

NEW YORK STATE OF OPPORTUNITY | Department of Environmental Conservation

Albany South End Community Air Quality Study

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List of Acronyms and Abbreviations

ACHD	Albany County Health Department
AADT	Annual Average Daily Traffic
BAQS	Bureau of Air Quality Surveillance
BC	Black Carbon
CDTC	Capital District Transportation Committee
CO	Carbon Monoxide
CDTA	Capital District Transportation Authority
DGS	City of Albany's Department of General Services
ECOs	Environmental Conservation Officers
FHWA	Federal Highway Administration
GPS	Global Positioning System
HEV	High Emitting Vehicles
LDSA	Lung-Deposited Surface Area
m/s	Meters per Second
NAAQs	National Ambient Air Quality Standards
NO	Nitrogen Oxide
NO_2	Nitrogen Dioxide
NO_x	Nitrogen Oxides
number/cm^3	Number of Ultrafine Particles per Cubic Centimeter of Air (or #/cm^3)
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
NYSDOT	New York State Department of Transportation
O_3	Ozone
PAMS	Photochemical Assessment Monitoring Stations
PEJA	Potential Environmental Justice Area
PM_{10}	Particulate Matter less than 10 microns
$PM_{2.5}$	Particulate Matter less than 2.5 microns
ppb	Parts per Billion
STEP	Science and Technology Entry Program
TD	Thermal Desorption
TRAP	Traffic-Related Air Pollution
TSP	Total Suspended Particles
UFP	Ultrafine Particle
µg/m^3	Micrograms per Cubic Meter
USEPA	U.S. Environmental Protection Agency
VOC	Volatile Organic Compound

Executive Summary

Background

The NYS Department of Environmental Conservation (NYSDEC) designed the Albany South End Community Air Quality Study in response to community concerns regarding air quality in this community. The South End community is bisected by South Pearl Street and is next to the Port of Albany. The port can be accessed by a network of roads, including Interstate-787, a railroad, and from marine vessels operating on the Hudson River. Within the Port of Albany, there are two facilities that store and transfer petroleum products, gasoline, and ethanol. The Port of Albany also contains an asphalt storage facility, a flour milling operation, the Albany County Water Purification facility, and waste handling and recycling businesses. Across the Hudson River, in the Port of Rensselaer, there are several facilities transferring and storing petroleum, gasoline, and ethanol, and an operation that produces asphalt paving material.

Air quality near port communities, like Albany's South End, can be affected by releases from diesel trucks, trains, marine vessels, cargo handling equipment, oil and gas storage, commercial operations, and industrial facilities handling petroleum products. Albany's South End community residents reported concerns about health, safety (due to their proximity to rail cars), odors, noise, vehicle speed, and heavy truck traffic. Community members asked NYSDEC to conduct a more comprehensive neighborhood monitoring effort to understand how their air quality is affected by port activities and heavy truck traffic. Staff met with community members in August 2016, and presented an approach to study the community's air quality.

With the community's input, the Albany South End Community Air Quality Study was designed to evaluate four specific objectives:

- Evaluate how much particulate matter comes from motor vehicles versus port activities;
- Develop an understanding of how far particulate matter travels from the road into the surrounding neighborhood;
- Determine how activities at the ports of Albany and Rensselaer and motor vehicles on roadways contribute to benzene concentrations in the study area; and
- Create approaches to help the community understand air quality.

The study began in July 2017 when the first air quality monitoring station began operation. It is located at Ezra Prentice Homes on South Pearl Street (NY Route 32), which runs through the middle of the property. This portion of South Pearl Street is a major truck route[1] that provides access to nearby businesses and into the City of Albany. The fixed[2] monitoring station at Ezra Prentice included instruments that measured pollutants associated with traffic, pollutants released from the movement and storage of petroleum products, and other pollutants associated with industrial activities in the Port of Albany. Measured pollutants included larger size particulate matter (10 microns and less in size, PM_{10}), fine particulate matter (2.5 microns and less in size, $PM_{2.5}$), black carbon (BC), ultrafine particles (UFPs) (0.1 microns and less in size), and gases including nitrogen dioxide (NO_2) and benzene. UFPs are very small particles that are

[1] This portion of NY Route 32 is classified as a 'highway designated as qualifying or access highway for larger dimension vehicles" under 17 NYCRR Part 8000 and 17 NYCRR Part 8100.

[2] We use this term fixed to indicate that the monitoring station remained at the same location throughout the entire study because portable instruments also were used to measure air pollution.

much smaller than PM_{10} and $PM_{2.5}$, as illustrated in Figure 1.[3] The New York State Department of Transportation (NYSDOT) installed a traffic counter for this study that measured a daily average of 9,086 vehicles with 960 of those being larger trucks .

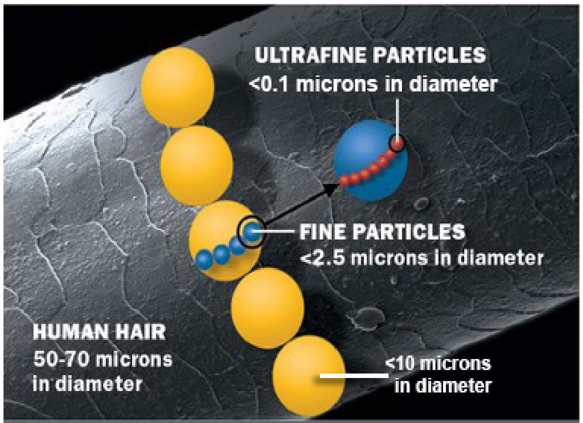

Figure 1. Particle Sizes
(Modified image from Tufts University)

NYSDEC also installed a study monitor in the community on Third Avenue, which is not a major truck route. This fixed monitor was used to measure urban background pollutant concentrations. A NYSDEC network monitor located at the Albany County Health Department (ACHD), in operation since 1973, and another site nearby, called the South Albany monitor (Schuyler and Pearl Streets), were used in this study to provide additional information about pollutant concentrations in the Albany South End neighborhood.

Along with the fixed monitors, another valuable component of the study involved using portable instruments to measure UFPs and BC as indicators of traffic-related air pollution (TRAP) at locations closer to homes and at different distances from the road over shorter periods of time. UFPs can rapidly change in size and composition once they are released into the air. Typically, TRAP disperses quickly as you move away from the edge of an active roadway. Other factors including type of vehicles, changes in wind speed, and the location of buildings and trees and shrubs can influence how TRAP travels from the road.

In 2015, NYSDEC demonstrated the effectiveness of using portable UFP monitoring near roadways.[4] The results showed occasional high measurements ("peaks") of UFPs from individual diesel vehicles.

For this study, portable monitoring was conducted across the South End community with a focus on the Ezra Prentice Homes along South Pearl Street, and for comparison purposes a second location in a residential neighborhood along Southern Boulevard. Southern Boulevard was selected because it has similar traffic volume, but fewer diesel-powered vehicles. Portable monitoring was used to identify the types of diesel vehicles emitting peak TRAP (referred to as high emitting vehicles, or HEVs) and how far TRAP travels from the road into the neighborhood.

NYSDEC also conducted a benzene sampling effort that covered both the Albany South End community and the ports of Albany and Rensselaer to understand how the activities at these ports and motor vehicles contribute to benzene concentrations in the study area.

Staff used a variety of approaches to convey information about the study methods and results collected during the study period.

[3] The particles in the image are represented as spheres. In ambient air sampling, particles vary in shape and density but have an aerodynamic diameter (of 2.5 microns for $PM_{2.5}$ or 10 microns for PM_{10}) when they pass through the appropriate inlet at a specific flow rate.

[4] Frank, B.P., Wurth, M.J., LaDuke, G.H., Tang, S.D., *Spatial Persistence and Patterns of Ultrafine Particle Short-term Peak Concentrations in the Near-Roadway Microenvironment*, in preparation.

Key Findings

- **More particulate matter is coming from motor vehicles than port activities.**

  Fixed monitoring found that particulate matter ($PM_{2.5}$ and PM_{10}) concentrations were greater at the Ezra Prentice study monitor compared to the Albany County Health Department (ACHD) network monitor due to the higher volume of truck[5] traffic adjacent to Ezra Prentice. Ultrafine particle (UFP) concentrations were similar at Ezra Prentice and ACHD. Local contributions were mostly from truck traffic related to port and local business activities.

  Particulate matter at Ezra Prentice is higher when the wind blows across South Pearl Street (from northeast or east). Particulate matter decreases when winds pick up in the afternoon, which creates greater dispersion of particulate matter and other traffic-related pollutants. During weekdays, the highest concentrations occur at the same time as the morning traffic increase. The $PM_{2.5}$ concentration at Ezra Prentice is 13 percent greater than concentrations at ACHD and this increase corresponds directly to the increase in morning truck traffic volume.

- **Traffic-related air pollution (TRAP) is considerably greater and extends farther from the South Pearl Street at Ezra Prentice due to the type of motor vehicles traveling this roadway.**

  NYSDEC portable monitoring found TRAP (UFP and BC) measured at Ezra Prentice homes closest to the road is considerably greater than the rest of the South End specifically due to HEVs from a range of vehicle types, including small buses transporting people with disabilities, school buses, and large trucks traveling to and from local businesses south of Ezra Prentice to the Port of Albany and the City of Albany. Less than 10 percent of the all vehicles contributed to greater than 25 percent of the total TRAP. On average, TRAP measured closest to South Pearl Street at Ezra Prentice is approximately twice the amount measured at Southern Boulevard, and it remains elevated for longer distances from the road at Ezra Prentice.

  NYSDEC concludes that TRAP is lower at Southern Boulevard because there are fewer buses and large trucks traveling along the road. Along South Pearl Street at Ezra Prentice, 24 percent of the vehicles were identified as large trucks and buses compared to 4 percent identified at Southern Boulevard.

- **Particulate emissions from locomotives and port shipping transport are minimal compared to local traffic.**

  The portable monitors stationed at Ezra Prentice for five hours, over multiple measurement periods, identified repeat, brief periods of time when measurements of UFP and BC peaked. These concentration peaks are characteristic of high-emitting vehicles (HEVs) traveling along South Pearl Street near the Ezra Prentice Homes. It is unlikely these peaks are from other transportation sources, such as trains or marine vessels on the Hudson River, which move much slower and less frequently. Monitors located close to the train tracks did not show repeated peak measurements like those observed near roadway. While not identified as an important contributor of emissions in this study, rail activities may have other negative impacts on the community such as noise, ground vibration, and safety concerns.

[5] Following the Federal Highway Administration's classification for vehicles, NYSDEC researchers characterized classes 1-3 as "cars" and class 4 and higher will be labeled as "trucks". See Figure 6 for the classification scheme.

- **Port activities contribute to measurable increases in local benzene concentrations.**

  The Albany South End study included different approaches to determine the sources of benzene and the impact of those sources on residents in the study area. The spatial study identified locations of sources of benzene. It showed that the parts of the South End in or downwind of the petroleum storage and distribution facilities had consistently higher and more variable concentrations of benzene year-round. Lower and less variable concentrations of benzene were measured in the residential areas.

  The study included an air toxics monitor at Ezra Prentice in order to determine the impact of those sources of benzene. This monitor operated for a year and provided data comparable to the existing ACHD monitor and to the rest of the State's air toxics network. Benzene concentrations at Ezra Prentice were lower than concentrations measured near the ACHD network monitor. Benzene annual averages are somewhat higher in South Albany compared to other NYSDEC network monitors in urban areas.

New Actions to Reduce Air Pollution and Exposure

As a result of DEC's South End Air Quality Study, and directed by Governor Cuomo, state agencies and our local partners are undertaking new actions to reduce community exposure to truck pollutants:

- **DEC and DOT are making $20 million available from the Volkswagen settlement and other resources to fund clean trucks** statewide, with a focus on environmental justice communities like the South End, and DEC is working with identified truck fleets to evaluate ways fleets can reduce emissions. DEC has allocated an additional $52.4 million for future projects to replace transit, school, and paratransit buses statewide.

- **DEC is conducting enforcement checks and imposing fines** on trucks with high emissions on South Pearl Street.

- **DEC is conducting frequent leak detection inspections** at gasoline and petroleum handling facilities using new state-of-the-art equipment, followed by enforcement, as appropriate. DEC has required one gasoline and petroleum terminal in Rensselaer to repair leaks identified using that equipment.

- **DOT, in coordination with the City of Albany, has reclassified four roads within the Port of Albany** to create the potential for trucks to be rerouted away from the area near Ezra Prentice.

- **DOT is committed to providing technical support** to the City of Albany, including direct engineering assistance, in support of the city's continued assessment of South Pearl Street and potential alternative routes for truck traffic.

- **The Mayor's Office is helping coordinate the voluntary rerouting of frequent truck traffic** by several commercial entities with a presence in and near the South End. Traffic monitoring demonstrates that these efforts have reduced truck and bus traffic by 30 percent on South Pearl Street.

- **The Mayor's Office directed the City of Albany Department of General Services (DGS) to prohibit its vehicles from using South Pearl Street other than for regularly scheduled solid waste pickup and street cleaning.** DGS has acquired a street cleaning vacuum to use along the South Pearl Street corridor daily to help reduce particle resuspension. Mayor Kathy Sheehan also assisted the State's efforts by facilitating meetings between DEC and local transportation companies to help provide additional data.

- **DEC continues to monitor traffic-related pollutants** at Ezra Prentice while evaluating ways to adapt and transfer knowledge gained from this study to other near-road and Environmental Justice communities across the state to mitigate traffic pollutants.

- **The Albany Housing Authority (AHA) is minimizing residents' indoor exposure to traffic pollutants**. AHA is providing professionally installed window air conditioners where appropriate, as early as this year, beginning with residences closest to South Pearl Street and moving outward. AHA is evaluating other strategies for reducing pollution from entering the apartments such as the effectiveness of central air conditioning. AHA will increase door-to-door advocacy with healthcare partners to increase awareness and education related to indoor air quality.

- **DEC, the Mayor's Office, and AHA are leading a workgroup** to develop mitigation strategies and ensure implementation of overall approaches. The workgroup will evaluate the effectiveness of roadside barriers such as green walls where appropriate.

Introduction

The air quality near port communities like Albany's South End is impacted by diesel trucks, trains, marine vessels, cargo handling equipment, petroleum and gas storage, commercial area sources, and industrial facilities handling petroleum products. Albany's South End community residents have reported concerns about health, proximity to rail cars, odors, noise, vehicle speed, and heavy truck traffic. Living close to roads with large amounts of traffic may expose communities to an increased level of pollutants associated with adverse health effects.[6]

The New York State Department of Environmental Conservation (NYSDEC) responded to community concerns by conducting a nearly two-year-long community air quality study. The study, which began in July 2017, evaluated levels of specific pollutants in the community and was specifically designed to assess:

- How much particulate matter comes from motor vehicles versus port activities?
- How far does particulate matter from the road extend into the surrounding neighborhood?
- How do commercial and industrial activities at the ports of Albany and Rensselaer and on-road motor vehicles contribute to benzene concentrations within the study area?
- Approaches to assist the community understand air quality.
- How can exposure to pollutants be reduced?

Community Description

The study's primary sampling area includes the neighborhoods of Albany's South End, Mount Hope, and Krank Park – Cherry Hill. All three neighborhoods are considered potential environmental justice areas (PEJA) following NYSDEC's guidance, which is based on percent minority and income level. PEJA have been identified across New York State in both rural and urban areas.[7]

Some pollutant and traffic measurements were taken outside the primary sampling area to compare traffic counts and motor vehicle pollution, and to better understand benzene sources across the broader community.

The study community lies adjacent to the New York State Thruway and Interstate-787, which is the main highway for travel into and out of downtown Albany. The length of Interstate-787 closest to South Pearl Street has an annual average daily traffic (AADT) volume of 58,744 vehicles.[8]

Lower income and communities of color are subject to disparate impacts from environmental hazards such as proximity to industrial activity and high traffic corridors with higher pollution levels, odors, noise, and overall reduced quality of life. Studies have documented that a disproportionate number of people of color and lower income residents live in high traffic density areas.[9,10] Research suggests exposures from

[6] These pollutants are defined as traffic-related air pollution or TRAP. Health Effects Institute (HEI) Panel on the Health Effects of Traffic-Related Air Pollution. 2010. *Traffic-Related Air Pollution: A Critical Review of the Literature on Emissions, Exposure, and Health Effects.* 2010 HEI Special Report 17. Health Effects Institute, Boston, MA.

[7] A "by county" listing can be found at: https://www.dec.ny.gov/public/911.html.

[8] New York State Department of Transportation, 2014 Traffic Volume Report. The section of Interstate-787 referenced is noted by marker: 787I11011016.

[9] Rowangould, Gregory M, *A census of the US near-roadway population: Public health and environmental justice considerations*. Transportation Research Part D. (25) 2013, 59-67.

[10] Brugge, Doug, et. al., *Developing Community-Level Policy and Practice to Reduce Traffic-Related Air Pollution Exposure*. Environmental Justice. 8(3), 2015, 95-104.

traffic-related air pollution are higher than average for people of color and low socioeconomic status populations compared to lower than average for Caucasian and high socioeconomic status populations.[11,12,13] Environmental justice communities also tend to lack access to health care, pharmacies,[14,15] open green space,[16] and grocery stores with nutritious foods.[17] Limited options for affordable housing also present challenges for low income residents to relocate.[18] Social and environmental stressors may further influence susceptibility to health effects from exposure to pollution, especially for children, the elderly, and individuals whose health is already vulnerable. The cumulative effects produce significant and persistent health disparities between different socioeconomic and racial or ethnic groups.[19]

Environmental justice programs strive to improve public health and the environment by reducing exposure to pollution in communities. The NYSDEC Office of Environmental Justice aims to achieve this goal by organizing outreach with community leaders and residents to better understand the potential environmental impacts in their community and by working with Environmental Conservation Officers and NYSDEC staff to conduct enhanced inspections of local emission sources and to evaluate compliance with federal and State regulations. The work in the Albany South End community is a culmination of various NYSDEC program efforts working together to address community concerns for this environmental justice neighborhood.

The primary focus of the study is to better assess the ambient air quality for the residents at the Ezra Prentice Homes on South Pearl Street. The section of South Pearl Street/NY 32 between First Avenue and Old South Pearl Street is a “Designated Truck Access Highway” with approximately 1,700 trucks per day traveling along South Pearl Street at the location of the Ezra Prentice Homes.[20]

[11] Marshall, Julian D. Environmental inequality: *Air Pollution Exposures in California’s South Coast Air Basin*. Atmospheric Environment 42, 2008, 5499-5503.

[12] Pratt, Gregory, C., et al. *Traffic, Air Pollution, Minority and Socio-Economic Status: Addressing Inequities in Exposure and Risk*. Int. J. Environ. Res. Public Health, (12), 5355-5372, 2015.

[13] Clark, Lara P., et. al., *Changes in Transportation-Related Air Pollution Exposures by Race-Ethnicity and Socioeconomic Status: Outdoor Nitrogen Dioxide in the United States in 2000 and 2010*. Environmental Health Perspectives. 125(9) 2017, [097012]

[14] Qato, Dima, et.al., *‘Pharmacy Deserts’ Are Prevalent in Chicago’s Predominantly Minority Communities, Raising Medication Access Concerns’* Health Affairs, 33:11 (1958-1965). 2014.

[15] Amstislavski, Philippe, et.al., *Medication deserts: survey of neighborhood disparities in availability of prescription medications*. International Journal of Health Geographics. 11:48. 2012.

[16] Jennings, Viniece, et.al., *Urban Green Space and the Pursuit of Health Equity in Parts of the United States*. International Journal of Environmental Research and Public Health. 14(11): 1432. 2017.

[17] Hilmers, Angel, et.al., *Neighborhood Disparities in Access to Health Foods and Their Effects on Environmental Justice*. American Journal of Public Health. 102(9). 1644-1654. 2012.

[18] Anu Paulose, *Economic Hazards of Environmental Justice for Lower-Income Housing Tenants*, William & Mary Environmental Law & Policy Rev. 39(2), Article 8, 507 (2015)

[19] Morello-Frosch, Rachel, et. al. *Understanding the cumulative impacts of inequalities in environmental health: implications for policy*. Health Affairs, 30(5), (879-87) 2011.

[20] City of Albany: S. Pearl St. Heavy Vehicle Travel Pattern Study http://www.cdtcmpo.org/images/freight/S-Pearl-HV-Final-Aug-7-2018_Reduced.pdf.

Land use in the Albany South End neighborhood is a mixture of industrial uses in the Port of Albany, residential homes to the west and north of the port, and commercial entities and small businesses. Interspersed within the community are parks and community service facilities (e.g., schools, churches, historic properties). There are a few solid waste management operations located in the port including a solid waste transfer station, a construction and demolition debris processing operation, and a recyclable handling and recovery facility. There are two major oil storage facilities on the Albany side of the Hudson River and seven on the Rensselaer side of the river. The Global Companies LLC facility is the one located closest to the Albany South End neighborhood. Three facilities (Global Companies LLC, Buckeye Albany Terminal LLC, and Albany County Water Purification District) in the port have Title V permits, the most comprehensive type of air permit.[21] Other Port of Albany facilities, including asphalt storage and flour milling operations, hold a Registration permit. Port of Albany operations also include a large rail yard and marine terminal, which are emission sources that are not required to obtain NYSDEC air permits.

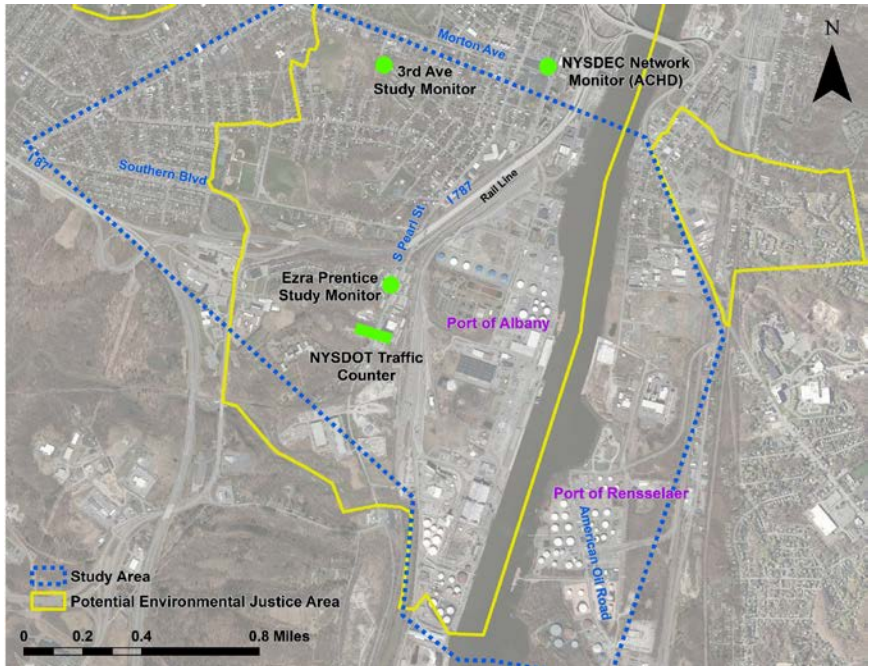

Figure 2. Albany South End General Study Area

[21] To learn more about the permitting of facilities by NYSDEC, read *Controlling Sources of Toxic Air Contaminants* online at: https://www.dec.ny.gov/chemical/89934.html

Response to Community Concerns

Community Meetings

Community engagement was a critical component of the study. NYSDEC kept the community informed about the study and the monitoring through community meetings, regular updates to the study website, and on-site viewing of the stationary monitors and real-time data. Prior to and during the study, NYSDEC held or participated in seven community information meetings.[22] During the community meetings, NYSDEC staff heard concerns from the community about heavy truck traffic and health concerns related to respiratory issues such as asthma. Table 1 provides a summary of the community briefings. During these presentations, representatives from Albany County Health Department (ACHD) and New York State Department of Health (DOH) were in attendance to answer questions related to health concerns.

Table 1. Community Presentations

Date	Presentation Information
8/31/2016	The first community meeting was held in August 2016 and the study design was presented with the goal of receiving feedback from the community on where to locate the study background monitor and where to conduct the portable monitoring.
1/18/2017	The four main study objectives were presented along with the pollutants to be studied, primary sources for these pollutants, sampling equipment to be used and proposed monitoring locations. We asked the community what information they would like us to report back at the next community meeting and whether the study objectives address their concerns.
3/8/2017	The community was provided with specific details on the portable monitoring portion of the study. The presentation included information the two types of pollutants measured as markers for traffic-related air pollution (ultrafine particles and black carbon) and the instruments used to measure these pollutants. Field testing of the instruments in 2015 proved that they were capable of portable monitoring for transportation related air pollution in the Albany South End Community. The meeting also provided an opportunity to let community members know how they could learn more about the portable monitors and potentially be involved by assisting NYSDEC staff.
3/27/2017	Staff presented much of the same information from the previous two presentations. The presentation included new information about benzene sampling throughout the Albany South End community and the ports of Albany and Rensselaer. Staff also asked for input from the community on the communication portion of the study.
7/28/2017	The study formally began in the community with an onsite press announcement with the NYSDEC Commissioner Basil Seggos, Albany Mayor Kathy Sheehan, other elected officials, community stakeholders, partnering agencies and local media. Factsheets summarizing the study objectives, pollutants measured, and instrumentation were distributed.
8/7/2017 and 8/9/2017	An overview of the study was provided on two different dates at two locations in the community. The presentation also included details on how the results will be analyzed. The New York State Department of Health presented information on the health implications for the pollutants measured. Lastly, NYSDEC presented details on the Volkswagen settlement which could potentially affect the community if grant monies are used to reduce emissions from diesel vehicles and equipment used by businesses in the community.
1/10/2018 and 1/18/2018	Staff provided a progress update on two different dates at two locations in the community. The community was also notified about the installation of a traffic counter on South Pearl Street, south of the Ezra Prentice homes.

[22] The website for Albany's South End Neighborhood Air Quality Initiative can be found at: http://www.dec.ny.gov/chemical/108978.html.

Previous Screening Assessment

In early 2014, residents in the Albany South End community expressed their concerns to NYSDEC about potential air quality impacts due to the movement and storage of crude oil in the area. The production of crude oil from the Bakken formation in North Dakota and Saskatchewan created a need for rail transportation of crude oil to seaports where it could be transported to refineries on the east coast. The Global and Buckeye petroleum storage and transfer terminals in the Port of Albany used their facilities to unload crude oil from rail cars, store it in tanks, and load it onto barges for shipment down the Hudson River. The Buckeye terminal ceased moving crude oil prior to the start of the current study, and the Global terminal did not move crude by rail during the study period. These two facilities also store and transfer other petroleum products, e.g., gasoline and fuel oil**.**

Residents asked NYSDEC to perform a survey of air quality in the area. Staff met with residents in the community and designed a short-term air quality assessment. NYSDEC staff explained that in addition to the movement of petroleum products into and out of the port, the area has other sources of air contaminants including those from the Kenwood rail yard, manufacturing, asphalt production, sewage treatment, local residential and commercial space heating, and mobile sources emissions from nearby Interstate-787 and other roadways.

The design of the NYSDEC screening assessment included 1-hour samples collected simultaneously at three locations in the Albany South End community on five separate days. In addition, a community volunteer collected a 1-hour sample on six days. NYSDEC collected samples when meteorological conditions favored potentially high air contaminant concentrations. Sampling collected by the community volunteer targeted instances of public complaints and odor episodes.

NYSDEC's laboratory analyzed all samples for a suite of air contaminants known as Volatile Organic Compounds (VOCs). This category of air contaminants volatilizes readily into the atmosphere and includes chemicals associated with crude oil and petroleum products. Additionally, NYSDEC analyzed the samples for specific light-weight alkanes which have been identified as components of crude oil originating from the North Dakota and Saskatchewan Bakken formation.[23] The alkanes were added to the study because when matched with benzene, the concentrations provide an indication of the impact of evaporative emissions from crude oil in the community. The light-weight alkanes evaluated in this screening assessment were butane, hexane, isobutane, iso-pentane, pentane, and propane. At ambient temperature and pressure, liquid alkanes readily volatilize.[24] Alkanes in general are not considered to be toxic in concentrations found in ambient air but they are an air quality concern because they contribute to ozone formation. NYSDEC monitors for these ozone precursors to evaluate and modify source control strategies.[25]

The NYSDEC screening assessment found the concentrations for VOCs and light-weight alkanes from all samples were below NYSDEC's short-term health-based air concentration values and most were below the long-term health-based air concentration values. Additionally, the results for routinely measured VOCs were similar to concentrations routinely found at other locations in the State.

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[23] *Safety debate eyes taming Bakken Crude before it hits rails*. Thomas Reuters News posted May 12, 2014. Available online at: http://www.reuters.com/article/2014/05/12/us-davegrailways-safety-crude-analysis-idUSKBN0DS18620140512. Accessed 7/2/2014.

[24] Butane, isobutane and propane are gases at ambient temperature and pressure.

[25] More information about NYSDEC's Photochemical Assessment Monitoring Stations monitoring can be found in the 2014 Monitoring Network Plan which is available online at: http://www.dec.ny.gov/chemical/54358.html.

In May 2014, the U.S. Environmental Protection Agency (USEPA) collected air samples onsite at the Global and Buckeye petroleum storage and transfer terminals and one air sample in the Albany South End neighborhood. USEPA collected short-duration air samples, approximately 20-second intervals, and used equipment similar to the equipment used by NYSDEC. USEPA evaluated the air samples for 79 individual constituents, including VOCs that are part of the composition of crude oil and light-weight alkanes. For the neighborhood sample, the constituents commonly found in crude oil and petroleum products were found to be similar to concentrations in NYSDEC's neighborhood sample results.

NYSDEC's screening assessment concluded that none of the concentrations of toxic air contaminants were of immediate public health concern and all concentrations were similar to what was measured in other locations within the state.

Capital District Transportation Committee Study

The Capital District Transportation Committee (CDTC) researched and analyzed heavy vehicle traffic patterns along South Pearl Street (NY 32). The results of that research were used to develop potential strategies to mitigate the negative impacts of heavy vehicle traffic on the residents in the study area. CDTC began with Study Advisory Committee meetings in the first half of 2017 and collected origin-destination information on heavy vehicle traffic on South Pearl Street at the Ezra Prentice Homes and at destination points to the north and south in April 2017. A draft report with a summary of key findings was presented to the community in May 2018 with a public comment period open until July 2, 2018. The final report was released on August 7, 2018.[26]

The CDTC study found that 17% of the heavy vehicles that pass by the Ezra Prentice Homes were traveling to, or from, the Port of Albany entrance to the south. An estimated 81% of the northbound heavy vehicles that pass the Ezra Prentice Homes originate between Ezra Prentice and South Port Road.

South Albany Truck Traffic

The Port of Albany hired a consulting firm to study heavy vehicles (classes 4 through 13) traveling on South Pearl Street adjacent to the Ezra Prentice Homes and the extent to which those trips are generated by the port. Over a period of eight days in September 2016, automatic traffic recorders were installed at five locations along entry points at the port, South Pearl Street, and key intersections. The Port of Albany study found that 12,200 vehicles per day pass the Ezra Prentice Homes and approximately 14% of these, or 1,700, are heavy vehicles. The Port of Albany study found that 17% of these heavy vehicles on South Pearl Street adjacent to the Ezra Prentice Homes were traveling to and from the southern port entry road.[27]

[26] City of Albany: S. Pearl St. Heavy Vehicle Travel Pattern Study http://www.cdtcmpo.org/images/freight/S-Pearl-HV-Final-Aug-7-2018_Reduced.pdf.

[27] Creighton Manning. Final Technical Memorandum, South Albany Truck Traffic City of Albany, NY. Prepared for the Port of Albany. January 16, 2017.

Measurement of Mobile Source Emissions

Emissions from mobile sources (motor vehicles) have been a concern of the NYSDEC since 1970. As examples, research performed in New York helped advance catalytic converters, develop a light-duty dynamometer test sequence, and more recently, demonstrated the need for more stringent heavy-duty diesel engine certification standards. NYSDEC and the New York State Department of Motor Vehicles manage the light-duty (New York Vehicle Inspection Program) and heavy-duty diesel vehicle inspection and maintenance programs to ensure that motor vehicles are meeting standards applicable to their fuel type and model year. Agency staff also enforce heavy-duty diesel anti-idling laws designed to reduce emissions in populated areas.

Mobile source emissions on a per vehicle basis have been declining as more advanced emission control systems and cleaner fuels have been required and used in the on-road fleet. Despite these improvements, these emissions still are a major source of air pollutants in many areas of the state, especially in urban areas and near roadways. Heavy-duty diesel-powered trucks contribute greater nitrogen oxides and particulate matter emissions compared to light-duty vehicles (e.g., gasoline-powered cars and trucks).

It is impossible to precisely measure one specific pollutant representative of heavy-duty diesel emissions in ambient air. Diesel exhaust is a mixture of volatile, semi-volatile, and particulate matter, and many of these pollutants are also released from other urban sources. Additionally, specific components of diesel exhaust undergo transformation processes including evaporation and coagulation as they disperse from the point of emission. The relatively stable components such as black carbon travel from the point of origin and their concentrations diminish due to dispersion and aggregation. Other compounds such as ultrafine particles are very sensitive to environmental factors such as temperature and humidity. The concentration of ultrafine particles can quickly diminish due to diffusion, coagulation, and evaporation. In any case, the UFP number decreases, but the emissions constituents are still present. As examples, liquid particles may evaporate and form gases, while small solid particles may coagulate and form larger particles—both examples would no longer represent ultrafine particles.

Some of the pollutants emitted from diesel engines, such as black carbon and ultrafine particles, can be identified and measured. When a measurable pollutant can be associated with a source, the pollutant is designated as a potential indicator pollutant. The presence of indicator pollutants can only be used to identify a specific source of emissions when other sources that emit the same pollutants are not present or are likely to be negligible. The multitude of potential sources (e.g., vehicles, building heating, residential wood combustion, food preparation, etc.) makes it difficult to identify or apportion sources in urban areas. The process of source apportionment uses patterns of pollutant concentrations as well as knowledge of local sources of emissions to estimate the impact of individual source categories. Because the dominant fuel type for building heat in the City of Albany is natural gas,[28] in this study, black carbon and ultrafine particles were used as indicators of diesel-powered vehicle emissions on weekdays when other sources of black carbon and ultrafine particles were minimal.

[28] City of Albany, 2012. Albany 2030: The City of Albany Comp. Plan. Appendix D Climate Action Plan.

Health Effects of Mobile Source Emissions

Motor vehicles are a significant source of air pollution directly releasing gases such as carbon dioxide, carbon monoxide, nitrogen oxides, benzene, 1,3-butadiene, acetaldehyde, and formaldehyde. Gaseous emissions (such as benzene, 1,3-butadiene, and aldehydes) will combine with nitrogen oxides to form ozone. Additionally, the combustion of vehicle fuels emits particles directly as well as indirectly through the emission of VOCs that contribute to the formation of additional particulate matter (PM).

This mixture of gaseous pollutants such as nitrogen dioxide (NO_2) and PM is commonly referred to as traffic-related air pollution (TRAP). Vehicle type, age, condition, and fuel type influence the quantity and composition of TRAP. PM is a mixture of multiple components and particles of many sizes including PM_{10} (10 microns or less in size), $PM_{2.5}$ (2.5 microns or less in size), BC (less than 2.5 microns in size), diesel exhaust particulate matter, and UFP (less than 0.1 microns in size). TRAP is generally elevated within 300 to 500 meters (1,000 to 1,640 feet) of major roads.[29] Studies have shown that exposure to TRAP aggravates asthma and is suggestive of possibly causing asthma onset, other respiratory symptoms, reduced lung function, increased risk of pre-term birth, cardiovascular (heart and circulatory system) and neurocognitive (brain) effects.[30,31,32,33,34,35] Recent research provides supporting evidence that early life exposures to TRAP are associated with risk of childhood asthma onset in lower income neighborhoods.[36, 37]

A local-scale air quality modeling and health impact analysis of on-road mobile source contributions in New York City concluded heavy-duty diesel-powered trucks and buses contributed the largest share of primary $PM_{2.5}$ emissions and air quality burden. Disproportionate impacts were found for high poverty neighborhoods. Heavy-duty diesel-powered trucks and buses contributed 7.5% of $PM_{2.5}$ levels in high poverty areas and, the authors postulated, up to 0.6% of all deaths in the most affected neighborhood. $PM_{2.5}$ attributable emergency department visits for asthma were 8.3 times greater in high poverty compared to low poverty neighborhoods because of their higher truck traffic density and baseline asthma morbidity rates. Recommendations were made to focus on the most polluting vehicles in these neighborhoods.[38]

[29] Karner, A.A., Eisinger, D.S., Niemeier, D.A. (2010). *Near-Roadway Air Quality: Synthesizing the Findings from Real-World Data*. Environmental Science and Technology. 44: 5334-5344.

[30] Anderson HR, et. al., *Long-term exposure to air pollution and the incidence of asthma: Meta-analysis of cohort studies*. Air Quality, Atmosphere & Health 1(6):47-56, 2013.

[31] Pedersen M., et al. *Ambient air pollution and pregnancy-induced hypertensive disorders: A systematic review and meta-analysis*. Hypertension 64:494-500, 2014.

[32] Stieb DM, et al. *Ambient air pollution, birth weight and preterm birth: A systematic review and meta-analysis*. Environ Res 117:100-111, 2012.

[33] Clifford A, et al. *Exposure to air pollution and cognitive functioning across the life course--a systematic literature review*. Environ Res 147:383-398, 2016.

[34] Power MC, et al. *Exposure to air pollution as a potential contributor to cognitive function, cognitive decline, brain imaging, and dementia: A systematic review of epidemiologic research*. Neurotox, 56:235-253, 2016.

[35] Tzivian L, et al. *Effect of long-term outdoor air pollution and noise on cognitive and psychological functions in adults*. Int J Hyg Environ Health 218:1-11, 2015.

[36] Kravitz-Wirtz, Nicole et al. *Early-life air pollution exposure, neighborhood poverty, and childhood asthma in the United States, 1990-2014*. International Journal of Env. Research and Public Health. 15, 2018.

[37] Alotaibi, Raed, et al. *Traffic related air pollution and the burden of childhood asthma in the contiguous United States in 2000 and 2010*. Environment International, Vol 127, 858-867. 2019.

[38] Kheirbek, I., Haney, J., Douglas, S., Ito, K. and Matte, T. *The contribution of motor vehicle emissions to ambient fine particulate matter public health impacts in New York City: a health burden assessment*. Environmental Health 15:89. 2016.

Exposure to PM is associated with a variety of health effects. The range of PM size fractions that are considered by researchers looking at human health impacts include dust or total suspended particulates (TSP), large-size particulates (PM_{10}), fine particulates ($PM_{2.5}$), and UFP. Exposure to windblown dust and larger coarse particulates (TSP) can be associated with eye, nose, and throat irritation; smaller particulate matter can be inhaled and can aggravate respiratory symptoms.

Inhaling fine particulates has been associated with mortality, symptoms and changes in the cardiovascular system (the heart and circulatory system), and is believed to cause adverse effects in the respiratory and nervous systems. Research looking at the health effects from exposure to ultrafine particle pollution is relatively recent and there are no air quality standards that apply to these very small particles. Unlike most of the larger particulate matter fractions, ultrafine particles readily change their size and composition once airborne. This makes it more difficult to understand when, where, and how they might pose a health risk. From what is known about particles and health, it is important to consider the range of particle sizes we encounter in the environment.

Evidence suggests exposure to ultrafine particles may cause adverse effects in the cardiovascular, respiratory, and central nervous systems. There are animal studies indicating inhaled ultrafine particles can reach the brain and cause oxidative stress and inflammatory responses.[39] Sub-chronic exposure in animals caused changes in the brain (atrophy and decreased white matter) and neurodegenerative effects with observed behavioral changes.[40,41] Epidemiological studies evaluating long-term exposure to ultrafine particles and its central nervous system effects are limited and more research is needed to refine exposure estimates for ultrafine particles due to their high degree of spatial variability.[42] One longitudinal cohort study in Spain compared schools located within high and low pollution areas. Results showed children exposed to higher measured levels of traffic-related air pollutants (including ultrafine particles, NO_2, and elemental carbon) at their school had a smaller improvement in cognitive development compared to children exposed to lower levels.[43]

There is insufficient scientific evidence to conclude that short-term exposures to ultrafine particles have effects that are different from those of larger particles.[44] A recent synthesis report of large epidemiological studies using proximity to roadway and ultrafine particles and black carbon as traffic-related air pollution indicators concluded traffic exposure is associated with adverse cardiovascular

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[39] Cheng, H., Saffari, A., Sioutas, C., Forman, H., Morgan, T., Finch, C. *Nanoscale Particulate Matter from Urban Traffic Rapidly Induces Oxidative Stress and Inflammation in Olfactory Epithelium with Concomitant Effects on Brain*. Environmental Health Perspectives, Vol. 124, No. 10. October 2016.

[40] Cacciottolo, M., Wang, X., Driscoll, I., Woodward, N., Saffari, A., Reyes, J. et al. *Particulate air pollutants, APOE alleles and their contributions to cognitive impairment in older women and to amyloidogenesis in experimental models*. Transl Psychiatry (2017) 7.

[41] Woodward, N., Pakbin, P., Saffari, A., Shirmohammadi, F., Haghani, A., Sioutas, C. et al. *Traffic-related air pollution impact on mouse brain accelerates myelin and neuritic aging changes with specificity for CA1 neurons*. Neurobiology of Aging 53 (2017) 48-58.

[42] Meier, R., Eeftens, M., Aguilera, I., Phuleria, H., Ineichen, A., Davey, M., et al. (2015). Ambient Ultrafine Particle Levels at Residential and Reference Sites in Urban and Rural Switzerland. Environmental Science and Technology. 49: 2709-2715.

[43] Sunyer, J., Esnaoloa, M., Alvarez-Pedreroi, M., Forms, J., Rivas, I., Lopez-Vicente, M. et al. (2015) *Association between Traffic-Related Air Pollution in Schools and Cognitive Development in Primary School Children: A Prospective Cohort Stu*dy. PLoS Med 12(3).

[44] Health Effects Institute (HEI) HEI Review Panel on Ultrafine Particles. *Understanding the Health Effects of Ambient Ultrafine Particles*. HEI Perspectives 3. Health Effects Institute, Boston, MA, 2013.

outcomes including systemic inflammation, elevated blood pressure, irregular heartbeat, and stroke. The report suggested that exposure to black carbon and ultrafine particles is more strongly associated with cardiovascular outcomes than $PM_{2.5}$, but also noted better exposure estimates and further research in more diverse populations is needed to support these general findings.[45]

As outlined above, there are no studies in the literature telling us what levels of ultrafine particles and black carbon should be considered acceptable. In the absence of this information, NYSDEC is taking a precautionary approach by advocating for reduced exposures to TRAP which includes black carbon, ultrafine particles and other components of diesel exhaust. An objective of this study is to better understand the locations of sources and the times of day where we see them. This information will help develop strategies to reduce exposures in the absence of guidelines or regulatory standards for ultrafine particles and black carbon.

$PM_{2.5}$ was included in the study because it is a component of TRAP and it has a health-based annual National Ambient Air Quality Standard (NAAQS) of 12 µg/m^3 and a daily NAAQS of 35 µg/m^3. The Clean Air Act requires USEPA to set air quality standards for specific pollutants considered harmful to public health and the environment. It requires these standards to be reviewed every five years. USEPA began the current review of the particulate matter NAAQS in 2013. The peer-reviewed studies that have been published since the last review have been summarized and included in the October 2018 Integrated Science Assessment for Particulate Matter.[46] The USEPA Administrator will consider that review to determine if the $PM_{2.5}$ NAAQS should be revised.

In addition to particles, motor vehicles are large contributors of VOCs in the ambient air and short-term exposure to high concentrations of mobile source related air toxics (VOCs and carbonyls) can cause asthma exacerbation, headaches, and irritation to the eyes, nose and throat.

Long-term exposure to air toxics has the potential to initiate cancer and other health issues such as developmental, respiratory and cardiovascular effects. Because of the ubiquitous nature of motor vehicles and diesel- and gasoline-powered equipment, air toxics related to these sources are commonly found in all locations of the state.

Table 2. Summary of Pollutants of Concern, Sources, Standards, and Health Effects

Pollutant	Sources	Standard	Health Effects
$PM_{2.5}$	Traffic, burning of heating fuels, dust from activities like waste handling, asphalt paving production	Federal air quality standard	• Changes in the cardiovascular system • Adverse effects in the respiratory and nervous systems • People with breathing and heart problems, children, and the elderly may be particularly sensitive.
PM_{10}	Crushing or grinding operations, tire and brake wear, and dust stirred up by vehicles on roads	Federal air quality standard	• Increased number and severity of asthma attacks • Bronchitis or aggravated bronchitis and other lung diseases • Reduced ability to fight infections • Irregular heartbeat, heart attacks, and premature death in people with heart and lung disease

[45] Jhun, Iny et al. *Synthesis of Harvard EPA Center Studies on Traffic-Related Particulate Pollution and Cardiovascular Outcomes in the Greater Boston Area*, Journal of the Air & Waste Management Association, DOI: 10.1080/10962247.2019.1596994.2019.

[46] Integrated Science Assessment (ISA) for Particulate Matter (External Review Draft), October 23, 2018. https://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=341593.

Table 2. Summary of Pollutants of Concern, Sources, Standards, and Health Effects			
Pollutant	**Sources**	**Standard**	**Health Effects**
Ultrafine Particles (UFP)	Diesel-powered vehicles and other combustion sources	No air quality standard Used as a marker or indicator pollutant for traffic	• May cause adverse effects in the cardiovascular, respiratory and central nervous systems
Black Carbon (BC)	Diesel-powered vehicles and equipment, industrial processes, burning of petroleum-based heating fuels and wood	No federal or state air quality standard but black carbon is a component of diesel exhaust and $PM_{2.5}$ Used as a marker or indicator pollutant for traffic, specifically diesel	• Associated with health problems including respiratory and cardiovascular disease
Diesel Exhaust[47]	Diesel-powered vehicles and equipment	Mixture of pollutants (gas and particulate) for which a standard is difficult to develop	• Eye, nose, and throat irritation • May affect lung function and worsen medical conditions such as asthma and heart disease • Diesel exhaust particulates are reasonably anticipated to be a human carcinogen as determined by the US Department of Health and Human Services, National Toxicology Program (Ninth Report on Carcinogens (2000)).[48]
Nitrogen Oxides	Produced when petroleum-based fuels are burned. Motor vehicles are large sources of nitrogen oxides.	Nitrogen dioxide (NO_2) regulated by a federal air quality standard	• Irritation of the airways in the respiratory system • Aggravation of respiratory diseases like asthma • Causes asthma in children • Longer exposures may contribute to the development of asthma and potentially increase susceptibility to respiratory infections
Benzene	In gasoline and also produced during combustion of gasoline. Released from asphalt paving production, crude oil handling and movement of gasoline from terminal storage vessels to trucks	No federal or state air quality standard, but NYSDEC has both short-term and long-term guideline concentrations	• Short-term inhalation exposure of benzene may cause drowsiness, dizziness, headaches, as well as eye, skin, and respiratory irritation. • Long-term inhalation exposures have caused blood disorders and increased incidence of leukemia (cancer affecting the blood and bone marrow). • USEPA has classified benzene as a known human carcinogen.

[47] Based upon recent studies in animals, emissions from modern diesel engines with advanced control technology are less harmful if the emission controls are operating and properly maintained. Diesel particulate filters are highly effective in reducing particulate matter. Nitrogen oxide emissions are also effectively reduced with advanced control systems. (Health Effects Institute, 2015. The Advanced Collaborative Emissions Control Study) A recent laboratory study in human subjects found that increased NO_2 emissions from newer diesel particulate-filtering technologies exaggerated the subjects' response to an allergen challenge. Therefore, the authors noted that particulates are not necessarily the only pollutant responsible for the harmful effects of diesel exhaust. (Wooding et al. 2019. Particle Depletion Does Not Remediate Acute Effects of Traffic-Related Air Pollution and Allergen: A Randomized, Double-Blinded Crossover Study. American Journal of Respiratory and Critical Care Medicine Apr 12. doi: 10.1164/rccm.201809-1657OC.)

[48] US Department of Health and Human Services, National Toxicology Program – Ninth Report on Carcinogens, 2000. Exposure to diesel exhaust particulates is reasonably anticipated to be a human carcinogen, based on limited evidence of carcinogenicity from studies in humans and supporting evidence from studies in experimental animals and mechanistic studies. Human exposures to diesel exhaust are complicated by the fact that diesel exhaust varies in composition and is usually confounded with exposures to gasoline exhaust. It is often difficult to disentangle the effects of diesel- and gasoline-driven engines, Additionally, diesel engine technology has changed over time in response to increasingly stringent regulations to control engine emissions. The most rigorous technology measures took effect after the date of the IARC determination in 2014. The new diesel engine technology has been shown to reduce particulate mass emissions by more than two orders of magnitude. Although implications for carcinogenicity are not yet known, the new technology will likely bring an improvement to public health.

Study Design

Study Area

The study area, as shown in Figure 2 (on page 8), includes the neighborhoods of Albany South End, Mount Hope, and Krank Park – Cherry Hill.[49] Portable monitoring also included portions of the Delaware Avenue neighborhood.

Study Monitoring Locations

Two fixed monitoring sites were installed in the study area. The monitors were located at the Ezra Prentice Homes and on Third Avenue near Hawk Street. The real-time data from the fixed monitors were used to help determine how much pollution comes from motor vehicles versus commercial and industrial activities in the Port of Albany. The monitors collected concentrations of gaseous chemicals and particulate matter and provided information on windspeed and direction. Results for many of the pollutants monitored can be viewed online[50] and some can be seen in the window of the monitor at Ezra Prentice.

The results from the monitor on Third Avenue were considered to represent urban background concentrations for a location in the South End community for which monitoring concentrations would not be influenced by large numbers of diesel vehicles. Third Avenue is a one-way street with a posted speed limit of 25 miles per hour. Evaluation of the area and the surrounding streets using the portable monitors confirmed that local vehicle traffic was not significantly affecting the monitor.

The ACHD fixed monitor has been in operation in the community since 1973. Concentrations of particulate matter, black carbon and ultrafine particulate matter from this monitor were also used in the study.

The fixed monitoring station on Third Avenue

The study included street-by-street portable sampling for TRAP in Albany's South End to better understand their sources and people's exposures to them. The portable instruments measured UFP and BC and operated for a short period (3 to 5 hours) over several measurement periods. They were carried in backpacks to make it easier to walk through the neighborhood to collect measurements. Local students and volunteer interns assisted in the monitoring efforts by carrying a backpack. Residents were also invited to assist staff.

Portable instruments were also mounted on tripods which collected data on windspeed and direction (“mini-stations”). These tripods were placed temporarily at locations to provide a more detailed look at how concentrations of ultrafine particles and black carbon vary in small areas, for example, within a housing complex or a

[49] For ease of discussion, the area will be referenced as Albany South End.

[50] NYSDEC Air Monitoring Websites accessed online at: http://www.nyaqinow.net/.

residential block. The portable monitoring was used to identify how traffic emissions influence pollutant levels for short periods of time and how much and how far particulate matter extends from the road into the neighborhood.

A unique feature of the study was using data from the fixed monitor to decide where and when to deploy the portable monitors. Figure 3 shows how the portable monitors were used to “zoom in” on times and places of interest based on the readings from the fixed monitors, e.g., times when traffic emission levels were highest at Ezra Prentice.

The benzene samplers were installed at multiple (5 to 10) locations for two-week periods throughout the study. Sampling occurred at over 100 locations from August 2017 through November 2018. Three locations were consistently sampled: the Ezra Prentice and Third Avenue fixed sites, and the South Albany (Schuyler and South Pearl Streets) network monitoring site. The remaining samplers were installed at different locations every two weeks within residential, commercial, industrial, and roadway areas. Figure 4 shows the locations of the samplers and category assigned to each sample location. In most cases, samplers were attached to light poles within the public right-of-way along roads. These locations were categorized as roadway unless the site was within a residential neighborhood, adjacent to a gas station, or within the ports of Albany and Rensselaer. The sampling locations were accessible to the public except for the locations in the right-of-way along I-90 and I-787. NYSDEC obtained permits from NYSDOT and the New York State Thruway Authority to place samplers in those locations.

The focus of the benzene assessment was to better understand the longer-term average concentrations of benzene within the study area. The selection of sampling locations was comprehensive to ensure that sampling took place at all likely sources of benzene. The choice of sampling locations was flexible by design. If a sample result was found to be higher than neighboring values, the next sampling period was used to focus in on the likely source and to pinpoint the location of a specific source.

A community volunteer (left) sampling with NYSDEC staff

Figure 3. How Fixed and Portable Monitoring Work Together

Fixed Monitoring	Portable Monitoring
24-hours / 7 days a week	3–5 hours at a time
Includes periods of high and low concentrations	Provides information about select period when concentrations are expected to be higher
Fixed: location & plan	Changing: locations & plan
Overall pattern and trends such as daily, weekly, and seasonal patterns at the monitor location	Local pattern (street-by-street)
Overall picture	Zoom in

The sampling collection period of two weeks ensured that each sample location captured normal variations in benzene release from the nearby source. Additionally, the two-week period included weekdays and weekends and short-term variation in meteorological conditions (i.e., wind direction, wind speed, and temperatures).

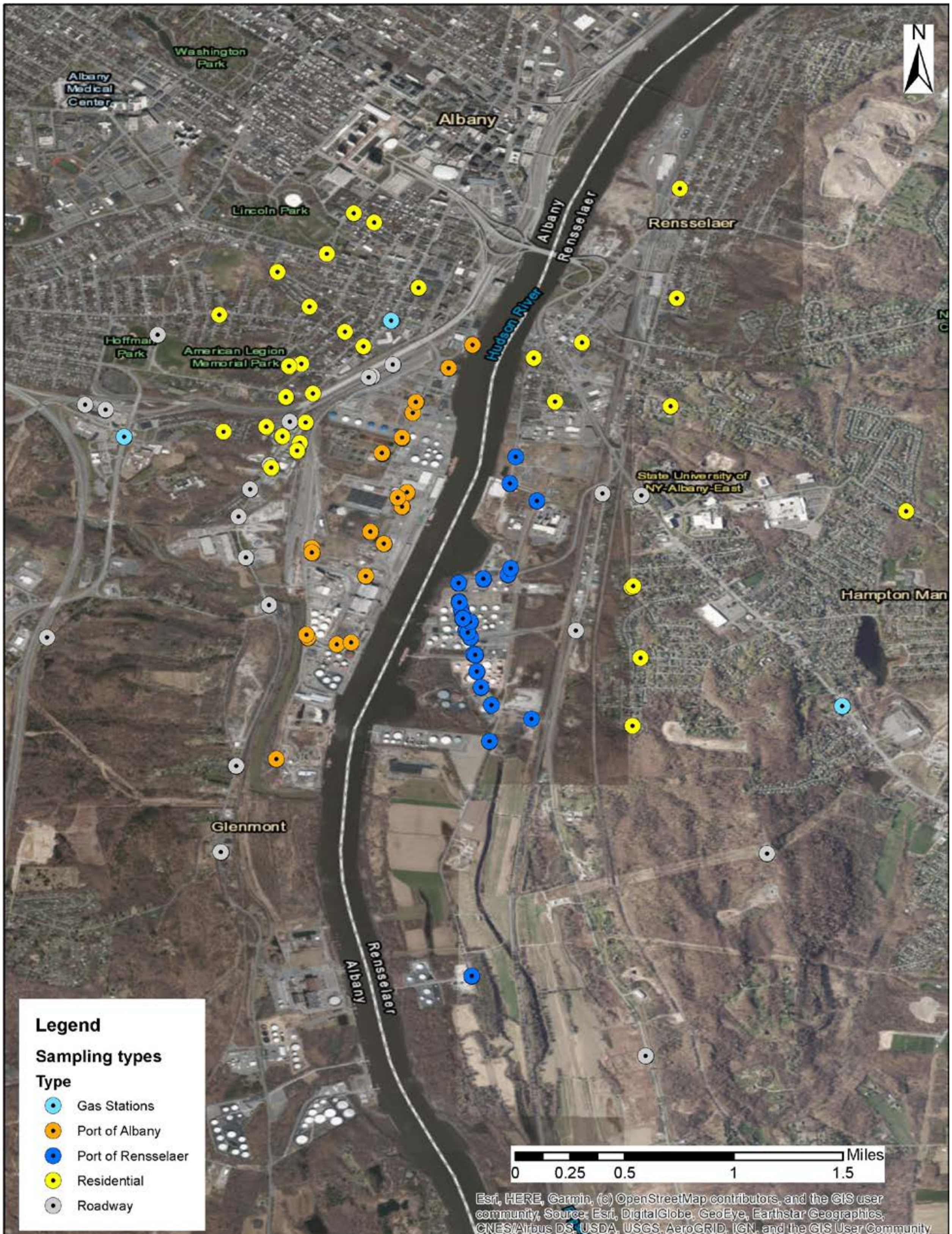

Figure 4. Map of Benzene Passive Sampler Locations

Study Parameters and Instrumentation

Figure 5 summarizes the length of time each instrument operated at the fixed monitoring locations.

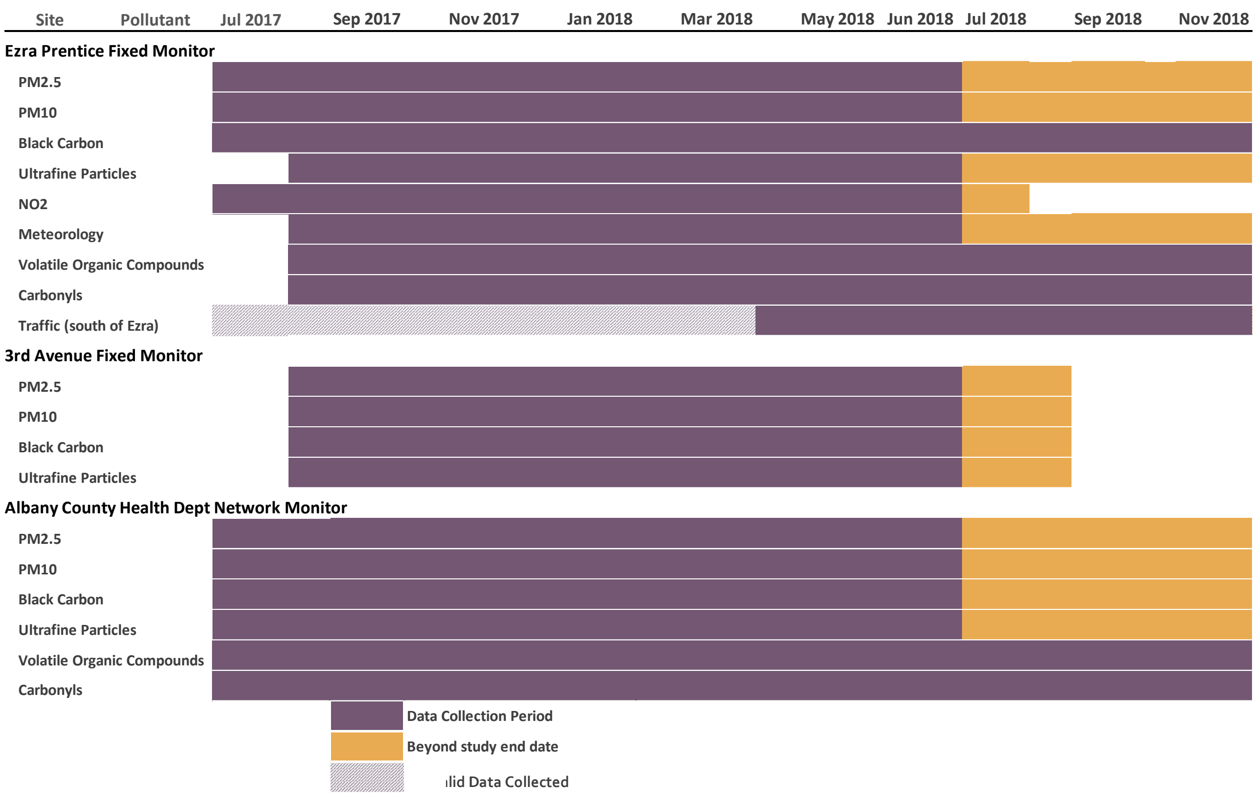

Figure 5. Monitoring Locations and Parameters

Particulate Matter

Fixed Stations – Ezra Prentice, Third Avenue and ACHD

Fine particulate matter ($PM_{2.5}$) and PM_{10} data were collected at the fixed monitoring sites using a T640 PM Mass monitor (Teledyne Advanced Pollution Instrumentation).[51] The detection system is based on light scattering and the instrument is an USEPA-approved federal equivalent method for $PM_{2.5}$. Data were averaged over hourly intervals for this study. PM_{10} data were occasionally impacted by fog episodes, and those data were removed from the study dataset.

