

# Health Consultation

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**Brooklyn Township PM<sub>2.5</sub>**

**Brooklyn Township, Susquehanna County, Pennsylvania**

**Cost Recovery Number: 3A4K00**

APRIL 22, 2016

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES  
Agency for Toxic Substances and Disease Registry  
Division of Community Health Investigations  
Atlanta, Georgia 30333

## **Health Consultation: A Note of Explanation**

A health consultation is a verbal or written response from ATSDR or ATSDR's Cooperative Agreement Partners to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR or ATSDR's Cooperative Agreement Partner which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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HEALTH CONSULTATION

Brooklyn Township PM<sub>2.5</sub> Health Consultation

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Cost Recovery Number: 3A4K00

Prepared By:

U. S. Department of Health and Human Services  
Agency for Toxic Substances and Disease Registry  
Division of Community Health Investigations  
Atlanta, Georgia 30333



## SUMMARY

<p><b>Introduction:</b></p>	<p>In June 2015, local residents presented citizen-collected ambient air data and a summary of self-reported health symptoms to federal and state agencies. Citizens requested assistance from the Pennsylvania Department of Health (PA DOH), Pennsylvania Department of Environmental Protection (PA DEP), Agency for Toxic Substances and Disease Registry (ATSDR), and U.S. Environmental Protection Agency (EPA) with assessing particulate matter exposures in the vicinity of the Williams Central natural gas compressor station (Station) in Brooklyn Township, Susquehanna County, Pennsylvania. This request resulted in an 18-day EPA field air monitoring event in August and September 2015. This EPA field activity produced valid and representative fine particulate matter data (PM<sub>2.5</sub>), which was provided to ATSDR on September 17, 2015 for public health evaluation. ATSDR completed its review of the EPA data and presents its analysis, conclusions, recommendations, and limitations in this health consultation (HC).</p> <p>Although citizens presented self-collected ambient air data (using Speck particle sensors) and requested assistance with evaluating airborne particulate matter exposures near the Station, their health concerns were broad to include concerns about other potential environmental impacts associated with natural gas drilling and distribution (e.g., groundwater contamination, air emissions). This health consultation focuses on fine particulate matter exposures and is based on the data collected by EPA in August and September 2015.</p>
<p><b>CONCLUSIONS</b></p>	<p>ATSDR reached two important conclusions for this site:</p>
<p><b>Conclusion 1</b> (Short-Term Exposures)</p>	<p>Exposure to maximum levels of PM<sub>2.5</sub> may be harmful to unusually sensitive populations, such as those with respiratory or heart disease, but are not at levels that are a concern to the general population.</p>
<p><b>Basis for Conclusion 1</b></p>	<p>The average ambient 24-hour PM<sub>2.5</sub> concentration observed at one residence in Brooklyn Township (19 µg/m<sup>3</sup>) was higher than the nearest regional NAAQS monitoring station (12.3 µg/m<sup>3</sup>) in Scranton, PA, over the same 18-day period.</p> <p>EPA AirNow AQI Calculator concludes that exposure to 24-hr PM<sub>2.5</sub> at 32 µg/m<sup>3</sup>, the maximum one day concentration recorded in Brooklyn Township, is not of concern for the general population or sensitive subpopulations. Some unusually sensitive subpopulations, such as people with respiratory or heart disease, the elderly and children, are the most at risk for adverse health effects from daily exposure to this maximum concentration.</p> <p>The 24-hour PM<sub>2.5</sub> concentrations at the monitored location did not exceed the EPA 24-hour NAAQS criteria of 35 µg/m<sup>3</sup>, except on one day of sampling at one monitoring location. Most studies reported effects in the range of ~1% to 4% increase in respiratory hospital admissions and emergency department visits and</p>

	<p>were observed in study locations with mean 24-hour PM<sub>2.5</sub> concentrations ranging from 6.1-22 µg/m<sup>3</sup>.</p> <p>Sampling was conducted at a home in Brooklyn Township, where residents have noted health effects on days of poor air quality (e.g., visible emissions and nuisance odors). Sensitive populations, such as elderly individuals, live in the area.</p>
<b>Conclusion 2</b> (Chronic Exposures)	The estimated annual average PM <sub>2.5</sub> concentration of 15 to 16 µg/m <sup>3</sup> may be harmful to the general population and sensitive subpopulations, including the elderly, children, and those with respiratory or heart disease.
<b>Basis for Conclusion 2</b>	<p>The estimated annual average is based on eighteen days of Brooklyn Township sampling data at one residence (with three monitors) and correlation of this Brooklyn Township data set with 24-hour PM<sub>2.5</sub> concentration trends in the regional monitor (Scranton, PA) and multiple NAAQS regional monitors in Pennsylvania. Uncertainty about local PM<sub>2.5</sub> emissions limits our confidence in this estimated annual average range.</p> <p>There is evidence that long-term exposure to PM<sub>2.5</sub> can cause several potential health effects including: an increase in mortality (i.e., all cause and cardiovascular) at average concentrations of 10–32 µg/m<sup>3</sup>; increased respiratory symptoms and asthma incidence, as well as respiratory hospitalizations, at average PM<sub>2.5</sub> concentrations of 9.7–27 µg/m<sup>3</sup>; developmental outcomes, specifically reductions in birth weight, at average PM<sub>2.5</sub> concentrations of 11–19.8 µg/m<sup>3</sup>; and pre-term births at concentrations as low as 5.3 µg/m<sup>3</sup>.</p>
<b>Limitations</b>	<p>Our conclusions are limited due to data assurance issues and site-specific variables. The PM<sub>2.5</sub> data collected and analyzed represents air quality at one location in close proximity to the Williams Central Compressor Station and should not be generalized to all natural gas compressor stations or to other locations in Brooklyn Township. ATSDR does not have emissions data to determine whether or not monitoring occurred during peak emissions periods at the compressor.</p> <ul style="list-style-type: none"> <li>• Only PM<sub>2.5</sub> data were collected and assessed in this health consultation.</li> <li>• Federal reference or equivalent methods (FRM, FEM) were not used for sampling.</li> <li>• Only 18 days of data were collected, making it difficult to determine what long-term PM<sub>2.5</sub> exposures (&gt;1 year) may be.</li> <li>• Only one location was monitored.</li> <li>• Staging of monitors was not ideal (e.g., not certain of dominant local wind direction; some obstacles obstruct samplers).</li> <li>• No valid and representative meteorological data were obtained at the sampling location.</li> </ul>
<b>Next Steps</b>	The information from this health consultation will be shared with the concerned residents near the Williams Central Compressor Station and relevant state health and environmental agencies.

ATSDR recommends that unusually sensitive individuals (people with respiratory or heart disease, the elderly and children) should monitor air quality action days for the region (i.e., Scranton NAAQS data) as well as their own local air quality conditions, and consider reducing activities that include prolonged or heavy exertion on days with poor air quality. The Air Quality Forecast and Alert system can be found at: <http://airnow.gov/>

ATSDR recommends that the PADEP, working with permitted sources in the area, consider steps to reduce emissions of PM and PM precursor chemicals.

As a matter of prudent public health practice, ATSDR recommends that state and local agencies consider mitigating other known sources of respirable PM (e.g., unpaved roadways) in Brooklyn Township, PA.

Per the local citizen request, only PM<sub>2.5</sub> data were collected to assess local citizen's specific environmental health concern at this location. Given the potential that there are additional air emissions of potential public health concern at these locations, ATSDR recommends more robust assessment of air quality, including seasonal monitoring, including winter, near this natural gas compressor station.

If requested, ATSDR will provide technical assistance to the local community and local, state and federal agency stakeholders (e.g., assessing environmental sampling or modeling data, or the development of environmental monitoring strategies.)





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## Introduction

In June 2015, local residents presented citizen-collected ambient air data and a summary of self-reported health symptoms to federal and state agencies. Citizens requested assistance from the Pennsylvania Department of Health (PADOH), Pennsylvania Department of Environmental Protection (PADEP), Agency for Toxic Substances and Disease Registry (ATSDR), and U.S. Environmental Protection Agency (EPA) with assessing particulate matter exposures in the vicinity of the Williams Central natural gas compressor station (Station) in Brooklyn Township, Susquehanna County, Pennsylvania. The citizen-collected data were obtained from a recently-developed particulate matter (PM) sensor known as a first generation “Speck” sensor. In addition to submitting Speck sensor data, local residents expressed concerns about air contamination in their community, noting both nuisance odor events and self-reported health effects from exposure to emissions, including upper respiratory tract irritation and bloody noses.

