Implementation of the 2015 Primary Ozone NAAQS: Issues Associated with Background Ozone

White Paper for Discussion

This paper discusses the issue of background ozone as part of the implementation of the 2015 ozone standards. The U.S. Environmental Protection Agency (EPA) is using this white paper to establish a common understanding and foundation for additional conversations on background ozone and to inform any further action by the Agency.

1. Overview:

The EPA recognizes that, periodically, in some locations in the U.S., sources other than domestic manmade emissions of ozone (O_3) precursors can contribute appreciably to monitored O_3 concentrations. The EPA is seeking input from states, tribes, and interested stakeholders on aspects of background O_3 that are relevant to attaining the 2015 O_3 NAAQS in a manner consistent with the provisions of the Clean Air Act (CAA). This white paper clarifies the specific definition of background O_3 that EPA has used and will continue to use in addressing implementation of the O_3 NAAQS, describes the sources and processes that lead to background O_3 across the U.S., summarizes estimates of background O_3 levels across the U.S., and describes policy tools that are available, or have been suggested, to address implementation challenges that result from background O_3. The EPA intends to hold a workshop in early 2016 to discuss the information in this white paper and to further advance our collective understanding of the technical and policy issues associated with background O_3. We will evaluate the need for further guidance and/or rules to address background O_3 after receiving feedback on this white paper and after conducting the workshop.

The EPA revised the primary O_3 NAAQS to a level of 0.070 ppm (70 ppb) on October 1, 2015.[1] This level was determined from health evidence to be requisite to protect public health with an adequate margin of safety.[2] The Administrator selected the final level of the NAAQS from the upper end of the range of proposed levels without considering the issue of proximity to background O3 concentrations in some areas. However, the EPA considered the extent and importance of background O_3 throughout the NAAQS review process. This began with the integrated science assessment (ISA), which summarized the state of knowledge regarding background O_3 in the peer-reviewed literature.[3] The ISA was followed by the policy assessment (PA), which described a pair of new air quality modeling analyses designed to

[1] "National Ambient Air Quality Standards for Ozone; Final Rule," 80 Federal Register 65292 (Oct. 26, 2015; hereinafter "Final Ozone NAAQS").

[2] The Administrator also determined that a standard level of 0.070 ppm would provide a requisite level of protection to public welfare.

[3] U.S. EPA (2013).

estimate current background O_3 levels across the U.S.[4] The notice of proposed rulemaking (NPR)[5] for the O_3 NAAQS identified CAA implementation provisions that air agencies can use to address background O_3. The regulatory impact analysis (RIA) that accompanied the proposed rule presented O_3 design value projections for 2025 and identified several locations in the western U.S. that had relatively small modeled responses to large regional NOx and VOC reductions.[6] Also, at the time of the proposal, the EPA released a fact sheet and a summary document designed to address possible air agency and stakeholder implementation questions about background O_3. As part of the communications material associated with the final rule, the EPA provided information on tools for addressing background O_3.

With regard to the remainder of this white paper, Section 2 discusses how the EPA defines background O_3 and provides information on how background O_3 is formed and estimated. Section 3 summarizes estimates of current background O_3 levels over the U.S., and Section 4 discusses how these levels may change in the future. Sections 5 and 6 provide preliminary conceptual models for attainment planning and a discussion of policy tools, respectively. Section 7 provides a preliminary list of questions related to background O_3 and NAAQS implementation that warrant additional discussions with stakeholder groups. The Appendix provides more information related to modeling estimates of background O_3, including the tables and figures referred to in this white paper.

2. Basics of background O_3: definitions, formation, and estimation techniques:

For the purposes of this white paper and the continuing discussion of background O_3 issues in the NAAQS implementation context, the EPA considers background O_3 to be any O_3 formed from sources or processes *other than* U.S. manmade emissions of nitrogen oxides (NOx), volatile organic compounds (VOC), methane (CH_4), and carbon monoxide (CO).[7] This definition of background is specifically referred to as U.S. background (USB).[8] It is important to recognize that USB does not include intrastate or interstate transport of manmade O_3, which can also influence O_3 concentrations in downwind areas, but which can be addressed by certain provisions of the CAA. The EPA acknowledges that stakeholders may have their own definitions of background O_3. From the highly local perspective, some may conclude that all emissions outside the specific locality are outside jurisdictional control and are, therefore, background. At the other end of the spectrum, from an international perspective, some may conclude

[4] U.S. EPA (2014).

[5] "National Ambient Air Quality Standards for Ozone; Proposed Rule", 79 Federal Register 75234 (Dec. 17, 2014).

[6] U.S. EPA (2015).

[7] See Final Ozone NAAQS, 80 Federal Register at 65436.

[8] Unless otherwise specified, any use of the term background from this point forward in the white paper refers specifically to U.S. background (USB). As part of the USB definition, one should note that determining which emissions are manmade, or from the U.S., can be difficult. There can be debate as to how to assign source categories such as international shipping or international aviation. Additionally, there is often debate as to whether certain types of fires (e.g., prescribed fires) should be considered manmade for the purpose of defining background O_3.

that all manmade emissions are controllable and, therefore, background O_3 is only generated from non-manmade sources.

Away from the earth's surface, O_3 can have an atmospheric lifetime on the order of weeks. As a result, background O_3, and to a lesser extent background O_3 precursors, can be transported long distances in the upper troposphere and be available to mix down to the surface when conditions are favorable. One of the largest natural sources of O_3 originates from production of O_3 in the stratosphere through interactions between ultraviolet light and molecular oxygen. O_3 exists in large quantities in the stratosphere and natural atmospheric exchange processes can transport stratospheric air into the troposphere. During certain meteorological conditions, discrete plumes of stratospheric air can be displaced far into the troposphere and impact ground-level O_3 concentrations. These events are called stratospheric intrusions and can result in relatively high USB levels of O_3 at the surface, especially at higher-elevation sites.[9] Other natural sources of O_3 precursor emissions include wildfires, lightning, and vegetation. Biogenic emissions of methane, which can be chemically converted to O_3 over relatively long time scales, can also contribute to USB O_3 levels. Finally, manmade precursor emissions from other countries can contribute to the global burden of O_3 in the troposphere and to increased USB O_3 levels.

USB O_3 levels can vary considerably in space and time. When assessing USB O_3 concentrations, it is important to clarify the averaging time being considered. From a broad characterization perspective, it can be useful to identify annual or seasonal mean concentrations by location. However, from an air quality management perspective, it is more important to consider background concentrations on specific high O_3 days when concentrations may approach or exceed the NAAQS. Section 3 of the white paper summarizes the estimates of USB O_3 over both categories of averaging times.

While some surface monitoring locations in certain rural areas in the inter-mountain western U.S.[10] can be substantially affected by USB O_3, multiple analyses have shown that even the most remote O_3 monitoring locations in the U.S. are at least periodically affected by U.S. manmade emissions.[11] As a result, the EPA believes that it is inappropriate to assume that monitored O_3 levels at a remote surface site (e.g., Grand Canyon or Yellowstone National Parks) can be used as a proxy for USB O_3. This conclusion is supported by recent data analyses of rural O_3 observations in Nevada[12] and Utah[13] in which it was demonstrated that natural sources, international O_3 transport, O_3 transported from upwind states, and O_3 transported from urban areas within the state all contributed to monitored O_3 levels at rural sites in these two states. Measurements of O_3 above the surface (e.g., from sondes, profilers, or aircraft) can provide useful information about the influx of O_3 from upwind locations and can be

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[9] Langford et al. (2015); State of Wyoming Department of Environmental Quality (2013); Langford et al. (2009).

[10] In this document, the term "inter-mountain western U.S." generally refers to locations in AZ, CO, NM, NV, UT, WY, and the high-elevation portions of eastern CA.

[11] Parrish et al. (2009); Wigder et al. (2013).

[12] Fine et al. (2015).

[13] State of Utah Department of Environmental Quality (2013).

valuable toward informing USB concentrations. However, vertical profile measurements of O_3 tend to be infrequent and spatially sparse.

Because of the limitations in quantifying USB contributions solely from monitoring data (i.e., monitors cannot distinguish the origins of the measured ozone), photochemical grid models have been widely used as a means to estimate the contribution of background sources to observed surface O_3 concentrations.[14] Several modeling studies have attempted to estimate background O_3 levels by assessing the remaining O_3 in a model simulation in which certain emissions were removed. This basic approach, which is often referred to as "zero-out" modeling (i.e., U.S. manmade emissions are removed) or "emissions perturbation" modeling, has been used to estimate USB O_3 levels. Another modeling technique, referred to as "source apportionment" modeling, can also be used to estimate the sources that contribute to modeled O_3 concentrations. This approach estimates the contribution of certain source categories (e.g., natural sources, non-U.S. manmade sources) to modeled O_3 at each model grid cell on an hourly basis. More information about the modeling estimates of USB O_3 is provided in the Appendix. Section 3 of the white paper summarizes the key findings from the EPA analyses of background O_3 levels using both the zero-out and source apportionment techniques. As discussed further below, it is important to remember that model estimates of USB are limited by the biases, errors, and uncertainties inherently associated with modeling simulations.

