APPENDIX B

Local-Scale Assessment of Primary PM2.5 for Five Urban Areas

This assessment quantifies the impacts of local sources of primary PM2.5 within selected urban areas. Local-scale air quality modeling is used to examine the spatial variability of direct PM2.5 concentrations associated with emissions of primary PM2.5 within each urban area and to quantify the impact of specific emissions source groups to ambient PM2.5 concentrations at Federal Reference Method (FRM) monitoring sites. We focused this assessment on five urban areas: Birmingham, Seattle, Detroit, Chicago and Pittsburgh. An assessment for the first three of these areas had been presented in the RIA for the propose rule and has updated here based on an updated emission inventory. Each of these areas has different characteristics in terms of the mixture of emissions sources, meteorology, and associated PM2.5 air quality issues. As such, they are representative of other areas across the eastern and western US and therefore this assessment provides insights that may be applicable to these other areas. This assessment has a future focus on the incremental impacts of direct PM2.5 sources within these areas after implementation of the Clean Air Interstate Rule (CAIR), Clean Air Mercury Rule (CAMR), and Clean Air Visibility Rule (CAVR).

Based on 2001 meteorology data and a 2015 base inventory (denoted "2015bi") for primary PM2.5 which incorporates CAIR/CAMR/CAVR impacts, the AERMOD modeling system was applied to each urban area to provide concentration estimates of directly emitted PM2.5 by species across a specified network of receptors within each urban area. AERMOD computes concentrations by individual sources and/or source groups that can then be used to analyze the relative impacts of different types of emissions sources. The modeling domain encompasses each urban area and surrounding areas that have large point source emissions. It includes both an emissions domain, which consists of the urban area and surrounding counties, and a receptor grid, which consists of a set of evenly-spaced receptors within the urban core and at individual monitoring sites [i.e., Federal Reference Method (FRM) and Speciation Trends Network (STN) monitors].

For each area, AERMOD inputs include 2001 meteorological data from the nearest National Weather Service (NWS) Station, geographic information on terrain, the 2015bi emission inventory for direct PM2.5 for counties comprising the emissions domain, and receptor locations. Based on these inputs, AERMOD provides an estimate of the pollutant fate and transport in the atmosphere. This modeling predicts how the directly emitted PM2.5 is transported, dispersed, and deposited over the area of interest. Initially, the fate of the directly emitted PM2.5 is largely determined by the source release characteristics. After being emitted into the atmosphere, its transport, dispersion, and deposition are determined by meteorological conditions, terrain characteristics, and deposition rates of the direct PM2.5. The concentration for each PM2.5 species and total mass from each source is estimated at each receptor.

Section I provides an overview of the AERMOD modeling system and the inputs used for this local-scale assessment, while Section II details the results of applying the AERMOD modeling system in evaluating these direct PM2.5 controls for each urban area.

I. AERMOD Modeling System and Inputs

In 1991, the American Meteorological Society (AMS) and the United States Environmental Protection Agency (EPA) initiated a formal collaboration to develop a state-of-the-science dispersion model that reflected advances in planetary boundary layer (PBL) meteorology and science. This joint effort resulted in the development of the AMS/EPA Regulatory Model (AERMOD), which is a steady-state plume dispersion model for air quality assessments of inert pollutants that are directly emitted from a variety of sources[1,2,3, 4]. Based on an advanced characterization of the atmospheric boundary layer turbulence structure and scaling concepts, AERMOD is applicable to rural and urban areas, flat and complex terrain, surface and elevated releases, and multiple sources (including point, area, or volume sources). The model employs hourly sequential preprocessed meteorological data to estimate concentrations at receptor locations for averaging times from one hour to one year. AERMOD incorporates both dry and wet particle and gaseous deposition as well as source or plume depletion. Through final rulemaking (effective December 9, 2005), the Agency established AERMOD as the preferred air dispersion model in its "Guideline on Air Quality Models." (40 CFR 51, Appendix W)

Figure 1 shows the flow and processing of the complete AERMOD modeling system, which consists of the AERMOD dispersion model and two pre-processors: AERMET and AERMAP. The AERMOD meteorological pre-processor, AERMET, is a stand-alone program that uses meteorological information and surface characteristics to calculate the boundary layer parameters for use by AERMOD to generate the needed meteorological variables.[5] In addition, AERMET passes all meteorological observations to AERMOD. The AERMOD mapping program, AERMAP, is a stand-alone terrain pre-processor that characterizes terrain and generates receptor grids for use by AERMOD.[6]

AERMOD is a steady-state plume dispersion model in that it assumes that concentrations at all distances during a modeled hour are governed by the set of hourly averaged meteorology inputs (Cimorelli et al, 2005; Perry et al, 2005). In the stable boundary layer, AERMOD assumes the concentration distribution to be Gaussian in both the vertical and horizontal. In the convective boundary layer, the horizontal distribution is also assumed to be Gaussian, but the vertical distribution is described with a bi-Gaussian probability density function. AERMOD constructs vertical profiles of required meteorological variables based on measurements and extrapolations of those measurements using similarity (scaling) relationships. Vertical profiles of wind speed, wind direction, turbulence, temperature, and temperature gradient are estimated using all available meteorological observations. AERMOD has been designed to handle the computation of pollutant impacts in both flat and complex terrain within the same modeling framework. In general, AERMOD models a plume as a combination of two limiting cases: a horizontal plume (terrain impacting) and a terrain-following, or responding, plume. Therefore, for all situations, the total concentration, at a receptor, is bounded by the concentration predictions from these two states.

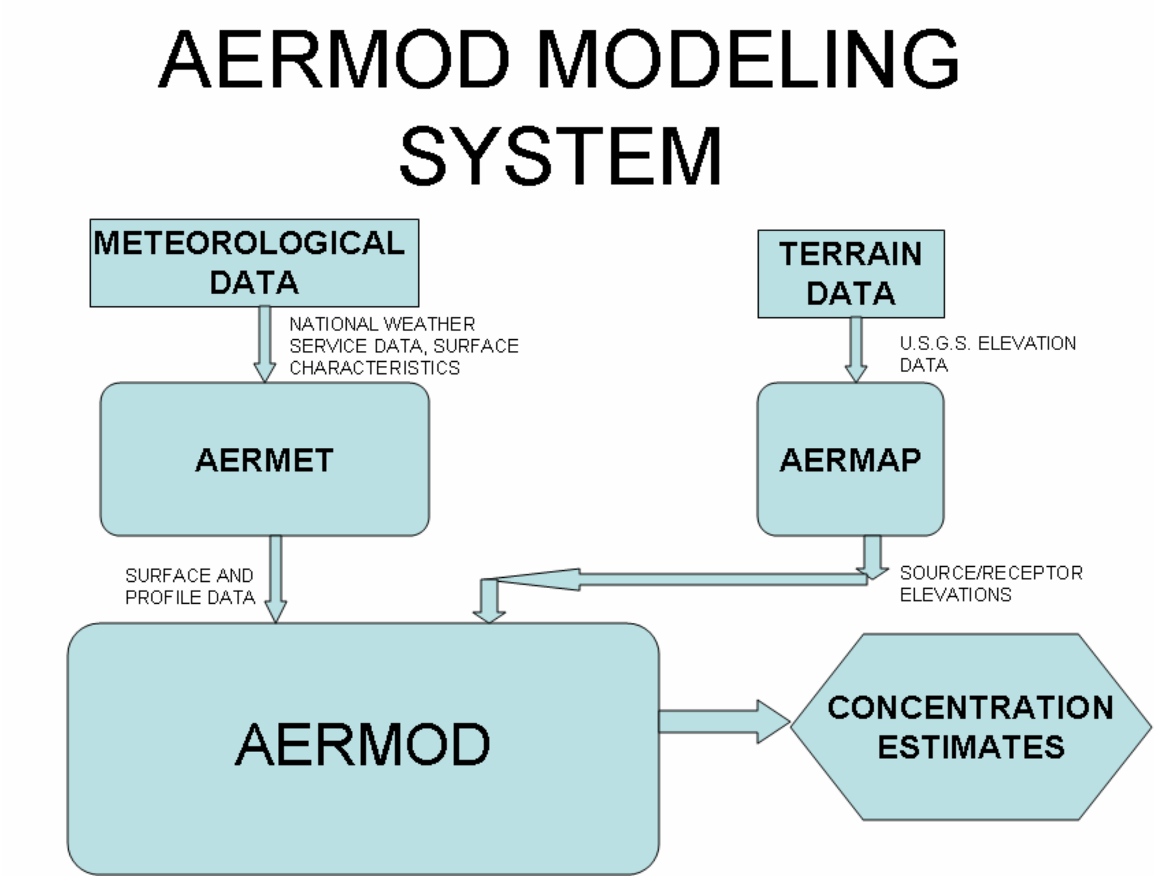

Figure 1. Flow Diagram of the AERMOD Modeling System

I.A Modeling Domain and Receptors

Modeling domains were developed for each of the five urban areas: Birmingham, Detroit Seattle, Chicago, and Pittsburgh. These modeling domains were defined such that the urban geographic area and significant sources of direct PM2.5 were captured, and such that receptors within the urban area were placed to determine the spatial gradient with additional receptors placed at monitor locations to allow for the evaluation of impacts of potential controls. The modeling domain consists of an emission domain, defined by counties surrounding the urban area, and a receptor "grid", that includes equally spaced receptors within the urban area and specific receptors placed at individual PM2.5 monitoring sites. Figures 2 thru 6 present the modeling domain for each urban area including the associated emissions domain (encircled counties) and receptor grid (boxed area within urban core). As shown in Figure 6, for Pittsburgh, the receptors were distributed in a ring around the monitor of interest.

<u>I.A.1 Emissions Domain</u>

For each urban area, an emission domain was developed comprised of counties whose emissions were expected to potentially contribute to the modeled concentrations in the urban area based on their proximity to the receptor “grid”. The emission domain was developed by visually examining maps of the area, the location of Federal Reference Method (FRM) monitors, and the urban characteristics. Counties comprising the emission domain for each urban area are shown in each figure.

I.A.2 Receptor Grid

A receptor grid domain was placed at the core of the urban areas, with receptors placed at 1 km spacing across a square (e.g., 36 x 36 km in Birmingham) or rectangular area (e.g., 36 by 108 km in Seattle), depending upon the particular urban area. Given that AERMOD can predict PM2.5 concentrations for each of these receptor locations, this dense network of receptors allows for the prediction of the urban gradient for primary PM2.5 based on the AERMOD model results. Additional receptors were also placed at FRM monitoring sites in order to evaluate the contribution of sources to PM2.5 levels at these monitor locations and effectiveness of controls in progressing towards attainment of alternative NAAQS standard options. The receptor grids for each urban area are shown in each figure.

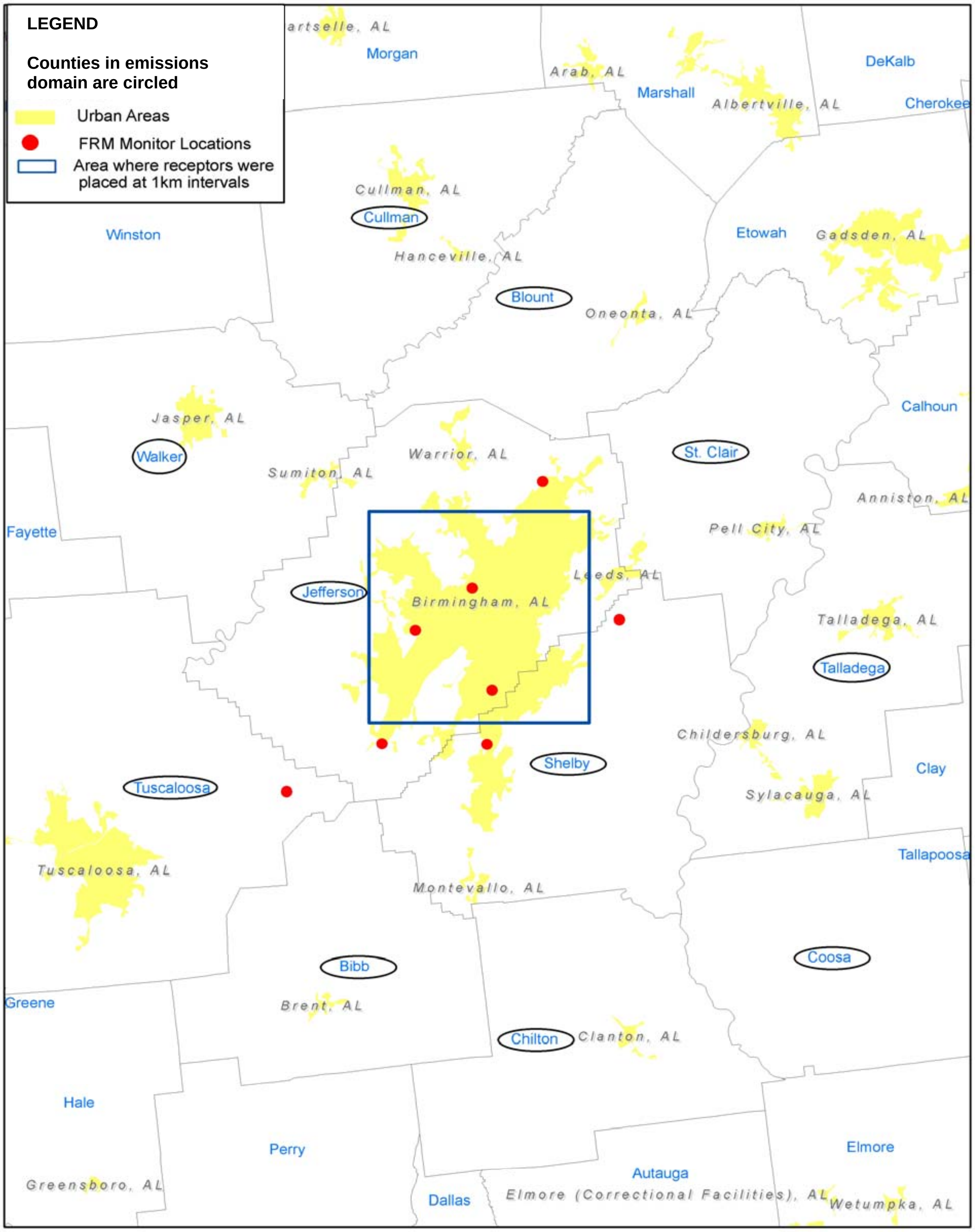

Figure 2: Birmingham Modeling Domain: Emissions Domain by County and Receptor Grid within Urban Area and at Monitoring Sites

