Appendix A

Ambient PM2.5 Data Analysis

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A. AMBIENT PM2.5 DATA ANALYSIS

The concentration of ambient particulate matter that is 2.5 microns or less in diameter (PM2.5) at any given location in the San Joaquin Valley (Valley) is a function of meteorology, the natural environment, atmospheric chemistry, and emissions of directly emitted PM2.5 and PM2.5 precursors from regulated and unregulated sources. The San Joaquin Valley Air Pollution Control District (District), the California Air Resources Board (CARB), and other agencies[1] monitor PM2.5 concentrations throughout the Valley,[2] using filter-based monitoring (starting in 1999) and real-time concentration monitoring (starting in 2002). The U.S. Environmental Protection Agency (EPA) serves as the official repository of ambient PM2.5 data and analysis.[3]

The District uses the collected data to show air quality improvement through the standardized design value calculations, using EPA protocols to document basin-wide improvement and attainment of the National Ambient Air Quality Standards (NAAQS). As shown in this appendix, the design value (DV) data shows steady, long-term air quality improvement that will lead to the attainment of the federal PM2.5 standards.

The District also uses the data to evaluate the impact of changing daily, quarterly, and annual PM2.5 concentrations on public health. These trend analyses provide the District with critical information about how to develop control measures and incentive programs that provide the most impact to public health improvements, as guided by the District's Health Risk Reduction Strategy (see Chapter 3).

This appendix provides the technical details used to evaluate and analyze the District's PM2.5 concentration data. It also shows the multiple factors that affect ambient PM2.5 concentrations in the Valley (e.g. meteorology, exceptional events) and the evidence for air quality improvement through District regulatory actions, including the District's highly successful Rule 4901 (Wood Burning Fireplaces and Wood Burning Heaters).

A.1 PM2.5 CONCENTRATIONS—MEASUREMENT AND INFLUENCES

The District, CARB, and other agencies manage an extensive air monitoring network throughout the Valley. Information obtained from the PM2.5 monitors within this network provides the District with necessary information for demonstrating attainment of the NAAQS and valuable information for protecting public health throughout the year. The monitoring network captures the spatial, seasonal, daily, weekly, and annual variations in PM2.5 concentrations throughout the Valley that result from changing meteorology, the occurrence of exceptional events (e.g. high winds and wildfires), and PM2.5 emissions from regulated and unregulated sources.

[1] Other agencies include the Chukchansi and Tachi Yokut Tribe and the National Park Service.
[2] *San Joaquin Valley Air Pollution Control District Air Monitoring Network Plan*: June 21,2017 submittal to EPA. Available at https://www.valleyair.org/aqinfo/Docs/2017-Air-Monitoring-Network-Plan.pdf
[3] U.S. Environmental Protection Agency: Technology Transfer Network (TTN), Air Quality System (AQS): *AQS Web Application.* (2010). Available at https://www.epa.gov/aqs

A.1.1 PM2.5 Monitor Types

The District and CARB use three types of PM2.5 monitors in the Valley:

- Filter-based Federal Reference Method (FRM) monitors, defined as the standard for data collection;
- Real-time beta-attenuation method (BAM) monitors designated as federal equivalent method (FEM) monitors, and hereafter referred to as BAM/FEM monitors;
- Ordinary BAMs, not designated FEM, and hereafter referred to as BAM; and
- Filter-based speciation monitors, similar to FRM monitors.

Only FRM and BAM/FEM monitors produce data that is suitable for comparison with the NAAQS, and are therefore used for design value calculations. Real-time monitors (BAM/FEM and BAM) produce hourly measurements that the District uses daily to produce daily air quality forecasts, wood burning declarations, public health notifications, and Real-time Air Advisory Network (RAAN) notifications for schools.

Filter-based speciation monitors operate similarly to standard FRM monitors; however, due to the specific analysis requirements for the different PM2.5 species (e.g. metals, silicon, chlorine, organics), multiple filter media are required, hence a multi-filter collection system. The evaluation and analysis of multiple PM2.5 species is critical to the development of an effective attainment strategy.

A.1.2 Meteorological Influences on PM2.5 Concentrations

Particulates in the atmosphere are dispersed by horizontal and vertical mixing within an air mass. Wind flow (horizontal mixing) and temperature instability (decreasing temperature with height leading to vertical mixing) provides the strongest mechanisms for dispersing pollutants. Wind speed can greatly influence the pollutant concentrations by horizontally mixing and dispersing pollutants over a large area. Generally, the higher the wind speed, the lower the PM2.5 concentrations; however, in some cases, excessive winds may cause elevated PM2.5 levels as high winds entrain PM10 as well as PM2.5.

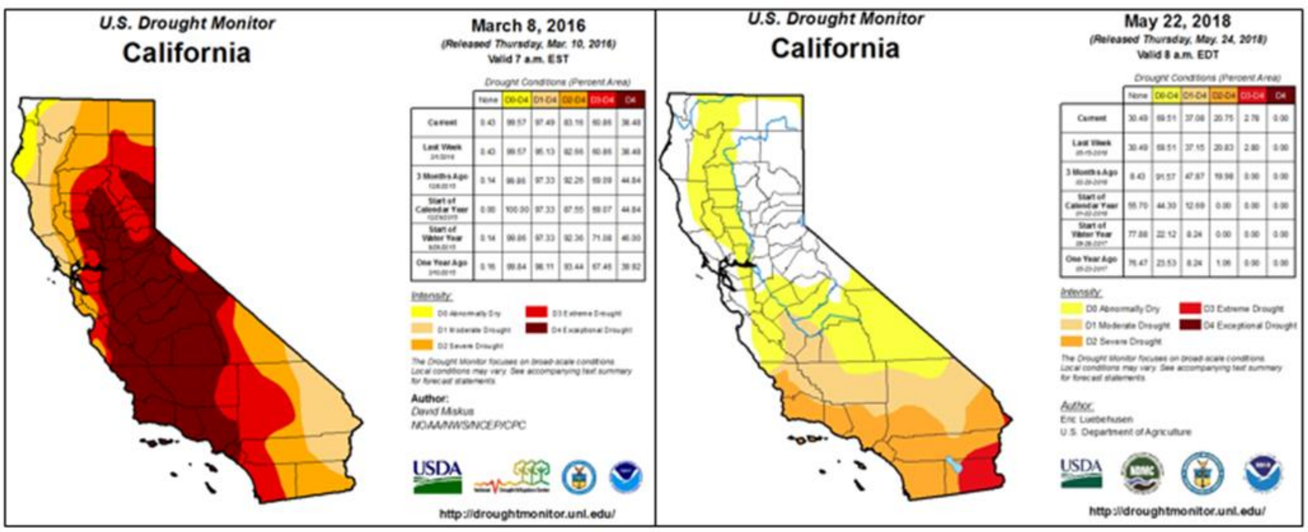
Vertical mixing of the air mass can result from atmospheric instability. A temperature inversion, or increasing temperature with increasing height, can inhibit the vertical mixing of an air mass, and create a situation in which pollutants remain trapped near the surface. Prolonged periods of high pressure and stable conditions with low wind speeds can cause stagnant conditions that trap pollutants near the surface. PM2.5 concentrations increase during these poor dispersion periods. During low pressure events, unstable conditions and stronger wind speeds occur. PM2.5 concentrations can decrease or increase depending on the strength and characteristics of the low pressure system.

Atmospheric weather patterns influence climate conditions, local meteorology, and PM2.5 concentrations. The next section describes the air quality impacts from the extreme drought.

A.1.2.1 Valley Drought

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 A-1 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 A-1 Drought Extent and Severity in California



Many cities in California, including those in the Valley, had record low rainfall totals during the 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 A-1).

Table A-1 Rainfall Totals for Select Cities Across California

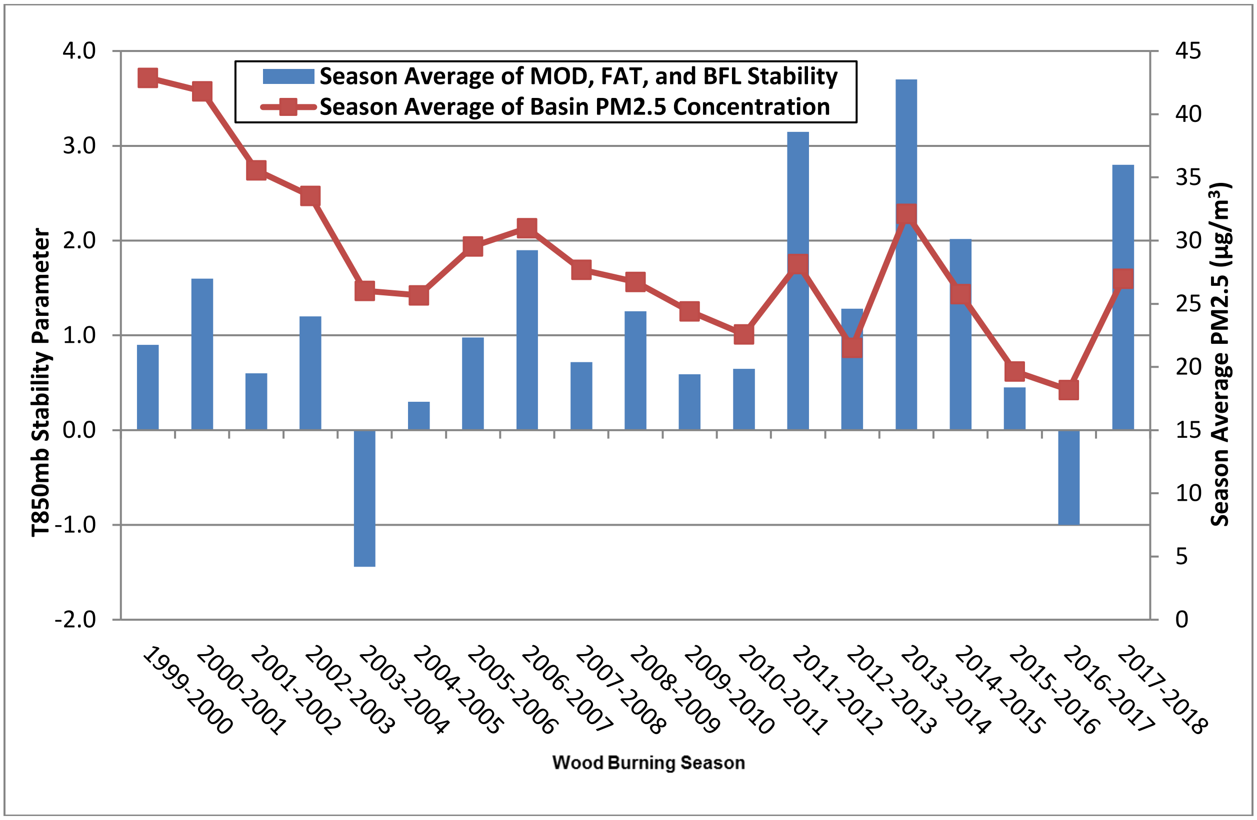
Region	City	1983-2013	2015	2016	2017	Record Low Rainfall	
		Average (inches)	Total (inches)	Total (inches)	Total (inches)	Year	Total (inches)
Northern California	San Francisco	19.73	8.45	25.5	26.62	2013	3.39
	Sacramento	17.6	8.53	22.92	27.16	2013	5.81
San Joaquin Valley	Modesto	12.17	7.25	16.24	12.93	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 the 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 A-2, 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 control measures have been achieving permanent emissions reductions.

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



A.1.2.2 Exceptional Event Influences on PM2.5 Concentrations

Valley PM2.5 concentrations are also affected by exceptional events such as wildfires, high winds, and fireworks. An exceptional event is defined as an event that affects air quality; is not reasonably controllable or preventable; is caused by either a human activity that is unlikely to recur at a particular location or a natural event; and is determined by EPA to be an exceptional event.[4] Such events can result in PM2.5 concentration peaks or extended high-concentration episodes, such as summertime wildfires.

Although not every event results in a formal submittal to EPA, the District tracks these events and their impact on attainment as part of its ongoing air quality analysis. These ongoing efforts help the District to more accurately characterize ambient PM2.5 concentrations and attainment progress. The District has experienced fireworks activity, high wind events, and wildfire events in the past that caused PM2.5 concentrations to exceed the federal PM2.5 standards.

The continued drought conditions experienced in the San Joaquin Valley and across the western United States from 2011-2015 led to a number of conditions that exacerbated the Valley's air quality challenges. Air pollution generated from wildfires is enormous

[4] Treatment of Air Quality Monitoring Data Influenced by Exceptional Events, 72 Fed. Reg. 55, pp. 13560–13581. (2007, March 22). (to be codified in 40 C.F.R. pts. 50 and 51), (40 CFR 50.14)

and can well exceed total industrial and mobile source emissions in the San Joaquin Valley, overwhelming all control measures and resulting in periods of excessively high PM concentrations. For example in 2015, emissions from the Rough Fire in Fresno County consisted of heavy fuel loads with high emissions estimates per acre of fuel burned. As compared to the Valley's emissions, direct PM2.5 emissions from the Rough Fire at its peak day were 105 times greater than the PM2.5 emissions from the District's entire stationary, area, and mobile source inventories combined. Similarly, NOx emissions, a precursor to PM2.5, were 8 times greater than the District's inventory.

Due to the excessively dry conditions, the buildup of combustible materials, and the mortality of millions of trees from the drought and bark beetle infestation, the region has experienced a number of large wildfires and California has reached an all-time high for fire danger. The 2017 wildfire season has brought more wildfires across California compared to last year and the 5 year average through the same time period, as the following table displays.

Table A-2 Number of Wildfire Occurrences in California

Timeframe	Fires
January 1 through December 31, 2017	7,117
January 1 through December 31, 2016	4,785
5 Year Average (same interval)	4,835

Source: CAL FIRE

With proper documentation and EPA concurrence, data influenced by exceptional events can be excluded from official attainment demonstration design value calculations. Design values, which will be discussed fully in Section A.2, represent a three-year average of 24-hour and annual mean PM2.5 concentrations.

A.2 Attainment Demonstration—Design Values

Design values represent the official metric for assessing air quality improvements and attainment of the NAAQS per the Federal Clean Air Act and EPA regulations. Design value calculations are three-year averages that follow EPA protocols for rounding, averaging conventions, data completeness, sampling frequency, data substitutions, and data validity. The results provide consistency and transparency to determine basin-wide attainment for both components of the 1997 PM2.5 standard, which includes the 24-hour PM2.5 standard of 65 µg/m^3 and the annual PM2.5 standard of 15 µg/m^3; the 2006 24-hour PM2.5 standard of 35 µg/m^3, and the 2012 annual PM2.5 standard of 12 µg/m^3. If any monitoring site within the air basin has either a 24-hour or annual PM2.5 design value higher than the respective standards, then the entire air basin is designated nonattainment.

Table A-3 provides the generalized descriptions of how the 24-hour average and annual average design values are calculated for PM2.5. EPA provides detailed guidelines and standards for the calculation[5] and data handling[6] methodologies.

Table A-3 General PM2.5 Design Value Calculation Methods

Averaging Period	Level	Calculation Method
24-hour	65 µg/m³ (1997) 35 µg/m³ (2006)	**Step 1:** *Determine the 98th percentile value for each year over a consecutive three year period.* **Step 2:** *Average the three 98th percentile values.* **Step 3:** *Round the resulting value to the nearest 1.0 µg/m³.* **Step 4:** *Compare the result to the standard.*
Annual	15.0 µg/m³ (1997) 12.0 µg/m³ (2012)	**Step 1:** *Calculate the average of each quarter of each year over a three year period.* **Step 2:** *Average the four quarters in a calendar year to determine the average for each year.* **Step 3:** *Average the three annual values.* **Step 4:** *Round the resulting value to the nearest 0.1 µg/m³.* **Step 5:** *Compare the result to the standard.*

Table A-4 through Table A-7 show the trend of the 24-hour average and annual average values for each PM2.5 monitoring site in the Valley by year as well as the three-year average design values for these metrics through the year 2016.

24-hour single-year 98th-percentile averages (Table A-4) are used to generate the three-year average 24-hour design values (Table A-5). Single-year average PM2.5 concentrations (Table A-6) are used to generate the three-year average annual design values (Table A-7). This data is shown graphically in Figures A-3 through A-18 for select sites within each county in the Valley.

Average ambient PM2.5 concentrations vary by monitoring site within the Valley. In general, monitoring sites in the northern part of the Valley record the lowest ambient PM2.5 concentrations, with concentrations increasing toward the central and southern portions of the Valley. For the 2015-17 period, all Valley air monitoring sites meet the 1997 24-hour average standard of 65 µg/m³, while a handful of sites still exceed the annual average standard of 15.0 µg/m³. With PM2.5 concentrations continuing to improve, both 24-hour and annual average design values are trending downward across the Valley, bringing the region closer to attaining the federal PM2.5 standards.

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[5] Interpretation of the National Ambient Air Quality Standards for PM2.5, 40 C.F.R. Pt. 50 Appendix N (2012). Available at https://www.law.cornell.edu/cfr/text/40/appendix-N_to_part_50

[6] 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 NEPIS.epa.gov

Table A-4 Single Year 24-hour Average PM2.5 98th Percentile Values (ug/m^3)

SJV Monitoring Sites	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Stockton-Hazelton	79	55	58	50	41	36	44	42	48	61.6	40.4	29.7	44.8	33.9	56.3	44.5	39.1	32.4	44.2
Manteca												44*	38.9	30.9	40.2	40	42.7	29.3	36.4
Modesto	100	71	69	69	47	45	55	52	57.4	53.9	54.5	37.3	54.7	40.8	56.4	49.5	30.8	36.2	51.1
Turlock										67.4	53.1	43.5	57.4	45.4	55.4	51.2	47.3	38.5	48
Merced - M St	91.9	68.4	49.3	57.6	44.7	46.9	48.6	52.5	53	53.6	49.8	39.1	38.5	41.8	67.3	45.9	39	34.6	40.3
Merced - Coffee											41.4*	39.9	47.4	35.6	42.3	43.8	40.3	32.8	44.7
Madera City												57*	59.1	43.2	54.6	56	43.7	35.7	45.8
Clovis	83.2	72.5	76.2	53.5	48.4	56	67.1	60.5	61.2	49.7	49	44.3	68.5	48	56.2	64.5	45.7	37.7	54
Fresno-Garland														52.6	63.8	66.7	52	42.7	68
Fresno-1st	120	90	75	75	56	52	71	51	67	57.4	55.8	48.8	69.5	93.4*					
Fresno 1st/Garland	120	90	75	75	56	52	71	51	67	57.4	55.8	48.8	69.5	52.6	63.8	66.7	52	42.7	68
Fresno-Pacific		65.1	72.1	73	52	52.1	74.1	65	57.9	46.4	52.3	40.2	67.5	51.3	71.6	61.8	42	40	73.2
Tranquillity											35.8	27*	27.5	26.9	35.7	31.2*	35.8	27	34.4
Corcoran	53	55.1	120.6	77.4	48.5	49.6	77.8	63.8	59.5	47.9	53.4	47.2	40.8	40	66	71		45.9	69.7
Hanford												48.5	64.6	48.3	67.6	81.9	51.4	43.3	68.7
Visalia	114	103	96	70	47	54	65	50	59.7	62.1	53.9	36.3	50.7	53.8	62.5	75.4	45.8	40.7	74.6
Bakersfield-Golden/M St	97.5	102.5	96.3	81.6	57.1	54.6	77.9	75.2	69.4	60.9	68.6						51.5	51.4	71.3
Bakersfield-CA	97.4	92.7	94.9	73	48.3	61.5	63.2	60.5	73	64.5	66.7	53.3	65.5	56.4	71.8	79.9	57.2	47	71.8
Bakersfield-Planz		76.5	90.6	66.8	47.5	47.6	66.4	64.7	72.2	72.3	65.5	56.2	43.2	40.6	96.7	76.7	56.5	50.7	69.7

* Values are incomplete causing concentrations unrepresentative of ambient conditions.

Table A-5 24-hour Average PM2.5 Design Values (Three-Year Averages, μg/m^3)

SJV Monitoring Sites	1999-2001	2000-2002	2001-2003	2002-2004	2003-2005	2004-2006	2005-2007	2006-2008	2007-2009	2008-2010	2009-2011	2010-2012	2011-2013	2012-2014	2013-2015	2014-2016	2015-2017
Stockton-Hazelton	64	54	50	42	40	41	45	51	50	44	38	36	45	45	47	39	39
Manteca											38	38	37	37	41	37	36
Modesto	80	70	62	54	49	51	55	54	55	49	49	44	51	49	46	39	39
Turlock										55	51	49	53	51	51	46	45
Merced-M St	70	58	51	50	47	49	51	53	52	48	42	40	49	52	51	40	38
Merced-Coffee										41*	43	41	42	41	42	39	39
Madera-City											58*	53	52	51	51	45	42
Clovis	77	67	59	53	57	61	63	57	53	48	54	54	58	56	55	49	46
Fresno-Garland												53*	58*	61	61	54	54
Fresno-1st	95	80	69	61	60	58	63	58	60	54	58	59*	70*				
Fresno-1st/Garland	95	80	69	61	60	58	63	58	60	54	58	57*	62*	61	61	54	54
Fresno-Pacific	69*	70	66	59	59	64	66	56	52	46	53	53	63	62	58	48	52
Tranquillity									36*	31*	30*	27*	30	31	34	31	32
Corcoran	76	84	82	59	59	64	67	57	54	50	47	43	49	59	*	*	*
Hanford										49*	57*	54	60	66	67	59	54
Visalia	104	90	71	57	55	56	58	57	59	51	47	47	56	64	61	54	54
Bakersfield-Golden/M St	99	93	78	64	63	69	74	69	66	65*	69*			*	*		58
Bakersfield-CA	95	87	72	61	58	62	66	66	68	62	62	58	65	69	70	61	59
Bakersfield-Planz	84*	78	68	54	54	60	68	70	70	65	55	47	60	71	77	61	59

* Values are incomplete causing concentrations unrepresentative of ambient conditions.

Table A-6 Single Year Annual Mean PM2.5 Concentrations (µg/m³)

SJV Monitoring Sites	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Stockton-Hazelton	19.7	15.5	13.9	16.7	13.6	13.2	12.5	13.1	12.9	14.4	11.3	10.6	11.3	12.4	17.7	12.1	12.8	11.8	12.1
Manteca												17.6*	10.7	8.1	11.6	9.8	12.6	9.8	11.1
Modesto	24.9	18.7	15.6	18.7	14.5	13.6	13.9	14.8	15	16	13	12.1	14.7	11.9	14.3	11.4	9.1*	11.1	12.9
Turlock										30.3*	16.1	12.7	17.1	14.8	15	12.3	14.2	12.6	12.7
Merced-M St.	22.6*	16.7	14.5	18.7	15.7	15.2	14.1	14.8	15.2	14.9*	13.6	11.2	10.4	9.5	13.5	11.2	12.6	11.2	12.6
Merced-Coffee											22.7*	16.3	15.6	11	13.3	10.8	12.7	11.9	13.3
Madera-City												21.1*	20.4	16	17.8	14	13.8	12	12.5
Clovis	19.8	16.3	18	16.2	18.5*	16.4	16.3	16.4	16.4	16.2	18.3	14.6	17.9	15.4	15.9	14.8	15	12.5	13.3
Fresno-Garland														14.1	16.8	15.1	14.4	12.7	14.9
Fresno-1st	27.6	24.5*	19.8	21.5	17.8	16.3	16.7	16.8	18.8	17.4	15.1	13	15.5	40.3*					
Fresno-1st/Garland	27.6	24.5*	19.8	21.5	17.8	16.3	16.7	16.8	18.8	17.4	15.1	13	15.5	14.1	16.8	15.1	14.4	12.7	14.9
Fresno-Pacific		18.4	18.6	21.3	17.8	17	16.9	17.6	16.8	16.5	14.6	13.4	15.4	12.7	15.9	13.8	14.1	13	15
Tranquillity											11.8*	7*	8.2	7	8.3	7.6*	10	7.7	8.3
Corcoran	14.3*	16.4	19.2	21.5	16.2	17.4	17.5	16.9	18.4	15.8	17.7	17.9	12.8*	16.5*	15.6	15.4	*	14.8	16
Hanford												14.5	18	14.8	18.2	17.5	16.5	15.5	17.2
Visalia	27.6	23.9	22.5	23.2	18.2	17	18.8	18.8	20.4	19.8	16	13.6	16.1	14.8	18.9	17.9	16.1	14.7	16.3
Bakersfield-Golden/M St	26.2	22.6	21.8	24.1	19.6	18.2	19.1	18.6	19.9	17.9*	20					*	16.7	14.8	16.2
Bakersfield-CA	23.8	22.5	21.2	22.7	17.1	18.9	18	18.7	22	21.9	19	14.2	16.2	13	20	18.6	16.3	14.8	15.9
Bakersfield-Planz		20.3	20.8	23.5	17.8	17.4	19.8	19.3	21.8	23.5	22.5	17.6	14.5	14.7	22.8	21.6	17.9	15.9	18.2

* Values are incomplete causing concentrations unrepresentative of ambient conditions.

