

Staff Report

SO₂ Area Designation Recommendations for the 2024 Secondary Annual SO₂ National Ambient Air Quality Standard

November 2025



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Appendices (Attached)

- Appendix 1 – Five Factor Analysis for California Air Basins
- Appendix 2 – 2024 Annual SO₂ Design Values for All Sites in California
- Appendix 3 – California SO₂ Attainment Area Boundary Descriptions

Executive Summary

On December 10, 2024, the United States Environmental Protection Agency (U.S. EPA) revised the secondary annual sulfur dioxide (SO₂) national ambient air quality standard, strengthening it from 0.5 parts per million (ppm) as a 3-hour average, not to be exceeded more than once in a year, to an annual standard with a level of 10 parts per billion (ppb), averaged over three years. The Clean Air Act identifies two types of air quality standards. Primary standards are designed to protect public health, while secondary standards are designed to protect public welfare from adverse effects, including, but not limited to, those related to effects on soils, water, crops, vegetation, wildlife, and visibility. The State of California is required to submit recommendations for SO₂ area designations and boundaries to U.S. EPA by December 11, 2025. This report provides the California Air Resources Board's (CARB) recommendations on designations and supporting technical analysis for the revised federal secondary annual SO₂ standard.

The final review for the SO₂ standard was published in the Federal Register on December 27, 2024, and can be accessed via the link below:

<https://www.govinfo.gov/content/pkg/FR-2024-12-27/pdf/2024-29463.pdf>

CARB staff have determined designations for areas throughout the State using an approach provided in U.S. EPA's guidance memorandum.¹ The attainment or nonattainment status of an area is based on comparing the design value (DV), a three-year average of annual average concentrations, to the level of the standard. The U.S. EPA determined that the current SO₂ monitoring network is adequate to provide the data needed to implement the revised secondary annual SO₂ standard and expects that states would recommend that areas be designated based on the most recent three full calendar years of certified air quality data from the existing monitoring network¹. Therefore, CARB staff recommendations are based primarily on SO₂ air quality monitoring data for the years 2022 to 2024.

To ensure that boundaries are sufficiently sized, recommendations rely on a weight of evidence approach described in U.S. EPA's guidance¹ and should consider the following five factors:

- Air quality data;
- Emissions data;
- Geography/topography;
- Meteorology; and
- Jurisdictional boundaries.

¹ Revised January 16, 2025, Initial Area Designations for the 2024 Revised Secondary Annual Sulfur Dioxide National Ambient Air Quality Standard, Memorandum from Peter Tsirigotis, Director, Office of Air Quality Planning and Standards to Regional Administrators, Regions 1-10.

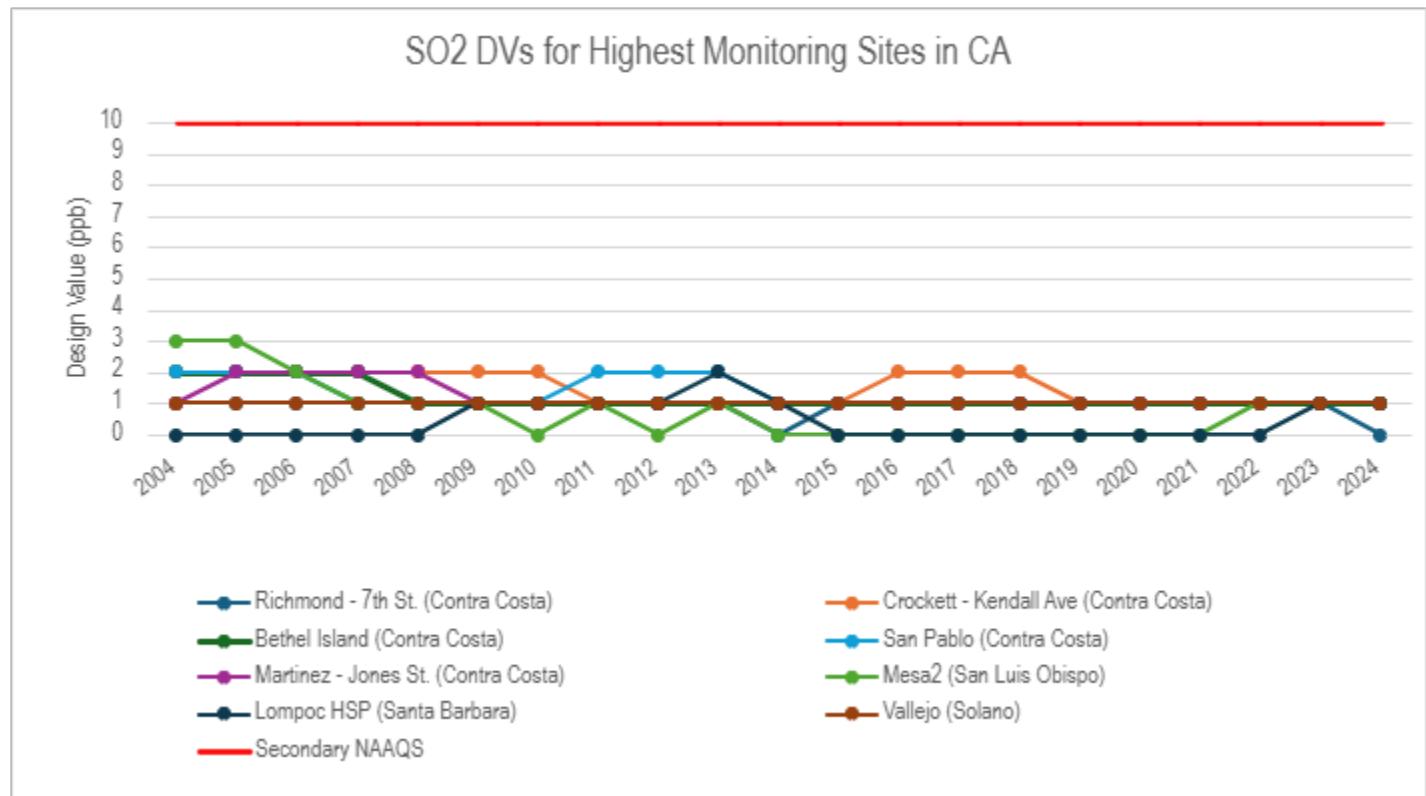
After considering this information, CARB staff are recommending all areas in California be designated as attainment based on the 2022-2024 SO₂ air quality monitoring data.