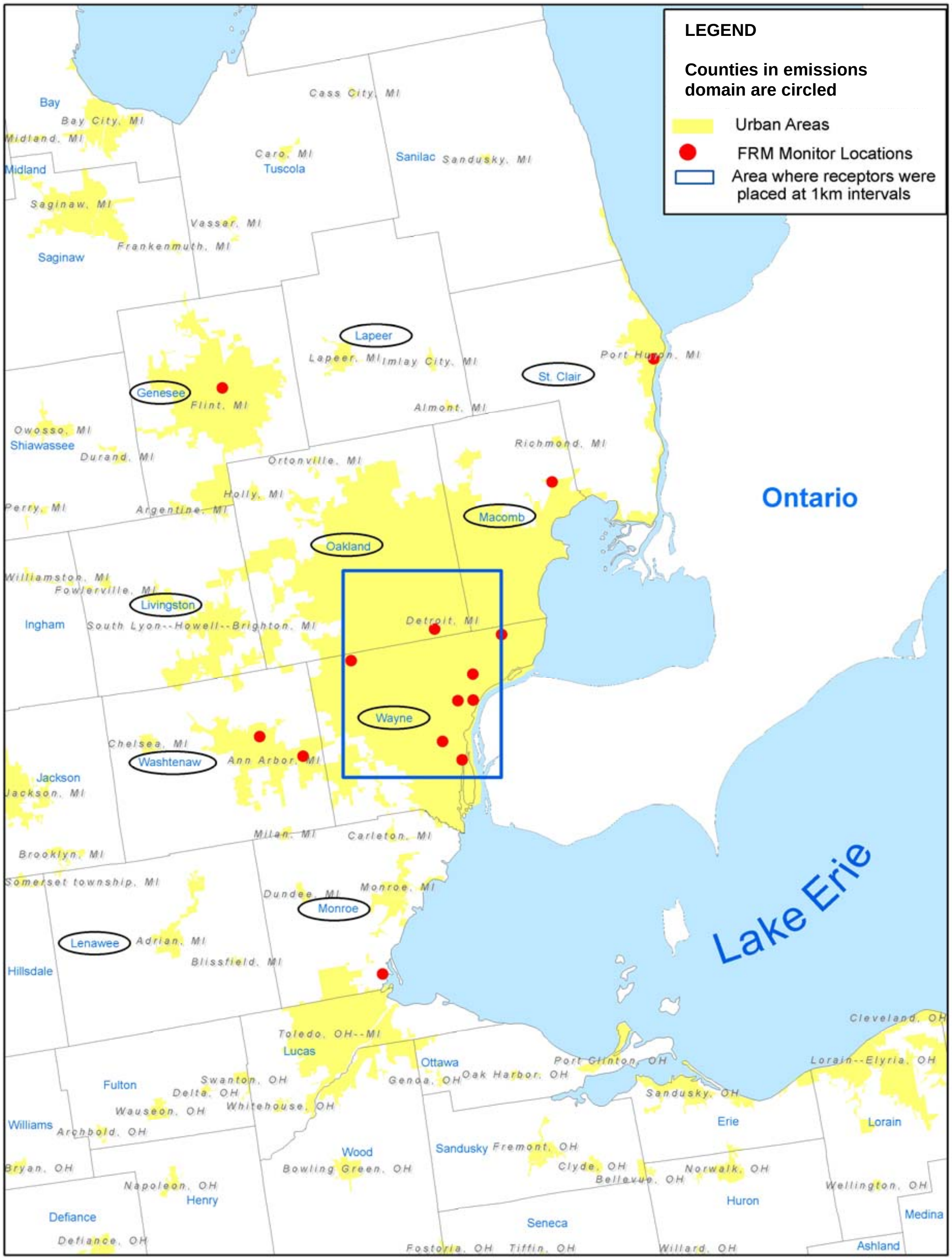

Figure 3: Detroit Modeling Domain: Emissions Domain by County and Receptor Grid within Urban Area and at Monitoring Sites

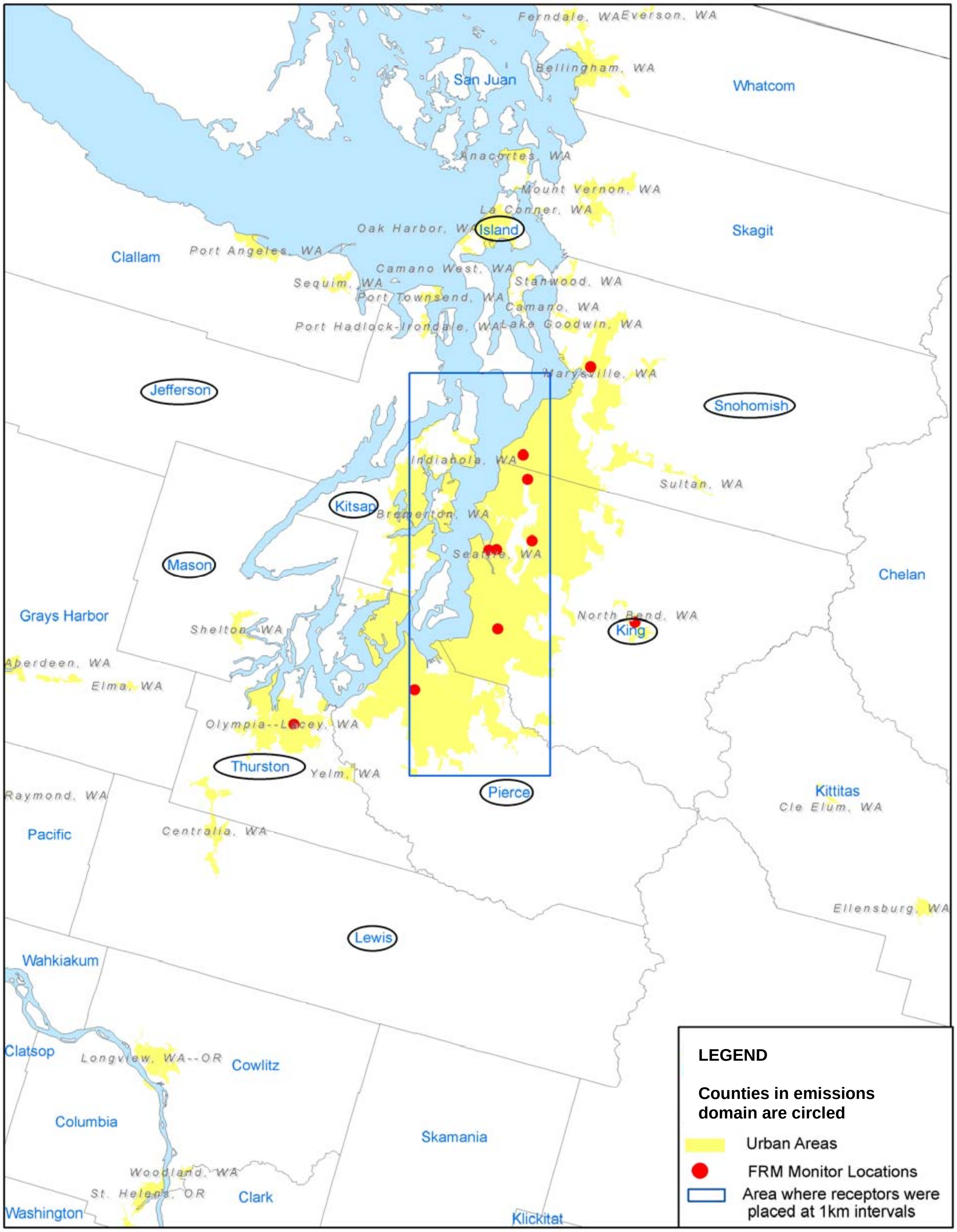

Figure 4: Seattle Modeling Domain: Emissions Domain by County and Receptor Grid within Urban Area and at Monitoring Sites

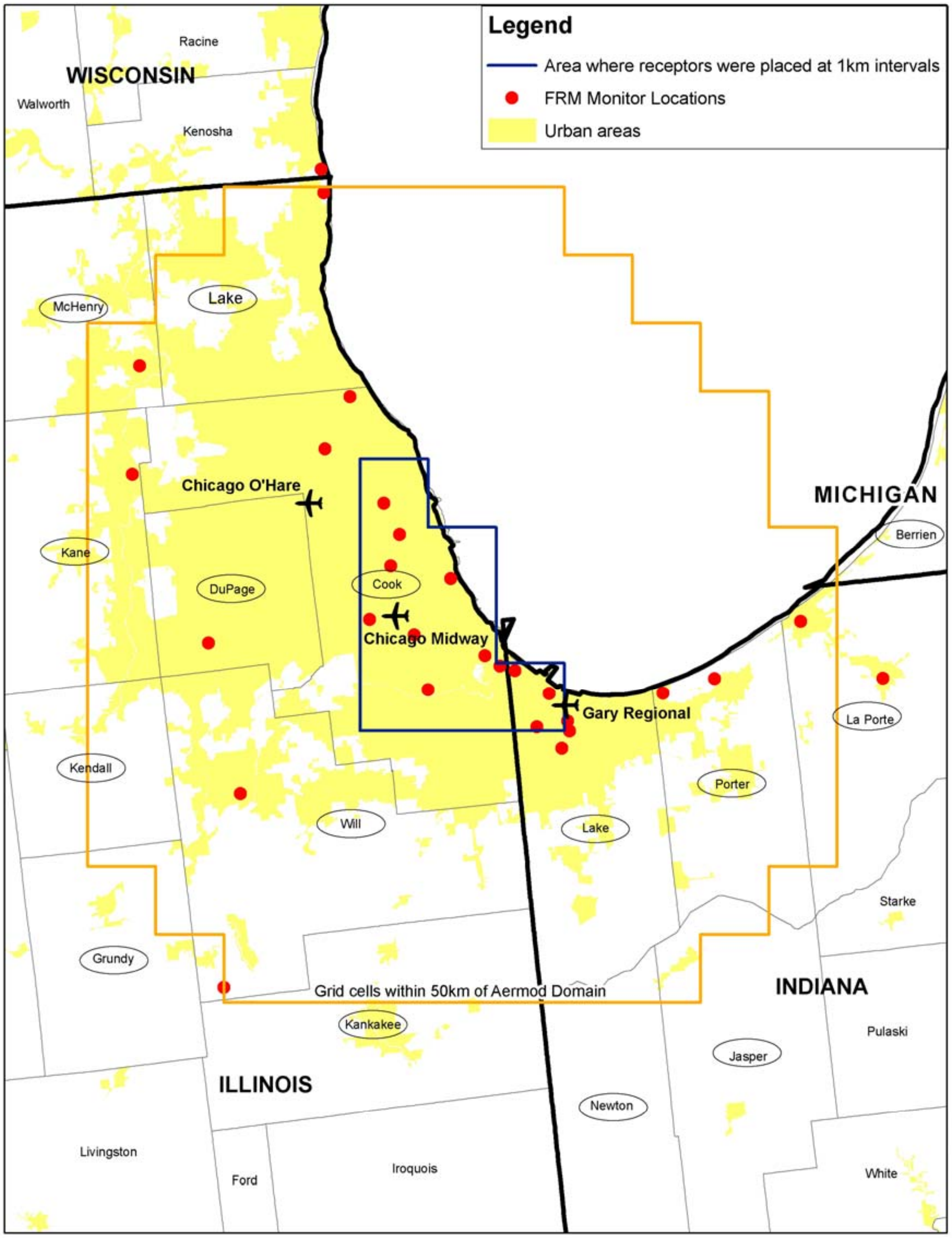

Figure 5: Chicago Modeling Domain: Emissions Domain by County and Receptor Grid within Urban Area and at Monitoring Sites