3. <u>What are the current best estimates of U.S. background O_3 levels nationally?</u>

A. Summary of previous exercises to estimate background O_3 levels:

Over the past 10-15 years, multiple photochemical modeling analyses have been conducted to estimate the contribution of background sources on U.S. O_3 levels. The EPA summarized in the ISA for the 2015 NAAQS review the modeling studies that were published before 2012.[15] The main points from this summary were: 1) seasonal mean background concentrations are highest in the inter-mountain western U.S., 2) seasonal mean background concentrations are generally highest in the spring and early summer, 3) background impacts can occur on episodic and non-episodic scales with the highest concentrations associated with discrete events such as stratospheric intrusions or wildfires, and 4) air quality models compare reasonably with one another in terms of seasonal mean O_3 background estimates, but are not capable of precise background estimates on a daily level.[16] Table 1 provides summary information from the ISA regarding a modeling study[17] of USB O_3 by region and season at

[14] Fiore et al. (2003); Wang et al. (2009); Zhang et al. (2011), Emery et al. (2012), Lin et al. (2012), EPA (2014); Lefohn et al. (2014); Dolwick et al. (2015).

[15] U.S. EPA (2013).

[16] EPA (2013).

[17] Zhang et al (2011).

selected locations from the CASTNET[18] monitoring network. Model estimates of seasonal mean USB, daily 8-hour ozone maxima (MDA8) O_3 range from as high as 42 ppb in the spring at high elevation sites in the western U.S. (non-California) to as low as 24 ppb in the summer at sites in the northeast U.S.

Subsequent to the publication of the ISA, additional model-based estimates of background O_3 have become available that show greater variability in model estimates of background.[19] The global Geophysical Fluid Dynamics Laboratory AM3 model was used to estimate springtime North American background (NAB) levels at high elevation western U.S. sites.[20] (NAB is similar to USB except that NAB does not include the contribution from manmade sources of emissions in Canada and Mexico as background.) This study concluded that April-June mean NAB MDA8 O_3 values could be as high as 50 ppb at many of these sites. An additional analysis used a coupled global-regional modeling system that included the Comprehensive Air Quality Model with Extensions (CAMx) O_3 source apportionment technique to track the contribution of background sources to total O_3 within the simulation.[21] This analysis concluded that "emissions-influenced background," a metric intended to represent the combined influence of natural sources and sources of O_3 from outside the modeling domain on total modeled O_3, as well as combined chemical interactions between the U.S. manmade and background sources, could comprise a substantial fraction (e.g., greater than 70 percent) of the annual-average, total hourly O_3 at high elevation sites in the western U.S. Additionally, the EPA summarized the results of zero-out and source apportionment-based estimates of 2007 background levels in the PA for the 2015 O_3 NAAQS review. These EPA estimates of background O_3 are summarized in more detail in the next section, first in terms of seasonal means, then in terms of USB levels on days with high modeled O_3.

B. Recent estimates of USB concentrations from the EPA

The EPA estimated 2007 seasonal (i.e., April through October) mean USB MDA8 O_3 concentrations using a combination of the GEOS-Chem global model and the Community Multi-scale Air Quality (CMAQ) (zero out) and CAMx (source apportionment) regional models. The two separate model approaches estimated similar background impacts over the rural portions of the western U.S.[22] The greatest difference between the two model estimation approaches occurred in urban areas, where the CAMx source apportionment technique predicted lower USB concentrations. The general consistency between the two approaches increased confidence in the model findings.

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[18] The Clean Air Status and Trends Network is a national monitoring network established to assess trends in pollutant concentrations, atmospheric deposition and ecological effects due to changes in air pollutant emissions. More information on CASTNET monitoring sites is available at http://www2.epa.gov/castnet.

[19] Fiore et al. (2014).

[20] For this analysis, we considered a site to be high-elevation if it was located at an altitude above 1 km mean sea level.

[21] Lefohn et al. (2014).

[22] Dolwick et al. (2015).

The EPA modeling was also roughly consistent with the previous estimation exercises summarized in Section 3.A. The 2007 CMAQ and CAMx simulations estimated that seasonal mean USB MDA8 O_3 levels ranged from 25-50 ppb across the U.S., as shown in Figure 1. Locations with seasonal mean contributions greater than 40 ppb are confined to the inter-mountain western U.S., with substantially lower values in the eastern U.S. and along the Pacific Coast.

From a seasonal mean, fractional contribution perspective, USB was estimated to represent a relatively larger percentage (e.g., 60-80%) of the seasonal mean total MDA8 O_3 at locations within the inter-mountain western U.S. and along the U.S. borders with Mexico and Canada. A few locations outside of these areas (such as locations in Florida) also had relatively high fractional contributions of USB to seasonal means, but absolute O_3 concentrations modeled in these areas are lower and do not approach the level of the standard. In locations where O_3 levels are generally higher, for example urban areas in California and the eastern U.S., the seasonal mean background fractions are relatively smaller (e.g., 40-60%).

From an implementation perspective, the values of USB O_3 on possible O_3 NAAQS exceedance days are a more meaningful consideration than seasonal mean levels. The first draft policy assessment document considered this issue in detail, via a re-analysis of zero-out modeling reviewed as part of the ISA, and concluded that "results suggest that background concentrations on the days with the highest total O_3 concentrations are not dramatically higher than typical seasonal average background concentrations."[23] Based on this finding, the EPA concluded that "anthropogenic sources within the U.S. are largely responsible for 4th highest 8-hour [average] daily maximum O_3 [MDA8] concentrations."[24] This re-analysis examined modeling results at the national level and by region. Although absolute USB O_3 concentrations were generally higher in the western U.S. at high elevation sites than at other locations in the U.S., this analysis showed that the general pattern of background O_3 on days with high versus low O_3 levels was also seen in the inter-mountain western U.S., making the conclusions relevant even in locations with the highest seasonal mean background concentrations.

The more recent modeling from the EPA using a 2007 base year, and the two distinct modeling methodologies described above, corroborated the finding from the previous modeling analyses. Again, the highest modeled O_3 site-days (i.e., days of more interest from an implementation perspective) tend to have smaller fractional contributions from USB O_3 and conversely greater contributions from U.S. manmade emissions. Figures 2a and 2b show the distribution of daily USB MDA8 levels (absolute magnitudes and relative fractions, respectively) from the source apportionment simulation. The 2007 modeling shows that the days with highest O_3 levels have similar distributions (i.e., means, inter-quartile ranges) of USB O_3 levels as days with lower values, down to approximately 40 ppb. As a result, when considered from a national perspective, the proportion of total O_3 that has USB origins is smaller on high O_3 days (e.g., days > 60 ppb) than on the more common lower O_3 days that tend to drive seasonal means. Figure 2b also indicates that there are cases in which the model predicts much larger USB proportions, as shown by the upper outliers in the figure. These infrequent episodes usually occur in relation to a specific event, and occur more often in specific geographical locations, such as at high

[23] U.S. EPA (2014) page 2-20, based on results from Zhang et al. (2011), Emery et al. (2012), and U.S. EPA (2012).

[24] U.S. EPA (2014) page 2-20.

elevations (e.g., due to stratospheric intrusions) or areas prone to influences from wildfires. As noted in the ISA, the ability of the model to capture influences from discrete events is uncertain. There are multiple monitor-oriented assessments (i.e., non-modeling) that have also shown substantial influence of sources of USB O_3 on certain observed high O_3 days.[25] As in the modeling, these days generally occur in relation to a specific event (e.g., stratospheric intrusions, wildfires). EPA is working with states and other researchers to develop improved models (e.g., incorporating data collected during the DISCOVER-AQ field studies), and we anticipate that this work will result in increasingly improved estimates of the contributions of USB on high O_3 days.[26]

Based on previous modeling exercises and the more recent EPA analyses summarized in the policy assessment document, the EPA believes the following three conclusions summarize the role of background O_3 in relationship to the O_3 NAAQS.

i. USB O_3 can comprise a considerable fraction of the total MDA8 O_3 across the U.S., with the largest relative contributions at higher-elevation, rural locations in the inter-mountain western U.S. in the spring and early summer seasons.

ii. Existing modeling analyses indicate that U.S. manmade emission sources are generally the dominant contributor to the modeled exceedances of the 2015 O_3 NAAQS, nationally and within individual regions across the country. Higher O_3 days generally have smaller fractional contributions from USB across all regions. When averaged over the entire U.S., the models estimate that the mean USB fractional contribution to daily maximum 8-hour average O_3 concentrations above 70 ppb is less than 35 percent. As with any other modeling exercise, these simulations have uncertainties and potential biases/errors and the EPA plans to work with states on monitoring and modeling studies to further improve our estimates of USB contributions on high O_3 days.

iii. Analyses suggest that there can be infrequent events where MDA8 O_3 concentrations approach or exceed 70 ppb largely due to the influence of USB sources like a wildfire or stratospheric intrusion. As discussed in more detail in Section 6 of this white paper, the CAA and EPA implementation policy allow for the exclusion of air quality monitoring data from design value calculations when there are exceedances caused by certain event-related USB influences. As a result, these "exceptional events" will not factor into attainability concerns. The EPA analyses also indicate that there may be also be a limited number of rural areas where USB O_3 is appreciable, but not the sole contributor to an exceedance of the NAAQS. Even in these areas, there is no indication that USB O_3 concentrations will prevent attainment of the 2015 O_3 NAAQS.