Table A-7 Annual PM2.5 Design Values (Three-Year Averages, µg/m³)

SJV Monitoring Sites	1999-2001	2000-2002	2001-2003	2002-2004	2003-2005	2004-2006	2005-2007	2006-2008	2007-2009	2008-2010	2009-2011	2010-2012	2011-2013	2012-2014	2013-2015	2014-2016	2015-2017
Stockton-Hazelton	16.4	15.4	14.7	14.5	13.1	12.9	12.8	13.5	12.9	12.1	11.1	11.4	13.8	14.1	14.2	12.2	12.2
Manteca											10.7*	9.4*	10.1	9.8	11.3	10.7	11.2
Modesto	19.7	17.7	16.3	15.6	14.0	14.1	14.6	15.3	14.7	13.7	13.3	12.9	13.6	12.5	12.9*	10.5	11.0*
Turlock									16.1*	14.4*	15.3	14.9	15.6	14.0	13.8	13.0	13.2
Merced-M St.	15.6*	16.6	16.3	16.5	15.0	14.7	14.7	15.0*	14.4*	12.4*	11.7	10.4	11.1	11.4	12.4	11.7	12.1
Merced-Coffee										16.3*	16.0*	14.3	13.3	11.7	12.3	11.8	12.7
Madera-City											20.4*	18.2*	18.1	15.9	15.2	13.3	12.8
Clovis	18.0	16.8	17.1	16.3	16.4	16.4	16.4	16.3	17.0	16.4	16.9	16.0	16.4	15.4	15.2	14.1	13.6
Fresno-Garland												14.1	15.5	15.3	15.4	14.1	14.0
Fresno-1st	23.7*	20.7*	19.7	18.5	16.9	16.6	17.4	17.7	17.1	15.2	14.5	14.3*	15.5*				
Fresno-1st/Garland	23.7*	20.7*	19.7	18.5	16.9	16.6	17.4	17.7	17.1	15.2	14.5	14.2	15.5	15.3	15.4	14.1	14.0
Fresno-Pacific	18.5	19.4	19.2	18.7	17.2	17.2	17.1	17.0	16.0	14.8	14.5	13.8	14.7	14.1	14.6	13.6	14.0
Tranquillity											8.2*	7.6*	7.8	7.7	8.7	8.5	8.7
Corcoran	17.8	19.0	19.0	18.4	17.0	17.3	17.6	17.0	17.3	17.1	17.8*	17.9*	15.6*	15.5*	*	*	*
Hanford										14.5	16.3	15.8	17.0	16.8	17.4	16.5	16.4
Visalia	24.7	23.2	21.3	19.5	18.0	18.2	19.3	19.7	18.7	16.5	15.2	14.8	16.6	17.2	17.6	16.2	15.7
Bakersfield-Golden/M St	23.5	22.8	21.8	20.6	19.0	18.6	19.2	19.3	20.0	20.0	20.0				16.7*	15.8*	15.9
Bakersfield-CA	22.5	22.1	20.3	19.6	18.0	18.5	19.6	20.9	21.0	18.4	16.5	14.5	16.4	17.2	18.3	16.5	15.7
Bakersfield-Planz	20.6	21.5	20.7	19.6	18.3	18.8	20.3	21.5	22.6	21.2	18.2	15.6	17.3	19.7	20.8	18.4	17.3

Notes for Tables A-4, A-5, A-6, and A-7:

- Source: U.S. Environmental Protection Agency: Air Quality System AQS): AMP 480 Report, available at https://www.epa.gov/aqs , July 19, 2018.
- Empty cell: No data or insufficient data
- Asterisk (*) and highlighted cells: Values do not meet completeness criteria
- Corcoran 2015, 2016, 2017 design values are not representative of ambient concentrations due to incomplete data in 2015 resulting from the shelter being destroyed in a fire.
- Bakersfield-Golden/M St. is not shown since it was influenced by incomplete data in 2014 and is not representative of ambient conditions.

