Appendix C
Response to informal comments received during consultation on draft boundaries:

Responsiveness Summary to Comments Received During Stakeholder Outreach
Stakeholder comments

Air Quality Division
September 23, 2024 Proposed

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This responsiveness summary contains the Arizona Department of Environmental Quality's (ADEQ) responses to all comments received on ADEQ's proposed Initial Draft $PM_{2.5}$ Boundary Recommendation (see https://azdeq.gov/AQD/2024Revisions) that was made available for a 30-day informal comment period commencing on June 21, 2024.

Commenter	Summary of Comment	Response
Maricopa County Air Quality Department (MCAQD)	Commenter asserted the spatiotemporal scales of some of the analyzed factors were not focused on the largest $PM_{2.5}$ issues, thus making the draft nonattainment area unnecessarily large.	ADEQ disagrees that the analysis was not appropriately focused. Additionally, ADEQ disagrees that the nonattainment area is unnecessarily large. While, ADEQ agrees that the largest $PM_{2.5}$ concentrations occur in the fall and winter, ADEQ believes the scales analyzed are appropriate. EPA's memorandum states, "contributions to monitored ambient $PM_{2.5}$ concentrations at a violating monitor throughout the entire 3-year period are relevant to determining the appropriate boundaries for a nonattainment area."[1] Based on EPA's memorandum, ADEQ must analyze all data from the 2021 - 2023 time period. While smaller temporal scales may be helpful in identifying potential control measures, the temporal scale must include the 3-year period. Based on its five-factor analysis, ADEQ disagrees that the proposed nonattainment area boundary is unnecessarily large.
MCAQD	**Air Quality Data:**	**See Below**
	Commenter asserted ADEQ's analysis could be strengthened by focusing on finer temporal scale periods, such as the late fall and early winter months (i.e., the wood burning season), which is normally	While ADEQ agrees the majority of exceedances occur in fall and winter, ADEQ notes that exceedances of the 9 $\mu g/m^3$ standard also occur in spring and summer. Therefore, ADEQ

[1] Initial Area Designations for the 2024 Revised Primary Annual Fine Particle National Ambient Air Quality Standard, Memorandum from Joseph Goffman, Assistant Administrator, to Regional Administrators, Regions 1-10 (February 7, 2024), Attachment 3, 5, https://www.epa.gov/system/files/documents/2024-02/pm-naaqs-designations-memo_2.7.2024-_-jg-signed.pdf.

	the only time when monthly $PM_{2.5}$ averages exceed 9 μg/m^3.	maintains that the five-factor analysis must include the entire year.
MCAQD	Commenter provided Figures 2 and 3 that display $PM_{2.5}$ concentrations during the wood burning season on a time of week and time of day basis. Commenter notes Figure 3 shows a concentration spike in morning traffic and work activity. Commenter noted the Durango Complex monitor is in an industrial area and displays the largest morning spike, while the nighttime spikes at South and West Phoenix are higher during the wood burning season.	ADEQ appreciates the analysis provided. ADEQ notes that Figure 3 appears to show an inflection point around 6:00 AM in the curves for the South Phoenix and West Phoenix monitors. The rate change in $PM_{2.5}$ concentrations moves from the decreasing rate from the overnight high to an increasing trend until the morning high around 8:00 AM. ADEQ believes it is worth examining if the morning increases are associated with morning commute hours before the inversion layer breaks up, rather than wood burning.
MCAQD	Commenter noted Figure 3 shows that the night time spikes at the Durango Complex occurs later than those at the South and West Phoenix monitors suggesting particulate matter is being transported to the area from neighborhoods surrounding central, south, and west Phoenix.	ADEQ agrees that there is likely transport of $PM_{2.5}$ pollution to the Durango Complex. However, ADEQ believes there is evidence to support the conclusion that there is $PM_{2.5}$ being transported to the violating monitors from beyond the neighborhoods surrounding central, south, and west Phoenix. As will be provided in greater detail elsewhere, ADEQ has run HYSPLIT modeling for the violating monitors that supports its conclusion. This HYSPLIT analysis will be provided in the updated draft boundary recommendation.
MCAQD	Commenter stated these patterns provide evidence suggesting that residential activity, such as wood burning, are among the dominant sources during this time of year.	ADEQ agrees that non-point source activities that correlate with population density are a significant contributor to $PM_{2.5}$ pollution during the fall and winter. However, ADEQ notes that the morning spike in $PM_{2.5}$ emissions are less likely to be associated with residential wood burning. Based on the timing, the morning spikes might be associated with morning commute hours.

MCAQD	Commenter stated its Figure 4 shows the prevalence of residential activity during the late fall and early winter around holidays. Commenter asserted that industrial and transportation sources are curtailed during these holidays. Commenter states this provides strong evidence that residential activity is the source, especially during the Christmas and New Year's Day holidays when seasonal activities such as wood burning and fireworks are so prevalent.	ADEQ requests that the commenter provide additional information to support that industrial or transportation are curtailed significantly during these holidays. ADEQ is not aware of any enforceable control measures that would permanently provide for emission reductions on these days. ADEQ agrees that it is likely that there is increased residential activity during winter holidays. However, as part of its analysis, ADEQ considered whether to pursue exceptional event demonstrations for these days. ADEQ determined that it would be unlikely to make a regulatory significant impact to develop and submit such exceptional events.
MCAQD	Commenter states increase spatial resolution would be useful as part of the analysis because $PM_{2.5}$ sources generally have a short-range effect on surrounding areas. Commenter presents its Figure 5, displaying a correlation matrix, between monitoring sites in Maricopa County and Pinal County. Commenter states a strong correlation is generally considered to be >0.70. Commenter states Figure 5 shows that the highest correlation in this dataset is 0.57 and 87% of the air monitoring sites have less than 0.40 correlation.	ADEQ disagrees with the use of correlation coefficients for evaluating contributions to the violation monitors as ADEQ is unaware of this methodology being used in prior boundary recommendations. Additionally, ADEQ is unaware of EPA utilizing this methodology to support prior boundary recommendations. As Commenter notes, Figure 5 was taken from the Maricopa County Air Monitoring Network Assessment 2015-2019 and represents a five-year average of $PM_{2.5}$ concentrations in that time period.[2] MCAQD noted its monitoring network assessment was based on EPA's network assessment

[2] Maricopa County Air Quality Dept., Maricopa County Air Monitoring Network Assessment 2015-2019 (Nov. 2020), (https://www.maricopa.gov/DocumentCenter/View/63726/2020-Air-Monitoring-Network-Assessment-PDF

		guidance from 2007.[3] EPA's guidance states, "Concentrations measured at one monitor are compared to concentrations measured at other monitors to determine if concentrations correlate temporally. Monitor pairs with correlation coefficient values near one are highly correlated and should be ranked lower than those with correlation coefficient values near zero. Monitors that do not correlate well with other monitors exhibit unique temporal concentration variation relative to other monitors and are likely to be important for assessing local emissions, transport, and spatial coverage. Monitors with concentrations that correlate well (e.g., $r^2 > 0.75$) with concentrations at another monitor may be redundant. This analysis should be performed for each pollutant."[4] EPA's continues: "Conversely, a monitor with concentrations that do not correlate with other nearby monitored concentrations may be unique and have more value for spatial monitoring objectives."[5] Lastly, the guidance states: "Determining the monitor-to-monitor correlation in a network requires at least two steps: (1) determining the temporal correlation between monitors through a regression analysis of concentrations; and (2) ranking the monitor's uniqueness. Step one can be accomplished most simply by calculating Pearson correlation coefficients (r^2) between each monitoring pair. Simple linear

[3] EPA, Ambient Air Monitoring Network Assessment Guidance: Analytical Techniques for Technical Assessments of Ambient Air Networks (Feb. 2007), https://www.epa.gov/sites/default/files/2020-01/documents/network-assessment-guidance.pdf.
[4] *Supra* note 1 at 3-2.
[5] *Id.* at 3-17.

		regressions can introduce error in the correlation coefficients, since they assume the ordinal axis has no error. Alternative methods include calculating Deming Regression or other types of correlation coefficients. In addition, choice of monitoring metrics may influence results (i.e., 1-hr peak ozone, every hour, 8-hr peak ozone, 24-hr average). Site pairs that have correlation coefficients with values near one are highly correlated and should be ranked lower than those with correlation coefficient values near zero. Sites that do not correlate well with other sites have unique temporal concentration variation relative to other sites and are likely to be important for assessing local emissions, transport, and spatial coverage. Conversely, those monitors that correlate with many other monitors may be redundant."[6] ADEQ understands based on the above information that site pairs that do not correlate well with other sites have unique temporal concentrations. ADEQ agrees, based on EPA's guidance, that it is helpful in a monitoring network analysis to identify monitors that might be redundant. However, ADEQ is unaware of instances where EPA has utilized such an analysis of the ambient air quality network to support a nonattainment boundary designation. Commenter does not provide any such examples or support for utilizing the Ambient Air Monitoring Network Assessment Guidance has been utilized in the boundary recommendation process. Therefore, ADEQ declines to utilize the commenters suggested

[6] *Id.* at 3-18.

		correlation analysis.
MCAQD	Commenter stated that if Maricopa County sites alone were correlated, the average correlation is 0.31. Commenter asserts this provides substantial evidence that the effect of sources on $PM_{2.5}$ air monitors is very localized.	ADEQ disagrees that the correlation demonstrates that there is substantial evidence that the effect of sources on $PM_{2.5}$ air monitors is very localized. While localized emissions impact the violating monitors, ADEQ's five-factor analysis examines an area that does not meet or that contributes to ambient air quality in a nearby area that does not meet. Based on the five-factor analysis, ADEQ believes there is evidence that transport of $PM_{2.5}$ emissions to the violating monitors from nearby areas is contributing to the violation of EPA's revised NAAQS.
MCAQD	Commenter conducted studies with mobile and/or low-cost $PM_{2.5}$ sensors. This includes wintertime only studies that were conducted annually between 2013 and 2020, as well as the multi-year Phoenix as a Testbed for Air Quality Sensors (PTAQS) done in conjunction with EPA. However, EPA did not publish the results from PTAQS, other than some internal reports focusing on sensor performance and correction factor creation. A presentation regarding the results was attached to the comment letter.	ADEQ appreciates the depth of the analysis commenter's studies provide. However, ADEQ disagrees with the use of non-Federal Reference Method sensors as a basis for developing its nonattainment boundary recommendations. ADEQ has found no support in EPA's rules or guidance for the use of these sensors in making regulatory decisions. ADEQ believes it is highly likely EPA will disregard information based on these sensors.
MCAQD	Commenter emphasized that which included $PM_{2.5}$ chemical speciation, source identification, and pattern analysis, was discontinued in 2020 because results were so consistent from year to year. Additionally, commenter stated there have been no significant changes to types or quantity of $PM_{2.5}$ sources in the studied areas.	ADEQ thanks the commenter for providing this analysis.
MCAQD	Commenter provided Figure 6, a map created for one of MCAQD's	ADEQ appreciates the complexity and work in the interpolation and

	wintertime studies that shows an interpolated surface showing $PM_{2.5}$ patterns during the $PM_{2.5}$ area. Commenter noted that average $PM_{2.5}$ concentrations greater than 9 μg/m^3 were generally located in central, southern, and western Phoenix.	wintertime studies. However, ADEQ disagrees with the use of interpolation for regulatory purposes as ADEQ is not aware of any prior EPA action that relies on such an analysis. MCAQD's analysis focuses on identifying areas that are violating the standard. However, CAA § 107(d)(1)(A)(i), and EPA's boundary recommendation guidance, direct the state's recommendation for nonattainment areas to include areas that any area that does not meet (or that contributes to ambient air quality in a nearby area that does not meet). The commenter's analysis does not significantly address potential contribution to the violating monitors from sources outside of the commenter's proposed boundary. Therefore, ADEQ believes the comment overlooks a key component of the five-factor analysis by failing to examine contributions from areas that are not themselves violating. ADEQ is unaware of any prior EPA action that has determined a nonattainment boundary based, either in whole or in part, on interpolation from non-regulatory sensors. However, ADEQ agrees that monitoring data from the regulatory monitors supports the statement that monitored concentrations greater than 9 μg/m^3 are located in central, southern, and western Phoenix.
MCAQD	Commenter stated these surfaces and other data demonstrate residential wood burning is a major source of $PM_{2.5}$ during the late fall and early winter. Commenter also	ADEQ agrees that it is likely that wood burning occurs primarily in late fall and winter. ADEQ agrees that it is likely that plumes drift to the west-southwest overnight.

	stated wood burning activity normally starts in the early evening, especially on weekends, in the Phoenix area and light breezes and atmospheric subsidence cause the plumes to drift to the west-southwest overnight. The eastern metropolitan area almost always exhibited much lower concentrations during this and the other wintertime studies.	Commenter has identified a mechanism where emissions from the eastern portions of the metropolitan area can be transported to the violating monitors in the west-southwestern areas. This is supported in Figure 10 of the comment.
MCAQD	**Emissions Inventory:**	**See Below**
MCAQD	Commenter stated ADEQ's analysis examined annual emissions, and that at this scale it is apparent transportation and point sources are minor contributors to $PM_{2.5}$ concentrations. At the annual scale, non-point sources are more significant.	ADEQ agrees that non-point sources constitute a larger source of $PM_{2.5}$ emissions than point sources and onroad mobile sources in terms of direct $PM_{2.5}$ emissions. However, as the form of the 2024 revised primary $PM_{2.5}$ NAAQS, ADEQ's recommendations must be based on the air quality data from the 3 most recent years of monitoring data available at the time for the recommendation. While the majority of exceedances occur during the fall and winter, exceedances do occur in the spring and fall. Therefore, ADEQ believes it applied the appropriate time scale in its evaluation.

MCAQD	Commenter stated that the MCAQD 2020 Periodic Emissions Inventory for PM2.5 from airport operations were 77.8 tons in 2020 (about 0.4% of total $PM_{2.5}$ emissions) for Maricopa County. Commenter also noticed that local estimates are significantly lower than EPA's estimates (136.6 tons in 2020). Commenter suggested new modeling may be needed to confirm $PM_{2.5}$ emissions from small airports are as high or higher than emissions from Sky Harbor.	ADEQ understood that both the NEI and MCAQD's PEI were based on the same Aviation Environmental Design Tool to estimate emissions. MCAQD's PEI states: "For aircraft, APUs, and airport GSE categories, the Federal Aviation Administration (FAA) Aviation Environmental Design Tool (AEDT) Version 3d computed emissions related to aircraft operation."[7] The NEI support documentation states: "For activity that included aircraft-specific data, ERG used the Federal Aviation Administration's (FAA) Aviation Environmental Design Tool (AEDT) to estimate emissions."[8] Both documents stated that the utilized Version 3d of the AEDT. ADEQ would welcome more information from MCAQD to explain the difference between these inventories as both appear to be based off the same model.
MCAQD	Commenter stated that onroad vehicle emissions were 636.2 tons in 2020 or 3% of total $PM_{2.5}$ emissions in Maricopa County.	ADEQ thanks the commenter for this information. ADEQ notes the difference between the 2020 NEI and MCAQD's 2020 PEI and Errata
MCAQD	Commenter stated that adjusting the temporal scale to look at winter months, residential wood burning (and fireworks during holidays) become important sources. Commenter stated when emissions	ADEQ agrees that residential wood burning (and fireworks for more limited days out of the year) are important sources that contribute to exceedances of the NAAQS. However, as stated above, EPA will

[7] Maricopa County Air Quality Dept., 2020 Periodic Emissions Inventory for Particulate Matter less than 10 Microns in Diameter, (Nov. 2022), 52, available at https://www.maricopa.gov/DocumentCenter/View/78701/2020-Periodic-Emissions-Inventory-for-Ozone-Precursors-PDF.

[8] Eastern Research Group, 2020 National Emissions Inventory: Aviation Component (Oct. 25, 2022), 1-1, available at https://www.epa.gov/system/files/documents/2023-01/2020%20NEI%20Aviation%20Documentation%20Revised%20-%2010252022.pdf.

	are temporally allocated by heating degree days, typical daily emissions from $PM_{2.5}$ emissions from residential wood combustion are 10,335 pounds per days compared to 3,578 pounds of $PM_{2.5}$ from point sources	likely consider the entire 2021 to 2023 time period, without adjusting the temporal scale, when making its final boundary recommendations.
MCAQD	Commenter stated, these temporal patterns are not apparent in the national emissions inventory data. However, they are noted in data from the above-mentioned annual wintertime $PM_{2.5}$ studies conducted by MCAQD. A significant portion of these studies included $PM_{2.5}$ speciation and modeling, which demonstrated residential wood burning and fireworks as a source of major impact during the wood burning season and especially during holidays (Figure 8). MCAQD noted that all of the $PM_{2.5}$ speciation data that were collected in MCAQD's wintertime studies, which took place annually between 2013 and 2020, were modeled with the EPA's Positive Matrix Factorization model which allows for source identification and quantification. Most of the $PM_{2.5}$ speciation sampling occurred at the West Phoenix site, but some sampling was also done at the Durango Complex, South Phoenix, and Tempe sites, as well as a temporary site in Laveen.	ADEQ believes MCAQD's wintertime study raises additional questions regarding secondary $PM_{2.5}$ formation. Based on Figure 30 in the wintertime study, it appears that secondary formation is on-average approximately 6 $\mu g/m^3$. The winter study uses a profile for the secondary $PM_{2.5}$ that highlights ammonium nitrate (and organic carbon -- see for example Figure 28), that does not provide information for the origin for the NO_X that formed that nitrate. However, vehicle exhaust and EGUs are the frequent sources of NO_X in urban environments. Biogenics can also contribute to NO_X emissions. While residential wood combustion and fires could contribute NO_X to secondary formation, one could reasonably anticipate a higher SO_X signature, and therefore more ammonium sulfate. ADEQ notes the minimal levels of sulfur in their secondary profile (see MCAQD's wintertime Figure 28). Therefore, it is important for the boundary recommendation to consider the potential role that secondary formation of $PM_{2.5}$ from transportation and point sources (e.g. potential sources of NO_X).
MCAQD	Commenter stated that focusing on point and transportation sources, especially airports, is counterproductive and will result in a boundary area that is too large.	ADEQ disagrees with this comment. ADEQ's analysis of the emissions inventory was a holistic review of the National Emissions Inventory and MCAQD's Periodic

	Commenter states this will create an unnecessary regulatory burden on industries that are a relatively minor source of PM2.5 at the violating monitors.	Emissions Inventory, looking at all source sectors and did not focus on a particular sector. ADEQ understands that EPA's final boundary recommendations may create a regulatory burden through the imposition of various Clean Air Act requirements. However, ADEQ notes that EPA's five factor analysis does not contemplate states considering the economic cost. ADEQ draft boundary recommendation is necessary to address CAA § 107(d)(1)(A) that states in relevant part, "The Governor of each State shall . . . submit to the Administrator a list of all areas (or portions thereof) in the State, designating as – (i) nonattainment, any area that does not meet (or that contributes to ambient air quality in a nearby area that does not meet) the national primary or secondary ambient air quality standard for the pollutant." Under A.R.S. § 49-405(C), ADEQ is required to develop proposed recommendations regarding designations for geographic areas of this state as being in attainment or nonattainment or unclassifiable with respect to EPA's revised NAAQS. ADEQ is required to provide its proposed recommendations to the Governor of Arizona. In making its boundary recommendations, ADEQ must evaluate areas that do not meet the NAAQS or contribute to nearby areas that do not meet the NAAQS. However, EPA does not define a contribution threshold or the term nearby. In its memorandum, EPA states: "While technical assessments can help to define the magnitude and relative magnitude

		of contribution from nearby areas, the EPA is not setting a threshold contribution level or bright line test for determining whether an area should be included within the boundaries of a given nonattainment area. Section 107(d) of the CAA does not require the EPA to set a threshold contribution and the EPA does not believe that such a threshold is helpful as it could result in boundaries that are either over- or under inclusive. For these reasons, and as was done in prior designations for the NAAQS, the contribution determination will be made through a case-by-case evaluation of the relevant facts and circumstances in each nonattainment area."[9] ADEQ believes draft recommendations' five factor analysis supports its proposed boundary within Maricopa County.
MCAQD	Commenter stated their specialized 2013-2020 annual winter time studies provide evidence of wood burning sources and how smoke emissions are being transported to the violating monitors.	ADEQ appreciates the additional insight provided by the specialized 2013-2020 studies. ADEQ notes that it is required to analyze data from 2021 to 2023 as the most recent design value data. However, the studies help provide insight into wood burning sources of $PM_{2.5}$ emission.

[9] *Supra* note 1 at Attachment 3, 2.

MCAQD	Commenter stated the density of single-family residences and age of residential construction are good proxies for identifying residential wood burning, but it is better when paired with the location of the violating monitors (Figure 9) and meteorological data (Figure 10).	ADEQ generally agrees that population and housing density are good proxies for identifying wood burning activity. However, ADEQ notes that Figure 9 shows large areas of the Phoenix area that were constructed between 1883 and 1998, including areas that were not included in either ADEQ's or MCAQD's boundaries. Specifically, ADEQ notes the south-eastern portion of the metropolitan area (Ahwatukee, Chandler, and Gilbert appear to contain older homes that could have pre-existing fireplaces that could be used for residential wood burning. Additionally, Figure 10 appears to show the nighttime downslope averages from this area are flowing toward south and central Phoenix. ADEQ requests commenter provide additional information regarding potential contributions from these areas to the violating monitors. Additionally, ADEQ disagrees with the assumption that wood-burning is restricted to fireplaces that are part of residential structures built prior to the enactment of A.R.S. § 11-875. Residential wood burning can occur in backyards in fire pits/chimineas/other outdoor wood burning devices, regardless of the construction age of the residential structure.
MCAQD	Commenter stated there is evidence that much of the wintertime residential wood burning is taking place in west, south, and midtown Phoenix and the smoke from these emissions is often transported overnight through atmospheric subsidence toward the lower-elevation southwest valley, where it lingers until the morning	ADEQ generally agrees that smoke and $PM_{2.5}$ emissions are often transported overnight through atmospheric subsidence toward the lower-elevation of the southwest valley. However, as described above, Figures 9 and 10 suggest that wood burning activity could occur in eastern portions of the valley and be transported overnight to the violating monitors.

MCAQD	Meteorology:	See below
MCAQD	Commenter noted that ADEQ's meteorological analysis was well done. Commenter noted that when broken down to a finer scale of time-of-day as highlighted in MCAQD’s 2013-2020 annual wintertime studies, it provides additional evidence about the sources and transport of $PM_{2.5}$.	ADEQ appreciates this comment. ADEQ agrees that a finer time scale is helpful in identifying sources. However, as previously noted, ADEQ believes it is still required to examine the 3 years of most recent monitoring data.
MCAQD	**Geography/Topography:**	**See below**
MCAQD	Commenter noted the draft boundaries tend to follow the structure of the Lower Salt River Airshed. Commenter urged ADEQ to consider other natural boundaries South Mountain, the Tempe and Papago Buttes, Camelback Mountain, Phoenix Mountain Preserves, North Mountain, and Shaw Butte. Commenter referenced its PTAQS study to support these boundaries as well as regulatory data from the Eastwood, Tempe, and Mesa air monitors. Commenter asserted that areas to the north and east of these natural boundaries are not major contributors to wintertime $PM_{2.5}$ violations.	ADEQ disagrees with MCAQD regarding whether some of the topological features identified by MCAQD are sufficient to act as barriers for upwind air pollution being transported to the violating monitors. Specifically, ADEQ does not believe that there is sufficient evidence to support finding that the Tempe and Papago Buttes Camelback Mountain, Phoenix Mountain Preserves, North Mountain, and Shaw Butte significantly influence the fate and transport of $PM_{2.5}$ emissions. In its draft boundary recommendation, ADEQ agreed South Mountain likely is to be a topological boundary for the nonattainment area. However, new HYSPLIT data indicate that parcels of air are capable of moving from the South side of the mountain to the North. ADEQ intends to update its draft recommendation and technician support document with this new analysis. Based on EPA’s memorandum and the topological features of the relevant airsheds, ADEQ believes that the valley features contributing to cold air drainage are likely to implicate transport of overnight

		$PM_{2.5}$ emissions from the East Valley to the West. As previously addressed, ADEQ is not applying a specific threshold for determining contribution of $PM_{2.5}$ to the violating monitors. Rather, ADEQ is utilizing EPA's five factor analysis to determine its boundary recommendation.
MCAQD	**Jurisdictional Boundaries:**	**See below**
MCAQD	Commenter asserted that the proposed boundary should not necessarily be along county lines and would be larger than necessary.	ADEQ agrees that strictly following county lines would result in a nonattainment area larger than necessary.
MCAQD	Commenter proposed the appropriate boundary should be along the eastern borders of the City of Phoenix, in conjunction with the previously mentioned topographical borders.	ADEQ disagrees with the use of city boundaries to define the nonattainment area. In its memorandum EPA states that: "intends to consider existing jurisdictional boundaries for the purposes of providing a clearly defined legal boundary and carrying out the CAA's air quality planning and enforcement functions for nonattainment areas. Examples of jurisdictional boundaries include, but are not limited to, counties, air districts, areas of Indian country, metropolitan planning organizations, and existing nonattainment areas."[10] The legal boundaries that are relevant for the boundary recommendation process are those that are relevant for carrying out the CAA planning and enforcement functions. For the areas around the violating monitors, relevant jurisdictions carrying out CAA responsibilities are MAG, MCAQD, and ADEQ. While cities may be responsible for adopting measures as part of a nonattainment or maintenance plan, local municipalities do not

[10] *Supra* note 1 at Attachment 3, 11.

		have an individual role in air quality planning or enforcement under state law. Therefore, ADEQ disagrees with using city boundaries as a method for analyzing the jurisdictional boundary factor. Furthermore, ADEQ is not aware of any past nonattainment area that has been based on city boundaries. Rather, the opposite appears to be true. In its December 2010 Addendum to its May 5, 2010 Technical Support Document Pinal County, Arizona Area Designation for the 2006 24-hour Fine Particle National Ambient Air Quality Standards, EPA discussed the use of municipal borders in boundary recommendations. Specifically, EPA stated, "Because the sources that are the primary contributors to PM2.5 are regulated by the State and County, rather than by municipalities, EPA does not believe the inclusion of a portion of Casa Grande within the nonattainment area (or conversely, the exclusion of a portion of the City of Maricopa as Arizona has proposed), presents jurisdictional challenges. Further, municipal boundaries are subject to change. As a result, in this case EPA does not believe that municipal boundaries are a major factor in determining the boundary of the nonattainment area. By including all state lands within T5S, R4E, additional agricultural lands, some of which lie within Casa Grande's incorporated boundaries, are included in the nonattainment area."[11] Therefore, ADEQ does not believe the municipal boundaries

[11] EPA, December 2010 Addendum to EPA's May 5, 2010 Technical Support Document Pinal County, Arizona Area Designation for the 2006 24-hour Fine Particle National Ambient Air Quality Standards (Dec. 2010),10, https://www3.epa.gov/pm/designations/2006standards/rec/letters/09_AZ_EPAMOD4.pdf.

		are a major factor in recommending the boundary for Maricopa County. However, ADEQ does agree that the size of Western counties are large and contain nonattainment areas whose boundaries are not associated with county linked or air districts.
MCAQD	**Conclusion:**	
MCAQD	Commenter stated the boundary recommendation should be focused on the violating air monitoring sites and the areas impacting those sites. Commenter states its wintertime studies that smoke is generated in central, south, and west Phoenix during the wood burning season and generally transported to the lower elevations in the southwest valley.	ADEQ agrees, consistent with CAA § 107(d)(1)(A)(i), the boundary recommendation focuses on areas that do not meet (or that contributes to ambient air quality in a nearby area that does not meet). ADEQ agrees that smoke is generated in central, south, and west Phoenix. However, the five-factor analysis also supports that $PM_{2.5}$ emissions are being transported to violating monitors from other parts of the metropolitan area and are therefore contributing to ambient air quality in a nearby area that does not meet.
MCAQD	Commenter stated the data indicate that north Phoenix and areas to the east of Phoenix, such as Scottsdale, Tempe, and Mesa, are not major contributors to the violating $PM_{2.5}$ air monitors. Rather, the topography of the central valley creates appropriate natural boundaries for the south, east, and north sides of the proposed nonattainment area; these natural boundaries include South Mountain, the Tempe and Papago Buttes, Camelback Mountain, Piestewa Peak/Phoenix Mountain Preserves, North Mountain, and Shaw Butte. Commenter provides Figure 11 as an alternative configuration for the proposed nonattainment boundary.	ADEQ appreciates commenter providing its alternative configuration, and GIS shapefiles, to enable ADEQ to consider this recommendation. ADEQ disagrees that the data show areas to the east of Phoenix are not contributing $PM_{2.5}$ emissions to the violating $PM_{2.5}$ air monitors. ADEQ disagrees with commenter's classification of $PM_{2.5}$ emissions from other areas as major or not. Neither EPA nor ADEQ have defined a threshold contribution level or a bright line test for what would be considered a "major" or "significant" contribution as CAA 107(d) does not require this determination. Therefore, as EPA recommends, contribution

		determinations are made through a case-by-case evaluation of relevant facts and circumstances in each nonattainment area. As described above, ADEQ disagrees with the characterization of the listed topological features (excluding South Mountain) as natural boundaries.
MCAQD	Commenter stated its proposal is based upon the EPA's five-factored analysis and includes the violating air monitors and the major emissions (residential wood burning, traffic, and industrial areas) that are likely impacting those monitors. Meteorology and topography are considered, as the area is surrounded to the south, east, and northeast by mountains and buttes, and this valley contains the daytime westerly wind currents and nighttime easterly katabatic winds (Figure 10). Lastly, jurisdiction is considered as the proposed boundary does not cross into sovereign tribal nations and is respective to the eastern border of the City of Phoenix.	ADEQ reviewed the boundary recommendation and shape file provided. Based on ADEQ's further analysis involving HYSPLIT modeling and the gridded emissions analysis presented in the recommendation boundary recommendation. ADEQ believes these additional analyses show that there is contribution of PM2.5 from areas beyond the commenter's proposed boundary that are impacting the three violating monitors (Durango Complex, South Phoenix, and West Phoenix). As noted above, ADEQ disagrees with the use of the correlation analysis presented in the comment letter. ADEQ does not find that there is a sufficient basis to rely on studies based on the sensor data, as it is unlikely that EPA will rely on such data in evaluating the state's recommendations. ADEQ agrees that the general wind pattern in Phoenix is daytime westerly winds and night time easterly katabatic winds. However, the nighttime katabatic winds tend to support

		transport of PM2.5 from areas that are not violating to the violating monitors at night, when the PM2.5 levels are at their highest. Therefore, ADEQ disagrees with commenters conclusions of its five-factor analysis.
MCAQD	Commenter's proposed nonattainment area covers 256 square miles, as compared to the 853 square miles of the ADEQ proposed nonattainment area.	ADEQ believes that the commenter's proposed nonattainment area does not adequately address sources that are contributing to the violating monitors due to transport of $PM_{2.5}$ emissions. As described above, since the proposal was provided to the public, ADEQ (working with EPA) has been able to complete HYSPLIT analysis. ADEQ's additional HYSPLIT analysis shows that sources outside of MCAQD's proposed nonattainment area are likely contributing to the violations at the South Phoenix, West Phoenix, and Durango Complex monitors. In comparison, the 2006 $PM_{2.5}$ West Central nonattainment area is 323 square miles, with significantly lower population.
Carolyn Wesolek	Commenter stated, "Please consider moving the $PM_{2.5}$ requirements west in PHX from the current 303 boundary to the white tanks mountains so that the facilities being Built west of the 303 are included."	ADEQ thanks the commenter for their comment. ADEQ has evaluated this comment and based on additional analysis is proposing to expand the western boundary of the recommendation to include the 303. However, as described in Section 3 of this proposed recommendation, ADEQ does not believe that there is sufficient evidence to support the expansion of the boundary to the White Tanks Mountains.

Gmail AirPlanning - AZDEQ <airplanning@azdeq.gov>

Fwd: PM2.5 Comments

1 message

Chelsey Fenton <fenton.chelsey@azdeq.gov> Fri, Jul 19, 2024 at 3:28 PM
To: AirPlanning - AZDEQ <airplanning@azdeq.gov>
Cc: Allison Price <price.allison@azdeq.gov>, Zachary Dorn <dorn.zachary@azdeq.gov>, Elias Toon <toon.elias@azdeq.gov>, Elizabeth Sterner <sterner.elizabeth@azdeq.gov>

PM2.5 Comments from Maricopa County

Chelsey Fenton
Planning and Analysis Manager
Air Quality Improvement Planning Section
Ph: 602-921-3699

azdeq.gov

Your feedback matters to ADEQ. Visit azdeq.gov/feedback

---------- Forwarded message ---------
From: **Kimberly Butler (AQD)** <Kimberly.Butler@maricopa.gov>
Date: Fri, Jul 19, 2024 at 3:16 PM
Subject: PM2.5 Comments
To: mackenzie.kelly@azdeq.gov <mackenzie.kelly@azdeq.gov>, Fenton.chelsey@azdeq.gov <fenton.chelsey@azdeq.gov>, Kelly Poole <poole.kelly@azdeq.gov>
Cc: Hether Krause <krause.hether@azdeq.gov>

Good afternoon Kelly,

Please find attached the comments from MCAQD. Unfortunately, I couldn't find the group email address to send this. Let me know if you have any questions.

Thanks

MARICOPA COUNTY

Kimberly Butler

Planning and Analysis Division Manager

Air Quality

Planning and Analysis

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E: Kimberly.Butler@Maricopa.Gov

[**Maricopa.Gov**]

Facebook | **Instagram** | **Twitter** | **YouTube** | **LinkedIn**

Customer Satisfaction Survey

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3 attachments

PM2.5 Comments.pdf
1781K

PurpleAir PTAQS Study.pdf
2161K

Burn Season Study Results 2019-2020.pdf
16305K

July 19, 2024

Ms. Karen Peters
Chief Executive Officer
Arizona Department of Environmental Quality (ADEQ)
1110 W. Washington St.
Phoenix, AZ 85007

Dear Ms. Peters,

The Maricopa County Air Quality Department (MCAQD) thanks the Arizona Department of Environmental Quality (ADEQ) for presenting the $PM_{2.5}$ Initial Draft Boundary Recommendation for the new $PM_{2.5}$ nonattainment area in Maricopa County. MCAQD appreciates the opportunity to comment on these draft boundaries and the analyses that were used in their development.

