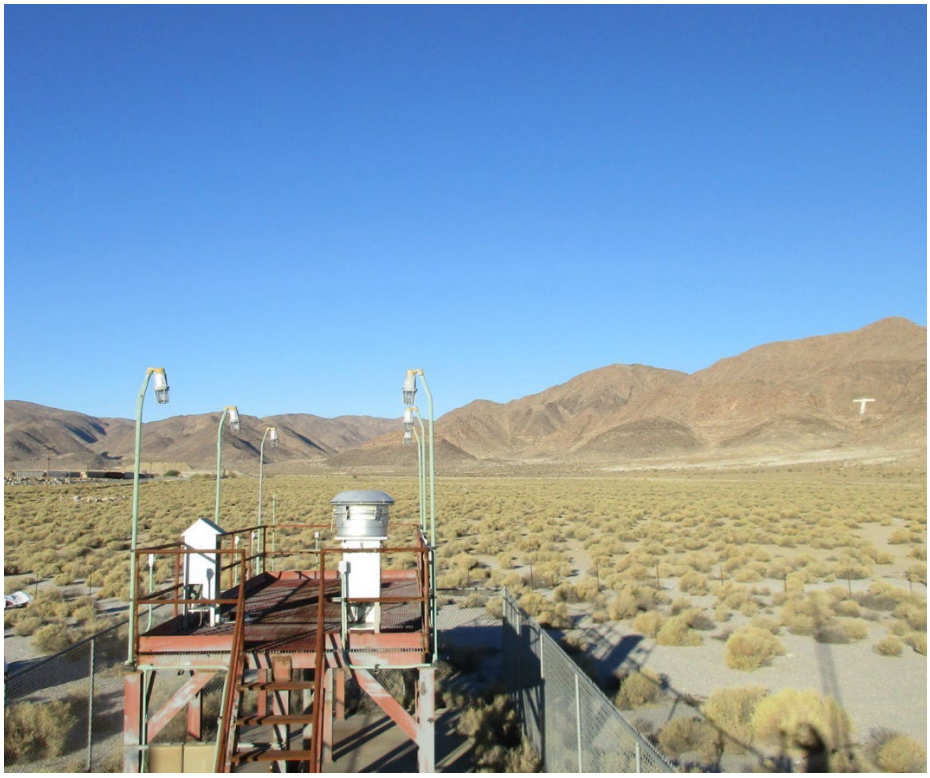
Annual Report on California Air Resources Board's Fine Particulate Matter Monitoring Program July 2022



CALIFORNIA AIR RESOURCES BOARD

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Background

Health and Safety Code, Section 39619.5(g) requires the California Air Resources Board (CARB) to provide an update each year on the status and results of the fine particulate matter ($PM_{2.5}$) monitoring program. This report provides a summary of $PM_{2.5}$ monitoring activities in 2021 and how the data are being used to support CARB programs.

California's $PM_{2.5}$ air quality monitoring program provides information used for determining which areas violate $PM_{2.5}$ standards, characterizing the sources that contribute to $PM_{2.5}$ pollution, determining background concentrations, assessing pollution transport, and supporting health studies and other research. Monitoring data also provide information to develop and evaluate programs for improving air quality. Newly emerging technologies are evaluated and incorporated continuously in California's $PM_{2.5}$ monitoring program to provide improved monitoring data.

California's $PM_{2.5}$ regulatory monitoring network, jointly operated by CARB and the local air districts, began collecting data in 1998. A number of different types of $PM_{2.5}$ regulatory monitors are operated to provide data on $PM_{2.5}$ mass and chemical composition which are summarized below. The type and number of $PM_{2.5}$ regulatory monitors in operation has changed from year to year depending upon programmatic needs and available funding.

