**State of California**

**California Environmental Protection Agency**

**AIR RESOURCES BOARD**

# Staff Report

# Imperial County 2013 State Implementation Plan for the 2006 24-Hour PM2.5 Moderate Nonattainment Area

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**For questions, contact:**

Mr. Webster Tasat
Manager, Central Valley Air Quality Planning Section
Phone: (916) 323-4950
Email: webster.tasat@arb.ca.gov

PO Box 2815
Sacramento, California 95814

Or

Ms. Elizabeth Melgoza
Project Lead
Phone: (916) 322-6161
Email: elizabeth.melgoza@arb.ca.gov

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# I. INTRODUCTION

On December 2, 2014, the Imperial County Air Pollution Control District (District) adopted a revision to the State Implementation Plan (SIP) (2013 PM2.5 Plan) to address the 24-hour fine particulate matter (PM2.5) national ambient air quality standard (NAAQS or standard) of 35 µg/m. The 2013 PM2.5 Plan addresses Clean Air Act (Act) requirements for the Imperial County PM2.5 nonattainment area. The nonattainment area represents a portion of Imperial County containing the cities of Brawley, El Centro, and Calexico.

As a result of ongoing State and local control programs, PM2.5 air quality has improved throughout Imperial County in recent years. Concentrations have declined 12 to 53 percent, and monitors located in the cities of El Centro and Brawley now record PM2.5 design values that are well below the standard. The Calexico monitor, located within one mile of the international border with Mexicali, Mexico, remains above the standard. Due to its proximity, Calexico is impacted daily by emissions from Mexicali. On a few days each year, this impact is large enough to cause exceedances of the 24-hour PM2.5 standard. These days occur during stagnant weather conditions, with predominant airflow from the south, and often coincide with wintertime holiday celebrations in Mexico where the use of bonfires and refuse burning along with fireworks displays are commonplace.

The Act includes a specific provision for areas located next to an international border that allows states to take into consideration the impacts of cross border transport of pollutants. The 2013 PM2.5 Plan demonstrates that emissions in the Imperial County PM2.5 nonattainment areas are at a level sufficient to attain the 24-hour PM2.5 standard absent the impact of emissions from Mexicali, Mexico. Areas impacted by cross border pollution must still comply with requirements in the Act to demonstrate that appropriate actions have been taken to reduce local emissions and their impact. For Imperial County, the SIP must include certain requirements and SIP elements for a moderate nonattainment area.

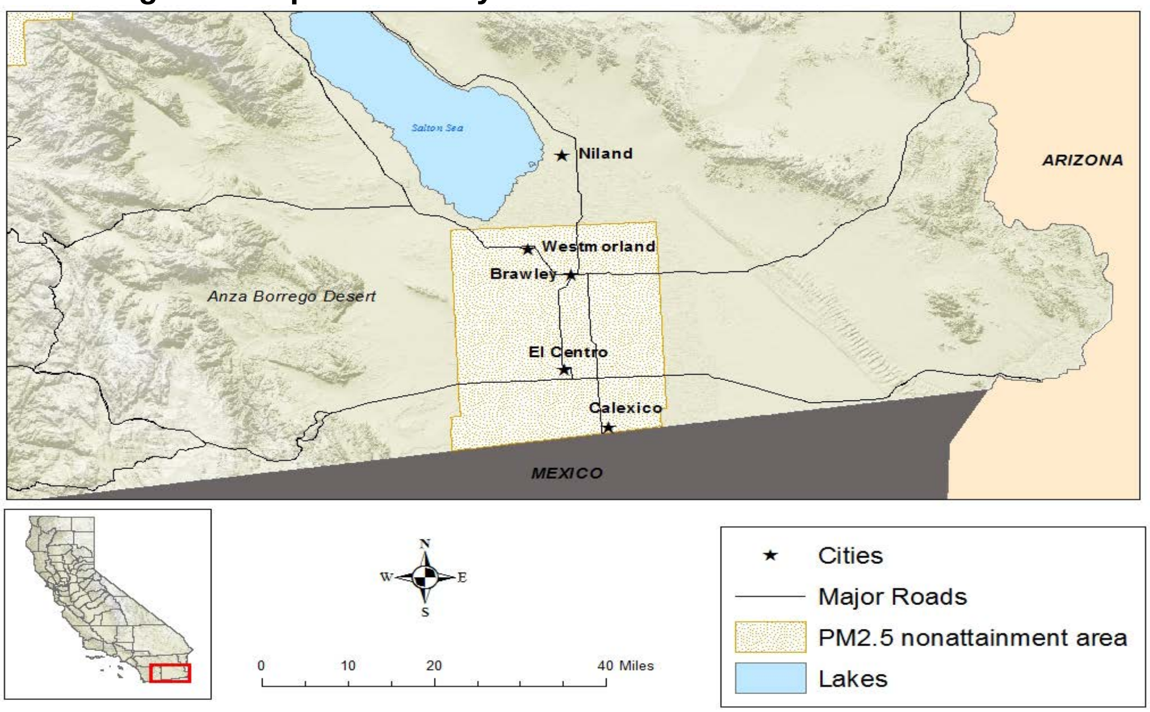
Air Resources Board (ARB) staff continues to work with the District, the U.S. Environmental Protection Agency (U.S. EPA), and representatives from Mexico's environment ministry in efforts to improve air quality along the border region. For example, the Border 2020 Program is a multi-agency cooperative effort to improve environmental conditions, including air quality along the Calexico-Mexico border. The ARB's Heavy Duty Vehicle Inspection Program is another focused effort to improve border air quality. Heavy duty vehicles are routinely inspected at border crossings in Calexico to ensure that trucks and buses entering the State meet California's strict vehicle emission standards.

Other efforts are underway by the District to enhance the dissemination of information about air quality in the Imperial County. An air quality and health information website notifies residents by email or cell phone when the levels of air pollutants are forecasted to be unhealthy. The District also leads a "no burn" campaign that provides radio and television broadcasts to help educate residents about the air quality impact from open burning. The District will continue these efforts as well as evaluate the potential for additional measures to improve air quality in the region as part of the development of the SIP for the 12 ug/m3 annual PM2.5 standard due in 2016.

## II. BACKGROUND

The Imperial County PM2.5 nonattainment area is an agricultural region located in the southeast corner of California that shares its southern border with Mexicali, Mexico. Most of the population, commercial activity, and farming operations occur in the PM2.5 nonattainment area, comprising approximately one-fourth the width of the county. The nonattainment area includes the three largest cities in Imperial County- Brawley, El Centro and Calexico. Each of these cities are similar in size with populations of 25,000 to 43,000 people. A map of Imperial County, the boundaries of the PM2.5 nonattainment area, and the Mexico border area is shown in Figure 1.

**Figure 1. Imperial County and the PM2.5 Nonattainment Area**




The nonattainment area contains relatively few major industrial sources, with unpaved road dust and fugitive windblown dust emissions representing the largest emission sources. Other significant emission sources in the nonattainment area consist of managed burning and disposal, emissions from aircraft, and tilling emissions from farming operations.

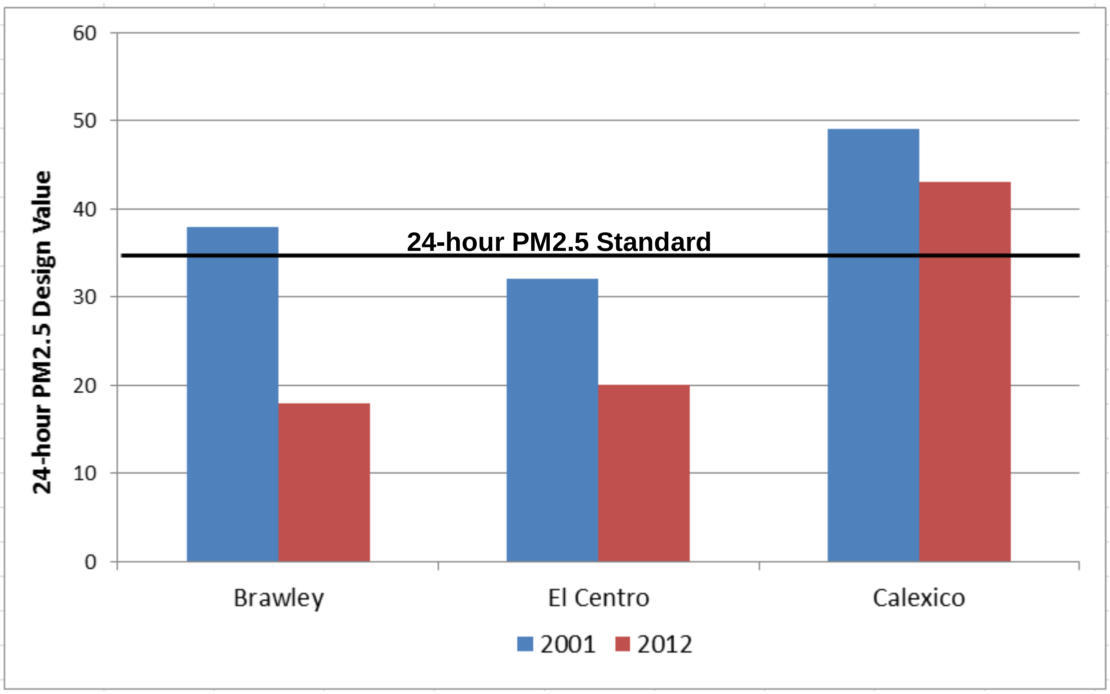
In contrast, the city of Mexicali, with a population of nearly 700,000 has a large number of industrial, mobile, and area sources. These sources are generally subject to less stringent emission regulations than those in California. Consequently, emissions from Mexicali industrial sources are approximately 15 times higher, and mobile source emissions are almost three times higher than in the Imperial County nonattainment area.

## Current Air Quality and Trends

Despite the challenges that Imperial County's geography, climate, and proximity to Mexico pose for air quality, the combined efforts of State and local control programs have resulted in improved air quality in the region. Concentrations recorded at PM2.5 monitors in Imperial County currently comply with the 35 µg/m3 24-hour PM2.5 standard at all locations, except for the monitor in Calexico.

The metric used for determining if an area attains the PM2.5 standard is called the design value. To reduce year-to-year variability, design values are based on a three-year average. In 2012, the Calexico 24-hour PM2.5 design value was 43 µg/m3, more than twice the design values from monitors located in Brawley and El Centro (18 µg/m3 and 20 µg/m3, respectively) (Figure 2).

**Figure 2. 2001 and 2012 24-hour Design Values for Brawley, El Centro and Calexico**




## SIP Requirements

The Imperial County PM2.5 nonattainment area was designated as nonattainment by U.S. EPA in 2009, and subsequently classified as moderate in 2014, requiring a SIP submittal by the end of 2014. The 2013 PM2.5 Plan was developed under the provisions of Section 179B of the Act that allows consideration of the impact of international cross border transport of pollutants. Under this provision, the Act does not require states to develop an attainment strategy addressing pollutants that originate from beyond the United States borders. The 2013 PM2.5 Plan includes a comprehensive technical analysis of these cross border impacts, and a demonstration that the nonattainment area would have attained the 35 µg/m3 24-hour PM2.5 standard absent these international emissions from Mexicali. The 2013 PM2.5 Plan also addresses Act requirements to demonstrate that appropriate local actions have been taken to reduce emissions and provide ongoing public health protection.

## III. TECHNICAL DEMONSTRATION OF CROSS-BORDER IMPACTS

While Calexico is impacted daily by emissions from Mexicali, on a few days every year, this impact is large enough to cause exceedances of the 35 µg/m3 24-hour PM2.5 standard. Between 2010 and 2012, the Calexico filter-based federal reference monitor measured PM2.5 concentrations that exceeded the 35 µg/m3 PM2.5 NAAQS on five winter days due to transport from Mexicali (Table 1).

**Table 1. 179B International Transport Days**

| Transport Day | Concentration (µg/m3) |
|---|---|
| December 4, 2010 | 50.9 |
| February 5, 2011 | 80.3 |
| December 11, 2011 | 44.4 |
| January 31, 2012 | 37.7 |
| December 23, 2012 | 64.7 |

U.S. EPA guidelines on demonstrating attainment in areas impacted by emissions from outside the United States are based on implementation of the PM10 NAAQS. This guidance identifies five types of analyses that may be used to evaluate the impact of international emissions on the nonattainment area.

1. Compare emission inventories from each side of the border to assess the magnitude of the emission differences;
2. Evaluate changes in PM2.5 concentrations with the corresponding wind direction;
3. Analyze filters for specific particles that may be tied to foreign emission sources;
4. Analyze the emission inventory on the U.S. side of the border and demonstrate that the impact of U.S. sources would not in and of itself cause the NAAQS to be exceeded; and/or
5. Perform air dispersion and/or receptor modeling (source apportionment) to quantify the impacts from U.S. and foreign emission sources.

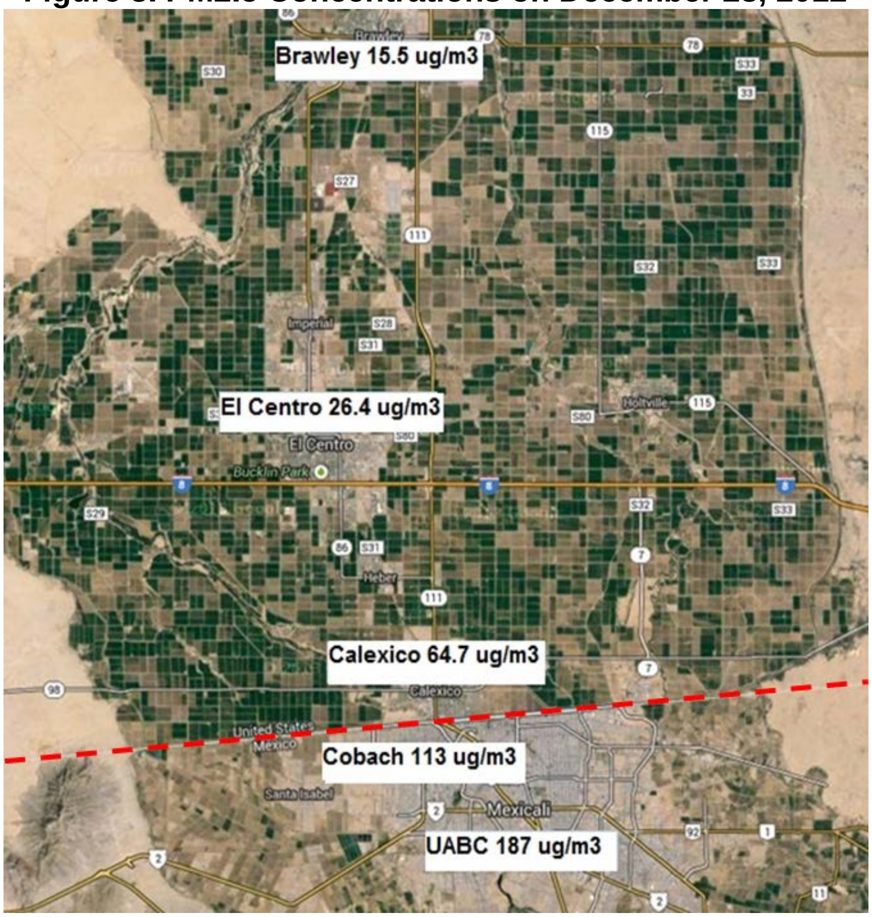
Staff examined the available monitoring and meteorology data from Calexico, other Imperial County monitoring sites, and Mexicali, and applied the guideline techniques to evaluate the impacts of emissions emanating from Mexicali and Imperial County on attainment of the 35 µg/m3 24-hour PM2.5 standard.

Staff first compared the area, population, and emissions data for Mexicali and the Imperial County nonattainment area. Mexicali has more than four times the population of the entire nonattainment area and more than 17 times the population of Calexico. Emissions from Mexicali are also significantly higher than those in the Imperial nonattainment area. For example, direct PM2.5 emissions in Mexicali are twice the level as emissions in the nonattainment area, and NOx emissions are more than four times higher.

Staff also evaluated the relationship between wind direction and resulting PM2.5 concentrations. This analysis indicated that although conditions on exceedance days were typically stagnant, the occurrence of very low winds were predominantly from the south and hourly PM2.5 concentrations in Calexico increased when the wind direction was from the south. Winter days where the wind direction was from the north during more than 75 percent of the day were also examined to assess PM2.5 concentrations during conditions when the potential for impacts from Mexicali were minimized. This analysis showed that on these types of days, there were no exceedances of the 35 µg/m3 24-hour PM2.5 standard.

As a result of the meteorological conditions that occur on exceedance days, the highest PM2.5 concentrations on all five days occurred in Mexicali and Calexico, with a gradient of decreasing concentrations at sites located further north from the border. Figure 3 provides an example of this gradient on December 23, 2012.

**Figure 3. PM2.5 Concentrations on December 23, 2012**




Staff also evaluated the chemical make-up of exceedance day samples. This type of information is useful in helping to identify the type of emissions that resulted in an exceedance of the standard. The chemical composition of the PM2.5 particles indicated their origin as combustion emissions such as those produced from motor vehicles or wood/waste burning. The analysis also indicated that elements, such as chromium and zinc, normally measured at very low levels throughout Imperial County and the rest of the State were five to eight times higher at Calexico. The potential sources of these elements can include the combustion of refuse or other non-biomass materials and are an indicator of burning and fireworks that occurred on these days in Mexicali. Further evaluation of the correlations between wind direction and these source signatures, indicated that the origin of these pollutants was south-southeast of the monitoring site in the direction of Mexicali.

Together with the proximity of Calexico to Mexicali, analysis of the emission inventory for each area, the prevalent meteorological conditions during exceedance days, and the chemical composition of samples on those days, the available evidence supports the international cross-border impact of Mexicali on the Imperial County PM2.5 nonattainment area. Staff also analyzed the hourly PM2.5 concentration data measured at Calexico, which was consistent with data showing PM2.5 concentrations in Mexicali impacting Imperial County.

The complete analysis summarized above is included in Appendix A and in the 2013 PM2.5 Plan. Excluding these five days that were significantly impacted by international transport, the 24-hour design value for the Imperial County nonattainment area decreases to 29 µg/m3 which is below the PM2.5 standard of 35 µg/m3. Table 2 shows the resulting design values in Calexico for 2012 and 2013 with and without the five international transport days. Staff also analyzed data collected from a continuous PM2.5 monitor at Calexico. Although this monitor does not provide data suitable for determining compliance of the PM2.5 standard, elevated concentrations at this monitor occurred under the same conditions as observed on the five exceedance days.

**Table 2. Calexico 24-hour PM2.5 Concentrations and Design Values**

| | **2012 (µg/m3)** | **2013 (µg/m3)** |
|---|---|---|
| Including 5 international transport days | 43 | 42 |
| Excluding 5 international transport days | 29 | 29 |

## IV. OTHER CLEAN AIR ACT REQUIREMENTS

In addition to the technical demonstration of cross border impacts, the other required SIP elements in the 2013 PM2.5 Plan include an emissions inventory of sources in the nonattainment area; quantitative emission milestones every three years, Reasonable Available Control Measures/Reasonable Available Control Technology (RACM/RACT) demonstration; contingency measures for the quantitative milestone years; and, transportation conformity budgets. As discussed previously, these requirements are designed to address the control of local emissions within the nonattainment area.

### Emission Inventory

An emission inventory consists of a systematic listing of the sources of air pollutants with an estimate of the amount of pollutants from each source and source category over a given period of time. A SIP must contain base year and future year forecasts for all pollutants identified as contributing to PM2.5 concentrations. The base year inventory is an essential element of the plan that forms the basis for all future year projections and also establishes the emission levels against which progress in emission reductions will be measured. U.S. EPA regulations establish general guidelines for selecting an inventory base year. Based on those guidelines, ARB and the District selected 2008 as the base year for the 2013 PM2.5 Plan. In addition to a base year inventory, U.S. EPA regulations require future year inventory projections for specific milestone years. 2011 was the inventory year used to address quantitative milestone requirements, and 2012 was the inventory year used to demonstrate attainment of the 24-hour PM2.5 standard. Emission inventories for each of these years were developed for PM2.5, nitrogen oxides (NOx), sulfur oxides (SOx), volatile organic compounds (VOC) and ammonia.

ARB and District staff worked jointly to prepare an updated emission inventory for the 2013 PM2.5 Plan. The inventory includes a category-by-category review and update using the most recent information available on emissions-generating activities and anticipated population and economic growth in the region. A summary of the emissions inventory along with additional information on the inventory methodologies can be found in Appendix B.

**Quantitative Milestones**

SIPs must provide for steady progress in reducing emissions during the years leading to attainment. These interim reductions are known as quantitative milestones. With a base year of 2008, the quantitative milestone years are 2011 and the 2012 attainment year. Emissions are provided in these years for directly-emitted PM2.5, $NO_X$, VOC, $SO_X$ and ammonia emissions. Emissions of all these constituents decreased or were constant from 2008 to 2012 within the Imperial County PM2.5 nonattainment area.

**RACM/RACT**

The Act requires that moderate nonattainment areas implement RACM/RACT for significant emission sources within the nonattainment area. Under U.S. EPA guidance, significant sources of PM10 are defined as those that contribute more than 5 ug/m3 to the 150 ug/m3 PM10 standard (3.3 percent). Using this same relationship, significant sources of PM2.5 were defined as those contributing more than 3.3 percent to the 35 ug/m3 standard. Based on this analysis, the District determined that unpaved road dust, fugitive windblown dust, farming operations (tilling), managed burning and disposal, and emissions from aircraft were deemed significant and required further analysis. The District conducted a RACM/RACT assessment for all of these sources with the exception of aircraft emissions, which are under federal control. The District's RACM/RACT assessment relied on a previous RACM/RACT analysis in their 8-hour ozone SIP as well as the best available control measure (BACM) assessment conducted for PM10.

Unpaved road dust, fugitive windblown dust, and tilling emissions from farming operations are all controlled under District Regulation VIII. Regulation VIII requires a variety of control techniques, including paving, chemical stabilization, application of water or dust suppressants, alternative tilling, and the fallowing of land. U.S. EPA approved these categories as BACM in July 2013. This rule therefore also meets the requirements for RACM/RACT.

Rule 701 was approved as RACM in 2003 and controls emissions from managed burning and disposal. The District implements Rule 701 under the District Smoke Management Program, which conforms with requirements of ARB's Smoke Management Guidelines. If a burn day is called, the District allocates the permitted burns to minimize smoke impacts and safeguard public health. Rule 701 does not allow any burning to be a nuisance, to reduce visibility or to impact a sensitive receptor within 1.5 miles. All permit holders are required to give notice and advise neighbors of a potential burn. This noticing requirement is known as the Good Neighbor Policy under the District's Smoke Management Program. Based on this assessment, the District determined that their current rules met the RACM/RACT requirement for moderate PM2.5 nonattainment areas.

**Further Study Measures**

Although the 2013 PM2.5 Plan demonstrated that current rules met the RACM/RACT requirement, the District also committed to examining the potential for additional ammonia emission reductions from the following sources: confined animal facilities, composting facilities, and agricultural fertilizers.

<u>Confined Animal Facilities</u>
District Rule 217 (Large Confined Animal Facilities) addresses VOC and ammonia emissions from permitted dairy operations and beef feedlots. Rule 217 requires a mitigation measures to be implemented by each dairy and feedlot operation. The District will evaluate the existing effectiveness of Rule 217 and potential enhancements to the mitigation measures.

<u>Composting Facilities</u>
The District currently regulates composting facilities which are subject to controls that reduce VOC and ammonia emissions through a permit, rather than a rule. The District is committed to working with industry to develop a composting rule that further reduces VOC and ammonia emissions in Imperial County.

<u>Agricultural Fertilizers</u>
The State Regional Water Quality Control Board (SRWQCB) implements performance standards for agricultural fertilizer management, storage, and application in beef and dairy operations. These performance standards limit the contamination of water and reduce air emissions from agricultural fertilizers. The District is committed to working with SRWQCB to ensure that these performance standards achieve emission reductions.

**Contingency Measures**

Contingency measures are a required element of a nonattainment area SIP and provide additional emission reductions in the event the area fails to achieve quantitative milestones or attain the NAAQS. In the context of a SIP developed under the provisions of Section 179B, contingency measures only apply to the quantitative milestone years. However, since required emission levels in the quantitative milestone years of 2011 and 2012 have already been met, further contingency measures are not required.

**Transportation Conformity**

Under Section 176(c) of the Act, transportation activities that receive federal funding must ensure that transportation emissions do not interfere with an area's air quality progress. Section 176 of the Act requires that transportation plans, programs, and projects conform to an area's plan before being approved by a Metropolitan Planning Organization. In order for transportation emissions to conform to a plan the activities must not:

1. Cause or contribute to any new violation of any standard;
2. Increase the frequency or severity of any existing violation of any standard in any area; or
3. Delay timely attainment of any standard or any required interim emission reductions or other milestones in any area.

The portion of the total emissions inventory allocated to highway and transit vehicles in the emission inventory is the motor vehicle emissions budget. The 2013 PM2.5 Plan establishes nonattainment area-level on-road mobile exhaust and municipal unpaved road dust emissions. Motor vehicle emission budgets were established for NOx and PM2.5 for a winter day in the attainment year of 2012 and were calculated using EMFAC2011.

The emission budgets established in the 2013 PM2.5 Plan fulfill requirements of the Act and U.S. EPA regulations to ensure that transportation projects will not interfere with progress and attainment of the 24-hour PM2.5 standard.

## V. COLLABORATIVE EFFORTS WITH MEXICO

The District, ARB, and the U.S. EPA are working together with Mexico on many efforts to identify and implement programs that will improve air quality in the border region. In 2012, the U.S. and Mexico signed the Border 2020 Program, which is a cooperative effort between U.S. EPA, Mexico, ARB, the District, and other agencies to improve the border environment by cleaning the air, water, hazardous waste, and ensuring emergency preparedness along the U.S.-Mexico border region. The Border 2020 Program includes the Imperial-Mexicali Air Quality Task Force. The Task Force was organized to address air quality issues unique to the border region and provide educational information to residents from both sides of the border.

To better understand emissions occurring in Mexicali and impacting air quality on both sides of the border, ARB and officials from Baja California recently began developing a plan to conduct PM2.5 monitoring at several sites in Mexicali. This binational, multi-year monitoring effort is expected to begin in 2015 and will produce high quality information on PM2.5 air quality originating in Mexicali. The District also continues to work with counterparts in Mexico to discuss and implement emission reduction strategies and projects that would improve the air quality in the Mexicali-Imperial region.

Finally, in July of 2014, Governor Brown and officials from Mexico's Ministry of Environment and Natural Resources and the Mexican National Forestry Commission signed an agreement addressing air quality, climate change and other environmental issues. The agreement identifies joint actions between California and Mexico and includes the following specific areas of cooperation and coordination with respect to air quality:

- Reducing emissions of criteria pollutants, and air toxic contaminants;
- Continuing and increasing cooperation related to air quality along the border, including capacity building on air quality monitoring, audits of air quality monitoring equipment, the use of specialized equipment and, exchange of technical and policy information on air quality; and
- Supporting new and expanded markets for clean and efficient energy technologies in the industrial, electricity and transportation sectors.

The agreement will enhance binational efforts to improve air quality throughout the border region, which will benefit residents of both Imperial County and Mexicali, Mexico.

## VI. RECOMMENDATION

ARB staff recommends that the Board approve the Imperial County 2013 PM2.5 Plan as a revision to the California SIP including the technical analysis of the impacts of international transport demonstrating the Imperial PM2.5 nonattainment area would have attained the 35 ug/m3 24-hour PM2.5 standard absent the impact of these international emissions.

# APPENDIX A: 179B TRANSPORT ANALYSIS

California Environmental Protection Agency

Air Resources Board

**DRAFT**

# 179B Analysis for PM2.5 Emissions Impacting Calexico in Imperial County

**September 24, 2014**

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## Table of Contents

## I. Overview

The purpose of this analysis is to identify the origin of emissions impacting PM2.5 concentrations in the Imperial County nonattainment area (Imperial NA) next to the Mexico international border. The Imperial NA is an agricultural community located in the southeast corner of California which shares its southern border with Mexicali, Mexico. The Imperial NA includes three PM2.5 monitoring sites, located in the cities of El Centro, Brawley and Calexico. These three cities are about the same size and, in general, have emission sources that are similar. Calexico is the only violating PM2.5 monitor in the Imperial NA.

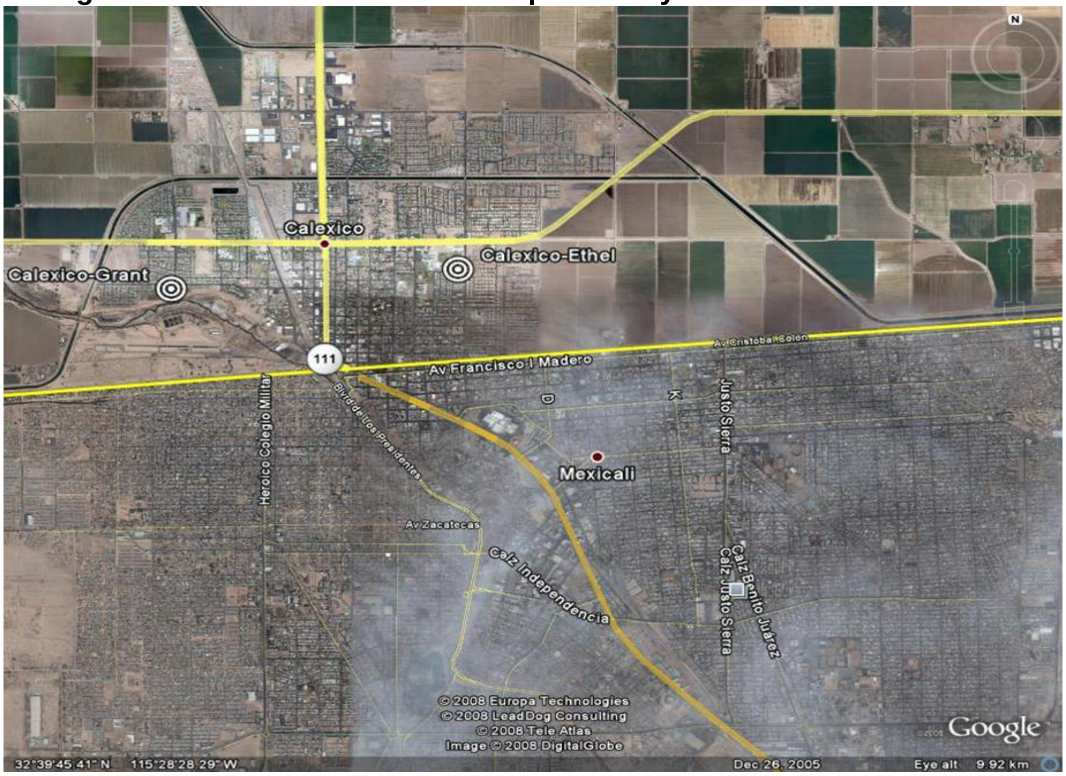
This analysis provides technical documentation that in 2012 the Imperial NA attained the 24-hour PM2.5 standard of 35 micrograms per cubic meter (µg/m3) but for emissions emanating from Mexico. The Clean Air Act (Act) contains a specific provision in Section 179B for areas that are affected by the international cross-border transport of pollutants. Exceedances that occur due to international transport may cause violations of the standard; however, the Act does not require states to develop an attainment strategy addressing pollution that originates from sources beyond United States borders.

U.S. EPA guidelines on demonstrating that an area is in attainment but for emissions emanating from outside the United States identifies five types of information that may be used in evaluating the impact of emissions from outside U.S. borders on a nonattainment area. States may use one or more of these approaches based on the specific circumstances and the data available:

1. Compare emission inventories from each side of the border to assess the magnitude of the emission differences;
2. Evaluate changes in PM2.5 concentrations with wind direction;
3. Analyze filters for specific particles that may be tied to foreign emission sources;
4. Analyze the emission inventory on the U.S. side of the border and demonstrate that the impact of U.S. sources does not cause NAAQS exceedances;
5. Perform air dispersion and/or receptor modeling (source apportionment) to quantify the impacts from U.S. and foreign emission sources.

For this analysis, staff used all of these approaches to evaluate the impact of Mexicali emissions on the Calexico PM2.5 monitor.

**Figure 1. Mexicali and Calexico Separated by the International Border**



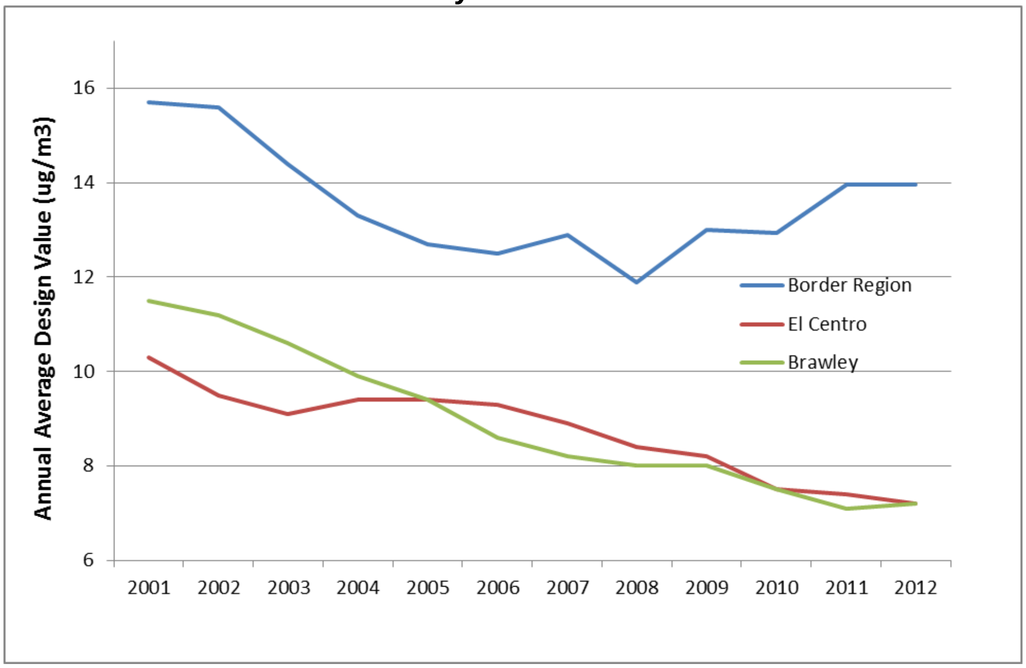

From an air quality perspective, Calexico and the Mexicali Metropolitan Area share a common air shed. Since the topography does not restrict airflow from either side of the border and both areas experience similar meteorology, Mexicali pollution impacts Calexico (Figure 1). The Calexico site is less than one mile from the international border and, according to United States Environmental Protection Agency (U.S. EPA) monitor siting criteria, is representative of air pollution from both Calexico and Mexicali.