We acknowledge and appreciate that the U.S. Environmental Protection Agency (EPA) requires a five-factor analysis to be used in developing the boundary recommendation[1]. However, the spatiotemporal scales of some of the analyzed factors were not focused on the largest $PM_{2.5}$ issues, thus making the draft nonattainment area unnecessarily large. Instead, focusing the boundaries around the violating $PM_{2.5}$ air monitors and excluding areas which contribute little to the problem would be a more effective strategy. With this in mind, MCAQD offers the following comments on the five-factor analysis and resulting draft $PM_{2.5}$ boundaries.

Air Quality Data

This analysis looks at the available regulatory ambient $PM_{2.5}$ air monitoring data, the location of violating monitors, contributions from sources impacting the violating monitor(s), and official annual design values. ADEQ's analysis could be strengthened by focusing on finer temporal scale periods, such as the late fall and early winter months (i.e., the wood burning season), which is normally the only time when monthly $PM_{2.5}$ averages exceed 9 $\mu g/m^3$ (Figure 1). Section 3.1.1 of the ADEQ's Draft Report includes a temporal analysis of $PM_{2.5}$ in Maricopa County; however, focusing these analyses when monthly $PM_{2.5}$ averages exceed 9

[1] EPA Office of Air and Radiation, Initial Area Designations for the 2024 Revised Primary Annual Fine Particle National Ambient Air Quality Standard, February 7, 2024, accessed at https://www.epa.gov/system/files/documents/2024-02/pm-naaqs-designations-memo_2.7.2024-_-jg-signed.pdf.

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μg/m^3 would help show which sources are having the most effect on the violating monitors (e.g., residential vs. industrial/transportation). To illustrate this, Figures 2 and 3 display $PM_{2.5}$ concentrations during the wood burning season on a time-of-week and time-of-day basis, respectively. Note that Figure 3 displays a similar pattern to Figure 7 in the ADEQ Draft Report, but in this instance the data have been restricted to the wood burning season. Figure 3 shows a concentration spike in the morning as traffic and work activity begin and Durango Complex, being in an industrial area, displays the largest morning spike; however, unlike the annual data shown in the Draft Report, the nighttime spikes at the South and West Phoenix sites are higher during the wood burning season. Also note that the nighttime spike at Durango Complex occurs later than those at South and West Phoenix, suggesting that particulate matter is being transported to the area from the neighborhoods surrounding central, south, and west Phoenix. These patterns provide evidence suggesting that residential activity, such as recreational wood burning, are among the dominant sources during this time of year.

Figure 1. Interquartile range of monthly $PM_{2.5}$ averages for the period 2014 - 2023 at the three violating monitors in Maricopa County. Note that the monthly mean only exceeds 9 μg/m^3 for the months November through February (Durango Complex is an exception with a monthly mean of 9.45 μg/m^3 for October).

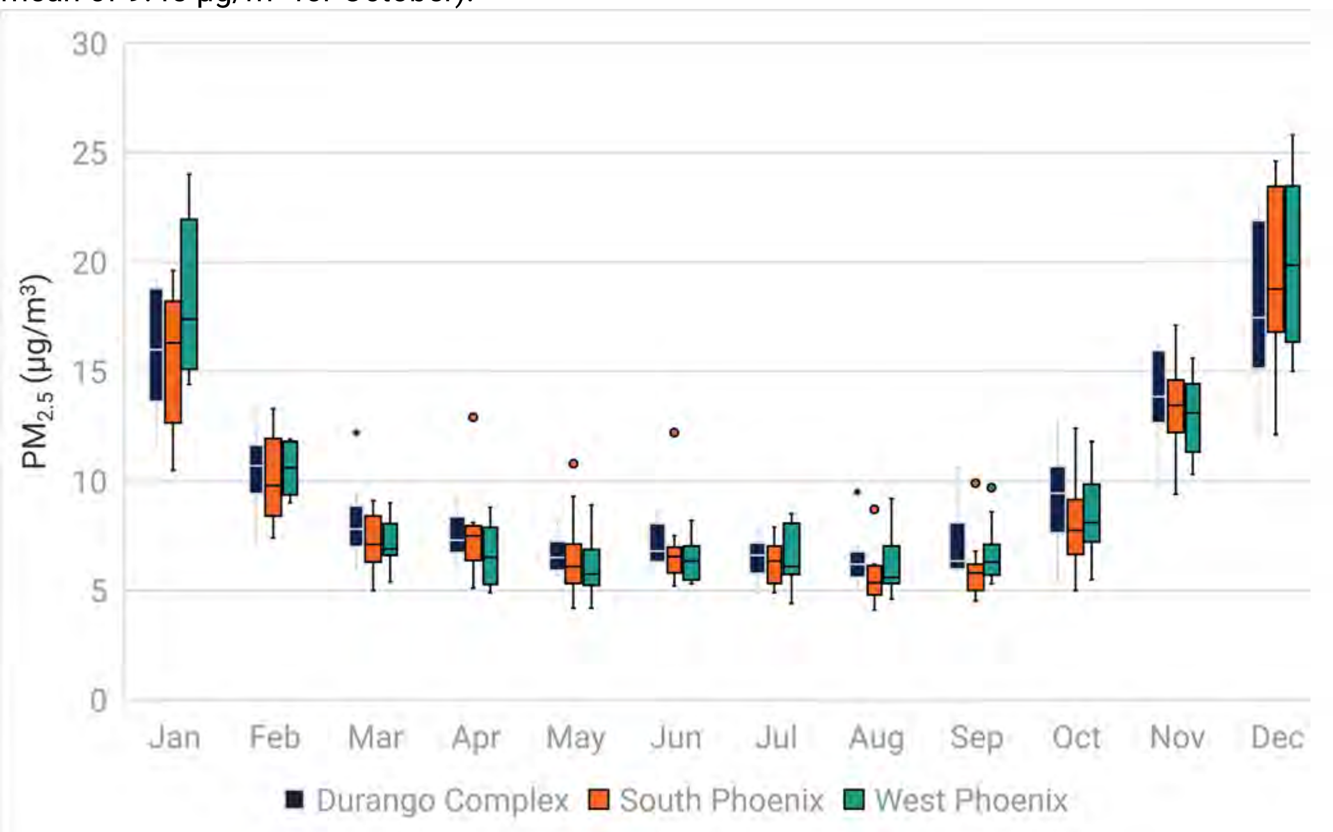


Figure 2. Average $PM_{2.5}$ by day of the week for 2021 - 2023. Only includes the months where the median $PM_{2.5}$ is higher than 9 µg/m^3 at all three sites, i.e., November through February.

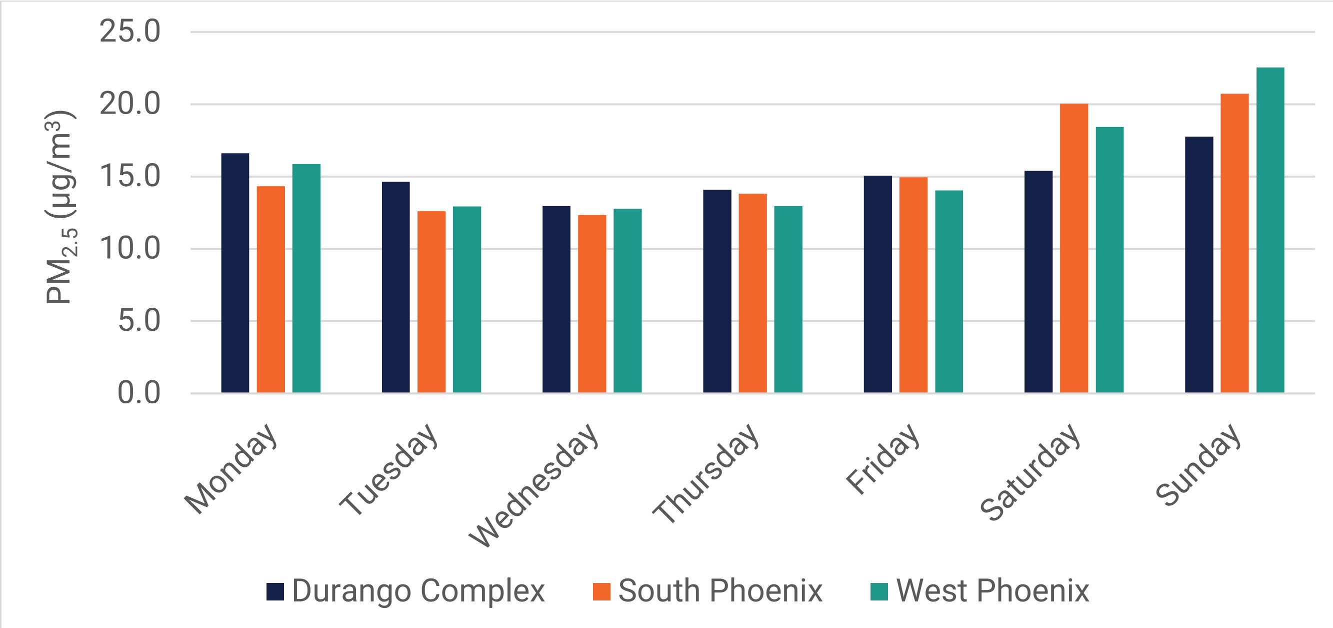
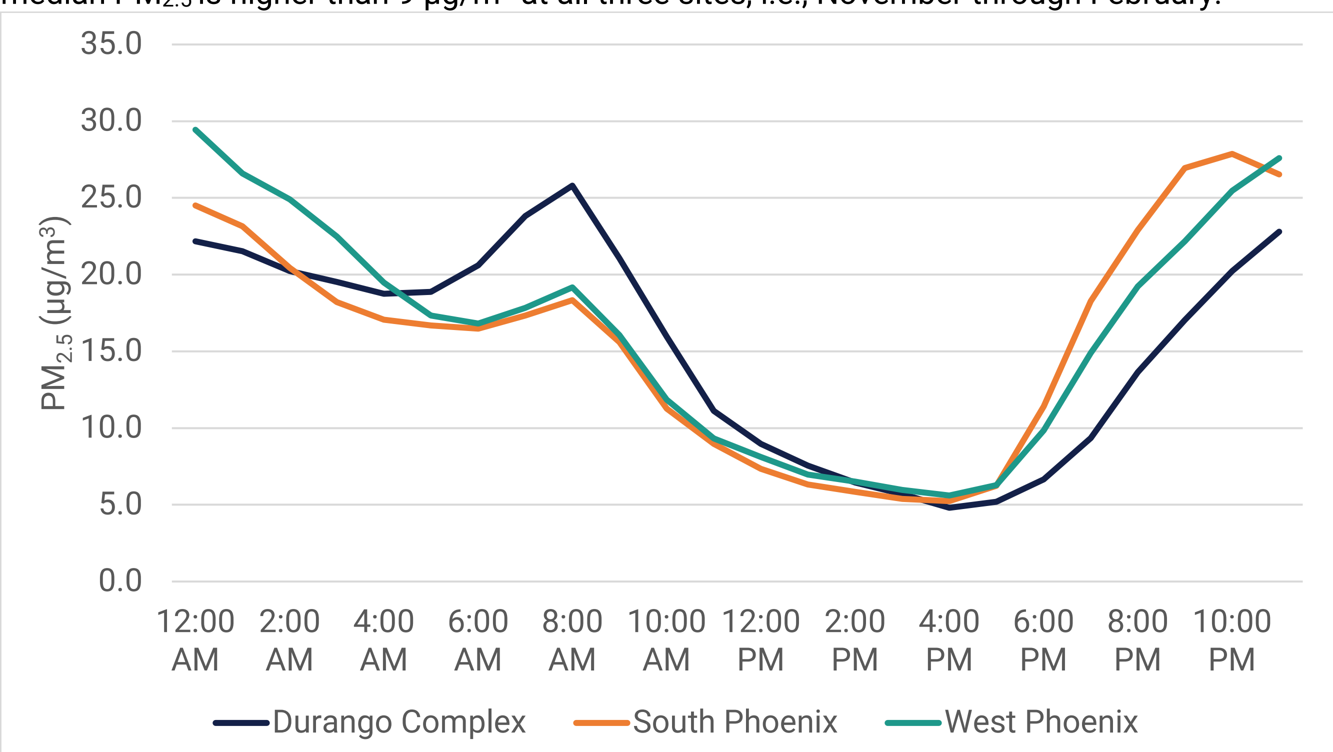
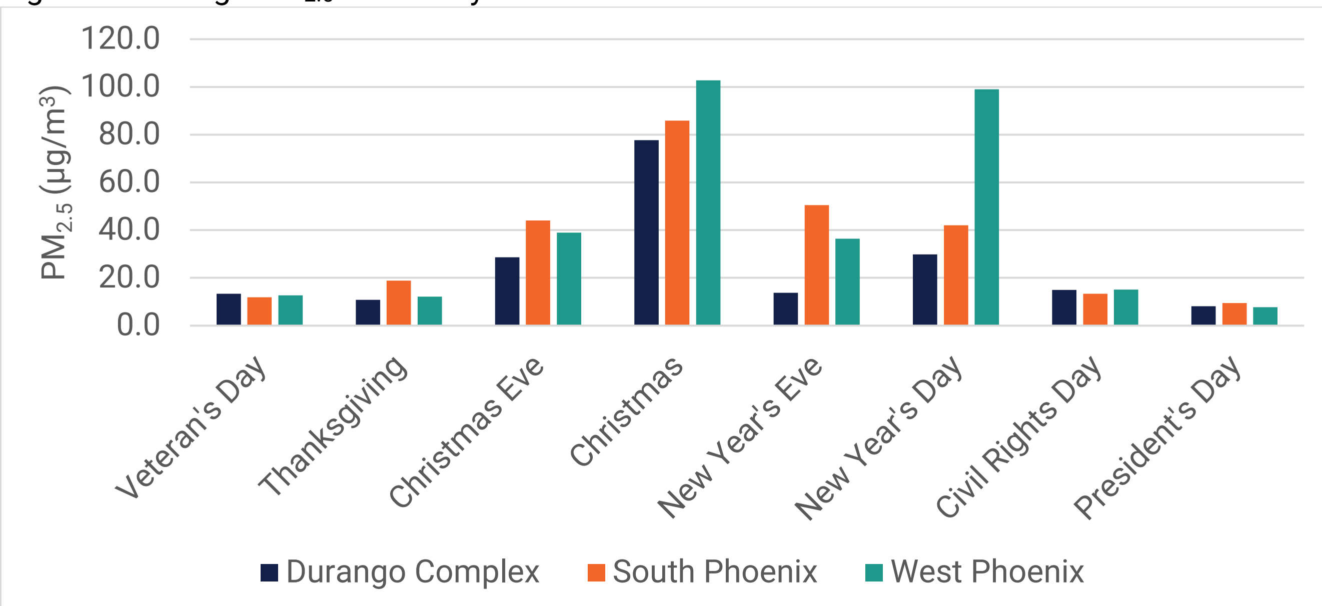


Figure 3. Average $PM_{2.5}$ by Time of Day for 2021 - 2023. Only includes the months where the median $PM_{2.5}$ is higher than 9 µg/m^3 at all three sites, i.e., November through February.



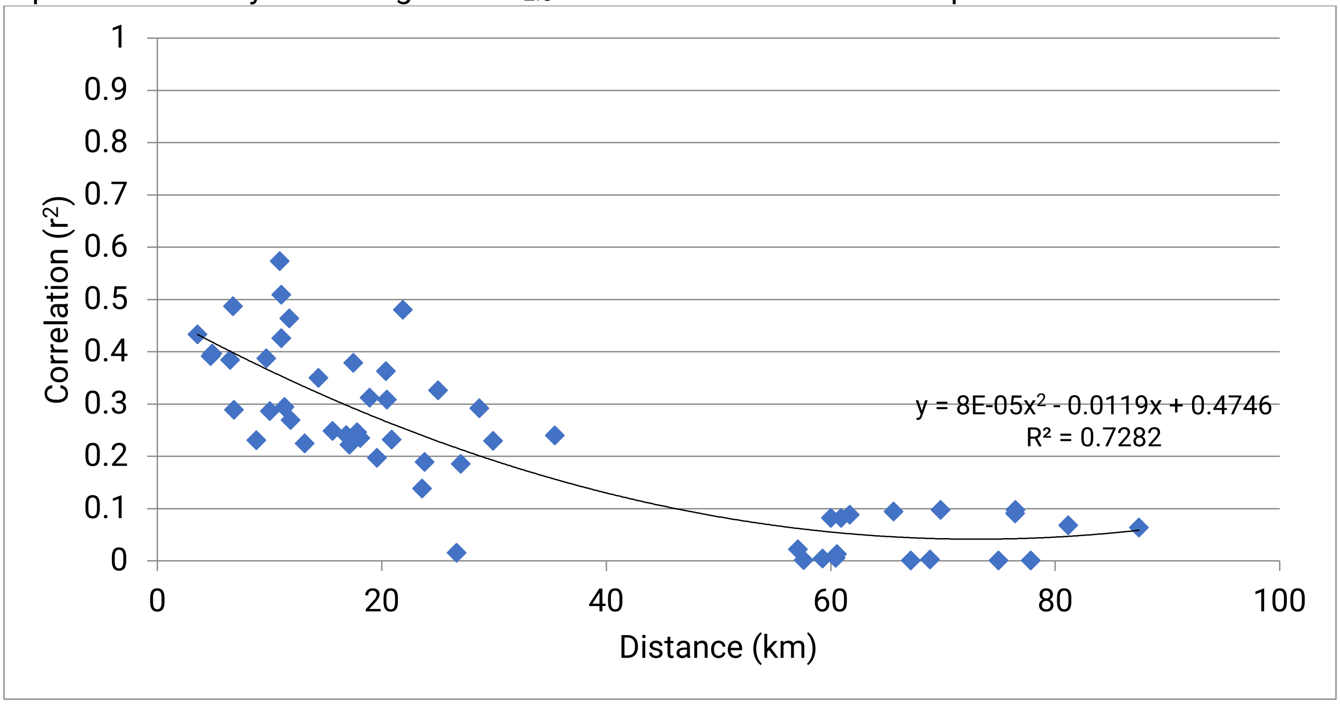
Another example showing the prevalence of residential activity at this time of year is from holiday data, as demonstrated in Figure 4, which shows $PM_{2.5}$ concentrations on holidays during the wood burning season. Since industrial and transportation sources are curtailed during these holidays, it provides strong evidence that residential activity is the source, especially during the Christmas and New Year's Day holidays when seasonal activities such as wood burning and fireworks are so prevalent.

Figure 4. Average $PM_{2.5}$ on holidays in 2021-2023.



Increased spatial resolution would also be a very useful component to this analysis because $PM_{2.5}$ sources generally have a short-range effect on surrounding areas. For example, Figure 5 is a visual display of a correlation matrix, or correlogram, between $PM_{2.5}$ monitoring sites in Maricopa and Pinal Counties. Strong correlation is generally considered to be >0.70, whereas the highest correlation in this dataset is 0.57 and 87% of the air monitoring sites have less than 0.40 correlation. Even if considering Maricopa County alone where the average distance between $PM_{2.5}$ monitoring sites is only 16 km, the average correlation is only 0.31. This provides substantial evidence that the effect of sources on $PM_{2.5}$ air monitors is very localized.

Figure 5. Correlogram of $PM_{2.5}$ air monitors in Maricopa and Pinal Counties. This chart was taken from the Maricopa County Air Monitoring Network Assessment 2015-2019 and represents a five-year average of $PM_{2.5}$ concentrations in that time period.



Over the years, MCAQD has conducted many studies with mobile and/or low-cost $PM_{2.5}$ sensors which can greatly augment data from regulatory $PM_{2.5}$ monitors in showing the extent of problem areas. These various studies include wintertime only studies that were conducted annually between 2013 and 2020, as well as the multi-year Phoenix as a Testbed for Air Quality Sensors (PTAQS) study that was done in conjunction with the EPA. The EPA did not publish the results from PTAQS, other than some internal reports focusing on sensor performance and correction factor creation, but MCAQD did create a presentation for internal use which describes the project[2]. Note that the annual wintertime studies, which included $PM_{2.5}$ chemical speciation, source identification, and pattern analysis, was discontinued in 2020 because results were so consistent from year to year. Since 2020, there have been no significant changes to the type and quantity of sources in the areas where the wintertime studies were conducted.

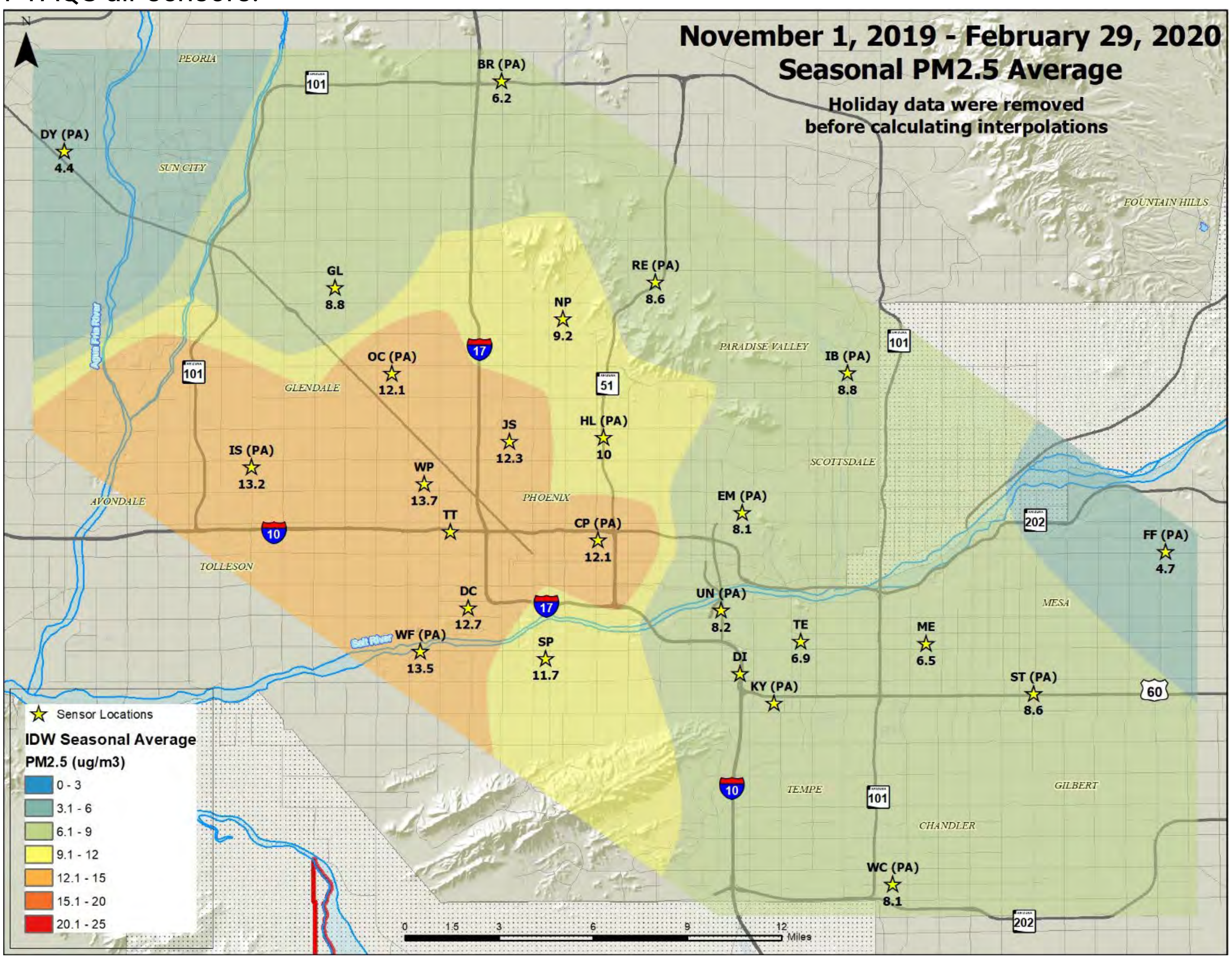
Figure 6 displays a map that was created for one of MCAQD's wintertime studies[3]. This map utilized official $PM_{2.5}$ air monitoring data, as well as data from the air sensors that were part of the EPA's PTAQS project, to create an interpolated surface showing the patterns of $PM_{2.5}$ during the study period. Note that average $PM_{2.5}$ concentrations greater than 9 µg/m³ were generally located in central, southern, and western Phoenix. Numerous spatially explicit

[2] Pope, R. and Domsky, I. 2022. *PurpleAir and the Phoenix Testbed for Air Quality Sensors Project.* Presentation prepared for Maricopa County Air Quality Department.

[3] Maricopa County Air Quality Department. 2021. *Holiday/Burn Season Fine Particulate Matter Study for the 2019-2020 Season.* White paper created for internal review of the project.

surfaces such as these were created for this and other MCAQD annual wintertime studies at a number of scales, such as monthly, weekly, daily, and hourly. These surfaces, along with other data collected such as chemically-speciated $PM_{2.5}$, demonstrate that residential wood burning is a major source during the late fall and early winter. This activity normally starts in the early evening, especially on weekends, in the Phoenix area and light breezes and atmospheric subsidence cause the plumes to drift to the west-southwest overnight. The eastern metropolitan area almost always exhibited much lower concentrations during this and the other wintertime studies.

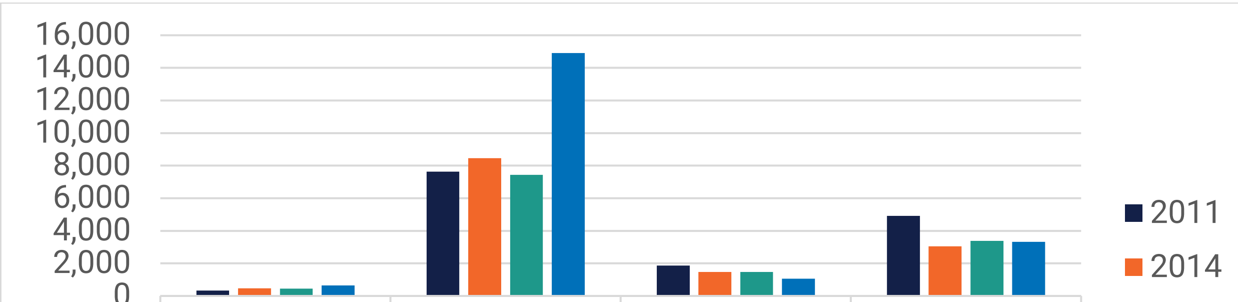
Figure 6. Interpolated $PM_{2.5}$ values that were created for the MCAQD report "Holiday/Burn Season Fine Particulate Matter Study for the 2019-2020 Season". This report focused on data that were collected from November 2019 through February 2020 and included data from the PTAQS air sensors.



Emissions Inventory

The emissions analysis prepared by ADEQ examined annual emissions. At this scale, it is apparent that transportation and point sources are minor contributors to $PM_{2.5}$ concentrations, and that nonpoint sources are more significant contributors (Figure 7).

Figure 7. $PM_{2.5}$ emissions (tons/year) within Maricopa County by source category in 2011, 2014, 2017, and 2020.



	Point	Nonpoint	Nonroad Mobile	Onroad Mobile
2011	337	7,632	1,876	4,912
2014	470	8,460	1,474	3,051
2017	459	7,440	1,481	3,381
2020	649	14,906	1,056	3,313

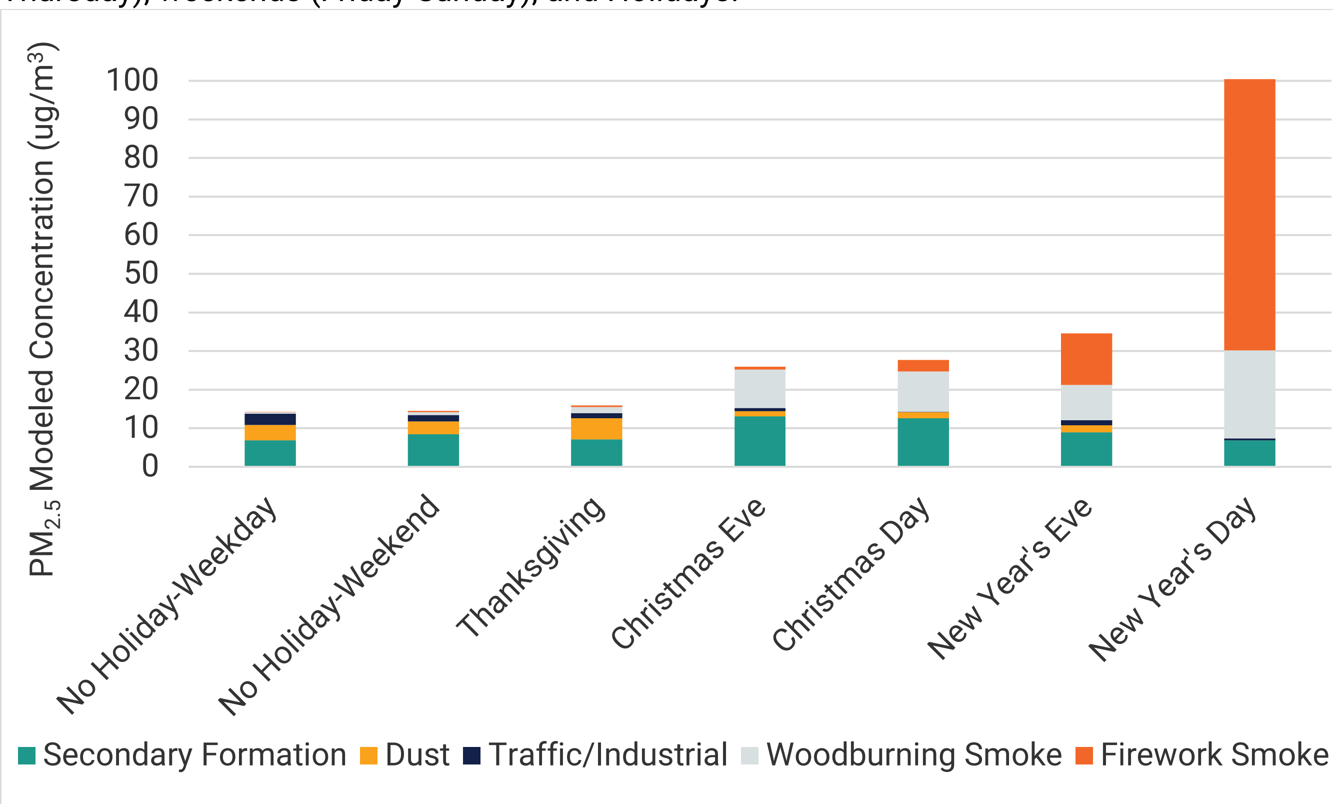
Specifically, the MCAQD 2020 Periodic Emissions Inventory for Particulate Matter shows that $PM_{2.5}$ emissions from airport operations (including ground support equipment, auxiliary power units, and aircraft) were 77.8 tons in 2020, or 0.4% of the total $PM_{2.5}$ emissions in Maricopa County. It is important to note that local estimates of airport $PM_{2.5}$ emissions (77.8 tons in 2020) are significantly lower than EPA estimates of airport emissions (136.6 tons in 2020). Additionally, new modeling may be needed to confirm that $PM_{2.5}$ emissions from small airports, such as Falcon Field and Phoenix Deer Valley, are as high as or higher than emissions from Phoenix Sky Harbor International Airport (Table 7 in the ADEQ Draft Report).

Similarly, emissions from onroad vehicles (including exhaust, tire wear, break wear, but excluding paved and unpaved road fugitive dust) were 636.2 tons in 2020, or 3% of the total $PM_{2.5}$ emissions in Maricopa County.

When adjusting the temporal scale to look at the winter months, residential wood burning (as well as fireworks during the holidays) become important sources. When emissions are temporally allocated by heating degree days, the typical daily $PM_{2.5}$ emissions from residential wood combustion are 10,335 pounds per day, compared with 3,578 pounds of $PM_{2.5}$ per day from all point sources in Maricopa County. Unfortunately, emissions from fireworks are not quantified in the National Emissions Inventory or the Periodic Emissions Inventory due to lack of available data.

While these temporal patterns are not apparent in the national emissions inventory data, they are noted in data from the above mentioned annual wintertime $PM_{2.5}$ studies conducted by MCAQD. A significant portion of these studies included $PM_{2.5}$ speciation and modeling, which demonstrated residential wood burning and fireworks as a source of major impact during the wood burning season and especially during holidays (Figure 8). Note that all of the $PM_{2.5}$ speciation data that were collected in MCAQD's wintertime studies, which took place annually between 2013 and 2020, were modeled with the EPA's Positive Matrix Factorization (PMF) model which allows for source identification and quantification. Most of the $PM_{2.5}$ speciation sampling occurred at the West Phoenix site, but some sampling was also done at the Durango Complex, South Phoenix, and Tempe sites, as well as a temporary site in Laveen.

Figure 8. Speciation modeling results from the West Phoenix air monitoring site, 2014-2020 (November-January only). $PM_{2.5}$ concentrations are averaged by Weekday (Monday-Thursday), weekends (Friday-Sunday), and Holidays.



Focusing too much on point and transportation sources, especially airports, is counter-productive and will result in a boundary area that is too large, which will create unnecessary regulatory burden on industries that are relatively minor sources of $PM_{2.5}$ at the violating monitors. While data regarding the location of residential wood burning is relatively sparse, MCAQD does have the specialized 2013-2020 annual wintertime studies that provide evidence on the location of wood burning sources and how smoke emissions are transported toward the violating monitors. The density of single-family residences and age of residential construction (i.e. older homes) are good proxies for identifying residential wood burning sources, but it is even better when these characteristics are paired with the location of violating air monitors (Figure 9) and meteorological data (Figure 10). Thus, we have evidence that much of the wintertime residential wood burning is taking place in west, south, and midtown Phoenix and the smoke from these emissions is often transported overnight through atmospheric subsidence toward the lower-elevation southwest valley, where it lingers until the morning (Figure 6).

Figure 9. Density and construction year of single-family residences (SFR) in Maricopa County. Note that homes built after 1998 are restricted from having a wood burning fireplace unless it complies with 40 CFR Part 60, Subpart AAA (Maricopa Association of Governments Building Code Amendments and Standards Manual BCAS #2).

