2020 Five-Year Network Assessment of the Philadelphia Air Quality Surveillance System

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City of Philadelphia
Department of Public Health
Air Management Services

June 30, 2020

EXECUTIVE SUMMARY

Starting July 1, 2010, and every five years thereafter, 40 CFR Part 58.10(d) requires the City of Philadelphia's Department of Public Health, Air Management Services (AMS) to submit to the United States Environmental Protection Agency (EPA) an assessment of the air quality surveillance system (Assessment). This Assessment focuses primarily on Ozone and Particulate Matter less than 2.5 microns ($PM_{2.5}$) using EPA's online ambient air monitoring network assessment tool kit NetAssess v1.1 (https://sti-r-shiny.shinyapps.io/EPA_Network_Assessment/). This assessment tool also has the ability to analyze the other criteria pollutants: Carbon Monoxide (CO), Sulfur Dioxide (SO_2), Nitrogen Dioxide (NO_2), Lead (Pb), and Particulate Matter of less than 10 microns (PM_{10}).

This Assessment supplements the annual Air Monitoring Network Plan (AMNP, or Plan) submitted on July 1, 2020. The Assessment and Plan provide a comprehensive review of the Philadelphia air monitoring network and the relative value of each monitor and station. In general, the Assessment determined that the AMS network still meets the monitoring objectives. The results of this Assessment are as follows:

- $PM_{2.5}$: The commitment to EPA requires five $PM_{2.5}$ monitoring sites. AMS has transitioned to continuous/FEM monitors as the primary monitor at all locations.

- Ozone: AMS currently operates 3 ozone monitors.

- Other Criteria Pollutants: The trends for CO, SO_2, NO_2, Pb, and PM_{10} show large declines over the past 15 years and are well below the corresponding NAAQS. AMS operates two near-road NO_2 monitors and an NCore site.

- Monitoring Equipment: There is a need to replace many of the current air monitoring devices within the next five years. Many of the indirect air monitoring equipment will approach or exceed the expected life span and may require replacement. The cost of replacement for many of the analysis machines is significant when compared to the cost of individual monitors.

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INTRODUCTION / REGULATORY REQUIREMENT

Philadelphia currently has an air monitoring network of ten air monitoring stations that house instruments measuring ambient levels of gaseous, solid and liquid aerosol pollutants, including nine EPA required regulatory sites and one Village Green (community) site. It is operated by the City of Philadelphia, Department of Public Health, Air Management Services (AMS), the local air pollution control agency for the City of Philadelphia. This network is part of a broader network of air monitoring agencies in Pennsylvania, New Jersey, Delaware and Maryland that make up the Philadelphia-Camden-Wilmington, PA-NJ-DE-MD Core-Based Statistical Area.

The United States Environmental Protection Agency (EPA) created regulations on how the air monitoring network is to be set up. These regulations can be found in Title 40 - Protection of Environment in the Code of Federal Regulations (CFR) Part 58 – Ambient Air Quality Surveillance, located online at: https://ecfr.io/Title-40/pt40.6.58

Beginning July 1, 2007, and each year thereafter, AMS has submitted to EPA Region III, an Air Monitoring Network Plan (Plan) which assures that the network stations continue to meet the criteria established by federal regulations.

Per 40 CFR Part 58.10(d), AMS shall perform and submit to EPA Region III an assessment of the air quality surveillance system every 5 years to determine, at a minimum, if the network meets the monitoring objectives defined in 40 CFR Part 58 appendix D, whether new sites are needed, whether existing sites are no longer needed and can be terminated, and whether new technologies are appropriate for incorporation into the ambient air monitoring network. The network assessment must consider the ability of existing and proposed sites to support air quality characterization for areas with relatively high populations of susceptible individuals (e.g., children with asthma), and for any sites that are being proposed for discontinuance, the effect on data users other than the agency itself, such as nearby States and Tribes or health effects studies. AMS must submit a copy of this 5-year assessment (Assessment), along with a revised Plan, to EPA Region III. The first Assessment was submitted July 1, 2010. The second and last Assessment was submitted July 1, 2015.

This Assessment, in combination with the Plan, provides a comprehensive review of the Philadelphia air monitoring network and the relative value of each monitor and station with consideration of data users such as nearby States or health effect studies, using tools provided by EPA. It covers the National Ambient Air Quality Standards (NAAQS), Air Toxics, and meteorological monitoring networks and associated technology for which AMS has responsibility, with an emphasis on those NAAQS associated with high human health risk. This Assessment helps to optimize the network to achieve, with limited resources, the best possible scientific value and protection of public and environmental health and welfare, focusing on pollutants that are new or persistent challenges, addressing multiple, interrelated air quality issues, and deemphasizing pollutants that are steadily becoming less problematic and better understood.

NETWORK ASSESSMENT TOOLS

Previously a Web-based tool kit published by Lake Michigan Air Directors Consortium (LADCO) workgroup was used for the 2015 Assessment. Now EPA has issued a similar Web-based assessment tool kit, NetAssess2020 v1.1 (Tools), available to all state and local agencies at https://sti-r-shiny.shinyapps.io/EPA_Network_Assessment/. This network assessment uses the EPA Tools.

The EPA Tools gather monitoring data from recent years up to 2018, including $PM_{2.5}$ annual 98th percentile, $PM_{2.5}$ annual design value, $PM_{2.5}$ 24-hour design value, O_3 annual 4th highest 8-hour value, O_3 annual design value, etc., as well as data of other criteria pollutants. Active site and monitor records were taken from EPA's Air Quality System (AQS).

The Tools aid in the network assessment to answer mainly two questions:

- Which sites are redundant and could possibly be either removed or relocated?
- Where is more information needed to better characterize air quality and could, therefore, use a new site?

The Tools are used as a weight of evidence in deciding whether or not to keep a site or possibly establish a new site. These Tools include the area served tool, the correlation matrix tool, the exceedance probabilities tool, and the removal bias tool.

The Area Served tool uses a spatial analysis technique known as Voronoi or Thiessen polygons to show the area represented/served by a monitoring site. The shape and size of each polygon is dependent on the proximity of the nearest neighbors to a particular site. All points within a polygon are closer to the monitor in that polygon than to any other monitor. Once the polygons are calculated, data from the 2010 decennial census are used to find the census tract centroids within each polygon. The population represented by the polygon is calculated by summing the populations of these census tracts.

The Correlation Matrix tool calculates and displays the data correlation, value difference, and distance between each pair of sites. The purpose of this tool is to provide a means of determining possible redundant sites that could be removed. Possible redundant sites would exhibit fairly high correlations consistently across all of their data pairings and would have low average value difference in their data. Usually, it is expected that correlation between two sites will decrease as distance increases. However, for a regional air pollutant such as ozone, sites in the same air shed can have very similar concentrations and be highly correlated. More unique sites would exhibit the opposite characteristics. They would not be very well correlated with other sites and their value difference would be higher than other site-to-site pairs.

On the diagonal line in the correlation matrix from upper-left to lower-right, the 2018 design value of each site is shown. In the upper-right triangle of the matrix, the number indicates the distance (km) between two sites, and the shade of red color indicates the mean absolute value difference (see Figure 3 as an example). In the lower-left triangle of the matrix, the value is the number of observation data pairs used in correlation while the shade of blue color indicates Pearson correlation (1 being the highest). The correlation between two sites quantitatively describes the degree of relatedness between the measurements made at two sites. That relatedness could be caused by various influences including a common source affecting both sites to pollutant transport caused by meteorology. The correlation may indicate whether a pair of sites is related, however it does not indicate if one site consistently measures pollutant concentrations at levels substantially higher or lower than the other (i.e. value differences). For this purpose, the red color shades in the upper-right triangle should be examined. Besides the color shades, the precise values of correlation and measurement difference can be downloaded from the Tools.

The correlation matrix tool uses daily summary pollutant concentration data for ozone and $PM_{2.5}$ collected between January 1, 2016 and December 31, 2018. Data was retrieved from EPA's AQS database. For ozone, the correlation matrix tool calculates a Pearson correlation (R) for all valid 8-hour average ozone (AQS code 44201) concentration pairs. Individual monitoring sites are identified using the AQS Site ID, which is a combination of the state code, county code, and site ID fields (XX-XXX-XXXX). If a site has more than one monitor collecting ozone data, the daily maximum 8-hour ozone concentration is the average of all valid results for that site on that date. For $PM_{2.5}$, the correlation matrix tool calculates Pearson Correlations (R) for all valid 24-hour fine particle concentration pairs stored under AQS parameter codes 88101 (PM2.5 Local Conditions - FRM/FEM/ARM). If a site has more than one monitor collecting $PM_{2.5}$ data, the daily average $PM_{2.5}$ concentration is the average of all valid results for that site on that date.

The Exceedance Probabilities tool consists of maps for spatial comparisons. One objective of the network assessment is to determine if new sites are needed. In order to make that decision, it is helpful to have some estimation of the extreme pollution levels in areas where no monitors currently exist. The tool provides ozone and $PM_{2.5}$ maps of the contiguous US that can be used to make spatial comparisons regarding the probability of daily values exceeding a certain threshold.

The surface probability maps show the probability of exceeding the National Ambient Air Quality Standards (NAAQS), based on 2014 – 2016 monitoring data. The probability estimates alone should not be used to justify a new monitor. The maps should be used in conjunction with existing monitoring data. If a monitor has historically measured high values, then the probability map gives an indication of areas where you would expect to observe similar extreme values. This information, along with demographic and emissions data, could be used in a weight of evidence approach for proposing new monitor locations.

The Removal Bias tool is meant to aid in determining redundant sites. The bias estimation uses the nearest neighbors to each site to estimate the concentration at the location of the site if the site had been removed or never existed. This is done using the Voronoi Neighborhood Averaging algorithm with inverse distance squared weighting. The squared distance allows for higher weighting on concentrations at sites located closer to the site being examined. The bias was calculated for each day at each site by taking the difference between the predicted value from the interpolation and the measured concentration. A

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positive average bias would mean that if the site being examined was removed, the neighboring sites would generate an estimated concentration higher than the measured concentration. Likewise, a negative average bias would suggest that the estimated concentration, based on neighboring sites, at the location of the site is smaller than the actual measured concentration.

PURPOSE/GOALS OF ASSESSMENT

The goals of the air monitoring network are to protect the health and quality of life for the citizens of Philadelphia from the adverse effects of air contaminants. To achieve this, air monitors are placed in areas of high concentrations or high populations. This assessment uses population data from the 2010 US Census, which was the most recent census. Based on 2010 census data, Philadelphia ranked as the 5th largest city in United States with a population of 1,526,006 people. Figure 1 shows the population by census tracts in 2010.

Currently, Philadelphia County is in attainment for all NAAQS except for Ozone. The Philadelphia-Wilmington-Atlantic City, PA-NJ-MD-DE 8-hour Ozone nonattainment area consists of eighteen counties in Pennsylvania (Bucks, Montgomery, Chester, Delaware, and Philadelphia), New Jersey (Atlantic, Burlington, Camden, Cape May, Cumberland, Gloucester, Mercer, Ocean, and Salem), Maryland (Cecil), and Delaware (Kent, New Castle, and Sussex). As of July 1, 2015, this area is classified as marginal nonattainment for the 2008 8-hour Ozone standard. The NEA monitor is one of the highest design value monitors in the region.

To be consistent with the previous 5-year assessments and with the area divisions in the NetAssess2020 tools, note that this assessment covers the Philadelphia-Camden-Wilmington, PA-NJ-DE-MD Core-Based Statistical Area (CBSA), which includes 11 counties in Pennsylvania (Bucks, Chester, Delaware, Montgomery, and Philadelphia), New Jersey (Burlington, Camden, Gloucester, and Salem), Delaware (New Castle), and Maryland (Cecil).

This Assessment focuses mainly on $PM_{2.5}$ and Ozone. The other criteria pollutants are briefly discussed.