The Mexicali Metropolitan Area has a population of close to 1,000,000 (U.N. Data) as compared with the significantly smaller city of Calexico, which has a population of approximately 38,600 (2010 U.S. Census). Figure 2 shows an aerial image of Calexico and Mexicali during the night which highlights the large differences in size and population. Emissions inventory data for Mexicali shows that emissions are orders of magnitude higher than emissions in the Imperial NA. Also, Mexicali ranks as the third most polluted city in the world for PM10 behind cities in India and China (*Choked*. Retrieved on June 2, 2014 from: http://www.economist.com/blogs/graphicdetail/2013/01/daily-chart-11).

**Figure 2. Mexicali and Calexico**

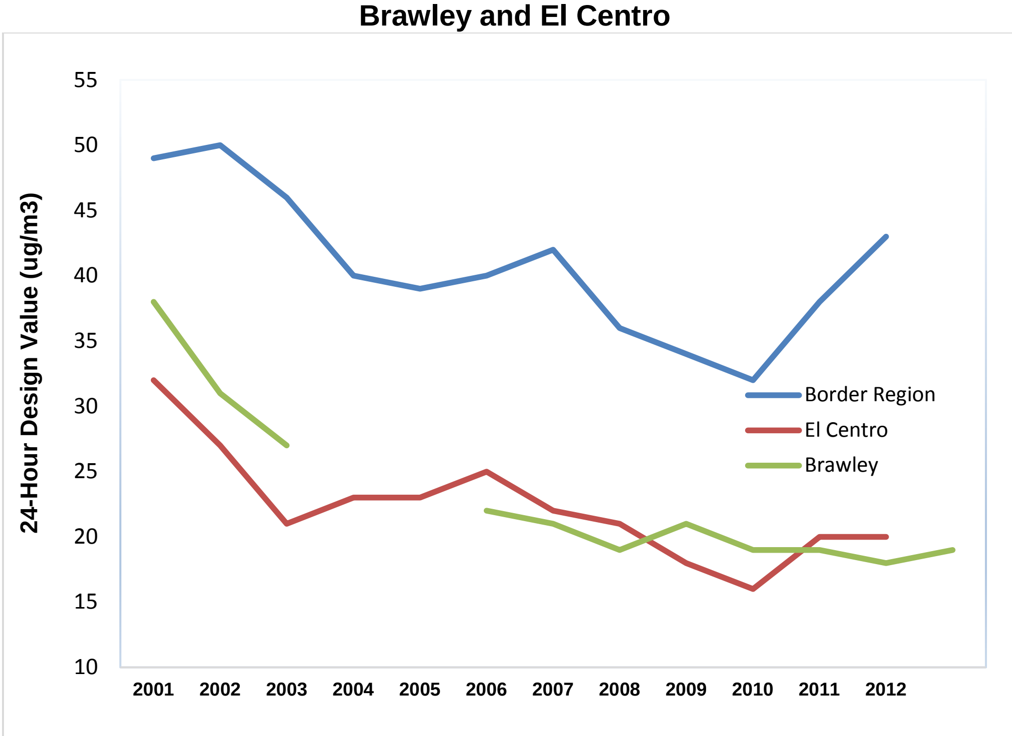

On a daily basis, ambient PM2.5 concentrations in Calexico are significantly impacted by Mexicali emission sources. In Mexicali, a large population of industrial, mobile, and area sources are subject to less stringent emission regulations. Consequently, Mexicali industrial sources emit approximately 15 times more emissions and mobile sources emit almost three times more emissions than the entire Imperial NA. Due to these emission differences, PM2.5 concentrations measured in the Imperial NA typically follow a gradient with the lowest PM2.5 concentrations measured in the north at Brawley and the highest concentrations in the south at Calexico. As shown in Figures 3 and 4, Brawley and El Centro have responded similarly to California control programs and air quality has improved as a result. However, in Calexico, air quality has not improved and remains above the revised federal annual average PM2.5 standard of 12 μg/m3 and the 24-hour PM2.5 standard of 35 μg/m3.

**Figure 3. 2001-2012 Annual Design Values for the Border Region, Brawley and El Centro**




*Calexico data includes ARB invalidated and transport days in the design value calculation

**Figure 4. 2001-2012 24-hour Design Values for the Border Region, Brawley and El Centro**




*Calexico data includes ARB invalidated and transport days in the design value calculation

While Calexico is impacted daily by emissions from Mexicali, on a few days every year, that impact is exacerbated resulting in exceedances of the 24-hour PM2.5 standard. Between 2010 and 2012, the Calexico monitor measured PM2.5 concentrations that exceeded the PM2.5 National Ambient Air Quality Standard (NAAQS) on five winter days (Table 1). These days occurred during stagnant weather conditions, often with predominant airflow from the south. Stagnant meteorological conditions impede dispersion and facilitate the build-up of PM2.5 concentrations in the Calexico-Mexicali air shed. Most of these days coincide with wintertime holiday celebrations in Mexico where the use of bonfires and refuse burning along with fireworks displays are commonplace, further increasing emissions in Mexicali. As a result, in 2012, the Calexico 24-hour PM2.5 design value was 43 µg/m3, more than twice that of Brawley and El Centro levels (18 µg/m3 and 20 µg/m3 respectively). On all exceedance days included in this analysis, the average concentration at the Calexico site was more than 60 percent higher than the average concentrations at El Centro and Brawley.

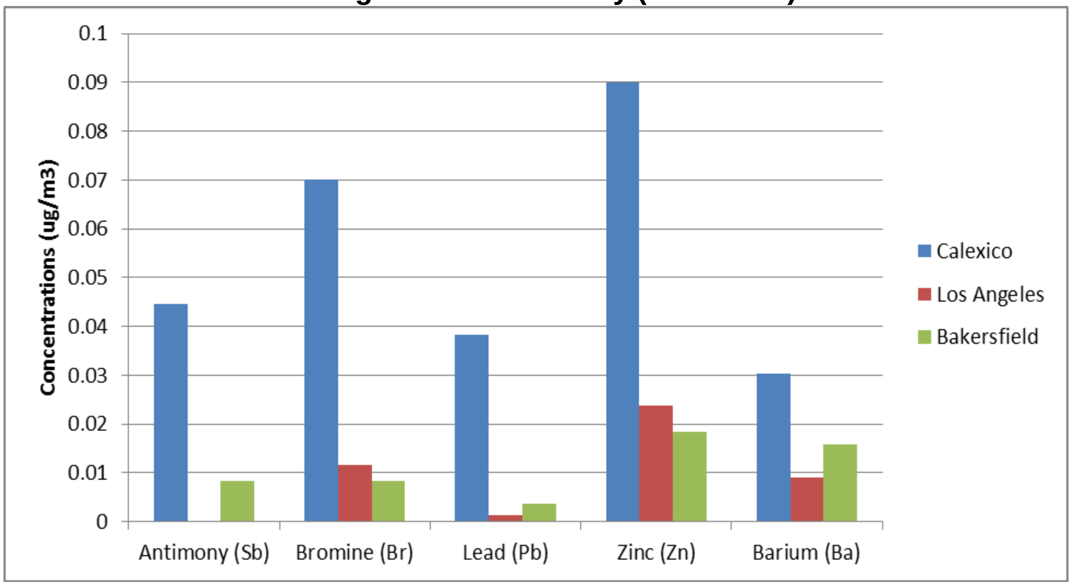
In addition, no exceedances for PM2.5 were recorded at Calexico when the predominant wind flow was from the north, northerly winds defined as winds from the north at least 18 hours per day with speeds in excess of 1.5 meters per second (mps) (see Section IX). A more refined concentration-wind direction analysis presented in this document also shows that no violations of the PM2.5 NAAQS occurred during northerly wind flow over the 2010-2012 time period.

**Table 1. PM2.5 Measurements Exceeding the 24-Hour PM2.5 Standard at the Calexico Monitoring Site in 2010-2012**

| Date | Calexico PM2.5 (µg/m3 ) |
|---|---|
| 12/4/2010 | 50.9 |
| 2/5/2011 | 80.3 |
| 12/11/2011 | 44.4 |
| 1/31/12 | 37.7 |
| 12/23/2012 | 64.7 |

In order to evaluate the impact emission sources in Mexicali on elevated PM2.5 concentrations measured in Calexico, staff analyzed the chemical composition data of PM2.5 samples and compared them with the composition of PM2.5 from monitoring sites around California. The PM2.5 chemical composition provides a signature for identifying types of activities potentially impacting a monitor. On the days exceeding the 24-hour PM2.5 standard, the chemical composition showed high values of organic carbon and elements. The high level of organic carbon indicates that combustion activities are a major source of emissions affecting Calexico. The high levels of organic carbon correlated well with high levels of chlorine and fine particulate antimony. Both chlorine and fine particulate antimony are associated with refuse burning, which is known to occur in Mexico. Some elemental components measured three to thirty times higher than at other sites in California (Figure 5). High concentrations of lead, bromine, zinc and barium, are typically associated with fireworks, tire burning and leaded gasoline. This suggests that source signatures contributing to high Calexico PM2.5 levels were unique to this site and not found at other sites in California. Significantly, open refuse burning, which might produce these analytical results, has been banned in California since 2004.

**Figure 5. Concentrations of Select Elemental Species on an Average Exceedance Day (2010-2012)**




Further, the ARB laboratory performed additional elemental analysis on PM2.5 filters in Brawley and El Centro coinciding with the five exceedance days. The difference between elemental species concentrations at Calexico and the other two Imperial County sites, El Centro and Brawley, was similar to the difference observed between Calexico and other California sites. As a result, the analysis indicates that emissions impacting the Calexico monitor are not typical of emissions affecting monitors elsewhere in Imperial County, but originate from sources south of the border. Source apportionment modeling substantiated PM2.5 chemical composition analysis and indicated that refuse burning and secondary nitrate were the major contributors to the PM2.5 concentration on transport days.

Overall, the analysis shows that Calexico 24-hour PM2.5 exceedances are due to emission sources not found in California. This interpretation is based on analyses indicating that during stagnant conditions, pollution from holiday activities in Mexicali, including extensive fireworks displays and bonfires containing plastics, tires and other refuse materials fill the entire air shed and drift into Calexico. PM2.5 concentrations at El Centro and Brawley, which are more representative of local emission within Imperial County, were significantly lower on Calexico exceedance days.

These analyses indicated that Calexico PM2.5 levels would have attained the 24-hour PM2.5 standard in 2012 “but for” increased pollution emissions from the Mexicali Metropolitan area. If Mexicali emissions were not impacting the Calexico site, Calexico’s design value would likely be closer to that of El Centro considering the similarity in sources and emission profiles. In addition, Imperial County emissions are expected to continue declining in the future, which ensures continued maintenance of attainment. These analyses and documentation provides evidence for U.S. EPA to approve the Imperial County 2013 PM2.5 SIP under Section 179B of the Clean Air Act.

## II. Regulatory Requirements and Guidance

179B Demonstration

Section 179B of the Act includes language that reduces planning requirements in international border areas subject to emissions from outside the United States. Specifically, 179B references requirements for State Implementation Plans as well as Plan revisions:

"Section 179(B) INTERNATIONAL BORDER AREAS

(a) IMPLEMENTATION PLANS AND REVISIONS.—Notwithstanding any other provision of law, an implementation plan or plan revision required under this chapter shall be approved by the Administrator if—

> (1) such plan or revision meets all the requirements applicable to it under the Act other than a requirement that such plan or revision demonstrate attainment and maintenance of the relevant national ambient air quality standards by the attainment date specified under the applicable provision of this Act, or in a regulation promulgated under such provision, and
>
> (2) the submitting State establishes to the satisfaction of the Administrator that the implementation plan of such State would be adequate to attain and maintain the relevant national ambient air quality standards by the attainment date specified under the applicable provision of this chapter, or in a regulation promulgated under such provision, but for emissions emanating from outside of the United States."

U.S. EPA Guidance

In addition to statutory language in the Act, U.S. EPA published guidelines to assist in the application of Section 179B. The guidelines outline five types of information that may be used to substantiate the effect of emissions emanating from outside the United States on a nonattainment area. A state may use one or more of these analytical approaches based on the specific case under evaluation and the availability data. Summarized with respect to PM2.5, the five types of information consist of the following:[1]

[1] "State Implementation Plans for Serious PM-10 Nonattainment Areas, and Attainment Date Waivers for PM-10 Nonattainment Areas Generally; Addendum to the General Preamble for the Implementation of Title I of the Clean Air Act Amendments of 1990," 59 Federal Register 157 (16 August 1994), pp. 41998 - 42016.

1. Evaluate and quantify any changes in monitored PM2.5 concentrations with a change in the predominant wind direction (see Sections VII and XI);

2. Comprehensively inventory emissions within the United States in the vicinity of the nonattainment area and demonstrate that the impact of those sources on the nonattainment area after application of reasonably available controls does not cause the NAAQS to be exceeded. Analysis must include an influx of background PM in the area. Background PM levels could be based, for example, on concentrations measured in a similar nearby area not influenced by emissions from outside the United States (see Section IX);

3. Analyze ambient sample filters for specific types of particles emanating from across the border (although not required, characteristics of emissions from foreign sources may be helpful) (see Sections VIII, X, and XI);

4. Inventory the sources on both sides of the border and compare the magnitude of PM emissions originating within the United States to those emanating from outside the United States (see Section VI);

5. Perform air dispersion and/or receptor modeling to quantify the relative impacts on the nonattainment area of sources located within the United States and of foreign sources of PM emissions (this approach combines information collected from the international emission inventory, meteorological stations, ambient monitoring network, and analysis of filters) (see Section XI).

The guidelines also indicate that states may use any of these approaches, or other techniques, "depending on their feasibility and applicability, to evaluate the impact of emissions emanating from outside the United States on the nonattainment area." States are not required to address all of the approaches, but should provide a weight of evidence that international impacts affect the attainment ability of the area.

It is also important to note that the analysis needs to show that the area would have attained but for international transport, not that all days that are over the standard are due to international transport. The form of the 24-hour PM2.5 standard is the $98^{th}$ percentile, which allows for some days over the standard. Exceedances recorded on five days from 2010 through 2012 provide a needed subset for demonstrating the impact from Mexico. PM2.5 concentrations from the Imperial County side of the border, as assessed from PM2.5 data screened by wind direction and speed, provide substantial evidence that the Imperial NA is in attainment in the absence of emissions from sources under Mexicali's jurisdiction.

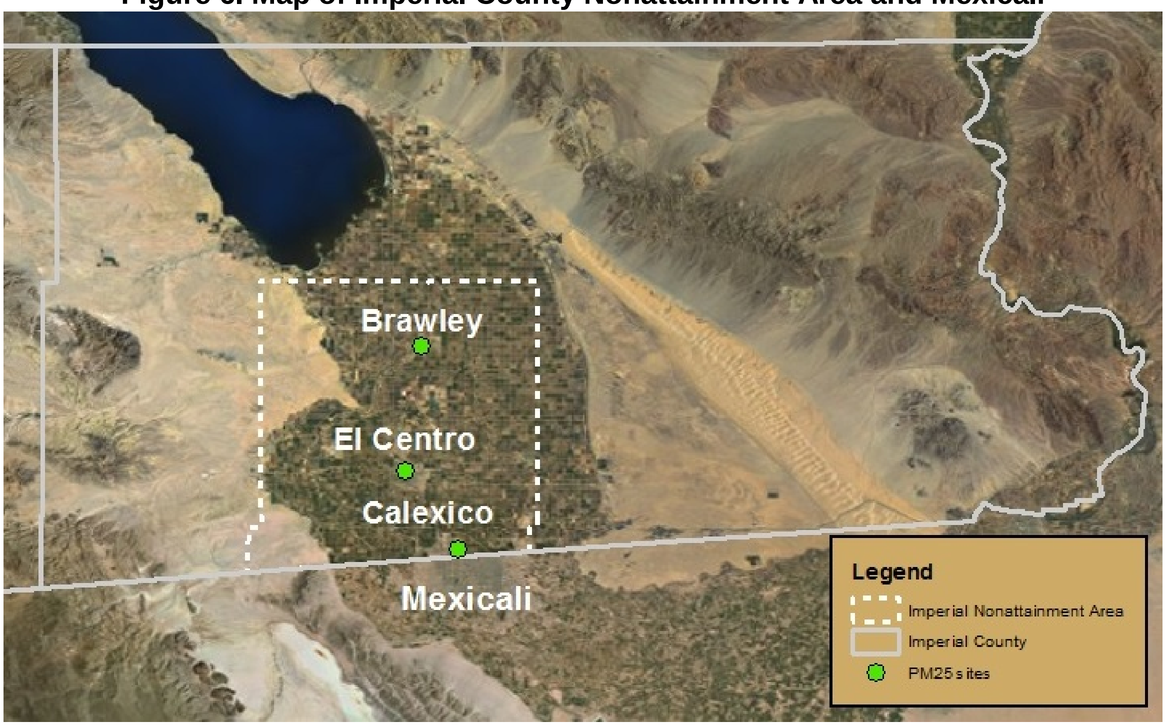
Monitoring data and general meteorological and emissions characteristics for all exceedance days, when available, were examined first. Staff focused closely on the five specific days in Table 1 and examined the available monitoring and meteorology data from Calexico, other Imperial County monitoring sites, and Mexicali, and applied all or portions of the guideline techniques to evaluate the impacts of emissions emanating from Mexicali and from Imperial County on attainment of the 24-hour PM2.5 standard.

## III. Profile of Imperial County and Mexicali, Mexico

Imperial County

Located in the southeast corner of California, Imperial County is approximately 4,500 square miles with a population of 174,528 (U.S. Census). The county includes the Imperial Valley with the Santa Rosa Mountain Range to the west, the Chocolate Mountains to the east, and Mexico to the south. The three most populated cities in the county are Brawley, El Centro, and Calexico with populations of about 25,567; 43,107, and 39,310, respectively (U.S. Census). These three cities form a north-south axis through the approximate center of the county from the southern end of the Salton Sea to the Mexican border. Most of the population, commercial activity, and farming operations occur in this relatively narrow land area comprising approximately one-fourth the width of the county. A map of Imperial County, including the cities of Calexico, El Centro, and Brawley, the boundaries of the PM2.5 nonattainment area, and the border area of Mexicali is shown in Figure 6.

**Figure 6. Map of Imperial County Nonattainment Area and Mexicali**




The area contains relatively few major emission sources, but may experience significant on-road vehicular traffic, particularly near Calexico, given proximity to two international ports of entry into the United States. Other emission sources consist of geothermal power generation, food processing, plaster manufacturing, and light industrial facilities. Imperial Valley agriculture produces a variety of crops including hay, vegetables, and dairy products. Beyond the urban and rural areas of Imperial County are large expanses of open desert and the Salton Sea with little human activity.

Imperial County PM2.5 Nonattainment Area

The Imperial County PM2.5 nonattainment area encompasses about 690 square miles within the central portion of the county. U.S. EPA established the Imperial County nonattainment area based on analysis of air quality around Calexico, the county's only violating monitor. The nonattainment boundary includes the cities of Calexico, El Centro, and Brawley, and a portion of the major roads in southern Imperial County. The nonattainment area comprises the majority of the county's population and mobile source emissions in the county.

Mexicali

Mexicali is one of the largest cities along the U.S.-Mexico border and is the capital of Baja California. The population of Mexicali proper is approximately 690,000 while the entire Mexicali Metropolitan Area is estimated to have nearly one million residents (U.N. Data). Mexicali has a strong agricultural and manufacturing economy that includes manufacturing centers for the aerospace, automotive, medical device, and electronics industries. Agriculture in the region consists of year around irrigated cultivation of cotton, wheat, alfalfa, and vegetables. The climate is hot and arid, averaging about three inches of rainfall a year or less. Mexicali residents celebrate several religious holidays every winter. During these celebrations it is customary to light bonfires. Bonfires and firework displays occur nightly during these celebration periods and will typically continue until the early morning hours.

Table 2 compares the population and area of Imperial County, the nonattainment area, the City of Calexico, and the City of Mexicali. Mexicali is more than 5 times the area of Calexico with about 18 times as many residents. This difference in area and population, coupled with the associated difference in area and population-based activities, supports the observed difference in pollution emissions between the two cities.

**Table 2. Population and Area of Imperial County, Imperial County Nonattainment Area, Calexico, and Mexicali**

| | Imperial County | Nonattainment Area | City of Calexico | City of Mexicali |
|---|---|---|---|---|
| **Area (square miles)** | 4,176 | 690 | 8.4 | 43.9 |
| **Population (2010)** | 174,528 | 150,094 | 38,572 | 689,775 |

*Source: U.S. Census, U.N. Data*

# IV. Ambient Air Monitoring in Imperial County and Mexicali

## PM2.5 Monitoring Stations in Imperial County

The three PM2.5 monitoring stations in Imperial County currently employ filter-based samplers and continuous Beta Attenuation Monitors (BAMs). The Brawley and El Centro stations both include a PM2.5 Federal Reference Method (FRM) filter-based sampler while the Calexico station includes collocated, regulatory Federal Equivalent Method (FEM) filter-based samplers, an FRM filter based sampler, and collocated non-FEM BAMs. In addition to PM2.5 instruments, each of the PM2.5 monitoring locations in Imperial County is equipped with devices for measuring meteorological parameters, including horizontal wind speed (HWS), wind direction (WD), outside temperature (OT), relative humidity (RH), barometric pressure (BP), and solar radiation (SR) (Table 3).

For comparison with Calexico PM2.5 measurements, this 179B analysis incorporates PM2.5 concentrations and meteorological data from the Brawley and El Centro sites. The cities of Brawley and El Centro are similar to Calexico in terms of population and the type and magnitude of local emission sources, with the caveat that Calexico is located adjacent to Mexicali. Logically, air quality in all three cities should also be similar.

**Table 3. Imperial County PM2.5 Monitoring Locations**

| Monitoring Site[2] | Spatial Scale | Meteorological Parameters |
|---|---|---|
| Calexico | Neighborhood | OT, RH, WD, HWS, BP, SR |
| El Centro | Neighborhood | OT, WD, HWS, BP |
| Brawley | Neighborhood | OT |

*Source: Imperial County Air Pollution Control District Draft Ambient Air Monitoring Annual Network Plan (June 2014) and California Air Resources Board Monitoring and Laboratory Division*.

In ambient air monitoring the spatial scale of representativeness defines a distance over which pollutant concentrations are expected to be the same, given similar emission sources and meteorological conditions. The spatial scale of representativeness for the Calexico PM2.5 monitor is an important factor in establishing the origin of emissions leading to elevated concentrations.

The Calexico air monitoring station was sited to conform to U.S. EPA criteria for the neighborhood spatial scale. Concentrations measured at the neighborhood scale monitor are expected to be relatively uniform over a radius of 2.5 miles around the monitor. Given that the Calexico PM2.5 monitor is about 0.8 miles from the

[2] PM2.5 samplers at the Calexico site include two regulatory, filter-based samplers and two non-FEM BAMs; El Centro and Brawley each have one filter-based sampler.

international border, PM2.5 air quality in Calexico is a function of United States emission sources plus emissions emanating from Mexico and is not limited to sources in the immediate vicinity of the monitor. The common air shed concept is a recognized factor in poor air quality in cities along the U.S.-Mexico border and is referenced in the air pollution reduction goal of the Border 2020 Program.[3]

PM2.5 Monitoring Stations in Mexicali

The air monitoring network in Mexicali consists of six sites, most of which were established between 1996 and 2000 during the U.S.-Mexico Border XXI Program. Only two of the six monitoring sites measure PM2.5. These sites are the Engineering Institute of the Autonomous University of Baja California (UABC) and the Vocational School of Baja California (COBACH). UABC and COBACH are located in the urban area of Mexicali near the border, 2.6 and 2.0 miles from the Calexico monitor, respectively. PM2.5 measurements at UABC and COBACH are made using BAMs. While the availability and quality of PM2.5 monitoring data from UABC and COBACH are often inconsistent, when available, these data are nevertheless useful in providing comparative information regarding the magnitude of PM2.5 concentrations in Mexicali.

## V. Imperial County PM2.5 Air Quality

As described above, PM2.5 concentrations measured in Calexico include non-FEM BAM instruments. Appendix N, Section 3.0(a), of 40 CFR Part 50 indicates that all valid FRM and FEM PM2.5 mass concentration data submitted to EPA's Air Quality System (AQS), and meeting applicable requirements of 40 CFR Part 58, shall be used in design value calculations. Evaluating PM2.5 concentrations measured using the *non*-FEM BAM at Calexico were therefore not considered in determining compliance with the NAAQS.[4] Data used for design value calculations, trend analysis, and completeness relies exclusively on 2010-2012 FRM data. However, to better understand the potential influence of emissions from Mexico on the Calexico station, hourly BAM data for 2010 through 2012 were also evaluated. These hourly PM2.5 concentration data are provided in Section XII.

Design Values

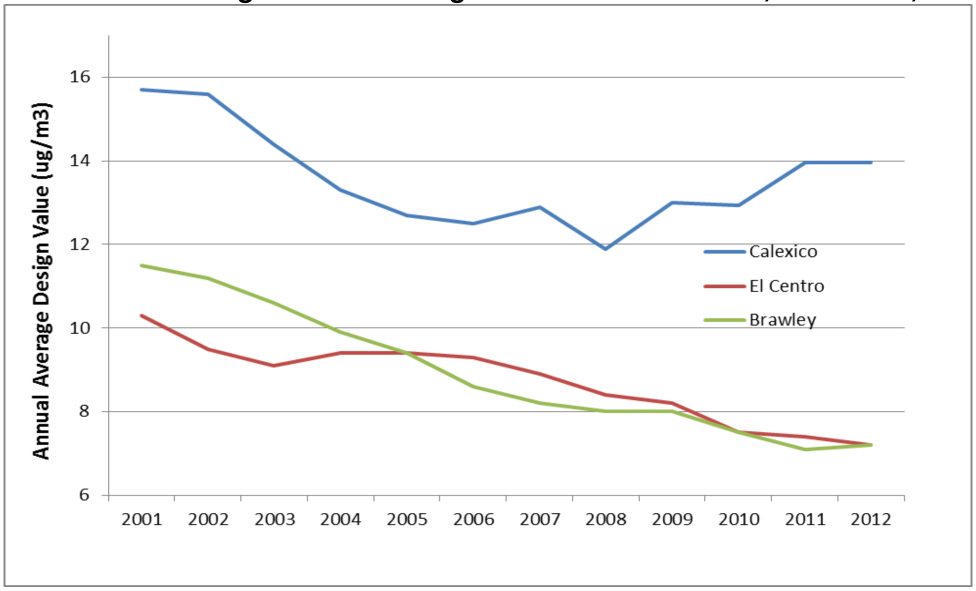
Despite the challenges that geography, climate, and proximity to Mexico pose for Imperial County air quality, the combined efforts of State and local emission control programs have resulted in improving air quality in the region, with the exception of the border area represented by the Calexico monitor. The trend in average annual design

[3] http://www2.epa.gov/border2020/goals-and-objectives

[4] 40 CFR, Part 53, provides requirements for air quality monitors to be considered either "Federal Reference Methods" or "Federal Equivalent Methods". BAMs at the Calexico site (currently and from 2010-2012) are considered non-FEM since they do not meet configuration and/or operating parameters detailed in U.S. EPA's list of Designated Reference and Equivalent Methods (http://www.epa.gov/ttn/amtic/files/ambient/criteria/reference-equivalent-methods-list.pdf). Unless otherwise noted, mention of BAM instruments in this document refers to non-FEM BAMs.

values for Calexico, El Centro, and Brawley are shown in Figure 7. The figure illustrates the extent to which Brawley and El Centro annual average design values track each other and how Calexico differs in the magnitude and trend of the design value.

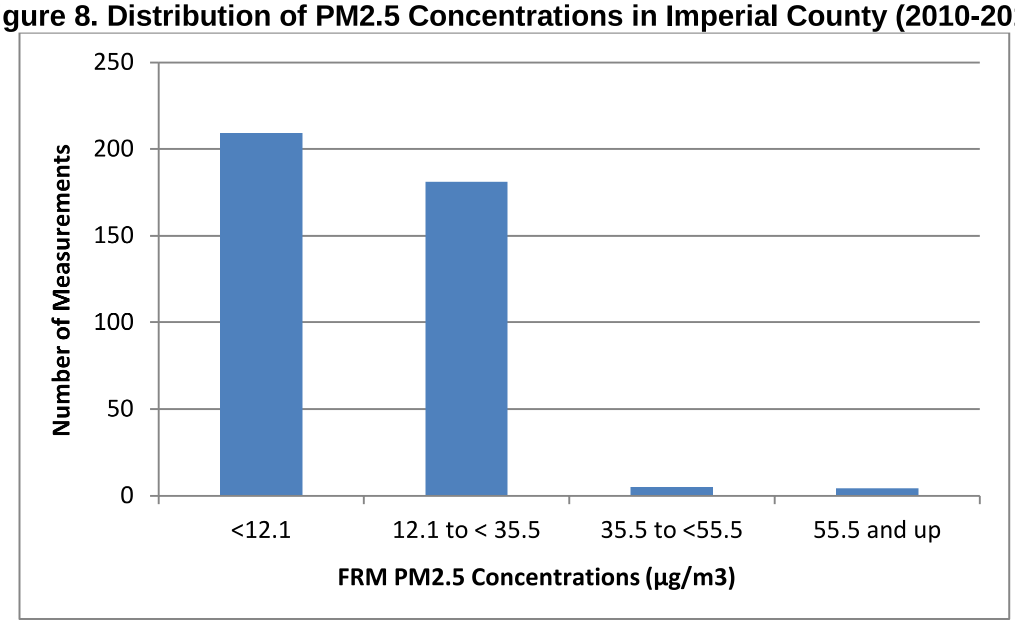
**Figure 7. 2001-2012 Average Annual Design Values for Calexico, El Centro, and Brawley**




*Calexico data includes invalidated and transport days in the design value calculation

Violations of the 24-hour PM2.5 standard are typically limited to Calexico during the winter months of December through February. Figure 8 shows that more than 52 percent of the PM2.5 concentrations measured in Imperial County between 2010 and 2012 were less than 12.1 µg/m3 and 98 percent were below 35.5 µg/m3.

**Figure 8. Distribution of PM2.5 Concentrations in Imperial County (2010-2012)**




*Invalidated and transport days are included

The 2012 and 2013 24-hour design values for the Imperial NA are 43 µg/m3 and 42 µg/m3, respectively. The annual average design values for 2012 and 2013 are 14 µg/m3 and 14.1 µg/m3. These design values include three data points that were originally invalidated by ARB's Laboratory, but were nevertheless included in AQS. The investigation into data quality and subsequent invalidation of three data values was prompted by significant differences in mass measured using FRM filter samplers and non-FEM BAM monitors.

PM2.5 FRM Trends

Figure 9 below shows time series plots of FRM PM2.5 concentrations at the Imperial County monitoring sites of Calexico, El Centro, and Brawley from 2010 through 2012 and highlights the extent of exceedances over the three year period. Figure 9 also shows that Brawley and El Centro air quality track well with each other, while Calexico values are significantly different.

Ten exceedances were noted from 2010 through 2012. Five of the ten exceedances occurred in Calexico during the months of December, January, or February. ARB, in consultation with the Imperial County Air Pollution Control District (District), determined that Calexico PM2.5 samples collected on October 15, 2011, March 31, 2012, and May 25, 2012, were not representative of ambient air quality based on analyses indicating that the filter loading included particles significantly larger than PM2.5. These large particles were likely the result of high wind events. These three samples were deemed invalid by ARB.

Excluding the three samples invalidated by ARB results in a 2012 PM2.5 design value for the Calexico site of 32 µg/m3, less than the 24-hour PM2.5 standard of 35 µg/m3. Including these three samples would result in a 2012 PM2.5 design value of 43 µg/m3. However, excluding the five days impacted by transport from Mexicali—the intent of this "but for" analysis—would result in a PM2.5 design value of 29 µg/m3, even if the invalidated samples were included.

Irrespective of the three invalidated samples, transport events from Mexico during the winter months are suspected as the primary cause of PM2.5 exceedances at the Calexico site on the remaining exceedance days, with the exception of two exceedances occurring in summer of 2010 and 2011. The exceedance of June 28, 2010, was determined to have been caused by a fire in Mexico and the August 28, 2011, exceedance is suspected to have been caused by high winds.

Data Completeness

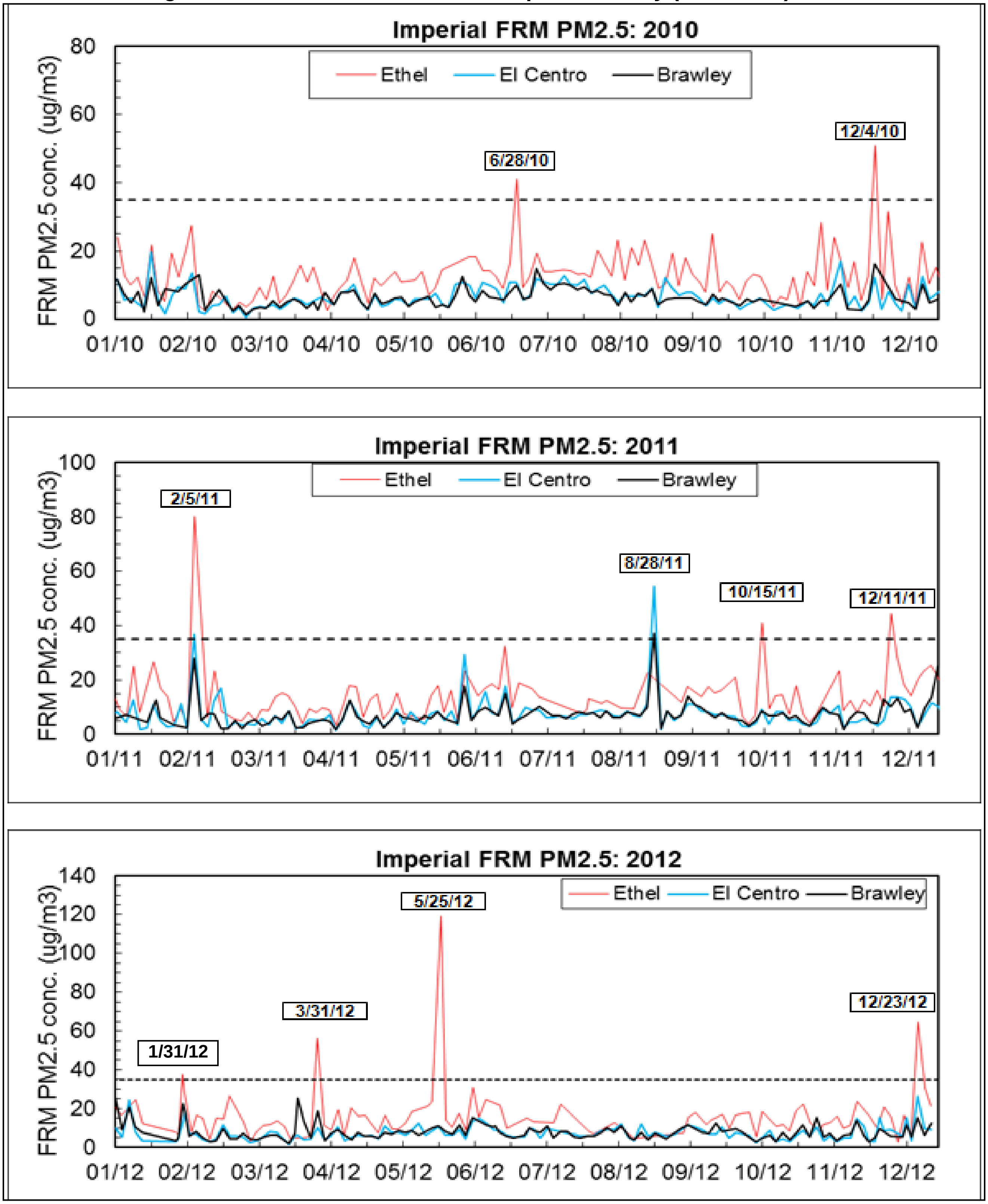
The FRM data are complete for all quarters, except quarter three of 2011 and 2012. The two incomplete quarters had 71 percent data completeness, which means they were 4 percent (or 2 samples) short of the minimum 75 percent required for a complete quarter. The data completeness improved significantly in 2013, with the lowest quarterly data capture of 87 percent. Table 4 provides the design values and data completeness for the Calexico site for all data from 2010-2013.