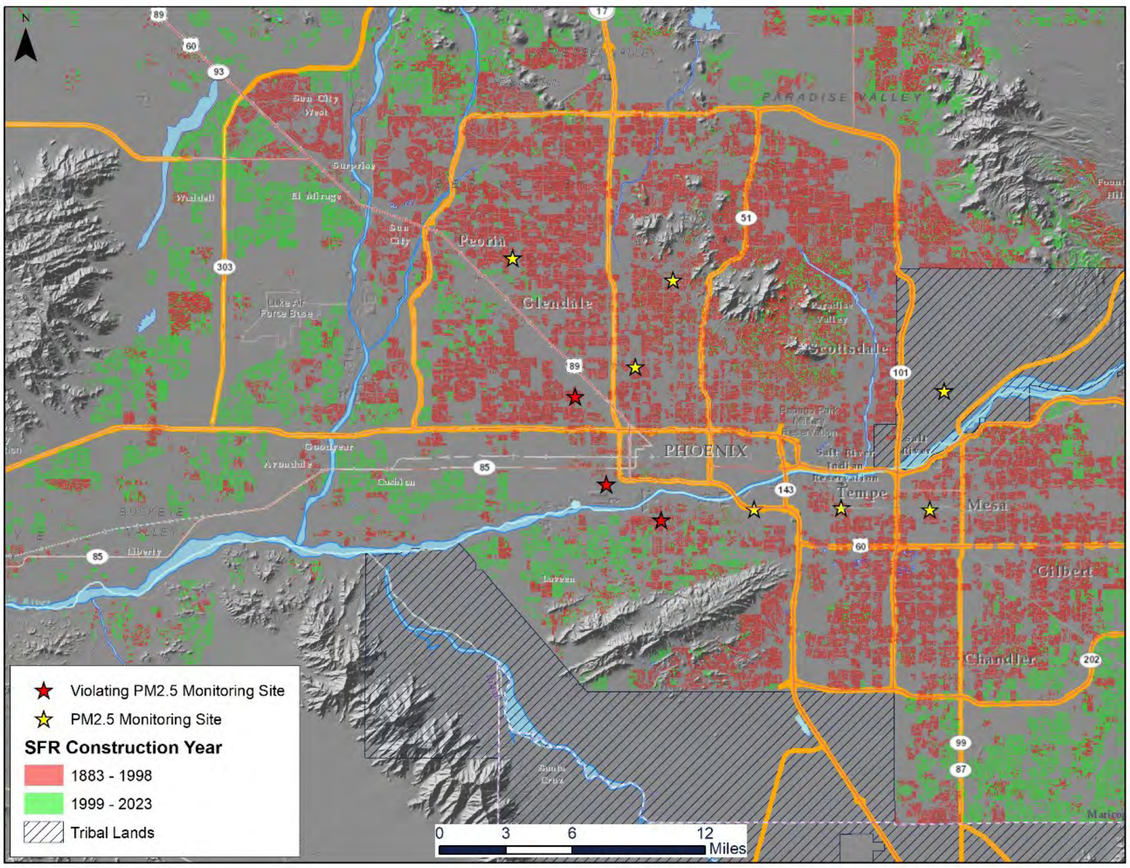
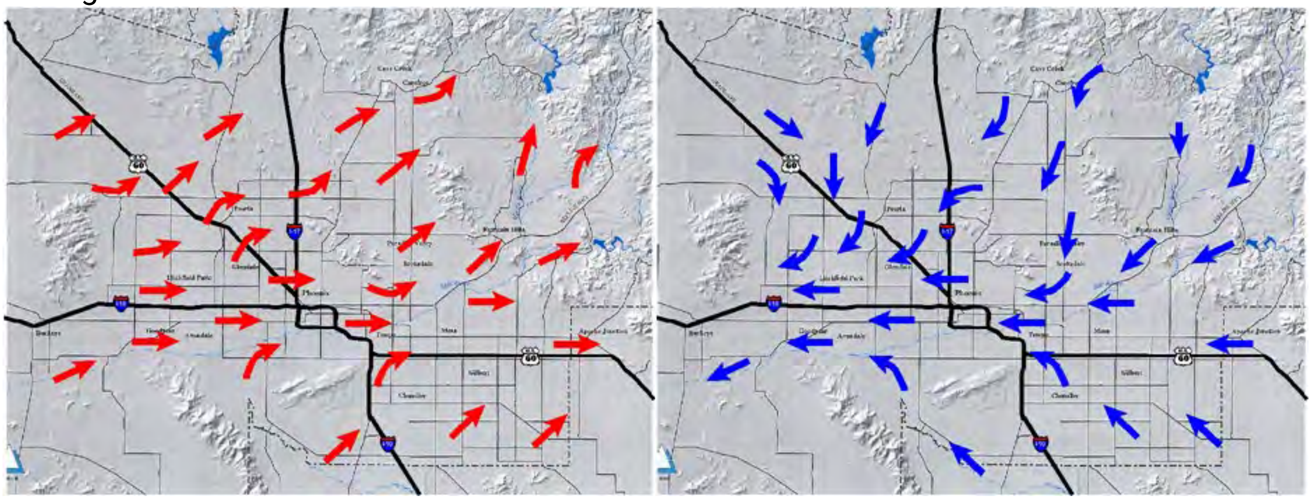


Figure 10. Average diurnal wind direction in Maricopa County. The left figure displays daytime upslope (anabatic) averages, and the right figure displays nighttime downslope (katabatic) averages.



Meteorology

The meteorological analyses, which break down conditions by season and $PM_{2.5}$ conditional probability factors, are well done. Figures 18-26 in the ADEQ draft report, illustrate perfectly that Maricopa County's $PM_{2.5}$ issues are a seasonal wood burning problem due to sources located relatively close to the exceeding monitors. When broken down to an even finer scale of time-of-day, as was done in many of MCAQD's 2013-2020 annual wintertime studies (e.g., Figures 17-20 in MCAQD's Holiday/Burn Season Fine Particulate Matter Study for the 2019-2020 Season), it provides further evidence about the sources and transport of $PM_{2.5}$.

Geography/Topography

MCAQD notes that the draft boundaries tend to follow the structure of the Lower Salt River Airshed that was identified in the Draft Report. However, there are some natural topographical features that would also be important natural boundaries, as is evidenced in our studies, especially the PTAQS study. These natural boundaries include South Mountain, the Tempe and Papago Buttes, Camelback Mountain, Phoenix Mountain Preserves, North Mountain, and Shaw Butte. These natural boundaries surround the area that MCAQD's wintertime studies have identified as contributing to the $PM_{2.5}$ violations, i.e., central, south, and west Phoenix. The PTAQS study, the MCAQD 2013-2020 annual wintertime studies, as well as regulatory $PM_{2.5}$ data from the Eastwood, Tempe, and Mesa air monitoring sites, confirms that areas to the north and east of these natural boundaries are not major contributors to wintertime $PM_{2.5}$ violations.

Jurisdictional Boundaries

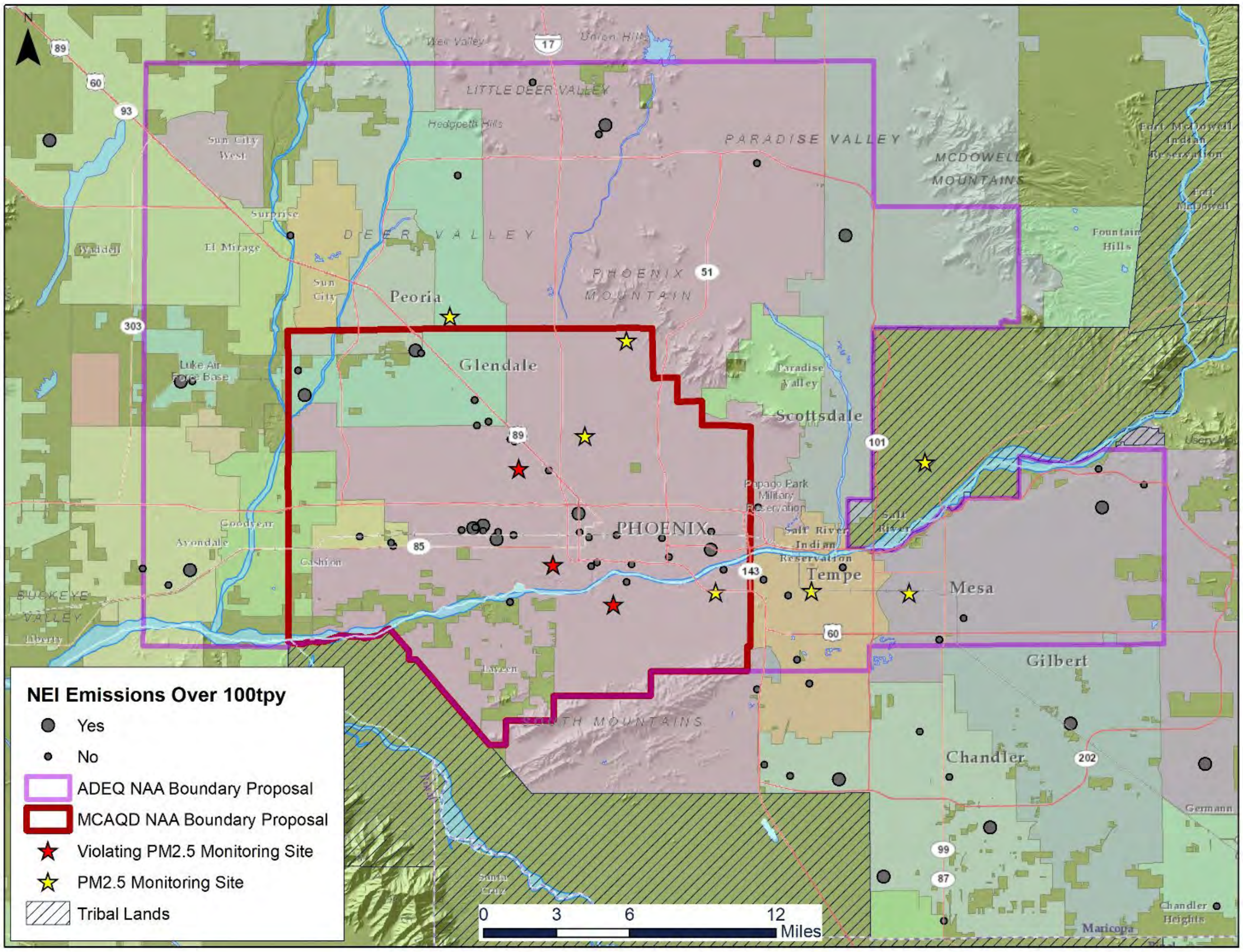
The proposed boundary should not necessarily be along county lines, as that would encompass a larger area than necessary and is not where the sources of $PM_{2.5}$ are located. EPA's guidance provides that where existing jurisdictional boundaries (e.g. county lines, air district boundaries, etc.) are not adequate to describe the nonattainment area, other clearly defined and permanent landmarks or geographic coordinates are recommended to be used[4]. As counties in the West are large and contain areas that are urban, suburban, and rural, nonattainment boundaries are frequently not associated with county lines or air district boundaries, but in correlation to areas where sources are located and geography/topography. This approach has been considered with several prior nonattainment areas in Arizona, including the Maricopa County PM_{10} Nonattainment area and the West Pinal PM_{10} nonattainment area. MCAQD agrees that the draft boundary of the non-attainment area should not cross the borders of Maricopa County or the boundaries of sovereign tribal nations. MCAQD proposes that the appropriate boundary should be along the eastern borders of the City of Phoenix, in conjunction with the previously mentioned topographical borders.

Conclusion

The $PM_{2.5}$ nonattainment area boundary recommendation should be focused on the violating air monitoring sites and the areas impacting those sites, as wintertime studies have shown that residential wood burning in areas of central, south, and west Phoenix, as well as adjacent towns, are a major contributor to violations at the $PM_{2.5}$ monitors. Our annual wintertime studies show that smoke is generated in central, south, and west Phoenix during the wood burning season and generally transported to the lower elevations in the southwest valley. The data indicates that north Phoenix and areas to the east of Phoenix, such as Scottsdale, Tempe, and Mesa, are not major contributors to the violating PM2.5 air monitors. Rather, the topography of the central valley creates appropriate natural boundaries for the south, east, and north sides of the proposed nonattainment area; these natural boundaries include South Mountain, the Tempe and Papago Buttes, Camelback Mountain, Piestewa Peak/Phoenix Mountain Preserves, North Mountain, and Shaw Butte. Figure 11 shows an alternative configuration for the proposed boundaries. This proposal is based upon the EPA's five-factored analysis and includes the violating air monitors and the major emissions (residential wood burning, traffic, and industrial areas) that are likely impacting those monitors. Meteorology and topography are considered, as the area is surrounded to the south, east, and northeast by mountains and buttes, and this valley contains the daytime westerly wind currents and nighttime easterly katabatic winds (Figure 10). Lastly, jurisdiction is considered as the proposed boundary does not cross into sovereign tribal nations and is respective to the eastern border of the City of Phoenix. MCAQD's proposed nonattainment area covers 256 square miles, as compared to the 853 square miles of the ADEQ proposed nonattainment area.

[4] EPA Office of Air and Radiation, Initial Area Designations for the 2024 Revised Primary Annual Fine Particle National Ambient Air Quality Standard, February 7, 2024, p. 11, accessed at https://www.epa.gov/system/files/documents/2024-02/pm-naaqs-designations-memo_2.7.2024-_-jg-signed.pdf.

Figure 11. Map of MCAQD proposed alternative boundaries for the $PM_{2.5}$ nonattainment area. Note that ADEQ's proposed nonattainment boundaries are also displayed on this map for comparison.



You may direct any questions to Kimberly Butler, Manager of the Planning & Analysis Division, at 602-506-6731 or Kimberly.Butler@Maricopa.Gov.

Sincerely,

DocuSigned by:
Philip McNeely
E2594C67E6C0460...

Philip A. McNeely
Director

Cc email: Daniel Czecholinski

Maricopa County Air Quality Department
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Maricopa.gov/AQ
CleanAirMakeMore.com

Holiday/Burn Season Fine Particulate Matter Study for the 2019-2020 Season

SUMMARY

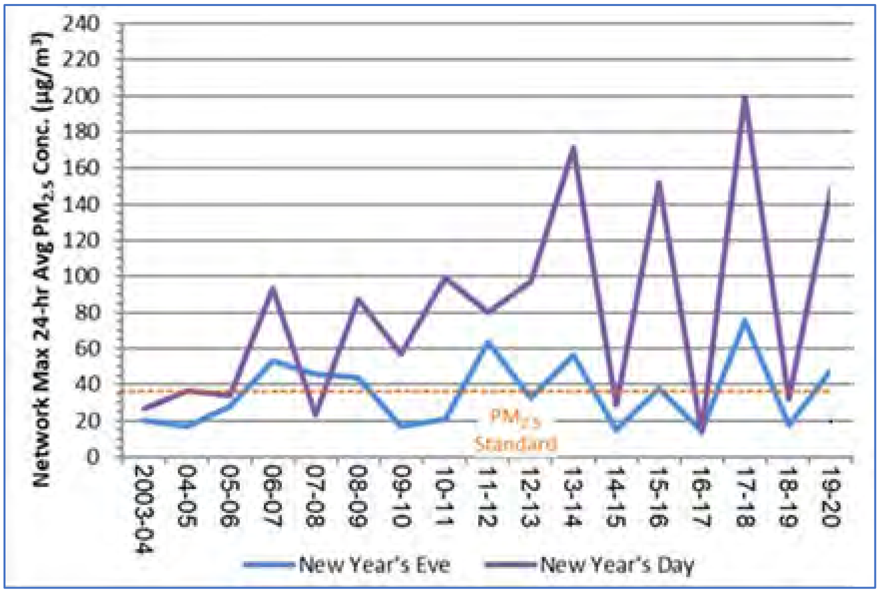
Maricopa County Air Quality Department (MCAQD) conducted its annual study of particulate matter less than 2.5 microns in diameter ($PM_{2.5}$) patterns for the winter burn season of November 2019 through February 2020. The goals of this study were to analyze data coming from the U.S. Environmental Protection Agency's (EPA) network of low-cost sensors to discover $PM_{2.5}$ concentrations in previously unmonitored areas and to have chemical speciation assets in place in case additional evidence was needed to support an exceptional event demonstration. $PM_{2.5}$ data from regulatory monitors at eight MCAQD sites and one Arizona Department of Environmental Quality (ADEQ) site were used for the study. Twenty-three temporary PurpleAir sensors were deployed across the study area, many in areas previously unmonitored for $PM_{2.5}$, as part of the EPA's Phoenix as a Testbed for Air Quality Sensors (PTAQS) study; fifteen of these sensors returned data that were suitable to be used in this analysis. Lastly, chemical speciation data were collected from samplers at MCAQD's West Phoenix site and ADEQ's JLG Supersite.

Results showed that January 2020 had the highest average concentrations of $PM_{2.5}$ during this four-month study, even after removing holidays from the analysis. As has been observed in previous years, it was noted that smoke from wood burning is likely the overall largest source of $PM_{2.5}$. Based upon the pattern of high $PM_{2.5}$ concentrations, much of this burning appears to originate early in the evening in neighborhoods in central and western Phoenix; smoke from these areas then tends to transport down in elevation to the west-southwest areas near the Salt River where it concentrates later in the night. The hot spots of $PM_{2.5}$ during this study concentrated in west Phoenix near the Thirty-third, West Phoenix, Indian School, and West 43rd Avenue monitoring sites, in that order. Data from the chemical speciation samplers clearly showed that the high $PM_{2.5}$ concentrations were coming from smoke from wood burning, and that smoke from fireworks was a significant contribution around the New Year's holiday.

BACKGROUND AND GOALS

Compliance with the National Ambient Air Quality Standards (NAAQS) for $PM_{2.5}$ is at risk because of high daily concentrations of $PM_{2.5}$ during the winter burning season. Recreational wood burning increases during holidays, and wood burning, in general, increases during the winter months. Increases in burning affect the annual average $PM_{2.5}$ concentrations enough that Maricopa County has come close to exceeding the $PM_{2.5}$ annual average NAAQS. One of the most alarming trends is a significant increasing trend in $PM_{2.5}$ during New Year's Day (Figure 1). Since daily monitoring for $PM_{2.5}$ commenced in 2003, the only exceptions to exceedances of the 24-hour average $PM_{2.5}$ NAAQS on Christmas and New Year's days have been when the weather has been rainy and/or windy. Further, the 24-hour NAAQS is frequently exceeded on the eve of those holidays. Maricopa County is currently in attainment with both the 24-hour and annual $PM_{2.5}$ NAAQS, but the risk of violating these NAAQS is very concerning.

Figure 1. Daily averaged $PM_{2.5}$ concentrations for New Year's Eves and Days since 2003 and 2004, respectively.



Furthermore, research conducted by MCAQD, the Maricopa County Department of Public Health and the U.S. Centers for Disease Control[1] shows significant increases in hospital visits after the holiday exceedances, which is consistent with the research that supports the NAAQS. The research clearly shows that $PM_{2.5}$ concentrations above the NAAQS pose a serious risk to public health.

To address these issues, MCAQD has conducted special wintertime $PM_{2.5}$ studies every year since 2013. These studies have used a number of methods to:

- better understand the sources of high pollution during the season;
- quantify $PM_{2.5}$ concentrations in unmonitored locations;
- gauge transport of $PM_{2.5}$ across the metropolitan area;
- quantify the amount of $PM_{2.5}$ coming from fireworks smoke, wood smoke, and other sources;
- provide supporting evidence for exceptional event demonstrations; and
- provide data necessary to support MCAQD's outreach and remediation programs (e.g., the fireplace retrofit and propane firepit programs).

Several different data collection and analysis techniques have been utilized in these studies. This includes collecting $PM_{2.5}$ data from the official MCAQD and ADEQ regulatory monitoring networks; setting up networks of temporary, portable $PM_{2.5}$ monitors in previously unmonitored locations; and using temporary and permanent networks of $PM_{2.5}$ chemical speciation monitors to determine the chemical composition of $PM_{2.5}$ particles. Data analyses techniques include traditional statistical analysis, visibility analysis, and Geographical Information System (GIS) modeling. Chemical speciation data were analyzed with the Positive Matrix Factorization (PMF) model, an EPA-derived mathematical receptor model that allows quantification of $PM_{2.5}$ sources.

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[1] Pope, R., Stanley, K. M., Domsky, I., Yip, F., Nohre, L., & Mirabelli, M. C. (2016). The relationship of high $PM_{2.5}$ days and subsequent asthma-related hospital encounters during the fireplace season in Phoenix, AZ, 2008–2012. *Air Quality, Atmosphere & Health*, 1-9.

The specific goals of the 2019-2020 season study were to:

1. Analyze the data coming from the EPA's PurpleAir network to discover $PM_{2.5}$ average concentrations in previously unmonitored locations and, with the inclusion of data from permanent monitoring sites, obtain a clearer picture of $PM_{2.5}$ spatiotemporal patterns across the metropolitan area. In mid-2019, the EPA, with the assistance of MCAQD, began operating a large network of temporary portable PurpleAir® particulate matter sensors. The EPA's main goal was to evaluate the performance of these sensors, but another benefit is the large spatial coverage of $PM_{2.5}$ that these sensors provide. The EPA has developed a correction formula that enables PurpleAir data to be comparable with MCAQD's permanent $PM_{2.5}$ regulatory network. Including the PurpleAir $PM_{2.5}$ sites created the most spatial coverage area since the wintertime analyses began.

2. Provide supporting evidence in the case an exceptional events demonstration needs to be submitted for a NAAQS exceedance caused by a qualifying event. This is especially important during the New Year's holiday when fireworks smoke can reach concentrations high enough to exceed PM_{10} NAAQS (the 24-hour PM_{10} NAAQS are 150 $\mu g/m^3$). To support this goal, data were collected from a temporary $PM_{2.5}$ chemical speciation monitor deployed by MCAQD and the permanent Phoenix speciation monitor operated by ADEQ. Data from these speciation monitors were also analyzed and compared with previous years to determine if there have been any significant changes in source contributions.

STUDY DESIGN

Study Area and Period

The region analyzed in this study was about a 690 square mile portion of the Phoenix metropolitan area. Study boundaries ranged east-west from Dysart Avenue in the town of Surprise to Higley Road in east Mesa and north-south from Beardsley Road in north Phoenix to Frye Road in Chandler. Municipalities included Phoenix, Glendale, Peoria, Surprise, Scottsdale, Paradise Valley, Tempe, Chandler, Gilbert, and Mesa.

The burn season defined in this study was from November 2019 until February 2020, and regulatory monitors and PurpleAir temporary sensors were operating continuously throughout this period. $PM_{2.5}$ chemical speciation was conducted from November 23, 2019 until January 16, 2020.

$PM_{2.5}$ Regulatory Sites

MCAQD operates eight permanent regulatory $PM_{2.5}$ monitoring sites in the Phoenix metro area and these are the primary source of quality assured $PM_{2.5}$ data for this study. However, during the study period the near-road site, Diablo, was permanently shut down due to road widening construction. The Diablo $PM_{2.5}$ monitor was temporarily moved to the Thirty-third near-road site. When road construction is finished, the monitor at Thirty-third will be moved to a new near-road site that is close to the previous Diablo location.

In addition, $PM_{2.5}$ data were collected from the one permanent regulatory monitor in central Phoenix operated by ADEQ; these data are similarly quality assured. See Table 1 and Figure 2 for details of sites with a regulatory $PM_{2.5}$ monitor.

Table 1. Air monitoring sites with a regulatory $PM_{2.5}$ monitor operating.

Site Name	Code	AQS Code	Operating Agency	Location
Diablo	DI	04-013-4019	MCAQD	I-10 & US-60 Interchange, Tempe
Durango Complex	DC	04-013-9812	MCAQD	27th Ave & Durango St, Phoenix
Glendale	GL	04-013-2001	MCAQD	59th Ave & Olive Ave, Glendale
JLG Supersite	JS	04-013-9997	ADEQ	17th Ave & Campbell Ave, Phoenix
Mesa	ME	04-013-1003	MCAQD	Dobson Rd & Broadway Rd, Mesa
North Phoenix	NP	04-013-1004	MCAQD	7th St & Butler Dr, Phoenix
South Phoenix	SP	04-013-4003	MCAQD	Central Ave & Broadway Rd, Phoenix
Tempe	TE	04-013-4005	MCAQD	College Ave & Apache Blvd, Tempe
Thirty-third	TT	04-013-4020	MCAQD	I-10 & 33rd Avenue, Phoenix
West Phoenix	WP	04-013-0019	MCAQD	39th Ave & Earll Dr, Phoenix

$PM_{2.5}$ PurpleAir Temporary Sites

The EPA began operating a large network of low-cost $PM_{2.5}$ sensors as part of their PTAQS study. The first phase of PTAQS involved deploying temporary low-cost and portable $PM_{2.5}$ air sensors manufactured by PurpleAir at existing MCAQD $PM_{2.5}$ sites beginning in November 2018. The number of sensors were limited in this first phase, as the purpose was to assess the sensor's data quality as compared to a collocated regulatory $PM_{2.5}$ sensor, as well as test sensor durability and reliability in a hot, arid environment. The next phase of the study began in October 2019 and involved deploying 23 PurpleAir sensors in the Phoenix metropolitan area. Some of these sites are existing MCAQD regulatory sites that lack a $PM_{2.5}$ monitor, while others are temporary sites where monitoring was not being conducted. There were also PurpleAir sensors collocated with existing MCAQD regulatory $PM_{2.5}$ monitors to continue the comparisons. Of the 23 sensors originally deployed, 15 provided data that were suitable to use in this study. The other sensors were either at collocated sites, in which case the regulatory monitor data were used, or had malfunctions that created an unacceptable data return. Table 2 and Figure 2 lists these 15 sites.

Table 2. Sites with a PurpleAir $PM_{2.5}$ sensor operating.

Site Name	Code	Location
Beardsley	BR	Loop 101 & 19th Ave, Phoenix
Central Phoenix	CP	16th St & Roosevelt St, Phoenix
Dysart	DY	Dysart Rd & Bell Rd, Surprise
Emergency Management	EM	52nd St & McDowell Rd, Phoenix
Falcon Field	FF	Greenfield Rd & McKellips Rd, Mesa
Highland	HL	SR-51 & Highland Ave, Phoenix
Indian Bend	IB	Hayden Rd & Indian Bend Rd, Scottsdale
Indian School	IS	83rd Ave & Indian School Rd, Phoenix
Kyrene	KY	Kyrene Rd & Baseline Rd, Tempe

Ocotillo	OC	47th Ave & Glendale Ave, Glendale
Residence 1	RE	32nd St & Shea Blvd, Phoenix
Stapley	ST	Stapley Dr & US-60, Mesa
University	UN	SR-143 & University Ave, Tempe
West 43rd Ave	WF	43rd Ave & Broadway Rd, Phoenix
West Chandler	WC	Ellis St & Frye Rd, Chandler

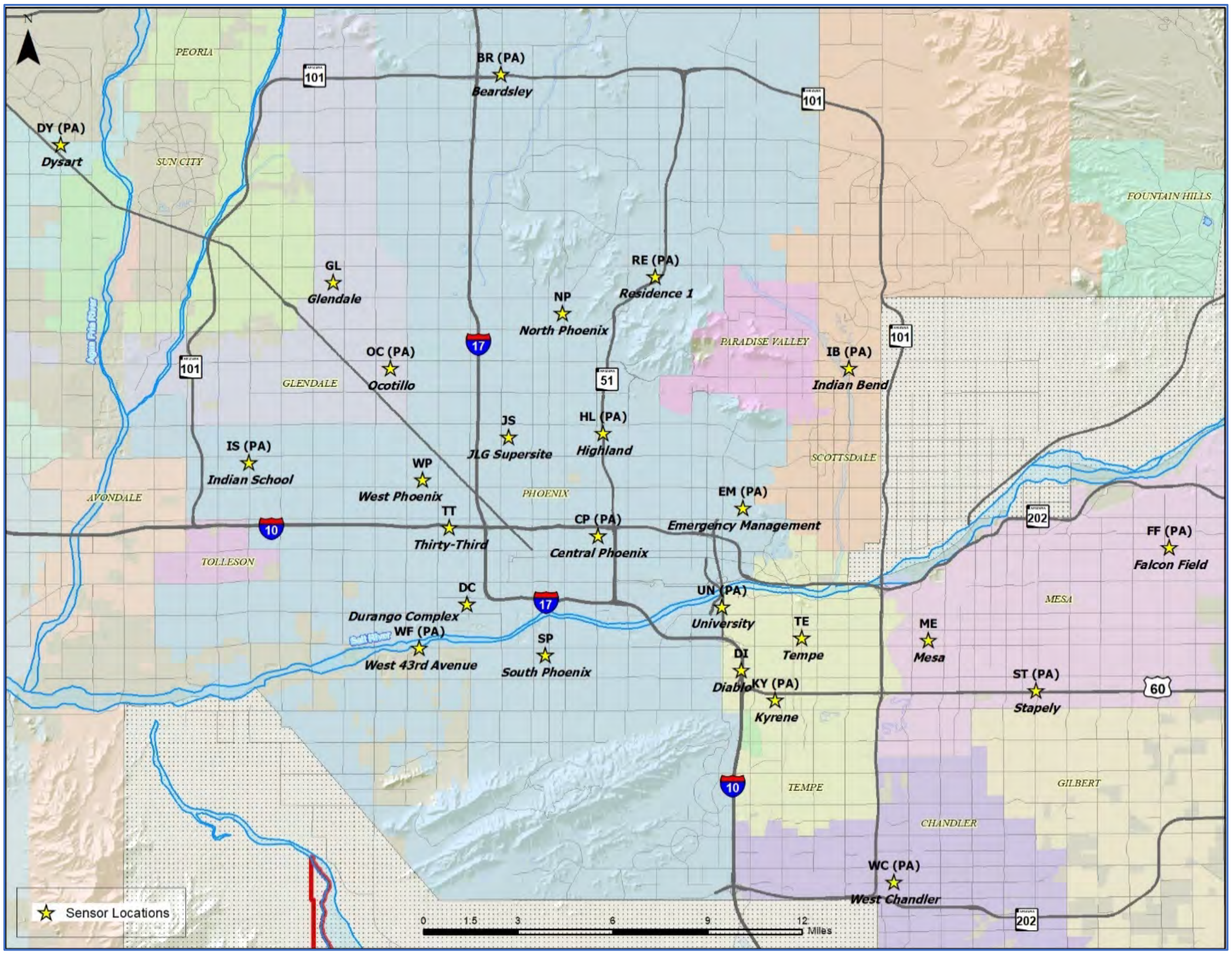
$PM_{2.5}$ Data Recovery Issues

Data were not available for all sites for the entire study period. If a $PM_{2.5}$ monitor or sensor did not return >70% data completeness, data from that device were excluded from the analyses for that specific time period. Issues that caused data to be excluded include the site not being operational, monitor or sensor malfunctions, or data identified as poor quality during quality assurance checks. Table 3 lists the major data exclusions for this study.

Table 3. Data were excluded from these analyses due to unacceptable data recovery.

Site Name	Data Excluded for these time-period Analyses
Diablo	Seasonal, January, February
JLG Supersite	December, Christmas Eve & Day, New Year's Eve & Day
Kyrene	Seasonal, January, February
Thirty-third	Seasonal, November, December, Thanksgiving, Christmas Day
University	December, Thanksgiving, Christmas Eve & Day, New Year's Eve & Day

Figure 2. Locations of $PM_{2.5}$ sensors in the wintertime study. Sites that are operating a temporary PurpleAir $PM_{2.5}$ sensor as part of the EPA's PTAQS study are labeled (PA).



$PM_{2.5}$ Chemical Speciation

The collection of $PM_{2.5}$ chemical speciation data by MCAQD was limited to the West Phoenix site since the purpose was to have corroborative evidence to support an exceptional event petition in the case of a PM_{10} or $PM_{2.5}$ exceedance; this is unlike previous years where more extensive sampling was conducted in an effort to better characterize the sources of $PM_{2.5}$. MCAQD operated the speciation sampler at the West Phoenix site from November 23, 2019 until January 16, 2020, collecting 14 samples. $PM_{2.5}$ speciation data were also collected at the ADEQ's JLG Supersite, though no special arrangements were made to collect holiday samples outside of the normal 1-in-3 day sample schedule. Table 4 displays the dates that samples were collected at West Phoenix and JLG Supersite.

Due to the relatively few speciation samples that were collected in this study, PMF modeling was not conducted on the 2019-2020 study alone. However, speciation sampling has been conducted at the West Phoenix site every winter season since 2014, so data from the 2019-2020 study were aggregated together with those from the previous seasons to create a modeling database from 2014-2020. This multi-year dataset is helpful in revealing recurrent patterns and sources in wintertime $PM_{2.5}$ concentrations.

Table 4. Schedule of $PM_{2.5}$ sample days in 2019-2020 for the West Phoenix (WP) and JLG Supersite (JLG) speciation samplers.

