Report on Air Sampling Conducted in Monroe, Conecuh and Escambia Counties, Alabama (August 1-5, 2005)

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EXECUTIVE SUMMARY

In August, 2005, Wilma Subra and the Oil and Gas Accountability Project spent five days in Monroe, Conecuh and Escambia counties in Alabama. The purpose of the visit was to measure concentrations of hydrogen sulfide (H_2S) and volatile organic compounds (VOCs) in the vicinity of known sources of air emissions, and to measure ambient concentrations of H_2S and VOCs in residential neighborhoods. The goal of the project was not to identify facilities that have been breaking air quality laws, but rather, to determine if there is a potential air pollution problem that needs to be investigated and addressed in order to protect the health of the citizens in these Alabama counties.

Hydrogen sulfide may be released during the extraction, production and refinement oil and natural gas. Other industrial sources of H_2S include pulp and paper manufacturing, sewage treatment plants, manure-handling operations, leather tanneries, rayon production, and coke oven plants.

State agencies from across the United States have received H_2S-related complaints from citizens. Based on these complaints, agencies in Arkansas, Louisiana, New Mexico, and North Dakota have performed monitoring around oil and gas facilities. Concentrations have varied from location to location, with average concentrations at all sites in the low parts per billion level, and maximum H_2S concentrations ranging from 35 ppb to 15,000 ppb (i.e., 15 parts per million).

Research suggests that long-term exposure to H_2S at concentrations above 7 ppb may affect the ear, nose and throat, and damage the central nervous and respiratory systems, and that some health effects may be permanent. High concentrations (above 1,000 ppm) may cause immediate collapse and death.

Oil and natural gas contain varying amounts and species of volatile organic compounds, and consequently, during the extraction, processing and distribution of oil and gas, a variety of VOCs may be released (e.g., via leaky equipment and tank hatches, or through intentional venting and flaring of natural gas).

A recent study conducted in Colorado demonstrates that volatile organic compounds associated with oil and natural gas production have the potential to be released at concentrations that are harmful to human health. Maximum concentrations of 56 parts per billion were measured close to oil and gas facilities in Garfield County, Colorado; this is close to three times what the California Environmental Protection Agency has set as the concentration at which no adverse health effects are likely to occur.

Several VOCs are linked to health problems in humans. Harmful VOCs include 1-3 butadiene, benzene, ethylbenzene, toluene and xylenes, all of which have been associated with oil and gas production.

In our study, hydrogen sulfide levels sampled in residential areas were measured at concentrations in the 100s and 1,000s of parts per billion. This is significantly elevated compared to normal urban background levels, which are typically less than 1 ppb, but comparable to other oil and gas regions in the U.S., where levels of H_2S have been measured in the 100-15,000 ppb range in the vicinity of wells and facilities.

Total VOC levels were frequently measured in the parts per million range. Since our study did not include the identification of specific VOCs in air, it is strongly recommended that attempts be made by government agencies to identify and monitor the concentrations of VOCs in the air in Monroe, Escambia and Conecuh counties. Not only may individual VOCs, such as benzene, be contributing to health problems in the area, the VOCs may also be contributing to the formation of ground-level ozone, which is also a health hazard.

Based on the findings for both H_2S and VOCs, it is recommended that monitoring occur both in residential and oil and gas production areas. This will help to hone-in on operations that may be emitting large volumes of H_2S and VOCs, and evaluate whether the concentrations in residential neighborhoods are posing a threat to human health and the environment.

1.0 BACKGROUND

In 2004, Wilma Subra, an environmental chemist from Louisiana, was contact by Audrey Silcox and Thomas McKenzie. At the time, Silcox and McKenzie were living in the same rural-residential area of Monroe County, Alabama. Both Silcox and McKenzie had been experiencing health problems, but their doctors had not been able to determine the cause of their symptoms. Other members of the Silcox and McKenzie families, as well as neighbors and other residents in Monroe and nearby Conecuh county, had also been experiencing similar health issues.

Subra, who has worked for decades on environmental pollution and community health issues, visited with Silcox and McKenzie to try to determine if there might be a connection between environmental pollution and their health problems. During Subra's visit, and based on her research, it occurred to her that the oil and gas facilities located throughout the county were possible sources of air contamination that could be affecting residents' health.

There are both sweet and sour oil and gas wells in Monroe and neighboring counties – sour gas contains high concentrations of hydrogen sulfide (H_2S). Subra, who is familiar with oil and gas air emissions, was able to smell H_2S and volatile organic compounds (VOCs) during her tour of the area.

During a subsequent visit to Monroe County, efforts were made by Subra to encourage various federal and state agencies to examine the potential problems with air emissions in Monroe County. Silcox and McKenzie also asked state agencies to monitor the air quality in the county (Appendix 1). Unfortunately, the requests from Subra, Silcox and McKenzie were unsuccessful, and to-date no agency has seriously undertaken an investigation of air emissions from oil and gas or other facilities in the county.

In August, 2005, Wilma Subra and the Oil and Gas Accountability Project spent five days in Monroe, Conecuh and Escambia counties. The purpose of the visit was to measure concentrations of hydrogen sulfide and volatile organic compounds in the vicinity of known sources of air emissions, and to measure ambient concentrations of H_2S and VOCs in residential neighborhoods. The goal of the project was not to identify facilities that have been breaking air quality laws, but rather, to determine if there is a potential air pollution problem that needs to be investigated and addressed in order to protect the health of the citizens in these Alabama counties.

2.0 METHODS

Hydrogen sulfide was measured using a Jerome 631-X hydrogen sulfide analyzer, which has a detection level of 0.001 ppm.

Volatile Organic Compounds (VOCs) were measured using a "ppb-Rae" portable photo-ionization detector (PID). The ppb-RAE is a broad-spectrum monitor that measures the total concentration of VOCs that have a carbon range from one to ten (C1 – C10). It should be noted that this PID <u>does not measure methane</u> (and only weakly detects ethane).[1]

This particular PID was chosen because of the ability of the ppb-RAE to detect VOCs at concentrations as low as 1 ppb, and as high as 199 ppm. One drawback of this monitoring device is that it measures the total concentration of VOCs (excluding methane), but cannot tell the user which particular gases are present when there is a mixture of VOCs.

Measurement Dates and Locations

Measurements were taken over a five-day period of August 1-5, 2005.

Data were collected from sites in Monroe, Conecuh and Escambia counties in Alabama. Numerous sites were selected based on their possibility of being sources of H_2S and VOCs (e.g., oil and natural gas facilities; wood product facilities). H_2S and VOC concentrations were measured at the perimeter or in the parking areas of wells sites, gas processing plants, and other industrial facilities. Consequently, the distance between the measurement location and air emission sources (e.g., spilled fluids; flares; other equipment) varied from one location to the next.

Additionally, measurements of ambient H_2S and VOC concentrations took place in residential areas, at varying distances from the potential H_2S /VOC sources. Residential sites were selected based on their proximity to the various sources of air emissions. In some cases, where there was a suspected major emission source, measurements were taken along rough transects away from the source in the direction that the wind was blowing. The purpose of measuring along a transect was to determine the potential areal extent-of-influence of an emission source. Based on GPS locational data, it is possible to determine the air-distance from the source to the sampling locations.

Monitoring Conditions

The monitoring project was limited to a five-day period in August. During this time, the weather was extremely variable, and included sunny days, rain, fog, and at time, fairly strong winds.

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[1] RAE Systems. 2006. *Conversion of PID Readings To Methane Equivalent or Hexane Equivalent FID Response*. Technical Note TN-158. Available from URL: http://www.raesystems.com/~raedocs/App_Tech_Notes/Tech_Notes/TN-158_PID-FID_Conversion.pdf

3.0 LITERATURE REVIEW

3.1 Hydrogen Sulfide

Hydrogen sulfide is a gas that is produced from natural and industrial sources. It has a tell-tale "rotten egg" odor at low concentrations, and is fatal if inhaled at high levels. Being heavier than air, H_2S tends to sink and flow into low-lying areas where it can accumulate in concentrations that can injure or kill livestock, wildlife and human beings.

3.1.1 Sources of H_2S releases

The majority of sources of H_2S to the environment are natural.[2] Hydrogen sulfide is released into the air as a product of the decomposition of dead plant and animal material, especially when this occurs in wet conditions with limited oxygen, such as in swamps. There are also geothermal sources of H_2S, such as hot springs and volcanoes.

In addition to natural sources, human activities also result in the release of H_2S to the atmosphere. The principal source of anthropogenic H_2S is as a by-product in the purification of natural gas and refinement of crude oil.[3] It may also be produced during the extraction oil and natural gas, and other industrial sources of H_2S include pulp and paper manufacturing,[4] sewage treatment plants, manure-handling operations, leather tanneries, rayon production,[5] and coke oven plants.[6]

Within Monroe, Escambia and Conecuh counties, potential sources of H_2S include sewage treatment plants, concentrated animal feeding operations (CAFOs), lumber and wood product operations, and oil and gas facilities.

H_2S from Oil and Natural Gas

Natural gas that contains measurable concentrations of hydrogen sulfide (H_2S) is often terms "sour gas." Depending on the jurisdiction, the official definition of sour gas varies. For example, in Canada, the petroleum industry considers natural gas to be sour if it contains more than 1% H_2S. The U.S. Environmental Protection Agency (EPA)

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[2] U.S. Environmental Protection Agency (EPA). *Report to Congress on Hydrogen Sulfide Air Emissions Associated with the Extraction of Oil and Natural Gas*. EPA-453/R-93-045, October 1993. p.III-4.

[3] Chou, S. 2003. *Hydrogen Sulfide: Human Health Aspects*. Concise International Chemical Assessment Document 53. Prepared for the World Health Organization. p. 6. Available from URL: http://www.who.int/ipcs/publications/cicad/en/cicad53.pdf

[4] New York State Department of Health: Available from URL: http://www.health.state.ny.us/nysdoh/environ/btsa/sulfide.htm

[5] Ammann, 1986, p. 4, ***in*** Collins, James and David Lewis, Air Toxicology and Epidemiology Section, California Office of Environmental Health Hazard Assessment (OEHHA). September 1, 2000. *Hydrogen Sulfide: Evaluation of Current California Air Quality Standards with Respect to Protection of Children*. Prepared for California Air Resources Board, CA OEHHA.

[6] Agency for Toxic Substances and Disease. September 2004. *Public Health Statement for Hydrogen Sulfide*. Available from URL: http://www.atsdr.cdc.gov/toxprofiles/tp114-c1.pdf

considers natural gas to be "sour" if H_2S is present in amounts greater than 5.7 milligrams per normal cubic meters, which is equivalent to 0.25 grains per 100 standard cubic feet.[7]

It has been estimated that 15–25% of natural gas in the U.S. may contain H_2S.[8] Worldwide, the percentage could be as high as 30%. It has been reported, as well, that new drilling is increasingly focused on deep gas formations that tend to be sour.[9] Although the exact number of sour wells are not available, the EPA has reported that in the U.S. "the potential for routine H_2S emissions [at oil and gas wells] is significant."[10]

Releases of H_2S from sour gas wells or facilities may occur in a number of ways. U.S. EPA has collected documentation of sour gas well blowouts, line releases, extinguished flares, collection of sour gas in low-lying areas, and leakage from idle or abandoned wells that have impacted the public near oil and gas extraction sites.[11] In addition to releases from sour gas wells, H_2S also may be routinely or accidentally released into the atmosphere at oil refineries, natural gas processing facilities and desulfurization plants.

In areas with coalbed methane production, hydrogen sulfide gas has been detected in surface soils, groundwater and the atmosphere (in association with methane gas).[12]

3.1.2 Studies on H_2S from oil and natural gas production

State agencies from across the United States have received H_2S-related complaints from citizens. In 2006, Lana Skrtic, a Masters degree student at the University of California at Berkeley, collected information on state studies conducted in response to H_2S complaints related to oil and gas operations in Arkansas, Louisiana, New Mexico, and North Dakota. According the Skrtic, "These studies are of varying quality and scope, but each sheds some light on the topic of hydrogen sulfide emissions and oil and gas operations."[13]

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[7] U.S. Environmental Protection Agency. 1995. "Petroleum Industry," *Compilation of Air Pollutant Emission Factors, Vol. 1, Stationary Point and Area Sources*. Available from URL: http://www.epa.gov/ttn/chief/ap42

[8] Dalrymple, D.A., Skinner, F.D. and Meserole, N.P. 1991. *Investigation of U.S. Natural Gas Reserve Demographics and Gas Treatment Processes*. Topical Report, GRI-91/0019, Section 3.0, pp. 3-1 to 3-13. Gas Research Institute. ***And*** Hugman, R.H., Springer, P.S. and Vidas, E.H. *Chemical Composition of Discovered and Undiscovered Natural Gas in the United States: 1993 update*. Topical Report, GRI-93/0456. p. 1-3. Gas Research Institute. ***In*** McIntush, K.E., Dalrymple, D.A. and Rueter, C.O. 2001. "New process fills technology gap in removing H2S from gas," *World Oil*, July, 2001.

[9] Quinlan, M., 1996. "Evaluation of selected emerging sulfur recovery technologies," *GRI Gas Tips*, 3(1):26-35. *In* McIntush, K.E., Dalrymple, D.A. and Rueter, C.O. 2001. "New process fills technology gap in removing H2S from gas," *World Oil*, July, 2001.

[10] U.S. Environmental Protection Agency. October 1993. "Report to Congress on Hydrogen Sulfide Air Emissions Associated with the Extraction of Oil and Natural Gas." EPA-453/R-93-045, p.III-35.

[11] *ibid*. p.III-38.

[12] La Plata County, Colorado. 2002. *La Plata County Impact Report*. p. 3-105. Available from URL: http://co.laplata.co.us/publications.htm

[13] Skritic, L. May, 2006. *Hydrogen Sulfide, Oil and Gas, and People's Health*. A paper submitted for the fulfillment of a Masters Degree, Energy Resources Group, UC Berkeley. p. 35. Available from URL: http://www.earthworksaction.org/publications.cfm?pubID=168

The following paragraphs summarize the studies conducted in the four states:

ARKANSAS: During the 1990s, the Arkansas Department of Environmental Quality conducted hydrogen sulfide monitoring studies in response to health and welfare related complaints from residents living close to gas processing plants.[14] An initial scoping study confirmed the presence of hydrogen sulfide in ambient air, and so between March 1998 and March 1999, a more rigorous study was undertaken. At one site, the average H_2S concentration was 3.4 ppb; while the maximum H_2S level was 35 ppb. At a second site, the average H_2S concentration was 5.5 ppb, and the maximum was 127 ppb.

LOUSIANA: In Louisiana, numerous odor complaints from residents prompted the state's Department of Environmental Quality to undertake monitoring of hydrogen sulfide and sulfur dioxide concentrations downwind of the Calumet Refinery in Shreveport.[15] The hourly average concentration for hydrogen sulfide, for the monitoring period from October 2002 to April 2005, was 2.56 ppb, with a maximum of 50.15 ppb and a median of 1.92 ppb.

NEW MEXICO: In February 2002, the Air Quality Bureau of the New Mexico Environment Department monitored hydrogen sulfide levels to determine if ambient concentrations near certain facilities, including oil and gas operations, were in compliance with the state's ambient standards.[16] The data clearly demonstrated that H_2S was present at elevated levels near oil and gas facilities in southern New Mexico. Hydrogen sulfide levels measured at flaring, tank storage, and well drilling sites, averaged from approximately 100-200 ppb (compared to an average of 7 ppb at two "control" sites (without expected sources of H_2S); and a maximum concentration of 15,000 ppb was measured near dehydrator, located at a natural gas compression facility.

NORTH DAKOTA: Between 1980 and 1992, the North Dakota State Department of Health and Consolidated Laboratories monitored hydrogen sulfide emissions from oil and gas wells in the state. The study found that hydrogen sulfide was routinely being emitted near oil and gas wells in that state: At one site, six miles north of the Theodore Roosevelt National Park, the one-hour average H_2S concentrations frequently exceeded 200 ppb.[17] At another site, in a valley with several wells within one mile from the monitor, H_2S concentrations reached 250 ppb.[18]

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[14] Pleasant Hills H_2S Study, obtained February 2006 by mail from Jay Justice, Senior Epidemiologist with the Arkansas DEQ.

[15] James M. Hazlett, "Report for the Calumet Air Monitoring Project," Louisiana Department of Environmental Quality, Office of Environmental Assessment. June 8, 2005. (Obtained from the author and used with permission.)

[16] New Mexico Environment Department (NMED), Air Quality Bureau. "Trip Report: H_2S Survey, March 18-22, 2002." By Steve Dubyk and Sufi Mustafa. Obtained from the author.

[17] U.S. Environmental Protection Agency. "Report to Congress on Hydrogen Sulfide Emissions," p.III-26.

[18] U.S. Environmental Protection Agency. "Report to Congress on Hydrogen Sulfide Emissions," p.III-30.

Table 1. Summary of average and maximum H_2S concentrations (parts per billion) near oil and gas facilities in Arkansas, Louisiana, New Mexico and North Dakota.

Monitoring Location	H_2S concentration measured at monitoring site (ppb)	
	Average	Max.
Arkansas		
Rural residential 1 - near gas processing facility	2.4 – 3.4	24 - 35
Rural residential 2 - near gas processing facility	4 – 5.5	55 - 127
Louisiana		
Downwind of refinery	2.56	50.15
New Mexico		
Indian Basin Hilltop (control site)	7	8
Indian Basin Compressor Station	6	9
Indian Basin Active Well Drilling Site	114	190
Indian Basin Flaring, Production, and Tank Storage Site	203	1,200
Marathon Indian Basin Refining and Tank Storage Site	16	370
Carlsbad City Limits, near 8 to 10 wells and tank storage sites	6	7
Carlsbad City Limits (control site)	7	8
Compressor station, dehydrators – Location A	4	5
Compressor station, dehydrators – Location B	1372	15,000
Huber Flare/Dehydrating Facility	77	12
Snyder Oil Well Field	4	5
Empire Abo Gas Processing Plant	300	1,600
Navajo Oil Refinery	7 - 8	14
North Dakota		
Lostwood Wildlife Refuge	-	88
Lone Butte, 6 miles N. of Theodore Roosevelt Park	> 200	-
Unnamed valley, several wells in vicinity of monitor	-	250

These monitoring studies reveal that hydrogen sulfide is present at or near oil and gas facilities, including oil and gas wells, tank batteries, gas processing plants, flares, compressor stations and refineries. When facilities such as these are situated near residential areas, there is the possibility that residents will be routinely exposed to hydrogen sulfide.

The levels of H_2S in the four monitoring studies ranged from the relatively low concentration of 2 ppb recorded in Louisiana to concentrations in the 1,000 ppb range observed in New Mexico. Even the lowest average H_2S concentration at these sites is higher than normal urban background levels, which are typically less than 1 ppb.[19]
As reported by Skrtic, "The levels measured in this study may be expected to produce a persistent odor, which has been shown in one study to have a negative effect on the mood of nearby residents."[20]

[19] Agency for Toxic Substances and Disease Registry (ATSDR). 2004. Toxicological profile for hydrogen sulfide (*Draft for Public Comment*). Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service. Chapter 2, p. 1.
[20] Schiffman, Susan S., Elizabeth A. Sattely, et al. "The Effect of Environmental Odors Emanating From Commercial Swine Operations on the Mood of Nearby Residents," *Brain Research Bulletin*. 37:4 369-375.

Furthermore, as seen in Section 3.1.3 of this report, chronic exposure to low-level concentrations of hydrogen sulfide may result in neurological symptoms such as fatigue, loss of appetite, irritability, impaired memory, headaches, and dizziness.[21] One of the studies discussed in Section 3.1.3, below, reports central nervous system, respiratory system, and ear, nose and throat symptoms associated with annual average hydrogen sulfide levels ranging from 7 to 27 ppb.[22] It is possible, too, that exposures to these levels of H_2S may cause serious, long-term health effects.

3.1.3 Health Issues associated with H_2S

Exposure to H_2S is one of the leading causes of sudden death in the workplace.[23] At high concentrations (greater than 500 parts per million[24]) inhalation of H_2S can lead to immediate collapse and unconsciousness. A single breath at 1,000 ppm results in immediate loss of consciousness, cardiac arrest and death unless the unconscious victim is successfully revived.[25] Unconsciousness and death have occurred in situations of prolonged exposure to H_2S at concentrations of 50 ppm.[26] Many occupational and community studies have documented the adverse health effects of exposure to relatively high levels of H_2S.[27]

Table 2 outlines the various types of health effects that have been associated with hydrogen sulfide in air.

1995. _Cited in_: Skritic, L. May, 2006. *Hydrogen Sulfide, Oil and Gas, and People's Health*. A paper submitted for the fulfillment of a Masters Degree, Energy Resources Group, UC Berkeley. p. 19.

[21] McGavran, Pat. "Literature Review of the Health Effects Associated with the Inhalation of Hydrogen Sulfide." Idaho Department of Environmental Quality, Boise, Idaho. June 19, 2001. p.3.

[22] Legator, M., Singleton, C. , Morris, D. and Philips, D. 2001. "Health effects from chronic low-level exposure to Hydrogen Sulfide," *Archives of Environmental Health*. 56:2:123-131.

[23] U.S. Environmental Protection Agency. 1992. *Health assessment document for hydrogen sulfide*. Environmental Criteria and Assessment Office, Office of Health and Environmental Assessment. Research Triangle Park, NC. EPA/600/8-86/026F.

[24] Beauchamp, 1984. In NC Scientific Advisory Board. 2003. *Summary of the toxicity assessment of hydrogen sulfide conducted by the Secretary's Scientific Advisory Board on Toxic Air Pollutants*. Available from URL: http://daq.state.nc.us/toxics/studies/H2S

[25] Kilburn, Kaye. "Effects of Hydrogen Sulfide on Neurobehavioral Function." *Southern Medical Journal*. 96:(7) 639-646. 2003.

[26] Henderson, R. 2005. "Toxic gas accidents affect far more than the workers on site," *Petromin*.

[27] Various citations _in_: Legator, M., Singleton, C. , Morris, D. and Philips, D. 2001. "Health effects from chronic low-level exposure to Hydrogen Sulfide," *Archives of Environmental Health*. 56:2:123-131.

