Appendix A

Ambient PM2.5 Data Analysis

2015 Plan for the 1997 PM2.5 Standard
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Appendix A: Ambient PM2.5 Data Analysis

The concentration of ambient of 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 (ARB), 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 show steady, long-term air quality improvement that will lead to the attainment of the 1997 PM2.5 Standard.

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 as summarized in Chapters 2 of this *2015 Plan for the 1997 PM2.5 Standard* (*2015 PM2.5 Plan*). 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, ARB, and other agencies manage an extensive air monitoring network throughout the Valley. The information obtained from the PM2.5 monitors within this network provide 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*: January 28, 2015 submittal to EPA. Available at http://www.valleyair.org/aqinfo/Docs/2014-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 http://www.epa.gov/ttn/airs/airsaqs/aqsweb/

A.1.1 PM2.5 Monitor Types

The District and ARB 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 every day to produce daily air quality forecasts, wood burning declarations, public health notifications, and Real-time Air Advisory Network (RAAN) notifications for schools.

The filter-based speciation monitors operate similarly to the standard FRM monitors; however, because of 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.

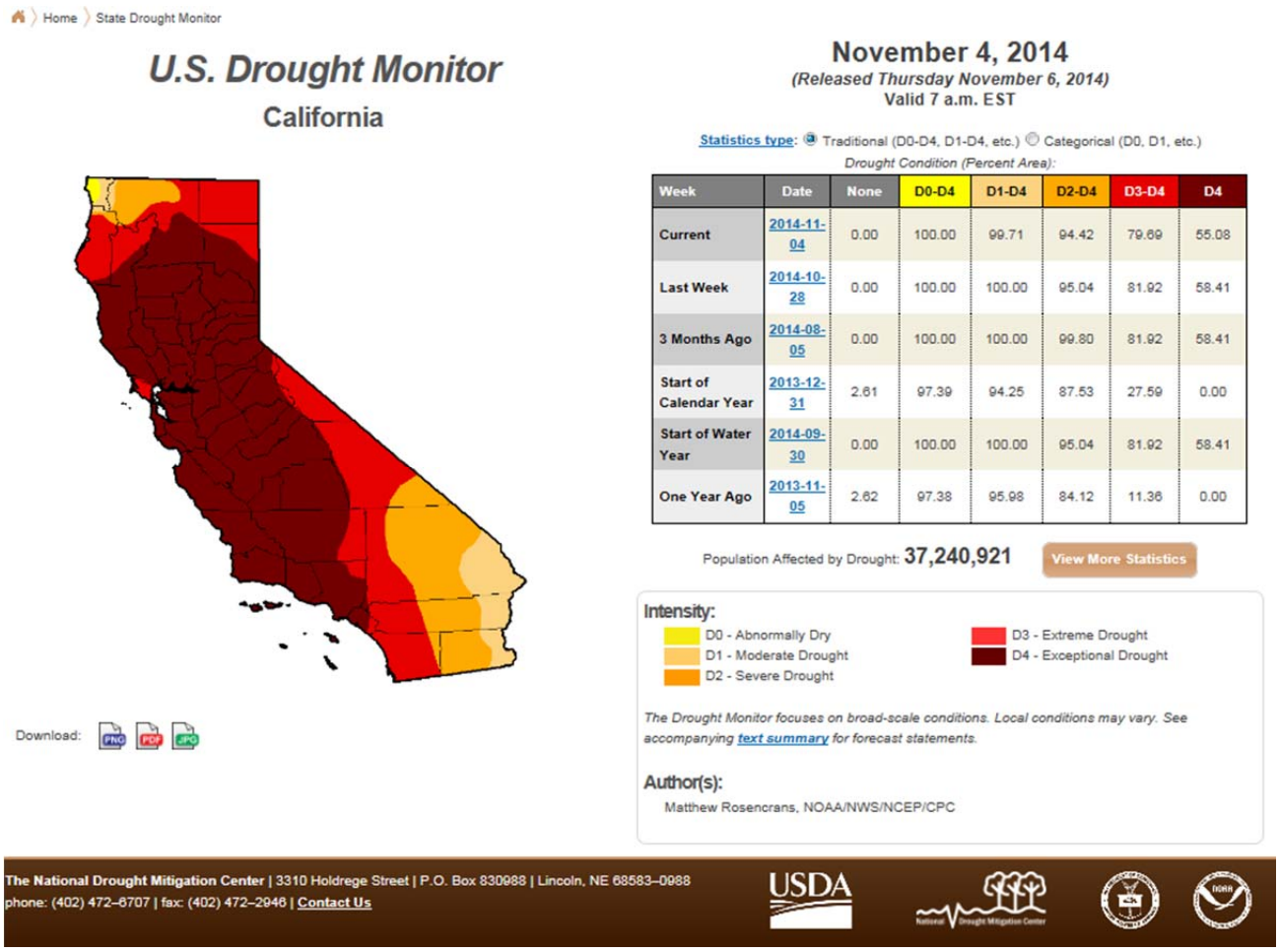
Vertical mixing of the air mass can result from atmospheric instability. A temperature inversion, or increasing temperature with increasing height, can inhibit the vertical mixing of an air mass, and create a situation in which pollutants remain trapped near the surface. Prolonged periods of high pressure 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 United States Geologic Survey, California is experiencing its worst drought in over a century. The 2013-2014 Winter represented the third consecutive year of drought conditions in the Valley, and was by far the driest winter of the three years. On January 17, 2014, the Governor of California declared a drought emergency for all of California. 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 November 4, 2014.

Figure A-1 Drought Extent and Severity in California



A persistently strong high pressure ridge over the eastern Pacific Ocean and the western United States effectively blocked weather disturbances from entering California. The historic strength and longevity of this high pressure resulted in a lack of rainfall throughout the Valley, and California as a whole (Table A-1).

Many cities in California, including those in the Valley, had record low rainfall totals during 2013 calendar year, with some records that have stood for over 100 years being broken.

Table A-1 2013 Calendar Year Rainfall Totals for Select Valley and California Cities

Region	City	1981-2010 Average (inches)	2013 Total (inches)	Previous Record Low (inches)	Previous Record Year
Valley	Modesto	13.11	4.70	5.70	1929
	Merced	12.50	3.79	6.00	2007
	Fresno	11.50	3.01	3.55	1947
	Visalia	10.93	3.47	4.10	1910
	Bakersfield	6.47	3.43	1.87	1959
Other parts of California	Sacramento	18.52	5.81	6.67	1976
	San Francisco	23.65	5.59	9.00	1917
	San Jose	14.90	3.80	6.04	1929
	Los Angeles	12.82	3.65	4.08	1953
	San Diego	10.34	5.57	3.41	1953

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 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 even extended high-concentration episodes such as summertime wildfires.

Since exceptional events are not reasonably preventable or controllable, it is inappropriate to use data influenced by these events. 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.

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 PM2.5 Standard. Two examples include a fireworks event in July 2007 and a summertime wildfire event in 2008. Analyses presented in the *2012 PM2.5 Plan* illustrated how fireworks and wildfire events can also influence the design value calculations and whether or not an area may achieve attainment of the PM2.5 Standard.

[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)

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, including the 24-hour PM2.5 standard of 65 µg/m³ and the annual PM2.5 standard of 15.0 µg/m³. If any monitoring site within the air basin has either a 24-hour or annual PM2.5 design value higher than the respective standard, then the entire air basin is designated nonattainment.

Table A-2 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-2 General PM2.5 Design Value Calculation Methods

Averaging Period	Level	Calculation Method
24-hour	65 µg/m³	**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	**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.*

Tables A-3 through A-6 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 2013.

24-hour single-year 98th-percentile averages (Table A-3) are used to generate the three-year average 24-hour design values (Table A-4). Single-year average PM2.5 concentrations (Table A-5) are used to generate the three-year average annual design values (Table A-6). These data are also shown graphically in Figures A-2.1 through A-

[5] Interpretation of the National Ambient Air Quality Standards for PM2.5, 40 C.F.R. Pt. 50 Appendix N (2012). Available at http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=9bdb7a34dcb75892aef9ee60b74da642&rgn=div9&view=text&node=40:2.0.1.1.1.0.1.18.15&idno=40

[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 http://www.epa.gov/ttn/oarpg/t1/memoranda/pmfinal.pdf

2.32 for a number of monitoring sites in the Valley. Note that the Fresno-First monitoring site was closed in early 2012 and its nearby replacement site of Fresno-Garland was opened soon after. To form a continuous data record, these two sites were combined to create a Fresno-First/Garland historical record.

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. Currently more Valley air monitoring sites meet the 1997 24-hour average standard of 65 $\mu g/m^3$ than the annual average standard of 15.0 $\mu g/m^3$. For 2013, all District sites have met the 1997 24-hour PM2.5 Standard. For the annual average PM2.5 Standard, most monitoring sites are showing a downward trend; however, the concentrations remain above the annual mean NAAQS.

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

SJV Monitoring Site	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Stockton	79.0	55.0	58.0	50.0	41.0	36.0	44.0	42.0	48.0	61.6	40.4	29.7	44.8	33.9	56.3
Manteca													38.9	30.9	40.2
Modesto	100.0	71.0	69.0	69.0	47.0	45.0	55.0	52.0	57.4	53.9	54.5	37.3	54.7	40.8	56.4
Turlock											53.1	43.5*	57.4	45.4	55.4
Merced-Coffee												39.9	47.4	35.6	42.3
Merced-M	91.9	60.0	49.3	55.1	44.2	43.0	48.3	43.8	52.7	54.0	45.2	35.5	38.5	41.8	67.3
Madera-City												57.0	59.1	43.2	54.6
Fresno-First	120.0	90.0	75.0	75.0	56.0	52.0	71.0	51.0	67.0	57.4	55.8	48.8	69.5		
Fresno-Garland														52.6	63.8
Fresno-Winery		64.8	61.5	71.9	49.7	49.4	71.2	55.0	57.4	44.5	48.2	37.0	67.5	51.3	71.6
Clovis	59.2	72.5	71.5	53.2	48.1	52.4	63.0	51.3	60.9	49.0	49.0	44.3	68.5	48.0	56.2
Tranquility												27.7	27.5	26.9	35.7
Corcoran	53.0*	55.1	89.5	65.1	42.2	49.4	74.5	50.1	57.9	47.9	53.4	47.2	40.8*	40.0*	66.0
Hanford													64.6	48.3	67.6
Visalia	114.0	103.0	96.0	70.0	47.0	54.0	65.0	50.0	59.7	62.1	53.9	36.3	50.7	53.8	62.5
Bakersfield-Golden	95.3	93.9	95.9	80.4	51.9	53.9	74.9	64.4	67.7	60.8	68.6				
Bakersfield-California	97.4	92.7	94.9	73.0	48.3	61.5	63.2	60.5	73.0	64.5	66.7	53.3	65.5	56.4	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

Table A-4 24-hour Average PM2.5 Design Values (Three-Year Averages, µg/m^3), end year listed (2011-2013, 2013)

SJV Monitoring Site	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Stockton	64	54	50	42	40	41	45	51	50	44	38	36	45
Manteca												38*	37
Modesto	80	70	62	54	49	51	55	54	55	49	49	44	51
Turlock									60	55*	51*	49*	53
Merced-Coffee											43**	41	42
Merced-M	67	55	50	47	45	45	48	50	51	45	42	40	49
Madera-City												53	52
Fresno-First	95	80	69	61	60	58	63	58	60	54	58		
Fresno-Garland													58***
Fresno-Winery	63	66	61	57	57	59	61	52	50	43	53	53	63

SJV Monitoring Site	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Clovis	68	66	58	51	55	56	58	54	53	47	54	54	58
Tranquillity											30**	27	30
Corcoran	66	70	66	52	55	58	61	52	53	49	47*	43	49
Hanford												54*	60
Visalia	104	90	71	57	55	56	58	57	59	51	47	47	56
Bakersfield-Golden	95	90	76	62	60	64	69	64	66				
Bakersfield-California	95	87	72	61	58	62	66	66	68	62	62	58	65
Bakersfield-Planz	84	78	68	54	54	60	68	70	70	65	55	47	60

Table A-5 Single Year Annual Mean PM2.5 Concentrations (µg/m^3)

SJV Monitoring Site	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Stockton	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
Manteca													10.7	8.1	11.6
Modesto	24.9	18.7	15.6	18.7	14.5	13.6	13.9	14.8	15.0	16.0	13.0	12.1	14.7	11.9	14.3
Turlock											16.1	12.5*	17.1	14.8	15.0
Merced-Coffee												16.3	15.6	11.0	13.3
Merced-M	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
Madera-City												21.1*	20.4	16.0	17.8
Fresno-First	27.6	24.5	19.8	21.5	17.8	16.3	16.7	16.8	18.8	17.4	15.1	13.0	15.5		
Fresno-Garland														14.1	16.8
Fresno-Winery		18.4	18.6	21.3	17.8	17.0	16.9	17.6	16.8	16.5	14.6	13.4	15.4	12.7*	15.9*
Clovis	19.8	16.3	18.0	16.2	18.5*	16.4	16.3	16.4	16.4	16.2	18.3	14.7	17.9	15.4	15.9
Tranquillity												7.0*	8.2	7.0	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
Hanford													18.0	14.8	18.2
Visalia	27.6	23.9	22.5	23.2	18.2	17.0	18.8	18.8	20.4	19.8	16.0	13.6	16.1	14.8	18.9
Bakersfield-Golden	26.2	22.6	21.8	24.1	19.6	18.2	19.1	18.6	19.9	17.9	20.0				
Bakersfield-California	23.8	22.5	21.2	22.7	17.1	18.9	18.0	18.7	22.0	21.9	19.0	14.2	16.2	13.0	20.0
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

Table A-6 Annual PM2.5 Design Values (Three-Year Averages, µg/m^3), end year listed (2011-2013, 2013)

SJV Monitoring Site	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Stockton	16.4	15.3	14.7	14.5	13.1	12.9	12.8	13.5	12.9	12.1	11.1	11.4	13.8
Manteca												12.1*	10.2
Modesto	19.7	17.7	16.2	15.6	14.0	14.1	14.6	15.3	14.7	13.7	13.3	12.9	13.6
Turlock											15.3*	14.9*	15.7
Merced-Coffee											18.2**	14.3	13.3
Merced-M	17.9*	16.6*	16.3*	16.5	15.0	14.7	14.7	15.0	14.6	13.2	11.7	10.4	11.1
Madera-City												18.2**	18.1
Fresno-First	24.0	21.9	19.7	18.6	16.9	16.6	17.4	17.7	17.1	15.2	14.5		
Fresno-Garland													15.5***
Fresno-Winery	18.5	19.4	19.2	18.7	17.2	17.2	17.1	17.0	16.0	14.9	14.5	13.8*	14.7*
Clovis	18.0	16.8	17.6	17.0	17.1	16.4	16.4	16.3	17.0	16.4	16.8	16.0	16.4
Tranquillity											7.6**	7.4	7.8
Corcoran		19.0	19.0	18.4	17.0	17.2	17.6	17.0	17.3	17.1	16.2*	15.8*	15.0*
Hanford												15.8*	17.0
Visalia	24.7	23.2	21.3	19.5	18.0	18.2	19.3	19.7	18.8	16.5	15.2	14.8	16.6
Bakersfield-Golden	23.6	22.8	21.8	20.6	19.0	18.6	19.2	18.8	19.3				
Bakersfield-California	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
Bakersfield-Planz		21.5	20.7	19.6	18.4	18.9	20.3	21.5	22.6	21.2	18.2	15.6	17.3

Notes for Tables A-3, A-4, A-5, and A-6

- Source: U.S. Environmental Protection Agency: Air Quality System (AQS): AMP 480 Report, available at http://www.epa.gov/ttn/airs/airsaqs/aqsweb/, January 6, 2015.
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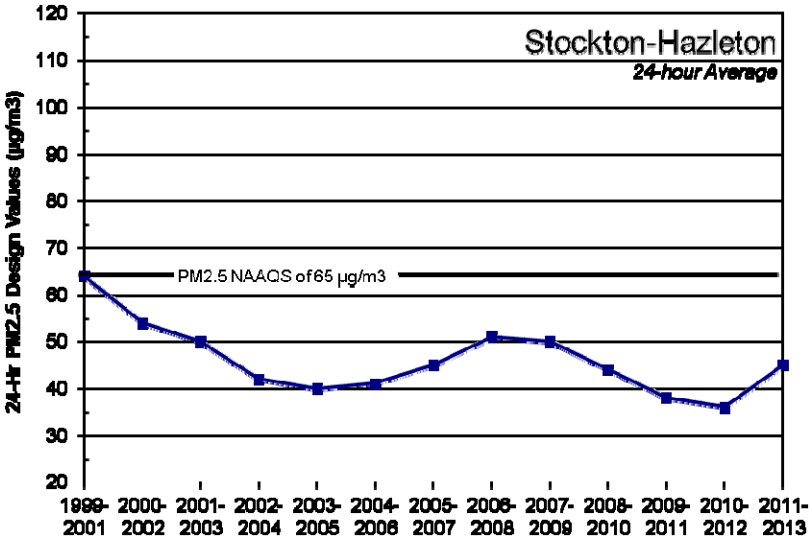
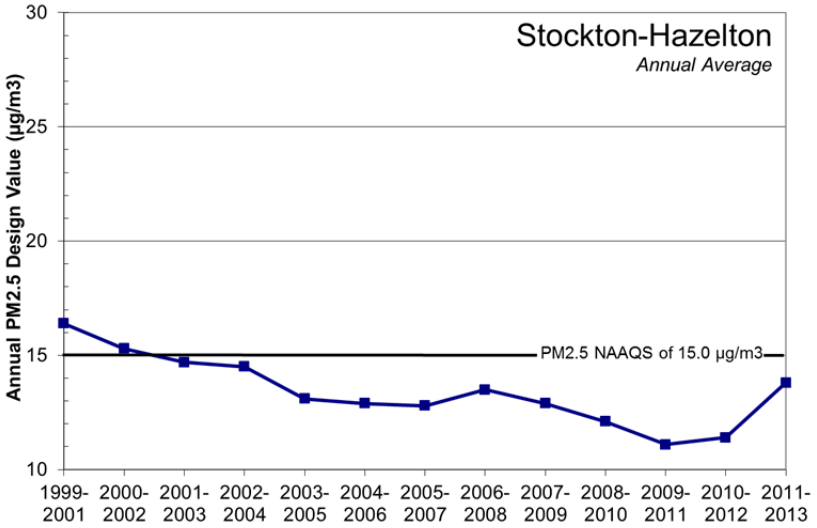
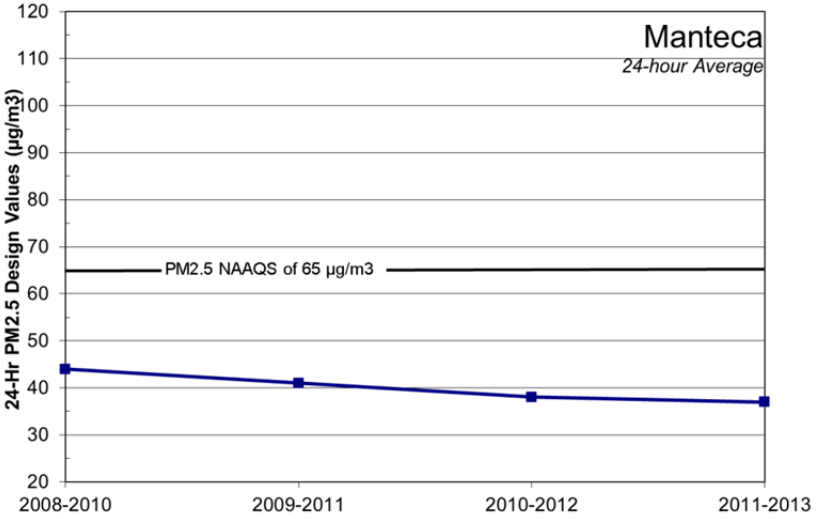
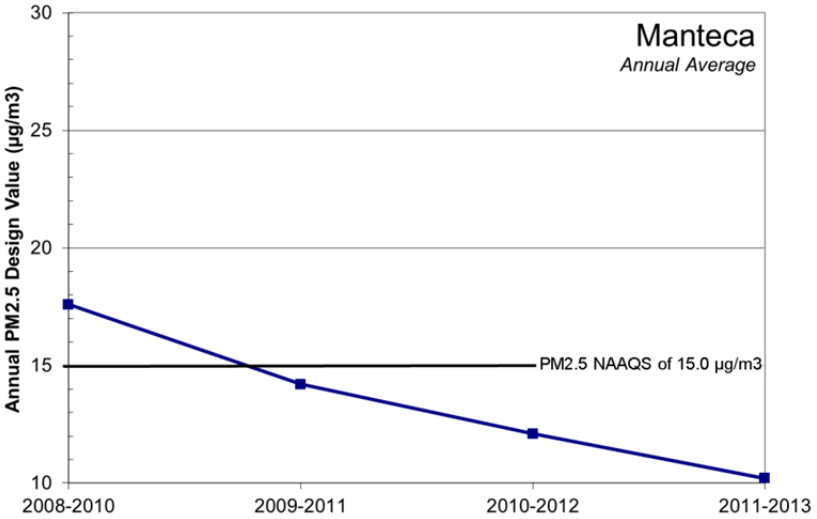
- Asterisk (*): Values do not meet completeness criteria
- Double asterisk (**): Value based on 2-year average of 2010-2011, 2009 had minimal sampling, Value based on 2-year average of 2011-2012, 2010 had minimal sampling
- Triple asterisk (***): Value based on 2-year average of 2012-2013

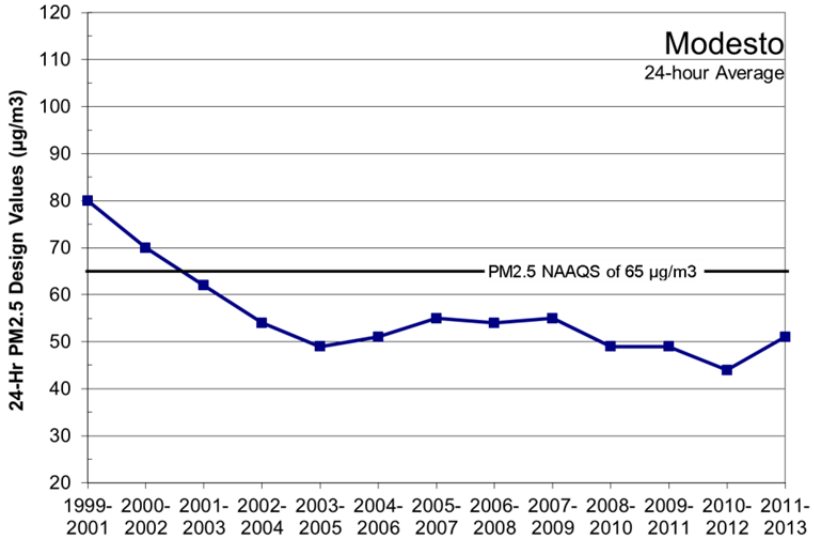
Figures A-2.1 through A-2.32 24-hour and Annual Design Value Trends

