# Appendix A

## Ambient 1-Hour Ozone Data Analysis

*2013 Plan for the Revoked 1-hour Ozone Standard*
SJVUAPCD

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# APPENDIX A: AMBIENT 1-HOUR OZONE DATA ANALYSIS

## A.1 OVERVIEW

The concentration of ambient ozone at any given location in the San Joaquin Valley (Valley) is a function of meteorology, the natural environment, atmospheric chemistry, and ozone precursor emissions from both biogenic (natural) and anthropogenic (human caused) sources. The San Joaquin Valley Air Pollution Control District (District), the California Air Resources Board (ARB), and other agencies monitor ozone concentrations throughout the Valley, as detailed in the 2011 Air Monitoring Network Plan.[1] The U.S. Environmental Protection Agency (EPA) serves as the official repository of ambient ozone data.[2]

The District uses the collected data to show air quality improvement through the standardized design value and attainment test 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 data show steady, long-term air quality improvement.

The District also uses the data to evaluate the impact of changing daily, monthly, and annual ozone concentrations on public health. These trend analyses provide the District with critical information about how to develop control measures and incentive programs that contribute to the greatest public health improvements and greatest progress toward EPA air quality standards. This appendix provides the technical details used to evaluate and analyze the District's ozone concentration data, as summarized in Chapter 2 of this *2013 Plan for the Revoked 1-hour Ozone Standard*.

## A.2 OZONE MONITORING NETWORK

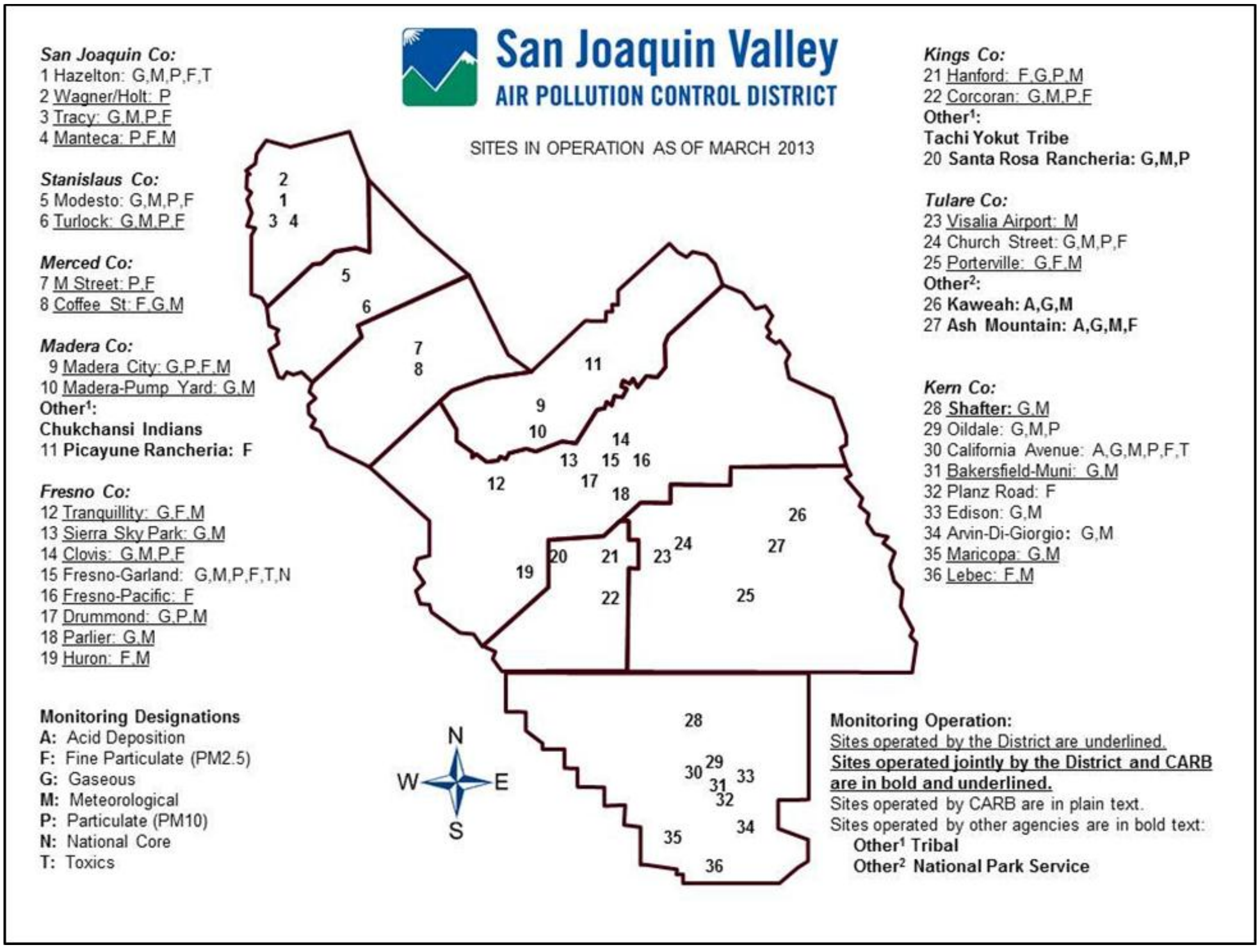
The District operates an extensive air monitoring network to measure progress towards compliance with the NAAQS. As shown in Figure A-1, the ozone monitoring network in the Valley is comprised of a number of ozone monitoring sites, including sites operated by the District, ARB, the National Park Service, the Tachi Yokut Tribe, and the Chukchansi Indians.

Most sites are intended to represent population exposures and maximum concentrations; therefore most ozone monitors are representative of neighborhood and regional scales. Ozone monitoring networks are designed to monitor areas with high population densities, areas with high pollutant concentrations, areas impacted by major pollutant sources, and areas representative of background concentrations. Among the ozone monitors operating in the Valley, the majority are suitably located to measure

[1] San Joaquin Valley Air Pollution Control District [SJVAPCD]. (2011). *2011 Air Monitoring Network Plan.* Fresno, CA: June 30, 2011 submittal to EPA. Available at http://www.valleyair.org/aqinfo/Docs/2011/1_2011AirMonitoringNetworkPlanandAppendixA_Final2.pdf
[2] 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/

representative concentrations in areas of high population density, while the remaining monitors are located in high ozone concentration areas, areas intended to measure air moving into Fresno and Bakersfield, and remote areas to measure background ozone concentrations. The Valley's State and Local Air Monitoring Stations (SLAMS) ozone monitors are continuous analyzers that detect ozone through ultraviolet absorption. As continuous devices, these monitors meet the timely and public monitoring objectives, providing District staff with the data used in Air Quality Index forecasting and reporting.

**Figure A-1 Monitoring Network within the San Joaquin Valley**

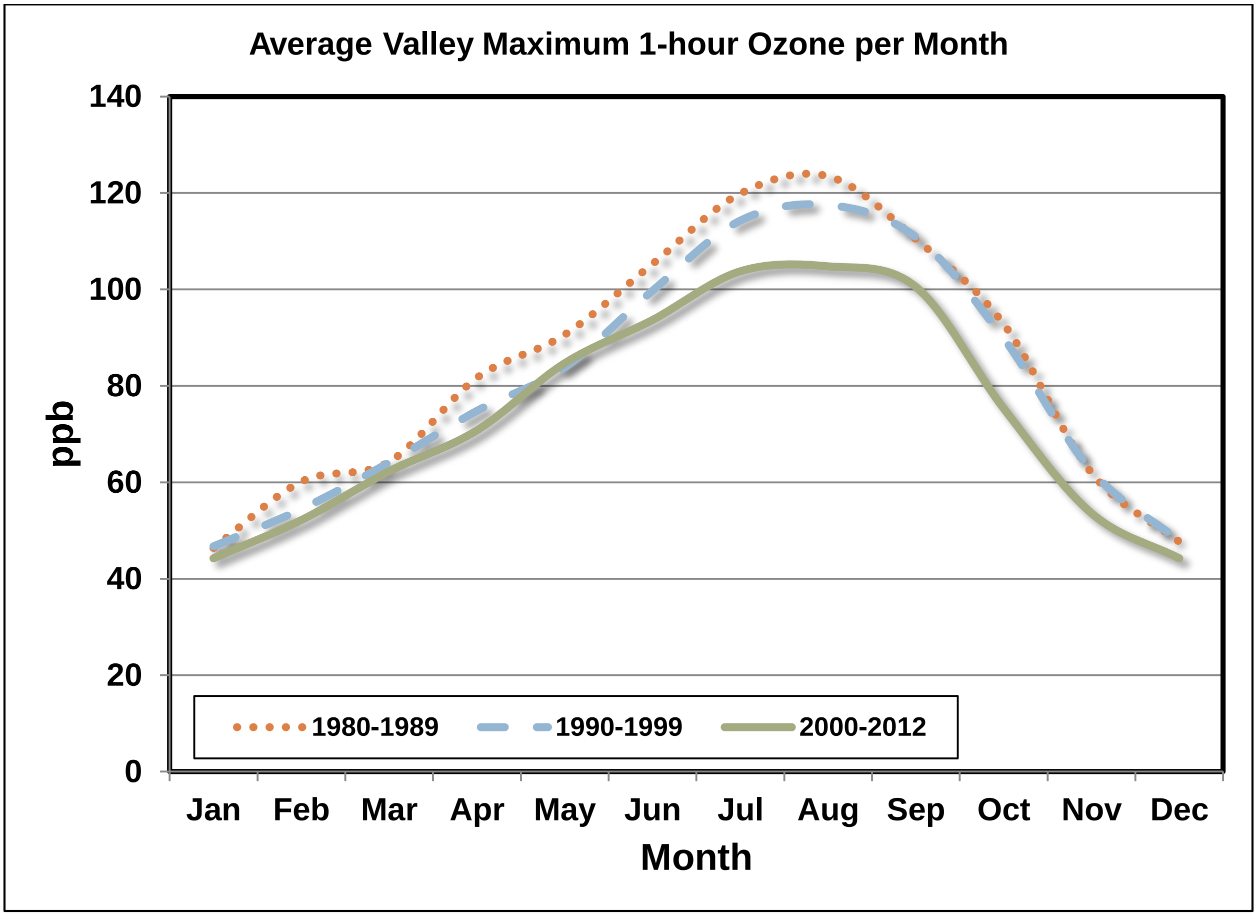


## A.3 Effect of the Natural Environment On Ozone In The Valley

### A.3.1 Meteorology

The peak of ozone season occurs during the summer months. Figure A-2 shows the average basin maximum ozone concentration per month in the Valley for both past and recent time periods.

**Figure A-2 Peak Concentrations during Ozone Season**

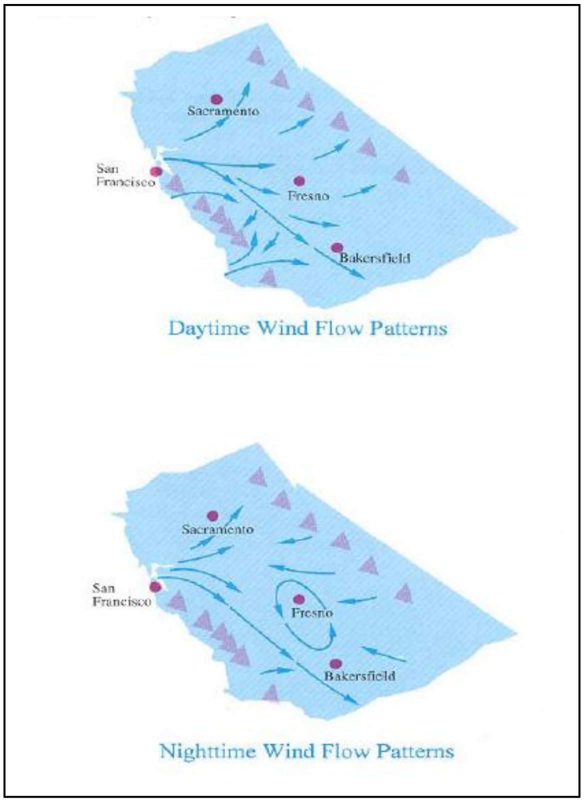



The Valley is located in a semi-arid climate characterized by long, hot, dry summers and mild winters. During the summer, the presence of high pressure over the eastern Pacific Ocean and a thermal low pressure system over the Desert Southwest produces hot, dry conditions and causes thermally driven wind flow patterns across the Valley. Such conditions cause poor dispersion and stagnation which are conducive to the formation of elevated ozone concentrations in the Valley. Atmospheric stability causes ozone precursors to accumulate over time.

Wind speed and direction play an important role in the dispersion and transport of air pollutants. Wind directs ozone precursors downwind from emission sources where ozone formation occurs. The dominant wind flow pattern during the daytime in the

Valley is from the northwest to the southeast. Figure A-3 depicts typical daytime and nighttime wind flow patterns during the ozone season in the Valley.

**Figure A-3 San Joaquin Valley Wind Patterns during the Ozone Season**




Surface winds enter the Valley from the northwest through the Delta, and also through passes in the Coastal Range. The airflow generally moves from Stockton to Bakersfield, carrying ozone and its precursor emissions that contribute to ozone formation. While the effect of the transport is seen in the accumulation of ozone in the central and southern portions of the Valley, high ozone levels also occur closer to emission sources. Historically, the city of Parlier (down-wind of Fresno) and the communities of Edison and Arvin (down-wind of Bakersfield) have often experienced the highest ozone levels in the Valley. In recent years, high ozone levels have also occurred in the cities of Clovis and Fresno.

Ozone is also transported out of the Valley as air flows over the Tehachapi Mountains (southeast of Bakersfield) into the Mojave Desert during the daytime. Additionally, daytime heating causes air to flow upslope and carry ozone into the Sierra Nevada and coastal mountains.

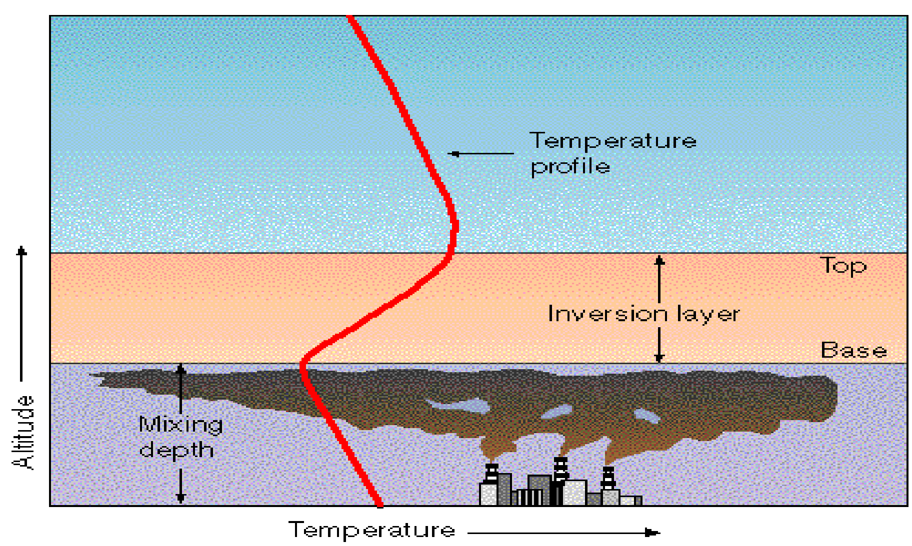
At night, the general northwest to southeast surface wind flow pattern continues along the western parts of the Valley; however, some nighttime wind circulation changes also occur:

1) The airflow is no longer able to exit the southern end of the Valley because it encounters cooler drainage winds from the surrounding mountains.
2) A nocturnal jet stream approximately 1,000 feet above the surface flows at speeds up to 33 miles per hour (mph), transporting air into the southern portion of the Valley (over the western parts of the Valley); however, the mountains surrounding the southern end of the Valley cause the air to turn counterclockwise and flow back toward the north along the eastern edge of the Valley. This flow, referred to as the Fresno eddy, circulates the pollution plume back toward Fresno, where it accumulates more ozone precursors.
3) Pollutants carried upslope the mountains during the day via daytime heating are then carried downslope back toward the Valley floor via mountain breezes caused by nocturnal surface cooling.

**Temperature Inversion**

Vertical mixing of the air mass can result from atmospheric instability. A temperature inversion, or increasing temperature with increasing height (Figure A-4), can shut down the vertical mixing of an air mass, thus creating a situation in which pollutants are trapped near the surface. Temperature inversions are common in the Valley throughout the year. Since the inversion is often lower than the height of the surrounding mountain ranges, the Valley effectively becomes a bowl capped with a lid that traps pollution near the surface. When horizontal dispersion (transport flow) and vertical dispersion (rising air) are minimized, ozone concentrations can rapidly build, especially during the summer.

**Figure A-4 Effect of Temperature Inversion on Pollutant Dispersion**



When high pressure is dominating the weather pattern during the overnight and early morning hours, a surface based temperature inversion forms. The morning inversion erodes during the day with daytime heating. Depending on the atmospheric conditions, inversions may not erode completely and, in some cases, pooling of ozone aloft can occur. Subsequently, the next day's heating and vertical mixing mechanisms enable the "ozone" pollutant pool aloft to mix down and accumulate with the new ozone being formed at the surface, causing higher ozone concentrations to occur.

**Radiation Inversion**

During many high ozone events, the Valley is likely experiencing a combination of radiation and subsidence inversions. A radiation inversion is primarily caused by overnight cooling of the air near the Earth's surface. The radiation inversion extends upward several hundred feet from the ground and occurs during the evening and early morning hours. During a radiation inversion, little vertical and horizontal mixing occurs, which minimizes pollutant dispersal. At daybreak, the sun begins to heat the ground, which in turn heats the lower layers of the atmosphere and eventually erodes or breaks the inversion, thereby facilitating pollutant dispersal. As daytime heating increases the height of the inversion rises and can range from 2,000 to over 5,000 feet, and even higher over mountain ranges due to heating of the slopes. On the worst dispersion days the inversion may remain only a few hundred feet above the surface of the Valley.

**Subsidence Inversion**

Subsidence inversions are caused by downward motion (subsidence), high in the atmosphere, and help reinforce the "lid" that traps pollutants at the surface. Subsidence inversions are typically associated with a ridge of high pressure over California. The ridge results in sinking air causing strengthening stability (poor dispersion) and clear skies.

During strong high pressure events, temperature inversions strengthen, air pollutant emissions build up in the atmosphere below the inversion. In the presence of sunlight; ozone precursors then react to form ozone, and levels increase from day to day. 1-hour concentrations of ozone that exceed federal standards typically occur in the Valley when strong inversions and light winds are present.

### A.3.2 Wildfires

Wildfires emit particulates and ozone precursors into the atmosphere, which are then carried away by the wind. Although particulates in the smoke plume can slightly reduce ozone formation rates by blocking sunlight, the precursors still have the potential to react and form ozone. A single 1,000-acre wildfire can generate particulate matter and ozone precursors that are up to three times higher than the Valley's daily total emission inventory. Intense wildfires can consume 1,000 acres in a matter of minutes, while less intense wildfires may take several days or weeks.

Wildfires have been linked to increased ozone concentrations in the Valley. For example in 2008, California experienced a record number of wildfires: a total of 6,255 fires burned 1,593,690 acres.[3] The resulting emissions caused serious public health impacts and unprecedented levels of particulate matter and ozone in the Valley and other regions throughout the state. Historically clean rural areas experienced their worst air quality in decades. Throughout the Valley, pollutant levels and the number of daily exceedances of the health-based standards in 2008 were significantly higher than other recent years.

With proper documentation and EPA concurrence, data influenced by exceptional events like wildfires can be excluded from official attainment demonstration calculations. Such documentation is extensive and requires significant District resources.[4] But since exceptional events are not reasonably preventable or controllable, it is inappropriate to use data influenced by these events without recognition of these circumstances.

EPA generally reviews only those requests that will directly affect an area’s attainment status. 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 ozone concentrations and attainment progress.

## A.4 EXCEEDANCE DAY TRENDS

### A.4.1 Exceedance Days as the Attainment Test

If any monitoring site in the Valley does not meet the federal 1-hour ozone standard, then the entire Valley is deemed as not demonstrating attainment of the standard, also referred to as “nonattainment”. The 1-hour ozone standard is 0.12 parts per million (ppm) rounded to the closest one hundredth. Thus, 1-hour ozone concentrations at or greater than 0.125 ppm are above the standard, and 1-hour ozone concentrations at or lower than 0.124 ppm meet the standard. If any hour in a day is above the standard, then that day is an exceedance day. The highest hourly concentration on a given day is

[3] CALFire 2008 Fire Summary, http://www.fire.ca.gov/downloads/redbooks/2008/02-wildland-statistic-all-agencies/11-2008-FIRE-SUMMARY.pdf

[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)

recorded as the 1-hour ozone concentration for that day (though all hourly concentrations are kept on record and analyzed as well).

The attainment test for the 1-hour ozone standard is based on the number of exceedance days per year, averaged over a three-year period. A site with an average of 1.0 or fewer exceedance days per year, as averaged over a three-year period, meets the standard. In other words, if the site has 3 or fewer exceedance days in a three-year period, it meets the standard; if that site has more than 3 exceedance days in a three-year period, then it does not meet the standard.

Table A-1 shows the number of exceedance days per year, per monitoring site in the Valley. The attainment test results are shown in Table A-2, which displays the three-year average number of days over the standard for each site over the time period of 1990-2012. The cells shaded red signify the attainment test resulting in an average over 1.0, indicating non-attainment. This data shows that the counties of Fresno and Kern have historically had a number of air monitoring sites that had not yet met the 1-hour ozone attainment test. However, the averages have decreased substantially since the 1990s. Over the 1990-2012 time period, the highest Valley maximum 3-year average occurred in 1993-1995, with 30.67 exceedance days. Comparing this to the maximum average value in 2010-2012, which was 1.67, this metric has decreased by over 94%.

The 3-year average of 2009-2011 had only two sites that failed the attainment test, those being Clovis and Arvin-Bear Mountain. The average during the 3-year timeframe of 2010-2012 had only the Clovis and Fresno-Drummond sites fail the attainment test. Since the Arvin-Bear Mountain site was closed in December 2010, the 3-year averages for 2009-2011 and 2010-2012 were not included in Table A-2 due to incomplete data. The Valley continues to be very close to attaining this standard, and compared to the average values 20 years ago, the region has a come a long way in reducing ozone concentrations and meeting this goal.

## Table A-1 1-Hour Ozone Exceedance Days by Site per Year from 1990-2012

| Monitoring Site | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **San Joaquin County** | | | | | | | | | | | | | | | | | | | | | | | |
| Stockton-Hazelton Street | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tracy-Airport | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Stanislaus County** | | | | | | | | | | | | | | | | | | | | | | | |
| Modesto-14th Street | 1 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| Turlock-S Minaret Street | -- | -- | 0 | 2 | 0 | 2 | 1 | 0 | 4 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 3 | 1 | 0 | 0 | 0 |
| **Merced County** | | | | | | | | | | | | | | | | | | | | | | | |
| Merced-S Coffee Avenue | -- | 2 | 0 | 1 | 0 | 3 | 1 | 0 | 3 | 2 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 |
| **Madera County** | | | | | | | | | | | | | | | | | | | | | | | |
| Madera-28261 Avenue 14 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0 | 0 | 0 |
| Madera-Pump Yard | -- | -- | -- | -- | -- | -- | -- | -- | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Fresno County** | | | | | | | | | | | | | | | | | | | | | | | |
| Clovis-N Villa Avenue | 1 | 3 | 17 | 13 | 9 | 7 | 16 | 9 | 26 | 5 | 8 | 10 | 7 | 1 | 1 | 2 | 2 | 0 | 5 | 0 | 3 | 2 | 0 |
| Fresno-1st Street | 8 | 27 | 12 | 11 | 7 | 14 | 15 | 1 | 15 | 4 | 5 | 5 | 11 | 5 | 0 | 3 | 4 | 0 | 7 | 0 | 2 | 0 | -- |
| Fresno-Garland | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 1 |
| Fresno-Drummond Street | 7 | 8 | 7 | 5 | 0 | 0 | 8 | 1 | 8 | 4 | 2 | 1 | 9 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1* |
| Fresno-Sierra Skypark | 1 | 5 | 3 | 6 | 3 | 3 | 5 | 1 | 13 | 1 | 8 | 10 | 15 | 1 | 0 | 2 | 1 | 0 | 2 | 0 | 2 | 0 | 1 |
| Parlier | 5 | 14 | 12 | 10 | 3 | 9 | 18 | 9 | 13 | 15 | 17 | 12 | 21 | 14 | 0 | 1 | 1 | 0 | 2 | 0 | 1 | 1 | 1 |
| Tranquillity | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0 | 0 | 0 |
| **Kings County** | | | | | | | | | | | | | | | | | | | | | | | |
| Hanford-S Irwin Street | -- | -- | -- | -- | 0 | 0 | 8 | 2 | 3 | 2 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | -- | -- | 2 | 0 | 0 |
| Corcoran-Patterson Avenue | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 3 | 0 | -- | -- | -- |
| Santa Rosa Rancheria | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0 | 2 | 0 | 0 | 0 | 0 |
| **Tulare County** | | | | | | | | | | | | | | | | | | | | | | | |
| Porterville | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0 | 0 | 0 |
| Ash Mountain - SNP | -- | -- | -- | -- | -- | -- | -- | -- | -- | 2 | 0 | 0 | 1 | 2 | 0 | 1 | 0 | 0 | 5 | 0 | 0 | 0 | 0 |
| Lower Kaweah - SNP | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| Visalia-N Church Street | 1 | 1 | 2 | 9 | 10 | 2 | 4 | 1 | 6 | 1 | 1 | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 |
| **Kern County** | | | | | | | | | | | | | | | | | | | | | | | |
| Arvin-Di Giorgio | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0 | 0 | 0 |
| Arvin-Bear Mountain Blvd | 23 | 28 | 9 | 13 | 17 | 19 | 37 | 7 | 12 | 9 | 9 | 16 | 15 | 26 | 8 | 6 | 12 | 3 | 14 | 3 | 2 | -- | -- |
| Bakersfield-5558 California Avenue | -- | -- | -- | -- | 0 | 2 | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| Bakersfield-Golden State Avenue | -- | -- | -- | -- | 0 | 1 | 3 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | -- | -- | -- | -- |
| Edison | 22 | 22 | 3 | 27 | 31 | 34 | 25 | 3 | 22 | 5 | 9 | 6 | 8 | 3 | 1 | 0 | 9 | 1 | 5 | 2 | 1 | 0 | 0 |
| Maricopa-Stanislaus Street | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Oildale-3311 Manor Street | 1 | 1 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Shafter-Walker Street | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| **Basin** | **45** | **51** | **29** | **43** | **43** | **44** | **56** | **16** | **39** | **28** | **30** | **32** | **31** | **37** | **9** | **8** | **18** | **3** | **19** | **4** | **7** | **3** | **3** |

*The 1-hour ozone exceedance at the Fresno-Drummond air monitoring site on August 10, 2012 has been flagged as an exceptional event due to a fire that potentially caused the exceedance. As an exceptional event, this exceedance would not be counted toward attainment determination, upon concurrence by EPA.

