Chapter 2
Air Quality Challenges and Trends

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2. AIR QUALITY CHALLENGES AND TRENDS

2.1 PM2.5 CHALLENGES AND TRENDS IN THE SAN JOAQUIN VALLEY

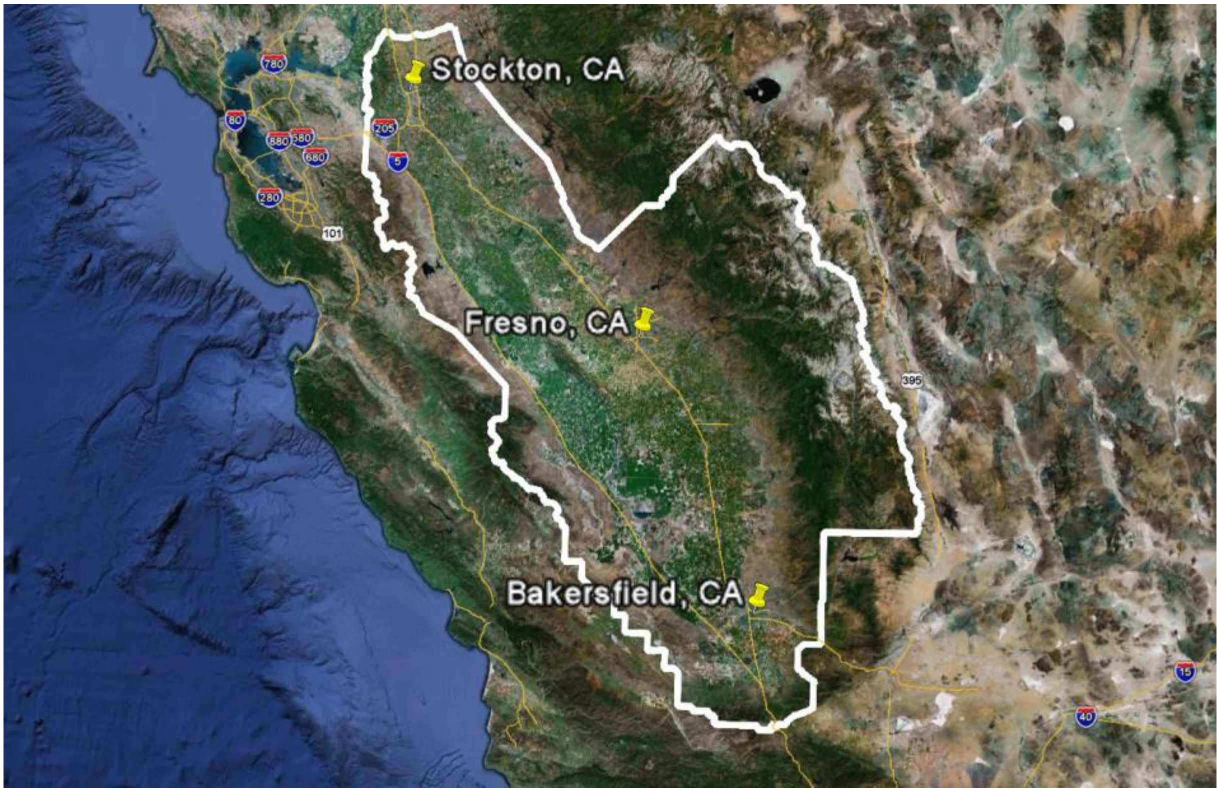
The San Joaquin Valley's (Valley) natural environment supports one of the most productive agricultural regions in the country; the Sierra Nevada provides the necessary water for growing the abundance of crops, and a temperate climate provides a long growing season. However, these same natural factors present significant challenges for air quality: the surrounding mountains trap pollution and block airflow, and the mild climate keeps pollutant-scouring winds at bay most of the year.

Despite these challenges, the San Joaquin Valley Air Pollution Control District (District) is making progress in attaining the national ambient air quality standards (NAAQS, or standards) and improving public health for Valley citizens. Due to the significant investments made by Valley businesses and residents and stringent regulatory programs by the District and the California Air Resources Board (CARB), the Valley's ozone and PM2.5 precursor emissions are at historically low levels and air quality over the past few years has been better than any other time on record. Emissions from stationary sources have been reduced by 85%, cancer risk from exposure to air pollutants has been reduced by 95%, population exposure to elevated PM2.5 levels have been reduced by 85%, and population exposure to elevated ozone levels have been reduced by 90%.

2.1.1 UNIQUE CLIMATE AND GEOGRAPHY

The challenge to attaining the federal air quality standards in the Valley is grounded in the unique topographical and meteorological conditions found in the region. The Valley, as seen in Figure 2-1, is an inter-mountain valley encompassing nearly 25,000 square miles. Surrounded by mountain ranges to the west, east, and south; the airflow through the Valley can be blocked, leading to severely constrained dispersion. During the winter, high-pressure systems can cause the atmosphere to become stagnant for longer periods of time, where wind flow is calm and air movement is minimal. These stagnant weather systems can also cause severe nighttime temperature inversions, which exacerbate the build-up of PM2.5 and related precursors beneath the evening inversion layer.

