California Environmental Protection Agency

Air Resources Board

Report on Arvin Special Purpose PM2.5 Monitoring Project

Planning and Technical Support Division

Air Quality Data Branch

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Introduction

In order to respond to community concerns regarding PM2.5 air quality in the community of Arvin, the Air Resources Board (ARB) conducted a short-term special purpose monitoring study to compare PM2.5 levels in Arvin with those in Bakersfield, where routine monitoring is conducted. Bakersfield is California's third largest inland city, after Sacramento and Fresno, with a population of about 350,000. Bakersfield lies near the southern end of the San Joaquin Valley at an elevation of about 384 feet. The city's economy relies on agriculture, petroleum extraction and refining, and manufacturing. Arvin, while part of the Bakersfield Metropolitan Statistical Area, is located about 15 miles southeast of Bakersfield at an elevation of 450 feet. Arvin is primarily a rural agricultural community with a population of approximately 16,000. Figure 1 shows the location of the two communities.

The United States Environmental Protection Agency (U.S. EPA) requires states to monitor air pollution to assess the healthfulness of air quality. These data are used to drive regulatory decisions, including designating areas as attainment or nonattainment, developing cost-effective control programs, and tracking air quality progress. California's PM2.5 monitoring network addresses these objectives through the operation of compliance monitors which are required to be located in populated areas, with special emphasis on representing neighborhood or larger scale health exposure.

The routine PM2.5 monitoring network in the San Joaquin Valley (as shown in Figure 2) meets U.S. EPA regulatory requirements for collecting data for comparison to the federal health-based air quality standards. The San Joaquin Valley has some of the highest PM2.5 concentrations in the country and currently exceeds both the annual and 24-hour federal air quality standards. The PM2.5 monitoring network in the Valley has shown that concentrations are highest in the Bakersfield area. Two monitors are currently operated in Bakersfield as part of the routine PM2.5 monitoring network to characterize population exposure in this region. Given the high levels, Bakersfield is the focus of regulatory efforts to meet the federal PM2.5 standards. The emission reductions needed to reduce PM2.5 levels in Bakersfield will also ensure that the federal PM2.5 air quality standards are achieved throughout the Valley.

The remainder of this report will provide background information on the nature of PM2.5 in the Valley, discuss PM2.5 monitoring methodologies, describe the special purpose monitoring that was conducted, and present the results of the study.