California Attainment Area Designation Recommendations for the 10 ppb Secondary Annual SO₂ Standard

Sulfur Dioxide Air Quality

There are eight SO₂ monitors that recorded valid DVs in 2024, and all the valid values were below the revised secondary annual SO₂ standard (ranging from 0 - 1 ppb). California has attained the federal primary 1-hour SO₂ standard since the late 1980s. Annual average concentrations for all current SO₂ monitors have remained below 4 ppb since 2002. Figure 1 below shows the trends in annual average DVs for the eight highest monitoring sites in California and the counties they are in. The 20-year trend shows that the sites with the highest annual average SO₂ concentrations in 2024 have remained well below the standard since 2004.

FIGURE 1
SO₂ Design Values for 8 Highest Monitoring Sites in California



Emissions

CARB maintains a comprehensive inventory of sulfur oxide (SO_x) emissions. Staff estimate that SO₂ comprises 97% of the SO_x inventory. Additionally, in most combustion categories, almost all SO_x will be SO₂. Therefore, in this report, SO_x emissions are used to represent SO₂ emissions.

Emissions of SO_x declined tremendously in California between 2004 and 2024. Statewide, emissions have decreased by 78% since 2004, such that in 2024, 24,504 tons of SO_x were emitted in California. In comparison to national totals for which the most recent year of data available through the U.S. EPA National Emissions Inventory is 2020, total SO_x emissions equaled 1,841,380 tons across the country in 2020. California emissions account for only 1.3% of the national inventory. Table 1 shows the SO_x reductions by emissions category. SO_x emissions numbers provided below and in Appendix 1 represent a data extraction on November 4, 2025, from CARB's CEPAM database.²

TABLE 1
SO_x Emissions Reductions by Category (2004-2024)

Emissions Category	Percent Reduction
Stationary Sources	58%
Areawide Sources	26%
Mobile Sources	91%

SO_x emissions from stationary sources have decreased due to improved industrial source controls and switching from fuel oil to natural gas for electric generation and industrial boilers. SO_x emissions from stationary sources in California are a fraction of the levels in other parts of the country, a substantive portion of which come from large fossil fuel electrical generation facilities located in the eastern and southern states. The two largest sources of SO_x emissions in California, two refineries in the Bay Area, have emissions of approximately 763 tons per year and 476 tons per year, respectively.

The SO_x emissions from on- and off-road gasoline and diesel-fueled engines and vehicles have also decreased due to lower sulfur content in the fuel and regulations to reduce the sulfur content in fuel used by commercial harbor crafts. As SO_x is emitted primarily from

² 2022 Ozone SIP Baseline Emission Projection - Version 1.01B, Annual Average, Base year of 2018, Grown and Controlled. OGV emissions extend to 100 nautical miles from shore

combustion of fuels, emission control efforts have focused largely on reducing the content of sulfur in fuels. California has required the use of ultra-low-sulfur diesel fuel for on-road vehicles since 2006. In 2007, the U.S. EPA followed suit, requiring ultra-low sulfur content (15 ppm) first in on-road diesel fuel sold in the United States and then in off-road diesel fuel by 2010. The U.S. EPA also required railroad locomotive and marine diesel fuel to be reduced to 500 ppm sulfur in 2007 and then to ultra-low sulfur in 2012. Since the end of 2014, all highway, off-road, locomotive, and marine diesel fuel supplied in the United States has been ultra-low-sulfur diesel.