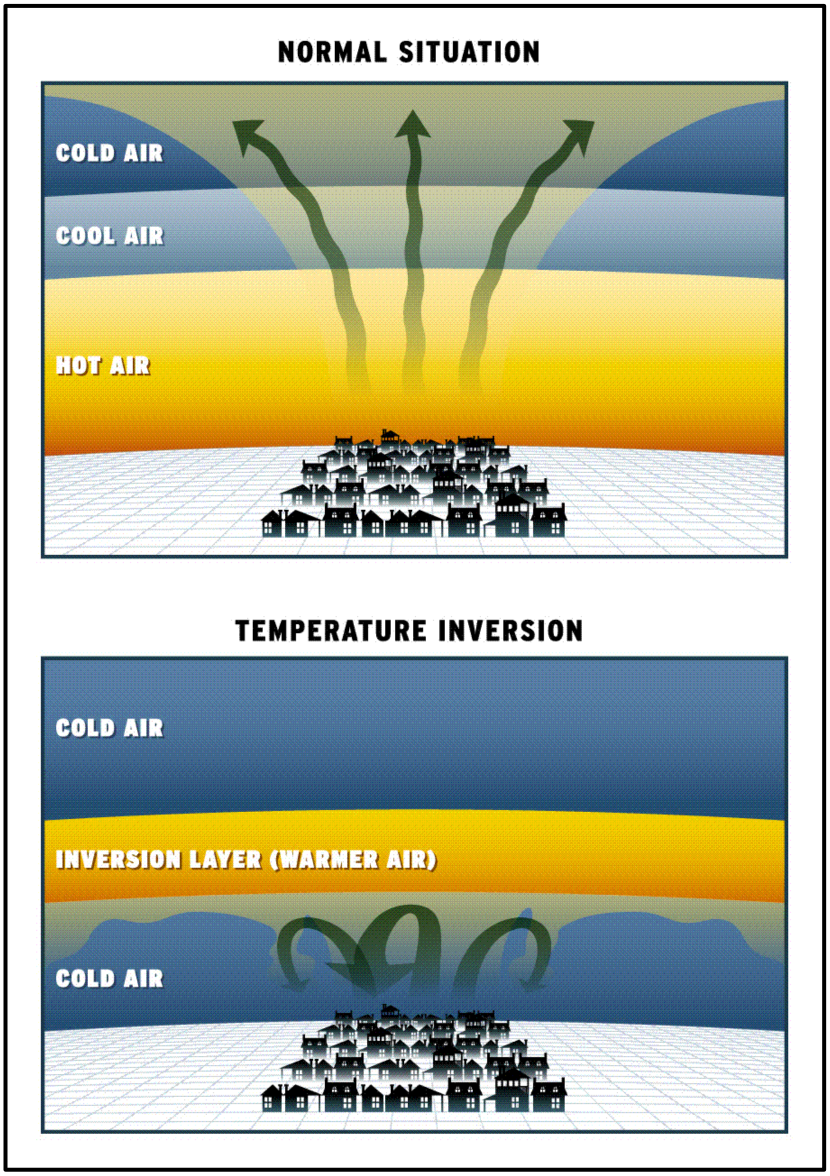
Figure 2-1 San Joaquin Valley Air Basin



Under normal conditions, temperature decreases with increasing altitude, but during temperature inversions the temperature gradient is reversed, with temperatures increasing with altitude, causing warmer air to be above cooler air. Figure 2-2 shows that this reversal of the “normal” pattern impedes the upward flow of air, causes poor dispersion, and traps pollutants near the earth’s surface. Temperature inversions are common in the Valley throughout the year. Since the inversion is often lower than the height of the surrounding mountain ranges, the Valley effectively becomes a bowl capped with a lid that traps emissions near the surface. When horizontal dispersion (transport flow) and vertical dispersion (rising air) are minimized, PM2.5 concentrations can build quickly, especially in the winter. These naturally occurring meteorological conditions have the net effect of spatially concentrating direct PM2.5 concentrations near their sources; promoting the formation and regional buildup of secondary species, particularly ammonium nitrate; and chemically aged organic carbon species, resulting in an increase in their relative toxicity.

Given these challenges, the Valley needs even more effective emissions reductions to attain the PM2.5 standards; and the District continues to pursue these reductions through its numerous air quality attainment plans, regulatory control strategy and innovative non-regulatory emission reduction strategy, which includes a robust incentive program, a comprehensive legislative platform, and rigorous outreach and education efforts.

Figure 2-2 Atmosphere without and with Temperature Inversion[1]



2.1.2 THE VALLEY'S CARRYING CAPACITY

In the context of air quality, "carrying capacity" refers to the density of emissions that an air basin can "absorb" or "carry" and still meet ambient air quality standards for a given pollutant. The key factors that shape variations in a regional carrying capacity include meteorology, climate, and topography. The Valley's carrying capacity for PM2.5 is greatly affected by prevailing weather during the winter months and the region's topography (surrounding mountains). Temperature inversions are common during the winter months in the Valley. During these sometimes lengthy stagnant air episodes, PM2.5 emissions from daily activities rapidly build up to levels above the standard. It is during these events (or in anticipation of these events) that the District's Check-Before-

[1] Image source: http://ffden-2.phys.uaf.edu/212_spring2007.web.dir/Amber_Smith/Effects_of_Inversions.htm

You-Burn program and Real-time Air Advisory Network (RAAN) system intervene to inform (or require) the public to limit activity that generates PM2.5 emissions.

2.1.3 POPULATION GROWTH IN THE SAN JOAQUIN VALLEY

To further exacerbate current air quality challenges, the Valley is one of the fastest growing regions in California. The Population Research Unit of the California Department of Finance (DOF) released revised population growth projections in March 2017 that demonstrate how significantly the Valley's population is expected to grow in the coming years.

Based on the revised 2015 to 2030 DOF data, the Valley's population is expected to increase by 19.3% (Table 2-1). In contrast, the total population for the State of California is projected to increase by only 12.5% over the same time period. Increasing population generally means increases in air pollutant emissions as a result of increased consumer product use and more automobile and truck vehicle miles traveled (VMT). In addition to increased VMT resulting from increased Valley population, the Valley will also see increased vehicular traffic along the State's major goods and people movement arteries, both of which run the length of the Valley.