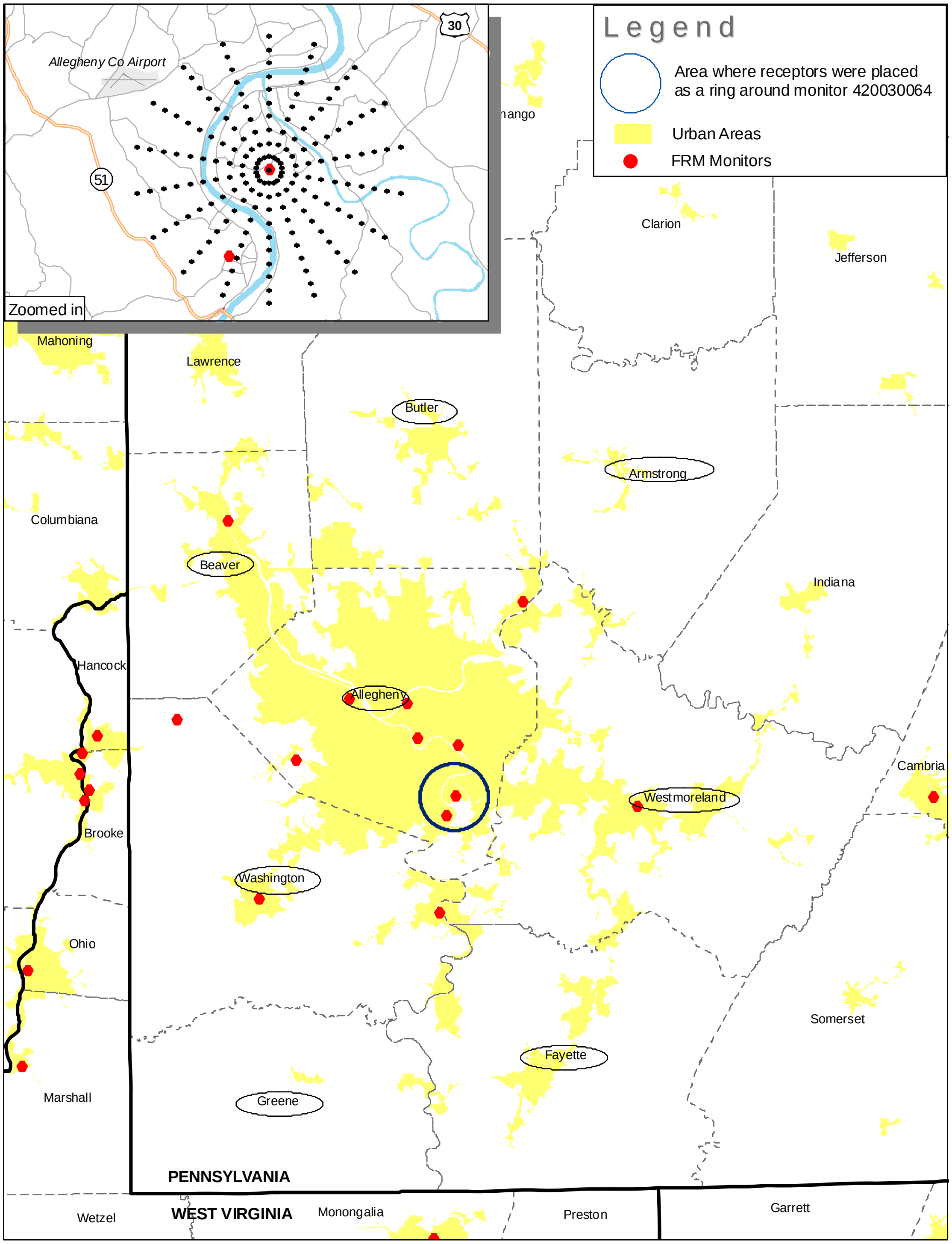

Figure 6: Pittsburh Modeling Domain: Emissions Domain by County and Receptor Grid within Urban Area and at Monitoring Sites

I.B Emissions Inventory and Processing

The emissions input data used for this local-scale modeling are based on the projected 2015 national emissions inventory reflecting implementation of the Clean Air Interstate Rule, the Clean Air Visibility Rule and the Clean Air Mercury Rule (CAIR/CAVR/CAMR http://www.epa.gov/airmarkets/mp/cair_camr_cavr.pdf). This inventory, denoted 2015bi, is consistent with the inventory used in the Community Multiscale Air Quality (CMAQ) photochemical modeling of PM2.5 for this rule. As such, it should be noted that this national-scale inventory is not a local scale inventory in that it does not contain all of the parameters typical for use in a local-scale assessment such as building parameters, fugitive and area source release parameters, and dimensions and locations for individual stacks. In addition, although stack-level emissions are provided for facilities in this national inventory, these estimates do not include detailed site specific stack parameters for all sources because, in many situations, stack parameters were defaulted based on either the process or industrial characterization for the facilities. In lieu of a detailed local scale inventory for each of these areas, we employed the national inventory and accepted its inherent limitations.

The SMOKE modeling system was used to generate temporalized and speciated PM2.5 emissions and sulfuric acid (SULF) from all source sectors emitting these pollutants emissions. The species of PM2.5 emissions generated here are the following:

- PSO4—Primary sulfate,
- PNO3—Primary nitrate,
- POA—Primary organic aerosol,
- PEC—Primary elemental carbon, and
- PMFINE— Primary "other" reflecting the remaining mass not included in above categories.

In addition to the above PM2.5 species, SULF (sulfuric acid), which is generated during SMOKE emissions modeling from SO2, was added to the SMOKE generated PSO4 prior to modeling in AERMOD as this is the approach used in CMAQ modeling.

Table 1 provides the source sectors of primary PM2.5 for the emissions inventory as processed by SMOKE. For each area, the following source sectors were modeled with AERMOD:

- Birmingham—all source sectors
- Detroit—all source sectors
- Seattle—ptipm, ptnonipm and certain oarea (residential wood, commercial cooking and natural gas combustion) and nonroad (airport-related sources and commercial marine vessel).
- Chicago – all source sectors
- Pittsburgh – ptipm, ptnonipm and pfdust (small but included in order to maintain all emissions at the facilities being modeled)

These source sectors (other than pfdust) were selected based on a review of their importance from an emissions standpoint within each urban area (see Table 3 for emissions data by sector).

Table 1. Inventory Sectors of Primary PM2.5 Emission Inventory

SMOKE Inventory Sector	Description
ptipm	Point sources: Electric Generating Units from the IPM 2015 bi case
ptnonipm	Point sources: nonEGU
ptfdust	Point sources: fugitive dust
oarea	Stationary non-point sources excluding fugitive dust and fires (county-level)
afdust	Stationary non-point fugitive dust sources (county-level)
avgfires	Fires–average fires used for wildfires and prescribed burning, and open burning (county-level)
Mobile	Onroad mobile sources (county-level)
Nonroad	Nonroad mobile sources (county-level)

The temporal resolution of the emissions generated from SMOKE was different for different source sectors. For fugitive dust sectors, hourly emissions were provided for a representative day for each season. For avgfires, hourly emissions were provided for a representative day for each month. For all other sectors, hourly emissions were provided from SMOKE for a representative Saturday, Sunday, Monday and Tuesday, as well as any special days, mostly holidays in the month. Tuesday was used as a representative weekday (excluding Monday).

The SMOKE generated hourly emissions for representative days were mapped to every day for the relevant months. For each urban area, emissions for four individual months representing each season, were generated for input into AERMOD as follows:

- Birmingham — February, April, June and September,
- Detroit — January, April, July and November, and
- Seattle — January, April, August and November
- Chicago — January, April, July and October
- Pittsburgh —, January, April, July and October

AERMOD computes concentrations by source groups that can then be used to analyze the relative impacts of different types of emissions sources. We assigned source groups within the SMOKE source sectors listed in Table 1 to capture the relative impacts of more refined source groups. The general approach was to capture the largest facilities (i.e., emissions greater than 50 tons per year in the inventory) and large groups of county-level emissions within the other SMOKE source sectors.

Table 2 shows the detailed source groupings used for each urban area except Pittsburgh as processed by SMOKE in developing model-ready emissions inputs to AERMOD. For Pittsburgh, point sources were individually grouped based on size / location from monitor of interest. As shown, for example, area fugitive dust sector is composed of four sub-groupings including agriculture-related, construction-related, road-related, and other. Furthermore, "IPM" and "nonIPM" source groups in Table 2 are an aggregate of those individual point sources not individually distinguished as a separate stationary point source. Tables 3 and 4 provide sector and county total emission summaries of primary PM2.5 emissions for the emission domains for each area.

Table 2. Detailed source groups used for each urban area in emission processing, Birmingham, Detroit, Seattle, and Chicago

Group Number	SMOKE Inventory Sector	Detailed Source Group
00	IPM	IPM sources not categorized as individual sources
01	non IPM	non IPM sources not categorized as individual sources
02	point fugitive dust	point fugitive dust
03	area fugitive dust	area fugitive dust other (i.e., not agriculture, construction or road-related)
04	area fugitive dust	area fugitive dust, agriculture-related
05	area fugitive dust	area fugitive dust, construction-related
06	area fugitive dust	area fugitive dust, road-related (paved/unpaved roads)
07	nonroad	aircraft
08	nonroad	Commercial marine vessel
09	nonroad	locomotives
10	nonroad	nonroad gasoline
11	nonroad	other nonroad (diesel (not including locomotives), CNG, LPG)
12	mobile	onroad gasoline
13	mobile	onroad diesel
14	avgfires	Wildfires
15	avgfires	prescribed burning
16	avgfires	agricultural burning
17	avgfires	open burning
18	oarea	residential wood burning
19	oarea	commercial cooking
20	oarea	natural gas combustion
21	oarea	residential waste burning
22	oarea	other oarea
41-70	individual IPM sources	individual IPM sources
80-99	individual non IPM sources	individual non IPM sources

Table 3. Sector Emissions Summary for Birmingham, Detroit, Seattle, Chicago, and Pittsburgh AERMOD Emission Domains

		Pollutant Emissions (tons) modeled through AERMOD						
	Sector	**POA**	**PEC**	**PMFINE**	**PNO3**	**PSO4**	**SULF**	**Total PM 2.5**
Birmingham 11-county area	**NonEGU**	1,982	183	6,025	44	2,361	212	10,807
	EGU	1,238	62	3,869	31	990	2,489	8,679
	Afdust	253	20	3,435	3	7	0	3,718
	Other Area	913	163	1,788	4	194	60	3,121
	Average Fire	2,848	451	511	9	63	0	3,883
	Nonroad	297	303	32	3	17	0	651
	On-Road	178	155	56	1	9	0	399
	Pfdust	10	1	154	0	0	0	165
	Total	7,720	1,338	15,869	94	3,641	2,761	31,423
Detroit 10-county area	**EGU**	2,417	121	7,545	60	1,932	5,941	18,016
	Afdust	676	52	9,505	10	18	0	10,261
	Other Area	1,497	181	2,148	4	296	303	4,429
	NonEGU	698	96	1,912	13	874	74	3,668
	Nonroad	822	868	161	7	162	0	2,020
	On-Road	533	431	170	2	27	0	1,164
	Average Fire	338	28	122	1	6	0	495
	Pfdust	1	0	14	0	0	0	15
	Total	6,983	1,777	21,578	96	3,315	6,318	40,067
Seattle 9-county area	**Other Area**	3,128	319	2,488	9	298	23	6,264
	EGU	548	23	1,449	12	395	271	2,698
	Nonroad	882	911	191	7	267	0	2,258
	NonEGU	364	70	1,055	7	536	11	2,043
	Average Fire	1,230	189	234	4	27	0	1,685
	Afdust	96	8	1,206	1	4	0	1,314
	On-Road	403	345	126	1	20	0	896
	Pfdust	0	0	0	0	0	0	0
	Total	6,652	1,865	6,748	41	1,547	306	17,159
Chicago 15-county area	**Other Area**	2,313	210	1,953	6	397	250	5,128
	EGU	123	95	4,447	1	4,662	4,021	13,349
	Nonroad	1,862	1,960	326	16	390	0	4,554
	NonEGU	6,238	346	16,956	355	5,096	221	29,212
	Average Fire	152	12	55	1	3	0	222
	Afdust	549	41	8,388	9	12	0	8,998
	On-Road	741	501	278	2	46	0	1,568
	Pfdust	20	2	222	0	1	0	245
	Total	11,998	3,165	32,626	389	10,606	4,492	63,277

	Pollutant Emissions (tons) modeled through AERMOD							
	Sector	**POA**	**PEC**	**PMFINE**	**PNO3**	**PSO4**	**SULF**	**Total PM 2.5**
Pittsburgh 8-county area (only point sources modeled)	**NonEGU**	614	60	2,152	112	848	35	3,822
	EGU	46	29	1,341	0	196	217	1,828
	Pfdust	1	0	17	0	0	0	19
	Total	661	89	3,510	113	1,044	252	5,669

Table 4. County-level Emissions Summary in Birmingham, Detroit, Chicago, and Pittsburgh AERMOD Emission Domains