[51] The instrument uses a light scattering process to measure $PM_{2.5}$ and PM_{10}.

Ultrafine Particles

Fixed Stations – Ezra Prentice, Third Avenue and ACHD

Ultrafine particles (UFP) were measured in this study using an API Model 651 water-based condensation particle counter. The instrument is also available directly from the manufacturer under the model name TSI 3783. The instrument is the first UFP instrument to be specifically designed for long-term deployments in ambient air monitoring stations. Additionally, researchers have found that this instrument performs well in areas near busy highways.[52] The instrument does not determine the mass of particulate matter in the air, but rather counts particles which are 0.007 to 0.1 microns in size. The instrument uses condensation to grow particles into a large enough size for them to obstruct a beam of light. A light detector then provides a signal which is converted to the number of particles per cubic centimeter.

Portable Monitors – Backpack Units

UFPs were measured with the Enmont PUFP water-based condensation particle counter. This instrument operates the same way as the API Model 651 described above but is portable, battery powered, and has a global positioning system (GPS). Using the GPS signal allows this instrument to make a map of the number of UFPs in different locations. It records these data every second.

Portable Monitors – Mini-Stations

UFPs were measured with the TSI CPC3007 condensation particle counter, which uses isopropyl alcohol ("rubbing alcohol") instead of water. It is portable, battery-powered and is better suited to staying in one location than being carried in a backpack. It records these data every second.

Portable instruments mounted on weather tripod

Portable Monitors – Backpack Units & Mini-Stations

UFPs were also measured using the Naneos Partector, which measures lung-deposited surface area. This is a measure of the surface area of UFPs that can be inhaled deep into the lung. (Lung-deposited surface area measurements are more fully described in Appendix A.) The Partector is portable and battery powered, and was used for both the backpack units and the mini-stations. It records data every second.

[52] Lee, Eon S. et al, *Water-based condensation particle counters comparison near a major freeway with significant heavy-duty diesel traffic*, Atmospheric Environment, Volume 68, April 2013, Pages 151–161.

Black Carbon

Fixed Stations – Ezra Prentice, Third Avenue, and ACHD

Black carbon (BC) was measured using an API model 633 Aethalometer® (also Magee Scientific model AE33 Aethalometer®).[53] The Aethalometer® collects $PM_{2.5}$ particles through a BGI model 1.828 sharp cut cyclone at 5 liters per minute onto a filter tape. It calculates light attenuation due to particles deposited on the filter relative to a clean part of the filter. By measuring the rate of change in light attenuation (assumed to be due solely to absorption by BC), the mass concentration is determined. However, as the BC loading increases, the response becomes non-linear, leading to an underestimation of the BC concentration. The model 633 collects two samples simultaneously with different rates of particle accumulation. The two results are combined to eliminate non-linearities and provide autocorrected BC mass concentrations. The data from the model 633 were processed into hourly intervals for this report.

Portable Monitors – Backpack Units & Mini-Stations

BC was measured using an Aeth Labs MA300 microAethalometer®. This instrument operates the same way as the API Model 633 described above but is portable, battery powered, and has GPS. Using the GPS signal allows this instrument to make a map of the amount of BC in different locations. It was used for both the backpack units and the mini-stations, and records data every minute.

Nitrogen Oxides

Fixed Station – Ezra Prentice

Nitrogen oxides (NO, NO_2, NO_x) were measured using an API model T200 NO/NO_2/NO_x analyzer. Measurements are based on the light emitted when NO is reacted with O_3. The NO_2 in the sample air is converted to NO in a heated molybdenum catalytic reactor. This NO is then combined with the sample air and reacted with O_3 to determine total NO_x (NO + NO_2). NO_2 is determined by subtraction of the NO signal from the total NO_x.

Volatile Organic Compounds and Carbonyls

Fixed Stations – Ezra Prentice and ACHD

Sampling for VOCs and carbonyls was done on a one-in-six-day schedule, over a 24-hour period. This sampling schedule is the same as the USEPA sample collection for the national air toxics monitoring program.

For the evaluation of VOCs, air samples were collected using an evacuated 6-liter SUMMA canister with a mass flow-controlled sampler. After each 24-hour sampling event, the canisters were returned to NYSDEC's Bureau of Air Quality Surveillance (BAQS) laboratory to be analyzed using gas chromatography/mass spectrometry. The air samples were analyzed using USEPA's method TO-15 for 43 target compounds[54] consistent with NYSDEC's Toxics Air Monitoring Network and the PAMS target list for ozone precursor compounds.[55]

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[53] Hansen, A.D.A., Rosen, H., Novakov, T. *The Aethalometer — An instrument for the real-time measurement of optical absorption by aerosol particles,* Science of Total Environment, July 1984 (36), 191-196.

[54] TO-15 suite of VOC measured can be found here: Community Air Screen program http://www.dec.ny.gov/public/81654.html.

[55] Additional information regarding the EPA PAMS program can be found here: https://www3.epa.gov/ttnamti1/pamsmain.html.

The carbonyl analysis followed protocols outlined in USEPA Method TO-11a.[56] Carbonyls in air are trapped by reaction with 2, 2-dinitrophenyl hydrazine coated silica gel contained within a commercially available sampling cartridge (Supelco LpDNPH S10). Following sampling, the cartridges were sent to the BAQS laboratory for analysis using high performance liquid chromatography.

Benzene

The NYSDEC selected USEPA Method 325A/B for the benzene source analysis but modified the protocol for this study. This method was beneficial as it allows for detailed spatial coverage. The method collects benzene and other volatile organic compounds on a sorbent material contained within a stainless-steel tube. The tubes were deployed for two-week intervals at different locations within the study area. At the completion of each two-week sampling period, the tubes were capped and returned to NYSDEC's BAQS laboratory for analysis. The tubes were then heated to release the VOCs adsorbed to the material and the desorbed gas was injected into a gas chromatograph for analysis. The analysis yielded results for benzene, toluene and *m,p*-xylene. The method is more fully described in Appendix B along with details on the validation assessment.

The sample collectors include lightweight hoods that shelter the passive benzene collectors from direct sunlight, rain, and snow. These samplers require no electrical power and were easy to install at locations attached to lamp poles and fences in the public right-of-way often between private properties where regular monitoring equipment could not be deployed. The samplers were installed at about 10 feet above the ground to reduce the likelihood of tampering. No samplers were damaged or lost during the study and no data were invalidated due to concerns about sample integrity.

Benzene passive sampler mounted on a telephone pole

Meteorology

The Ezra Prentice site included a Climatronics AIO Model 2 All-In-One weather sensor for meteorological data collection. The sensor collected wind direction, wind speed, temperature, relative humidity, and barometric pressure information. The sensor was situated at approximately 5 meters above ground level. Each of the portable mini-stations were equipped with the same model weather sensor as the Ezra Prentice site.

Traffic Data

On December 11, 2017, NYSDOT installed a Quixote ADR Plus™ traffic sensor on South Pearl Street about 600 feet south of the Ezra Prentice fixed monitor. Because of issues with the counter properly reporting specific classes of vehicles,[57] the counter was replaced by NYSDOT on February 20, 2018, with an International Road Dynamics iSINC® Lite. Figure 6 below illustrates the FHWA vehicle classifications used by NYSDOT. Initially, the sensor did not record any class 2 (e.g.,

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[56] The suite of carbonyls analyzed are: acetaldehyde, benzaldehyde, n-butyraldehyde, crotonaldehyde, formaldehyde, hexanal, methyl ethyl ketone, methacrolein, propionaldehyde, valeraldehyde, and m-tolualdehyde.

[57] NYSDOT uses the Federal Highway Administration's vehicle classification scheme. https://www.fhwa.dot.gov/policyinformation/tmguide/tmg_2013/vehicle-types.cfm.

passenger cars), class 3 (e.g., pick-up trucks and vans), or class 5 (e.g., motor homes, recreation vehicles, and small buses) vehicles. NYSDOT corrected the counter's vehicle classification scheme. Although minor misclassification of vehicles between classes 3, 4, and 5, took place, NYSDEC staff reclassified vehicles based on axle spacing. The reprocessed data still reflected some misclassification which appeared to assign class 5 vehicles as class 3. Staff were not able to completely resolve this discrepancy but felt comfortable with this limited error in the data. NYSDEC believes the misclassification slightly undercounts the number of diesel-powered vehicles. NYSDEC researchers followed the assumption used by other researchers[58] that assumes most vehicles within classes 4–13 are diesel-powered. If the strength of association between diesel vehicle volume and pollutant concentrations was strong and well correlated, the misclassification should not greatly affect the outcome. Traffic data from April–November 2018 were used in the study analysis.

NYSDEC researchers also found issues with the traffic counter's clock. Data were corrected to reflect National Institute of Standards and Technology time accessed from their server.

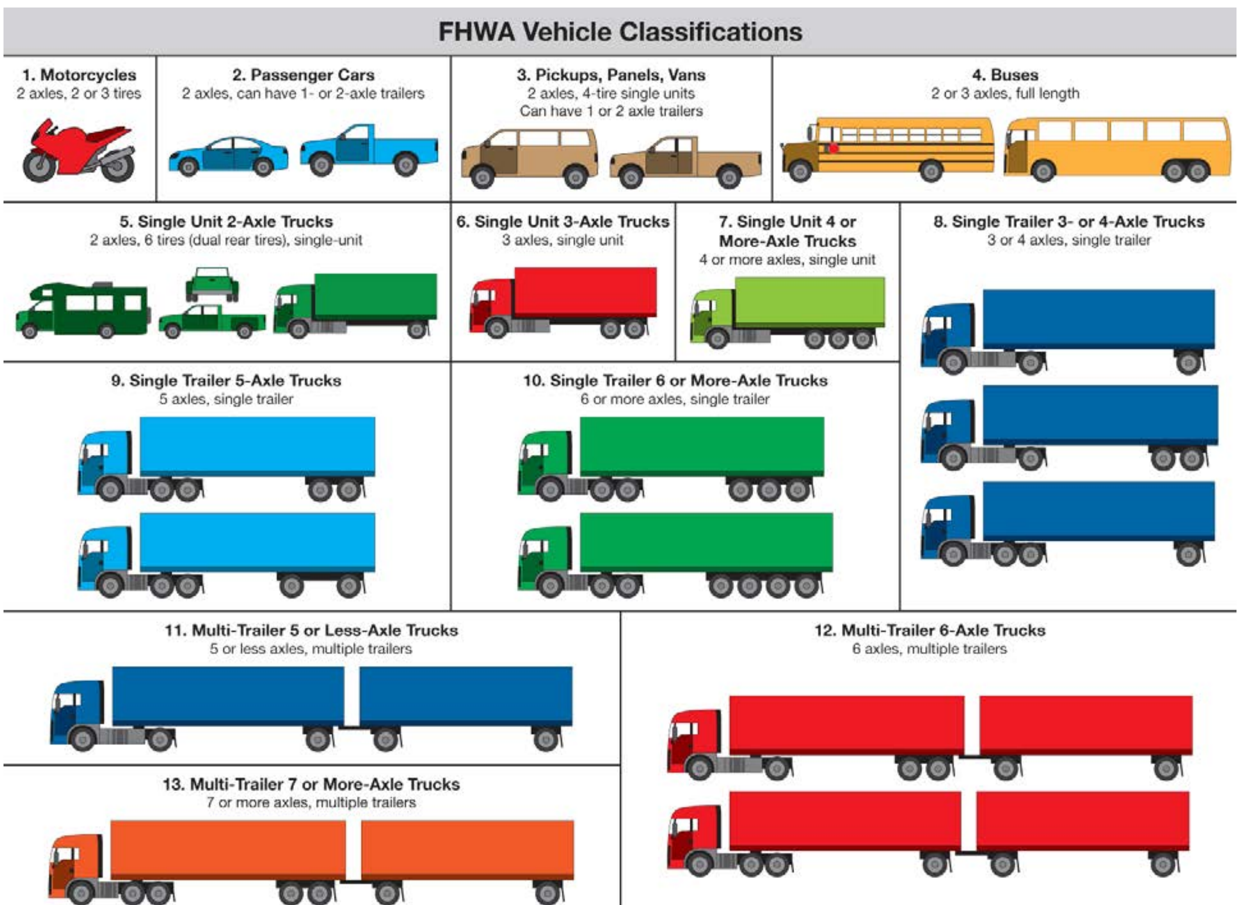

Figure 6. Federal Highway Administration's (FHWA) vehicle classification

58 Levy, Johnathan, et.al., *Influence of traffic patterns on particulate matter and polycyclic aromatic hydrocarbon concentrations in Roxbury, Massachusetts*. Journal of Exposure Analysis and Environmental Epidemiology 2003 (13), 364-371.

Results

Data Summaries

Summaries of the data results for the period of time (see Figure 5) used for analysis in this study are provided in this section.

Particulate Matter

Fixed Stations – Ezra Prentice and ACHD

Table 3 shows the summary concentrations for all three fixed monitors and number of valid data hours for the whole study.

Table 3. Summary of $PM_{2.5}$ Concentrations at Three Fixed Sites

$PM_{2.5}$ (1 hour)	3rd Ave	ACHD	Ezra Prentice
Mean (µg/m^3)	7.68	7.78	8.26
Median (µg/m^3)	6.40	6.62	7.02
Max (µg/m^3)	51.70	40.40	35.40
Min (µg/m^3)	0.30	0.37	0.44
Number of hours measured	8,428	11,624	11,610
Data completeness, %	85	99.5	99.3

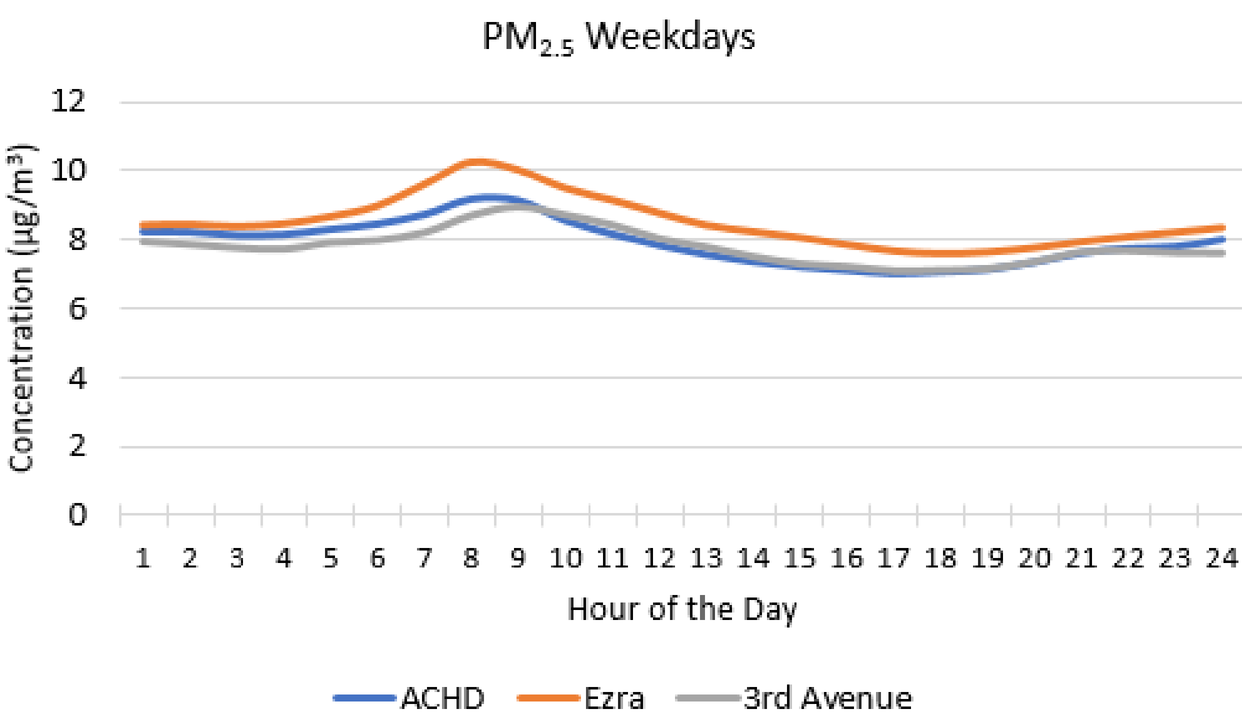

Figure 7. $PM_{2.5}$ Diurnal Plots Weekdays Fixed Monitors

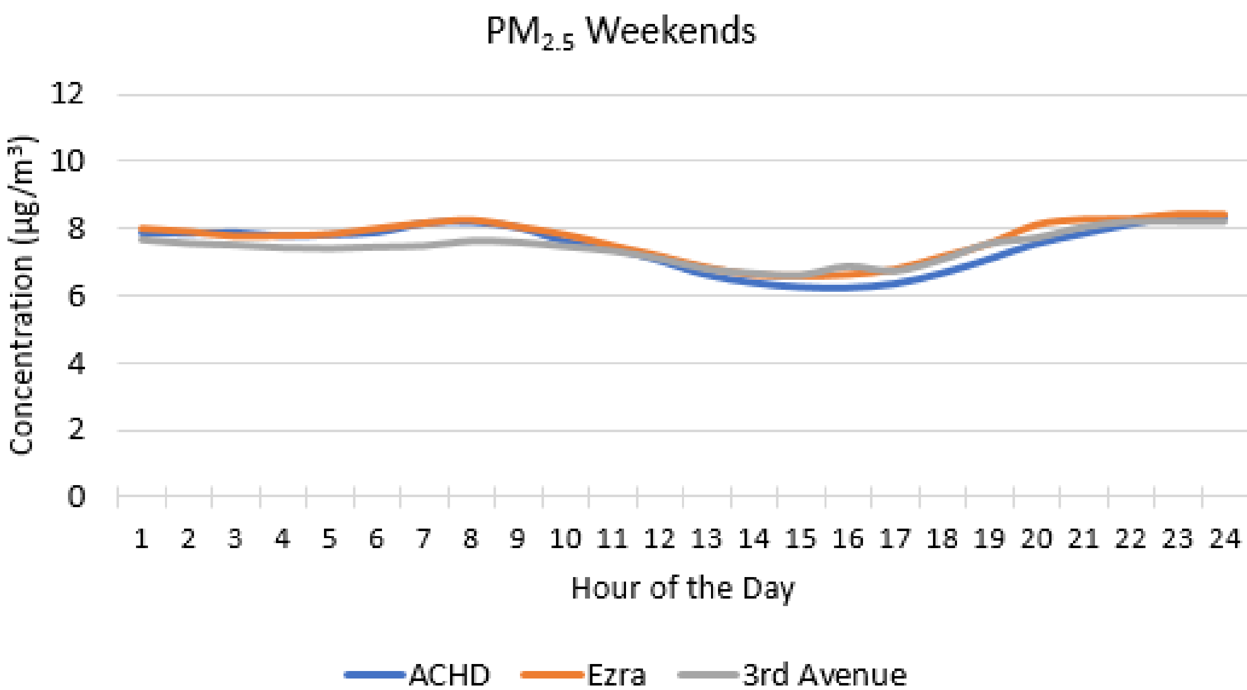

Figure 8. $PM_{2.5}$ Diurnal Plots Weekends Fixed Monitors

Table 4. Summary of PM_{10} Concentrations at Three Fixed Sites			
PM_{10} (1 hour)	**3rd Ave**	**ACHD**	**Ezra Prentice**
Mean (µg/m^3)	14.67	16.56	20.05
Median (µg/m^3)	13.40	14.64	16.61
Max (µg/m^3)	74.00	149.30	252.90
Min (µg/m^3)	0.80	0.70	1.15
Number of hours measured	8,427	11,608	11,602
Data completeness, %	85	99.3	99.3

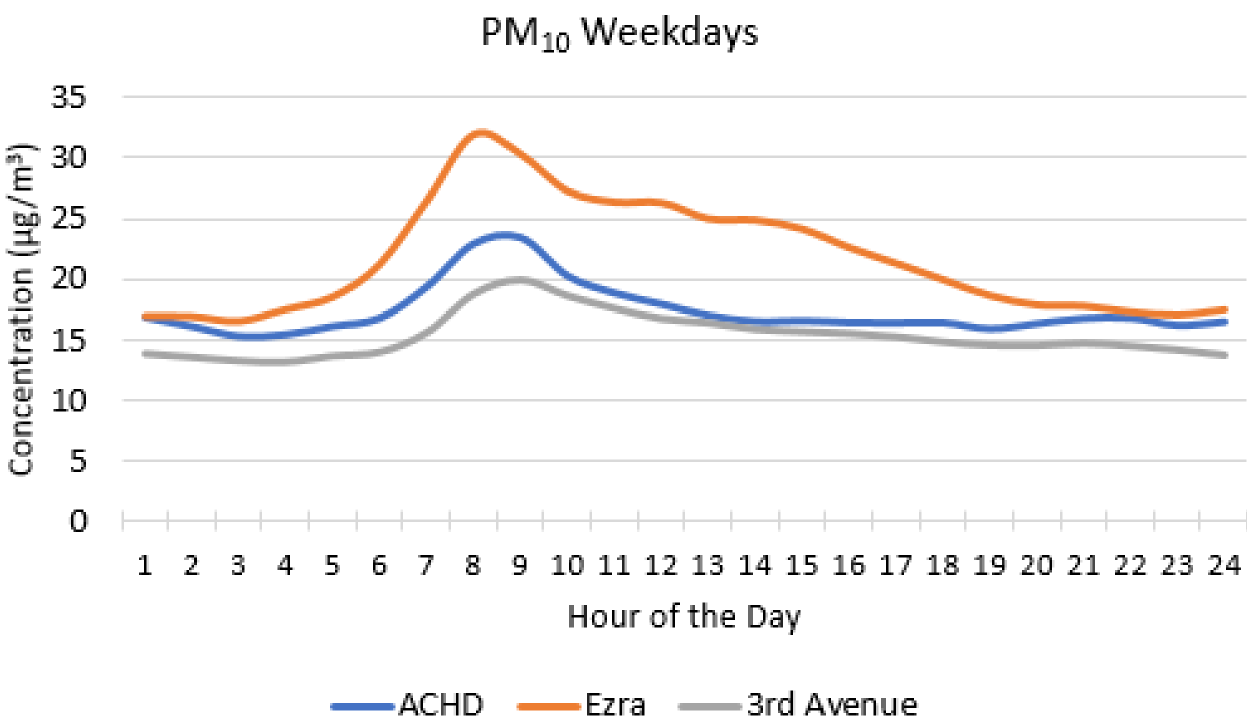

Figure 9. PM_{10} Diurnal Plots   Weekdays Fixed Monitors

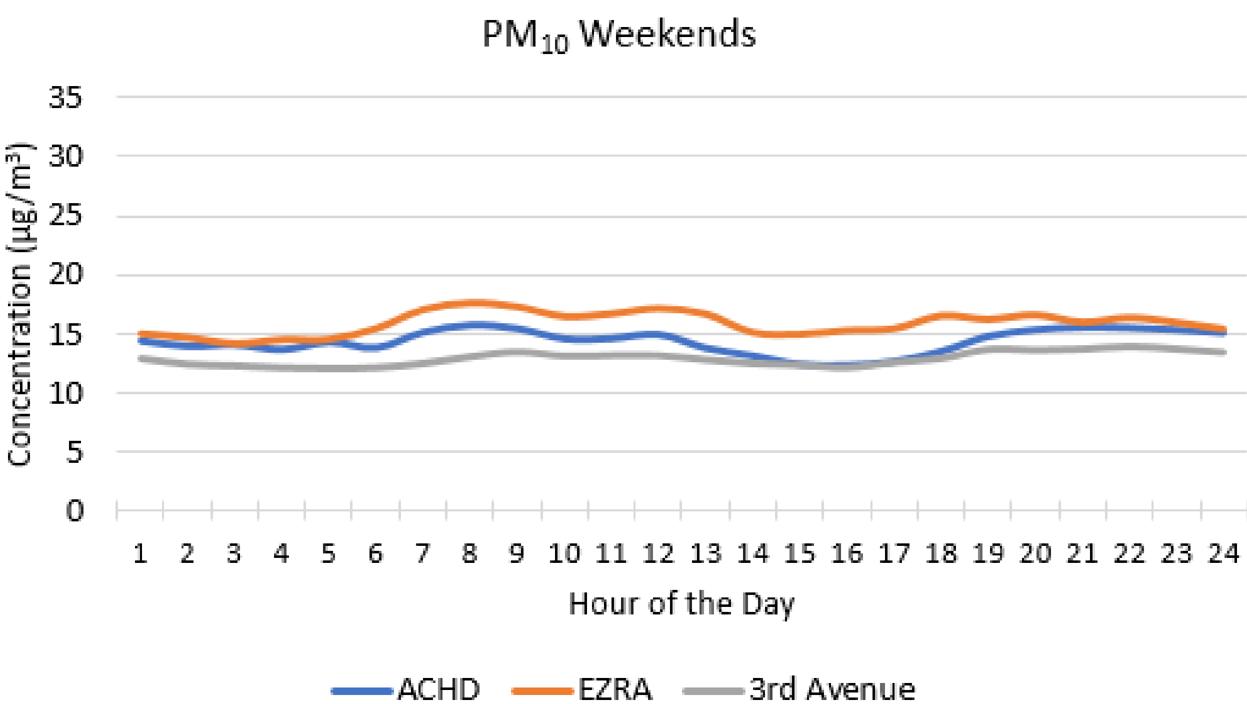

Figure 10. PM_{10} Diurnal Plots   Weekends Fixed Monitors

Ultrafine Particles

Fixed Stations – Third Ave, Ezra Prentice and ACHD

Table 5. Summary of Ultrafine Particles at Three Fixed Sites

UFP (1 hour)	3rd Ave	ACHD	Ezra Prentice
Mean (number/cm^3)	8,188	9,834	9,438
Median (number/cm^3)	7,319	8,517	8,113
Max (number/cm^3)	59,538	78,250	78,689
Min (number/cm^3)	477	226	627
Number of hours measured	8,969	11,032	10,350
Data completeness, %	90.5	94.4	88.6

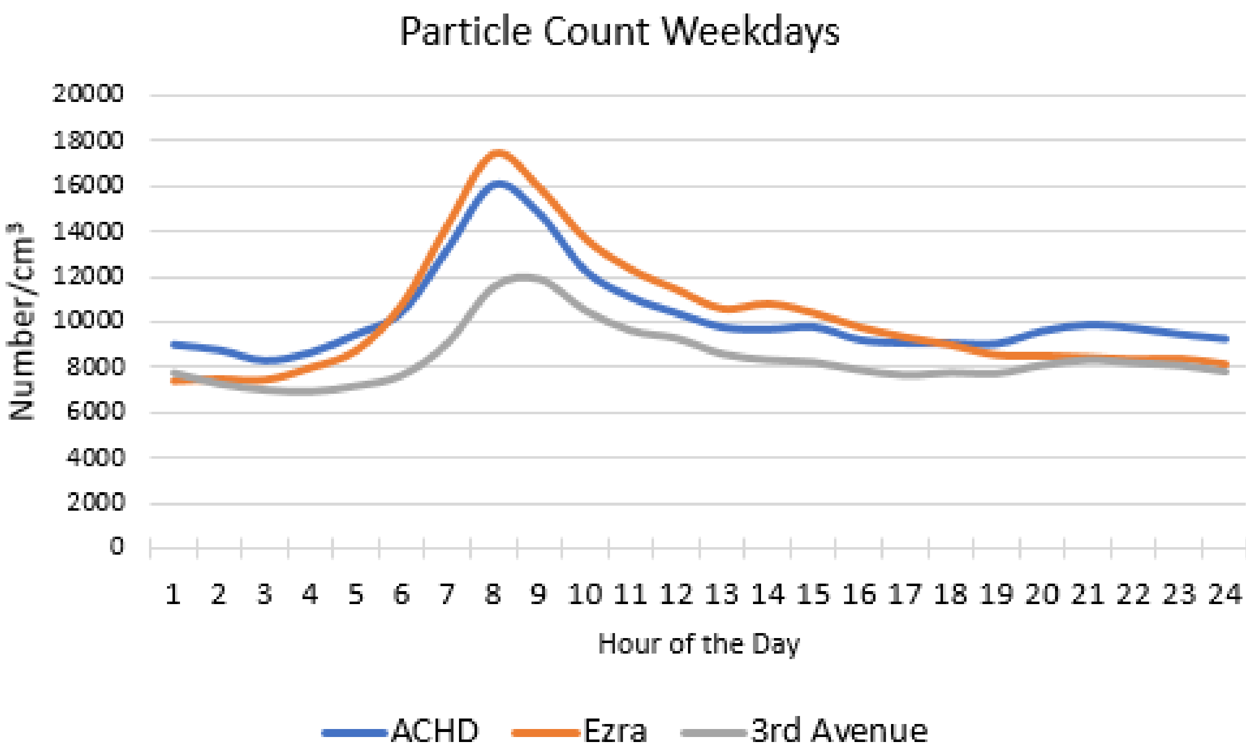

Figure 11. Ultrafine Particles Diurnal Plots Weekdays Fixed

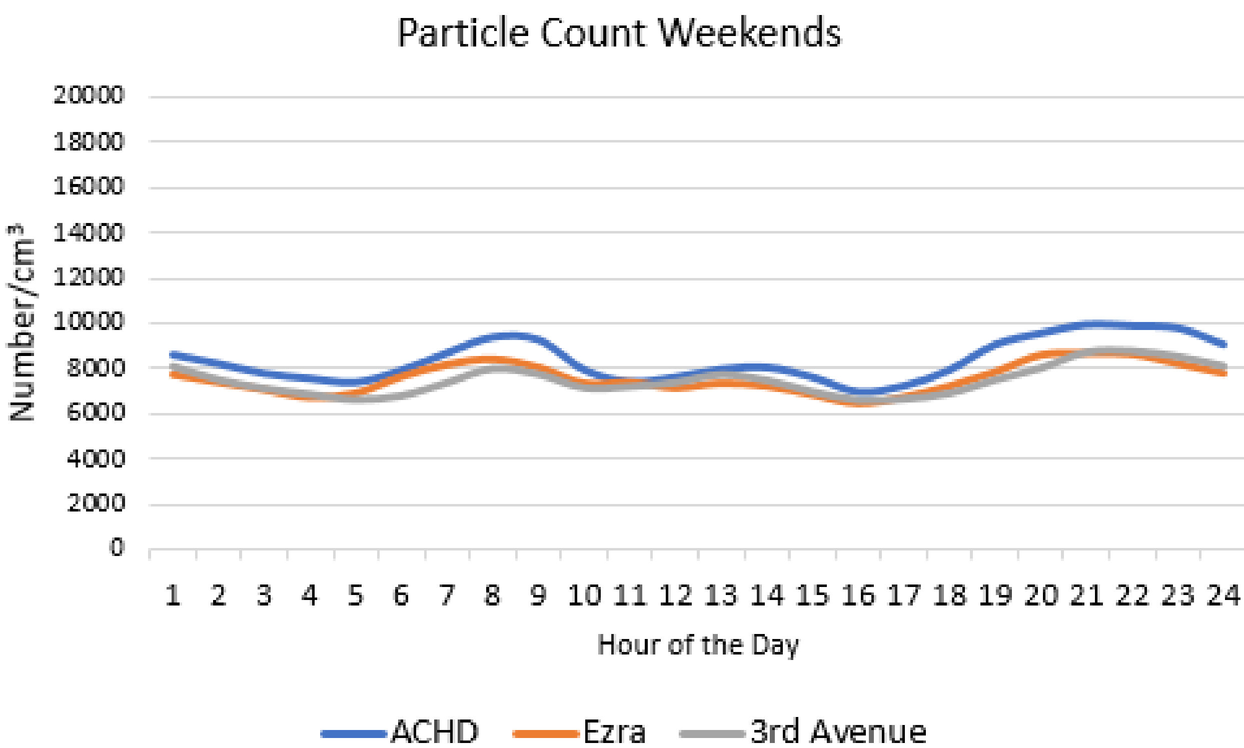

Figure 12. Ultrafine Particles Diurnal Plots   Weekends Fixed

Portable Stations – Ezra Prentice and Southern Blvd

Table 6. Summary of Ultrafine Particles at Ezra Prentice Portable Stations 1 6 and Fixed Monitoring Station

Ultrafine Particles (1 minute)	Portable 1	Portable 2	Ezra Prentice Monitor	Portable 3	Portable 4	Portable 5	Portable 6
Distance from road (ft)	445	83	66	12	14	142	227
Side of road	West	West	West	West	East	East	East
Mean (#/cm3)	7,132	9,402	9,890	10,136	14,004	11,033	9,578
Median (#/cm3)	5,468	9,086	8,669	9,065	11,462	8,940	7,584
Max (#/cm3)	41,980	38,993	63,600	90,401	82,733	69,647	66,752
Min (#/cm3)	1,490	1,086	1,900	1,646	2,525	1,811	2,399
Number of minutes measured	1500	1500	1500	1500	1500	1500	1500

An hourly average comparison of portable mini-stations and the Ezra Prentice fixed monitor is available in Appendix C.

Table 7. Summary of Ultrafine Particles at Southern Boulevard Portable Stations 1 6						
Ultrafine Particles (1 minute)	**Portable 1**	**Portable 2**	**Portable 3**	**Portable 4**	**Portable 5**	**Portable 6**
Distance from road (ft)	202	83	16	17	84	185
Side of road	South	South	South	North	North	North
Mean (#/cm^3)	6,259	7,405	7,613	5,970	4,248	5,481
Median (#/cm^3)	6,346	6,931	7,010	3,957	3,505	4,723
Max (#/cm^3)	36,574	105,264	121,952	55,214	19,584[59]	33,959
Min (#/cm^3)	1,427	1,867	1,445	1,152	0	1,441
Number of minutes measured	1500	1500	1500	1500	1500	1500

Black Carbon

Fixed Stations – Third Ave, Ezra Prentice, and ACHD

Table 8. Summary of Black Carbon Concentrations at Three Fixed Sites			
BC (1 hour)	**3rd Ave**	**ACHD**	**Ezra Prentice**
Mean (µg/m^3)	0.46	0.62	0.56
Median (µg/m^3)	0.35	0.46	0.44
Max (µg/m^3)	7.18	12.56	7.46
Min (µg/m^3)	0	0	0
Number of hours measured	9,806	11,564	11,544
Data completeness, %	98.9	98.9	98.8

[59] Station 5 data at Southern Boulevard was low compared to other observations for a single day (8-21-18). A significant amount of daily variation was observed in the study, and other location-based factors may have influenced the measurements at Station 5. However, an instrument intercomparison suggested that the low readings were most likely due to instrument performance issues on this date.

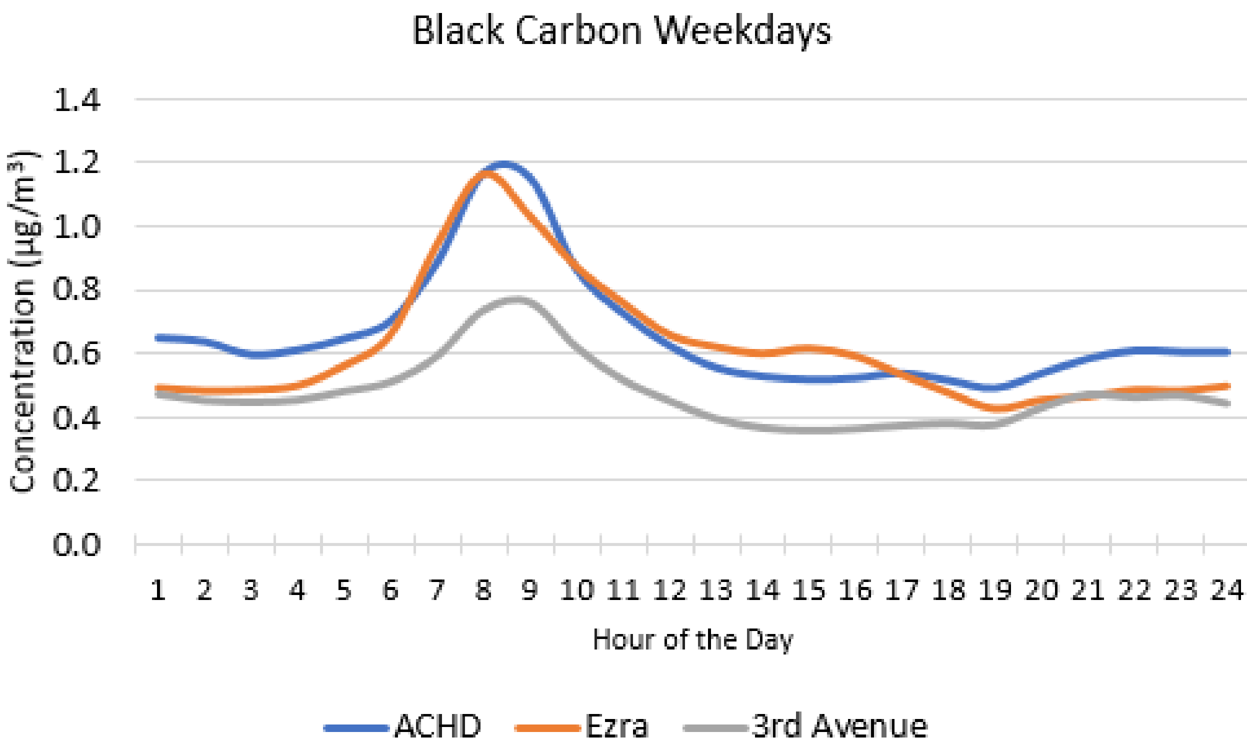

Figure 13. Black Carbon Diurnal Plots Weekdays Fixed

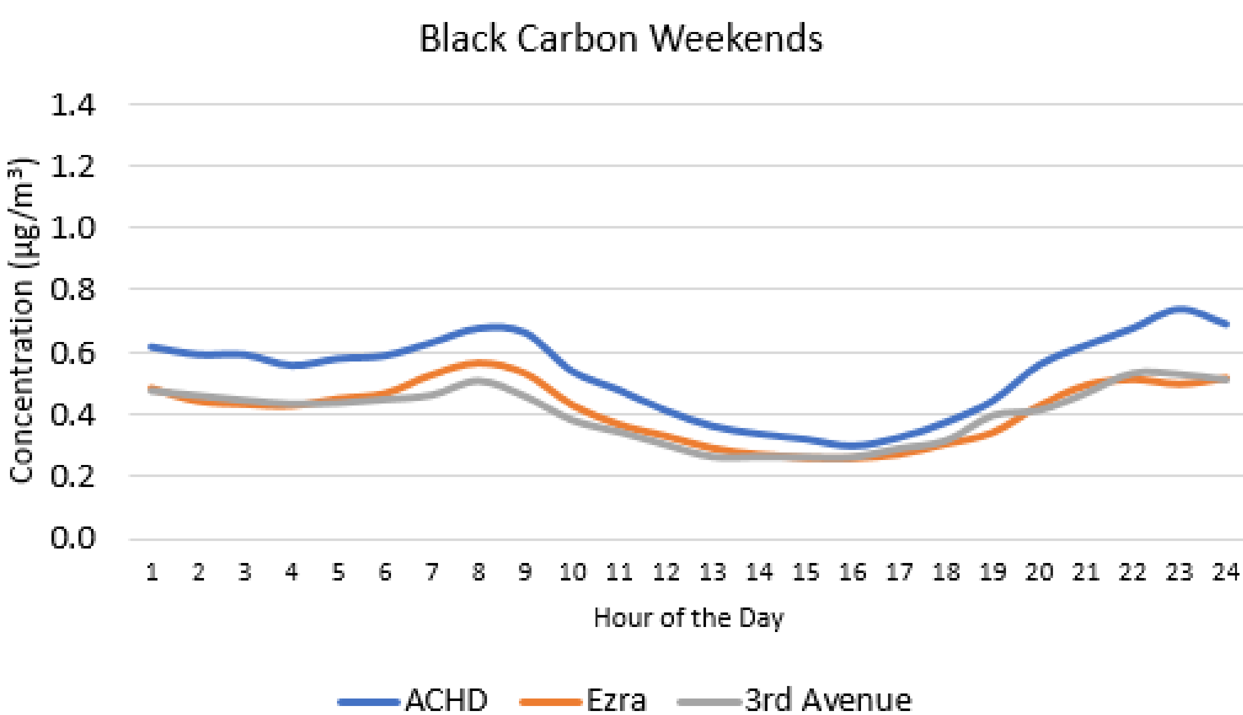

Figure 14. Black Carbon Diurnal Plots Weekends Fixed

Table 9. Summary of Black Carbon Concentrations at Ezra Prentice Portable Stations and Fixed Station			
Black Carbon (1 minute)	**Portable Station 3**	**Ezra Prentice Fixed Monitor**	**Portable Station 2**
Distance from road (ft.)	12	66	83
Side of road	West	West	West
Mean (µg/m^3)	0.82	0.75	0.51
Median (µg/m^3)	0.56	0.63	0.40
Max (µg/m^3)	35.95	9.43	6.47
Min (µg/m^3)	0.01	0.01	0.01
Number of minutes measured	1500	1500	1500

An hourly average comparison of the portable mini-stations and the Ezra Prentice fixed monitor is available in Appendix C.

Table 10. Summary of Black Carbon Concentrations at Southern Boulevard Portable Stations		
Black Carbon (1 minute)	**Portable Station 4**	**Portable Station 5**
Distance from road (ft.)	12	83
Side of road	North	North
Mean (µg/m^3)	0.61	0.45
Median (µg/m^3)	0.41	0.26
Max (µg/m^3)	7.52	5.26
Min (µg/m^3)	0.02	0.00
Number of minutes measured	1500	1500

Nitrogen Oxides

Fixed Stations – Ezra Prentice

Table 11. Summary of Nitrogen Oxides at Ezra Prentice			
Ezra (1 hour)	**NO**	**NO_2**	**NO_x**
Mean (ppb)	4.76	8.83	13.61
Median (ppb)	1.5	6.6	8.4
Max (ppb)	238.4	61.2	281
Min (ppb)	0	0.5	0.7
Number of hours measured	8,515	8,515	8,515
Data completeness, %	72.9	72.9	72.9

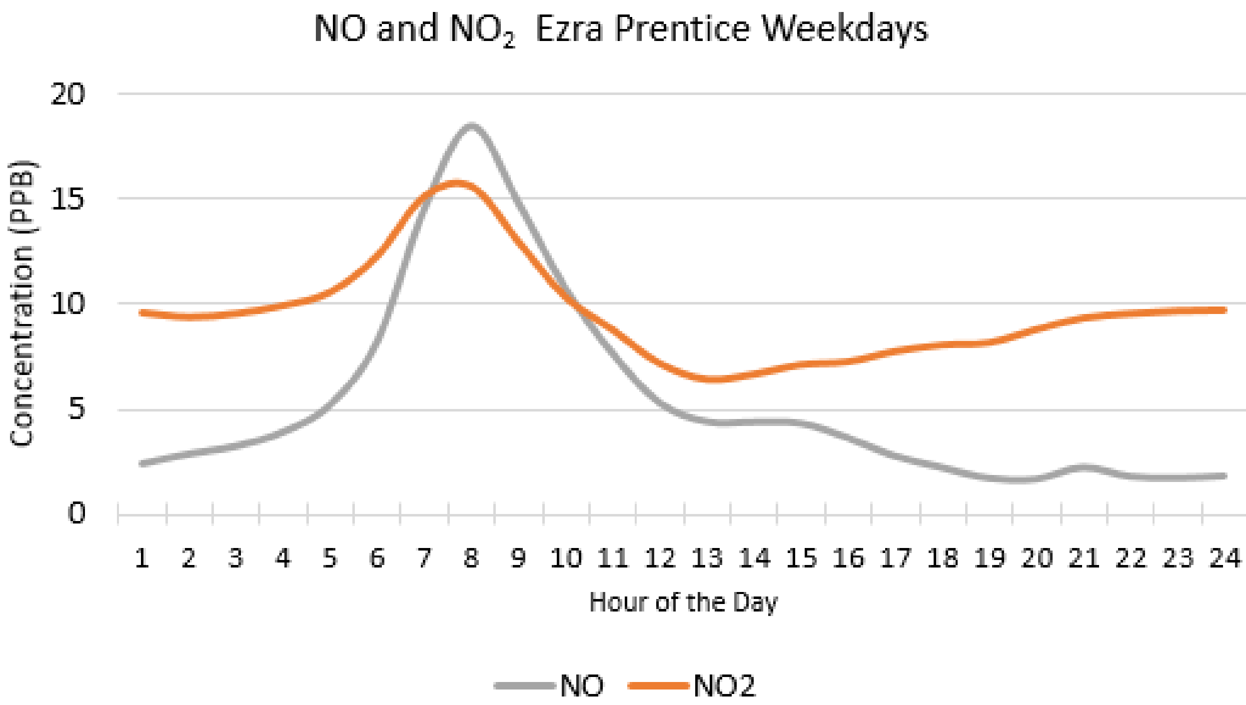

Figure 15. Nitrogen Oxides Diurnal Plots Weekdays Fixed

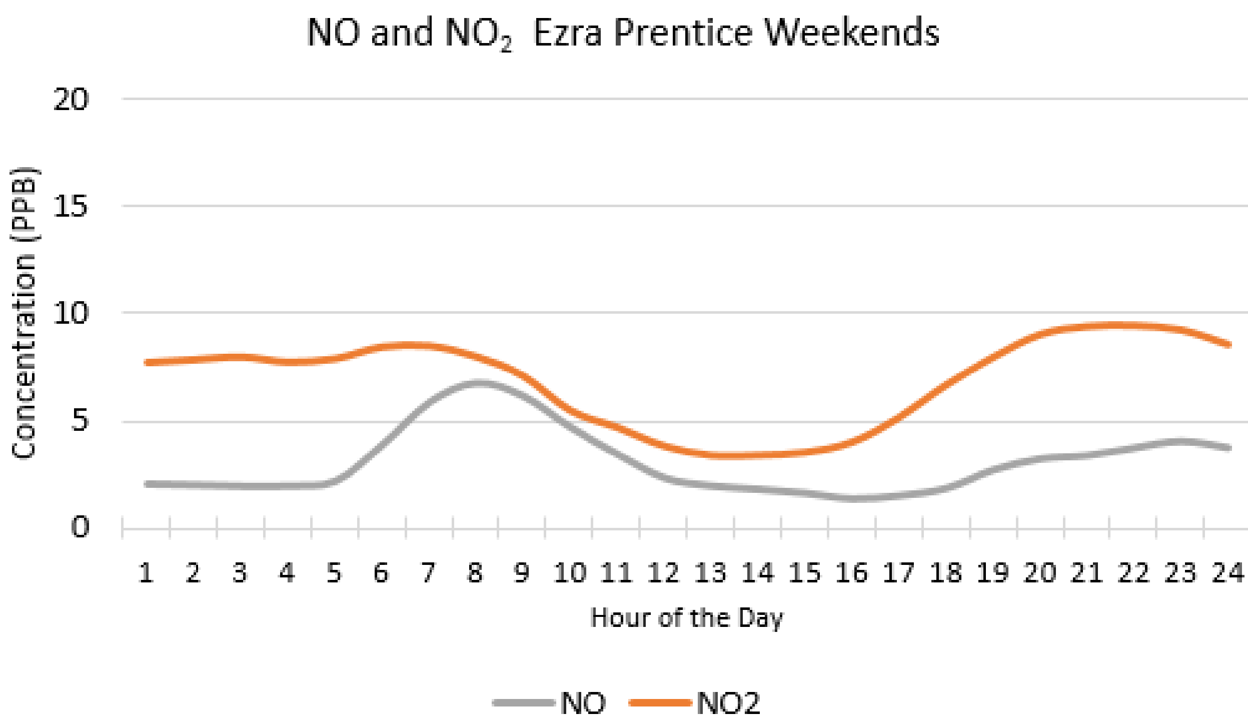

Figure 16. Nitrogen Oxides Diurnal Plots Weekends Fixed

Volatile Organic Compounds

Fixed Stations – Ezra Prentice

The air samples collected by SUMMA canister were analyzed for the presence of 43 air toxics VOCs and 54 VOCs recognized as ozone precursors.[60] Air samples collected by cartridge were analyzed for the presence of 11 carbonyls. Twenty-three VOCs and eight carbonyls were detected with sufficient frequency (75%) to calculate a 12-month average, and these averages are provided in Appendix D, Tables 1–3 along with comparisons to NYSDEC's monitoring network and long-term health-based guideline concentrations (AGCs).[61] For ease of visualization, comparisons to NYSDEC's air toxics network also are shown graphically in Appendices E and F. All air toxics have been included, even those with insufficient data to prepare a 12-month average. NYSDEC monitors have been grouped by land-use classification.

The results for air toxics (VOCs and carbonyls) typically associated with movement of petroleum products[62] can be found in Table 11 along with a comparison to NYSDEC's air monitoring network and the associated short-term and long-term health-based air concentrations.

As shown, the 12-month average concentration for three of the six petroleum-related air toxics were above the long-term health-based air concentrations. More information about these comparisons is provided in Appendix D.

NYSDEC AGCs

There are no Federal Standards for VOCs. In order to assess health impacts and to set necessary controls on sources, DEC establishes AGCs which are based on the health impacts from long term exposure to specific VOCs. There are two health outcomes from long term exposures cancer and non cancer endpoints such as reproductive, developmental, respiratory, and cardiovascular effects. The non cancer AGC is established for an air concentration that is not expected to cause health effects during a lifetime of continuous exposure. The AGC is very conservative. The non cancer health endpoints generally require higher exposures to elicit a response when compared to cancer health endpoints. The other health outcome possible from long term exposure is cancer. Cancer AGCs are defined as chemical concentrations in air that are associated with an estimated excess lifetime human cancer risk of 1 in a million (1 x 10 6). Under the 1990 Clean Air Act, the acceptable cancer risk used by the EPA to make regulatory decisions regarding the need for further air pollution reductions from sources or to identify significant concerns from ambient monitoring data is 100 in a million (1 x 10 4). The acceptable cancer risk used by the DEC s Division of Air Resources to make regulatory permitting decisions about the need to consider further air pollution controls for sources ranges from 1 in a million to 10 in a million (1 x 10 5). The selection of an acceptable level of concern is a risk management decision.

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[60] USEPA Photochemical Assessment Monitoring Stations description: https://www3.epa.gov/ttnamti1/pamsmain.html.

[61] More information about controlling air toxics and the derivation of short-term health-based guideline concentrations (SGCs) and long-term health-based guideline concentrations (AGCs) can be found online at: http://www.dec.ny.gov/chemical/89934.html.

[62] NYSDEC's factsheet 'DEC Responses to Community Questions & Requests Regarding Global Companies Plan to Heat Crude Oil at the Port of Albany, March 6, 2014', provides a link to a table of chemical constituents commonly found in crude oil, developed by the Centers for Disease Control and Prevention (CDC). NYSDEC's factsheet is available online at: http://www.dec.ny.gov/permits/95623.html. CDC's table can be found online at: http://www.bt.cdc.gov/gulfoilspill2010/pdf/chemical_constituents_table.pdf.

Table 12. Petroleum Related Air Contaminants Twelve Month Average							
Location	**Acet aldehyde (ppb)**	**Benzene (ppb)**	**Ethyl benzene (ppb)**	**Form aldehyde (ppb)**	**m,p Xylene (ppb)**	**o Xylene (ppb)**	**Toluene (ppb)**
Ezra Prentice – Study Monitor	0.93	0.18	0.049	2.2	0.13	0.048	0.31
Urban – Network							
Albany South End	0.91	0.21	0.065	2.0	0.18	0.065	0.41
Buffalo	--	0.15	0.037	--	0.11	0.040	0.23
NYC (IS52)	0.98	0.19	0.054	3.0	0.15	0.053	0.35
NYC (PS274)	--	0.19	0.056	--	0.17	0.059	0.35
NYC (Pfizer)	0.74	0.18	0.037	2.0	0.096	0.035	0.24
NYC (Queens College)	1.1	0.17	0.041	3.0	0.11	0.039	0.26
Rochester	0.59	0.13	0.025	1.8	0.063	0.024	0.47
Suburban – Network							
Tonawanda	ns	0.17	0.032	ns	0.091	0.032	0.25
Source – Network							
Niagara Falls	0.62	0.12	0.028	1.5	0.087	0.048	0.18
Staten Island	1.00	0.20	0.050	2.2	0.14	0.057	0.33
Tonawanda	0.58	0.34	0.031	1.7	0.098	0.033	0.27
Near-Road – Network							
Buffalo	0.58	--	--	1.8	--	--	--
NYC (Queens)	0.93	--	--	3.0	--	--	--
Rochester	0.65	--	--	1.8	--	--	--
Rural – Network							
Pinnacle St. Park	--	0.091	0.0083	--	0.015	0.0063	0.081
Whiteface Mtn	0.46	0.069	0.0061	0.76	0.015	0.0066	0.13
Short-Term (1 hour) Health-Based Air Concentration Values	260	400	12,000	24	5,100	5,100	9,800
Long-Term Health-Based Air Concentration Values	0.25	0.040	230	0.050	23	23	1,300

Note: '- -' indicates no monitoring collection for the air contaminant
ns – insufficient data to calculate representative annual average

Benzene

Benzene was measured throughout the study area using passive samplers that were installed at 5 to 10 locations for two-week periods throughout the study. Three locations were consistently sampled: the Ezra Prentice and Third Avenue fixed sites and the South Albany network monitoring site. The remaining samplers were installed at new locations every two weeks in residential neighborhoods and commercial, industrial and roadway areas.

To differentiate the impact of known sources of benzene the results have been categorized by source type and a summary of the results for August 2017–November 2018, as shown in Table 13 below. The benzene concentration in the residential areas had less variability than the concentrations measured at the two ports and roadway sites. The results from samples collected adjacent to gas stations had the least variability, but also the least number of samples.

Table 13. Summary Benzene Concentrations by Location Type

Summary (Two Week Samples)	Port of Rensselaer	Port of Albany	Roadway	Residential	Gas Stations
Avg Concentration (ppb)	0.74	0.17	0.17	0.18	0.16
Min Concentration (ppb)	0.16	0.12	0.07	0.09	0.15
Max Concentration (ppb)	3.32	2.24	0.35	0.31	0.19
Number of samples	66	25	22	122	3

The data distribution for the benzene passive sampling by source category is shown in Figure 17. A source of benzene was identified in the Port of Rensselaer as evidenced by the three outliers illustrated in Figure 17. Staff intensively sampled the area after these higher results. Staff surveyed the sources in the area with a specialized camera (called a Forward-Looking Infrared (FLIR)) to look for leaks of gaseous compounds.[63]

The benzene levels in the Port of Rensselaer were consistently higher than in the Port of Albany. This was entirely the result of the placement of the passive samplers which were located near an active fuel loading facility in the Port of Rensselaer. The facilities along American Oil Road are on small properties, and the road is very close to petroleum storage tanks and loading facilities. As such, the passive samplers needed to be located very close to these activities. Additionally, the road is used as a staging area for trucks waiting to load fuels.

As shown in Figure 18, the terminals are very close to American Oil Road and trucks park alongside the road as they wait to load fuels for distribution. The passive benzene monitors were mounted on the telephone poles that can be seen between the trucks and the storage tanks.

[63] Staff identified an issue with one of the gasoline storage tanks which will be discussed in more detail in *Interpreting Results and Conclusions: Objective 3.*

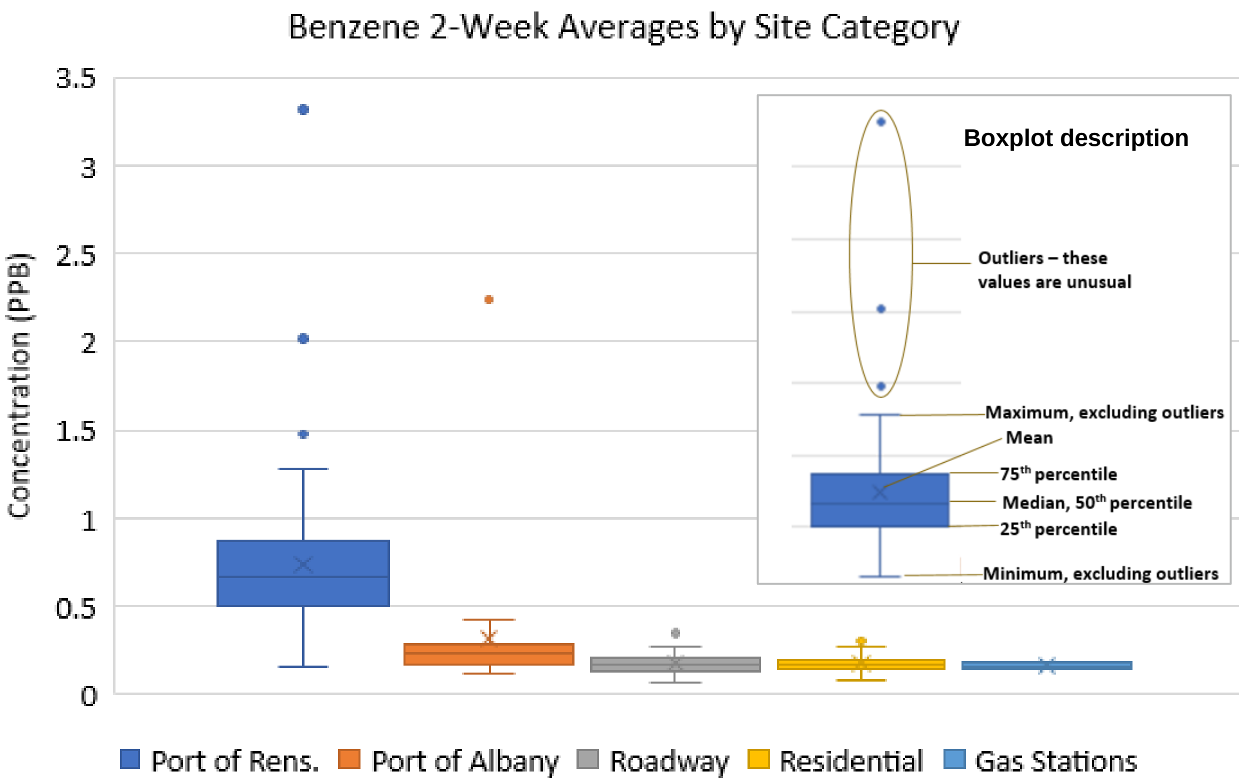

Figure 17. Data Distribution for Benzene Passive Sampling by Site Category

Figure 18. Port of Rensselaer Terminals

All locations and concentrations measured for the benzene passive sampling are shown in Figure 19. Both the ports of Albany and Rensselaer report the highest concentrations of benzene collected in the study.

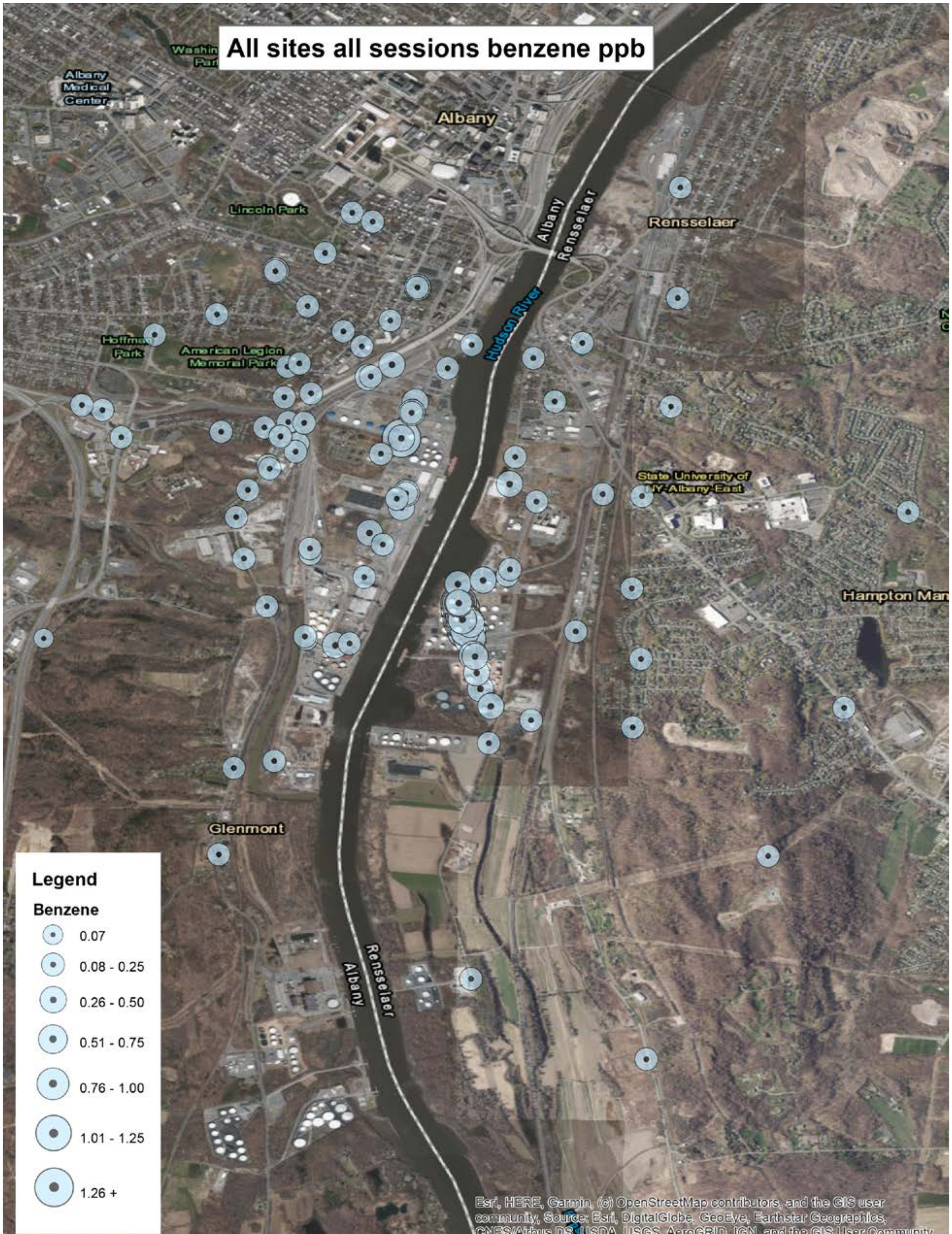

Figure 19. Results from the Benzene Passive Sampling

Benzene was also measured at the Ezra Prentice fixed station and the South Albany network monitor (South Pearl Street). The results for the suite of pollutants measured are further discussed in the *Results – Volatile Organic Compounds* but a summary of benzene is presented here.

