Second Avenue Subway (SAS) Project

Technical Appendix

Air Quality Monitoring Study of Construction Activities between 69th and 87th Street on Second Avenue

Prepared for:

MTA Capital Construction

Prepared by:

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Technical Team

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I. Introduction

This appendix provides back-up documentation and additional detail to support the conclusions of the air quality monitoring study. Section II describes the Second Avenue Subway (SAS) construction activities and highlights those activities that took place during the month-long monitoring period. Section III identifies the monitoring locations and pollutants that were monitored for this study. Section IV contains the description of the reference levels selected as benchmarks for the monitored pollutants. The analysis of the collected monitored data is in Section V. The evaluation of CAMP data is in Section VI and the odor investigation is in Section VII. Section VIII provides a list of references.

For clarity, the objectives of this air monitoring study are listed below:

- To assess air quality and dust impacts of the underground blasting (and other construction-related activities) on the adjacent abutters and affected public by measuring a variety of pollutants at multiple locations along Second Avenue between 69th and 87th Streets during a four-week period (between September 12, 2011 and October 8, 2011) and comparing the results to reference levels, using existing ambient air standards and guidelines established by federal and state institutions as benchmarks.
- To assess the odor effects of construction activities on abutters and the public by performing interviews with the public and through the analysis of the odor-related pollutant data collected as part of the monitoring program.
- To assess the adequacy of the contractor's ongoing Community Air Monitoring Program (CAMP), and to provide recommendations for improving its efficacy as a warning system to take corrective mitigation action.

II. Second Avenue Subway Construction Activities

A. Project Overview

The full length Second Avenue Subway (SAS) will be an 8 1/2 mile, two-track line beneath Second Avenue from 125th Street to the financial district in lower Manhattan. Sixteen new underground stations will be constructed along the right-of-way (ROW) and the existing Lexington Avenue/63rd Street Station will be renovated.

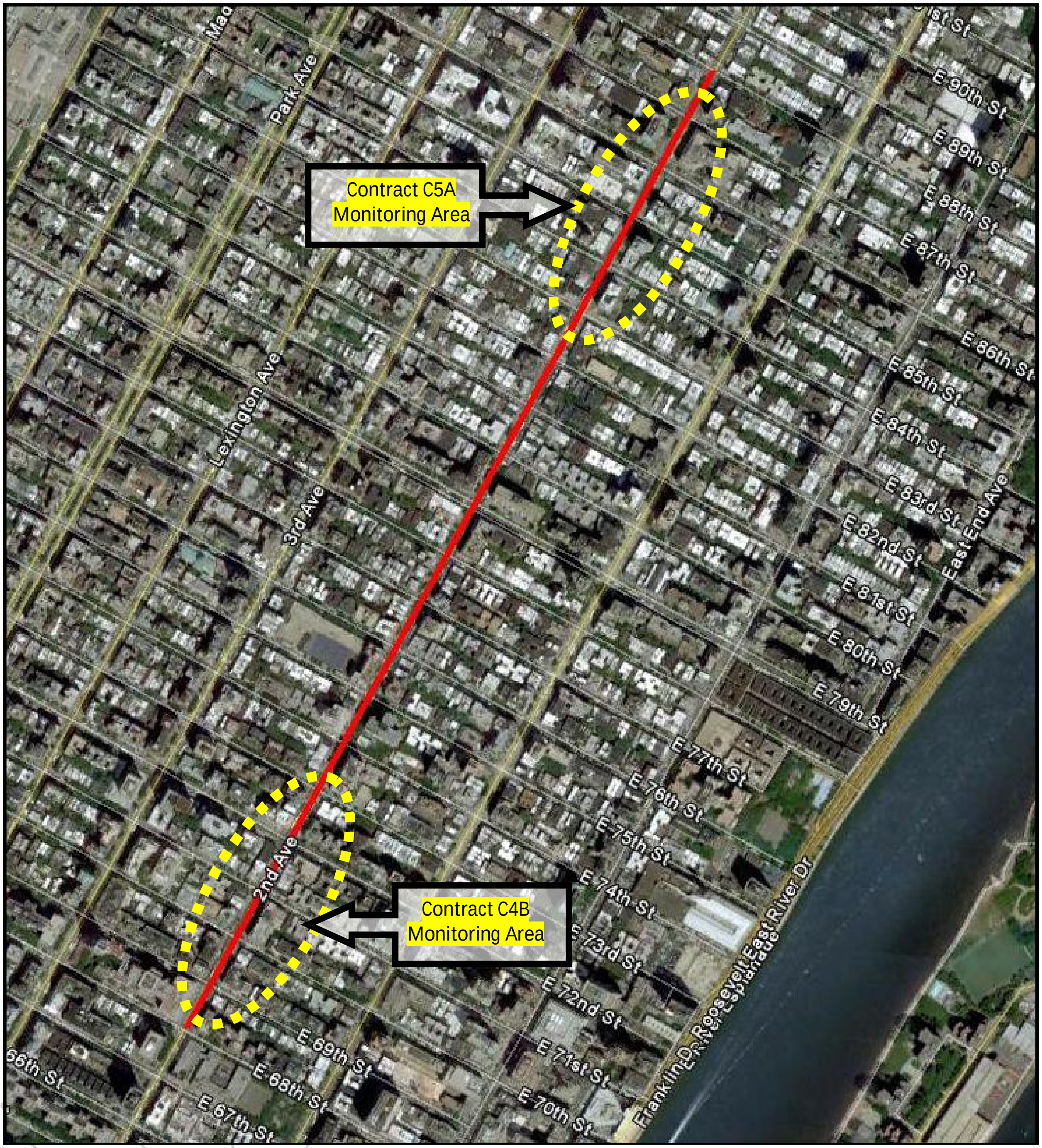
MTA Capital Construction is currently constructing the first of the four phases, a minimum operating segment that will run from a terminal station at 96th Street and connect to the existing 63rd Street Broadway Line for service to lower Manhattan and Brooklyn. New stations will be constructed at 96th, 86th, and 72nd Streets and the existing Lexington Avenue/63rd Street Station will be renovated. Track and systems will be installed from 105th Street to 63rd Street.

Phase I of SAS construction consists of eleven contracts and is scheduled to be completed in December 2016.

The monitoring program was designed to cover the effects of construction activities in the 72nd and 86th Street Station areas (Contracts C4B and C5A, respectively).

Figure II-1 provides a view of the area covered by the monitoring study, which encompasses Second Avenue between 69th and 87th Streets.

Figure II-1: Project Study Area



B. Construction Activities During Air Monitoring Period

The monitoring program was designed to cover the effects of construction activities associated with Contracts C4B and C5A.

B.1. Activities for 72nd Street Station Area (Contract 4B)

On October 1, 2010, MTA awarded Contract 4B to a joint venture between Shea, Shiavone and Kiewit (hereafter referred to as "SSK") for the mining of the tunnels connecting the 72nd Street Station to the existing 63rd Street Station, and for the cavern excavation and station structures of the 72nd Street Station.

Two structures (called muck houses) were erected in the area for the 72nd Street Station (Contract C4B) between 69th and 73rd Street prior to September 2011 to enclose two excavation shafts, gantry cranes, and hoppers used to bring excavated material from the cavern to street-level for disposal by truck. Each one occupies two lanes of Second Avenue traffic for almost a full block. These structures act as noise insulated enclosures with rolling gates at each end for passage of trucks and equipment. The contractor has been performing underground blasting in the 72nd Street Station cavern nearly on a daily basis. Blasting times normally occur on weekday afternoons between 3:00 and 7:00 p.m. (a list of blasting events and times is included in this report). Material is removed from the cavern and lifted to the surface during the day. Trucks carry the excavated material away during morning and afternoon hours.

Underground activities also include shotcrete spraying operations inside the caverns typically between 9:00 a.m. and 1:00 p.m. using cement and an accelerant (Meyco 160), which is pumped underground from surface storage tanks.

Surface activities at these sites also included groundwater treatment plant maintenance, materials storage, equipment movement, excavation of test pits at Ancillary Building 2, sidewalk shed installation at various locations, building remediation at various locations, lead abatement at Ancillaries Buildings 1 and 2, and preparation for petroleum storage tank removal at Ancillary Building 2. Weekday construction activities end at around 10 p.m. at the surface, and continue overnight underground. There is no major construction activity during weekends.

Figure II-2 provides a view of a muck house during the monitoring period.

Figure II-2: Muck House view at Second Avenue and 73rd Street

B.2. Activities for 86th Street Station Area (Contract 5A)

In June 2009, the first of three contracts for the 86th Street Station, Contract 5A was awarded to J. D'Annunzio & Sons, Inc. (hereafter referred to as "JDSI") for the advance utility relocation work and construction of cut-and-cover shaft areas at 83rd and 86th Streets. This contract provided two vertical starter shafts that will be used by Contract 5B (awarded on August 4, 2011 to Skanka/Traylor Joint Venture) for station cavern mining between 83rd and 86th Streets. The work will entail blasting of bedrock, installation of two station entrances, and two ancillary ventilation buildings.

Construction in the area of the 86th Street Station (Contract C5A) extending between 83rd and 87th Streets included initial shaft excavation in two locations. These two shafts are approximately 30 feet below grade, with decking already installed over the 83rd Street shaft.

The activities at these two shafts included drilling and blasting, hoe ramming to trim rock, installing deck beams and deck panels, installing a gas main across the 83rd Street shaft, and installing toe anchors and rock dowels. There were no structures (muck houses) at these two locations at the time of the monitoring program. Test blasting and excavation occurred periodically during the monitoring period at the 86th Street shaft.

Figure II-3 provides a view of activities under Contract C5A.

Figure II-3 Construction Contract C5A Activities (view of Second Avenue and 83rd Street)

C. Blasting Operations

The excavation of the 72nd Street Station is being performed by blasting of the rock cavern underneath at a depth of 80 to 90 feet below the surface. Blasting of the rock is performed every afternoon mostly between 3:00 and 7:00 p.m. at multiple underground locations that are vented to the surface through the two excavation shafts located inside the muck houses at 69th – 70th Streets and 72nd – 73rd Streets. Dust from the pulverized rock and explosive material migrates to the surface through both excavation shafts.

Test blasting at the 86th Street shaft occurred for approximately two weeks at a depth of 20 to 30 feet between 9:00 a.m. and 5:00 p.m. during the monitoring period. A rock drill was also used to break rock within the 86th Street and 83rd Street shafts.

The blasting contractor for both contracts used an ammonium nitrate/fuel oil (ANFO)-like explosive (Trade Names of Emulex and Red-D Prime, see Attachment A for material safety data sheet (MSDS)). This is the only explosive authorized by the NYC Fire Department.

Per U.S. Environmental Protection Agency's (EPA) AP-42 Compilation of Air Emission Factors[1], there is little relationship between the type of explosive and the end products of detonation. The end products are primarily determined by the oxygen balance of the explosive. If the explosive has a deficiency of oxygen, this favors more carbon monoxide (CO) and other unburned organic compounds but produces little if any nitrogen oxide (NOx) compounds. An excess of oxygen causes more nitrogen oxides but less carbon monoxide and other unburned organics. ANFO-type explosives with a fuel content greater than 5.5 percent creates a deficiency of oxygen. The material safety data sheet (MSDS) for the Emulex/Red-D Prime explosives being used at the site indicates a petroleum hydrocarbon content of 3 to 9 percent. Since the petroleum hydrocarbon content varies, either situation (excess oxygen or oxygen deficiency) may occur with the use of these explosives.

During the majority of blasting events, a visible plume of dust was observed from the street levels from 5 to 10 minutes after the blasting events. This plume generally dissipated within 10 to 15 minutes.

A schedule of the blasting operations during the four-week monitoring period is presented in Tables II-1 and II-2.

[1] EPA. 1995. AP-42. *Compilation of Air Emission Factors. Chapter 13.3 Explosives Detonation*. Fifth Edition. Office of Air Quality Planning and Standards

Table II-1 Blasting Schedule (Contract C4B)

Date	Location	Time
8/26/2011	69th St.- Adits- Ancillary 2, service tunnel #1	5:07 PM
8/26/2011	72nd St. Shaft-Top heading, southwest slash	5:07 PM
8/26/2011	G3/S1 Cavern II	5:52 PM
8/30/2011	69th St. Shaft- Top heading, northwest slash	5:02 PM
8/30/2011	69th St.- Adits- Ancillary 2, service tunnel #2	5:02 PM
8/30/2011	69th St.- Adits- Ancillary 2, service tunnel #2	5:02 PM
8/30/2011	G3/S1 Cavern II	6:40 PM
8/30/2011	G3/S1 Cavern II	6:40 PM
8/31/2011	69th St. Shaft- Top heading, northwest slash	4:56 PM
8/31/2011	69th St.- Adits- Ancillary 2, service tunnel #3	4:56 PM
9/1/2011	G3/S1 Cavern II	3:32 PM
9/1/2011	69th St.- Adits- Ancillary 2, ventillation tunnel #1	5:00 PM
9/1/2011	72nd St. Shaft-Top heading, southwest slash	5:00 PM
9/1/2011	69th St. Shaft- Top heading, northwest slash	5:01 PM
9/1/2011	G3/S1 Cavern II	6:20 PM
9/1/2011	G3/S1 Cavern II	6:20 PM
9/2/2011	G3/S1 Cavern II	3:31 PM
9/2/2011	69th St.- Adits- Ancillary 2, ventillation tunnel #1	4:56 PM
9/2/2011	69th St.- Adits- Ancillary 2, ventillation tunnel #1	4:56 PM
9/2/2011	72nd St. Shaft-Top heading, southwest slash	4:56 PM
9/2/2011	69th St. Shaft- Top heading, northwest slash	4:57 PM
9/2/2011	G3/S1 Cavern II	6:22 PM
9/2/2011	G3/S1 Cavern II	6:22 PM
9/6/2011	72nd St. Shaft-Top heading, southwest slash	4:59 PM
9/6/2011	69th St. Shaft- Top heading, northwest slash	4:59 PM
9/6/2011	69th St.- Adits- Ancillary 2, ventillation tunnel #2	4:59 PM
9/6/2011	G3/S1 Cavern II	6:29 PM
9/7/2011	69th St. Shaft- Top heading, northwest slash	3:26 PM
9/7/2011	G3/S1 Cavern II	4:26 PM
9/7/2011	G3/S1 Cavern II	4:26 PM
9/7/2011	72nd St. Shaft-Top heading, southwest slash	4:58 PM
9/7/2011	69th St.- Adits- Ancillary 2, egress tunnel #2	5:11 PM
9/7/2011	G3/S1 Cavern II	6:30 PM
9/8/2011	69th St. Shaft- Top heading, northwest slash	3:48 PM
9/8/2011	72nd St. Shaft-Top heading, southwest slash	5:01 PM
9/8/2011	69th St.- Adits- Ancillary 2, ventilation tunnel #3	5:02 PM
9/8/2011	G3/S1 Cavern II	6:26 PM
9/8/2011	G3/S1 Cavern II	6:26 PM
9/9/2011	69th St. Shaft- Top heading, northwest slash	4:06 PM
9/9/2011	72nd St. Shaft-Top heading, southwest slash	4:57 PM
9/9/2011	69th St.- Adits- Ancillary 2, egress tunnel #3	4:57 PM
9/9/2011	G3/S1 Cavern II	5:21 PM
9/12/2011	69th St. Shaft – Northwest slash	3:38 PM
9/12/2011	69th St. Shaft - G3-S1 – East wall and west wall	5:08 PM
9/12/2011	72nd St. Shaft – Southwest slash	5:17 PM
9/12/2011	72nd St. Shaft – Ventilation Tunnel	5:18 PM
9/13/2011	69th St. Shaft- Top heading, northwest slash	3:36 PM
9/13/2011	72nd St. Shaft-Top heading, southwest slash	4:17 PM
9/13/2011	G3/S1 Cavern 1	6:50 PM
9/14/2011	69th St. Shaft- Top heading, northwest slash	3:29 PM
9/14/2011	72nd St. Shaft-Top heading, southwest slash	5:46 PM
9/14/2011	69th St.- Adits- Ancillary 2, ventillation tunnel #5	5:47 PM
9/14/2011	69th St.- Adits- Ancillary 2, egress tunnel #5, invert	5:48 PM
9/14/2011	G3/S1 Cavern 1	6:30 PM
9/15/2011	69th St. Shaft- Top heading, northwest slash	3:48 PM
9/15/2011	72nd St. Shaft-Top heading, southwest slash	3:49 PM
9/15/2011	G3/S1 Cavern 1	5:40 PM
9/16/2011	69th St. Shaft- Top heading, northwest slash	3:35 PM
9/16/2011	72nd St. Shaft-Top heading, southwest slash	4:31 PM
9/16/2011	69th St.- Adits- Ancillary 2, ventillation tunnel #6	4:40 PM
9/19/2011	69th St. Shaft- Top heading, northwest slash	3:58 PM
9/19/2011	72nd St. Shaft-Top heading, southwest slash	5:15 PM
9/19/2011	69th St.- Adits- Ancillary 2, ventillation tunnel #7	5:16 PM
9/19/2011	G3/S1 Cavern 1	6:17 PM
9/20/2011	69th St. Shaft- Top heading, northwest slash	3:30 PM
9/20/2011	72nd St. Shaft-Top heading, southwest slash	3:30 PM
9/20/2011	G3/S1 Cavern 1	5:42 PM
9/21/2011	69th St. Shaft- Top heading, northwest slash	3:47 PM
9/21/2011	72nd St. Shaft-Top heading, southwest slash	4:40 PM
9/21/2011	69th St.- Adits- Ancillary 2, ventillation tunnel #8	4:41 PM
9/22/2011	69th St. Shaft- Top heading, northwest slash	4:01 PM
9/22/2011	72nd St. Shaft-Top heading, southwest slash	4:40 PM
9/22/2011	69th St.- Adits- Ancillary 2, ventillation tunnel #9	4:41 PM
9/22/2011	G3/S1 Cavern 1	5:54 PM
9/23/2011	69th St. Shaft- Top heading, northwest slash	3:50 PM
9/23/2011	72nd St. Shaft-Top heading, southwest slash	4:40 PM
9/23/2011	69th St.- Adits- Ancillary 2, ventillation tunnel #10	4:41 PM
9/23/2011	G3/S1 Cavern 1	6:43 PM
9/26/2011	69th St. Shaft- Top heading, northwest slash	3:45 PM
9/26/2011	72nd St. Shaft-Top heading, southwest slash	3:45 PM
9/26/2011	G3/S1 Cavern 1	5:34 PM
9/26/2011	G3/S1 Cavern 1	5:34 PM
9/27/2011	69th St. Shaft- Top heading, northwest slash	3:34 PM
9/27/2011	72nd St. Shaft-Top heading, southwest slash	4:49 PM
9/27/2011	69th St.- Adits- Ancillary 2, ventillation tunnel #11	4:50 PM
9/27/2011	G3/S1 Cavern 1	6:01 PM
9/27/2011	G3/S1 Cavern 1	6:01 PM
9/28/2011	G3/S1 Cavern 1	3:13 PM
9/28/2011	69th St. Shaft- Top heading, northwest slash	4:12 PM
9/28/2011	69th St.- Adits- Entrance #2	5:00 PM
9/28/2011	72nd St. Shaft-Top heading, southwest slash	5:16 PM
9/29/2011	69th St. Shaft- Top heading, northwest slash	4:07 PM
9/29/2011	72nd St. Shaft-Top heading, southwest slash	4:46 PM
9/29/2011	69th St.- Adits- Ancillary 2, ventillation tunnel #12	4:47 PM
9/29/2011	G3/S1 Cavern 1	6:10 PM
9/30/2011	72nd St. Shaft-Top heading, southwest slash	4:00 PM
9/30/2011	69th St. Shaft- Top heading, northwest slash	4:01 PM
9/30/2011	G3/S1 Cavern 1	5:29 PM
10/3/2011	69th St. Shaft- Top heading, northwest slash	4:08 PM
10/3/2011	72nd St. Shaft-Top heading, southwest slash	4:09 PM
10/3/2011	69th St.- Adits- Ancillary 2, ventillation tunnel #13	4:10 PM
10/4/2011	69th St. Shaft- Top heading, northwest slash	4:16 PM
10/4/2011	72nd St. Shaft-Top heading, southwest slash	5:45 PM
10/4/2011	69th St.- Adits- Entrance #2	5:46 PM
10/4/2011	69th St.- Adits- Ancillary 2, ventillation tunnel #14	5:47 PM
10/4/2011	G3/S1 Cavern 1	6:50 PM
10/5/2011	69th St. Shaft- Top heading, northwest slash	3:58 PM
10/5/2011	72nd St. Shaft-Top heading, southwest slash	3:59 PM
10/5/2011	G3/S1 Cavern 1	6:05 PM
10/6/2011	69th St. Shaft- Top heading, northwest slash	4:00 PM
10/6/2011	72nd St. Shaft-Top heading, southwest slash	4:01 PM
10/6/2011	69th St.- Adits- Entrance #2	4:02 PM
10/6/2011	G3/S1 Cavern 1	6:10 PM
10/7/2011	69th St. Shaft- Top heading, northwest slash	4:14 PM
10/7/2011	72nd St. Shaft-Top heading, southwest slash	4:15 PM
10/7/2011	69th St.- Adits- Entrance #2	4:16 PM
10/7/2011	G3/S1 Cavern 1	6:44 PM

Table II-2 Blasting Schedule (Contract C5A)

C5A Test Blast Schedule

Date	Location	Time
9/8/2011	2nd and 86th Street (North pit)	9:56 AM
9/8/2011	2nd and 86th Street (North pit)	12:40 PM
9/8/2011	2nd and 86th Street (North pit)	2:42 PM
9/9/2011	2nd and 86th Street (North pit)	8:55 AM
9/9/2011	2nd and 86th Street (North pit)	10:32 AM
9/9/2011	2nd and 86th Street (North pit)	12:39 PM
9/15/2011	2nd and 86th Street (North pit)	8:53 AM
9/15/2011	2nd and 86th Street (North pit)	10:17 AM
9/15/2011	2nd and 86th Street (North pit)	11:47 AM
9/15/2011	2nd and 86th Street (North pit)	1:52 PM
9/16/2011	2nd and 86th Street (North pit)	8:51 AM
9/16/2011	2nd and 86th Street (North pit)	10:36 AM
9/16/2011	2nd and 86th Street (North pit)	12:55 PM
9/16/2011	2nd and 86th Street (North pit)	2:13 PM
9/20/2011	2nd and 86th Street (North pit)	8:32 AM
9/20/2011	2nd and 86th Street (North pit)	10:18 AM
9/20/2011	2nd and 86th Street (North pit)	12:31 PM
9/21/2011	2nd and 86th Street (North pit)	8:23 AM
9/21/2011	2nd and 86th Street (North pit)	10:32 AM
9/21/2011	2nd and 86th Street (North pit)	1:46 PM
9/21/2011	2nd and 86th Street (North pit)	4:44 PM
9/22/2011	2nd and 86th Street (North pit)	12:59 PM
9/22/2011	2nd and 86th Street (North pit)	4:36 PM

D. Contractor’s Dust and Air Pollution Control Measures (During Air Monitoring Period)

The contractors were required to prepare and submit to MTACC a dust and air pollution control plan related to emissions generated during construction activities.

For the 72nd Street Station contract, air pollution control measures in place during the monitoring period included:

- Use of water spraying devices (Dust Bosses) above and below ground directed at the surface area of the excavation shafts during blasting operations (see Figures II-4 and II-5).
- Lowering the rate of ventilation fans (which provide fresh air to the workers in the cavern) to a minimum during blasting operations, and in some instances stopping the ventilation fans completely to slow the movement of the dust plume and increase the efficiency of water spraying devices.
- Efforts to avoid stockpiling of materials on the streets, and covering/wetting stockpiles to prevent dust.
- Covering trucks when transporting spoils from excavation
- Spraying truck wheels and underside before leaving the construction sites.
- Use of ultra-low sulfur diesel (ULSD) on all diesel powered construction equipment.

For the 86th Street Station contract, similar measures were in place at the surface. Blast mats were used during blasting for the initial top-down excavation of the shafts.

Figure II-4: Water Spraying During Blasting Operations

Figure II-5: Water Spraying Underground

E. Contractor's Community Air Monitoring Program (CAMP)

The contractor's CAMP includes monitoring the air pollution effects of construction activities (including blasting operations) based on real-time monitoring for total volatile organic compounds (VOC) and coarse particles (PM_{10}) at the perimeter of the working areas.

These CAMPs follow the guidelines established by NYS Department of Health (NYSDOH),[2] which includes action levels with an alarm system to notify the contractor if specified levels are exceeded. These action levels are based on 15-minute average concentrations for VOC and PM_{10}. MTACC elected to follow CAMP guidelines as a means to enforce better dust control by its contractors.