		Pollutant Emissions (tons) modeled through AERMOD						
	County	**POA**	**PEC**	**PMFINE**	**PNO3**	**PSO4**	**SULF**	**Total PM 2.5**
Birmingham Counties	Bibb	304	65	191	1	20	1	582
	Blount	231	53	573	1	24	2	885
	Chilton	287	67	337	1	26	4	722
	Coosa	211	46	154	1	12	0	423
	Cullman	317	72	922	2	26	8	1,347
	Jefferson	2,574	392	6,866	45	2,003	1,153	13,034
	St Clair	300	76	492	2	70	3	943
	Shelby	1,196	169	2,531	19	651	652	5,217
	Talladega	510	124	999	4	316	212	2,165
	Tuscaloosa	959	164	766	4	80	21	1,993
	Walker	831	111	2,039	14	414	704	4,112
	Birmingham Total	**7,720**	**1,338**	**15,869**	**94**	**3,641**	**2,761**	**31,423**
Detroit Counties	Genesee	399	133	1,570	3	57	35	2,196
	Lapeer	163	57	1,054	1	26	5	1,306
	Lenawee	186	56	1,359	2	26	6	1,635
	Livingston	363	82	1,540	3	62	5	2,056
	Macomb	498	156	1,110	4	98	51	1,916
	Monroe	1,385	160	5,555	34	1,335	2,781	11,250
	Oakland	797	290	1,528	4	94	104	2,818
	St Clair	1,020	160	3,494	20	664	2,020	7,378
	Washtenaw	339	110	1,346	2	47	24	1,868
	Wayne	1,834	574	3,021	23	906	1,287	7,644
	Detroit Total	**6,983**	**1,777**	**21,578**	**96**	**3,315**	**6,318**	**40,067**
Seattle Counties	Island	192	53	466	1	19	0	731
	Jefferson	266	48	219	2	140	1	676
	King	2,171	774	957	10	345	14	4,271
	Kitsap	574	105	680	2	34	2	1,398
	Lewis	866	112	1,844	14	409	215	3,460
	Mason	237	50	277	1	16	1	582
	Pierce	902	319	874	7	435	70	2,606
	Snohomish	951	288	894	4	105	2	2,243
	Thurston	494	116	536	2	44	1	1,193
	Seattle Total	**6,652**	**1,865**	**6,748**	**41**	**1,547**	**306**	**17,159**

.		Pollutant Emissions (tons) modeled through AERMOD						
	County	**POA**	**PEC**	**PMFINE**	**PNO3**	**PSO4**	**SULF**	**Total PM 2.5**
Chicago Counties ***(*=partial county modeled)***	Cook, IL	4,537	1,532	6,071	33	1,931	738	14,842
	DuPage, IL	695	301	1,078	4	91	27	2,196
	Grundy, IL	67	10	229	48	21	2	376
	Kane, IL	516	117	1,555	3	76	12	2,279
	Kankakee, IL	146	26	760	2	25	1	960
	Kendall, IL	110	22	580	1	14	3	730
	Lake, IL	644	194	1,460	4	461	382	3,146
	McHenry, IL	135	29	650	1	38	1	856
	Will, IL	797	212	4,650	8	1,741	1,317	8,724
	Jasper, IN	85	37	1,561	0	985	793	3,462
	Lake, IN	2,167	426	7,416	30	3,628	785	14,452
	La Porte, IN	174	39	788	3	435	293	1,731
	Newton, IN	10	3	76	0	1	0	91
	Porter, IN	1,867	215	5,638	251	1,141	138	9,250
	Pulaski, IN	35	2	15	0	9	0	61
	Starke, IN	2	0	2	0	0	0	5
	Berrien, MI	11	1	96	0	7	0	115
	Chicago Total	**11,998**	**3,165**	**32,626**	**389**	**10,606**	**4,492**	**63,277**
Pittsburgh Counties ***(*=only sources within 50 km of monitor; italics= counties w/ all point sources modeled)***								
	Allegheny	539	65	2,400	10	801	137	3,952
	Armstrong*	2	1	20	0	4	0	27
	Beaver*	2	0	2	0	0	0	4
	Butler*	0	0	1	0	0	0	1
	Fayette*	4	0	37	0	27	0	68
	Greene*	2	0	1	0	1	0	4
	Washington	55	17	879	102	142	114	1,309
	Westmoreland*	56	4	170	1	70	2	304
	Pittsburgh Total	**661**	**89**	**3,510**	**113**	**1,044**	**252**	**5,669**

I.C Meteorological Inputs and Surface Characteristics

Meteorological inputs for AERMOD were generated by AERMET, which is the meteorology pre-processing program that inputs meteorological and surface information to calculate the boundary layer parameters for use by AERMOD to generate profiles of the needed meteorological variables.[5] AERMET uses meteorological measurements representative of the modeling domain to compute certain boundary layer parameters needed to estimate profiles of wind, turbulence and temperature. For this assessment, we used 2001 meteorological observations for each urban area from National Weather Service (NWS) surface and corresponding upper air stations. Table 5 provides information on the NWS station sites that were used as representative of each of the five urban areas. The surface station sites were chosen based on their geographic representation of the area of interest, while the upper air stations were chosen based on their proximity and their meteorological compatibility with the corresponding surface station.

Table 5. Summary of National Weather Service Station Sites For Each Urban Area

WBAN #	Station Name	Lat (degrees)	Lon (degrees)	Elevation (m)
Surface Station Sites				
13876	Birmingham Municipal	+33.57	-86.75	+189
14819	Chicago Midway	+41.78	-87.75	+187
9484	Detroit Metro. Airport	+42.22	-83.35	+194
94823	Pittsburgh	+40.50	-80.23	+351
24233	Seattle-Tacoma Intl	+47.47	-122.32	+122
Upper Air Station Sites				
53823	Birmingham	+33.17	-86.77	
94982	Davenport	+41.60	-90.57	
4830	Detroit/Pontiac	+42.70	-83.47	
94823	Pittsburgh	+40.50	-80.23	
94240	Quillayute	+47.95	-124.55	

AERMET processes the meteorological data in the following three stages:

1) The first stage extracts meteorological data from archive data files and processes the data through various quality assessment checks.
2) The second stage merges all data available for 24-hour periods (NWS and site-specific data) and stores these data together in a single file.
3) The third stage reads the merged meteorological data and estimates the necessary boundary layer parameters for use by AERMOD.

The parameterization of the boundary layer and the dispersion of pollutants within it are influenced on a local scale by surface characteristics such as surface roughness, reflectivity (albedo), and the availability of surface moisture (Bowen ratio).

These surface characteristics depend on land-use type (e.g., urban area, deciduous/coniferous forest, cultivated land, calm waters) and vary with the seasons and wind direction. We used land use data at a 30m resolution from the National Land Cover Dataset (NLCD) provided by USGS and the Earth Resources Observation & Science (EROS).[1] Based on this data, Table 6 provides the percentage of each dense receptor domain falling in each of seven land use categories.

[1] Descriptions of this data can be found at http://landcover.usgs.gov/natllandcover.asp and data can be downloaded at http://edcftp.cr.usgs.gov/pub/data/landcover/states/.

Table 6: Distribution of Land Use within Modeling Domain for each Urban Area

Land Use Category		Percent of Domain (%)				
NLCD Land Use Category[1]	**AERMET Land Use Category[2]**	**Birmingham**	**Chicago**	**Detroit**	**Pittsburgh**	**Seattle**
Commercial/Industrial/Transportation	Industrial (Urban)	20	12	34	3	20
Low & High Intensity Residential	Residential (Urban)	50	81	42	11	55
Deciduous Forest & Mixed Forest[3]	Deciduous Forest	20	3	10	41	7
Evergreen Forest & Mixed Forest[3]	Coniferous Forest	5	0	0	2	7
Grasslands/Herbaceous, Pasture Hay, Row Crops, Small Grains & Fallow	Cultivated Land	5	3	6	35	5
Open Water	Water[4]	0	0	2	8	6
Woody Wetlands & Emergent Herbaceous Wetlands	Swamp	0	1	6	0	0

[1] NLCD land use categories not listed in the table were either not present or minimally represented in the domain.
[2]The surface roughness values for the industrial (1m) and residential (0.5m) land use categories were taken from the CALPUFF User's Guide and the same values were applied for all four seasons. The seasonal albedo and Bowen ratio values were taken from the AERMET User's Guide for urban land use.
[3]For areas labeled by NLCD as mixed forest, 50% of the area was listed as being deciduous forest and 50% as coniferous forest.
[4]To avoid biasing the surface roughness low, the water land use category was incorporated as the percentage of land bordering water, instead of the percentage of the actual domain covered by water.

After having determined the land use categories describing each dense receptor grid and the associated surface characteristic values for each of these categories, we calculated the seasonal surface characteristic values for each area as shown in Table 7.

Table 7: Surface Characteristics Used in AERMET for each Urban Area.

Urban Area	Season	Albedo	Bowen Ratio	Roughness (m)
Birmingham	Winter	0.40	0.5	0.62
	Spring	0.14	0.4	0.72
	Summer	0.15	0.8	0.79
	Fall	0.16	0.8	0.68
Chicago	Winter	0.36	1.5	0.93
	Spring	0.14	1.0	0.95
	Summer	0.16	1.9	0.96
	Fall	0.18	1.9	0.94

Detroit	Winter	0.37	1.5	0.61
	Spring	0.14	0.9	0.66
	Summer	0.16	1.6	0.70
	Fall	0.17	1.7	0.65
Pittsburgh	Winter	0.48	0.9	0.31
	Spring	0.09	0.4	0.52
	Summer	0.09	0.4	0.64
	Fall	0.10	0.7	0.44
Seattle	Winter	0.36	1.5	0.61
	Spring	0.14	0.9	0.64
	Summer	0.15	1.6	0.67
	Fall	0.17	1.7	0.62

Note: Winter corresponds to December, January and February; Spring corresponds to March, April and May; Summer corresponds to June, July and August; and Fall corresponds to September, October and November.

In addition to the boundary layer parameters, AERMET passes all meteorological measurements of wind, temperature, and turbulence in a form AERMOD needs. Meteorological data for each area were processed by AERMET for the following months:

- Birmingham — February, April, June and September,
- Detroit — January, April, July and November, and
- Seattle — January, April, August and November.
- Chicago—January, April, July, and October.
- Pittsburgh— January, April, July, and October.

Tables 8 through 12 provide 2001 monthly summary statistics for meteorological variables for each of these urban areas.

Table 8. Monthly Summary Statistics for Meteorological Variables in Birmingham: 2001.

MET Variables	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yr.
Avg. Daily Temp (^{0}F)	40.1	51.0	49.7	64.5	70.5	75.3	80.1	78.5	71.6	60.6	58.6	49.3	62.5
Total Precipitation (in)	5.2	4.4	8.4	7.3	5.3	7.5	3.6	7.4	6.3	2.4	4.2	4.8	66.7
Mean Wind Speed (mph)	5.9	6.8	7.7	6.9	5.4	5.0	4.5	4.2	4.7	5.5	5.0	6.2	5.7
Prevailing Wind Direction	NW	N	N	SW	SW	SE	N	NE	NE	SE	SE	N	N

Table 9. Monthly Summary Statistics for Meteorological Variables in Detroit: 2001.

MET Variables	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yr.
Avg. Daily Temp (⁰F)	26.2	29.7	35.1	51.2	61.2	69.6	73.6	74.1	62.3	52.5	47.6	35.9	51.6
Total Precipitation (in)	0.7	2.9	0.9	3.2	3.7	3.4	1.2	2.9	4.3	6.8	2.4	2.2	34.5
Mean Wind Speed (mph)	9.5	11.0	9.7	9.8	8.6	7.4	7.6	7.5	8.2	11.0	9.9	10.2	9.2
Prevailing Wind Direction	SW	NW	NW	E	SW	S	NE	S	NE	SW	SW	SW	SW

Table 10. Monthly Summary Statistics for Meteorological Variables in Seattle: 2001.

MET Variables	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yr.
Avg. Daily Temp (⁰F)	42.0	40.7	45.4	48.0	55.4	57.6	62.5	64.8	59.8	50.9	46.7	41.5	51.3
Total Precipitation (in)	2.7	2.1	2.7	3.2	1.4	3.1	1.0	2.3	0.8	3.1	9.3	5.9	37.6
Mean Wind Speed (mph)	6.8	6.8	7.7	7.5	6.4	6.0	5.5	5.6	5.0	7.9	7.1	9.3	6.8
Prevailing Wind Direction	SE	N	SW	SW	SW	SW	SW	SW	N	SW	SW	SE	SW

Table 11. Monthly Summary Statistics for Meteorological Variables in Chicago: 2001.

MET Variables	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yr.
Avg. Daily Temp (⁰F)	24.6	26.1	34.2	52.5	60.0	67.4	74.6	73.2	61.9	52.1	48.2	43.4	50.7
Total Precipitation (in)	1.1	2.6	1.3	2.8	3.3	2.6	3.0	12.3	6.1	8.5	1.2	1.0	45.8
Mean Wind Speed (mph)	9.4	10.5	10.3	11.3	9.2	7.6	7.4	7.5	8.3	10.4	9.4	9.6	9.2
Prevailing Wind Direction	SW	W	NE	SW	SW	SW	SW	SW	NE	W	SW	W	W

Table 12. Monthly Summary Statistics for Meteorological Variables in Pittsburgh: 2001.