Table 2: Health Effects Associated with Hydrogen Sulfide (adapted from Skrtic, 2006).[28]

Concentration of H_2S in air (ppm)	Length of Exposure	Effect	Source[29]
0.003 – 0.02	Immediate	Detectable odor	EPA (1993), p. III-5
0.2	Not reported	Detectable odor	Fuller, p. 940
0.250 – 0.300	Prolonged	Nuisance due to odor from prolonged exposure	Milby, p. 194
10	10 minutes	Eye irritation, chemical changes in blood and muscle tissue after 10 min.	New York State Department of Health
> 30	Prolonged	Fatigue, paralysis of olfaction from prolonged exposure	Snyder, p. 200
50	Not reported	Eye and respiratory irritation	Fuller, p. 940
50 – 100	Prolonged	Eye irritation (painful conjunctivitis, sensitivity to light, tearing, clouding of vision) and serious eye injury (permanent scarring of the cornea)	Milby p. 194; EPA (1993), p. III-5
150 - 200	Not reported	Olfactory nerve paralysis	EPA (1993), p.III-6
200	Not reported	Respiratory and other mucous membrane irritation	Snyder, p.200
250	Not reported	Damage to organs and nervous system; depression of cellular metabolism	EPA (1993), p.III-5
250	Prolonged	Possible pulmonary edema from prolonged exposure	Milby p. 193
320 – 530	Not reported	Pulmonary edema with risk of death	Kilburn (1999), p. 212
500	30 minutes	Systemic symptoms after 30 minutes	Fuller, p. 940
500 –1000	Immediate	Stimulation of respiratory system, leading to hyperpnoea (rapid breathing); followed by apnea (breathing stops)	EPA (1993), p.III-5
750	Immediate	Unconsciousness, death	Fuller, p. 940
1000	Immediate	Collapse, respiratory paralysis, followed by death	Fuller, p. 940, EPA (1993) p. III-5.
750 – 1000	Immediate	Abrupt physical collapse, with possibility of recovery if exposure is terminated; if not terminated, fatal respiratory paralysis	Milby, p. 192
1000 – 2000	Not reported	Immediate collapse with paralysis of respiration	Kilburn (1999), p. 212
5000	Immediate	Death	Fuller, p. 940

Almost all organ systems are affected by H_2S, but the most susceptible are those with exposed mucous membranes (e.g., eyes,[30] noise and throat) and those with high oxygen demands (e.g., lungs, brain). Neurotoxicity of the central nervous system (causing

[28] Skrtic, L. May, 2006. *Hydrogen Sulfide, Oil and Gas, and People's Health*. A paper submitted for the fulfillment of a Masters Degree, Energy Resources Group, UC Berkeley. p. 13.
[29] See Bibliography for complete references.
[30] Symptoms affecting the eyes are generally associated with repeated exposures to 50 ppm. H_2S NC Scientific Advisory Board. 2003. *Summary of the toxicity assessment of hydrogen sulfide conducted by the Secretary's Scientific Advisory Board on Toxic Air Pollutants.*

nausea, dizziness, confusion, headaches and sleeping problems) and pulmonary edema (build-up of fluid in the lungs) are other well-documented effects of H_2S poisoning. Cardiovascular and gastrointestinal toxicity are also associated with H_2S exposure.

Research conducted by Kaye Kilburn, a medical doctor and professor of medicine at the University of Southern California, suggests that exposure to H_2S may cause long-term, irreversible human health effects. Kilburn performed physiologic and psychological measurements on nineteen exposed individuals, and compared results with 202 unexposed subjects.[31] Of the 19 exposed subjects, 10 were exposed at work sites, which included four oil and gas operations, and nine were exposed in their residences, which were near various sources of H_2S. The concentrations to which the subjects were exposed are not known. Kilburn found that depression, anger, fatigue, tension, confusion and respiratory ailments were significantly higher in exposed subjects than the control group.

Increasingly, scientific research is revealing that even low concentrations of H_2S (in the low parts per million or even the parts per billion range) can affect human health, especially when exposure occurs over an extended period of time. For example, data collected in a study of sewer workers indicated that low-level exposure to H_2S may be associated with reduced lung function.[32] The following studies provide more information on the potential association between low-level exposures to H_2S and health effects.

1) A study of H_2S in the workplace found that workers complained of eye pain at a level of 6.4 ppm.[33]

2) Clinical studies suggest that short-term exposure to H_2S at concentrations of 2 ppm may induce bronchial obstruction. In a study investigating the effects of H_2S on asthmatics, two out of ten subjects exhibited a pronounced response when exposed to 2 ppm H_2S. Airway resistance and conductivity were affected by more than 30%, suggesting significant bronchial obstruction.[34]

3) Former workers and residents living downwind of a crude oil processing plant had neurophysiological abnormalities. Residents in this study were exposed to H_2S at 10 ppb, although H_2S concentrations occasionally reached 100 ppb.[35]

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[31] Kilburn, Kaye H. "Effects of Hydrogen Sulfide on Neurobehavioral Function." *Southern Medical Journal*. 96:(7) 639-646. 2003.

[32] Richardson, D. 1995. "Respiratory effects of chronic hydrogen sulfide exposure." Am J Ind Med. 28:99-108.

[33] Van Hoorne, et al. 1991. "Survey of chemical exposures in a viscose rayon plant." *Ann Occup Hyg*. 35(6):619-631. ***In*** NC Scientific Advisory Board. 2003. *Summary of the toxicity assessment of hydrogen sulfide conducted by the Secretary's Scientific Advisory Board on Toxic Air Pollutants*. Available from URL: http://daq.state.nc.us/toxics/studies/H2S

[34] Jappinen, P. et al. 1990. "Exposure to hydrogen sulfide and respiratory function." *British J Ind Medicine*. 47:824-828. In NC Scientific Advisory Board. 2003. *Summary of the toxicity assessment of hydrogen sulfide conducted by the Secretary's Scientific Advisory Board on Toxic Air Pollutants*. Available from URL: http://daq.state.nc.us/toxics/studies/H2S

[35] Kilburn, K.H., Warshaw, R.H. 1995. "Hydrogen sulfide and reduced-sulfur gases adversely affect neurophysiological functions." *Toxicology and Industrial Health*. 11:185-197.

4) Residents near pulp and paper mills in Finland have reported an excess of health symptoms compared to residents living in a community without any industrial H_2S sources. The annual mean concentrations of H_2S in the affected community was 8 $\mu g/m^3$ (5.7 ppb). Symptoms included respiratory, eye and nasal problems). Residents in the pulp and paper community were also exposed to other sulfur compounds, but H_2S accounted for more than two-thirds of the sulfur compounds monitored in the community.[36]

5) Symptoms of adverse health effects experienced by residents in Odessa, TX and Puna, Hawaii, two communities with industrial sources of H_2S were compared to the same symptoms in three communities without industrial sources of H_2S. The residents in Odessa were exposed to H_2S concentrations of 7-27 ppb (annual average), with maximum 8-hour measurements between 335 and 503 ppb. Exposure in Puna is less clear, but some data from the 1990s indicate hourly averages in the low-ppb range, with most below 1 ppb. Between June 1996 and 1997, peak H_2S concentrations was 301.7 ppb. In other years, releases of H_2S between 200-500 ppb were reported. The two H_2S-exposed communities were similar with respect to the adverse health effects (e.g., central nervous systems, ear/nose/throat, respiratory, muscle/bone, skin, immune, cardiovascular, digestive, teeth/gums, urinary, blood) reported by residents. Percentages of affected residents in the H_2S-exposed communities were statistically different (higher) than the non-exposed communities.[37]

The results of other community and occupational studies indicate a considerable variety of adverse health effects from low-level, chronic H_2S exposure.[38]

3.1.4 H_2S Regulations

There are no international health-based standards for H_2S. The World Health Organization (WHO) has an air quality guideline for H_2S of 150 $\mu g/m^3$ (10.6 ppb) averaged over a 24-hour period.[39] This guideline is based on the avoidance of eye irritation. Also, WHO recommends that H_2S concentrations not exceed 0.005 ppm (5 ppb; 7 $\mu g/m^3$), over a 30-minute period, to avoid substantial complaints about odor.[40]

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[36] Marttila, O., Jaakkola, J.J.K., Partti-Pellinen, K. 1995. "South Karelia air pollution study: daily symptom intensity in relation to exposure of malodorous sulfur compounds from pulp mills." *Envir Res*. 71:122-27.
[37] Legator, M., Singleton, C. ,Morris, D. and Philips, D. 2001. "Health effects from chronic low-level exposure to Hydrogen Sulfide," *Archives of Environmental Health*. 56:2:123-131.
[38] Mehlman, M.A. 1992. Dangerous and cancer-causing properties of product and chemicals in the oil refining and petrochemical industry. VII. Adverse health effects and toxic manifestations caused by exposure to hydrogen sulfide. *Journal of Occupational Med Toxicol*. 1:143-158.
[39] World Health Organization. 2003. *Concise International Chemical Assessment Document 53, Hydrogen Sulfide: Human Health Aspects*. Geneva, Switzerland: World Health Organization. p. 21. Available from URL: http://www.who.int/entity/ipcs/publications/cicad/en/cicad53.pdf
[40] *ibid*.

Table 3. State Ambient Hydrogen Sulfide Standards[41]

State	Standard	Duration	Justification
Arizona	128 ppb	1 hr	AAAQG, health based, on OSHA guidelines
	78 ppb	24 hr	
California	8 ppb	Chronic exposure	Odor/nuisance guideline.
	30 ppb	1 hr	
Delaware	60 ppb	avg. not to be exceeded over any consecutive 3 min.	
	30 ppb	avg. not to be exceeded over any consecutive 60 min.	
Hawaii	25 ppb	1 hr	Combination of health and nuisance
Iowa	30 ppb	1 hr daily maximum	"Health effects standard"
Kentucky	10 ppb	1 hr maximum	Public health and welfare
Louisiana	330 ppb	8-hr average	1/42 of NIOSH/OSHA safety standard
Massachusetts	0.65 ppb	24-hr and annual limit	Based on EPA RfC, Threshold Effects Limit and Allowable Ambient Limit
Minnesota	50 ppb	1/2-hr avg. not to be exceeded > twice/yr	
	30 ppb	1/2-hr avg. not to be exceeded > twice in any 5 consecutive days	
Missouri	50 ppb	1/2 hr avg. not to be exceeded > twice/yr	
	30 ppb	1/2 hr avg. not to be exceeded > twice in any 5 consecutive days	
Montana	50 ppb	hourly avg. not to be exceeded > once/yr	Health based
Nevada	80 ppb	1-hr average	Health based
New Mexico	10 ppb	1-hr avg. not to be exceeded >once/year	
	100 ppb	1/2 hour average	for the Pecos-Permian Basin (PPB) Intrastate Air Quality Control Region
	30 ppb	1/2 hour average	within 5 miles of municipalities in PPB with > 20,000 people
New York	10 ppb	1-hr average	Odor and aesthetic
North Dakota	10,000 ppb	ceiling, maximum instantaneous concentration not to be exceeded	Health based
	200 ppb	1-hr avg. not to be exceeded > once/mo.	
	100 ppb	24-hr avg. not to be exceeded >once/yr	
	20 ppb	max. arithmetic mean concentration averaged over 3 consecutive months	
Oklahoma	200 ppb	24-hr average concentration	
Oregon	0.3 ppb*	annual average concentration	EPA's RfC, proposed benchmark
Pennsylvania	5 ppb	24-hr average	
	100 ppb	1-hr average	
Texas	80 ppb	30-min average	if H_2S affects a residential, business, or commercial property
	120 ppb	30-min average	if H_2S affects only property not normally occupied by people.
Vermont	24 ppb	24-hr	Health based
Wyoming	50 ppb	1/2-hour avg. not to be exceeded > twice/yr	
	0.03 ppm 30 ppb	1/2 hour avg. not to be exceeded > twice/5 consecutive days	

[41] See Appendix 2 for state-by-state references.

Within the United States, there is no federal ambient air quality standard for H_2S, but more than 30 states have chosen to independently regulate H_2S levels to protect the public from adverse effects related to H_2S exposure. Some states have standards based on short-term H_2S levels (average H_2S concentrations over 15 minutes), while others use an average of H_2S concentrations over much longer periods of time (extending up to one-year).[42] Table 3 includes information for states that have ambient air quality standards (or guidelines) for H_2S.

The most stringent one-hour standard – found in New Mexico, New York and Kentucky – is 10 parts per billion (ppb). In other words, those states believe there will be some effect on citizens exposed to H_2S at a level of 10 ppb for at least one hour. The effects may be health-related or the odors may create a nuisance for the citizens.

At least twelve states have standards for H_2S measured over a 24-hour period. These levels are lower than the 1-hour limits, and vary from concentrations of 0.65 ppb (Massachusetts) to 200 ppb (Oklahoma).

3.2 Volatile Organic Compounds (VOCs)

3.2.1 Sources of VOCs

General sources of VOCs include motor vehicle exhaust, waste burning, gasoline marketing, industrial and consumer products, pesticides, degreasing operations, pharmaceutical manufacturing, and by-products from dry cleaning and other industrial operations.[43]

3.2.1.1. VOCs from oil and natural gas

During the extraction, processing and distribution of oil and gas, dozens of volatile organic compounds are released.

Table 4 provides a list of the VOCs that were emitted in high volumes during oil and gas extraction and distribution in the United Kingdom (UK) in 2003. More than 50 VOCs are associated with oil and gas extraction and distribution in the UK,[44] but not all of them are emitted in high volumes. Table 4 lists the 29 most significant VOCs, as identified by the UK Department for Environment, Food and Rural Affairs.

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[42] State Survey of Ambient Air Standards. Available from URL: http://daq.state.nc.us/toxics/studies/H2S/H2S_Survey.pdf

[43] California Air Resources Board. "Toxic Air Contaminants Monitoring" (page updated February 15, 2005) Available from URL: http://www.arb.ca.gov/aaqm/toxics.htm

[44] DEFRA (the Department for Environment, Food and Rural Affairs. United Kingdom. "E-Digest Statistics about: Air Quality: Volatile organic compounds (VOCs)." Available from URL: http://www.defra.gov.uk/environment/statistics/airqual/aqvoc.htm

Table 4. The 29 most significant VOCs from UK fossil fuel extraction and distribution.

Volatile Organic Compound	Amount of VOC (metric tonnes)	Volatile Organic Compound	Amount of VOC (metric tonnes)
Butane	69,492	Toluene	232
Ethane	38,261	Formaldehyde	209
Propane	34,026	m-xylene	86
Pentane	28,640	Dichloromethane	65
Heptane	14,999	Nonane	61
Hexane	14,786	o-xylene	41
Octane	13,239	Ethylene	37
2-methylpropane	12,597	Ethylbenzene	25
2-methylbutane	10,781	Decane	23
2-methylpentane	2,078	Propylene	21
2-pentene	1,408	p-xylene	20
3-methylpentane	1,147	Acetylene	19
2-butene	804	1,3-butadiene	8
Benzene	663	1,2,4-trimethylbenzene	5
2-methylpropene	256		

During oil and gas extraction and distribution (which includes gas compression and transport via pipelines), there are numerous opportunities for VOCs to be released to the atmosphere.

Natural Gas Dehydration: Natural gas is often produced along with liquid hydrocarbons, hydrogen sulfide, carbon dioxide, water, water vapor, mercaptans, nitrogen, helium, and solids (sediments). The mixture of gases and fluids is sometimes piped directly from the well to a gas plant for processing; in other cases, the fluids may be removed from the gas (i.e., gas is "dehydrated") at the well site. Dehydration is accomplished by several methods, but the most popular is glycol dehydration. Glycol absorbs water from the gas stream, but also absorbs benzene and other organic compounds. The glycol is regenerated and reused by heating the glycol to remove the water. The heating process not only releases water vapor, it also emits any volatile organic compounds absorbed by the glycol. [45]

Venting: the direct emission of natural gas to the atmosphere. Venting of waste gases, which contain VOCs, may occur at well sites, during the separation and dehydration of natural gas, oil and gas processing facilities, and at pipelines, e.g., during maintenance activities. On a per well basis, large volumes of VOCs may be released every year. For example, in has been estimated that in 2002, gas wells in New Mexico vented more than 20 tons of VOCs to the atmosphere.[46]

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[45] Vermaa, Dave K., Johnson, Diane M., and McLean, James D. 2000. "Benzene and Total Hydrocarbon Exposures in the Upstream Petroleum Oil and Gas Industry," *American Industrial Hygiene Association Journal*. 61:255–263.

[46] Pollack, A., Russell, J., Grant, J., Friesen, R., Fields, P. and Wolf, M. August, 2006. *Ozone Precursors Emission Inventory for San Juan and Rio Arriba Counties, New Mexico*. Prepared for New Mexico Environment Department. p. 2-19. Available from URL: http://www.nmenv.state.nm.us/aqb/projects/San_Juan_Ozone/NM_Area_Emissions_report.pdf

Flaring: the combustion of natural gas prior to release to the atmosphere. Combustion converts VOCs into carbon dioxide and water. Even when flaring occurs, some VOCs will be emitted to the atmosphere, because complete combustion never occurs. Complete combustion requires sufficient combustion air and proper mixing of air and waste gas. Properly operated flares should achieve at least 98 % combustion efficiency in the flare plume, meaning that less than 2% of hydrocarbons will be emitted in the gas stream.[47]

A field study conducted in Alberta, Canada found that sweet gas flared at oilfield battery sites burned with an efficiency of only 62 – 71%. Flaring of a sour gas solution burned with 82-84% efficiency. Hydrocarbons found in the emissions above the flames included benzene, styrene, ethynyl benzene, ethnyl-methyl benzenes, toluene, xylenes, and others. Emissions from the sour flare also contained reduced sulfur compounds and thiophenes.[48]

Tank emissions: there are three types of emissions from hydrocarbon (e.g., crude oil or condensate) storage tanks. These include working losses (i.e., displacement of vapors as a tank is filled), breathing losses (i.e., displacement of vapors due to changes in tank temperature and pressure), and flashing losses. Flashing losses occur when a liquid with entrained gases goes from a high- to a low-pressure situation. As the pressure drops, some of the lighter (volatile) compounds dissolved in the liquids are released or flashed. These flashing losses/VOC emissions are often vented to the atmosphere through a tank's pressure relief valve or hatch.[49]

Waste Pits: During drilling, stimulation or well workover, chemicals are injected into a well to perform certain functions (e.g., kill bacteria, prevent pipe corrosion, etc.). A portion of these chemicals returns to the surface with produced water or hydrocarbons. Many of these chemicals are volatile, and consequently, if the produced water is stored in open pits the chemicals will escape into the atmosphere.[50]

Fugitive Emissions: The U.S. EPA reports that on an annual basis, natural gas plants in the United States release 45-128 million cubic feet of natural gas as fugitive emissions.[51] Fugitive emissions also occur from wellheads, pipelines and storage vessels.

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[47] U.S. Environmental Protection Agency. AP-42, CH 13.5: Industrial Flares. Available from URL: http://www.epa.gov/ttn/chief/ap42/ch13/final/c13s05.pdf

[48] Strosher, M. Alberta Research Council. 1996. *Investigations of Flare Gas Emissions in Alberta*. Report prepared for Environment Canada, the Alberta Energy and Utilities Board and the Canadian Association of Petroleum Producers. 157 pp.

[49] Oklahoma Department of Environmental Quality. 2004. *Calculation of Flashing Losses/VOC Emissions from Hydrocarbon Storage Tanks*. Fact sheet. Available from URL: http://www.deq.state.ok.us/factsheets/ air/CalculationLosses.pdf

[50] The Endocrine Disruption Exchange (TEDX). November 17, 2006. *Chemicals Used in Natural Gas Development and Delivery*. Available from URL: http://www.earthworksaction.org/publications.cfm?pubID=162
TEDX has reviewed chemical information for more than 200 chemicals used at natural gas sites in Colorado. Of these chemicals, TEDX found that 26% are volatile.

[51] U.S. Environmental Protection Agency. *Directed Inspection And Maintenance At Gas Processing Plants And Booster Stations*. Lessons Learned From Natural Gas STAR Partners. Available from URL: http://www.epa.gov/gasstar/pdf/lessons/ll_dimgasproc.pdf

3.2.1.2 Studies on VOCs from oil and natural gas production

A recent study conducted in Colorado demonstrates that volatile organic compounds associated with oil and natural gas production have the potential to be released at concentrations that are harmful to human health.

In 2002, concerns raised by residents in Garfield County, Colorado, prompted the county, state and the federal governments to undertake a collaborative study to sample for air toxics around oil and gas sites within the county.[52] Twenty air samples were collected from seven locations, and sample sites included two natural gas wells; another well with an active flare; a residence; and three other locations. The samples were analyzed for 42 VOCs. Six were present at detectable concentrations: acetone; methyl ethyl ketone; benzene; toluene; m,p-xylene and o-xylene. It was acknowledged, however, that other VOCs may have been present, but that the equipment may not have been sensitive enough to detect a number of other VOCs.[53]

In 2005, a second round of air quality monitoring was initiated in Garfield County. This time, the effort was funded entirely by the County. The two-year study, expected to cost approximately $300,000, was designed to characterize county-wide ambient air quality, as well as localized odor/emission problems from oil and gas facilities. The samples are being analyzed for 43 VOC compounds. To date, 17 VOCs have been detected.[54]

The benzene levels measured in Garfield county in 2002 ranged from 0 – 6.5 $\mu g/m^3$ (2.04 ppb).[55] As of February, 2006, 89 samples had been taken in the second air quality study. The average benzene level was 5.7 $\mu g/m^3$ (1.79 ppb) and there was a maximum benzene reading of 180 $\mu g/m^3$ (56.42 ppb).[56] Benzene at these concentrations may pose health risks to residents living in the area (see Section 3.2.3 of this report).