The CAMP action levels were set at 150 $\mu g/m^3$ for PM_{10} and 5 ppm for VOC over a 15-minute period. The action levels for PM_{10} and VOCs are not related to NAAQS or any health-based guidance levels established by federal or state environmental agencies. Section VI provides an evaluation of the CAMP monitoring data using the collocated monitors with this program.

The 72nd Street Station Contract (C4B) includes four locations with permanent monitors collecting real-time data (minute by minute) for total VOC and PM_{10} since December of 2010. The monitors were attached to light poles with an inlet approximately 5 feet from the ground.

- CAMP 2 and 3 were located on 72nd Street north sidewalks (east and west of Second Avenue) at approximately 100 feet or more from Second Avenue.
- CAMP 1 was located at the corner of Second Avenue and 73rd Street.
- CAMP 4 was located at the northwest corner of Second Avenue and 69th Street. This monitor was relocated to the Conex box on Second Avenue and 69th Street.

The 86th Street Station Contract (C5A) has two permanent monitoring stations, which collect real-time data for PM_{10} and total VOCs:

- CAMP 1 was located on the southwest corner of 83rd Street, mounted approximately 5 feet from the ground attached to a light pole.
- CAMP 2 was located on the northeast corner of 86th Street, mounted approximately 5 feet from the ground attached to a light pole.

Particulates were measured using TSI's DUSTTRAK; total VOCs were measured using MultiRAE PLUS with a photo ionization detector (PID).

[2] NYSDOH (2000, June 20). Attachment 1 - New York State Department of Health Generic Community Air Monitoring Plan

Figure II-6: CAMP Monitor at 73rd Street

F. Regional Pollutant Levels

Across the country and in New York City (NYC) air quality has improved in recent decades because of measures implemented to meet EPA clean air regulations. Emission controls are now required for motor vehicles, factories, power plants and products like motor fuels and paints, which have been reformulated to reduce emissions. In addition, state agencies, including the NYSDEC, act to enforce emission limits and to develop other measures to reduce air pollution, such as promoting car pooling and encouraging the use of public transportation. These federal and state actions have produced significant improvements in air quality in most parts of the country and in NYC. Despite these efforts, routine air monitoring shows that the New York City metropolitan area still does not meet the clean air standards for ozone (O_3), and, until very recently, for fine particulate matter ($PM_{2.5}$). About half of NYC's $PM_{2.5}$ levels come from the regional sources outside the city that include vehicles and power plants in the metropolitan area and beyond. The rest can be attributed to local sources including diesel and gasoline engines, building furnaces and boilers, cooking and road dust.

F.1. Particulate Matter

Particulate matter is a broad class of air pollutants that exists as liquid droplets or solids, with a wide range of sizes and chemical composition. Particulate matter is emitted by a variety of sources, both natural and man-made. Natural sources include the condensed and reacted forms of natural organic vapors, salt particles resulting from the evaporation of sea spray, wind-borne pollen, fungi, molds, algae, yeasts, rusts, bacteria, and debris from live and decaying plant and animal life, particles eroded from beaches, desert, soil and rock, and particles from volcanic and geothermal eruptions and forest fires. Major man-made sources of particulate matter include the combustion of fossil fuels, such as vehicular exhaust, power generation and home heating, chemical and manufacturing processes, construction activities (including equipment exhaust and re-entrained dust), agricultural activities, and wood-burning fireplaces. Fine particulate matter is also derived from combustion material that has volatilized and then condensed to form primary particulate matter (often after release from a stack or exhaust pipes) or from precursor gases reacting in the atmosphere to form secondary particulate matter. It is also derived from mechanical breakdown of coarse particulate matter (e.g., from building demolition or roadway surface wear).

Of particular health concern are those particles that are smaller than or equal to 10 microns (PM_{10}) in size and 2.5 microns ($PM_{2.5}$) in size. The principal health effects of airborne particulate matter are on the respiratory and cardiovascular systems. Inhaled fine particles can penetrate deep into the lungs, causing inflammation of the airways and blood vessels.

F.2. Carbon Monoxide

CO is a colorless and odorless gas that is generated in the urban environment primarily by the incomplete combustion of fossil fuels in motor vehicles. In New York City, more than 80 percent of CO emissions are from motor vehicles. Prolonged exposure to high levels of CO can cause headaches, drowsiness, loss of equilibrium, or heart disease. CO concentrations can vary greatly over relatively short distances. Relatively high concentrations of CO are typically found near congested intersections, along heavily used roadways carrying slow-moving traffic, and in areas where atmospheric dispersion is inhibited by urban “street canyon” conditions. CO levels have decreased considerably during the last two decades due to cleaner motor vehicles, and NYC has met the CO standards for over a decade.

F.3. Sulfur Dioxide

Sulfur dioxide (SO_2) is a highly reactive gas. According to the EPA, the largest sources of SO_2 emissions in the United States are fossil fuel combustion at power plants (73 percent) and other industrial facilities (20 percent). Smaller sources of SO_2 emissions include industrial processes, and the burning of high–sulfur fuels by trains, large ships, and non-road equipment. SO_2 reacts with water vapor and other substances in the air to form acid, sulfates, $PM_{2.5}$, and other harmful pollutants. SO_2 can exacerbate asthma and, along with $PM_{2.5}$, can contribute to other respiratory illnesses and exacerbation of heart disease. Under current law, heating oil in New York City can contain 2,000–3,000 parts per million (ppm) sulfur, compared with only 15 ppm sulfur in on-road motor vehicles diesel fuel. Today still a large number of buildings in NYC use the high sulfur oil as heating fuel.

F.4. Pollutant levels measured in NYC by NYSDEC

In order to evaluate which portion of the monitored concentrations collected by this monitoring program could be attributed to regional levels; concentrations measured by NYSDEC in New York City were examined for the time period of this monitoring program.

The NYSDEC $PM_{2.5}$ sites used in this analysis are roof top monitoring stations at the following locations:

- CCNY campus at 160 Convent Avenue on the upper west side between 136th and 137th Streets.
- Public School PS19 at 185 First Avenue at 12th Street
- Division Street between Bowery and the entrance to Manhattan Bridge.

Figure II-7 provides the available $PM_{2.5}$ data collected in Manhattan by NYSDEC monitoring network for the concurrent period. The data set for the CCNY monitoring station has several missing days during this period.

There are currently two NYSDEC PM_{10} monitors in Manhattan. They are collocated with the $PM_{2.5}$ monitors at Division Street and at PS19 stations. The PM_{10} monitoring follows a one-in-three day schedule. All available data collected for the time concurrent with the monitoring period is presented on Figure II-8.

Figure II-7: $PM_{2.5}$ – NYSDEC Regional Levels

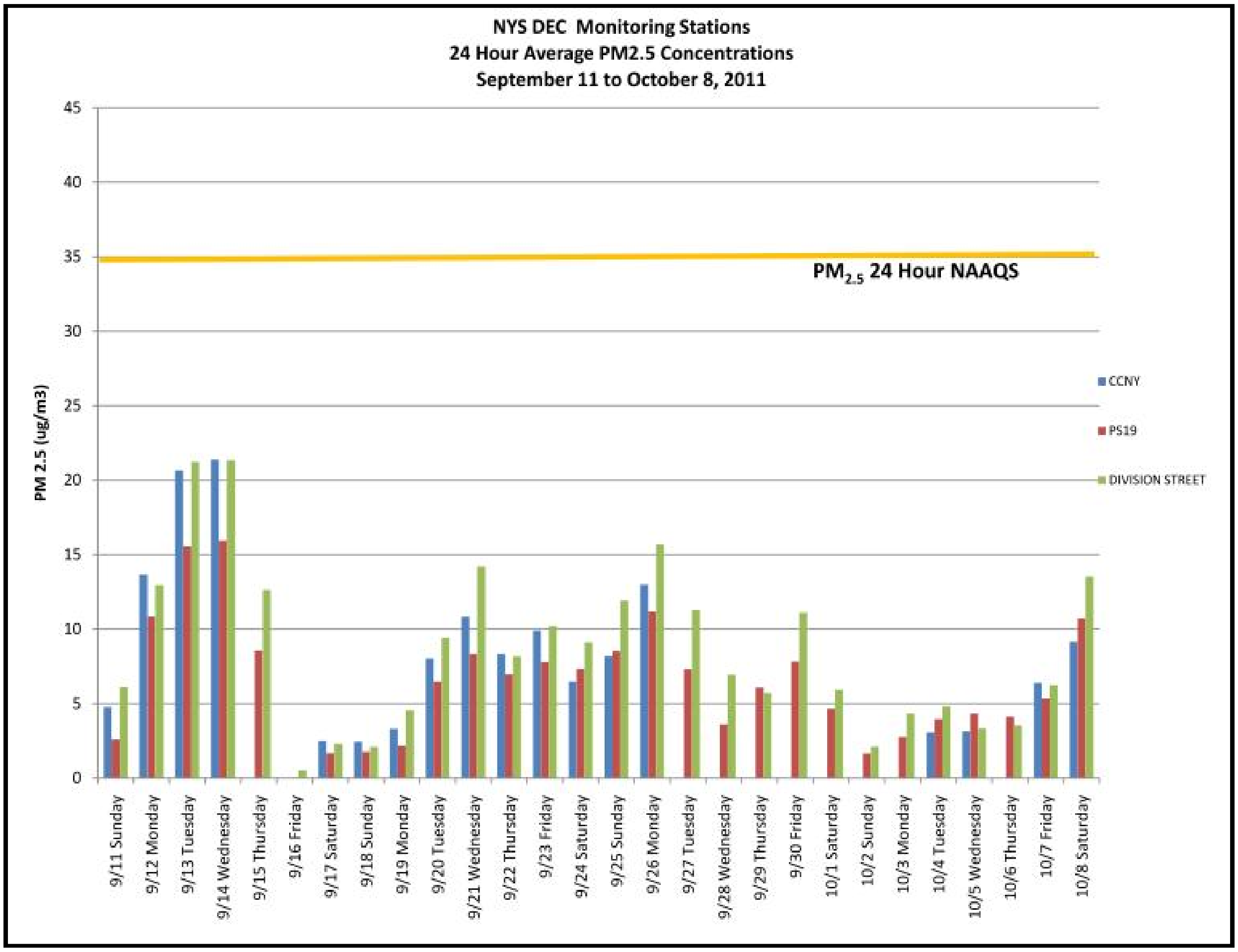


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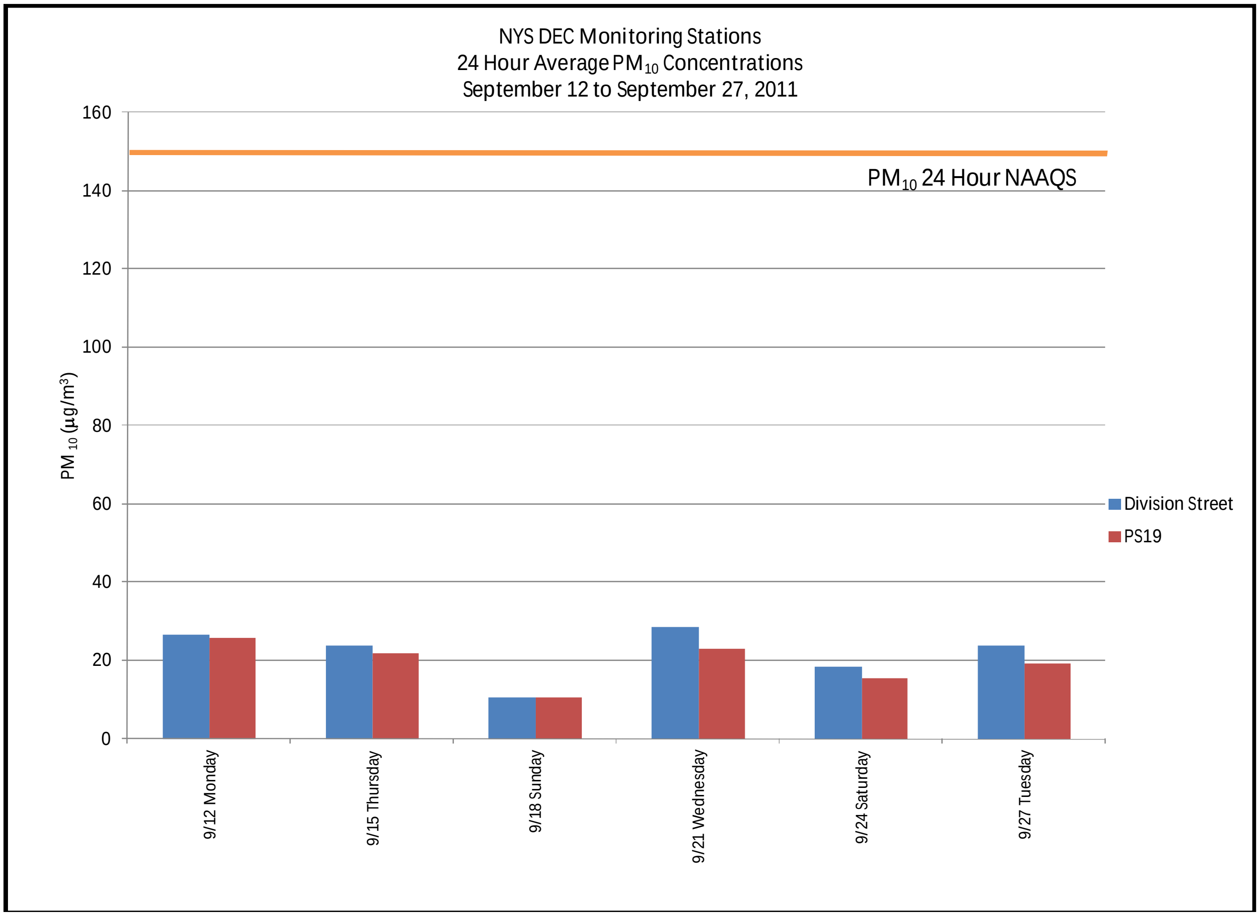
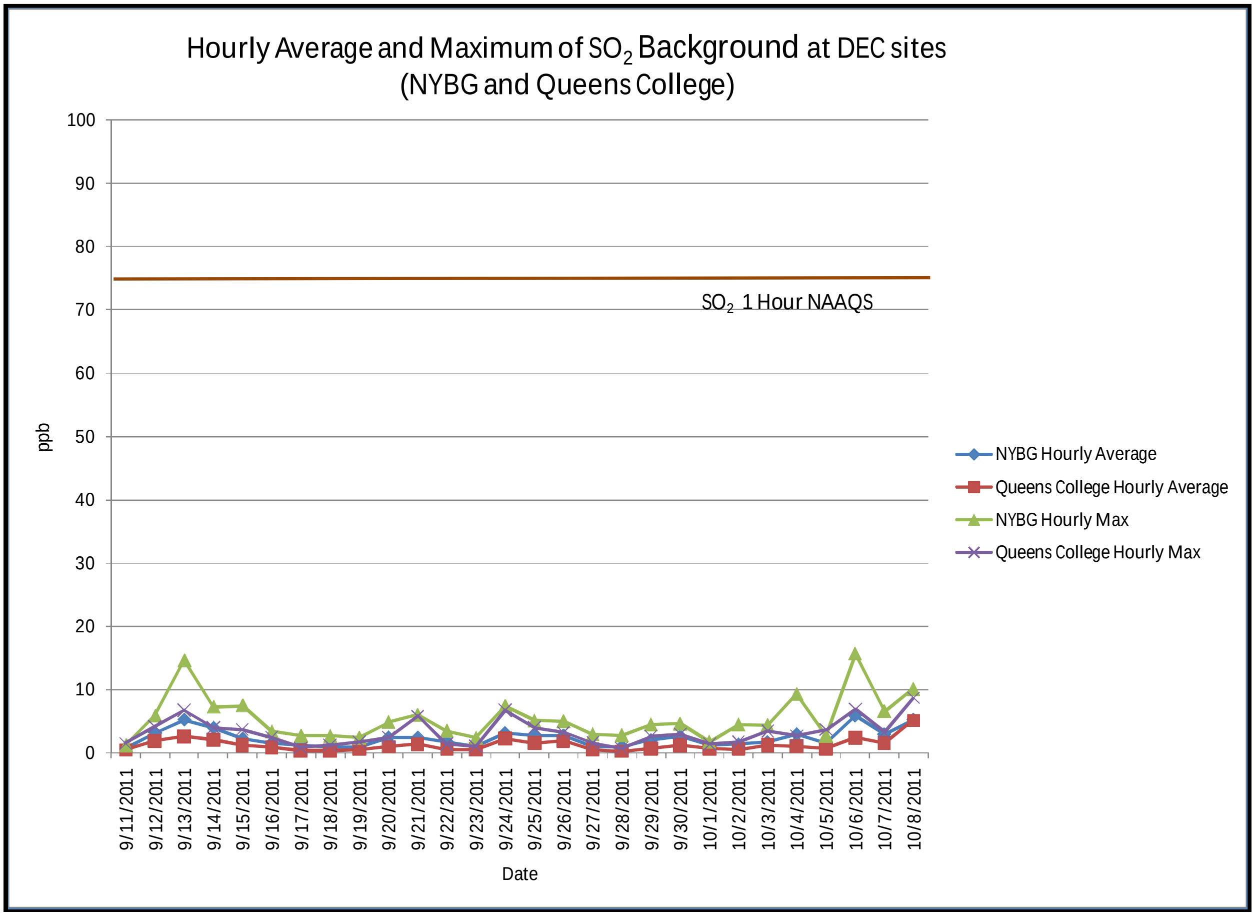
Figure II-8: PM_{10} – NYSDEC Regional Levels



The levels of carbon monoxide, once the main pollutant of concern from motor vehicles and other gasoline and diesel-fueled equipment, have fallen low in the recent years because of the strict emission control measures. There are two CO monitors in New York, at the New York Botanical Garden in the Bronx and at Queens College in Queens. Concentrations recorded at these monitors during the monitoring period ranged from 0.1 to 1.2 ppm with the average level of 0.5 ppm

The sulfur dioxide levels in New York are monitored at the same two locations as the CO concentrations. The maximum and average hourly levels for each day at each station during the monitoring period are presented on Figure II-9. The highest hourly SO_2 concentration observed during the monitoring period was 18 ppb.

Figure II-9: SO_2 – NYSDEC Regional Levels



III. Monitored Pollutants

A. Selection of Pollutants to be monitored

Ten pollutants were selected for the monitoring program in order to characterize the effects of construction and blasting activities on ambient air quality levels and assist in the identification of odors.

Among these selected pollutants, the most significant pollutant from construction activities is particulate matter—PM_{10} and $PM_{2.5}$:

- PM_{10}, (coarse particles) are associated with demolition and debris removal, excavation, blasting and drilling, materials loading and unloading, and suspended road dust.
- $PM_{2.5}$, (fine particles) are also associated with construction activities, as well as other combustion sources (power plants, motor vehicle exhaust, heating, etc.). Since these particles are smaller and can travel farther away from the site of origin, the regional component of $PM_{2.5}$ measured levels is significant. New York City has historically, on occasion, exceeded the Federal standards for this pollutant until recently.

Silica is one of the most common minerals on earth and present in the Manhattan rock being excavated as: quartz, cristobalite and tridymite. Respirable silica (as a component of dust particles) is a significant health concern in underground mining operations, and was identified as a concern by the community in the dust released from blasting operation.

Carbon monoxide (CO), VOC, nitrogen oxides (NO and NO_2) and sulfur dioxide (SO_2) were included since they are the product of fuel combustion, produced by motor vehicles, and possible byproduct from blasting operations. In addition, NO, NO2, SO2, Ammonia (NH_3) and hydrogen sulfide (H_2S) can be odor-producing blasting by-products.

The monitors collected minute-by-minute data for PM_{10}, $PM_{2.5}$, CO, NO, VOC, NO_2, SO_2 H_2S and NH_3 for a continuous duration of one month. The data collected from these monitors was used to determine worst-case public exposure levels at close range to the construction zones.

B. Selection of Monitoring Locations

Ten monitoring locations were selected in consultation with representatives from EPA Region II to:

- Capture the effects of construction activities
- Represent “worst-case” public exposure - close proximity of each excavation shaft (30-80 feet distance) at ground level and elevated locations to represent abutters windows or balconies
- Provide sufficient coverage to capture multiple wind directions in a high density urban environment.

The 10 air monitoring stations (AMS) were installed throughout the Contacts C4B and C5A work areas. AMS 1 through 6 were installed within the limits of Contract C4B, and AMS 7 through 10 at Contract C5A.

At each AMS there were two weatherproof boxes identified as unit A and B which contain the equipment needed to measure all the pollutants already described.

AMS 1 – AMS boxes were mounted on a wood panel on top of a blue contractor Conex box, approximately 15 feet above grade, adjacent to SSK's CAMP Station 4. The Conex box is located within a storage area on the southeast corner of 69th Street and Second Avenue.

AMS 2 – AMS boxes were placed on the fire escape on the 3rd Floor of 1315 Second Avenue (Ancillary Building 1), on the northwest corner of 69th Street and Second Avenue. The stations were approximately 30 feet above grade.

AMS 3 – AMS boxes were mounted on a wood panel on the eastern railing of the upper deck of the Hoghouse on the northeast corner of 70th Street and Second Avenue. Silica monitors were also installed at this location, identified as AMS 3C.

AMS 4 – AMS boxes were mounted on a wood panel along the Second Avenue fence line on the southeast corner of 72nd Street and Second Avenue. Silica monitors were also installed at this location, identified as AMS 4C.

AMS 5 – AMS boxes were mounted on a wood panel against the 3rd floor fire escape railing at the southeast corner of 72nd Street and Second Avenue. The AMS boxes were approximately 30 feet above grade.

AMS 6 – AMS boxes were mounted above the fence at approximately 10 feet above grade facing the Second Avenue sidewalk. Located on the northeast corner of 73rd Street, the monitors were located adjacent to the water treatment center.

AMS 7 – AMS boxes were located on the southeast corner of 83rd Street and Second Avenue. The boxes were mounted on the fence line at approximately 5 feet about grade, facing 83rd Street. Silica monitors were also installed at this location identified as AMS 7C.

AMS 8 – AMS boxes were placed on the 3rd floor fire escape facing Second Avenue of Gothic Cabinet, on the northwest corner of 83rd Street. The boxes were approximately 30 feet above grade.

AMS 9 – AMS boxes were installed above the fence line at approximately 10 feet on the northeast corner of 86th Street and Second Avenue. The boxes were installed adjacent to the Second Avenue sidewalk, at the entrance to the work area.

AMS 10 – AMS boxes were installed above the fence line at approximately 10 feet on the southeast corner of 87th Street and Second Avenue. The boxes were installed along 87th Street near the entrance to the work area.

Table III-1 provides the locations and pollutants monitored at each monitoring station.

Table III-1: Air Monitoring Station Locations and Pollutants

Station No (Contract)	Location	Pollutant					
		CO, NO, NO_2, NH_3,	Total VOC	H_2S SO_2	PM_{10}	$PM_{2.5}$	Silica
1 (C4B)	69th Street, SE corner, inside gate on top of blue conex container	X	X	X		X	
2 (C4B)	69th Street, NW corner, Ancillary 1, third floor fire escape of the	X	X		X		
3 (C4B)	70th Street, NE corner, upper level of Hoghouse deck	X	X	X	X		X
4 (C4B)	72nd Street, SE corner, inside fence in lay-down area	X	X	X	X		X
5 (C4B)	72nd Street, SE corner, third floor fire escape of the above pizzeria	X	X			X	
6 (C4B)	73rd Street, NE corner, directly inside fence, mounted to unistrut channels	X	X	X	X		
7 (C5A)	83rd Street, SE corner, directly inside fence, mounted to unistrut channels	X	X		X		X
8 (C5A)	83rd Street, NW corner, third floor fire escape of the former Gothic Cabinet Building	X	X			X	
9 (C5A)	86th Street, NE corner, directly inside fence, mounted to unistrut channels	X	X		X		
10 (C5A)	87th Street, SE corner, directly inside fence, mounted to unistrut channels	X	X		X		

Note: Silica monitoring extended for 2 week period to cover at least 10 blasting events.

