Chapter 3

Air Quality in the San Joaquin Valley: Challenges and Trends

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While presented with unique geographical and meteorological challenges, the San Joaquin Valley (Valley) has made significant progress in reducing total PM2.5 emissions and PM2.5 precursor emissions and in improving air quality for Valley residents. Through progressively more stringent regulations and improved control technologies, the overall amount of directly emitted PM2.5 emissions has decreased by 17.9% over the last five years and will continue to decrease through 2019. Similarly, the overall amount of NOx (a significant precursor to PM2.5 in the Valley) emissions has decreased by 35% over the last five years and will also continue to decrease through 2019.

PM2.5 concentrations have also decreased over this time period, although achieving these reductions has been quite challenging given frequent meteorological conditions conducive to PM2.5 formation that are characteristic of the Valley, and which are outside human (and regulatory) control. Annual fluctuations in weather patterns affect the Valley's carrying capacity (the ability to disperse pollutants), which is reflected in long- and short-term ambient air quality trends. Despite the impacts of these uncontrollable meteorological conditions, the Valley is progressing toward attainment of the 2006 PM2.5 National Ambient Air Quality Standard (NAAQS).

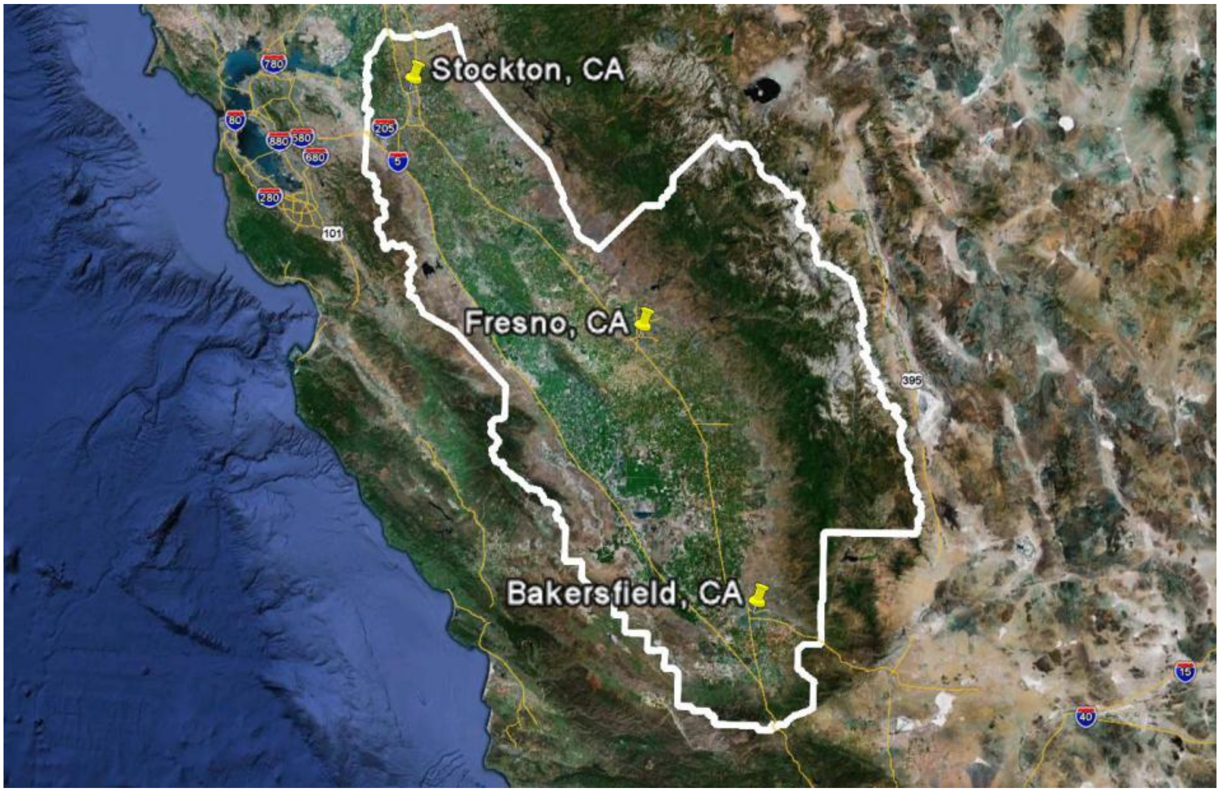
3.1 CHALLENGES OF THE NATURAL ENVIRONMENT

The Valley's 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 air flow, and the mild climate keeps pollutant-scouring winds at bay most of the year. Despite the challenges, the District and the Valley are making progress in attaining the national air quality standards and improving public health for Valley citizens.

3.1.1 Unique Climate and Geography

The challenge of PM 2.5 NAAQS attainment in the Valley is grounded in the unique topographical and meteorological conditions found in the region. The Valley, as seen in Figure 3-1, is an inter-mountain valley encompassing nearly 25,000 square miles. Surrounded by mountain ranges to the west, east, and south, the air flow 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 both beneath and above the evening inversion layer.

Figure 3-1 San Joaquin Valley Air Basin



Normally, temperature decreases with increasing altitude, but during temperature inversions the normal temperature gradient is reversed, with temperatures *increasing* with altitude, causing warmer air to be above cooler air. Figure 3-2 shows that this reversal of the "normal" pattern impedes the upward flow of air, causes poor dispersion, and traps pollutants near the 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 NAAQS.