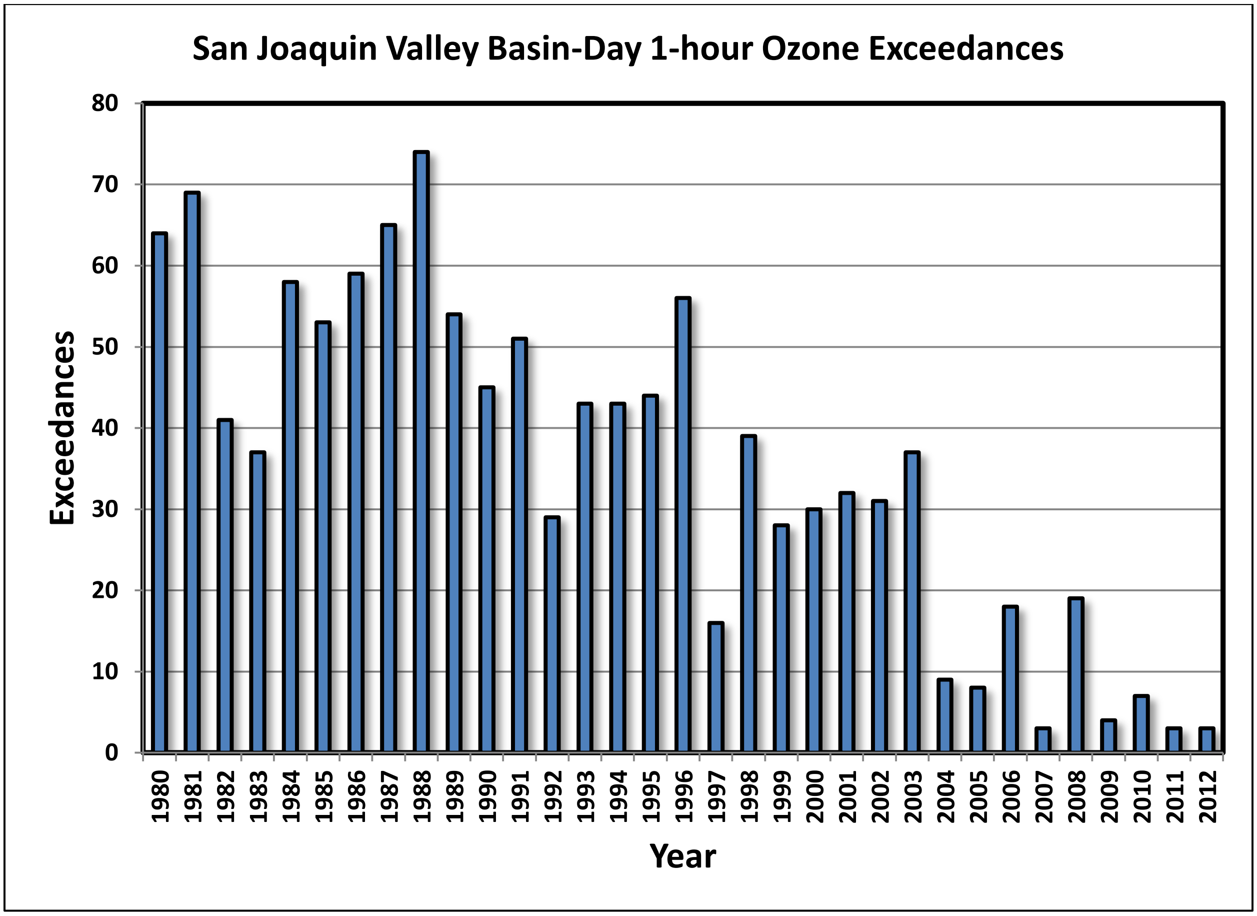
## Table A-2 Attainment Test: Number of Exceedance Days per 3-Year Averaging Period from 1990 to 2012

| Monitoring Site | 1990-92 | 1991-93 | 1992-94 | 1993-95 | 1994-96 | 1995-97 | 1996-98 | 1997-99 | 1998-00 | 1999-01 | 2000-02 | 2001-03 | 2002-04 | 2003-05 | 2004-06 | 2005-07 | 2006-08 | 2007-09 | 2008-10 | 2009-11 | 2010-12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **San Joaquin County** | | | | | | | | | | | | | | | | | | | | | |
| Stockton-Hazelton Street | 0.00 | 0.00 | 0.33 | 0.67 | 0.67 | 0.33 | 0.33 | 1.00 | 1.00 | 0.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Tracy-Airport | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **Stanislaus County** | | | | | | | | | | | | | | | | | | | | | |
| Modesto-14th Street | 0.33 | 0.00 | 0.00 | 0.67 | 1.33 | 1.33 | 1.67 | 1.00 | 1.33 | 0.33 | 0.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.33 | 0.33 | 0.33 | 0.00 | 0.00 |
| Turlock-S Minaret Street | -- | -- | 0.67 | 1.33 | 1.00 | 1.00 | 1.67 | 1.33 | 1.67 | 0.33 | 0.67 | 0.33 | 0.33 | 0.00 | 0.00 | 0.00 | 1.00 | 1.33 | 1.33 | 0.33 | 0.00 |
| **Merced County** | | | | | | | | | | | | | | | | | | | | | |
| Merced-S Coffee Avenue | -- | 1.00 | 0.33 | 1.33 | 1.33 | 1.33 | 1.33 | 1.67 | 1.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.00 | 0.00 | 0.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 |
| **Madera County** | | | | | | | | | | | | | | | | | | | | | |
| Madera-28261 Avenue 14 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0.00 |
| Madera-Pump Yard | -- | -- | -- | -- | -- | -- | -- | -- | 0.67 | 0.00 | 0.67 | 0.67 | 0.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **Fresno County** | | | | | | | | | | | | | | | | | | | | | |
| Clovis-N Villa Avenue | 7.00 | 11.00 | 13.00 | 9.67 | 10.67 | 10.67 | 17.00 | 13.33 | 13.00 | 7.67 | 8.33 | 6.00 | 3.00 | 1.33 | 1.67 | 1.33 | 2.33 | 1.67 | 2.67 | 1.67 | 1.67 |
| Fresno-1st Street | 15.67 | 16.67 | 10.00 | 10.67 | 12.00 | 10.00 | 10.33 | 6.67 | 8.00 | 4.67 | 7.00 | 7.00 | 5.33 | 2.67 | 2.33 | 2.33 | 3.67 | 2.33 | 3.00 | 0.67 | -- |
| Fresno-Garland | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Fresno-Drummond Street | 7.33 | 6.67 | 4.00 | 1.67 | 2.67 | 3.00 | 5.67 | 4.33 | 4.67 | 2.33 | 4.00 | 4.67 | 4.33 | 1.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 | 1.00* |
| Fresno-Sierra Skypark | 3.00 | 4.67 | 4.00 | 4.00 | 3.67 | 3.00 | 6.33 | 5.00 | 7.33 | 6.33 | 11.00 | 8.67 | 5.33 | 1.00 | 1.00 | 1.00 | 1.00 | 0.67 | 1.33 | 0.67 | 1.00 |
| Parlier | 10.33 | 12.00 | 8.33 | 7.33 | 10.00 | 12.00 | 13.33 | 12.33 | 15.00 | 14.67 | 16.67 | 15.67 | 11.67 | 5.00 | 0.67 | 0.67 | 1.00 | 0.67 | 1.00 | 0.67 | 1.00 |
| Tranquillity | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0.00 |
| **Kings County** | | | | | | | | | | | | | | | | | | | | | |
| Hanford-S Irwin Street | -- | -- | -- | -- | 2.67 | 3.33 | 4.33 | 2.33 | 1.67 | 1.00 | 0.67 | 0.67 | 0.33 | 0.00 | 0.33 | 0.33 | -- | -- | -- | -- | 0.67 |
| Corcoran-Patterson Avenue | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Santa Rosa Rancheria | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0.67 | 0.67 | 0.00 | 0.00 |
| **Tulare County** | | | | | | | | | | | | | | | | | | | | | |
| Porterville | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0.00 |
| Ash Mountain - SNP | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0.67 | 0.33 | 1.00 | 1.00 | 1.00 | 0.33 | 0.33 | 1.67 | 1.67 | 1.67 | 0.00 | 0.00 |
| Lower Kaweah - SNP | 0.00 | 0.67 | 1.00 | 1.00 | 0.33 | 0.00 | 0.33 | 0.33 | 0.33 | 0.00 | 0.33 | 0.33 | 0.33 | 0.00 | 0.00 | 0.00 | 0.33 | 0.33 | 0.33 | 0.00 | 0.00 |
| Visalia-N Church Street | 1.33 | 4.00 | 7.00 | 7.00 | 5.33 | 2.33 | 3.67 | 2.67 | 2.67 | 1.33 | 1.33 | 1.00 | 0.67 | 0.33 | 0.33 | 0.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 |
| **Kern County** | | | | | | | | | | | | | | | | | | | | | |
| Arvin-Di Giorgio | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0.00 |
| Arvin-Bear Mountain Blvd | 20.00 | 16.67 | 13.00 | 16.33 | 24.33 | 21.00 | 18.67 | 9.33 | 10.00 | 11.33 | 13.33 | 19.00 | 16.33 | 13.33 | 8.67 | 7.00 | 9.67 | 6.67 | 6.33 | -- | -- |
| Bakersfield-5558 California Avenue | -- | -- | -- | -- | 1.67 | 1.67 | 1.00 | 0.00 | 0.33 | 0.67 | 0.67 | 0.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.33 | 0.33 | 0.33 | 0.00 | 0.00 |
| Bakersfield-Golden State Avenue | -- | -- | -- | -- | 1.33 | 1.33 | 1.33 | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 | 0.00 | 0.00 | 0.00 | 0.33 | 0.33 | -- | -- | -- | -- |
| Edison | 15.67 | 17.33 | 20.33 | 30.67 | 30.00 | 20.67 | 16.67 | 10.00 | 12.00 | 6.67 | 7.67 | 5.67 | 4.00 | 1.33 | 3.33 | 3.33 | 5.00 | 2.67 | 2.67 | 1.00 | 0.33 |
| Maricopa-Stanislaus Street | 0.00 | 0.00 | 0.00 | 0.33 | 0.33 | 0.33 | 2.67 | 2.67 | 2.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Oildale-3311 Manor Street | 0.67 | 0.33 | 0.00 | 0.33 | 1.00 | 1.00 | 0.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Shafter-Walker Street | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.33 | 0.33 | 0.33 | 0.00 | 0.00 |
| **Maximum** | 20.00 | 17.33 | 20.33 | 30.67 | 30.00 | 21.00 | 18.67 | 13.33 | 15.00 | 14.67 | 16.67 | 19.00 | 16.33 | 13.33 | 8.67 | 7.00 | 9.67 | 6.67 | 6.33 | 1.67 | 1.67 |

*The 1-hour ozone exceedance that occurred at the Fresno-Drummond air monitoring site on August 10, 2012 is being evaluated as a possible exceptional event. Upon formal documentation of the event and concurrence by EPA, this data point would be removed from attainment calculations for the District.

Figure A-5 shows for each year from 1980-2012 the number of days that at least one air monitoring site in the Valley exceeded of the 1-hour ozone standard, also referred to as a "basin-day". Since 1980, basin-day exceedances of the 1-hour ozone standard have sharply declined, decreasing by over 95%.

**Figure A-5 Basin-Day Exceedances per Year**




### A.4.2 Where Do Exceedance Days Occur?

The following figures (Figures A-6 through A-9) show the decreasing trends in exceedance days over time at some of the Valley monitoring sites that have historically experienced the highest 1-hour ozone concentrations.

Note that the Fresno-First Street site was closed in 2011 and moved two blocks north to the Fresno-Garland Avenue site. Based on previous analysis and the close proximity of these locations, observations from these two sites were merged into a single continuous data record for the following analyses.

**Figure A-6 Exceedance Day Trend at Fresno-First (Garland 2012)**

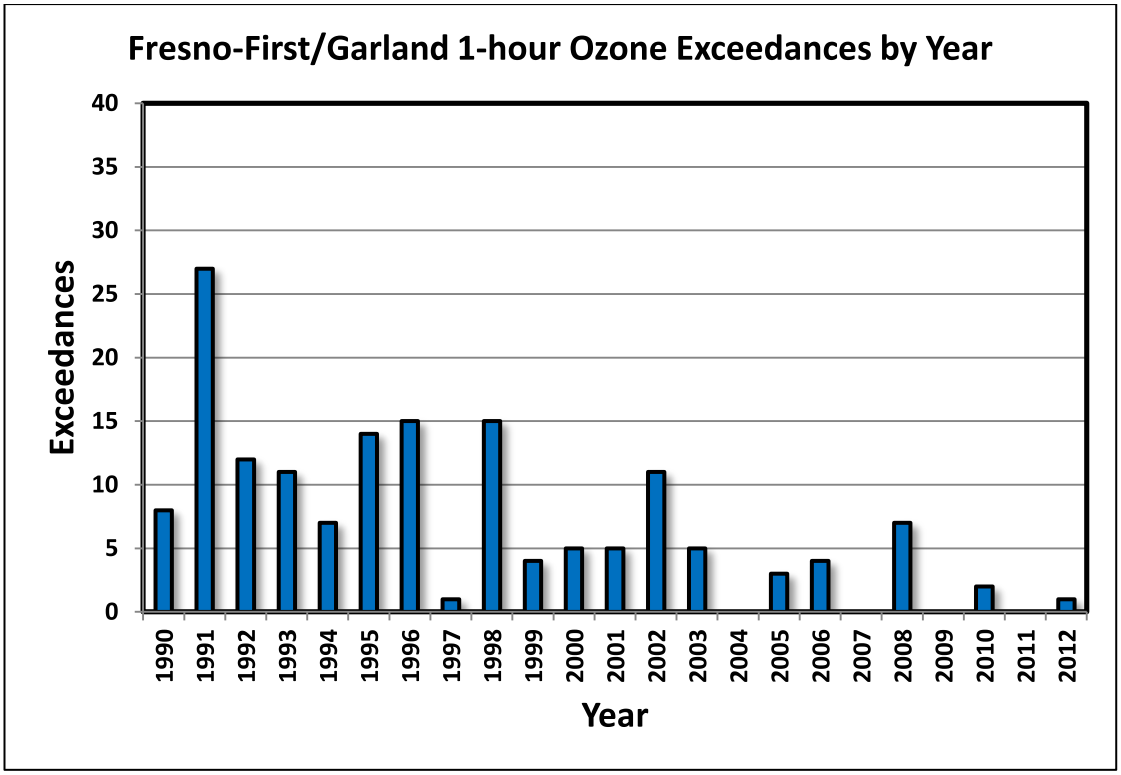



**Figure A-7 Exceedance Day Trend at Parlier**

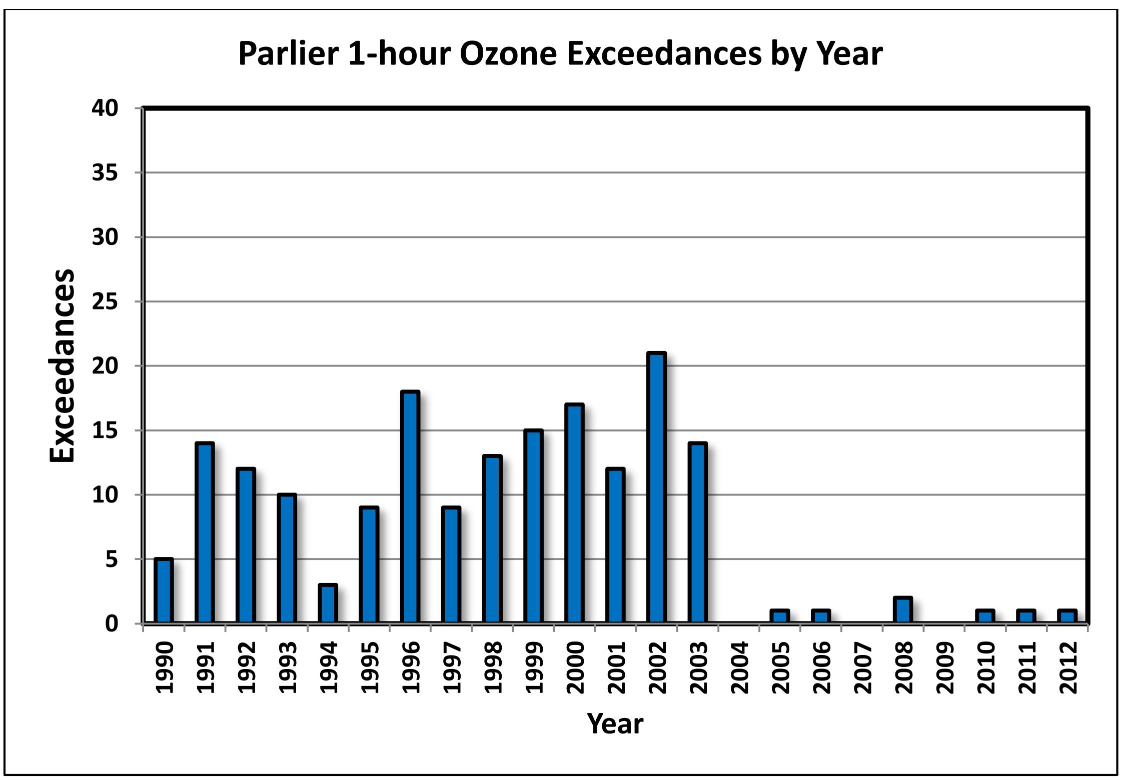


**Figure A-8 Exceedance Day Trend at Edison**

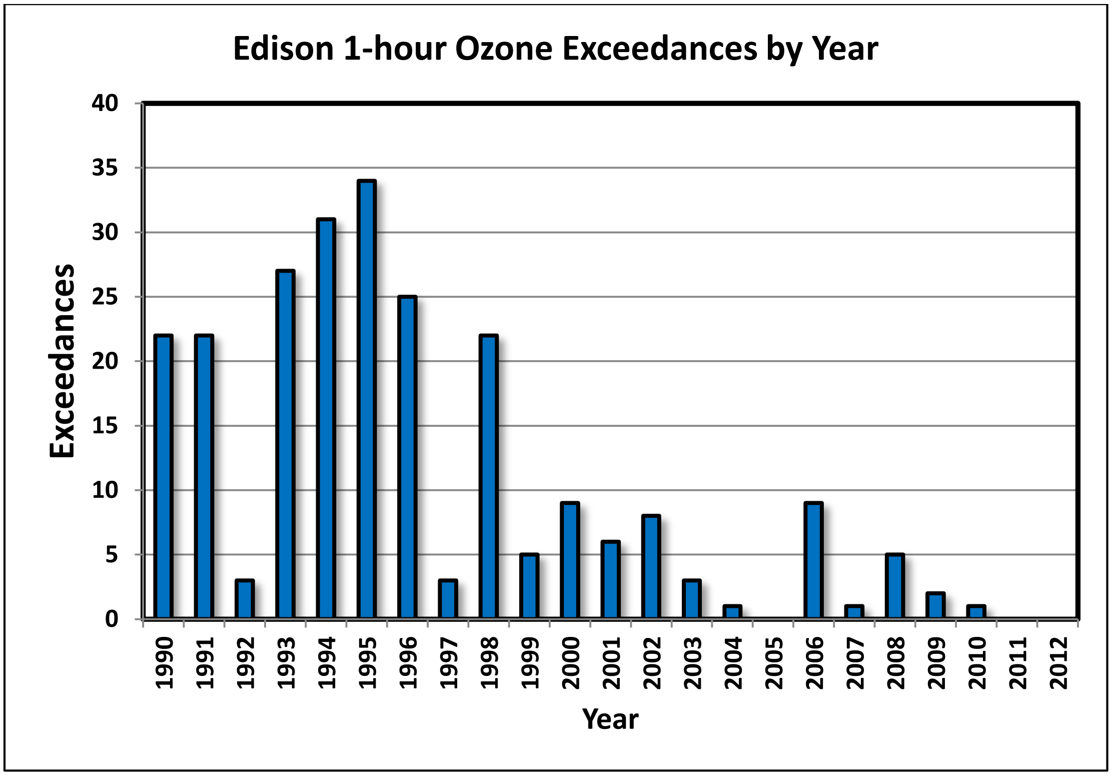



**Figure A-9 Exceedance Day Trend at Arvin-Bear Mountain**

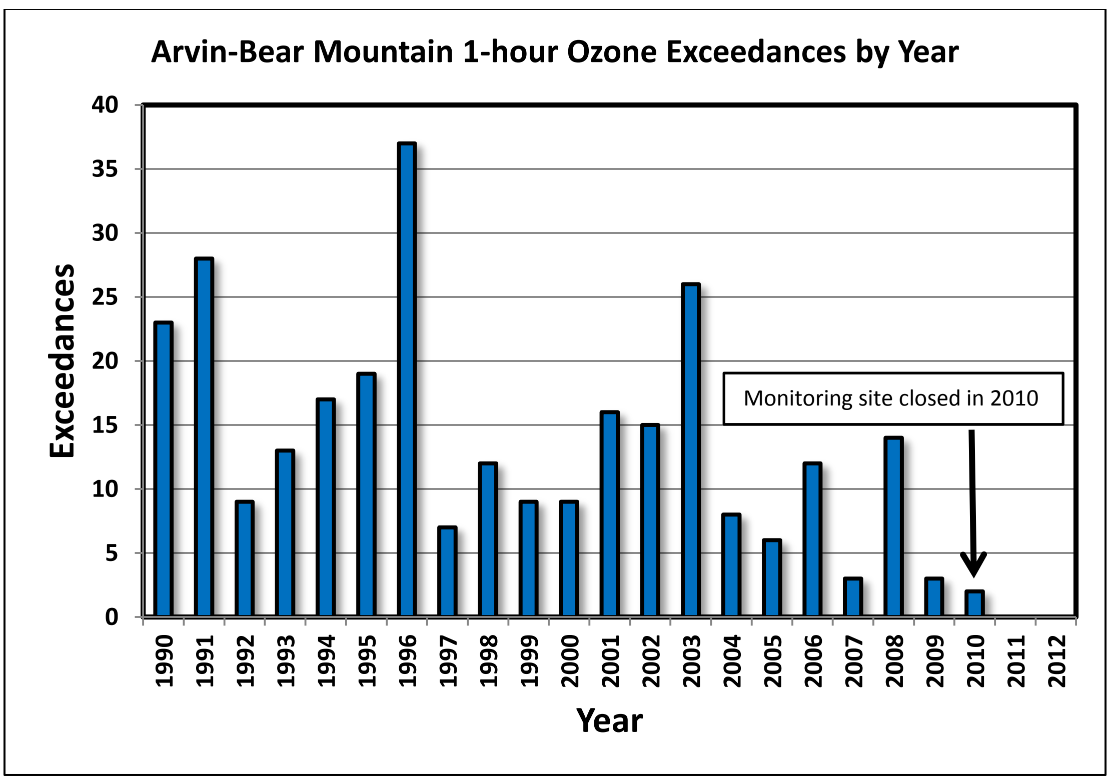


Table A-3 shows the number of days over the standard by county. Historically, 1-hour ozone exceedances have been most common in Fresno and Kern counties, while days over the standard in the northern portion of the Valley have been and continue to be rare. In the last two years, 2011 and 2012, 1-hour ozone exceedances have been restricted to Fresno County only. Comparing this to 1996, when exceedances occurred in every county, it is apparent that the peak ozone problem that was once a Valley-wide problem has now narrowed to a smaller portion of the Valley.