Although there is no EPA standard for Benzene, it is measured using USEPA's TO-15 Method. Annual averages are determined for each site location. Figure 20 shows the comparative average for all monitors in the NYSDEC network including Ezra Prentice. Additionally, NYSDEC's health-based annual guideline concentration (0.04) is provided (Figure 20). As seen below, all averages are above the guideline concentration (0.04), even in the most rural locations of the State. Please note that Source Tonawanda in Figure 20 reflects data collected while the source was operating. It is no longer in operation.

The 12-month average at Ezra Prentice was 0.18 ppb, which is lower than the concentration at South Albany (0.21 ppb) and in line with other urban areas in the State. The South Albany air toxics site at South Pearl and Schuyler Streets is the long-term air toxics site for the region and its location was selected to represent the highest non-source ambient concentration of air toxics within Albany. USEPA guidance requires selecting locations that represent the highest possible concentrations for a city and not necessarily the concentrations where the majority of the residents reside. This is a siting strategy that provides a high (conservative) estimate for exposures to air toxics compounds.

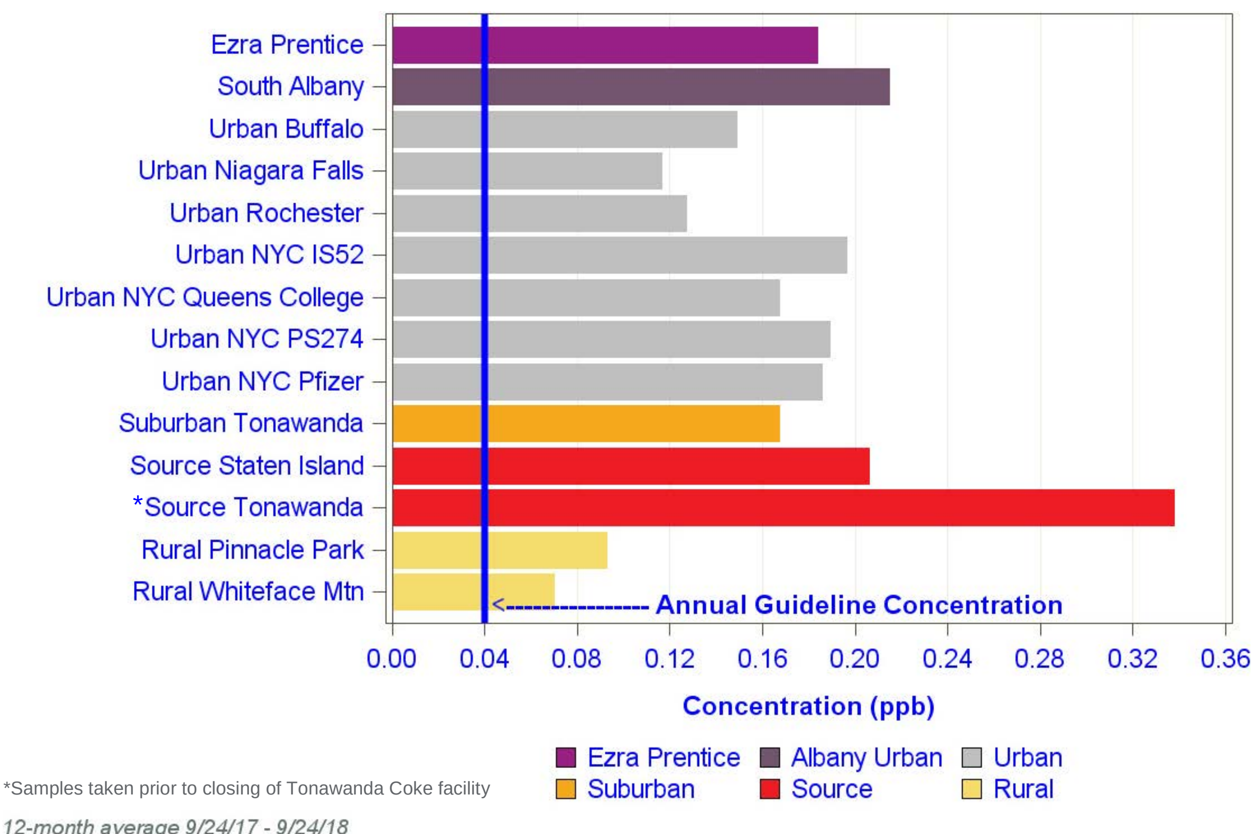

Figure 20. Benzene Annual Average Ezra Prentice and South Albany compared to NYSDEC Network Monitors

Meteorology

Fixed Stations – Ezra Prentice

Table 14. Summary of Meteorological Data for Ezra Prentice August 2017 November 2018

Ezra Prentice (1 hour)	Mean	Median	Minimum	Maximum	Number of Readings
Wind Speed (mph)	5.84	5.1	1	54.3	11,537
Temperature (Fahrenheit)	53.0	54.3	-4.8	99.2	11,638
Relative Humidity (%)	69.4	71.0	8.0	97.0	11,638
Barometric Pressure (inches of mercury)	29.97	29.97	28.73	30.78	11,638

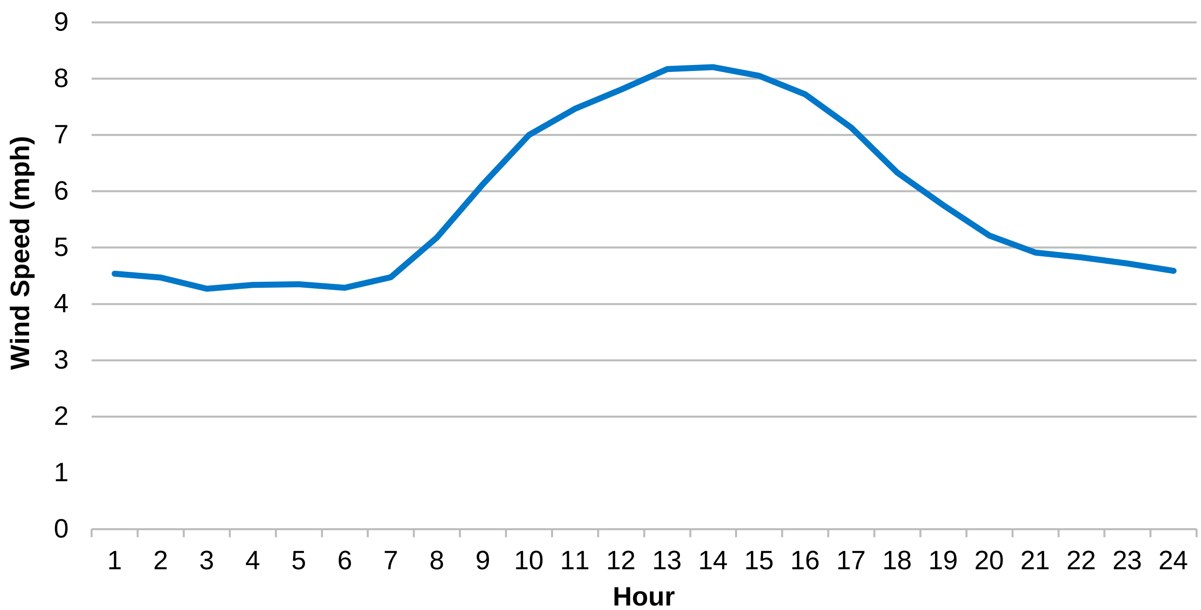

Figure 21. Diurnal Pattern for Wind Speed at Ezra Prentice, August 2017 November 2018

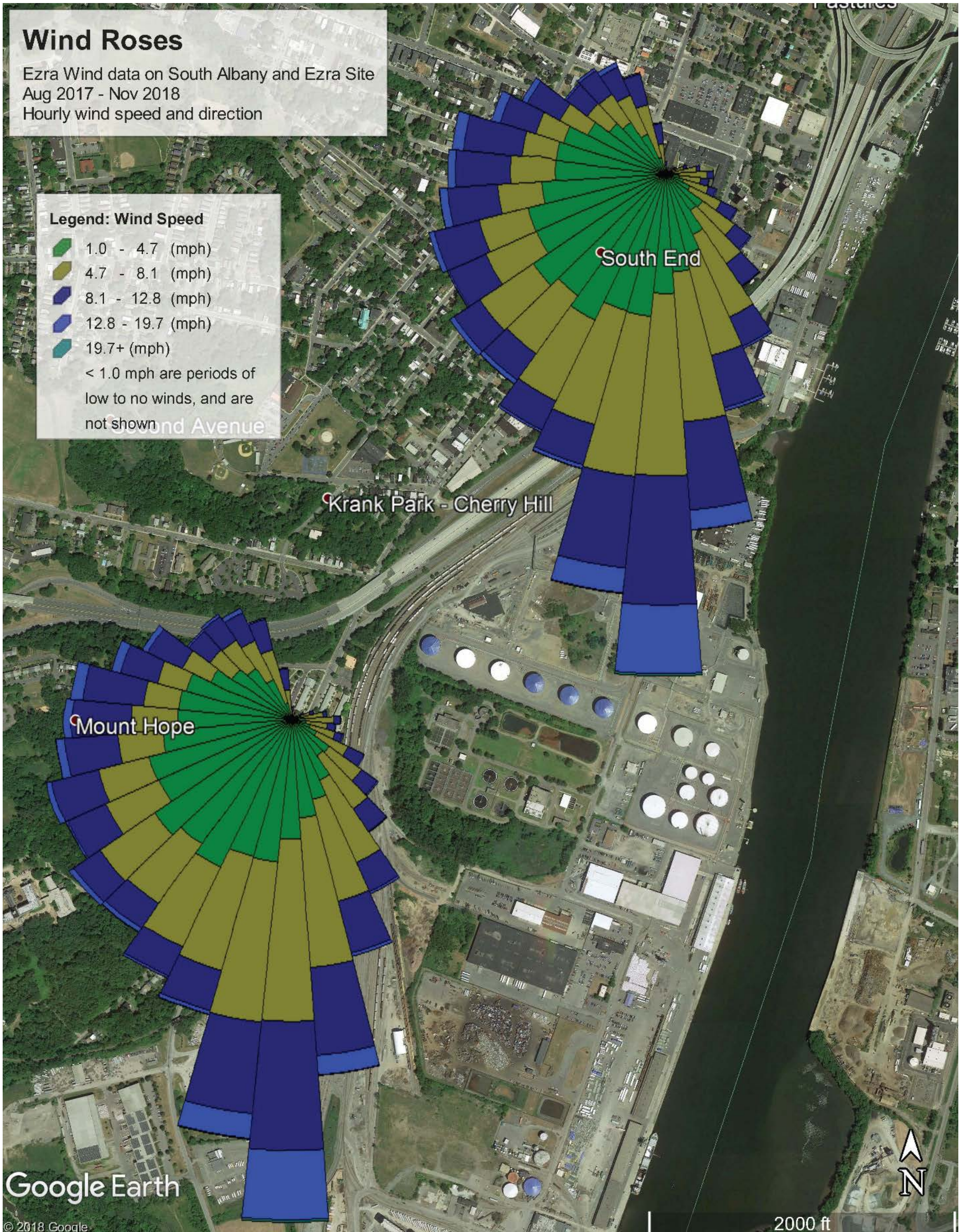

Figure 22. Wind Rose Plots for Ezra Prentice and ACHD

Portable Stations – Ezra Prentice

Table 15. Summary Meteorology Ezra Prentice Portable Stations 1 6 and Fixed Monitoring Station June and July 2018

Mean Values (1 minute)	Portable 1	Portable 2	Ezra Prentice Monitor	Portable 3	Portable 4	Portable 5	Portable 6
Wind Speed (mph)	2.1	2.3	8.2	1.8	2.0	3.1	2.2
Temperature (Fahrenheit)	77.4	77.5	75.5	77.0	77.6	77.3	79.5
Relative Humidity (%)	48.5	46.7	49.2	47.3	46.1	43.5	41.2
Barometric Pressure (inches of mercury)	29.97	30.03	29.98	30.02	30.00	29.99	29.96
Data Completeness (%)	76.1	99.1	94.5	88.6	99.1	99.6	99.9

Traffic

A summary of the vehicle count from April to November 2018 is shown in Table 16. Total Vehicles April–November 2018. For this study, classes 1–3, which include gasoline-powered motorcycles, passenger cars and light-duty trucks were compared with classes 4–13 which include buses, paratransit vehicles, and heavy-duty trucks. The majority of vehicles in classes 4–13 are diesel-powered and this assignment is consistent with the literature evaluating the influence of diesel traffic on pollutant concentrations.[64] Using this classification, NYSDEC found the percentage of diesel-powered vehicles to be 10.6% of the total vehicles counted. This percentage is less than the previous estimate of 14.07% reported by CDTA in 2017.[65] The apparent under counting of trucks may be related to an error discovered in the traffic counter. A comparison of vehicle classification, by visually inspecting photos collected, suggests there should have been greater assignment of vehicles to class 3 for this study.

Table 16. Total Vehicles April November 2018

Class	Description	Total
1	Motorcycles	18,400
2	Passenger Cars	1,447,425
3	Pickups, Panels, Vans	508,683
4	Buses	81,088
5	Single Unit 2-Axle Trucks	1,748
6	Single Unit 3-Axle Trucks	36,656
7	Single Unit 4 or more Axle Trucks	9,476
8	Single Trailer 3 or 4-Axle Trucks	14,214
9	Single Trailer 5-Axle Trucks	53,118
10	Single Trailer 6 or more Axle Trucks	33,038
11	Multi-Trailer 5 or less Axle Trucks	442
12	Multi-Trailer 6-Axle Trucks	88
13	Multi-Trailer 7 or more Axle Trucks	3,556

[64] Levy, Jonathan, et.al. *Influence of traffic patterns on particulate matter and polycyclic aromatic hydrocarbon concentration in Roxbury, Massachusetts*. Journal of Exposure Analysis and Environmental Epidemiology. (2003) 13, 364-371.

[65] Capital District Transportation Committee: City of Albany: S. Pearl Street Heavy Vehicle Traffic Pattern Study, April 7, 2018. Based on traffic count in April 28, 2017–May 4, 2017.

The diurnal plots in Figure 23, show the hourly average number of cars (left plot) and trucks (right plot) on weekdays (blue), Saturdays (orange), and Sundays (gray). For this study, classes 1-3 will be characterized as “cars” since they are the most numerous and class 4 and higher will be labeled as “trucks.” On weekdays, car traffic peaks at around 8:00 a.m. and again at 5:00–6:00 p.m. in the evening, which reflects commuting in and out of Albany. Truck traffic is more uniform throughout the day and has a morning peak on Saturday. Truck traffic is lowest on Sunday.

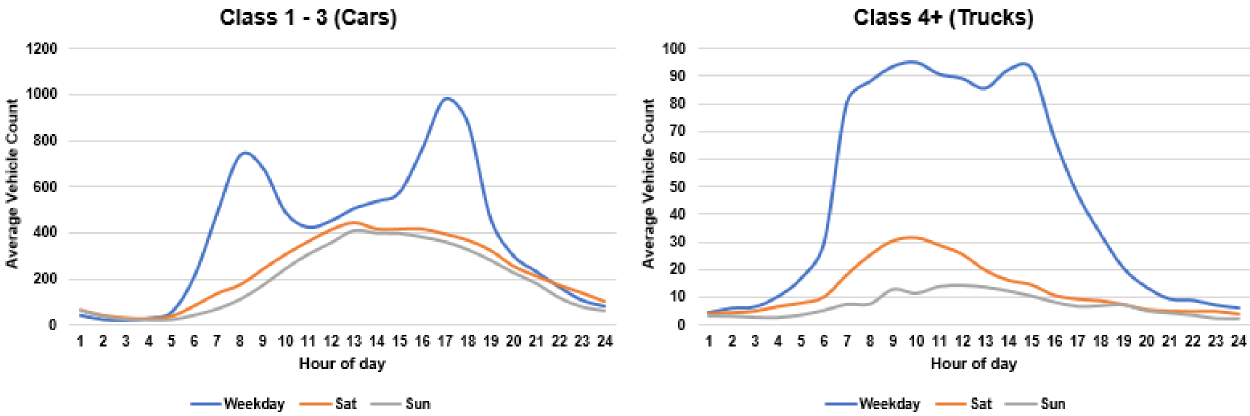

Figure 23. Diurnal Patterns for Cars and Trucks, April November 2018.

Interpreting Results and Conclusions

Objective 1: Evaluate how much particulate matter comes from motor vehicles versus Port activities

We evaluated the results from the fixed monitoring sites and the portable monitoring for this objective. In addition to evaluating particulate matter ($PM_{2.5}$, PM_{10}, and UFP), we used the results from the other pollutants (BC, NO, and NO_2) collected which are also released from mobile sources. For this study, mobile sources are the emissions (from tailpipe) and potentially wear-releases (degradation of tires and brake pads) from motor vehicles, namely, automobiles and trucks. There were additional mobile sources emissions, including locomotives and marine vessels, impacting the study area. These other mobile sources are sporadic and do not necessarily take place at the same time as roadway vehicles. Our approach to evaluate the relationship between mobile source emissions and pollutant concentrations is to match both pieces of information on an hourly basis. If the two are correlated, they both will increase and decrease within relatively the same time. The emissions from marine vessels and locomotives cannot typically be matched to pollutant concentrations because the schedules are not known. Additionally, since they are further from the monitoring sites, their impacts are lower.

Mobile source pollutants disperse quickly moving from the edge of an active roadway. Typically, the concentrations drop to background levels within a few hundred feet from the edge of the roadway. This is an important consideration because the distance to the roadway has a bigger impact on local pollutant concentrations than the number of vehicles on that roadway. An objective of this study was an evaluation of how far particulate matter extends from the road into the neighborhood. The results are provided in *Objective 2 – Develop an understanding of how far particulate matter travels from the road into the neighborhood,* of this report.

Fixed Monitoring

Because $PM_{2.5}$ can stay suspended in the atmosphere for weeks, most of the $PM_{2.5}$ measured at the three fixed monitoring sites used in the study originates from upwind locations hundreds, or even thousands, of miles away. We call this regional or long-range transport of $PM_{2.5}$. The regional influence of $PM_{2.5}$ is apparent at the monitoring stations because it impacts the three study sites equally. As illustrated in Figure 24, all three monitors have similar weekday and weekend diurnal profiles. The relatively minor differences in $PM_{2.5}$ between the monitoring site with the fewest local sources (Third Avenue, considered the background monitor) and the other two monitoring sites represents the impact from local sources.

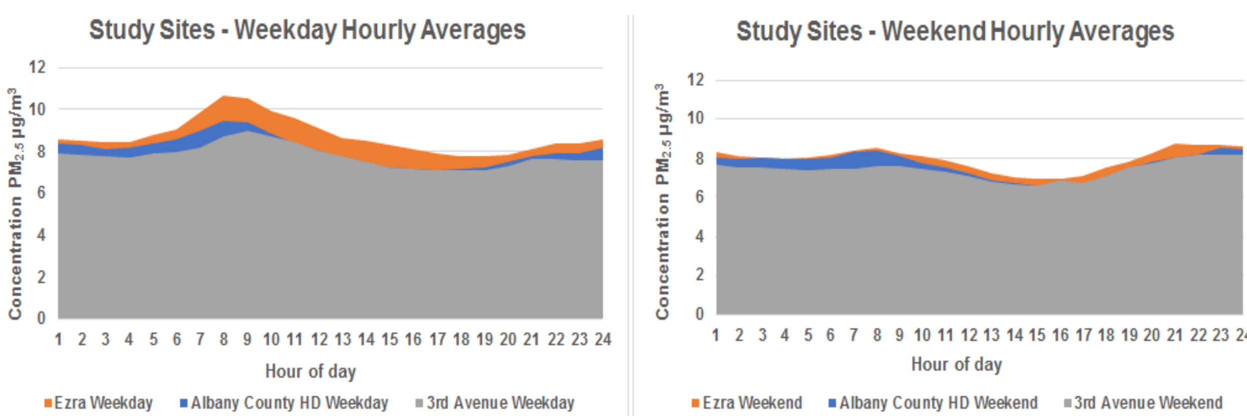

Figure 24. Diurnal Plots for $PM_{2.5}$, Weekdays, and Weekends

Also shown in Figure 24, the concentrations of $PM_{2.5}$ at the Third Avenue monitor are relatively consistent across the hours of measurement and primarily reflect the regional background for $PM_{2.5}$. The site is located on an infrequently travelled one-way road so contributions from nearby vehicle emissions are minimal in comparison to impacts near the ACHD and Ezra Prentice monitors. The concentrations at the Third Avenue monitor are approximately 88 to 97% (gray portion of graph) of overall concentrations in the study area, which means that long-range transport of $PM_{2.5}$ to the area dominates the measurements in the study area.

The local sources of $PM_{2.5}$ in the study area are reflected in the measurements collected at ACHD (blue portion of graph) and Ezra Prentice (orange portion of graph). The peaks in the graphs are higher for the Ezra Prentice monitor, which indicates a greater contribution of local sources. This also suggests a disproportionate impact for the residents near this location.

Because PM_{10} particles are larger and for the most part, heavier than $PM_{2.5}$, they do not stay suspended as long and do not travel as far from where they were released. Consequently, the portion of regional contribution of PM_{10} is lower than the contribution from regional $PM_{2.5}$. This is illustrated graphically in Figure 25. The regional background for PM_{10} is 52 to 82% of the average hourly values measured at the Ezra Prentice and ACHD monitors, respectively.

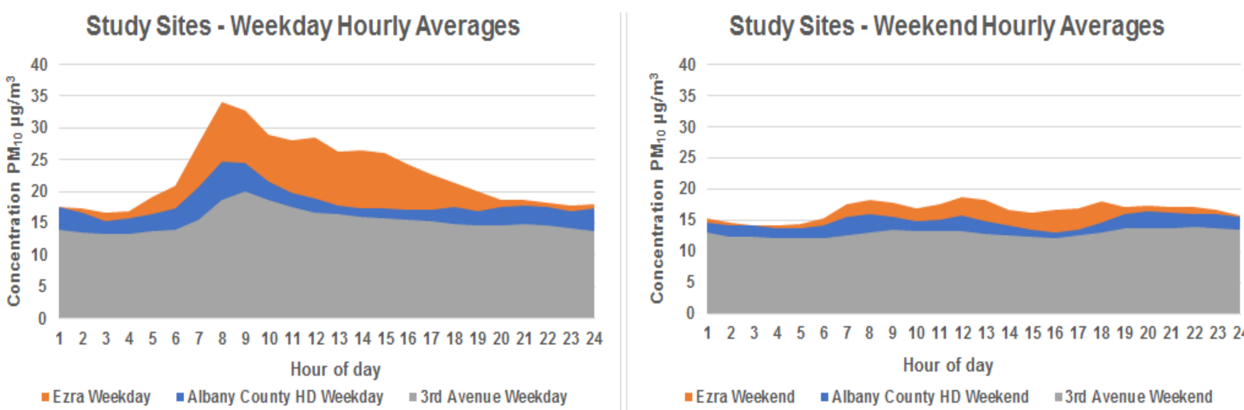

Figure 25. Diurnal Plots for PM_{10} Weekdays and Weekends

Table 17 presents the average concentration and percentage of the local source contribution (increase above the Third Avenue fixed monitor) of $PM_{2.5}$ and PM_{10} at the ACHD and Ezra Prentice monitors by weekday and weekend. The average weekday $PM_{2.5}$ concentrations are higher at the Ezra Prentice monitor(12% above background) as compared to the ACHD (4% above background) monitor. The maximum weekday increase is also greater at Ezra Prentice (22% above background) compared to ACHD (9% above background). The peak $PM_{2.5}$ concentration at Ezra Prentice occurs at 8:00 a.m., which matches the morning increase in traffic as illustrated in Figure 23. The $PM_{2.5}$ levels are also higher throughout the day, suggesting a greater impact from trucks than cars.

At ACHD, the average increase in $PM_{2.5}$ is higher during the week (4%) as compared to the weekend (3%). Although the average increase is higher, the overall concentration of $PM_{2.5}$ is lower on the weekend across all monitoring sites.

In comparison, the PM_{10} concentration and average increase is higher during the week at both ACHD and Ezra Prentice and the average as seen in Table 17. This correlates with the increase in truck traffic during the week. The traffic-related air pollutants achieve a maximum daily concentration at about the same time as the peak volume for morning traffic on South Pearl Street and on I-787, further supporting the linkage between motor vehicle emissions as the primary contributor of local source $PM_{2.5}$ and PM_{10}.

Table 17. $PM_{2.5}$ and PM_{10} Increase above Third Avenue Monitor								
	Weekday		Weekend		Weekday		Weekend	
ACHD	$PM_{2.5}$		$PM_{2.5}$		PM_{10}		PM_{10}	
Average increase [µg/m³ | % Difference]	0.28	4%	0.25	3%	2.81	18%	1.94	15%
1 Hr Max increase [µg/m³ | % Difference]	0.76	9%	0.85	11%	5.87	33%	2.95	24%
	Weekday		Weekend		Weekday		Weekend	
Ezra Prentice	$PM_{2.5}$		$PM_{2.5}$		PM_{10}		PM_{10}	
Average increase [µg/m³ | % Difference]	0.96	12%	0.55	7%	7.39	48%	3.69	29%
1 Hr Max increase [µg/m³ | % Difference]	1.95	22%	0.95	13%	15.31	82%	5.50	43%

Traffic-related air pollutants of NO, NO_2, BC and UFP were evaluated to see how closely they are related to vehicle emissions in this community. The weekday diurnal concentrations are shown in Figure 26. The local source contribution is defined as the difference between Third Avenue and the two fixed monitors at ACHD and Ezra Prentice. The concentration differences for BC and UFP reach a maximum during the morning traffic peak, as noted by the red arrows. Both the Ezra and ACHD monitors are experiencing the same increase in pollutant concentrations, unlike the increases seen for $PM_{2.5}$ and PM_{10}. The Third Avenue and ACHD sites do not have a NO_x monitor. As illustrated in Figure 26, the NO and NO_2 measurements at Ezra Prentice also reach a maximum at the same time as the peak in morning traffic. An afternoon peak does not occur for any of the pollutants shown in Figure 26, because wind speeds are higher in the afternoon, which disperses the pollutants and decreases measured concentrations. The increase in windspeed is illustrated in Figure 21.

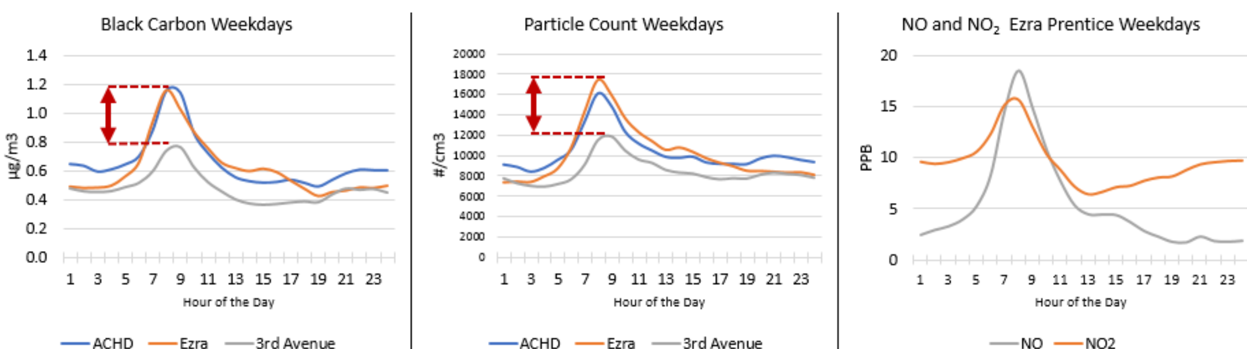

Figure 26. Weekday Diurnal Plots for Nitrogen Oxides, Black Carbon, Ultrafine Particles

The meteorological data collected at Ezra Prentice also informs the evaluation of the origin of local source pollution. The plots in Figure 27 illustrate pollution roses[66] which show the average concentration of a pollutant by wind direction. The $PM_{2.5}$ plot displays higher concentrations when the winds come from the northeast and east. These directions correspond to the location of South Pearl Street in relation to the location of the monitor at Ezra Prentice. The traffic-related air pollutants, UFP, BC, NO, and NO_2, also reflect higher concentrations when winds originate from the direction of South Pearl Street.

66 Henry, Ronald, et.al., *Locating nearby sources of air pollution by nonparametric regression of atmospheric concentrations on wind direction*. Atmospheric Environment. 36 (2002) 2237-2244.

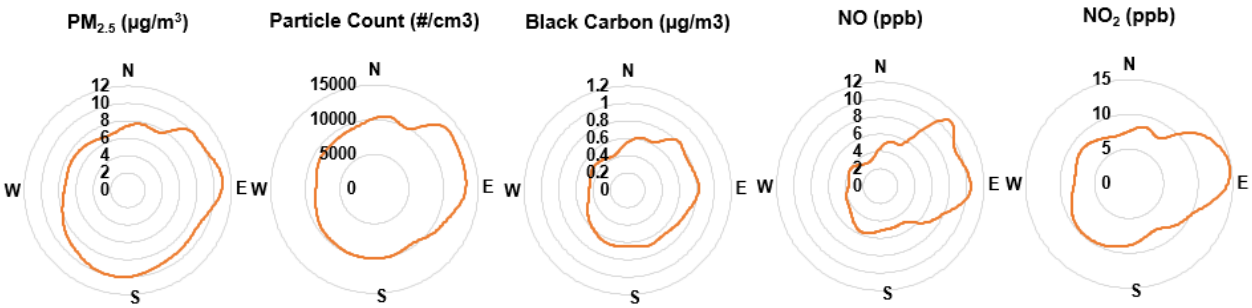

Figure 27. Pollution Rose Plots at Ezra Prentice for $PM_{2.5}$, UFP, BC, NO, and NO_2

Pollution roses also can be prepared for the ACHD site using the meteorological data collected at the Ezra Prentice monitor. As illustrated in Figure 28, the $PM_{2.5}$ concentration is higher in the direction (northeast and east) of I-787. Traffic-related air pollutants of UFP and BC are also higher in the direction of I-787.

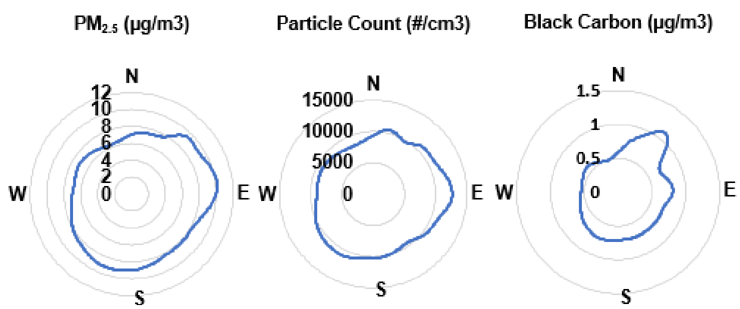

Figure 28. Pollution Rose Plots at ACHD for $PM_{2.5}$, UFP, and BC

The diurnal plots show that maximum concentrations of the traffic-related air pollutants correspond with peak morning traffic volume. The pollution rose plots show that the peak concentrations are in the direction of the heavily traveled roads of South Pearl Street for Ezra Prentice and I-787 for ACHD.

We also evaluated the influence of port activities on the concentrations of $PM_{2.5}$ and PM_{10} and other traffic-related air pollutants in the study area. Some operations in the port release large-size particulate matter (PM_{10} or greater) through the activities of grain movement, metal recycling operations, and dust generated from unpaved roads. Because large-size particles do not stay suspended long and do not travel as far from where they were released, PM_{10} sources must be closer to the monitor than $PM_{2.5}$ sources. PM_{10} concentrations at the Ezra Prentice monitor are higher than both Third Avenue's and ACHD's throughout the day, which correlates with higher truck traffic during those hours. It is likely that activities at the port could occasionally impact PM_{10} levels at the Ezra Prentice monitor, but these sporadic and more distant sources have less of an impact than the trucks travelling close to the monitor on South Pearl Street. The NYSDOT lists South Pearl St (NY 32) as an access highway for larger size vehicles.[67] This designation includes the length of NY Route 32 from Greene County to the south (through the Ezra Prentice community) to the entrance ramp of I-787. Motor vehicles using South Pearl Street to access area businesses or related to port activities would be the greatest contributors of locally generated PM_{10} measured at the Ezra Prentice monitor.

This designation of South Pearl Street as an access route for larger size vehicles results in increased numbers of trucks on this portion of South Pearl Street. At times in the middle of a work day, the ratio of trucks to cars reaches 0.23 or almost one in four. This ratio is much higher than NYSDOT determines through periodic vehicle classification studies on other roads in the area. For example, the ratio of trucks to cars is 0.04 on Second Avenue between South Pearl Street and Delaware Avenue.

[67] 17 NYCRR Part 8000, 8100

Trucks are considerably heavier than automobiles and require more fuel to move through the study area. The increase in fuel usage is directly related to the larger amount of emissions coming from trucks. Nearly all the heavy-duty trucks are diesel-powered which has a different emissions pollutant profile than cars using gasoline. Trucks release more $PM_{2.5}$,[68] BC,[69] UFP,[70] NO and NO_2[71] than cars. In fact, the USEPA's rule of thumb is that one truck emits about ten times more NO_2 than a car.[72] These differences in emissions between trucks and cars help to differentiate the impact of cars versus trucks on residents in the study area.

In another analysis, the peak concentrations of traffic-related air pollutants (BC, UFP, and NO), $PM_{2.5}$, and PM_{10} and peak traffic counts are compared to examine the relationship between local pollutant concentrations and vehicle counts (traffic volume). The analysis was designed to determine whether cars (classes 1–3) or heavy trucks (classes 4–13) were responsible for most of the mobile source impacts to residents in the study area.

In Figure 29–Figure 34, percentile rankings of hourly averages of the number of cars and trucks passing by the Ezra Prentice monitor by weekday and Sunday are plotted with corresponding hourly average traffic-related air pollutants. Sunday was selected because heavy truck volume is significantly reduced. If there is a relationship between increasing vehicle counts (blue line) and pollutant concentrations (red, gray, and yellow lines), then all lines (vehicle count and pollutant concentration) will steadily increase together. The horizontal axis in each plot is the percentile of the number of vehicles from 0 to 100.

As shown in Figure 29, UFP displays an inconsistent relationship with the number of cars on South Pearl Street during the weekday. As the volume of cars increases, the UFP count increases slightly but then drastically decreases at the 90th percentile for cars. For heavy trucks, the UFP count increases after the number of trucks exceeds the 60th percentile, or about 60 trucks per hour.

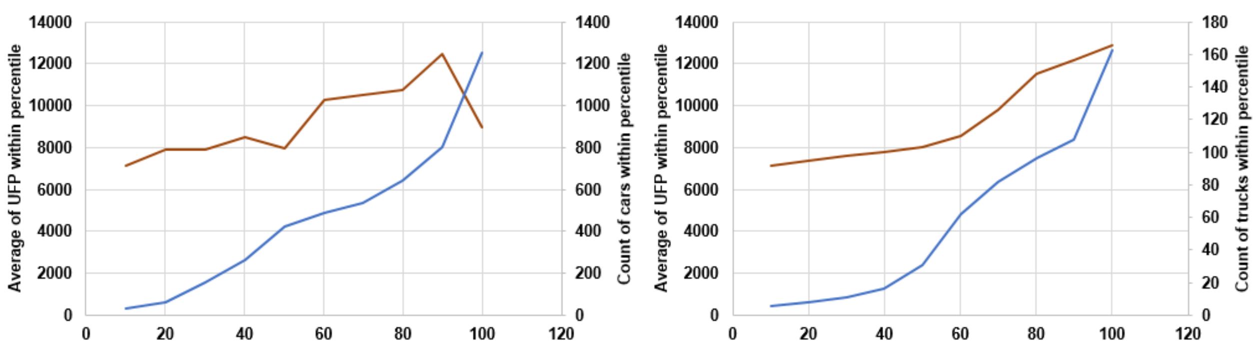

Figure 29. Weekday Percentile Comparison Total Cars (left, blue) and Trucks (right, blue) with UFP (red)

[68] US Department of Transportation, Bureau of Transportation Statistics – Estimated National Average Vehicle Emissions Rates per Vehicle Type Using Gasoline and Diesel.

[69] US Environmental Protection Agency, Black Carbon – Basic Information. Accessed 3/10/16 http://www3.epa.gov/blackcarbon/basic.html

[70] Park, Seong Suk, et.al., *Emission Factors for High-Emitting Vehicles Based on On-Road Measurements of Individual Vehicle Exhaust with a Mobile Measurement Platform. Journal of Air & Waste Management Association*. 61: 1046-1056. 2011.

[71] USDOT – Bureau of Transportation Statistics

[72] Near-Road NO_2 Monitoring Technical Assistance Document, USEPA, 2012.

As illustrated in Figure 30, there is no relationship between cars and UFP on Sunday until the 90th percentile for cars (500 cars per hour). Similarly, on Sunday when there is low truck volume, there also is very little correlation with UFP counts.

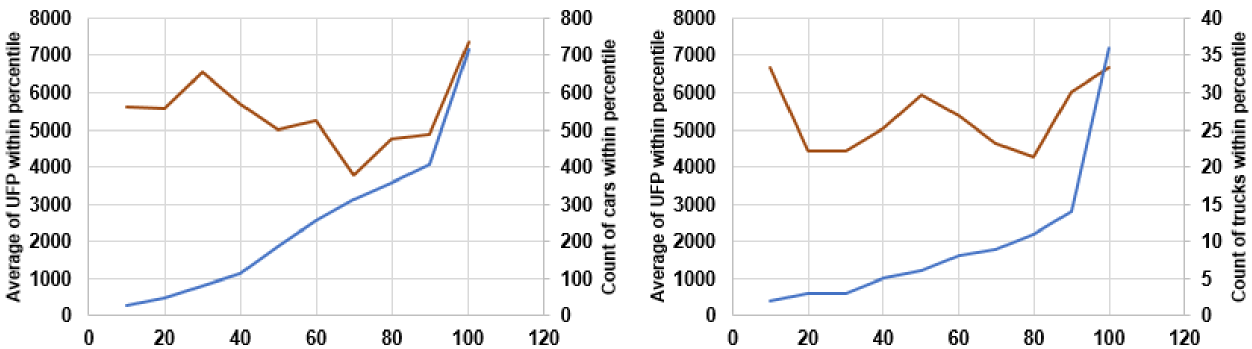

Figure 30. Sunday Percentile Comparison Total Cars (left, blue) and Trucks (right, blue) with UFP (red)

For BC, as shown in Figure 31, there is a general relationship between the increase in the number of cars on South Pearl Street and an increase in concentration of BC during the weekday. There is a decrease in the concentration of BC when the number of cars is at the 60th percentile and then an increase at the 70th percentile. But at the 90th percentile volume for cars, or 1,300 cars per hour, the concentration of BC rapidly decreases. In comparison, as the volume of trucks steadily increases, the BC concentration also increases during the weekday. BC increases after the number of trucks exceeds the 40th percentile, or about 11 trucks per hour. The relationship with UFP is similar to that of BC.

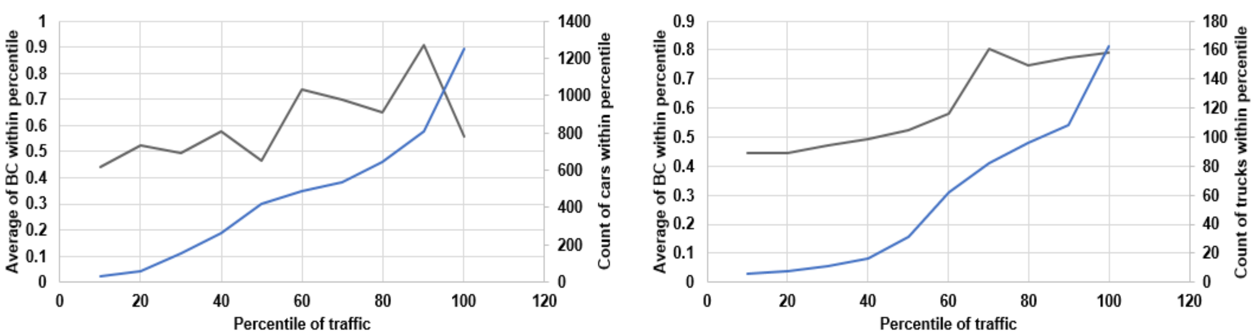

Figure 31. Weekday Percentile Comparison Total Cars (left, blue) and Trucks (right, blue) with Black Carbon (gray)

The comparison between BC and car volume on Sundays, shows an increase until the 30th percentile and then a decrease until the 70th where BC levels off. Overall, it would be considered a negative relationship. Similarly, with Sunday truck volume, BC does not demonstrate a positive correlation.

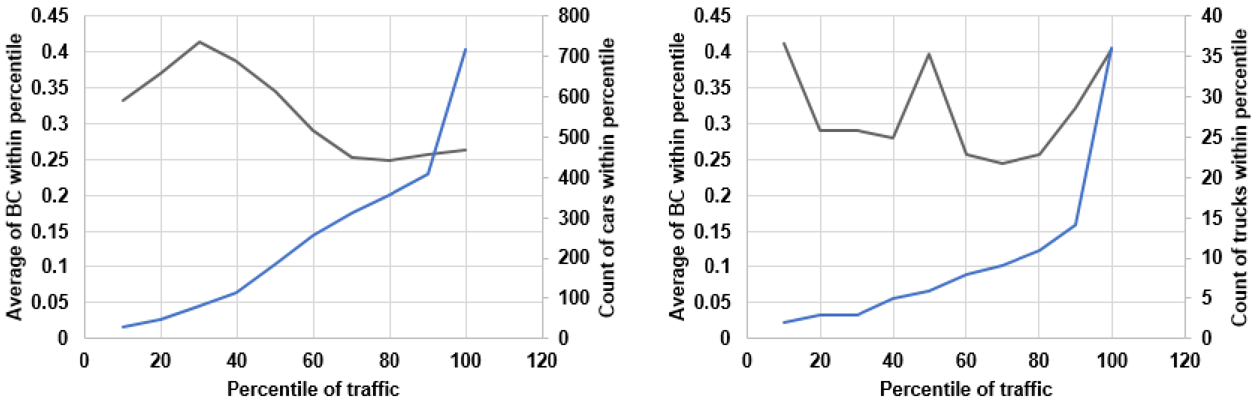

Figure 32. Sunday Percentile Comparison Total Cars (left, blue) and Trucks (right, blue) with Black Carbon (gray)

As illustrated in Figure 33, NO has an inconsistent relationship with the number of cars on South Pearl St during the weekday. The concentration of NO drops off after the 90th percentile, or about 800 cars per hour. This is likely due to the time of day when car traffic is highest. Car traffic peaks during the afternoon commute at 4:00–5:00 p.m. when wind speeds are higher (see Figure 21), create better dispersion, and tend to decrease pollutant concentrations.

For trucks, the relationship with NO is different than with BC and UFP. The amount of NO is proportional and is more closely correlated with the number of trucks on South Pearl Street from the 10th to the 100th percentile of trucks. Unlike BC and UFP, which are particles and have a fairly high background, NO is a chemically reactive gas and has a low background concentration. Even low numbers of trucks per hour impact NO concentrations at Ezra Prentice.

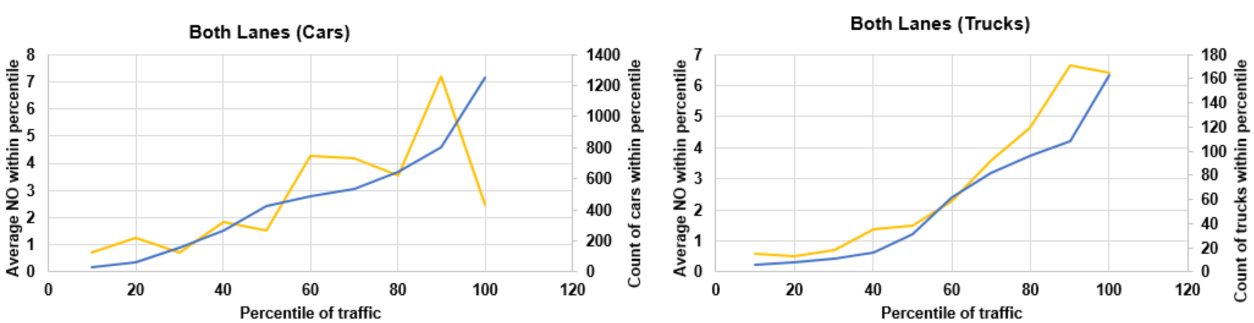

Figure 33. Weekday Percentile Comparison Total Cars (left, blue) and Trucks (right, blue) with NO (orange)

The relationship between NO and cars on Sunday is poor as illustrated in Figure 34. NO is positively correlated with truck traffic on Sunday though not as strongly as during weekdays.

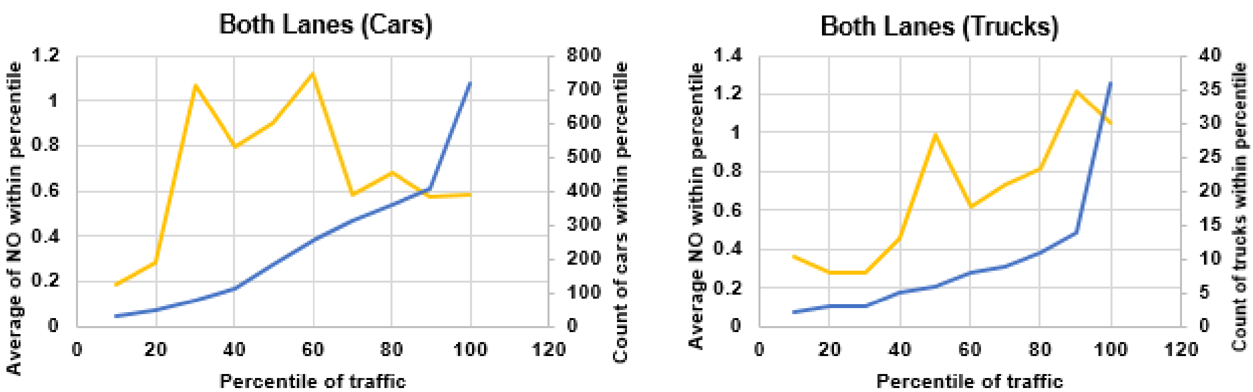

Figure 34. Sunday Percentile Comparison Total Cars (left, blue) and Trucks (right, blue) with NO (orange)

The results from the comparisons between the numbers of cars and trucks on South Pearl Street and the concentrations of mobile source pollutants were evaluated using a statistical tool called a Spearman Rank Correlation. This tool provides a correlation coefficient, and values closer to 1 indicate a stronger correlation. As illustrated in Table 18, truck traffic during the week is more strongly correlated with traffic-related air pollution than cars. On Sunday, neither cars or trucks are correlated with UFP and BC. A correlation was found for NO for both cars and trucks on Sunday. These correlation coefficients support the relationship illustrated in Figure 29–Figure 34.

The Spearman Rank Correlation analysis only looks at the relationship between the concentration of individual pollutants and the numbers of cars or trucks. Sometimes the relationship may be altered by other variables such as wind speed and temperature. We conducted a regression analysis to better understand the relationship between trucks, cars, meteorological parameters, and other variables with pollutant concentrations. Results of that analysis can be found in Appendix G.

In summary, on weekdays, cars and trucks are both traveling through the study area, but the increase in the number of trucks appears to be better correlated with increased traffic-related air pollutants. For trucks on Sunday, there are increases in BC and UFP when the number of trucks in the study area exceeds 11 per hour. NO is positively correlated with truck traffic on Sunday though not as well as during weekdays.

Table 18. Spearman Rank Correlation Coefficients

Pollutant	Weekday		Sunday	
	Cars	Trucks	Cars	Trucks
UFP	0.28	0.41	-0.10	-0.0089*
BC	0.21	0.31	-0.17*	-0.045*
NO	0.57	0.71	0.37	0.34

* Statistical analysis not significant, all others are significant at $p < 0.0001$

Additionally, the figures show that car traffic on Sunday does not increase the concentrations of BC or NO. The concentration of UFP does increase, but not until the number of cars exceeds 400 per hour.

The number of trucks in the study area is positively correlated with the concentration of the traffic-related air pollution as well as with PM_{10}, which is not shown. BC is a traffic-related air pollutant in the $PM_{2.5}$ size range which does contribute to a measurable concentration of suspended particulate matter. The increases in the local concentrations of BC and PM_{10} associated with commercial truck emissions shows that truck traffic related to the Port of Albany and local business activities are responsible for the majority the local impact of traffic-related air pollution in the study area.

Portable Monitoring

Near-roadway studies have shown that traffic sources can generate particulate matter and considerable amounts of ultrafine particles in areas very close to a roadway, especially along sidewalks and at bus stops.[73,74] In 2015, NYSDEC conducted a preliminary study in the South End to evaluate the effectiveness of portable monitoring for surveying the near-roadway environment.[75] The results showed that portable instrumentation was effective for conducting such studies, and also identified repeated, high UFP concentrations along local traffic corridors. The study results demonstrated that these brief, but frequent, peak concentrations are generated by traffic sources, typically from diesel-fueled vehicles.

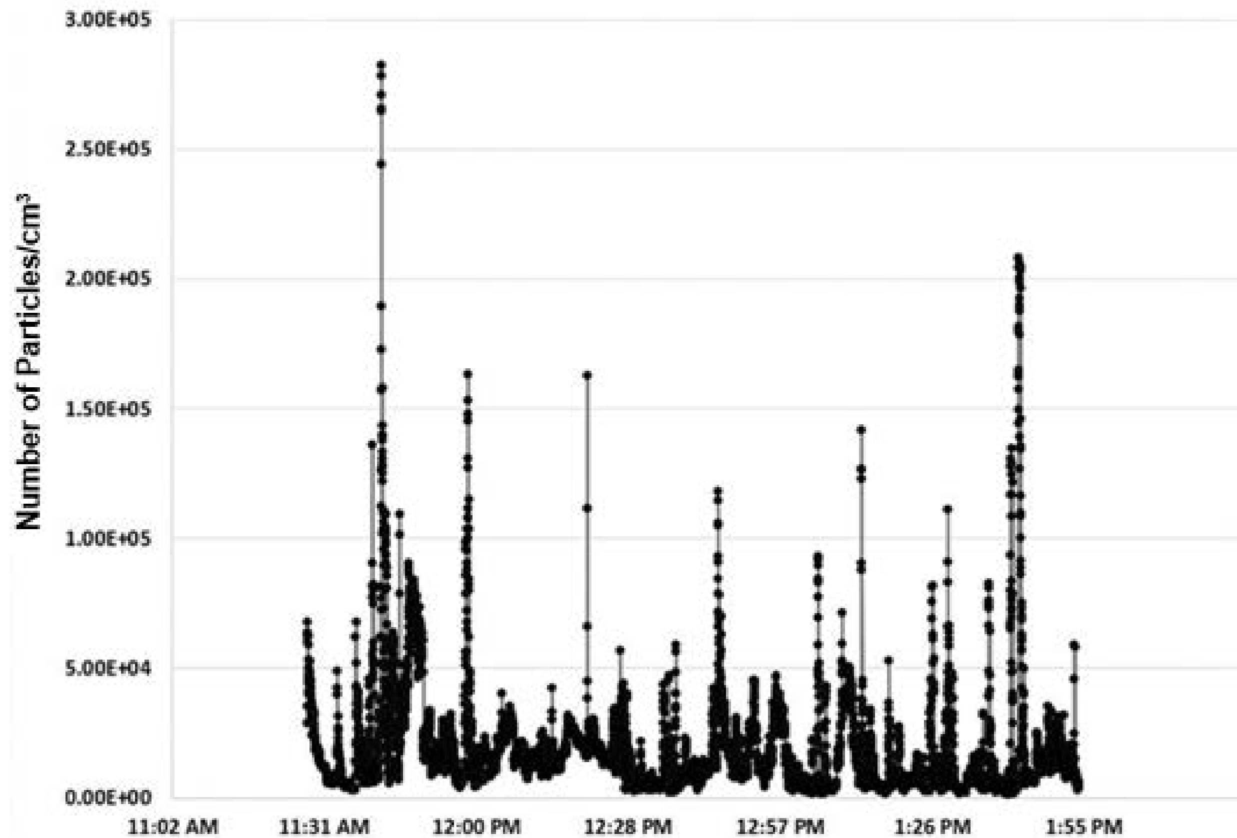

Figure 35. Typical Ultrafine Particle Concentration at Ezra Prentice on 4/27/2017

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73 Kumar. P., Fennell, P., Langley, D., Britter, R. (2008). *Pseudo-simultaneous measurements for the vertical variation of coarse, fine and ultrafine particles in an urban street canyon*. Atmospheric Environment. 42: 4304-4319.

74 Manigrasso, M. and Avino, P. (2012). *Fast evolution of urban ultrafine particles: Implications for deposition doses in the human respiratory system*. Atmospheric Environment. 51: 116-123.

75 Frank, B.P., Wurth, M.J., LaDuke, G.H., Tang, S.D., *Spatial Persistence and Patterns of Ultrafine Particle Short-term Peak Concentrations in the Near-Roadway Microenvironment*, in preparation.

Figure 35 shows a typical ultrafine particle measurement session (a few hours) at the Ezra Prentice homes within a few feet of South Pearl Street. A feature seen in such measurements is the large number of peaks that reflect high concentrations occurring frequently. It is unlikely that these concentration peaks—which last less than a minute on average—could be coming from sources other than traffic. Sources such as trains or shipping vessels on the Hudson River move much slower and less frequently through the area.

Additionally, monitors placed close to the train tracks (as shown in Figure 36, inset) did not show repeated peak measurements like those observed along the road. Figure 36 also demonstrates that particle concentrations near the train tracks were consistently lower than those near the road, and this was true even when train activity was observed on the tracks.

These observations support the conclusion from the fixed monitoring results earlier in this section that more particulate matter is coming from local traffic than from the port. While not identified as an important contributor of emissions in this study, these transport activities can have other negative impacts on the community such as noise, ground vibration, and safety concerns.

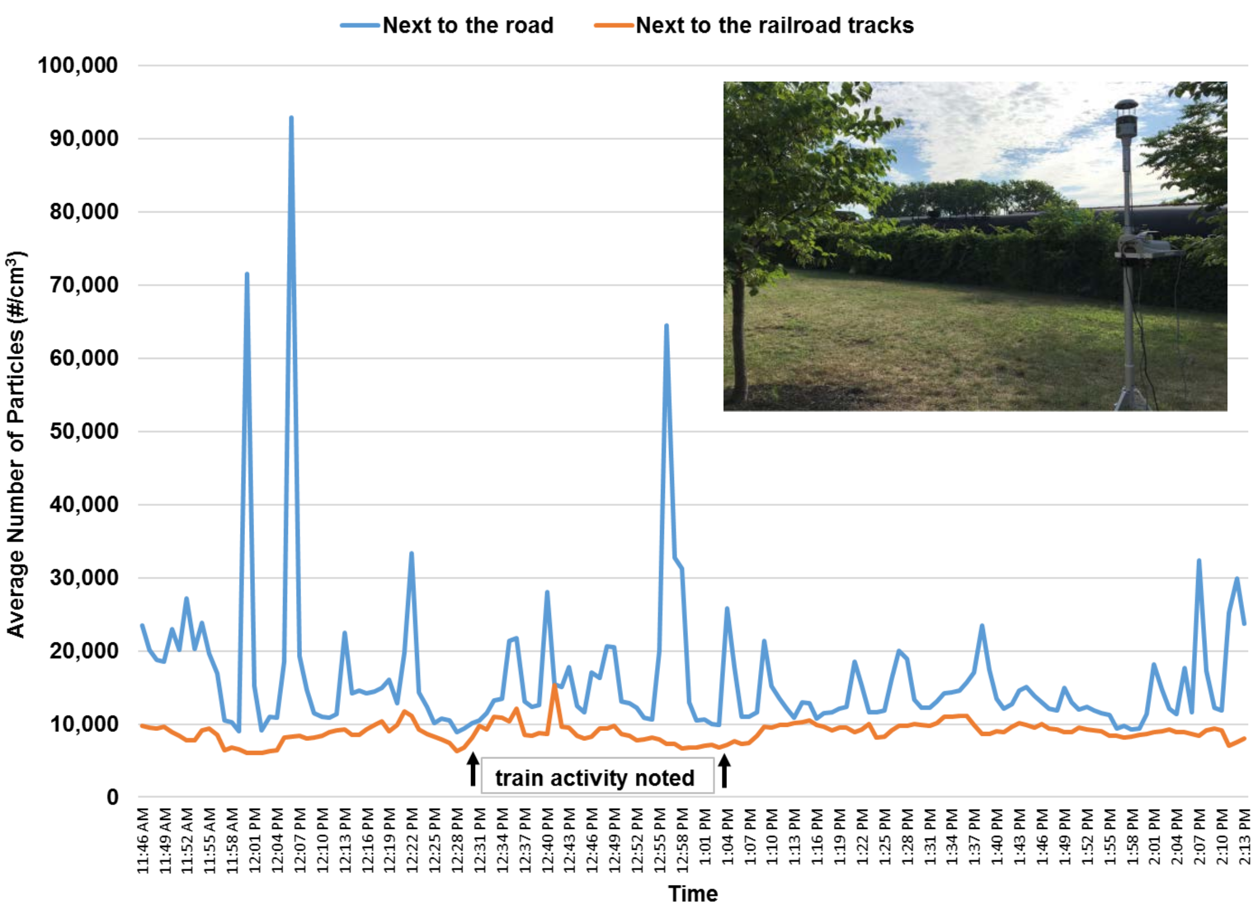

Figure 36. Average Number of Ultrafine Particles Next to the Road and Next to the Railroad Tracks

The concentration peaks in Figure 35 are generated by High-Emitting Vehicles (HEVs), (i.e., vehicles with emissions so much higher than other vehicles that they are statistically considered to be a separate group). Based on repeated measurements such as the distinct peaks shown in Figure 35, HEVs represent approximately 10% of the total traffic at Ezra Prentice, yet they are responsible for approximately the highest 25% of the total TRAP emissions. This is illustrated in Figure 37.