**Table 4. Calexico Design Values and Data Completeness 2010-2013**

| Year | 24-hour Statistics | | Annual Statistics | | Data Capture | | | |
|---|---|---|---|---|---|---|---|---|
| | 98th Percentile | Design Value | Avg | Design Value | Qtr1 | Qtr2 | Qtr3 | Qtr4 |
| 2010 | 31.7 | 32 | 12.8 | 12.9 | 97 | 90 | 97 | 100 |
| 2011 | 40.9 | 38 | 13.2 | 14 | 100 | 97 | 71 | 93 |
| 2012 | 56.3 | 43 | 15.8 | 14 | 84 | 90 | 71 | 100 |
| 2013 | 27.4 | 42 | 13.3 | 14.1 | 87 | 97 | 100 | 100 |

*Data includes concentrations on invalidated and transport days

**Figure 9. PM2.5 concentrations in Imperial County (2010-2012)**




*Speciation data was available for only four of the five exceedance days.

## VI. Border Area Emission Inventories

The analyses presented in this discussion focus on identifying emission sources leading to PM2.5 exceedances at the Calexico station and provide the basis for assessing the applicability of Section 179B to the consequences of those exceedances. The analyses show that PM2.5 samples collected in Calexico differ substantially in chemical composition than typical PM2.5 samples collected at other locations around the State and point to Mexicali as the source of emissions impacting the Calexico monitor. Together with the proximity of Calexico to Mexicali, an emission inventory for each area, and an assessment of the prevalent meteorological conditions during exceedance days, the available evidence supports the cross-border impact of Mexicali on the Imperial County nonattainment area.

PM2.5 Emissions in Imperial County and Mexicali

A comparison of PM2.5 emission inventories for the Imperial County nonattainment area and Mexicali shows the relative impact of domestic and international sources on PM2.5 air quality in the Calexico area. Annual emission inventories for the Imperial NA and the Mexicali Metropolitan Area are shown in Tables 5 and 6 below.

**Table 5. 2008 Annual Imperial NA Emission Inventory (tons/day)**

| Source Category | NOx | SOx | VOC | PM2.5 |
|---|---|---|---|---|
| Point Sources | 1.9 | 0.1 | 1.1 | 0.5 |
| Area Wide Sources | 0.6 | 0.1 | 9.3 | 10.9 |
| On-Road Mobile | 8.4 | 0.0 | 2.1 | 0.3 |
| Off-road Mobile | 8.0 | 0.2 | 5.8 | 1.1 |
| ***TOTAL*** | **18.9** | **0.4** | **18.3** | **12.8** |

**Table 6. 2005 Annual Mexicali Emission Inventory (tons/day)**

| Source Category | NOx | SO2 | VOC | PM2.5 |
|---|---|---|---|---|
| Point – Federal Sources | 38.2 | 10.0 | 1.8 | 0.4 |
| Point – State Sources | 1.2 | 2.7 | 0.2 | * |
| Area Wide Sources | 3.3 | 0.4 | 41.9 | 18.5 |
| On-Road Mobile | 23.5 | 0.5 | 24.6 | 1.8 |
| Nonroad Mobile | 12.3 | 0.2 | 1.5 | 1.5 |
| ***TOTAL*** | **78.5** | **13.7** | **70.0** | **22.1** |

** Emissions not estimated.*

The 2005 Mexicali Emissions Inventory developed by Eastern Research Group, Inc., (ERG) is the most recent, verifiable Mexicali inventory available. Point sources within the jurisdiction of the State of Baja California (approximately 173 sources) were not estimated in the ERG inventory; therefore, it is likely that the actual point source PM2.5 emission estimates are higher than the estimate in Table 6. In addition, ARB staff anticipates that the Mexicali emission inventory would be higher if windblown dust was included.

The 2008 Imperial County emission inventory is the base year inventory used for the Imperial NA SIP. A comparison of the 2005 and 2008 annual inventories shows the relative magnitude of the emissions in each area by source category. Emissions from sources in Mexicali are significantly higher than in the Imperial NA for NOx, SOx, and VOCs.

Significantly, the emission inventory for Mexicali does not account for episodic emissions associated with cultural celebrations common in Mexico during the winter months of December and January. These celebrations are known to include extensive fireworks displays and the lighting of bonfires containing plastics, tires, and other materials. If incorporated into an annual emission inventory, the estimate of Mexicali emissions of PM2.5 and other pollutants would increase substantially.

Gridded Emission Inventory for Calexico and Mexicali

To further evaluate local emissions in Calexico and Mexicali, ARB staff analyzed information from a gridded inventory from Imperial County for 2008 and Mexicali for 2005, based on the available PM2.5 and NOx emissions data for both areas (Figures 10 and 11). The emission data sets used for gridding originated from the 2008 National Emissions Inventory (NEI) and the 2005 Mexicali emissions inventory work conducted by ERG.

The gridded inventory allocates emissions spatially and provides further evidence of the emission differences between Calexico and Mexicali. The maximum emissions per grid cell are intended to illustrate the maximum potential difference on each side of the border and underscore the extent of differences between Mexicali and Imperial County.

**Figure 10. Gridded PM2.5 Emission Inventory for Calexico and Mexicali (4 km)**

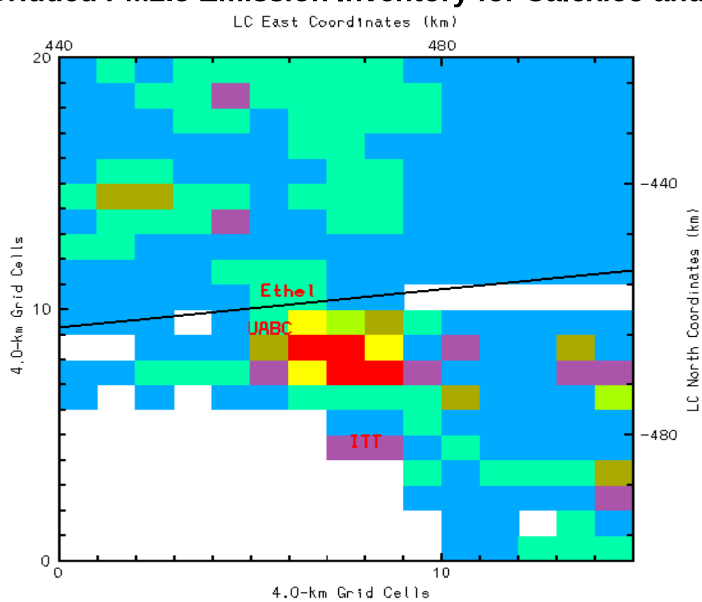


**Figure 11. Gridded NOx Emission Inventory for Calexico and Mexicali (4 km)**

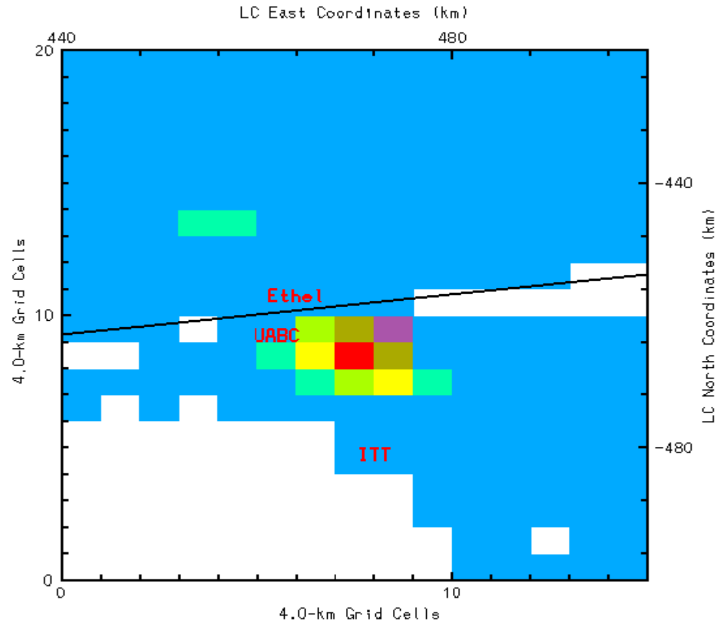
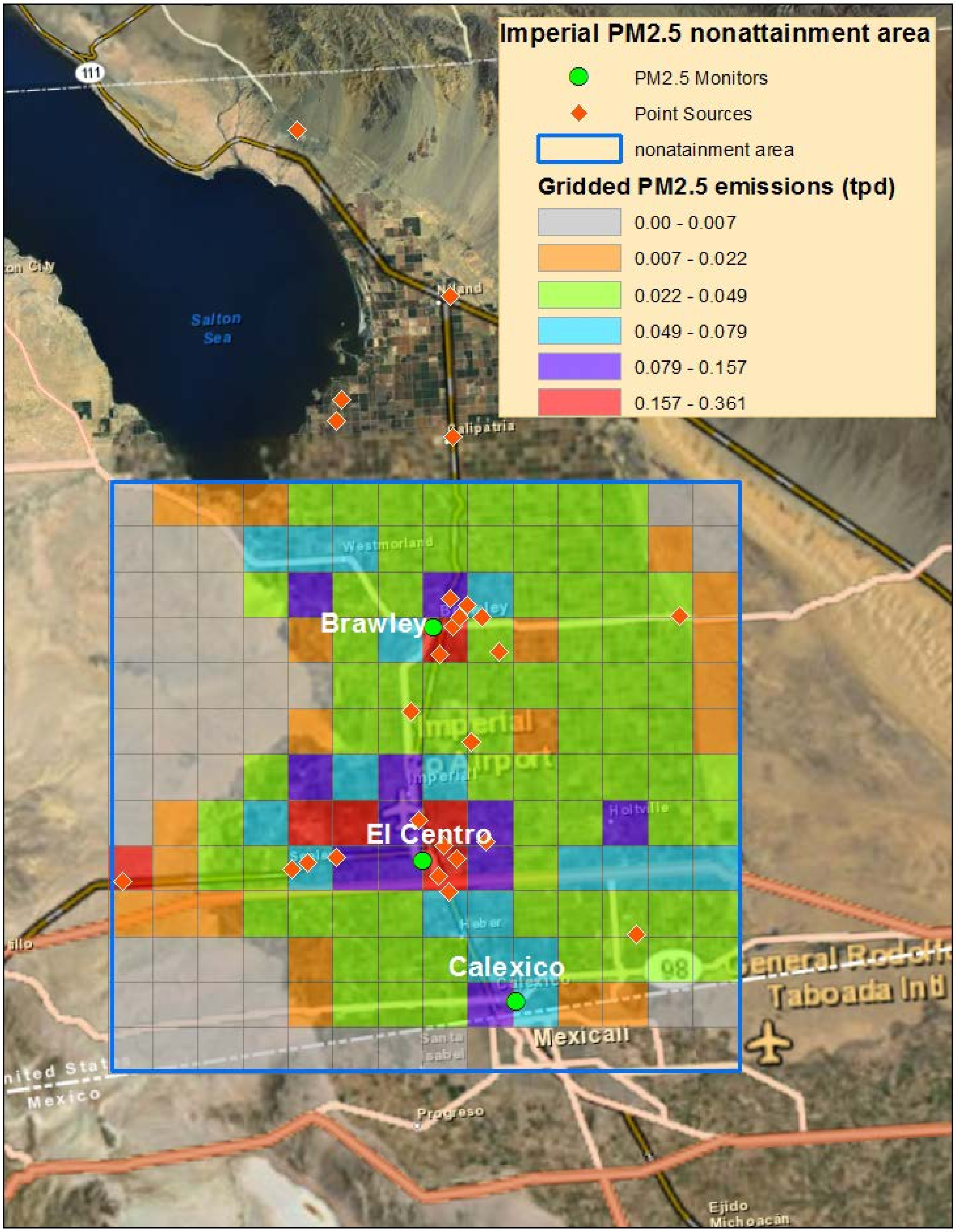



Figure 12 shows the average weekday winter PM2.5 emissions in 2012 for the Imperial NA. The plot displays all sources of emissions in the nonattainment area except for windblown dust, since all of the exceedances occurred on days with stagnant conditions characterized by little or no wind. The plot also shows that PM2.5 emissions are relatively uniform throughout the nonattainment area. The PM2.5 emissions are highest in the grid that contains El Centro. The total emissions for the nonattainment area grid are approximately 6.7 tons per day (tpd) of PM2.5. Considering local emissions only, and based on gridded inventory information, one might expect El Centro to have higher measured concentrations than Calexico. The fact that this is not the case supports the case that higher emissions from outside the Imperial NA are impacting the Calexico monitor.

**Figure 12. Gridded PM2.5 Emission Inventory for the Imperial Nonattainment Area**



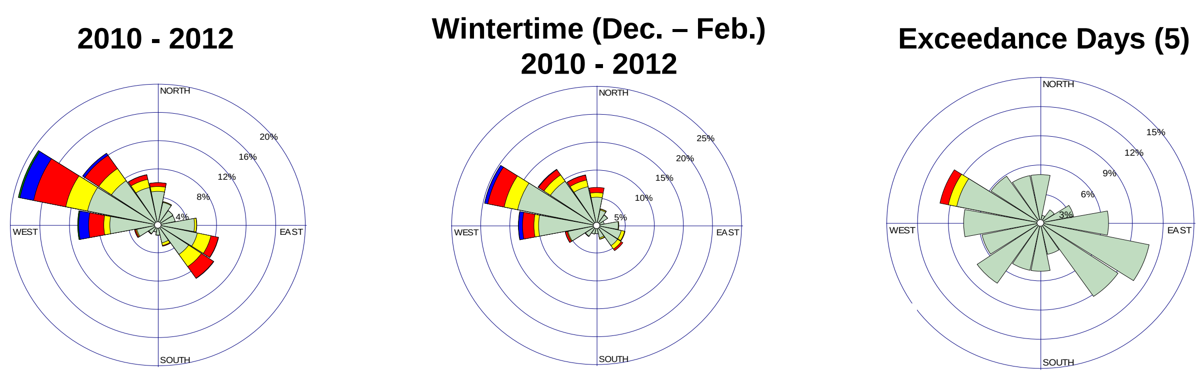
## VII. Border Area Meteorology

The majority of exceedances in Imperial County occur in Calexico where the impact of transport from Mexico is greatest. Monitors in Brawley and El Centro may also be impacted by emissions from Mexico, but their PM2.5 design values are below the 24-hour and annual standards. Exceedances in Calexico occur primarily during the winter months when meteorological conditions tend towards atmospheric stagnation with emissions accumulating near the border. These exceedances share the same pattern of low wind conditions coupled with low ambient temperatures. Summer month exceedances in Calexico, occurring once between 2010 and 2012, are atypical. Better dispersion of PM2.5 in the summer occurs as the rising valley floor temperature helps to break up inversions formed at night and in the early morning hours.

<u>Wind Direction</u>

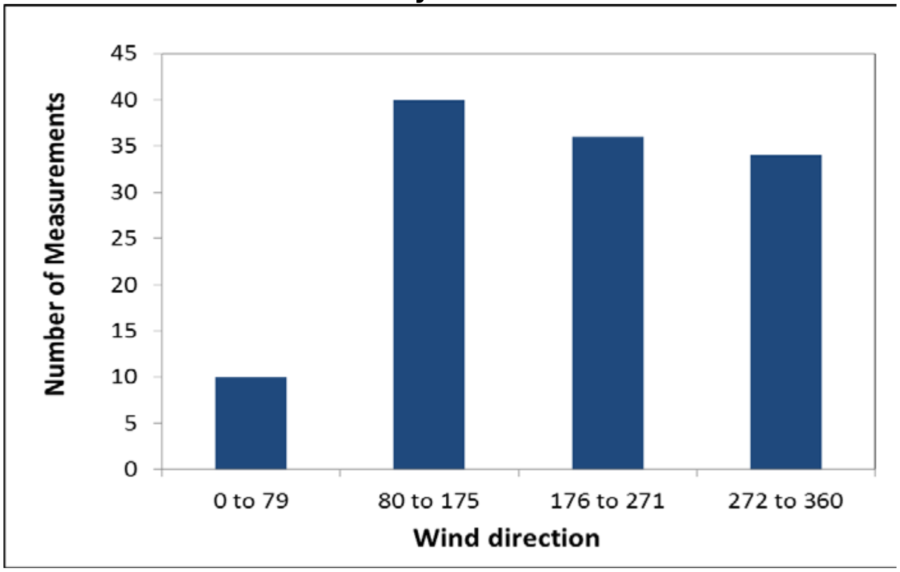
Wind rose plots were made of the hourly average wind direction in Calexico from 2010 through 2012, the hourly average wind direction during the winter months of December through February, and the hourly average wind direction on the five exceedance days (Figure 13). A comparison of the three plots shows that exceedance days were associated with very calm winds with little directionality. Generally, wind vanes exhibit isotropic behavior under calm conditions so that at very low wind speeds, the precise direction of the wind cannot be accurately established. The multi-directional wind rose accompanied by very low wind speed is indicative of stagnant atmospheric conditions. Under these stagnant conditions, pollutants within the Calexico-Mexicali air shed will tend to accumulate and exceedances will occur with greater frequency.

**Figure 13. Calexico Wind Rose Plots**




To the extent that wind direction did affect transport, BAM PM2.5 measurements were binned by wind direction on exceedance days. From a total of 120 high PM2.5 measurements between 2010 and 2012, approximately two-thirds occurred during southerly winds (79 to 272 degrees) (Figure 14). A description of how wind flow is established as originating from the north or south is detailed later in this document (see Section IX).

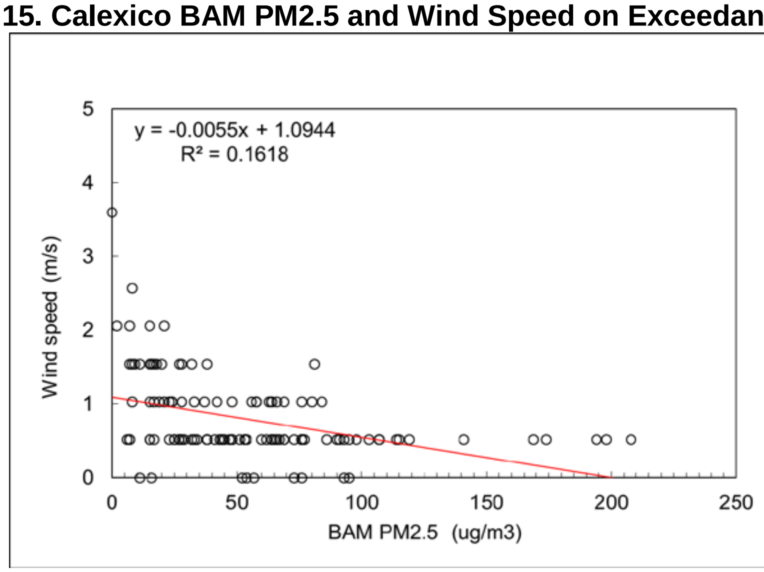
**Figure 14. Calexico BAM PM2.5 by Wind Direction on Exceedance Days**




Wind Speed

The connection between wind speed and BAM PM2.5 concentrations was evaluated by plotting hourly BAM measurements with wind speed data. Figure 15 illustrates the clustering of higher PM2.5 concentrations with winds equal to or less than about 1.5 mps. This coincides with wind rose data showing that low wind speeds were consistent with exceedances measured in Calexico.

**Figure 15. Calexico BAM PM2.5 and Wind Speed on Exceedance Days**



Meteorological data suggest that the prevailing atmospheric conditions in Calexico during the winter exceedance days were stagnant with little or no dispersion, leading to elevated PM2.5 concentrations from higher emissions on the Mexicali side of the border.

## VIII. Estimate of the Source and Direction of Emissions Impacting Calexico

To assist in identifying the source and location of emissions impacting the Calexico PM2.5 monitor, two analyses were performed. First, Calexico speciation data were evaluated for the presence of specific elements or chemical composition that would help indicate a specific type of emissions source. Since speciation samples are collected at selected California monitoring sites every sixth sampling day, it is also possible to compare the speciation profile and composition from Calexico samples with those from other monitoring sites with known emission impacts.

Second, to estimate the direction of potential sources impacting Calexico, an analysis using conditional probability was performed. The conditional probability function (CPF) for each elemental species uses the concentration coupled with wind direction over the period from 2010 through 2012 to estimate the potential direction of sources impacting the Calexico monitor.

<u>Chemical Composition Data</u>

Compositional analysis of PM2.5 samples provides important information regarding the source of emissions. Samples collected from Calexico indicate that the particulate matter is heavily dominated by carbonaceous aerosols (organic matter plus elemental carbon), which comprise about 58 percent of the PM2.5 mass on an average exceedance day between 2010 and 2012 (Figure 16). Most of the carbonaceous aerosol particles originate from combustion sources (tailpipe emissions, wood burning, etc.). Compared with the annual average, a typical exceedance day contains about 20 percent more organic matter (Figure 17). In contrast, the contribution from geological material is smaller on a typical exceedance day. Fugitive dust from sources such as unpaved roads and open fields is therefore a smaller contributor to PM2.5 exceedances in Calexico. Organic matter concentrations, on the other hand, appear as the primary contributor to exceedance values.

**Figure 16. Calexico 2010-2012 Exceedance Day Composition**

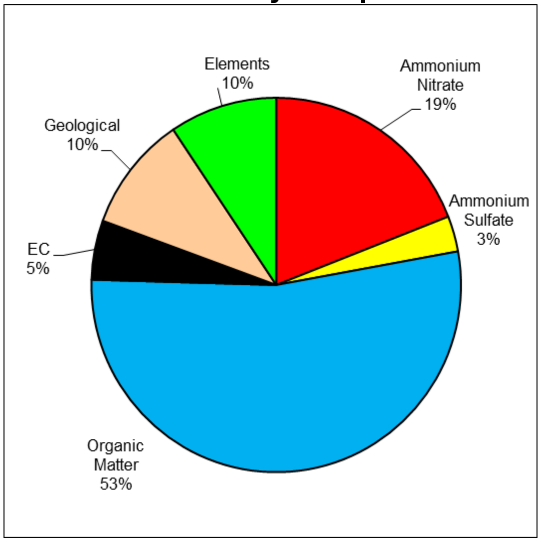



**Figure 17. Calexico 2010-2012 Annual Composition**

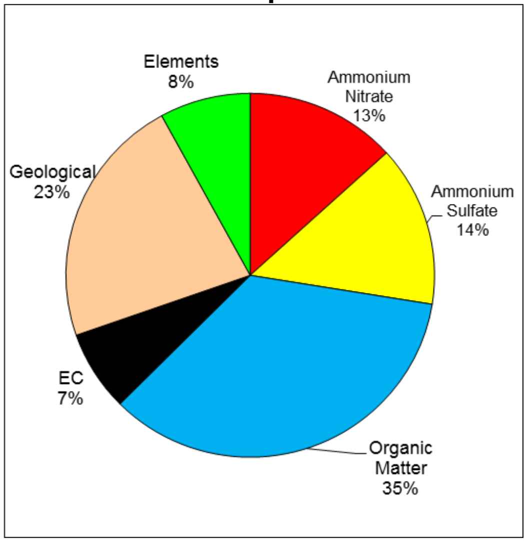
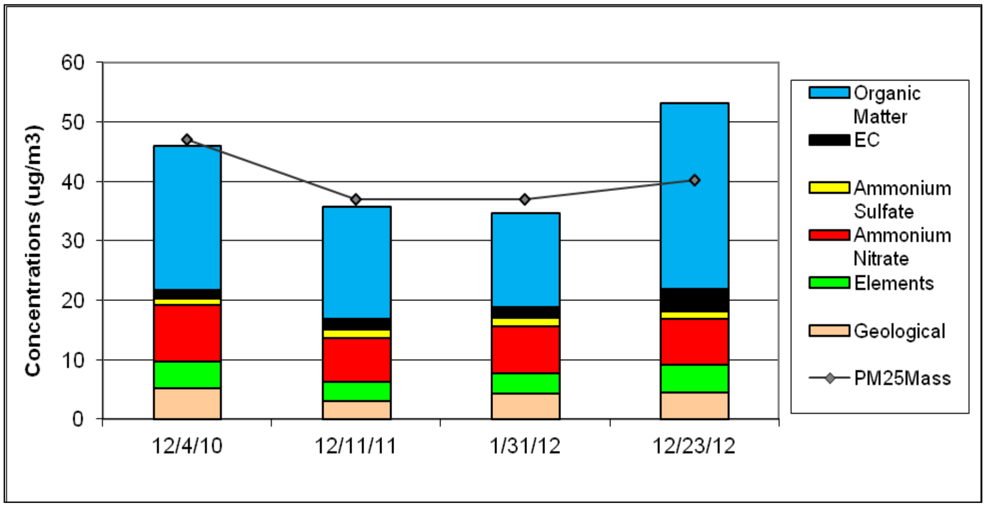


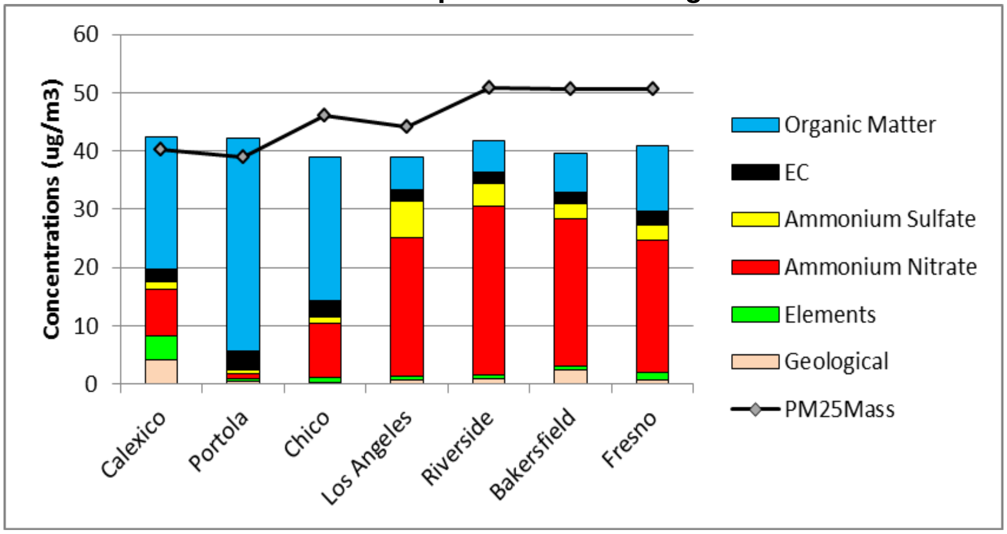
Figure 18 below shows that on days with PM2.5 concentrations exceeding the standard, the proportional composition was consistent. Organic carbon comprised the largest portion of the mass, while ammonium nitrate was the second largest component. Concentrations of elemental species comprised a significant portion (10 percent) of the mass on these exceedance days.

**Figure 18. 2010-2012 Chemical Composition on Exceedance Days at Calexico**




Staff also compared Calexico speciation data to other locations in the State and noted both similarities and differences in the profiles. Organic matter and elements are present in the Calexico samples, as with other sites in California, but the concentration of elemental species at Calexico is 90 percent higher compared with other sites, including wood burning areas and urban locations. The similar scale of organic matter concentrations among the Calexico, Portola, and Chico monitoring sites suggests combustion as a source of emissions on exceedance days. Chico and Portola organic matter concentrations are associated with wood burning (Figure 19). The similarity in organic matter concentrations in Calexico, Portola, and Chico speciation data suggests that some type of wood burning may also be a factor in emissions impacting the Calexico monitoring site.

**Figure 19. 2010-2012 Chemical Composition on Average PM2.5 Exceedance Days**



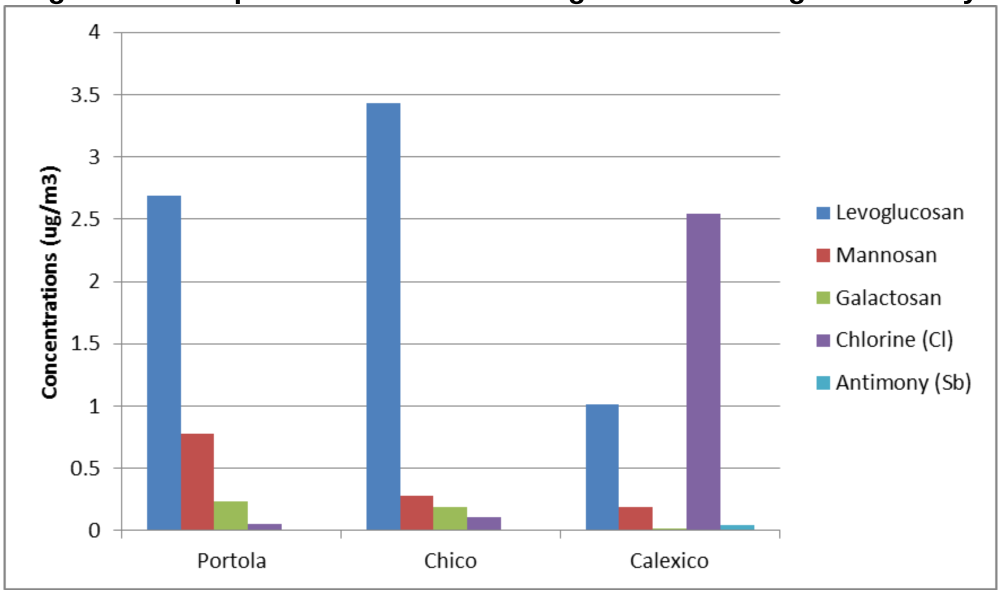

<u>Analysis of Wood Burning Tracers</u>

Levoglucosan, mannosan, and galactosan are combustion byproducts of cellulose and are often used as tracers for identifying biomass combustion. Staff evaluated the Calexico samples for concentrations of these tracers to further help in identifying the type of combustion emissions impacting the Calexico monitor. Areas with wood burning activity generally have elevated levels of all three tracers. At Calexico, concentrations of levoglucosan are elevated, but still up to 70 percent lower compared to Portola and Chico. Similarly, concentrations of mannosan and galactosan are substantially lower at Calexico compared to Chico and Portola.

Higher concentrations of galactosan in a community impacted by wood burning are consistent with research indicating that galactosan is the most promising marker to indicate biomass burning limited to wood only, without refuse, which might contain paper, cardboard, or other wood-related products (Christian et al. 2010). The very low concentrations of galactosan observed at Calexico, coupled with unusually high concentrations of chlorine and antimony (discussed below), help rule out the typical residential or agricultural wood combustion as a probable source of the high PM2.5 concentrations at the Calexico monitor (Figure 20).

These analyses of wood burning tracers substantiate the idea that emissions impacting Calexico are atypical of simple wood burning and more likely indicate combustion associated with wood burning combined with refuse or other non-biomass material. Further elemental analysis was undertaken to help identify the source of the organic matter.

**Figure 20. Comparison of Wood Burning Markers on High PM2.5 Day**

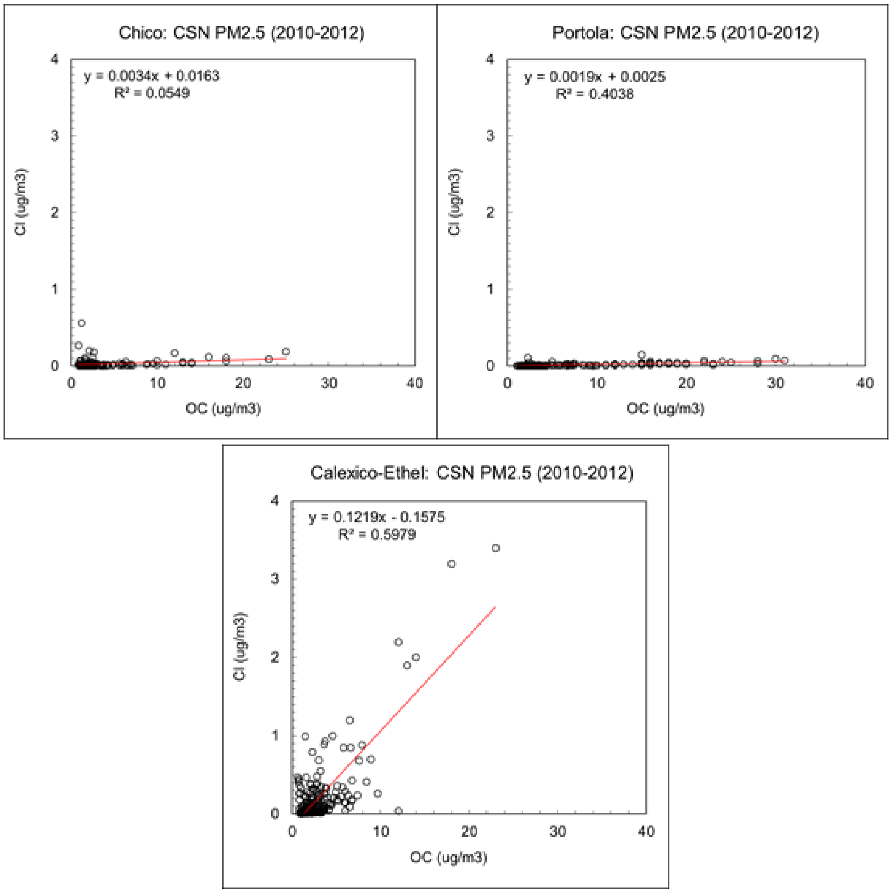



<u>Elemental Analysis</u>

Staff evaluated speciation data by plotting the organic carbon and chlorine concentrations present in Calexico samples from 2010 through 2012. The purpose was to assess if concentrations of organic carbon typically associated with combustion were the same in Calexico and in other California locations. The concentrations of selected elements were added to the plots to help determine what types of materials were burned. Similar plots were made with data from samples collected at monitoring sites in Chico and Portola. Chico and Portola are known to have increased rates of wood burning and comparing the correlations for all three sites further established if the exceedances could be due solely to an increase in biomass/wood burning.