Figure 3-2 Atmosphere with and without a Temperature Inversion

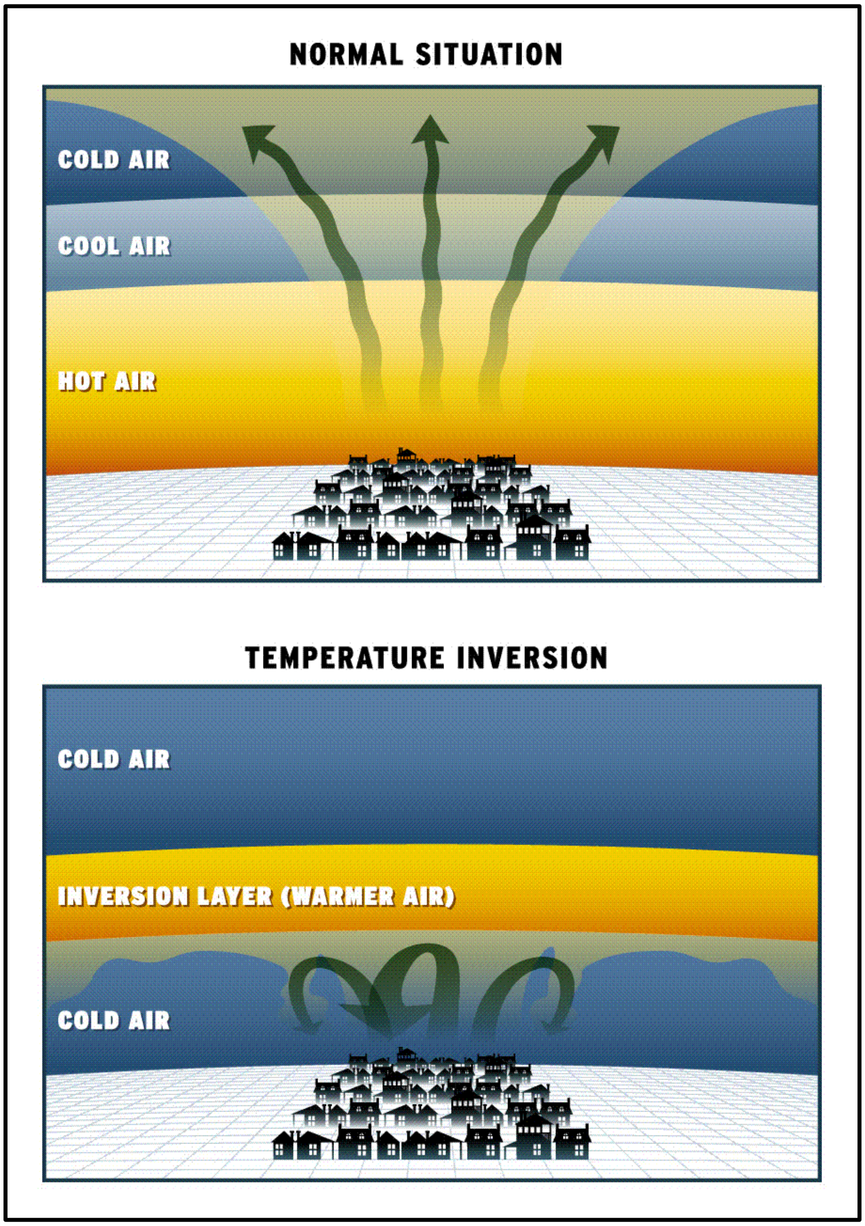
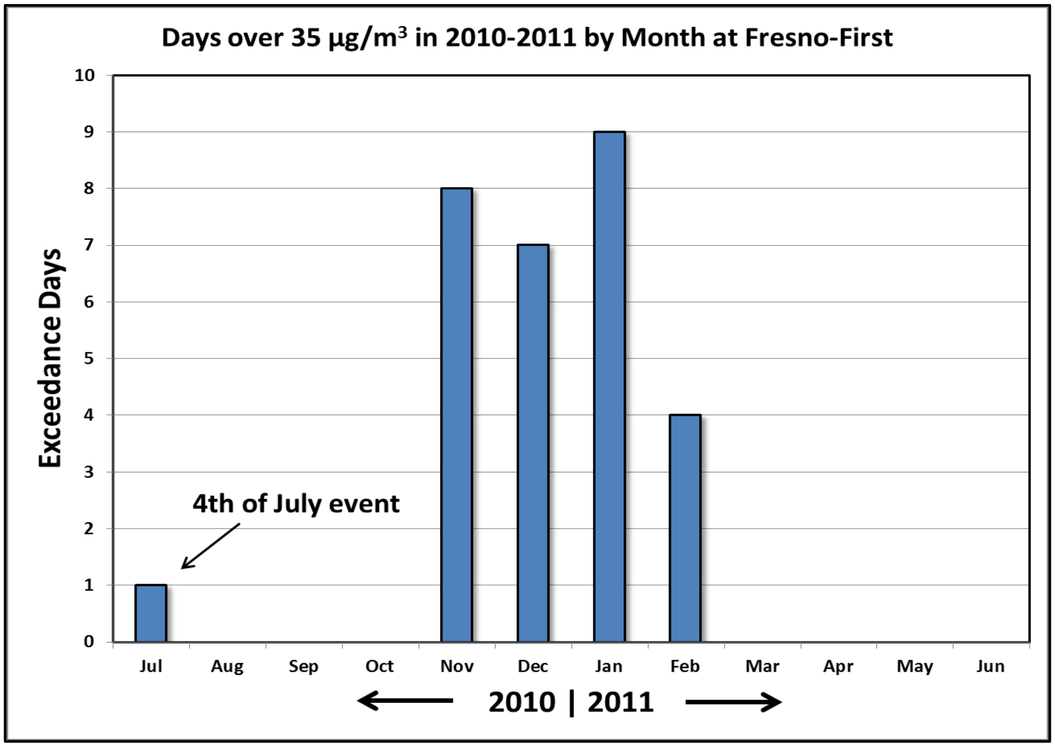


Image source: http://ffden-2.phys.uaf.edu/212_spring2007.web.dir/Amber_Smith/Effects_of_Inversions.htm

Because of frequent stagnant conditions during Valley winters, PM2.5 concentrations tend to be the highest from November to February. As an example, Figure 3-3 shows the number of days per month during the 2010–2011 time period when the Fresno-First air monitoring site exceeded the 2006 PM2.5 NAAQS threshold of 35 µg/m^3.

