Attachment 1

Environmental Protection Agency Modeling for 2017 and 2025

The Environmental Protection Agency recently performed nationwide photochemical air quality modeling to support several ozone National Ambient Air Quality Standards (NAAQS) related rulemakings. Base year modeling was performed for 2011. Future year modeling was performed for 2017 to support the proposed Cross-State Air Pollution Rule Update (CSAPR Update, 80 FR 75705, December 3, 2015[1]) for the 2008 Ozone NAAQS. Future year modeling was performed for 2025 to support the Regulatory Impact Assessment (RIA) of the final 2015 Ozone NAAQS.[2] The outputs from these model runs included hourly concentrations of fine particulate matter ($PM_{2.5}$) that were used in conjunction with measured data to project annual average $PM_{2.5}$ design values for 2017 and 2025.

Areas that were designated as Moderate $PM_{2.5}$ nonattainment areas for the 2012 annual $PM_{2.5}$ NAAQS in 2014 must attain the NAAQS by December 31, 2021 (the end of the 6th calendar year after designation) or as expeditiously as practicable. Although neither the available 2017 nor 2025 future year modeling data corresponds directly to the future year attainment deadline for Moderate $PM_{2.5}$ nonattainment areas, the EPA believes the modeling information can still be useful to help identify potential nonattainment and maintenance receptors in the 2017-2021 time period.

Air Quality Modeling

The CAMx photochemical model version 6.11 (Environ, 2014) is the air quality model used for both the 2017 and 2025 modeling analyses. CAMx is a three-dimensional grid-based Eulerian air quality model designed to simulate the formation and fate of oxidant precursors, primary and secondary particulate matter concentrations, and deposition over regional and urban spatial scales [e.g., the contiguous United States (U.S.)]. Consideration of the different processes (e.g., transport and deposition) that affect primary (directly emitted) and secondary (formed by atmospheric processes) pollutants at the regional scale in different locations is fundamental to understanding and assessing the effects of emissions on air quality concentrations. Figure A-1 shows the geographic extent of the modeling domain that was used for air quality modeling in these analyses. The domain covers the 48 contiguous states along with the southern portions of Canada and the northern portions of Mexico.

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[1] *See* Notice of Data Availability, 80 FR 46271 (August 4, 2015); CSAPR Update, Proposed Rule, 80 FR 75705 (December 3, 2015).

[2] *See* 2015 ozone NAAQS RIA at: *http://www3.epa.gov/ozonepollution/pdfs/20151001ria.pdf.*