The plots in Figure 21 indicate that Calexico has an unusually high chlorine concentration with a strong correlation between organic carbon and chlorine. Samples from Chico and Portola did not show a similar correlation. This suggests that the Calexico samples were impacted by combustion emissions, but not from biomass burning. The presence of chlorine indicates combustion associated with the burning of plastics or other refuse. Since 2004, ARB's Residential Burning Air Toxics Control Measure (ATCM) has largely prohibited the burning of refuse in California, so it is unlikely that combustion emissions with a trash-burning signature originated on the Calexico side of the border. Rather, the high concentrations of organic carbon and chlorine in samples from Calexico suggest that combustion emissions impacting the monitor were from Mexicali, where the burning of residential refuse is well documented (Li et al., 2012).

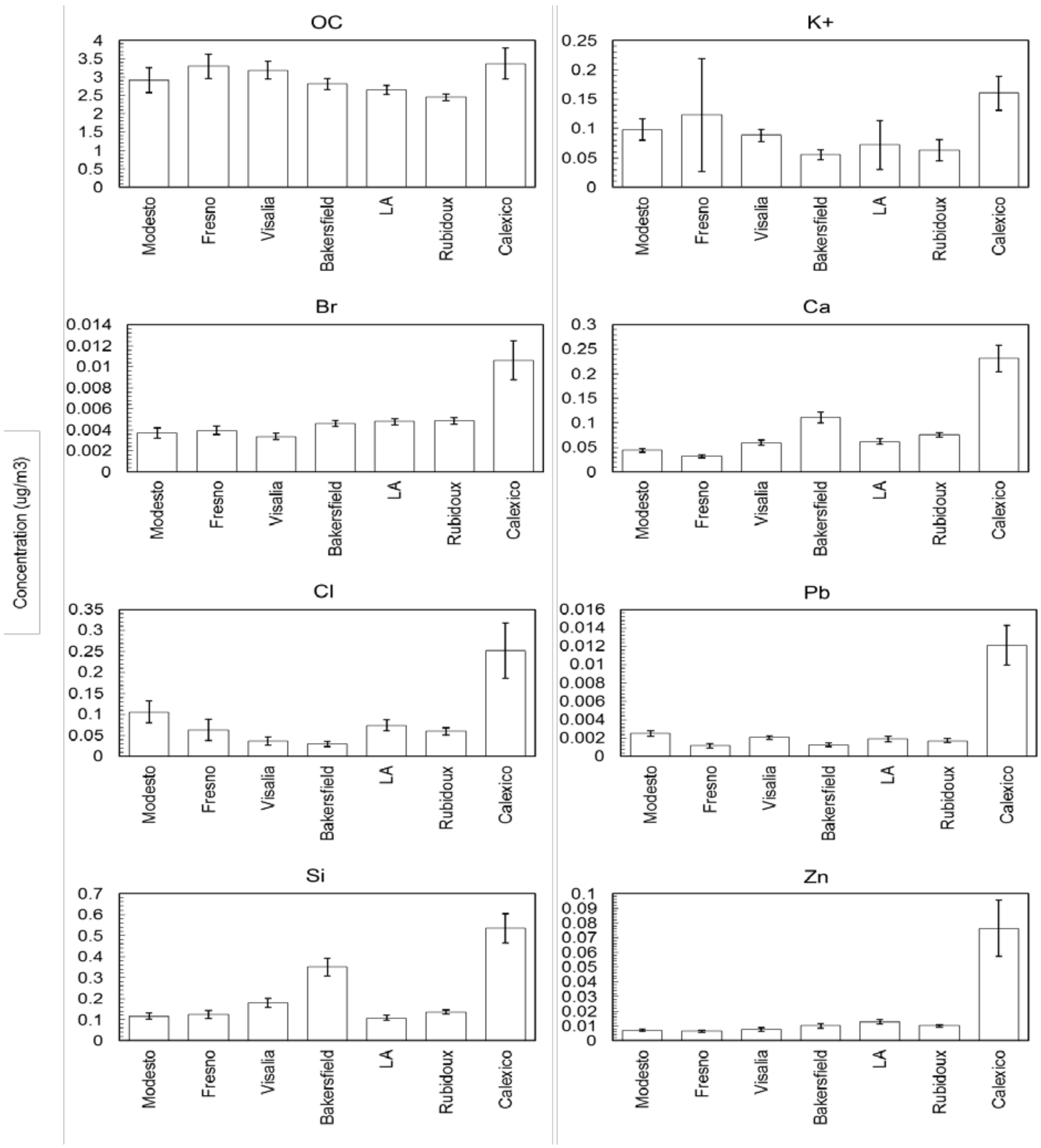
**Figure 21. Organic Carbon vs. Chlorine at Calexico, Chico, and Portola (2010-2012)**




Identification of potential sources impacting the Calexico monitor was further assessed by comparing speciation data from Calexico with other monitoring locations in the State from 2010 - 2012 (Figure 22). Concentrations of several elemental species besides chlorine are significantly higher at Calexico compared to other California sites. These species include bromine, lead, and zinc and imply that emissions impacting the Calexico monitor are fundamentally different than emissions impacting other monitors around the State.

The comparison sites in the Central Valley and Southern California are impacted by a variety of emission sources and are indicative of the elemental concentrations typically present at California monitoring locations. The differences in measured element concentrations, particularly with respect to elemental lead, an identified toxic air contaminant strictly controlled for decades, indicates that the source of emissions impacting the Calexico monitor are most probably not from within the U.S.

**Figure 22. Speciation Analysis: Calexico & Six Other California Locations (2010-2012)**




Figures 23 and 24 compare concentrations of select elemental species at Calexico to other sites on exceedance days, including sites known to be impacted by wood burning. Considering only the four exceedance days for which speciation data were available, the most abundant elemental species sampled at Calexico is chlorine. Concentrations of other elemental species, including antimony, bromine, lead, zinc, and barium are 3 to 30 fold greater than at other California sites.

**Figure 23. Concentrations of Select Elemental Species on an Average Exceedance Day (2010-2012)**

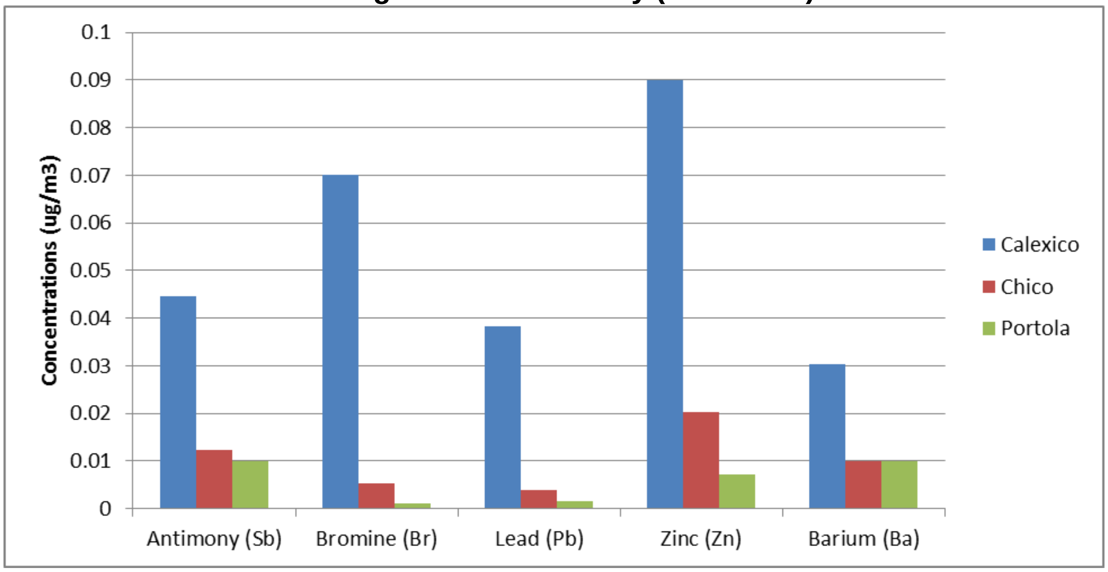
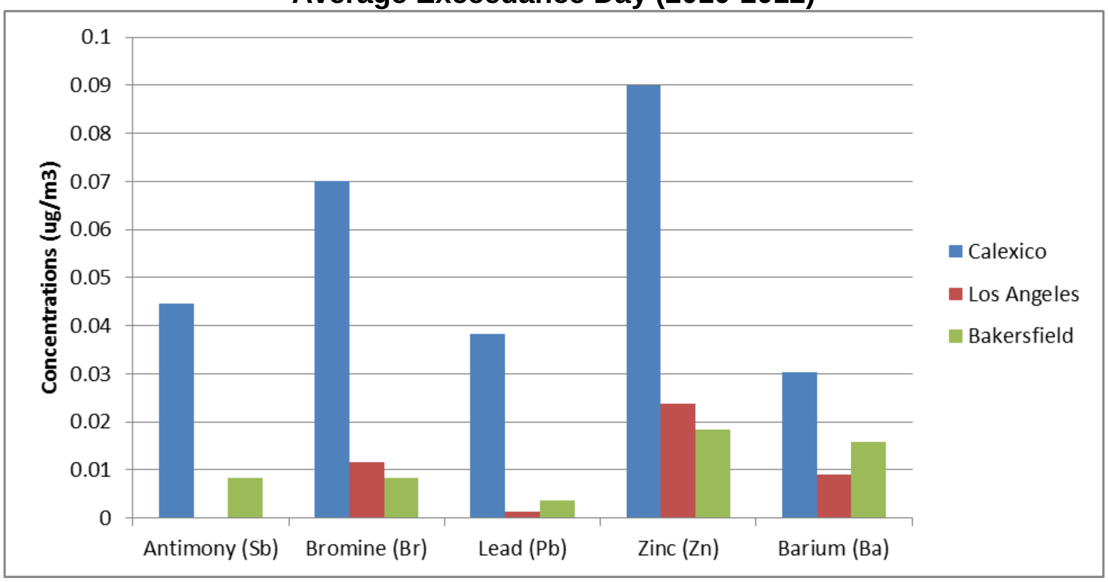



**Figure 24. Concentrations of Select Elemental Species on an Average Exceedance Day (2010-2012)**




The implications of the data presented in Figures 23 and 24 involve combustion and the elemental signatures typical of combustion. In addition to chlorine, fine particle antimony is a potential tracer of general refuse burning in Mexico, including the burning of plastics, rubber, fabrics, and other waste (Christian et al., 2010 and Hodzic et al., 2012).

Antimony is used as a flame retardant for textiles and in lead alloy batteries and antimony trioxide is used as a catalyst in the production of soft drink bottles and textile polyester fibers, all potential combustible materials. It is possible that industrial sources of antimony and other metals exist in Mexico, but there is currently not enough data to estimate their emissions. High concentrations of both chlorine and antimony, coinciding with high PM2.5 concentrations, indicate that refuse or other non-biomass combustion in Mexicali is likely an important source of PM2.5 mass on Calexico exceedance days.

Elemental Analysis from FRM Filters

Since PM2.5 speciation data are not collected at El Centro and Brawley, FRM filters from the three Imperial County sites matching four of the Calexico exceedance days were analyzed by X-Ray Fluorescence Analysis (XRF) for elements. Sample dates and measured PM2.5 mass are listed in Table 8.

**Table 8. PM2.5 filters analyzed by XRF**

| | PM2.5 Concentrations (µg/m3 ) | | |
|---|---|---|---|
| **Date** | **Calexico** | **Brawley** | **El Centro** |
| 12/4/2010 | 50.9 | 16.2 | 12.2 |
| 12/11/2011 | 44.4 | 10.2 | 13.7 |
| 1/31/2012 | 37.7 | 22.7 | 13.0 |
| 12/23/2012 | 64.7 | 15.5 | 26.4 |
| **Avg. PM2.5** | **49.4** | **16.3** | **16.3** |

Typically, chemical composition data are obtained by operating a separate multi-filter PM2.5 sampler and subjecting the filters to different types of chemical analysis aimed at qualifying different sets of chemical species. Because the cost of operating and analyzing chemical composition data is very high, Imperial County has only one speciation sampler operating at Calexico.

While FRM Teflon filters normally are not analyzed for PM2.5 species, it is nevertheless possible to perform certain types of chemical analysis on the Teflon substrate. The archived FRM Teflon filters were provided to ARB's Laboratory for chemical analyses to estimate the PM2.5 chemical constituents from a Teflon filter. These new data were intended to determine if elevated concentrations of elemental species are unique to Calexico or common to all Imperial County sites. The lab analyzed Teflon filters by XRF to provide concentrations of elemental species.

The analytical results meet all quality assurance/quality control (QA/QC) criteria for XRF analysis per ARB Monitoring and Laboratory Division's standard operating procedure, except for the non-uniform distribution of particles across the surface area of the filter matrix. This impacts the quantitative accuracy of the XRF analysis. Therefore, the data reflect the general spatial variation in concentrations, but are of limited value in terms of quantitative estimate of elemental species concentrations.

The average concentration of elemental species was five to eight times higher at Calexico compared to El Centro and Brawley (Figure 25). The average concentration of geological material was six to eight times greater at Calexico compared to the other two sites (Figure 26).

**Figure 25. Average Elemental Species Concentrations**

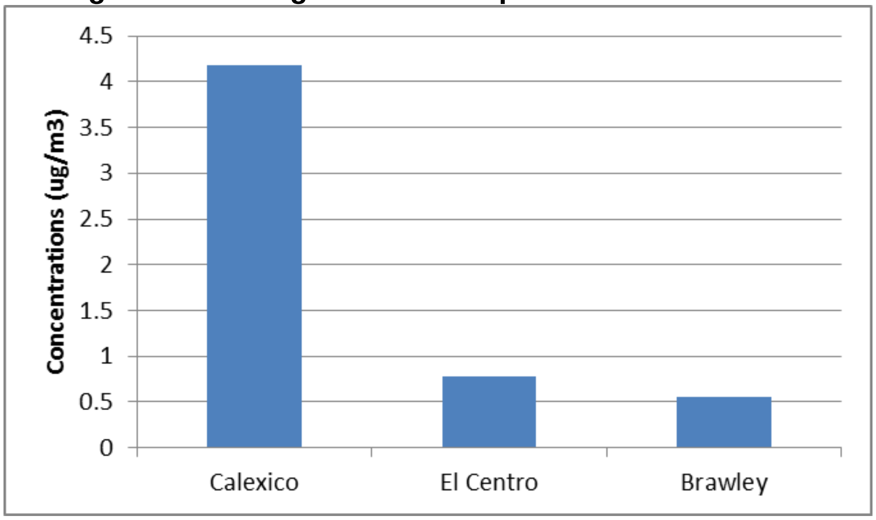
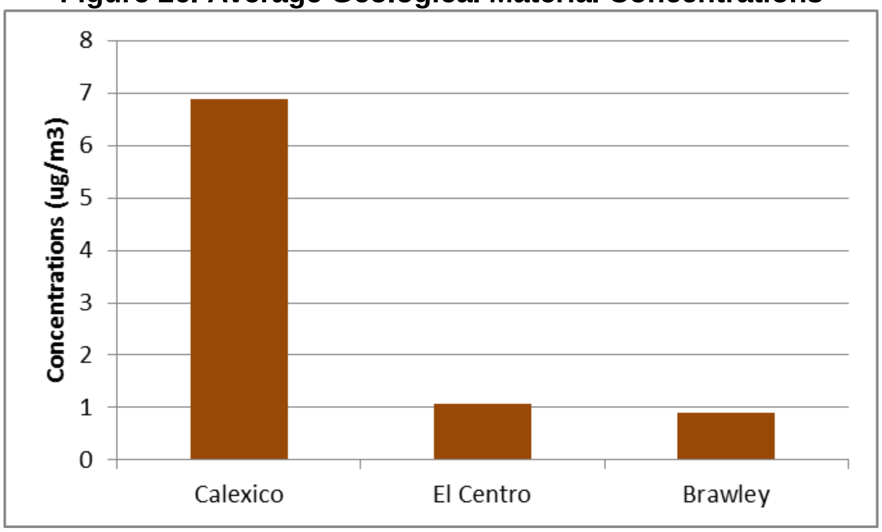



**Figure 26. Average Geological Material Concentrations**




The difference between elemental species concentrations at Calexico and the other two Imperial County sites, El Centro and Brawley, was similar to the difference observed between Calexico and other California sites. Average concentration of chlorine was 7 to 15 times higher at Calexico (Figure 27). Concentrations of antimony and barium were below the detection limit at El Centro and Brawley, but they were in the 0.03 µg/m3 to 0.05 µg/m3 range at Calexico (Figure 28). Calexico concentrations of bromine, lead, and zinc were 5 to 12 times the levels at the other two sites.

**Figure 27. Average Chlorine Concentration at Imperial County**

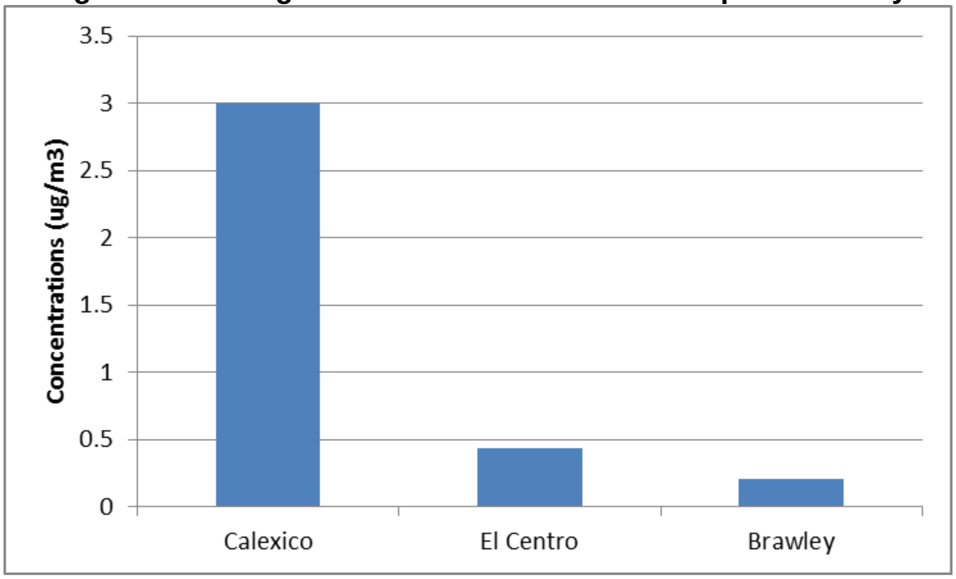
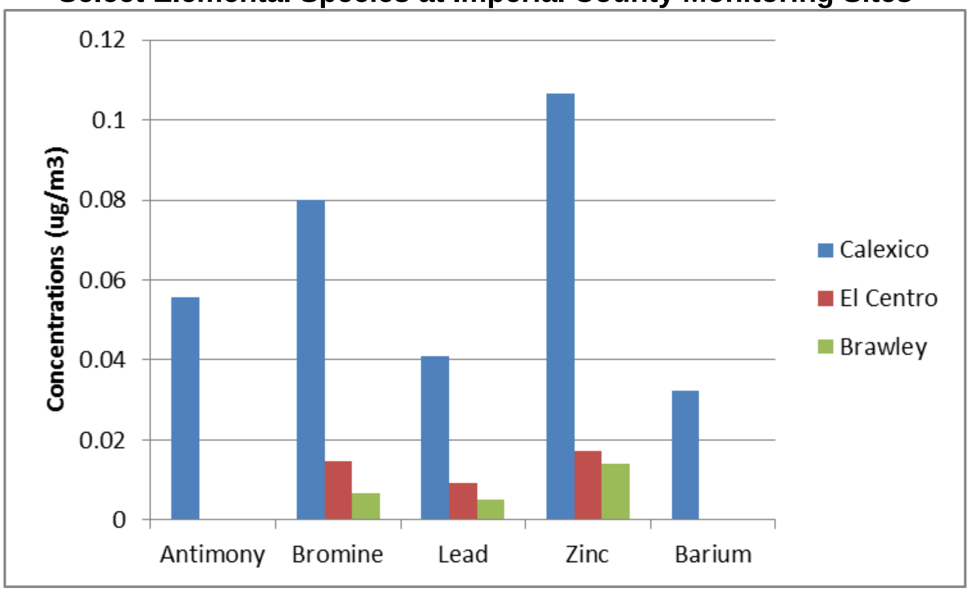
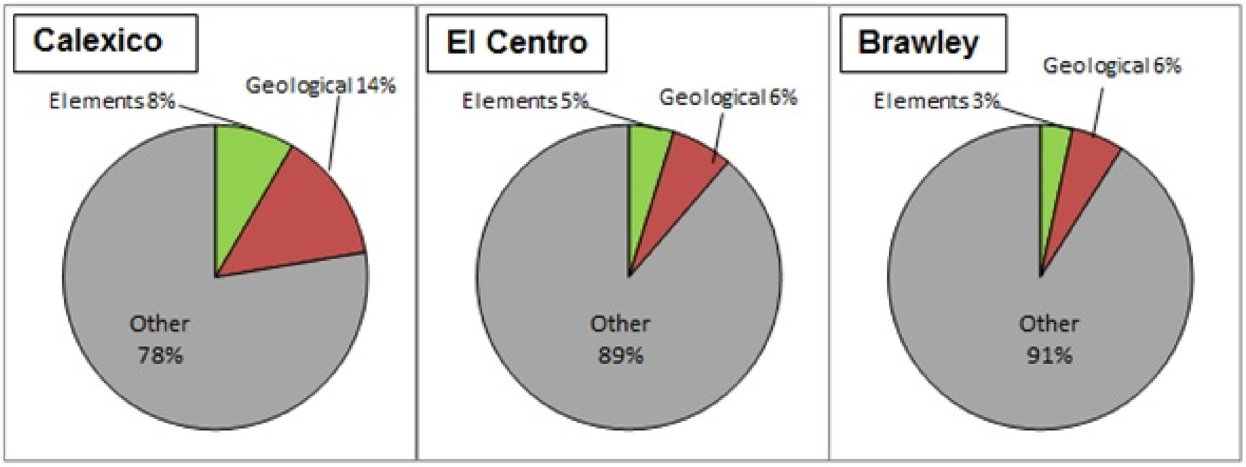



**Figure 28. Comparison of Average Concentration of Select Elemental Species at Imperial County Monitoring Sites**




The XRF analysis also revealed that on exceedance days the total elemental species comprise a smaller percent of the measured PM2.5 mass with increasing distance north of the border (Figure 29). This further suggests that the elements linked to refuse combustion, as well as other elemental species measured at Calexico, likely originated on the Mexico side of the border.

**Figure 29. Elements and Geological Material as Fraction of PM2.5 Mass**




Estimate of Emission Source Directions

To estimate the potential direction of the local sources impacting the Calexico monitor, the conditional probability function (Kim and Hopke, 2004) was calculated for each chemical species. The CPF estimates the probability that a chemical species from a given direction will exceed a pre-set high concentration threshold. The CPF plots below show the top 10 percent of species on any given day for 2010-2012. The length of each line for each direction is a probability which ranges from 0 to 1. Potential sources are likely to be located in directions that have high probability values. The same 24-hour concentration was assigned to each hour of a given day to match to the hourly wind data. Very calm winds were excluded from this analysis and 24 wind sectors of 15 degrees were chosen to show the potential directionality of the emission sources.

Motor vehicle emissions are typically identified by high concentration of organic carbon, elemental carbon, nitrate ion, and minor species such as bromine. In Figure 30, the CPF plots for those four species all point southwest from the Calexico monitor and toward the international port of entry. It suggests these concentrations were likely from vehicles at the United States-Mexico border crossing.

As shown in Figure 31, major sources of chlorine were identified as south of the monitoring site and widely distributed. Coupled with the elemental analyses discussed earlier, this result points to refuse burning as one of the major emission sources impacting Calexico.

Figure 32 shows the CPF plots for selected metals (chromium, lead, antimony, and zinc). The potential sources of these metals were located south-southeast of the monitoring site in the direction of Mexicali. Again, activities that produce airborne metals, including combustion of refuse or other non-biomass materials, are the likely source.

**Figure 30. Conditional probability function plots for OC, EC, NO3, and Br (Length of each line represents a probability)**

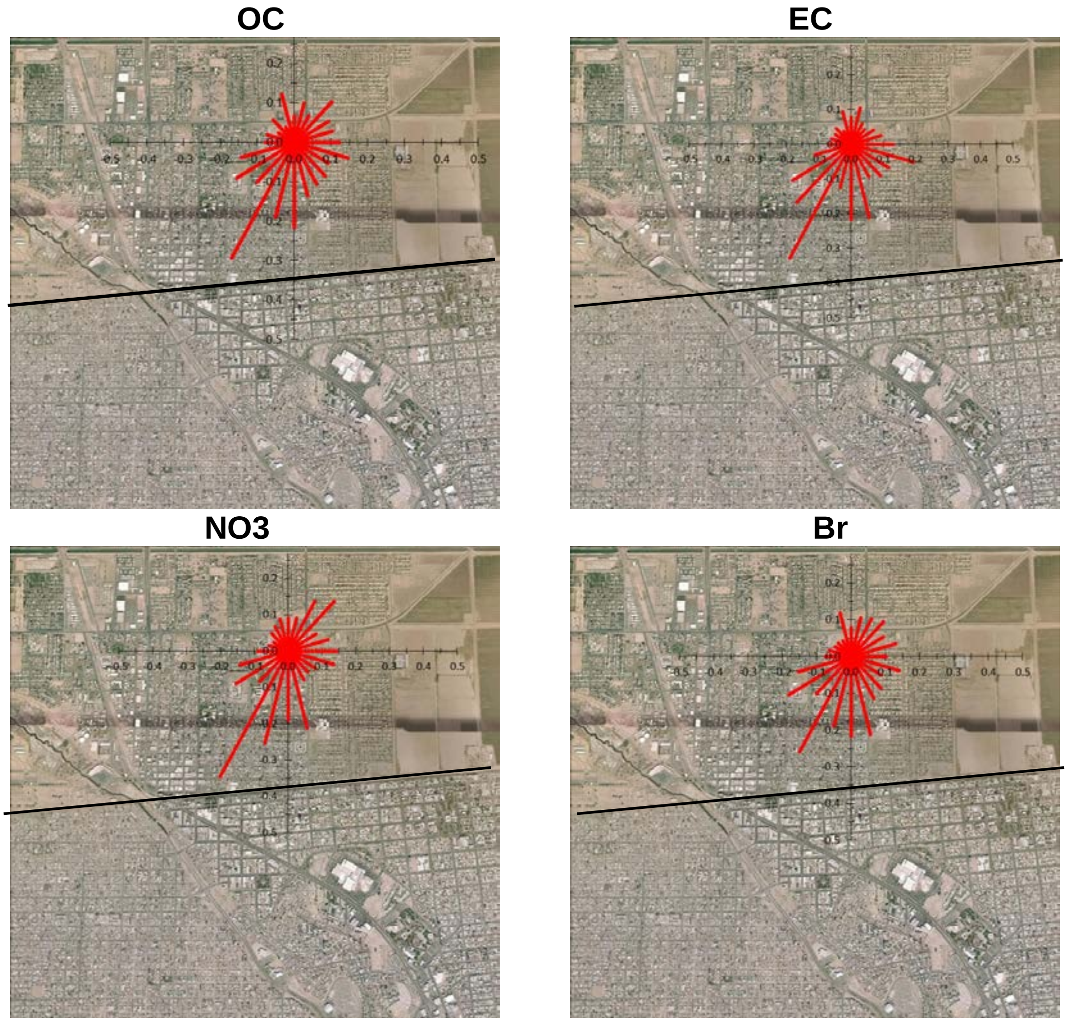



**Figure 31. Conditional probability function plot for Cl (Length of each line represents a probability)**

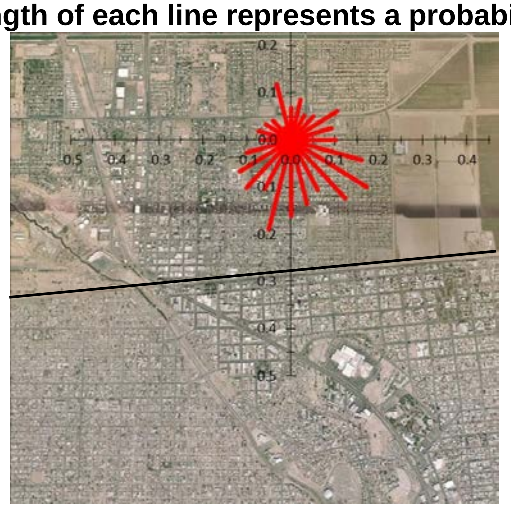
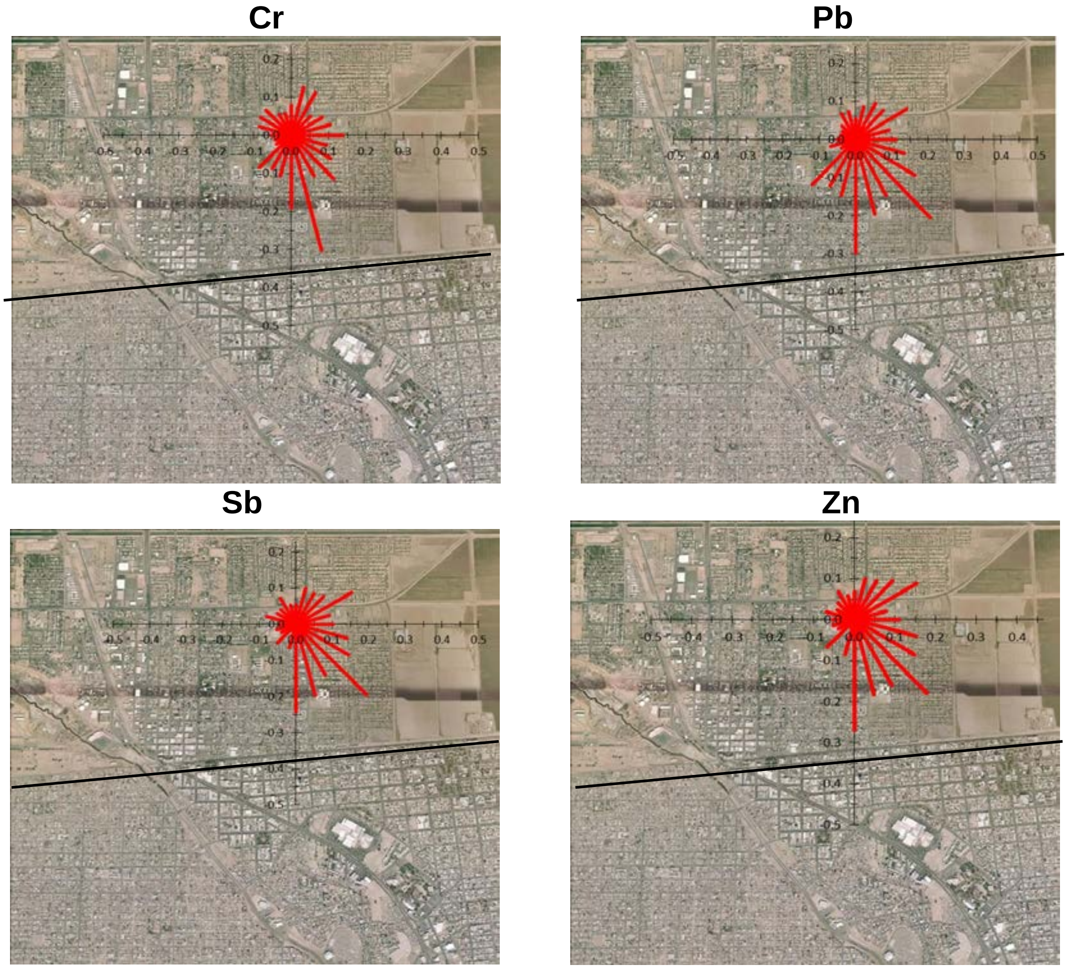


**Figure 32. Conditional probability function plots for Cr, Pb, Sb, and Zn (Length of each line represents a probability)**




Related to the previously discussed composition analyses, the ratio of BAM-measured PM2.5 to PM10 for the five exceedance days was averaged and compared to one summer day exceedance at Calexico during which both the PM2.5 and PM10 BAMs exceeded the standard. The much larger percentage of PM2.5 during the winter exceedance days is indicative of combustion. The August 9 exceedance—composed of a much higher percentage of PM10—was more likely due to fugitive dust (Table 7).

**Table 7. Ratio of BAM PM2.5 to PM10 on Exceedance Days**

| Date | BAM PM2.5 | PM10 | % of PM2.5 |
|---|---|---|---|
| 12/4/2010 | 50.5 | 117.3 | 43 |
| 12/10/2010 | 36.4 | 91.6 | 40 |
| 12/11/2011 | 39.6 | 83.9 | 47 |
| 1/22/2012 | 36.5 | 83.1 | 44 |
| 12/23/2012 | 69.1 | 117.8 | 59 |
| **Winter Exceedance Average** | | | **47** |
| 8/9/2012 | 49.1 | 387.3 | 13 |

## IX. Estimate of PM2.5 Concentration Impact from Imperial County Emissions

Efforts to isolate the impacts of cross-border transport on PM2.5 concentrations recorded at the Calexico monitor using only hourly pollutant and meteorological data from this site were conducted using several statistical approaches. The approach considered the most appropriate and definitive was one based on the premise that hourly-average winds with speeds above a pre-determined threshold blowing from compass azimuths within an arc bounded by and to the north of the international border would best minimize impacts from cross-border emissions sources. This approach is described below. As with other analyses in this weight-of-evidence 179B demonstration, the results are not conclusive, but provide strong evidence that, but for the impacts of cross-border emission transport, the 24-hour PM2.5 NAAQS was attained during the 2010-2012 evaluation period.

To assure temporal completeness, the analysis was based on all hourly monitoring data collected at the Calexico site during calendar years 2010, 2011, and 2012. Hourly-average PM2.5, wind speed, and wind direction data were recorded at the Calexico site during these three years (AQMIS).