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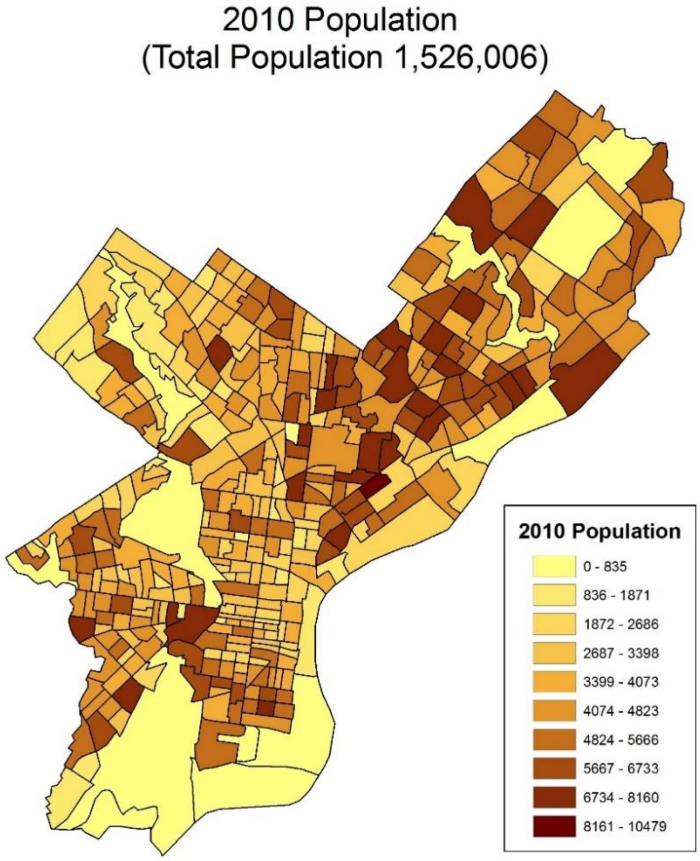
Figure 1. 2010 Philadelphia County Population



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NETWORK ASSESSMENT

1. $PM_{2.5}$

Monitoring Introduction

AMS currently monitors $PM_{2.5}$ (FRM, continuous, or speciated) at five monitoring sites[1]. The LAB Site (AQS ID 421010004) $PM_{2.5}$ was discontinued on 1/1/2019. The focus of this discussion pertains to $PM_{2.5}$ monitors designated as the primary monitor at each location. Table 1 and Figure 2 show the $PM_{2.5}$ monitoring network in and around Philadelphia County. Tables 2 and 3 show trends for the annual and 24-hour averages for $PM_{2.5}$[2]. The most recent data include the 4th quarter of 2019.

[1] The count does not include the Village Green monitor (VGR, a community site; see 2020-2021 Air Monitoring Network Plan for more information).

[2] $PM_{2.5}$ data downloaded from EPA's AirData website www.epa.gov/airdata on 4/22/2020.

Table 1. PM$_{2.5}$ Monitoring Sites in Philadelphia

AMS Site	AQS Site ID	PM$_{2.5}$ Monitor	Latitude	Longitude	Comment
NEW	421010048	Continuous; Speciated	39.991389	-75.080833	
RIT	421010055	Continuous; Speciated	39.922867	-75.186921	
FAB	421010057	Continuous	39.960048	-75.142614	
TOR	421010075	Continuous	40.054171	-74.985166	
MON	421010076	Continuous	39.988842	-75.207205	Started on 7/1/2015

Figure 2. PM$_{2.5}$ Monitoring Sites in and around Philadelphia County

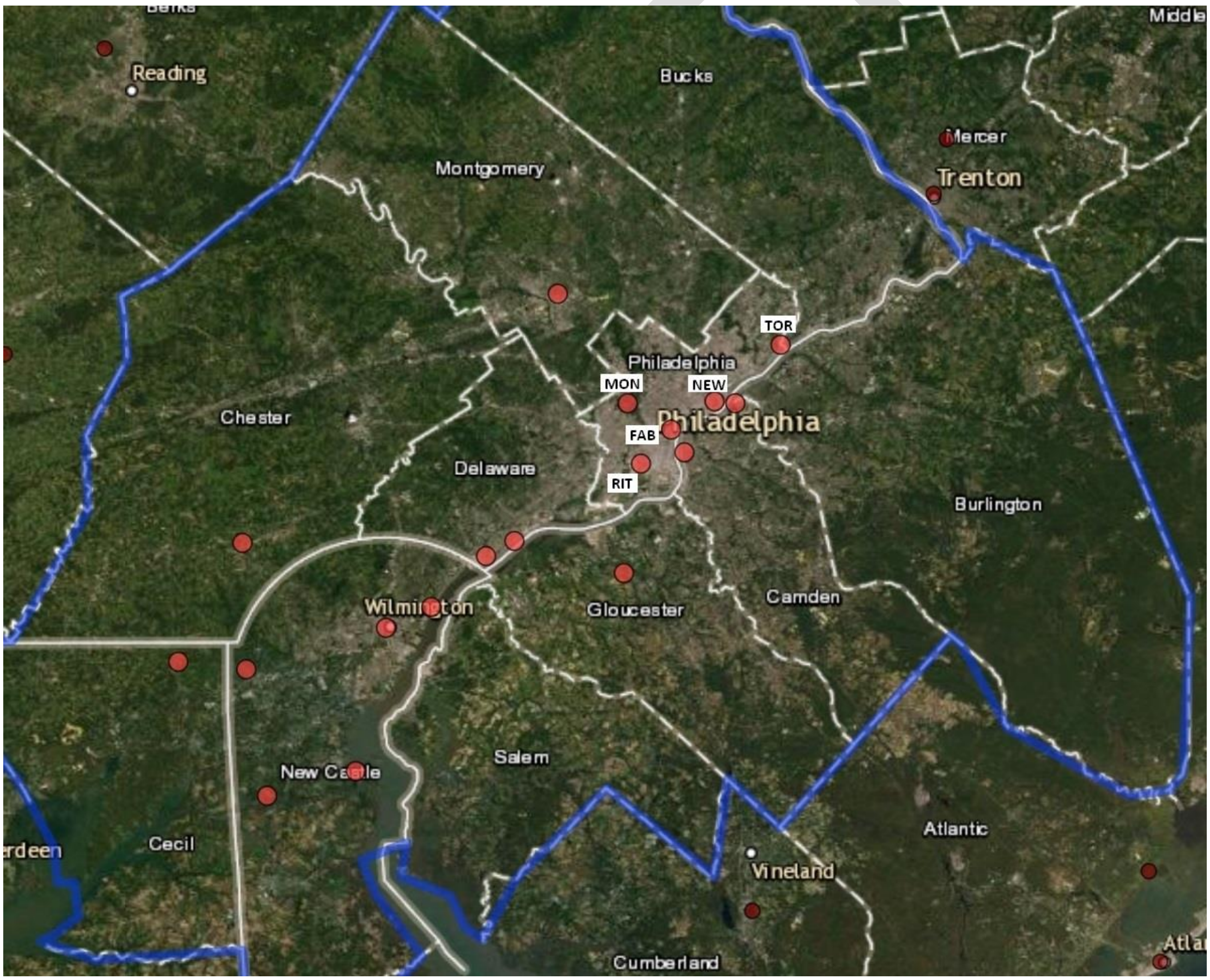

Table 2. $PM_{2.5}$ Annual Arithmetic Mean ($\mu g/m^3$)

YEAR	NEW	RIT	FAB	TOR	MON	LAB*
2010		11.3	10.9			10.7
2011		11.4	11.4			8.9
2012		10.3	10.1			9.7
2013	10.9	11.5	10.5			9.2
2014	11.0	12.7	11.9	11.8		9.8
2015	10.3	11.2	11.0	10.7	9.0	10.3
2016	9.8	10.5	9.4	9.4	8.2	8.0
2017	9.1	10.0	10.1	8.5	8.6	8.2
2018	8.6	9.8	8.0	9.7	8.7	8.1
2019	8.3	8.4	7.3	8.7	8.3	

* LAB site discontinued on 1/1/2019

Table 3. $PM_{2.5}$ 24-Hour 98th Percentile ($\mu g/m^3$)

YEAR	NEW	RIT	FAB	TOR	MON	LAB*
2010		28.9	27.9			27.6
2011		30.6	30.5			23.7
2012		24.8	23.3			21.1
2013	35.3	29.8	25.5			35.1
2014	28.4	30.8	31.7	27.3		28.2
2015	26	30	27	27	30	27
2016	22	22	22	22	21	24
2017	22	20	20	22	20	22
2018	20	21	18	23	19	21
2019	25	22	18	22	20	

* LAB site discontinued on 1/1/2019

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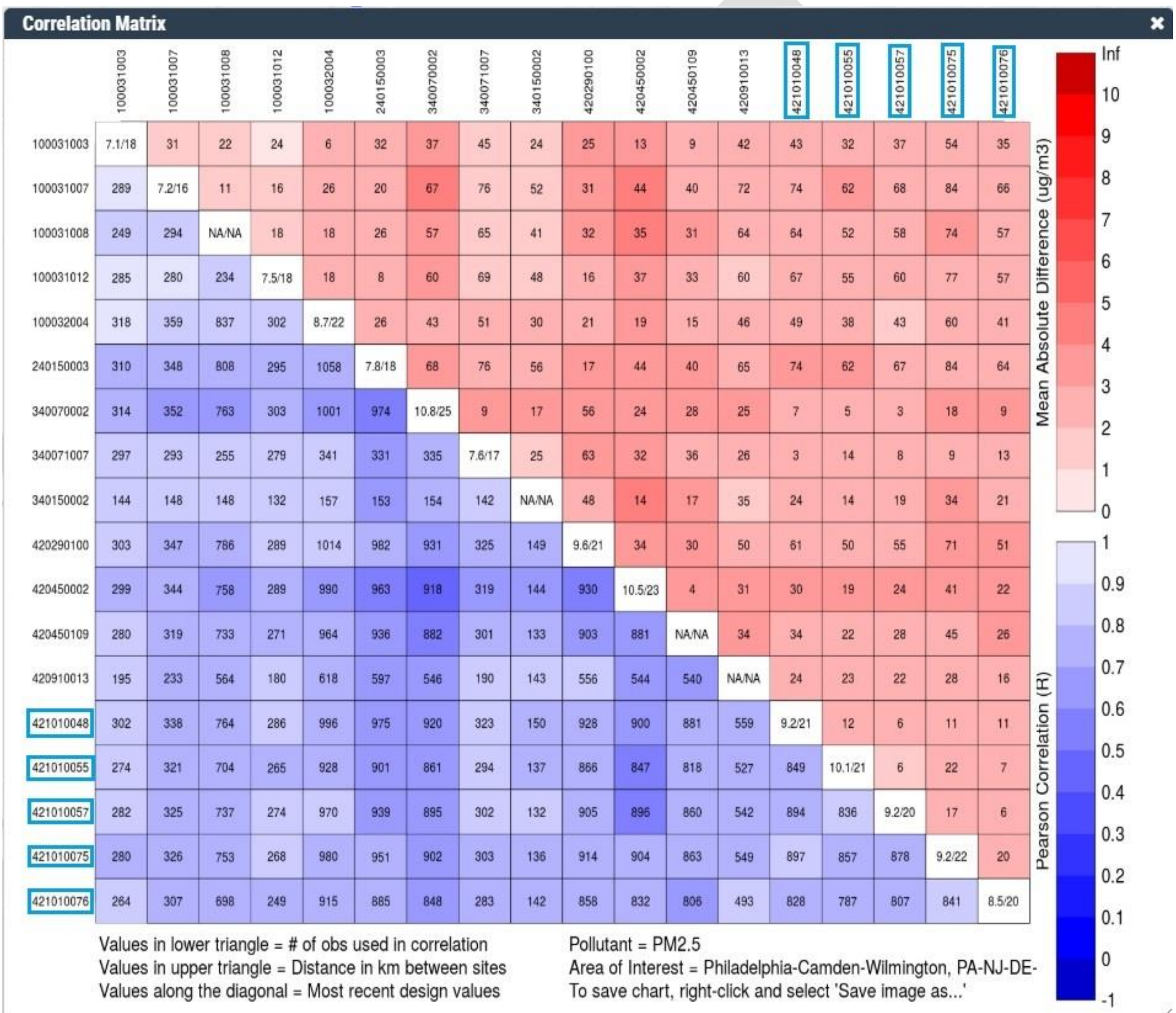
Results of Correlation Matrix Tool

Figure 3 shows the correlation matrix generated with the Tools for all current $PM_{2.5}$ monitoring sites in the Philadelphia CBSA. Tables 4 – 8 show data generated in the correlation matrix.

Figure 3. $PM_{2.5}$ FRM/FEM Daily Value Correlation Matrix – Philadelphia CBSA

Philadelphia County sites marked in blue boxes: 421010048 (NEW), 421010055 (RIT), 421010057 (FAB), 421010075 (TOR), and 421010076 (MON)



In general, the correlations and average differences for the Philadelphia monitors had two noticeable trends. The NEW (NCore) site was moderately correlated (correlations 0.8 ~ 0.9) with TOR and the nearby New Jersey site 340071007 (3 km away), as shown in Table 4. The FAB site was moderately correlated (correlations 0.8 ~ 09) with RIT and neighboring New Jersey site 340071007 (8 km away), as in Table 6.