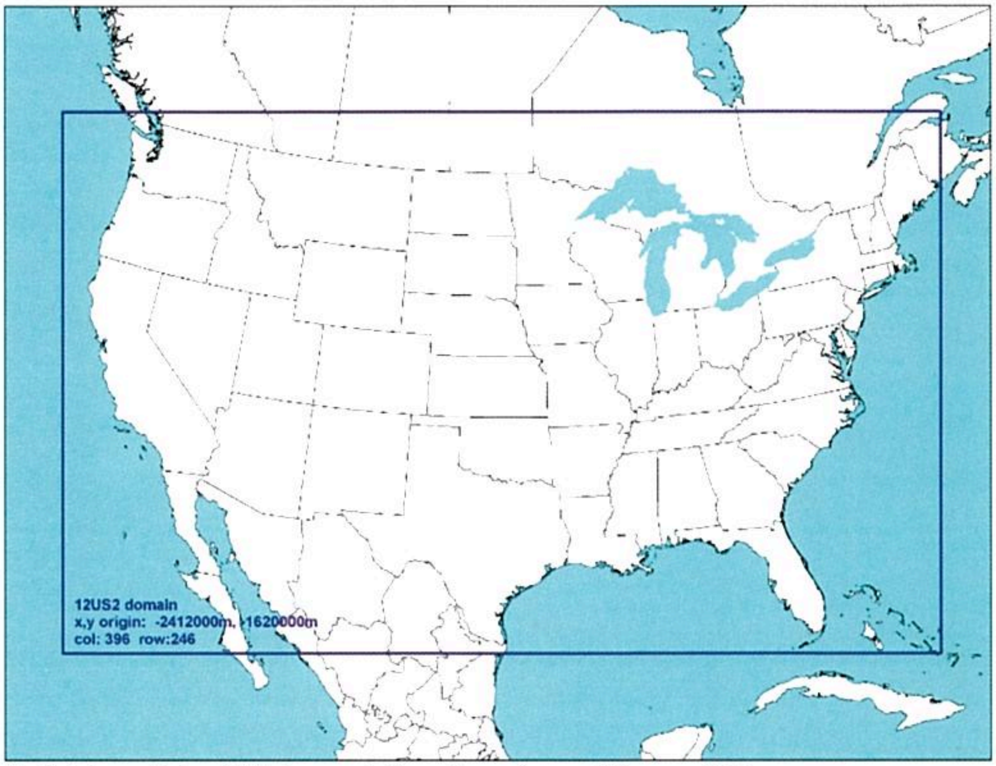

Figure A-1. Map of the CAMx modeling domain used for modeling.

CAMx requires a variety of input files that contain information pertaining to the modeling domain and simulation period. These include gridded, hourly emissions estimates and meteorological data, and initial and boundary concentrations. Separate emissions inventories were prepared for the 2011 base year and the 2017 and 2025 base cases. All other inputs (i.e., meteorological fields, initial concentrations and boundary concentrations) were specified for the 2011 base year model application and remained unchanged for the future-year model simulations. The 2011 base year modeling platform was chosen due to the availability of National Emissions Inventory (NEI) data for that year. In addition, based on nationwide trends, the $PM_{2.5}$ concentrations are generally steady or declining through the 2009-2013 time period. There does not appear to be any unusual PM concentration trends (either nationally or regionally) that would make 2011 unsuitable for use as a base year for the purpose of projecting $PM_{2.5}$ concentrations to future years (*see* the EPA PM trends website for more details: *http://www3.epa.gov/airtrends/pm.html*).

Additional details on the model setup, emissions, meteorology and model performance can be found in the air quality modeling and emissions technical support documents (TSDs) for the respective rulemakings. The CSAPR Update air quality modeling information is documented in a modeling TSD, which can be found here: *http://www3.epa.gov/airtransport/pdfs/Updated_2008_Ozone_NAAQS_Transport_AQModeling_TSD.pdf* (*see* also the ozone NAAQS RIA for more information on the 2025 modeling). The emissions inventory data used for the 2011, 2017 and 2025 modeling is documented in an emissions TSD, which can be found here: *http://www3.epa.gov/ttn/chief/emch/2011v6/2011v6_2_2017_2025_EmisMod_TSD_aug2015.pdf*. Additional information on 2011 base year $PM_{2.5}$ model performance can be found in U.S. Environmental Protection Agency, 2011. Bayesian space-time downscaling fusion model (downscaler) - Derived Estimates of Air Quality for 2011, Research Triangle Park, NC. EPA-454/S-15-001.

Modeled $PM_{2.5}$ Concentrations

Since the photochemical model was run with $PM_{2.5}$ emissions and precursors (SO_2, NO_x, VOC and NH_3), and included full aerosol chemistry, the EPA was able to perform additional post-processing of the model results in order to develop projected 2017 and 2025 annual average $PM_{2.5}$ design values.[3]

For this analysis, the EPA followed the procedures in the current $PM_{2.5}$ photochemical modeling guidance.[4] The modeling guidance recommends using air quality modeling results in a "relative" sense to project future concentrations of $PM_{2.5}$. Rather than use the absolute model-predicted future year $PM_{2.5}$ concentrations, the base year and future year predictions are used to calculate a (relative) percent change in $PM_{2.5}$ concentrations. In this approach, the ratio of future year model predictions (i.e., 2017) to 2011 base year model predictions are used to adjust (2009-2013) ambient measured data based on the relative (percent) change in model predictions for each location.