3.2.2 Health issues associated with VOCs

VOCs are organic compounds that vaporize easily at ambient temperatures. Some VOCs are highly reactive and play a critical role in the formation of ozone. Other VOCs have adverse chronic and acute health effects. In some cases, VOCs can be both highly

[52] Colorado Department of Public Health and Environment. Oct, 2002. *A Community-based Short-term Ambient Air Screening Study in Garfield County for Oil and Gas Related Activities*. Available from URL: http://oil-gas.state.co.us/Library/piceancebasin/GarfieldFinalReport10-31.pdf
[53] Pierce, G. (CO Dept. of Public Health and Envt). Nov. 2002. *Garfield County Air Monitoring Results*. Available from URL: http://oil-gas.state.co.us/Library/piceancebasin/GarfieldCountyMonitoring.pdf
[54] Rada. J. April, 2006. *Status of Garfield County's Air Quality Monitoring Program*. Power point presentation. Available from URL: http://www.garfield-county.com/docs/air_quality_study__4.6.06.ppt
[55] Columbia Analytical Services. For benzene (molecular weight = 78), the conversion from $\mu g/m^3$ to ppb(volume) is: ppbv = x ug/m3 * 24.45 / 78. Available from URL: http://www.caslab.com/FAQsv.php#q2
[56] Rada. J. April, 2006. *Status of Garfield County's Air Quality Monitoring Program*. Power point presentation. Available from URL: http://www.garfield-county.com/docs/air_quality_study__4.6.06.ppt

reactive and potentially toxic.[57] Examples of harmful VOCs include 1-3 butadiene, benzene, ethylbenzene, toluene and xylenes.

British researchers studying childhood cancers and atmospheric carcinogens have found that, "(1) that childhood cancers and leukaemias in Great Britain exhibit geographical clustering of birth places; (2) they occur at increased densities around industrial sites with large scale combustion processes or using volatile organic compounds (VOCs). . .".[58]

The authors conclude that, "Childhood cancers/leukaemia births are closely associated with high atmospheric emissions from combustion processes, mainly oil based, and from organic evaporation. Demonstrated associations with 1-3, butadiene, dioxins and benz(a)pyrene, but possibly others as well, are probably causal. Such toxic emissions may account for a majority of all cases."[59]

The following section summarizes health effects related to VOCs that are known to be associated with oil and gas development. Given that our study relates directly to the presence of VOCs in air, the health effects information for these selected VOCs included in this section refers to human exposure via inhalation (unless otherwise noted).

1,3-Butadiene: 1,3-butadiene is usually found in ambient air at low levels in urban and suburban areas. Studies show that short-term inhalation of elevated levels of 1,3-butadiene results in irritation of the eyes, nasal passages, throat, and lungs. Also, studies have reported a possible association between 1,3-butadiene exposure and cardiovascular diseases. EPA has classified 1,3-butadiene as a Group B2, probable human carcinogen.[60]

Benzene: Studies suggest that acute exposure to benzene (e.g., greater than 50 ppm) may depress the central nervous system. Common symptoms of acute exposure include drowsiness, fatigue, dizziness, headaches, nausea, vomiting, nose and throat irritation, slurred speech, loss of balance, and death.[61]

Prolonged exposure to benzene mainly affects the skin (e.g., redness, drying and cracking of the skin) and blood (e.g., may suppress the production of red and white blood cells, and clotting cells). Benzene may also increase the incidence of a specific type of

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[57] California Air Resources Board. "Toxic Air Contaminants Monitoring" (page updated February 15, 2005) Accessed Jan. 2, 2006. Available from URL: http://www.arb.ca.gov/aaqm/toxics.htm

[58] Knox, E.G. 2005. "Childhood cancers and atmospheric carcinogens," *Journal of Epidemio. Community Health*. 2005:59:101-105. p. 101,

[59] *ibid*. p. 104.

[60] U.S. Environmental Protection Agency. Technology Transfer Network Air Toxics Website. *1,3-Butadiene*. "Hazard Summary" (revised January, 2000). Available from URL: http://www.epa.gov/ttn/atw/hlthef/butadien.html

[61] Canadian Association of Petroleum Producers. 2006. *Best Management Practices - Control of Benzene Emissions from Glycol Dehydrators*. p. 65 Available from URL: http://www.capp.ca/default.asp?V_DOC_ID=763&PubID=80610

leukemia (acute myelogenous leukemia) and other forms of leukemia and lymphomas.[62] According to the U.S. EPA, there is sufficient evidence to show that benzene is a human carcinogen (cancer-causing agent).[63]

When benzene exposure occurs with exposure to other chemicals, the health effects may be enhanced. For example, exposure to benzene and ethanol can increase the effects to the blood system; and toluene decreases the ability of the body to remove benzene by competing with benzene for metabolic pathways.[64]

Ethylbenzene: Short-term, acute exposure to ethylbenzene results in respiratory effects, such as throat irritation and chest constriction, as well as irritation of the eyes and dizziness. Animal studies have shown effects on the blood, liver, and kidneys from chronic inhalation exposure to ethylbenzene. In a study by the National Toxicology Program (NTP), exposure to ethylbenzene by inhalation resulted in an increased incidence of kidney and testicular tumors in rats, and lung and liver tumors in mice.[65]

Toluene: The central nervous system (CNS) is the primary target organ for both short and long-term toluene exposures. Symptoms of CNS dysfunction resulting from short-term inhalation include fatigue, sleepiness, headaches and nausea. Chronic inhalation exposure causes irritation of the upper respiratory tract and eyes, sore throat, dizziness, and headache.

Human studies have also reported developmental effects in the children of pregnant women exposed to toluene. These effects included attention deficits, as well as craniofacial and limb anomalies. An association between exposure to toluene and an increased incidence of spontaneous abortions has also been noted. The U.S. EPA notes, however, that these studies are not conclusive.[66]

Xylenes: Exposure to xylenes via short-term inhalation causes irritation of the eyes, nose, and throat, gastrointestinal effects and neurological effects. Chronic inhalation exposure results in central nervous system (CNS) effects, such as headaches, dizziness,

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[62] Canadian Association of Petroleum Producers. 2006. *Best Management Practices - Control of Benzene Emissions from Glycol Dehydrators*. p. 65

[63] U.S. Environmental Protection Agency. 2002. *Integrated Risk Information System (IRIS) on Benzene*. National Center for Environmental Assessment, Office of Research and Development. Available from URL: http://www.epa.gov/iris/subst/0276.htm

[64] Canadian Association of Petroleum Producers. 2006. *Best Management Practices - Control of Benzene Emissions from Glycol Dehydrators*. p. 65 Available from URL: http://www.capp.ca/default.asp?V_DOC_ID=763&PubID=80610

[65] U.S. Environmental Protection Agency. Technology Transfer Network Air Toxics Website. *1,3-Ethylbenzene*. "Hazard Summary" (revised January, 2000). Available from URL: http://www.epa.gov/ttn/atw/hlthef/ethylben.html

[66] U.S. Environmental Protection Agency. Technology Transfer Network Air Toxics Website. *1,3-Toluene*. "Hazard Summary" (revised January, 2000). Available from URL: http://www.epa.gov/ttn/atw/hlthef/toluene.html

fatigue, tremors, and decrease in coordination. Respiratory, cardiovascular, and kidney effects have also been reported.[67]

3.2.3 Regulation of VOCs

There are a number of oil-and-gas-related VOCs that are regulated as air, soil and water contaminants.[68] Several of the VOCs emitted from oil and gas facilities are regulated as toxic air pollutants under the federal *Clean Air Act*. These compounds include BTEX, formaldehyde, hexane and 1,3-butadiene.[69]

The U.S. EPA, Region 9, has developed risked-based exposure guidelines for a number of air contaminants at Superfund Sites. These concentrations, known as Preliminary Remediation Goals (PRG) are deemed to be protective of human health. EPA uses the PRG concentrations as a screening tool – if the concentrations of the air contaminants are below the PRG concentrations, EPA generally will not require any action to further reduce concentrations. EPA has set ambient air PRGs for a number of VOCs. The table below includes some examples of PRG concentrations. For a complete list, visit: http://www.epa.gov/region09/waste/sfund/prg

Table 5. EPA Risk-Based Exposure Concentrations for Selected VOCs.

Volatile Organic Compound	EPA Region 9 Preliminary Remediation Goals for Volatile Organic Compounds in Ambient Air (μg/m³)
Acetone	3300
Chloroform	0.083
1,4-Dichlorobenzene	0.31
Benzene	0.25
Toluene	400
Ethylbenzene	1100
Xylenes	110

The California Environmental Protection Agency (CalEPA) has established chronic inhalation reference exposure levels for 80 air contaminants, including a number of

[67] U.S. Environmental Protection Agency. Technology Transfer Network Air Toxics Website. *1,3-Xylenes*. "Hazard Summary" (revised January, 2000). Available from URL: http://www.epa.gov/ttn/atw/hlthef/xylenes.html

[68] EPA has set Maximum Contaminant Levels (MCLs) for BTEX in drinking water: 0.005 ppm benzene; 1.0 ppm toluene; 0.7 ppm ethylbenzene; and 10 ppm xylenes (total). The MCL is set so that a lifetime exposure at the MCL concentration would result in no more than 1 - 100 excess cases of cancer per million people exposed. (U.S. EPA. *List of Contaminants & their MCLs*. Available from URL: http://www.epa.gov/safewater/mcl.html)

[69] U.S. Environmental Protection Agency. *Health Effects Notebook for Hazardous Air Pollutants*. Available from URL: http://www.epa.gov/ttn/atw/hlthef/hapindex.html

VOCs.[70] For example, they have established an inhalation reference exposure level of 0.06 mg/m^3 (60 μg/m^3 or 18.8 ppb) for benzene based on hematological effects in humans.[71] The CalEPA reference exposure level is a concentration at or below which adverse health effects are not likely to occur.

For some VOCs, occupational exposure limits have been set to protect human health and safety. In some cases, the limits are "advisory," e.g., those provided by the American Industrial Hygiene Association (AIHA) or the American Conference of Governmental and Industrial Hygienist (ACGIH). Other exposure limits, such as those set by the Occupational Safety and Health Administration (OSHA), have been incorporated into government regulations. These levels are much higher than the ambient air quality guidelines above, because these represent short-term exposures to the air contaminants.

Table 6. Examples of health-and-safety-based exposure limits for various VOCs.[72]

	AIHA ERPG 2[73] (1-hour exposure – no irreversible or serious health effects)	AIHA ERPG 1[74] (1-hour exposure – only mild, transient adverse health effects)	ACGIH STEL[75] (15-minute exposure)
1,3-Butadiene	442 mg/m^3 200 ppm	22.1 mg/m^3 10 ppm	-
Benzene	489 mg/m^3 150 ppm	163 mg/m^3 50 ppm	8 mg/m^3 2.5 ppm
Ethylbenzene	-	-	545 mg/m^3 125 ppm
Toluene	1130 mg/m^3 300 ppm	188 mg/m^3 50 ppm	-
Xylenes	-	-	655 mg/m^3 151 ppm

[70] California Office of Environmental Health Hazard Assessment. "Chronic Reference Exposure Levels Adopted by OEHHA as of Feb. 2005." Available from URL: http://www.oehha.ca.gov/air/chronic_rels/AllChrels.html

[71] California Environmental Protection Agency (CalEPA). *Air Toxics Hot Spots Program Risk Assessment Guidelines: Part III. Technical Support Document for the Determination of Noncancer Chronic Reference Exposure Levels*. *SRP Draft*. Office of Environmental Health Hazard Assessment, Berkeley, CA. 1999. Available from URL: http://www.oehha.ca.gov/air/chronic_rels/pdf/relsP32k.pdf

[72] All data from the U.S. Environmental Protection Agency. *Health Effects Notebook for Hazardous Air Pollutants*. Available from URL: http://www.epa.gov/ttn/atw/hlthef/hapindex.html

[73] **AIHA ERPG 2**-- is the maximum airborne concentration below which it is believed nearly all individuals could be **exposed up to one hour without experiencing or developing irreversible or other serious health effects** that could impair their abilities to take protective action.

[74] **AIHA ERPG 1**--American Industrial Hygiene Association's emergency response planning guidelines. ERPG 1 is the maximum airborne concentration below which it is believed nearly all individuals could be **exposed up to one hour without experiencing other than mild transient adverse health effects** or perceiving a clearly defined objectionable odor.

[75] **ACGIH STEL**--American Conference of Governmental and Industrial Hygienist's threshold limit value short-term exposure limit; a **15-minute exposure, not be exceeded** at any time during a workday.

4.0 RESULTS

Appendix 2 includes information on all of the sample sites from our study where there were measurable concentrations of H_2S and VOCs. The following sections provide summaries and graphical representations of the sampling results.

4.1 Hydrogen Sulfide

Hydrogen sulfide concentrations varied over the five-day monitoring period. The highest reading, 2.6 ppm (2,600 ppb), was measured in a residential area.

Oil and Gas Wells – H_2S concentrations in the vicinity of well sites were below 8 ppb.

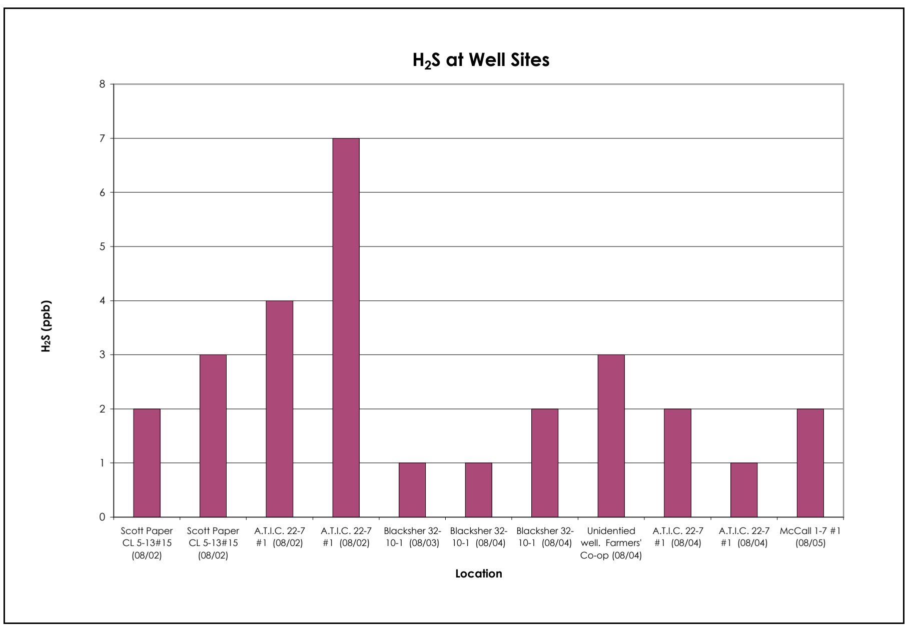
Oil and Gas Facilities (gas plants, tank batteries, metering stations, "refinery") – concentrations ranged from 0 – 1,200 ppb.

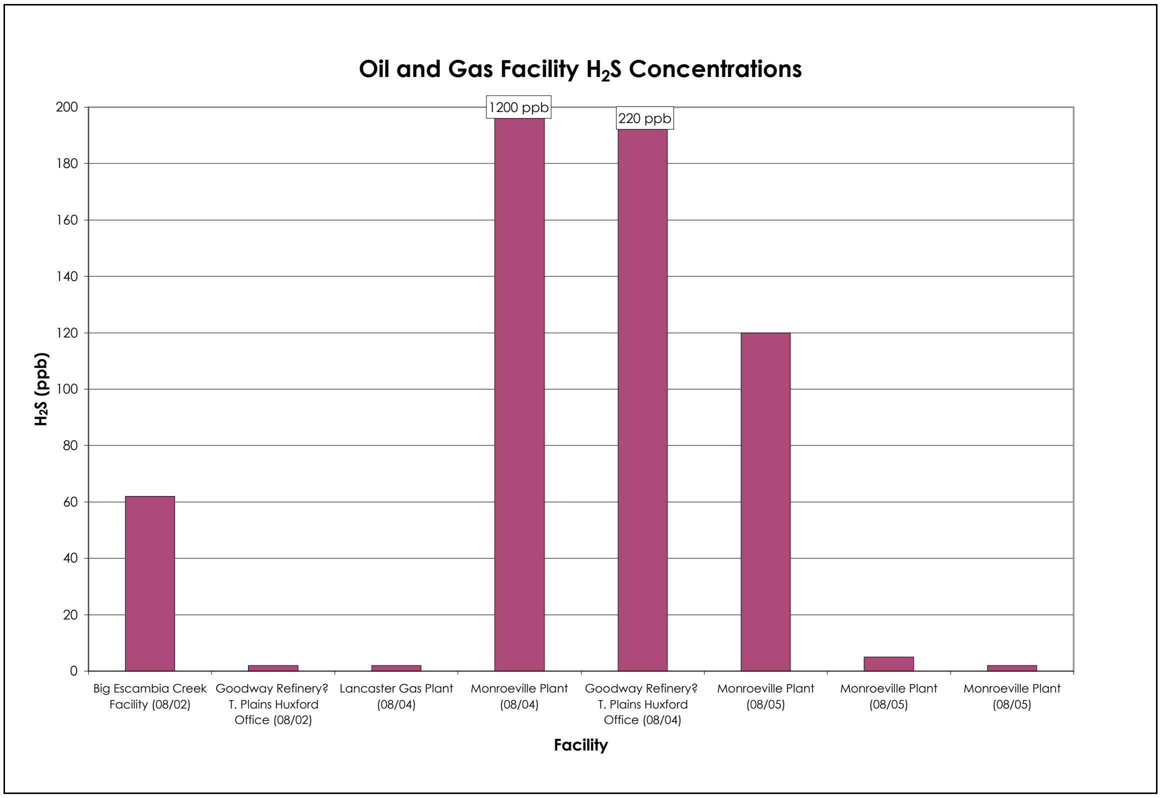
Wood Product Operations – H_2S concentrations were 1 - 7 ppb near all facilities except Harrigan Lumber in Monroeville, which had H_2S readings as high as 1,400 ppb.

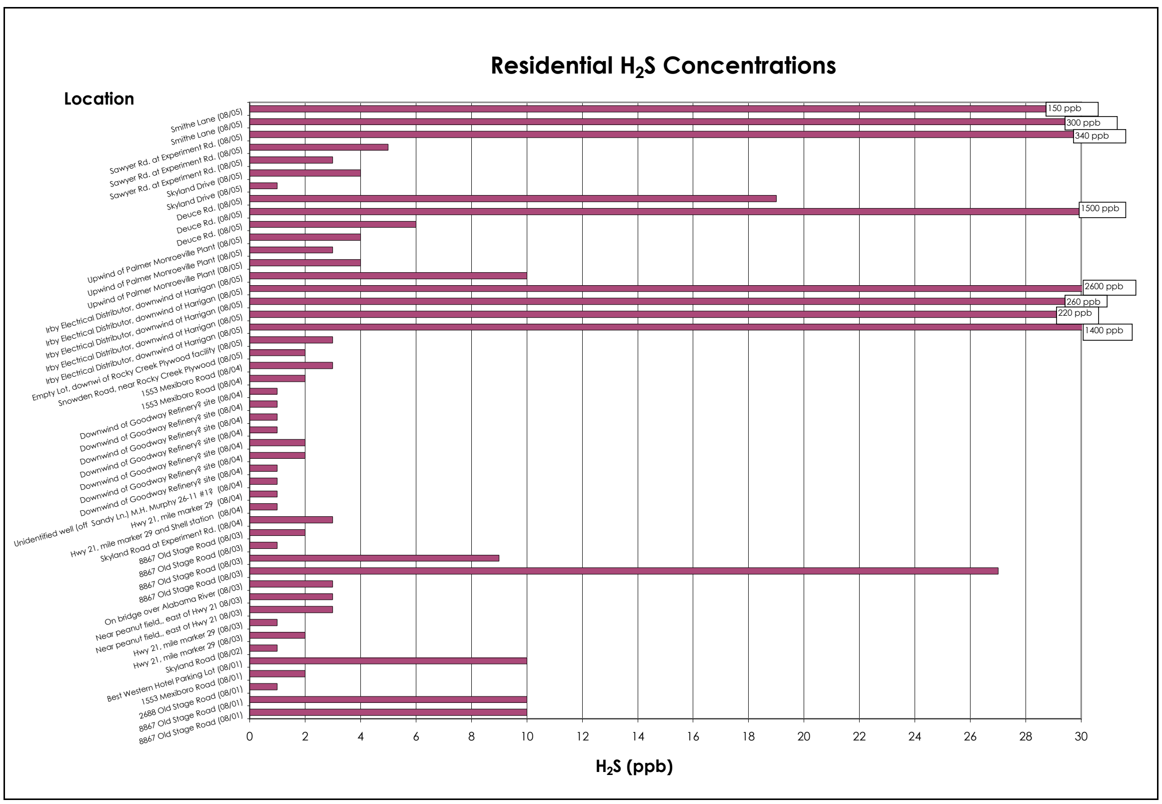
Sewage Treatment Plant – the concentrations of H_2S measured at a sewage treatment plant that serves the municipality of Monroeville, were in the 3 – 4 ppb range.

Residential areas – the majority of H_2S readings were below 10 ppb; five were between 150 and 300 ppb; and three were between 1,400 and 2,600 ppb (one downwind of Monroeville Gas Plant, and two downwind of Harrigan Lumber).

The following charts show sites where H_2S was detected over the sampling period.




