SAN JOAQUIN VALLEY AIRSHED

INTRODUCTION

This chapter describes the naturally occurring determinants of air quality in the San Joaquin Valley Air Basin (SJVAB) relative to PM10. There are numerous factors that influence the effects of pollutants in the air, including the topographical and meteorological characteristics of the SJVAB. This chapter provides a description of the basin and its typical meteorological conditions, discusses the PM10 air quality monitoring network, and summarizes the available ambient air quality data.

AIR BASIN TOPOGRAPHY

The SJVAB is a major geographic, population, and agricultural subregion of California. It includes the counties of San Joaquin, Stanislaus, Merced, Madera, Fresno, Kings, Tulare, and the Valley portion of Kern County. Comprising nearly 25,000 square miles, it represents approximately 16 percent of the geographic area of California. The SJVAB has a population of over 3.3 million people, with major urban centers in Bakersfield, Fresno, Modesto and Stockton.

The SJVAB consists of a continuous inter-mountain valley approximately 250 miles long and averaging 80 miles wide. On the western edge is the Coast Mountain range, with peaks reaching 5,020 feet, and on the east side of the valley is the Sierra Nevada range with some peaks exceeding 14,000 feet. The Tehachapi Mountains form the southern boundary of the valley. This mountain range includes peaks over 6,000 feet, and contains mountain passes to the Los Angeles basin and the Mojave Desert.

METEOROLOGY AND CLIMATE

General Weather Types and Seasons

The SJVAB has an "inland Mediterranean" climate, which is characterized by hot, dry summers and cool, rainy winters. The most significant single control of the weather pattern is the semi-permanent subtropical high-pressure belt, often referred to as the “Pacific High”. It is located off the west coast of North America and is a cell in which air descends almost continuously. The descending air is compressed, thereby raising its temperature and lowering the relative humidity. Major storms and region-wide precipitation are not typical when this pressure cell is dominant. This belt of high pressure migrates north and south seasonally. The SJVAB is under its influence almost continuously during summer months. In winter, the influence of the Pacific High is intermittent, giving rise to alternate periods of stormy, unsettled weather and periods of stable, rainless conditions. The SJVAB averages over 260 sunny days per year. Annual rainfall totals vary from north to south, with northern counties experiencing as much as eleven inches of rainfall and southern counties experiencing as little as four inches per year. Air pollutants are generally transported from the north to the south and in a reverse flow in the winter due to these influences. Strong temperature inversions occur throughout the SJVAB in the summer, fall and winter. According to air quality monitoring data, exceedances of the federal 24-hour PM10 standard are generally seasonal, occurring usually during fall and winter months.

Precipitation

Precipitation in the SJVAB is confined primarily to the winter months with some occurring in late fall and early spring. Nearly 90 percent of the annual precipitation in the SJVAB falls between the months of November through April. Average annual rainfall for the entire SJVAB is about 10 inches on the valley floor. There are north-south and east-west regional differences, with higher rainfall occurring in the northern and eastern parts of the SJVAB. Historical evaluations have correlated increased annual rainfall to decreased PM10 concentrations.

Temperature

The valley floor is characterized by warm to hot, dry summers and cooler winters. The average mean temperature over a 30-year period is 65°F. Daily high temperature readings in summer average 95°F in the valley. Over the last 30 years, the SJVAB averaged 106 days per year 90°F or hotter, and 40 days a year 100°F or hotter. The daily summer temperature variation can exceed 30°F.

Winter temperatures in the SJVAB are generally mild. Temperatures will drop below freezing occasionally, but throughout the valley, winter daytime highs are around 55°F, with lows around 35°F. Despite the latitudinal extent of the valley, the variation of temperature in winter is small. The average January temperature is about 44°F, with little difference between the northern and southern portions of the valley. Surface temperatures are dependent on elevation, with colder temperatures on the mountain ridges both east and west of the valley floor.

Inversion Layers

Inversion layers exist when the air temperature increases with elevation above the ground. The strength, altitude of, and duration of inversions determine the amount of vertical atmospheric mixing which occurs, which subsequently contributes to PM10 concentrations in the SJVAB. Temperature inversions occur in a stable atmosphere of warm air over cooler air hindering the upward dispersion of pollutants. Mixing ceases at the base of the inversion, which is also known as the mixing height. The SJVAB experiences two common types of inversions: radiation inversions and subsidence inversions.