Figure A-3 San Joaquin County 24-hr Design Value Trend

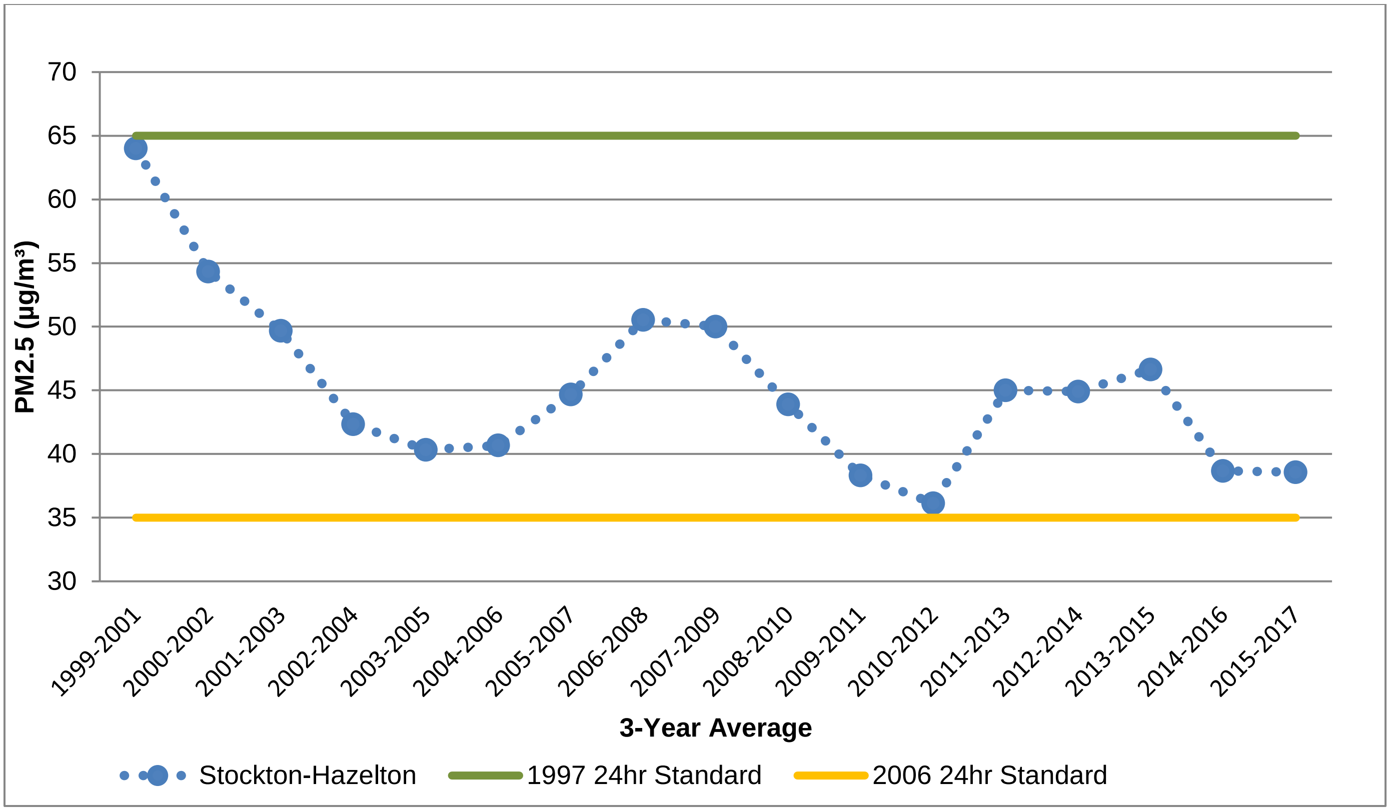


Figure A-4 San Joaquin County Annual Design Value Trend

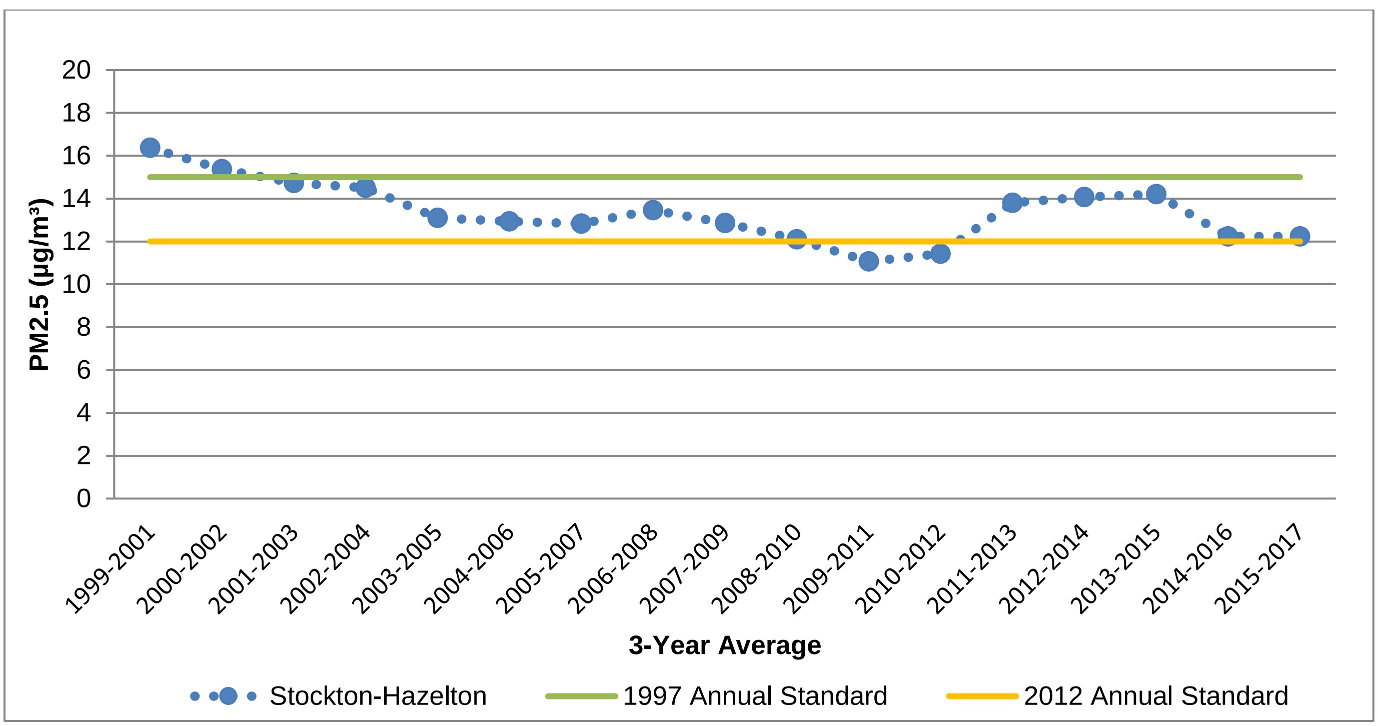


Figure A-5 Stanislaus County 24-Hour Design Value Trend

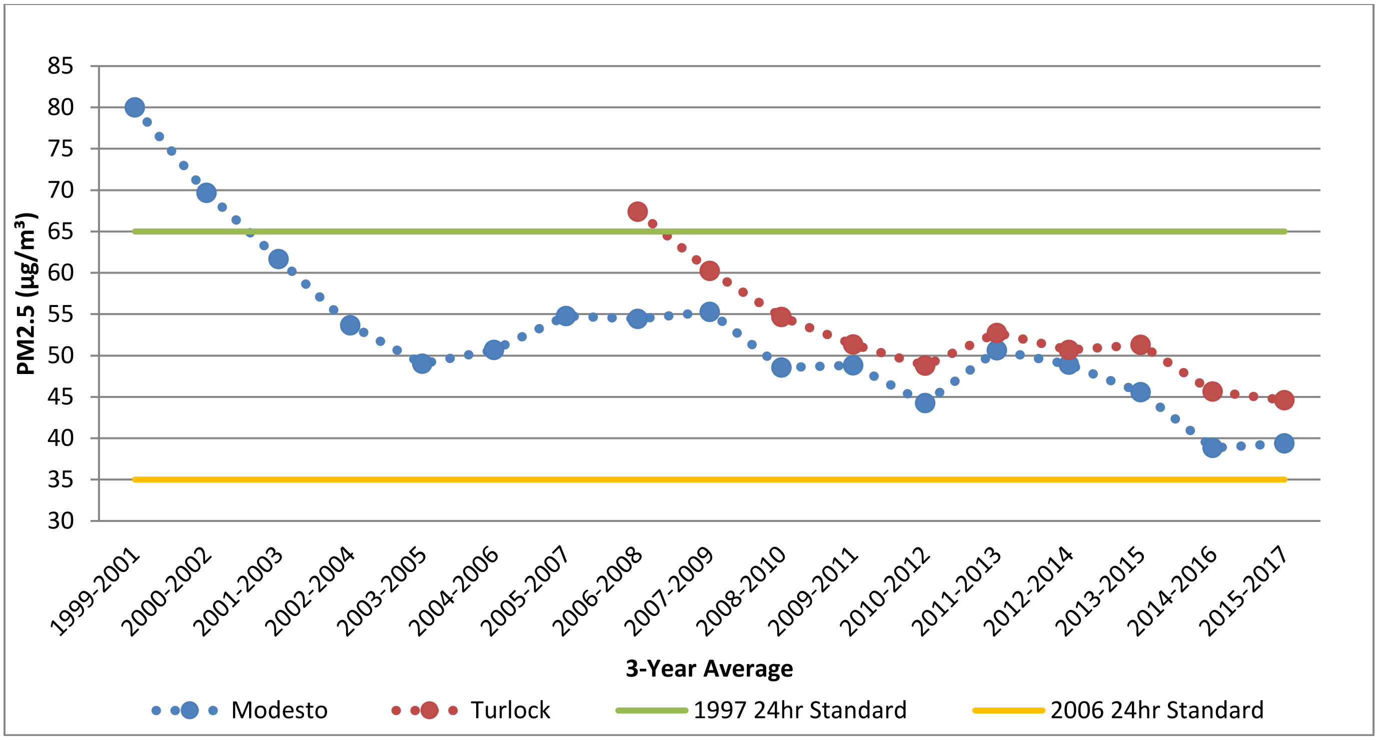


Figure A-6 Stanislaus County Annual Design Value Trend

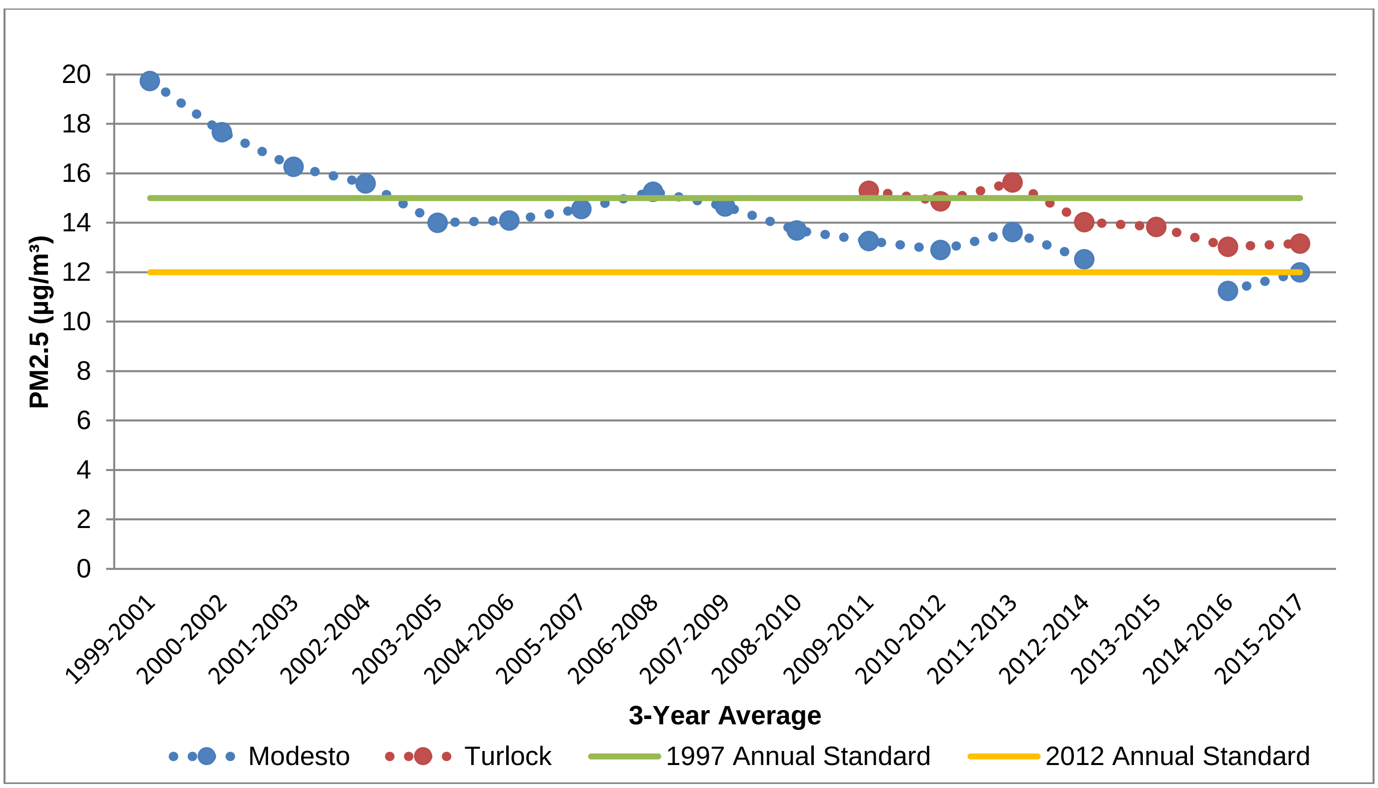


Figure A-7 Merced County 24-Hour Design Value Trend

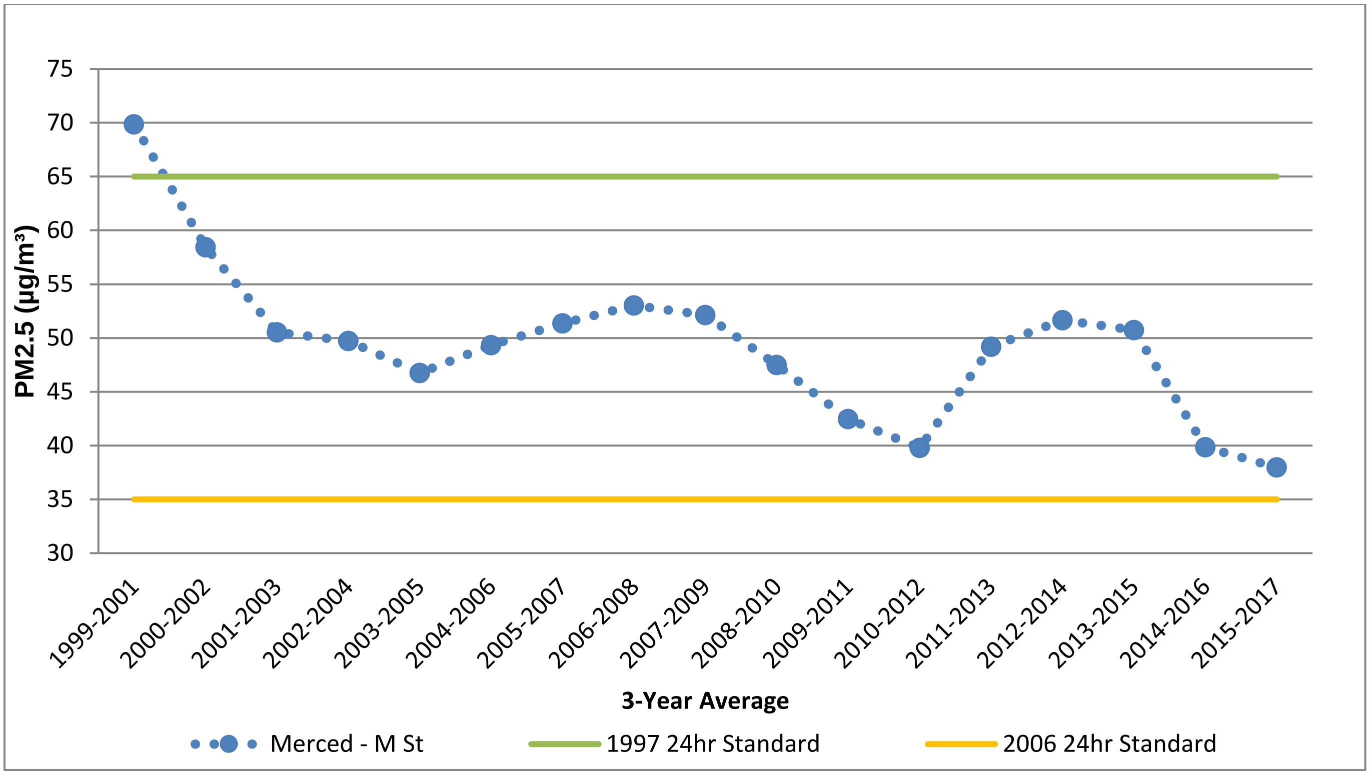


Figure A-8 Merced County Annual Design Value Trend

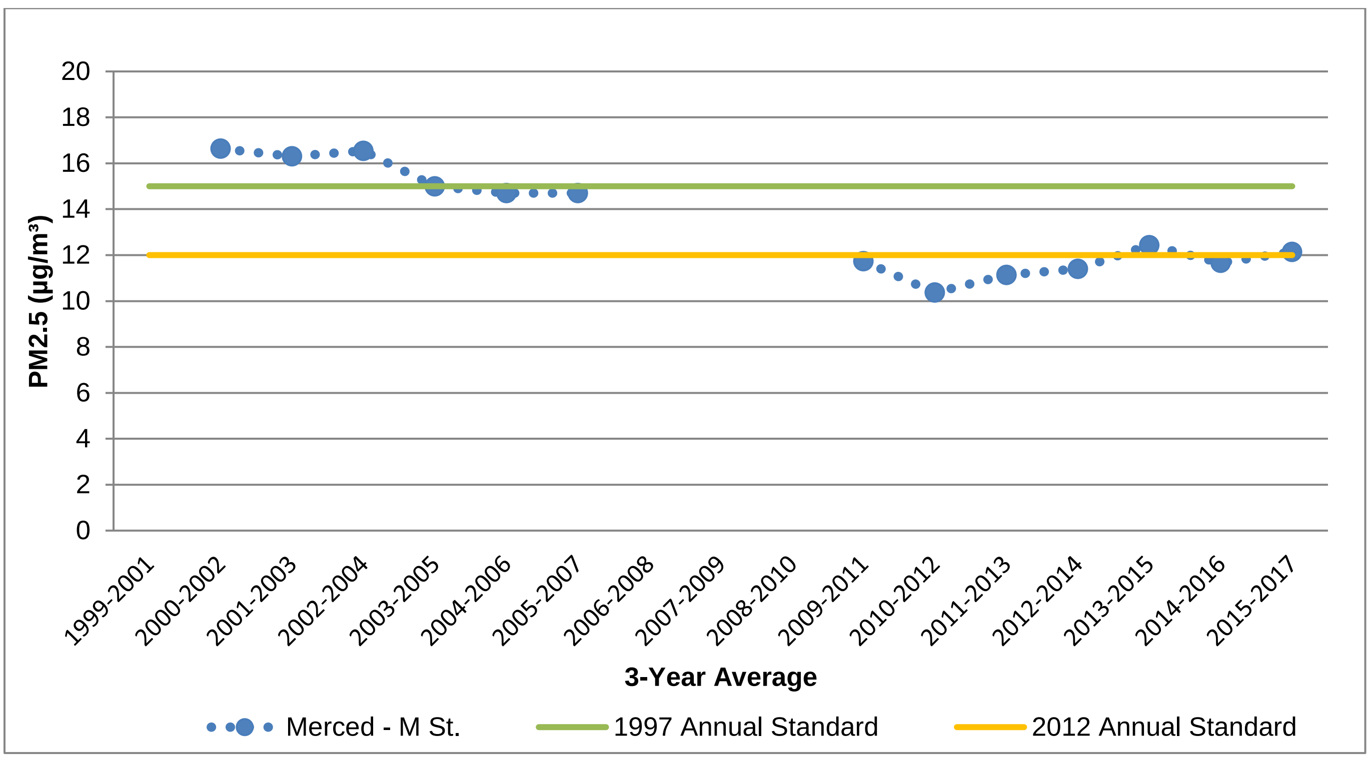


Figure A-9 Madera County[7] 24-Hour Design Value Trend

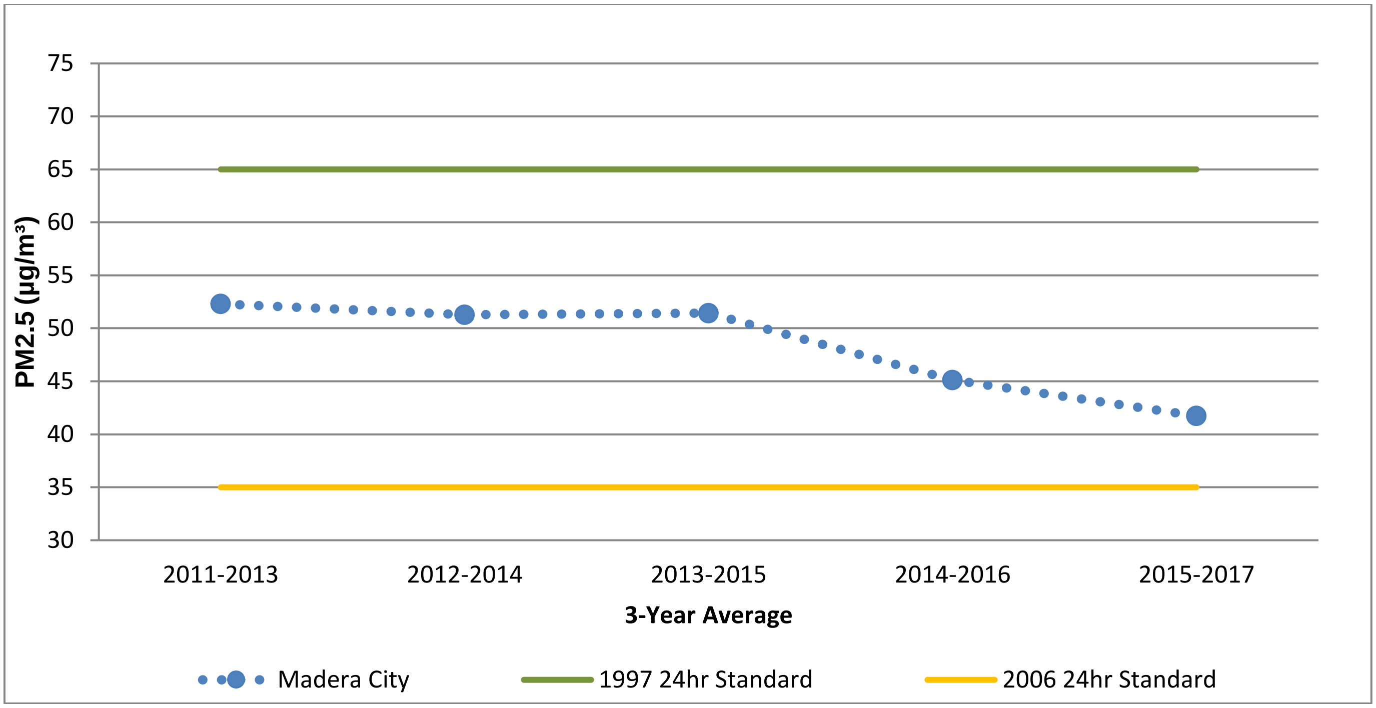
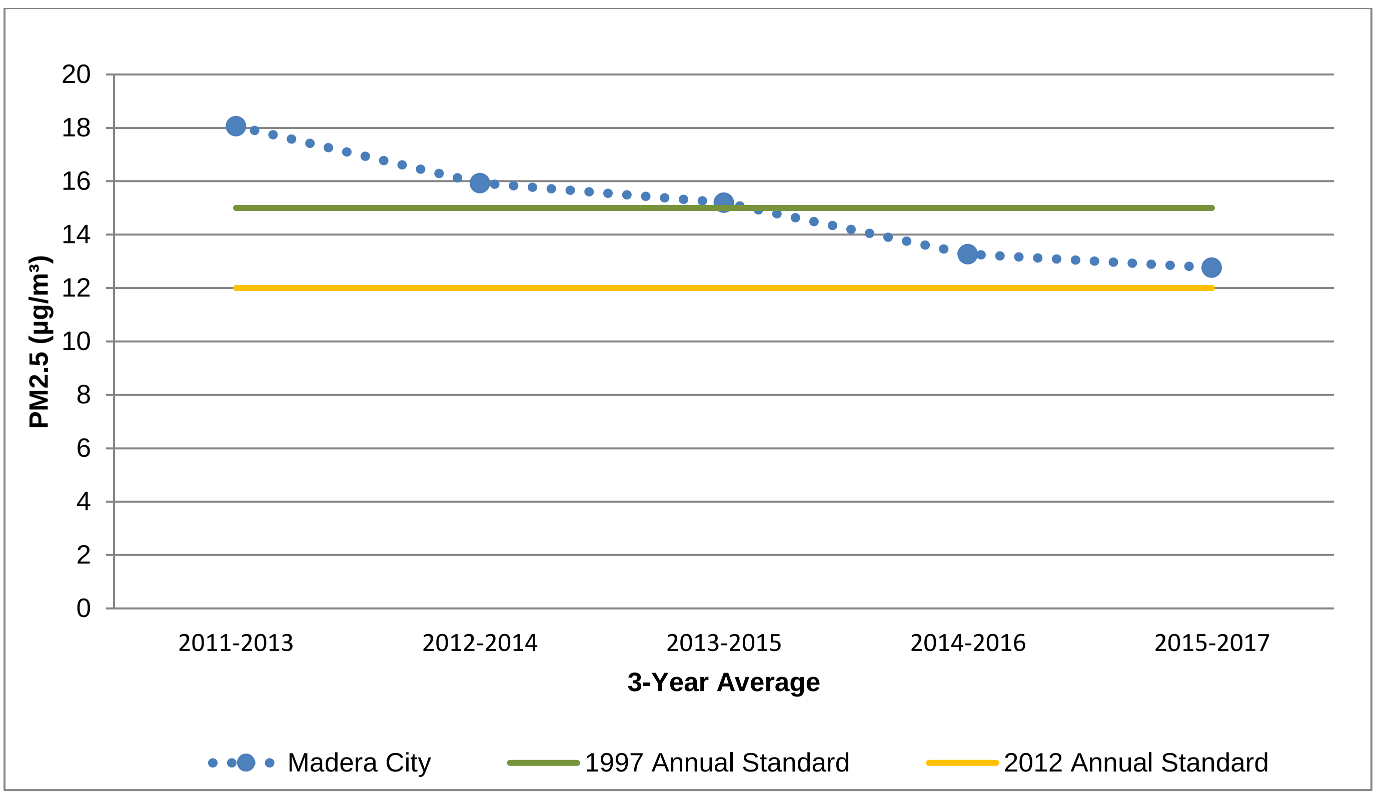