### Table A-3 1-hour Ozone Exceedance Days by County per Year from 1980-2012[5]

| Year | San Joaquin | Stanislaus | Merced | Madera | Fresno | Kings | Tulare | Kern | Basin |
|---|---|---|---|---|---|---|---|---|---|
| 1980 | 6 | 2 | -- | -- | 54 | 1 | 10 | 23 | **64** |
| 1981 | 4 | 11 | -- | -- | 36 | 0 | 2 | 50 | **69** |
| 1982 | 1 | 0 | -- | -- | 26 | 0 | 13 | 21 | **41** |
| 1983 | 4 | 5 | -- | -- | 23 | 1 | 4 | 20 | **37** |
| 1984 | 4 | 13 | -- | -- | 38 | 0 | 3 | 26 | **58** |
| 1985 | 5 | 10 | -- | -- | 34 | 2 | 6 | 27 | **53** |
| 1986 | 3 | 2 | -- | -- | 39 | 0 | 13 | 33 | **59** |
| 1987 | 1 | 18 | -- | -- | 43 | 2 | 10 | 45 | **65** |
| 1988 | 4 | 5 | -- | 1 | 47 | 3 | 4 | 56 | **74** |
| 1989 | 0 | 3 | -- | 0 | 24 | 1 | 10 | 42 | **54** |
| 1990 | 1 | 3 | -- | 0 | 14 | 0 | 1 | 37 | **45** |
| 1991 | 0 | 0 | 2 | 2 | 30 | 0 | 1 | 37 | **51** |
| 1992 | 0 | 0 | 0 | 0 | 25 | 0 | 2 | 10 | **29** |
| 1993 | 1 | 2 | 1 | 6 | 19 | 0 | 10 | 37 | **43** |
| 1994 | 1 | 0 | 0 | 0 | 14 | 0 | 12 | 37 | **43** |
| 1995 | 2 | 2 | 3 | 0 | 22 | 0 | 3 | 38 | **44** |
| 1996 | 2 | 2 | 1 | 2 | 31 | 8 | 4 | 44 | **56** |
| 1997 | 0 | 0 | 0 | 0 | 13 | 2 | 1 | 8 | **16** |
| 1998 | 1 | 4 | 3 | 2 | 30 | 3 | 6 | 29 | **39** |
| 1999 | 3 | 0 | 2 | 0 | 18 | 2 | 3 | 12 | **28** |
| 2000 | 0 | 1 | 0 | 0 | 23 | 0 | 1 | 16 | **30** |
| 2001 | 0 | 0 | 0 | 0 | 21 | 1 | 2 | 16 | **32** |
| 2002 | 0 | 1 | 2 | 2 | 25 | 1 | 3 | 17 | **31** |
| 2003 | 0 | 0 | 0 | 0 | 17 | 0 | 3 | 28 | **37** |
| 2004 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 8 | **9** |
| 2005 | 0 | 0 | 0 | 0 | 5 | 0 | 1 | 6 | **8** |
| 2006 | 0 | 0 | 0 | 0 | 5 | 1 | 0 | 15 | **18** |
| 2007 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | **3** |
| 2008 | 0 | 3 | 3 | 0 | 9 | 3 | 6 | 14 | **19** |
| 2009 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 3 | **4** |
| 2010 | 0 | 0 | 0 | 0 | 5 | 2 | 0 | 2 | **7** |
| 2011 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | **3** |
| 2012 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | **3** |

[5] The basin total is not the sum of the individual counties. A basin exceedance day is any day where at least one site in the basin (in one or more counties) recorded an exceedance day.

### A.4.3 When Are Exceedance Days Occurring?

**Exceedance Days by Month**

Not only are 1-hour ozone exceedance days now limited to a smaller geographical area than in the past (as discussed above), but 1-hour ozone exceedances are now limited to a smaller window of time than they once were.

Table A-4 shows the number of basin-days over the standard for each year and for each month from 1980 through 2012. The cells in Table A-4 are shaded according to the magnitude of the value, where the highest numbers are shaded a darker color of red and progressing toward values of zero with no shading.

In past years, 1-hour ozone exceedances used to occur as early as the spring months of March, April, and May, with maximum frequency occurring through the summer, and extending into the fall months of October and November. In recent years, days over the 1-hour ozone standard are only occurring during the months of June to September. Ozone has become a much more focused summer time issue, and is less of a concern during the spring and fall.

## Table A-4 1-hour Ozone Basin Exceedances by Month per Year from 1980-2012

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Sum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1980 | 0 | 0 | 0 | 1 | 2 | 4 | 16 | 10 | 13 | 14 | 4 | 0 | 64 |
| 1981 | 0 | 0 | 0 | 3 | 1 | 13 | 22 | 21 | 9 | 0 | 0 | 0 | 69 |
| 1982 | 0 | 0 | 0 | 0 | 4 | 2 | 13 | 11 | 10 | 1 | 0 | 0 | 41 |
| 1983 | 0 | 0 | 0 | 0 | 5 | 2 | 8 | 8 | 11 | 3 | 0 | 0 | 37 |
| 1984 | 0 | 0 | 0 | 0 | 7 | 7 | 15 | 16 | 13 | 0 | 0 | 0 | 58 |
| 1985 | 0 | 0 | 0 | 4 | 1 | 11 | 12 | 14 | 6 | 5 | 0 | 0 | 53 |
| 1986 | 0 | 0 | 2 | 0 | 3 | 10 | 13 | 24 | 6 | 1 | 0 | 0 | 59 |
| 1987 | 0 | 0 | 0 | 5 | 2 | 10 | 6 | 17 | 15 | 10 | 0 | 0 | 65 |
| 1988 | 0 | 0 | 1 | 1 | 2 | 7 | 18 | 16 | 14 | 15 | 0 | 0 | 74 |
| 1989 | 0 | 0 | 0 | 2 | 0 | 4 | 17 | 9 | 13 | 8 | 1 | 0 | 54 |
| 1990 | 0 | 0 | 0 | 1 | 0 | 6 | 13 | 13 | 9 | 3 | 0 | 0 | 45 |
| 1991 | 0 | 0 | 0 | 0 | 0 | 3 | 10 | 9 | 14 | 15 | 0 | 0 | 51 |
| 1992 | 0 | 0 | 0 | 1 | 1 | 1 | 4 | 11 | 9 | 2 | 0 | 0 | 29 |
| 1993 | 0 | 0 | 0 | 0 | 0 | 7 | 7 | 11 | 14 | 4 | 0 | 0 | 43 |
| 1994 | 0 | 0 | 0 | 0 | 0 | 13 | 12 | 13 | 5 | 0 | 0 | 0 | 43 |
| 1995 | 0 | 0 | 0 | 0 | 1 | 5 | 9 | 18 | 11 | 0 | 0 | 0 | 44 |
| 1996 | 0 | 0 | 0 | 1 | 1 | 10 | 16 | 18 | 5 | 5 | 0 | 0 | 56 |
| 1997 | 0 | 0 | 0 | 0 | 1 | 2 | 4 | 6 | 3 | 0 | 0 | 0 | 16 |
| 1998 | 0 | 0 | 0 | 0 | 0 | 1 | 14 | 19 | 5 | 0 | 0 | 0 | 39 |
| 1999 | 0 | 0 | 0 | 0 | 1 | 1 | 6 | 6 | 12 | 2 | 0 | 0 | 28 |
| 2000 | 0 | 0 | 0 | 0 | 1 | 6 | 5 | 9 | 8 | 1 | 0 | 0 | 30 |
| 2001 | 0 | 0 | 0 | 0 | 7 | 6 | 5 | 8 | 3 | 3 | 0 | 0 | 32 |
| 2002 | 0 | 0 | 0 | 0 | 1 | 3 | 6 | 11 | 10 | 0 | 0 | 0 | 31 |
| 2003 | 0 | 0 | 0 | 0 | 3 | 6 | 8 | 6 | 14 | 0 | 0 | 0 | 37 |
| 2004 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 6 | 2 | 0 | 0 | 0 | 9 |
| 2005 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 1 | 2 | 0 | 0 | 0 | 8 |
| 2006 | 0 | 0 | 0 | 0 | 1 | 4 | 3 | 3 | 7 | 0 | 0 | 0 | 18 |
| 2007 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 3 |
| 2008 | 0 | 0 | 0 | 0 | 0 | 5 | 5 | 6 | 3 | 0 | 0 | 0 | 19 |
| 2009 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 4 |
| 2010 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 5 | 0 | 0 | 0 | 7 |
| 2011 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 3 |
| 2012 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 3 |

## Exceedance Days by Day of the Week

Anthropogenic ozone precursor emissions rates can vary day to day throughout the week based on human activity. For example, a weekday (Monday through Friday) will have a higher rate of emissions early in the morning and late in the afternoon during their respective rush hours, while a weekend (Saturday and Sunday) may have a more uniform rate of emissions throughout the day. These differences in activity can translate to higher ozone concentrations during specific times of the week.

In this analysis, the number of 1-hour ozone exceedances per day of the week were averaged over three separate 3-year periods: 1990-1992, 2000-2002, and 2010-2012. This analysis used the basin maximum 1-hour ozone value per day.

For the 1990-1992 time period displayed in Figure A-10, 1-hour ozone exceedances occurred more often on Monday, Tuesday, and Friday, with Wednesday close behind. The 1-hour ozone exceedances occurred less on Sunday. Since emissions levels were much higher in the early 1990s relative to recent years, exceedances were likely to happen any day of the week without any discernible pattern among the days of the week.

For the 2000-2002 time period shown in Figure A-11, the chart clearly shows a trend of fewer 1-hour ozone exceedances occurring at the beginning of the week and progressively having the most on Thursday. Sunday and Monday were the cleanest days of the week. As emissions were reduced through the 1990s and into the early 2000s, the lower emissions load in the Valley may have a required a multi-day buildup toward the end of the week in order for exceedances to become more frequent. This would explain the gradual increasing trend in the frequency of days over the 1-hour ozone standard toward the end of the week as emissions in the Valley continued to build upon itself from day to day toward the weekend.

The more recent 2010-2012 time period displayed in Figure A-12 shows that exceedances have become rare in the Valley for any day of the week, with Sunday and Monday having no 1-hour ozone exceedances. Exceedances of the 1-hour ozone standard occurred more often on Thursday, with Tuesday close behind. Similar to the 2000-2002 time period, days over the standard are still more frequent during the middle to the end of the week, showing evidence that a buildup is still required due to a reduced emissions load throughout the Valley. In addition, 1-hour ozone exceedances in recent years have required meteorology that was strongly conducive to ozone formation in order for concentrations to rise above the federal standard. These strong episodes have happened all days of the week in recent years during the summer, but exceedances still only occur in the middle to the end of the week, showing that a buildup is still necessary even under severe meteorology.

**Figure A-10 Average Frequency of 1-hour Ozone Exceedances per Year per Day of the Week from 1990-1992**

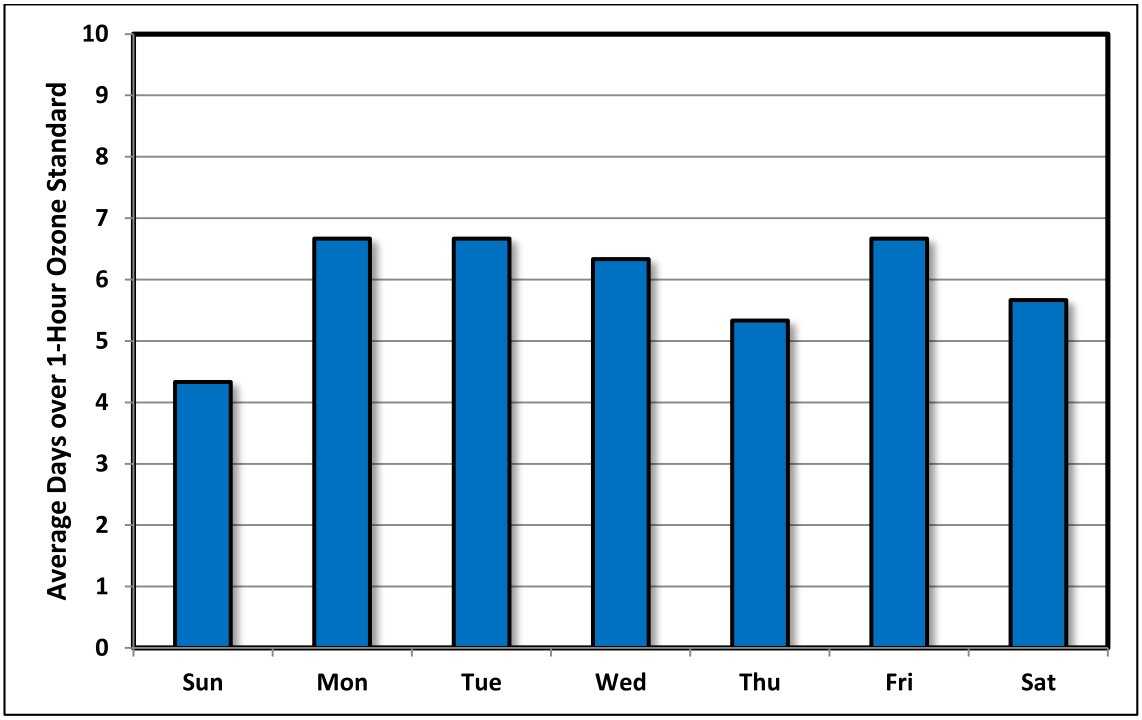



**Figure A-11 Average Frequency of 1-hour Ozone Exceedances per Year per Day of the Week from 2000-2002**

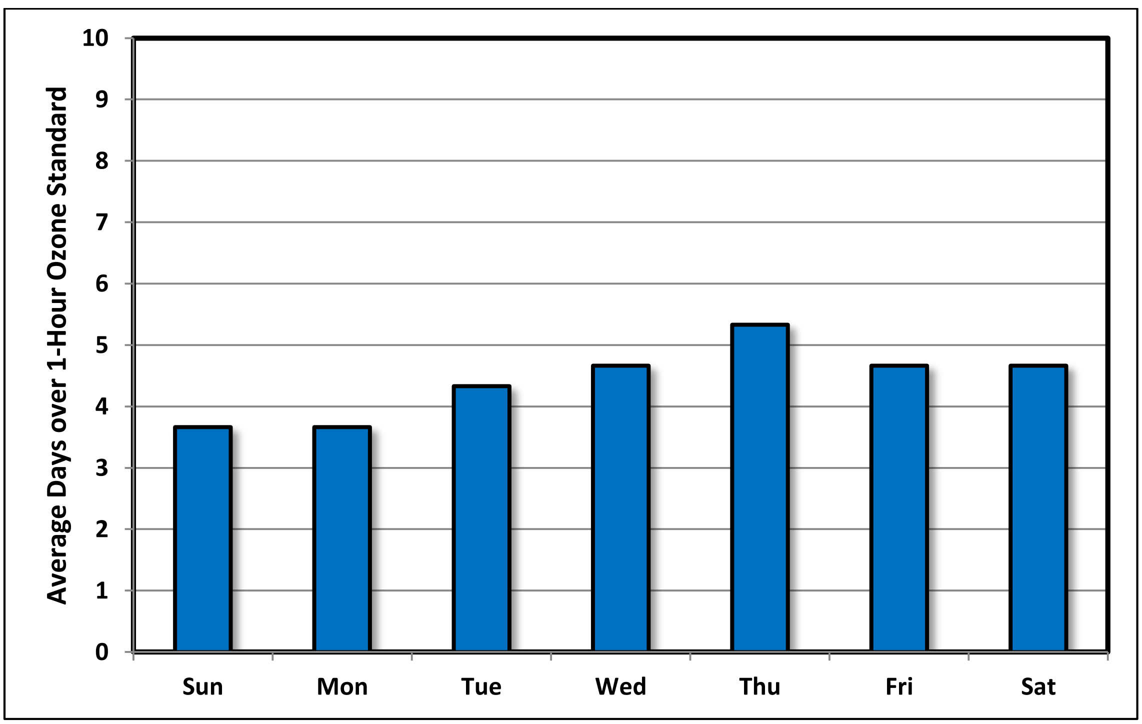
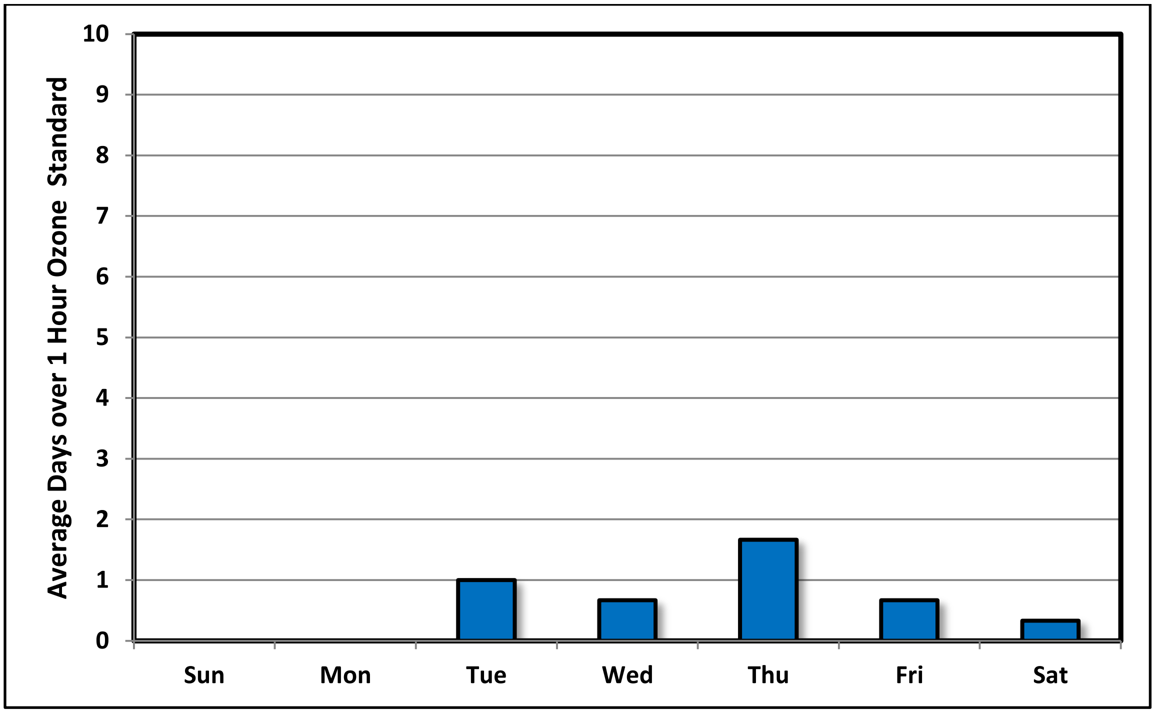


**Figure A-12 Average Frequency of 1-hour Ozone Exceedances per Year per Day of the Week from 2010-2012**



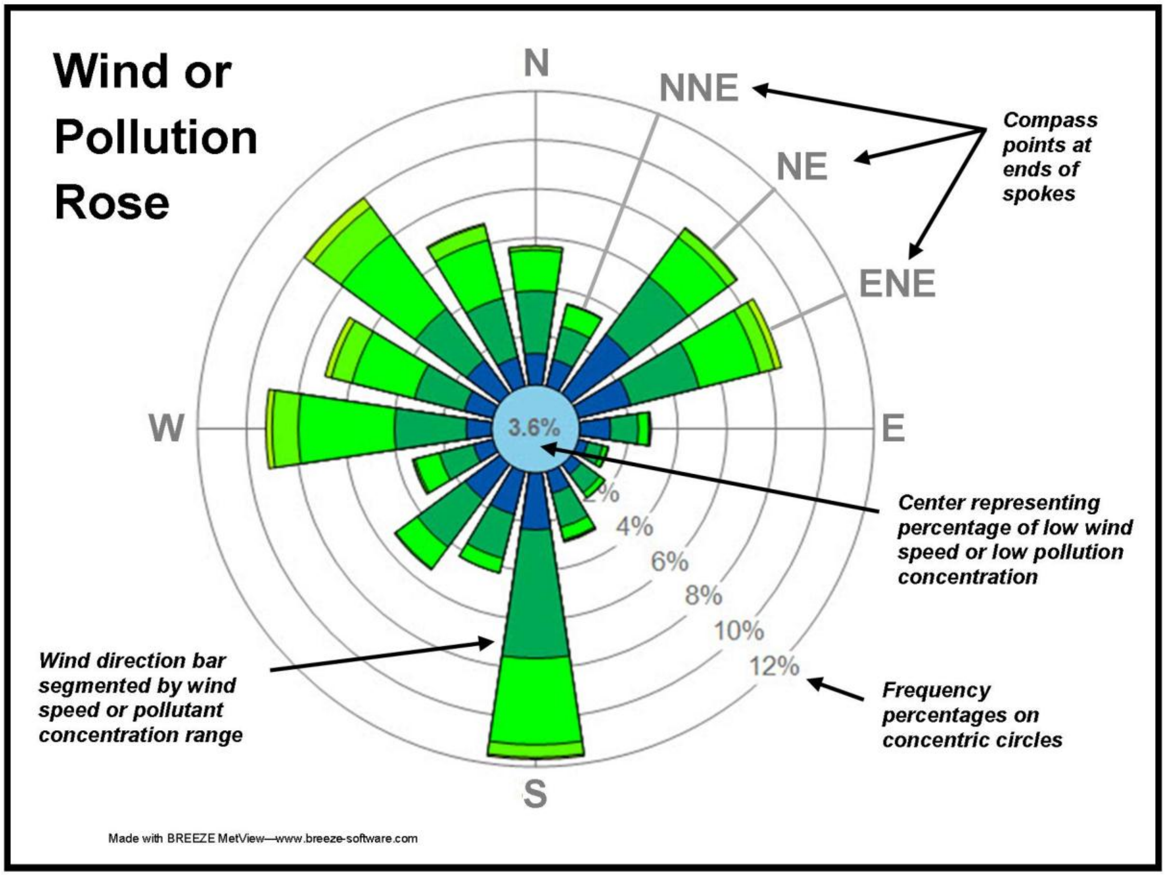

## A.4.4 Analysis of 2011-2012 Exceedance Days

### How to interpret wind and pollution roses

Wind roses are diagrams that show the strength and frequency of the wind from various directions over a specified amount of time. As an example in Figure A-13, a wind rose plot or diagram uses either compass points (N, NNE, NE, etc.) or degrees (0˚, 45˚, 90˚, etc.) to show the measured prevailing wind direction for each hour over the time frame being considered. These directions are the spokes of the plot. Prevailing wind direction data is organized into compass-point groupings and displayed as a percentage of the total time that the wind was coming from a specific compass direction. This percentage is designated as a bar extending from the center along the spokes to the frequency percentage, which are shown as concentric circles moving away from the center of the plot. The individual directional bars can be segmented by color and bar thickness to show the wind speed associated with a given direction with highest wind speeds (thickest bars) farthest away from the center. The center of the plot is usually reserved to show the percentage of time that the wind speed was below a certain speed, generally indicating stagnant wind flow.

Pollution roses show the correlation between the average concentrations of a pollutant, the location of the pollution plume, and wind direction. Similar to a wind rose, a *pollution rose* also summarizes the wind direction over a given period of time; however, instead of segmenting each bar along a directional spoke by wind speed, the bar is segmented to show the concentration of a given pollutant for each hour. Concentration ranges are designated by different colors and increasing bar thickness. The center of the plot is usually reserved for low pollutant concentration values, indicating the percentage of time that concentrations were below that level.

**Figure A-13 Sample Wind/Pollution Rose Diagram**




## Wind and pollution rose analysis for recent 1-hour ozone exceedances, 2011-2012

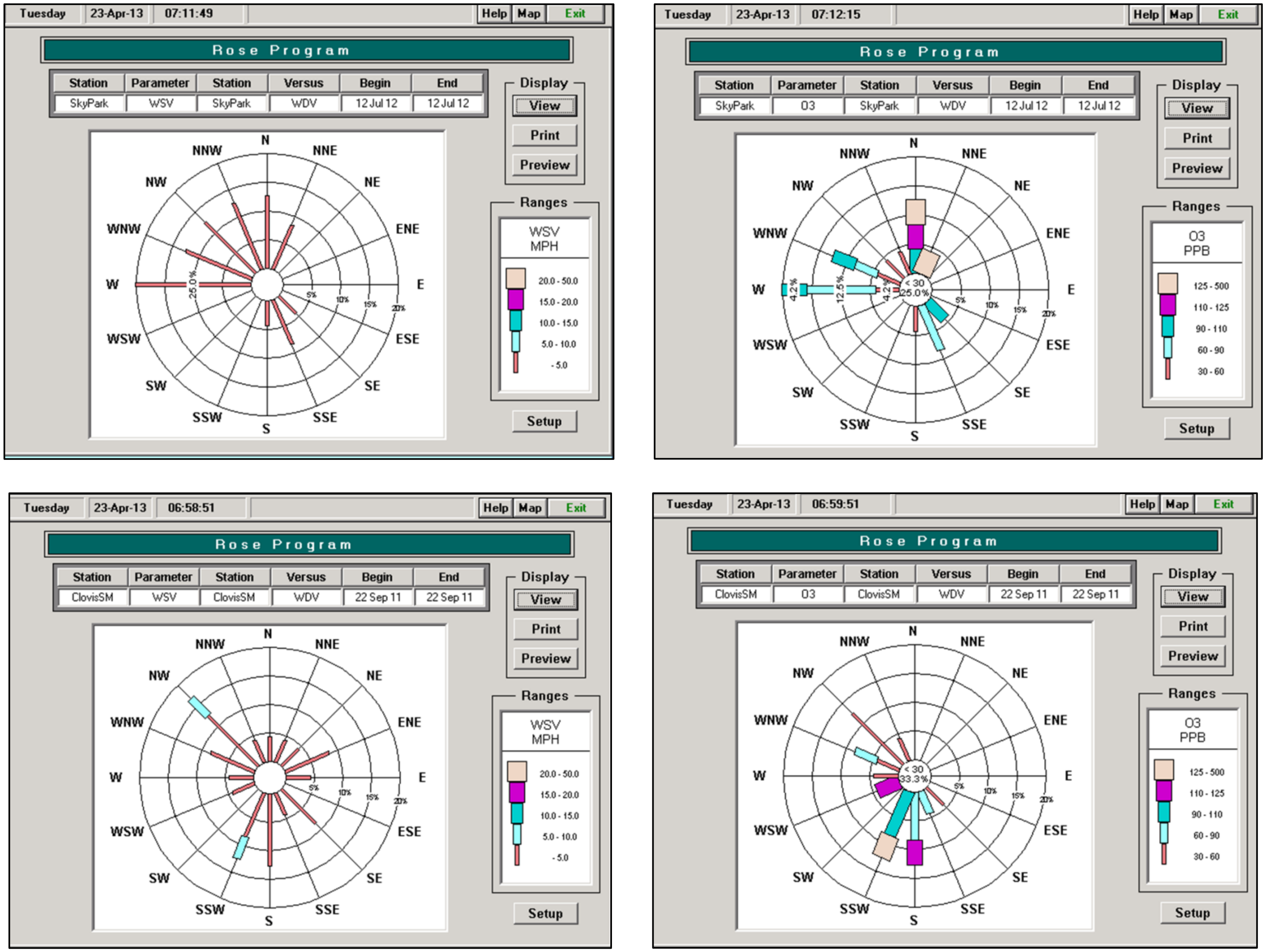
Table A-5 summarizes wind and pollution rose information for 1-hour ozone exceedance days that occurred in 2011 and 2012 at the Fresno-Sky Park, Clovis, Fresno-Garland, Parlier, and Fresno-Drummond sites. The wind and pollution rose figures for all of the events analyzed follow below (Figures A-14 to A-33).

