UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Office of Air Quality Planning and Standards
Research Triangle Park, NC 27711

April 15, 2011

MEMORANDUM

SUBJECT: $PM_{2.5}$ Air Quality Analyses - Update

FROM: Mark Schmidt, OAR/OAQPS/AQAD

TO: PM NAAQS Review Docket EPA-OAQR-2007-0492

Overview

This memorandum documents updates to $PM_{2.5}$ air quality analyses conducted for the review of the particulate matter (PM) national ambient air quality standards (NAAQS) previously presented in Schmidt et al., 2010.[1] The purpose of these analyses was to inform staff conclusions on alternative $PM_{2.5}$ standards that are appropriate to consider in the current PM NAAQS review.

Specific analyses conducted, including tasks, assumptions, caveats, and processing methodologies are described in more details below. In summary, these analyses address the following:

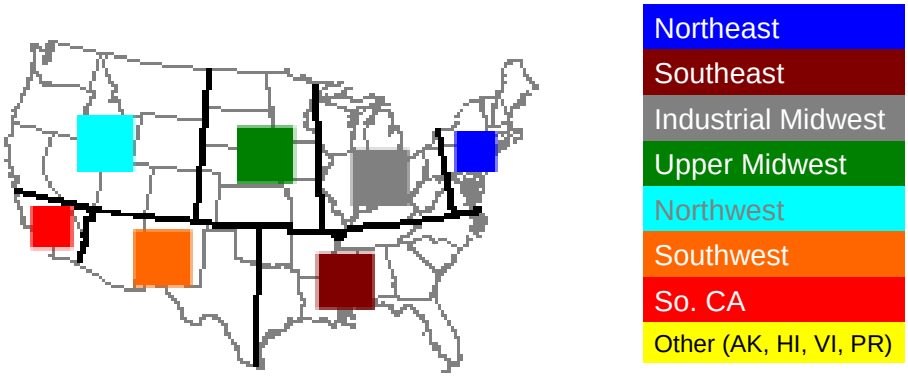
- Analysis A – Evaluation of the spatial averaging provisions for the $PM_{2.5}$ annual standard, specifically, a demographic analysis of the potential for disproportionate impacts on potentially vulnerable populations (i.e., environmental justice analysis) – clarification of Analysis 1 described in Schmidt et al., 2010.
- Analysis B – County-level 24-hour design values versus annual design values, 2007-2009 – update of Analysis 4 described in Schmidt et al., 2010.
- Analysis C – Assessment of areas not likely to meet current and alternative $PM_{2.5}$ standards[2] - update of Analysis 5 described in Schmidt et al., 2010.

In Analyses B and C counties were identified and/or aggregated by U.S. geographic region (Figure 1). These regional definitions are identical to regions considered in the *Quantitative Health Risk Assessment for Particulate Matter* (EPA-452/R-10-005)[3] and in previous PM NAAQS reviews.

Additional data processing details are described in the analysis-specific descriptions below.

[1] Schmidt M, Hassett-Sipple B, Rajan P (2010). $PM_{2.5}$ Air Quality Analyses. Memorandum to PM NAAQS review docket EPA-HQ-OAR-2007-0492. July 22, 2010. Available at: http://www.epa.gov/ttn/naaqs/standards/pm/s_pm_2007_td.html .
[2] This assessment was not considered as a basis for staff conclusions presented in the *Policy Assessment for the Review of the Particulate Matter National Ambient Air Quality Standards* (April 2011), available: http://www.epa.gov/ttn/naaqs/standards/pm/s_pm_2007_pa.html
[3] Available http://www.epa.gov/ttn/naaqs/standards/pm/data/PM_RA_FINAL_June_2010.pdf

Figure 1. Regional definitions used in analyses



Analysis A – Evaluation of the spatial averaging provisions for the $PM_{2.5}$ annual standard, specifically, a demographic analysis of the potential for disproportionate impacts on potentially vulnerable populations (i.e., environmental justice analysis)