Figure A-10 Madera County Annual Design Value Trend



[7] PM2.5 monitoring in Madera began in 2010

Figure A-11 Fresno County 24-Hour Design Value Trend

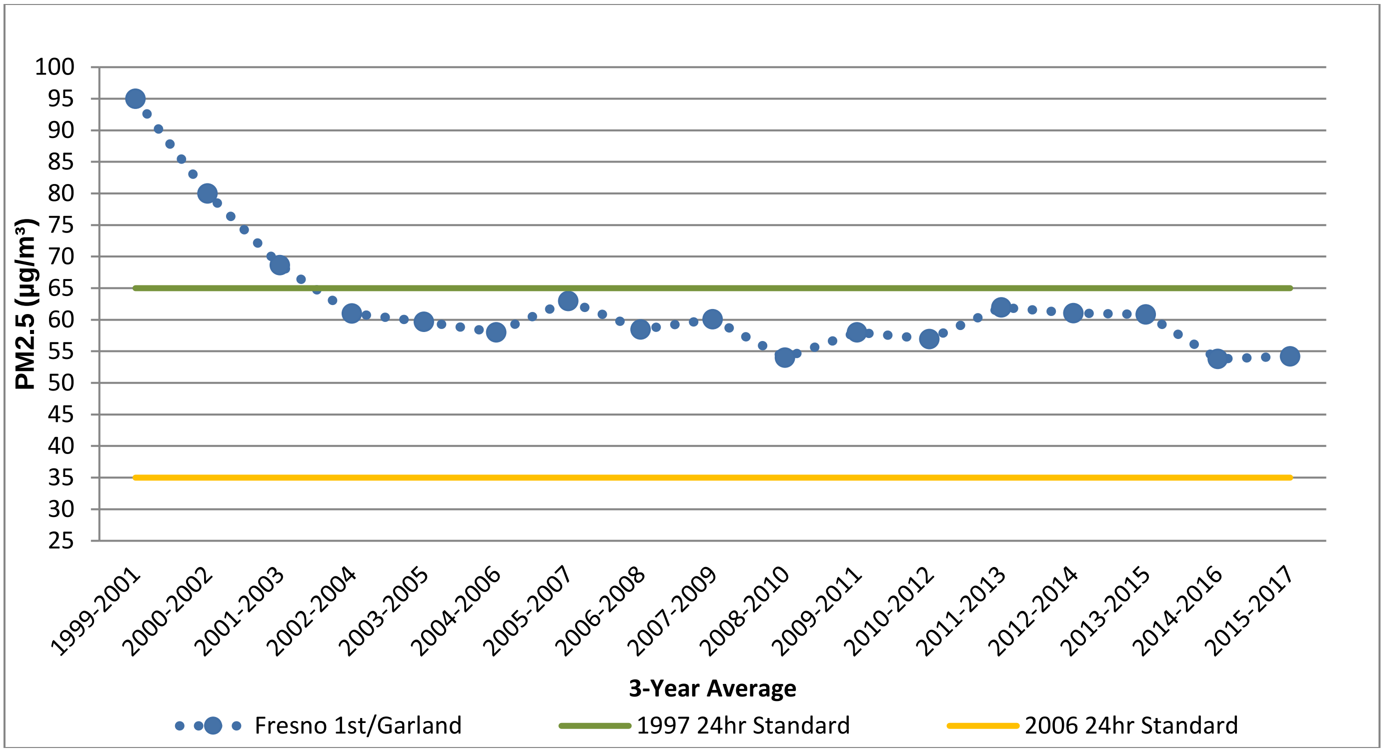


Figure A-12 Fresno County Annual Design Value Trend

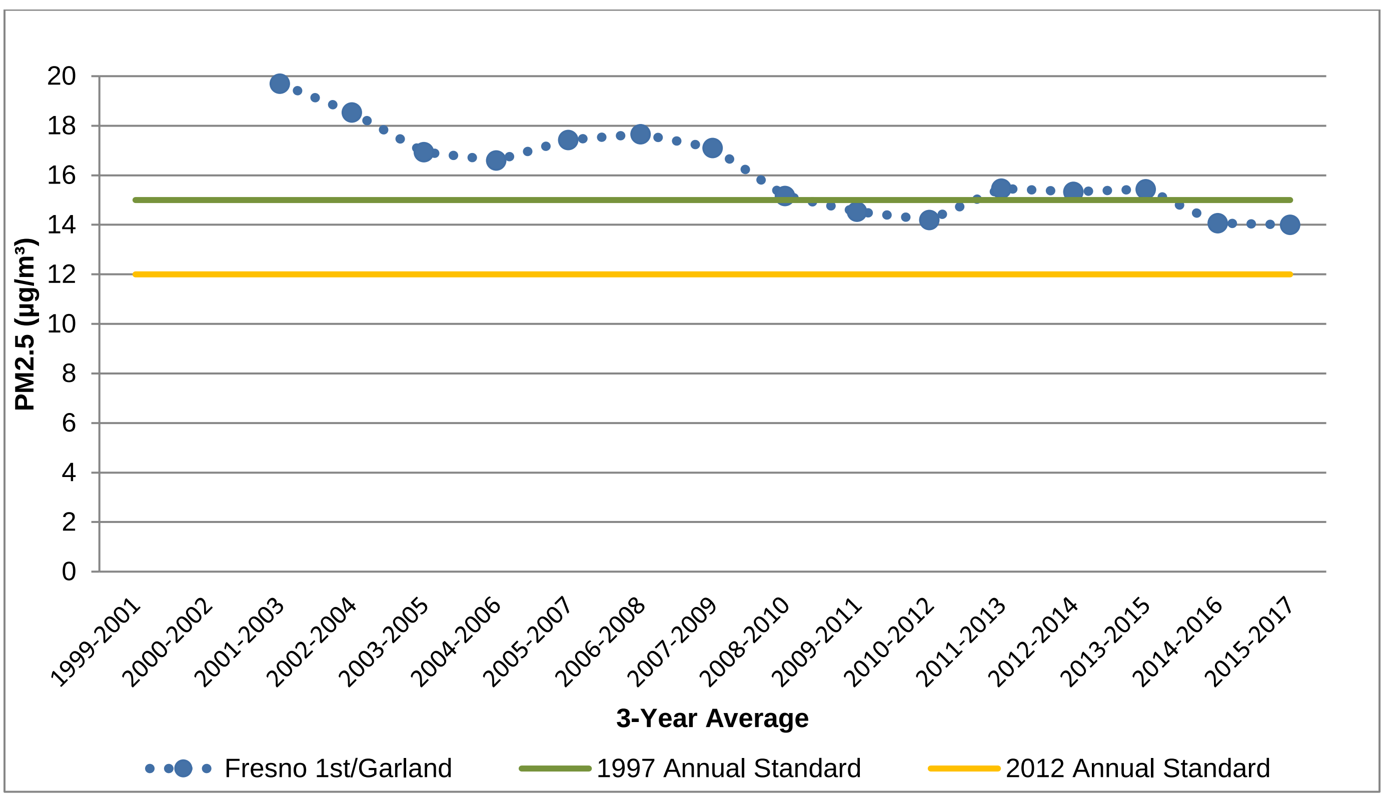


Figure A-13 Kings County 24-Hour Design Value Trend

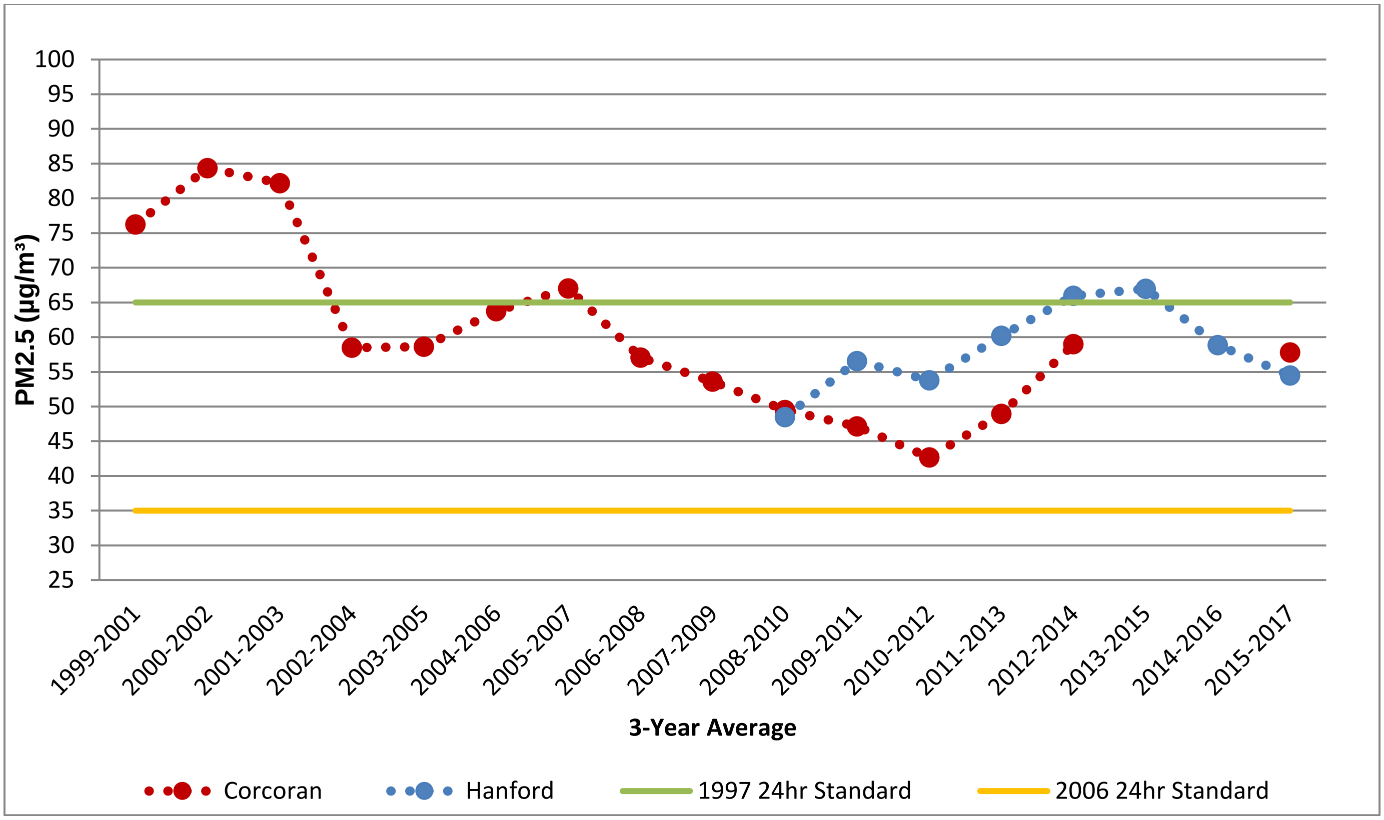


Figure A-14 Kings County Annual Design Value Trend

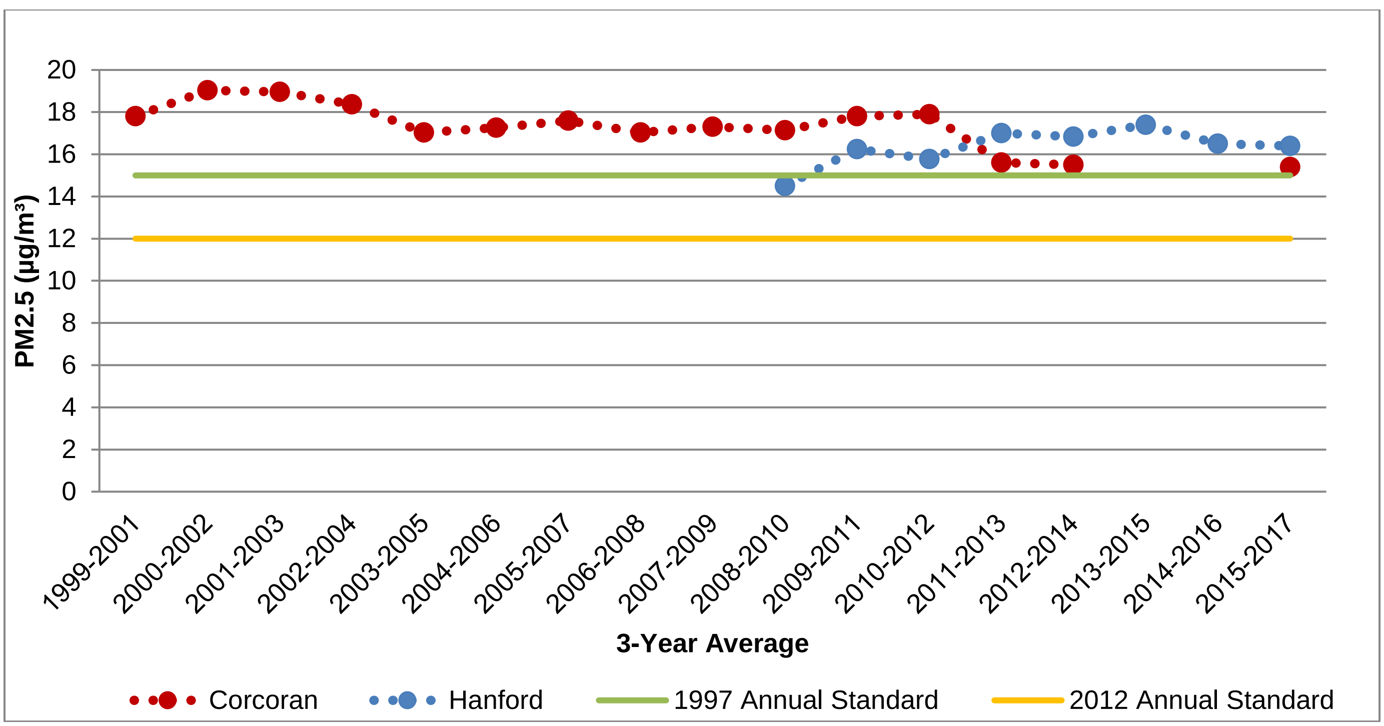


Figure A-15 Tulare County 24-Hour Design Value Trend

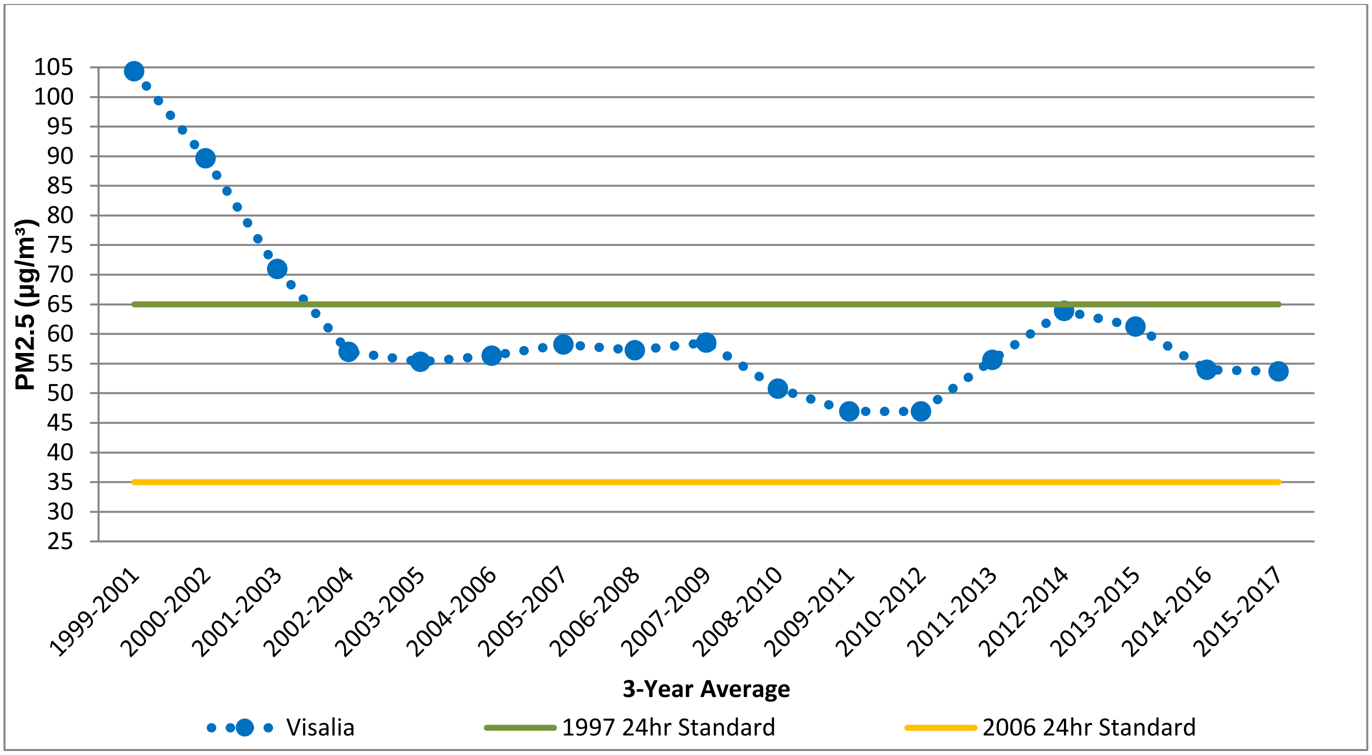


Figure A-16 Tulare County Annual Design Value Trend

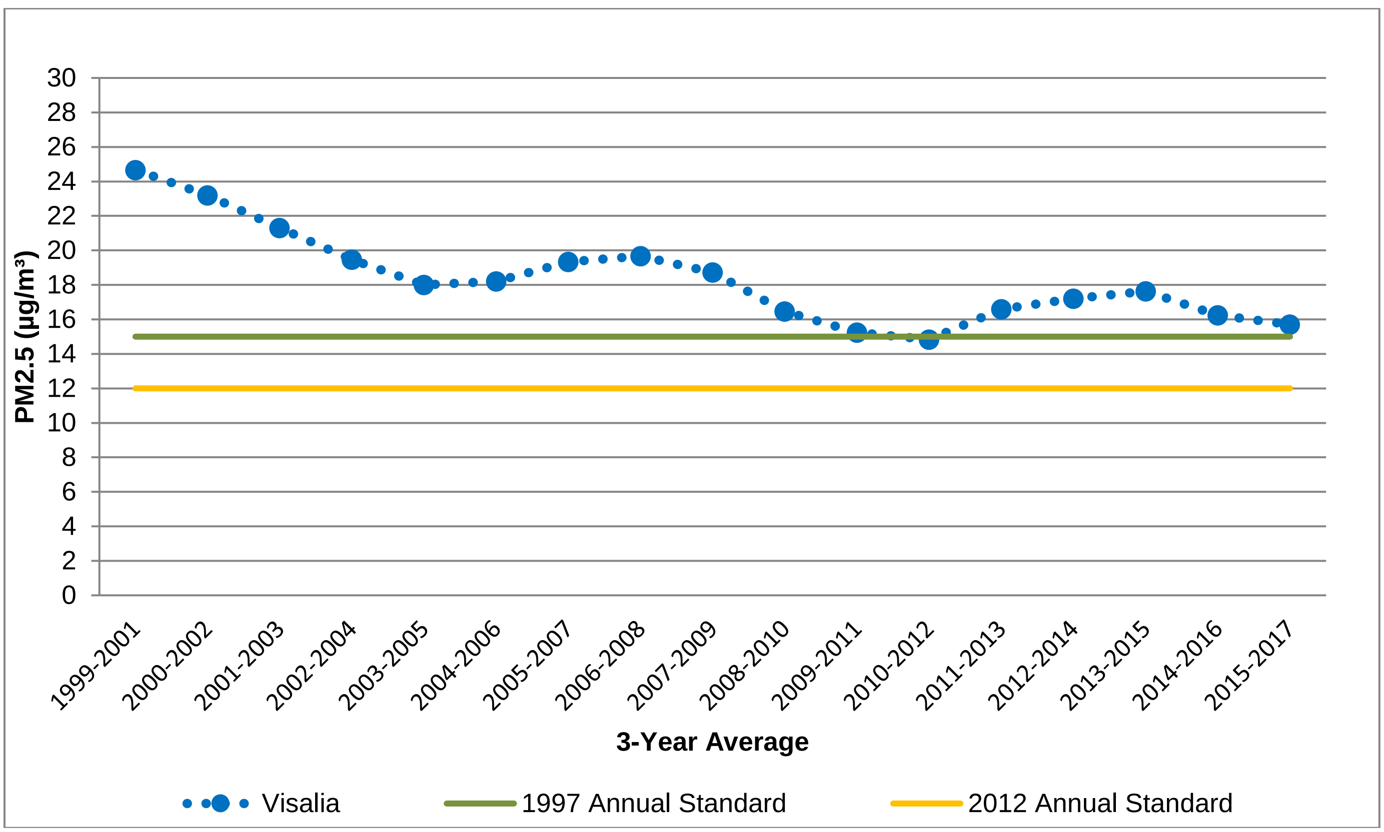


Figure A-17 Kern County 24-Hour Design Value Trend

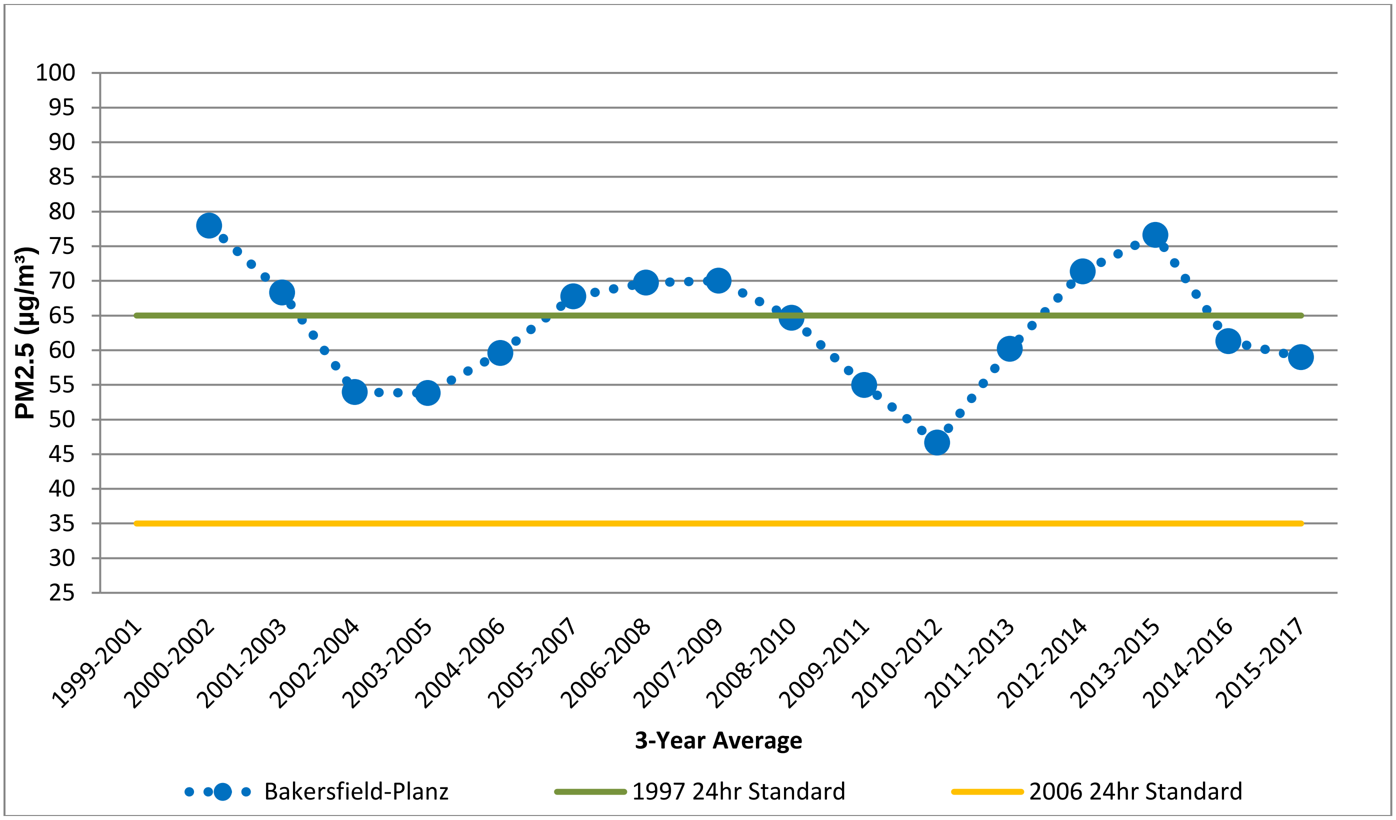
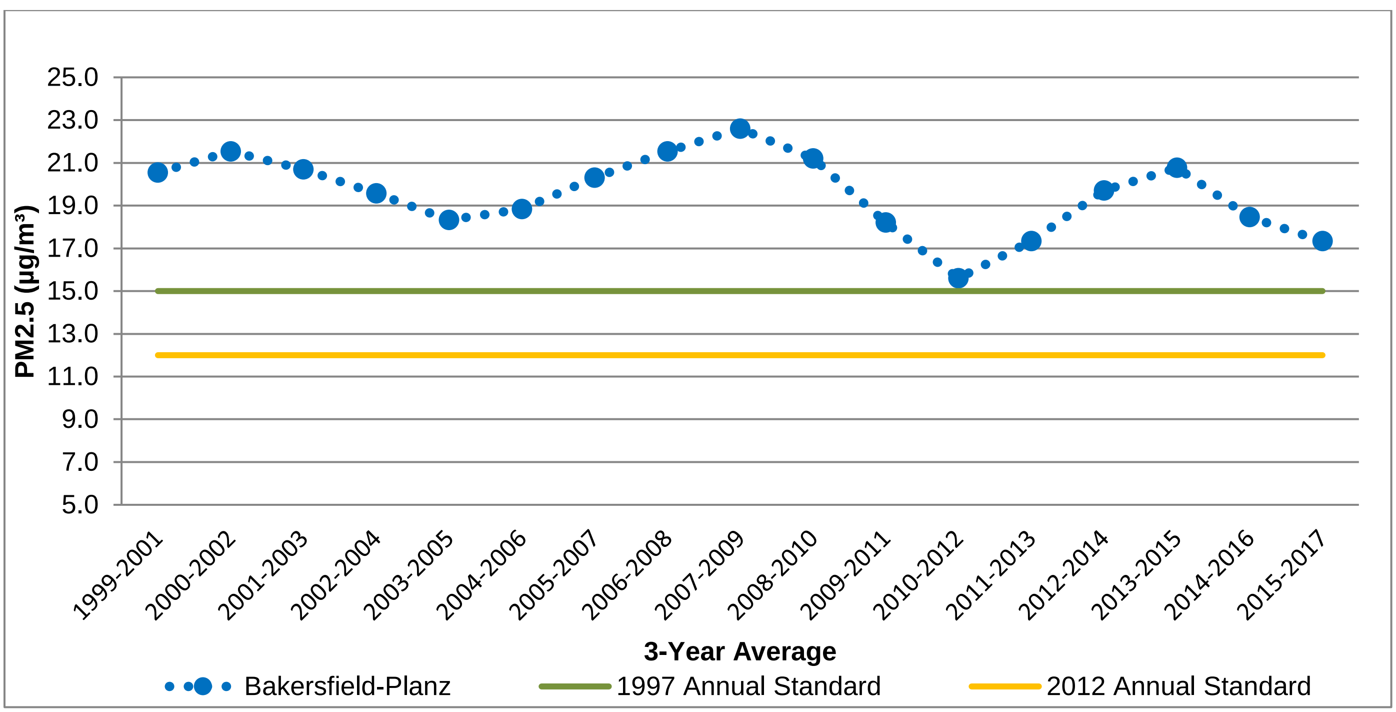


Figure A-18 Kern County Annual Design Value Trend



A.3 AMBIENT PM2.5 CONCENTRATION DATA TRENDS

Design values summarize data from a monitoring site with just two concentration values representing a three-year time period: an annual average and a value representing 24-hour peaks. These parameters are required for attainment demonstrations, but design values alone do not reveal the hourly, daily, weekly, seasonal, and regional PM2.5 effects on public health, nor do they track air quality improvements within such parameters. The District uses data from air monitoring sites to analyze air quality trends to provide a deeper understanding of changes in ambient PM2.5 concentrations as they relate to the implementation of District programs and to inform the attainment planning process and Health Risk Reduction Strategy.

A.3.1 DAYS OVER THE 24-HOUR PM2.5 STANDARD OF 65 UG/M³

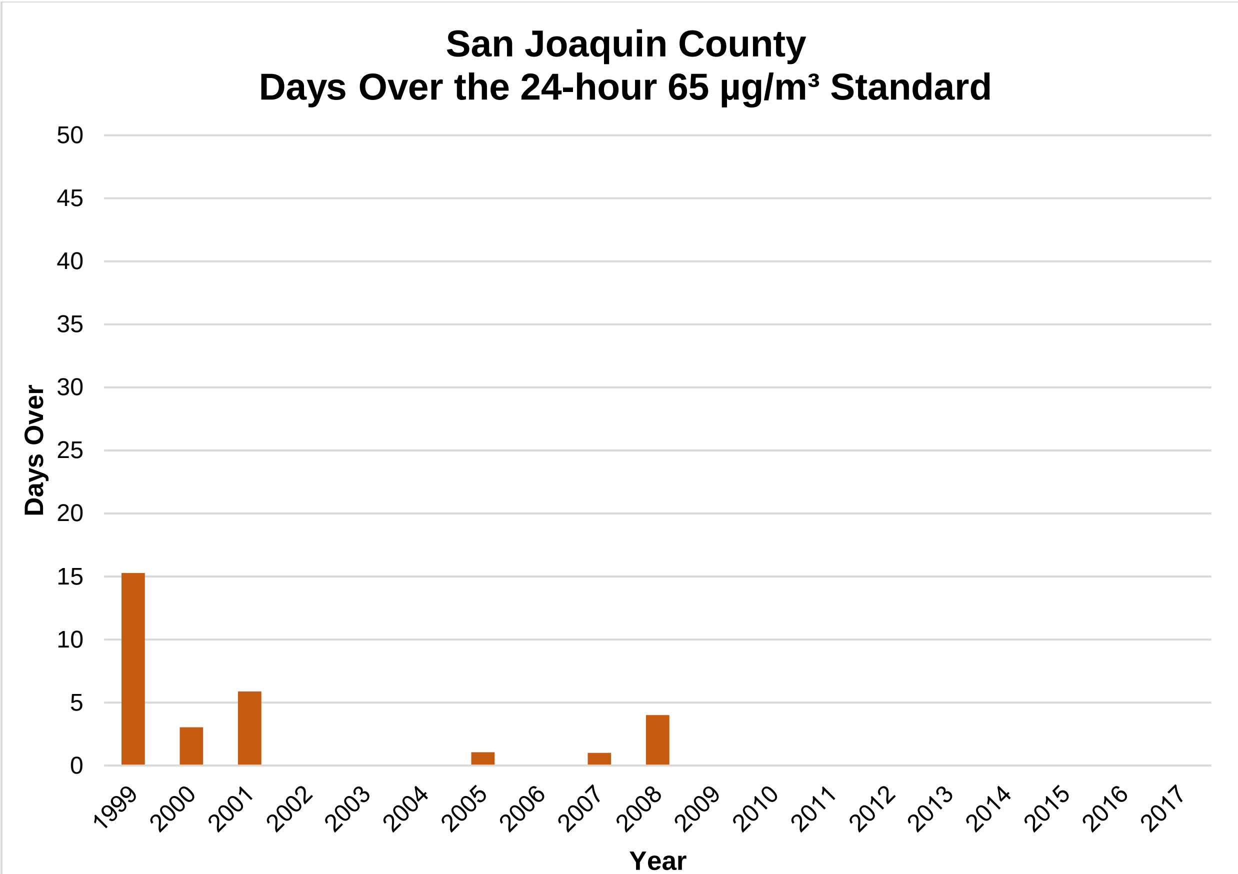
The number of days over the 24-hour PM2.5 standard is another indicator of air quality progress. Figure A-19 to Figure A-26 show the trend of the number of days above the 1997 24-hour PM2.5 standard of 65 µg/m^3 in each county within the District's jurisdiction. These counts have been estimated and normalized to account for the varying sampling schedules of the Valley's 1-in-6-day, 1-in-3-day, and daily PM2.5 monitors.

Design value calculations for the 24-hour standard use the 98th-percentile concentration value from each monitoring site (higher values in the 99th and 100th percentiles are not used to account for extreme outliers). Because of this, a region may experience a limited number of days over the standard, but still be considered in attainment.

As shown in Figure A-19 to Figure A-26, the Valley has experienced a significant drop in the number of exceedances of the 65 µg/m^3 standard since the turn of the last century (1999 and 2000). As an example of the progress that has been made, Fresno County recorded 41 exceedances in 1999, and recorded zero exceedances in the year 2016. Similarly, Kern County recorded 32 exceedances in 1999, and recorded only 1 exceedance in the year 2016.

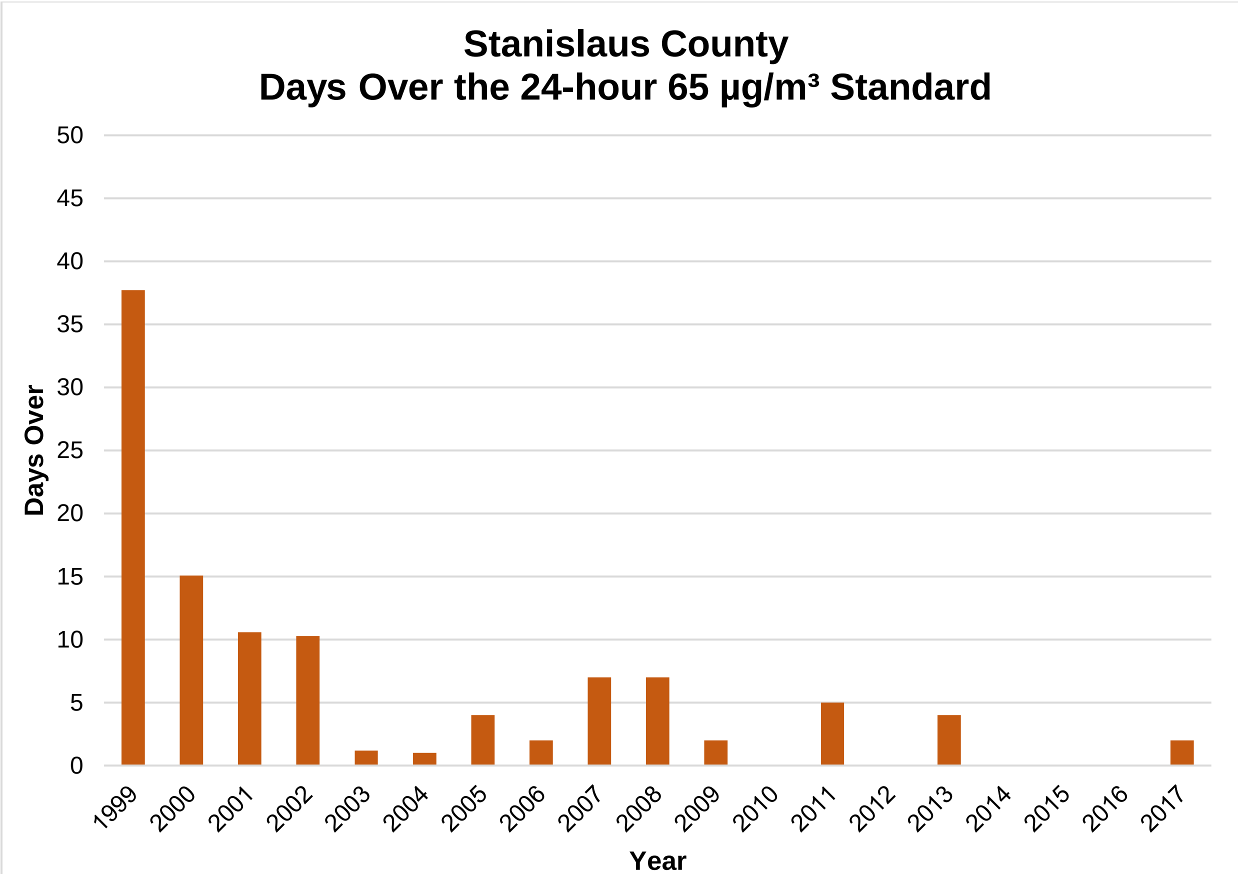
As these trends display, exceedances of the 1997 24-hour PM2.5 standard have become very rare in the Valley, despite some years influenced by drought or exceptionally poor dispersion conditions. This progress has brought the region into attainment of this portion of the standard. It is important note that the recent winter season of 2017-2018 was heavily influenced by wildfire emissions and long periods of poor dispersion conditions, both of which created conditions conducive for high concentrations of PM2.5 to form across the Valley.

Figure A-19 San Joaquin County - Days Over the 24-hour 65 µg/m³ Standard[8]



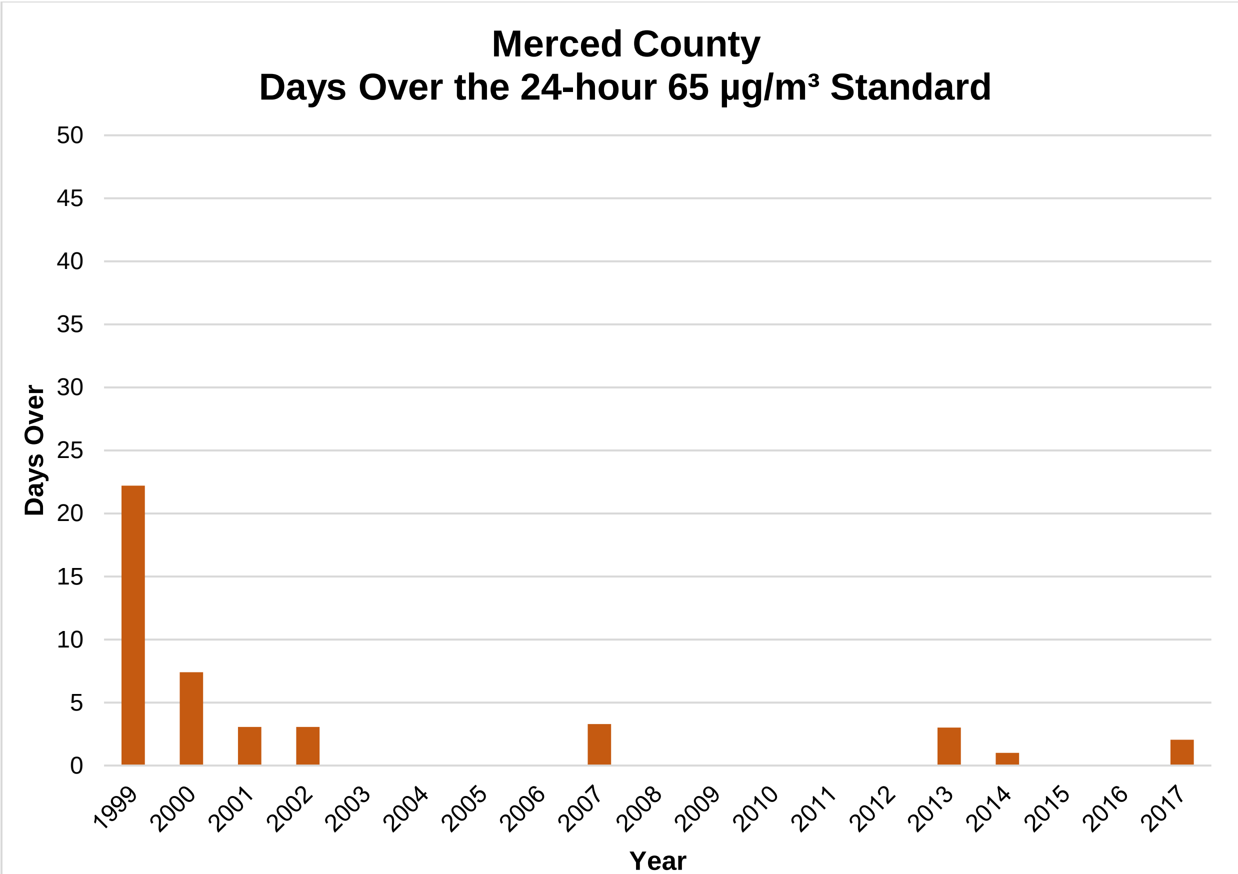
[8] Note: Years and sites with no data represent zero exceedances. Data has been normalized.

Figure A-20 Stanislaus County – Days Over the 24-hour 65 µg/m³ Standard[9]



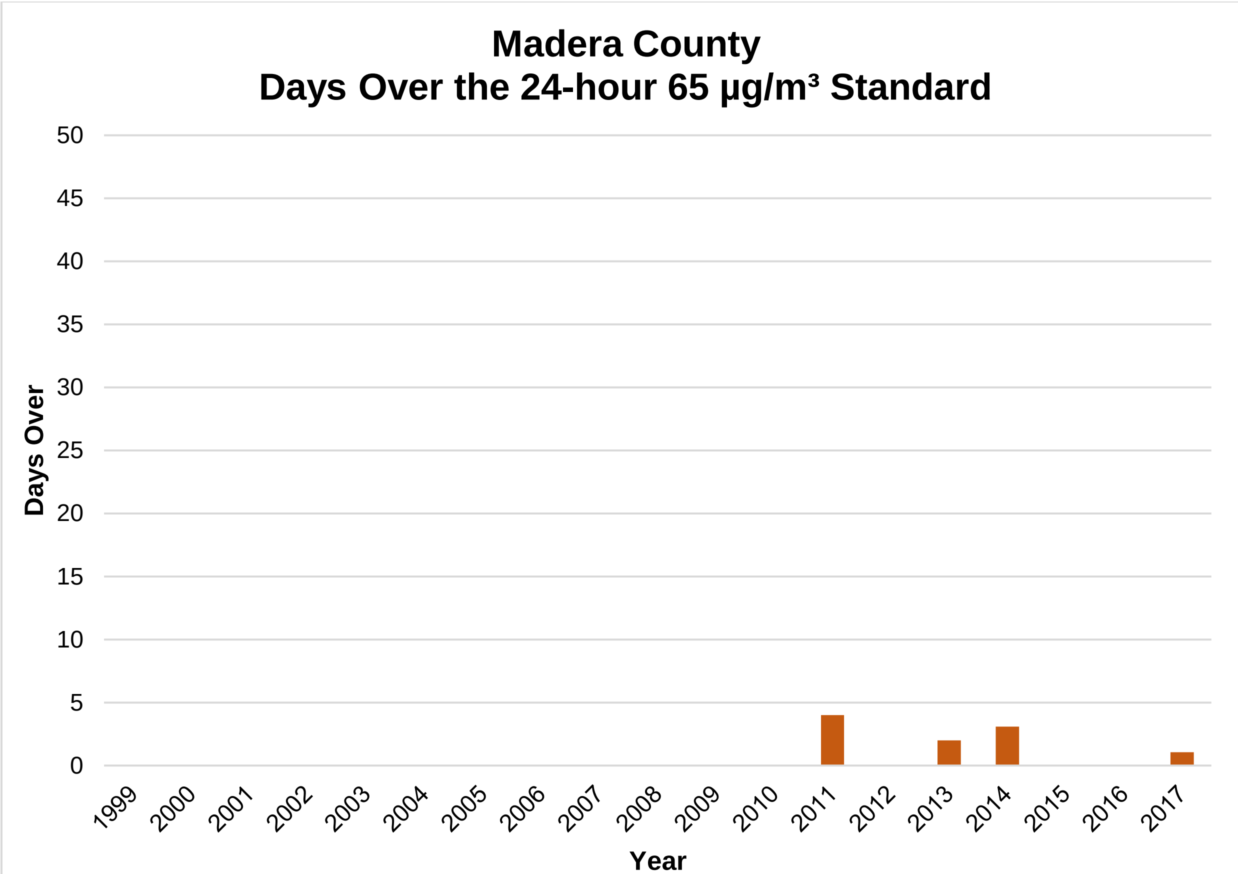
[9] Note: Years and sites with no data represent zero exceedances. Data has been normalized.

Figure A-21 Merced County - Days Over the 24-hour 65 µg/m³ Standard[10]



[10] Note: Years and sites with no data represent zero exceedances. Data has been normalized.

