State of Delaware
Department of Natural Resources and Environmental Control

Division of Air Quality

Eden Park Community Ambient Air Quality Study
Wilmington, Delaware: Analytical Report

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Project Title:
Eden Park Community Ambient Air Quality Study Wilmington, Delaware

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Executive Summary

In September of 2016, Delaware's Division of Air Quality (DAQ) launched the Eden Park Project using the Moveable Monitoring Platform (MMP) to investigate air quality for the community of Eden Park. Eden Park is one of several communities along the upper Route 9 corridor outside Wilmington, Delaware. The community is surrounded by various commercial/industrial processes including bulk material processing, metal recycling, concrete manufacturing, as well as the Interstate 495 corridor.

The Eden Park community specifically described visible "dust" as cause for concern. The current 24-hour federal measure of particulate pollution is based on the concentration of microscopic fine particulates, referred to as $PM_{2.5}$. In order to monitor for visible particles, the method used for the former 24-hour federal measure of particulate pollution for the concentration of total suspended particulates (TSP) was used. The state of Delaware maintains the former 24-hour federal standards for TSP as indicators of action to empower regulators to prevent backsliding.

Monitoring was conducted from September of 2016 through January of 2019. Two additional studies were conducted under the umbrella of the Eden Park Project. The Xact Study was planned as an effort to identify sources of particulate pollution. The Dust Distribution Study was planned in response to community questions regarding whether particulate and volatile organic compound (VOC) pollution was isolated to Eden Park.

Through the course of the Eden Park Project, no results above the federal National Ambient Air Quality Standards (NAAQS) were observed for pollutants monitored at the MMP. Results for these pollutants were comparable to the urban monitoring station of MLK in Wilmington. VOC sampling results from the Dust Distribution Study were also similar to results seen at the MLK station.

Concentrations of TSP at Eden Park were observed above the state standards and were significantly higher than concentrations recorded at the MLK station. An analysis of the patterns of TSP concentrations showed higher concentrations during business hours during the workweek. Concentrations were also highest from November through December. The Dust Distribution Study results indicated that elevated TSP concentrations were isolated to Eden Park. Despite TSP concentrations above State Primary and Secondary Standards, the fine particulate ($PM_{2.5}$) measurements taken at the same time and place did not exceed federal health-based standards (NAAQS).

The community also expressed concern regarding the composition of the "dust" they observed. TSP samples were analyzed for metal composition, which were further evaluated to estimate possible source contributions and health assessment. Data on metals was submitted to Delaware Division of Public Health (DPH) for risk assessment. The risk assessment was conducted using EPA developed formulas and risk factors, consistent with previous risk assessments conducted by the Division of Public Health. DPH determined that the metals monitored did not pose an increased risk.

The Xact study used a sophisticated monitoring method to analyze metal composition *(on an hourly basis)* at the MMP. A computer model was then used to estimate sources from the composition. Three types of sources were identified: concrete dust, soil dust, and brake/tire wear from vehicles. The concrete dust component was the largest, followed closely by soil dust, with brake/tire wear the smallest estimated component. As the concentration of TSP increased the concrete dust component increased, more than the soil component. An analysis on patterns of dust components indicate that concrete and soil dust concentrations were higher during business hours, while brake/tire wear indicated a mobile source pattern. Higher concrete and soil dust concentrations were estimated to occur when wind blows from the west-northwest at higher wind speeds. The brake/tire wear concentrations were highest at low wind speeds near the MMP.

At the beginning of the study, DAQ began working with local industry to evaluate their dust control plans and look for ways to improve conditions. Dust control plans include several methods to help reduce dust at the facilities: sweeping of facilities with a mobile sweeper truck, wetting of stockpiles and roads, and using paved roads for truck traffic when possible. The results of this project will be used to further guide those efforts and help narrow the focus.

Plain Language Summary

In September of 2016, Delaware's Division of Air Quality (DAQ) launched the Eden Park Project using the Moveable Monitoring Platform (MMP) to investigate air quality for the community of Eden Park. The community specifically described visible "dust" as a cause for concern and questioned what was in the dust. DAQ investigated the air quality from September 2016 through January 2019 with a focus on large particles to address the dust concerns.

DAQ found the amount of most types of air pollution were below federal standards. Air quality in Eden Park is very similar to air quality found at other state monitoring locations, particularly in the nearby city of Wilmington. However, the amount of large particle pollution was confirmed to be higher than seen at other sites. The amount of dust was above state standards on several occasions. The dust was higher during colder months, business hours, and the workweek. Levels of dust measured in areas nearby to Eden Park were not found to be nearly as high.

DAQ investigated where the dust may be coming from and what was in the dust. Working with a contractor using a sophisticated method and computer model three main types of dust were identified: concrete dust, soil dust, and dust from tire/brake wear. The concrete dust was the largest part especially when dust levels were high. When the wind blows from the west-northwest at high speeds, the concrete and soil parts of the dust were greater. Concrete and soil dust were higher during business hours and the workweek.

At the beginning of the study, DAQ began working with local industry to evaluate their dust control plans and look for ways to improve conditions. Dust control plans include several methods to help reduce dust at the facilities: sweeping of facilities with a mobile sweeper truck, wetting of stockpiles and roads, and using paved roads for truck traffic when possible. The results of this project will be used to guide further efforts to reduce dust.

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Glossary of Terms & Acronyms

Ambient Air: Generally, the atmosphere; usually refers to the troposphere**.**

Geometric Mean: The geometric average of the data, the nth root of the product of n numbers

Attainment: EPA designation that an area meets the NAAQS.

DAQ: Delaware Division of Air Quality

DNREC: Delaware Department of Natural Resources and Environmental Control

Exceedance: An incident occurring when the concentration of a pollutant in ambient air is higher than the NAAQS

FEM: Federal Equivalent Method for monitoring air pollution

Fluorescence: The production of light in response to the application of radiant energy such as ultraviolet rays

FRM: Federal Reference Method for monitoring of air pollution

IO-3.3: Inorganic Compendium Method 3.3, EPA method for Determination of Metals in Ambient Particulate Matter using X-ray Fluorescence Spectroscopy

MDL: Minimum detection limit

MMP: Moveable Monitoring Platform

NAAQS: National Ambient Air Quality Standard set by EPA to protect human health and welfare.

NCore: National Core monitoring station, part of an enhanced national EPA monitoring program, successor to the NAMS program

Nonattainment: EPA designation that an area does not meet the NAAQS

PM: Particulate matter, subscript denotes diameter of particles, i.e. 2.5 = 2.5 microns

ppb: Parts per billion by volume.

ppm: Parts per million by volume.

SLAMS: State and/or Local Air Monitoring Stations

Spectrometry: The measurement of electromagnetic wavelengths (spectra**)**

Synthetic Minor: A source that has a potential to emit that is at or above the Title V emission thresholds, but the source accepts restrictions on emission rates, process controls, or other limitations in a permit in order to stay below the major source emission thresholds.

Title V: "Major sources" The EPA defines a major source as a facility that emits, or has the potential to emit (PTE) any criteria pollutant or hazardous air pollutant (HAP) at levels equal to or greater than the Major Source Thresholds (MST) set in the Clean Air Act. The Major Source Threshold for criteria pollutants may vary depending on the attainment status (e.g. severe, serious, extreme) of the geographic area and the Criteria Pollutant or HAP in which the facility is located.

TO-15: Toxic Organic Compendium Method 15, EPA method for Determination of Volatile Organic Compounds (VOCs) in air collected in specially-prepared canisters and analyzed by Gas Chromatography/Mass Spectrometry (GC/MS)

TSP: Total Suspended Particulates

$\mu g/m^3$: Micrograms per cubic meter

VOC: Volatile Organic Compounds

XRF: X-ray Fluorescence Spectroscopy

24-hour Average: The average concentration for a 24-hour period

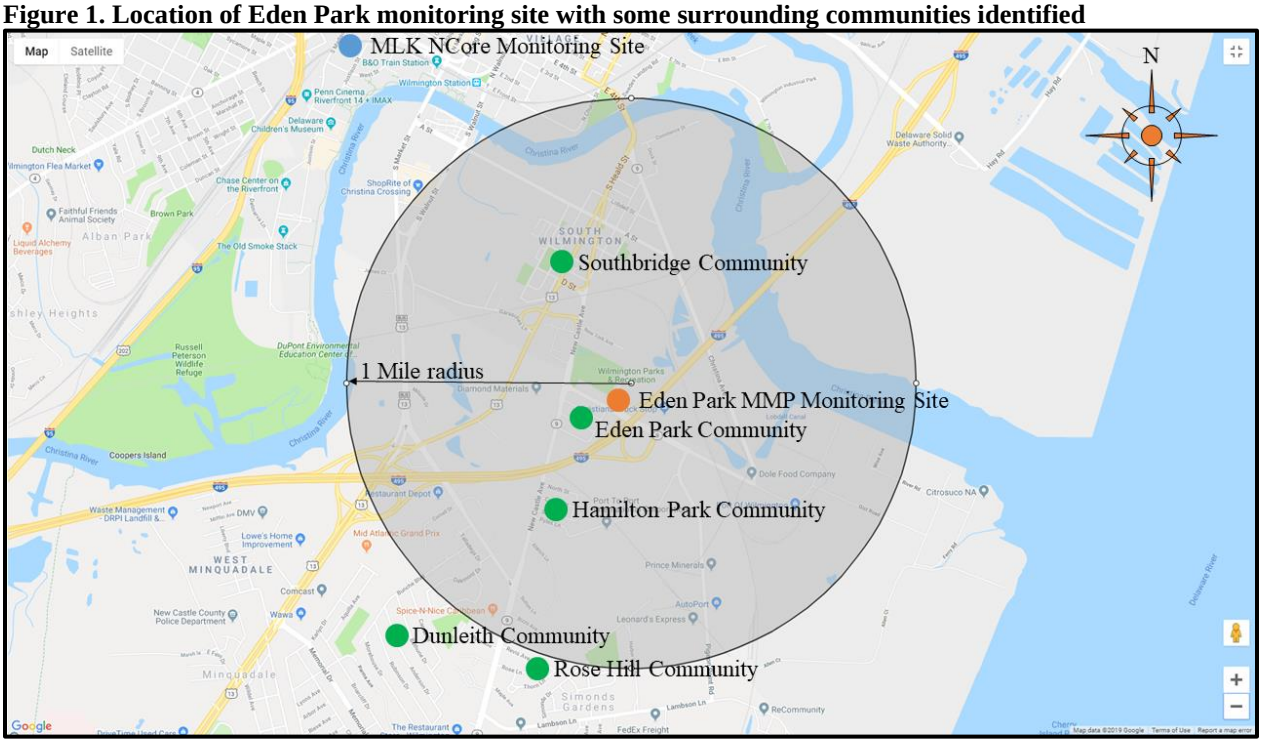
Introduction

The communities of Eden Park and those outside of Wilmington, Delaware along the upper Route 9 corridor have raised concerns regarding local air quality due to surrounding industry and traffic. The Eden Park community has specifically expressed concerns regarding particulate pollution. Located west of the Port of Wilmington, the community is surrounded by various commercial/industrial processes including bulk material processing, metal recycling, and concrete manufacturing, as well as the Interstate 495 corridor.

In September of 2016, the Division of Air Quality (DAQ) initiated the Eden Park Study by deploying the Moveable Monitoring Platform (MMP) and additional particulate monitoring equipment near the community of Eden Park. Monitoring was conducted through January of 2019. Two additional studies ran concurrently in the last few months of the Eden Park Study. The Xact Study was planned as an effort to identify sources of particulate pollution. The Dust Distribution Study was planned in response to questions from the larger Route 9 corridor community regarding whether particulate pollution was isolated to Eden Park.

The MMP was sited adjacent to Eden Park at the Department of Parks and Recreation City of Wilmington Municipal Services Complex parking lot. This location was central to the surrounding pollutant sources and the residential community (Figure 1).

Figure 1. Location of Eden Park monitoring site with some surrounding communities identified



Objectives

This report discusses the Eden Park Project, which included the original Eden Park Study, Xact and Dust Distribution Studies. The objective of the Eden Park Study was to address community concerns by evaluating ambient air concentrations of select pollutants. Community concerns have focused primarily on "dust" that settles on their vehicles, prevents them from drying laundry outdoors, and clogs their HVAC Filters. They report observing fugitive dust from nearby bulk materials handling operations. These observations lead DAQ to focus on particulate monitoring.

The methods available for use with the MMP are able to quantify pollution but the ability to identify sources with those methods is limited. Therefore, the Xact Study was implemented using a sophisticated monitoring and analytical method to attempt particulate source identification. The Dust Distribution Study was carried out to determine if pollution in Eden Park differed from other Route 9 locations. The results of the Eden Park Project are being used to assess local air quality and guide actions to mitigate pollution affecting the communities. Results were compared to DAQ's permanent monitoring network.

At the start of the Eden Park Project Delaware's 2014 Emissions Inventory was used to identify significant permitted particulate sources in the area (Figure 2 & Table 1).