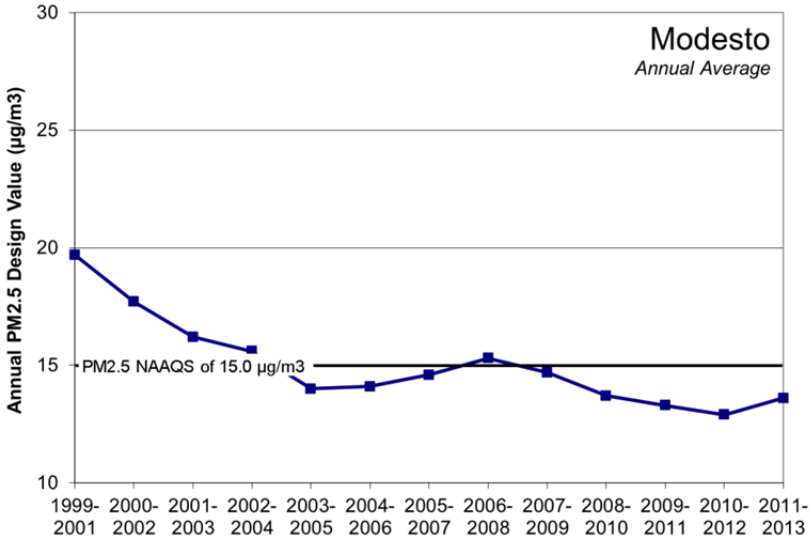


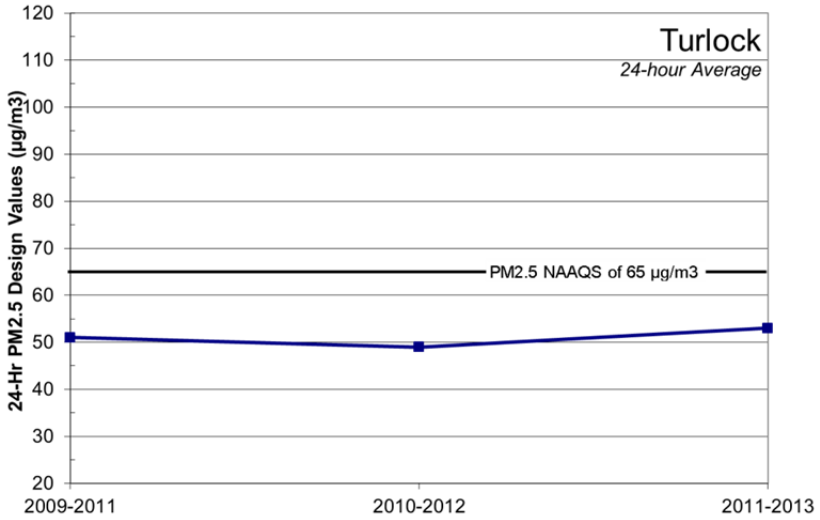


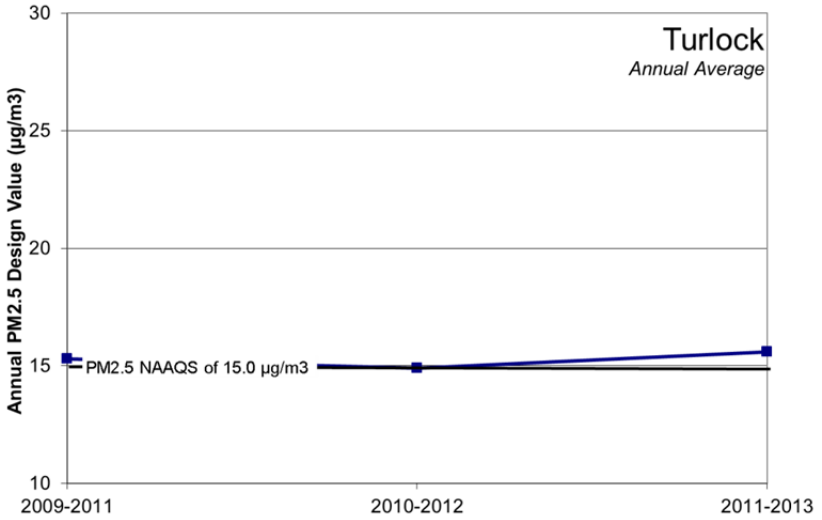





Modesto
24-hour Average
24-Hr PM2.5 Design Values (µg/m3)
PM2.5 NAAQS of 65 µg/m3
120
110
100
90
80
70
60
50
40
30
20
1999-2001
2000-2002
2001-2003
2002-2004
2003-2005
2004-2006
2005-2007
2006-2008
2007-2009
2008-2010
2009-2011
2010-2012
2011-2013


Modesto
Annual Average
Annual PM2.5 Design Value (µg/m3)
PM2.5 NAAQS of 15.0 µg/m3
30
25
20
15
10
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


Turlock
24-hour Average
24-Hr PM2.5 Design Values (µg/m3)
PM2.5 NAAQS of 65 µg/m3
120
110
100
90
80
70
60
50
40
30
20
2009-2011
2010-2012
2011-2013


Turlock
Annual Average
Annual PM2.5 Design Value (µg/m3)
PM2.5 NAAQS of 15.0 µg/m3
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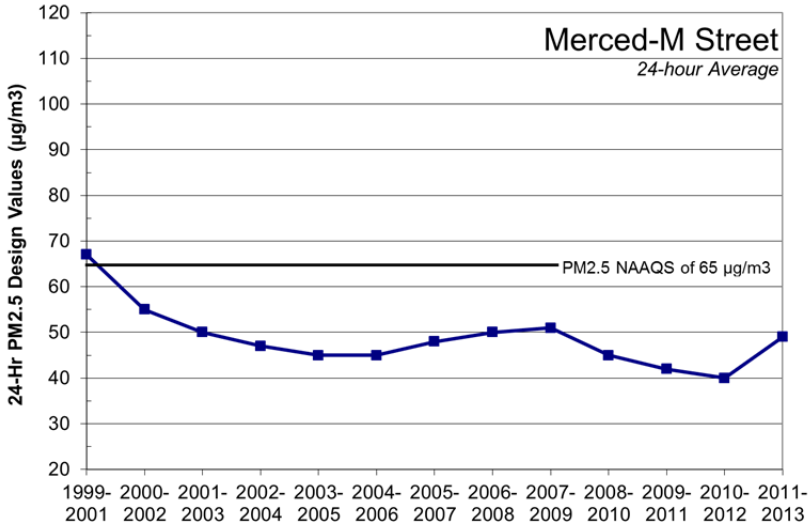
2009-2011
2010-2012
2011-2013


Merced-M Street
24-hour Average
24-Hr PM2.5 Design Values (µg/m3)
PM2.5 NAAQS of 65 µg/m3
120
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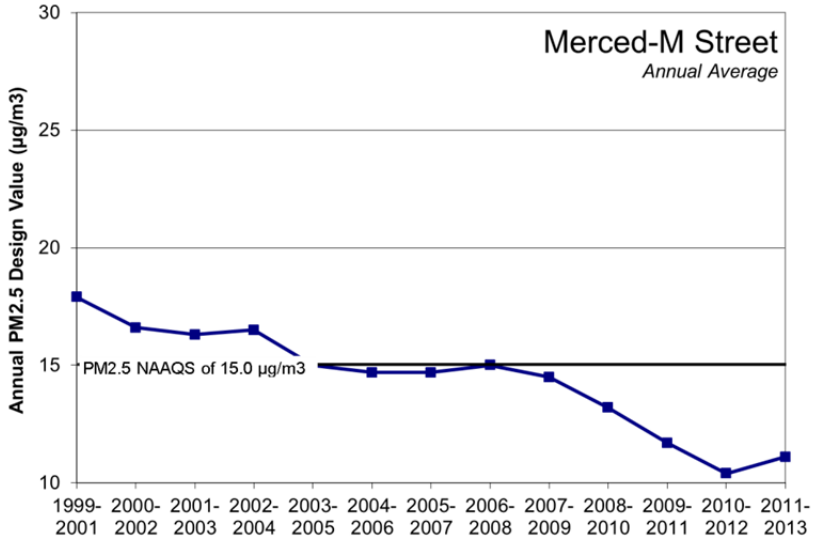
Merced-M Street
Annual Average
Annual PM2.5 Design Value (µg/m3)
PM2.5 NAAQS of 15.0 µg/m3
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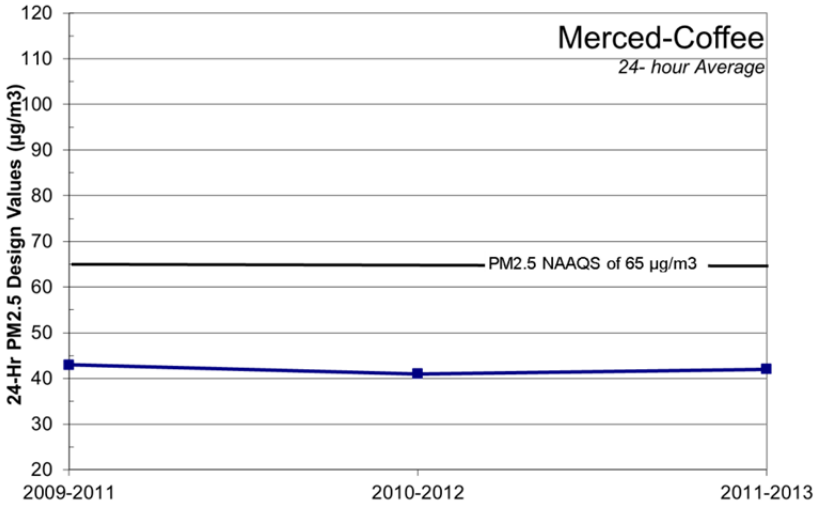
Merced-Coffee
24- hour Average
24-Hr PM2.5 Design Values (µg/m3)
PM2.5 NAAQS of 65 µg/m3
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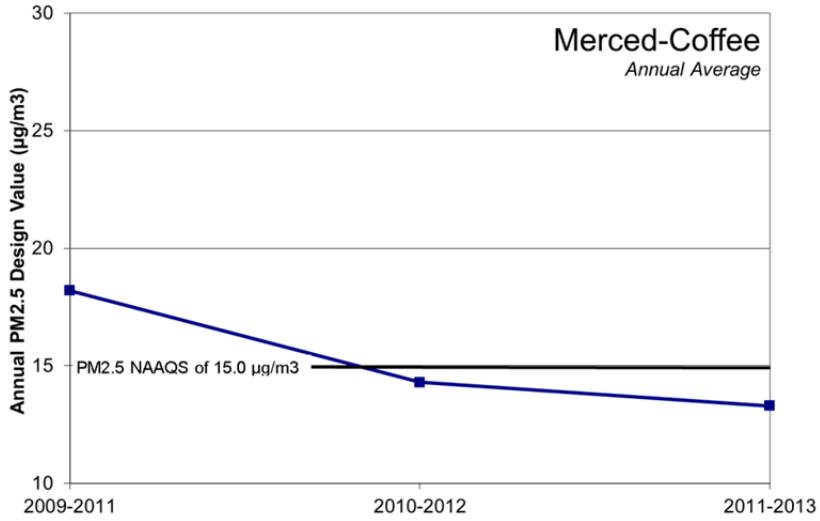
2011-2013


Merced-Coffee
Annual Average
Annual PM2.5 Design Value (µg/m3)
PM2.5 NAAQS of 15.0 µg/m3
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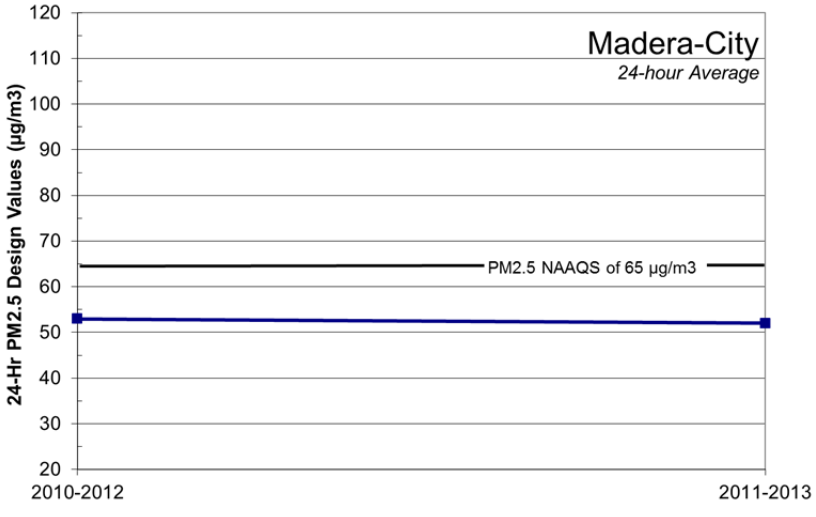
2011-2013


Madera-City
24-hour Average
24-Hr PM2.5 Design Values (µg/m3)
PM2.5 NAAQS of 65 µg/m3
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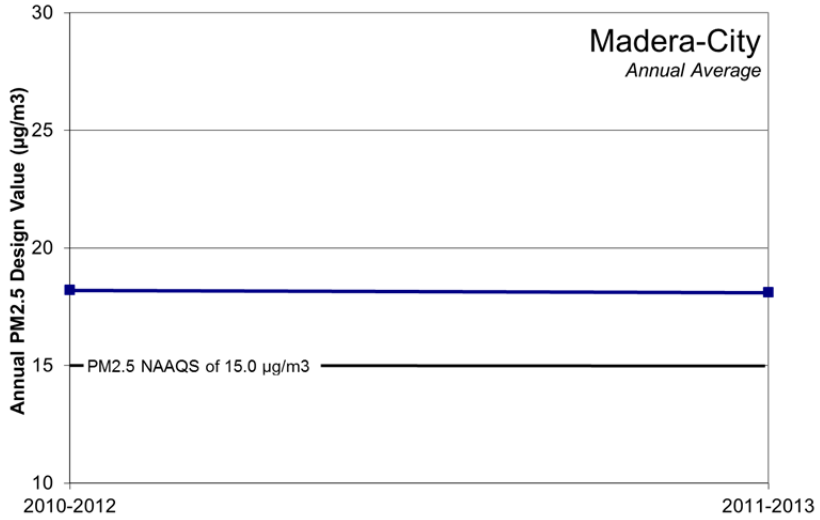
2010-2012
2011-2013


Madera-City
Annual Average
Annual PM2.5 Design Value (µg/m3)
PM2.5 NAAQS of 15.0 µg/m3
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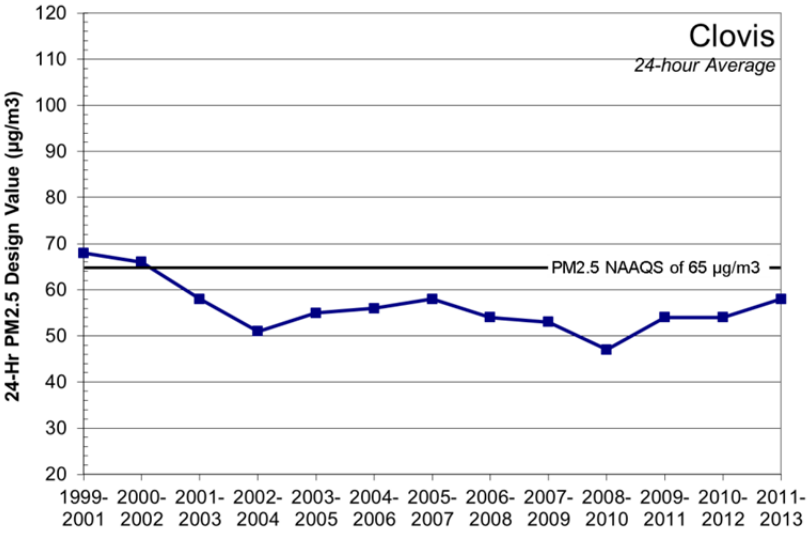
Clovis
24-hour Average
24-Hr PM2.5 Design Value (µg/m3)
PM2.5 NAAQS of 65 µg/m3
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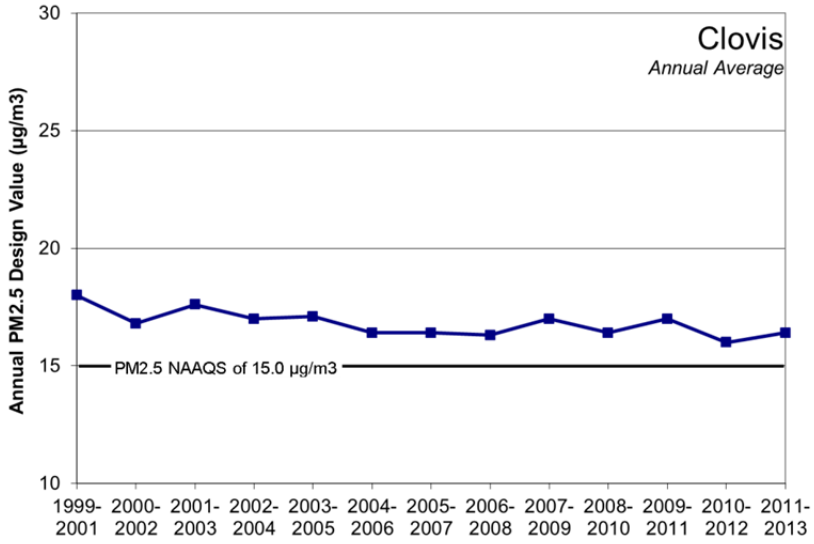
Clovis
Annual Average
Annual PM2.5 Design Value (µg/m3)
PM2.5 NAAQS of 15.0 µg/m3
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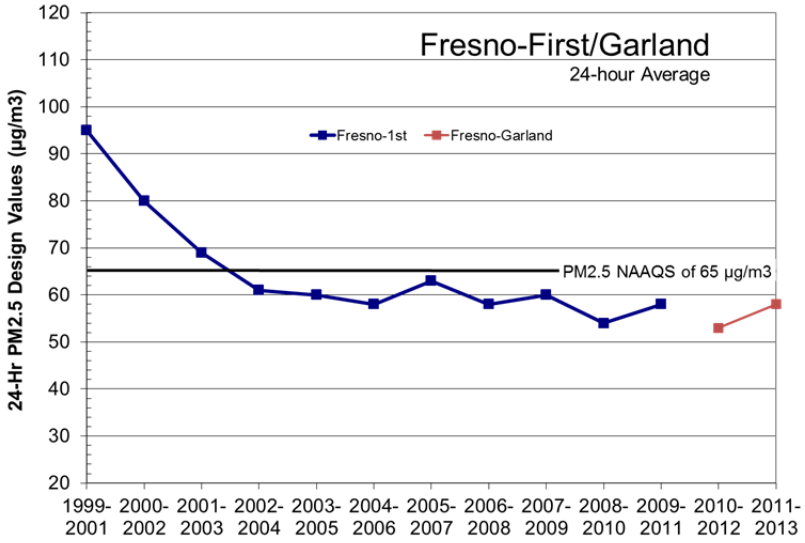
Fresno-First/Garland
24-hour Average
Fresno-1st
Fresno-Garland
PM2.5 NAAQS of 65 µg/m3
24-Hr PM2.5 Design Values (µg/m3)
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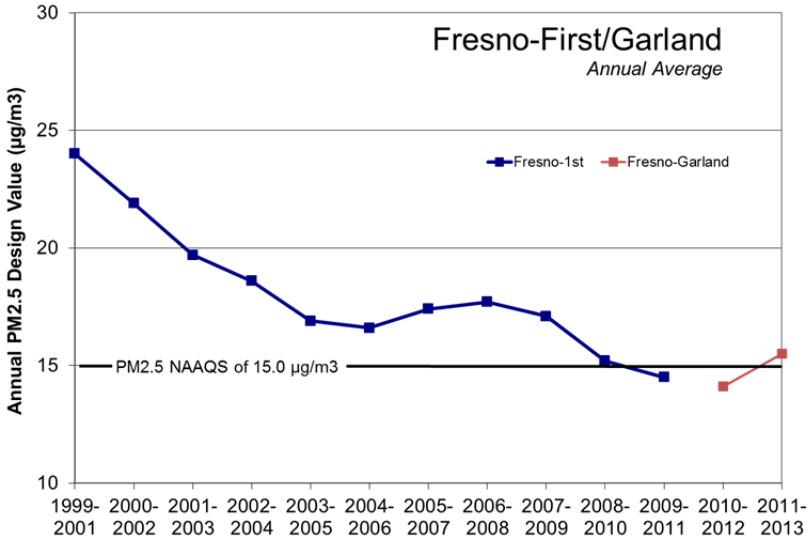
Fresno-First/Garland
Annual Average
Fresno-1st
Fresno-Garland
PM2.5 NAAQS of 15.0 µg/m3
Annual PM2.5 Design Value (µg/m3)
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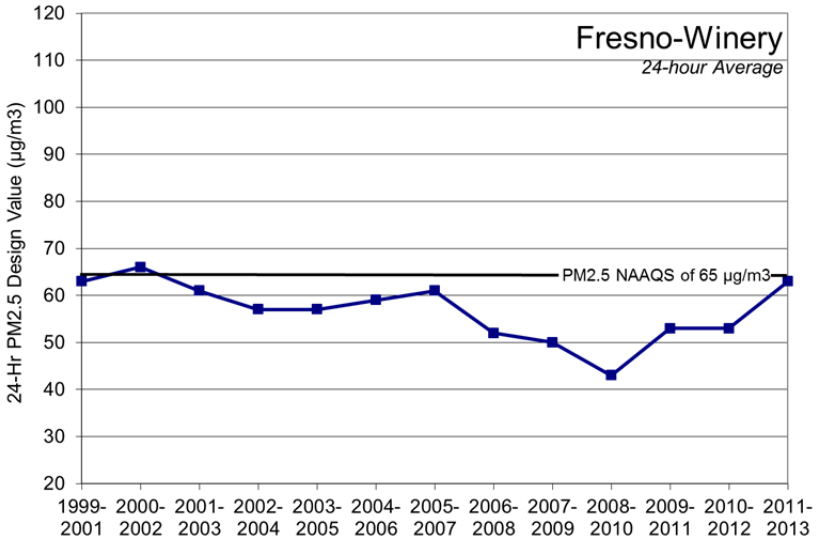
Fresno-Winery
24-hour Average
PM2.5 NAAQS of 65 µg/m3
24-Hr PM2.5 Design Value (µg/m3)
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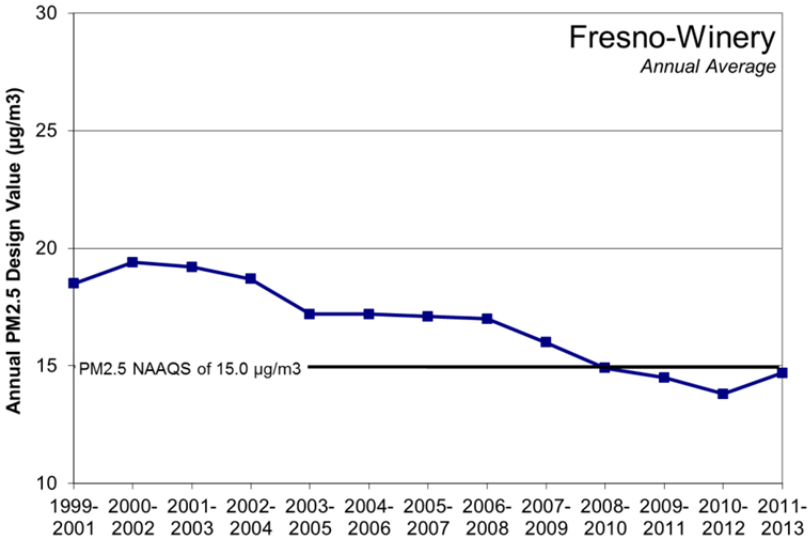
Fresno-Winery
Annual Average
PM2.5 NAAQS of 15.0 µg/m3
Annual PM2.5 Design Value (µg/m3)
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1999-2001
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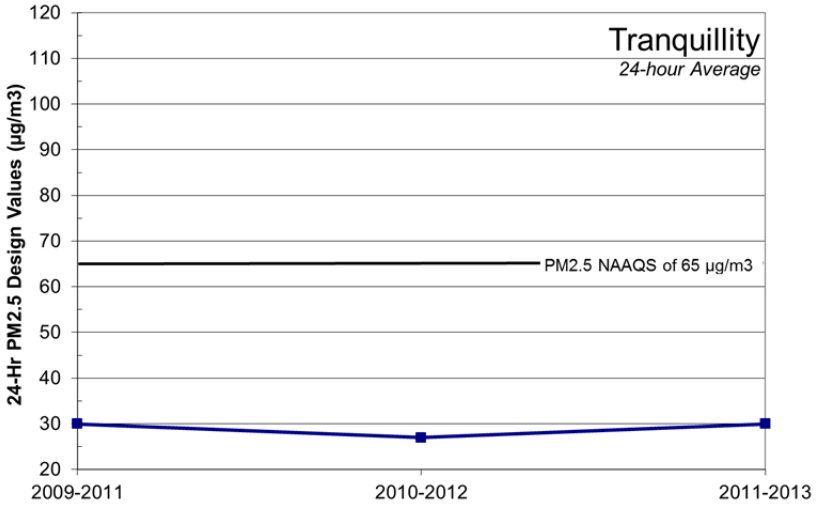
Tranquillity
24-hour Average
24-Hr PM2.5 Design Values (µg/m3)
PM2.5 NAAQS of 65 µg/m3
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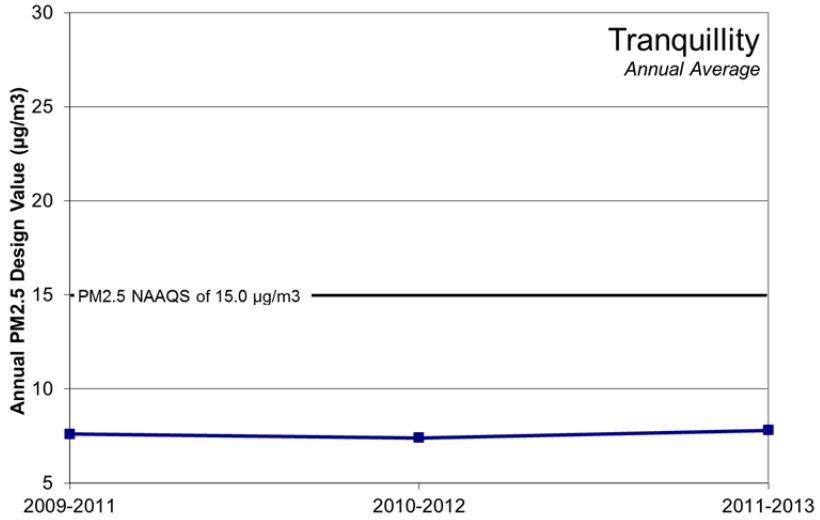
Tranquillity
Annual Average
Annual PM2.5 Design Value (µg/m3)
PM2.5 NAAQS of 15.0 µg/m3
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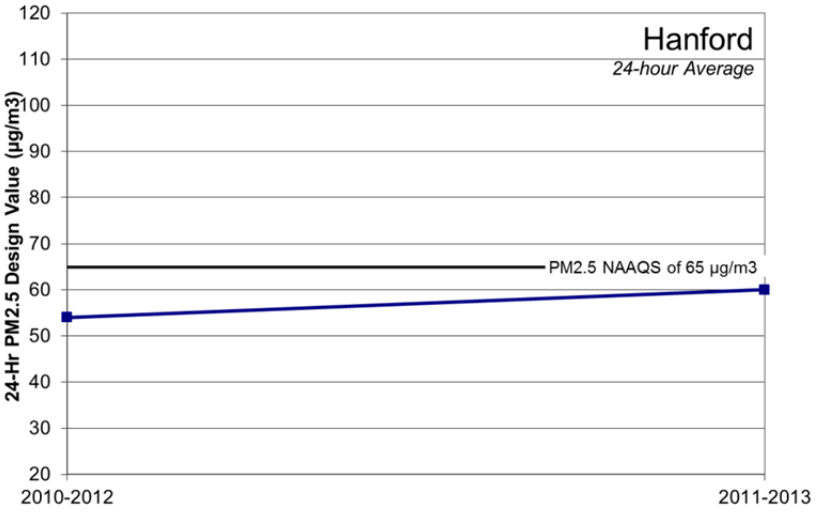
Hanford
24-hour Average
24-Hr PM2.5 Design Value (µg/m3)
PM2.5 NAAQS of 65 µg/m3
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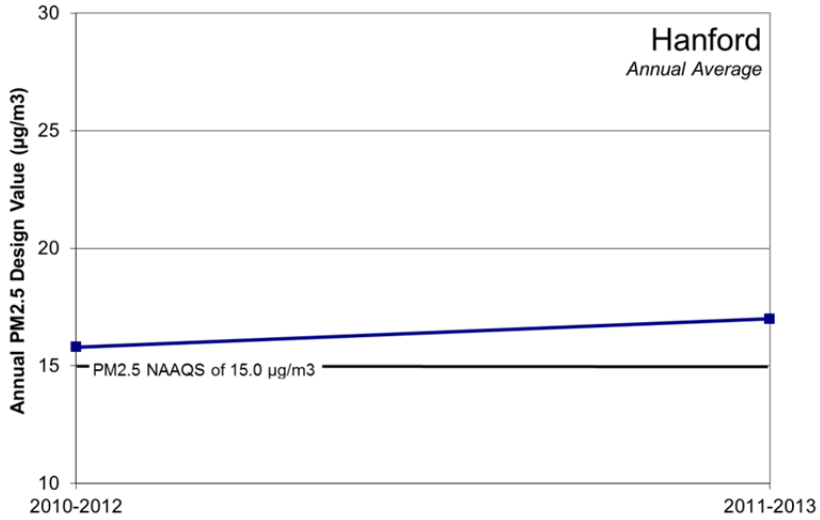
2010-2012
2011-2013