The wind roses for those exceedance days all indicate that the wind direction varied throughout the day, but a westerly component was commonly present in the wind flow. The pollution roses show a correlation between the common wind direction component of the wind and the direction associated with the exceedances and additional peaks that occurred. In general, this analysis shows that in recent years, the meteorological conditions on an exceedance day have been stagnant with light and variable wind flow. This supports the observation that a buildup under stagnant weather conditions is necessary for a 1-hour exceedance to occur.

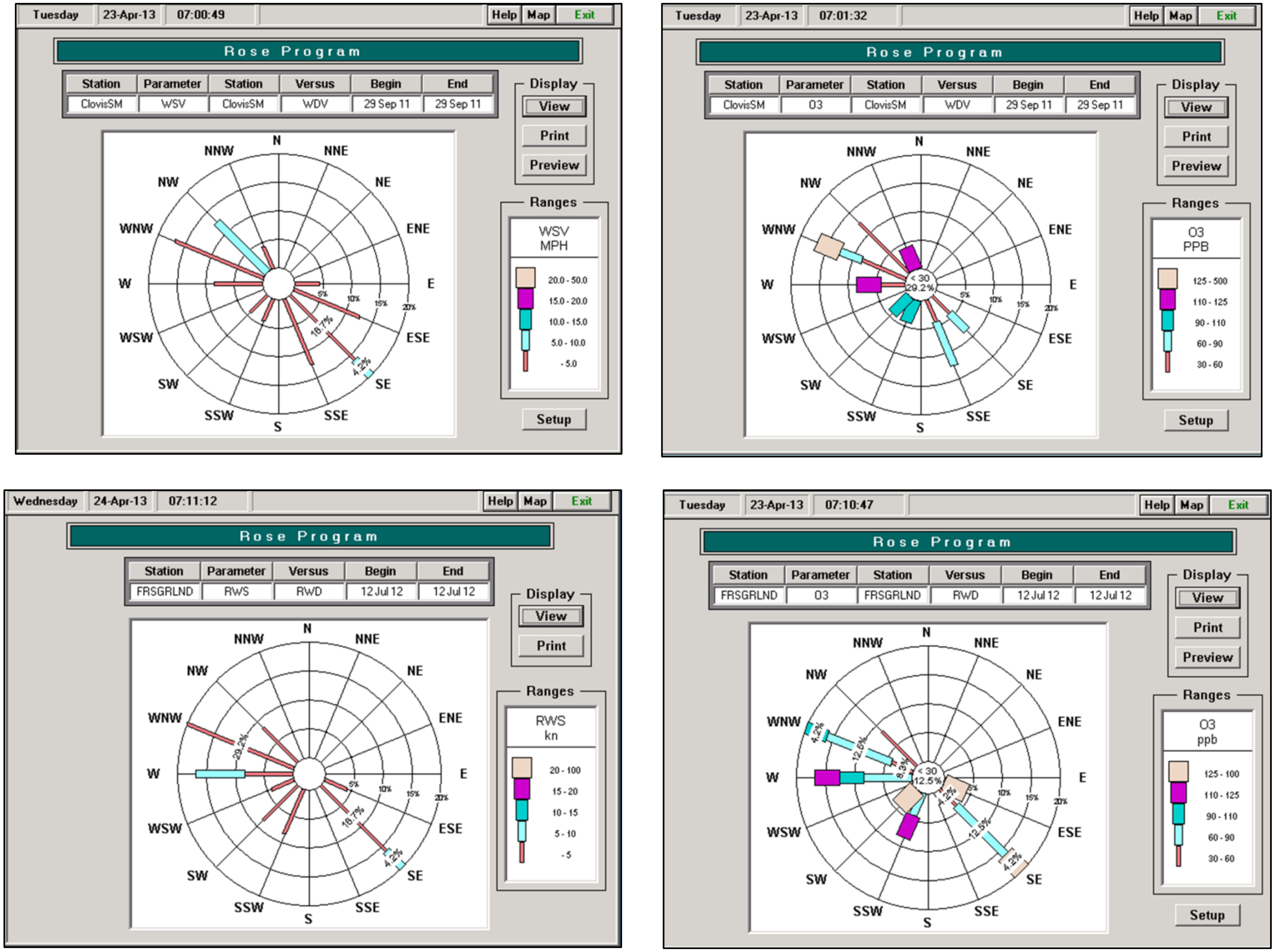
## Table A-5 Summary of Wind and Pollution Rose Results

| Site | Date | 1-Hour Ozone Max | Common Wind Direction Component | Wind Direction Associated with Exceedance | Wind Direction Associated with Additional Peak Concentrations |
|---|---|---|---|---|---|
| Fresno-Sky Park | 7/12/2012 | 133 ppb | Westerly | North Northeast | |
| Clovis | 9/22/2011 | 133 ppb | Westerly | South Southwest | |
| | 9/29/2011 | 131 ppb | Westerly and Southerly | West Northwest | West |
| Fresno-Garland | 7/12/2012 | 135 ppb | Southerly | Southeast | Southwest |
| Fresno-Drummond | 9/20/2011 | 127 ppb | Westerly | Northwest | |
| | 9/22/2011 | 129 ppb | Southerly and Westerly | Southwest | Southeast and West Northwest |
| | 9/29/2011 | 129 ppb | Westerly | Northwest | |
| | 8/10/2012 | 127 ppb | Northwesterly | West Southwest | |
| Parlier | 9/20/2011 | 134 ppb | Westerly | Northwest | |
| | 6/1/2012 | 126 ppb | Southwesterly | Northwest | |

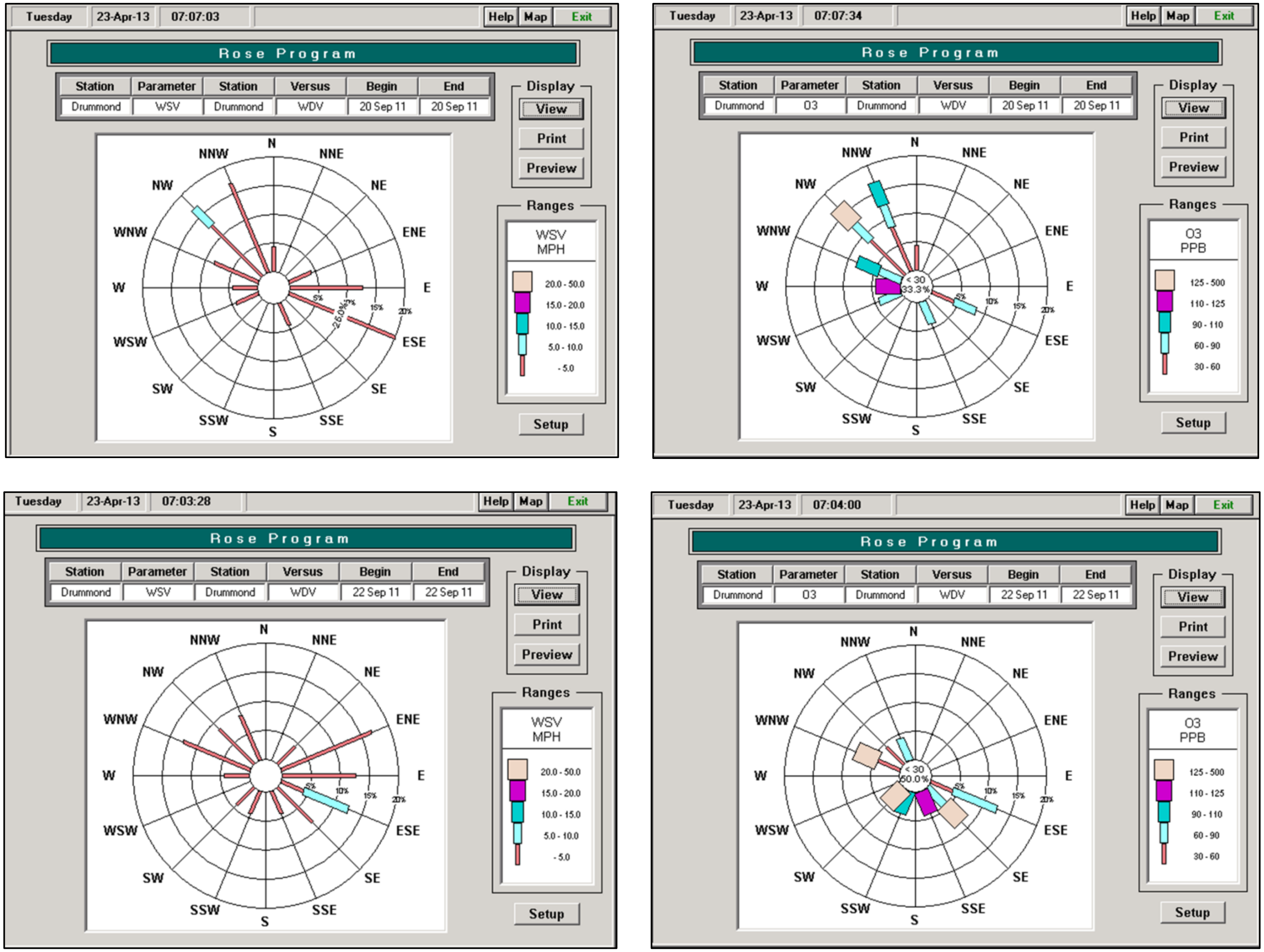
## Figures A-14 to A-17 Wind and Pollution Roses for Fresno-Sky Park (7/12/2012) and Clovis (9/22/2011)



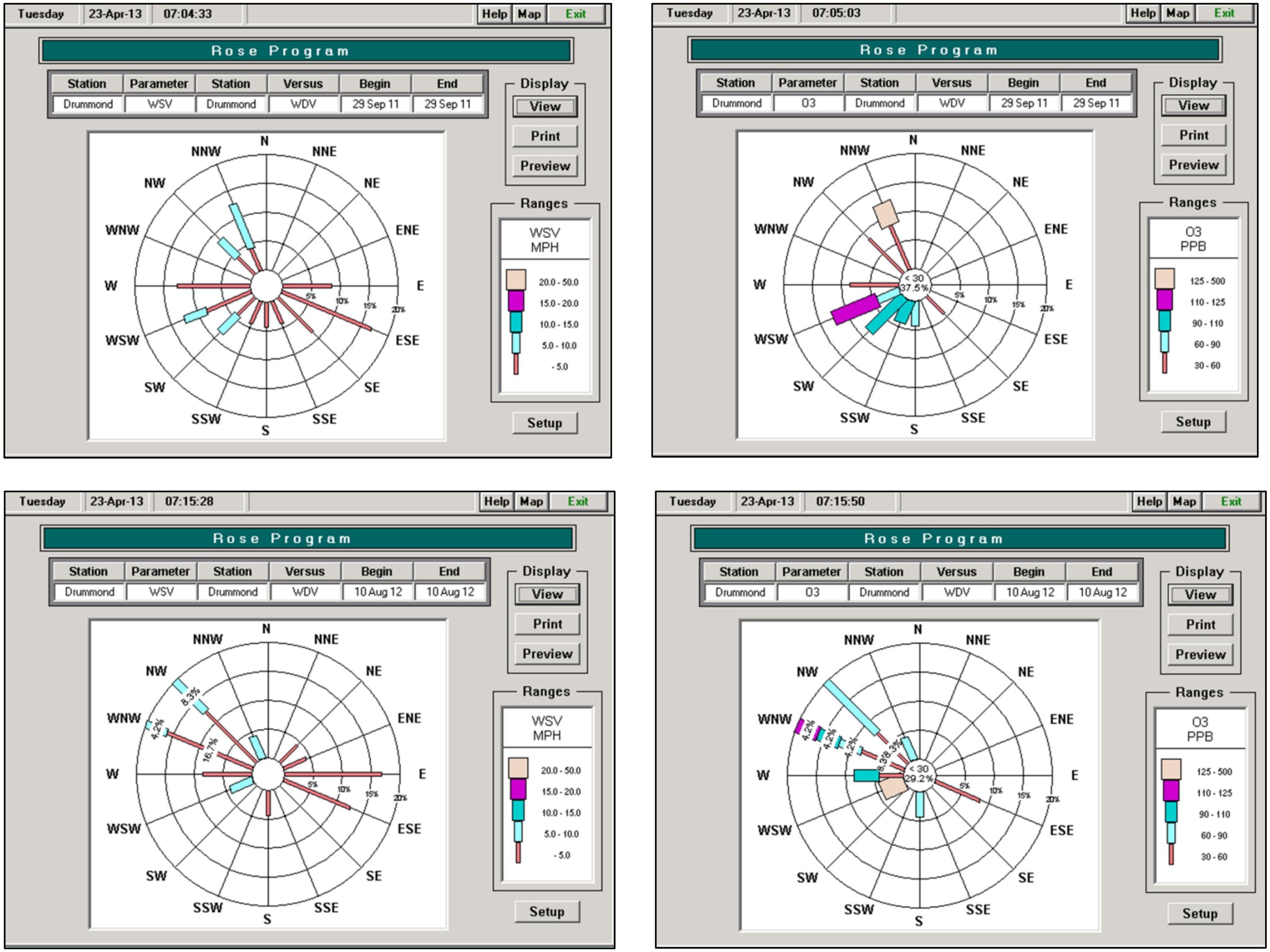
## Figures A-18 to A-21 Wind and Pollution Roses for Clovis (9/29/2011) and Fresno-Garland (7/12/2012)



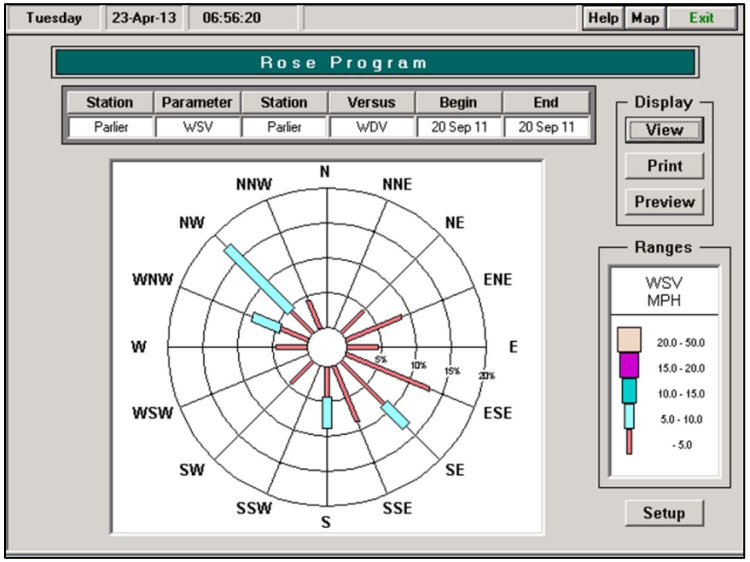
## Figures A-22 to A-25  Wind and Pollution Roses for Fresno-Drummond (9/20/2011 and 9/22/2011)

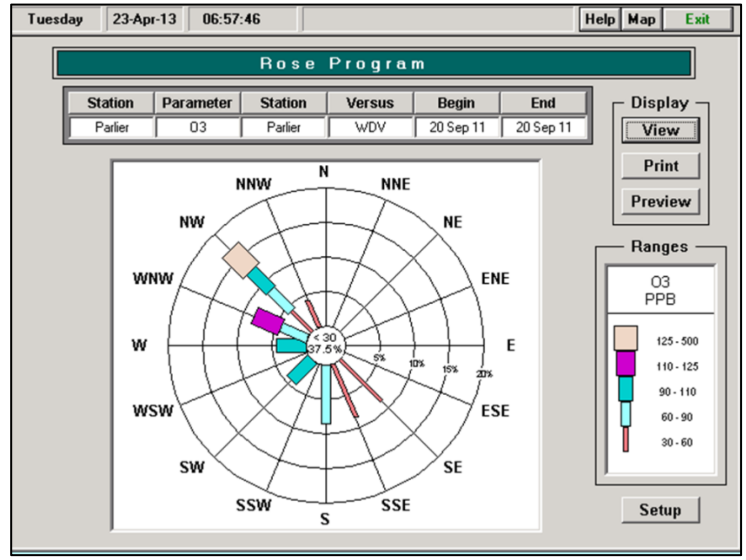


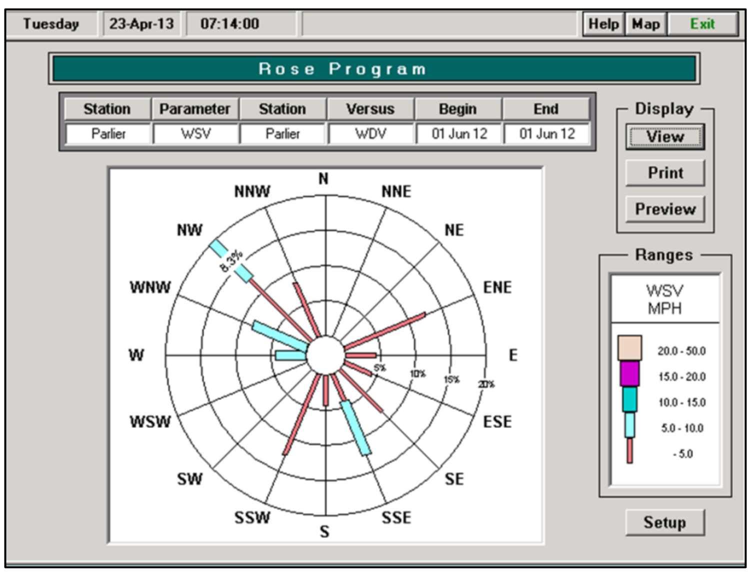
## Figures A-26 to A-29 Wind and Pollution Roses for Fresno-Drummond (9/29/2011 and 8/10/2012)

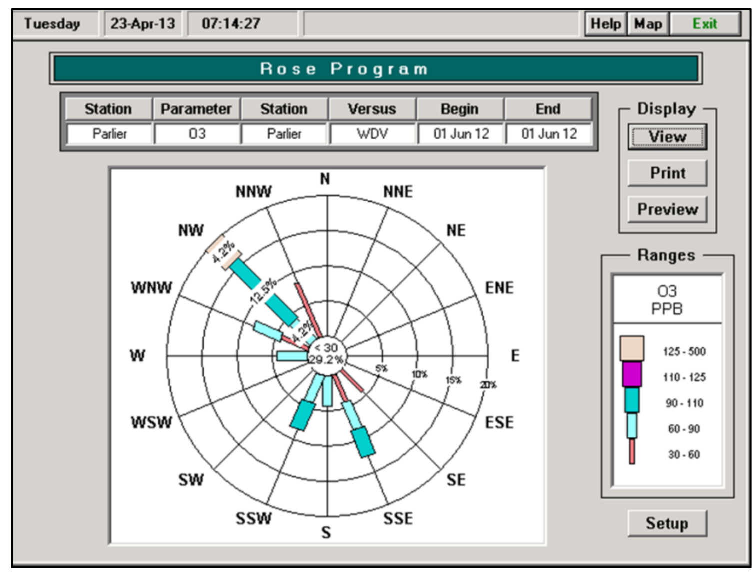


## Figures A-30 to A-33 Wind and Pollution Roses for Parlier (9/20/2011 and 6/1/2012)



## A.5 HOURLY OZONE TRENDS

### A.5.1 Number of Exceedance Hours

On an exceedance day, there may have been one hour over the level of the 1-hour ozone standard, or there may have been several hours over the standard. The total number of hours exceeding the ozone standard on an exceedance day has been decreasing over time Valley-wide, as shown in Figures A-34 through A-38. This trend shows that the overall exposure to peak ozone levels is declining.