Figure 1. Location of Bakersfield and Arvin

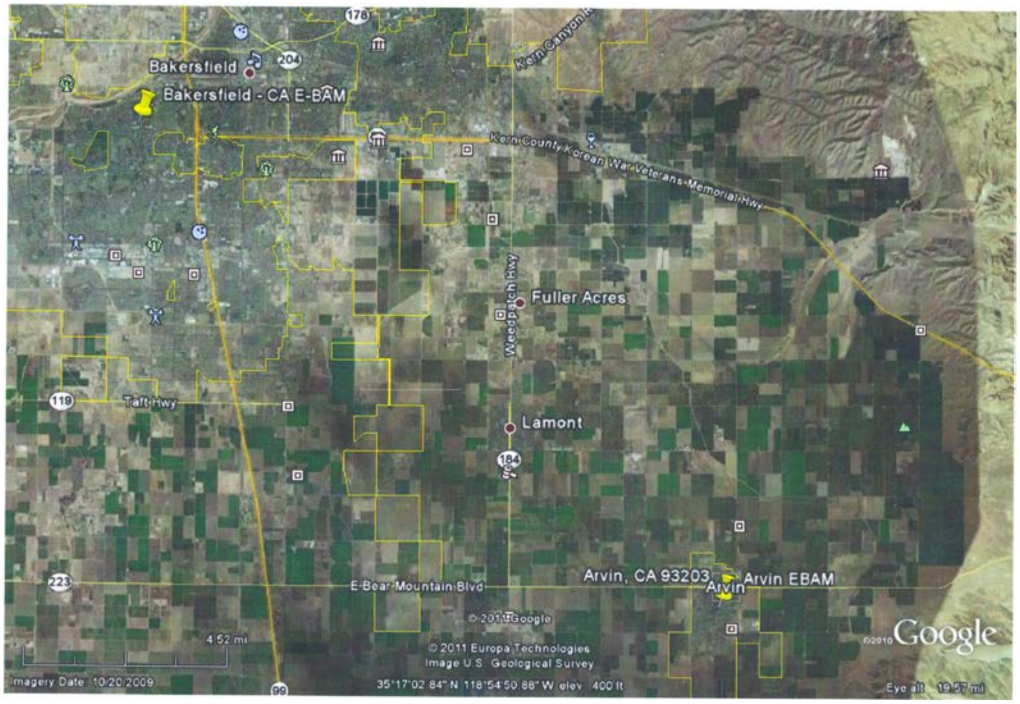
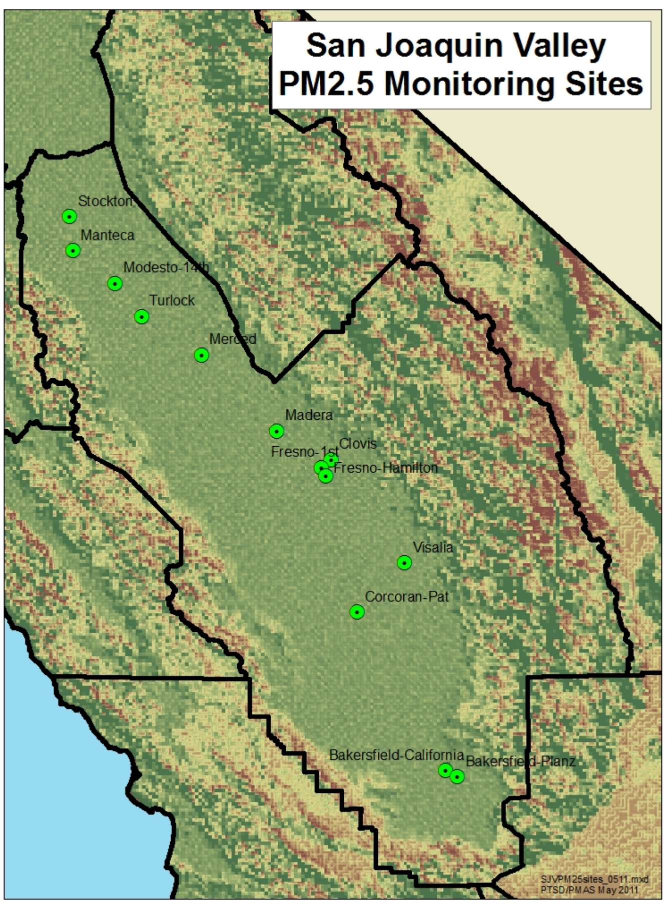


Figure 2. San Joaquin Valley PM2.5 monitoring network



Nature of PM2.5 in the San Joaquin Valley

The U.S. EPA has established both annual and 24-hour PM2.5 air quality standards. The annual standard is 15 micrograms per cubic meter (ug/m3). The 24-hr standard was recently revised to a level of 35 ug/m3. The San Joaquin Valley is designated nonattainment for both standards.

PM2.5 particles can be either directly emitted (known as primary particulate matter) or formed via atmospheric reactions (known as secondary particulate matter). Primary particles are emitted from cars, trucks, and heavy equipment, as well as residential wood combustion, forest fires, and agricultural waste burning. The main components of secondary particulate matter in the Valley are ammonium nitrate and ammonium sulfate which forms when nitrogen oxide and sulfur dioxide emissions from cars, trucks, and industrial facilities react with ammonia. Particulate pollution measured at a given location can have both a local and a regional contribution. The local pollution is mostly primary in nature while the regional pollution is generally secondary in nature.

To better understand the nature of the PM2.5 problem in the San Joaquin Valley, the ARB, U.S. EPA, San Joaquin Valley Air Pollution Control District, and other public and private sponsors conducted the $27 million California Regional Particulate Matter Air Quality Study (CRPAQS). The CRPAQS network included 38 sites where PM2.5 data were measured for 14 months, from December 1999 through February 2001. Intensive measurements were focused on the winter months when PM2.5 concentrations are highest. Cool stable conditions and low wind speeds coupled with the Valley's topography limit dispersion of pollutants and allow multi-day buildups of PM2.5 concentrations to occur during this time of year.