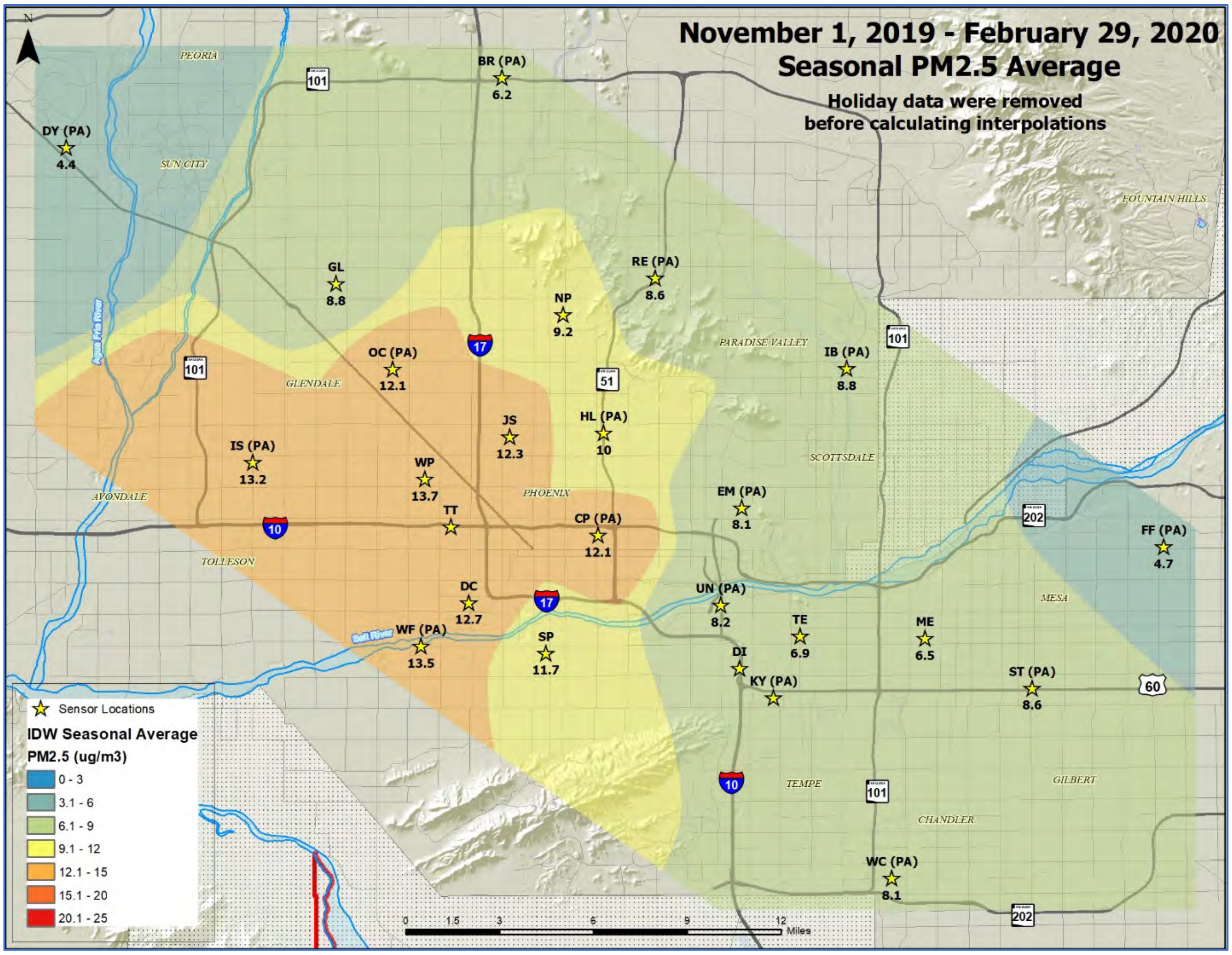
Site	Saturday, November 23	Tuesday, November 26	Thursday, November 28	Friday, November 29	Monday, December 2	Thursday, December 5	Sunday, December 8	Wednesday, December 11	Saturday, December 14	Tuesday, December 17	Friday, December 20	Monday, December 23	Tuesday, December 24	Wednesday, December 25	Thursday, December 26	Sunday, December 29	Tuesday, December 31	Wednesday, January 1	Saturday, January 4	Tuesday, January 7	Friday, January 10	Monday, January 13	Thursday, January 16
WP	x		x	x		x		x		x			x	x		x	x	x	x		x		x
JLG	x	x		x	x	x	x	x	x	x	x	x			x	x		x	x	x	x	x	x

RESULTS

$PM_{2.5}$ Overall Seasonal Patterns

$PM_{2.5}$ seasonal values from all temporary sensors and regulatory monitors were averaged across the burn season. These average concentrations were then analyzed within ArcGIS using inverse distance weighted (IDW) interpolation to determine patterns of $PM_{2.5}$ (Figure 3). Holidays (Thanksgiving, Christmas, and New Year's) had much higher averages than other days during the study, so data from these days were removed as outliers prior to conducting any analyses. The average $PM_{2.5}$ concentration for all monitors and sensors during the season was 9.6 $\mu g/m^3$. Results showed that the portion of study area located south of Glendale Avenue and west of Central Avenue, and a small area surrounding the Central Phoenix monitor had higher concentrations of $PM_{2.5}$. The average $PM_{2.5}$ concentrations for monitors in this area was 12.8 $\mu g/m^3$, as compared to average of 8.3 $\mu g/m^3$ for monitors outside of that area. The areas around West Phoenix and West 43rd Avenue were the hotspots of the study with these sites having an average concentration of 13.6 $\mu g/m^3$ (Figure 3).

Figure 3. $PM_{2.5}$ average concentrations (November 2019 – February 2020) with holiday data excluded.



Monthly $PM_{2.5}$ Pattern Analysis

Analyses showed that January had the highest average $PM_{2.5}$ concentrations across the study period, even after eliminating data from holidays that occurred during for the study (Figure 4). The Thirty-third site averaged the highest concentrations in January and February, but the monitor was not yet operational in November and December (Figure 5). Spatial patterns during the three months were consistent with the overall seasonal patterns (Figures 6-9).

Figure 4. Average PM2.5 (µg/m³) concentrations by month between 11/1/19 and 2/29/20 across the study area. Values are depicted both including and excluding holidays.

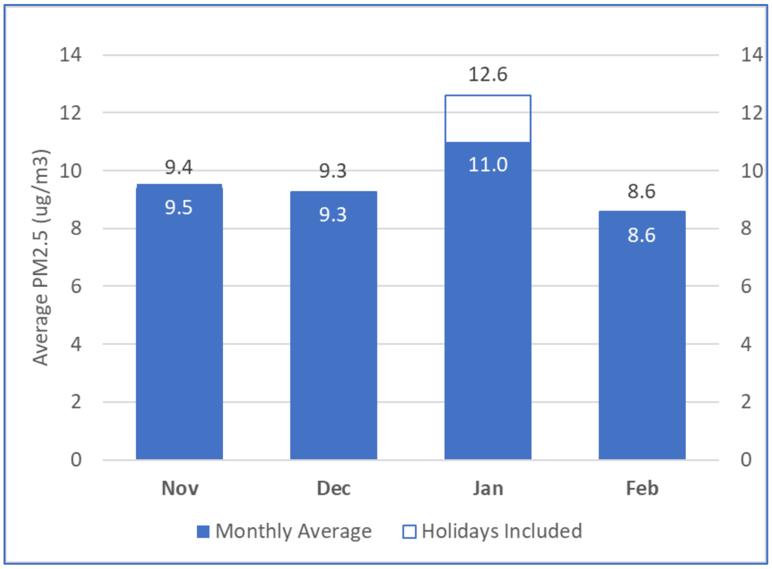


Figure 5. Average PM2.5 (µg/m³) concentration by month and sites between 11/1/19 and 2/29/20.

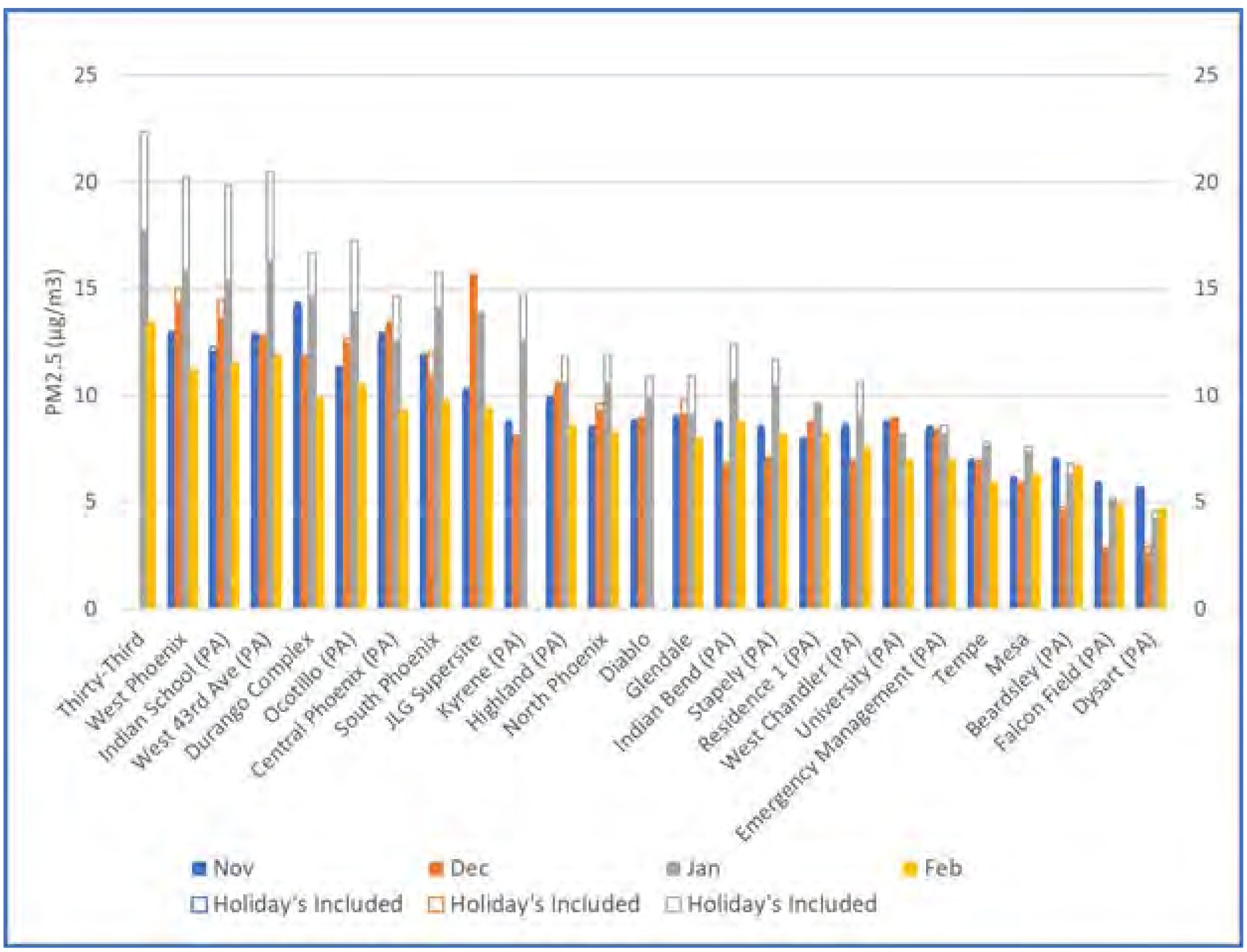


Figure 6. Spatial $PM_{2.5}$ patterns across the study area for November 2019. Holidays were removed from the dataset before conducting IDW interpolations.

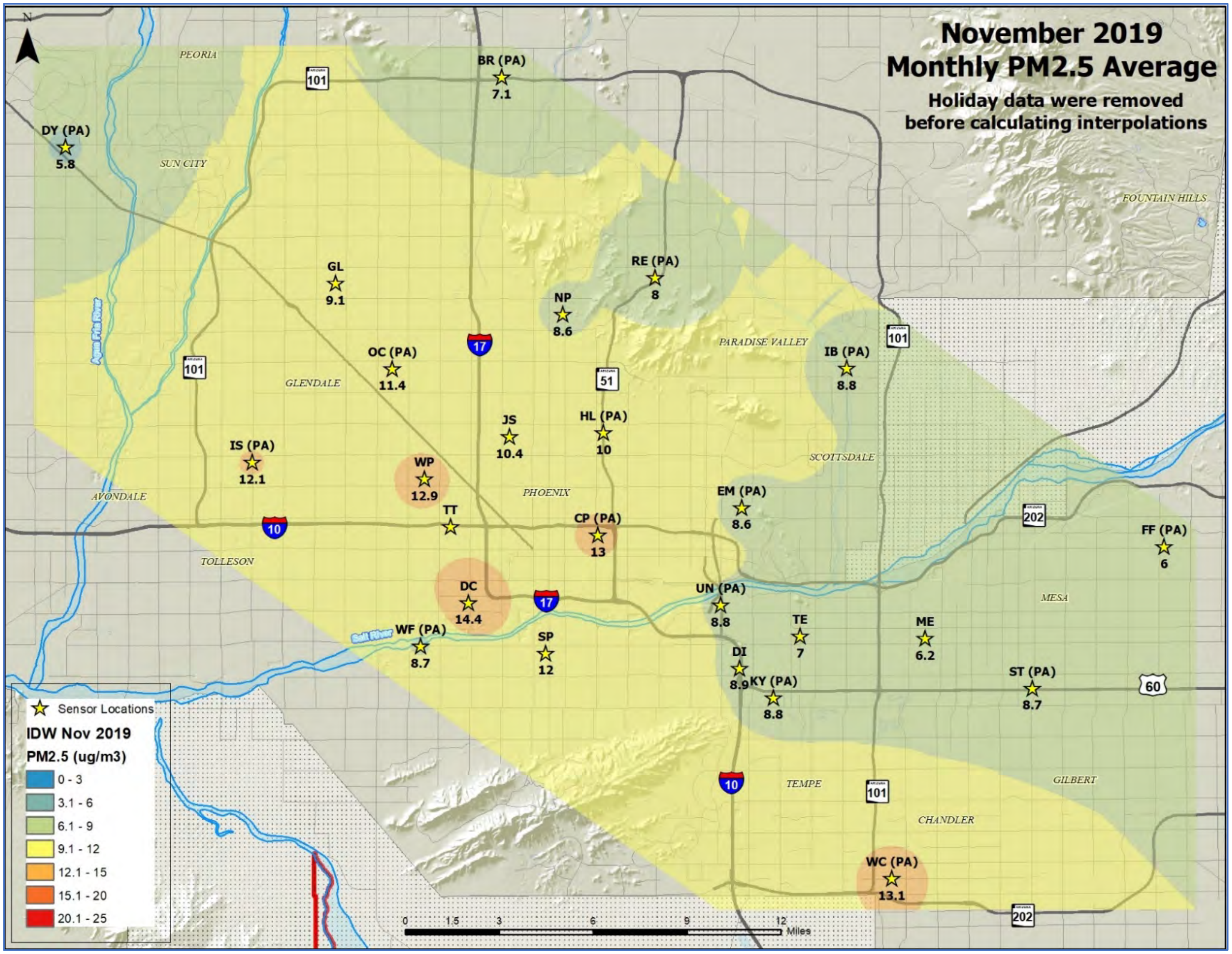


Figure 7. Spatial $PM_{2.5}$ patterns across the study area for December 2019. Holidays were removed from the dataset before conducting IDW interpolations.

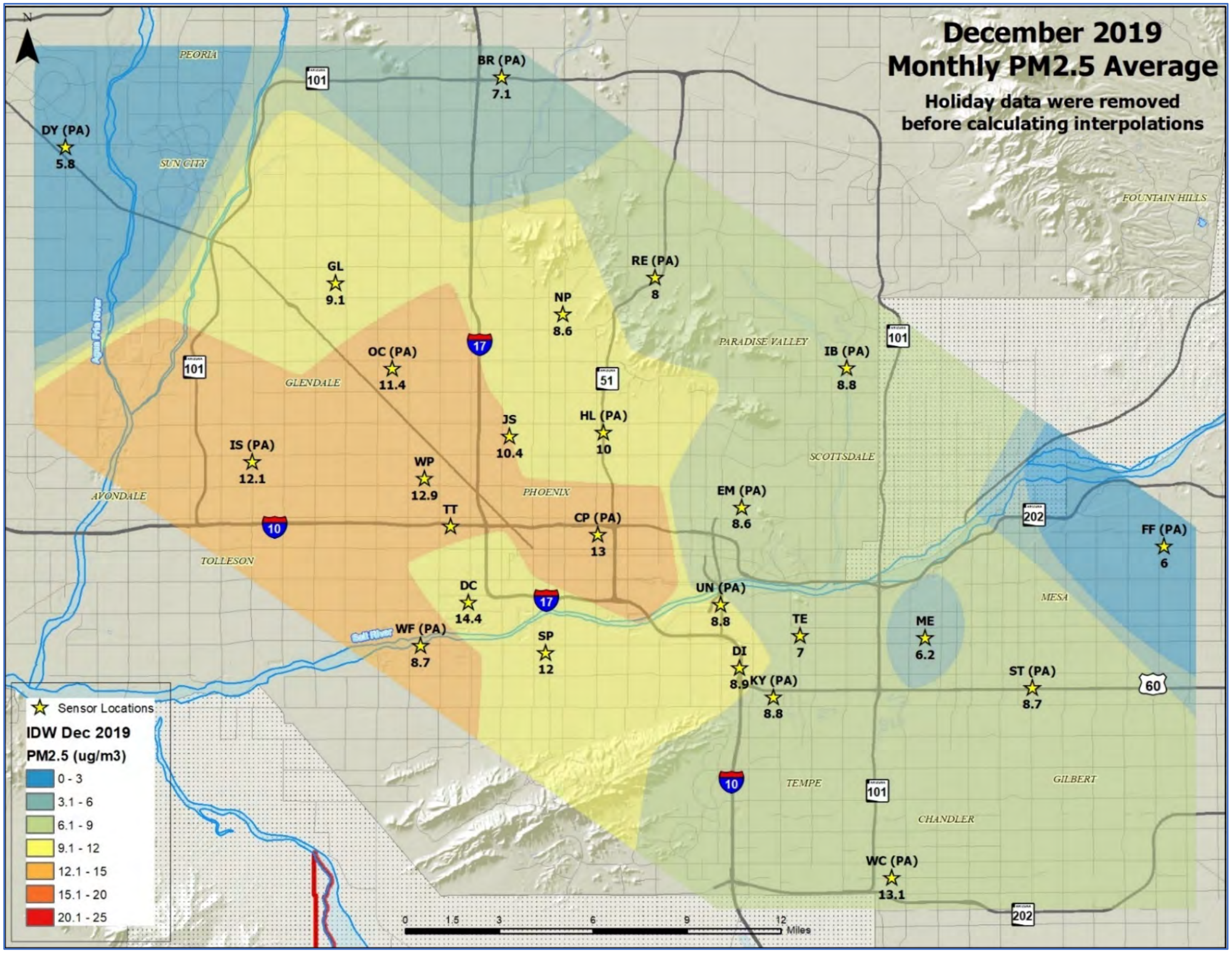


Figure 8. Spatial $PM_{2.5}$ patterns across the study area for January 2020. Holidays were removed from the dataset before conducting IDW interpolations.

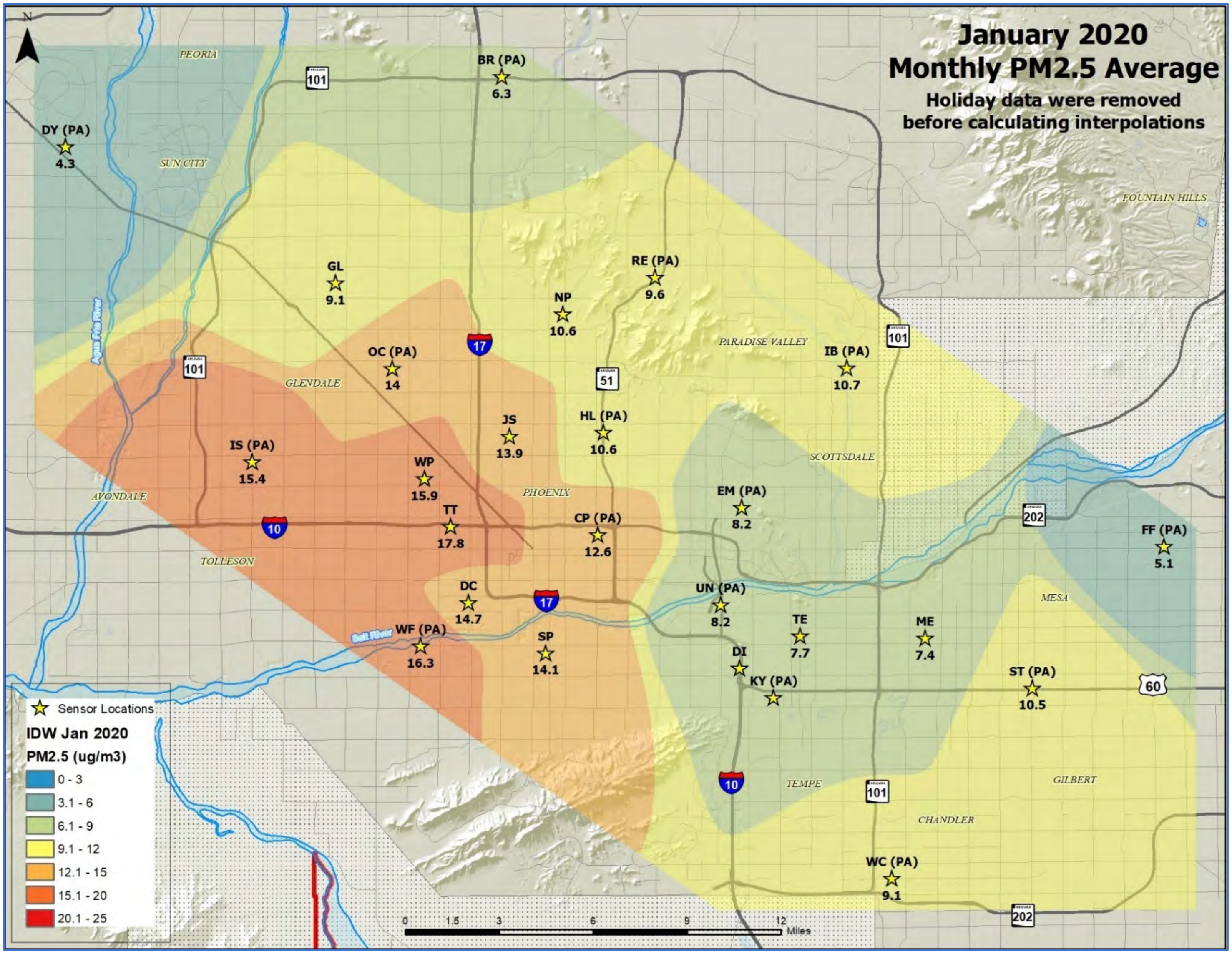
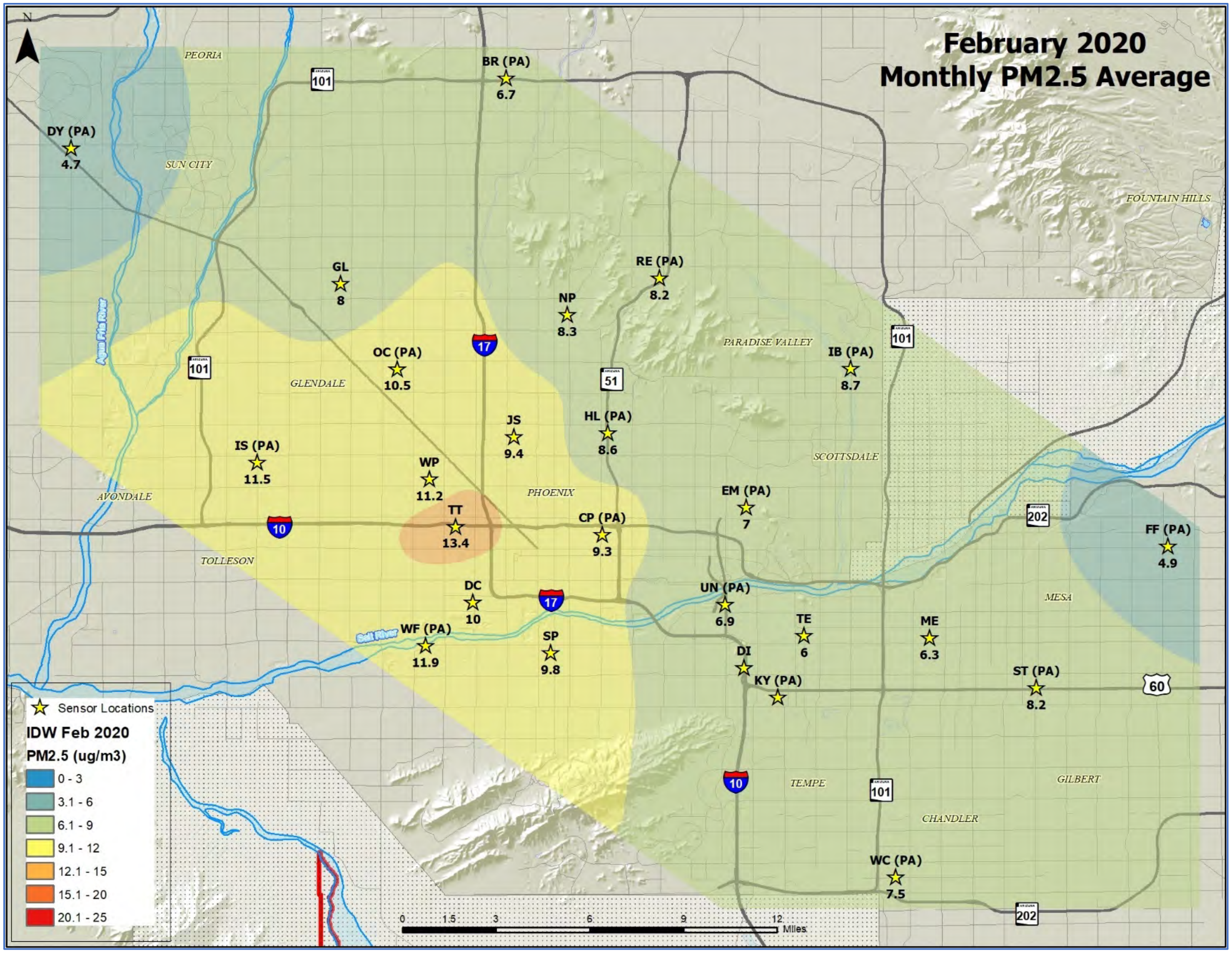


Figure 9. Spatial $PM_{2.5}$ patterns across the study area for February 2020.



Day of the Week Analysis

$PM_{2.5}$ values across the study area were analyzed for spatial and temporal patterns. $PM_{2.5}$ values were on average higher during weekends (Friday - Sunday) vs. weekdays (Monday - Thursday) (Figure 10). These weekend patterns provide strong evidence that the largest source of this $PM_{2.5}$ is recreational wood burning since that is known to occur at much higher frequencies on the weekends.

The spatial patterns showed that $PM_{2.5}$ tended to be focused on southwest Phoenix on both weekdays and weekends, but the higher concentrations extended farther west in the study area on weekends (Figures 11-14). Holidays had much higher concentrations than other days of the month, so the spatial analyses were conducted after removing holidays from the dataset.

Figure 10. $PM_{2.5}$ averaged by month and day of the week for November 2019 (A), December 2019 (B), January 2020 (C), and February 2020 (D). Where appropriate, values are depicted both including and excluding holiday outliers.

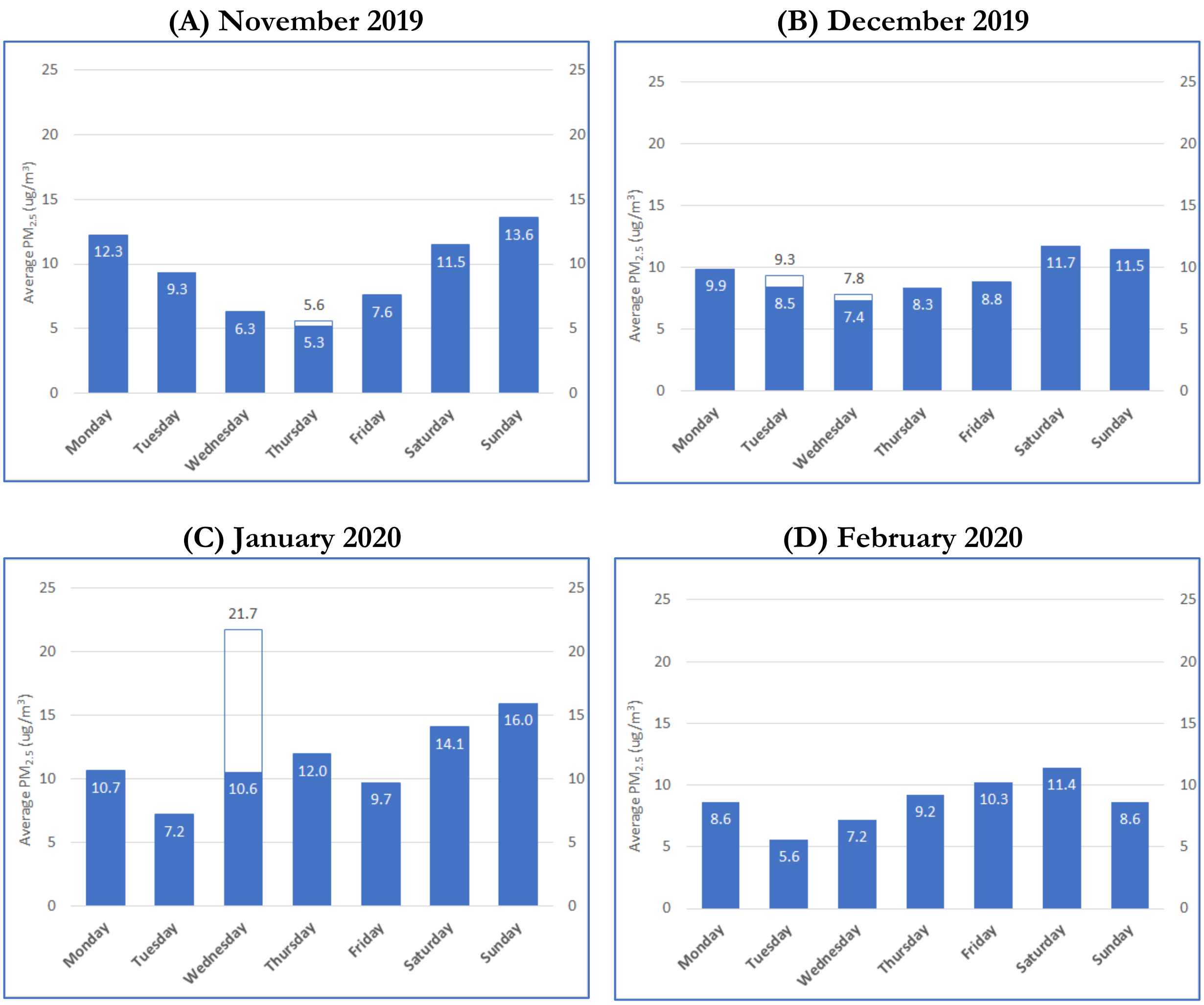
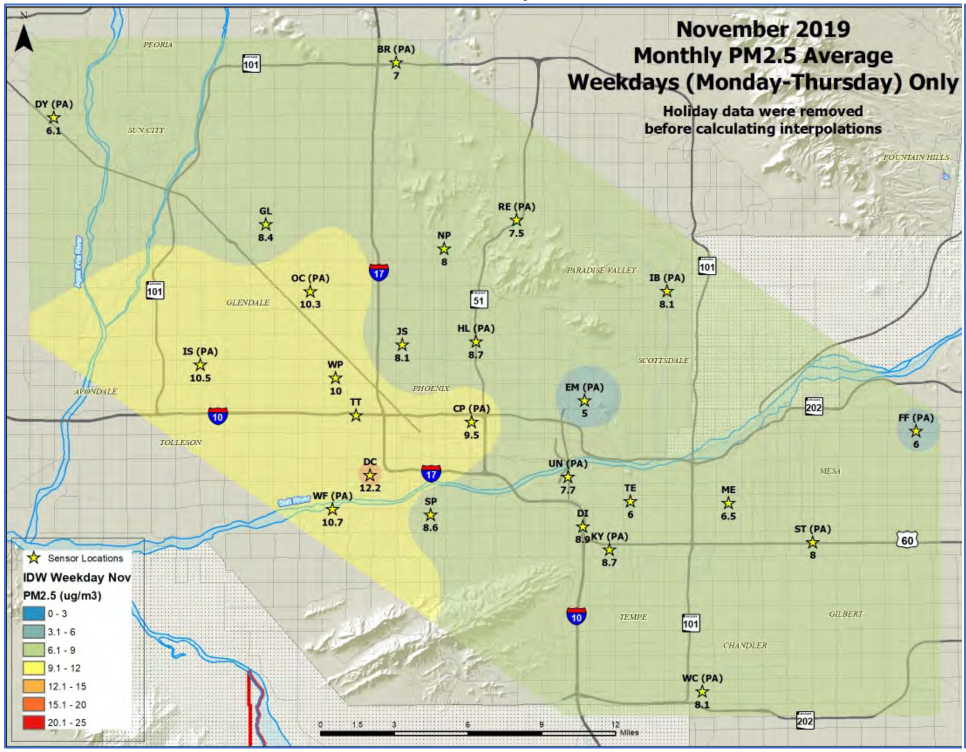


Figure 11. $PM_{2.5}$ spatial patterns for weekdays (Monday – Thursday) and weekends (Friday – Sunday) in November 2019. Holiday data were removed prior to creating the IDW interpolations.

Weekdays



Weekends

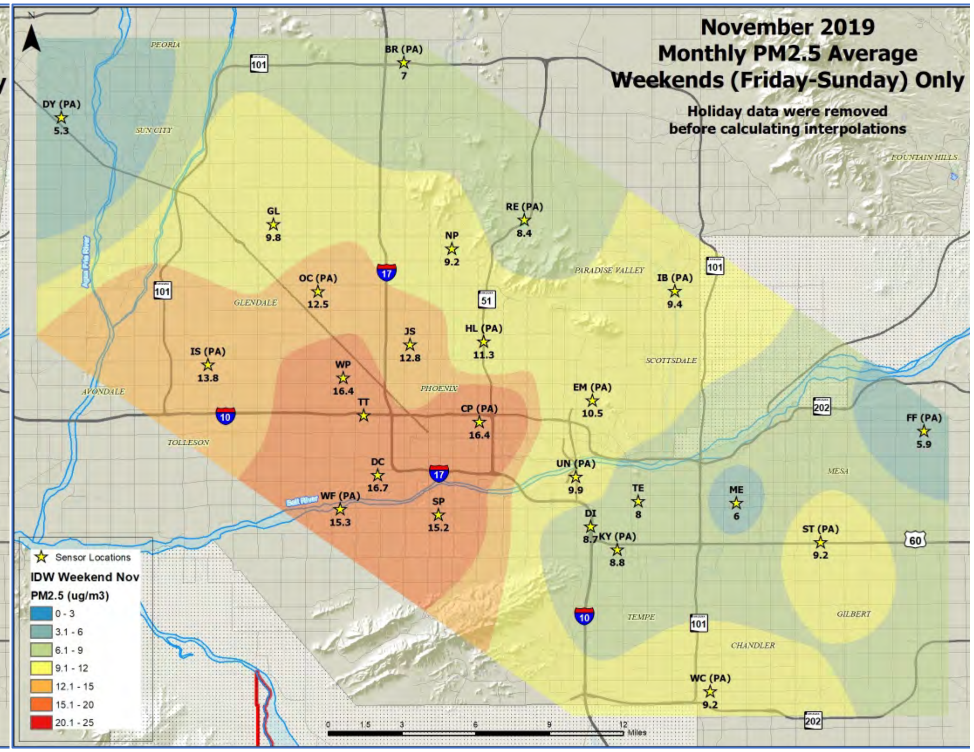


Figure 12. $PM_{2.5}$ spatial patterns for weekdays (Monday – Thursday) and weekends (Friday – Sunday) in December 2019. Holiday data were removed prior to creating the IDW interpolations.