**Figure A-34 Number of Hours over 1-hour Ozone Standard by Year at Clovis**

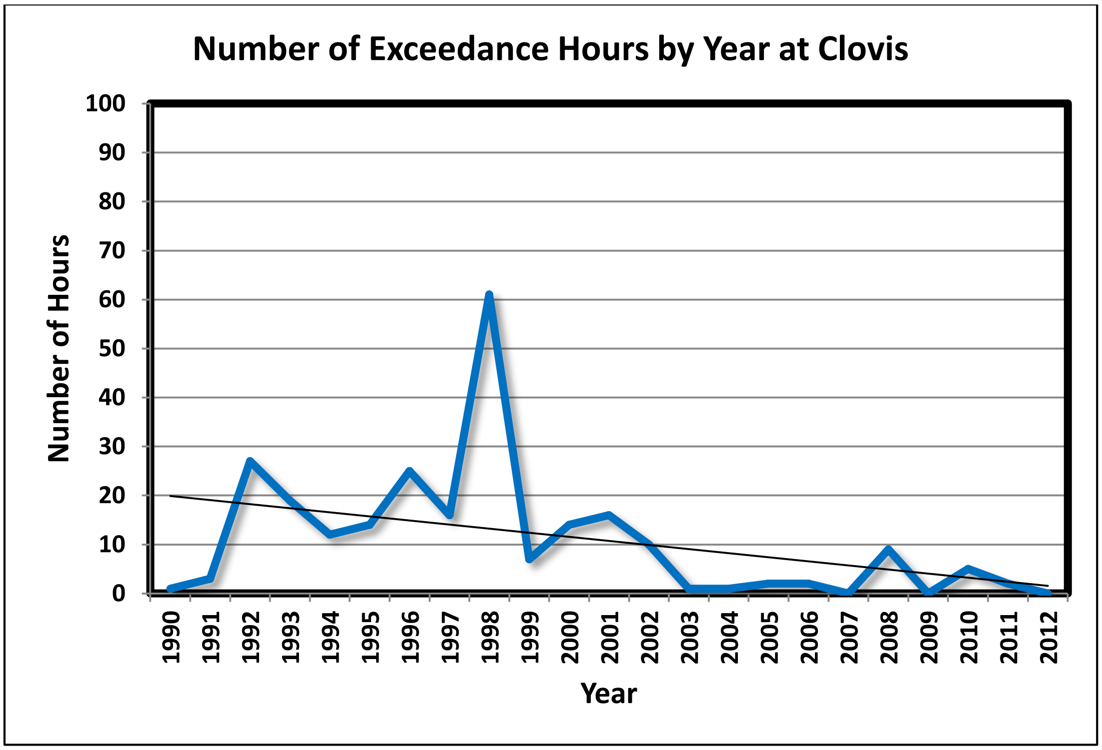


**Figure A-35 Number of Hours over 1-hour Ozone Standard by Year at Fresno-First/Garland**

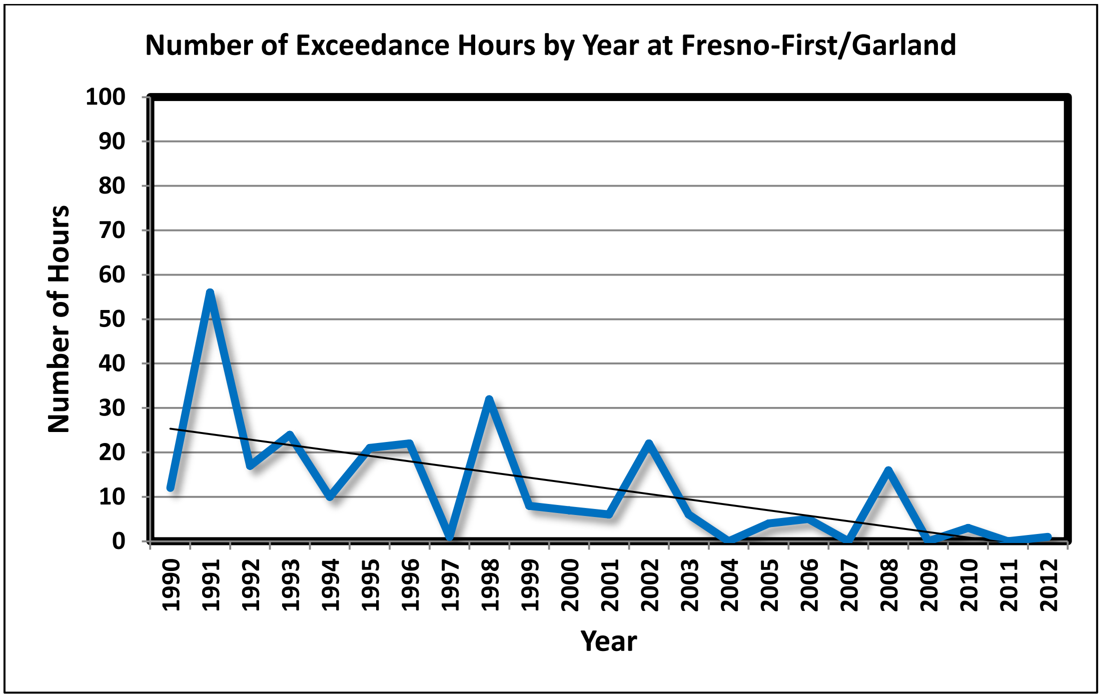



**Figure A-36 Number of Hours over 1-hour Ozone Standard by Year at Parlier**

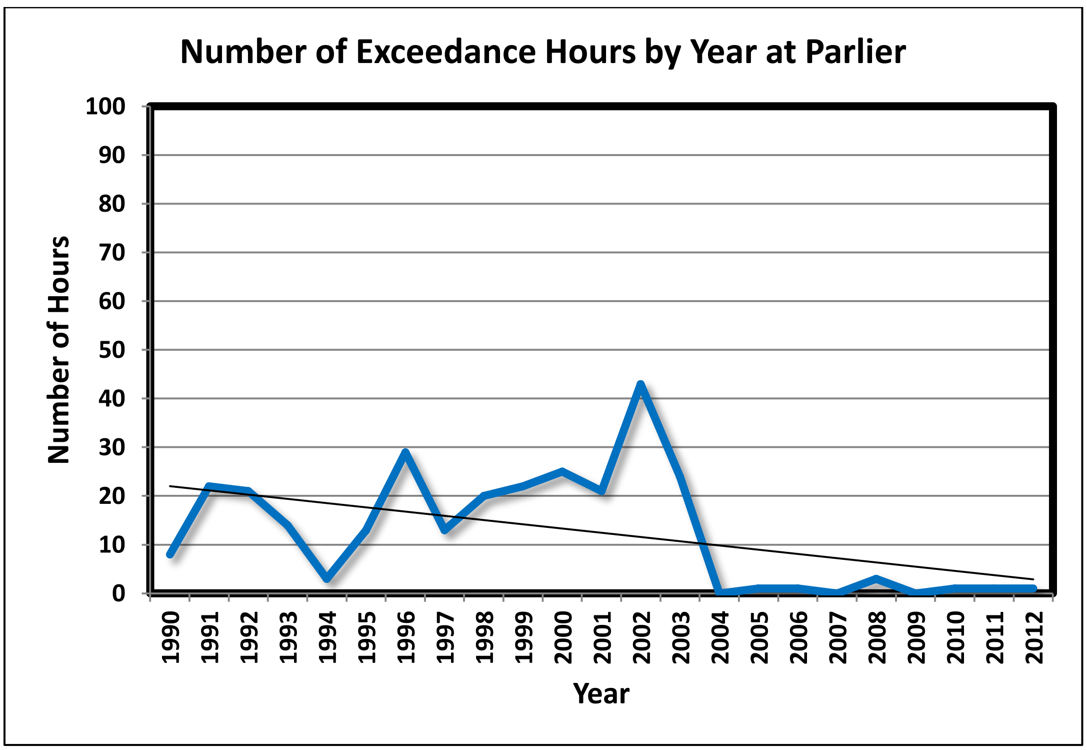


**Figure A-37 Number of Hours over 1-hour Ozone Standard by Year at Edison**

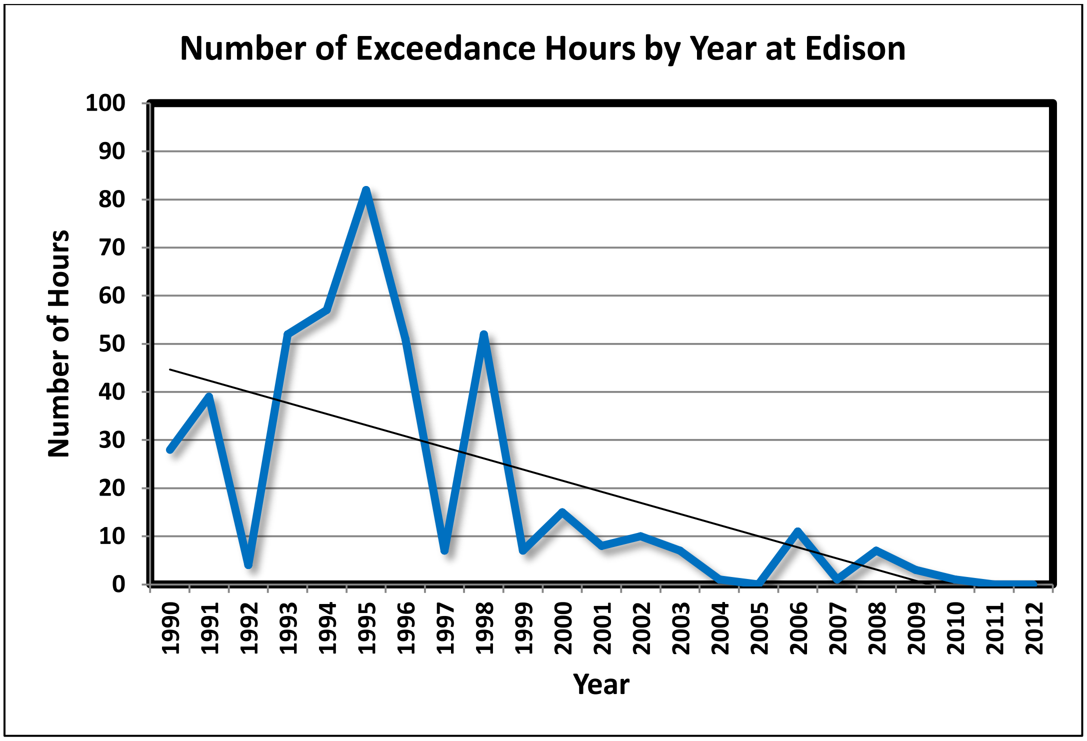
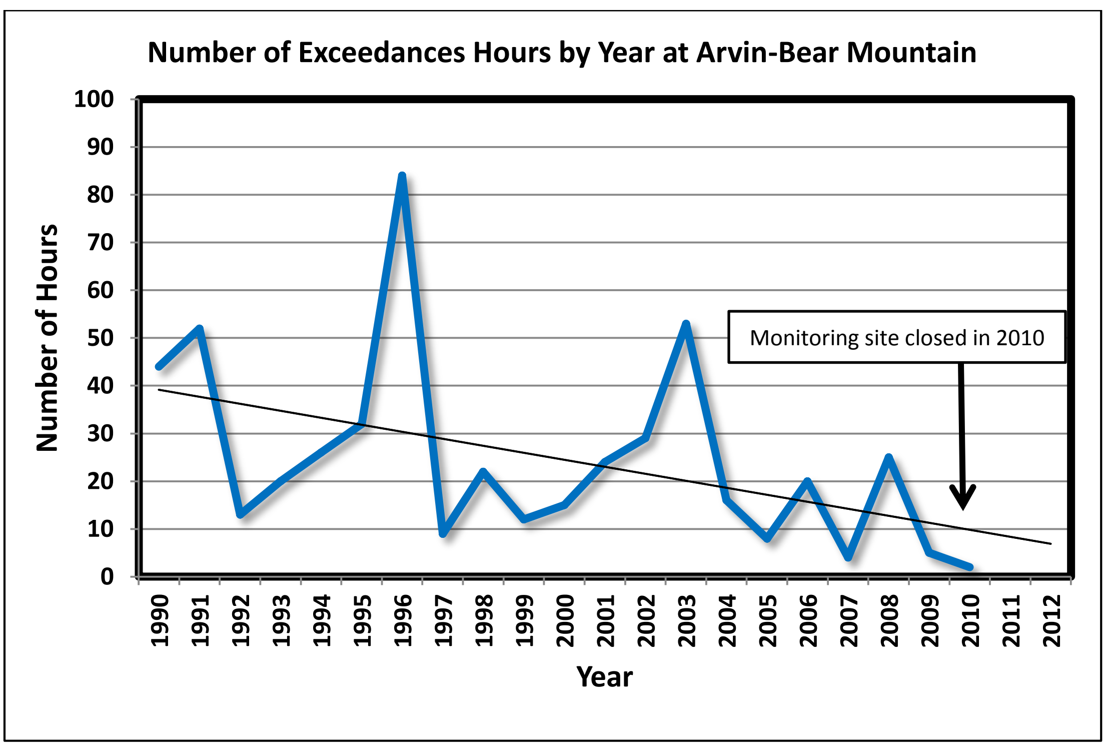



**Figure A-38 Number of Hours over 1-hour Ozone Standard by Year at Arvin-Bear Mountain**

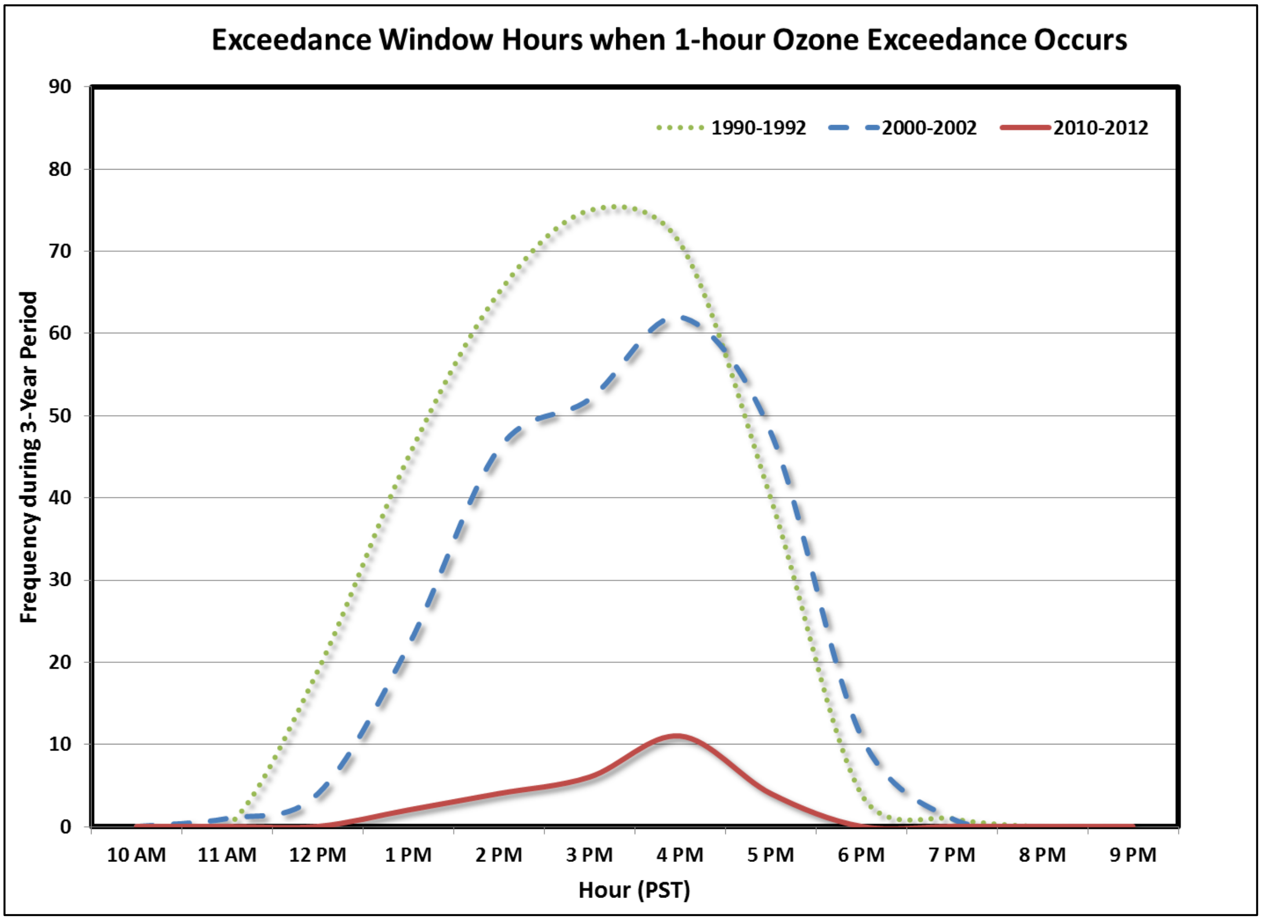


### A.5.2 Exceedance Window

Analysis has shown that the number of hours over the standard per exceedance day is decreasing, but additionally the range of hours during a day in which a 1-hour ozone exceedance occurs is also decreasing. Figure A-39 shows this 1-hour ozone “exceedance window” as a frequency of exceedances measured at a particular hour, from 10 AM to 9 PM Pacific Standard Time (PST), for time periods of 1990-1992, 2000-2002, and 2010-2012. In the recent years of 2010-2012, the 1-hour ozone exceedance window has significantly narrowed compared to the earlier years of 1990-1992 and 2000-2002.

The peak occurrence of a 1-hour exceedance from 1990-1992 was hour 14 (3 PM PST), with 75 occurrences of a 1-hour ozone exceedance at a monitor during any given day, with hour 15 (4 PM PST) closely behind with 71 occurrences. From 2010-2012, the peak occurrence of a 1-hour ozone exceedance hours has shifted to hour 15 (4 PM PST), with a total of 11 occurrences, followed by hour 14 (3 PM PST) with 6 occurrences. Additionally, the peak occurrence of 1-hour ozone exceedance hours has shifted later in the day by 1-hour, from hour 14 to hour 15. Figure A-39 also reveals that the frequency of 1-hour exceedances has considerably decreased, as is evident in the smaller area beneath the 2010-2012 curve compared to the 1990-1992 and 2000-2002 curves.

**Figure A-39 1-hour Ozone Exceedance Window Trend**

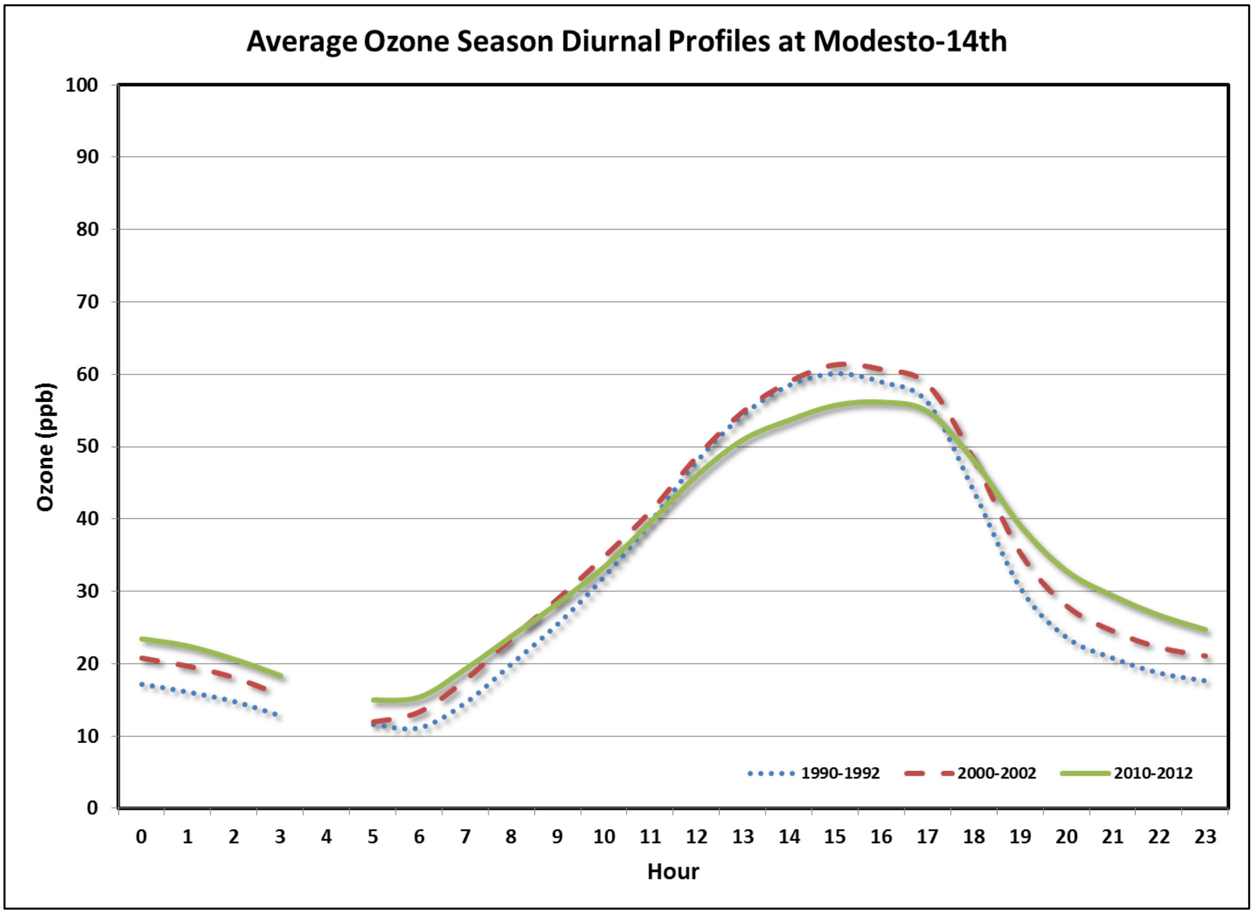



## A.5.3 Trends in Diurnal Ozone Profiles

A "diurnal ozone profile" is the pattern of ozone concentrations occurring from hour to hour throughout the day. Changes in diurnal profiles may indicate changes in patterns of ozone precursor emissions. The diurnal profiles for several Valley monitoring sites (Modesto-14th, Clovis, Fresno-First/Garland, Fresno-Drummond, Parlier, Visalia-Church, Bakersfield-California, Edison, and Arvin-Bear Mountain) were evaluated for three 3-year time periods: the early 1990s (varied for each site depending on beginning of ozone monitoring), 2000-2002, and 2010-2012 (see Figures A-40 through A-48). The ozone concentrations for each hour of the day over these three 3-year periods were averaged to give an average diurnal profile for each period.

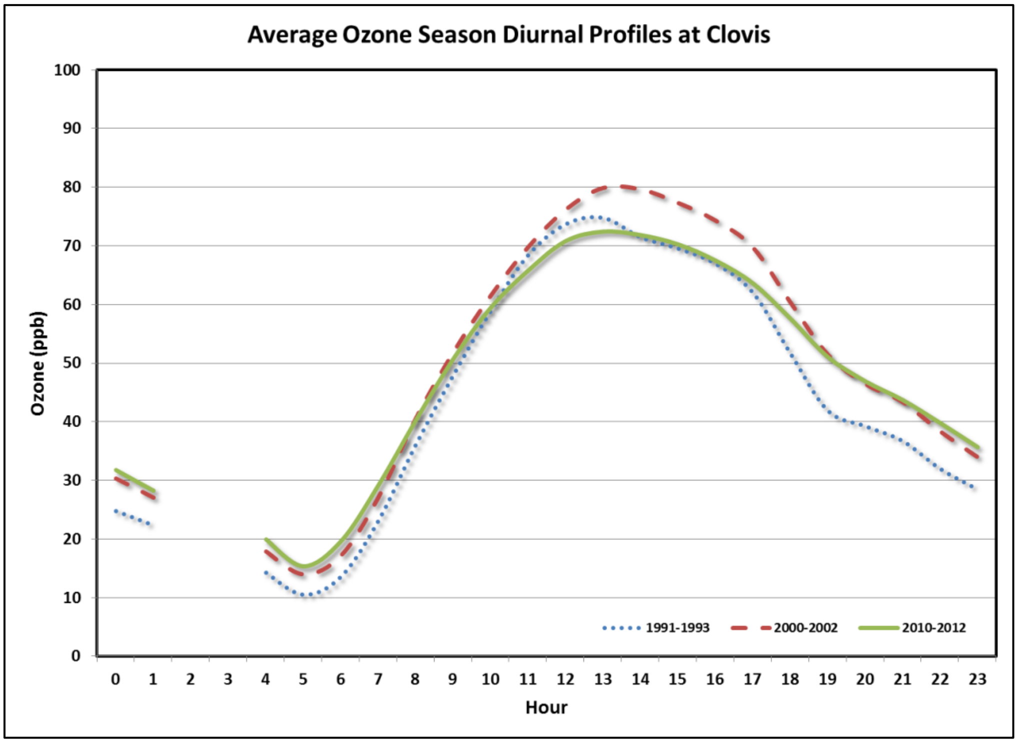
This analysis shows that the diurnal profiles maintain relatively consistent shapes over time, although the afternoon peaks have shifted downward as ozone concentrations have decreased over time, as discussed throughout this appendix. In the 1990-1992 time period, ozone concentrations decreased more rapidly in the late afternoon than in more recent years. In the past, when oxides of nitrogen (NOx) emissions levels were higher in the Valley, excess ozone was more easily scavenged and consumed by NOx through chemical reactions in the late afternoon to evening timeframe, reducing ozone concentrations rapidly. In more recent years, with much lower NOx emissions, ozone scavenging does not occur on the same scale as in the past, and so ozone concentrations tend to stay more elevated in the late afternoon to early evening.[6] [7]

**Figure A-40 Ozone Diurnal Profiles at Modesto-14th**

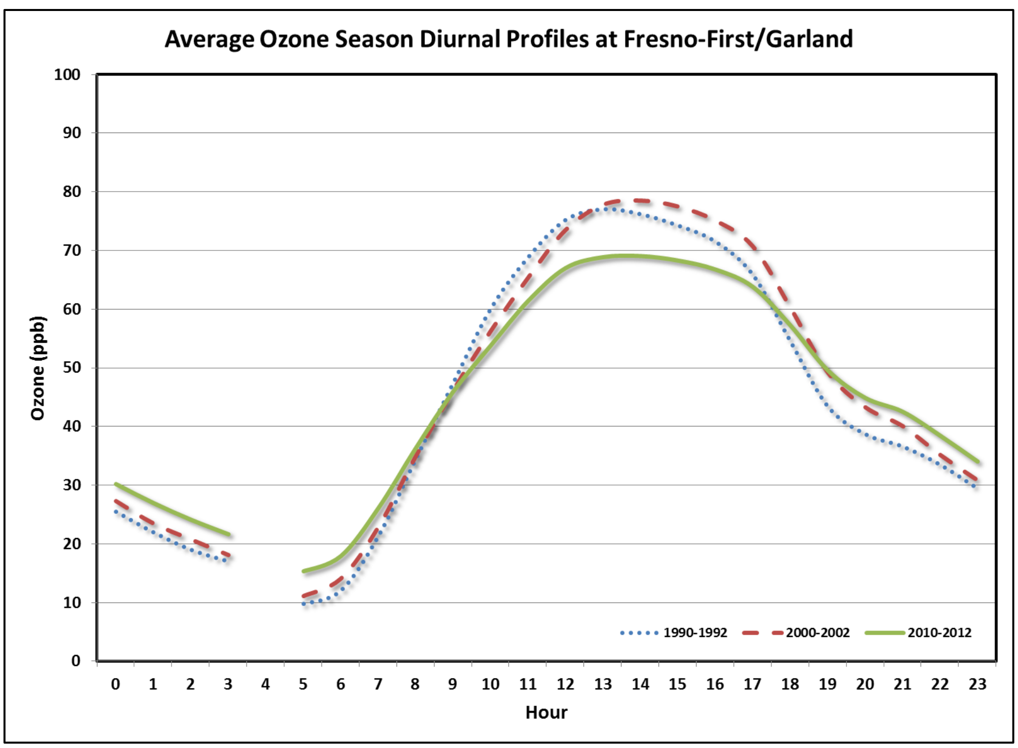



[6] Pusede, S. & Cohen R. (2012). On the observed response of ozone to NOx and VOC reactivity reductions in San Joaquin Valley California 1995-present. *Atmospheric Chemistry and Physics*, 12, 8323-8339.
[7] European Environment Agency [EEA] (1998). *Tropospheric Ozone in the European Union "The Consolidated Report"* (Topic Report no. 8/1998). Retrieved April 25, 2013 from http://www.eea.europa.eu/publications/TOP08-98

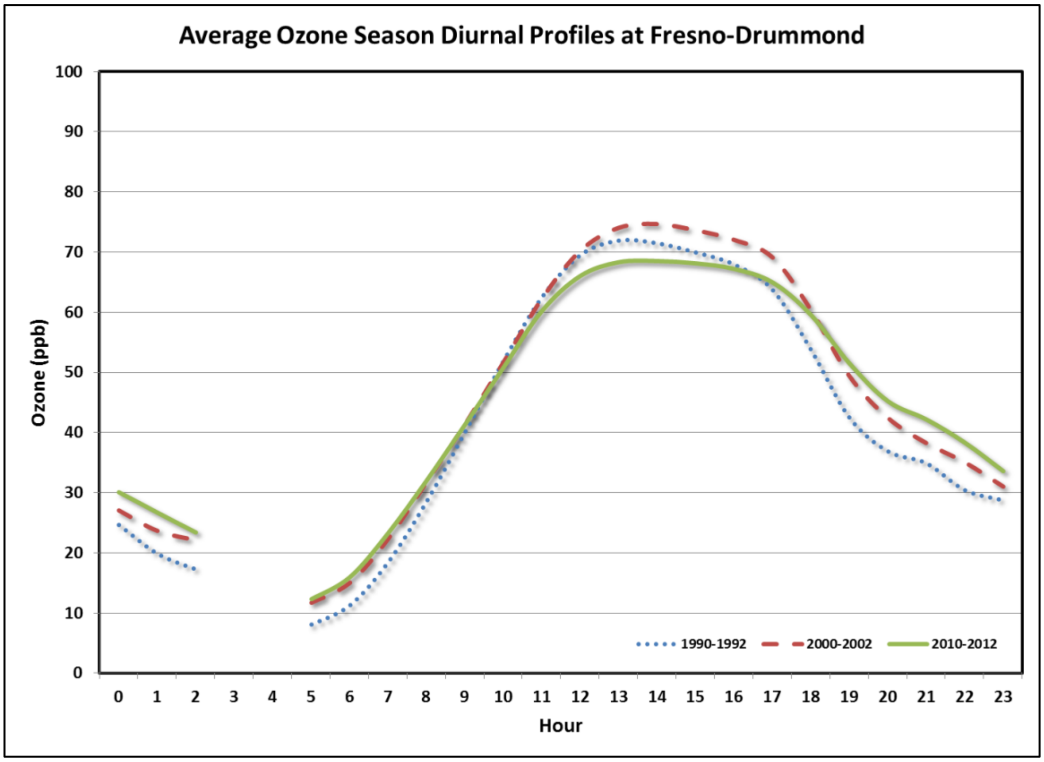
## Figure A-41 Ozone Diurnal Profiles at Clovis