Nocturnal cooling of an air layer near the SJVAB surface causes radiation inversions. It extends upward several hundred feet and occurs during the evening and early morning hours. During a radiation inversion, little vertical mixing occurs near the surface. The inversion dissipates when solar radiation warms the ground, which in turn heats the lower layers of the atmosphere. This heating causes the surface-based inversion to weaken, and finally dissipate, which allows vertical mixing through a greater depth in the atmosphere. Inversions are more persistent (stable) during the winter months, when inversions occur from 50 to 1,000 feet above the SJVAB floor. Studies in the southern part of the SJVAB indicate more frequent and persistent early morning radiation inversions than in the northern part of the valley due to the lack of marine air intrusion.

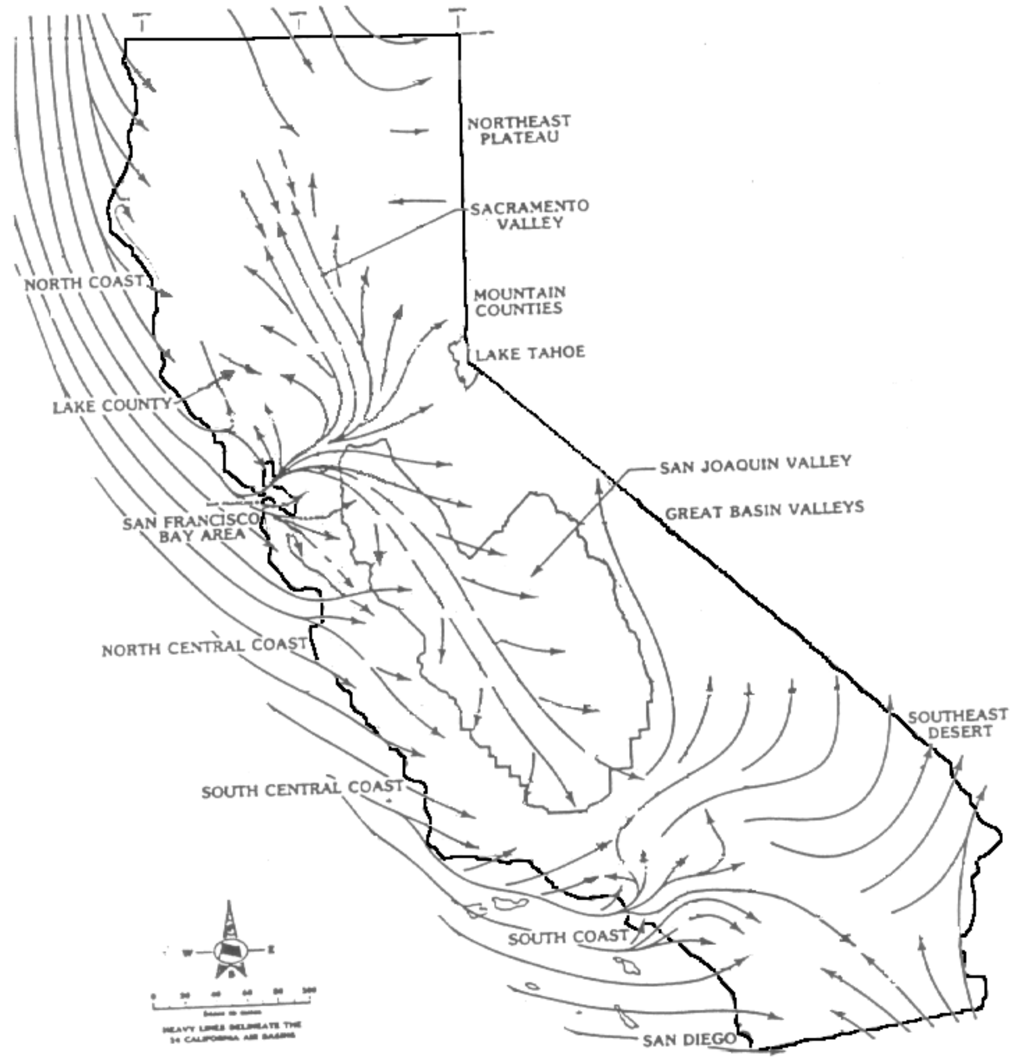
Subsidence inversions are caused by downward vertical motion in the atmosphere. As air descends, it warms due to compression, and as a result becomes warmer than the air beneath it. This is common when the semi-permanent Pacific High pressure system is located off the west coast, which typically occurs during the summer months.