This analysis focused on determining if the spatial averaging provisions as modified in 2006 could introduce inequities in protection for susceptible populations exposed to $PM_{2.5}$. The current form of the annual $PM_{2.5}$ standard includes provisions for spatial averaging if certain criteria are met (i.e., 40 CFR Pt. 50 App. N, 2.0(b)); those criteria were not checked in the analysis described here. We evaluated whether persons with a lower socioeconomic status (SES) are more likely than the general population to live in areas in which the monitors recording the highest air quality values in an area are located. Data used in this analysis included demographic parameters measured at the Census Block or Census Block Group level including percent minority population, percent minority subgroup population, percent people living below poverty level, percent people 18-years old or younger, and percent people 65 years and older.

The air quality data for this project originated from EPA's Air Quality System (AQS) database, the official repository of NAAQS-comparable ambient measurements. Two sets of AQS data were extracted on May 9, 2010: 1) a file of raw 2000-2008, 24-hour duration (filter-based), monitor-level, federal reference method (FRM) data, and 2) a file of hourly (continuous) 2000-2008, monitor-level, federal equivalent method (FEM) data summarized in AQS to a 24-hour basis. The two monitor-level files were subsequently combined and then aggregated to a site basis by averaging by site-day. That is, in situations where there was more than one 24-hour average concentration reported for the same site location (i.e., collocated monitors) for the same day, the multiple 24-hour averages were averaged together. The following statistical metrics were computed from the site-level 24-hour average $PM_{2.5}$ concentrations:

1) annual 98^{th} percentile 24-hour average concentrations,
2) 3-year average 98^{th} percentile concentrations (24-hour design value estimates),
3) annual means, and
4) 3-year average annual means (annual design value estimates)

The metrics were computed at the site level using the regular (non-seasonal) protocols specified in 40CFR Part 50, Appendix N. A completeness criterion of a minimum of 11 samples per quarter for all 4 quarters of each year (or all 12 quarters of a 3-year period for design value estimates) was imposed on all the site-based metrics. Appendix N provides additional options for validating the annual and 3-year metrics, depending on the metric type and level in relation to the associated NAAQS. To avoid the level and metric validation bias, an across-the-board 11 sample minimum per quarter criterion was imposed.

Also, Appendix N has a special 98th percentile computation protocol for sites authorized to sample seasonally (that is, to sample at a less stringent frequency in months when lower concentrations are expected). The seasonal calculation protocol was not used in these analyses; 98th percentile values were computed at all sites using the regular calculation protocol. Because of the possible differences in metric validation and 98th percentile calculation protocol options, the generated 3-year metrics are referred to as design value *estimates*.

Air quality data from 2006-2008, summarized as 3-year annual $PM_{2.5}$ DV estimates, were evaluated in order to identify the highest concentration site location for each urban area that contained at least two valid DV monitoring locations. Using 2000 Census block and block group information, the population demographics of the areas surrounding the high site location as characterized by buffer radii of 0.5, 1.0, 2.0, and 3.0 miles, were compared to the population demographics for the overall urban area to determine if there were any SES-related differences. Core Based Statistical Area (CBSA) definitions were used to classify the urban areas. As described in the General Data Processing section above, an across-the-board data completeness criterion of 11 or more samples for each quarter of the 12-quarter period (2006-2008) was used to validate the annual DV estimates. 116 CBSAs, with sum population of almost 176 million, contained at least two valid annual DV locations for the period 2006-2008 and hence were used in the analysis. Table 1 lists the 116 CBSAs and Figure 2 maps them along with the corresponding high site locations. The high site buffer radii demographic attributes were determined by summarizing data for Census blocks whose centroids fell within the determined cut point distances. The overall CBSA attributes were based on a summarization of all Census blocks located in the county-based CBSA definitions. Some of the summarized Census population information (e.g., population below the poverty line, population of under age 18, and population of age 65 and over) were actually reported using Census block group as the lowest level, and for these variables, data were prorated to blocks according to total population.