Oil and Gas Facility H2S Concentrations
H2S (ppb)
200
180
160
140
120
100
80
60
40
20
0
1200 ppb
220 ppb
Big Escambia Creek Facility (08/02)
Goodway Refinery? T. Plains Huxford Office (08/02)
Lancaster Gas Plant (08/04)
Monroeville Plant (08/04)
Goodway Refinery? T. Plains Huxford Office (08/04)
Monroeville Plant (08/05)
Monroeville Plant (08/05)
Monroeville Plant (08/05)
Facility


Residential H2S Concentrations
Location
Smithe Lane (08/05)
Smithe Lane (08/05)
Sawyer Rd. at Experiment Rd. (08/05)
Sawyer Rd. at Experiment Rd. (08/05)
Sawyer Rd. at Experiment Rd. (08/05)
Skyland Drive (08/05)
Skyland Drive (08/05)
Deuce Rd. (08/05)
Deuce Rd. (08/05)
Deuce Rd. (08/05)
Upwind of Palmer Monroeville Plant (08/05)
Upwind of Palmer Monroeville Plant (08/05)
Upwind of Palmer Monroeville Plant (08/05)
Irby Electrical Distributor, downwind of Harrigan (08/05)
Irby Electrical Distributor, downwind of Harrigan (08/05)
Irby Electrical Distributor, downwind of Harrigan (08/05)
Irby Electrical Distributor, downwind of Harrigan (08/05)
Irby Electrical Distributor, downwind of Harrigan (08/05)
Empty Lot, downwi of Rocky Creek Plywood facility (08/05)
Snowden Road, near Rocky Creek Plywood (08/05)
1553 Mexiboro Road (08/04)
1553 Mexiboro Road (08/04)
Downwind of Goodway Refinery? site (08/04)
Downwind of Goodway Refinery? site (08/04)
Downwind of Goodway Refinery? site (08/04)
Downwind of Goodway Refinery? site (08/04)
Downwind of Goodway Refinery? site (08/04)
Downwind of Goodway Refinery? site (08/04)
Downwind of Goodway Refinery? site (08/04)
Unidentified well (off Sandy Ln.) M.H. Murphy 26-11 #1? (08/04)
Hwy 21, mile marker 29 (08/04)
Hwy 21, mile marker 29 and Shell station (08/04)
Skyland Road at Experiment Rd. (08/04)
8867 Old Stage Road (08/03)
8867 Old Stage Road (08/03)
8867 Old Stage Road (08/03)
8867 Old Stage Road (08/03)
On bridge over Alabama River (08/03)
Near peanut field,, east of Hwy 21 08/03)
Near peanut field,, east of Hwy 21 08/03)
Hwy 21, mile marker 29 (08/03)
Hwy 21, mile marker 29 (08/03)
Skyland Road (08/02)
Best Western Hotel Parking Lot (08/01)
1553 Mexiboro Road (08/01)
2688 Old Stage Road (08/01)
8867 Old Stage Road (08/01)
8867 Old Stage Road (08/01)
150 ppb
300 ppb
340 ppb
1500 ppb
2600 ppb
260 ppb
220 ppb
1400 ppb
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
H2S (ppb)

4.2 Volatile Organic Compounds

Concentrations of volatile organic compounds varied over the five-day monitoring period. They ranged from non-detectable to 199 parts per million (the maximum concentration that the ppb-RAE monitor can record). Since 199 ppm is the upper limit of the VOC monitor, it is probable that when we recorded readings of 199 ppm, the actual concentrations were above 199 ppm.

The highest VOC readings occurred at a well site, and in residential areas (downwind of a gas processing plant).

Oil and Gas Wells – concentrations ranged from 870 ppb 199 ppm. Eight wells had readings greater than 100 ppm.

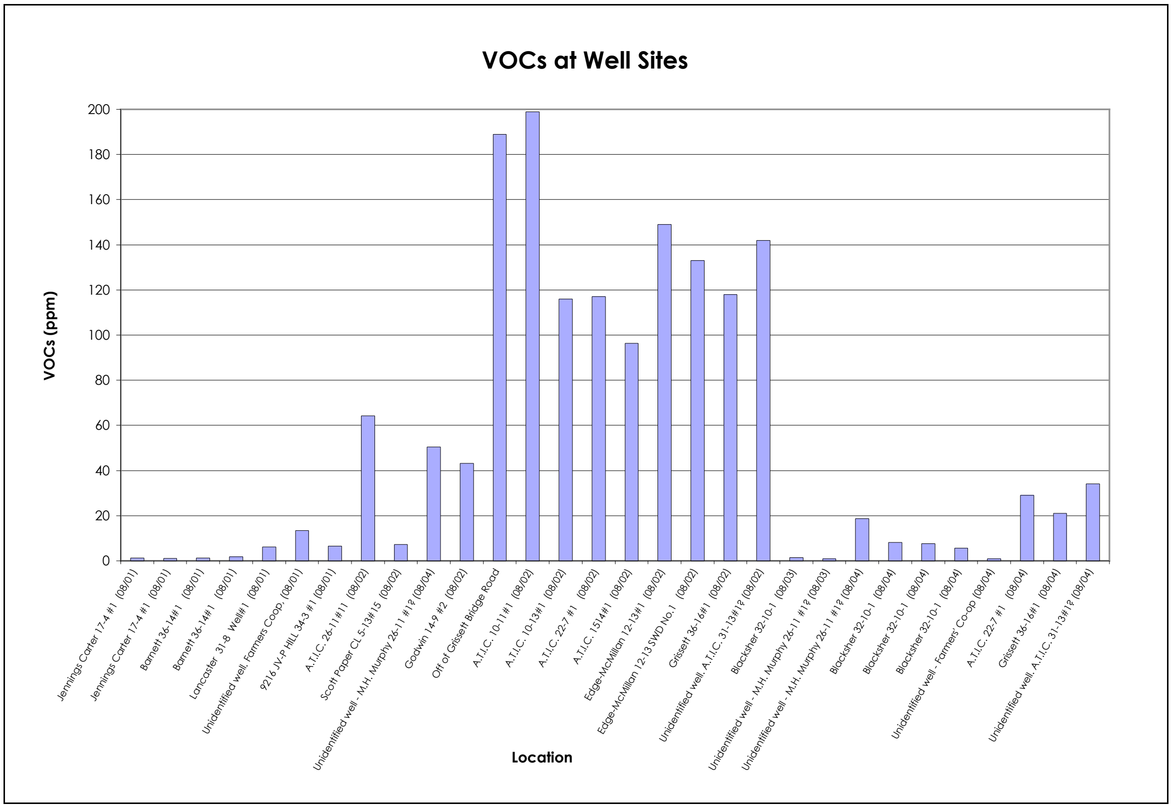
Oil and Gas Facilities (gas plants, tank batteries, metering stations, "refinery") – VOC concentrations ranged from 400 ppb to 178 ppm. Three sites had VOC readings above 100 ppm.

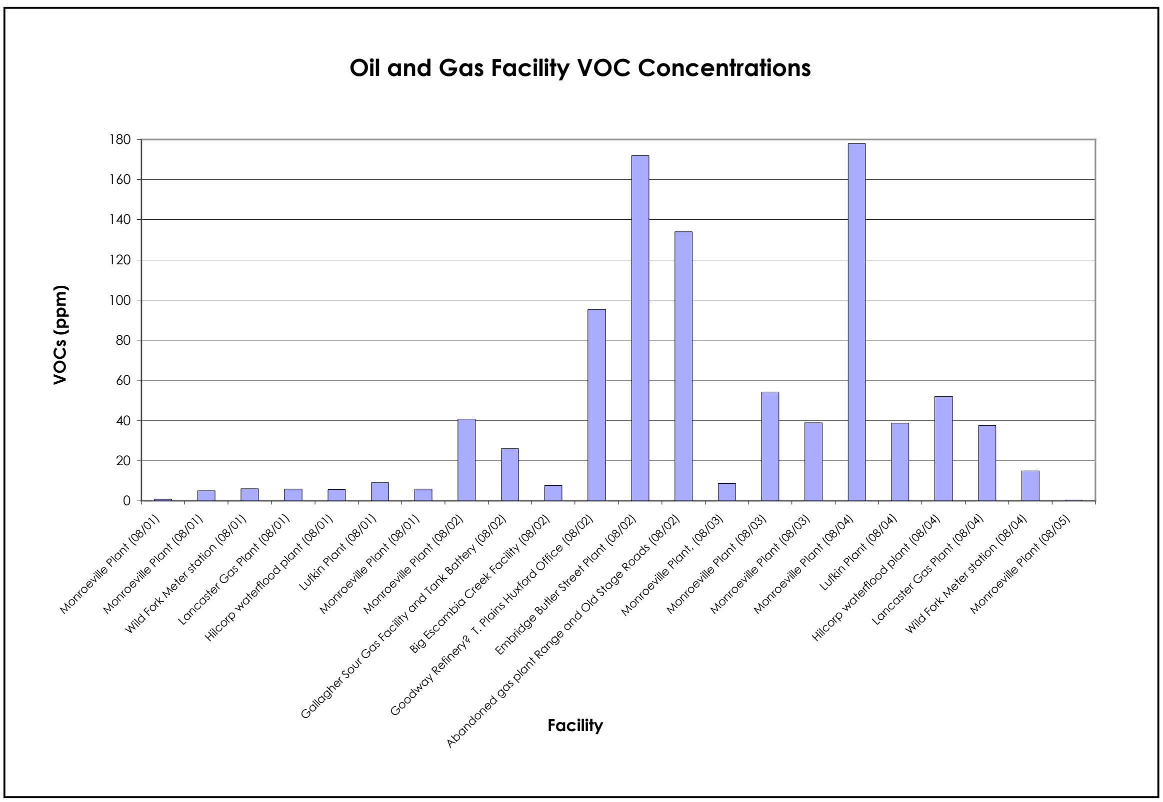
Wood Product Operations – the lowest VOC readings, which were less than 400 ppb, were at or near the Harrigan Lumber facility (but it was fairly windy when the measurements were taken, so the VOCs may have been dispersed). The Georgia Pacific operation had VOC levels of approximately 5 ppm. The Rocky Creek Plywood facility, and nearby neighborhoods, had much higher VOC concentrations, up to 60 ppm at the facility and 98 ppm in the neighborhood.

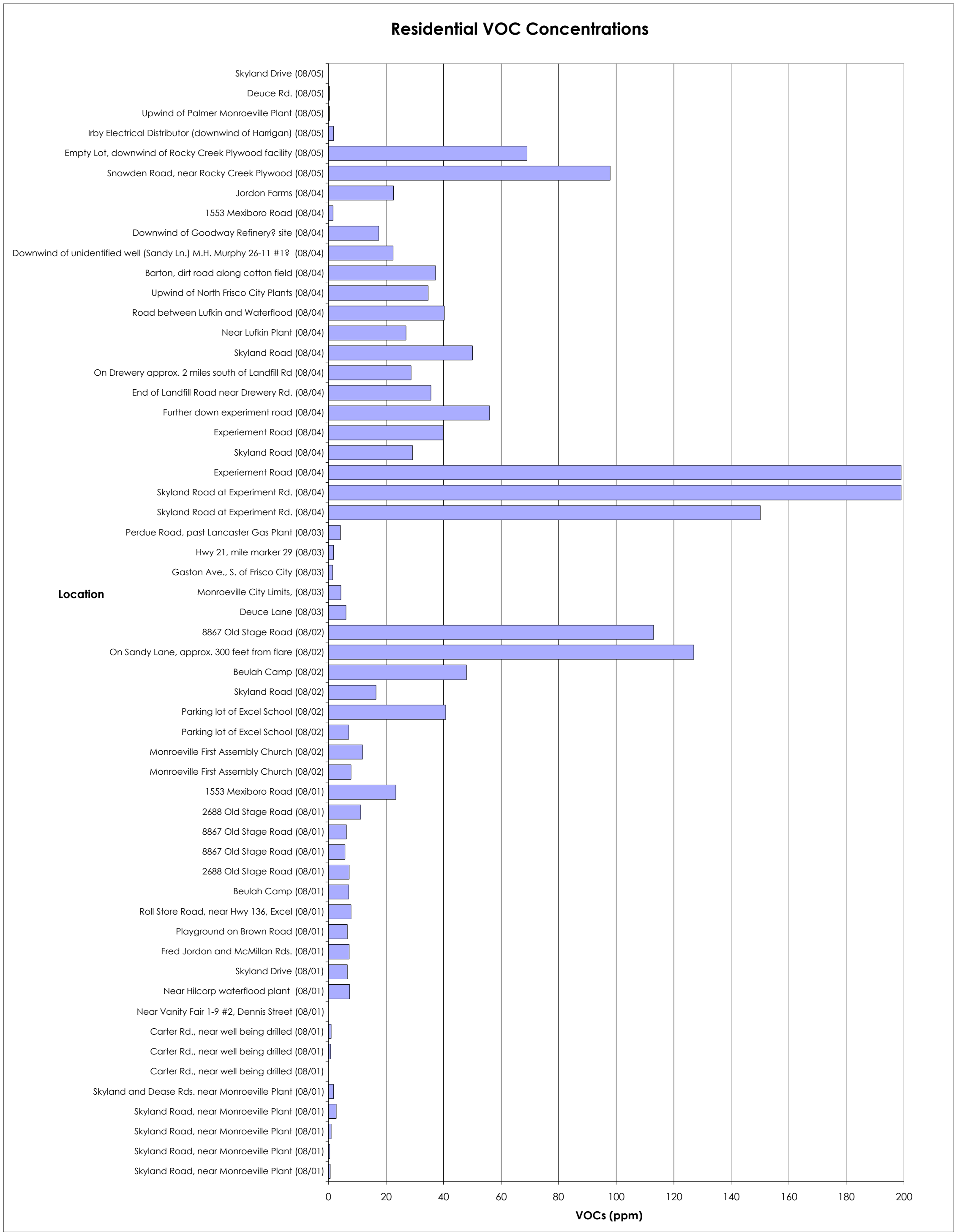
Sewage Treatment Plant – VOCs were not measured.

Residential areas – the concentrations varied from no detectable VOCs to 199 ppm. Four locations had concentrations greater than 100 ppm.

The charts on the following pages show all of the sites where VOCs were detected during our five-day sampling period.


VOCs at Well Sites
VOCs (ppm)
200
180
160
140
120
100
80
60
40
20
0
Jennings Carter 17-4 #1 (08/01)
Jennings Carter 17-4 #1 (08/01)
Barnett 36-14#1 (08/01)
Barnett 36-14#1 (08/01)
Lancaster 31-8 Well#1 (08/01)
Unidentified well. Farmers Coop. (08/01)
9216 JV-P HILL 34-3 #1 (08/01)
A.T.I.C. 26-11#11 (08/02)
Scott Paper CL 5-13#15 (08/02)
Unidentified well - M.H. Murphy 26-11 #1? (08/04)
Godwin 14-9 #2 (08/02)
Off of Grissett Bridge Road
A.T.I.C. 10-11#1 (08/02)
A.T.I.C. 10-13#1 (08/02)
A.T.I.C. 22-7 #1 (08/02)
A.T.I.C. 1514#1 (08/02)
Edge-McMillan 12-13#1 (08/02)
Edge-McMillan 12-13 SWD No.1 (08/02)
Grissett 36-16#1 (08/02)
Unidentified well. A.T.I.C. 31-13#1? (08/02)
Blacksher 32-10-1 (08/03)
Unidentified well - M.H. Murphy 26-11 #1? (08/03)
Unidentified well - M.H. Murphy 26-11 #1? (08/04)
Blacksher 32-10-1 (08/04)
Blacksher 32-10-1 (08/04)
Blacksher 32-10-1 (08/04)
Unidentified well - Farmers' Co-op (08/04)
A.T.I.C. 22-7 #1 (08/04)
Grissett 36-16#1 (08/04)
Unidentified well. A.T.I.C. 31-13#1? (08/04)
Location


Oil and Gas Facility VOC Concentrations
VOCs (ppm)
180
160
140
120
100
80
60
40
20
0
Monroeville Plant (08/01)
Monroeville Plant (08/01)
Wild Fork Meter station (08/01)
Lancaster Gas Plant (08/01)
Hilcorp waterflood plant (08/01)
Lufkin Plant (08/01)
Monroeville Plant (08/01)
Monroeville Plant (08/02)
Gallagher Sour Gas Facility and Tank Battery (08/02)
Big Escambia Creek Facility (08/02)
Goodway Refinery? T. Plains Huxford Office (08/02)
Embridge Butler Street Plant (08/02)
Abandoned gas plant Range and Old Stage Roads (08/02)
Monroeville Plant, (08/03)
Monroeville Plant (08/03)
Monroeville Plant (08/03)
Monroeville Plant (08/04)
Lufkin Plant (08/04)
Hilcorp waterflood plant (08/04)
Lancaster Gas Plant (08/04)
Wild Fork Meter station (08/04)
Monroeville Plant (08/05)
Facility


Residential VOC Concentrations
Skyland Drive (08/05)
Deuce Rd. (08/05)
Upwind of Palmer Monroeville Plant (08/05)
Irby Electrical Distributor (downwind of Harrigan) (08/05)
Empty Lot, downwind of Rocky Creek Plywood facility (08/05)
Snowden Road, near Rocky Creek Plywood (08/05)
Jordon Farms (08/04)
1553 Mexiboro Road (08/04)
Downwind of Goodway Refinery? site (08/04)
Downwind of unidentified well (Sandy Ln.) M.H. Murphy 26-11 #1? (08/04)
Barton, dirt road along cotton field (08/04)
Upwind of North Frisco City Plants (08/04)
Road between Lufkin and Waterflood (08/04)
Near Lufkin Plant (08/04)
Skyland Road (08/04)
On Drewery approx. 2 miles south of Landfill Rd (08/04)
End of Landfill Road near Drewery Rd. (08/04)
Further down experiment road (08/04)
Experiement Road (08/04)
Skyland Road (08/04)
Experiement Road (08/04)
Skyland Road at Experiment Rd. (08/04)
Skyland Road at Experiment Rd. (08/04)
Perdue Road, past Lancaster Gas Plant (08/03)
Hwy 21, mile marker 29 (08/03)
Gaston Ave., S. of Frisco City (08/03)
Monroeville City Limits, (08/03)
Deuce Lane (08/03)
8867 Old Stage Road (08/02)
On Sandy Lane, approx. 300 feet from flare (08/02)
Beulah Camp (08/02)
Skyland Road (08/02)
Parking lot of Excel School (08/02)
Parking lot of Excel School (08/02)
Monroeville First Assembly Church (08/02)
Monroeville First Assembly Church (08/02)
1553 Mexiboro Road (08/01)
2688 Old Stage Road (08/01)
8867 Old Stage Road (08/01)
8867 Old Stage Road (08/01)
2688 Old Stage Road (08/01)
Beulah Camp (08/01)
Roll Store Road, near Hwy 136, Excel (08/01)
Playground on Brown Road (08/01)
Fred Jordon and McMillan Rds. (08/01)
Skyland Drive (08/01)
Near Hilcorp waterflood plant (08/01)
Near Vanity Fair 1-9 #2, Dennis Street (08/01)
Carter Rd., near well being drilled (08/01)
Carter Rd., near well being drilled (08/01)
Carter Rd., near well being drilled (08/01)
Skyland and Dease Rds. near Monroeville Plant (08/01)
Skyland Road, near Monroeville Plant (08/01)
Skyland Road, near Monroeville Plant (08/01)
Skyland Road, near Monroeville Plant (08/01)
Skyland Road, near Monroeville Plant (08/01)
Location
0
20
40
60
80
100
120
140
160
180
200
VOCs (ppm)

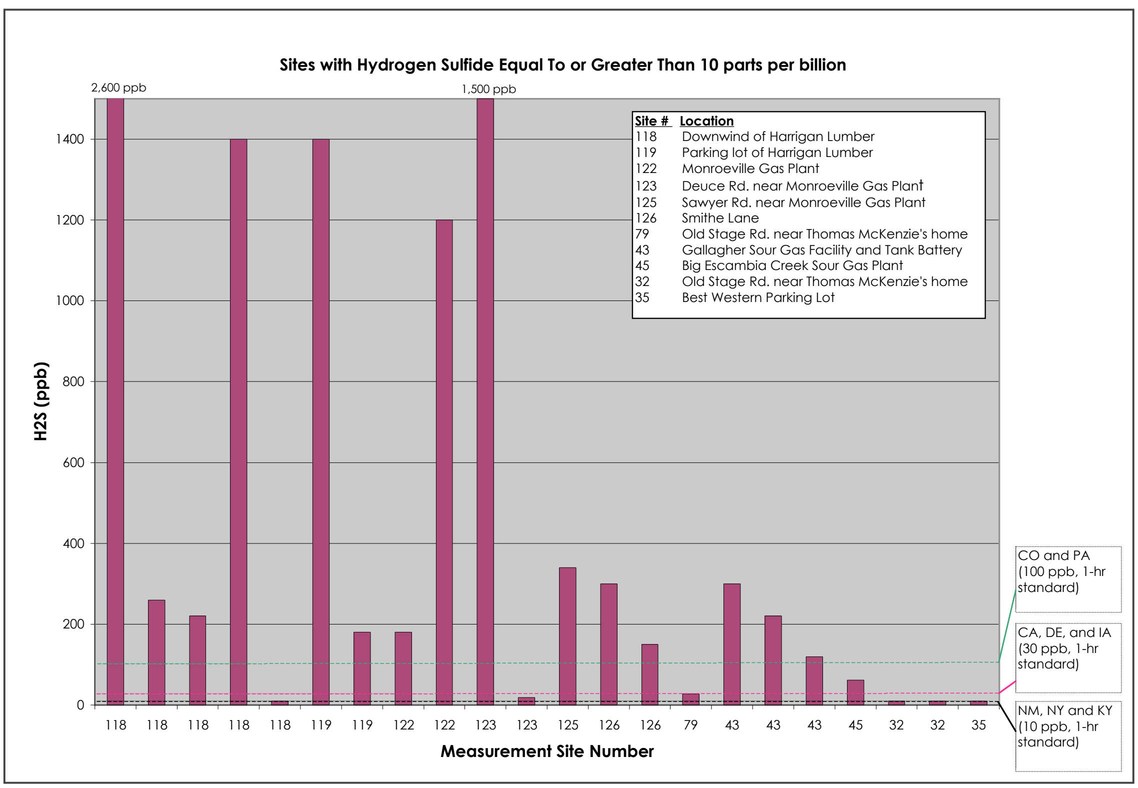
5.0 Discussion

Table 7. Summary table for ranges in H_2S and VOC concentrations.

	Oil and Gas Wells	Gas Plants	Wood Products	Sewage	Residential
H_2S (ppb)	< 8	0 – 1,200	1 - 1,400	3 - 4	10 – 2,600
VOCs (ppb)	870 – 199,000	400 – 178,000	<400 – 60,000	-	0 – 199,000

5.1 Hydrogen Sulfide

Alabama does not have an ambient air quality standard for H_2S. Thus, we have taken the liberty of comparing H_2S concentrations measured in these three Alabama counties to standards that have been set by other states. Ten parts per billion (ppb) is the value that some states (NM, NY, KY) have set as the average value not to be exceeded when H_2S is monitored over a 1-hour period. The chart below depicts our sampling sites that had H_2S concentrations equal to or greater than 10 ppb. Twenty-two measurements at ten separate sites exceeded the 10 ppb value.