Procedures for Processing Ambient $PM_{2.5}$ Data

In this analysis we use measurements of ambient $PM_{2.5}$ data from several state and federal monitoring networks. This includes data from over 600 Federal Reference Method (FRM) $PM_{2.5}$ sites in the U.S. In addition, speciated $PM_{2.5}$ data from the Chemical Speciation Network and IMPROVE network are used to estimate $PM_{2.5}$ species concentrations at each FRM site. The certified and quality assured ambient data used in this analysis were obtained from the EPA's Air Quality System[5] for the time-period between 2009 and 2013.

The $PM_{2.5}$ ambient data were processed consistent with the formats associated with the NAAQS for $PM_{2.5}$. For $PM_{2.5}$, we evaluated concentrations of the annual $PM_{2.5}$ NAAQS. The annual $PM_{2.5}$ standard is not met if the 3-year average of the annual mean concentration is greater than 12.0 micrograms per cubic meter ($\mu g/m^3$) (12.05 $\mu g/m^3$ or greater when rounded up). The 3-year average annual mean concentration is computed at each site by averaging the daily FRM samples by quarter, averaging these quarterly averages to obtain an annual average, and then averaging the three annual averages. The 3-year average annual mean concentration is referred to as the annual average design value.

When projecting ambient monitoring data to future time periods using relative response factors, the modeling guidance recommends using the average of the three design value periods centered on the year of the base year emissions. Since 2011 was the base emissions year, we used the design values for 2009-2011, 2010-2012 and 2011-2013 to represent the base period $PM_{2.5}$ concentrations. The most recent certified and quality assured $PM_{2.5}$ design values are accessible at: *http://www3.epa.gov/airtrends/pdfs/PM25_DesignValues_20122014_FINAL_08_19_15.xlsx*.

Ambient design values from monitoring sites were included in our analysis if the site had at least one complete[6] design value in the 2009-2013 period.[7] There were 738 monitoring sites that had at least one complete design value period for the annual $PM_{2.5}$ NAAQS. Note that several states have had recent data quality issues identified as part of the $PM_{2.5}$ designations process. Some ambient $PM_{2.5}$ data (for certain

[3] PM source apportionment modeling was not performed for any of the modeling applications referenced.
[4] $PM_{2.5}$ modeling guidance available at: *http://www3.epa.gov/ttn/scram/guidance_sip.htm*.
[5] *See http://www.epa.gov/ttn/airs/airsaqs/* for access to raw data.
[6] Design value completeness was determined according to the monitoring rules in 40 CFR part 50 Appendix N.
[7] Ambient monitoring data is generally not used for regulatory actions (e.g., designations and redesignations) unless there is enough complete, certified data to calculate a valid design value for comparison to the NAAQS. If there is only one complete design value, then the nonattainment and maintenance design values are the same.

time periods between 2009 and 2013) in Florida (except Palm Beach County), Illinois, Idaho, Tennessee (except Hamilton County), and Jefferson County, Kentucky, did not meet all data quality requirements under 40 CFR Appendix L to part 50. The ambient data that was determined to be not valid was not used in the projections of data to 2017 and 2025 for this memo. Documentation of the data quality issues can be found in the 2012 $PM_{2.5}$ NAAQS designations rule docket (docket number EPA-HQ-OAR-2012-0918).

Projection of Future Design Values and Determination of Potential Nonattainment and Maintenance for Annual $PM_{2.5}$

In order to identify receptors with potential nonattainment and maintenance concerns with respect to the 2012 $PM_{2.5}$ NAAQS, we applied the methodology used in the CSAPR, 76 FR 48208 (August 8, 2011), to identify such receptors with respect to the 1997 and 2006 $PM_{2.5}$ standards.