Table 2 shows summary results of the comparison between the four high site buffers and the overall CBSA area. These results are identical to those documented in Schmidt et al, 2010 except for results outlined in red. After Schmidt et al, 2010 was finalized, errors were discovered in the processing of the "Below Poverty Level" information. This memo (i.e., the Analysis A results) corrects the previous mistakes, but in no way changes the previous (and current) message which is: In general, the areas surrounding the high monitor of an area were observed to have higher percentages of minorities and people under the poverty level than the area as a whole.

Table 1. CBSAs Used in the Spatial Averaging Analysis.

CBSA	CBSA name	CBSA population (1000's)	Number of sites in CBSA
10420	Akron, OH	695	3
10740	Albuquerque, NM	730	3
10900	Allentown-Bethlehem-Easton, PA-NJ	740	2
11260	Anchorage, AK	320	2
12060	Atlanta-Sandy Springs-Marietta, GA	4,248	8
12260	Augusta-Richmond County, GA-SC	500	3
12540	Bakersfield, CA	662	4
12580	Baltimore-Towson, MD	2,553	7
12940	Baton Rouge, LA	706	5
13820	Birmingham-Hoover, AL	1,052	10
14460	Boston-Cambridge-Quincy, MA-NH	4,391	10
14500	Boulder, CO	291	2
14860	Bridgeport-Stamford-Norwalk, CT	883	4
15380	Buffalo-Niagara Falls, NY	1,170	3
16580	Champaign-Urbana, IL	210	2
16620	Charleston, WV	310	2
16700	Charleston-North Charleston, SC	549	2
16740	Charlotte-Gastonia-Concord, NC-SC	1,330	4
16860	Chattanooga, TN-GA	477	3
16980	Chicago-Naperville-Joliet, IL-IN-WI	9,098	27
17140	Cincinnati-Middletown, OH-KY-IN	2,010	11
17300	Clarksville, TN-KY	232	2
17460	Cleveland-Elyria-Mentor, OH	2,148	9
17900	Columbia, SC	647	3
17980	Columbus, GA-AL	282	4
18140	Columbus, OH	1,613	2
19100	Dallas-Fort Worth-Arlington, TX	5,162	6
19340	Davenport-Moline-Rock Island, IA-IL	376	4
19380	Dayton, OH	848	3
19740	Denver-Aurora, CO	2,203	5
19780	Des Moines-West Des Moines, IA	481	2
19820	Detroit-Warren-Livonia, MI	4,453	11
20100	Dover, DE	127	2
20260	Duluth, MN-WI	275	3
20940	El Centro, CA	142	3
21340	El Paso, TX	680	3
21660	Eugene-Springfield, OR	323	3
21780	Evansville, IN-KY	343	4
22900	Fort Smith, AR-OK	273	2
23420	Fresno, CA	799	2
23540	Gainesville, FL	232	2
24540	Greeley, CO	181	2
24860	Greenville-Mauldin-Easley, SC	560	2
25180	Hagerstown-Martinsburg, MD-WV	223	2
25420	Harrisburg-Carlisle, PA	509	2
26180	Honolulu, HI	876	3
26420	Houston-Sugar Land-Baytown, TX	4,715	3
26580	Huntington-Ashland, WV-KY-OH	289	2
26900	Indianapolis-Carmel, IN	1,525	5
27260	Jacksonville, FL	1,123	2
27540	Jasper, IN	53	3
28060	Kalispell, MT	74	2
28140	Kansas City, MO-KS	1,836	8
28700	Kingsport-Bristol-Bristol, TN-VA	298	2
28940	Knoxville, TN	616	5
29180	Lafayette, LA	239	2
29340	Lake Charles, LA	194	2
29740	Las Cruces, NM	175	2