Horizontal Mixing and Dispersion

In addition to vertical mixing, horizontal mixing, or transport, is also important in the dispersal of air pollutants. The greater the velocity of wind in the mixing layer, the greater the amount of mixing (dispersion) and transport of pollutants. Wind speed and direction play an important role in dispersion and transport of air pollutants. Wind at the surface and aloft can disperse pollution by vertical mixing and by transporting it to other locations. Wind speed and direction data indicate that during the summer the light and variable winds usually result from an influx of air from the Pacific Ocean through the Bay Area delta region, entering the north end of the valley. The wind generally flows in a south-southeasterly direction through the valley, through the Tehachapi Pass, and into the Southeast Desert Air Basin portion of Kern County.

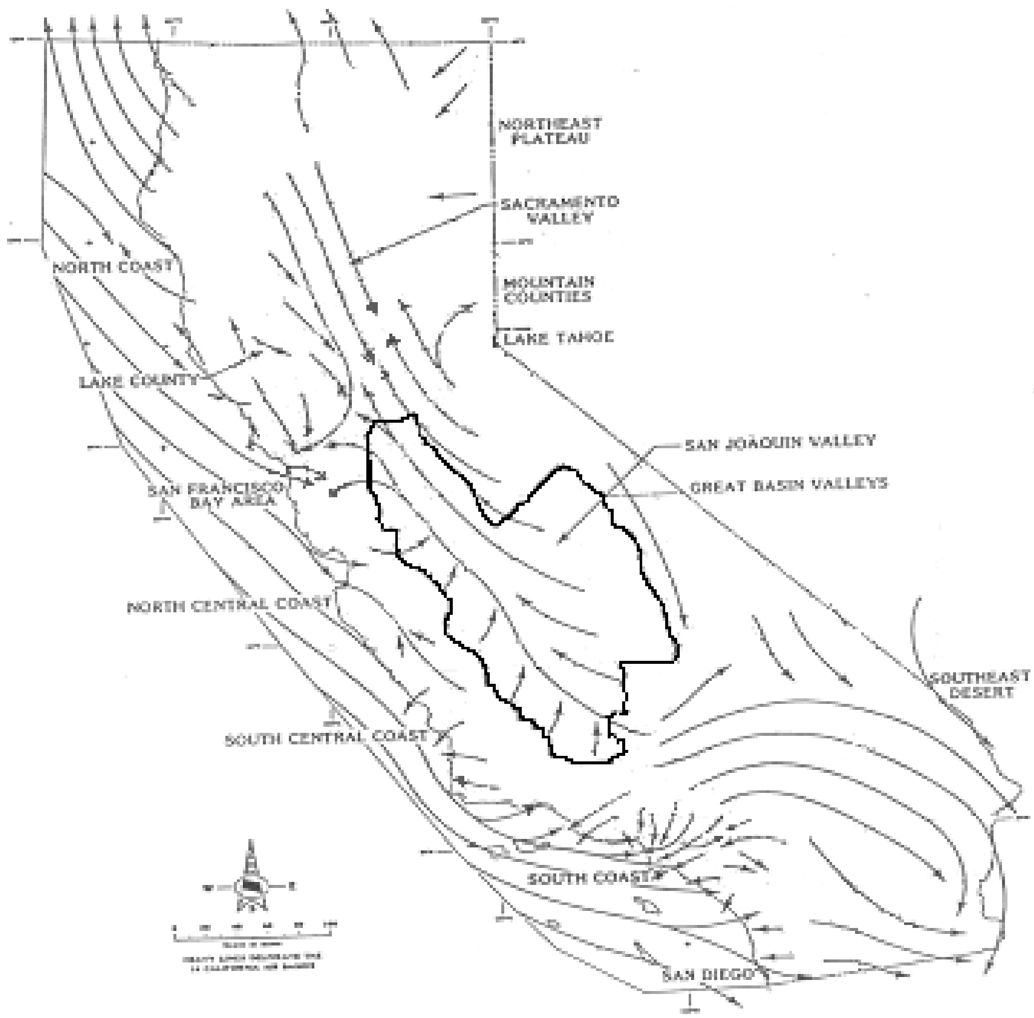
See Figure 2-1 for the wind flow entries and exits during the valley's summer months.

Figure 2-1



During the winter, wind speed and direction data indicate that wind occasionally varies from the south-southeasterly direction, and originates from the south end of the Valley, flowing in a north-northwesterly direction. Also during the winter months, the Valley experiences light, variable winds of less than 10 mph. Low wind speeds, combined with low-lying inversion layers in the winter, create a climate conducive to the formation of high PM10 concentrations. See Figure 2-2 for winter wind patterns.