[25] California Air Resources Board (2011), State of Wyoming Department of Environmental Quality (2013), Langford et al. (2015).

[26] Crawford and Pickering (2014).

4. What are the expected O_3 and background O_3 levels across the U.S. in the near future?

A. Summary of ambient trends in USB O_3

Ambient data analyses have shown that mid-tropospheric O_3 concentrations in remote areas, within the U.S. and globally, have been increasing over the past two decades at a rate of approximately 0.4 ppb/year within an overall uncertainty range of 0.1 to 0.7 ppb/year.[27] Whether this trend continues is largely dependent upon global changes in emissions of methane, as well as changes in other manmade O_3 precursor emissions outside of the U.S., which are highly uncertain.[28] Additionally, climate change has the potential to affect global background O_3 levels via changes in temperatures, wildfire emissions, synoptic weather patterns and other factors that influence O_3.[29]

While projecting future trends in emissions is highly uncertain, NO_x emissions are expected to continue to decline in North America and Europe out to 2030 and then stabilize. NO_x emissions in East and South Asia, however, are expected to continue to increase. Technologies and policies do exist that, if implemented, could lead to an overall decrease in global NO_x emissions. Implementation of an aggressive climate change mitigation policy might halt the growth of NOx emissions globally, due to changes in fuels and efficiency. Total emissions of methane are expected to continue to increase globally into the future, albeit at a slower rate with the implementation of an aggressive climate change mitigation policy. There are known emissions control technologies and policies that could significantly decrease methane emissions globally.[30]

The EPA continues to work with other federal agencies, our counterparts in other countries, and the international community to improve our understanding of the sources and impacts of background O_3 in order to enable and motivate control of pollution sources in other countries that affect the U.S. Working with the European Commission in the context of the Long-range Transboundary Air Pollution Convention, we are leading an international scientific effort to improve the databases and modeling tools that enable us to characterize the intercontinental transport of O_3 and assess potential control strategies. We are also working with Mexico through the Border 2020 Program[31], Canada under the US-Canada Air Quality Agreement[32], and China through agreements on cooperation with their environment and science ministries[33] to improve air quality management and address key sources of ozone precursor emissions in these countries. We are also working through multilateral efforts, such as the Global

[27] Cooper et al. (2012); Lin et al. (2015).

[28] Task Force on Hemispheric Transport of Air Pollution (2010).

[29] Jacob and Winner (2009).

[30] Amann et al. (2013); Klimont et al. (2015).

[31] http://www2.epa.gov/border2020/border-2020-partners.

[32] https://www.ec.gc.ca/Air/default.asp?lang=En&n=1E841873-1.

[33] http://www2.epa.gov/international-cooperation/epa-collaboration-china.

Methane Initiative and the Climate and Clean Air Coalition to Reduce Short Lived Climate Pollutants, to engage governments and the private sector to achieve decreases in methane emissions which contribute to background O_3. Ultimately, these efforts will benefit air quality in the U.S. by decreasing international contributions to background air pollution.

B. Estimates of future O_3 levels in 2025

As part of the final RIA that accompanied the 2015 revised O_3 NAAQS, the EPA conducted modeling for a future year of 2025 to project future O_3 design values as part of an illustrative analysis to estimate the costs and benefits of achieving the revised O_3 standards. Emissions inventories were prepared for a 2011 base year, a 2025 base case, and several 2025 emissions sensitivity scenarios. This modeling assumed no change in boundary conditions or meteorology between the base and future years. The final RIA modeling identified 12 sites (out of 1,165 sites analyzed) in rural portions of the inter-mountain western U.S. that had relatively small modeled response to large regional reductions in NOx and VOC emissions. The EPA concluded that the O_3 levels at these 12 sites were strongly influenced by USB (e.g., international emissions, stratospheric O_3, wildfire emissions) or by interstate O_3 transport from domestic manmade sources located outside the region. Despite the small response to regional emissions reductions, the RIA modeling projected enough O_3 reduction to yield design values less than the 70 ppb standard by 2025 at these 12 sites.

The RIA modeling also indicated that the vast majority of counties throughout the eastern U.S. with 2014 design values above 70 ppb would be below 70 ppb by 2025 as the result of anticipated reductions in U.S. manmade NOx and VOC emissions in the coming years due to existing federal regulations. The RIA modeling also shows that additional reductions in U.S. manmade NOx and VOC emissions could result in attaining O_3 air quality in many parts of California that currently have design values above 70 ppb. However, areas in the southern Central Valley and other historically high O_3 areas in Southern California have persistent high O_3 (i.e., > 70 ppb) despite expected improvements. The RIA modeling predicts levels above 70 ppb in the Denver area, but the remainder of the inter-mountain western U.S. is predicted to be at levels below 70 ppb by 2025.

5. <u>Preliminary conceptual model of O_3 attainment planning over the U.S. for the revised NAAQS</u>

Under the 2-year schedule required by CAA 107(d)(1) for initial area designations following the promulgation of a new or revised NAAQS, the EPA is required to make designation decisions for the 2015 O_3 NAAQS by October 2017, and generally, EPA would rely on monitoring data for the most recent 3-year period in making such designations, which would mean using 2014-2016 data in making a 2017 designation determination.[34] In order to build an understanding of contributions to O_3 levels above 70 ppb and a conceptual model of attainment planning, the EPA has compiled the most recent site-specific

[34] Such period may be extended for up to one year in the event the EPA Administrator has insufficient information to promulgate the designations.

O_3 design values,[35] recent emissions estimates by county,[36] and more recent CAMx modeled source attribution estimates.[37] The CAMx source apportionment data summarize the fraction of the near-future (2017) O_3 design value prediction that is due to U.S. manmade sources, as well as the fraction that is due to in-state anthropogenic emissions.

Tables 2a, 2b, and 2c show the 2012-2014 O_3 design values, model source apportionment data, and 2011 NOx emissions data for all counties with at least one monitoring site that exceeded 70 ppb during the 2012-2014 period (i.e., the most recent period of official data), for three regions of the country: the eastern U.S., California, and non-California portions of the western U.S. For sites with multiple monitors above the 70 ppb threshold, data are only provided for the location with the highest O_3. The purpose of Tables 2a, 2b, and 2c is to combine several existing data sets (i.e., design values, emissions, source apportionment modeling) to examine the variability in these data in counties with 2012-2014 design values above 70 ppb and to inform preliminary conceptual models of O_3 attainment planning. While the existing emissions, design values, and source apportionment data all represent different years (2011, 2014, and 2017, respectively), the EPA believes the data can inform the conceptual models described below.

Eastern U.S. - As shown in Table 2a, there were 178 counties in the eastern U.S. with a monitor for which the design value exceeded 70 ppb for 2012-2014. The CAMx source apportionment modeling suggests that the highest O_3 values in this region are caused predominantly by U.S. manmade sources, either from local in-state emissions or from interstate transport of manmade O_3 from other states. Across the 178 eastern U.S. counties with design values that exceeded 70 ppb for the 2012-2014 period, the average fractional contribution of U.S. manmade emissions to O_3 design values was estimated to be 64 percent, ranging from a low of 39 percent (Bell County, TX) to a high of 75 percent (Washington County, RI). Only three counties had an estimated U.S. manmade contribution of less than 50 percent. The information suggests the preliminary conceptual model of O_3 attainment planning in the eastern U.S. would be to continue to employ measures that would achieve local and regional NOx and VOC reductions, which have been successful in lowering O_3 levels in the eastern U.S. over the past several decades.[38]

California - A slightly different conceptual model of O_3 attainment planning is seen within California (Table 2b). At most locations across California, there is nearly equal contribution from manmade emissions in California and USB sources, with generally small impacts from manmade transport from outside the state. The average contribution of U.S. manmade emissions in the 27 California counties

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[35] See design value information available at http://www3.epa.gov/airtrends/values.html.

[36] County level NOx emissions were pulled from version 2 of the 2011 NEI. Provide link to documentation.

[37] Based on 2017 CAMx source apportionment modeling that was released publically on January 22, 2015 as part of the memo: Information on the Interstate Transport "Good Neighbor" Provisions for the 2008 O_3 National Ambient Air Quality Standards under Clean Air Act Section 110(a)(2)(D)(i)(I). A copy of this memo and related documents can be found at the following website: http://www3.epa.gov/airtransport/ozonetransportNAAQS.html

[38] Cooper et al. (2012); Simon et al. (2014).

with design values that exceeded 70 ppb based on the 2012-2014 data is 50 percent, ranging from a low of 31 percent (Imperial County) to a high of 63 percent (Orange County). This suggests the conceptual model of attainment planning in California will be to continue to seek in-state NOx and VOC emission reductions, while assessing the impact of event-driven USB sources like fires and stratospheric intrusions. The USB impacts of international emissions may also need to be assessed in California locations close to the Mexican border (e.g., Imperial County, and to a lesser degree San Diego County).