CBSA name	CBSA population (1000's)	Number of sites in CBSA
Las Vegas-Paradise, NV	1,376	3
Lexington-Fayette, KY	408	2
Little Rock-North Little Rock-Conway,	611	3
Logan, UT-ID	103	2
Los Angeles-Long Beach-Santa Ana, CA	12,366	10
Louisville/Jefferson County, KY-IN	1,162	7
Macon, GA	222	2
Medford, OR	181	2
Memphis, TN-MS-AR	1,205	4
Miami-Fort Lauderdale-Pompano Beac	5,008	8
Milwaukee-Waukesha-West Allis, WI	1,501	7
Minneapolis-St. Paul-Bloomington, MN	2,969	9
Mobile, AL	400	2
Nashville-Davidson-Murfreesboro-Fran	1,312	3
New Haven-Milford, CT	824	5
New Orleans-Metairie-Kenner, LA	1,317	2
New York-Northern New Jersey-Long	18,323	21
Ogden-Clearfield, UT	443	3
Oklahoma City, OK	1,095	2
Omaha-Council Bluffs, NE-IA	767	5
Orlando-Kissimmee, FL	1,645	3
Oxnard-Thousand Oaks-Ventura, CA	753	4
Philadelphia-Camden-Wilmington, PA-	5,687	12
Phoenix-Mesa-Scottsdale, AZ	3,252	8
Pittsburgh, PA	2,431	11
Portland-Vancouver-Beaverton, OR-WA	1,928	2
Providence-New Bedford-Fall River, RI	1,583	5
Provo-Orem, UT	377	4
Rapid City, SD	113	2
Richmond, VA	1,097	4
Riverside-San Bernardino-Ontario, CA	3,255	9
Sacramento--Arden-Arcade--Roseville,	1,797	5
St. Louis, MO-IL	2,721	9
Salt Lake City, UT	969	4
San Diego-Carlsbad-San Marcos, CA	2,814	4
San Francisco-Oakland-Fremont, CA	4,124	5
San Juan-Caguas-Guaynabo, PR	2,509	2
San Luis Obispo-Paso Robles, CA	247	2
Santa Barbara-Santa Maria-Goleta, CA	399	2
Savannah, GA	293	2
Seattle-Tacoma-Bellevue, WA	3,044	2
Sheridan, WY	27	2
Springfield, MA	680	3
Tampa-St. Petersburg-Clearwater, FL	2,396	4
Terre Haute, IN	171	2
Toledo, OH	659	2
Trenton-Ewing, NJ	351	2
Truckee-Grass Valley, CA	92	2
Tucson, AZ	844	2
Tulsa, OK	860	2
Virginia Beach-Norfolk-Newport News	1,576	3
Washington-Arlington-Alexandria, DC-	4,796	9
Weirton-Steubenville, WV-OH	132	5
Wheeling, WV-OH	153	2
Wichita, KS	571	4
Winston-Salem, NC	422	2
Worcester, MA	751	2
Youngstown-Warren-Boardman, OH-P	603	4
Total population of 116 CBSAs	**175,761**	

Figure 2. Map of CBSAs Used in Spatial Averaging Analysis.