The procedure for calculating future year annual $PM_{2.5}$ design values is called the modeled attainment test. The modeled attainment test approach can be applied using a software tool available from EPA called Modeled Attainment Test Software, or MATS.[8] The software (including documentation) is available at: *http://www.epa.gov/scram001/modelingapps_mats.htm.*

Design values of $PM_{2.5}$ in 2017 were estimated by applying the 2011 to 2017 relative change in model-predicted $PM_{2.5}$ species concentrations to the measured (2009-2013) $PM_{2.5}$ species concentrations. The $PM_{2.5}$ species include sulfate, nitrate, ammonium, particle bound water, elemental carbon, salt, other primary $PM_{2.5}$ and organic aerosol mass (by difference). Organic aerosol mass by difference is defined as the difference between FRM $PM_{2.5}$ and the sum of all of the other components.

For each FRM $PM_{2.5}$ monitoring site, all valid design values (up to 3) from the 2009-2013 period were averaged together, resulting in the "average" design value. Averaging the three values together has the effect of creating a 5-year weighted average. The middle year (2011) is weighted 3 times, the 2nd and 4th years (2010 and 2012) are weighted twice, and the 1st and 5th years (2009 and 2013) are weighted once. We refer to this as the 5-year weighted average design value concentration. For sites that did not have three valid design values, the "average" of all valid design values from the time-period were used.

Following the procedures used in the analysis for CSAPR, the 5-year weighted average design values were used to project concentrations for the 2017 and 2025 scenarios in order to examine which monitoring sites may be potential nonattainment receptors for the future year scenarios. We also projected design values for each of the individual valid 3-year design value periods (i.e., 2009-2011, 2010-2012 and 2011-2013) for use in identifying potential receptors that may have problems maintaining the standard in the future year scenarios.

The modeling guidance methodology for determining future year $PM_{2.5}$ concentrations was applied for each FRM site. As described in the modeling guidance, the procedure is performed on a species-specific basis. For example as shown in Table A-1 below, the measured sulfate concentration at a monitoring location is 4.82 ug/m3, the modeled sulfate concentration in 2011 is 5.81 ug/m3 and the 2017 modeled sulfate concentration is 3.13 ug/m3. The modeled Relative Response Factor (RRF) (3.13/5.81) is 0.5387 (unitless). This means that based on the modeled change in emissions, the model predicted a ~46 percent reduction in sulfate concentration at the monitoring location between 2011 and 2017. The modeled RRF

[8] The latest version of MATS is version 2.6.1.

is then multiplied by the base year measure sulfate value to get the future year (2017) sulfate concentration (4.82 ug/m3 * 0.5387 = 2.59 ug/m3). The procedure is completed on a quarterly average basis (for all four quarters) and for all $PM_{2.5}$ species. The future year $PM_{2.5}$ design value is derived from the sum of all the calculated future year species concentrations.

Table A-1. Simplified example future year concentration calculation for sulfate.

Measured sulfate (2009-2013)	Modeled 2011 sulfate concentration	Modeled 2017 sulfate concentration	RRF	Projected future year sulfate concentration (2017)
4.82 ug/m^3	5.81 ug/m^3	3.13 ug/m^3	0.5387	2.59 ug/m^3

The calculated $PM_{2.5}$ design values are truncated after the second decimal place.[9] This is consistent with the truncation and rounding procedures for the 12 μg/m^3 annual $PM_{2.5}$ NAAQS. Any value that is greater than or equal to 12.05 μg/m^3 is rounded to 12.1 μg/m^3 and is considered to be violating the NAAQS. Thus, using the approach for identifying receptors applied in CSAPR, sites with future year annual $PM_{2.5}$ design values of 12.05 μg/m^3 or greater, based on the projection of 5-year weighted average concentrations, are projected to be potential nonattainment sites (we refer to the future year values projected from 5-year weighted average values as future year "average" design values). Sites with future year maximum design values[10] of 12.05 μg/m^3 or greater are projected to be potential maintenance sites. The CSAPR methodology uses the term "nonattainment sites" to refer to those sites that are projected to exceed the NAAQS based on both the average and maximum future year design values. Those sites that are projected to exceed the NAAQS based on the maximum future year design value are referred to as maintenance sites. All nonattainment sites are necessarily also maintenance sites; those sites projected to be in attainment based on the average future year design value but projected to exceed the NAAQS based on the maximum future year design values are only maintenance sites.

