$PM_{2.5}$ SIP

Appendix I

Modeling Demonstration and Analyses

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Appendix I.1

Air Quality Technical Support Document

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ALLEGHENY COUNTY HEALTH DEPARTMENT $PM_{2.5}$ STATE IMPLEMENTATION PLAN FOR THE 2012 NAAQS

AIR QUALITY TECHNICAL SUPPORT DOCUMENT

RAMBOLL ENVIRON

CONTENTS

TABLES

FIGURES

1. OVERVIEW

This document presents details on the $PM_{2.5}$ attainment demonstration modeling for the Allegheny County, PA nonattainment area (NAA) to address the 2012 $PM_{2.5}$ National Ambient Air Quality Standards (NAAQS).

1.1 Background

In 1997, U.S. EPA promulgated annual and 24-hour $PM_{2.5}$ National Ambient Air Quality Standard (NAAQS) with thresholds of 15 and 65 µg/m^3, respectively. The form of the annual $PM_{2.5}$ NAAQS is the 3-year average of the annual $PM_{2.5}$ concentrations. The form of the 24-hour $PM_{2.5}$ NAAQS is the three year average of the 98^{th} percentile 24-hour $PM_{2.5}$ concentration in a year. In December 2006, EPA lowered the 24-hour $PM_{2.5}$ NAAQS from 65 to 35 µg/m^3 and kept the annual $PM_{2.5}$ NAAQS at 15 µg/m^3. On December 14, 2012, EPA lowered the annual $PM_{2.5}$ NAAQS from 15 to 12 µg/m^3. The $PM_{2.5}$ attainment demonstration State Implementation Plan (SIP) for the 2012 annual $PM_{2.5}$ NAAQS were due by October 2016. Allegheny County Health Department (ACHD) is the regulatory agency required to conduct the $PM_{2.5}$ attainment demonstration modeling and work with the State of Pennsylvania to prepare a PM2.5 SIP and submit to the U.S. EPA that demonstrates attainment of the annual $PM_{2.5}$ NAAQS by 2021.

The Liberty-Clairton area in Allegheny County was designated as nonattainment with respect to the 1997 $PM_{2.5}$ NAAQS based on 2001-2003 monitored data and the 2006 24-hour $PM_{2.5}$ NAAQS based on 2006-2008 monitoring data. The entirety of Allegheny County was designated nonattainment for 2012 annual $PM_{2.5}$ based on 2011-2013 monitored data.

While more than one site in Allegheny County violated the annual $PM_{2.5}$ NAAQS prior to the 2011-2013 timeframe, only the Liberty monitor violated the annual $PM_{2.5}$ NAAQS based on 2011-2013 and with more recent monitored data. Liberty 24-hour data has shown design values just below or above the 24-hour NAAQS with recent data, with the most recent data for 2014-2016 just above the standard.

1.2 Purpose

This document is the Air Quality Technical Support Document (AQTSD) for the Allegheny County $PM_{2.5}$ SIP that presents the attainment demonstration modeling for the 2012 annual $PM_{2.5}$ NAAQS. The Comprehensive Air Quality Model with extensions (CAMx) photochemical grid model (PGM) was applied for the 2011 calendar year on a 36/12/4/1.33 km resolution nested grid structure with the 1.33 km domain focused on the Allegheny County NAA and the 4 km domain focused on southwestern Pennsylvania (SWPA) and portions of surrounding states. The modeled total $PM_{2.5}$ mass and speciated $PM_{2.5}$ were compared against available observations as part of a model performance evaluation (MPE). Details of the MPE are presented in a separate, concurrent MPE report (Ramboll Environ, 2017b). Local sources were treated by a subgrid-scale Plume-in-Grid (PiG) module that uses a Gaussian puff model to simulate the plume impacts of local sources until the size of the plume is big enough to be resolved by the 1.33 km grid size used. Once released into the grid model, the contributions of the local sources were tracked using the Particulate Source Apportionment Technology (PSAT) source apportionment tool. CAMx was also applied for a 2021 emissions scenario that reflected the effects of growth and emission controls on the local and regional sources. The CAMx 2011 and 2021 modeling results were used to project future year annual and 24-hour $PM_{2.5}$ Design Values across Allegheny County and throughout the 4 km modeling domain for comparison with the 2012 $PM_{2.5}$ NAAQS.

2. SUMMARY OF APPROACH

Below we present an overview of the approach used for the Allegheny County $PM_{2.5}$ attainment demonstration modeling to address the 2012 $PM_{2.5}$ NAAQS. More details on the approach are provided in the separate CAMx Modeling Protocol report (Ramboll Environ, 2017a).

2.1 Episode Selection

The 2011 year was selected for the Allegheny County $PM_{2.5}$ attainment demonstration baseline modeling because it was part of the 2011-2013 monitoring timeframe used for designations and is representative of PM levels in the region. Additionally, there is a comprehensive 2011 modeling databases that includes the 2011 National Emissions Inventory (NEI2011v2).

2.2 Model Selection

Three types of models were used in the Allegheny County attainment demonstration modeling: meteorological, emissions, and air quality. More details about each component can be found in the Modeling Protocol (Ramboll Environ, 2017a).

- The Weather Research and Forecasting (WRF[1]) meteorological model was selected to represent meteorological conditions in the study area. The Advanced Research WRF dynamic core (WRF-ARW) was used to simulate three-dimensional meteorological conditions for the 2011 modeling year.

- Emissions modeling was performed using the Sparse Matrix Operator Kernel Emissions (SMOKE[2]) modeling system (Coats, 1995; Houyoux, et al., 2000). Biogenic emissions were generated using the Biogenic Emissions Inventory System (BEIS3).

- The Comprehensive Air-quality Model with extensions (CAMx[4]) Photochemical Grid Model (PGM) was selected for the Allegheny County attainment demonstration modeling (Ramboll Environ, 2016). The Particulate Source

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[1] https://www.mmm.ucar.edu/weather-research-and-forecasting-model
[2] https://www.cmascenter.org/smoke/
[3] https://www.epa.gov/air-emissions-modeling/biogenic-emission-inventory-system-beis
[4] http://www.camx.com/home.aspx

Appointment Technology (PSAT) feature was used to track source groups, including $PM_{2.5}$ contributions from local source components, and the sub-grid scale Plume-in-Grid (PiG) feature was used to simulate dispersion of major local sources in Allegheny County that were sampled using a receptor network at very fine (~100 m) resolution.

2.3 Domain Selection

WRF and CAMx were run for a 36/12/4/1.33 km domain structure as depicted in Figures 2-1 and 2-2. CAMx was applied on the 36/12 km domains using two-way grid nesting and the results were post-processed to generate boundary condition (BC) inputs for the 4 km western Pennsylvania domain (i.e., one-way grid nesting between the 12 and 4 km domains). CAMx was then applied on the 4/1.33 km domains using two-way grid nesting.

The four domains use a Lambert Conic Conformal (LCC) projection. The LCC grid projection has a pole of projection of 40 degrees North, -97 degrees East and standard parallels of 33 and 45 degrees, the so-called standard Regional Planning Organization (RPO) projection. The four domains are defined as follows:

- A 36 km continental U.S. (CONUS) domain is defined to be the standard RPO CONUS domain.
- A 12 km northeastern U.S. (NEUS) domain identical to the NEUS domain used by the Ozone Transport Commission (OTC) 12 km domain that is also used by MARAMA.
- A 4 km domain that covers all of Pennsylvania (PA) and adjacent areas in West Virginia and Ohio.
- A nested grid of 1.33 km for the Allegheny County NAA and portions of adjacent counties.

The proposed modeling domains were devised to include all the major area and point sources of NO_X, SO_2 and $PM_{2.5}$ emissions in Allegheny County. The WRF domains were defined to be slightly larger than the CAMx domains to eliminate any boundary artifacts in the WRF simulations from influencing the CAMx meteorological inputs.

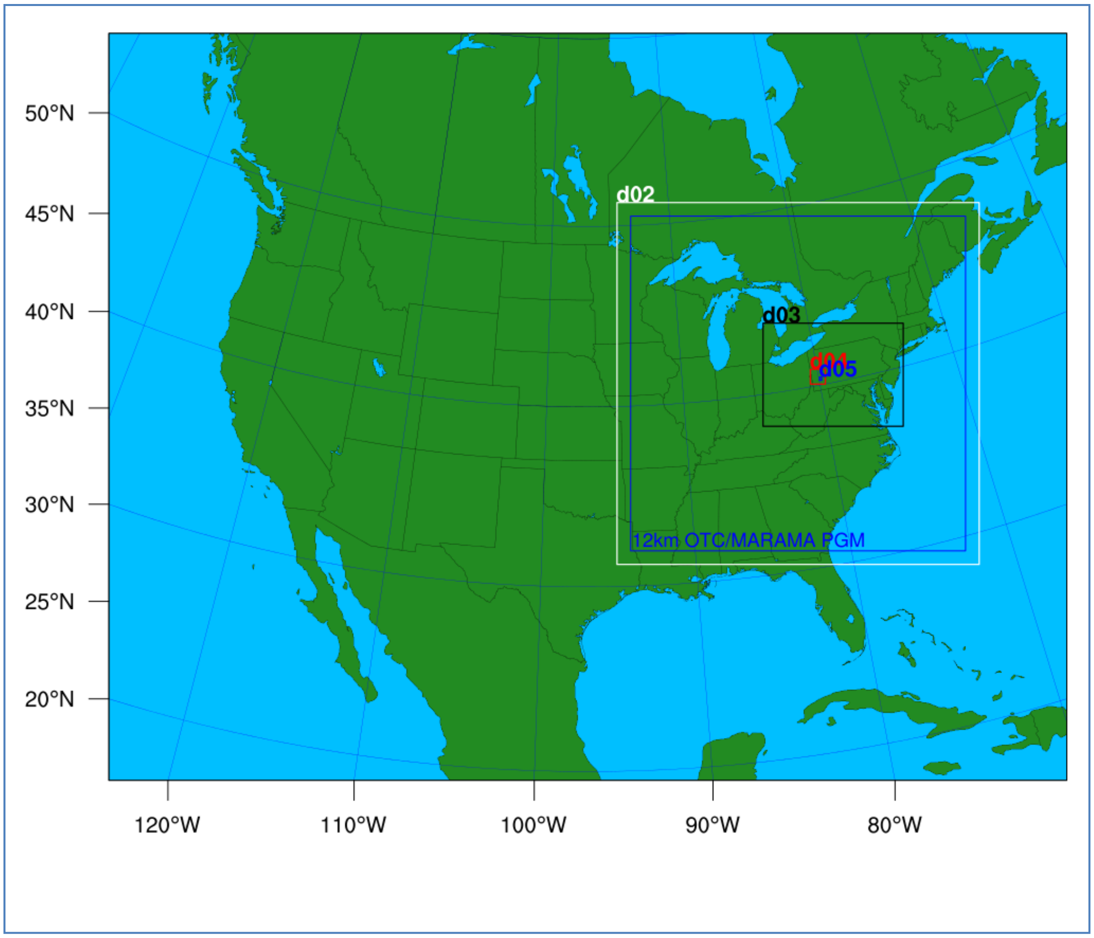

Figure 2-1. Large Scale WRF and CAMx 36 (d01), 12 (d02), 4 (d03) and 1.33 (d04) km Resolution Horizontal Modeling Domains

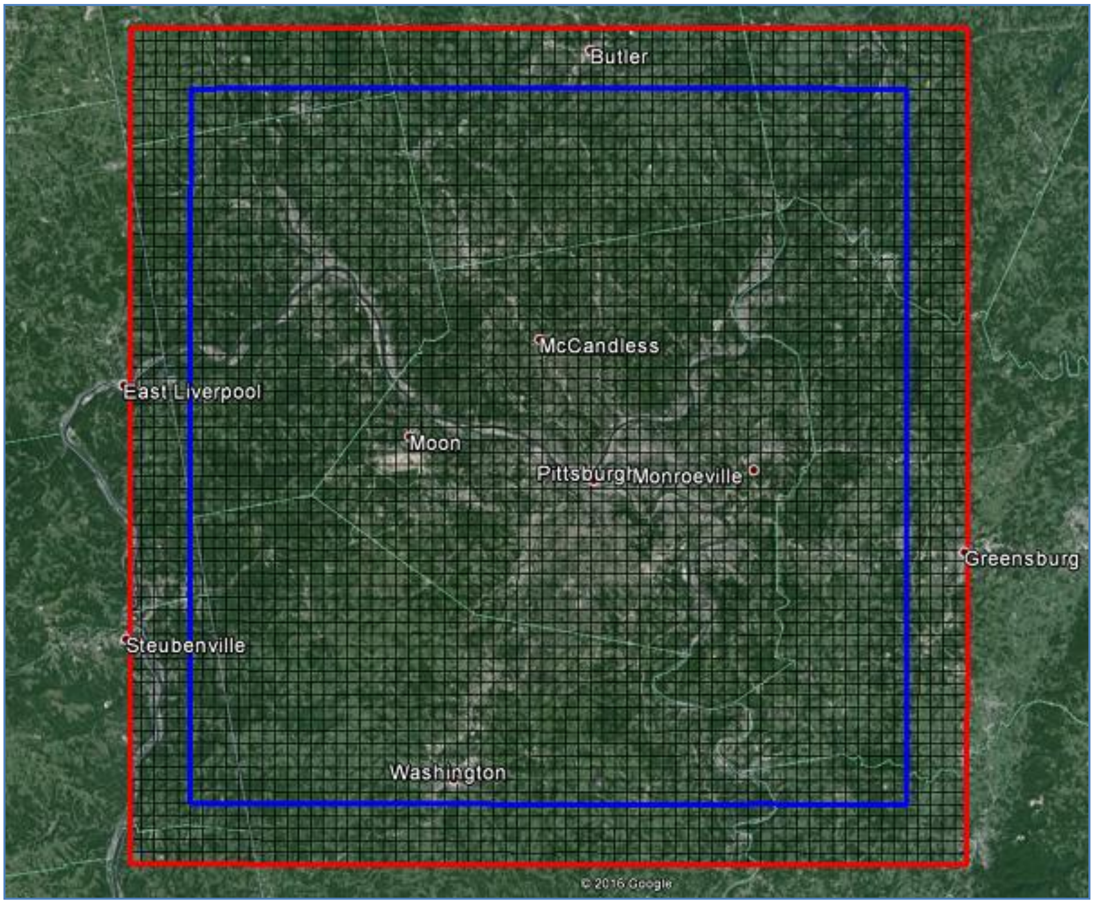

Figure 2-2. Allegheny County 1.33 km (d04) Resolution WRF (red) and CAMx (blue) Horizontal Modeling Domains

2.4 Vertical Layer Structure

The WRF output was processed using the WRFCAMx processor to generate CAMx meteorological inputs. WRF was run with 37 levels (36 layers). WRFCAMx can perform layer collapsing to reduce the vertical layers in WRF to fewer vertical layers for the CAMx modeling to reduce the CAMx computational requirements. The WRF 36 layers were collapsed to 26 vertical layers for the CAMx modeling. Refer to the Modeling Protocol for more details about the CAMx vertical layer structure in this analysis (Ramboll Environ, 2017a).

2.5 Base Year Emissions Modeling

2.5.1 Emissions Inputs

The Sparse Matrix Operator Kernel Emissions (SMOKE; Coats, 1995; Houyoux et al., 2000) modeling system was used to generate the hourly gridded speciated emissions inputs to the CAMx model, for the 2011 year and the 36/12/4/1.33 km domains. Biogenic emissions were generated using the SMOKE-BEIS model.

The emissions databases used for the 2011 base year were provided by a variety of sources. The emissions data for the 1.33 km fine grid were developed and provided for modeling by ACHD. The EPA 2011 v6.2 modeling platform (MP) inventory along with hourly continuous emissions monitoring (CEM) data from EPA's Clean Air Markets Division (CAMD) website were used for EGU point sources through the modeling domains. Local sources in Allegheny County are based on actual emissions data reported for 2011 provided by ACHD and include stacks, quench towers, ambient-temperature fugitives, and coke oven batteries.

Emissions data for areas outside of the 1.33 km grid were provided by MARAMA and the EPA (EPA 2011 v6.2 MP) for the Eastern US and by the EPA (EPA 2011 v6.2 MP) for the rest of the US. The Modeling Protocol contains more information about the emissions databases used in this project (Ramboll Environ, 2017a). The raw emissions data were processed with SMOKE to provide the hourly, gridded, speciated files required by CAMx. Table 2-1 summarizes the base year inventory by region and major source category.

Table 2-1. Base Year Inventory Data Sources

Source Category	Allegheny County (1.33 km Domain)	Mid-Atlantic (4 km Domain)	Eastern U.S. (12 km Domain)	Continental U.S. (36 km Domain)
Area / Nonroad	MARAMA Alpha2 2011	MARAMA Alpha2 2011	EPA 2011 v6.2 MP	EPA 2011 v6.2 MP
Onroad (Mobile)	MARAMA Alpha2 2011	MARAMA Alpha2 2011	EPA 2011 v6.2 MP	EPA 2011 v6.2 MP
Point	ACHD Local + MARAMA Alpha2 2011	ACHD Local + MARAMA Alpha2 2011	EPA 2011 v6.2 MP	EPA 2011 v6.2 MP
EGU Point	EPA 2011 v6.2 MP 2011 w/CAMD CEMS	EPA 2011 v6.2 MP 2011 w/CAMD CEMS	EPA 2011 v6.2 MP 2011 w/CAMD CEMS	EPA 2011 v6.2 MP 2011 w/CAMD CEMS
Fires	EPA 2011 v6.2 FIRES	EPA 2011 v6.2 FIRES	EPA 2011 v6.2 FIRES	EPA 2011 v6.2 FIRES
Biogenics	EPA 2011 NEIv2 BEIS	EPA 2011 NEIv2 BEIS	EPA 2011 NEIv2 BEIS	EPA 2011 NEIv2 BEIS
Sea Salt and Lightning	CAMx processors	CAMx processors	CAMx processors	CAMx processors

Notes:
1. MARAMA Alpha2 and EPA v6.2 MP are developed from 2011 NEI V2
2. Point sources include non-EGUs and small EGU.
3. EGU emissions include SO2/NOx CAMD CEMS data for temporal profile; EPA 2011 (annualized) for other pollutants
4. ACHD Local is corrected MARAMA inventory for emissions, stack parameters, coordinates, etc. 36/12 km domains are used to develop boundary conditions for 4/1.33 km domains

2.5.2 Summary of Base Year Emission Results

Table 2-2 summarizes the anthropogenic emissions within the 1.33 km domain by major source category for an average day in 2011. The largest source of anthropogenic CO emissions in the 1.33 km domain is the on-road mobile sector (49%), followed by non-road mobile sources (28%). On-road mobile sources also contributes the most to NO_x emissions (43%) in the 1.33 km domain, followed by point sources (27%). Area (47%) and on-road (29%) sources are the largest two contributors to VOC emissions in the 1.33 km domain with non-road mobile sources (17%) contributing most of the remainder. Point sources contribute the majority of SO_2 (82%) in the 1.33 km domain while area sources (46%) and point sources (40%) both contribute heavily to $PM_{2.5}$ emissions. Area sources dominate NH_3 emissions (73%), followed by on-road mobile sources (18%).

Table 2-2. Summary of Total 2011 Anthropogenic Emissions within the 1.33 km Domain for an Average Day (tons per day).

Source Category	CO	NO_x	VOC	SO_2	$PM_{2.5}$	NH_3
Area Source	67.1	25.6	54.0	8.2	11.5	5.6
Non-Road	199.9	16.6	20.1	0.1	1.5	0.02
Onroad Mobile	343.9	61.3	34.1	0.4	2.0	1.4
Point Source	91.1	38.1	7.8	39.8	9.9	0.6

2.6 CAMx 2011 Base Year Modeling

CAMx Version 6.30 (released in April 2016) was used for the 2011 base case modeling. CAMx was first run for the 36/12 km domains using Boundary Conditions (BCs) for the 36 km CONUS domain based on the GEOS-Chem global chemistry model. The CAMx 36/12 km model output was post-processed to generate BCs for the 4 km domain. CAMx was then used for the 2011 base case using two-way grid nesting with the 4/1.33 km modeling domains. Emissions from local point sources were treated using the subgrid-scale Plume-in-Grid (PiG) module. The PiG module treats the early chemistry and dispersion of point source plumes using a Gaussian puff model. When the size of the PiG puff is commensurate with the size of the 1.33 km grid cell, the mass from the puff is released to the photochemical grid model. The local sources were also tagged to be treated by the Particulate Source Apportionment Technology (PSAT) that track the contributions of the local sources to all particulate species (e.g., sulfate, nitrate, ammonium and primary PM) except secondary organic aerosol (SOA). SOA was not tracked due to the small amount of SOA precursors from the local sources and the short distance from the local sources to the nearest monitor sites, during which there would be little time for SOA formation. Tracking SOA requires significant computational expense due to the many tracers needed to account for the SOA formation pathways in the PSAT source apportionment tool. The CAMx PiG puffs were sampled at 100 m intervals around the majority of monitoring sites within the 1.33 km domain. Figure 2-3 shows the placement of the PiG sampling grids in Allegheny County. The total concentrations in each CAMx 1.33 km grid cell were obtained by averaging the live puffs sampling across all the receptors in a grid cell and adding the average to the CAMx grid model estimate in each grid cell. The local source concentrations were obtained by combining the live puffs and the PSAT local source contributions (dumped puffs). Regional concentrations are obtained by subtracting the local source concentrations from the total concentrations. CAMx concentration estimates without the contribution from major local source primary emissions were also calculated, which is the $PM_{2.5}$ component that can be directly modeled using AERMOD.

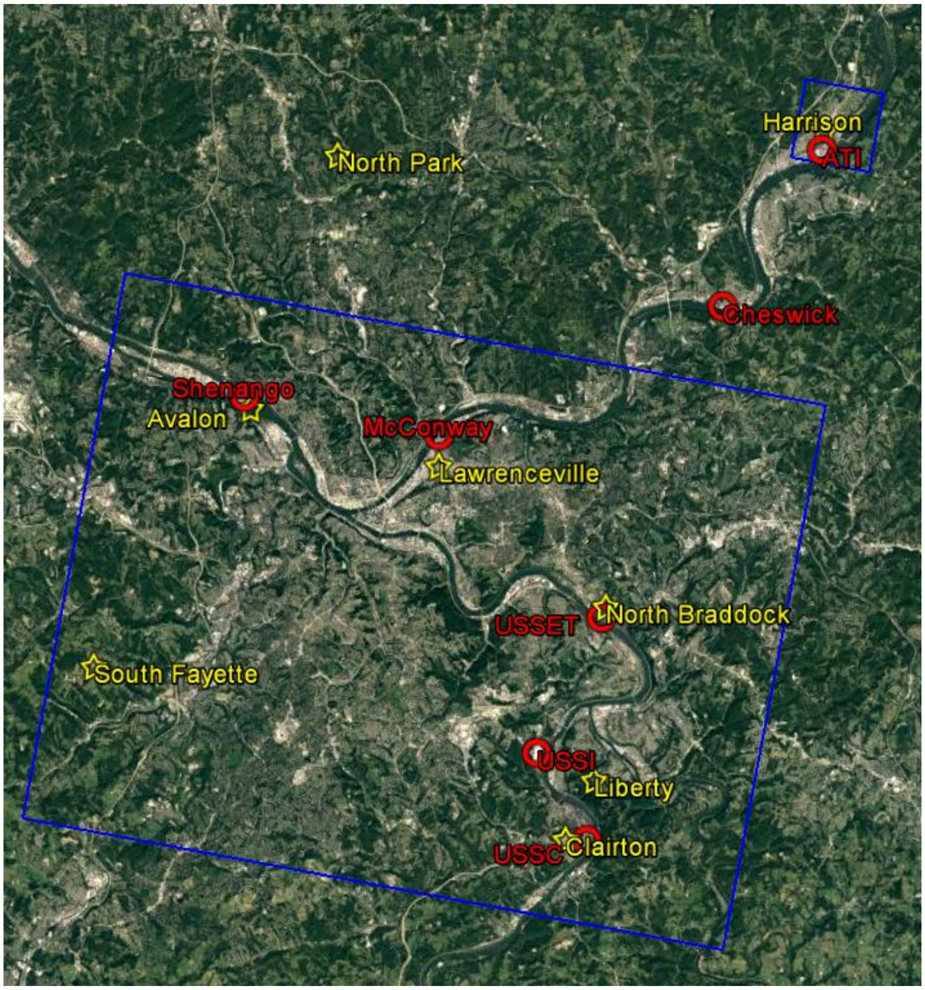

Figure 2-3. PiG live puffs sampling grids (blue boxes) along with local major sources (red) and FRM $PM_{2.5}$ monitoring sites (yellow) within Allegheny County.

2.7 Base Year Model Performance Evaluation

The CAMx 2011 base year modeling results were compared against measured ambient concentrations as part of a model performance evaluation. CAMx was mainly evaluated for total $PM_{2.5}$ mass and speciated $PM_{2.5}$. Details of the CAMx 2011 base case model performance evaluation are presented in the accompanying MPE report (Ramboll Environ, 2017b), with a summary of model performance provided below.

To obtain results presented in Section 2.7.2 through Section 2.8, $PM_{2.5}$ concentrations in live PiG puffs are combined with regional/background $PM_{2.5}$ and $PM_{2.5}$ in dumped PiG puffs using bilinear interpolation techniques. At each point in the gridded model domain, the bilinear interpolation method combines concentrations from the closest four grid cells in a bi-linear (2-direction) approach. During interpolation, model results in each 1.33 km grid cell are interpolated to the resolution of the PiG sampling grid (~100 m spacing).

Beginning in Section 2.11, $PM_{2.5}$ concentrations from live PiG puffs are combined with regional/background $PM_{2.5}$ using averaging techniques in place of bilinear interpolation. During averaging, all PiG receptors within each 1.33 km CAMx grid cell are averaged together and added to the $PM_{2.5}$ concentrations in the 1.33 km grid cell. This ensures that the spatial dimensions and resolution of the 1.33 km CAMx grid cell domain are used to calculate $PM_{2.5}$ design values in MATS instead of the very fine (~100 m spacing) PiG sampling grid domain. Additionally, the future year projection of $PM_{2.5}$ design values are calculated by using the average values within a grid cell array surrounding the monitor site, so averaging PiG values in each 1.33 km grid cell is more appropriate than using bilinear interpolation. Using averaging techniques to incorporate the live PiG puff component during calculation of $PM_{2.5}$ design values is consistent with techniques used in previous Allegheny County SIP analyses and EPA modeling guidance (EPA, 2014).

2.7.1 Spatial Plots of Average $PM_{2.5}$

Figure 2-4 shows the spatial distribution of modeled surface-level, quarterly average $PM_{2.5}$ for the base case 2011 36-km CONUS domains. For all quarters, average $PM_{2.5}$ values are higher in the eastern US compared to the west, with maximum values of 23 μg/m^3. Agricultural activity combined with industry and traffic are major contributors to $PM_{2.5}$ concentrations in the central and eastern US. The highest surface-level $PM_{2.5}$ concentrations in the eastern US occur in big cities during the cooler months (quarter 1, quarter 4). During these periods, $PM_{2.5}$ emissions associated with home heating is significant and shallower boundary layers tend to concentrate $PM_{2.5}$ closer to the surface. Overall, the spatial patterns and magnitudes of $PM_{2.5}$ shown in Figure 2-4 are qualitatively in line with expectations given the location of major $PM_{2.5}$ sources across the United States.

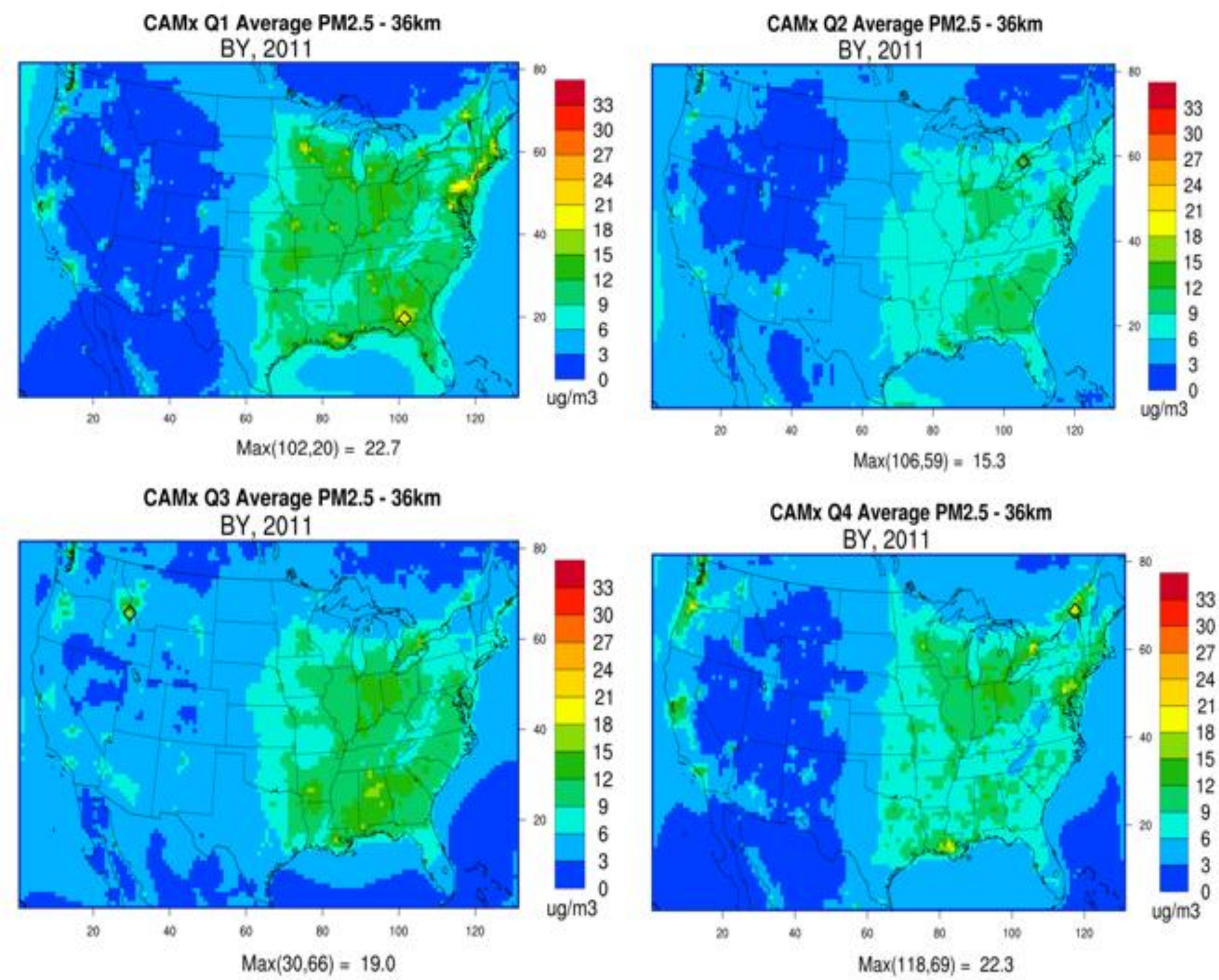

Figure 2-4. Quarterly Average $PM_{2.5}$ for 36 km domain

2.7.2 Total $PM_{2.5}$ Mass

Table 2-3 shows Federal Reference Method (FRM), Tapered Element Oscillating Balance (TEOM) monitoring data total $PM_{2.5}$ Fractional Bias (FB) and Fractional Error

(FE) performance statistics for the 1.33 km domain. In Table 2-3, results from each monitoring site within a network are averaged together to calculate mean FB and FE values for each quarter. Statistics for each quarter are presented along with the average FB and FE values across all quarters. For both monitoring networks, all FB and FE values achieve the performance criteria by a wide margin and half of the quarters exceed the PM performance goals. When the FB and FE values for each quarter are averaged together, the PM performance goals are achieved in all cases.

Table 2-3. Comparison of Quarterly FRM and TEOM $PM_{2.5}$ Fractional Bias and Error Performance Statistics with PM Performance Goals and Criteria for 1.33 km Domain

Network	Number Sites	Quarter	**Fractional Bias** Criteria: ≤±60% Goal: ≤±30%	**Fractional Error** Criteria: ≤75% Goal: ≤50%
TEOM	2	1	+35.1%	50.5%
		2	-14.4%	44.3%
		3	+1.6%	46.4%
		4	+33.6	53.6%
		Average	+14.0%	48.7%
FRM	8	1	+45.8%	48.0%
		2	+6.8	35.1%
		3	-2.5	36.8%
		4	+36.4	45.8%
		Average	+21.6%	41.4%

Figure 2-5 is a quantile-quantile (Q-Q) plot that compares daily observed (FRM) and modeled $PM_{2.5}$ concentrations at Liberty for 2011. In the Q-Q plot, daily observed and modeled concentrations are each sorted from highest to lowest and then paired together such that the highest observed and modeled values are directly compared. Exact matches between modeled and observed values are located along the black 1:1 line that stretches diagonally across the center of the plot. All points that fall between the black centerline and the two dashed lines (red) indicate that modeled and measured values agree within a factor of two. Annual mean observed and modeled values, along with other relevant statistics, are also shown on the Q-Q plot. Figure 2-5 shows that there is good agreement (within a factor of two) between modeled and measured $PM_{2.5}$ concentrations at Liberty across the vast majority of the frequency distribution. The agreement is best at the upper end of the range and the model slightly overestimates concentrations at the middle and lower end. Both the observed and modeled annual $PM_{2.5}$ values at Liberty exceed the NAAQS (12 μg/m^3), which are 14.1 μg/m^3 and 16.4 μg/m^3, respectively. The annual mean estimated by CAMx is higher than the observed annual mean, suggesting that CAMx is maintaining a degree of conservatism at Liberty. The model performance evaluation report contains similar Q-Q plots for several other monitoring sites within Allegheny County. Overall, CAMx tends to overestimate $PM_{2.5}$ concentrations, suggesting that the $PM_{2.5}$ estimates predicted by CAMx during the future year simulation will likely be conservative (i.e., tending toward overestimation).

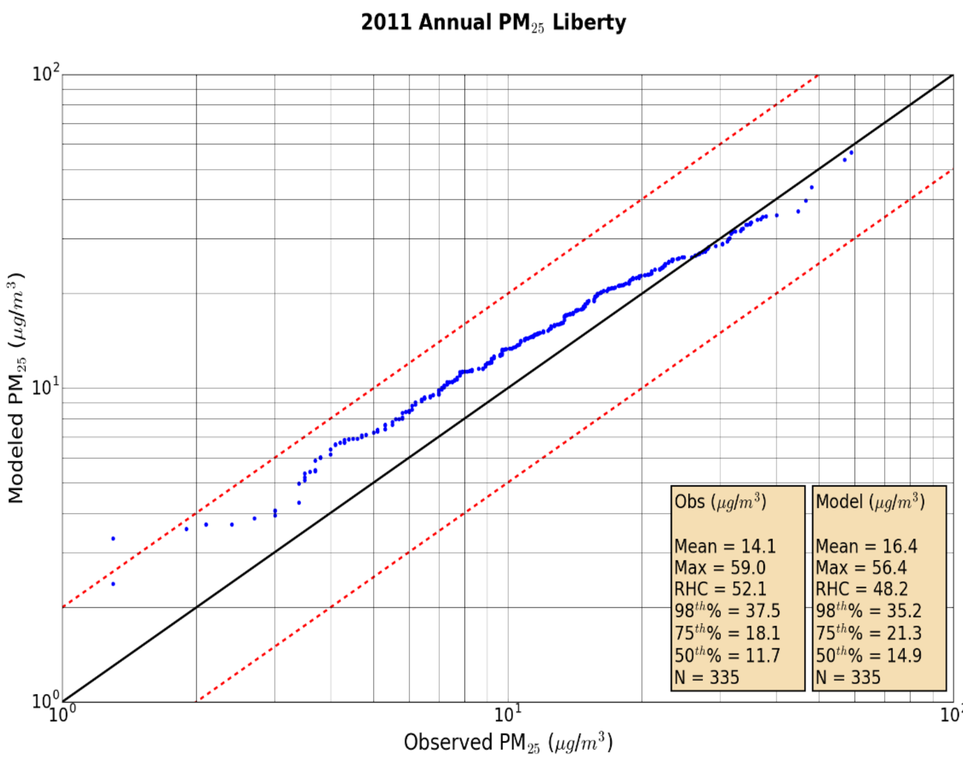

Figure 2-5. Annual Q-Q Plot of 24-hour FRM and Modeled $PM_{2.5}$ at Liberty

2.7.3 Speciated $PM_{2.5}$

This full model performance evaluation report compares modeled and observed speciated $PM_{2.5}$ (SO_4, NO_3, NH_4, and total carbon) measurements for each quarter. For the vast majority of species, sites, and seasons, the fractional bias and error metrics meet the performance criteria, which indicates reasonable model-measurement agreement. Similar to total $PM_{2.5}$, the best agreement is seen during the warmer seasons.

2.7.4 Base Year Model Performance Evaluation Conclusions

The 2011 base year CAMx results presented in this study indicate that there is good agreement between modeled and observed $PM_{2.5}$ concentrations across Allegheny County. The model performance results presented in this study indicate that CAMx is a suitable model to be used in the future year modeling scenario.

2.8 Local Source Contributions to Annual Average $PM_{2.5}$

Table 2-4 shows the local and regional contributions to annual average $PM_{2.5}$ contributions at several sites within Allegheny County.

Table 2-4. Local and Regional Contributions to Annual Average $PM_{2.5}$

	$PM_{2.5}$ (µg/m^3)			
Site	**Observed (FRM)**	**Modeled**		
	Total	**Total**	**Regional**	**Local**
Clairton	10.9	14.1	11.3	2.7
Lawrenceville	11.1	14.5	13.0	1.5
Liberty	14.1	16.2	11.3	4.9
North Braddock	12.4	15.2	10.9	4.3
South Fayette	10.7	9.5	9.2	0.3

At Liberty, model results suggest that local sources contribute 30% to overall annual average $PM_{2.5}$. There is a wide range of local source contribution at these five monitoring sites. The contribution of local sources to annual average $PM_{2.5}$ is 28% at North Braddock, 19% at Clairton, 10% at Lawrenceville, and 3% at South Fayette.

Figure 2-6 presents pie charts illustrating the chemical speciation associated with the local source component of annual average $PM_{2.5}$ at Liberty. The pie chart on the left was generated using 2011 Chemical Speciation Network (CSN) observations within the Pittsburgh metropolitan statistical area (MSA). Speciated CSN measurements across the MSA were used to obtain mean background concentrations, and the local (or "excess") $PM_{2.5}$ contribution at Liberty was determined by taking the difference between background concentrations and CSN measurements at Liberty. The observed annual average $PM_{2.5}$ excess at Liberty is 3.8 µg/m^3. The pie chart on the left shows that annual average excess $PM_{2.5}$ at Liberty is dominated by SO_4, EC, and OA, followed by NH_4 and other (e.g., soil, fine particulates).

The pie chart on the right shows the modeled chemical speciation associated with the local source component at Liberty. Live PiG puffs and PSAT output were combined to estimate the $PM_{2.5}$ associated with local (major and minor) sources at the Liberty monitoring site. The modeled local source contribution at Liberty is 4.9 μg/m^3, which is slightly higher compared to the observed $PM_{2.5}$ excess (3.8 μg/m^3), although these two methods vary drastically in their approach. The modeled local source component at Liberty is dominated by species such as soil and fine particulates, followed by NH_4 and SO_4. Both the observed and modeled local component at Liberty show that NO_3 is a minor component of $PM_{2.5}$ compared to fine particulates, soil, NH_4, EC, OA, and SO_4. The differences in speciated $PM_{2.5}$ distributions is at least partially related to differences in observed and modeled species mapping algorithms (i.e., which individual species are grouped together for each category).

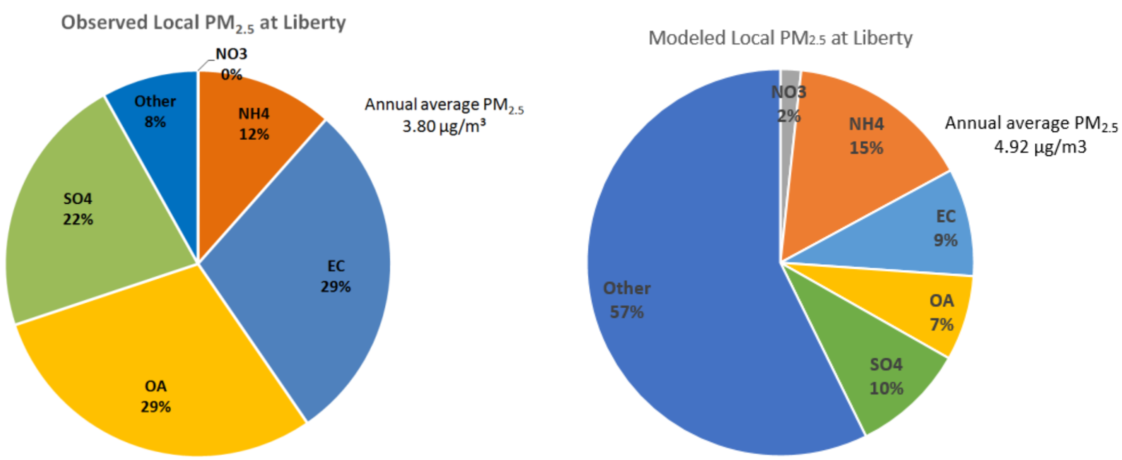

Figure 2-6. Speciated "Excess" $PM_{2.5}$ at Liberty, Observed and Modeled, 2011.