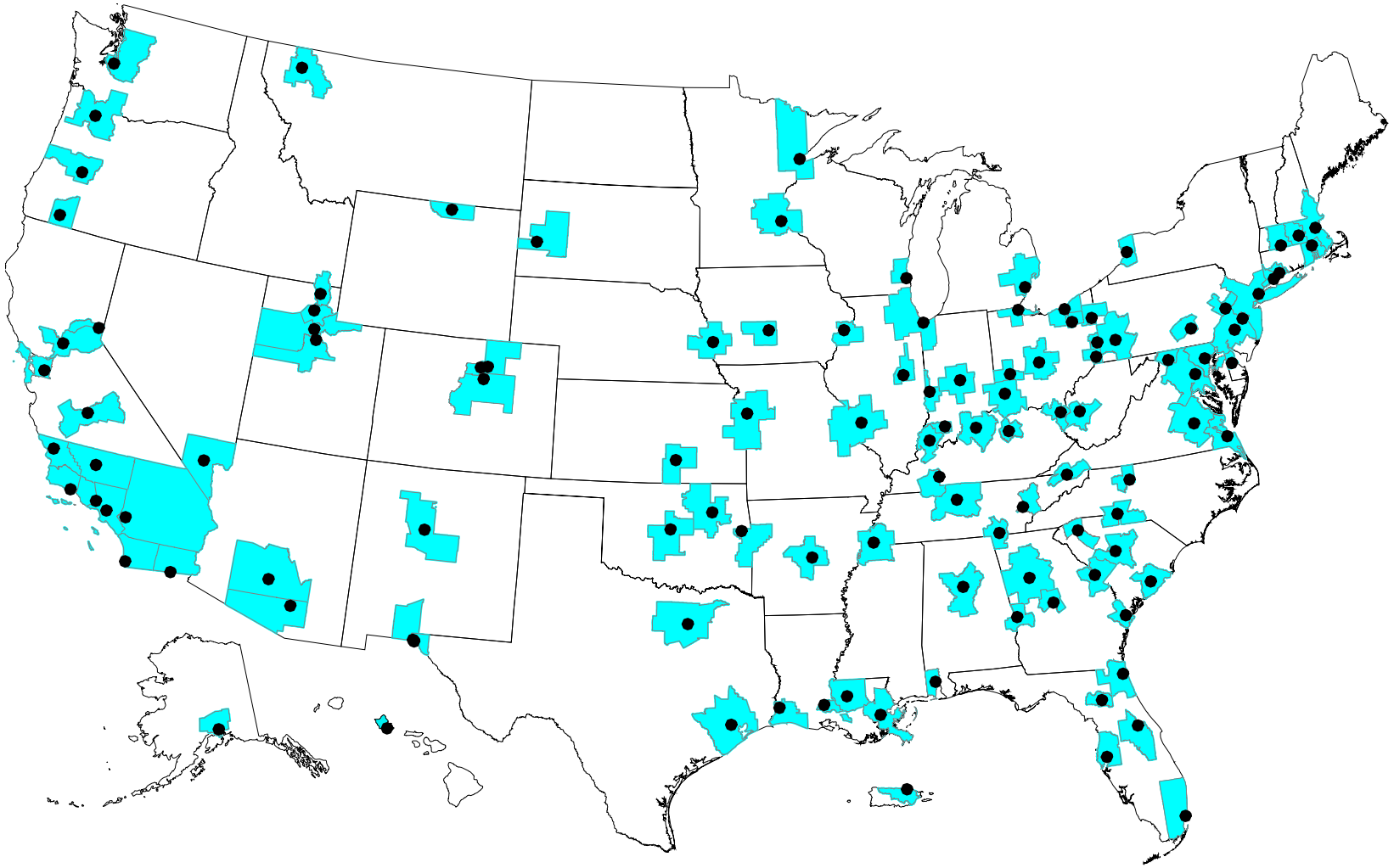


Table 2. Summary Results: Comparison Between the Four High Site Buffers and the Overall CBSA Area

Area counts (for 116 CBSAs) comparing SES variables within 0.5, 1.0, 2.0, and 3.0 mile radii buffers versus SES variables across overall CBSA