Non-California Portions of Western U.S. - As noted earlier in this white paper, the effects of USB O_3 are most notable at a relatively small number of sites in the inter-mountain western U.S. As shown in Table 2c, there are 26 counties with at least one site where the 2012-2014 design value exceeds 70 ppb. Across these 26 counties, there is a wide range of the extent to which USB influences O_3 design values. In certain highly urban locations in this region, such as Denver (Adams, Douglas, and Jefferson Counties, CO) and Phoenix (Maricopa County, AZ), the modeling suggests a sizeable contribution to the ozone design values from U.S. manmade sources, ranging from 45 to 50 percent. In other urban locations, such as Las Vegas (Clark County, NV) or Salt Lake City (Salt Lake County, UT), the contribution from U.S. manmade emissions is smaller, with values around 30 percent. At rural sites within this region, the contribution from U.S. manmade emissions is still smaller. The CAMx modeling indicated that the county with the lowest influence from U.S. manmade emissions (i.e., the highest contribution from USB) is El Paso County, CO with only a 10 percent contribution from U.S. manmade sources to the projected 2017 O_3 design value. Overall, this information suggests that it will be important to assess and account for the contributions from USB sources to O_3 nonattainment in this region, particularly in the rural portions.

It should be noted that any conclusions from this initial conceptual model of attainment planning for the 2015 O_3 NAAQS are subject to change pending additional information, such as updated design value data, updated emissions data, updated O_3 trends, and any updated attribution modeling. For instance, the currently available 2015 O_3 data (through the end of September 2015) suggest that O_3 levels were lower in 2015 than in 2012 at almost all of the sites in the inter-mountain western U.S. Thus, the 3-year design values for 2015 (and beyond) may be lower than the 2014 design values shown here, and fewer monitors may be above 70 ppb at the time that the EPA would complete initial area designations.[39]

6. Overview of policy tools and issues for consideration:

Some states and other stakeholders have expressed concern about the fairness and practicality of applying the CAA's regulatory relief mechanisms in locations where it can be argued that nearby manmade emissions are not largely responsible for elevated O_3 levels.[40] They argue that the CAA's relief mechanisms provide insufficient relief, or they express skepticism that state and federal air

[39] Prior to the EPA making final designation decisions, we expect quality-assured, certified air quality monitoring data from 2016 will be available, and the EPA's final designation decisions will be based on data from 2014 to 2016.

[40] Association of Air Pollution Control Agencies (2015).

management agencies will be able to efficiently and successfully apply the CAA's provisions without significant burden.

Policy tools are available, or have been recommended by commenters, to apply to areas experiencing exceedances of the O_3 NAAQS that are appreciably impacted by USB O_3. The tool(s) available for each affected location will depend on the specific nature of background O_3 in each area. Some tools would provide relief from a nonattainment designation; others would only provide relief from some of the CAA-prescribed nonattainment area requirements. To employ any of the available tools, states would need to work cooperatively with the EPA to develop supporting documentation and to take whatever public process steps are legally necessary to use the relief provisions.[41]

Exceptional Events Exclusions (CAA section 319): Air monitoring data that would otherwise indicate an exceedance of the O_3 standards and lead to a nonattainment designation may be excluded from designation determinations, if the data are determined to be affected by exceptional events. From an air quality perspective, an exceptional event is one that affects air quality, is not reasonably controllable or preventable, and is either a natural event or one caused by human activity that is unlikely to recur at a particular location.[42] It should be noted that not all sources of background O_3 meet these criteria (e.g., routine biogenic VOC emissions, international manmade emissions). Other sources that contribute to background O_3 (e.g., wildfires, stratospheric intrusions) may be eligible for treatment as exceptional events. A state may request that the EPA exclude data showing one or more exceedances of the NAAQS from design value calculations, which could be used in regulatory determinations, if it can demonstrate that an exceptional event caused the exceedance. The EPA proposed revisions to the 2007 Exceptional Events Rule in November 2015 to further facilitate review and approval of O_3-producing events, such as stratospheric intrusions and wildfires. The EPA intends to issue a final rule in the summer of 2016. In some locations, the exclusion of data influenced by exceptional events may affect whether the design value for the location exceeds the 70 ppb standard. In other words, exclusion of one or more exceedances may mean that an area that would otherwise violate the standard is instead meeting it and thus would be designated "unclassifiable/attainment." Also, in some locations, the exclusion of data influenced by exceptional events may not result in a design value that meets the standard, but may lower the design value such that the area qualifies for a lower nonattainment classification and thus the area would be subject to fewer mandatory CAA requirements.

Small nonattainment area boundaries for sites minimally impacted by nearby sources (CAA section 107(d)): The CAA requires a nonattainment area to be comprised of the area not meeting the NAAQS and the nearby area that is contributing to the area not meeting the NAAQS. At monitor locations exceeding the 70 ppb standard where there are no or few nearby permanent sources of O_3 precursors, or where nearby sources are shown to be unlikely contributors on days with high O_3, states can recommend, and the EPA may be able to finalize, a nonattainment area boundary that includes a limited

[41] Beyond the four policy tools discussed below, three other mechanisms for accounting for background ozone in the implementation of the new NAAQS have been suggested. These include: a) revising data handling procedures to exclude exceedances attributable to background O_3, b) deferring designations in locations impacted by background O_3, and/or c) designating areas influenced by background O_3 as unclassifiable. These additional mechanisms were not included here due to legal or other deficiencies.

[42] "Treatment of Data Influenced by Exceptional Events; Proposed Rule", 80 Federal Register 224 (20 November 2015), pp. 72840-72897.

area associated with a reasonable jurisdictional boundary, for example, a park boundary for a monitor located in a national park. Additionally, land above a certain elevation for high elevation sites with no local sources, or other appropriate indicators may also be well-suited for a small nonattainment area boundary (see, for example, Tehama County, CA where portions of the area above 1,800 feet in elevation were designated nonattainment for the 2008 O_3 standard). In some instances, these relatively small nonattainment areas may also help support a state's request that an area be identified as a Rural Transport Area, a determination that provides relief from certain otherwise applicable requirements. A relatively small nonattainment boundary also limits the area subject to nonattainment New Source Review (NSR) permitting and federal conformity.

*Rural transport areas (RTAs) (CAA section 182(h))***:** The RTA provisions of the CAA allow the EPA Administrator to determine that a nonattainment area can be treated as if it were a Marginal nonattainment area regardless of the area's design value and regardless of whether the area attains the standard by any given deadline. To qualify, a nonattainment area must not be adjacent to, or include any part of, a Metropolitan Statistical Area (MSA) and must not have sources of NOx and VOC that significantly contribute to the violation in the area or to violations in other areas. If a state demonstrates to the satisfaction of the EPA Administrator that these conditions are met for an area, the state would not be required to develop an attainment plan and demonstration for the area. Four O_3 nonattainment areas have previously been approved for RTA status: Door County Area, WI; Edmonson County Area, KY; Essex County Area (Whiteface Mountain), NY; and Smyth County Area (White Top Mountain), VA. These RTAs were approved for the 1-hour O_3 standard. The EPA will work cooperatively with states to develop the request for an RTA determination, and also provide assistance with meeting other CAA-required implementation program provisions for Marginal nonattainment areas (e.g., emissions statement rules, periodic emissions inventory, nonattainment NSR program). The EPA is currently planning to include more specific guidance on how to demonstrate eligibility for a RTA determination in the forthcoming area designations guidance scheduled for release in early 2016.

International transport provisions (CAA section 179B): In nonattainment areas appreciably affected by international transport, the CAA provides that under certain circumstances the state's attainment plan may be approved even if it does not demonstrate attainment. To receive such an approval, the state would need to show that its plan would achieve attainment by the relevant attainment date "but for" the influence of international emissions. When applicable, this CAA provision relieves states from imposing control measures on emissions sources in the state's jurisdiction beyond those necessary to address reasonably controllable emissions from within the U.S. The EPA will assist states with conducting the analyses necessary to demonstrate "but for" attainment, including estimating the extent of international contribution on high O_3 days.

7. Questions for further discussion:

As noted earlier, the EPA intends to hold a workshop in early 2016 to discuss the information in this white paper and to further advance our collective understanding of the technical and policy issues associated with background O3. The EPA plans to evaluate the need for further guidance to address background O3 after receiving feedback on this white paper and after conducting the workshop. Here is a list of questions we would like to stakeholders to consider for discussion at the workshop.

A. Has the EPA properly characterized the current best estimates of background O_3? Are there additional existing data analyses or modeling simulations that need to be folded into the assessment?

B. What additional data elements and/or model improvements are needed to improve characterization of background O_3 levels across the U.S.?

C. EPA has focused on USB in this white paper. Are there other definitions of background ozone that concern stakeholders?

D. Does the EPA preliminary conceptual model of O_3 attainment planning align with stakeholder perspectives on the O_3 planning process?

E. Has the EPA identified all of the CAA mechanisms available to address areas influenced by background O_3?

F. What other approaches (consistent with CAA provisions) should be considered to deal with background O_3 in implementing the 2015 O_3 NAAQS?