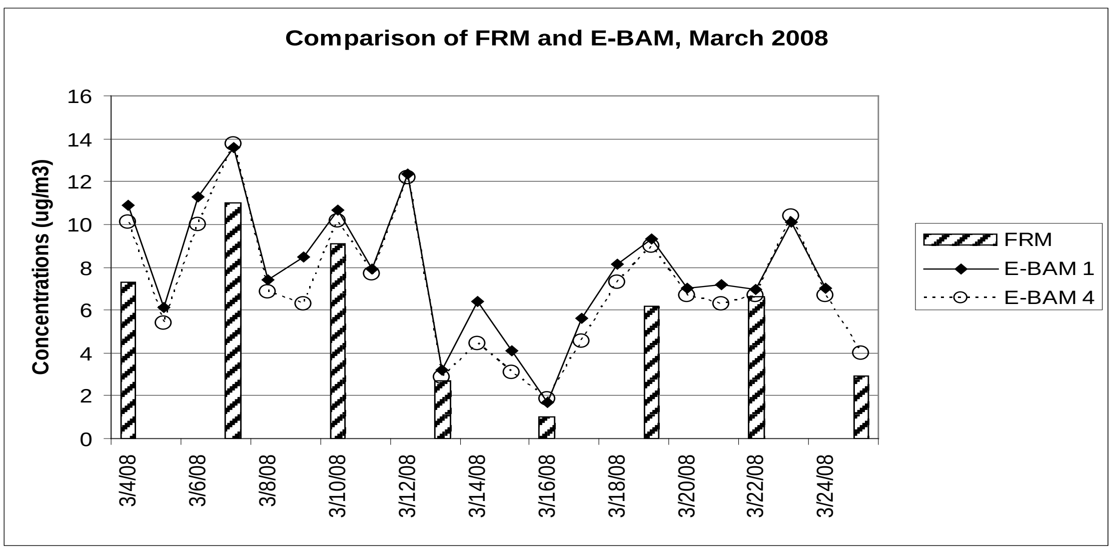
One of the goals of CRPAQS was to examine the spatial variability of PM2.5 throughout the Valley, as well as the differences between urban and rural PM2.5 levels. Results from the CRPAQS winter intensive showed a fairly uniform distribution of secondary ammonium nitrate throughout the southern San Joaquin Valley, with similar concentrations at both urban and rural sites. Study analyses indicated that Bakersfield was located at the southern boundary of the region of maximum ammonium nitrate, with concentrations decreasing sharply to the south of the city. In contrast, concentrations of primary PM2.5 due to mobile sources and residential wood combustion were highest in urban areas, with lower concentrations in rural areas. The higher concentrations of primary PM2.5 in Bakersfield, combined with a decrease of ammonium nitrate concentrations to the south of town, suggest that PM2.5 concentrations at Bakersfield should be higher compared to Arvin.

PM2.5 Monitoring Methodologies

The PM2.5 monitoring network includes a variety of monitoring instruments to collect data for different objectives. Monitoring sites that provide data for a comparison to the federal air quality standards must employ U.S. EPA certified Federal Reference Method (FRM) or Federal Equivalence Method (FEM) sampling techniques. In contrast, special purpose studies often rely on portable instruments that are not FRMs or FEMs. The E-BAM is one example of a portable instrument that is commonly used. E-BAMs are well suited for short term special studies due to their cost effectiveness and mobility, but the collected data cannot be used for determining compliance with the PM2.5 standards.

The FRMs and E-BAMs operate on different principals. The FRM collects data on a filter, usually over a 24-hour period, which is then transported to a lab for a weighing. An E-BAM is a continuous air sampler that collects hourly data based upon the principal of beta ray attenuation. The mass is determined based on the loss of beta rays due to absorption by particles collected on a glass filter tape. ARB has used E-BAMs for over five years for emergency response, complaint evaluation, and assessing the impacts of wildfires. To assess their performance, ARB has operated E-BAMs alongside FRM monitors in various studies. This assessment has shown that while E-BAM data track well with the FRM, they tend to record concentrations that are slightly higher than the FRM as shown in a 2008 comparison (Figure 3).