Population Variable	Buffer	Percentage of areas where variable percentage greater in high site buffer than in overall CBSA	Percentage of areas where variable percentage not greater in high site buffer than in overall CBSA	Mean difference in variable percentage in high site buffer minus variable percentage in overall CBSA	Median difference in variable percentage in high site buffer minus variable percentage in overall CBSA	Mean ratio of variable percentage in high site buffer / variable percentage in overall CBSA	Median ratio of variable percentage in high site buffer / variable percentage in overall CBSA
Minority	0.5 mile	58.9%	41.1%	8.9%	2.8%	1.57	1.16
	1.0 mile	67.2%	32.8%	11.6%	6.1%	1.66	1.37
	2.0 miles	72.4%	27.6%	11.6%	7.8%	1.63	1.50
	3.0 miles	76.7%	23.3%	11.4%	9.6%	1.59	1.47
	avg of 4 buffers	68.8%	31.2%	10.9%	6.6%	1.61	1.38
African American	0.5 mile	49.1%	50.9%	6.5%	-0.1%	1.83	0.90
	1.0 mile	57.8%	42.2%	7.3%	1.1%	1.66	1.16
	2.0 miles	58.6%	41.4%	8.2%	1.0%	1.62	1.32
	3.0 miles	66.4%	33.6%	8.4%	3.1%	1.59	1.52
	avg of 4 buffers	58.0%	42.0%	7.6%	1.3%	1.68	1.23
Native American	0.5 mile	52.7%	47.3%	0.3%	0.0%	1.51	1.03
	1.0 mile	62.9%	37.1%	0.8%	0.1%	1.64	1.21
	2.0 miles	65.5%	34.5%	0.5%	0.1%	1.43	1.14
	3.0 miles	66.4%	33.6%	0.5%	0.0%	1.33	1.11
	avg of 4 buffers	61.9%	38.1%	0.5%	0.1%	1.48	1.12
Other and Multiracial	0.5 mile	59.8%	40.2%	2.1%	0.4%	1.32	1.10
	1.0 mile	58.6%	41.4%	3.5%	2.1%	1.46	1.25
	2.0 miles	66.4%	33.6%	2.9%	1.0%	1.37	1.19
	3.0 miles	66.4%	33.6%	2.5%	1.2%	1.32	1.27
	avg of 4 buffers	62.8%	37.2%	2.8%	1.2%	1.37	1.20
Hispanic	0.5 mile	55.4%	44.6%	3.9%	0.3%	1.50	1.09
	1.0 mile	60.3%	39.7%	5.8%	1.1%	1.77	1.28
	2.0 miles	66.4%	33.6%	5.3%	1.4%	1.68	1.32
	3.0 miles	75.0%	25.0%	4.5%	1.1%	1.54	1.33
	avg of 4 buffers	64.3%	35.7%	4.9%	1.0%	1.62	1.26
Below Poverty Line	0.5 mile	75.0%	25.0%	9.2%	5.4%	1.81	1.47
	1.0 mile	75.9%	24.1%	8.7%	6.1%	1.77	1.51
	2.0 miles	77.6%	22.4%	8.0%	7.3%	1.70	1.60
	3.0 miles	76.7%	23.3%	6.8%	6.7%	1.59	1.55
	avg of 4 buffers	76.3%	23.7%	8.2%	6.4%	1.72	1.53

Under age 18	0.5 mile	48.2%	51.8%	-1.6%	-0.5%	0.94	0.98
	1.0 mile	50.9%	49.1%	-0.2%	0.1%	0.99	1.01
	2.0 miles	51.7%	48.3%	0.0%	0.0%	1.00	1.02
	3.0 miles	54.3%	45.7%	0.1%	0.2%	1.00	1.01
	avg of 4 buffers	51.3%	48.7%	-0.4%	-0.1%	0.98	1.01
Age 65 and over	0.5 mile	53.6%	46.4%	-0.5%	0.3%	0.97	1.03
	1.0 mile	49.1%	50.9%	0.0%	-0.2%	1.01	0.98
	2.0 miles	52.6%	47.4%	0.2%	0.1%	1.00	1.01
	3.0 miles	56.0%	44.0%	0.3%	0.3%	1.04	1.03
	avg of 4 buffers	52.8%	47.2%	0.0%	0.1%	1.01	1.01