ATSDR requested air monitoring assistance from EPA due to concerns with the quality and representativeness (further discussed in the Appendix) of the Speck sensor data presented by residents. Using three E-BAM real-time particulate monitors for 18 days at one residence in Brooklyn Township, PA, EPA produced a validated data set for particulate matter with an aerodynamic diameter of 2.5 micrometers or less (PM<sub>2.5</sub>). These data were provided to the ATSDR for review on September 17, 2015. ATSDR completed its review of the data and presents its conclusions and recommendations in this health consultation.

## Background

After a July 21, 2015 meeting with EPA, ATSDR, and the concerned residents, an EPA Region 3 On-Scene Coordinator (OSC) agreed to conduct ambient air particulate monitoring to support ATSDR’s assessment of exposures to PM<sub>2.5</sub> in Brooklyn Township, Susquehanna County, PA. The EPA-produced data were collected from one residential property approximately 0.5 mile northwest of the source of concern (i.e., Williams Central Compressor Station) using three Met-One Instruments beta attenuation mass monitors (E-BAM). E-BAMs are considered by the manufacturer to be portable, real-time beta gauges comparable to U.S. EPA methods for PM<sub>2.5</sub> particulate measurements (Met-One 2015).

Originally, EPA prepared to conduct monitoring at two residential monitoring locations close to the Station to determine the concentration of PM<sub>2.5</sub> over a two-week period. However, due to denial of access at one of the two locations, sampling was conducted at only one residence, and the sampling period was extended to 18 consecutive days (August 17 through September 3, 2015).

The rest of this section provides information about the site and the source of concern; provides a description of the contaminant of concern (PM<sub>2.5</sub>) and potential PM<sub>2.5</sub> in the Brooklyn Township community, describes the E-BAM data; and, details the concerns expressed by the community to

health and environmental agencies prior to the EPA monitoring activities. The field sampling and data summary section presents the PM<sub>2.5</sub> data collected by EPA and describes how it was collected and reported. The discussion section includes a public health evaluation of the PM<sub>2.5</sub> data, and summarizes the public health implications of PM<sub>2.5</sub> exposures at the levels detected in the community. The final section of this health consultation provides conclusions and limitations to the data evaluation and recommendations for how to reduce exposures to unhealthy levels of PM<sub>2.5</sub> in the community.

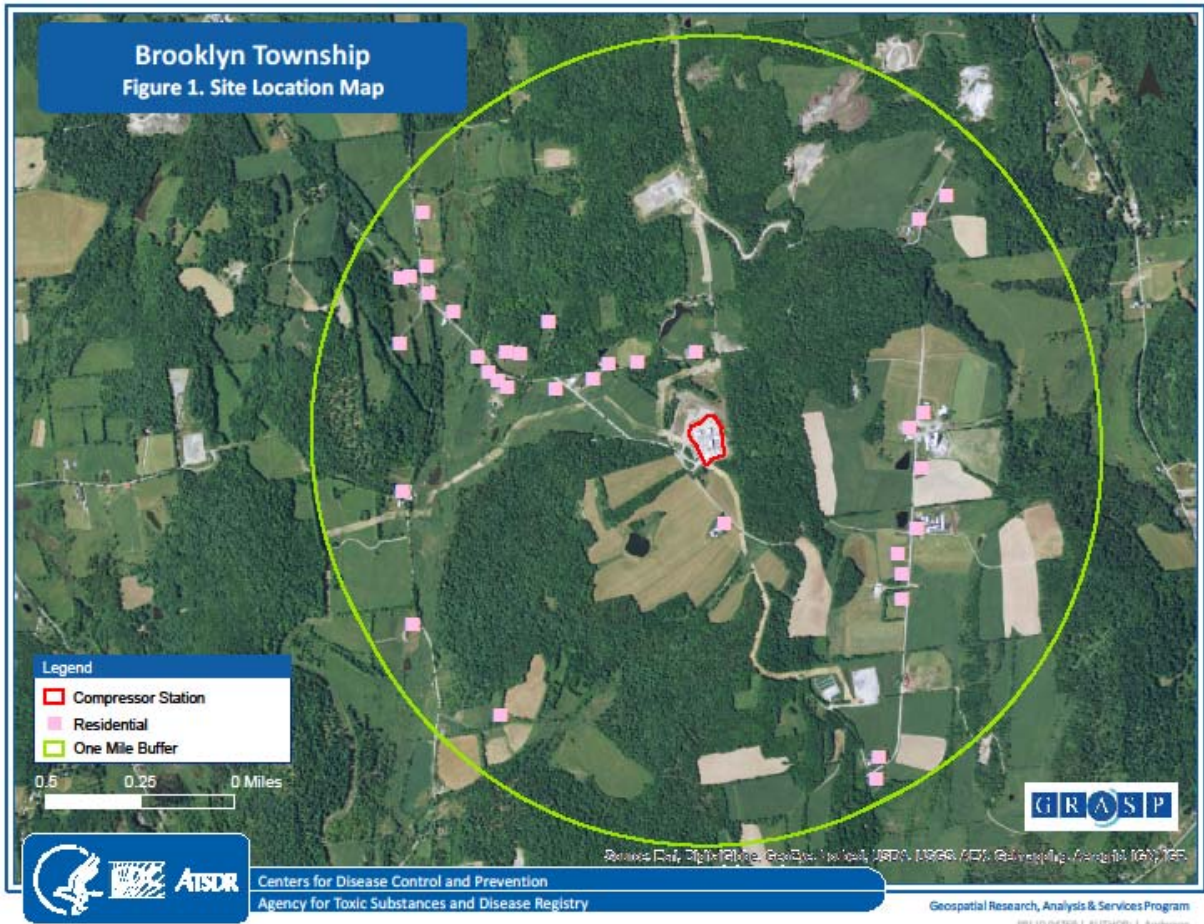
### Site Description

Brooklyn Township, Susquehanna County, Pennsylvania is a rural, agricultural area characterized by rolling hills and valleys where natural gas drilling, extraction and distribution activities are occurring and associated infrastructure continues to be developed. The Williams Central Compressor Station (Station), located along Old Turnpike Road, was permitted for development and use in 2012. It has been in operation for approximately three years. The Station was identified by local residents as a primary source of air pollution, including PM<sub>2.5</sub>, in their community. The Station has PADEP air quality permits allowing it to emit hazardous air pollutants (HAPs), priority pollutants and greenhouse gases up to specific quantities on an annual basis. A brief description of the Station and the expected pollutant emissions for which it has been permitted is provided in the next section.

An EPA Region 3 OSC responded to the citizen's and the subsequent ATSDR request for air monitoring assistance by placing three PM<sub>2.5</sub> monitors at a residence located approximately a half (0.5) mile northwest of the Station. The residence where monitoring was conducted sits along a south-facing slope in a shallow valley (see Figure 1). The residence is at a slightly lower elevation than the compressor station, which sits on the opposite side of the same valley to the southeast of the residential monitoring point (See Figure 2). The residence is primarily covered with trees and open, grass-covered land. The 0.5 mile-wide valley between the monitoring location and the Station is forested to the northwest and agricultural cropland to the southeast, with residences along Puzo Road situated at the bottom of the valley.

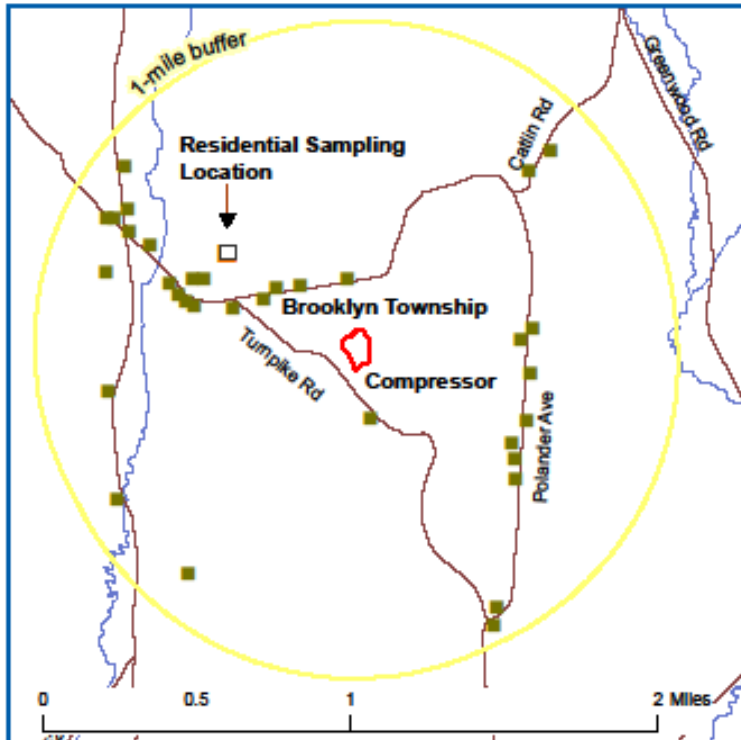
### PM<sub>2.5</sub> Emissions Sources

There are a number of potential sources of PM<sub>2.5</sub> in the site area, including automobile and other internal engine emissions, and the burning of wood and wastes by residents and farmers. The Williams Central Compressor Station is the only known facility with a permit for PM emissions in the immediate site area. Further discussion of emission sources is provided in the appendix.