MET Variables	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yr.
Avg. Daily Temp (^{0}F)	28.4	35.1	35.3	54.3	60.0	68.4	70.2	73.1	62.1	54.2	48.2	37.5	52.5
Total Precipitation (in)	1.4	1.1	3.3	3.8	2.1	3.4	3.2	7.1	2.2	2.3	3.5	2.4	35.7
Mean Wind Speed (mph)	7.3	9.5	9.5	8.3	6.6	5.7	6.2	5.4	6.1	8.2	6.8	7.7	7.3
Prevailing Wind Direction	WSW	WNW	W	SW	ESE	WSW	SW	SW	N	SSW	SSW	SW	SW

I.D Terrain and Elevation Inputs

Terrain and elevation inputs were generated by AERMAP, which is a terrain pre-processor program to AERMOD that reads terrain data from United States Geological Survey (USGS) Digital Elevation Model (DEM) files. Receptor, monitor, and source locations are read into AERMAP to calculate the approximate elevation for each location as well as critical hill height values for each receptor.

The terrain around Birmingham, Detroit , Seattle, Chicago, and Pittsburgh was examined to determine whether or not terrain data was required for AERMOD simulations, i.e.,

- Birmingham lies at the southern end of the Appalachian Mountain chain. The area consists of valleys and ridges that run generally northeast to southwest. Differences in elevations between valley floors and the surrounding ridge tops are on the order of several hundred feet and so would require terrain as part of the analysis.

- Detroit is on the western side of the Detroit River that flows between Lake St. Clair and Lake Erie. The terrain is relatively flat with a variation of less than 100 feet between minimum and maximum elevations in and around the Detroit area. An area of rolling hills lies in a west-southwest to east-northeast direction with the closest hills located about 20 miles away to the north-northwest of the city.

- Seattle lies along the eastern shore of Puget Sound. On the western shore, mountains rise up to over 7,000 feet. To the east, the terrain rises into the Cascade Mountains where mountain heights are generally over 7,000 feet. These mountain ranges are oriented north-south and are about 40 miles away from Seattle.

- Pittsburgh lies in the foothills of the Allegheny Mountains at the confluence of the Allegheny and Monongahela Rivers. River valleys are very steep sided with numerous cliffs and sharp drop-offs. Differences in elevation between the river bottom and plateau tops are on the order of several hundred feet. There are many streams cutting through the plateau; feeding the three major rivers in the area.

- Chicago is located along the southwestern shore of Lake Michigan on top of the glacial moraine left over from the last Ice Age. The terrain is very flat with differences measured in tens of feet over large distances.

Where terrain is significant, AERMOD needs to account for terrain effects on air dispersion. Therefore, we prepared terrain data for Birmingham and Seattle and it was preprocessed through AERMAP. Detroit, Chicago, and Pittsburgh were modeled as flat terrain and therefore did not require any preprocessing from AERMAP.

II. Modeling Results

This section provides results of the local-scale modeling for each urban area. We determined percent reductions for the specific groups modeled using the same data used in the CMAQ modeling for 15/65, 15/35 and 14/35 scenarios. The modeling shows large spatial concentration gradients within the urban areas that are not predicted by the regional-scale, photochemical grid modeling (i.e., CMAQ). Therefore, the local modeling provides important complementary modeling results in evaluating the ability of areas to attain future PM2.5 standards. The results indicate that primary PM2.5 emissions from local sources are a significant contributor to PM2.5 concentrations. The most influential sources varied by receptor location depending on proximity to sources, especially in the case of the daily standard.

This assessment shows that controls on primary PM2.5 emissions from local sources can play an important role in attaining the PM2.5 standards. It demonstrates that known controls can provide significant reductions in incremental concentrations of PM2.5 required to meet an annual and daily standard. The following sections provide the detailed modeling results for each area including tables with source contributions of primary PM2.5 to monitors of interest (i.e., potential annual and daily exceedences of proposed standard) and graphs illustrating the spatial gradient of primary PM2.5 for the urban area.

Birmingham

Tables 15 and 16 show the AERMOD modeling results for primary PM2.5 impacts at monitor locations in Jefferson County exceeding the proposed annual (15 ug/m^3) and daily (35 ug/m^3) standards, respectively. In addition, Figure 7 provides the spatial gradient of primary PM2.5 for the urban area associated with emissions from all sources. For the annual standard, as shown in Table 15, the Jefferson County monitor #10730023 is expected to exceed 15 ug/m^3 by 0.99 ug/m^3 in 2015. The modeling results indicate that local sources of primary PM2.5 contribute 4.8 ug/m^3 to this monitor location and that the application of controls for the 15/65 scenario would yield a 1.2 ug/m^3 reduction with no additional controls for 15/35 or 14/35. Metal processing, mineral/rock wool manufacturing, and other industrial sources contribute significantly to this monitor with a combined contribution of 2.6 ug/m^3 of the 4.8 ug/m^3 total contribution from all modeled sources, or 55 percent. Table 15 also shows that the Jefferson County monitor #10732003 is expected to exceed 15 ug/m^3 by roughly 1.2 ug/m^3 in 2015. The modeling results indicate that local sources of primary PM2.5 contribute 4.3 ug/m^3 to this monitor location and that the application of controls for the 15/65 scenario would yield a 1.8 ug/m^3 reduction in annual PM2.5 concentrations here with no additional controls for 15/35 or 14/35. Metal processing and other industrial sources contribute significantly to this monitor with a combined contribution of 2.84 ug/m^3 of the 4.3 ug/m^3 total contribution from all modeled sources, or 66 percent. The AERMOD predicted reductions in primary PM2.5 presented here for each of these monitors is 3 to 5 times greater than the CMAQ prediction for Jefferson County which was roughly 0.36 ug/ m^3 for the 15/65 scenario.

For the daily standard, as shown in Table 16, the Jefferson County monitor #10732003 is expected to exceed 35 ug/m^3 by 3.4 ug/m^3 in 2015. The modeling results indicate that local sources of primary PM2.5 contribute 10.3 ug/m^3 to this monitor location, and that the application of controls for the 15/65 scenario would yield a 5.6 ug/m^3 reduction in PM2.5 concentrations here with no additional controls for 15/35 and 14/35. As with the annual concentrations at this monitor, the most significant contributors are metal processing and other industrial sources in addition to point fugitive dust.

Table 15. Summary of Modeled Source Contributions of Primary PM2.5 to Monitors with Potential Annual Exceedences in Birmingham: 2015

Source Sectors	Primary PM2.5 Emissions (ton/yr)	Model Predicted Annual Concentrations (ug/m3)			
		Primary PM2.5 Contribution	15/65 Control Scenario	15/35 Control Scenario	14/35 Control Scenario
Jefferson County Monitor #10730023, Annual DV = 15.99**					
Metal Processing	5,109	1.509	0.521	0.000	0.000
Mineral/Rock Wool	409	0.753	0.000	0.000	0.000
Other industrial sources	1,630	0.380	0.352	0.000	0.000
Point fugitive dust	166	0.352	0.000	0.000	0.000
Other area	686	0.328	0.000	0.000	0.000
Commercial cooking	285	0.261	0.000	0.000	0.000
Mining	1,242	0.252	0.245	0.000	0.000
Area fugitive dust	3,717	0.244	0.000	0.000	0.000
Nonroad (gasoline and diesel)	505	0.148	0.039	0.000	0.000
Onroad (gasoline and diesel)	400	0.115	0.000	0.000	0.000
Residential wood burning	927	0.096	0.000	0.000	0.000
Prescribed/open burning	2,461	0.080	0.000	0.000	0.000
CMV, Aircraft, Locomotive	146	0.069	0.034	0.000	0.000
Power Sector	8,679	0.057	0.000	0.000	0.000
Wildfires	1,404	0.041	0.000	0.000	0.000
Paper and Forest Products	1,115	0.030	0.000	0.000	0.000
Natural gas combustion*	1,196	0.026	0.000	0.000	0.000
Residential waste burning	28	0.025	0.000	0.000	0.000
Cement Manufacturing	617	0.013	0.000	0.000	0.000
Structural Clay and Bricks	249	0.009	0.009	0.000	0.000
Agricultural burning	18	0.000	0.000	0.000	0.000
Total, All Sources	30,989	4.787	1.201	0.000	0.000
Jefferson County Monitor #10732003, Annual DV = 16.22					
Metal Processing	5,109	2.543	1.369	0.000	0.000
Other industrial sources	1,630	0.299	0.260	0.000	0.000
Area fugitive dust	3,717	0.228	0.000	0.000	0.000
Point fugitive dust	166	0.209	0.000	0.000	0.000
Other area	686	0.156	0.000	0.000	0.000
Commercial cooking	285	0.129	0.000	0.000	0.000
Mining	1,242	0.128	0.116	0.000	0.000
Prescribed/open burning	2,461	0.094	0.000	0.000	0.000
Nonroad (gasoline and diesel)	505	0.081	0.015	0.000	0.000
Onroad (gasoline and diesel)	400	0.070	0.000	0.000	0.000
Power Sector	8,679	0.065	0.000	0.000	0.000
Mineral/Rock Wool	927	0.058	0.000	0.000	0.000
Residential wood burning	1,404	0.048	0.000	0.000	0.000
Wildfires	409	0.048	0.000	0.000	0.000
CMV, Aircraft, Locomotive	146	0.033	0.018	0.000	0.000
Structural Clay and Bricks	1,196	0.024	0.000	0.000	0.000
Residential waste burning	249	0.023	0.023	0.000	0.000
Cement Manufacturing	1,115	0.017	0.000	0.000	0.000
Paper and Forest Products	617	0.016	0.000	0.000	0.000
Natural gas combustion*	28	0.014	0.000	0.000	0.000
Agricultural burning	18	0.000	0.000	0.000	0.000
Total, All Sources	30,989	4.283	1.800	0.000	0.000

*Natural gas combustion emissions are adjusted here to reflect 94 percent reduction in baseline emissions due to new emissions factor.

**Major point sources adjusted to reduce overestimate bias and better reflect incremental contribution to this monitor.

Table 16. Summary of Modeled Source Contributions of Primary PM2.5 to Monitors with Potential Daily Exceedences in Birmingham: 2015

Source Sectors	Primary PM2.5 Emissions (ton/yr)	Model Predicted Daily Concentrations (ug/m3)*			
		Primary PM2.5 Contribution	15/65 Control Scenario	15/35 Control Scenario	14/35 Control Scenario
Jefferson County Monitor #10732003, Daily DV = 38.4**					
Metal Processing	5,109	8.233	5.242	0.000	0.000
Point fugitive dust	166	0.964	0.000	0.000	0.000
Other industrial sources	1,630	0.308	0.237	0.000	0.000
Area fugitive dust	3,717	0.158	0.000	0.000	0.000
Residential wood burning	927	0.124	0.000	0.000	0.000
Other area sources	686	0.110	0.000	0.000	0.000
Commercial cooking	285	0.087	0.000	0.000	0.000
Structural Clay and Bricks	400	0.057	0.000	0.000	0.000
Onroad (gasoline and diesel)	505	0.051	0.007	0.000	0.000
Nonroad (gasoline and diesel)	1,404	0.050	0.000	0.000	0.000
Wildfires	249	0.046	0.046	0.000	0.000
Cement Manufacturing	2,461	0.038	0.000	0.000	0.000
Prescribed/open burning	617	0.031	0.000	0.000	0.000
CMV, Aircraft, Locomotive	146	0.026	0.016	0.000	0.000
Natural Gas Combustion	1,242	0.011	0.006	0.000	0.000
Mining	1,196	0.009	0.000	0.000	0.000
Residential waste burning	8,679	0.003	0.000	0.000	0.000
Mineral/Rock Wool	409	0.003	0.000	0.000	0.000
Power Sector	1,115	0.001	0.000	0.000	0.000
Paper and Forest Products	18	0.001	0.000	0.000	0.000
Agricultural burning	28	0.001	0.000	0.000	0.000
Total, All Sources	30,989	10.315	5.554	0.000	0.000

*Natural gas combustion emissions are adjusted here to reflect 94 percent reduction in baseline emissions due to new emissions factor.

**Daily results reflect the 98th percentile day or the 3rd highest day modeled with AERMOD so for monitor #10732003 that day is Feb 14th.