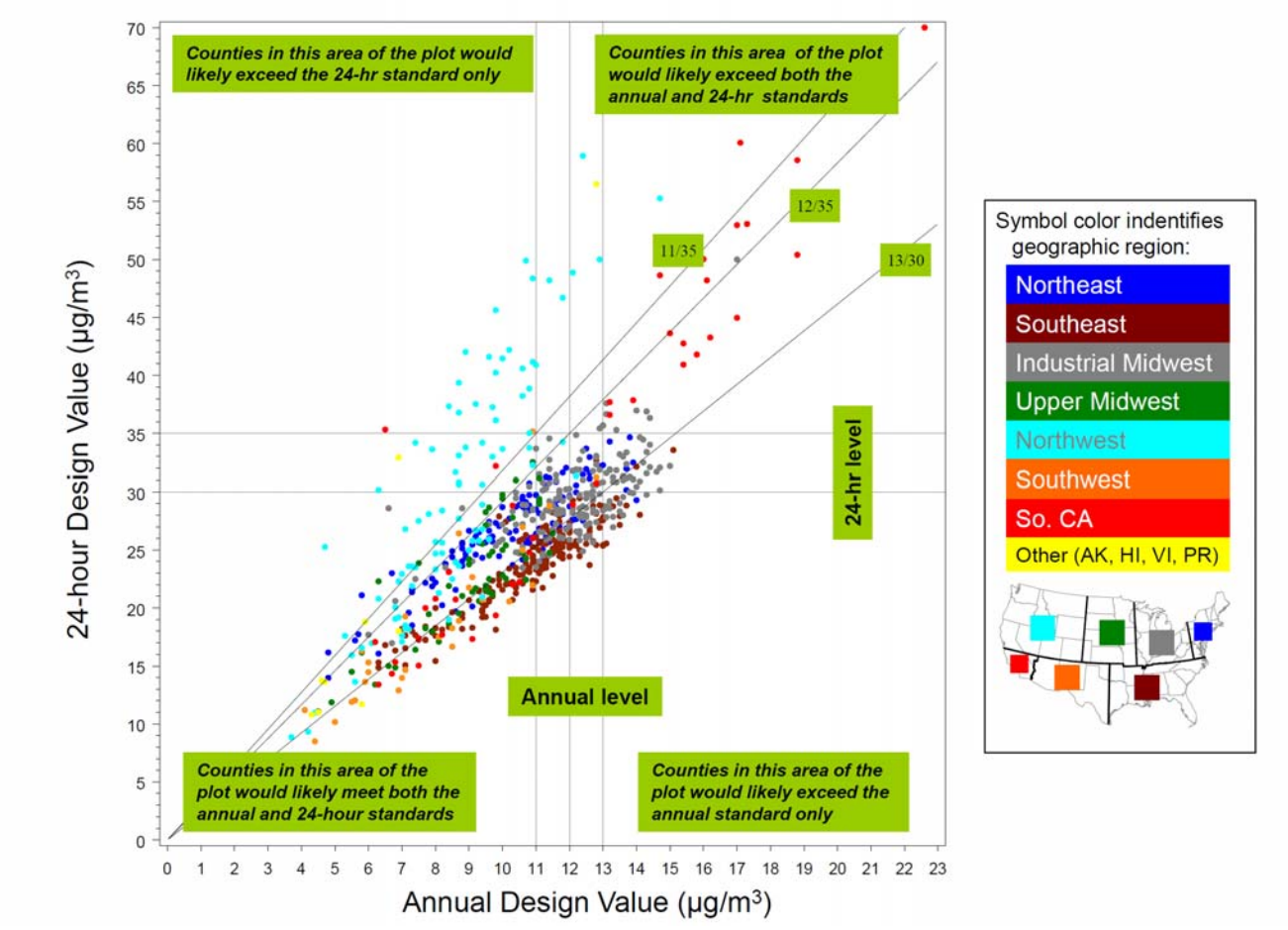
Average percentage of people living within each buffer for each demographic category

Buffer	Minority	African American	Native American	Other and Multiracial	Hispanic	Living Below Poverty Line	Under Age 18	Age 65 and Over
CBSA	22.9	12.1	0.8	9.9	11.1	12.6	27.3	12
within 0.5 mile	32.9	19.3	1.2	12.4	15.5	21.8	26.6	12
within 1 mile	34.4	19.5	1.6	13.3	16.9	21.3	27.1	12
within 2 miles	34.5	20.3	1.3	12.8	16.4	20.7	27.3	12.2
within 3 miles	34.2	20.5	1.3	12.4	15.5	19.5	27.3	12.4

Analysis B - county-level 24-hour DVs versus Annual DVs, 2007-2009.