Figure 2. Map of particulate sources at 1 to 3 miles from the Eden Park site

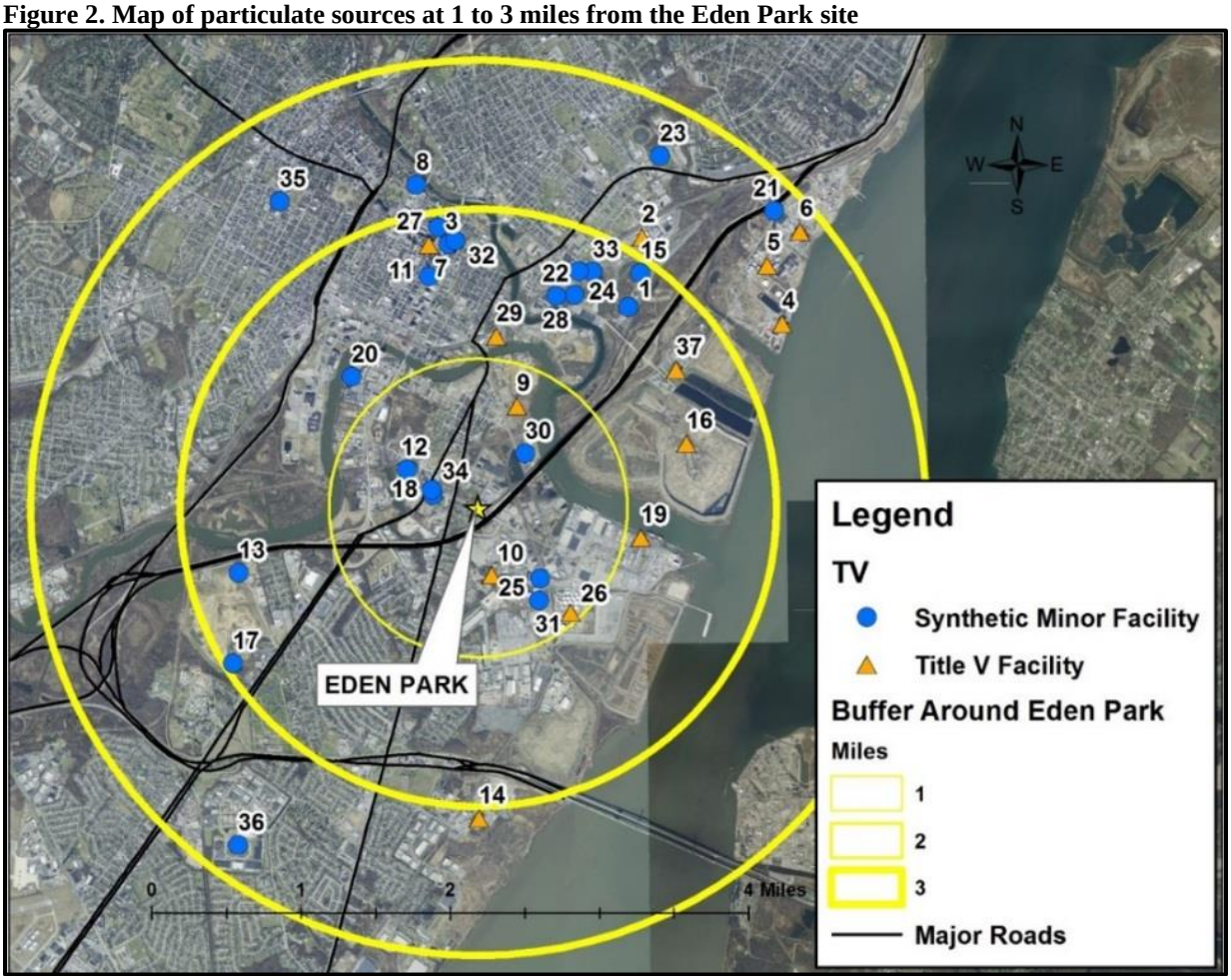


Table 1. Facility list key to Map in Figure 2

Map Number	Facility Name	Facility Classification
1	ALLEN MEYERS	SYNTHETIC MINOR
2	AMTRAK WILMINGTON MAINTENANCE FACILITY	TITLE V
3	BRACEBRIDGE CORP - BRACEBRIDGE	SYNTHETIC MINOR
4	CALPINE EDGE MOOR ENERGY CENTER	TITLE V
5	CALPINE HAY ROAD ENERGY CENTER	TITLE V
6	CHEMOURS EDGE MOOR	TITLE V
7	CHEMOURS WILMINGTON OFFICE BUILDING	TITLE V
8	CHRISTIANA CARE - WILMINGTON HOSPITAL	SYNTHETIC MINOR
9	CHRISTIANA ENERGY CENTER	TITLE V
10	CLEAN EARTH OF NEW CASTLE	TITLE V
11	CONECTIV THERMAL SYSTEMS	SYNTHETIC MINOR
12	CONTRACTORS MATERIALS LLC HOT MIX PLT	SYNTHETIC MINOR
13	CORRADO CONSTRUCTION CO LLC	SYNTHETIC MINOR
14	CRODA INC.	TITLE V
15	DANA RAILCARE	SYNTHETIC MINOR
16	DE SOLID WASTE AUTHORITY CHERRY ISLAND	TITLE V
17	DELAWARE RECYCLABLE PRODUCTS INC	SYNTHETIC MINOR
18	DIAMOND MATERIALS LLC	SYNTHETIC MINOR
19	DIAMOND STATE PORT CORPORATION - PORT OF WILMINGTON	TITLE V
20	HERITAGE CRYSTAL CLEAN	SYNTHETIC MINOR
21	HOLLAND MULCH INC	SYNTHETIC MINOR
22	HOWARD R. YOUNG CORRECTIONAL INSTITUTION	SYNTHETIC MINOR
23	JP MORGAN CHASE - 4001 GOV PRINTZ BLVD	SYNTHETIC MINOR
24	LARS RECYCLING LLC	SYNTHETIC MINOR
25	MAGCO INC.	SYNTHETIC MINOR
26	MAGELLAN TERMINALS HOLDINGS, L.P.	TITLE V
27	MCCONNELL JOHNSON	SYNTHETIC MINOR
28	NEW HAVEN PACKAGING, LLC	SYNTHETIC MINOR
29	NORAMCO INC	TITLE V
30	PORT CONTRACTORS, INC. - RAIL TRANSSHIPMENT FACILITY	SYNTHETIC MINOR
31	PRINCE MINERALS LLC	SYNTHETIC MINOR
32	PS-5 LLC	SYNTHETIC MINOR
33	PURE GREEN INDUSTRIES INC	SYNTHETIC MINOR
34	R & M RECYCLING	SYNTHETIC MINOR
35	ST. FRANCIS HOSPITAL	SYNTHETIC MINOR
36	VERISIGN	SYNTHETIC MINOR
37	WILMINGTON WASTEWATER TREATMENT PLANT	TITLE V

During the course of the Eden Park Project, observations were made in efforts to determine potential particulate sources. On several occasions, particularly under high wind conditions, visible particulates were observed blowing from unpaved surfaces such as dirt roads and parking lots. Buildup of particulates was observed on local roadways and could be observed being stirred up by traffic. Particulate buildup on monitoring equipment was also noted (Figure 3)

Figure 3.Observations of non-facility dust sources and particulates building up on hood of MMP

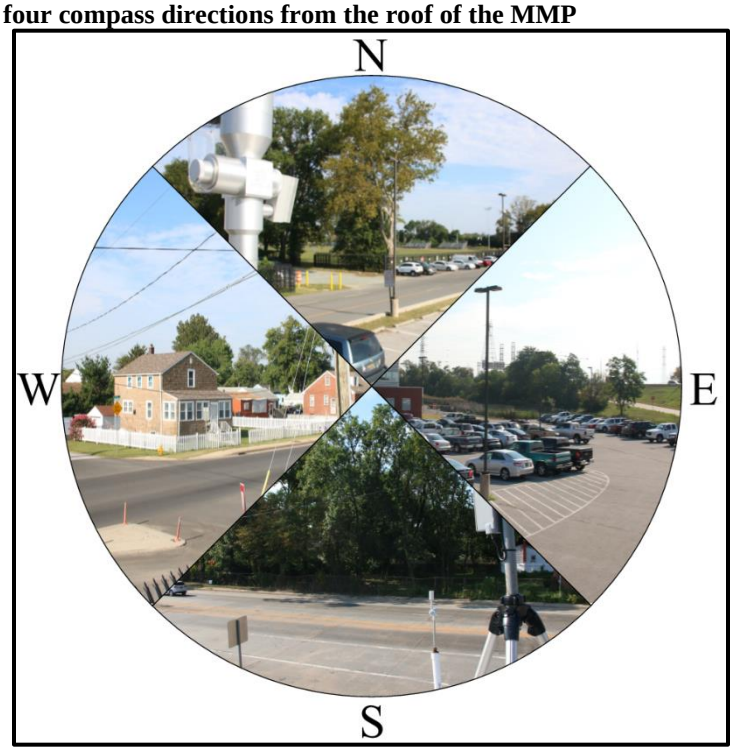
Implementation

Site Selection

A site adjacent to the community of Eden Park was selected based on requirements for access, electricity, relation to the community, and central to possible sources of pollution (Figure 4). The Division of Air Quality (DAQ) coordinated with the City of Wilmington to allow the placement of the MMP in the city's Municipal Service Complex parking lot at the intersection of Terminal and Wilmington Avenues (Figure 5). The Xact Study also utilized the MMP at this site.

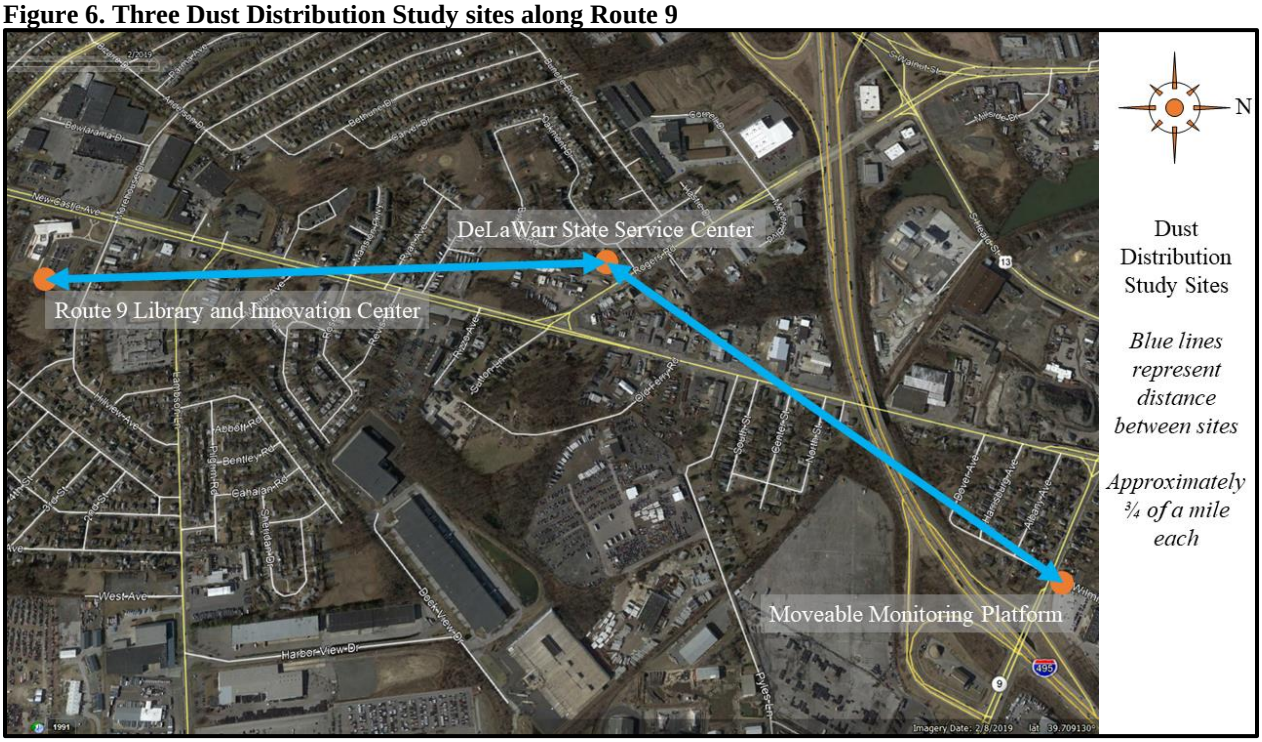
Figure 4. Satellite view of the MMP and Eden Park Community

Figure 5. Views of the four compass directions from the roof of the MMP



The Dust Distribution Study utilized battery operated samplers at three sites (Figure 6). DAQ coordinated with the Route 9 Library and Innovation Center (R9L) and DeLaWarr State Service Center (DLW) for monitor placement on their properties. The roof of the MMP provided the third site.

Figure 6. Three Dust Distribution Study sites along Route 9



Monitoring Parameters

The MMP monitored using the following parameters at varying times during the Eden Park Project:

- 24-hr Filter Based Total Suspended Particulates (TSP)
  - High-volume & Low-volume Methods
- Continuous Parameters
  - Fine and Large inhalable Particulate Matter ($PM_{2.5}$ & PM_{10})
  - Ozone (O_3)
  - Sulfur Dioxide (SO_2)
  - Oxides of Nitrogen (NO-NO_2-NO_x)
  - Black Carbon (BC_{370} & BC_{880})
- Meteorological Parameters
  - Wind Speed & Wind Direction (WS/WD)
  - Temperature
  - Relative Humidity
  - Pressure

The following parameters were monitored included in the Xact Study:

- 24-hr Filter Based PM_{10}
- Continuous Parameters
  - X-ray Fluorescence (XRF) of Select Elemental Metals by Xact Monitor
  - Fine and Large inhalable Particulate Matter ($PM_{2.5}$ & PM_{10})
  - Sulfur Dioxide (SO_2)
  - Oxides of Nitrogen (NO-NO_2-NO_x)
  - Black Carbon (BC_{370} & BC_{880})
- Meteorological Parameters
  - Wind Speed & Wind Direction (WS/WD)

The following parameters were monitored during the Dust Distribution Study:

- 24-hr Filter Based Total Suspended Particulates (TSP)
  - Low-volume Method
- 24-hr Volatile Organic Compound (VOC) Canister Collection

Methods

Visible "dust" from the surrounding operations as described by the community consists of particles with diameters larger than 2.5 microns, the particle size cut off for the pollutant $PM_{2.5}$ for which the EPA has established a National Ambient Air Quality Standard (NAAQS). Manual method particulate sampling is conducted by drawing a known volume of air through a filter for 24 hours with or without a size selective inlet depending on the particle size of interest. The filter is weighed before and after sampling. The change in weight, sample volume, and sample time are used to calculate particulate concentration. DAQ contracts with an outside lab to handle filter weighing and so there is a delay in the receipt of results following sampling collection.

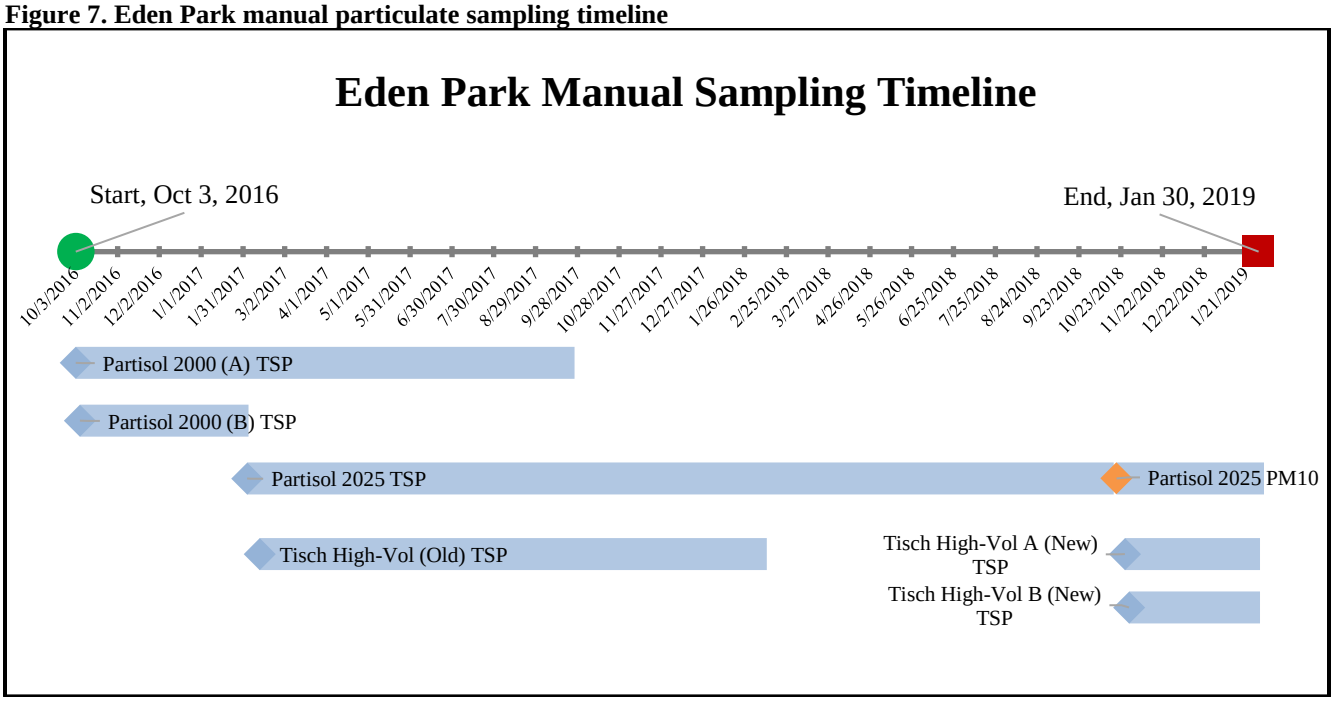
Total Suspended Particulates

To address community concerns regarding dust, particulate samplers were deployed and configured for total suspended particulate (TSP) monitoring. TSP sampling collects all

particle size classes but are most efficient at collecting particles 100 microns or less in diameter. Initial sampling for TSP was conducted using two low-volume single sample Partisol® samplers (2000-A & B) with 47mm Teflon filters. Partisols are a Federal Reference Method (FRM) for $PM_{2.5}$ and PM_{10} sampling when configured with appropriate size selective inlet. Following the EPA National Sampling Schedule, sampling was conducted every third day (1-3). The samplers alternated collection to ease operator burden and for quality assurance, collocation occurred every sixth day (1-6). In February of 2017 when a sequential (multiple sample) Partisol sampler (2025) became available, it was deployed to replace one of the units as the primary sampler continuing a 1-3 day sample schedule and the other unit operated as a 1-6 collocate.