<u>Wind Direction Assessment – Defining North Winds</u>

Wind directions, under which the transport of emissions generated by U.S. sources, were determined by mapping an appropriate compass arc that excluded impacts from non-U.S. sources. An aerial photograph of the Calexico-Mexicali metropolitan area was used to determine an appropriate compass arc of wind directions that would exclude transport of cross-border emissions to the monitor. This photograph/map is shown in Figure 33. Examination of the satellite photograph revealed reasonably clear boundaries of the Mexicali Metropolitan Area, the region within which the vast majority of sources of directly-emitted PM2.5 transported to the Calexico monitor are located. Compass azimuths connecting the location of the monitor to the points where the Mexicali urban edge intersects the international border are shown as straight lines in Figure 34. These azimuths lie at angles of 94 and 257 degrees from true North.

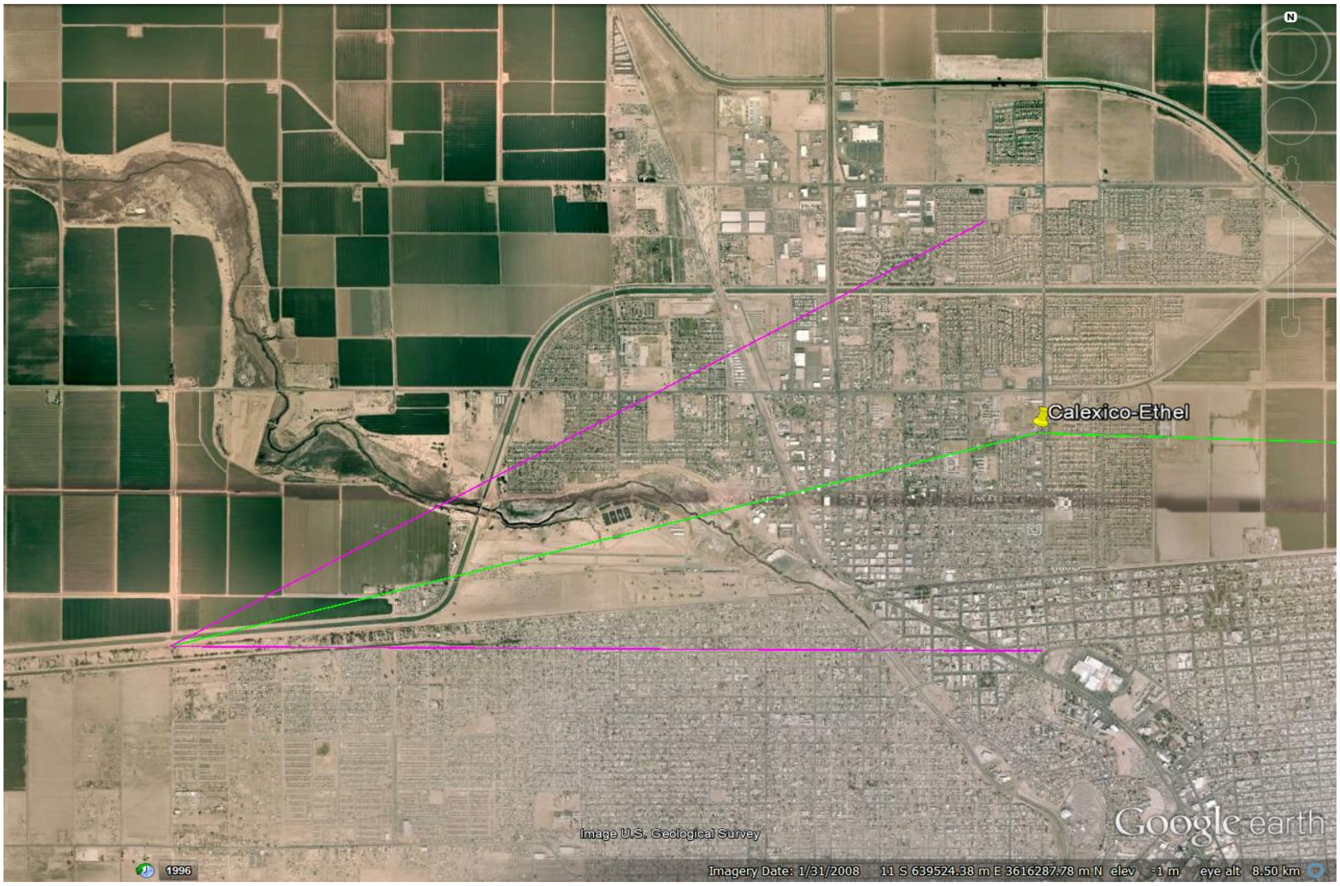
The use of these compass azimuths to bracket wind directions transporting emissions from U.S. sources, and not those under Mexican jurisdiction, provides the starting point for identification of bracketing wind directions that separate plumes from U.S. sources from those under Mexican jurisdiction.

Historical research and recent dispersion modeling analysis show that the full arc subtended by an airborne emission plume as measured from the point of pollutant release ranges from approximately 20 degrees to about 30 degrees, and is a function of wind speed and vertical mixing potential (Slade, 1968; MAG 2012 Five Percent Plan for PM10 for the Maricopa County Nonattainment Area). Airborne emission plumes are generally symmetrical about downwind centerlines and, thus, plume half-arcs—as measured from the centerline to the edge of a plume—generally range from 10 to 15 degrees. Figure 34 shows the effective outer edges (as purple lines) of a hypothetical

30-degree arc emission plume with a release point at the intersection of the international border and the edge of the Mexicali urban area and a plume centerline (shown as a green line) that passes over the Calexico monitoring site (which replicates the western azimuth shown in Figure 33).

**Figure 33. Wind Direction Azimuths Extending From the Calexico Monitor to Subtend an Arc Bounding the Mexicali Urban Area**

**Figure 34. Boundaries of a Hypothetical Emission Plume Generated by a Border Source with a Lateral Spread of 30 Degrees and a Centerline Crossing Over the Calexico Monitoring Site**




In order to avoid a border-source emission plume as shown in Figure 34 from being included in the analysis of U.S. sources impacting the Calexico monitor, the western wind azimuth bracketing the directional arc of cross-border sources must be rotated clockwise by the maximum plume half-arc (15 degrees) from the plume centerline shown in green in Figure 34. At this orientation, the hypothetical worse case plume centerline would remain in Mexican territory, represented by the lower purple line in Figure 34, and the edge of the plume would just touch the Calexico monitor. In that case, the plume would not contribute to PM2.5 concentrations measured at the monitor.

To assure that emissions from cross border sources did not influence an analysis of the impacts of sources under U.S. jurisdiction, the wind directions bounding an arc within which only U.S. sources would lie upwind of the Calexico monitor (i.e., northerly winds) were selected to be 79 degrees (= 94 degrees – 15 degrees) and 272 degrees (= 257 degrees + 15 degrees) from true north. The subsequent analyses of north wind impacts at the Calexico monitor were based on the northern arc bracketed by these two wind directions.

Analysis of peak PM2.5 days recorded at the Calexico monitor during calendar years 2010, 2011, and 2012 revealed that a most days on which the 24-hour average PM2.5

concentration exceeded the 24-hour standard of 35 μg/m$^3$ were winter days during which stagnation wind conditions were recorded. On these days, mixing heights during nocturnal hours dropped to within 100 meters of the surface, wind speeds ranged between 0.0 and 1.0 mps, and PM2.5 emissions generated within the shared urban area tended to move as much by lateral diffusion as by wind transport.

As discussed earlier (Section VII), with low wind speeds in the range of 0.0 to 0.5 mps, the reported wind direction is not representative of the true wind direction. High hourly PM2.5 concentrations measured during such hours most likely represented impacts from sources within a few kilometers of the monitor on both sides of the international border, within the common Calexico-Mexicali air shed. Because of the suspected contribution of sources under Mexican jurisdiction to PM2.5 concentrations measured at the Calexico monitor during nocturnal stagnation hours, data from these hours were also omitted from the analysis of impacts from U.S. sources. The 1.5 mps threshold for stagnating winds was chosen since on the transport exceedance days, concentrations were highest when the winds were below 1.5 mps.

Average PM2.5 Concentrations during Non-Transport Hours

Because of the 24-hour averaging time of the standard, this portion of the 179B demonstration focuses on estimating the resultant daily average historical PM2.5 concentrations at the Calexico monitor in the absence of impacts from Mexicali. From the evaluations described above, hours of cross-border transport were determined to be those hours during which hourly average wind speeds exceeded 1.5 mps and wind azimuths were less than 79 degrees or greater than 272 degrees.

Consideration was given to the backfilling of excluded hourly PM2.5 concentrations recorded during south wind or stagnation wind speed hours in order to include representative non-cross-border PM2.5 values to facilitate an assessment of potential attainment but for the impacts from Mexico. A search for continuous PM2.5 monitors located in Imperial County to provide replacement PM2.5 values found no other continuous monitors operating during this period. As a result, analyses of the PM2.5 hourly concentrations at the Calexico monitor were conducted using the screened dataset that did not contain any values substituted for those excluded in the north wind screening process. These data were reasonably well distributed by hour of day and month as is shown in Figures 35 and 36.

**Figure 35. Number of Hourly PM2.5 Values in Screened 2010-2012 Calexico Data Grouped By Hour of the Day**

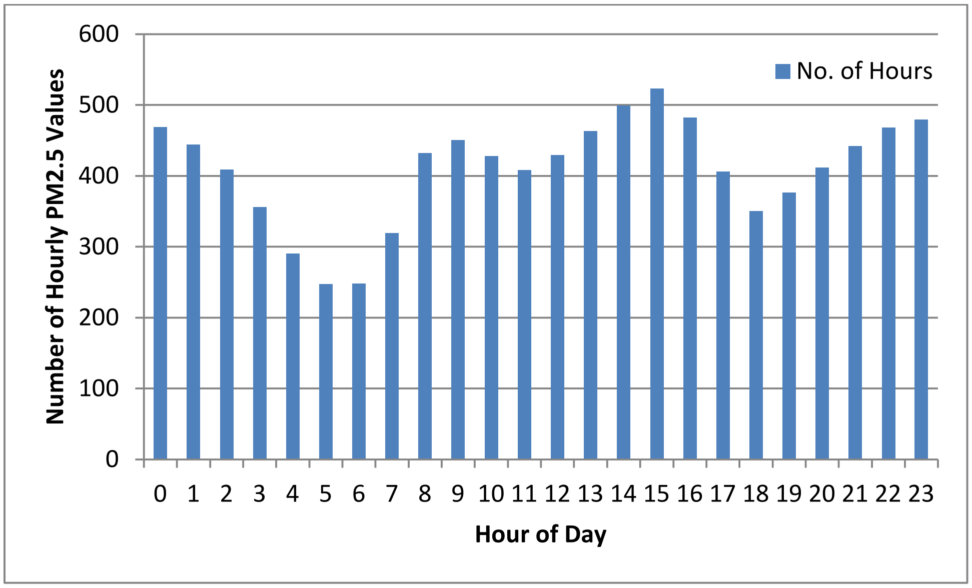
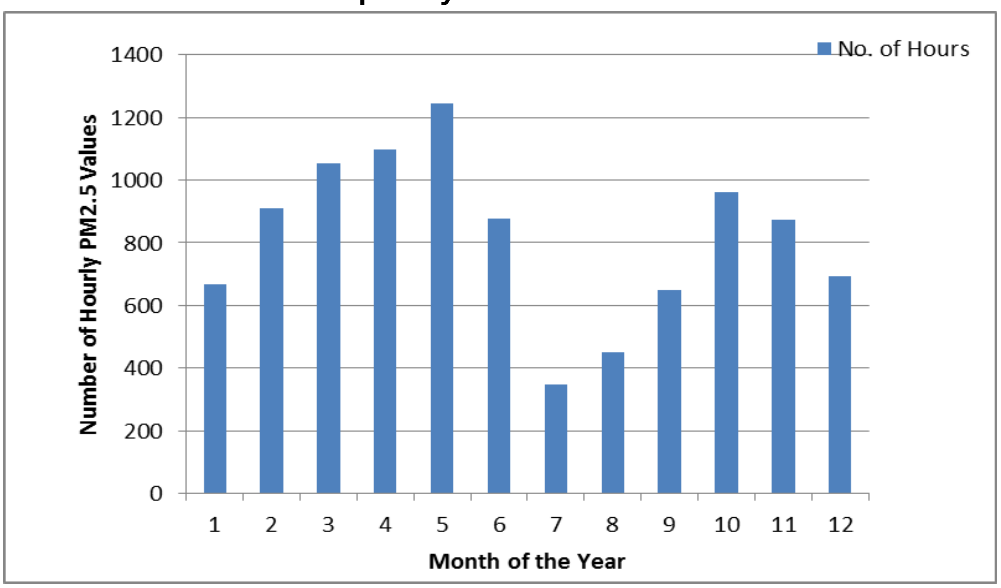


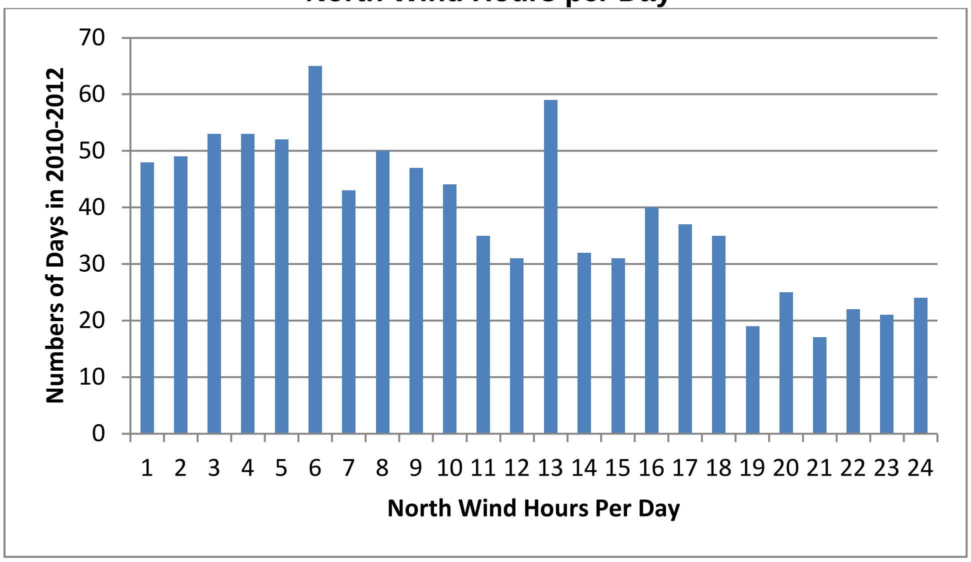

**Figure 36. Number of Hourly PM2.5 Values in Screened 2010-2012 Calexico Data Grouped By Month of the Year**




These distributions of hourly PM2.5 values by hour-of-the-day and month-of-the-year suggest that the sub-population of screened data is reasonably representative of the full database with the possible exception of values recorded in July and August, for which there are very few data points. During the summer months, few elevated PM2.5 days are recorded at the Calexico monitor, suggesting that the relatively low number of data points found in these months will not have a significant impact on data representativeness. The screened data were analyzed to determine the potential for the Calexico monitor to show attainment under north/non-stagnant wind speed hours.

The average PM2.5 concentration from all hours that satisfied north wind/non-stagnation wind speed ("north wind") screens was calculated for each day in which at least one hour satisfied screening requirements. This grouping of hours by date produced records for 932 days. The range of north wind hours per day extends from 1 to 24 hours. When days with the same numbers of north wind hours are grouped, the resulting distribution of total days per number of north wind hours generally declines from the total of days with 1 qualifying hour (48 days) to those with 24 qualifying hours (24 days). A plot of these days-per-number of north wind hours is shown in Figure 37.

**Figure 37. Numbers of Days in 2010-2012 Grouped by the Numbers of North Wind Hours per Day**




The distribution of daily average PM2.5 concentrations reported by the screened hourly PM2.5 values was plotted against the number of north wind hours per day to determine whether the numbers of exceedances of the 24-hour PM2.5 standard declined with increasing numbers of north wind hours per day. This plot is shown in Figure 38.

**Figure 38. Daily Average PM2.5 Concentrations for Days in 2010-2012 Grouped by the Numbers of North Wind Hours per Day**

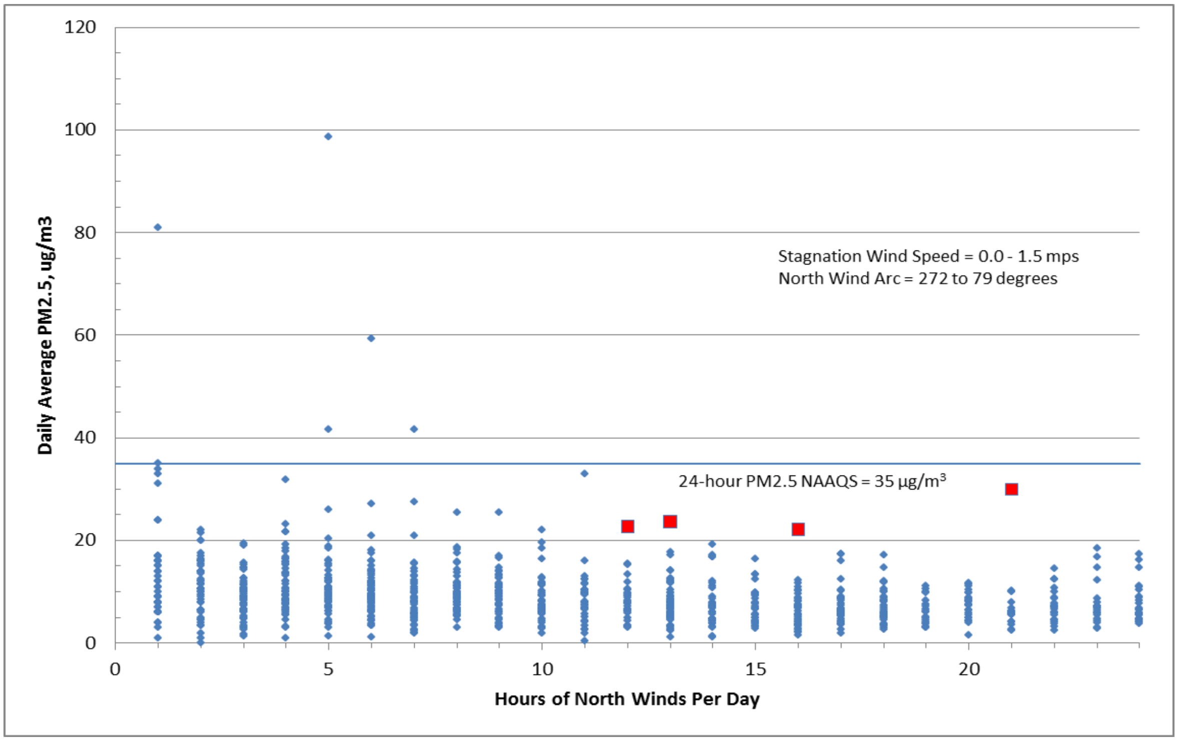



Figure 38 shows no daily average PM2.5 concentration above the level of the PM2.5 standard for all days having 15 or more north wind hours. The plot also shows that only six days between 2010 and 2012 would have exceeded under this screening approach. A calculation of the design value produced a value of 24.0 µg/$m^3$.

Staff assessed the cause of high "outlier" PM2.5 daily averages for days having 12 or more north wind hours. For this subset of days, a threshold value of 20 µg/$m^3$ daily average PM2.5 concentration was used to define high (or outlier) PM2.5 days when winds impacting the Calexico monitor were primarily from the north. The days satisfying these two conditions (i.e., 12 hours or more of north winds, daily average PM2.5 exceeding 20 µg/$m^3$) were identified from the plot in Figure 38 (as red squares) and are tabulated in Table 9.

**Table 9. Daily Average PM2.5 Concentrations for Outlier Days Under All Wind and North Wind Conditions**

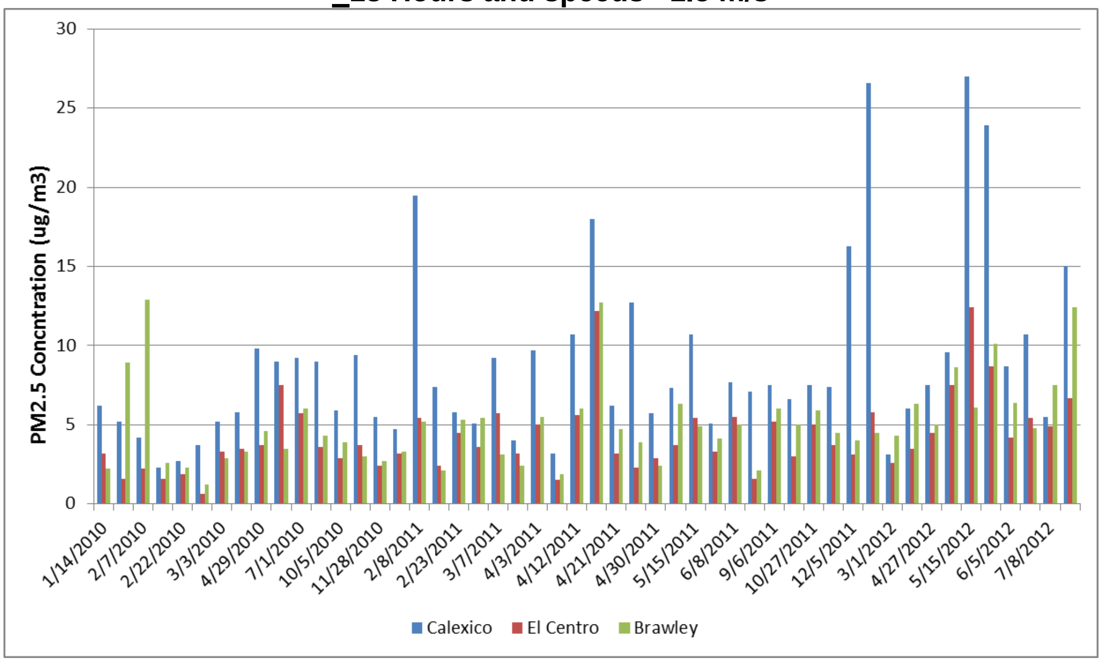
| Date | Number of North Wind Hours | Daily Average PM2.5 Concentration (µg/$m^3$) | |
|---|---|---|---|
| | | All Wind Hours | North Wind Hours Only |
| August 11, 2010 | 16 | 19.5 | 22.6 |
| April 14, 2011 | 16 | 24.6 | 22.2 |
| June 5, 2011 | 13 | 24.6 | 23.6 |
| May 15, 2012 | 21 | 27.2 | 30.0 |

Daily Average Concentrations in the Imperial NA

Staff also used hourly meteorological data to obtain days during 2010-2012 when winds were from the north at least 18 hours per day and wind speeds were non-stagnant (i.e., >1.5 mps). The resulting days were matched with FRM sampling dates for the Calexico, El Centro, and Brawley sites. Figure 39 displays the resulting 50 days.

The results show that for the majority of days, concentrations at Calexico recorded higher values than the other two sites. This is consistent with data seen from all wind directions throughout this time period. More important is the fact that under these north wind conditions, there were no exceedances of the 24-hour PM2.5 standard.

**Figure 39. FRM PM2.5 Concentrations in 2010-2012 when North Winds ≥18 Hours and speeds >1.5 m/s**




Using available speciation data for four of the five FRM exceedance days, staff compared the average speciation on these four days to the average speciation (mass) values that met the above criteria for wind direction and speed (Section IX). From these data, the exceedance days are associated with significant increases in organic matter, ammonium nitrate, and elements. Generally, the mass speciation on days with north winds is significantly less than the mass speciation seen on days where transport from Mexicali occurred (Table 10).

**Table 10. Average Speciation on Exceedance Days and North Wind Days**

| Exceedance day speciation mass averages | | | | | | |
|---|---|---|---|---|---|---|
| OC | EC | Geological | Elements | Nitrate | Sulfate | Ammonium |
| 22.6 | 2.2 | 4.2 | 4.0 | 6.3 | 0.9 | 3.0 |
| **Average Speciation on 31 North Wind Days** | | | | | | |
| 2.0 | 0.4 | 1.5 | 0.6 | 0.6 | 0.9 | 0.4 |

## X. Estimate of PM2.5 Concentration Impact from Mexicali Emissions

To estimate the impact of Mexicali emissions on the PM2.5 concentrations experienced at the Calexico monitor on the five exceedance days, staff binned PM2.5 measurements made at each site during the period of 2010 - 2012 by meteorological conditions that were present during the five exceedance days at Calexico. The differences in the binned concentrations were evaluated based on the following considerations:

First, by limiting the comparison of concentrations to those measurements made under similar meteorological conditions, any differences due to meteorology are minimized. The variables affecting the concentrations at each site are reduced and the focus becomes the emission sources surrounding each site.

Second, the size and type of U.S. sources surrounding all three sites (Calexico, El Centro, and Brawley) are similar and, therefore, in the absence of other sources, it is expected that all three sites would experience the same PM2.5 concentrations during similar meteorological conditions. Observed differences in PM2.5 concentrations suggest that emission sources outside of Imperial County and the Imperial County nonattainment area are impacting the concentrations.

The meteorological conditions used to segregate the concentration data were those conditions observed on the five Calexico exceedance days during the first 10 hours of the day (midnight to 10:00 am) during the months of December through February. Specifically, average wind speed less than or equal to 1.5 mps and average ambient temperature less than 66° F. Wind speeds of 1.5 mps or less typically reflects stagnant conditions and renders the influence of wind direction negligible.

On average, concentrations measured at Calexico are almost three times higher than the other two urban sites in Imperial County when stagnant, cold conditions are present:

| **Imperial County Monitoring Site** | **Number of Days Binned by Similar Meteorology (2010 – 2012)** | **Average Concentration (µg/m3 )** |
|---|---|---|
| Calexico | 22 | 26.4 |
| El Centro | 27 | 9.9 |
| Brawley | 12 | 9.1 |

Under similar meteorological conditions, and with similar nearby United States sources, one would expect that PM2.5 concentrations measured at the Calexico monitor would be within a relatively narrow range of the El Centro and Brawley monitors. An average difference of 16.9 µg/m3 suggests that emission sources outside the United States are significantly impacting the Calexico monitoring site beyond what would be expected from known sources on the U.S. side.

## XI. Calexico Day-Specific Analyses

The following section details day-specific information for five days in which ambient concentrations of PM2.5 exceeded the 24-hour NAAQS of 35µg/m3 at the Calexico monitoring site. These analyses use both FRM data and non-FEM BAM data to further evaluate the exceedance days. Non-FEM BAM data were used to track the PM2.5 on an hourly basis with corresponding meteorological information. Although non-FEM BAM data is non-regulatory and is therefore not used in the calculation of an area's design value, these data were valuable in evaluating diurnal and other patterns observed on exceedance days. The conclusion that the five days listed in Table 11 would not have exceeded the standard but for emissions from Mexico is substantiated for each day using elemental analysis data derived from filter particle loadings, meteorological data, and other supporting information, where available.

**Table 11. PM2.5 Measurements Exceeding the 24-Hour PM2.5 Standard at the Calexico Monitoring Site in 2010-2012**

| Date | Day | Calexico PM2.5 (µg/m3 ) | Speciation Data? |
|---|---|---|---|
| 12/4/2010 | Saturday | 50.9 | Yes |
| 2/5/2011 | Saturday | 80.3 | No |
| 12/11/2011 | Sunday | 44.4 | Yes |
| 1/31/2012 | Tuesday | 37.7 | Yes |
| 12/23/2012 | Sunday | 64.7 | Yes |

Significantly, four of the five exceedance days occurred on a weekend day. Information on these weekend days indicates holiday celebrations were the likely source of elevated PM2.5 concentration measurements.

**December 4, 2010**

<u>Analysis Methods</u>

For the December 4, 2010, exceedance day analysis, staff evaluated the following information: (1) PM2.5 concentration gradient within the Imperial NA plus the Air Quality Index (AQI) for Imperial County; (2) changes in the non-FEM BAM PM2.5 concentrations with the wind speed and atmospheric mixing height; (3) predominant wind speed and wind direction in the area from December 2 through December 5; (4) an air parcel back-trajectory starting at the hour of highest hourly recorded concentration at the Calexico site; (5) speciation data on December 4, to identify the major components of PM2.5, including a further breakdown of elemental species; and, (6) source apportionment results using receptor based modeling.

Data not available for this analysis include concentrations from monitoring stations in Mexicali from December 4; specific media reports from either north or south of the border, which would substantiate activities impacting air quality in the area; clear satellite imagery for detecting smoke from combustion activities; and PM2.5 BAM data for Brawley and El Centro. However, PM2.5 mass and speciation data, coupled with meteorological data and back-trajectory analysis, provide strong supporting evidence that the Calexico monitor would not have recorded an exceedance of the 24-hour NAAQS in the absence of emissions from Mexico.

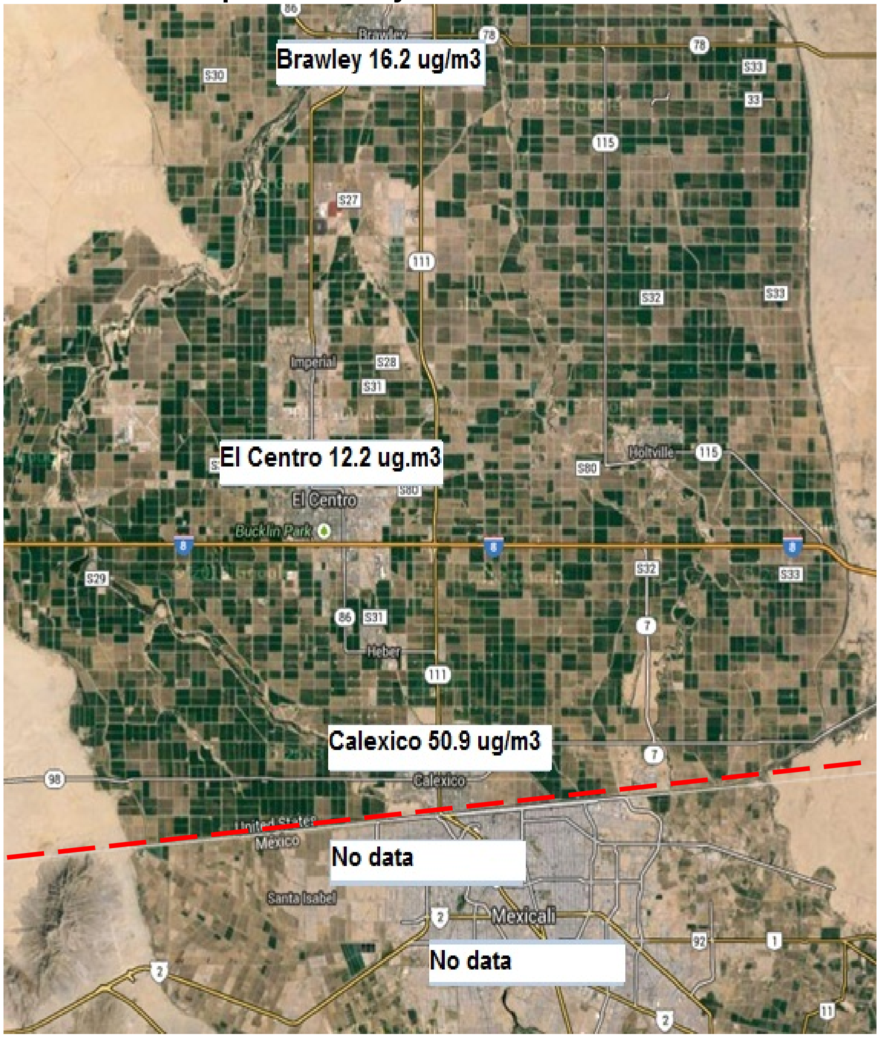
PM2.5 Concentrations

On Saturday, December 4, the Calexico monitor recorded a 24-hour average PM2.5 concentration of 50.9 μg/m3. Filter-based PM2.5 measurements at the El Centro and Brawley monitoring sites were 12.2 and 16.2 μg/m3, respectively. Continuous PM2.5 monitors at Calexico began recording increased PM2.5 concentrations on the night of December 2. Concentrations remained high the morning and night of December 3 and this trend continued into December 4. The AQI value on this day was 139 (unhealthy for sensitive groups) and was the highest AQI value recorded in Imperial County for 2010.

The PM2.5 concentration was roughly half the measured PM10 concentration on December 4, suggesting that the PM impact was largely influenced by combustion sources. Agricultural burning was either not permitted or did not occur in Imperial County on December 2, 3, or 4, and District records indicate no burning violations or complaints were received during those days. Although not all of the combustion emissions are expected to have come from Mexicali, the combination of the magnitude of the emission inventory in Mexicali, the number of stationary sources in Mexicali, the number and age of motor vehicles in Mexicali, and the lack of agricultural burning in Imperial County implies that most of the combustion emissions originated from outside the County.

Figure 40 shows the spatial distribution of 24-hour average PM2.5 concentrations recorded at each monitoring site in the Imperial NA on December 4. The 50.9 μg/m3 concentration measured at Calexico was nearly three times the annual average for that site in 2010. The strong PM2.5 concentration gradient from the Calexico monitor—less than a mile from Mexicali—to the Brawley and El Centro sites just to the north suggests that the emissions impact on the Calexico monitor differs substantially from the impact experienced by the Brawley and El Centro monitors. With similar sources and meteorology, the expectation is that PM2.5 concentrations measured at Calexico, El Centro, and Brawley would be similar. The decreasing gradient northward is consistent with the Calexico-Mexicali single air shed concept and points to cross-border emissions as the source of high concentrations measurements at Calexico.

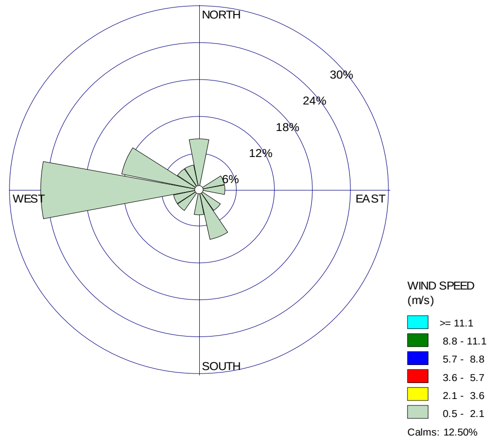
**Figure 40. Mexicali and Imperial County PM2.5 concentrations on December 4, 2010**




<u>Meteorology</u>

Surface hourly wind data collected at the Calexico station indicate that variable, low wind speed conditions were prevalent throughout the day on December 4. The 24-hour average wind speed at Calexico was 0.6 mps with maximum wind speeds reaching 1.6 mps. Wind direction was variable with approximately 24 percent of the winds originating from the west. A wind rose plot for December 4 (Figure 41) indicates that low wind speeds on that day are coupled with variable wind direction. These conditions are typically associated with stagnant meteorological conditions. For purposes of these analyses, wind speeds of 1.5 mps or less are used to identify stagnant conditions and indicate little or no dispersion, i.e., emissions within the common Calexico-Mexicali airshed result in high measured values. Identifying meteorological stagnation in terms of low wind speed in the range of 0 to 1.5 mps is consistent with earlier cross-border transport studies (Chow et al., 2000).