Weekdays **Weekends**

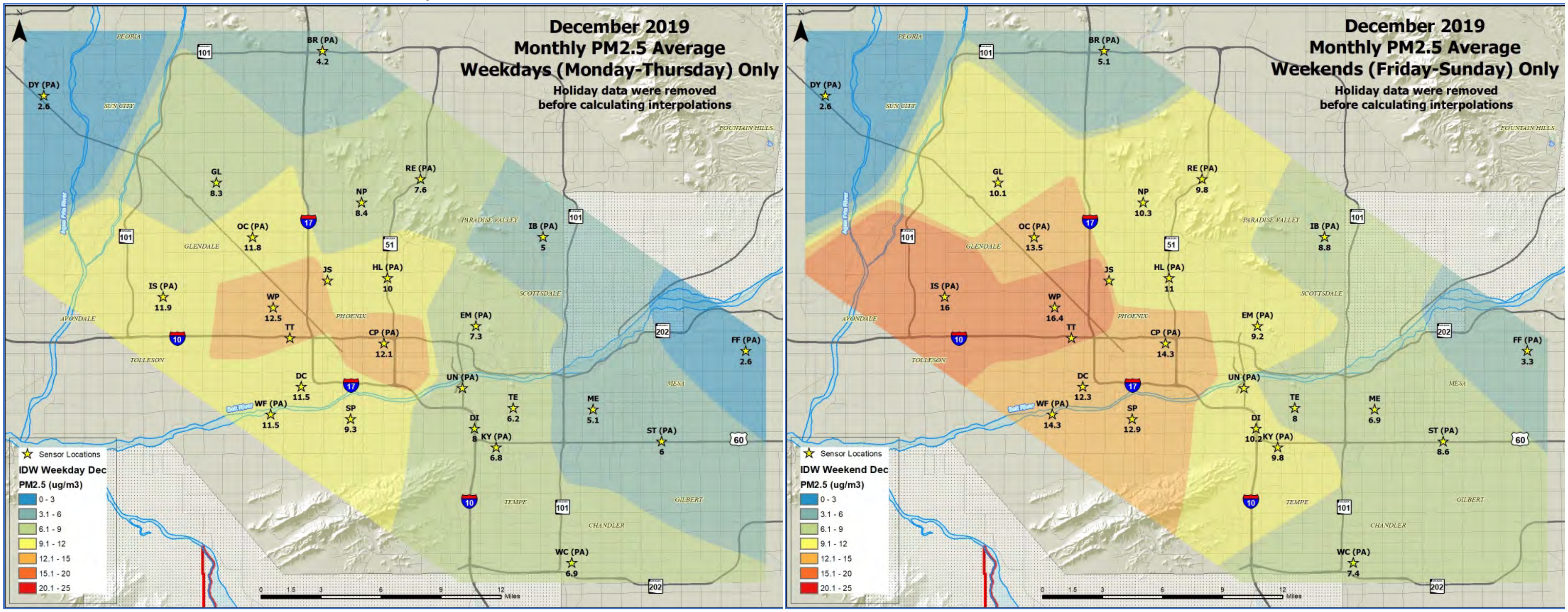
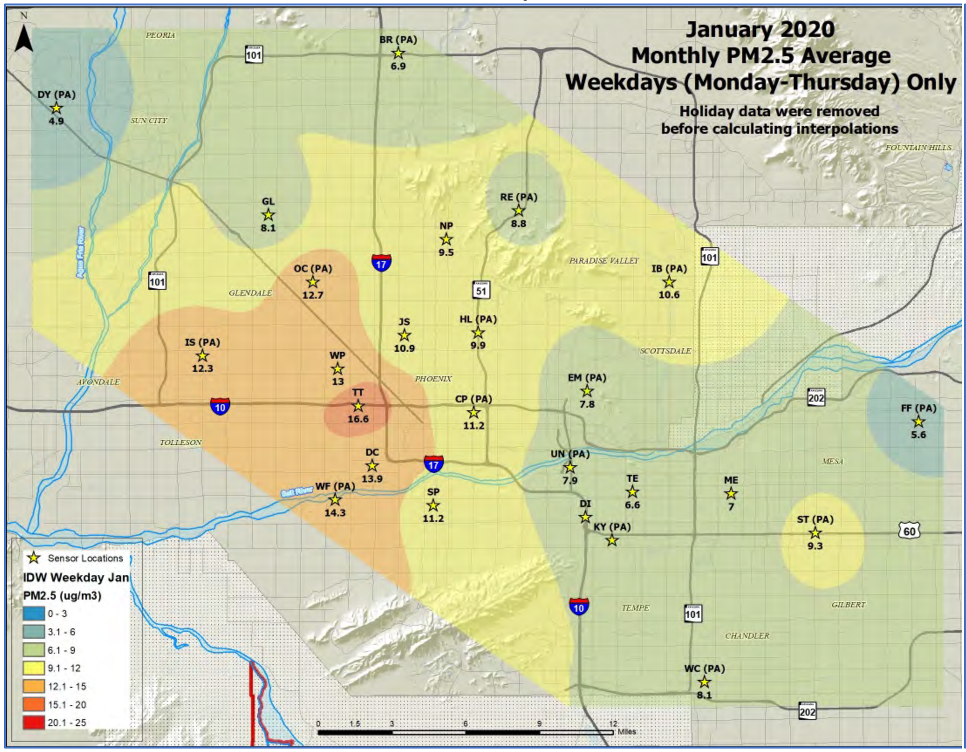


Figure 13. $PM_{2.5}$ spatial patterns for weekdays (Monday – Thursday) and weekends (Friday – Sunday) in January 2020. Holiday data were removed prior to creating the IDW interpolations.

Weekdays



Weekends

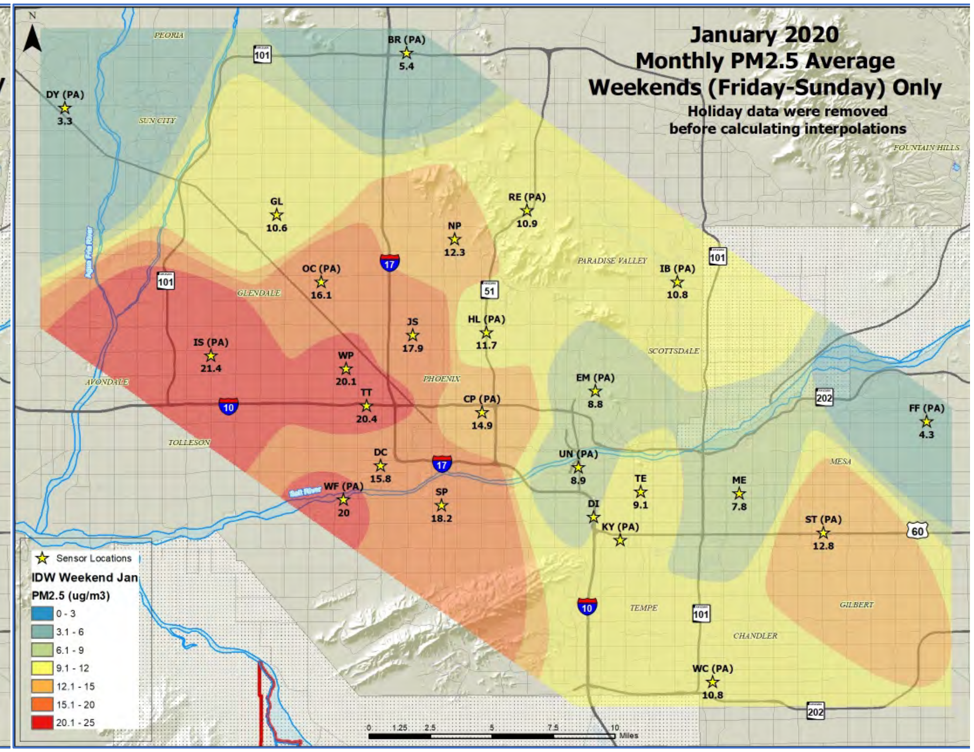
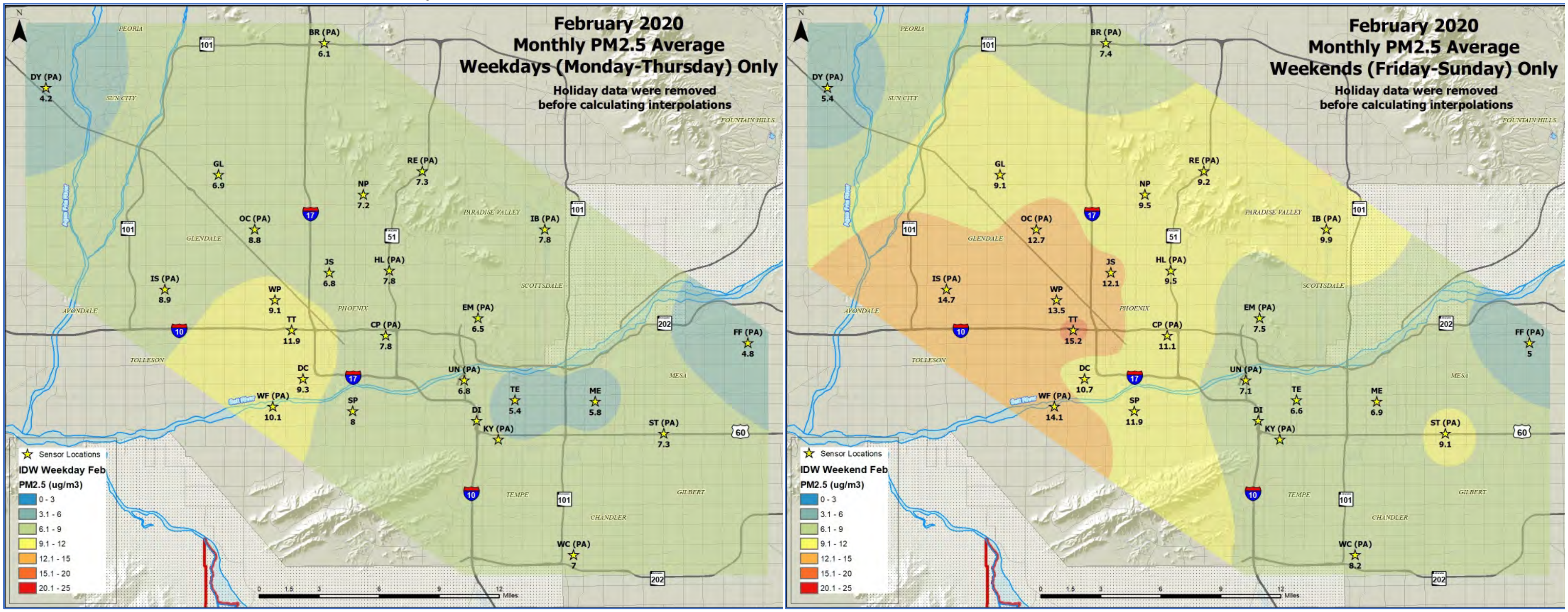


Figure 14. $PM_{2.5}$ spatial patterns for weekdays (Monday – Thursday) and weekends (Friday – Sunday) in February 2020.

Weekdays **Weekends**



Time of Day Analysis

To determine the spatial pattern dynamics of $PM_{2.5}$ in relation to the time of day, values of hourly $PM_{2.5}$ were averaged into four six-hour blocks for each day. This analysis revealed that the highest values of $PM_{2.5}$ were in the evening (6 p.m. – 11 p.m.), which corresponds with the time of day that most recreational wood burning is occurring. Concentrations at night (12 a.m. – 5 a.m.) were the second highest and likely are the result of lingering smoke from the previous evening's burning activity. Values in the afternoon (12 p.m. – 5 p.m.) range were consistently the lowest (Figure 15). When looking at time of day together with day of week, the evening and night concentrations were highest on weekends. Afternoon concentrations tended to make up a greater proportion of the daily $PM_{2.5}$ average during weekdays, corresponding with traffic emissions from the evening rush hour (Figure 16).

Spatial patterns show that evening and night concentrations are highest in the southwest portions of the study area, with hotspots near the West Phoenix site extending down to the South Phoenix site. Morning (6 a.m. – 11 a.m.) concentrations tend to be highest in the areas near the Durango Complex site; which is likely a result of smoke concentrations from the previous evening lingering near the lower elevations of the Salt River, as well the morning commencement of industrial and agricultural activities which are common in the area (Figures 17-20).

Figure 15. Monthly average of hourly $PM_{2.5}$ concentrations. Grouped by time of day: night (12 a.m. – 6 a.m.), morning (6 a.m. – 11 a.m.), afternoon (12 p.m. – 5 p.m.) and evening (6 p.m. – 11 p.m.).

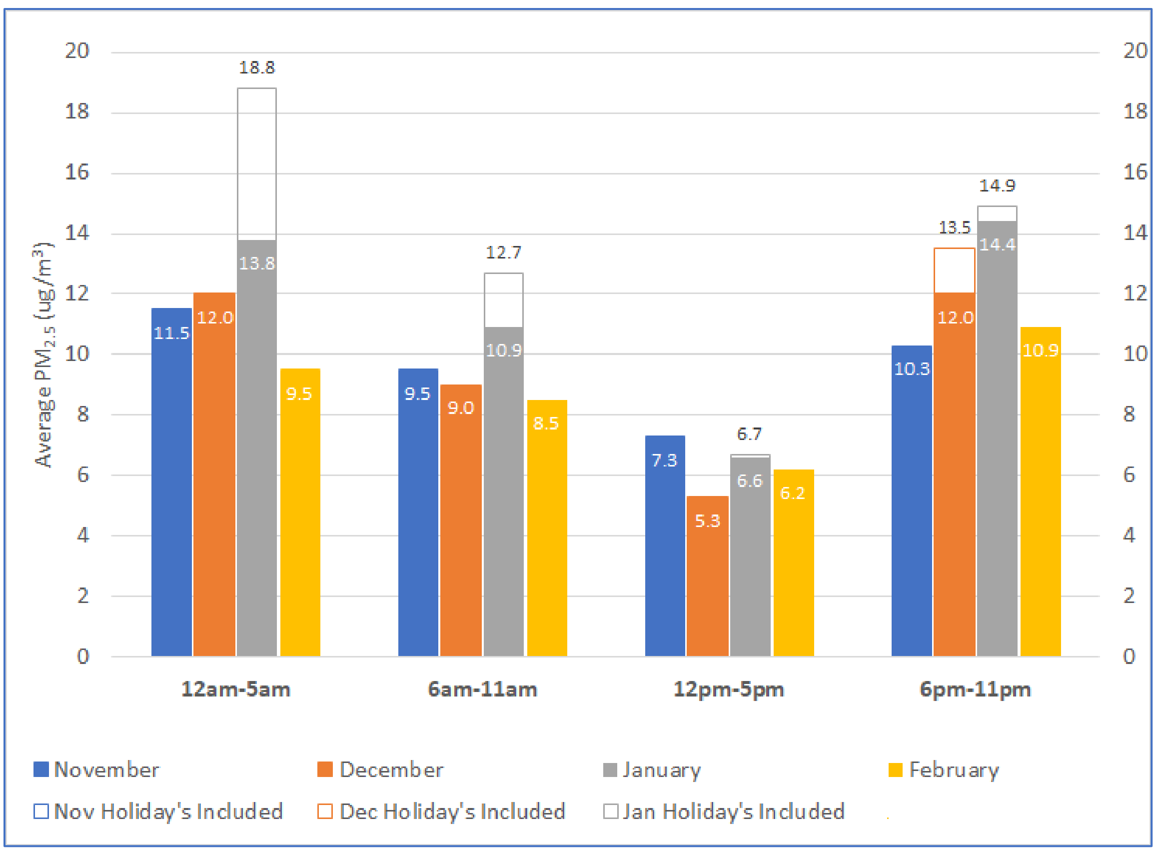


Figure 16. $PM_{2.5}$ average concentrations by Day of the Week and Time of Day for November 2019 through February 2020. Holiday data have been removed from this chart.

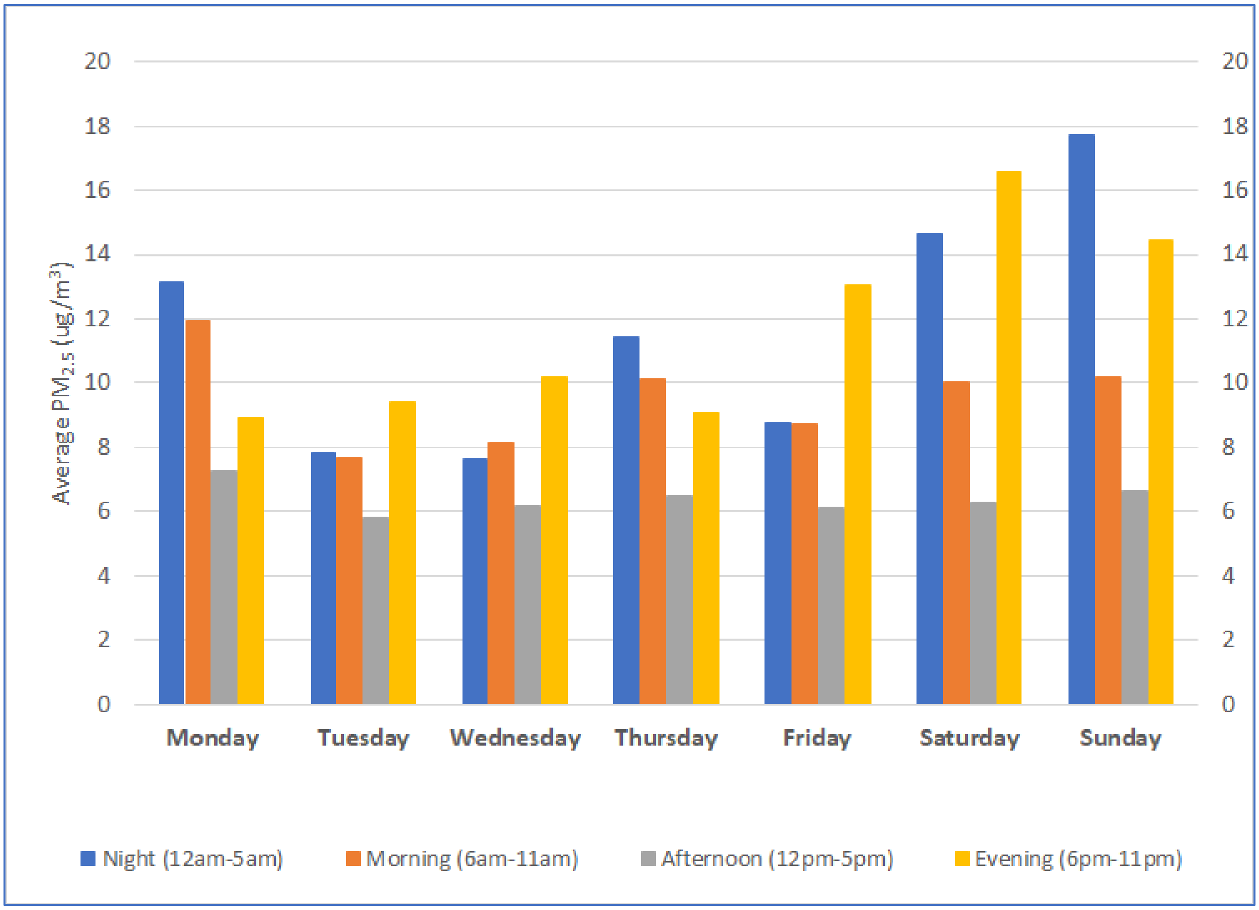
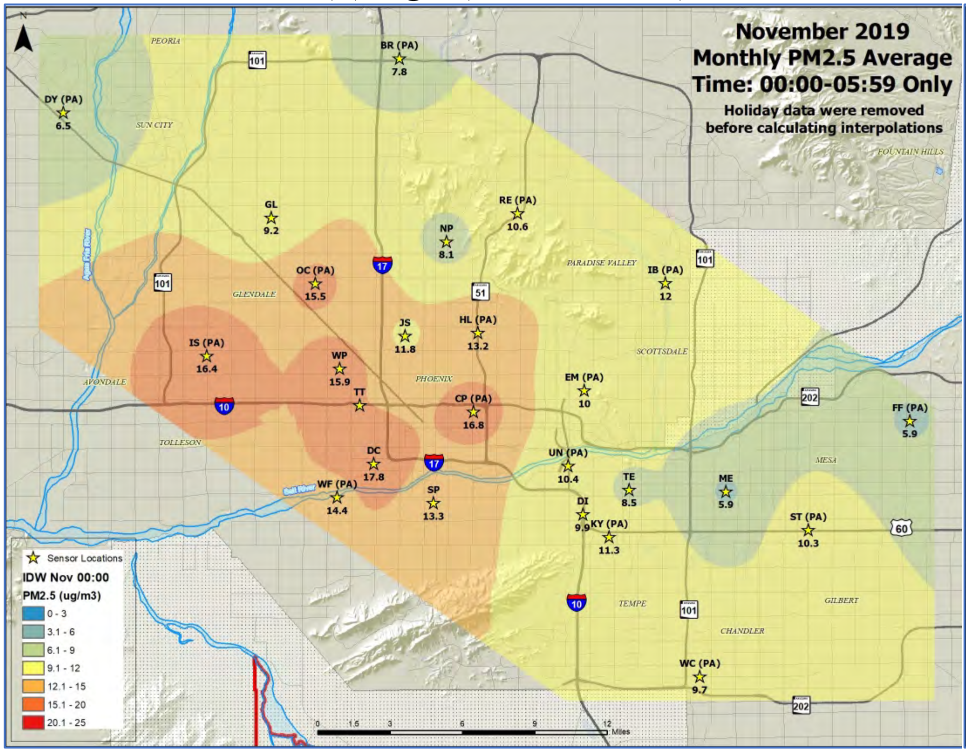
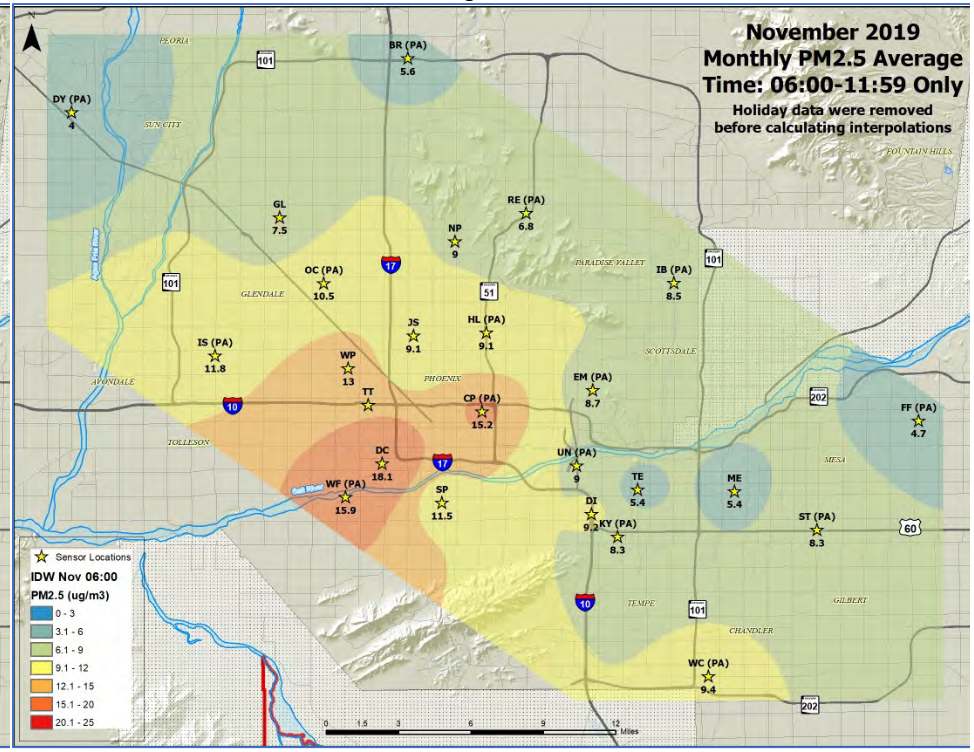


Figure 17. Spatial patterns of $PM_{2.5}$ for November 2019, averaged by time of day: Night (A), Morning (B), Afternoon (C), and Evening (D). Holiday data were removed prior to creating the IDW interpolations.

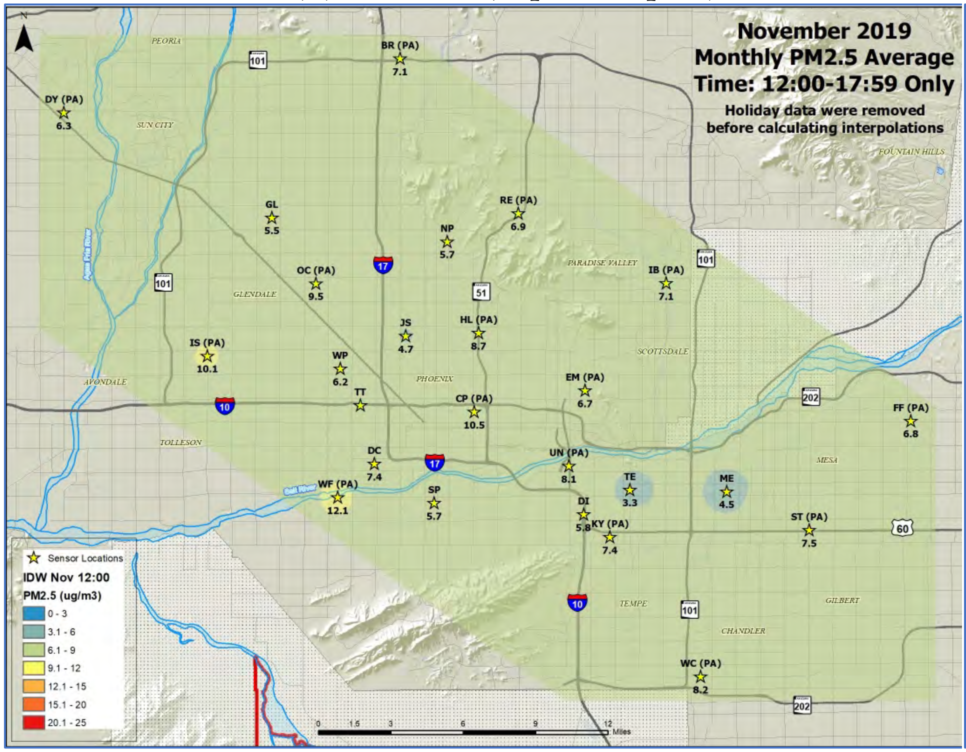
(A) Night (12 a.m. – 5 a.m.)



(B) Morning (6 a.m. – 11 a.m.)



(C) Afternoon (12 p.m. – 5 p.m.)



(D) Evening (6 p.m. – 11 p.m.)

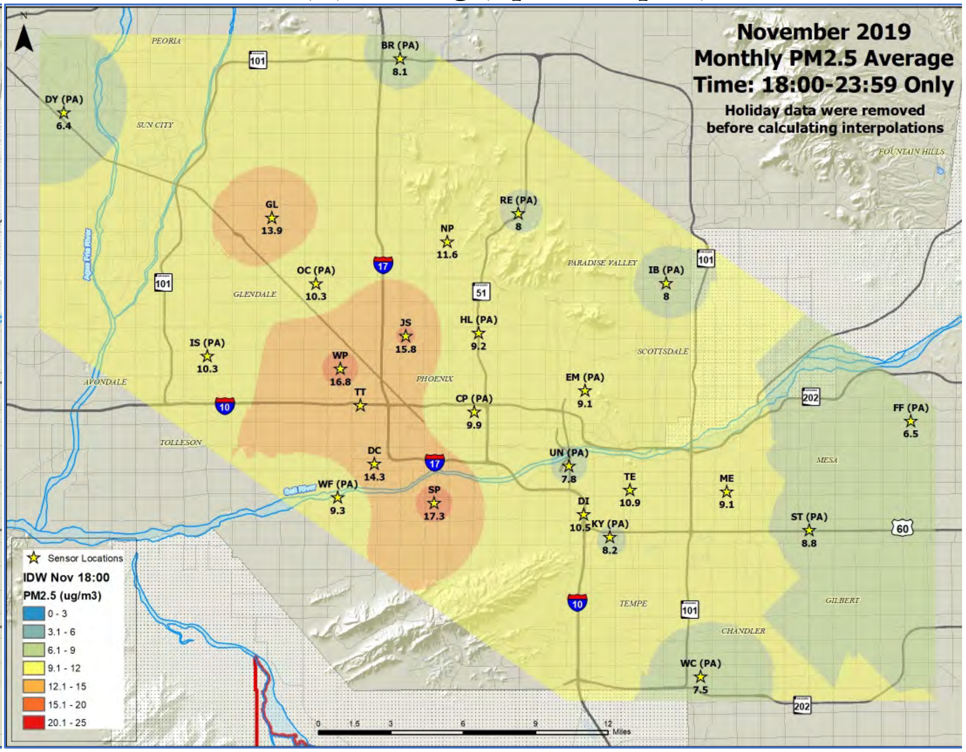
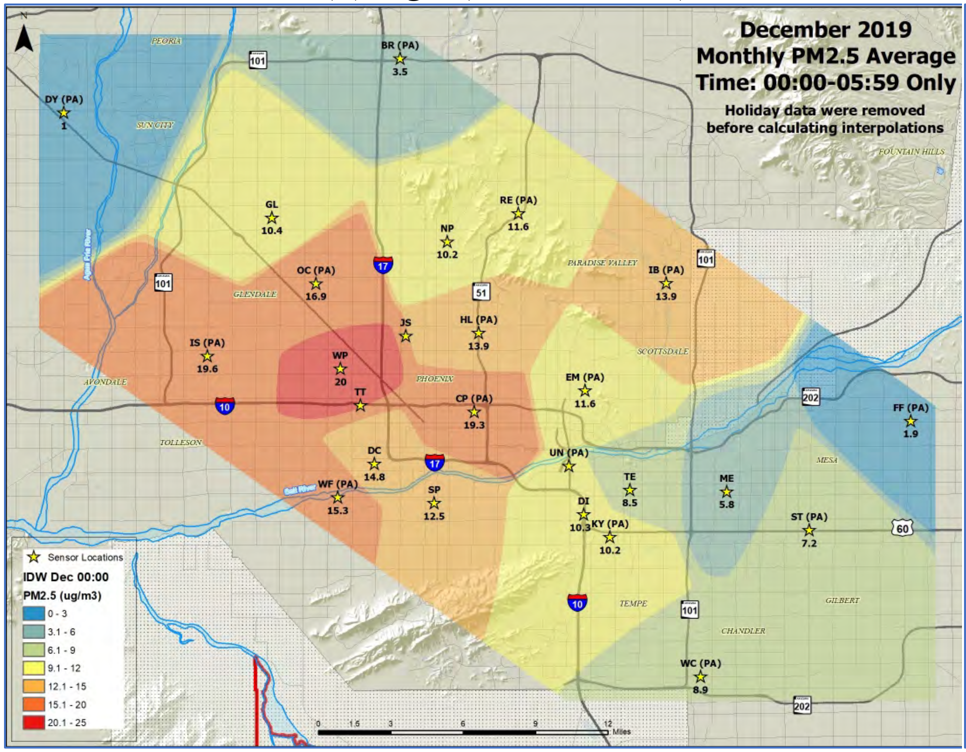
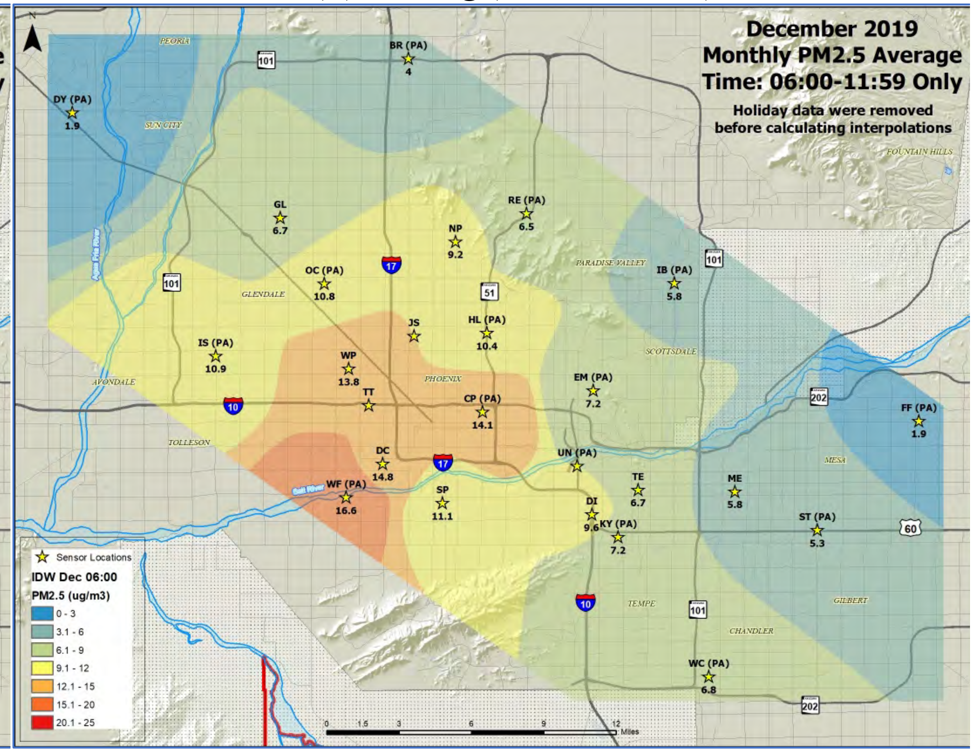


Figure 18. Spatial patterns of $PM_{2.5}$ for December 2019, averaged by time of day: Night (A), Morning (B), Afternoon (C), and Evening (D). Holiday data were removed prior to creating the IDW interpolations.