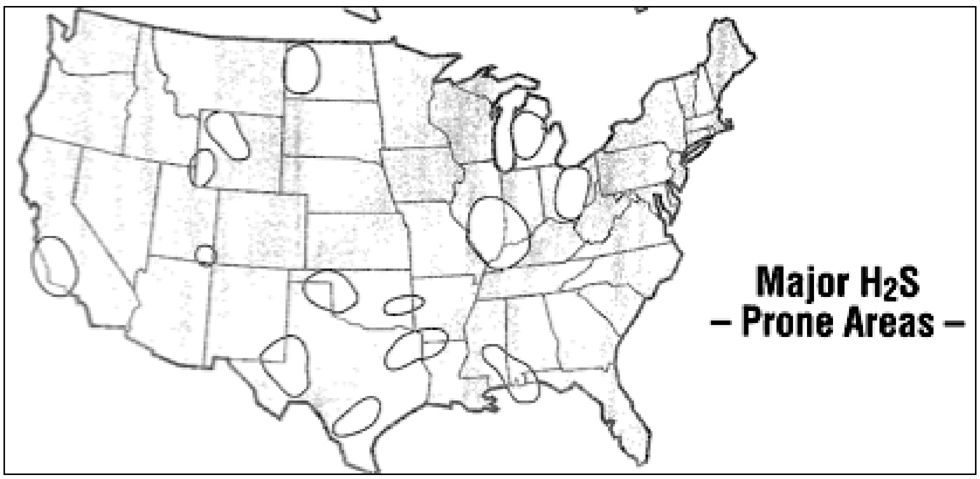


These levels of hydrogen sulfide are between 10 and 2600 times greater than normal urban background levels, which are typically less than 1 ppb.[76] In unpolluted areas, concentrations of H_2S may be as low as 0.03 – 0.1 μg/m3 (0.02 – 0.07 ppb).[77]

We did not take an average measurement over a 1-hour period; rather, our readings reflect the average taken over less than a minute. Regardless of our measurement technique, however, these results suggest that ambient concentrations at some locations are likely exceed many state regulatory standards that have been set to protect human health, welfare and quality of life.

5.1.1 Gas wells and processing plants

As seen in the map below, the southwest region of Alabama contains some oil and gas reservoirs that have a high content of hydrogen sulfide.



Source: Gas Research Institute, 1990.[78]

In Alabama, the Oil and Gas Board (OGB) defines a sour gas operation as a facility that handles hydrogen sulfide concentrations equal to one hundred (100) parts per million (ppm) or more.[79]

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[76] Agency for Toxic Substances and Disease Registry (ATSDR). 2004. *Toxicological Profile For Hydrogen Sulfide* (Draft for Public Comment). Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service. Chapter 2, p.1.

[77] Chou, S. 2003. *Hydrogen Sulfide: Human Health Aspects*. Concise International Chemical Assessment Document 53. Prepared for the World Health Organization. p. 7. Available from URL: http://www.who.int/ipcs/publications/cicad/en/cicad53.pdf

[78] Energy and Environmental Analysis. Nov. 1990. *Chemical Composition of Discovered and Undiscovered Natural Gas in the Lower-48 United States*. Prepared for the Gas Research Institute. 90/0248. p. 1-13.

[79] Alabama Oil and Gas Board. *Rules and Regulations of the State Oil and Gas Board of Alabama Governing Onshore Lands Operations*. 400-1-1-.05. Definitions. (69) "Sour gas operations." Available from URL: http://www.ogb.state.al.us/HTMLS/OGBRULES/4001.htm#400-1-1-.05

The Alabama OGB has identified fifteen sour gas fields in Escambia and Conecuh counties in southwest Alabama, and three gas processing plants that process the hydrogen-sulfide-laden gas (Table 8).[80]

Table 8. Producing oil and gas fields and plants in Conecuh, Escambia, and Monroe counties with 100 parts per million (ppm) or greater of hydrogen sulfide.[81]

FIELDS	COUNTY
Appleton	Escambia
Big Escambia Creek	Escambia
Big Spring	Escambia
Fanny Church	Escambia
Flomaton	Escambia
Huxford	Escambia
Little Cedar Creek	Conecuh
Little Escambia Creek	Escambia
Little Rock	Escambia
Northwest Appleton	Escambia
Northwest Hall Creek	Escambia
Northwest Smiths Church	Escambia
South Burnt Corn Creek	Escambia
West Appleton	Escambia
Wild Fork Creek	Escambia
PLANTS	**COUNTY**
Castleberry Plant	Conecuh
Big Escambia Creek Plant	Escambia
Flomaton Plant	Escambia

The oil and gas wells located in these fields, as well as the plants themselves (due to fugitive or intentional releases of gas) are likely sources of H_2S. Table 9 contains a list of some of the sour gas wells in Escambia and Conecuh counties. The table includes the H_2S content of the gas extracted from these wells.[82]

We did not have the opportunity to sample around most of these well sites to determine H_2S emissions coming off of the equipment (e.g., through leaky values and connections or on-site venting and flaring of natural gas). We did sample near one sour well (A.T.I.C. 22-7 #1), and measured H_2S concentrations between 1 and 7 ppb.

[80] Alabama Oil and Gas Board gas plant data. Letter from Berry H. Tew, Jr., Oil and gas supervisor, to Thomas McKenzie and Audrey Silcox. June 20, 2005. The letter included a chart entitled "Producing fields and plants in Conecuh, Escambia and Monroe Counties with 100 parts per million (ppm) or greater of Hydrogen Sulfide."

[81] Information included in a letter from Alabama Oil and Gas Board to Audrey Silcox and Thomas McKenzie. June 20, 2005.

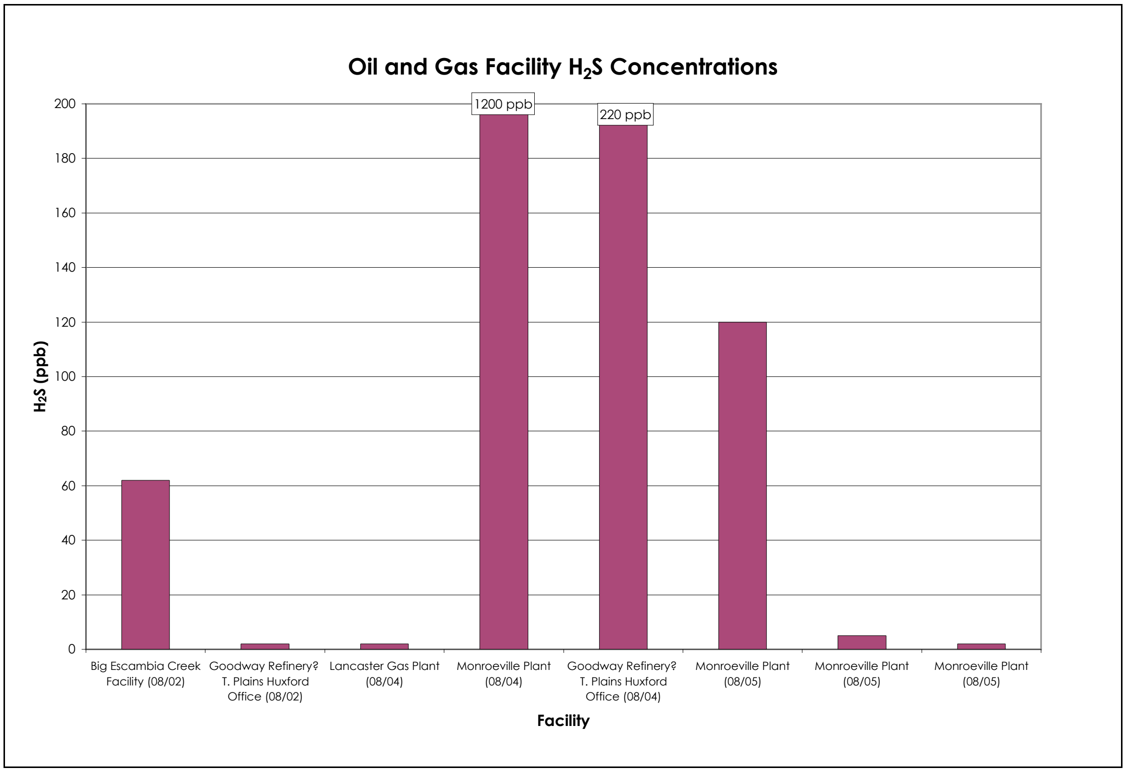
[82] Data from the Alabama State Oil and Gas Board "PVT database", which includes reservoir engineering parameters such as formation volume factor, solution gas/oil ratio, full well stream hydrocarbon analyses, and API gravity. Database can be accessed at: http://www.ogb.state.al.us/HTMLS/dbpvt.htm

Table 9. Wells in Escambia and Conecuh Counties with greater than 100 ppm H_2S in the gas stream.

County	Permit #	Well name	H_2S Mol %	H_2S ppm[83]	Field
Escambia	1869	DORA J. STEELY #36-2	2.2	22000	Fanny Church-Oil
Escambia	3581	ATIC 35-6 #2	0.03	300	Huxford-Oil
Escambia	3584	APPLETON UNIT 2-14 #1	1.75	17500	Appleton-Oil
Escambia	3986	APL UNIT TR 5: MCMILLAN TRUST 11-1 #2	1.6	16000	Appleton-Oil
Escambia	4693-B	PARSONS 4-16 #2	3.45	34500	Catawba Springs-Oil
Escambia	5178	HUXFORD 34-2 #1	0.67	6700	Hanberry Church-Oil
Escambia	5272	EARL H. WEAVER 22-15 #1	0.68	6800	South Burnt Corn Creek-Oil
Escambia	5411	IPC 5-10 #1	4.2	42000	Wild Fork Creek-Oil
Escambia	5757	P.H. GALLAGHER 16-3 #1	0.69	6900	West Appleton-Oil
Escambia	6943	EDGE-WEFEL TRUST 24-5 #1	3.64	36400	North Smiths Church-Oil
Escambia	10166	A.T.I.C. 34-4 #1	3.42	34200	Northwest Smiths Church-Oil
Escambia	10217	A.T.I.C. 10-10 #1	0.1	1000	Chitterling Creek-Oil
Escambia	10572	A.T.I.C. 21-5 #1	0.7	7000	East Robinson Creek-Oil
Escambia	11030-B	MCMILLAN 3-9 #1	2.54	25400	Northwest Appleton-Oil
Escambia	11116-B	A.T.I.C. 22-7 #1	2.27	22700	Southwest Canaan Church-Oil
Escambia	13756	ATIC 27-8 #1	1.52	15200	Wildcat
Conecuh	10560	CEDAR CREEK LAND & TIMBER CO. 30-1 #1	0.29	2900	Little Cedar Creek-Oil
Conecuh	13472	PUGH 22-2	0.07	700	Little Cedar Creek-Oil

As seen in the graph on the next page, the concentrations measured at the perimeter of some the gas processing plants were in the range of 2 to 1200 ppb.

[83] If H_2S contents are reported in ppm or grains (gr) per 100 scf, use the following factors to convert to mole %: 10,000 ppm H_2S = 1 mole % H_2S; 627 gr H_2S/100 scf = 1 mole % H_2S.
Source: U. S. Environmental Protection Agency. *AP-42 Emissions Factors, Ch. 5, Petroleum Industry, S. 5.3, Natural Gas Processing*. p.5.3-1. Available from URL: http://www.epa.gov/ttn/chief/ap42/ch05/final/c05s03.pdf



In Alabama, there are regulations that pertain to acceptable H_2S concentrations near refineries and gas plants. Section 335-3-5-.03 of the Alabama Administrative Code applies to facilities that handle natural gas or refinery gas that contains more than 0.10 grain of hydrogen sulfide per standard cubic foot (SCF). The regulation states:

> *No person shall cause or permit the emission of a process gas stream containing more than 0.10 grain of hydrogen sulfide per SCF into the atmosphere unless it is properly burned to maintain the ground level concentrations of hydrogen sulfide to less than twenty (20) parts per billion beyond plant property limits, averaged over a thirty (30) minute period.*[84]

While we do not have the capability of proving that H_2S measured near the gas processing plants originated from the plants, the above graph shows that four measurements taken at the fence-line of gas plants/refineries exceeded the 20 ppb standard. On August 4 and 5, the Monroeville plant had readings of 120 and 1,200 ppb, respectively. The Big Escambia Plant had a reading of 62 ppb on August 2, and the "Goodway Refinery"[85] had a reading of 220 ppb on August 4.

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[84] *ADEM Admin. Code R. Chapter 335-3-5 Control of Sulfur Compound Emissions* Section. 03 Petroleum Production. Available from URL: http://www.adem.state.al.us/Regulations/Div3/Div3%207-06.pdf

[85] There was no identifying sign on this facility. The only sign in front of the facility read: "Thomas Plains Huxford Office. We referred to it as "Goodway Refinery." It is referenced as Site 49 in Appendix 2 of this report. It appeared to be a gas plant/fueling station.

Interestingly, the concentration near Big Escambia, the one "sour" gas plant in our study, did not register the highest H_2S concentration. There are a couple of possible reasons for this: (1) we were not directly downwind of any H_2S emissions from the plant; (2) the plant was not venting at the time; (3) the plant is well maintained (e.g., leaky fixtures and valves are immediately addressed) because it is not safe to allow H_2S into the working environment of the plant.

Meanwhile, one of the plants that processes sweet gas (i.e., Monroeville) appeared to be one of the larger H_2S emissions sources in the sampling area. It is possible that this is because the gas at Monroeville does contain some H_2S (but not enough to have it considered "sour"), and that the facility's flare does not efficiently burn the H_2S. Or perhaps, assuming that the gas contains some H_2S, vented gas and fugitive emissions from the site are large enough to allow these high readings. Alternatively, the H_2S measured at the Monroeville facility had a source other than the Monroeville plant.

5.1.2 H_2S near wood product facilities

In Alabama, there are H_2S-related regulations for pulp mills.[86] Our highest readings were near a particle board plant (Harrigan Lumber). There may be cause for health concerns for residents living near this plant. Concentrations measured at and downwind from the facility were as high as 1400 ppb.

5.2 Volatile Organic Compounds

As mentioned in the methods section of this report, the equipment used to measure VOC concentrations did not provide information on concentrations of individual VOCs. Rather, the reading reflected the sum of all volatile carbon compounds in the C1 to C10 range (excluding methane). The intention of our study was simply to identify whether emissions from the various industries in the counties may be creating an unhealthy level of VOCs.

We measured VOC concentrations as high as 199 ppm, which was the upper limit of the photo-ionization detector (i.e., VOC sampling device), indicating that in all likelihood, concentrations exceeded 199 ppm in some locations. These levels may be a cause for concern. As mentioned in the Section 3 (Literature Review) of this report, other oil and gas producing regions have measured elevated levels of VOCs. In Garfield County,

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[86] *ADEM Admin. Code R. Chapter 335-3-5 Control of Sulfur Compound Emissions.* Section 04 Kraft Pulp Mills. "(a) No person shall cause or permit the emissions of total reduced sulfur (TRS) from recovery furnaces, lime kilns, digesters, and multiple effect evaporators to exceed 1.2 pounds (expressed as hydrogen sulfide on a dry gas basis) per ton of air-dried pulp from kraft pulp mills. (b) The pulp production rates for kraft pulp mills referred to in this Rule shall be calculated as provided in Rule 335-3-4-.07(3). (c) Notwithstanding the specific limits set forth in this Rule, in order to maintain the lowest possible emission of air contaminants, the highest and best practicable treatment and control for TRS currently available shall be provided for new kraft pulp mills."

Colorado, total VOC concentrations were much lower than what we measured (i.e., parts per billion range[87]), but benzene at some Garfield County sites was measured at levels that could pose a threat to human health.

5.2.1 Flares

As mentioned in Section 3 (Literature Review) of this report, in addition to venting and fugitive emissions of natural gas, a likely source of VOCs and other potentially hazardous air emissions related to oil and gas operations are flares.

Recently, Midroc Operating Company was fined by the Alabama Department of Environmental Management (ADEM) for violating provisions of its air quality permits. Between September 28 and October 6, 2005, an ADEM staff member conducted visible emissions observations on twelve flares located at oil and gas production and separation sites in Conecuh County. The visible emissions observations resulted in nine flares having periods in which visible emissions exceeded allowable levels outlined in the company's air permits.[88]

A report by the Environmental Integrity Project, "Smoking Guns," contends that large volumes of air pollution are released because flares are poorly operated and do not burn cleanly.[89] The U.S. Environmental Protection Agency (EPA), as well, has identified visibly smoking flares as being, "far less efficient than properly maintained flares." [90]

During the week of August 1-5, 2005, when we conducted our sampling operations, we found a number of sites that had smoking flares (see photographs on the following pages). While ADEM appears to have taken a good first step in penalizing operations with inefficient flares, the problem may be more widespread than the department realizes.

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[87] Pers. Comm. Lisa Sumi, OGAP, and Jim Rada, Garfield County Health Department. Oct. 25, 2006.
[88] Alabama Department of Environmental Management. Consent Order No. 06-___-Cap. In The Matter Of: Midroc Operating Company, Castleberry, Conecuh County, Alabama, Air Facility ID No. 103-0011, Air Facility ID No. 103-0017, and Air Facility ID No. 103-0018. Available from URL: http://www.adem.state.al.us/PublicNotice/Mar/AO/Midrock.pdf
[89] U.S. Environmental Protection Agency Office of Air Quality Planning and Standards, Regulatory Impact Analysis for the Petroleum Refinery NESHAP, Revised Draft (1994). *Cited in*: Environmental Integrity Project. 2002. *Smoking Guns*. Available from URL: http://www.environmentalintegrity.org/pub75.cfm
[90] *ibid*.

Gallagher Sour Gas Facility and Tank Battery, Conecuh County, Aug. 2, 2005 (Site #43 in Appendix 3)

This facility is owned by Vintage Petroleum.

There were visible emissions from the flare stack, and H_2S odors. The maximum H_2S reading immediately downwind of this site was 300 parts per billion (ppb).

The maximum VOC reading at the site was 26 parts per million (ppm).

Unidentified well off of Sandy Lane, Escambia County, Aug. 2, 2005 (Site #47 in Appendix 3).

There was no identification sign at this site. Based on the GIS data, it was most likely Stetson Petroleum Corporation's M.H. Murphy 26-11 #1 well, permit #4577. (Latitude 31.19187; Longitude 87.43942)

Clearly, there were visible emissions from the flare stack. No H_2S was detected on August 2, but a VOC reading of 50 ppm was recorded. There are homes located as close as approximately 300 feet from the well site.

Lancaster Gas Plant, Monroe County, Aug. 4, 2005 (Site #20, Appendix 3)

Torch Operating Company operates this gas plant, which is located next to two other gas facilities.

There were visible emissions from the flare at this facility.

VOCs ranged from 27 to 52 ppm over a 25-minute period.

Figure 1 shows there are many flares that are operating in the region.

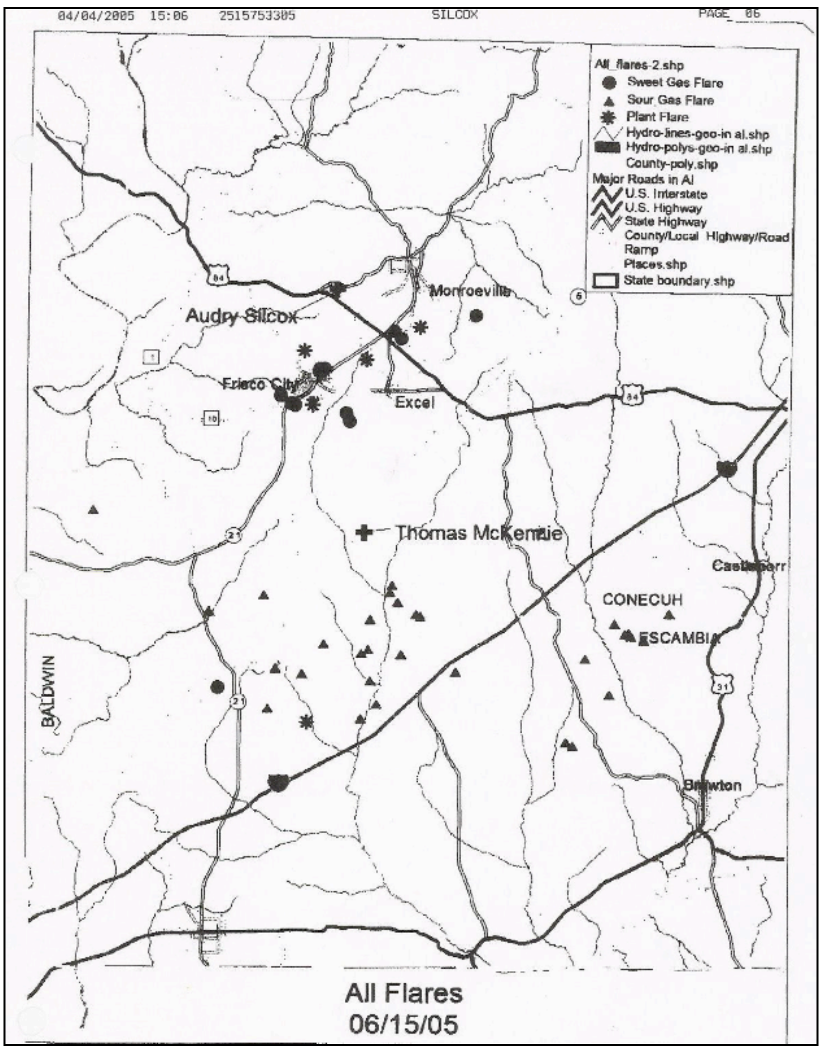


Figure 1. Sweet and sour gas flares from oil and gas wells and gas plants in Escambia, Conecuh and Monroe Counties in Alabama.