Table 2-1 Estimated Valley and State Populations by County, 2015-2030[2]

County	2015	2020	2025	2030
Fresno	979,636	1,033,095	1,088,990	1,145,673
Kern[3]	883,494	930,885	996,506	1,068,729
Kings	149,832	154,549	162,195	170,251
Madera	154,753	162,990	174,332	186,937
Merced	269,870	286,746	306,143	326,923
San Joaquin	728,110	782,662	838,755	894,330
Stanislaus	537,608	572,000	605,463	638,840
Tulare	464,337	487,733	513,541	540,580
VALLEY TOTAL	***4,167,640***	***4,410,660***	***4,685,925***	***4,972,263***
CALIFORNIA TOTAL	**39,059,415**	**40,639,392**	**42,326397**	**43,939,250**

While the bulk of the Valley's remaining emissions come from mobile sources outside of the District's regulatory authority, under the federal Clean Air Act (CAA), the responsibility to bring the region into attainment with the federal standards rests with the local air district. Additionally, the region will be subject to sanctions that would be devastating to the Valley's economy if mobile sources under federal regulatory authority are not adequately controlled. As such, given the enormity of the reductions needed for attainment, mobile sources, particularly in the goods movement sector, must transition

[2] California Department of Finance. Retrieved July 18, 2018 from: http://www.dof.ca.gov/Forecasting/Demographics/projections/
[3] Includes entire Kern County population

to zero or near-zero emission levels through the implementation of transformative measures. The District does not have the authority to implement regulations requiring ultra-low tailpipe emissions standards on mobile sources. New state and federal regulations coupled with a robust incentive-based emission reduction strategy are necessary to achieve the enormous reductions that are necessary to attain the federal standards. The U.S. Environmental Protection Agency (EPA) must take responsibility for implementing regulatory and incentive-based measures for sources under their jurisdiction. The District has been working closely with CARB to develop an attainment strategy that includes significant emissions reductions from mobile sources.

2.2 PM2.5 Emissions Inventory Trends

The emissions inventory is the foundation for the attainment planning process. The District and CARB maintain an accounting of PM2.5 and precursor emissions for the Valley based on known sources within the Valley and those sources outside the Valley that influence Valley air quality (inter-region transport). The District requires detailed accounting of emissions from regulated sources throughout the Valley. CARB makes detailed estimations of emissions from mobile, area, and geologic sources using known emissions factors for each source or activity and accounting for relevant economic and population data. Together, these feed into the emissions inventory that represents an estimate of how much direct pollution is going into the Valley air basin as a result of the cumulative pollutant-generating activities and sources.

The District uses the emissions inventory to develop control strategies, to determine the effectiveness of permitting and control programs, to provide input into air quality modeling, to fulfill reasonable further progress requirements, and to screen regulated sources for compliance investigations.

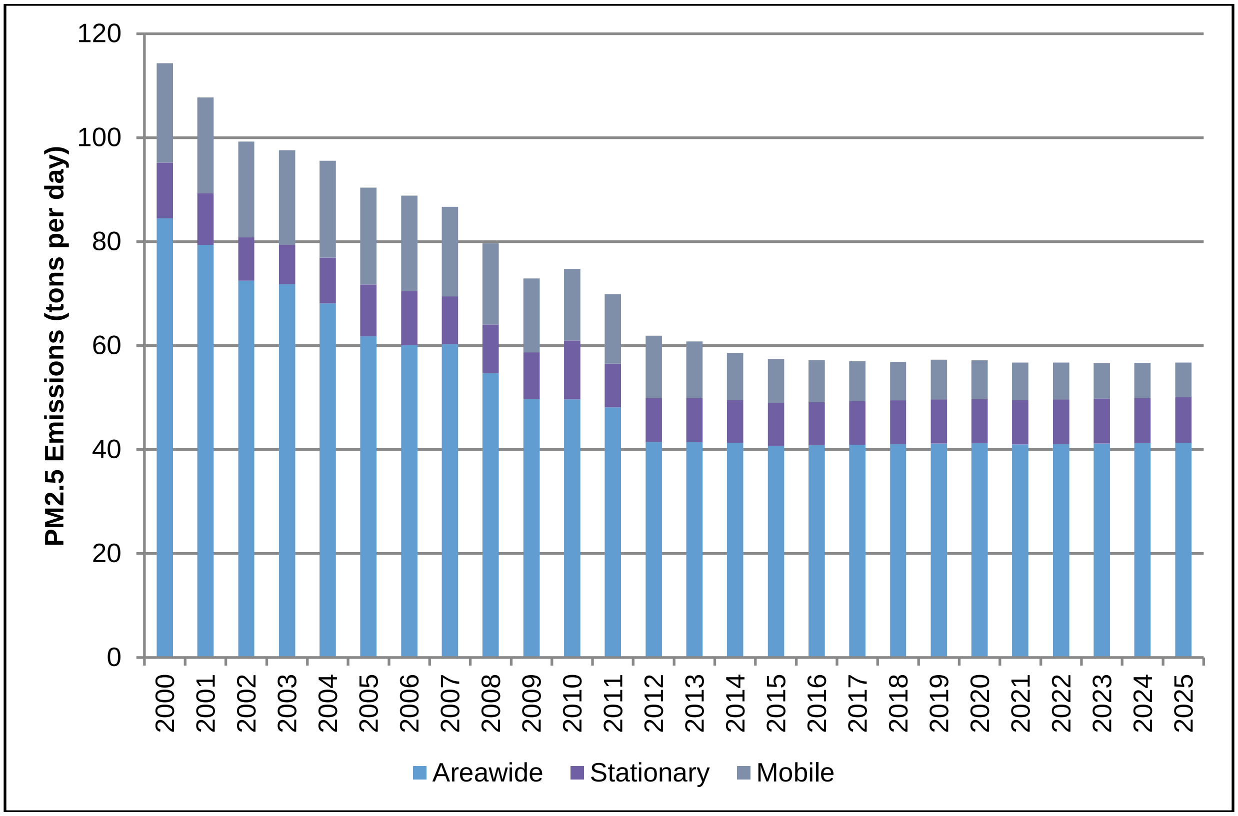
The following general list represents the major inventory categories for which emissions are recorded and tracked. Appendix B to this Plan contains the detailed accounting of the emissions inventory with projected emissions based on anticipated growth of each source and the anticipated control (regulatory or non-regulatory) of each source, if applicable.