Figures III-1 to III-4 provide the monitoring locations

Figure III-1: East 69th Street to East 70th Street Shaft

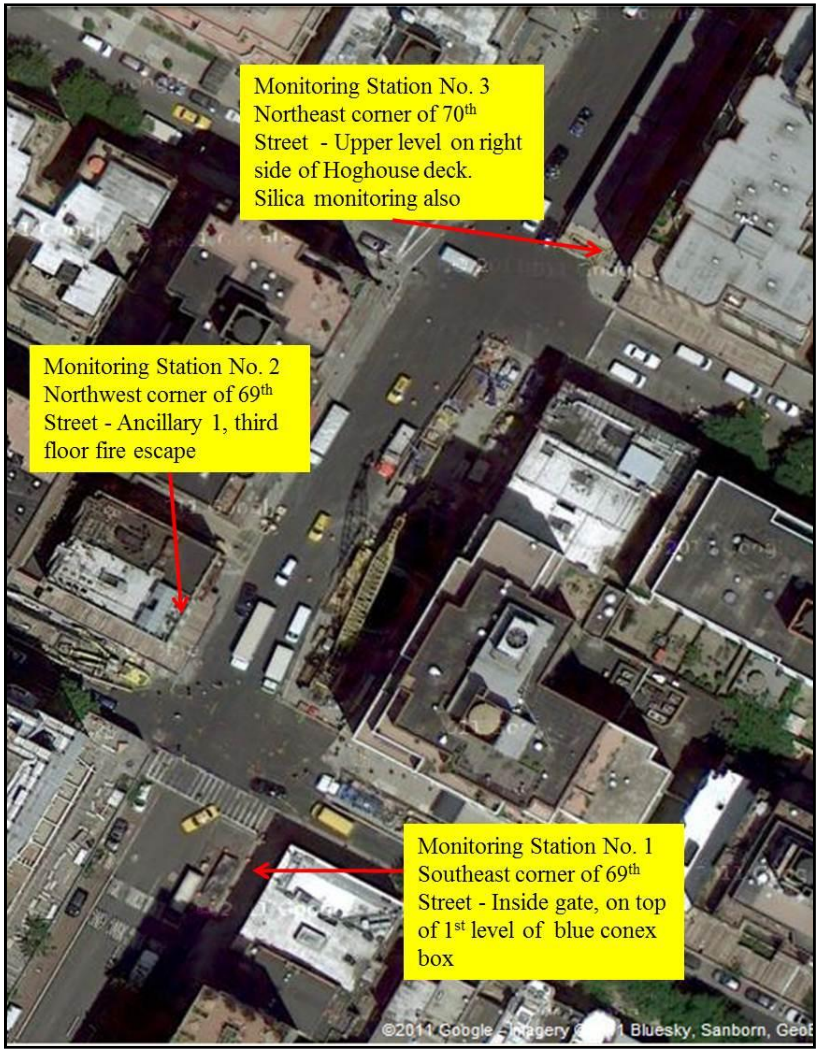


Figure III-2: East 72nd Street to East 73rd Street Shaft

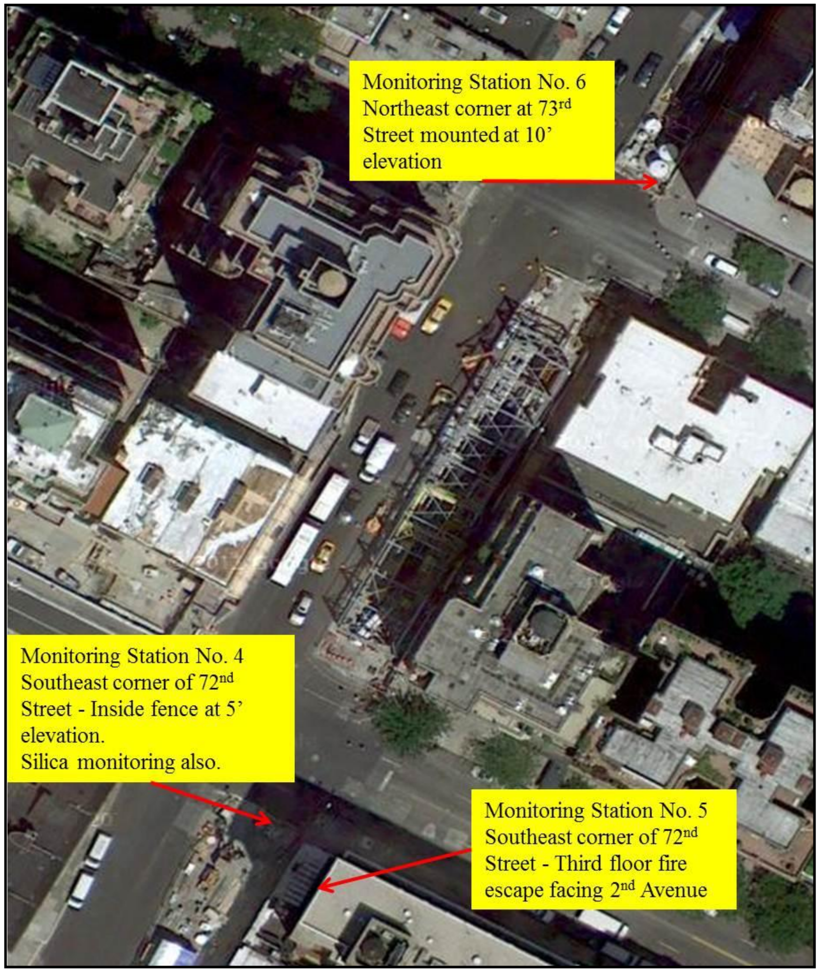


Figure III-3: East 83rd Street Shaft

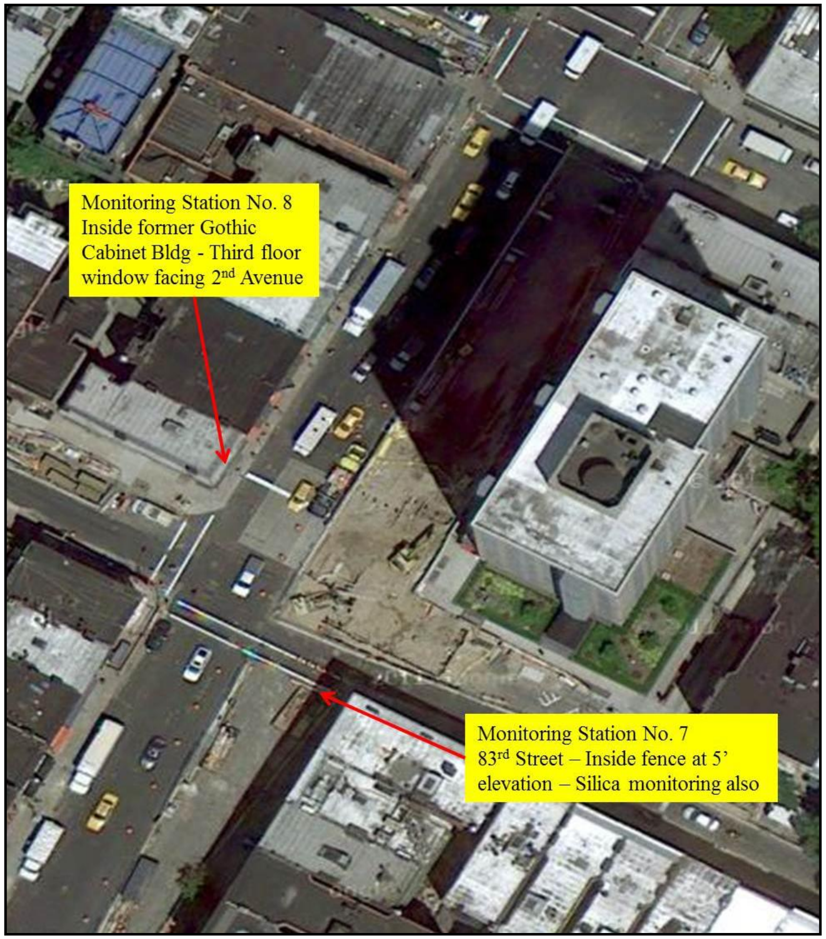
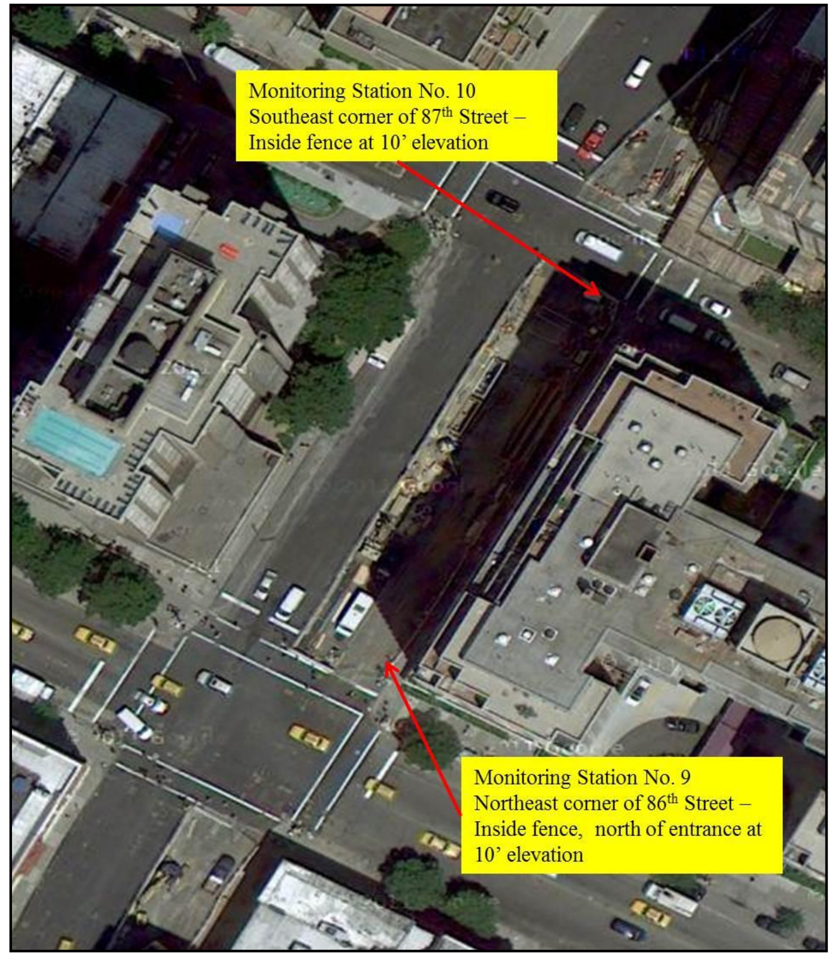


Figure III-4: East 86th Street Shaft



C. Monitoring Equipment

The equipment deployed included MIE DR-4000 area dust monitors for PM_{10} and $PM_{2,5,}$ VRAEs (one for CO, and the other for NH_3, NO and NO_2) and a PID VOC monitors. Additionally, a RKI Eagle-II gas detector was used to achieve a 0.01 ppm detection limit for SO_2 and a Jerome 631-X H_2S analyzer was used to achieve a 0.003 ppm detection limit for H_2S. This type of equipment has sufficient accuracy to provide a reasonable indication of exposure levels, and is adequate for this type of short-term monitoring program. However these are not EPA Reference Method instruments (the type used to determine long-term air pollution trends for certification if an area is in compliance with NAAQS). EPA concurred that the type of monitoring equipment used for this study was appropriate to meet the stated study objectives.

Silica levels were measured by three gravimetric low volume air sampling monitors (filter based) in the immediate public area adjacent to the work areas: one at 70th Street, NE corner, upper level of Hoghouse deck (AMS 3C), the second at 72nd Street, SE corner, inside fence in lay-down area (AMS 4C), the third at 83rd Street, SE corner, directly inside the fenced area (AMS 7C).

These silica monitors collected data during both blasting (AMS 3C and 4C) and non-blasting events (AMS 7C). A sampling interval of 24 hours was needed to obtain a volume of air necessary to measure a detection limit of 5 $\mu g/m^3$ for quartz, tridymite and cristobalite.

The PM samples collected in the filters were submitted for laboratory analysis to determine the percentage of silica, quartz and other components. All silica samples were analyzed using NIOSH Method 7500 – Silica, Crystalline Analysis of Air samples by X-Ray diffraction (XRD), which is less susceptible to interferences from other minerals. EMSL Analytical, Inc., located in Cinnaminson, NJ, performed the laboratory analysis. Air collecting units were Buck Libra L-4 sampling pumps, 37 mm three-piece PVC filter cassettes and aluminum cyclones. The pumps were calibrated using a low flow rotameter to flow rate of 2.5 liters per minute. Aluminum cyclones were used to separate out large dust particles so that only the smaller particles are collected on the sampling filter. These smaller particles, measuring 4 microns or less, are referred to as “respirable” particles. Table III-2 provides the detection limits of each pollutant and type of equipment.

Table III-2: Monitored Pollutants, Instrument Type, Detection Limits (Resolution), and monitoring Range

Monitored Pollutants	Monitoring Instrument	Detection Limit	Monitoring Range
CO	VRAE	1 ppm	0-500 ppm
PM_{10}	MIE DR-4000	0.1 $\mu g/m^3$	0.1 $\mu g/m^3$ – 400 mg/m^3
$PM_{2.5}$			
Respirable Silica	Buck Libra L-5	5 $\mu g/m^3$	
NO_2	VRAE	0.1 ppm	0 – 20 ppm
NO	VRAE	1 ppm	0 – 250 ppm
SO_2	RKI Eagle-2	0.01 ppm	0 – 6 ppm
NH_3	VRAE	1 ppm	0 – 50 ppm
H_2S	Jerome 631X	0.003 ppm	0 – 0.99 ppm
VOC	MiniRAE 2000	0.1 ppm	0 – 99 ppm

D. Data collection Process

For all 10 AMS stations, each station box (A and B) were equipped with a modem and antenna. Each piece of equipment was connected to the box's modem, and would send data electronically through the modem to a "Cloud," which is a web-based database that logged all data. Each piece of equipment was programmed to collect a data point every minute continuously. Parsons Brinckerhoff personnel could log onto a website and view the Cloud's collected data from any unit in either table or graph form.

There were instances when data were not transmitting to the Cloud, also known as a period of lost telemetry. Reasons causing telemetry loss were power failure, modem failure, cable issues, or equipment failure. When any of these issues occurred, data from the equipment were downloaded manually in the field. Each piece of equipment has the capability to be programmed to log data every minute for a specific period of time. Sometimes data could not be downloaded due to an equipment or power issue; if the equipment was not on, it could not log data points.

The RKI Eagle-II and Jerome meters that were located at four AMS (1, 3, 4 and 6) were not connected to a modem and therefore could not transmit data to the Cloud. The data logged by these instruments had to be downloaded daily in the office, which required a temporary shut down during the downloading process.

D.1. Sampling Methods

All monitoring instrumentation was placed in the field at approved designated locations. Prior to installation all monitoring instrumentation was calibrated and programmed to collect data at one minute intervals. The instrumentation were monitored on a daily basis (except weekends) by professional personnel. The monitoring instrumentation were calibrated using gases of known concentrations levels for zero and a set level depending on the instrument range according the specific manufacturer's instructions. Silica bulk sampling was performed in the vicinity of the 72nd Street and 83rd Street shaft areas to determine the silica characteristics of the rock material with the vicinity of the respective work areas. Upon completion of the sampling, the bulk samples were delivered to the laboratory. This was necessary to determine the three main components of silica rock: α-Quartz, Cristobalite and Tridymite.

D.2. Data Handling and Custody Chain

The VRAE, DataRam and PID instruments were set to data log 24 hours/day, 7-days/week. In addition, this monitoring instrumentation was configured to collect data and transmit the collected data via wireless modem to an off-site data center. From that point, the data center transmitted collected data to Environet, which is a fully-hosted, web-based application that enables end users to perform real-time monitoring and review historical analysis of captured data. All data was downloaded and saved by a Parsons Brinckerhoff team member. The Environet website was supported by the monitoring instrumentation rental company.

The data from the RKI Eagle-2 and Jerome 631X were downloaded manually on a daily basis. The data collected from these units were saved and transferred to a network file that can be accessed by the Parsons Brinckerhoff team.

The silica air monitoring cassettes collected from silica monitor pump (Buck Libra L-5) were hand delivered to the laboratory (EMSL Analytical, Inc.). Prior to delivering the silica air samples to the laboratory, the chain-of-custody form was completed and signed by the Parsons Brinckerhoff team member responsible for this task. The cassettes were retained by the laboratory for 30 days. Silica bulk samples were retained for 60 days.

D.3. Quality Control Requirements

Prior to installing the monitoring instrumentation at their respective AMSs, the instrumentation ID numbers or serial numbers associated with each instrument were recorded. In order to determine that the instruments were functioning properly during the one-month-long air monitoring study, all instrumentation was inspected on a daily basis. Items such as cable connections, modem communication to the Environet website, and functionality of the DR-4000 heaters were checked daily (except weekends). The monitoring instrumentation was calibrated, bump-tested or zeroed as per the manufacturer's recommendations and guidelines. In addition, back-up instruments and parts (cables, filters, AC adapters, heaters, etc) provided by the rental company were stored on-site for a replacement as needed. If an instrument malfunctioned, the troubleshooting was performed to fix the problem. If the problem could not be fixed, the equipment was replaced by the working unit provided by the rental company.

D.4. Calibration Procedures

DR-4000, Jerome, and VRAE monitors were calibrated by the rental company prior to being delivered to the site. DR-4000 instruments were zeroed out on a daily basis. VRAE and MiniRae monitors were zero and span calibrated every day. The Jerome monitor was zero calibrated and adjusted daily during the monitoring study. The Eagle gas monitor was calibrated using the Eagle 2 Data Logger Management program every day.

Silica Buck Libra L-4 sampling pumps was calibrated using a low flow rotameter to flow rate of 2.5 liters per minute. Aluminum cyclones were used to separate out large dust particles so that only the smaller particles are collected on the sampling filter. These smaller particles, measuring 4 microns or less, are referred to as "respirable" particles.

D.5. Data Completeness and Percent Recovery

The hourly and daily values were considered valid when at least 75 percent of the data for that specific hour (over 45 minute readings) were valid. The same concept was applied for the daily PM_{10} and $PM_{2.5}$ values (over 75 percent of the hours of that day had to be valid levels). This follows EPA standard procedures for the validation of monitoring data.

The data recovery for the gaseous pollutants considering all monitoring stations was between 84 and 96 percent. The data recovery for the PM monitoring stations was between 74.2 and 78.6 percent. The lower recovery rate for the PM monitors was mostly due to the effects of rainfall and very high percent humidity during a significant storm which affected the reading of the instruments.

The number of observations and percent recovery for each monitoring location are provided in Attachment B.

Table III-3: Percentage of Data Recovered and Number of Valid Readings for all Monitoring Stations

Pollutant	Percentage of Data Recovered All Stations	Number of Valid Hours All Stations	Number of Valid Days All Stations
PM_{10}	74.2 [1]	3546	137
$PM_{2.5}$	78.6 [1]	1612	66
CO	93.6	5,672	NA
NH_3	94.2	5,664	NA
H_2S	94.9	493	NA
NO	94.2	5,663	NA
NO_2	92.6	5,577	NA
VOC	96.8	6,042	NA
SO_2	84.9	1,344	NA

1. Percent Recovered is for Valid Days for PM_{10} and $PM_{2.5}$

IV. Determination of Reference Levels as Benchmarks

A series of benchmark reference concentrations were selected to highlight potential exposures that might be associated with health impacts.

The primary source of these health-based reference levels were the EPA NAAQS. For the pollutants that do not have NAAQS, such as NH_3, H_2S and respirable silica, the New York State Department of Environmental Conservation (NYSDEC) Short Term (1 hour) Air Guideline Levels, the World Trade Center Air Task Force Action levels, and the 60-minute Acute Exposure Guideline Level-1 (AEGL-1) developed by the National Advisory Committee for the Development of Acute Exposure Guideline Levels for Hazardous Substances were used.

A. National Ambient Air Quality Standards (NAAQS)

The NAAQS are established by EPA under the Clean Air Act for pollutants considered harmful to public health and the environment. The Clean Air Act specifies two types of national air quality standards. Primary standards set limits to protect public health, including the health of “sensitive” populations such as asthmatics, children, and the elderly. Secondary standards set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings. EPA has set NAAQS for six principal pollutants, which are called “criteria” pollutants.

The Clean Air Act requires periodic review of both the science upon which the standards are based, and the standards themselves. The review process begins with a workshop to obtain the input of the Clean Air Science Advisory Committee (CASAC). Next, EPA drafts an Integrated Science Assessment (ISA), or a concise evaluation, integration, and synthesis of the most policy-relevant science, including key science judgments that will be used in conducting risk and exposure assessments. CASAC and the public have an opportunity to comment on the draft ISA.

In order to determine if an area (city or region) is in compliance, a permanent air monitoring network is established by the State Environmental Agency. This network is required to follow an extensive protocol in terms of monitoring locations to represent population exposure, type of equipment (identified as reference level equipment), and duration of monitoring period. EPA has specific siting requirements for monitors used to assess NAAQS compliance, stating that “the plume from the local minor sources should not be allowed to inappropriately impact the air quality data collected at a site.”[3] Because of this, monitors are usually placed away from local sources (such as roadways, construction sites, etc), NYSDEC places its Manhattan monitors on the rooftops of buildings. Monitors located near sources would be expected to observe higher concentrations for pollutants originating from the source than these rooftop monitors, as pollution gets diluted (dissipates) as it moves away from the original source.

The NAAQS for the pollutants, which are called “criteria” pollutants and were monitored for this study, are listed below. Units of measure for the standards are parts per million (ppm – 1 part in 1,000,000) by volume, parts per billion (ppb – 1 part in 1,000,000,000) by volume, milligrams per cubic meter of air (mg/m^3), and micrograms per cubic meter of air (µg/m^3). The notes below the table state details of the terms of compliance.

[3] 40 C.F.R. Part 58, Appendix E

Table IV-1: Relevant National Ambient Air Quality Standards

	Primary Standards		Secondary Standards	
Pollutant	Level	Averaging Time	Level	Averaging Time
Carbon Monoxide	9 ppm (10 mg/m^3)	8-hour (1)	None	
	35 ppm (40 mg/m^3)	1-hour (1)		
Particulate Matter (PM_{10})	150 µg/m^3	24-hour (2)	Same as Primary	
Particulate Matter ($PM_{2.5}$)	15.0 µg/m^3	Annual (3) (Arithmetic Average)	Same as Primary	
	35 µg/m^3	24-hour (4)	Same as Primary	
Sulfur Dioxide	0.03 ppm (1971 std)	Annual (5) (Arithmetic Average)	0.5 ppm	3-hour (1)
	0.14 ppm (1971 std)	24-hour (1)(5)		
	0.075 ppm	1-hour(6)	None	

(1) Not to be exceeded more than once per year.
(2) Not to be exceeded more than once per year on average over 3 years.
(3) To attain this standard, the 3-year average of the weighted annual mean $PM_{2.5}$ concentrations from single or multiple community-oriented monitors must not exceed 15.0 µg/m^3.
(4) To attain this standard, the 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area must not exceed 35 µg/m^3 (effective December 17, 2006).
(5) The 1971 sulfur dioxide standards remain in effect until one year after an area is designated for the 2010 standard, except that in areas designated nonattainment for the 1971 standards, the 1971 standards remain in effect until implementation plans to attain or maintain the 2010 standards are approved.
(6) Final rule signed June 2, 2010. To attain this standard, the 3-year average of the 99th percentile of the daily maximum 1 hour average at each monitor within an area must not exceed 75 ppb

B. New York State Department of Environmental Conservation (NYSDEC) DAR-1

The NYSDEC DAR-1 policy provides guidance for the control of toxic ambient air contaminants in New York State and outlines the procedures for evaluating sources of air pollution for those chemical contaminants directly addressed by New York State or federal regulations and those for which no State or federal ambient air quality standards exist. The DAR-1 policy which applies to the permitting of facilities includes tables which list all the Short-term (one-hour) and Annual Guideline Concentrations (SGCs and AGCs, respectively).

Many organizations and agencies derive short-term or annual exposure limits to protect workers or the general public from adverse exposure to toxic air contaminants. Each one of these exposure limits requires extensive research and development time. As such, the NYSDEC often uses the limits published by other agencies or organizations to derive SGCs or AGCs. When short-term or annual exposure limits are derived by NYSDEC, the EPA or the New York State Department of Health (NYSDOH), the most conservative (lowest) of these preliminary values will be adopted most of the time as the AGC or SGC value. If there are no exposure limits derived by NYSDEC, EPA or NYSDOH, the AGC/SGC values will be derived from Threshold Limit Values (TLVs), TLV Ceiling Limits or Short-Term Exposure Limits (STELs) published by the American Conference of Governmental Industrial Hygienists (ACGIH). When no exposure limits or ACGIH values are available, NYSDEC will often derive AGC/SGC values based on an analogy to a compound with similar toxicological properties.