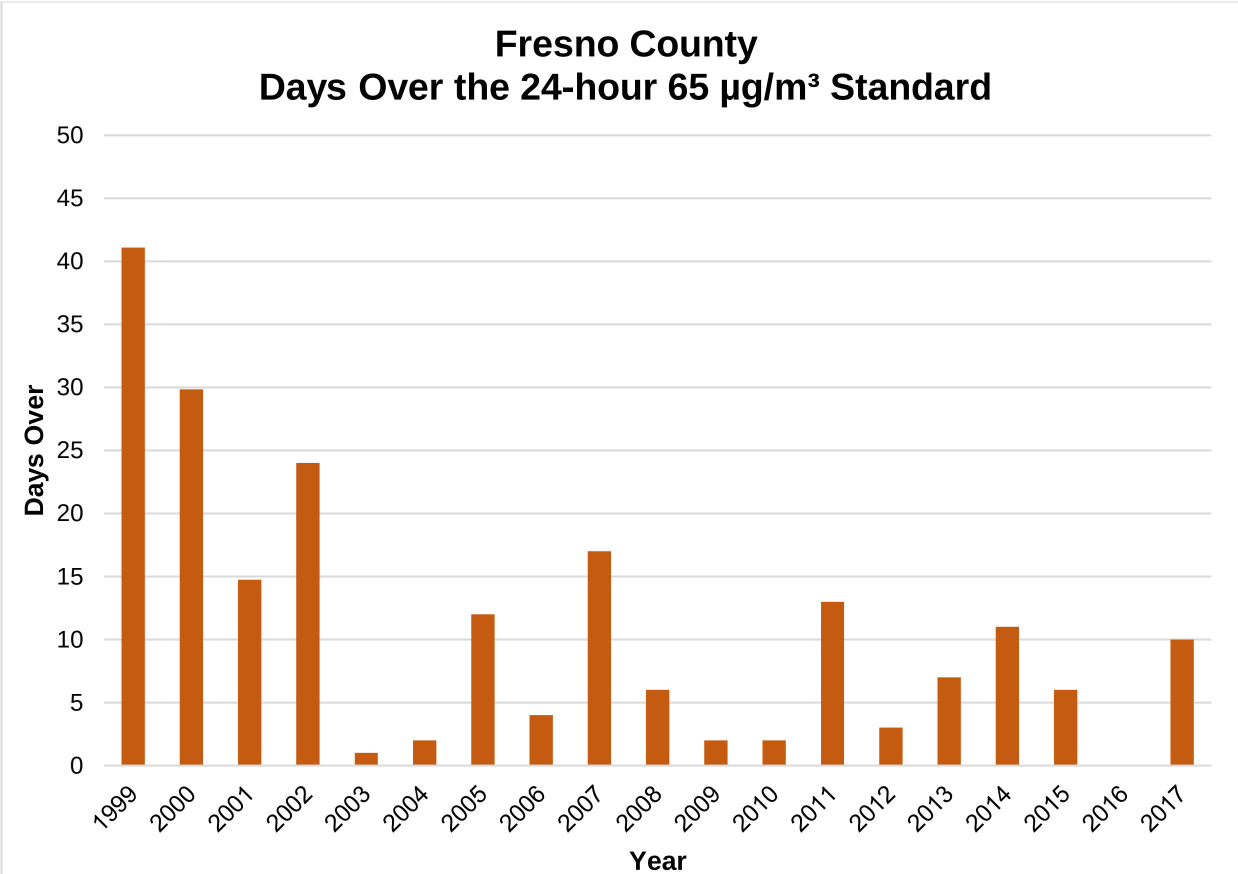
Figure A-22 Madera County[11] - Days Over the 24-hour 65 µg/m³ Standard[12]



[11] PM2.5 monitoring in Madera began in 2010

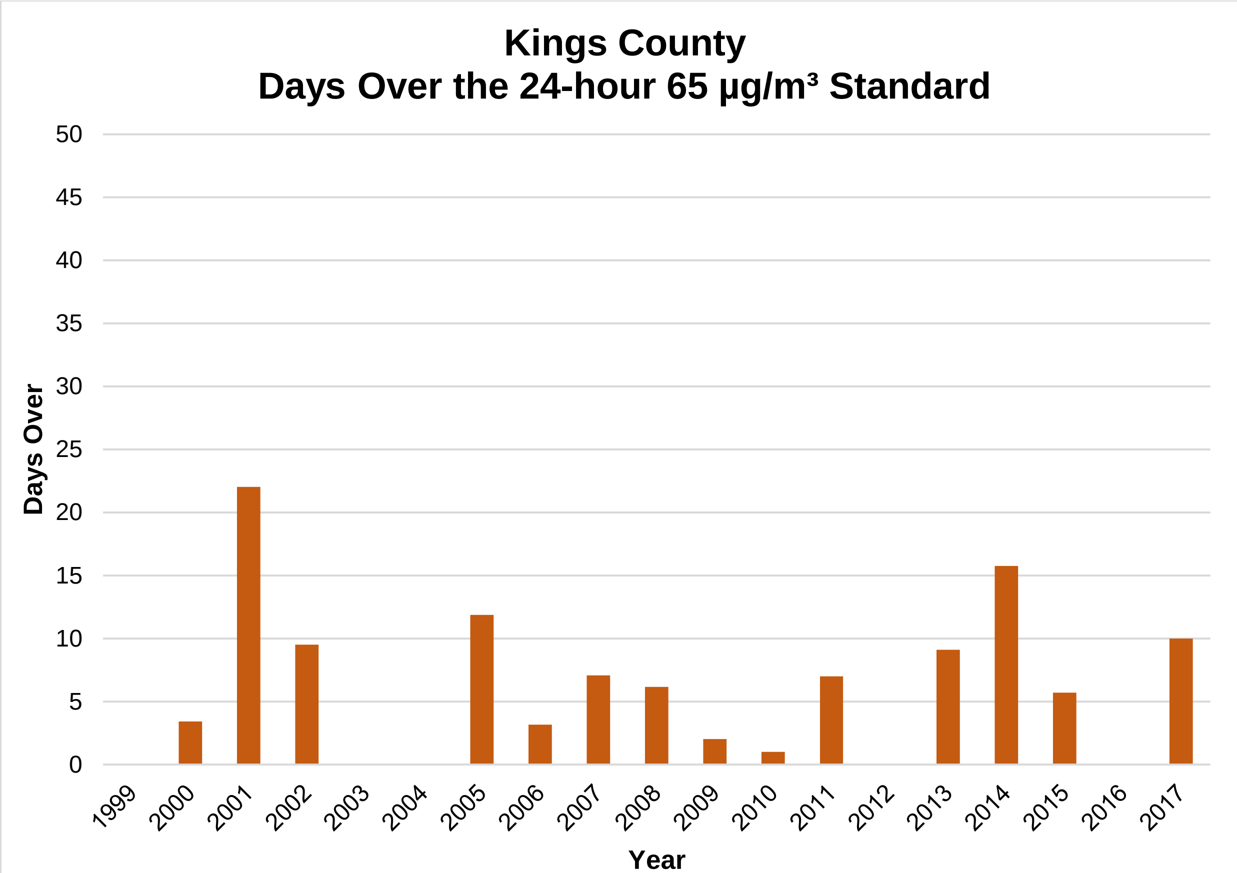
[12] Note: Years and sites with no data represent zero exceedances. Data has been normalized.

Figure A-23 Fresno County - Days Over the 24-hour 65 µg/m³ Standard[13]



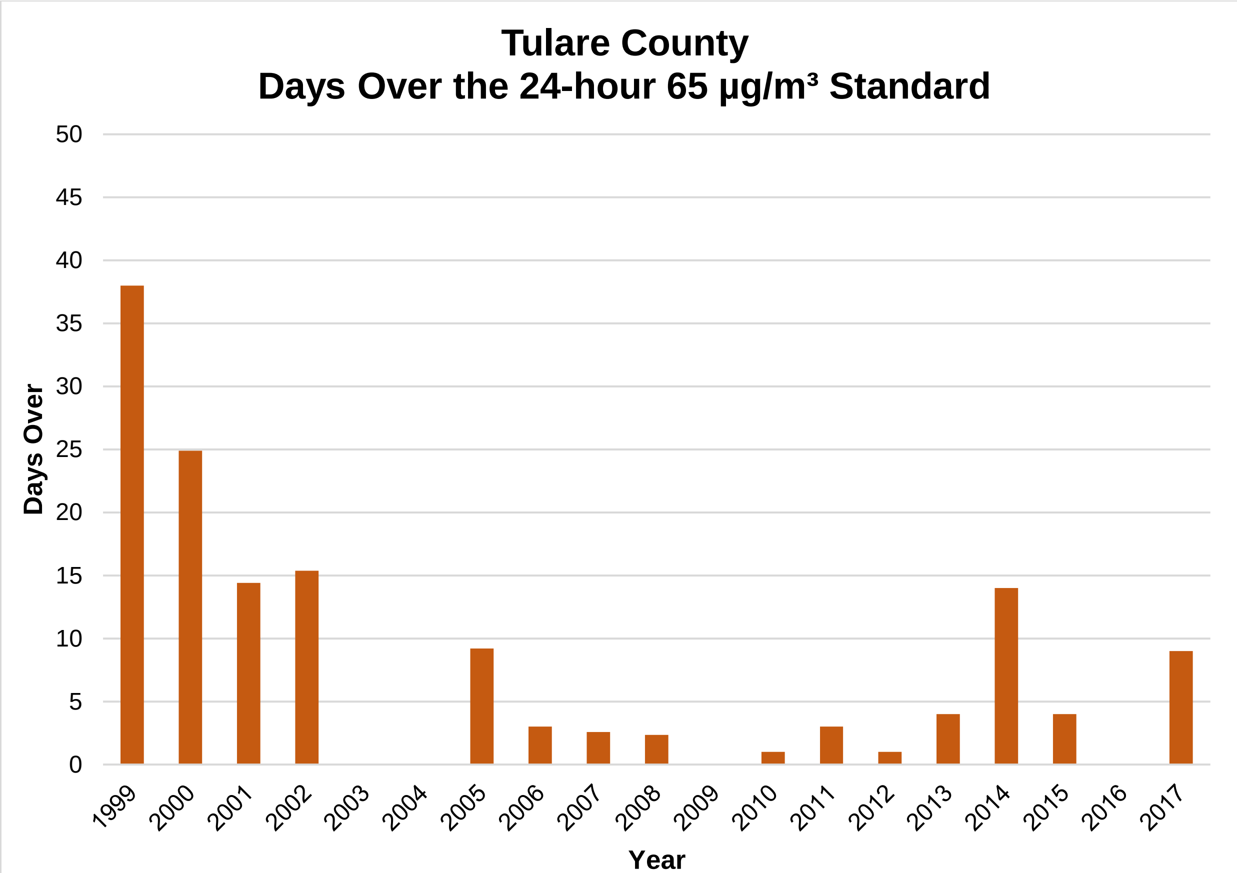
[13] Note: Years and sites with no data represent zero exceedances. Data has been normalized.

Figure A-24 Kings County - Days Over the 24-hour 65 µg/m³ Standard[14]



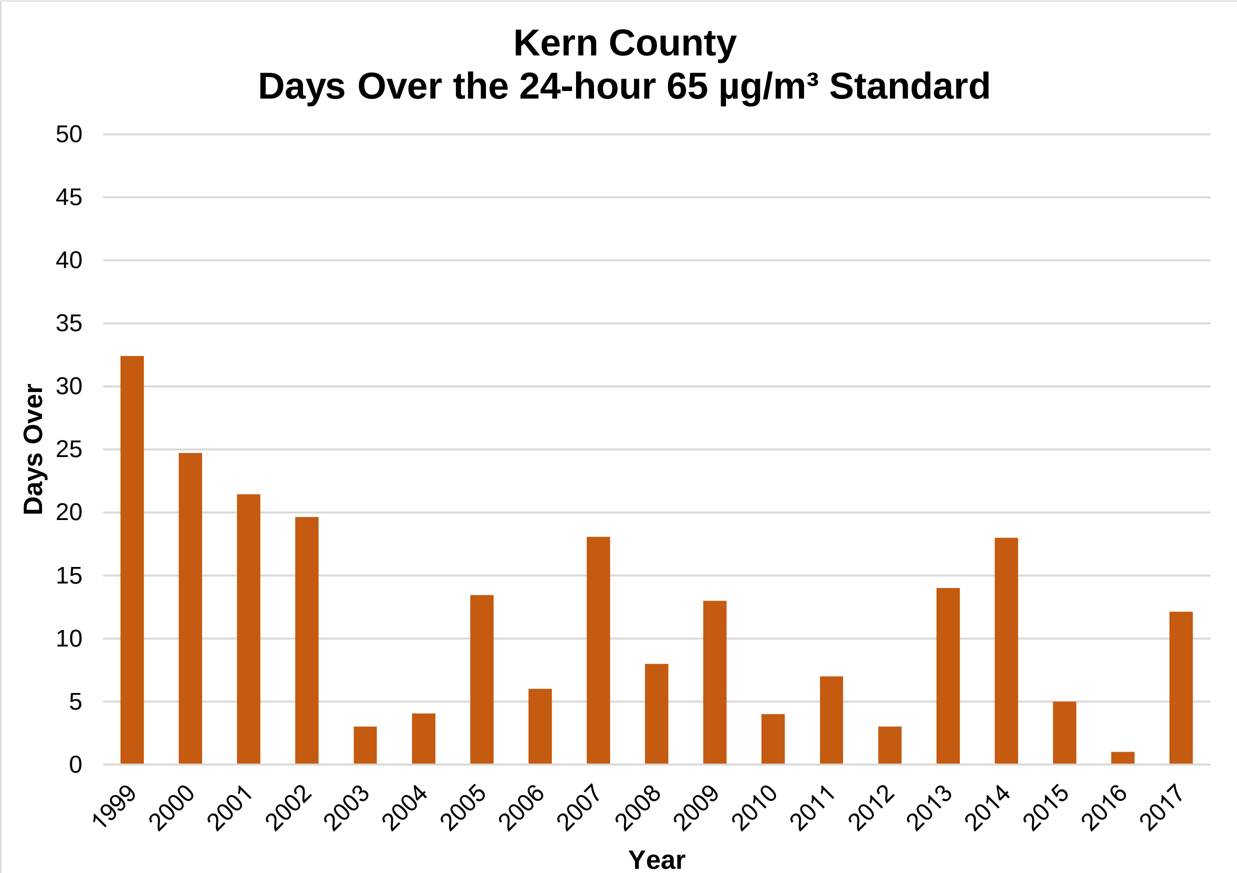
[14] Note: Years and sites with no data represent zero exceedances. Data has been normalized.

Figure A-25 Tulare County - Days Over the 24-hour 65 µg/m³ Standard[15]



[15] Note: Years and sites with no data represent zero exceedances. Data has been normalized.

Figure A-26 Kern County - Days Over the 24-hour 65 µg/m³ Standard[16]



[16] Note: Years and sites with no data represent zero exceedances. Data has been normalized.

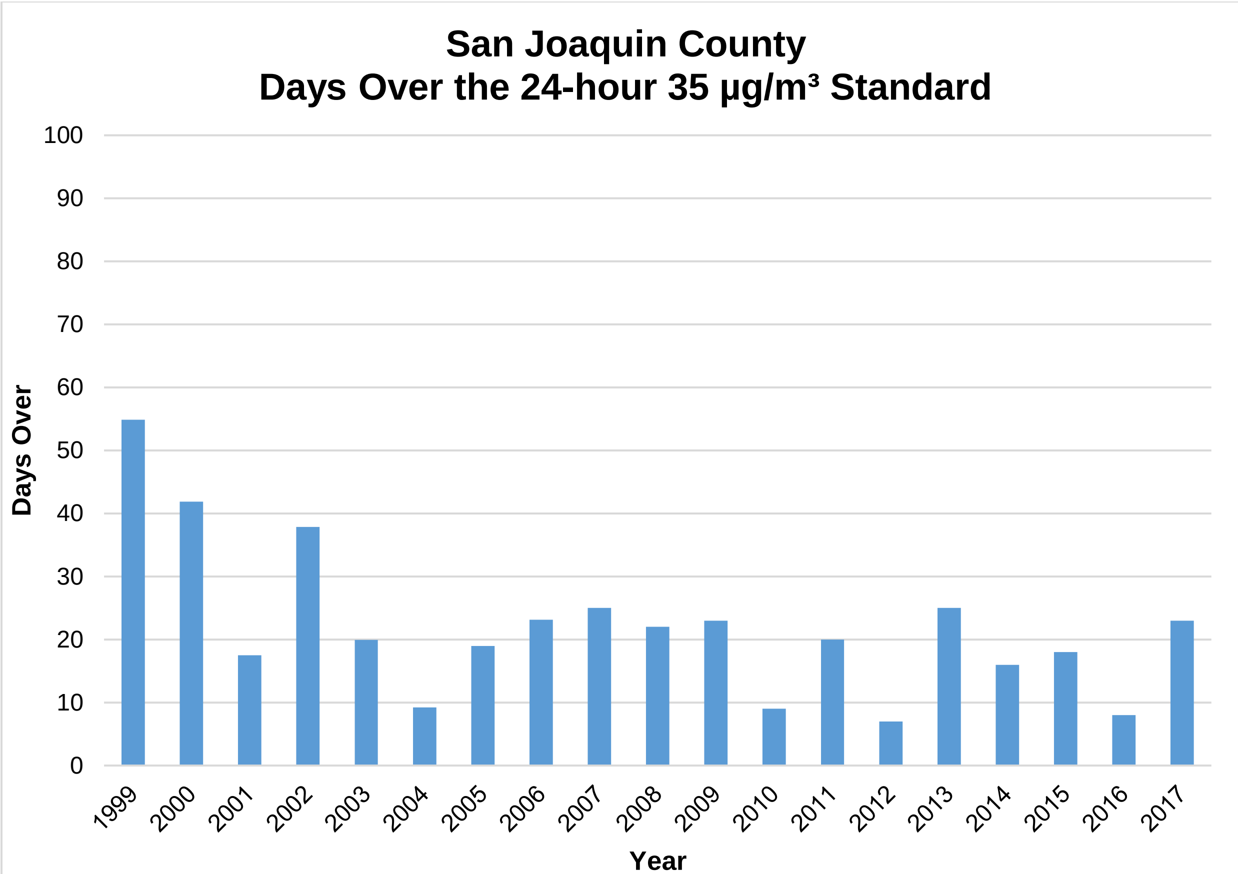
Trend in Days over the 2006 24-Hour PM2.5 Standard of 35 μg/m³

Figure A-27 to Figure A-34 show the trend of exceedances of the 2006 24-hour PM2.5 standard of 35 μg/m³ at select sites in each county within the District's jurisdiction. These counts have been estimated and normalized to account for the varying sampling schedules of the Valley's 1-in-6-day, 1-in-3-day, and daily PM2.5 monitors.

As shown in Figure A-27 to Figure A-34, the Valley has experienced an overall decrease in the number of exceedances of the 35 µg/m³ standard since PM2.5 has been monitored. During the height of drought years from 2013 to 2015, the Valley experienced an increase in the number of days exceeding this standard. As an example of the progress that has been made, Fresno County recorded 89 exceedances in 1999, and recorded 20 exceedances in the year 2016, representing a 77% decrease over this period. Similarly, Kern County recorded 77 exceedances in 1999, and recorded 27 exceedance in the year 2016, representing a 65% decrease over this same period.

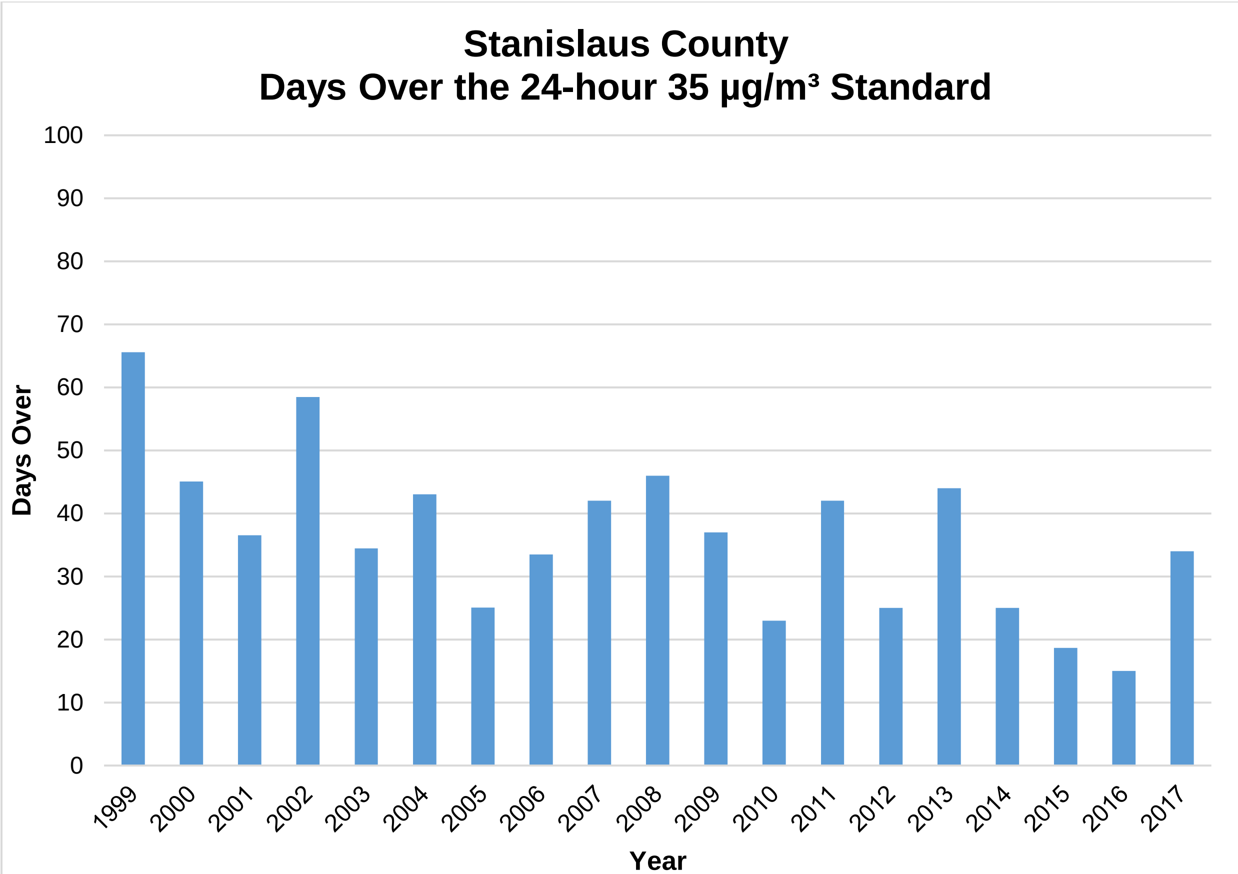
It is important to note that the recent winter season of 2017-2018 was heavily influenced by wildfire emissions and long periods of poor dispersion conditions, both of which created conditions conducive for high concentrations of PM2.5 to form across the Valley.

Figure A-27 San Joaquin County - Days Over the 24-hour 35 µg/m³ Standard[17]



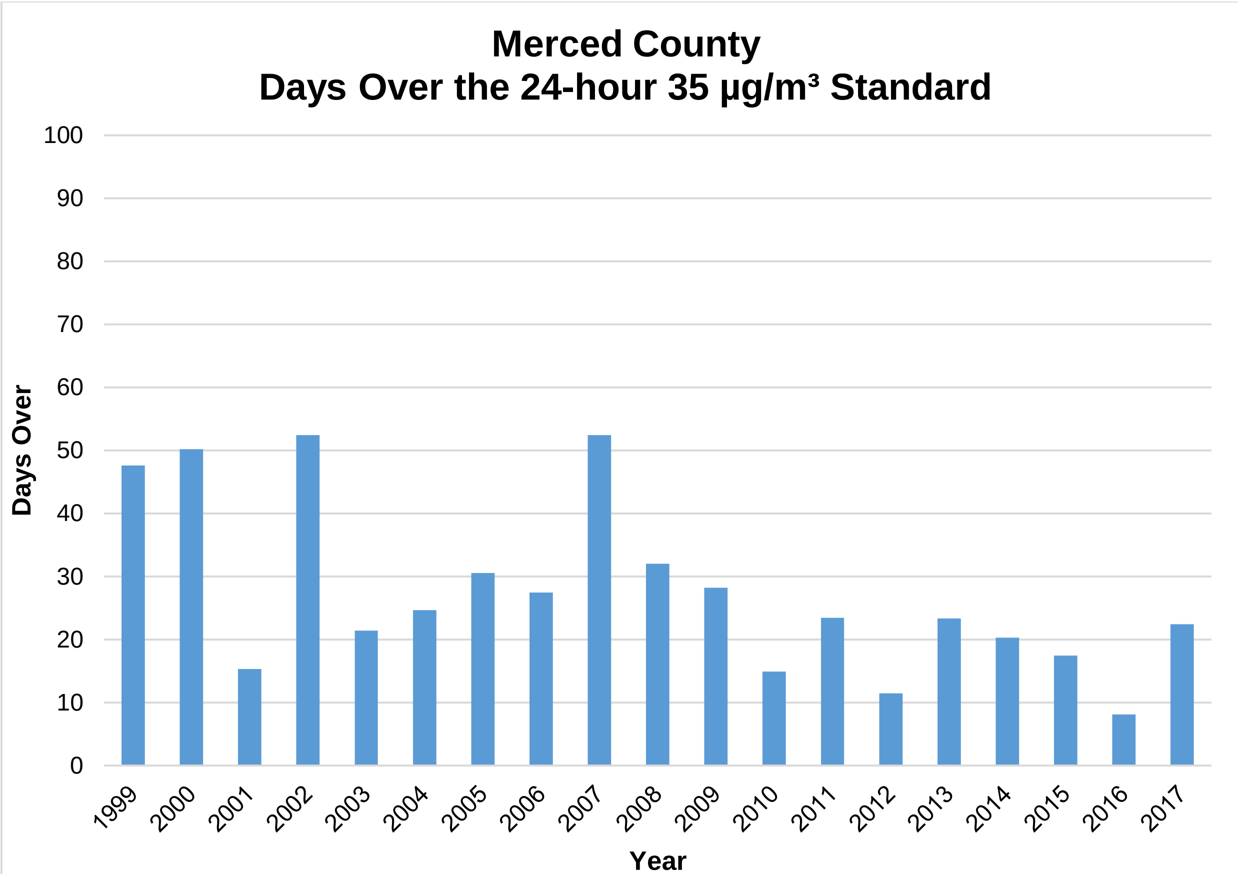
[17] Note: Years and sites with no data represent zero exceedances. Data has been normalized.