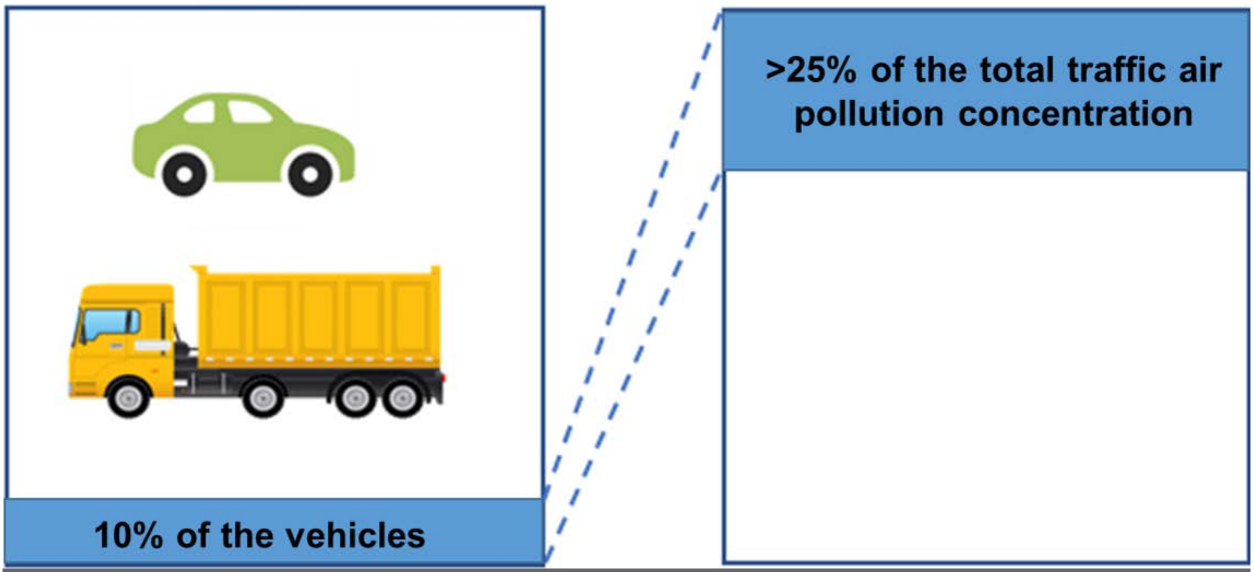

Figure 37. Contribution of High Emitting Vehicles (HEVs) to Total TRAP Emissions

Identifying these vehicles became the highest priority for the portable monitoring portion of the study. Reducing their contribution to TRAP is a first step to reducing TRAP at Ezra Prentice. Two questions were investigated:

- Where are these HEVs found?
- What types of vehicles or fleets are HEVs?

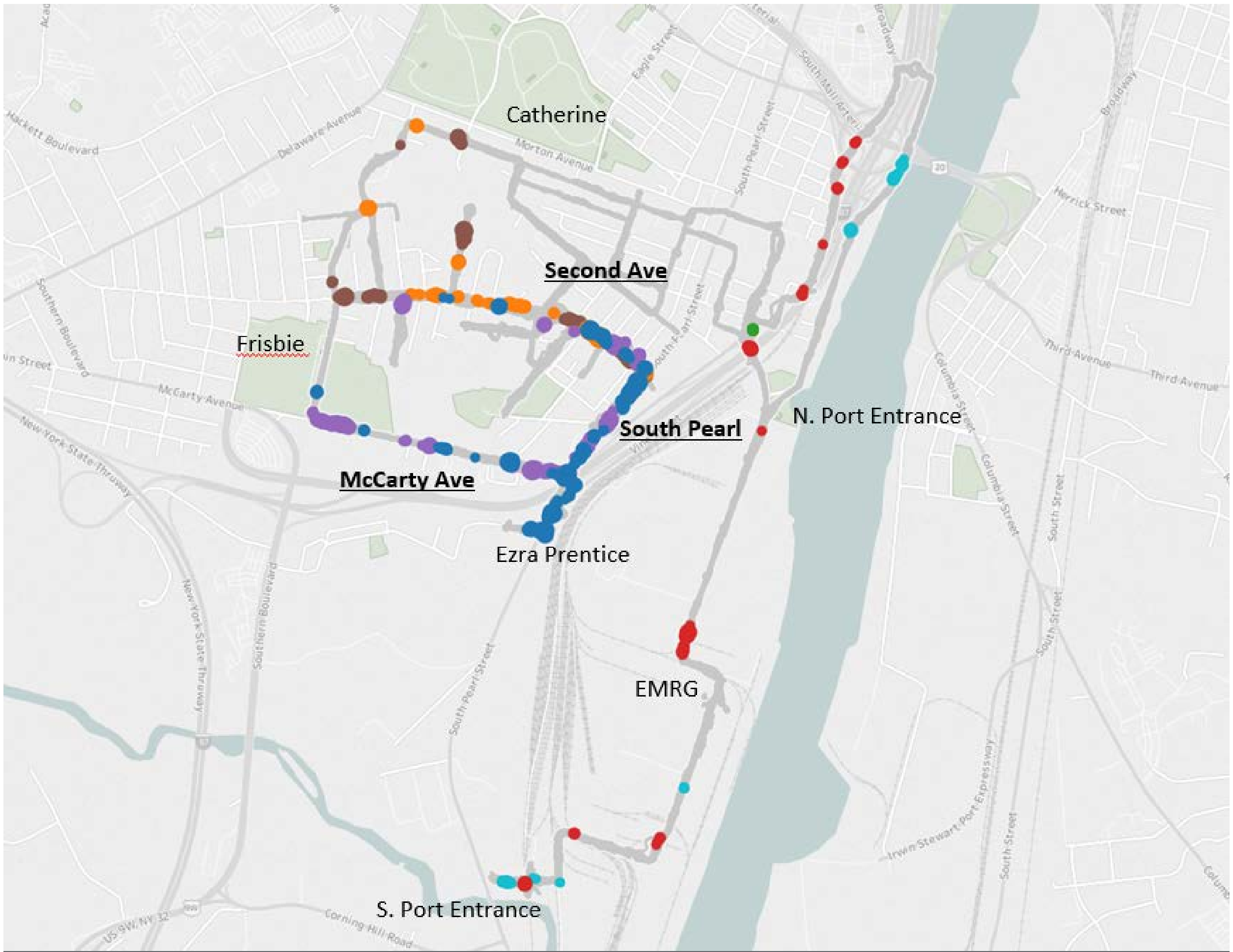

Figure 38. Air Monitoring Backpack Survey of the South End (2015)

Figure 38 shows the streets in the South End and the Port of Albany that were surveyed with portable backpack monitors during the 2015 study referenced above. Each street was surveyed multiple times and the colored dots are concentration peaks that occur during different days and times. The peaks are concentrated along high-traffic streets within the South End, specifically along South Pearl Street, Second Avenue, and McCarty Avenue. They are not seen along side streets without through traffic (such as Liebel Street, which parallels Second Avenue). They also occur on the local traffic corridors within the South End (high density, lower speed traffic) rather than within the port (low density, higher speed traffic).

We shared results (Figure 38) with the community during the early phase of the study. That resulted in two questions:

- How do high-traffic streets within the South End compare to each other? (i.e., "Am I being unfairly exposed to higher TRAP emissions than my neighbors who live on other busy streets in the South End?")
- How does Ezra Prentice fit into this pattern? (i.e., "Isn't Ezra Prentice just like any other street in the South End with a lot of traffic?")

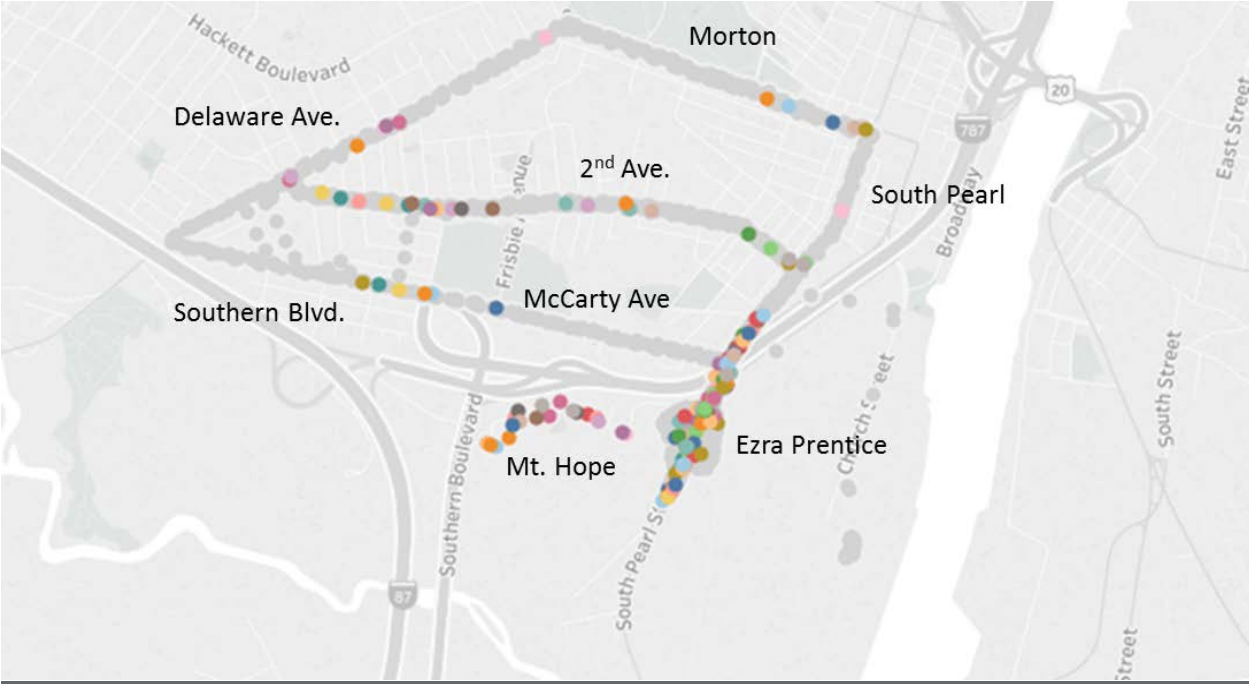

Figure 39. Air Monitoring Backpack Survey of the South End (2017 2018)

The grey dots in Figure 39 show the streets that were surveyed with the backpack during 2017–2018 in response to these questions. Each street was surveyed multiple times. The colored dots are peaks that occur during different days and times. Each colored dot represents one peak occurrence and the different colors represent different peak periods. This survey focused only on high-traffic through streets, so Figure 39 compares these streets to each other, not to side streets.

As Figure 39 shows, emissions along high-traffic streets are relatively similar throughout the South End. In other words, there is not a large difference in the amount of TRAP that residents of the South End are being exposed to, based on where they live. Additionally, the survey covered streets that cross both the NYSDEC-designated Potential Environmental Justice Area (PEJA)[76] and non-PEJA areas of the South End and found little difference between them. An example of this is Second Avenue, which is PEJA near the South Pearl end of the street and non-PEJA near the Delaware Avenue end of the street (part of the Delaware Avenue neighborhood rather than the South End).

The exception to this pattern is South Pearl Street in the area of the Ezra Prentice Homes. TRAP emissions in this area are significantly greater than the rest of the South End (Appendix K). This difference is not due to the amount of traffic passing Ezra Prentice, as this traffic volume is very similar to other high-traffic streets in the South End (e.g., Southern Boulevard between Frisbie and Delaware Avenues). Instead, the greater emissions are due to the types of vehicles that are traveling along this street.

Figure 39 also shows two additional features. First, the peaks along South Pearl Street drop off after the I-787 on-ramp (which was also seen by the CDTC traffic study). Second, peaks are also found along Mt. Hope Drive (surveyed at community request), west of the Ezra Prentice Homes. Both observations suggest that HEVs are coming from south of Ezra Prentice along South Pearl Street. This affirms a conclusion of the CDTC traffic study.

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[76] New York State Department of Environmental Conservation Commissioner's Policy 29 (CP-29)

Ezra Prentice and Southern Boulevard Communities Comparison

Based on the backpack measurements described above, further portable measurement focused on South Pearl Street at the Ezra Prentice Homes and on Southern Boulevard. These two locations are described further in this section. The built infrastructure and terraced layout of the Ezra Prentice apartment complex is very different from the residential neighborhood along Southern Boulevard. South Pearl Street divides the Ezra Prentice apartment complex. The west side of the complex is on a hill and extends approximately 450 feet from South Pearl Street while the east side is flat, and its furthest extent is approximately 230 feet from the street. The east side is adjacent to the railroad tracks and Port of Albany complex and the west side is adjacent to I-787. Previously completed community-based vehicle counts and transportation studies have documented a total of 12,200 vehicles, and over 1,000 heavy-duty vehicles, passing through the Ezra Prentice Homes daily. Many of these vehicles are traveling to and from local businesses south of the Ezra Prentice Homes, to the Port of Albany, and to the City of Albany. The I-787 on-ramp is located at the north end of the complex.

The Southern Boulevard location is a typical residential city block with rows of single-family homes and side streets. The New York State Thruway runs parallel to and is approximately 870 feet from Southern Boulevard. A major intersection at the end of I-787 and the NYS Thruway toll plaza is located to the southeast. Southern Boulevard was chosen as comparable to South Pearl Street at Ezra Prentice Homes because of its traffic volume. The NYSDOT Annual Average Daily Traffic (AADT) counts, as shown in Figure 40, indicate Southern Boulevard has more traffic (13,323) on an annual basis than South Pearl Street passing through Ezra Prentice (9,280). In addition, the backpack survey with portable instrumentation showed some peak particle number concentrations along Southern Boulevard, but this location was less frequently measured compared to Ezra Prentice. These results suggest Southern Boulevard has at least equal and/or greater traffic volume, but possibly a different vehicle mix with fewer diesel-fueled heavy vehicles. Southern Boulevard is also outside the PEJA of the South End as illustrated in Figure 2. The Southern Boulevard location appeared to be an ideal comparison case for Ezra Prentice to evaluate potential differences in traffic and pollution levels.

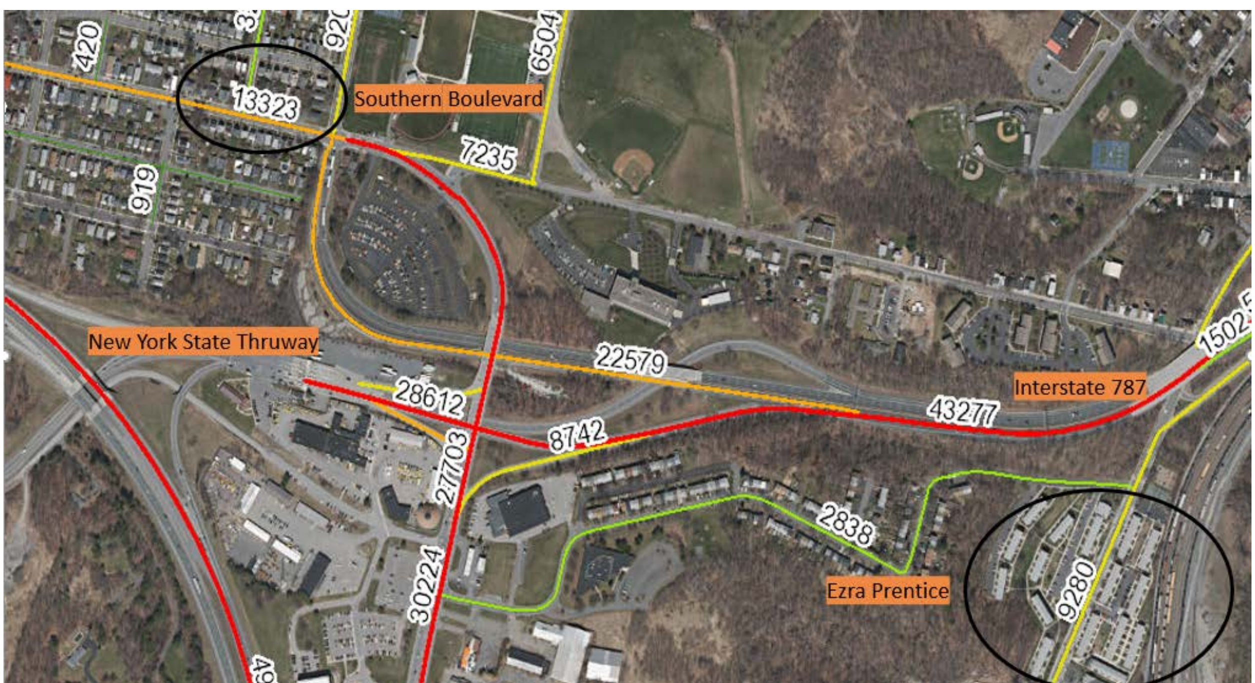

Figure 40. NYSDOT Annual Average Daily Traffic Counts (circled) for Ezra Prentice and Southern Boulevard

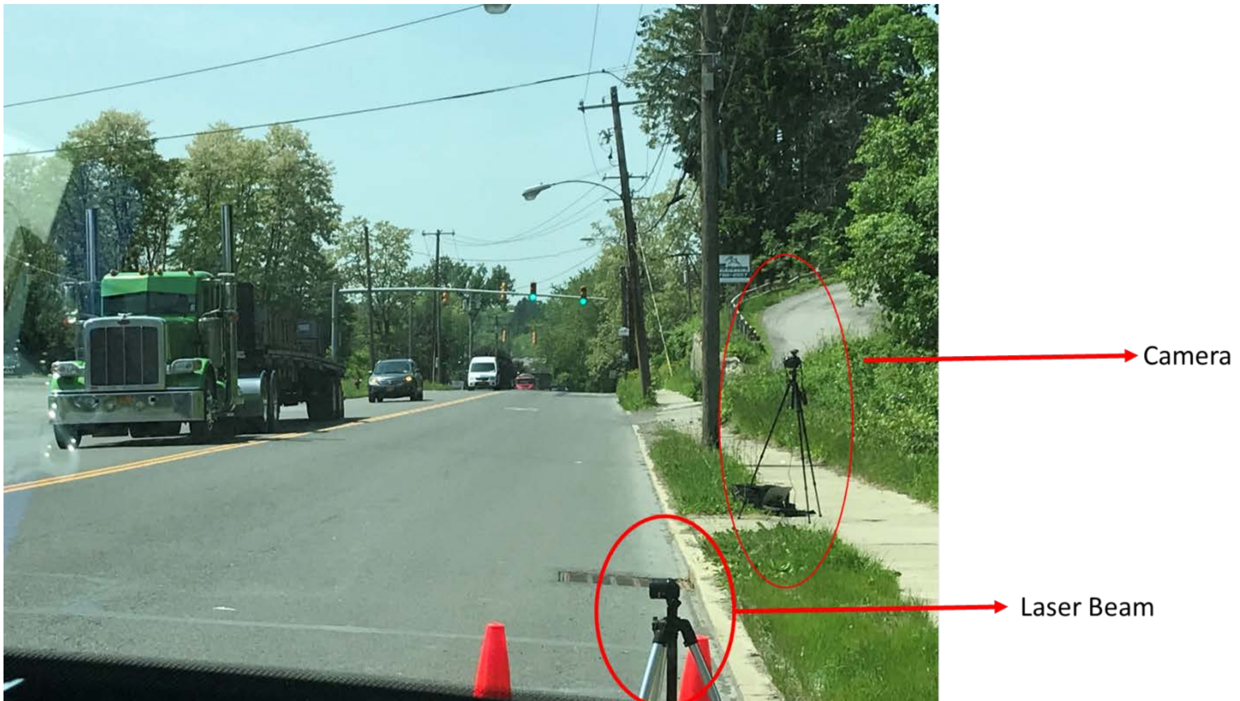

Figure 41. Vehicle Camera System

To learn more about the identity of the HEVs operating on South Pearl Street at Ezra Prentice and Southern Boulevard, NYSDEC supplemented the mini-monitoring stations with the ability to take pictures of passing vehicles (Figure 41). This system was not a commercial system and was designed by Emissions Measurement Research Group staff for the purpose of this study. A camera was set up along the side of the road next to the mini-monitoring station with a laser beam projecting across both lanes of traffic. Whenever a vehicle breaks the beam, the camera takes a picture. The system takes a picture of every vehicle that passes the mini-stations.

When this system was originally tested on traffic inside the Port of Albany (which has relatively few vehicles compared to Ezra Prentice), it could easily identify individual vehicles. However, traffic at Ezra Prentice averages approximately 11 vehicles per minute during peak UFP concentration traffic times and 9 vehicles per minute during low number low UFP concentration traffic times. Thus, each vehicle is only within range of the camera for approximately 6 seconds. This is too small an amount of time to definitively identify an individual vehicle as an HEV, considering the many changing variables such as vehicle speed, wind speed, wind direction, exhaust flow leaving the tailpipe, etc.

The pictures from the cameras were evaluated on a minute basis. The durations of the concentration peaks are less than a minute, and statistically each minute is separate (Appendix H). Therefore, peaks detected during a minute can only be from a very limited number of specific vehicles that passed by the mini-station during that minute.

To avoid “flagging” vehicles that were also present during these minutes but may not be responsible for the peak, an equal number of minutes at the lowest concentration were also chosen for comparison. The statistical method used to identify peak and low minutes is described fully in Appendix I. The pictures were used to identify every vehicle present during the peak and low concentration minutes (4,157 vehicles total). These vehicles were then further identified by vehicle class using the FHWA classification (Figure 6).

A preliminary evaluation (Table 19) of the numbers and types of vehicles associated with the peak and low concentration minutes suggests that class 4–10 vehicles are contributing to the high particle concentrations, especially at Ezra Prentice, where they are most prevalent. The number of class 1–3 vehicles is relatively consistent across all measurement periods with Southern Boulevard having more class 1–3 vehicles than Ezra Prentice. These results support those presented earlier in this section for fixed monitoring which indicate that cars (classes 1–3) rather than trucks (classes 4–13) were responsible for most of the traffic emissions impacts to residents in the study area.

Table 19. Summary of Ultrafine Particles and Vehicles during Monitoring at Ezra Prentice and Southern Boulevard

Location Concentration Minutes	Ezra Prentice Peak	Southern Boulevard Peak	Ezra Prentice Low	Southern Boulevard Low
Portable Station 3 Roadside (average number of particles/cm^3)	26,569	16,662	7,208	3,752
Portable Station 4 Roadside (average number of particles/cm^3)	20,936	10,688	4831	3,505
Class 1–3 Vehicles	336	419	296	424
Class 4–10 Vehicles	125	24	11	17

The number of vehicles in each class during peak and low concentration minutes were then compared to each other, to determine what types of vehicles were present during minute grouping. The results of this comparison are shown in Table 20. Class 1–3 vehicles were identified, but are not included in the comparison since they do not make a significant contribution, as discussed previously. Class 8 and Class 11–13 vehicles were not found frequently at Ezra Prentice and so are also not included.

Table 20. Vehicle Classes Present During Peak and Low Minutes at Ezra Prentice

Vehicle Class	4	5	6	7	9	10
% of vehicles present during peak minutes	13	42	13	9	11	13
Number of vehicles during peak versus low minutes	2.7	2.0	1.8	1.4	2.0	1.4

Two conclusions can be drawn from Table 20. First, of the total number of class 4–10 vehicles present during peak minutes (2,303 vehicles), the largest percentage of them were Class 5 vehicles, at 42% of the total vehicles. Class 5 is a very diverse class that includes paratransit[77] vehicles, box trucks, etc. Second, the class with the highest ratio of vehicles present during peak versus low minutes is class 4 (buses). There are 2.7 times as many buses present during peak emission minutes as during low emission minutes. This ratio is twice as high as that for the class 7 trucks.

To find out more about the identity of the vehicles within these classes, photos from the classes with the four highest ratios were examined further: Class 4, followed by classes 5, 9, and 6. Photos of 625 vehicles in these classes were examined to see if individual fleets could be identified. Details for each class can be found in Appendix J. A summary is as follows:

> Class 4: The fleet most frequently present was First Student School Bus, which has a fleet depot south of Ezra Prentice (49% of class 4 vehicles, ratio of peak versus low vehicles of 7.6). Capital District Transportation Authority (CDTA) ranked second with 14% and a ratio of 5.5 (all cases of bus idling were removed for CDTA).
>
> Class 5: The vehicles in this class were highly diverse. Seventy-two percent (72%) of the class 5 photos could not identify a fleet or there were only a few vehicles of a certain type present. Of the few identifiable fleets, all represent paratransit vehicles. Among these, the fleet most frequently present was the Center for Disability Services, which has a fleet depot immediately adjacent to Ezra Prentice (17% of class 5 vehicles, ratio of peak versus low vehicles of 2.3). Class 5 First Student and CDTA vehicles were also present, but to a lower extent.

The Center for Disability Services fleet presents a unique opportunity for fleet outreach, as these vehicles' identifying information is clearly visible in the images. Vehicles from this fleet could be classified to either the HEV or non-HEV category with a greater degree of certainty than any other fleet, especially since some specific vehicles were present up to 3 times during either peak or low minutes on different days.

The current data set identified 29 specific vehicles in the Center for Disability Services' fleet for which the evidence supports classification as non-HEVs, and 22 specific vehicles for which the evidence supports classification as HEVs. Because this information is so specific, a direct comparison between these vehicles could yield valuable insight into why some vehicles within the same fleet are HEVs while others are not.

Evaluation of vehicles from Durham School Services is also recommended. This fleet depot is also located to the south of Ezra Prentice, between the Center for Disability Services and the First School Bus depots. Despite the fact that the fleet consists of similar vehicles and is in a similar location, it is represented weakly in the HEV data sets (11% for class 4 and 2% for class 5). Durham School Services has recently relocated fleet operations and no longer deploys vehicles from this location but was operating along South Pearl Street during the study period.

With assistance from the Albany Mayor's Office, NYSDEC has opened a cooperative dialogue with the above three fleets and with the Albany City School District. It is important to emphasize that these fleet operators are not deliberately engaging in harmful practices and may not be in violation of any regulatory or statutory requirements. The reasons that these vehicle fleets appeared as HEVs in our study are unknown at this point and these operators were not aware that this was the case. We believe working with these fleets will help identify operating practices (e.g., operating under cold

[77] Paratransit vehicles provide specialized transportation services for people with disabilities.

start) or vehicle characteristics that may help with reducing TRAP in this and other communities with a large volume of truck traffic.

These fleets are voluntarily collaborating with NYSDEC by sharing their fleet and vehicle information. By examining this information (such as by investigating the questions below), it may be possible to learn the reasons for the existence of these HEVs without the need for further monitoring or testing. Additionally, the voluntary cooperation of these fleets could help determine whether other sampling methods (e.g., smoke opacity meters, onboard diagnostics, and other direct tailpipe testing) could identify these HEVs.

- What is the difference between HEVs and non-HEVs within a fleet? An example of this would be looking at the difference between the HEVs and non-HEVs within the Center for Disability Services fleet. Possible factors such as vehicle age, model, or maintenance procedures/schedules can all affect vehicle emissions.
- What is the difference in the number of HEVs between fleets? An example of this would be looking at the differences between the First Student and Durham School bus fleets. Factors such as the type of vehicles in the fleet, how they are operated and maintained, what routes they are traveling, and the time of day could all affect their emissions impact on Ezra Prentice.
- What are the fleet compositions and operating procedures of other fleets to the south of Ezra Prentice that did not show up at all in the HEV data set? Similar factors to those above could explain their lack of impact on Ezra Prentice.

The potential implications of these investigations extend beyond Ezra Prentice and the South End. If there are unknown factors contributing to HEVs among classes 4 and 5 vehicles, then the lessons learned from discovering these factors and applying mitigation strategies could be applied statewide.

NYSDEC's collaboration with these fleets may also provide a model for working cooperatively with additional vehicle fleets in the South End, and with fleets in other near-roadway and environmental justice communities. NYSDEC recommended that fleet outreach be directed initially to the fleets identified above. Lower-priority fleets may also be identified for these and other vehicle classes as the data are analyzed further, and as more pictures and data are gathered.

The class 5 vehicles constituted a large number of the vehicles present during peak concentration minutes (42% of total vehicles), indicating that strategies to reduce emissions from this class of vehicles could be highly effective in reducing exposure. However, since they are so diverse and contain a small percentage of identifiable fleets (28% of class 5), there are inherent limitations to a fleet-based strategy for this class. Another approach is needed to address the HEVs in this class, potentially one that could be applied more comprehensively. For example, future mandatory medium and heavy-duty onboard diagnostic[78] (OBD) inspections could potentially be instituted on a statewide basis.

Class 9: Vehicles within this class had no fleets frequently present during peak minutes. Seventy-six percent (76%) of class 9 vehicles, either could not be identified or there were only a few vehicles of a certain fleet present. Examination of the pictures found that this class was dominated by tanker trucks (57%), approximately half of which are carrying DOT class 3 flammable liquids, i.e., fuels (Table 21).

[78] https://www.dec.ny.gov/chemical/8621.html

Table 21. Types of Class 9 Vehicles Present during Peak Minutes at Ezra Prentice	
Description	**% of Total Class 9 Vehicles**
Tanker Trucks: DOT Class 3 Flammable Liquids	29
Tanker Trucks: Unknown Contents	25
Tanker trucks: Other DOT Class	3
Tractor-Trailers	32
Other	11

Tanker trucks carrying fuels are likely coming from, or going to, the petroleum terminals on the west bank of the Hudson River (including those south of Ezra Prentice on River Rd./NY 144 in Glenmont), or potentially even those on the east bank. A fleet-based strategy is unlikely to work for addressing HEVs among the class 9 fuel tankers. Most of them are registered out of state and owned and operated by independents or smaller trucking companies. Few of the suppliers own or operate their own fleet of trucks. They may be under contract with the terminal, but many of them are contracted with the destination, e.g., gasoline stations and home heating oil suppliers.

Class 6: Vehicles within this class had no fleets frequently present during peak minutes. Seventy-six percent (76%) of class 6 vehicles either could not be identified or had only a few vehicles of a certain fleet present. Examination of the pictures found that this class was dominated by dump trucks (69%) (Table 22). These dump trucks may be carrying materials to or from any facility or large project in the area, including the Port of Albany, and many are likely owned by independent contractors. Similar to the class 9 vehicles, a fleet-based strategy is unlikely to work for addressing HEVs among class 6 vehicles due to the diversity of owners.

Table 22. Types of Class 6 Vehicles Present during Peak Minutes at Ezra Prentice	
Description	**% of Total Class 6 Vehicles**
Dump Trucks	69
Other	31

Similar examination of photos of 4,420 vehicles at the Southern Boulevard reference site indicates a similar amount of total traffic but a different distribution of vehicles among classes, as indicated in Table 21. Seventy-eight percent of the class 4–10 vehicles present during peak minutes were class 5 vehicles; this class dominated such vehicles both at Southern Boulevard and at Ezra Prentice. Because of the fewer number of other class 4–10 vehicles, class 5 vehicles could be observed in isolation at Southern Boulevard and were found to contribute approximately 54% of HEV emissions for all traffic pollutants that were measured.

Due to the fewer number of heavy-duty vehicles, there was weak evidence for any fleets making a strong contribution at Southern Boulevard. However, it should also be noted that both Center for Disability Services and CDTA STAR vehicles were found to be present among the class 5 vehicles observed.

Figure 42 shows an overlay of peak and average values for Ezra Prentice and Southern Boulevard. This figure illustrates two points. First, the influence of peak concentrations from HEVs is greatest closest to the road. This indicates that residents living closest to the road are most impacted by these peak concentrations, which suggests that reducing peak concentrations from HEVs would have the greatest benefit for these same residents. Second, average concentration values at Ezra Prentice and peak concentration values at Southern Boulevard are roughly equivalent. This suggests that if emissions from the vehicles contributing peak concentrations at Ezra Prentice could be reduced, concentrations at Ezra Prentice could be more comparable to Southern Boulevard, and by extension more comparable to the rest of the South End.

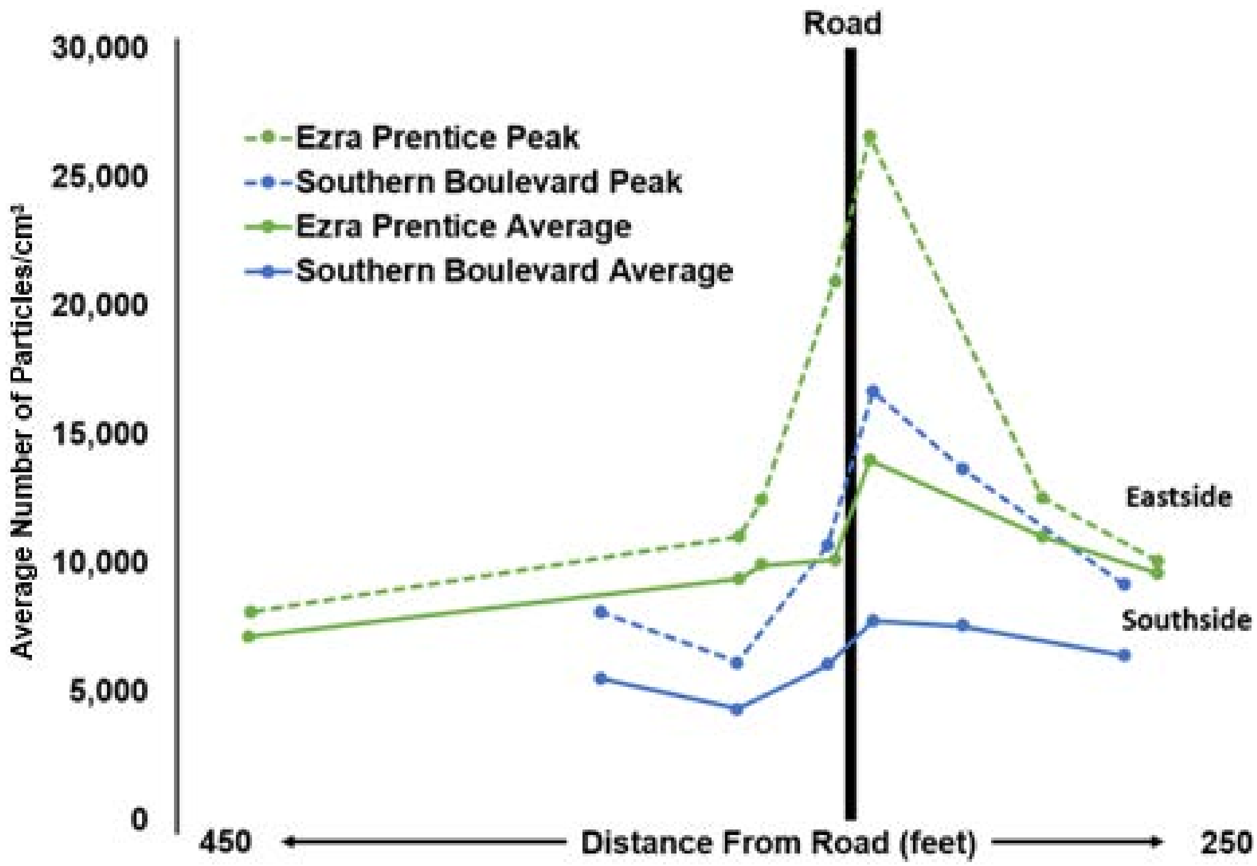

Figure 42. Peak and Average Ultrafine Particle Concentrations at Ezra Prentice and Southern Boulevard

Objective 2: Develop an understanding of how far particulate matter travels from the road into the neighborhood

Portable Monitoring

As vehicle pollution travels away from the road, the amount of pollution (the concentration) changes. This change in concentration across an area is called a concentration gradient. Usually, there is a rapid decline in the concentration of UFP and other pollutants emitted by vehicles with distance from the road. UFP concentrations may decrease by at least 50% at distances greater than 500 feet.[79] Varying traffic levels, types of vehicles, driving behavior, changes in wind speed and direction, and location of buildings and vegetation can influence how pollution disperses from the road.[80,81] A multipoint network of portable instruments mounted on weather tripods (portable mini-stations) was deployed to each side of the road across the Ezra Prentice apartment complex, across South Pearl Street, and in a residential neighborhood along Leighton Street, across Southern Boulevard.

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[79] Karner, A.A., Eisinger, D.S., Niemeier, D.A. (2010). *Near-Roadway Air Quality: Synthesizing the Findings from Real-World Data*. Environmental Science and Technology. 44: 5334-5344.

[80] Choi, W., Ranasinghe, D., Bunavage, K., DeShazo, J.R., Wu, L., Seguel, R., Winer, A.M., Paulson, S.E. (2016). *The effects of the built environment, traffic patterns, and micrometeorology on street level ultrafine particle concentrations at a block scale: Results from multiple urban sites*. Science of the Total Environment. 553: 474-485.

[81] Choi, W., Ranasinghe, D., DeShazo, J.R., Kim, J., Paulson, S.E. (2018). *Where to locate transit stops: Cross-intersection profiles of ultrafine particles and implications for pedestrian exposure*. Environmental Pollution. 233: 235-245.

The mini-stations collected data at 1.7-meter elevations (approximate average adult breathing height). The portable instruments measure traffic-related air pollutants (TRAP) of ultrafine particles and black carbon. To capture the time of day when traffic pollutants were expected to be greatest, short-term measurements for an approximate 5-hour period (8:00 a.m. to 2:00 p.m.) were taken over 5 different weekdays at each location. The portable mini-stations were placed at varying distances across both locations to better understand how the pollution from traffic traveled from the road into the neighborhoods. Efforts were made to keep the station locations at the same distances from the road at both locations, but physical structures and other boundaries required some changes in station location. Additionally, due to instrumentation limitations, the mini-stations could only be operated at temperatures above 40°F, from approximately mid-June to mid-September.

Portable Mini Station

Ultrafine Particles

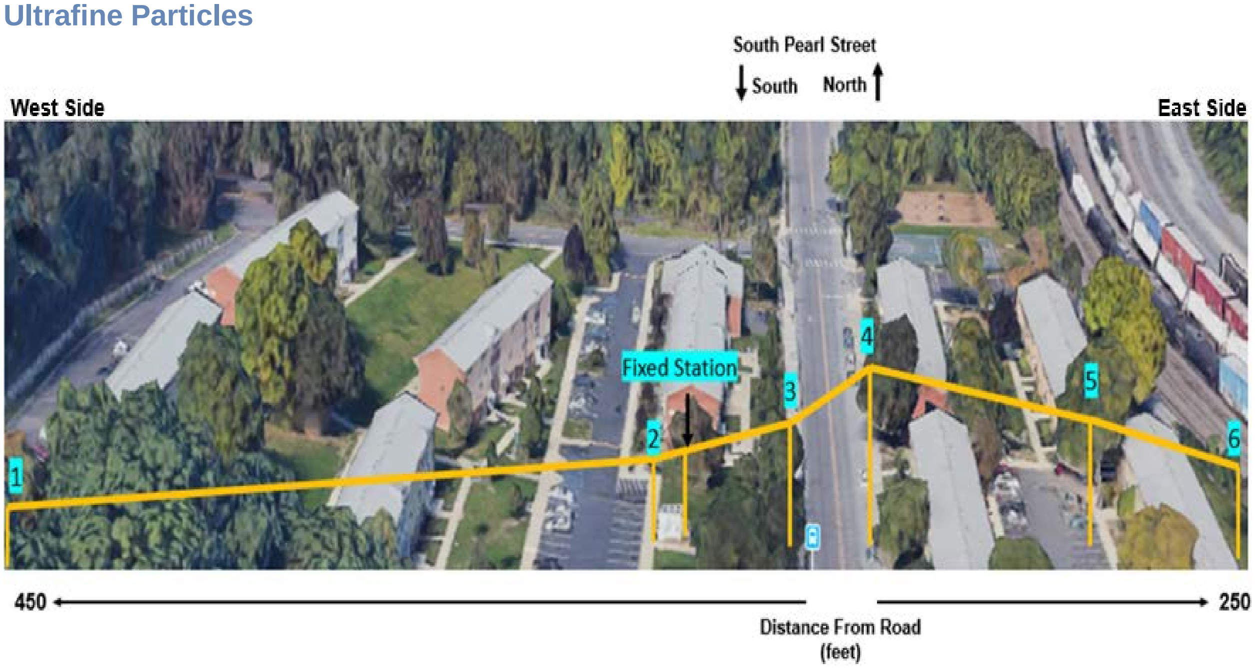

Figure 43. Portable Mini station Network Deployed across the Ezra Prentice Apartment Complex along South Pearl Street

Figure 43 shows the mini-stations placed at varying distances from the edge of the roadway at South Pearl Street. The Ezra Prentice fixed monitoring station is located next to portable mini-station 2. Mini-stations 3 and 4 are located closest to South Pearl Street (within approximately 15 feet). Mini-stations 1 and 6 are farthest from South Pearl Street, at distances of 450 feet and 250 feet, respectively). The height of the yellow line is an approximate representation of the average number of UFP per cubic meter (concentration of UFP). As illustrated by the yellow line, the average concentration of UFP decreases with increasing distance from South Pearl Street.

Figure 43 also illustrates the offset of higher UFP concentrations towards the east side of South Pearl Street at Ezra Prentice. This offset may be due a number of factors, including the vehicle mix and traffic flow in the northern direction along the east side of South Pearl Street. It may also be due to the presence of buildings along the east side blocking the dispersion of TRAP. The west side of South Pearl Street has more open space in the area surrounding the fixed monitor.

Figure 44. Portable Mini station Network Deployed across Leighton Street Perpendicular to Southern Boulevard

Figure 44 above shows the mini-stations placed along Leighton Street at varying distances from Southern Boulevard. Mini-stations 1 and 6 are farthest from Southern Boulevard. Mini-stations 3 and 4 are located closest to Southern Boulevard, within approximately 17 feet. The mini-station locations were chosen to match the locations used at Ezra Prentice within the constraints of Leighton Street. As illustrated by the yellow line, the average concentration of UFP at Southern Boulevard decreases with increasing distance from the road on the north side (west-bound traffic). The effect is less pronounced on the south side (east-bound traffic). The height of the yellow line is an approximate representation of the average concentration of UFP.

Figure 45 displays the values for the average concentration of UFP measured during the five different deployments of mini-stations 1–6 at Ezra Prentice. The concentration of UFP is highest at mini-station 4, which is closest to the road on the east side (north-bound traffic). The lowest concentrations are approximately 50% less at mini-station 1 than at mini-station 4, closest to the roadway. The next highest concentration to mini-station 4 is at mini-station 5, followed by similar concentrations at mini-stations 2, 3, and 6 (according to the statistical analysis in Appendix K). This suggests that Ezra Prentice is divided into four distinct areas of exposure to TRAP:

- East side of South Pearl Street at mini-station 4
- East side of South Pearl Street at mini-station 5
- The rest of the complex (mini-stations 2, 3, and 6)
- Farthest west side of South Pearl Street at mini-station 1 (not directly affected by mobile sources on South Pearl Street)

Figure 45 displays the values for the average concentration of UFP measured during five different deployments of mini-stations 1–6 at Southern Boulevard. The concentration of UFP is highest at mini-station 3, which is closest to the road on the south side (east-bound traffic).The concentration of UFP is lowest at mini-station 5, which is closer to the road than mini-stations 1 and 6. Mini-station 6 at Southern Boulevard was placed at the end of the street at approximately 185 feet. Side street traffic adjacent to Leighton Street and traffic emissions from the New York State Thruway may be influencing concentrations at mini-stations 1 and 6. Figure 45 suggests the average concentration of UFP measured at Ezra Prentice is approximately twice the average concentration measured at Southern Boulevard. The average concentration of UFP at Ezra Prentice and Southern Boulevard are significantly different based upon statistical data analysis (Appendix K).

Figure 45 includes the spread of the data (the height of the bar representing 95^{th} to 5^{th} percentile values) to show the amount of variability in the average concentration of UFP from day-to-day measurements (5-hour periods, 5 days) taken at both locations. The bars indicate there is considerable variability across the sampling sessions at each location. These variations could be a function of the traffic patterns, the vehicle mix, and changes in wind speed and direction.

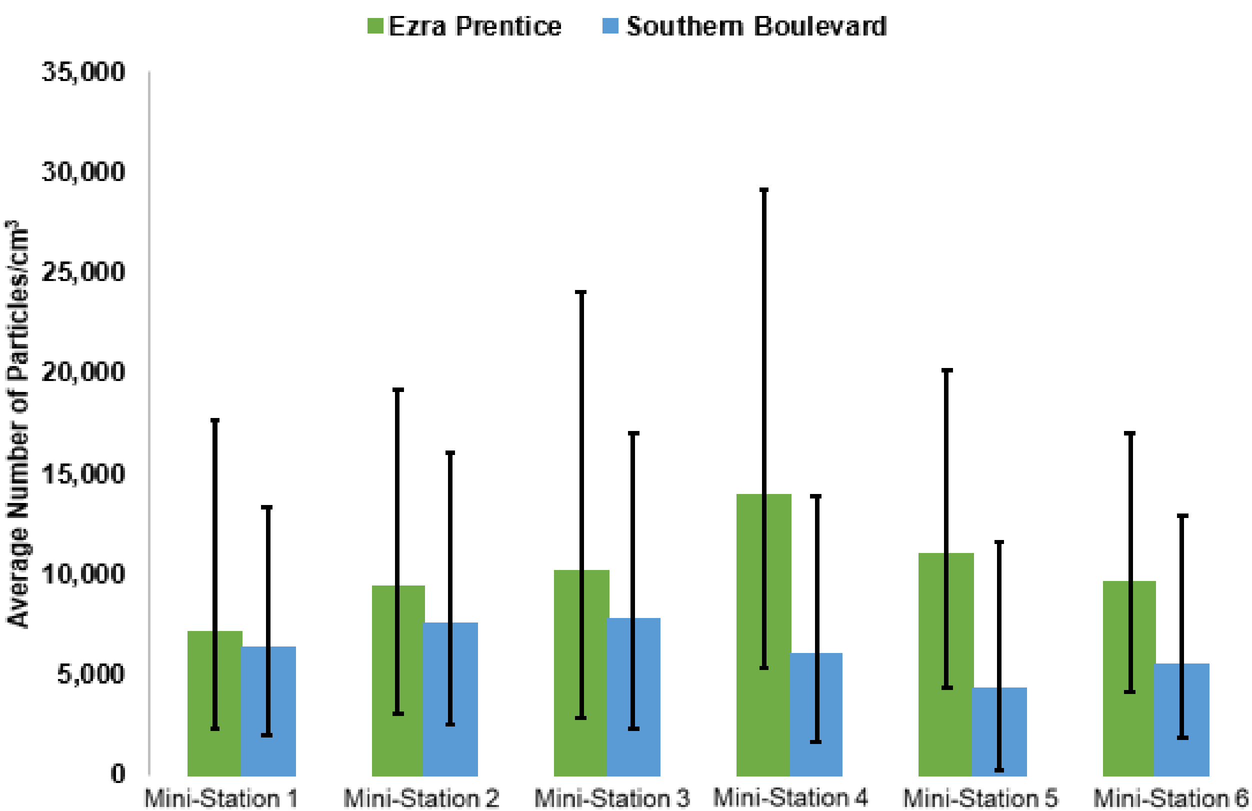

Figure 45. A Comparison of Ultrafine Particles Measured at Each Portable Mini station Located at Ezra Prentice and Southern Boulevard

HEVs traveling along South Pearl Street are having the greatest effect at locations closest to the road at Ezra Prentice. This includes the front of Buildings 624, 626, 628 (28 units total) and the playground. At Southern Boulevard, HEVs also have a greater effect on locations closest to the road, but the HEVs' effect is far less compared to Ezra Prentice because there are far fewer HEVs present. At both locations, the UFP concentration gradient is also higher on one side of the road. There are factors, including vehicle mix, traffic flow (low speed, stop-and go traffic), wake turbulence from passing traffic, and the amount of open space and location and shape of buildings along the road, that may affect pollution dispersion. More data and further evaluation are necessary.[82,83]

The number of cars was about the same during all portable monitoring times, with Southern Boulevard having a greater proportion of cars (96% of all vehicles) than Ezra Prentice (76% of all vehicles). Along South Pearl Street at Ezra Prentice, 24% of the vehicles were identified as large trucks and buses compared to 4% identified at Southern Boulevard. Many of these vehicles are traveling to and from local businesses south of the Ezra Prentice Homes, to the Port of Albany, and to the city of Albany. The I-787 on-ramp is located at the north end of Ezra Prentice. UFP number concentrations are much less at Southern Boulevard because there are fewer large trucks and buses traveling along the road compared to Ezra Prentice.

UFP measurements taken closest to the road are characterized by a series of short, frequent concentration peaks that are orders of magnitude above urban background. As an illustration of this effect, the time series in Figure 46 shows an hour of measurements from a mini-station close to the road at Ezra Prentice, the Ezra Prentice fixed station, and the urban background fixed station on Third Avenue. Note that Third Avenue is not characterized by short-term peaks. It was chosen as a background site because it is located on a one-way street and has low traffic volume, as confirmed by backpacking surveys. The Ezra Prentice fixed station also captured some of these higher peaks, but they are often lower in magnitude due to the increased distance from the road.

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[82] Mehel, A. and Murzyn, F. (2105) *Effect of air velocity on nanoparticles dispersion in the wake of a vehicle model: Wind tunnel experiments*. Atmospheric Pollution Research 6: 612-617.

[83] Choi, W., Ranasinghe, D., Bunavage, K., DeShazo, J.R., Wu, L., Seguel, R., Winer, A.M., Paulson, S.E. (2016). *The effects of the built environment, traffic patterns, and micrometeorology on street level ultrafine particle concentrations at a block scale: Results from multiple urban sites*. Science of the Total Environment. 553: 474-485.

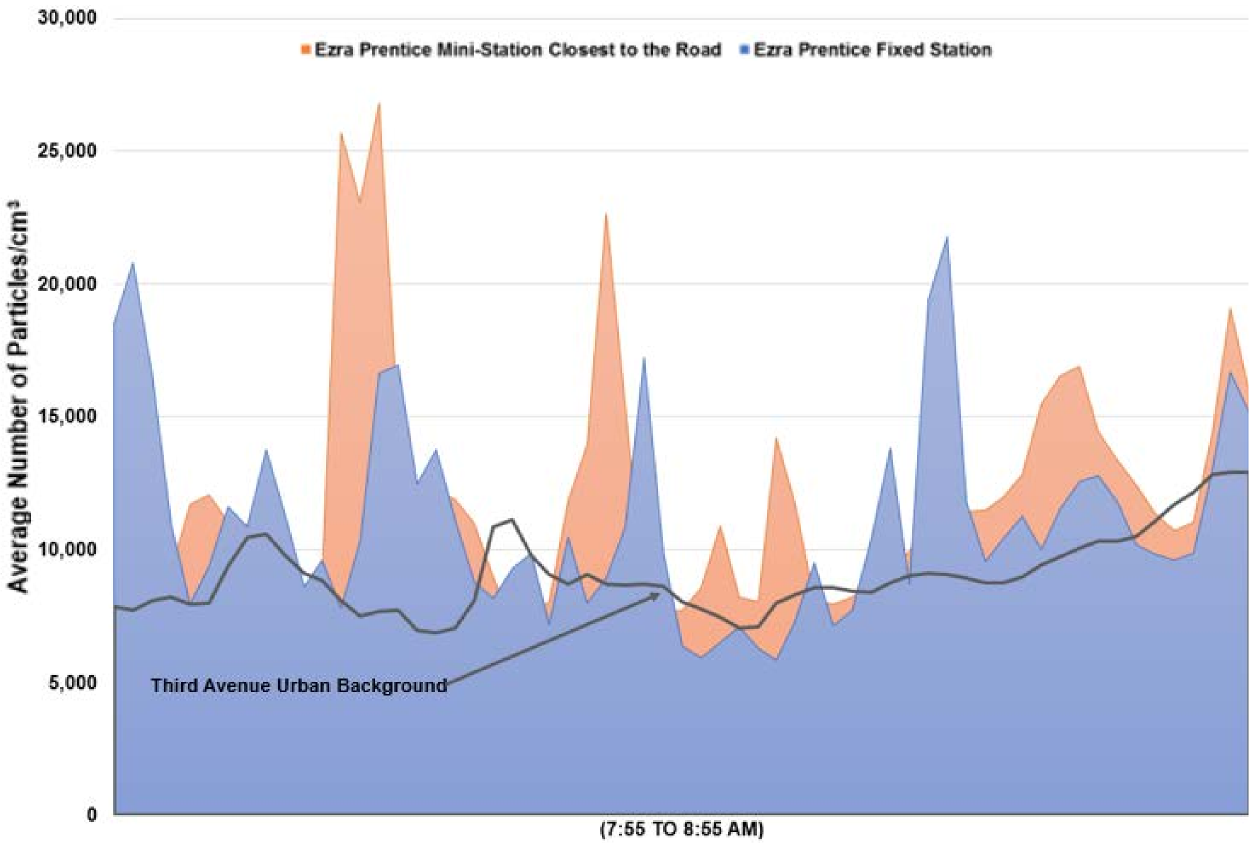

Figure 46. Average Number of Ultrafine Particles per Minute for One Hour

This diminishing influence of the short-term peaks with increasing distance from the road is more fully illustrated by Figure 47, which shows only the peak UFP concentrations above urban background measured with distance from the road. The influence of the peaks due to the presence of HEVs decreases logarithmically with distance from the road, with the highest concentration measured within 50 feet of the road. These concentrations decrease to background levels at distances greater than 250 feet at Ezra Prentice. Concentrations at Southern Boulevard do not decrease to background levels at 200 feet; this was the farthest location measured (end of street).

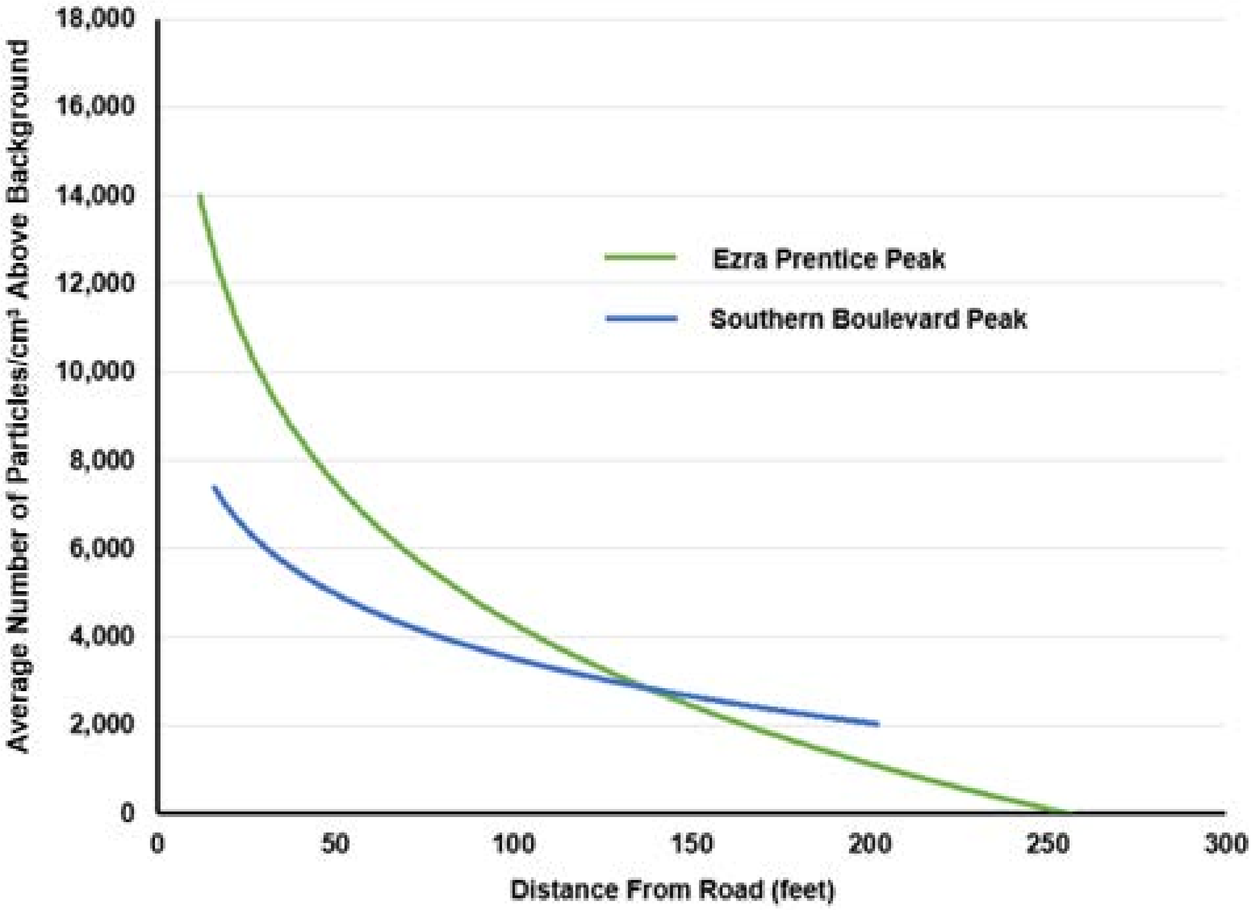

Figure 47. Average Peak Ultrafine Particle Concentrations above Background at Ezra Prentice and Southern Boulevard

Black Carbon (BC) ($\mu g/m^3$)

The available three instruments measuring BC were placed on the west side of Ezra Prentice and the north side of Southern Boulevard. Based on an instrument intercomparison, the BC data from the mini-station located farthest from the road at both locations were excluded from the data set because it appeared to be biased high at both measurement locations (see Appendix L).

The portable monitoring showed BC concentrations at Ezra Prentice were highest at mini-station 3, closest to the road at approximately 15 feet (Figure 48). HEVs at Ezra Prentice that are also emitting peak BC concentrations are having the greatest effect on the concentration gradient with concentrations approximately 1.5 times greater than average concentrations.

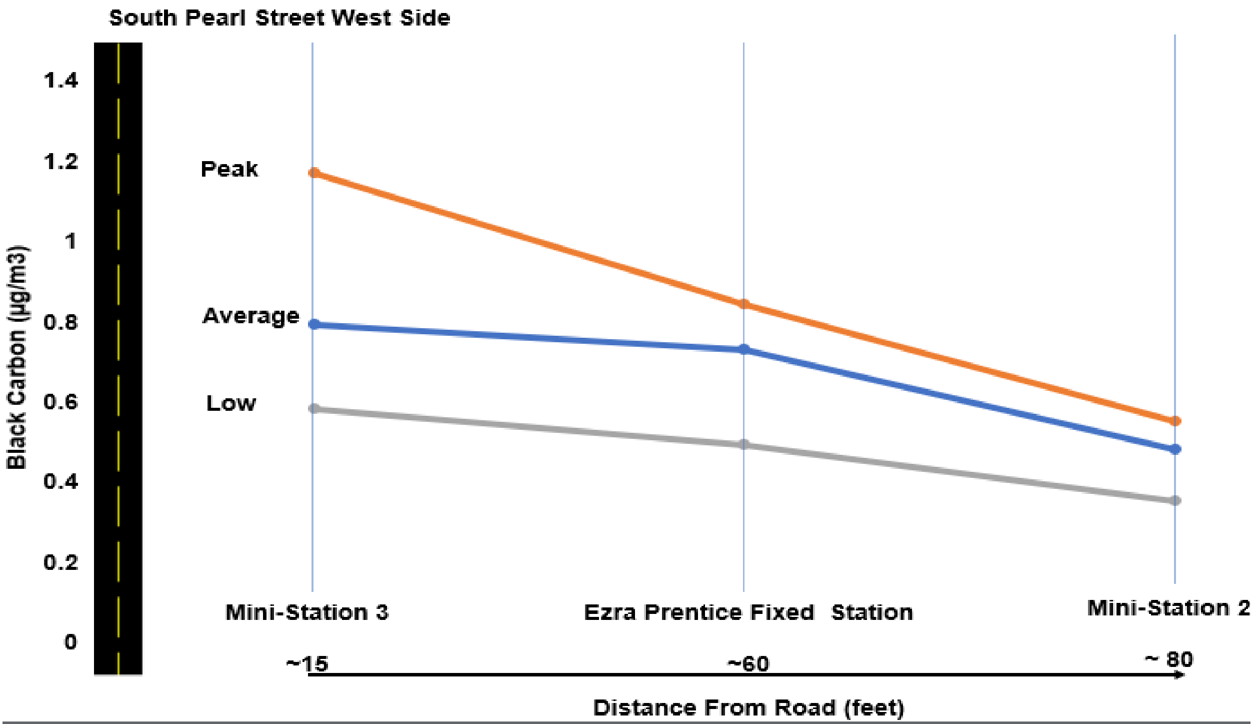

Figure 48. Peak, Average, and Low Black Carbon Concentrations Measured at Ezra Prentice

HEVs emitting peak BC concentrations at Southern Boulevard are having slightly less of an effect on the concentration gradient as shown in Figure 49. Peak concentrations are approximately 1.40 times greater than average concentrations. At both Ezra Prentice and Southern Boulevard, the BC concentrations are decreasing with increasing distance from the road.