$PM_{2.5}$ monitors intended to provide $PM_{2.5}$ data for regulatory purposes are identified as either Federal Reference Method (FRM) or Federal Equivalent Method (FEM) monitors. FRM $PM_{2.5}$ monitors use the oldest method, which relies on weighing $PM_{2.5}$ collected on filters. Measurement of $PM_{2.5}$ in the air has evolved over time as new instruments have been developed. FEM $PM_{2.5}$ monitors, for example, continuously measure $PM_{2.5}$ mass concentration using more recently developed measurement technologies. $PM_{2.5}$ non-regulatory monitors are not used to provide $PM_{2.5}$ data for regulatory purposes primarily due to not meeting federal monitoring requirements.

Figure A1 displays the locations of $PM_{2.5}$ regulatory monitors throughout the State. Due to the statewide stay-at-home order in March 2020, CARB was forced to reduce its air monitoring operations. Air monitoring operations were reduced to essential functions for the ozone, $PM_{2.5}$, and PM_{10} programs. CARB continued to remotely operate the other continuous parameters (CO, NOx, SO2) as resources allowed. All operations were implemented with personnel health and safety requirements following recommendations from the California Department of Public Health and Center for Disease Control guidelines.

In early December 2020, a new statewide stay-at-home order required CARB to further reduce its operations. CARB's air monitoring support was limited to only 3 sites (Bakersfield-California, Bakersfield-Southeast Planz, and Portola), which were deemed critical for attainment determinations. CARB worked closely with the U.S. Environmental Protection Agency (U.S. EPA) and local agencies to inform them of the situation and the potential

impacts. In February 2021, CARB received approval to resume its air monitoring operations for all programs at all sites.

In April and May 2021, CARB resumed full air monitoring operations for all programs at all sites. All operations were implemented with personnel health and safety requirements following recommendations from the California Department of Public Health and Center for Disease Control guidelines. CARB continues to work closely with the U.S. EPA and local agencies to inform them of the situation and any updates. During the interlude, many FRM monitors were replaced by FEM units to reduce staff maintenance and operation demands during COVID stay-at-home orders.

Additional information on $PM_{2.5}$ monitoring can be found on our *Ambient Air Monitoring-Regulatory*[1] and *Community Air Monitoring*[2] webpages.

PM2.5 Monitor Siting

The $PM_{2.5}$ monitoring network consists of sites owned and operated by State, Local, and Tribal monitoring agencies and is comprised of manual Federal Reference Methods (FRMs) and automated continuous Federal Equivalent Methods (FEMs). The primary use of both types of methods is to assess compliance with the *PM2.5 National Ambient Air Quality Standards (NAAQS)*. Since continuous FEMs are automated, they are also readily used to support forecasting and reporting of $PM_{2.5}$ in the Air Quality Index (AQI). The requirements for monitoring $PM_{2.5}$ can be found in *40 CFR part 58 Appendix D*.[3]

$PM_{2.5}$ monitoring sites are to be population-oriented, measuring exposures where people live, work, and play. For comparison to the annual $PM_{2.5}$ standard, the locations must be community-oriented and as such, these do not necessarily correspond to the locations of highest PM concentrations in an area. Existing Metropolitan Statistical Areas are first examined to determine where the majority of the people live in each state. These are then broken down into smaller populated entities which may include county, zip code, census tract, or census block boundaries. Combinations of these population entities are combined to define Metropolitan Planning Areas. These may be further sub-divided into Community Monitoring Zones, based on examination of existing PM measurements, source locations, terrain, and meteorology. Finally, $PM_{2.5}$ monitors are located at specific sites that represent neighborhood or urban scales to determine compliance with the annual standard and at maximum, population oriented locations for comparison with the 24-hour standard. Transport and background sites are located between and away from planning areas to determine regional increments to PM measured within the planning area.