Figure A-28 Stanislaus County - Days Over the 24-hour 35 µg/m³ Standard[18]



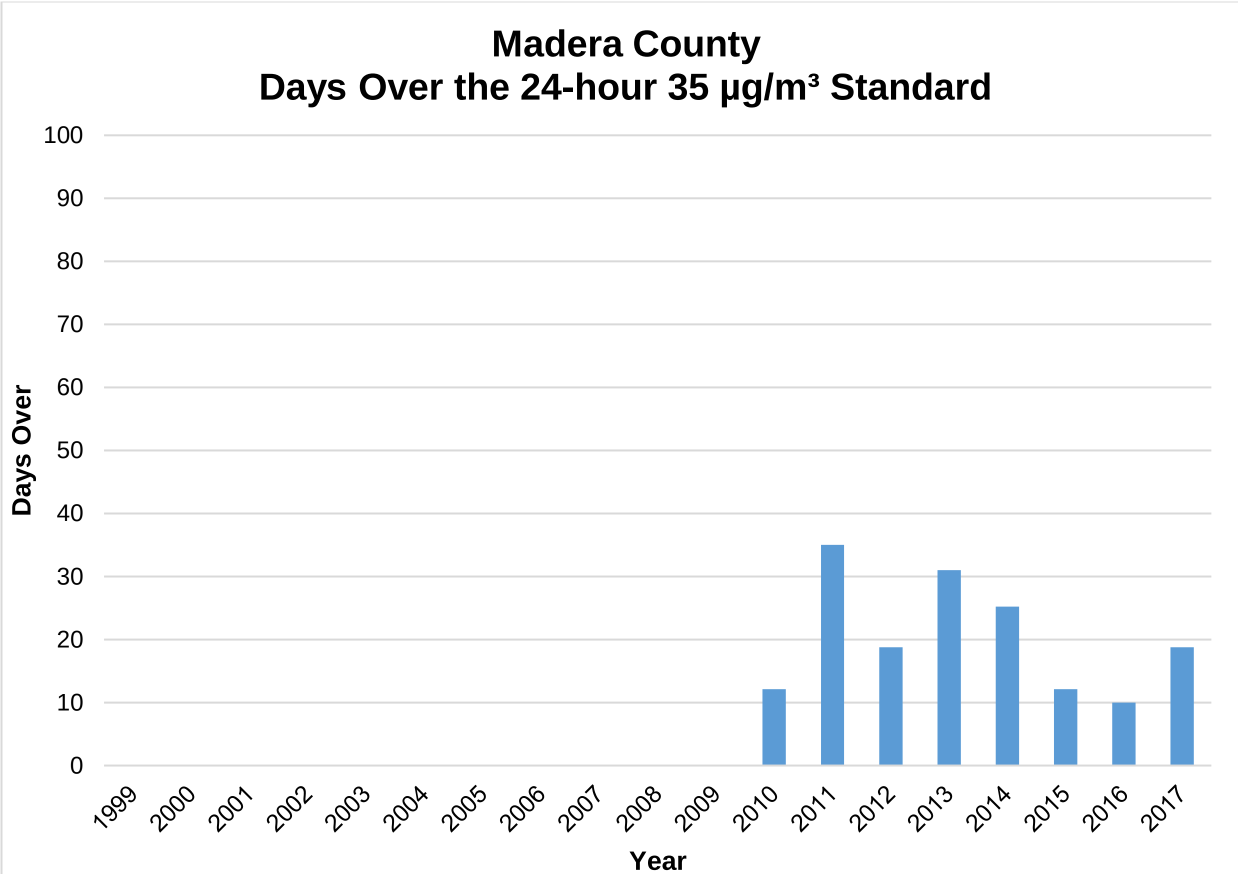
[18] Note: Years and sites with no data represent zero exceedances. Data has been normalized.

Figure A-29 Merced County - Days Over the 24-hour 35 µg/m³ Standard[19]



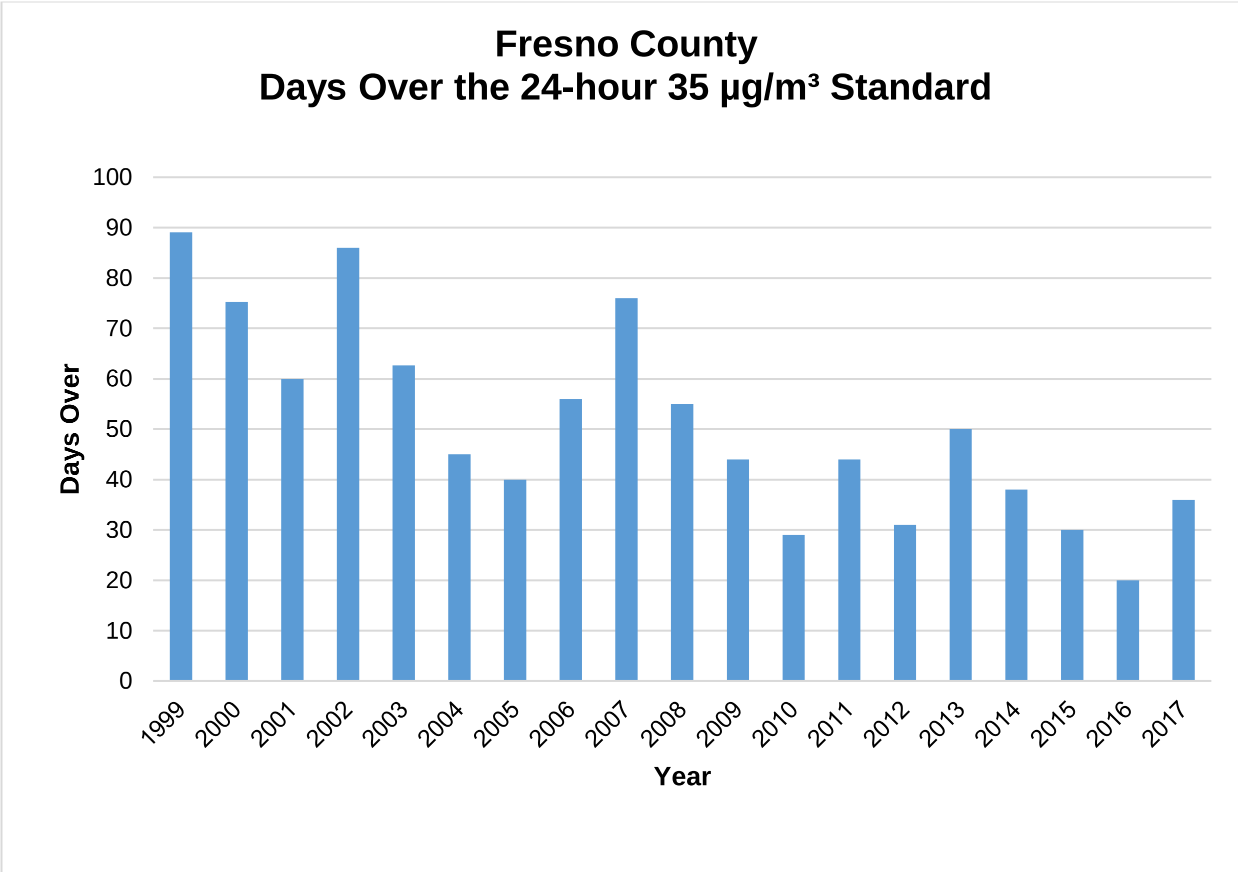
[19] Note: Years and sites with no data represent zero exceedances. Data has been normalized.

Figure A-30 Madera County[20] – Days Over the 24-hour 35µg/m³ Standard[21]



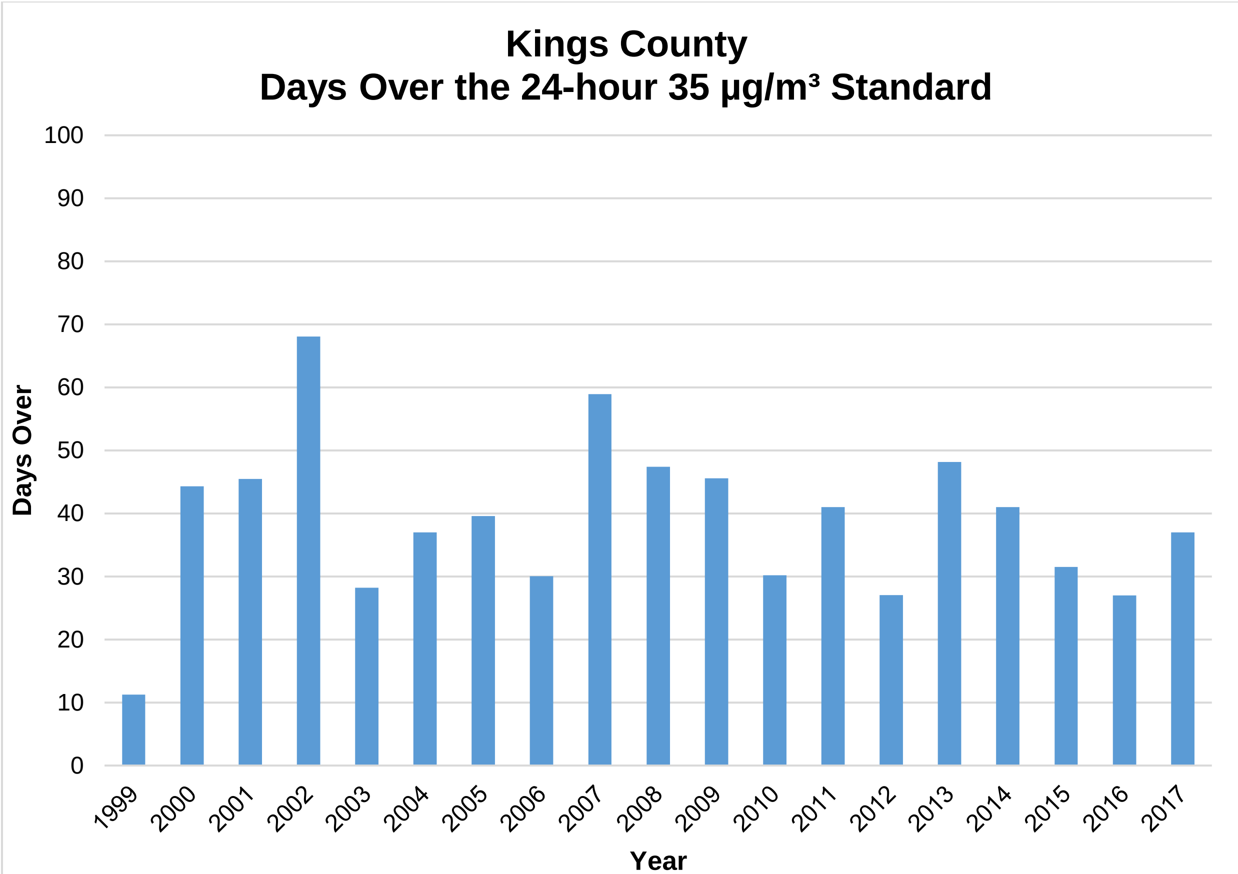
[20] PM2.5 monitoring in Madera began in 2010
[21] Note: Years and sites with no data represent zero exceedances. Data has been normalized.

Figure A-31 Fresno County - Days Over the 24-hour 35 µg/m³ Standard[22]



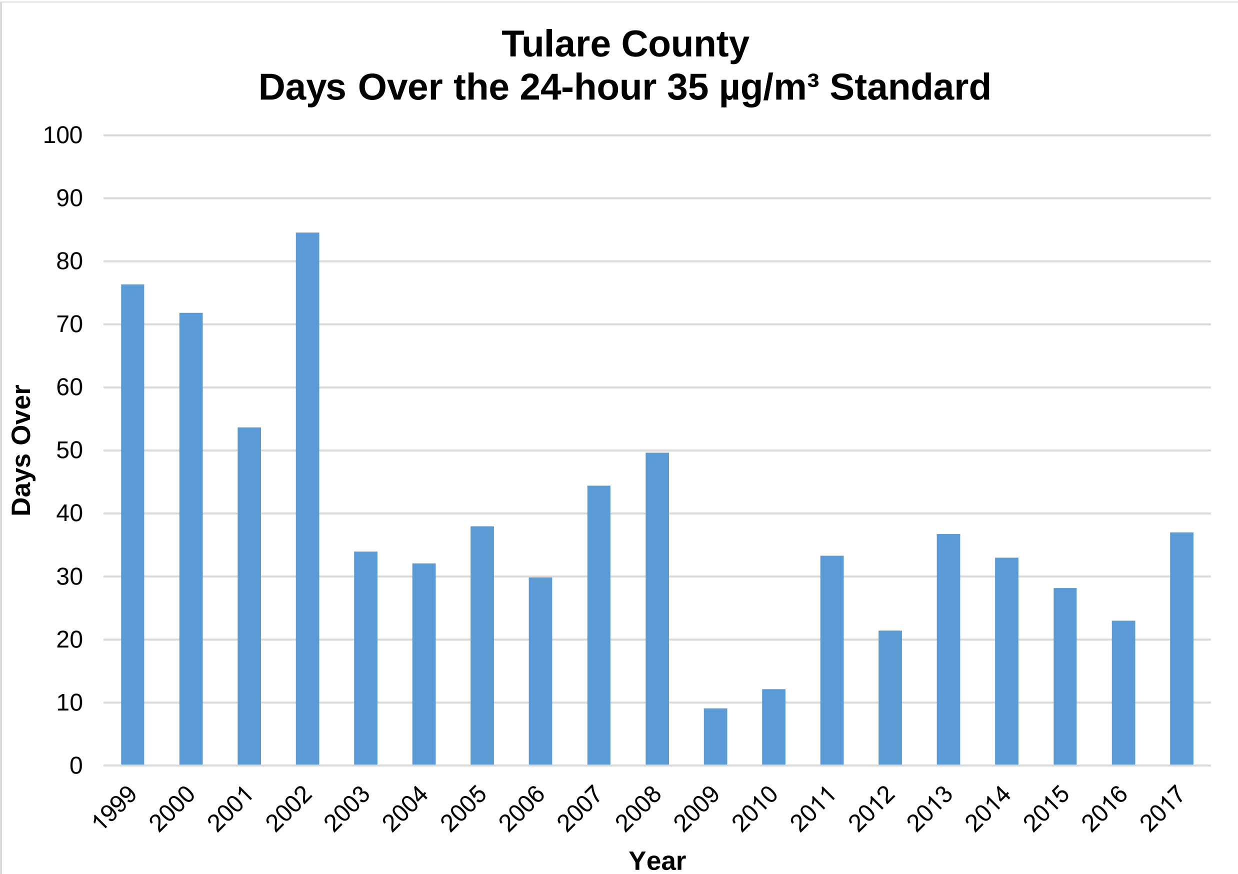
[22] Note: Years and sites with no data represent zero exceedances. Data has been normalized.

Figure A-32 Kings County - Days Over the 24-hour 35 µg/m³ Standard[23]



[23] Note: Years and sites with no data represent zero exceedances. Data has been normalized.

Figure A-33 Tulare County - Days Over the 24-hour 35 µg/m³ Standard[24]



[24] Note: Years and sites with no data represent zero exceedances. Data has been normalized.

Figure A-34 Kern County - Days Over the 24-hour 35 µg/m³ Standard[25]

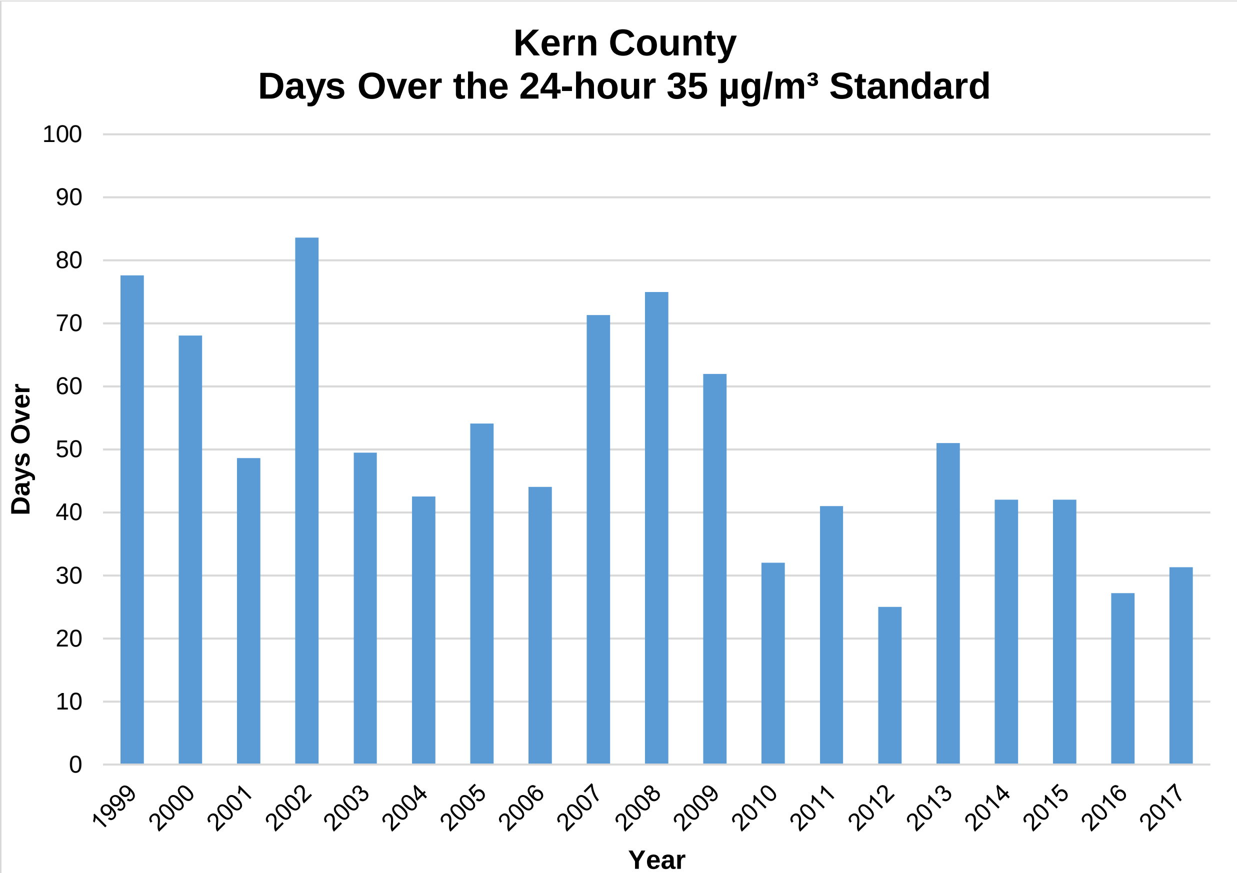


Table A-8 shows the number of days per month the Valley exceeded the 1997 24-hour PM2.5 standard of 65 µg/m³, and Table A-9 shows the number of days per month the Valley exceeded the 2006 24-hour PM2.5 standard of 35 µg/m³. The data are grouped by winter season instead of year, as to highlight the decrease in PM2.5 per season when concentrations are the highest in the year.

Starting in 2008, the District increased the number of real-time PM2.5 analyzers operating throughout its air monitoring network, allowing for more daily average samples being sampled instead of collecting samples every three or six days through filter-based methods. Through this change, the PM2.5 monitoring record is able to better demonstrate the day-to-day air quality trends throughout the Valley. As shown in Table A-8 and Table A-9, the Valley has shown a significant drop in the number of exceedances of both the 65 and 35 µg/m³ standards, even with additional real-time analyzers added to the network.

In the 2000-2001 winter season, 42 days of exceedances of the 1997 24-hour PM2.5 standard occurred across the District. Comparing this to the 28 exceedances that occurred in the 2013-2014 period, this represents a 33%

[25] Note: Years and sites with no data represent zero exceedances. Data has been normalized.

decrease in the number of violations throughout the District even with the addition of real-time monitors, and even with the exceptionally poor dispersion conditions that occurred during the 2013-2014 winter season. In recent years, exceedances of the 65 µg/m³ PM2.5 standard have become very rare. This difference demonstrates the progress that the District has made in improving the PM2.5 air quality throughout the Valley.

Additionally, the Valley has experienced a significant reduction in the number of days when the 2006 24-hour PM2.5 standard of 35 µg/m³ has been exceeded. As Table A-9 details, the 2002-2003 period recorded 90 days when this standard was exceeded somewhere in the Valley, while the 2016-2017 season recorded only 32 exceedances, representing a 64% decrease in this metric.

As noted in section A.1.2, the 2011-2012 and 2013-2014 winter seasons had very stable atmospheric stagnation periods due to California's exceptional drought, which increased the District's PM2.5 concentrations. Despite the increase during the drought, the District has still experienced a downward trend in the number of exceedances of both the 65 µg/m³ and 35 µg/m³ standards compared to the beginning of PM2.5 measurements in the Valley during the 1999-2000 period, highlighting the efficacy of the Valley's attainment strategy.

Table A-8 Number of Days Valley Exceeded 65 µg/m³ PM2.5 Standard

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
1999-00				2	12	19	7						***40***
2000-01					11	16	9	6					***42***
2001-02					12	1	4	10					***27***
2002-03					9	6							***15***
2003-04						1							***1***
2004-05					1	3							***4***
2005-06					5	11		3					***19***
2006-07					1	2	7	4					***14***
2007-08	2				6	5	2	3				2	***20***
2008-09					3	1	5						***9***
2009-10				2	1	4				1			***8***
2010-11	1					2							***3***
2011-12				1		13	5						***19***
2012-13							1	1			1		***3***
2013-14						13	13					2	***28***
2014-15					6		7						***13***
2015-16													***0***
2016-17						1							***1***
2017-18*					1	13	4						***18***

Note: Months with no data represent zero exceedances. 2018 data is preliminary.
*Winter of 2017-18 affected by smoke from wildfires, strong high pressure systems, and poor dispersion

Table A-9 Number of Days Valley Exceeded 35 μg/m³ PM2.5 Standard

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
1999-00				12	22	26	19	3					***82***
2000-01				6	23	27	18	8	3				***85***
2001-02	1			4	18	15	25	17		1			***81***
2002-03		7		9	24	14	25	9	2				***90***
2003-04				4	14	9	18	5	5				***55***
2004-05	1			5	18	13	4	11	4				***56***
2005-06				4	15	15	13	12					***59***
2006-07			3	2	11	20	26	10					***72***
2007-08	2		2	5	22	13	13	11	2		1	8	***79***
2008-09	6		2	6	18	16	24	5					***77***
2009-10				8	14	22	11	7	1	1			***64***
2010-11	1		2	3	14	11	15	5				1	***52***
2011-12				8	10	28	22	3					***71***
2012-13					11	5	19	6	2		1		***44***
2013-14	5	3		3	15	26	28	3				3	***86***
2014-15	2			1	14	6	24	12	1	1			***61***
2015-16		3	3		6	8	6	9					***35***
2016-17			1		13	10	3	2	2		1		***32***
2017-18*	1		4	4	9	28	9	7					***62***

Note: Months with no data represent zero exceedances. 2018 data is preliminary.
*Winter of 2017-18 affected by strong high pressure systems, poor dispersion, and smoke from wildfires.

A.3.2 PM2.5 Driven Air Quality Index Analysis

The EPA and the District use the Air Quality Index (AQI) to provide daily information about the Valley's air quality, educate the public about how they can protect their health, and to inform the public about how unhealthy air may affect them. AQI scales exist for all of the criteria pollutants regulated by the Clean Air Act, including PM2.5. The current 24-hour average PM2.5 AQI scale is shown in Table A-10 below.