Table 4. $PM_{2.5}$ Correlation Matrix for NEW (421010048)

Site 1	Site 2	Correlation	No. Obs	Mean Diff.	Distance (km)
NEW	100031003	0.844	302	2.69	43
NEW	100031007	0.786	338	2.76	74
NEW	100031008	0.740	764	2.95	64
NEW	100031012	0.845	286	2.39	67
NEW	100032004	0.789	996	2.30	49
NEW	240150003	0.648	975	3.13	74
NEW	340070002	0.683	920	2.92	7
NEW	**340071007**	**0.863**	**323**	**2.35**	**3**
NEW	340150002	0.798	150	2.45	24
NEW	420290100	0.726	928	2.79	61
NEW	420450002	0.668	900	3.13	30
NEW	420450109	0.703	881	2.93	34
NEW	420910013	0.773	559	2.39	24
NEW	RIT (421010055)	0.753	849	2.60	12
NEW	FAB (421010057)	0.790	894	2.37	6
NEW	**TOR (421010075)**	**0.816**	**897**	**2.27**	**11**
NEW	MON (421010076)	0.794	828	2.39	11

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Table 5. $PM_{2.5}$ Correlation Matrix for RIT (421010055)

Site 1	Site 2	Correlation	No. Obs	Mean Diff.	Distance (km)
RIT	100031003	0.826	274	2.89	32
RIT	100031007	0.703	321	3.04	62
RIT	100031008	0.725	704	2.92	52
RIT	100031012	0.767	265	2.86	55
RIT	100032004	0.784	928	2.37	38
RIT	240150003	0.643	901	3.32	62
RIT	340070002	0.639	861	2.96	5
RIT	340071007	0.822	294	2.55	14
RIT	340150002	0.707	137	2.78	14
RIT	420290100	0.710	866	2.87	50
RIT	420450002	0.594	847	3.54	19
RIT	420450109	0.771	818	2.60	22
RIT	420910013	0.726	527	2.67	23
RIT	NEW (421010048)	0.753	849	2.60	12
RIT	**FAB (421010057)**	**0.860**	**836**	**1.83**	**6**
RIT	TOR (421010075)	0.735	857	2.68	22
RIT	MON (421010076)	0.762	787	2.60	7

Table 6. $PM_{2.5}$ Correlation Matrix for FAB (421010057)

Site 1	Site 2	Correlation	No. Obs	Mean Diff.	Distance (km)
FAB	100031003	0.872	282	2.45	37
FAB	100031007	0.751	325	2.68	68
FAB	100031008	0.761	737	2.54	58
FAB	100031012	0.823	274	2.40	60
FAB	100032004	0.850	970	1.84	43
FAB	240150003	0.663	939	2.87	67
FAB	340070002	0.641	895	2.88	3
FAB	**340071007**	**0.876**	**302**	**2.07**	**8**
FAB	340150002	0.803	132	2.20	19
FAB	420290100	0.785	905	2.46	55
FAB	420450002	0.594	896	3.64	24
FAB	420450109	0.762	860	2.49	28
FAB	420910013	0.776	542	2.11	22
FAB	NEW (421010048)	0.790	894	2.37	6
FAB	**RIT (421010055)**	**0.860**	**836**	**1.83**	**6**
FAB	TOR (421010075)	0.731	878	2.58	17
FAB	MON (421010076)	0.754	807	2.39	6

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Table 7. $PM_{2.5}$ Correlation Matrix for TOR (421010075)

Site 1	Site 2	Correlation	No. Obs	Mean Diff.	Distance (km)
TOR	100031003	0.792	280	2.90	54
TOR	100031007	0.747	326	2.99	84
TOR	100031008	0.734	573	3.04	74
TOR	100031012	0.806	268	2.59	77
TOR	100032004	0.757	980	2.54	60
TOR	240150003	0.703	951	2.87	84
TOR	340070002	0.659	902	3.07	18
TOR	340071007	0.795	303	2.82	9
TOR	340150002	0.705	136	3.43	34
TOR	420290100	0.709	914	3.12	71
TOR	420450002	0.706	904	3.17	41
TOR	420450109	0.737	863	2.85	45
TOR	420910013	0.745	549	2.78	28
TOR	NEW (421010048)	**0.816**	**897**	**2.27**	**11**
TOR	RIT (421010055)	0.735	857	2.68	22
TOR	FAB (421010057)	0.731	878	2.58	17
TOR	MON (421010076)	0.837	841	2.24	20

Table 8. $PM_{2.5}$ Correlation Matrix for MON (421010076)

Site 1	Site 2	Correlation	No. Obs	Mean Diff.	Distance (km)
MON	100031003	0.807	264	2.37	35
MON	100031007	0.745	307	2.53	66
MON	100031008	0.712	698	2.70	57
MON	100031012	0.797	249	2.14	57
MON	100032004	0.768	915	2.47	41
MON	240150003	0.714	885	2.67	64
MON	340070002	0.640	848	3.44	9
MON	340071007	0.770	283	2.40	13
MON	340150002	0.775	142	2.49	21
MON	420290100	0.707	858	3.10	51
MON	420450002	0.723	832	3.44	22
MON	420450109	0.700	806	3.02	26
MON	420910013	0.839	493	2.11	16
MON	NEW (421010048)	0.794	828	2.39	11
MON	RIT (421010055)	0.762	787	2.60	7
MON	FAB (421010057)	0.754	807	2.39	6
MON	TOR (421010075)	0.837	841	2.24	20

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Results of Area Served Tool

Figure 4 shows the Area Served polygons for the five $PM_{2.5}$ monitoring sites in Philadelphia. The population statistics are shown in Table 9. The area served by NEW has the highest percentage of ethnic minority population (80%), while the area served by TOR has the highest percentage of people 65 years and older (16%).

Figure 4. $PM_{2.5}$ Monitors Area Served

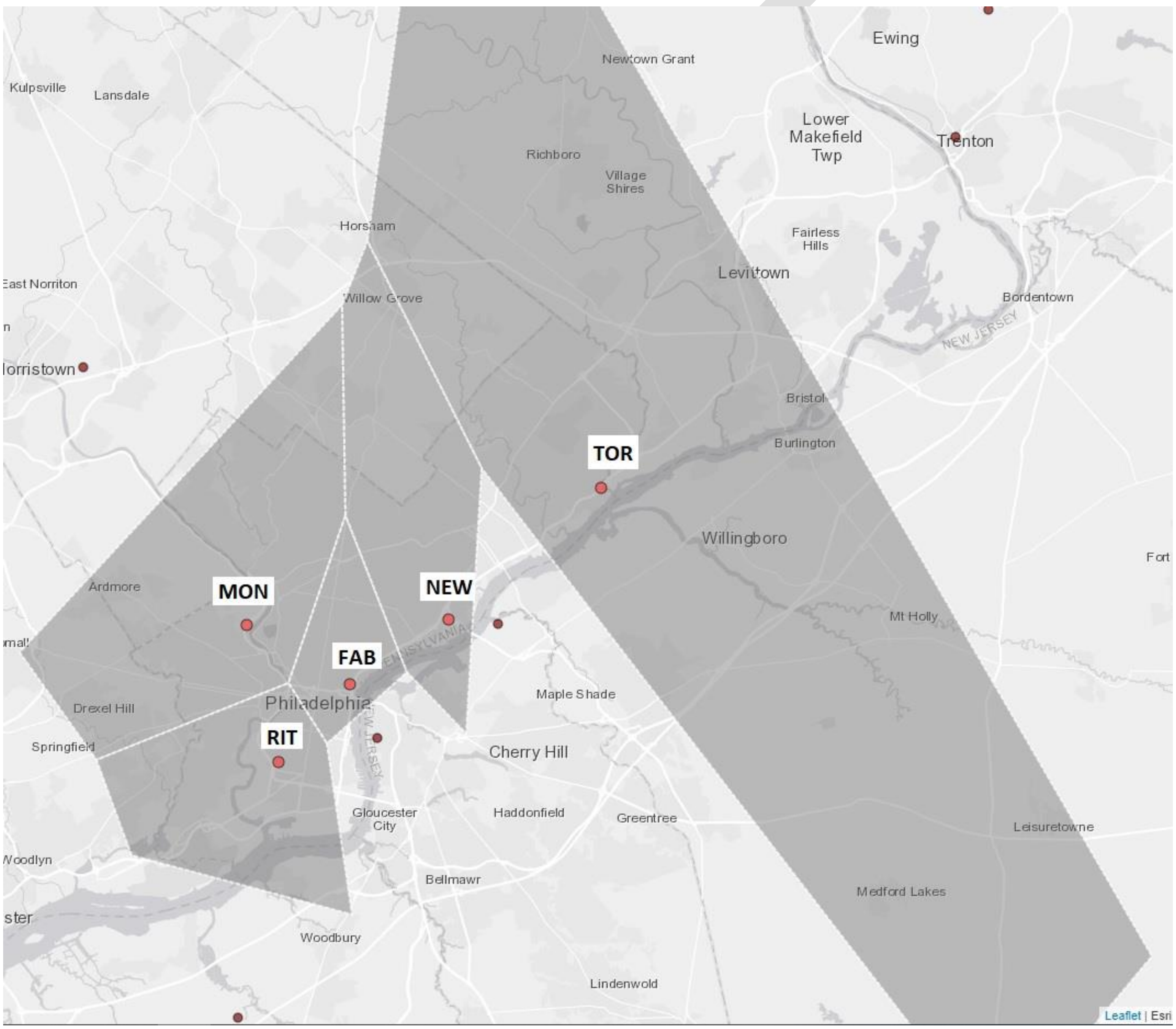


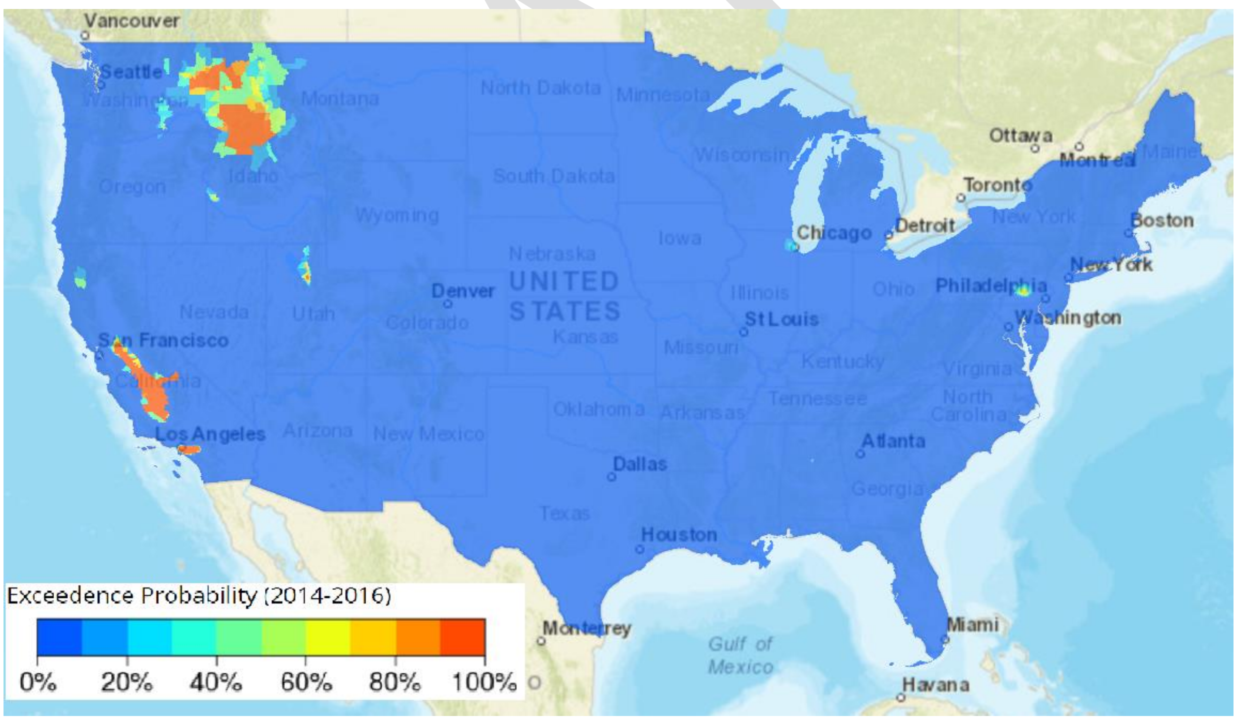
Table 5. PM2.5 Monitors Area Served Population Statistics (Voronoi Polygon)

SITE	TOTAL POPULATION (2010)	TOTAL AGE 65 AND UP	TOTAL MINORITY	AREA (km^2)	POPULATION DENSITY (per km^2)
NEW	407,745	41,224	327,676	113	3,608
RIT	305,400	35,075	198,711	88	3,470
FAB	246,543	24,791	201,221	33	7,471
TOR	735,617	119,793	196,872	1,002	734
MON	669,072	89,678	434,151	197	3,396