Figure 3. Comparison of 24-hour average concentrations measured using FRM and E-BAM at Sacramento-T Street site



Study Design

The objective of the special purpose study was to compare PM2.5 concentrations in Bakersfield and Arvin over a limited one-month time period. Because of their portability and ease-of-use, E-BAMS were therefore the most appropriate monitoring technology. Two E-BAM monitors of the same make and model were deployed to collect data for this comparison. The PM2.5 E-BAMs were operated at Bakersfield-California - the permanent monitoring site in central Bakersfield, and DiGiorgio Park in Arvin, approximately 15 miles southeast Bakersfield. Pictures of the two locations are provided in Figures 4 and 5.

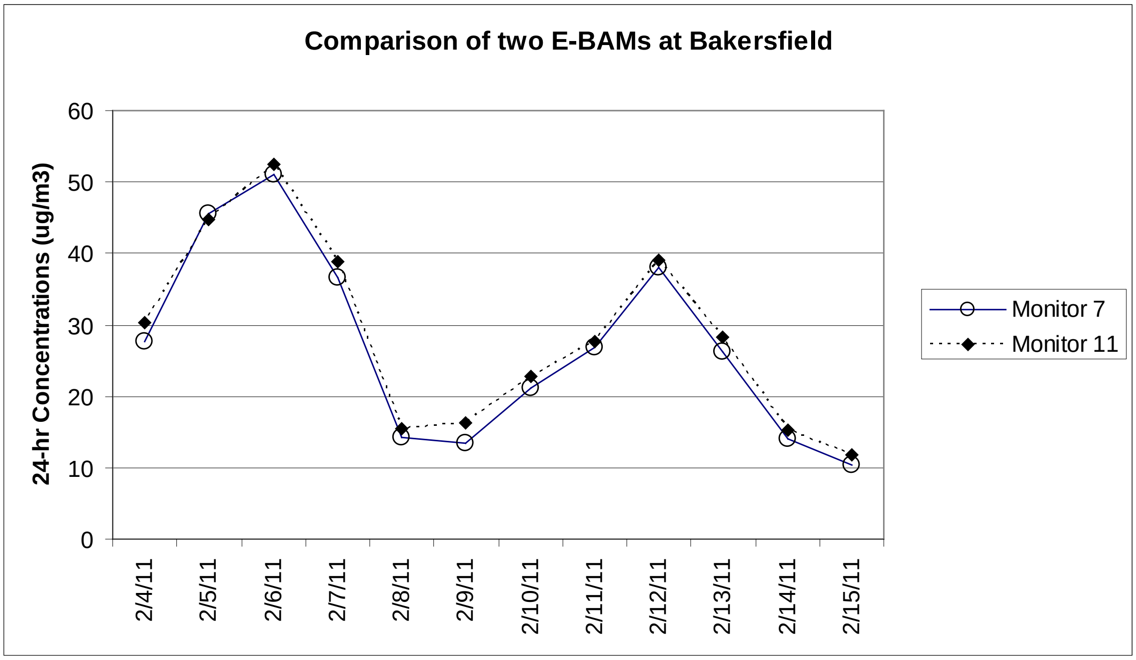
To ensure data comparability, the two samplers were first operated in parallel at the Bakersfield site between February 4 and 15, 2011. Based on the 12 days with matching data, the two E-BAM monitors tracked each other very well as illustrated in Figure 6. The monitor with the highest concentrations (reflecting an overall bias of 1.4 ug/m3 or 7.3 percent) was subsequently moved to Arvin.

Hourly PM2.5 E-BAM data at the Bakersfield and Arvin sites were collected from February 18, 2011 through March 20, 2011. This time frame included the last part of winter months when peak PM2.5 concentrations occur in the San Joaquin Valley.

Figure 4. E-BAM location at Arvin-DiGiorgio Pool monitoring site

Figure 5. E-BAM location at Bakersfield-California monitoring site

Figure 6. Comparison of two E-BAMs at Bakersfield



Analysis of Data

The PM2.5 hourly data were averaged for each day to create a 24-hour average value. Only the hours with matching data between sites were averaged.