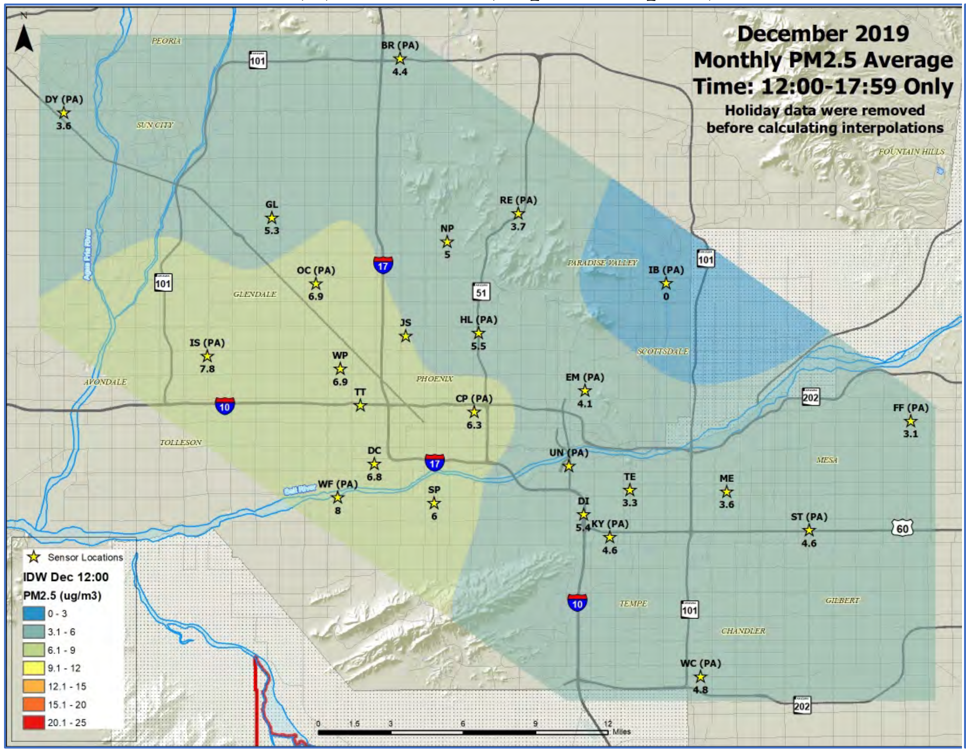
(A) Night (12 a.m. – 5 a.m.)



(B) Morning (6 a.m. – 11 a.m.)



(C) Afternoon (12 p.m. – 5 p.m.)



(D) Evening (6 p.m. – 11 p.m.)

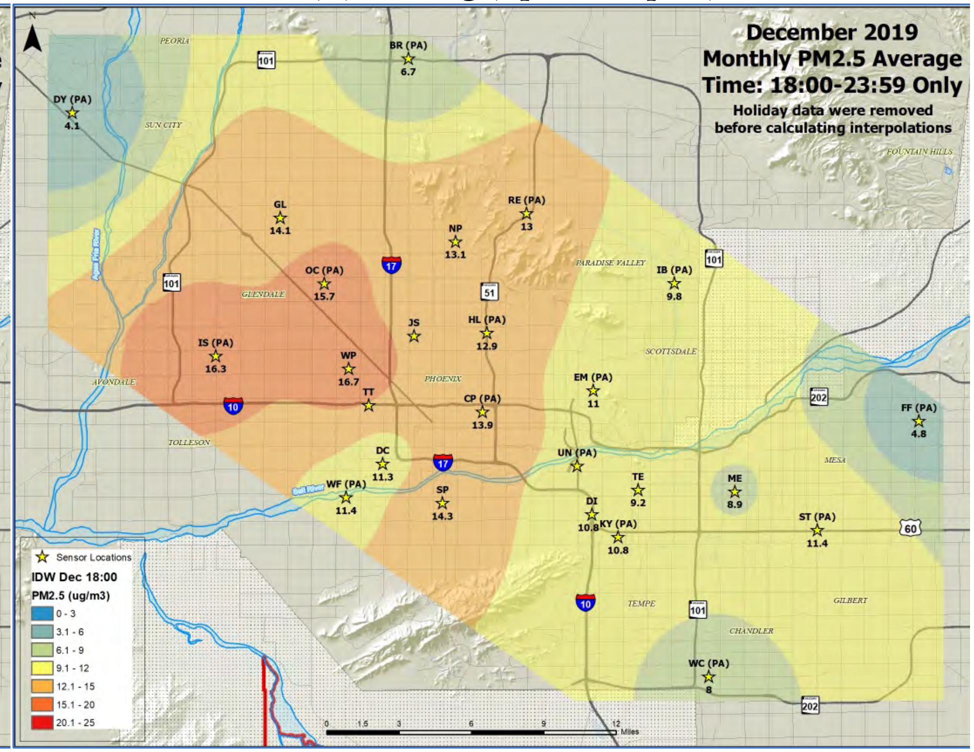
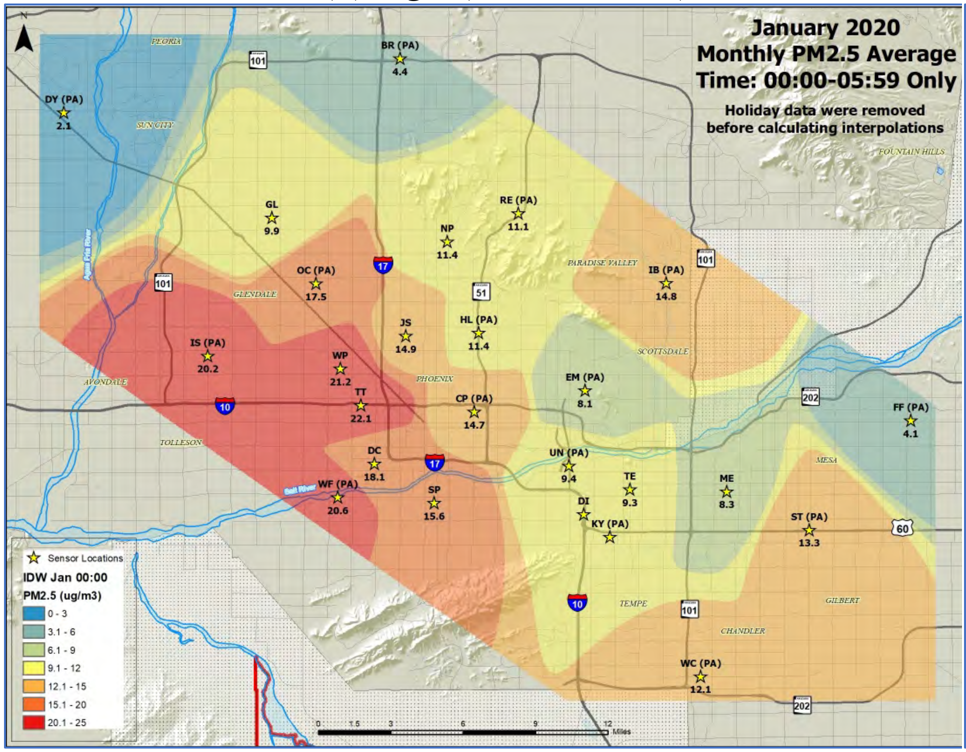
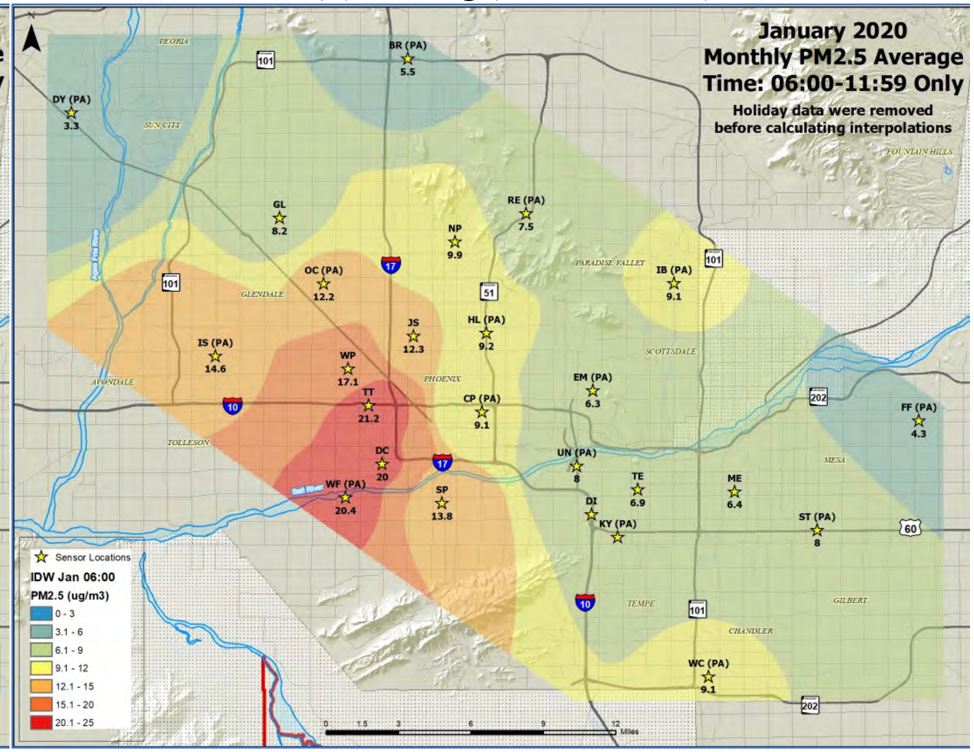


Figure 19. Spatial patterns of $PM_{2.5}$ for January 2020, averaged by time of day: Night (A), Morning (B), Afternoon (C), and Evening (D). Holiday data were removed prior to creating the IDW interpolations.

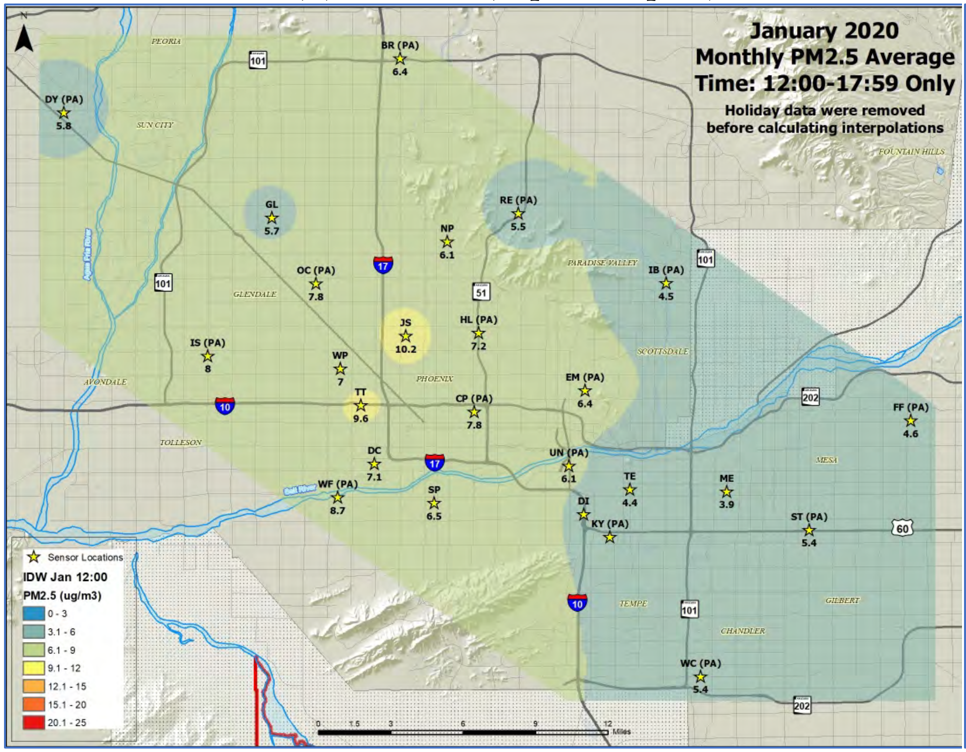
(A) Night (12 a.m. – 5 a.m.)



(B) Morning (6 a.m. – 11 a.m.)



(C) Afternoon (12 p.m. – 5 p.m.)



(D) Evening (6 p.m. – 11 p.m.)

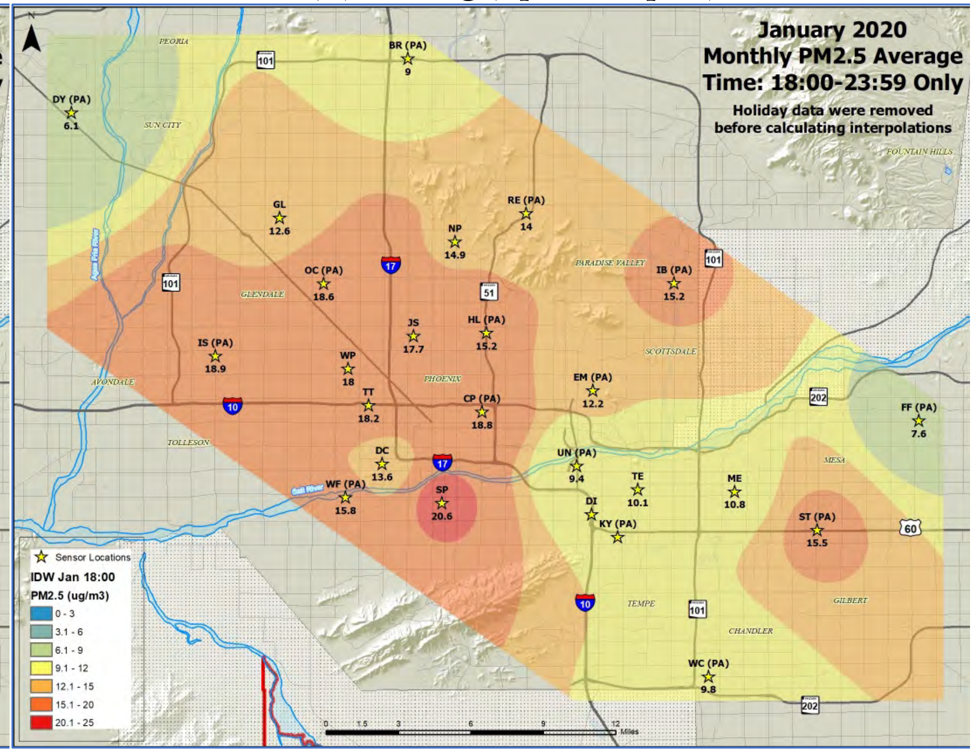
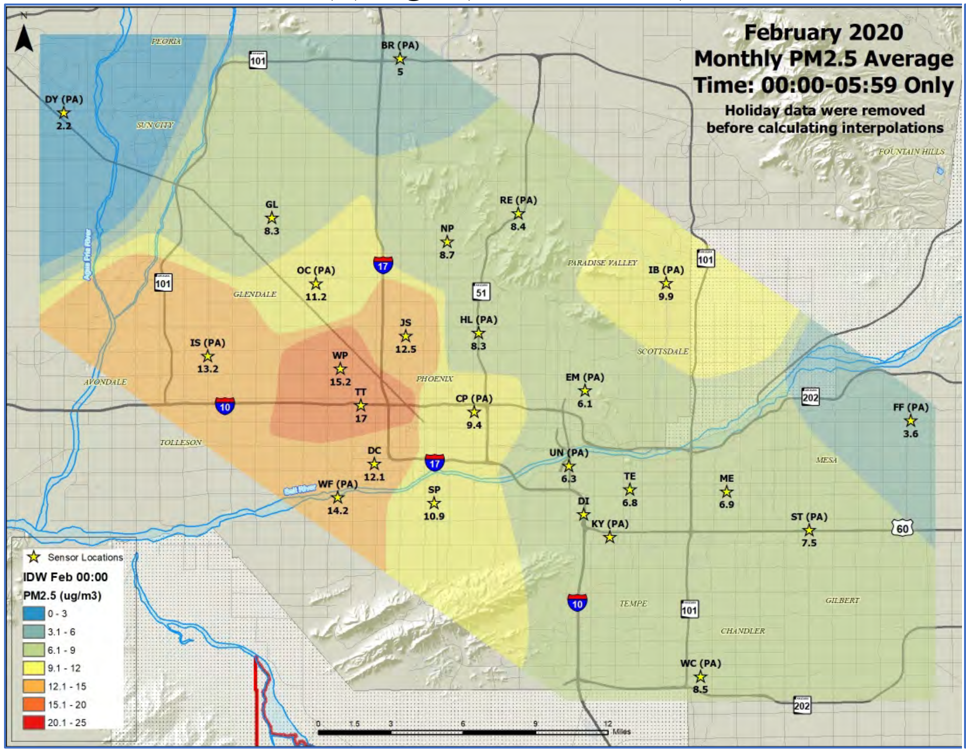
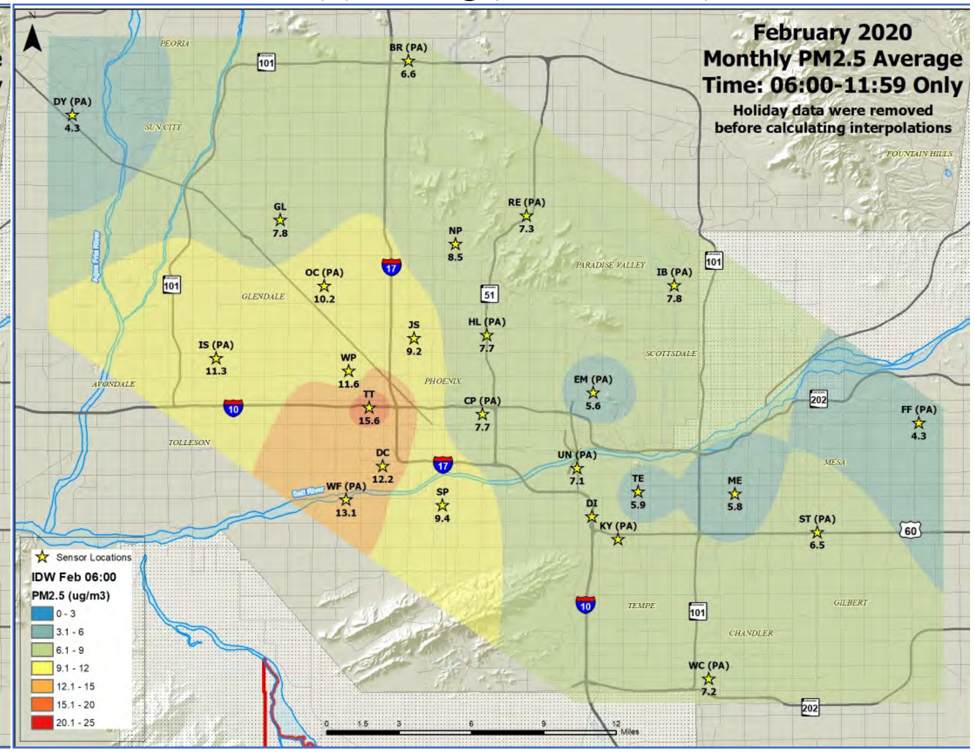


Figure 20. Spatial patterns of $PM_{2.5}$ for February 2020, averaged by time of day: Night (A), Morning (B), Afternoon (C), and Evening (D).

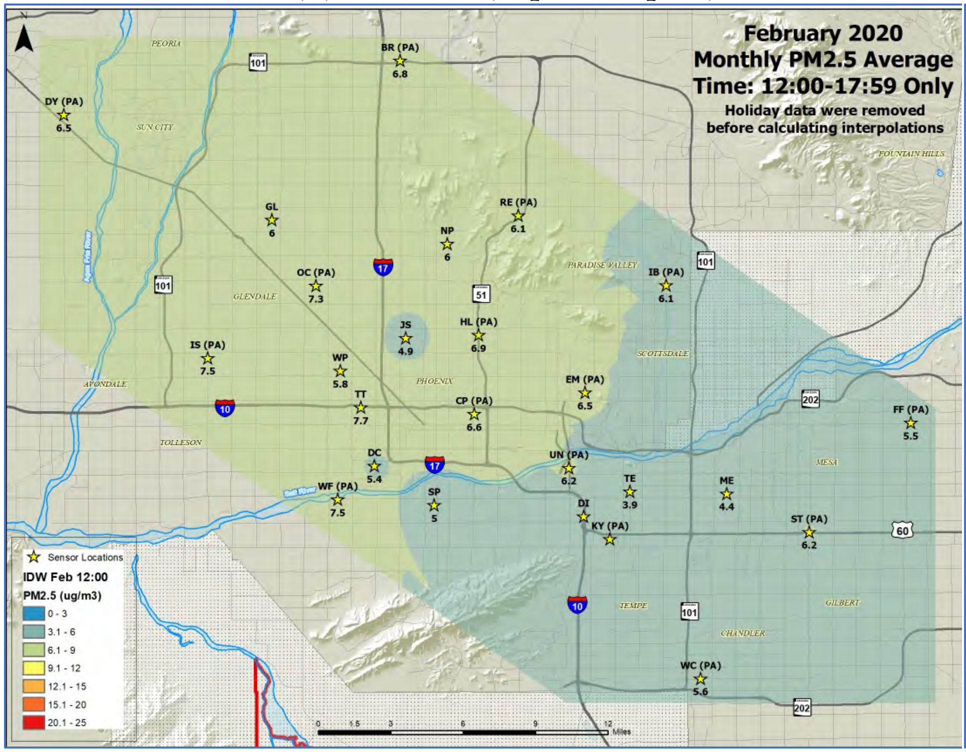
(A) Night (12 a.m. – 5 a.m.)



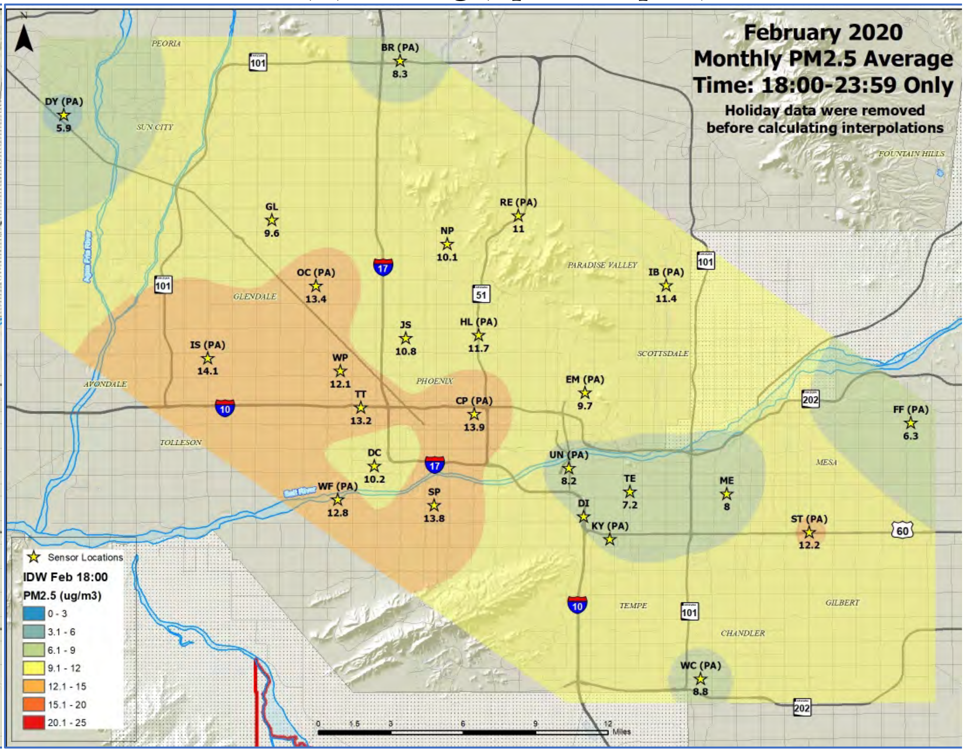
(B) Morning (6 a.m. – 11 a.m.)



(C) Afternoon (12 p.m. – 5 p.m.)



(D) Evening (6 p.m. – 11 p.m.)

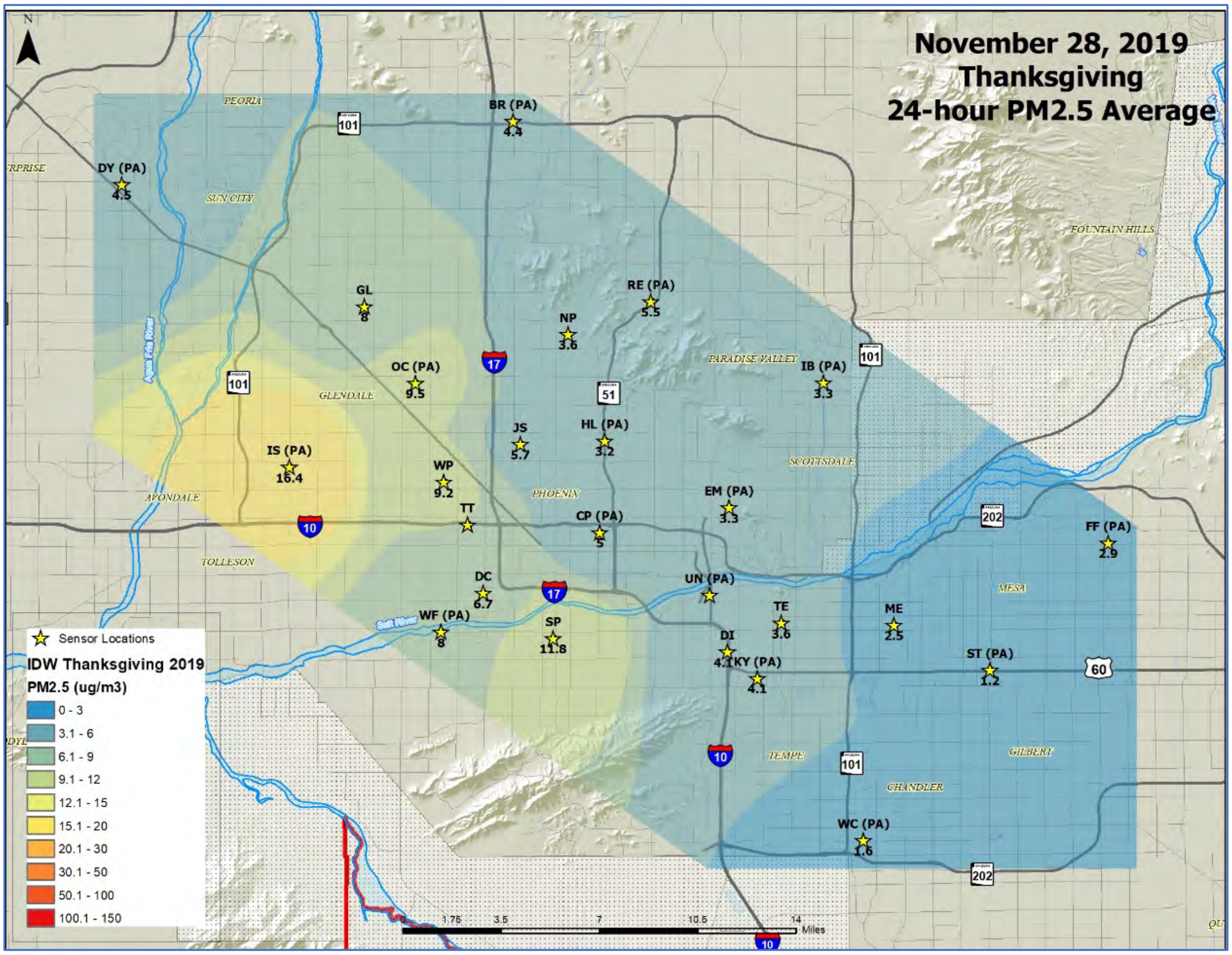


HOLIDAYS

Thanksgiving

There were no exceedances of the $PM_{2.5}$ NAAQS on Thanksgiving Day 2019, and the 24-hour average in most areas ended up in the good air quality index (AQI) range (the concentration range for all sites except Indian School was 1.2-11.8 $\mu g/m^3$). The Indian School site, in the western portion of Phoenix, was the only site to have a 24-hour concentrations in the low moderate AQI range with a 24-hour average of 16.4 $\mu g/m^3$ (Figure 21). This is unlike the conditions in Thanksgiving 2018 where wood burning activities created high $PM_{2.5}$ concentrations and multiple exceedances of the NAAQS. Weather conditions in 2019 were cool with wind and rain beginning in the evening of November 28.

Figure 21. Spatial patterns of $PM_{2.5}$ on Thanksgiving, 11/28/19. 24-hour average concentrations are marked on the map underneath each monitoring location.



Christmas

As with Thanksgiving 2019, Christmas Eve and Day 2019 saw much lower $PM_{2.5}$ concentrations than what has been typically observed in previous years. There were no NAAQS exceedances, and AQI values on Christmas Eve stayed in the good AQI range (the concentration range for all sites was 0-10.1 $\mu g/m^3$) (Figure 22). Values on Christmas Day were also in the good AQI range for most sites, though several locations (Glendale, Indian School, Ocotillo, Residence 1, and West Phoenix) did end up in the low moderate range (Figure 23). The low $PM_{2.5}$ concentrations observed on Christmas Eve and Day were likely the result of the weather. A major winter storm impacted most of Arizona and brought rainy conditions for the Phoenix metropolitan area on December 24 and 25, 2019.

Figure 22. Spatial patterns of $PM_{2.5}$ on Christmas Eve, 12/24/19. 24-hour average concentrations are marked on the map underneath each monitoring location.

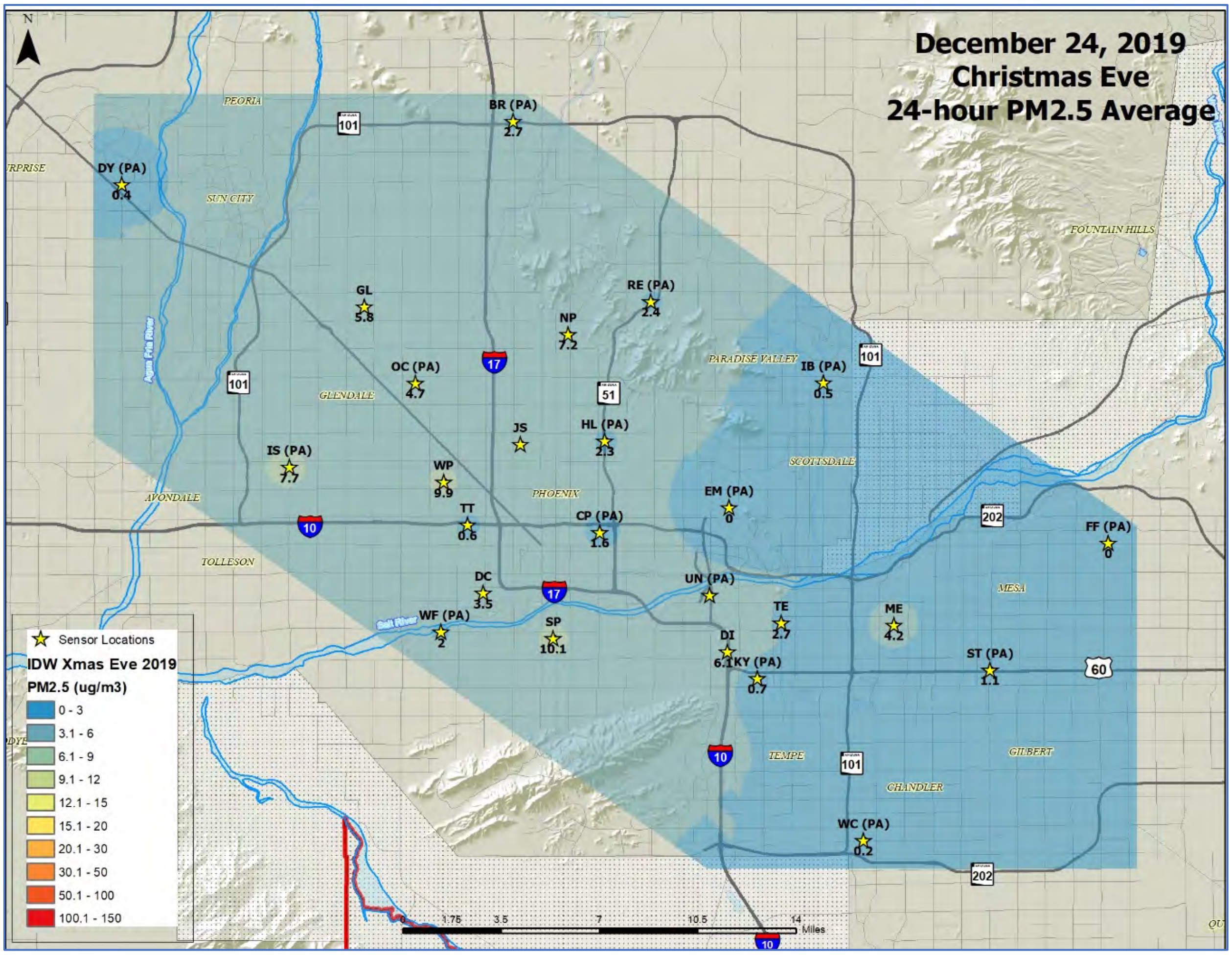
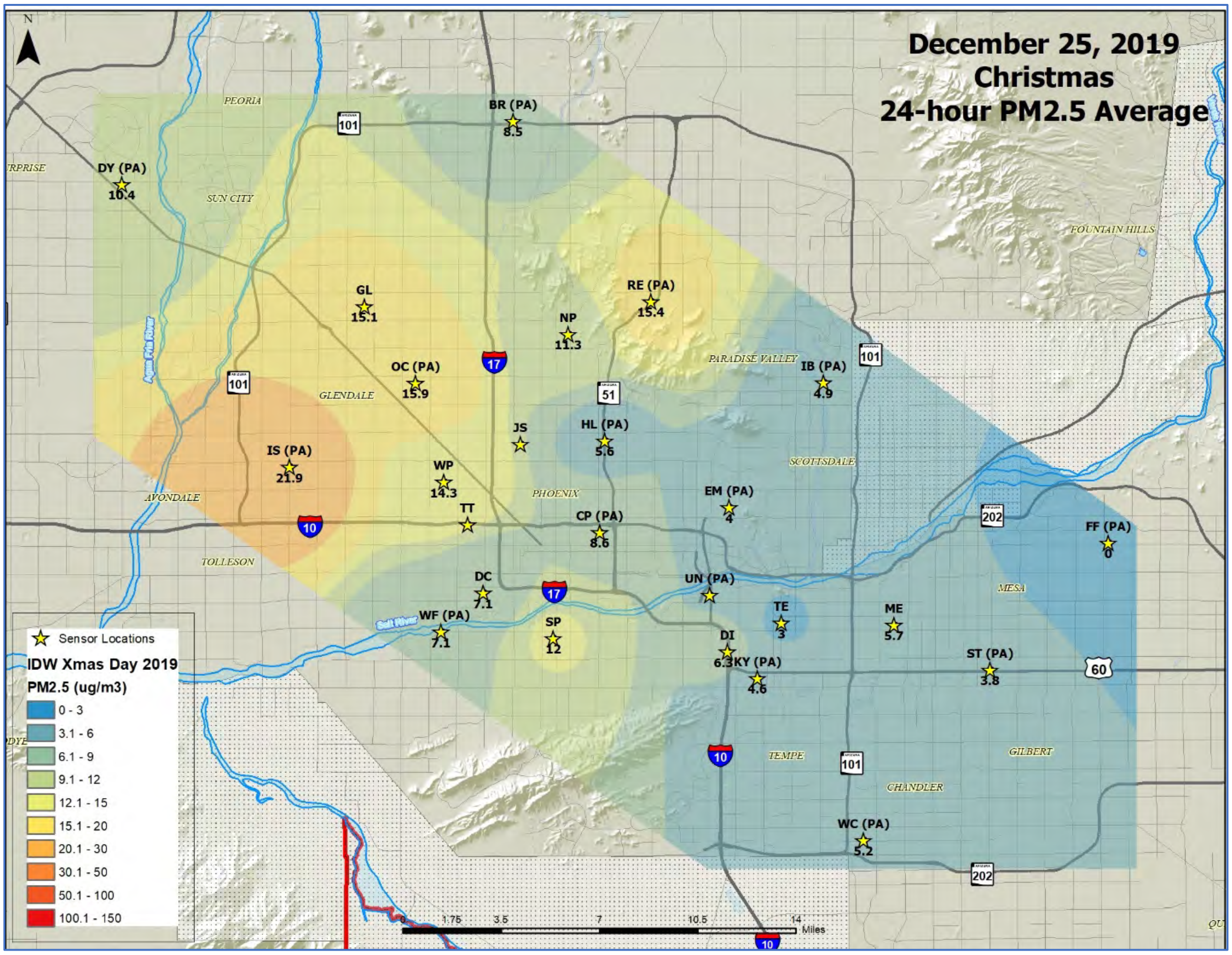


Figure 23. Spatial patterns of $PM_{2.5}$ on Christmas Day, 12/25/19. 24-hour average concentrations are marked on the map underneath each monitoring location.