This monitoring program selected as benchmark levels the SGCs for NH_3 and H_2S given the lack of NAAQS for these contaminants.

C. World Trade Center Air Task Force Working Group

Following the collapse of the World Trade Center on September 11, 2001, federal, state, and municipal health and environmental agencies (including EPA, NYSDEC and NYCDEP) initiated numerous studies to assess environmental conditions in the area. A multi-agency task force was specifically formed to evaluate indoor environments for the presence of contaminants that might pose long-term health risks to local residents. As part of this evaluation, a task force committee was established to identify contaminants of primary health concern and establish health-based benchmarks for those contaminants in support of ongoing residential cleanup efforts in Lower Manhattan. In September 2002, the committee released a draft document titled "World Trade Center (WTC) Indoor Air Assessment: Selecting Contaminants of Potential Concern (COPC) and Setting Health-Based Benchmarks." In October 2002, a panel of 11 experts conducted an independent peer review of the draft COPC document to ensure that the evaluations presented in the document were technically based and scientifically sound. A final report with peer reviewers' conclusions and recommendations was released in February 2003.

Where relevant and appropriate, existing standards/regulations were utilized. The NAAQS for $PM_{2.5}$ and PM_{10} (24 hour average) were used by the group. In cases where appropriate standards/regulations do not exist, risk-based Action Levels have been developed as per the risk assessment paradigm detailed in EPA's "Hazard Evaluation Handbook (HEH). For contaminants lacking environmental toxicity criteria (e.g., Cancer Slope Factors and/or RfCs/RfDs), occupational standards by the Occupational Safety and Health Administration (OSHA) (e.g., PELs, ACGIH – TLVs) served as a starting point for Action Level development. An order of magnitude (10 X) safety factor was employed to account for differences in exposure duration and sensitivity between the general public and the worker population. Additional safety factors were added to account for higher exposure and greater sensitivity within the general population.

A health-based benchmark for crystalline silica in indoor air was developed in this manner setting an action level of 10 $\mu g/m^3$ over a 24-hour period for quartz, cristobalite, and tridymite. This level is 10 times smaller than the OSHA (ACGIH) worker protection level of 100 $\mu g/m^3$ for a typical 40-hour working week. As a reference, this level is also 5,000 times smaller than the OSHA – Immediate Danger to life and health (30 minutes) exposure of 50,000 $\mu g/m^3$. This SAS air monitoring program adopted the 10 $\mu g/m^3$ action level as a benchmark for silica. An action level is the point at which measures to reduce levels should be undertaken for precautionary reasons and does not represent the point at which health effects may be triggered. Measurements below this level are considered safe according to the most stringent threshold.

D. AEGL-1 (One hour Acute Exposure Guideline Level-1)

Since construction activities and blasting events produce intermittent emissions of a short duration, a comparison of the maximum 1-hour measured concentrations for SO_2, NH_3 and H_2S to AEGL-1 values was also considered in the determination of reference levels.

The Development of AEGLs is a collaborative effort of the public and private sectors worldwide. AEGLs are intended to describe the risk to humans resulting from once-in-a-lifetime, or rare, exposure to airborne chemicals. EPA has been actively involved since 1988 in this program. The AEGL-1 value is the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic, non-sensory effects. However, these effects are not disabling and are transient and reversible upon cessation of exposure.

E. Selected Reference Levels used as Benchmarks

This short-term monitoring program was designed to capture the possible air pollution effects of construction activities using worst-case public exposure (i.e., at close proximity to construction areas). Given the limited duration of the program, the placement of the monitors adjacent to construction and motor vehicle sources of emissions and the detection level of the instrumentation used, the results cannot be used to determine compliance with the NAAQS or guidelines established for long-term or life-time exposure.

As such, the selected reference benchmark levels serve as an indication of a potential impact: if monitored concentrations are below such level, no adverse health effect is expected to occur. However, if an individual monitoring result exceeds the reference level, this does not represent a violation of a NAAQS or health-based standard, but provides an indication to adjust construction procedures to mitigate the exposure in order to reduce the potential for an impact to the extent practicable.

This program established reference levels for PM_{10}, $PM_{2.5}$, respirable silica, CO, SO_2, NH_3 and H_2S (see Table IV-2). In the case of SO_2 and NH_3 where two health-based thresholds have been established, the lower of the two was selected as a benchmark.

Table IV-2: Benchmark Levels

Pollutant	Time Period	Reference Level	Basis
PM_{10}	Daily	150 μg/m³	24 hour NAAQS
$PM_{2.5}$	Daily	35 μg/m³	24 hour NAAQS
Silica Crystalline	Daily	10 μg/m³	WTC Task Force – OSHA-PEL (100% respirable silica) divided by 10
CO	Hourly	35 ppm	1-hour NAAQS
SO_2	Hourly[1]	0.075 ppm	1-hour NAAQS
NH_3	Hourly[2]	3.4 ppm	NYSDEC- SGC
H_2S	Hourly	0.51 ppm	AEGL-1 (1 hour)

Notes:
1. AEGL-1 for SO_2 is 0.20 ppm
2. AEGL-1 for NH_3 is 30 ppm

V. Measured Air Quality Data - Analysis and Results

As described in the previous sections, the monitoring program collected minute-by-minute concentrations of PM_{10}, $PM_{2.5}$, VOC, NO, NO_2, NH_3, SO_2, H_2S and CO continuously for one month from September 12th through October 8th and respirable silica during a two week period. The monitoring instrumentation was configured to collect data and transmit the collected data via wireless modem to an off-site data center. Data from the monitoring equipment that required manual downloads was downloaded on a daily basis during weekdays. In addition, the 37mm three-piece PVC filter cassettes, associated with the silica monitoring program, were collected each weekday during the silica monitoring program.

This section provides a summary and analysis of the collected data. The data collected went through quality assurance and quality control (QA/QC) following the Quality Assurance Project Program (QAPP) prepared for this monitoring program (see Attachment C), and was compiled into hourly and daily levels for comparison to the reference levels.

A. PM_{10} Data Analysis and Results

PM_{10} levels were collected at seven air monitoring stations: Sites 2, 3, 4, and 6 within Contract C4B limits (between 69th and 73rd Streets) were selected to capture the effects of construction and blasting operations of the 72nd Street Station cavern; and Sites 7, 9, and 10 within Contract C5A limits (83rd to 87th Streets) were selected to capture the effects of open ceiling excavation and tests blasts performed for the 86th Street Station.

A.1. Evaluation of Daily Data and Comparison to Reference Levels

In order to compare to the reference levels, the data were aggregated into 24 hour averages. Figure V-1 and V-2 provide daily (24 hour average) PM_{10} concentrations for each contract area (Sites 2, 3, 4, and 6 for C4B and Sites 7, 9 and 10 for C5A).

The monitoring results for PM_{10} indicate that the daily levels were well below the PM_{10} reference level of 150 $\mu g/m^3$, with weekday levels ranging from 15 to 60 $\mu g/m^3$, and a weekend levels from 5 to 40 $\mu g/m^3$.

The PM_{10} concentrations measured at the Second Avenue sites were comprised of several components: the regional background emissions, the local source contributions and the impacts of construction activities and blasting.

Summaries of the data used in the graphs and plots are provided in Attachment D.

Figure V-1: PM_{10} – 24-Hour Average Concentrations (Sites 2, 3, 4, and 6)

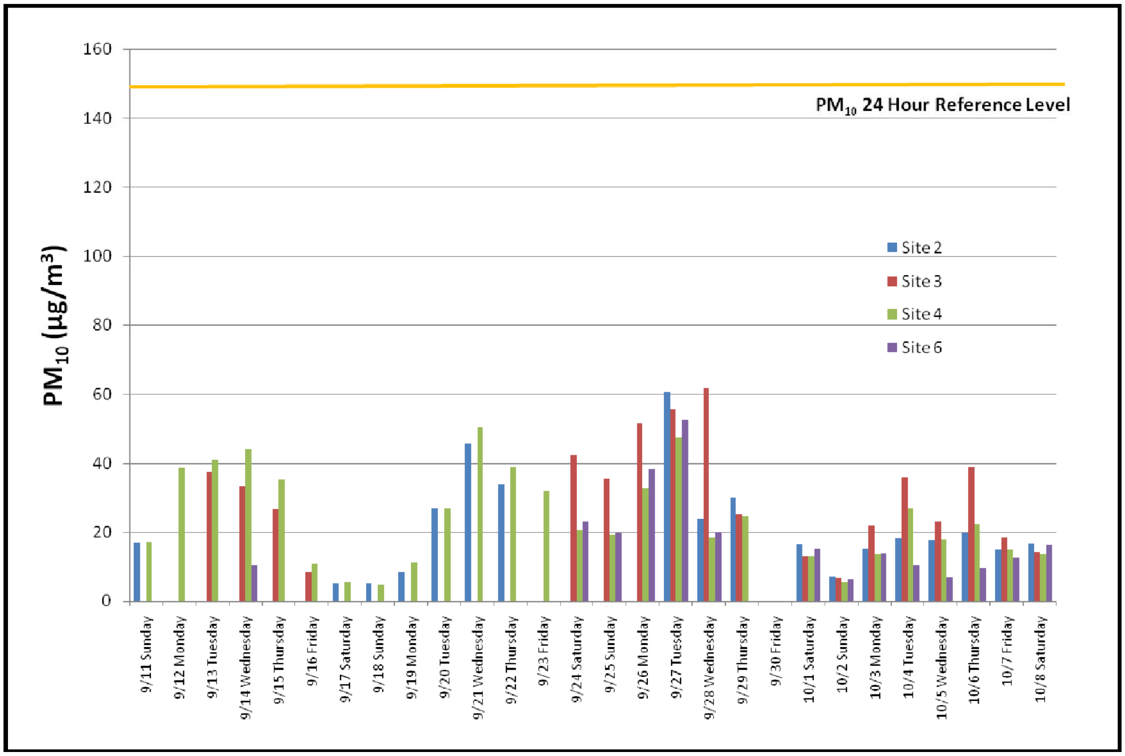
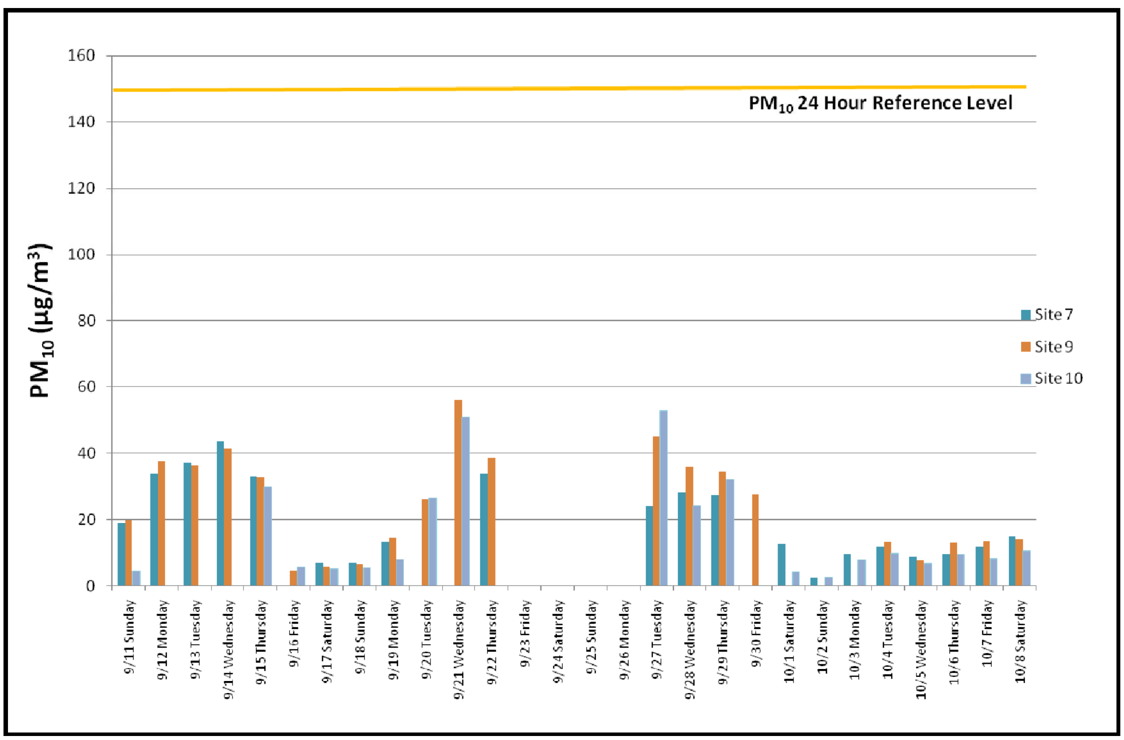


Figure V-2: PM_{10} – 24 Hour Average Concentrations (Sites 7, 9, and 10)



A.2. Evaluation of Hourly Data

The reference level for PM10 is based on the NAAQS, which is a 24-hour average value. In setting the standard, EPA took into account that for short periods of time, levels would be higher or lower than the 24-hour average value. In addition, EPA siting criteria locates air monitoring equipment away from local sources, such as roadways and construction projects. However, given that a stated objective of this monitoring program is to capture the possible air pollution effects of construction activities (using worst-case monitoring locations), an analysis of the hourly data was performed.

In order to better understand the effects of blasting activities, the hourly concentrations were analyzed by plotting the monthly maximum and average levels for each hour of the day separating weekdays from weekends. This process is repeated for the $PM_{2.5}$ data evaluation.

72nd Street Area (Contract 4B)

Figures V-3 to V-4 provide the maximum and average hourly PM_{10} levels for the weekdays during the four-week monitoring period, and Figures V-5 and V-6 the maximum and average weekend levels for Sites 2, 3, 4 and 6 (i.e., for Contract C4B).

The weekday plots indicate that the peak levels are associated with the afternoon blasting events. Site 3 (located at 70th Street directly across the street from the north side of the muck house) recorded the highest concentration of 573 $\mu g/m^3$ on September 28 (note that Figure V-3 uses a different scale from the others). Sites 4 and 6 recorded concentrations over 200 $\mu g/m^3$, while concentrations at Site 2 located on the west side of Second Avenue at a third floor fire stairs did not show peaks similar to the other three sites. This indicates that the PM_{10} effects of blasting operations are localized and limited to the areas in close proximity to the muck houses. Average hourly weekday concentrations (Figure V-4) follow a similar pattern as the maximum levels on Figure V-3, but the actual concentrations were much lower (about a quarter of the peaks, with all sites below 100 $\mu g/m^3$).

These plots confirmed that high peak levels during blasting events were not a daily occurrence. It seems that the daily variability of number of blasting events, its intensity and underground locations, underground air flow conditions, and the localized street level wind conditions contribute to the significant variability of recorded hourly concentrations. The average hourly levels varied from 20 to 36 $\mu g/m^3$ and 95 percent of all measurements were below 95 $\mu g/m^3$. The variability between peak and average concentrations reflect the fact that construction and blasting operations have a noticeable effect on short-term PM_{10} levels.

The weekend hourly PM_{10} plots for the four sites (in Contract C4B) recorded lower levels (below 90 $\mu g/m^3$ for peaks levels, and 40 $\mu g/m^3$ for average levels) with the highest values between 9:00 a.m. and 3:00 p.m. The character of the diurnal variation of the weekend concentrations points to a connection with the emissions from Second Avenue traffic.

86th Street Area (Contract 5A)

Figures V-5 to V-6 provide the maximum and average hourly PM_{10} levels for the weekdays during the four-week monitoring period, and Figures V-7 and V-8 the maximum and average weekend levels for Sites 7, 9, and 10 (Contract C5A).

The weekday plots indicate some effect from the test blasts at 86th Street (Figure V-5) at Site 9, but the effect is much less pronounced than at sites in Contract C4B (Figures V-1 and V-2). The other two sites (7 and 10) do not reflect any effect of blasting events. The average weekday levels are much lower than the peak hours at the three sites (less than a third), and the average pattern is consistent with motor vehicle emission patterns at Second Avenue (highest during morning period between 7:00 a.m. and 9:00 a.m.).

The weekend hourly PM_{10} plots for these three sites indicate much lower levels (peak levels below 50 $\mu g/m^3$, and average levels 20 $\mu g/m^3$) with the highest values after 7:00 a.m., which also reflects a certain correspondence to the Second Avenue traffic emissions.

Summaries of the data used in the graphs and plots are provided in Attachment D.

Figure V-3: PM_{10} – Maximum Hourly Levels (Weekdays, Sites 2, 3, 4 and 6)

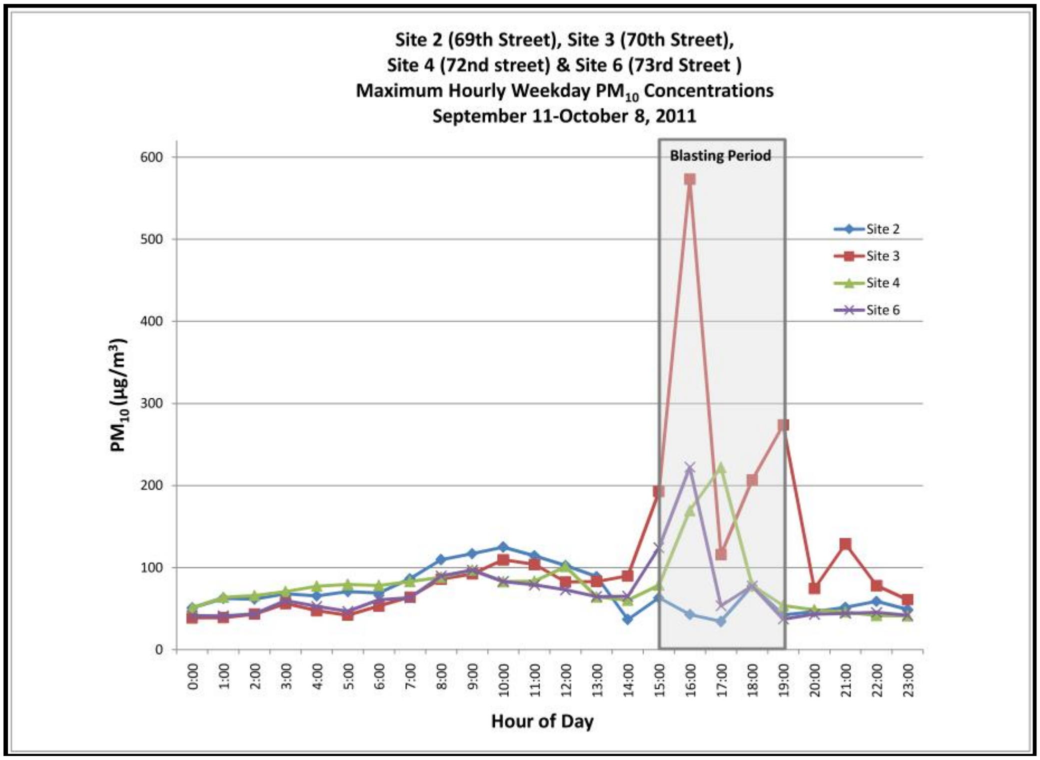


Figure V-4: PM_{10} – Average Hourly Levels (Weekdays, Sites 2, 3, 4 and 6)

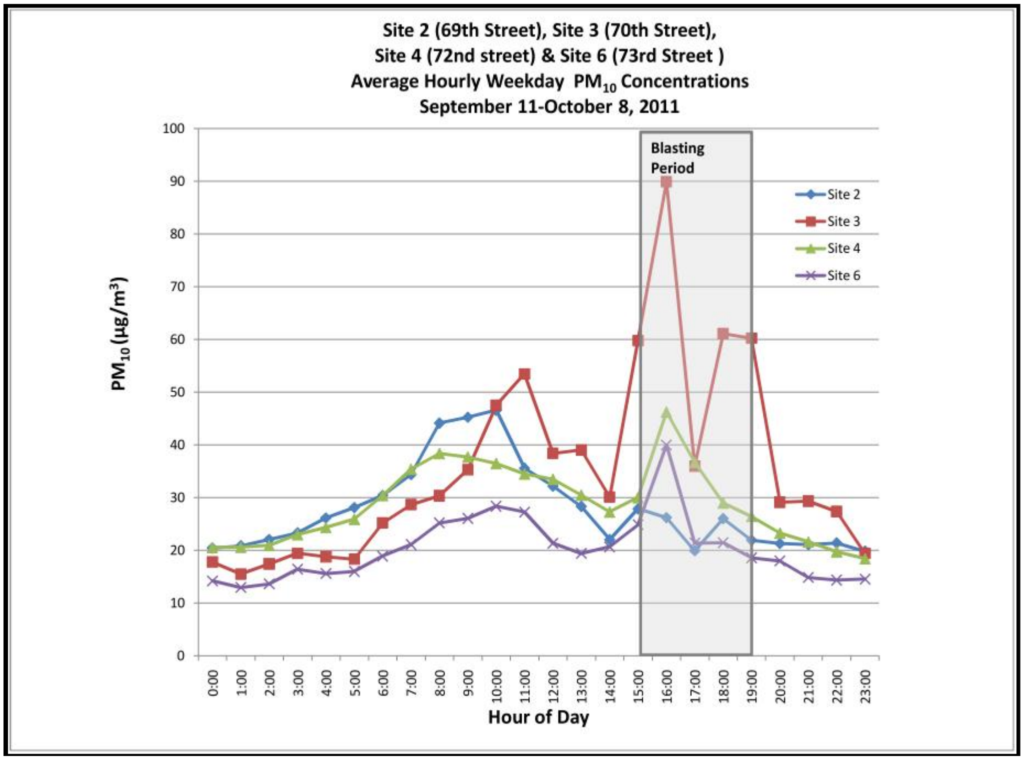


Figure V-5: PM_{10} – Maximum Hourly Levels (Weekends, Sites 2, 3, 4 and 6)

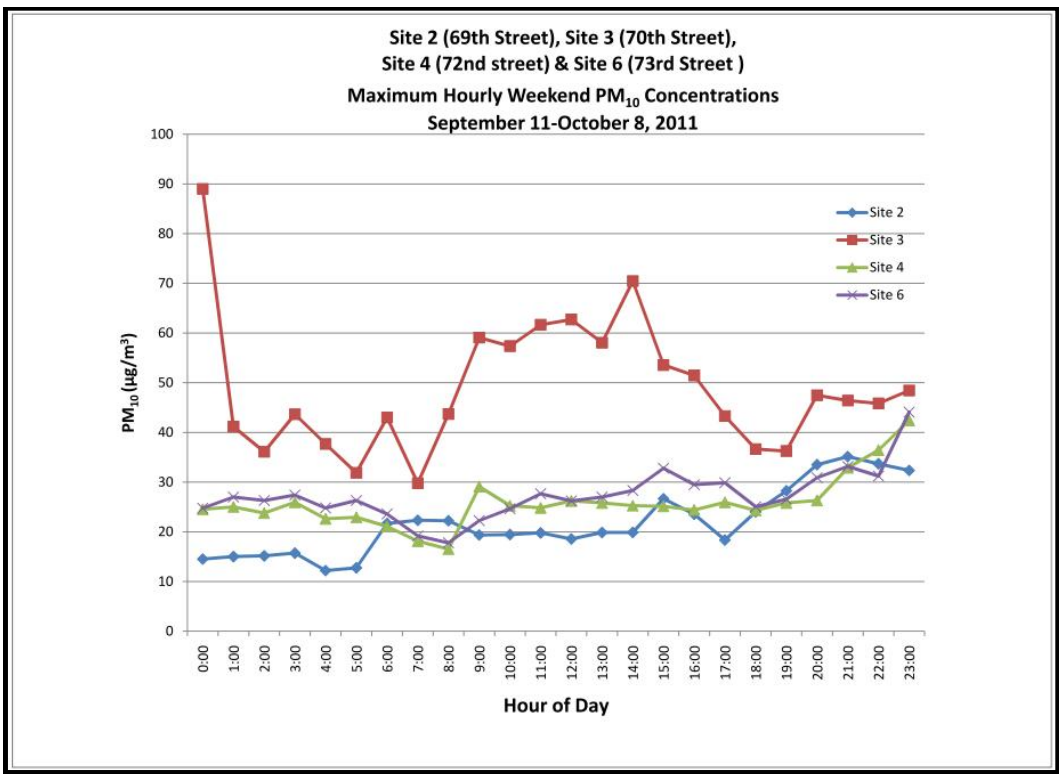


Figure V-6: PM_{10} – Average Hourly Levels (Weekends, Sites 2, 3, 4 and 6)