**Figure 41. Wind Rose on December 4, 2010**[5]




To further characterize meteorological conditions on December 4 which may have influenced PM2.5 concentrations measured at the Calexico station, staff evaluated data on atmospheric mixing height and its correlation with PM2.5 mass data. The nearest routine data collection points to Calexico for radiosonde data are Yuma, Arizona, and Tucson, Arizona. Both of these locations have topography similar to that of Calexico. Appropriate data from the Yuma site were unavailable for December 4, so Tucson data were used to generate a plot of hourly mixing heights over a three day period that includes the December 4 exceedance. All mixing height data originate from the National Oceanic and Atmospheric Administration (NOAA) Earth System Research Laboratory website and are research-quality data.

Figure 42 displays the mixing height and hourly PM2.5 BAM measurements at Calexico. While data gaps exist for the atmospheric soundings, the overall trend over the three day period shows an inverse relationship between mixing height and concentrations. Decreasing mixing height corresponds to increasing PM2.5 concentrations as low vertical mixing confines pollutants. This plot corroborates surface wind data and supports the concept that emissions from Mexicali, confined to the Calexico-Mexicali air shed with reduced pollutant dispersion due to low wind speed and reduced mixing height, resulted in higher PM2.5 concentrations on December 4 than would have been observed in the absence of emissions from Mexico.

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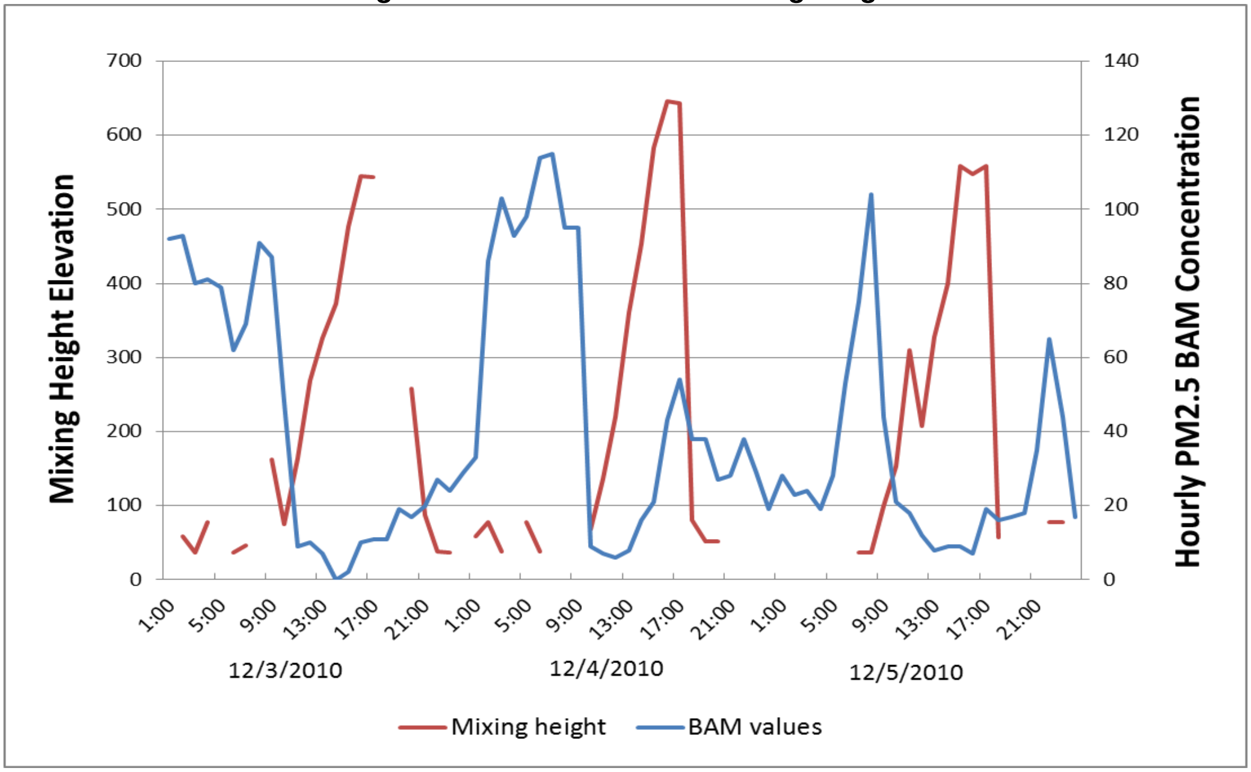
[5] Wind rose plot generated using Lakes Environmental WRPLOT View™ software program. This program uses <0.5 mps as the default wind speed threshold for identifying "calm" winds.

**Figure 42. PM2.5 BAM vs. Mixing Height**

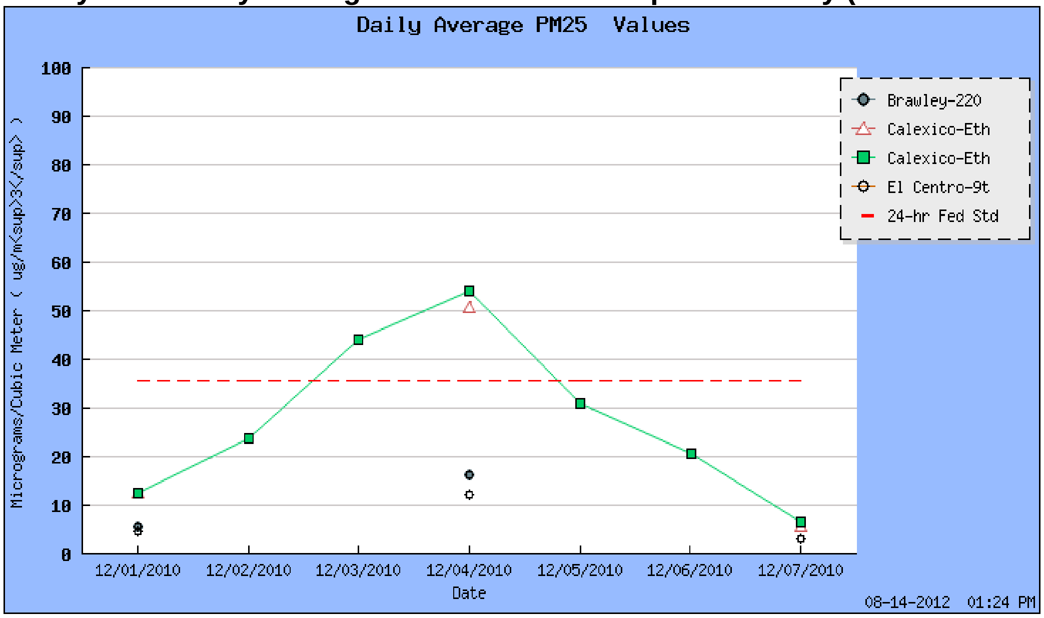



<u>Analysis of the Event</u>

To place Calexico PM2.5 values in the context of the Imperial NA's other PM2.5 monitoring sites Figure 43 shows the daily and hourly PM2.5 concentration data measured during the first week of December 2010. The data show lower PM2.5 values at the El Centro and Brawley sites with somewhat elevated concentrations on December 4. This pattern is consistent with the spatial gradient shown in Figure 40 and suggests that emissions from south of the border may be influencing measurements further to the north. The plot also illustrates the consistency between the FRM measurements at Calexico (POC 1) and non-FEM BAM measurements at Calexico (POC 3) on December 4 as well as on December 7. The BAM value on December 4, for example, was 50.5 µg/m3, consistent with that day's FRM value of 50.9 µg/m3.

While high PM2.5 concentrations at the Calexico monitoring site occurred under stagnant meteorological conditions, when the wind speed and direction changed prior to, during, and following the exceedance day, those changes were matched with hourly PM2.5 concentration data to reveal any patterns that might better characterize the temporal nature of PM2.5 concentrations. Wind speed and wind direction data were plotted with BAM PM2.5 concentration measurements from December 2 through December 5 (Figures 44 and 45).

**Figure 43. Daily and Hourly Average PM2.5 Values in Imperial County (12/1/2010 – 12/7/2010)**




*POC1 is on a 1-in-3 day sampling schedule and POC3 records hourly data

**Figure 44. PM2.5 BAM vs. Wind Speed at Calexico for December 2-5, 2010**

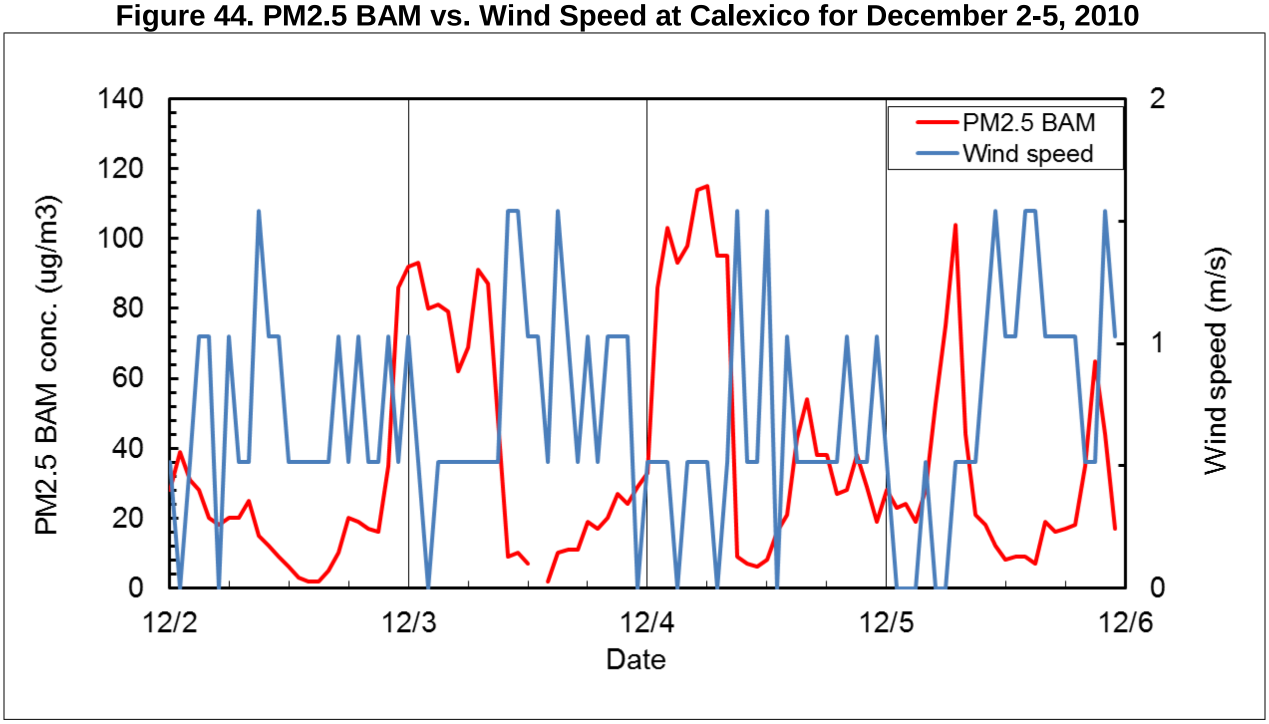
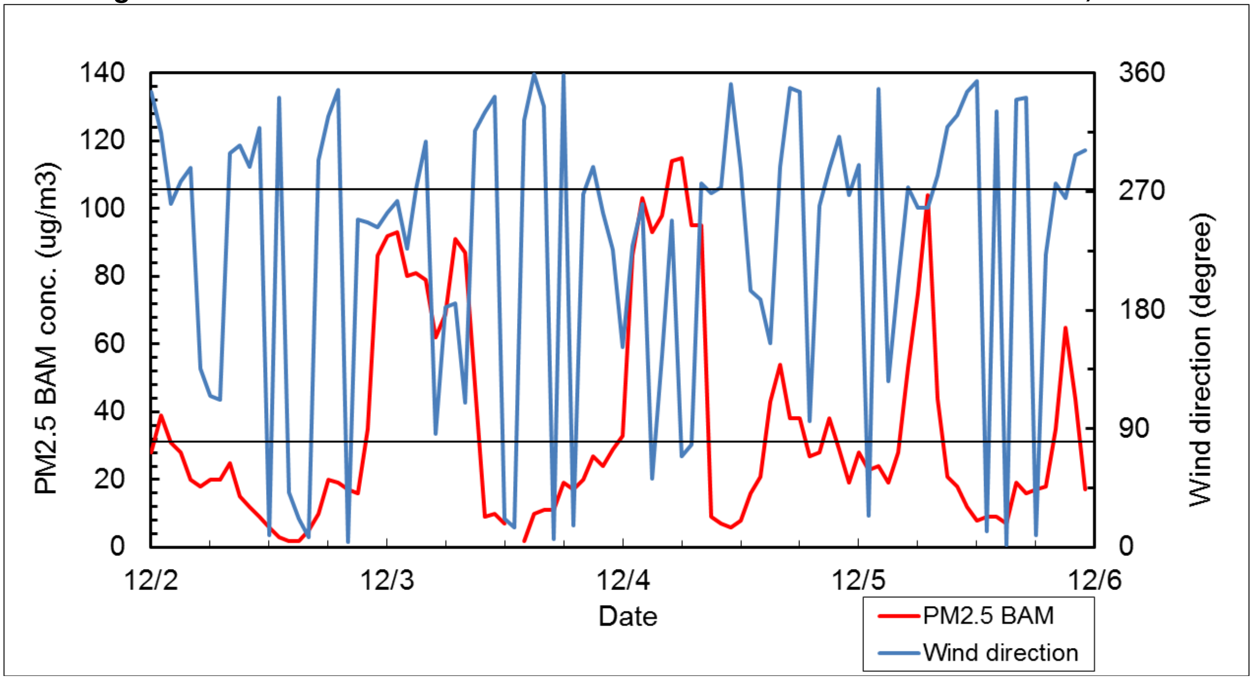


**Figure 45. PM2.5 BAM vs. Wind Direction at Calexico for December 2 - 5, 2010**




*79-272 degree winds are from the south. 273-78 degree winds are from the north.

Hourly PM2.5 concentrations began to increase substantially at approximately 10:00 pm on December 2 when the wind direction changed from a northern to a south/south west flow. Concentrations remained elevated above 20 µg/m3 until 8:00 am on the following day, December 3, while the wind direction continued from a southerly direction. When the wind direction changed to a northern flow, PM2.5 concentrations began to decrease. In the evening of December 3, concentrations increased again and remained high until mid-morning on December 4, consistent with a shift to a southern flow. PM2.5 concentrations were very high (85-115 µg/m3) from 1:00 am through 8:00 am and decreased after another wind shift to the north. Concentrations began to increase again after 2:00 pm, with a wind direction shift to a more southerly flow, and remained moderately high for the rest of the day, as wind direction became more variable.

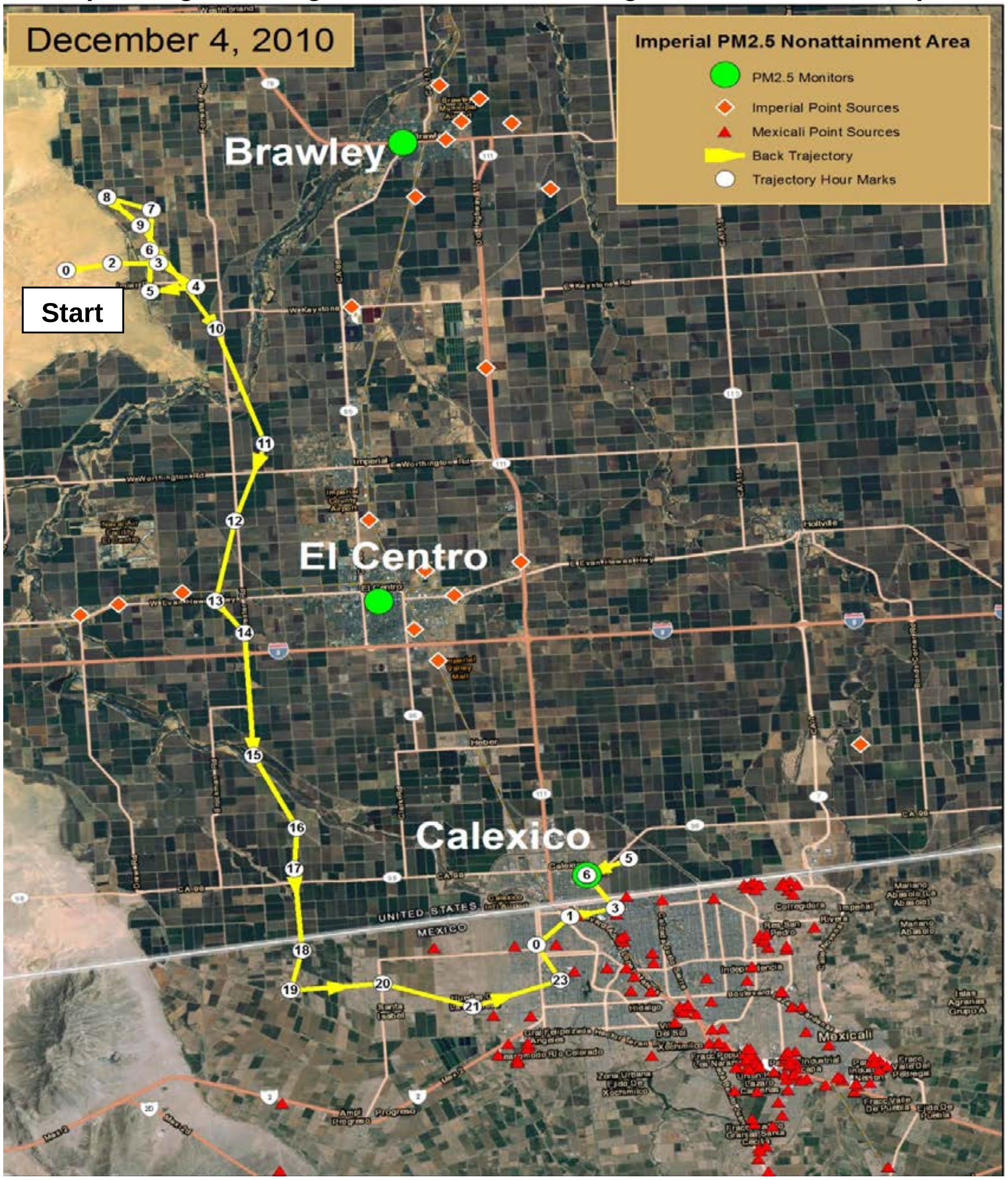
Data from Figure 44 show that low wind speeds, particularly in the early morning hours, are correlated with higher PM2.5 concentrations. Generally, the highest concentrations on December 4 were seen under southerly flow conditions (79 to 272 degrees) in the early morning hours (Figure 45) (see Section IX for wind direction analysis).

The spatial nature of the December 4 exceedance event was assessed using a back-trajectory plot (Figure 46). The objective of a back-trajectory plot is to discern the pathway that an air parcel traveled prior to passing over the site of a continuous pollutant monitor, i.e., a PM2.5 BAM. By calculating the coordinates of this traverse and overlaying the resulting travel path onto an aerial photograph, the potential for transport of emissions from sources under the path to the monitor may be evaluated (see Appendix A for complete back-trajectory methodology).

Coordinate calculations for the back-trajectory are conducted in a stepwise fashion beginning at the monitor location and using the wind speed and direction data for each preceding hour to compute path coordinates back to zero hours on the day prior to December 4. The back-trajectory plot in Figure 46 begins at the hour of the highest PM2.5 BAM concentration (6:00 am) and traced the pollution back to midnight (00 hours) on December 3. From this analysis, it may be concluded that the air parcel impacting the Calexico station at 6:00 am on December 4 was in Mexicali in the early morning hours of the December 4 and the late night hours on December 3. The low temperatures, low inversion height, and increased emissions in Mexicali impacted the PM2.5 concentration at the Calexico site. The shorter line in between the trajectory hours also shows that the air parcel traveled less distance over the time period in Mexicali, which caused pollution to accumulate under these stagnant conditions. Mexicali point sources are included in the photo to gauge the potential influence these emission sources have on the air parcel prior to its reaching the Calexico station.

We considered a back-trajectory analysis using the HYSPLIT model in combination with one of several available meteorological databases. During winter stagnation episodes, wind speeds are typically less than 3.0 mps and hourly back-trajectory vectors range from 2 to 10 kilometers (km) in length. The meteorological databases used by the HYSPLIT model use grid sizes varying from 6 to 40 km. As a result of this difference in grid resolution, HYSPLIT was not used since it would not provide the micro scale back-trajectories needed to appropriately determine the traverse on United States side of the border versus the traverse in Mexico prior to arriving at the Calexico station.

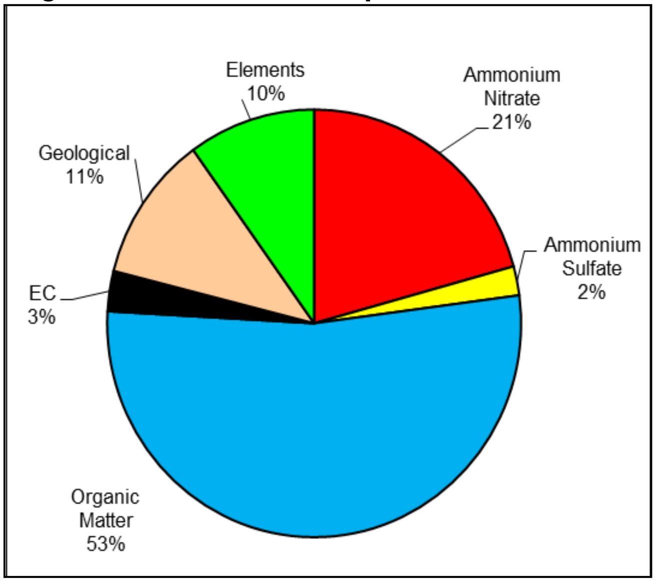
**Figure 46. December 4, 2010 Air Parcel Back-Trajectory**
**(Starting at midnight on 12/3/10 and ending at 6:00 am on 12/4/10)**




<u>Identification of Emissions</u>

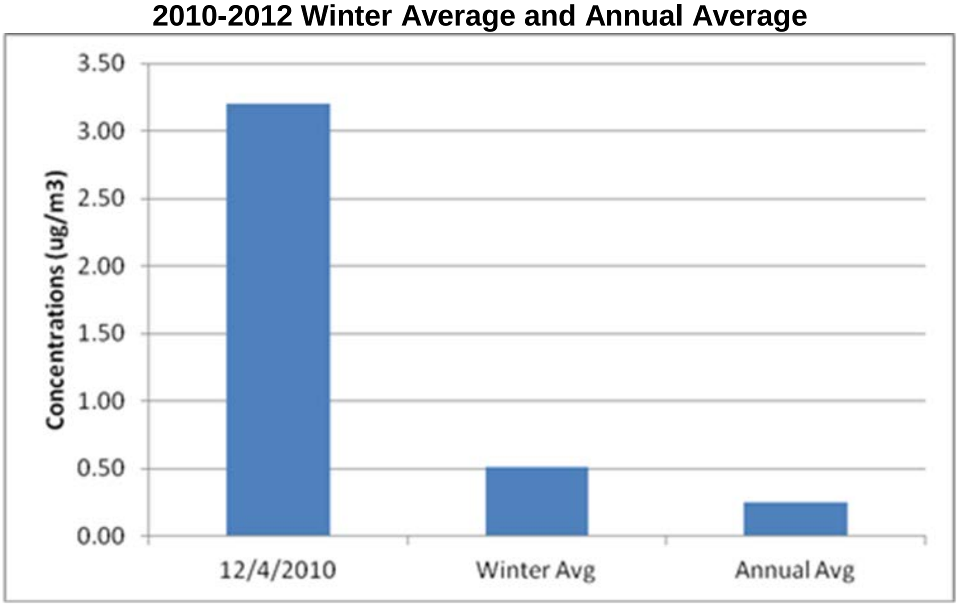
To aide in identifying the source of emissions potentially impacting the Calexico monitor, staff analyzed speciation data available on December 4. The speciation data show that over half of the concentration was from organic matter and 21 percent was from ammonium nitrate. High concentrations of elemental species were also present on this day. High concentrations of carbonaceous aerosols suggest that combustion was the main source of PM2.5, while high concentrations of elemental species suggest that emissions come from non-fossil fuel sources (Figure 47). See Section VIII for supporting information.

**Figure 47. 12/4/2010 Composition at Calexico**



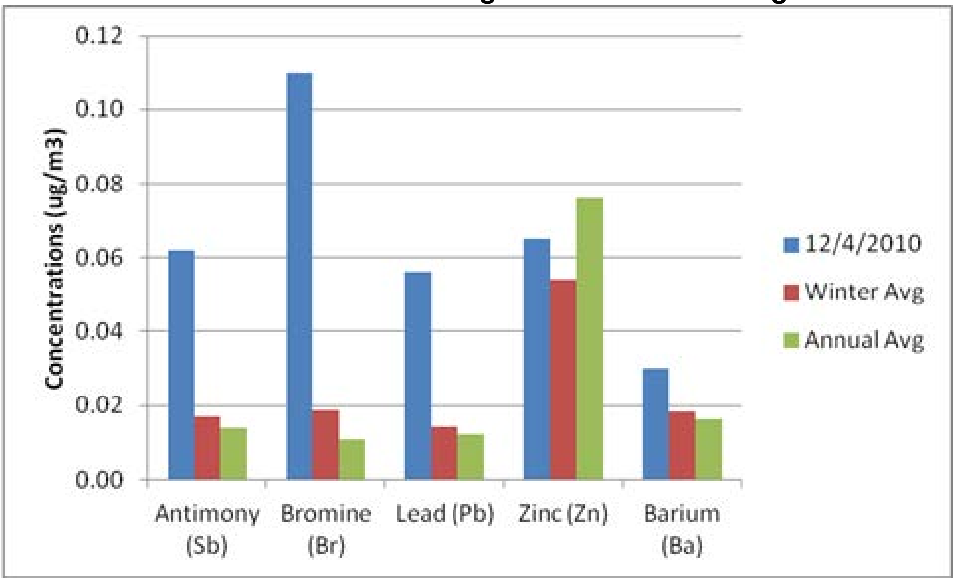

On December 4 elemental species concentrations at Calexico were elevated compared to both winter average and annual average concentrations. Concentrations of elemental chlorine were six times higher compared to winter average and 13 times higher compared to annual average (Figure 48). Concentrations of antimony, bromine, lead, and chlorine were four to six times higher compared to winter concentrations and four to 13 times higher compared to annual average. Concentrations of zinc and barium were close to the average levels (Figure 49).

**Figure 48. Comparison of Chlorine Concentrations on 12/4/2010 to 2010-2012 Winter Average and Annual Average**




*This data does include transport days but does not include invalidated days

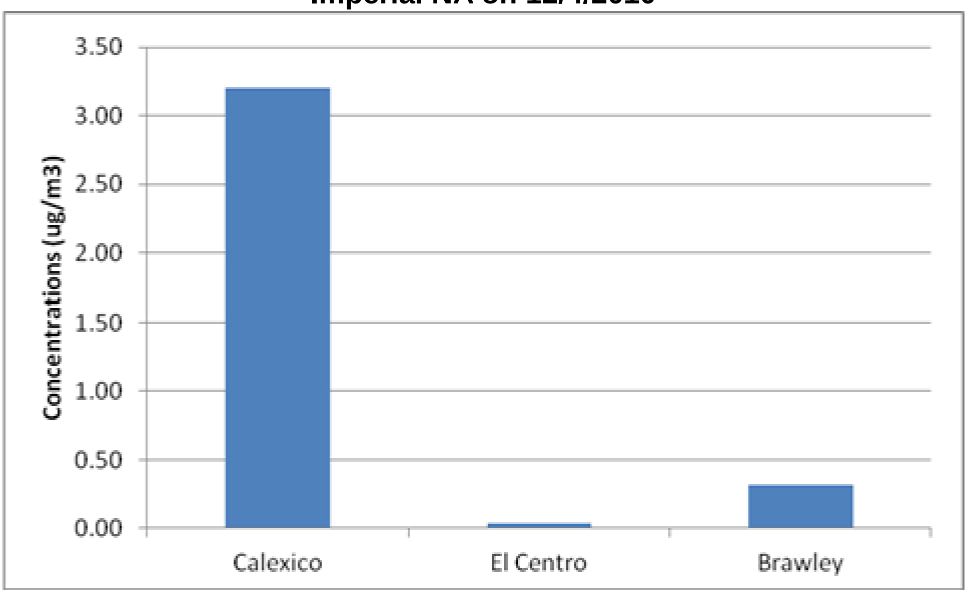
**Figure 49. Comparison of Select Species Concentrations on 12/4/2010 to 2010-2012 Winter Average and Annual Average**




*This data does include transport days but does not include invalidated days

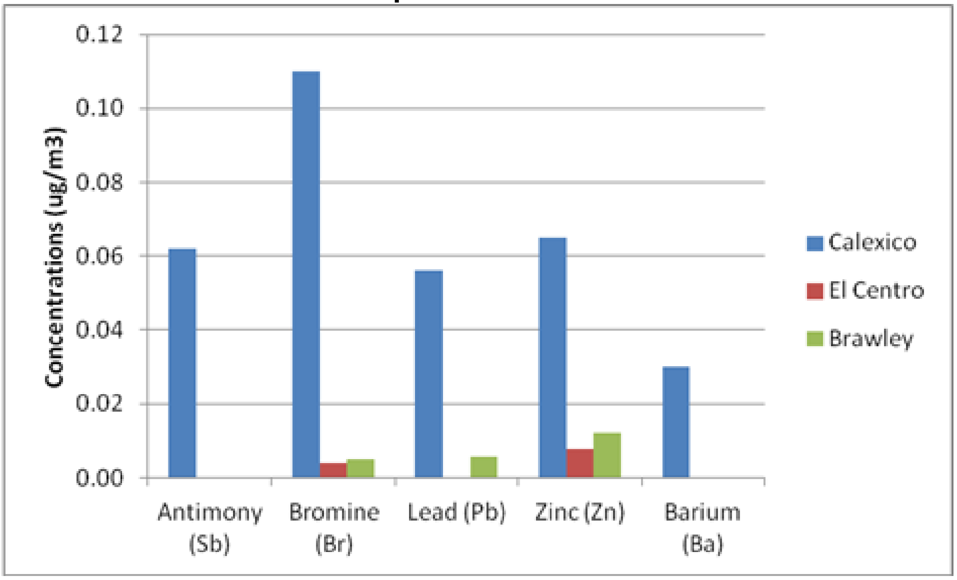
The December 4 data across the Imperial NA reveals that Calexico was the only site with elevated elemental species concentrations. Brawley and El Centro had concentrations below or close to the detection limits (Figures 50 and 51).

**Figure 50. Comparison of Chlorine Concentrations Across Imperial NA on 12/4/2010**




*This data does include transport days but does not include invalidated days

**Figure 51. Comparison of Select Elemental Species Concentrations Across Imperial NA on 12/4/2010**

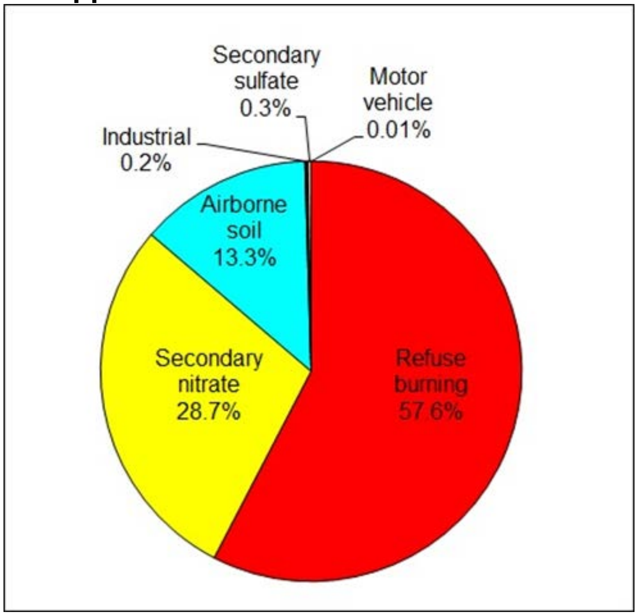



*This data does include transport days but does not include invalidated days

To provide information on possible sources of emissions impacting the Calexico monitor, PM2.5 speciation data were analyzed using a source apportionment model—Positive Matrix Factorization 2 (PMF2). PMF2 is a multivariate receptor model based on the positive matrix factorization (PMF) method. Fundamentally, this model analyzes characteristics of pollutants at the receptor site and, using mathematical algorithms, estimates the source contributions. This model is based on a weighted least square method that weights data points by their analytical uncertainties. A detailed description of the PMF2 model procedure for Calexico is included in Appendix B.

For the PMF2 analysis, a total of 159 samples and 27 species including PM2.5 concentrations collected between 2010 and 2012 were analyzed and six major sources/chemical components were identified: airborne soil, motor vehicle, secondary sulfate, secondary nitrate, refuse burning, and industrial sources. Figure 52 suggests that refuse burning and secondary nitrate were the major sources of emissions on December 4. Refuse burning is estimated to contribute 29.3 µg/m3 of the 50.9 µg/m3 concentration recorded at Calexico. Since refuse burning is not a permitted activity in Imperial County, this impact—coupled with meteorological data presented earlier—is strongly suggestive that these emissions originate from Mexicali.

**Figure 52. Source Apportionment PM2.5 Contribution on December 4, 2010**




To link results of the PMF2 analysis to specific emitting activities, percentages for refuse burning and industrial emissions were used to estimate the PM2.5 contribution at Calexico on December 4 (Table 12). Without refuse burning emissions, it is likely that concentrations at the Calexico monitor would not have exceeded the 24-hour PM2.5 standard. If industrial emissions from Mexicali are excluded, the concentration on this day decreases further. This decrease is significant given that refuse burning and industrial emissions of the type identified PMF2 are essentially non-existent on the U.S. side of the border in Imperial County, but are known to occur in Mexicali.