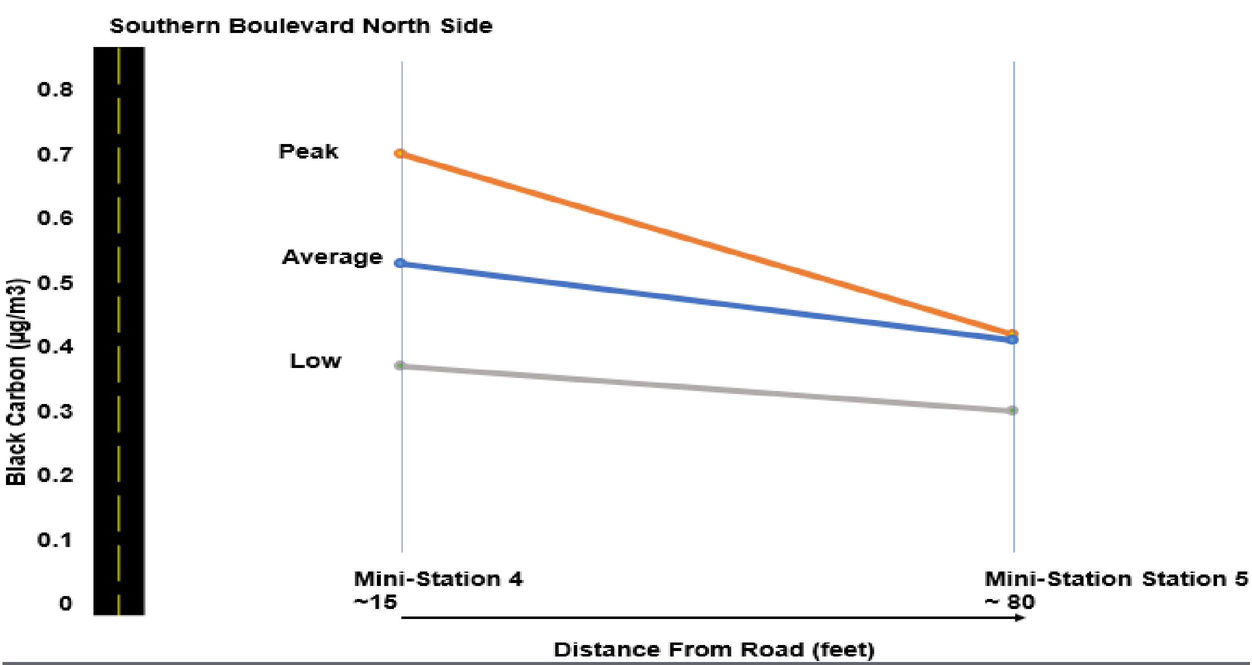

Figure 49. Peak, Average, and Low Black Carbon Concentrations Measured at Southern Boulevard

As shown in Figure 50, average BC concentrations measured at Ezra Prentice closest to the road are 1.5 times greater than the BC concentrations measured closest to the road at Southern Boulevard. The graphs include the spread of the data (the height of the bar represents the 5th to 95th percentile values) to show the amount of variability in the average concentration of BC from day-to-day measurements (5-hour periods, 5 days) taken at both locations. The bars indicate there is considerable variability across the sampling sessions at each location. These variations could be a function of the traffic patterns, the type of vehicles, and changes in wind speed and direction.

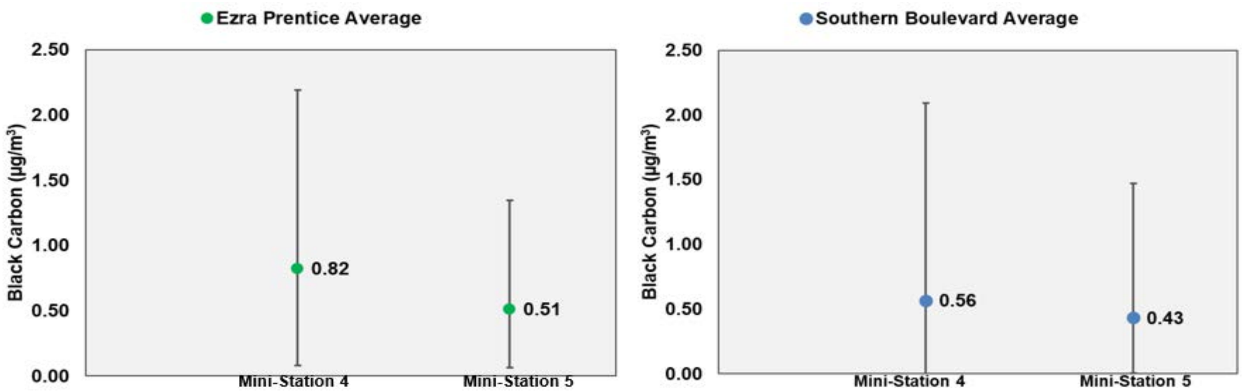

Figure 50. Average Black Carbon Concentrations Measured at Ezra Prentice and Southern Boulevard

Average peak BC concentrations at Ezra Prentice are also much higher closest to the road and remain above the range of average background levels measured at Third Avenue at approximately 80 feet. (Figure 51). However, at Southern Boulevard, BC concentrations are similarly greatest closest to the road but reach background levels before 80 feet from the road.

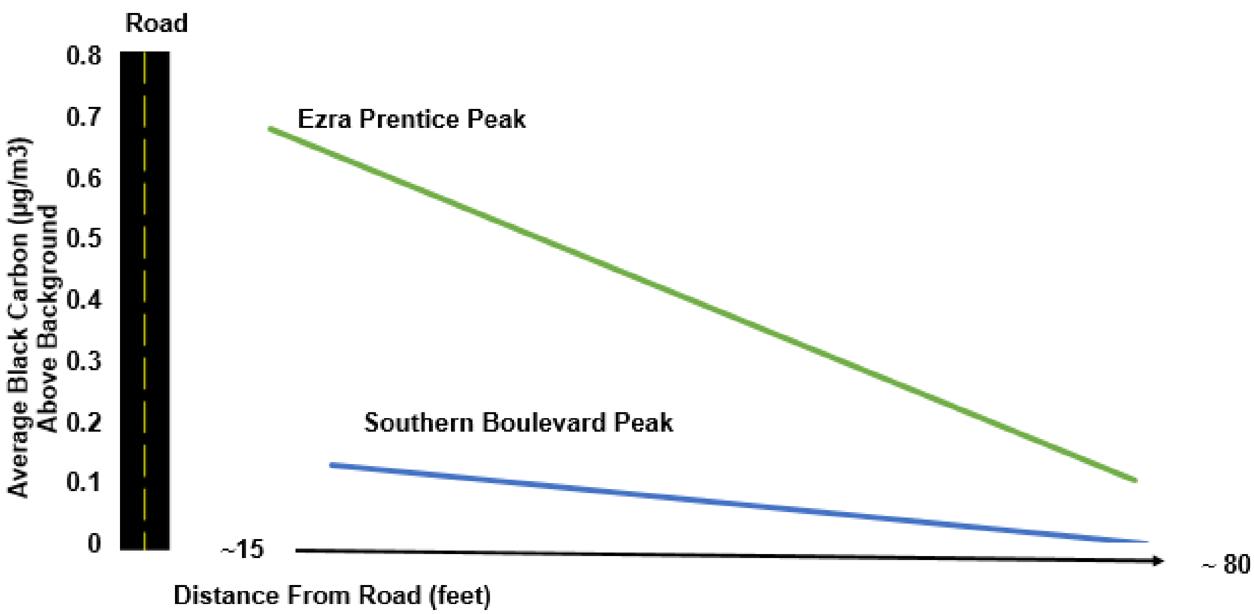

Figure 51. Average Peak Black Carbon Concentrations above Background at Ezra Prentice and Southern Boulevard

Objective 3: Determine how activities at the ports of Albany and Rensselaer and motor vehicles contribute to benzene concentrations in the Study area

This portion of the study was designed to evaluate local contributions of benzene within the Albany South End and surrounding community. Benzene samplers were placed next to every likely source of benzene within the study area at least once. The selection of sampling locations was flexible and allowed for repeated sampling in locations where benzene concentrations were found to be elevated. Over 100 locations were sampled from August 2017–November 2018. Samples were collected in public spaces or along public roadways, but not on private property.

The results of the spatial analysis are presented in Figure 19, which is a map of the study area. The magnitude of the concentration is reflected in the size of the circles. The map illustrates uniform results, reflecting common contributions from gasoline-powered motor vehicles and equipment. There is also a contribution from benzene sources outside the study area, through transport into the study area. Higher concentrations show localized sources of benzene.

Table 13 summarizes the concentrations by location types, which are residential neighborhoods and commercial, industrial, and roadway areas. The average is affected by the number of samples collected, but residential neighborhoods were consistently sampled throughout the entire collection period resulting in a greater number of residential benzene samples than for other location types. The residential benzene average was 0.18 ppb which is similar to what is found in other urban residential areas monitored in the state (Figure 20).

To evaluate contributions from sources in the area, the results from the samples collected in the residential locations were compared with results collected at source locations. For each two-week sample session, the lowest residential result was subtracted from the highest residential result for that session. The difference reflected the local source contribution. Local benzene sources were categorized as releases from activities in the ports of Albany and Rensselaer or from vehicles on roadways, including local roads and highways. Gas stations were not included in the analysis because the sampling yielded concentrations similar to the residential results.

After subtracting the lowest residential benzene result from the highest value in each specific two-week session, the average of these differences was determined to be 0.05 ppb benzene or just under one third of the average benzene concentration in a residential area. 0.05 ppb represents the contribution of local sources at the location where the highest value was found. The highest results were found in various locations over the study period but were most frequently found at the South Albany air toxics site on South Pearl and Schuyler Streets. Other maximum impact locations included First Avenue east of Elmendorf Street, east of the Amtrak terminal, South Pearl Street and McCarty Avenue, and Second Avenue and Regent Street. The residential locations with the lowest benzene concentrations included Third Avenue, the Ezra Prentice Homes, First Avenue, Route 32 at the Rail Trail and in Rensselaer south and east of the Port of Rensselaer.

An attempt was made to identify the sources of local benzene emissions. Since the passive samplers were able to collect a few VOCs in addition to benzene, increases and likely sources of these other compounds could provide clues as to where the local increases in benzene originated. Benzene concentrations were found to be similar throughout the residential sample sites, but the concentrations of toluene and *m,p*-xylene vary more widely, and these concentrations were used to assign likely source categories. In the plot on the left in Figure 52, the concentrations of benzene at the highest and lowest residential sites are similar but the concentration of toluene is more than twice as high at the residential site with higher benzene. That local increment of benzene was accompanied by higher toluene, which is not likely to come from roadway emissions, so that benzene source was assigned to a port influence. In the plot on the right in Figure 52, toluene and *m,p*-xylene were not elevated at the residential site with higher benzene, so the slight increase in local benzene was assigned to a roadway influence.

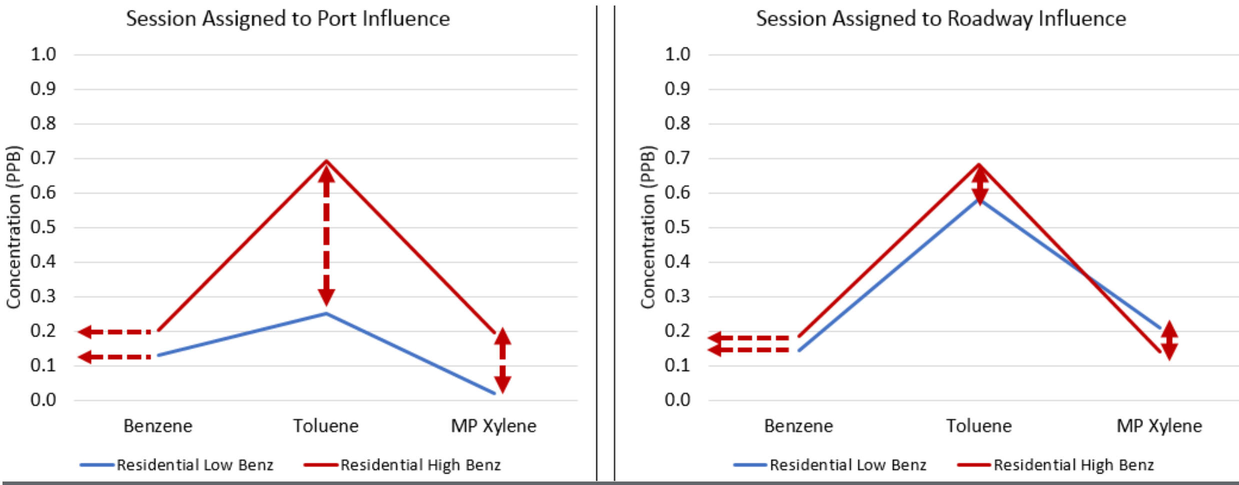

Figure 52. Example of Residential Area Benzene Session Assigned to Port (left) and Roadway (right)

On average, the difference between the benzene concentration at the highest and lowest residential sites was 0.05 ppb. For just over half (17 of 33) of the sampling sessions, the source contribution at the residential site was attributed to both releases from the ports and motor vehicles on heavily traveled nearby roads. For 10 of the sampling sessions, port activities were identified as the primary source contributor with an average contribution of 0.07 ppb. Motor vehicle releases on heavily traveled roads were the primary source contributor in 4 sessions, with an average contribution of 0.03 ppb.

The overall results of the source attribution analysis show that the emissions from the ports of Albany and Rensselaer can account for a portion of, and on some occasions, nearly all of the local source benzene. At other times, the benzene releases from the ports are overwhelmed by motor vehicle releases from roadways.

The results from the South Albany air toxics site and the study monitor at Ezra Prentice were compared to the results from the passive benzene sampling. The results showed that the benzene concentration at the South Albany monitor was 0.04 ppb higher than the results at the Ezra Prentice monitor, which is consistent with what was measured by the passive samplers. The South Albany air toxics monitor is downwind of both ports and I-787. The Ezra Prentice study monitor is upwind of I-787 and is less frequently downwind of releases from both ports.

Markers for Petroleum Products

Some VOCs are recognized as ozone precursors and are monitored during the ozone season because of their contribution to ozone formation but generally not because the VOC is toxic. VOCs include chemicals that can evaporate from gasoline and other petroleum products. Benzene is a regulated component of gasoline[84], and refiners and importers report to the USEPA the amount of benzene in the fuels they produce and import. In the Albany area in 2017 and 2018, the benzene content in regular (87 octane) gasoline was found to be 0.83 and 0.69%, respectively. Gasoline is comprised of many chemicals, but the majority are lighter VOCs such as alkanes and aromatics and many of those compounds are ozone precursors.

NYSDEC monitors ozone precursors in New York City and Long Island where ozone concentrations are sometimes above the level of health-based air quality standards in the warmer seasons. Ozone precursors were measured in the samples collected at the South Albany and Ezra Prentice monitors to evaluate evaporative releases of the components of gasoline.

The compounds that make up gasoline vary due to the nature of the crude oil used to refine the fuel, formulations specific to a manufacturer and regulatory requirements. n-butane, iso-pentane, iso-butane, and n-pentane are some of the components commonly found in gasoline. [85]

As illustrated in Figure 53, the concentrations of these compounds measured at the South Albany and Ezra Prentice monitors show that the area is impacted by evaporative emissions to a higher degree compared to monitor locations in the Bronx and Queens. The monitor in Staten Island is downwind of large petroleum refining and storage facilities in New Jersey, which explains why the alkanes in Figure 53 are higher for that location.

The time series plot in Figure 54 provides additional evidence that the residential and roadway locations had lower and less variable levels of benzene than the ports of Albany and Rensselaer. The benzene concentrations at the residential locations (orange line) were consistent across the study period with a slight increase around the highest level measured in the Port of Rensselaer.

As illustrated in Figure 20, the annual average at the South Albany monitor is higher than the annual average at the Ezra Prentice monitor and slightly higher than averages seen at the New York City monitors. When winds are from the south-southeast, south, and south-southwest, which is frequent, as illustrated in Figure 22, the South Albany monitor would be downwind from the activities at the ports of Albany and Rensselaer more frequently than the Ezra Prentice monitor.

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84 The Mobile Source Air Toxics rule, beginning January 1, 2011, requires refiners to meet an annual average gasoline benzene content standard of 0.62 volume percent (%) for all their gasoline, both reformulated and conventional, nationwide. Because this is an average for each refiner, some locations may be higher or lower than 0.62%, if the overall average achieves that target.

85 Chin, J., et al. *VOC composition of current motor vehicle fuels and vapors, and collinearity analyses for receptor modeling*. Chemosphere 86 (2012) 951-958; Doskey, P., et al. *Source Fingerprints for Volatile Non-Methane Hydrocarbons.* Journal of Air & Waste Management Association 42 (1992) 1437-1445.

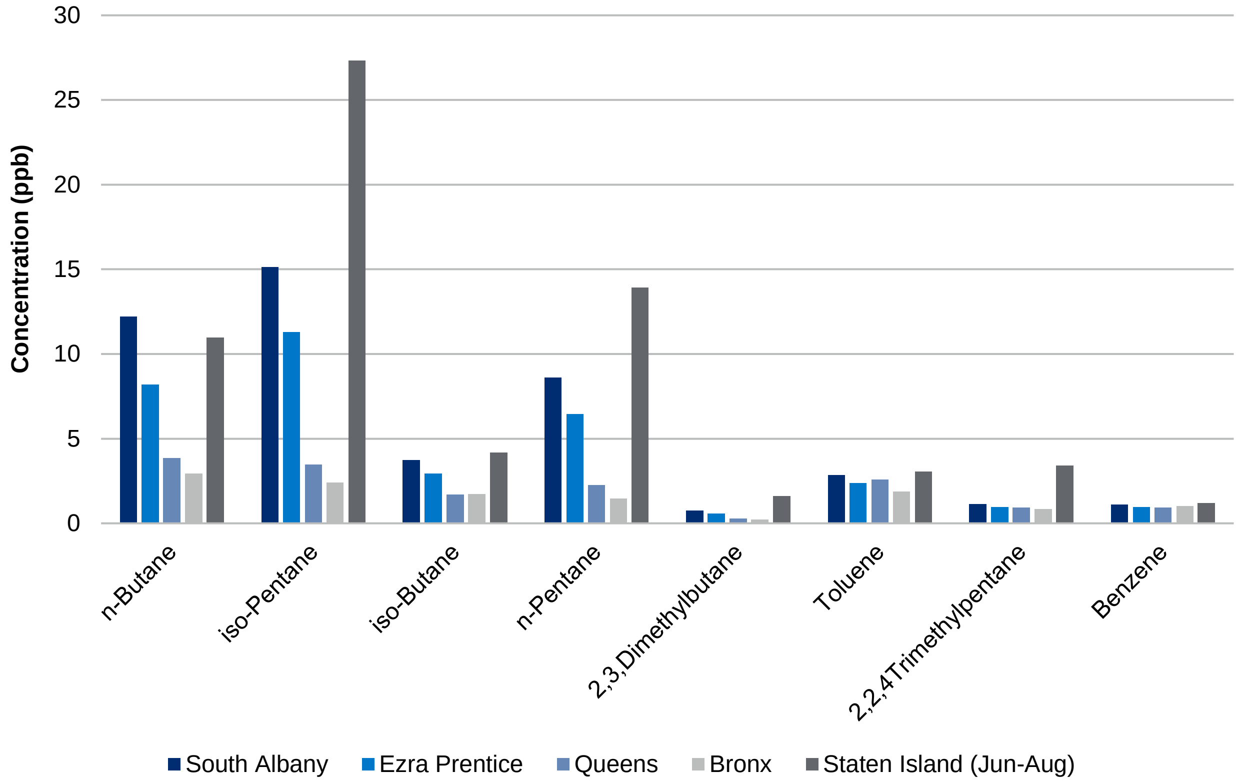

Figure 53. Predominant Compounds in Gasoline Vapor: Average June December 2018

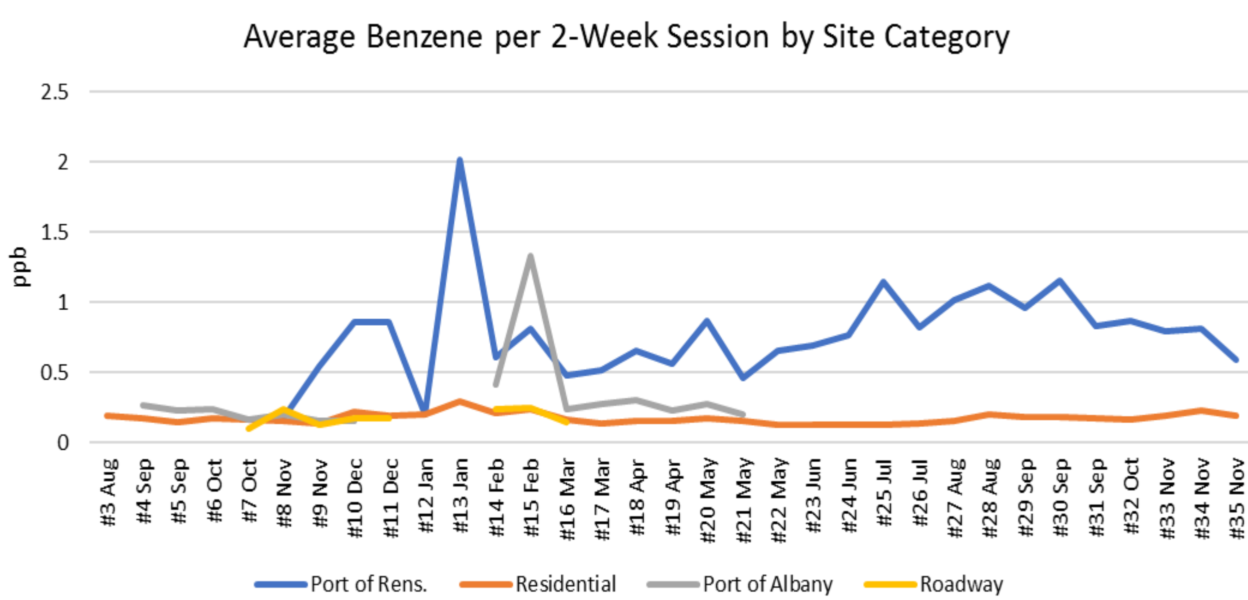

Figure 54. Average Benzene Concentration per Two Week Session by Site Category

Because the ports of Albany and Rensselaer are large distribution points for petroleum products such as gasoline, the storage and transfer of petroleum products and fuel combustion from motor vehicles are contributing sources of benzene to the Albany South End community.

During sampling in December 2017, high results for benzene were obtained from a sample in the Port of Rensselaer. Successive sampling at this location yielded additional high concentrations. NYSDEC staff using a specialized camera called a FLIR looked for potential leaks from a gasoline storage tank. The owner of a facility was made aware of the results from the FLIR evaluation. The owner emptied and later refilled the storage tank and the benzene concentrations dropped in subsequent samples.

Objective 4: Create approaches to help the community understand air quality

Communicating technical information—such as details about a community air quality monitoring study—has always been a challenge for scientists. NYSDEC staff used a variety of approaches to explain the technical aspects of our air quality study. Aside from the standard methods of communicating in plain non-technical English and multiple presentations to the community on the study progress, we also spent considerable time working in the community and working with community volunteers collecting samples. Before, during, and after each community presentation, we displayed posters with technical details illustrated as information graphics and staff were available to answer questions. We also installed a computer monitor that displayed monitoring results in real-time, viewed through a large picture window in the community monitoring station. Overall, one-on-one discussions proved to be the best method of communication because it allowed us to immediately receive feedback and test alternate ways of explaining our research. A summary of all our interactions with the community follows.

Community Meetings

In **2014**, the community initially voiced concern about air quality due to the movement by train and storage of crude oil in the Port of Albany. In March 2014, NYSDEC met with members of the community and staff from the Albany County Health Department to begin discussions about air sampling in the Albany South End Community. Over the next month, staff continued discussions with the community and stakeholders and presented a preliminary air screening plan to the community at the end of April. The screening plan included a component for the community to collect their own air samples.

Air samples were collected in May and early June, and a final report was presented to the community on August 14, 2014. Over the six-month period from conception to completion, staff met multiple times with community stakeholders over breakfast to discuss the progress of the air screening and community concerns. These informal meetings created an opportunity for staff to understand community concerns and to explore ways to explain information better. Additionally, allowing the community to collect their own air samples gave them an opportunity to physically be part of the screening assessment and a mechanism to reach out to staff with specific questions, such as, “What is the best time to collect the air sample?,” “What are you measuring in my air sample?,” and “How will the sample be analyzed?”

In **2016**, the community asked NYSDEC to conduct a more intensive neighborhood monitoring effort to understand how their air quality is impacted by activities (such as movement of petroleum products) in the Port of Albany and heavy truck traffic through residential neighborhoods. Staff met with the community in August 2016 and presented an initial approach to study the community's air quality. During this meeting and afterward, NYSDEC received input from the community on the study design. Another meeting was held on January 2017, which outlined more specifics of the study—goals, pollutants, and monitoring locations. Further input was received from the community. In March 2017, staff met with the community to provide details on the portable monitoring component of the study. The study was launched in July 2017 with a ceremony that included local elected officials and the NYSDEC Commissioner, Basil Seggos. Staff gave tours of the monitoring station. The community has been briefed on the study progress through two community presentations on August 2017 and January 2018.

After the initial presentations and as the concepts became more technical, we developed informational graphics (infographics) and created posters for each separate topic. The posters were on display before, during, and after the community presentations. This gave the community members a chance to meet and ask us questions, in a private and less formal format than the public meeting.

Website

At the outset of the study, a comprehensive website was developed which provided a platform to list all the activities conducted by NYSDEC in the Albany South End Community. In addition to the air quality study, staff conducted heavy-duty diesel truck and facility inspections, and an odor screening assessment.

Several truck inspections and checkpoints took place in the South End community before and during the study period. In 2016, NYSDEC Environmental Conservation Officers carried out about 400 visual inspections at diesel truck air quality checkpoints and on roving patrols on South Pearl Street (Route 32). Officers checked more than 20 heavy-duty diesel truck tailpipes to make sure emissions were in compliance with State and federal environmental laws. Officers conducted several details focused on diesel trucks operating in the community during 2018. Through random checkpoints and roving patrols, officers visually inspected hundreds of trucks each time. When a vehicle showed signs of potential violations, it was directed to a safe location for a more detailed inspection, including testing with a smoke opacity meter and a visual examination of the emissions system, as well as checking for leaking fuel and fluids.

Fugitive releases are air emissions from a facility or operation that are not released through a stack. During the study, NYSDEC staff inspected what are called fugitive releases from facilities in the ports of Albany and Rensselaer. Often, these releases are through vents or along pipe fittings or valves. Fugitive releases can also be unintended releases such as those that take place along leaks in a pipe system. Staff used a specialized FLIR camera to identify gaseous leaks. NYSDEC inspected 11 facilities, some more than once (16 visits total).

In 2015, 2016, and 2017, staff conducted an odor screening assessment in the Port of Albany using hydrogen sulfide as a surrogate for investigating sources of odorous releases. The screening assessment was conducted in the warmer months when hydrogen sulfide levels were expected to be higher. Hydrogen sulfide was rarely detected and when it was, all results were clustered in an area outside an asphalt plant.

Community Visibility

A key component of the Albany South End study has been the use of two types of portable air monitoring equipment. One was a backpack that held different types of instruments measuring particle concentrations. Staff and volunteers wore these backpacks and walked through the community measuring in real-time various particle concentrations.

A second type of portable instrument used was a "mini-station." These were large tripods which held meteorological and particle measuring instruments. Staff used up to six instruments at a time to study how rapidly pollutant concentrations decrease away from heavily traveled roads. These periods when the portable instruments were deployed provided opportunities for staff to answer questions from the community and describe what the instruments measure, where concentrations of pollutants are likely to be higher, and how traffic influences pollutant concentrations. Staff spent over 260 hours in the community with both types of portable equipment, and staff and volunteers logged in 780 miles of walking in the community.

During the summers of 2017 and 2018, staff worked with middle and high school students in the Science and Technology Entry Program (STEP). Students learned about the study in general and specific details on the instrumentation by participating in some of the portable air monitoring sessions. The students presented the results of their work in statewide science competitions in 2017, 2018, and 2019.

A second opportunity for staff to answer questions from the community during field work happened when staff installed the benzene passive samplers (see Figure 55). Over the study period, the benzene samplers were placed in over 100 locations in the Albany South End and community surrounding the Port of Rensselaer. The samplers were deployed for two-week intervals and 35 sessions. The presence of staff in the community, changing out the sampling units or installing new locations, afforded people a chance to ask about this segment of study.

Figure 55. Installation of benzene passive samplers

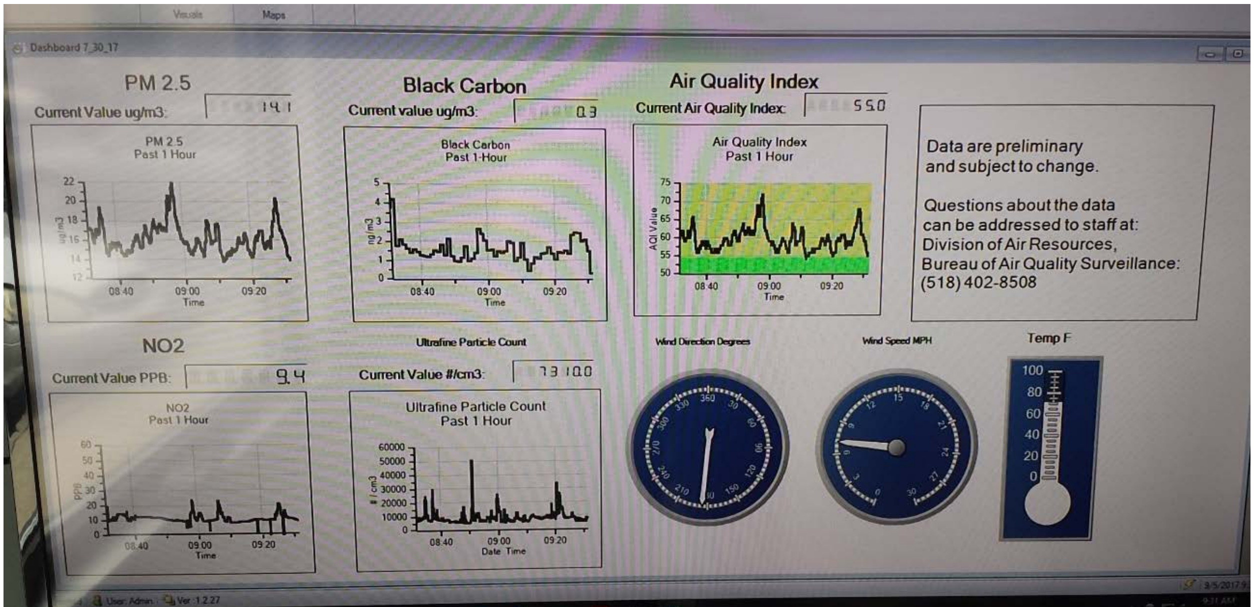

Figure 56. Monitor Display of Pollutant Results at the Ezra Prentice Station

Finally, the monitoring station at Ezra Prentice was designed with a window on one side. A large computer monitor was placed against the window to display results in real-time for pollutants measured by direct-read instruments (e.g., fine ($PM_{2.5}$) and ultrafine particulate matter, nitrogen dioxide, and black carbon) (see Figure 56). Current meteorological information was illustrated with information graphics. The Air Quality Index graph on the monitor was explained by two charts alongside the window. During the study, staff gave multiple tours of the monitoring station. Visitors included medical students from the Albany Medical School, Radix Center's EcoJustice Summer Youth Employment Program in 2017 and 2018, two groups of land use planners, and elected officials. Staff presented study information at the National Night Out event in the Albany South End in August 2017.

General Recommendations

- Evaluate ways to adopt and transfer knowledge gained from this study to other near road communities throughout New York State.
- Support pilot programs to develop data-driven policies that not only reduce traffic-related air pollutants, but also incorporate the Climate Leadership and Community Protection Act goals of reducing co-pollutant and greenhouse gas (GHG) emissions in disadvantaged communities.
  - Coordinate community housing, energy and transportation planning to maximize environmental and public health benefits from mitigation strategies to reduce traffic-related air pollutants while increasing energy efficiency, utilizing renewable energy, and reducing GHG emissions.
  - Evaluate the benefits of green infrastructure to reduce traffic-related air pollutants and provide other co-benefits including reducing urban heat island effects, storm runoff, and energy usage for heating and cooling. Living near trees and green space also reduces stress and enhances quality of life.
- Prioritize Environmental Justice communities for implementing mitigation strategies for traffic-related pollutants.
  - Facilitate community members participating in workgroup efforts to develop mitigation strategies.
  - Utilize culturally appropriate approaches to increase environmental literacy. This will empower communities to address the sources of environmental pollution, as well as support efforts to promote wellness and allow individuals to make informed lifestyle choices and reduce health risks. Improving the environmental literacy of communities will help increase their understanding of scientific results and potential involvement in community-engaged research.
  - Enhance community relationships by engaging students in STEM education projects to foster interests in science-based research and innovative technology.
- Integrate health impact assessment (HIA) into the environmental impact assessment (EIA) practice under the State Environmental Quality Review Act to improve public health through the coordination of land use, zoning, housing, and transportation planning especially for vulnerable and disadvantaged communities.
- Support development of a guidance document for municipal planning departments to highlight setbacks and other recommendations for siting new schools, residences, day care centers, playgrounds, and other sensitive land uses (i.e., locations with children, pregnant women, the elderly, and those with existing health problems)
- Evaluate mandatory, statewide, medium and heavy-duty diesel onboard diagnostic-based I/M inspections to reduce traffic-related pollutants

Limitations/Uncertainties

- Limitations with Traffic Data – The analysis with pollutants and diesel (or truck) traffic may be underestimated as the traffic data sensor installed after February 20, 2018, incorrectly assigned class 5 vehicles to class 3. This type of error reduced the count of the source variable, diesel vehicles (combined count of classes 4–13). Because an association between diesel vehicle volume and pollutant concentration was found in this study, it demonstrated that the relationship was strong enough to overcome the misclassification.

- NYSDEC vehicle identification is based upon groups (vehicle classes) of vehicles during peak concentration minutes and not individual vehicles attributed to each peak. Traffic at Ezra Prentice is approximately 11 vehicles per minute during peak UFP concentration traffic times and 9 vehicles per minute during low number low UFP concentration traffic times. Thus, each vehicle is only within range of the camera for approximately 6 seconds. This is too small an amount of time to definitively identify an individual vehicle as an HEV, taking into account the many changing variables such as vehicle speed, wind speed, wind direction, exhaust flow leaving the tailpipe, etc.

- Limitations of Exposures – Exposure is a key step in determining potential health risk. For this study we assumed that people were exposed to the concentrations measured at either the fixed monitoring locations or the portable monitors. But this assumption isn't completely accurate because people move around from one location to another, such as outdoors to indoors, and commute to work or school, etc. These changes in location can increase or decrease someone's exposure to the pollutants measured in our study. Also, people may have higher exposure to pollutants at work or through personal activities such as smoking, or hobbies that use solvents or tools that create dust. Although there is some uncertainty in characterizing people's exposure, many studies take the approach we did and find it a useful approach to characterize air quality in a community, as a whole.

  We didn't measure exposure variation vertically; the mini stations collected data at 1.7-meter elevation (approximate average adult breathing height) horizontally across South Pearl Street at the Ezra Prentice Homes. Researchers measured higher concentrations closer to the ground (0.55 meter) next to the road. Infants pushed in strollers or adults seated in wheelchairs next to the road may be exposed to higher concentrations.[86] We don't know the vertical profile and whether the concentrations increase or decrease at locations higher than the location of the mini-station or the fixed monitor. Obtaining this information would help inform whether concentrations increase,

[86] Garcia-Algar, O. et al. *Different exposure of infants and adults to ultrafine particles in the urban area of Barcelona*. Environmental Monitoring and Assessment January 2015, 187:4196.

decrease or remain the same at the second-floor windows of the apartment buildings. A study of the vertical distribution of particulate air pollution in a near-highway urban neighborhood found the number of particles/cm^3 decreased by 7.7% compared to 3.6% for particulate matter ($PM_{2.5}$) as the measurement elevation increased from 0 to 35 meters.[87] One study attributed a maximum vertical particle concentration at ~3.4 meter under downwind conditions and wind speeds greater than 1 meter/second to the height of the tailpipe (~2.7 meter above the road) in heavy duty vehicles and the generation of a thermal plume rise.[88] Vertical measurements may help explain why specific vehicle types (class 4 bus and class 5 paratransit) which have tailpipe emissions closer to the ground were among the frequent vehicles identified as HEVs. In comparison, large trucks (classes 6-13), generally have exhaust pipes that extend above truck cab, and were not seen as frequently as an HEV. More research is needed to better understand the differences between classes 4 and 5 compared to classes 6–13.

Although not a goal of this study, other studies have found higher concentrations of TRAP in the cabin of vehicles under certain operating conditions (specific window/ventilation parameters).[89]

- Limitations of Risk Estimates – Conservative (meaning health protective) long-term health-based guideline concentrations (AGCs) have been used in this study. The estimates assume people in the community are continuously exposed to the concentration measured at a fixed study monitor for 70 years (365 days per year, 24 hours per day) and that the monitor concentration remains constant for 70 years. We know that's not the case, as people move about during the day to travel to work or school. In addition, all air toxics with a cancer risk associated with them are based upon the "upper-bound" excess lifetime cancer risk resulting from continuous exposure to an air contaminant. The use of an "upper-bound" means that the true risk of developing cancer from exposure is not likely to be higher and may be lower than the estimates provided in this study.

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[87] Wu et al. *Mapping the vertical distribution of population and particulate air pollution in a near-highway urban neighborhood: Implications for exposure assessment*. Journal of Exposure Science and Environmental Epidemiology (2014) 24, 297-304.

[88] He, M. and Dhaniyala, S, *Vertical and horizontal concentration distributions of ultrafine particles near a highway*. Atmospheric Environment 46 (2012) 225-236.

[89] Leavey, Anna, et.al., *Comparing on-road real-time simultaneous in-cabin and outdoor particulate as gaseous concentrations for a range of ventilation scenarios.* Atmospheric Environment 166 (130-141), 2017.

Appendices

Appendix A: Lung Deposited Surface Area (LDSA)

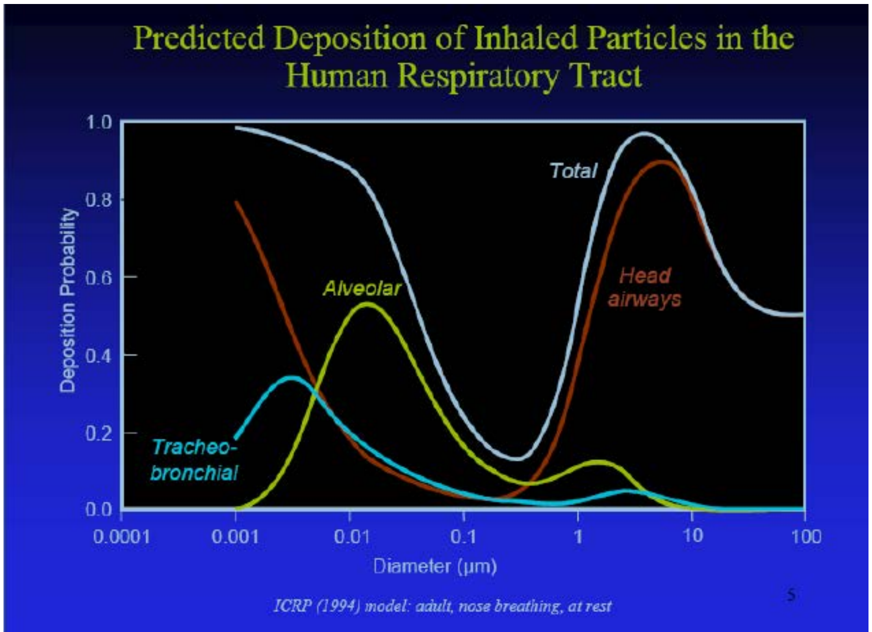

Figure 1. International Commission on Radiological Protection (ICRP) Lung Deposition Model

This Appendix provides a summary of LDSA measurements collected alongside ultrafine particle (UFP) and black carbon (BC) measurements on South Pearl Street at the Ezra Prentice Homes and a comparison area in Albany South End on Southern Boulevard.

Ultrafine particles (UFPs) comprise the smallest size (< 0.1 µm or 100 nm) fraction of particulate matter (PM). Among the particles measured, UFPs are the greatest in terms of particle number and surface area. Particle size and surface area are important metrics to consider when evaluating health risks from exposure to ambient PM. Both characteristics affect lung deposition site and potential toxicity.[1]

Instruments (such as the Naneos Partector) are available to measure UFPs and estimate LDSA ($\mu m^2/cm^3$) in the deepest region of the lung (alveolar) in real time. LDSA can be estimated by the Partector with at least ±30% accuracy for particle sizes between 20 to 400 nm. To estimate LDSA, the instrument assumes all particles are spherical and incorporates the probability of deposition in the alveoli as a function of aerodynamic particle diameter. The surface area measured by the instrument is multiplied by the deposition fraction to calculate the LDSA.

The lung deposition model was derived by the International Commission on Radiological Protection (ICRP) to estimate fractional deposition in each region of the respiratory tract for an adult male, nose breathing, at various exertion conditions (the deposition curve at resting conditions is illustrated in Figure 1). According to the ICRP model, 200–300 nm particles have minimal deposition (10%) in the alveolar region compared to 50% particle deposition with 40 nm particles.

LDSA is another metric for measuring UFP concentration and is being evaluated as a potential, health-relevant exposure metric for health effects related to alveolar deposition, since it measures the surface area of particles in the respirable size range. Researchers have reported a range of LDSA measurements collected in different study locations including urban areas impacted by traffic, residential areas with wood

[1] Oberdörster G. *Significance of particle parameters in the evaluation of exposure-dose-response relationships of inhaled particles*. Inhalation Toxicology, 1996; 8 Suppl: 73-89.

combustion, and in school and home microenvironments. Vehicle traffic has been identified as a main ambient source, causing increases in LDSA with average concentrations varying from 12 (park area) to 94 µm²/cm³ (inner city area next to major road). The highest ambient exposures were observed for walking or biking along high-traffic impacted routes, while using public buses, and in traffic jams.[2]

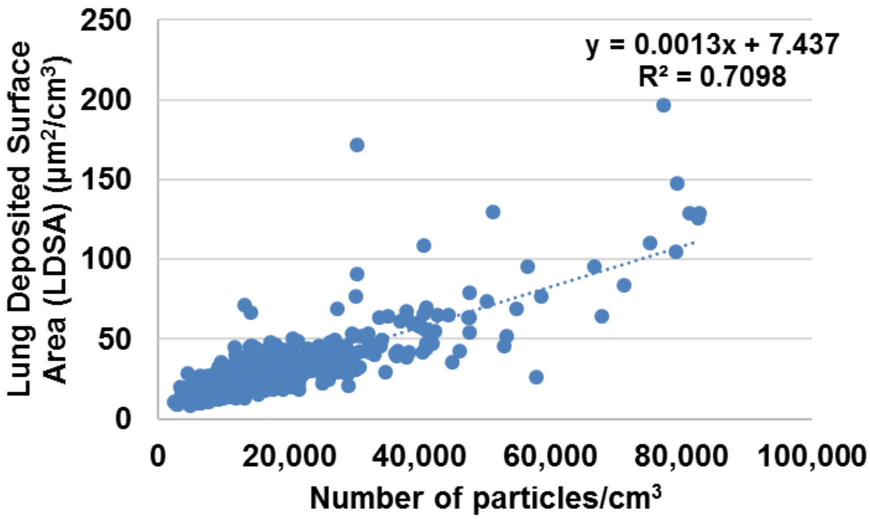

Figure 2. Lung Deposited Surface Area (LDSA) (µm²/cm³) as a Function of Ultrafine Particle (UFP) Concentration (number of particles/cm³)

The UFP particle number concentration and LDSA are strongly and positively correlated in these studies (Figure 2). Our data also shows number of particles/cm³ and LDSA are strongly and positively correlated (R^2=0.71). Investigations of the relationship between number of particles/cm³ and LDSA indicate that they are correlated but also exhibit differences, possibly based on the source of emissions and particle size.[3]

As explained in Appendix H (Statistically Peak Minutes are Separate), LDSA was used to identify peak and low concentration minutes. The four Partectors which measure LDSA were deployed at each mini-station at Ezra Prentice and Southern Boulevard sampling periods. Figure 3 and Figure 4 indicate average LDSA measurements were higher at Ezra Prentice compared to Southern Boulevard. At both locations, LDSA was highest closest to the road and decreased with increasing distance from the road. The average LDSA gradient is less steep than number concentration gradient (shown in the report Figures 42 and 46). Standard deviation error bars are included to show the amount of variability in the average LDSA from day-to-day measurements (5-hour periods, 5 days).

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[2] Kuuluvainen, H. et al. 2016. *Lung deposited surface area size distributions of particulate matter in different urban areas*. Atmospheric Environment 136, 105-113. Geiss, O. et al. 2016. *Lung-deposited surface area concentration measurements in selected occupational and non-occupation environments*. Journal of Aerosol Science, 96: 24-37; Eeftens, M. et al. 2015. *Spatial and temporal variability of ultrafine particles, NO2, PM2.5, PM2.5 absorbance, PM10 and PMcoarse in Swiss study areas*. Atmospheric Environment. 111: 60-70. Reche, C., et al. 2015. *Determinants of aerosol lung-deposited surface area variation in an urban environment*. Science of the Total Environment, 517: 38-47. Spinazze, A. et al. 2015. *Multi-metric measurement of personal exposure to ultrafine particles in selected urban microenvironments*. Atmospheric Environment. 110: 8-17; Buonanno, G. et al. 2013 *Health effects of daily airborne particle doses in children: direct association between personal dose and respiratory health effects*. Environmental Pollution, 180: 246-250. Kristensson, A. et al. 2013. *Size-resolved respiratory tract deposition of sub-micrometer aerosol particles in a residential area with wintertime wood combustion*. Aerosol and Air Quality Research, 13: 24-35).

[3] Marilyn Wurth, Brian P. Frank, Gil H. LaDuke, Oliver V. Rattigan, H. Dirk Felton, Jake Lindberg, Nicole Vitillo, Patricia Fritz, and Thomas Wainman, Poster: *Simultaneous Measurements of Lung Deposited Surface Area, Particle Number Concentration, Particle Size, and Black Carbon to Characterize Near Roadway and Biomass Emission Sources*, 10th International Aerosol Conference, St. Louis, MO, September 2-7, 2018.

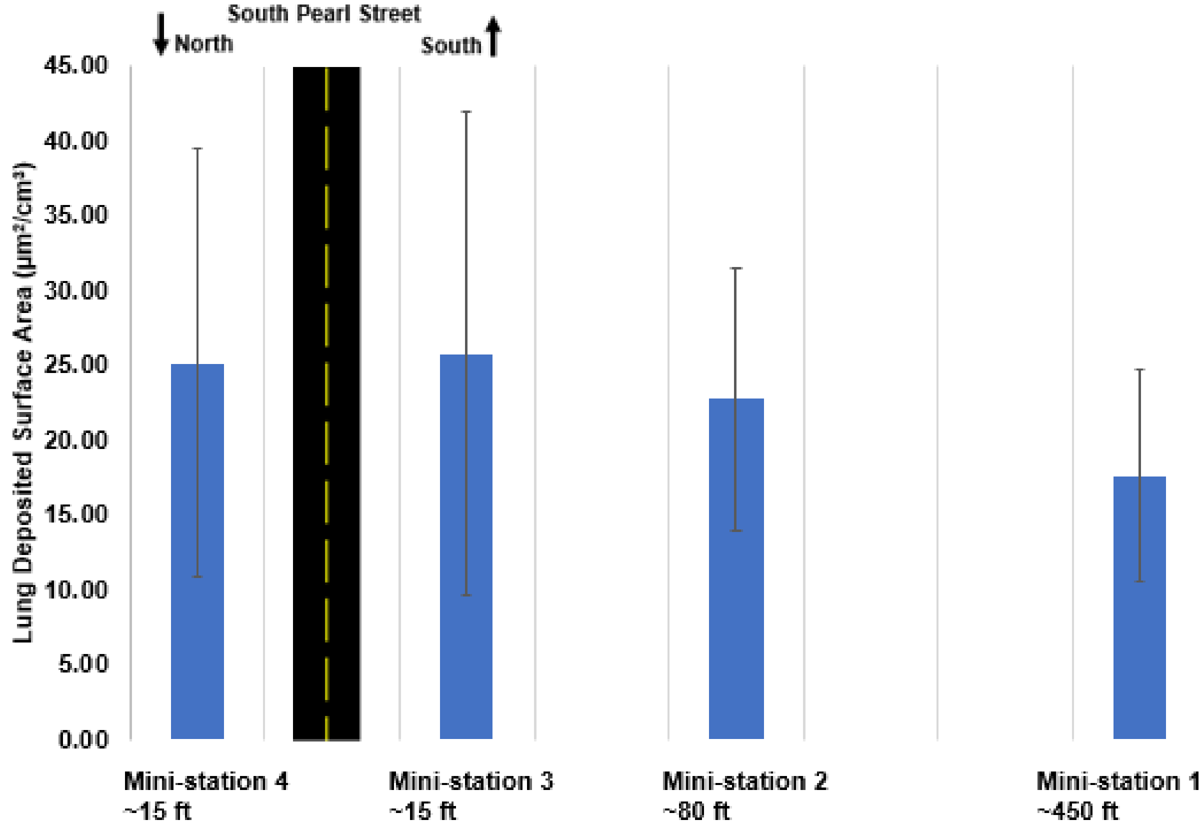


Figure 3. LDSA Gradient at Ezra Prentice

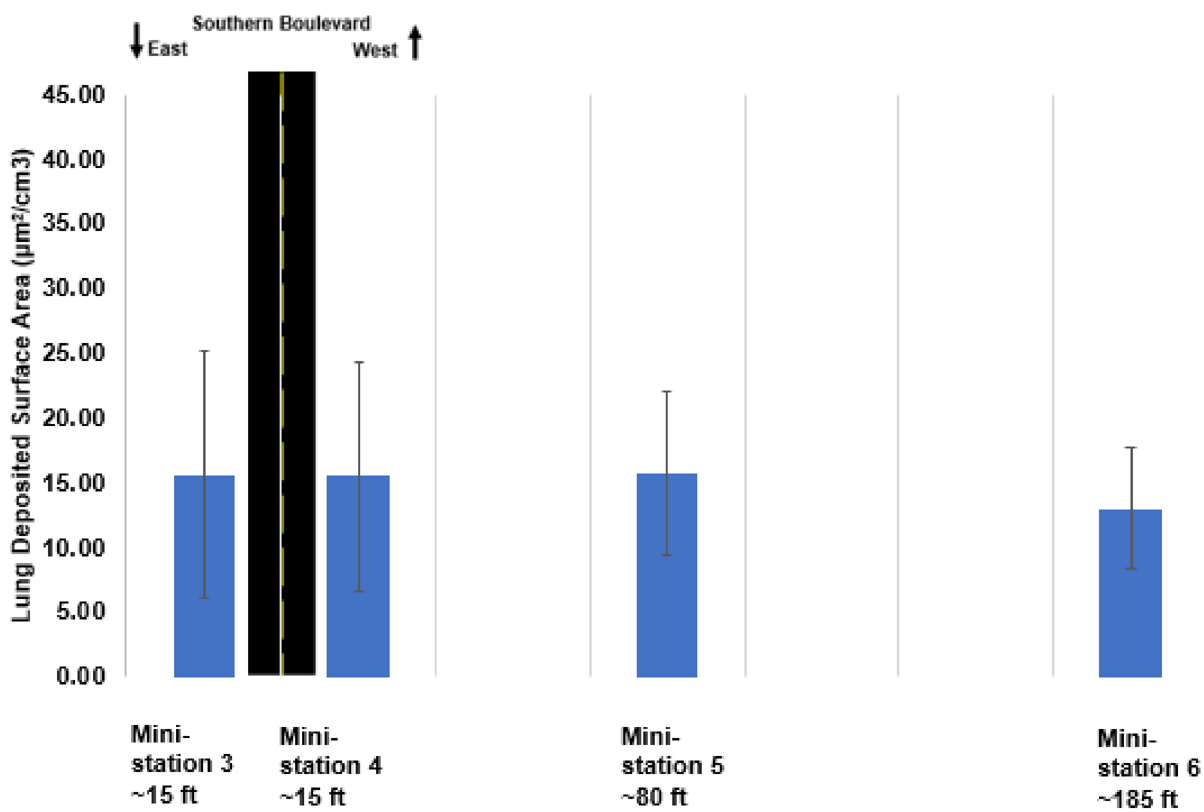


Figure 4. LDSA Gradient at Southern Boulevard

Figure 5 and Figure 6 demonstrate the peak, average, and low LDSA measurements at Ezra Prentice and Southern Boulevard. Peak LDSA measurements are approximately 1.5 times greater at Ezra Prentice closest to the road compared to Southern Boulevard. High-emitting vehicles are the greatest contributors to LDSA measurements closest to the road.

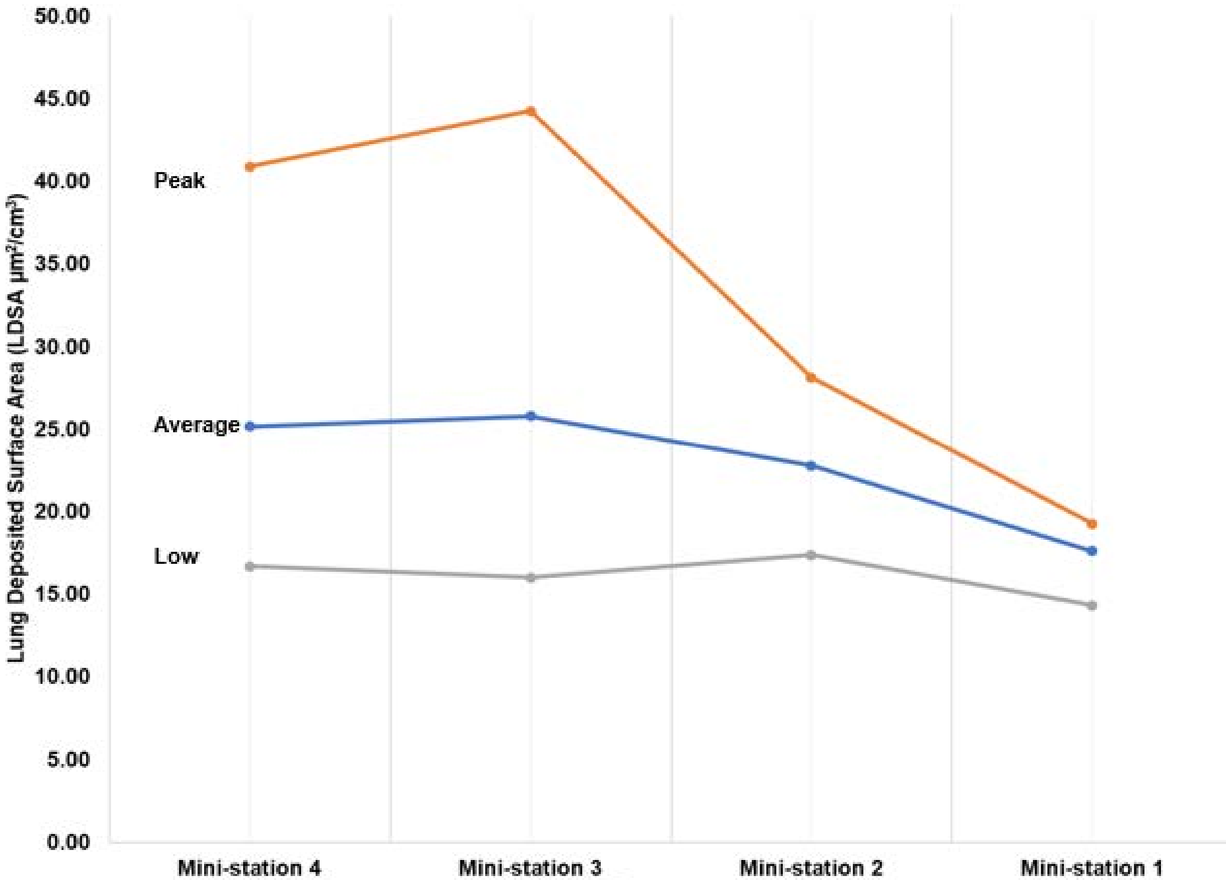


Figure 5. Peak, Average, and Low LDSA Measurements at Ezra Prentice

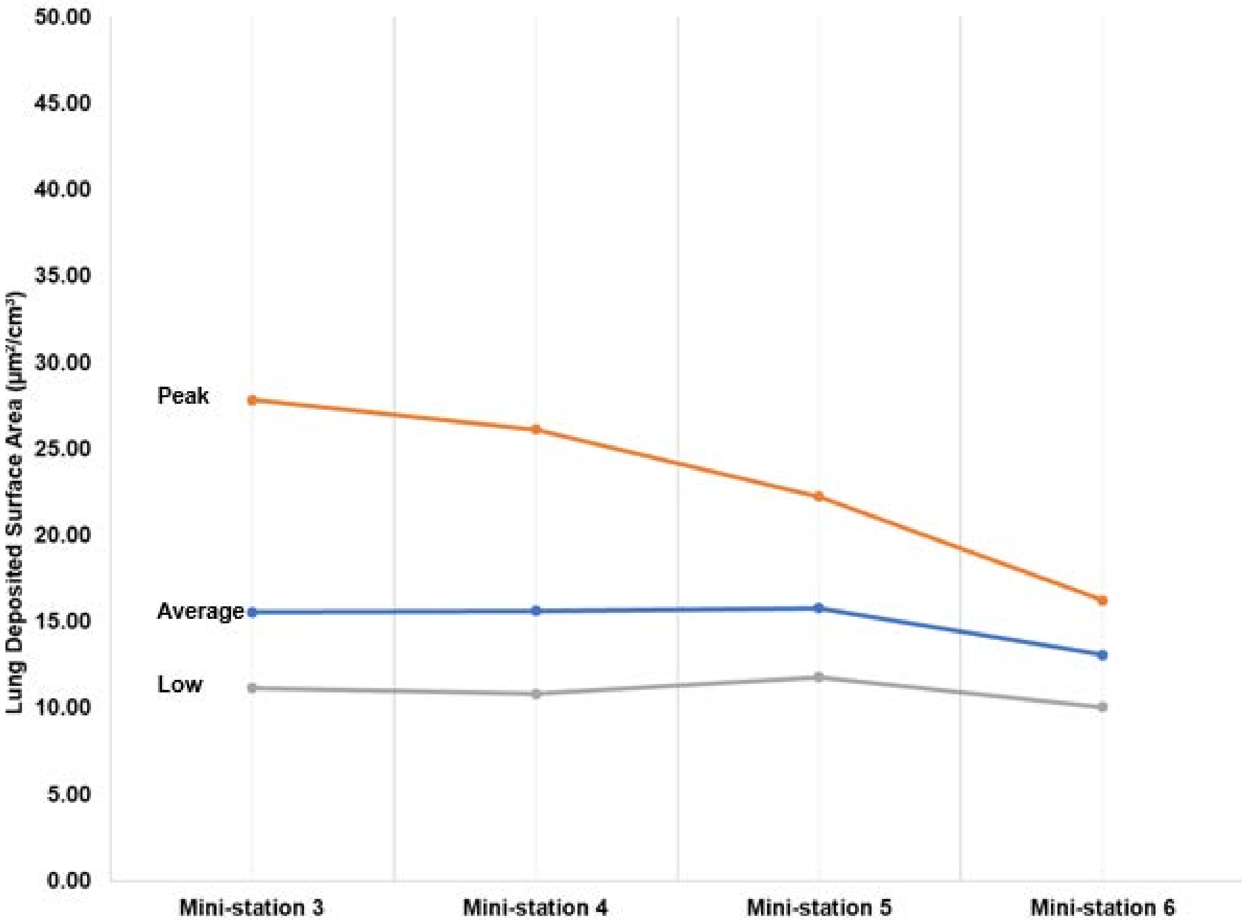


Figure 6. Peak, Average, and Low LDSA Measurements at Southern Boulevard

Appendix B: Supplemental Information for Passive Benzene Sampling

USEPA Method 325A/B is a collection and analysis method that utilizes passive or diffusive sampling, defined as the “unassisted molecular diffusion of gaseous analytes through a diffusive region and onto an adsorbent.” The method was developed to passively monitor fugitive VOCs over 14-day intervals around the perimeter or fence line of oil refineries using stainless-steel thermal desorption (TD) tubes packed with carbon-based adsorbents. The EPA designed this method to address fugitive emissions, so they subtract the lowest benzene concentration per session from the highest per session in order to determine the concentration of benzene leaving a facility over each 14-day interval. Facilities were then required to report this data to the EPA quarterly. Corrective action would be triggered if the annual average of benzene leaving a specific facility exceeded 2.8 ppb.