Figure 3-3 Days Over 35 μg/m^3 by Month at Fresno-First from 2010–2011



3.1.2 Valley Carrying Capacity

Carrying capacity, in the context of air quality, 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 the topography. Some air basins may have a high total pollutant emission rate (emissions per person or area), but if those emissions are easily dispersed or removed from the basin, that basin is much more likely to meet ambient standards despite high emission rate. On the other hand, an air basin may have a lower emission rate (or the same rate, over the same time period), but because of unfavorable environmental factors (low air flow, stagnant air, inversions) those pollutant concentrations typically accumulate (possibly above the standard) and remain in the air basin until weather patterns change. The latter scenario describes the San Joaquin Valley, and the first scenario is analogous to the Los Angeles (L.A.) air basin, especially for NOx emissions and the formation of ozone.

As an example, total NOx emissions for the L.A. basin were 754 tons per day (tpd) in 2008. During that year, the L.A. basin recorded 80 days above the 1997 national 8-hour ozone standard. For the same year, the total NOx emissions for the Valley air basin were 409 tpd (over a larger area), yet the Valley recorded 82 days above the standard. NOx dispersal is primarily dependent on summertime weather patterns. The L.A. basin experiences regular coastal winds through much of the summer that not only disburse pollutants from the air basin, but also moderates temperatures. Conversely, the Valley, surrounded by mountain ranges, routinely experiences stagnant weather patterns (less wind) and extended periods of high temperatures, both of which build and concentrate ozone to levels above the standard. In this real example, it is obvious that the Valley has a much lower carrying capacity than the L.A. basin for NOx, a precursor to ozone formation.

While not as drastic as the NOx-ozone example above (in terms of emission rate), the Valley's carrying capacity for PM2.5, when compared to the L.A. basin, is greatly affected by prevailing weather during the winter months and the region's topography (surrounding mountains). For 2008, the annual average direct PM2.5 emission rate for the L.A. basin was 80 tpd; during that year, that basin recorded 19 days above the national PM2.5 24-hour standard. For the same year, the Valley's annual average direct PM2.5 emission rate was 82 tpd; however, the Valley recorded 66 days above the 24-hour standard. During this same time period, the NOx and SOx emissions, which are also precursors to PM2.5, were significantly lower in the Valley compared to the L.A. Basin (NOx—409 tpd and 754 tpd, respectively, as stated above; and SOx—13 tpd and 54 tpd, respectively). As noted in Section 3.1.1, 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 anticipation of these events) that the District's Check-Before-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.

The District uses quantitative carrying capacity analysis in its modeling of attainment demonstrations. Such analyses can determine which combinations of PM2.5 and PM2.5 precursor emissions reductions can contribute to future attainment given anticipated population and activity growth, potential regulations or control measures, and the unchanging natural physical constraints. Chapter 4 presents the carrying capacity analyses conducted for this plan.

3.2 PM2.5 EMISSIONS INVENTORY TRENDS

The emissions inventory is the foundation for the attainment planning process. The District and the California Air Resources Board (ARB) 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. ARB 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.

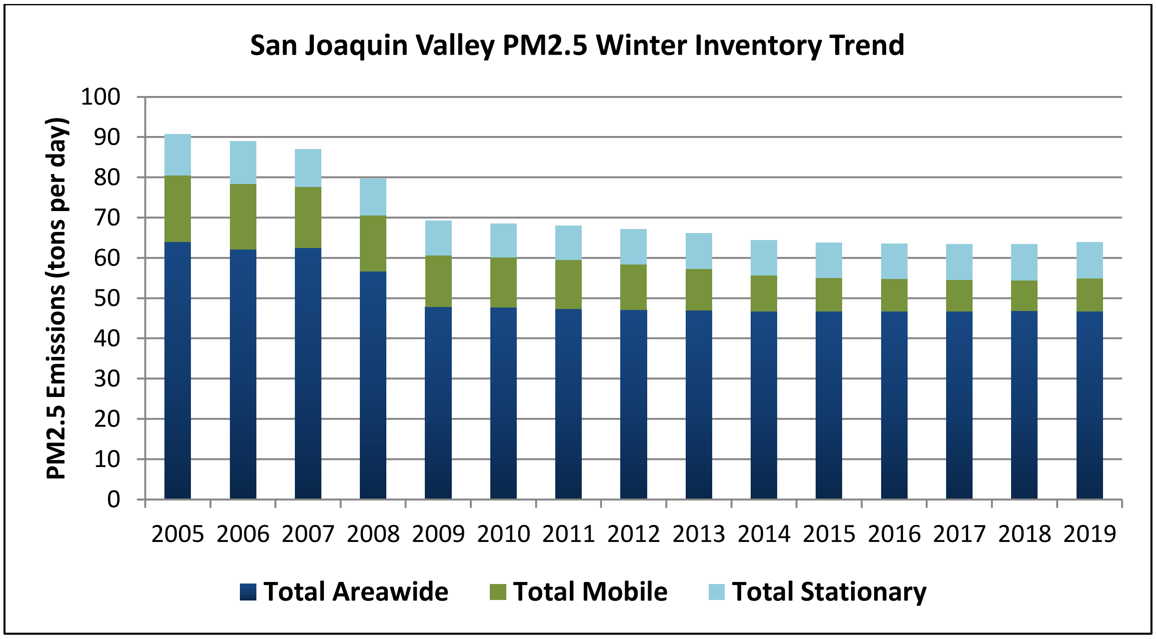
The District uses the emissions inventory to develop control strategies, to determine the effectiveness of permitting and control programs, to provide input into air quality modeling, to fulfill reasonable further progress requirements, and to screen regulated sources for compliance investigations.

