
# *Long-Term Ambient Air Monitoring Project near Permanent Marcellus Shale Gas Facilities Protocol*

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**Commonwealth of Pennsylvania**
**Department of Environmental Protection**

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www.depweb.state.pa.us

**Table of Contents**

**Background**

The Pennsylvania Department of Environmental Protection (PA DEP) is conducting a one-year ambient air monitoring project, set to begin on July 23, 2012, with an emphasis on characterizing near-source concentrations of criteria and hazardous air pollutants from permanent facilities related to the Marcellus Shale gas industry (compressor stations, gas processing).

Shale gas is available in many basins across the United States. The Marcellus Shale Formation, which extends from New York into Pennsylvania, Maryland, Ohio, Virginia, and West Virginia, and covers approximately 95,000 square miles, is the most expansive shale gas "play" in the United States. The Marcellus play located within the borders of Pennsylvania is now one of the most active shale plays in terms of drilling, with operations primarily in the southwest, northcentral and northeast portions of the state. In recent years, the number of Marcellus Shale wells drilled in Pennsylvania has rapidly increased. In 2008, the number of wells drilled to tap Marcellus Shale gas was 195. In 2009 that number jumped to 768. Even more gas wells were drilled in 2010 at 1,386 wells.

The extraction of natural gas from Marcellus Shale involves many stages and provides many opportunities for the release of air pollutants during the process. The major stages and infrastructure involved in natural gas extraction and processing include: pad, impoundment and road construction; drilling; fracturing; flaring; condensate tanks; compressor stations; and gas processing facilities.

Along with the increased drilling operations, there has been an increase in the number of complaints to the Department's regional offices concerning Marcellus Shale operations. In response to the increased number of well sites and concerns about the impact of the Marcellus Shale natural gas drilling activities on air quality, the PA DEP completed three short-term, screening-level air quality sampling initiatives in 2010 that are described in Table 1.

Table 1. PA DEP short-term screening-level ambient air sampling initiatives.

| Region | Period | Facilities Sampled |
|---|---|---|
| Southwest | Apr. to Aug. | Two compressor stations, condensate tank farm, wastewater impoundment and background site |
| Northeast | Aug. to Oct. | Two compressor stations, a functioning well, a well site during fracking operations and background site |
| Northcentral | Aug. to Dec. | Two compressor stations, a well site during flaring operations, an active well-drilling site, and background site |

The goals of the initiatives included the short-term screening of ambient air concentrations of target pollutants near certain of Marcellus Shale gas drilling operations, assessing preliminary air quality impacts and determining if there were any immediate health risks from ambient pollutant concentrations to nearby residents or communities.

Each regional sampling initiative included four or five "sampling weeks" utilizing the PA DEP Bureau of Laboratories Mobile Analytical Unit to measure the concentrations of a target list of pollutants associated with gas drilling. The Mobile Analytical Unit used Gas Chromatography/Mass Spectrometry and Open Path Fourier Transform Infrared samplers to screen for approximately 48 volatile organic compounds (VOCs), including methane and benzene. Additional air samples were collected in canisters over a 24-hour period and analyzed by the PA DEP Laboratory. The sampling weeks focused on ambient air pollution levels near various permanent and temporary Marcellus operations.

The key findings for the screen sampling in all three regions can be summarized as follows:

- Short-term sampling did detect concentrations of certain natural gas constituents including methane, ethane and propane, and associated compounds such as benzene, in the air near Marcellus Shale drilling operations.
- Elevated levels of natural gas constituents were detected at all compressor station sampled in the three regions.
- Certain compounds, mainly methyl mercaptan, were detected at levels which generally produce odors.
- Results of the limited ambient air sampling initiative conducted in the southwest region did not identify concentrations of any compound that would likely trigger air-related health issues associated with Marcellus Shale drilling activities.
- The PA DEP was unable to determine whether the potential cumulative emissions of criteria pollutants from natural gas exploration activities will result in violations of the health and welfare-based federal standards.
- A specialized infrared camera that can detect emissions of certain pollutants from a source that otherwise may be invisible to the naked eye, did detect direct and fugitive emissions from sources such as the compressor stations that could have contributed to the ambient concentrations detected at the site.