Hanford
Annual Average
Annual PM2.5 Design Value (µg/m3)
PM2.5 NAAQS of 15.0 µg/m3
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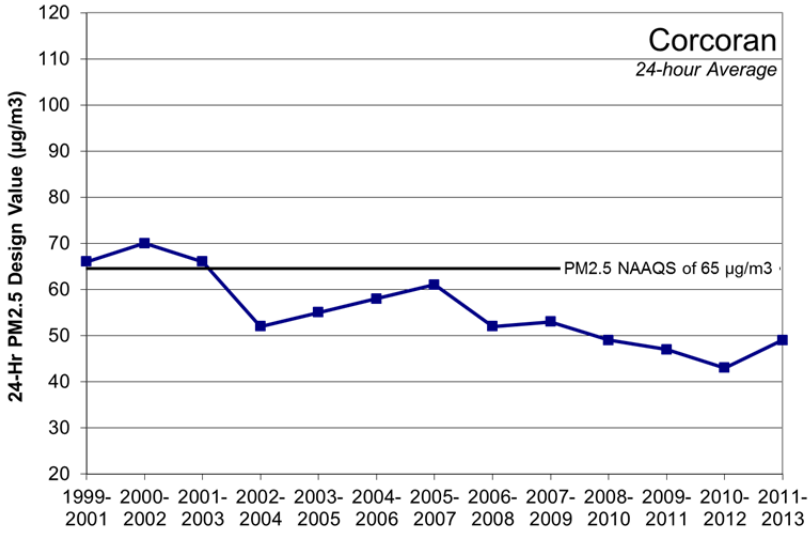
Corcoran
24-hour Average
24-Hr PM2.5 Design Value (µg/m3)
PM2.5 NAAQS of 65 µg/m3
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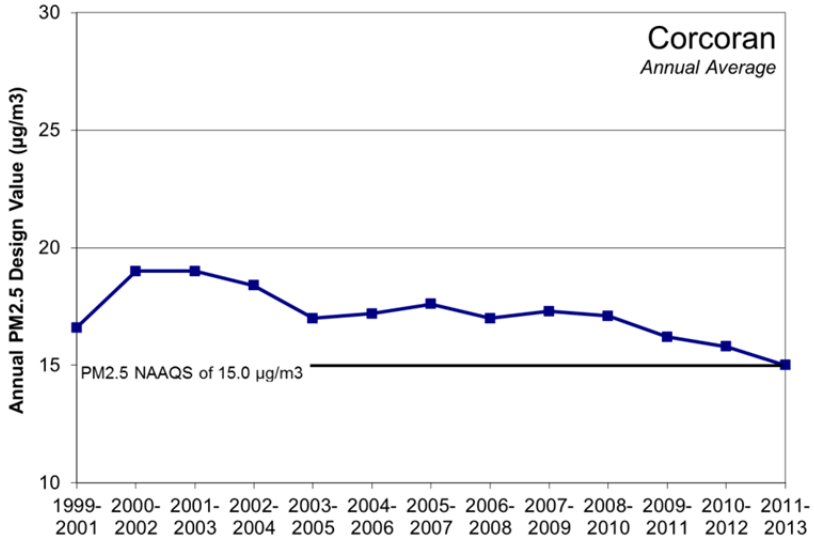
Corcoran
Annual Average
Annual PM2.5 Design Value (µg/m3)
PM2.5 NAAQS of 15.0 µg/m3
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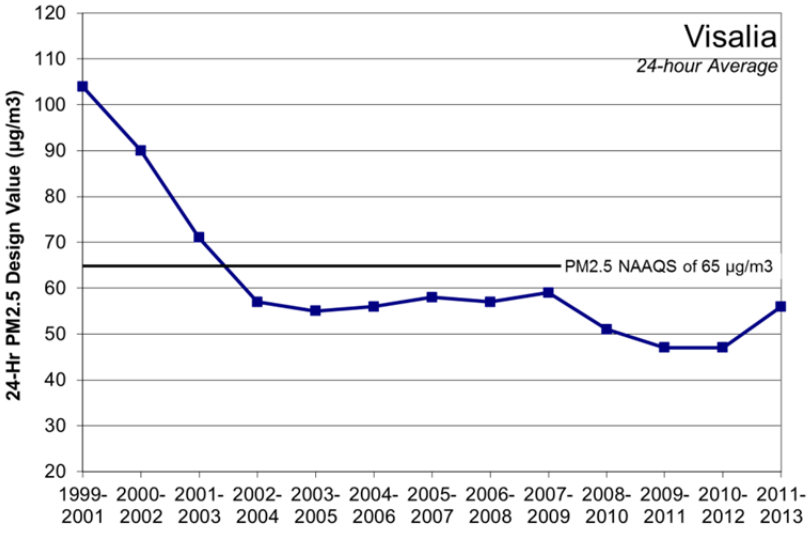
Visalia
24-hour Average
24-Hr PM2.5 Design Value (µg/m3)
PM2.5 NAAQS of 65 µg/m3
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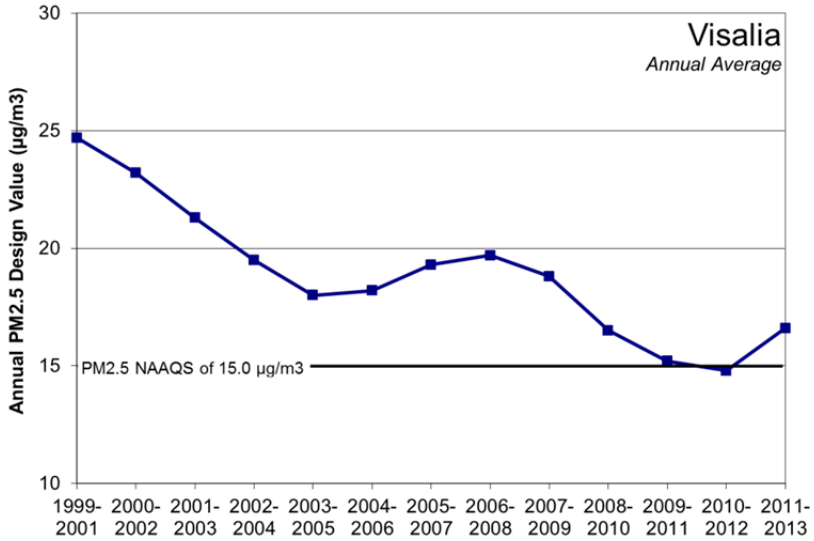
Visalia
Annual Average
Annual PM2.5 Design Value (µg/m3)
PM2.5 NAAQS of 15.0 µg/m3
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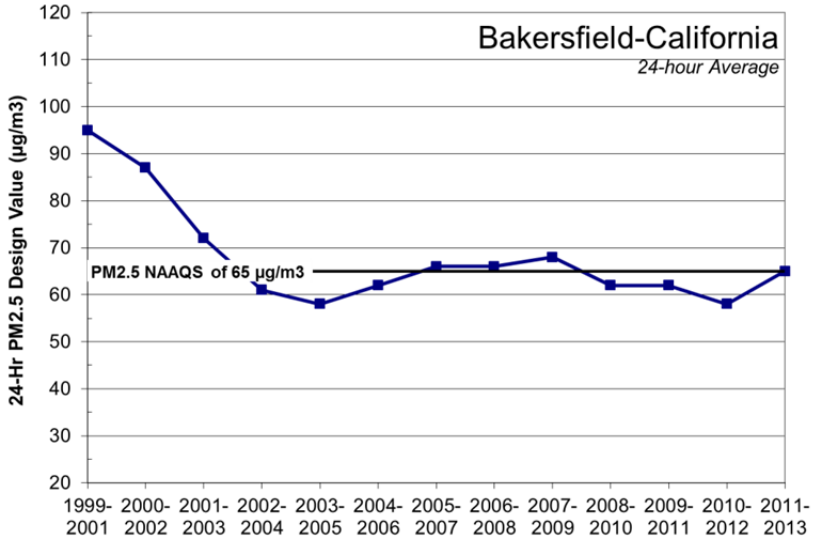
Bakersfield-California
24-hour Average
24-Hr PM2.5 Design Value (µg/m3)
PM2.5 NAAQS of 65 µg/m3
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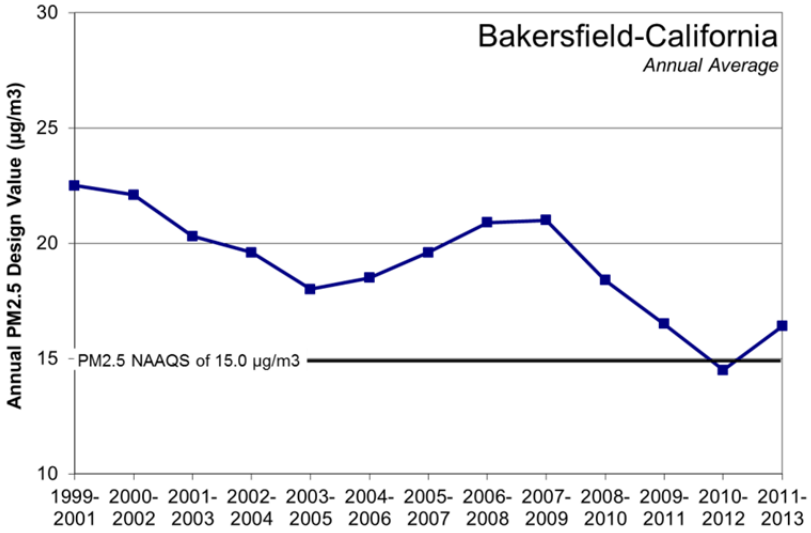
Bakersfield-California
Annual Average
Annual PM2.5 Design Value (µg/m3)
PM2.5 NAAQS of 15.0 µg/m3
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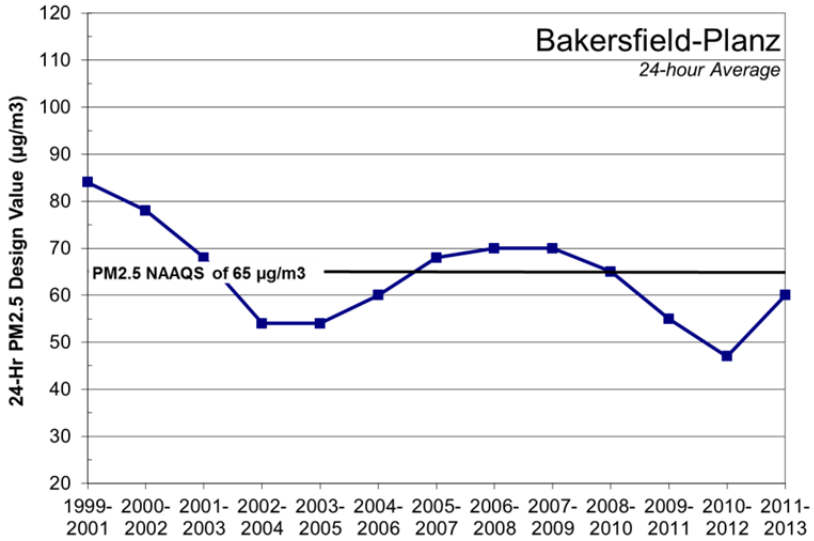
Bakersfield-Planz
24-hour Average
24-Hr PM2.5 Design Value (µg/m3)
PM2.5 NAAQS of 65 µg/m3
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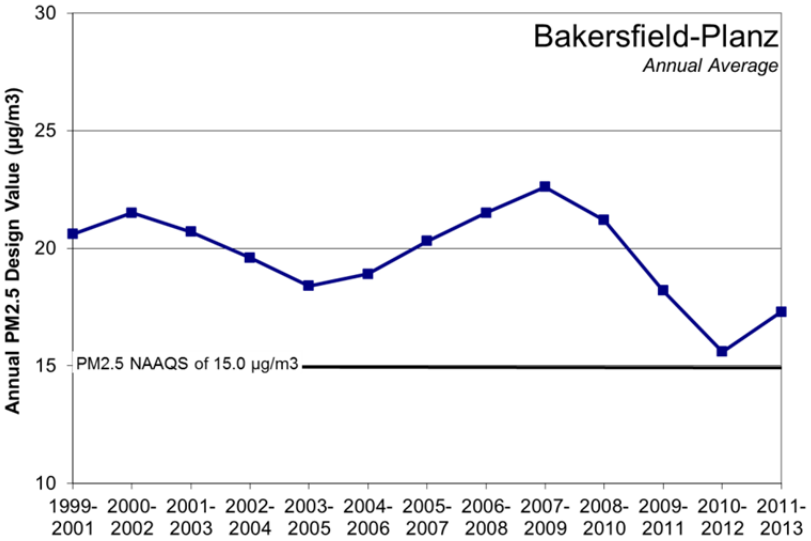
Bakersfield-Planz
Annual Average
Annual PM2.5 Design Value (µg/m3)
PM2.5 NAAQS of 15.0 µg/m3
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A.3 AMBIENT PM2.5 CONCENTRATION DATA TRENDS

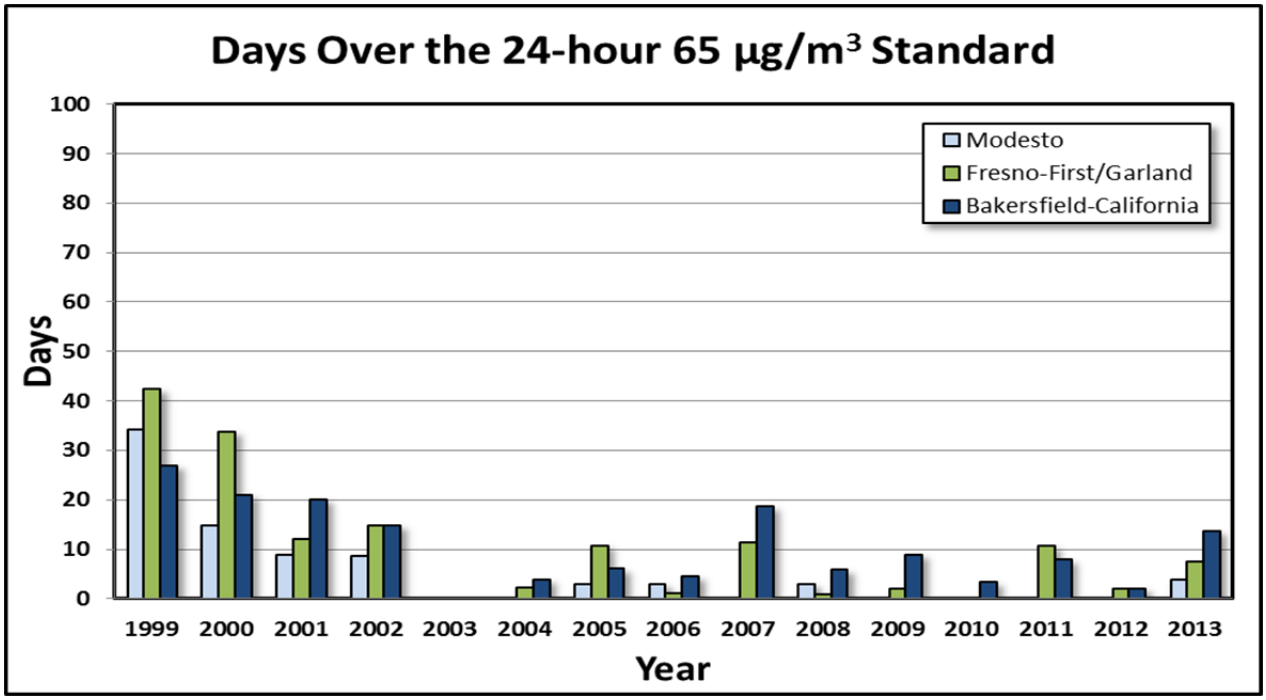
Design values summarize data from a monitoring site with just two concentration values representing a three-year time period: an annual average and a value representing 24-hour peaks. These parameters are required for attainment demonstrations, but design values alone do not reveal the hourly, daily, 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

The number of days over the PM2.5 Standard is another indicator of air quality progress. Focusing on historical air monitoring sites from the northern, central, and southern portions of the Valley, Figure A-3 shows the trend of the number of days above the 1997 standard at the Modesto, Fresno-First/Garland, and Bakersfield-California monitoring sites. 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.

Figure A-3 Trend in Days over the 1997 24-Hour PM2.5 Standard



Note: Years and sites with no data (colored bars) represent zero exceedances.

As shown in Figure A-3, the Valley has experienced a significant drop in the number of exceedances of the 65 µg/m³ standard since the turn of the last century (1999 and 2000). In 1999, approximately 104 exceedances of this standard occurred between the sites of Modesto, Fresno-First/Garland, and Bakersfield-California. Comparing this to the 25 exceedances that occurred in 2013, this represents a 76% decrease in the number of violations among these sites.

The District's emissions reduction strategy, the investment from the regulated industry in control technology, and the public's willingness to make a change for cleaner air have all played key roles in the reduction of concentrations over this time period. During the winter, with unfavorable stagnant meteorology as experienced during the 2011–2012 winter season, which has repeated itself each winter since and has created (as of 2014) the historic three year drought, has contributed greatly to the recent higher than expected PM2.5 concentrations and exceedances under identical regulatory controls. Similar poor dispersion conditions were experienced during the winter of 1999–2000; however, under those similar conditions, the number of exceedances in 2011 and onward has been markedly less than the number of exceedances in 1999, which strongly suggests a real reduction in emissions.

A.3.2 Seasonal Trends - 1st and 4th Quarter Averages

Since the Valley's highest PM2.5 concentrations occur during the fall and winter months, in the 1st and 4th quarters (January through March and October through December, respectively), these months tend to have the highest average PM2.5 concentrations. Observing the trend in these quarterly averages can shed light on how the peak of the PM2.5 season is changing over time.

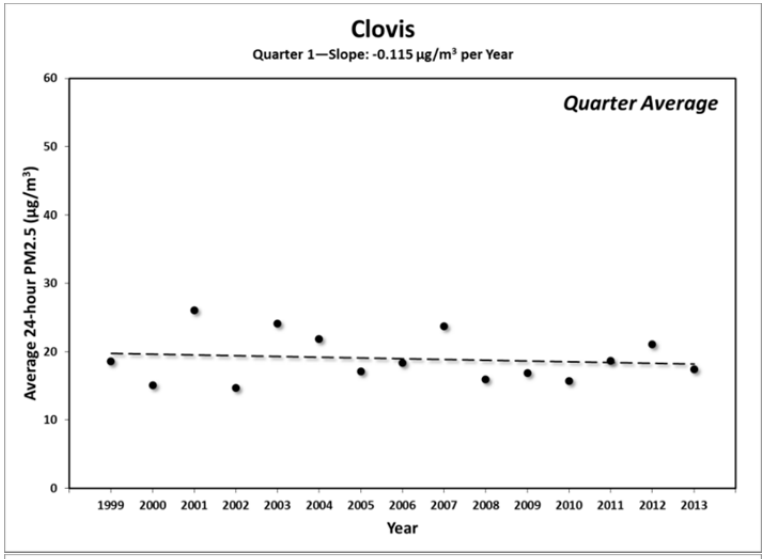
The data used in this analysis utilizes PM2.5 filter values from 1999 through 2013 focusing on the 1st and 4th quarters at six sites in the District that tend to have the highest concentrations; Clovis, Fresno-First/Garland, Corcoran, Visalia, Bakersfield-California, and Bakersfield-Planz. Note that the Fresno-First monitoring site was closed in early 2012 and its nearby replacement site of Fresno-Garland was opened soon after. To form a continuous data record, these two sites were combined to create a Fresno-First/Garland historical record.