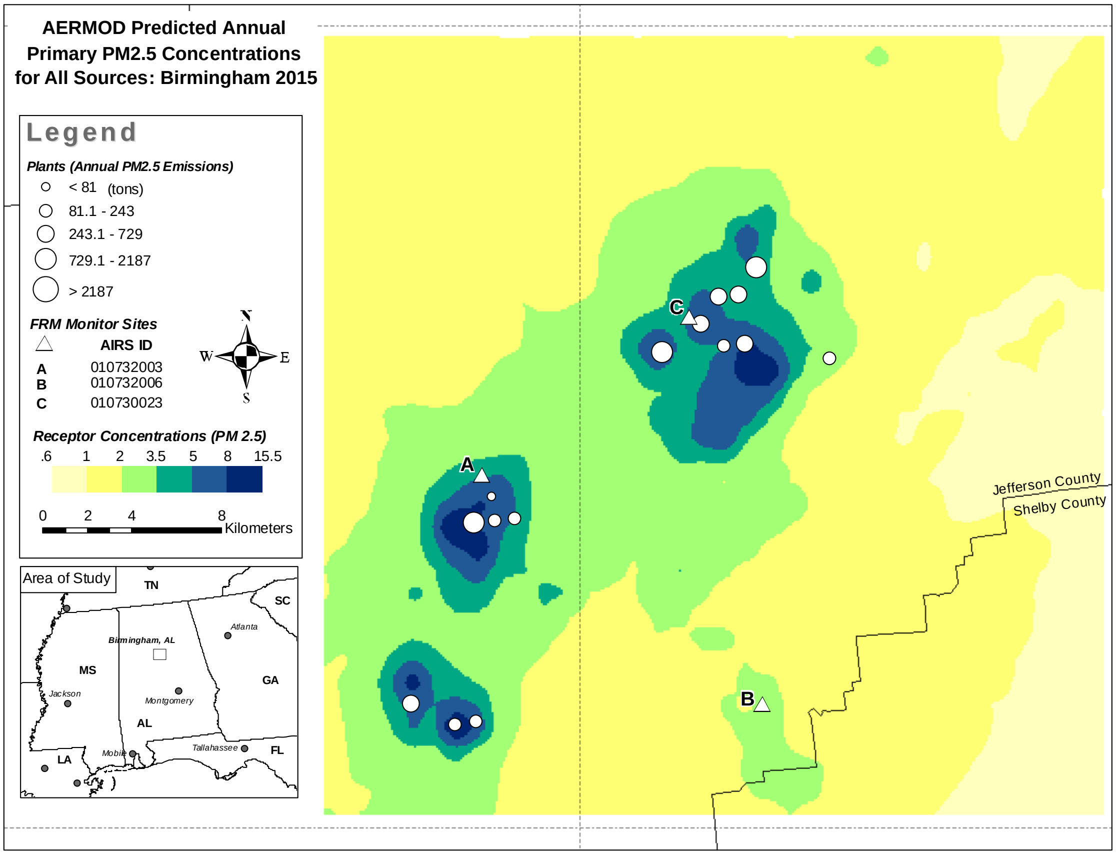

Figure 7. Spatial Gradient in Birmingham, AL of AERMOD Predicted Annual Primary PM2.5 Concentrations (ug/m^3) for All Sources: 2015
Note: Dashed lines reflect the 36km grid cells from regional-scale modeling with CMAQ model.

Detroit

Tables 17 and 18 show the AERMOD modeling results for primary PM2.5 impacts at monitor locations in Wayne County exceeding the proposed annual (15 ug/m^3) and daily (35 ug/m^3) standards, respectively. In addition, Figure 8 provides the spatial gradient of primary PM2.5 for the urban area associated with emissions from all sources. For the annual standard, as shown in Table 17, the Wayne County monitor #261630033 is expected to exceed 15 ug/m^3 by 2.4 ug/m^3 in 2015. The modeling results indicate that local sources of primary PM2.5 contribute 3.3 ug/m^3 to this monitor location and that the application of controls for the 15/65 scenario would yield a 0.56 ug/m^3 reduction in PM2.5 concentrations. The modeling results indicate little additional reductions at this monitor for the 15/35 scenario but an additional 0.46 ug/m^3 reduction in PM2.5 concentrations for the 14/35 scenario. Table 17 also shows that Wayne County monitor #261630015 is expected to exceed 15 ug/m^3 by roughly 0.7 ug/m^3 in 2015. The modeling results indicate that local sources of primary PM2.5 contribute 3.0 ug/m^3 to this monitor location and that the application of controls for the 15/65 scenario would yield a 0.55 ug/m^3 reduction in PM2.5 concentrations here. Table 17 shows little additional reductions for the 15/35 scenario but an additional 0.32 ug/m^3 reduction in PM2.5 concentrations for the 14/35 scenario.

Based on application of the 15/65 control set in Detroit, AERMOD predicted reductions in annual direct PM2.5 that were roughly 2 times higher than that predicted by CMAQ, i.e., a reduction in predicted direct PM2.5 concentrations by 0.56 $\mu g/m^3$ versus 0.26 $\mu g/m^3$. The models produced similar reductions in direct PM2.5 concentrations for the 15/35 control set, i.e., a reduction in predicted direct PM2.5 concentrations by 0.043 $\mu g/m^3$ versus 0.057 $\mu g/m^3$. For the 14/35 control set, the AERMOD predicted reductions were again higher than the CMAQ predictions like the 15/65 control set. The difference in results here are due to the nature of the controls so that when controls are applied to stationary point sources there will be greater differences while controls applied to more dispersed sources like area and mobile will result in more similar results.

Table18 summarizes the AERMOD daily concentrations at monitors expected to exceed 35 ug/m^3 in 2015. As shown in the table, the Wayne County monitor #261630033, which shows the highest daily design value (DV), is expected to exceed 35 ug/m^3 by 4.1 ug/m^3 in 2015. The modeling results indicate that local sources of primary PM2.5 contribute 6.4 ug/m^3 to this monitor location and that the application of controls for the 15/65 scenario would yield a 1.3 ug/m^3 reduction in PM2.5 concentrations. Table 18 shows little additional reductions for the 15/35 scenario but an additional 0.97 ug/m^3 reduction in PM2.5 concentrations for the 14/35 scenario. Results are also shown for Wayne County monitor #261630015 and indicate similar impacts of the 15/65 and 15/35 control sets but additional reductions under the 14/35 control set.

Table 17. Summary of Modeled Source Contributions of Primary PM2.5 to Monitors with Potential Annual Exceedences in Detroit: 2015

		Model Predicted Annual Concentrations (ug/m3)			
Source Sectors	**Primary PM2.5 Emissions (ton/yr)**	**Primary PM2.5 Contribution**	**15/65 Control Scenario**	**15/35 Control Scenario**	**14/35 Control Scenario**
	Wayne County Monitor #261630033, Annual DV = 17.4				
Other industrial sources	1,375	0.712	0.171	0.000	0.222
CMV, Aircraft, Locomotive	638	0.540	0.191	0.000	0.000
Metal Processing	852	0.484	0.037	0.000	0.000
Onroad (gasoline and diesel)	1,187	0.336	0.000	0.025	0.025
Commercial cooking	984	0.271	0.050	0.000	0.000
Area fugitive dust	10,270	0.237	0.000	0.000	0.000
Power Sector	18,016	0.233	0.059	0.000	0.014
Other area	888	0.210	0.000	0.000	0.168
Nonroad (gasoline and diesel)	1,603	0.197	0.033	0.019	0.019
Natural gas combustion	119	0.034	0.000	0.000	0.000
Residential wood burning	703	0.026	0.005	0.000	0.000
Residential waste burning	1,741	0.015	0.000	0.000	0.007
Glass Manufacturing	334	0.010	0.000	0.000	0.000
Cement Manufacturing	700	0.009	0.009	0.000	0.000
Auto Industry	413	0.005	0.000	0.000	0.000
Prescribed/open burning	444	0.004	0.000	0.000	0.003
Point fugitive dust	15	0.001	0.000	0.000	0.000
Wildfires	51	0.001	0.000	0.000	0.000
Total, All Sources	40,333	3.324	0.556	0.043	0.459
	Wayne County Monitor #261630015, Annual DV = 15.69				
CMV, Aircraft, Locomotive	638	0.727	0.257	0.000	0.000
Metal Processing	852	0.399	0.031	0.000	0.000
Other industrial sources	1,375	0.395	0.094	0.000	0.125
Commercial cooking	984	0.365	0.068	0.000	0.000
Power Sector	18,016	0.311	0.064	0.000	0.031
Onroad (gasoline and diesel)	1,187	0.214	0.000	0.016	0.016
Area fugitive dust	10,270	0.183	0.000	0.000	0.000
Other area	888	0.154	0.000	0.000	0.123
Nonroad (gasoline and diesel)	1,603	0.147	0.025	0.014	0.014
Residential wood burning	703	0.024	0.005	0.000	0.000
Residential waste burning	1,741	0.013	0.000	0.000	0.007
Glass Manufacturing	334	0.009	0.000	0.000	0.000
Cement Manufacturing	700	0.008	0.008	0.000	0.000
Auto Industry	413	0.005	0.000	0.000	0.000
Prescribed/open burning	444	0.003	0.000	0.000	0.003
Natural gas combustion	119	0.002	0.000	0.000	0.000
Point fugitive dust	15	0.001	0.000	0.000	0.000
Wildfires	51	0.000	0.000	0.000	0.000
Total, All Sources	40,333	2.962	0.550	0.030	0.319

*Natural gas combustion source category results are adjusted to reflect new emissions factor (94 percent reduction).

Table 18. Summary of Modeled Source Contributions of Primary PM2.5 to Monitors with Potential Daily Exceedences in Detroit: 2015

Source Sectors	Primary PM2.5 Emissions (ton/yr)	Model Predicted Daily Concentrations (ug/m3)*			
		Primary PM2.5 Contribution	15/65 Control Scenario	15/35 Control Scenario	14/35 Control Scenario
Wayne County Monitor #261630033, Daily DV = 39.06**					
Power Sector	18,016	0.896	0.344	0.000	0.021
Metal Processing	852	0.623	0.048	0.000	0.000
Cement Manufacturing	700	0.024	0.024	0.000	0.000
Glass Manufacturing	334	0.025	0.000	0.000	0.000
Auto Industry	413	0.014	0.000	0.000	0.000
Other industrial sources	1,375	1.691	0.378	0.000	0.579
CMV, Aircraft, Locomotive	638	0.833	0.297	0.000	0.000
Nonroad (gasoline and diesel)	1,603	0.296	0.041	0.030	0.030
Onroad (gasoline and diesel)	1,187	0.475	0.000	0.035	0.035
Residential waste burning	1,741	0.022	0.000	0.000	0.011
Residential wood burning	703	0.038	0.008	0.000	0.000
Commercial cooking	984	0.587	0.109	0.000	0.000
Prescribed/open burning	444	0.006	0.000	0.000	0.005
Wildfires	51	0.000	0.000	0.000	0.000
Area fugitive dust	10,270	0.522	0.000	0.000	0.000
Point fugitive dust	15	0.002	0.000	0.000	0.000
Other area	888	0.362	0.000	0.000	0.289
Natural gas combustion	119	0.003	0.000	0.000	0.000
Total, All Sources	40,333	6.418	1.250	0.065	0.970
Wayne County Monitor #261630015, Daily DV = 38.6**					
Power Sector	18,016	0.730	0.149	0.000	0.083
Metal Processing	852	1.604	0.123	0.000	0.000
Cement Manufacturing	700	0.003	0.003	0.000	0.000
Glass Manufacturing	334	0.008	0.000	0.000	0.000
Auto Industry	413	0.003	0.000	0.000	0.000
Other industrial sources	1,375	0.844	0.264	0.000	0.153
CMV, Aircraft, Locomotive	638	2.082	0.725	0.000	0.000
Nonroad (gasoline and diesel)	1,603	0.118	0.017	0.012	0.012
Onroad (gasoline and diesel)	1,187	0.189	0.000	0.014	0.014
Residential waste burning	1,741	0.021	0.000	0.000	0.011
Residential wood burning	703	0.015	0.003	0.000	0.000
Commercial cooking	984	0.534	0.099	0.000	0.000
Prescribed/open burning	444	0.005	0.000	0.000	0.004
Wildfires	51	0.000	0.000	0.000	0.000
Area fugitive dust	10,270	0.159	0.000	0.000	0.000
Point fugitive dust	15	0.003	0.000	0.000	0.000
Other area	888	0.160	0.000	0.000	0.128
Natural gas combustion	119	0.024	0.000	0.000	0.000
Total, All Sources	40,333	6.502	1.383	0.026	0.406

*Natural gas combustion source category results are adjusted to reflect new emissions factor (94 percent reduction).
**Each daily results reflects the 98th percentile day or the 3rd highest day modeled with AERMOD so for monitor #261630015 that day is Nov 18th, for monitor #261630033 that day is Jan 1st.

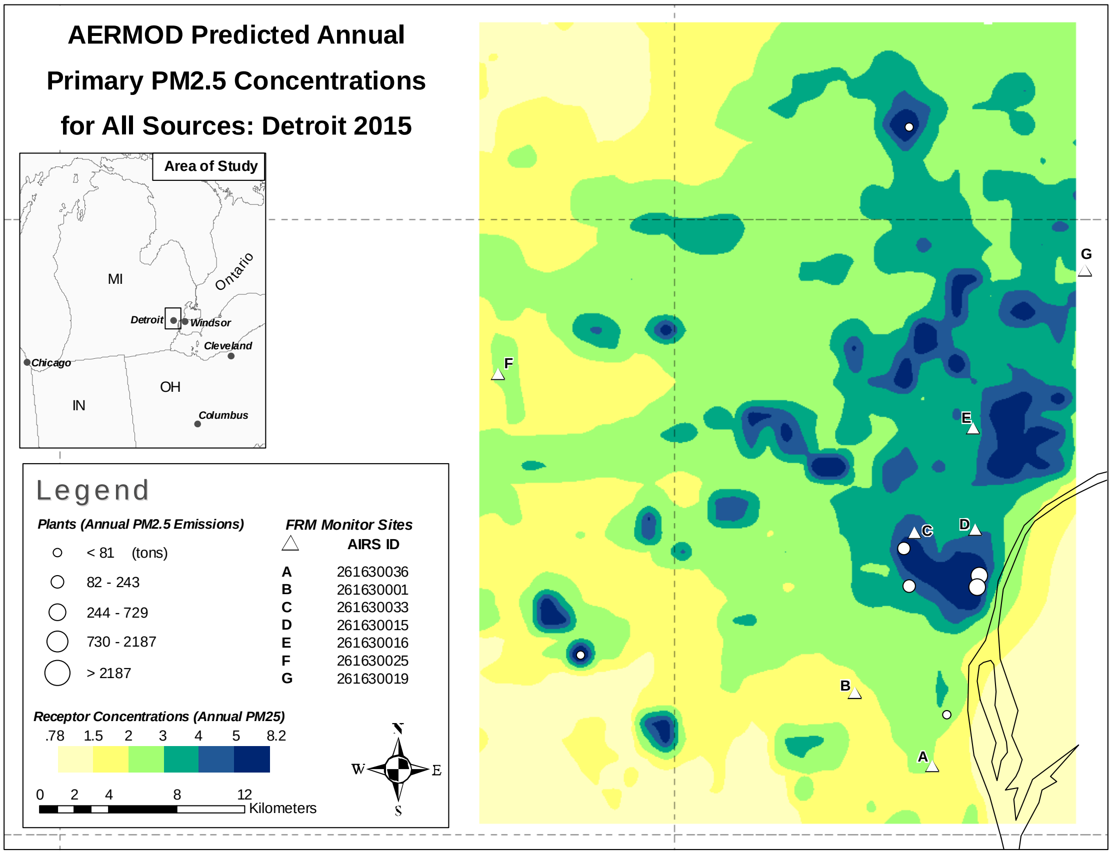

Figure 8. Spatial Gradient in Detroit, MI of AERMOD Predicted Annual Primary PM2.5 Concentrations (ug/m^3) for All Sources: 2015
Note: Dashed lines reflect the 36km grid cells from regional-scale modeling with CMAQ model.