Reports for the three regional short-term sampling initiatives have been published and are available at: www.depweb.state.pa.us.

Due to the limited scope and duration of the sampling and the limited number of sources and facilities sampled, the findings only represented conditions at the time of the sampling and did not represent a comprehensive long-term study of ambient concentrations.

The PA DEP long-term ambient air study is to determine any chronic or long-term risks to the public from individual or multiple shale gas sources. The study is taking place in the southwestern portion of the state due to the "wet" nature of the gas in that region, meaning the presence of some other volatile organic compounds in the gas stream besides methane. The sampling will take place near large-scale compressor and/or gas processing stations. These two types of facilities are being selected for the following reasons:

- Are permanent facilities, whereas well-installation activities (drilling, fracking, etc.) are more short-term and don't factor in chronic risk analysis.
- Have been shown to be a source of methane, nitrogen oxide ($NO_x$), carbon monoxide (CO) and hazardous air pollutant (HAP) emissions during the PA DEP short-term studies.
- Are a source of complaints to DEP Regional Offices for malodor and other issues,
- Are components of an industry that as a whole, could be considered a major new area source and affect Pennsylvania's attainment of the National Ambient Air Quality Standards.

The monitoring data will provide estimates of community exposure to air pollutants and create a valuable database for the analysis of long-term health impacts. The sampling and risk information obtained from this project will allow general assumptions about many similar sources in other areas of the Commonwealth.

## Technical Approach

### *Objectives Completed*

1) Determine sampling locations. PA DEP chose large compressor stations and a gas processing facility as target sources for sampling based on factors such as pollutant emissions, potential community impacts, and environmental complaints.
2) Install the main monitoring site. The main monitoring site has been installed in the prevailing downwind direction, or site of maximum impact from the largest of the three sources, the MarkWest Houston gas processing facility. The main site holds a full suite of sampling equipment including criteria and toxic monitors. More details are provided below.
3) Install three satellite monitoring sites. Two of the satellite sites are downwind (or in the maximum impact zone) of the other two chosen target sources, the Nancy Stewart and Brigich compressor stations. The third satellite site is a background site in an upwind direction of the MarkWest Houston facility. The satellite sites do not contain criteria pollutant monitors but will take toxic measurements.

### *Future Objectives*

1) Measure target pollutant concentrations at all sites over a one-year period to assess the potential chronic health risk to HAPs and other pollutants measured.
2) Conduct visual emission surveys of the target sources using the FLIR camera to document direct and fugitive emissions.
3) Use EPA-approved data reduction, summary and risk analysis techniques to characterize the data and associated long-term health risks. An outside contractor may be hired for this work (to be determined).

4) Evaluate the implications of the study results for similar facilities and community exposures in other regions of the state.

***Statement of Work***

The PA DEP Central Office will coordinate the project work with the Bureau of Laboratories and Southwest Regional Office.

*Main Monitoring Site*

PA DEP has located, installed and will operate the main monitoring site near the large MarkWest Houston gas processing facility in an area of maximum impact. The station on Meddings Road (Canonsburg) is equipped with a 10-meter meteorological tower and houses a full array of monitors to capture gas-related emissions including: a continuous methane/non-methane analyzer, continuous $NO_x$, CO, $PM_{2.5}$ and $H_2S$ sensors, and a VOC/Carbonyl sampler.

Data is recorded and processed by a datalogger connected to a cellular modem so that data can be polled on an hourly basis by PA DEP. All equipment will be rigorously maintained and audited according to standard protocol.

*Satellite Sites*

PA DEP has located, installed and will operate satellite monitoring sites near the Nancy Stewart and Brigich compressor stations. Two satellite sites, one on Henderson Road (Hickory), and one at Jaspen Way (Canonsburg) are smaller in scale than the main site but will sample for the same toxic pollutants on the same sampling schedule. The third satellite site on Welsh Road (Washington) is designated as a background site to the main site, and is located in an upwind direction from the MarkWest Houston facility.