Figure 2-2



PM10 geologic dust emissions in the SJVAB do not follow the conventional assumption that wind erosion is the dominant factor. Average wind velocity is the lowest in the nation for an area this large. Winds normally exceed erosive velocity levels at a site for only 30 to 50 days per year and sometimes less. Sites along the southeastern edge of the SJVAB have a significantly lower number of erosive wind days than the western edge due to the mountain ranges, which act as wind barriers adjacent to these areas. Over 75 percent of the winds with enough velocity to cause erosion occur in the spring and summer seasons in the Air Basin when PM10 levels in the ambient air are among the lowest. This suggests that these winds are effective in dispersing PM10 concentrations and/or transporting PM10 out of the SJVAB.

Other factors such as soil type and soil moisture content prevent these winds from entraining a large amount of PM10 during this period. Erosive winds are defined as having a velocity of 13 mph at a height of one foot above the ground or eighteen miles per hour at a height of approximately thirty-three feet above the ground; these two wind speeds are considered equivalent. Erosive wind speeds can be much lower for some soil conditions[1].

PM10 originating from or going to other air basins, referred to as pollutant transport, has not been definitively quantified. PM10 readings in the SJVAB are most severe during the fall and winter periods when wind speed and direction are not conducive to interregional transport. Monitoring and speciation techniques currently available are not able to identify the origin of PM10 sources with sufficient detail to indicate if the SJVAB is experiencing transport from outside the air basin or contributing transport of PM10 to other air basins.

MONITORING NETWORK

PM10 Monitoring Network Requirements

The EPA requires that the state and the San Joaquin Valley Air Pollution Control District (District) measure the ambient levels of air pollution to determine compliance with the NAAQS. The District and the state operate the ambient monitoring network in order to comply with this mandate. The ARB and the District currently operate fifteen sites throughout the SJVAB. In addition, the agencies operate numerous co-located monitors to measure the precision and accuracy of data collected from the monitoring sites.

Air quality monitoring for PM10 is performed at State and Local Air Monitoring Stations (SLAMS) within the District, including National Air Monitoring Stations (NAMS) and Photochemical Assessment Monitoring Stations (PAMS). The EPA uses data from NAMS sites to develop national air quality trends.

Federal regulations require SLAMS networks to meet four basic monitoring objectives:

- Monitoring the highest concentration of a pollutant
- Monitoring representative concentrations in areas of high population density
- Monitoring the impact of major pollutant sources, and
- Monitoring pollutant background concentrations.

The physical location of an air monitoring station must achieve a spatial scale of representativeness that is consistent with the monitoring objective. Spatial scales of representativeness are categories of sampling exposure. The spatial scale for each site results from the physical location of the site with respect to the pollutant sources and the population or area that is to be represented by the monitoring site. The

[1] NRCS Field Office Technical Guidelines and National Agronomy Manual, Second Edition, Part 502, Wind Erosion, US Department of Agriculture, Soil Conservation Service, March 1988

categories are classified by the size of the area surrounding the monitoring site which experiences uniform pollutant concentrations.

The categories of spatial scale range from microscale, which is an area of uniform pollutant concentrations with a radius ranging from several meters up to 100 meters, to *Regional Scale* – which is a very large area that has a radius from tens to hundreds of kilometers.

Monitoring for PM10 and finer particulate matter is focused primarily on monitoring representative population exposure concentrations. Thirteen of the fifteen current PM10 monitoring stations are at the neighborhood scale. The Bakersfield-California and Oildale-Manor stations are designed for middle scale.

According to Title 40, Code of Federal Regulations, Part 58, Appendix D, section 3.7, the District is required to operate a minimum of three PM10 NAMS in the Stockton, Fresno, and Bakersfield urbanized areas and a minimum of one in the Modesto urbanized area based on 2000 census population figures and because the District is characterized by high concentrations of PM10.

SLAMS/NAMS PM10 Monitoring Network

Table 2-1 lists the SLAMS/NAMS PM10 monitoring network for the SJVAB.