By February 2017, it was observed that some concentrations collected were above the original 24-hour State Secondary Standard for TSP of 150 $\mu g/m^3$. The state regulation specifies use of the FRM for TSP determination, which requires a high-volume air sampler. DAQ therefore deployed a Tisch high-volume sampler with an 8”x10” quartz fiber filter for sample collection beginning in February of 2017. A timeline of equipment sampling methods is illustrated in Figure 7.

Figure 7. Eden Park manual particulate sampling timeline



Low-volume method sampling continued along with the high-volume method for comparison. In February of 2018 maintenance issues with the high-volume sampler and no other available high-volume samplers lead to the discontinuation of high-volume sampling. Low-volume method sampling for TSP continued until September of 2018 when the monitor began experiencing maintenance issues and preparations for the Xact Study were beginning. Because the sequential sampler was going to be used to collect PM_{10} as part of the Xact Study, two new high-volume method TSP samplers were

purchased to run sequentially collecting on an every third day schedule. The samplers were deployed in October of 2018 and operated through the conclusion of the project.

Low-volume method TSP filters collected from late September of 2016 through August of 2017 were analyzed by a contract laboratory using EPA Method IO-3.3 for X-ray Fluorescence (XRF) spectroscopy to determine specific metal element species. Elemental analysis can be used to evaluate a specific portion of particulate matter to help in determining sources. The results for the metal element species represents a portion of the total composition of a particulate sample.

Fine Particulate Matter

To estimate the fine particulate matter ($PM_{2.5}$) portion of the dust, $PM_{2.5}$ was monitored by a continuous monitor. Continuous monitors typically sample at 1-minute intervals. $PM_{2.5}$ was monitored at the MMP with a Federal Equivalent Method (FEM) designated continuous 5030 SHARP monitor for the first two periods of the study. Prior to the start of the Dust Distribution Study the State switched its network of continuous $PM_{2.5}$ monitors to TAPI® T640s, newly designated FEM for $PM_{2.5}$, one of which was installed in the MMP. Data from these finer time resolved monitors allow for the evaluation of temporal patterns and patterns associated with wind speed/direction. The T640 additionally provides continuous monitoring of PM_{10}, which was evaluated as an indicator for patterns of TSP.

Black Carbon

The Black Carbon portion of $PM_{2.5}$ was monitored using an Aethalometer, which is useful as an indicator of "Diesel Emissions". The Aethalometer was used to address additional community concerns regarding several large lots where diesel vehicles are parked. Influence from local through traffic and surrounding highway traffic may be detected by the Aethalometer.

Ozone, Sulfur Dioxide, and Nitrogen Dioxide

Monitoring for the gaseous pollutants ozone, sulfur dioxide, and oxides of nitrogen were implemented for evaluation of local concentrations and comparison to nearby monitoring network sites. Gaseous analyzers measure on a continuous basis at 1-minute intervals that are compiled as 1-hour averages for analysis. Wind Speed and Wind Direction were measured using an ultrasonic transducer. Data was collected at 1, 5, and 60-minute averages and reported to the central Data Acquisition System (DAS).

Xact Study

The Xact Study added a Cooper Environmental 625i Xact® Monitor to the MMP. The Xact monitor collects particles on a Teflon filter and analyzes for selected metal elements using XRF on a continuous basis. For this study, the Xact was configured to sample PM_{10} as an indicator of TSP and provide hourly averages of metal concentrations. For quality assurance the sequential Partisol that had been used for TSP monitoring was maintained and configured to monitor for PM_{10} on a 24-hour every third day schedule. Filters from this monitor were also sent to the same lab as the low-volume TSP filters for elemental metal analysis to compare with the results of the Xact Monitor.

Dust Distribution Study

The Dust Distribution Study used six low-volume battery operated ARA N-FRM® samplers configured to sample TSP for 24-hours. Samplers were paired at each site, operating every 6 days (1-6). The samplers were set to alternate so that a sample was collected every 3 days. The sampling followed the EPA National Schedule. In addition to TSP, evacuated canisters for sampling Volatile Organic Compounds (VOCs) with critical flow orifices and timers programmed for a 24-hour midnight-to-midnight collection time were deployed at each site. Canisters were analyzed by contracted laboratory using EPA Method TO-15 for VOCs. VOCs were collected on the EPA National Schedule once every six days (1-6).

Data Collection

Data was analyzed weekly to determine if there were any instances when local ambient air quality was above any standards and for comparison to other stations in the state monitoring network. Low-volume particulate filters collected from the MMP and Dust Distribution Study were analyzed in the same manner as the filters for the State PM Program (Reference 1 & 4 [37]). High-volume TSP filters were analyzed for TSP concentration only, in the same manner as filters for the State Heavy Metals Analysis Program determine TSP concentration (Reference 2 [37]). Analysis of canisters used in the Dust Distribution Study was provided by contract lab using EPA Method TO-15, which is the same method but different lab than used for VOC monitoring at the MLK NCore site. The MLK NCore monitoring station, which includes a suite of similar instrumentation to monitors used in this project, was used for comparison. The NCore site is located approximately 1.5 miles to the northeast of Eden Park in the city of Wilmington and specifically monitors air pollution concentrations in an urban environment.

Data analysis for the Xact Study was performed by Sonoma Technology Inc. using data gathered from the Xact monitor and other monitors at the MMP.

Quality Assurance

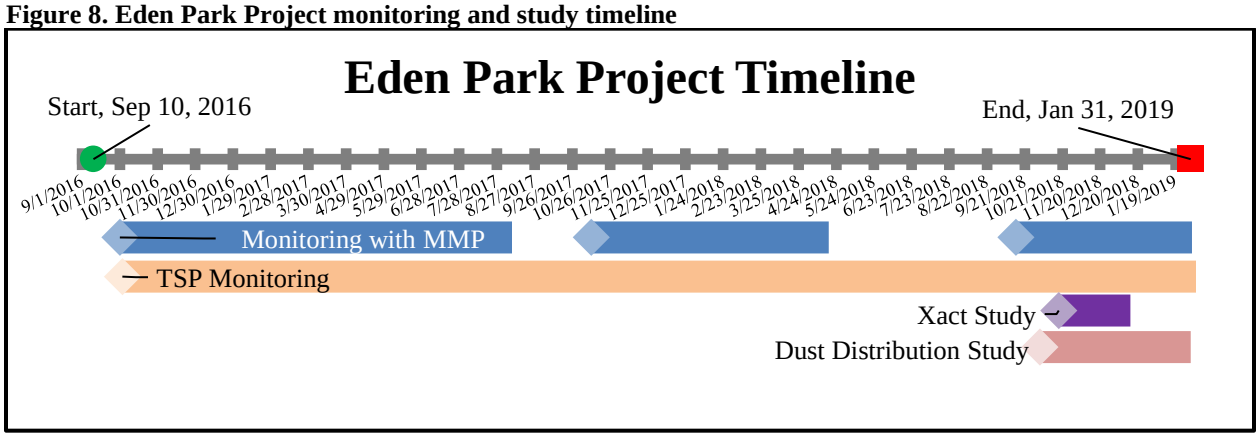
All monitors were operated per approved Standard Operating Procedures (SOP) or manufacturer specifications for monitors without SOPs. Quality control and assessment procedures followed the project Quality Assurance Program Plans (Reference 3 & 4 [37]), and included at a minimum multi-point calibrations on-site at the beginning of the study period and weekly quality control checks on all gaseous analyzers. The continuous PM and Black Carbon monitors included bi-weekly and monthly quality control checks performed per the current SOPs. Manual particulate samplers received monthly checks in accordance with the SOPs for Partisol and High-Vol. operation. The EPA established method quality objectives (MQOs) for all FEM analyzers and monitors were followed. Any deviations from quality assurance protocols were documented. All outside laboratory analysis was performed per analysis QA/QC protocol established by each lab.

Data Analysis

Data Summary

The project operation dates ranged from September 2016 through January of 2019 and includes all three studies. Monitoring for TSP was conducted throughout the entirety of the project (Figure 8).

Figure 8. Eden Park Project monitoring and study timeline



Monitoring with the MMP was divided into three periods due to critical maintenance issues that arose during the course of the project. In August of 2017, water leakage was threatening equipment, which required the MMP be removed for repair. The MMP was returned to the site in October of 2017. In May of 2018 issues with interior environmental controls, updates to equipment load out, and re-fit in preparation for the Xact study required downtime to complete. The MMP was returned to the site in October of 2018. The Xact Study and Dust Distribution Studies (Dust Dist.) began in October of 2018. The Xact Study ran for 2 months, and the Dust Distribution Study ran until the conclusion of the project. All equipment was removed from the sites and monitoring ended in February of 2019.

Data capture exceeded 75% for most monitors (Table 2). Maintenance issues with the Ozone calibrator and NO_x analyzer account for their lower data captures.

Table 2. % Data capture by parameter and study period for the Eden Park Project

		NAAQS Parameters					Indicator Parameters	
** Monitoring method(s) varied*		**Ozone** (O_3)	**Sulfur Dioxide** (SO_2)	**Oxides of Nitrogen** (NO-NO_2-NO_x)	**Particulate Matter 2.5** ($PM_{2.5}$)	**Particulate Matter 10** (PM_{10})	**Black Carbon** (BC 370 & 880)	**Total Suspended Particulates** (TSP)
% Data Capture	2016-2017 -	28%	95%	74%	99%		80%	95%*
	2017-2018 -	28%	89%	0%	84%		88%	(*Over entire*
	Dust Dist. -	0%	99%	79%	87%*	87%	86%	*project*)

Meteorology

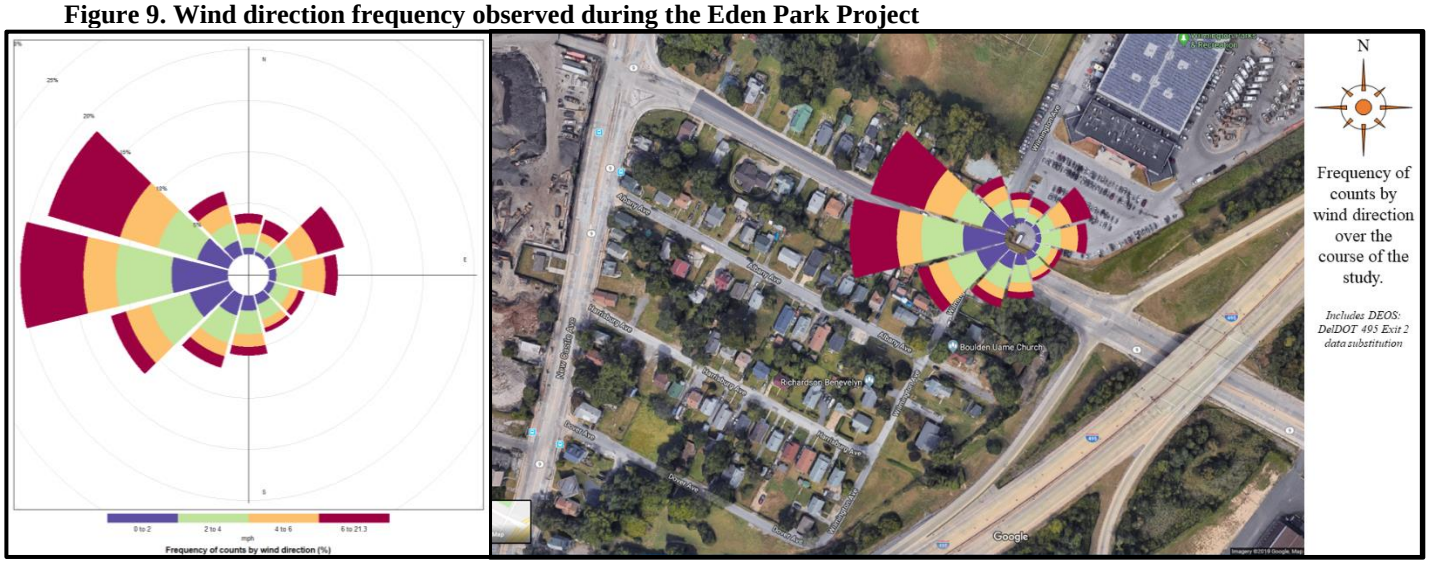
Meteorological (Met) data was collected at Eden Park as part of the MMP's suite of instrumentation. This data can be helpful for understanding how air pollution moves locally. Met data collected for this study can be used for informative purposes however; it does not meet EPA siting criteria. Met data capture for each period exceeded 75% with the exception of Wind Speed and Wind Direction (WS/WD) during the 2016-2017 sample period (Table 3). Data for WS/WD has been substituted for the invalid MMP data for informative purposes. Substitute data was retrieved from a nearby Delaware Environmental Observation System (DEOS) site.

Table 3. % Data capture by Met parameter and study period for the Eden Park Project

		Meteorological Data				
		Wind Speed (WS)	**Wind Direction** (WD)	**Temperature** (T)	**Relative Humidity** (RH)	**Pressure** (Pr)
	Units	*mph*	*º*	*ºF*	*%*	*mmHg*
% Data Capture	2016-2017 -	42%	42%	99%	99%	99%
	2017-2018 -	100%	100%	100%	100%	100%
	Dust Dist.Study -	87%	87%	87%	87%	87%

Overall, wind direction blew predominately from the west (Figure 9). To the west are also several particulate sources of interest as noted by the community and identified by DAQ.