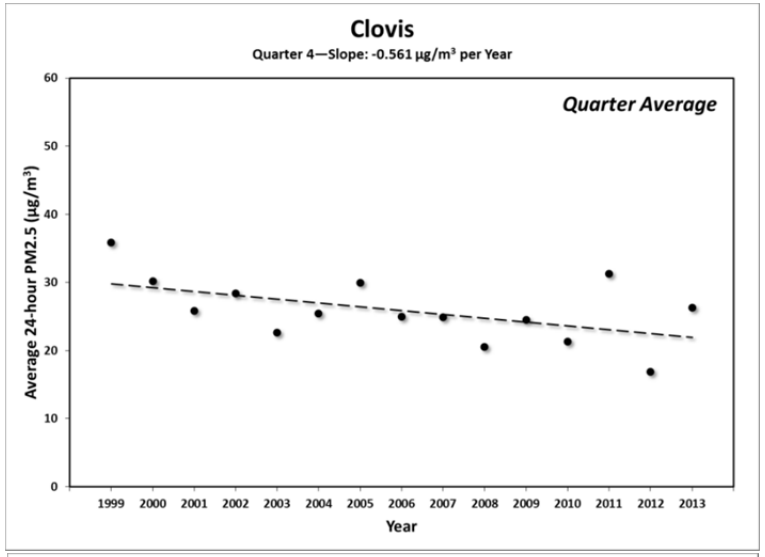
An analysis of the 24-hour PM2.5 historical filter data depicts a general trend of reductions in both the average over the quarter (*Quarter Average*), as well as the average over the quarter of the five highest (maximum) values (*Top 5 Average*). The *Top 5 Average* data demonstrates the episodic nature of PM2.5 pollution, the severity of peak PM2.5 episodes, and the public exposure to peak concentrations of PM2.5. The *Quarter Average* charts shown below (Figures A-4.1 through A-4.12) indicate that all sites are trending downward; averaging 0.8 µg/m³ less PM2.5 per year, collectively. In regards to the *Top 5 Average* (Figures A-5.1 through A-5.12) all but one site are trending downward. Clovis is the anomaly showing a slight upward trend. However, this may be due to random variation of the data resulting in the unusually high values in the first quarter of 2012 and the fourth quarter of 2011 and 2013 that pulls both quarter trend lines upward. Without those three data points the trend line would be flat, and not significantly increasing or decreasing. Despite Clovis, the overall trend for all of the *Top 5 Average* sites is averaging downward at 1.4 µg/m³ less PM2.5 per year. This demonstrates the reducing severity of the PM2.5 episodic peaks over time.

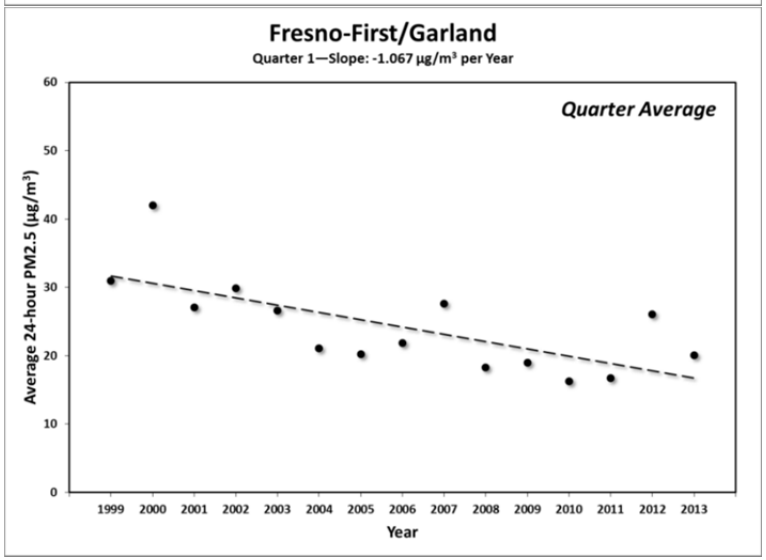
The *Quarter Average* with the greatest rate of reduction in PM2.5 is almost unanimously in the fourth quarter and less so in the first quarter. Conversely, the quarter with the greatest rate of reduction in PM2.5 for the *Top 5 Average* is almost unanimously in the first quarter and less so in the fourth quarter (except for Clovis).

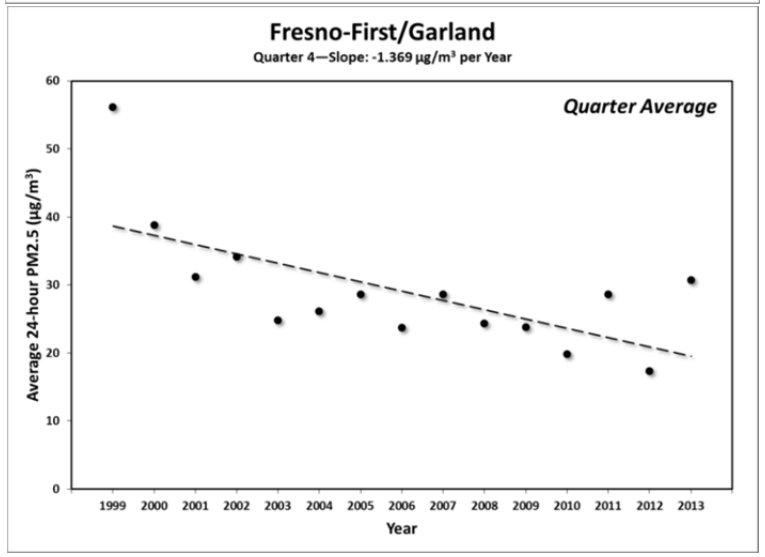
In conclusion, the overall quarterly downward trends of both the *Quarter Averages* and the *Top 5 Averages* are important indicators for attaining the District's Health-Risk Reduction Strategy and the annual average PM2.5 standard.