Table 2-1
SJVAB SLAMS/NAMS PM10 Monitoring Network

Station Name	Scale	Monitoring Objective	Type	Agency
Bakersfield-California	Middle	Representative Concentration	SLAMS	ARB
Bakersfield-Golden State	Neighborhood	High Concentration	SLAMS	SJVAPCD
Clovis-Villa	Neighborhood	Representative Concentration	NAMS	SJVAPCD
Corcoran-Patterson	Neighborhood	High Concentration	SLAMS	SJVAPCD
Fresno-Drummond	Neighborhood	Representative Concentration	NAMS	SJVAPCD
Fresno-First Street	Neighborhood	High Concentration	NAMS	ARB
Hanford-Irwin	Neighborhood	Representative Concentration	SLAMS	SJVAPCD
Merced-2334 M Street	Neighborhood	Representative Concentration	SLAMS	SJVAPCD
Modesto-14th Street	Neighborhood	Representative Concentration	SLAMS	ARB
Oildale-Manor	Middle	Source Impact	SLAMS	ARB
Stockton-Hazelton	Neighborhood	High Concentration	NAMS	ARB
Stockton-Wagner/Holt	Neighborhood	Representative Concentration	NAMS	SJVAPCD
Taft-College	Neighborhood	Representative Concentration	SLAMS	SJVAPCD
Turlock-Minaret	Neighborhood	Representative Concentration	SLAMS	SJVAPCD
Visalia-Church	Neighborhood	Representative Concentration	SLAMS	ARB

AMBIENT AIR QUALITY DATA AND ANALYSIS

The current federal standards for PM10 are 50 ug/m^3 for an annual arithmetic mean, and 150 ug/m^3 for a maximum 24-hour concentration. The monitoring network discussed earlier provides the data, and this section presents some key findings of that data.

Recent Ambient Air Data

Table 2-2 summarizes the 24-hour maxima of PM10 data for the years 1995-2001 by site. Table 2-3 presents the sites in exceedance of the PM10 24-hour standard and the estimated number of days in exceedance. It is important to realize that since the District monitors PM10 only once in six days, the specific number of days that exceed the 24-hour standard cannot be determined. Table 2-4 presents specific dates when exceedances were observed. Although monitoring for PM10 started in 1987, only recent data are included in these tables.

Table 2-2
Trend Data: PM10 24-Hour Maximum
(μ/m^3)

Station Name	1995	1996	1997	1998	1999	2000	2001
Bakersfield-California	130	153	137	148	143	140	190
Bakersfield-Golden State	132	153	124	159	183	145	205
Clovis-Villa	120	108	103	113	151	114	155
Corcoran-Patterson	---	141	199	128	174	128	165
Fresno-Drummond	126	121	121	132	162	138	186
Fresno-First Street	122	144	124	141	154	138	193
Hanford-Irwin	186	120	143	146	143	119	185
Madera-Library	110	---	---	---	---	---	---
Merced-2334 M Street	---	---	---	---	134	104	113
Modesto-I Street	115	133	119	61	---	---	---
Modesto-14th Street	---	74	---	125	132	112	158
Oildale-Manor	195	138	125	103	156	122	158
Stockton-Hazelton	109	127	98	106	150	91	140
Stockton-Wagner/Holt	---	117	130	99	118	104	119
Taft-College	93	94	78	84	101	99	128
Turlock-Minaret	120	122	111	108	157	104	148
Visalia-Church Street	128	115	96	160	152	130	143

Table 2-3
SJV Monitoring Sites that Violate the
24-Hour PM10 NAAQS (Estimated)

Monitoring Station	Estimated 1999 Exceedances	Estimated 2000 Exceedances	Estimated 2001 Exceedances	Average # of Exceedances per year 1999-2001
Modesto 14th St	0.0	0.0	1.0	1.0
Fresno Drummond	8.4	0.0	6.0	4.8
Fresno First St	0.0	0.0	6.0	2.0
Clovis	0.0	0.0	6.0	2.0
Bakersfield Golden State	6.0	0.0	12.0	6.0
Bakersfield California Ave	0.0	0.0	9.0	3.0
Oildale	3.8	0.0	5.6	3.1
Corcoran	6.1	0.0	7.6	4.6
Hanford	0.0	0.0	12.6	4.2
Turlock	11.5	0.0	0.0	3.8

Table 2-4
Site Concentrations of Days Exceeding the 24-Hour
PM10 NAAQS (Observed)

