuri Gorby
Sempertiv ✓ 9 PETER MONTAGUE CHEVY CHASE, M.
10 Lenore Lesick — US
11. Howard Lukasiewsko — PL
12 Jeremy Bernardinelli — Monessen PA
13 Eli Neophytou — CYPRUS
14. SANJA SYRKOTA — MONTENEGRO
15. JAHEL MIELKE — GERMANY
16. NATHAN BITTLE — New Zealand
17. SILVIA VLASCEANU — ROMANIA
18. SALISHA GOMES — TRINIDAD AND TOBAGO
19 IBRAHIM SAID ARINC — TURKEY
20 NGUYEN THE THANG — VIET NAM
21 YOUSSEF MEJAI — TUNISIA
22 Raouzi Mannoubi — Tunisia
23 Dorothy Bassett Washington Co, PA
24 DR. BHARATKUMAR VIRABHAI GAMI — INDIA
25 Yanping Shen — China



Leaking V.O.C. from well head.

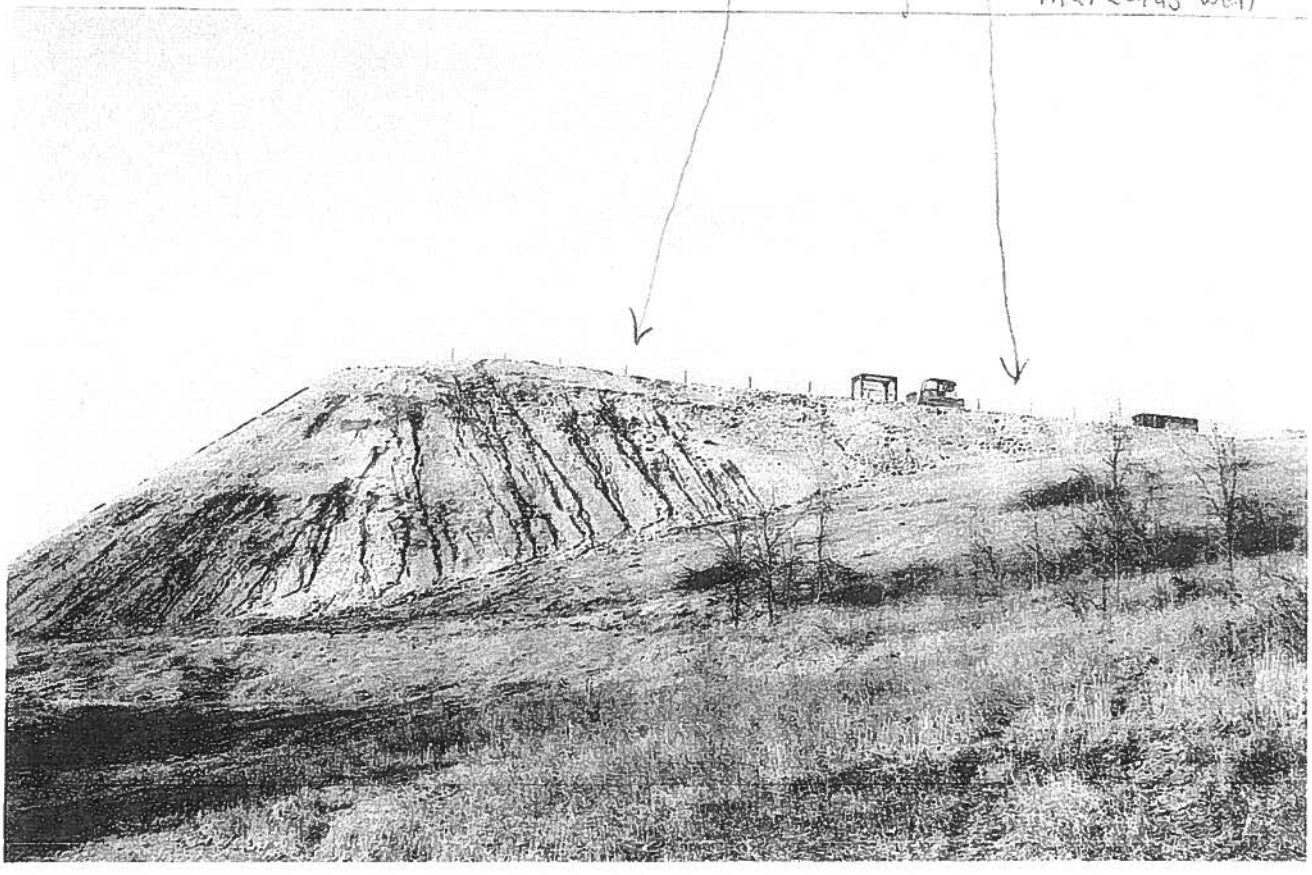
House located here
XXX



Photos of drill pad. Destroyed nearly 90 acres of farm land, I used help to put up hay on this farm.