Results of Exceedance Probabilities Tool

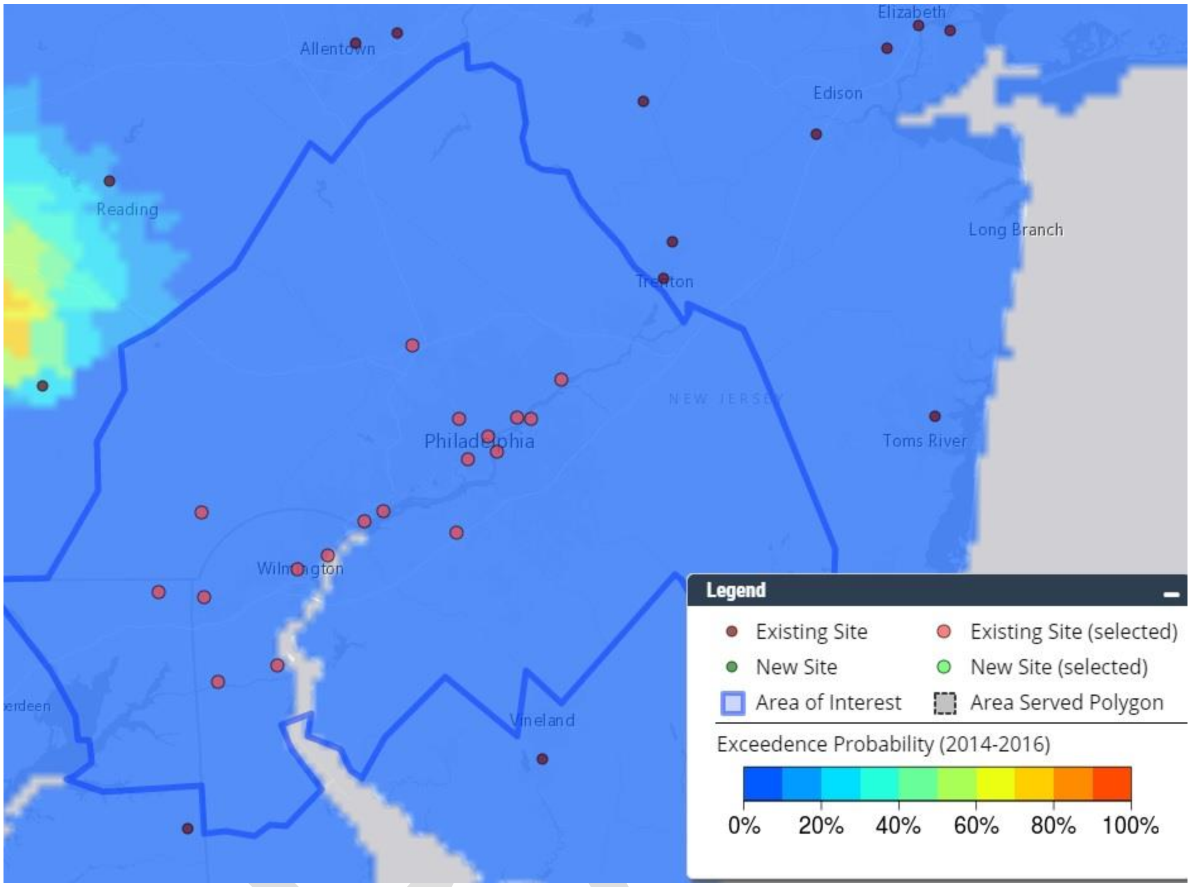
Surface probability maps for the continental United States and the Philadelphia area are shown in Figures 5 and 6. The maps are based on 2014 – 2016 monitoring data.

Figure 5. Daily PM2.5 Surface Exceedance Probability Map for Continental US



The map in Figure 6 shows the $PM_{2.5}$ exceedance probability in the Philadelphia area is fairly low (around 10%).

Figure 6. Daily $PM_{2.5}$ Surface Exceedance Probability Map for Philadelphia Area



<u>Results of Removal Bias Tool</u>

The results from the removal bias tool are shown in Figure 7 and Table 10. NEW, FAB, TOR and MON sites had either a significant positive or significant negative mean removal bias. RIT had a relatively small mean removal bias.

Figure 7. PM2.5 Removal Bias Map for Philadelphia

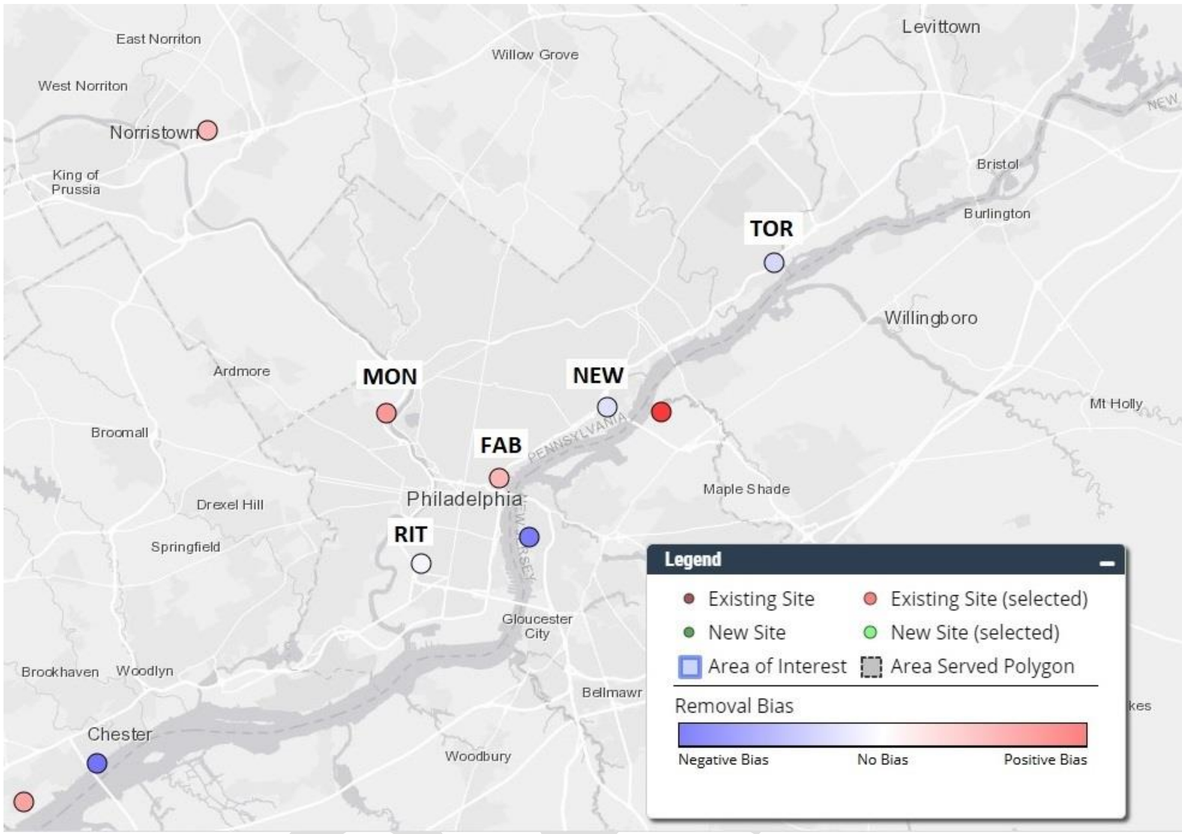


Table 6. PM2.5 Removal Bias Summary for Philadelphia Sites

SITE ID	MEAN REMOVAL BIAS (µg/m³)	MIN REMOVAL BIAS (µg/m³)	MAX REMOVAL BIAS (µg/m³)	REMOVAL BIAS STANDARD DEVIATION	NEIGHBORS INCLUDED	MEAN RELATIVE REMOVAL BIAS (%)	MIN RELATIVE REMOVAL BIAS (%)	MAX RELATIVE REMOVAL BIAS (%)
NEW	-0.33	-12.9	17.2	2.66	6	8.5	-72	1295
RIT	-0.12	-10.5	20.8	2.71	5	4.8	-62	230
FAB	0.75	-7.3	21.2	2.9	4	16.8	-67	549
TOR	-0.42	-11.3	9.2	2.78	6	13.5	-67	3396
MON	1.05	-6	11.9	2.7	5	29.8	-53	1718

PM2.5 Future Plans: 2020 – 2025

On January 15, 2015, EPA published the final rule (80 FR 2206) designating Philadelphia County as Unclassifiable/Attainment for the 2012 annual PM2.5 NAAQS.

On April 12, 2015, EPA published the final rule (80 FR 22112) determining that the Pennsylvania portion of the Philadelphia-Wilmington, PA-NJ-DE Nonattainment Area (Philadelphia Area) attained the 1997 annual and 2006 24-hour $PM_{2.5}$ NAAQS.

AMS' commitment to EPA requires five $PM_{2.5}$ monitoring sites. As of June 30, 2020, AMS has five operating FEM/FRM $PM_{2.5}$ monitors. Over the next five years, AMS plans to:

- Establish a monitoring site near the Philadelphia port to measure $PM_{2.5}$
- Further optimize the network, pending cost
- Add one PM2.5 Monitor around West Philly area and EJ communities where high concentration and population occurred

Additionally, AMS will continue to operate ultrafine particulate monitoring and black carbon monitoring that were started as of July 1, 2015 at the near-road site MON to learn more about these subtypes of atmospheric particles.

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2. OZONE

Monitoring Introduction

AMS currently monitors Ozone at three monitoring sites: LAB, NEA, and NEW. Table 11 and Figure 8 show the ozone monitoring network in and around Philadelphia County. Data for trends for the 4th highest 8-hour values and design values are shown in Tables 12 and 13[3]. The most recent data include the 4th quarter of 2019. As the values in Table 13 indicate, the NEA site generally had the highest ozone design values over the years.

Table 11. Ozone Monitoring Sites in Philadelphia

AMS Site	AQS Site ID	Latitude	Longitude
LAB	421010004	40.008889	-75.097780
NEA	421010024	40.076389	-75.011944
NEW	421010048	39.991389	-75.080833

[3] Data downloaded from www.epa.gov/airdata on 4/22/2020.

Table 12. Ozone 4th Highest 8-Hour Values (ppm)

Year	LAB	NEA	NEW
2007	0.073	0.095	
2008	0.062	0.087	
2009	0.059	0.072	
2010	0.077	0.088	
2011	0.070	0.089	
2012	0.065	0.085	
2013	0.047	0.068	0.036*
2014	0.058	0.072	0.068
2015	0.057	0.079	0.078
2016	0.069	0.080	0.076
2017	0.042	0.076	0.076
2018	0.071	0.079	0.076
2019	0.067	0.071	0.072

*NEW site had incomplete data in 2013

Table 13. Ozone 8-Hour Design Values (ppm)

Year	LAB	NEA	NEW
2007 - 2009	0.064	0.084	
2008 - 2010	0.066	0.082	
2009 - 2011	0.068	0.083	
2010 - 2012	0.070	0.087	
2011 - 2013	0.060	0.080	
2012 - 2014	0.056	0.075	
2013 - 2015	0.054	0.073	0.061
2014 - 2016	0.061	0.077	0.074
2015 - 2017	0.056	0.078	0.077
2016 - 2018	0.061	0.078	0.076
2017 - 2019	0.060	0.075	0.075

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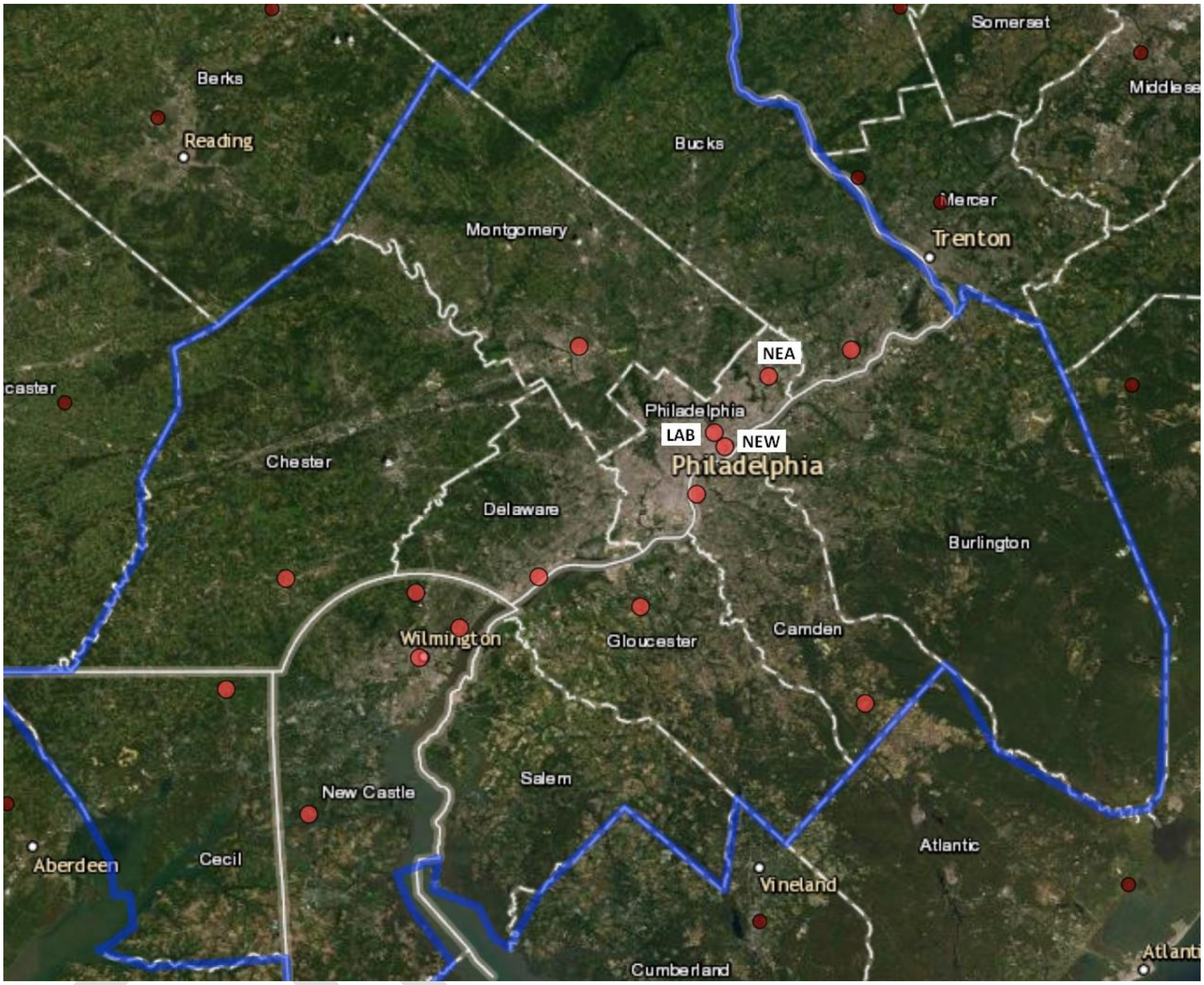
Figure 8. Ozone Monitoring Sites in and around Philadelphia County