***Sampling Methods, Equipment and Target Pollutants***

All sampling methods follow EPA methods and equipment manufacturers operating manuals Please refer to EPA's Compendium Method TO-15, Section 8, for a description of the sampling method PA DEP uses to collect air samples in canisters. Refer to Tables 2 and 4 for a list of the target pollutants and equipment used in the study. The equipment makes and models may change depending on availability.

***Laboratory Analysis***

The PA DEP Bureau of Laboratories will analyze the canister samples using standard operating procedure that is again based on EPA Compendium Method TO-15. TO-15 analysis includes compounds not related to Marcellus Shale gas but will be reported since they are part of the suite of results. Method detection limits for most of these compounds (as defined in 40 CFR 136 Appendix B) are from 0.04 to 0.08 ppbv. The PA DEP Lab is a NELAP-Recognized Accrediting Authority and participates in NATTS PT VOC audits.

**Data Analysis**

The data analysis objective of this project is exposure assessment and risk characterization. Elements of the project design (discussed thoroughly in the previous section) that ensure the data analysis objective is met include:

- The use of quality, reliable monitoring equipment; the same make and model equipment used in the other Pennsylvania monitoring networks.

- Experienced operators who have extensive knowledge in operating, maintaining and troubleshooting the equipment.
- The use of a sampling schedule for discreet samples that statistically provide enough samples for long-term analysis and account for varying operating schedules of the sources monitored.
- An established preventative maintenance routine.
- The use of peer-reviewed risk factors, EPA accepted methodology and acceptability ranges for the cancer and non-cancer risk assessment of the HAP results.
- Experienced risk assessment staff.

Table 2. List of target pollutants for the proposed study

| Target Pollutant List | | |
|---|---|---|
| Methane/Non-Methane Compounds | 1-Ethyl-4-methy benzene | Hexachloro-1,3-butadiene |
| Ozone | 2-Butanone (MEK) | m&p-Xylene |
| Nitrogen Oxides | 2-Hexanone | Methylene chloride |
| Carbon Monoxide | 2-Methoxy-2-methylpropane (MTBE) | n-Heptane |
| Hydrogen Sulfide | 4-Methyl-2-pentanone (MIBK) | n-Hexane |
| Particulate Matter (<2.5 microns) | Acetone | o-Xylene |
| 1,1,1-Trichloroethane | Acrolein | Propene |
| 1,1,2,2-Tetrachloroethane | Benzene | Styrene |
| 1,1,2-Trichloro-1,2,2-trifluoroethane | Bromodichloromethane | Tetrachloroethene (PERC) |
| 1,1,2-Trichloroethane | Bromoform | Tetrahydrofuran (THF) |
| 1,1-Dichloroethane | Bromomethane | Toluene |
| 1,1-Dichloroethene | Carbon disulfide | trans-1,2-Dichloroethene |
| 1,2,4-Trichlorobenzene | Carbon tetrachloride | trans-1,3-Dichloro-1-propene |
| 1,2,4-Trimethylbenzene | Chlorobenzene | Trichloroethylene (TCE) |
| 1,2-Dibromoethane | Chloroethane | Trichlorofluoromethane |
| 1,2-Dichloro-1,1,2,2-tetrafluoroethane | Chloroethene | Acetaldehyde |
| 1,2-Dichlorobenzene | Chloroform | Acetone |
| 1,2-Dichloroethane | Chloromethane | Benzaldehyde |
| 1,2-Dichloropropane | cis-1,2-Dichloroethene | Butyraldehyde |
| 1,3,5-Trimethylbenzene | cis-1,3-Dichloro-1-propene | Formaldehyde |
| 1,3-Butadiene | Cyclohexane | Isovaleraldehyde |
| 1,3-Dichlorobenzene | Dibromochloromethane | Propionaldehyde |
| 1,4-Dichlorobenzene | Dichlorodifluoromethane | trans-2-Butenal |
| 1-Bromopropane | Ethy benzene | |
| | | |
| - Continuous meaurements for these compounds | | |

**Community Collaboration / Outreach**

PA DEP has been collaborating with communities affected by the Marcellus Gas industry (and will continue to do so) in the form of emergency response to environmental incidents, responding to citizen's complaints, answering questions via phone and e-mail, attending Marcellus Shale gas forums and participating in conference calls.