# Brooklyn Township

Susquehanna County, Pennsylvania



## Demographic Statistics

Within 1 mile buffer of site boundary

Measure	Estimate
Total Population	141
White Alone	140
Black Alone	0
Am. Indian & Alaska Native Alone	0
Asian Alone	0
Native Hawaiian & Other Pacific Islander Alone	0
Some Other Race Alone	0
Two or More Races	2
Hispanic or Latino	2
Children Aged 8 and Younger	9
Adults Aged 65 and Older	23
Females Aged 15 to 44	25
Housing Units	53

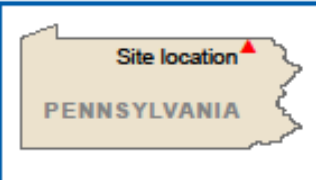
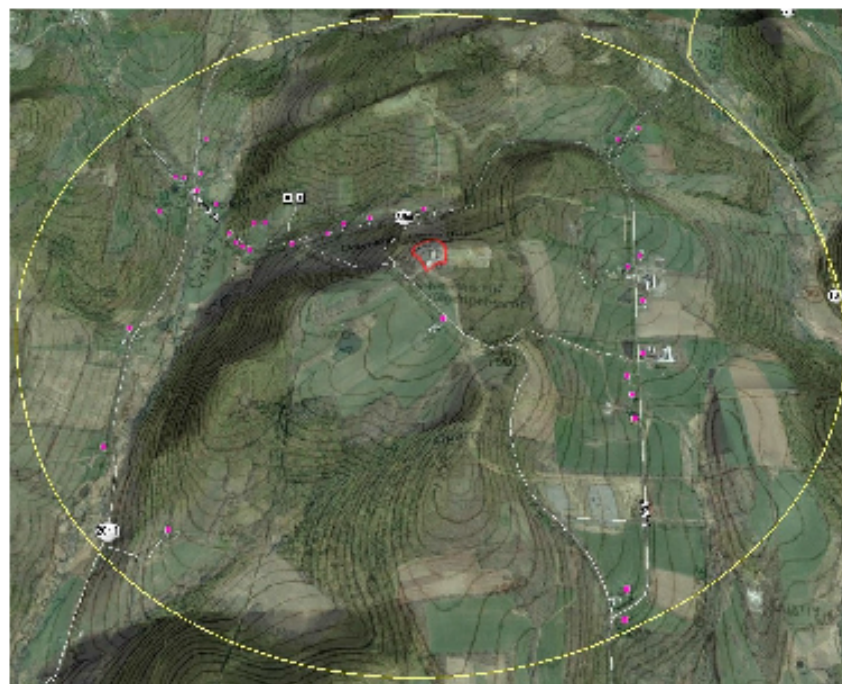
### Data Sources:

Demographic: U.S. Census (2010)

■ Residential dwellings: Digitized from ESRI World Imagery service

Basemap: Tom Tom

Map projection: Pennsylvania State Plane (North)



The Brooklyn Township compressor station is located close to South Montrose in Susquehanna County in Pennsylvania. The compressor is located along Tumpike Road and the road on the map going from top left to bottom right is Puzo Road.

The image was created in Google Earth using 2 times vertical exaggeration.

The Pink dots indicate residence inside the 1-mile buffer. The two white dots are the Residential Sampling Location.

## Williams Central Compressor Station

Construction of the Station began in 2011 and it received an air quality general permit for operation of its varied infrastructure on May 8, 2012 (PADEP, 2015). Equipment listed in the Station's permit paperwork includes three Caterpillar engines, three dehydrator units with reboilers, one flare and multiple produced water tanks. Based on the permit proposal and approval documents, the Station is expected to emit the following types and quantities of chemicals to the air:

- 5.43 tons per year (tpy) of particulate matter (PM)
- 70.91 tpy of nitrogen oxides (NO<sub>x</sub>)
- 1.18 tpy of sulfur dioxide (SO<sub>2</sub>)
- 40.97 tpy of volatile organic compounds (VOC)
- 73.19 tpy of carbon monoxide (CO)
- 6.93 tpy hazardous air pollutants (HAPs)
- 98,639 tpy carbon dioxide equivalents (CO<sub>2</sub>-e)

Relevant to an assessment of ambient respirable particle emissions, the Station is permitted to directly emit up to 5.43 tons of particulate matter per year (over 29 pounds per day) into the atmosphere. PM<sub>2.5</sub> is also formed secondarily in the atmosphere from the emissions of sulfur dioxide, nitrogen oxides, and VOCs, of which a total of 113.06 tons of emissions per year (over 600 pounds per day) is permitted at the Station.

### Particulate Matter with an Aerodynamic Diameter of 2.5 Microns or Less (PM<sub>2.5</sub>)

Particulate matter, or PM, is the term for particles found in the air, including dust, dirt, soot, smoke, and liquid droplets. These solid and liquid particles come in a wide range of sizes (EPA 2015). PM<sub>2.5</sub> is a fraction of total PM, and refers to particulate matter with an aerodynamic diameter of 2.5 microns or less. Some of these small particles can be suspended in the air for long periods of time. Some particles are large or dark enough to be seen as soot or smoke. Others are so small that individually they can only be detected with an electron microscope (EPA 2015).

There are natural and manmade sources of particulate matter. Particulate matter is a mixture with physical and chemical qualities that vary by source and location. Common chemical constituents of particulate matter can include sulfates, nitrates, ammonium and other inorganic ions, organic or elemental carbon, metals such as cadmium, copper, nickel, vanadium and zinc, and polycyclic aromatic hydrocarbons (PAHs). However, currently at the population level, there is not enough evidence to identify the differences in the effects of particles with different chemical constituents (WHO, 2013). "Primary" emissions sources, or sources that release PM<sub>2.5</sub> directly into the air, are responsible for some airborne PM<sub>2.5</sub>. In addition to primary emission sources, "secondary" particles form in the air from chemical reactions involving precursor gaseous emissions, such as sulfur dioxide, nitrogen oxides, and VOCs. Note that these secondary particles can form at locations far from those emissions sources that released the precursors (EPA 2009). As noted in

the previous section, the Williams Central Compressor Station is permitted as both a primary source of particulate matter and as a source of PM<sub>2.5</sub> precursor chemicals.

Particles less than 10 micrometers in diameter (PM<sub>10</sub>), also known as respirable particles, pose a health concern because they can be inhaled into and are small enough to penetrate into the thoracic region of the respiratory system (WHO, 2013). PM<sub>2.5</sub> particles are referred to as "fine" particles and are believed to pose the greatest health risks. Because of their small size (approximately 1/30th the average width of a human hair), fine particles can lodge deeply into the lungs (EPA 2015). Sources of fine PM include all types of combustion activities (motor vehicles, power plants, wood burning, etc.) and certain industrial processes. Many manmade and natural sources emit PM directly to the atmosphere or emit other pollutants that react in the atmosphere to form PM.

### ATSDR Health-Based PM<sub>2.5</sub> Comparison Value

ATSDR uses the nominal PM<sub>2.5</sub> 24-hour (35 µg/m<sup>3</sup>) and annual National Ambient Air Quality Standards (NAAQS) (12 µg/m<sup>3</sup>), without the 3-year averaging performed under the regulatory procedure, as the health-based comparison value for the initial screen of the environmental data set. ATSDR has not developed a health-based comparison value<sup>1</sup> for particulate matter, but the EPA has developed NAAQS for PM<sub>2.5</sub>. The U.S. EPA's NAAQS require annual average concentrations of PM<sub>2.5</sub>, averaged over three consecutive calendar years, to not exceed 12.0 micrograms per cubic meter (µg/m<sup>3</sup>). Additionally, the 98th percentile of 24 hour average PM<sub>2.5</sub> concentrations, averaged over three consecutive calendar years, must not exceed 35 µg/m<sup>3</sup>. The EPA considered a PM<sub>2.5</sub> NAAQS for a period less than 24 hours during its recent reevaluation of the PM NAAQS, but concluded the available information "when viewed as a whole, is too unclear, with respect to the indicator, averaging time and health outcome, to serve as a basis for consideration of establishing a primary PM<sub>2.5</sub> standard with an averaging time shorter than 24-hours at this time" (Federal Register, 2012, U.S. EPA, 2011).