Comparison of the observed and modeled local source $PM_{2.5}$ at Liberty provides some indication that the Plume-in-Grid algorithm is doing a reasonable job treating local sources in Allegheny County. In Section 2.11 we present a comparison of PiG and AERMOD treatment of the $PM_{2.5}$ from local sources in Allegheny County.

2.9 CAMx 2021 Future Year Modeling

CAMx was exercised for a 2021 future year emissions scenario using the same model configuration as the 2011 base case (i.e., use of 36/12 km and 4/1.33 km two-way grid nests and treating local sources using the PiG module and PSAT tool). Emissions for the 2021 CAMx scenario are presented in Table 2-5. For certain source categories, MARAMA Alpha2 2018 and 2028 inventories were interpolated (see Table 2-5). The EPA v6.2 MP 2017 and 2025 inventories were also interpolated in some cases (see Table 2-5). Additional data and corrections for local sources within Allegheny County from ACHD were also applied. In addition to the CAMx model configuration, several inputs to CAMx were held constant between the 2011 and 2021 base case simulations: GEOS-Chem 2011 BCs for the 36 km CONUS domain; WRF 2011 meteorological conditions; biogenic emissions from SMOKE-BEIS; sea salt emissions; lightning emissions; and emissions from fires (wildfires, prescribed burns and agricultural burning). The Modeling Protocol report contains more details about the emissions used for the future year CAMx run (Ramboll, Environ, 2017a).

Table 2-5 summarizes the future year inventory by region and major source category.

Table 2-5. Future Year Inventory Data Sources

Source Category	Allegheny County (1.33 km Domain)	Mid-Atlantic (4 km Domain)	Eastern U.S. (12 km Domain)	Continental U.S. (36 km Domain)
Area	MARAMA Alpha2 Interpolated 2018/2028	MARAMA Alpha2 Interpolated 2018/2028	EPA v6.2 MP Interpolated 2017/2025	EPA v6.2 MP Interpolated 2017/2025
Nonroad	EPA v6.2 MP Interpolated 2017/2025	EPA v6.2 MP Interpolated 2017/2025	EPA v6.2 MP Interpolated 2017/2025	EPA v6.2 MP Interpolated 2017/2025
Onroad (Mobile)	MARAMA Alpha2 2018	MARAMA Alpha2 2018	EPA v6.2 MP 2017	EPA v6.2 MP 2017
Point	ACHD Local + MARAMA Alpha2 Interpolated 2018/2028	ACHD Local + MARAMA Alpha2 Interpolated 2018/2028	EPA v6.2 MP Interpolated 2017/2025	EPA v6.2 MP Interpolated 2017/2025
EGU Point	ERTAC v2.4L2 2021	ERTAC v2.4L2 2021	ERTAC v2.4L2 2021	ERTAC v2.4L2 2021
Fires	EPA 2011 v6.2 FIRES	EPA 2011 v6.2 FIRES	EPA 2011 v6.2 FIRES	EPA 2011 v6.2 FIRES
Biogenics	EPA 2011 NEIv2 BEIS	EPA 2011 NEIv2 BEIS	EPA 2011 NEIv2 BEIS	EPA 2011 NEIv2 BEIS
Sea Salt and Lightning	CAMx processors	CAMx processors	CAMx processors	CAMx processors

Notes:
1. MARAMA Alpha2 and EPA v6.2 MP are developed from NEI V2 w/projections
2. Point sources include non-EGUs and small EGUs
3. For onroad (mobile), 2018/2017 are used as conservative estimates for future case
4. For nonroad in 1.33 and 4 km domains, EPA interpolations used due to issues with the MARAMA 2018/2028 files
5. ERTAC 2021 is based on projected EGU emissions for OTC, LADCO, SESARM, and CENSARA regions
6. Fires and biogenics are held constant for future case
7. ACHD Local is projected based on known modifications/shutdowns (other sources held constant)
8. 36/12 km domains are used to develop boundary conditions for 4/1.33 km domains

2.9.1 ERTAC Emissions

For the future year CAMx scenario, the Eastern Regional Technical Advisory Committee (ERTAC) Electrical Generation Unit (EGU) Emission Projection Tool[5] was used to project base year 2011 EGU emissions to future year 2021. The projected 2021 emissions were used for the 1.33, 4, and 12 km CAMx domains.

[5] https://www.epa.gov/air-emissions-inventories/eastern-regional-technical-advisory-committee-ertac-electricity-generating

ERTAC inventories contain emissions information for the Continental United States (CONUS). The ERTAC committee includes state regulators throughout the eastern U.S, industry representatives, and members from multi-jurisdictional planning organizations (MJOs). The growth factors are based on AEO2015 and up-to-date information on changes such as new units, modifications to control technology, fuel changes, and shutdowns are included in the inventory. The ERTAC EGU tool allows for SO_2 and NO_x emission projections for specific fossil fuel units that report emissions (i.e., CEMS data) to the EPA Clean Air Market Division (CAMD) and generate at least 25 MW. Emission projections take into account factors such as expected changes in population growth, control technology, fuel types, and operational status and utilize regional electricity generation forecasts from the Energy Information Agency (EIA) and National Energy Reliability Corporation (NERC). Within each region, electrical generating units are separated by source type (coal, oil, natural gas – combined cycle, natural gas – single cycle, natural gas – boiler gas).

For the future year CAMx simulation, the ERTAC EGU projection tool version 2.4L2[6,7] (release date: July 2015) was used to develop future year EGU emission estimates. ERTAC v2.4L2 is a modified version of ERTAC v2.4 that is expected to be conservative. Comparison of SO_2 and NO_x emissions in ERTAC v2.4 and ERTAC v2.4L2 highlights the degree of conservatism in ERTAC v2.4L2. The projected annual SO_2 and NO_x sums in Pennsylvania is more conservative in ERTAC v2.4L2 for 2021 compared to ERTAC v2.4 for 2019.

For the ERTAC v2.4L2 2021 emission projection, focus was placed on permanent changes while maintaining a consistent generation capacity from base case to future case inventory-wide . The ERTAC-projected 2021 emissions take into account only enforceable control measures (as of July 2015), fuel changes, and operational status changes (including shutdowns). As a result, some uncontrolled plants were assigned increased emissions from base case in order to account for losses in overall generating capacity due to shutdowns and operational changes.

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[6] http://www.marama.org/images/stories/documents/CONUS2.4/Documentation%20of%20ERTAC%20EGU%20CONUS%202.4-%20Final.docx

[7] http://www.marama.org/2013-ertac-egu-forecasting-tool-documentation

Additionally, EGU changes associated with pending regulatory actions (e.g., Clean Power Plan, Cross-State Air Pollution Rule, Mercury and Air Toxics rule) in the eastern U.S. are not included in the projection from base year 2011 to 2021. Many reductions in SO_2 due to 2010 NAAQS requirements have also not been included in the modeling. These factors add additional degrees of conservatism to the 2021 EGU emission projections because future actions will likely lead to decreased EGU emissions throughout the region.

2.10 Comparison of Base Year and Future Year CAMx Modeling Results

This section provides a comparison of base year and future year CAMx modeling. Table 2-6 displays the 2011 and 2021 $PM_{2.5}$, PM_{10}, SO_2, NO_X, VOC and NH_3 emissions in Allegheny County and the percent changes in emissions from 2011 to 2021. Primary $PM_{2.5}$ emissions in the domain are dominated by point (43%) and area (43%) sources in 2011, with area sources estimated to increase (+8.7%) and point sources estimated to decrease (-9.0%) in 2021.[8] Similar changes are estimated for coarser portions of PM (PM_{10}) from 2011 to 2021. SO_2 emissions in Allegheny County are dominated by point sources (89% in 2011, 84% in 2021), with considerable decreases from 2011 to 2021 (-56%). Large reductions of NO_X and VOC are estimated from all source categories for 2021 (-36% and -25%, respectively), most notably from on-road mobile emissions. NH_3 emissions in the region are estimated to be reduced by 9% between 2011 and 2021.

[8] A refined local area analysis, if performed, may revise the primary $PM_{2.5}$ point source total for the future case.

Table 2-6a. 2011 and 2021 emissions in Allegheny County in tons per year (TPY) and percent change ((2021-2011)/2011) by major source category.

Allegheny County	**$PM_{2.5}$ (TPY)**			**PM_{10} (TPY)**			**SO_2 (TPY)**		
Source Category	**2011**	**2021**	(%)	**2011**	**2021**	(%)	**2011**	**2021**	(%)
Point Sources	2,503	2,277	-9.0	2,987	2,753	-7.8	13,460	5,921	-56.0
Area Sources	2,491	2,708	+8.7	4,683	5,486	+17.1	1,528	1,079	-29.4
Non-Road Mobile	361	234	-35.2	378	248	-34.4	11	5	-52.7
On-Road Mobile	450	266	-40.8	894	722	-19.2	78	31	-60.2
Total	5,805	5,485	-5.5	8,942	9,209	+3.0	15,077	7,036	-53.3

Table 2-6b. 2011 and 2021 emissions in Allegheny County in tons per year (TPY) and percent change ((2021-2011)/2011) by major source category.

Allegheny County	**NO_X (TPY)**			**VOC (TPY)**			**NH_3 (TPY)**		
Source Category	**2011**	**2021**	(%)	**2011**	**2021**	(%)	**2011**	**2021**	(%)
Point Sources	11,128	7,928	-28.8	1,669	1,534	-8.1	207	202	-2.4
Area Sources	6,979	6,664	-4.5	11,200	10,221	-8.7	621	615	-1.0
Non-Road Mobile	3,921	2,212	-43.6	3,780	2,752	-27.2	5	6	+28.0
On-Road Mobile	13,259	5,708	-56.9	7,383	3,479	-52.9	304	209	-31.3
Total	35,287	22,512	-36.2	24,032	17,986	-25.2	1,137	1,032	-9.2

Figure 2-7 presents base year and future year annual average $PM_{2.5}$ in the 4 km domain and Figure 2-8 shows the comparison for the 1.33 km domain. Note that live PiG puff concentrations are not included in Figures 2-7 and 2-8.

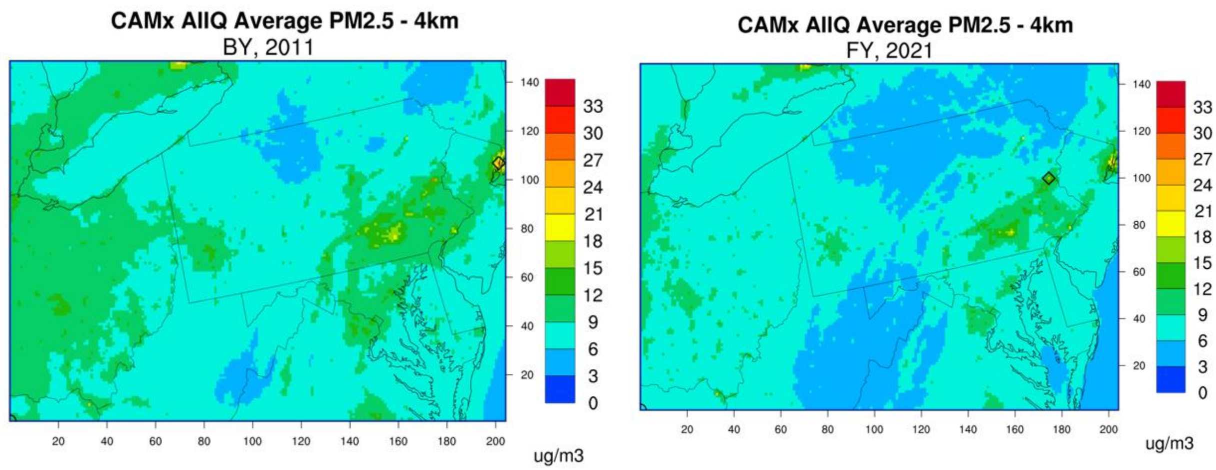

Figure 2-7. Base and Future Year Annual Average $PM_{2.5}$ in 4 km domain.

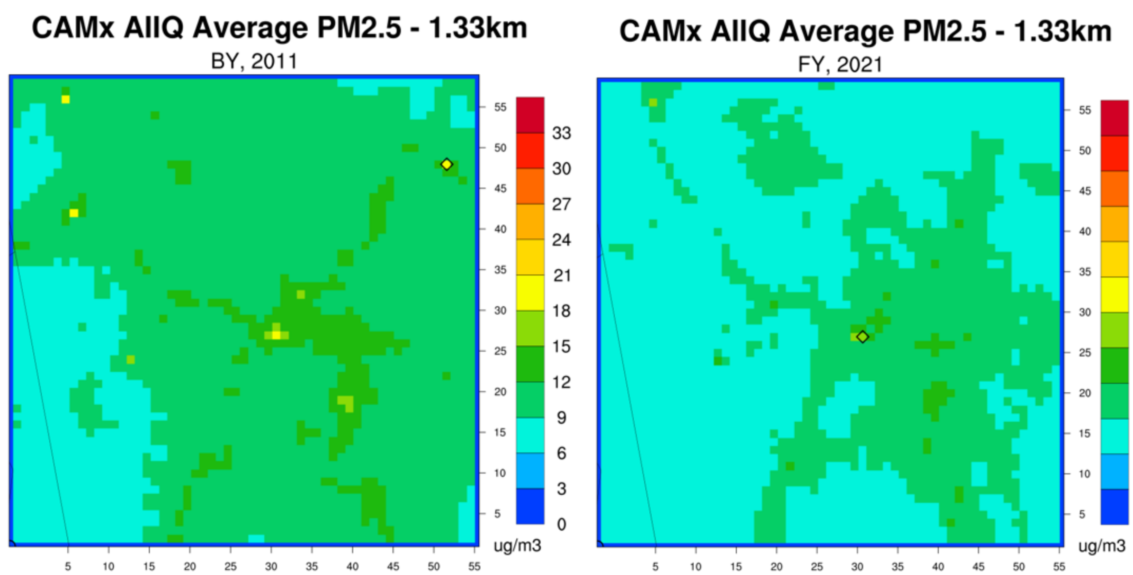

Figure 2-8. Base and Future Year Annual Average $PM_{2.5}$ in 1.33 km domain.

Figures 2-7 and 2-8 show that there are overall decreases in annual average $PM_{2.5}$ in the future year scenario compared to the base year scenario in both modeling domains. In the 4 km domain, the maximum annual average $PM_{2.5}$ is 29.7 μg/m^3 in the base year and 26.3 μg/m^3 in the future year. In the 1.33 km domain, the maximum annual average $PM_{2.5}$ is 20.3 μg/m^3 in the base year and 17.0 μg/m^3 in the future year.

Figure 2-9 is a Q-Q plot comparing daily $PM_{2.5}$ over a year for the base and future year CAMx runs at Liberty. Across the vast majority of the frequency distribution, daily total (local plus regional) $PM_{2.5}$ concentrations are lower in the future year scenario. The annual average $PM_{2.5}$ value at Liberty is 14.9 µg/m^3 in the future year scenario, which is 1.3 µg/m^3 (8%) lower compared to the base case run.

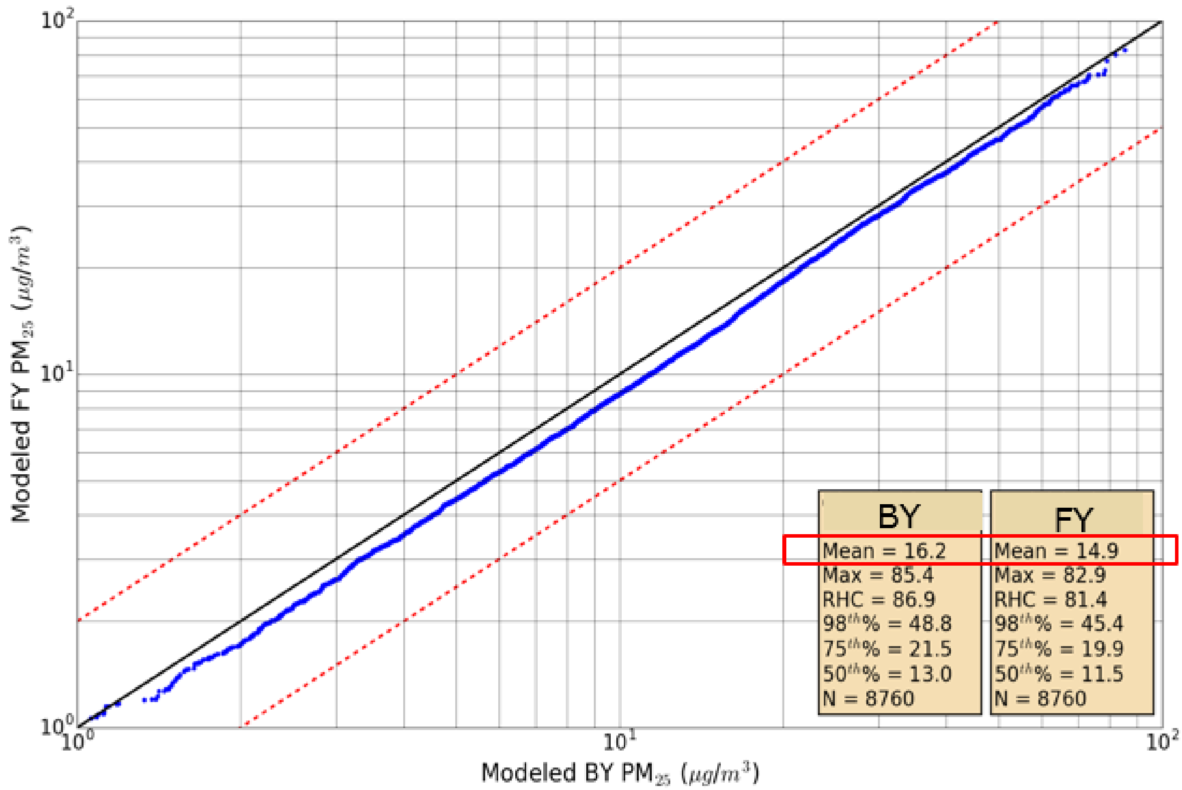

Figure 2-9. Annual Q-Q plot Comparing 24-hour $PM_{2.5}$ at Liberty in the Base and Future Year Model Runs.

At Liberty, the decrease in $PM_{2.5}$ in the future year is largely attributed to regional decreases in $PM_{2.5}$. Table 2-7 compares the local contribution to annual average $PM_{2.5}$ in the base and future years across Allegheny County. In Table 2-7, live PiG puffs and PSAT output were combined to estimate the $PM_{2.5}$ associated with local (major and minor) sources within Allegheny County. Similar to Liberty, CAMx estimates minor changes in the local source $PM_{2.5}$ contributions at North Braddock, North Park, and South Fayette. Local $PM_{2.5}$ contributions are decreased in the future year at Avalon, Harrison, and Lawrenceville. At Clairton, local $PM_{2.5}$ concentrations are increased by 0.7 µg/m^3 in the future year scenario, likely related to predicted production increases near the monitor site. Overall, the contribution of local sources to $PM_{2.5}$ is expected to either remain the same or decrease across much of Allegheny County, with the exception of the vicinity immediately surrounding the Clairton monitoring site.

The local source values presented in Table 2-7 are calculated using every day sampling frequencies. If 1:6 day CSN sampling frequencies are used, the base year local source value at Liberty is 4.1 $\mu g/m^3$, which is in better agreement with the observed local $PM_{2.5}$ excess at Liberty (3.8 $\mu g/m^3$).

Table 2-7. Local Contributions to Annual Average $PM_{2.5}$ in Base and Future Years

	$PM_{2.5}$ ($\mu g/m^3$)	
Site	**Base Year**	**Future Year**
Avalon	2.0	0.8
Clairton	2.7	3.4
Harrison	5.1	3.4
Lawrenceville	1.5	0.7
Liberty	4.9	4.9
North Braddock	4.3	4.2
North Park	0.3	0.2
South Fayette	0.3	0.2

2.11 Local Source AERMOD Modeling

The AERMOD Gaussian plume model was also used to simulate the effects of primary $PM_{2.5}$ emissions from local sources on $PM_{2.5}$ concentrations at the Liberty monitoring site. The unique, sub-grid cell terrain features surrounding Liberty and its proximity to major $PM_{2.5}$ sources can make it difficult to accurately model $PM_{2.5}$ at Liberty.

As discussed in the Modeling Protocol (Ramboll Environ, 2017a), the AERMOD model can be used to estimate $PM_{2.5}$ contributions associated with primary $PM_{2.5}$ emissions from local major sources. This is an alternative approach to using PiG/PSAT treatment to obtain the contributions of local sources. It is informative to compare the model-estimated local $PM_{2.5}$ from both AERMOD and PiG/PSAT approaches and utilize both methods to calculate $PM_{2.5}$ design values in Allegheny County.

The AERMOD model (v16216r) was applied for the local sources associated with the 2011 base case emissions scenario. AERMOD meteorological inputs were generated by passing 2011 WRF model output through the Mesoscale Model Interface (MMIF) Program[9] using both 1.33 km and 0.444 km WRF horizontal resolution data. The AERMOD local source contributions were combined with the CAMx regional source contributions to provide total concentration estimates (i.e., using AERMOD results to replace the CAMx PiG/PSAT local source contributions). AERMOD receptors were placed at the same locations as all PiG sampling grid receptors within the two PiG sampling grids.

Figure 2-10 compares quantile-quantile (Q-Q) cumulative frequency distributions plots of predicted and observed (FRM) 24-hour $PM_{2.5}$ concentrations at Liberty for 2011. In Figure 2-10, FRM observations are compared to the following set of model outputs: CAMx without contributions from primary $PM_{2.5}$ emissions tied to local major sources, CAMx using PiG/PSAT for local sources (CAMx+PiG), and the combined CAMx regional plus AERMOD local source contributions (CAMx+AERMOD). In the CAMx+PiG scenario, live PiG puff $PM_{2.5}$ concentrations at all PiG receptors within the 1.33 km CAMx grid containing Liberty were averaged together and added to the $PM_{2.5}$ concentrations in the 1.33 km CAMx grid cell. The $PM_{2.5}$ concentrations

[9] https://www3.epa.gov/ttn/scram/models/relat/mmif/MMIFv3.3_Users_Manual.pdf

in the 1.33 km CAMx grid cell are a combination of background and dumped PiG puff concentrations. For the CAMx+AERMOD scenario, $PM_{2.5}$ concentrations at all AERMOD receptors in the 1.33 km CAMx grid cell containing Liberty were averaged together and added to $PM_{2.5}$ concentrations in the 1.33 km CAMx grid cell.

Figure 2-10 shows that $PM_{2.5}$ values are higher across the distribution when the contribution from local major sources is included, both using PiG/PSAT or AERMOD techniques. The CAMx+AERMOD simulation performs better than the CAMx+PiG simulation across much of the frequency distribution, except for the highest observed concentrations (> ~25 μg/m^3). This suggests that CAMx+PiG is doing a better job than CAMx+AERMOD in reproducing the high observed $PM_{2.5}$ at Liberty that occurs during local inversion weather conditions. The annual average $PM_{2.5}$ in the CAMx+AERMOD simulation is 14.5 μg/m^3, which is much closer to the observed annual average (14.1 μg/m^3) compared to the CAMx+PiG simulation (17.1 μg/m^3 when PiG values are averaged in each 1.33 km CAMx grid cell, 16.2 μg/m^3 when PiG values are included in the CAMx grid cell using interpolation methods).

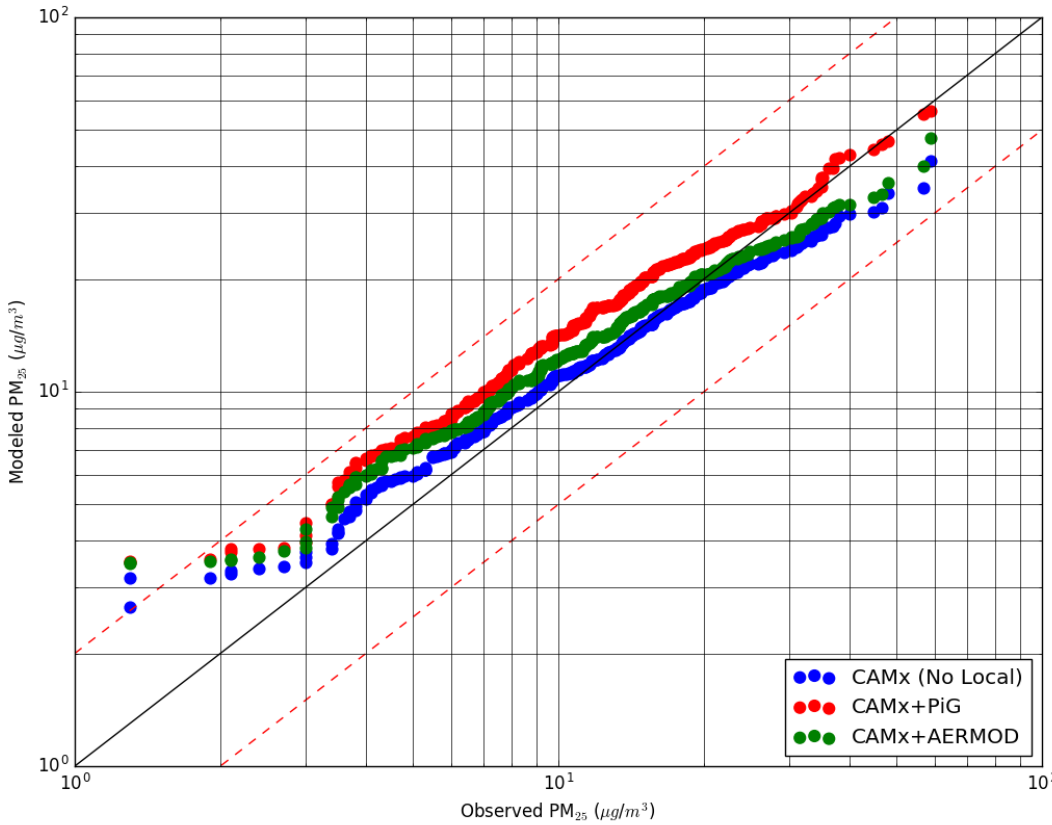

Figure 2-10. Annual Q-Q plot Comparing 24-hour $PM_{2.5}$ at Liberty in the Base Year Model Runs.

Using PiG/PSAT techniques and the average PiG value in each 1.33 km CAMx grid cell, the annual average $PM_{2.5}$ associated with emissions of primary $PM_{2.5}$ from local major sources at Liberty in the base year is 4.01 μg/m^3 and is 5.06 μg/m^3 in the future year. These estimates include the gaseous emissions associated with local major sources in the live PiG puffs.

Using AERMOD techniques and the average AERMOD value in each 1.33 km CAMx grid cell, the annual average $PM_{2.5}$ associated with emissions of primary $PM_{2.5}$ from local major sources at Liberty in the base year is 1.44 μg/m^3 and 1.38 μg/m^3 in the future year for this particular AERMOD model configuration. These estimates are considerably lower than those predicted using PiG/PSAT, although this may be partially explained by the lack of local major source gaseous emissions in AERMOD.

The AERMOD base year local source $PM_{2.5}$ contributions at Liberty (1.44 $\mu g/m^3$) is also considerably lower than the estimated actual local source contribution (3.8 $\mu g/m^3$) taken from the difference in speciated $PM_{2.5}$ concentrations at Liberty and other monitoring sites in Allegheny County (see Figure 5-12 in Ramboll Environ, 2017b).

Figure 2-10 suggests that CAMx+AERMOD simulation is in better agreement with $PM_{2.5}$ observations at Liberty compared to the CAMx+PiG simulation for all but the highest contributions potentially because CAMx is overestimating the regional $PM_{2.5}$ contribution while AERMOD is underestimating the local source contribution for this particular set of AERMOD modeling inputs and assumptions. The CAMx+PiG simulation does an excellent job reproducing the highest daily $PM_{2.5}$ concentrations, which are relied upon to calculate 24-hr $PM_{2.5}$ design values.

2.12 2021 Attainment Demonstration Modeling

The CAMx 2011 and 2021 modeling results were used to make 2021 $PM_{2.5}$ Design Value (DV) projections for all monitoring sites within Allegheny County using the Modeled Attainment Test Software (MATS)[10] version 2.6.1. As mentioned in the previous section, additional design value calculations using AERMOD modeling were performed at Liberty and are described in a separate report. The Liberty design value results presented in this report were estimated using MATS.

In MATS, modeled relative response ratios (RRFs) are used to scale the monitored data by species on quarterly average (for the annual standard) and high-day (for the 24-hour standard) bases. The CAMx 2011 and 2021 modeling scenarios are based on the same year of meteorology and use identical natural emission profiles. Anthropogenic emissions have been adjusted in the 2021 scenario to reflect estimated emissions for a controlled future case. For both the base and future year CAMx scenarios, the average $PM_{2.5}$ concentration from all live PiG puff receptors in each 1.33 km CAMx grid cell is added to $PM_{2.5}$ concentrations in each grid cell. Concentrations of $PM_{2.5}$ in each grid cell are a combination of background $PM_{2.5}$ and PiG puffs that have been dumped to the grid after growing to the size of the 1.33 km grid cell. This approach was also used to obtain 2021 $PM_{2.5}$ DV projections at all FRM sites in and nearby southwest Pennsylvania using the 4 km CAMx results.

[10] https://www.epa.gov/scram/photochemical-modeling-tools

Note the Software for the Modeled Attainment Test - Community Edition (SMAT-CE) Version 1.2 beta version has been released as a replacement to MATS 2.6.1. This software includes updated monitored data through 2015 (including SANDWICH speciation data) as part of the installer package. However, testing of this software revealed several "bugs," including the omission of sites from the attainment test results. Therefore, MATS 2.6.1 was used for the calculation of all design values. Design value results obtained through MATS were then passed through SMAT-CE to create GIS-based plots that allow for visualization of design values across the 1.33 km and 4 km modeling domains.

MATS 2.6.1 uses EPA-recommended (EPA, 2014) model attainment test methodology to project observed current year $PM_{2.5}$ DV to 2021 using the relative changes in the CAMx modeling results between 2011 and 2021. The observed $PM_{2.5}$ DVs based on the FRM observations were speciated using the SANDWICH (sulfate, adjusted nitrate, derived water, inferred carbonaceous material balance approach) observed $PM_{2.5}$ speciation data. Corrections to monitor input data as well as a detailed description of MATS settings, including deviations from EPA defaults, are described in section 3.

Using MATS, the projected 2021 Liberty annual $PM_{2.5}$ DV is 12.5 μg/m^3 and 24-hour $PM_{2.5}$ DVs is 38.6 μg/m^3. The projected 2021 annual and 24-hour $PM_{2.5}$ DVs are well below the NAAQS at the other monitoring sites. Details on the 2021 $PM_{2.5}$ DV projections are provided in Section 3 of this AQTSD.

3. ATTAINMENT DEMONSTRATION MODELING

This section presents the procedures and results of the 2021 $PM_{2.5}$ Design Values projections using the approach discussed in Section 2.13. The 2021 $PM_{2.5}$ Design Value projections were performed following the procedures recommended by EPA (EPA, 2014).

3.1 2011 and 2021 $PM_{2.5}$ Model Results Used In MATS

The CAMx 2011 base case simulation is described in Sections 2.7 and 2.8 with details contained in the accompanying Base Year Model Performance Evaluation Report. The CAMx 2021 future year simulation was performed in a consistent fashion to the 2011 base case, differing only in the anthropogenic emission inventories used in the model simulations.

Figure 3-1 presents the base year (2011) and future year (2021) CAMx-modeled annual average $PM_{2.5}$ concentrations used in MATS across the 4 km CAMx domain. Figure 3-2 shows similar information for the 1.33 km model domain (note the difference in colorbars between Figure 3-1 and Figure 3-2). Figure 3-1 shows that modeled $PM_{2.5}$ concentrations are highest in the greater New York City region in both 2011 and 2021. Modeled $PM_{2.5}$ values are also high in southeast Pennsylvania, which is likely related to fertilizer emissions from farming. Figure 3-2 shows that modeled $PM_{2.5}$ concentrations in 2011 are highest in northeast Allegheny County, near ATI and the Harrison monitor. $PM_{2.5}$ concentrations are also high near USSET, USSI, and USSC, which are located near the North Braddock, Liberty, and Clairton monitors. In 2021, modeled $PM_{2.5}$ concentrations are decreased compared to 2011 across much of the domain, except for the $PM_{2.5}$ increase near the Liberty monitor.

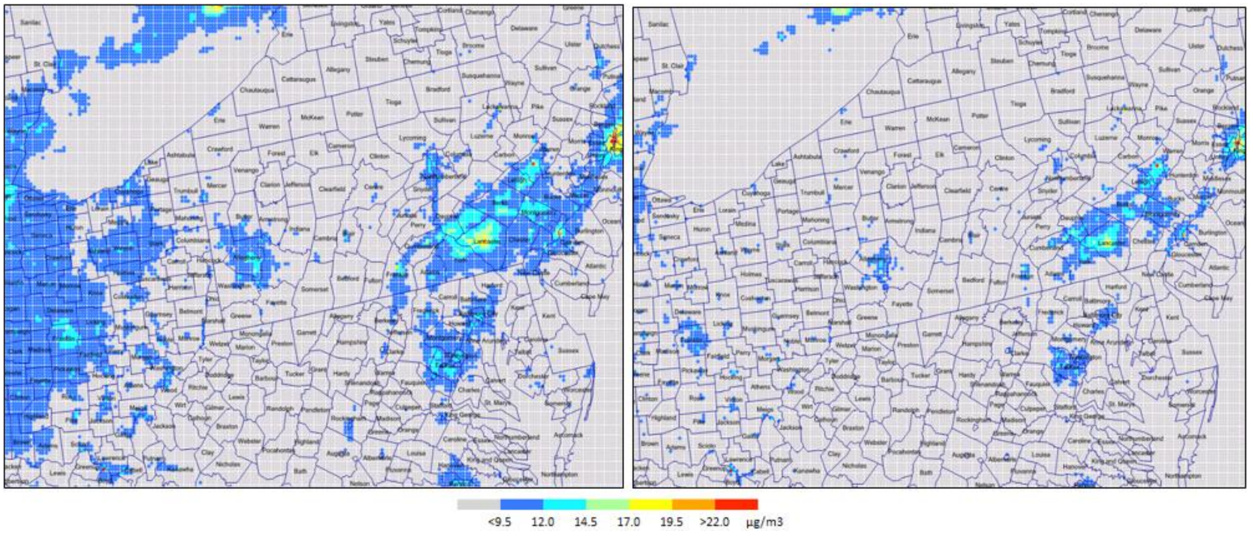

Figure 3-1. Modeled $PM_{2.5}$ in 4 km CAMx domain for 2011 (left) and 2021 (right).

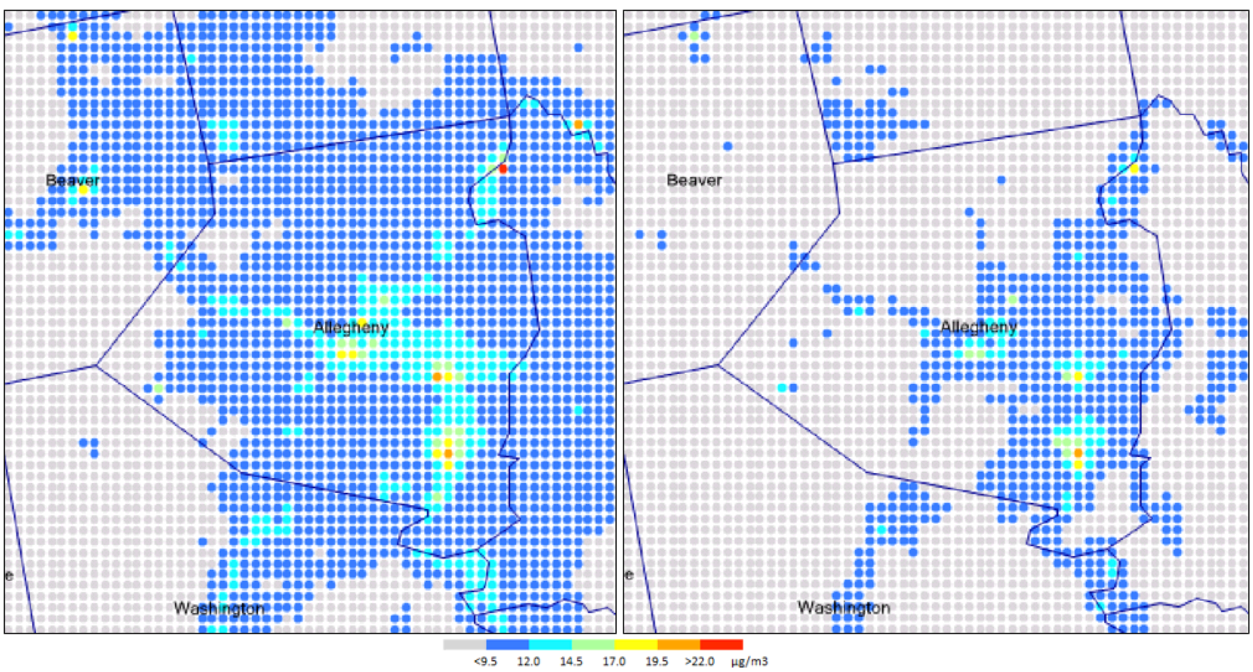

Figure 3-2. Modeled $PM_{2.5}$ in 1.33 km CAMx domain for 2011 (left) and 2021 (right).

3.2 Attainment Demonstration Overview

The Modeled Attainment Test Software (MATS Version 2.6.1; Abt, 2014) was applied using the CAMx 2011 and 2021 1.33 km and 4 km modeling results to obtain an estimate of projected 2021 future year annual and 24-hour $PM_{2.5}$ DVFs at eight FRM monitoring sites within Allegheny County as well as at other monitoring sites within the 4 km model domain. For all CAMx scenarios, the average $PM_{2.5}$ concentrations from local major sources in Allegheny County contained in live PiG puffs within each 1.33 km CAMx grid cell are added to $PM_{2.5}$ concentrations in each grid cell. Concentrations of $PM_{2.5}$ in each CAMx grid cell are a combination of background $PM_{2.5}$ and PiG puffs that have been dumped to the grid after growing to the size of the 1.33 km grid cell. Sections 3.2.2 and 3.2.3 describe the MATS settings used, including deviations from defaults, and alterations to MATS monitored input data.

Relative changes in the CAMx 2021 and 2011 modeling results for each major $PM_{2.5}$ component (e.g., SO_4, NO_3, etc.) are used to scale the current year observed Design Value (DVC) $PM_{2.5}$ components to obtain future year $PM_{2.5}$ components that are summed to obtained the projected future year (2021) $PM_{2.5}$ Design Value (DVF). The model derived scaling factors are referred to as Relative Response Factors (RRFs) and are the ratio of the 2021 to 2011 modeling results (in simple terms, DVF = DVC x RRF).

The $PM_{2.5}$ Model Attainment Test Guidance provided in EPA (2014) was used to make the 2021 DV projections, which utilizes official FRM observations and speciated $PM_{2.5}$ observations.

3.2.1 Monitoring Data Assumptions and Corrections

The FRM 24-hour $PM_{2.5}$ measurements are used to define the current year Design Value (DVC) used in making the 2021 future year Design Value projections (DVF). Speciated $PM_{2.5}$ measurements from the Chemical Speciation Network (CSN) are also used in Design Value projections. The measured speciated $PM_{2.5}$ data are processed using the SANDWICH (sulfate, adjusted nitrate, derived water, inferred carbonaceous material balance approach) method outlined by EPA Modeling Guidance, which reconstructs $PM_{2.5}$ species to better represent FRM monitored data (Frank, 2006a,b). Using this technique, species are adjusted as follows:

- Nitrate is based on retained estimations

- Ammonium concentrations are derived, based on sulfate and nitrate concentrations and degree of neutralization (DON) values
- Organic carbon is calculated by mass balance from all other species
- Water is calculated from sulfate, nitrate, and ammonium values

Assumptions are made with the monitored data handling to ensure that all species are accounted for and that the speciation data are correctly used for each FRM site. Assumptions for the CSN speciation and FRM data are listed below**:**

- Organic carbon mass by mass balance accounts for all differences between the FRM and other species and can include trace elements or other species that may be associated with organic carbon. Default organic carbon mass balance checks are used (floor = 1.0, ceiling = 0.8).
- Indirect ammonium best accounts for the ammonium and the calculated particle-bound water species. Any measured excess of ammonium may or may not be retained on the FRM filter and is accounted for in the organic carbon mass by mass balance. Furthermore, the ammonium generated by the CAMx model is based on associated sulfate and nitrate.
- No exceptional events or anomalies are evident in the FRM or speciation data.
- Degrees of Neutralization (DON) of sulfate are held constant for baseline to future case. DON has been supplied with the pre-calculated EPA speciation MATS data set.
- Default blank mass of 0.5 μg/m^3 is used.

