Second Avenue Subway (SAS) Project

Final Report

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

Prepared for:

MTA Capital Construction

Prepared by:

Parsons Brinckerhoff

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I. Introduction

Air pollution from construction activities occurs primarily in the form of particulate matter, which is created by dust-generating activities (excavation, grading, blasting, trucking, demolition, etc.) and exhaust from the diesel engines that power the majority of construction equipment and trucks. Particulate matter is a mixture of solid particles and liquid droplets found in the air. Some particles (e.g., dust, dirt, soot, or smoke) are large or dark enough to be seen with the naked eye; others are so small, they can be detected only by using an electron microscope. Of particular health concern, due to their effects on the respiratory system, are those particles that are smaller than or equal to 10 microns (PM_{10}) and 2.5 microns ($PM_{2.5}$) in size.

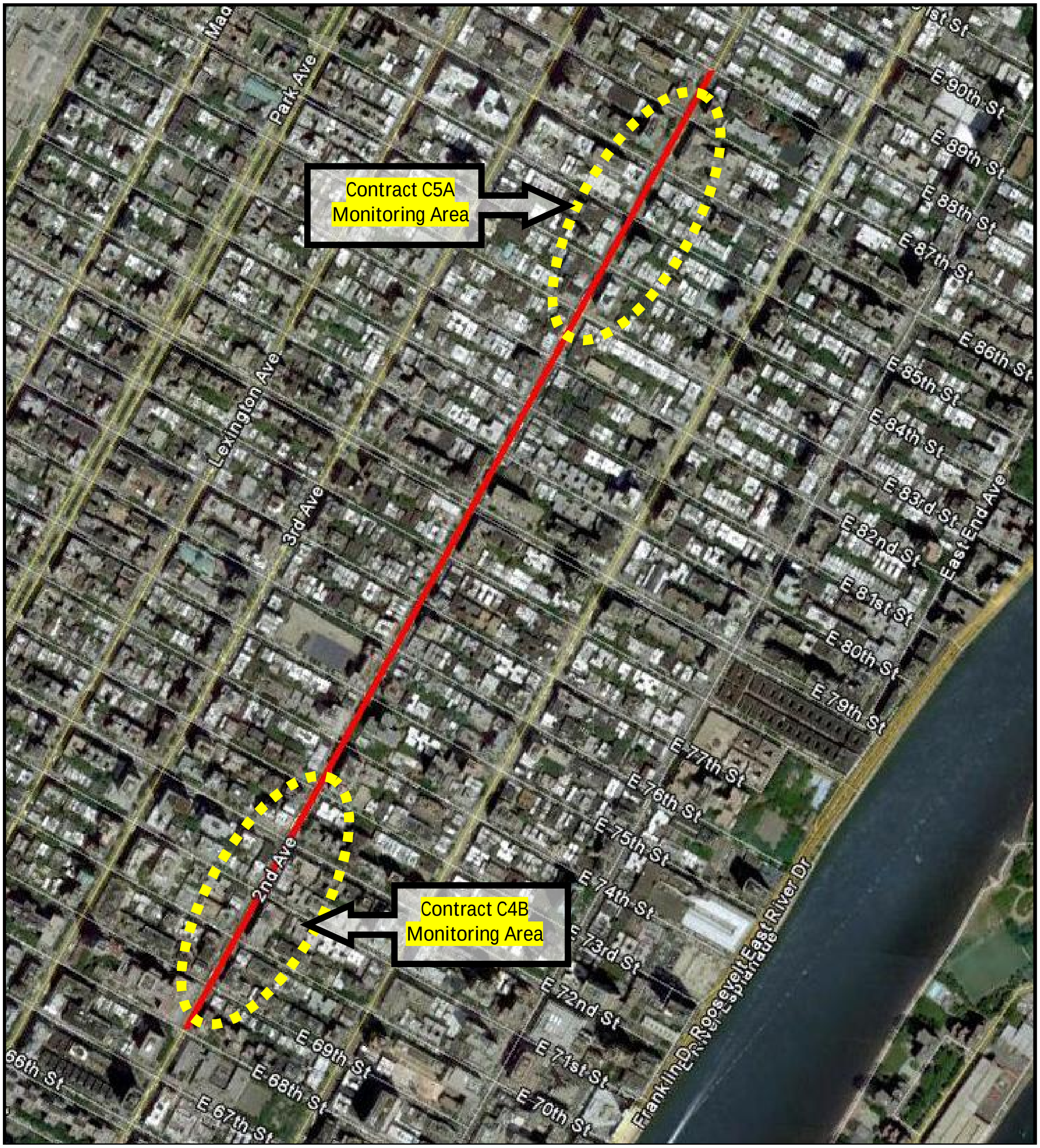
In the case of the Second Avenue Subway (SAS) project, the dust generated by underground blasting operations for the excavation of the station caverns has contributed to visible sources of construction dust. Concerns over the potential health effect on the adjacent public of these dust particles and other pollutant emissions that could result from construction triggered the need for this air monitoring study.

Unlike fixed industrial and mobile transportation sources, the air pollution effects of construction activities are considered a temporary problem. There is no US Environmental Protection Agency (EPA) or New York State Department of Conservation (NYSDEC) regulatory requirements to monitor the ambient air pollutant levels associated with construction activities. As such, this air quality monitoring study (referred to as the SAS air monitoring study) was voluntary, and was initiated by MTA Capital Construction (MTACC) in the fall of 2011.

This report reviews the study objectives and provides a description of the construction activities and the contractor's air pollution and dust control programs during this monitoring study. The selection process to identify the locations and pollutants monitored, the rationale for selecting health-based reference levels, a description of the findings for each pollutant measured, the evaluation of the contractor's air monitoring program, a summary of additional mitigation measures implemented by the contractor after this monitoring program, and recommendations for future monitoring are outlined.

Figure I-1 provides a view of the area covered by the monitoring study, which encompasses Second Avenue between 69th and 87th Streets, and delineates the construction areas for the 72nd Street Station (Contract C4B) between 69th and 73rd Street, and the 86th Street Station (Contract C5A), extending between 83rd and 87th Streets.