- **Mobile sources** – motorized vehicles
    - On-road sources include automobiles, motorcycles, buses, and trucks
    - Other or off-road sources include farm and construction equipment, lawn and garden equipment, forklifts, locomotives, boats, aircraft, and recreational vehicles
- **Stationary sources** – fixed sources of air pollution
    - Power plants, refineries, and manufacturing facilities
    - Aggregated point sources, i.e. facilities (such as gas stations and dry cleaners) that are not typically inventoried individually, but are estimated as a group and reported as a single source category
- **Area sources** – human activity that takes place over a wide geographic area
    - Includes consumer products, residential wood burning, controlled burning, tilling, and unpaved road dust

- **Natural sources** – naturally occurring emissions
  - Geologic sources, such as petroleum seeps
  - Biogenic sources, such as emissions from plants
  - Wildfire sources

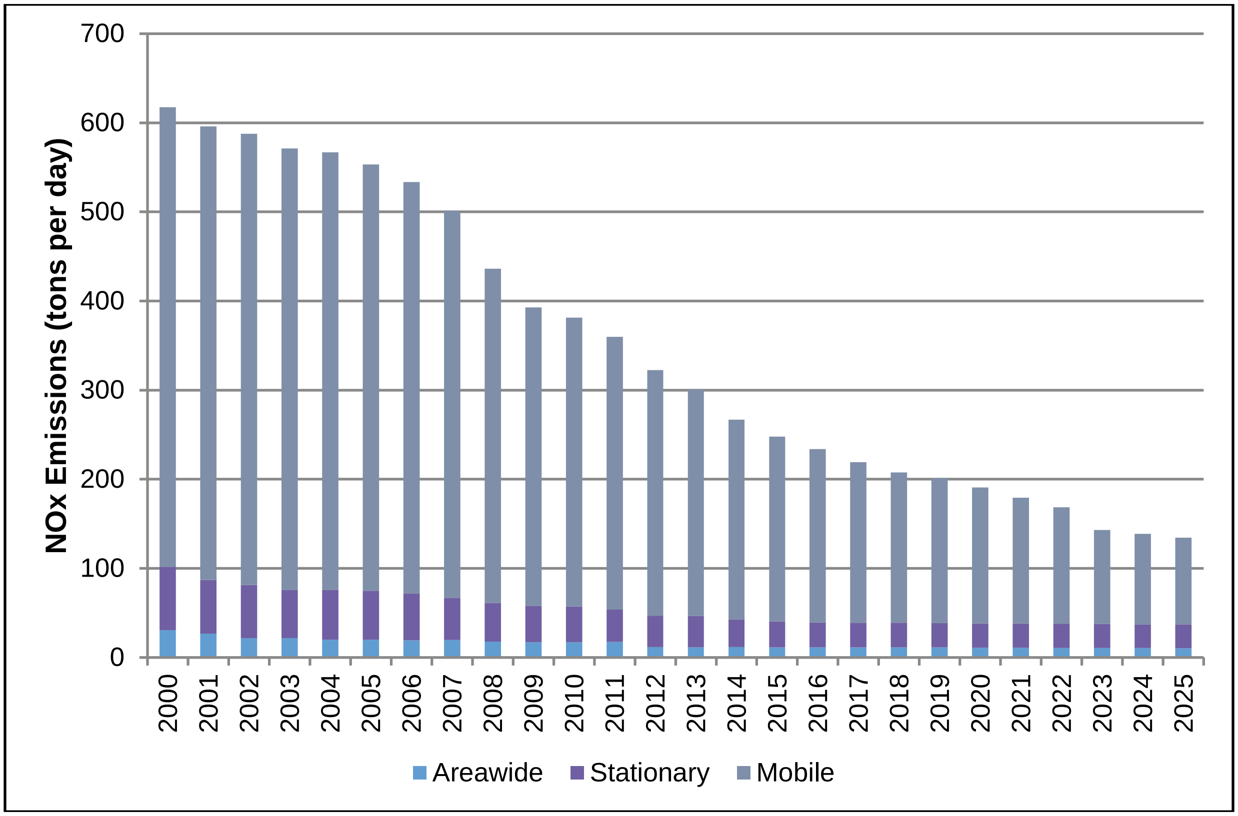
Figure 2-3 Valley PM2.5 Winter Emissions Inventory Trend shows the PM2.5 emissions inventory trend for the mobile, stationary, and area source categories.

Figure 2-3 Valley PM2.5 Winter Emissions Inventory Trend



Because NOx is a significant PM2.5 precursor and the Valley is NOx-limited, the District relies heavily on NOx emissions to reduce PM2.5 emissions. Figure 2-4 summarizes the NOx emissions inventory trends for the mobile, stationary, and area source categories. District and CARB control strategies for NOx play a significant role in reducing both ozone and PM2.5 emissions.

Figure 2-4 Valley Winter NOx Emissions Inventory Trend



Emissions inventory trends show the progress made through progressive regulatory and non-regulatory activities, e.g. as rules are amended with tighter emission limits, or as reduction technologies improve, overall emissions decrease. Winter PM2.5 emissions have decreased significantly, in large part due to the effectiveness of Rule 4901 (Wood Burning Fireplaces and Wood Burning Heaters). Continued emissions reductions are based on current control strategies that will continue to take effect into the future. In light of the Valley's projected increase in population, the projected emissions reductions highlight the success of the control measures adopted and enforced by the District, CARB, and other regulatory agencies.