NYSDEC modified Method 325A/B for this study. Rather than monitoring one specific facility, we sampled for VOCs in the community-scale study area. Additionally, we did not subtract background concentrations. Concentrations from the sampling locations were compared relative to one another spatially. We used this method to gain a better understanding of the benzene concentrations and sources in the study area.

USEPA Method 325A/B specifies that TD tubes are to be inert-coated stainless steel with dimensions of 3.5 inches long x 0.25 inches outside diameter x 0.5 mm inner diameter, and packed with either Carbograph™ 1 TD, Carbopack™ B, or Carbopack™ X or equivalent. Tubes must be equipped with diffusive sampling caps fitted with stainless steel gauze. The tubes were to be deployed under non-VOC emitting, weatherproof hoods which will not impede the ingress of ambient air. Adhering to these parameters, NYSDEC deployed Entech Diffusive Sorbent Pens™ (DSPs) pre-packed by the manufacturer with Carbopack™ X absorbent and sheltered in *Entech* Sorbent Pen *Hoods*.

Entech Diffusive Sorbent Pens™

DSPs (or Pens) are made of Silonite™-coated 316 stainless steel, with a Silonite™ treated retaining frit and mesh screen for the absorbent. Stainless steel diffusers are attached to the end of the Pens during sampling to prevent fluctuations in wind from affecting sampling rates.

The absorbent material used in the DSPs was Carbopack™ X, which is a graphitized carbon black surface with good absorption and desorption properties including a Brunauer-Emmett-Teller surface area of 240 m^2/g and a mean pore volume of 100 angstroms (Å). It is granular, friable and hydrophobic and can withstand high bake-out temperatures (<400°C) without losing mechanical or chemical integrity. Volatile compounds in ambient air pass through a diffusive barrier in the DSP and bind to the absorbent’s active sites via surface interactions which depend solely on London dispersion force.

These samplers require no electrical power and were easy to install at locations attached to lamp poles and fences in the public right-of-way, often between private properties where regular monitoring equipment could not be deployed. The Pens were deployed under stainless steel *Entech* Sorbent Pen *Hoods* to moderate the effects of solar heating and rain on sampling rates. The hoods have three clips in them designed to hold the pens vertically. The hoods were mounted to telephone poles, street lamps, fenceposts, or a tripod with a bungee cord or zip tie, approximately two and half meters off the ground. A NYSDEC "Do Not Disturb" sign was attached to each hood with general information about the apparatus and a telephone number for public inquiries. No samplers were damaged or lost during the study and no data was invalidated due to concerns about sample integrity.

Field logs were kept to document session number, Pen ID numbers, site locations including GPS coordinates and a physical description of the site, date and time of deployment and removal, operator initials, and notes such as activities or odors observed in the vicinity during time spent at sites. Samples were deployed and taken down at approximately the same hour of the day to keep the process as consistent as possible from one session to the next.

Pens were thermally desorbed with an Entech 5800 Sorbent Pen Desorption Unit in conjunction with an 7890B Gas Chromatograph (GC) and 5977B Mass Spectrometer Detector. The Entech 5800 Thermal Desorber met the requirements specified in Method 325A section 6.6 and 325B section 11. A Pen is placed in the Desorber, the user presses the "start" button, and a leak-check is performed by a pressure sensor. To obtain rapid injection onto the GC column, the adsorbent was heated for 60 seconds to 300°C.

Calibration curves were prepared by spiking known aliquots of a 270 ppb benzene, toluene, ethylbenzene, and xylenes standard in nitrogen, which was supplied and certified by a specialty gas supplier onto DSPs via the Entech 4200 Sorbent Pen Spiking System. Standards were prepared at concentrations ranging from 0.02 to 4.0 ppbv. For each target compound, a multipoint concentration curve was created. A new calibration curve was prepared with every two-week session analyzed, therefore internal standards were not used to monitor calibration and mass spectrometer tuning. This approach differed from the requirements in Method 325B.

Conditioned Pens were periodically desorbed and analyzed to ensure that no VOCs were present on the adsorbent before being deployed to the field. System blank checks were performed at the beginning of each run by running an un-packed Pen through the desorption process. Blanks were also run between standards and samples to ensure the columns had been completely back flushed.

NYSDEC did not formally determine a method detection limit for Method 325A/B. All of the ambient data were well above the lowest calibration point. Instead, the project instituted a reporting limit (RL) 0.04 ppb, which provides a lower value at which data will not be reported because accuracy cannot be assessed if values are below calibration values. None of the field samples were below the RL.

To demonstrate precision, all samples were deployed in duplicate. Two Pens were installed in a hood at every site in the study, and both were opened and capped at the same time. For each target compound concentration, the relative percent difference between the duplicate samples had to be within 30% to be considered valid. The Method 325A/B precision was determined by calculating the percent difference of the results from the primary and the duplicate sampling tube for each sample. All of the data were used in the calculation and no low values were screened. The median percent difference over the study was 1% and the 5th and 95th percentiles were -24% and 17% respectively.

The passive method was developed and evaluated to measure benzene around refineries and other large sources of benzene, so the USEPA did not characterize the method for low concentrations. The accuracy of Method 325A/B was externally assessed by comparing the data from the passive pens with the data from the canisters that are analyzed via USEPA Method TO-15. The pens and the TO-15 canisters were collocated at the South Albany sampling site for 28 sampling sessions as shown in Figure 1. At the South Albany air toxics site, a SUMMA canister fitted with a two-week passive orifice (pre-calibrated with ENTECH Flow Professor) was co-located to collect an ambient air sample during the same sampling sessions. The median percent difference for benzene over the study was -15.8% and the 5th and 95th percentiles were -32% and 25%, respectively. The average concentration of benzene as determined by Method 325A/B was 0.201 ppb and by Method TO-15 was 0.204 ppb.

Passive samplers were deployed in every two-week session over the entire study at the South Albany monitoring site to allow for precision comparisons between the two types of benzene sample collections and analysis methods. Additionally, consistent collection at one location allowed for calculation of seasonal and annual averages for the type collection methods.

For the study, NYSDEC installed a SUMMA canister sampler for TO-15 analysis of air toxics at the Ezra Prentice fixed monitor. Since the passive samplers were also deployed at Ezra Prentice, the canister data were used to evaluate the ability of passive sampling to accurately characterize the difference in benzene concentrations between locations. This is important because while the canister results were used for comparison to health-based guidelines, the passive results were used to show where the concentrations of benzene are higher or lower throughout the study area.

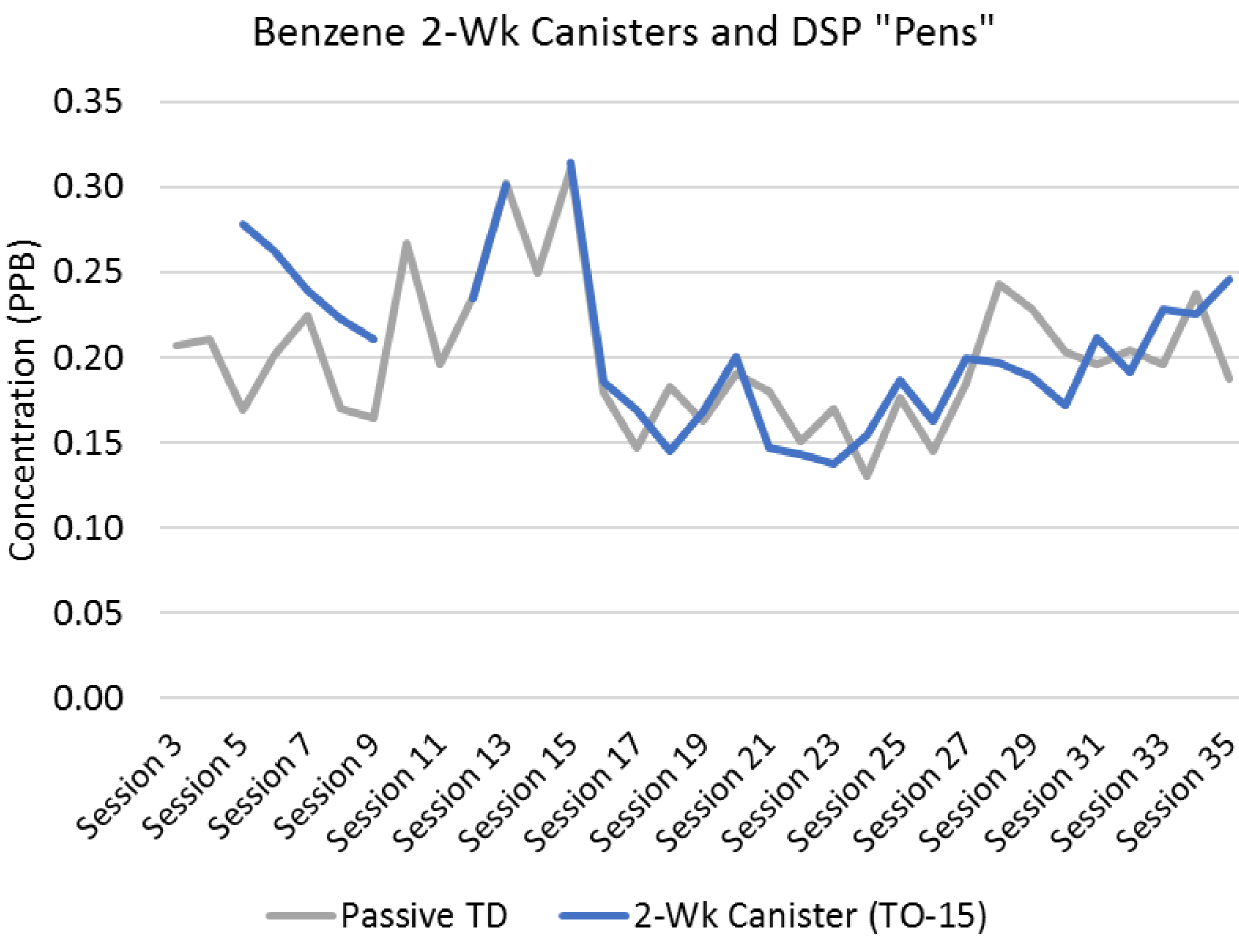


Figure 1. Comparison with SUMMA Canister and Passive Tubes

Appendix C: Portable Mini-station and Ezra Prentice Fixed Monitor, Hourly Averages for Ultrafine Particles and Black Carbon

Figures 1 and 2 compare portable mini-station hourly measurements for ultrafine particle (UFP) concentrations (number of particles/cubic centimeter (cm^3)) and black carbon (BC) (micrograms per cubic meter ($\mu g/m^3$)) to the Ezra Prentice fixed station. Mini-station 4 is closest to South Pearl Street and measured higher UFP concentrations (8 to 10 a.m.) than the fixed monitor and mini-station 2, which were at greater distances from South Pearl Street. Mini-station 4 also captured black carbon peaks at 8 a.m. and 12 p.m. Overall, the portable mini-stations tracked the fixed monitor on an hourly basis.

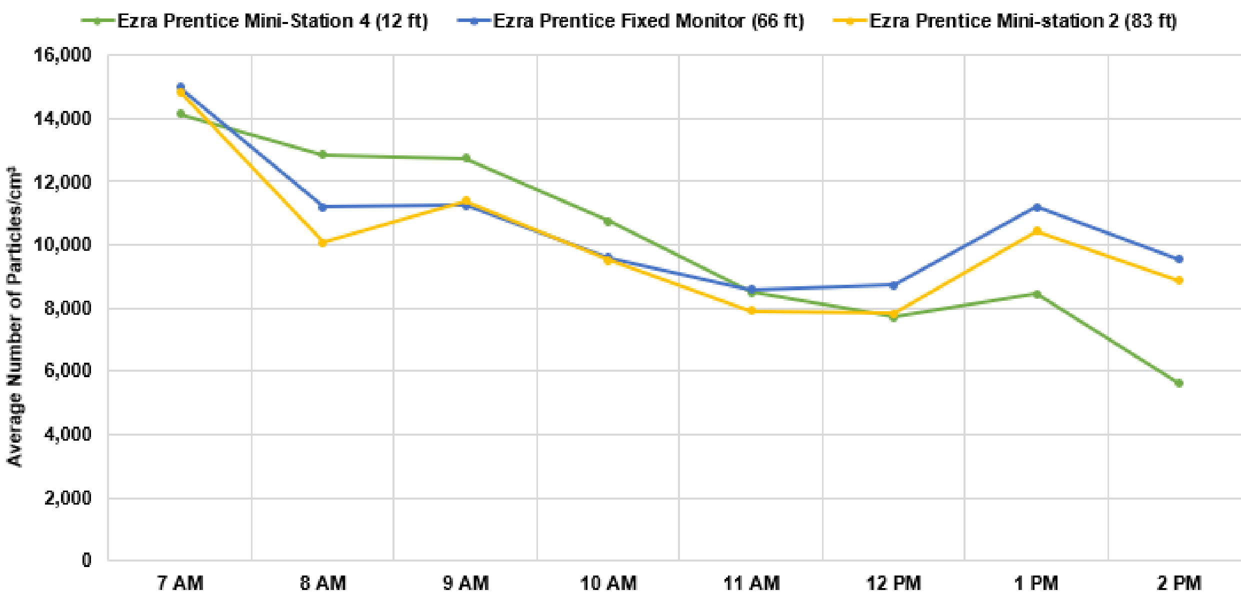


Figure 2. Hourly Average Ultrafine Particle Concentrations (numbers of particles/cm^3) at Ezra Prentice

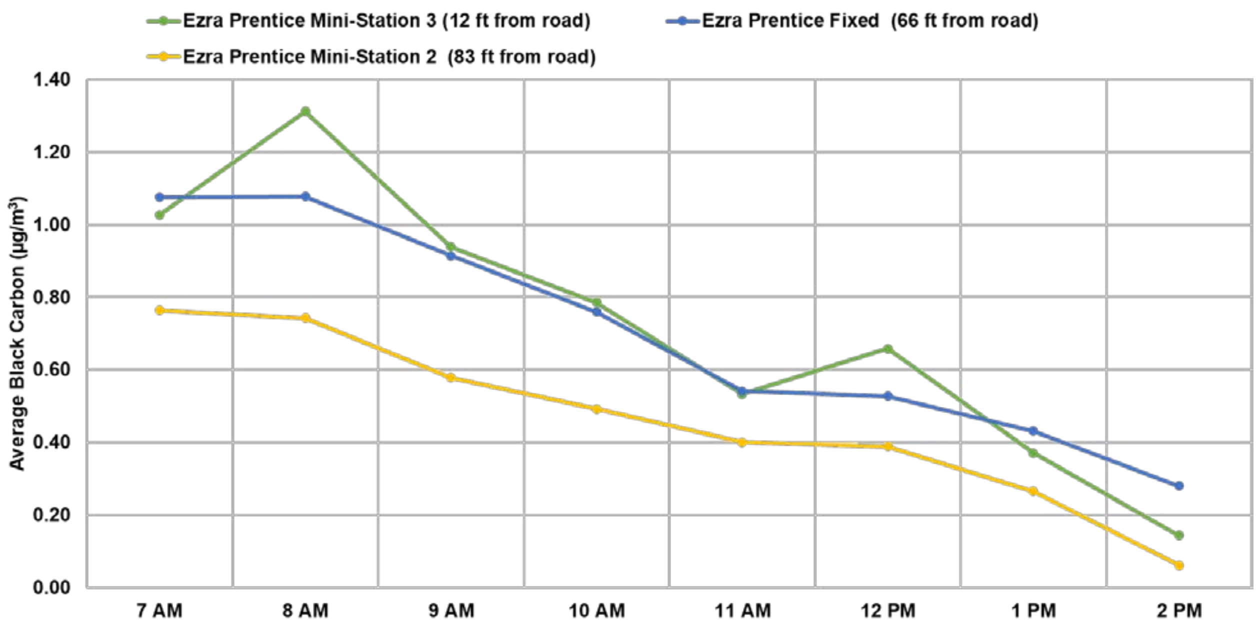


Figure 3. Hourly Average Black Carbon Concentrations (µg/m^3) at Ezra Prentice

Appendix D: Twelve-Month Averages for Volatile Organic Compounds and Carbonyls

Interpretation of Results – Volatile Organic Compounds

As shown in Table 1, the results for four volatile organic compounds (VOCs) monitored at Ezra Prentice are above respective long-term health-based air annual guideline concentrations (AGCs) while the remaining VOCs are below. The 12-month average for the four VOCs (1,2-dichloroethane, 1,3-butadiene, benzene, carbon tetrachloride), although above the guideline concentration, are within the acceptable target risk level (1 to 10-in-a-million) used by NYSDEC to make decisions about the need to consider further air pollution controls for sources. These four VOCs also are well below USEPA's acceptable level of concern at a 100-in-a-million cancer risk level. The results for the Ezra Prentice monitoring were compared graphically to NYSDEC's Air Toxics Monitoring Network in Appendix E. As shown, the concentration at the Ezra Prentice Study Monitor is within the range found in other urban areas in the state for these four VOCs. The comparisons suggest that the level of air toxics measured in the South End Neighborhood are not unlike concentrations found in other locations of similar urban development.

1,2-Dichloroethane was measured in the same range as found in all locations of the state, indicating that source for this VOC is relatively common. It is used as a solvent and released in the charbroiling cooking process (i.e., (charcoal grilling). The breakdown of municipal waste in landfills also releases 1,2-dichloroethane.

Carbon tetrachloride was used as a refrigerant and a cleaning solvent. It was phased out in January 1996 by the Montreal Protocol because of its ozone depleting potential. However, it is a chemical that has been reported to have a half-life of 50 years or more, so it will remain a ubiquitously distributed airborne contaminant for many years to come.

The primary sources of 1,3-butadiene and benzene in Albany South End neighborhood come from gasoline-powered motor vehicles and equipment. Benzene is also released from the storage and transfer of petroleum products, especially gasoline.

Interpretation of Results – Carbonyls

As shown in Table 3, for the carbonyls monitored at the Ezra Prentice, the 12-month average for two results (acetaldehyde, formaldehyde) are above the long-term health-based air guideline concentrations. Although acetaldehyde is above the guideline concentration, the average is within the acceptable target risk level (1-in-a-million to 10-in-a-million) used by NYSDEC to make decisions about the need to consider further air pollution controls for sources. Formaldehyde is above the 10-in-a-million risk level in all areas of the state. This is primarily due to secondary formation. VOCs are released from industry, commercial businesses, and vehicles, and in the presence of sunlight, they break down to form formaldehyde (which we call secondary formation). VOCs released (such as isoprene) from trees and other vegetation also contribute to the formation of formaldehyde. In 2014, in New York, secondary formation of formaldehyde was estimated to account for 73% of outdoor concentrations of formaldehyde.[1]

[1] U.S. Environmental Protection Agency's National-scale Air Toxics Assessment for 2014.

The results from the Ezra Prentice monitoring were compared graphically to NYSDEC's Air Toxics Monitoring Network in Appendix F. As illustrated, the concentrations are similar to measurements obtained in other areas of the state.

NYSDEC's Health-based Air Guideline Concentrations

Many organizations and agencies derive exposure limits to protect workers or the general public from adverse health outcomes from exposures to air contaminants. Each one of these exposure limits requires extensive research and development time. As such, NYSDEC establishes both long-term and short-term air guideline concentrations by adopting the most conservative health-based air comparison values developed by NYSDEC or others, such as the USEPA or the New York State Department of Health (NYSDOH). NYSDEC uses these values as part of its strategy to determine the degree of pollutant removal required for sources releasing air contaminants or to identify significant concerns from ambient monitoring data. These health-based air guideline concentrations are being used in this study.

First, NYSDEC compared the year-long monitoring results for both the VOCs and carbonyls to annual guideline concentrations (AGCs). AGCs are ambient (for outdoor air) annual-based concentrations that NYSDEC uses to protect the public from adverse health outcomes associated with long-term (e.g., continuous lifetime) exposure to an air contaminant. AGCs are compared to annual average results from a full year of monitoring or air dispersion modeling estimates.

NYSDEC then compared the 1-hour community air sample results to short-term guideline concentrations (SGCs) to determine whether the results represent an immediate public health concern. NYSDEC established SGCs to protect the general public from adverse health outcomes associated with short-term (1-hour) exposures to toxic air contaminants. The general public includes infants and children, and other individuals who may be more sensitive to lower concentrations than healthy adults. Examples of health outcomes from short-term exposures may include headaches, nausea, allergic reactions, asthma exacerbation, and irritation to the eyes, nose, and throat.

There are two health outcomes from long-term exposures—cancer and non-cancer endpoints such as reproductive, developmental, respiratory, and cardiovascular effects. The non-cancer AGC is established for an air concentration that is not expected to cause health effects during a lifetime of continuous exposure. The AGC is very conservative. The non-cancer health endpoints generally require higher exposures to elicit a response when compared to cancer health endpoints.

The other health outcome possible from long-term exposure is cancer. Cancer AGCs are defined as chemical concentrations in air that are associated with an estimated excess lifetime human cancer risk of 1-in-a-million (1×10^{-6}). Under the 1990 Clean Air Act, the acceptable cancer risk used by the USEPA to make regulatory decisions regarding the need for further air pollution reductions from sources or to identify significant concerns from ambient monitoring data is 100-in-a-million (1×10^{-4}). The acceptable cancer risk used by NYSDEC's Division of Air Resources to make regulatory permitting decisions about the need to consider further air pollution controls for sources ranges from 1-in-a-million to 10-in-a-million (1×10^{-5}). This is more conservative than USEPA's acceptable level of concern. The selection of an acceptable level of concern is a risk management decision.[2]

[2] The interpretation of the sample results involves evaluating potential risk from the measured air concentrations. This process is called risk assessment—developing estimates of potential health effects associated with the exposure of individuals or populations to the measured air concentrations. Risk Management is a distinctly different process from risk assessment. Risk managers use the results of the risk assessment to make further decisions such as the need for more

These guideline values are not bright lines between air concentrations that cause health effects and those that do not. They are values that are used by NYSDEC to assess the acceptability of proposed new air pollution sources during the permitting process and are also used to evaluate the results of ambient air monitoring studies that measure the impacts of numerous sources of air pollution in an area. The purpose of the guideline is to help guide decisions about reducing community exposure to air pollution.[3]

Table 1. Volatile Organic Compounds 12 Month Average

Chemical	Ezra Prentice - Study Monitor (ppb)	South Albany (ppb)	Brookside Terrace (ppb)	Buffalo (ppb)	Freshkills West (ppb)	Grand Island Blvd (ppb)	IS52 (ppb)	Long Term Health Based Guideline Concentrations (AGC) (ppb)	Carcinogen
1,1,1-Trichloroethane	0.0036	0.0028	ns	ns	ns	ns	0.0029	900	
1,2,4-Trimethylbenzene	0.038	0.056	0.020	0.029	0.036	0.020	0.049	1	
1,2-Dichloroethane	0.017	0.017	0.016	0.016	0.018	0.016	0.016	0.01	yes
1,2-Dichloropropane	0.0035	0.0036	ns	ns	ns	ns	ns	0.87	
1,3,5-Trimethylbenzene	0.010	0.016	0.0070	0.010	0.014	0.0075	0.014	1.2	
1,3-Butadiene	0.021	0.021	ns	0.014	0.017	0.014	0.030	0.015	yes
1,4-Dichlorobenzene	0.010	0.0062	ns	ns	0.0054	ns	0.036	0.015	yes
Benzene	0.18	0.21	0.17	0.15	0.20	0.34	0.19	0.040	yes
Bromomethane	0.0079	0.0080	0.0076	0.0074	0.0095	0.0076	0.0082	1.3	
Carbon tetrachloride	0.084	0.085	0.083	0.084	0.082	0.084	0.084	0.027	yes
Chloroform	0.027	0.028	0.026	0.023	0.024	0.023	0.035	3.0	yes
Chloromethane	0.52	0.55	0.49	0.49	0.51	0.49	0.52	44	
Dichlorodifluoromethane	0.48	0.49	0.47	0.47	0.47	0.47	0.49	2400	
Dichloromethane	0.087	0.10	0.096	0.081	0.12	0.088	0.21	17	yes
Dichlorotetrafluoroethane	0.015	0.016	0.015	0.015	0.015	0.015	0.016	2400	
Ethylbenzene	0.049	0.065	0.032	0.037	0.050	0.031	0.054	230	
m,p-Xylene	0.13	0.18	0.091	0.11	0.14	0.098	0.15	23	

[3] More information about controlling air pollution sources and the derivation of SGCs and AGCs can be found online at: http://www.dec.ny.gov/chemical/89934.html.

Table 1. Volatile Organic Compounds 12 Month Average									
Chemical	**Ezra Prentice - Study Monitor (ppb)**	**South Albany (ppb)**	**Brookside Terrace (ppb)**	**Buffalo (ppb)**	**Freshkills West (ppb)**	**Grand Island Blvd (ppb)**	**IS52 (ppb)**	**Long Term Health Based Guideline Concentrations (AGC) (ppb)**	**Carcinogen**
o-Xylene	0.048	0.065	0.032	0.040	0.057	0.033	0.053	23	
Styrene	0.035	0.0081	0.012	0.073	0.014	0.010	0.011	230	
Tetrachloroethylene	0.013	0.013	0.010	0.016	0.015	0.0093	0.058	0.60	yes
Toluene	0.31	0.41	0.25	0.23	0.33	0.27	0.35	1300	
Trichlorofluoromethane	0.22	0.23	0.20	0.21	0.20	0.20	0.22	900	
Trichlorotrifluoroethane	0.067	0.069	0.065	0.066	0.066	0.066	0.067	23000	

ns – Insufficient number of observations for 12-month average

Table 2. Volatile Organic Compounds 12 Month Average *continued*									
Chemical	**Niagara Falls (ppb)**	**PS274 (ppb)**	**Pfizer (ppb)**	**Pinnacle (ppb)**	**Queens College (ppb)**	**Rochester (ppb)**	**Whiteface (ppb)**	**Long Term Health Based Guideline Concentration s (AGC) (ppb)**	**Carcinogen**
1,1,1-Trichloroethane	ns	ns	0.0025	ns	0.0027	0.0039	ns	900	
1,2,4-Trimethylbenzene	0.020	0.058	0.030	ns	0.033	0.017	ns	1	
1,2-Dichloroethane	0.016	0.016	0.016	0.016	0.016	0.016	0.014	0.01	yes
1,2-Dichloropropane	ns	ns	ns	ns	ns	ns	ns	0.87	
1,3,5-Trimethylbenzene	0.0069	0.025	0.0086	ns	0.0089	ns	ns	1.2	
1,3-Butadiene	ns	0.031	0.027	ns	0.021	0.012	ns	0.015	yes
1,4-Dichlorobenzene	ns	0.043	0.019	ns	0.015	ns	ns	0.015	yes
Benzene	0.12	0.19	0.18	0.091	0.17	0.13	0.069	0.040	yes
Bromomethane	0.0074	0.0080	0.0082	0.0075	0.0089	0.0079	0.0070	1.3	
Carbon tetrachloride	0.085	0.083	0.083	0.082	0.084	0.085	0.081	0.027	yes
Chloroform	0.024	0.031	0.030	0.017	0.027	0.025	0.017	3.0	yes

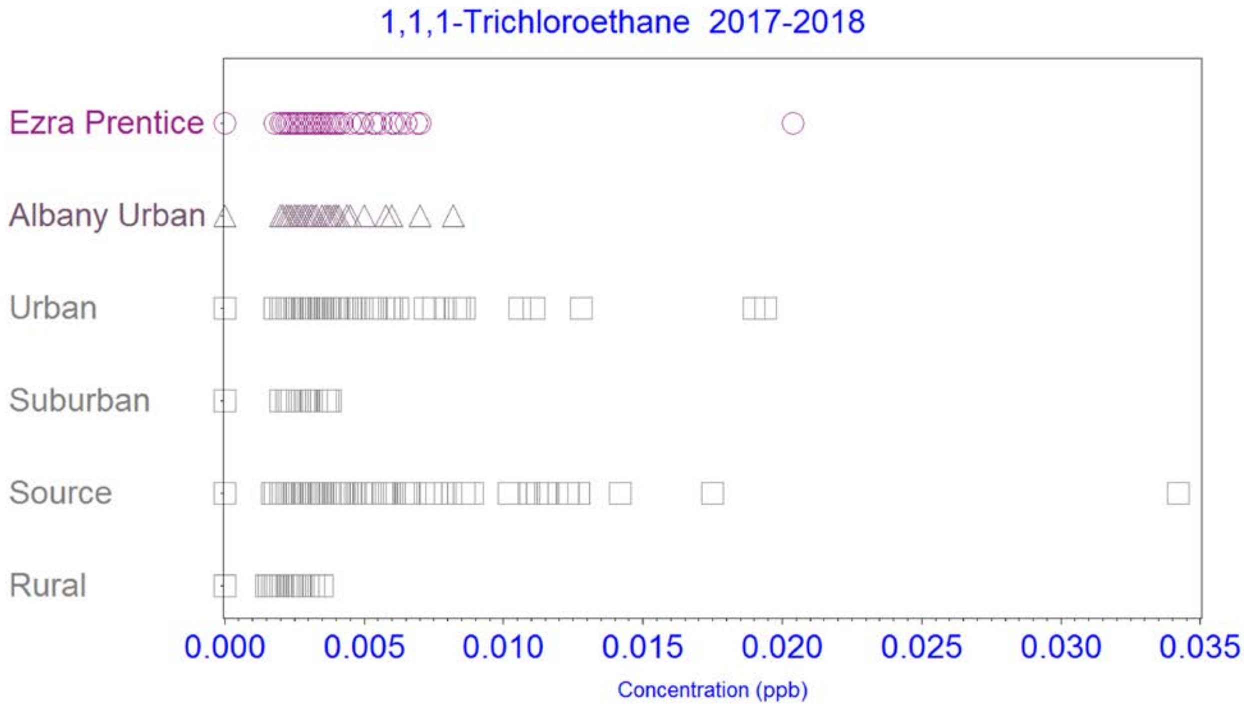
Table 2. Volatile Organic Compounds 12 Month Average *continued*									
Chemical	**Niagara Falls (ppb)**	**PS274 (ppb)**	**Pfizer (ppb)**	**Pinnacle (ppb)**	**Queens College (ppb)**	**Rochester (ppb)**	**Whiteface (ppb)**	**Long Term Health Based Guideline Concentrations (AGC) (ppb)**	**Carcinogen**
Chloromethane	0.48	0.50	0.52	0.50	0.51	0.51	0.48	44	
Dichlorodifluoromethane	0.48	0.47	0.48	0.47	0.49	0.48	0.47	2400	
Dichloromethane	0.083	0.16	0.11	0.068	0.10	0.14	0.073	17	yes
Dichlorotetrafluoroethane	0.015	0.015	0.015	0.015	0.015	0.016	0.015	2400	
Ethylbenzene	0.028	0.056	0.037	0.0083	0.041	0.025	ns	230	
m,p-Xylene	0.087	0.17	0.096	0.015	0.11	0.063	0.015	23	
o-Xylene	0.048	0.059	0.035	0.0063	0.039	0.024	ns	23	
Styrene	0.0059	0.013	0.0079	ns	0.0062	ns	ns	230	
Tetrachloroethylene	0.012	0.043	0.029	0.0052	0.028	0.010	ns	0.60	yes
Toluene	0.18	0.35	0.24	0.08	0.26	0.47	0.13	1300	
Trichlorofluoromethane	0.21	0.20	0.21	0.20	0.21	0.21	0.20	900	
Trichlorotrifluoroethane	0.069	0.065	0.065	0.064	0.066	0.066	0.065	23000	

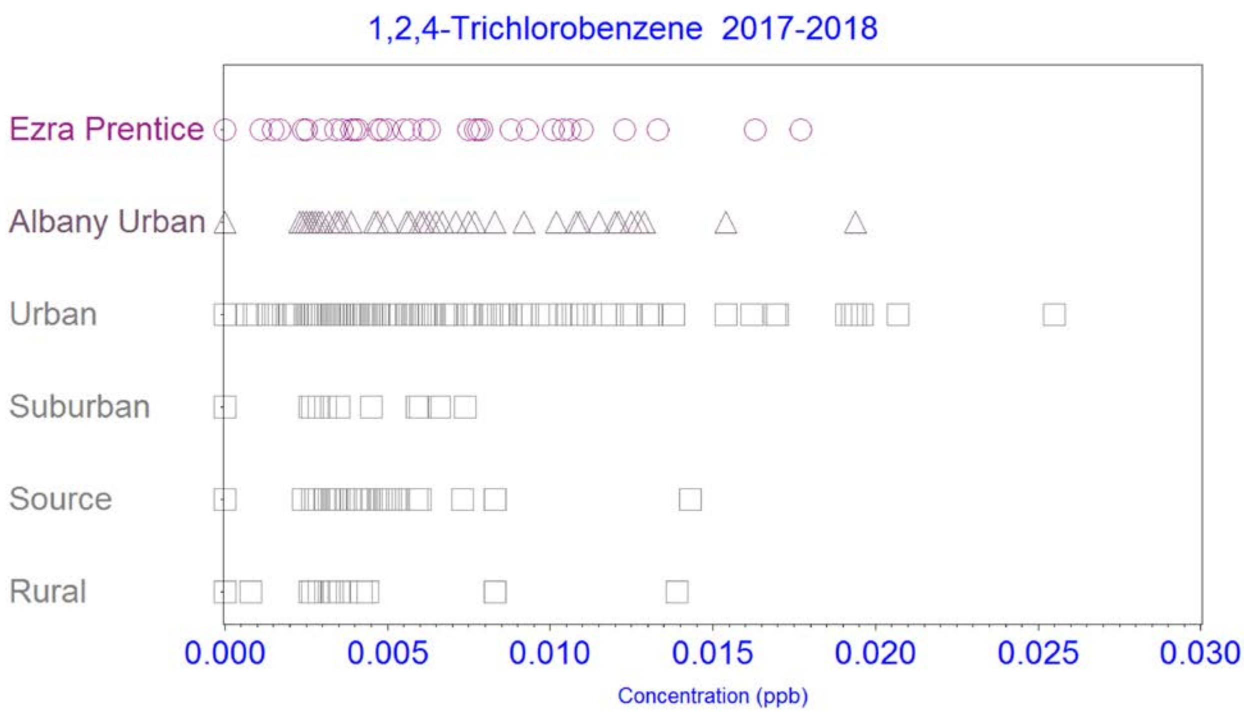
ns – Insufficient number of observations for 12-month average

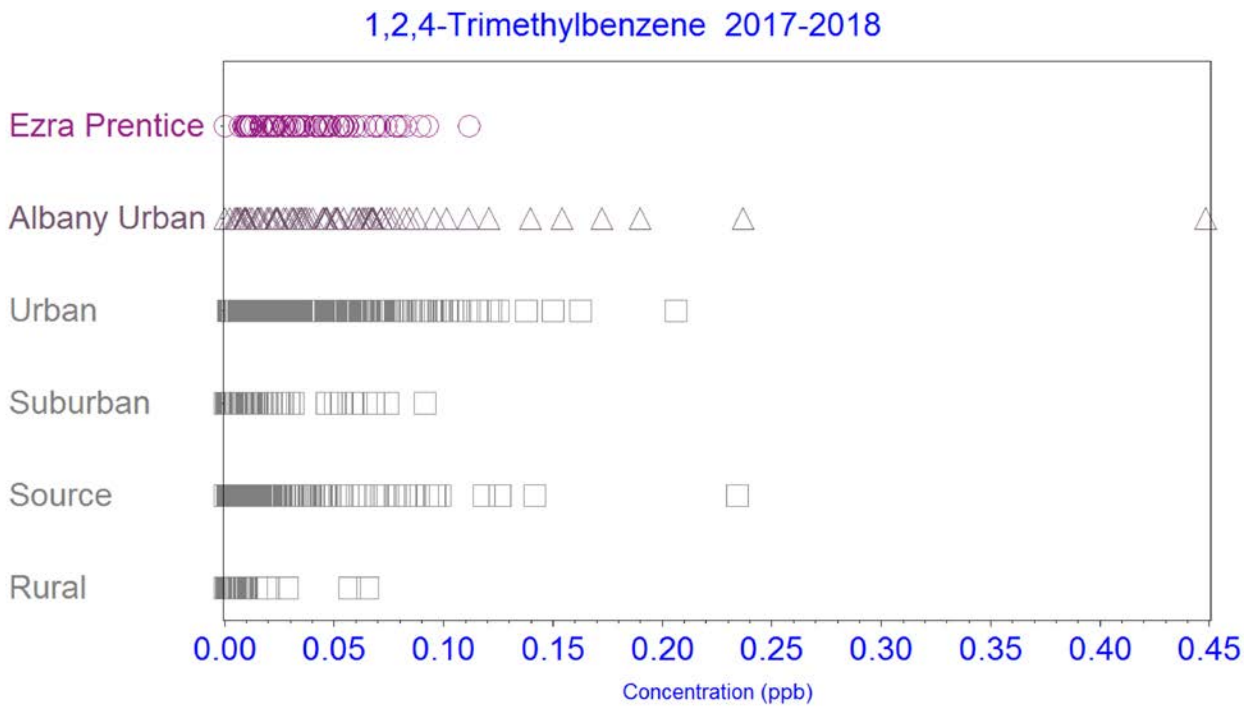
Table 3. Carbonyls 12 Month Average								
Chemical	**Acet aldehyde (ppb)**	**Benz aldehyde (ppb)[a]**	**Butyr aldehyde (ppb)[a]**	**Form aldehyde (ppb)**	**Hexan aldehyde (ppb)[a]**	**Methyl ethyl ketone (ppb)**	**Propion aldehyde (ppb)**	**Valer aldehyde (ppb)**
Ezra Prentice - Study Monitor	0.93	0.069	0.057	2.2	0.062	0.11	0.11	0.037
South Albany	0.91	0.078	0.054	2.0	0.052	0.19	0.094	0.019
Buffalo Near-Road	0.58	0.056	0.038	1.8	0.042	0.12	0.066	0.021
Freshkills West	1.0	0.065	0.072	2.2	0.068	0.26	0.096	0.026
Grand Island Blvd	0.58	0.046	0.038	1.7	0.039	0.16	0.057	0.019
IS 52	0.98	0.080	0.065	3.0	0.083	ns	0.088	ns
Niagara Falls	0.62	0.046	0.038	1.5	0.045	0.16	0.058	0.019
Pfizer	0.74	0.072	0.044	2.0	0.063	0.16	0.063	0.034
Queens College	1.1	0.072	0.095	3.0	0.076	0.17	0.11	0.044
Queens College Near-Road	0.93	0.070	0.067	3.0	0.080	0.12	0.085	0.040
Rochester	0.59	0.052	0.062	1.7	0.042	0.11	0.055	0.022
Rochester Near-Road	0.65	0.051	0.045	1.8	0.044	0.12	0.069	0.028
Whiteface Base	0.46	0.049	0.025	0.76	0.018	ns	0.029	ns
Long-Term Health-Based Guideline Concentrations (AGC)	0.25	2.1	5.1	0.05	4.9	1700	46	120
Carcinogens	yes			yes				

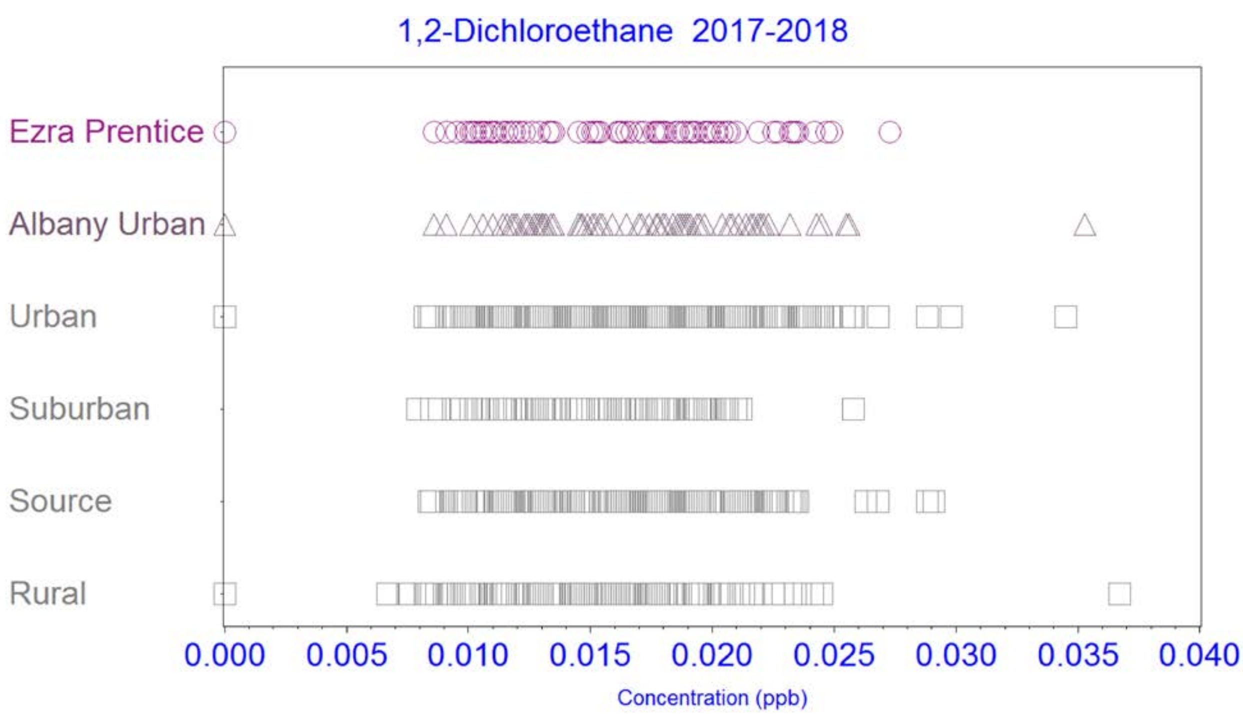
na – A long-term health-based guideline concentration has not been derived by NYSDEC at the time of this report.
ns – Insufficient number of observations for 12-month average
[a] – Using an interim AGC developed for the Tonawanda study

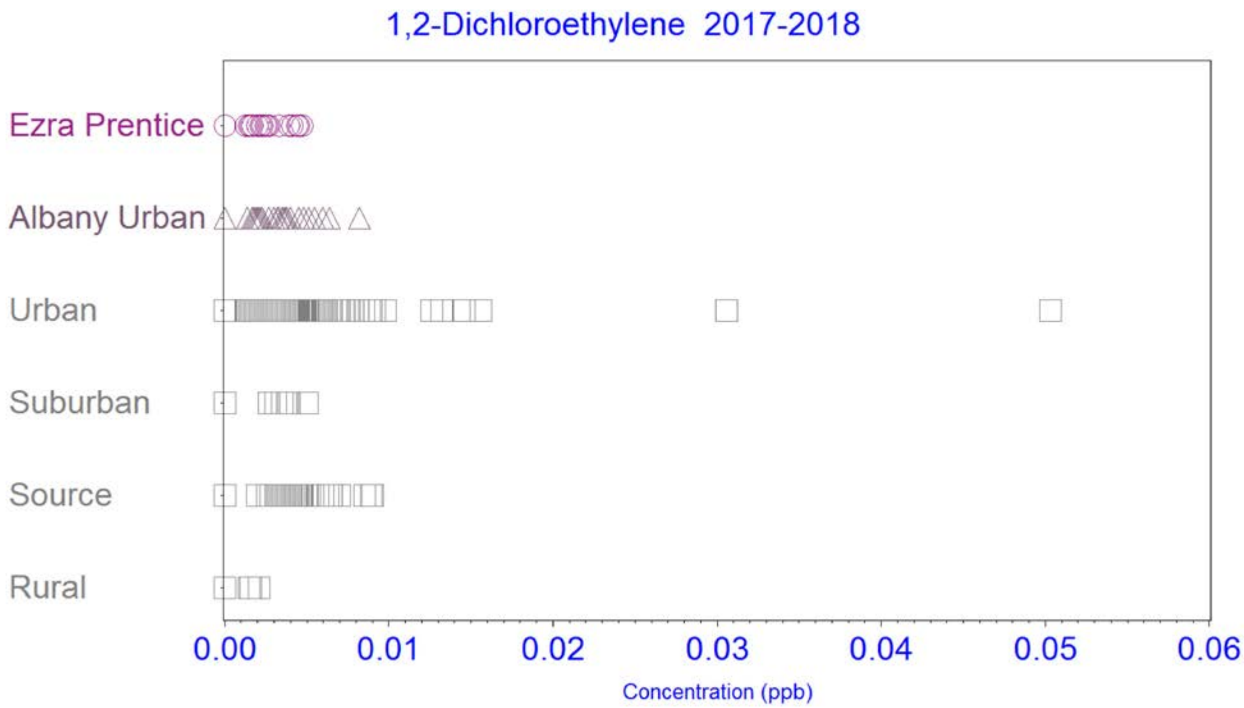
Appendix E: Graphic Comparison Volatile Organic Compounds Measured at Ezra Prentice Compared to NYSDEC Monitoring Network



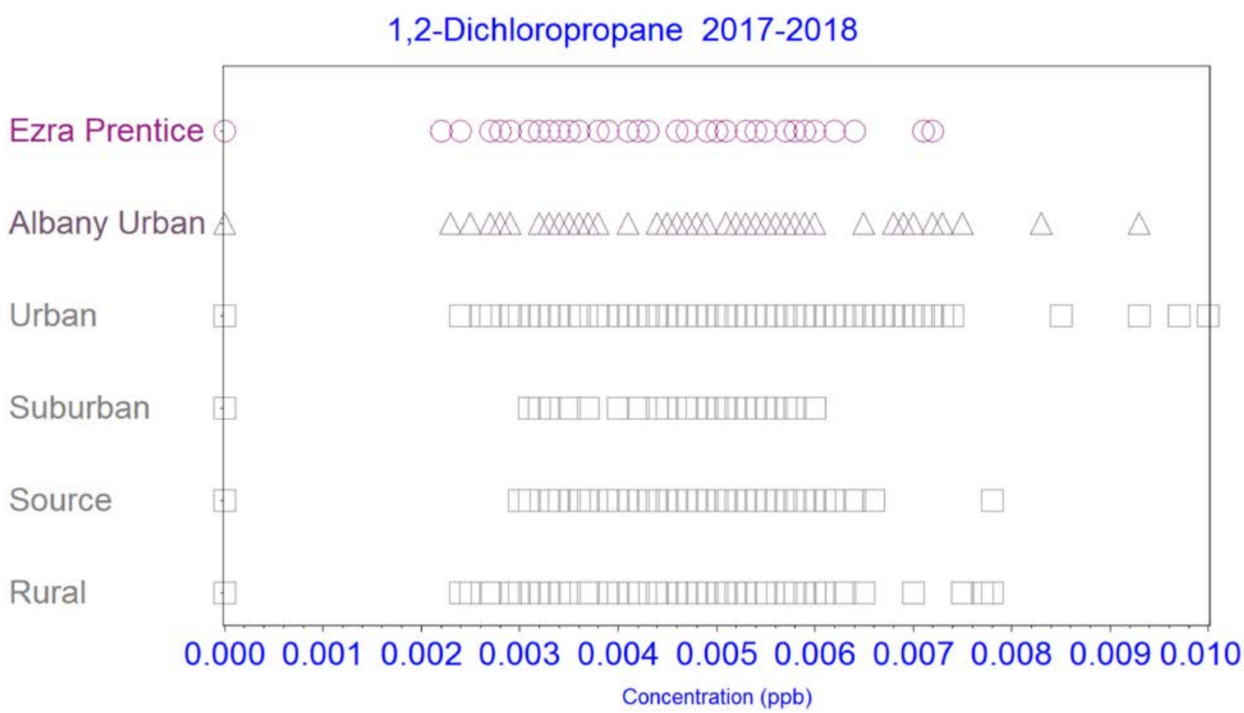



1,2,4-Trimethylbenzene 2017-2018
Ezra Prentice
Albany Urban
Urban
Suburban
Source
Rural
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
Concentration (ppb)

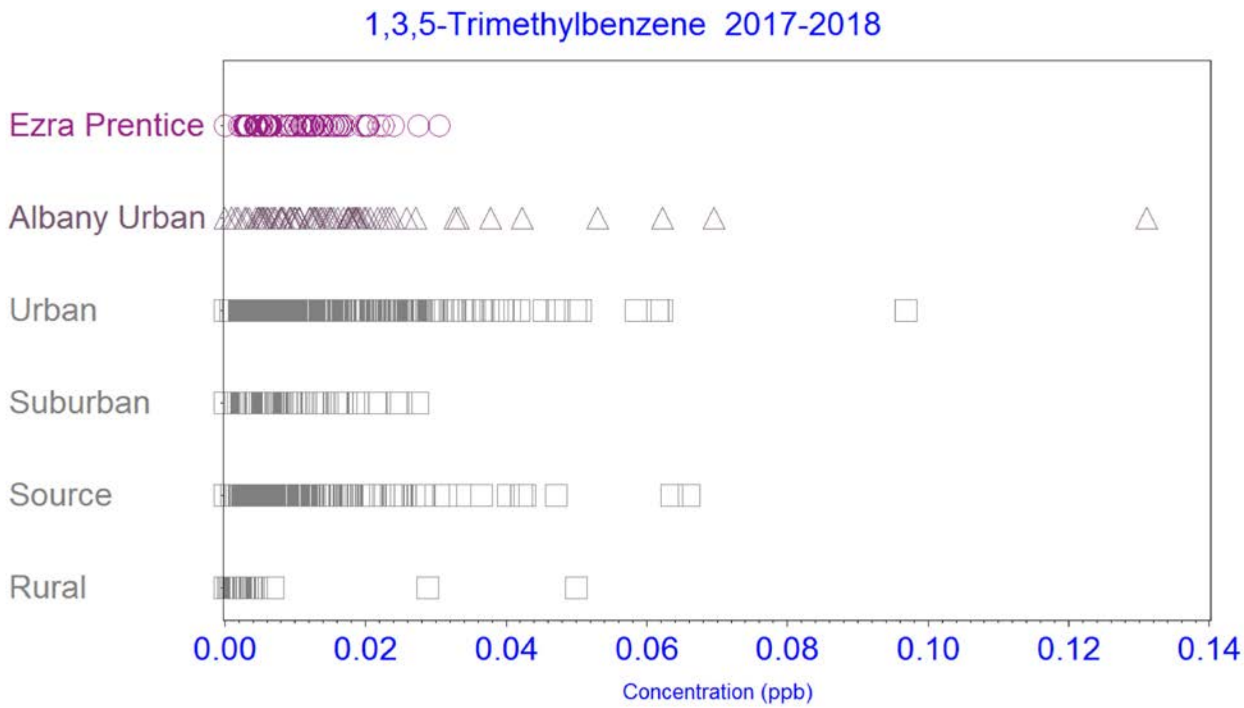

1,2-Dichloroethane 2017-2018
Ezra Prentice
Albany Urban
Urban
Suburban
Source
Rural
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
Concentration (ppb)

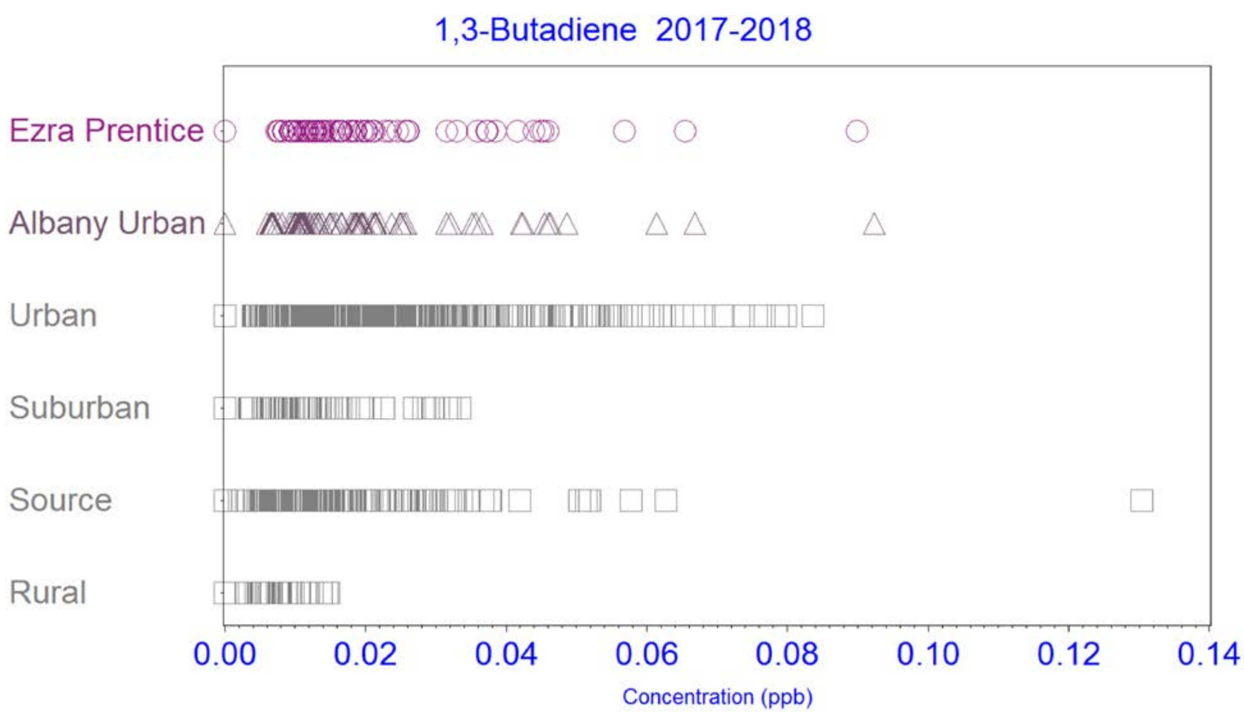


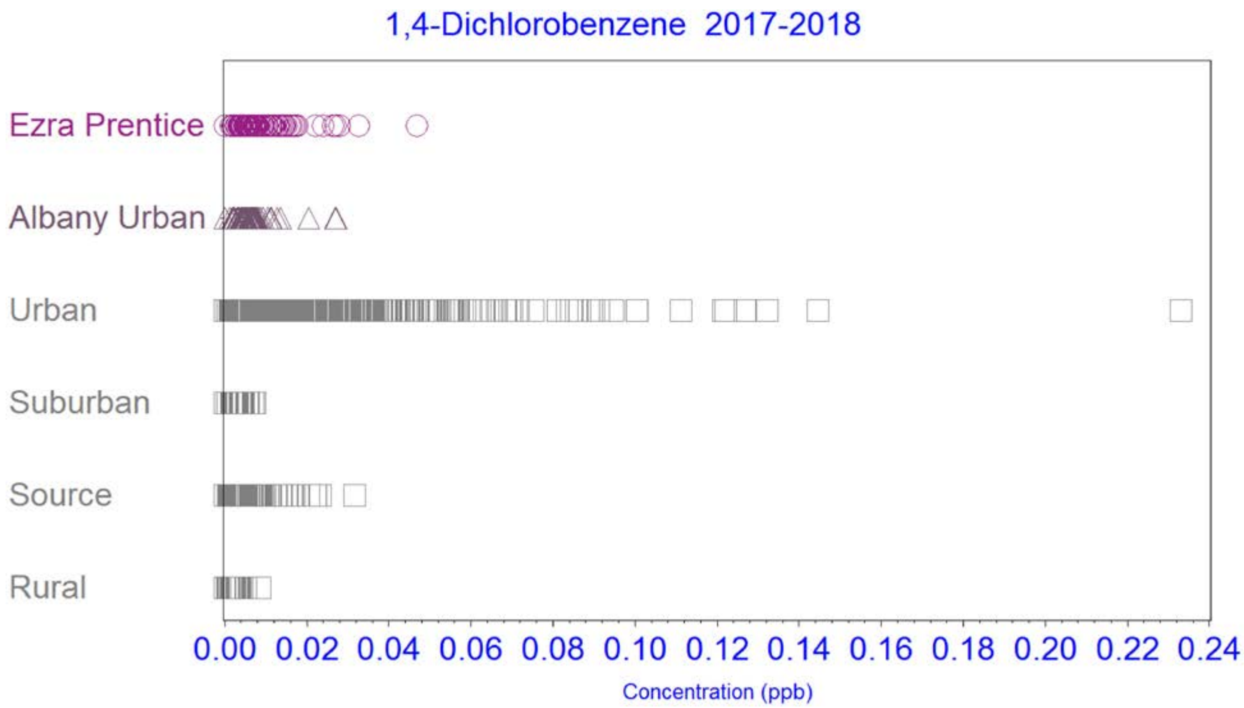
1,2-Dichloroethylene 2017-2018
Ezra Prentice
Albany Urban
Urban
Suburban
Source
Rural
0.00
0.01
0.02
0.03
0.04
0.05
0.06
Concentration (ppb)

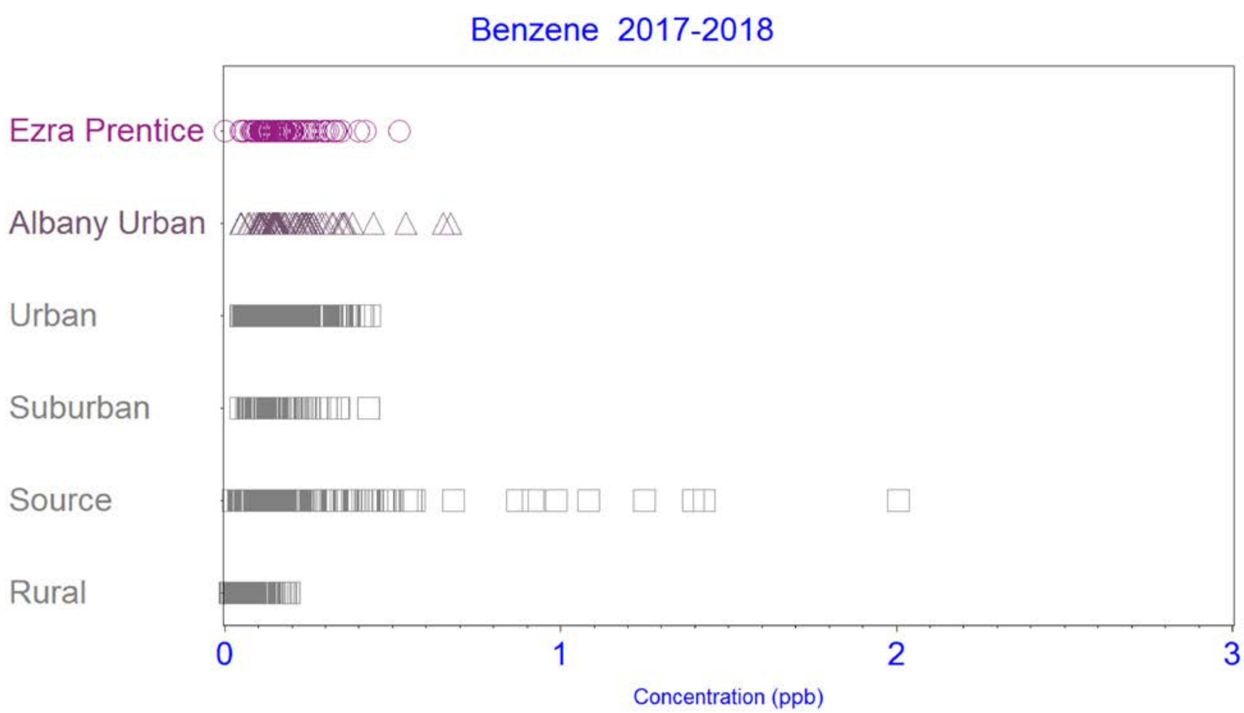


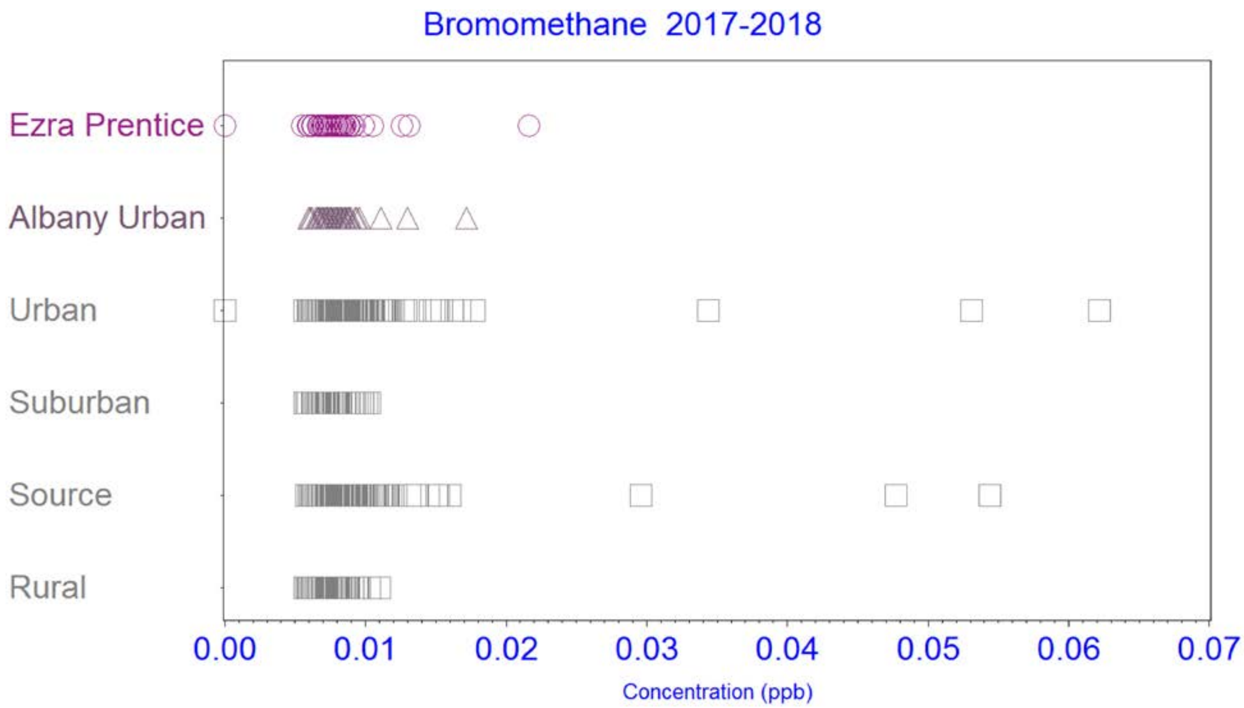
1,2-Dichloropropane 2017-2018
Ezra Prentice
Albany Urban
Urban
Suburban
Source
Rural
0.000
0.001
0.002
0.003
0.004
0.005
0.006
0.007
0.008
0.009
0.010
Concentration (ppb)