Air quality data from 2007-2009 were evaluated to identify the distributions of the ratios of 98th percentile DVs to annual mean DVs by geographic region. Data utilized in this analysis were extracted from AQS on 1/29/2011; these data served two primary purposes: 1) to generate official updated design values (not estimates) and supporting statistics for public dissemination (i.e., via the EPA Air Trends website, specifically at http://epa.gov/airtrends/values.html), and 2) to support Analysis B and C described in this memo. Site-level $PM_{2.5}$ annual design values and 24-hour (98th percentile) design values were calculated using the protocols specified in 40 CFR Appendix N. County- level design values were derived by identifying the highest valid (i.e., complete) site-level design values in each monitored county, as consistent with Table 4 of the posted official design value Excel file). Figure 3 presents a scatter plot of annual and 24-hour DVs in counties across the U.S., color-coded by geographic region. This figure provides a visual perspective of whether the annual or 24-hour standard is likely to be the controlling standard for various combinations of standards. In Figure 3, the horizontal lines represent alternative 24-hour standard levels (i.e., 35 or 30 µg/m^3) with a 98th percentile form, averaged over three years, while the vertical lines represent alternative annual standard levels (i.e., 13, 12, or 11 µg/m^3), using an annual arithmetic mean averaged over three years. The diagonal lines that intercept the origin and the intersection of a suite of alternative standard levels (e.g., the "11/35" line) represents the point of demarcation between those counties where the 24-hour standard is the controlling standard (to the left of the diagonal line) and those areas where the annual standard level represents the controlling standard (to the right of the diagonal line).

Figure 3. County-level 24-hour DVs versus Annual DVs, 2007-2009.



Analysis C – Assessment of potential $PM_{2.5}$ non-attainment areas

To provide some perspective on the implications of various alternative suites of annual and 24-hour standards, we compared the most recent (2007-2009) official county level $PM_{2.5}$ annual and 24-hour DVs to those alternative levels as well as to the current standards. As noted above, the input data for the design values were extracted from AQS on 1/19/2011, and all calculations were performed according to the 40CFR Part 50 Appendix N protocols.

The percentage of counties and the population in those counties that would likely not meet the current and various alternative suites of standards are presented in Table 3. Results are summarized for the entire U.S. level as well as the specific geographic regions illustrated in Figure 1.

Table 3. Predicted Percent of Counties with Monitors (and percent of population in counties with monitors) Not Likely to Meet Current and Alternative Annual and 24-hour $PM_{2.5}$ Standards

Region >		All U.S.	Northeast	Southeast	Industrial Midwest	Upper Midwest	Southwest	Northwest	Southern California	Outlying areas
Total # of counties >		**532**	**93**	**149**	**135**	**45**	**17**	**69**	**17**	**7**
Total population (x 1,000)>		**184,180**	**44,345**	**40,271**	**37,512**	**7,694**	**8,962**	**20,821**	**22,663**	**1,913**
Current Standards										
annual µg/m³	**24-hour µg/m³**	**Statistic**	**Numbers of counties, populations, and percentages of total**							
15	35	# counties	35	0	1	5	0	1	19	8	1
		population	28,801	0	662	3,683	0	180	6,615	17,579	83
		% # counties	7%	0%	1%	4%	0%	6%	28%	47%	14%
		% population	16%	0%	2%	10%	0%	2%	32%	78%	4%
Alternative Standards										
annual µg/m³	**24-hour µg/m³**	**Statistic**	**Numbers of counties, populations, and percentages of total**							
12	35	# counties	149	21	30	66	0	2	20	9	1
		population	76,579	14,936	10,318	23,998	0	218	6,634	20,393	83
		% # counties	28%	23%	20%	49%	0%	12%	29%	53%	14%
		% population	42%	34%	26%	64%	0%	2%	32%	90%	4%
11	35	# counties	263	39	82	102	5	3	22	9	1
		population	107,447	22,952	21,224	31,346	1,491	3,290	6,668	20,393	83
		% # counties	49%	42%	55%	76%	11%	18%	32%	53%	14%
		% population	58%	52%	53%	84%	19%	37%	32%	90%	4%
13	30	# counties	130	21	10	50	2	3	32	10	2
		population	78,286	13,688	6,152	23,692	1,627	393	12,210	20,411	114
		% # counties	24%	23%	7%	37%	4%	18%	46%	59%	29%
		% population	43%	31%	15%	63%	21%	4%	59%	90%	6%