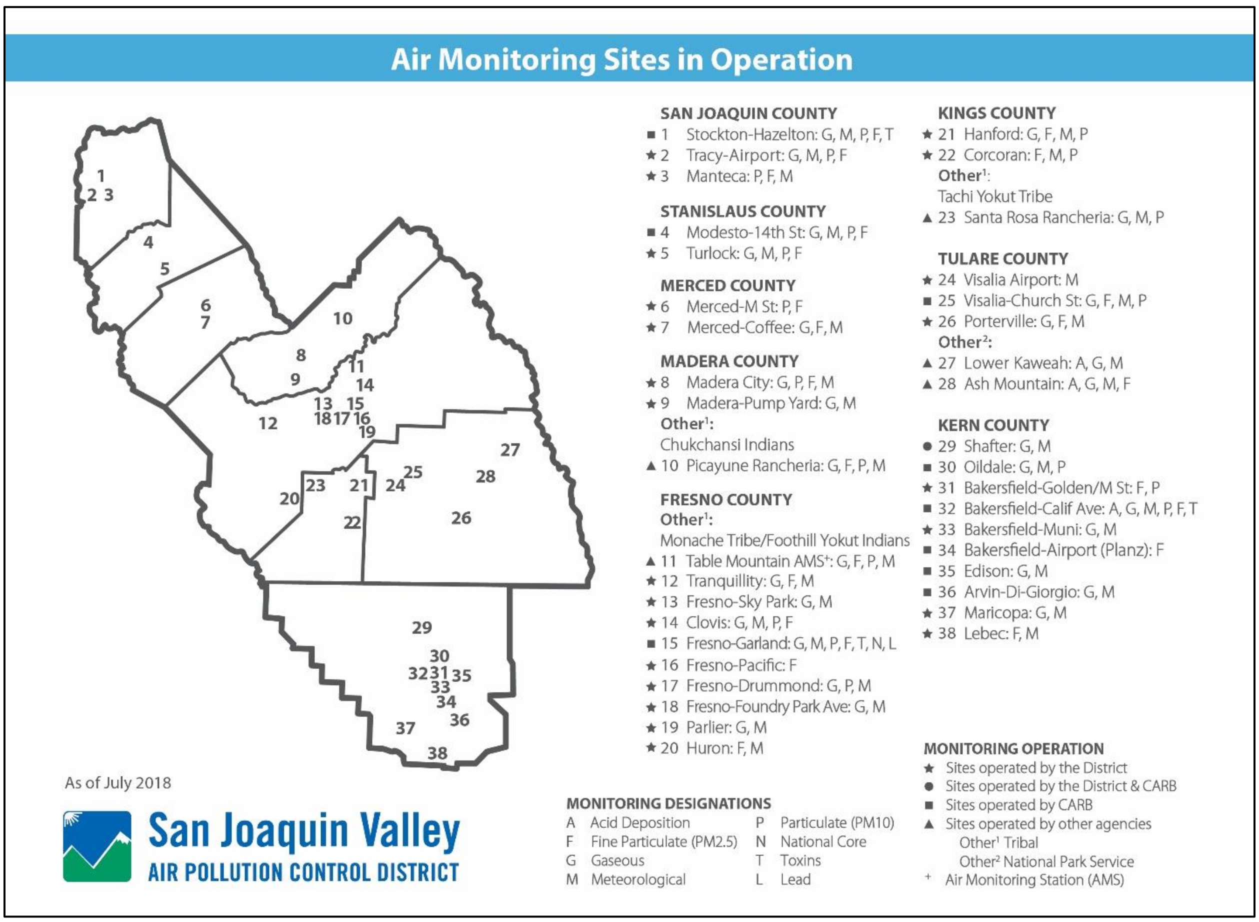
2.3 PM2.5 Air Quality Trends

As a public health agency charged with monitoring Valley air quality and ensuring progress toward meeting national air quality standards, the District has established an extensive air monitoring network that provides ongoing data for evaluating such progress. Information from this extensive monitoring network, which began measuring PM2.5 concentrations in 1999, allows the District to track air quality trends that show progress toward attainment and inform the planning process for reaching attainment.

2.3.1 AIR MONITORING NETWORK

Numerous pollutants and meteorological parameters are measured throughout the Valley on a daily basis using an extensive air monitoring network managed by the District, CARB, and other agencies. This network measures pollutant concentrations necessary to show progress toward compliance with the NAAQS. The network also provides real-time air quality measurements used for daily air quality forecasts, residential wood-burning declarations, Air Alerts, and RAAN. Air quality monitoring networks are designed to monitor areas with high population densities, areas with high pollutant concentrations, areas impacted by major pollutant sources, and areas representative of background concentrations. Together, the District, CARB, and other agencies operate 38 air monitoring stations throughout the Valley. Most air monitoring sites in the Valley represent population exposures and/or maximum concentrations representative of neighborhood and regional scales.

Figure 2-5 Valley Air Monitoring Sites



PM2.5 is measured and expressed as the mass of particles contained in a cubic meter of air (micrograms per cubic meter, or μg/m^3). The data collected from the District's network of PM2.5 monitors is used to calculate design values for the 24-hour and annual PM2.5 standards, as outlined in EPA guidance and regulations.[4,5]

2.3.2 AIR QUALITY PROGRESS

Air quality progress can be assessed in several ways. The calculation of *design values* is the official method used to determine whether an area is in attainment of a standard; however, other indicators can reveal more about the progress being made toward attaining that standard. Comparing the days per year when each monitor exceeded the PM2.5 24-hour NAAQS threshold from year to year shows the progress in reducing the number of days with the highest concentrations, while quarterly averages can help to show progress with respect to seasonal peaks in concentration levels. Some of the conclusions from these analyses are included below, followed by a more detailed discussion in Appendix A.