<u>Results of Correlation Matrix Tool</u>

Tables 14, 15, 16, and Figure 9 show the correlation matrix for all ozone monitoring sites in the Philadelphia CBSA. Table 15 shows that NEA is highly correlated with several neighboring monitors with a low value of mean difference, including NEW (correlation 0.973, mean difference 0.0039 ppm), Pennsylvania site 420170012 (correlation 0.971, mean difference 0.0027 ppm), and New Jersey site 340070002 (correlation 0.963, mean difference 0.0038 ppm). NEA is the site with the highest ozone in Philadelphia and one of the highest ozone sites in the region. Table 14 shows that LAB is highly correlated with several neighboring monitors as well (correlation > 0.9), but with relatively large values of mean difference. The LAB site tends to have lower ozone values compared with neighboring sites.

Table 14. Ozone Correlation Matrix for LAB (421010004)

Site 1	Site 2	Correlation	n	Mean Diff	Distance (km)
LAB	100031007	0.910	688	0.0064	74
LAB	100031010	0.886	646	0.0074	45
LAB	100031013	0.931	699	0.0064	43
LAB	100032004	0.948	692	0.0044	49
LAB	240150003	0.849	399	0.0073	73
LAB	340070002	0.973	712	0.0039	9
LAB	340071001	0.824	456	0.0056	41
LAB	340150002	0.898	419	0.0059	25
LAB	420170012	0.958	675	0.0055	21
LAB	420290100	0.897	961	0.0065	60
LAB	420450002	0.936	703	0.0050	30
LAB	420910013	0.945	628	0.0051	21
LAB	NEA (421010024)	0.972	709	0.0064	10
LAB	NEW (421010048)	0.976	685	0.0033	2

Table 15. Ozone Correlation Matrix for NEA (421010024)

Site 1	Site 2	Correlation	n	Mean Diff	Distance (km)
NEA	100031007	0.905	991	0.0045	84
NEA	100031010	0.906	932	0.0047	55
NEA	100031013	0.919	1018	0.0043	53
NEA	100032004	0.938	1035	0.0043	60
NEA	240150003	0.877	671	0.0047	83
NEA	**340070002**	0.963	1053	0.0038	18
NEA	340071001	0.854	735	0.0064	45
NEA	340150002	0.913	698	0.0044	35
NEA	**420170012**	0.971	984	0.0027	12
NEA	420290100	0.911	1006	0.0044	70
NEA	420450002	0.927	1037	0.0043	41
NEA	420910013	0.954	941	0.0037	26
NEA	LAB (421010004)	0.972	709	0.0064	10
NEA	**NEW (421010048)**	0.973	988	0.0039	11

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Table 16. Ozone Correlation Matrix for NEW (421010048)

Site 1	Site 2	Correlation	n	Mean Diff	Distance (km)
NEW	100031007	0.914	943	0.0049	74
NEW	100031010	0.900	886	0.0056	45
NEW	100031013	0.927	972	0.0046	43
NEW	100032004	0.955	990	0.0031	49
NEW	240150003	0.888	642	0.0050	74
NEW	340070002	0.977	1005	0.0024	7
NEW	340071001	0.869	706	0.0049	39
NEW	3401-0002	0.935	673	0.0035	24
NEW	420170012	0.971	938	0.0034	21
NEW	420290100	0.910	961	0.0050	61
NEW	420450002	0.941	994	0.0037	30
NEW	420910013	0.949	897	0.0037	24
NEW	LAB (421010004)	0.976	685	0.0033	2
NEW	NEA (421010024)	0.973	988	0.0039	11

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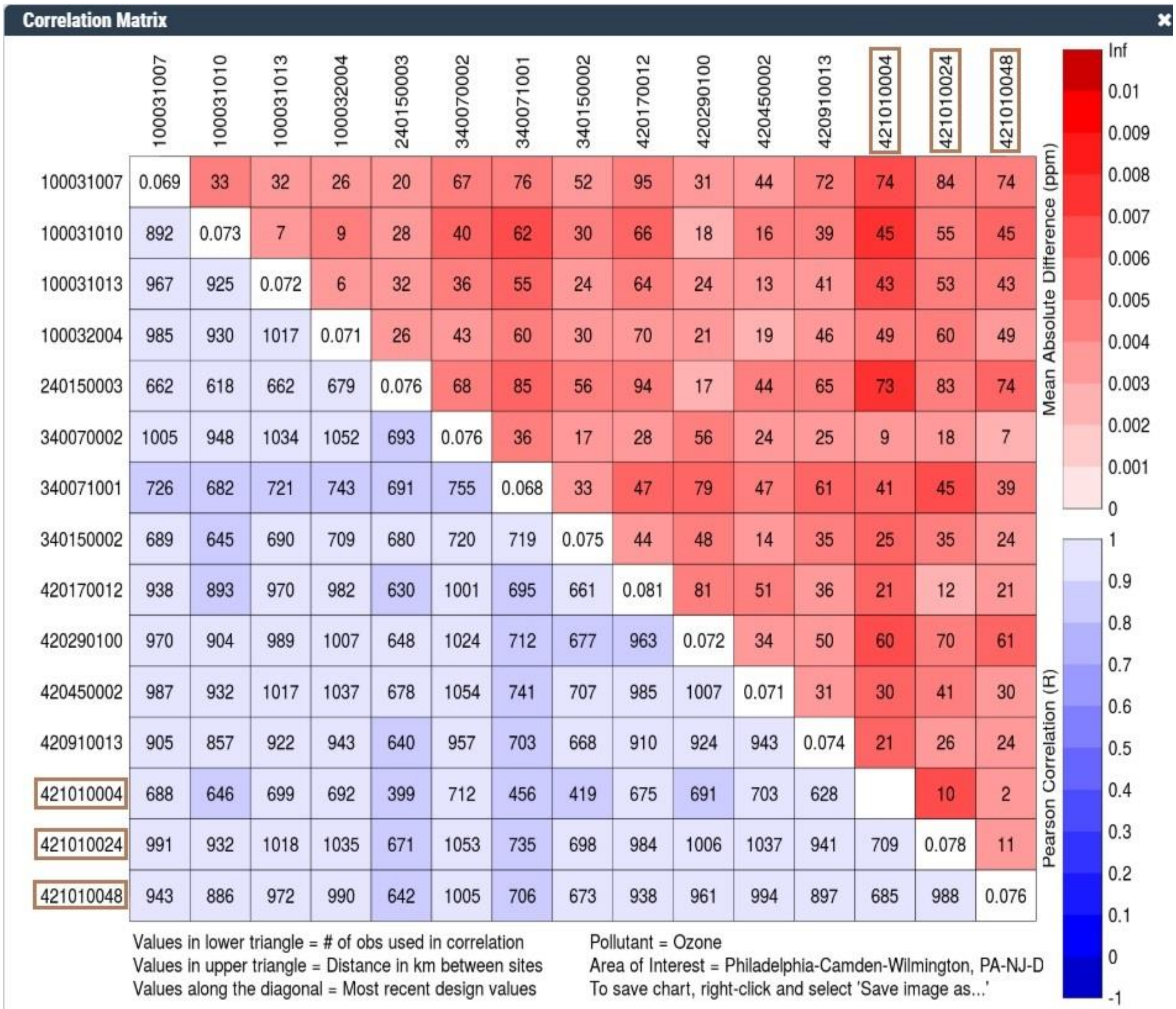
Figure 9. Ozone Correlation Matrix

Philadelphia County sites marked in brown boxes: 421010004 (LAB), 421010024 (NEA), and 421010048 (NEW)



	100031007	100031010	100031013	100032004	240150003	340070002	340071001	340150002	420170012	420290100	420450002	420910013	421010004	421010024	421010048
100031007	0.069	33	32	26	20	67	76	52	95	31	44	72	74	84	74
100031010	892	0.073	7	9	28	40	62	30	66	18	16	39	45	55	45
100031013	967	925	0.072	6	32	36	55	24	64	24	13	41	43	53	43
100032004	985	930	1017	0.071	26	43	60	30	70	21	19	46	49	60	49
240150003	662	618	662	679	0.076	68	85	56	94	17	44	65	73	83	74
340070002	1005	948	1034	1052	693	0.076	36	17	28	56	24	25	9	18	7
340071001	726	682	721	743	691	755	0.068	33	47	79	47	61	41	45	39
340150002	689	645	690	709	680	720	719	0.075	44	48	14	35	25	35	24
420170012	938	893	970	982	630	1001	695	661	0.081	81	51	36	21	12	21
420290100	970	904	989	1007	648	1024	712	677	963	0.072	34	50	60	70	61
420450002	987	932	1017	1037	678	1054	741	707	985	1007	0.071	31	30	41	30
420910013	905	857	922	943	640	957	703	668	910	924	943	0.074	21	26	24
421010004	688	646	699	692	399	712	456	419	675	691	703	628		10	2
421010024	991	932	1018	1035	671	1053	735	698	984	1006	1037	941	709	0.078	11
421010048	943	886	972	990	642	1005	706	673	938	961	994	897	685	988	0.076

Results of Area Served Tool

Figure 10 shows the results of Area Served for the three Ozone monitoring sites in Philadelphia. The population statistics are shown in Table 17. The area served by LAB has the highest percentage of ethnic minority population (86%), while the area served by NEA has the highest percentage of people 65 years and older (17%).

Figure 10. Ozone Monitors Area Served

Table 17. Ozone Monitors Area Served Population Statistics (Voronoi Polygon)

SITE	TOTAL POPULATION (2010)	TOTAL AGE 65 AND UP	TOTAL MINORITY	AREA (km^2)	POPULATION DENSITY (per km^2)
LAB	685,953	76,703	590,017	156	4.397
NEA	491,583	83,707	114,399	376	1,307
NEW	236,681	32,263	107,665	162	1,461

Results of Exceedance Probabilities Tool

Surface exceedance probability maps for the continental United States and the Philadelphia area are shown in Figures 11 and 12 (8-hour ozone NAAQS 0.070 ppm). The maps provide information about the spatial distribution of the 8-hour average ozone values and are intended to be used for spatial comparison.