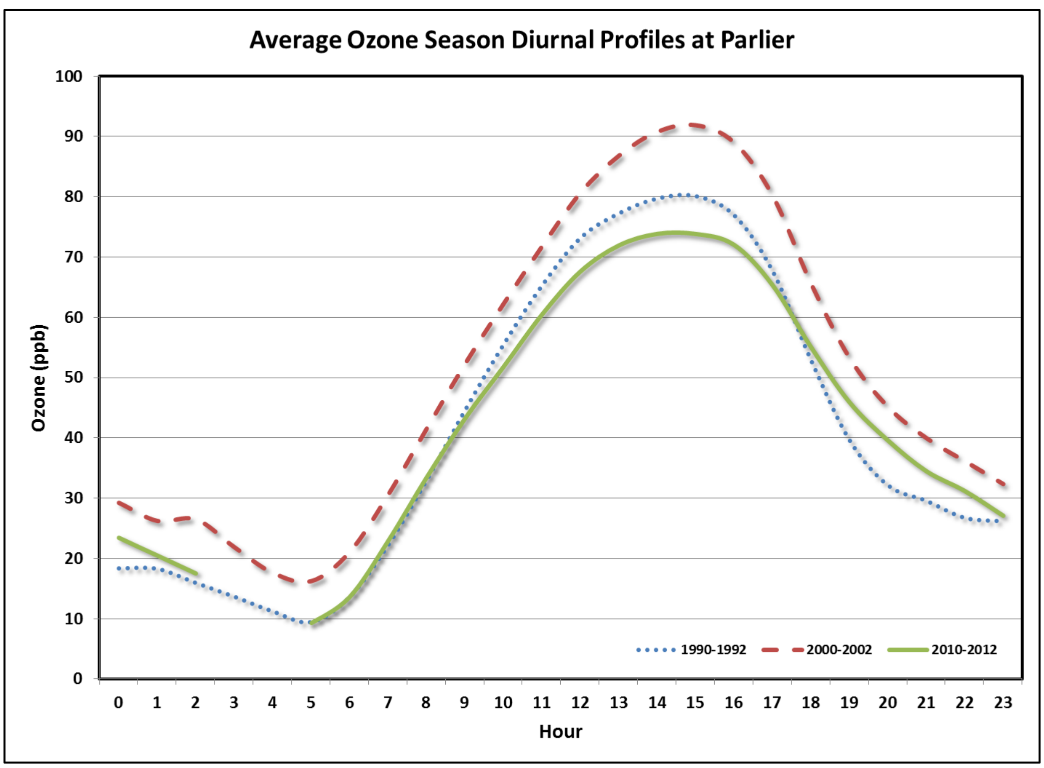

## Figure A-42 Ozone Diurnal Profiles at Fresno-First/Garland



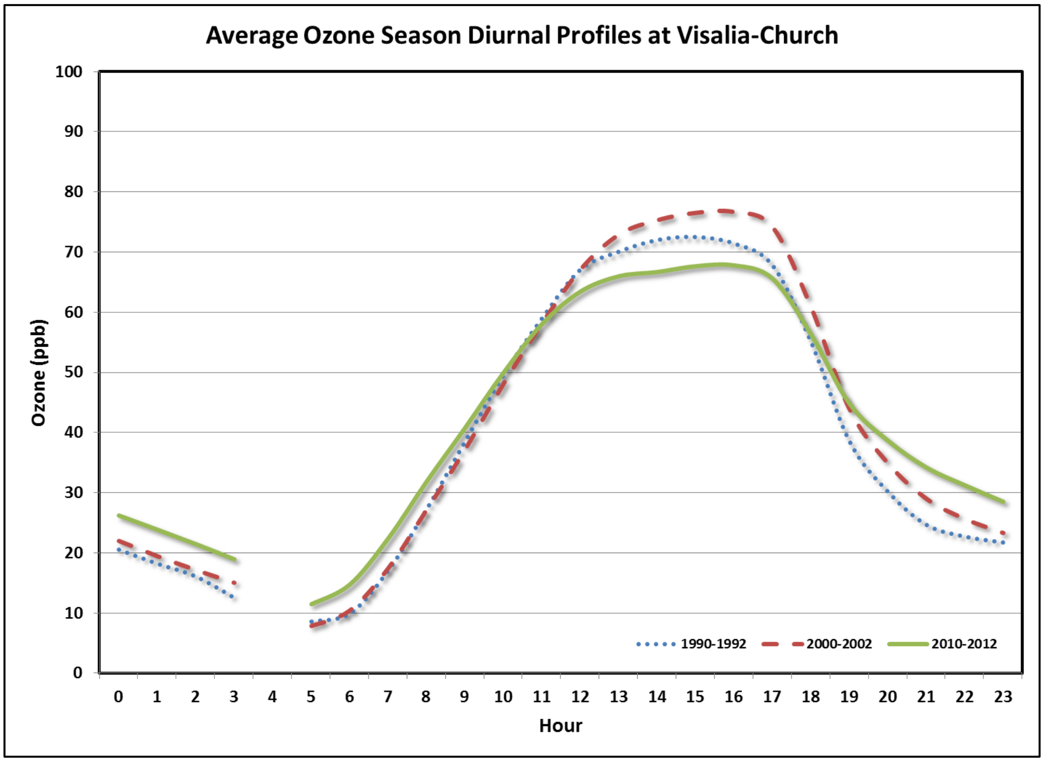
## Figure A-43 Ozone Diurnal Profiles at Fresno-Drummond



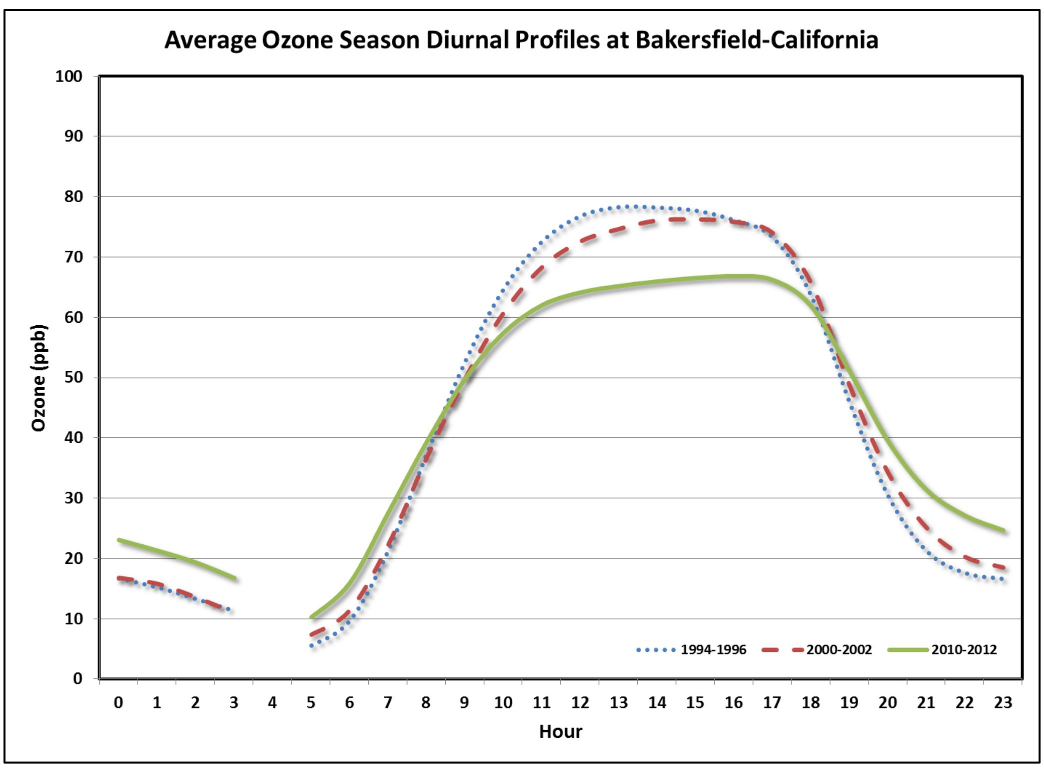

## Figure A-44 Ozone Diurnal Profiles at Parlier



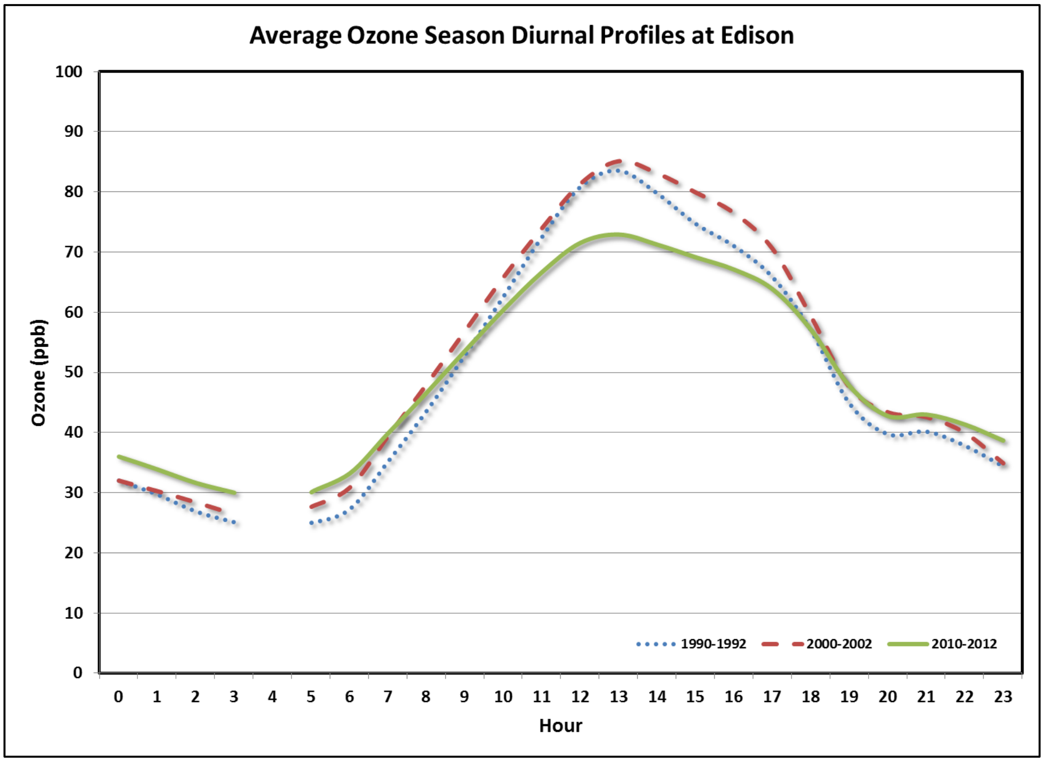
## Figure A-45 Ozone Diurnal Profiles at Visalia-Church



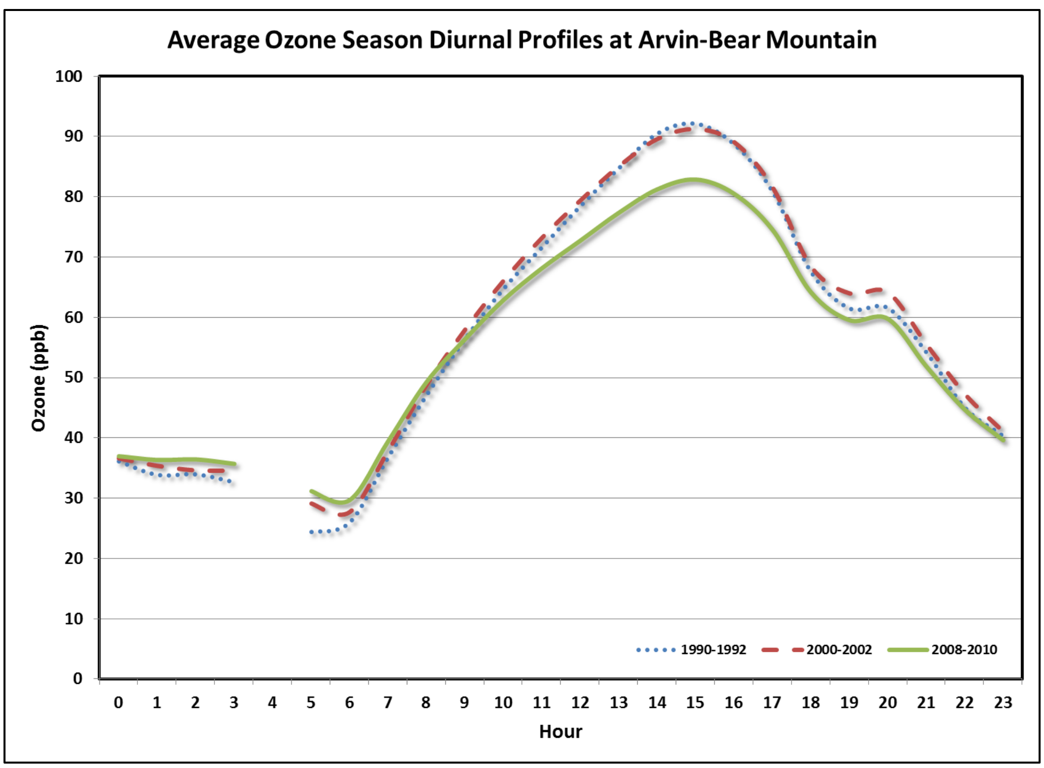

## Figure A-46 Ozone Diurnal Profiles at Bakersfield-California



## Figure A-47 Ozone Diurnal Profiles at Edison




## Figure A-48 Ozone Diurnal Profiles at Arvin-Bear Mountain



## A.6 Design Values

The fourth highest 1-hour ozone value for the three-year period – the "design value" – is indicative of how close an area is to attainment of the standard. Design value calculations follow EPA protocols for rounding, averaging conventions, data completeness, sampling frequency, data substitutions, and data validity. A 1-hour ozone design value at or greater than 0.125 ppm indicates nonattainment for that monitor (if the fourth highest value over the three-year period is an exceedance day, then there were more than the 3 allowed exceedance days over that three-year period). Because of this connection between design values and the exceedance-day-based attainment test, future year design values are modeled to determine when a region will reach attainment (see Chapter 2).

The generalized description of how the design value for 1-hour ozone is calculated is as follows:

- **Step 1:** Determine the daily maximum 1-hour value per day over a 3-year period of complete data.
- **Step 2:** Rank the values over the 3-year period and select the 4$^{th}$ highest value.
- **Step 3:** Round the resulting value to the nearest one hundredth.
- **Step 4:** Compare the result to the standard.

EPA provides detailed guidelines and standards for the calculation[8] and data handling methodologies. A design value between 0.121 and 0.124 ppm (inclusive) is considered meeting the standard since rounding these values to the closest one hundredth would both result in 0.12 ppm. Alternatively, a design value between 0.125 and 0.129 ppm (inclusive) would be rounded up to 0.13 ppm, a value above the standard of 0.12 ppm.

Table A-6 shows the trend of the 1-hour ozone design values for each ozone monitoring site in the Valley by year from 1990 through the year 2012. As a standard labeling convention, a 3-year time period used to calculate a design value is labeled as the end year, e.g. the year 2000 design value represents the 3-year timeframe of 1998-2000. The Valley basin maximum design value data in Table A-6 is also shown in Figure A-49.

Average ambient ozone concentrations vary by monitoring site within the Valley. In general, monitoring sites in the northern part of the Valley record the lowest ambient ozone concentrations, while monitoring sites in the central and southern portions of the Valley tend to record the highest ozone concentrations, namely the Fresno and Bakersfield areas. As can be observed in Table A-6, the majority of Valley ozone air monitoring site design values are currently below the 1-hour ozone standard of 0.12 ppm. The year 2012 design values show that presently the sites exceeding the standard are limited to the Clovis and Fresno-Drummond air monitoring.

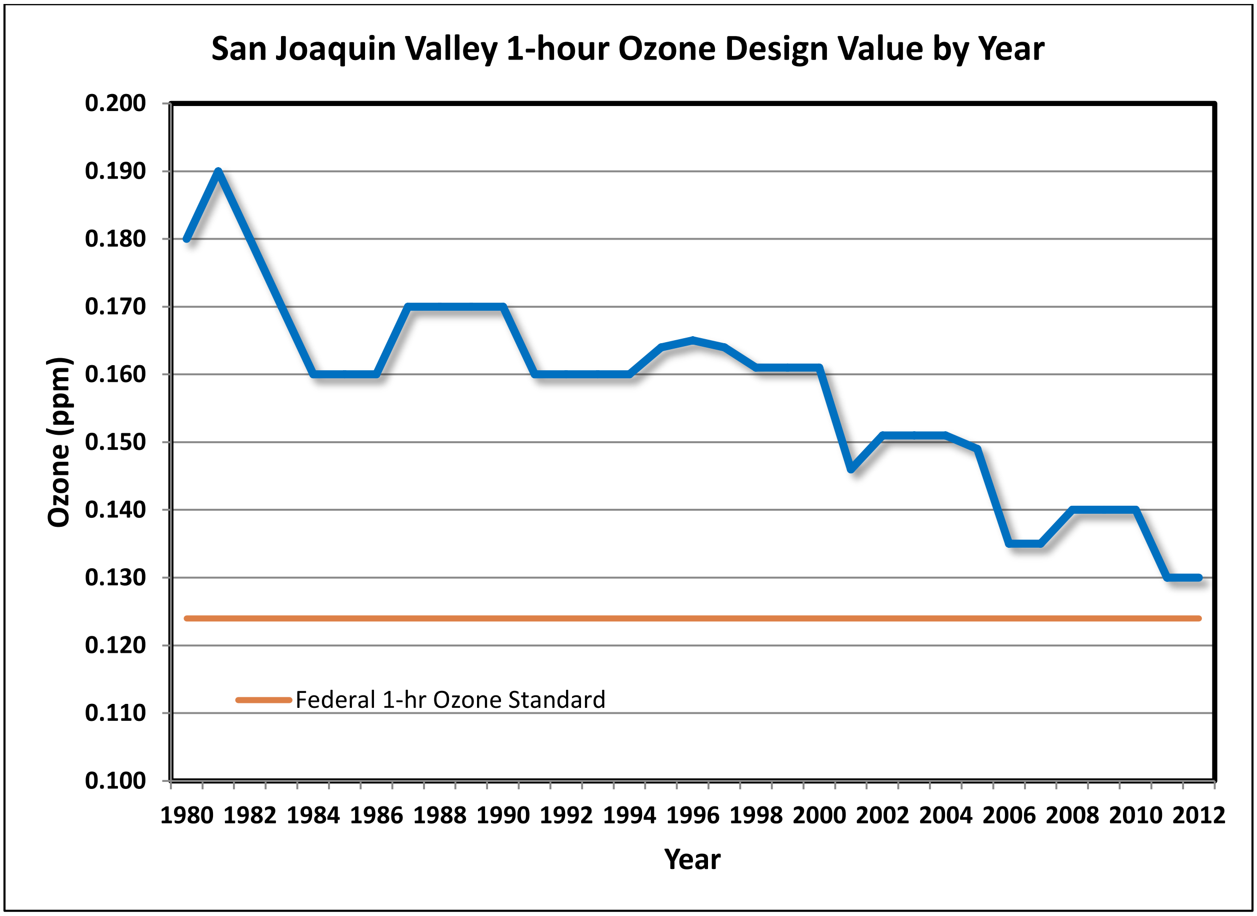
[8] Interpretation of the 1-hour Primary and Secondary National Ambient Air Quality Standards for Ozone, 40 C.F.R. Pt. 50 Appendix H (2013). Available at http://www.ecfr.gov/cgi-bin/text-idx?c=ecfr&SID=a19eca235a0f73d286947df28da3381e&rgn=div9&view=text&node=40:2.0.1.1.1.0.1.19.9&idno=40

## Table A-6 1-hour Ozone Design Values (ppm) by Site per Year from 1990-2012

| Monitoring Site | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **San Joaquin County** | | | | | | | | | | | | | | | | | | | | | | | |
| Stockton-Hazelton Street | 0.110 | 0.110 | 0.110 | 0.110 | 0.110 | 0.120 | 0.120 | 0.118 | 0.104 | 0.107 | 0.107 | 0.107 | 0.102 | 0.101 | 0.101 | 0.099 | 0.101 | 0.101 | 0.102 | 0.095 | 0.105 | 0.095 | 0.092 |
| Tracy-Airport | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0.120 | 0.118 | 0.118 | 0.104 | 0.108 | 0.099 | 0.106 |
| **Stanislaus County** | | | | | | | | | | | | | | | | | | | | | | | |
| Modesto-14th Street | 0.120 | 0.110 | 0.110 | 0.110 | 0.114 | 0.123 | 0.125 | 0.125 | 0.131 | 0.131 | 0.131 | 0.109 | 0.109 | 0.109 | 0.106 | 0.107 | 0.109 | 0.109 | 0.113 | 0.106 | 0.106 | 0.093 | 0.092 |
| Turlock-S Minaret Street | -- | -- | 0.120 | 0.130 | 0.120 | 0.125 | 0.123 | 0.123 | 0.129 | 0.127 | 0.130 | 0.111 | 0.123 | 0.119 | 0.119 | 0.111 | 0.106 | 0.104 | 0.122 | 0.125 | 0.125 | 0.110 | 0.112 |
| **Merced County** | | | | | | | | | | | | | | | | | | | | | | | |
| Merced-S Coffee Avenue | -- | -- | 0.130 | 0.130 | 0.120 | 0.125 | 0.125 | 0.125 | 0.131 | 0.132 | 0.132 | 0.120 | 0.121 | 0.122 | 0.122 | 0.118 | 0.106 | 0.102 | 0.125 | 0.118 | 0.118 | 0.108 | 0.108 |
| **Madera County** | | | | | | | | | | | | | | | | | | | | | | | |
| Madera-28261 Avenue 14 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0.120 | 0.106 | 0.105 |
| Madera-Pump Yard | -- | -- | -- | -- | -- | -- | -- | 0.085 | 0.123 | 0.118 | 0.117 | 0.104 | 0.115 | 0.119 | 0.119 | 0.103 | 0.097 | 0.095 | 0.105 | 0.105 | 0.110 | 0.104 | 0.097 |
| **Fresno County** | | | | | | | | | | | | | | | | | | | | | | | |
| Clovis-N Villa Avenue | 0.130 | 0.130 | 0.150 | 0.140 | 0.144 | 0.144 | 0.146 | 0.146 | 0.161 | 0.161 | 0.161 | 0.142 | 0.137 | 0.136 | 0.131 | 0.126 | 0.126 | 0.125 | 0.140 | 0.140 | 0.140 | 0.130 | 0.130 |
| Fresno-1st Street | 0.150 | 0.160 | 0.160 | 0.160 | 0.140 | 0.140 | 0.140 | 0.140 | 0.146 | 0.146 | 0.146 | 0.135 | 0.135 | 0.135 | 0.135 | 0.131 | 0.130 | 0.130 | 0.133 | 0.127 | 0.127 | 0.124 | -- |
| Fresno-Garland | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0.119 |
| Fresno-Drummond Street | 0.150 | 0.150 | 0.150 | 0.150 | 0.140 | 0.140 | 0.131 | 0.131 | 0.142 | 0.137 | 0.137 | 0.131 | 0.131 | 0.132 | 0.131 | 0.128 | 0.119 | 0.110 | 0.114 | 0.118 | 0.118 | 0.127 | 0.127 |
| Fresno-Sierra Skypark | 0.140 | 0.140 | 0.140 | 0.140 | 0.130 | 0.131 | 0.131 | 0.131 | 0.141 | 0.141 | 0.141 | 0.136 | 0.144 | 0.144 | 0.144 | 0.123 | 0.124 | 0.124 | 0.124 | 0.119 | 0.126 | 0.119 | 0.118 |
| Parlier | 0.150 | 0.150 | 0.150 | 0.150 | 0.150 | 0.140 | 0.144 | 0.144 | 0.151 | 0.145 | 0.152 | 0.146 | 0.151 | 0.151 | 0.151 | 0.135 | 0.121 | 0.121 | 0.122 | 0.121 | 0.122 | 0.121 | 0.122 |
| Tranquillity | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0.093 | 0.093 | 0.096 |
| **Kings County** | | | | | | | | | | | | | | | | | | | | | | | |
| Hanford-S Irwin Street | -- | -- | -- | -- | 0.113 | 0.110 | 0.138 | 0.138 | 0.138 | 0.128 | 0.128 | 0.124 | 0.124 | 0.121 | 0.121 | 0.113 | 0.112 | 0.110 | -- | -- | 0.131 | 0.126 | 0.118 |
| Corcoran-Patterson Avenue | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0.132 | 0.132 | -- | -- | -- |
| Santa Rosa Rancheria | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0.113 | 0.113 | 0.117 | 0.105 | 0.103 |
| **Tulare County** | | | | | | | | | | | | | | | | | | | | | | | |
| Porterville | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0.109 | 0.104 | 0.104 |
| Ash Mountain - SNP | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0.127 | 0.127 | 0.125 | 0.124 | 0.126 | 0.126 | 0.126 | 0.117 | 0.119 | 0.132 | 0.132 | 0.130 | 0.113 | 0.112 |
| Lower Kaweah - SNP | 0.112 | 0.112 | 0.116 | 0.121 | 0.123 | 0.123 | 0.122 | 0.115 | 0.118 | 0.112 | 0.109 | 0.108 | 0.118 | 0.122 | 0.122 | 0.115 | 0.113 | 0.113 | 0.115 | 0.115 | 0.115 | 0.095 | 0.098 |
| Visalia-N Church Street | 0.140 | 0.140 | 0.130 | 0.140 | 0.150 | 0.150 | 0.140 | 0.132 | 0.139 | 0.127 | 0.129 | 0.126 | 0.126 | 0.124 | 0.124 | 0.117 | 0.115 | 0.112 | 0.121 | 0.121 | 0.122 | 0.115 | 0.111 |
| **Kern County** | | | | | | | | | | | | | | | | | | | | | | | |
| Arvin-Di Giorgio | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0.120 | 0.118 | 0.118 |
| Arvin-Bear Mountain Blvd | 0.170 | 0.160 | 0.160 | 0.160 | 0.150 | 0.147 | 0.156 | 0.156 | 0.156 | 0.137 | 0.141 | 0.134 | 0.142 | 0.150 | 0.151 | 0.149 | 0.134 | 0.131 | 0.135 | 0.135 | 0.139 | -- | -- |
| Bakersfield-5558 California Avenue | -- | -- | -- | -- | 0.123 | 0.128 | 0.128 | 0.126 | 0.124 | 0.119 | 0.119 | 0.116 | 0.117 | 0.116 | 0.113 | 0.112 | 0.117 | 0.117 | 0.120 | 0.117 | 0.114 | 0.111 | 0.104 |
| Bakersfield-Golden State Avenue | -- | -- | -- | -- | 0.122 | 0.123 | 0.126 | 0.124 | 0.124 | 0.118 | 0.118 | 0.115 | 0.116 | 0.116 | 0.115 | 0.109 | 0.105 | 0.108 | 0.110 | -- | -- | -- | -- |
| Edison | 0.160 | 0.150 | 0.150 | 0.160 | 0.160 | 0.164 | 0.165 | 0.164 | 0.158 | 0.154 | 0.154 | 0.138 | 0.141 | 0.134 | 0.134 | 0.127 | 0.135 | 0.135 | 0.136 | 0.135 | 0.134 | 0.124 | 0.118 |
| Maricopa-Stanislaus Street | 0.130 | 0.120 | 0.110 | 0.110 | 0.110 | 0.119 | 0.121 | 0.121 | 0.130 | 0.130 | 0.137 | 0.110 | 0.114 | 0.112 | 0.112 | 0.102 | 0.101 | 0.100 | 0.097 | 0.097 | 0.097 | 0.102 | 0.102 |
| Oildale-3311 Manor Street | 0.130 | 0.120 | 0.120 | 0.120 | 0.120 | 0.116 | 0.121 | 0.121 | 0.122 | 0.119 | 0.120 | 0.113 | 0.113 | 0.114 | 0.112 | 0.111 | 0.112 | 0.112 | 0.114 | 0.112 | 0.110 | 0.102 | 0.102 |
| Shafter-Walker Street | 0.120 | 0.120 | 0.110 | 0.110 | 0.110 | 0.110 | 0.118 | 0.112 | 0.115 | 0.111 | 0.111 | 0.109 | 0.109 | 0.112 | 0.112 | 0.111 | 0.104 | 0.105 | 0.106 | 0.106 | 0.106 | 0.102 | 0.102 |
| **Maximum** | **0.170** | **0.160** | **0.160** | **0.160** | **0.160** | **0.164** | **0.165** | **0.164** | **0.161** | **0.161** | **0.161** | **0.146** | **0.151** | **0.151** | **0.151** | **0.149** | **0.135** | **0.135** | **0.140** | **0.140** | **0.140** | **0.130** | **0.130** |

The Valley's maximum 1-hour ozone design values have decreased dramatically since the pollutant began to be widely monitored in the region. Figure A-49 below shows the change in the basin maximum design value from 1980 through 2012, during which maximum design values have decreased 27% (from 0.18 ppm in 1980 to 0.13 ppm in 2012). Since the Valley is close to attaining this standard, continuing this downward trend will be important to meet this federal air quality standard in the near future.