Rather than using yearly maximum concentrations for the PM2.5 standards, EPA requires the use of design values for the attainment metric, which represents a three-year average of air quality data. Details on how PM2.5 design values are calculated are provided in Appendix A of this Plan. As seen in Figure 2-6 and Figure 2-7, the Valley maximum 24-hour and annual average PM2.5 design value trends show that although there are some year-to-year variation, progress has been made in reducing PM2.5 concentrations over the long-term sampling record in the Valley. The Valley's peak 24-hour design value has decreased by over 43% over the 1999–2017 period, while the peak annual design value has decreased by 30% over the same period.

[4] Environmental Protection Agency [EPA]: Office of Air Quality Planning and Standards. (1999, April). *Guideline on Data Handling Conventions for the PM NAAQS* (EPA-454/R-99-008). Retrieved from http://www.epa.gov/ttn/oarpg/t1/memoranda/pmfinal.pdf

[5] Interpretation of the National Ambient Air Quality Standards for PM2.5, 40 CFR Pt. 50 Appendix N (2012).

Figure 2-6 Valley 24-hour PM2.5 Design Value Trend

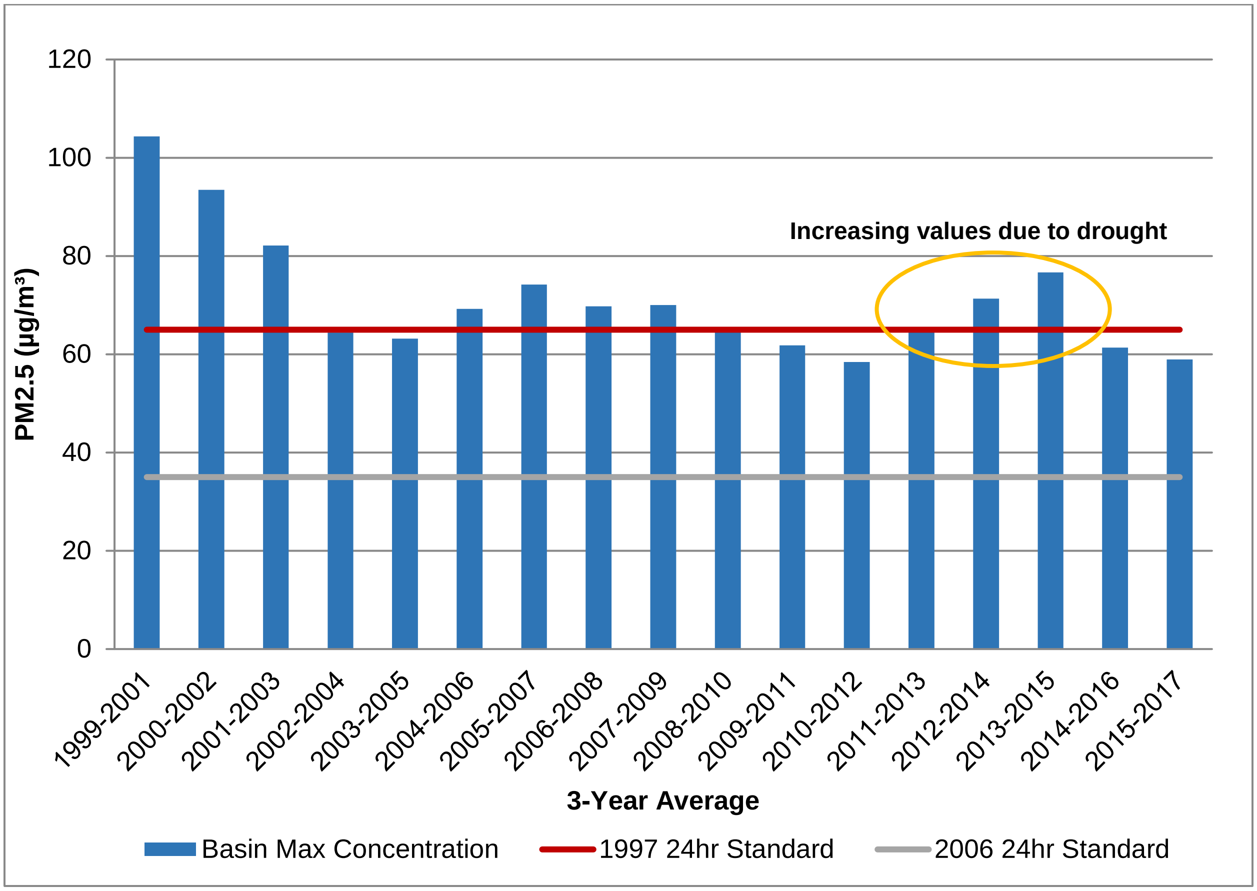
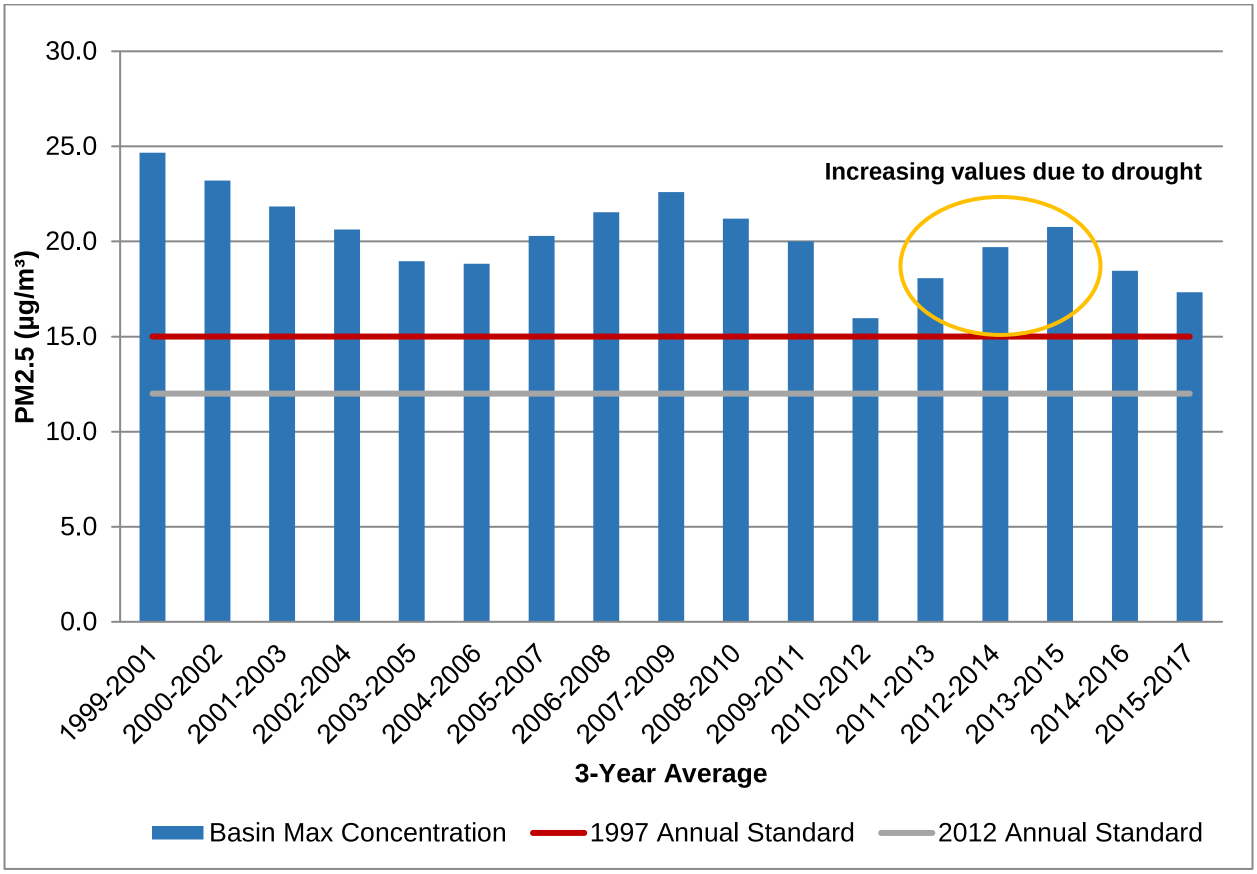