Two statistical analyses were used to compare concentrations from the two sites. One was to compare the daily differences between the two sites in terms of absolute concentrations as well as percent. The second method was a standard linear regression method which calculated slope, intercept, and coefficient of correlation squared (r^2).

Simultaneous occurrences of stagnation periods and storms during the one month study period resulted in similar large-scale changes at each site, as illustrated in Figure 7. Site specific statistics are also summarized in Table 1. The 24-hour average PM2.5 concentrations during the observation period ranged from 1.6 ug/m3 to 33.9 ug/m3 with a 30 day average of 14.5 ug/m3 at Bakersfield and from 1.1 ug/m3 to 32.6 ug/m3, with an average of 13.6 ug/m3 at Arvin. Overall, the average PM2.5 concentration at Arvin was 7.4 percent (about 1 ug/m3) lower than Bakersfield during the one month monitoring period.

Figure 7. Comparison of 24-hr average concentrations at Bakersfield and Arvin

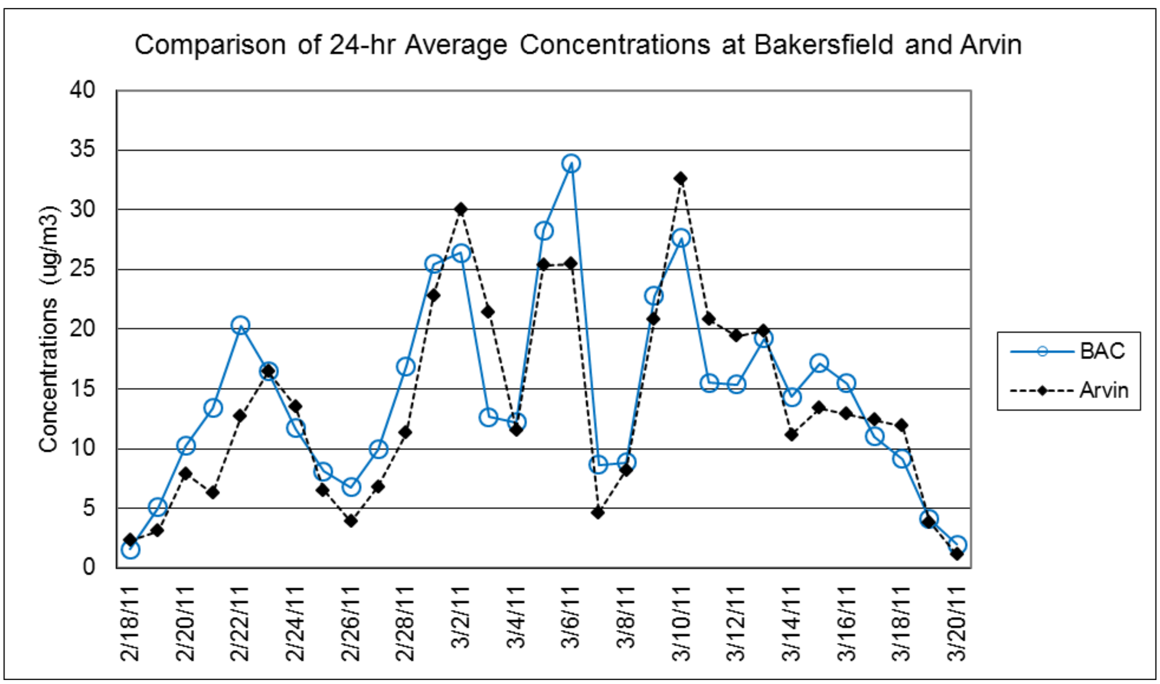
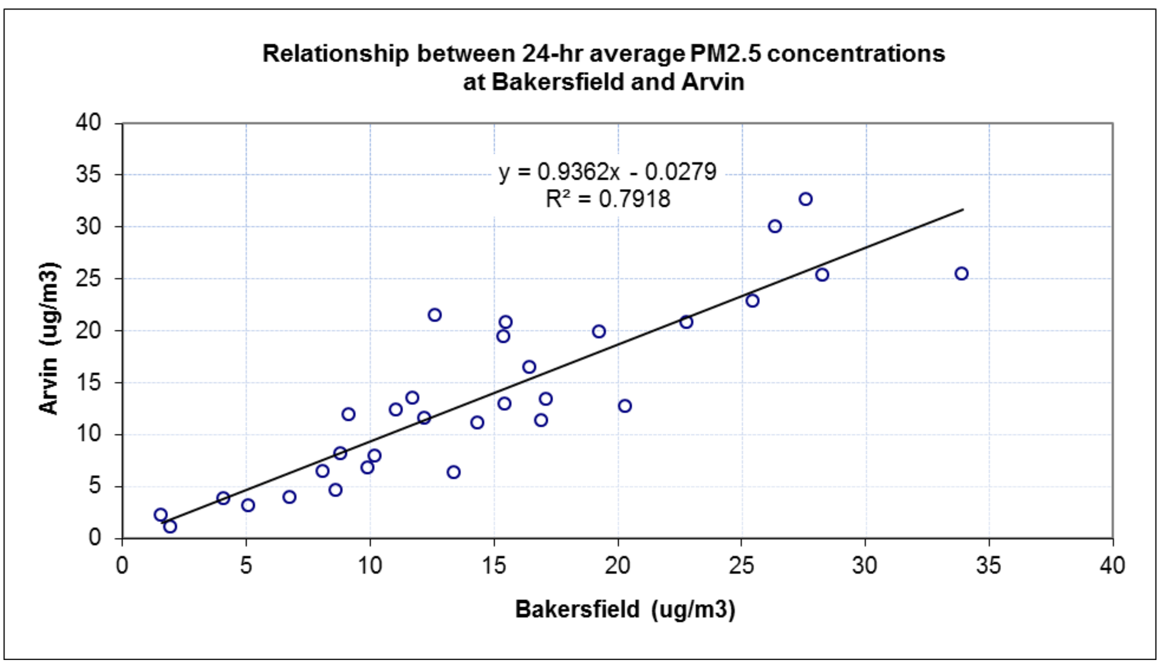