New Years

Weather conditions on New Year's Eve and Day 2019-2020 were slightly cooler than average, but otherwise unremarkable. It was breezy in the afternoon of December 31, but by 6 p.m. those breezes had died down. Concentrations of $PM_{2.5}$ began to ramp up after nightfall, especially in western and southern Phoenix, but by 11 p.m. the entire study area (with the exception of Surprise and Sun City which are represented by the Dysart monitor) reported elevated values. Values peaked at all sites between midnight and 2 a.m., but very high concentrations persisted until mid-morning on New Year's Day. The patterns suggest that concentrations came from wood burning on New Year's Eve and culminated with fireworks use around midnight. Smoke then lingered in the metropolitan area until the morning when it was cleared out by the increase of mixing and ventilation as the sun rose. Although the highest concentrations were found in the southwestern portions of the study area, the increased monitoring coverage with non-regulatory PurpleAir monitors demonstrated that values were elevated across the entire valley (Figures 24 and 25).

Two NAAQS exceedances occurred at regulatory monitoring sites on New Year's Eve, but the lingering smoke on New Year's Day caused many more sites to exceed (Table 5).

Table 5. $PM_{2.5}$ conditions on New Year's Ever, 12/31/19, and New Year's Day, 1/1/20.

	New Year's Eve	**New Year's Day**
Average $PM_{2.5}$ Concentrations Across Study Area	17.2 μg/m^3	57.9 μg/m^3
Regulatory Monitoring Sites Exceeding $PM_{2.5}$ NAAQS	South Phoenix (48.4 μg/m^3) West Phoenix (40.4 μg/m^3)	Durango Complex (76.3 μg/m^3) Glendale (64.9 μg/m^3) North Phoenix (51.4 μg/m^3) South Phoenix (64.7 μg/m^3) Thirty-third (141.4 μg/m^3) West Phoenix (149.1 μg/m^3)
Non-Regulatory Monitoring Sites Exceeding NAAQS	Residence 1 (43.3 μg/m^3)	Central Phoenix (68.9 μg/m^3) Highland (43.4 μg/m^3) Indian Bend (55.9 μg/m^3) Indian School (138.0 μg/m^3) Ocotillo (104.3 μg/m^3) Stapley (41.8 μg/m^3) West Chandler (53.4 μg/m^3) West 43rd Avenue (130.4 μg/m^3)

Figure 24. Spatial patterns of $PM_{2.5}$ on New Year's Eve, 12/31/19. 24-hour average concentrations are marked on the map underneath each monitoring location.

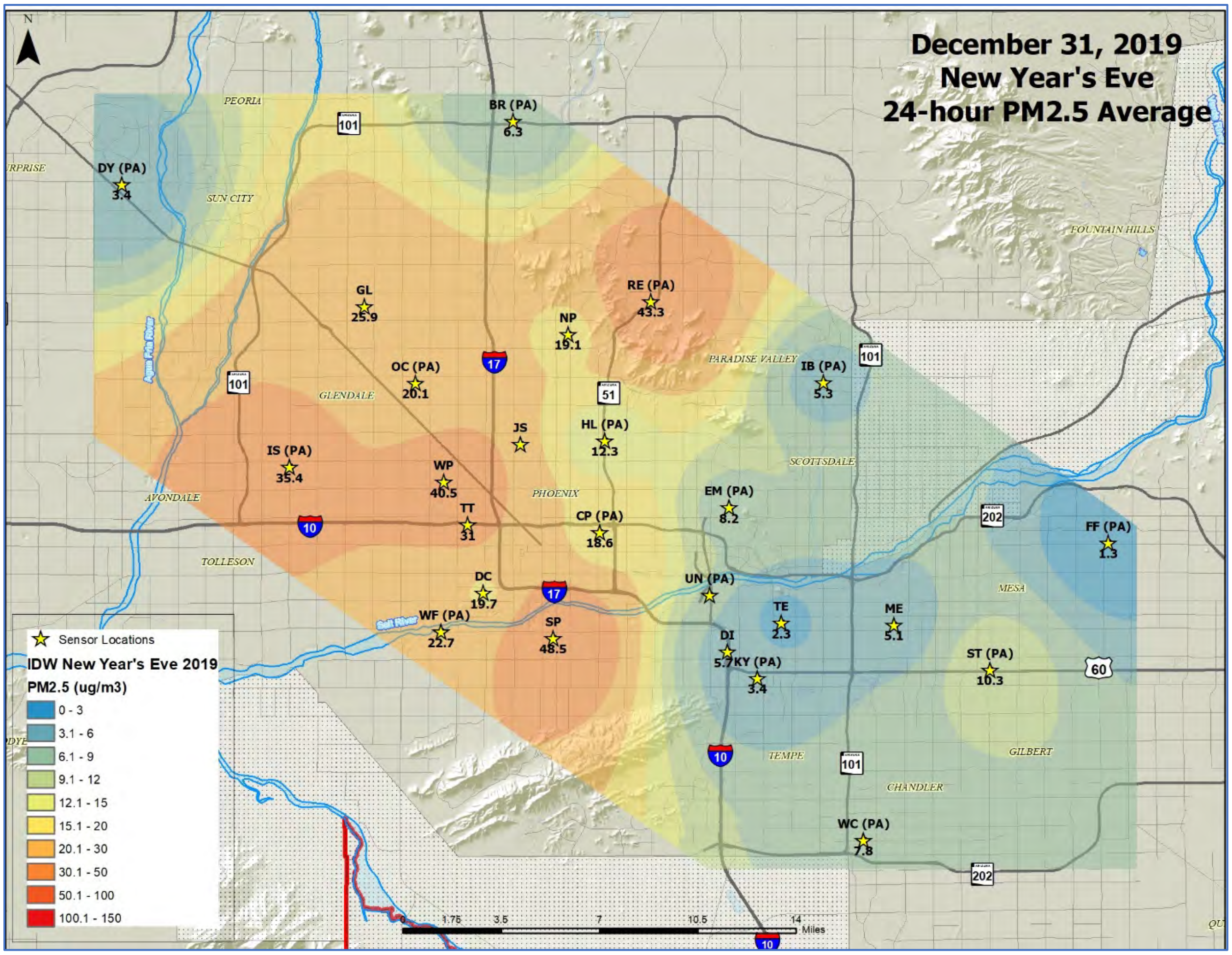
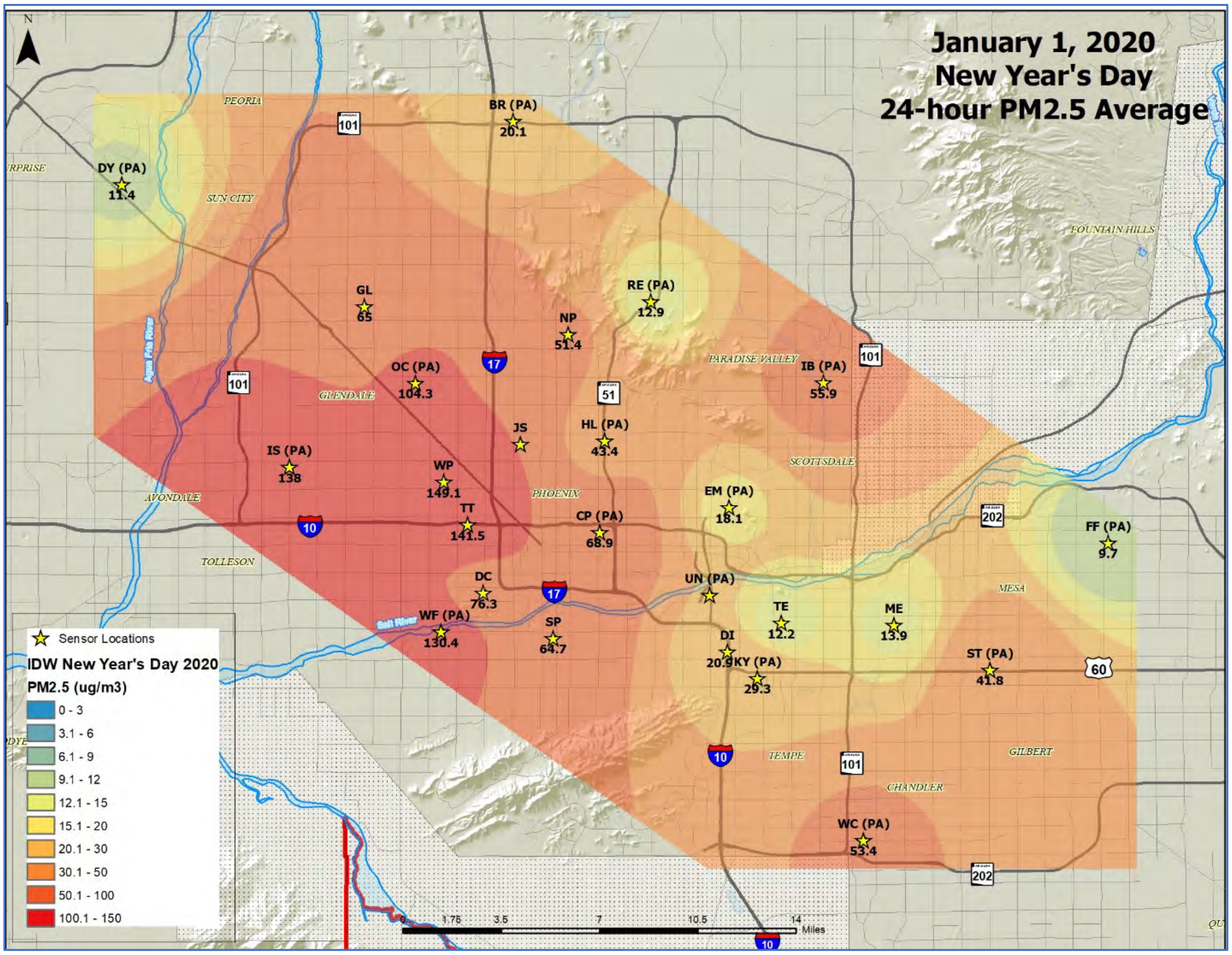


Figure 25. Spatial patterns of $PM_{2.5}$ on New Year's Day, 1/1/20. 24-hour average concentrations are marked on the map underneath each monitoring location.

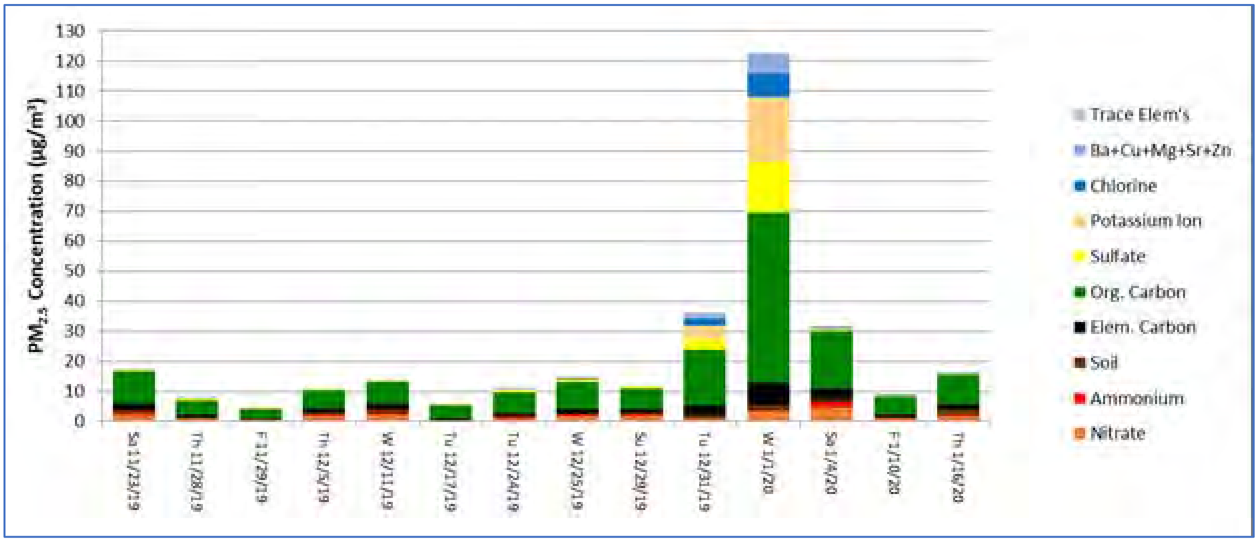


CHEMICAL SPECIATION

Chemical speciation samples were collected at the West Phoenix site during 14 days between November 23, 2019 and January 16, 2020 (Table 4). These samples of fine particulates are collected on filter media and then sent to a laboratory where they are analyzed by various methods to provide 24-hour average concentrations for total $PM_{2.5}$ and 51 different chemical species, which includes 5 water soluble compounds, 13 elemental and organic carbon species, 29 metallic and semi-metallic elements, and 4 nonmetallic elements. Carbon species typically make up the bulk of the weight of the total $PM_{2.5}$ sample, but the smaller quantities of trace elements are nevertheless important for identifying the source of the particles.

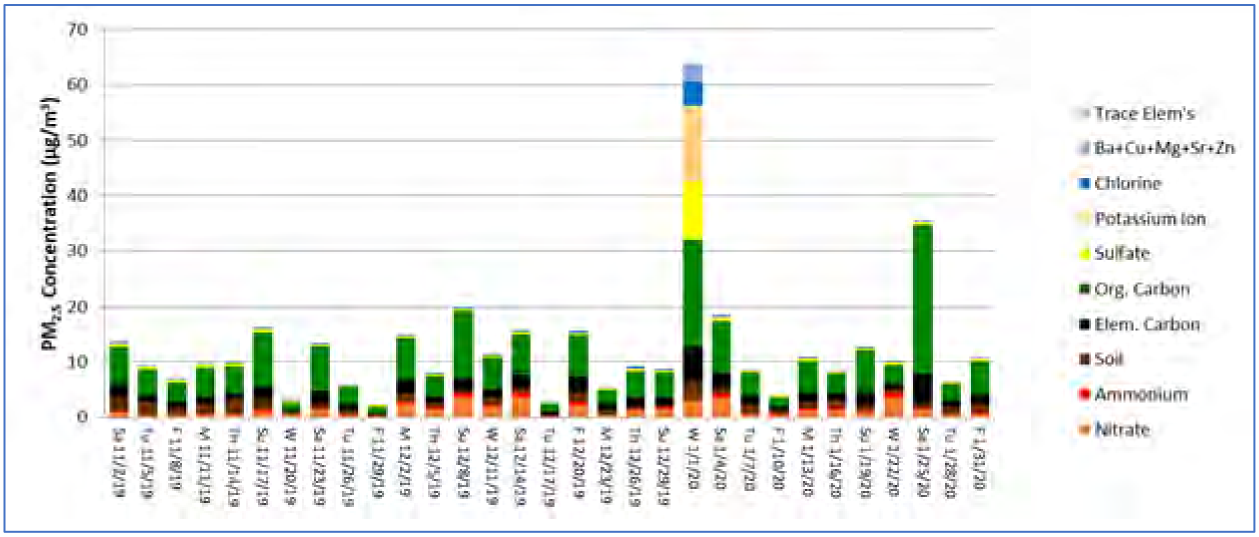
The chemical species sampled from West Phoenix were aggregated together as appropriate; e.g. metallic elements typically found in geologic dust (aluminum, calcium, iron, silicon and titanium) were aggregated into a 'soil' group and the fireworks colorant metals barium, copper, magnesium, strontium and zinc, normally trace elements, were aggregated. The IMPROVE (Interagency Monitoring of PROtected Visual Environments) visibility algorithm for soil elements was applied to the raw data weights to increase the accuracy of the results; the IMPROVE algorithm corrects for weight that would otherwise have been lost since elements such as oxygen were not accounted for in the analytes. The results of this speciation analysis are presented in Figure 26.

Figure 26 Chemical speciation samples collected at the West Phoenix site during the 2019-2020 study. The graph shows the total $PM_{2.5}$ concentration of the sample, as well as the concentration of chemicals within the samples. The IMPROVE algorithm is applied to the soil category.



The chemical speciation sampler operated by ADEQ at the JLG Supersite runs on a year-round basis with samples normally collected every 3rd day to keep in line with the EPA's official 1-in-3 day filter sampling schedule. The equipment and laboratory methods used by ADEQ in samples taken from the JLG Supersite are identical to those utilized by MCAQD at the West Phoenix site. For this study, samples collected at JLG Supersite from November 2019 until January 2020 were analyzed. Laboratory results quantifying the different chemical species sampled during this period are displayed in Figure 27; note that the IMPROVE visibility algorithm was applied to the raw data from both soil and organic carbon elements to improve the quantification of their weight.

Figure 27 Chemical speciation samples collected at the JLG Supersite during the 2019-2020 study. Samples were collected on the official 1-in-3 day EPA schedule. The graph shows the total $PM_{2.5}$ concentration of the sample, as well as the relative concentration of chemicals within the samples. The IMPROVE algorithm is applied to the soil and organic carbon categories.



PMF Modeling

Chemical speciation quantifies the various elements and compounds in a specific $PM_{2.5}$ sample, but modeling is required in order to attribute and quantify these chemicals to a source of pollution. For example, most pollution sources (such as automotive and industrial emissions, wood burning, and soil dust) contain carbon, but a model will use the contribution of other trace elements to attribute the emissions to specific sources. We applied the Positive Matrix Factorization (PMF) model, a state-of-the-art mathematical receptor model developed by the EPA. The PMF model reduces the large number of variables in complex analytical data sets to combinations of species called source types and source contributions. Identification of the source types requires expert interpretation of the profile. Once identified, the contribution of that source to the $PM_{2.5}$ sample can be quantified. As this is a statistical model, a measurement of the uncertainty and error is incorporated in the results. The more samples included in the dataset will generally lower the error of the analysis.

Since there were only 14 $PM_{2.5}$ chemical speciation samples collected at West Phoenix for the 2019-2020 season, error in the PMF model would likely be unacceptably high. Therefore, since speciation sampling has been conducted on the site for the last six winter burn seasons, results for the West Phoenix site were modeled using the 129 samples taken during the time period of 2014-2020. The best fit model identified five factors and these sources were identified as 1) smoke from wood burning; 2) $PM_{2.5}$ from secondary particle formation (especially from ammonium nitrate); 3) $PM_{2.5}$ from soil; 4) emissions from traffic and industry; and 5) smoke from fireworks. Figure 28 details these factors and their chemical fingerprints; note that the fingerprint, the factor's temporal pattern, and meteorological patterns at the site were used to identify the sources associated with the factor.

Figure 28. West Phoenix PMF factor chemical fingerprints for samples collected in the 2014-2020 winter burn seasons. Note that a significant portion of each factor is unexplained $PM_{2.5}$, which includes chemicals that weren't specifically measured, for example oxygen and hydrogen, as well as error in the model.

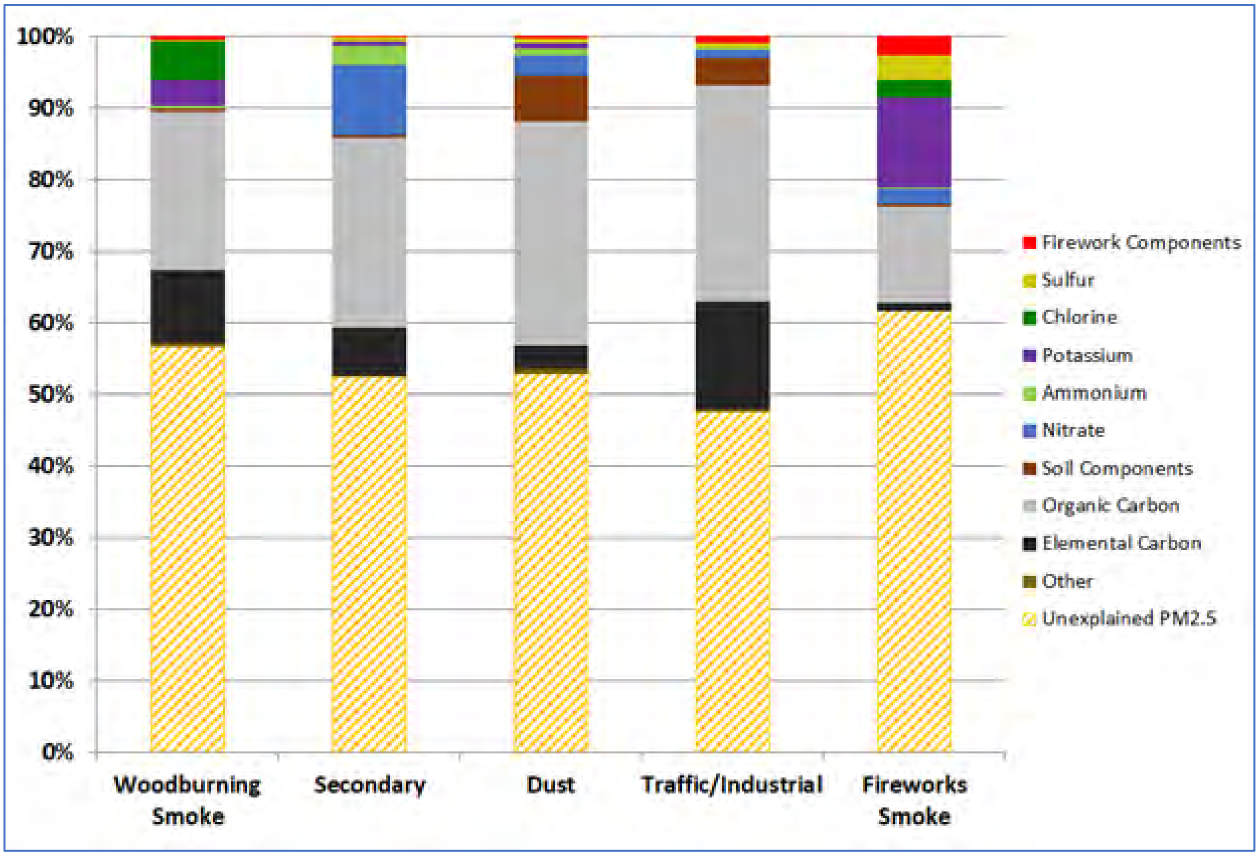


Figure 29 displays the contribution of these five sources to the daily $PM_{2.5}$ concentration of the past six study seasons and compares the average weekday, weekend, and holiday (Christmas and New Year only) values. This chart clearly shows the major contribution of smoke from wood burning on the holidays, the contribution of traffic and industrial emissions on weekdays, and the overwhelming effect of fireworks during New Year's Eve and Day. Figure 30 illustrates more detail on the daily source contributions outside of the effect of holidays. The increased amount of $PM_{2.5}$ from smoke is evident on weekends, whereas weekdays have increased impact from traffic and industrial sources. Figure 31 shows each of the actual daily modeled concentrations for the six seasons of speciated $PM_{2.5}$ sampling. The high concentrations on holidays, sourced particularly from woodburning smoke and firework smoke, as well as the positive effect of rain events occurring on a holiday, are evident in the displayed data.

Figure 29. Results from the PMF modelling of the 2014-2020 burn seasons; source types and contributions are plotted as 24-hour total $PM_{2.5}$ averages. Average concentrations on weekdays (Monday-Thursday), weekends (Friday-Sunday), and holidays are displayed.

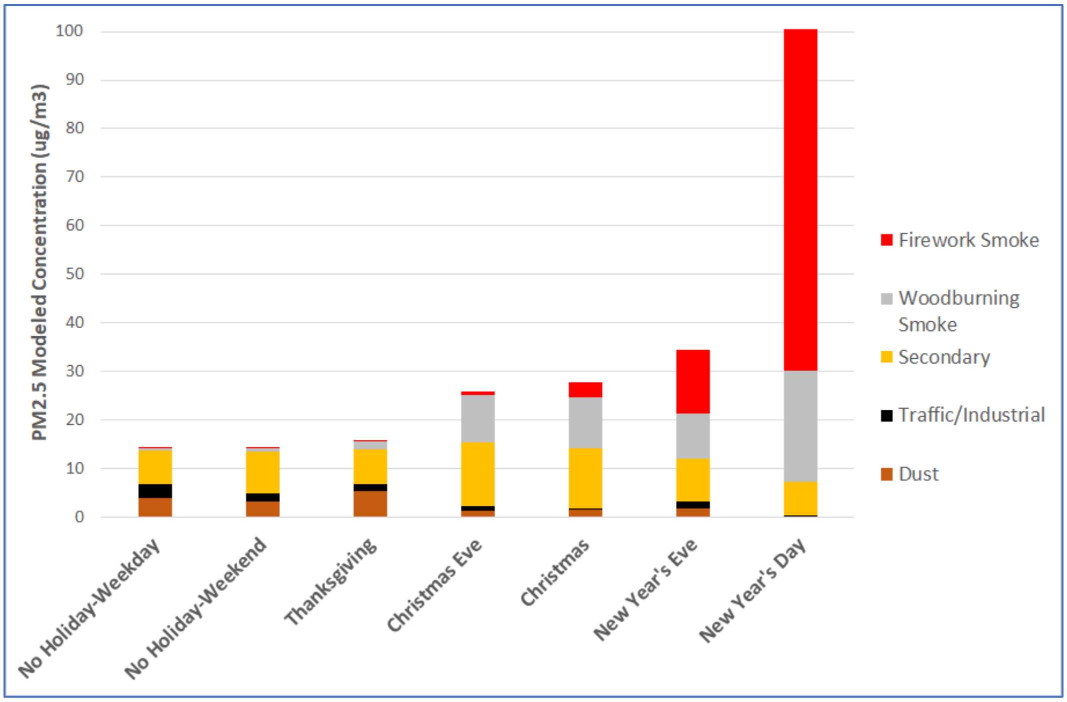


Figure 30. Results from the PMF modeling of the 2014-2020 burn seasons; all holidays have been excluded and this chart shows the average daily contribution by source for each day of the week.

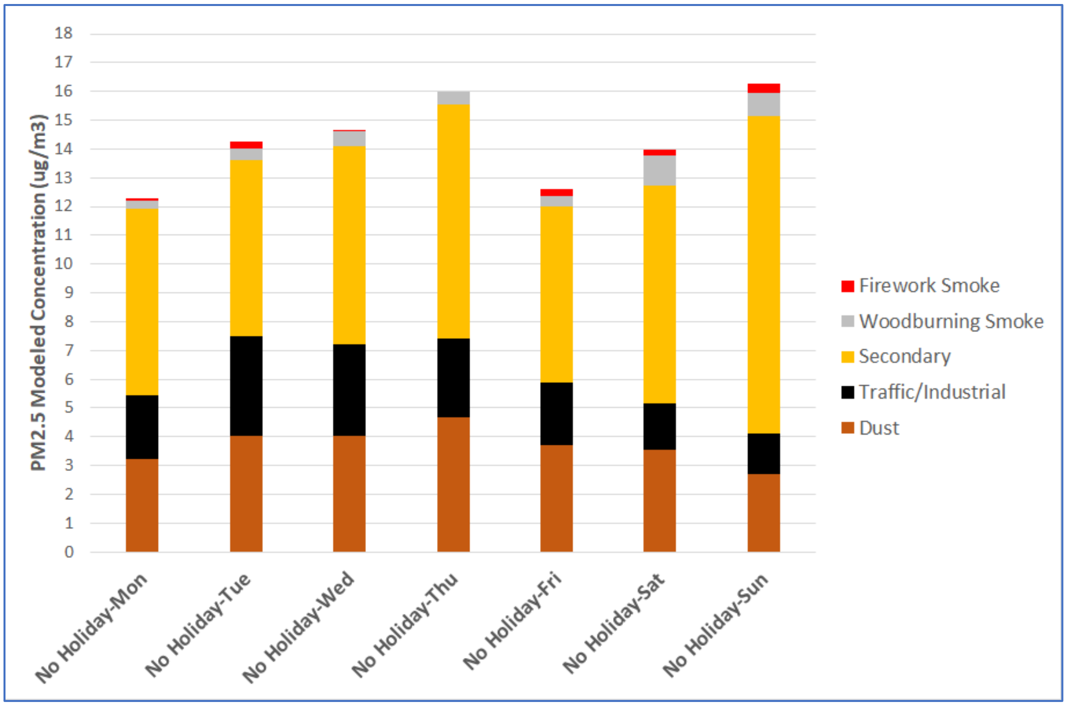
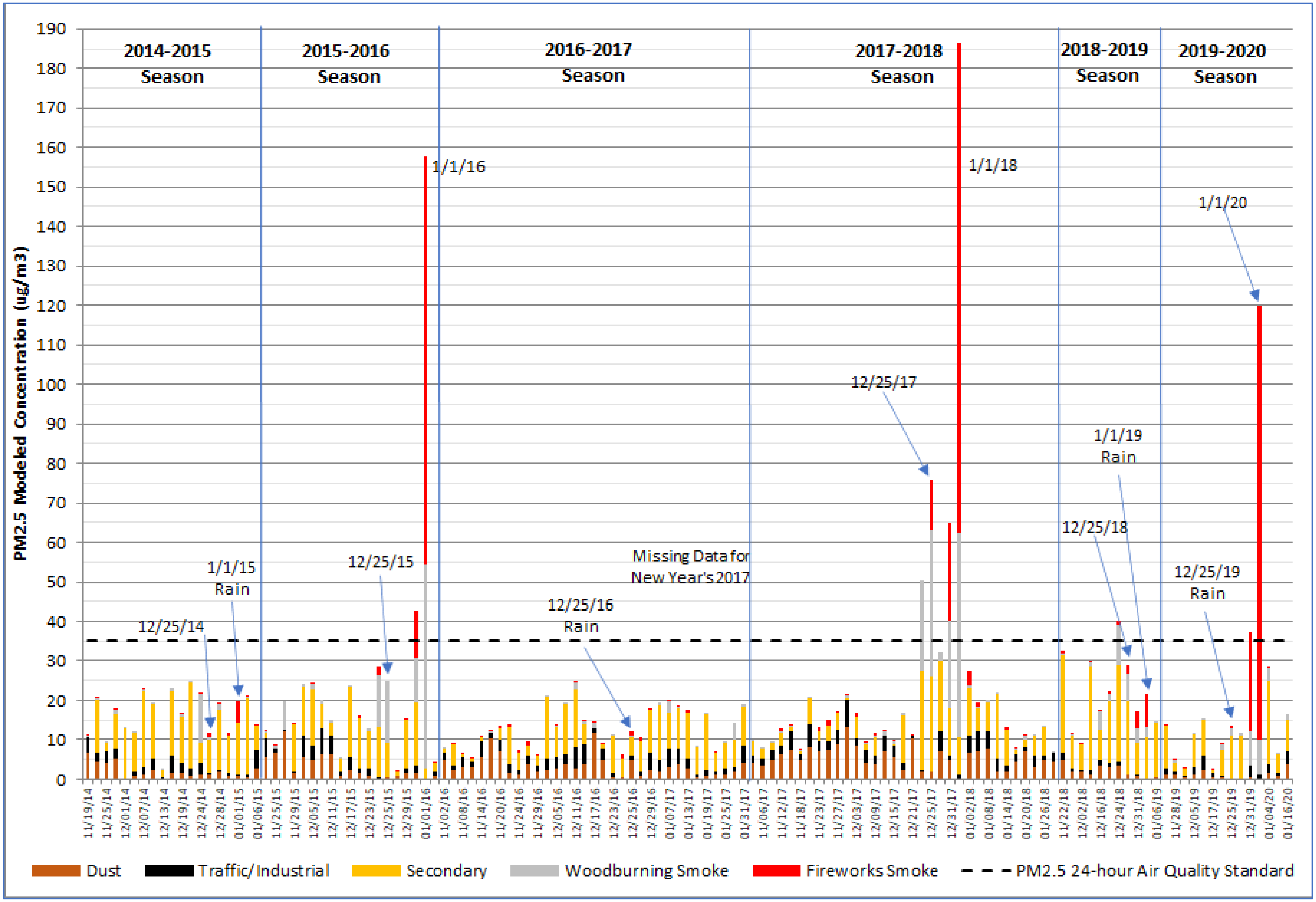


Figure 31. Actual daily modeling results for the six seasons (2014-2020) of speciated $PM_{2.5}$ sampling. Christmas and New Year holidays, including those with rain events, are noted on the chart.



CONCLUSIONS

There were two main goals in this study; conclusions are shown in relation to these goals:

1. The first goal was to analyze the data coming from the EPA's PurpleAir network to discover $PM_{2.5}$ average concentrations in previously unmonitored locations.