### World Health Organization Air Quality Guidelines

The World Health Organization (WHO) air quality guidelines (AQGs) for PM<sub>2.5</sub> are more conservative than the NAAQS regulatory values (WHO, 2006). The WHO annual average AQG is 10 µg/m<sup>3</sup> and the 24-hour AQG is 25 µg/m<sup>3</sup>. The WHO annual AQG was derived based on an American Cancer Society study (health effects observed between 9- 33.5 µg/m<sup>3</sup>) and the Harvard Six-Cities study (health effects observed at concentrations between 11- 29.6 µg/m<sup>3</sup>). The WHO 24-hour AQG is based on the relationship between 24-hour and annual particulate matter levels. WHO recommends that the annual average take precedence over the 24-hour average because at low levels there is less of a concern about episodic excursions. Similar to the EPA, the WHO has not proposed a particulate matter AQG for a period shorter than 24 hours.

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<sup>1</sup> Comparison values are chemical and media-specific concentrations in air, soil, and drinking water that are used by ATSDR health assessors and others to identify environmental contaminants at hazardous waste sites that require further evaluation.



## Met-One E-BAM Data

The U.S. EPA has specified methods to demonstrate *regulatory* compliance with the NAAQS for particulate matter in 40 CFR 50, Appendix L. These methods are referred to as Federal Reference Methods (FRM) or Federal Equivalent Methods (FEM). The method used to measure PM<sub>2.5</sub> during the Brooklyn Township assessment did not follow either the FRM or FEM. Studies (USDA, 2003, 2006) which compared E-BAM monitoring data against FRM data suggests E-BAMs consistently report slightly higher concentrations than FRM methods. For this assessment, the validated data, without a downward correction recommended by the USDA studies (2003, 2006), is used for assessing resident exposures. ATSDR also reviewed the data and removed any results that were recorded during an “error” in the instruments’ operations. Using the validated E-BAM data directly for public health exposure evaluation and without adjustment is considered appropriate given the available information about data accuracy from E-BAM methods. Why ATSDR made the decision to not adjust the E-BAM results downward and more information about removing data with “error” instrument messages is provided in Appendix A.

## Community Concerns

Residents who have requested assistance provided a number of lines-of-evidence to support their concern for ambient adverse air impacts in the community from compressor station emissions. In addition to providing Speck sensor data, residents noted visibly poor air quality, occasional nuisance odor events, and a list of adverse health effects that they believe are the result of emissions from the compressor station. These self-reported health effects include upper respiratory irritation (e.g., sore throat), headaches, and nose bleeds. Environmental and health agencies at the state and federal level have received multiple reports of poor air quality in this area from residents. Given the health concerns from residents in the area, the presence of a facility permitted for particulate and gaseous emissions, and review of the citizen-collected PM<sub>2.5</sub> sensor data, ATSDR requested field monitoring support from EPA. The EPA OSC agreed to collect quality-assured PM<sub>2.5</sub> data for public health evaluation using readily-available regional PM<sub>2.5</sub> equipment, particularly three Met-One E-BAMs.

## Field Sampling and Data Summary

On August 17, 2015, Weston Solutions Inc. (WESTON®) and EPA Environmental Response Team (ERT) personnel deployed three E-BAM units at a residence in Brooklyn Township, Pennsylvania. The E-BAM units ran continuously through September 3, 2015 (18 days), when WESTON personnel removed the E-BAM units from the residential property. Approximately 9% of the entire data set was flagged as erroneous and removed from the validated data set (see Appendix A for more information about this process).

Two E-BAM units, EPA41488 and EPA41489, were collocated in a small open field at the residence bounded to the north by a garage, to the east and south by trees, and to the west by low-

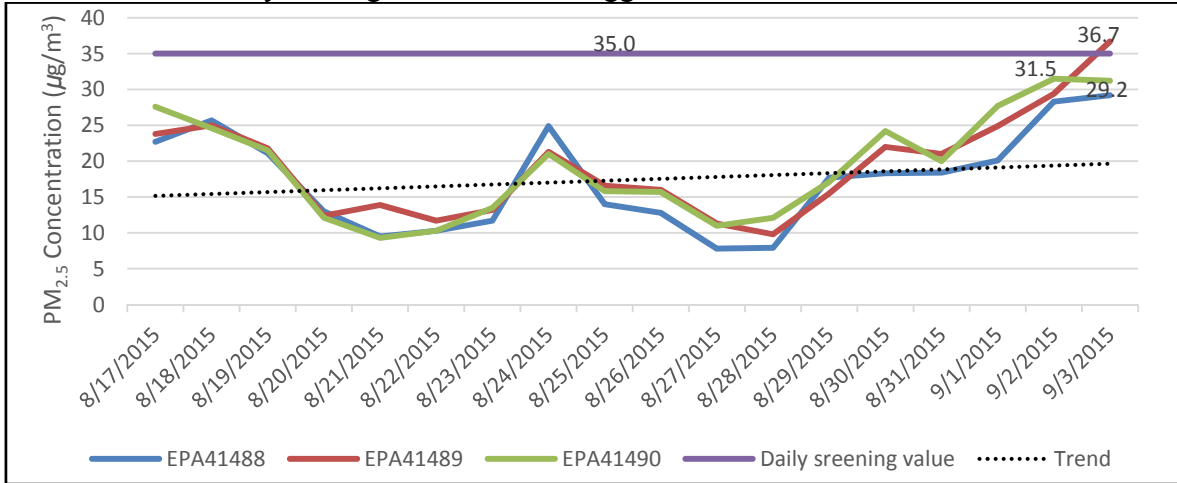
lying vegetation and the residential dwelling. The third E-BAM unit (EPA 41490) was located west of the other two E-BAMs and directly south of the residential dwelling. EPA41490 was not shielded to the south by any trees or other structures, however, tree stands were located to the west and southeast of this E-BAM unit. Table 1 and Figure 2 provide a summary of the daily average PM<sub>2.5</sub> concentrations for each of the three units staged at the residence.

**Table 1**  
Daily Average of 10-Minute PM<sub>2.5</sub> Data from E-BAM units

Date	EPA41488	EPA41489	EPA41490	Daily average of 3 monitors
	Co-located			
	µg/m <sup>3</sup>	µg/m <sup>3</sup>	µg/m <sup>3</sup>	µg/m <sup>3</sup>
8/17/2015	22.7	23.8	27.6	24.7
8/18/2015	25.7	25	24.6	25.1
8/19/2015	21.1	21.8	21.5	21.5
8/20/2015	13	12.4	12.1	12.5
8/21/2015	9.5	13.9	9.3	10.9
8/22/2015	10.3	11.7	10.3	10.8
8/23/2015	11.7	13.2	13.5	12.8
8/24/2015	24.9	21.3	21	22.4
8/25/2015	14	16.6	15.8	15.5
8/26/2015	12.8	16	15.7	14.8
8/27/2015	7.8	11.3	11	10.0
8/28/2015	7.9	9.8	12.1	9.9
8/29/2015	17.7	15.5	17.1	16.8
8/30/2015	18.3	22	24.2	21.5
8/31/2015	18.4	21	20	19.8
9/1/2015	20.1	24.9	27.7	24.2
9/2/2015	28.3	29.4	<b>31.5</b>	29.7
9/3/2015	<b>29.2</b>	<b>36.7</b>	31.2	32.4
<i>18 Day Average (rounded)</i>	<i>17</i>	<i>19</i>	<i>19</i>	<i>19</i>

Notes: Bolded values are maximum instrument 24-hour concentrations for entire period. ATSDR health-based 24-hour comparison value (HCV) is 35 µg/m<sup>3</sup> and the annual HCV is 12 µg/m<sup>3</sup>