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, fireplaces, 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

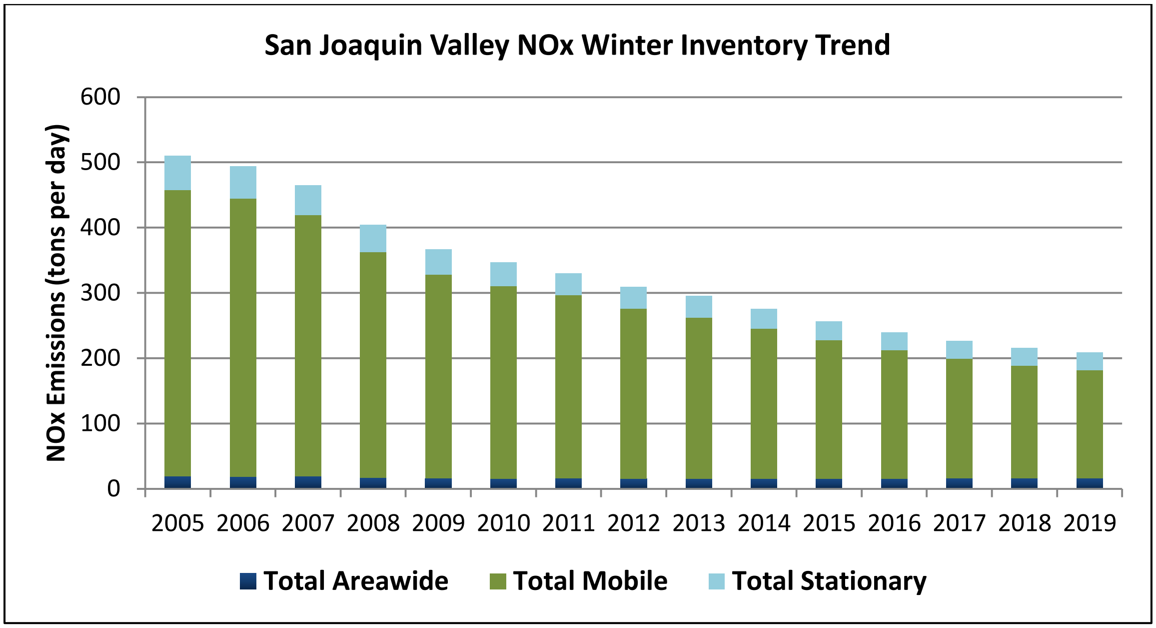
Figure 3-4 shows the PM2.5 emissions inventory trend for the mobile, stationary, and area source categories.

Figure 3-4 San Joaquin Valley PM2.5 Winter Emissions Inventory Trend



Because NOx is a significant PM2.5 precursor, the District relies heavily on NOx emissions to also reduce PM2.5 emissions. Figure 3-5 summarizes the NOx emissions inventory trends for the mobile, stationary, and area source categories. District and ARB control strategies for NOx play a significant role in reducing both ozone and PM2.5 emissions.

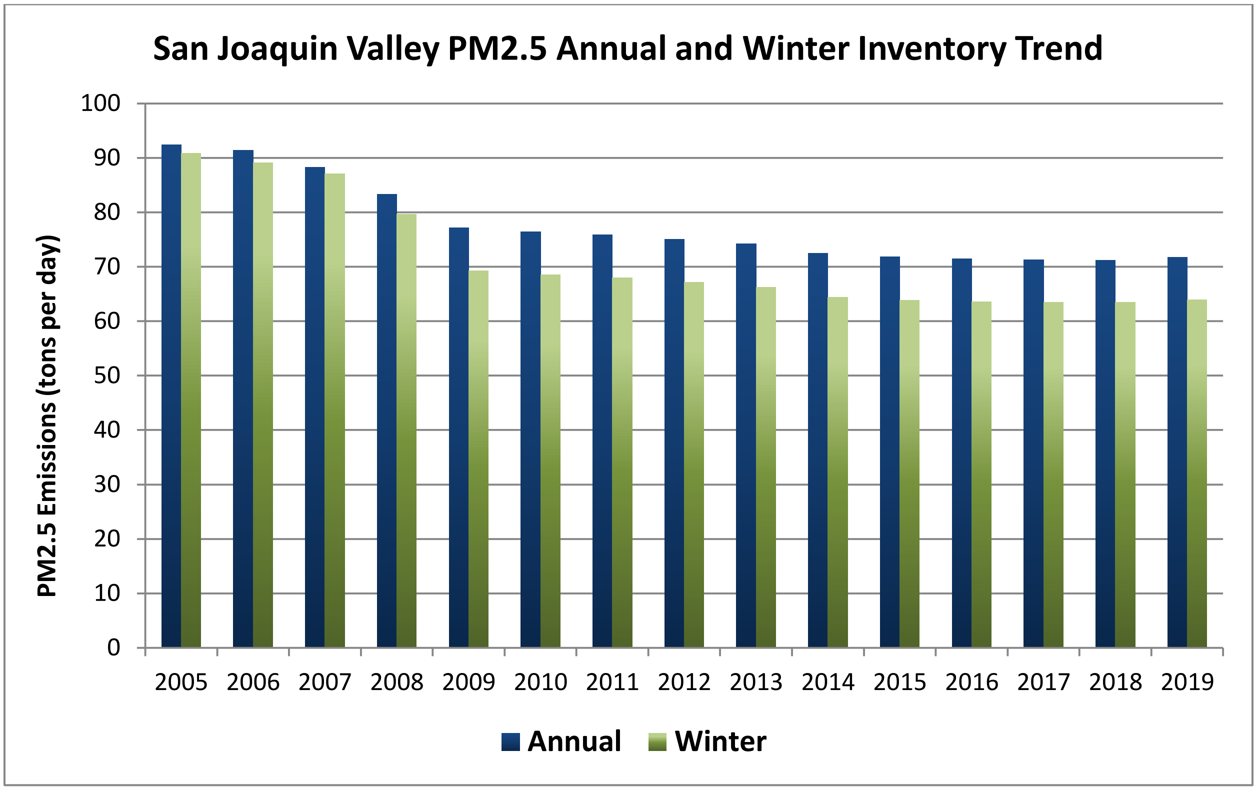
Figure 3-5 San Joaquin Valley Winter NOx Emissions Inventory Trend