Figure I-1: Project Study Area



II. Study Objectives

The objectives of this air monitoring study can be summarized as follows:

- To assess air quality impacts of the underground blasting (and other construction-related activities) on the adjacent abutters and affected public by measuring a number 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 analyzing the odor-related pollutant data collected as part of the monitoring program.
- To assess the adequacy of the contractor's ongoing Community Air Monitoring Plan (CAMP), and to provide recommendations for improving its efficacy as a warning system to take corrective mitigation action.

III. Construction Activities and Air Pollution Control Measures during this Study

A. 72nd Street Station Area

Two structures (called muck houses) were erected in the area prior to September 2011 for the 72nd Street Station (Contract C4B) between 69th and 73rd Street 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 muck house occupies two lanes of Second Avenue traffic for almost a full block. These structures act as noise-insulated enclosures with rolling doors at each end for passage of trucks and equipment. The contractor has been performing underground blasting in the 72nd Street Station cavern on an almost daily basis. Blasting times normally occur on weekday afternoons between 3:00 and 7:00 p.m. 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 (the practice of spraying cement on a surface) operations inside the caverns (typically between 9:00 a.m. and 1:00 p.m.). Surface activities at these sites also include groundwater treatment plant maintenance, materials storage, equipment movement, and other common construction-related activities. Weekday construction activities at the surface end at 10:00 p.m. and continue underground overnight. There is no major construction activity during weekends.

Figure III-1 provides a view of a muck house during the monitoring period.

Figure III-1: Muck House view at Second Avenue and 73rd Street

B. 86th Street Station Area

Construction in the area of the 86th Street Station (Contract C5A), extending between 83rd and 87th Streets, included initial shaft excavation in two locations. 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 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 III-2 provides a view of activities under Contract C5A.

Figure III-2 Construction Contract C5A Activities (view of Second Avenue and 83rd Street)

C. Contractor's Dust and Air Pollution Control Measures

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 openings of the excavation shafts during blasting operations.
- 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 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 top-down initial excavation of the shafts.

Subsequent to this monitoring study, additional mitigation measures were implemented for the 72nd Street Station contract, which are described in Section VII.

D. Contractor's Community Air Monitoring Plan (CAMP)

The CAMP program requires each contractor to measure the effects of construction activities (including blasting operations) using real-time monitoring for total volatile organic compounds (VOCs) and PM_{10} (dust or coarse particles) at the perimeter of the working areas. The contractor installed portable monitors on street light poles at an average height of 5 feet above the ground. The monitors are equipped with alarms to indicate when pollutant levels exceed a 15-minute threshold so that the contractor can take immediate action to alter construction methods and reduce dust. The main objective of the CAMP program is to serve as a warning system to take corrective mitigation actions to reduce construction-related air pollution impacts. It was established for use as a construction management tool, and the data collected do not relate to the health-based reference levels discussed in this report. This report evaluates the CAMP program, and recommends improvements to enhance its effectiveness (see Section VI).

IV. Selected Pollutants and Monitoring Locations

The SAS air monitoring program collected minute-by-minute data of coarse and fine particulate matter (PM_{10} and $PM_{2.5}$), respirable silica, VOC, nitric oxide (NO), nitrogen dioxide (NO_2), ammonia (NH_3) sulfur dioxide (SO_2), hydrogen sulfide (H_2S) and carbon monoxide (CO) continuously for one month from September 12 through October 8, 2011, at 10 air monitoring stations along Second Avenue. The rationale for the selection of these pollutants for the monitoring program is presented below.

- PM_{10} (coarse particles) data were collected as it is generally associated with construction activities.
- $PM_{2.5}$ (fine particles) data were collected as it is also associated with construction activities, as well as with other combustion sources (power plants, motor vehicle exhaust, construction equipment, 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 was, until recently, in violation of the National Ambient Air Quality Standards (NAAQS) for this pollutant.
- Respirable crystalline silica was analyzed to address public concerns that silica could be a component of dust particles due to its presence in the rock being excavated.
- The gaseous pollutants CO, VOC and SO_2 were included since they are the products of fuel combustion produced by motor vehicles and construction equipment and the possible by-products from blasting operations. In addition, NO, NO_2, SO_2, NH_3 and H_2S were evaluated as possible sources of odors that are formed as blasting by-products.

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

- Capture the effects of construction activities;
- Represent worst-case public exposure in the high density urban environment; and
- Provide sufficient coverage to capture multiple wind directions.

Six stations (located between 69th and 73rd Street) were positioned to capture the construction effects of activities associated with construction of the 72nd Street Station (Contract C4B). Four stations between 83rd and 87th Street were positioned to capture the construction effects of activities associated with the construction of the 86th Street Station (Contract C5A). Table IV-1 provides a description of each monitoring location and identifies the pollutants monitored.

Table IV-1: Air Monitoring Station Locations and Pollutants

Station No (Contract)	Location	Pollutant					
		CO, NO, NO_2, NH_3,	VOC	H_2S SO_2	PM_{10}	$PM_{2.5}$	Respirable 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.

The locations of the monitoring stations are shown in Figures IV-1 to IV-4.

Since air quality along the Second Avenue corridor is a combination of regional pollution from many sources, localized emissions from motor vehicles, residential boilers, other commercial sources, and emissions from construction activities, regional and local air pollution data and traffic activity were also evaluated.