**Figure 2**  
Daily Average of 10-minute logged data from E-BAM units



To place the data obtained from the residential monitoring location in context with regional air quality data collected by PADEP under their Clean Air Act NAAQS program, Table 2 provides data from the nearest NAAQS monitoring location in Scranton, Pennsylvania (Scranton Commonwealth of Pennsylvania Air Monitoring Station, or Scranton COPAMS) for the same dates that EPA monitoring was conducted in Brooklyn Township (August 17 through September 3, 2015). The monitoring conducted by EPA in Brooklyn Township did not follow a federal reference or equivalent method (FRM or FEM), however, and the Brooklyn Township site location has not been assessed to determine whether it meets NAAQS-specific siting requirements. Therefore, the data sets should not be compared directly without first considering the difference in monitoring methods and equipment, the difference in siting of monitors and the purpose of this assessment, which was to assess PM<sub>2.5</sub> exposures in close proximity to a known source of PM<sub>2.5</sub> emissions. Given that the Brooklyn Township monitoring location is located within the Scranton NAAQS region, PM<sub>2.5</sub> concentrations in Brooklyn Township that exceed the Scranton NAAQS concentrations may plausibly be attributed to local primary PM<sub>2.5</sub> sources in Brooklyn Township (in addition to regional sources of PM precursors). Evaluating trends in these data sets (Brooklyn Township data and Scranton NAAQS data) can help identify regional fluctuations, ranges, peaks, or seasonal variations in ambient PM<sub>2.5</sub> concentrations. This information is helpful in understanding what the time-limited (18-day) Brooklyn Township data set may mean for annual PM<sub>2.5</sub> exposures in this community. Using trends from the Scranton NAAQS and three other NAAQS stations in Pennsylvania, ATSDR estimates an annual average PM<sub>2.5</sub> concentration between 15 to 16 µg/m<sup>3</sup> at the Brooklyn Township location. How this annual average was estimated is discussed in more detail below.

**Table 2**  
Overall Daily Average PM<sub>2.5</sub> Concentrations for Brooklyn Township  
and four NAAQS-sited locations in Pennsylvania

Location:	Tioga County	Marcus Hook	Charleroi	4 NAAQS Sites Average	Scranton*	Brooklyn Twp. Site
Monitoring program:	FRM/FEM	FRM/FEM	FRM/FEM	FRM/FEM	FRM/FEM	E-BAM
8/17/2015	12.19	16.67	20.12	16.5	16.89	24.7
8/18/2015	15.26	14.45	8.72	14.4	19	25.1
8/19/2015	12.46	12.13	6.47	11.0	12.83	21.5
8/20/2015	1.98	4.4	6.24	4.2	4.2	12.5
8/21/2015	3.61	6.45	7.42	5.4	4.29	10.9
8/22/2015	5.48	6.02	10.05	6.7	5.32	10.8
8/23/2015	4.89	7.09	15.67	9.0	8.47	12.8
8/24/2015	8.48	11.52	10.52	10.2	10.22	22.4
8/25/2015	5.71	13.07	6.42	8.8	10.07	15.5
8/26/2015	5.76	8.92	8.21	7.4	6.72	14.8
8/27/2015	4.33	7.71	9.52	6.5	4.49	10.0
8/28/2015	4.82	8.44	14.47	8.0	4.3	9.9
8/29/2015	9.95	13.72	15.57	12.5	10.79	16.8
8/30/2015	11.66	13.05	13.63	13.7	16.62	21.5
8/31/2015	12.93	19.38	14.48	15.8	16.36	19.8
9/1/2015	14.79	22.73	19.97	19.4	20.14	24.2
9/2/2015	21.62	31.45	20.6	24.9	25.82	29.7
9/3/2015	16.26	29	19.43	22.3	24.34	32.4
Average:	9.6	13.7	12.6	<b>12.0</b>	12.3	<b>19</b>
2015 Annual Average:	7.8	10.55	11.12	10.08	10.84	<b>15-16 (est)</b>

Notes: Results in micrograms per cubic meter ( $\mu\text{g}/\text{m}^3$ ); \* = nearest NAAQS particulate matter monitoring location (~30 miles south); green highlighted cells indicate “good” air quality by EPA AQI calculator ([http://www.airnow.gov/index.cfm?action=resources.conc\\_aqi\\_calc](http://www.airnow.gov/index.cfm?action=resources.conc_aqi_calc)); yellow highlighted cells indicate “moderate” air quality by EPA AQI Calculator; E-BAM = Met-One beta-attenuation mass monitor; est = estimated annual concentration based on Scranton and 4 regional NAAQS data trends from [http://www.ahs.dep.pa.gov/air\\_apps/aadata/Reports/MonthlyParamDetail.aspx](http://www.ahs.dep.pa.gov/air_apps/aadata/Reports/MonthlyParamDetail.aspx); FRM/FEM = Federal reference method/federal equivalent method; NA = not available; NAAQS = National Ambient Air Quality System;

### Residents Log Notes and concurrent PM<sub>2.5</sub> concentrations

The residents, who permitted EPA access to stage sampling equipment, maintained a log of health symptoms and other notes during the 18-day sampling period. ATSDR reviewed the log and compared this log to both the 10 minute concentrations for the specific time noted and the daily average concentrations for each of the EBAMs on the specific days of interest. One date is of particular note: On August 19, 2015, when the EBAM units reported a daily average of 21.5  $\mu\text{g}/\text{m}^3$ , residents reported that at 3:50 am, they detected a smell that burned their noses. At 3:50

am, each of the three EBAMs reported a spike in PM<sub>2.5</sub> concentrations ranging from 40 to 84 µg/m<sup>3</sup>. While there is no way to correlate burning odors with PM<sub>2.5</sub> concentrations, the resident's specific note for this time period coincides with a spike in PM<sub>2.5</sub> concentrations for the day. Later on the same day (August 19<sup>th</sup>), the residents noted that they experience a smell, began sneezing and had a nosebleed around 10:30 pm. The range of concentrations from 10 pm through 10:30 pm on this day ranged from 27 to 37 µg/m<sup>3</sup>. The maximum 1-hour concentration range for the 18<sup>th</sup> and 19<sup>th</sup> was from 36 to 48 µg/m<sup>3</sup>.

## Discussion

For more than 30 years, various government agencies have regulated air concentrations of PM, and those regulations have been based on a scientific understanding of how different sizes of PM affect human health. PM<sub>2.5</sub>—or “fine particulate”—is the subset of total suspended particulate (TSP) composed of particles and droplets with aerodynamic diameters of 2.5 microns or less. By definition, PM<sub>2.5</sub> is also a subset of PM<sub>10</sub>. EPA started regulating air concentrations of PM<sub>2.5</sub> in 1997, after research demonstrated that exposure to these smaller particles can be associated with a range of adverse health effects. EPA's health-based standards require that annual average concentrations of PM<sub>2.5</sub>, averaged over three consecutive calendar years, do not exceed 12 µg/m<sup>3</sup>. Further, the 98<sup>th</sup> percentile of 24-hour average PM<sub>2.5</sub> concentrations, averaged over three consecutive calendar years, must not exceed 35 µg/m<sup>3</sup>. The World Health Organization (WHO) health guidelines for PM<sub>2.5</sub> are lower: the annual average health guideline is 10 µg/m<sup>3</sup>, and the 24-hour health guideline is 25 µg/m<sup>3</sup>.

### Screening of PM<sub>2.5</sub> Data

To complete the initial screening of the Brooklyn PM<sub>2.5</sub> data set, ATSDR used both the nominal EPA daily screening value of 35 µg/m<sup>3</sup> to compare to each of the E-BAMs daily averages and the overall 18-day E-BAM average to compare to the annual EPA screening value of 12 µg/m<sup>3</sup> to determine whether further exposure assessment is warranted. On the final day of monitoring, September 3, 2015, the 24-hour average of one of the E-BAM monitors, EPA41489 at 37 µg/m<sup>3</sup>, exceeded the EPA 24-hour NAAQS value (the average of all three E-BAM units for this day was 32 µg/m<sup>3</sup>). In addition, the overall average of PM<sub>2.5</sub> for the 18-day monitoring period was 19 µg/m<sup>3</sup>, which exceeds the nominal EPA annual average screening value of 12 µg/m<sup>3</sup>. Due to these exceedances, PM<sub>2.5</sub> is considered a contaminant of potential concern and exposures to PM<sub>2.5</sub> are further evaluated in the Public Health Implications Section below.