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[1] *https://ww2.arb.ca.gov/our-work/programs/ambient-air-monitoring-regulatory*
[2] *https://ww2.arb.ca.gov/capp-resource-center/community-air-monitoring*
[3] *https://www.govinfo.gov/content/pkg/CFR-2021-title40-vol6/pdf/CFR-2021-title40-vol6-part58-appD.pdf*

Federal Reference Method Monitors

The installation of federally-approved $PM_{2.5}$ mass monitors throughout California began in 1998. Prior to stay-at-home orders in March 2020, FRM (Figure 1) monitors were operated at 57 sites. To address the COVID stay-at-home order and minimize staff travel, many of these FRM monitors were replaced with FEM monitors that operate on a continuous basis and report $PM_{2.5}$ concentrations on a real-time basis. The three FRM monitors that remained collected particulate samples on filters, later weighed and analyzed in a laboratory. Because of this two-step process, $PM_{2.5}$ air quality data collected with FRM monitors are not immediately available. This approach is more labor intensive and provides less temporal resolution than the continuous $PM_{2.5}$ mass monitors CARB began to add to the network in the late 1990s.

Figure 1. Federal Reference Method Monitor

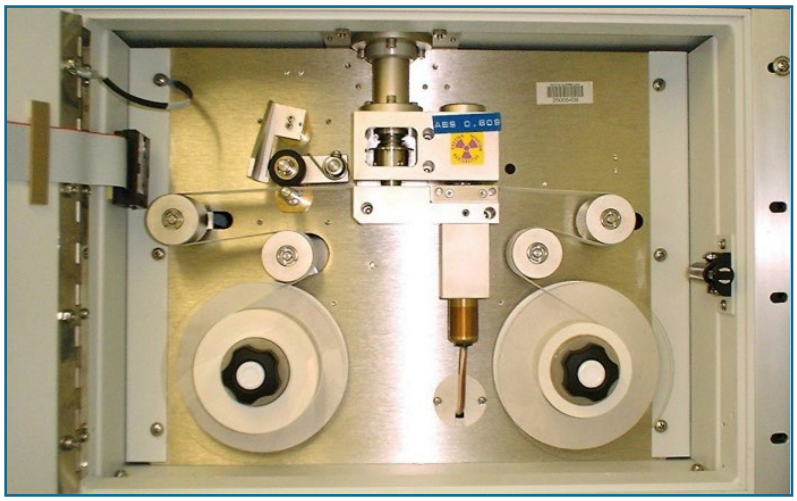
Continuous Mass Monitors

Continuous $PM_{2.5}$ concentration monitors provide valuable information for public reporting on $PM_{2.5}$ levels, temporal representation, health studies, transport studies, and background monitoring. $PM_{2.5}$ concentrations can be measured continuously with several different commercially available technologies. CARB chose the Beta Attenuation Monitor (BAM,

Figure 2) for use in California and several other types of continuous monitors (e.g., laser light scattering monitors) for limited use. BAM was first introduced to CARB $PM_{2.5}$ network in 1999. The U.S. EPA designated certain models of the continuous monitors as *FEM monitors*.[4] FEM monitors are considered equivalent to the FRM monitors and therefore used to determine compliance with federal standards. In addition to being less labor intensive than filter-based methods, continuous concentration monitors provide data at an hourly temporal resolution. CARB is continuously evaluating California's $PM_{2.5}$ monitoring network to determine if the existing sites meet U.S. EPA requirements and State programmatic needs.

Before stay-at-home orders in March 2020, 67 FEM monitoring sites were measuring $PM_{2.5}$ concentrations. As a result of the orders and temporary closure of the $PM_{2.5}$ laboratory, a number of FEM monitors replaced FRM monitors throughout the state. As of the end of 2021, 77 FEM monitors were being operated in the state.