G. Are sufficient technical tools, data, and EPA guidance available to make the demonstrations necessary to invoke relevant CAA provisions?

H. Do states want or need additional assistance from the EPA to develop the demonstrations necessary to invoke relevant CAA provisions?

I. What are stakeholders' perspectives on existing programs and cooperative agreements to reduce levels of background O_3 entering the U.S.?

Appendix: Additional detail on modeling estimates of background O_3:

The photochemical grid models used by the EPA and air agencies for O_3 planning are regional scale models, covering domains ranging from metropolitan areas to the continental U.S. with grid sizes of 4 km to 36 km. An important consideration in the use of these models to estimate background O_3 is how to set the O_3 concentrations at the edges of the domain (i.e., the top and lateral boundary conditions). Regional model boundary conditions can be informed by observations at surface sites near the boundary or from satellites, but they are typically determined using a global-scale photochemical grid model that covers the entire globe at a grid resolution between 50 km and 200 km. Regional models are developed to estimate O_3 concentrations on an hourly basis, whereas global models are typically run with temporal resolutions of 3 or 6 hours and are often evaluated by comparison to monthly or seasonal average observations. Although global models can often reproduce the relative patterns of observations over large areas and time scales of synoptic meteorology (e.g., passing of a frontal system), the absolute values estimated by these coarser models can differ significantly between models and often have biases in comparison to observations.[43] Any global model biases can be carried forward in the boundary conditions into the regional model, adding to the uncertainty in the regional modeled estimates of USB O_3.

Although the EPA analyses summarized in Section 3 utilized state-of-the-science modeling tools and best practice techniques for model input development and model evaluation, these estimates may contain biases and errors on specific days at specific sites.[44] Comparisons of background estimates from these global model applications have been found to differ in magnitude. These differences are thought to result from differences in the treatment of stratospheric-tropospheric exchange, wildfire emissions, lightning NOx emissions, biogenic VOC emissions, and isoprene oxidation chemistry between the modeling systems.[45] The EPA anticipates that improvements in ambient data collection and modeling capabilities will continue in the coming years, and we will work collectively with air agencies to incorporate any new findings into the O_3 NAAQS implementation process.[46] The EPA is also working with the international research community through such bodies as the Task Force on Hemispheric Transport of Air Pollution (HTAP) under the Convention on Long-range Transboundary Air Pollution (LRTAP) to improve our understanding of the intercontinental transport of air pollutants and the ability of global and regional models to estimate the influence of extra-regional sources of pollutants on air quality in the U.S.[47]

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[43] Fiore et al. (2009); Fiore et al. (2014).

[44] Bias and error in air quality modeling simulations typically occur due to both uncertain inputs (e.g., emissions and meteorology) as well as from incomplete model treatment of the full physiochemical elements of the atmosphere.

[45] Fiore et al. (2014).

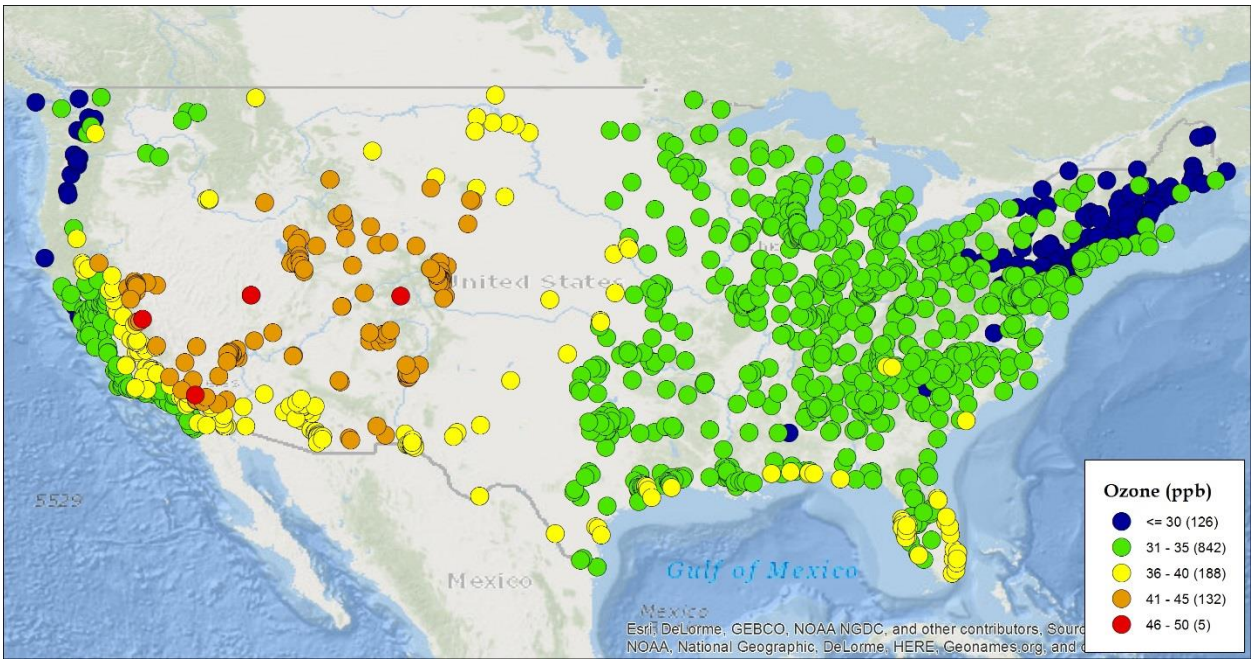
[46] Cooper et al. (2015).

[47] See http://www.htap.org.

Table 1. Subset of information from Table 3-1 of ISA. Summary of Zhang et al. (2011) estimates of seasonal mean MDA8 O_3 observations, seasonal mean model concentrations from the GEOS-Chem global model, and GEOS-Chem estimates of seasonal mean USB O_3 at selected CASTNET sites by region.[48]

Region	Spring mean observed MDA8 O_3 (ppb)	Spring mean base model MDA8 O_3 (ppb)	Spring mean model USB MDA8 O_3 (ppb)	Summer mean observed MDA8 O_3 (ppb)	Summer mean base model MDA8 O_3 (ppb)	Summer mean model USB MDA8 O_3 (ppb)
California	58 (+/- 12)	52 (+/- 11)	38 (+/- 7)	69 (+/- 14)	66 (+/- 18)	37 (+/- 9)
West	54 (+/- 9)	53 (+/- 7)	42 (+/- 6)	55 (+/- 11)	55 (+/- 11)	40 (+/- 9)
North Central	47 (+/- 10)	47 (+/- 8)	33 (+/- 6)	50 (+/- 12)	51 (+/- 14)	27 (+/- 7)
Northeast	48 (+/- 10)	45 (+/- 7)	33 (+/- 7)	45 (+/- 14)	45 (+/- 13)	24 (+/- 7)
Southeast	52 (+/- 11)	51 (+/- 7)	32 (+/- 7)	52 (+/- 16)	54 (+/- 9)	29 (+/- 10)

Figure 1. Map of 2007 CMAQ-estimated seasonal mean USB O_3 concentrations (ppb) from zero out modeling. Same as Figure 2-11 in the EPA Policy Assessment.



[48] The "west" region includes: AZ, CO, ID, MT, NM, NV, OR, UT, WA, and WY. The "north central" region includes: IA, IL, IN, KS, KY, MI, MN, MO, ND, NE, OH, SD, and WI. The "northeast" region includes: CT, DE, MA, MD, ME, NH, NJ, NY, PA, RI, VA, VT, and WV. The "southeast" region includes: AL, AR, FL, GA, LA, NC, MS, OK, SC, TN and TX.

Figure 2a. Distributions of absolute estimates of USB O_3, from 2007 CAMx source apportionment modeling, binned by model MDA8 O_3. Same as Figure 2-14 in the EPA Policy Assessment.