Review of the monitored input files supplied with SMAT-CE revealed some issues with the included data. ACHD made a number of corrections to the supplied files (see filenames with "_rev1" in SIP supporting documents), which are described in the following sub-sections.

Official (Quarterly) Annual and 24-hour FRM $PM_{2.5}$ Data Files

In the official (quarterly) annual and 24-hour FRM data files:

- official_24-hr-PM25.NID2002thru2015_v2.csv;
- official_annual-PM25.NID2002thru2015_v2.csv,

Completion codes of "4" were changed to "1" for Allegheny County samples over the attainment demonstration timeframe (2009-2013). In this analysis, completion codes of "1" indicate complete data. Monitoring sites with completion codes of "4" indicate that a year did not contain sufficient data to allow for calculation of a valid 3-year design value (based on consecutive 3-year periods) but that the resulting design value was below the NAAQS. The completion code "4" is assigned to the last year in a 3-year period if that 3-year period is deemed incomplete.

However, completion codes are used somewhat improperly by the MATS software. First, each quarter in the last year of a 3-year period is assigned completion codes, which may not always be applicable to a specific weighted averaging period. For example, year 2009 may contain completion codes of "4" for each quarter based on the 2007-2009 design value period, although 2009 may actually be a valid year based on quarterly completeness. Subsequently, for a weighted timeframe of 2009-2013, year 2009 would be omitted from the weighted design value calculations even though it contains sufficient data. It should also be noted that the use of custom design values does not override the completion codes even if the minimum number of valid samples and quarters are met.

Within Allegheny County, several monitoring sites contained completion codes of "4" during the 2009-2013 time period. During this time period, the Clairton monitoring site contained 3 years of "incomplete" data due to one quarter in 2011 having less than 11 valid samples. In order to have MATS calculate $PM_{2.5}$ design values at Clairton, the "4" completion codes were manually changed to "1". Additionally, annual $PM_{2.5}$ design values were calculated using a customized version of official 24-hr FRM observed design values so that 1 invalid quarter does not potentially exclude a full 3-year period. The official 24-hr FRM observed design values were calculated by setting the number of valid samples equal to 11 and number of valid quarters equal to 10.

Several other sites in Allegheny County (see Table 3-1) included completion codes of "4" in one or more years during the 2009-2013 time period, but all quarters contained at least 11 valid samples. In order to use the maximum of amount of data for the 2021 design value forecasts, completion codes of "4" associated with these sites were also set to "1". It should be noted that all monitoring sites with these manual completion code changes have shown monitored attainment since the

2011-2013 design value period and these corrections do not impact the high site (Liberty) calculations.

Table 3-1. Monitor Sites in Allegheny County with Completion Codes of "4" in the Official FRM $PM_{2.5}$ Data Files.

Site	AQS Code	Annual Quarters (revised codes of total)	24-Hour Quarters (revised codes of total)
Avalon[1]	42-003-0002	8 of 16	8 of 16
North Park	42-003-0093	8 of 20	8 of 20
Harrison	42-003-1008	4 of 20	12 of 20
North Braddock	42-003-1301	4 of 20	--
Clairton	42-003-3007	12 of 20	12 of 20

[1]Note: Avalon did not operate in 2009 and only has 16 quarters of total data

Species Fraction Data File

In the species fraction data file:

- SpeciesForFractions2002to2015_v2.csv,

Salt concentrations at the Liberty CSN monitor (42-003-0064) were replaced by the average of surrounding CSN sites. The SANDWICH technique incorrectly calculates the salt component, generally assumed to be sea salt or road salt, based on measured chlorine concentrations at Liberty (as 1.8*Cl). In regional modeling demonstrations, salt emissions are often kept constant during the base and future simulations. For the Liberty monitor, some chlorine can be associated with road salt, but the majority of measured chlorine is presumed to be associated with industrial point sources. For more information, refer to the speciation and source apportionment analysis discussion in the SIP.

For Liberty, the average salt concentrations from concurrent measurement samples at surrounding CSN sites (Lawrenceville, Florence, Greensburg) were substituted for Liberty salt to better represent wintertime road salt concentrations. For these surrounding sites, salt is being appropriately calculated from chlorine when examining seasonal concentrations, concentrations of cations associated with road salt (Na, Ca, Mg), and vehicle traffic from adjacent roadways. For example, chlorine concentrations are highest at Lawrenceville during weekdays with icy or snowy conditions. Additionally, there is a strong correlation between chlorine and sodium.

When salt is recalculated for Liberty, mass is then better reapportioned as organic carbon mass during mass balance (OCMmb). Chlorine concentrations can be substantially elevated at Liberty during peaks of other species, such as organic and elemental carbon. As a result, chlorine from sources containing controls for carbon-related processes is properly accounted for with the recalculation of OCMmb.

It should also be noted that design values at point locations are based on interpolated nearby speciation data for all FRM sites. Therefore, incorrect species fractions at the Liberty monitor can also impact other nearby FRM sites when MATS performs interpolations to each point location.

Unofficial $PM_{2.5}$ Data File

The unofficial $PM_{2.5}$ data file:

- PM25ForFractions2002to2015_v2.csv,

is used as the total FRM (or FEM) mass associated with concurrent speciation samples. Samples with missing concurrent FRM masses are excluded from the quarterly averaging by default. However, measured CSN total mass is usually available on these dates and was often substituted in place of missing FRM values. While CSN mass is generally higher than FRM samples, the use of CSN mass can boost data completeness so that more quarters can be utilized for the species fractions calculations.

For example, if 11 valid samples per quarter are selected as requirements for the species fractions calculations in MATS, there may be a quarter with 12 valid CSN samples (valid for all species) and only 10 concurrent valid FRM samples. The substitution of 2 CSN masses in place of the missing FRM samples allows for a valid quarter to be used in the calculations, without adding much bias into the FRM mass data.

Table 3-2 indicates the number of substituted CSN masses for missing FRM samples for southwestern PA CSN sites:

Table 3-2. Monitoring Sites with CSN Masses Substituted for missing FRM Samples in Southwestern Pennsylvania

Site	CSN Mass Substitutions (substitutions of total)
Liberty	6 of 252
Lawrenceville	12 or 476
Florence	9 or 281
Greensburg	10 of 263

[1]Note: Lawrenceville is a 1-in-3 day site for CSN samples while the other sites are 1-in-6 day sites.

3.2.2 Current Year Design Values

The current year $PM_{2.5}$ Design Values (DVC) were based on the average of the three year average Design Values (DVs) from 2009-2013 5-year period using 24-hour Federal Reference Method (FRM) $PM_{2.5}$ monitoring data as suggested in EPA's modeling guidance for a 2011 modeling year (EPA, 2014). Annual and 24-hour $PM_{2.5}$ DVs are defined as the three year average of the, respectively, annual average and 98th percentile 24-hour average $PM_{2.5}$ concentrations. Then this has an effect of weighting the annual and 98th percentile 24-hour $PM_{2.5}$ concentrations for the years 2009-2013 by weighting factors of 1, 2, 3, 2 and 1, giving the observed $PM_{2.5}$ data for the 2011 center modeling year the greatest weight.

Official $PM_{2.5}$ design values are used to project 24-hr annual $PM_{2.5}$ design values. As noted above, custom observed $PM_{2.5}$ design values are used to project annual $PM_{2.5}$ design values in Allegheny County so that 1 invalid quarter does not potentially exclude a full 3-year period. Custom $PM_{2.5}$ design values were calculated by setting the number of valid samples equal to 11 and number of valid quarters equal to 10.

For example, Table 3-3 displays the 98th percentile 24-hour $PM_{2.5}$ concentrations at Liberty for the years 2009-2013, the corresponding 3-year average 24-hour $PM_{2.5}$ DVs and the 5-year weighted DVC that is used in making 2021 DV projections.

Table 3-4 presents similar results for the annual average $PM_{2.5}$ Liberty Design Values.

Table 3-3. Calculation of current year 24-hour $PM_{2.5}$ Design Value (DVC) at Liberty used in making future year 2021 Design Value projections.

Parameter	2009	2010	2011	2012	2013
98^{th} Percentile	45.3	48.8	38.0	42.5	31.1
24-Hour $PM_{2.5}$ DVs		44.0	43.1	37.2	
DVC			41.4		

Table 3-4. Calculation of current year annual average $PM_{2.5}$ Design Value (DVC) at Liberty used in making future year 2021 Design Value projections.

Parameter	2009	2010	2011	2012	2013
Annual Average	15.0	16.1	14.0	14.3	12.0
Annual $PM_{2.5}$ DVs		15.0	14.8	13.4	
DVC			14.4		

3.2.3 MATS Settings

MATS Version 2.6.1 was used to generate the annual and 24-hour attainment tests and projected design values for all Allegheny County sites with both the 4 km and 1.33 km domains. Default settings were generally used for MATS, with the specific settings listed below as selected by ACHD. It should be noted that all options tested with MATS led to similar results, with all sites except Liberty showing projected design values below the NAAQS for both the 4 km and 1.33 modeling domains.

Settings for MATS were as follows:

Standard Analysis: Interpolation of speciation monitor data to FRM monitor sites and temporally adjustment (forecast to future case). Spatial fields (or gradient-adjusted FRM data) were not used.

Data Input: Corrected species and monitor files were used (see section 3.2.1). CAMx model data was in daily format for year 2011 (projected to 2021) and PiG live-puff concentrations were averaged and added into each CAMx grid cell for both the 4 km and 1.33 km resolution domains (see section 2.12 for more detail).

IMPROVE[11]/STN Monitor Fractions: 2009-2013 CSN (STN) speciation data was used for species fractions with minimum data requirements as follows: 8 valid days per quarter, 1 valid year for a valid quarter/season, 1 valid quarter/season for valid monitor. EPA-specified deletions were excluded from dataset. A minimum of 8 valid samples (or 50% completeness) were used instead of 11 due to some missing data at the Liberty CSN monitor. Since Liberty is a key monitor for the design value calculations, the use of as many quarters as possible was favored. Table 3-5 below shows the number of valid samples for Liberty by quarter for 2009-2013. Note that CSN data is not official $PM_{2.5}$ data used for comparison to the NAAQS, so there are no data completeness requirements for valid monitors. Optionally, a 3-year period of 2010-2012 (using the base year 2011 as the same middle year) can also be used for these calculations. Similar to the use of 8 valid samples, it was deemed that the use of more quarters than less was better representative of the 2009-2013 weighted timeframe for the demonstration.

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Table 3-5. Valid Samples Each Quarter at Liberty from 2009-2013

CSN Quarter	2009	2010	2011	2012	2013
1st	8	7	9	10	15
2nd	16	15	15	13	15
3rd	15	15	15	16	15
4th	2	11	10	14	16

$PM_{2.5}$ Fractions: For the 2009-2013 $PM_{2.5}$ monitor data (unofficial) for fractions, minimum data requirements include 8 valid days per quarter, 1 valid year for valid quarter/season, and 1 valid quarter/season for valid monitor. EPA-specified deletions were excluded from the data. Coinciding with the species data, the same timeframe and requirements were used for the concurrent $PM_{2.5}$ total masses. MATS uses these FRM samples to generate the adjusted mass balances (based on the SANDWICH methodology) from the CSN species.

$PM_{2.5}$ Calculations (annual): 2009-2013 custom design values are used for annual 2021 design value projection. The custom design values were calculated using a minimum of 11 valid FRM samples for a valid quarter, 10 valid quarters for a valid design value period, and a minimum of 1 valid design value. Custom design values were used instead of official design values so that 1 invalid quarter does not potentially exclude a full 3-year period (see discussion of the Clairton monitor in section 3.2.1.).

$PM_{2.5}$ Calculations (24-hour): 2009-2013 default design values were used for the 24-hour calculations, with a minimum of 1 valid design value. The top 10% of days (both monitored and modeled) were used for high-day fractions and for RRFs. The "mean" statistic was for averaging.

Temporal Adjustment: 3x3 grid cell array averages were used for point forecasts at each monitor. The 2014 Draft Modeling Guidance recommends a 3x3 array (or more cells) for modeled grid resolution greater than 12 km (i.e., grid cells that are smaller than 12 km in width).

3.2.4 Annual $PM_{2.5}$ Design Value Projection Approach

Details on the Design Value calculation methodology for the annual $PM_{2.5}$ NAAQS is given in the EPA Draft Modeling Guidance (EPA, 2014). Species reconstruction is based on the SANDWICH technique described above. The steps for the annual $PM_{2.5}$ SMAT are as follows:

Calculate 5-year weighted FRM quarterly averages: This is the average of the 2009-2011, 2010-2012, and 2011-2003 3-year quarterly averages as described in Section 3.2.2.

Calculate retained nitrate (NO3r) by speciation sample: This has been provided as part of the MATS data set, pre-calculated by EPA. The formula used for retained nitrate is shown below, as given in the EPA Modeling Guidance:

$$\text{delta NO3 (ug/m3)} = 745.7/T_R * 1/24 * \sum_{i=1}^{24} (\mathbf{K}_i^{1/2})$$

delta NO3 is the amount of volatilized nitrate

T_R is the reference temperature

$\mathbf{K}_i$ is the dissociation constant for ammonium nitrate

Calculate quarterly averages of non-dependent species: Averages for nitrate, sulfate, carbons, other primary $PM_{2.5}$ (OPP), and concurrent FRM values are calculated. Quarterly averages for measured organic carbon are used for comparison to an organic carbon minimum (or OCfloor). Quarterly averages for DON are also calculated for use in the retained ammonium calculation.

Calculate quarterly averages of retained ammonium (NH4r): Averages for retained ammonium are calculated from quarterly sulfate, nitrate, and DON averages. The formula is given below, as given in the EPA Modeling Guidance:

$$NH4_r = DON*SO4 + 0.29*NO3_r$$

Calculate quarterly averages of particle bound water (PBW): Averages for PBW are calculated from quarterly sulfate, retained nitrate, and indirect ammonium averages. See the MATS User's Guide (Abt, 2014) for the complete formula.

Calculate quarterly averages of organic carbon mass by mass balance (OCMmb): Averages for OCMmb are calculated from the concurrent FRM quarterly averages minus the sum of the other species. This accounts for material associated with organics and/or uncertainties in the measured species. The calculated organic mass is compared to the OCfloor to ensure that the mass balance method does not lead to lower concentrations than measured.

Calculate quarterly species compositions; apply to weighted quarterly FRM averages: This is done by calculating fractions of the total (minus 0.5 passive blank mass) by individual species. The species fractions are then applied to the weighted FRM values.

Calculate quarterly Relative Response Factors (RRFs) from modeling: Direct RRFs are calculated from baseline and future CAMx modeling for sulfate, nitrate, OCMmb, elemental carbon, and OPP.

Calculate future quarterly species averages from RRFs, re-calculate ammonium and PBW: The RRFs reduce the sulfate, nitrate, carbons, and OPP from the weighted baseline case values. Future case ammonium and PBW is calculated from the new quarterly averages.

Calculate the future design value: This is done by adding the future case species by quarter (plus 0.5 blank) and averaging the quarterly future FRM values, rounded to the nearest tenth for comparison to the annual standard. The default MATS configuration includes basing the modeled RRFs using an average across a 3 x 3 array of 1.33 km grid cells centered on each monitoring site.

3.2.5 24-Hour $PM_{2.5}$ Design Value Projection Approach

The SMAT for the 24-hour standard uses the same methodology as the annual standard for reconstruction of species and RRFs. But, modeled and observed concentrations are based on specific high-days instead of quarterly averages. For the both projection approaches the following steps were undertaken to make future year 24-hour $PM_{2.5}$ projections.

Identify observed (monitored) high days in baseline timeframe: This is done by selecting the 8 highest days in each quarter for each FRM monitor over the 2009-2013 timeframe. This method focuses on high days that represent seasonal highs rather than overall maximums.

Calculate quarterly species compositions for speciation high days: This is done using the same technique as the annual species compositions, but the quarterly averages are based on the highest 10% (3 samples were used per quarter) of speciation samples by overall concentration.

Calculate weighted species compositions for baseline high days: This is done by using the quarterly species fractions for each of the high observed days. The end results are 8 species compositions per quarter for each year (2009-2013).

Calculate quarterly Relative Response Factors (RRFs) for high days from modeling: The high modeled days are identified after summing all components. The top 10% (10 days) by quarter are then averaged for sulfate, nitrate, carbons, and OPP. RRFs are calculated from the baseline and future modeled results.

Calculate future high days from RRFs; re-calculate ammonium and PBW for each future high day: Using the same methodology as the annual test, high day species are reduced for the future case by the quarterly RRFs, and ammonium and PBW concentrations are re-calculated from the future sulfate, nitrates.

Calculate future design value: The future projected high days are re-ranked by year, and the 98^{th}-percentile value is identified. The weighted 98^{th}-percentile average is the average of the 2009-2011, 2010-2012, and 2011-2013 3-year averages, rounded to the nearest integer for comparison to the 24-hour $PM_{2.5}$ NAAQS.

The MATS 24-hour $PM_{2.5}$ projections were done in a similar fashion for all FRM sites and using 3 x 3 rather than a single grid cell modeling results for the RRFs.

3.3 Annual and 24-Hour $PM_{2.5}$ Projection Results using MATS

3.3.1 MATS Annual and 24-hr $PM_{2.5}$ Projections in 1.33 km CAMx Domain

The Modeled Attainment Test Software (MATS) was used with the CAMx 2011 and 2021 1.33 km modeling results (CAMx+PiG) to obtain current year (DVC) and projected 2021 future year (DVF) annual $PM_{2.5}$ Design Values at all of the FRM monitoring sites within the 1.33 km modeling domains. MATS was run in default mode except for the settings discussed in sections 3.2.2 and 3.2.3. Table 3-6 displays the MATS results for annual $PM_{2.5}$ in the 1.33 km domain and Table 3-7 presents the 24-hour $PM_{2.5}$ results. Figure 3-3 and Figure 3-4 show DVC and DVF values at all monitoring sites in the domain. There are eight FRM monitoring sites in the 1.33 km domain: Avalon (42003002), Clairton (420033007), Harrison (420031008), Lawrenceville (420030008), Liberty (420030064), North Braddock (420031301), North Park (420030093), and South Fayette (420030067). Based on 2009-2013 FRM data, the Liberty site has the highest DVCs that exceed both the annual and 24-hour $PM_{2.5}$ NAAQS, at 14.4 µg/m^3 and 41.4 µg/m^3, respectively. The Avalon (12.4 µg/m^3) and North Braddock (12.3 µg/m^3) sites also have DVC values the exceed the annual $PM_{2.5}$ NAAQS. MATS estimates that the projected 2021 DVF at all FRM sites in the 1.33 km domain, except Liberty, will be below the 2012 annual and 24-hr $PM_{2.5}$ NAAQS. Estimated DVF values at Liberty are 12.5 µg/m^3 for annual average $PM_{2.5}$ and 38.6 µg/m^3 for 24-hour average $PM_{2.5}$.

Table 3-6. Current year (DVC) and projected 2021 future year (DVF) annual $PM_{2.5}$ Design Values at Allegheny County FRM monitoring sites in the 1.33 km modeling domain (µg/m^3) using MATS.

Site	FRM ID#	Lat	Long	DV	Blank	OPP	EC	NH_4	OC_{mb}	SO_4	NO_3	PBW	NaCl
	Current Year DVC (µg/m^3)												
Avalon	420030002	40.500	-80.071	12.4	0.5	0.587	0.820	1.103	4.929	2.940	0.635	0.890	0.027
Clairton	420033007	40.294	-79.885	10.7	0.5	0.477	1.419	1.133	2.680	3.038	0.444	1.021	0.015
Harrison	420031008	40.617	-79.728	11.5	0.5	0.595	0.985	1.146	3.657	3.090	0.589	0.961	0.0260
Lawrenceville	420030008	40.465	-79.961	11.0	0.5	0.620	0.750	1.127	3.460	2.946	0.682	0.900	0.032
Liberty	420030064	40.324	-79.868	14.4	0.5	0.586	1.800	1.393	4.584	3.732	0.535	1.259	0.017
North Braddock	420031301	40.402	-79.861	12.3	0.5	0.591	1.363	1.282	3.405	3.413	0.597	1.111	0.023
North Park	420030093	40.607	-80.022	9.3	0.5	0.580	0.677	1.030	2.251	2.815	0.589	0.819	0.026
South Fayette	420030067	40.376	-80.170	10.3	0.5	0.541	0.851	1.081	2.861	3.075	0.546	0.873	0.0120
	Model Relative Response Factors (RRFs)												
Avalon	420030002	40.500	-80.071	--	0.5	0.679	0.620	0.670	0.959	0.655	0.892	0.658	1
Clairton	420033007	40.294	-79.885	--	0.5	1.066	0.893	0.744	1.009	0.726	0.876	0.719	1
Harrison	420031008	40.617	-79.728	--	0.5	0.832	0.643	0.747	0.949	0.718	0.892	0.717	1
Lawrenceville	420030008	40.465	-79.961	--	0.5	0.779	0.706	0.719	0.981	0.679	0.875	0.682	1
Liberty	420030064	40.324	-79.868	--	0.5	1.055	0.838	0.759	1.012	0.749	0.837	0.744	1
North Braddock	420031301	40.402	-79.861	--	0.5	1.028	0.725	0.742	0.937	0.722	0.857	0.718	1
North Park	420030093	40.607	-80.022	--	0.5	1.023	0.707	0.722	0.986	0.678	0.910	0.684	1

Site	FRM ID#	Lat	Long	DV	Blank	OPP	EC	NH_4	OC_{mb}	SO_4	NO_3	PBW	NaCl
South Fayette	420030067	40.376	-80.170	--	0.5	1.071	0.747	0.717	0.994	0.674	0.933	0.679	1
	2021 Future Year DVF (µg/m^3)												
Avalon	420030002	40.500	-80.071	10.0	0.5	0.398	0.508	0.772	4.727	1.926	0.566	0.586	0.028
Clairton	420033007	40.294	-79.885	9.2	0.5	0.508	1.266	0.843	2.703	2.205	0.389	0.734	0.014
Harrison	420031008	40.617	-79.728	9.4	0.5	0.495	0.633	0.856	3.470	2.219	0.525	0.689	0.0260
Lawrenceville	420030008	40.465	-79.961	9.0	0.5	0.483	0.530	0.810	3.395	1.999	0.597	0.614	0.032
Liberty	420030064	40.324	-79.868	12.5	0.5	0.618	1.509	1.058	4.637	2.795	0.448	0.937	0.017
North Braddock	420031301	40.402	-79.861	10.0	0.5	0.608	0.989	0.951	3.192	2.463	0.512	0.797	0.023
North Park	420030093	40.607	-80.022	7.6	0.5	0.593	0.478	0.743	2.219	1.908	0.536	0.560	0.026
South Fayette	420030067	40.376	-80.170	8.5	0.5	0.579	0.636	0.774	2.844	2.071	0.509	0.592	0.020

Table 3-7. Current year (DVC) and projected 2021 future year (DVF) 24-Hour $PM_{2.5}$ Design Values at Allegheny County FRM monitoring sites in the 1.33 km modeling domain (µg/m[3]) using MATS.

Site	FRM ID#	Lat	Long	DV	Blank	OPP	EC	NH_4	OC_{mb}	SO_4	NO_3	PBW	NaCl
	Current Year DVC (µg/m³)												
Avalon	420030002	40.500	-80.071	27.0	0.5	1.151	1.682	2.461	11.604	6.273	1.067	2.256	0.056
Clairton	420033007	40.294	-79.885	25.4	0.5	0.922	4.144	2.537	7.720	7.005	7.17E-05	2.568	0.015
Harrison	420031008	40.617	-79.728	27.6	0.5	1.113	2.176	2.708	9.633	8.660	0	2.843	0.021
Lawrenceville	420030008	40.465	-79.961	25.2	0.5	1.300	1.353	2.555	8.94	7.624	0.462	2.508	0.042
Liberty	420030064	40.324	-79.868	41.4	0.5	1.247	4.958	3.388	19.108	7.604	2.043	2.545	0.051
North Braddock	420031301	40.402	-79.861	31.7	0.5	1.211	3.788	3.358	9.6377	9.143	0.838	3.246	0.046
North Park	420030093	40.607	-80.022	22.4	0.5	1.210	1.343	2.687	6.219	6.059	2.186	2.109	0.097
South Fayette	420030067	40.376	-80.170	25.6	0.5	1.072	1.984	2.807	7.262	8.935	0.325	2.751	0.029
	Model Relative Response Factors (RRFs)												
Avalon	420030002	40.500	-80.071	--	0.5	0.527	0.574	0.890	0.781	0.519	3.341	0.489	2.681
Clairton	420033007	40.294	-79.885	--	0.5	0.943	0.855	0.742	1.004	0.637	11548.11	0.601	2.572
Harrison	420031008	40.617	-79.728	--	0.5	0.781	0.620	0.668	0.914	0.568	-9	0.554	2.635
Lawrenceville	420030008	40.465	-79.961	--	0.5	0.770	0.736	0.726	0.975	0.569	3.203	0.578	2.074
Liberty	420030064	40.324	-79.868	--	0.5	1.001	0.789	0.744	1.132	0.655	1.102	0.605	1.178
North Braddock	420031301	40.402	-79.861	--	0.5	0.973	0.677	0.701	0.862	0.501	2.868	0.457	2.075
North Park	420030093	40.607	-80.022	--	0.5	1.058	0.706	0.572	1.091	0.705	0.267	0.671	0.482
South Fayette	420030067	40.376	-80.170	--	0.5	1.108	0.746	0.575	0.957	0.509	2.152	0.510	1.351

Site	FRM ID#	Lat	Long	DV	Blank	OPP	EC	NH_4	OC_{mb}	SO_4	NO_3	PBW	NaCl
	2021 Future Year DVF (μg/m^3)												
Avalon	420030002	40.500	-80.071	21.4	0.5	0.606	0.965	2.191	9.064	3.258	3.564	1.104	0.150
Clairton	420033007	40.294	-79.885	21.4	0.5	0.869	3.542	1.882	7.753	4.464	0.828	1.542	0.038
Harrison	420031008	40.617	-79.728	20.7	0.5	0.870	1.348	1.809	8.807	4.917	0.862	1.574	0.055
Lawrenceville	420030008	40.465	-79.961	20.4	0.5	1.000	0.996	1.855	8.723	4.334	1.480	1.449	0.087
Liberty	420030064	40.324	-79.868	38.6	0.5	1.248	3.910	2.520	21.634	4.978	2.253	1.540	0.060
North Braddock	420031301	40.402	-79.861	23.4	0.5	1.178	2.564	2.353	8.304	4.577	2.403	1.484	0.096
North Park	420030093	40.607	-80.022	17.3	0.5	1.280	0.948	1.537	6.783	4.272	0.585	1.416	0.047
South Fayette	420030067	40.376	-80.170	18.4	0.5	1.188	1.480	1.613	6.952	4.552	0.700	1.404	0.039

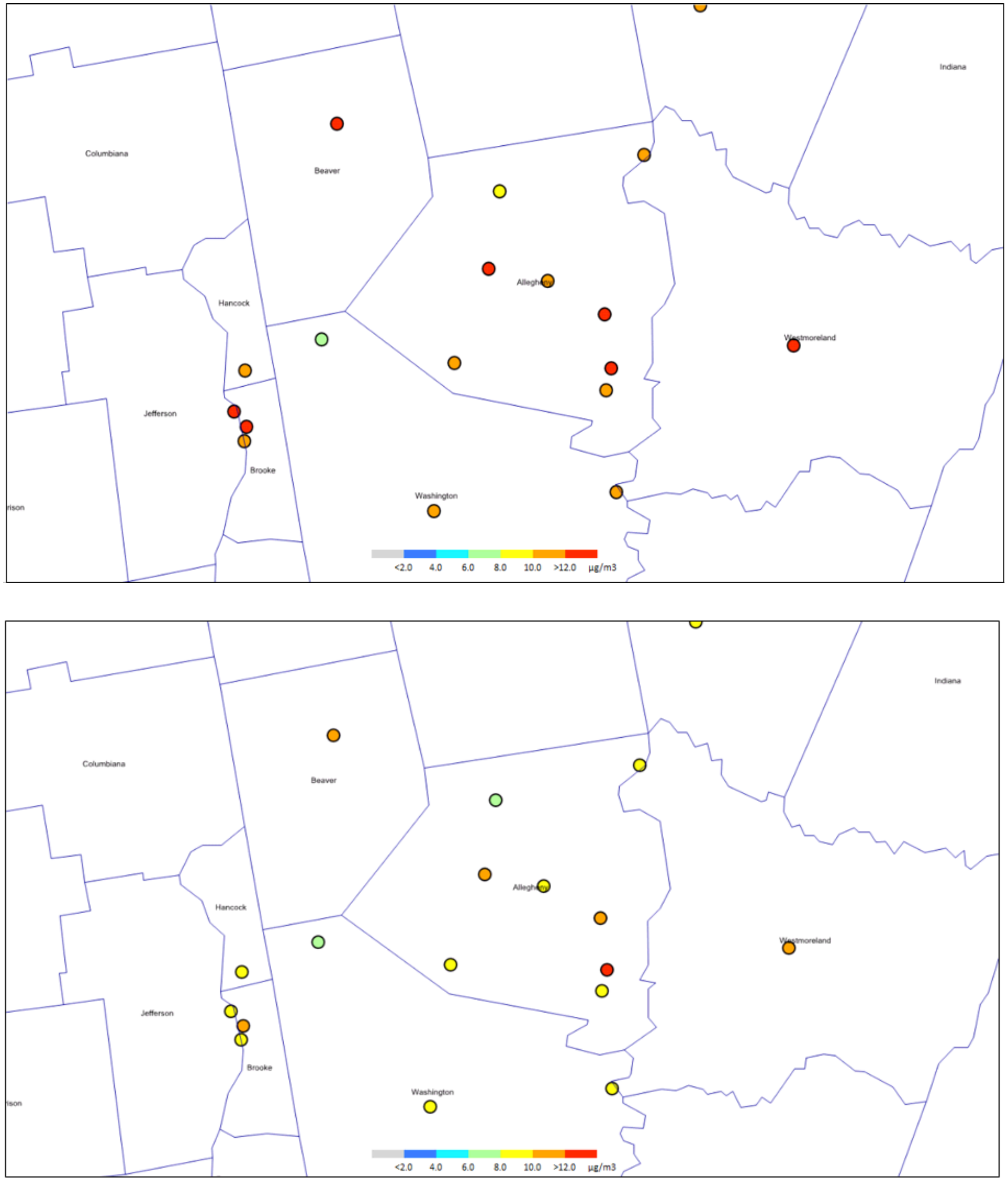
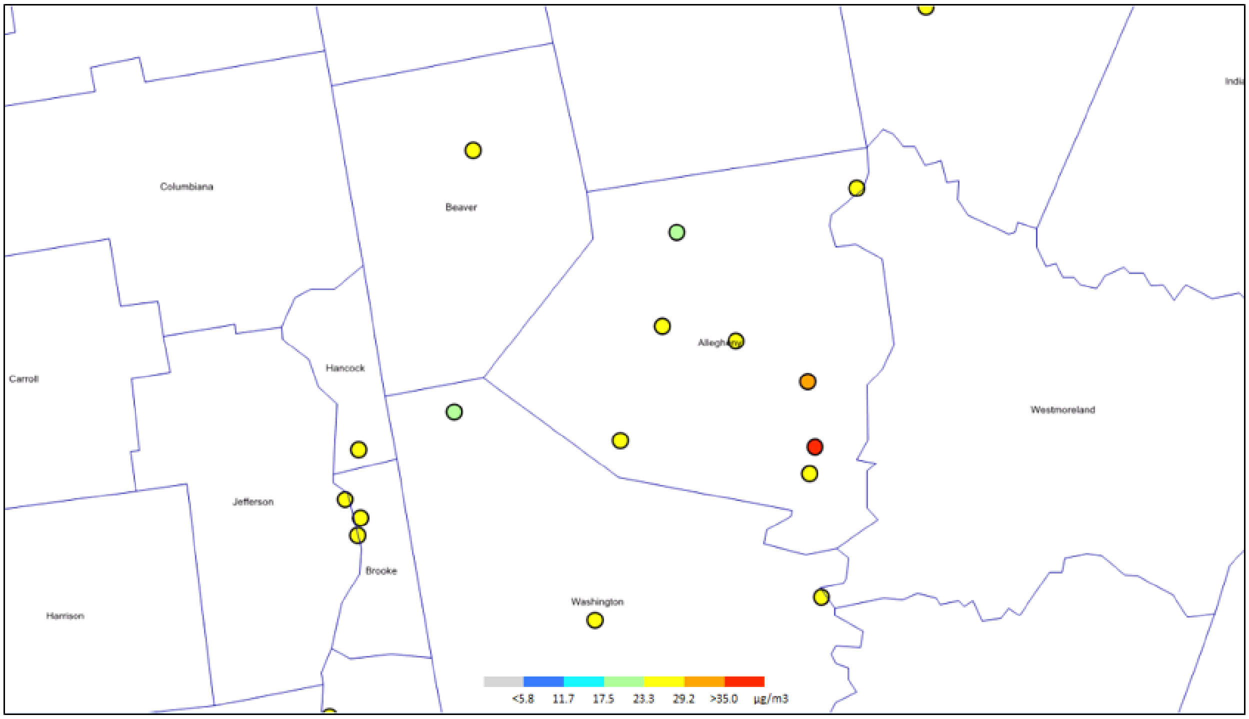


Figure 3-3. Annual $PM_{2.5}$ DVC (top) and DVF (bottom) at Monitor Sites in 1.33 km Domain



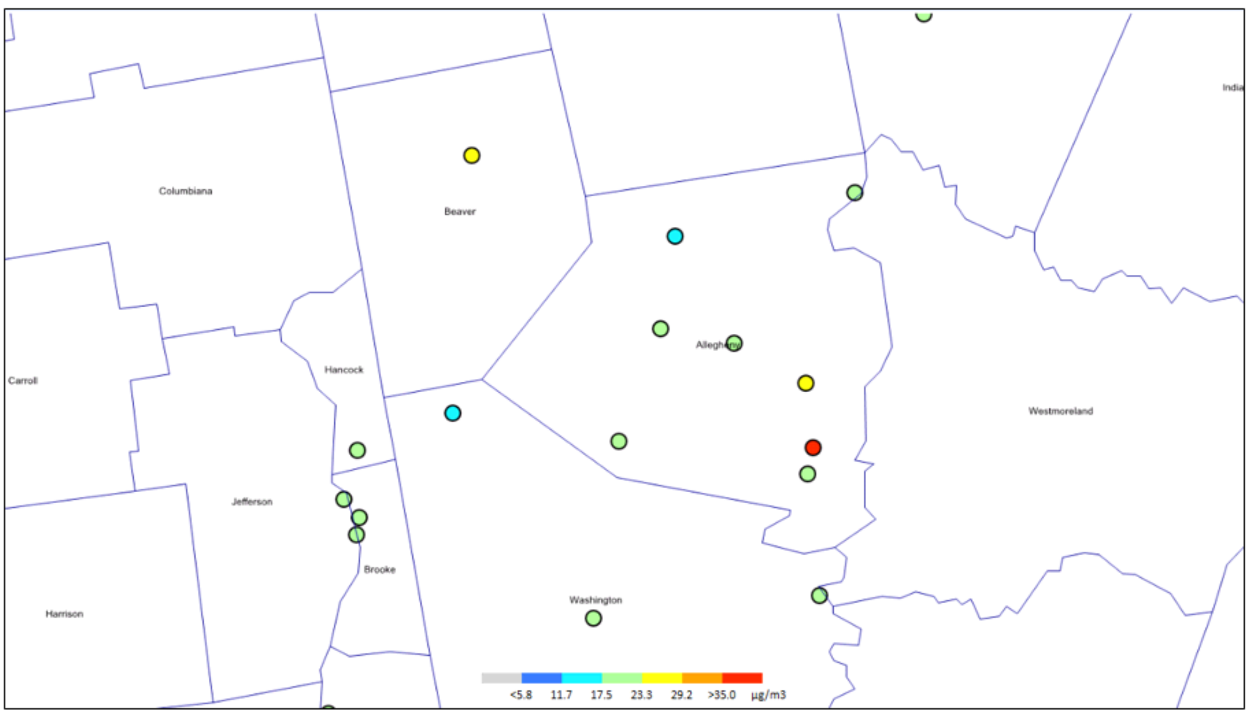


Figure 3-4. 24-Hour $PM_{2.5}$ DVC (top) and DVF (bottom) at Monitor Sites in 1.33 km Domain

3.3.2 MATS Annual and 24-hr $PM_{2.5}$ Projections in 4 km CAMx Domain

The CAMx 2011 and 2021 4 km modeling results (CAMx + PiG) were used with MATS to estimate projected 2021 annual and 24-hour $PM_{2.5}$ Design Values (DVF) for all FRM sites in the 4 km domain (Table 3-8). Figure 3-5 and Figure 3-6 show DVC and DVF values at all monitoring sites in the domain. There are 171 FRM sites in the 4 km domain with 17 of them having annual $PM_{2.5}$ DVCs above the NAAQS and the highest value of 14.4 μg/m^3 at Liberty. The MATS projected 2021 DVFs are below the annual $PM_{2.5}$ NAAQS for all FRM monitors in the 4 km domain with the exception of Liberty, which has a DVF of 12.2 μg/m^3. The Liberty annual DVF calculated using the CAMx 4 km modeling results is slightly lower than when the 1.33 km CAMx results are used, potentially due to the larger regional influence in the 4 km domain compared to the 1.33 km domain. Emissions are expected to decrease more regionally than locally by 2021. Liberty is the only FRM site in the 4 km domain that has a 24-hr $PM_{2.5}$ DVC above the NAAQS (41.4 μg/m^3). The Liberty monitoring site is also the only site in the domain to have a 24-hr $PM_{2.5}$ DVF that exceeds the NAAQS (38.6 μg/m^3).

Table 3-8. Current year (DVC) and projected 2021 future year (DVF) annual and 24-hour $PM_{2.5}$ Design Values at FRM monitoring sites in the 4 km modeling domain (μg/m^3) using MATS.