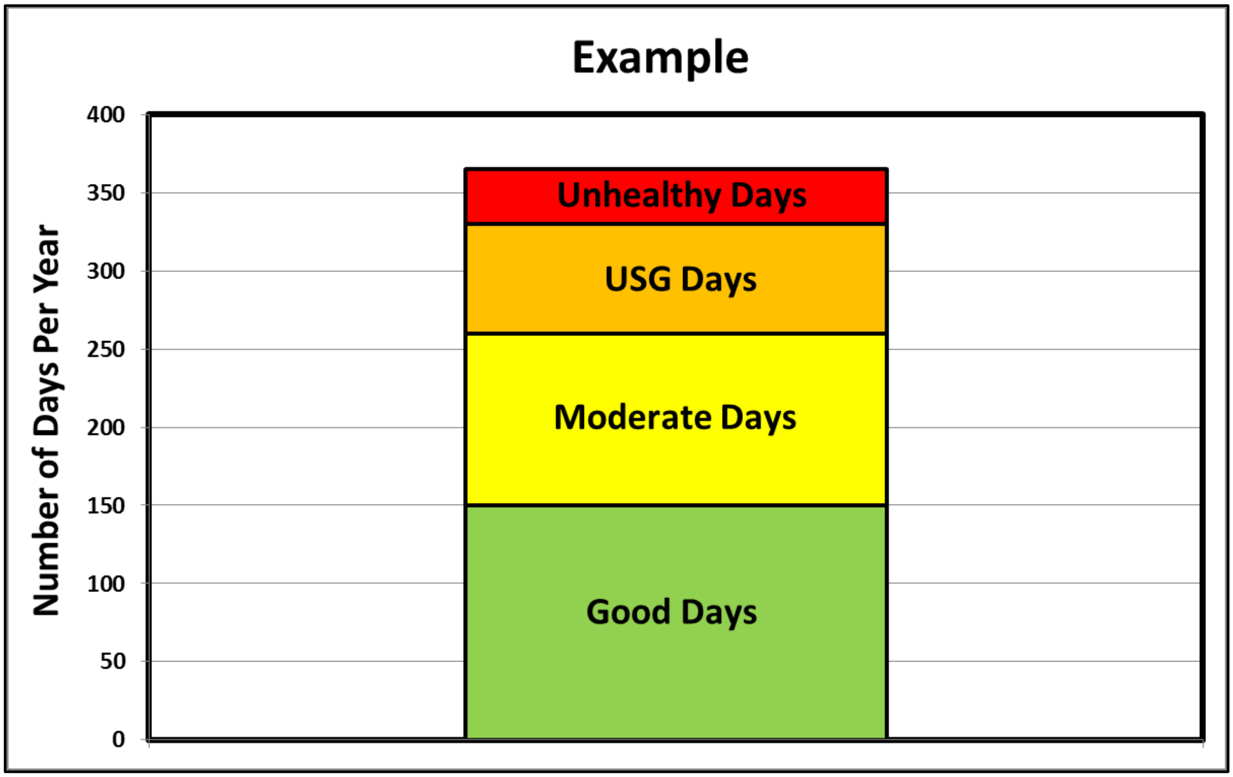
Table A-10 PM2.5 AQI Scale

AQI Category	Index Values	Concentration (µg/m^3, 24-hr average)
Good	0-50	0 – 12.0
Moderate	51-100	12.1 – 35.4
Unhealthy for Sensitive Groups (USG)	101-150	35.5 - 55.4
Unhealthy	151-200	55.5 - 150.4
Very Unhealthy	201-300	150.5 - 250.4
Hazardous	301+	250.5+

The District analyzed the trends in the PM2.5 data from the sites with at least two years of daily AQI observations based on real-time data. For this analysis, the AQI trends are based upon PM2.5 concentrations only, and do not include ozone, PM10, or other pollutants. By excluding the other pollutants, the District is able to isolate the change in air quality trends related to PM2.5 only.

Figure A-35 is shown as a reference for interpreting the AQI trends shown in Figure A-36 through Figure A-44. The stacked bars represent the number of days within each year that fell within each of the AQI categories (totaling 365 days). Because of regular maintenance or repairs, monitors may be non-operational for a day or longer. For years with “missing” days, proportional adjustments were made to estimate the missing days to provide a full year’s data to display. Within each stacked bar, the categories are ordered as Good, Moderate, etc. from the bottom up.

Figure A-35 Air Quality Index (AQI) Categories



For the majority of the Valley sites, the observed PM2.5 AQI data for the 2008-2016 timeframe shows an improvement in PM2.5 air quality. Over these 8 years, the frequency of Good AQI days increased, coupled with a decrease in the frequency of the Moderate, Unhealthy-for-Sensitive-Groups (USG), and Unhealthy AQI days. For example, at the Fresno-First /Garland site (see Figure A-40), the number of Good days increased from 190 in 2008, to 229 in 2017. At the same time, the Moderate and USG and higher AQI days decreased from 124 to 109, and 51 to 27, respectively.

A similar pattern occurred at other sites with the frequency of Good AQI days increasing and the frequency of the Moderate and USG AQI days decreasing. For example, at the Bakersfield-California site (see Figure A-44), the number of Good days increased from 112 in 2008 to 185 in 2017. At the same time, the Moderate and USG AQI days decreased from 189 to 152, and 65 to 28, respectively.

In Figure A-36 to Figure A-44, the data for each site was averaged for each year. Visual analysis of these figures, which are arranged from north to south, shows that the northern sites have more Good AQI days than the southern sites. For example, Stockton-Hazelton averaged nearly 66% Good AQI days, about 25 more percentage points in the Good AQI category than the Visalia and Bakersfield sites, which averaged around 41% Good AQI. Analysis of Figure A-36 to Figure A-44 demonstrates that the dominant annual PM2.5 AQI categories are the Good and Moderate across the Valley.

As noted above, over recent winter seasons, a persistent and strong high-pressure ridge over the eastern Pacific Ocean and the western United States effectively blocked weather disturbances from entering California that would normally have removed and replenishment of the valley's air with clean air. The historic strength and longevity of this high pressure resulted in a lack of rainfall and stagnation conditions leading to a subsequent increase in the suspended particulate matter in the atmosphere. In addition, the Valley was also impacted by multiple wildfires significantly elevating PM2.5 concentrations. This caused the exceptionally high PM2.5 concentrations found in the Valley and throughout the state of California. Despite these conditions, air quality has improved over the entire period of PM2.5 monitoring in the Valley, as this analysis indicates.

Figure A-36 Stockton-Hazelton PM2.5 AQI Trend

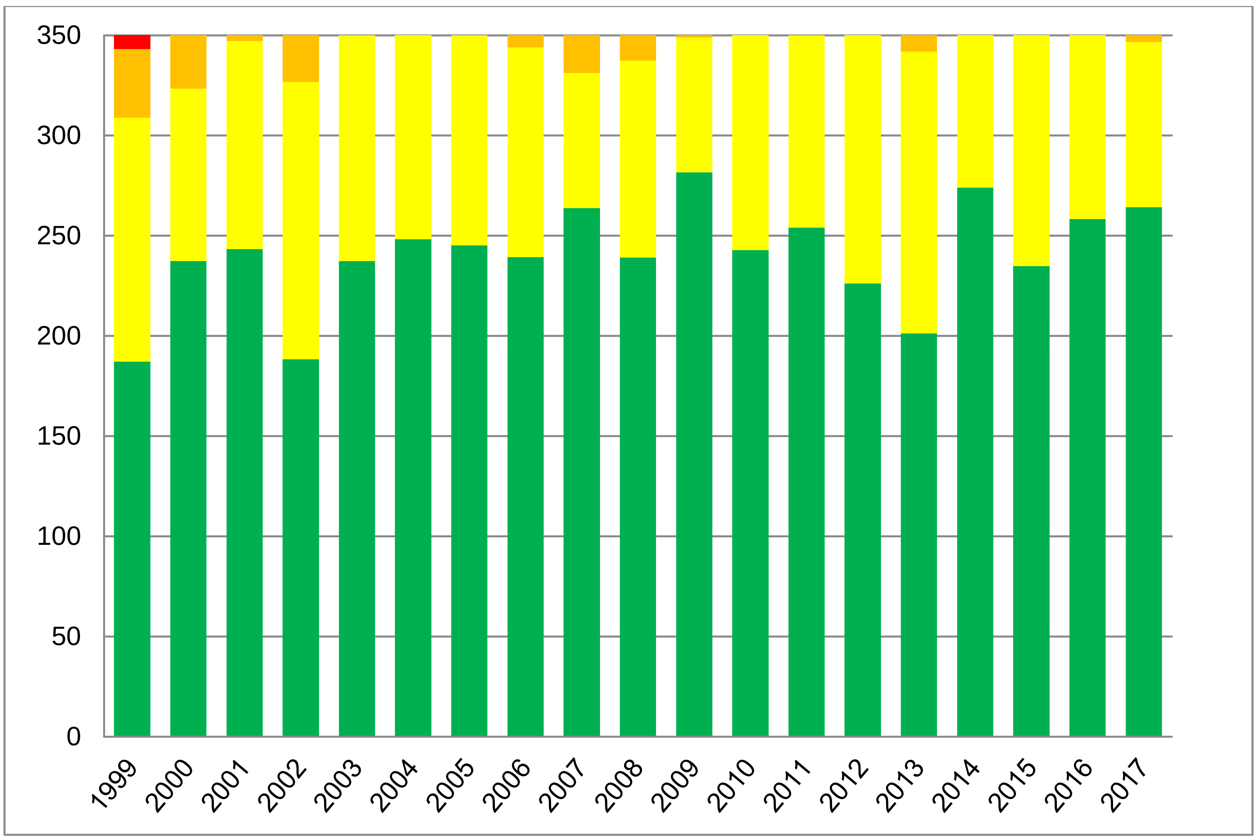


Figure A-37 Modesto-14th Street PM2.5 AQI Trend

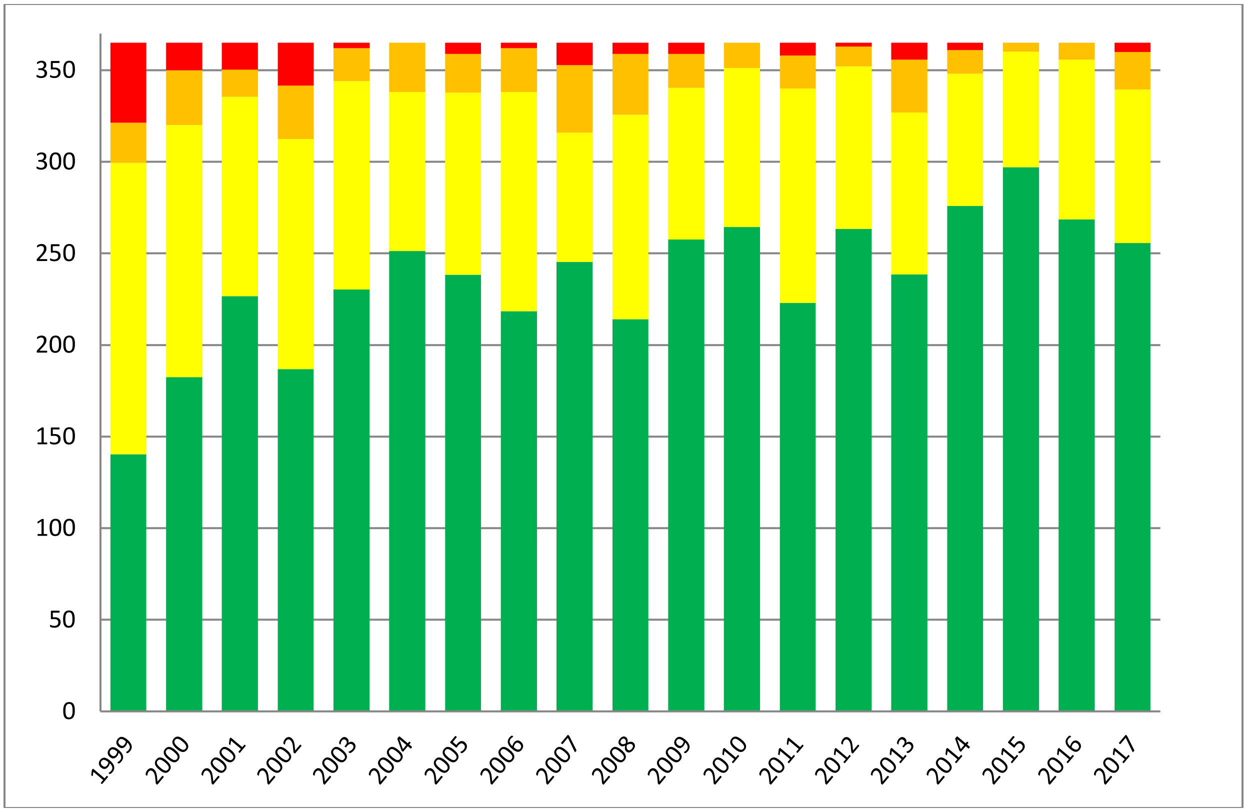


Figure A-38 Merced-M Street PM2.5 AQI Trend

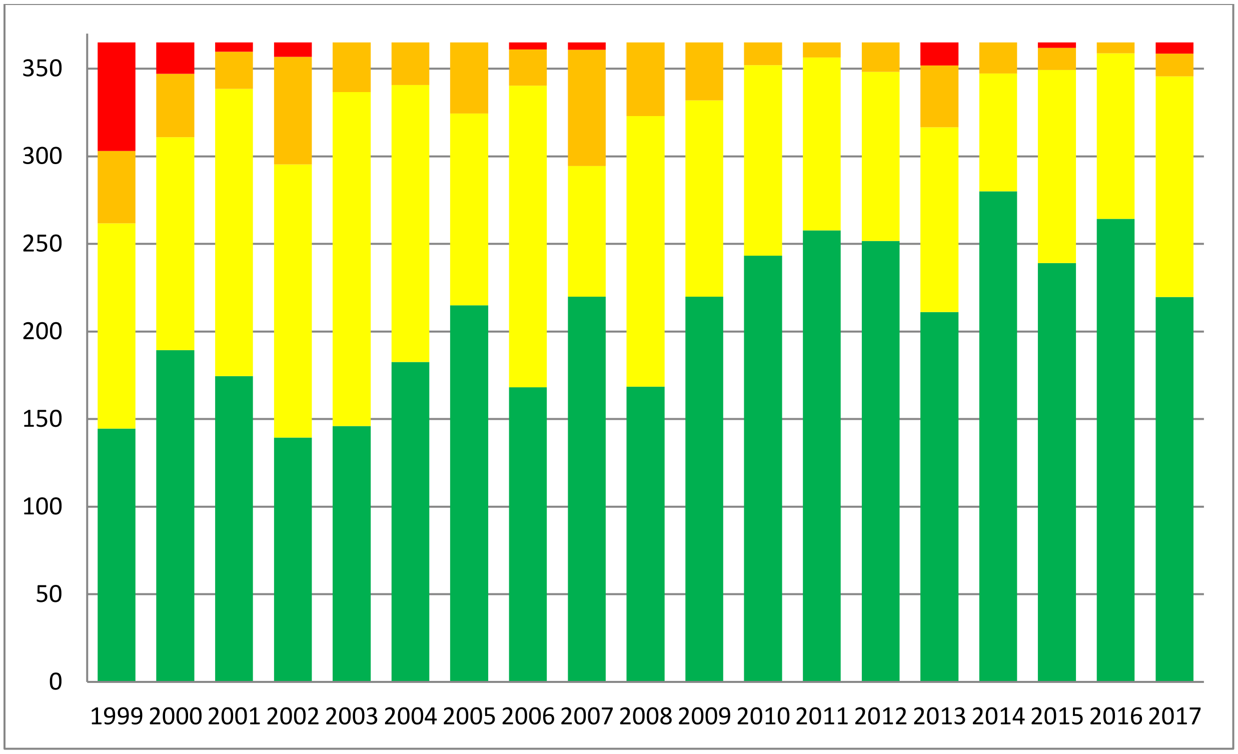


Figure A-39 Madera-City PM2.5 AQI Trend[26]

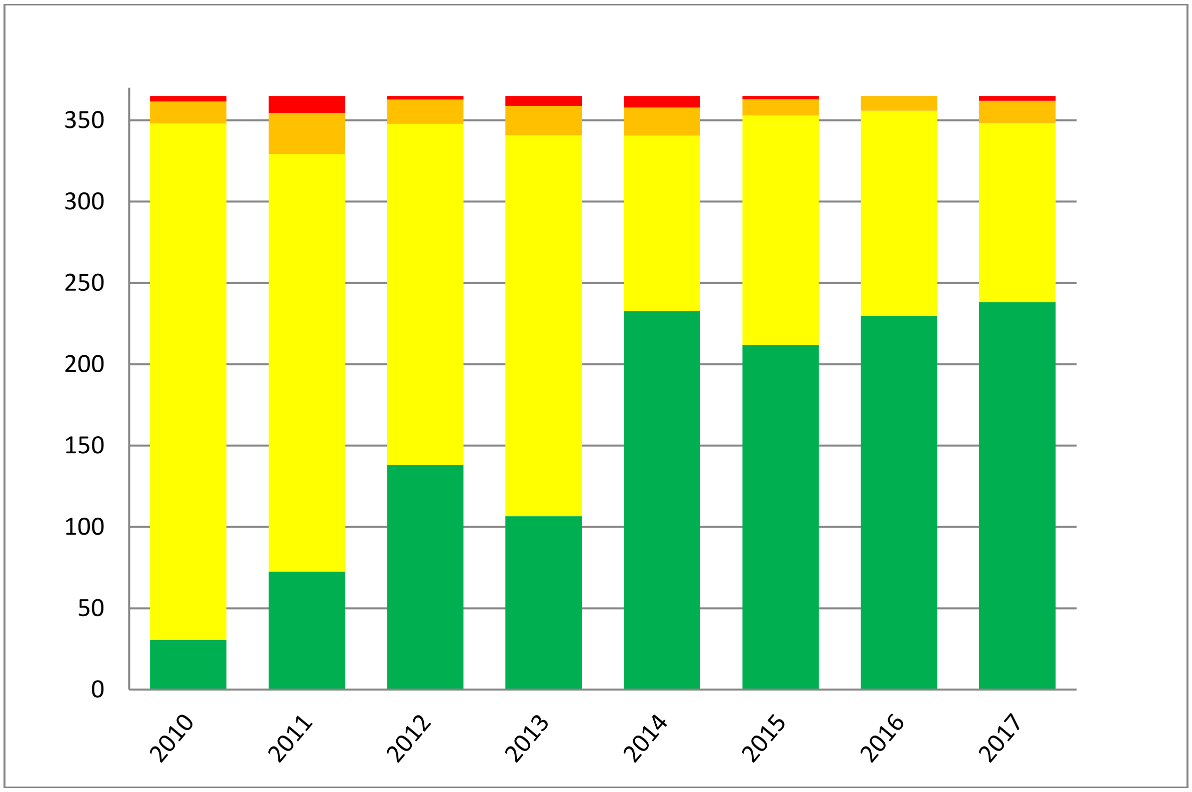
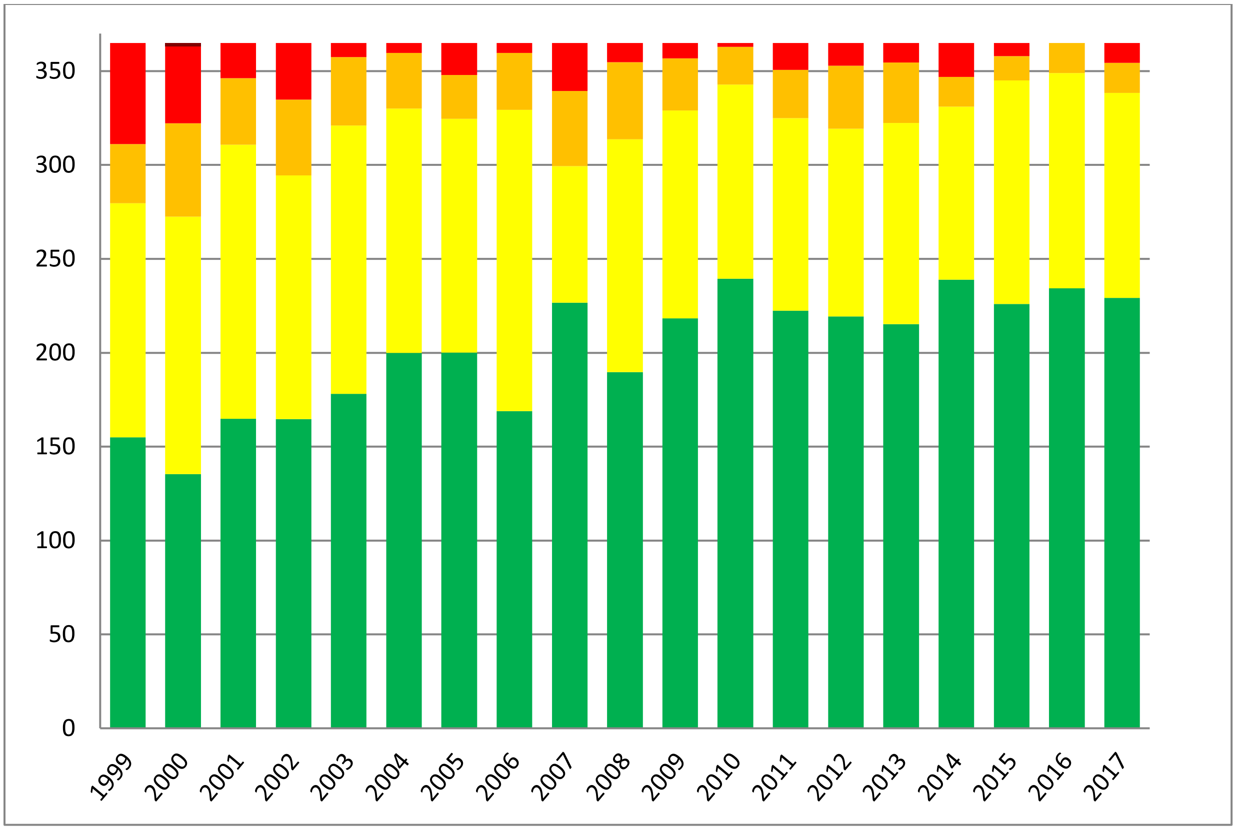
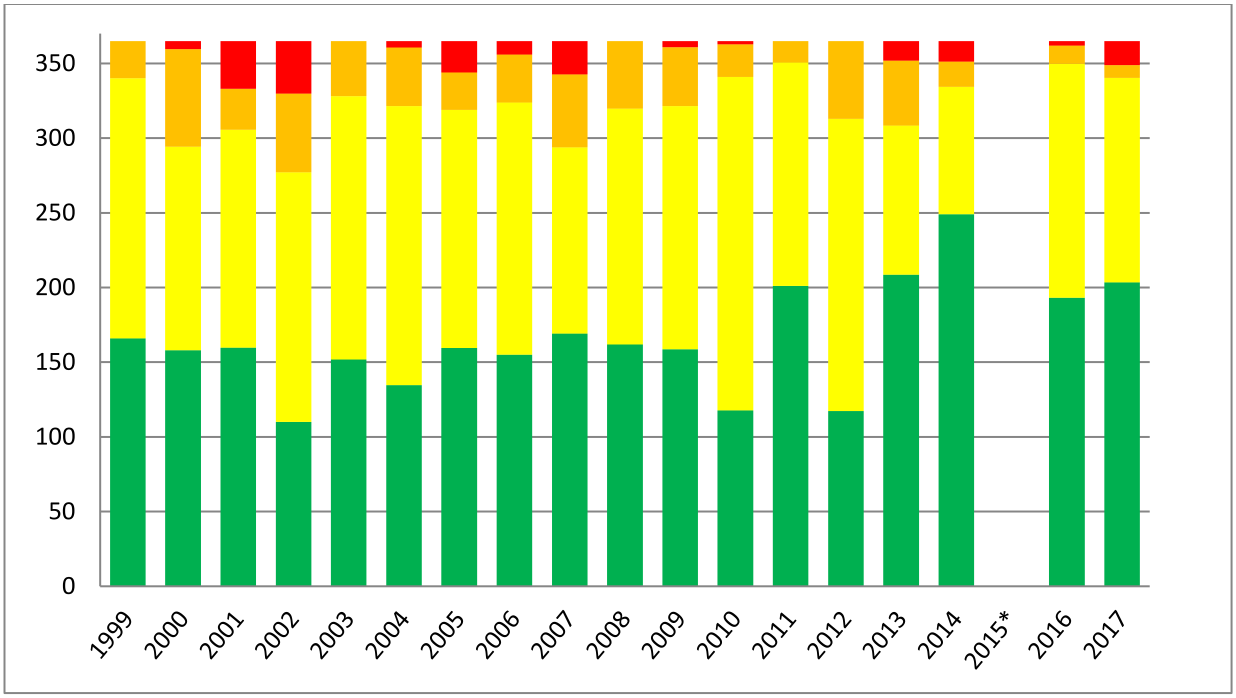


Figure A-40 Fresno-First/Garland PM2.5 AQI Trend



[26] Data collection began 7/06/2010

Figure A-41 Corcoran PM2.5 AQI Trend[27]



[27] Data not available in 2015 due to air monitoring site being damaged by fire.