Though not used for screening purposes, a comparison to the World Health Organization (WHO) guidelines indicates there were five days when at least one monitor exceeded the 24-hour PM<sub>2.5</sub> concentration of 25 µg/m<sup>3</sup>, and the overall 18-day PM<sub>2.5</sub> average of 19 µg/m<sup>3</sup> exceeded the annual WHO value of 10 µg/m<sup>3</sup>.

### Brooklyn Township and Regional PM<sub>2.5</sub> Data and an Estimated Annual Average

If the average PM<sub>2.5</sub> concentration of 19 µg/m<sup>3</sup> was present in the ambient air for a duration longer than monitoring had occurred (i.e., a year or more), the risk for adverse health effects from chronic exposures for some exposed individuals (i.e., sensitive populations such as infants and the elderly, and health-compromised individuals) would be increased. However, monitoring at the site was of a short duration, and there is uncertainty in what the long term average PM<sub>2.5</sub> concentrations would be in this community.

There are important local variables (e.g., local weather and topography, use of wood stoves and trash burning) that might influence local PM<sub>2.5</sub> concentrations, and making comparisons with regional air quality monitors can be difficult. For example, the Brooklyn Township monitors were placed close to a permitted source of PM<sub>2.5</sub> emissions and ATSDR does not have any information about daily or seasonal emissions from this known source (i.e., Williams Central Compressor Station). Therefore, it is difficult to determine whether short-term fluctuations in PM<sub>2.5</sub> would be consistent with regional NAAQS monitors, including the Scranton regional NAAQS monitor, which encompasses Brooklyn Township. However, comparing the 18 days of Brooklyn Township data to the Scranton data and three additional NAAQS monitors suggests regional trends in PM<sub>2.5</sub> concentrations are present in the Brooklyn Township data set (see Table 2).

For the same 18 days of Brooklyn Township monitoring, the Scranton NAAQS monitor, which assesses the regional air quality and encompasses Brooklyn Township, recorded an approximately 36% lower average PM<sub>2.5</sub> concentration (12.3 µg/m<sup>3</sup>) and a narrower and lower range of daily concentrations (4.2 to 25.8 µg/m<sup>3</sup>) than the three Brooklyn Township E-BAMs (average of 19 µg/m<sup>3</sup> and range of 9 to 37 µg/m<sup>3</sup>). For most of the eighteen days (16 out of 18 days), the Brooklyn Township EBAMs followed the same pattern of increases and reductions in daily PM<sub>2.5</sub> concentrations as the Scranton regional air quality monitor, indicating a correlation in the air quality between the Scranton regional monitor and the Brooklyn E-BAM monitors. As previously noted, the consistently higher concentrations in Brooklyn Township suggest a local source of PM<sub>2.5</sub> is contributing to the regional air quality monitored in Scranton.

To estimate an annual average for Brooklyn Township, and to better understand the impact of seasonal variability on annual average ambient particulate levels, ATSDR compared the Brooklyn data to both the nearest regional NAAQS monitor (i.e., Scranton, PA) and three additional NAAQS monitors in Pennsylvania (PADEP 2015). The three additional NAAQS monitors include Tioga County (nearest PM<sub>2.5</sub> monitor to the west of site and also in Marcellus shale gas extraction region), Charleroi (Washington County, southwest PA, also in Marcellus shale gas extraction region), and the Marcus Hook site (Delaware County, southeast PA, near multiple permitted industrial facilities).

The 18 day average for the Scranton NAAQS monitor (12.3 µg/m<sup>3</sup>) was approximately 13% higher than its annual average (10.84 µg/m<sup>3</sup>) and 22% higher than the third quarter which included the 18

days of monitoring. If the same trend in air quality is to be expected throughout the Scranton region, which encompasses Brooklyn Township, then Brooklyn Township should expect an approximate 13 percent lower annual PM<sub>2.5</sub> average concentration (just over 16 µg/m<sup>3</sup>) than that recorded over the 18-day period of monitoring. The 18-day average PM<sub>2.5</sub> concentration for all four regional NAAQS monitors (12.05 µg/m<sup>3</sup>) was approximately 20 percent higher than the annual average for the same four monitors. By using the composite trend for the 4 selected NAAQS monitors (18 day average over the annual average), the annual average PM<sub>2.5</sub> concentration in Brooklyn Township is estimated to be just under 16 µg/m<sup>3</sup>. In summary, ATSDR estimates an annual PM<sub>2.5</sub> average range in Brooklyn Township to be between 15 and 16 µg/m<sup>3</sup>. Estimating PM<sub>2.5</sub> concentrations for Brooklyn Township based on regional data assumes local sources consistently emit PM<sub>2.5</sub> year round. ATSDR recognizes this uncertainty in the annual estimate of PM<sub>2.5</sub> concentrations in Brooklyn Township.

To understand seasonal fluctuations, the quarterly PM<sub>2.5</sub> averages for the Scranton NAAQS monitoring station are provided: first quarter: 13.8 µg/m<sup>3</sup>; second quarter: 8.6 µg/m<sup>3</sup>; third quarter: 9.6 µg/m<sup>3</sup>; and fourth quarter: 11.4 µg/m<sup>3</sup> (through December 14, 2015). By comparing the quarterly average concentrations with the annual average in Scranton, a seasonal trend can be estimated for Brooklyn Township. Based on this comparison, Brooklyn Township may expect higher PM<sub>2.5</sub> concentrations in the first (+27%, ~20.9 µg/m<sup>3</sup>) and fourth quarter (+5%, ~17.2 µg/m<sup>3</sup>) of the year and slightly lower concentrations in the second (-21%, 14.4 µg/m<sup>3</sup>) and third quarters (-12%, 14.5 µg/m<sup>3</sup>) when comparing quarterly concentrations with the annual average in Scranton. As previously noted, there is uncertainty in these annual and quarterly estimates due to the lack of information about variability in PM<sub>2.5</sub> emissions in Brooklyn Township.

#### Public Health Implications of Exposure to PM<sub>2.5</sub>

PM<sub>2.5</sub> health effect thresholds have not been identified. Therefore, there does not appear to be a safe level of exposure below which no health effects occur. Given that there is a substantial interpersonal variability in PM<sub>2.5</sub> exposure and subsequent harmful effects, it is unlikely that any standard or guideline value will lead to complete protection for everyone against all possible adverse health effects (WHO 2006). Population subgroups that may be more sensitive to the effects of PM exposure include infants; older adults (65+ years); individuals with asthma, chronic obstructive pulmonary disorder (COPD) or cardiovascular disease; diabetics; individuals with lower socioeconomic status; and, those with certain genetic polymorphisms (EPA 2009). Mortality, and cardiovascular and respiratory morbidity have been associated with both short-and long-term exposure to PM<sub>2.5</sub> (EPA 2009).

#### Acute Exposure

Epidemiologic studies that examined the effect of PM<sub>2.5</sub> on cardiovascular emergency department (ED) visits and hospital admissions reported consistent positive associations (predominantly for ischemic heart disease and congestive heart failure), with the majority of studies reporting increases ranging from 0.5 to 3.4% per 10 µg/m<sup>3</sup> increase in PM<sub>2.5</sub>. These effects were observed in

study locations with average 24-hour PM<sub>2.5</sub> concentrations ranging from 7-18 µg/m<sup>3</sup>. The recently-evaluated epidemiologic studies report consistent positive associations between short-term exposure to PM<sub>2.5</sub> and respiratory ED visits and hospital admissions for chronic obstructive pulmonary disease (COPD) and respiratory infections. Positive associations were also observed for asthma ED visits and hospital admissions for adults and children combined, but effect estimates are imprecise and not consistently positive for children alone. Most studies reported effects in the range of ~1% to 4% increase in respiratory hospital admissions and ED visits and were observed in study locations with mean 24-hour PM<sub>2.5</sub> concentrations ranging from 6.1-22 µg/m<sup>3</sup>. An evaluation of the epidemiologic literature indicates consistent positive associations between short-term exposure to PM<sub>2.5</sub> and all-cause, cardiovascular-, and respiratory-related mortality. The evaluation of multicity studies found that consistent and precise risk estimates for all-cause (non-accidental) mortality ranged from 0.29 to 1.21% per 10 µg/m<sup>3</sup> increase in PM<sub>2.5</sub> at lags of 1 and 0-1 days (EPA, 2009).