FRM ID#	State	County	Lat	Long	Annual		24-hour	
					DVC	DVF	DVC	DVF
90011123	Connecticut	Fairfield	41.399	-73.443	9.0	7.8	24.8	22.9
90050005	Connecticut	Litchfield	41.821	-73.297	5.6	4.9	16.4	12.8
100010002	Delaware	Kent	38.987	-75.557	8.7	7.2	21.9	18.1
100010003	Delaware	Kent	39.155	-75.518	8.9	7.3	22.9	18.9
100031003	Delaware	New Castle	39.761	-75.492	9.6	7.9	22.9	19.4
100031007	Delaware	New Castle	39.551	-75.732	9.0	7.5	22.5	17.8
100031012	Delaware	New Castle	39.692	-75.761	10.1	8.4	23.3	19.2
100032004	Delaware	New Castle	39.739	-75.558	10.4	8.7	25.7	22.6
100051002	Delaware	Sussex	38.654	-75.611	9.0	7.5	23.6	18.6
110010041	D.C.	D.C.	38.896	-76.958	10.3	8.7	25.9	22.4
110010042	D.C.	D.C.	38.876	-77.034	10.1	8.5	23.8	19.4

FRM ID#	State	County	Lat	Long	Annual		24-hour	
					DVC	DVF	DVC	DVF
110010043	D.C.	D.C.	38.922	-77.013	10.0	8.4	24.5	21.0
210190017	Kentucky	Boyd	38.459	-82.640	10.4	8.9	23.0	18.7
210430500	Kentucky	Carter	38.239	-82.988	8.7	7.2	18.3	15.2
240031003	Maryland	Anne Arundel	39.170	-76.628	10.5	9.1	24.5	21.4
240051007	Maryland	Baltimore	39.462	-76.632	9.6	8.1	21.7	19.2
240053001	Maryland	Baltimore	39.311	-76.474	10.8	9.3	27.0	24.5
240150003	Maryland	Cecil	39.701	-75.860	10.3	8.6	26.7	22.0
240230002	Maryland	Garrett	39.706	-79.012	8.9	7.6	19.5	15.8
240251001	Maryland	Harford	39.410	-76.297	10.1	8.5	23.6	19.9
240290002	Maryland	Kent	39.305	-75.797	10.2	8.6	24.1	20.9
240313001	Maryland	Montgomery	39.114	-77.107	10.1	8.8	24.5	21.5
240330025	Maryland	Prince George's	38.941	-76.932	10.8	9.2	22.9	20.2
240330030	Maryland	Prince George's	39.055	-76.878	10.5	9.1	24.9	21.2
240338003	Maryland	Prince George's	38.812	-76.744	8.7	7.2	20.9	16.3
240430009	Maryland	Washington	39.564	-77.720	10.9	9.3	27.4	25.1
245100006	Maryland	Baltimore (City)	39.341	-76.582	10.0	8.6	22.4	19.8
245100007	Maryland	Baltimore (City)	39.345	-76.685	9.8	8.3	22.6	19.0
245100008	Maryland	Baltimore (City)	39.288	-76.547	10.4	8.9	25.6	21.9
245100040	Maryland	Baltimore (City)	39.298	-76.605	11.0	9.5	27.1	24.3
260990009	Michigan	Macomb	42.731	-82.793	8.7	7.4	23.5	20.3
261150005	Michigan	Monroe	41.764	-83.472	9.7	8.2	24.4	20.8
261250001	Michigan	Oakland	42.463	-83.183	9.2	7.7	24.8	20.5
261470005	Michigan	St. Clair	42.953	-82.456	9.1	8.1	23.8	21.3
261610008	Michigan	Washtenaw	42.241	-83.600	9.4	8.0	23.3	20.7
261630001	Michigan	Wayne	42.229	-83.208	10.3	8.8	25.5	22.2
261630015	Michigan	Wayne	42.303	-83.107	10.8	9.3	25.5	22.7
261630016	Michigan	Wayne	42.358	-83.096	9.9	8.4	25.6	22.0

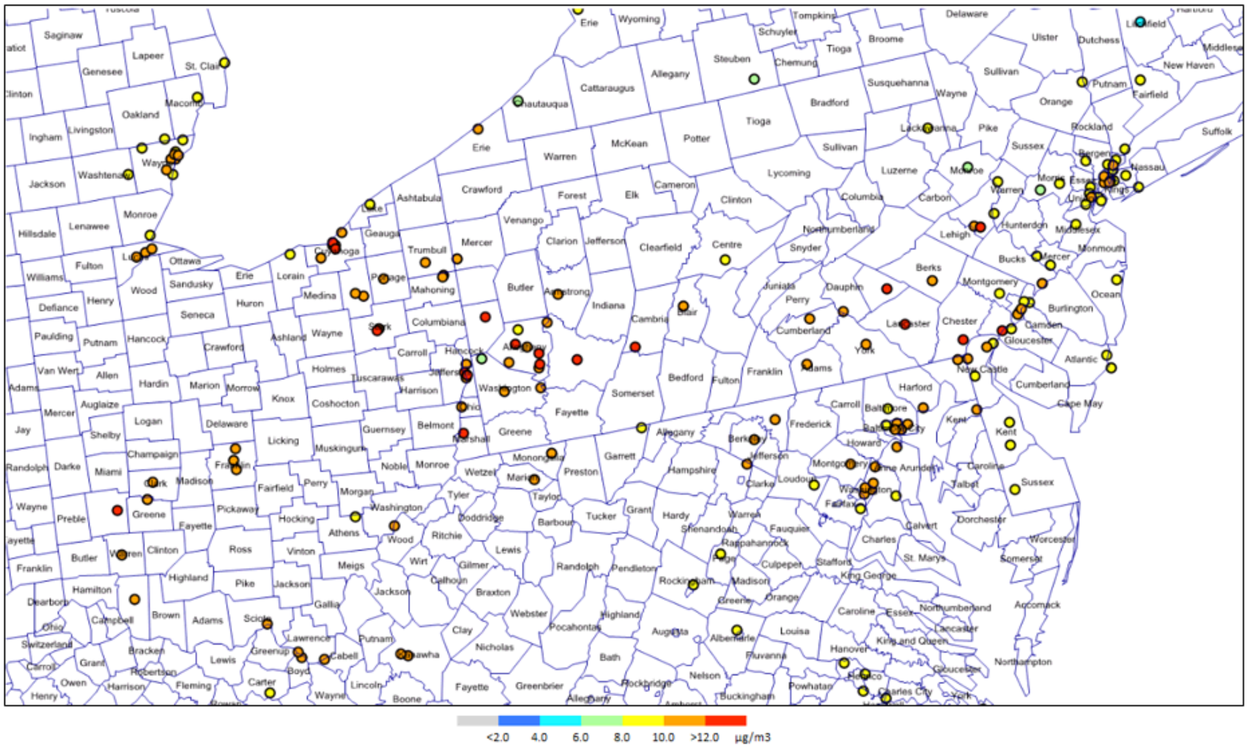
FRM ID#	State	County	Lat	Long	Annual		24-hour	
					DVC	DVF	DVC	DVF
261630019	Michigan	Wayne	42.431	-83.000	9.7	8.2	27.0	23.9
261630025	Michigan	Wayne	42.423	-83.426	9.4	7.9	23.7	20.4
261630033	Michigan	Wayne	42.307	-83.149	11.5	10.0	28.4	25.3
261630036	Michigan	Wayne	42.187	-83.154	9.2	7.7	22.1	18.8
261630038	Michigan	Wayne	42.335	-83.110	10.2	8.7	26.8	22.4
261630039	Michigan	Wayne	42.323	-83.068	10.2	8.7	26.1	23.0
340010006	New Jersey	Atlantic	39.465	-74.449	8.1	6.7	21.0	17.0
340011006	New Jersey	Atlantic	39.363	-74.431	8.9	7.4	23.2	18.4
340030003	New Jersey	Bergen	40.852	-73.973	9.2	7.3	23.5	18.7
340071007	New Jersey	Camden	39.989	-75.050	9.5	7.9	22.6	18.6
340130003	New Jersey	Essex	40.721	-74.193	9.5	8.0	22.8	20.2
340150004	New Jersey	Gloucester	39.831	-75.285	9.3	7.4	22.2	18.6
340171003	New Jersey	Hudson	40.725	-74.052	10.2	8.4	26.8	21.7
340172002	New Jersey	Hudson	40.773	-74.032	11.1	9.3	26.0	22.0
340210008	New Jersey	Mercer	40.222	-74.763	9.5	8.2	25.0	22.0
340218001	New Jersey	Mercer	40.312	-74.873	8.2	6.9	20.0	17.6
340230006	New Jersey	Middlesex	40.473	-74.422	8.0	6.8	19.3	16.2
340270004	New Jersey	Morris	40.801	-74.483	8.4	7.2	21.1	17.4
340273001	New Jersey	Morris	40.788	-74.676	7.6	6.5	20.9	16.2
340292002	New Jersey	Ocean	39.995	-74.170	8.5	7.2	22.7	18.7
340310005	New Jersey	Passaic	40.918	-74.168	9.3	7.9	24.3	21.8
340390004	New Jersey	Union	40.641	-74.208	11.2	9.4	29.4	24.6
340390006	New Jersey	Union	40.673	-74.214	9.6	8.0	23.6	20.5
340392003	New Jersey	Union	40.604	-74.276	9.7	8.1	23.5	19.9
340410006	New Jersey	Warren	40.699	-75.181	9.2	8.0	25.3	21.6
340410007	New Jersey	Warren	40.925	-75.068	8.6	7.4	26.7	24.8
360050080	New York	Bronx	40.836	-73.920	11.9	9.8	28.0	24.3

FRM ID#	State	County	Lat	Long	Annual		24-hour	
					DVC	DVF	DVC	DVF
360050133	New York	Bronx	40.868	-73.878	9.8	7.8	24.5	20.9
360130011	New York	Chautauqua	42.291	-79.590	7.4	6.4	21.1	16.1
360290005	New York	Erie	42.877	-78.810	9.4	8.2	24.5	21.2
360470122	New York	Kings	40.720	-73.948	10.0	8.3	24.1	19.7
360590008	New York	Nassau	40.631	-73.734	8.9	7.4	23.0	18.6
360610079	New York	New York	40.800	-73.934	9.8	7.8	24.1	19.2
360610128	New York	New York	40.730	-73.984	11.8	10.0	25.7	22.8
360610134	New York	New York	40.714	-73.995	11.3	9.6	26.2	22.3
360710002	New York	Orange	41.499	-74.009	8.0	6.9	21.7	19.2
360810124	New York	Queens	40.736	-73.822	9.1	7.6	24.2	20.7
360850055	New York	Richmond	40.633	-74.137	9.5	7.7	23.0	19.6
360850067	New York	Richmond	40.597	-74.125	8.5	6.9	22.7	17.9
361010003	New York	Steuben	42.091	-77.210	6.9	5.9	19.3	15.4
361191002	New York	Westchester	40.931	-73.766	9.1	7.4	25.4	20.4
390090003	Ohio	Athens	39.442	-81.909	8.8	7.2	17.1	13.8
390230005	Ohio	Clark	39.929	-83.809	11.8	9.7	26.4	21.4
390250022	Ohio	Clermont	39.083	-84.144	11.3	9.1	26.6	19.5
390350034	Ohio	Cuyahoga	41.555	-81.575	10.0	8.1	23.2	19.2
390350038	Ohio	Cuyahoga	41.477	-81.682	12.8	10.9	28.8	25.9
390350045	Ohio	Cuyahoga	41.472	-81.657	12.0	10.0	26.3	21.7
390350060	Ohio	Cuyahoga	41.492	-81.678	12.8	10.7	29.4	25.1
390350065	Ohio	Cuyahoga	41.447	-81.662	12.5	10.5	26.0	22.2
390351002	Ohio	Cuyahoga	41.396	-81.819	10.4	8.6	23.0	19.1
390490024	Ohio	Franklin	39.999	-82.993	11.6	9.5	24.8	21.1
390490025	Ohio	Franklin	39.928	-82.981	11.4	9.4	25.8	20.5
390490081	Ohio	Franklin	40.088	-82.960	10.8	8.7	23.6	20.0
390570005	Ohio	Greene	39.808	-83.887	11.2	9.1	21.8	18.2

FRM ID#	State	County	Lat	Long	Annual		24-hour	
					DVC	DVF	DVC	DVF
390810017	Ohio	Jefferson	40.366	-80.616	12.1	9.9	27.2	22.6
390811001	Ohio	Jefferson	40.322	-80.606	11.6	9.3	24.0	21.4
390850007	Ohio	Lake	41.727	-81.242	9.5	7.7	22.3	17.2
390870012	Ohio	Lawrence	38.508	-82.659	11.0	9.5	22.3	18.6
390933002	Ohio	Lorain	41.463	-82.114	9.6	8.2	22.7	18.5
390950024	Ohio	Lucas	41.644	-83.546	10.6	8.9	24.8	22.1
390950026	Ohio	Lucas	41.621	-83.642	10.6	8.9	24.2	21.3
390950028	Ohio	Lucas	41.663	-83.478	10.9	9.3	25.6	22.3
390990005	Ohio	Mahoning	41.111	-80.645	11.1	9.4	26.4	21.5
390990014	Ohio	Mahoning	41.096	-80.659	11.1	9.4	24.8	22.0
391130032	Ohio	Montgomery	39.761	-84.188	12.1	9.9	26.6	23.1
391330002	Ohio	Portage	41.164	-81.235	10.3	8.3	24.1	18.9
391450013	Ohio	Scioto	38.755	-82.917	10.4	8.8	21.1	17.5
391510017	Ohio	Stark	40.787	-81.394	12.9	10.9	27.9	25.2
391510020	Ohio	Stark	40.801	-81.373	11.6	9.7	25.6	22.2
391530017	Ohio	Summit	41.064	-81.469	11.9	9.6	26.5	21.7
391530023	Ohio	Summit	41.088	-81.542	11.1	8.8	24.8	19.8
391550005	Ohio	Trumbull	41.231	-80.802	10.2	8.6	23.9	19.7
391650007	Ohio	Warren	39.427	-84.201	11.5	9.4	26.3	20.7
420010001	Pennsylvania	Adams	39.920	-77.310	11.5	10.0	28.8	24.2
420030002	Pennsylvania	Allegheny	40.500	-80.071	12.4	10.4	27.0	22.3
420030008	Pennsylvania	Allegheny	40.465	-79.961	11.0	9.1	25.2	20.6
420030064	Pennsylvania	Allegheny	40.324	-79.868	14.4	12.2	41.4	38.6
420030067	Pennsylvania	Allegheny	40.376	-80.170	10.3	8.5	25.6	18.3
420030093	Pennsylvania	Allegheny	40.607	-80.022	9.3	7.6	22.4	17.2
420031008	Pennsylvania	Allegheny	40.617	-79.728	11.5	9.6	27.6	21.2
420031301	Pennsylvania	Allegheny	40.402	-79.861	12.3	10.0	31.7	24.0

FRM ID#	State	County	Lat	Long	Annual		24-hour	
					DVC	DVF	DVC	DVF
420033007	Pennsylvania	Allegheny	40.294	-79.885	10.7	9.0	25.4	20.6
420050001	Pennsylvania	Armstrong	40.814	-79.565	11.2	9.8	25.5	21.2
420070014	Pennsylvania	Beaver	40.748	-80.316	12.0	10.2	27.4	23.7
420110011	Pennsylvania	Berks	40.320	-75.927	10.9	9.4	27.4	25.6
420130801	Pennsylvania	Blair	40.535	-78.371	11.9	10.3	29.8	28.0
420170012	Pennsylvania	Bucks	40.107	-74.882	10.9	9.6	28.8	27.1
420210011	Pennsylvania	Cambria	40.310	-78.915	12.3	11.0	30.2	27.9
420270100	Pennsylvania	Centre	40.811	-77.877	9.4	8.1	25.0	21.6
420290100	Pennsylvania	Chester	39.834	-75.768	12.3	10.7	29.6	25.6
420410101	Pennsylvania	Cumberland	40.247	-77.187	11.0	9.5	30.9	28.3
420430401	Pennsylvania	Dauphin	40.247	-76.847	12.0	10.5	31.5	29.5
420450002	Pennsylvania	Delaware	39.836	-75.373	12.8	11.0	29.7	26.4
420490003	Pennsylvania	Erie	42.142	-80.039	11.6	10.5	26.6	23.4
420692006	Pennsylvania	Lackawanna	41.443	-75.623	9.2	8.2	23.6	21.3
420710007	Pennsylvania	Lancaster	40.047	-76.283	12.0	10.5	30.9	28.7
420750100	Pennsylvania	Lebanon	40.337	-76.383	12.3	10.7	--	--
420850100	Pennsylvania	Mercer	41.215	-80.485	10.4	9.0	24.8	20.8
420890002	Pennsylvania	Monroe	41.083	-75.323	7.9	6.9	20.4	17.6
420910013	Pennsylvania	Montgomery	40.112	-75.309	9.9	8.4	25.8	22.4
420950025	Pennsylvania	Northampton	40.628	-75.341	12.9	11.6	32.1	28.7
420950027	Pennsylvania	Northampton	40.646	-75.404	10.6	9.4	28.7	26.5
421010004	Pennsylvania	Philadelphia	40.009	-75.098	9.7	7.9	25.5	20.7
421010047	Pennsylvania	Philadelphia	39.945	-75.165	10.8	8.8	30.4	25.8
421010055	Pennsylvania	Philadelphia	39.923	-75.187	11.1	8.9	28.2	22.6
421010057	Pennsylvania	Philadelphia	39.960	-75.142	11.0	9.3	28.0	23.3
421250005	Pennsylvania	Washington	40.147	-79.902	11.8	9.8	26.4	21.2
421250200	Pennsylvania	Washington	40.171	-80.261	10.9	9.1	24.8	19.8

FRM ID#	State	County	Lat	Long	Annual		24-hour	
					DVC	DVF	DVC	DVF
421255001	Pennsylvania	Washington	40.445	-80.421	7.8	6.5	17.7	14.5
421290008	Pennsylvania	Westmoreland	40.305	-79.506	12.6	11.0	--	--
421330008	Pennsylvania	York	39.965	-76.699	11.5	10.0	28.6	26.2
510030001	Virginia	Albemarle	38.077	-78.504	8.4	7.1	18.6	14.5
510360002	Virginia	Charles	37.344	-77.259	8.6	7.1	20.3	15.3
510410003	Virginia	Chesterfield	37.435	-77.451	9.5	8.0	21.0	17.1
510590030	Virginia	Fairfax	38.773	-77.105	9.2	7.8	23.0	19.8
510690010	Virginia	Frederick	39.281	-78.082	10.0	8.6	23.4	20.1
510870014	Virginia	Henrico	37.557	-77.400	9.2	7.7	21.4	17.6
510870015	Virginia	Henrico	37.671	-77.566	8.7	7.2	19.2	15.1
511071005	Virginia	Loudoun	39.025	-77.489	9.3	7.9	20.2	18.1
511390004	Virginia	Page	38.664	-78.504	8.8	7.5	20.8	16.9
511650003	Virginia	Rockingham	38.478	-78.820	9.7	8.4	21.8	19.0
516500008	Virginia	Hampton City	37.104	-76.387	7.9	6.3	20.6	16.2
540030003	West Virginia	Berkeley	39.448	-77.964	11.4	9.9	29.1	25.5
540090005	West Virginia	Brooke	40.341	-80.597	12.4	10.2	26.2	21.2
540110006	West Virginia	Cabell	38.424	-82.426	11.4	9.7	23.3	20.0
540291004	West Virginia	Hancock	40.422	-80.581	11.2	9.3	27.0	20.7
540390010	West Virginia	Kanawha	38.346	-81.628	10.5	8.5	22.7	17.5
540391005	West Virginia	Kanawha	38.366	-81.694	11.8	9.7	24.1	19.2
540490006	West Virginia	Marion	39.481	-80.135	11.3	9.6	24.2	20.8
540511002	West Virginia	Marshall	39.916	-80.734	12.5	10.8	27.6	26.0
540610003	West Virginia	Monongalia	39.649	-79.921	10.2	8.4	23.6	18.1
540690010	West Virginia	Ohio	40.115	-80.701	11.4	9.2	25.2	20.1
541071002	West Virginia	Wood	39.324	-81.552	11.5	9.8	24.2	20.4



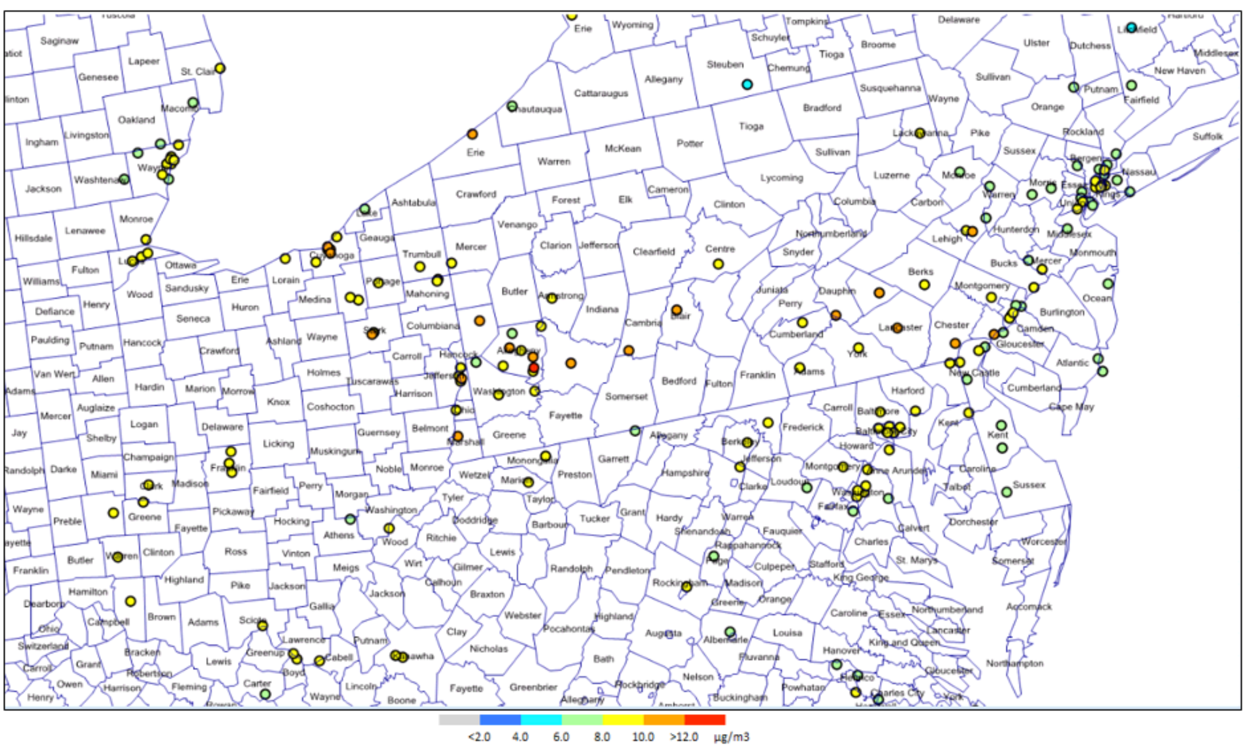


Figure 3-5. Annual $PM_{2.5}$ DVC (top) and DVF (bottom) at Monitor Sites in the 4 km Domain

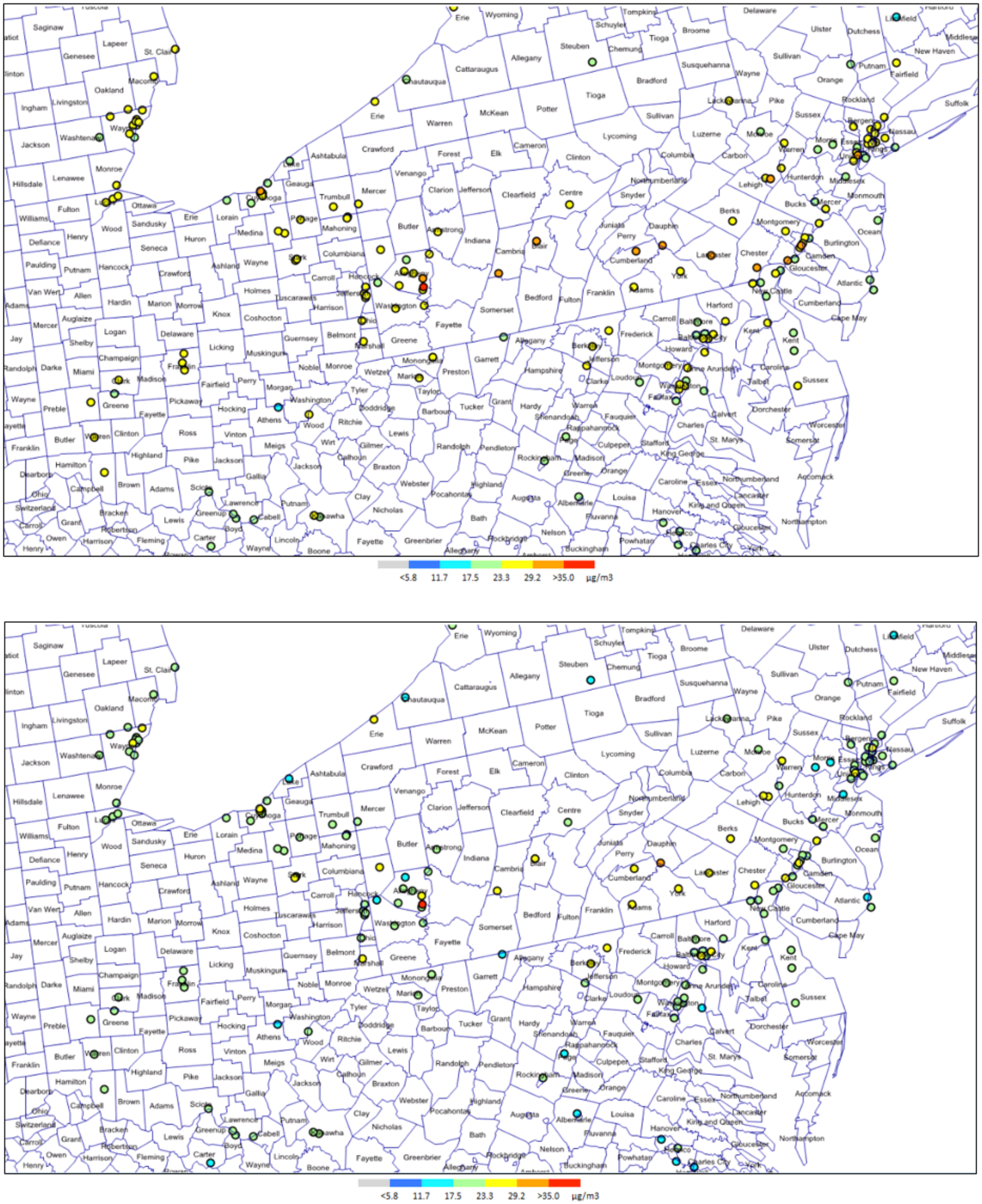


Figure 3-6. 24-Hour $PM_{2.5}$ DVC (top) and DVF (bottom) at Monitor Sites in the 4 km Domain

3.4 Modeled Attainment Test Conclusions

The main focus of the Allegheny County $PM_{2.5}$ attainment demonstration modeling is to demonstrate that the all FRM monitors in the county would achieve attainment of the 2012 annual $PM_{2.5}$ NAAQS by 2021. In this TSD, MATS was used to estimate future year 2021 $PM_{2.5}$ Design Value (DVF) projections based on 2009-2013 current design values (DVC). Model results from both the 1.33 km and 4 km CAMx domains were incorporated into MATS. The local source contributions contained in live PiG puffs within each CAMx grid cell (i.e., 1.33 km, 4 km) are averaged and added to the $PM_{2.5}$ speciated concentrations in each CAMx grid cell.

The Liberty, Avalon, and North Braddock FRM monitor sites have annual $PM_{2.5}$ DVCs above the NAAQS, at 14.4 μg/m^3, 12.4 μg/m^3, and 13.3 μg/m^3, respectively. Only Liberty FRM monitor has a projected 2021 annual $PM_{2.5}$ DVF that exceeds the NAAQS (12.5 μg/m^3). The projected 2021 annual $PM_{2.5}$ DVF at Liberty is slightly lower (12.2 μg/m^3) when the 4 km CAMx model output is used, possibly because emission reductions in 2021 are anticipated to be larger on the regional scale compared to within Allegheny County. Additionally, model results are smoothed over larger spatial extents compared to the 1.33 km domain, which can impact the resolution of model results. The Liberty site is the only site in the 4 km CAMx domain to have 24-hr $PM_{2.5}$ DVC (41.4 μg/m^3) and DVF (38.6 μg/m^3) above the NAAQS.

This TSD demonstration has shown that all sites in Allegheny County are expected to be in compliance with respect to annual and 24-hour PM25 NAAQS by 2021, except for Liberty. Due to potential issues involving model resolution as well as species characterization and reapportionment, additional work must be performed to estimate 2021 design values at the Liberty monitoring site. Further refinement at Liberty is also needed due to the conservatism and inaccuracy surrounding select local and regional emissions. An accompanying report will discuss additional design value calculations at Liberty using a localized, refined approach that combines both CAMx and AERMOD model results.

4. REFERENCES

Abt Associates, Inc. 2014. Modeled Attainment Test Software: User's Manual. Prepared for Office of Air Quality Planning and Standards, U.S. EPA. Research Triangle Park, NC.

Coats, C.J. 1995. Sparse Matrix Operator Kernel Emissions (SMOKE) Modeling System, MCNC Environmental Programs, Research Triangle Park, NC.

EPA. 2014. Draft Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$ and Regional Haze. U.S. Environmental Protection Agency, Research Triangle Park, NC. December. (http://www3.epa.gov/ttn/scram/guidance/guide/Draft-O3-PM-RH-Modeling_Guidance-2014.pdf)

Frank, N. 2006a. Retained Nitrate, Hydrated Sulfates, and Carbonaceous Mass in Federal Reference Method Fine Particulate Matter for Six Eastern U.S. Cities. *J. Air & Waste Management Assoc.*, 56, 500-511.

Frank, N. 2006b. SANDWICH Material Balance Approach for $PM_{2.5}$ Data Analysis. Presented at 2006 National Air Monitoring Conference, Las Vegas, NV. November. (https://www3.epa.gov/ttnamti1/files/2006conference/frank.pdf)

Houyoux, M.R., J.M. Vukovich, C.J. Coats, Jr. N.J.M. Wheeler, and P. Kasibhatla. 2000. Emission inventory development and processing for the seasonal model for regional air quality. *J. Geophysical Research*, **105**, (D7), 9079-9090.

Ramboll Environ. 2016. User's Guide – Comprehensive Air-quality Model with extensions, Version 6.30. ENVIRON International Corporation, Novato, California. (http://www.camx.com)

Ramboll Environ. 2017a. Allegheny County Health Department $PM_{2.5}$ State Implementation Plan for the 2012 NAAQS – CAMx Modeling Protocol. Ramboll Environ US Corporation, Lynnwood, WA and Novato, CA. July.

Ramboll Environ. 2017b. Allegheny County Health Department $PM_{2.5}$ State Implementation Plan for the 2012 NAAQS – CAMx Base Case Modeling and Model Performance Evaluation. Ramboll Environ US Corporation, Lynnwood, WA and Novato, CA. December.

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Appendix I.2

Liberty Local Area Analysis

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Liberty Local Area Analysis

Allegheny County, PA $PM_{2.5}$ Nonattainment Area, 2012 NAAQS

Allegheny County Health Department
Air Quality Program

December 2018

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1 OVERVIEW

This document contains details of the Liberty local area analysis (LAA) for the Allegheny County, PA $PM_{2.5}$ State Implementation Plan (SIP) for the 2012 National Ambient Air Quality Standards (NAAQS). The LAA was performed by the Allegheny County Health Department (ACHD) after review of the CAMx results[1] that showed projections that were above the NAAQS.

The refined modeling for the LAA used the AERMOD[2] modeling system for major local source impacts combined with the regional CAMx impacts according to procedures outlined in the AERMOD Modeling Protocol (see Appendix F of the SIP). The monitored data timeframe was based on 2009-2013 (weighted to 2011) for the base case calculations, projected to a future case year 2021 using modeled relative response factors (RRFs).

Included in this document are the following:

- Modeled results for the LAA
- Design value calculations used for the Liberty attainment tests
- Plant diagrams/configurations used in the model
- Summary of the MMIF meteorological data
- Sample input files used for the modeling

The local primary material (LPM) sources modeled with AERMOD were the U. S. Steel (USS) Mon Valley Works (Clairton, Edgar Thomson, and Irvin Plants), ATI Allegheny Ludlum, McConway and Torley, and Shenango. Appendix A of this document includes plant diagrams of the stacks and buildings used in AERMOD. Emissions were based on 2011 for base case emissions, projected to a future 2021 case. Buoyant line fugitives at the USS Clairton Plant were modeled using the BLP[3]/AERMOD hybrid alternative approach.

Meteorological inputs were based on 2011 MMIF[4] prognostic site-specific data extracted from WRF[5] at each source location. Appendix B of this document includes the locations of the grid cells used, along with wind roses at increasing vertical levels for the Clairton MMIF data.

Samples of the AERMOD, MMIF, and BLP modeling files are provided in Appendix C of this document. All modeling files and spreadsheets used for the LAA can be made available via data storage device.

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[1] Comprehensive Air Quality Model with Extensions (http://www.camx.com/)

[2] American Meteorological Society/Environmental Protection Agency Regulatory Model (https://www.epa.gov/scram/air-quality-dispersion-modeling-preferred-and-recommended-models)

[3] Buoyant Line and Point source dispersion model (https://www3.epa.gov/ttn/scram/userg/regmod/blpug.pdf)

[4] Mesoscale Model Interface Program (https://www.epa.gov/scram/air-quality-dispersion-modeling-related-model-support-programs)

[5] Weather Research and Forecasting Model (https://www.mmm.ucar.edu/weather-research-and-forecasting-model)

2 MODELED RESULTS

Figure 2-1 below shows a map of the Liberty receptors (shown in red) used for the local (LPM) impacts along with the corresponding CAMx grid cells (shaded in white) used for the regional impacts. The CAMx impacts from the two cells were averaged on a 24-hour basis by species.

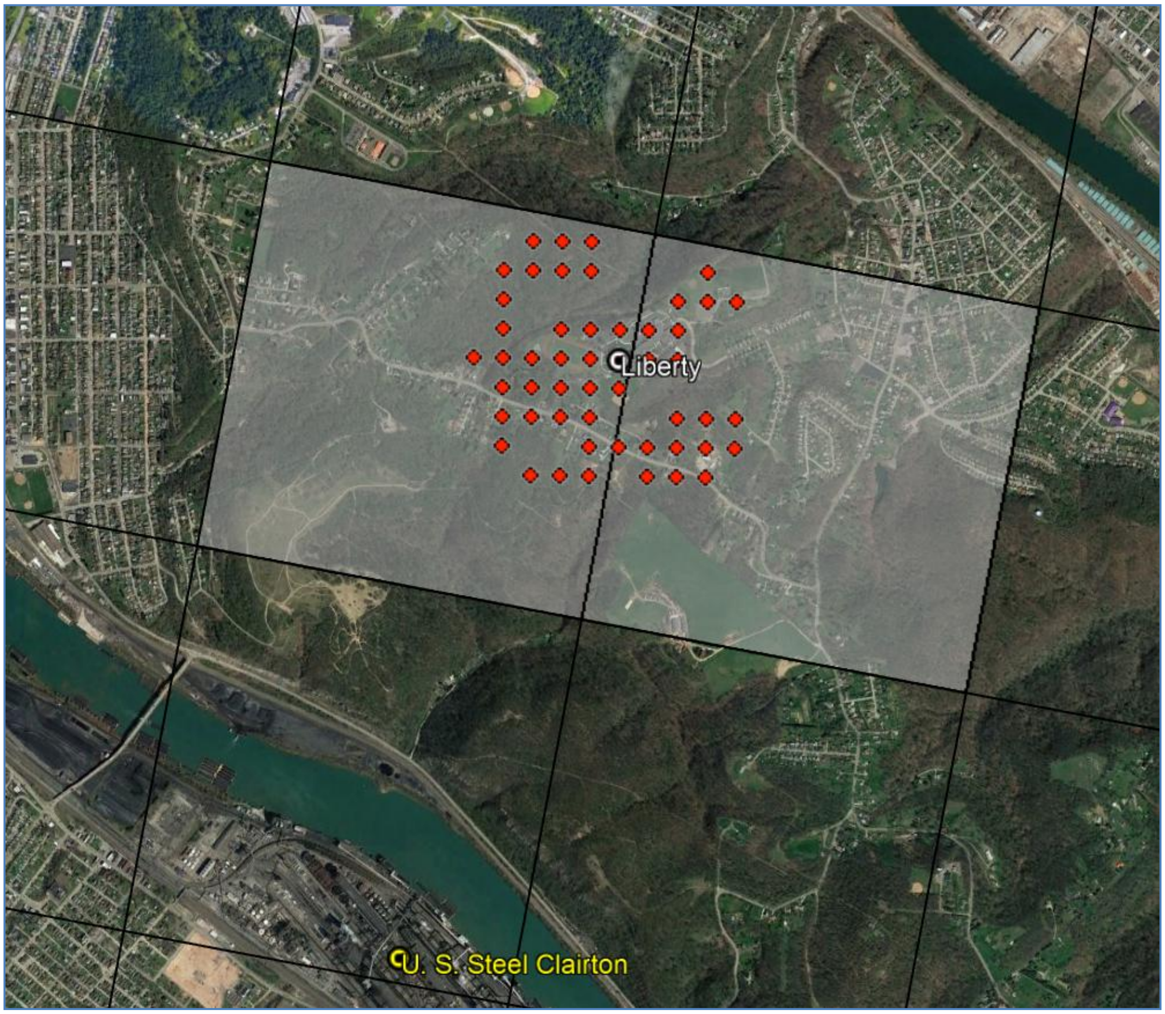

Figure 2-1. Liberty LPM Receptors and Regional CAMx Grid Cells

The CAMx regional results included secondary impacts (formed from precursor emissions) from all sources and sectors, as well as primary $PM_{2.5}$ impacts from all sources/sectors other than the LPM sources. The local LPM results included only impacts from primary $PM_{2.5}$ (filterable and condensable) emissions from six LPM sources.

Figure 2-2 shows the annual modeled source contributions at the Liberty monitor from the LPM sources for base case 2011. Source contributions are grouped by process or facility, with distant sources as the total from Allegheny Ludlum, Shenango, and McConway & Torley.

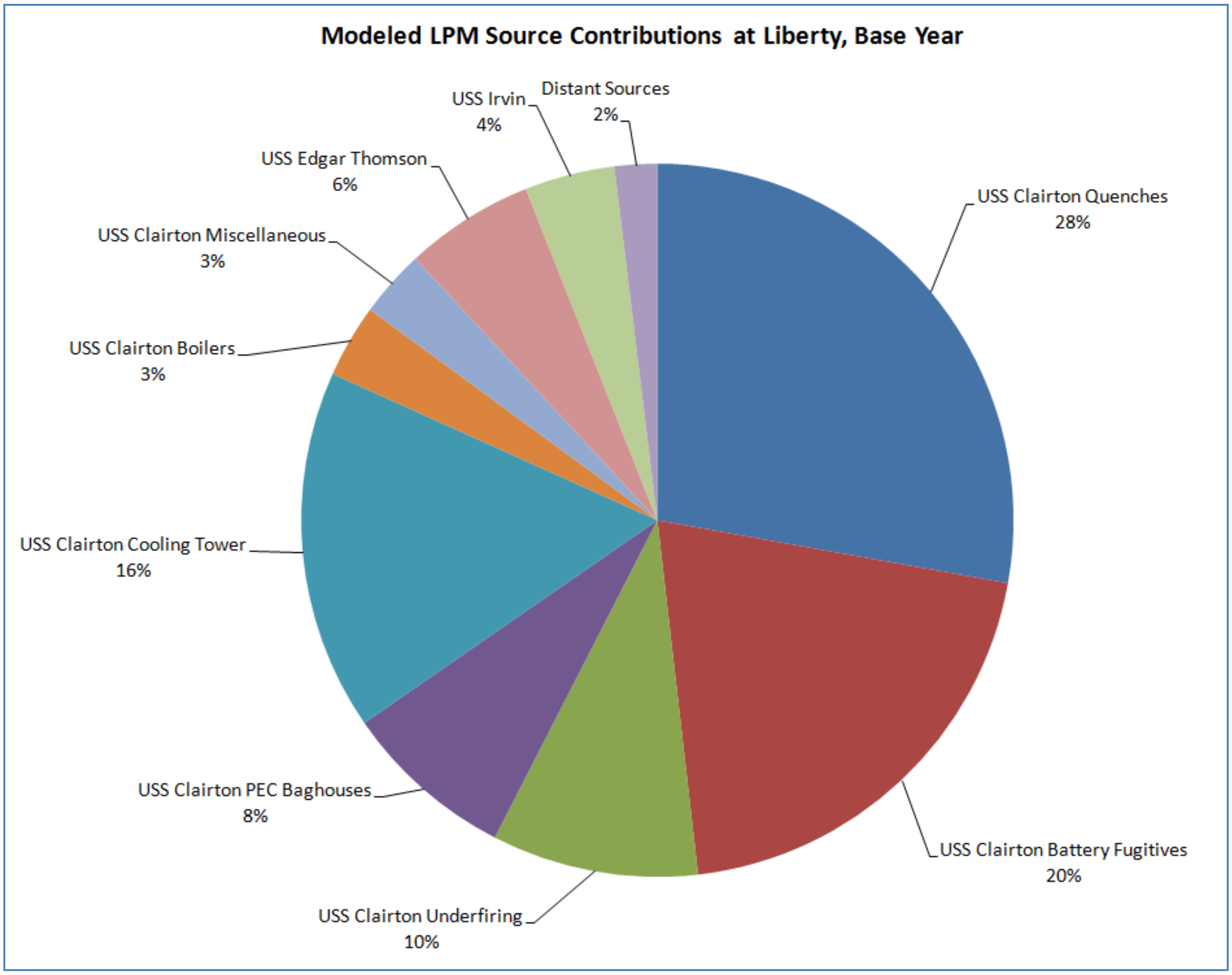

Figure 2-2. Modeled Source Contributions, LPM at Liberty, 2011

The modeled contributions show that the USS Clairton Plant sources represent the majority (88%) of the year-round contributions from the LPM sources at the Liberty monitor location.[6] The control strategy for the Liberty area was therefore focused on controls for the Clairton Plant.

[6] Based on the design of the AERMOD local modeling with post-processing of different runs, along with the method used by AERMOD to tabulate source groups impacts by receptor, this analysis is not readily available as output for the full Liberty receptor grid. The single-receptor source contributions in Figure 2-1 are assumed to be consistent throughout the expanded-scale Liberty receptor grid.

Table 2-1 shows a glossary of terms used for $PM_{2.5}$ species based on measured CSN[7] data and the SANDWICH[8] methodology. The SANDWICH technique is used for the reconstruction of speciation data when used in combination with FRM[9] results.