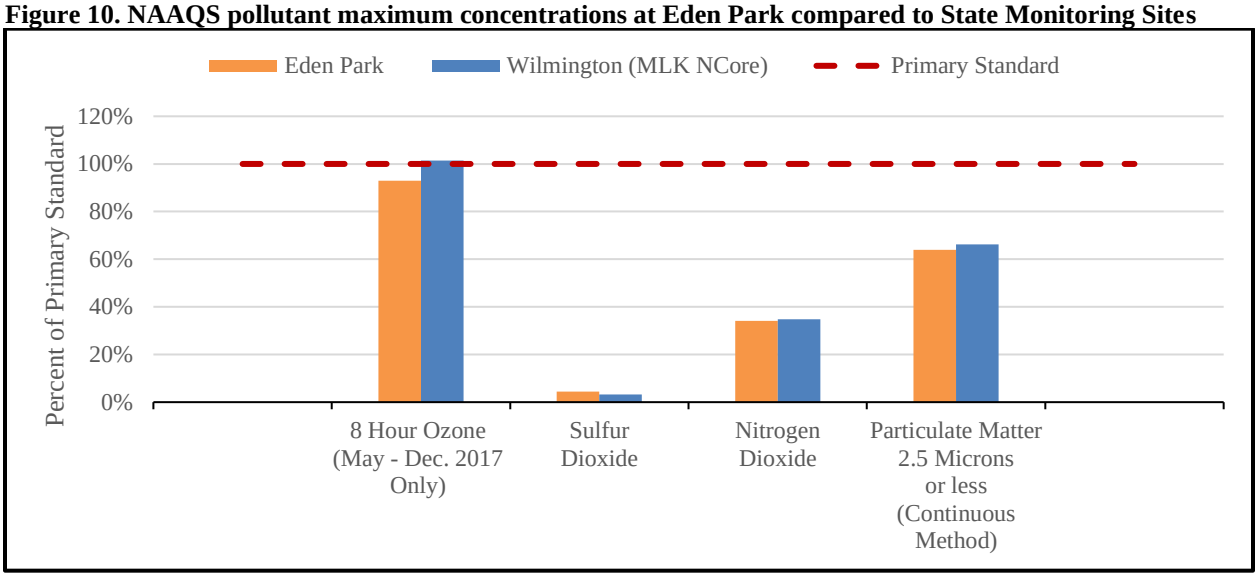
Figure 9. Wind direction frequency observed during the Eden Park Project



Pollutants with National Ambient Air Quality Standards

No exceedances for pollutants with EPA National Ambient Air Quality Standards (NAAQS) were measured at Eden Park during the course of the project. When data is compared to other sites in Delaware's network, Eden Park is most similar to the MLK NCore site in Wilmington, DE (Figure 10). One exception, the site with the highest ozone value is located in Brandywine Creek State Park. As noted previously, ozone data capture was extremely poor and was discontinued early on in the project since existing ozone monitors are representative for the region.

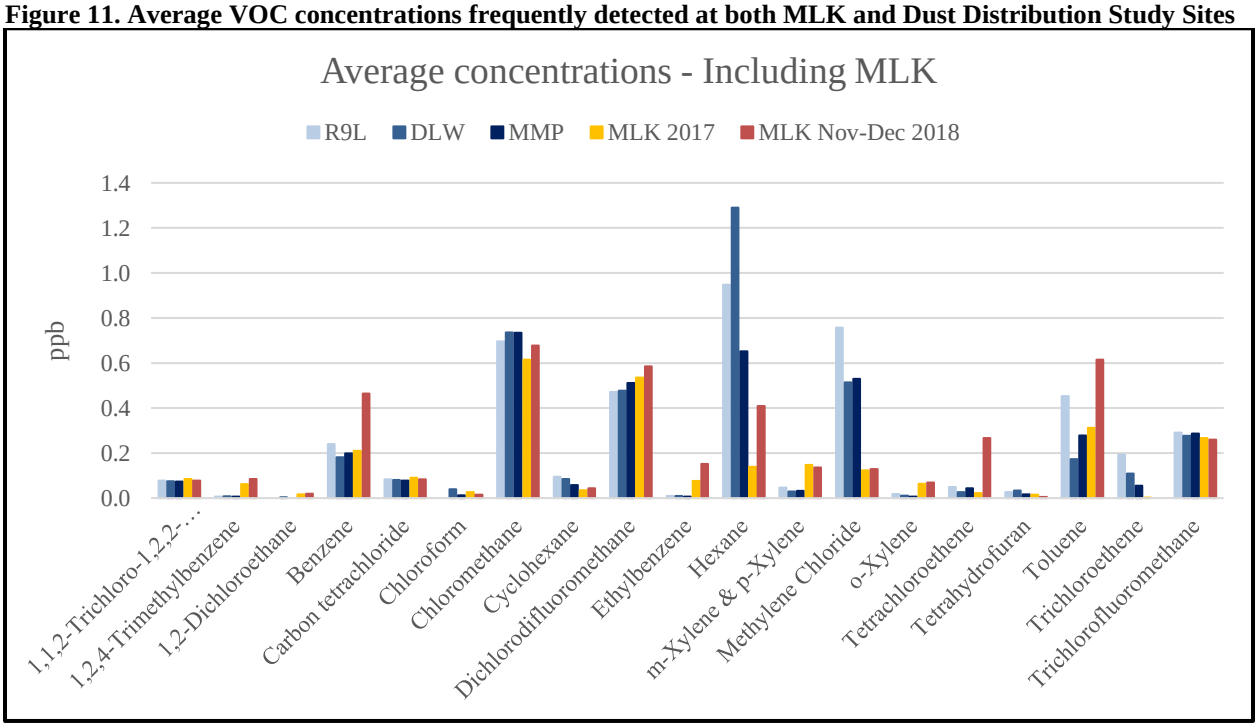
Figure 10. NAAQS pollutant maximum concentrations at Eden Park compared to State Monitoring Sites



Volatile Organic Compounds (Dust Distribution Study)

Evacuated canister sampling for VOCs was implemented to address concerns by the communities that other chemicals of concern might be present. Sampling was included at the three sites of the Dust Distribution Study to evaluate if VOC concentrations varied between locations. Data was compared to the MLK NCore site that has a history of VOC sampling. In general, concentrations at all sites were similar to those historically seen at MLK. However, MLK samples were analyzed by a different lab. Due to changes in laboratory reporting, compounds analyzed at MLK differ depending on year (Figure 11).

Figure 11. Average VOC concentrations frequently detected at both MLK and Dust Distribution Study Sites



Due to timer malfunctions, total data capture was 72%, below the goal of 75%. Data capture for all three sites on the same day was 55%, decreasing the level of confidence in the comparison between sites. Overall, concentrations of all compounds are low, with the majority of results below the reporting limit, but above the minimum detection limit for most compounds. To increase confidence in results, several collocated canisters were collected the MMP site. Precision as measured by the collocated samples was acceptable for some compounds, but poor for most. This variability is to be expected given low concentration and limited number of samples. Despite the small sample size, no statistically significant differences between concentrations at the three sites were detected.

Total Suspended Particulates

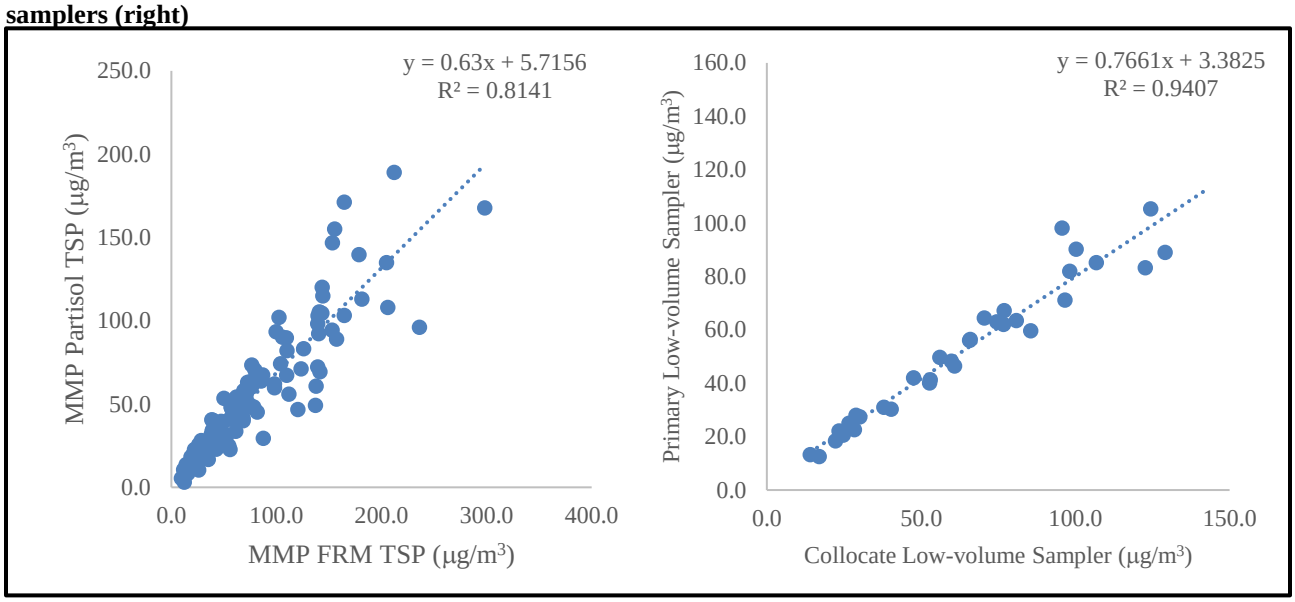
Impact of Different TSP Sampling Methods

Beginning in 1971 as part of the Clean Air Act, National Ambient Air Quality Standards (NAAQS) for particulate matter (PM) pollution were established with total suspended particulates (TSP) concentrations as the indicator. TSP consists of particles 100 microns in diameter or less. The standards are divided into primary and secondary standards. Primary standards are the stronger indicator set to protect public health, while the secondary standards are set to protect the environment; sometimes the standards are the same for both.

In 1987 the inhalable fraction of PM, particles less than 10 microns in diameter (PM_{10}), replaced TSP as the indicator for the PM concentration standards. Further, in 1997, the standards for finer PM less than 2.5 microns in diameter ($PM_{2.5}$) were established as stronger indicators for unhealthy PM while retaining PM_{10} standards. The current standards for $PM_{2.5}$ and PM_{10} where last adjusted in 2012. The original TSP standards have been preserved in Delaware regulations to help empower regulators to prevent backsliding and control fugitive dust. In this study, the original State TSP standards based on the former National Standards, serve as “indicators of action” to aid in the evaluation of air quality in the community and help guide agency response.

Two different methods were used at varying times throughout the study. Comparing concentrations observed from low-volume and high-volume methods show a strong correlation with an r^2 of 0.81 (Figure 12). Results from the high-volume method on average were biased 41% higher than results from the low-volume method. Collocated low-volume methods showed strong correlation with an r^2 of 0.94 (Figure 12).

Figure 12. Correlation between low and high volume TSP samplers (left) and between collocated low-volume samplers (right)



An inquiry was made to the EPA for more information regarding the observed bias between methods. In response, two recent studies where shared on inlets and low-volume samplers being evaluated for TSP sampling. Negative bias upwards of 66% was observed by researchers due to inlet geometries and differences in flow rates between low-volume and high-volume samplers (Reference 5 [37]). The results observed in these studies explain the similar differences between results observed from methods used in the Eden Park Project.

Monitor Siting

High-volume sampler collection efficiency can be impacted by wind speed and direction (Reference 6 [37]). Siting criteria is another factor that can affect data. Ideally, samplers should be sited away from barriers with the pitch of the sampler hood orientated to the predominant wind direction. Samplers were sited along an open fence at ground level approximately 3 meters from the MMP. Concentrations above the State TSP Standards were recorded with both methods and in the low-volume samplers used for the Dust Distribution Study on the roof of the MMP giving confidence that while siting may not be ideal, it is representative. Figure 13 shows the arrangement of samplers during two different phases of the study.

Figure 13. Photos of manual TSP samplers used in the Eden Park Project

Eden Park Study Results

Typically, an analysis does not combine data from different methods. For this study, in order to evaluate data from the entire study period and provide the most conservative interpretation, the daily maximum concentration regardless of method was used. Results by method are noted in Table 4.

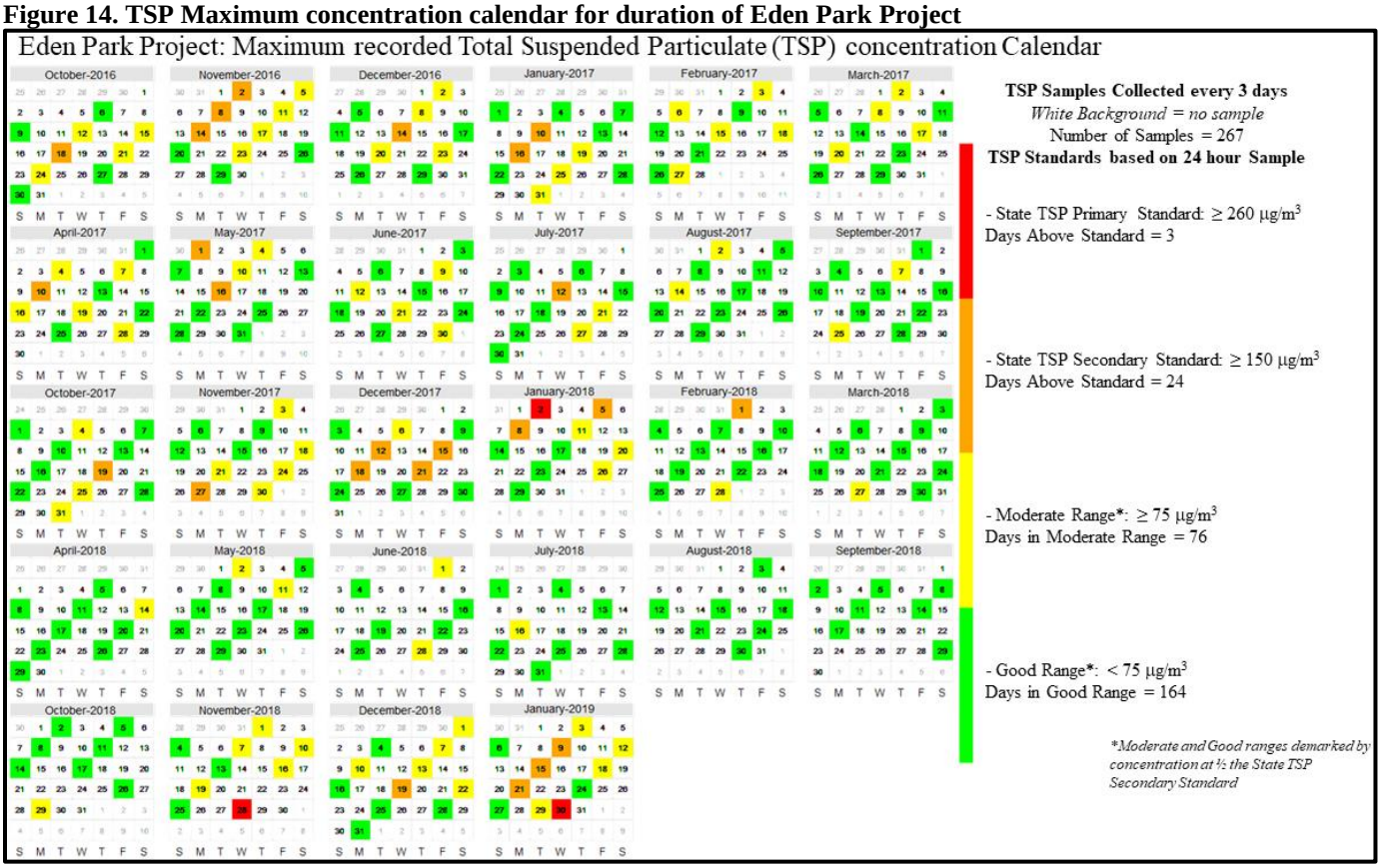
Table 4. TSP sampling data summary

	Total Suspended Particulate Sampling			
	Low Volume Methods	High Volume Methods		Maximum Concentration
	Partisol (2000s & 2025)	**Tisch High-volume** (Old)	**Tisch High-volume** (New A & B)	Combined Methods
Units	μg/m^3	μg/m^3	μg/m^3	μg/m^3
Sample Size	233	110	33	271
Average	57.1	79.7	110.0	73.7
Geometric Mean	43.5	60.4	90.2	55.3
Maximum	245.6	298.2	355.6	355.6

Using the State TSP Standards as an indicator of action, three concentrations were recorded above the Primary Standard of 260 μg/m^3. Twenty-four samples were recorded above the Secondary Standard of 150 μg/m^3.