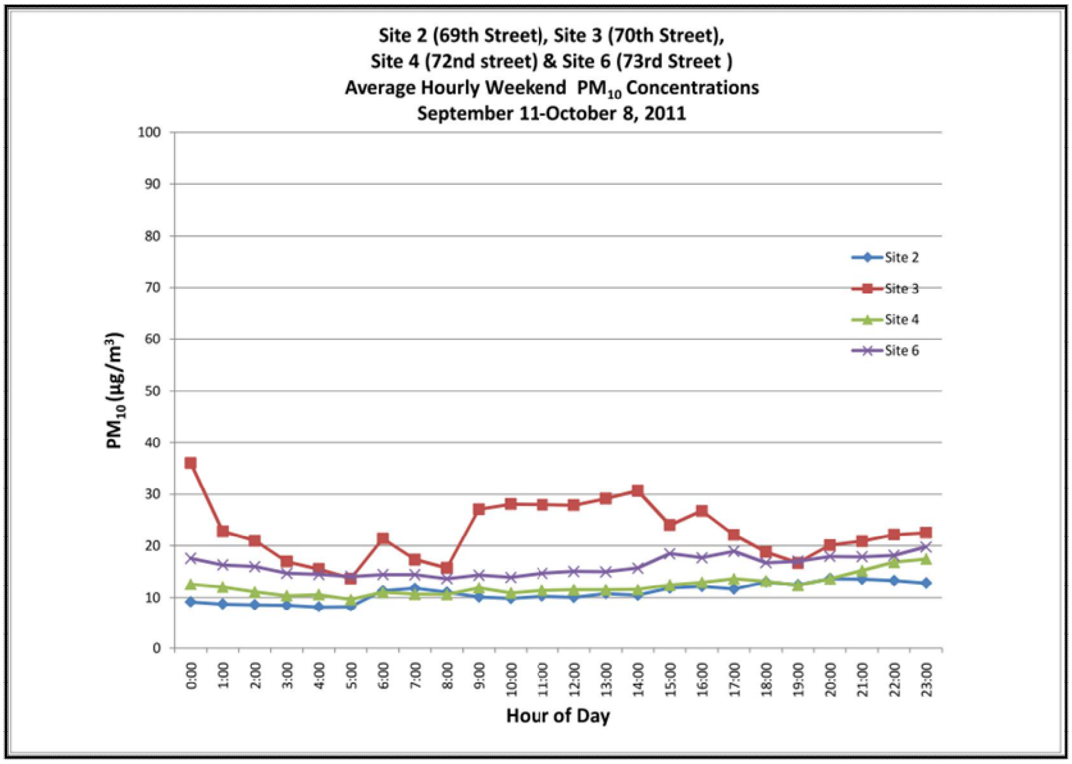


Figure V-7: PM_{10} – Maximum Hourly Levels (Weekdays, Sites 7, 9, and 10)

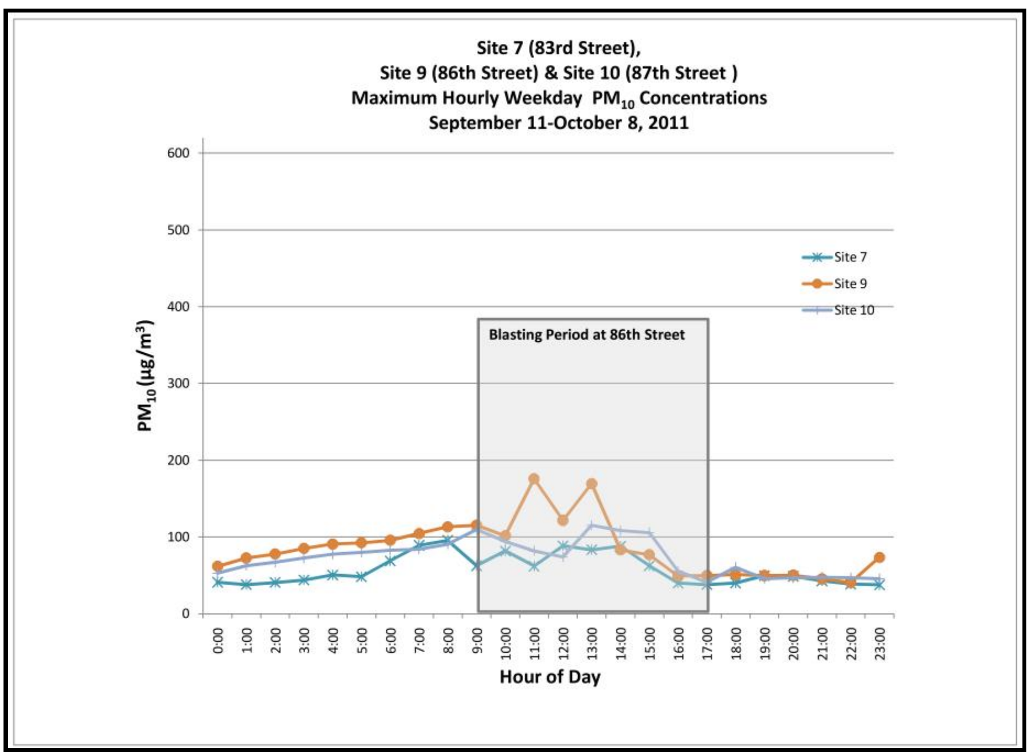


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Figure V-8: PM_{10} – Average Hourly Levels (Weekdays, Sites 7, 9, and 10)

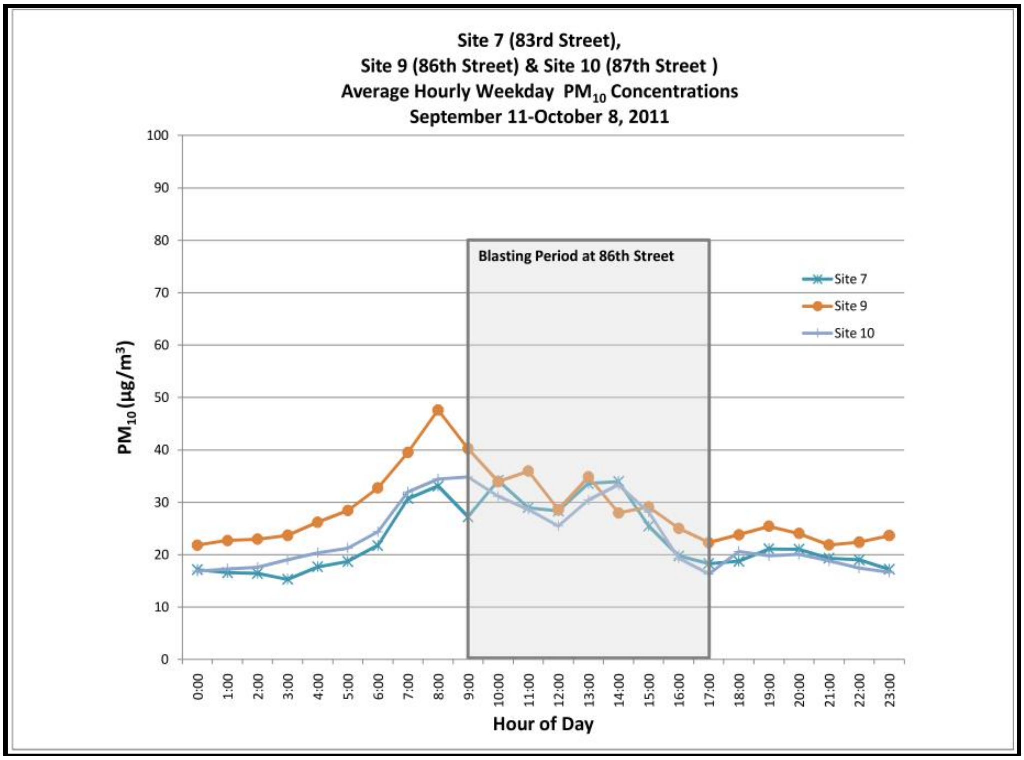


Figure V-9: PM_{10} – Maximum Hourly Levels (Weekends, Sites 7, 9, and 10)

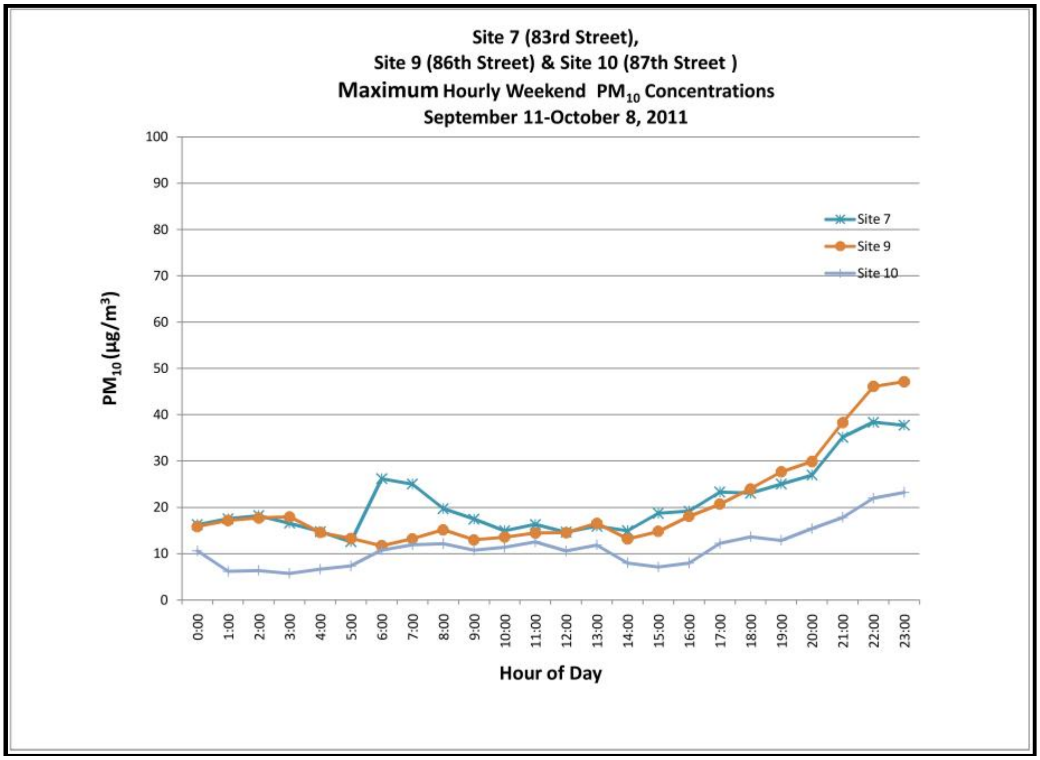
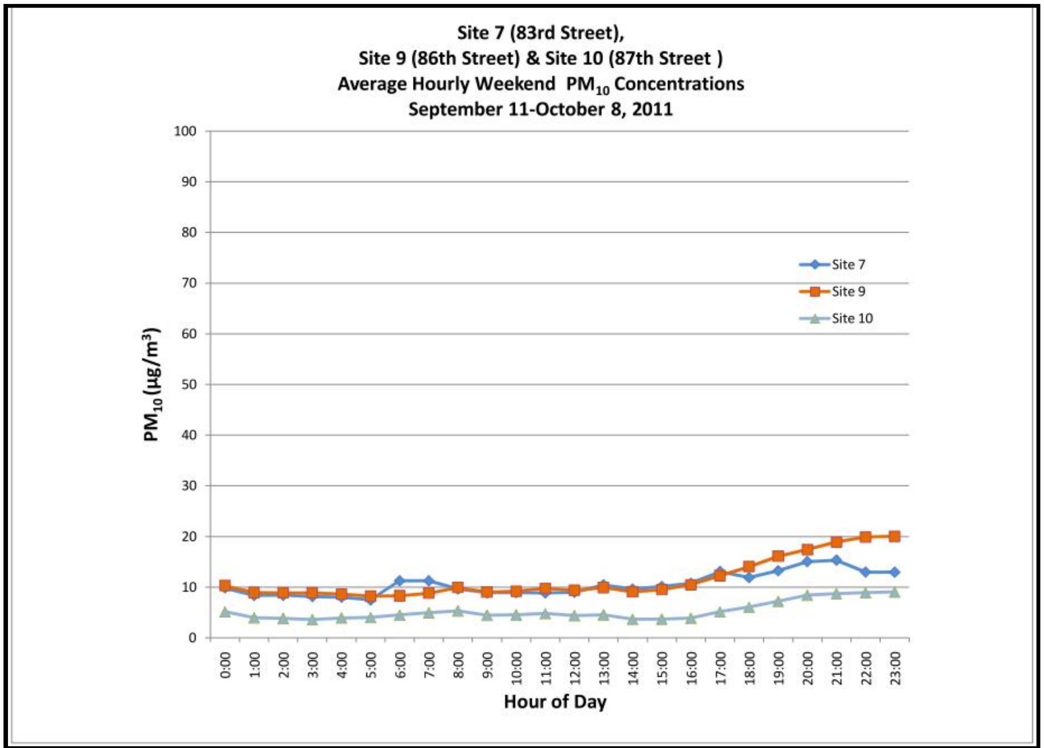


Figure V-10: PM_{10} – Average Hourly Levels (Weekends, Sites 7, 9, and 10)



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B. $PM_{2.5}$ Data Analysis and Results

$PM_{2.5}$ levels were collected at three Air Monitoring Stations: two (Sites 1 and 5) within Contract C4B limits (between 69th and 73rd Streets), and one (Site 8) at 83rd Street.

B.1. Evaluation of Daily Data and Comparison to Reference Levels

In order to compare to the reference levels, the data were aggregated into 24-hour average concentrations. Figures V-11 and V-12 provide daily (24-hour average) $PM_{2.5}$ concentrations for each contract area (Sites 1, 5 and 8). Each Site had one weekday with levels above the $PM_{2.5}$ reference level of 35 $\mu g/m^3$. The highest measured level was close to 40 $\mu g/m^3$ and was monitored on Tuesday, September 27th, at Site 5. Weekday average levels were between 15.3 and 21 $\mu g/m^3$. The weekend levels were approximately half of the weekday levels with average levels between 8.2 and 11.7 $\mu g/m^3$.

Summaries of the data used in the graphs and plots are provided in Attachment D.

Figure V-11: $PM_{2.5}$ – 24-Hour Average Concentrations (Sites 1 and 5)

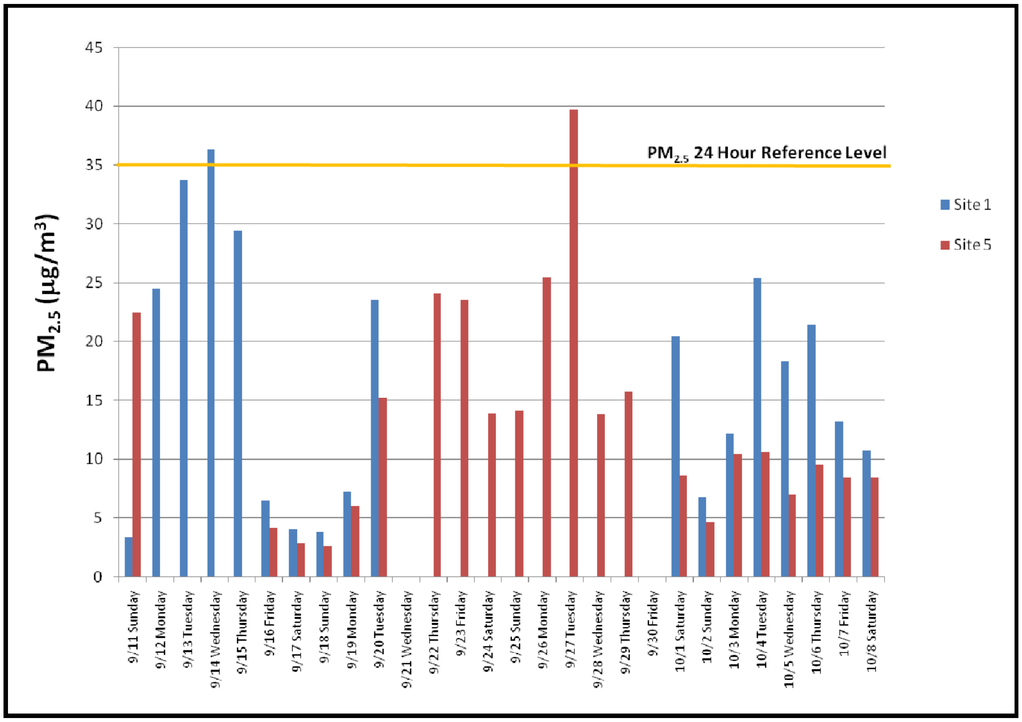
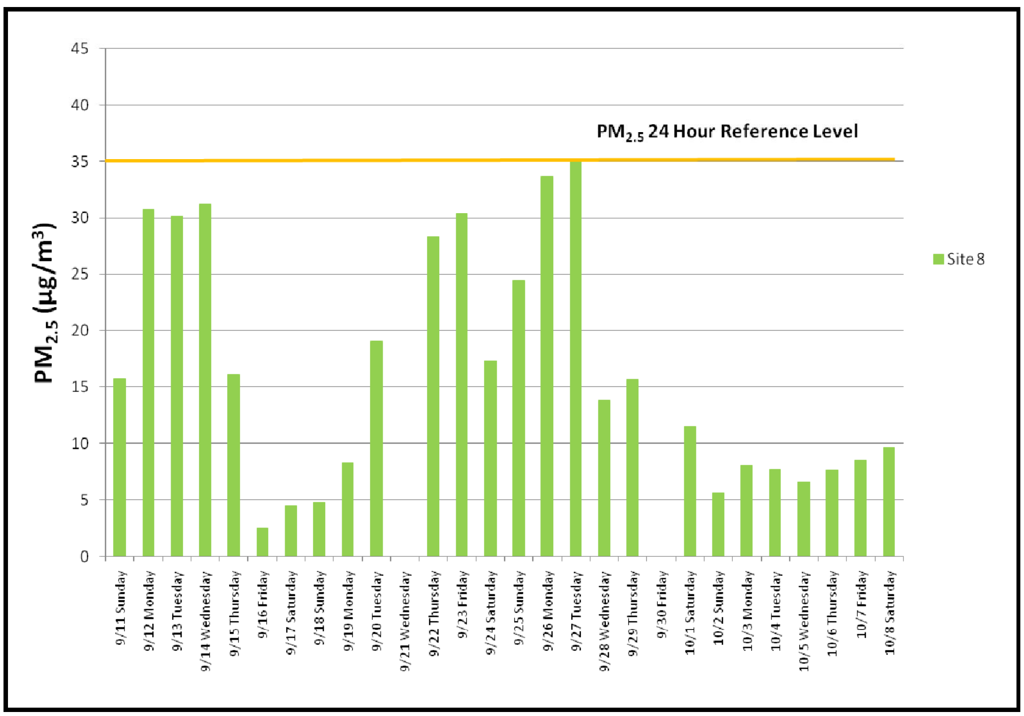


Figure V-12: $PM_{2.5}$ – 24 Hour Average Concentrations (Site 8)



B.2. Evaluation of Hourly Data

The reference level for $PM_{2.5}$ is based on the NAAQS, which is a 24-hour average value. In setting the standard, EPA took into account that for short periods of time, levels would be higher or lower than the 24-hour average value. However, given that a stated objective of this monitoring program is to capture the possible air pollution effects of construction activities (using worst-case monitoring locations), an analysis of the hourly data was also performed for $PM_{2.5}$.

The evaluation of hourly data first considers the hourly measurements for the three days when the daily levels exceeded the reference level, and it continues the evaluation of the maximum and average hourly levels for the full monitoring period separating the weekdays and the weekends as done for PM_{10}.

Figure V-13 provides the hourly data at each monitor during the three occasions when daily $PM_{2.5}$ concentrations exceeded the reference levels. As observed in this figure, blasting operations had no significant effect on the $PM_{2.5}$ levels. The highest $PM_{2.5}$ levels occur during morning hours and correlate with motor vehicle traffic.

Figure V-14 provides the average hourly traffic volumes during the weekday and weekend at 71st Street from data collected during November 2011. As it can be observed in these figures, the total volumes during the weekdays are higher than during the weekends, and experience an earlier morning peak during the weekdays. A similar graphic for 86th Street, and the data supporting these graphics is included in Attachment E.

Figure V-14 also includes (in the right scale) the hourly $PM_{2.5}$ motor vehicle emissions in grams per mile for the hourly traffic volume at Second Avenue between 71st and 72nd Street. These emissions are calculated from the Second Avenue and 71st Street traffic counts performed during November 2011 (volume of traffic by vehicle class) and Mobile 6.2 emission factors (grams per mile by vehicle class). The higher motor vehicle emissions during the morning rush hour reflects the higher percentage of truck traffic operating at this time on Second Avenue as compared to other times of the day.

Figures V-15 to V-16 provide the maximum and average hourly $PM_{2.5}$ levels for the weekdays, and Figures V-17 and V-18 the maximum and average weekend levels for Sites 1 and 5 (72nd Street Station area - Contract C4B). The maximum weekday recorded hourly levels were between 76 and 83 $\mu g/m^3$. As it can be observed, the morning $PM_{2.5}$ concentration curve follows the traffic emissions, while in the afternoon a peak over the traffic emissions indicate some possible effect from blasting operations.

The weekend hourly $PM_{2.5}$ plots for the Contract C4B sites indicate that hourly levels were close to half of the weekday levels. There was one anomaly on the early morning of October 1st for Site 1 for which there is no explanation. Site 5 data reflects the weekend traffic patterns on Second Avenue.

Figures V-19 to V-20 provide the maximum and average Hourly $PM_{2.5}$ levels for the weekdays, and Figures V-21 and V-22 the maximum and average weekend levels for Site 8 (86th Street Station area - Contract C5A). The weekday plot for Site 8 has a similar pattern to Site 5 with the morning peak levels higher than the afternoon peak levels. There is no indication that the small blasting events at 86th Street had any significant effect on hourly $PM_{2.5}$ levels. The weekend levels also follow the Site 5 pattern, with evening peaks and overall levels approximately half of the weekday levels.

Due to the limited scope of this study, specifically the limited amount of traffic data collected (that did not correspond to the dates of the monitoring period), background conditions could not be established. However, the vehicular volumes and associated emissions estimate indicate that the $PM_{2.5}$ levels recorded during the monitoring study are largely a result of vehicle emissions and regional pollution. Summaries of the data used in the graphs and plots are provided in Attachment D.