Table 2-1. Glossary of $PM_{2.5}$ Speciation Terms

OC	Organic Carbon (modeled, used for RRFs for OCMmb)
OCMmb	Organic Carbon Mass by mass balance (FRM minus other species)
NO3	Nitrate (modeled, used for RRFs for NO3r)
NO3r	Retained Nitrate, calculated by EPA using KPIT temp and relative humidity
SO4	Sulfate (measured or modeled)
NH4	Ammonium (measured)
NH4r	Retained (Indirect) Ammonium, calculated from DON, SO4, and NO3r
EC	Elemental Carbon (measured or modeled)
CRUST	Crustal Component, calculated from Si, Ti, Ca, Fe, w/o Al (alt formula)
OTHER	Other Primary PM2.5, modeled (analogous to crustal component)
DON	Degree of Neutralization of SO4, calculated from NH4, NO3r, and SO4
PBW	Particle Bound Water, calculated
FRMc	FRM concentration, concurrent with speciation samples (base timeframe)
FRMw	FRM weighted average concentration (base timeframe)
FRMh	FRMc high-day concentration
LPM	Local Primary Material (mix of species), measured or modeled
SALT	Crustal salt (measured or modeled), calculated from chlorine
Blank	Passive blank mass (constant)
Non-Blank	Sum of all species except passive blank
FRMf	FRM future projected concentration (weighted avg or high-day)

Formulas not shown above in Table 2-1 for calculated or assumed species are as follows (based on EPA modeling guidance and attainment test software):

<u>NO3r</u>:

$$\text{delta NO3 (ug/m3)} = 745.7/T_R * 1/24 * \sum_{i=1}^{24} (\mathbf{K}_i^{1/2})$$

delta NO3 is the amount of volatilized nitrate

T_R is the reference temperature

$\mathbf{K}_i$ is the dissociation constant for ammonium nitrate

<u>DON</u>:

DON = (NH4 – (0.29 * NO3r)) / SO4

with a maximum of 0.375

[7] Chemical Speciation Network

[8] Sulfate, Adjusted Nitrate, Derived Water, Inferred Carbon Hybrid material balance approach

[9] Federal Reference Method

NH4r:

NH4r = (DON * SO4) + (0.29 * NO3r)

Crustal:

CRUST = 3.73*Si + 1.63*Ca + 2.42*Fe + 1.94*Ti

Salt:

SALT = 1.8*Cl

PBW:

Intermediate variables:

S = SO4 / (SO4 + NO3r + NH4r)
N = NO3r / (SO4 + NO3r + NH4r)
A = NH4r / (SO4 + NO3r + NH4r)

For low acidity (DON ≥ 0.225):

PBW = (SO4+NO3r+NH4r) * {202048.975 - 391494.647 *S - 390912.147 *N + 442.435 *(S**1.5)
- 155.335 *(N**1.5) - 293406.827 *(A**1.5) + 189277.519 *(S**2) + 377992.610 *N*S
+ 188636.790 *(N**2) - 447.123 *(S**2.5) - 507.157 *(S**1.5)*N - 12.794 *(S**3)
+ 146.221 *(N**1.5)*S + 217.197 *(N**2.5) + 29.981 *(N**1.5)*(S**1.5) - 18.649 *(N**3)
+ 216266.951 *(A**1.5)*S + 215419.876 *(A**1.5)*N - 621.843 *(A**1.5)*(S**1.5)
+ 239.132 *(A**1.5)*(N**1.5) + 95413.122 *(A**3)}

OCMmb:

OCMmb = FRM – (EC + SO4 + NO3r + NH4r + PBW + CRUST + SALT + Blank)

Blank:

Blank = 0.5 µg/m³

Note about blank mass: The 2014 draft EPA modeling guidance[10] recommended a blank mass of 0.5 µg/m³. The 2018 final EPA modeling guidance[11] lowered the recommended amount to 0.2 µg/m³ based on more recent nationwide blank measurements. Design value calculations for Liberty were tested using the lower blank mass value, and the effects were minimal (differences of less than 0.01 µg/m³) compared to the use of 0.5 µg/m³ for blank mass. For consistency with the projected design values for the other Allegheny County sites using the EPA MATS[12] software (which uses blank mass of 0.5 µg/m³), blank mass of 0.5 µg/m³ was used for the Liberty attainment tests. The use of larger blank mass also makes for more conservative projections overall, since blank mass is added as the final step to species reconstruction for projected FRM values.

[10] https://www3.epa.gov/ttn/scram/guidance/guide/Draft_O3-PM-RH_Modeling_Guidance-2014.pdf

[11] https://www3.epa.gov/ttn/scram/guidance/guide/O3-PM-RH-Modeling_Guidance-2018.pdf

[12] Modeled Attainment Test Software (https://www3.epa.gov/ttn/scram/guidance/guide/MATS_2-6-1_manual.pdf)

Table 2-2 shows the LAA modeled concentrations and RRFs by species on a quarterly average basis, used for the annual attainment test. Table 2-3 shows the modeled concentrations and RRFs by species on a quarterly average high-day basis (top 10% of days in each quarter), used for the 24-hour attainment test. RRFs are the ratio of the future case to the base case, by species.

LPM results are based on the AERMOD modeled impacts, while results for all other species are based on the CAMx regional impacts. Modeled results are not shown for NH4r or PBW, since they are calculated species (after the RRFs are applied). Salt, passive (blank) material, and degree of neutralization (DON) are held constant from base to future case.

Table 2-2. Modeled Quarterly Average Concentrations (μg/m³) and RRFs (ratios)

Base Case (2011)	QTR	LPM	OC	EC	SO4	NO3	OTHER
	1Q	3.030	6.975	1.017	2.573	2.199	1.465
	2Q	3.129	2.583	0.612	2.964	0.954	1.458
	3Q	3.574	2.872	0.752	4.282	1.121	1.411
	4Q	5.271	4.563	0.944	1.931	1.989	1.454
Future Case (2021)	**QTR**	**LPM**	**OC**	**EC**	**SO4**	**NO3**	**OTHER**
	1Q	2.505	7.034	0.810	2.102	1.917	1.696
	2Q	2.609	2.566	0.426	1.768	0.695	1.507
	3Q	3.177	2.816	0.494	2.461	0.763	1.482
	4Q	4.349	4.610	0.703	1.590	1.563	1.657
RRFs	**QTR**	**LPM**	**OC**	**EC**	**SO4**	**NO3**	**OTHER**
	1Q	0.827	1.008	0.796	0.817	0.872	1.157
	2Q	0.834	0.993	0.696	0.596	0.729	1.034
	3Q	0.889	0.981	0.657	0.575	0.681	1.050
	4Q	0.825	1.010	0.745	0.823	0.786	1.140

Table 2-3. Modeled Quarterly Average High-Day Concentrations (μg/m³) and RRFs (ratios)

Base Case (2011)	QTR	LPM	OC	EC	SO4	NO3	OTHER
	1Q	10.148	10.028	1.537	5.524	4.549	2.117
	2Q	7.829	4.967	1.000	5.258	3.008	2.215
	3Q	7.542	4.708	1.149	7.775	3.321	2.211
	4Q	13.187	8.753	1.763	2.427	5.612	2.619
Future Case (2021)	**QTR**	**LPM**	**OC**	**EC**	**SO4**	**NO3**	**OTHER**
	1Q	7.675	11.481	1.283	4.159	3.595	2.605
	2Q	5.649	5.343	0.768	2.763	2.660	2.321
	3Q	6.452	4.659	0.765	4.135	2.296	2.284
	4Q	10.318	9.211	1.317	2.244	4.459	2.917
RRFs	**QTR**	**LPM**	**OC**	**EC**	**SO4**	**NO3**	**OTHER**
	1Q	0.756	1.145	0.835	0.753	0.790	1.230
	2Q	0.722	1.076	0.768	0.525	0.884	1.048
	3Q	0.855	0.990	0.666	0.532	0.691	1.033
	4Q	0.782	1.052	0.747	0.925	0.795	1.114

3 ATTAINMENT TESTS

This section provides the calculations used to generate the projected design values for the annual and 24-hour attainment tests for Liberty. Quarterly modeled RRFs are used to scale the weighted base case monitored results by species. All concentrations (except fractions or ratios) are given in units of µg/m³.

3.1 Annual Attainment Test

As the initial step in the annual design value calculation, the weighted quarterly FRM averages are calculated for the 2009-2013 timeframe, as shown in Table 3-1. This is done by calculating the quarterly averages for 2009-2011, 2010-2012, and 2011-2013. The average of these values is the "weighted" quarterly FRM average, since the base year 2011 is included in each of the three-year calculations.

Table 3-1. Liberty Weighted Quarterly FRM Averages (µg/m³)

FRM Quarterly Avgs

Year	Qtr	Avg
2009	1Q	14.924
2009	2Q	13.740
2009	3Q	15.051
2009	4Q	16.377
2010	1Q	14.728
2010	2Q	15.025
2010	3Q	18.555
2010	4Q	15.844
2011	1Q	12.176
2011	2Q	12.413
2011	3Q	15.448
2011	4Q	15.966
2012	1Q	14.139
2012	2Q	13.716
2012	3Q	15.380
2012	4Q	13.939
2013	1Q	12.789
2013	2Q	10.841
2013	3Q	12.579
2013	4Q	11.707

Quarterly Avgs (3-Year)

3-Year Period	Qtr	Avg
2009-2011	1Q	13.943
2009-2011	2Q	13.726
2009-2011	3Q	16.351
2009-2011	4Q	16.062
2010-2012	1Q	13.681
2010-2012	2Q	13.718
2010-2012	3Q	16.461
2010-2012	4Q	15.250
2011-2013	1Q	13.035
2011-2013	2Q	12.323
2011-2013	3Q	14.469
2011-2013	4Q	13.870

Weighted Quarterly Avgs

Qtr	Avg
1Q	13.553
2Q	13.256
3Q	15.760
4Q	15.061

Table 3-2 shows the steps used to determine the weighted quarterly composition of $PM_{2.5}$ by species. Quarterly averages are first calculated for available Liberty CSN species in each quarter over the 2009-2013 timeframe (quarters with low data recovery are omitted). Quarterly averages are then determined for the five-year timeframe, and indirect species retained ammonium (NH4r) and particle bound water (PBW) are calculated from the quarterly averages of other species. Organic carbon mass (OCMmb) is calculated as the difference of total mass and all other non-blank species (including salt). Quarterly fractional compositions (species as fractions of the total non-blank concurrent FRM mass) are calculated and used to determine the quarterly concentrations of each species of the weighted non-blank FRM mass. Blank mass is held constant at 0.5 µg/m³, and the weighted concentrations (FRMw) are the weighted quarterly averages from Table 3-1.

Table 3-2. Quarterly Composition (µg/m³) of Liberty, Base Case, Annual

Yearly Quarterly Averages	YEAR	QTR	FRMc	SO4	NO3r	EC	CRUST	DON	SALT	
	2009	1Q	12.088	3.939	1.636	1.270	0.505	0.370	0.048	
	2009	2Q	13.638	4.112	0.000	1.521	1.035	0.372	0.009	
	2009	3Q	14.233	5.027	0.000	1.258	0.615	0.351	0.010	
	2009	4Q								low recovery
	2010	1Q								low recovery
	2010	2Q	17.060	4.197	0.000	2.905	0.798	0.361	0.009	
	2010	3Q	15.460	4.942	0.000	2.023	0.511	0.320	0.008	
	2010	4Q	17.527	4.202	1.401	2.555	1.065	0.324	0.025	
	2011	1Q	8.622	3.991	1.568	0.599	0.468	0.348	0.025	
	2011	2Q	11.787	3.714	0.089	1.586	0.580	0.344	0.010	
	2011	3Q	16.173	5.689	0.000	2.103	0.659	0.300	0.011	
	2011	4Q	11.520	2.727	0.630	1.663	0.479	0.334	0.020	
	2012	1Q	15.660	3.188	0.472	2.315	0.450	0.356	0.012	
	2012	2Q	12.946	2.980	0.000	2.120	0.765	0.307	0.009	
	2012	3Q	16.131	3.889	0.000	2.835	0.688	0.320	0.009	
	2012	4Q	17.979	3.401	0.671	2.562	0.741	0.324	0.015	
	2013	1Q	11.140	2.244	1.387	0.807	0.379	0.329	0.041	
	2013	2Q	12.120	2.949	0.000	1.225	0.545	0.334	0.014	
	2013	3Q	15.053	4.215	0.000	2.025	0.743	0.310	0.008	
	2013	4Q	9.188	2.149	0.774	1.028	0.295	0.280	0.007	

Quarterly Averages	QTR	FRMc	SO4	NO3r	EC	CRUST	DON	SALT	NH4r	PBW	OCMmb
	1Q	11.877	3.340	1.266	1.248	0.450	0.351	0.031	1.540	1.077	2.425
	2Q	13.510	3.590	0.018	1.871	0.745	0.344	0.010	1.239	1.321	4.216
	3Q	15.410	4.753	0.000	2.049	0.643	0.320	0.009	1.522	1.639	4.295
	4Q	14.053	3.120	0.869	1.952	0.645	0.316	0.017	1.237	0.958	4.755

Fractional Compositions	QTR	Non-Blank	OCMmb	EC	SO4	NO3r	CRUST	NH4r	PBW	SALT
	1Q	1.000	0.213	0.110	0.294	0.111	0.040	0.135	0.095	0.003
	2Q	1.000	0.324	0.144	0.276	0.001	0.057	0.095	0.102	0.001
	3Q	1.000	0.288	0.137	0.319	0.000	0.043	0.102	0.110	0.001
	4Q	1.000	0.351	0.144	0.230	0.064	0.048	0.091	0.071	0.001

Weighted Quarterly Avgs	QTR	FRMw	Blank	Non-Blank	OCMmb	EC	SO4	NO3r	CRUST	NH4r	PBW	SALT
	1Q	13.553	0.500	13.053	2.782	1.432	3.832	1.452	0.517	1.766	1.236	0.036
	2Q	13.256	0.500	12.756	4.134	1.835	3.520	0.017	0.730	1.214	1.295	0.010
	3Q	15.760	0.500	15.260	4.396	2.097	4.864	0.000	0.658	1.558	1.678	0.009
	4Q	15.061	0.500	14.561	5.109	2.097	3.352	0.934	0.693	1.329	1.029	0.018

In order to "split" the localized Liberty component from the regional[13] component, the quarterly compositions of the surrounding CSN sites in the Pittsburgh Metropolitan Statistical Area (MSA) are first calculated in the same manner as the Liberty quarterly compositions. (Calculations similar to those shown in Table 3-2 for the regional sites are available via spreadsheet.) For the regional component, the quarterly compositions of the Lawrenceville, Florence, and the Greensburg sites are averaged, as shown in Table 3-3. (Liberty is also shown at the bottom of the table.) For consistency with Liberty, averages were calculated on a non-weighted basis and without low recovery quarters at Liberty.[14]

Table 3-3. Quarterly Composition (μg/m³) of Pittsburgh MSA Sites, Base Case, Annual

	QTR	FRMc	Blank	Non-Blank	OCMmb	EC	SO4	NO3r	CRUST	NH4r	PBW	SALT
Lawrenceville	**QTR**	**FRMc**	**Blank**	**Non-Blank**	**OCMmb**	**EC**	**SO4**	**NO3r**	**CRUST**	**NH4r**	**PBW**	**SALT**
	1Q	10.457	0.500	9.957	2.693	0.626	2.503	1.525	0.457	1.314	0.783	0.055
	2Q	10.008	0.500	9.508	3.355	0.659	2.851	0.011	0.722	0.917	0.982	0.011
	3Q	12.510	0.500	12.010	4.259	0.820	3.998	0.000	0.674	1.149	1.097	0.012
	4Q	10.165	0.500	9.665	3.760	0.891	2.047	0.810	0.655	0.866	0.598	0.039
Florence	**QTR**	**FRMc**	**Blank**	**Non-Blank**	**OCMmb**	**EC**	**SO4**	**NO3r**	**CRUST**	**NH4r**	**PBW**	**SALT**
	1Q	6.704	0.500	6.204	1.081	0.350	2.173	0.836	0.262	0.888	0.606	0.008
	2Q	8.357	0.500	7.857	2.954	0.426	2.630	0.012	0.522	0.708	0.597	0.008
	3Q	10.248	0.500	9.748	3.321	0.487	3.793	0.000	0.568	0.851	0.722	0.006
	4Q	6.275	0.500	5.775	1.519	0.399	1.964	0.511	0.329	0.618	0.429	0.007
Greensburg	**QTR**	**FRMc**	**Blank**	**Non-Blank**	**OCMmb**	**EC**	**SO4**	**NO3r**	**CRUST**	**NH4r**	**PBW**	**SALT**
	1Q	9.590	0.500	9.090	3.238	0.621	2.228	0.897	0.382	0.984	0.687	0.053
	2Q	12.252	0.500	11.752	5.431	0.671	3.090	0.034	0.542	0.969	1.004	0.010
	3Q	13.260	0.500	12.760	5.562	0.796	3.802	0.000	0.412	1.105	1.073	0.009
	4Q	9.167	0.500	8.667	3.924	0.748	1.808	0.717	0.310	0.689	0.444	0.026
MSA Regional	**QTR**	**FRMc**	**Blank**	**Non-Blank**	**OCMmb**	**EC**	**SO4**	**NO3r**	**CRUST**	**NH4r**	**PBW**	**SALT**
(Avg)	**1Q**	8.917	0.500	8.417	2.338	0.532	2.302	1.086	0.367	1.062	0.692	0.039
	2Q	10.206	0.500	9.706	3.913	0.585	2.857	0.019	0.596	0.865	0.861	0.010
	3Q	12.006	0.500	11.506	4.381	0.701	3.865	0.000	0.551	1.035	0.964	0.009
	4Q	8.536	0.500	8.036	3.068	0.679	1.940	0.680	0.431	0.724	0.490	0.024
Liberty	**QTR**	**FRMc**	**Blank**	**Non-Blank**	**OCMmb**	**EC**	**SO4**	**NO3r**	**CRUST**	**NH4r**	**PBW**	**SALT**
	1Q	11.877	0.500	11.377	2.425	1.248	3.340	1.266	0.450	1.540	1.077	0.031
	2Q	13.510	0.500	13.010	4.216	1.871	3.590	0.018	0.745	1.239	1.321	0.010
	3Q	15.410	0.500	14.910	4.295	2.049	4.753	0.000	0.643	1.522	1.639	0.009
	4Q	14.053	0.500	13.553	4.755	1.952	3.120	0.869	0.645	1.237	0.958	0.017

The Liberty local component is determined from a series of calculations shown in Table 3-4, subtracting the average quarterly regional species concentrations from the Liberty species and adjusting the local and regional fractions of the Liberty concentrations.

The raw Liberty local composition is first determined by subtracting the regional (MSA) quarterly average non-blank species from the total Liberty quarterly average non-blank species (from Table 3-3). The negative concentrations for the Liberty local component are then corrected to zero (i.e., there is no excess for those species/quarters at Liberty). The Liberty regional is next calculated as the difference of the adjusted Liberty local and the total Liberty non-blank concentrations (from Table 3-3) by species and quarter. Since the indirect species NH4r and PBW are dependent on sulfate, nitrate, and DON specific to each site, these species are recalculated specifically for the Liberty regional component. The quarterly

[13] For the purposes of the LAA, "regional" is considered to be the Greater Pittsburgh area without the localized impacts at Liberty. The regional component can be further apportioned into metropolitan and rural components when looking at more distant speciation sites.

[14] The weighted FRM values include all FRM samples over the five-year timeframe. Use of the non-weighted data allows for the exclusion of specific quarters with low recovery.

LPM is calculated as the difference of total non-blank Liberty mass and the sum of the recalculated regional species (by quarter).

In order to split the weighted composition for Liberty, the LPM and regional species are then converted into fractional compositions of the total (similar to those shown in Table 3-2). The non-blank weighted Liberty mass is then multiplied by the fraction of each species to determine the weighted LPM and regional species compositions by quarter.

Table 3-4. Liberty Local and Regional Compositions (μg/m³), Base Case, Annual

Liberty Local (by subtraction)	QTR	Non-Blank	OCMmb	EC	SO4	NO3r	CRUST	NH4r	PBW	SALT
	1Q	2.961	0.087	0.716	1.039	0.180	0.083	0.478	0.386	-0.007
	2Q	3.304	0.303	1.286	0.734	-0.001	0.149	0.374	0.460	0.000
	3Q	3.404	-0.086	1.348	0.888	0.000	0.092	0.487	0.675	0.000
	4Q	5.518	1.688	1.273	1.180	0.190	0.214	0.513	0.468	-0.007

Liberty Local Adjusted (non-negative)	QTR	Non-Blank	OCMmb	EC	SO4	NO3r	CRUST	NH4r	PBW	SALT
	1Q	2.968	0.087	0.716	1.039	0.180	0.083	0.478	0.386	0.000
	2Q	3.305	0.303	1.286	0.734	0.000	0.149	0.374	0.460	0.000
	3Q	3.490	0.000	1.348	0.888	0.000	0.092	0.487	0.675	0.000
	4Q	5.525	1.688	1.273	1.180	0.190	0.214	0.513	0.468	0.000

Liberty Regional (total minus local adjusted)	QTR	Non-Blank	OCMmb	EC	SO4	NO3r	CRUST	NH4r	PBW	SALT
	1Q	8.409	2.338	0.532	2.302	1.086	0.367	1.062	0.692	0.031
	2Q	9.705	3.913	0.585	2.857	0.018	0.596	0.865	0.861	0.010
	3Q	11.420	4.295	0.701	3.865	0.000	0.551	1.035	0.964	0.009
	4Q	8.029	3.068	0.679	1.940	0.680	0.431	0.724	0.490	0.017

Liberty Regional (recalculated for NH4r and PBW) and LPM	QTR	LPM	Non-Blank	OCMmb	EC	SO4	NO3r	CRUST	NH4r	PBW	SALT
	1Q	2.871	8.506	2.338	0.532	2.302	1.086	0.367	1.123	0.728	0.031
	2Q	2.994	10.016	3.913	0.585	2.857	0.018	0.596	0.987	1.050	0.010
	3Q	2.918	11.992	4.295	0.701	3.865	0.000	0.551	1.238	1.333	0.009
	4Q	5.343	8.210	3.068	0.679	1.940	0.680	0.431	0.810	0.586	0.017

Liberty Regional Fractional Compositions (of regional non-blank)	QTR	Non-Blank	OCMmb	EC	SO4	NO3r	CRUST	NH4r	PBW	SALT
	1Q	1.000	0.275	0.063	0.271	0.128	0.043	0.132	0.086	0.004
	2Q	1.000	0.391	0.058	0.285	0.002	0.059	0.099	0.105	0.001
	3Q	1.000	0.358	0.058	0.322	0.000	0.046	0.103	0.111	0.001
	4Q	1.000	0.374	0.083	0.236	0.083	0.053	0.099	0.071	0.002

Local/Regional Ratios (of total non-blank)	QTR	LPM	Regional
	1Q	0.252	0.748
	2Q	0.230	0.770
	3Q	0.196	0.804
	4Q	0.394	0.606

Liberty Weighted Local/Regional Split	QTR	FRMw	Blank	Non-Blank	LPM	Regional
	1Q	13.553	0.500	13.053	3.294	9.759
	2Q	13.256	0.500	12.756	2.936	9.820
	3Q	15.760	0.500	15.260	2.987	12.274
	4Q	15.061	0.500	14.561	5.740	8.821

Liberty Weighted Regional Compositions	QTR	Non-Blank	OCMmb	EC	SO4	NO3r	CRUST	NH4r	PBW	SALT
	1Q	9.759	2.682	0.611	2.640	1.246	0.421	1.288	0.835	0.036
	2Q	9.820	3.837	0.574	2.801	0.017	0.584	0.967	1.030	0.010
	3Q	12.274	4.396	0.718	3.955	0.000	0.564	1.267	1.364	0.009
	4Q	8.821	3.296	0.730	2.084	0.730	0.463	0.870	0.630	0.018

As the final step for the annual design value calculation, the weighted base case quarterly species concentrations from Table 3-4 are multiplied by the RRFs in Table 2-2 to generate future case Liberty concentrations for the modeled species (LPM, OC, EC, SO4, NO3r, OTHER). (OC is used to project OCMmb, and OTHER is used to project crustal component.) The indirect species NH4r and PBW are then calculated from the other species, and the quarterly future total masses (FRMf) are summed from all species plus blank mass. The future case design value is calculated as the average of the quarterly totals of the future components, as shown in Table 3-5 below.

Table 3-5. Liberty Future Case Design Value (μg/m³), Annual

QTR	FRMf	Blank	Non-Blank	OCMmb	EC	SO4	NO3r	CRUST	NH4r	PBW	SALT	LPM
1Q	11.933	0.500	11.433	2.705	0.486	2.157	1.087	0.488	1.072	0.679	0.036	2.723
2Q	10.645	0.500	10.145	3.811	0.399	1.670	0.013	0.604	0.578	0.614	0.010	2.448
3Q	12.325	0.500	11.825	4.310	0.472	2.273	0.000	0.593	0.728	0.784	0.009	2.655
4Q	13.174	0.500	12.674	3.329	0.544	1.716	0.574	0.528	0.708	0.520	0.018	4.737
AVG	**12.02**											

The future case annual design value was calculated as 12.02 μg/m³, which rounds to 12.0 μg/m³ based on the NAAQS conventions.[15] Thus, the Liberty LAA passes the $PM_{2.5}$ annual attainment test, equal to the standard of 12.0 μg/m³.

3.2 24-Hour Attainment Test

The 24-hour attainment test calculations are similar to the annual calculations in regard to the reconstruction of species. However, the compositions and projections are performed on a high-day basis instead of an overall average basis.

Table 3-6 shows the steps used to determine the weighted quarterly high-day composition of $PM_{2.5}$ by species. Similar to Table 3-2, quarterly averages are calculated for available Liberty CSN species in each quarter over the 2009-2013 timeframe (quarters with low data recovery are omitted). However, for the high-day basis, only the highest three samples per quarter (based on the FRMc mass) are used for the quarterly averages. Quarterly high-day averages are then determined for the full five-year timeframe, and indirect species (NH4r, PBW) are calculated from the quarterly averages of the other species. OCMmb is calculated as the difference of total mass and all other non-blank species. Blank mass of 0.5 μg/m³ is used for each sample, similar to the annual basis.

[15] See 40 CFR Part 50 Appendix N.

Table 3-6. Quarterly High-Day Composition (µg/m³) of Liberty, Base Case, 24-Hour

Yearly Quarterly Averages	YEAR	QTR	FRMc	SO4	NO3r	EC	CRUST	DON	SALT	
	2009	1Q	18.467	5.513	2.697	2.380	0.710	0.375	0.091	
	2009	2Q	23.167	7.450	0.000	2.637	1.230	0.375	0.017	
	2009	3Q	27.267	9.293	0.000	2.890	1.080	0.353	0.019	
	2009	4Q								low recovery
	2010	1Q								low recovery
	2010	2Q	30.800	6.283	0.000	5.770	1.367	0.375	0.013	
	2010	3Q	35.733	11.027	0.000	4.953	0.837	0.356	0.012	
	2010	4Q	31.233	5.897	0.063	5.243	2.300	0.375	0.012	
	2011	1Q	14.333	7.057	4.133	0.930	0.513	0.375	0.048	
	2011	2Q	25.367	7.170	0.000	4.610	0.773	0.367	0.017	
	2011	3Q	30.100	11.517	0.000	4.103	1.100	0.360	0.017	
	2011	4Q	20.833	4.740	1.450	3.260	0.657	0.365	0.036	
	2012	1Q	23.733	4.080	0.050	3.927	0.803	0.375	0.012	
	2012	2Q	26.433	5.517	0.000	5.503	1.757	0.375	0.010	
	2012	3Q	24.933	5.043	0.000	6.490	1.110	0.375	0.018	
	2012	4Q	43.367	6.763	1.770	7.560	1.503	0.375	0.032	
	2013	1Q	21.900	3.793	2.447	2.373	0.790	0.375	0.076	
	2013	2Q	20.600	4.590	0.000	2.177	0.520	0.364	0.015	
	2013	3Q	24.733	6.753	0.000	3.677	0.850	0.375	0.008	
	2013	4Q	17.133	4.087	1.083	2.347	0.447	0.375	0.012	

Quarterly Averages	QTR	FRMc	SO4	NO3r	EC	CRUST	DON	SALT	NH4r	PBW	OCMmb
	1Q	19.608	5.111	2.332	2.403	0.704	0.375	0.057	2.593	1.575	4.335
	2Q	25.273	6.202	0.000	4.139	1.129	0.371	0.014	2.302	2.236	8.751
	3Q	28.553	8.727	0.000	4.423	0.995	0.364	0.015	3.175	3.199	7.520
	4Q	28.142	5.372	1.092	4.603	1.227	0.373	0.023	2.318	1.807	11.201

Fractional Compositions	QTR	Non-Blank	OCMmb	EC	SO4	NO3r	CRUST	NH4r	PBW	SALT
	1Q	1.000	0.227	0.126	0.267	0.122	0.037	0.136	0.082	0.003
	2Q	1.000	0.353	0.167	0.250	0.000	0.046	0.093	0.090	0.001
	3Q	1.000	0.268	0.158	0.311	0.000	0.035	0.113	0.114	0.001
	4Q	1.000	0.405	0.167	0.194	0.039	0.044	0.084	0.065	0.001

The local and regional split on a high-day basis (shown in Table 3-7) is similar to that used for the annual calculations, with the Pittsburgh MSA sites used to generate an average regional composition. The regional compositions are based on days concurrent with Liberty high-day samples, ensuring that samples are paired in time for the regional and local component.

Table 3-7. Quarterly High-Day Composition (μg/m³) of Pittsburgh MSA Sites, Base Case, 24-Hour

Site	QTR	FRMc	Blank	Non-Blank	OCMmb	EC	SO4	NO3r	CRUST	NH4r	PBW	SALT
Lawrenceville	1Q	14.817	0.500	14.317	3.275	0.907	3.725	2.442	0.632	2.048	1.159	0.130
	2Q	16.537	0.500	16.037	6.286	1.044	4.572	0.000	0.993	1.499	1.627	0.017
	3Q	18.677	0.500	18.177	5.747	1.250	6.073	0.000	1.060	1.940	2.087	0.019
	4Q	15.433	0.500	14.933	5.657	1.339	3.087	1.384	1.039	1.426	0.961	0.041
Florence	1Q	8.473	0.500	7.973	1.691	0.434	2.693	0.927	0.346	1.090	0.780	0.012
	2Q	10.834	0.500	10.334	3.534	0.687	3.699	0.000	0.664	0.959	0.782	0.009
	3Q	13.077	0.500	12.577	2.815	0.642	5.673	0.000	0.870	1.431	1.134	0.012
	4Q	8.657	0.500	8.157	1.906	0.542	2.645	0.816	0.604	0.970	0.666	0.008
Greensburg	1Q	11.726	0.500	11.226	3.739	0.817	2.789	1.216	0.410	1.307	0.883	0.066
	2Q	20.367	0.500	19.867	8.730	1.095	5.577	0.000	0.675	1.812	1.963	0.014
	3Q	20.786	0.500	20.286	8.141	1.031	6.579	0.000	0.499	1.987	2.033	0.016
	4Q	14.675	0.500	14.175	6.836	1.234	2.778	0.914	0.487	1.106	0.797	0.023
MSA Regional (Avg)	1Q	11.672	0.500	11.172	2.902	0.719	3.069	1.528	0.462	1.482	0.940	0.069
	2Q	15.912	0.500	15.412	6.183	0.942	4.616	0.000	0.777	1.424	1.457	0.013
	3Q	17.513	0.500	17.013	5.568	0.974	6.108	0.000	0.810	1.786	1.751	0.016
	4Q	12.922	0.500	12.422	4.800	1.038	2.837	1.038	0.710	1.167	0.808	0.024
Liberty	1Q	19.608	0.500	19.108	4.335	2.403	5.111	2.332	0.704	2.593	1.575	0.057
	2Q	25.273	0.500	24.773	8.751	4.139	6.202	0.000	1.129	2.302	2.236	0.014
	3Q	28.553	0.500	28.053	7.520	4.423	8.727	0.000	0.995	3.175	3.199	0.015
	4Q	28.142	0.500	27.642	11.201	4.603	5.372	1.092	1.227	2.318	1.807	0.023

The Liberty local high-day component is determined from a series of calculations shown in Table 3-8, similar to those shown in Table 3-4 for the annual test. The raw Liberty local composition is determined by subtraction, and negative high-day concentrations for the local component are corrected to zero. The high-day regional component is then calculated as the difference of the adjusted local and the total high-day concentrations by species and quarter, and indirect species (NH4r, PBW) are recalculated specifically for the Liberty high-day regional component. The quarterly LPM is then calculated as the difference of total non-blank Liberty component and the sum of the recalculated regional species.

Table 3-8. Liberty High-Day Local and Regional Compositions (µg/m³), Base Case, 24-Hour

	QTR	LPM	Non-Blank	OCMmb	EC	SO4	NO3r	CRUST	NH4r	PBW	SALT
Liberty Local (by subtraction)	1Q		7.937	1.433	1.683	2.042	0.803	0.242	1.111	0.634	-0.013
	2Q		9.361	2.568	3.197	1.586	0.000	0.352	0.878	0.778	0.001
	3Q		11.040	1.952	3.448	2.618	0.000	0.185	1.389	1.448	-0.001
	4Q		15.220	6.402	3.564	2.535	0.054	0.517	1.150	1.000	-0.001
Liberty Local Adjusted (non-negative)	1Q		7.949	1.433	1.683	2.042	0.803	0.242	1.111	0.634	0.000
	2Q		9.360	2.568	3.197	1.586	0.000	0.352	0.878	0.778	0.000
	3Q		11.041	1.952	3.448	2.618	0.000	0.185	1.389	1.448	0.000
	4Q		15.221	6.402	3.564	2.535	0.054	0.517	1.150	1.000	0.000
Liberty Regional (total minus local adjusted)	1Q		11.159	2.902	0.719	3.069	1.528	0.462	1.482	0.940	0.057
	2Q		15.414	6.183	0.942	4.616	0.000	0.777	1.424	1.457	0.014
	3Q		17.012	5.568	0.974	6.108	0.000	0.810	1.786	1.751	0.015
	4Q		12.421	4.800	1.038	2.837	1.038	0.710	1.167	0.808	0.023
Liberty Regional (recalculated for NH4r, PBW) and LPM	1Q	7.864	11.244	2.902	0.719	3.069	1.528	0.462	1.594	0.939	0.031
	2Q	8.868	15.905	6.183	0.942	4.616	0.000	0.777	1.713	1.664	0.010
	3Q	10.122	17.931	5.568	0.974	6.108	0.000	0.810	2.222	2.239	0.009
	4Q	14.945	12.696	4.800	1.038	2.837	1.038	0.710	1.358	0.899	0.017
Liberty Regional Fractional Compositions (of regional non-blank)	1Q		1.000	0.258	0.064	0.273	0.136	0.041	0.142	0.083	0.003
	2Q		1.000	0.389	0.059	0.290	0.000	0.049	0.108	0.105	0.001
	3Q		1.000	0.311	0.054	0.341	0.000	0.045	0.124	0.125	0.001
	4Q		1.000	0.378	0.082	0.223	0.082	0.056	0.107	0.071	0.001

Local/Regional Ratios (of total non-blank)	QTR	LPM	Regional
	1Q	0.412	0.588
	2Q	0.358	0.642
	3Q	0.361	0.639
	4Q	0.541	0.459

The quarterly high-day fractional compositions are used to determine the base case quarterly high-day concentrations of each species of the non-blank FRM high-day masses. These compositions are shown on the left side (under "Base") of Tables 3-9 through 3-12 (showing the calculations by quarter). The highest eight FRM concentrations in each quarter over the 2009-2013 timeframe are used as the base case high days (FRMh).

The base case high-day concentrations for the modeled species are then multiplied by the RRFs in Table 2-3 to generate future case Liberty high-day species, shown on the right side (under "Future") of Tables 3-9 through 3-12. Indirect species NH4r and PBW are calculated for each future case high day, and the sum of all species plus blank mass is used as projected future mass (FRMf) for each high day.

As specified in the AERMOD Modeling Protocol, the modeled high days and RRFs can be determined in two ways (separately by local and regional component, or by total mass), with the method leading to the highest 24-hour design value used as the projection. (Both ways were tested, and the method by separate components led to the higher design value.)