Figure 11. Ozone 8-Hour (70 ppb) Exceedance Probability Map for Continental US

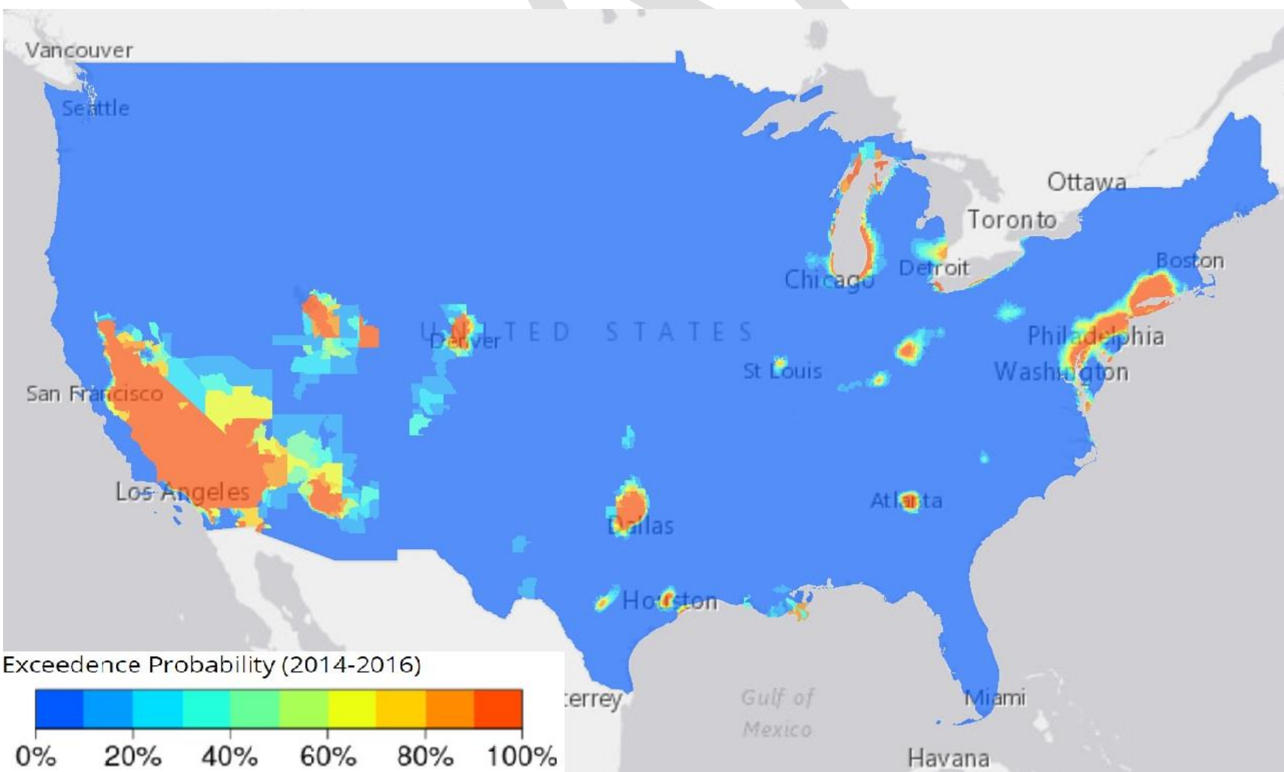
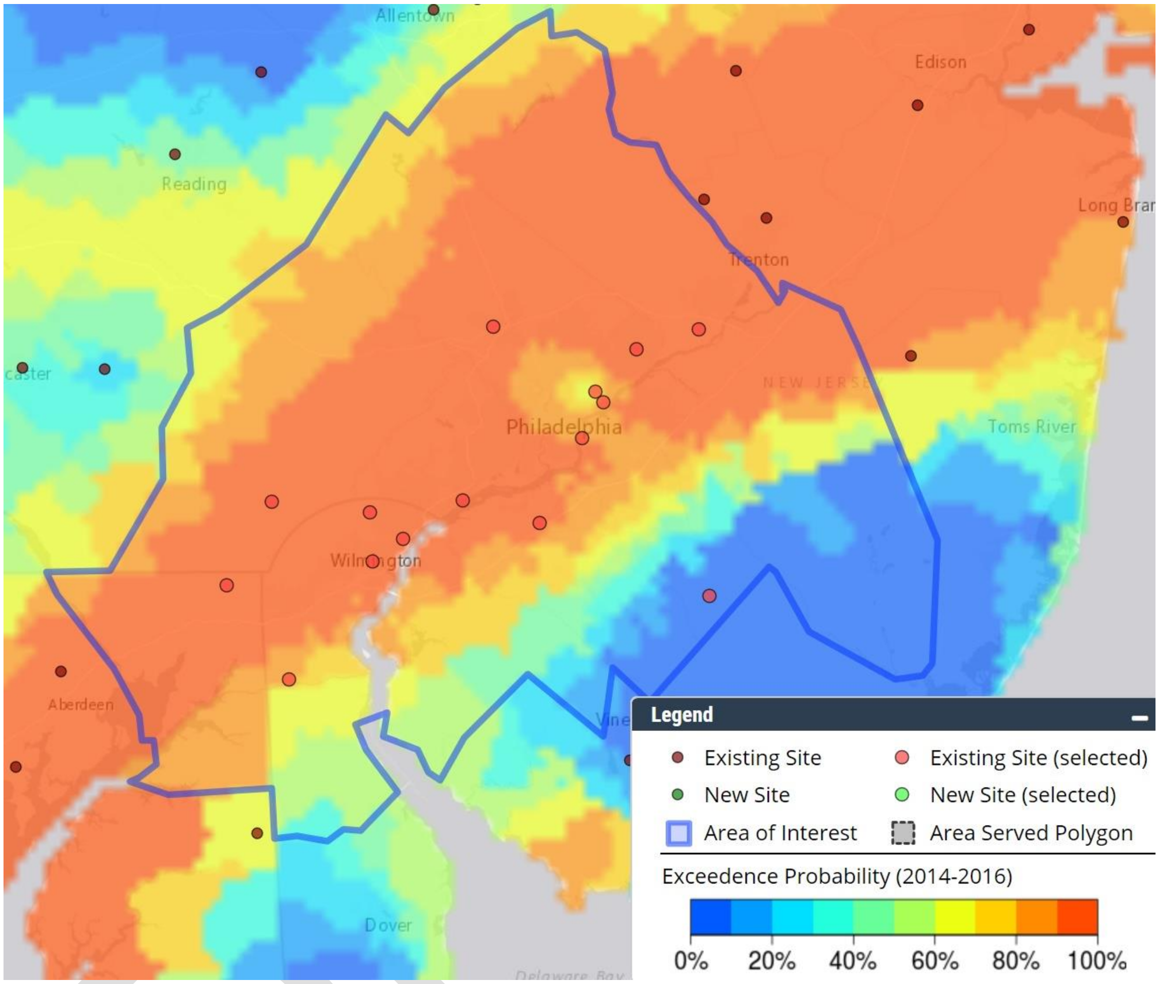


Figure 12. Ozone 8-Hour (70 ppb) Exceedance Probability Map for Philadelphia Area



The map in Figure 12 indicates the ozone exceedance probability in the Philadelphia area is very high (around 90%).

Results of Removal Bias Tool

Figure 13 and Table 18 show the removal bias tool results for the three ozone monitors in Philadelphia.

Figure 13. Ozone Removal Bias Map for Philadelphia

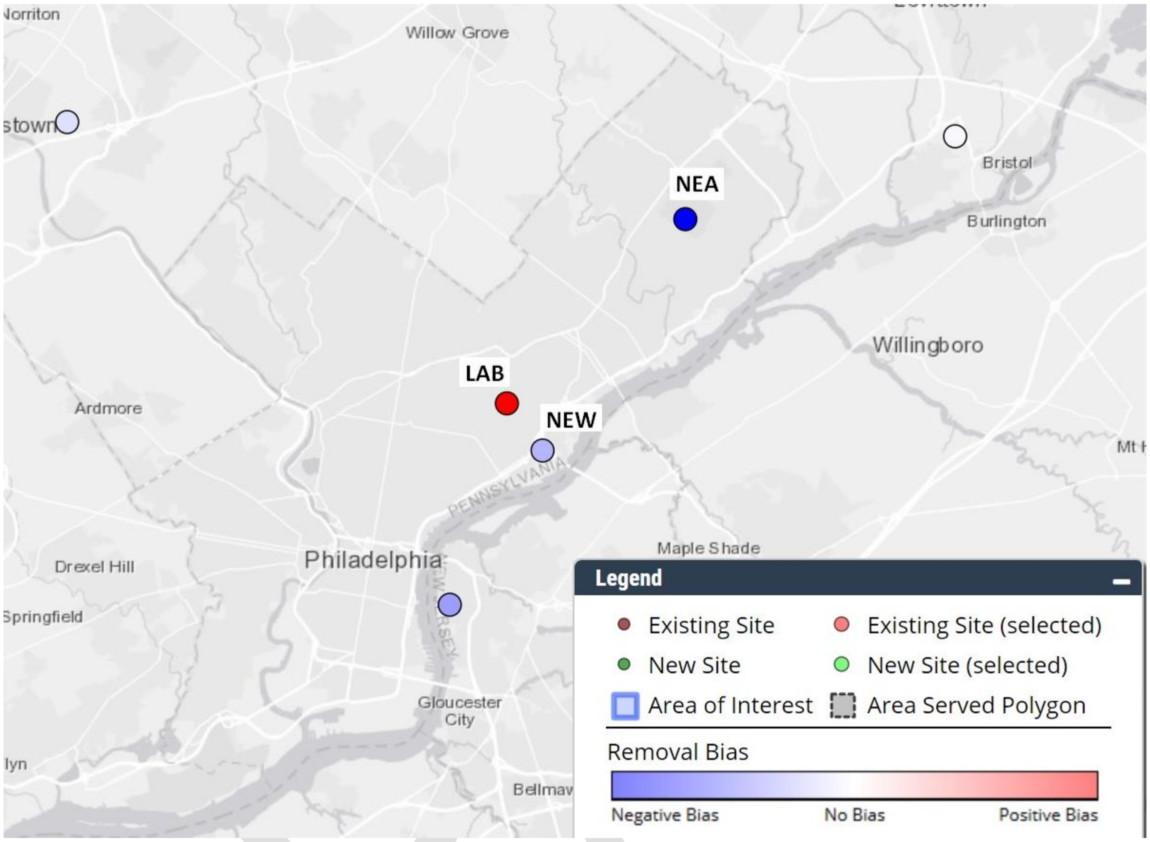


Table 18. Ozone Removal Bias Summary for Philadelphia

SITE ID	MEAN REMOVAL BIAS (ppm)	MIN REMOVAL BIAS (ppm)	MAX REMOVAL BIAS (ppm)	REMOVAL BIAS STANDARD DEVIATION	NEIGHBORS INCLUDED	MEAN RELATIVE REMOVAL BIAS (%)	MIN RELATIVE REMOVAL BIAS (%)	MAX RELATIVE REMOVAL BIAS (%)
LAB	0.0031	-0.006	0.019	0.0031	4	11.1	-37	115
NEA	-0.0031	-0.017	0.013	0.0029	5	-8.2	-90	123
NEW	-0.0009	-0.013	0.026	0.0035	5	-1.8	-74	172

The above data indicate that LAB has a significant positive mean removal bias and NEA has a significant negative mean removal bias. The NEW site has a relatively small mean removal bias.

Ozone Future Plans: 2020 – 2025

On October 26, 2015, EPA published a final rule with revisions to the 8-hour NAAQS for ozone to a level of 0.070 parts per million (ppm) (80 FR 65292).

On June 4, 2018, EPA published a final rule to designate Philadelphia County as Nonattainment (Marginal) for the 2015 ozone NAAQS (83 FR 25776).

Over the next five years, AMS plans to (pending any additional requirements from any new rule):

- Continue to measure at NEA as it has one of the highest ozone values in the Philadelphia area
- Possibly move the ozone monitor at LAB to another location
- Continue to measure at the NCore site NEW
- Implement the 2015 Ozone SIP revisions in efforts to achieve attainment
- Add one ozone monitor around West Philly area and Environmental Justice communities where high concentration and population occurred

3. OTHER CRITERIA POLLUTANTS

Discussion and Future Plans

Table 19 shows the maximum concentrations summary for CO, NO_2, SO_2, PM_{10}, and Pb from 2014 – 2019[4]. The maximum values for these criteria pollutants are well below the NAAQS. Monitoring locations, requirements and future plans are documented in the Plan.

Table 19. Maximum Concentrations Summary for CO, NO_2, SO_2, PM_{10} and Pb

Year	CO 2nd Max 1-hr	CO 2nd Max 8-hr	NO2 98th Percentile 1-hr	NO2 Annual Mean	SO2 99th Percentile 1-hr	PM10 2nd Max 24-hr	Pb * 3-month rolling avg
2019	2.2	1.7	52	13	17	49	
2018	1.7	1.3	43	11	14	45	
2017	4.1	2.6	45	11	10	46	
2016	3.5	1.9	58	16	19	53	0.04
2015	2.1	1.6	63	18	10	48	0.02
2014	1.9	1.4	51	18	15	60	0.02
Standard	**35 ppm**	**9 ppm**	**100 ppb**	**53 ppb**	**75 ppb**	**150 µg/m3**	**0.15 µg/m3**

[4] Air Quality Statistics Report from www.epa.gov/airdata, downloaded 4/22/2020

*Pb monitoring in Philadelphia was discontinued in 2017 due to consistent low levels of Lead.

MONITORING EQUIPMENT ASSESSMENT

An important and often overlooked component of a network assessment is the evaluation of the condition and cost of all monitoring equipment as well as any indirect equipment needed to support the air monitoring network.