Seattle

Table 19 shows the AERMOD modeling results for primary PM2.5 impacts at monitor locations in Pierce County exceeding the proposed daily (35 ug/m^3) standard. In addition, Figure 9 provides the spatial gradient of primary PM2.5 for the urban area associated with emissions from all modeled sources. For the daily standard, as shown in Table 19, the Pierce County monitor #530330029 is expected to exceed a 35 ug/m^3 daily standard by 8 ug/m^3 in 2015. The modeling results indicate that local sources of primary PM2.5 contribute 2.4 ug/m^3 to this monitor location, and that the application of controls to meet the 15/35 and 14/25 standard levels would yield a 1.1 ug/m^3 reduction in PM2.5 concentration here. Paper and forest products plants, commercial and marine vessels, residential wood burning, and commercial cooking contribute significantly to the Pierce County monitor's daily value with a combined contribution of just over 2 ug/m^3 of the 2.4 ug/m^3 total contribution from all modeled sources, or 85 percent. Table 19 also shows that the Snohomish County monitor #530611007 is expected to exceed a 35 ug/m^3 daily standard by 5.2 ug/m^3 in 2015. The modeling results indicate that local sources of primary PM2.5 contribute 3.4 ug/m^3 to this monitor location, and that the application of controls to meet the 15/35 and 14/25 standard levels would yield a 1.5 ug/m^3 reduction in PM2.5 concentration here. Residential wood and waste burning contribute significantly to the Snohomish County monitor's daily value with 3 ug/m^3 of the 3.4 ug/m^3 total contribution from all modeled sources, or almost 90 percent.

As discussed in the proposal RIA, the Seattle urban area was also evaluated using photochemical grid modeling through application of the Response Surface Model (RSM). There are important differences across these modeling approaches that limit the direct comparability of these modeling results. A major difference is that the RSM includes background and transported concentrations of direct PM2.5 within the urban area but focused only on organic components of primary PM2.5 whereas the AERMOD modeling was limited to only those emissions sources in the city and surrounding counties but included other direct species of PM2.5 like crustal materials. Despite these differences a comparison of results from these assessments provides insights of use here. For comparison purposes, in Snohomish county, the RSM suggested that direct PM2.5 emissions of carbon contribute around 2.2 ug/m^3 to the daily design value in 2015 whereas the AERMOD estimate for modeled sources in the proposal RIA was 3.3 ug/m^3. This comparison suggests that there is an additional 50 percent contribution of direct PM2.5 attributable to a combination of direct PM2.5 emissions of crustal materials (which were not evaluated with the RSM approach) and the effect of "local" modeling that provides a more resolved spatial gradient within this urban area. Furthermore, both AERMOD and RSM predict that residential wood burning, which is an area source, is the major contributor at this monitor location. In King County, the RSM suggested that direct PM2.5 emissions of carbon contribute around 2.5 ug/m^3 to the daily design value which was comparable to the AERMOD prediction of 2.4 ug/m^3 from all modeled sources of direct PM2.5 emissions within Seattle. This indicates that background or transported concentrations of primary PM2.5 may be more important at this monitor location.

Table 19. Summary of Modeled Source Contributions of Primary PM2.5 to Monitors with Potential Daily Exceedences in Seattle: 2015

		Model Predicted Daily Concentrations (ug/m3)**			
Source Sectors	**Primary PM2.5 Emissions (ton/yr)**	**Primary PM2.5 Contribution**	**15/65 Control Scenario**	**15/35 Control Scenario**	**14/35 Control Scenario**
Pierce County Monitor #530330029, Daily DV = 43.0					
Paper and Forest Products	965	0.748	0.000	0.707	0.707
CMV	648	0.476	0.160	0.000	0.000
Residential wood burning	2,115	0.417	0.000	0.202	0.202
Commercial cooking	1,646	0.388	0.000	0.072	0.072
Other industrial sources	458	0.116	0.000	0.110	0.110
Power Sector	2,671	0.065	0.000	0.000	0.000
Residential waste burning	1,696	0.059	0.000	0.030	0.030
Metal Processing	283	0.036	0.000	0.001	0.001
Aircraft	114	0.027	0.000	0.000	0.000
Natural gas combusion	29	0.025	0.000	0.000	0.000
Cement and Mining	233	0.013	0.000	0.000	0.000
Nonroad (gasoline and diesel)	10	0.003	0.000	0.000	0.000
Naval Shipyards	107	0.000	0.000	0.000	0.000
Total, All Sources	10,976	2.373	0.160	1.122	1.122
Snohomish County Monitor #530611007, Daily DV = 40.2					
Residential wood burning	2,115	2.114	0.000	1.025	1.025
Residential waste burning	1,696	0.891	0.000	0.446	0.446
Natural gas combusion	29	0.221	0.000	0.000	0.000
Commercial cooking	1,646	0.171	0.000	0.032	0.032
Aircraft	114	0.006	0.000	0.000	0.000
Paper and Forest Products	965	0.005	0.000	0.002	0.002
Other industrial sources	458	0.002	0.000	0.002	0.002
Metal Processing	283	0.001	0.000	0.000	0.000
Cement and Mining	233	0.001	0.000	0.000	0.000
Naval Shipyards	107	0.001	0.000	0.000	0.000
Power Sector	2,671	0.000	0.000	0.000	0.000
CMV	648	0.000	0.000	0.000	0.000
Nonroad (gasoline and diesel)	10	0.000	0.000	0.000	0.000
Total, All Sources	10,976	3.412	0.000	1.507	1.507

*Natural gas combustion emissions are adjusted here to reflect 94 percent reduction in baseline emissions due to new emissions factor.

**Each daily results reflects the 98th percentile day or the 3rd highest day modeled with AERMOD so for monitor #530330029 that day is Jan 11th and for monitor 530611007 that day is Jan 16th.

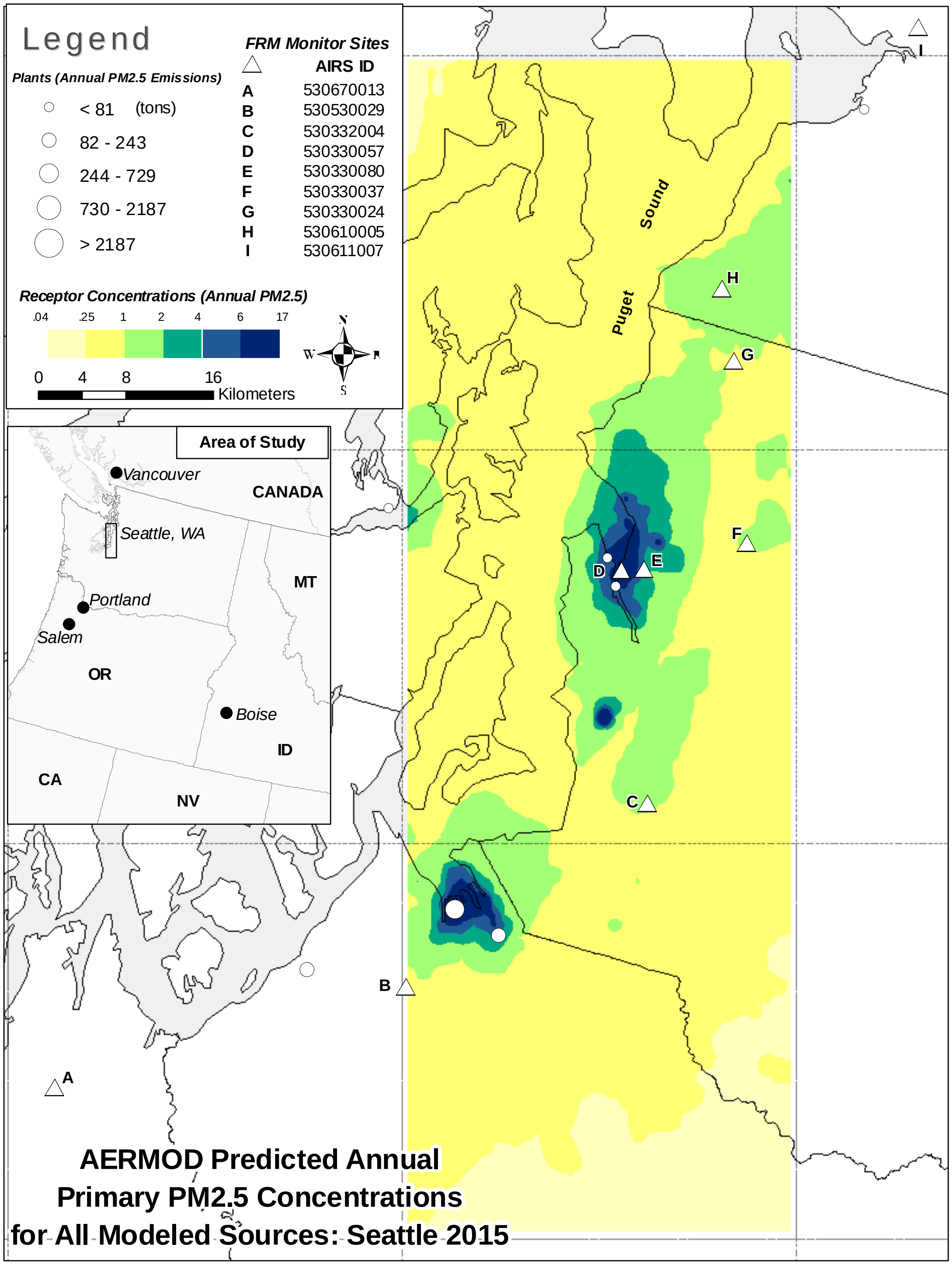

Figure 9. Spatial Gradient in Seattle, WA of AERMOD Predicted Annual Primary PM2.5 Concentrations (ug/m^3) for All Modeled Sources: 2015

Note: Dashed lines reflect the 36km grid cells from regional-scale modeling with CMAQ model.

Chicago

Table 20 shows the AERMOD modeling results for primary PM2.5 impacts at monitoring site #170310052 Cook County exceeding the proposed annual (15 ug/m^3) and daily (35 ug/m^3) standards, respectively. In addition, Figure 8 provides the spatial gradient of primary PM2.5 for the urban area associated with emissions from all sources. For the annual standard, as shown in Table 20, the Cook County monitor #170310052 is expected to exceed 15 ug/m^3 by 0.5 ug/m^3 in 2015. The modeling results indicate that local sources of primary PM2.5 contribute 3.9 ug/m^3 to this monitor location and that the application of controls for the 15/65 scenario would yield a 1.09 ug/m^3 reduction in PM2.5 concentrations. The modeling results indicate little additional reductions at this monitor for the 15/35 and 14/35 scenarios. For the daily standard, as shown in Table 20, this monitor is expected to exceed a 35 ug/m^3 daily standard by 2.1 ug/m^3 in 2015. The modeling results indicate that local sources of primary PM2.5 contribute 11.35 ug/m^3 to this monitor location and that the application of controls to meet the 15/65 scenario would yield a 3.0 ug/m^3 reduction in PM2.5 concentrations. The modeling results indicate that the 15/35 and 14/25 scenarios show little additional reductions, i.e., almost 0.05 ug/m^3 reduction in PM2.5 concentration here.