Figures A-4.1 through A-4.12 Quarter Average Trends

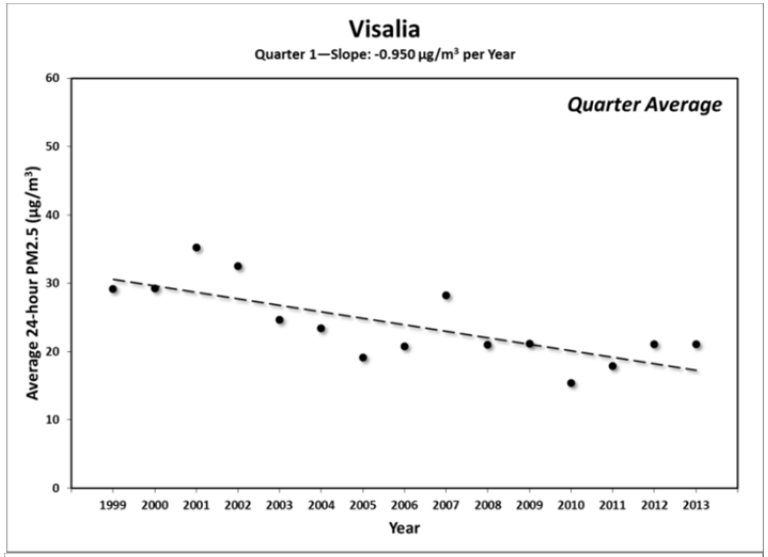


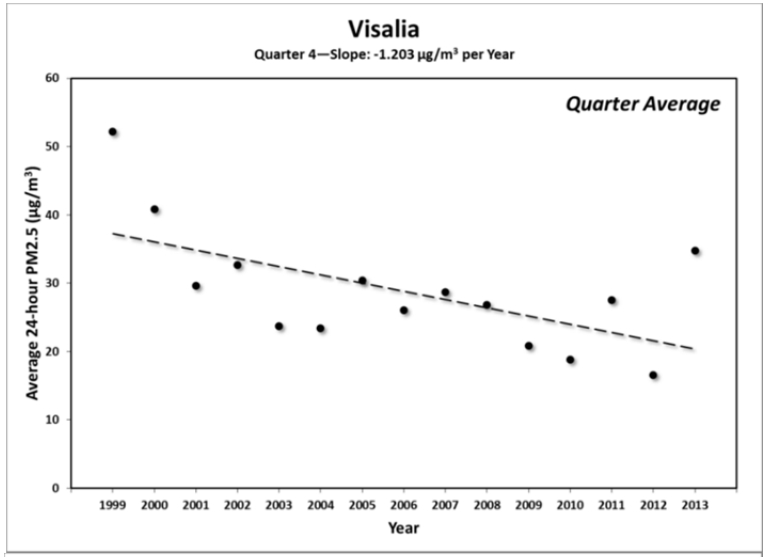


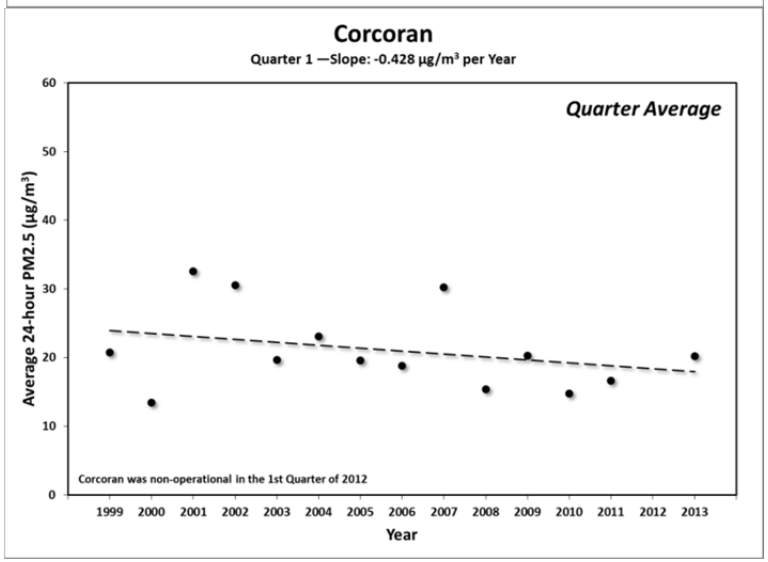


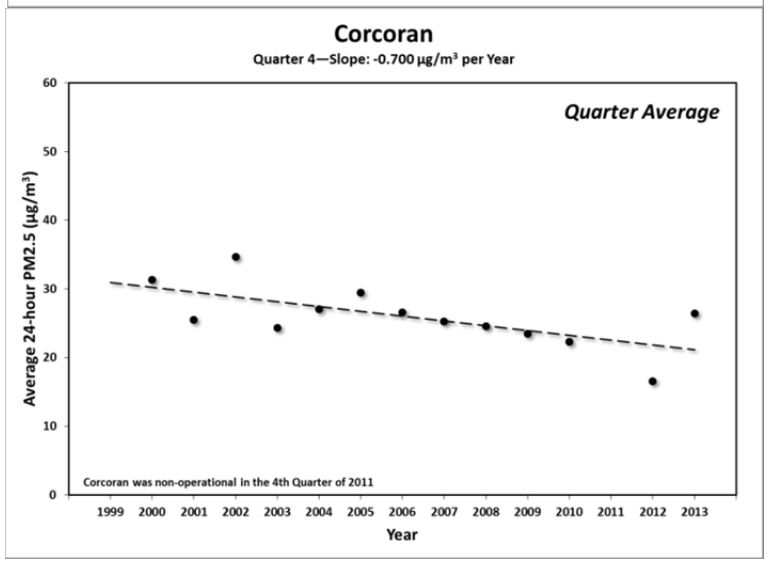


Figures A-4.1 through A-4.12 Quarter Average Trends

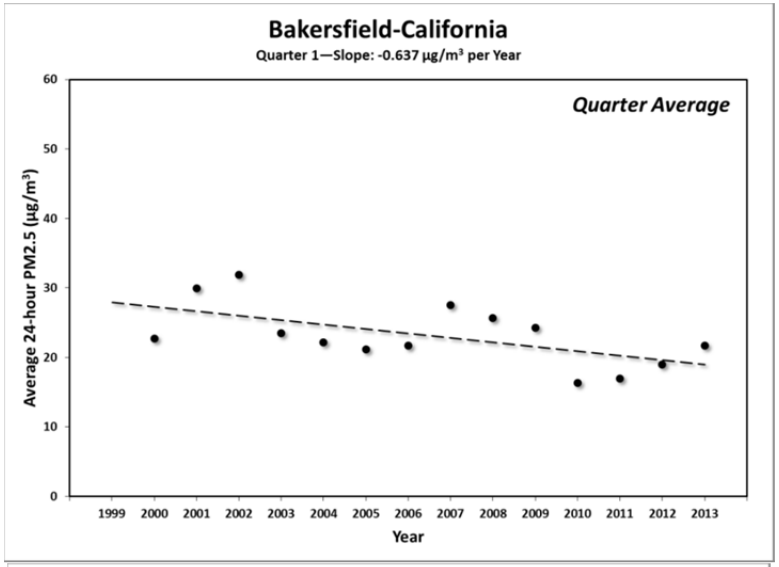


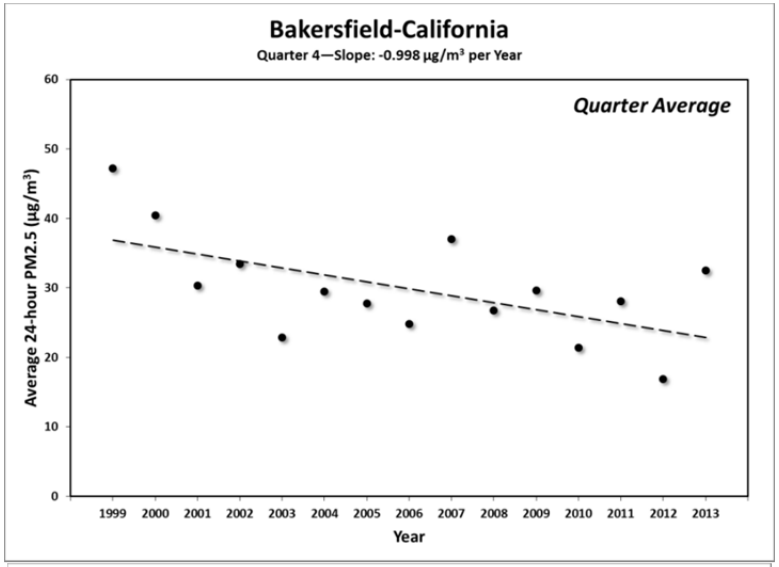


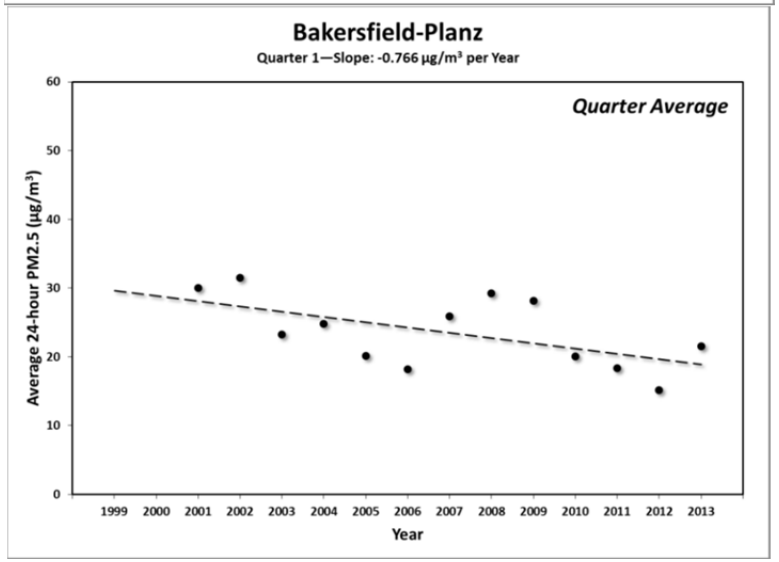


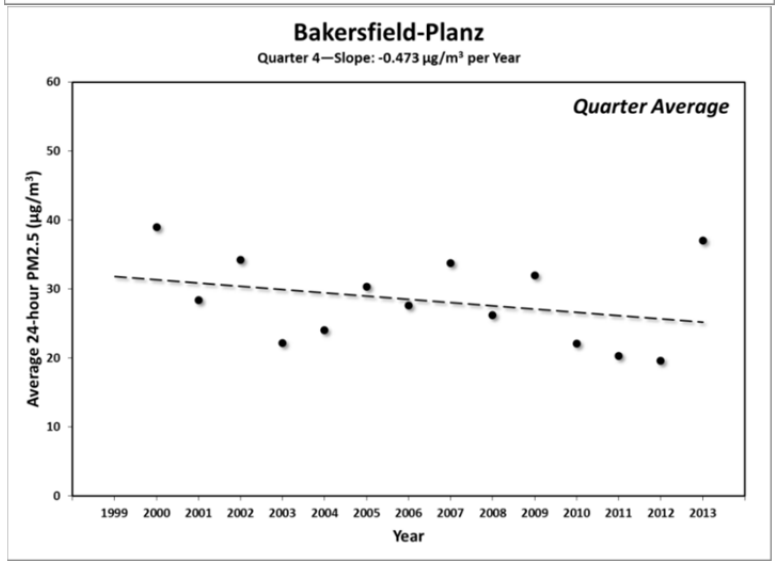


Figures A-4.1 through A-4.12 Quarter Average Trends

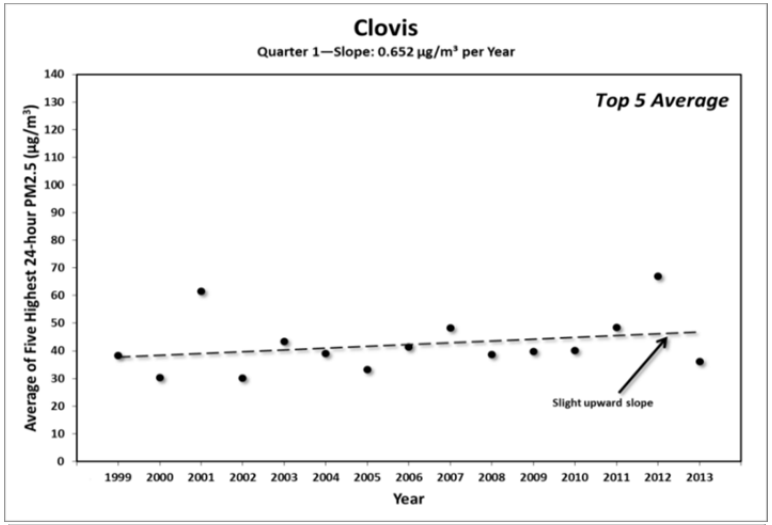


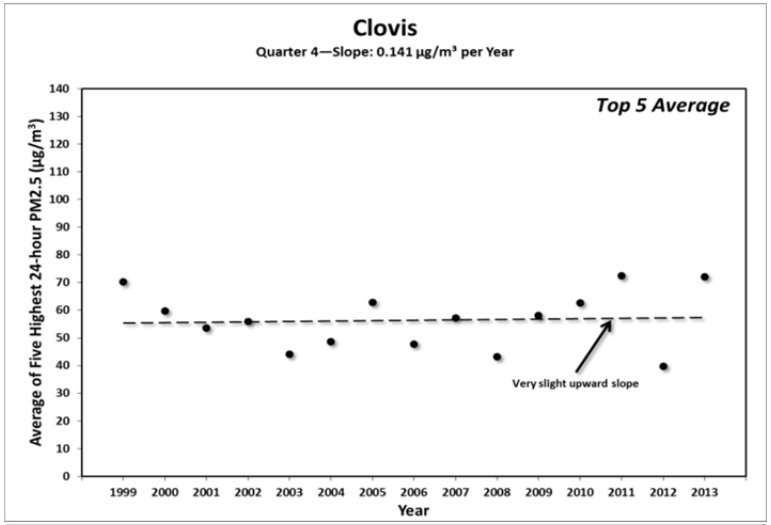


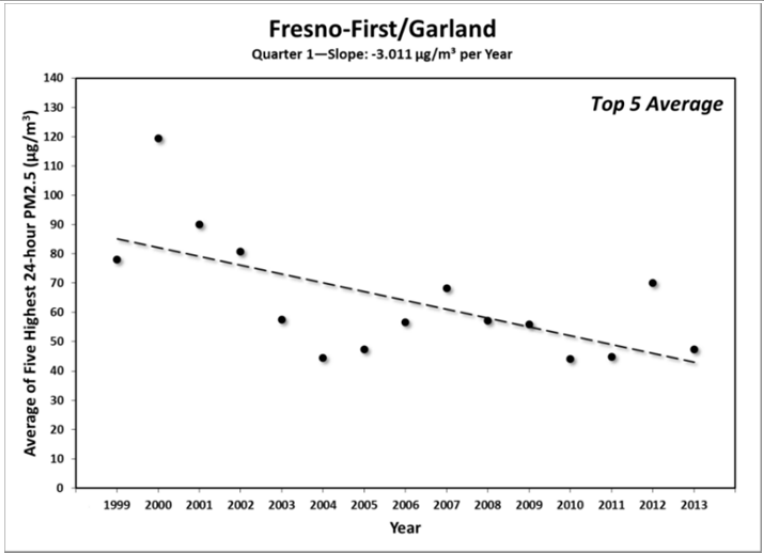


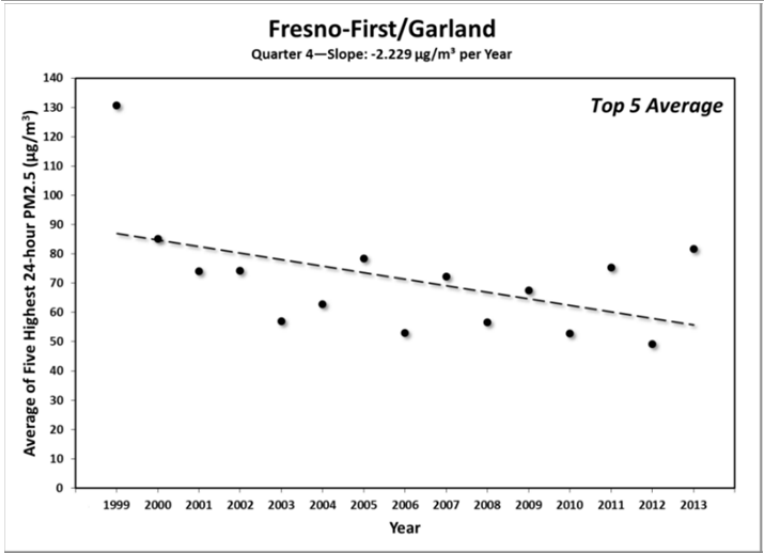


Figures A-5.1 through A-5.12 Collection of *Top 5 Average* Trends

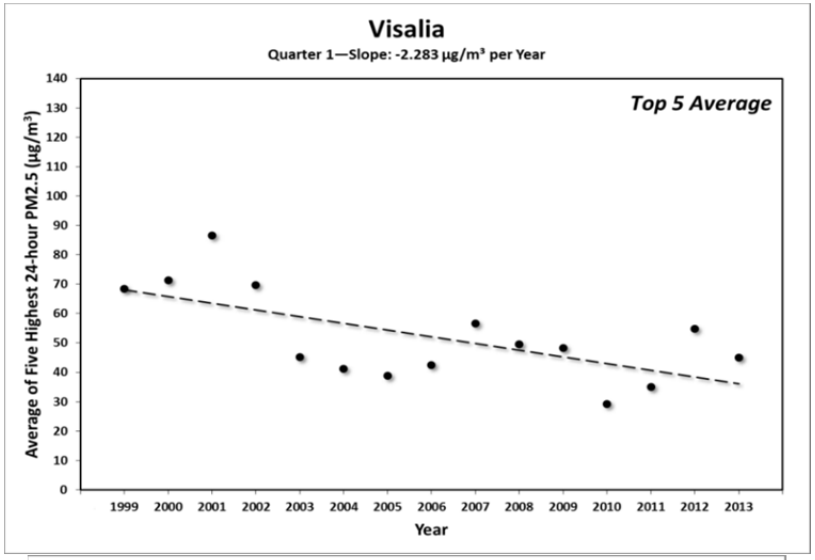


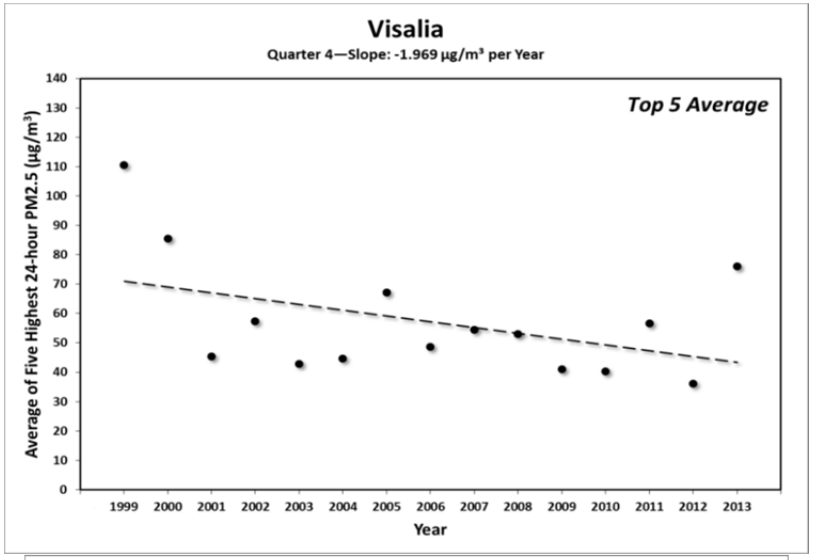


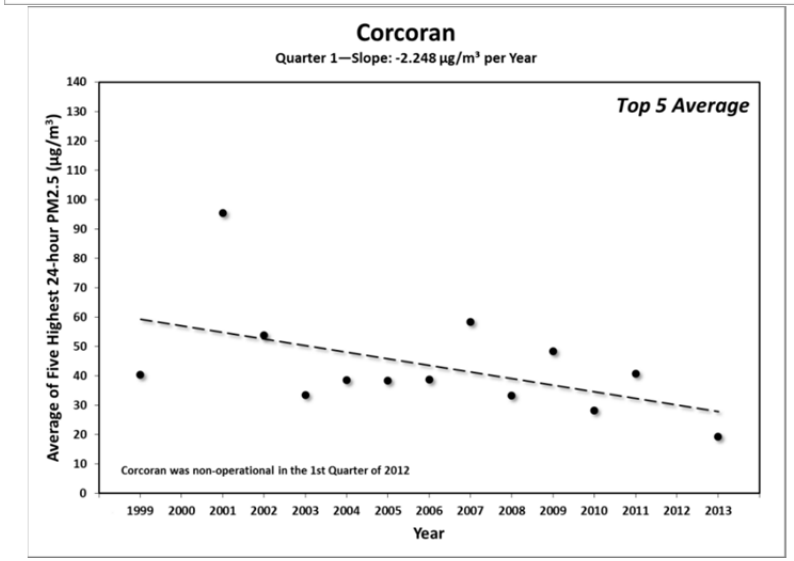


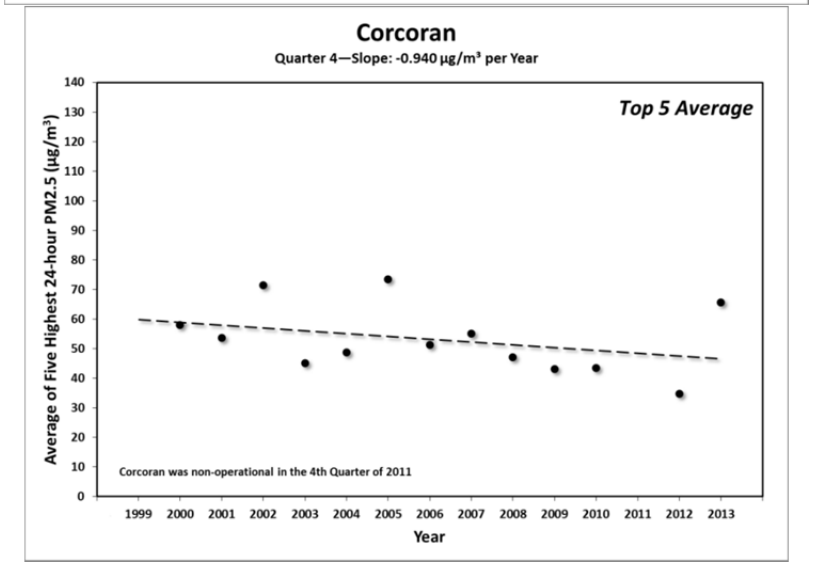


Figures A-5.1 through A-5.12 Collection of *Top 5 Average* Trends

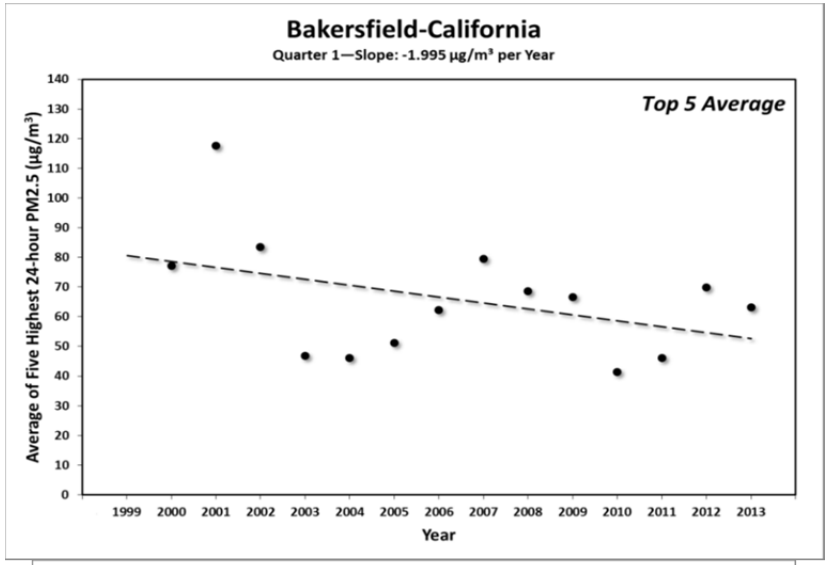


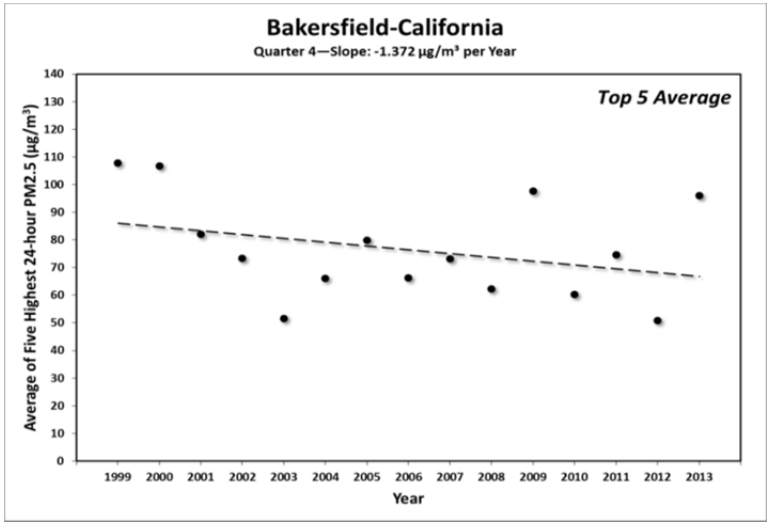


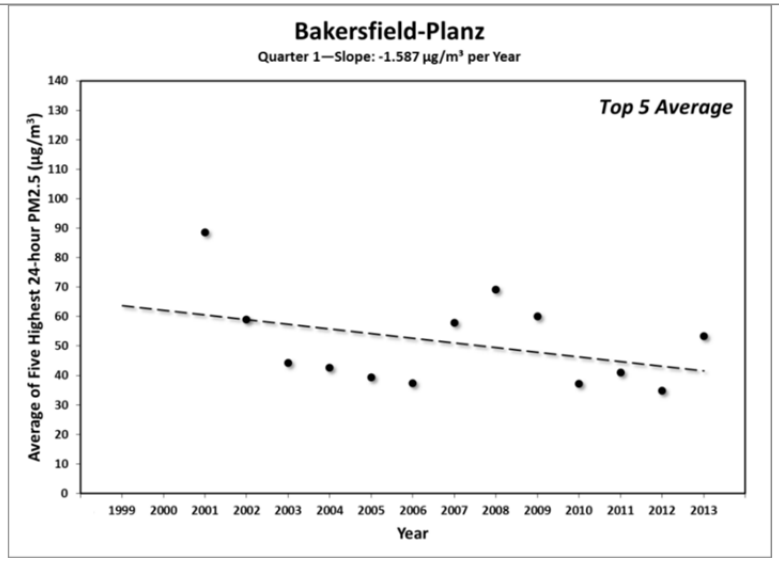


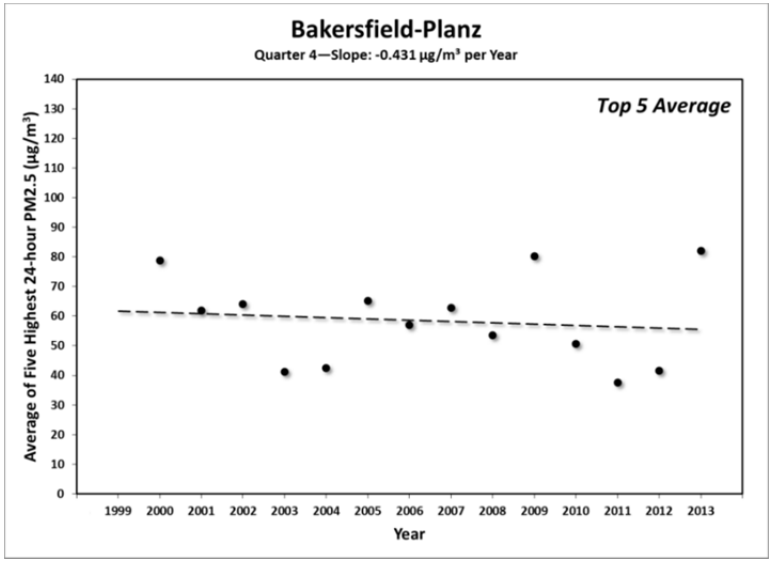


Figures A-5.1 through A-5.12 Collection of *Top 5 Average* Trends









A.3.3 Annual Trends

The District collects hourly PM2.5 concentration data using real-time monitors. The District uses this data every day to produce air quality forecasts, wood burning declarations, public health notifications, and Real-time Air Advisory Network (RAAN) notifications.

Based on historical hourly data, the District has compiled long-term diurnal profiles to evaluate how PM2.5 concentrations vary throughout the day at each of the Valley monitoring sites that measure PM2.5. An analysis of hourly measurements can show which portions of the day tend to have the highest and lowest concentrations. Understanding such profiles helps in the development of control strategies and programs that target activities during times of peak concentrations.

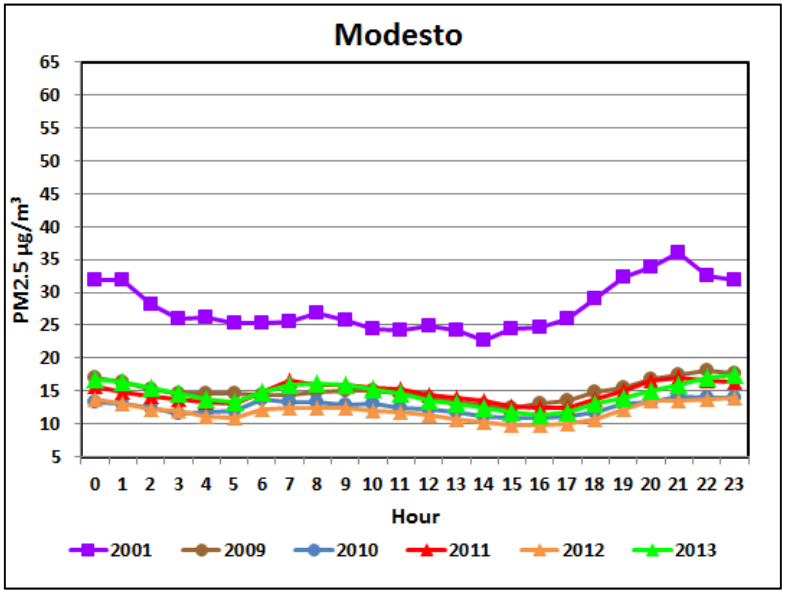
The long-term diurnal profiles can also indicate how the curve has changed from year to year. The District compares relative changes in hourly PM2.5 concentrations from year to year at each monitoring site to better understand the implications and effectiveness of PM2.5 control measures, especially Rule 4901 (Wood Burning Fireplaces and Wood Burning Heaters). Prior to 2003, Rule 4901 called for voluntary wood-burning curtailments. Such curtailments became mandatory beginning in the 2003–2004 winter season and have since been strengthened twice, once in 2008 and once again in 2014.

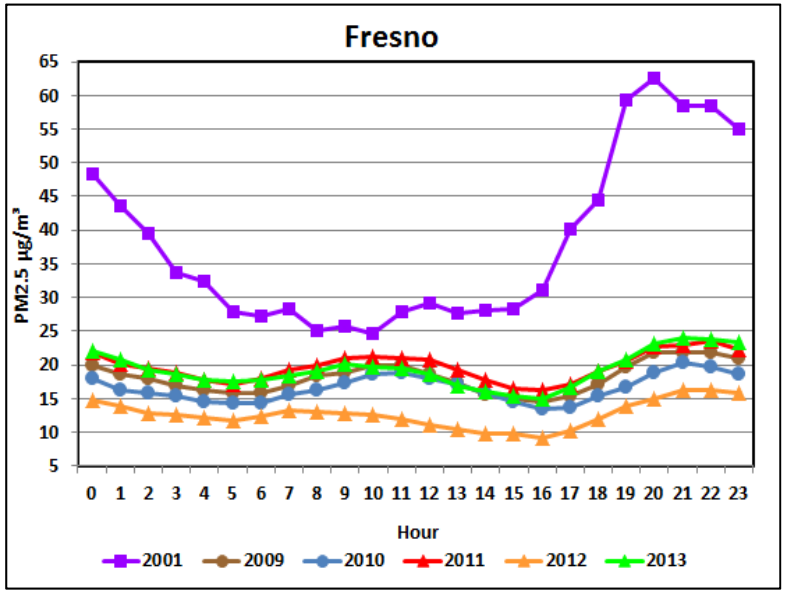
Prior to the 2008-2009 winter season, the Rule was amended to specify that wood-burning curtailments would be declared when a PM2.5 concentration of 30 $\mu g/m^3$ or higher was predicted for a county. Prior to the 2014-15 winter season, the threshold was lowered to 20 $\mu g/m^3$ or higher and contained a tiered system which effectively mitigates emissions from residential wood-burning by discouraging, limiting, or prohibiting wood burning in fireplaces and other non-EPA certified residential wood burning devices during the winter months.

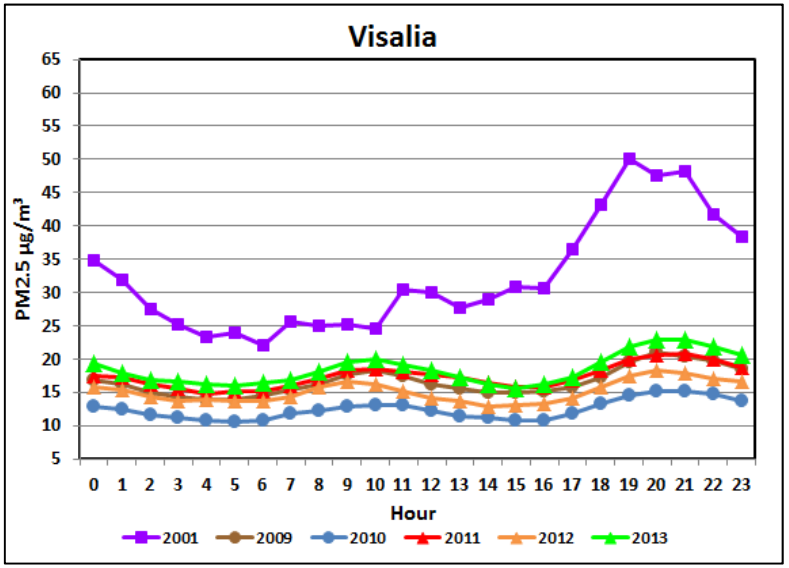
Figures A-6.1 through A-6.16 show a comparison of the yearly average diurnal profiles over time at select real-time monitoring sites within the District's monitoring network. As indicated in profiles A-8.1 through A-8.4, Modesto, Fresno[7], Visalia, and Bakersfield have a longer history of monitoring PM2.5 than the other sites and clearly illustrate that PM2.5 concentrations were much higher prior to the strengthening of Rule 4901.

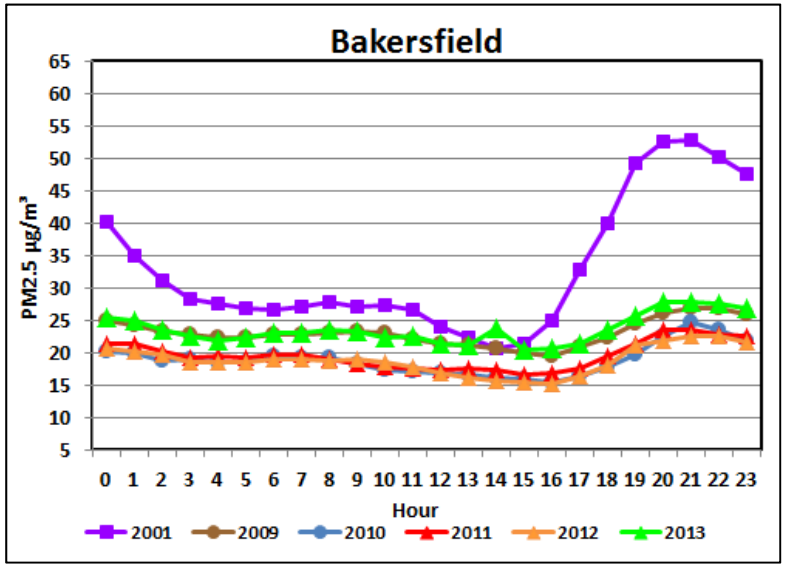
[7] The Fresno-First Street monitor was relocated one block north to Garland Avenue in 2011 and is now the Fresno-Garland site. The two sites are considered to be the same site so data from the Fresno-First Street and Fresno-Garland sites were combined and used to create the Fresno chart.