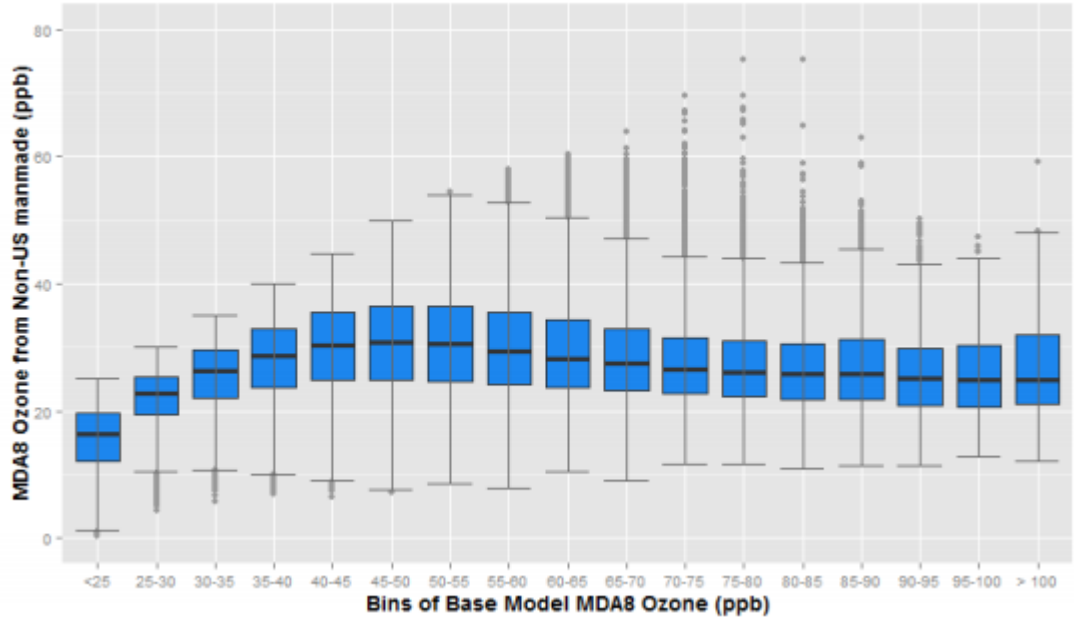


Figure 2b. Distributions of the relative proportion of USB O_3 to total O_3, from 2007 CAMx source apportionment modeling, binned by model MDA8 O_3. Same as Figure 2-15 in the EPA Policy Assessment.

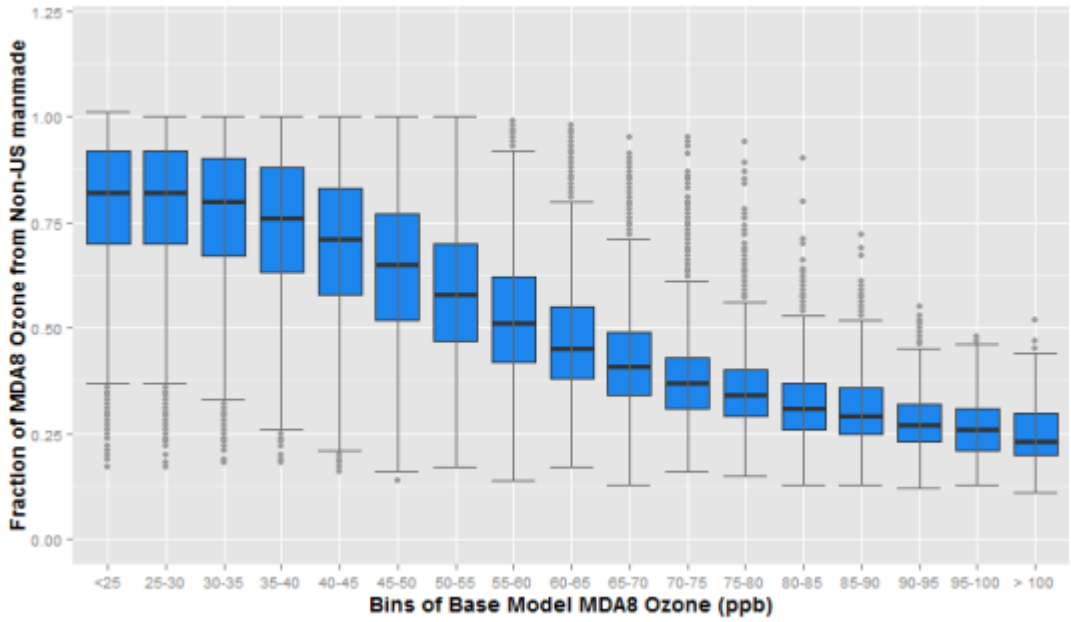


Table 2a. List of counties in the eastern U.S. with 2012-2014 O_3 design values greater than 70 ppb. For counties with multiple sites greater than 70 ppb, only the site with the highest 2012-2014 DV is shown. The table lists the 2012-2014 O3 design values (ppb), the 4th high ozone value from 2014 (ppb), the model-estimated contribution (%) of U.S. sources to the projected 2017 design value in the county, the model-estimated contribution (%) of in-State sources to the projected 2017 design value, and the total NOx emissions in the county..

State	County	SiteID	Site Type	2012-2014 DV (ppb)	2014 4th high (ppb)	Fraction of 2017 DV from manmade US sources	Fraction of 2017 DV from manmade in-State sources	County NOx 2011 NEI (kTPY)
Arkansas	Crittenden	50350005	SLAMS	71	67	0.62	0.09	8
Arkansas	Pulaski	51191002	SLAMS	71	65	0.60	0.40	18
Connecticut	Fairfield	90019003	SLAMS	85	81	0.67	0.05	18
Connecticut	Hartford	90031003	SLAMS	77	77	0.63	0.08	18
Connecticut	Middlesex	90070007	SLAMS	81	80	0.65	0.09	5
Connecticut	New Haven	90099002	SLAMS	81	69	0.67	0.09	16
Connecticut	New London	90110124	SLAMS	79	65	0.67	0.11	8
Connecticut	Tolland	90131001	SLAMS	80	77	0.63	0.12	3
D.C.	D.C.	110010043	SLAMS	73	68	0.69	0.07	9
Delaware	Kent	100010002	SLAMS	72	66	0.69	0.03	5
Delaware	New Castle	100031007	SLAMS	71	71	0.67	0.01	14
Delaware	Sussex	100051003	SLAMS	74	67	0.65	0.10	11
Florida	Hillsborough	120570081	SLAMS	69	71	0.55	0.47	37
Georgia	DeKalb	130890002	SLAMS	72	70	0.70	0.47	15
Georgia	Fulton	131210055	SLAMS	76	73	0.70	0.48	24
Georgia	Gwinnett	131350002	SLAMS	72	68	0.67	0.46	17
Georgia	Henry	131510002	SLAMS	77	75	0.69	0.44	7
Georgia	Rockdale	132470001	SLAMS	77	79	0.66	0.45	2
Illinois	Cook	170317002	SLAMS	78	72	0.70	0.40	113
Illinois	Jersey	170831001	SLAMS	74	65	0.65	0.14	1
Illinois	Lake	170971007	SLAMS	79	73	0.72	0.42	21
Illinois	Madison	171191009	SLAMS	76	70	0.67	0.13	17
Illinois	McLean	171132003	SLAMS	71	66	0.48	0.21	7
Illinois	Randolph	171570001	SLAMS	72	71	0.64	0.18	7
Illinois	Saint Clair	171630010	SLAMS	72	67	0.68	0.14	9
Indiana	Boone	180110001	SLAMS	71	66	0.55	0.24	4
Indiana	Clark	180190008	SLAMS	72	66	0.65	0.22	5
Indiana	Floyd	180431004	SLAMS	73	66	0.64	0.17	4
Indiana	Greene	180550001	SLAMS	71	64	0.62	0.37	2
Indiana	LaPorte	180910005	SLAMS	79	70	0.69	0.16	9
Indiana	Marion	180970073	SLAMS	71	65	0.60	0.37	39

State	County	SiteID	Site Type	2012-2014 DV (ppb)	2014 4th high (ppb)	Fraction of 2017 DV from manmade US sources	Fraction of 2017 DV from manmade in-State sources	County NOx 2011 NEI (kTPY)
Indiana	Porter	181270024	SLAMS	73	71	0.67	0.14	18
Indiana	St. Joseph	181410015	SLAMS	71	67	0.65	0.18	10
Indiana	Vanderburgh	181630013	SLAMS	72	70	0.61	0.28	6
Indiana	Warrick	181730011	SLAMS	71	66	0.62	0.27	15
Kansas	Leavenworth	201030003	SLAMS	71	68	0.65	0.22	4
Kansas	Sedgwick	201730010	SLAMS	73	69	0.49	0.20	18
Kansas	Sumner	201910002	SLAMS	73	67	0.50	0.13	6
Kentucky	Campbell	210373002	SLAMS	75	71	0.63	0.17	3
Kentucky	Daviess	210590005	SLAMS	72	64	0.64	0.29	8
Kentucky	Henderson	211010014	SPECIAL_P	74	69	0.61	0.20	4
Kentucky	Jefferson	211110027	SLAMS	71	65	0.59	0.29	38
Kentucky	Livingston	211390003	SLAMS	72	65	0.58	0.30	2
Kentucky	McCracken	211451024	SLAMS	72	65	0.57	0.28	19
Kentucky	Oldham	211850004	SLAMS	74	68	0.61	0.25	2
Louisiana	East Baton Rouge	220330003	SLAMS	72	75	0.63	0.46	22
Louisiana	Jefferson	220511001	SLAMS	69	71	0.60	0.41	27
Louisiana	Livingston	220630002	SPECIAL_P	71	73	0.58	0.43	4
Louisiana	Pointe Coupee	220770001	SLAMS	71	71	0.56	0.40	16
Louisiana	St. Bernard	220870004	SPECIAL_P	67	71	0.54	0.36	13
Louisiana	St. Tammany	221030002	SPECIAL_P	71	74	0.55	0.40	8
Maine	York	230312002	SLAMS	73	66	0.60	0.02	7
Maryland	Anne Arundel	240030014	SLAMS	74	66	0.67	0.24	21
Maryland	Baltimore	240053001	SLAMS	72	68	0.72	0.32	22
Maryland	Calvert	240090011	SLAMS	73	70	0.67	0.20	3
Maryland	Cecil	240150003	SLAMS	77	74	0.66	0.25	4
Maryland	Charles	240170010	SLAMS	71	67	0.67	0.17	4
Maryland	Harford	240251001	SLAMS	75	67	0.70	0.29	6
Maryland	Kent	240290002	SLAMS	74	68	0.70	0.23	1
Maryland	Prince George's	240338003	SLAMS	76	69	0.71	0.17	21
Massachusetts	Hampshire	250154002	SLAMS	71	68	0.62	0.06	3
Michigan	Allegan	260050003	SLAMS	83	77	0.71	0.04	5
Michigan	Benzie	260190003	SLAMS	73	69	0.65	0.04	1
Michigan	Berrien	260210014	SLAMS	79	73	0.68	0.03	7
Michigan	Cass	260270003	SLAMS	73	66	0.65	0.03	2
Michigan	Genesee	260492001	SLAMS	72	68	0.53	0.26	12
Michigan	Huron	260630007	SLAMS	71	66	0.53	0.21	3
Michigan	Kalamazoo	260770008	SLAMS	73	67	0.63	0.08	8