Table 3-9. Liberty Base and Future Case High-Day Compositions (µg/m³), 24-Hour, 1st Quarter

					Base							Future									
YEAR	QTR	FRMh	Blank	Non-Blank	LPM	OCMmb	EC	SO4	NO3r	OTHER	SALT	LPM	OCMmb	EC	SO4	NO3r	OTHER	SALT	NH4r	PBW	FRMf
2009	1Q	54.8	0.5	54.3	22.35	8.25	2.04	8.72	4.34	1.31	0.09	16.90	9.44	1.71	6.57	3.43	1.62	0.09	3.46	2.00	45.7
	1Q	42.2	0.5	41.7	17.16	6.33	1.57	6.70	3.33	1.01	0.07	12.98	7.25	1.31	5.04	2.64	1.24	0.07	2.66	1.54	35.2
	1Q	40.3	0.5	39.8	16.38	6.04	1.50	6.39	3.18	0.96	0.07	12.39	6.92	1.25	4.81	2.52	1.18	0.07	2.53	1.47	33.6
	1Q	35.1	0.5	34.6	14.24	5.25	1.30	5.56	2.77	0.84	0.06	10.77	6.02	1.09	4.18	2.19	1.03	0.06	2.20	1.28	29.3
	1Q	33.3	0.5	32.8	13.50	4.98	1.23	5.27	2.62	0.79	0.05	10.21	5.70	1.03	3.97	2.07	0.98	0.05	2.09	1.21	27.8
	1Q	32.5	0.5	32.0	13.17	4.86	1.20	5.14	2.56	0.77	0.05	9.96	5.56	1.01	3.87	2.02	0.95	0.05	2.04	1.18	27.1
	1Q	31.6	0.5	31.1	12.80	4.72	1.17	4.99	2.49	0.75	0.05	9.68	5.41	0.98	3.76	1.97	0.93	0.05	1.98	1.15	26.4
	1Q	27.4	0.5	26.9	11.07	4.08	1.01	4.32	2.15	0.65	0.04	8.37	4.68	0.85	3.25	1.70	0.80	0.04	1.71	0.99	22.9
2010	1Q	69.9	0.5	69.4	28.56	10.54	2.61	11.15	5.55	1.68	0.11	21.60	12.07	2.18	8.39	4.39	2.07	0.11	4.42	2.56	58.3
	1Q	59.8	0.5	59.3	24.40	9.01	2.23	9.52	4.74	1.43	0.10	18.46	10.31	1.86	7.17	3.75	1.77	0.10	3.78	2.19	49.9
	1Q	50.4	0.5	49.9	20.54	7.58	1.88	8.01	3.99	1.21	0.08	15.53	8.68	1.57	6.03	3.15	1.49	0.08	3.18	1.84	42.0
	1Q	41.8	0.5	41.3	17.00	6.27	1.55	6.63	3.30	1.00	0.07	12.85	7.18	1.30	4.99	2.61	1.23	0.07	2.63	1.52	34.9
	1Q	37.1	0.5	36.6	15.06	5.56	1.38	5.88	2.93	0.89	0.06	11.39	6.36	1.15	4.43	2.31	1.09	0.06	2.33	1.35	31.0
	1Q	36.2	0.5	35.7	14.69	5.42	1.34	5.73	2.86	0.86	0.06	11.11	6.21	1.12	4.32	2.26	1.06	0.06	2.27	1.32	30.2
	1Q	36.2	0.5	35.7	14.69	5.42	1.34	5.73	2.86	0.86	0.06	11.11	6.21	1.12	4.32	2.26	1.06	0.06	2.27	1.32	30.2
	1Q	35.2	0.5	34.7	14.28	5.27	1.31	5.57	2.78	0.84	0.06	10.80	6.03	1.09	4.20	2.19	1.03	0.06	2.21	1.28	29.4
2011	1Q	35.0	0.5	34.5	14.20	5.24	1.30	5.54	2.76	0.83	0.06	10.74	6.00	1.08	4.17	2.18	1.03	0.06	2.20	1.27	29.2
	1Q	33.5	0.5	33.0	13.58	5.01	1.24	5.30	2.64	0.80	0.05	10.27	5.74	1.04	3.99	2.09	0.98	0.05	2.10	1.22	28.0
	1Q	32.4	0.5	31.9	13.13	4.84	1.20	5.12	2.55	0.77	0.05	9.93	5.55	1.00	3.86	2.02	0.95	0.05	2.03	1.18	27.1
	1Q	28.1	0.5	27.6	11.36	4.19	1.04	4.43	2.21	0.67	0.05	8.59	4.80	0.87	3.34	1.74	0.82	0.05	1.76	1.02	23.5
	1Q	26.3	0.5	25.8	10.62	3.92	0.97	4.14	2.06	0.62	0.04	8.03	4.49	0.81	3.12	1.63	0.77	0.04	1.64	0.95	22.0
	1Q	25.9	0.5	25.4	10.45	3.86	0.96	4.08	2.03	0.61	0.04	7.91	4.42	0.80	3.07	1.61	0.76	0.04	1.62	0.94	21.6
	1Q	24.6	0.5	24.1	9.92	3.66	0.91	3.87	1.93	0.58	0.04	7.50	4.19	0.76	2.91	1.52	0.72	0.04	1.53	0.89	20.6
	1Q	23.5	0.5	23.0	9.47	3.49	0.87	3.69	1.84	0.56	0.04	7.16	4.00	0.72	2.78	1.45	0.68	0.04	1.46	0.85	19.7
2012	1Q	54.3	0.5	53.8	22.14	8.17	2.03	8.64	4.30	1.30	0.09	16.75	9.35	1.69	6.51	3.40	1.60	0.09	3.43	1.98	45.3
	1Q	48.6	0.5	48.1	19.80	7.30	1.81	7.72	3.85	1.16	0.08	14.97	8.36	1.51	5.82	3.04	1.43	0.08	3.06	1.77	40.5
	1Q	42.5	0.5	42.0	17.29	6.38	1.58	6.75	3.36	1.02	0.07	13.07	7.30	1.32	5.08	2.65	1.25	0.07	2.67	1.55	35.5
	1Q	34.8	0.5	34.3	14.12	5.21	1.29	5.51	2.74	0.83	0.06	10.68	5.96	1.08	4.15	2.17	1.02	0.06	2.18	1.26	29.1
	1Q	34.6	0.5	34.1	14.03	5.18	1.28	5.48	2.73	0.83	0.06	10.61	5.93	1.07	4.12	2.16	1.02	0.06	2.17	1.26	28.9
	1Q	31.4	0.5	30.9	12.72	4.69	1.16	4.96	2.47	0.75	0.05	9.62	5.37	0.97	3.74	1.95	0.92	0.05	1.97	1.14	26.2
	1Q	30.8	0.5	30.3	12.47	4.60	1.14	4.87	2.42	0.73	0.05	9.43	5.27	0.95	3.66	1.92	0.90	0.05	1.93	1.12	25.7
	1Q	30.4	0.5	29.9	12.31	4.54	1.13	4.80	2.39	0.72	0.05	9.31	5.20	0.94	3.62	1.89	0.89	0.05	1.90	1.10	25.4
2013	1Q	43.6	0.5	43.1	17.74	6.55	1.62	6.92	3.45	1.04	0.07	13.42	7.49	1.35	5.21	2.72	1.28	0.07	2.74	1.59	36.4
	1Q	41.9	0.5	41.4	17.04	6.29	1.56	6.65	3.31	1.00	0.07	12.89	7.20	1.30	5.01	2.62	1.23	0.07	2.64	1.53	35.0
	1Q	38.1	0.5	37.6	15.47	5.71	1.42	6.04	3.01	0.91	0.06	11.70	6.54	1.18	4.55	2.38	1.12	0.06	2.39	1.39	31.8
	1Q	36.1	0.5	35.6	14.65	5.41	1.34	5.72	2.85	0.86	0.06	11.08	6.19	1.12	4.30	2.25	1.06	0.06	2.27	1.31	30.1
	1Q	31.7	0.5	31.2	12.84	4.74	1.17	5.01	2.50	0.75	0.05	9.71	5.42	0.98	3.77	1.97	0.93	0.05	1.99	1.15	26.5
	1Q	26.8	0.5	26.3	10.82	3.99	0.99	4.22	2.10	0.64	0.04	8.19	4.57	0.83	3.18	1.66	0.78	0.04	1.67	0.97	22.4
	1Q	26.7	0.5	26.2	10.78	3.98	0.99	4.21	2.10	0.63	0.04	8.15	4.56	0.82	3.17	1.66	0.78	0.04	1.67	0.97	22.3
	1Q	25.7	0.5	25.2	10.37	3.83	0.95	4.05	2.02	0.61	0.04	7.84	4.38	0.79	3.05	1.59	0.75	0.04	1.60	0.93	21.5

Table 3-10. Liberty Base and Future Case High-Day Compositions ($\mu g/m^3$), 24-Hour, 2nd Quarter

					Base							Future									
YEAR	QTR	FRMh	Blank	Non-Blank	LPM	OCMmb	EC	SO4	NO3r	OTHER	SALT	LPM	OCMmb	EC	SO4	NO3r	OTHER	SALT	NH4r	PBW	FRMf
2009	2Q	35.0	0.5	34.5	12.35	8.61	1.31	6.43	0.00	1.08	0.01	8.91	9.26	1.01	3.38	0.00	1.13	0.01	1.25	1.22	26.7
	2Q	33.6	0.5	33.1	11.85	8.26	1.26	6.17	0.00	1.04	0.01	8.55	8.89	0.97	3.24	0.00	1.09	0.01	1.20	1.17	25.6
	2Q	33.0	0.5	32.5	11.63	8.11	1.24	6.06	0.00	1.02	0.01	8.40	8.73	0.95	3.18	0.00	1.07	0.01	1.18	1.15	25.2
	2Q	32.4	0.5	31.9	11.42	7.96	1.21	5.94	0.00	1.00	0.01	8.24	8.56	0.93	3.12	0.00	1.05	0.01	1.16	1.13	24.7
	2Q	30.7	0.5	30.2	10.81	7.54	1.15	5.63	0.00	0.95	0.01	7.80	8.11	0.88	2.96	0.00	0.99	0.01	1.10	1.07	23.4
	2Q	29.3	0.5	28.8	10.31	7.19	1.09	5.37	0.00	0.90	0.01	7.44	7.73	0.84	2.82	0.00	0.95	0.01	1.05	1.02	22.4
	2Q	28.8	0.5	28.3	10.13	7.06	1.08	5.27	0.00	0.89	0.01	7.31	7.60	0.83	2.77	0.00	0.93	0.01	1.03	1.00	22.0
	2Q	27.4	0.5	26.9	9.63	6.71	1.02	5.01	0.00	0.84	0.01	6.95	7.22	0.79	2.63	0.00	0.88	0.01	0.98	0.95	20.9
2010	2Q	43.0	0.5	42.5	15.21	10.61	1.62	7.92	0.00	1.33	0.02	10.98	11.41	1.24	4.16	0.00	1.40	0.02	1.54	1.50	32.7
	2Q	41.4	0.5	40.9	14.64	10.21	1.56	7.62	0.00	1.28	0.02	10.57	10.98	1.19	4.00	0.00	1.34	0.02	1.49	1.44	31.5
	2Q	37.5	0.5	37.0	13.24	9.23	1.41	6.89	0.00	1.16	0.01	9.56	9.93	1.08	3.62	0.00	1.22	0.01	1.34	1.31	28.6
	2Q	34.8	0.5	34.3	12.28	8.56	1.30	6.39	0.00	1.08	0.01	8.86	9.21	1.00	3.36	0.00	1.13	0.01	1.25	1.21	26.5
	2Q	33.4	0.5	32.9	11.78	8.21	1.25	6.13	0.00	1.03	0.01	8.50	8.83	0.96	3.22	0.00	1.08	0.01	1.20	1.16	25.5
	2Q	29.5	0.5	29.0	10.38	7.24	1.10	5.40	0.00	0.91	0.01	7.49	7.79	0.85	2.84	0.00	0.95	0.01	1.05	1.02	22.5
	2Q	27.7	0.5	27.2	9.74	6.79	1.03	5.07	0.00	0.85	0.01	7.03	7.30	0.79	2.66	0.00	0.89	0.01	0.99	0.96	21.1
	2Q	26.8	0.5	26.3	9.41	6.56	1.00	4.90	0.00	0.83	0.01	6.79	7.06	0.77	2.57	0.00	0.86	0.01	0.96	0.93	20.5
2011	2Q	35.2	0.5	34.7	12.42	8.66	1.32	6.47	0.00	1.09	0.01	8.96	9.32	1.01	3.40	0.00	1.14	0.01	1.26	1.22	26.8
	2Q	33.3	0.5	32.8	11.74	8.19	1.25	6.11	0.00	1.03	0.01	8.47	8.81	0.96	3.21	0.00	1.08	0.01	1.19	1.16	25.4
	2Q	31.5	0.5	31.0	11.10	7.74	1.18	5.78	0.00	0.97	0.01	8.01	8.32	0.91	3.04	0.00	1.02	0.01	1.13	1.09	24.0
	2Q	30.3	0.5	29.8	10.67	7.44	1.13	5.55	0.00	0.94	0.01	7.70	8.00	0.87	2.92	0.00	0.98	0.01	1.08	1.05	23.1
	2Q	29.3	0.5	28.8	10.31	7.19	1.09	5.37	0.00	0.90	0.01	7.44	7.73	0.84	2.82	0.00	0.95	0.01	1.05	1.02	22.4
	2Q	28.0	0.5	27.5	9.84	6.86	1.05	5.12	0.00	0.86	0.01	7.10	7.38	0.80	2.69	0.00	0.90	0.01	1.00	0.97	21.4
	2Q	26.4	0.5	25.9	9.27	6.46	0.98	4.83	0.00	0.81	0.01	6.69	6.95	0.76	2.54	0.00	0.85	0.01	0.94	0.91	20.2
	2Q	24.0	0.5	23.5	8.41	5.87	0.89	4.38	0.00	0.74	0.01	6.07	6.31	0.69	2.30	0.00	0.77	0.01	0.85	0.83	18.3
2012	2Q	36.9	0.5	36.4	13.03	9.08	1.38	6.78	0.00	1.14	0.01	9.40	9.77	1.06	3.56	0.00	1.20	0.01	1.32	1.28	28.1
	2Q	35.0	0.5	34.5	12.35	8.61	1.31	6.43	0.00	1.08	0.01	8.91	9.26	1.01	3.38	0.00	1.13	0.01	1.25	1.22	26.7
	2Q	33.3	0.5	32.8	11.74	8.19	1.25	6.11	0.00	1.03	0.01	8.47	8.81	0.96	3.21	0.00	1.08	0.01	1.19	1.16	25.4
	2Q	32.3	0.5	31.8	11.38	7.94	1.21	5.93	0.00	1.00	0.01	8.21	8.54	0.93	3.11	0.00	1.05	0.01	1.16	1.12	24.6
	2Q	27.8	0.5	27.3	9.77	6.81	1.04	5.09	0.00	0.86	0.01	7.05	7.33	0.80	2.67	0.00	0.90	0.01	0.99	0.96	21.2
	2Q	27.4	0.5	26.9	9.63	6.71	1.02	5.01	0.00	0.84	0.01	6.95	7.22	0.79	2.63	0.00	0.88	0.01	0.98	0.95	20.9
	2Q	26.2	0.5	25.7	9.20	6.41	0.98	4.79	0.00	0.81	0.01	6.64	6.90	0.75	2.52	0.00	0.85	0.01	0.93	0.91	20.0
	2Q	25.7	0.5	25.2	9.02	6.29	0.96	4.70	0.00	0.79	0.01	6.51	6.77	0.74	2.47	0.00	0.83	0.01	0.92	0.89	19.6
2013	2Q	28.2	0.5	27.7	9.92	6.91	1.05	5.16	0.00	0.87	0.01	7.16	7.44	0.81	2.71	0.00	0.91	0.01	1.01	0.98	21.5
	2Q	27.8	0.5	27.3	9.77	6.81	1.04	5.09	0.00	0.86	0.01	7.05	7.33	0.80	2.67	0.00	0.90	0.01	0.99	0.96	21.2
	2Q	27.7	0.5	27.2	9.74	6.79	1.03	5.07	0.00	0.85	0.01	7.03	7.30	0.79	2.66	0.00	0.89	0.01	0.99	0.96	21.1
	2Q	25.4	0.5	24.9	8.91	6.21	0.95	4.64	0.00	0.78	0.01	6.43	6.69	0.73	2.44	0.00	0.82	0.01	0.90	0.88	19.4
	2Q	25.0	0.5	24.5	8.77	6.11	0.93	4.57	0.00	0.77	0.01	6.33	6.58	0.72	2.40	0.00	0.81	0.01	0.89	0.86	19.1
	2Q	22.6	0.5	22.1	7.91	5.52	0.84	4.12	0.00	0.69	0.01	5.71	5.93	0.65	2.16	0.00	0.73	0.01	0.80	0.78	17.3
	2Q	22.5	0.5	22.0	7.88	5.49	0.84	4.10	0.00	0.69	0.01	5.68	5.91	0.64	2.15	0.00	0.72	0.01	0.80	0.78	17.2
	2Q	20.3	0.5	19.8	7.09	4.94	0.75	3.69	0.00	0.62	0.01	5.11	5.32	0.58	1.94	0.00	0.65	0.01	0.72	0.70	15.5

Table 3-11. Liberty Base and Future Case High-Day Compositions (µg/m³), 24-Hour, 3rd Quarter

					Base							Future								
YEAR	QTR	FRMh	Blank	Non-Blank	LPM	OCMmb	EC	SO4	NO3r	OTHER	SALT	LPM	OCMmb	EC	SO4	NO3r	OTHER	SALT	NH4r	PBW	FRMf
2009	3Q	41.9	0.5	41.4	14.94	8.22	1.44	9.01	0.00	1.20	0.01	12.78	8.13	0.96	4.79	0.00	1.24	0.01	1.74	1.76	31.9
	3Q	33.5	0.5	33.0	11.91	6.55	1.15	7.19	0.00	0.95	0.01	10.19	6.48	0.76	3.82	0.00	0.98	0.01	1.39	1.40	25.5
	3Q	31.7	0.5	31.2	11.26	6.19	1.08	6.79	0.00	0.90	0.01	9.63	6.13	0.72	3.61	0.00	0.93	0.01	1.31	1.32	24.2
	3Q	31.1	0.5	30.6	11.04	6.07	1.06	6.66	0.00	0.88	0.01	9.44	6.01	0.71	3.54	0.00	0.91	0.01	1.29	1.30	23.7
	3Q	28.4	0.5	27.9	10.07	5.54	0.97	6.08	0.00	0.81	0.01	8.61	5.48	0.65	3.23	0.00	0.83	0.01	1.18	1.18	21.7
	3Q	28.4	0.5	27.9	10.07	5.54	0.97	6.08	0.00	0.81	0.01	8.61	5.48	0.65	3.23	0.00	0.83	0.01	1.18	1.18	21.7
	3Q	27.5	0.5	27.0	9.74	5.36	0.94	5.88	0.00	0.78	0.01	8.33	5.30	0.62	3.13	0.00	0.81	0.01	1.14	1.15	21.0
	3Q	26.9	0.5	26.4	9.53	5.24	0.92	5.75	0.00	0.76	0.01	8.15	5.19	0.61	3.06	0.00	0.79	0.01	1.11	1.12	20.5
2010	3Q	51.7	0.5	51.2	18.47	10.16	1.78	11.15	0.00	1.48	0.02	15.80	10.06	1.18	5.93	0.00	1.53	0.02	2.16	2.17	39.3
	3Q	48.8	0.5	48.3	17.43	9.59	1.68	10.52	0.00	1.39	0.02	14.91	9.49	1.12	5.59	0.00	1.44	0.02	2.04	2.05	37.1
	3Q	47.1	0.5	46.6	16.81	9.25	1.62	10.15	0.00	1.35	0.02	14.38	9.15	1.08	5.40	0.00	1.39	0.02	1.96	1.98	35.9
	3Q	47.0	0.5	46.5	16.78	9.23	1.61	10.13	0.00	1.34	0.02	14.35	9.13	1.08	5.39	0.00	1.39	0.02	1.96	1.97	35.8
	3Q	46.5	0.5	46.0	16.60	9.13	1.60	10.02	0.00	1.33	0.02	14.20	9.04	1.06	5.33	0.00	1.37	0.02	1.94	1.95	35.4
	3Q	44.5	0.5	44.0	15.88	8.73	1.53	9.58	0.00	1.27	0.01	13.58	8.64	1.02	5.10	0.00	1.31	0.01	1.85	1.87	33.9
	3Q	41.8	0.5	41.3	14.90	8.20	1.43	8.99	0.00	1.19	0.01	12.75	8.11	0.96	4.78	0.00	1.23	0.01	1.74	1.75	31.8
	3Q	39.7	0.5	39.2	14.14	7.78	1.36	8.54	0.00	1.13	0.01	12.10	7.70	0.91	4.54	0.00	1.17	0.01	1.65	1.66	30.2
2011	3Q	36.3	0.5	35.8	12.92	7.11	1.24	7.80	0.00	1.03	0.01	11.05	7.03	0.83	4.15	0.00	1.07	0.01	1.51	1.52	27.7
	3Q	35.0	0.5	34.5	12.45	6.85	1.20	7.51	0.00	1.00	0.01	10.65	6.78	0.80	4.00	0.00	1.03	0.01	1.45	1.46	26.7
	3Q	35.0	0.5	34.5	12.45	6.85	1.20	7.51	0.00	1.00	0.01	10.65	6.78	0.80	4.00	0.00	1.03	0.01	1.45	1.46	26.7
	3Q	34.2	0.5	33.7	12.16	6.69	1.17	7.34	0.00	0.97	0.01	10.40	6.62	0.78	3.90	0.00	1.01	0.01	1.42	1.43	26.1
	3Q	31.9	0.5	31.4	11.33	6.23	1.09	6.84	0.00	0.91	0.01	9.69	6.17	0.73	3.64	0.00	0.94	0.01	1.32	1.33	24.3
	3Q	31.7	0.5	31.2	11.26	6.19	1.08	6.79	0.00	0.90	0.01	9.63	6.13	0.72	3.61	0.00	0.93	0.01	1.31	1.32	24.2
	3Q	30.3	0.5	29.8	10.75	5.91	1.03	6.49	0.00	0.86	0.01	9.20	5.85	0.69	3.45	0.00	0.89	0.01	1.26	1.27	23.1
	3Q	28.2	0.5	27.7	9.99	5.50	0.96	6.03	0.00	0.80	0.01	8.55	5.44	0.64	3.21	0.00	0.83	0.01	1.17	1.18	21.5
2012	3Q	29.7	0.5	29.2	10.54	5.80	1.01	6.36	0.00	0.84	0.01	9.01	5.74	0.68	3.38	0.00	0.87	0.01	1.23	1.24	22.7
	3Q	28.3	0.5	27.8	10.03	5.52	0.97	6.05	0.00	0.80	0.01	8.58	5.46	0.64	3.22	0.00	0.83	0.01	1.17	1.18	21.6
	3Q	28.3	0.5	27.8	10.03	5.52	0.97	6.05	0.00	0.80	0.01	8.58	5.46	0.64	3.22	0.00	0.83	0.01	1.17	1.18	21.6
	3Q	27.2	0.5	26.7	9.63	5.30	0.93	5.81	0.00	0.77	0.01	8.24	5.24	0.62	3.09	0.00	0.80	0.01	1.12	1.13	20.8
	3Q	26.3	0.5	25.8	9.31	5.12	0.90	5.62	0.00	0.74	0.01	7.96	5.07	0.60	2.99	0.00	0.77	0.01	1.09	1.10	20.1
	3Q	26.3	0.5	25.8	9.31	5.12	0.90	5.62	0.00	0.74	0.01	7.96	5.07	0.60	2.99	0.00	0.77	0.01	1.09	1.10	20.1
	3Q	25.7	0.5	25.2	9.09	5.00	0.88	5.49	0.00	0.73	0.01	7.78	4.95	0.58	2.92	0.00	0.75	0.01	1.06	1.07	19.6
	3Q	25.6	0.5	25.1	9.06	4.98	0.87	5.47	0.00	0.72	0.01	7.75	4.93	0.58	2.91	0.00	0.75	0.01	1.06	1.07	19.5
2013	3Q	30.0	0.5	29.5	10.64	5.85	1.02	6.42	0.00	0.85	0.01	9.11	5.79	0.68	3.42	0.00	0.88	0.01	1.24	1.25	22.9
	3Q	25.4	0.5	24.9	8.98	4.94	0.86	5.42	0.00	0.72	0.01	7.69	4.89	0.58	2.88	0.00	0.74	0.01	1.05	1.06	19.4
	3Q	25.4	0.5	24.9	8.98	4.94	0.86	5.42	0.00	0.72	0.01	7.69	4.89	0.58	2.88	0.00	0.74	0.01	1.05	1.06	19.4
	3Q	25.3	0.5	24.8	8.95	4.92	0.86	5.40	0.00	0.72	0.01	7.65	4.87	0.57	2.87	0.00	0.74	0.01	1.04	1.05	19.3
	3Q	25.0	0.5	24.5	8.84	4.86	0.85	5.33	0.00	0.71	0.01	7.56	4.81	0.57	2.84	0.00	0.73	0.01	1.03	1.04	19.1
	3Q	22.2	0.5	21.7	7.83	4.31	0.75	4.73	0.00	0.63	0.01	6.70	4.26	0.50	2.51	0.00	0.65	0.01	0.91	0.92	17.0
	3Q	22.2	0.5	21.7	7.83	4.31	0.75	4.73	0.00	0.63	0.01	6.70	4.26	0.50	2.51	0.00	0.65	0.01	0.91	0.92	17.0
	3Q	22.0	0.5	21.5	7.76	4.27	0.75	4.68	0.00	0.62	0.01	6.64	4.22	0.50	2.49	0.00	0.64	0.01	0.91	0.91	16.8

Table 3-12. Liberty Base and Future Case High-Day Compositions (µg/m³), 24-Hour, 4th Quarter

					Base							Future									
YEAR	QTR	FRMh	Blank	Non-Blank	LPM	OCMmb	EC	SO4	NO3r	OTHER	SALT	LPM	OCMmb	EC	SO4	NO3r	OTHER	SALT	NH4r	PBW	FRMf
2009	4Q	92.1	0.5	91.6	49.53	15.91	3.44	9.40	3.44	2.35	0.06	38.75	16.74	2.57	8.69	2.73	2.62	0.06	4.03	2.80	79.5
	4Q	59.2	0.5	58.7	31.74	10.19	2.21	6.02	2.20	1.51	0.04	24.83	10.73	1.65	5.57	1.75	1.68	0.04	2.58	1.80	51.1
	4Q	55.7	0.5	55.2	29.85	9.58	2.07	5.66	2.07	1.42	0.03	23.35	10.09	1.55	5.24	1.65	1.58	0.03	2.43	1.69	48.1
	4Q	49.9	0.5	49.4	26.71	8.58	1.86	5.07	1.85	1.27	0.03	20.90	9.03	1.39	4.69	1.47	1.41	0.03	2.17	1.51	43.1
	4Q	46.2	0.5	45.7	24.71	7.94	1.72	4.69	1.72	1.17	0.03	19.33	8.35	1.28	4.34	1.36	1.31	0.03	2.01	1.40	39.9
	4Q	45.3	0.5	44.8	24.22	7.78	1.68	4.60	1.68	1.15	0.03	18.95	8.19	1.26	4.25	1.34	1.28	0.03	1.97	1.37	39.1
	4Q	40.6	0.5	40.1	21.68	6.96	1.51	4.11	1.51	1.03	0.02	16.96	7.33	1.12	3.81	1.20	1.15	0.02	1.76	1.23	35.1
	4Q	35.9	0.5	35.4	19.14	6.15	1.33	3.63	1.33	0.91	0.02	14.98	6.47	0.99	3.36	1.06	1.01	0.02	1.56	1.08	31.0
2010	4Q	58.4	0.5	57.9	31.31	10.05	2.18	5.94	2.17	1.49	0.04	24.49	10.58	1.62	5.49	1.73	1.66	0.04	2.55	1.77	50.4
	4Q	50.7	0.5	50.2	27.14	8.72	1.89	5.15	1.88	1.29	0.03	21.24	9.17	1.41	4.76	1.50	1.44	0.03	2.21	1.54	43.8
	4Q	47.9	0.5	47.4	25.63	8.23	1.78	4.86	1.78	1.22	0.03	20.05	8.66	1.33	4.50	1.41	1.36	0.03	2.09	1.45	41.4
	4Q	43.6	0.5	43.1	23.30	7.48	1.62	4.42	1.62	1.11	0.03	18.23	7.88	1.21	4.09	1.29	1.23	0.03	1.90	1.32	37.7
	4Q	41.3	0.5	40.8	22.06	7.08	1.53	4.19	1.53	1.05	0.03	17.26	7.46	1.14	3.87	1.22	1.17	0.03	1.80	1.25	35.7
	4Q	40.6	0.5	40.1	21.68	6.96	1.51	4.11	1.51	1.03	0.02	16.96	7.33	1.12	3.81	1.20	1.15	0.02	1.76	1.23	35.1
	4Q	36.7	0.5	36.2	19.57	6.29	1.36	3.71	1.36	0.93	0.02	15.31	6.61	1.02	3.44	1.08	1.04	0.02	1.59	1.11	31.7
	4Q	34.1	0.5	33.6	18.17	5.83	1.26	3.45	1.26	0.86	0.02	14.21	6.14	0.94	3.19	1.00	0.96	0.02	1.48	1.03	29.5
2011	4Q	59.0	0.5	58.5	31.63	10.16	2.20	6.00	2.20	1.50	0.04	24.75	10.69	1.64	5.55	1.75	1.67	0.04	2.57	1.79	50.9
	4Q	57.0	0.5	56.5	30.55	9.81	2.12	5.80	2.12	1.45	0.03	23.90	10.32	1.58	5.36	1.69	1.62	0.03	2.49	1.73	49.2
	4Q	48.1	0.5	47.6	25.74	8.27	1.79	4.88	1.79	1.22	0.03	20.14	8.70	1.34	4.52	1.42	1.36	0.03	2.09	1.46	41.5
	4Q	46.7	0.5	46.2	24.98	8.02	1.74	4.74	1.73	1.19	0.03	19.55	8.44	1.30	4.38	1.38	1.32	0.03	2.03	1.41	40.3
	4Q	44.8	0.5	44.3	23.95	7.69	1.66	4.55	1.66	1.14	0.03	18.74	8.09	1.24	4.20	1.32	1.27	0.03	1.95	1.35	38.7
	4Q	40.1	0.5	39.6	21.41	6.88	1.49	4.06	1.49	1.02	0.02	16.75	7.24	1.11	3.76	1.18	1.13	0.02	1.74	1.21	34.6
	4Q	38.0	0.5	37.5	20.28	6.51	1.41	3.85	1.41	0.96	0.02	15.86	6.85	1.05	3.56	1.12	1.07	0.02	1.65	1.15	32.8
	4Q	37.3	0.5	36.8	19.90	6.39	1.38	3.78	1.38	0.95	0.02	15.57	6.72	1.03	3.49	1.10	1.05	0.02	1.62	1.13	32.2
2012	4Q	54.7	0.5	54.2	29.31	9.41	2.04	5.56	2.03	1.39	0.03	22.93	9.90	1.52	5.14	1.62	1.55	0.03	2.38	1.66	47.2
	4Q	48.9	0.5	48.4	26.17	8.40	1.82	4.97	1.82	1.24	0.03	20.48	8.84	1.36	4.59	1.44	1.38	0.03	2.13	1.48	42.2
	4Q	47.1	0.5	46.6	25.20	8.09	1.75	4.78	1.75	1.20	0.03	19.71	8.52	1.31	4.42	1.39	1.33	0.03	2.05	1.43	40.7
	4Q	42.8	0.5	42.3	22.87	7.34	1.59	4.34	1.59	1.09	0.03	17.90	7.73	1.19	4.01	1.26	1.21	0.03	1.86	1.29	37.0
	4Q	38.1	0.5	37.6	20.33	6.53	1.41	3.86	1.41	0.97	0.02	15.91	6.87	1.05	3.57	1.12	1.08	0.02	1.65	1.15	32.9
	4Q	32.2	0.5	31.7	17.14	5.50	1.19	3.25	1.19	0.81	0.02	13.41	5.79	0.89	3.01	0.95	0.91	0.02	1.39	0.97	27.8
	4Q	31.7	0.5	31.2	16.87	5.42	1.17	3.20	1.17	0.80	0.02	13.20	5.70	0.88	2.96	0.93	0.89	0.02	1.37	0.95	27.4
	4Q	30.7	0.5	30.2	16.33	5.24	1.13	3.10	1.13	0.78	0.02	12.78	5.52	0.85	2.87	0.90	0.86	0.02	1.33	0.92	26.5
2013	4Q	37.5	0.5	37.0	20.01	6.42	1.39	3.80	1.39	0.95	0.02	15.65	6.76	1.04	3.51	1.10	1.06	0.02	1.63	1.13	32.4
	4Q	35.5	0.5	35.0	18.92	6.08	1.31	3.59	1.31	0.90	0.02	14.81	6.40	0.98	3.32	1.04	1.00	0.02	1.54	1.07	30.7
	4Q	31.1	0.5	30.6	16.55	5.31	1.15	3.14	1.15	0.79	0.02	12.95	5.59	0.86	2.90	0.91	0.88	0.02	1.35	0.94	26.9
	4Q	26.2	0.5	25.7	13.90	4.46	0.97	2.64	0.96	0.66	0.02	10.87	4.70	0.72	2.44	0.77	0.74	0.02	1.13	0.79	22.7
	4Q	24.7	0.5	24.2	13.08	4.20	0.91	2.48	0.91	0.62	0.01	10.24	4.42	0.68	2.30	0.72	0.69	0.01	1.06	0.74	21.4
	4Q	24.6	0.5	24.1	13.03	4.18	0.91	2.47	0.90	0.62	0.01	10.20	4.40	0.68	2.29	0.72	0.69	0.01	1.06	0.74	21.3
	4Q	24.5	0.5	24.0	12.98	4.17	0.90	2.46	0.90	0.62	0.01	10.15	4.39	0.67	2.28	0.72	0.69	0.01	1.06	0.73	21.2
	4Q	24.4	0.5	23.9	12.92	4.15	0.90	2.45	0.90	0.61	0.01	10.11	4.37	0.67	2.27	0.71	0.68	0.01	1.05	0.73	21.1

The projected future case masses (FRMf) are then grouped by year and sorted from high to low to determine the future case 98th percentile for each year, as shown in Table 3-13 below. The 98th percentile rankings (7th-high or 8th-high) are based on the base case data recoveries.[16]

Table 3-13. Yearly Future Case High Days and 98th Percentiles (μg/m³), 24-Hour

Year	Qtr	Conc	Year	Qtr	Conc	Year	Qtr	Conc	Year	Qtr	Conc	Year	Qtr	Conc
2009	4Q	79.5	2010	1Q	58.3	2011	4Q	50.9	2012	4Q	47.2	2013	1Q	36.4
2009	4Q	51.1	2010	4Q	50.4	2011	4Q	49.2	2012	1Q	45.3	2013	1Q	35.0
2009	4Q	48.1	2010	1Q	49.9	2011	4Q	41.5	2012	4Q	42.2	2013	4Q	32.4
2009	1Q	45.7	2010	4Q	43.8	2011	4Q	40.3	2012	4Q	40.7	2013	1Q	31.8
2009	4Q	43.1	2010	1Q	42.0	2011	4Q	38.7	2012	1Q	40.5	2013	4Q	30.7
2009	4Q	39.9	2010	4Q	41.4	2011	4Q	34.6	2012	4Q	37.0	2013	1Q	30.1
2009	4Q	39.1	2010	3Q	39.3	2011	4Q	32.8	2012	1Q	35.5	2013	4Q	26.9
2009	1Q	35.2	2010	4Q	37.7	2011	4Q	32.2	2012	4Q	32.9	2013	1Q	26.5
2009	4Q	35.1	2010	3Q	37.1	2011	1Q	29.2	2012	1Q	29.1	2013	3Q	22.9
2009	1Q	33.6	2010	3Q	35.9	2011	1Q	28.0	2012	1Q	28.9	2013	4Q	22.7
2009	3Q	31.9	2010	3Q	35.8	2011	3Q	27.7	2012	2Q	28.1	2013	1Q	22.4
2009	4Q	31.0	2010	4Q	35.7	2011	1Q	27.1	2012	4Q	27.8	2013	1Q	22.3
2009	1Q	29.3	2010	3Q	35.4	2011	2Q	26.8	2012	4Q	27.4	2013	2Q	21.5
2009	1Q	27.8	2010	4Q	35.1	2011	3Q	26.7	2012	2Q	26.7	2013	1Q	21.5
2009	1Q	27.1	2010	1Q	34.9	2011	3Q	26.7	2012	4Q	26.5	2013	4Q	21.4
2009	2Q	26.7	2010	3Q	33.9	2011	3Q	26.1	2012	1Q	26.2	2013	4Q	21.3
2009	1Q	26.4	2010	2Q	32.7	2011	2Q	25.4	2012	1Q	25.7	2013	2Q	21.2
2009	2Q	25.6	2010	3Q	31.8	2011	3Q	24.3	2012	1Q	25.4	2013	4Q	21.2
2009	3Q	25.5	2010	4Q	31.7	2011	3Q	24.2	2012	2Q	25.4	2013	2Q	21.1
2009	2Q	25.2	2010	2Q	31.5	2011	2Q	24.0	2012	2Q	24.6	2013	4Q	21.1
2009	2Q	24.7	2010	1Q	31.0	2011	1Q	23.5	2012	3Q	22.7	2013	2Q	19.4
2009	3Q	24.2	2010	3Q	30.2	2011	2Q	23.1	2012	3Q	21.6	2013	3Q	19.4
2009	3Q	23.7	2010	1Q	30.2	2011	3Q	23.1	2012	3Q	21.6	2013	3Q	19.4
2009	2Q	23.4	2010	1Q	30.2	2011	2Q	22.4	2012	2Q	21.2	2013	3Q	19.3
2009	1Q	22.9	2010	4Q	29.5	2011	1Q	22.0	2012	2Q	20.9	2013	2Q	19.1
2009	2Q	22.4	2010	1Q	29.4	2011	1Q	21.6	2012	3Q	20.8	2013	3Q	19.1
2009	2Q	22.0	2010	2Q	28.6	2011	3Q	21.5	2012	3Q	20.1	2013	2Q	17.3
2009	3Q	21.7	2010	2Q	26.5	2011	2Q	21.4	2012	3Q	20.1	2013	2Q	17.2
2009	3Q	21.7	2010	2Q	25.5	2011	1Q	20.6	2012	2Q	20.0	2013	3Q	17.0
2009	3Q	21.0	2010	2Q	22.5	2011	2Q	20.2	2012	2Q	19.6	2013	3Q	17.0
2009	2Q	20.9	2010	2Q	21.1	2011	1Q	19.7	2012	3Q	19.6	2013	3Q	16.8
2009	3Q	20.5	2010	2Q	20.5	2011	2Q	18.3	2012	3Q	19.5	2013	2Q	15.5
		7th-high			7th-high			7th-high			7th-high			8th-high

[16] If more than 350 valid samples, the 98th percentile is the 8th-highest 24-hour concentration. If between 301-350 samples, the 98th percentile is the 7th-highest. See 40 CFR Part 50 Appendix N.

The 98th percentiles from each year are then averaged over consecutive three-year periods to determine future case design values, with the final weighted (five-year) future case design value calculated as the average of the three-year averages, as shown in Table 3-14.

Table 3-14. Liberty Future Case Design Value (µg/m³), 24-Hour

Future Projected FRM 98th Percentiles

	2009	2010	2011	2012	2013
98th Percentile	39.1	39.3	32.8	35.5	26.5

3-Year Design Values

3-Year Period	Avg
2009-2011	37.1
2010-2012	35.9
2011-2013	31.6

5-Year Weighted Average

5-Year Period	Avg
Future	34.8

The future case 24-hour design value was calculated as 34.8 µg/m³, which rounds to 35 µg/m³ based on the NAAQS conventions. Thus, the Liberty LAA passes the $PM_{2.5}$ 24-hour attainment test, equal to the standard of 35 µg/m³.

APPENDICES

APPENDIX A – Plant Diagrams

This appendix shows the plant diagram for each LPM facility modeled with AERMOD, including buildings (for potential downwash effects) for the U. S. Steel Mon Valley Works sources. Buildings were not included for the more distant sources, since downwash is not a factor several miles away from Liberty. Additionally, the Clairton Plant diagram includes the future case sources, while the distant sources include only the base case configuration (before modification or shutdown).

Figure A-1. U. S. Steel Clairton Plant Diagram

Figure A-2. U. S. Steel Irvin Plant Diagram

Figure A-3. U. S. Steel Edgar Thomson Plant Diagram

Figure A-4. Allegheny Ludlum Plant Diagram

Figure A-5. McConway & Torley Plant Diagram

Figure A-6. Shenango Plant Diagram

APPENDIX B – MMIF Data

Figure B-1 shows the locations of the 2011 MMIF meteorological site-specific data used for the LAA modeling, repeated from the AERMOD Modeling Protocol. The USS sources fell within the 0.444 km domain (used only for MMIF, not for the CAMx modeling), and the distant sources fell within the 1.33 km domain.

Figure B-1. MMIF Cell Locations, 2011

Table B-1 shows the profile base elevation for each MMIF cell compared to actual plant elevation. The USS cells from the higher resolution 0.444 km domain showed elevations that were closest to actual elevation, indicating that WRF is recognizing the depth of the river valley. For the distant sources, the 1.33 km domain retains some smoothing of higher terrain features within each MMIF cell.

Table B-1. MMIF Cell Elevations

Grid Cell	MMIF (Profile Base) Elevation	Actual Plant Elevation
USS Clairton	228 m	231 m
USS Edgar Thomson	227 m	225 m
USS Irvin	273 m	287 m
Allegheny Ludlum	260 m	233 m
McConway & Torley	257 m	224 m
Shenango	250 m	220 m

Figures B-2 through B-7 show aerial maps of each MMIF cell location.

Figure B-2. USS Clairton MMIF Cell (0.444 km Resolution)

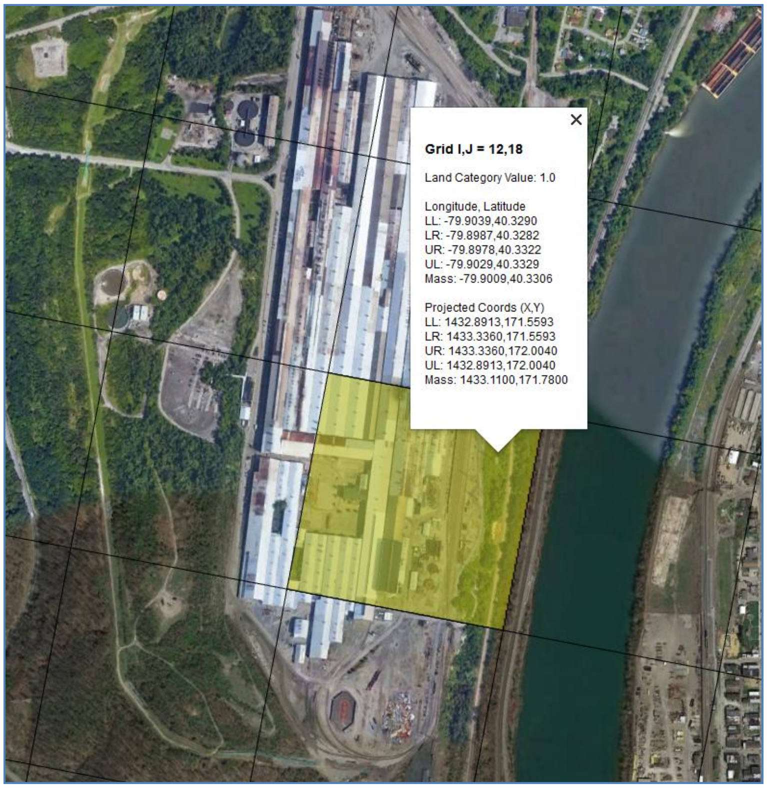

Figure B-3. USS Irvin MMIF Cell (0.444 km Resolution)

Figure B-4. USS Edgar Thomson MMIF Cell (0.444 km Resolution)

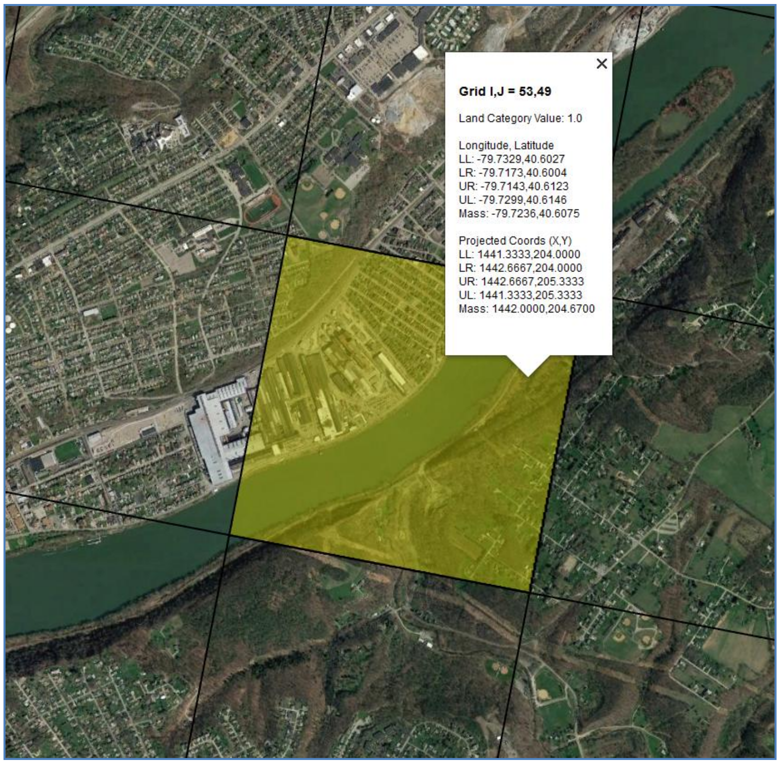

Figure B-5. ATI Allegheny Ludlum MMIF Cell (1.33 km Resolution)

Figure B-6. McConway & Torley MMIF Cell (1.33 km Resolution)

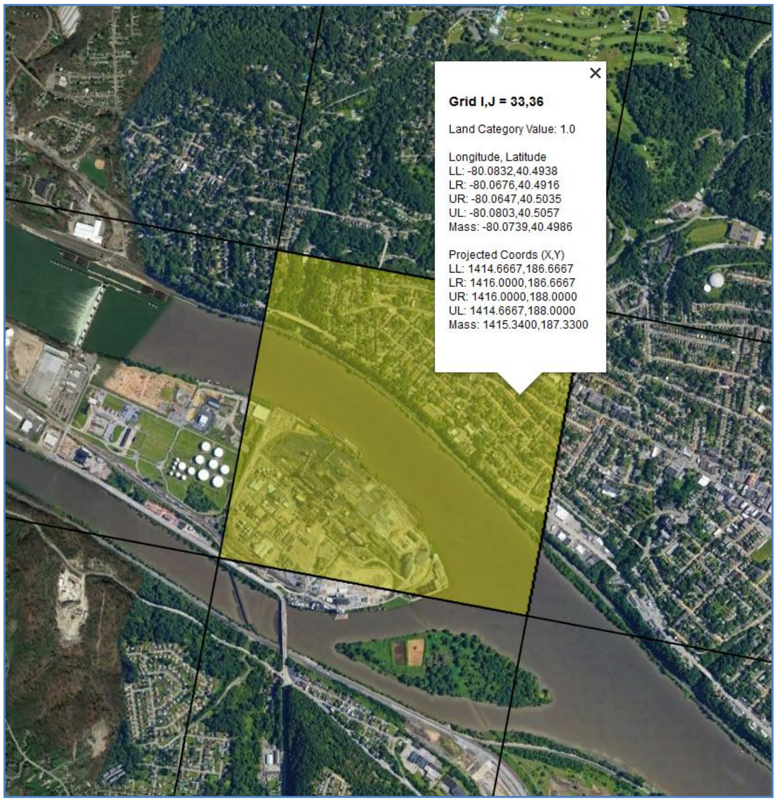

Figure B-7. Shenango MMIF Cell (1.33 km Resolution)

Figure B-8 shows wind roses of the USS MMIF cells at the 10 m surface level, revealing valley channel flow at the lowest vertical height. The Irvin location is higher than the other two cells and shows more regional flow, with winds predominately from the southwest.