**Figure A-49 Valley Maximum 1-hour Ozone Design Value Trend**



## A.7 TRENDS IN DAILY MAXIMUM OZONE CONCENTRATIONS

### A.7.1 Daily Maximum AQI/ROAR levels

EPA and the District use the Air Quality Index (AQI) to provide daily information about the Valley's air quality, to inform the public about how unhealthy air may affect them, and to educate the public about how they can protect their health. AQI scales exist for all of the criteria pollutants regulated by the Clean Air Act, including 1-hour ozone. However, the official EPA AQI scale for 1-hour ozone does not define AQI below the federal standard, but only defines the scale above the standard for the categories of Unhealthy for Sensitive Groups (USG) and above (i.e. Good and Moderate categories are not defined). Therefore, the official scale is unable to provide the full spectrum of the change in the frequency of the days in each AQI category over time.

As an alternative, the adopted 1-hour ozone real-time outdoor activity risk (ROAR) levels used within the District's Real-Time Air Advisory Network (RAAN)[9] were used in this analysis in order to show the change in the entire AQI spectrum. Table A-7 defines the ROAR levels for 1-hour ozone as used in RAAN.

**Table A-7 1-hour Ozone ROAR Levels Based on RAAN**

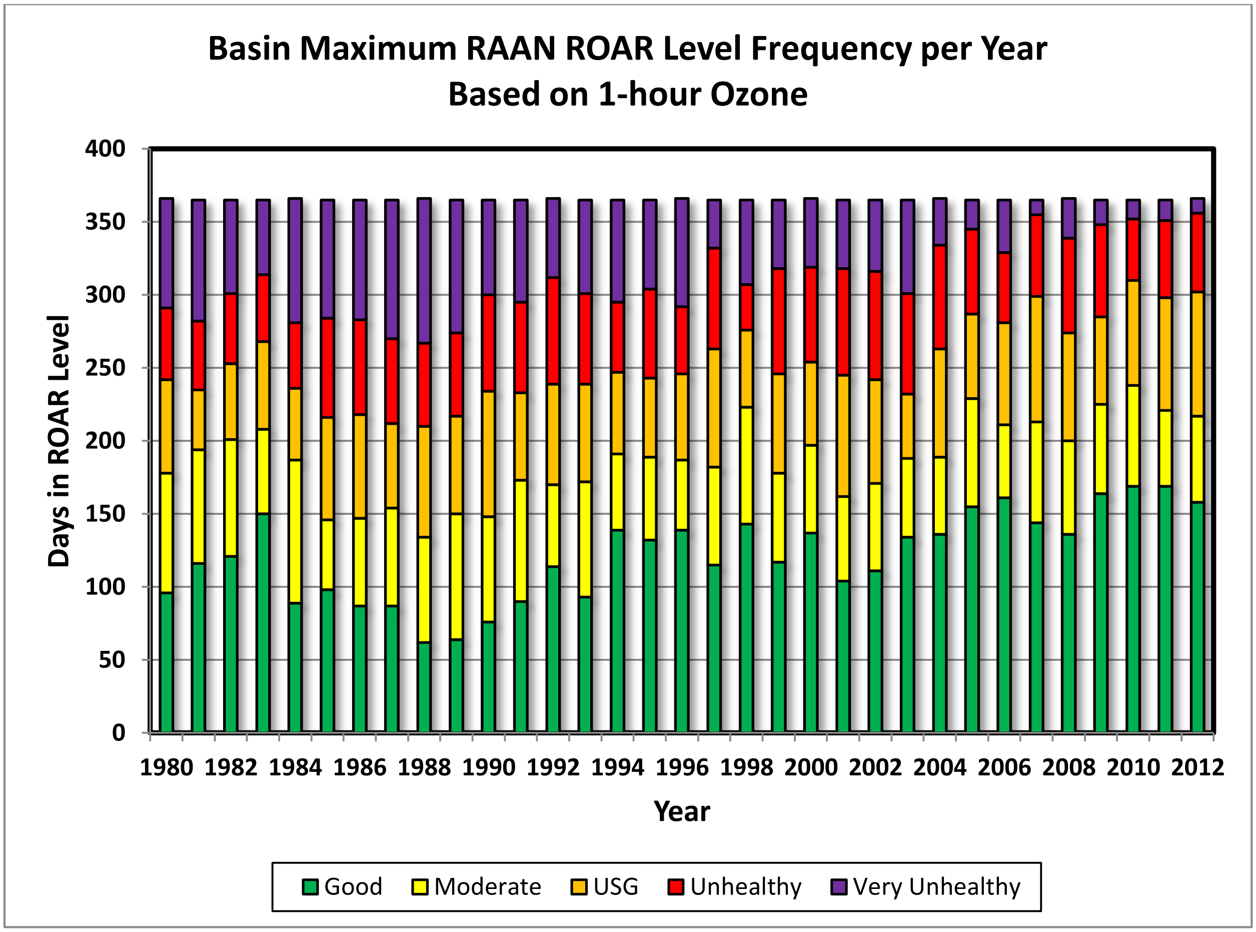
| Concentration (ppb) | ROAR Level | Color |
|---|---|---|
| 0 - 59 | Level 1: Good | Green |
| 60 - 75 | Level 2: Moderate | Yellow |
| 76 - 95 | Level 3: USG | Orange |
| 96 - 115 | Level 4: Unhealthy | Red |
| > 115 | Level 5: Very Unhealthy | Purple |

This analysis uses the Valley's basin maximum 1-hour ozone concentration for each day of each year. According to the scale defined in Table A-7, each year was separated into the five ROAR levels based on the frequency of each level occurrence. Figure A-50 shows the results of this analysis for each year from 1980 to 2012. The stacked bars represent the number of days within each year that fell within each of the ROAR levels (totaling 365 days). Within each stacked bar, the levels are ordered as Good (green), Moderate (yellow), etc. from the bottom to the top.

The frequency of Very Unhealthy days has decreased greatly since the early 1980s. As ozone concentrations have decreased over the years in the Valley, Very Unhealthy days have shifted down to Unhealthy days, Unhealthy days have shifted down to Unhealthy for Sensitive Groups days, and so forth. As this domino effect has continued down the ROAR level spectrum, the end result has been an increase in the number of Good days over the same time period. This downward shift in the frequency of the ROAR level categories provides further evidence of the improving ozone air quality in the Valley.

[9] http://www.valleyair.org/Programs/RAAN/raan_landing.htm

**Figure A-50  Distribution of ROAR Levels from 1980 to 2012**

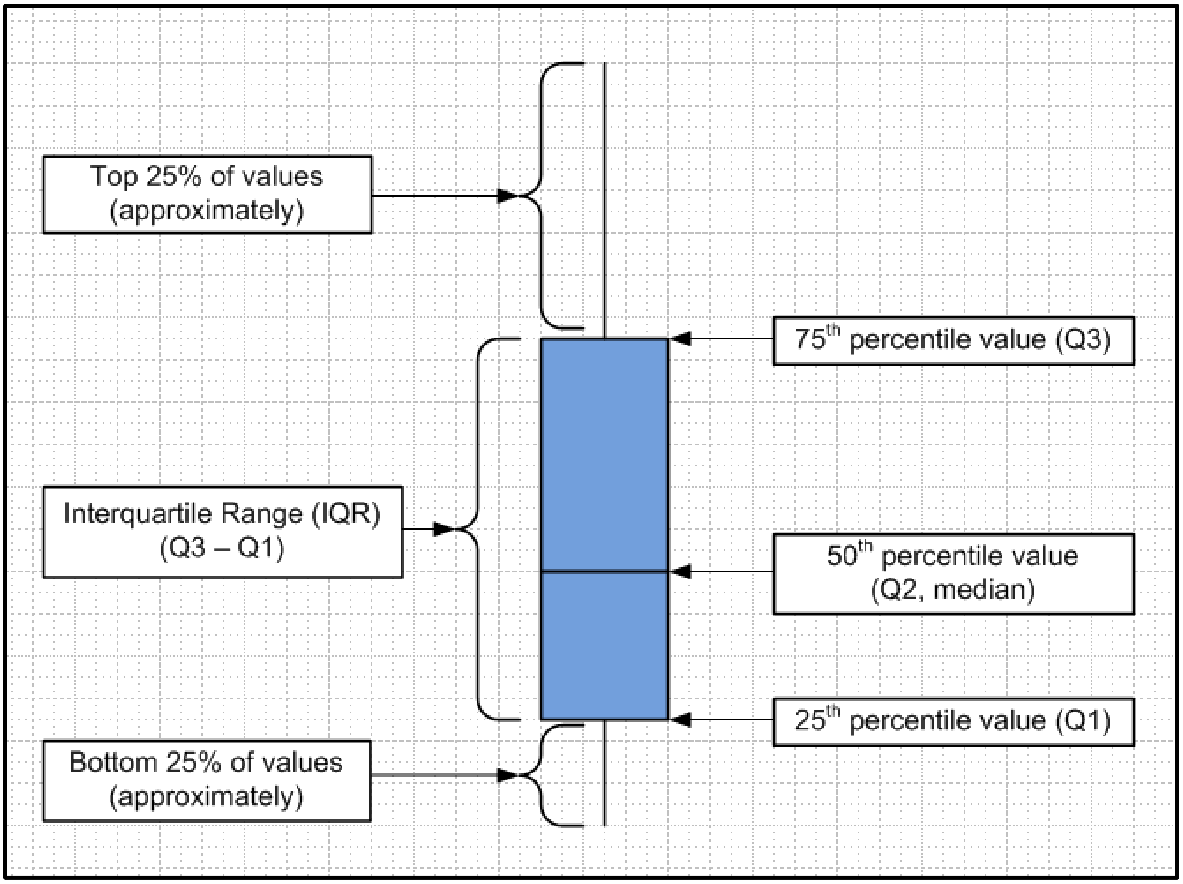



## A.7.2  Box-and-Whisker Plots

The District analyzed the distribution of daily maximum ozone concentrations from year to year for potential changes in the range of recorded ozone concentrations over time. One tool for this analysis is box-and-whisker plots, which the District constructed for a number of Valley ozone air monitoring sites.

Figure A-51 illustrates the general use of the box-and-whisker plots as follows: the box-and-whisker diagram for each year is a representation of the 25th (Q1), 50th (Q2), and 75th (Q3) percentile values in the ozone concentration dataset.  The “whiskers” extending from each end of the box represent the outer ends of the dataset (approximately the top and bottom 25% of the values), where any point outside of these boundaries is considered an outlier for this analysis method.  The difference between Q3 and Q1 is called the interquartile range (IQR).

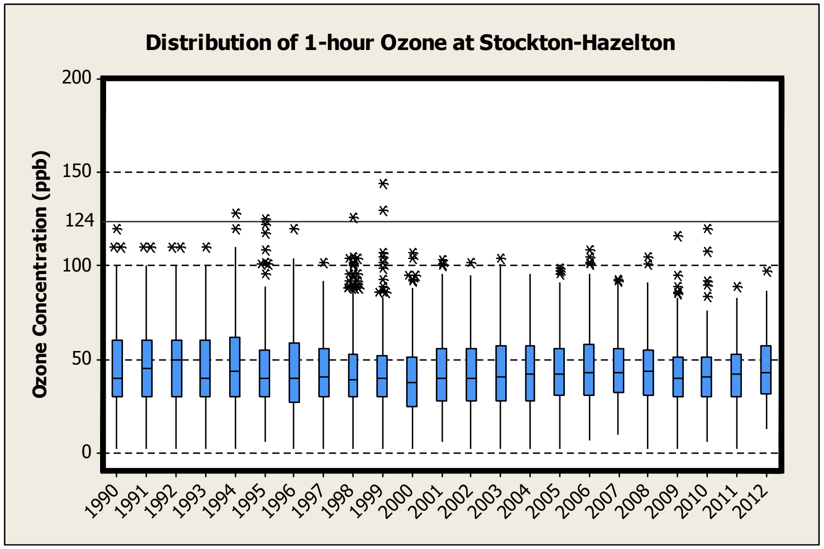
## Figure A-51 Box-and-Whisker Plot Interpretation

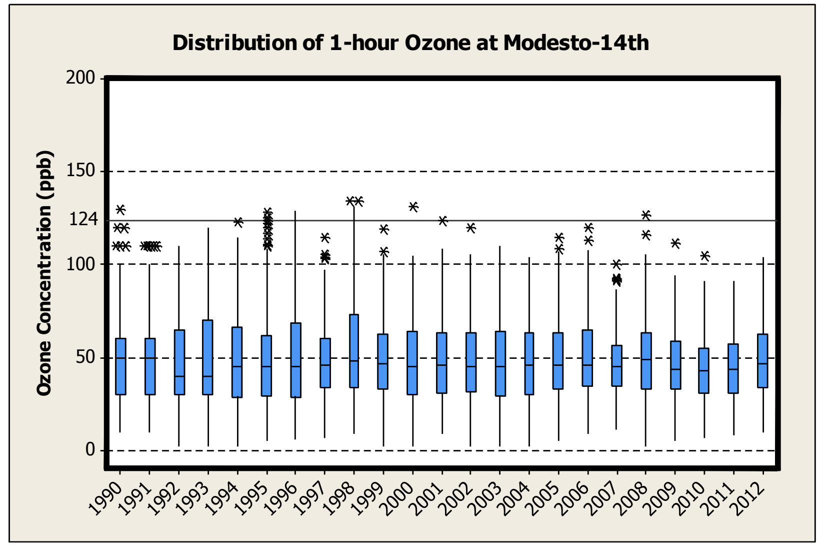


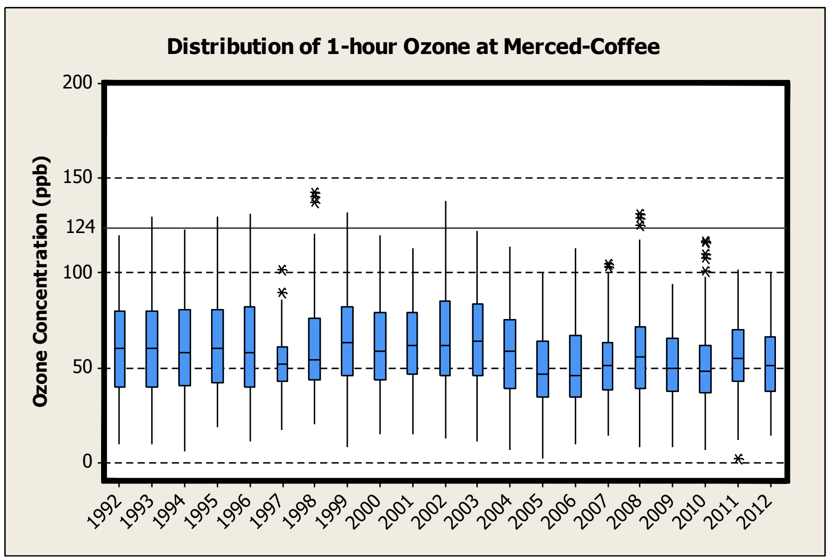

The box-and-whisker plots in the following Figures A-52 to A-63 show an analysis of the daily 1-hour ozone maximum concentrations that occurred at locations throughout the Valley from the 1990s through 2012. In general, the box-and-whisker plots displayed in the following figures show a declining IQR size, as well as gradually decreasing Q1 and Q3 values. The top 25% of values in each year have also been falling from the early 1990s to recent years. As can also be observed, both the frequency and value of outliers in the data distribution over the years have decreased over the displayed time period. Note that the figure for the Arvin-Bear Mountain ozone site has historically had minimal outliers. As a high ozone site in the Valley, this shows that the data is spread more evenly toward the higher values compared to other sites, meaning that high concentrations are much more frequent, thus reducing the number of data points meeting the outlier criteria.

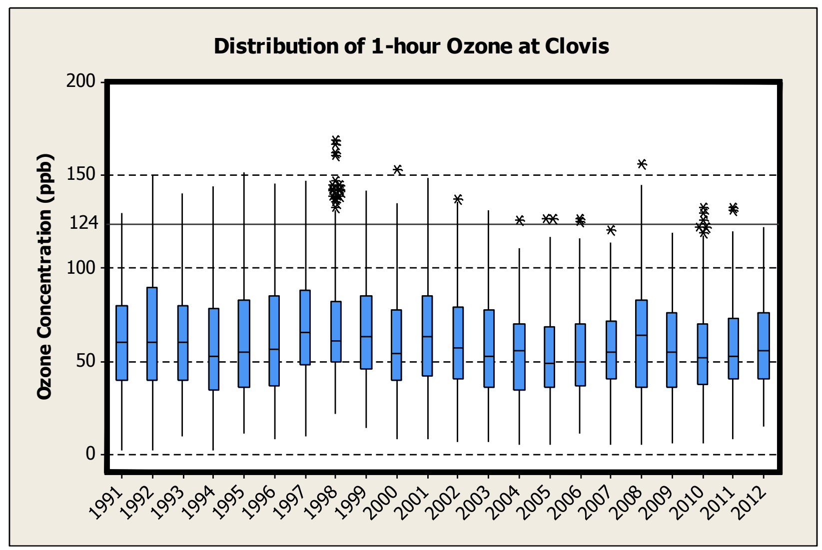
As a comparison, the northern ozone air monitoring sites tend to have smaller IQRs than the sites in the central and southern portions of the Valley. This shows that ozone in the northern part of the Valley tends to have a tighter dataset, where less variance occurs. Since the highest concentrations of ozone usually occur in the central and southern portions of the Valley, the IQR values for the sites in these regions are higher, showing greater variance.