Through an exhaustive evaluation of this inventory, which includes directly emitted PM2.5 and relevant PM2.5 precursors (NOx, SOx), the District has developed a control strategy that will be effective in reducing overall concentrations of PM2.5. Chapter 5 of this plan details the regulatory control measures based on this evaluation.

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. Figure 3-6 shows how the overall tons of PM2.5 emissions per day have decreased in the past and are anticipated to continue decreasing in the future based on anticipated growth and controls. Figure 3-6 also shows the comparative emission inventory reduction of winter PM2.5. 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, ARB, and other regulatory agencies.

Figure 3-6 San Joaquin Valley PM2.5 Annual and Winter Inventory Trends



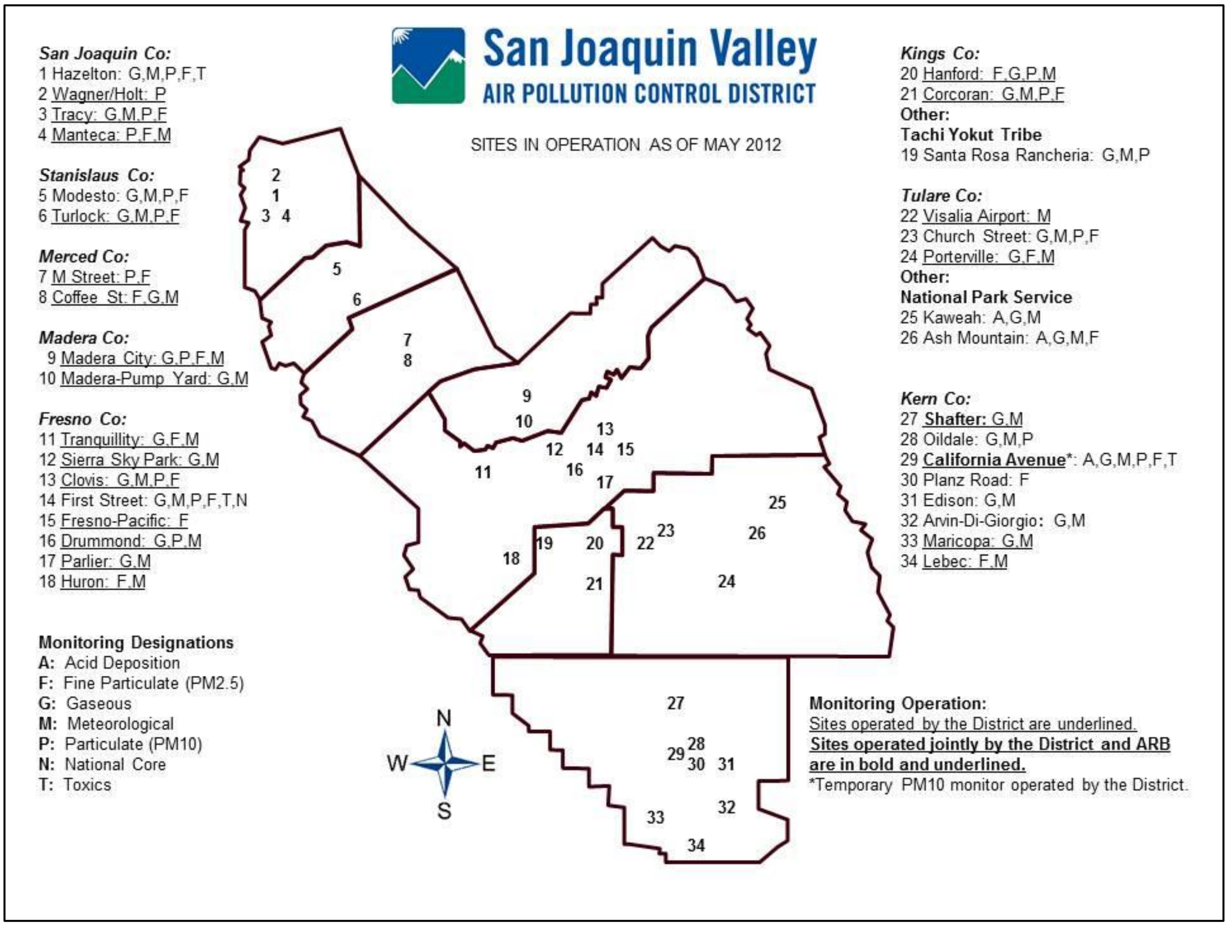
3.3 PM2.5 AIR QUALITY TRENDS

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.