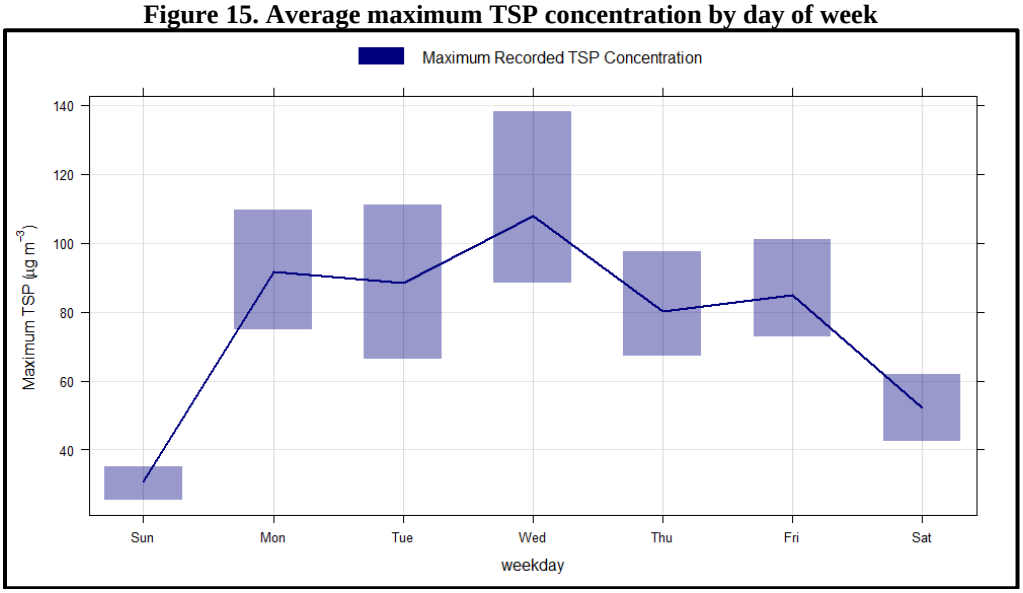
Using the EPA Air Quality Index (AQI) as a model, the remaining sample concentrations were divided into two categories: concentrations recorded at above half of the State TSP Secondary Standard were labeled as a Moderate and concentrations that were less than half of the State TSP Secondary Standard were considered Good (Figure 14).

Figure 14. TSP Maximum concentration calendar for duration of Eden Park Project



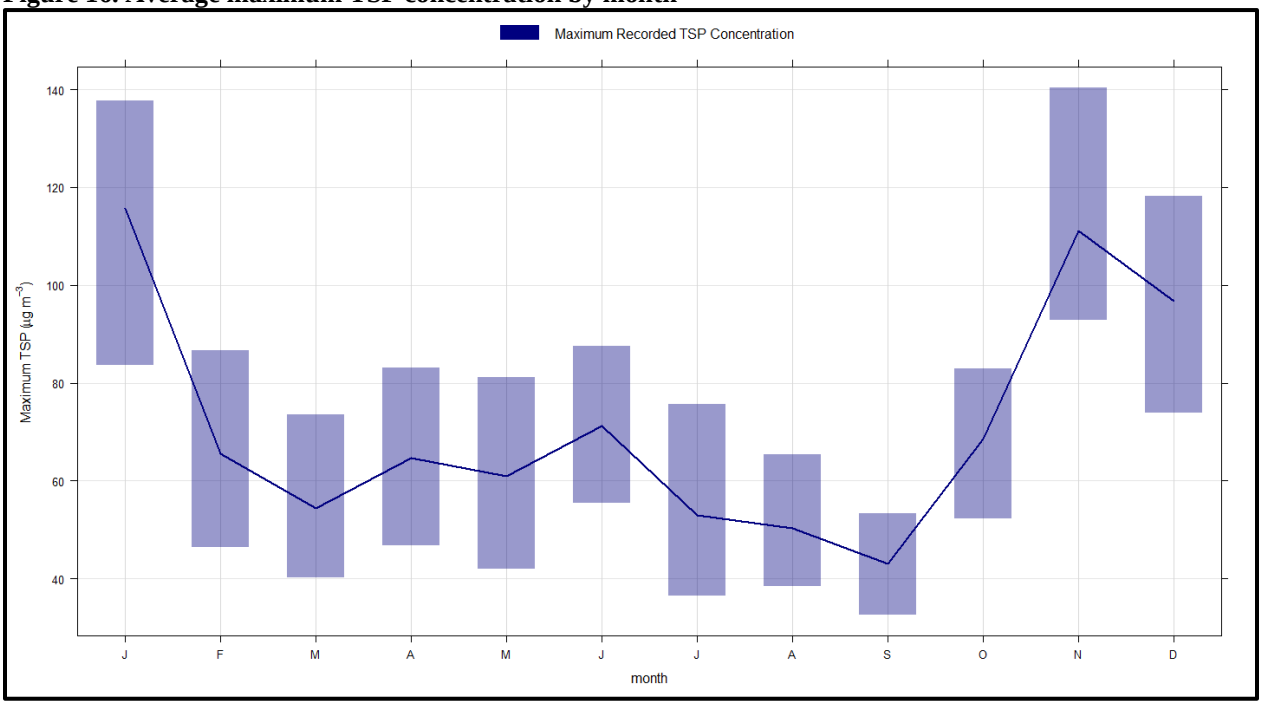
Higher concentrations of TSP were observed primarily during the workweek Monday through Friday peaking on Wednesday with an average of 108 µg/m^3. Concentrations were 54% lower on the weekend versus the weekday (Figure 15). This is indicative of commercial/industrial activity that occurs primarily during weekdays. Since these are 24-hour samples diurnal patterns cannot be determined from this data.

Figure 15. Average maximum TSP concentration by day of week



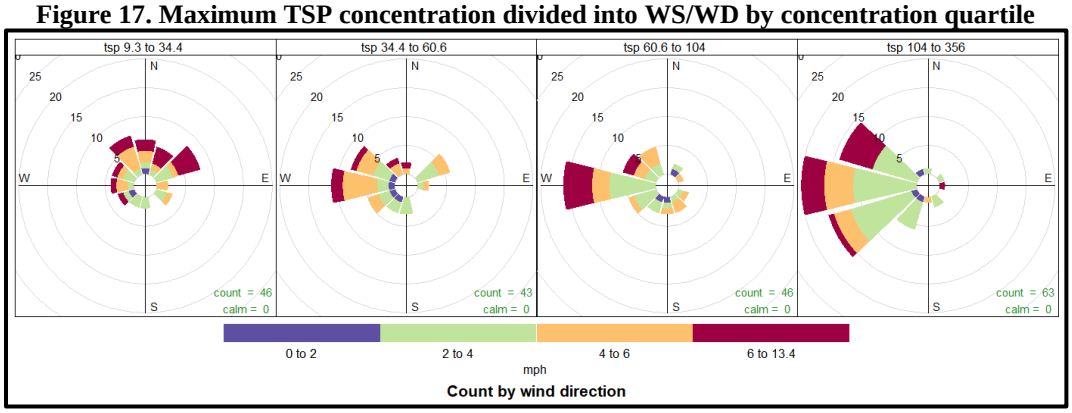
Maximum TSP concentrations by month were highest from November through January. The average for the three highest months is 43% higher than the average for other months combined (Figure 16). February to October average concentrations range from 43-71 μg/m^3. November to January ranges from 97-116 μg/m^3.

Figure 16. Average maximum TSP concentration by month



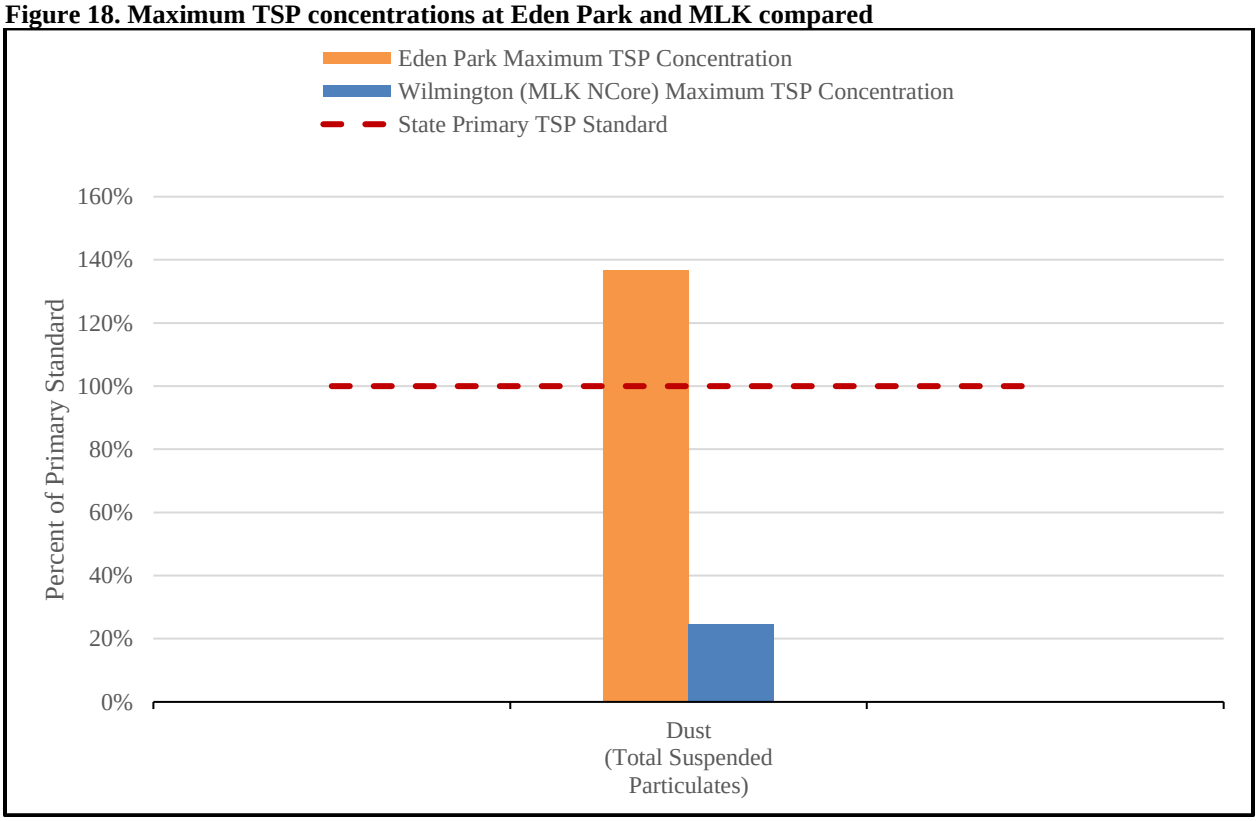
To evaluate conditions that result in high TSP, the concentrations were divided in to quartiles with the 24-hr average wind speed and wind direction (WS/WD) counts for each quarter (Figure 17). The Lowest concentrations appear to come from all directions while higher concentrations occur predominately with wind blowing from the west. Several different facilities with similar particulate emissions, as well as several unpaved surfaces are located to the west. However, identifying sources by WS/WD for 24-hour periods with a high level of confidence is not possible due to the lack of hourly TSP data. The 24-hour average limits the usefulness of WS/WD in that period, reducing statistical confidence in the data.

Figure 17. Maximum TSP concentration divided into WS/WD by concentration quartile



The only other TSP sampler in the statewide network is a high-volume sampler at the MLK NCore site running on a 1-6 day schedule. Although the MLK TSP sampler is used for evaluation of heavy metal concentrations, a TSP concentration is also calculated before the filter is analyzed. Concentration results are reported quarterly by an outside lab. The average difference in concentrations is 56.3 $\mu g/m^3$ with a higher concentrations observed at Eden Park. Figure 18 shows the maximum concentrations at MLK and Eden Park as a percent of the State TSP standard.