Figure 2. Beta Attenuation Monitor



Air Quality Sensors

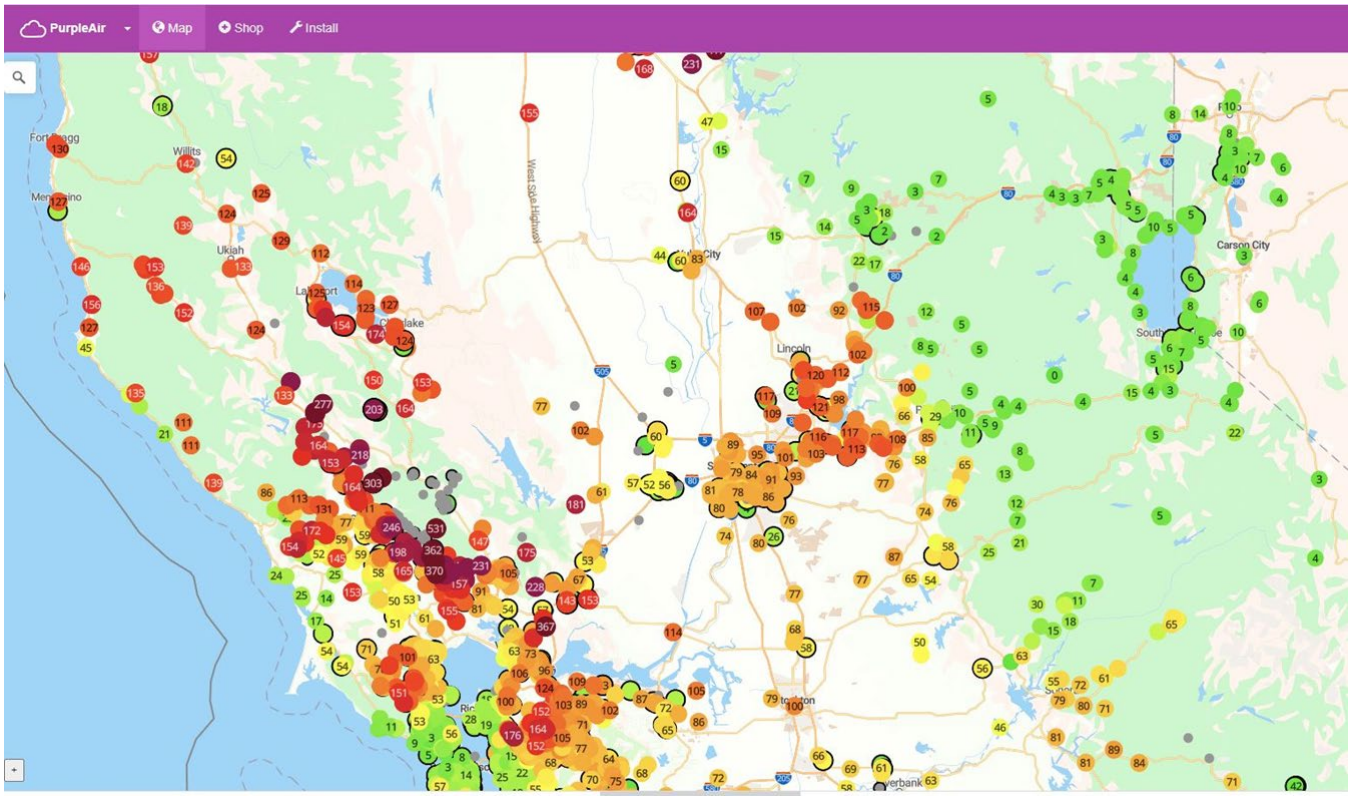
$PM_{2.5}$ concentrations can be estimated in real time with air quality sensors. Air quality sensors for $PM_{2.5}$ are newly emerging, low cost methods using optical sensors to count $PM_{2.5}$ particles and then estimate $PM_{2.5}$ concentrations. $PM_{2.5}$ sensors are non-regulatory monitors that are not used to provide $PM_{2.5}$ data for regulatory purposes because of concerns about their accuracy. However, $PM_{2.5}$ sensor data can be accessed instantly via the Internet and provide data at a 5-minute or better temporal resolution. As of December 2021, more than 6,000 non-regulatory air quality sensors have been purchased and deployed across California by community groups, government agencies, private citizens, and others. Figure A1 displays the locations of $PM_{2.5}$ sensors across the State as of December 2021. As an example, Figure 3