3.3.1 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, ARB, 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 and the ARB operate 34 air monitoring stations throughout the Valley; 21 of these sites measure PM2.5, either through the use of filter-based monitors that measure each 24-hour period or hourly monitors that use light energy to provide near-continuous concentration levels. Figure 3-7 shows the Valley's network of air monitoring sites.

Figure 3-7 Air Monitoring Sites within the San Joaquin Valley Air District



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 U.S. Environmental Protection Agency (EPA) guidance and regulations.[1,2]

3.3.2 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

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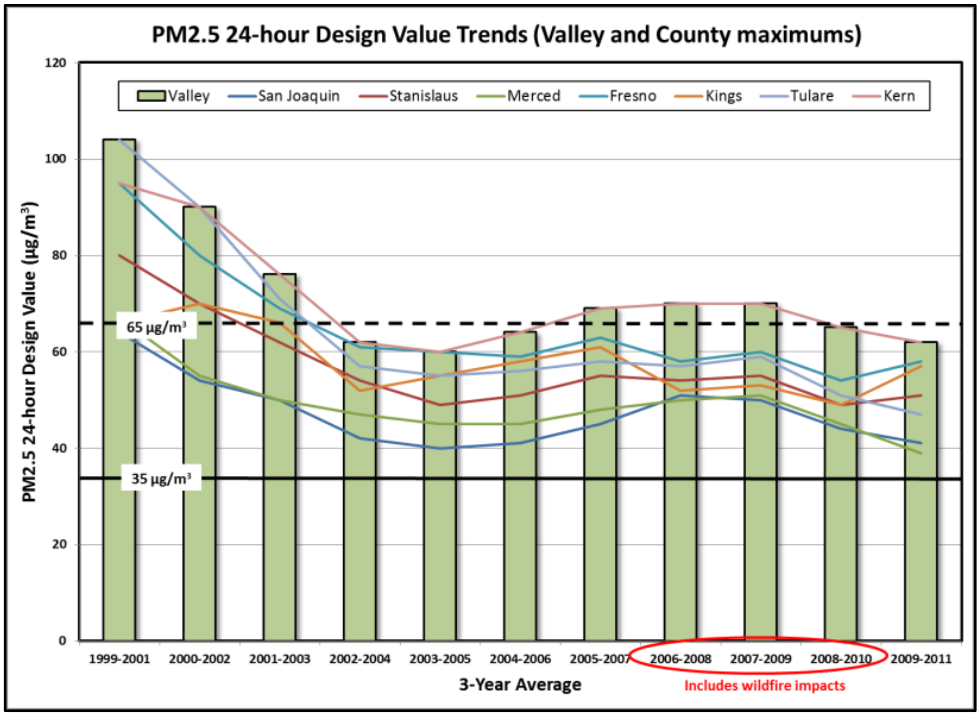
[1] Environmental Protection Agency [EPA]: Office of Air Quality Planning and Standards. (1999, April). *Guideline on Data Handling Conventions for the PM NAAQS* (EPA-454/R-99-008). Retrieved from http://www.epa.gov/ttn/oarpg/t1/memoranda/pmfinal.pdf

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

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, which also provides analysis results for a number of other air monitoring sites in the Valley.

Under the 2006 PM2.5 NAAQS, a region must meet both the 24-hour average standard of 35 µg/m^3 and the annual average standard of 15 µg/m^3 to meet attainment. Rather than using yearly maximum concentrations for the PM2.5 standards, EPA requires the use of design values for the attainment metric. Design values represent a three-year average and help to smooth out outlier years with exceptional meteorology or exceptional events. Details on how PM2.5 design values are calculated are provided in Appendix A of this plan. As seen in Figure 3-8, the Valley and county maximum 24-hour average PM2.5 design value trends show that although there is some year-to-year variation significant progress has been made in reducing long-term PM2.5 concentrations. Valley design value maximums have decreased by 40% over the 1999–2011 time period. This trend is also represented in the county maximum design values over the same time period. Note that some of the county design values calculated for the 2009–2011 data point have increased, partly due to the abnormal stagnation and poor air quality in late 2011.

Figure 3-8 Historical PM2.5 24-Hour Design Value Trends*



* Madera has not been included in this analysis since PM2.5 monitoring in Madera began in 2011.

Since monitoring began, the Bakersfield-Planz air monitoring site in Kern County has consistently been among the highest PM2.5 design values in the Valley. Figures 3-9 and 3-10 show the trend of the 24-hour and annual average design values at Bakersfield-Planz through 2011, as demonstrated with the 2009–2011 design value (3-year average).