State	County	SiteID	Site Type	2012-2014 DV (ppb)	2014 4th high (ppb)	Fraction of 2017 DV from manmade US sources	Fraction of 2017 DV from manmade in-State sources	County NOx 2011 NEI (kTPY)
Michigan	Kent	260810020	SLAMS	71	66	0.66	0.12	17
Michigan	Lenawee	260910007	SLAMS	73	68	0.52	0.21	4
Michigan	Macomb	260990009	SLAMS	74	71	0.61	0.29	21
Michigan	Manistee	261010922	TRIBAL	72	66	0.66	0.04	4
Michigan	Mason	261050007	SLAMS	74	70	0.68	0.04	1
Michigan	Muskegon	261210039	SLAMS	79	75	0.71	0.07	7
Michigan	Oakland	261250001	SLAMS	71	67	0.59	0.30	35
Michigan	Ottawa	261390005	SLAMS	75	71	0.67	0.07	17
Michigan	St. Clair	261470005	SLAMS	74	71	0.57	0.24	25
Michigan	Washtenaw	261610008	SLAMS	73	70	0.59	0.31	12
Michigan	Wayne	261630019	SLAMS	74	73	0.56	0.27	62
Mississippi	Harrison	280470008	SLAMS	69	73	0.66	0.32	16
Mississippi	Jackson	280590006	SLAMS	71	75	0.57	0.19	16
Missouri	Clay	290470006	SLAMS	74	66	0.64	0.24	9
Missouri	Clinton	290490001	SLAMS	73	64	0.64	0.26	1
Missouri	Jasper	290970004	SLAMS	72	65	0.51	0.05	6
Missouri	Jefferson	290990019	SLAMS	75	72	0.70	0.48	12
Missouri	Lincoln	291130003	SLAMS	75	67	0.61	0.34	3
Missouri	Perry	291570001	SLAMS	71	67	0.58	0.20	2
Missouri	Saint Charles	291831002	SLAMS	78	72	0.67	0.40	18
Missouri	Saint Louis	291890014	SLAMS	77	72	0.64	0.37	39
Missouri	Sainte Genevieve	291860005	SLAMS	72	69	0.59	0.31	9
Missouri	St. Louis City	295100085	SLAMS	73	66	0.68	0.40	11
New Jersey	Bergen	340030006	SLAMS	73	69	0.67	0.16	16
New Jersey	Camden	340071001	SLAMS	76	68	0.69	0.10	9
New Jersey	Essex	340130003	SLAMS	73	70	0.64	0.11	14
New Jersey	Gloucester	340150002	SLAMS	76	70	0.68	0.05	8
New Jersey	Hudson	340170006	SLAMS	70	72	0.64	0.13	10
New Jersey	Hunterdon	340190001	SLAMS	72	65	0.67	0.05	4
New Jersey	Mercer	340219991	CASTNET	73	71	0.69	0.04	8
New Jersey	Middlesex	340230011	SLAMS	74	71	0.67	0.15	16
New Jersey	Monmouth	340250005	SLAMS	72	64	0.66	0.16	11
New Jersey	Morris	340273001	SLAMS	72	68	0.65	0.11	9
New Jersey	Ocean	340290006	SLAMS	75	72	0.67	0.12	8
New York	Bronx	360050133	SLAMS	71	70	0.63	0.07	10
New York	Chautauqua	360130006	SLAMS	71	66	0.60	0.02	8
New York	Erie	360290002	SLAMS	71	63	0.53	0.05	21

State	County	SiteID	Site Type	2012-2014 DV (ppb)	2014 4th high (ppb)	Fraction of 2017 DV from manmade US sources	Fraction of 2017 DV from manmade in-State sources	County NOx 2011 NEI (kTPY)
New York	Queens	360810124	SLAMS	72	63	0.63	0.09	29
New York	Richmond	360850067	SLAMS	73	72	0.66	0.03	8
New York	Rockland	360870005	SLAMS	72	68	0.64	0.15	5
New York	Suffolk	361030004	SLAMS	75	64	0.68	0.24	39
New York	Westchester	361192004	SLAMS	75	74	0.67	0.12	16
North Carolina	Mecklenburg	371191009	SLAMS	73	68	0.63	0.39	29
Ohio	Allen	390030009	SLAMS	71	66	0.54	0.25	8
Ohio	Ashtabula	390071001	SLAMS	72	69	0.59	0.27	7
Ohio	Butler	390179991	CASTNET	74	69	0.61	0.21	15
Ohio	Clark	390230001	SLAMS	71	65	0.63	0.27	6
Ohio	Clermont	390250022	SLAMS	75	68	0.66	0.28	22
Ohio	Clinton	390271002	SLAMS	73	70	0.67	0.26	2
Ohio	Cuyahoga	390350034	SLAMS	75	71	0.67	0.31	35
Ohio	Delaware	390410002	SLAMS	71	66	0.58	0.24	7
Ohio	Franklin	390490029	SLAMS	75	70	0.65	0.35	37
Ohio	Hamilton	390610006	SLAMS	75	70	0.65	0.25	36
Ohio	Lake	390850003	SLAMS	78	75	0.68	0.38	18
Ohio	Lucas	390950024	SLAMS	71	70	0.62	0.25	24
Ohio	Madison	390970007	SLAMS	71	69	0.64	0.26	3
Ohio	Miami	391090005	SLAMS	71	66	0.59	0.29	5
Ohio	Montgomery	391130037	SLAMS	72	69	0.64	0.32	20
Ohio	Trumbull	391550011	SLAMS	72	65	0.57	0.27	10
Ohio	Warren	391650007	SLAMS	72	71	0.66	0.28	7
Oklahoma	Canadian	400170101	SLAMS	71	68	0.53	0.36	11
Oklahoma	Cleveland	400270049	SLAMS	71	67	0.50	0.31	7
Oklahoma	Comanche	400310651	SLAMS	73	69	0.48	0.25	7
Oklahoma	Creek	400370144	SLAMS	72	66	0.60	0.43	7
Oklahoma	Kay	400719010	TRIBAL	73	69	0.51	0.20	7
Oklahoma	Oklahoma	401091037	SLAMS	74	70	0.48	0.28	29
Oklahoma	Tulsa	401431127	SLAMS	74	65	0.61	0.44	28
Pennsylvania	Allegheny	420030008	SLAMS	73	65	0.67	0.24	35
Pennsylvania	Armstrong	420050001	SLAMS	74	68	0.61	0.33	30
Pennsylvania	Beaver	420070005	SLAMS	75	70	0.67	0.20	21
Pennsylvania	Berks	420110011	SLAMS	71	68	0.60	0.32	14
Pennsylvania	Bucks	420170012	SLAMS	75	71	0.69	0.28	13
Pennsylvania	Chester	420290100	SLAMS	73	71	0.68	0.23	12
Pennsylvania	Delaware	420450002	SLAMS	74	73	0.67	0.20	17