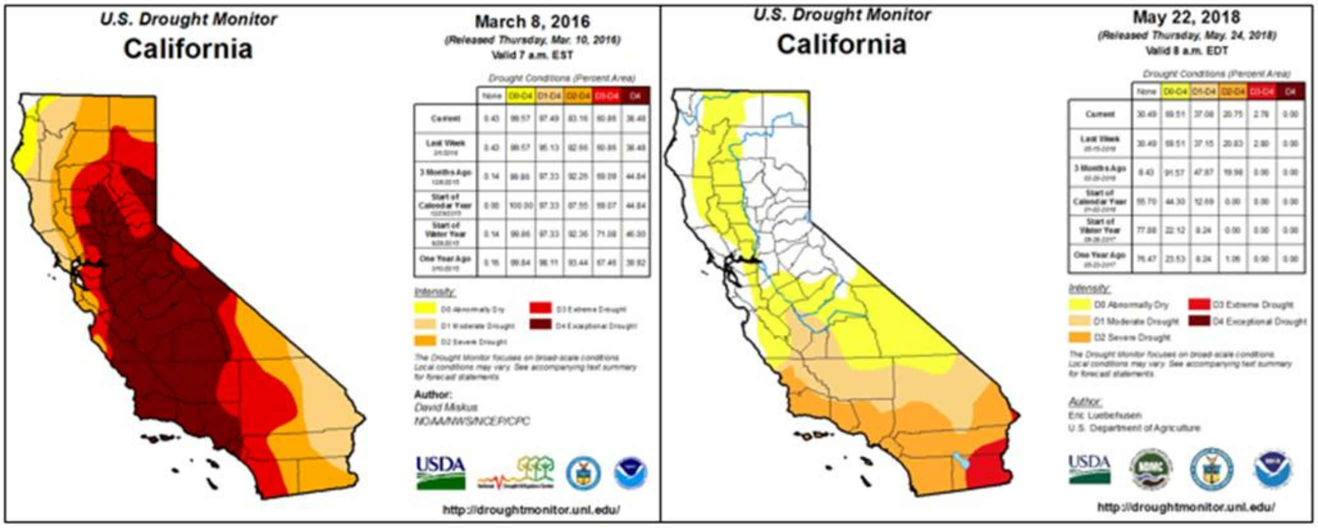
Figure 2-7 Valley Annual PM2.5 Design Value Trend



2.3.3 IMPACT OF EXCEPTIONAL DROUGHT-RELATED WEATHER CONDITIONS ON VALLEY PM2.5 CONCENTRATIONS

According to the U.S. Geological Survey, California experienced its worst drought in over a century between 2011 and 2015. The 2015-2016 winter season represented the fifth consecutive year of drought conditions in the Valley, and 2013-2014 was by far the driest winter during this time. On January 17, 2014, the Governor of California declared a drought emergency for all of California. Three years and two months later, the drought emergency declaration was finally lifted by the Governor of California on April 7, 2017. Figure 2-8 is a map produced by the National Drought Mitigation Center depicting the extent and severity of the drought affecting California as of March 8, 2016 and the degree of recovery that has occurred as of May 22, 2018.