Figures A-6.1 through A-6.16 PM2.5 Diurnal Profiles

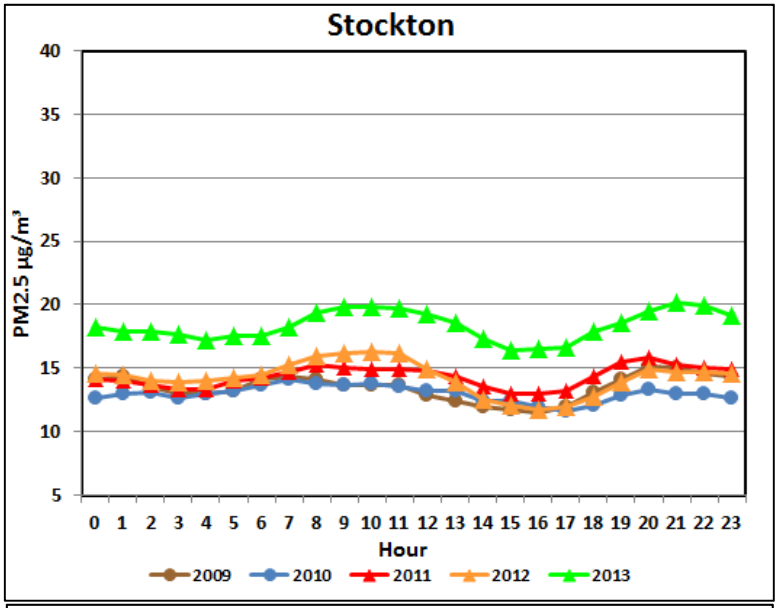


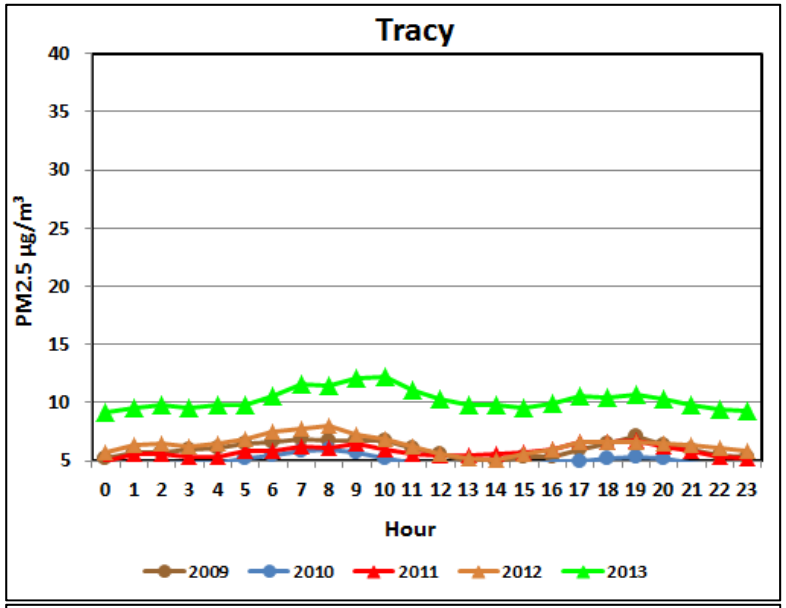


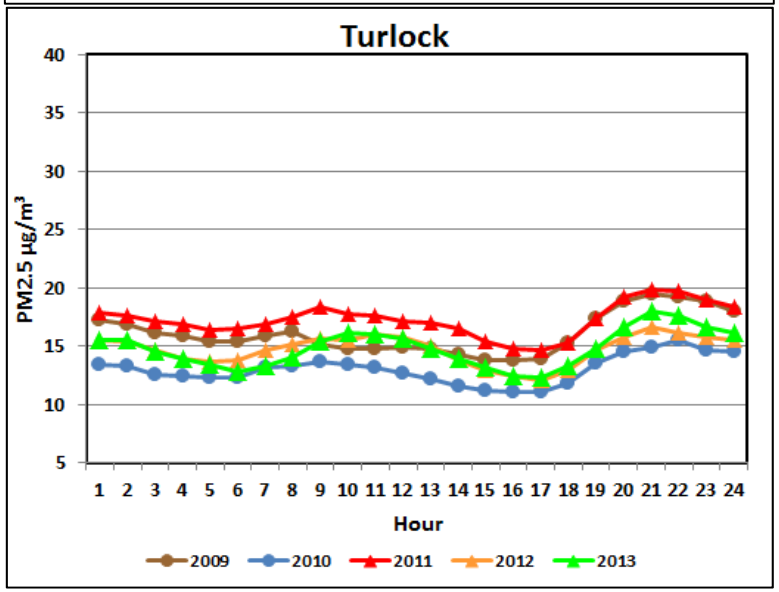


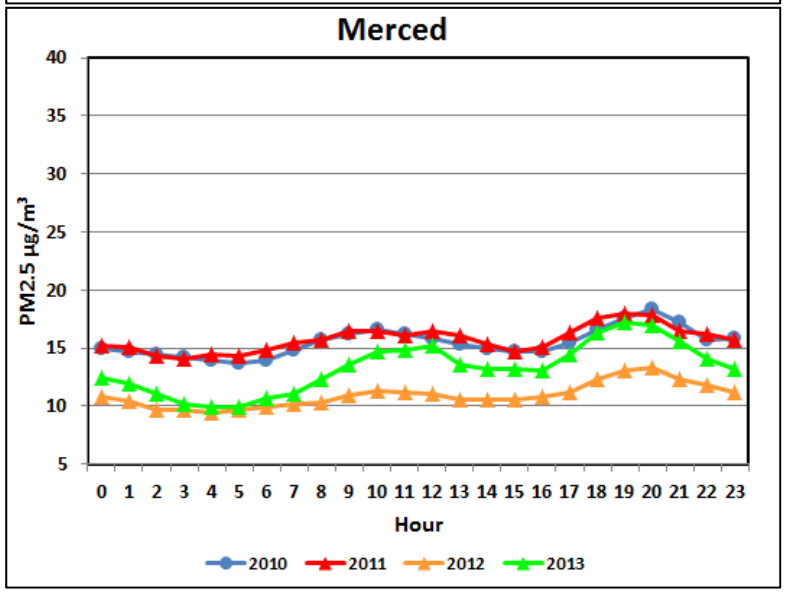


Figures A-6.1 through A-6.16 PM2.5 Diurnal Profiles

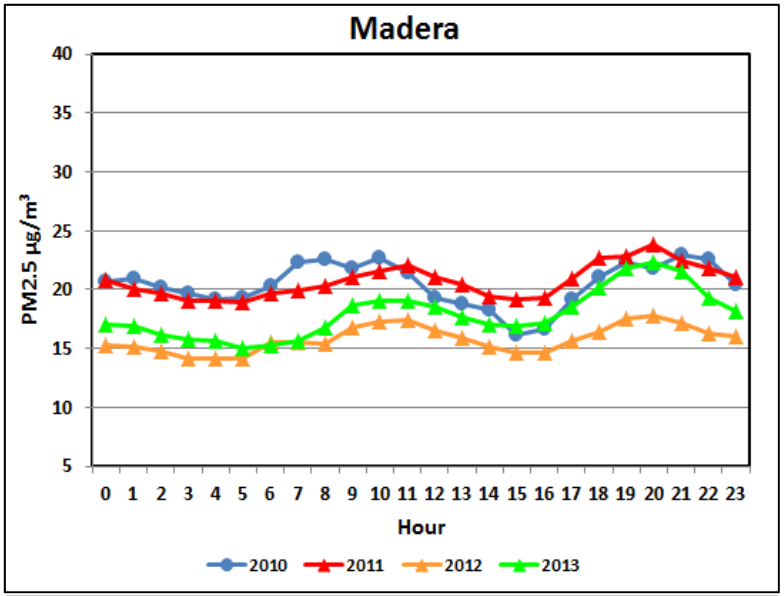


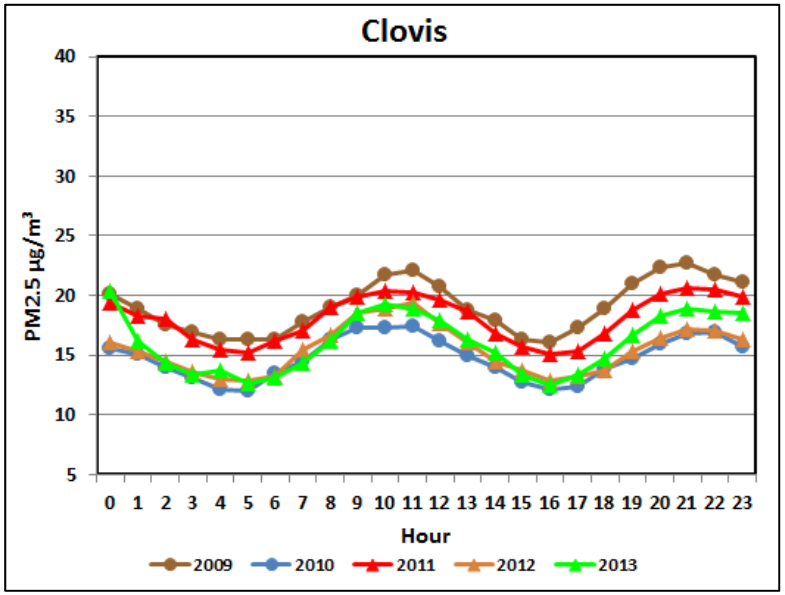


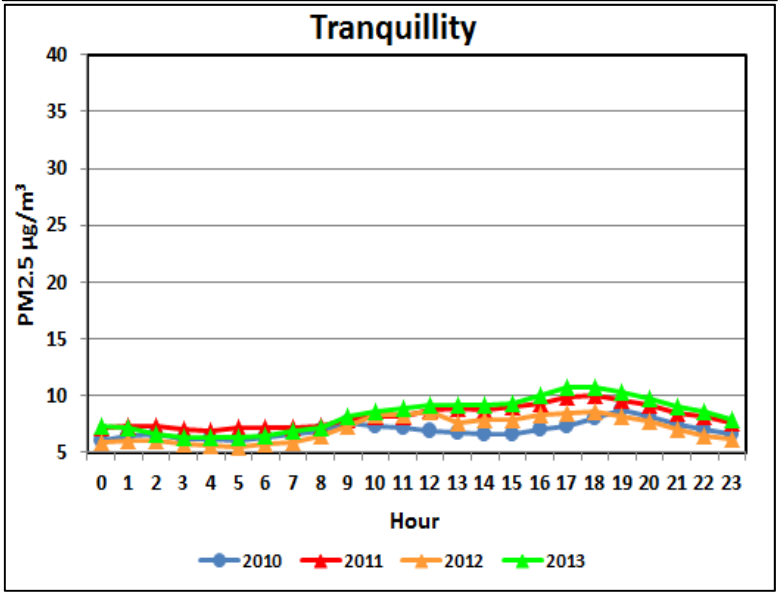


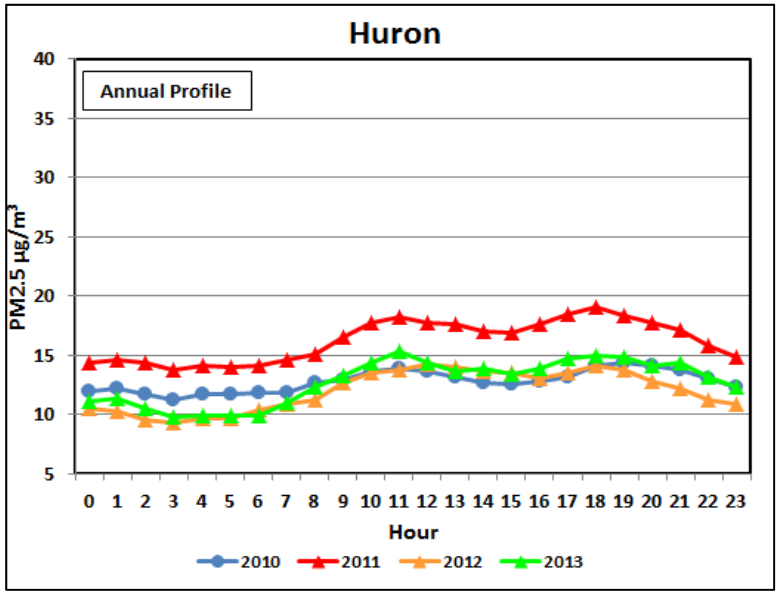


Figures A-6.1 through A-6.16 PM2.5 Diurnal Profiles

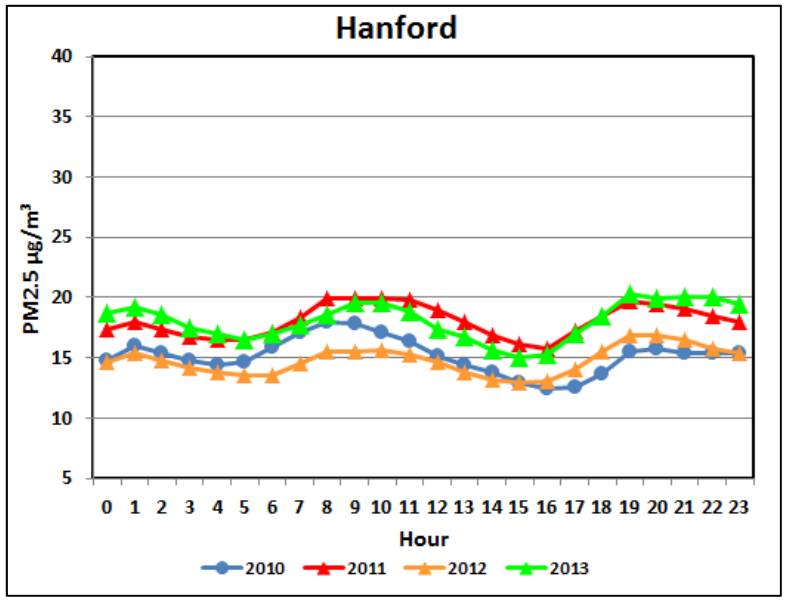


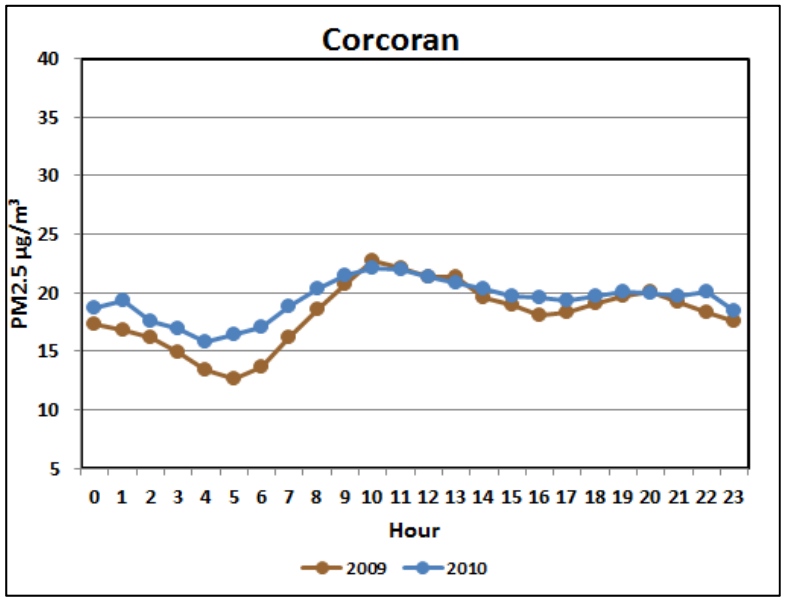


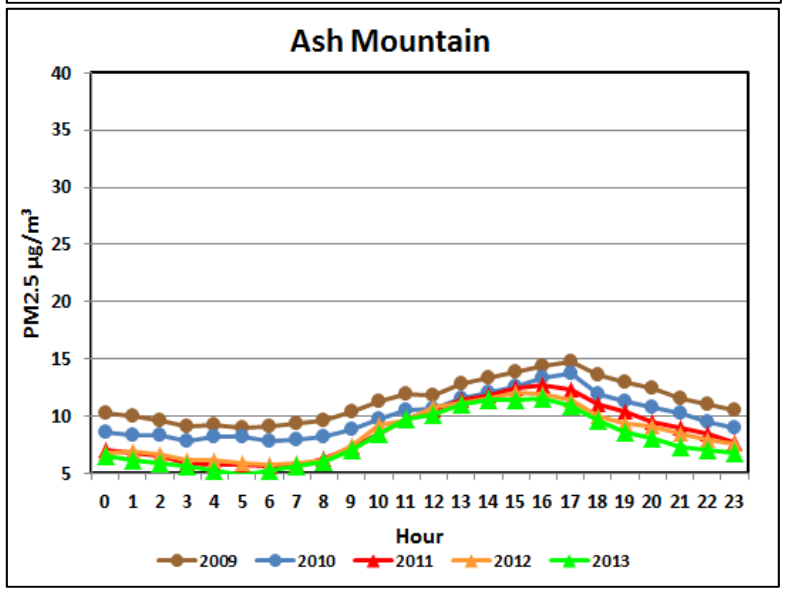


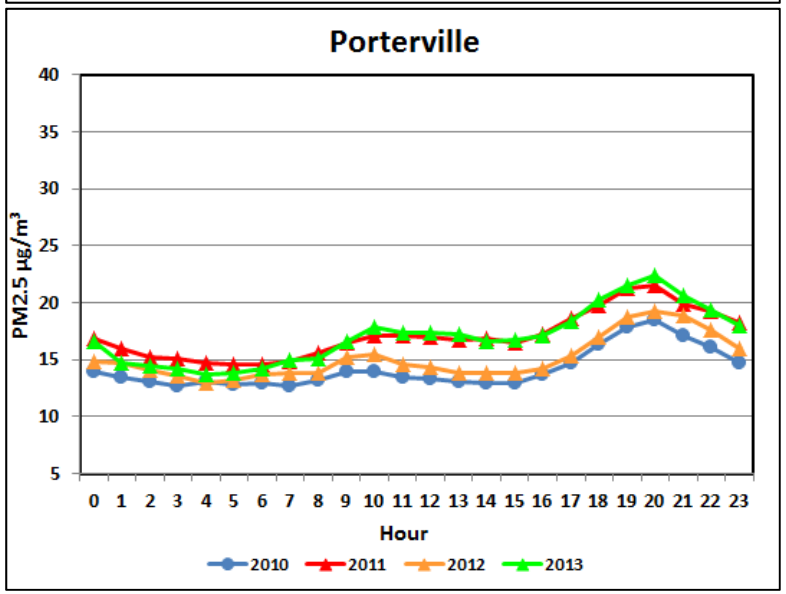


Figures A-6.1 through A-6.16 PM2.5 Diurnal Profiles









*Charts represent complete years of data within the past five years..

A.3.4 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[8] 24-hour average PM2.5 AQI scale is shown in Table A-7 below.

Table A-7 PM2.5 AQI Scale

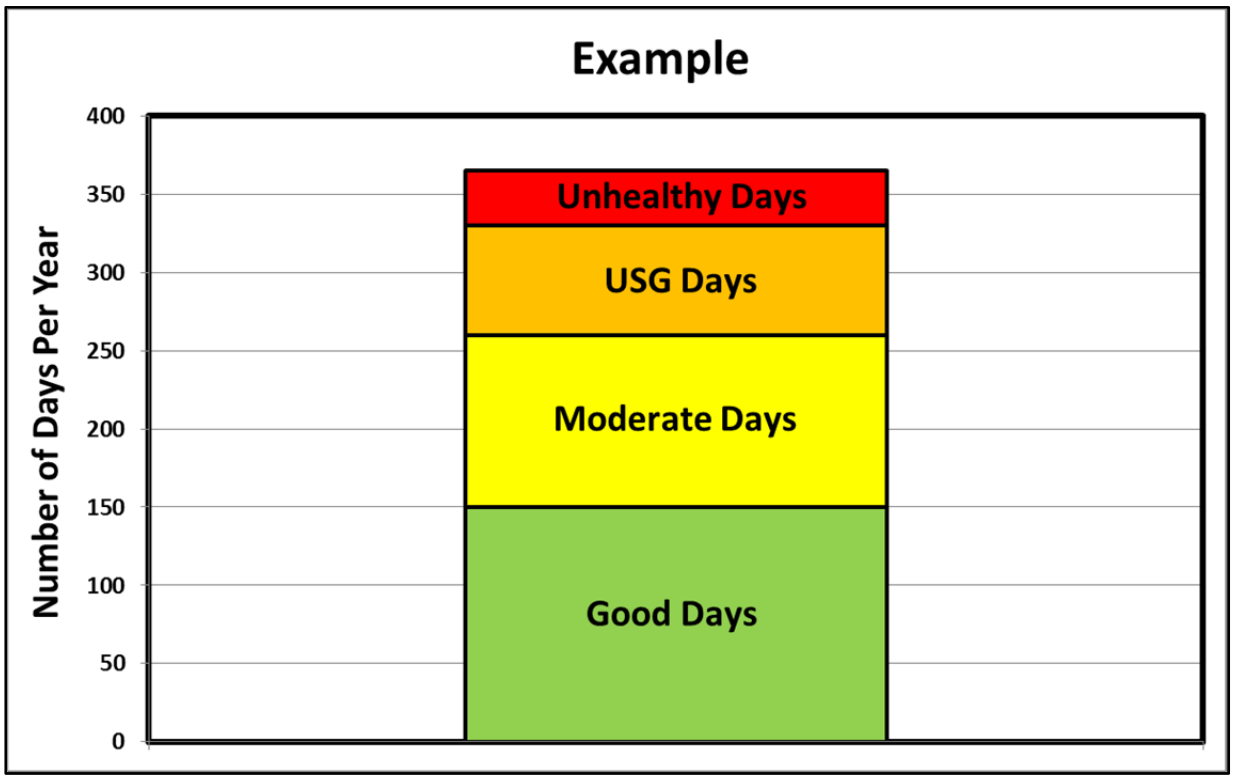
AQI Category	Index Values	Concentration ($\mu g/m^3$, 24-hr average)
Good	0-50	0 – 12.0
Moderate	51-100	12.1 – 35.4
Unhealthy for Sensitive Groups (USG)	101-150	35.5 - 55.4
Unhealthy	151-200	55.5 - 150.4
Very Unhealthy	201-300	150.5 - 250.4
Hazardous	301+	250.5+

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-7 is shown as a reference for interpreting Figures A-8.1 through A-8.11. 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 so as 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.

[8] CFR Appendix G to Part 58, Uniform Air Quality Index (AQI) and Daily Reporting

Figure A-7 Air Quality Index (AQI) Categories



For the majority of the Valley sites, the observed AQI data for the 2008–2013 timeframe shows an improvement in PM2.5 air quality. This finding is significant and needs to be emphasized because this improvement is expressed despite the data being subject to the lowered AQI break points, as noted above in Table A-7. Over these five years, the frequency of Good AQI days increased, coupled with a decrease in the frequency of the Moderate and Unhealthy-for-Sensitive-Groups AQI days. For example, at the Fresno-First /Garland site, the number of Good days increased from 189 in 2008, to 207 in 2013. At the same time, the Moderate and USG days decreased from 126 to 103, and 41 to 31, respectively.

At the Bakersfield-California site, a similar pattern occurred with the frequency of Good AQI days increasing, and the frequency of the Moderate and USG AQI days decreasing. For example, the number of Good days increased from 117 in 2008 to 157 in 2013. At the same time, the Moderate and USG days decreased from 181 to 152, and 48 to 27, respectively.

These improvements over the 2008–2013 timeframe reflect the emissions reductions occurring over these five years. A key part of the emissions reductions during this period is the District's Rule 4901 (Wood Burning Fireplaces and Wood Burning Heaters), which was strengthened just before the 2008–2009 winter season, lowering the curtailment threshold from 65 $\mu g/m^3$ to 30 $\mu g/m^3$. The observed improvement in PM2.5 AQI values is partly attributable to the amended wood-burning rule.

Since 2011, the PM2.5 air quality declined at some sites for some years, as compared to previous years. Abnormally stagnant meteorology during the winter of 2011–2012, which has repeated itself each winter since, has created (as of 2014) the historic three year drought and contributed greatly to this PM2.5 deterioration.

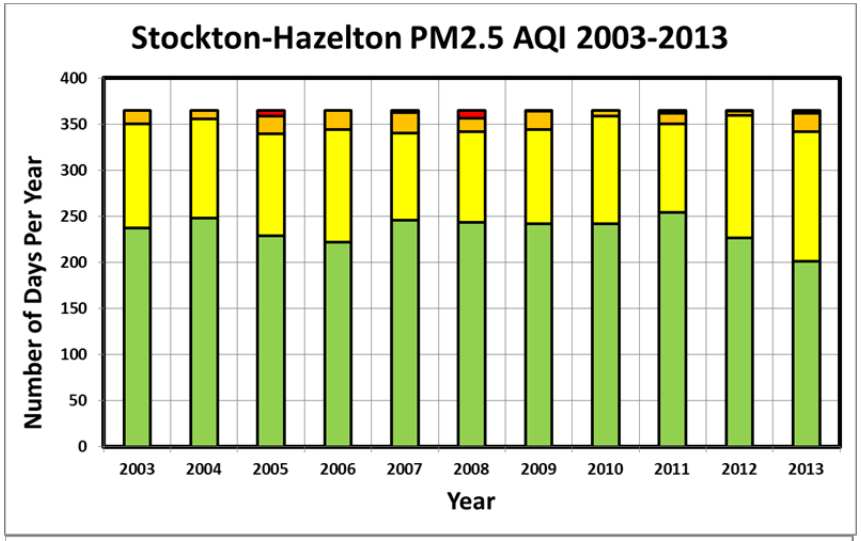
As noted above, over the past several winters, a persistent and strong high pressure ridge over the eastern Pacific Ocean and the western United States effectively blocked weather disturbances from entering California that would normally have removed and replenishment of the valley's air with clean air. 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. This caused of the exceptionally high PM2.5 concentrations found in the Valley and throughout the state of California. Despite these current conditions the general trend has been for improving air quality.

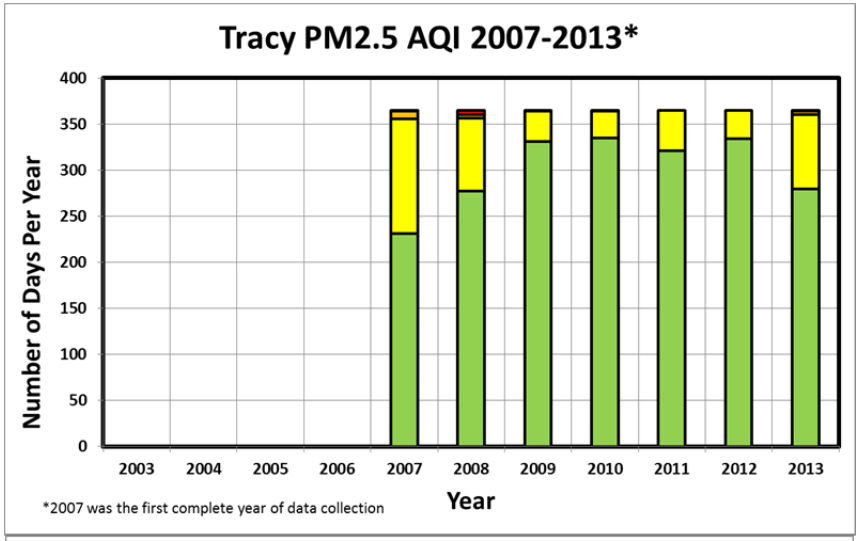
In Figure A-8.12, the data for each site was averaged for all years. In the graph the sites are arranged from north to south along the horizontal axis from left to right. This shows that the northern sites have more Good AQI days than the southern sites. The Stockton-Hazelton and Tracy sites (average between the two is approximately 72% Good AQI), and have about 25% more days in the Good AQI category than the Visalia and Bakersfield sites which average about 47% Good AQI.

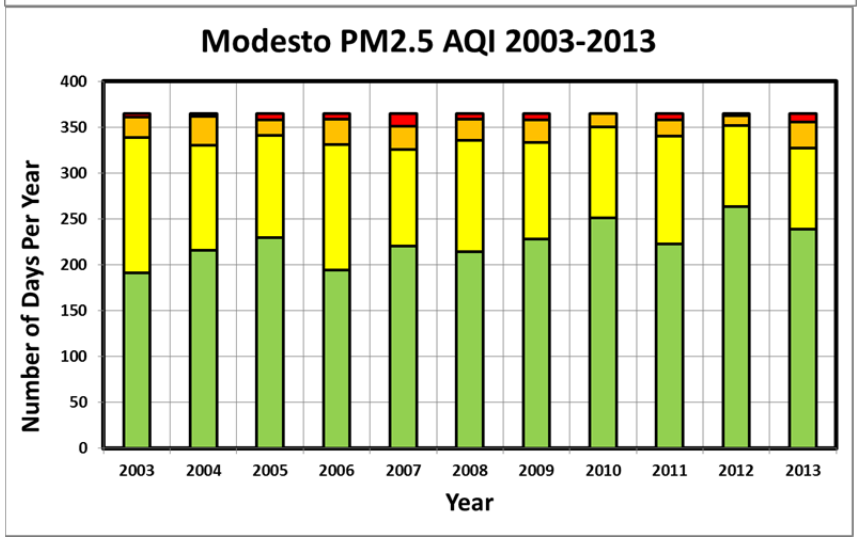
Figure A-8.13 presents the data by year averaging all the sites together for an overall regional view, illustrating that the percentage of Good AQI days is increasing for the District as a whole, while the percentage of Moderate AQI days is decreasing throughout the District. More specifically (and in terms of days instead of percent) for the 11 years between 2003 and 2013, the number of days in the Good AQI category increased by 58 days since 2003, while the number of days in the Moderate, USG, and Unhealthy AQI categories decreased by 46 days, 11, and 1 day, respectively. This finding is significant and needs to be emphasized because this improvement is expressed despite the population increase, the two year drought and winter atmospheric stagnation periods.