[4] *https://www.epa.gov/amtic/air-monitoring-methods-criteria-pollutants*

shows instantaneous $PM_{2.5}$ sensor concentrations in the Sacramento region at 11:40 pm on September 28, 2020 during the Glass Fire in Napa Valley. Real-time $PM_{2.5}$ data from air quality sensors can be found on the *PurpleAir: Real-time Air Quality Monitoring* website[5] as well as the

IVAN (Identifying Violations Affecting Neighborhoods) Imperial Air Monitoring website[6]. In the future, CARB may use air quality sensor information to site PM2.5 monitors.

Figure 3. $PM_{2.5}$ concentrations measured by PurpleAir Sensors in the Sacramento Region on September 28, 2020



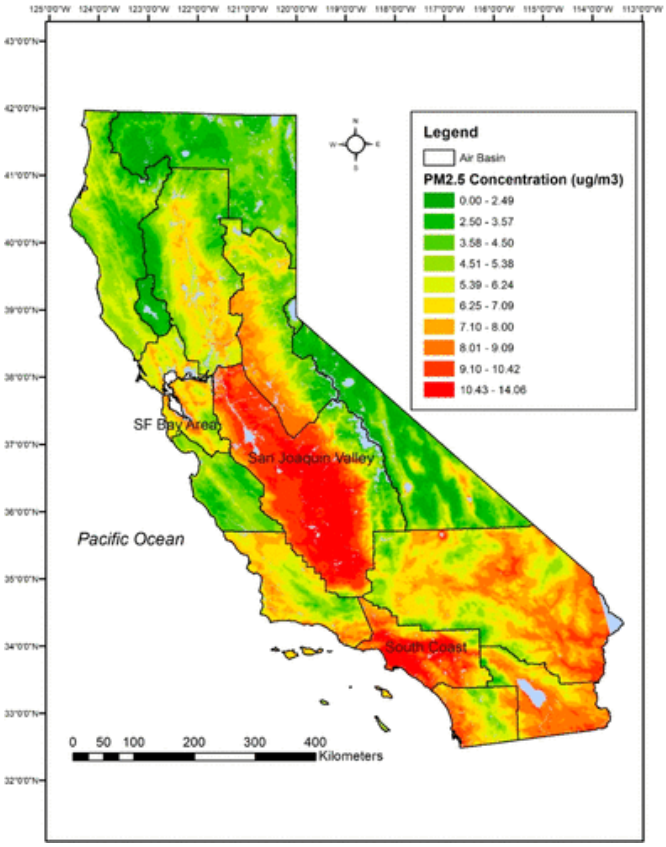
Satellite Remote Sensing

Satellite remote sensing has been used to estimate $PM_{2.5}$ concentrations and subsequently evaluate the spatial variabilities in $PM_{2.5}$ concentrations. Technologies have improved such that certain types of satellite data (e.g., aerosol optical depth) can be used to estimate the concentrations of $PM_{2.5}$ components, such as nitrate, sulfate, organic carbon, and elemental carbon. Satellite remote sensing can fill in $PM_{2.5}$ data in areas where there are no land-based

[5] *https://www2.purpleair.com/*
[6] *https://ivan-imperial.org/air/list*

$PM_{2.5}$ monitors and may be used in the future along with other information to site PM2.5 monitors. Satellite remote sensing refines our understanding of $PM_{2.5}$ spatial distribution and tracks $PM_{2.5}$ trends that assess the effectiveness of $PM_{2.5}$ mitigation strategies. The main disadvantage of satellite-based $PM_{2.5}$ measurements compared to land-based measurement methods is accuracy and temporal resolution (typically daily snapshots). For example, Figure 4 shows satellite-based $PM_{2.5}$ concentrations in 2016 (Lee,H.J., 2019. Environ. Sci. Technol. 53(21), 12774-12783)

Figure 4. Statewide variability in satellite-based annual average $PM_{2.5}$ concentrations in 2016