Evaluation of potential nonattainment and maintenance receptors for the 2012 annual $PM_{2.5}$ NAAQS

The projected design values were examined to see which sites are projected to have average or maximum design values above the standard in 2017 and 2025. In general, most $PM_{2.5}$ and $PM_{2.5}$ precursor emissions are declining over time (see the emissions TSD), and, as a result, design values beyond 2017 are in most cases expected to be lower. Therefore, if the projected design values in 2017 are below the NAAQS (attainment), then the design values would also be expected to remain below the NAAQS in the years following 2017, including the Moderate area attainment deadline of 2021. This can be verified by examining the projected 2025 design values to see if the 2017 projected attainment sites remain attainment, and whether projected 2017 nonattainment or maintenance sites are projected to become attainment by 2025. Applying the CSAPR framework for identifying potential air quality receptors, there are several possible outcomes of this analysis as described in Table A-2 below.

[9] For example, a calculated annual average concentration of 11.9475 becomes 11.94 when digits beyond two places to the right are truncated.

[10] We refer to future year values projected from the maximum base year design value as future year "maximum" design values.

Table A-2. Potential projections for 2017 and 2025 modeling.

Monitoring site projection in 2017	Monitoring site projection in 2025	Potential 2012 $PM_{2.5}$ NAAQS transport analysis
Average and maximum DV below the NAAQS	Average and maximum DV below the NAAQS	Likely not a potential nonattainment/maintenance receptor in 2021
Average or maximum DV exceeds the NAAQS	Average or maximum DV exceeds the NAAQS	Potential nonattainment/maintenance receptor in 2021
Average or maximum DV exceeds the NAAQS	Average and maximum DV below the NAAQS	Further analysis is likely needed to determine if the site may be a nonattainment or maintenance receptor in 2021

As described above in Table A-2, if a monitoring site is projected to be attainment in both 2017 and 2025, then it is likely not a potential nonattainment or maintenance receptor in 2021. If a monitoring site is projected to be nonattainment or maintenance in both 2017 and 2025, then the site should likely be considered a potential nonattainment or maintenance receptor in 2021. The more uncertain outcome is if a receptor is projected to be nonattainment or maintenance in 2017, but attainment in 2025. More analysis of such sites may be necessary to determine if they should be considered potential nonattainment or maintenance receptors for the 2012 $PM_{2.5}$ transport analysis.

Table A-3 lists the base year (2009-2013) 5-year weighted average annual $PM_{2.5}$ design values and the projected 2017 and 2025 average and maximum annual average $PM_{2.5}$ design values for monitoring sites with 2017 or 2025 average or maximum values that are above the 2012 $PM_{2.5}$ NAAQS. The full set of base and future year 2012 $PM_{2.5}$ NAAQS design values for all sites can be found in Attachment 2.[11]

Table A-3 shows that in 2017, there are 19 monitoring sites in the continental U.S. that are projected to have average or maximum future year annual average design values above the 2012 $PM_{2.5}$ NAAQS ($\geq$ 12.05 $\mu g/m^3$). Of these monitoring sites, 17 are located in either the South Coast (California) $PM_{2.5}$ nonattainment area or the San Joaquin Valley (California) $PM_{2.5}$ nonattainment area. There is one 2017 projected maintenance site in Shoshone County, Idaho, and one projected 2017 projected maintenance site in Allegheny County, Pennsylvania. All of the other monitoring sites (based on certified and quality assured ambient data) are projected to be attainment in 2017 and remain attainment in 2025 (*see* Attachment 2).

Examining the projected average and maximum future year design values for 2025 shows that 17 of these sites are projected to have average or maximum future year annual average design values above the 2012 $PM_{2.5}$ NAAQS ($\geq$ 12.05 $\mu g/m^3$) in 2025 (two sites switch from potential nonattainment to potential maintenance between 2017 and 2025). Therefore, these 17 sites could be considered potential nonattainment and maintenance receptors in 2021.