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

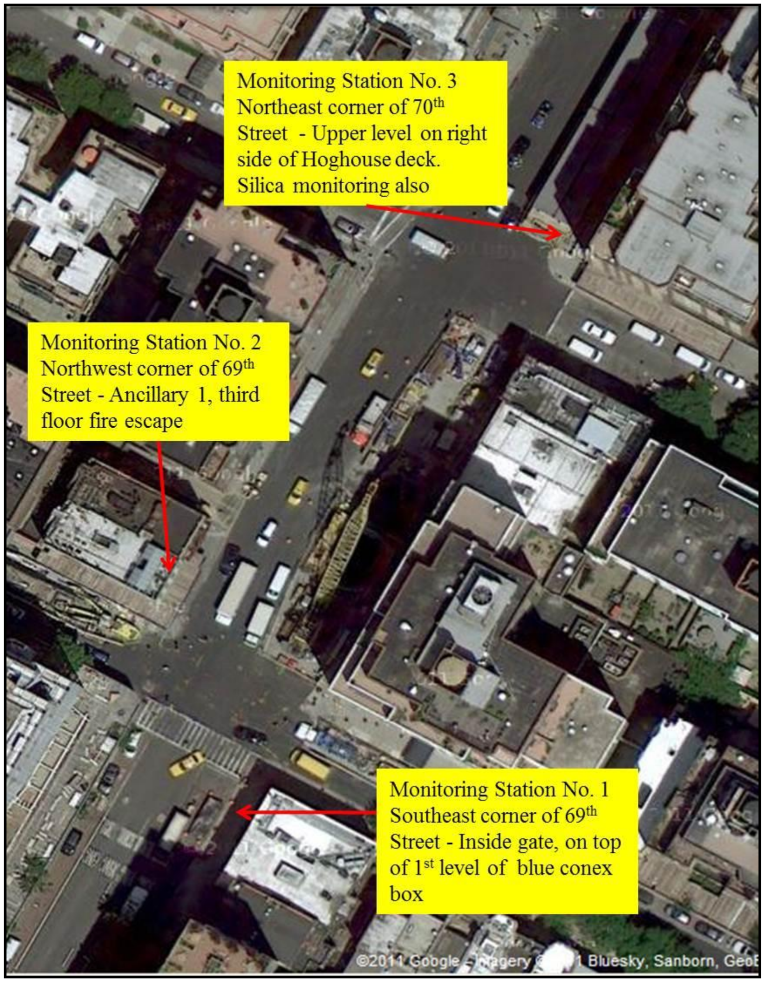


Figure IV-2: East 72nd Street to East 73rd Street Shaft

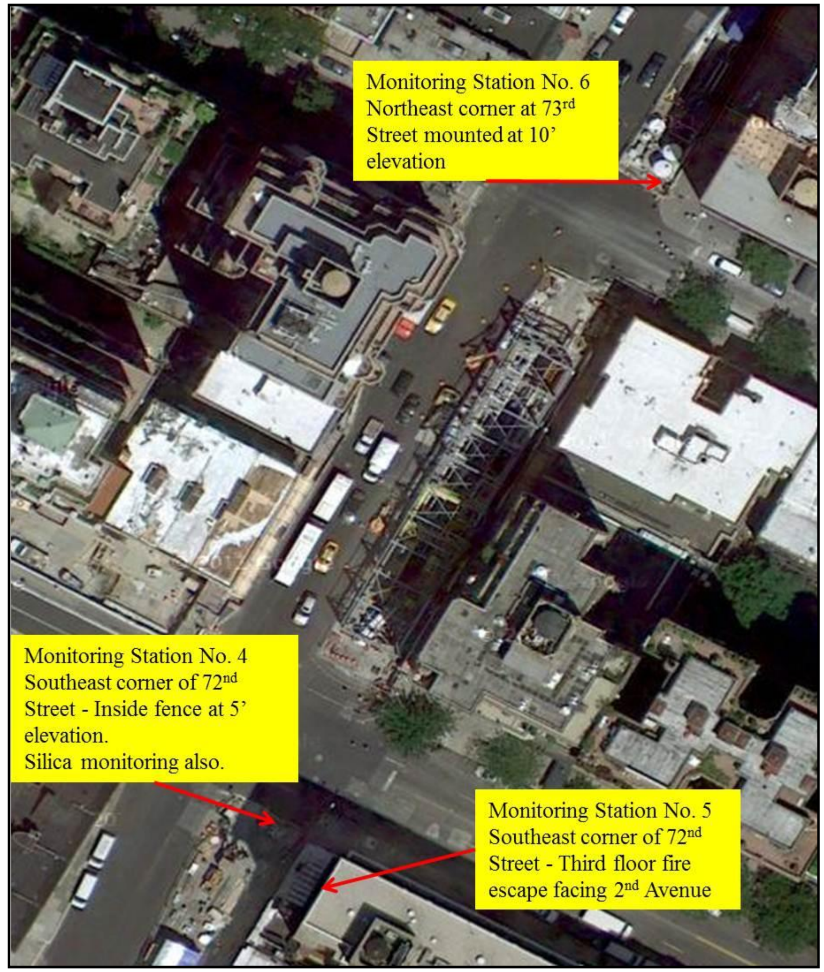


Figure IV-3: East 83rd Street Shaft

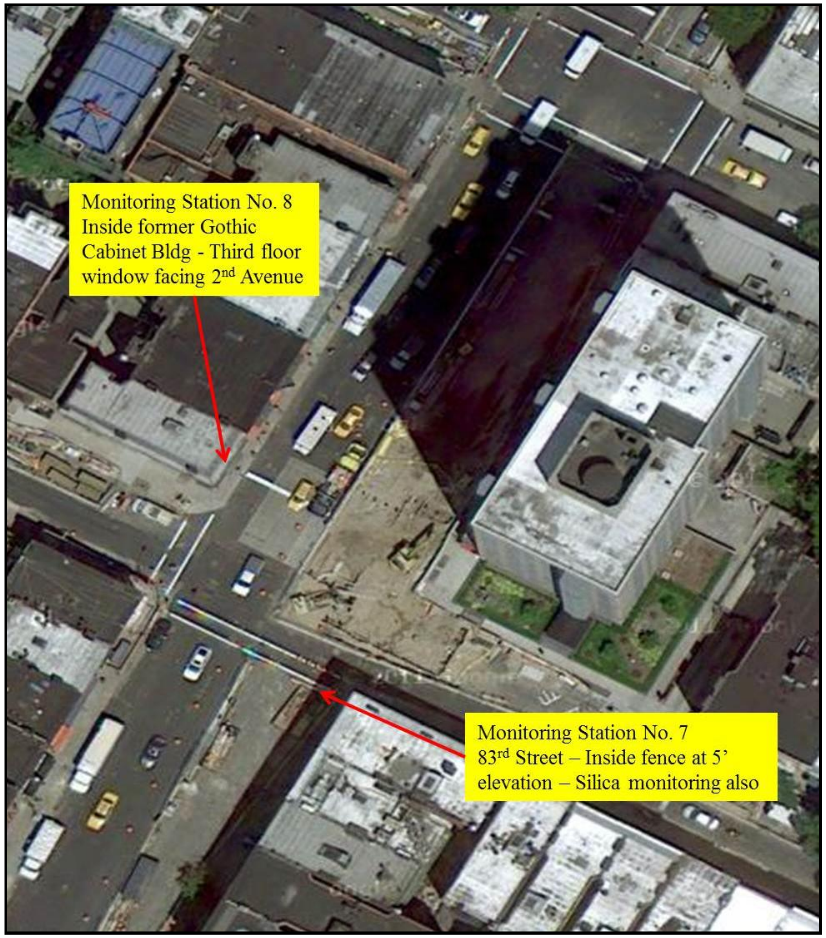
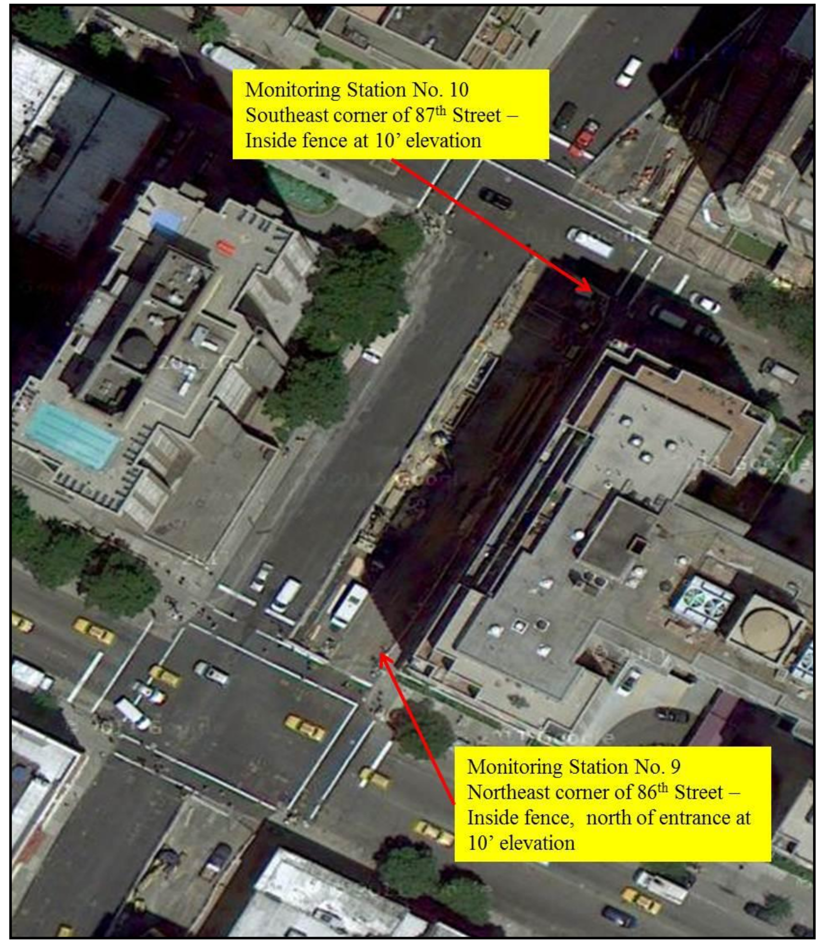


Figure IV-4: East 86th Street Shaft



V. Determination of Reference Levels as Benchmarks

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

The primary source of the health-based reference levels is the EPA NAAQS. For the pollutants that do not have NAAQS, such as NH_3, H_2S, and respirable silica, the 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.

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 NAAQS or guidelines established for long-term or life-time exposure.

To assess compliance with the NAAQS, monitors are required to be placed in locations that reflect the area-wide concentration of a pollutant and not the localized concentration from a specific source. Because of this, monitors are placed away from local sources (such as roadways, construction sites, etc). The 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.” [1] Because of the siting requirement, the 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 dilutes (dissipate) as it moves away from the original source.