Speciation Monitors

Another major stage of network implementation is the deployment of $PM_{2.5}$ speciation monitors (Figure 5). Speciation monitoring provides valuable information about the composition, and ultimately, the sources of $PM_{2.5}$ pollution. In 2014, along with states, U.S. EPA conducted a nationwide assessment of the $PM_{2.5}$ speciation network to determine whether the sites were meeting programmatic objectives and were still needed. Goals of the assessment were to create a speciation network that is sustainable going forward, redistribute resources to new or high priorities from those of low-priority or low-benefit,

extract more value from the existing network, fully leverage the value of other existing networks. The review[7] determined that all of the sites in California were needed and should continue to operate. The locations of California's speciation monitors are shown in Figure A2.

Figure 5. Speciation Monitor

Federally-Required Speciation Monitors

There are two components to the $PM_{2.5}$ speciation network in California. The first component, mandated by the U.S. EPA, requires filter-based $PM_{2.5}$ speciation monitoring at seven California sites that are now part of a national trends network for $PM_{2.5}$ speciation. The sites were selected based on a balance of many factors including location of an existing PAMS monitor, size of the urban area, and ozone and PM10 nonattainment status. These monitors are part of the Chemical Speciation Network (CSN) that are used to assess trends, develop state implementation plans, develop emission control strategies, track control program progress, aid in interpreting health studies, characterize seasonal and spatial variations of PM2.5 pollution. The seven CSN $PM_{2.5}$ speciation monitors are located in Bakersfield, El Cajon, Fresno, Los Angeles, Riverside, Sacramento, and San Jose.

[7] *CSN and IMPROVE Protocol Network Assessment | US EPA*

Additional Speciation Monitors

The second component of California's $PM_{2.5}$ speciation network is the deployment of samplers at Chemical Speciation Network (CSN) sites located at selected State and Local Air Monitoring Stations (SLAMS). Data from these sites provide additional information needed for developing effective air quality attainment plans. The focus of the $PM_{2.5}$ CSN is to enhance the spatial coverage of the CSN sites, particularly in areas with elevated PM levels.

CARB and local air districts operate filter-based speciation monitors at seven sites-Calexico, Chico, Mammoth Lakes, Modesto, Portola, Sacramento, and Visalia.

In 2007, CARB began monitoring for specific wood smoke tracers to determine the contribution of wood burning sources to $PM_{2.5}$ levels. Wood smoke tracers are being monitored at all six of the CSN sites-Calexico, Chico, Modesto, Portola, Sacramento, and Visalia during the winter season.

Accessing PM2.5 Data

Data collected as part of California's $PM_{2.5}$ monitoring program may be obtained in several ways. Daily $PM_{2.5}$ values as well as summary statistics can be accessed through the interactive query tool on CARB's *iADAM: Air Quality Data Statistics* webpage.[8]

Real-time hourly $PM_{2.5}$ data from California's continuous monitors can also be found at *Air Quality and Meteorological Information System (AQMIS)* webpage.[9]

AQview is a new community-focused air quality monitoring data portal bringing together many data sources across the State. The AQview Continuous Monitoring Download Tool is live and providing access to community air quality data. This information can be fount at the *AQview - Air Quality Viewer - California Air Resources Board* wepage.

PM2.5 Designations

The Clean Air Act requires the U.S. EPA to set national ambient air quality standards to protect public health, and to designate nonattainment areas that do not meet the national standards. U.S. EPA has set $PM_{2.5}$ ambient air quality standards with two averaging periods: 24-hour and annual. Further, CARB has established a more health protective State $PM_{2.5}$ ambient air quality standard as required by California State law. California State law also requires CARB to designate each area as attainment, nonattainment, or unclassified for the State standard. State and national $PM_{2.5}$ ambient air quality standards are shown in Table 1.