In addition to VOC emissions, these flares may be emitting other hazardous air pollutants such as polycyclic aromatic hydrocarbons (e.g., chrysene and benz(a)anthracene, which are recognized carcinogens),[91] as well as others such as acenaphthene, acenaphthylene, anthracene, pyrene, which have known health effects).[92] If the gas being flared is "sour," incomplete combustion can lead to the emission of hydrogen sulfide, as well sulfur other potentially hazardous sulfur compounds.

It is possible that routine emissions from these flares may be emitting high enough levels of air pollutants to be contributing or causing health problems in the region. It is also probable that these flares undergo "upset" situations, where large amounts of gas are vented without being burned. Upset emissions are non-routine events, such as equipment breakdowns, shutdown and maintenance at industrial facilities. As the result of upsets, pollution is often routed to a flare or vented directly to the air and normal pollution controls are bypassed.[93]

According to the Environmental Integrity Project (EIP), "Upsets are a significant source of air pollution. In some cases, releases from upsets actually dwarf a facility's routine emissions."[94]

EIP obtained upset reports for 57 facilities (18 refineries, 6 natural gas plants, 32 chemical plants, and a carbon black plant) in five states (Alabama was not included). Four of the six natural gas plants' 2003 upset emissions of VOCs were greater than the total VOC emissions that each plant reported to the state in 2002. Furthermore, EIP found that even though it is illegal under the *Clean Air Act* to emit more pollution than is allowable under a permit or rule, "approximately half of the states have created loopholes that allow pollution resulting from upsets to exceed those limits."[95]

Alabama has created such a loophole. An Alabama rule expressly exempts companies from complying with pollution permit limits during upsets. It states: "The Director may, in the Air Permit, exempt on a case by case basis any exceedances [sic] of emission limits which cannot reasonably be avoided, such as during periods of start-up, shut-down or load change."[96]

---

[91] State of California. Environmental Protection Agency. *Proposition 65. Chemical Listed Effective August 11, 2006 as Known to the State of California to Cause Cancer or Reproductive Toxicity*. Available from URL: http://www.oehha.ca.gov/prop65/prop65_list/files/P65single081106.pdf

[92] Strosher, M. Alberta Research Council. 1996. *Investigations of Flare Gas Emissions in Alberta*. Report prepared for Environment Canada, the Alberta Energy and Utilities Board and the Canadian Association of Petroleum Producers. 157 pp.

[93] Environmental Integrity Project. 2004. *Gaming the system: How off-the-books, industrial emissions cheat the public out of clean air*. p. 1. Available from URL: http://www.environmentalintegrity.org/pub240.cfm

[94] *ibid*.

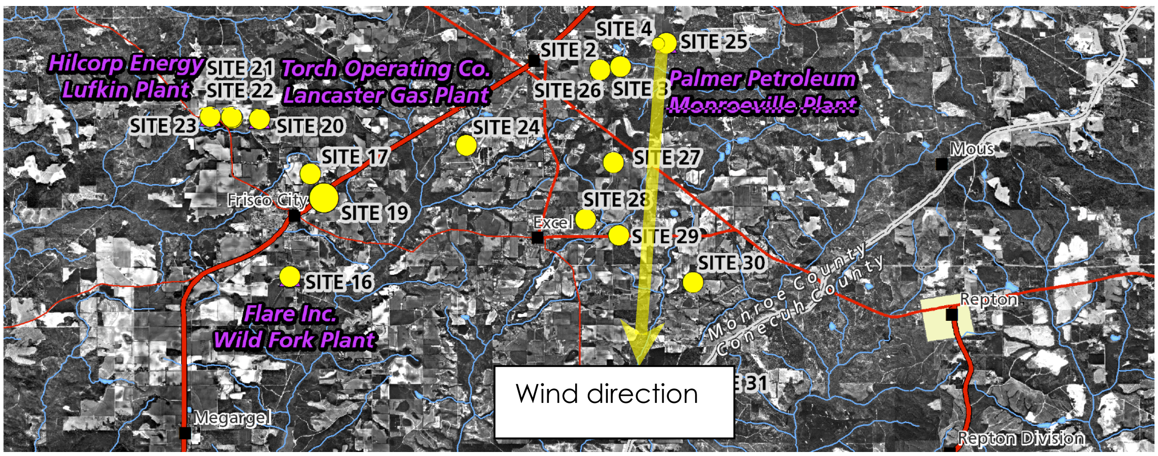
[95] Environmental Integrity Project. 2004. *Gaming the system: How off-the-books, industrial emissions cheat the public out of clean air*. p. 1

[96] Alabama Department of Environmental Management. *ADEM Admin. Code R. 335-.3.14-.03(1)(h)*. *Cited in*: Environmental Integrity Project. 2004. *Gaming the system: How off-the-books, industrial emissions cheat the public out of clean air*. p. 14.

5.2.2 Gas processing plant transects

On the afternoon of August 1, we measured elevated concentrations of VOCs near the Monroeville gas plant (Site 25, near the top of the map below). At the time, the wind was blowing toward the south and occasionally slightly toward the south-west. We headed south from the Monroeville Plant and took VOC measurements along a rough transect, up to a distance of approximately four miles from the plant.[97]

The concentrations of VOCs remained elevated along the transect. VOCs, which are extremely light compounds, are able to travel long distances via atmospheric transport, so there is the possibility that the VOCs being emitted from the Monroeville gas plant were being carried well beyond the point where we stopped taking measurements.



Date	Site #	Location	Time (p.m.)	Facility type	Visible Flare	VOC peak (ppb)
08/01	25	Monroeville Plant, far corner	5:06	Gas plant	Yes	5899
08/01	25	Monroeville Plant, corner of facility	5:12	Gas plant	Yes	4982
08/01	26	Skyland Drive (2.6 miles from Monroeville Plnt)	5:16	Residential		6522
08/01	27	Intersection of Fred Jordon and McMillan Rds	5:27	Residential		7174
08/01	28	Playground on Brown Road	5:33	Residential		6584
08/01	29	Roll Store Road, near Hwy 136, Excel	5:43	Residential		7887
08/01	30	Beulah Camp (4 miles from Monroeville Plant)	5:47	Residential		7126

As seen in the data table, above, the VOC concentrations measured at 2.6 - 4 miles from the Monroeville gas plant were actually higher than what we measured at the fenceline of the plant, which is not surprising. The plant's flare stack was approximately 20 – 25 feet tall, and because there was a wind it was likely that any VOCs emitted from the stack would be carried downwind from the facility, instead of settling to the ground in the immediate vicinity.

[97] The closest transect site, Skyland Drive, was 2.6 miles, and the farthest site, Beulah Camp, was 4.09 miles from the Monroeville Plant. These distances were calculated using the GPS coordinates recorded for both locations, and then calculating the distance using the following web site: http://jan.ucc.nau.edu/~cvm/latlongdist.html#formats

5.3 Are the data representative?

There were several constraints on the ability to obtain representative samples of the H_2S and VOC concentrations in air. First, the monitoring occurred during one five-day period in August. This period is but a snapshot in time. There were no other data with which to compare our readings, so it is not possible to know for sure if the concentrations were "average," worse or better than the typical air quality in the three counties. The measured values were simply the concentration of H_2S and VOC in the air at the exact time and location measurements were taken.

One way to estimate the amount of pollutants in air is to look at air emission data from various emission sources. The Alabama Oil and Gas Board requires companies to report the amount of gas vented to the atmosphere from its gas processing plants. Figure 2 shows that emissions of raw gas vented to the atmosphere (which would be a source of VOCs and possibly H_2S) were lower in August, 2005 than most other months of the year. In other words, it is quite possible that the concentrations of VOCs and H_2S that we measured near the gas processing plants were actually lower than average.

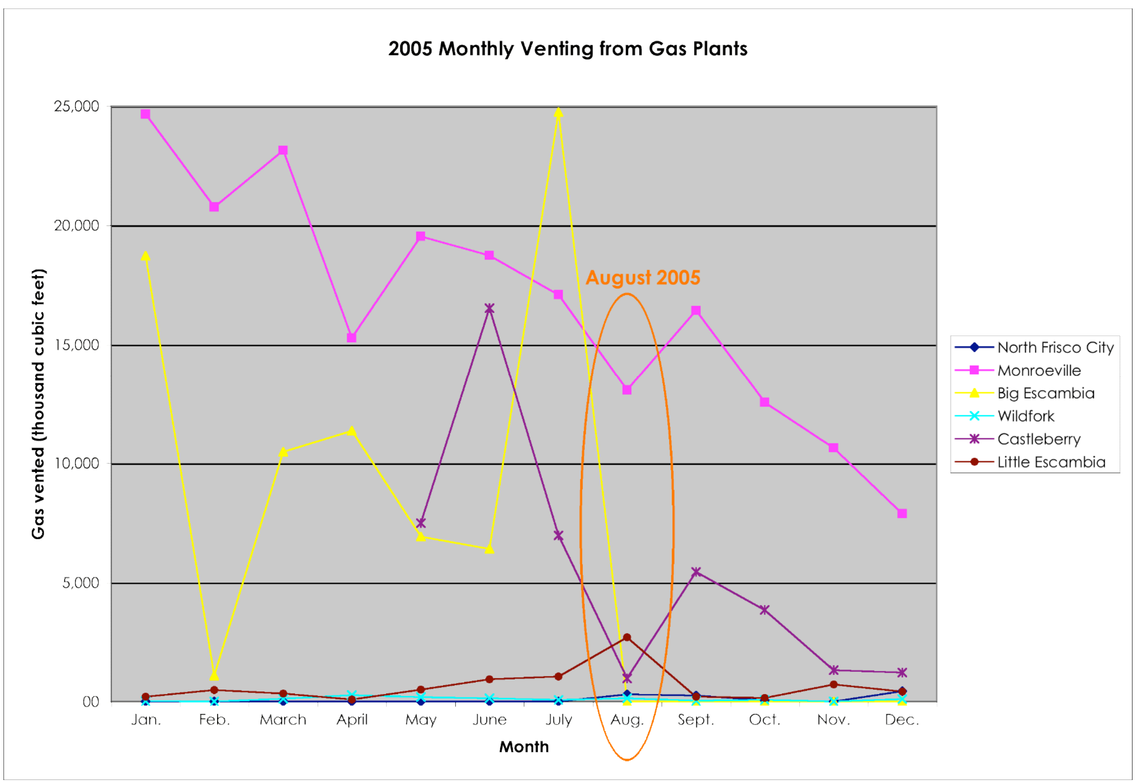


Figure 2. Monthly emissions from natural gas plants in Monroe, Conecuh and Escambia Counties.[98]

[98] Data from Alabama Oil and Gas Board on-line database: http://www.ogb.state.al.us/ogb/plant_production.aspx

6.0 CONCLUSIONS AND RECOMMENDATIONS

Hydrogen Sulfide

Hydrogen sulfide levels sampled in residential areas were measured at concentrations in the 100s and 1,000s of parts per billion. This is significantly elevated compared to normal urban background levels, which are typically less than 1 ppb, but comparable to other oil and gas regions in the U.S., where levels of H_2S have been measured in the 100-15,000 ppb range in the vicinity of wells and facilities.

It is not known whether or not concentrations in the 100-2,000 ppb range are experienced for extended periods of time in Conecuh, Monroe or Escambia counties, since our study was conducted over only a few days.

According to health literature, concentrations in the parts-per-billion range produce a nuisance due to odors. These odors, in turn, may lead to headaches, nausea and sleep disturbances if exposure is constant. Also, as discussed in Section 3 above, Legator *et al.* (2001) found central nervous system, respiratory, ear, nose and throat symptoms associated with annual average hydrogen sulfide levels ranging from 7 to 27 ppb.

Considering that there is the potential for long-term health effects from exposure to H_2S, (e.g., See Kilburn's and Legator's research in the Literature Review) a better characterization of H_2S exposure levels in this region of Alabama is imperative. Long-term monitoring sites should be set up near oil and gas facilities and residential areas.

Volatile Organic Compounds

Based on our findings of VOC levels in the parts per million range, it is strongly advised that attempts be made by the agencies to identify and monitor the concentrations of VOCs in the air in Monroe, Escambia and Conecuh counties. Not only may individual VOCs, such as benzene, be contributing to health problems in the area, the VOCs may also be contributing to the formation of ground-level ozone, which is also a health hazard.

It is recommended, as well, that VOC identification and monitoring occur not only in residential areas, but also in the vicinity of oil and gas operations.[99] This will help to hone-in on operations that may be emitting large volumes of VOCs due to fugitive emissions; venting from dehydration units; or VOC emissions due to inefficient burning of waste gas during flaring operations.

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[99] Strosher, M. 1996. *Investigations of Flare Gas Emissions in Alberta*. Alberta Research Council, November 1996. p. 28. Strosher measured concentrations of hydrocarbon compounds emitted from sweet and sour gas flares in Alberta, and used the information to predict ground-level concentrations of hazardous air pollutants near the well. Predicted values of some hydrocarbons byproducts were comparable to concentrations found in large industrial cities.

APPENDIX 1

Letter from Alabama Department of Environmental Management to Audrey Silcox. June 20, 2005.

04/04/2005 15:06 2515753305 SILCOX PAGE 12

ADEM

ALABAMA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

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Laboratory: 277-6718
Mining: 394-4326

June 20, 2005

Mrs. Audrey Silcox
P. O. Box 1360
Monroeville, Al 36461

Dear Mrs. Silcox:

At your recent meeting with Mr. Trey Glenn, ADEM agreed to consider installing a hydrogen sulfide (H_2S) monitor near you. ADEM's Air Division has investigated the feasibility of establishing a continuous H_2S monitoring site in your area. At the present, the Department does not have the equipment needed for this task. The price for a continuous H_2S monitor ranges from $15,000 to $40,000. With the addition of operational and related equipment (data logger, computer, meteorological equipment, utility building, chain link fence, electrical power) expenses, the cost for initial startup for a project of this type could exceed $70,000. The facility would require additional personnel resources to establish and maintain the site. Weekly visits to the site by personnel from the Montgomery office would be required to download data (H_2S, meteorological) and to maintain the site.

Given the above, ADEM does not have the resources to purchase and operate an H_2S monitor in your area.

Please find enclosed three maps showing locations of natural gas facilities in your area.

Sincerely,

Timothy S. Owen, Chief
Energy Branch
Air Division

TSO/jpk

Birmingham Branch
110 Vulcan Road
Birmingham, Alabama 35209-4702
(205) 942-6168
(205) 941-1603 [Fax]

Decatur Branch
2715 Sandlin Road, S.W.
Decatur, Alabama 35603-1333
(256) 353-1713
(256) 340-9359 [Fax]

Mobile Branch
2204 Perimeter Road
Mobile, Alabama 36615-1131
(251) 450-3400
(251) 479-2593 [Fax]

Mobile – Coastal
4171 Commanders Drive
Mobile, Alabama 36615-1421
(251) 432-6533
(251) 432-6598 [Fax]

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APPENDIX 2

State Ambient Hydrogen Sulfide Standards

State	Standard	Duration	Justification	Source
Arizona	0.128 ppm 128 ppb	1 hr	AAAQG, health based, on OSHA guidelines	Arizona Ambient Air Quality Guidelines. http://www.azdeq.gov/environ/air/permits/download/ambient.pdf
	0.078ppm 78 ppb	24 hr		
California	8 ppb	Chronic Exposure	Odor/nuisance	California Office of Environmental Health Hazard Assessment http://www.oehha.ca.gov/air/chronic_rels/pdf/7783064.pdf
	0.03 ppm 30 ppb	1 hr		California Air Resources Board, Nov 2005: http://www.arb.ca.gov/aqs/aaqs2.pdf
Delaware	0.06 ppm 60 ppb	avg. concentration not to be exceeded taken over any consecutive 3 min.		Delaware Ambient Air Quality Standards, http://www.dnrec.state.de.us/air/aqm_page/docs/pdf/reg_3.pdf
	0.03 ppm 30 ppb	avg. concentration not to be exceeded taken over any consecutive 60 min.		
Hawaii	25 ppb	1 hr	Combination of health and nuisance	Hawaii State Ambient Air Quality Standards, http://www.hawaii.gov/health/environmental/air/chart.pdf
Iowa	30 ppb	1-hr daily maximum	"health effects standard"	Iowa Administrative Bulletin. Aug. 18, 2004. http://www.legis.state.ia.us/Rules/2004/Bulletin/IAB040818.pdf
Kentucky	10 ppb	1 hour	Public health and welfare	401 KAR 53:010. Ambient air quality standards http://www.lrc.state.ky.us/kar/401/053/010.htm
Louisiana	330 ppb	8-hr average	NIOSH/OSHA safety standard, took 1/42 of their level	Personal Communication, Lana Skrtic, OGAP, and Jim Hazlett, Air Quality Assessment, Louisiana Department of Environmental Quality
Massachusetts	0.65 ppb	24-hr and annual limit	Based on EPA RfC, Threshold Effects Limit and Allowable Ambient Limit	Massachusetts Rule 310: Ambient Air Exposure Limits for Chemicals http://www.mass.gov/dep/air/aallist.pdf
Minnesota	0.05 ppm 50 ppb	1/2 hr avg. not to be exceeded over 2 times/yr		Minnesota Pollution Control Agency, State Ambient Air Quality Standards, Chapter 7009.0080 http://www.revisor.leg.state.mn.us/arule/7009/0080.html
	0.03 ppm 30 ppb	1/2 hr avg. not to be exceeded over 2 times in any 5 consecutive days		
Missouri	0.05 ppm 50 ppb	1/2 hr avg. not to be exceeded over 2 times/yr		Missouri Ambient Air Quality Standards CSR 10-6.010, http://www.sos.mo.gov/adrules/csr/current/10csr/10c10-6a.pdf
	0.03 ppm 30 ppb	1/2 hr avg. not to be exceeded over 2 times in any 5 consecutive days		
Montana	0.05 ppm 50 ppb	hourly avg. not to be exceeded more than once/yr	health based	Montana Rule 17-8-214 deq.mt.gov/dir/legal/Chapters/CH08-02.pdf
Nevada	0.08 ppm 80 ppb	1-hr average	health based	Nevada Chapter 445B – Air Controls, section 22097, http://www.leg.state.nv.us/NAC/NAC-445B.html#NAC445BSec22097
New Mexico	0.010 ppm 10 ppb	1-hr avg. not to be exceeded more than once/year		New Mexico Ambient Air Quality Standards, Title 20, Chapter 2, Part 3 http://www.nmenv.state.nm.us/aqb/regs/20_2_03nmac_103102.pdf
	0.100 ppm 100 ppb	1/2 hour average	Pecos-Permian (PP) Basin Intrastate Air Qual. Control Region	
	0.030 ppm 30 ppb	1/2 hour average	within 5 miles of municipalities in PP Basin with > 20,000 people	

State	Standard	Duration	Justification	Source
New York	0.01 ppm 10 ppb	1-hr average	odor and aesthetic	New York Rules and Regulations, Chapter III, Subpart 257-10; http://www.dec.state.ny.us/website/regs/subpart257_10.html
North Dakota	10 ppm 10,000 ppb	ceiling, maximum instantaneous concentration not to be exceeded	health based	North Dakota Ambient Air Quality Standards, Chapter 33-15-2 http://www.legis.nd.gov/information/acdata/html/..%5Cpdf%5C33-15-02.pdf
	0.20 ppm 200 ppb	maximum 1-hr average concentration not to be exceeded more than once per month		
	0.10 ppm 100 ppb	maximum 24-hr average concentration not to be exceeded more than once per year		
	0.02 ppm 20 ppb	maximum arithmetic mean concentration averaged over three consecutive months		
Oklahoma	200 ppb	24-hr average concentration		Oklahoma Air Pollution Control Rules, Title 252, Chapter 100-31-7 http://www.deq.state.ok.us/rules/100.pdf
Oregon	0.3 ppb*	annual average concentration	based on EPA's RfC, proposed benchmark	Personal Communication, Bruce Hope, Senior Environmental Toxicologist, Oregon Department of Environmental Quality, Air Quality Division. Feb. 10, 2006.
Pennsylvania	0.005 ppm 5 ppb	24-hr average		Pennsylvania Article III, Chapter 131, http://www.pacode.com/secure/data/025/chapter131/025_0131.pdf
	0.1 ppm 100 ppb	1-hr average		
Texas	0.08 ppm 80 ppb	30-min average	if the downwind concentration of hydrogen sulfide affects a property used for residential, business, or commercial purposes	Texas Administrative Code, Title 30 Part 1, Chapter 112, subchapter B; info.sos.state.tx.us/pls/pub/readtac$ext.ViewTAC?tac_view=5&ti=30&pt=1&ch=112&sch=B&rl=Y
	0.12 ppm 120 ppb	30-min average	if the downwind concentration of hydrogen sulfide affects only property used for other than residential, recreational, business, or commercial purposes, such as industrial property and vacant tracts and range lands not normally occupied by people.	
Vermont	0.024 ppm 24 ppb	24-hr	health based	Current standard is equivalent to 33.3 μg/m³. Proposing 1 μg /m³ annual average, to be determined in April; current standard available at http://www.anr.state.vt.us/air/docs/apcregs.pdf
Wyoming	0.05 ppm 50 ppb	1/2 hour average not to be exceeded more than 2 times per year		Wyoming Department of Environmental Quality, Air Quality Division, Ambient Air Quality Standards, Chapter 2: deq.state.wy.us/aqd/stnd/Chapter2_2-3-05FINAL_CLEAN.pdf
	0.03 ppm 30 ppb	1/2 hour average not to be exceeded more than 2 times in any 5 consecutive days		