Figure 18. Maximum TSP concentrations at Eden Park and MLK compared



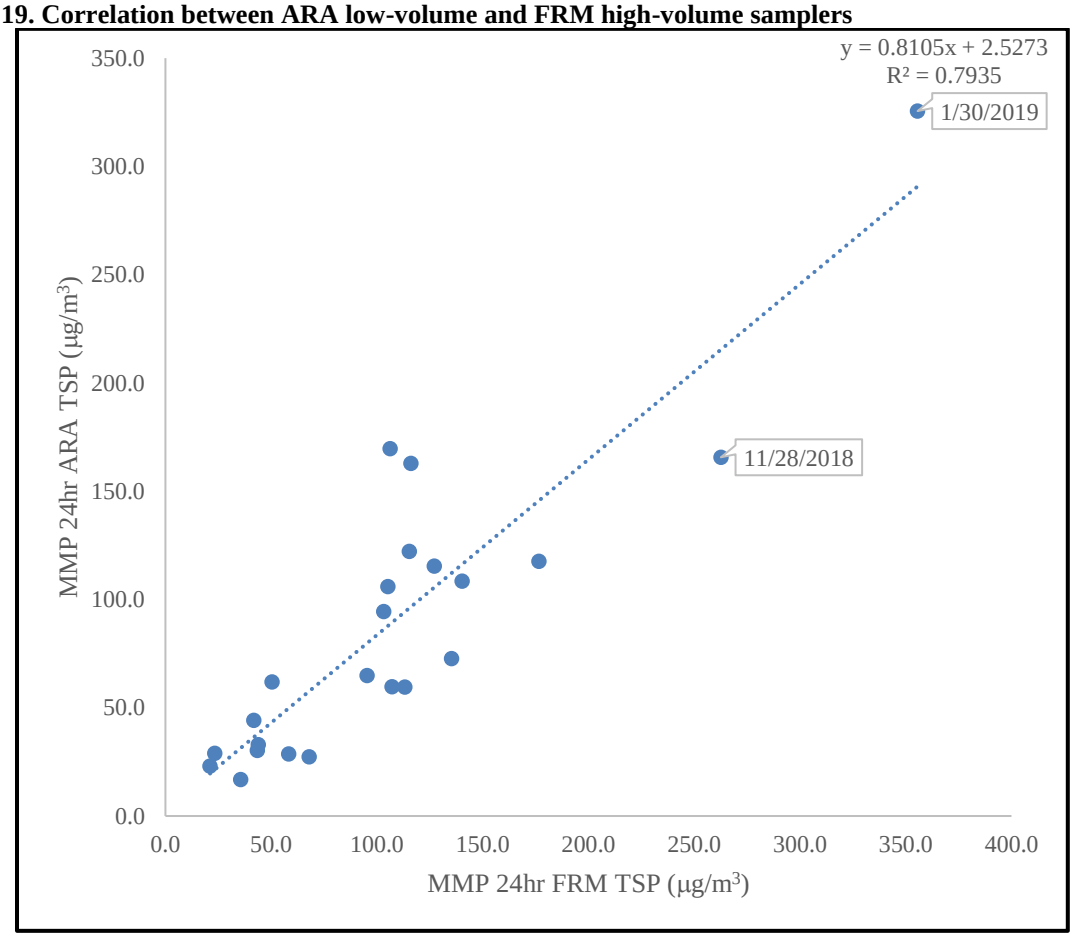
Dust Distribution Study

Elevated levels of TSP recorded at Eden Park led to questioning whether dust was affecting communities outside of the Eden Park area. To address those questions, DAQ implemented the Dust Distribution Study.

Total data capture for this study exceeded 75%; however, issues with sampler battery life resulted in only 47% data capture at all three sites on the same day. An investigation conducted with ARA, the manufacturer of the samplers, indicated that pressure drop for some filters used was at the upper end of EPA tolerance levels. This was indicated by sample durations under 24 hours; the greater flow resistance resulted in batteries draining faster than normal. A combination of upgrades to samplers and a switch to new batch of filters improved sample capture. Criteria for collection time of 24-hour samples is usually 23 to 25-hours, however for the purposes of this study 22-hours was deemed acceptable.

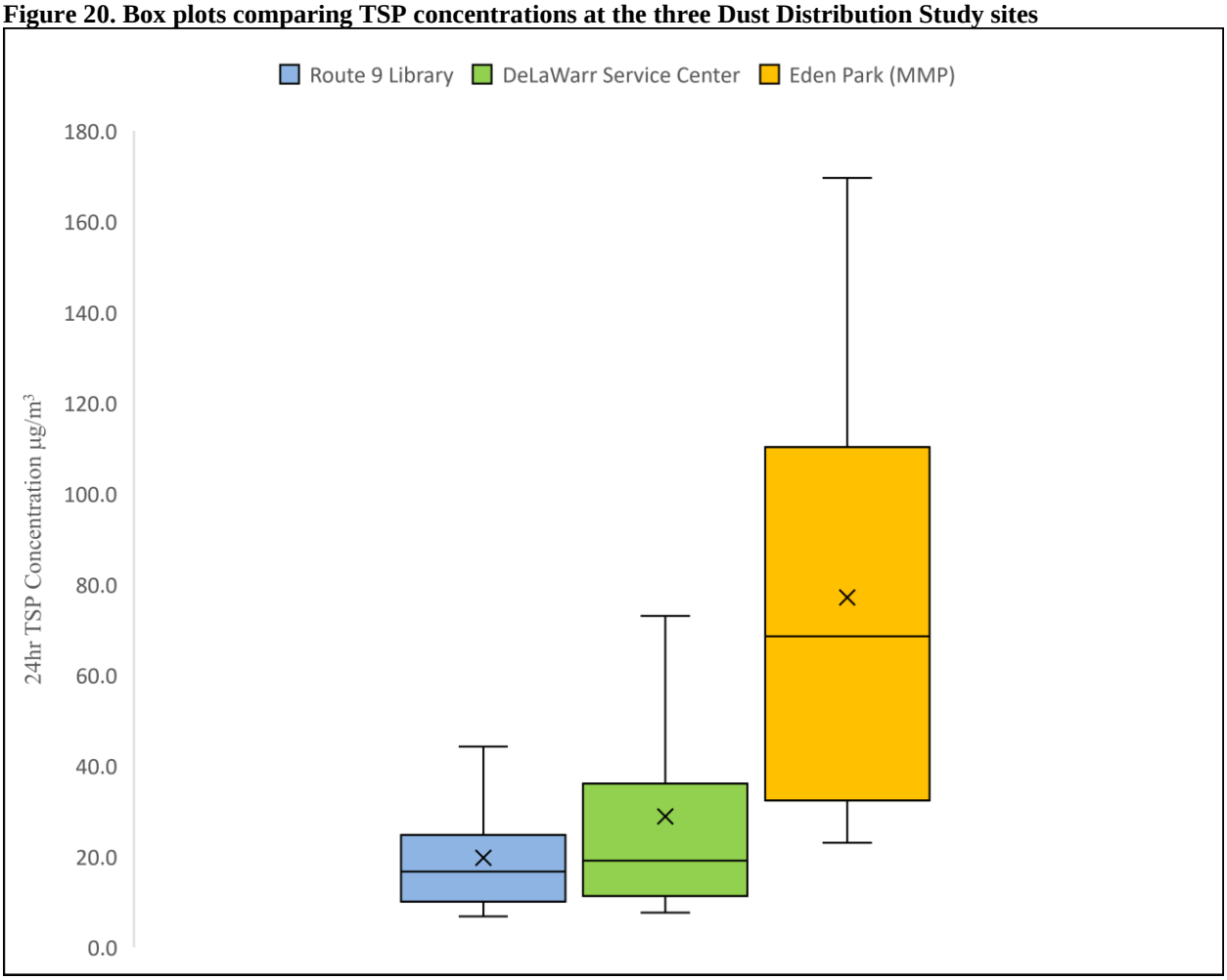
Correlation between the ARA unit at the MMP and the high-volume (FRM) TSP samplers was good with an r^2 =0.79 (Figure 19). Four samples at the MMP indicated a concentration above the State Secondary standard of 150 μg/m^3. On 11/28/2018 a concentration collected by the high-volume sampler and collocated samples collected with the low-volume ARA samplers where all above state standards. On 1/30/2019, the concentrations of samples collected by both samplers was above the state primary standard. The remaining samples above the State standards did not correspond to a concentration above that standard with the high-volume sampler. This may be due to the location of the ARA sampler on the roof the MMP with a generally un-obstructed path of air to the sampler.

Figure 19. Correlation between ARA low-volume and FRM high-volume samplers



Despite the small sample size, the correlation with the high-volume sampler gives us confidence in the data from the low-volume samplers for representation of TSP concentrations. Using the Tukey Test for Pairwise Multiple Comparisons, at $P < 0.050$ the MMP site average concentrations were different from R9L and DLW with statistical significance. The R9L and DLW sites do not differ significantly. This is best illustrated with box plots in Figure 20 where the interquartile range (box) for the MMP site barely overlaps the DLW site and does not overlap the R9L site. It is well documented that larger particles settle out faster and so do not travel very far from their sources (Reference 7 [37]). Each site is approximately ¾ of a mile apart.

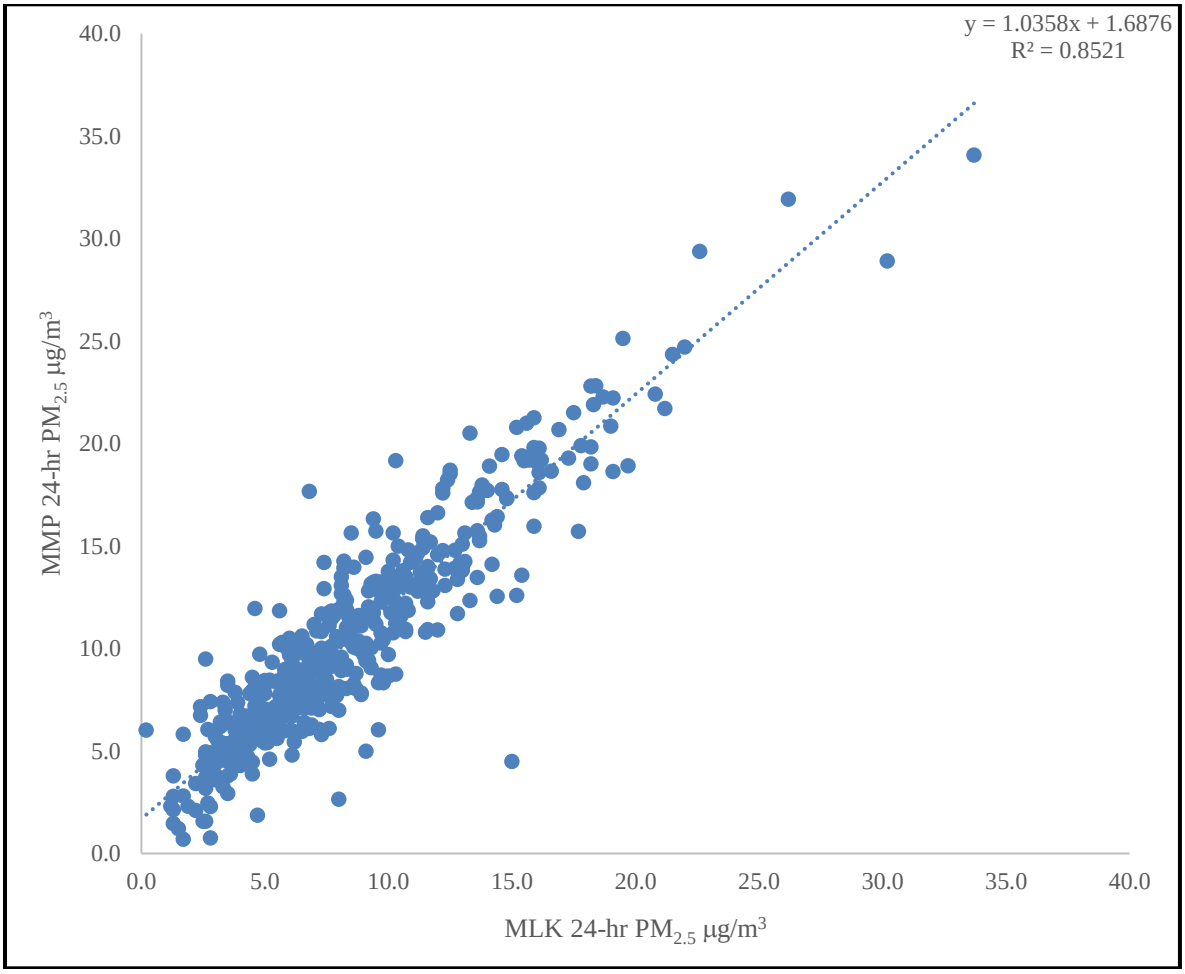
Figure 20. Box plots comparing TSP concentrations at the three Dust Distribution Study sites



$PM_{2.5}$ & PM_{10} Fraction of TSP

Particles 2.5 microns or less ($PM_{2.5}$) in diameter are considered fine particulates and can travel deeper into the respiratory system. Fine particulates are monitored throughout the state for compliance with the NAAQS. $PM_{2.5}$ represents a portion of TSP and was monitored at Eden Park for comparison to other sites. No exceedances of the NAAQS were recorded for $PM_{2.5}$ at Eden Park during the study with either monitor methods used (Figure 10). When 24 hour averages for $PM_{2.5}$ at the MMP are compared with the primary monitoring method from the MLK station there is a strong correlation $r^2 = 0.85$ (Figure 21).

Figure 21. Correlation between 24-hr $PM_{2.5}$ concentrations by continuous monitors at the MMP and primary manual monitor at MLK



As stated previously, the original NAAQS for TSP was replaced by NAAQS for the inhalable particulates:

24 Hour NAAQS:

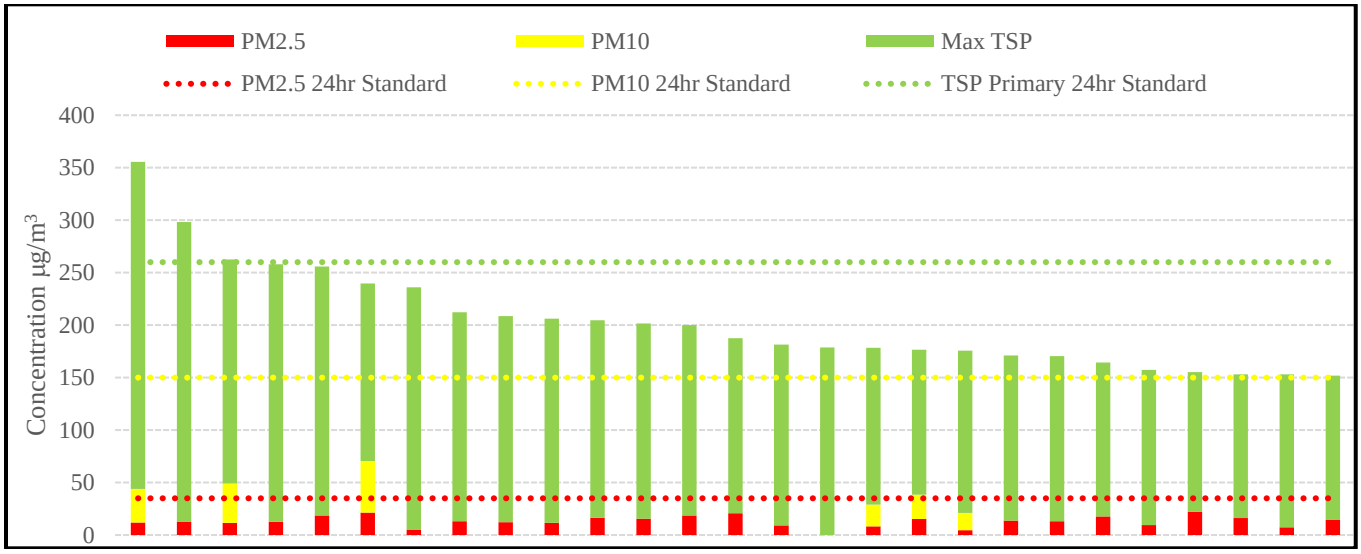
- $PM_{2.5}$ Primary& Secondary = 35 µg/m^3
- PM_{10} Primary & Secondary = 150 µg/m^3