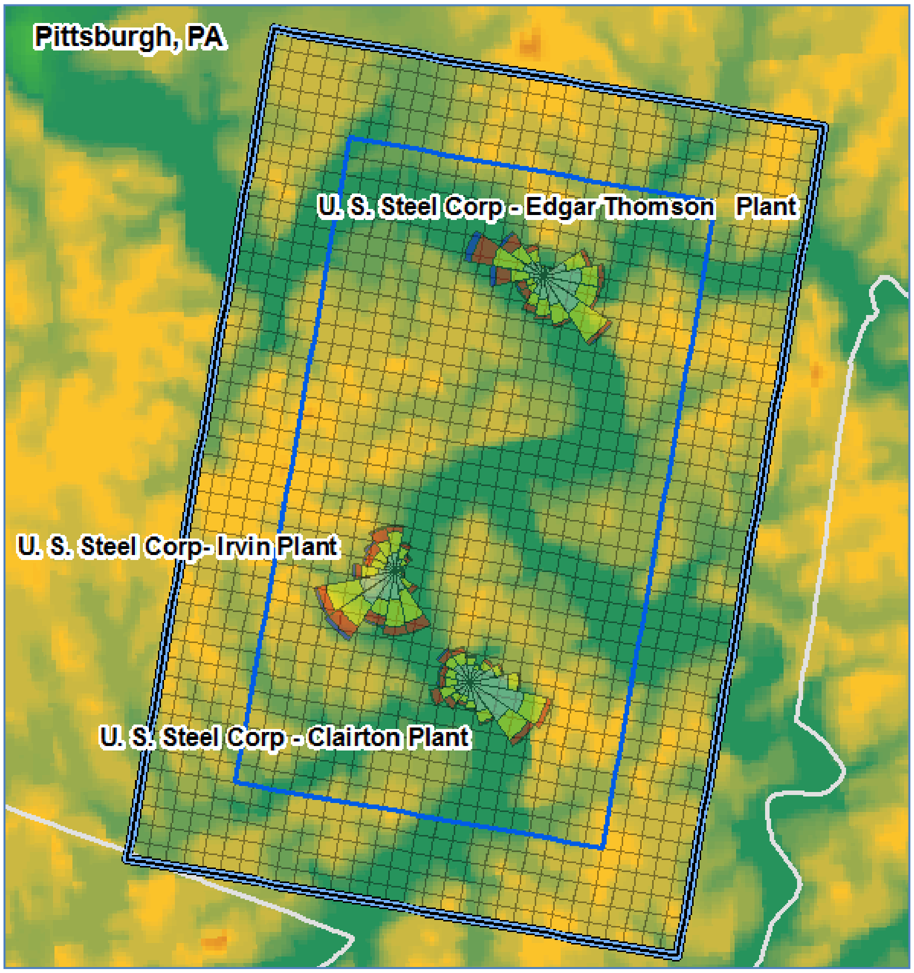

Figure B-8. U. S. Steel MMIF Wind Roses, 10 m (0.444 Resolution)

Figures B-9 through B-14 provide additional wind roses at increasing vertical levels (30 m through 160 m) for the Clairton MMIF data, based on the AERMOD-processed[17] meteorological data. The wind roses show that the valley flow converges to more regional wind flow at increasing heights, with the top of the valley terrain about 120-130 m above the river level. More stagnant conditions are also present in-valley, with the highest percentage of calm winds (< 0.5 m/s wind speed) at the lowest level.

[17] AERMOD uses the supplied meteorological data (in this case, MMIF) to build a profile from ground level (0 m) to 5000 m for each hour. The wind roses were based on these results, as generated as output by AERMOD's DEBUG METEOR option.

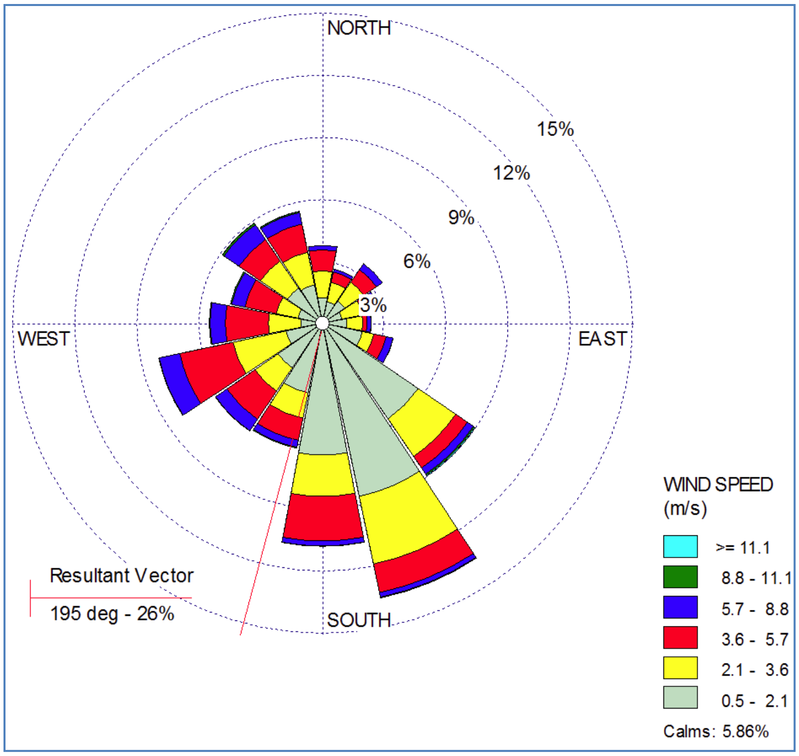

Figure B-9. MMIF Clairton 2011 Wind Rose (30 m Level)

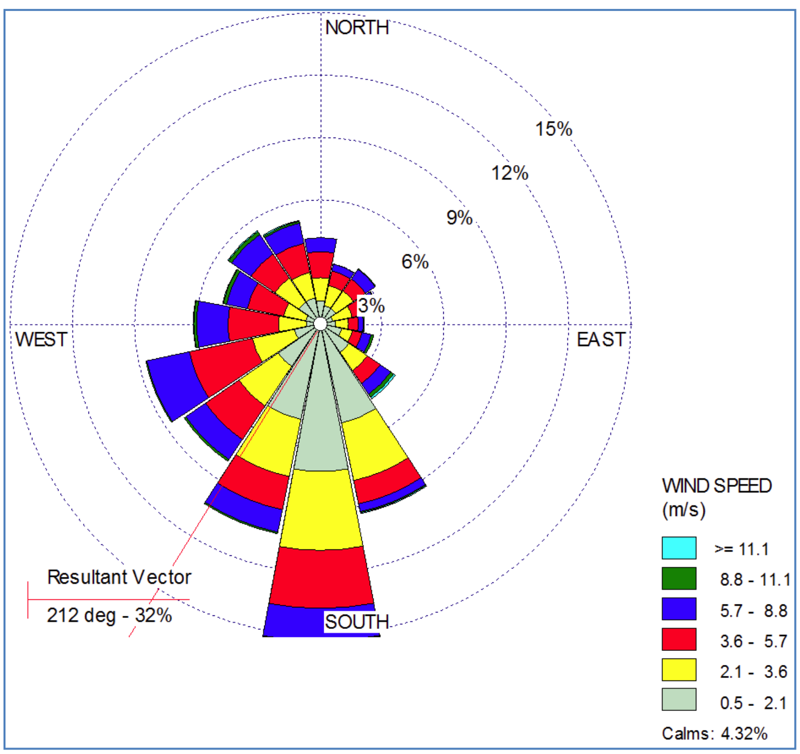

Figure B-10. MMIF Clairton 2011 Wind Rose (50 m Level)

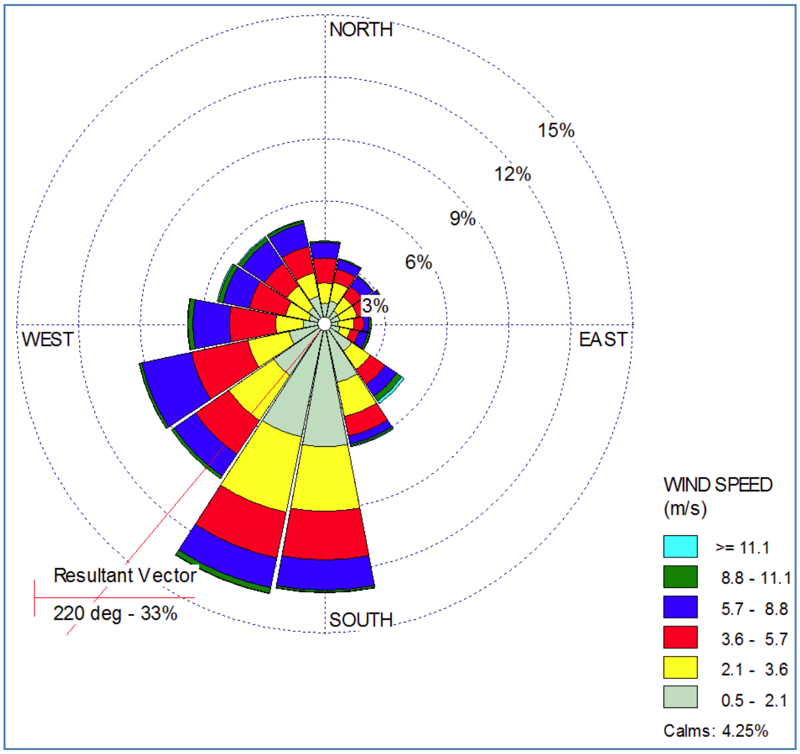

Figure B-11. MMIF Clairton 2011 Wind Rose (70 m Level)

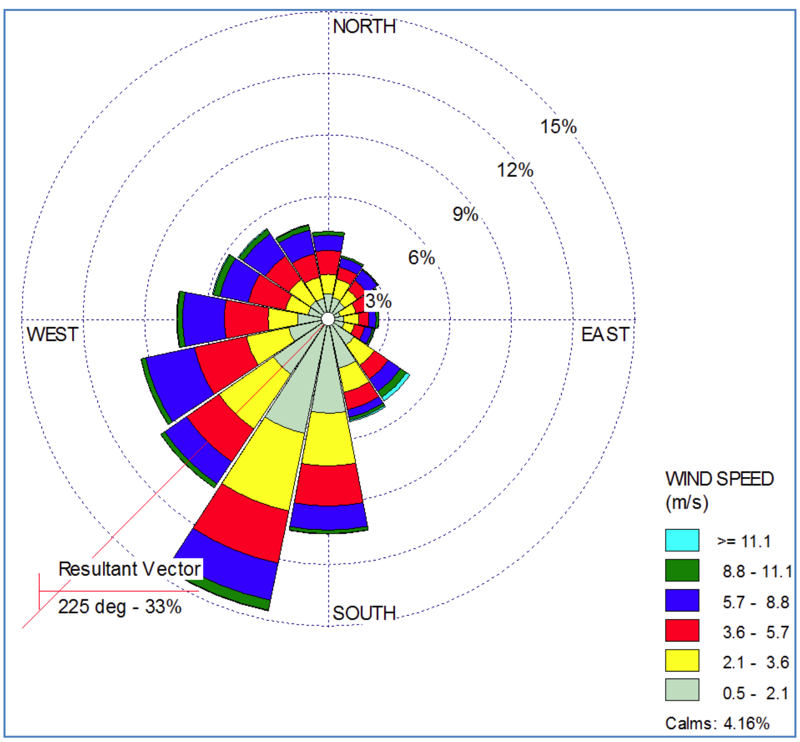

Figure B-12. MMIF Clairton 2011 Wind Rose (90 m Level)

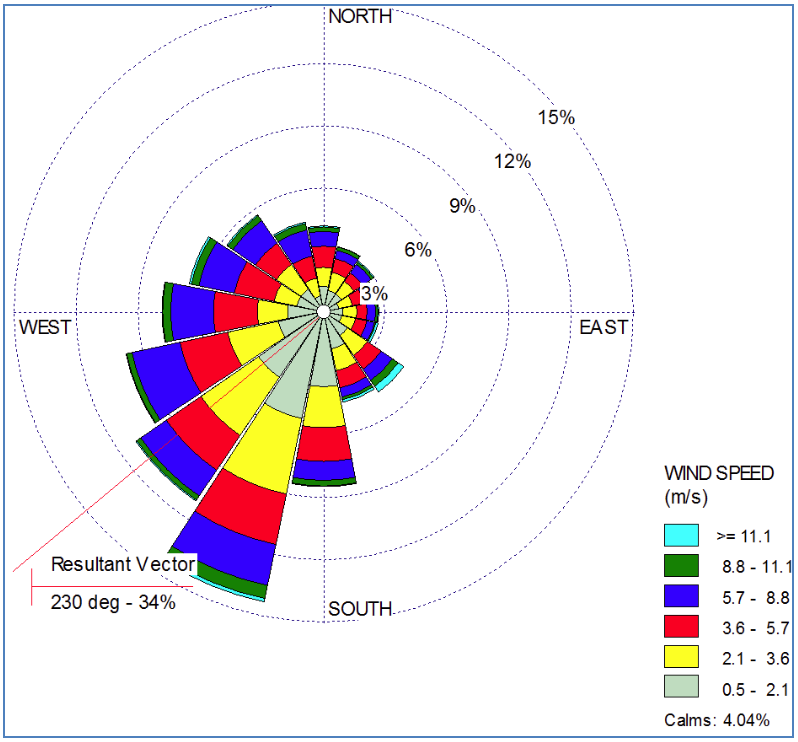

Figure B-13. MMIF Clairton 2011 Wind Rose (120 m Level)

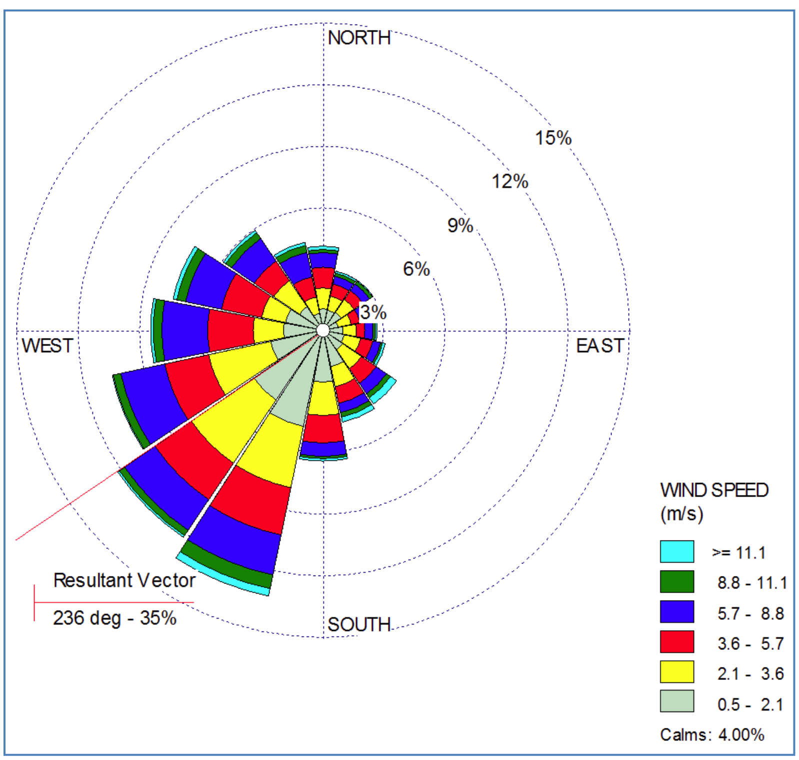

Figure B-14. MMIF Clairton 2011 Wind Rose (160 m Level)

APPENDIX C – Sample Model Files

This appendix includes sample model files used in the LAA modeling. Modeling files can be made available via DVD or data storage device (note: some output files are very large in size).

Sample AERMOD Input

```
CO STARTING
   TITLEONE  USS Clairton, Base 2011 Actuals, Liberty 500m Receptors
   TITLETWO  2012 PM2.5 NAAQS SIP, MMIF 2011 D05 WS50 NT, Refined Inputs
   POLLUTID  OTHER
   MODELOPT  DFAULT CONC
   FLAGPOLE  0.0
   AVERTIME  1 24 PERIOD
   RUNORNOT  RUN
   ERRORFIL  ERRORS.OUT
CO FINISHED

SO STARTING
   ELEVUNIT  METERS
**
**                QS       HS      TS      VS     DS
** POINT          ----     ---     ----    ----   ---
** UNITS          g/s       m       K      m/s     m
**
** DESCRSRC  US STEEL CLAIRTON Quench Tower 1
   LOCATION  CLQNCH1   POINT     595964  4461731    231
   SRCPARAM  CLQNCH1   1.6765   30.48   358.49    3.54   6.80
   BUILDHGT  CLQNCH1     8.50    8.50    8.50    0.00    0.00    0.00
   BUILDHGT  CLQNCH1     0.00    0.00    8.50    8.50    8.50    8.50
   BUILDHGT  CLQNCH1     8.50    8.50    8.50    8.50    8.50    8.50
   BUILDHGT  CLQNCH1     8.50    8.50    8.50    0.00    0.00    0.00
   BUILDHGT  CLQNCH1     0.00    0.00    8.50    8.50    8.50    8.50
   BUILDHGT  CLQNCH1     8.50    0.00    8.50    8.50    8.50    8.50
   BUILDWID  CLQNCH1   318.78  337.64  346.24    0.00    0.00    0.00
   BUILDWID  CLQNCH1     0.00    0.00  265.00  223.99  176.17  123.00
   BUILDWID  CLQNCH1    66.09   24.71  156.47  207.83  252.88  290.24
   BUILDWID  CLQNCH1   318.78  337.64  346.24    0.00    0.00    0.00
   BUILDWID  CLQNCH1     0.00    0.00  265.00  283.82  243.16  195.12
   BUILDWID  CLQNCH1   141.15    0.00  156.48  207.83  252.88  290.24
   BUILDLEN  CLQNCH1   283.82  243.16  195.12    0.00    0.00    0.00
   BUILDLEN  CLQNCH1     0.00    0.00  237.00  275.77  306.16  327.25
   BUILDLEN  CLQNCH1   338.39  339.97  351.95  350.44  338.28  315.85
   BUILDLEN  CLQNCH1   283.82  243.16  195.12    0.00    0.00    0.00
   BUILDLEN  CLQNCH1     0.00    0.00  237.00  318.78  337.64  346.23
   BUILDLEN  CLQNCH1   344.31    0.00  351.95  350.44  338.28  315.85
   XBADJ     CLQNCH1    -1.91   -6.76  -11.40    0.00    0.00    0.00
   XBADJ     CLQNCH1     0.00    0.00 -253.00 -293.96 -325.98 -348.10
   XBADJ     CLQNCH1  -359.65 -360.26 -368.55 -362.84 -346.10 -318.85
   XBADJ     CLQNCH1  -281.91 -236.40 -183.72    0.00    0.00    0.00
   XBADJ     CLQNCH1     0.00    0.00   16.00  -24.82  -11.65    1.87
   XBADJ     CLQNCH1    15.34    0.00   16.60   12.40    7.82    3.00
   YBADJ     CLQNCH1   134.57  157.16  174.99    0.00    0.00    0.00
   YBADJ     CLQNCH1     0.00    0.00  135.50  110.08   81.33   50.10
   YBADJ     CLQNCH1    17.34  -15.61  -11.87  -45.58  -77.92 -107.88
   YBADJ     CLQNCH1  -134.57 -157.16 -174.99    0.00    0.00    0.00
   YBADJ     CLQNCH1     0.00    0.00 -135.50 -140.00 -114.82  -86.16
   YBADJ     CLQNCH1   -54.87    0.00   11.87   45.58   77.92  107.88
……
**
** DESCRSRC  US STEEL CLAIRTON Coke Storage/Erosion (South Yard, Area = 16100 m²)
   LOCATION  CLEROS2   AREAPOLY  595726  4460737     231
   SRCPARAM  CLEROS2   3.662832E-07     6.10       4
   AREAVERT  CLEROS2   595726  4460737  595781 4460960  595848 4460943  595794 4460722
……
**
```

```
**
** DESCRSRC  US STEEL CLAIRTON B Battery Fugitives
   LOCATION  CLBBS01   VOLUME   595521.36   4462332.37    231
   SRCPARAM  CLBBS01    0.072687     112.44   7.77   26.15
   LOCATION  CLBBS02   VOLUME   595532.50   4462319.93    231
   SRCPARAM  CLBBS02    0.072687     112.44   7.77   26.15
   LOCATION  CLBBS03   VOLUME   595543.65   4462307.49    231
   SRCPARAM  CLBBS03    0.072687     112.44   7.77   26.15
   LOCATION  CLBBS04   VOLUME   595554.79   4462295.05    231
   SRCPARAM  CLBBS04    0.072687     112.44   7.77   26.15
   LOCATION  CLBBS05   VOLUME   595565.93   4462282.61    231
   SRCPARAM  CLBBS05    0.072687     112.44   7.77   26.15
   LOCATION  CLBBS06   VOLUME   595577.07   4462270.17    231
   SRCPARAM  CLBBS06    0.072687     112.44   7.77   26.15
……
**
** HOUREMIS  US STEEL B Battery Fugitives
   HOUREMIS  BATTS_2011.prn  CLBBS01 CLBBS02 CLBBS03 CLBBS04 CLBBS05 CLBBS06
……
**
   SRCGROUP  ALL
**
SO FINISHED

RE STARTING
   INCLUDED  LB_500m.rec
RE FINISHED

ME STARTING
   SURFFILE  USSC_MMIF_AERMET_D05_2011_WS50_NT_AER_ADJU.SFC
   PROFFILE  USSC_MMIF_AERMET_D05_2011_WS50_NT_AER_ADJU.PFL
   SURFDATA  99999  2011  MMIF_USS_CLN
   UAIRDATA  99999  2011  MMIF_USS_CLN
   SITEDATA  99999  2011  MMIF_USS_CLN
   STARTEND  2011 01 01  2011 12 31
   PROFBASE  228.0  METERS
ME FINISHED

OU STARTING
   RECTABLE  ALLAVE  FIRST
   MAXTABLE  ALLAVE  5
   SUMMFILE  MMIF_CLN_LIB_ALL_BASE.SUM
   POSTFILE  1  ALL UNFORM  MMIF_CLN_2011.POS    47
OU FINISHED
```

Sample AERMET Input (Stage 1)

```
JOB
    MESSAGES USSC.AERMET.2011.ER1
    REPORT   USSC.AERMET.2011.OU1

UPPERAIR
    DATA     USSC.AERMET.2011.UPA.FSL      FSL
    EXTRACT  USSC.AERMET.2011.UPA.FSL.IQA
    QAOUT    USSC.AERMET.2011.UPA.FSL.OQA

    LOCATION 99999   40.307N   79.880W   5
    XDATES   2011/01/01 2011/12/31
    AUDIT    UAPR UAHT UATT UATD UAWD UAWS

ONSITE
    DATA     USSC.AERMET.2011.DAT
    QAOUT    USSC.AERMET.2011.OQA
    XDATES   2011/01/01 2011/12/31
    LOCATION 99999   40.307N   79.880W   0     228.06
    READ    1 OSYR OSMO OSDY OSHR INSO PRCP PRES
    READ    2 HT01 TT01 RH01 DT01
    READ    3 HT02 WS02 WD02 TT02 RH02
    READ    4 HT03 WS03 WD03 TT03 RH03
    READ    5 HT04 WS04 WD04 TT04 RH04
    READ    6 HT05 WS05 WD05 TT05 RH05
    READ    7 HT06 WS06 WD06 TT06 RH06
    READ    8 HT07 WS07 WD07 TT07 RH07
    READ    9 HT08 WS08 WD08 TT08 RH08
    READ   10 HT09 WS09 WD09 TT09 RH09
    READ   11 HT10 WS10 WD10 TT10 RH10
    READ   12 HT11 WS11 WD11 TT11 RH11
    READ   13 HT12 WS12 WD12 TT12 RH12
    READ   14 HT13 WS13 WD13 TT13 RH13
    READ   15 HT14 WS14 WD14 TT14 RH14
    READ   16 HT15 WS15 WD15 TT15 RH15
    READ   17 HT16 WS16 WD16 TT16 RH16
    READ   18 HT17 WS17 WD17 TT17 RH17
    READ   19 HT18 WS18 WD18 TT18 RH18
    READ   20 HT19 WS19 WD19 TT19 RH19
    READ   21 HT20 WS20 WD20 TT20 RH20
    READ   22 HT21 WS21 WD21 TT21 RH21
    READ   23 HT22 WS22 WD22 TT22 RH22
    READ   24 HT23 WS23 WD23 TT23 RH23
    READ   25 HT24 WS24 WD24 TT24 RH24
    READ   26 HT25 WS25 WD25 TT25 RH25
    READ   27 HT26 WS26 WD26 TT26 RH26
    READ   28 HT27 WS27 WD27 TT27 RH27
    READ   29 HT28 WS28 WD28 TT28 RH28
    READ   30 HT29 WS29 WD29 TT29 RH29

    FORMAT  1 (2x,4I2.2,F10.2,2F10.3,1x)
    FORMAT  2 (10x,F10.2,20x,3F10.3)
    FORMAT  3 (10x,F10.2,4F10.3)
    FORMAT  4 (10x,F10.2,4F10.3)
    FORMAT  5 (10x,F10.2,4F10.3)
    FORMAT  6 (10x,F10.2,4F10.3)
    FORMAT  7 (10x,F10.2,4F10.3)
    FORMAT  8 (10x,F10.2,4F10.3)
    FORMAT  9 (10x,F10.2,4F10.3)
    FORMAT 10 (10x,F10.2,4F10.3)
    FORMAT 11 (10x,F10.2,4F10.3)
    FORMAT 12 (10x,F10.2,4F10.3)
    FORMAT 13 (10x,F10.2,4F10.3)
    FORMAT 14 (10x,F10.2,4F10.3)
    FORMAT 15 (10x,F10.2,4F10.3)
    FORMAT 16 (10x,F10.2,4F10.3)
    FORMAT 17 (10x,F10.2,4F10.3)
    FORMAT 18 (10x,F10.2,4F10.3)
    FORMAT 19 (10x,F10.2,4F10.3)
```

```
    FORMAT 20 (10x,F10.2,4F10.3)
    FORMAT 21 (10x,F10.2,4F10.3)
    FORMAT 22 (10x,F10.2,4F10.3)
    FORMAT 23 (10x,F10.2,4F10.3)
    FORMAT 24 (10x,F10.2,4F10.3)
    FORMAT 25 (10x,F10.2,4F10.3)
    FORMAT 26 (10x,F10.2,4F10.3)
    FORMAT 27 (10x,F10.2,4F10.3)
    FORMAT 28 (10x,F10.2,4F10.3)
    FORMAT 29 (10x,F10.2,4F10.3)
    FORMAT 30 (10x,F10.2,4F10.3)

    DELTA_TEMP    1     2.00    10.00
    OSHEIGHTS      2.0
    OSHEIGHTS      10.00     25.00     35.00     50.00     70.00     90.00
    OSHEIGHTS     112.50    137.50    162.50    187.50    225.00    275.00
    OSHEIGHTS     325.00    375.00    425.00    475.00    550.00    650.00
    OSHEIGHTS     750.00    850.00    950.00   1250.00   1750.00   2250.00
    OSHEIGHTS    2750.00   3250.00   3750.00   4500.00
    THRESHOLD     0.0
    RANGE WS 0 <= 50 999
    RANGE WD 0 <= 360 999
    RANGE TT -49 < 49 999
    RANGE DT01 -2 < 5 999
    RANGE INSO -1 < 1250 9999
    RANGE PRES 7500 < 10999 99999

    AUDIT TT01 DT01 RH01 INSO PRCP PRES
```

Sample AERMET Input (Stage 2)

```
JOB
    MESSAGES USSC.AERMET.2011.ER2
    REPORT   USSC.AERMET.2011.OU2

UPPERAIR
    QAOUT    USSC.AERMET.2011.UPA.FSL.OQA

ONSITE
    QAOUT    USSC.AERMET.2011.OQA

MERGE
    XDATES   2011/01/01 2011/12/31
    OUTPUT   USSC.AERMET.2011.MER
```

Sample AERMET Input (Stage 3)

```
JOB
    MESSAGES USSC.AERMET.2011.ER3
    REPORT   USSC.AERMET.2011.OU3

METPREP
    DATA     USSC.AERMET.2011.MER
    XDATES   2011/01/01 2011/12/31
    MODEL    AERMOD
    METHOD   STABLEBL BULKRN
    METHOD   STABLEBL ADJ_U*
    METHOD   WIND_DIR NORAND
    METHOD   ASOS_ADJ NO_ADJ
    METHOD   UASELECT SUNRISE
    AERSURF  USSC.AERMET.2011.AERSFC.DAT
    OUTPUT   USSC_MMIF_AERMET_D05_2011_WS50_NT_AER_ADJU.SFC
    PROFILE  USSC_MMIF_AERMET_D05_2011_WS50_NT_AER_ADJU.PFL
```

Sample AERMAP Input

```
CO STARTING
   TITLEONE  Liberty Cartesian Receptors (500 m) for PM2.5 LPM
   TITLETWO  Cartesian to 500 m Radius, ±50 ft of Liberty flagpole
   TERRHGTS  EXTRACT
   FLAGPOLE  0.0
   DATATYPE  NED
   DATAFILE  10m1.tif
   DATAFILE  10m2.tif
   DATAFILE  10m3.tif
   DATAFILE  10m4.tif
   DOMAINXY  590000.0 4457900.0 17  602100.0 4469700.0 17
   ANCHORXY  0.0    0.0   0.0    0.0   17   4
   DEBUGOPT  ALL
   RUNORNOT  RUN
CO FINISHED


RE STARTING
   DISCCART   595855.89 4463909.52     0.0
   DISCCART   595955.89 4463909.52     0.0
   DISCCART   596055.89 4463909.52     0.0
   DISCCART   596255.89 4463909.52     0.0
   DISCCART   596355.89 4463909.52     0.0
   DISCCART   596455.89 4463909.52     0.0
   DISCCART   595755.89 4464009.52     0.0
   DISCCART   596055.89 4464009.52     0.0
   DISCCART   596155.89 4464009.52     0.0
   DISCCART   596255.89 4464009.52     0.0
   DISCCART   596355.89 4464009.52     0.0
   DISCCART   596455.89 4464009.52     0.0
   DISCCART   596555.89 4464009.52     0.0
   DISCCART   595755.89 4464109.52     0.0
   DISCCART   595855.89 4464109.52     0.0
   DISCCART   595955.89 4464109.52     0.0
   DISCCART   596055.89 4464109.52     5.0
   DISCCART   596355.89 4464109.52     0.0
   DISCCART   596455.89 4464109.52     0.0
   DISCCART   596555.89 4464109.52     0.0
   DISCCART   595755.89 4464209.52     0.0
   DISCCART   595855.89 4464209.52     0.0
   DISCCART   595955.89 4464209.52     0.0
   DISCCART   596055.89 4464209.52     0.0
   DISCCART   596155.89 4464209.52     0.0
   DISCCART   595655.89 4464309.52     0.0
   DISCCART   595755.89 4464309.52     0.0
   DISCCART   595855.89 4464309.52     0.0
   DISCCART   595955.89 4464309.52     0.0
   DISCCART   596055.89 4464609.52     0.0
   DISCCART   596455.89 4464609.52     0.0
   DISCCART   595855.89 4464709.52     0.0
   DISCCART   595955.89 4464709.52     0.0
   DISCCART   596055.89 4464709.52     0.0
……
RE FINISHED


OU STARTING
   RECEPTOR  LB_500m.rec
**
**   DEBUGHIL  HILLBUG.OUT
**   DEBUGREC  RECBUG.OUT
OU FINISHED
```

Sample MMIF Control Input

```
; This file must be space-delimited or comma-delimited, or a mixture.
; Comment characters are #, ;, and !.  Blank lines are ignored.
; Omitting keywords is the same as giving their default values.

start      2011 01 01 01    ; start time in LST, hour-ending format
stop       2011 12 31 24    ; end   time in LST, hour-ending format

# TimeZone is relative to GMT, i.e. -5 (GMT-05) is the US East Coast

TimeZone   -5   ! default is zero, i.e. GMT-00

# LAYERS has four options: TOP, MID, K, followed by the values to be used.
# Default is the EPA/FLM Guidance layers.
# ACHD Levels

layers top 20 30 40 60 80 100 125 150 175 200 250 300 350 400 450 500 600 700 800 900 1000 1500
2000 2500 3000 3500 4000 5000

aer_mixht     AERMET
aer_min_mixht 1.0     ! default (same as AERMET)
aer_min_obuk  1.0     ! default (same as AERMET)
aer_min_speed 0.0     ! default (MMIF Guidance, 2018)
FSL_INTERVAL       6


# ------------------------------------

# Output section (d05 444 m domain)

POINT LL 40.3070 -79.8800
### USSC US Steel Clairton
# AERMET
Output aermet useful   mmif.achd_lev.D05/USSC.AERMET.2011.csh
Output aermet onsite   mmif.achd_lev.D05/USSC.AERMET.2011.dat
Output aermet upperair mmif.achd_lev.D05/USSC.AERMET.2011.upa.fsl
Output aermet aersfc   mmif.achd_lev.D05/USSC.AERMET.2011.aersfc.dat
# AERMOD
Output aermod useful   mmif.achd_lev.D05/USSC.AERMOD.2011.info.txt
Output aermod sfc      mmif.achd_lev.D05/USSC.AERMOD.2011.SFC
Output aermod pfl      mmif.achd_lev.D05/USSC.AERMOD.2011.PFL

# ------------------------------------

# INPUT gives filenames of either MM5 or WRF files

INPUT  ../2010-12-31/wrfout_2011-01-01_00:00:00
INPUT  ../2010-12-31/wrfout_2011-01-01_12:00:00
INPUT  ../2010-12-31/wrfout_2011-01-02_00:00:00
INPUT  ../2010-12-31/wrfout_2011-01-02_12:00:00
INPUT  ../2010-12-31/wrfout_2011-01-03_00:00:00
INPUT  ../2010-12-31/wrfout_2011-01-03_12:00:00
…..
INPUT  ../2011-12-26/wrfout_2011-12-29_00:00:00
INPUT  ../2011-12-26/wrfout_2011-12-29_12:00:00
INPUT  ../2011-12-26/wrfout_2011-12-30_00:00:00
INPUT  ../2011-12-26/wrfout_2011-12-30_12:00:00
INPUT  ../2011-12-31/wrfout_2011-12-31_00:00:00
INPUT  ../2011-12-31/wrfout_2011-12-31_12:00:00
```

<u>Sample MMIF Onsite Input</u>

- Surface level: solar radiation, precipitation, pressure
- First level (2 m): delta_T (temperature difference to next available level)
- For each specified level: wind speed, wind direction, temperature, relative humidity

{Headers added for descriptive purposes}

```
Date        Radiation    Precip  Pressure
2011010101       0.00     0.000  9903.168
               Height     Speed  Direction     Temp    Rel Hum    Delta_T
                 2.00                          7.575    78.224      2.224
                10.00     1.711    98.361      9.799    73.000
                25.00     1.510   146.481      9.989    72.000
                35.00     1.927   170.371      9.997    72.000
                50.00     2.824   184.832     10.077    72.000
                70.00     4.345   191.695     10.286    70.000
                90.00     5.848   193.459     10.546    69.000
               112.50     7.346   194.247     10.863    67.000
               137.50     8.703   195.021     11.172    65.000
               162.50     9.933   196.057     11.453    63.000
               187.50    11.263   197.885     11.753    61.000
               225.00    13.001   201.347     12.137    59.000
               275.00    15.125   206.352     12.446    57.000
               325.00    17.151   214.816     13.508    52.000
               375.00    17.213   217.275     13.796    50.000
               425.00    17.344   220.491     14.177    48.000
               475.00    17.323   220.562     14.168    48.000
               550.00    16.628   223.107     13.878    48.000
               650.00    15.829   225.188     13.273    52.000
               750.00    15.484   226.059     12.952    54.000
               850.00    14.658   227.921     11.983    60.000
               950.00    14.114   228.125     11.434    64.000
              1250.00    11.867   225.182      9.610    79.000
              1750.00    10.307   218.629      6.348    93.000
              2250.00    11.740   226.156      3.012    98.000
              2750.00    16.357   237.597     -0.093    83.000
              3250.00    17.887   239.914     -1.009    76.000
              3750.00    19.865   242.673     -4.851    57.000
              4500.00    20.979   243.791     -8.068    38.000
```

…..

Sample MMIF Upper Air Input

4 soundings (hours 0, 6, 12, 18, in UTC)

{Headers added for descriptive purposes}

```
REC_TYPE   HOUR     DAY     MONTH    YEAR
    254      0       2       JAN     2011
       WBAN#  WMO#     LAT     LON     ELEV  RTIME
      1  99999 999999  40.31N 79.88W   228      0
       HYDRO  MXWD   TROPL  LINES  INDEX  SOURCE
      2  32767  32767  32767     33  32767  32767
                                      SONDE  WSUNITS
      3         NONE                  32767     ms
         PRES    HT     TEMP  DEWPT    DIR    SPD
      9   986   228    107     99    128     22
      5   984   238    114    102    141     20
      5   982   253    116    102    164     28
      5   981   263    116    102    171     33
      5   979   278    116    103    179     40
      5   977   298    117    103    184     50
      5   975   318    117    103    190     59
      5   972   341    116    103    197     68
      5   969   366    116    103    203     77
      5   967   391    116    104    207     87
      5   963   416    115    104    212     99
      5   959   453    115    104    216    115
      5   954   503    114    105    220    134
      5   946   553    111    105    228    160
      5   942   603    109    104    231    166
      5   935   653    105    103    236    175
      5   935   703    105    102    236    175
      5   922   778     97     97    241    177
      5   909   878     90     90    243    175
      5   903   978     86     86    244    174
      5   888  1078     79     79    244    173
      5   879  1178     75     75    241    176
      5   847  1478     63     64    236    195
      5   798  1978     43     44    234    223
      5   747  2478     22     14    234    239
      5   689  2978    -12    -27    233    250
      5   674  3478    -20    -38    232    252
      5   613  3978    -64   -111    233    284
      5   571  4728    -96   -174    234    310
```

…..