Tables 20 – 24 inventory the types, conditions, and cost for all air monitoring and indirect equipment. These tables show that in the next five years, many of the indirect air monitoring equipment will approach or exceed expected life span and may require replacement. The cost of replacement for many of the analysis machines is significant when compared to the cost of individual monitors. The tables also show a need to replace many of the current air monitoring devices within the next five years.

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Table 20. Air Monitoring Equipment Inventory

Station: MON - AQS Site 421010076										
Instrument	**Vendor**	**Model**	**CP#**	**Year Purchased**	**Age (years)**	**Average Life Span**	**Expiration Date**	**Estimated Cost**	**Condition**	**Replacement Recommended**
Weather Transmitter	Vaisala	WXT520	648807	Jan-14	6	5		$3000.00	5	NO
Environmental Shelter	ShelterOne		652342	Jan-15	5	20		$25,000.00	5	NO
Calibrator	Teledyne - API	700E	653277	Nov-14	6	10		$16,000.00	5	NO
Zero Air Generator	Teledyne - API	701H	653281	Jan-15	5	10		$6,000.00	5	NO
8872 Datalogger	Agilaire	8872	657361	Nov-14	6	5		$6,000.00	7	YES
Continuous PM 2.5/BAM 1020	Met One	1020	657677	Nov-15	5	5		$23,000.00	7	YES
CO	Teledyne - API	T300	674548	Oct-16	4	5		$13,000.00	5	NO
Utrafine	Teledyne - API	M651	677004	Dec-15	5	5		$25,000.00	5	NO
NOx	Teledyne - API	T200	688522	Feb-18	2	7		$13,000.00	5	NO
TSP*	General Metal Works	N/A	607286	Feb-87	33	15		$4,000.00	5	NO
TSP*	General Metal Works	N/A	607287	Feb-87	33	15		$4,000.00	5	NO
Carbon Black	Teledyne - API	M633	N/A	Sep-13	7	5		$25,000.00	5	NO
Cellular Modem	Sierra Wireless	Raven XE EVDO		Aug-12	8	5		$500.00	7	YES
CO Gas		FF18626		May-15	5		4/8/2023			NO
NO Gas		FF32113		Jul-19	1		7/8/2022			NO

Station: RIT - AQS Site 421010055										
Instrument	**Vendor**	**Model**	**CP#**	**Year Purchased**	**Age (years)**	**Average Life Span**	**Expiration Date**	**Estimated Cost**	**Condition**	**Replacement Recommended**
TSP*	General Metal Works		558360	Feb-90	30	15		$4,000.00	5	NO
Canister Sampler	Tisch	T123	595977	Jul-08	12	5		$12,000.00	7	YES

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Carbonyl Label Printer	ATEC		629602		5	5			5	NO
8872 datalogger	Agilaire	8872	635433	Nov-14	6	5		$6,000.00	7	YES
Continuous PM 2.5	Teledyne- API	T640	705941	Oct-19	1	5		$25,000.00	5	NO
Calibrator	Teledyne- API	700E	652422	Nov-14	6	10		$16,000.00	5	NO
Zero Air Generator	Teledyne - API	701H	652426	Nov-14	6	10		$6,000.00	5	NO
SO_2	Teledyne - API	T100	653518	Oct-14	6	5		$13,000.00	5	NO
Carbonyl	ATEC	2200	688524	Jun-18	2	7		$17,000.00	5	NO
Speciated PM 2.5	Met One	SASS	620416	2012	8	5		$13,500.00	5	NO
Speciated PM 2.5	URG	3000N	620589	2012	8	5		$22,000.00	5	NO
Environmental Shelter	ShelterOne					20			5	NO
SO2 Gas		D574347		May-18	2		5/21/2022			NO
Cellular Modem	Sierra Wireless	Raven XE EVDO		Jul-11	9			$500.00	7	YES

Station: NEA - AQS Site 421010024

Instrument	Vendor	Model	CP#	Year Purchased	Age (years)	Average Life Span	Expiration Date	Estimated Cost	Condition	Replacement Recommended
Environmental Shelter	ShelterOne		511945			20			5	NO
Zero Air Generator	Teledyne - API	701H	653281	Jul-13	7	10		$6,000.00	5	NO
Ozone-D	Teledyne - API	T400	674549	Jan-15	5	5		$13,000.00	5	NO
8872 Datalogger	Agilaire	8872	692853	Feb-19	1	5		$6,000.00	7	YES
Spare Ozone (new)	Teledyne - API	T400	705468	Feb-19	1	5		$13,000.00	5	NO
Ozone Calibrator	Teledyne - API	T703	705470	Jun-19	1	10		$16,000.00	5	NO
Cellular Modem	Sierra Wireless	Raven XE EVDO		Nov-12	8	5		$500.00	7	YES

Station: SWA - AQS Site 421010063

Instrument	Vendor	Model	CP#	Year Purchased	Age (years)	Average Life Span	Expiration Date	Estimated Cost	Condition	Replacement Recommended
Canister Sampler	Tisch	T123	600114	Apr-09	11	5		$12,000.00	7	YES

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Toxic Air Sampler/Carbonyl	ATEC	2200	646008	Jun-14	6	7		$17,000.00	5	NO
Carbonyl Label Printer	ATEC		646009	Jun-14	6				5	NO
Environmental Shelter	ShelterOne					20			5	NO
Hygro-Thermometer Clock	Extech	445702		Sep-19	1	1			5	YES

Station: ROX - AQS Site 421010014

Instrument	Vendor	Model	CP#	Year Purchased	Age (years)	Average Life Span	Expiration Date	Estimated Cost	Condition	Replacement Recommended
Canister Sampler	Tisch	T123	595978	Jul-08	12	5		$ 12,000.00	7	YES
Toxic Air Sampler/Carbonyl	ATEC	2200	646007	Mar-14	6	5		$ 17,000.00	5	NO
Carbonyl Label Printer	ATEC		646010	Mar-14	6	5			5	NO
Environmental Shelter	ShelterOne		**511946**			20			5	NO
Hygro-Thermometer Clock	Extech	445702		Sep-19	1	1				YES

Station: NEW - AQS Site 421010048

Instrument	Vendor	Model	CP#	Year Purchased	Age (years)	Average Life Span	Expiration Date	Estimated Cost	Condition	Replacement Recommended
FRM - PM 2.5	Thermo	2025	576073	Jul-05	15	5		$25,000.00	7	YES
Canister	TISCH	T123	595981	Apr-08	12	5		$12,000.00	7	YES
FRM - PM 2.5	Thermo	2025	600413	May-09	11	5		$25,000.00	7	YES
Speciated PM 2.5	URG	3000N	603523	Dec-09	11	5		$22,000.00	5	NO
Zero Air Generator	Teledyne - API	701H	603685	Nov-09	11	10		$6,000.00	7	YES
Speciated PM 2.5	Met One	SASS	604236	May-10	10	5		$13,500.00	5	NO
TSP*	TISCH	TE-5005	607288	Dec-09	11	15		$4,000.00	8	NO
8872 Datalogger	Agilaire	8832	619761	Feb-12	8	5		$6,000.00	7	YES
Zero Air Generator	Teledyne - API	701H	620411	Aug-14	6	10		$6,000.00	5	NO

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Toxic Air Sampler/Carbonyl	ATEC	8000-3	627464	Jul-13	7	7		$17,000.00	5	NO
Carbonyl Label Printer	ATEC		627465	Jul-13	7	5			5	NO
Continuous PM 2.5/BAM 1020	Met One	1020	635640	Jul-13	7	5		$22,000.00	5	NO
Air Conditioner	Freidrich	WE10C33D	650719	Jan-15	5	5		$500.00	5	NO
SO_2	Teledyne - API	T100U	654714	Nov-14	6	7		$13,000.00	5	NO
Weather Transmitter	Vaisala	WXT520	657262	Jan-16	4	5		$3,000.00	5	NO
Toxic Air Sampler/Carbonyl	ATEC	8000-3	673589	Dec-16	4	7		$17,000.00	5	NO
Ceilometer	Vaisala	CL51	680970	Jul-18	2	5		$25,000.00	5	NO
True NO2	Teledyne - API	T500U	684282	Feb-18	2	5		$25,000.00	5	NO
8872 Datalogger	Agilaire	8872	686257	Feb-18	2	5		$6,000.00	5	YES
Weather Tower Support			686262	Jan-18	2	20			5	NO
Continuous PM 2.5	Teledyne	T640X	690752	Feb-18	2	5		$25,000.00	5	NO
FRM - PM 2.5	Thermo	2025i	691151	Aug-18	2	5		$25,000.00	5	NO
Calibrator	Teledyne - API	T700	692765	Feb-19	1	10		$16,000.00	5	NO
AutoGC	CAS	GCCPU866	694304	Mar-19	1			$150,000.00	5	NO
UV Radiation	Eppley		695036	Mar-19	1	5			5	NO
NOy	Teledyne - API	T200U	704189	Feb-19	1	5		$16,000.00	5	NO
Ozone	Teledyne - API	T400	705467	Feb-19	1	5		$13,000.00	5	NO
Ozone Calibrator	Teledyne - API	T703	705469	Feb-19	1	10		$13,000.00	5	NO
CO	Teledyne - API	T300U	706583	Jan-20	0	7			5	NO
Environmental Shelter	ShelterOne					20			5	NO
Environmental Trailer	ShelterOne					20			5	NO
Cellular Modem	Sierra Wireless	Raven XE EVDO		Aug-12	8	5		$500.00	7	YES
Cellular Modem	Sierra Wireless	Raven XE EVDO		Dec-16	4	5		$500.00	7	YES
Carbonyl Label Printer	ATEC					5			5	NO
Rain Gauge	Met One	375D		Jul-19	1	5			5	NO
Solar Radiometer	Eppley	8-48		Jul-19	1	5			5	NO

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SO2 Gas		D574322		May-18	2		5/21/2022			NO
CO Gas		CLM-007214		May-17	3		5/19/2025			NO
NO Gas		FF9460		Jul-19	1		7/8/2022			NO

Station: FAB - AQS Site 421010057										
Instrument	**Vendor**	**Model**	**CP#**	**Year Purchased**	**Age (years)**	**Average Life Span**	**Expiration Date**	**Estimated Cost**	**Condition**	**Replacement Recommended**
8872 Datalogger	Agilaire	8872	635432	Jan-13	7	5		$6,000.00	7	YES
Continuous PM 2.5/BAM 1020	Met One	1020	666745	Feb-16	4	5		$22,000.00	8	YES
Continuous PM 2.5	Teledyne	T640	696013	May-19	1	5		$2,2000.00	5	NO
Cellular Modem	Sierra Wireless	Raven XE EVDO		Jan-13	7	5		$500.00	7	YES

Station: TOR - AQS Site 421010075										
Instrument	**Vendor**	**Model**	**CP#**	**Year Purchased**	**Age (years)**	**Average Life Span**	**Expiration Date**	**Estimated Cost**	**Condition**	**Replacement Recommended**
CO	Teledyne - API	T300	630801	Oct-13	7	7		$13,000.00	5	NO
Environmental Shelter	ShelterOne		632294			20			5	NO
Zero Air Generator	Teledyne - API	T701H	633892	Mar-13	7	10		$6,000.00	5	NO
8872 Datalogger	Agilaire	8872	635436	Jan-13	7	5		$6,000.00	7	YES
Continuous PM 2.5	Teledyne- API	T640	705940	Oct-19	1	5		$25,000.00	5	NO
Weather Transmitter	Vaisala	WXT520	648806	Jan-14	6	5		$3,000.00	5	YES
NOx	Teledyne - API	T200	653520	Sep-13	7	7		$13,000.00	5	NO
Calibrator	Teledyne - API	T700	656899	Mar-15	5	10		$16,000.00	5	NO
CO Gas		FF3279		Jul-13	7		7/11/2021			NO
NO Gas		D574323		May-18	2		5/21/2021			NO
Cellular Modem	Sierra Wireless	Raven XE EVDO		Aug-12	8	5		$500.00	7	YES

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Station: LAB - AQS Site 421010004										
Instrument	**Vendor**	**Model**	**CP#**	**Year Purchased**	**Age (years)**	**Average Life Span**	**Expiration Date**	**Estimated Cost**	**Condition**	**Replacement Recommended**
Environmental Shelter	ShelterOne		627747	Jan-13	7	20			5	NO
8872 Datalogger	Agilaire	8872	635436	Jan-16	4			$6,000.00	7	YES
Ozone	Teledyne - API	T400	639017	Jan-13	7	5		$13,000.00	5	NO
Zero Air Generator	Teledyne - API	701H	663412	Apr-15	5	10		$6,000.00	5	NO
Ozone Calibrator	Teledyne - API	T703	684449	Nov-17	3	10		$16,000.00	5	NO
Cellular Modem	Sierra Wireless	Raven XE EVDO		Jan-16	4			$500.00	7	YES
Radnet	Hi-Q Environmental	HVP-4004BRL								