Sulfur Dioxide Monitoring Network Requirements

The monitoring regulations for SO₂ require monitors to be placed in Core Based Statistical Areas (CBSAs) based on a population weighted emissions index (PWEI) for the area. The PWEI is calculated by multiplying the latest available SO₂ emissions data within each CBSA by the population of the CBSA and then dividing the result by one million. The final rule requires:

- One SO₂ monitor in CBSAs with PWEI values greater than 5,000 but less than 100,000;
- Two SO₂ monitors in CBSAs with PWEI values greater than 100,000 but less than one million; and
- Three SO₂ monitors in CBSAs with PWEI values of one million or more.

California has thirty-five CBSAs with populations ranging from 18,000 to more than 13 million people. Table 2 lists the three CBSAs in California that require SO₂ monitoring. In addition, Table 2 shows that these CBSAs exceed federal monitoring requirements for SO₂. California's monitoring network currently consists of 23 monitors, exceeding the three monitors required based on the PWEI.

Table 2
Minimum Monitoring Requirements for Sulfur Dioxide

CBSA	Counties in CBSA	SO₂ Emissions (2023 tpy)	Population (2020)	PWEI (Million persons-tpy)	Required SO₂ Monitors	Existing SO₂ Monitors
Los Angeles - Long Beach - Anaheim	Los Angeles, Orange	5,044	13,200,998	66,586	1	2
San Francisco - Oakland - Fremont	Alameda, Contra Costa, Marin, San Francisco, San Mateo	6,953	4,749,008	33,020	1	7
Riverside - San Bernardino - Ontario	Riverside, San Bernardino	1,344	4,599,839	6,182	1	2

Recommended Area Designations

CARB staff evaluated the available ambient SO₂ data and SO_x emissions data to determine appropriate area designations throughout the State. The recommendations in this report are based primarily on SO₂ air quality data collected between 2022 and 2024. The analysis was conducted for each monitoring site in the State for which data are available. For areas without a valid 2024 design value, the five factor analysis shown in Appendix 1 discusses why staff still recommend an attainment designation. The design value for the secondary annual SO₂ standard is the 3-year average of the annual mean of daily mean values for a monitoring site.

CARB staff conducted a five-factor analysis to determine the appropriate designations and boundaries. The five factors recommended by U.S. EPA for the purpose of determining the appropriate attainment area boundaries include: jurisdictional boundaries, geography/topography, meteorology, emissions data, and air quality data. No areas with monitors in California violate the federal secondary annual SO₂ standard.

Areas of the State where no monitors exist are generally more rural in nature and have lower total SO_x emissions, in comparison to the rest of the state. Since the existing monitoring network indicates that all areas with monitors are well below the standard, CARB staff conclude that areas without monitors should also be below the standard.

Therefore, CARB staff are recommending that all areas in California be designated attainment for the secondary annual SO₂ standard. Staff are recommending air basins as the appropriate boundary for all attainment areas. Consistent with State law, California's air basin boundaries were established based on a scientific assessment of emissions, geography, and meteorology, with consideration of political jurisdictions. Air basin boundaries are formally adopted by CARB in regulation and are the boundaries used for the federal primary SO₂ standard.

The five-factor analysis for each air basin is provided in Appendix 1. Annual averages and design values for individual monitoring sites are provided in Appendix 2. The recommended area designations are summarized in Table 3 below by air basin.

Table 3
Area Designation Recommendations

Air Basin Name	Recommended Designation	2024 Design Value (ppb)
Great Basin Valleys	Attainment	0***
Lake County	Attainment	N/A
Lake Tahoe	Attainment	N/A
Mojave Desert	Attainment	N/A
Mountain Counties	Attainment	N/A
North Central Coast	Attainment	N/A
North Coast	Attainment	0
Northeast Plateau	Attainment	N/A
Sacramento Valley	Attainment	0*
Salton Sea	Attainment	0
San Diego	Attainment	0**
San Francisco Bay Area	Attainment	1***
San Joaquin	Attainment	0*
South Central Coast	Attainment	1
South Coast	Attainment	0

*2021 design value

**2022 design value

***2023 design value

Summary

CARB has used California's air quality monitoring and emissions data to develop recommended area designations for U.S. EPA's revised secondary annual SO₂ standard. The statewide monitoring network shows no violations, and the highest concentrations are far below the new standard. A review of the statewide monitoring data and SO_x emissions shows that California attains the SO₂ standard. Therefore, CARB recommends all air basins in California be designated as attainment.