Figure V-13: $PM_{2.5}$ - Hourly Levels at Site **1** (69th Street), Site **5** (72nd Street), and Site **8** (83rd Street)

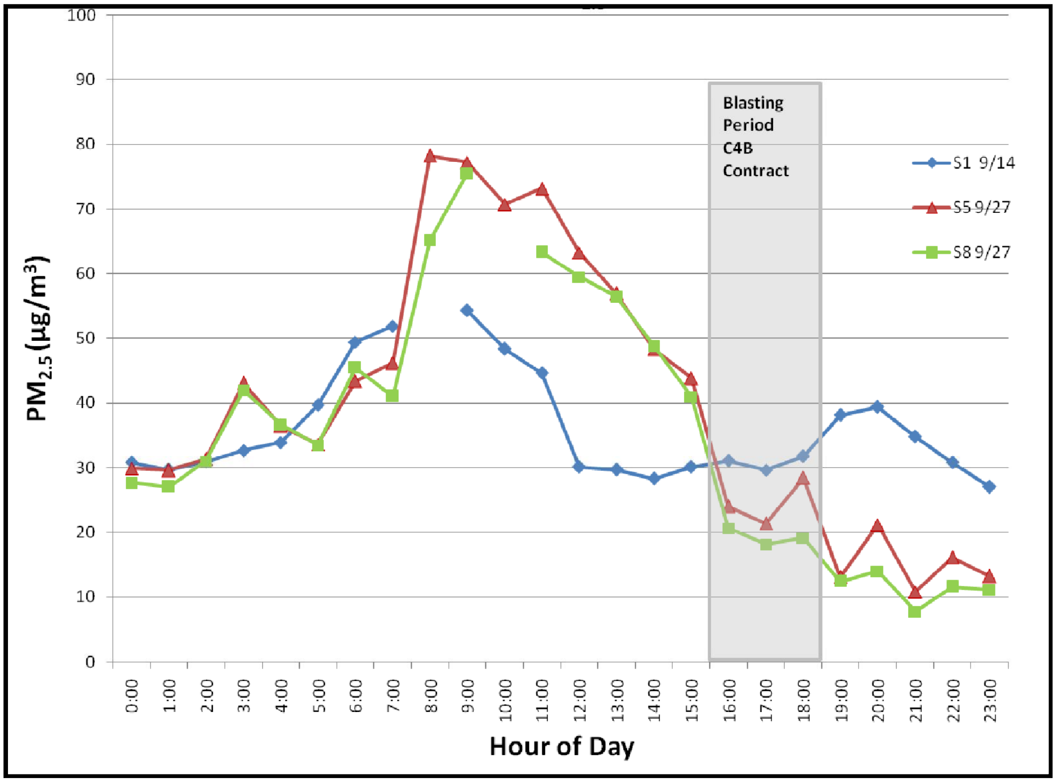


Figure V-14: Average Hourly Traffic Volume and Motor Vehicle Emissions (Second Avenue @ 71st Street)

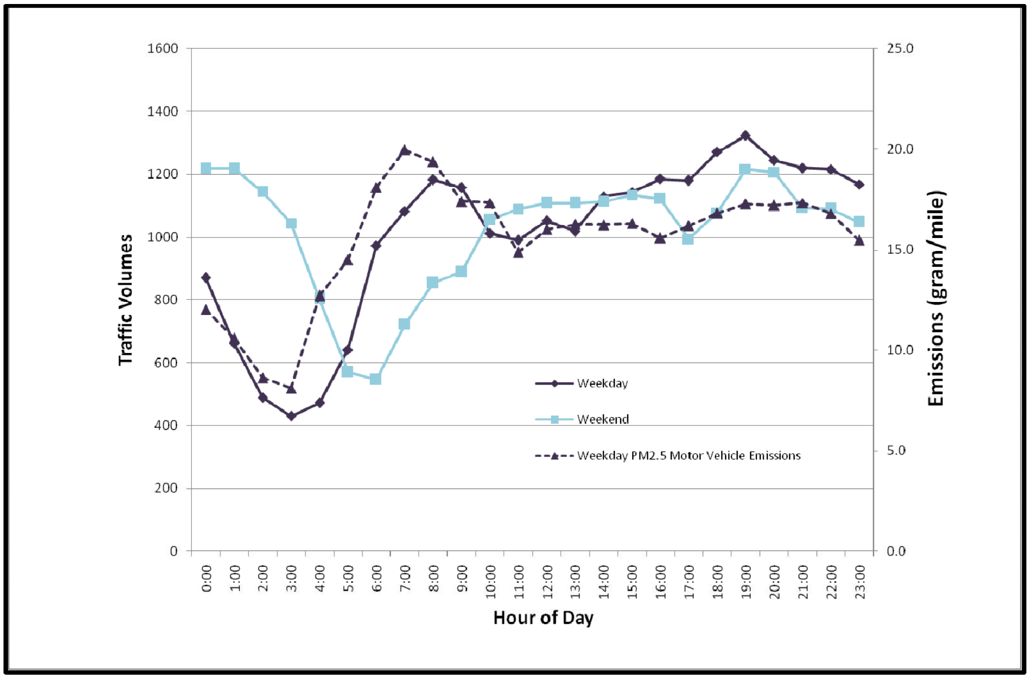


Figure V-15: $PM_{2.5}$ – Maximum Hourly Levels (Weekdays, Sites 1 and 5)

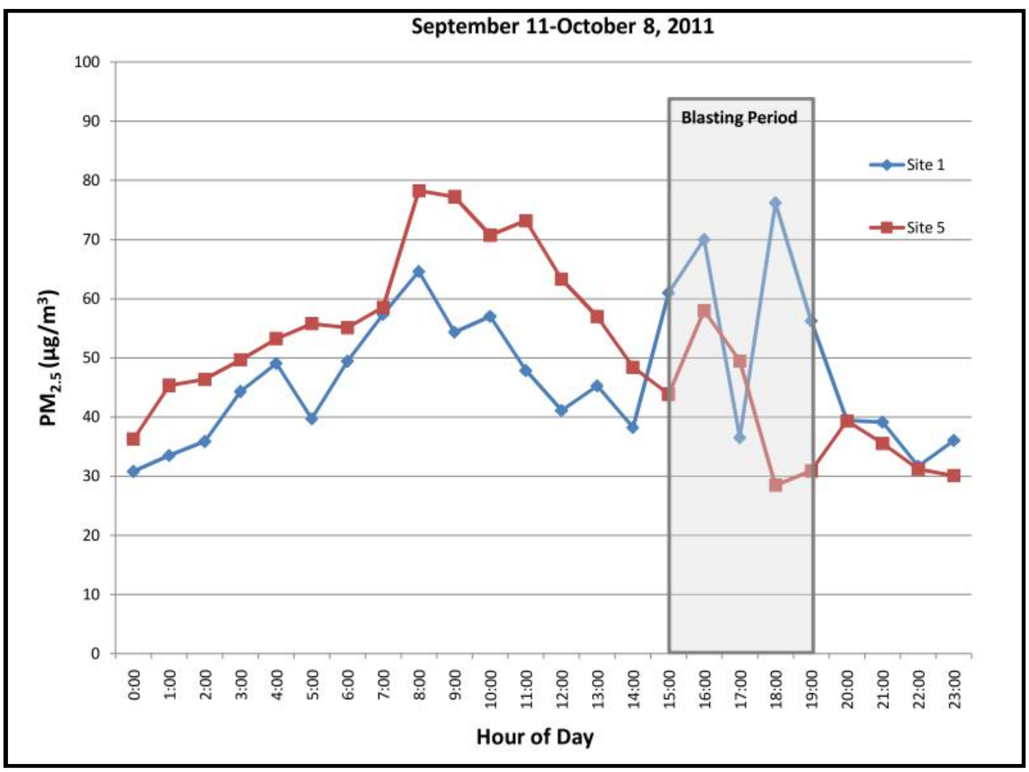


Figure V-16: $PM_{2.5}$ – Average Hourly Monitoring Values (Weekdays, Sites 1 and 5)

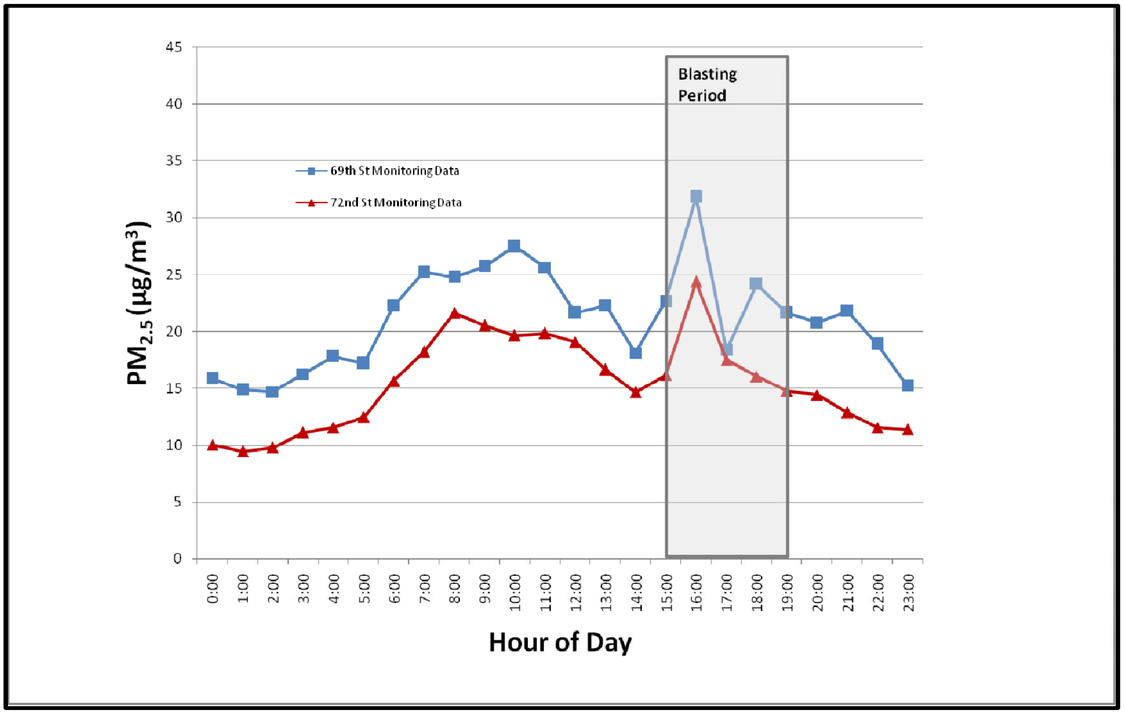


Figure V-17: $PM_{2.5}$ – Maximum Hourly Levels (Weekends, Sites 1 and 5)

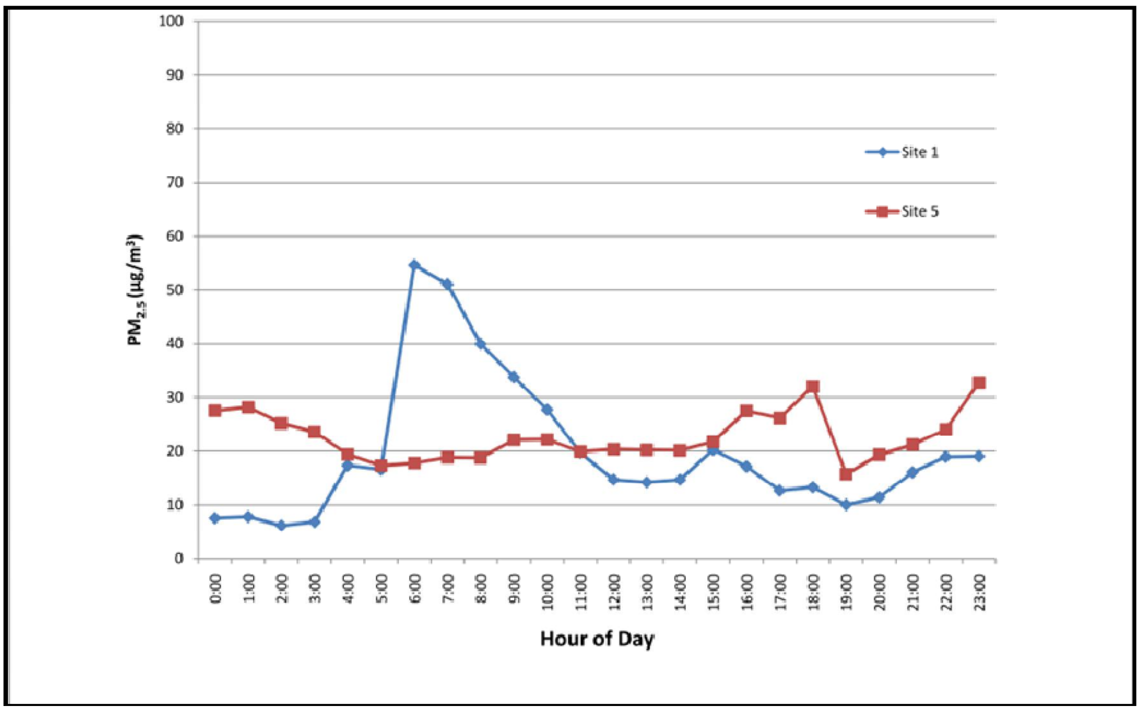


Figure V-18: $PM_{2.5}$ – Average Hourly Levels (Weekends, Sites 1 and 5)

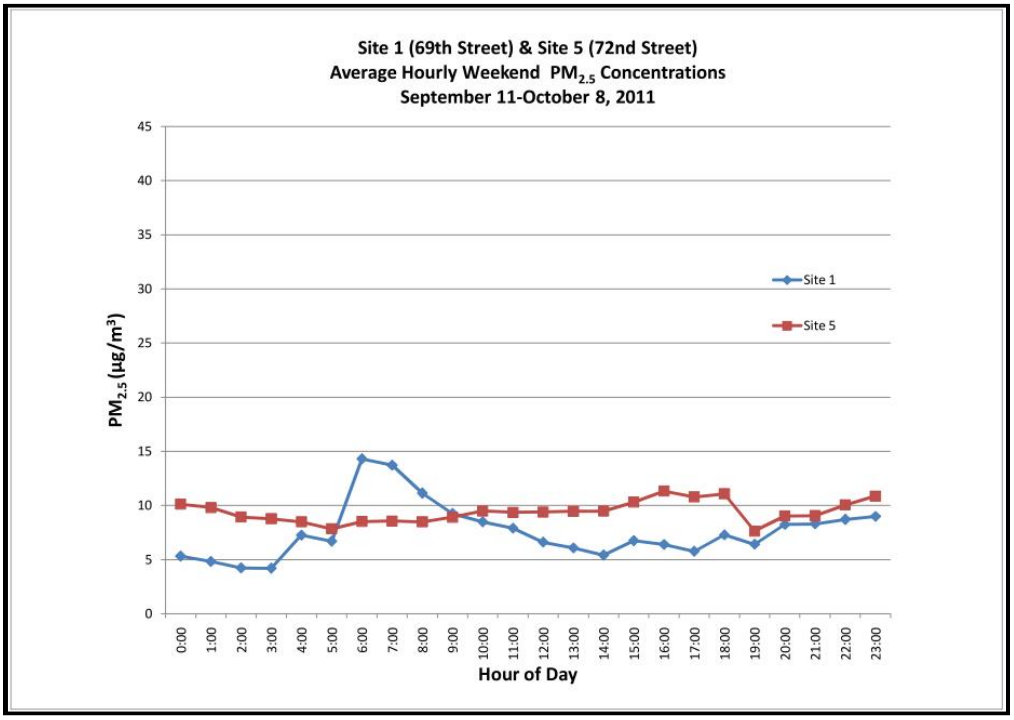


Figure V-19: $PM_{2.5}$ – Maximum Hourly Levels (Weekdays, Site 8)

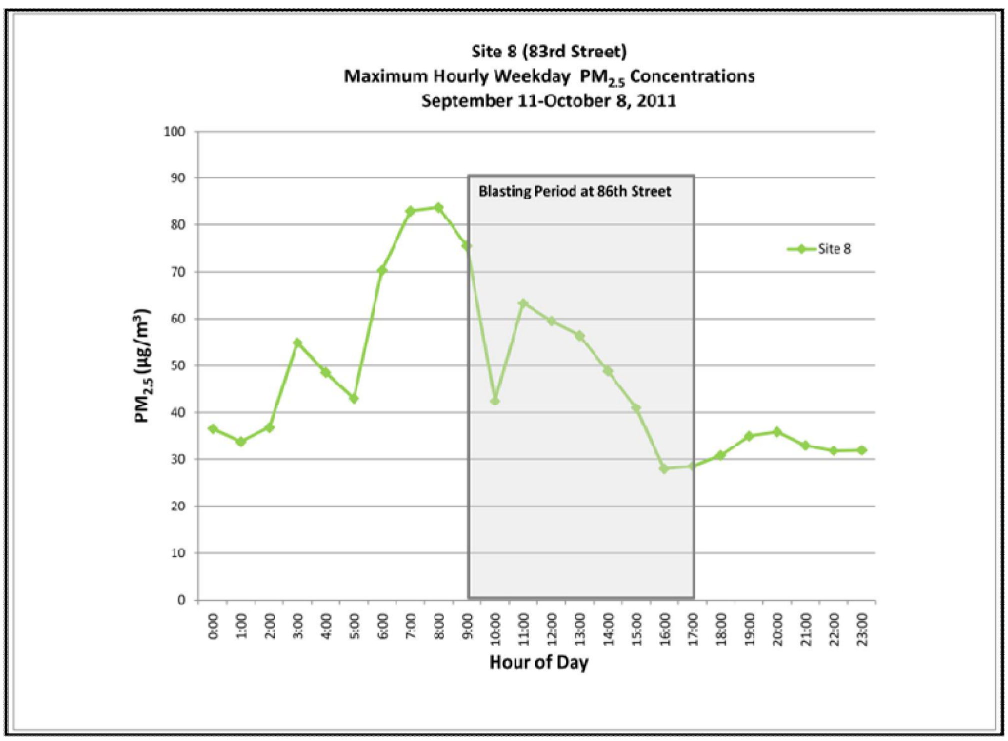


Figure V-20: $PM_{2.5}$ – Average Hourly Monitoring Values (Weekdays, Site 8)

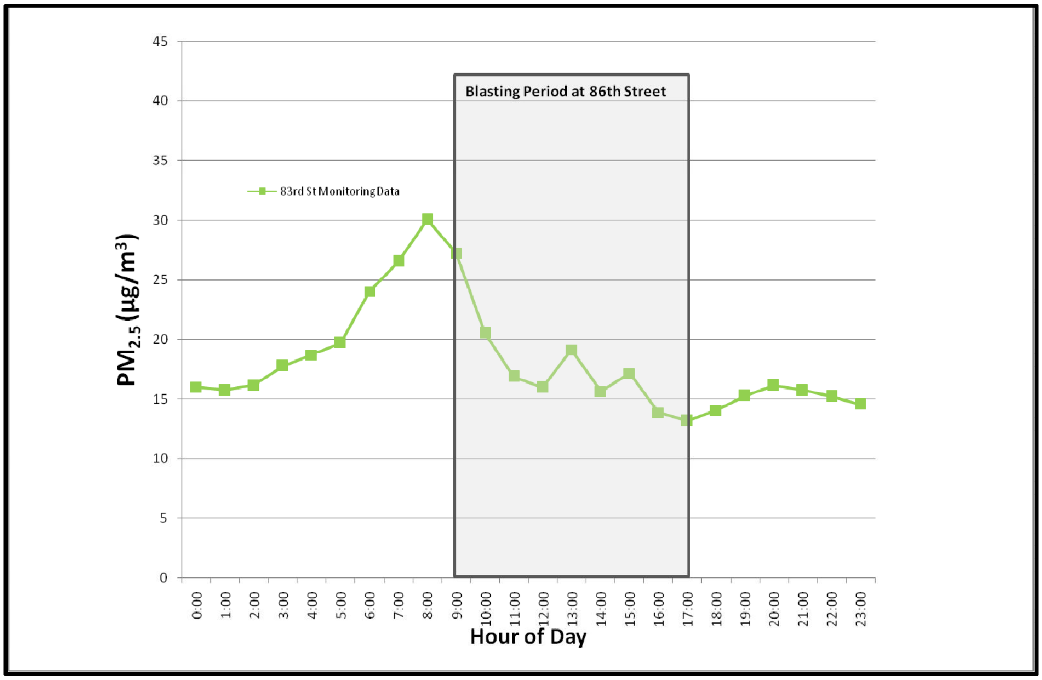


Figure V-21: $PM_{2.5}$ – Maximum Hourly Levels (Weekends, Site 8)

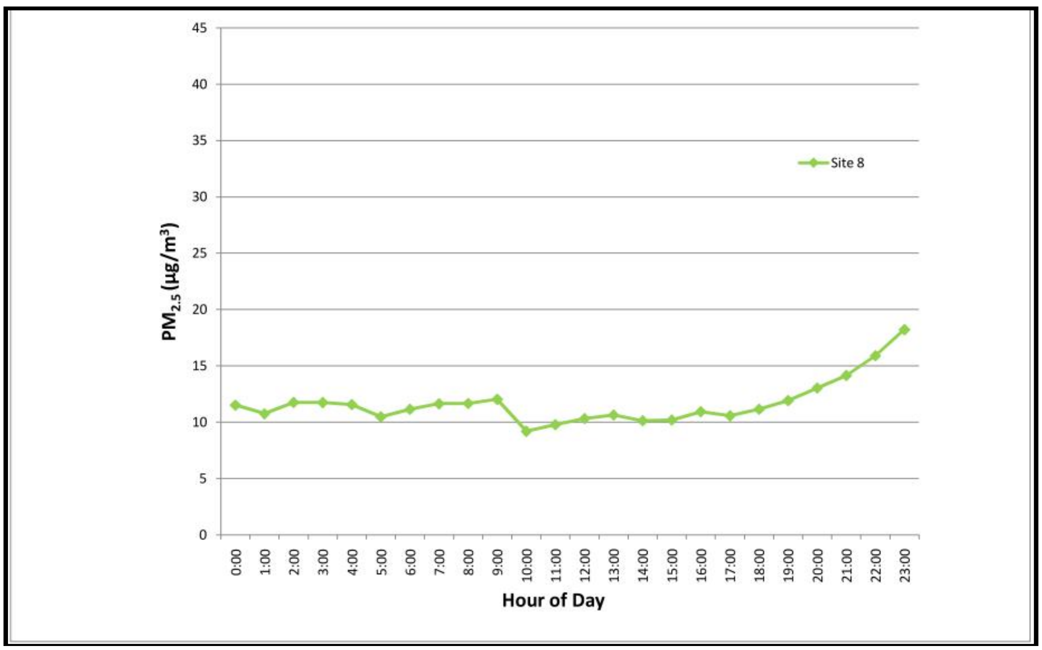
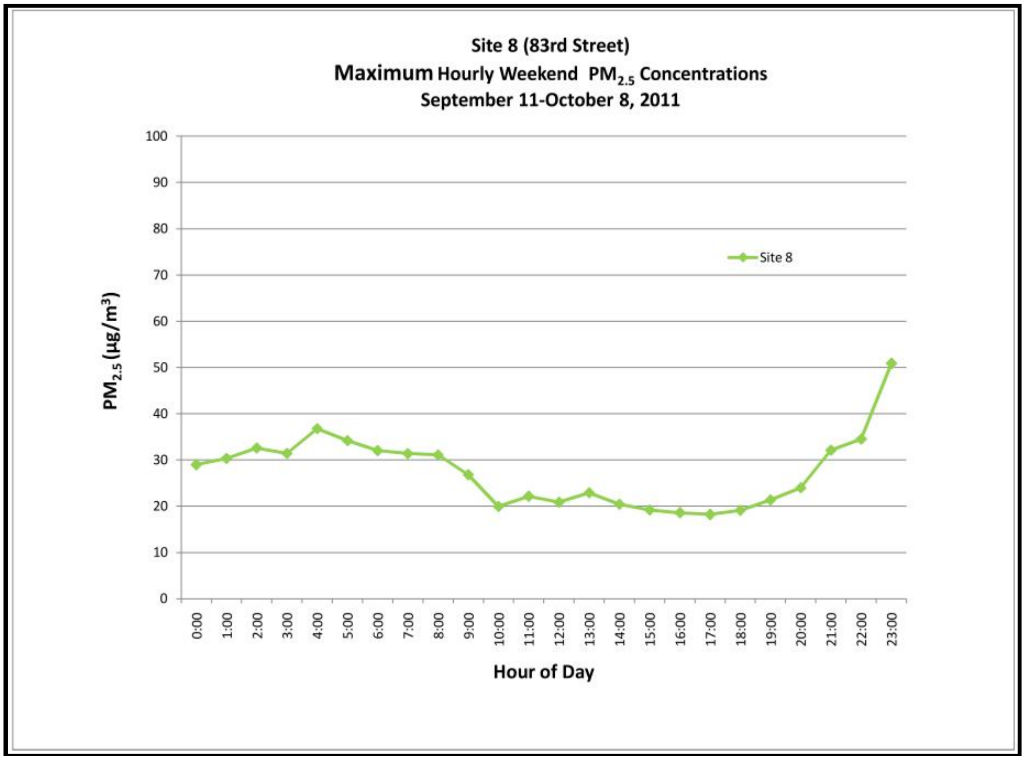


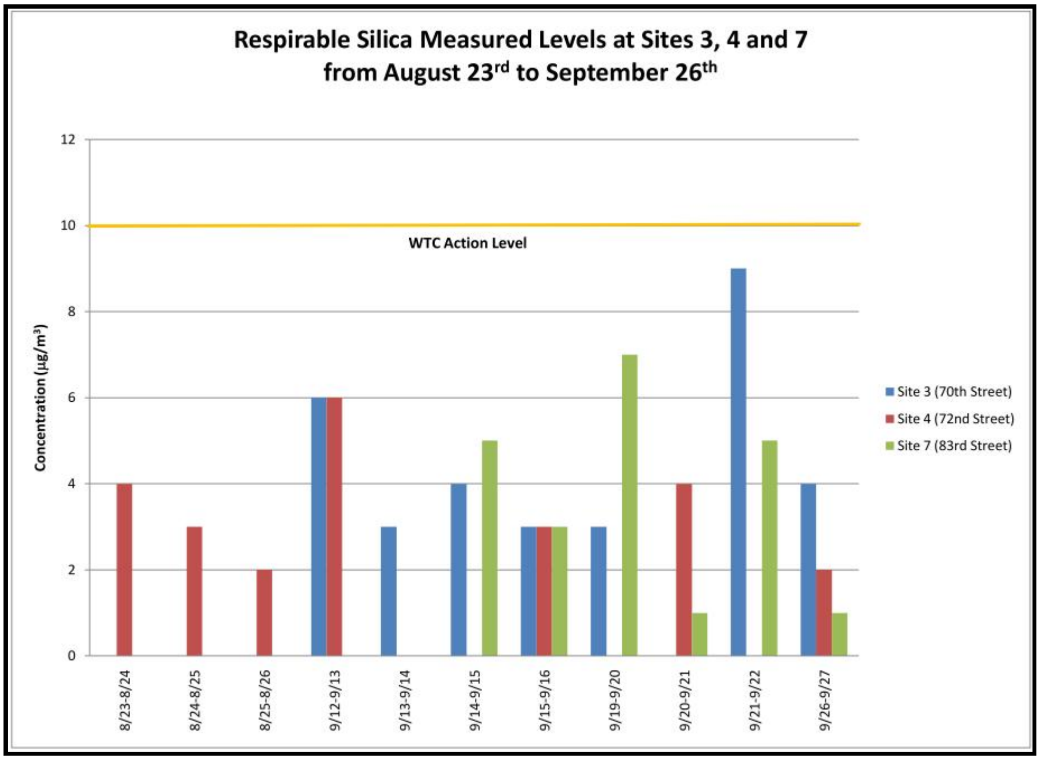
Figure V-22: $PM_{2.5}$ – Average Hourly Levels (Weekends, Site 8)



C. Respirable Silica

From August 23, 2011, to September 26, 2011, 19 silica samples were collected: 14 silica samples were collected at AMS 3 and AMS 4 and 5 samples were collected at AMS 7. All measured levels were below the established reference level of 10 µg/m^3 for a daily average as shown on Figure V-27. This action level is conservative and is ten times lower than the Occupational Safety and Health Administration (OSHA) 40-hour week exposure level. There are no standards for respirable silica exposure to the general public. The laboratory results are presented in Attachment F.