Hills side collapsed down the hill near house

Location of drill rig marcellus well



White spots in photo is marine life being dumped

Impoundment pond on same farm

This is suspose to be fresh water, Does it look [redacted] like to you,

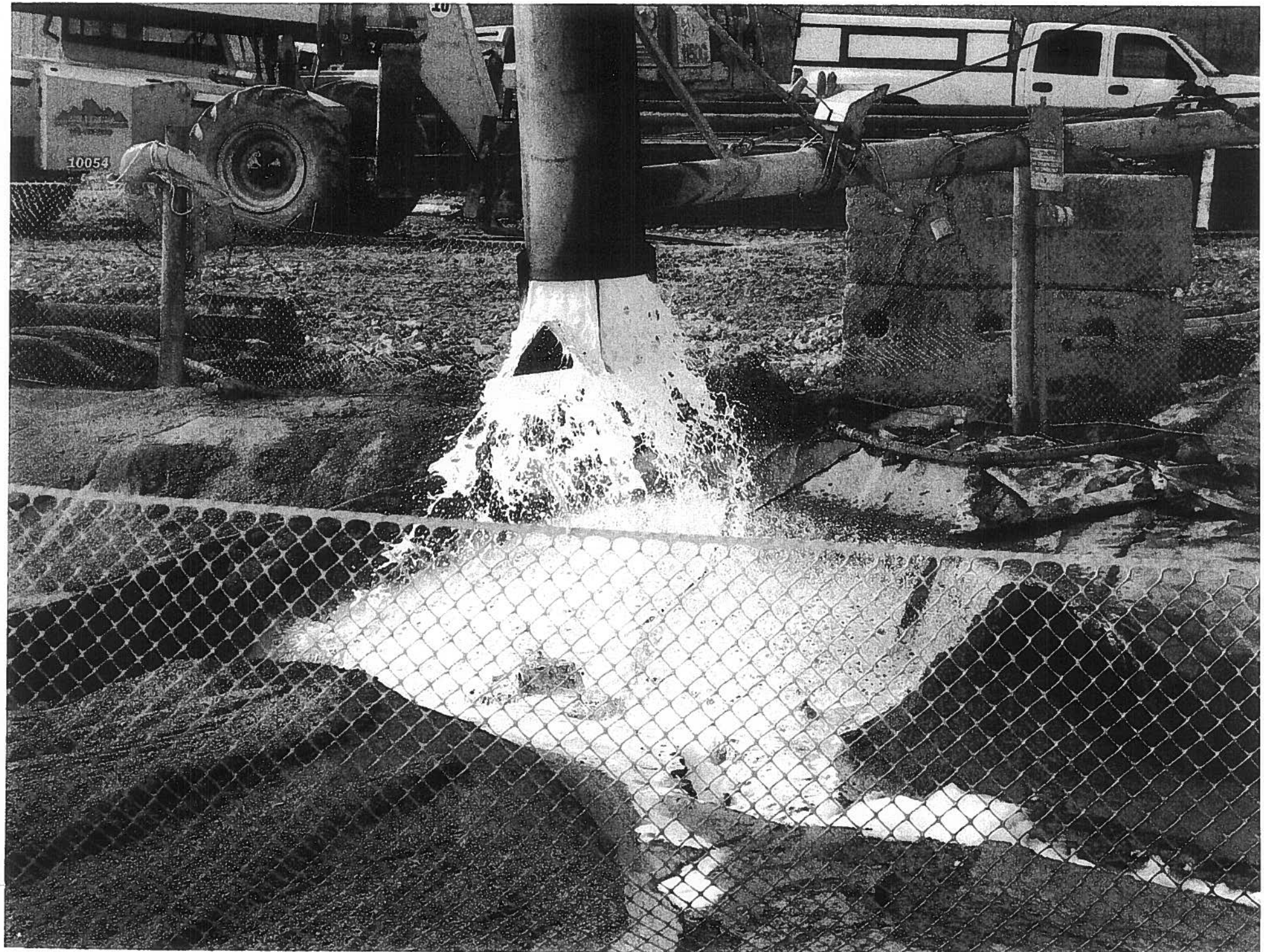


Photo of drilling fluids next to the right

Thousand acres of forest being destroyed by pipe line along with wild life Habitat were wild animals live


Compressor Station
Pipe Line
Pipe Lines

photos: chemicals used to control vegetation along roads and near water. when spraying the chemicals end up in water

Pipeline company had a fifty foot right of way Paid the farmer $1,200.00 and ended up take a 100 ft. right of way. Destroyed all the trees for about three foot right away. Trees moved [illegible]