Table 20. Summary of Modeled Source Contributions of Primary PM2.5 to Monitor with Potential Exceedences in Chicago: 2015

		Model Predicted Concentrations (ug/m3)			
Source Sectors	**Primary PM2.5 Emissions (ton/yr)**	**Primary PM2.5 Contribution**	**15/65 Control Scenario**	**15/35 Control Scenario**	**14/35 Control Scenario**
Cook County Monitor #170310052, Annual DV = 15.5					
Power Sector	8,514	0.100	0.005	0.000	0.000
Metal Processing	17,625	0.344	0.123	0.000	0.000
Stone, Clay, Cement	561	0.013	0.005	0.000	0.000
Chemical Manufacturing	1,392	0.056	0.016	0.000	0.000
Petroleum industry	1,939	0.051	0.016	0.000	0.000
Paper and Allied Products	181	0.006	0.000	0.000	0.000
Food and Kindred Products	1,609	0.080	0.000	0.000	0.000
Other industrial sources	8,386	0.928	0.592	0.000	0.000
CMV, Aircraft, Locomotive	1,435	0.167	0.045	0.000	0.000
Nonroad (gasoline and diesel)	3,119	0.555	0.114	0.028	0.028
Onroad (gasoline and diesel)	1,568	0.286	0.028	0.001	0.001
Residential waste burning	400	0.003	0.000	0.000	0.000
Residential wood burning	877	0.209	0.062	0.000	0.000
Commercial cooking	1,699	0.434	0.080	0.000	0.000
Prescribed/open burning/wildfire	222	0.002	0.000	0.000	0.000
Area fugitive dust	8,998	0.425	0.000	0.000	0.000
Other area	729	0.228	0.000	0.000	0.000
Total, All Sources	59,255	3.887	1.086	0.029	0.029
Cook County Monitor #170310052, Daily DV = 37.1*					
Power Sector	8,514	0.432	0.034	0.000	0.000
Metal Processing	17,625	0.538	0.075	0.000	0.000
Stone, Clay, Cement	561	0.030	0.004	0.000	0.000
Chemical Manufacturing	1,392	0.104	0.022	0.000	0.000
Petroleum industry	1,939	0.237	0.075	0.000	0.000
Paper and Allied Products	181	0.030	0.000	0.000	0.000
Food and Kindred Products	1,609	0.301	0.000	0.000	0.000
Other industrial sources	8,386	2.596	1.732	0.000	0.000
CMV, Aircraft, Locomotive	1,435	0.335	0.114	0.000	0.000
Nonroad (gasoline and diesel)	3,119	1.007	0.252	0.043	0.043
Onroad (gasoline and diesel)	1,568	1.028	0.106	0.004	0.004
Residential waste burning	400	0.002	0.000	0.000	0.000
Residential wood burning	877	1.327	0.393	0.000	0.000
Commercial cooking	1,699	1.098	0.203	0.000	0.000
Prescribed/open burning/wildfire	222	0.002	0.000	0.000	0.000
Area fugitive dust	8,998	1.465	0.000	0.000	0.000
Other area	729	0.823	0.000	0.000	0.000
Total, All Sources	59,255	11.354	3.010	0.047	0.047

*Daily results reflect the 98th percentile day or the 3rd highest day modeled with AERMOD so for monitor #170310052 that day is January 11.

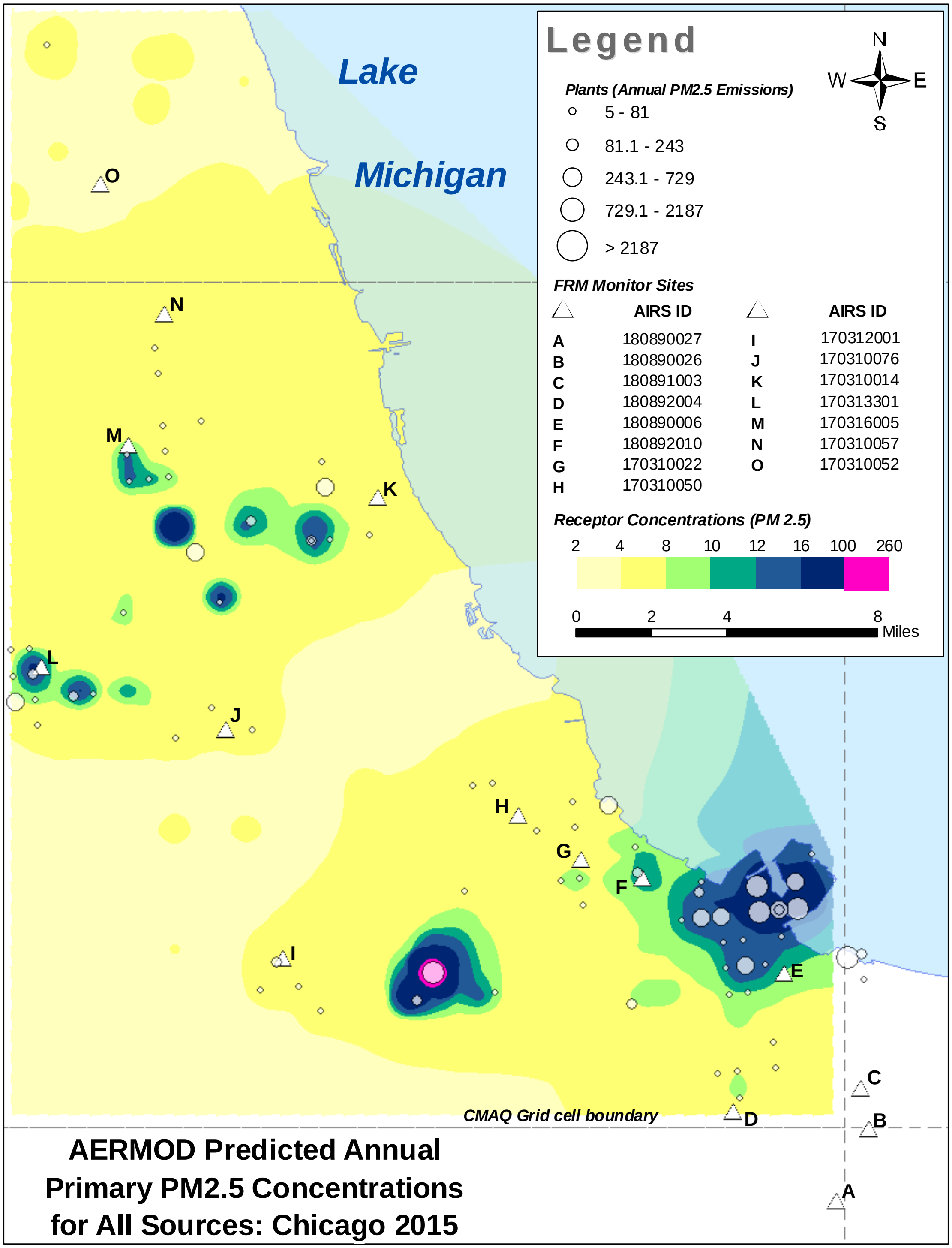

Figure 10. Spatial Gradient in Chicago, IL of AERMOD Predicted Annual Primary PM2.5 Concentrations (ug/m^3) for All Modeled Sources: 2015

Note: Dashed lines reflect the 36km grid cells from regional-scale modeling with CMAQ model.

Pittsburgh

Table 21 shows the AERMOD modeling results for primary PM2.5 impacts at the monitor location in Allegheny County exceeding the proposed annual (15 ug/m^3) and daily (35 ug/m^3) standards, respectively. In addition, Figure 8 provides the spatial gradient of primary PM2.5 for the urban area associated with emissions from point sources within 50 km of this monitor. Local sources contributing to direct PM2.5 concentrations here include as metal manufacturing, coal combustion, and mining. As shown in the table, the Allegheny County monitor #420030064 is expected to exceed the annual standard of 15 ug/m^3 by 1.8 ug/m^3 and the daily standard of 35 ug/m^3 by 17.4 ug/m^3 in 2015. The modeling results indicate that local sources of primary PM2.5, which emit roughly 5,700 tons, contribute 1.75 ug/m^3 to the annual concentrations and 7.9 ug/m^3 to the 3rd highest daily concentration at this monitor location. However, the application of controls associated with 15/35 and 14/35 scenarios would yield roughly a 0.1 ug/m^3 reduction in annual concentrations and roughly a 0.25 ug/m^3 reduction in the daily concentration. Given the limited number of local sources modeled through AERMOD, the modeling results are not comparable to those obtained from CMAQ which included all regional and local sources of direct PM2.5 contributing to this monitoring site.

Table 21. Summary of Modeled Source Contributions of Primary PM2.5 to Monitor with Potential Exceedences in Pittsburgh: 2015

		Model Predicted Concentrations (ug/m3)			
Source Sectors	**Primary PM2.5 Emissions (ton/yr)**	**Primary PM2.5 Contribution**	**15/65 Control Scenario**	**15/35 Control Scenario**	**14/35 Control Scenario**
	Allegheny County Monitor #420030064, Annual DV = 16.47				
Power Sector	1,828	0.077	0.009	0.017	0.004
Metal Processing	1,435	1.400	0.011	0.038	0.038
Other manufacturing	2,387	0.271	0.097	0.057	0.057
Point fugitive dust	19	0.003	0.000	0.000	0.000
Total, All Sources	5,669	1.751	0.116	0.112	0.099
	Allegheny County Monitor #420030064, Daily DV = 53.43**				
Power Sector	1,828	0.217	0.029	0.035	0.009
Metal Processing	1,435	7.015	0.002	0.057	0.057
Other manufacturing	2,387	0.644	0.192	0.162	0.162
Point fugitive dust	19	0.000	0.000	0.000	0.000
Total, All Sources	5,669	7.877	0.223	0.254	0.228

*Natural gas combustion emissions are adjusted here to reflect 94 percent reduction in baseline emissions due to new emissions factor.

**Daily results reflect the 98th percentile day or the 3rd highest day modeled with AERMOD so for monitor #420030064 that day is July 23.

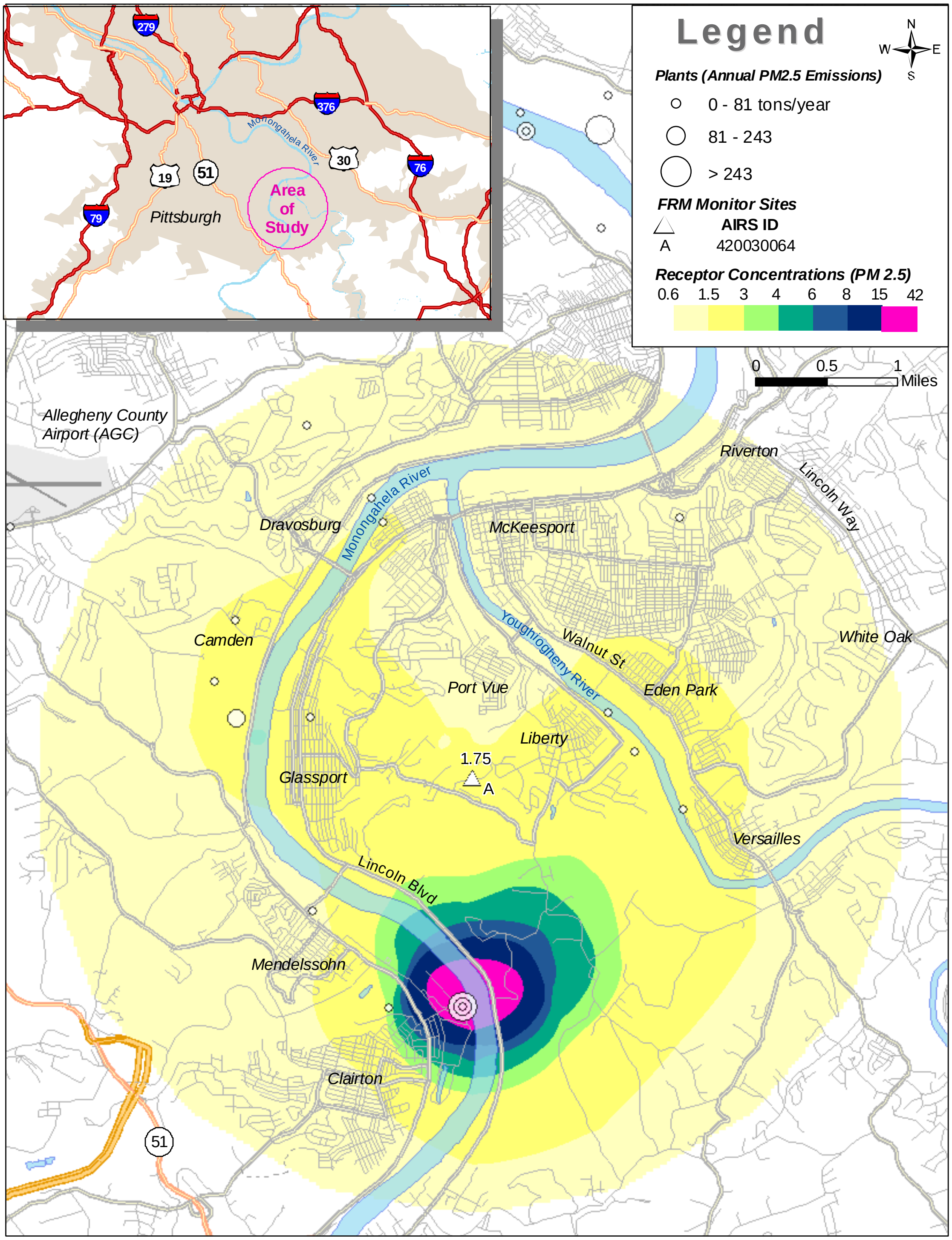

Figure 10. Spatial Gradient in Pittsburgh, PA of AERMOD Predicted Annual Primary PM2.5 Concentrations (ug/m^3) for Point Sources within 50km: 2015
Note: Dashed lines reflect the 36km grid cells from regional-scale modeling with CMAQ model.

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