Figure V-23: Respirable Silica Measured (Sites 3, 4, and 7)



D. Gaseous Pollutants

CO, NO, NO_2, SO_2, NH_3, and H_2S minute-by-minute concentrations were compiled into hourly averages for comparison with the reference levels. As described in Section IV, reference levels were established for CO, SO_2, NH_3 and H_2S (see Table IV-2). The collected NO and NO_2 concentrations were used only as indicators for the odor investigation.

Table V-1 provides the average and maximum hourly levels measured at each monitoring station during the full four-week period for CO, SO_2, NH_3 and H_2S.

Table V-1: Measured Hourly Pollutant Levels with Corresponding Reference Levels

Period September 11-October 8, 2011 Part Per Million (PPM)					
Monitoring Station		CO	NH_3	SO_2	H_2S
1	Average	0.4	1.1	0.00	0.01
	Maximum	2.8	3.7	0.00	0.01
2	Average	0.1	0.0		
	Maximum	2.4	0.5		
3	Average	0.2	0.4	0.01	0.00
	Maximum	11.7	1.1	0.80	0.01
4	Average	0.2	0.0	0.00	0.00
	Maximum	33.4	0.4	0.11	0.01
5	Average	0.2	0.1	—	—
	Maximum	3.4	0.5	—	—
6	Average	0.2	0.1	0.01	0.00
	Maximum	8.6	0.8	0.26	0.01
7	Average	0.1	0.0	—	—
	Maximum	1.4	0.6	—	—
8	Average	0.1	0.0	—	—
	Maximum	1.7	0.5	—	—
9	Average	0.1	0.3	—	—
	Maximum	1.6	3.6	—	—
10	Average	0.1	0.1	—	—
	Maximum	3.6	0.6	—	—
Reference Levels		*35*	*3.4*	*0.075*	*0.51*

CO levels were very low for the vast majority of the time at all 10 locations and all measured levels were below the reference level of 35 ppm. The average levels were below 0.5 ppm at all locations. There was one anomaly, an elevated level of 33.4 ppm that was monitored at Site 4 on September 23rd at 7 p.m. This was not during the blasting operations and the source of this short-term spike could not be identified. This level is still below the reference level of 35 ppm. The NYSDEC CO monitors in Queens and the Bronx recorded average levels of 0.5 ppm during this time period, with a maximum of 1.2 ppm.

NH_3 levels were very low most of the hours recorded, with two hours exceeding the reference level of 3.4 ppm at Sites 1 and 9. These two occurrences were between 1:00 and 3:00 a.m. on September 27th and 29th. While the highest measured value of 3.7 ppm is slightly above the reference level, it is well below the AEGL-1 for NH3 (at 30 ppm).

H_2S average levels were very low during the monitoring period and mostly undetected by the instruments. All measured hourly levels were well below the reference level of 0.51 ppm during the monitoring period.

SO_2 levels were measured at 4 locations using a RKI Eagle II gas detector. Measured levels were below detection limits for most of the monitoring period with the exception of six days at three monitoring sites when hourly levels exceeded the reference level of 0.075 ppm. Figures V-28, V-29 and V-30 provide the time and measured concentrations for the events which exceeded the reference level.

The highest levels occurred at Sites 3 and 6 on October 5th, 6th and 7th between noon and 7 p.m. as shown on Figures V-28 and V-30. The SO_2 levels peaked before the blasting events and could not be correlated with this activity. The cause of the peak concentrations is currently unknown.

As a result of the elevated SO_2 readings, MTACC investigated all construction activities to identify a source of sulfur that could potentially give rise to SO_2 emissions at concentrations recorded on the sidewalk-level monitors. This effort involved:

- Reviewing the chemical make-up of the construction materials used both in the tunnel and at street-level. Sulfur compounds such as SO2 are created only when sulfur is present. Neither the explosives nor associated blasting products contain sulfur-bearing ingredients.
- Monitoring for SO_2 using hand held monitors in the vicinity of shotcrete cement operations, diesel equipment, welding and other construction activities. SO_2 was not detected during this investigation.
- Laboratory analysis of the blasting emissions collected on a specially treated filter held in a canister following a standard testing protocol (a reliable method from the National Institute for Occupational Safety and Health (NIOSH) called the NIOSH 6004 test method. SO_2 was not detected in any of the NIOSH 6004 tests performed. Laboratory results are included in Attachment G.
- Lab analysis of rock core samples from the 72nd Street Station area to investigate if sulfur compounds could be present. The results indicate that the sulfur content of the rock is low, ranging from 0.0009 to 0.75 percent. It is highly unlikely that blasting operations could generate SO_2 from this amount of sulfur in the rock. The NIOSH 6004 tests confirm this conclusion. Laboratory results are included in Attachment G.
- Testing possible interference of other gases on the SO2 levels recorded by the instrument. These tests revealed that the instruments are highly sensitive to the presence of other gases in the atmosphere, which can lead to false SO2 readings.
- Continuous SO_2 monitoring at sidewalk locations during November/December 2011; during that period SO_2 was below the reference level.

These tests did not identify the presence of sulfur in any construction activity that would generate SO_2. As such, the elevated readings on those six days in September/October could not be attributed to blasting operations or construction activities.

Figure V-24: SO_2 – Hourly Concentrations at Peak Days (Site **3** @ 70th Street)

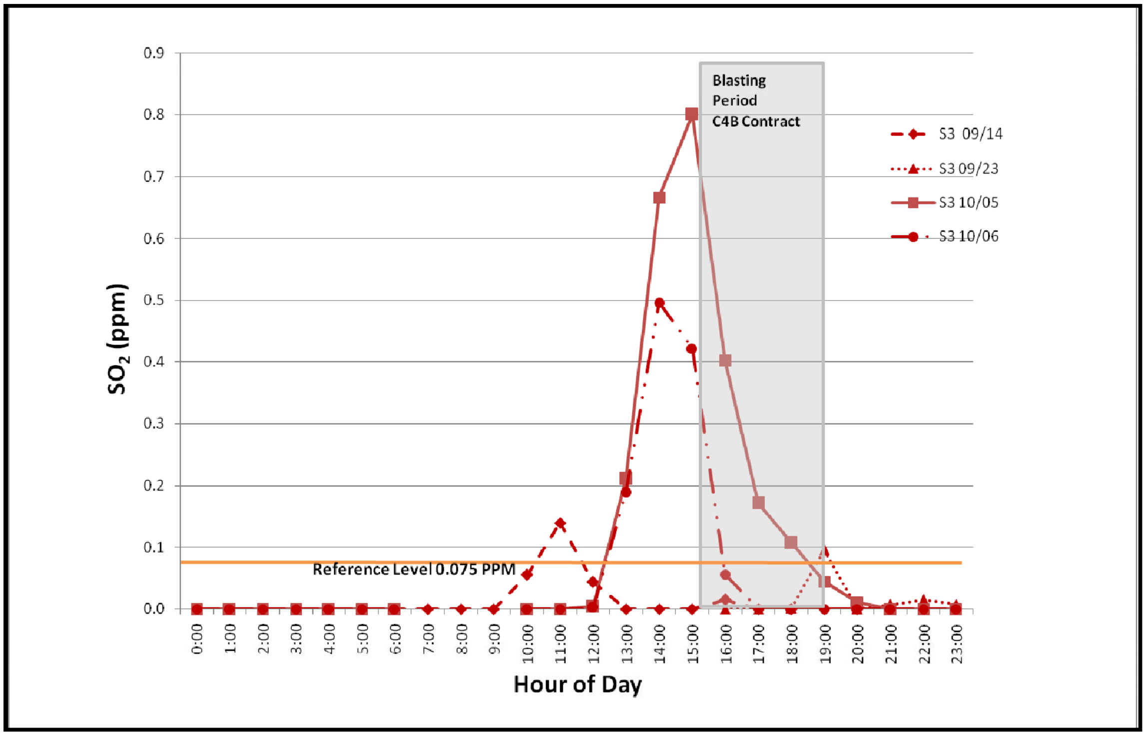


Figure V-25: SO_2 – Hourly Concentrations at Peak Days (Site **4** @ 72nd Street)

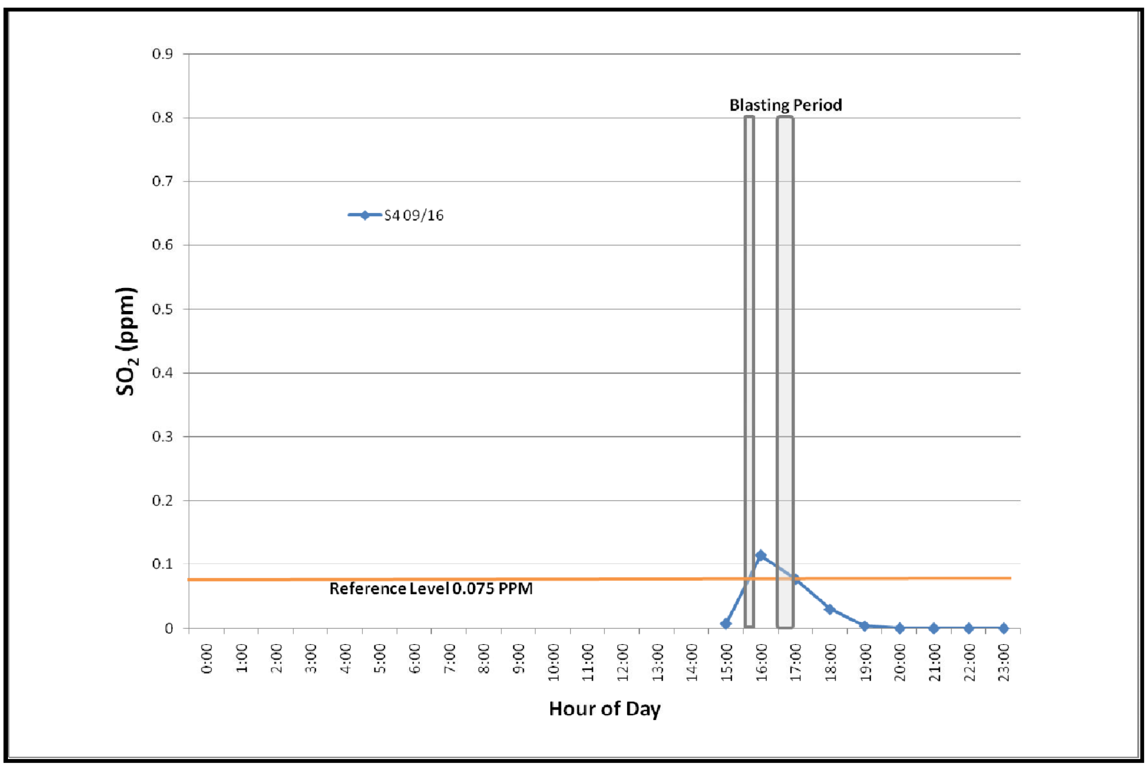
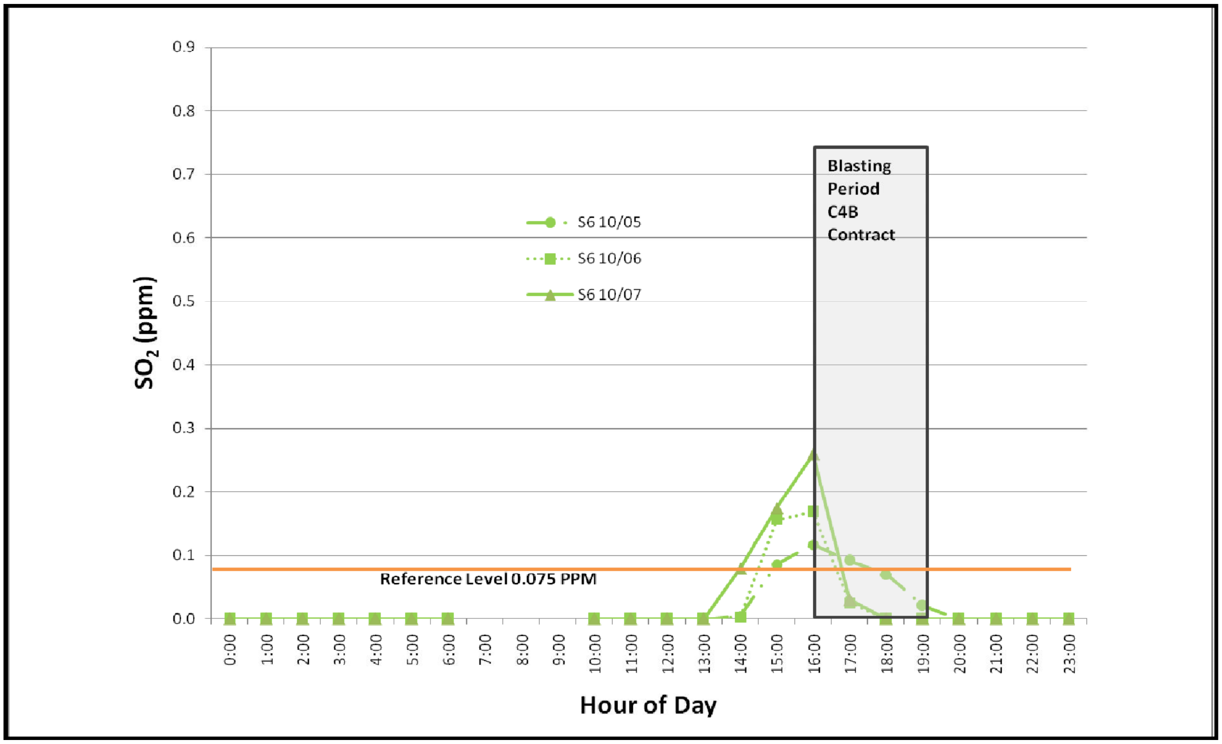


Figure V-26: SO_2 – Hourly Concentrations at Peak Days (Site **6** @ 73rd Street)



VOC levels were measured at 10 locations. The main purpose of these measurements was to evaluate the data collected by the CAMP program that has established a total VOC action level of 5 ppm for a 15-minute period. This action level was not included in the reference levels for this study since there are no health based state or federal standards for VOCs. The vast majority of the levels monitored were very low with averages below 0.5 ppm. Table V-2 provides the average and maximum 15-minute levels recorded at all monitoring stations. Site 2 recorded levels above the 5 ppm contractor action level at 16 occasions during two days. Site 4 recorded two occasions on one day above 5 ppm. The majority of these levels above 5 ppm occurred during the morning hours.

These levels are not unusual at a heavily travelled avenue with many possible sources of VOC, such as gasoline engines, small gas powered equipment, and the possible evaporation of petroleum-based materials used at the construction areas (glues, solvents, paints, etc.).

Table V-2: VOC – Average/Maximum Levels (measured at 15-minute intervals)

Pollutant		Monitoring Station									
		1	2	3	4	5	6	7	8	9	10
VOC (ppm)	Average	0.2	0.2	0.3	0.4	0.1	0.1	0.1	0.0	0.1	0.1
	Max	2.2	7.4	4.7	7.0	1.0	0.8	4.7	0.5	2.5	0.8

ppm = parts per million

VI. Evaluation of Contractor's Community Air Monitoring Program (CAMP)

The contractor's CAMP, which includes preparation of an Air Monitoring Plan at the beginning of each construction contract, is required to monitor the air pollution effects of construction activities (including blasting operations) based on real-time monitoring for PM_{10} and VOC at the perimeter of the work areas. The program includes action levels with an alarm system to notify the contractor if these levels are exceeded. These action levels are based on 15-minute average concentrations for PM_{10} and VOC.

An analysis of the CAMP data indicates multiple measurements recording PM_{10} and VOC levels above the established action levels. An evaluation of the contractor records and frequency of calibration procedures indicated that monitored levels for VOC were outside the expected pollutant ranges as measured by this SAS monitoring program. Our team could not find any evidence that the CAMP monitors were calibrated at the frequency necessary to provide continuous reliable data. It is relevant to indicate that no significant sources of VOCs were identified in the construction areas.

The best approach to determine the accuracy of the recorded PM_{10} and VOC levels collected by the CAMP equipment was to identify the collocated monitors between the CAMP and this monitoring program and perform an analysis of the concurrent data for the September–October period.

A comparison of the maximum 15-minute PM_{10} data during the weekdays between September 14 and October 8, 2011 at Site 6 (73rd street), which is collocated with a CAMP monitor, is presented in Figure VI-1. A correlation analysis for both monitoring sites is presented in Figure VI-2. The results indicate that an unsatisfactory correlation exists ($R^2 = 0.2941$), and that Site 6 measured higher levels than the CAMP monitor during most of the time periods analyzed.

A similar comparison was performed for the 15-minute VOC data at two collocated sites: Site 1 (69th street) and Site 6 (73rd street). The results (Figures VI-3 to VI-6) for the weekday data collected between September 12 and October 8, 2011, indicate almost no correlation between Site 1 (R^2= 0.0132) and Site 6 (R^2=0.0169). In addition, the CAMP monitors recorded VOC levels up to 10 ppm, while Sites 1 and 6 never exceeded 2 ppm. It appears that irregular instrument calibration and quality assurance/ quality control procedures have produced unreliable CAMP data.

The supporting data is presented in Attachment H.

Recommendations for improvement of the contractor's CAMP are provided in Section VIII.

Figure VI-1: PM_{10} – Comparison of Maximum 15-minute Weekday Concentrations between CAMP and Site **6** (73rd Street)

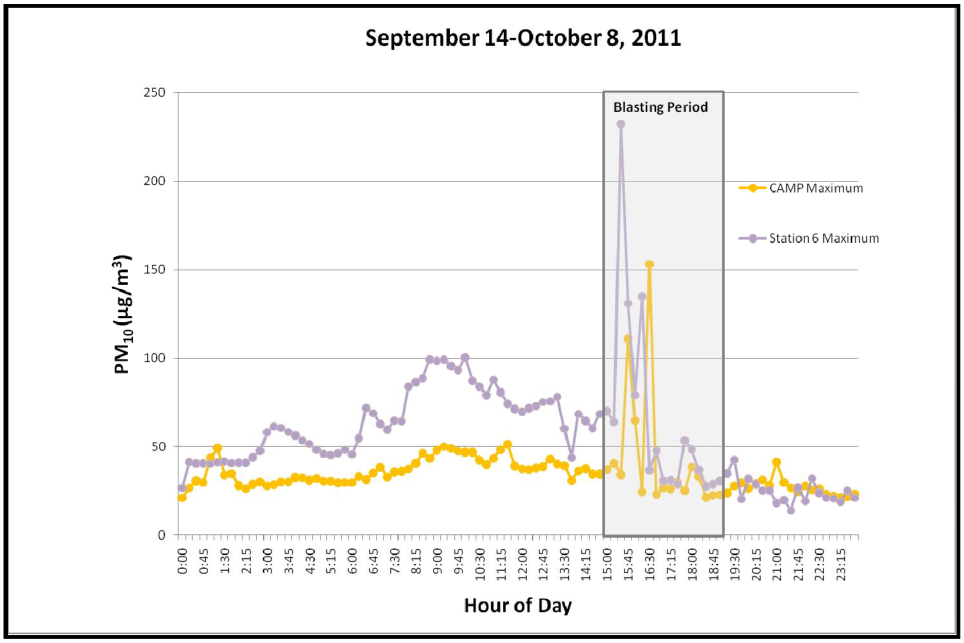


Figure VI-2: PM_{10} – Correlation Analysis of Maximum 15-minute Weekday Concentrations between CAMP and Site **6** (73rd Street)

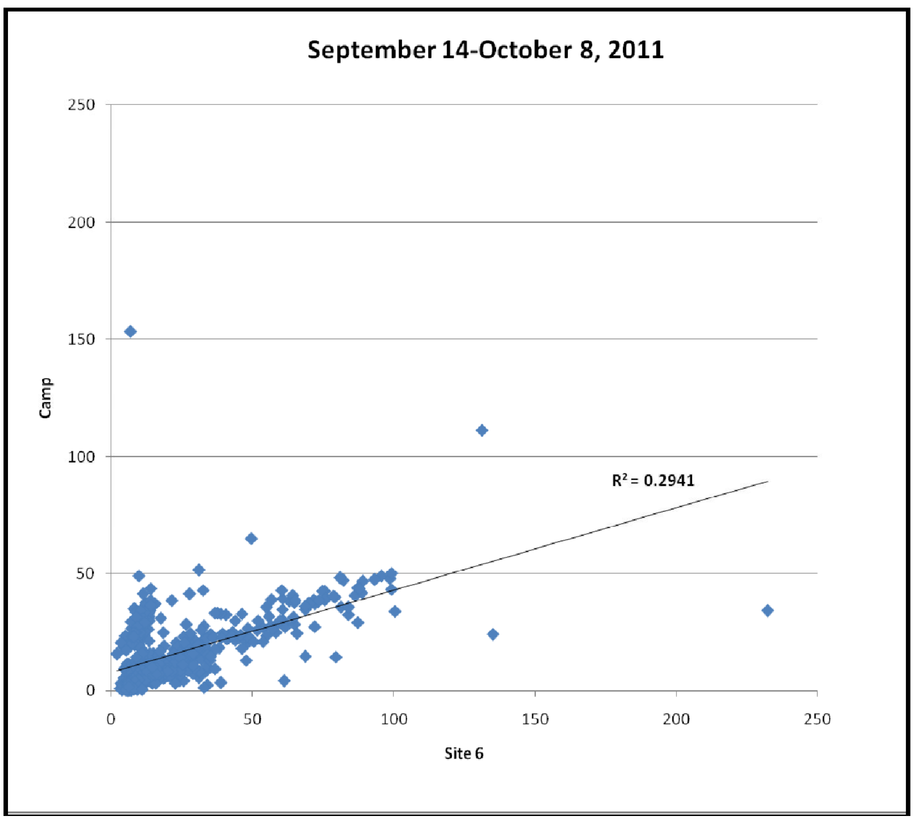


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Figure VI-3: VOC – Comparison of Maximum 15-minute Weekday Concentrations between CAMP and Site **1** (69th Street)

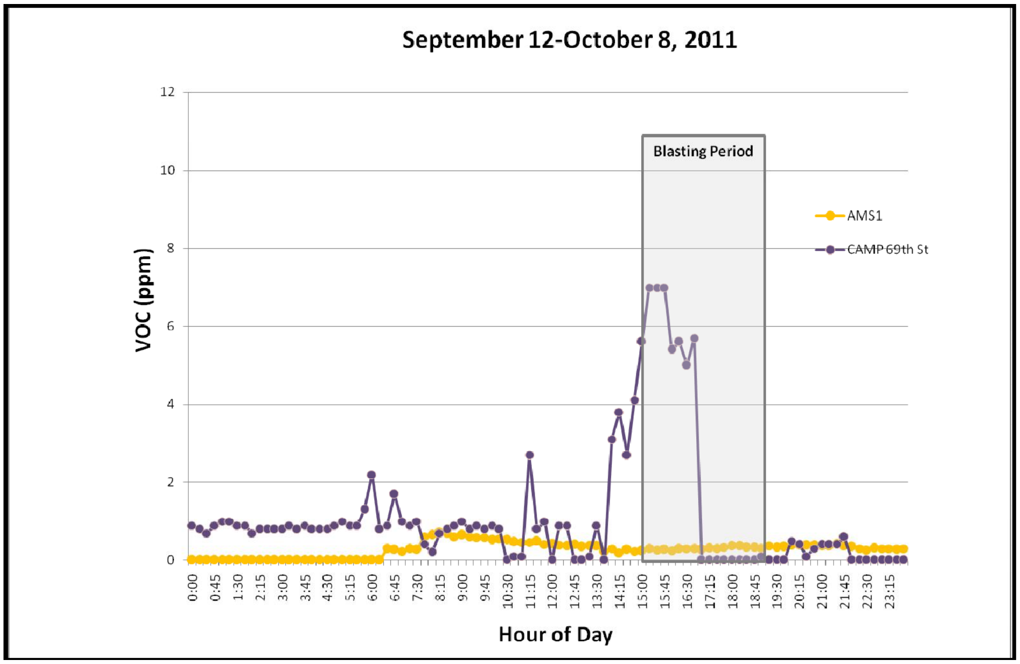


Figure VI-4: VOC – Correlation Analysis of Maximum 15-minute Weekday Concentrations between CAMP and Site **1** (69th Street)