Figure 3-9 Trend of 24-Hour Average PM2.5 Design Values at Bakersfield-Planz

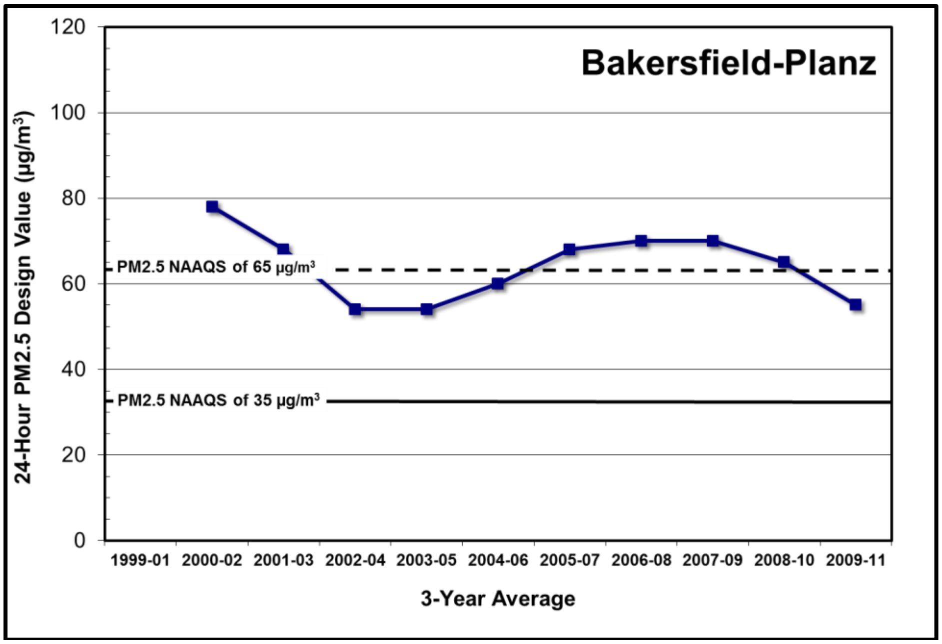
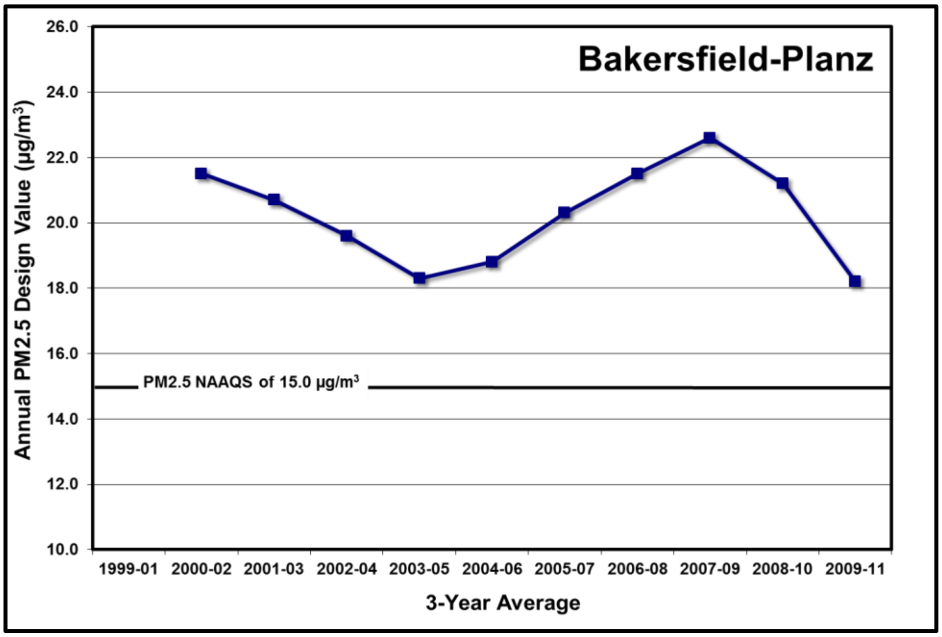


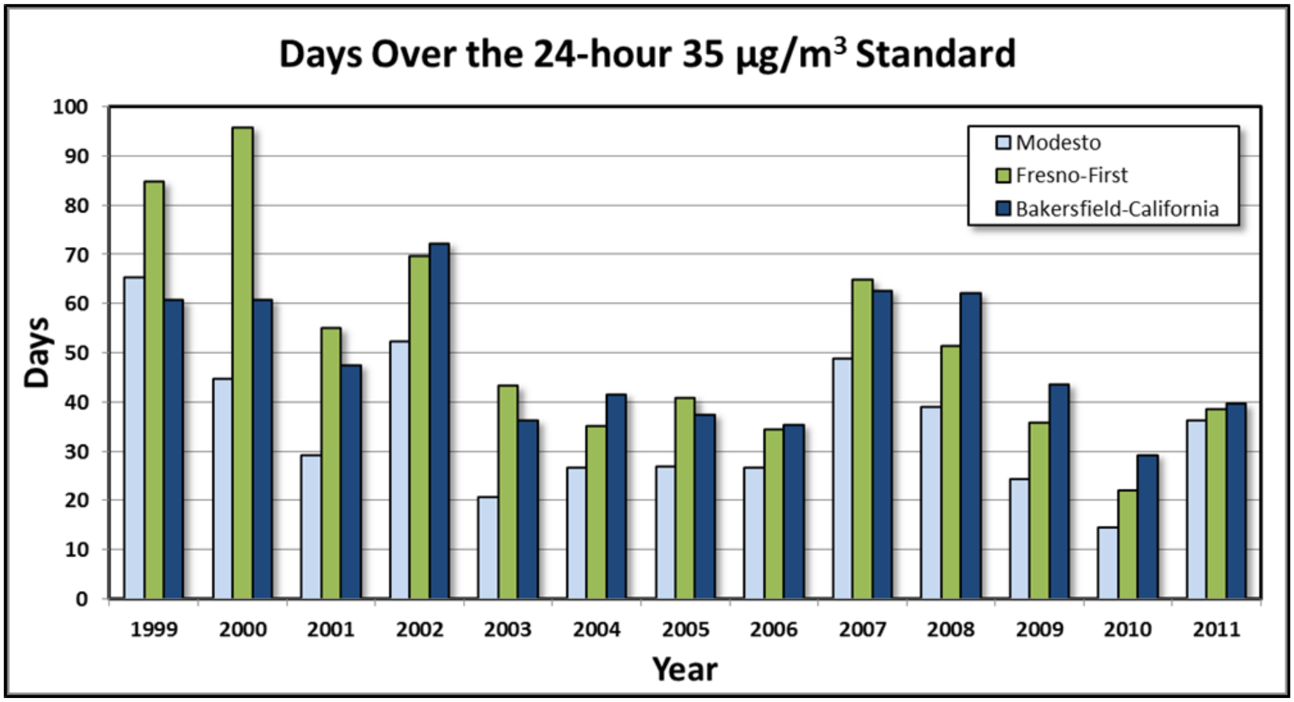
Figure 3-10 Trend of Annual Average PM2.5 Design Values at Bakersfield-Planz