The Allegheny County, Pennsylvania monitoring site (420030064) is a projected potential maintenance receptor in 2017, but is projected to be below the NAAQS in 2025. Therefore, more analysis of this site may be necessary to determine if it should be considered a potential nonattainment or maintenance receptor for the 2012 $PM_{2.5}$ transport analysis. One possible follow-up analysis is to linearly interpolate between 2017 and 2025 to estimate the expected concentration in 2021. Whether it is appropriate to

[11] Future year design values were not calculated for ambient monitoring sites that had no valid design values for the 2009-2013 period. This includes sites previously referenced above that had invalid data due to laboratory quality assurance issues. However, based on modeled RRFs at those monitor locations, the overall $PM_{2.5}$ concentrations are expected to continue to decline through 2017 and 2025.

linearly interpolate between 2017 and 2025 may depend on the timing and location of emissions reductions that are expected to occur between those years. But, at a minimum, a linear interpolation of the data may provide useful information. A simple linear interpolation between the 2017 and 2025 projected design values for Allegheny County leads to a projected 2021 average design value of 11.42 ug/m^3 and a maximum design value of 11.91 ug/m^3, which are both below the 2012 $PM_{2.5}$ NAAQS. This could indicate that this monitor would be attaining the annual $PM_{2.5}$ NAAQS in 2021, but additional information about emissions and trends may be needed to further support that conclusion.

Table A-3. Projected 2017 and 2025 average and maximum future year annual $PM_{2.5}$ design values for monitoring sites with projected design values that are above the 2012 $PM_{2.5}$ NAAQS.

Monitor ID	State	County	5-Year Weighted Average Design Value 2009-2013 (ug/m^3)	Maximum Design Value 2009-2013 (ug/m^3)	Average Design Value 2017 (ug/m^3)	Maximum Design Value 2017 (ug/m^3)	Average Design Value 2025 (ug/m^3)	Maximum Design Value 2025 (ug/m^3)
60190011	California	Fresno	14.74	15.46	13.69	14.36	13.09	13.72
60195001	California	Fresno	16.44	16.94	15.43	15.9	14.9	15.36
60195025	California	Fresno	14.33	14.67	13.43	13.75	12.94	13.22
60250005	California	Imperial	13.64	13.76	14.19	14.32	14.83	14.97
60290014	California	Kern	15.77	16.45	14.24	14.85	13.78	14.37
60290016	California	Kern	17.02	18.18	15.4	16.43	14.94	15.93
60311004	California	Kings	16.33	16.98	15.38	16.01	14.82	15.4
60392010	California	Madera	18.32	18.58	17.37	17.62	16.9	17.14
60470003	California	Merced	14.54	16.05	13.84	15.27	13.52	14.92
60658005	California	Riverside	15.31	15.9	13.89	14.41	13.63	14.15
60990006	California	Stanislaus	15.27	15.65	14.44	14.79	13.97	14.31
61072002	California	Tulare	15.54	16.59	14.63	15.6	14.06	14.96
60658001	California	Riverside	13.6	14.15	12.25	12.74	11.99	12.47
60990005	California	Stanislaus	13.25	13.61	12.5	12.84	12.03	12.34
60371002	California	Los Angeles	12.92	13.65	11.6	12.25	11.42	12.07
60710025	California	San Bernardino	13.03	13.65	11.79	12.35	11.61	12.15
60771002	California	San Joaquin	12.09	13.78	11.49	13.09	11.16	12.71
160790017	Idaho	Shoshone	12.34	12.77	12.01	12.43	11.8	12.22
420030064	Pennsylvania	Allegheny	14.4	15.02	11.67	12.16	11.18	11.65

References:

Abt Associates, 2014. User's Guide: Modeled Attainment Test Software. *http://www3.epa.gov/scram001/modelingapps_mats.htm.*

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