As such, the established reference benchmark levels serve as an indication of a potential impact: if monitored concentrations are below reference levels, 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 that construction procedures need to be adjusted to mitigate exposure in order to reduce the potential for an adverse impact to the extent practicable.

This study selected reference levels for PM_{10}, $PM_{2.5}$, and respirable silica, CO, SO_2, NH_3 and H_2S. The selected levels with their time periods and source used are provided in Table V-1. 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.

[1] 40 C.F.R. Part 58, Appendix E

Table V-1: Benchmark Action 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

VI. Summary of Findings

A. Particulate Matter (PM_{10}, $PM_{2.5}$ and Respirable Silica) Results

PM_{10} levels were collected at seven locations using MIE DR-4000 area dust monitors.

The monitoring results for PM_{10} (i.e., coarse particles) indicate that daily (24-hour average) levels were lower than the PM_{10} reference level of 150 μg/m³, with weekday levels ranging from 15 to 60 μg/m³, and weekend levels from 5 to 40 μg/m³. Figure VI-1 and VI-2 provide daily PM_{10} concentrations for each contract area (Sites 2, 3, 4, and 6 for the 72nd Street area [C4B] and Sites 7, 9, and 10 for the 86th Street area [C5A]).

$PM_{2.5}$ levels were collected at three locations also using MIE DR-4000 area dust monitors.