* Proposed, to be reviewed April 2, 2006

APPENDIX 3

Data Collected in Monroe, Conecuh and Escambia Counties, August 1 – 5, 2005

Sample Date	SITE #	X-ref	Location	Time (CST)	Facility type	Oil/Gas Well ID	Vis. Flare	VOC peak (ppb)	H2S (ppb)	GPS reading (North)	GPS reading (West)	Wind	Other comments
08/01	2	2	Skyland Road (near Monroeville Plant)	12:23	Residential			630	0	31 28.150'	87 19.56'	from east	
08/01	2	2	Skyland Road (near Monroeville Plant)	12:26	Residential			511	0				
08/01	2	2	Skyland Road (near Monroeville Plant)	12:29	Residential			979	0				
08/01	2	2	Skyland Road (near Monroeville Plant)	12:30	Residential			2662	0				
08/01	3	3	Skyland and Dease Roads (near Monroeville Plant)	12:36	Residential			1700	0	31 28.202'	87 19.259'		
08/01	4	1	Palmer Petroleum Monroeville Plant, at corner of facility	12:45	Gas plant, flaring		Yes	848	0	31 28.543'	87 18.698'		flare roaring
08/01	5	5	Carter Rd.	12:56	Residential			240	0	31.4993	87.29275	calm	new well being drilled
08/01	5	5	Carter Rd.	12:57	Residential			835	0				
08/01	5	5	Carter Rd.	12:58	Residential			972	0				
08/01	6	6	Jennings Rd	1:14	Well	Jennings Carter 17-4 #1 Monroe Co. AL Sec 17 T6N R8E Permit# 13340	No	1332	0	31.4928	87.2897	toward well	no well ID sign, got ID from map
08/01	6	6	Jennings Rd	1:20	Well	Jennings Carter 17-4 #1 Monroe Co. AL Sec 17 T6N R8E Permit# 13340	No	1068	0				hydrocar-bons seeping from reclaimed reserve pit located behind well pad
08/01	9	9	Dennis Street (Mockingbird plant?)	1:45	Residential	Vanity Fair 1-9 #2 Permit#11215 API 99.01099-202236		173	0	31.5125	87.33165		
08/01	10	10			Well	Barnett 36-14#1 Sec36 T7N R7E Monroe Co. Permit#12910-B	No	1265	0	31.5281	87.31588		equipment
08/01	10	10			Well		No	1849	0				equipment
08/01	11	11	Vanity Fair Dye Facility (South Alabama Ave)	2:13	Factory		N/A	882	0	31 31.183	87.19.382		
08/01	11	11	Vanity Fair Dye Facility (South Alabama Ave)	2:14	Factory		N/A	1013	0				
08/01	14	14	Maughaon's Laundry, Excel	3:01	Laundry			177	0				
08/01	16	16	Lee Street (Wild Fork Meter station)	3:17	Metering station		No	6046	0	31.4183	87.40252	slight	
08/01	17	17	Meriwether Road, Northeast of Frisco (Jones Mill Field)	3:47	Well	Lancaster 31-8 Well#1 Permit#10636 Sec31 T6N R7E	No	6221	0	31.4437	87.39742		
08/01	19	19	Near Houston Road, Frisco (Farmers' Co-op wells)	3:57	Well		No	13400	0	31.4378	87.39402		
08/01	20	20	Torch Operating Co. Lancaster Gas Plant	4:11	Gas plant, flaring	North Frisco City (Lancaster LPG plant)	Yes	5870	0	31.4571	87.41003	upwind from site	Plant 1
08/01	21	21	Hilcorp waterflood plant (North Frisco Field)	4:17	Waterflood plant, flaring		Yes	5590	0	31.4576	87.41683	upwind of Lufkin plant flare	Plant 2
08/01	22	22	Near Hilcorp waterflood plant	4:23	Residential			7350	0	31.4573	87.41672	down-wind of flare	about 300' from flare, downwind
08/01	23	23	Perdue Road (North Frisco City), Hilcorp Energy Lufkin Plant	4:28	Gas plant, flaring		Yes	9048	0	31.4577	87.42212		Plant 3 -flare
08/01	24	24	Sugar Hill Road, near Monroeville airport	4:48	Well	Canecutter Production Inc.Well 9216 JV-P HILL 34-3 #1 Permit #10727-B	No	6513	0	31.4506	87.359		
08/01	25	1	Monroeville Plant,far corner	5:06	Gas plant, flaring		Yes	5899	0	31.4758	87.30963	3.2 mph, wind away from us	

APPENDIX 3

Data Collected in Monroe, Conecuh and Escambia Counties, August 1 – 5, 2005

Date	SITE #	X-ref	Location	Real Time (CST)	Facility type	Oil/Gas Well ID	Vis. Flare	VOC peak (ppb)	H2S (ppb)	GPS reading: North	GPS reading: West	Wind	Other comments
08/01	25	1	Monroeville Plant,,Corner of facility	5:12	Gas plant, flaring		Yes	4982	0				flare almost straight up
08/01	26	2	Skyland Drive	5:16	Residential			6522	0	31 28.150'	87 19.56'	down-wind from Palmer Plant	Palmer flare plume chasing
08/01	27	27	Intersection of Fred Jordon and McMillan Roads	5:27	Residential			7174	0	31.4464	87.32267		Palmer flare plume chasing
08/01	28	28	Playground on Brown Road	5:33	Residential (playground)			6584	0	31.4325	87.32958	3.2 mph	Playgrou0 - took two samples because ATV drove by during first
08/01	29	29	Roll Store Road, near Hwy 136, Excel	5:43	Residential			7887	0	31.4285	87.32133		sick woman at this house
08/01	30	30	Beulah Camp	5:47	Residential			7126	0	31.4169	87.3031		Palmer flare plume chasing
08/01	31	31	2688 Old Stage Road (near Audrey Silcox's old house)	5:54	Residential			7297	0				
08/01	32	32	8867 Old Stage Road (Thomas McKenzie's old house)	6:04	Residential			5723	10	31.3245	87.35762		Palmer flare plume chasing
08/01	32	32	8867 Old Stage Road (Thomas McKenzie's old house)	6:09	Residential			6213	10				
08/01	33	33	2688 Old Stage Road (near Audrey's old house)	6:30	Residential			11300	1				after rain
08/01	34	34	1553 Mexiboro Road (Anne Hank's house)	6:47	Residential			23500	2	31.5031	87.38395	no wind	Anne Hank's house
08/01	35	35	Best Western Hotel Parking Lot	7:00	Residential				10				
08/02	36	36	Monroeville First Assembly Church		Residential			11800	0				
08/02	37	37	C.R. 136, Parking lot of Excel School	10:45	Residential (school)			7000	0				
08/02	37	37	C.R. 136, Parking lot of Excel School		Residential (school)			40800	0	31 25.934	87 20.492	gusting	
08/02	38	1	Monroeville Plant, at corner of facility	11:12	Gas plant, flaring		Yes	40700	0	31.4758	87.30963		flare straight to slightly NE
08/02	39	2	Skyland Road	11:19	Residential			16600	1	31 28.150'	87 19.56'	slight	
08/02	40	30	Beulah Camp	12:01	Residential			48000	0	31.4169	87.3031	out of NE, 4.3 mph	
08/02	41	41	Old Stage Road and Range Road	12:32	Residential	None	No		0	31.2839	87.33495		raining
08/02	42	42		1:03	Well	ATIC 26-11#11 Sec26 T4N R78 Conecuh Co. AL Permit#10636-B	No	64300	0	31.2784	87.33603		H2S sign
08/02	43	43	Lowry Landing Road (Vintage Petroleum Gallagher Sour Gas Facility and Tank Battery)	1:34	Gas plant, sour		Yes, large	26100	300	31 13.796	87 10.190	down-wind of flare	
08/02	43	43	Lowry Landing Road (Vintage Petroleum Gallagher Sour Gas Facility and Tank Battery)	1:36	Gas plant, sour		Yes, large		220				

APPENDIX 3

Data Collected in Monroe, Conecuh and Escambia Counties, August 1 – 5, 2005

Date	SITE #	X-ref	Location	Real Time (CST)	Facility type	Oil/Gas Well ID	Vis. Flare	VOC peak (ppb)	H2S (ppb)	GPS reading: North	GPS reading: West	Wind	Other comments
08/02	43	43	Lowry Landing Road (Vintage Petroleum Gallagher Sour Gas Facility and Tank Battery)	1:40	Gas plant, sour		Yes, large		120			wind shifted	
08/02	43	43	Lowry Landing Road (Vintage Petroleum Gallagher Sour Gas Facility and Tank Battery)	1:41	Gas plant, sour		Yes, large		5				
08/02	44	44	Stanley Road off 113	2:20	Residential		No		0	31 11.817	87 18.682		tanks, wind- sock
08/02	45	45	Big Escambia Creek Facility	3:06	Gas plant			7673	62	31 04.204	87 29.666	from NW	at perimeter of site
08/02	45	45	Big Escambia Creek Facility	3:08	Gas plant				2				
08/02	45	45	Big Escambia Creek Facility	3:10	Gas plant				3	31 04.255	87 22.458		down the road, at creek where sludge was present
08/02	46	46	Down road from Escambia Creek Facility	3:20	Well	Scott Paper CL 5-13#15 Permit# 10757-B Sec5 T1N R7E		7170	2	31 04.362	87 23.521		photo is of pipeline sign on road to well.
08/02	46	46	Down road from Escambia Creek Facility	3:22	Well	Scott Paper CL 5-13#15 Permit# 10757-B Sec5 T1N R7E			3				
08/02	47	47	Unidentified well (off of Sandy Lane)	3:55	Well, flaring	Most likely Stetson Petroleum Corp. M.H. Murphy 26-11 #1, S 26T3NR6E Escambia Co. Permit #4577 Lat. 31.19187 Long. 87.43942	Yes	50500	0	31.1932	87.4398		H2S site, no well I.D., green flag, sock for windsock missing
08/02	48	48	On Sandy Lane, approx. 300 feet from flare of unidentified well	4:03	Residential		Yes	1E+05	0	31.1947	87.44208	down-wind of flare	in front of a trailer - several houses in the immediate area
08/02	49	49	Goodway Refinery? Sign read: "Thomas Plains Huxford Office"	4:14	Refinery, flaring		Yes	95400	0	31.1823	87.43813		small flare, avian deterrents? on the stacks, tanks, gas loading area
08/02	50	50	Behind peanut warehouse, near Huxford plant	4:30	Well	Pruet Production Godwin 14-9 #2 Permit#10168-B	No	43200	0	31 13.311	87 25.953		
08/02	51	51	Enbridge Butler Street Plant Sec. 12 T3N R6E	4:44	Well	Butler Street and Lee Pond Road	No	2E+05	0	31.2414	87.4302		at entrance to the site
08/02	51	51	Enbridge Butler Street Plant Sec. 12 T3N R6E	4:46	Well	Butler Street and Lee Pond Road		99700	0				in front of muffler
08/02	52	52	Butler street , across from Enbridge plant	4:48	Well	Huxford SWD 11-2 Permit#10482-SWD-93-6 Sec11 T3N R6E Escambia Co, AL			0	31.242	87.4351		
08/02	53	53	Off of Grissett Bridge Road	5:17	Well			2E+05	0	31.245	87.36048		dry hole? or not-yet completed? well with plywood over well, unlined drilling pit, etc.
08/02	54	54		5:35	Well	Pruet Production Co. Permit# 12226, A.T.I.C. 10-11#1 Sec10 T3N R7E Escambia, Co	No	>199000	0	31.2362	87.35458		
08/02	55	55		5:40	Well	Pruet Production Co. Permit# 12226, A.T.I.C. 10-13#1 434' F.W.L 546' F.S.L. Sec10 T3N R7E Escambia, Co Ala. Permit#10956	No	1E+05	0	31.233	87.35943		flare present, but not flaring.
08/02	56	56		5:56	Well, flaring	Pruet Production APIC 22-7 #1 Permit#11116-B Sec22 T3N R7E	Yes	1E+05	0	31.2136	87.35242	Out of NE	flare

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Date	SITE #	X-ref	Location	Real Time (CST)	Facility type	Oil/Gas Well ID	Vis. Flare	VOC peak (ppb)	H2S (ppb)	GPS reading: North	GPS reading: West	Wind	Other comments
08/02	56	56		5:57	Well, flaring	Pruet Production APIC 22-7 #1 Permit#11116-B Sec22 T3N R7E	Yes		4				Hydrogen sulfide pipeline on location with well. We could hear the pipeline venting.
08/02	56	56		5:58	Well, flaring	Pruet Production APIC 22-7 #1 Permit#11116-B Sec22 T3N R7E	Yes		7				
08/02	57	57		6:08	Well	Pruet Production ATIC 1514#1 Permit#11940 Sec14 T3N R7E Escambia Co.	No	96400	0	31.2181	87.35453		H2S site; gravel vibrating arou0 well head
08/02	58	58		6:22	Well	Edge-McMillan 12-13#1 Sec12 T3N R7E Escambia Co. Permit#10256		1E+05	0	31.2326	87.3268		rusted sign
08/02	59	59	Adjacent to Site 58	6:32	Well, saltwater disposal	Edge-McMillan 12-13 SWD No.1 Permit#10580 SWD94-3 Sec12 T3N R7E Escambia Co. Permit#10256		1E+05	0	31.2343	87.32608		
08/02	60	60		6:40	Well	Grissett 36-16#1 660 FEL Sec 36 T4N R7E Conecuh Co. Permit#5568		1E+05	0				ID sign laying on grou0
08/02	63	63		7:00 p.m.	Well	De Soto Oil and Gas, Inc. A.T.I.C. 31-13#1. Permit#10596. Conecuh, Co. S31 T4N R8E.	No	1E+05	0	31.2609	87.31003		tanks leaking oil
08/02	64	64	Range Road and Old Stage Road (abandoned gas plant)	7:32	Gas plant, abandoned			1E+05	0	31 19.044	87 21.581		
08/02	65	32	8867 Old Stage Road (Thomas McKenzie's old house)	7:33	Residential			1E+05	0	31.3245	87.35762		
08/03	67	1	Monroeville Plant, at corner of facility	11:35	Gas plant, flaring		Yes	8767	0	31.4758	87.30963	calm	
08/03	67	1	Monroeville Plant, at corner of facility	11:35	Gas plant, flaring		Yes	54200	0			out of S-SW - shifting	clear sensor reading occurred
08/03	67	1	Monroeville Plant, at corner of facility	11:39	Gas plant, flaring		Yes	39000	0			From SE	
08/03	68	68	Back end of Deuce Lane	11:50	Residential			6061	0	31 28.41	87 19.405	calm	Attempting a transect from Monroeville Plant
08/03	69	69	Monroeville City Limits, Road 37	12:07	Residential			4258	0	31 29.089	87 19.263	gusting, 3.6 mph, out of NE 30 deg.	sample taken downwind from flare (assumed wind was constant)
08/03	70	70	Gaston Ave., South of Frisco City	1:06	Residential			1434	0	31 25.430	87 25.172	4.1 mph - 6.6 mph from east 85 deg.	
08/03	71	71	Claude D. Kelly State Park	1:55	State park			4318	0	31 15.758	87 29.482	variable	flare visible from this location, which was in the park
08/03	72	72	Claude D. Kelly State Park	2:07	Well, flaring	Blacksher 32-10-1 Sec26 T4N R6E Permit#11185 Monroe Co., AL	Yes	1529	1	31 15.882	87 29.427	calm or away from monitor	at site (H2S site, wind sock).
08/03	73	47	At the site off Sandy Lane	3:59	Well, flaring	Unidentified well (off of Sandy Lane) but most likely Stetson Petroleum Corp. M.H. Murphy 26-11 #1, S 26T3NR6E Escambia Co. Permit #4577	Yes	873	0			wind out of NNW; blowing flare away from us	
08/03	74	74	Hwy 21, mile marker 29	4:26	Residential			1833	2	31 22.441	87 25.746	calm	smelled H2S from highway; were told that it was a fungicide for peanut crop

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Data Collected in Monroe, Conecuh and Escambia Counties, August 1 – 5, 2005

Date	SITE #	X-ref	Location	Real Time (CST)	Facility type	Oil/Gas Well ID	Vis. Flare	VOC peak (ppb)	H2S (ppb)	GPS reading: North	GPS reading: West	Wind	Other comments
08/03	74	74	Hwy 21, mile marker 29	4:29	Residential				1				
08/03	75	75	Near peanut field, across railroad tracks (east of Hwy 21)	4:40	Residential				3	31 22.833	87 25.402		across railroad tracks, near peanut field
08/03	75	75	Near peanut field, across railroad tracks (E of Hwy 21)	4:45	Residential				3				
08/03	76	20	Perdue Road, past Torch Operating Co. Lancaster Gas Plant	5:12	Gas plant		Yes	4226	0	31 27.658	87 25.761		after large rainfall event; 1/2 mile downwind of flare; all 3 plants North Frisco City plants flaring
08/03	77	77	On bridge over Alabama R.	5:44	Residential				3			away from us	rainy
08/03	78	78	Alabama River Pulp Mill (entrance, not at mill)	5:49	Pulp mill				2			away from us	rainy
08/04	80	80	Monroeville Plant, at corner of facility	######	Gas plant, flaring		Yes	#####	0	31.4758	87.30963	variable, ENE	
08/04	81	2	Skyland Road at stop sign to Experiment Rd.	4:32	Residential			#####	3	31 28.150'	87 19.56'		generally downwind of flare
08/04	81	2	Skyland Road at stop sign to Experiment Rd.	4:33	Residential			#####	0				wind towrad us
08/04	82	82	Experiement Road	4:34	Residential			#####	0	31 28.052	87 19.610		wind
08/04	83	69	Monroeville City Limit	4:47	Residential			0	0	31 29.089	87 19.263	wind in our direction	
08/04	84	2	Skyland Road	5:23	Residential			29,200	0			from ENE	value climbs when wind toward instrument
08/04	85	82	Experiement Road	5:30	Residential			40,000	0	31 28.052	87 19.610	from ENE	
08/04	86	86	Further down experiment road	5:37	Residential			56,000	0	31 27.801	87 19.382		started at 56 ppm - clear sensor reading
08/04	87	87	End of Landfill Road near Drewery Rd.	5:53	Residential			35,600	0	31.4831	87.28287		
08/04	88	88	On Drewery approx. 2 miles south of Landfill Rd	6:13	Residential			28,800	0	31.4833	87.24893		
08/04	89	2	Skyland Road	6:44	Residential			50,100	0			60 deg out of ENE	
08/04	90	90	Near Lufkin Plant	7:05	Gas plant, flaring		yes	26,900	0	31 27.658	87 25.761		all three plants in the area flaring
08/04	91	91	Hilcorp Energy Lufkin Plant	7:18	Gas plant, flaring		yes	38,800	0			from ENE at 60 deg	we were downwind of 20 plant; wind away from instruments
08/04	92	21	Hilcorp waterflood plant - North Frisco Field	7:25	Waterflood plant, flaring		yes	52,100	0	31.4576	87.41683	from NE 40-55	
08/04	93	93	Road between Lufkin and Waterflood	7:34	Residential			40300	0	31.457	87.41403	60 deg NE; gusts to 3.6 mph (avg. 2)	downwind of flare that is smoking
08/04	94	20	Torch Operating Co. Lancaster Gas Plant	7:41	Gas plant, flaring		yes	37500	0	31.457	87.41133	gusts 1-2 mph	wind away from meter
08/04	95	95	Upwind of North Frisco City Plants	7:50	Gas plant, flaring		yes	34700	0	31.4611	87.40487	gusting to 0.8 - 1.2 mph	upwind of North Frisco City plant
08/04	96	96	Barton, dirt road along cotton field	7:58	Residential			37200	0	31.4694	87.38915		upwind of North Frisco City plant

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Data Collected in Monroe, Conecuh and Escambia Counties, August 1 – 5, 2005

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08/04	97	16	Lee Street (Wild Fork Meter station)	8:20	Metering station		no	15000	2	31.4183	87.40252	50-70 degrees NE; gusting 1.5 - 2.5 avg, up to 3.2	downwind of facility; concentrations increase as wind increases
08/04	98	98	Hwy 21, mile marker 29 and Shell station		Residential				1	31 22.792	87 25.705		smelled H2S from highway at same site where fungicide was used on peanut crop
08/04	99	74	Hwy 21, mile marker 29		Residential				1	31 22.441	87 25.746		service road
08/04	100	49	Goodway Refinery? Thomas Plains Huxford Office	9:10	Refinery, flaring		yes		2	31.1823	87.43813	from NE	gas loading area; no VOC b/c didn't want to saturate meter
08/04	101	47	Unidentified well (off of Sandy Lane)	9:17	Well	Most likely Stetson Petroleum Corp. M.H. Murphy 26-11 #1, S 26T3NR6E Escambia Co. Permit #4577 Lat. 31.19187 Long. 87.43942	no	18700	0	31.1932	87.4398	85 deg from E; 6 mph	Flare blowing away from meter; site less flooded than day before
08/04	102	102	Downwind of Unidentified well (off of Sandy Lane)	9:36	Residential		no	22500	1	31.1888	87.44688	3.5-4 mph, 65 deg.	adjacent to agriculture site
08/04	103	103	Downwind of site 100 (Goodway Refinery?)	9:48	Residential		yes	17500	1	31.1829	87.44682	45 deg; 0-43 mph	flare due east of sampling location
08/04	103	103	Downwind of site 100 (Goodway Refinery?)	9:49	Residential		yes		2				
08/04	104	71	Claude D. Kelly Park	10:14	State park			14600	1	31.2603	87.49292	50 deg; 1 - 2.5 mph	when wind let up the VOC level went higher
08/04	105	72	Claude D. Kelly State Park - front gate up the hill	10:16	Well, flaring	Blacksher 32-10-1 Sec26 T4N R6E Permit#11185 Monroe Co., AL	yes	8244	0	31 15.882	87 29.427	75 deg; calm to 1 - 2.5 mph	flare smoking; not consistent; generally blowing away from us;
08/04	105	72	Outside permieter fence	10:35	Well, flaring	Blacksher 32-10-1 Sec26 T4N R6E Permit#11185 Monroe Co., AL	yes	7550	1				water flowing off site through pipes through berm
08/04	105	72	At front gate	10:37	Well, flaring	Blacksher 32-10-1 Sec26 T4N R6E Permit#11185 Monroe Co., AL	yes	5599	2				
08/04	106	19	Near Houston Road, Frisco (Farmers' Co-op wells)	11:15	Well			940	3	31.4378	87.39402	gusting up to 4.5 - 6.3 at 45 deg	wind blowing off site
08/04	107	34	1553 Mexiboro Road (Anne Hank's house)	11:46	Residential			1620	2	31.5031	87.38395	100 - 110 deg; under 2 mph. Then shifted to 70 deg; 2.4 - 2.7 mph	back yard
08/04	107	34	1553 Mexiboro Road (Anne Hank's house)	11:47	Residential				3			ENE at 7 mph	front yard
08/04	108	108	Sewer plant, Hwy 47	12:00	Sewage treatment plant				3	31 30.808	87 21.366		animal shelter near plant
08/04	108	108	Sewer plant, Hwy 47	12:02	Sewage treatment plant				4				parking lot
08/04	108	108	Sewer plant, Hwy 47	12:04	Sewage treatment plant				4				around back of plant - with permission from plant employees
08/04	108	108	Sewer plant, Hwy 47	12:06	Sewage treatment plant				3				