Overall decreasing PM2.5 concentrations at the Bakersfield-Planz air monitoring site are shown in the design value trend for that site. Figure 3-9 shows that the site now has a 24-hour design value below the 1997 24-hour PM2.5 standard of 65 µg/m^3. Figure 3-10 shows that the annual average design value for the 2009–2011 time period was at an all-time low for the site at 18.2 µg/m^3. This downward trend will need to continue at all sites within the Valley as the Valley strives for attainment of the 2006 PM2.5 NAAQS.

The District also assesses long-term trends of PM2.5 concentration by looking at the number of days per year that a monitoring site measures concentrations over the PM2.5 2006 24-hour NAAQS limit of 35 µg/m^3. Figure 3-11 shows the general downward trend of this metric from 1999 to 2011 for air monitoring sites at Modesto (Stanislaus County), Fresno-First (Fresno County), and Bakersfield-California (Kern County). Overall, these sites have measured a 46% decrease in the number of days exceeding a concentration of 35 µg/m^3. The increase in the number of days over the standard in 2011 reflects unfavorable meteorology during the winter of that year. However, similar meteorology was experienced during the 1999–2000 and 2000–2001 winter seasons, yet there were a much greater number of days exceeding 35 µg/m^3 during these years, supporting the fact that emissions have been reduced since 1999.

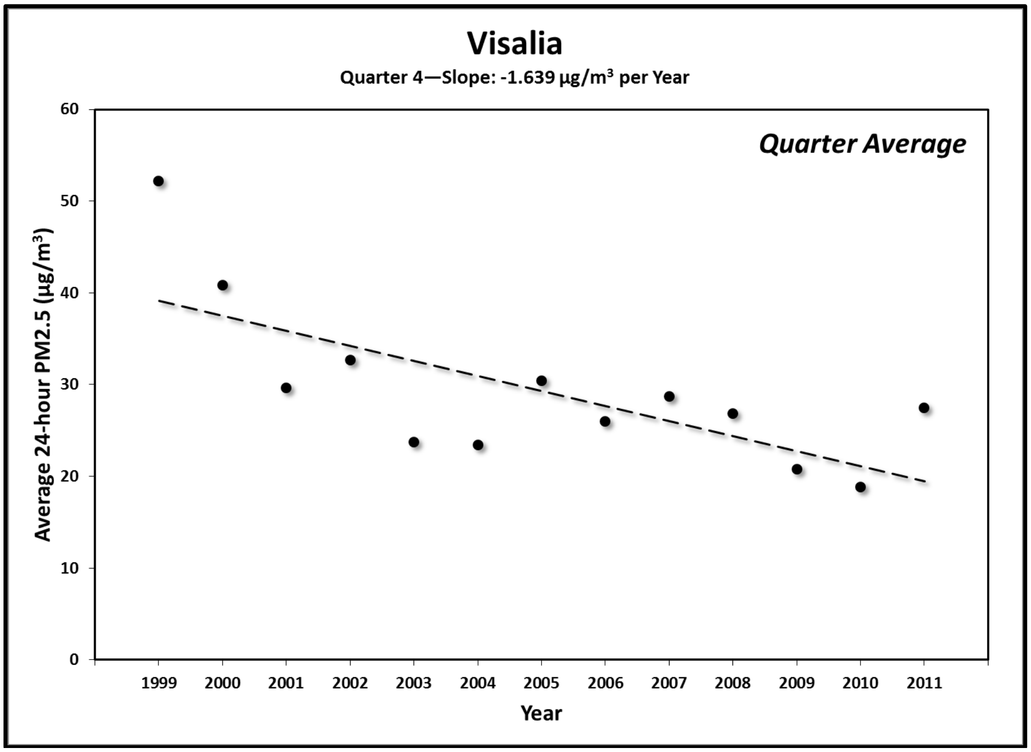
Figure 3-11 Annual Trends in Days over 35 µg/m3



Since the Valley's highest PM2.5 concentrations occur during the fall and winter months, the first (January through March) and fourth (October through December) quarters tend to have the highest average concentrations. Observing the trend in these quarterly averages can shed light on how the peak of the PM2.5 season is changing over time.

Data from the Visalia monitoring site, as shown in Figure 3-12, is representative of fourth-quarter averages among the PM2.5 sites in the Valley. This data also shows a downward trend of 1.64 µg/m³ per year. The District anticipates continuation of this trend as the Valley gets closer to attaining the annual average PM2.5 standard of 15 µg/m³. Appendix A contains detailed results of this analysis.

Figure 3-12 Trend of Fourth-Quarter Average at Visalia



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