Table 1. Summary of PM2.5 Concentrations at Bakersfield and Arvin during the one-month study period

Statistic	**Bakersfield**	**Arvin**
Average	14.5 ug/m3	13.6 ug/m3
Minimum	1.6 ug/m3	1.1 ug/m3
Maximum	33.9 ug/m3	32.6 ug/m3

The purpose of the linear regression analysis was to explore the relationship between corresponding measurements at the two sites across a range of concentrations. The regression procedure determines the “best” available straight line for describing this relationship. Data collected from Arvin monitor were compared through linear regression analysis to the data collected from Bakersfield monitor. Figure 8 shows a comparison of the Arvin data to Bakersfield. The averaged coefficient of correlation squared (r^2) was 0.79, the average slope was 0.94, and the average intercept was 0.03 ug/m3. An r^2 of 0.79 indicates a fairly strong correlation between concentrations at the two sites. The magnitude of the slope suggests that for every 1 ug/m3 increase in PM2.5 concentrations at Bakersfield, the concentrations at Arvin will increase 0.94 ug/m3. This analysis further confirms that the two sites experience similar PM2.5 conditions, with concentrations slightly lower at Arvin.

Figure 8. Relationship between 24-hr average PM2.5 concentrations at Bakersfield and Arvin



Conclusions

PM2.5 concentrations in the southern San Joaquin Valley are driven by large scale meteorology. Therefore, concentrations tend to rise and fall simultaneously at both sites. The study captured several PM2.5 episodes with moderate concentrations. During the study concentrations at Arvin and Bakersfield tracked each other well and both sites observed similar day to day changes in concentrations. While Arvin was higher on few days, overall concentrations at Bakersfield were higher. The highest concentration, 33.9 ug/m3, was measured at Bakersfield, compared to a peak concentration at Arvin of 32.6 ug/m3. The average concentration was also higher at Bakersfield, 14.5 ug/m3 compared to 13.6 ug/m3 at Arvin.

Overall, the results of the study indicate that due to the correlation between measurements at both sites, as well as the presence of higher concentrations at Bakersfield, control strategies aimed at reducing PM2.5 in Bakersfield will also reduce levels in Arvin as the Valley moves towards attainment of the federal standards.

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