Sample MMIF Surface Characteristics Input

Monthly albedo, Bowen ratio, surface roughness, averaged to MMIF cell (1 sector)

```
** Generated by MMIF VERSION 3.4 2018-05-08
** Center Latitude  (decimal degrees):     40.30705
** Center Longitude (decimal degrees):    -79.87991
** Datum: NWS-84
** Study radius (km) for surface roughness:      0.44444
** The rest of the AERSURFACE inputs are not applicable
**
   FREQ_SECT  MONTHLY  1
   SECTOR   1    0  360
**          Month    Sect    Alb      Bo        Zo
   SITE_CHAR    1       1     0.38     3.11   0.04502
   SITE_CHAR    2       1     0.35     2.29   0.04950
   SITE_CHAR    3       1     0.13     0.96   0.06589
   SITE_CHAR    4       1     0.13     0.92   0.09800
   SITE_CHAR    5       1     0.15     0.93   0.14130
   SITE_CHAR    6       1     0.15     0.79   0.14843
   SITE_CHAR    7       1     0.15     0.75   0.14146
   SITE_CHAR    8       1     0.14     0.77   0.13538
   SITE_CHAR    9       1     0.13     0.80   0.12786
   SITE_CHAR   10       1     0.13     1.54   0.10673
   SITE_CHAR   11       1     0.12     1.72   0.07326
   SITE_CHAR   12       1     0.10     1.76   0.05467
```

Sample BLP Input

```
USS CLAIRTON B BATTERY
&GEN
NLINES=1
NREC=13
LPART=.TRUE.
LCOMPR=.TRUE.
LINPUT=.TRUE.
LUTMS=.TRUE.
LTRANS=.FALSE.
/
&RISE
L=106.0
HB=15.1
WB=16.7
WM=1.0
DX=0.0
FPRIME=2408.2
/
&METIN
LMETIN=.FALSE.
LMETOT=.FALSE.
IDSURF=99999
IYSURF=2011
IDUPER=99999
IYUPER=2011
ZMEAS=10.0
IDELS=1
IRU=1
IDAYS=365*1
/
&CALC
/
&OUTPUT
IPCL=1,0,0,0,0,0,0,0,0,0,1
/
.....
/
  595515.8 4462338.6  595585.5 4462260.7      15.1      1.00     231.0
```

Sample BLPRISE Output

BLPRISE is the modified BLP code, with plume rise (DH) output

```
         BLP -- MULTIPLE BUOYANT LINE AND POINT SOURCE DISPERSION MODEL     SCRAM VERSION (DATED 99176)                 07/13/18
                                                                                                                        17:40:55
*******************************************************************************************************************************
```

.....

USS CLAIRTON B BATTERY

.....

NUMBER OF LINES: 1

LINE NUMBER	X START (M)	Y START (M)	X END (M)	Y END (M)	Q (GM/SEC)	HEIGHT (M)	ELEVATION (M)
1	595515.8	4462338.6	595585.5	4462260.7	1.00	15.10	231.0

.....

PLUME RISE HEIGHTS AND DISTANCES OUTPUT

YR	JDAY	HR	DH1	DH2	DH3	DH4	DH5	DH6	DH7	XF1	XF2	XF3	XF4	XF5	XF6	XF7	XFB	XFS
2011	1	1	0.00	21.11	36.81	52.73	68.17	83.04	97.34	0.00	82.10	110.95	139.79	168.64	197.49	226.33	82.10	226.33
2011	1	2	0.00	23.93	39.82	55.54	70.60	84.98	98.76	0.00	97.84	132.11	166.39	200.67	234.94	269.22	97.84	269.22
2011	1	3	0.00	26.65	42.44	58.08	73.12	87.53	101.35	0.00	96.20	126.91	157.62	188.33	219.03	249.74	96.20	249.74
2011	1	4	0.00	41.04	60.29	77.81	93.87	108.81	122.86	0.00	105.87	152.61	199.35	246.09	292.83	339.57	105.87	339.57
2011	1	5	0.00	31.93	51.04	68.43	84.33	99.10	112.99	0.00	105.18	157.74	210.31	262.87	315.43	367.99	105.18	367.99
2011	1	6	0.00	16.10	33.12	49.35	64.47	78.66	92.09	0.00	101.46	159.69	217.93	276.16	334.40	392.63	101.46	392.63
2011	1	7	0.00	14.87	31.90	48.07	63.09	77.17	90.48	0.00	101.67	164.38	227.10	289.81	352.53	415.24	101.67	415.24
2011	1	8	0.00	15.88	32.25	48.22	63.28	77.50	91.02	0.00	100.08	151.61	203.14	254.67	306.19	357.72	100.08	357.72
2011	1	9	0.00	11.60	26.42	41.82	56.75	71.06	84.78	0.00	86.79	131.01	175.22	219.43	263.65	307.86	86.79	307.86
2011	1	10	0.00	17.04	39.01	60.64	81.02	100.25	118.50	0.00	90.54	143.65	196.76	249.87	302.97	356.08	90.54	356.08
2011	1	11	0.00	32.70	141.25	220.59	288.28	349.12	405.25	0.00	104.75	448.79	792.82	1136.86	1480.90	1824.94	104.75	1824.94
2011	1	12	0.00	43.16	166.29	255.34	331.21	399.37	462.23	0.00	105.64	449.68	793.72	1137.75	1481.79	1825.83	105.64	1825.83
2011	1	13	0.00	37.29	154.64	240.03	312.85	378.27	438.62	0.00	105.03	449.07	793.11	1137.15	1481.19	1825.23	105.03	1825.23
2011	1	14	0.00	16.03	111.99	185.87	249.40	306.68	359.61	0.00	100.24	444.28	788.32	1132.36	1476.40	1820.44	100.24	1820.44
2011	1	15	0.00	15.26	98.61	162.53	217.50	267.06	312.85	0.00	101.65	445.69	789.73	1133.77	1477.81	1821.85	101.65	1821.85
2011	1	16	0.00	24.89	49.91	72.42	92.83	111.71	129.40	0.00	103.38	175.84	248.30	320.77	393.23	465.69	103.38	465.69
2011	1	17	0.00	32.48	51.05	68.28	84.20	99.08	113.13	0.00	104.34	150.48	196.63	242.77	288.92	335.07	104.34	335.07
2011	1	18	0.00	38.41	56.91	74.15	90.13	105.10	119.26	0.00	104.73	145.91	187.08	228.25	269.42	310.59	104.73	310.59
2011	1	19	0.00	57.85	75.86	92.80	108.66	123.60	137.79	0.00	105.90	137.41	168.92	200.44	231.95	263.47	105.90	263.47
2011	1	20	0.00	30.30	47.09	64.03	80.56	96.55	111.99	0.00	65.35	83.56	101.77	119.97	138.18	156.39	65.35	156.39
2011	1	21	0.00	55.10	72.38	88.84	104.38	119.13	133.18	0.00	104.88	133.05	161.22	189.38	217.55	245.72	104.88	245.72
2011	1	22	0.00	63.32	77.02	90.68	104.13	117.30	130.16	0.00	80.87	92.03	103.18	114.34	125.49	136.65	80.87	136.65
2011	1	23	0.00	5.25	21.81	41.11	60.17	78.53	96.15	0.00	31.03	57.78	84.53	111.29	138.04	164.79	31.03	164.79
2011	1	24	0.00	5.81	24.09	43.91	62.90	80.92	98.08	0.00	78.73	153.41	228.09	302.77	377.45	452.13	78.73	452.13

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Appendix I.3

Unmonitored Area Analysis

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Unmonitored Area Analysis (UAA)

An unmonitored area analysis (UAA) can be performed for gridded model demonstrations to examine predicted concentrations within an entire domain. This analysis is based on gradient-adjusted spatial fields calculated from both modeled results and monitored results. The CAMx with PiG[1] modeled results from the 1.33 km domain were used for this analysis.

The UAA is intended to be a means for identifying potentially high $PM_{2.5}$ concentrations in unmonitored locations within or near a nonattainment area. It is a separate and supplemental analysis from the attainment test and is not used for direct comparison to the NAAQS. The UAA can include some uncertainties since the results are based on interpolations of monitored and absolute modeled results, while the attainment test is based on relative modeled values in conjunction with actual monitored data.

For the point analysis used for attainment tests, design values are projected at monitor locations using modeled reductions from grid cells closest to the monitor site, on a multiple-cell average basis.[2] For the gradient-adjusted spatial field analysis, base case design values are first interpolated to each grid cell and then scaled according to modeled concentration gradients. These "fused" grid cells are then temporally adjusted based on future case modeled reductions for each cell. The SMAT[3] software program was used to generate the spatial results, which utilizes an enhanced Voronoi Neighbor Averaging (eVNA)[4] technique for the interpolation of data. Spatial analysis is only available for annual projections and not 24-hour projections with the current version of SMAT.

Note that the most recent ACHD five-year monitor network assessment (ACHD, 2015) found that the current monitor network is appropriate for $PM_{2.5}$ monitoring requirements, with sufficient coverage for population exposure in areas of concern. Each site also has additional value for site-specific objectives (industrial, urban, background, etc.). An additional monitor, not used in the attainment demonstration, has also been deployed for near-road surveillance purposes.

The figure below shows the gradient-adjusted spatial field for the future case 2021 for Allegheny County. For a more realistic projection of sulfate for this analysis, an additional 5% reduction of sulfate (year-round, for each day) was applied to the future case modeled projections, based on comparisons of ERTAC 2.4L2 emissions to ERTAC 2.5 as well as CAMD 2016-2017 emissions.

---

[1] Comprehensive Air Quality Model with Extensions, with the Plume-in-Grid option for selected large sources

[2] Based on $PM_{2.5}$ modeling guidance, a 3 x 3 cell average is recommended.

[3] Software for the Modeled Attainment Test

[4] Voronoi Neighbor Averaging (VNA) is an algorithm used to interpolate air quality monitoring data to an unmonitored location by first identifying the set of monitors that best "surround" the center of the population grid cell and then taking an inverse-distance weighted average of the monitoring values. Enhanced VNA (eVNA) uses modeled concentration gradients to adjust the interpolated fields at each grid cell location. See the MATS User's Manual for more information.

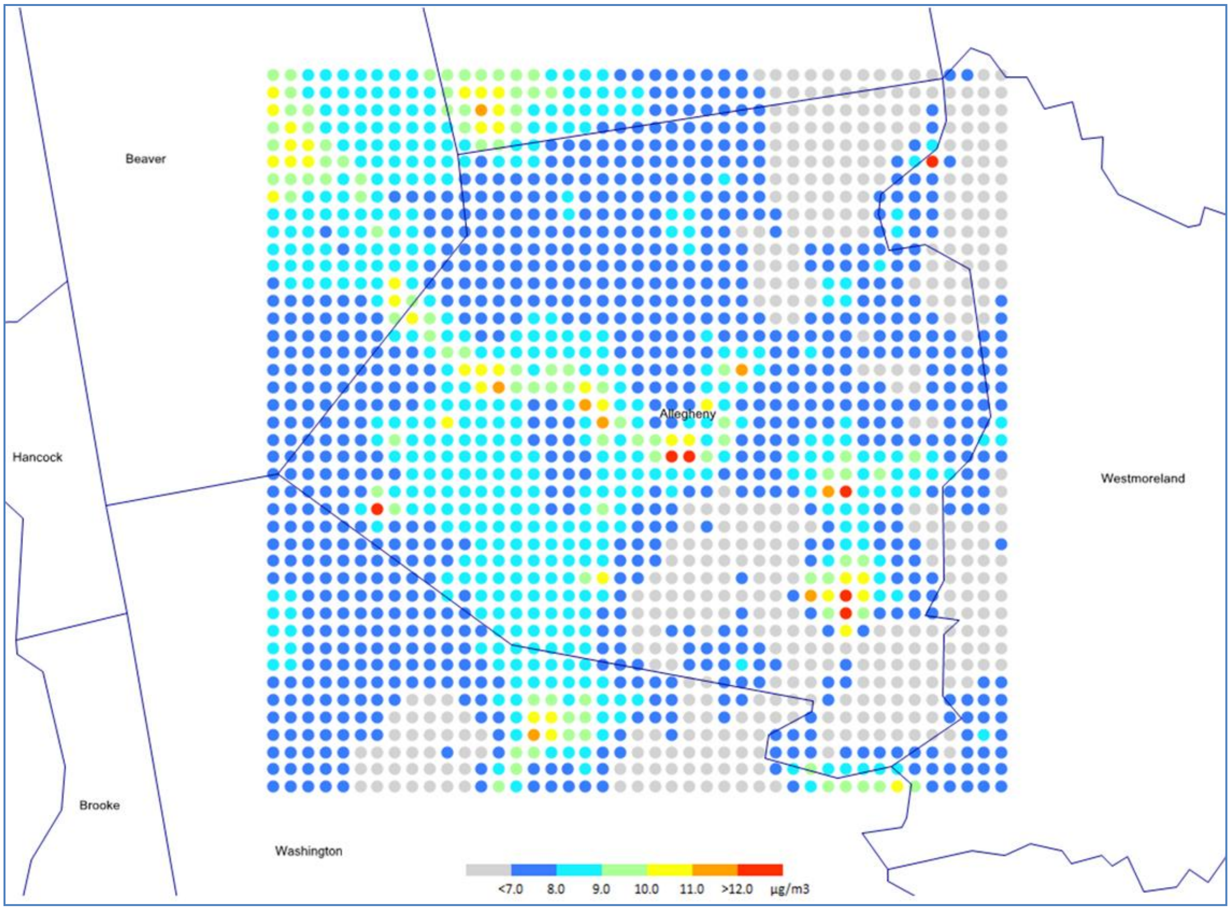

Figure 1. Projected 1.33 km Design Values from the Gradient-Adjusted Spatial Analysis

The gradient-adjusted spatial field analysis showed seven cells (in five distinct areas) with potential projected levels above the NAAQS, listed in the table below.

Table 1. Projected Gradient-Adjusted Spatial Field Cells > NAAQS

1.33 km Grid Cell	Future Case Spatial Field Annual DV (µg/m³)	Location
17042	15.1	Clairton
18042	12.4	Liberty
24042	13.3	North Braddock
43047	13.6	Harrison
23015	14.2	Findlay
26032	12.4	Downtown Pittsburgh (west)
26033	12.9	Downtown Pittsburgh (east)

Each of the areas involves modeled gradients created by large point or nonpoint sources. The areas are described in more detail below.

Clairton and Surrounding Area

Grid cell 17042 contains the U. S. Steel Clairton Plant in Clairton, as well as portions of Lincoln and Glassport. Modeled concentrations in this grid cell are considerably higher than surrounding grid cells because the majority of PM emissions from the Clairton Plant are emitted into cell 17042. Modeled concentration gradients can have a large impact on UAA because they are used to scale interpolated design values in each grid cell. Because of this scaling, the steep modeled concentration gradients in this area may lead to overestimates in future year design values estimated by SMAT spatial field analyses.

Figure 2. Clairton and Liberty Grid Cells

Large portions of the cell also include the Monongahela River and the immediate Lincoln and Glassport hilltops, which are not suitable $PM_{2.5}$ site locations. For highest-concentration PM surveillance, the

Lincoln site (shown in the figure) in the grid cell immediately to the east includes hourly PM_{10} monitoring.

Additionally, in the upwind area, the Clairton $PM_{2.5}$ FRM monitor one grid cell to the south in the figure has shown attainment of the NAAQS since 2011.

Grid cell 18042 includes portions of Liberty and Glassport as well as the location of the Liberty monitor. The Liberty monitor is the most important location for the SIP demonstration, since it's the only location showing nonattainment based on FRM design values through 2017. As explained in the local area analysis, the Liberty monitor (and grid cell 18042) required a refined analysis using the AERMOD dispersion model for the proper treatment of localized impacts, beyond the use of the CAMx Plume-in-Grid (PiG) treatment. Based on the results of the local area analysis, the Liberty monitor and expanded receptor area are projected to attain the NAAQS for the future case.

The Glassport PM_{10} TEOM[5] monitor site, also located within grid cell 18042, shows concentrations similar to or lower than the Liberty PM_{10} TEOM monitor. It is assumed that $PM_{2.5}$ is consistent at both locations at about the same distance from the Clairton Plant.

[5] Tapered Element Oscillating Microbalance

North Braddock

Grid cell 24042 contains the U. S. Steel Edgar Thomson Plant in North Braddock/Braddock. Similar to the grid cell 17042 in Clairton, grid cell 24042 is not applicable for the gradient-adjusted analysis since it contains on-property emissions from the Edgar Thomson Plant. A portion of this grid cell also includes the Monongahela River, which is not suitable for $PM_{2.5}$ site locations.

Figure 3. Edgar Thomson Grid Cell

In the grid cell immediately to the north, the North Braddock $PM_{2.5}$ FRM monitor has shown attainment of the NAAQS since 2013 and is projected to show continued attainment based on the modeled attainment tests. This $PM_{2.5}$ monitor site is deemed to be adequate for population-based exposure near the Edgar Thomson Plant.

The point analysis performed in tandem with this UAA analysis uses a refined modeling technique to demonstrate that the North Braddock monitor will be in attainment in year 2021. The point analysis uses model output from CAMx with the PiG option employed, and Edgar Thomson was one of the sources modeled with the PiG option. The PiG algorithm simulates dispersion of sub-grid scale plumes on a 100-m spaced receptor grid nested within specified 1.33 km CAMx grid cells.

Harrison

Grid cell 43047 contains the ATI Allegheny Ludlum facility in Harrison. Similar to the U. S. Steel locations, grid cell 43047 is not applicable for the gradient-adjusted analysis since it contains the majority of the on-property emissions from Allegheny Ludlum. Portions of this grid cell also include the Allegheny River (not suitable for $PM_{2.5}$) as well as Westmoreland County (outside of the nonattainment area).

Figure 4. Allegheny Ludlum Grid Cell

The Harrison $PM_{2.5}$ FRM monitor in the grid cell just to the north has shown monitored attainment of the NAAQS since 2012 and is projected to show continued attainment based on the modeled attainment tests. This site is deemed to be adequate for the population-based exposure near Allegheny Ludlum.

Similar to Edgar Thomson (and the North Braddock monitor site), Allegheny Ludlum was also modeled with the PiG treatment, so the Harrison monitor projections are based on a refined modeling technique.

Findlay

Grid cell 23015 contains the Republic (formerly Allied Waste) Imperial Municipal Waste Landfill in Findlay. Similar to above, grid cell 23015 is not applicable for the gradient-adjusted analysis since it contains all of the on-property emissions from the facility.

Figure 5. Imperial Grid Cell

Looking at the model configuration for this source in more detail, the majority (73%) of the primary $PM_{2.5}$ emissions were modeled at a fugitive release height of 1 meter above ground and with negligible flow. This may be an unrealistic methodology for these emissions, leading to an exaggerated surface-level concentration gradient of primary $PM_{2.5}$ in the area. (A height of at least 2 or 3 meters may have been more appropriate for these emissions.) Also, the Imperial Landfill was not selected as a source for refined treatment with the CAMx PiG option. Use of the PiG option (or AERMOD) and higher fugitive release heights would likely show more realistic (lower) impacts for this source.

The Imperial Landfill is located in the general upwind/background area of Allegheny County. The closest $PM_{2.5}$ monitors are South Fayette (in Allegheny Co.) and Florence (in Washington Co.), which show some of the lowest design values in southwestern PA (for 2015-2017, design values of 8.4 and 8.0 µg/m³, respectively). It is unlikely that the landfill is contributing to several µg/m³ of excess PM in the area, and it is presumed that the projected spatial field design value is an overestimation of modeled $PM_{2.5}$ impacts for this grid cell.

Downtown Pittsburgh

Grid cells 26032 and 26033 contain most of the Central Business District (Downtown) of the City of Pittsburgh. There are many small-scale complexities in urban core areas that photochemical grid models may not be able to fully reproduce, such as variability in surface-level mobile source emissions (e.g., traffic), construction dust, and the impacts of individual buildings on small-scale meteorological parameters. Given these complexities, there may be discrepancies between modeled and observed PM emissions in urban core zones in some cases.

Figure 6. Downtown Pittsburgh Grid Cells

Air quality studies by Carnegie Mellon University and the University of Pittsburgh have pointed to elevated levels of diesel PM from buses in the downtown area, especially at street level. The ACHD 2015 network assessment has also indicated that downtown may be an appropriate new location for $PM_{2.5}$ monitoring based on increased downtown living.

However, Allegheny County has committed to several programs for fleet modernization with newer and cleaner buses by the future case year of 2021. Also, micro-scale $PM_{2.5}$ monitoring in the street canyons of a downtown area is generally not recommended unless it is used to assess long-term exposure near inhabited areas (usually above street level in Pittsburgh).

Flag Plaza is a current ACHD PM_{10} site in the downtown area in grid cell 26033, located 10 meters above street level. An estimate of the $PM_{2.5}$ fraction at Flag Plaza can be determined from surrounding PM_{10} and $PM_{2.5}$ monitor sites. The closest and most urban-influenced site with measured PM fractions is Lawrenceville (about 2 miles downwind of Flag Plaza), which has a fraction of 0.62 for $PM_{2.5}$ to PM_{10}.[6] Applying this ratio to the most recent 3-year (2015-2017) PM_{10} annual averages at Flag Plaza, an annual design value of 10.4 µg/m³ can be estimated for $PM_{2.5}$ at Flag Plaza.

Additionally, the Parkway East site has been deployed in 2016 specifically for micro-scale near-road requirements, including $PM_{2.5}$ surveillance. While the site characteristics at Parkway East are different from Flag Plaza, the site was chosen based on emissions from similar sources of concern (mobile sources, road dust, etc.). Parkway East shows an annual design value of 10.6 µg/m³ for $PM_{2.5}$ (for 2016-2017).

A listing of urban $PM_{2.5}$ monitored design values for major U.S. cities is given in the table below for the most recent available three-year period (2015-2017), ranked by design value (highest to lowest).[7]

Table 1. $PM_{2.5}$ Design Values, U.S. Urban Areas

City	State	2015-2017 Annual DV (µg/m³)
Los Angeles	CA	12.1
Detroit	MI	11.2
Houston	TX	10.7
Oakland	CA	10.6
Cleveland	OH	10.6
Philadelphia	PA	10.6
Atlanta	GA	10.5
Chicago	IL	10.2
Indianapolis	IN	10.2
Newark	NJ	9.7
New York	NY	9.7
Cincinnati	OH	9.5
Washington	DC	9.2
Columbus	OH	9.0
St. Louis	MO	8.9
Dallas	TX	8.9
Phoenix	AZ	8.8
Baltimore	MD	8.7
Charlotte	NC	8.7
Seattle	WA	8.7
Minneapolis	MN	8.0
Buffalo	NY	7.6
Boston	MA	7.2
Denver	CO	7.1

[6] Lawrenceville measures PM_{coarse} by subtracting $PM_{2.5}$ from PM_{10} at collocated continuous monitors.

[7] EPA design values: https://www.epa.gov/air-trends/air-quality-design-values

Of the national urban $PM_{2.5}$ monitors, only Los Angeles shows a design value above the NAAQS. Los Angeles is a considerably larger area for mobile source emissions and is subject to different meteorological effects than Pittsburgh.

The most comparable cities in the Mid-Atlantic/Midwest regions for comparison to Pittsburgh might be Cleveland, Indianapolis, or Philadelphia, which show a range of 10.2-10.6 µg/m³ for urban core concentrations. Additionally, nearly all the urban core monitor sites are similar to Flag Plaza by site characteristics, located adjacent to the central business districts or heavy-traffic areas and not in street canyons.

Based on national urban sites and Allegheny County sites, $PM_{2.5}$ in Downtown Pittsburgh would likely fall within a range of 10-11 µg/m³ on an annual basis.

Summary

The unmonitored area analysis shows that spatial-field projections for 2021 are below the annual $PM_{2.5}$ standard across the vast majority of Allegheny County. Projections that exceed the standard in a few areas without $PM_{2.5}$ monitors can be attributed to large modeled concentration gradients associated with major facilities within grid cells, sub-optimal characterization of low-level area sources, and difficulty modeling micro-scale features (PM emissions, meteorology) in urban core locations.

The official projections for $PM_{2.5}$ are performed for the monitor site locations, and the current monitors are located in areas adequate to demonstrate attainment of the $PM_{2.5}$ NAAQS for Allegheny County. Additionally, monitoring network adequacy is reviewed each year for the annual network monitoring plan and every five years for the monitor network assessment.

Appendix I.4

Precursor Insignificance Demonstration

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ACHD Precursor Insignificance

Ramboll, 2018-09-28

Introduction and Objectives

Three CAMx runs were performed as part of a sensitivity analysis for a comprehensive precursor attainment plan demonstration[1]. In a comprehensive precursor demonstration, the air quality impacts of all emissions of a precursor in the nonattainment area are evaluated.

Results from the concentration-based analysis (see the speciation analysis in Appendix C) indicated that all precursors showed ambient monitored levels that were above the thresholds for significant contribution. Sensitivity modeling of a precursor allows for a more in-depth analysis of its potential effect on concentrations.

Reductions in atmospheric ammonia (NH_3) and volatile organic compounds (VOC) have the potential to decrease secondary $PM_{2.5}$ formation. For this sensitivity analysis, two alternate emissions scenarios were incorporated into CAMx to investigate $PM_{2.5}$ sensitivity to reductions of NH_3 and VOC emissions in Allegheny County.

Model and Emissions Configurations

The CAMx runs performed for this analysis are similar to the 2021 4/1.33 km CAMx run described in the modeling protocol (Ramboll Environ, 2017). The CAMx model version, model year and duration, boundary conditions, meteorology, and most emission inventories were not modified. The precursor sensitivity analysis runs differ from the 2021 4/1.33 km CAMx run in the following ways:

1. CAMx was run with 4 km horizontal resolution across the modeling domain shown in Figure 1. CAMx was not run with 1.33 km horizontal resolution and there was no 2-way nesting between grids.
2. CAMx was run without the Plume-In-Grid scheme and Particulate Source Apportionment Technology.

[1] https://www.epa.gov/sites/production/files/2016-12/documents/webinar_slides_for_pm_2.5_draft_precursor_guidance.pdf

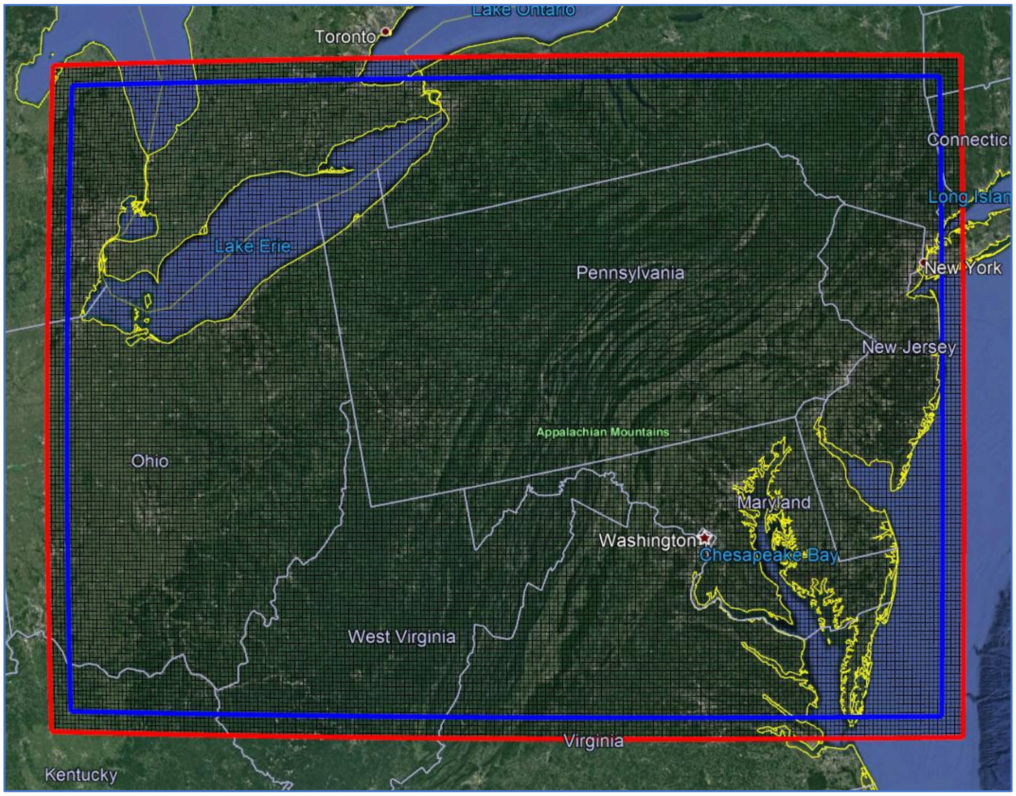

Figure 1. Allegheny County 4 km (d03) WRF (red) and CAMx (blue) Horizontal Modeling Domains.

No other modifications were made for the first CAMx run, which was used as the base case for precursor insignificance testing. For the two sensitivity-case runs, anthropogenic precursor emissions in Allegheny County were reduced as follows:

1. One CAMx run with 50% reduction of anthropogenic VOC emissions within Allegheny County.
2. One CAMx run with 50% reduction of anthropogenic NH_3 emissions within Allegheny County.

In both CAMx sensitivity-case runs, the reductions were applied to both point source and area source anthropogenic emissions. All other emissions were held constant. A close-up view of the grid cells for Allegheny County within the 4 km modeling domain is shown in Figure 2.

Figure 2. Allegheny County Grid Cells within the 4 km (d03) Horizontal Modeling Domain.

An emissions summary across the 4 km CAMx modeling domain for all cases is presented below in Table 1. Additionally, a comparison of anthropogenic and biogenic emissions for the base-case and reduced-VOC scenarios is presented in Table 2. (Note: emissions are allocated at the grid cell-level for the modeling and at the county-level for the emissions inventory. Since the 4 km grid cells do not align perfectly with the county border, the reductions in the tables are not exactly equal to 50% of the VOC and NH_3 emissions in the 2021 inventory. Emissions from a grid cell were used for county emissions if more than half of the grid cell fell within the county border.)

Table 1: Summary of base-case and sensitivity-case emissions across the 4 km domain, in tons per year.

4 km Emissions, TPY	NOX	SO2	CO	NH3	VOC	PM25	PM10
TOTAL base case	1,593,826	841,111	7,436,463	297,378	3,274,033	331,082	521,698
TOTAL reduced-NH3	1,593,826	841,111	7,436,463	296,849	3,274,033	331,082	521,698
TOTAL reduced-VOC	1,593,826	841,111	7,436,463	297,378	3,265,595	331,082	521,698
Allegheny NH3 reduction				529			
Allegheny VOC reduction					8,438		

Table 2: Comparison of 2021 anthropogenic emissions to corresponding biogenic emissions. This does not include prescribed fire or wildfire emissions.

ACHD 4 km CAMx domain	NOX (TPY)	CO (TPY)	VOC (TPY)
Base Case Anthropogenic	1,593,826	7,436,463	3,274,033
Reduced-VOC Anthropogenic	1,593,826	7,436,463	3,265,595
Biogenic, TPY	**70,439**	**307,979**	**1,965,892**

Results

The CAMx results for all three model runs were post-processed into SMAT/MATS-ready format. Comparison of absolute model results reveals that $PM_{2.5}$ concentrations in Allegheny County are insensitive (decreases of 0.06% or less) to significant reductions in anthropogenic VOC emissions. $PM_{2.5}$ concentrations are more sensitive to reductions in NH_3 emissions in Allegheny County, as absolute modeled concentrations decrease by 0.007-3.1% when anthropogenic NH_3 emissions are reduced by 50%.

Figures 3 and 4 below show maps of the absolute modeled $PM_{2.5}$ annual concentration changes for southwestern PA for the VOC and NH_3 sensitivity cases, respectively, as generated by the EPA SMAT-CE[2] software. The figures indicate that $PM_{2.5}$ in the urban downwind portion of the county is most sensitive to VOC reductions, while the most sensitivity to NH_3 reductions is seen in the Monongahela Valley. Small decreases in concentration are also present in surrounding counties from the Allegheny County reductions.

[2] Software for the Modeled Attainment Test - Community Edition, Version 1.2

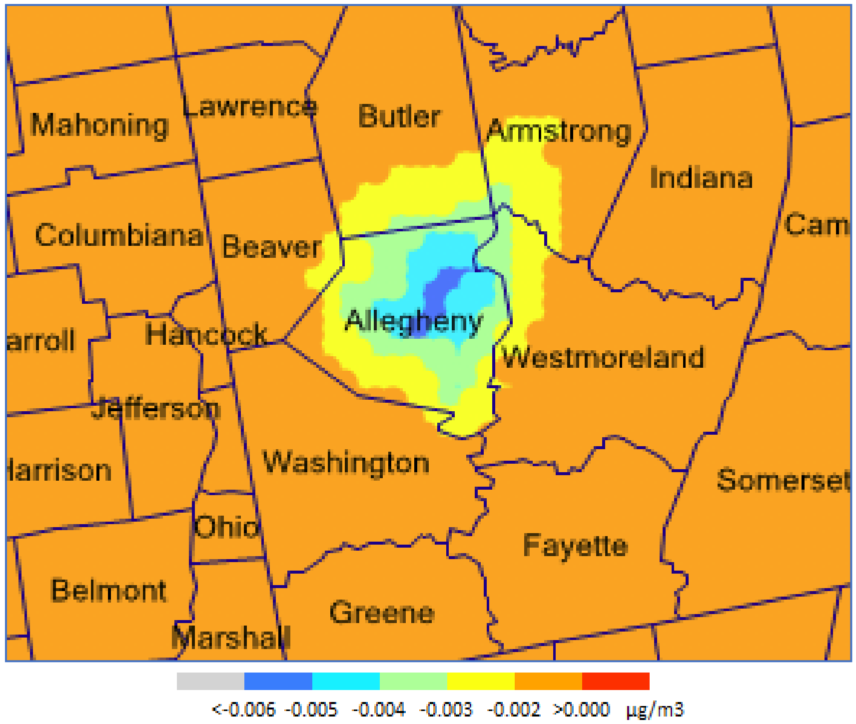

Figure 3. Modeled Change in Annual Concentration (µg/m³) in Southwestern PA, VOC Sensitivity Case.

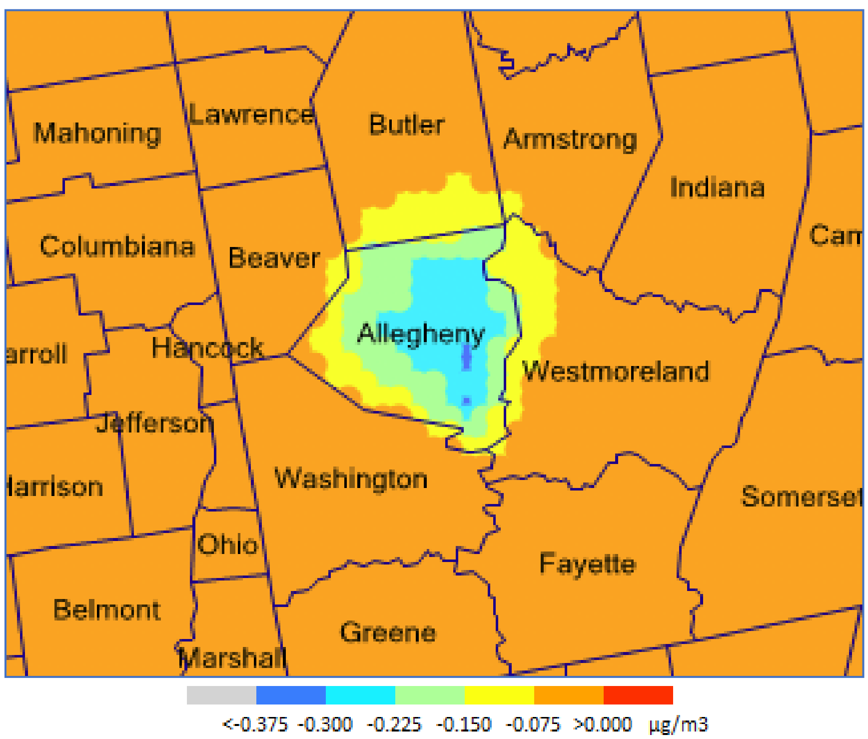

Figure 4. Modeled Change in Annual Concentration (µg/m³) in Southwestern PA, NH_3 Sensitivity Case.

From the EPA precursor demonstration guidance (U.S. EPA, 2016), the effect of a precursor for a comprehensive demonstration is determined by the changes in design values at monitored sites within the nonattainment area. The EPA MATS[3] software was used to generate design values (DVs) with and without the precursor reductions for monitor sites in the Allegheny County, PA nonattainment area. MATS settings were identical to those described in the Air Quality Technical Support Document for the SIP (Ramboll Environ, 2018).

Tables 3 through 6 show the annual and 24-hour design values for the sensitivity cases for each monitor site. The differences in design values between the base case and the reduced precursor cases were compared to the significant contribution thresholds of 0.2 µg/m³ (annual) and 1.3 µg/m³ (24-hour), as given in the precursor guidance.

Table 3: Sensitivity test design values and differences for NH_3, annual standard.

Site	AQS ID	Base Case DV	Reduced Case DV	Difference
Avalon	42-003-0002	12.43	12.23	0.20
Lawrenceville	42-003-0008	11.01	10.78	0.23
Liberty	42-003-0064	14.40	14.25	0.15
South Fayette	42-003-0067	10.34	10.24	0.10
North Park	42-003-0093	9.28	9.11	0.17
Harrison	42-003-1008	11.54	11.41	0.13
North Braddock	42-003-1301	12.28	12.07	0.21
Clairton	42-003-3007	10.72	10.59	0.13

Table 4: Sensitivity test design values and differences for NH_3, 24-hour standard.

Site	AQS ID	Base Case DV	Reduced Case DV	Difference
Avalon	42-003-0002	27.0	26.9	0.1
Lawrenceville	42-003-0008	25.2	25.2	0.0
Liberty	42-003-0064	41.4	40.6	0.8
South Fayette	42-003-0067	25.6	25.5	0.1
North Park	42-003-0093	22.4	21.5	0.9
Harrison	42-003-1008	27.6	27.6	0.0
North Braddock	42-003-1301	31.7	31.3	0.4
Clairton	42-003-3007	25.4	25.4	0.0

[3] Modeled Attainment Test Software, Version 2.6.1

Table 5: Sensitivity test design values and differences for VOC, annual standard.

Site	AQS ID	Base Case DV	Reduced Case DV	Difference
Avalon	42-003-0002	12.43	12.42	0.01
Lawrenceville	42-003-0008	11.01	11.01	0.00
Liberty	42-003-0064	14.40	14.40	0.00
South Fayette	42-003-0067	10.34	10.34	0.00
North Park	42-003-0093	9.28	9.28	0.00
Harrison	42-003-1008	11.54	11.54	0.00
North Braddock	42-003-1301	12.28	12.28	0.00
Clairton	42-003-3007	10.72	10.72	0.00

Table 6: Sensitivity test design values and differences for VOC, 24-hour standard.

Site	AQS ID	Base Case DV	Reduced Case DV	Difference
Avalon	42-003-0002	27.0	27.0	0.0
Lawrenceville	42-003-0008	25.2	25.2	0.0
Liberty	42-003-0064	41.4	41.4	0.0
South Fayette	42-003-0067	25.6	25.6	0.0
North Park	42-003-0093	22.4	22.3	0.1
Harrison	42-003-1008	27.6	27.6	0.0
North Braddock	42-003-1301	31.7	31.7	0.0
Clairton	42-003-3007	25.4	25.4	0.0

The reductions in design values from the sensitivity testing were less than the significant contribution thresholds.[4] Therefore, the precursors NH_3 and VOC can be deemed insignificant for the attainment plan for the area.

[4] For annual NH_3 reductions, all values are 0.2 µg/m³ or less based on rounding conventions used for the $PM_{2.5}$ NAAQS.

References

Ramboll Environ. 2017. Allegheny County Health Department PM2.5 State Implementation Plan for the 2012 NAAQS – CAMx Modeling Protocol. Ramboll Environ US Corporation, Lynnwood, WA and Novato, CA. July.

Ramboll Environ. 2018. Allegheny County Health Department PM2.5 State Implementation Plan for the 2012 NAAQS – Air Quality Technical Support Document. Ramboll Environ US Corporation, Lynnwood, WA and Novato, CA. January.

U.S. EPA. 2016. PM2.5 Precursor Demonstration Guidance, Draft. U.S. Environmental Protection Agency, Research Triangle Park, NC. EPA-454/P-16-001. November 17.