24 Hour State of Delaware TSP Standards:

- TSP Primary = 260 µg/m^3
- TSP Secondary = 150 µg/m^3

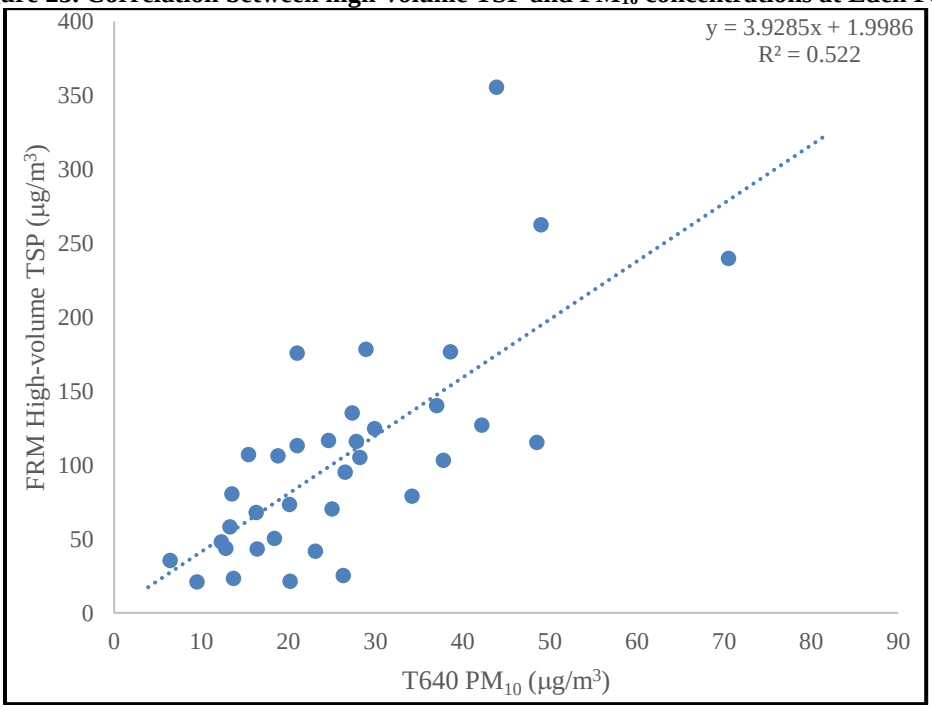
At TSP concentrations above the state standards, the $PM_{2.5}$ concentrations varied independently and never exceeded the $PM_{2.5}$ NAAQS (Figure 22). The few times PM_{10} concentrations were recorded at the same time as a TSP concentration above the TSP standard are also plotted with no exceedances of the PM_{10} NAAQS. While TSP levels were above their indicators of action, because the inhalable fractions were below their respective NAAQS, dust control methods have focused on fugitive dust emissions.

Figure 22. TSP concentrations above state standards with $PM_{2.5}$ & PM_{10} concentrations during each occurrence



Due to the physics and geometry of TSP inlets, there is no accurate continuous monitor for TSP. To allow the use of hourly data for detailed data analysis, the hypothesis that PM_{10} could serve as an indicator of TSP was explored. Continuous PM_{10} data was converted to a 24-hour average and compared to the 24-hour TSP high-volume filter data for the same sample days. There was moderate correlation with an r^2 of 0.51 (Figure 23). The correlation was judged sufficient to use PM_{10} as an indicator for TSP at hourly time intervals.

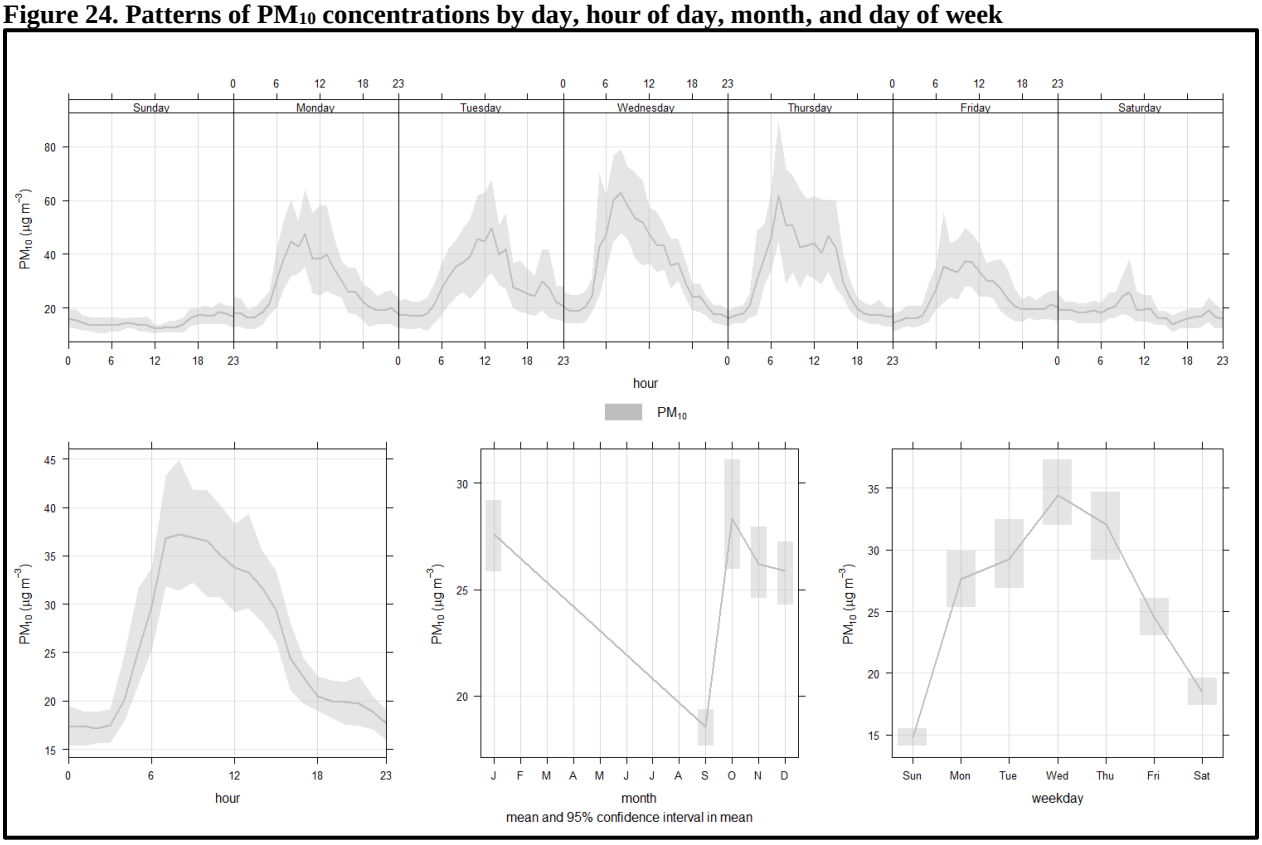
Figure 23. Correlation between high-volume TSP and PM_{10} concentrations at Eden Park



An analysis of PM_{10} patterns over time can help indicate sources. A typical indication of a mobile source is a diurnal pattern of a sharp morning peak followed by broader evening peak. PM_{10}'s diurnal pattern peaks from 7:00 a.m. to 11:00 a.m. with an average between 35-37 $\mu g/m^3$ before dropping to below 21 $\mu g/m^3$ around 6:00 p.m., which suggests an operation during business hours (Figure 24). PM_{10} does not seem to correlate with either NO_x or Black Carbon, which are also typical diesel and mobile source indicators. The daily pattern is relatively consistent over the week though the concentration indicated by the peak height is shorter on Fridays.

A similar weekday pattern for PM_{10} is seen as with the 24-hour TSP concentrations.PM_{10} peaked on Wednesdays with an average of 34 $\mu g/m^3$ and the average dropping below 20 $\mu g/m^3$ on Saturdays and Sundays.

Figure 24. Patterns of PM_{10} concentrations by day, hour of day, month, and day of week

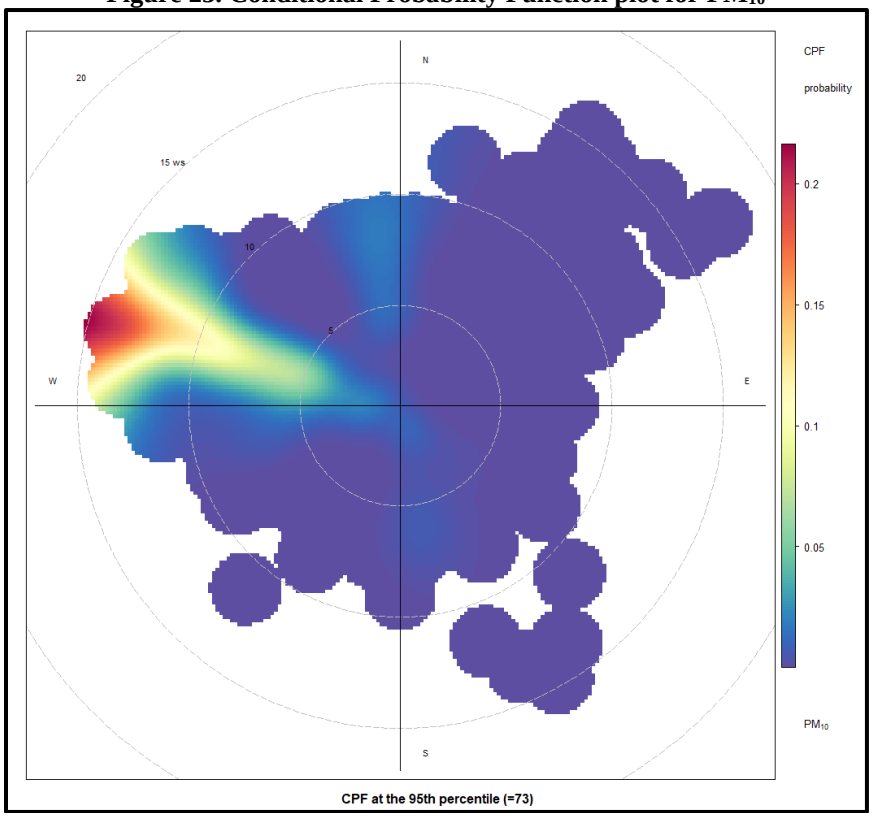


To estimate directionality of sources contributing to TSP, hourly PM_{10} was used as an indicator. A conditional probability function (CPF) plot was used to visualize estimates of the direction of higher PM_{10} concentrations. The CPF plot calculates the probability of a selected percentile of concentrations occurring at a given wind speed/directional sector and displays the probability as a heat map over a compass plot.

Warmer areas of the plot indicate a higher probability that the specified percentile of concentrations occur at a given wind speed/direction. PM_{10} concentrations at the 95th percentile, concentrations higher than 73 $\mu g/m^3$, are most likely to occur at higher wind

speeds from a westerly direction (Figure 25). As discussed previously, several unpaved lots and facilities that are sources of particulate emissions can be found in this direction.

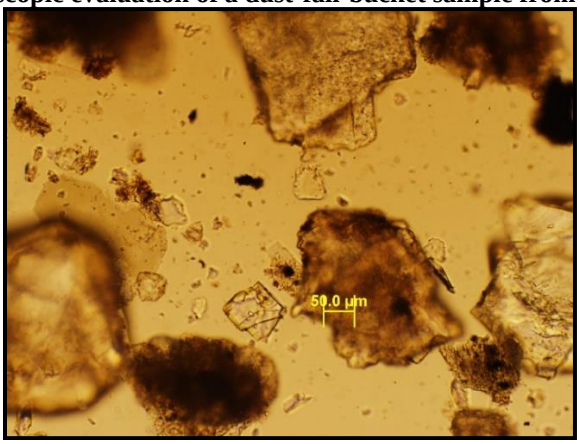
Figure 25. Conditional Probability Function plot for PM_{10}



Microscopy

A dust-fall-bucket sample was collected at the MMP from atop the primary Partisol unit and the sample examined using polarized light microscopy. It was observed that the sample consisted of 45% quartz, 20% brownish to black irregular humus, and 35% other minerals (Figure 26). The bulk of the sample is consistent with components of soil, which matches estimates from the elemental analysis discussed in the next section.

Figure 26. Image from microscopic evaluation of a dust-fall-bucket sample from Eden Park

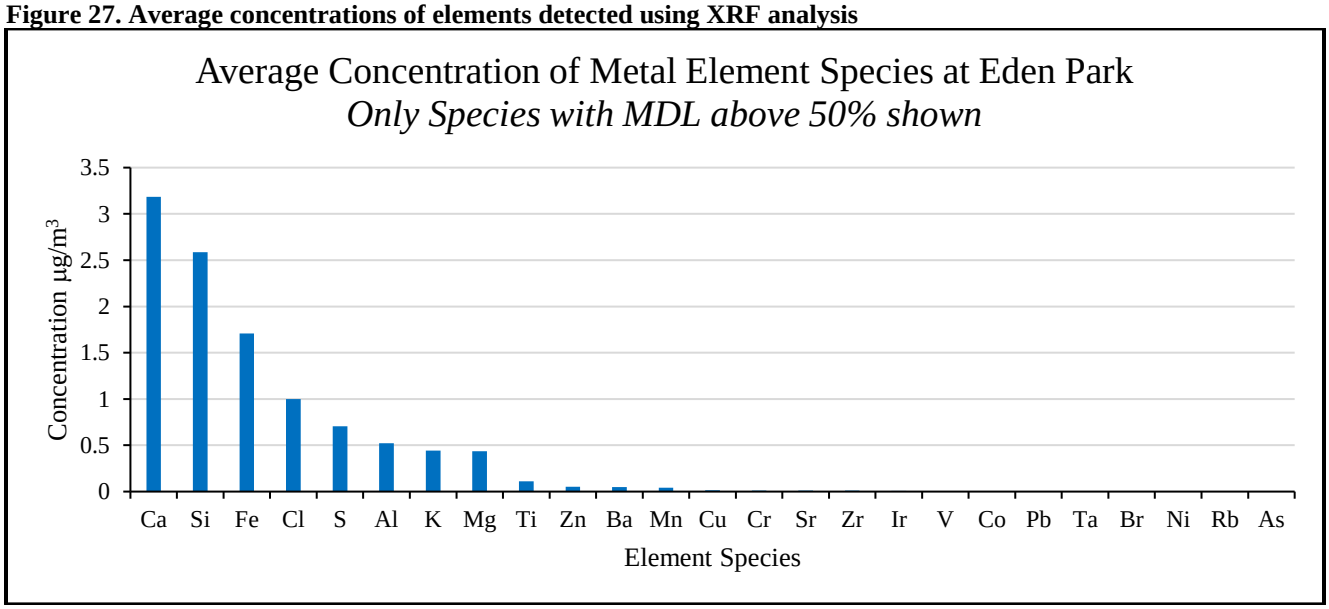


Select Particulate Composition Analysis for Source Identification

Low-volume sampler TSP filters collected from 9/26/2016 to 8/29/2017 were sent to an outside lab for metal composition using Inorganic Compendium Method 3.3 (IO-3.3) x-ray fluorescence (XRF) spectroscopy analysis. Only low-volume method Teflon filters can be analyzed by this XRF analysis. A total of 135 TSP filters were analyzed including filters from the primary sampler, selected collocate filters, and Field Blanks. Additional filters sampled for PM_{10} and collected as quality assurance for the Xact Study were sent to the same lab for analysis.