**Table 12. Contribution of Refuse Burning and Industrial Emissions to PM2.5 Concentrations on December 4, 2010**

| FRM Concentration | Without Refuse Burning Emissions | Without Refuse Burning & Industrial Emissions |
|---|---|---|
| 50.9 µg/m3 | 21.6 µg/m3 | 21.5 µg/m3 |

**February 5, 2011**

Analysis Methods

Consistent with U.S. EPA guidance, staff evaluated the following data to analyze PM2.5 concentrations recorded on the February 5 exceedance day: (1) U.S. EPA PM2.5 Air Quality Index (AQI) map for February 5; (2) the PM2.5 concentration gradient within the Imperial County PM2.5 NA; (3) daily wind rose information; (4) atmospheric mixing height data; (5) local media reports; (6) hourly wind speed and direction data from stations in southern Imperial County for the period of February 3 through February 6, 2011; (7) the relationship between the hourly BAM PM2.5 concentrations, wind speed and wind direction recorded by the Calexico monitor; and, (8) air parcel back-trajectory plots identifying the areas from which emitted PM2.5, contributing to peak hourly impacts on February 5, 2011, was transported to the Calexico and El Centro monitoring sites.

Data not available for this analysis included hourly and daily average PM2.5 concentrations from monitoring stations in Mexicali; clear satellite imagery for detecting smoke from combustion activities; hourly BAM PM2.5 concentrations recorded at the Brawley and El Centro sites; and PM2.5 speciation data for February 3 through February 5. In the absence of speciation data, useful tools like positive matrix factorization (PMF) were also not available for use in this analysis.

PM2.5 Concentrations

On Saturday, February 5, 2011, the Calexico and El Centro filter based monitors recorded 24-hour average PM2.5 concentrations of 80.3 µg/m3 and 36.9 µg/m3, respectively. On the same day, a filter-based monitor at the Brawley monitoring site recorded a 24-hour average PM2.5 concentration of 28 µg/m3. The Calexico PM2.5 data downloaded from the U.S. EPA's AQS online database included a flag signifying the monitoring technician's observation of PM2.5 impacts at the monitor from very low temperatures and subsequent burning in Mexicali.

Elevated hourly PM2.5 concentrations at the Calexico station were recorded over a three day period in early February 2011. The observed trend using continuous PM2.5 monitors at Calexico recorded increased PM2.5 concentrations on the night of February 3. Hourly PM2.5 concentrations remained high during the next two days and into the morning of February 6. The AQI value on February 5 was 164 (unhealthy) which was the highest AQI value recorded in Imperial County for 2011 (Figure 53).

Initial discussions with District staff revealed that February 4 and 5 were no burn days; however, open burning was allowed on February 3. On February 3, a total of 925 agricultural acres were burned along with a much smaller number of acres on non-agricultural lands. No burning violations or complaints were recorded by the District during those days. Figure 54 shows the locations of all of the February 3, 2011 agricultural burns (in green) and miscellaneous burns (in red) for which permits were issued and post-burn reports were submitted. Ignition times for the agricultural burns were reported to be between noon and 2:30 pm. The non-agricultural burns were reported to have ignition times between 10:00 am and 3:00 pm and most were reported to be 1 to 2 piles in size. Although there were a number of pile burns near the Brawley monitor, the PM2.5 values recorded on February 3 were below the standard at this station. The yellow tacks on Figure 53 show the locations of PM2.5 monitors. The agricultural burning conducted on February 3 may have contributed to increased background PM2.5 concentrations throughout the valley on February 4 and 5, but ARB staff does not believe these fires were the primary cause of the exceedances.

A review of meteorological data collected at the Calexico site indicates that the lowest nighttime temperature during the 2010-2011 winter was recorded in the early morning of February 3, 2011. Low temperatures were also recorded in the early morning hours of February 4 and 5, 2011. These low temperatures occurred in combination with low wind speeds, resulting in stagnant conditions on these nights in Imperial County. These stagnant conditions, more than agricultural burning, were the likely key factor resulting in elevated concentrations on February 5. In addition, increased rates of fuel combustion for residential heating and outdoor fires in Mexicali were documented in one of the city's local newspapers *La Cronica*.

**Figure 53. Daily Peak AQI Map on February 5, 2011**

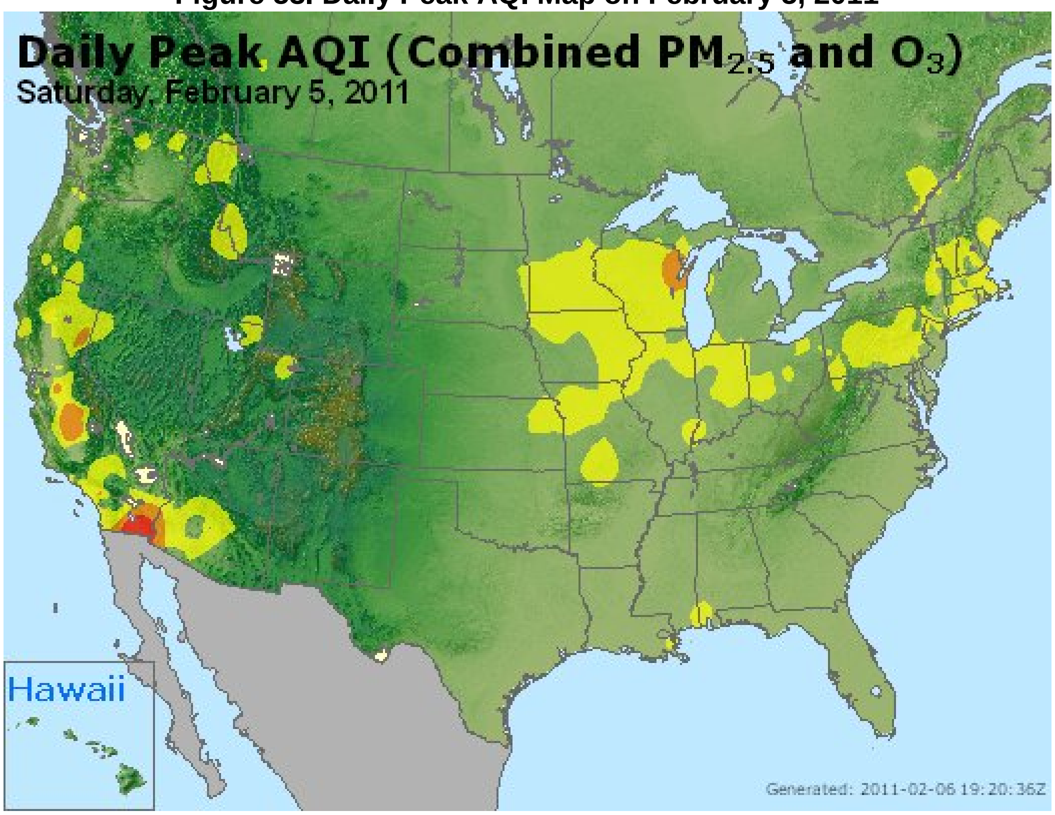


**Figure 54. Agricultural and Pile Burns in Imperial County on February 3, 2011**

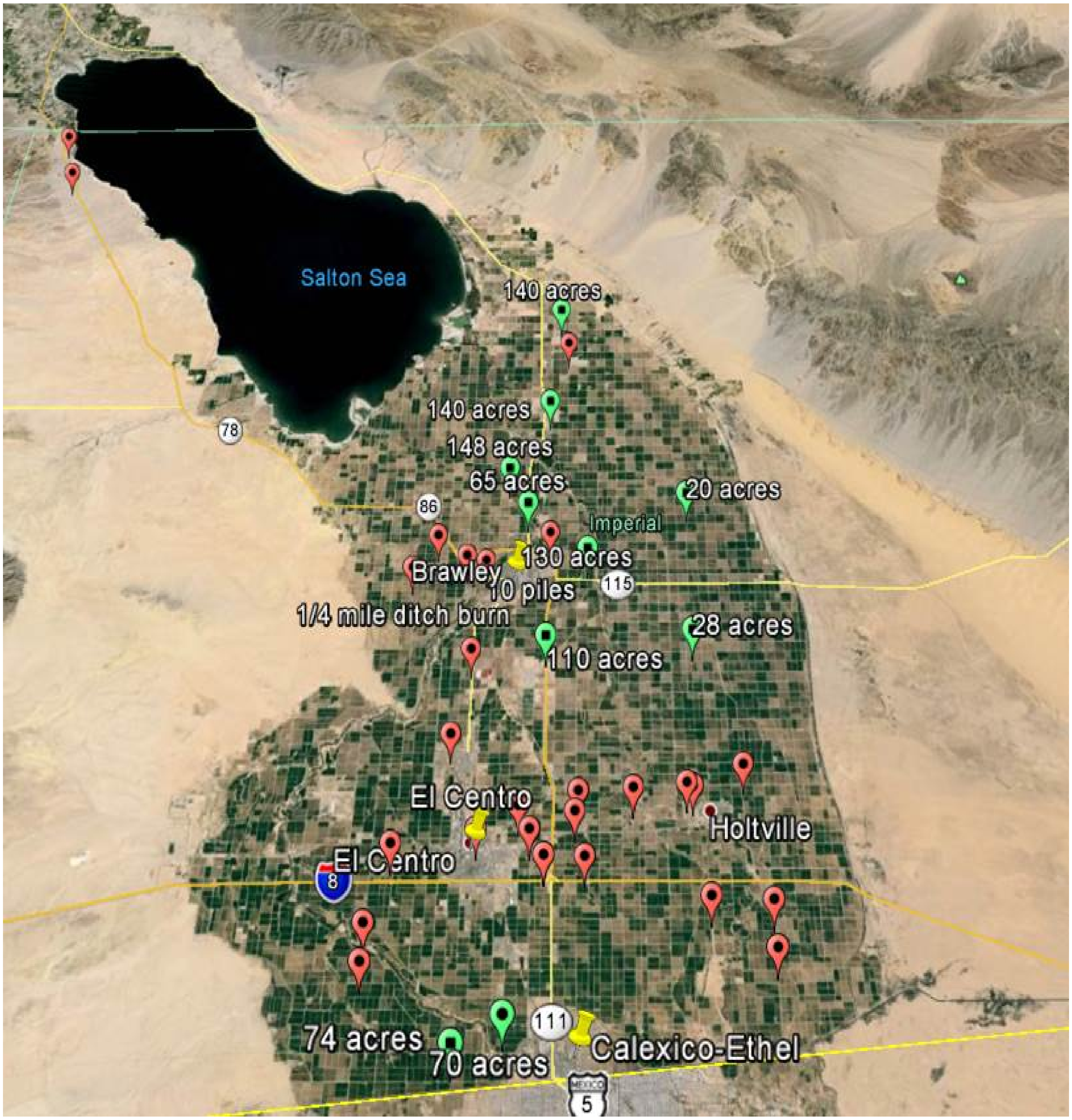
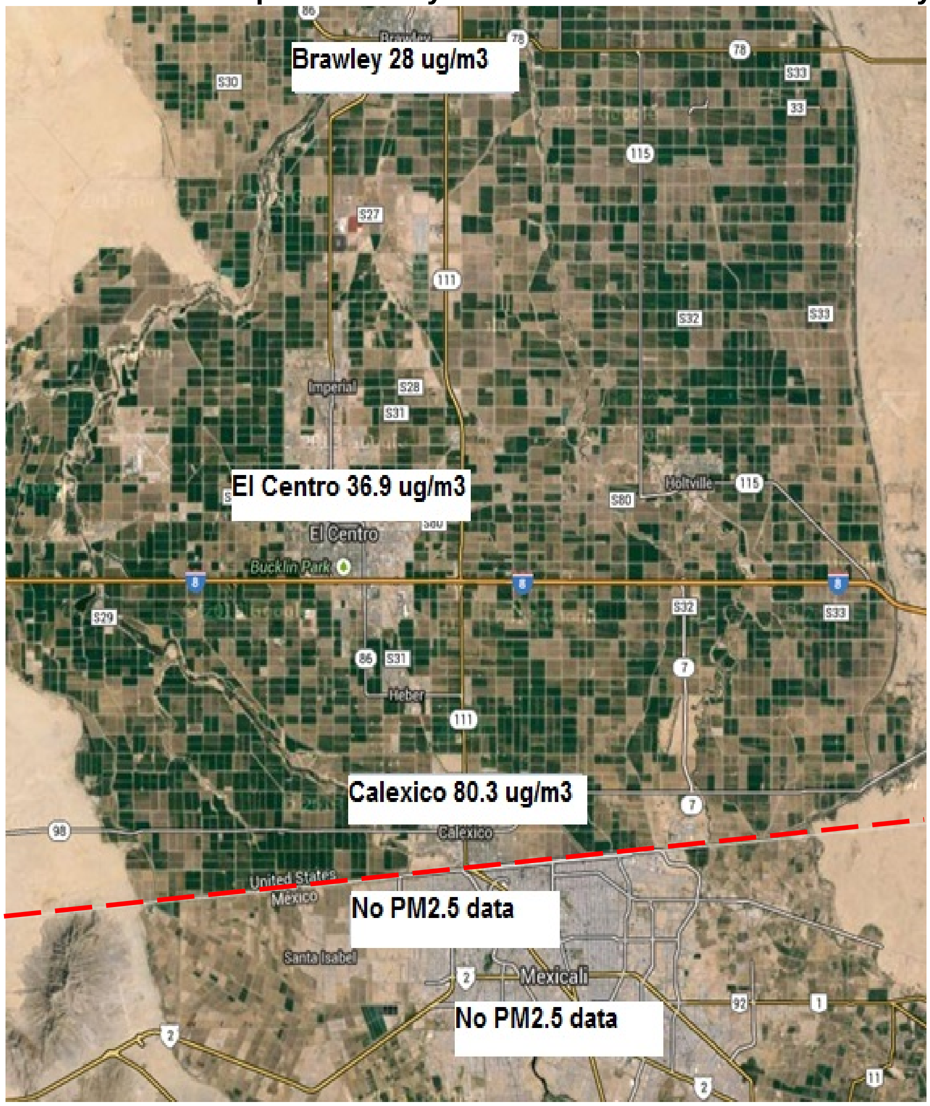



Figure 55 shows the spatial distribution of 24-hour average PM2.5 concentrations recorded at each monitoring site in the Imperial NA on February 5. The 80.3 µg/m3 concentration measured at Calexico was nearly six times the annual average for that site in 2011. Notably, the 80.3 µg/m3 measurement on February 5, 2011 was an outlier from the 2010-2012 data stream as it was more than nine standard deviations above the mean value at this site recorded in those years.

The strong PM2.5 concentration gradient from the Calexico monitor to the Brawley and El Centro sites to the north suggests that the emissions impact on the Calexico monitor differs substantially from the impact experienced by the Brawley and El Centro monitors. As with the analysis for December 4, with similar sources and meteorology, the expectation is that PM2.5 concentrations measured at Calexico, El Centro, and Brawley would be similar. The decreasing PM2.5 concentration gradient northward suggests the predominance of a high emission source area to the south of the Calexico station. Although the El Centro site exceeded the 24-hour PM2.5 standard on this day, the concentration at Calexico was more than twice the concentration measured at El Centro.

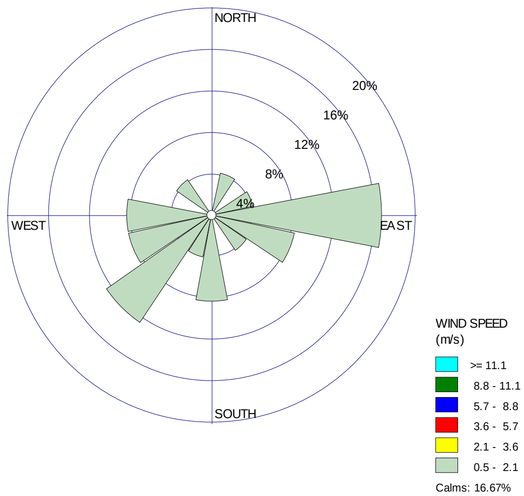
**Figure 55. Mexicali and Imperial County PM2.5 concentrations on February 5, 2011**



Meteorology

Meteorological data collected at the Calexico monitoring site confirm that stagnant surface conditions occurred throughout the day on February 5. The 24-hour average resultant wind speed at Calexico was 0.6 mps and the maximum was 1.5 mps. In addition, the majority of the hourly wind directions were from the south (16 out of 24 hourly measurements). Winds were calm on this day in Calexico as shown in the February 5 wind rose (Figure 56).

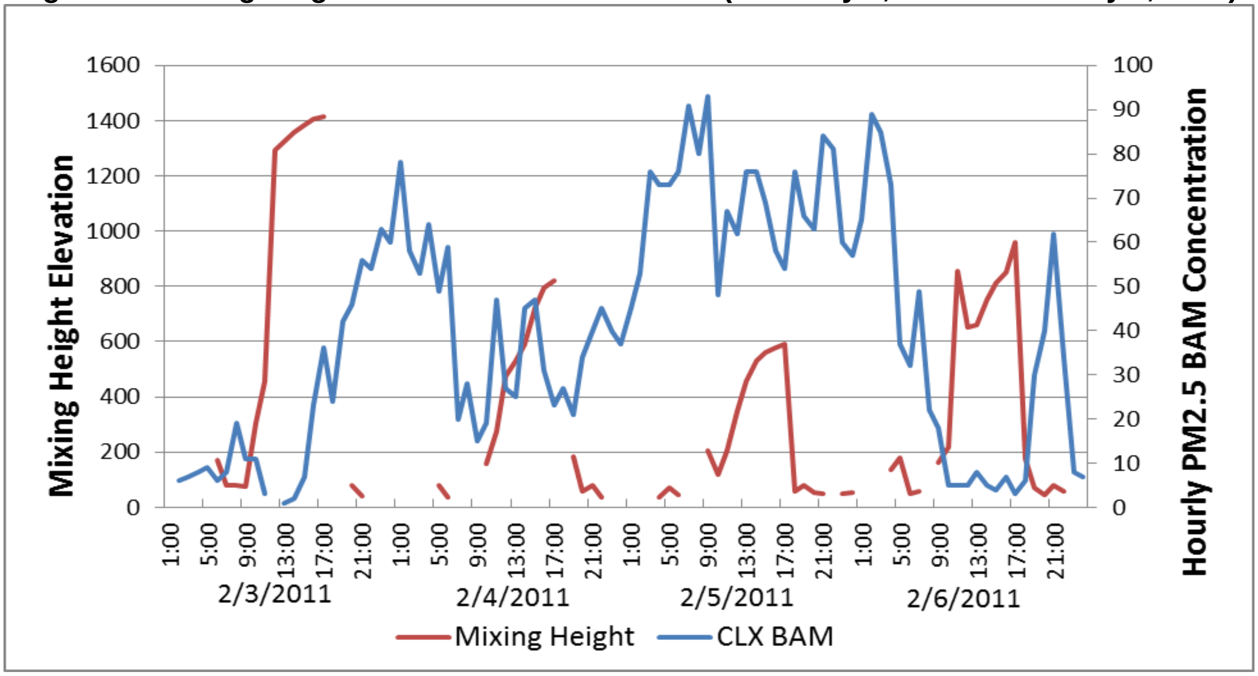
**Figure 56. Wind Rose on February 5, 2011**




Staff evaluated the relationship between atmospheric mixing heights and PM2.5 concentrations recorded on February 5. The nearest radiosonde data collection sites to Calexico are Yuma, Arizona, and Tucson, Arizona. Both of these locations have climatology similar to that of Calexico. Both sites also reported incomplete mixing height datasets for February 5, but the Tucson dataset was more complete (18 hours) than the Yuma dataset (13 hours) on this day. For those hours during which sufficient measurement data existed at both sites to calculate mixing heights, the mixing heights were very similar to each other. Data from Tucson were used to generate a plot of hourly mixing heights over a three day period that includes the February 5 exceedance.

Figure 57 displays the Tucson mixing height estimates and hourly Calexico PM2.5 BAM measurements for February 3 through February 6, 2011. The overall trend over the four day period shows an inverse relationship between mixing height and concentrations. Similar to the December 4 exceedance day mixing height trend, this plot suggests that stagnant meteorological conditions occurred during this period, which is corroborated by the very low surface wind speeds recorded and supports the concept that emissions from Mexicali mixed with those of Calexico to produce higher PM2.5 concentrations than would have been observed in the absence of emissions from Mexico.

**Figure 57. Mixing Height and BAM Concentrations (February 3, 2011 – February 6, 2011)**




Analysis of the Event

At the end of January and the beginning of February, a low pressure trough was situated just east of Calexico. This trough maintained a west-to-east pressure differential that caused resultant hourly wind speeds at Calexico to average approximately 2.2 mps, with maximum hourly wind speeds up to 5.1 mps. 24-hour average PM2.5 concentrations at the Calexico BAM monitors were low, less than 10 µg/m3. On February 3, the low pressure trough moved eastward and its place was taken by the edge of the Pacific high pressure cell. Hourly wind speeds dropped to less than 0.9 mps and temperatures dropped at night. This created stagnant meteorological conditions that prompted the District to declare a ban on agricultural burning for February 4 and 5.

PM2.5 concentrations began to rise at the Calexico monitoring station after 2:00 pm on February 3, coincident with a slight increase in wind speeds and a shift in a general direction from southeast to southwest. Concentrations remained elevated throughout the day, reaching a maximum of 69 µg/m3 at 10 pm. A portion of the PM2.5 concentration rise at this time may have been due to the burning of 143 acres of hay stubble just west of Calexico earlier that day.

As noted earlier, February 3 was the coldest day of 2011 in Imperial County. Calexico's temperature dropped to 32° F while the El Centro Naval Facility recorded 21° F. Accuweather.com reported a freeze in Imperial County on February 3 and 4. Figure 58 discusses the damage to the winter vegetables and fruit in Imperial County from the sub-freezing temperatures. The low temperatures in the morning hours of February 4 were generally a few degrees warmer than those of the previous night and nighttime temperatures continued to rise—at most monitoring sites in Imperial County—by 10 degrees or more by February 6. This temperature trend supports the concept that cold, stagnant air creates conditions conducive to the formation of elevated PM2.5 levels in the Imperial NA, heavily influenced by emissions originating from south of the border.

**Figure 58.** **Another Freeze for the Imperial Valley, Other Agricultural Areas**

## Another Freeze for the Imperial Valley, Other Agricultural Areas

February 4, 2011; 6:02 AM ET

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Temperatures dipped close to all-time record lows in a number of locations over the Imperial Valley of California and other agricultural areas Thursday morning, with another freeze occurring Friday morning.

El Centro dropped to 19 degrees Thursday morning, one degree shy of their all-time record low of 18 degrees set in Jan. 4, 1949. El Centro did set their all-time lowest February record, shattering the old record of 24 set on Feb. 12, 1965.

Multiple hours of sub-freezing temperatures were experienced in not only the Imperial Valley, but also the Gila Valley of California and in the lower Colorado Valley of Arizona.

Photo by photos.com

There undoubtedly was some damage to these areas Thursday morning and more sub-freezing temperatures were beginning to occur early Friday morning, but not quite to the severely low levels just 24 hours earlier.

These regions produce winter vegetables and fruit to the U.S. and other areas.

South Texas has also been hit with sub-freezing temperatures recently. In fact, part of the lower Rio Grande Valley never recovered to the freezing mark Thursday, after dipping into the upper 20s Thursday morning.

While clear skies at night were contributing to the low temperatures in the Southwest, including sub-zero readings in Arizona, cloud cover and a "norther" were contributing to the freeze in Texas.

The extent of the damage from these freezes is not yet known, but it could impact prices at your local grocery store in the coming weeks, if the supply of quality fruit and vegetables is reduced or has to be retrieved from more distant locations.

The cold weather did not hit the Central Valley of California nearly as hard with low temperatures generally at or above the freezing mark. Temperatures have remained and should continue to remain well above cold levels in central and southern Florida in the coming days and weeks.


After a cold start, temperatures will rebound markedly over the Southwest by this afternoon, but a slower temperature recovery is in store for South Texas with more record cold in store Saturday morning in the lower Rio Grande Valley.

The relatively low temperatures recorded on February 3, 2011, resulted in an increase in residential space heating and outdoor fires which produced emissions that likely continued as nighttime minimum temperatures remained below 40° F through February 5. Documentation of this activity is contained in an article published on February 5 in the Mexicali newspaper, *La Cronica*. Figure 59 discusses how people in Mexicali began burning very early in the morning for comfort heat. This burning activity, together with the very low mixing height estimated, may have produced the abrupt increase in PM2.5 concentrations seen after midnight on the morning of February 5.

**Figure 59. Mexicali newspaper article published on February 5, 2011 regarding freezing temperatures and burning "Improved Climate after Passage of Cold Front"**

Sábado
5 de febrero de 2011


En la colonia Agualeguas, Alejandra Martínez y María, madre e hija, se levantaron muy temprano a encender una fogata para calentarse un poco, luego de una noche muy fría.

# Mejorará clima tras paso de frente frío

Las condiciones climatológicas mejoraran considerablemente en la región tras el paso de un frente que trajo heladas para Mexicali y el Valle, informó Enrique Dávalos.

El técnico de Meteorología de la Universidad Autónoma de Baja California (UABC) mencionó que para este fin de semana se incrementan las temperaturas, además que habrá días despejados, vientos débiles.

Explicó que la helada que se registró el jueves, se debió a que en el Estado había un sistema frontal que no estaba tan fuerte pero en combinación con un frente continental ocasionó las heladas.

"Fue un frío muy seco, sin lluvias que provocó heladas, no nevadas, el agua se pude congelar de los 4 grados para abajo y ése fue el fenómeno que se vivió con algunos congelamientos de árboles, fuentes y agua", apuntó.

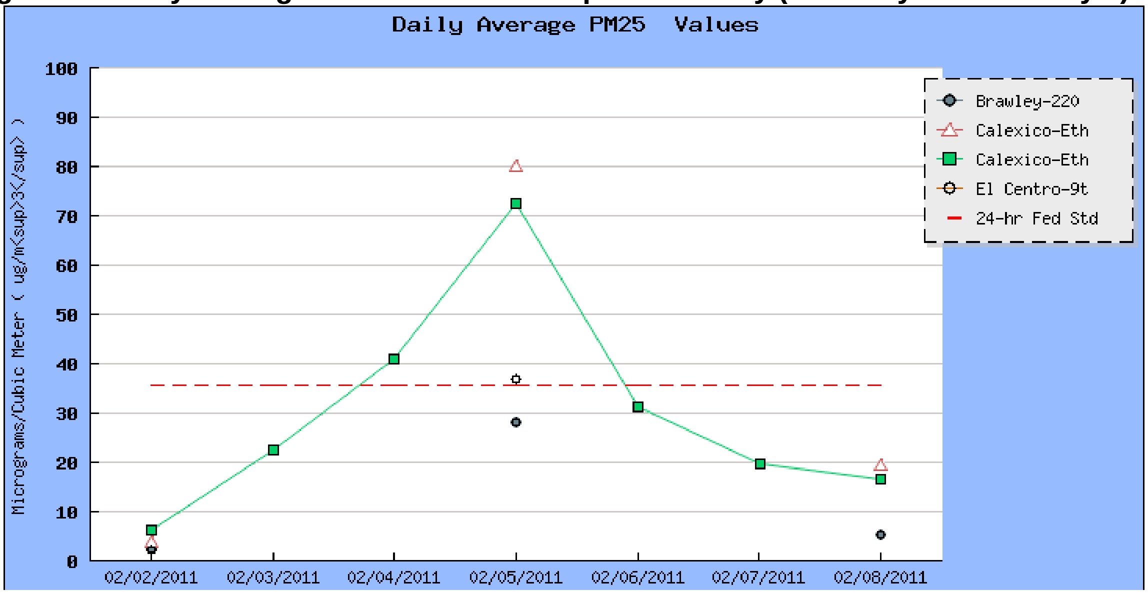
La temperatura del jueves que se registró durante la madrugada ha sido la más baja en lo que va del año y fue de 1.5 grados centígrados, mientras que el viernes la más baja fue de 2.8 grados centígrados.

Para hoy sábado se espera un día soleado con algunas nubes, además de temperaturas mínimas de 8 grados centígrados y máximas de 24; mientras que para el domingo el termómetro podría alcanzar mínimas de 10 grados centígrados y máximas de 27.

– POR YADIRA MURILLO

Figure 60 shows the daily PM2.5 concentration data recorded between February 2 and February 8, 2011. The data show lower PM2.5 values at the El Centro and Brawley sites with somewhat elevated concentrations on February 5. This pattern is consistent with the spatial gradient shown in Figure 55 and suggests that emissions from south of the border may be influencing measurements further to the north. The plot indicates consistency between the FRM measurements at Calexico and non-FEM BAM measurements at Calexico on February 5 as well as on February 8. The BAM value on February 5, for example, was 69 μg/m3, relatively close to that day's FRM value of 64.7 μg/m3.

**Figure 60. Daily Average PM2.5 Values in Imperial County (February 2 – February 8)**




*POC1 is on a 1-in-3 day sampling schedule and POC3 records hourly data

The wind direction on February 5, 2011 was predominantly from either a southern direction or too calm to determine. BAM PM2.5 concentrations remained high throughout the day, regardless of the wind speed, which averaged 0.6 mps, or the direction, which was predominantly from the south. The AQI classification was increased to Unhealthy. All hourly PM2.5 concentrations on February 5 at the Calexico site were above 40 µg/m$^3$ and reached as high as 103 µg/m$^3$. Concentrations did not begin to significantly decrease until after 9 pm, the same time that the wind speed increased to almost 1.8 mps and shifted from south to north.

February 6, 2011 began with high hourly PM2.5concentrations for the first five hours. These concentrations reached 90 µg/m3 but decreased rapidly to 5 µg/m3 by 9:00 am as wind directions shifted toward the north, wind speeds increased to 3.0 mps, and temperatures increased to above 70 degrees—evidence also that mixing heights had risen dramatically. Under these meteorological conditions, hourly PM2.5 concentrations remained below 10 µg/m$^3$ for the remaining daylight hours. A drop in wind speeds and onset of falling mixing heights after 5:00 pm was accompanied by a sharp, but short-lived, rise in PM2.5 concentrations. The 24-hour average PM2.5 concentration, although high, remained below the NAAQS.

Wind speed and wind direction data were plotted with the BAM PM2.5 concentration measurements from February 3 through February 6. These data show that low wind speeds, particularly in the early morning hours, are correlated with higher PM2.5 concentrations (Figure 61). Generally, the highest concentrations on February 5 were seen under a combination of southerly flow conditions (79 – 272 degrees) (Figure 62) and calm to low winds.

**Figure 61. PM2.5 BAM vs. Wind Speed at Calexico on February 3 – February 6**

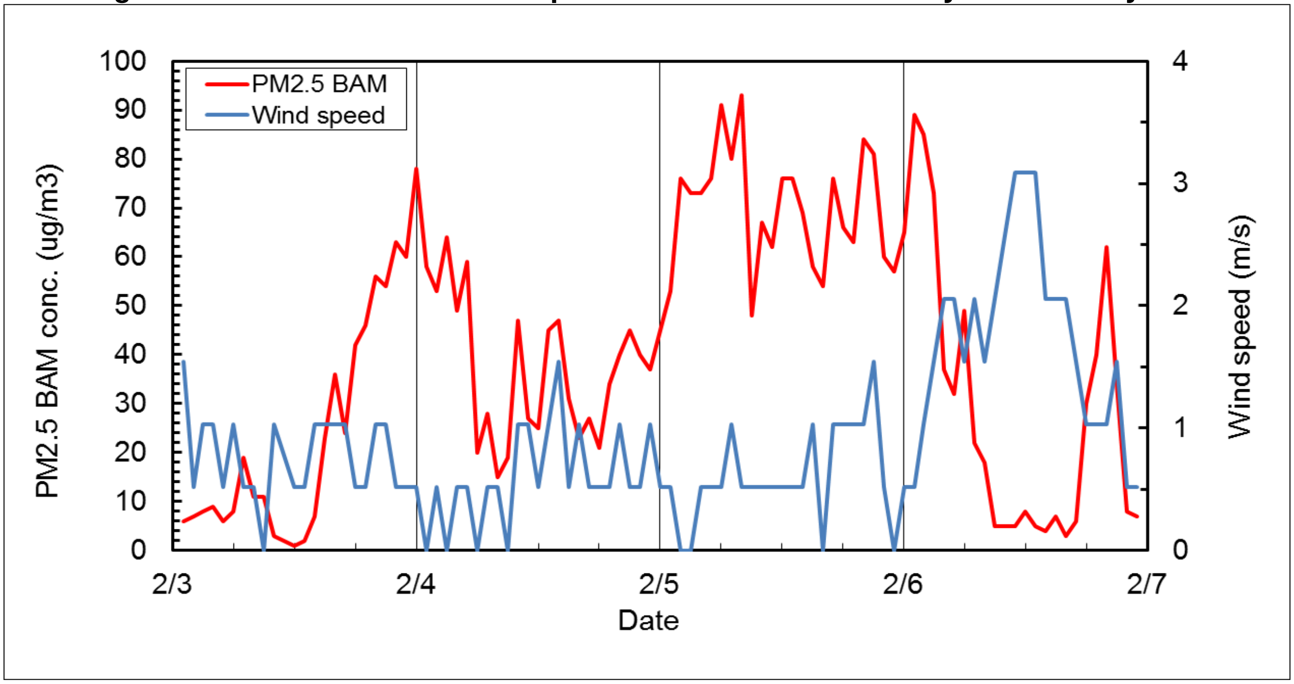
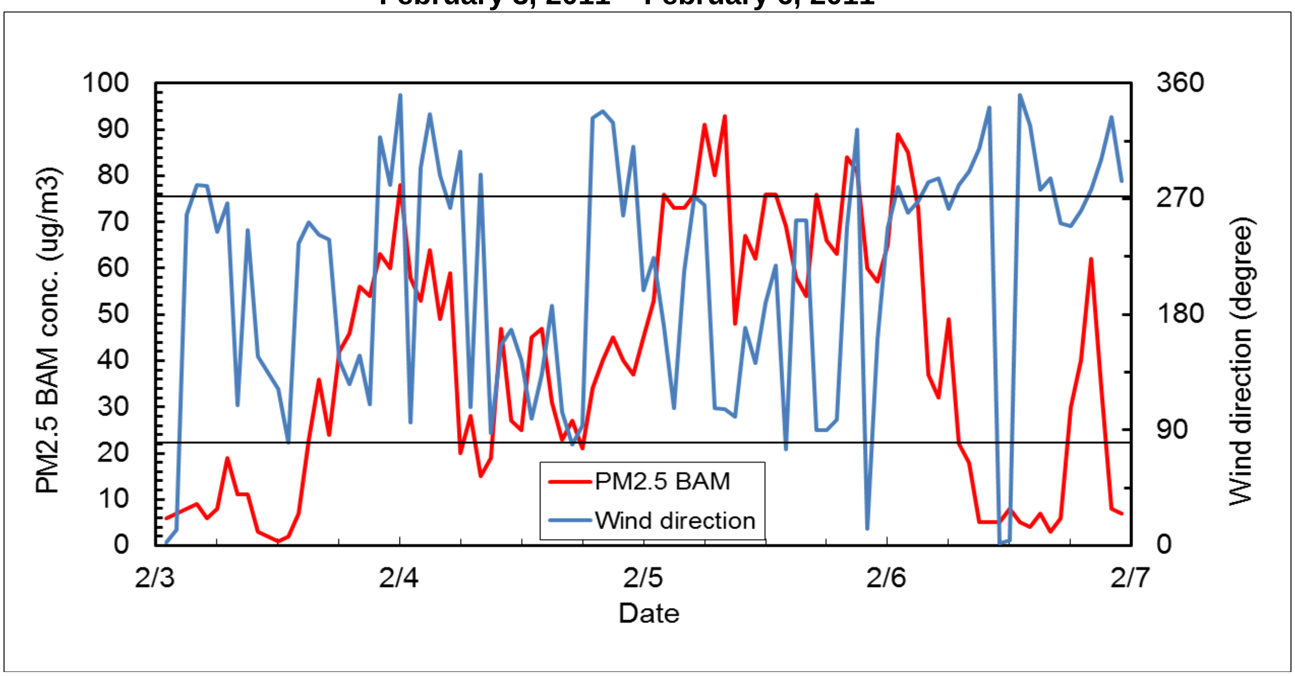


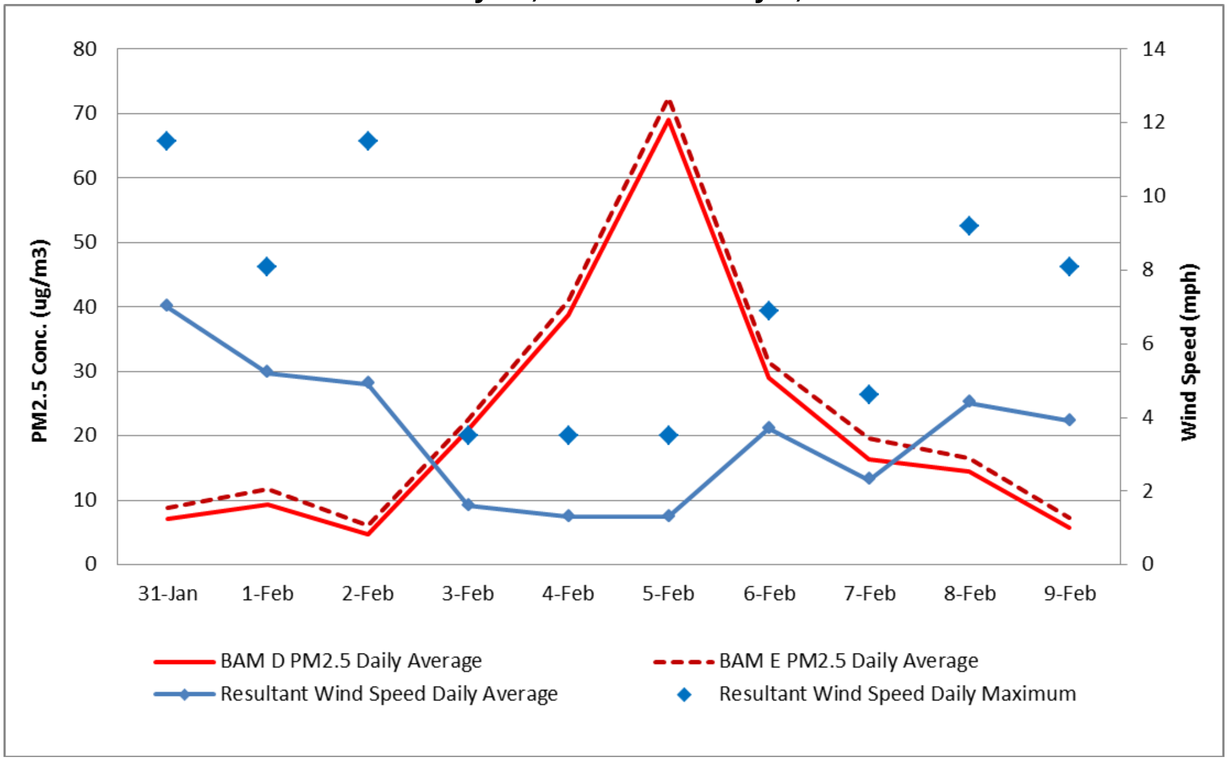

**Figure 62. PM2.5 BAM vs. Wind Direction at Calexico on February 3, 2011 – February 6, 2011**




*79-272 degree winds are from the south. 273-78 degree winds are from the north.