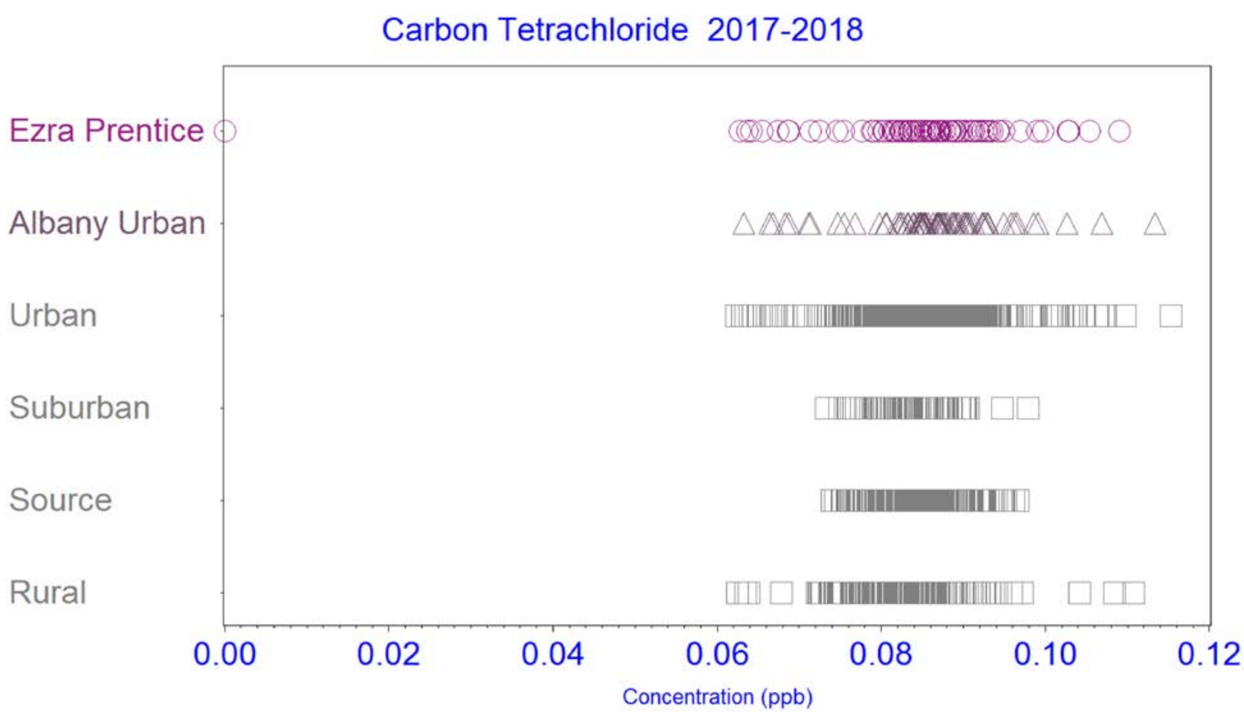

1,3,5-Trimethylbenzene 2017-2018
Ezra Prentice
Albany Urban
Urban
Suburban
Source
Rural
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
Concentration (ppb)

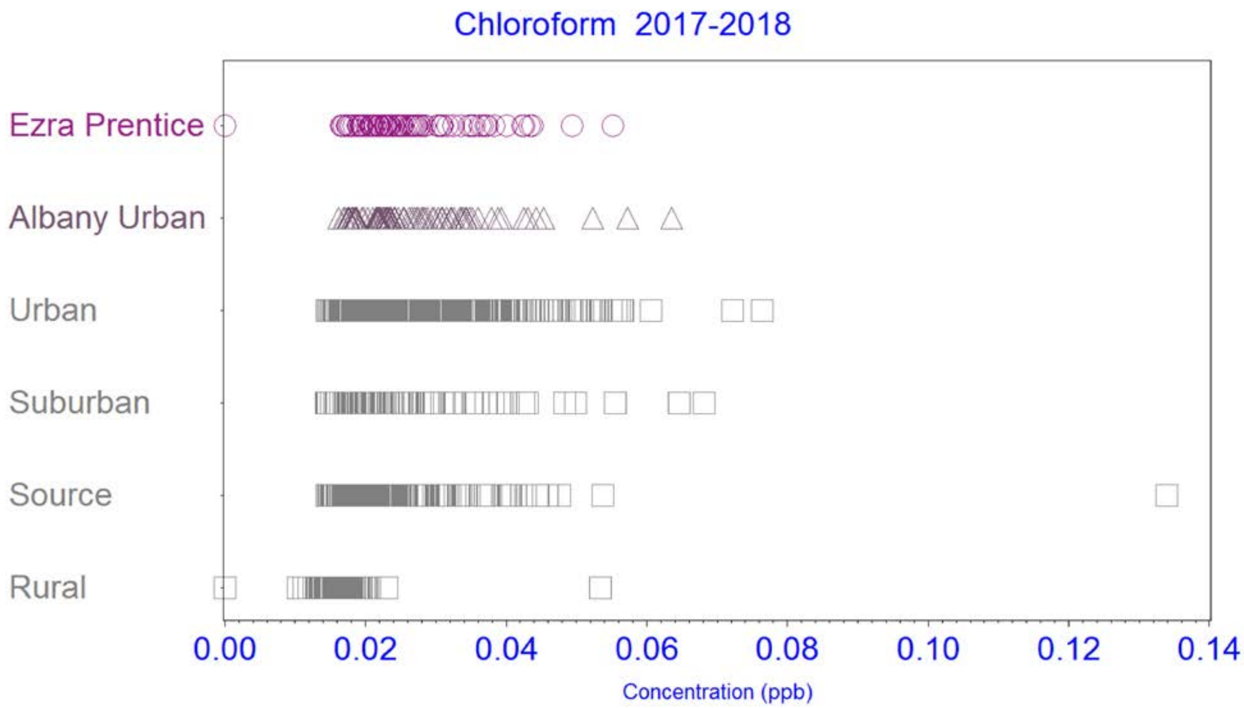

1,3-Butadiene 2017-2018
Ezra Prentice
Albany Urban
Urban
Suburban
Source
Rural
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
Concentration (ppb)

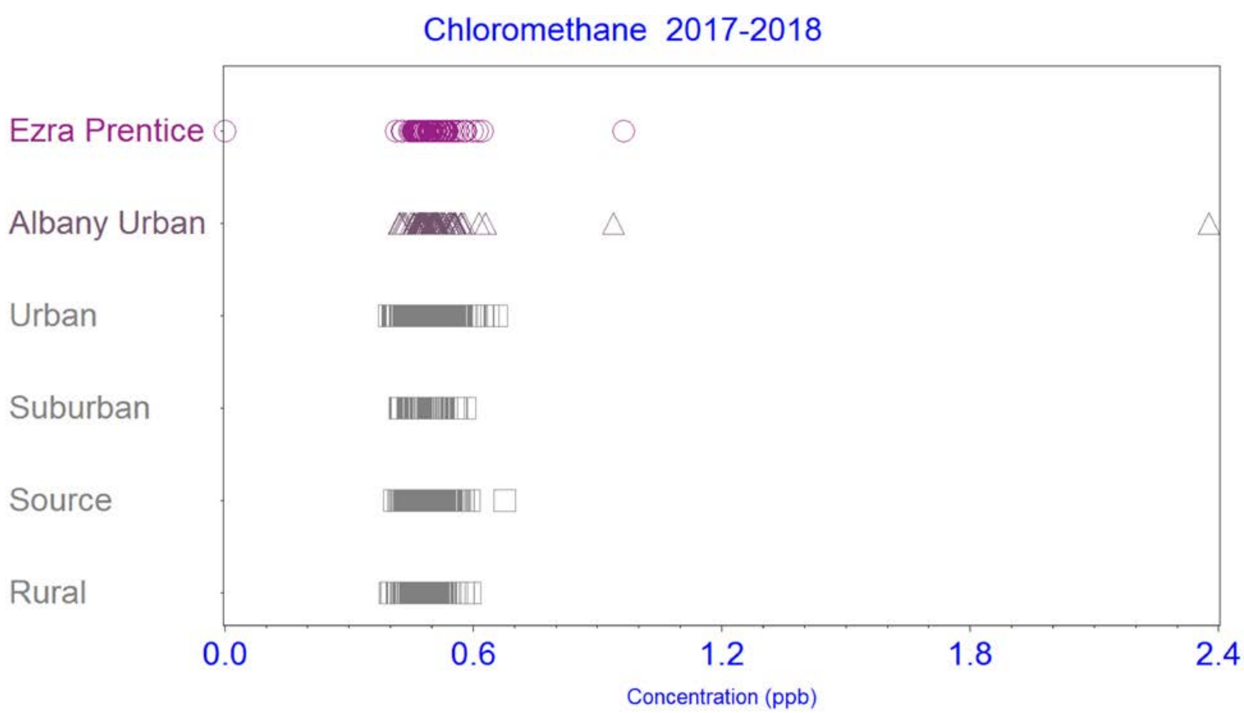

1,4-Dichlorobenzene 2017-2018
Ezra Prentice
Albany Urban
Urban
Suburban
Source
Rural
0.00 0.02 0.04 0.06 0.08 0.10 0.12 0.14 0.16 0.18 0.20 0.22 0.24
Concentration (ppb)

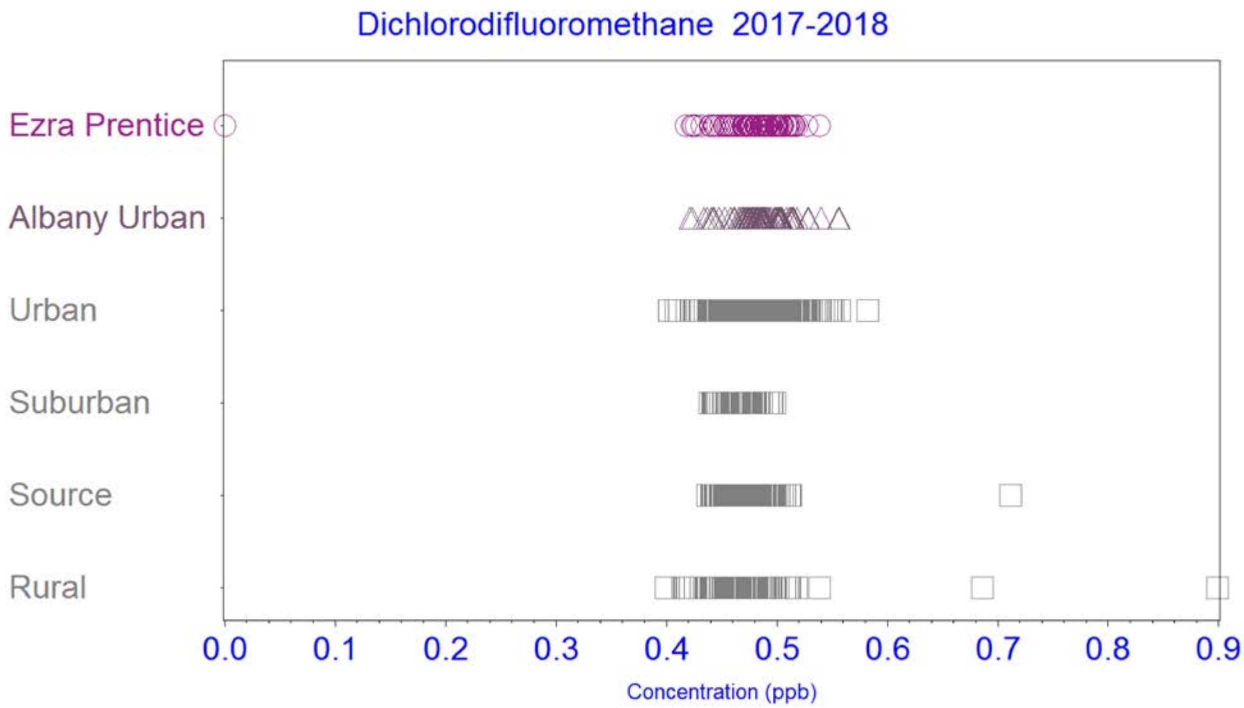

Benzene 2017-2018
Ezra Prentice
Albany Urban
Urban
Suburban
Source
Rural
0
1
2
3
Concentration (ppb)

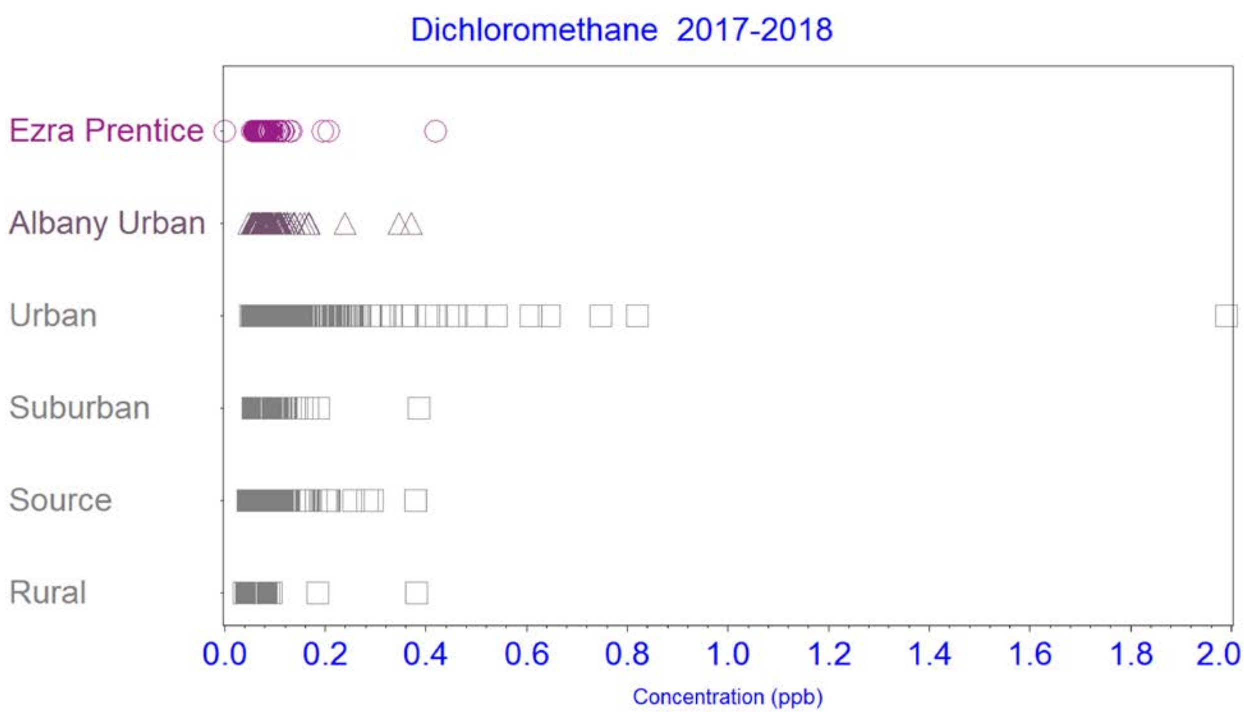

Bromomethane 2017-2018
Ezra Prentice
Albany Urban
Urban
Suburban
Source
Rural
0.00
0.01
0.02
0.03
0.04
0.05
0.06
0.07
Concentration (ppb)

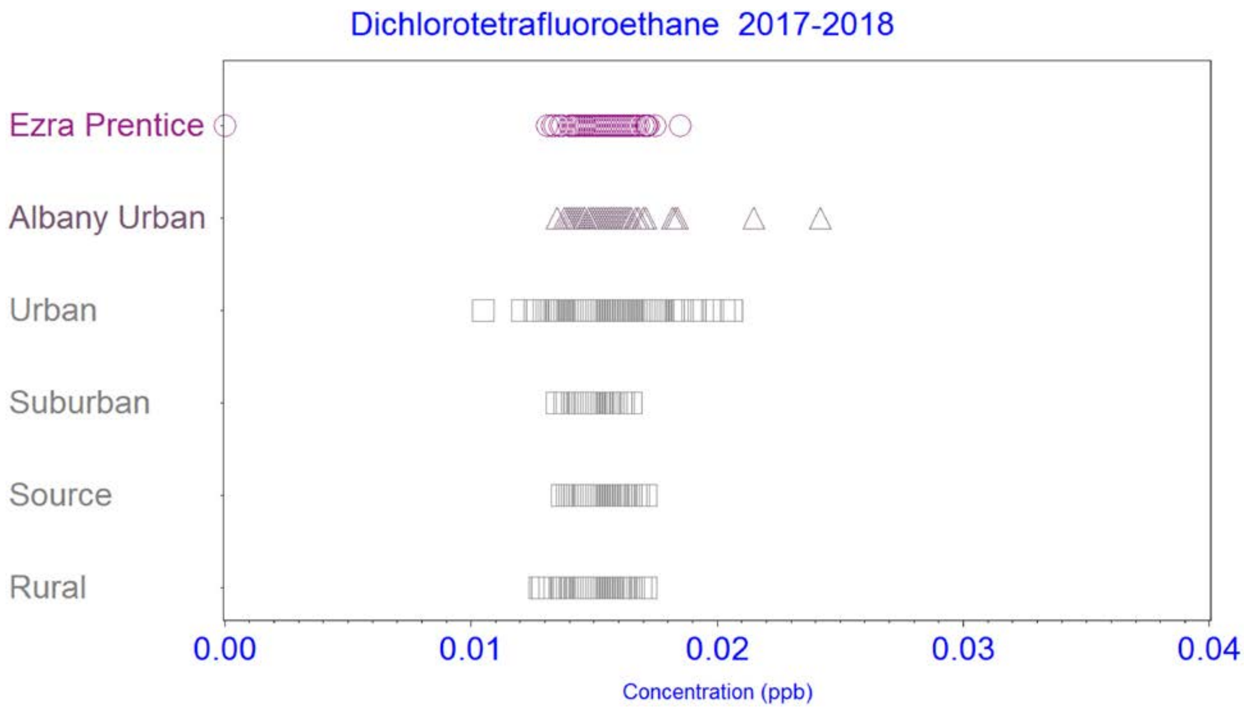

Carbon Tetrachloride 2017-2018
Ezra Prentice
Albany Urban
Urban
Suburban
Source
Rural
0.00
0.02
0.04
0.06
0.08
0.10
0.12
Concentration (ppb)

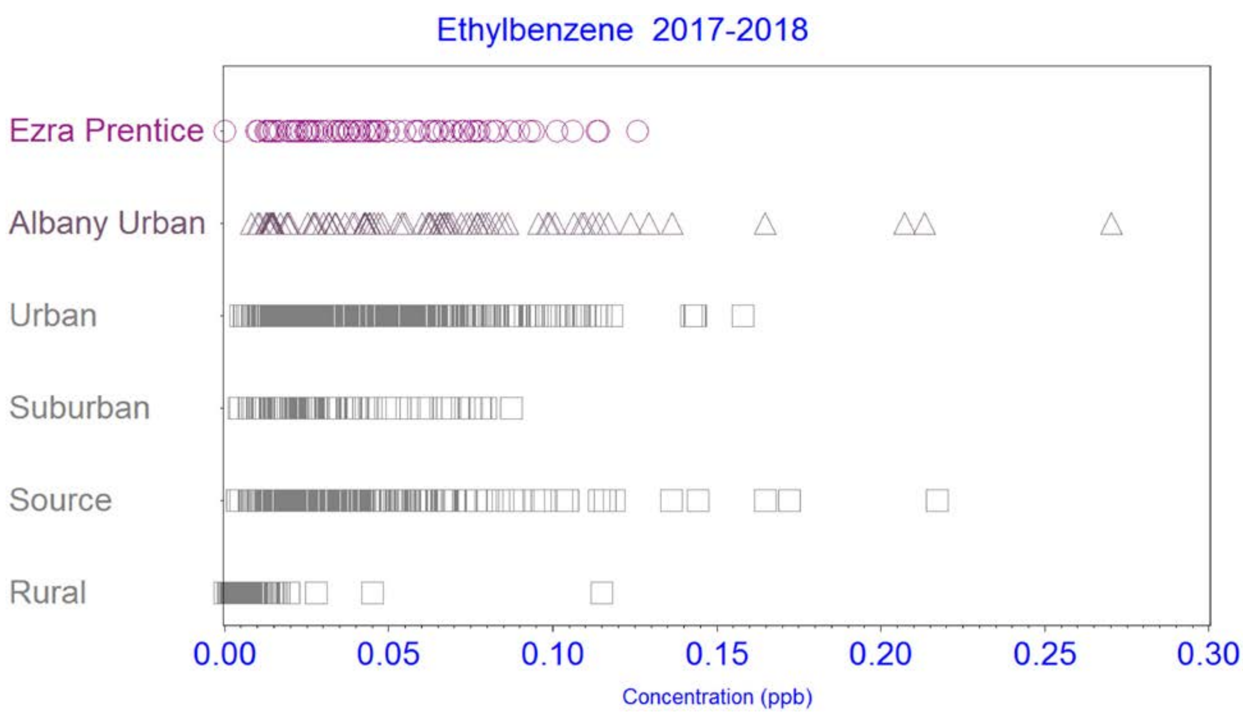

Chloroform 2017-2018
Ezra Prentice
Albany Urban
Urban
Suburban
Source
Rural
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
Concentration (ppb)

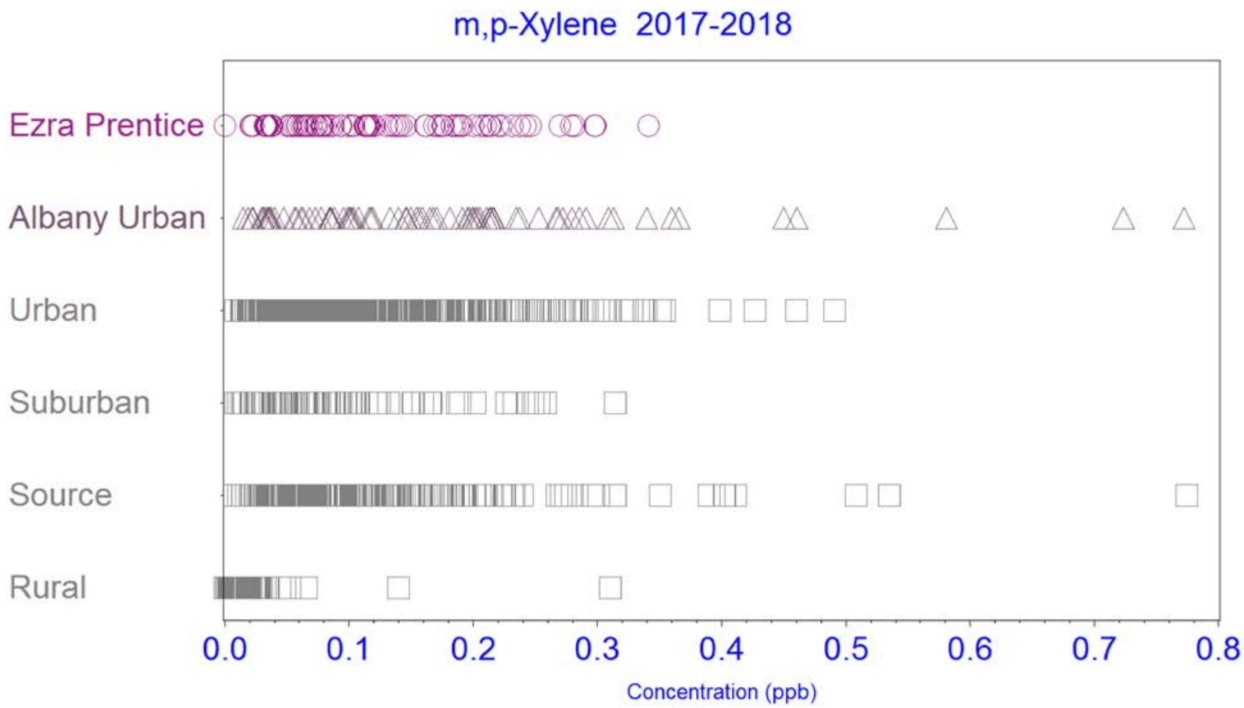

Chloromethane 2017-2018
Ezra Prentice
Albany Urban
Urban
Suburban
Source
Rural
0.0
0.6
1.2
1.8
2.4
Concentration (ppb)

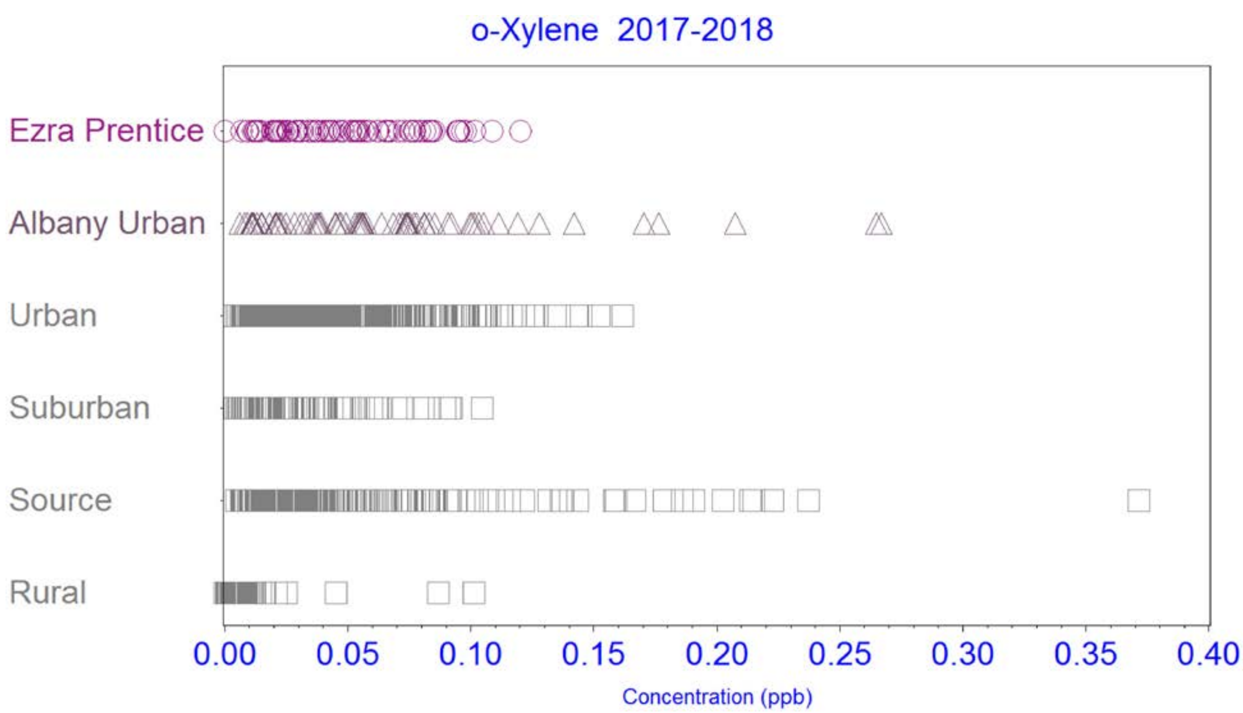

Dichlorodifluoromethane 2017-2018
Ezra Prentice
Albany Urban
Urban
Suburban
Source
Rural
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Concentration (ppb)

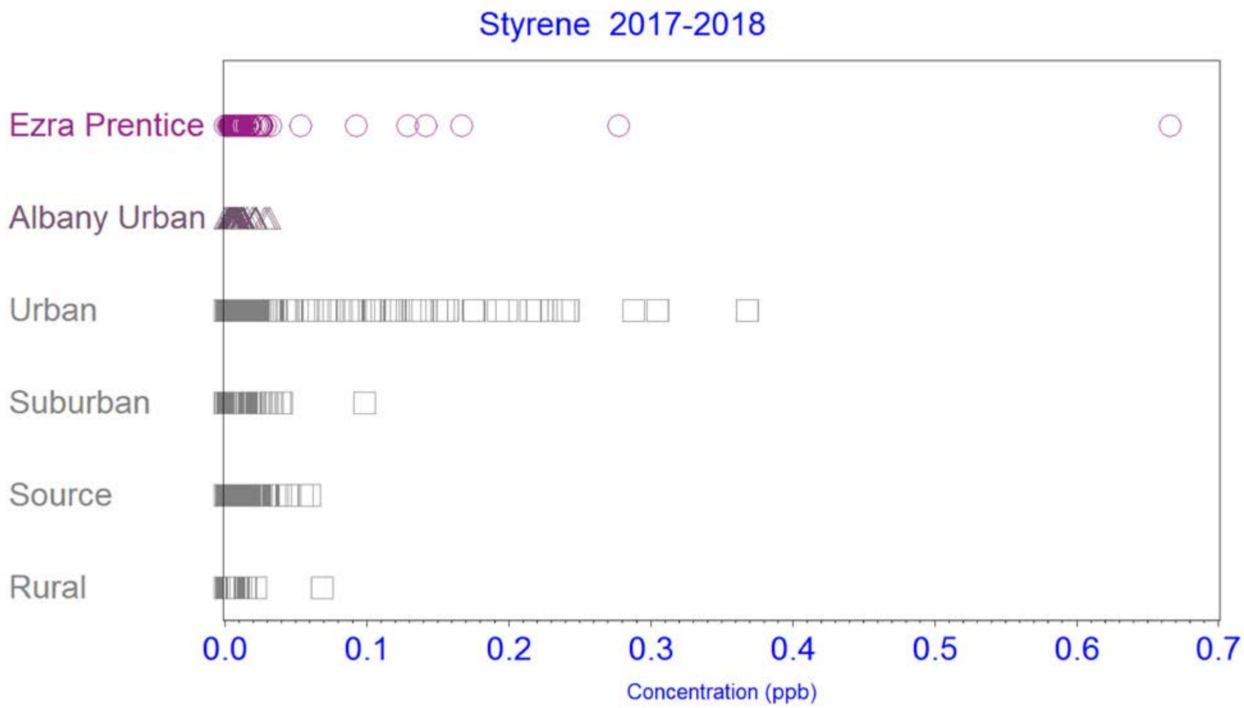

Dichloromethane 2017-2018
Ezra Prentice
Albany Urban
Urban
Suburban
Source
Rural
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Concentration (ppb)

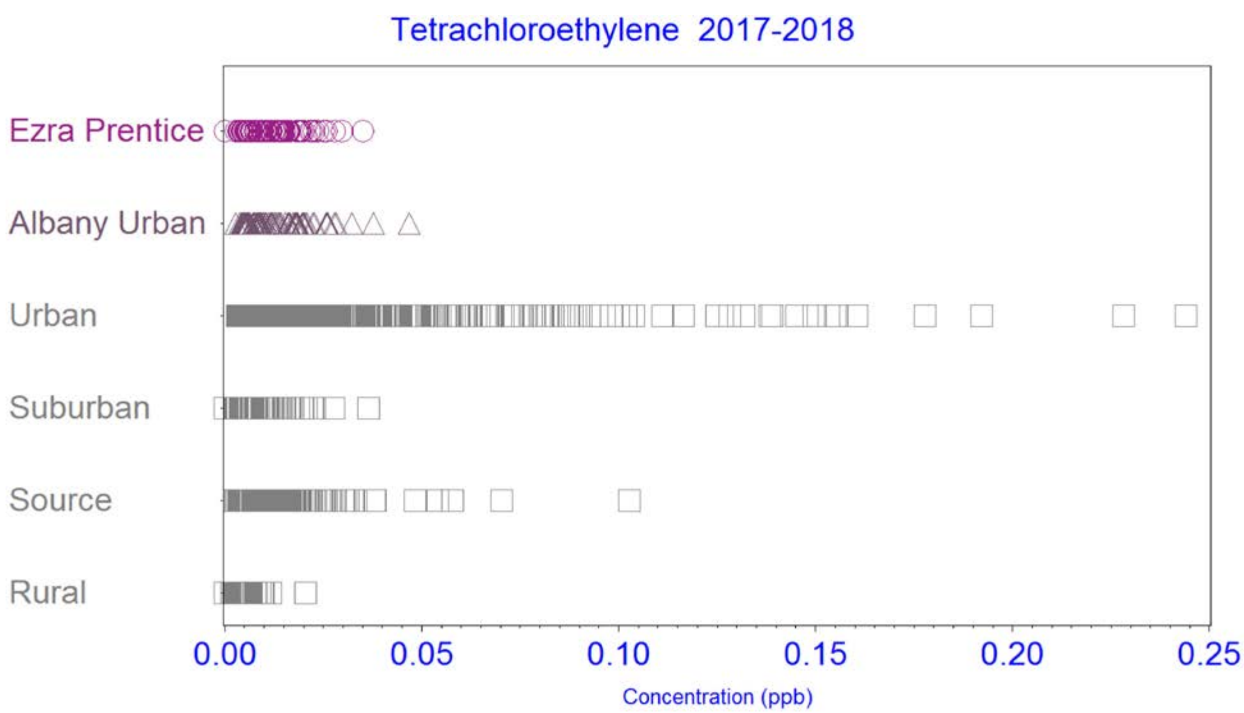

Dichlorotetrafluoroethane 2017-2018
Ezra Prentice
Albany Urban
Urban
Suburban
Source
Rural
0.00
0.01
0.02
0.03
0.04
Concentration (ppb)

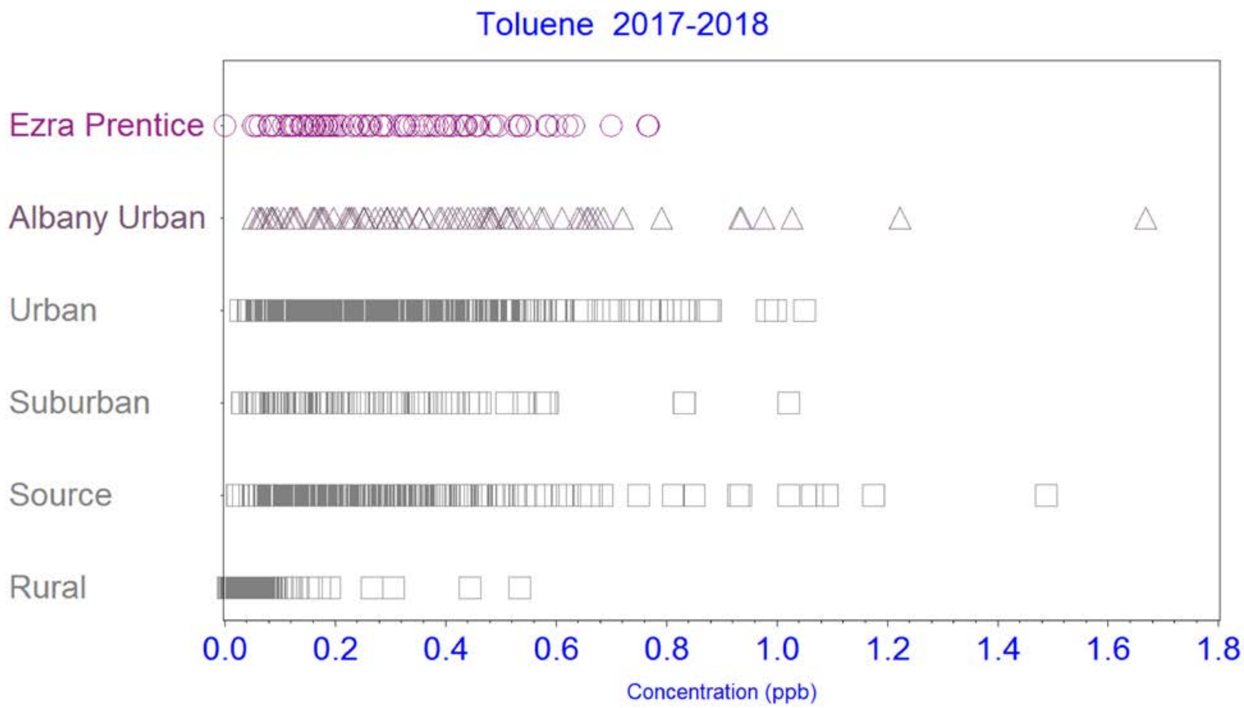

Ethylbenzene 2017-2018
Ezra Prentice
Albany Urban
Urban
Suburban
Source
Rural
0.00
0.05
0.10
0.15
0.20
0.25
0.30
Concentration (ppb)

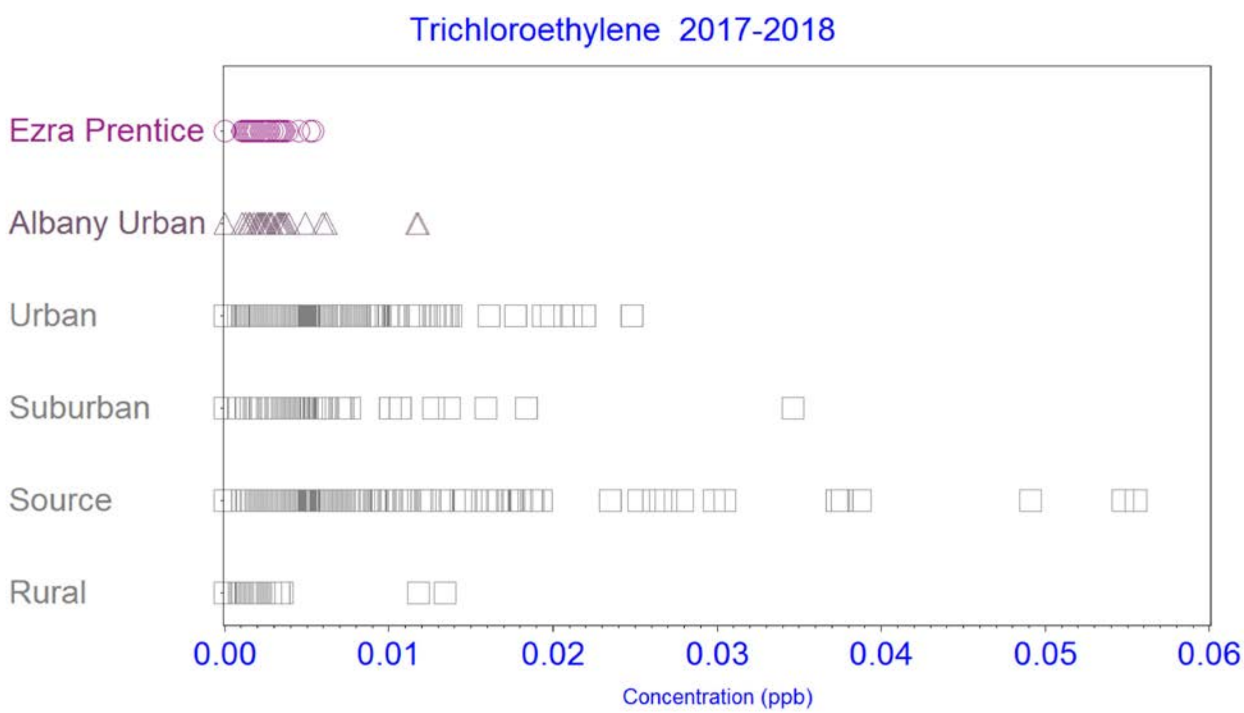

m,p-Xylene 2017-2018
Ezra Prentice
Albany Urban
Urban
Suburban
Source
Rural
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Concentration (ppb)

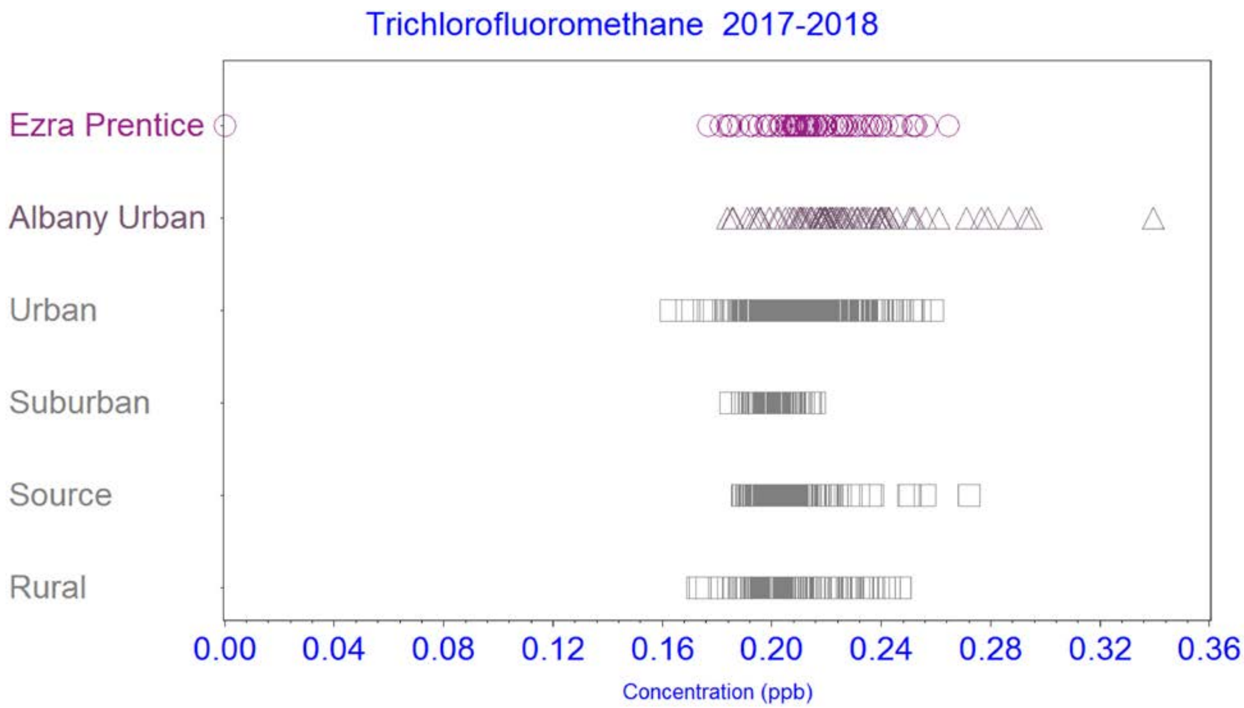

o-Xylene 2017-2018
Ezra Prentice
Albany Urban
Urban
Suburban
Source
Rural
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
Concentration (ppb)


Styrene 2017-2018
Ezra Prentice
Albany Urban
Urban
Suburban
Source
Rural
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Concentration (ppb)

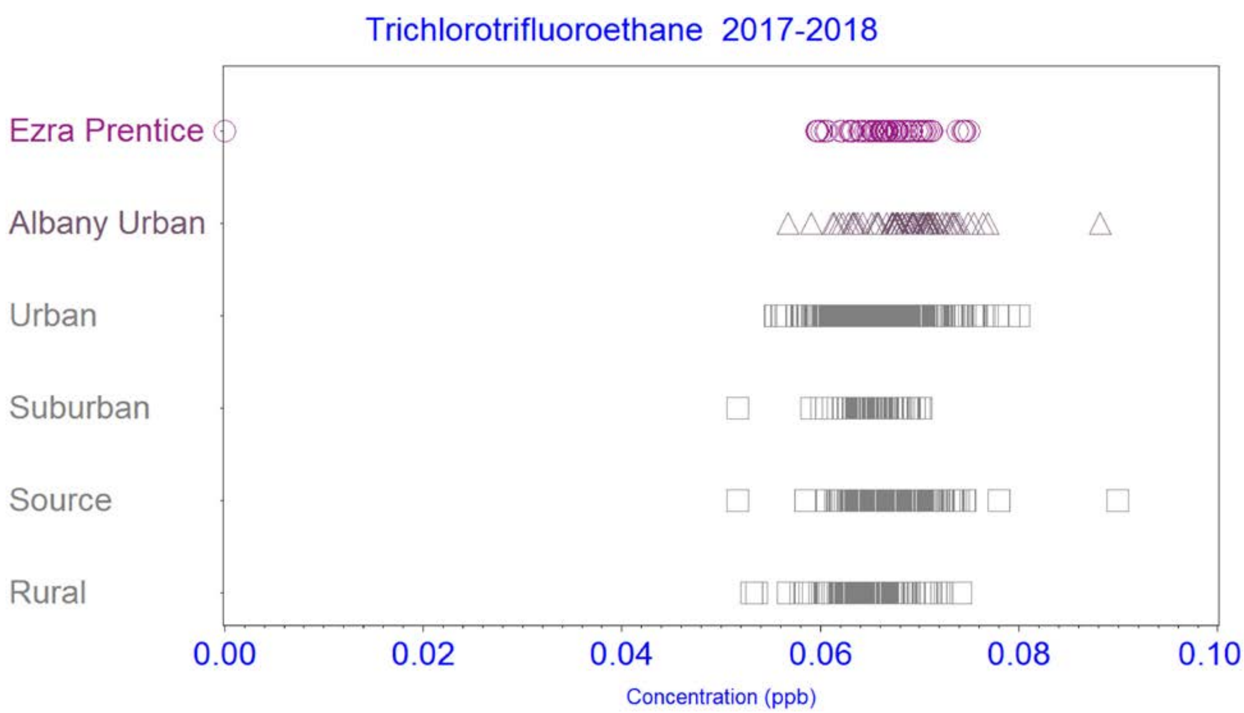

Tetrachloroethylene 2017-2018
Ezra Prentice
Albany Urban
Urban
Suburban
Source
Rural
0.00
0.05
0.10
0.15
0.20
0.25
Concentration (ppb)


Toluene 2017-2018
Ezra Prentice
Albany Urban
Urban
Suburban
Source
Rural
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
Concentration (ppb)


Trichloroethylene 2017-2018
Ezra Prentice
Albany Urban
Urban
Suburban
Source
Rural
0.00
0.01
0.02
0.03
0.04
0.05
0.06
Concentration (ppb)

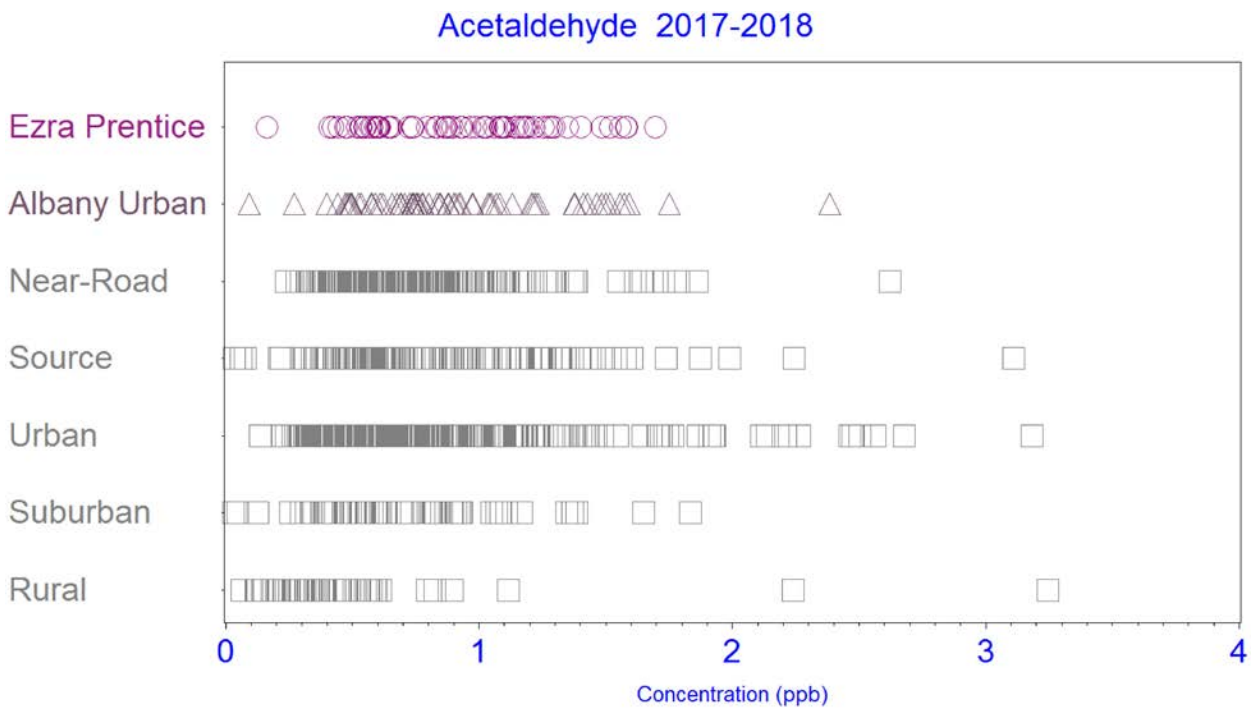


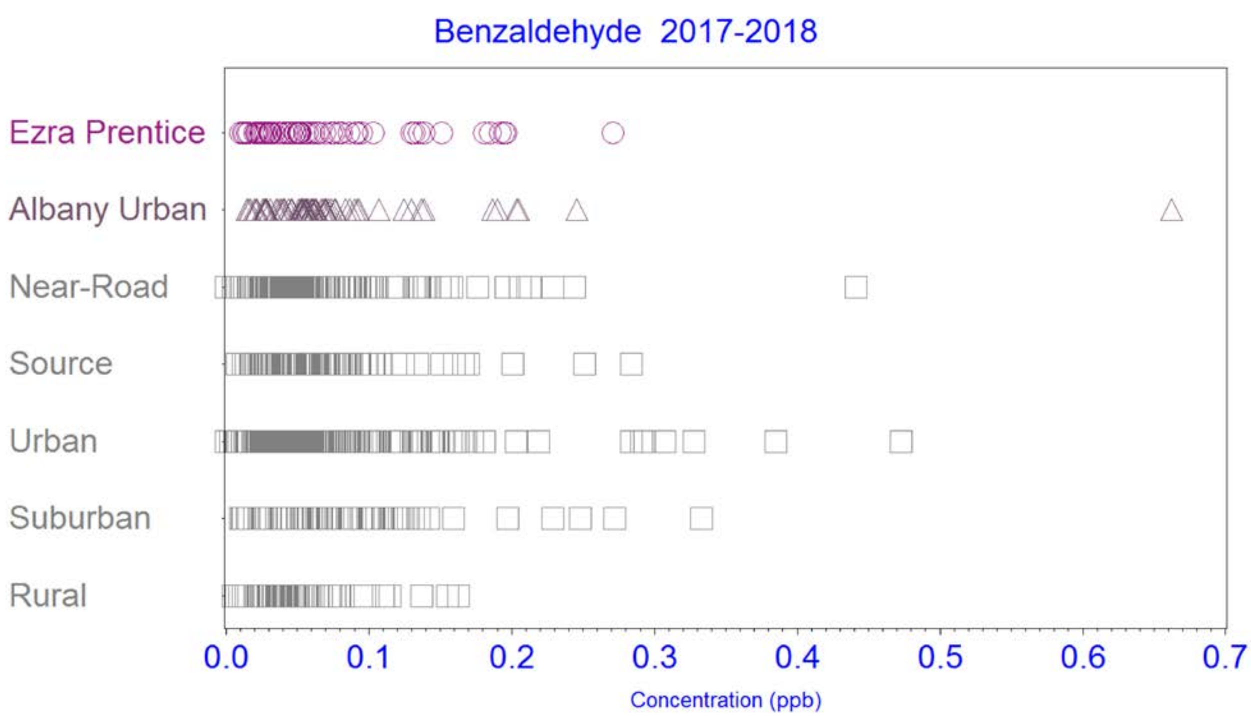
Trichlorofluoromethane 2017-2018
Ezra Prentice
Albany Urban
Urban
Suburban
Source
Rural
0.00 0.04 0.08 0.12 0.16 0.20 0.24 0.28 0.32 0.36
Concentration (ppb)

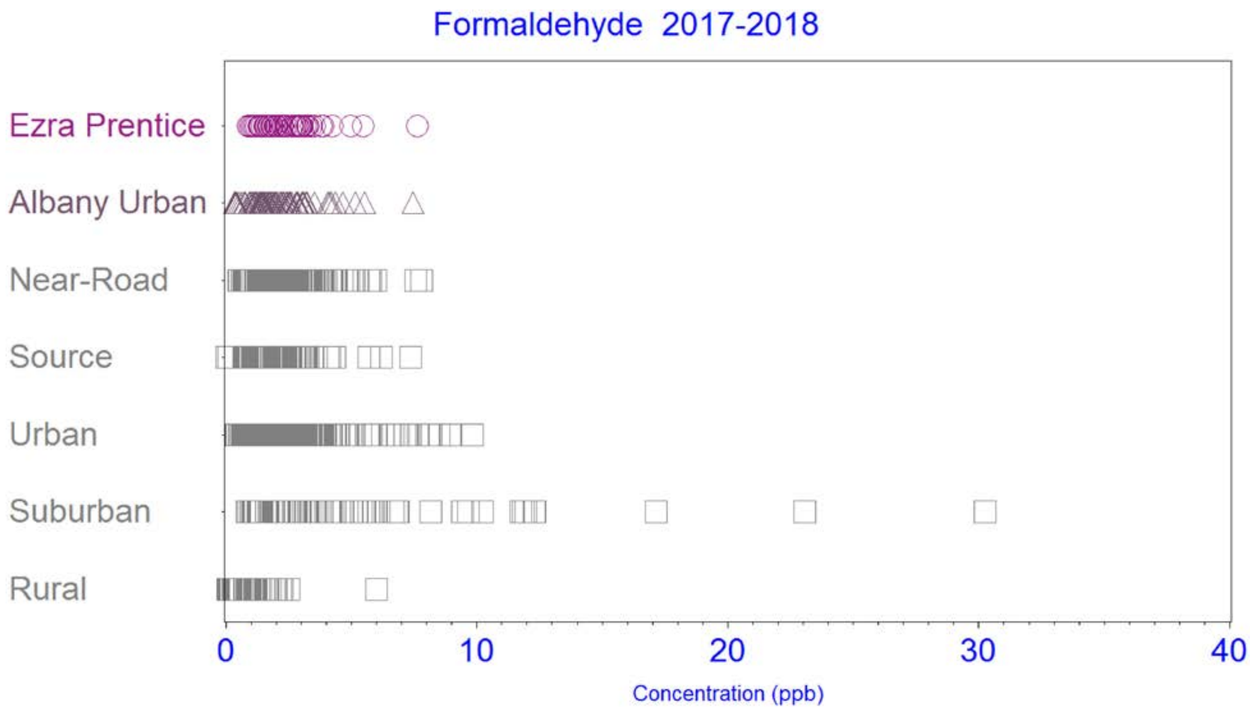


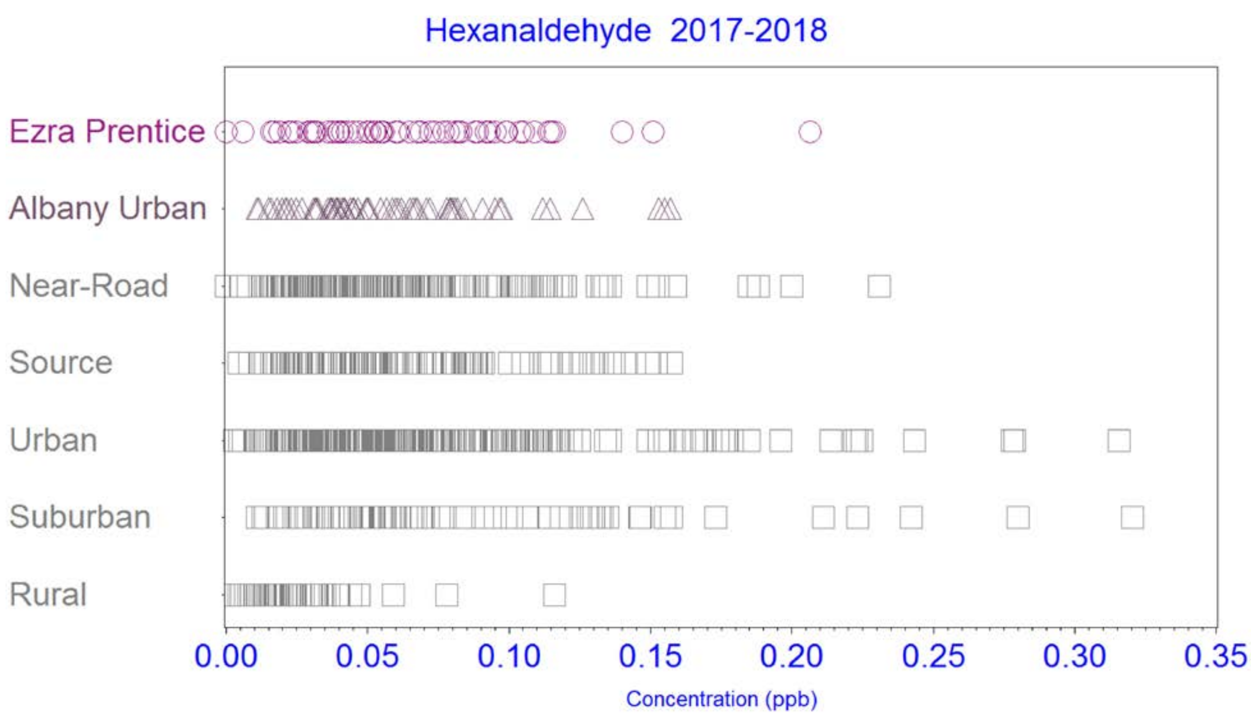
Trichlorotrifluoroethane 2017-2018
Ezra Prentice
Albany Urban
Urban
Suburban
Source
Rural
0.00 0.02 0.04 0.06 0.08 0.10
Concentration (ppb)

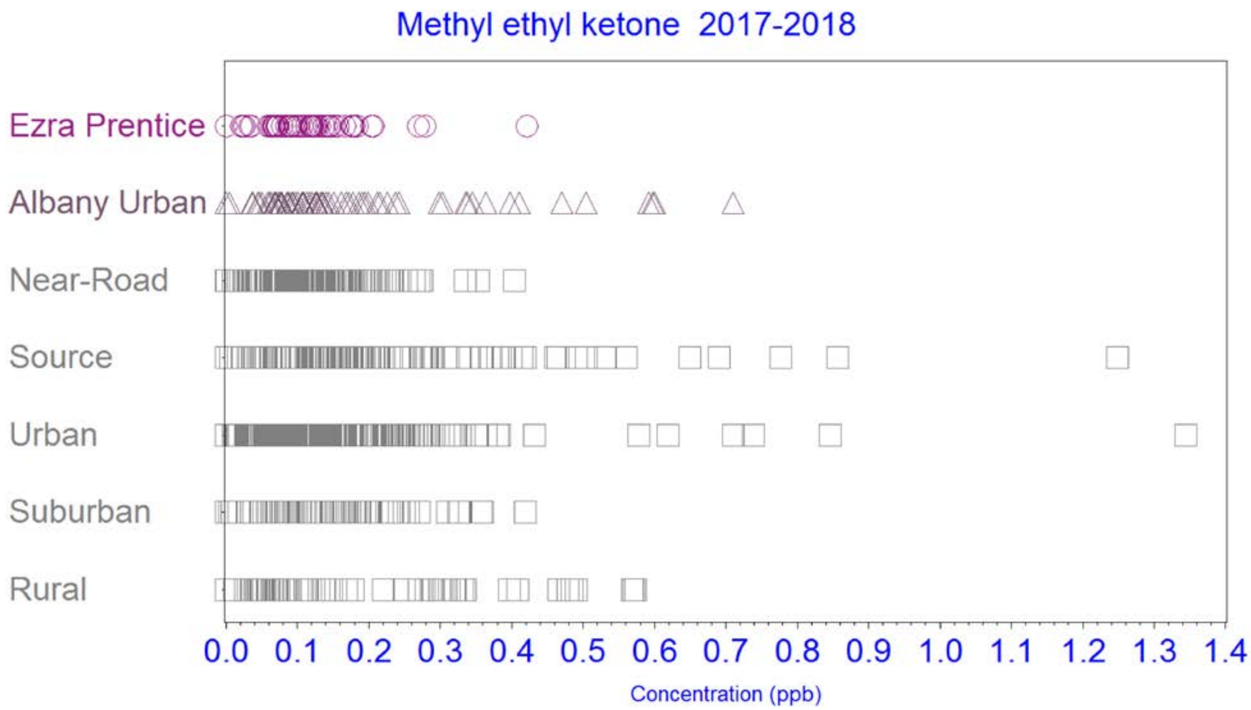
Appendix F: Graphic Comparison Carbonyls Measured at Ezra Prentice Compared to NYSDEC Monitoring Network



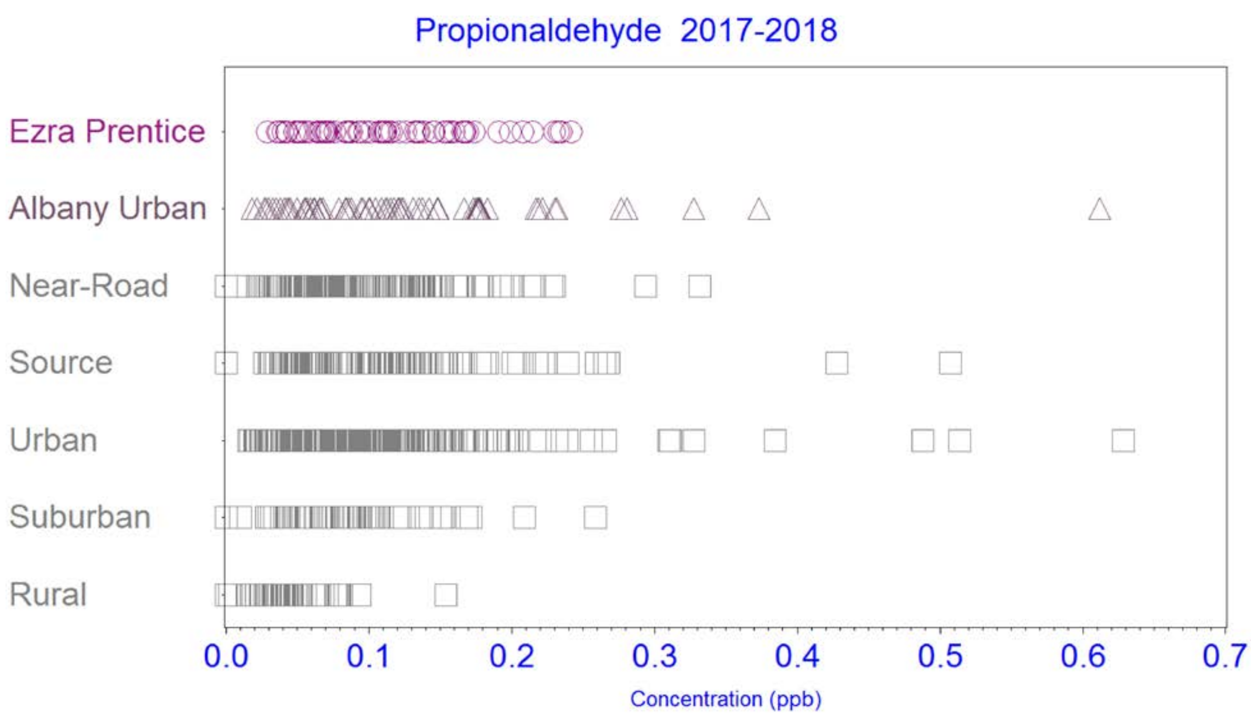



Formaldehyde 2017-2018
Ezra Prentice
Albany Urban
Near-Road
Source
Urban
Suburban
Rural
0
10
20
30
40
Concentration (ppb)

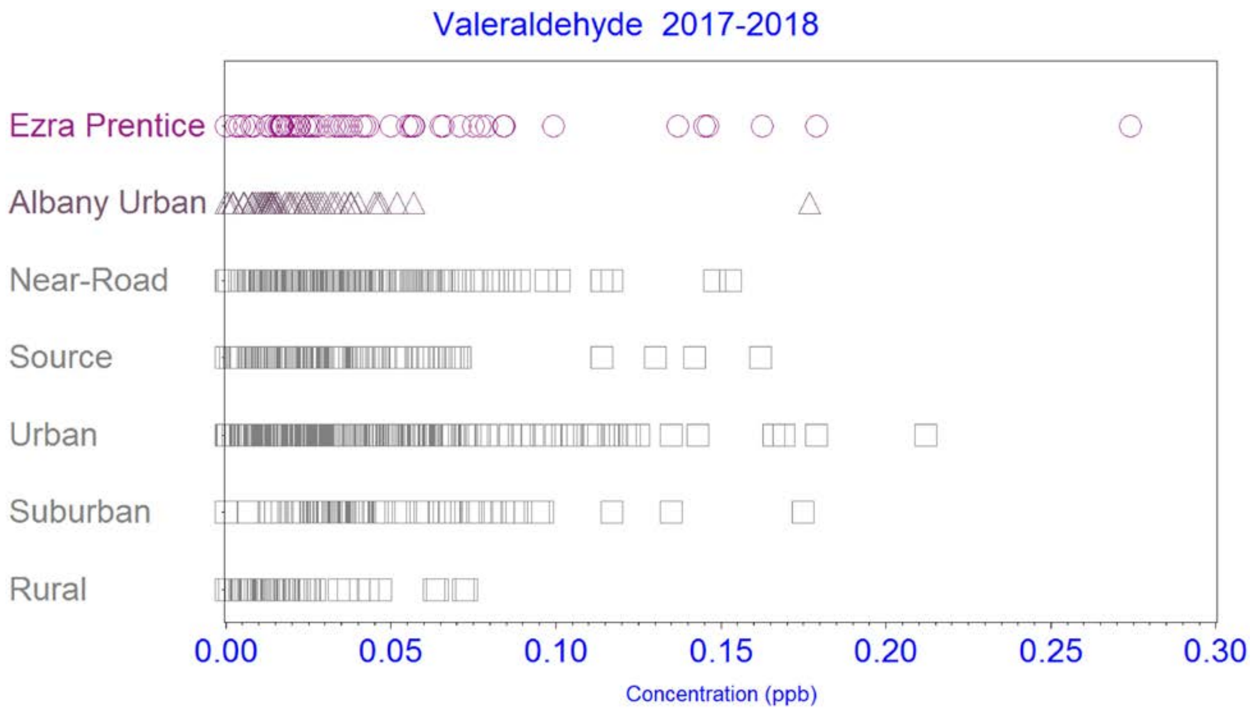

Hexanaldehyde 2017-2018
Ezra Prentice
Albany Urban
Near-Road
Source
Urban
Suburban
Rural
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
Concentration (ppb)



Methyl ethyl ketone 2017-2018
Ezra Prentice
Albany Urban
Near-Road
Source
Urban
Suburban
Rural
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4
Concentration (ppb)



Propionaldehyde 2017-2018
Ezra Prentice
Albany Urban
Near-Road
Source
Urban
Suburban
Rural
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7
Concentration (ppb)



Valeraldehyde 2017-2018
Ezra Prentice
Albany Urban
Near-Road
Source
Urban
Suburban
Rural
0.00
0.05
0.10
0.15
0.20
0.25
0.30
Concentration (ppb)

Appendix G: Regression Analysis on PM_{10}, $PM_{2.5}$, UFP, NO, and BC

In the report, we discuss the correlation (Spearman's rank-order correlation as shown in Table 15) or graphical relationship (as shown in Figures 29–34) of pollutant concentrations to other factors such as volume of cars and trucks or proximity to a roadway. In this Appendix, we report on the use of regression analysis to examine the simultaneous relationship of multiple variables on pollutant concentrations. A modeling approach was used to evaluate the nonlinear relationship between all the variables measured in the study with pollutant concentrations. The modeling approach used is called the multivariate adaptive regression splines.[1]

The following independent variables were used to evaluate their effect on pollutant concentration (dependent variable).