Note that these results are only estimates of select elemental metal contribution to TSP and do not represent the total composition of TSP. Analysis of metal species indicated concentrations of metal species typical of crustal or soil material were most common. Average concentrations are summarized in Figure 27 for both TSP as well as PM_{10} filters analyzed for the Xact Study.

Figure 27. Average concentrations of elements detected using XRF analysis



Particulate Composition Risk Assessment

Results of the metals analysis were submitted to the Delaware Division of Public Health for a risk assessment. The following summary of the risk assessment method used was provided by DHSS:

> *"The risk assessment was conducted using EPA developed formulas and risk factors, consistent with previous risk assessments conducted by the Division of Public Health.*
>
> *The analysis begins with the identification of inhalation unit risk and reference concentrations available via the US EPA risk screening level (RSL) table (https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables). These factors, when combined with other variables including inhalation rate, exposure*

time and duration and concentrations can be used to estimate the lifetime dose and potential risk. The cancer risk is expressed as additional number of cancer cases per 1,000,000 people. Delaware has historically used the level of one additional cancer case per 100,000 people (10 people per million) as the value to trigger further action. In calculating non-cancer risk, the risk is compared to the reference concentration for the given contaminant and any resulting ratio above one is considered high."

Metals with a cancer risk analyzed include: Nickel, Chromium, Cobalt, and Arsenic. Results indicate no increased cancer risks due to concentrations detected. Metals with a non-cancer risk include the above as well as: Aluminum, Barium, Chlorine, Lead, Manganese, Silicon, Sulfur, and Vanadium. Results for these concentrations also indicated no increased risk.

Xact Study Summary

To determine sources of particulates affecting Eden Park with a higher degree of confidence, DAQ contracted Sonoma Technology Inc. (STI) to provide an analysis using the sophisticated Xact monitor. The Xact monitor was rented for a two-month period from Mid-October to Mid-December of 2018. STI paired the elemental analysis of PM_{10} at hourly averages with meteorological conditions and continuous monitor data from the MMP to evaluate directionality, composition, and time variance as related to sources. The following summarizes STI's analysis for estimation of source apportionment.

As a measure of quality assurance, the sequential sampler used for TSP sampling was configured for PM_{10} sampling and the filters sampled during the Xact Study were submitted for XRF metals analysis by the same lab that analyzed the low-volume TSP samples. STI compared the results of the Xact monitor to XRF analysis of 24-hr PM_{10} samples collected and found the results to be comparable for most elements. Concentrations of elements that were below the minimum detection limit (MDL) 50% of the time were not included in their analysis.

Using data from the Xact and Black Carbon measurements from the MMP, STI used the EPA Positive Matrix Factorization (PMF) Model version 5.0 to estimate source factors. The PMF Model is a receptor model that uses elemental composition data, uncertainties, and number of sources provided by the user to estimate source profiles (factors), source contributions, and uncertainties. Source factors can be compared to measured profiles to estimate representativeness of a source. Source contributions estimate how much each source contributes to a sample. (Reference 8 [37])

It should be noted that these results are only estimates of elemental contribution to PM_{10} and do not represent the total composition of PM_{10}. STI narrowed their analysis to three source factors they deemed were most consistent and reproducible. Factor 1 was determined to represent crustal/soil dust using a representative nearby soil analysis for comparison. Factor 2 was determined to represent concrete dust based on the differences in the ratio of potassium (K) and calcium (Ca). While both elements are found in Factor 1 the ratio of Ca to K was higher in Factor 2, consistent with the ratio of calcium oxides and associated elements found in portland cement used in the most common type of concrete. Factor 3's signature was considerably

different from Factors 1 and 2 with elemental concentrations and a relation to black carbon that were most closely associated with tire and brake wear.

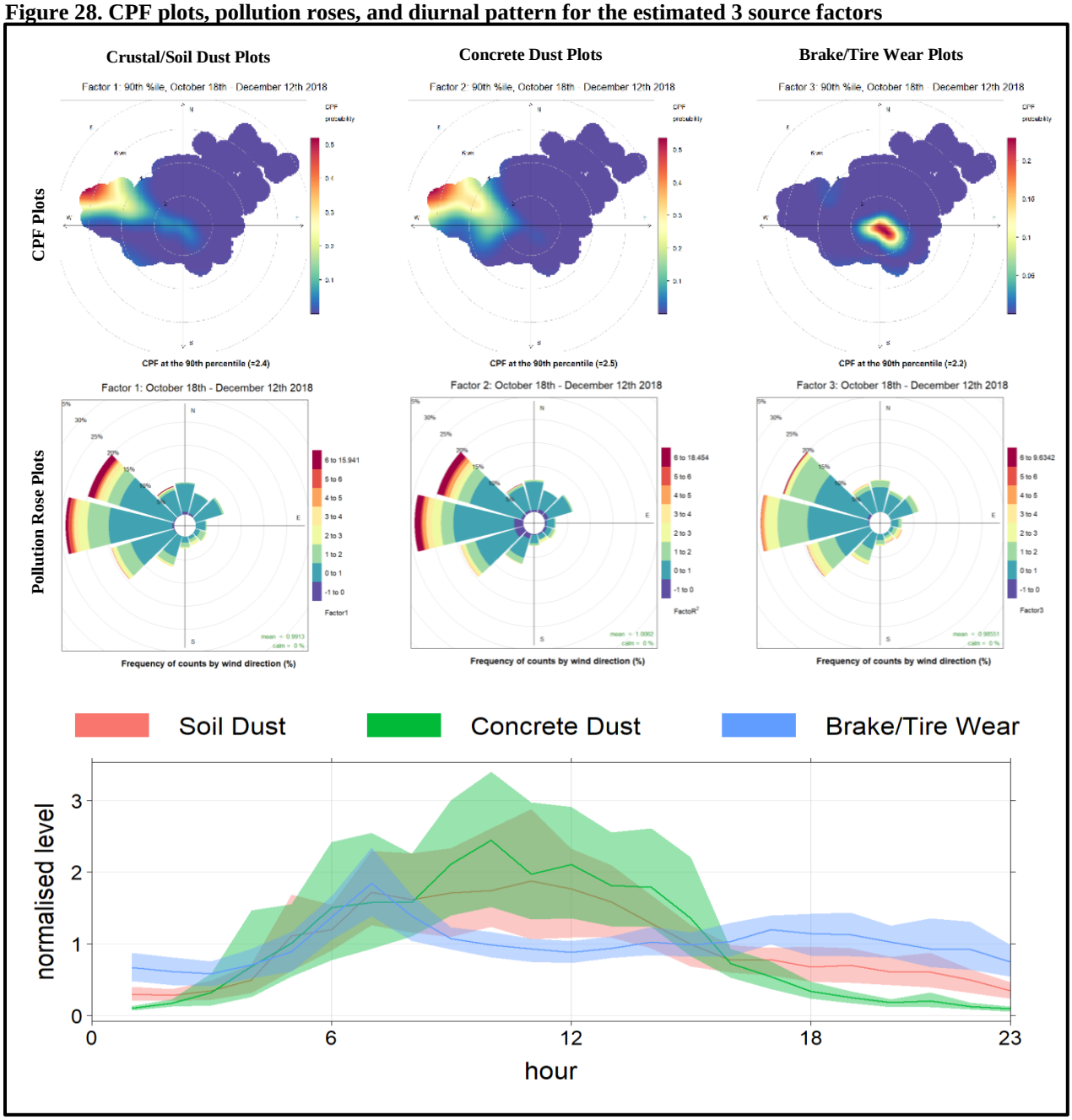
As discussed previously DAQ used PM_{10} as an indicator for TSP concentrations. DAQ asked STI to estimate the contribution of these three factors to PM_{10} concentrations. STI used EPA's Air Quality Index (AQI) for PM_{10} concentrations for the Good, Moderate, and Unhealthy for Sensitive Groups (USG) categories. In all three categories, concrete dust was the highest contributing factor followed by crustal/soil dust and then brake/tire wear (Table 5). As the concentration of PM_{10} increased the difference between concrete dust contribution and crustal/soil dust also increased. This would seem to suggest a process associated with concrete is a significant contributor to the dust affecting Eden Park.

Table 5. PM_{10} estimated factor contribution to PM_{10} at three AQI levels

		Concrete Dust		**Crustal/Soil Dust**		**Brake/Tire Wear**	
AQI Air Quality Designation	*n (hours)*	*median*	*IQR*	*median*	*IQR*	*median*	*IQR*
Good (PM_{10}: 0-54 μg/m^3)	1003	8%	17%	7%	7%	4%	3%
Moderate (PM_{10}: 55-154 μg/m^3)	130	32%	21%	12%	8%	1%	2%
USG (PM_{10}: 155-254 μg/m^3)	7	58%	14%	18%	4%	0%	1%

STI analyzed the three factors for directionality and variation over time (Figure 28). Concrete and Crustal/Soil Dust originate from a predominately westerly direction during higher wind speeds, as DAQ's PM_{10} analysis indicated. The diurnal pattern also matched the PM_{10} pattern indicative of operations occurring during business hours. The brake/tire wear factor, which is indicative of mobile sources, is highly localized at low wind speeds. Considering the MMP is sited in a parking lot, adjacent to Terminal Avenue and Interstate 495, this result is to be expected. The diurnal pattern is also consistent with the pattern for mobile sources with a sharp morning peak and broader peak later in the day.

Figure 28. CPF plots, pollution roses, and diurnal pattern for the estimated 3 source factors



Summary Discussion

In summary, no exceedances of the National Ambient Air Quality Standards (NAAQS) were observed for criteria pollutants monitored at the Moveable Monitoring Platform during the course of the project. Results for these pollutants and VOCs were comparable to other sites in Delaware's monitoring network. The urban National Core site of MLK in Wilmington is the most similar in patterns and concentrations of pollutants. This is consistent with both sites being located near heavy traffic corridors and in relatively close (approximately 1.5 miles) proximity.

TSP concentrations observed at Eden Park were significantly higher than the MLK site where TSP is also measured. Concentrations were observed above the State Primary and Secondary Standards, which serve as indicators of action. Analysis indicated that TSP concentrations were higher during weekdays and dropped significantly over the weekend. TSP concentrations were considerably higher from November to December. The predominant wind direction during the study was from the west where several sources of particulate emissions are located. Using PM_{10} concentrations as an indicator for TSP showed higher concentrations during business hours during the week, and the pattern was not typical of a mobile source pattern. The Dust Distribution Study results indicated that elevated TSP concentrations were localized to Eden Park and concentrations dropped significantly even ¾ of a mile away.

To summarize the analysis of TSP concentrations, conditions in Eden Park can lead to localized TSP concentrations above indicators of action that seem to be related to patterns of local commercial/industrial activity. Despite TSP concentrations above indicators of action, the fine particulate ($PM_{2.5}$) fraction of TSP does not exceed health-based standards (NAAQS).

The results of filter metals analysis were submitted to Delaware Division of Public Health (DPH) for risk assessment. The risk assessment was conducted using EPA developed formulas and risk factors, consistent with previous risk assessments conducted by the Division of Public Health. The DPH assessment determined that the metals monitored did not pose an increased risk.

Initially DAQ was only capable of analyzing a 24-hr TSP samples for composition. These results combined with a microscopy analysis seemed to indicate crustal/soil material as a significant contributing factor to the TSP. A grant from the EPA allowed DAQ to implement the Xact Study, which contracted Sonoma Technology Inc. to deploy a more sophisticated method for elemental metal analysis at the MMP, on an hourly basis. STI used EPAs Positive Matrix Factorization analysis to estimate three contributing Factors to the PM_{10} concentrations. The three Factors were; concrete dust, crustal/soil dust, and brake/tire wear from vehicles. The concrete dust contribution to PM_{10} was highest, followed closely by crustal/soil dust, with brake/tire wear the lowest estimated factor. As the concentration of PM_{10} increases the estimate of concrete dust contribution increases, more than the crustal/soil factor.

Diurnal patterns for the three factors indicated that concrete and crustal/soil dust concentrations were elevated during business hours. Brake/tire wear concentrations indicated a mobile source pattern. Higher concrete and crustal/soil dust concentrations emanate from west-northwest at higher wind speeds, while brake/tire wear concentrations are highest at low wind speeds near the MMP.

Analytical Contributors

Additional analyses included in this report were provided by the following:

1. **2014 Emissions Inventory Map and List**: Mark Prettyman and Jacquelyn Cuneo
2. **VOC and IO-3.3 data analysis and continuous monitor data validation**: Betsy Frey
3. **Dust-fall-bucket sample microscopy**: Michael McDowell
4. **Sonoma Technology, Inc. analyses**: Olivia S. Ryder, Jennifer L. DeWinter, Steven G. Brown

References

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9. US EPA Ambient Monitoring Technology Information Center: https://www3.epa.gov/ttnamti1/
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11. US EPA Toxic Organic Compendium Method TO-15: Determination of Volatile Organic Compounds (VOCs) in air collected in specially-prepared canisters and analyzed by Gas Chromatography/Mass Spectrometry (GC/MS)
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    1.0 General Provisions

    1.6.1 Ambient concentrations of total suspended particulates shall be determined by the reference high volume method in accordance with 40 CFR, Part 50, Appendix B, Reference Method for the Determination of Suspended Particulate Matter in the Atmosphere (High-Volume Method), April 22, 1983.

3.0 Suspended Particulates - 02/01/1981

3.1 The Primary Ambient Air Quality Standards for Particulate Matter are:

3.1.1 An annual geometric mean of 75 micrograms per cubic meter not to be exceeded, based upon 24 hour average concentrations.

3.1.2 A value of 260 micrograms per cubic meter not to be exceeded more than once per year, based upon 24 hour average concentrations.

3.2 The Secondary Ambient Air Quality Standards for Particulate Matter are:

3.2.1 An annual geometric mean of 60 micrograms per cubic meter as a guideline for achieving the secondary standard based upon 24 hour average concentrations.

3.2.2 A value of 150 micrograms per cubic meter not to be exceeded more than once per year, based upon 24 hour average concentrations.