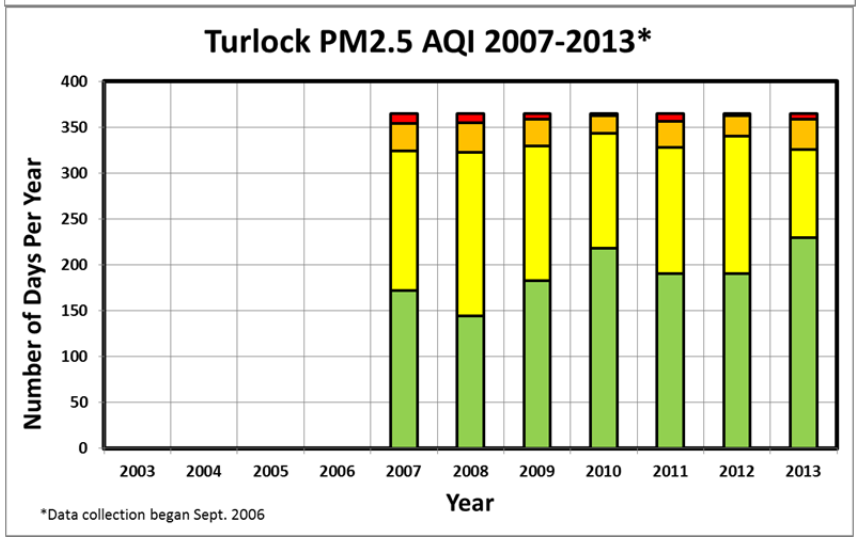
By observing all of the following figures, it is apparent that the dominant annual PM2.5 AQI categories are the Good and Moderate categories. The final figure (Figure A-8.14) is presented to summarize this observation. The data was averaged for all sites and all years (for all years that data that was available for each site). This analysis illustrates that for the Valley as a whole, and over the course of the eleven years, that 92% of all days (335 days) were within the Good and Moderate AQI categories. Breaking that down further shows that the Valley has averaged, 55% Good AQI days (199 days), 37% Moderate AQI days (136 days), 6% USG days (23 days), and 2% Unhealthy days (7 days).

Figures A-8.1 through A-8.4 **Number of Days per AQI Category per Year: Stockton-Hazelton, Tracy, Modesto, and Turlock**

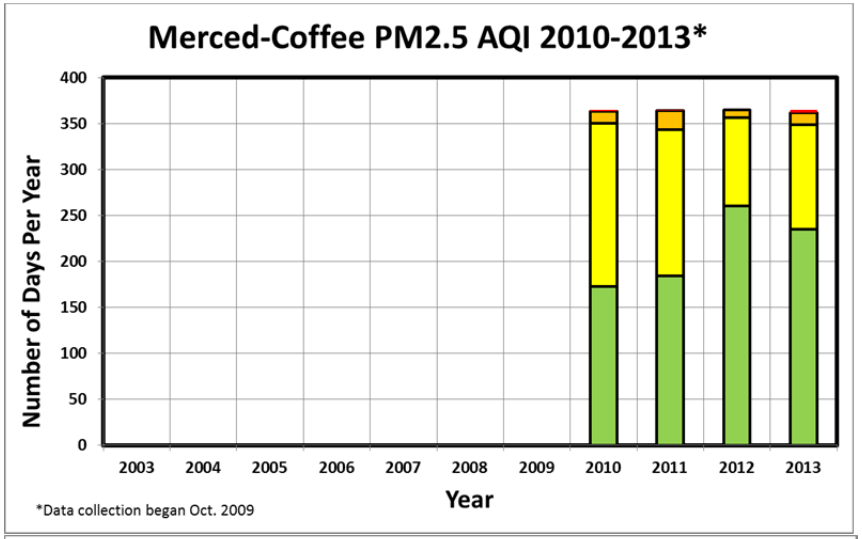


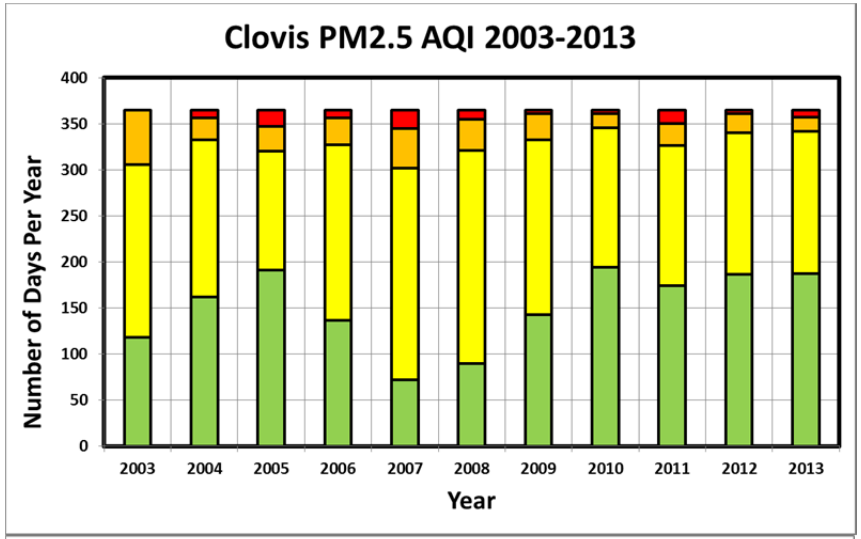


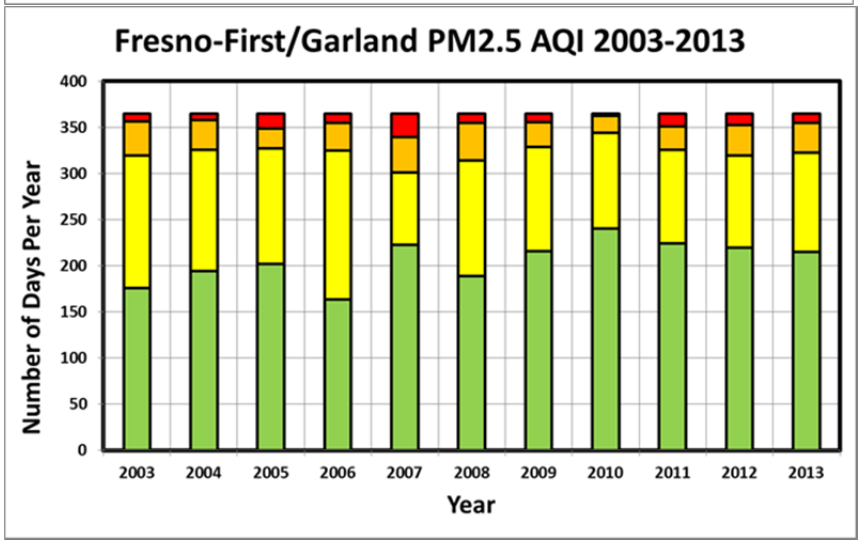


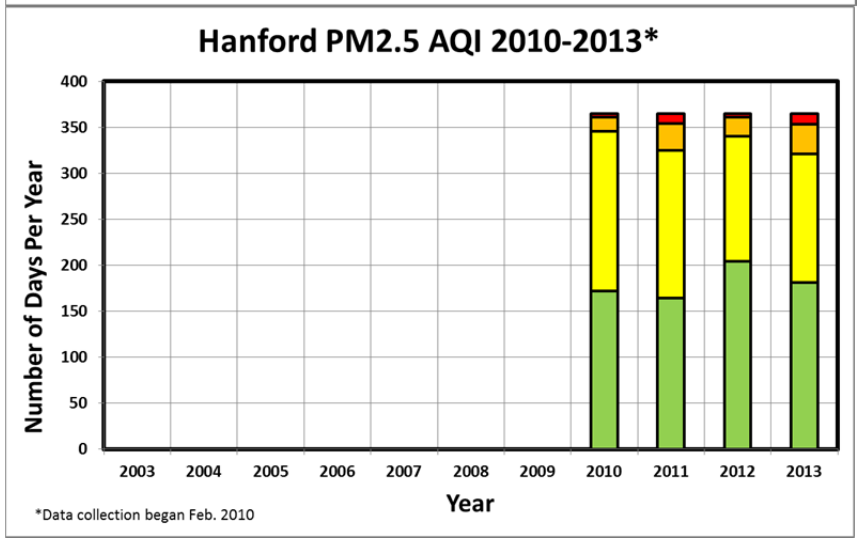


Figures A-8.5 through A-8.8 **Number of Days per AQI Category per Year; Merced, Clovis, Fresno-First/Garland, and Hanford**

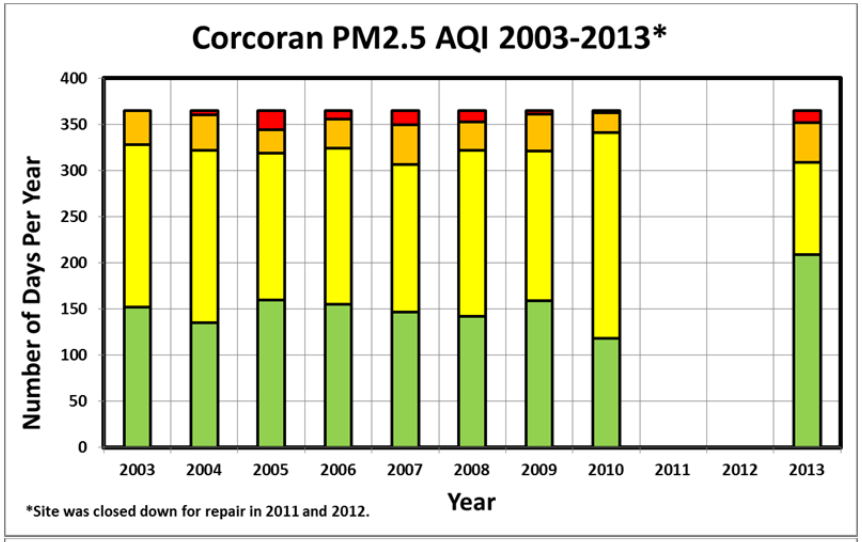


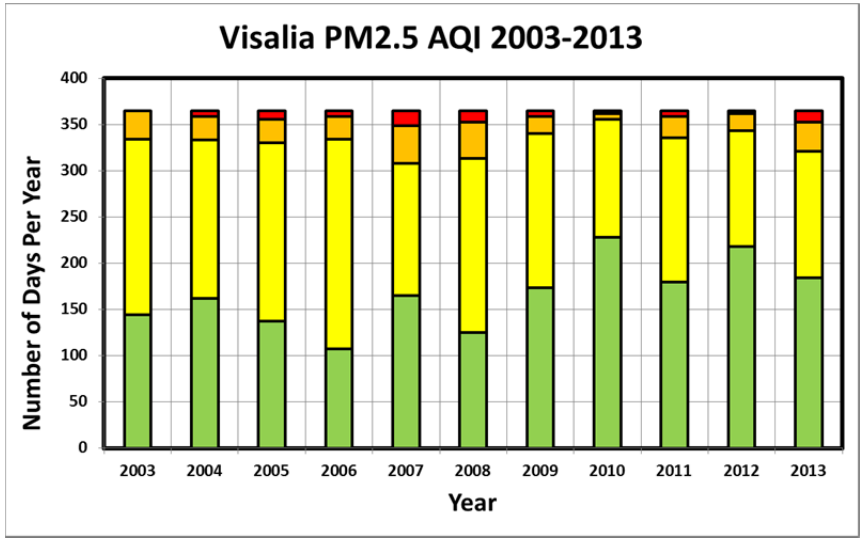


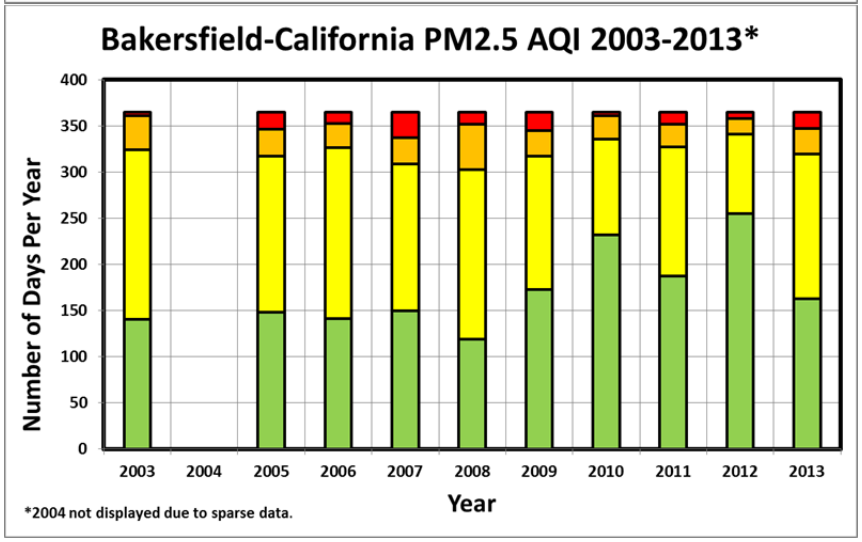




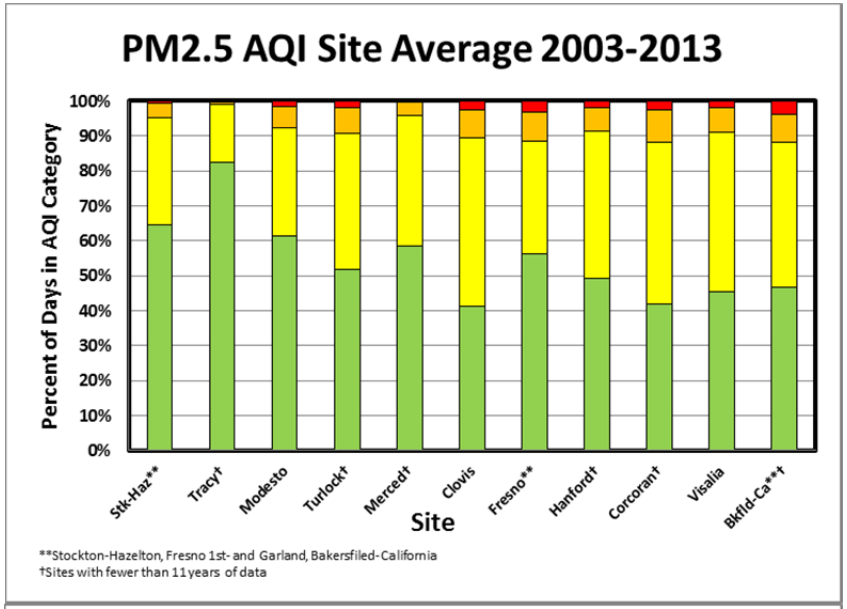
Figures A-8.9 through A-8.11 **Number of Days per AQI Category per Year: Corcoran, Visalia, and Bakersfield California**

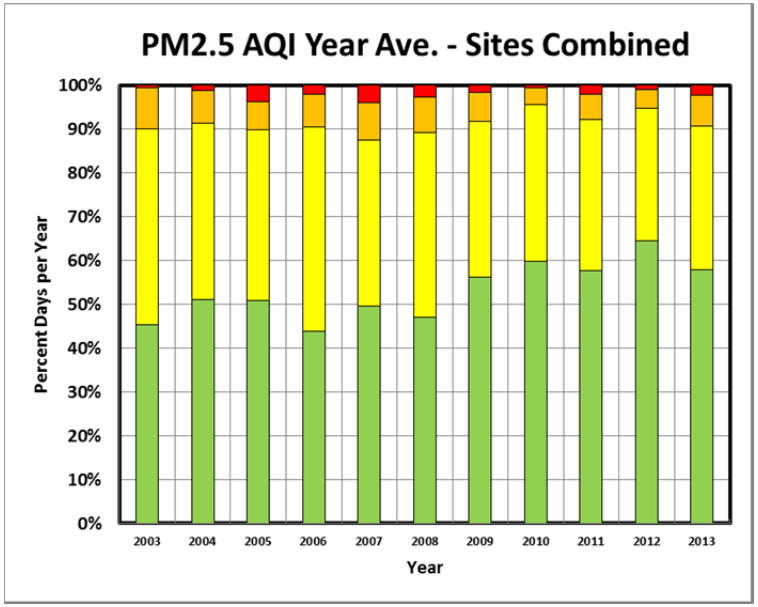


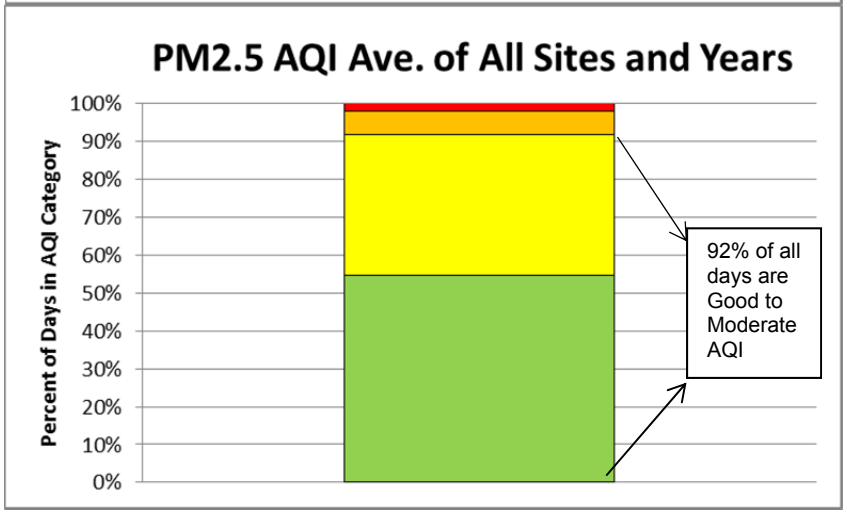




Figures A-8.12 through A-8.14 PM2.5 AQI Site Average, PM2.5 AQI Year Average, and PM2.5 AQI Average for All Sites and all Years Combined







A.3.5 Trends in PM2.5 Species

The NAAQS for particulate matter is established on the basis of the amount of particulate matter, by mass (weight) that a filter sampler is able to collect per cubic meter of air. Most air monitoring devices for particulate matter report only the mass of the particulate matter filtered from the air; however, the mass alone does not tell what source the particulate matter may have come from, or provide direct evidence to determine whether the State Implementation Plan (SIP) measures are having the expected impact on particulate emissions.

Additional monitoring is conducted with special samplers that collect filters for additional analysis of contributing materials (species). The samples collected by speciation samplers are subjected to extensive physical and chemical laboratory analysis. The data produced from the analysis can be used to evaluate trends in the various materials (species) that contribute to particulate emissions and provide information to verify source contributions. The speciation data is also used to support some types of modeling methods to predict future air quality. The variation of materials that contribute to particulate matter shown by samples collected over several years can reveal long term trends. The trend information of the materials observed in the air can be compared to the expected changes predicted from emissions reductions and modeling.

A.3.5.1 Valley Speciation Monitoring

There are four speciation monitors collecting samples in the Valley these are located in Bakersfield, Fresno, Modesto and Visalia. The ARB provides the extensive and expensive laboratory analysis of the collected speciation filters and compiles the resulting data.

A.3.5.2 Data provided by Speciation Analysis

Analysis of the filter collected by a speciation sampler reports a variety of contributing materials. The largest mass contributions are the focus of SIP measures to reduce emissions. However, the contributing source of the material may not be clear because many different sources may emit the same common materials. The smaller speciation mass categories are important for use as “tracers” or fingerprints to help identify the relative contribution of sources.

The following tables (A-8 and A-9) provide a summary of the different contributing materials (species) that are identified by laboratory analysis of the speciation sampler filters.

Table A-8 Largest Mass Contributions Reported in Speciation Analysis

Species Name	Description
PM2.5 Speciation Mass	Total mass of PM2.5 on the filter
OC CSN Unadjusted PM2.5 LC TOT *(there are a variety of different analysis methods reporting different fractions of this contribution)*	Organic Carbon *(VOC evaporation, incomplete combustion and biogenic)*
EC CSN PM2.5 LC TOT *(there are a variety of different analysis methods reporting different fractions of this contribution)*	Elemental Carbon *(combustion product)*
Nitrate (NO3-)	Key winter mass contribution to PM2.5
Sulfate (SO42-)	Year-round minor contributor
Ammonium (NH4+)	Connects to both Nitrate and Sulfate
Soluble Potassium (K+)	Shows vegetative burning primarily, some industrial contribution
Soluble Sodium (NA+)	Various sources
Aluminum (Al)	Indicator for soil, but also engine wear
Calcium (Ca)	Indicator for soil, but also construction
Chlorine (Cl)	Various sources
Iron (Fe)	Break wear, engine wear, but also soil
Potassium (K)	Various industrial and agricultural sources
Silicon (Si)	Indicator for soil
Sodium (Na)	Various sources
Sulfur (S)	Indicator for some agricultural activities and some industrial combustion sources
Levoglucosan	Newer method to show burning, sugar released by wood combustion

Table A-9 Smaller and Trace Level Mass Contributions Reported in the Speciation Analysis

Small or Moderate Contributing Sources	
Barium (Ba)	
Copper (Cu)	
Tin (Sn)	
Titanium (Ti)	
Zinc (Zn)	
Galactosan *(sugar related to wood combustion)*	
Mannosan *(sugar related to wood combustion)*	
Trace Contributions	
Antimony (Sb)	Mercury (Hg)
Arsenic (As)	Molybdenum (Mo)
Bromine (Br)	Nickel (Ni)
Cadmium (Cd)	Niobium (Nb)
Cerium (Ce)	Phosphorus (P)
Cesium (Cs)	Rubidium (Rb)
Chromium (Cr)	Samarium (Sm)
Cobalt (Co)	Scandium (Sc)
Europium (Eu)	Selenium (Se)
Gallium (Ga)	Silver (Ag)
Gold (Au)	Strontium (Sr)
Hafnium (Hf)	Tantalum (Ta)
Indium (In)	Terbium (Tb)
Iridium (Ir)	Tungsten (W)
Lanthanum (La)	Vanadium (V)
Lead (Pb)	Yttrium (Y)
Manganese (Mn)	Zirconium (Zr)

A.3.5.3 Trends and Findings Provided by Speciation Data

Speciation samples collected from 2001 through 2013 have been evaluated to determine variation of species on each of the collected filters. The resulting data from filter analysis has been evaluated to detect trends in the reported species. There are limiting factors that affect the trend analysis including:

- Only the four speciation sampler locations in Bakersfield, Fresno, Modesto and Visalia can be evaluated directly from the speciation filter data. These sites are representative of the Valley but may not explain every variation in total particulate observed at other monitoring locations

- The Fresno speciation sampler was moved to a new, but nearby, location in 2012. Data appear to be consistent for both locations; therefore, the trend evaluation is interpreted as a continuous period of sampling
- Organic carbon and elemental carbon test methodology has changed during the sampling period. Older methodology was used through early 2009. Newer methods were introduced in mid-2007 providing two years of comparison data. The two methods do not provide comparable data for creation of a long term trend analysis for the entire 2001 through 2013 period. Newer methodology reports low concentrations with a narrow range of variability which is not ideal for trend evaluation.

Findings from analysis of the speciation data are discussed for the following topics:

- Trends (multiyear trends in total particulate and major contributing species, responsive species and times of year, nonresponsive species and times of year, interpretation)
- Drought impacts (soil as an indicator for drought impact, observed trends, implications for the SIP)
- SIP implications (District strategy effectiveness)

Trends (multiyear trends in total particulate and major contributing species, responsive species and times of year, nonresponsive species and times of year, interpretation)

- **Total particulate:** Both the average value recorded at the four sites and the peak value recorded at the four sites show clear trends of reduction. Figure A-9 and A-10 shown below illustrates the total particulate trend in average and maximum PM2.5 speciation mass. Each of the four sites shows very similar trends to the group analysis. This suggests that all of the Valley sites are expected to be experiencing similar trends, despite the lack of speciation filter data for confirmation at sites other than the four speciation sampler sites. The average of values for the entire year shows improvement from 24 $\mu g/m^3$ of air to 16 $\mu g/m^3$. Both the Average value and Maximum value analyses show improvement from March to October that is approaching the 15 $\mu g/m^3$ annual standard. However, while improving, the late fall and winter months from November through February are proving to be resistant to change, creating challenges in the Valley's journey to attainment of the federal PM2.5 standards.