## Figures A-52 to A-55 Ozone Distributions for Stockton-Hazelton, Modesto-14th, Merced-Coffee, Clovis

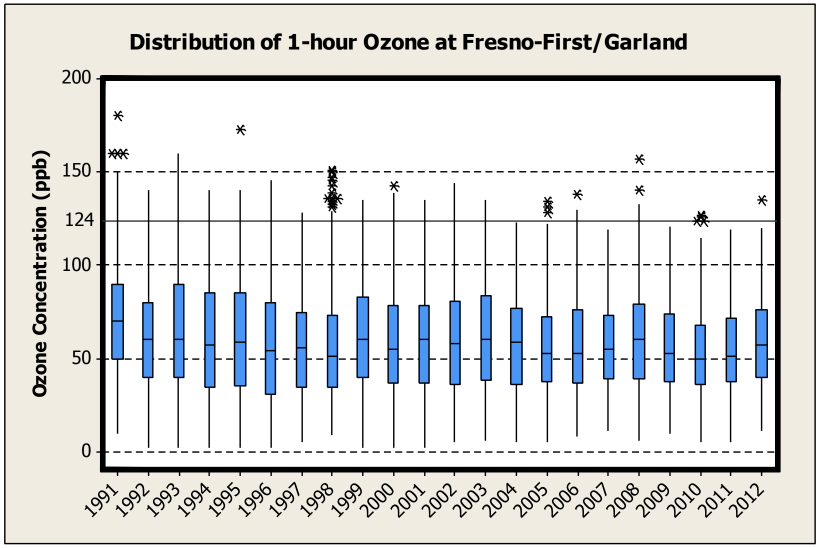


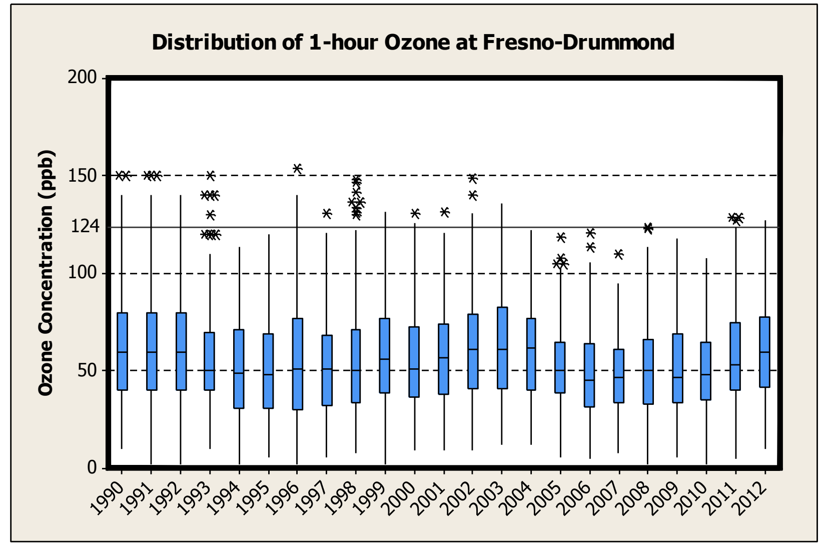



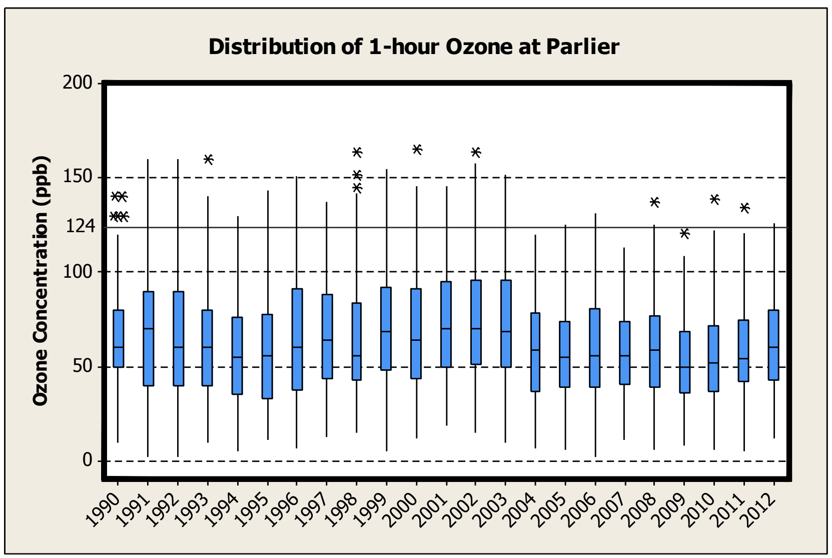



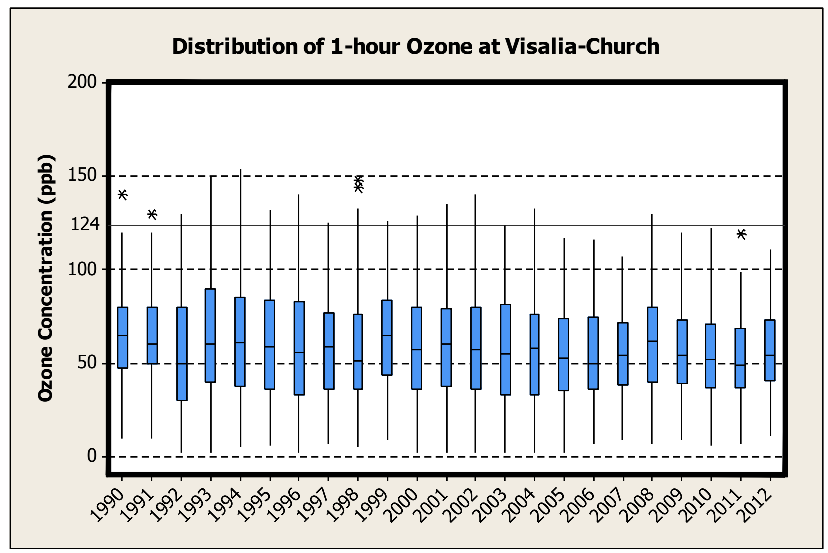



## Figures A-56 to A-59 Ozone Distributions for Fresno-First/Garland, Fresno-Drummond, Parlier, Visalia-Church

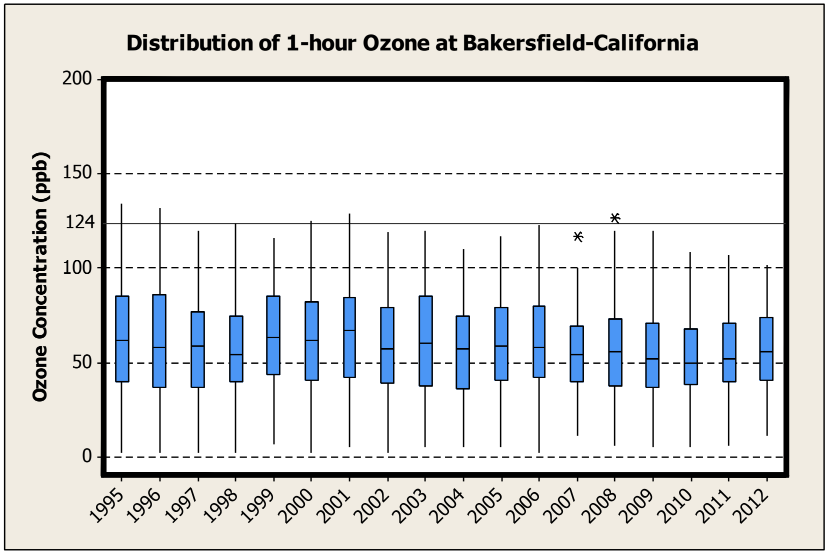


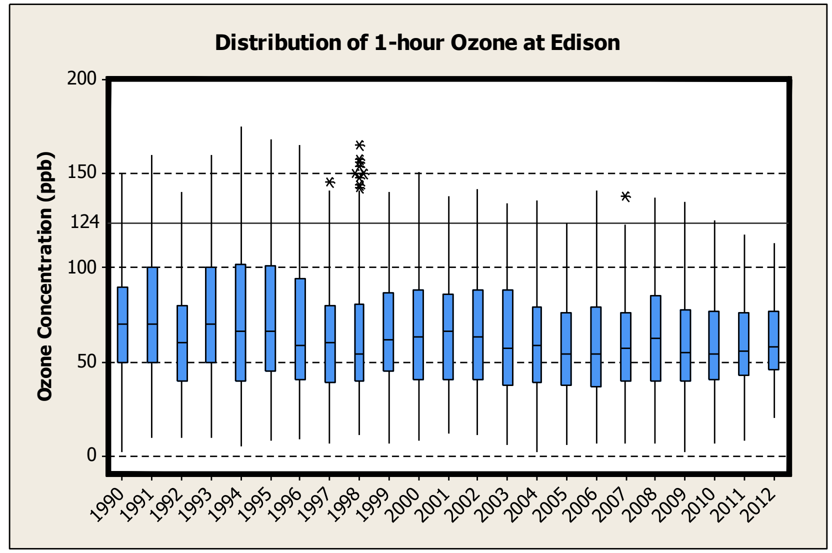



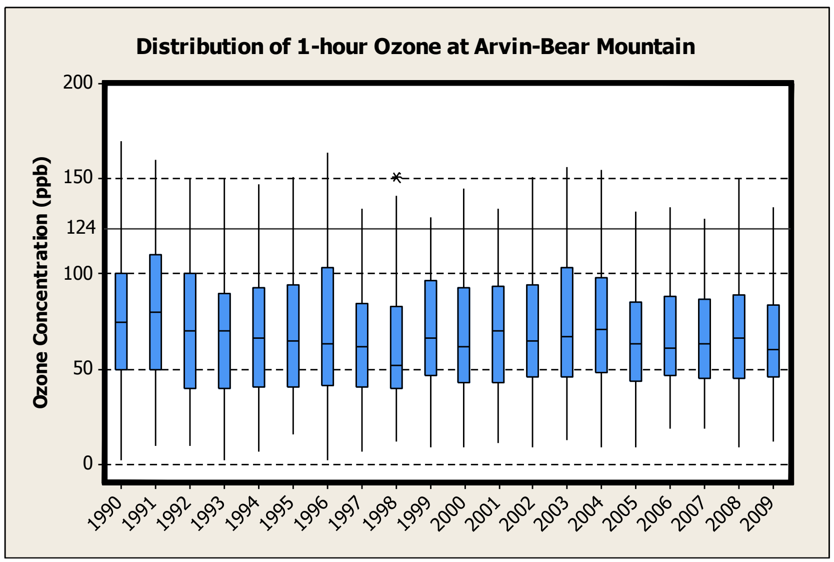



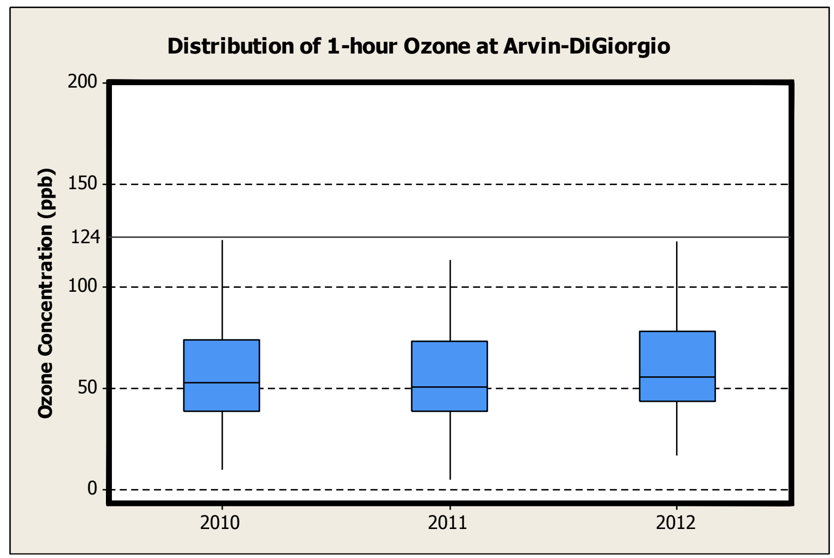



## Figures A-60 to A-63 Ozone Distributions for Bakersfield-California, Edison, Arvin-Bear Mountain, Arvin-DiGiorgio



### A.7.3 Meteorologically Adjusted Trends

Analysis to this point in the appendix has relied on direct observations of ozone. However, since ozone concentrations are highly dependent on weather conditions, long-term weather patterns such as cooler or windier-than-average summers make interpretation of ozone trends challenging. Variable weather parameters, such as temperature, wind, ultraviolet radiation, and vertical stability, result in years with greater or lesser potential to produce ozone than an "average" ozone season. District analysis indicates that long-term fluctuations in weather patterns create significant variability in ozone concentrations from year to year. Considering the effect of meteorology on ozone concentrations helps to determine to what extent changes in ozone concentrations are due to effective control strategies, and to what extent changes may be due to meteorological fluctuations.

During the past two decades, daily maximum 1-hour average meteorologically-adjusted ozone concentrations have steadily decreased, indicating that the observed long-term ozone improvement trend is most likely attributable to emission reductions and not weather variations. Further analysis indicates that the overall weather-adjusted ozone trend decreases faster than the overall unadjusted trend for all sites except Ash Mountain. This finding indicates that ozone trend analysis completed throughout this report is valid and potentially conservative for nearly all sites. The remainder of this section describes the process and results in further detail.

EPA developed a statistical method to account for annual weather-related variability of ozone concentrations[10]. This method compares observed daily maximum 1-hour average ozone concentrations averaged over the ozone season to estimated daily maximum 1-hour average ozone concentrations averaged over the ozone season with the influence of weather removed. Since this method uses seasonal average daily maximum concentrations, results cannot be directly compared to ambient air quality standards, which are generally based on daily maximum 1-hour concentrations. However, the method is an excellent choice for evaluating the overall influence of weather on the entire ozone season. With weather removed, the ozone trend can be used to evaluate changes in precursor emissions attributable to control measures.

To assess the underlying trends in ozone, the District first selected meteorological parameters most influential over Valley ozone concentrations. These selected parameters (temperature, relative humidity, wind speed, vertical stability and solar radiation) were used to develop quantitative relationships between ozone and meteorology for monitoring sites in the Valley. Results from these quantitative relationships were used to develop seasonal average ozone concentrations anticipated under typical weather conditions.

[10] Camalier, L., Cox, W., Dolwick, P. (2007) *The Effects of Meteorology on Ozone in Urban Areas and Their Use in Assessing Ozone Trends*. Atmospheric Environment 41: 7127-7137.

Figures A-64 through A-68 show the seasonal average daily maximum 1-hour ozone concentrations for the summer months of May through September from 1990 through 2012, although not all sites had observations for the entire period. Observed seasonal average concentrations are represented by open circles connected by dashed lines. Meteorologically adjusted seasonal averages are represented by solid circles connected by solid black lines. The heavy dashed red line and the heavy solid red line show the linear trend in seasonal average concentrations and weather-adjusted concentrations, respectively.

When an unadjusted value (open circle) is greater than the meteorologically adjusted value (solid circle), the seasonally averaged observed concentration was higher due to weather. When an unadjusted value (open circle) is less than the meteorologically adjusted value (solid circle), the seasonally averaged observed concentration was lower due to weather. When the adjusted value closely approximates the unadjusted value, the summer was near the statistical average. The meteorologically adjusted concentrations (solid black line with solid circles) and the associated trend line (heavy solid red line) represent the change in concentrations attributable to precursor emissions.

Figures A-64 through A-68 indicate that, meteorologically speaking, the summer of 2007 was near the statistical average for most sites, since observations are closely approximated by adjustments for weather. In addition, the significant increase in observed ozone concentrations (dashed black line with open circles) from 1998 to 2003, was largely due to the influence of weather, as is evident from the generally flat trend in ozone concentrations adjusted for weather (solid black line with solid circles) at most sites.

The influence on the 2008 northern California wildfires is strongly evident at Northern and Central Valley sites (Figure A-64 through A-66) where concentrations were observed to be much greater than anticipated based on the seasons meteorological conditions. Most Southern Valley sites (Figures A-67 and A-68) also show influence from the fires, but to a lesser degree.

After being adjusted for weather, all sites evaluated (Figures A-64 through A-68) show a decreasing trend in 1-hour ozone concentrations from 1990 to 2012. Since this trend is decreasing, rather than flat or increasing, it indicates that emissions reductions, not weather, were responsible for observed ozone reductions. In addition, the overall meteorologically adjusted ozone trend decreases faster than the overall unadjusted trend for all sites except Ash Mountain. This finding indicates that ozone trend analysis completed throughout this report is valid and potentially conservative.

## Figure A-64 Meteorologically Adjusted Ozone Trends in the Northern San Joaquin Valley

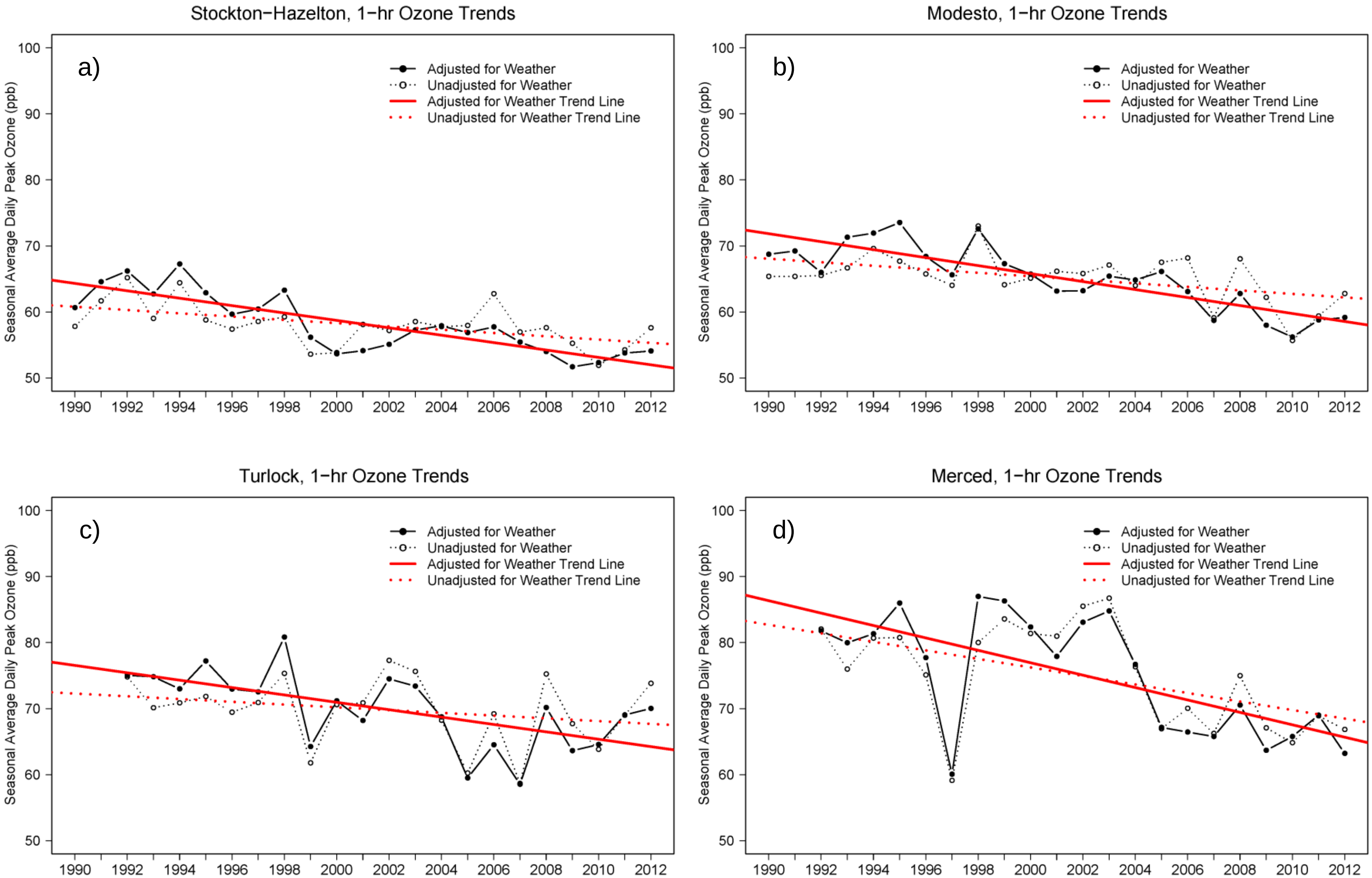
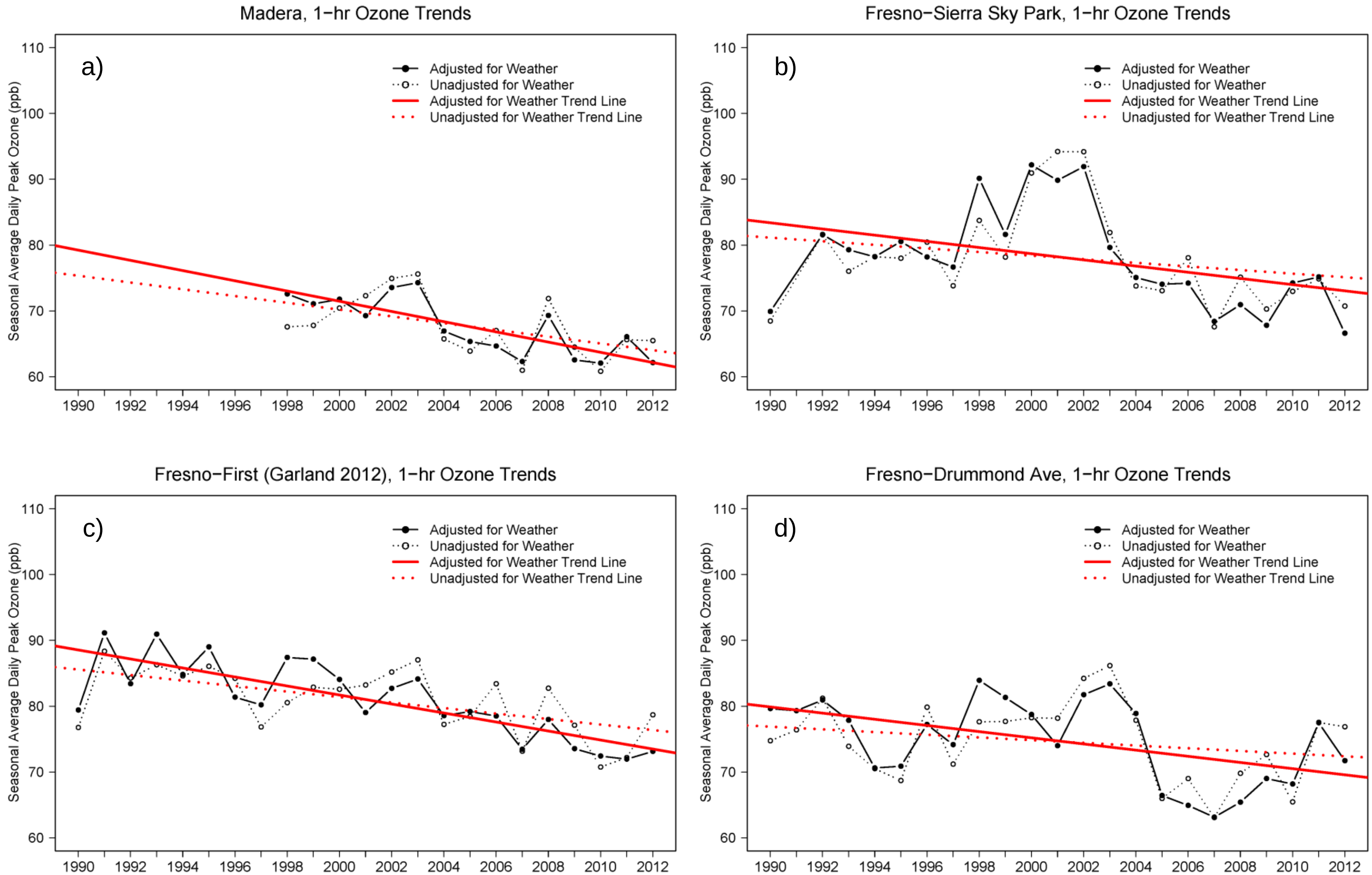
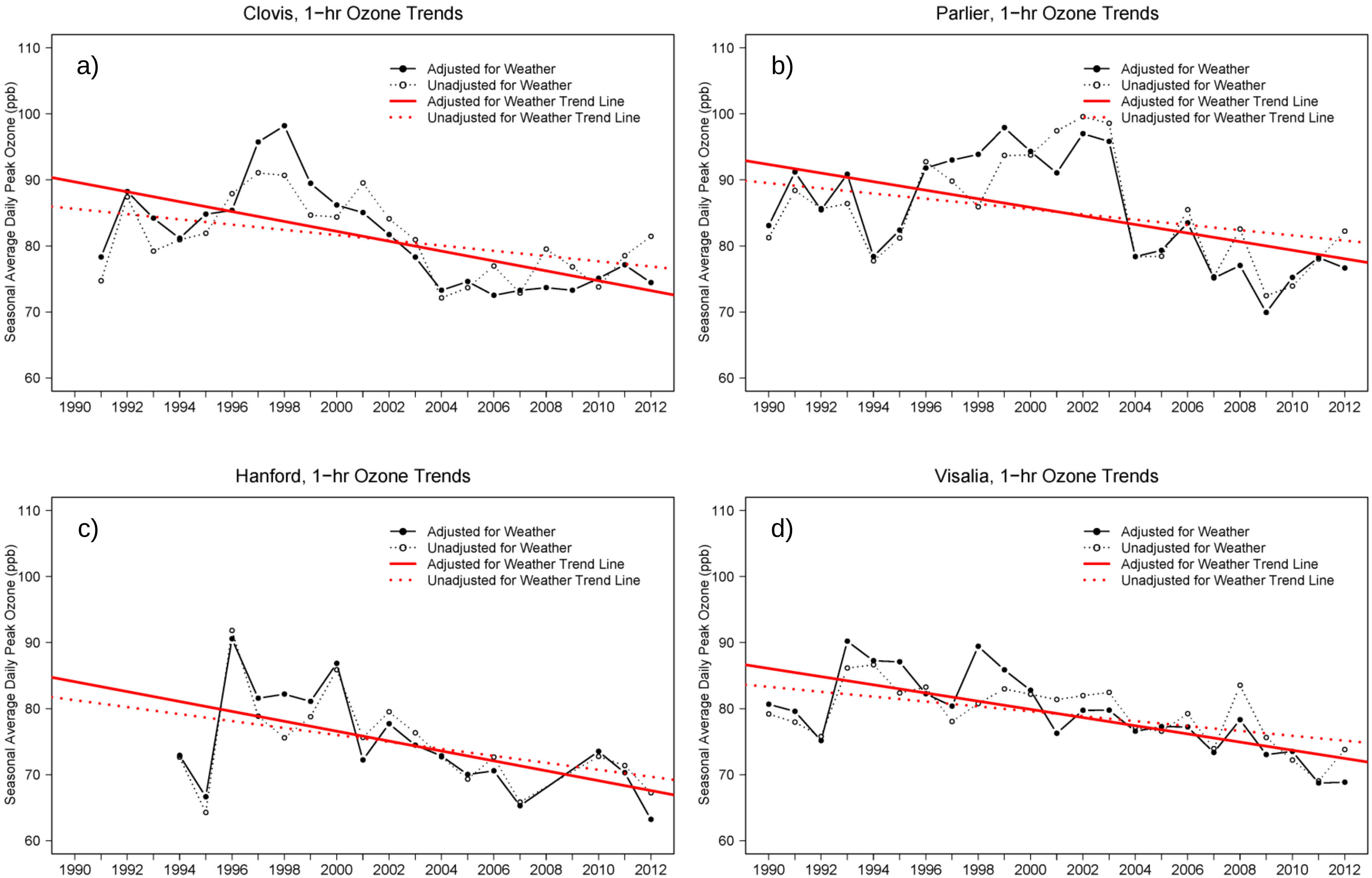


**Figure A-65 Meteorologically Adjusted Ozone Trends in the Central San Joaquin Valley**



## Figure A-66 Meteorologically Adjusted Ozone Trends in the Central San Joaquin Valley



## Figure A-67 Meteorologically Adjusted Ozone Trends in the Southern San Joaquin Valley

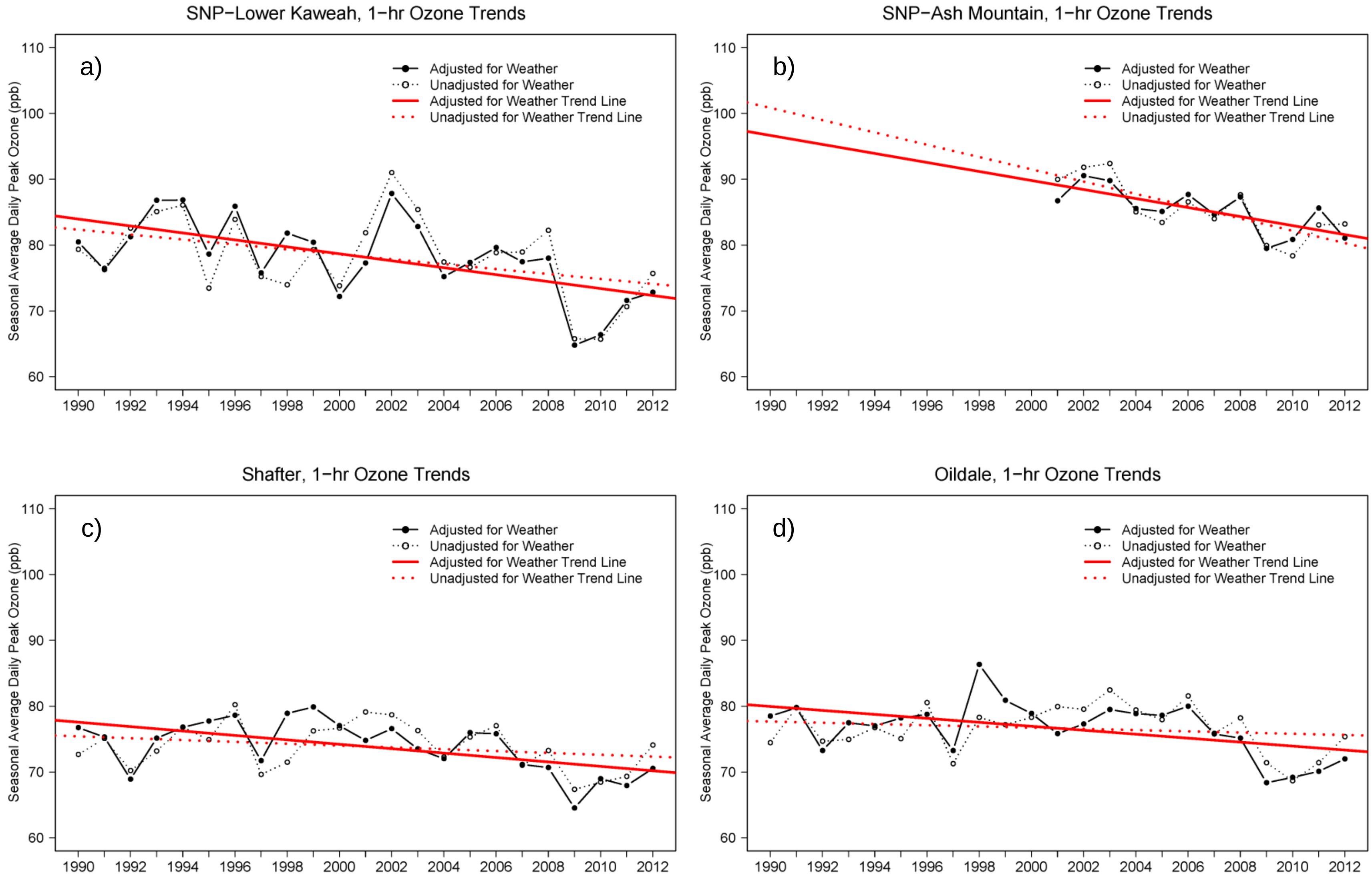


**Figure A-68 Meteorologically Adjusted Ozone Trends in the Southern San Joaquin Valley**