Daily (24-hour average) $PM_{2.5}$ concentrations are primarily generated by local traffic emissions, other local sources such as commercial and residential boilers, and regional or background levels. $PM_{2.5}$ levels measured by NYSDEC in New York City have historically, on occasion, exceeded the 35 μg/m³ level, so the monitored levels were not unusual, in particular, because the NYSDEC Manhattan monitors are located on rooftops, away from local sources such as traffic and construction projects. Daily (24-hour average) $PM_{2.5}$ concentrations measured during the monitoring period exceeded the daily reference level of 35 μg/m³ on three different days during the month-long monitoring period. Figures VI-3 and VI-4 provide daily (24-hour average) $PM_{2.5}$ concentrations for each contract area (Sites 1, 5 and 8). Based on an analysis of hourly data, blasting operations have no significant effect on the $PM_{2.5}$ levels during those three days.

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

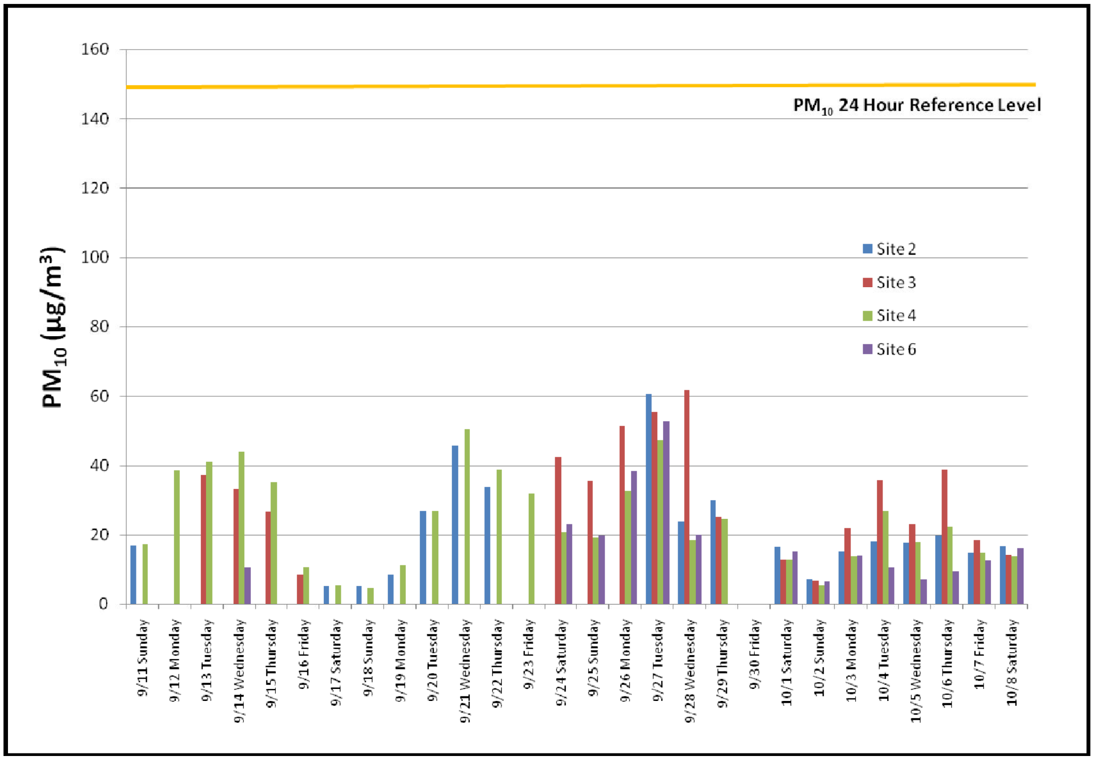


Figure VI-2: PM_{10} – 24 Hour Average Concentrations (Sites7, 9, and 10)

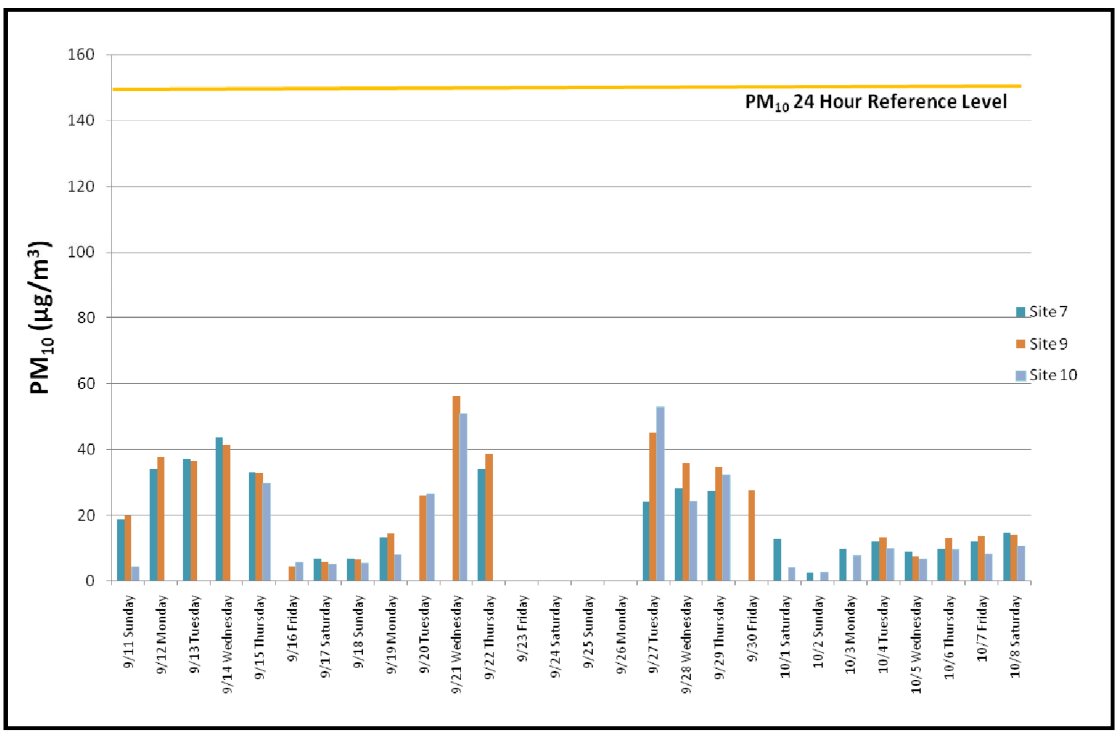


Figure VI-3: $PM_{2.5}$ – 24-Hour Average Concentrations (Sites 1 and 5)