    - Twenty-three PurpleAir sensors were deployed in the Phoenix metro area for the EPA study and data from fifteen of these sensors were suitable to be used toward this goal. Data from these low-cost sensors and the regulatory monitors showed that the highest $PM_{2.5}$ concentrations tend to be located in the southwest areas of the study area.
    - The hotspots of $PM_{2.5}$ are concentrated near the Thirty-third, West Phoenix, Indian School, and West 43rd Avenue monitoring sites, in that order. The temporary PurpleAir sensors were essential in identifying locations that have consistently higher $PM_{2.5}$ concentrations.
    - Spatiotemporal analysis demonstrated that the highest concentrations occurred in the evenings, night, and early morning (6 p.m. – 5 a.m.) and on the weekends (Friday-Sunday). The highest concentrations were in residential areas in the 6 p.m. – 12 a.m. time period, which is consistent with residential wood burning activities. In the 12 a.m. – 5 a.m. time period the highest concentrations tended to be in the lower elevations near the Salt River (close to the Thirty-third, Durango Complex, and West 43rd Avenue monitoring locations), which is indicative of early morning atmospheric subsidence leading to smoke transport.

2. The second goal of the study was to have chemical speciation data available to support an exceptional event demonstration. This is especially important during the New Year's holiday when fireworks smoke can reach concentrations high enough to exceed PM_{10} NAAQS (the 24-hour PM_{10} NAAQS are 150 $\mu g/m^3$). The ability to use speciation data and PMF modeling to quantify the contribution of PM from fireworks is useful for the demonstration since PM_{10} exceedances caused by holiday fireworks qualify as exceptional events.

    - Concentrations of PM_{10} on New Year's Day did exceed the PM_{10} NAAQS. The 24-hour average PM_{10} at the West Phoenix monitoring site was 159.6 $\mu g/m^3$; 149.1 $\mu g/m^3$ of this was $PM_{2.5}$. PMF modelling of the speciated $PM_{2.5}$ data demonstrated that 109.8 $\mu g/m^3$ of this 24-hour average resulted from the fireworks factor. The exceptional event was demonstrated because the data provide strong evidence that there would not have been a PM_{10} exceedance if not for the New Year's fireworks celebrations.

PurpleAir and the Phoenix Testbed for Air Quality Sensors Project

Ron Pope, PhD and Ira Domsky
Planning and Analysis Division

January 19, 2022

Maricopa County AIR QUALITY DEPARTMENT

Overview

- What is PurpleAir
- U.S. Environmental Protection Agency (EPA) low-cost sensor program
- The Phoenix Testbed for Air Quality Sensors (PTAQS) project
  - Phase 1 – testing and initial calibration
  - Phase 2 – wide scale deployment
- Results and Lessons Learned
- Using PTAQS data – Analysis of 2019-2020 winter burn season

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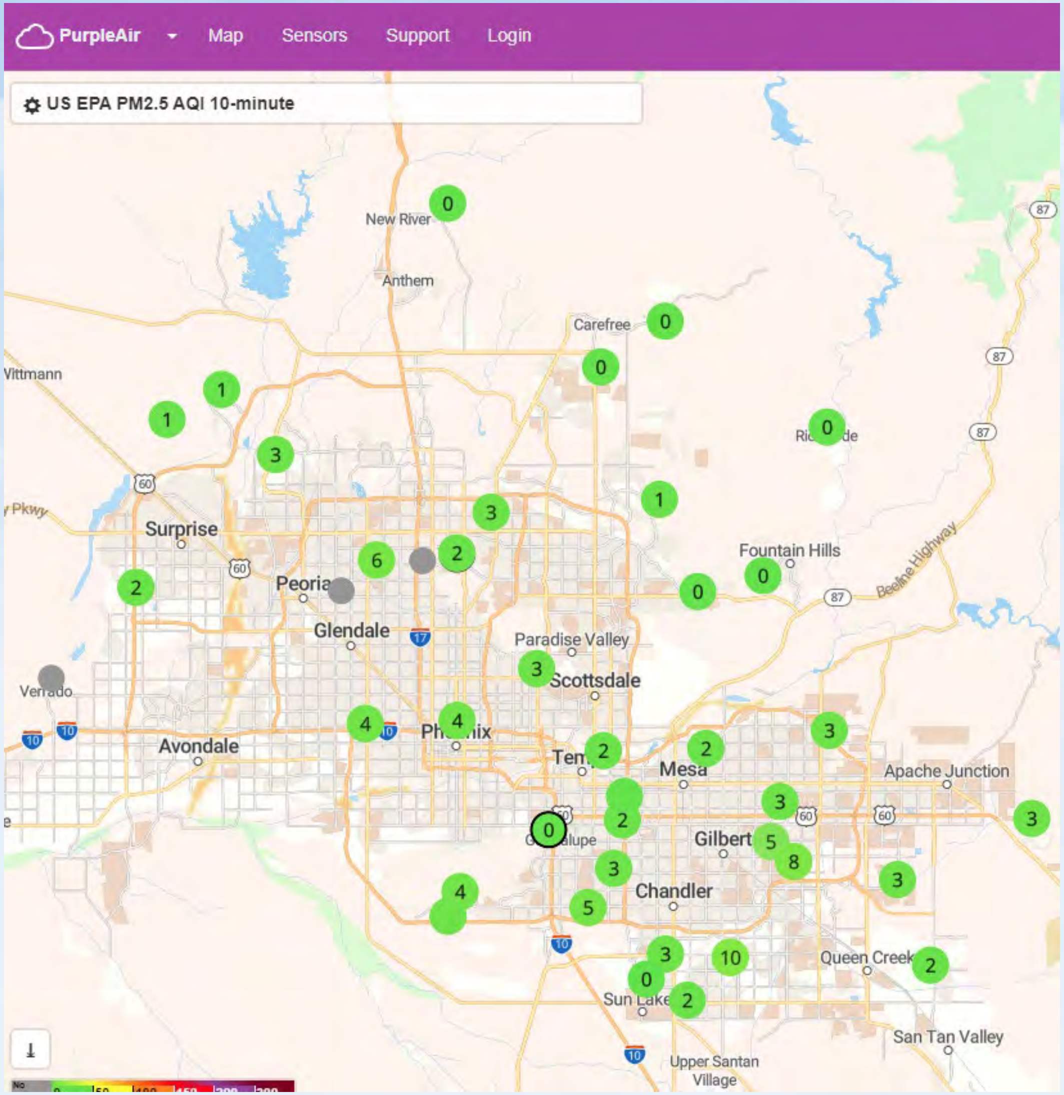
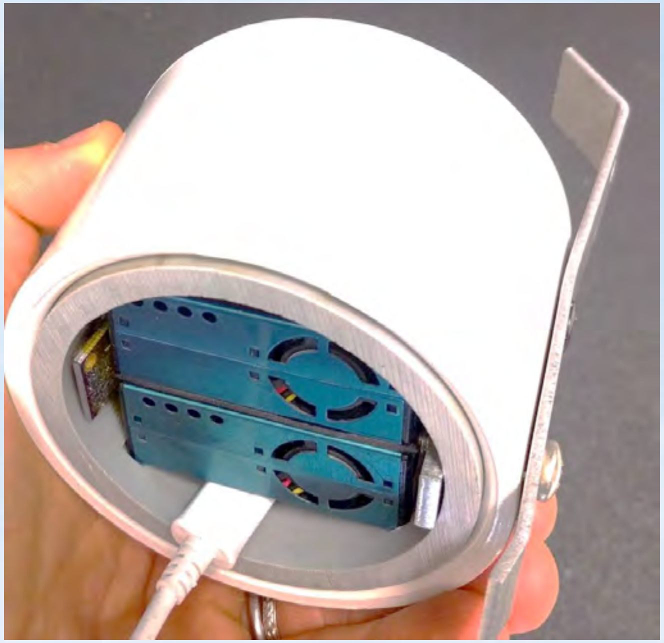
What is a PurpleAir Sensor?





PurpleAir Sensor

- 2 Plantower PMS5003 optical particle counters (channels A & B)
- PM_{10}, $PM_{2.5}$, $PM_{1.0}$
- Temperature, Relative Humidity
- 2-minute resolution
- ~$250

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Reliability of PurpleAir Data

- Probably the most studied and widely used low-cost sensor
  - Several thousand in the U.S., many which have been deployed by government agencies (see www.purpleair.com/map)
  - PM_{10} precision and accuracy are poor
  - $PM_{2.5}$ precision is good, but accuracy requires use of correction factors to correct high-bias
    - PurpleAir web site has four different correction factors that can be applied

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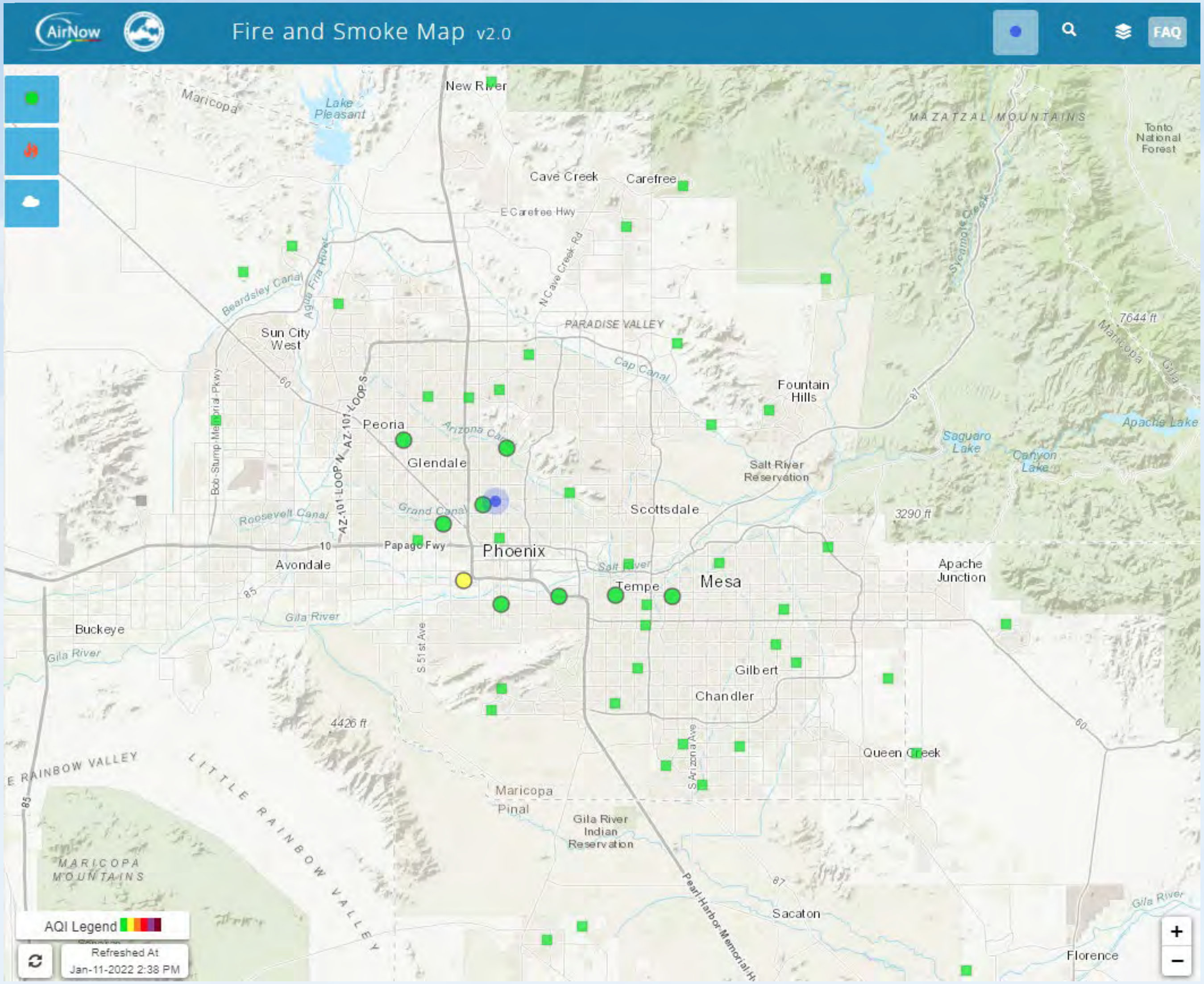
AirNow Fire and Smoke Map



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EPA's Low-Cost Sensor Programs

- Started around 2010 in response to "maker" technologists
- Understanding technologies available for public use and provide context for data collected by the public
- Evaluation of sensor precision, accuracy and durability started about 8 years ago
  - See www.aqmd.gov/aq-spec
- Development of "citizen science" tool kits
- Application through Village Green and grant programs

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PTAQS Project

- EPA Office of Research and Development: Center for Environmental Measuring and Modeling
  - Precision, accuracy and durability of sensors evaluated
  - Part of a national testbed study including several other states
  - No testing had been done in an arid, dusty, hot region of the country

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PTAQS Phase One

- November 2018 - June 2019
- Collocation of PurpleAir sensors with FEM monitors at three sites.
  - Tapered element oscillating microbalance (TEOM)
  - Teledyne T640
- MCAQD also conducted a winter fireplace smoke study in 2018-2019 in conjunction with Phase 1.
  - 10 PurpleAir sites
  - Focused on $PM_{2.5}$
  - Also measured PM_{10}

West Phoenix Monitoring Site

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PTAQS Phase Two

- July 2019 – March 2021
- Larger field study using sensors in a distributive network
  - 20 PurpleAir sites, some with wind sensors
  - Mobile FEM for Quality Assurance
  - Four black carbon analyzers
- Data uploaded to password protected database

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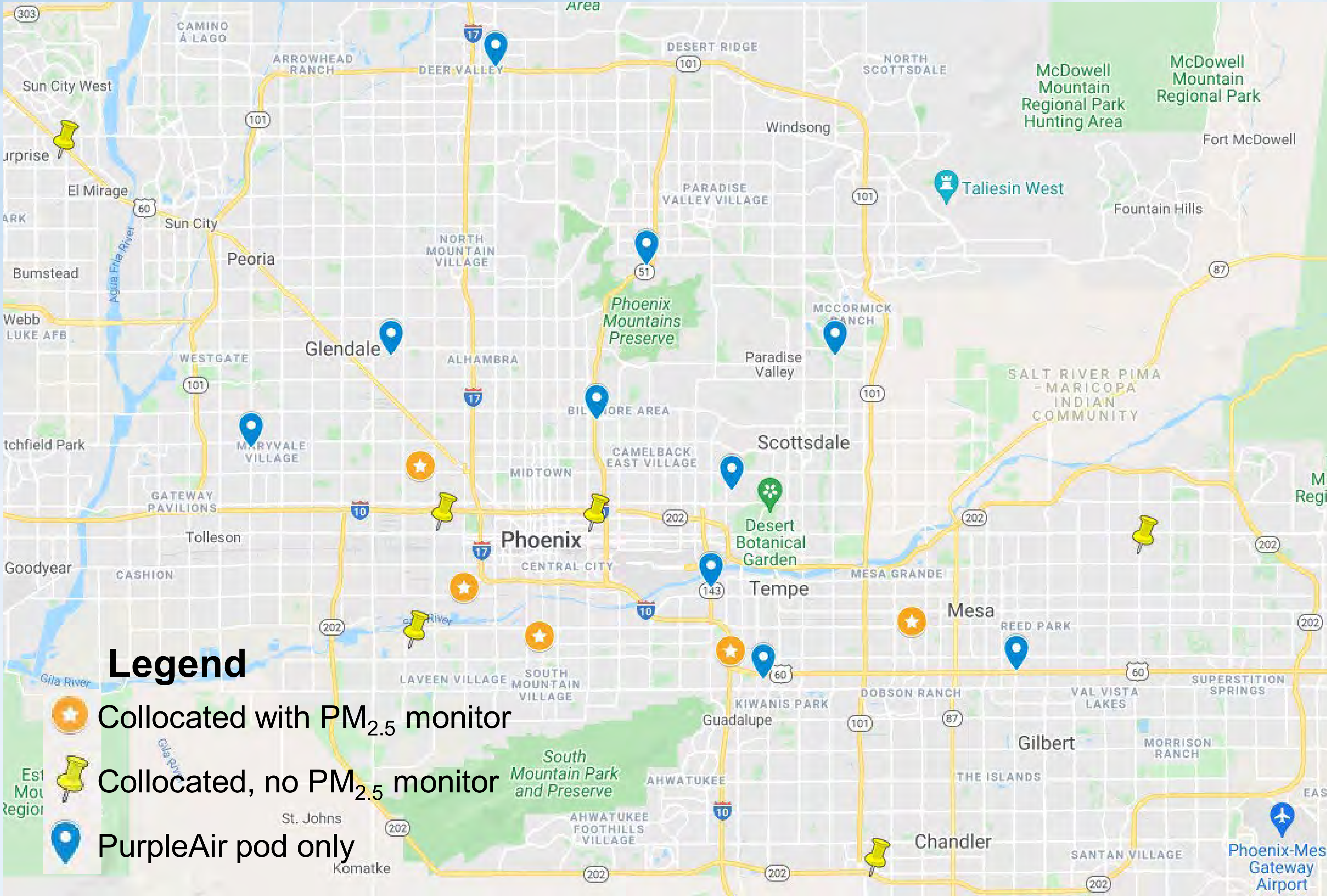
PTAQS Phase Two Network



Lessons Learned

- Operation & Maintenance (O&M) Issues
  - Off-the-shelf equipment
  - Wi-Fi hotspots
  - High temps in the field
    - Internal PurpleAir temperatures as high as 149.5 °F
- Failure/Replacement Rates (Phase Two)
  - 34% total replacement rate since beginning of study
  - 17% replacement rate on sensors operating at least a year

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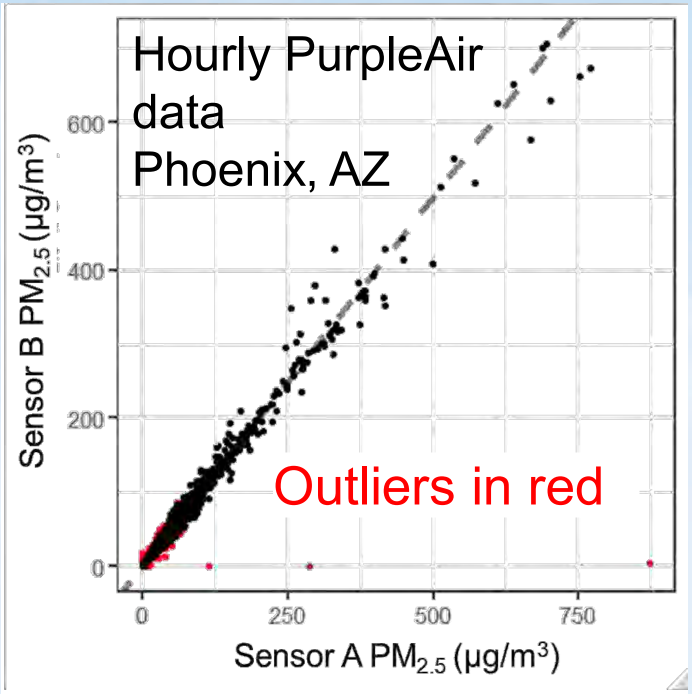
Lessons Learned – Data Issues

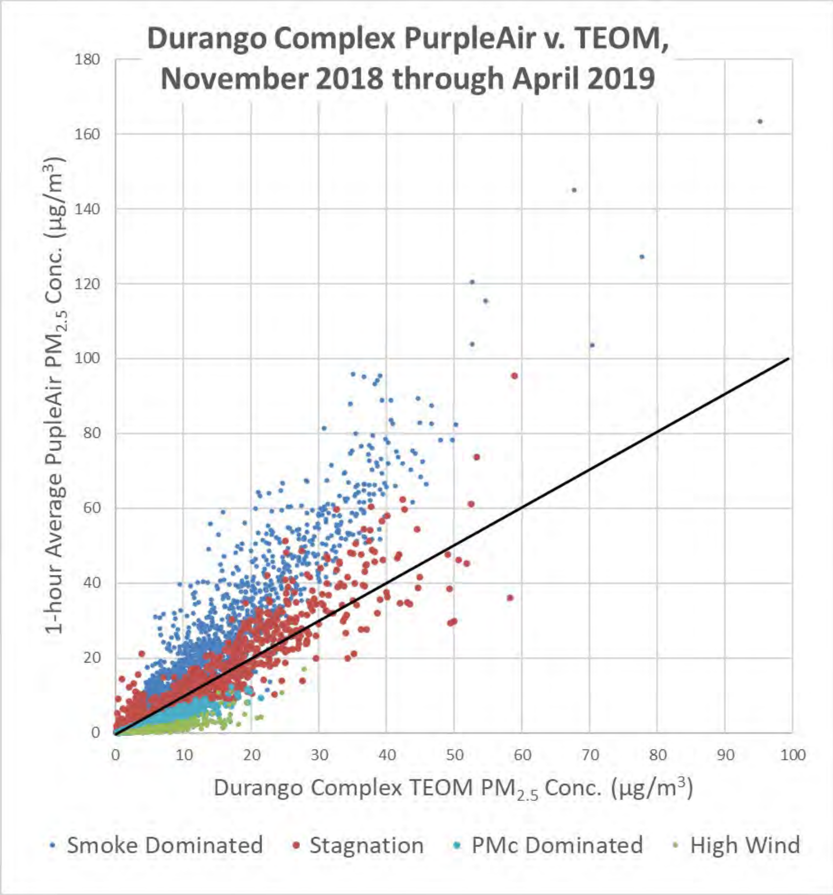
- Continuous data quality/validation checks of network
  - o Are there connectivity issues?
  - o Equipment malfunctions?
- PurpleAir Data Cleaning/Formatting
  - o Formatting irregularities removed
  - o A & B channels compared, and outliers flagged
  - o Raw data might need to be averaged to longer time interval



A comparison of A & B channels with outliers flagged.

Lessons Learned – Sensor Performance

- $PM_{2.5}$ data has acceptable precision, but accuracy bias differs
  - Aerosol composition affects performance
  - Meteorology, especially windspeeds >18 mph, affects performance
- $PM_{2.5}$ data can be significantly improved with correction factors



Another Lesson Learned: Value of Black Carbon Analyzers

- Helped document presence of transported wildfire smoke for ozone exceptional event assessments and winter wood smoke
- Helped select appropriate instrument for MCAQD
  - Aethlab analyzers used by EPA clogged, resulting in lost data
- A surrogate measure of presence of fireworks in $PM_{2.5}$

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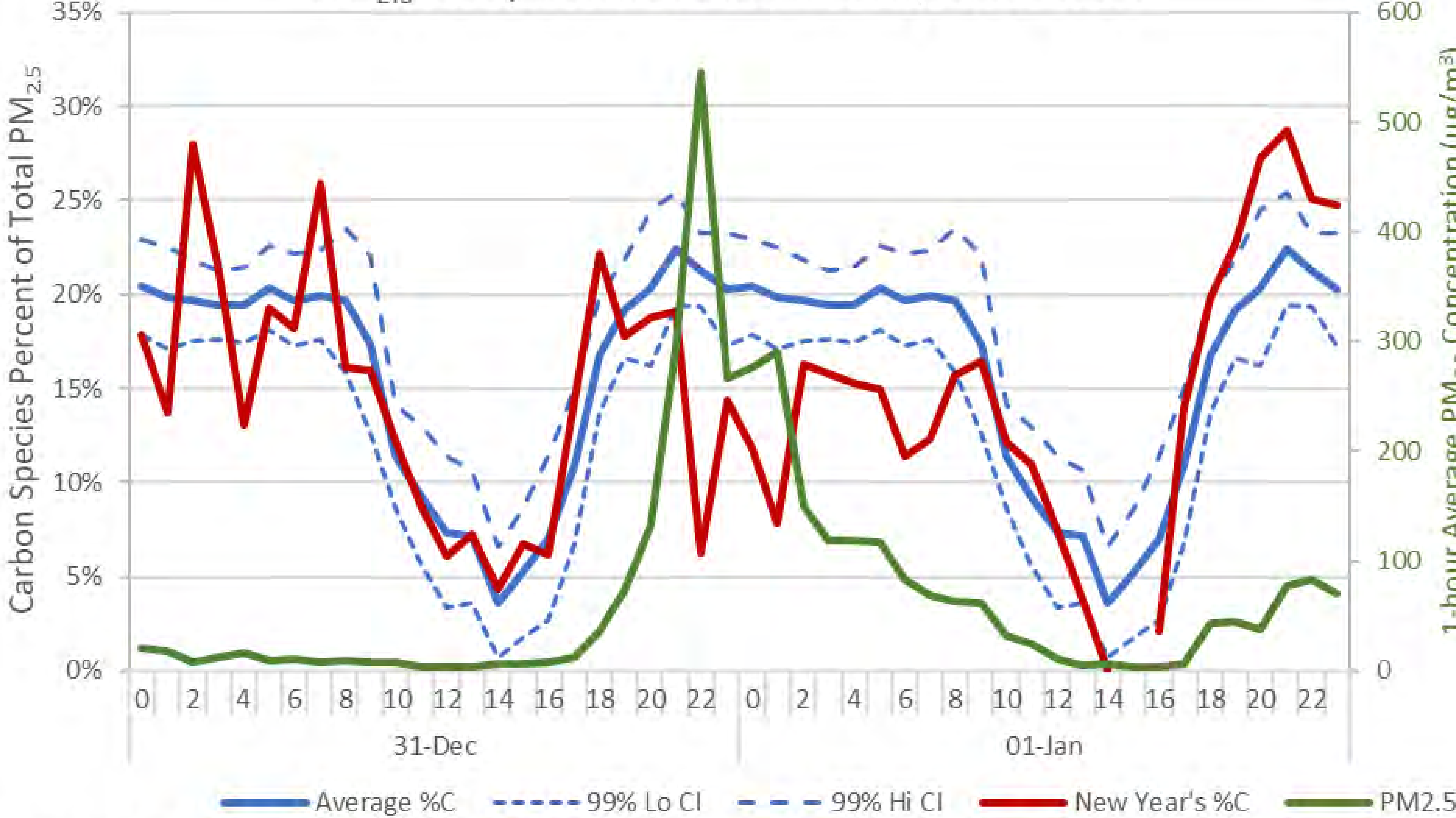
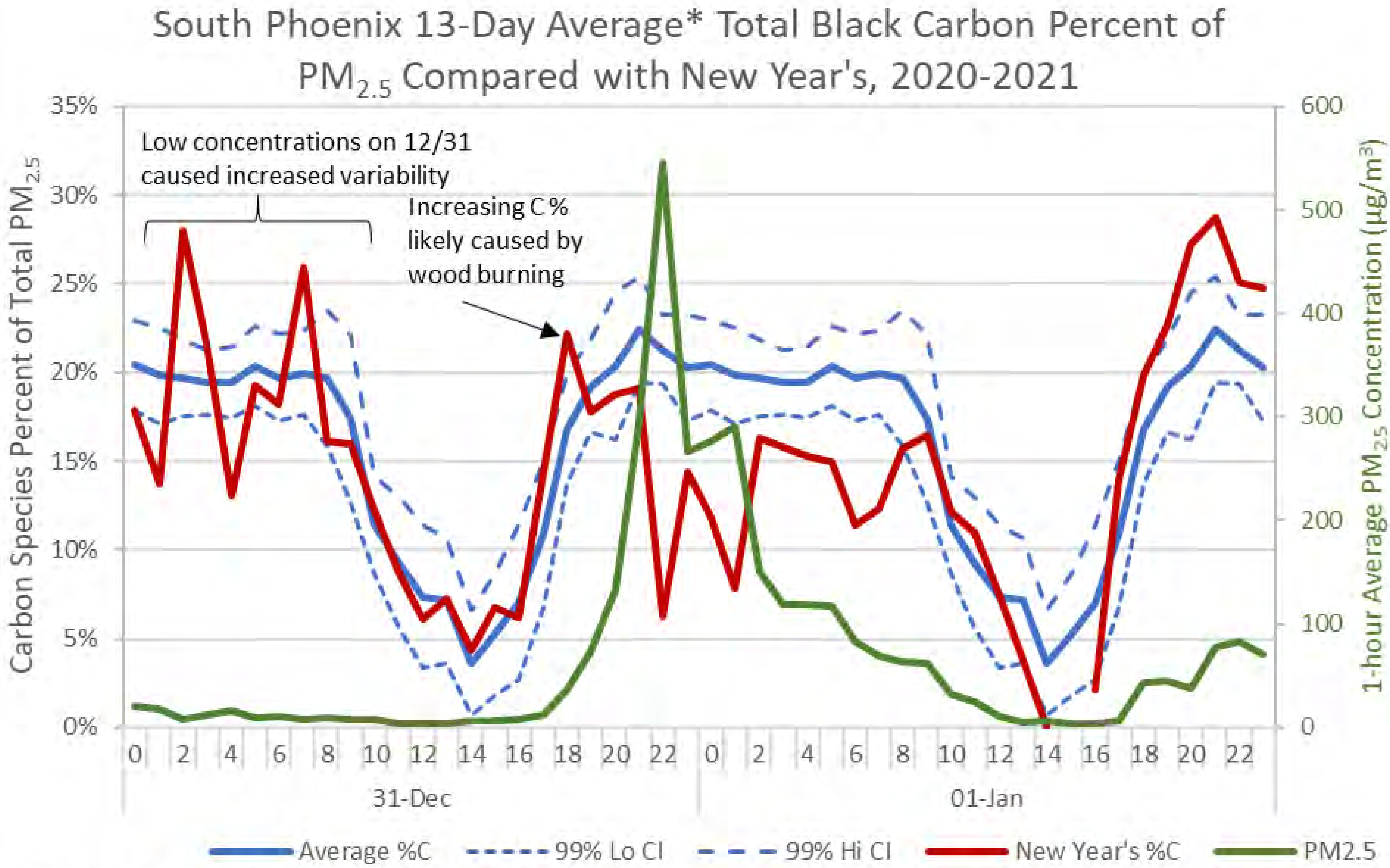
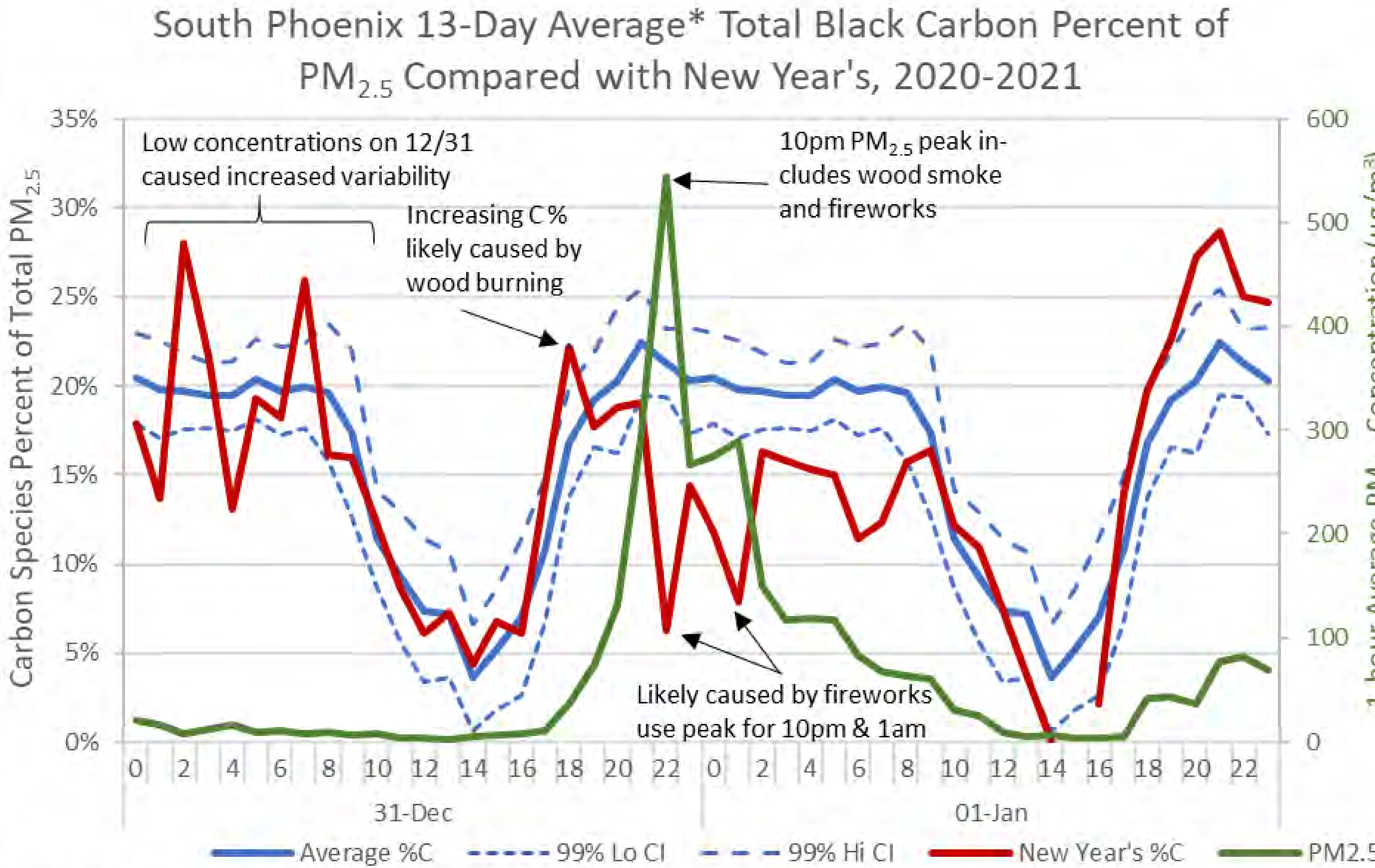
South Phoenix 13-Day Average* Total Black Carbon Percent of $PM_{2.5}$ Compared with New Year's, 2020-2021



*Averaging period is 12/16-22/20 and 1/2-9/21



*Averaging period is 12/16-22/20 and 1/2-9/21



*Averaging period is 12/16-22/20 and 1/2-9/21

The Research Team

- EPA – Sue Kimbrough, Andrea Clements, Ian VonWald
- MCAQD
  - Deployment, troubleshooting, O&M
    - Ben Davis, Bob Dyer and his team of tireless techs, Nikki Peterson, Hirna Patel
  - Consultation and data analysis
    - Ira Domsky and Ron Pope

Thank you.

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Maricopa County AIR QUALITY DEPARTMENT

Gmail AirPlanning - AZDEQ <airplanning@azdeq.gov>

PM 2.5 ruling comment

1 message

carolyn wesolek <carolynwesolek@yahoo.com> Fri, Jun 28, 2024 at 10:11 AM
To: "AirPlanning@azdeq.gov" <AirPlanning@azdeq.gov>

Please consider moving the PM 2.5 requirements west in PHX from the current 303 boundary to the white tanks mountains so that the facilities being Built west of the 303 are included.
Thank you,
Carolyn Wesolek
541-223-1335
carolynwesolek@yahoo.com