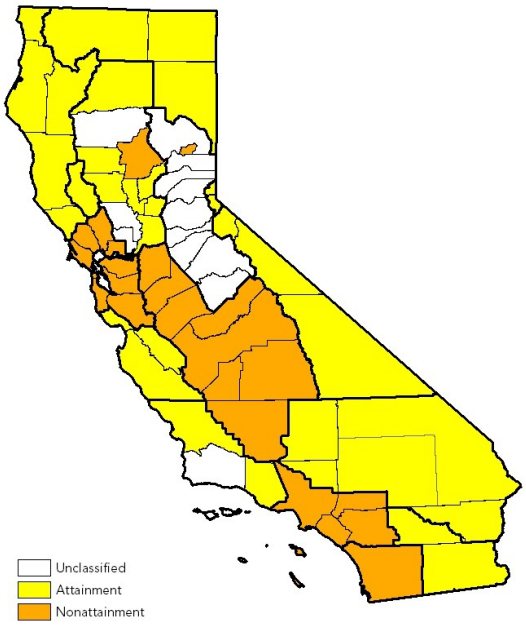
[8] *https://www.arb.ca.gov/adam*
[9] *https://www.arb.ca.gov/aqmis2/aqmis2.php*

Table 1. State and National $PM_{2.5}$ Ambient Air Quality Standards (µg/m³)

AAQS	California	National
Annual	12	12.0
24-hour	---	35

Based on 2018-2020 air quality data collected as part of California's $PM_{2.5}$ monitoring network, CARB designates the attainment status of areas with respect to the State annual average $PM_{2.5}$ ambient air quality standard of 12 µg/m³. Most urban areas of California, as well as several more isolated sub-areas, exceed the State $PM_{2.5}$ standard (Figure 6). However, as air pollution control programs have reduced $PM_{2.5}$ concentrations, more areas now meet the State $PM_{2.5}$ ambient air quality standard.

Figure 6. Designations for the State annual $PM_{2.5}$ ambient air quality standard