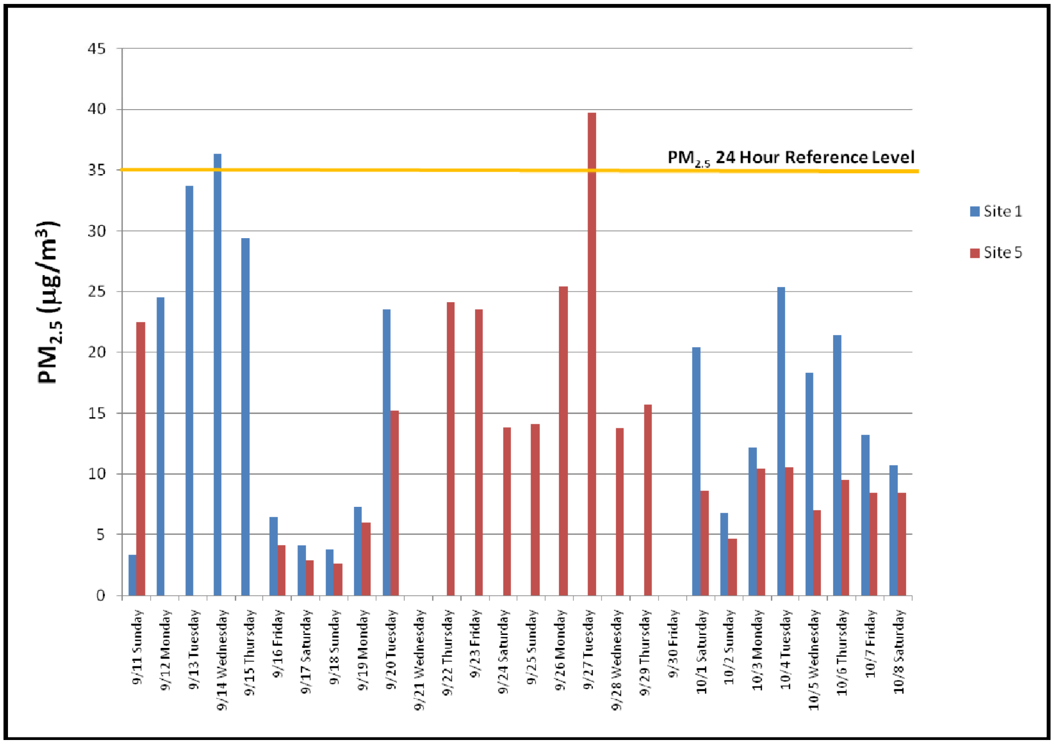
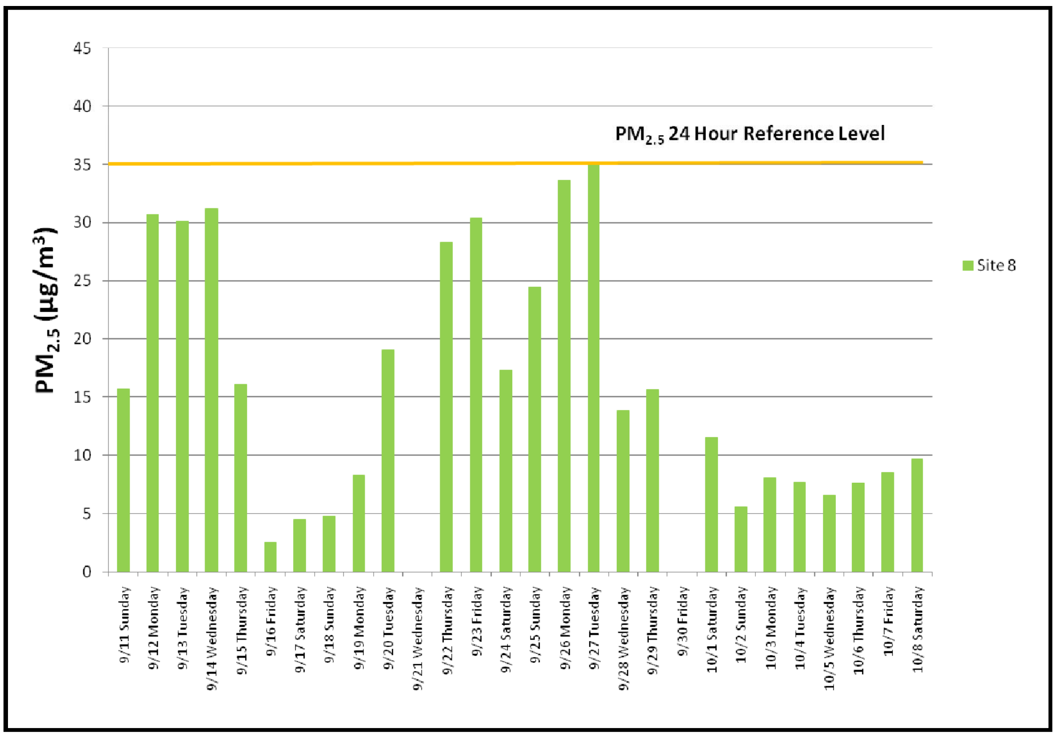


Figure VI-4: $PM_{2.5}$ – 24 Hour Average Concentrations (Site 8)