### Chronic Exposure

Several health studies have investigated potential health effects resulting from long-term exposure to PM. Historical mean PM<sub>2.5</sub> concentrations of 18 µg/m<sup>3</sup> (range 11.0 - 29.6 µg/m<sup>3</sup>) and 20 µg/m<sup>3</sup> were identified in the Six-Cities Study (range 9.0 – 33.5 µg/m<sup>3</sup>) and in the American Cancer Society (ACS) study, respectively (Dockery et al., 1993; Pope et al., 1995, 2002; HEI, 2000; Jerrett, 2005). Exposure levels where health effects are first seen (i.e., thresholds) are not apparent in these studies. In the ACS study, statistical uncertainty in the risk estimates becomes apparent at concentrations of about 13 µg/m<sup>3</sup>, below which the confidence bounds significantly widen because of the variability in the exposure concentrations. According to the results of the Dockery *et al.* (1993) study, the risks are similar in the cities with the lowest long-term PM<sub>2.5</sub> concentrations (i.e., 11 and 12.5 µg/m<sup>3</sup>). Increases in risk are apparent in the city with the next lowest long-term PM<sub>2.5</sub> average concentration (i.e., 14.9 µg/m<sup>3</sup>), indicating that when annual mean concentrations are in the range of 11–15 µg/m<sup>3</sup>, health effects can be expected (WHO 2006).

There is evidence that long-term exposure to PM<sub>2.5</sub> can cause an increase in mortality (i.e., all cause and cardiovascular) with long term average concentrations of 10-32 µg/m<sup>3</sup>; for respiratory symptoms and incident asthma, as well as respiratory hospitalizations, at long-term average PM<sub>2.5</sub> concentrations of 9.7-27 µg/m<sup>3</sup>; for developmental outcomes, specifically reductions in birth weight, at long-term average PM<sub>2.5</sub> concentrations of 11-19.8 µg/m<sup>3</sup>; and pre-term birth at concentrations as low as 5.3 µg/m<sup>3</sup> (U.S. EPA 2009, U.S. EPA 2012b).

### Public Health Implications for Brooklyn Township PM<sub>2.5</sub> Exposure

The public health implications from short term and long term exposures are discussed separately in the following sections. To determine the short term exposure concentration, the maximum daily average concentration for the three monitors combined (32 µg/m<sup>3</sup> on September 3, 2015) is used. To estimate chronic exposures, an estimated range, based on the 18 days of data from Brooklyn Township and trends in the Scranton NAAQS and three additional NAAQS monitors were used.



The estimated annual PM<sub>2.5</sub> concentration range is 15 to 16 µg/m<sup>3</sup>. As noted previously, this calculated annual average range is an estimate based on available information and may not be the actual annual average in Brooklyn Township. This uncertainty is based primarily on the short monitoring data set for Brooklyn Township and a lack of information about local emission rates from primary and secondary sources of PM<sub>2.5</sub>.

#### Acute Exposure Using the Maximum Daily PM<sub>2.5</sub> Average of 32 µg/m<sup>3</sup>

To determine the potential health implications from daily PM<sub>2.5</sub> concentrations data acquired by EPA in Brooklyn Township, ATSDR used the EPA AirNow Air Quality Indicator (AQI) tool, available online at [http://airnow.gov/index.cfm?action=resources.conc\\_aqi\\_calc](http://airnow.gov/index.cfm?action=resources.conc_aqi_calc). The EPA AirNow tool tells you how clean or polluted your outdoor air is, along with associated health effects that may be of concern (EPA 2015a).

The maximum 24-hour concentration of 37 µg/m<sup>3</sup> was identified on the final day of EPA monitoring (September 3, 2015) for one of the three E-BAM units. This maximum 24-hour concentration is classified as “unhealthy for sensitive groups” by the AQI calculator and would be of concern for sensitive individuals (i.e., people with respiratory or heart disease, the elderly and children) but is not expected to be of concern for the general population. The maximum average PM<sub>2.5</sub> concentration of all three monitors for any single day of sampling was 32 µg/m<sup>3</sup>, which is less than the EPA daily regulatory value of 35 µg/m<sup>3</sup>.

Results from the EPA AirNow AQI Calculator using this maximum daily PM<sub>2.5</sub> average (32 µg/m<sup>3</sup>) is not of concern for the general population or most sensitive subpopulations. Some unusually sensitive populations, such as people with respiratory or heart disease, the elderly and children, are the most at risk for adverse health effects at the maximum detected daily concentration (EPA 2015a). Twenty-four hour PM<sub>2.5</sub> concentrations were above 12 µg/m<sup>3</sup> on 14 of the 18 days of monitoring in Brooklyn Township. On each of the 14 days when PM<sub>2.5</sub> levels exceeded 12 µg/m<sup>3</sup>, the AQI was rated as “moderate.”

#### Chronic Exposure Using the Estimated PM<sub>2.5</sub> Concentration Range of 15 to 16 µg/m<sup>3</sup>

Potential health effects from chronic exposures are evaluated using the best available literature on long-term exposures to PM<sub>2.5</sub>. As noted in the chronic exposure section above, there is evidence that long-term exposure to PM<sub>2.5</sub> in the range of 10-32 µg/m<sup>3</sup> can cause an increase in mortality (i.e., all cause and cardiovascular); at 9.7-27 µg/m<sup>3</sup>, respiratory symptoms and incident asthma, as well as respiratory hospitalizations, have been reported; at long-term average PM<sub>2.5</sub> concentrations of 11-19.8 µg/m<sup>3</sup>, developmental outcomes, specifically reductions in birth weight are reported; and, at long-term concentrations as low as 5.3 µg/m<sup>3</sup>, pre-term births have been reported (U.S. EPA 2009, U.S. EPA 2012b). The WHO (2006) notes that increases in risk are apparent and health effects can be expected when annual mean concentrations are in the range of 11–15 µg/m<sup>3</sup>, (WHO 2006).

Chronic exposure (exceeding 1 year) to PM<sub>2.5</sub> at 15 to 16 µg/m<sup>3</sup> may be harmful to the general population, including sensitive individuals. Population subgroups that may be more sensitive to the effects of PM exposure include infants; older adults (65+ years); individuals with asthma, chronic obstructive pulmonary disorder (COPD) or cardiovascular disease; diabetics; individuals with lower socioeconomic status; and, those with certain genetic polymorphisms (EPA 2009). Chronic exposures to PM<sub>2.5</sub> at 15 to 16 µg/m<sup>3</sup> (the estimated annual average based on regional NAAQS trends in Pennsylvania), therefore, is expected to cause an increase in all cause and cardiovascular mortality and increased risks of respiratory symptoms, incident asthma, respiratory hospitalizations, reductions in birth weight, and pre-term births (U.S. EPA 2009, U.S. EPA 2012b, WHO 2006).

## Conclusions

### Acute Exposures (24 hour)

Using the EPA AirNow AQI Calculator, exposures to the maximum daily PM<sub>2.5</sub> average (32 µg/m<sup>3</sup>) are not of concern for the general population or most sensitive subpopulations. Some unusually sensitive populations, such as people with respiratory or heart disease, the elderly and children, are the most at risk for adverse health effects at the maximum detected daily concentration (EPA 2015a).

### Chronic Exposures (over 1 year)

If the average PM<sub>2.5</sub> concentration of 19 µg/m<sup>3</sup> was present in the ambient air for a duration longer than monitoring had occurred (i.e., a year or more), the risk for adverse health effects from chronic exposures for some exposed individuals (i.e., sensitive populations such as infants and the elderly, and health-compromised individuals) would be increased. However, monitoring at the site was of a short duration, and there is uncertainty in what the long term average PM<sub>2.5</sub> concentrations would be in this community.

The estimated annual average PM<sub>2.5</sub> concentration of 15 to 16 µg/m<sup>3</sup> may be harmful to the general population and sensitive subpopulations, including the elderly, children, and those with respiratory or heart disease.

## Data Limitations

There are important limitations to this health consultation and conclusions:

- **Only PM<sub>2.5</sub> data were collected and assessed in this health consultation.** Resident have reported health effects in this community that may be associated with emissions from the permitted facility or another source. However, this health consultation evaluated only the PM<sub>2.5</sub> data collected from one location in Brooklyn Township, PA.
- **Federal reference or equivalent methods (FRM, FEM) were not used for sampling.** However, EPA applied appropriate standard protocols in sample collection and reporting

and ATSDR removed the erroneous data before a public health evaluation was conducted of the data.