State	County	SiteID	Site Type	2012-2014 DV (ppb)	2014 4th high (ppb)	Fraction of 2017 DV from manmade US sources	Fraction of 2017 DV from manmade in-State sources	County NOx 2011 NEI (kTPY)
Pennsylvania	Erie	420490003	SLAMS	71	65	0.62	0.05	11
Pennsylvania	Indiana	420630004	SLAMS	74	68	0.61	0.34	36
Pennsylvania	Lancaster	420710007	SLAMS	71	66	0.67	0.37	14
Pennsylvania	Lawrence	420730015	SLAMS	72	68	0.67	0.29	4
Pennsylvania	Lebanon	420750100	SLAMS	71	67	0.60	0.29	5
Pennsylvania	Mercer	420850100	SLAMS	75	71	0.57	0.08	6
Pennsylvania	Montgomery	420910013	SLAMS	72	72	0.68	0.32	17
Pennsylvania	Philadelphia	421010024	SLAMS	75	72	0.68	0.27	21
Rhode Island	Providence	440071010	SLAMS	73	64	0.57	0.03	12
Rhode Island	Washington	440090007	SLAMS	74	63	0.67	0.05	3
Tennessee	Davidson	470370026	SLAMS	70	71	0.59	0.33	26
Tennessee	Jefferson	470890002	SLAMS	71	67	0.55	0.30	5
Tennessee	Shelby	471570075	SLAMS	73	66	0.65	0.35	32
Tennessee	Sumner	471650007	SLAMS	72	66	0.60	0.37	11
Texas	Bell	480271047	SLAMS	72	69	0.39	0.23	11
Texas	Bexar	480290052	SLAMS	80	72	0.43	0.31	48
Texas	Brazoria	480391004	SLAMS	80	71	0.62	0.45	15
Texas	Collin	480850005	SLAMS	78	74	0.58	0.47	12
Texas	Dallas	481130069	SLAMS	78	66	0.55	0.43	51
Texas	Denton	481210034	SLAMS	81	77	0.54	0.38	14
Texas	Ellis	481390016	SLAMS	71	62	0.51	0.39	12
Texas	Galveston	481671034	SLAMS	72	71	0.50	0.21	12
Texas	Gregg	481830001	SLAMS	71	66	0.58	0.35	7
Texas	Harris	482010066	SLAMS	76	70	0.56	0.43	99
Texas	Hood	482210001	SLAMS	76	73	0.53	0.38	4
Texas	Johnson	482510003	SLAMS	76	71	0.52	0.39	9
Texas	Montgomery	483390078	SLAMS	76	72	0.49	0.37	9
Texas	Parker	483670081	SLAMS	74	72	0.50	0.34	6
Texas	Rockwall	483970001	SLAMS	73	66	0.50	0.40	2
Texas	Smith	484230007	SLAMS	71	66	0.50	0.29	8
Texas	Tarrant	484393009	SLAMS	80	73	0.59	0.47	45
Virginia	Arlington	510130020	SLAMS	74	71	0.71	0.18	4
Virginia	Fairfax	510590030	SLAMS	72	65	0.71	0.23	15
Wisconsin	Dodge	550270001	SLAMS	72	71	0.59	0.12	4
Wisconsin	Door	550290004	SLAMS	73	65	0.68	0.11	2
Wisconsin	Kenosha	550590019	SLAMS	81	76	0.72	0.13	7
Wisconsin	Kewaunee	550610002	SLAMS	73	65	0.68	0.07	1
Wisconsin	Manitowoc	550710007	SLAMS	75	66	0.70	0.12	4
Wisconsin	Milwaukee	550790085	SLAMS	77	69	0.70	0.14	27
Wisconsin	Outagamie	550870009	SLAMS	71	70	0.53	0.15	8
Wisconsin	Ozaukee	550890008	SLAMS	77	74	0.67	0.10	4
Wisconsin	Sheboygan	551170006	SLAMS	81	72	0.67	0.13	7
Wisconsin	Walworth	551270005	SLAMS	72	73	0.56	0.05	4

Table 2b. List of counties in California with 2012-2014 O_3 design values greater than 70 ppb. For counties with multiple sites greater than 70 ppb, only the site with the highest 2012-2014 DV is shown. The table lists the 2012-2014 O3 design values (ppb), the 4th high ozone value from 2014 (ppb), the model-estimated contribution (%) of U.S. sources to the projected 2017 design value in the county, the model-estimated contribution (%) of in-State sources to the projected 2017 design value, and the total NOx emissions in the county.

State	County	SiteID	Site Type	2012-2014 DV	2014 4th high	Fraction of 2017 DV from manmade US sources	Fraction of 2017 DV from manmade in-State sources	County NOx 2011 NEI (kTPY)
California	Alameda	60010007	SLAMS	72	76	0.58	0.56	28
California	Amador	60050002	SLAMS	72	74	0.50	0.50	2
California	Butte	60070007	SPECIAL_P	74	74	0.45	0.44	8
California	Calaveras	60090001	SLAMS	71	71	0.49	0.48	2
California	El Dorado	60170010	SLAMS	84	82	0.55	0.54	4
California	Fresno	60190011	SLAMS	89	90	0.53	0.51	29
California	Imperial	60251003	SLAMS	80	78	0.30	0.27	11
California	Kern	60295002	SLAMS	88	88	0.48	0.47	47
California	Kings	60311004	SLAMS	84	86	0.53	0.52	8
California	Los Angeles	60376012	SLAMS	97	97	0.55	0.53	136
California	Madera	60392010	SLAMS	83	79	0.49	0.48	9
California	Mariposa	60430006	SPECIAL_P	78	77	0.40	0.38	1
California	Merced	60470003	SLAMS	81	82	0.51	0.50	13
California	Nevada	60570005	SLAMS	79	82	0.50	0.49	3
California	Orange	60592022	SLAMS	74	78	0.58	0.57	32
California	Placer	60610006	SLAMS	81	83	0.60	0.58	9
California	Riverside	60651016	TRIBAL	99	98	0.51	0.50	37
California	Sacramento	60670012	SLAMS	85	81	0.58	0.57	20
California	San Bernardino	60714003	SLAMS	102	99	0.57	0.56	69
California	San Diego	60731006	SLAMS	79	80	0.42	0.40	43
California	San Joaquin	60773005	SLAMS	79	79	0.57	0.56	23
California	San Luis Obispo	60798005	SLAMS	76	73	0.38	0.37	8
California	Santa Barbara	60831021	INDUSTRIAL	68	76	0.37	0.36	10
California	Santa Clara	60852006	SLAMS	70	73	0.55	0.53	25
California	Shasta	60890007	SLAMS	68	71	0.45	0.43	9
California	Stanislaus	60990006	SLAMS	84	81	0.59	0.58	13
California	Tehama	61030004	SPECIAL_P	75	76	0.40	0.39	6
California	Tulare	61070009	CASTNET	91	89	0.41	0.41	16
California	Tuolumne	61090005	SLAMS	73	75	0.44	0.43	3
California	Ventura	61112002	SLAMS	79	81	0.54	0.53	12

Table 2c. List of counties in the inter-mountain western U.S., but outside of California, with 2012-2014 O_3 design values greater than 70 ppb. For counties with multiple sites greater than 70 ppb, only the site with the highest 2012-2014 DV is shown. The table lists the 2012-2014 O3 design values (ppb), the 4th high ozone value from 2014 (ppb), the model-estimated contribution (%) of U.S. sources to the projected 2017 design value in the county, the model-estimated contribution (%) of in-State sources to the projected 2017 design value, and the total NOx emissions in the county.

State	County	SiteID	Site Type	2012-2014 DV	2014 4th high	Fraction of 2017 DV from manmade US sources	Fraction of 2017 DV from manmade in-State sources	County NOx 2011 NEI (kTPY)
Arizona	Cochise	40038001	CASTNET	71	68	0.08	0.06	20
Arizona	Coconino	40051008	SLAMS	71	73	0.10	0.06	17
Arizona	Gila	40070010	SLAMS	74	72	0.29	0.22	3
Arizona	La Paz	40128000	SLAMS	72	71	0.22	0.05	6
Arizona	Maricopa	40131004	SLAMS	80	78	0.50	0.45	88
Arizona	Pima	40190021	SLAMS	71	69	0.29	0.25	27
Arizona	Pinal	40218001	SLAMS	73	68	0.30	0.25	15
Arizona	Yavapai	40258033	SLAMS	71	77	0.14	0.09	13
Arizona	Yuma	40278011	SLAMS	77	78	0.31	0.07	8
Colorado	Adams	80013001	SLAMS	73	67	0.49	0.40	25
Colorado	Arapahoe	80050006	SLAMS	71	67	0.28	0.20	13
Colorado	Boulder	80130011	SLAMS	75	70	0.36	0.28	10
Colorado	Douglas	80350004	SLAMS	81	74	0.45	0.36	8
Colorado	El Paso	80410013	SLAMS	71	64	0.09	0.06	22
Colorado	Jefferson	80590006	SLAMS	82	77	0.44	0.35	14
Colorado	Larimer	80690011	SLAMS	78	74	0.37	0.31	12
Colorado	Weld	81230009	SLAMS	74	70	0.48	0.42	33
Nevada	Clark	320030075	SLAMS	78	79	0.35	0.22	52
Nevada	Washoe	320310016	SLAMS	70	71	0.10	0.02	14
Nevada	White Pine	320330101	CASTNET	71	64	0.13	0.02	1
New Mexico	Dona Ana	350130022	SLAMS	74	66	0.15	0.02	12
New Mexico	Eddy	350151005	SLAMS	71	72	0.25	0.08	12
Texas	El Paso	481410037	SLAMS	72	70	0.16	0.10	19
Utah	Davis	490110004	SLAMS	70	74	0.33	0.23	8
Utah	Salt Lake	490353006	SLAMS	75	72	0.31	0.20	29
Utah	Tooele	490450003	SLAMS	71	69	0.26	0.13	6
Utah	Utah	490495010	SLAMS	74	76	0.20	0.09	13
Utah	Weber	490571003	SLAMS	73	70	0.29	0.20	6

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