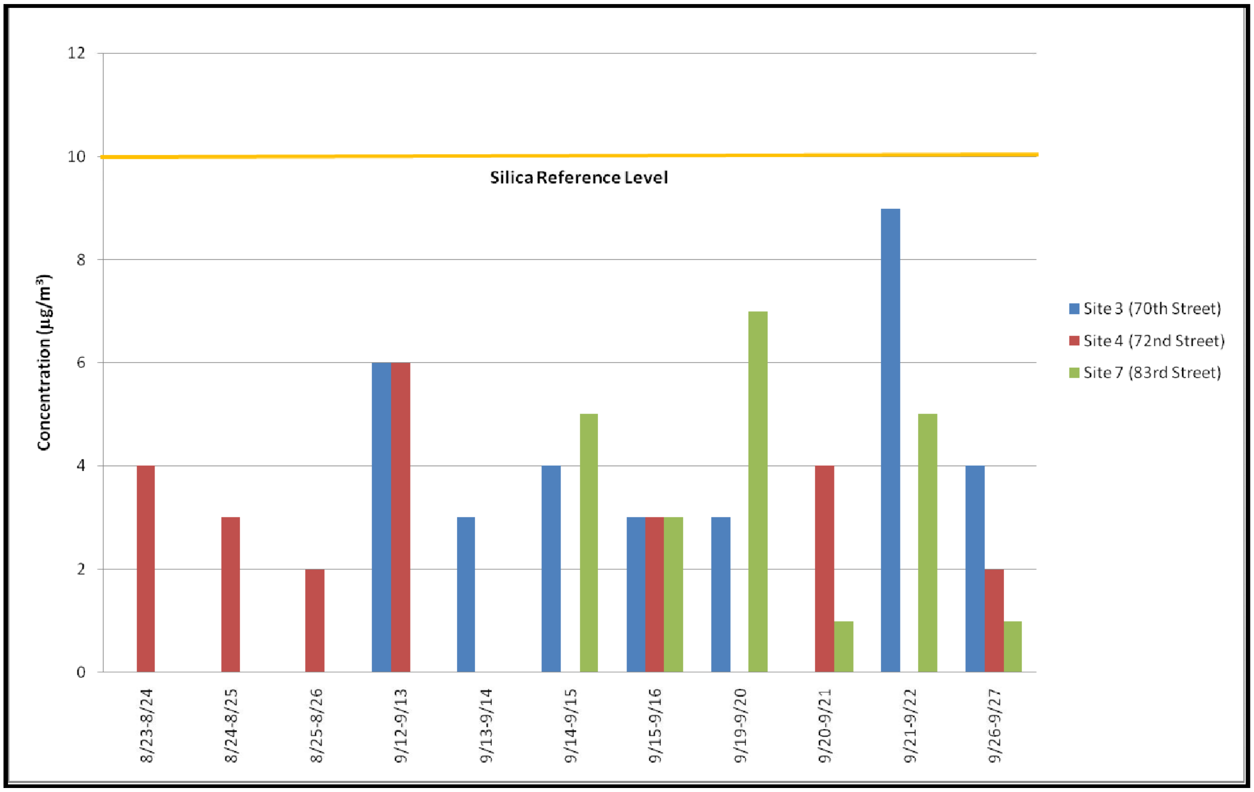


Respirable Silica levels were collected at three locations by the gravimetric low-volume air-sampling monitors.

This process collects particles in a filter for 24 hours, which is sent to a lab for analysis. All daily levels were below the reference level of 10 µg/m^3 as shown on Figure VI-5.

This reference level is considered to be a conservative action level because it 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.

Figure VI-5: Respirable Silica Measured (Sites 3, 4, and 7)



B. Gaseous Pollutants Results

The gaseous pollutants measured included CO, NH_3, H_2S, VOC, SO_2, NO and NO_2. This study selected reference levels for CO, SO_2, NH_3 and H_2S. NO and NO_2 data were used in the odor evaluation, and VOC was monitored to evaluate the data collected by the contractor's CAMP program. Table VI-1 provides the average and maximum hourly levels measured at each monitoring station during the full four-week period for these four pollutants with inclusion of their reference levels.

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

Period September 11–October 8, 2011					
Monitoring Station		part per million (ppm)			
		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*

Note: Values highlighted are above reference levels.

CO levels were measured at 10 locations using VRAE portable monitors. The measured hourly levels were very low (less than 2 ppm) for the vast majority of the time. There was one anomaly, an elevated level of 33.4 ppm, which was monitored at Site 4 on September 23rd at 7 p.m. This level was still below the reference level of 35 ppm. It did not occur during the blasting operations and the source of this short-term spike could not be identified.

NH3 levels were measured at 10 locations using VRAE portable monitors. The vast majority of the measured hourly levels were very low. The few NH3 levels slightly above the reference level of 3.4 ppm occurred during the night at the time when there was no surface construction activity. While the highest measured value of 3.7 ppm is slightly above the selected reference level, it is well below the AEGL-1 for NH_3 (at 30 ppm).

H_2S levels were measured at four locations using a Jerome 631-X analyzer. All measured hourly levels were well below the reference level of 0.51 ppm during the monitoring period.

NO and **NO_2** levels were measured at 10 locations using VRAE portable monitors to identify potential sources of odor resulting from construction activities. The data is discussed below in the Section C, Odor Investigation results.

VOC levels were measured at 10 locations using PID portable monitors. The main purpose of these measurements was to evaluate the data collected by the CAMP program that established a 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 NYSDEC or EPA ambient standards or guidelines for VOCs. The vast majority of the levels monitored were very low with averages below 0.5 ppm. There were only a few 15-minute periods that recorded levels between 4.5 and 7.5 ppm. 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.

SO_2 levels were measured at four 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 (which is based on the NAAQS).

In these six instances, the SO_2 levels rose before the blasting events and could not be correlated with these blasting operations. The cause of the peak concentrations is currently unknown. SO_2 is a common air pollutant typically formed during combustion or heating processes where sulfur is present, including reactions with other chemicals that include sulfur. 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 makeup of the construction materials used both in the tunnel and at street level. Sulfur compounds such as SO_2 are created only when sulfur is present. Neither the explosives nor associated blasting products contain sulfur-bearing ingredients.
- Monitoring for SO_2 using handheld 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). SO_2 was not detected in any of the NIOSH 6004 tests performed.
- Rock core samples from the 72nd Street Station area were collected and analyzed for sulfur. 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.
- Evaluation of possible interference of other gases on the SO_2 levels recorded by the RKI Eagle II gas detector revealed that the instrument is highly sensitive to the presence of other gases in the atmosphere, which can lead to false SO_2 readings.
- Continuous SO_2 monitoring at sidewalk locations during November/December 2011; during that period no elevated levels of SO_2 were detected.