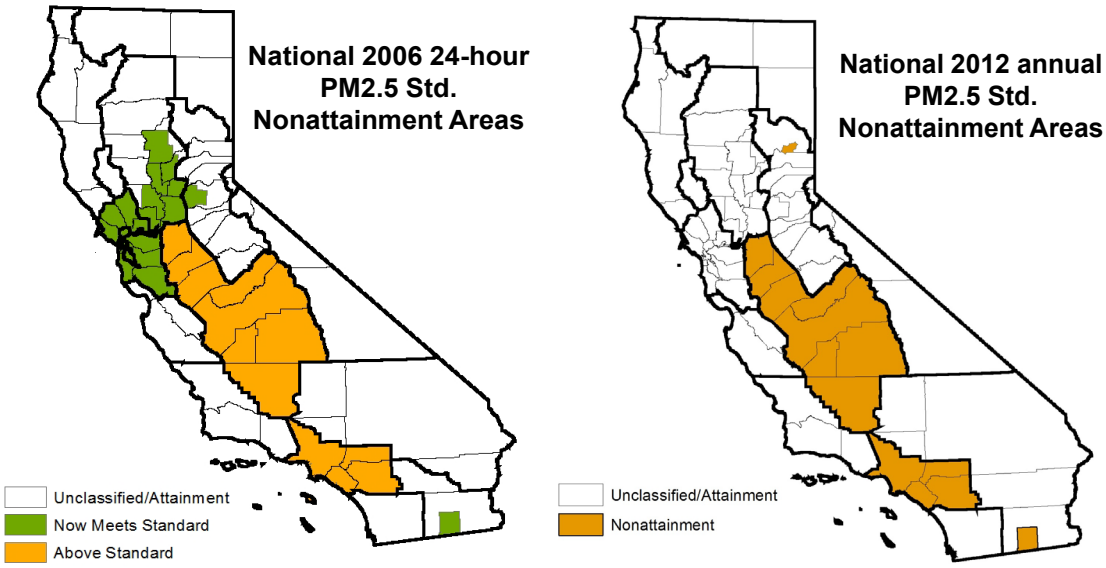


In 2006, U.S. EPA strengthened the national 24-hour $PM_{2.5}$ standard from 65 µg/m³ to 35 µg/m³. The U.S. EPA issued designations for this standard which became effective in December 2009. Seven areas in California were designated as not meeting the strengthened federal 24-hour $PM_{2.5}$ standard-the South Coast Air Basin, San Joaquin Valley Air Basin, Bay Area Air Basin, Sacramento Metropolitan area, a portion of the Feather River Air Pollution Control District, a portion of Butte County, and a portion of Imperial County. Since 2009, the Bay Area Air Basin, Sacramento Metropolitan area, Butte County and Imperial County have attained the standard, and Feather River Air Pollution Control District and Butte County have been redesignated to attainment by U.S. EPA. (Figure 7). Information on updated

designations may be found on the U.S. EPA webpage, *Nonattainment Areas for Criteria Pollutants*.[10]

In 2012, U.S. EPA strengthened the annual $PM_{2.5}$ standard from 15.0 µg/m3 to 12.0 µg/m3. U.S. EPA issued designations for this standard in December 2014. Four areas in California were designated as not meeting the lowered annual PM2.5 standard-South Coast Air Basin, San Joaquin Valley Air Basin, and portions of Imperial and Plumas Counties (Figure 7). Information on the State and federal designations may be found on the *CARB Federal Area Designations* webpage.[11]

Figure 7. Designations for the national $PM_{2.5}$ ambient air quality standards



PM2.5 Attainment Plans

Progress in reducing $PM_{2.5}$ levels has occurred throughout the State. As shown in Figure 7, four areas remain above the standards and have developed State Implementation Plans (SIPs). On March 14, 2019, U.S. EPA approved the South Coast Serious 24-hour $PM_{2.5}$ Plan. On October 15, 2020, U.S. EPA determined that the South Coast failed to attain the 35 µg/m^3 24-hour $PM_{2.5}$ standard by its December 31, 2019 attainment date. On December 31, 2020, CARB submitted a new plan for the 35 µg/m^3 standard for the South Coast. The San Joaquin Valley Air Pollution Control District adopted a comprehensive SIP in 2018 to address multiple $PM_{2.5}$ standards: the 65 µg/m^3 and 35 µg/m^3 24-hour and the 15.0 µg/m^3 and 12.0 µg/m^3 annual $PM_{2.5}$ standards. The SIP was approved by CARB in

[10] *https://www.epa.gov/green-book*
[11] *https://ww2.arb.ca.gov/our-work/programs/state-and-federal-area-designations/federal-area-designations/pm25*

January 2019. U.S. EPA approved the portions of the SIP pertaining to the 35 µg/m^3 standard in July 2020 and is reviewing the remaining portions. The District and CARB will continue to work jointly to implement the SIP. U.S. EPA determined that the San Joaquin Valley attained by 65 µg/m^3 24-hour standard in preliminary rulemaking in September 2021. The Imperial County Air Pollution Control District submitted the $PM_{2.5}$ SIPs for the 24-hour and annual standards in 2014 and 2018, respectively, for the nonattainment area that represents a portion of Imperial County. The Imperial County 24-hour $PM_{2.5}$ SIP was approved by CARB and transmitted to U.S. EPA in 2015. U.S EPA determined that Imperial County attained the 24-hour $PM_{2.5}$ standard and approved the emission inventory in March 2017 and May 2017, respectively. The Plumas County SIP for the annual $PM_{2.5}$ standard was submitted to U.S. EPA in 2017 and approved by U.S. EPA in March 2019.

Information on SIPs for the South Coast, the San Joaquin Valley, Imperial County, and Plumas County are available on the CARB *California State Implementation Plans* webpage.[12]

[12] *https://ww2.arb.ca.gov/our-work/programs/california-state-implementation-plans*

Figure A1: $PM_{2.5}$ sensor locations in California

Figure A2: $PM_{2.5}$ Monitoring Stations in California