The surrounding communities will be kept apprised of the results on a quarterly basis after data quality assurance and EPA notification. If requested, public meetings will be scheduled after project has ended to present the results and discuss any next steps.

Interested third parties, such as academic institutions and other agencies, will be encouraged to piggyback research at the project sites and to participate in the project by having graduate students collect samples.

**Environmental Results: Outcomes, Outputs, Performance Measures**

An output of this monitoring project includes long-term ambient air pollutant concentration data including the main natural gas constituent (methane), criteria pollutants ($NO_x$, CO, $PM_{2.5}$), hazardous air pollutants (benzene, carbonyls) and other associated pollutants ($H_2S$). An additional output includes a health-based risk assessment of the measured HAP's in terms of cancer and non-cancer risk using accepted EPA methods.

The immediate expected outcomes include the identification of any elevated long-term (annual) concentrations of criteria and/or hazardous air pollutants and increased community awareness of adverse air quality issues. State actions may include permit modification and/or new legislation on emissions control or fugitive releases. Any adverse outcomes from this monitoring project will provide the industry an opportunity for voluntarily mitigation efforts on emissions. The information gathered from this project may affect future decisions by local municipalities on zoning issues related to Marcellus gas.

If unfavorable results are discovered, the long-term outcome would be a statewide push to reduce community exposure to criteria and hazardous air pollutants from the Marcellus industry as it continues to expand. Performance measures include a 75% data collection efficiency for each pollutant measured, the ability to determine whether ambient air quality standards were met or exceeded, and the presence of unacceptable levels of cancer and non-cancer risk.

**Project Milestones**

The project milestones and the completion times can be found in Table 3. The data collected from this project will represent the first long-term look at the air quality near these facilities in Pennsylvania and can be used by others for continued investigation of impact by this relatively new industry.

Table 3. The project milestones and the days to complete each milestone.

| Project Phase | Milestone | Days to Complete Milestone | Tentative Competion Date |
|---|---|---|---|
| Active Sampling | Sampling | 365 | 7/23/2013 |
| | Sampling Complete and Data Received from Lab | 30 | 8/23/2013 |
| Post Sampling and Report Writing | Data Analysis and Summary | 30 | 9/23/2013 |
| | Report Writing and Approvals | 30 | 10/23/2013 |

Table 4. List of equipment used in the study.

| Make | Model | Description |
|---|---|---|
| Synspec | Alpha 114 | Methane/Non-methane Analyzer |
| Parker Balston | TOC-1250 | Zero Air Generator |
| ESC | 8832 | Datalogger |
| Teledyne API | 200A | NOx Analyzer |
| Teledyne API | 300 | CO Analyzer |
| Teledyne API | 101E | H2S Analyzer |
| Teledyne API | 400E | Ozone Analyzer |
| R&P Partisol Plus | 2025 | PM2.5 Sampler |
| ATEC | 2200-12-2 | Canister/Carbonyl Sampler |
| ATEC | 2200-12 | Canister Sampler |
| Jerome | X651 | Portable H2S Analyzer with Shelter |
| EKTO | 8'x8' | Main Shelter, Met Tower, Manifold |
| FLIR | GF-320 | Infrared Camera for Direct & Fugitive Emissions |
| Campbell Scientific | CM110 | SS Tripod Towers |
| Climatronics | Sonimometer | WS/WD with Datalogger, Heated, Self-Aligning |
| Campbell Scientific | SP10 | Solar Panel for Met Gear |