Station: VGR										
Instrument	**Vendor**	**Model**	**CP#**	**Year Purchased**	**Age (years)**	**Average Life Span**	**Expiration Date**	**Estimated Cost**	**Condition**	**Replacement Recommended**
Ozone	2B Technologies	106L	657358	1/1/2015	5			$5,000.00	5	NO
Environmental Bench				1/1/2015	5				5	NO
PM 2.5	Thermoscientific	PDR1500		1/1/2015	5			$4,000.00	5	NO
Weather Transmitter				1/1/2015	5				5	NO
Cellular Modem	Sierra Wireless	Raven XE EVDO		Aug-12	8				5	YES

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Table 21. Carbonyl (TO-11) Analysis Equipment

Carbonyl (TO-11) Analysis Equipment										
Instrument	**Vendor**	**Model**	**CP#**	**Year Purchased**	**Age (years)**	**Average Life Span**	**Expiration Date**	**Estimated Cost**	**Condition**	**Replacement Recommended**
HPLC-E	Alliance	2695 Sep Module w/sample and column heater, and 2487 dual uv/vis det; HPLC E – 03SM4850M, Detector E – D03487586M	556514	2003	17	10		$75,000.00	5	YES
HPLC-F	Alliance	2695 Sep Module w/sample and column heater, and 2487 dual uv/vis det; HPLC F – E03SM4834M; Detector F – D03487582M	556515	2003	17	10		$75,000.00	5	YES
HPLC-G	Alliance	2695 Sep Module w/sample and column heater, and 2487 dual uv/vis det; E03SM4839M; Dectector G – D03487565M	556516	2003	17	10		$75,000.00	5	YES
AX205DR Balance	Mettler Toledo	S/N 1126021226	537087	5/5/2018	11	10		$9,000.00	6	YES
Laboratory Oven	Thelco	10AS-1	289205	6/1/1996	24	15		$4,000.00	5	YES
Laboratory Oven	CMS		404590	1/1/1984	36	15		$4,000.00	5	YES
Direct-Q 3uv Reverse Osmosis Water Purifications System w/30L Storage Tank	Millipore		582871	2015	5	10		$10,000.00	5	NO

Table 22. PAMS and TO-15 Analysis Equipment

PAMS and TO15 Equipment										
Instrument	**Vendor**	**Model**	**CP#**	**Year Purchased**	**Age (years)**	**Average Life Span**	**Expiration Date**	**Estimated Cost**	**Condition**	**Replacement Recommended**
Auto Sampler - Canister Cleaner	Entech		567441	2004	16	10		$11,000.00	6	YES
Pre-Concentrator	Entech		656641	2015	5	10		$40,000.00	5	NO
GCMS	Agilent		686950	2017	3	10		$60,000.00	5	NO

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Table 23. Calibration Equipment

Calibration Equipment										
Instrument	**Vendor**	**Model**	**CP#**	**Year Purchased**	**Age (years)**	**Average Life Span**	**Expiration Date**	**Estimated Cost**	**Condition**	**Replacement Recommended**
Flow Meter - Deltacal	Mesa Lab	0074	535133	2001	19	15		$3,000.00	7	NO
Flow Meter - Deltacal	Mesa Lab	0084	535134	2001	19	15		$3,000.00	7	NO
Flow Meter - Deltacal	Mesa Lab	0148				15		$3,000.00	7	NO
Flow Meter - DEFINER 220	Bios	119295	604229	2010	10	10		$2,000.00	6	NO
Flow Meter - DEFINER 220	Bios	119296	604230	2010	10	10		$2,000.00	6	NO
Flow Meter - DEFINER 220	Bios	119110	604231	2010	10	10		$2,000.00	6	NO
Flow Meter - DEFINER 220	Bios	119111	604232	2010	10	10		$2,000.00	6	NO
Flow Meter - DEFINER 220	Bios	119112	604233	2010	10	10		$2,000.00	6	NO
Flow Meter - DEFINER 220	Bios	119252	604234	2010	10	10		$2,000.00	6	NO
Flow Meter - DEFINER 220	Bios	119253	604235	2010	10	10		$2,000.00	6	NO
Flow Meter - Alicat	Reliable Investment	192137		2019	1				3	NO
Flow Meter - Alicat	Reliable Investment	192138		2019	1				3	NO
Flow Meter - Alicat	Reliable Investment	192139		2019	1				3	NO
Flow Meter - Alicat	Reliable Investment	192140		2019	1				3	NO
Flow Meter - Alicat	Reliable Investment	247241		2019	1				3	NO
Flow Meter - Tetracal	Mesa Lab	159968	692405	2019	1				3	NO

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Flow Meter - Tetracal	Mesa Lab	159967	692424	2019	1				3	NO
Velometer	TSI Inc.	57030481							3	NO
Dilution Calibrator	Teledyne API	T700	633891	2013	7	10		$16,000.00	5	NO
Dilution Calibrator	Teledyne API	T700	652334	2014	6	10		$16,000.00	5	NO
Dilution Calibrator	Teledyne API	T700	652422	2014	6	10		$16,000.00	5	NO
Dilution Calibrator	Teledyne API	T700	656899	2014	6	10		$16,000.00	5	NO
Dilution Calibrator	Teledyne API	T700	657250	2014	6	10		$16,000.00	5	NO
Dilution Calibrator	Teledyne API	T700	663411	2015	5	10		$16,000.00	5	NO
Dilution Calibrator	Teledyne API	T700	684418	2018	2	10		$16,000.00	5	NO
Dilution Calibrator	Teledyne API	T700	692765	2019	1	10		$16,000.00	5	NO
Dilution Calibrator	Teledyne API	T750U	704190	2019	1	10		$16,000.00	5	NO
Zero Air Generator	Teledyne API	T701H	652338	2014	6	10		$9,000.00	5	NO
Zero Air Generator	Teledyne API	T701H	657251	2014	6	10		$9,000.00	5	NO
Zero Air Generator	Teledyne API	T701H	663412	2015	5	10		$9,000.00	5	NO
Zero Air Generator	Teledyne API	T701H	684419	2018	2	10		$9,000.00	5	NO
Zero Air Generator	Teledyne API	T700U	684495	2018	2	10		$9,000.00	5	NO
Zero Air Generator	Teledyne API	T751	672965	2017	3	10		$9,000.00	5	NO
Zero Air Generator	Teledyne API	T751	672966	2017	3	10		$9,000.00	5	NO
Digital Multimeter	Wavetek	702004							5	NO
Digital Multimeter	Fluke	59260631							5	NO
Digital Multimeter	B & K	388A/25009659							5	NO

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Digital Multimeter	Fluke	73/59260631							5	NO
Digital Multimeter	Fluke	73/77710030							5	NO
Digital Multimeter	Fluke	73-3/80890194							5	NO
Digital Multimeter	Fluke	73III/77540269							5	NO
Digital Multimeter	Fluke	87/67770757							5	NO
Digital Multimeter	Fluke	87/75900090							5	NO
Digital Multimeter	Fluke	87/91210357							5	NO
Barometer DPI	Druck	70518792							5	NO
Barometer DPI	Druck	70520804							5	NO
Barometer DPI	Druck	70562724							5	NO
Barometer DPI	Druck	70565343							5	NO
Barometer DPI	Druck	705/62724							5	NO
Barometer DPI	Druck	705/7446/00-06	532742						5	NO
Barometer DPI	Druck	705/7449/00-06	532743						5	NO
Sensor URG	Met One	B1993							5	NO
Sensor URG	Met One	B1994							5	NO
Sensor URG	Met One	G4363							5	NO
Sensor URG	Met One	H10868							5	NO
Sensor URG	Met One	H11610							5	NO
Temperature	Tegam	840 A/T-204266							5	NO
Temperature	Tegam	840A/T-207328							5	NO
Temperature	Tegam	840A/T-237588							5	NO
Temperature	Tegam	840A/T-243353							5	NO
Temperature	Tegam	840A/T-295676							5	NO
Temp & Humidity	Vaisala	HMP155/L2630033							5	NO

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Temp & Humidity	Vaisala	HMP75/M3650306							5	NO
Temp & Humidity	Vaisala	HMT 333/D1750059							5	NO
Temp & Humidity	Vaisala	HMT 333/M3710265							5	NO
Temp & Humidity	Vaisala	M170/L2520007							5	NO
Temp & Humidity	Vaisala	M170/M3340019	674474						5	NO
100 mg PM2.5 Weight	Ultra	W							5	NO
200 mg PM2.5 Weight	Ultra	W							5	NO
300 mg PM2.5 Weight	Ultra	W							5	NO
500 mg PM2.5 Weight	Ultra	W							5	NO
100 mg PM2.5 Weight	Class 1	P							5	NO
200 mg PM2.5 Weight	Class 1	P							5	NO
500 mg PM2.5 Weight	Class 1	P							5	NO
5 g TSP Weight	Class 1								5	NO
Orifice	Anderson	1802							5	NO
Orifice	Anderson	1803							5	NO
Orifice	Anderson	H69							5	NO
Orifice	Anderson	H70							5	NO
Orifice	Anderson	Z44							5	NO
CO Gas		FF21561					6/15/2024		5	NO
CO Gas		FF9430					6/15/2024		5	NO
CO Gas		FF24291					5/19/2025		5	NO
CO Gas		D574306					5/4/2026		5	NO
CO Gas		CC574298					5/4/2026		5	NO
CO Gas		D574292					5/4/2026		5	NO
CO Gas		EX0012821					07/01/2027		5	NO
NO Gas		SA25803					11/7/2020		6	NO
NO Gas		33-580					1/3/2020		6	YES
NO Gas		D574271					5/21/2021		5	NO

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NO Gas		D574349					5/21/2021		5	NO
NO Gas		CLM-004586					7/8/2022		5	NO
SO2 Gas		D574288					5/21/2022		5	NO
SO2 Gas		D574327					5/21/2022		5	NO
SO2 Gas		SV16113					7/8/2023		5	NO
SO2 Gas		D574301					5/21/2022		5	NO
SO2 Gas		FF3390					6/29/2020		6	YES
SO2 Gas		D574332					5/21/2022		5	NO

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Table 24. General Chemistry Equipment

Fuel Oils Equipment										
Instrument	**Vendor**	**Model**	**CP#**	**Year Purchased**	**Age (years)**	**Average Life Span**	**Expiration Date**	**Estimated Cost**	**Condition**	**Replacement Recommended**
Epsilon 3[x]	Panalytical	205214	650716	2014	6	10		60,000.00	5	YES
Saybolt Viscometer	Koehler	K2141010048S	684968	2018	2	10		7,265.00	5	NO
Acid Rain Equipment										
Instrument	**Vendor**	**Model**	**CP#**	**Year Purchased**	**Age (years)**	**Average Life Span**	**Expiration Date**	**Estimated Cost**	**Condition**	**Replacement Recommended**
PH and Conductance Meter		V15374	707294	2019	1	15		2,500.00	3	NO
TSP Equipment										
Instrument	**Vendor**	**Model**	**CP#**	**Year Purchased**	**Age (years)**	**Average Life Span**	**Expiration Date**	**Estimated Cost**	**Condition**	**Replacement Recommended**
AB104S Balance	Mettler Toledo	S/N 1120291235	539048	6/23/2001	19	10		6,000.00	6	YES
Paints Equipment										
Instrument	**Vendor**	**Model**	**CP#**	**Year Purchased**	**Age (years)**	**Average Life Span**	**Expiration Date**	**Estimated Cost**	**Condition**	**Replacement Recommended**
AG204 Balance	Mettler Toledo	S/N 1114063032	473902		25	10		6,000.00	6	YES
AG204 Balance	Mettler Toledo	S/N 1114150791	475162	5/1/1995	25	10		6,000.00	6	YES
Shaker	Fisher		695345	7/11/2019	1				3	NO
Laboratory Oven	Fisher Scientific		621339	2012	8				5	NO
Titrator	Mettler Toledo	B914490327	695344	7/11/2019	1	10		12,000.00	3	NO

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PM2.5 and Weighing Equipment										
Instrument	**Vendor**	**Model**	**CP#**	**Year Purchased**	**Age (years)**	**Average Life Span**	**Expiration Date**	**Estimated Cost**	**Condition**	**Replacement Recommended**
MT5 Balance	Mettler Toledo	S/N 11155500943	487945	2/1/1997	23	10		12,000.00	6	YES
Zymate XP Robot	Calipher		506447	2/1/1999	21	10		55,000.00	6	YES
MX5 Balance	Mettler Toledo	S/N 1122281049	550102	10/2/2001	19	10		12,000.00	6	YES
Environmental Controlled Clean Room			595928	2008	12				5	NO
Perc Equipment										
Instrument	**Vendor**	**Model**	**CP#**	**Year Purchased**	**Age (years)**	**Average Life Span**	**Expiration Date**	**Estimated Cost**	**Condition**	**Replacement Recommended**
Gas Chromatograph	Agilent	7890; SN CN11081101 1 CN1080001	611434	2015	5	10			5	NO
Autosampler	Agilent	7693	611436	2015	5	10			5	NO

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