Figure A-42 Visalia-Church PM2.5 AQI Trend

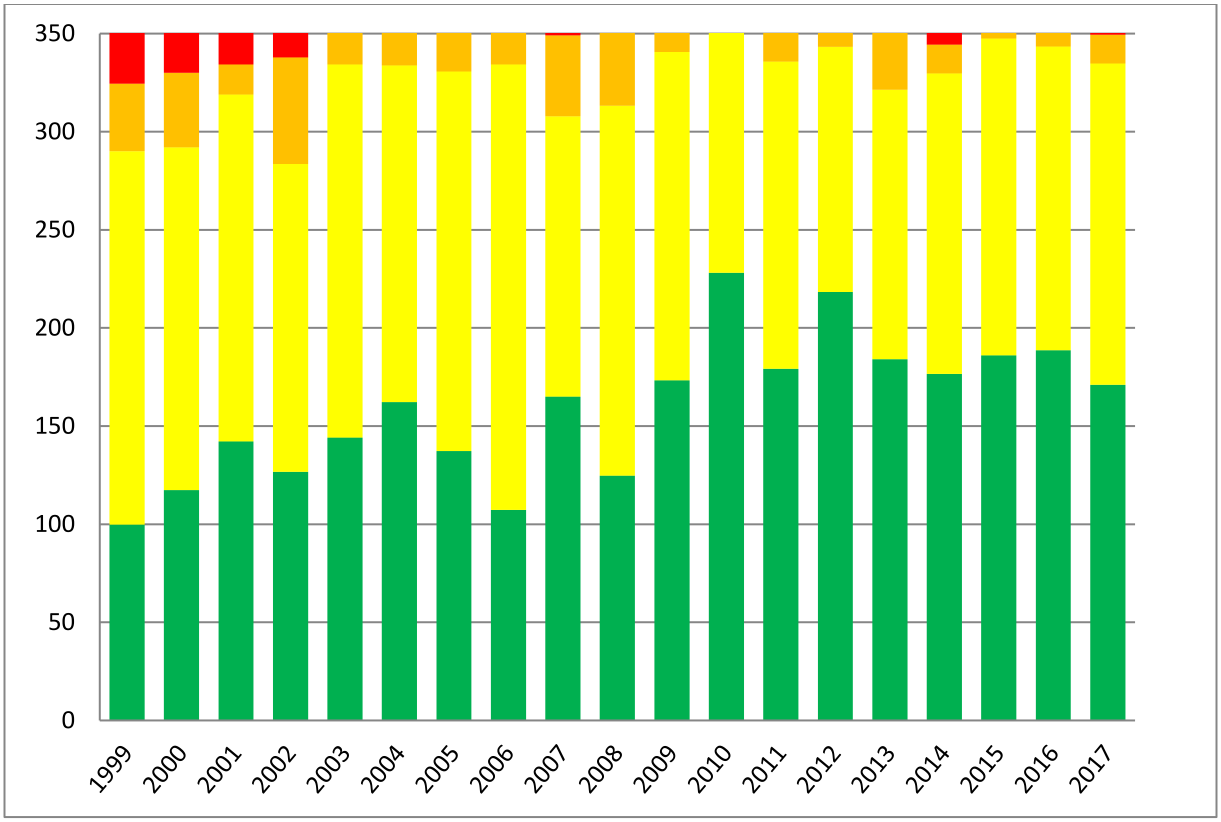


Figure A-43 Bakersfield-Planz PM2.5 AQI Trend

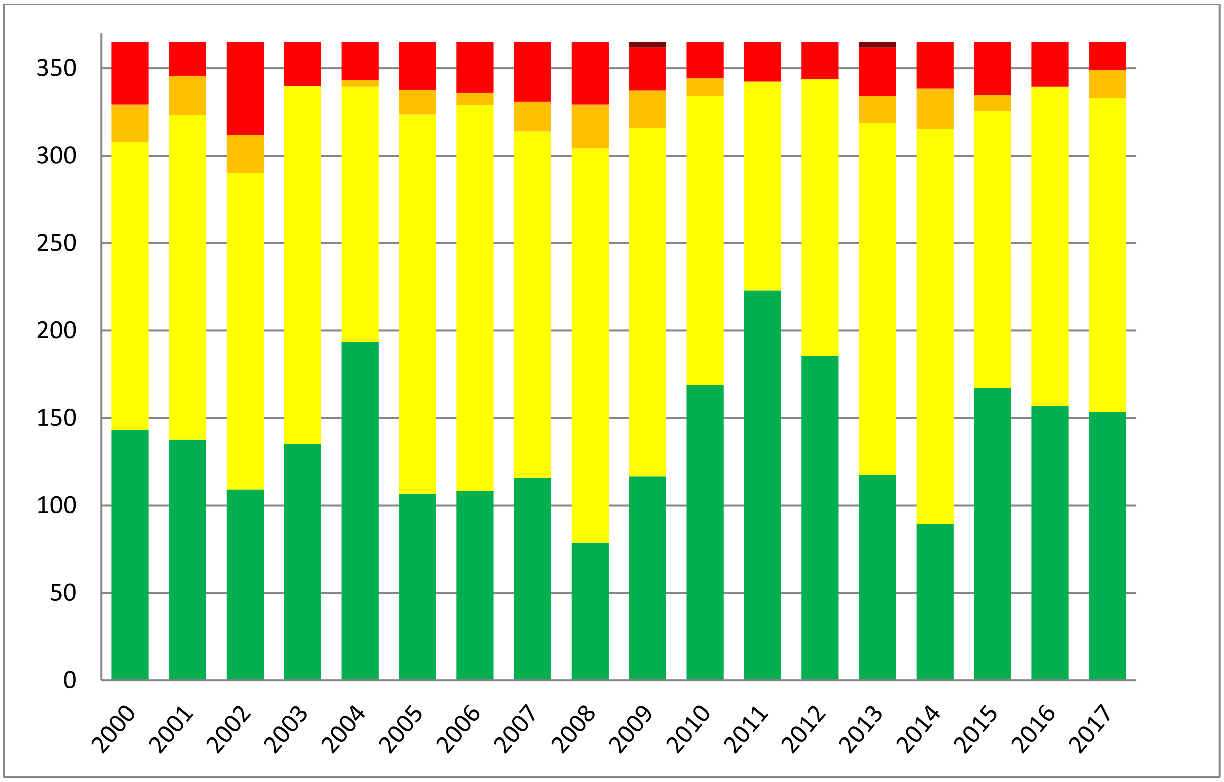


Figure A-44 Bakersfield-California PM2.5 AQI Trend

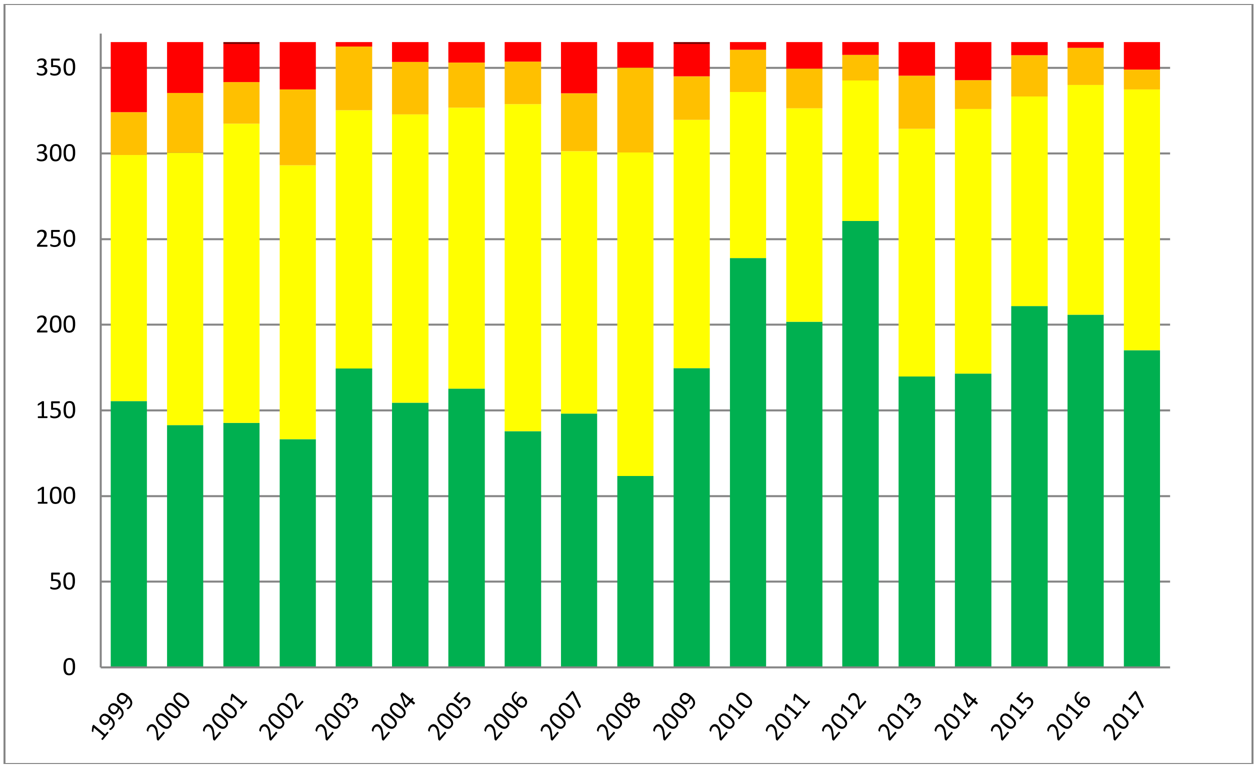


Figure A-45 shows the AQI category frequencies among all of the Valley's counties during the winter season and further illustrates the continuing trend of improving air quality. The recent 2016-2017 winter season recorded a historically low number of Unhealthy for Sensitive Group days and the highest number of Good days in the Valley's recorded history, marking a notable achievement for the region. Although the 2017-18 season experienced a decrease in Good days and an increase in Unhealthy for Sensitive Groups or worse days, this season was heavily influenced by strong atmospheric stability, poor dispersion, and wildfire emissions, as described earlier. However, over the entire period since the 1999-00 season, this analysis shows that the Valley has significantly increased its number of Good days and has decreased its number of Unhealthy days, both indicative of improving air quality.

Figure A-45 County-Day AQI Frequencies during the Winter Season[28]

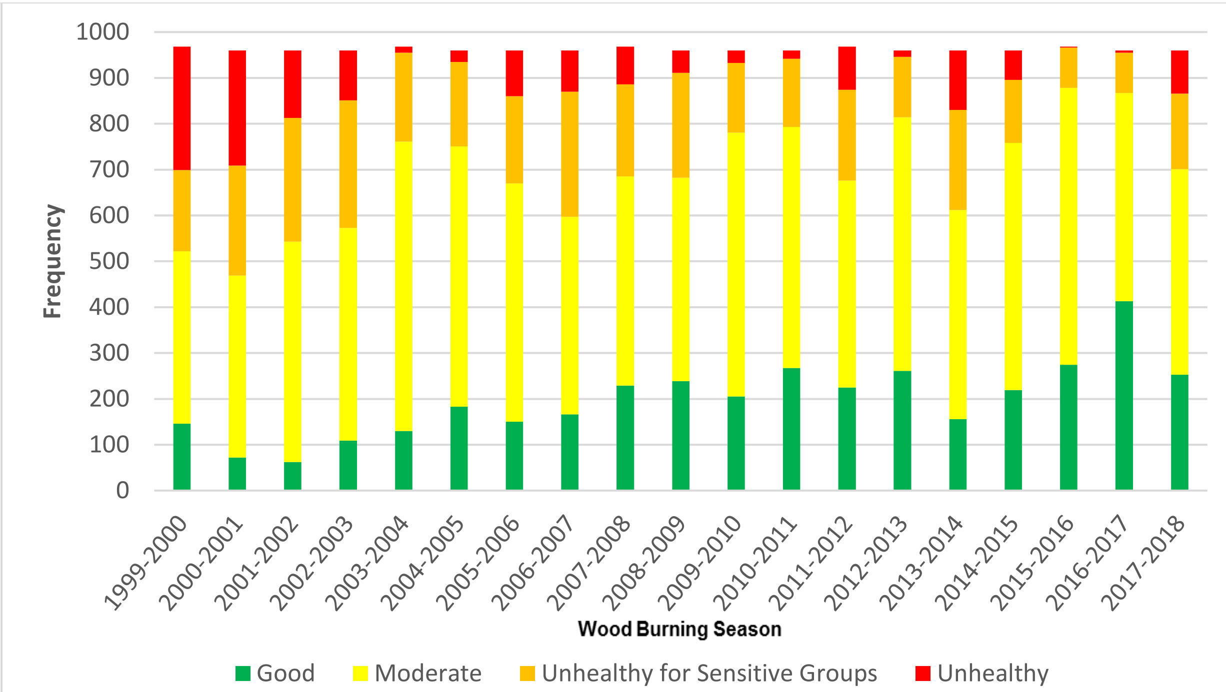


Figure A-46 to Figure A-51 compare the AQI categories for PM2.5 from 2000 and 2017 at the Stockton, Fresno, and Bakerfield stations. Each station shows a significant improvement within 17 years. Stockton shows an increase in Good and Moderate PM2.5 AQI categories from 323 days (88%) in 2000 to 347 days (95%) in 2017. Fresno, which has the greatest improvement, was 272 days (75%) in the Good to Moderate AQI categories for 2000, and in 2017 increased to 338 days (93%). Bakersfield changed from 300 days (82%) in 2000 to 337 days (93%) in 2017. This also demonstrates that the Unhealthy for Sensitive Groups and Unhealthy categories have decreased for PM2.5. The Stockton-Hazelton site had 6 days (2%) in the Unhealthy AQI category in 2000, and in 2017, there were zero. Fresno-First/Garland had 41 Unhealthy days (11%) and two Very Unhealthy days (<1%) in 2000. By 2017, the same station reported 11 Unhealthy days (3%) and zero Very Unhealthy days. A similar trend was experienced in Bakersfield, where in 2000, there were 30 Unhealthy days reported (8%) compared to 16 Unhealthy days (4%) in 2017.

[28] Note that for Leap Years (1999-2000, 2003-2004, 2007-2008, 2011-2012, and 2015-2016) the total County-Day AQI frequency total equals 968. For non-Leap Years, the total County-Day AQI frequency total equals 960.

Figure A-46 Percent AQI Days in Stockton 2000

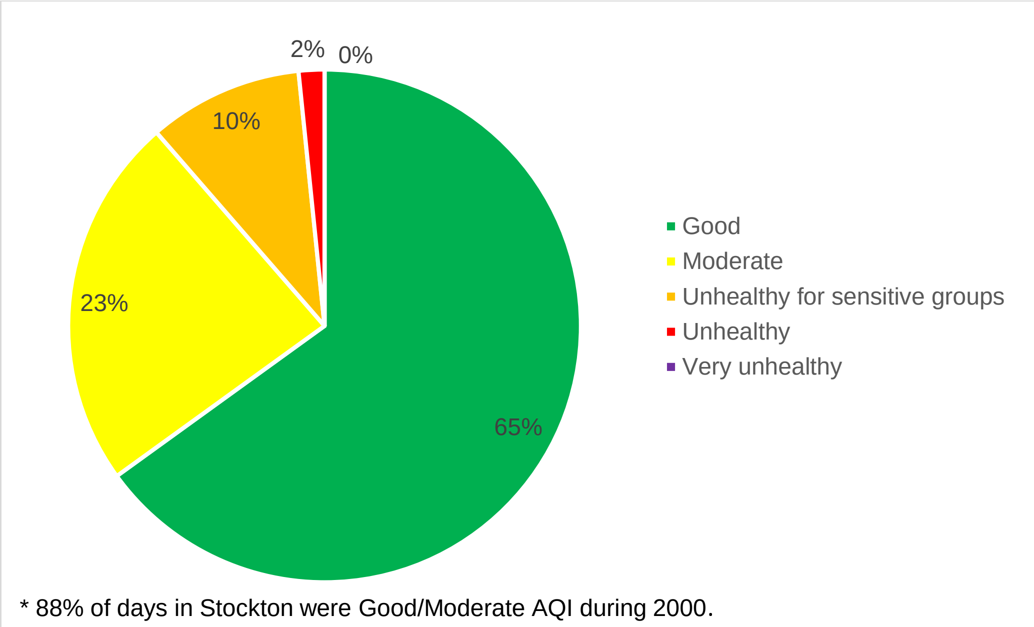


Figure A-47 Percent AQI Days in Stockton 2017

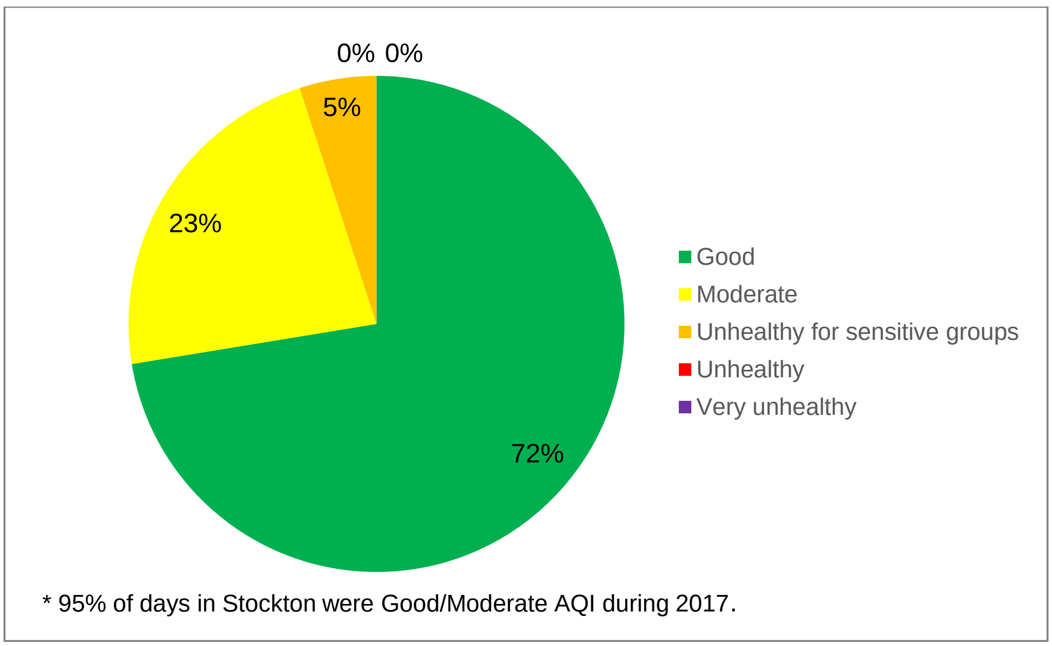


Figure A-48 Percent AQI Days in Fresno 2000

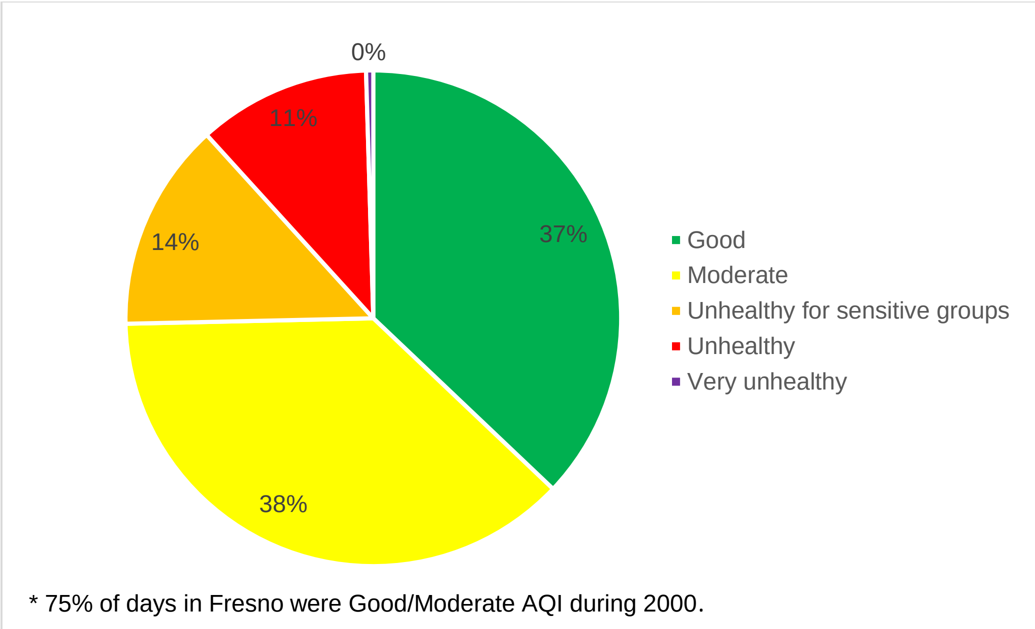


Figure A-49 Percent AQI Days in Fresno 2017

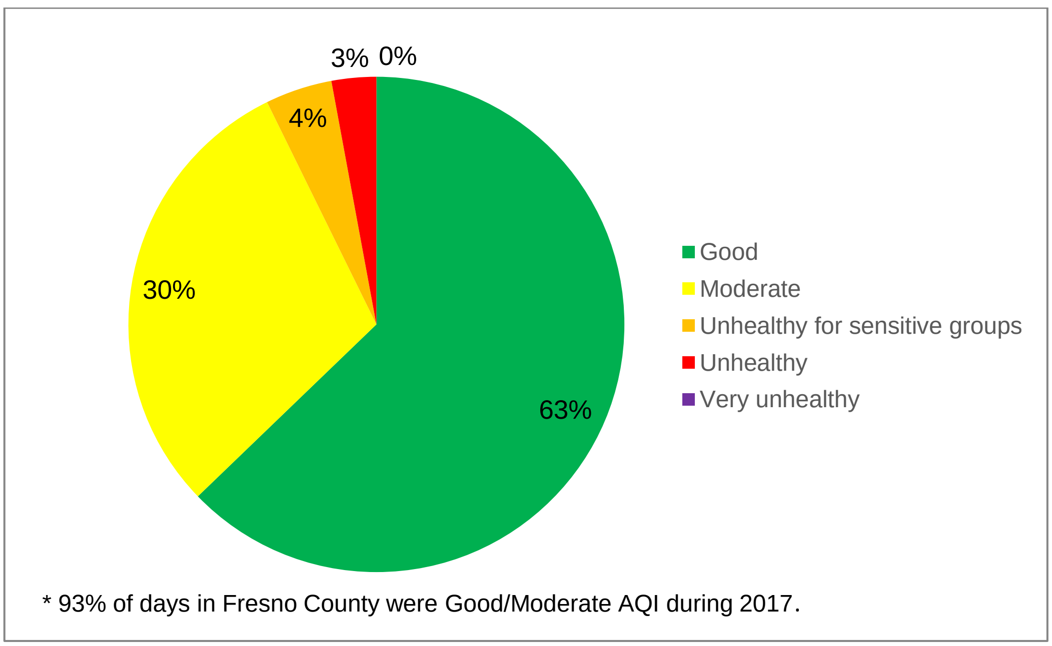


Figure A-50 Percent AQI Days in Bakersfield-CA 2000

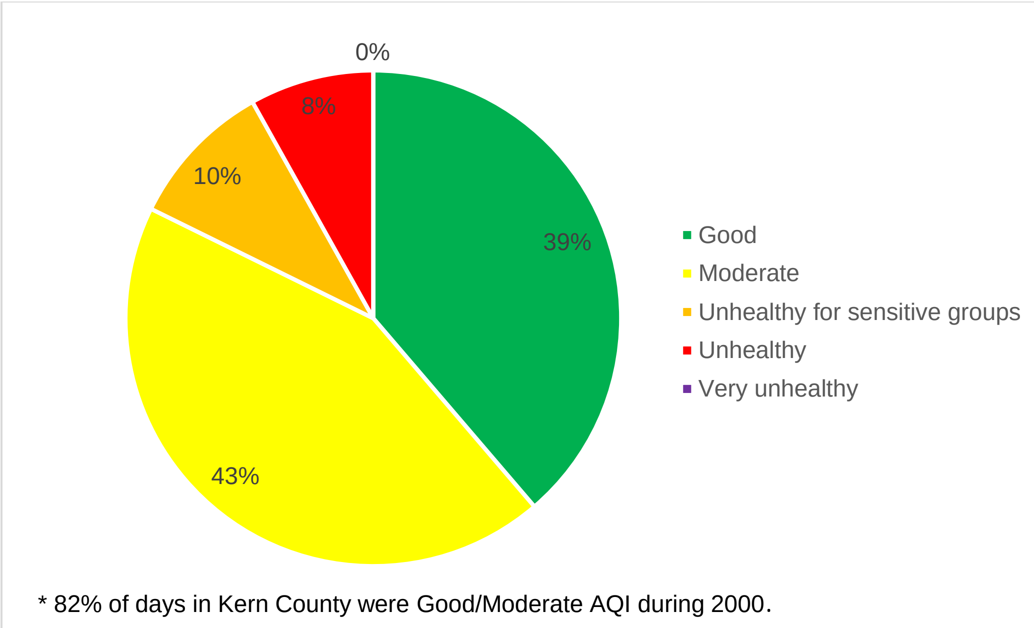


Figure A-51 Percent AQI Days in Bakersfield-CA 2017