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Date	SITE #	X-ref	Location	Real Time (CST)	Facility type	Oil/Gas Well ID	Vis. Flare	VOC peak (ppb)	H2S (ppb)	GPS reading: North	GPS reading: West	Wind	Other comments
08/04	109	109	Georgia Pacific Corp. Peterman Plywood Hwy 21, north of Morningside - Structural panels plant	1:46	Wood products			5057	2	31 34.310	87 16.921		
08/04	110	56		19:05	Well, flaring	Pruet Production APIC 22-7 #1 Permit#11116-B Sec22 T3N R7E	yes	29100	2	31.2136	87.35242	310 WNW; 0.9 - 1.2 mph	in main yard; near pipeline
08/04	110	56		19:07	Well, flaring	Pruet Production APIC 22-7 #1 Permit#11116-B Sec22 T3N R7E	yes		1				near well head; near pipeline
08/04	111	60		19:30	Well	Coastal Oil and Gas. Grissett 36-16#1 660 FEL Sec 36 T4N R7E Conecuh Co. Permit#5568	no	21000	0			no wind	site with brine overflowing; rusting tanks; sign on ground
08/04	112	63		19:40	Well	De Soto Oil and Gas, Inc. A.T.I.C. 31-13#1. Permit#10596. Conecuh, Co. S31 T4N R8E.		34100	0	31.2609	87.31003	calm	
08/04	113	113	Jordon Farms	20:23	Residential			22700	0	31 21.268	87 20.008	slight wind to calm	Degussa applied material - but none applied since November;
08/05	114	114	Mexboro Road, off Hwy 84; Rocky Creek Plywood	8:27	Wood products			60,000	1	31.4923	87.36963	wind away from monitor; peak of 60 ppm but was still climbing - didn't want to saturate monitor; gusting at 3 mph; steady at 1.4 mph from 80 deg (east)	daycare across road from plant
08/05	115	115	Snowden Road, near Rocky Creek Plywood	8:47	Residential			97,900	2	31.4949	87.37477	3.2 mph; downwind of plant; lower H2S when wind dies down (2 H2S samples - 0.001)	lumberyard is visible from site;smelled organic vapors; large number of homes and trailers in vicinity;
08/05	116	116	Empty Lot, downwi of Rocky Creek Plywood facility		Residential			69000	3	31.4951	87.37705	Odor of plywood and glue (2 H2S samples - 0.003)	
08/05	117	117	Hornady Dr., Parking Lot of Harrigan Lumber a Particle Board plant	9:44	Wood products			1,842	4	31.5159	87.29713	5.3 mph; downwind of plant; VOC level goes up when wind blows (several H2S samples;	
08/05	118	118	Irby Electrical Distributor (downwind of Harrigan)	10:07	Residential			1,798	2600	31 30.919	87 18.210	gentle wind	Houses and trailers between Harrigan and this site.
08/05	118	118	Irby Electrical Distributor (downwind of Harrigan)	10:08	Residential				260			gentle wind	
08/05	118	118	Irby Electrical Distributor (downwind of Harrigan)	10:09	Residential				220			slack wind	

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08/05	118	118	Irby Electrical Distributor (downwind of Harrigan)	10:11	Residential				1400			wind gust to 2.2 mph	
08/05	118	118	Irby Electrical Distributor (downwind of Harrigan)	10:14	Residential				10			slight wind gusts	
08/05	119	119	Hornady Dr., Parking Lot of Harrigan Lumber a Particle Board facility	10:16	Wood products				1400	31.5159	87.29713	gusting to 6.7 mph	wind from the facility across the parking lot
08/05	119	119	Hornady Dr., Parking Lot of facility	10:19	Wood products			380	180				
08/05	119	119	Hornady Dr., Parking Lot of facility	10:20	Wood products			380	7			gusting to 8.7 mph	
08/05	119	119	Hornady Dr., Parking Lot of facility	10:23	Wood products				4			gusting to 5 mph; average 3 mph	Old name of particle board facility is Temple Inland
08/05	120	120	Drewery Road	10:34	Well	McCall 1-7 #1 Sec1 T6W R78 Permit # 20256 Monroe County			2	31.5141	87.31417	gusting to 7.5; average 5 mph from due east	
08/05	121		Upwind of Palmer Monroeville Plant	10:47	Residential			262	4	31.4762	87.30698	8 mph from 80 deg.	adjacent to peanut field
08/05	121		Upwind of Palmer Monroeville Plant	10:48	Residential				3				
08/05	121		Upwind of Palmer Monroeville Plant	10:49	Residential				4				
08/05	122	1	Monroeville Plant, at corner of facility	10:55	Gas plant, flaring		Yes		180	31.4758	87.30963	6.7 mph, 80 deg	wind toward monitor
08/05	122	1	Monroeville Plant, at corner of facility	10:56	Gas plant, flaring		Yes		1200				
08/05	122	1	Monroeville Plant, at corner of facility	10:57	Gas plant, flaring		Yes	442	0				
08/05	123	123	Deuce Rd.	11:07	Residential				6	31.4734	87.32337	slight from the east 75 deg; 0.9 mph avg, 1.6 mph peak	wind toward monitor
08/05	123	123	Deuce Rd.	11:09	Residential				1500				
08/05	123	123	Deuce Rd.	11:10	Residential				19				
08/05	123	123	Deuce Rd.	11:15	Residential			389	0				
08/05	124	2	Skyland Drive	11:24	Residential				4	31.4684	87.32705	wind gusts to 4 mph from 60 deg.	
08/05	124	2	Skyland Drive	11:24	Residential			100	1			shift in wind	
08/05	125	125	Sawyer Rd. at Experiment Rd.	11:30	Residential				3	31 28.102	87 19.624	wind gusting, 92 deg	wind toward us
08/05	125	125	Sawyer Rd. at Experiment Rd.	11:32	Residential				5				
08/05	125	125	Sawyer Rd. at Experiment Rd.	11:34	Residential				340				

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Date	SITE #	X-ref	Location	Real Time (CST)	Facility type	Oil/Gas Well ID	Vis. Flare	VOC peak (ppb)	H2S (ppb)	GPS reading: North	GPS reading: West	Wind	Other comments
08/05	126	126	Smithe Lane	11:45	Residential (well in sight)				300	31.4748	87.33465	90 deg; gusting to 7.2, avg. 5.5	wind in direction of monitor
08/05	126	126	Smithe Lane	11:46	Residential (well in sight)				150				

Bibliography

Agency for Toxic Substances and Disease. September 2004. *Public Health Statement for Hydrogen Sulfide*. Available from URL: http://www.atsdr.cdc.gov/toxprofiles/tp114-c1.pdf

Agency for Toxic Substances and Disease Registry. 2004. *Toxicological Profile for Hydrogen Sulfide - Draft for Public Comment*. (Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service).

Alabama Department of Environmental Management. *ADEM Admin. Code*. Chapter 335-3-5. Control of Sulfur Compound Emissions. Section. 3, Petroleum Production. Available from URL: http://www.adem.state.al.us/Regulations/Div3/Div3%207-06.pdf

Alabama Department of Environmental Management. Consent Order No. 06-Cap. In The Matter Of: Midroc Operating Company, Castleberry, Conecuh County, Alabama, Air Facility ID No. 103-0011, Air Facility ID No. 103-0017, and Air Facility ID No. 103-0018. Available from URL: http://www.adem.state.al.us/PublicNotice/Mar/AO/Midrock.pdf

Alabama Oil and Gas Board. *Rules and Regulations of the State Oil and Gas Board of Alabama Governing Onshore Lands Operations*. 400-1-1-.05. Definitions. (69) "Sour gas operations." Available from URL: http://www.ogb.state.al.us/HTMLS/OGBRULES/4001.htm#400-1-1-.05

Alabama Oil and Gas Board. "PVT database." Database can be accessed at: http://www.ogb.state.al.us/HTMLS/dbpvt.htm

Ammann, H.M. 1986. "A new look at physiologic respiratory response to H_2S poisoning," *Journal of Hazardous Materials*. 13:369-374.

Beauchamp R.O., *et al*. 1984. "A critical review of the literature on hydrogen sulfide," *Critical Reviews in Toxicology*. 13:25–97.

California Air Resources Board. "Toxic Air Contaminants Monitoring." (page updated February 15, 2005). Available from URL: http://www.arb.ca.gov/aaqm/toxics.htm

California. Environmental Protection Agency. 2006. *Proposition 65. Chemical Listed Effective August 11, 2006 as Known to the State of California to Cause Cancer or Reproductive Toxicity*. Available from URL: http://www.oehha.ca.gov/prop65/prop65_list/files/P65single081106.pdf

California Environmental Protection Agency (CalEPA). *Chronic Reference Exposure Levels*. Adopted by OEHHA as of February 2005. (California Office of Environmental Health Hazard Assessment). Available from URL: http://www.oehha.ca.gov/air/chronic_rels/AllChrels.html

California Environmental Protection Agency (CalEPA). 1999. *Air Toxics Hot Spots Program Risk Assessment Guidelines: Part III. Technical Support Document for the Determination of Noncancer Chronic Reference Exposure Levels. SRP Draft*. (Office of Environmental Health Hazard Assessment, Berkeley, CA). Available from URL: http://www.oehha.ca.gov/air/chronic_rels/pdf/relsP32k.pdf

Canadian Association of Petroleum Producers. 2006. *Best Management Practices - Control of Benzene Emissions from Glycol Dehydrators*. Available from URL: http://www.capp.ca/default.asp?V_DOC_ID=763&PubID=80610

Chou, S. 2003. *Hydrogen Sulfide: Human Health Aspects*. Concise International Chemical Assessment Document 53. (World Health Organization). Available from URL: http://www.who.int/ipcs/publications/cicad/en/cicad53.pdf

Colorado Department of Public Health and Environment. October, 2002. *A Community-based Short-term Ambient Air Screening Study in Garfield County for Oil and Gas Related Activities – Results and Discussion*. Available from URL: http://oil-gas.state.co.us/Library/piceancebasin/GarfieldFinalReport10-31.pdf

Dalrymple, D.A., Skinner, F.D. and Meserole, N.P. 1991. *Investigation of U.S. Natural Gas Reserve Demographics and Gas Treatment Processes*. Topical Report, GRI-91/0019. (Gas Research Institute.)

DEFRA (the Department for Environment, Food and Rural Affairs). United Kingdom. "E-Digest Statistics about: Air Quality: Volatile organic compounds (VOCs)." Available from URL: http://www.defra.gov.uk/environment/statistics/airqual/aqvoc.htm

Dubyk, S. and Mustafa, S. 2002. "Trip Report: H_2S Survey, March 18-22, 2002." (New Mexico Environment Department, Air Quality Bureau).

Energy and Environmental Analysis. Nov. 1990. *Chemical Composition of Discovered and Undiscovered Natural Gas in the Lower-48 United States*. Prepared for the Gas Research Institute. 90/0248.

Environmental Integrity Project. 2004. *Gaming the system: How off-the-books, industrial emissions cheat the public out of clean air*. Available from URL: http://www.environmentalintegrity.org/pub240.cfm

Environmental Integrity Project. 2002. *Smoking Guns*. Available from URL: http://www.environmentalintegrity.org/pub75.cfm

Fuller, Douglas C., MD, MPH, and Anthony J. Suruda, MD, MPH. September, 2000. "Occupationally Related Hydrogen Sulfide Deaths in the United States From 1984 to 1994." *Journal of Occupational and Environmental Medicine*. 42:(9)939-942.

Hazlett, James M. June 8, 2005. *Report for the Calumet Air Monitoring Project*. (Louisiana Department of Environmental Quality, Office of Environmental Assessment).

Henderson, R. 2005. "Toxic gas accidents affect far more than the workers on site," *Petromin.*

Hugman, R.H., Springer, P.S. and Vidas, E.H. 1993. *Chemical Composition of Discovered and Undiscovered Natural Gas in the United States: 1993 update*. Topical Report, GRI-93/0456. (Gas Research Institute).

Jappinen, P. et al. 1990. "Exposure to hydrogen sulfide and respiratory function." *British J Ind Medicine*. 47:824-828.

Kilburn, Kaye. 2003. "Effects of Hydrogen Sulfide on Neurobehavioral Function." *Southern Medical Journal*. 96:7.

Kilburn, Kaye H. 1999. "Evaluating health effects from exposure to hydrogen sulfide: central nervous system dysfunction." *Environmental Epidemiology and Toxicology*. 1:207-216.

Kilburn, K.H., Warshaw, R.H. 1995. "Hydrogen sulfide and reduced-sulfur gases adversely affect neurophysiological functions." *Toxicology and Industrial Health*. 11:185-197.

Knox, E.G. 2005. "Childhood cancers and atmospheric carcinogens," *Journal of Epidemiology and Community Health*. 2005:59:101-105.

La Plata County, Colorado. 2002. *La Plata County Impact Report*. Available from URL: http://co.laplata.co.us/publications.htm

Lange, B. 2003. *State Survey of Ambient Air Standards*. (North Carolina Department of Environment and Natural Resources, Division of Air Quality). Available from URL: http://daq.state.nc.us/toxics/studies/H2S/H2S_Survey.pdf

Legator, M., Singleton, C. , Morris, D. and Philips, D. 2001. "Health effects from chronic low-level exposure to Hydrogen Sulfide," *Archives of Environmental Health*. 56:2.

Marttila, O., Jaakkola, J.J.K., Partti-Pellinen, K. 1995. "South Karelia air pollution study: daily symptom intensity in relation to exposure of malodorous sulfur compounds from pulp mills." *Environmental Research*. 71:122-27.

McGavran, Pat. June 19, 2001. "Literature Review of the Health Effects Associated with the Inhalation of Hydrogen Sulfide." (Idaho Department of Environmental Quality, Boise, Idaho).

McIntush, K.E., Dalrymple, D.A. and Rueter, C.O. July, 2001. "New process fills technology gap in removing H_2S from gas," *World Oil.*

Mehlman, M.A. 1992. "Dangerous and cancer-causing properties of product and chemicals in the oil refining and petrochemical industry. VII. Adverse health effects and toxic manifestations caused by exposure to hydrogen sulfide." *Journal of Occupational Medicine and Toxicology*. 1:143-158.

Milby, Thomas H. MD, and Randall C. Baselt, PhD. 1999. "Hydrogen Sulfide Poisoning: Clarification of Some Controversial Issues." *American Journal of Industrial Medicine*. 35:192-195.

New York State Department of Health. "Hydrogen Sulfide Chemical Information Sheet." Available from URL: http://www.health.state.ny.us/nysdoh/environ/btsa/sulfide.htm

North Carolina Scientific Advisory Board. 2003. *Summary of the toxicity assessment of hydrogen sulfide conducted by the Secretary's Scientific Advisory Board on Toxic Air Pollutants*. Available from URL: http://daq.state.nc.us/toxics/studies/H2S/SAB_Recommendations.pdf

Oklahoma Department of Environmental Quality. 2004. *Calculation of Flashing Losses/VOC Emissions from Hydrocarbon Storage Tanks*. Fact sheet. Available from URL: http://www.deq.state.ok.us/factsheets/ air/CalculationLosses.pdf

Oregon Department of Human Services, Health Division. Feb. 1994. *Technical Bulletin – BTEX*. Available from URL: http://www.oregon.gov/DHS/ph/dwp/docs/fact/btex.pdf

Pierce, G. November, 2002. *Garfield County Air Monitoring Results*. (Colorado Department of Public Health and Environment). Available from URL: http://oil-gas.state.co.us/Library/piceancebasin/GarfieldCountyMonitoring.pdf

Pollack, A., Russell, J., Grant, J., Friesen, R., Fields, P. and Wolf, M. August, 2006. *Ozone Precursors Emission Inventory for San Juan and Rio Arriba Counties, New Mexico*. Prepared for New Mexico Environment Department. p. 2-19. Available at: http://www.nmenv.state.nm.us/aqb/projects/San_Juan_Ozone/NM_Area_Emissions_report.pdf

Quinlan, M. 1996. "Evaluation of selected emerging sulfur recovery technologies," *GRI Gas Tips*, 3(1).

Rada. J. April, 2006. *Status of Garfield County's Air Quality Monitoring Program*. Power point presentation. Available from: http://www.garfield-county.com/docs/air_quality_study__4.6.06.ppt

RAE Systems. 2006. *Conversion Of PID Readings To Methane Equivalent or Hexane Equivalent FID Response*. Technical Note TN-158. Available from URL: http://www.raesystems.com/~raedocs/App_Tech_Notes/Tech_Notes/TN-158_PID-FID_Conversion.pdf

Richardson, D. 1995. "Respiratory effects of chronic hydrogen sulfide exposure." *American Journal of Industrial Medicine*. 28:99-108.

Schiffman, Susan S., Elizabeth A. Sattely, et al. 1995. "The Effect of Environmental Odors Emanating From Commercial Swine Operations on the Mood of Nearby Residents," *Brain Research Bulletin*. 37:4.

Skritic, L. May, 2006. *Hydrogen Sulfide, Oil and Gas, and People's Health*. A paper submitted for the fulfillment of a Masters Degree, Energy Resources Group, UC Berkeley. Available from URL: http://www.earthworksaction.org/publications.cfm?pubID=168

Snyder, Jack W., MD, PhD. *et al*. 1995. "Occupational Fatality and Persistent Neurological Sequelae After Mass Exposure to Hydrogen Sulfide." *American Journal of Emergency Medicine*. 13:(2)199-203.

Strosher, M. 1996. *Investigations of Flare Gas Emissions in Alberta*. Report prepared for Environment Canada, the Alberta Energy and Utilities Board and the Canadian Association of Petroleum Producers. (Alberta Research Council). 157 pp.

The Endocrine Disruption Exchange (TEDX). November 17, 2006. *Chemicals Used in Natural Gas Development and Delivery*. Available from URL: http://www.earthworksaction.org/publications.cfm?pubID=162

U.S. Environmental Protection Agency. 2002. *Integrated Risk Information System (IRIS) on Benzene*. (National Center for Environmental Assessment, Office of Research and Development). Available from URL: http://www.epa.gov/iris/subst/0276.htm

U.S. Environmental Protection Agency. Technology Transfer Network Air Toxics Website. *1,3-Butadiene*. "Hazard Summary." (Revised January, 2000). Available from URL: http://www.epa.gov/ttn/atw/hlthef/butadien.html

U.S. Environmental Protection Agency. Technology Transfer Network Air Toxics Website. *1,3-Ethylbenzene*. "Hazard Summary" (revised January, 2000). Available from URL: http://www.epa.gov/ttn/atw/hlthef/ethylben.html

U.S. Environmental Protection Agency. Technology Transfer Network Air Toxics Website. *1,3-Toluene*. "Hazard Summary" (Revised January, 2000). Available from URL: http://www.epa.gov/ttn/atw/hlthef/toluene.html

U.S. Environmental Protection Agency. Technology Transfer Network Air Toxics Website. *1,3-Xylenes*. "Hazard Summary" (Revised January, 2000). Available from URL: http://www.epa.gov/ttn/atw/hlthef/xylenes.html

U.S. Environmental Protection Agency. 1995. *Compilation of Air Pollutant Emission Factors, Vol. 1, Stationary Point and Area Sources*. "Petroleum Industry." Available from URL: http://www.epa.gov/ttn/chief/ap42

U.S. Environmental Protection Agency. 1994. Office of Air Quality Planning and Standards. *Regulatory Impact Analysis for the Petroleum Refinery NESHAP*. Revised Draft.

U.S. Environmental Protection Agency (EPA). October 1993. *Report to Congress on Hydrogen Sulfide Air Emissions Associated with the Extraction of Oil and Natural Gas*. EPA-453/R-93-045.

U.S. Environmental Protection Agency. 1992. *Health Assessment Document for Hydrogen Sulfide*. (Environmental Criteria and Assessment Office, Office of Health and Environmental Assessment. Research Triangle Park, NC). EPA/600/8-86/026F.

U.S. Environmental Protection Agency. *AP-42 Emissions Factors, Ch. 13.5. Industrial Flares*. Available from URL: http://www.epa.gov/ttn/chief/ap42/ch13/final/c13s05.pdf

U.S. Environmental Protection Agency. *AP-42 Emissions Factors, Ch. 5, Petroleum Industry, S. 5.3, Natural Gas Processing*. Available from URL: http://www.epa.gov/ttn/chief/ap42/ch05/final/c05s03.pdf

U.S. Environmental Protection Agency. *Directed Inspection And Maintenance at Gas Processing Plants and Booster Stations*. Lessons Learned From Natural Gas STAR Partners. Available from URL: http://www.epa.gov/gasstar/pdf/lessons/ll_dimgasproc.pdf

U.S. Environmental Protection Agency. *List of Contaminants & Their MCLs*. Available from URL: http://www.epa.gov/safewater/mcl.html

U.S. Environmental Protection Agency. *Health Effects Notebook for Hazardous Air Pollutants*. http://www.epa.gov/ttn/atw/hlthef/hapindex.html

Van Hoorne, et al. 1991. "Survey of chemical exposures in a viscose rayon plant." *Annals of Occupational Hygiene*. 35(6).

Vermaa, Dave K., Johnson, Diane M., and McLean, James D. 2000. "Benzene and Total Hydrocarbon Exposures in the Upstream Petroleum Oil and Gas Industry," *American Industrial Hygiene Association Journal*. 61:255–263.

World Health Organization. 2003. *Concise International Chemical Assessment Document 53, Hydrogen Sulfide: Human Health Aspects*. Geneva, Switzerland: World Health Organization. Available from URL: http://www.who.int/entity/ipcs/publications/cicad/en/cicad53.pdf