This indicates that the elevated readings on the six days in September/October were isolated events that could not be attributed to blasting operations or other construction activities.

C. Odor Investigation Results

Toward the end of September, the odor specialist conducted a series of interviews with residents who had complained of odors emanating from the construction sites. Although all the interviewees were affected by some type of odors at their residences, those that reside directly adjacent to the muck houses appeared to be the most bothered by the odors. All residents described the odor as having some type of sulfur component (skunk, natural gas, gunpowder, "sulfury"). Some also described irritant effects of emissions (choking, acrid, suffocating, "hitting the back of the throat") during the interview.

Of the monitored pollutants, NO, NO_2, SO_2, H_2S, and NH_3 have odor thresholds associated with them. The documented odor characters of these pollutants include descriptors such as sharp, biting, acrid, pungent, and irritating. The odor threshold is a characteristic of a compound and is defined as a concentration at which 50 percent of the population can detect the odor of that pollutant. The irritation threshold is defined as a concentration at which 50 percent of the population begins to experience an irritant effect such as tingling or slight burning sensation in the nose, throat, and eyes. Odor thresholds are not health-based values, nor are they federal or state guideline values.

A statistical analysis of the odor-related pollutants indicated that maximum one-hour concentrations observed during both blasting and non-blasting activities exceeded the odor thresholds for all pollutants. The odor specialist identified an odor of moderate intensity during blasting events, based on the American Society for Testing Materials (ASTM) testing method E544-04 odor intensity scale. None of the concentrations exceeded the respective irritation thresholds for each pollutant.

D. Evaluation of the Contractor's CAMP Program

The analysis of the contractor's CAMP data indicated multiple measurements recording PM_{10} and VOC levels above the established action levels and an unsatisfactory record of equipment maintenance and calibration. In order to determine the accuracy of the recorded PM_{10} and VOC levels, this study co-located air monitoring equipment with monitors installed by the 72nd Street Station contractor.

PM_{10} and VOC data from the CAMP and co-located monitors were compared for the same period. The results of this evaluation indicated an unsatisfactory correlation for both pollutants. High levels of VOCs recorded at the CAMP monitor were not detected in the co-located monitor. It appeared that irregular instrument calibration and quality assurance/quality control procedures by the contractor have produced unreliable data in the CAMP program.

The recommendation is that the CAMP instruments should be calibrated daily (using calibration gases adequate to the instrument operating range), and properly maintained. The data recorded while the instrument is not within the calibrated range should not be included in the monitoring reports (or, as an alternative, should be reported as invalid data). Also, the CAMP program should focus on PM_{10}, as it is the pollutant expected to be most affected by blasting events.

VII. Mitigation Measures Implemented and Recommendations for Future Monitoring

After the monitoring period ended, the 72nd Street Station contractor (C4B) in late November installed additional mitigation measures to control emissions from their controlled drill-and-blast operations. These additional measures included:

- Installing rooftop vents on each muck house with manually adjustable louvers to control air flow;
- Sealing door leaks and other vents to contain the smoke in the muck house after the blast to permit water spraying operations more dwell time to suppress the dust, and then directing the smoke through the rooftop vent only (during September/October the muck-house gates were left open to dissipate gases);
- Utilizing a wet burlap curtain barrier at the base of the excavation shaft;

- Redirecting the water spraying devices (Dust Bosses) to more effectively control dust; and
- Increasing the time interval (dwell time) between each blast event to maximize the effectiveness of the dust suppression and smoke control system.

Also, the explosive power of the blasts was reduced to gauge the effectiveness of the new mitigation system. These measures have been successful in reducing the visible smoke and odors at the street level and are expected to further reduce the sporadic spikes in PM_{10} levels recorded prior to their implementation. Since the system improvements, light smoke has been observed on occasion leaking from partially sealed doors and faint odors are detected for a few minutes after some blasts. Continued diligence in performing the established protocols after blast events is recommended as is sealing up any remaining air leaks in the muck houses.

The 86th Street Station contractor will utilize a different system to mitigate air emissions when blasting operations begin later this year. Limited and targeted monitoring is recommended between 83rd and 87th Streets to ensure that the emissions controls are adequate once controlled drill-and-blast operations commence. The pollutants recommended for monitoring in this area are PM_{10} and $PM_{2.5}$.

To further reduce odors associated with blasting activities, masking or deodorizer agents could be tested for use in the Dust Bosses. Careful consideration of the agent should be made such that additional “perfumed” odors are not released as a result of using the masking/deodorizer agent.

VIII. Conclusions

The monitoring program collected data for a comprehensive list of pollutants to capture the effects of construction activities. The data collected represents worst-case potential for public exposure and was compared to conservative benchmarks that were based on established health standards and guidelines.

The measured daily (24-hour) PM_{10} concentrations were below the reference level used as the benchmark to indicate no adverse PM_{10} health effects during the monitoring period. Daily $PM_{2.5}$ concentrations exceeded the daily reference level on three different days during the month-long monitoring period. The analysis of the data for the three days indicates that daily $PM_{2.5}$ concentrations were primarily attributed to local traffic emissions, other local sources such as commercial and residential boilers, and regional or background levels, with no significant contribution from blasting activities. The highest daily $PM_{2.5}$ levels measured in those three days were not unusual when compared to New York City peak levels recorded in the past by NYSDEC, and the close proximity of the street-level monitors to the traffic and construction activities. The respirable silica concentrations did not exceed the reference level during the study period.

Of the gaseous pollutants, SO_2 levels exceeded the reference levels on six different days. The time period of elevated levels did not coincide with the blasting operations. Subsequent tests performed by the MTA did not identify the presence of sulfur in any construction activity that would generate SO_2. As such, the elevated recorded levels on those six days could not be attributed to blasting operations or construction activities.

CO and H_2S did not exceed the reference levels, and NH_3 slightly exceeded the reference level during the nighttime when there was no surface construction activity in the area.