- Meteorological
  - Barometric pressure
  - Wind speed
  - Wind direction
  - Temperature
- Total number of vehicles
  - Classes 1–3 (mostly cars)
  - Classes 4–13 (trucks, mostly diesel)
  - Total vehicles
- Day of week
  - Weekday
  - Weekend

Only variables with a statistical significance less than 0.05 were retained in the model. The results for each pollutant are detailed in the following sections.

Particulate Matter 10 Microns and Less in Size (PM_{10})

As illustrated in Figure 9 of the report, the weekday PM_{10} concentration at Ezra Prentice peaks in the morning, which coincides with the morning peak traffic count for both cars and trucks. The concentration gradually declines over the rest of the day even though there is another peak in car traffic during the evening commute and the truck traffic remains high until 4:00 p.m. This suggests another factor or factors influencing the decline in PM_{10} concentration.

As illustrated in Table 1 of this Appendix, the variables that influence PM_{10} concentrations were total number of vehicles in classes 4-13 (trucks), wind speed, barometric pressure, relative humidity, and temperature. The model was improved by selecting winds blowing from the range of 45–135 degrees (northeast to southeast directions, which is the direction of South Pearl Street with reference to the monitor) and restricting the analysis to weekdays. The regression analysis resulted in an R-squared of 0.35, which means that 35% of the variability in PM_{10} concentrations can be explained by these five factors. As illustrated in Figure 1, PM_{10} concentrations increase until vehicle counts of 68, after which concentrations remain constant. Total vehicles in classes 4–13 had a model importance of 100%. Increasing wind speeds decrease PM_{10} concentration, and to a lesser degree when winds reach 3.1 miles per hour (mph). The wind speed variable had a model importance of 92%. In general, increasing barometric pressure increases PM_{10} concentrations, and barometric pressure was of 48% model importance. Relative humidity increases PM_{10} concentrations until 38%, after

[1] This model is a nonparametric approach. The pollutant concentrations evaluated were log-normally distributed.

which concentrations decrease, with rapid decline at 87% relative humidity. Relative humidity had a model importance of 47%. Temperature's importance in the model was low (9%) and predicted to increase PM_{10} concentrations until 36.1°F.

Conclusion: The strongest predictor of an increase in PM_{10} concentration was increased truck volume. Increasing wind speed decreases PM_{10} concentrations. Barometric pressure, in general, increases PM_{10} concentrations. Relative humidity increases PM_{10} until moderate-to-high relative humidity conditions, after which PM_{10} concentrations decrease. Lastly, temperature plays a small role in increasing PM_{10} concentrations but only when temperatures are below 36.1°F. These five variables explain 35% of the variability in UFP counts.

Table 1. PM_{10} Results of Regression Analysis

Independent Variable	Value for change in concentration	Importance in the model (%)
Total vehicles (Class 4–13) (Trucks)	68	100
Wind speed (mph)	3.1	92
Barometric pressure (inches of Hg)	29.79, 30.14	48
Relative humidity (%)	38, 87	47
Temperature (°F)	36.1	9

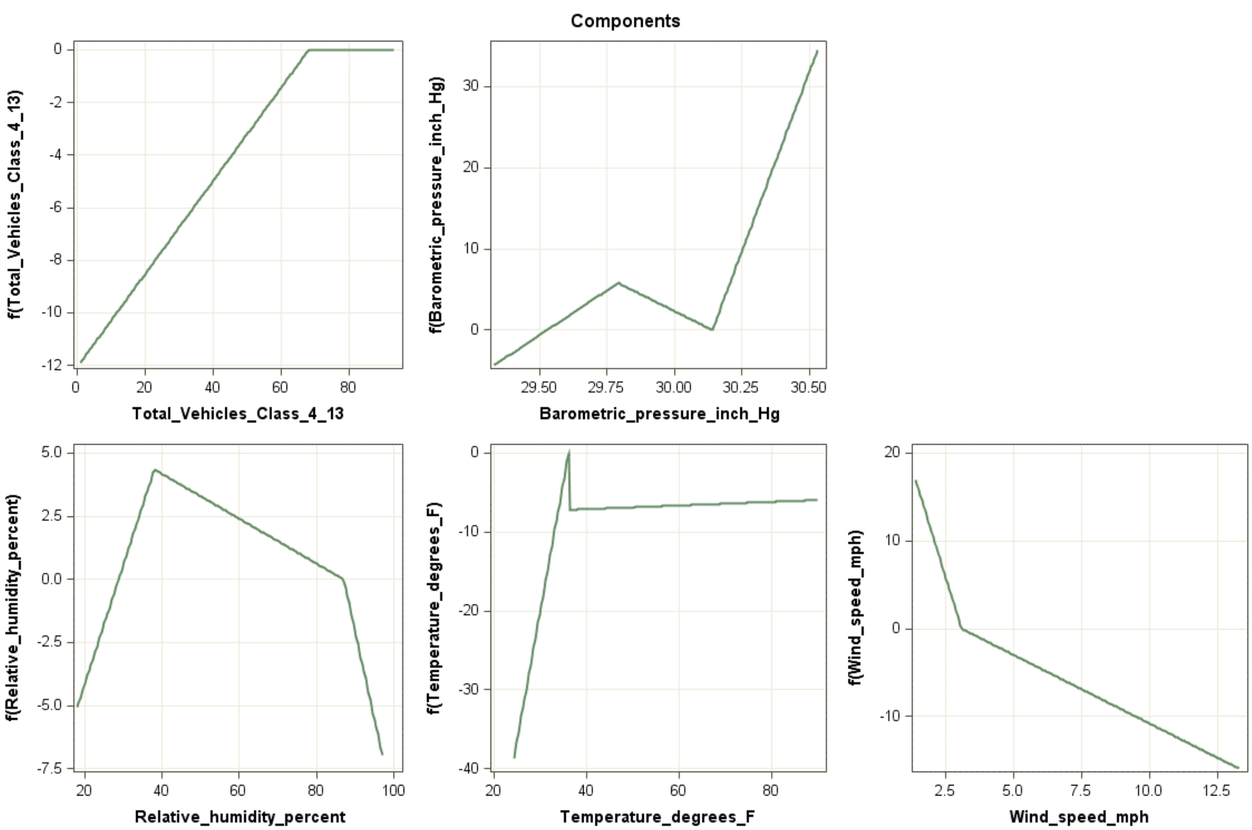


Figure 1. PM_{10} Concentration Modeled Relationship to Independent Variables

Fine Particulate Matter, 2.5 Microns and Less in Size ($PM_{2.5}$)

As illustrated in Figure 7 of the report, the weekday $PM_{2.5}$ concentration at Ezra Prentice peaks in the morning, which coincides with the morning peak traffic for both cars and trucks. The concentration gradually declines over the rest of the day even though there is another peak in car traffic during the evening commute and the truck traffic remains high until 4:00 p.m. This suggests another factor or factors influencing the decline in $PM_{2.5}$ concentration.

As illustrated in Table 2, the variables that influence $PM_{2.5}$ concentrations were temperature, wind speed, total number of vehicles in classes 4–13 (trucks) and wind direction. The model was greatly improved by restricting the analysis to weekdays. The regression analysis resulted in an R-squared of 0.25, which means that 25% of the variability in $PM_{2.5}$ concentration can be explained by these four factors. As illustrated in Figure 2, $PM_{2.5}$ concentrations increase after temperatures reach 63°F and this factor had a model importance of 100%. $PM_{2.5}$ concentrations gradually increase after wind speeds of 8.1 mph, and this factor had a model importance of 97%. As truck volume increases, $PM_{2.5}$ concentrations increase until vehicle counts of 71 (model importance of 19%), after which concentrations decrease. Winds from 180 to 360 degrees (south, west, and north) decrease $PM_{2.5}$ concentrations (model importance of 18%).

As shown in Figure 21 of the report, wind speeds increase after 8:00 a.m., the morning peak for traffic. Wind speeds continue to increase until about 2:00 p.m. in the afternoon, after which they decline.

Conclusion: The strongest predictor for increases in $PM_{2.5}$ concentrations is temperature. Increasing wind speeds decrease $PM_{2.5}$ concentrations. Winds from the south, west, and north decrease $PM_{2.5}$ concentrations at the Ezra Prentice monitor. Since $PM_{2.5}$ is primarily a regional pollutant, the modeling results support this conclusion. Only 25% of the variability in $PM_{2.5}$ concentrations can be predicted by temperature, wind speed, truck volume, and wind direction.

Table 2. $PM_{2.5}$ Results of Regression Analysis

Independent Variable	Value for change in concentration	Importance in the model (%)
Temperature (°F)	63	100
Wind speed (mph)	8.1	97
Total vehicles (Class 4–13) (Trucks)	71	19
Wind direction (degrees)	180, 225	18

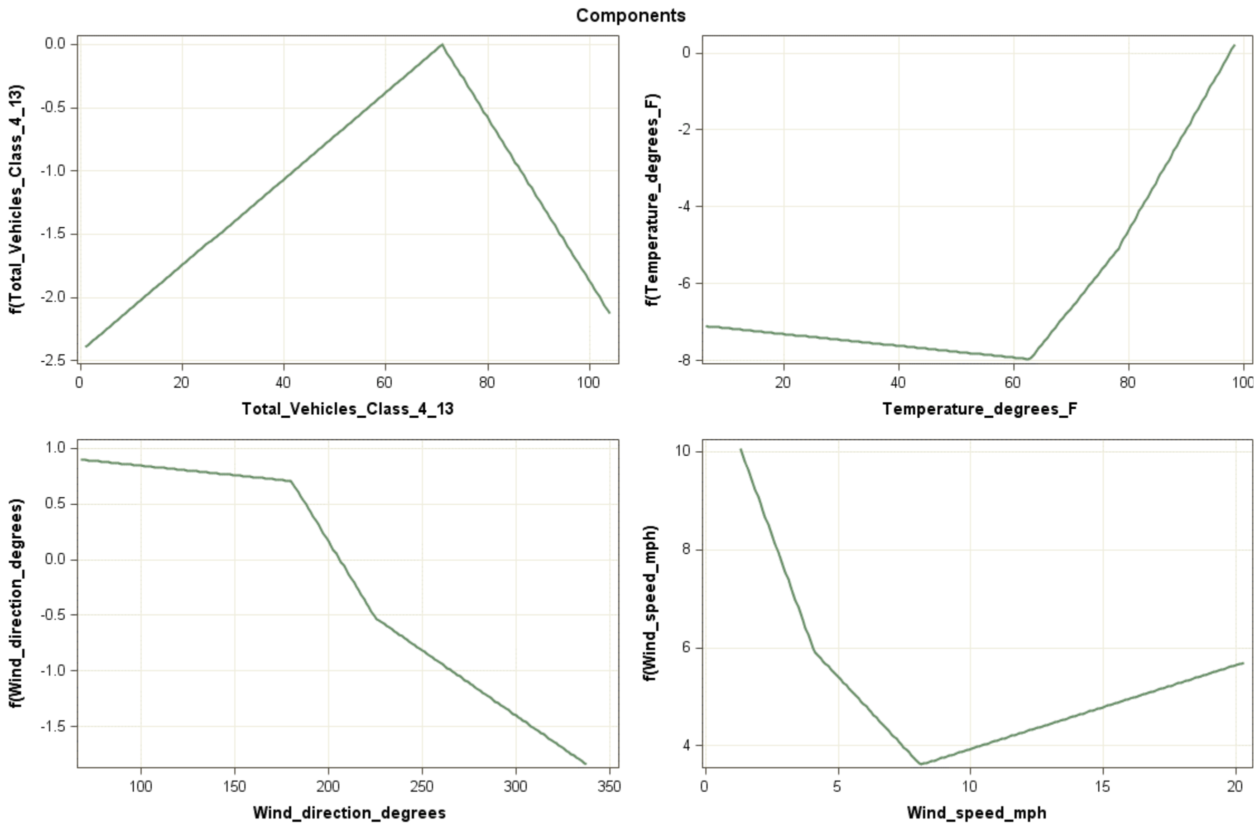


Figure 2. $PM_{2.5}$ Concentration Modeled Relationship to Independent Variables

Ultrafine Particles (UFP)

As illustrated in Figure 11 of the report, and similar to $PM_{2.5}$, the weekday UFP count at Ezra Prentice peaks in the morning, which coincides with the morning peak traffic for both cars and trucks. The concentration gradually declines over the rest of the day even though there is another peak in car traffic during the evening commute and the truck volume remains high until 4:00 p.m. This suggests another factor or factors influencing the decline in UFP counts.

As illustrated in Table 3, the variables that influence UFP counts were total number of vehicles in classes 4–13 (trucks), wind speed, and temperature. The model was greatly improved by selecting winds blowing from the range of 45–135 degrees (northeast to southeast directions, which is the direction of South Pearl Street with reference to the monitor) and restricting the analysis to weekdays. The regression analysis resulted in an R-squared of 0.51. Which means that roughly half of the variability in UFP counts can be explained by these five factors. As illustrated in Figure 3, UFP counts increase after truck volume reaches 34 per hour and this factor had a model importance of 100%. Wind speed decreases UFP counts after 3.3 mph with a model importance of 23%. As shown in Figure 21 of the report, wind speeds increase after 8:00 a.m., which coincides with the morning peak for traffic. Wind speeds continue to increase until about 2:00 p.m., after which they decline. Increase in temperatures above 50°F decrease UFP counts until 54°F, where the UFP count remains constant. At temperatures above 83°F, UFP counts rapidly decrease. UFP counts increase when the barometric pressure reaches 30.4 inches of Hg. Lastly, UFP counts decrease when the relative humidity is greater than 35%, which makes sense because under humid conditions UFP can adsorb moisture or attach to each other to become larger and less numerous.

Conclusion: The strongest predictor of rises in UFP counts is increasing truck volume. Higher wind speeds and temperatures decrease UFP counts. UFP counts increase with increased truck activity and when barometric pressure increases, and decrease as relative humidity increases. Five variables explain 51% of the variability in UFP counts.

Table 3. UFP Results of Regression Analysis

Independent Variable	Value for change in concentration	Importance in the model (%)
Total vehicles (Class 4 -13) (trucks)	34	100
Wind speed (mph)	3.3	23
Temperature (°F)	50, 54, 83	11
Barometric pressure (inches of Hg)	30.4	5
Relative humidity (%)	35	5

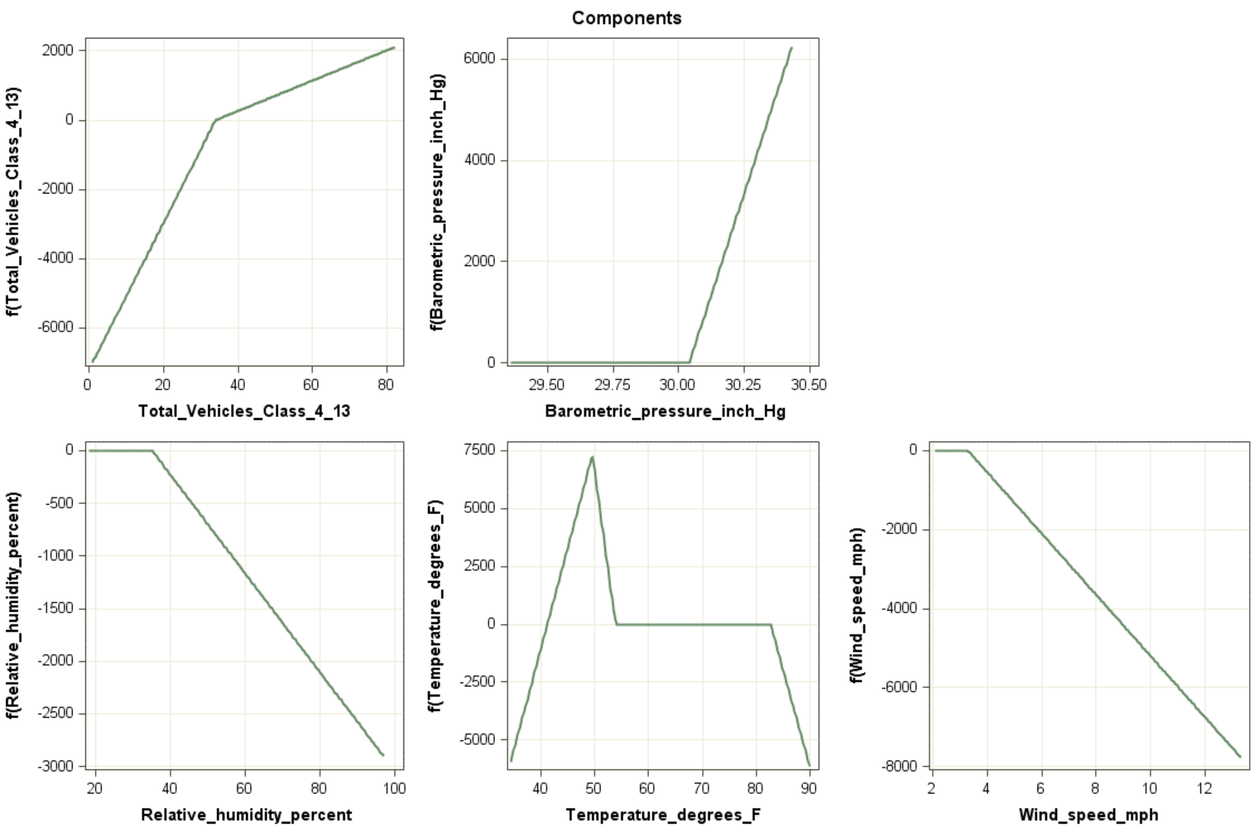


Figure 3. UFP Counts Modeled Relationship to Independent Variables

Black Carbon (BC)

As illustrated in Figure 13 of the report, and similar to $PM_{2.5}$ and UFP, the weekday BC concentration at Ezra Prentice peaks in the morning, which coincides with the morning peak traffic for both cars and trucks. The concentration gradually declines over the rest of the day even though there is another peak in car traffic during the evening commute and the truck traffic remains high until 4:00 p.m. This suggests another factor or factors influencing the decline in BC concentration.

In Table 4, the variables that influence BC concentration were total number of vehicles in classes 4–13 (trucks) and wind speed. The model was greatly improved by selecting winds blowing from the range of 45–135 degrees (northeast to southeast direction, which is the direction of South Pearl Street with reference to the monitor) and restricting the analysis to weekdays. The regression analysis resulted in an R-squared of 0.41, which means that 41% of the variability in BC concentration can be explained by these two factors. As illustrated in Figure 4, BC concentration increases until truck volume reaches 56 per hour, after which the BC concentration remains constant. The BC concentration increases after truck volume reaches 78 per hour. This factor had a model importance of 100%. Wind speed decreases BC concentration rapidly after winds reach 2.8 mph, as illustrated in Figure 3. The decline continues but not at the same rate when wind speed reaches 4.6 mph. This factor had a model importance of 62%. As shown in Figure 21 of the report, wind speeds increase after 8:00 a.m., the morning peak for traffic. Windspeeds continue to increase until about 2:00 p.m. in the afternoon, after which they decline.

Conclusion: The strongest predictor of an increase in BC concentration is increasing truck volume. BC concentration falls as wind speed increases. These two variables explain 41% of the variability in UFP counts.

Table 4. BC Results of Regression Analysis

Independent Variable	Value for change in concentration	Importance in the model (%)
Total vehicles (Class 4 -13)	56, 78	100
Wind speed (mph)	2.8, 4.6	62

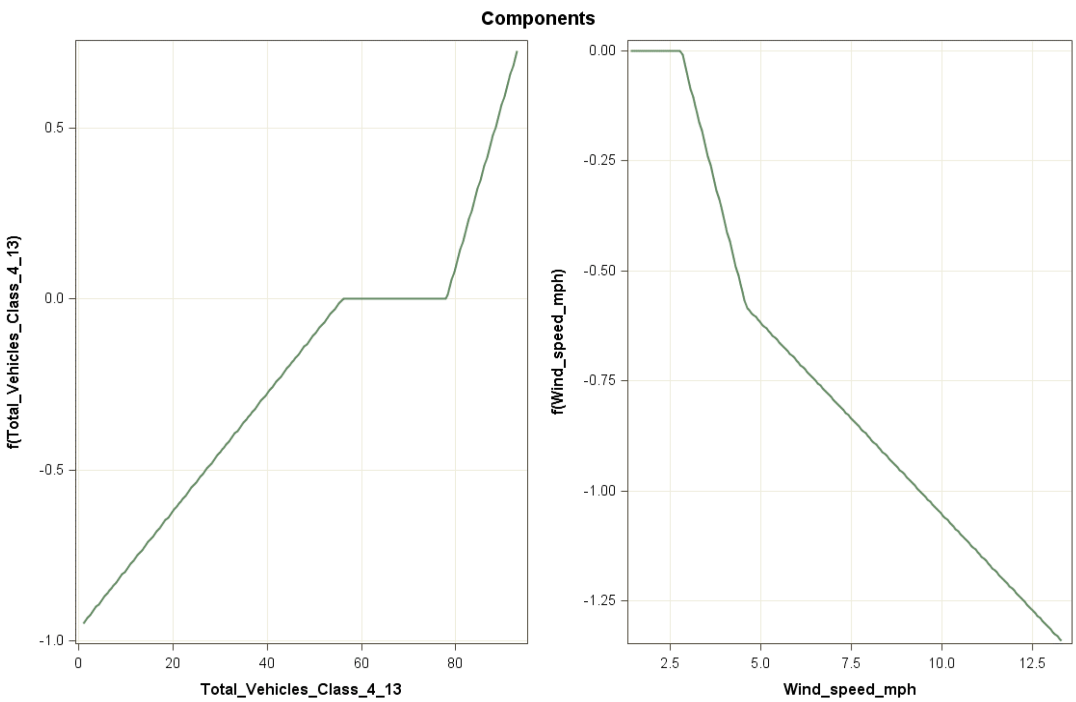


Figure 4. UFP Counts Modeled Relationship to Independent Variables

Nitrogen Oxide (NO)

As illustrated in Figure 15 of the report, and similar to $PM_{2.5}$, UFP, and BC, the weekday NO concentration at Ezra Prentice peaks in the morning, which coincides with the morning peak traffic for both cars and trucks. The concentration gradually declines over the rest of the day even though there is another peak in car traffic during the evening commute and the truck traffic remains high until 4:00 p.m. This suggests another factor or factors influencing the decline in NO concentration.

As illustrated in Table 5, the variables that influence NO concentration were total number of vehicles in classes 4–13 (trucks), barometric pressure, wind speed, and relative humidity. The model was greatly improved by selecting winds blowing from the range of 45–135 degrees (northeast to southeast, which is the direction of South Pearl Street with reference to the monitor) and restricting the analysis to weekdays. The regression analysis resulted in an R-squared of 0.40, which means that 40% of the variability in NO concentration can be explained by these four factors. As illustrated in Figure 5, NO concentration increases after truck volume reaches 66 per hour, and this factor had a model importance of 100%. NO concentration increases when the barometric pressure reaches 30.2 inches of Hg, with a model importance of 63%. Decreasing NO concentrations are measured with wind speeds above 4.0 mph. As shown in Figure 21 of the report, wind speeds increase after 8:00 a.m., the morning peak for traffic. Wind speeds continue to increase until about 2:00 p.m. in the afternoon, after which they decline. This factor had a model importance of 46%. Lastly, NO concentration increases until relative humidity reaches 47%, after which changes in relative humidity have no influence in NO concentration. This factor had a model importance of only 4.2%.

Conclusion: The strongest relationship for predicting an increase in NO concentration is with increasing truck volume. Increasing barometric pressure increases NO concentration, and increasing wind speed decreases NO concentration. Increasing relatively humidity to 47%, increases NO concentration. These four variables explain 40% of the variability in NO concentration.

Table 5. Nitrogen Oxide
Results of Regression Analysis

Independent Variable	Value for change in concentration	Importance in the model (%)
Total vehicles (Class 4 -13)	66	100
Barometric pressure (inches of Hg)	30.2	63
Wind speed (mph)	4.0, 4.8	46
Relative humidity (%)	47	4.2

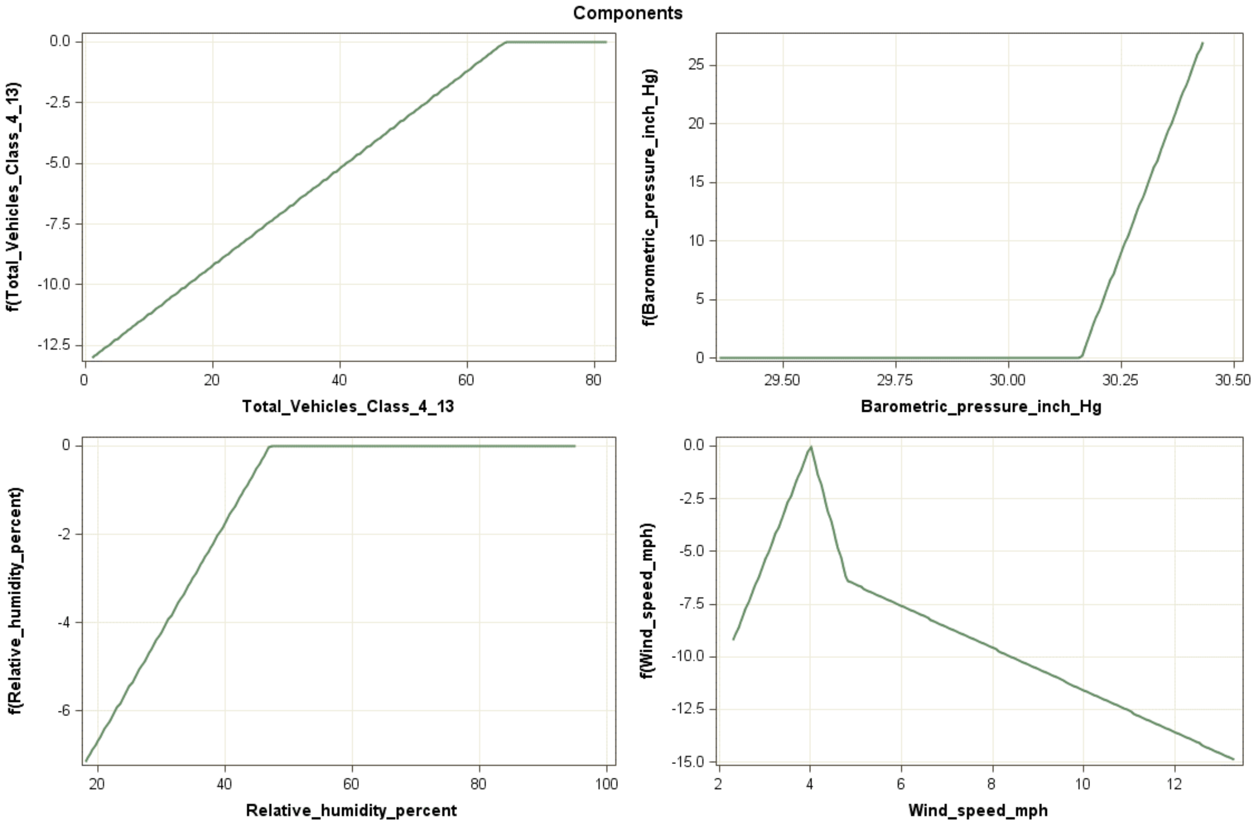


Figure 5. NO Concentration Modeled Relationship to Independent Variables

Appendix H: Statistically Peak Minutes Are Separate

Durbin-Watson Test Statistic

Ultrafine particles are counted (number of particles/cm^3) with condensation particle counters (CPCs), which use condensation to grow particles into a large-enough size for them to obstruct a beam of light. A light detector then provides a signal that is converted to the number of particles per cubic centimeter. CPCs have a very high time response and can perform one measurement per sec (1Hz) producing a very robust sample number. However, there is a concern that the values in this high frequency time series are not random and will be self-correlated or auto-correlated; i.e., the preceding values in the time series affect future values in time. Autocorrelation may result in sampling error. Comparing adjacent time periods (Lag 1) for autocorrelations is done to detect non-randomness.

The Durbin-Watson test is used to detect autocorrelation at Lag 1 in the residuals (prediction errors) in a regression analysis of variables. In this case, the regression is of the same variable (CPC data) at times t and (t-1). If the Durbin-Watson test statistic is approximately 2, there is no autocorrelation. The closer the statistic approaches 0, the more autocorrelation present. Table below shows the correlation and the Durbin-Watson test statistic with Lag 1 for CPC data collected on a 1-second- and 1-minute basis. The results indicate that on a 1-second basis, CPC data is more autocorrelated compared to the 1-minute average that shows no autocorrelation.

Table 1. Durbin Watson Test Statistic for Autocorrelation of CPC Data at 1 Second and 1 Minute Time Resolution

CPC Data (number of particles/cm^3) Time	Sample Number (n)	Correlation Lag 1	Durbin Watson Statistic
1 second	89995	0.96	1.58
1 minute	1496	0.53	2.07

The CPC data averaged to 1-minute were used to select minute time periods when concentrations were highest (peak) and lowest (Appendix I). Based upon the Durbin-Watson test statistic, the 1-minute concentration values are not autocorrelated and therefore, separate from one another. Peaks detected during a minute are from one or more of the vehicles that passed the mini-station during that minute.

Appendix I: Statistical Approach to Determine Peak and Low Concentration Minutes

Researchers analyzing high time resolution measurements of emissions from traffic sources, like those taken with portable instruments during this study, have developed a variety of approaches for determining when concentrations exceed some significant threshold ("peaks") compared to the rest of the data distribution.

No single method is the definitive approach, and here are some examples of the methods that have been applied:

- Choi (et. al., 2013)[1] defined the threshold as the baseline plus three times the standard deviation of the baseline;
- Buzzard (et. al., 2009)[2] defined the threshold as the average of the background concentration plus ten times the standard deviation of the background concentration, based on a three-point running average;
- Orkin (et. al., 2013)[3] employed density curves based on percentiles;
- Park (et. al., 2011)[4] employed an emission factor distribution;
- Hu (et. al., 2012)[5] set arbitrary threshold values.

In this study, the peak threshold value was set using the formal statistical definition of an outlier, i.e., equal to the third quartile (50th to 75th percentile of values) plus 1.5 times the interquartile range (highest 75th percentile value minus the lowest 25th percentile value). This approach was selected for the following reasons:

- Compared to the approaches outlined above, it is extremely conservative. Peak concentrations (outliers) represent a defined group of observations with measurements that are much higher than most of the remaining measurements. The distinction between peak emissions—and the times and vehicles associated with them—is a statistically significant and separate data set.
- Outliers constitute an important fraction of the data, i.e., ~10% of the data points and ~25% of the total particle concentration on all time scales.
- The outlier measurements reflect actual exposure measurements taken with the portables and should not be discarded as "noise."
- The outlier measurements can be shown to have patterns that correlate to traffic sources.

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[1]Choi, w. et al. 2013. Neighborhood-scale air quality impacts of emissions from motor vehicles and aircraft. Atmospheric Environment 80, 310-321.

[2] Buzzard, N. et al. 2009. Investigations into pedestrian exposure to near-vehicle exhaust emissions. Environmental Health, 8: 13.

[3] Orkin,A. et al. 2013. Peak event analysis: a novel empirical method for the evaluation of elevated particulate events. Environmental Health 12:92.

[4] Park, SS et al. 2011 Emission factors for high-emitting vehicles based on on-road measurements of individual vehicle exhaust with a mobile measurement platform. J Air Waste Mange Assoc. Oct; 61(10):1046-56.

[5] Hu, S. et al. 2012. Observation of Elevated Air Pollutant Concentrations in a Residential Neighborhood of Los Angeles California Using a Mobile Platform. Atmospheric Environment May 1; 51: 311–319.

- There was significant daily variation in the measured and background particle concentrations; the outlier approach allows peaks to be distinguished from the rest of the data regardless of whether the overall concentrations are high or low.

The method used in this study further incorporated the following principles:

- Ultrafine particle (UFP) counts (number of particles/cm^3) and lung deposited surface area (LDSA) ($\mu m^2/cm^3$) were given equal weight. Investigations of the relationship between particle number and LDSA indicate that they are correlated but also exhibit differences, possibly based on the source of the emissions and particle size.[6] Incorporating LDSA as well as particle count ensured that vehicles emitting particles with high LDSA would not be neglected in the data set.
- Data from mini-stations located on both sides of the road were also given equal weight. The reasons for the persistent difference between particle measurements on opposite sides of the road described in the report (high on the east side for Ezra Prentice, higher on the south side for Southern Boulevard) are not yet fully understood. Weighting both stations equally ensured that traffic on both sides of the road would be accounted for, as well as any effects such as local meteorology, etc. that may be contributing to the concentration asymmetry.
- Black carbon measurements were not included as a determiner of peak threshold for two reasons:
  - Black carbon measurements were not available on both sides of the road due to a shortage of available instrumentation.
  - Black carbon measurements did not exhibit peak behavior to the same degree as the UFP measurements. Two possible explanations for this are:
    - Black carbon measurements were taken at a lower time resolution (1-minute) than the UFP measurements (1-second).
    - Little is known about peak vehicle emissions in general; black carbon may not physically exhibit the same peak behavior as UFP emissions.

Based on the principles outlined above, the basic approach used was as follows:

- Determine separate peak thresholds for UFP counts and LDSA based on one second data.
- Average UFP and LDSA to a 1-minute basis and associate with corresponding 1-minute resolution data gathered for other metrics (e.g., black carbon). The Durbin-Watson test statistic demonstrates that UFP and LDSA are not autocorrelated on a 1-minute basis (Appendix H).

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[6] Marilyn Wurth, Brian P. Frank, Gil H. LaDuke, Oliver V. Rattigan, H. Dirk Felton, Jake Lindberg, Nicole Vitillo, Patricia Fritz, and Thomas Wainman, Poster: *Simultaneous Measurements of Lung Deposited Surface Area, Particle Number Concentration, Particle Size, and Black Carbon to Characterize Near Roadway and Biomass Emission Sources*, 10th International Aerosol Conference, St. Louis, MO, September 2-7, 2018.

- Split into four data sets based on thresholds:
  - UFP/peak
  - UFP/non-peak
  - LDSA/peak
  - LDSA/non-peak
- Calculate rank of individual measurements relative to each other within each data set based on either UFP or LDSA.
- Combine peak and non-peak data sets, i.e.,
  - (UFP/peak + LDSA/peak)
  - (UFP/non-peak + LDSA/non-peak)
- Calculate composite score within each data set
  - Composite score = UFP rank + LDSA rank
- Rank peak and non-peak data set by composite score
- Ranked peak data set = "peak concentration minutes." Equal weight was given to all UFP and LDSA data in subsequent analyses. The final data set included minutes classified as peak concentration based on either UFP or LDSA rank above their individual thresholds.
- The ranked non-peak data set was used to determine the "low concentration minutes" for vehicle class and fleet comparisons:
  - The number of peak minutes during a measurement day was determined.
  - An equal number of minutes was selected from the non-peak data set, starting from the lowest-concentration rankings.
  - This number was modified as needed since some peak concentration minutes had to be excluded from the final analysis due to missing measurements or photos for those times.

Appendix J: Fleet Composition of Class 4, 5, 6 & 9 Vehicles Present during Peak and Low Minutes

This study measured peak ultrafine particle (UFP) concentrations (number of particles/cm^3) generated by High-Emitting Vehicles (HEVs), i.e., vehicles with emissions statistically higher than other vehicles. A camera was set up along the side of the road, next to the mini-monitoring stations measuring the UFP concentrations, and a laser beam that projected across both lanes of traffic. When an object breaks the laser beam, the camera collects an image, so the system images every vehicle that passes.

The images from the cameras were evaluated on a one-minute basis. The durations of the concentration peaks are less than a minute, and statistically, each minute is separate (Appendix H). Therefore, peaks detected during a minute must be from one or more of the vehicles that passed the mini-station during that minute. To avoid penalizing vehicles that were also present during these minutes but may not be contributing to the peak, an equal number of minutes during the lowest UFP concentration were also chosen for comparison. The statistical method used to identify peak and low minutes is described fully in Appendix I.

The images were used to identify every vehicle present during the peak and low concentration minutes (4,157 vehicles total). Vehicles in the images were then further identified by vehicle class using the Federal Highway Administration classification. The number of vehicles in each class during peak and low concentration minutes were then compared to determine what types of vehicles were present during peak and low minute groupings. Tables 1, 2, 3, and 4 provide detailed information by vehicle class about the specific vehicle fleets present during peak and low minutes.

Table 1. Fleet Composition of Class 4 Vehicles Present during Peak and Low Minutes at Ezra Prentice

Fleet	First Student School Bus	CDTA (idling removed)	Durham School Bus	Fleet Not Strongly Present	Fleet Not Identifiable
% of Vehicles of this Class Present During Peak Minutes	49	14	11	8	19
Number of Potential HEVs	38	11	8	6	15
Number of Vehicles During Peak vs. Low Minutes	7.6	5.5	2.7	-	-

Table 2. Fleet Composition of Class 5 Vehicles Present during Peak and Low Minutes at Ezra Prentice

Fleet	Center for Disability Services	First Student School Bus	CDTA STAR	Durham School Bus	Fleet Not Strongly Present	Fleet Not Identifiable
% of Vehicles of this Class Present During Peak Minutes	17	7	3	1	31	41
Number of Potential HEVs	44	19	7	2	80	106
Number of Vehicles During Peak vs. Low Minutes	2.3	1.2	3.5	2	-	-

Table 3. Fleet Composition of Class 9 Vehicles Present during Peak and Low Minutes at Ezra Prentice					
Fleet	**Foodliner**	**Alynye**	**Mirabito**	**Fleet Not Strongly Present**	**Fleet Not Identifiable**
% of Vehicles of this Class Present During Peak Minutes	15	5	5	35	41
Number of Potential HEVs	10	3	3	23	27
Number of Vehicles During Peak vs. Low Minutes	2.3	3.0	3.0	-	-

Table 4. Fleet Composition of Class 6 Vehicles Present during Peak and Low Minutes at Ezra Prentice			
Fleet	**NYSDOT**	**Fleet Not Strongly Present**	**Fleet Not Identifiable**
% of Vehicles of this Class Present During Peak Minutes	24	35	41
Number of Potential HEVs	17	25	30
Number of Vehicles During Peak vs. Low Minutes	5.7	-	-

Appendix K: Statistical Difference Between Mean Ultrafine Particles (UFP) Concentrations at Ezra Prentice and Southern Boulevard

Ezra Prentice and Southern Boulevard

UFP concentrations measured at Ezra Prentice and Southern Boulevard are positively- or right-skewed due to the presence of outliers (defined as peak concentrations mainly attributed to high-emitting vehicles). Although the central tendency of a skewed distribution may be better represented by the median, UFP concentrations have been presented in this report as averages (means) rather than medians because means are more sensitive to outliers and we want these data to reflect the influence of the outliers, i.e., UFP concentrations from high-emitting vehicles.

Figure illustrates the data distribution (as boxplots) for the 6 mini-stations deployed during two separate measurement periods (5-hour periods, 5 days) at Ezra Prentice and Southern Boulevard. The boxplots show the mean UFP concentrations measured at Ezra Prentice and Southern Boulevard and the presence of outlier concentrations. The outliers in Figure are the points above the maximum value that excludes the outliers (top horizontal bracket above the box). Outliers increase the mean. The mean concentration for each mini-station is the "X" inside each box.

At Ezra Prentice, mini-stations 3 and 4 are located closest (within 15 feet) to South Pearl Street. Mini-stations 1 and 6 are farthest from South Pearl at ~450 and 230 feet, respectively. As shown, mini-station 4 measured the larger mean UFP concentrations closest to the road. At Southern Boulevard, mini-stations 3 and 4 are located closest to the road (within 17 feet). Mini-stations 1 and 6 are farthest from the road at ~200 and 185 feet, respectively. As shown, the mean UFP concentrations at Southern Boulevard are almost half the concentrations measured at some mini-stations at Ezra Prentice.

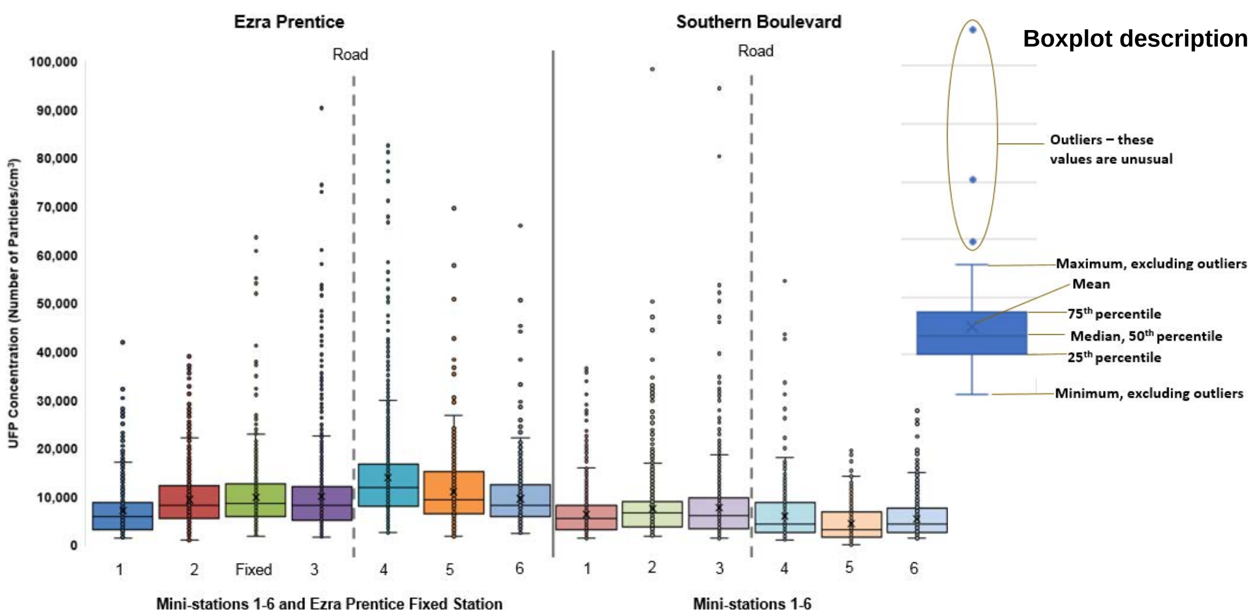

Figure 1. Boxplots of UFP Concentration Measured at Each Mini station at Ezra Prentice and Southern Boulevard

A more detailed statistical analysis is necessary to evaluate whether the differences between group means are significant (as determined by a p-value). A Kruskal-Wallis test is a rank-based nonparametric test that can be used to determine if there are statistically significant differences between three or more groups. Nonparametric tests are recommended when the data are not normally distributed (i.e., the data are skewed).

The Kruskal-Wallis test provided very strong evidence of a difference ($p<0.0001$) between the mean ranks of at least one pair of groups (UFP concentrations measured at Ezra Prentice mini-stations 1–6, and the Ezra Prentice (EP) fixed station).

Multiple comparisons using Dunn's procedure (a post-test following the Kruskal-Wallis test) were carried out on each pair of UFP concentrations measured at the mini-stations and the fixed station to determine which groups were significantly different. Table 1 demonstrates there was very strong evidence of a difference ($p<0.0001$) between UFP concentrations measured at mini-stations 1, 4, 5, and 6. There was no evidence of a difference between UFP concentrations measured at mini-stations 2, 3, and 6. There was no evidence of a difference between UFP concentrations measured at Ezra Prentice fixed station (EP fixed) versus mini-station 6. There was evidence of a difference between the UFP concentrations measured at the fixed station and the other mini-stations (1–5).

Table 1. Ezra Prentice Mini Station Multiple Comparisons (Dunn's Procedure)

Mini Station Comparison	Differences in UFP Concentration (Number of particles/cm^3)	p value	Significant Difference p<0.05
1 vs 2	-1464.590	<0.0001	Yes
1 vs 3	-1414.598	<0.0001	Yes
1 vs 4	-3243.775	<0.0001	Yes
1 vs 5	-2169.448	<0.0001	Yes
1 vs 6	-1636.702	<0.0001	Yes
2 vs 3	-222.104	0.66	No
2 vs 4	-1779.185	<0.0001	Yes
2 vs 5	-704.858	<0.0001	Yes
2 vs 6	-172.112	0.12	No
3 vs 4	-1829.177	<0.0001	Yes
3 vs 5	-754.851	<0.0001	Yes
3 vs 6	-222.104	0.05	No
4 vs 5	1074.326	<0.0001	Yes
4 vs 6	1607.073	<0.0001	Yes
5 vs 6	532.747	<0.0001	Yes
EP Fixed vs 1	1692.977	<0.0001	Yes
EP Fixed vs 2	228.387	0.04	Yes
EP Fixed vs 3	278.379	0.01	Yes
EP Fixed vs 4	-1550.798	<0.0001	Yes
EP Fixed vs 5	-476.471	<0.0001	Yes
EP Fixed vs 6	56.275	0.61	No

A nonparametric statistical test (two-sample Mann Whitney U Test) was used to compare the mean ranks of UFP concentrations measured at Ezra Prentice and Southern Boulevard and to determine whether the concentrations at Ezra Prentice are significantly different and greater than Southern Boulevard. This test compared two-sample sets of UFP concentrations measurements at Ezra Prentice and Southern Boulevard along their respective gradients.

Table 2 shows that based upon the Mann Whitney U Test statistics, UFP concentrations measured at Ezra Prentice are significantly different (p<0.0001) and greater than Southern Boulevard. In other words, the differences in concentrations at Ezra Prentice compared to Southern Boulevard are large enough to be statistically significant.

Mini-station 4 (EP 4) with the largest mean concentration had the largest effect size (r=0.49). The mini-station farthest from the road at Ezra Prentice (EP 1) with the lowest mean concentration had the smallest effect size (r=0.06) when compared to Southern Boulevard (SB 1). The effect size *absolute value (r*) is reported (standard value for r for small=0.1, medium=0.3, and large=0.5).

Table 2. Mann Whitney U Test Results for a 2 sample Comparison of UFP Concentrations Measured at Ezra Prentice (EP) and Southern Boulevard (SB)

Mini Station	n	U	Z value	p value two tailed	Effect Size (r)
EP 1	1499	1148924	3.17	<0.0001	0.06
SB 1	1437				
EP 2	1495	1278471	22.35	<0.0001	0.41
SB 2	1435				
EP 3	1487	1505805	19.08	<0.0001	0.35
SB 3	1437				
EP 4	1496	1681938	26.48	<0.0001	0.49
SB 4	1439				
EP 5	1488	1504370	19.15	<0.0001	0.35
SB 5	1435				
EP6	1498	1648923	24.95	<0.0001	0.46
SB 6	1436				

Appendix L: Black Carbon Portable Instrument Intercomparison

The available three instruments (Aeth Labs MA300 microAethalometer®) measuring black carbon (BC) were placed on the west side of Ezra Prentice. Three instruments (portable mini-stations 1, 2, and 3 with instruments MA300 13, MA300 10, and MA300 9, respectively) were placed ~ 15, 80, and 450 feet from South Pearl St. for five days at Ezra Prentice. As shown in Figure 1, the average BC concentration decreases for mini-station 2 but increases for mini-station 3 (MA300 9).

Three instruments were placed on the north side of Southern Boulevard for four days at increasing distances from the road of ~17, 80, and 185 feet (portable mini-stations 4, 5, and 6 with instruments MA300 13, MA300 10, and MA300 9, respectively). As shown in Figure 2, the average BC concentration for MA300 9 are higher than average BC concentration for the other two stations that are closer to the road.

Based upon an instrument intercomparison, the BC data from MA300 9 located farthest from the road at both locations were excluded from the data set because the instrument measurements appeared to be biased high at both locations.

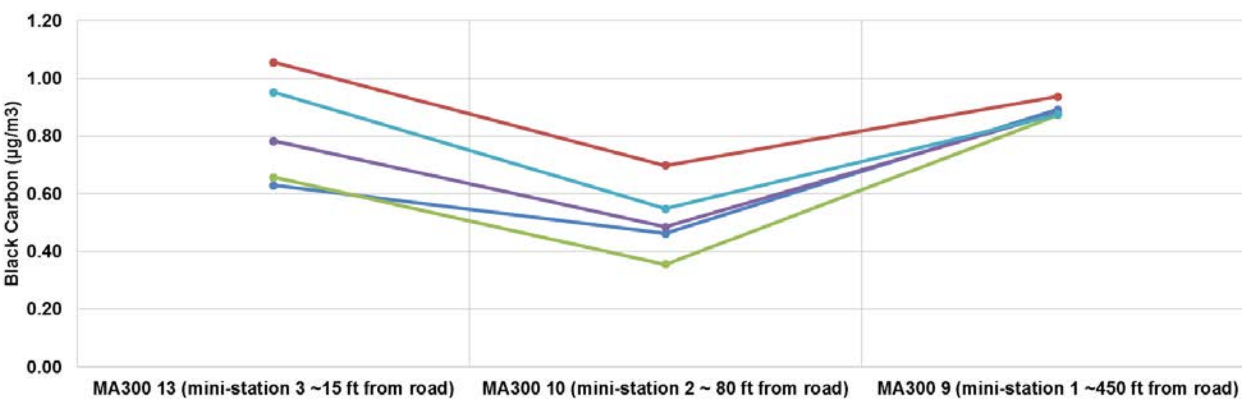

Figure 1. Black Carbon Measured at Ezra Prentice (South Pearl Street)

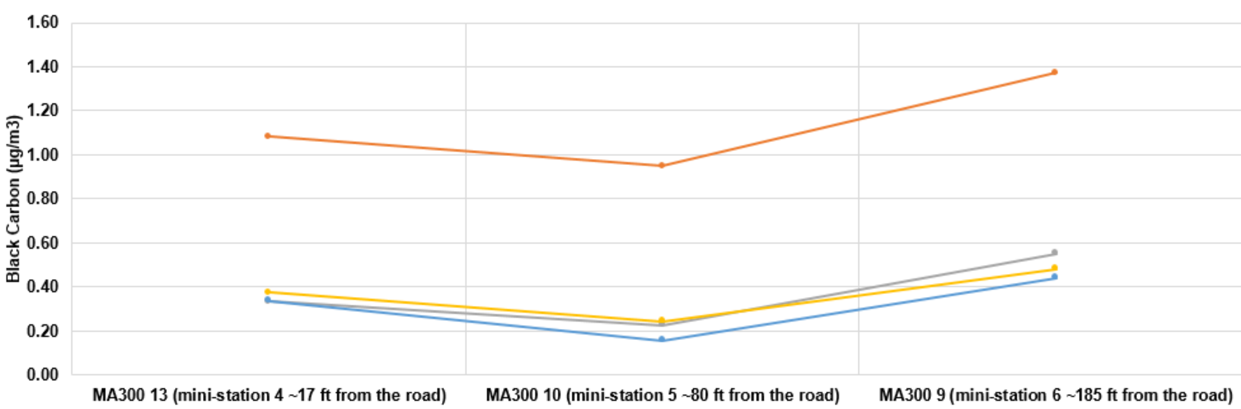

Figure 2. Black Carbon Measured at Southern Boulevard (Southern Boulevard)

As a further instrument intercomparison measure, the three MA300 instruments were simultaneously carried on a backpack during 10 deployments (approximately 2-hours each session) across the South End of Albany. The average, median and standard deviation results from the MA300 10 and MA300 13 instruments are in good agreement (Table 1) and are highly correlated (R^2= 0.91). However, MA300 9 results are much higher and variable and poorly correlated with MA300 10 and MA300 13 measurements (R^2=0.25).

Table 1. Comparison of Black Carbon Backpack Measurements

Instrument	MA300 9	MA300 10	MA300 13
BC (µg/m^3)			
Average	1.47	0.66	0.68
Median	1.00	0.46	0.48
Standard Deviation	2.67	1.40	1.50

BC Data Noise Reduction

The Optimized Noise-reduction Averaging (ONA) algorithm was used to post-process data from the microAethalometers®. When sampling at low concentrations and high time resolutions, BC data sets may have a high occurrence of negative values due to the presence of instrumental optical and electronic noise. The ONA method resolves the noise issue and reduces the occurrence of negative values. BC data was collected on a one minute-average basis and post-processed using the ONA algorithm.[1] Remaining negative values were removed for hourly and daily averaging.

[1] Hagler, G. et al. 2011. *Post-processing Method to Reduce Noise while Preserving High Time Resolution in Aethalometer Real-time Black Carbon Data*. Aerosol and Air quality Research, 11: 539-546.

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