Figure 2-8 Drought Extent and Severity in California



Many cities in California, including those in the Valley, had record low rainfall totals during 2013 calendar year, with some nearly 100-year old records being broken. Although rainfall totals slowly increased between 2015 and 2017, drought conditions have continued to persist despite a very wet 2016-2017 winter season (see Table 2-2).

Table 2-2 Rainfall Totals for Select Cities Across California

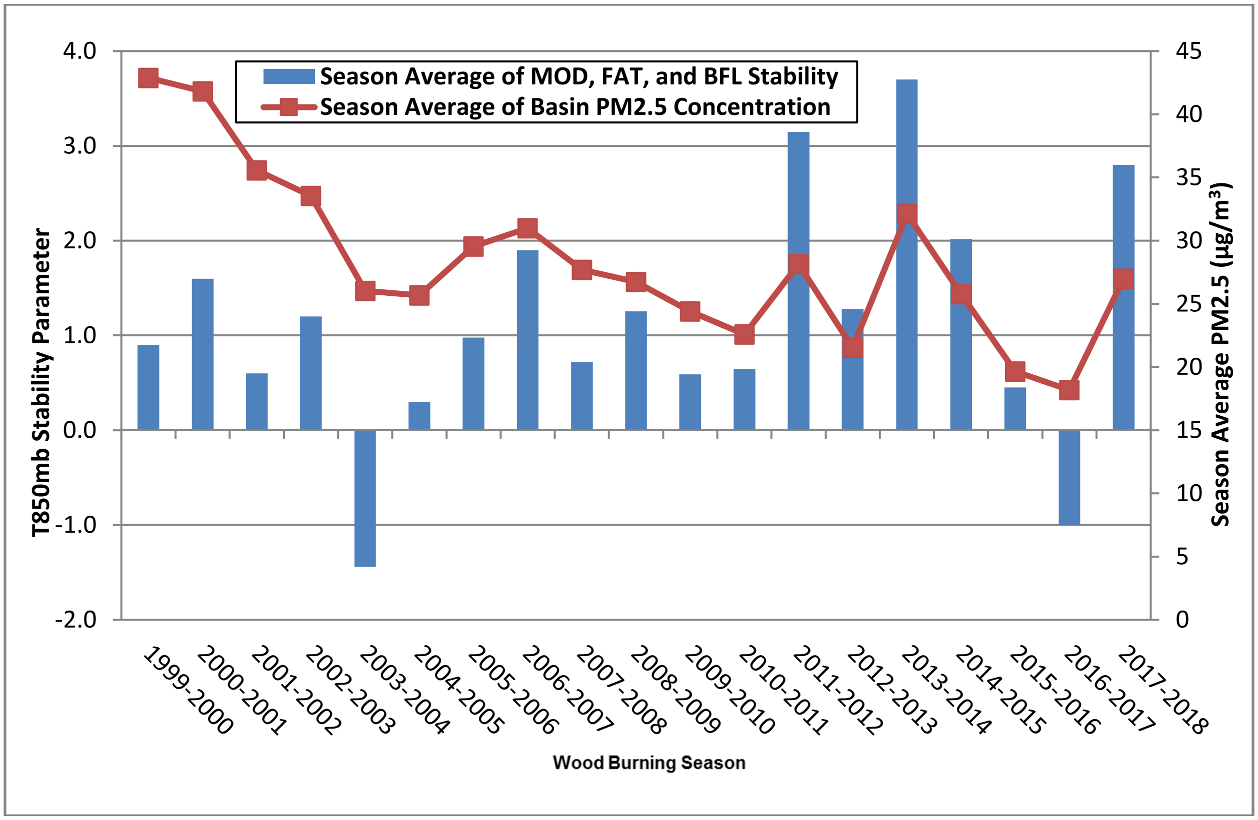
Region	City	1983-2013	2015	2016	2017	Record Low Rainfall	
		Average (inches)	Total (inches)	Total (inches)	Total (inches)	Year	Total (inches)
Northern California	San Francisco	19.73	8.45	25.5	26.62	2013	3.39
	Sacramento	17.6	8.53	22.92	27.16	2013	5.81
San Joaquin Valley	Modesto	12.17	7.25	16.24	12.93	2013	4.69
	Madera	12.3	4.14	16.02	10.61	2013	3.8
	Fresno	11.03	8.98	13.65	13.21	2013	3.01
	Visalia	9.91	5.33	8.94	11.52	2013	3.47
	Bakersfield	6.19	3.99	7.13	5.38	1959	1.87
Southern California	Los Angeles	12.32	5.96	10.27	12.26	1947	3.14
	San Diego	10.2	9.92	10.23	7.92	1953	3.41

NCDC https://www.ncdc.noaa.gov/cdo-web/search;jsessionid=8EECF3E54DC2BBA9D4F96C444434A990
NWS Hanford http://w2.weather.gov/climate/local_data.php?wfo=hnx
NWS San Diego http://w2.weather.gov/climate/local_data.php?wfo=sgx
California Nevada River Forecast Center http://www.cnrfc.noaa.gov/rainfall_data.php

During 2011–2015 winter seasons, extended periods of stagnation, and lack of ample precipitation were components of the historic drought that challenged the Valley's air quality during this period. These conditions overwhelmed the District's control measures and strategies, and contributed to the higher than expected PM2.5 concentrations and exceedances that occurred in the San Joaquin Valley during that period.

As demonstrated in Figure 2-9, the average PM2.5 concentration in the Valley has decreased over the period, despite low precipitation totals and increases in atmospheric stability over recent years. This provides evidence that District and CARB comprehensive strategy have been achieving permanent emissions reductions.

Figure 2-9 Seasonal Average Stability and PM2.5 Concentrations



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