Date	Monitoring Site	Concentration (µg/m³)
January 12, 1999	Oildale	156
October 21, 1999	Fresno- Drummond	162
	Corcoran	174
	Turlock	157
November 14, 1999	Bakersfield- Golden State	183
January 1, 2001	Fresno-Drummond	186
	Fresno-First St	193
	Clovis	155
	Bakersfield- Golden State	205
	Bakersfield- California Ave	186
	Oildale	158
January 3, 2001	Bakersfield- California Ave	190
January 7, 2001	Bakersfield- Golden State	174
	Bakersfield- California Ave	159
	Modesto	158
	Corcoran	165
	Hanford	185
November 9, 2001	Hanford	155

Trend and Spatial Variations

The SJVAB has followed the national trend of declining PM10 levels since the 1980s, with relatively stable values over the last few years. The national long-term trend of declining PM10 values and the unusual nature of recent meteorological influences of El Niño and La Niña affect District PM10 trends. The SJVAB also experiences periods of long-term drought that would be expected to increase the geologic component of PM10 by decreasing soil moisture and increasing the emission factors for sources that generate fugitive PM10 emissions. Complex meteorological phenomena make it challenging, if not impossible, to differentiate between improvements made in ambient air quality due to regulatory actions and voluntary emission reduction projects, and those improvements due to unusual meteorological effects.

Seasonal Variations

Extensive seasonal variation has been established for sources contributing to PM10 concentrations and atmospheric processes contributing to particle formation and retention. The period of October through January generally includes the most frequent and severe exceedances of the federal 24-hour PM10 standard. Analysis of filters reveals that different meteorological conditions and sources contribute to exceedances in the fall versus the winter. However, both periods commonly experience stagnant conditions. During a stagnant period, primary geologic or secondary particulates accumulate, resulting in concentrations that eventually exceed the PM10 standard.

The first of the two periods of the year is during the months of October, November, and December. Generally, rain has not occurred and there are low wind speeds and stagnant air. The PM10 during this period is dominated by primary particulates. One species of primary particulates (primary geologic) comprises the highest portion (at least two thirds) of the samples taken during this period. Primary geologic is simply dust generated from dirt that is under ten microns in size. Sources contributing to elevated geologic dust include paved and unpaved roads, construction activities, and agricultural operations. The nitrates become more prevalent in mid-November, while geologic materials do not decline until significant rainfall occurs, usually in the mid-November to mid-December time frame.

The second elevated PM10 period of the year begins mid-November to mid-December and extends through February. The second period is characterized by extended periods of stagnant air interspersed with cold, damp, foggy conditions conducive to the formation of particulate nitrate in amounts that are frequently the dominant component of PM10. Colder, frequently stagnant conditions occurring in December and January favor the formation of ammonium nitrate. Secondary PM10 species, such as ammonium nitrate, ammonium sulfate, and organic particles are formed through chemical interactions from directly emitted SOx, NOx, VOC and ammonia. The samples during this period are dominated by secondary particulates (often 70 percent or more of the material found on a filter). Secondary particulates are particles that are the end products of many chemical reactions that occur in the atmosphere. Precursors, the chemicals that are involved in the chemical reactions, are NOx, VOC, SOx and ammonia.

Diurnal Variations

During the Integrated Monitoring Study of 1995 (IMS95), a special study as part of the California Regional PM10/PM2.5 Air Quality Study (CRPAQS), special monitors were run on a daily basis for approximately one month with the filters being changed every three hours. The results of that study showed that in urban areas, the greatest concentrations of PM10 during December and January are measured in the evening hours after most people arrive home from work. This data suggest that PM10 could be emitted and be forming at increased rates during the evening hours (6:00 PM through midnight). Other findings from CRPAQS have already been incorporated in these discussions regarding seasons and episodic development and patterns.

Ongoing PM10 Data Analysis

The EPA requires that ongoing analysis of PM10 data from throughout the network be conducted to determine if the monitoring schedule meets the minimum sampling frequency requirements of Title 40, Code of Federal Regulations, Part 58.13. All PM10 monitoring in the SJVAB is conducted on a sixth-day minimum schedule, as required by EPA and the ARB. The PM2.5 monitor scheduling varies according to season. Sampling frequency from April-September is every six days and changes to every third day for the months of October-March.

CONCLUSION

Air pollution within the SJVAB is intensified by topographical and meteorological conditions, which hinder the movement of air, thereby reducing the dispersion and dilution of emissions. The surrounding mountain ranges block dispersion, minimizing wind flows into and out of the basin.

The SJVAB exceeds both the federal annual and 24-hour PM10 standards for ambient air quality. According to air quality monitoring data, exceedances of the 24-hour standard are generally seasonal and occur during fall and winter months.