Figure A-9 Average PM2.5 Speciation Mass

Month	Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Jan		79	43	37	33	23	25	44	27	38	22	24	37	32
Feb		40	44	22	15	29	29	30	29	15	17	12	16	20
Mar		20	17	14	21	16	10	13	14	11	10	10	12	10
Apr		10	12	7	11	9	8	10	10	10	9	7	12	8
May		16	9	11	10	9	15	12	12	11	8	7	9	10
Jun		13	11	12	10	9	11	11	18	9	8	9	9	11
Jul		14	13	13	10	12	16	12	20	10	11	11	10	14
Aug		12	19	12	10	11	14	12	13	12	11	11	11	10
Sep		16	13	16	10	11	17	14	16	12	11	14	12	8
Oct		20	24	19	19	17	19	16	19	14	11	18	13	13
Nov		44	48	33	32	33	30	40	37	26	21	22	17	29
Dec		27	32	25	29	44	43	28	25	34	26	52	21	48
Average		24	23	18	19	19	20	20	20	17	14	16	15	16

Figure A-10 Maximum PM2.5 Speciation Mass

Month	Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Jan		188	89	57	56	46	40	79	68	60	48	48	107	67
Feb		95	89	50	34	56	71	90	74	62	34	38	29	68
Mar		43	34	38	39	57	21	24	35	23	23	24	26	29
Apr		16	22	17	20	25	26	26	40	16	19	18	46	15
May		29	16	19	18	19	60	21	19	23	16	13	15	21
Jun		33	21	21	15	17	24	23	55	19	20	24	17	52
Jul		34	21	20	22	21	27	69	50	13	40	20	27	44
Aug		17	40	25	20	18	20	28	27	20	50	24	28	22
Sep		98	24	33	15	17	28	44	29	24	30	22	25	14
Oct		44	52	33	39	62	42	36	35	36	22	69	30	23
Nov		82	93	69	54	81	60	75	80	44	52	44	38	52
Dec		63	91	67	71	96	102	68	49	72	69	85	50	124
Maximum		188	93	69	71	96	102	90	80	72	69	85	107	124

The next step in analysis of the particulate trend is to evaluate which types of particulate matter are improving and which types are resistant to change. To perform trend analysis of the components included in particulate matter requires examining the major constituents (species) of particulate matter. Particulate matter can be divided into several major constituents: Nitrates, Sulfates, Organic Carbon, Elemental Carbon and Geologic material. Nitrates and Sulfates are formed in the atmosphere from gases (ammonia, NOx, SOx). Organic carbon is both directly emitted and formed in the

atmosphere. Elemental carbon (from combustion) and geological material (soil related plus trace elements) are directly emitted and do not change once emitted.

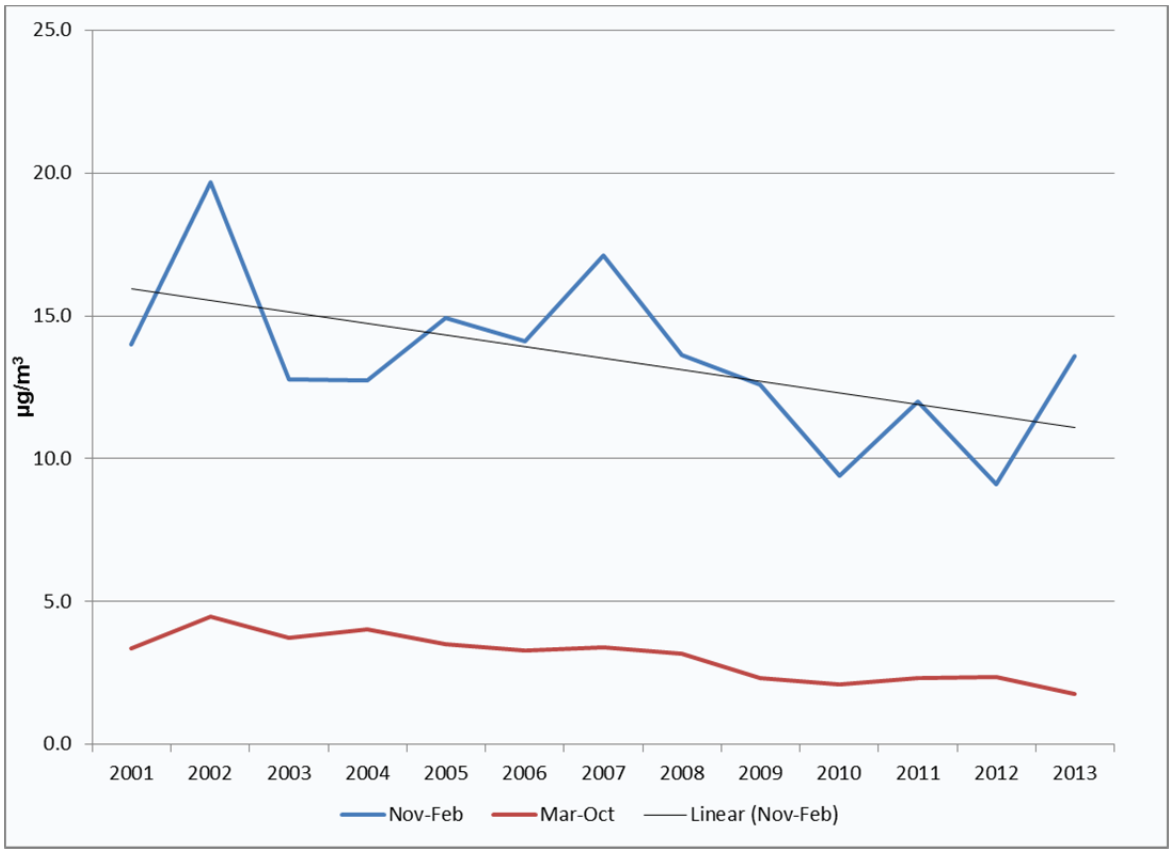
- **Nitrate:** Ammonium nitrate is the largest contributor to particulate matter on an annual basis. Ammonium nitrate is a material that forms in the atmosphere from materials that are considered to be gases (and would not collect on a filter sample) into a material that is considered to be particulate matter and does collect on filter samples. However, during the warmer times of year, while ammonium nitrate forms in the atmosphere it does not remain as particulate matter but evaporates and returns to the component gases. From March through October the amount of ammonium nitrate collected on filter samples is very low and is not the dominant source of particulate matter. The November through February levels of ammonium nitrate are a substantial portion of the total particulate mass. Ammonium nitrate is calculated from the speciation data by adding the reported amount of nitrate to a calculated portion of the ammonium (total reported ammonium minus the portion of ammonium that is involved in ammonium sulfate formation). Figure A-11 shown below illustrates the sum of ammonium (NH4+) and nitrate (NO3-) speciation mass.

Figure A-11 Sum of Ammonium (NH4+) and Nitrate (NO3-) Speciation Mass

Month	Year												
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Jan	15.7	18.5	17.8	15.4	9.4	9.8	19.5	11.5	17.2	8.8	10.6	16.1	11.4
Feb	10.0	22.9	9.7	6.4	14.4	14.1	15.1	14.5	6.3	7.8	4.2	5.7	7.7
Mar	8.2	8.5	6.9	11.1	7.5	3.9	6.0	6.5	4.1	3.7	3.7	4.2	3.7
Apr	3.1	4.4	2.8	3.3	3.2	3.3	3.9	2.5	2.1	3.1	1.9	3.0	1.7
May	1.8	2.5	2.7	2.0	2.2	3.1	2.0	2.1	2.0	1.8	1.3	1.6	1.2
Jun	1.7	2.2	2.2	1.7	1.5	1.5	1.6	2.0	1.6	0.8	1.5	1.2	1.1
Jul	1.9	2.1	2.0	1.7	1.7	1.6	1.7	2.0	1.1	1.2	1.3	1.3	1.3
Aug	1.6	3.2	2.6	2.2	1.9	2.6	1.6	1.3	1.4	1.4	1.4	1.4	0.9
Sep	2.3	2.7	3.4	2.7	2.7	2.8	3.3	2.8	1.9	1.8	2.1	2.0	1.1
Oct	6.3	10.3	7.3	7.3	7.4	7.7	7.3	6.1	4.7	3.2	5.4	4.1	3.2
Nov	21.1	24.5	14.0	15.3	16.5	14.4	21.4	17.8	10.8	8.6	9.0	6.2	11.8
Dec	9.2	12.9	9.7	13.8	19.4	18.1	12.5	10.8	16.1	12.3	24.2	8.6	23.6

Evaluation of the trends of the average values observed for ammonium nitrate data do show reduction during the 2001 to 2013 period. Figure A-12 shown below illustrates the average value ammonium nitrate trend. Both the March to October low values and the November to February higher values show reduction when looking at the average values observed. This indicates that the reduction measures to reduce nitrogen oxide emissions are having an impact on the formation of ammonium nitrate.

Figure A-12 Average Value Ammonium Nitrate Trend



The maximum values of ammonium nitrate observed have not followed the trend projected by the average values. March through November maximum value data does show an improving trend; however January, February and December data does not show the same improvement, as shown in Figure A-13 below. The maximum monthly percentage of PM2.5 attributable to ammonium nitrate is shown in Figure A-14 below.

Figure A-13 Sum of Ammonium (NH4+) and Nitrate (NO3-) Speciation Mass

	Year												
Month	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Jan	46.9	36.4	31.9	31.6	25.0	18.8	45.5	40.0	35.8	22.1	23.4	48.0	36.9
Feb	30.6	54.8	26.1	14.0	32.8	44.1	59.2	48.8	36.1	19.9	19.2	14.5	37.0
Mar	12.4	19.8	20.9	23.7	33.9	12.0	14.1	22.0	11.5	12.0	11.3	12.6	15.2
Apr	5.3	10.1	9.5	7.9	15.3	11.6	14.2	6.8	3.8	8.4	5.0	4.4	3.5
May	2.6	8.6	6.4	5.6	8.5	5.9	7.7	5.7	6.6	3.8	4.0	4.7	3.3
Jun	7.8	5.4	4.3	1.7	1.6	3.7	2.5	5.2	2.5	0.0	3.3	2.9	2.5
Jul	2.2	7.0	3.6	5.0	3.8	3.1	3.4	4.7	2.7	0.0	1.7	3.1	3.7
Aug	4.2	8.3	8.5	6.2	4.7	5.7	5.1	2.1	5.1	3.9	3.0	4.0	2.8
Sep	4.0	7.5	15.1	7.2	9.5	8.2	12.1	4.9	6.0	3.3	5.0	4.8	3.1
Oct	19.3	29.5	15.8	20.8	38.4	23.3	20.5	19.6	17.9	8.5	11.5	16.6	9.9
Nov	57.8	49.8	41.0	45.0	55.8	34.0	50.5	41.2	25.1	30.6	25.1	21.2	31.1
Dec	26.0	43.0	44.0	38.7	57.3	52.1	47.5	32.9	45.9	46.0	49.5	26.9	91.2

Figure A-14 Maximum Monthly Percentage of PM2.5 Attributable to Ammonium Nitrate

	Year												
Month	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Jan	25%	41%	56%	56%	54%	48%	57%	59%	60%	47%	49%	45%	55%
Feb	32%	62%	52%	41%	59%	62%	65%	66%	58%	59%	50%	51%	55%
Mar	29%	58%	55%	61%	60%	56%	59%	64%	50%	53%	47%	49%	52%
Apr	33%	46%	56%	40%	61%	45%	55%	17%	24%	45%	28%	10%	24%
May	9%	54%	34%	31%	45%	10%	36%	30%	29%	24%	31%	31%	16%
Jun	24%	26%	21%	11%	9%	16%	11%	9%	13%	0%	14%	17%	5%
Jul	7%	33%	18%	23%	18%	12%	5%	9%	20%	0%	8%	12%	9%
Aug	24%	21%	34%	32%	26%	28%	18%	8%	25%	8%	12%	14%	13%
Sep	4%	31%	46%	48%	55%	29%	28%	17%	25%	11%	22%	19%	21%
Oct	44%	56%	48%	53%	62%	55%	57%	56%	50%	40%	17%	55%	42%
Nov	70%	54%	60%	84%	69%	57%	67%	52%	57%	58%	57%	55%	60%
Dec	41%	47%	66%	54%	60%	51%	69%	67%	64%	67%	59%	53%	74%

Because the peak values in January, February and December have not shown a proportional reduction to the average emissions reduction and reduction of average observed values, it is difficult to determine how much additional reductions will be required to sufficiently impact the peak values. An important finding for the SIP is that reductions achieved have not been sufficient to achieve the ambient air quality standard and a target for additional reductions to achieve that objective is difficult to forecast.

Another important finding for the SIP is that ammonium nitrate continues to be a dominant source of PM2.5, contributing more than half of the particulate observed during winter, and must remain a key component for reduction efforts through effective reduction of NOx emissions (see Chapter 2).

The reason that nitrate emission reductions have not achieved the improvement predicted by the model may be attributable to a variety of factors. Each of these factors may play a partial role. Data is not available at this time to provide a revision to the model to account for these factors. The potential factors include but may not be limited to:

- Aqueous atmospheric reactions not currently available for inclusion in the model – missing reactions may account for under-prediction of atmospheric formation of nitrates in winter
- Horizontal diffusion parameters appropriate for winter, with diffusion more limited than the current 4 kilometer grid representation of mixing used in the model – requires field investigation to provide parameters and model code enhancement to improve the simulation of observed horizontal diffusion
- Vertical diffusion parameters for winter inversions – requires field investigation to provide parameters and model code enhancement to improve the simulation of observed vertical diffusion
- Adjustment of atmospheric chemistry for impacts of drought (lower humidity results in higher photochemistry activity which provides radicals that promote particulate formation)

- **Sulfate:** Ammonium sulfate is a small contributor to particulate matter on an annual basis. Ammonium sulfate is a material that forms in the atmosphere from materials that are considered to be gases (and would not collect on a filter sample) into a material that is considered to be particulate matter and does collect on filter samples. Once formed, ammonium sulfate is relatively stable in the atmosphere and is removed by deposition to vegetation or soil or by dispersion by gradual horizontal dissipation or by being carried to other locations by action of wind.

  Evaluation of the trends of the average values observed for ammonium sulfate data do show reduction during the 2001 to 2013 period. Reductions are apparent for every month and do not show resistance to improvement in winter except in December. The cause of resistance to improvement in December may be due to reduced inversion heights and severe episodes of air stagnation. Improvement throughout the year indicates that the reduction measures to reduce sulfur oxide (SOx) emissions are having an impact on the formation of ammonium sulfate.

Ammonium Sulfate is calculated from the speciation data by adding the reported amount of sulfate to a calculated portion of the ammonium (total reported ammonium minus the portion of ammonium that is involved in ammonium nitrate formation). Figure A-15 shown below illustrates the sum of sulfate and nitrate in the speciation mass.

Figure A-15 Sum of Sulfate ($(SO_4)^{2-}$) and Nitrate (NO_3^-) Speciation Mass

Month	Year												
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Jan	2.5	4.0	4.4	3.4	3.6	2.4	2.7	3.0	3.4	2.9	3.1	2.6	1.5
Feb	1.8	3.7	2.1	1.3	2.9	2.6	2.8	3.1	1.3	2.1	1.0	1.1	1.4
Mar	2.4	1.7	2.0	2.9	2.2	1.1	1.8	1.8	1.4	1.1	1.2	1.0	1.3
Apr	1.7	2.5	1.4	2.1	1.6	1.6	2.0	1.6	2.2	1.7	1.2	2.0	1.3
May	2.8	1.8	2.2	2.1	2.3	2.7	2.4	2.4	2.4	1.4	1.1	1.7	1.5
Jun	2.0	2.5	2.9	2.6	2.1	2.7	2.2	2.2	2.4	1.4	1.6	1.3	1.7
Jul	2.6	3.2	2.8	2.5	3.1	3.4	2.5	2.7	1.8	2.5	2.3	1.7	1.9
Aug	2.3	2.6	2.4	2.3	2.4	2.7	1.9	1.9	1.6	1.4	1.7	1.5	1.1
Sep	2.3	2.1	2.7	1.3	1.9	2.2	2.3	2.6	1.6	1.7	2.1	1.8	1.1
Oct	2.3	3.4	2.3	2.1	2.3	2.6	2.1	2.3	1.4	1.5	2.3	1.5	1.4
Nov	3.6	4.5	2.3	3.6	3.2	3.3	4.5	3.7	2.2	1.7	1.9	1.2	1.9
Dec	2.2	2.6	1.8	3.3	3.8	2.5	2.6	3.0	3.0	2.0	3.6	1.4	3.2

- **Elemental Carbon (EC) and Organic Carbon (OC)**: Elemental carbon from combustion is a small contributor to PM2.5. Organic carbon from incomplete combustion, evaporation and biogenic sources is a large contribution to observed levels of PM2.5, particularly during winter months. Elemental carbon reflects changes in industrial VOC emissions. Organic carbon reflects changes in evaporative VOC emissions and incomplete combustion processes such as charbroiling and residential wood combustion. Changes in the atmospheric levels of EC and OC are therefore important for evaluating the effectiveness of measure in the SIP.

  Laboratory filter sample speciation evaluation methods are used to determine how much of the observed carbon is elemental (does not contain oxygen) and how much is organic (contains oxygen). The combined processing to determine the EC and OC attributions requires discussion of both as a single topic. The laboratory methods for determining this apportionment have to use oxygen to break down compounds that contain carbon. The use of oxygen makes it difficult to determine an accurate measurement of elemental carbon if it is oxidized in the analysis process and made to appear to be organic carbon. The test methods have undergone several revisions to improve methodology.

The test method for organic carbon and elemental carbon changed during the sampling period. Older methodology was used through early 2009. Newer methods were introduced in mid-2007 providing two years of comparison data. The two methods do not provide comparable data for creation of a long term trend analysis for the entire 2001 through 2013 period. Newer methodology reports low concentrations with a narrow range of variability which is not ideal for trend evaluation.

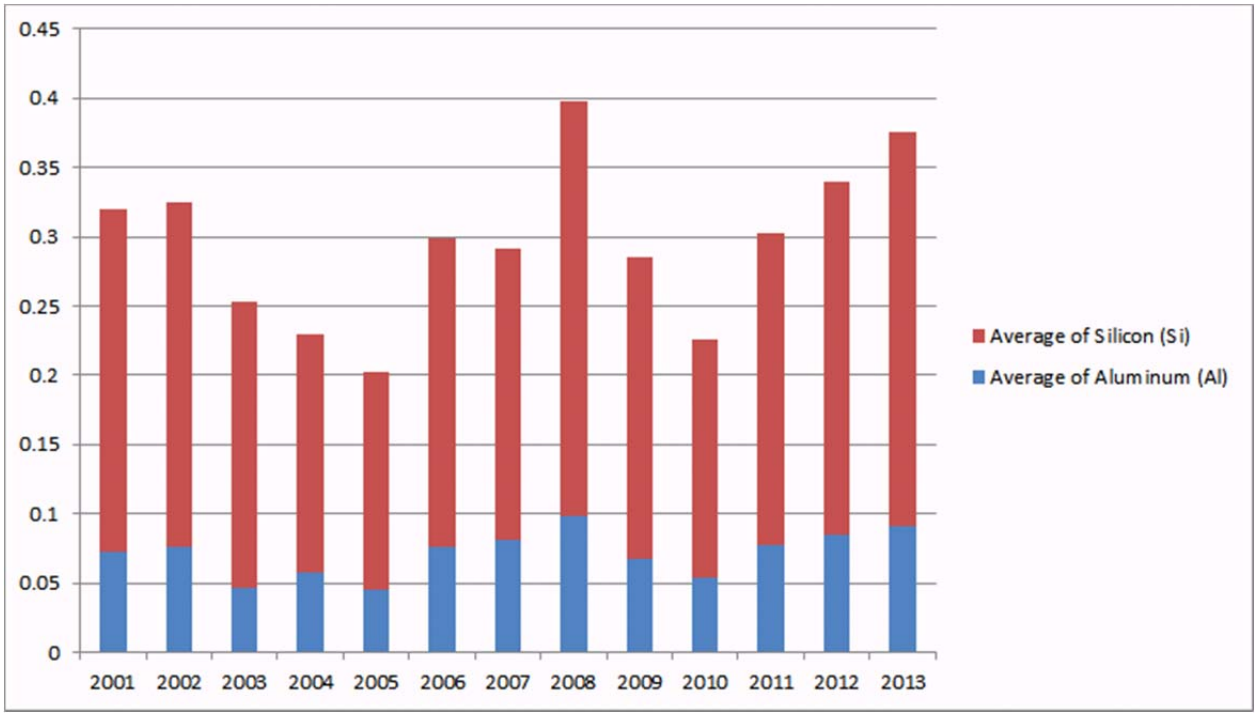
The limitations inherent in the test methodology have produced results that EPA does not consider reliable. EPA has recommended differencing methods for modeling and air monitoring speciation analysis where all easily quantifiable components are subtracted from the total PM 2.5 mass and the remainder is considered to be carbon. The recommended methodology of assigning carbon to all unknown material is not ideal for the 15 $\mu g/m^3$ annual standard due to the need for precision. Additionally this approach is not ideal for the 24-hour PM2.5 standard in areas like the Valley where windblown dust emissions have the potential to produce substantial levels of inert material, identifiable only from calculations for tracer compounds that must assume the molecular weight of the original material.

- **Geologic Material and Trace Elements**: Geologic material is related to windblown dust and trace elements contained in soil material, but geologic material also includes trace elements related to different sources such as fireworks, engine exhaust and tire and brake wear. The amount of geologic material in PM2.5 is generally the third largest source following nitrate and organic carbon. SIP measures to reduce geologic material have been effective but are beginning to show impact from the continuing drought.

Drought Impacts

Drought related impacts can be assessed by examining the speciation data trends of materials commonly found in soil. Drought increases the amount of soil entrained from roads, agricultural activities, wind entrainment and other soil disturbances that emit particulate into the air. Some uncertainty exists in such a trend analysis because soil is not the only source of many of the compounds commonly found in soil. Soils contains, in decreasing order, silicon, aluminum, iron, magnesium, calcium, sodium, and potassium. The organic fraction of soil also includes phosphorus and sulfur. Additional common elements in soil include copper, zinc, manganese, cobalt, chlorine, boron and molybdenum. More than eighty elements occur in soils. Most of the other compounds not mentioned specifically occur in much smaller quantities. Figure A-16 shown below illustrates the increase soil elements that occur during a drought.

Figure A-16 Increase of Soil Elements during a Drought



Evaluation of major and trace components of PM2.5 reported in the speciation data were evaluated for indications of drought impact. Silicon and aluminum provided the strongest indication of the recent multiyear drought. Year by year increase is shown from 2010 through 2013. As silicon and aluminum are components of soil, and not the full mass of soil, the impact of drought on PM2.5 total mass is more than the mass of the two tracer compounds. The tracers conservatively show an up to 1 µg/m^3 increase in PM2.5 mass due to increased soil emissions due to the drought.

A.3.5.4 SIP Implications (District Strategy Effectiveness)

Trend analysis of the total mass of PM2.5 shows improvement for the average of observed values. Peak values show improvement except for winter months from November through February. December and January show strong resistance to improvement of peak values.

- Ammonium nitrate (the largest contributor to winter PM2.5 mass) shows improvement in the average of monthly data but also shows resistance to improvement of peak values in winter months (December through February). Ammonium nitrate continues to be a dominant source of PM2.5, contributing more than half of the particulate observed during winter, and must remain a key component for reduction efforts.

- Organic Carbon (the second largest contributor to winter PM2.5 mass) shows less improvement than expected. This source category is difficult to assess due to limitations of the speciation analysis methods.

- Geologic material (the third largest contributor to winter PM2.5 mass) and trace compounds show improvement. However, geologic material is trending upward due to drought.

- Sulfate (a minor contributor) shows improvement.

- Elemental carbon (a minor contributor) shows improvement. This source category is difficult to assess due to limitations of the speciation analysis methods.

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