- **Only 18 days of data were collected.** It is not possible to determine, with certainty, what the PM<sub>2.5</sub> concentrations would be for the entire year, or potential seasonal variations in PM for this community or worst case scenarios that may occur during operational upsets or releases. However, ATSDR compared the data to the nearest NAAQS monitor and three additional stations in Pennsylvania to better understand the regional PM<sub>2.5</sub> fluctuations and trends.
- **Only one location was monitored.** This spatial limitation leads to uncertainty in identifying a source for the monitored PM<sub>2.5</sub> concentrations.
- **Staging of monitors was not ideal.** Due to access limitations and ground cover interferences (e.g., trees and structures obstructing the monitors from clear and open air pathways), the data may not be representative of other nearby locations and should be considered site-specific data only.
- **No valid and representative meteorological data were obtained at the sampling location.** Due to improper staging of the meteorological stations at the residential sampling location, site-specific weather information is not available. The onsite weather stations were placed too close to the particulate monitor intakes, which created a strong, local, and artificial influence on the wind direction and speed. These data were not representative of the local weather during the sampling period and were, therefore, discarded.

## Recommendations

ATSDR recommends that unusually sensitive individuals (people with respiratory or heart disease, the elderly and children) monitor air quality action day information for the region as well as their own local air quality conditions, and consider reducing activities that include prolonged or heavy exertion on days with poor air quality.

ATSDR recommends that the Pennsylvania Department of Environmental Protection (PADEP), working with permitted sources in the area, consider steps to reduce their emissions of PM and PM precursor chemicals.

As a matter of prudent public health practice, ATSDR recommends that state and local agencies consider mitigating other known sources of respirable PM (e.g., unpaved roadways) in Brooklyn Township, PA.

ATSDR recommends more robust assessment of air quality (including seasonal sampling to include winter) near this natural gas compressor station and other similar air permitted sources.

## Next Steps

The information from this health consultation will be shared with the concerned residents near the Williams Central Compressor Station and relevant state health and environmental agencies.

If requested, ATSDR will provide technical assistance to the local community and local, state and federal agency stakeholders (e.g., assessing environmental sampling or modeling data, or the development of environmental monitoring strategies.).

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## Appendix A

This appendix provides additional information about specific subject matter, including (1) emissions in Brooklyn Township, (2) Speck sensor data, and (3) E-BAM data considerations.

### PM<sub>2.5</sub> Emissions in Brooklyn Township

The average daily rate of permitted PM emissions for the Station is approximately 29.75 pounds per day (5.43 tons per year), of which only a portion of the total particulate will be PM<sub>2.5</sub>. The Station also emits precursors of PM<sub>2.5</sub>, including sulfur dioxide, nitrogen oxides, and volatile organic compounds (VOC), each of which contribute to ambient PM<sub>2.5</sub> levels through secondary formation in the atmosphere. This secondary formation of PM<sub>2.5</sub> usually occurs at some distance downwind of the emissions source (EPA 2009). Other sources of PM<sub>2.5</sub> in the site area include residential and agricultural combustion activities, such as wood, plant, yard and other waste burning and exhaust from internal combustion engines. A relevant source of total suspended particulate (TSP), including respirable particulate (i.e., PM<sub>10</sub> and smaller particles) for this community is diesel truck traffic and the re-entrainment of dust from unpaved roads, resulting in additional airborne respirable particulate, but additional PM<sub>2.5</sub> load from re-entrainment is considered negligible. Mold, spores, pollen, dust and dirt from re-entrainment along roads are sources of TSP, however, these particles are also typically coarser than PM<sub>2.5</sub>.

### Speck Sensor Data

From October 2014 through February 2015, Brooklyn Township, Pennsylvania residents monitored outdoor air quality at their residence using a recently developed air sensor known as the first edition Carnegie Mellon “Speck” sensor. The Speck sensor data reported to ATSDR by one resident indicated that estimated “PM<sub>2.5</sub>” surrogate levels (as calculated using this sensor) may be of public health concern in the ambient air at the sensor’s location, which was located for use on the front porch of a residence along Old Turnpike Road in Brooklyn Township, PA. The resident provided ATSDR and the EPA with a summary table of the Speck sensor data, including a chart of detections that exceeded levels the sensor estimates as equivalent to PM<sub>2.5</sub> levels of 50 micrograms per cubic meter ( $\mu\text{g}/\text{m}^3$ ). The maximum Speck sensor estimated PM<sub>2.5</sub> data concentrations from this location ranged from 54 to 757  $\mu\text{g}/\text{m}^3$ , with 24-hour average concentrations ranging from 13 to 58  $\mu\text{g}/\text{m}^3$ . While these data suggest that PM<sub>2.5</sub> may be present at levels of health concern, these data could not be used by ATSDR for public health assessment purposes for a number of reasons, including (1) a lack of quality control and assurance, (2) no procedural guidance for the unit’s operation, (3) no maintenance or calibration documentation, and (4) no data verification procedures. While these citizen-collected data provide valuable information in support of more rigorous PM<sub>2.5</sub> ambient air assessment, ATSDR concluded it could not rely on the Speck sensor data alone as representative of ambient air quality and residential exposures at this location.

In December 2014, the U.S. EPA Office of Research and Development (EPA ORD) released its results of a technology review of air sensors, including the Carnegie Mellon Speck sensor (EPA 2014). This EPA ORD report expressed concerns about a lack of operational guidance and proper siting guidelines (e.g., indoor versus outdoor use) for the instruments assessed, including the Speck sensor. In reviewing the test data generated during this study, EPA ORD found there was no correlation between the Speck sensor data and the collocated federal equivalent method (FEM) sensor data set produced during the study. EPA ORD noted that citizen scientists and others employing such devices (especially under outdoor monitoring conditions) must remain aware of the uncertainty surrounding the data being generated (EPA 2014). Based on the 2014 EPA ORD review of the Speck sensor, ATSDR concluded that the Speck sensor data from Brooklyn Township, PA was useful as a qualitative trigger for further evaluation, but was of insufficient quality assurance and representativeness to use for quantitative public health assessment.

### E-BAM Monitoring Data Comparison

USDA conducted comparison studies of particulate monitors in 2003 and 2006. The focus of these studies was on particulate emissions associated with forest fires and the accuracy and bias of monitoring instruments when compared to federal reference or equivalent methods (FRM/FEM). Essentially, these method comparison studies assessed much higher PM<sub>2.5</sub> concentrations than those observed in Brooklyn Township, PA. The USDA studies (2003, 2006) were focused on assessing particulate matter released during forest fires when significantly higher particulate concentrations are present in ambient air. Closer review of the data from these comparative USDA studies (2003, 2006) do not appear to indicate that E-BAMs consistently report higher concentrations than their FRM counterpart at *all* ambient concentrations: at concentrations below 50 µg/m<sup>3</sup>, these studies show that E-BAMs actually report slightly lower concentrations than the concurrent FRM data collected (See Figure 9, page 10 of USDA, 2006). These results at lower concentrations are not discussed in the text of the USDA studies; however the comparison graphs in those studies illustrate these important differences. Because the USDA studies do not specifically focus on particulate matter data at lower concentrations, such as those detected in Brooklyn Township, but the studies provide a graph suggesting a high bias is not observed at low concentrations, ATSDR has determined that the concentrations reported by the E-BAMs without a downward adjustment are appropriate for exposure assessment at this site.

### Erroneous E-BAM data

As noted in the EPA contractor's summary report for Brooklyn Township, at times E-BAM units faulted in their operations and the data during these operational periods were flagged as erroneous data. Data flagged with a "4" indicated the unit was experiencing high tape delta pressure and an associated loss of flow to the unit. Data flagged with a "256" indicated the delta temperature setpoint was exceeded. Data from these time periods were removed from the valid data set because they are not considered representative of ambient air quality during those times. Nine percent (9%) of the sampling data (661 out of 7,288 logged data points) were flagged and removed from the overall data set for these time periods.



## Notes about E-BAM Monitoring

The three E-BAM units were deployed with a “VIPER” wireless monitoring system to allow remote access to data during air monitoring activities.

With the exception of a few brief time periods when the E-BAM logged an equipment fault, valid data were obtained from each E-BAM unit for the entire 18 day monitoring duration. During faults or equipment malfunctions, data were flagged as possibly erroneous. Data from these time periods were removed from the data set (discussed above) and are not presented or assessed in this document.

The siting of the E-BAM units on the residential property was determined by the field team and in coordination with the property owner. The primary goals for staging the E-BAMs included being close to the dwelling, in areas where the residents are likely to be present, and in areas of the property with relatively open space. Each E-BAM was programmed to record environmental data at 10-minute intervals, to log faults in operation and flag the associated data, and to calculate 1-hour average concentrations for each monitor over the entire monitoring period.



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