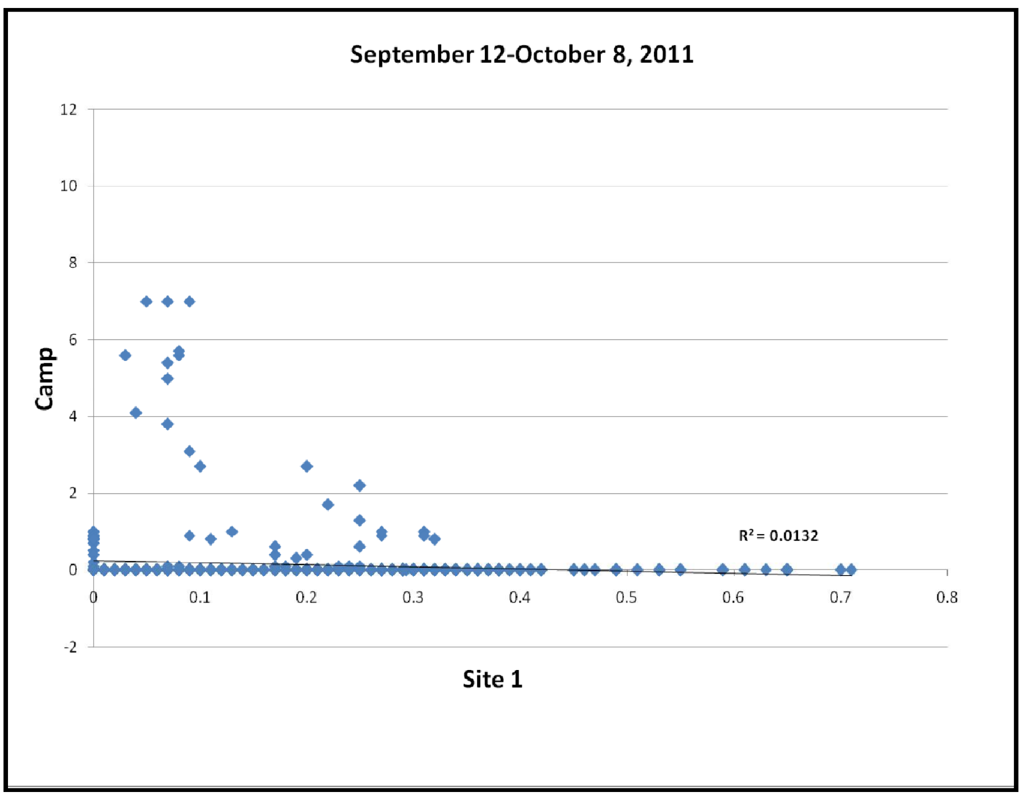


Figure VI-5: VOC – Comparison of Maximum 15-minute Weekday Concentrations between CAMP and Site 6 (73rd Street)

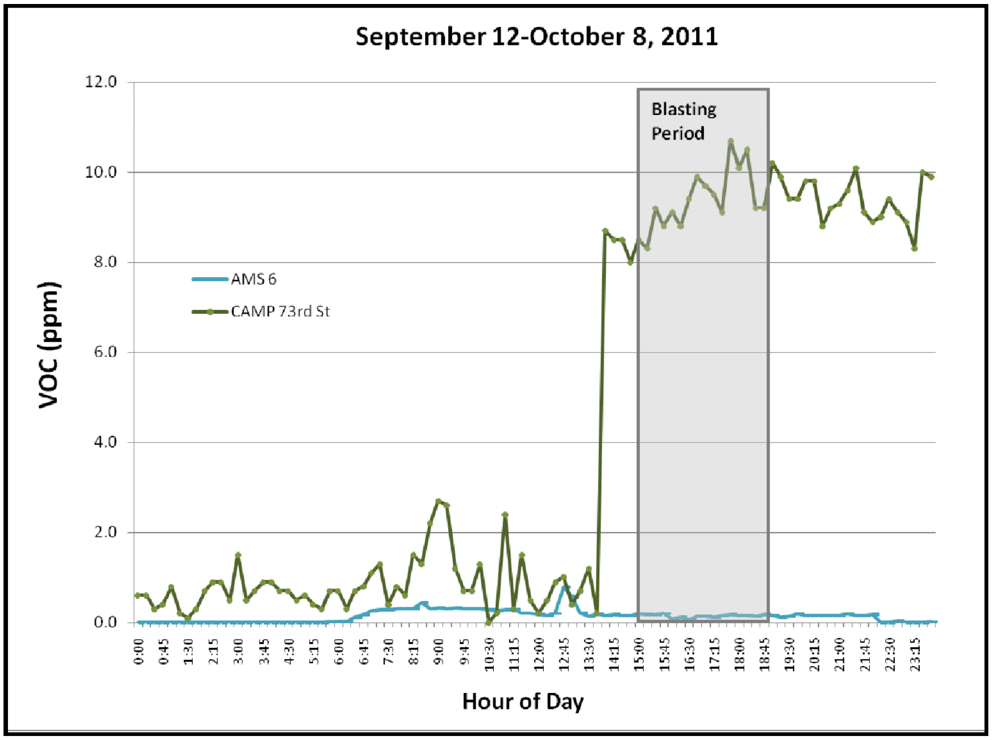
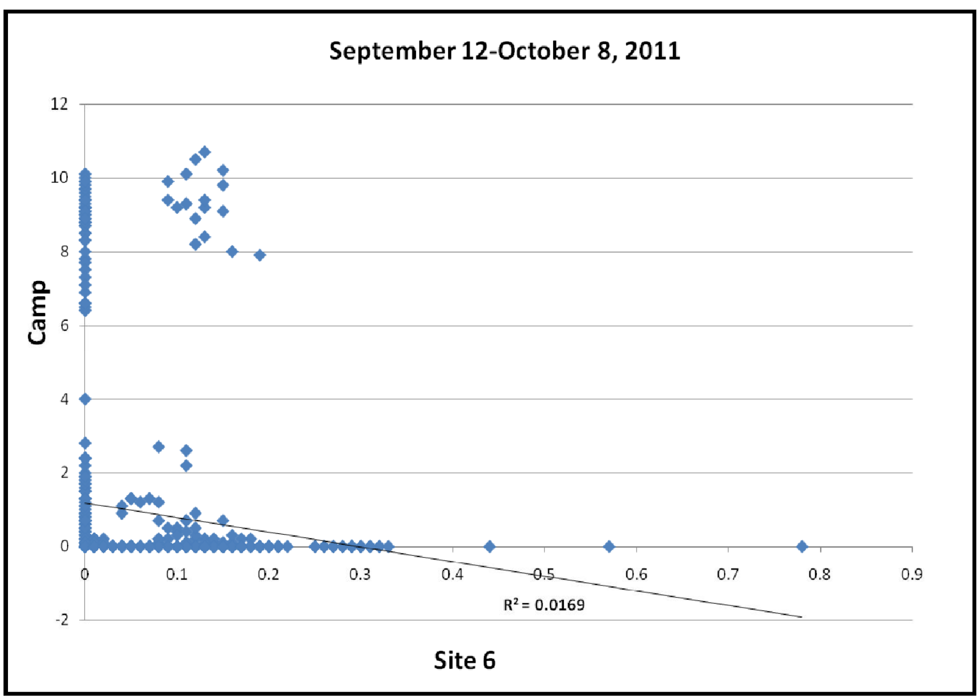


Figure VI-6: VOC – Correlation Analysis of Maximum 15-minute Weekday Concentrations between CAMP and Site 6 (73rd Street)



VII. Odor Investigation

From October 25 to 26, 2011, Dr. Karen Vetrano of TRC (odor specialist for the team) was on-site to observe the blasting and to interview resident abutters about their odor complaints. During the time on-site, two blasts on each day were observed. At the time of the blasts, a light tan, somewhat acrid emission was observed escaping from the muck houses (depending on where the blast occurred). Descriptions of the odor from the various observers included spent fireworks, acrid and smoky.

The American Society for Testing Materials (ASTM) Standard E544-04 (Standard Practices for Referencing Supra threshold Odor Intensity) defines the Odor Intensity Rating Scale as a scale of 1 to 8. Odor intensities of 1 through 3 are considered weak odors; intensities of 4, 5, and 6 are considered moderate odors; and intensities of 7 and 8 are strong odors. Based on Dr. Vetrano's best professional judgment, the intensity of the odors from the blasting emissions was a 5 at the time of the blast and could be considered a moderate odor. The intensity of the odor immediately began to decrease as the blasting gases dissipated.

A. Interviews

Arrangements were made by MTACC for Dr. Vetrano to interview resident abutters to record their impressions of odorous emissions as a result of the blasting events. Seven interviews were conducted on October 26, 2011. Residents A and B live on East 69th Street, across the street from the muck house located between 69th and 70th Streets. Five residents (C–G) live on the same side of the street as the muck houses (four live in buildings that are adjacent to the muck houses and one resides in a building that is between the muck houses).

A.1. Residents A and B

Residents A and B live across the street from the Second Avenue and 69th Street muck house. Resident A lives on the third floor with windows overlooking 69th Street, while Resident B lives on the seventh floor with windows also overlooking 69th Street. It should be noted that the building adjacent to theirs is in the process of being demolished so that there were ongoing construction activities occurring throughout the day.

Resident A

Resident A does not believe that odors she smells are related just to the blasting events. The odor is a "chemical related substance," and she typically smells it in both the morning and afternoon. The odor is typically observed when she is walking outside, predominantly when walking from west to east as approaching Second Avenue. She doesn't usually smell any odors in her apartment except for a few times and she thought those were coming from the adjacent building being demolished. Her biggest complaint is regarding the street odors, "they seem to be more concentrated with the compressed blasting schedule," and that "it takes a long time for the smoke to dissipate." She does not observe any odors on the weekends. She does not believe the odor has the characteristics of burnt, matches, sulfur or ammonia odors. The odors are more like a plastic, chemical odor. Resident A has occasionally felt tingling and burning sensation on her lips.

Resident **B**

Resident B keeps her windows open quite a lot. She doesn't typically smell odors throughout the day, but within 15 minutes of a blast occurring does smell an "exhaust" type odor. There is typically a dank/damp odor coming from the adjacent building that is currently being demolished. When walking, she does smell a plastic/chemical odor, however, the blast odors are more like a "burned" odor and are usually strongest near 70th Street. She also does not observe any odors on the weekends. Resident B has not had any irritation effects, just odor.

A.2. Resident **C**

Resident C lives on the fifth floor of a building located at Second Avenue and 71st Street, between the two muck houses. The apartment has a balcony overlooking Second Avenue with wall mounted air conditioner units below the windows. The windows are double-paned and were installed approximately five to seven years ago. There are kitchen and bathroom exhaust vents; however, the kitchen vent is blocked off because cooking odors from other apartments were entering from the vent. She leaves the windows and the terrace door open, but does close them when she hears the warning horn for the blasts. The odors seem to enter the apartment after a blast and Resident C describes it as an "acrid" odor and feels a "choking" sensation with the odors. She has also smelled the odor in the basement laundry room.

A.3. Resident **D**

Resident D lives on the eleventh floor of a building located at Second Avenue and 72nd Street. Her living room and bedroom both face Second Avenue and are located directly above the muck-house. During a blast, the smell is overwhelming. She keeps her windows closed due to the large smoke/dust cloud that comes up. She believes the odors are hard to describe but smell somewhat like natural gas or fireworks. The odor is not irritating but she believes the dust is irritating. Within her living space, there is a wall mounted air conditioner and she believes the odors and dust come through that unit. It is covered from the inside. Her windows are double-paned with metal frames and were replaced approximately 15 years ago. The resident manager of this building also provided some input and said that the odors were dependent on the number of blasts and the humidity. The odors were like sulfur and were pungent, acrid, and irritating.

A.4. Resident **E** and **F**

Residents E and F are a married couple living on the second floor of a building located at Second Avenue and 69th Street. Their living room and bedroom windows both face Second Avenue and the muck-house. According to the couple, the building has central air, which has been turned off; therefore, they need to open windows to get air. The resultant dust from the blast is "like it is snowing." The wife believes the cloud is dust or sulfur. If she is on the street, it is suffocating and she needs to cover her nose. The odors are worse on the street. The husband does not really smell it. They are also upset about the dirty windows and the loud noises coming from the muck-house when the hoppers are emptied into the trucks.

A.5. Resident **G**

Resident G lives on the second floor of a building located at Second Avenue and 72nd Street. His apartment faces Second Avenue. The odors have a "sulfury odor" and also smell like gunpowder. It "hits the back of the throat." In the hallways, it smells like a skunk up to 1-hour post-blast. The odors are inside the apartment as well. Since he has winterized the air conditioning unit, it has been slightly better. There are no vents in the apartment itself, but both the kitchen and the bathroom have windows with an exhaust fan. The odors lasted anywhere from 45 minutes to 1 hour. During non-blast periods and weekends, there are no odors. The sulfury and gunpowder odors are only attributable to blasting.

A.6. Interview Conclusions

Although all the interviewees were affected by some type of odors at their residence, those residents that reside directly adjacent to the muck-houses appear to be the most impacted by the odors. Some of these residents describe the odor as having some type of sulfur component (skunk, natural gas, gunpowder, “sulfury”). Some also describe potential irritant effects of the emissions (choking, acrid, suffocating, “hitting the back of the throat”) during the interview. Those residents that live across the street are primarily impacted inside their homes by the demolition that is occurring in the building next to them. Residents A and B, both describe different odors, some are dank and musty, others are chemical-like. Resident B does smell an “exhaust”/”Burnt” odor after the blasts.

B. Odor Evaluation

As discussed previously, the blasting contractor is using the explosives Emulex and Red-D Prime, which are Ammonium Nitrate/Fuel Oil (ANFO)-like explosives. The data collected by this SAS monitoring program were used to determine public exposure levels at close range to the construction zones.

Of the pollutants that were monitored, NO, NO_2, SO_2, H_2S and NH_3 have odor thresholds associated with them. The odor threshold is a characteristic of a compound and is defined as that concentration at which 50 percent of the population can detect the odor of the compound. Odor thresholds are not health-based values, nor are they federal or state guideline values. There are no chronic or acute health problems associated with the odor thresholds.

The odor emissions have also been described as acrid, choking, suffocating and “hit the back of the throat”, descriptors which all indicate an irritant component of the emissions. Some inhaled chemicals are volatile compounds that act as a stimulus triggering unwanted reactions such as nose, eye, and throat irritation. Perception of odor and of irritation is unique to each person and varies over time because of physical conditions or memory of past exposures to similar chemicals. Odor and sensory irritation may be perceived as a single event by the exposed individual. The irritation threshold of a compound is that concentration at which 50 percent of the population would begin to experience an irritant effect of the chemical such as a tingling or slight burning sensation in the nose, throat and eyes. The documented odor character of ammonia, nitric oxide, nitrogen dioxide and sulfur dioxide all include descriptors such as sharp, biting, acrid, pungent and irritating.

Table VII-1 presents a summary of the odor and irritation thresholds used in the evaluation.

In order to determine the impact of blasting on the release of odorous emissions, a comparison of the maximum 1-hour and the average 1-hour concentrations of these pollutants during blasting and non-blasting periods to their respective odor thresholds were conducted. The blasting and non-blasting time periods were based upon the daily blast log for locations C4B and C5A (Tables II-1 and II-2). In addition, a statistical comparison between the pollutant concentrations measured during the blasting and non-blasting periods was conducted using the Wilcoxon-Mann-Whitney (WMW) Test. The purpose was to determine if the concentrations measured during blasting periods were statistically different from those during non-blasting periods. Tables VII-2and VII-3 present the comparison data analysis for the 72nd Street Station area (C4B) and Tables VII-4 for the 86th Street station area (C5A), with the odor and irritation thresholds of the individual constituents.

Table VII-1: Odor and Irritation Thresholds

Compound	Odor Threshold (ppm)	Irritation Threshold (ppm)	Odor Description
Ammonia	0.037[1]	102 [2]	Sharp, pungent
Hydrogen Sulfide	0.00047[1]	10 [2]	Rotten eggs
Nitric Oxide	0.293 – 0.97[2]	NA	Sharp, sweet
Nitrogen Dioxide	0.058 – 0.14 [3]	10.6 [2]	Acrid, bleach, sharp, biting
Sulfur Dioxide	0.009[1]	1.9 [2]	Burnt matches, metallic taste, sharp, pungent, irritating

Sources:

1. The Science of Smell, Part 1:Odor Perception and Physiology Response. Iowa State University. PM1963a. May 2004.
2. Jon H. Ruth. Odor Thresholds and Irritation Levels of Several Chemical Substances. A Review. Am. Ind. Hyg. J. (47):A-142-A151. 1986.
3. Odor Thresholds for Chemicals with Established Occupational Health Standards. American Industrial Hygiene Association. 1997.

NA – Not Available

As shown in Tables VII-2, VII-3 and VII-4, the maximum 1-hour concentration for both the blasting period and non-blasting period exceeded the respective odor thresholds for SO_2, NH_3, NO, NO_2 and H_2S. The average 1-hour concentrations for NH_3, NO_2, SO_2 and H_2S during blasting and non-blasting periods also exceeded their respective odor thresholds at various locations collected from the contract C4B monitoring stations. Only one location from the contract C5A monitoring locations exceeded the average 1-hour level for NO_2 during the blasting period. No other average 1-hour concentrations exceeded the respective odor thresholds during either blasting or non-blasting periods. In addition, none of the concentrations exceeded the respective irritation thresholds for each compound.

The statistical evaluation showed no statistical differences between the readings collected during blasting and non-blasting periods with the exception of H_2S. H_2S readings were statistically elevated at 3 of the 4 monitoring stations (AMS 1, 3 and 4) during blasting periods as compared to non-blasting periods. The WMW test output is provided in Attachment G. Therefore, from this data it appears that the blasting is having some impact on increased odors in the area. As discussed previously the common odor descriptor from the interviews was a sulfur-like odor.

Table VII-2: Comparison to Odor Thresholds for NH_3, NO, NO_2 (Contract C4B)

	NH3		NO		N02	
Odor Threshold[1]	0.037 ppm		0.293 - 0.97 ppm		0.058 - 0.14 ppm	
Irritation Threshold[2]	102 ppm		-- [3]		10.6 ppm	
	Maximum 1-hr Average	Mean 1-hr Average	Maximum 1-hr Average	Mean 1-hr Average	Maximum 1-hr Average	Mean 1-hr Average
1B. Blast	**3.4**	**0.8**	ND	ND	**0.2**	**0.06**
1B. Non-Blast	**3.7**	**1.0**	**1.1**	0.002	**0.3**	**0.07**
2B. Blast	ND	ND	ND	ND	**0.2**	0.04
2B. Non-Blast	ND	ND	ND	ND	**0.2**	0.03
3B. Blast	ND	ND	**1.1**	0.05	**0.2**	**0.05**
3B. Non-Blast	**1.1**	0.01	ND	ND	**0.2**	0.03
4B. Blast	ND	ND	**1.4**	0.1	**0.1**	0.005
4B. Non-Blast	ND	ND	ND	ND	**0.1**	0.006
5B. Blast	ND	ND	ND	ND	**0.2**	0.01
5B. Non-Blast	ND	ND	ND	ND	**0.2**	0.01
6B. Blast	ND	ND	**1.1**	0.03	**0.4**	**0.1**
6B. Non-Blast	ND	ND	**1.2**	0.005	**0.4**	**0.1**

ND = Below the instrument detection level. See Table III-2 of the report for the individual detection limits.

Bold = > Odor Threshold

Italic = > Irritation Threshold

Shading = Statistically greater than non-blast period. WMW test $p<0.05$. See Appendix G for WMW test output

[1]Odor Threshold - defined as the concentration at which 50% of the population can detect the odor. An odor threshold is neither a health-based standard nor a Federal or State guideline level.

[2]Irritation Threshold - defined as the concentration at which 50% of the population begin to experience an irritant effect of the chemical such as a tingling or slight burning sensation in the nose, throat and eyes.

[3]Nitric oxide is readily oxidized to nitrogen dioxide and because of the concurrent exposure to nitrogen dioxide during nitric oxide exposures, it is difficult to discriminate nitric oxide irritant effects from nitrogen dioxide irritant effects.

Table VII-3: Comparison to Odor Thresholds for N_2S, SO_2 (Contract C4B)

Odor Threshold[1] Irritation Threshold[2]	H2S 0.00047 ppm 10 ppm		S02 0.009 ppm 1.9 ppm	
	Maximum 1-hr Average	Mean 1-hr Average	Maximum 1-hr Average	Mean 1-hr Average
AMS 1 Blast	0.009	0.006	ND	ND
AMS 1 Non-Blast	0.010	0.004	ND	ND
AMS 3 Blast	0.008	0.005	0.4	0.02
AMS 3 Non-Blast	0.010	0.003	0.8	0.01
AMS 4 Blast	0.009	0.006	0.1	0.01
AMS 4 Non-Blast	0.009	0.004	0.1	0.0004
AMS 6 Blast	0.009	0.004	0.3	0.03
AMS 6 Non-Blast	0.008	0.003	0.2	0.01

ND = Below the instrument detection level. See Table III-2 of the report for the individual detection limits.

Bold = > Odor Threshold

Italic = > Irritation Threshold

Shading = Statistically greater than non-blast period. WMW test $p<0.05$. See Appendix G for WMW test output

[1]Odor Threshold - defined as the concentration at which 50% of the population can detect the odor. An odor threshold is neither a health-based standard nor a Federal or State guideline level.

[2]Irritation Threshold - defined as the concentration at which 50% of the population begin to experience an irritant effect of the chemical such as a tingling or slight burning sensation in the nose, throat and eyes.

[3]Nitric oxide is readily oxidized to nitrogen dioxide and because of the concurrent exposure to nitrogen dioxide during nitric oxide exposures, it is difficult to discriminate nitric oxide irritant effects from nitrogen dioxide irritant effects.

Table VII-4: Comparison to Odor Thresholds (Contract C5A)

	NH3		NO		N02	
Odor Threshold[1]	0.037 ppm		0.293 - 0.97 ppm		0.058 - 0.14 ppm	
Irritation Threshold[2]	102 ppm		-- [3]		10.6 ppm	
	Maximum 1-hr Average	Mean 1-hr Average	Maximum 1-hr Average	Mean 1-hr Average	Maximum 1-hr Average	Mean 1-hr Average
7B. Blast	ND	ND	ND	ND	**0.3**	**0.09**
7B. Non-Blast	ND	ND	**2.9**	0.18	**1.0**	0.04
8B. Blast	ND	ND	ND	ND	ND	ND
8B. Non-Blast	ND	ND	ND	ND	**0.1**	0.002
9B. Blast	ND	ND	ND	ND	ND	ND
9B. Non-Blast	**3.6**	**0.2**	**1.8**	0.0604	**0.1**	0.0004
10B. Blast	ND	ND	ND	ND	**0.1**	0.02
10B. Non-Blast	ND	ND	**1.7**	0.0176	**0.2**	0.03

ND = Below the instrument detection level. See Table III-2 of the report for the individual detection limits.

Bold = > Odor Threshold

Italic = > Irritation Threshold

[1]Odor Threshold - defined as the concentration at which 50% of the population can detect the odor. An odor threshold is neither a health-based standard nor a Federal or State guideline level.

[2]Irritation Threshold - defined as the concentration at which 50% of the population begin to experience an irritant effect of the chemical such as a tingling or slight burning sensation in the nose, throat and eyes.

[3]Nitric oxide is readily oxidized to nitrogen dioxide and because of the concurrent exposure to nitrogen dioxide during nitric oxide exposures, it is difficult to discriminate nitric oxide irritant effects from nitrogen dioxide irritant effects.

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