Figure 63 shows the daily average PM2.5 BAM concentrations, daily average resultant wind speed (mph) and daily maximum resultant wind speed for January 31 through February 9. When the maximum and average wind speed decreased on February 3 through February 5, the BAM values increased. As wind speeds increased after February 5, concentrations began to decline.

**Figure 63. Calexico Wind Speeds and PM2.5 Concentrations**
**January 31, 2011 – February 9, 2011**




The back trajectory developed for February 5, 2011 started at the hour of the highest BAM PM2.5 concentration and traced the pollution back to 1:00 am and noon on February 4, 2011 (for Calexico and El Centro). The air parcel that impacted the Calexico site at 8:00 am on February 5 were in Mexicali in the early morning hours of February 5 and the late night hours on February 4 when concentrations were elevated (Figure 64). Figure 65 displays the back trajectory for El Centro. The El Centro site was 1.9 μg/m3 over the 24-hour PM2.5 standard and, although the trajectory does not pass into Mexicali, it is reasonable to assume that this site was likely impacted by 1) agricultural burning that occurred in Imperial County two days prior; 2) low temperatures on February 5; 3) a low mixing height inversion; and, 4) emissions transport from Mexicali.

**Figure 64. February 5 Calexico air parcel back-trajectory (Starting at 1:00 am on 2/4/11 and ending at 8:00 am on 2/5/11)**

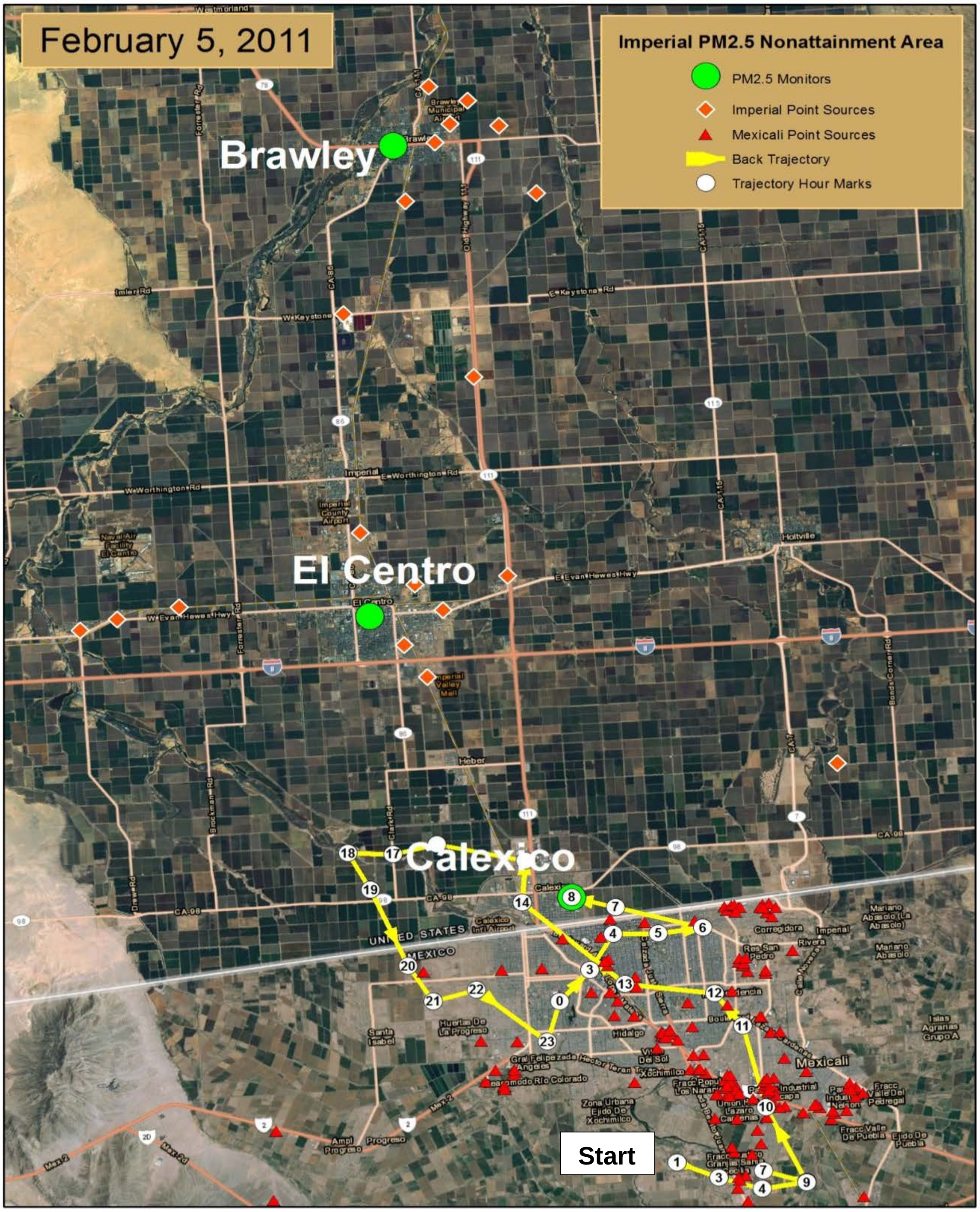
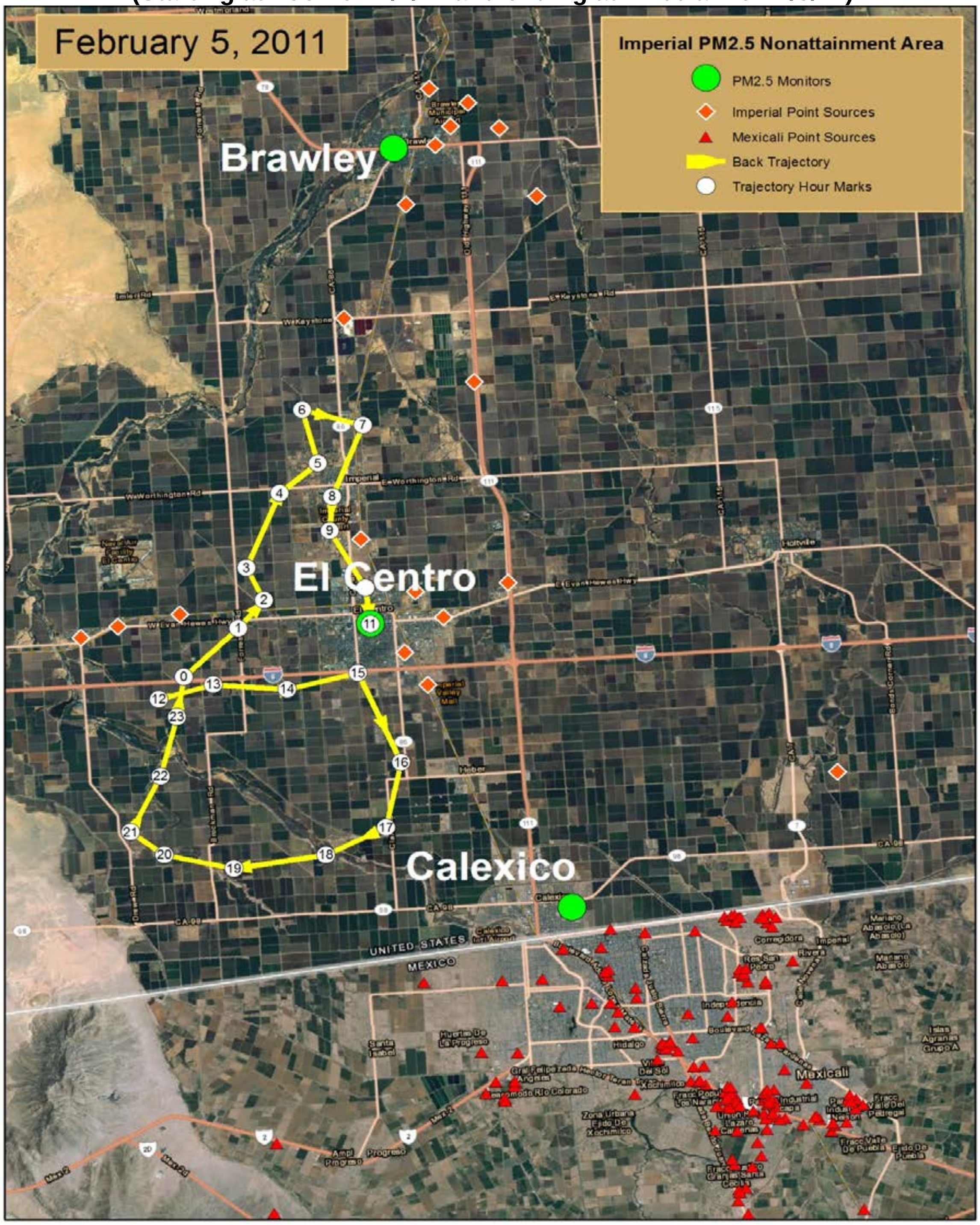


Figure 65. February 5 El Centro Air Parcel Back-trajectory
(Starting at noon on 2/4/11 and ending at 11:00 am on 2/5/11)



**December 11, 2011**

Analysis Methods

Staff evaluated the following data for December 11, 2011: (1) PM2.5 concentration gradient within the Imperial County NA and Mexicali; (2) predominant wind speed and wind direction in Calexico; (3) mixing height data for December 9 through December 12; (4) local media reports; (5) changes in the hourly BAM PM2.5 concentrations with the wind speed and direction; (6) air parcel back-trajectory starting at the hour of highest concentration at the Calexico site; (7) speciation data to aide in identifying the major components of PM2.5, including a further breakdown of elemental species; and, (8) a quantification of the emissions impact on concentrations at the Calexico site for chemical species.

Data not available for this analysis include; half of the hourly PM2.5 data at the Mexicali sites; satellite imagery (obscured by clouds); and the PM2.5 BAM data for Brawley and El Centro. However, hourly PM2.5 data coupled with meteorological data, speciation data, and a back-trajectory analysis, provide evidence that the Calexico monitor would not have recorded an exceedance of the 24-hour NAAQS but for emissions from Mexicali on December 11.

PM2.5 Concentrations

On Sunday, December 11, the Calexico FRM monitor recorded a 24-hour average PM2.5 concentration of 44.4 µg/m3. From filter-based measurements, PM2.5 concentrations at the El Centro and Brawley monitoring sites were 13.7 and 10.2 µg/m3, respectively. The AQI value on this day was 123 (unhealthy for sensitive groups) and was the third highest AQI value recorded in Imperial County for 2011. As shown in Figure 66, a high value was only recorded at Calexico, further indicating it was not a region-wide event.

The PM2.5 concentration was more than half the measured PM10 concentration on December 11, suggesting that the PM impact was largely influenced by combustion sources. Agricultural burning was not permitted and did not occur in Imperial County on December 9, 10, or 11, and no burning violations or complaints were received during those days. Although not all of the combustion emissions are expected to originate from Mexicali, the combination of the magnitude of the emission inventory in Mexicali, the number of stationary sources in Mexicali, the number and age of motor vehicles in Mexicali, and the lack of agricultural burning in Imperial County implies that most of the combustion emissions originated from outside the County.

**Figure 66. Daily Peak AQI Map on December 11, 2011**

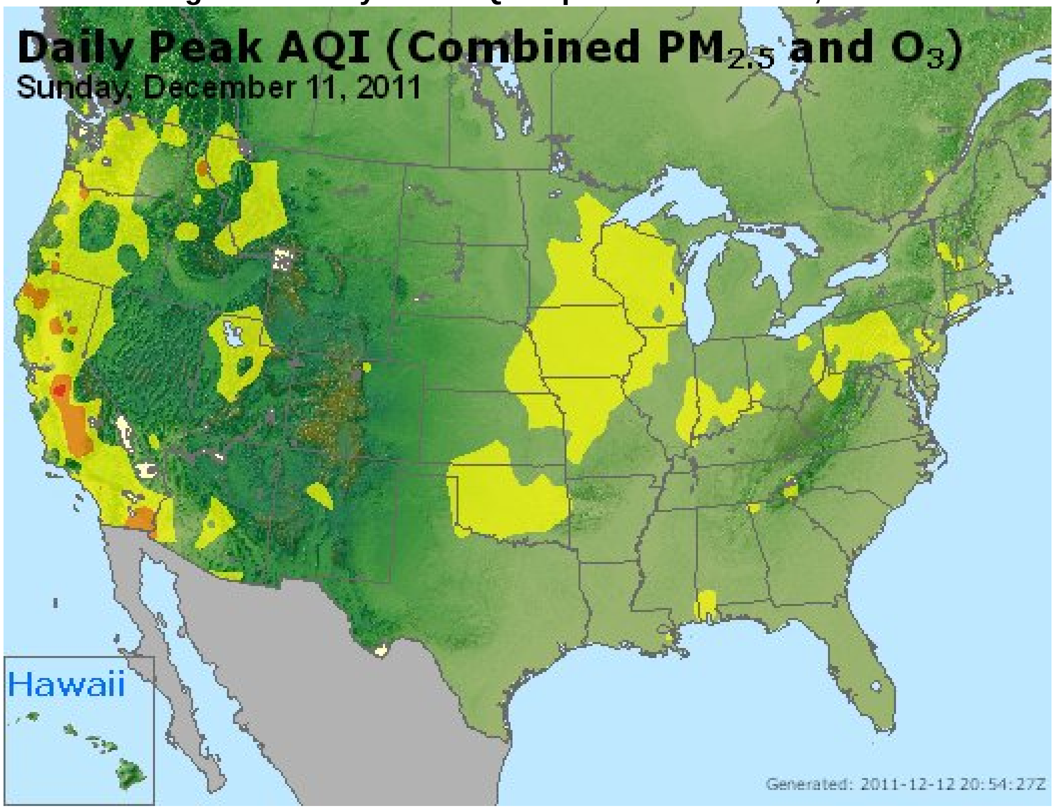
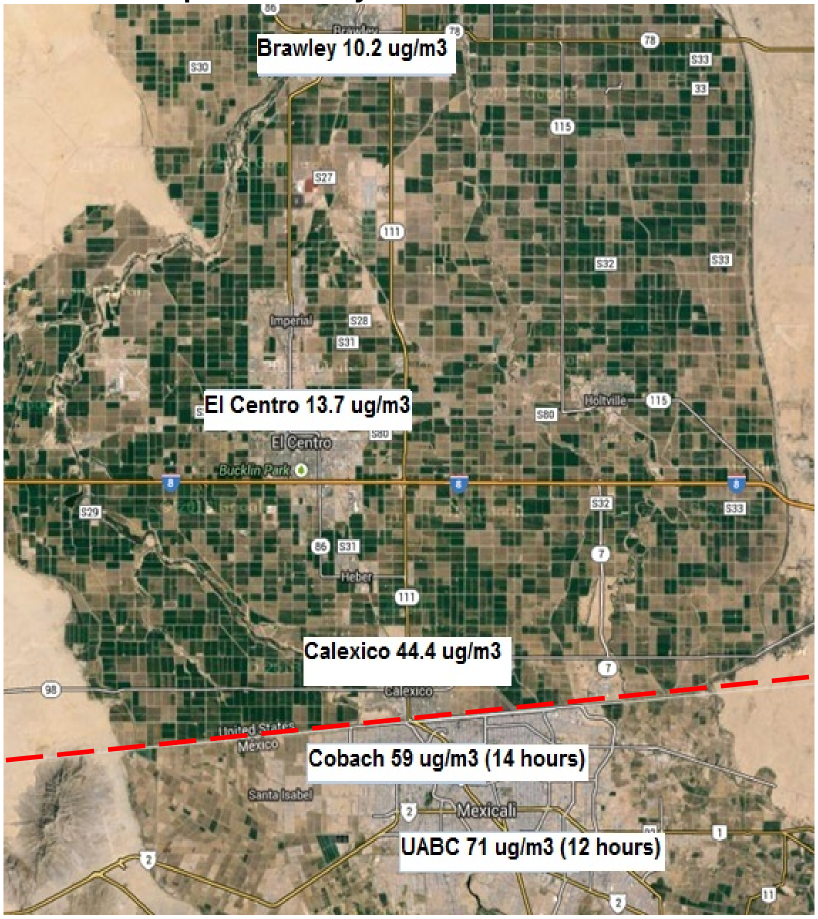



Figure 67 shows the spatial distribution of 24-hour average PM2.5 concentrations recorded at each monitoring site in Imperial County on December 11. The 44.4 µg/m³ concentration measured at Calexico was more than three times the annual average for that site in 2011. The PM2.5 concentration gradient from the Calexico monitor to the Brawley and El Centro sites to the north suggests that the emissions impact on the Calexico monitor differs from any impacts experienced by the Brawley and El Centro monitors.

The COBACH and UABC sites in Mexicali recorded partial data on December 11 (COBACH recorded an average of 59 µg/m3 over 14 hours; UABC 71 µg/m3 over 12 hours). The PM2.5 concentrations drop off significantly between Mexicali and Brawley. With similar emission sources and meteorology, the expectation is that PM2.5 concentrations measured at Calexico, El Centro, and Brawley would be similar. The decreasing gradient northward is consistent with the Calexico-Mexicali single air shed concept and points to cross-border emissions as the source of high concentrations measurements at Calexico.

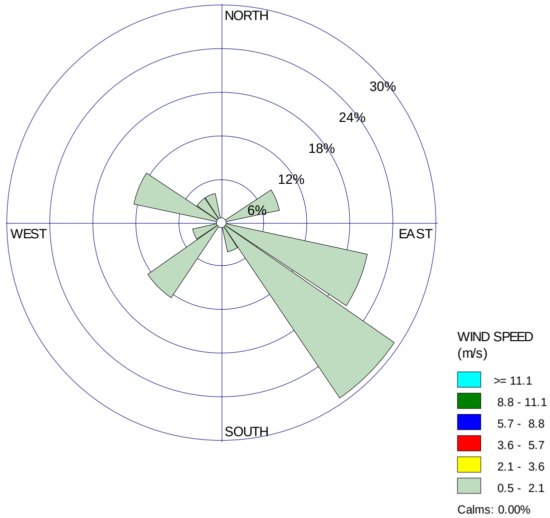
**Figure 67. Mexicali and Imperial County PM2.5 concentrations on December 11, 2011**




<u>Meteorology</u>

Meteorological data collected at the Calexico monitoring site confirm that stagnant surface conditions occurred throughout the day on December 11. The 24-hour average wind speed at Calexico was 1.1 mps and the maximum was 2.0 mps. In addition, the majority of the hourly wind directions were from the south (17 out of 24 hours). Winds were calm on this day in Calexico as shown in the December 11 wind rose (Figure 68)

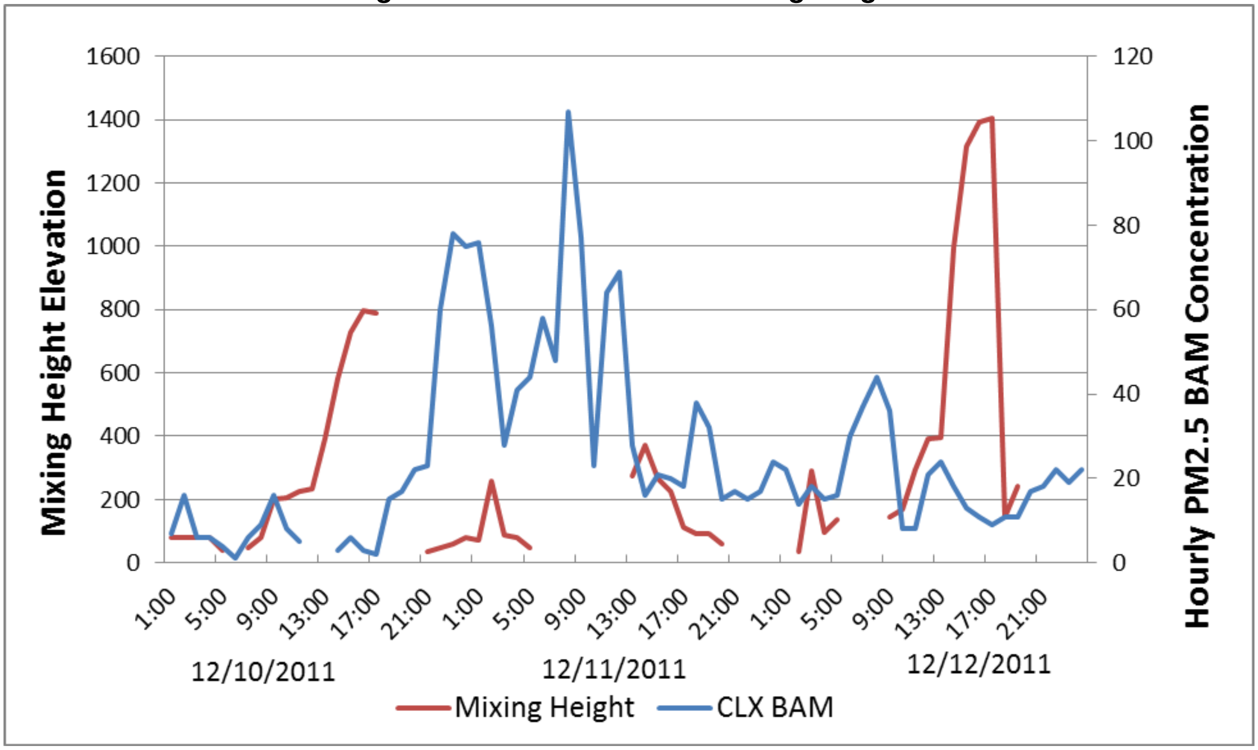
**Figure 68. Wind Rose on December 11, 2011**




To further characterize meteorological conditions on December 11 which may have influenced PM2.5 concentrations measured at the Calexico station, staff evaluated data on atmospheric mixing height and its correlation with PM2.5 mass data. The nearest routine data collection points to Calexico for radiosonde data are Yuma, Arizona, and Tucson, Arizona. Both of these locations have topography similar to that of Calexico. Yuma data were incomplete for December 11, data from Tucson were therefore used to generate a plot of hourly mixing heights over a three-day period that includes the December 11 exceedance.

Figure 69 displays the mixing height and hourly PM2.5 BAM measurements at Calexico. While data gaps exist for the atmospheric soundings, the overall trend over the three day period shows an inverse relationship between mixing height and concentrations. Decreasing mixing height corresponds to increasing PM2.5 concentrations as low vertical mixing confines pollutants. This plot corroborates surface wind data and supports the concept that emissions from Mexicali, confined to the Calexico-Mexicali air shed with reduced pollutant dispersion due to low wind speed and reduced mixing height, resulted in higher PM2.5 concentrations on December 11 than would have been observed in the absence of emissions from Mexico.

**Figure 69. PM2.5 BAM vs. Mixing Height**




Analysis of the Event

The December 11 exceedance occurred on a Sunday, the day before a major religious holiday in Mexico ("Our Lady of Guadalupe") on December 12. During the prior week, thousands of residents of Mexicali gather less than three miles from the Calexico air monitoring station for the celebrations. As with other religious celebrations in Mexico, merchants will typically set up booths in the area, attracting crowds with merchandise, food, and entertainment, along with customary bonfires and fireworks. Unusually high levels of PM2.5 are noted each year in Mexico on December 11 and 12 as a result of firework shows, the higher volume of vehicular traffic, and the burning of wood, tires, and garbage in bonfires. It is appropriate to assume that most of the festivities occurred over the weekend prior to the December 12 holiday and that these activities resulted in elevated ambient PM2.5 concentrations in and around the border region.

Figure 70 is an article published in 2013 in the local Mexicali newspaper, *La Cronica*. The article discusses the typical holiday celebrations for the winter, including the use of fireworks (*quema del castillo*).

**Figure 70. La Cronica Article “Everything is ready to celebrate the Day of the Virgin”**

# Está todo listo para celebrar el Día de la Virgen

El mismo miércoles, a partir de las 22:00 horas iniciará el programa especial guadalupano y las Mañanitas a la Virgen, seguidas de la y misa solemne que será presidida por el obispo de la Diócesis de Mexicali, José Isidro Guerrero Macías a las 23:00 horas.

Publicada: 11/12/2013 1:20 Por: Martha Sánchez msanchez@lacronica.com AUMENTAR REDUCIR

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MEXICALI, Baja California(PH) Como ya es tradición, la Catedral de Nuestra Señora de Guadalupe tiene todo preparado para la típica celebración mañana del Día de la Virgen de Guadalupe.

La celebración comenzará este miércoles 11 y concluirá hasta la noche del jueves, integrando las diferentes tradiciones, que los miles de asistentes esperan, en esta que es una de las fiestas principales de los católicos mexicanos.

El programa marca como actividad inicial el miércoles 11, una “fiesta popular”, en la que se presentarán bailables, solistas y grupos locales de las 18:00 a las 23:00 horas, mientras que las escenificaciones de las apariciones, tendrán dos horarios a las 19:00 y las 21:00 horas.

El mismo miércoles, a partir de las 22:00 horas iniciará el programa especial guadalupano y las Mañanitas a la Virgen, seguidas de la y misa solemne que será presidida por el obispo de la Diócesis de Mexicali, José Isidro Guerrero Macías a las 23:00 horas.

A partir del jueves 12 de diciembre, los cachanillas católicos podrán asistir a las celebraciones de la Santa Misa, que se realizará cada hora de las 06:00 a las 13:00 horas y de las 16:00 a las 21:00 horas.

El jueves 12 también se llevará a cabo la Misa de las Rosas, la cual se tiene programada a las 11:00 horas y la Misa del Seminario a las 19:00 horas, mientras que durante todo el día se celebrará un kermés.

Durante la kermés en la que se venderán antojitos mexicanos y habrá juegos mecánicos y diversiones para toda la familia, también se contará con un escenario en el que se desarrollarán, bailables y cantarán solistas y grupos locales de 11:00 a 22:00 horas.

Como última actividad a desarrollarse, a las 22:00 horas se tiene programa la típica quema del castillo, en la que se espera participen las cientos de familias que se espera.

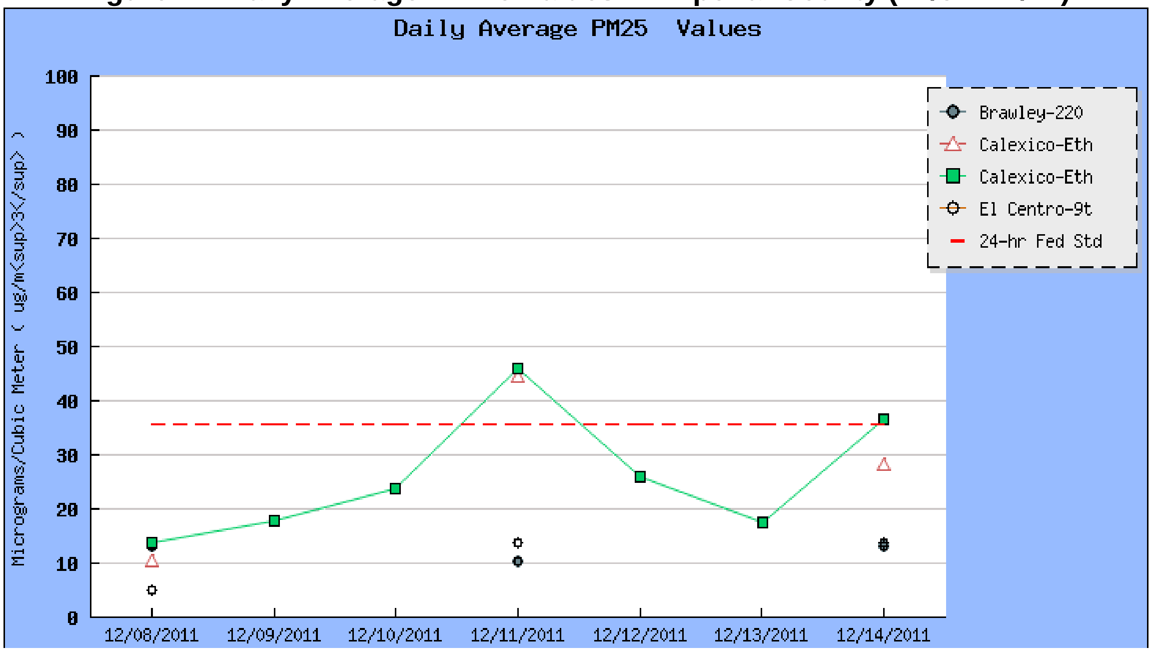
http://www.lacronica.com/EdicionEnLinea/Notas/Noticias/11122013/785016-Esta-todo-listo-para-celebrar-el-Dia-de-la-Virgen.html

To place Calexico PM2.5 values in the context of the Imperial NA’s other PM2.5 monitoring sites, Figure 71 shows the daily and hourly PM2.5 concentration data measured from December 8 through December 14. The data show lower PM2.5 values at the El Centro and Brawley sites with somewhat elevated concentrations on December 11. This pattern is consistent with the spatial gradient shown in Figure 67 and suggests that emissions from south of the border may be influencing measurements further to the north. The plot also illustrates the consistency between the FRM measurements at Calexico (POC 1) and non-FEM BAM measurements at Calexico (POC 3) on December 11 as well as on December 14. The BAM value on December 11, for example, was 39.7 µg/m3, consistent with that day’s FRM value of 44.4 µg/m3.

The continuous PM2.5 monitors at Calexico began recording increased PM2.5 concentrations after 4:00 pm on December 10 when the wind direction shifted from a northern to a southern direction. Concentrations peaked at 10 pm and remained high the morning of December 11, dropping only when winds briefly shifted from south to north. A peak PM2.5 concentration at 8:00 am of 107 µg/m3 occurred with a wind direction shift from southwest to south, with a further decrease in wind speeds. A wind shift to the north saw concentrations again decreasing, followed by an increase when the winds shifted back to the south. Concentrations decreased after noon with an increase in mixing height, along with slight wind speed increases. Concentrations remained moderately low for the remainder of the day.

Concentrations on December 12, after most of the Mexicali festivities had been completed, were half that seen on the previous day and followed a more typical workday pattern for Calexico. Hourly PM increases were seen during commute hours, but generally remained low throughout the day.

**Figure 71. Daily Average PM2.5 Values in Imperial County (12/8 – 12/14)**




*POC1 is on a 1-in-3 day sampling schedule and POC3 records hourly data

Wind speed and wind direction data were plotted with the BAM PM2.5 concentration measurements from December 9 through December 13. These data show that low wind speeds, particularly in the early morning and night hours, are correlated with higher PM2.5 concentrations (Figure 72). Generally, the highest concentrations on December 11 were seen under southerly flow conditions (79 - 272 degrees) in the early morning hours (Figure 73).

**Figure 72. PM2.5 BAM vs. Wind Speed at Calexico on 12/9-12/13/11**

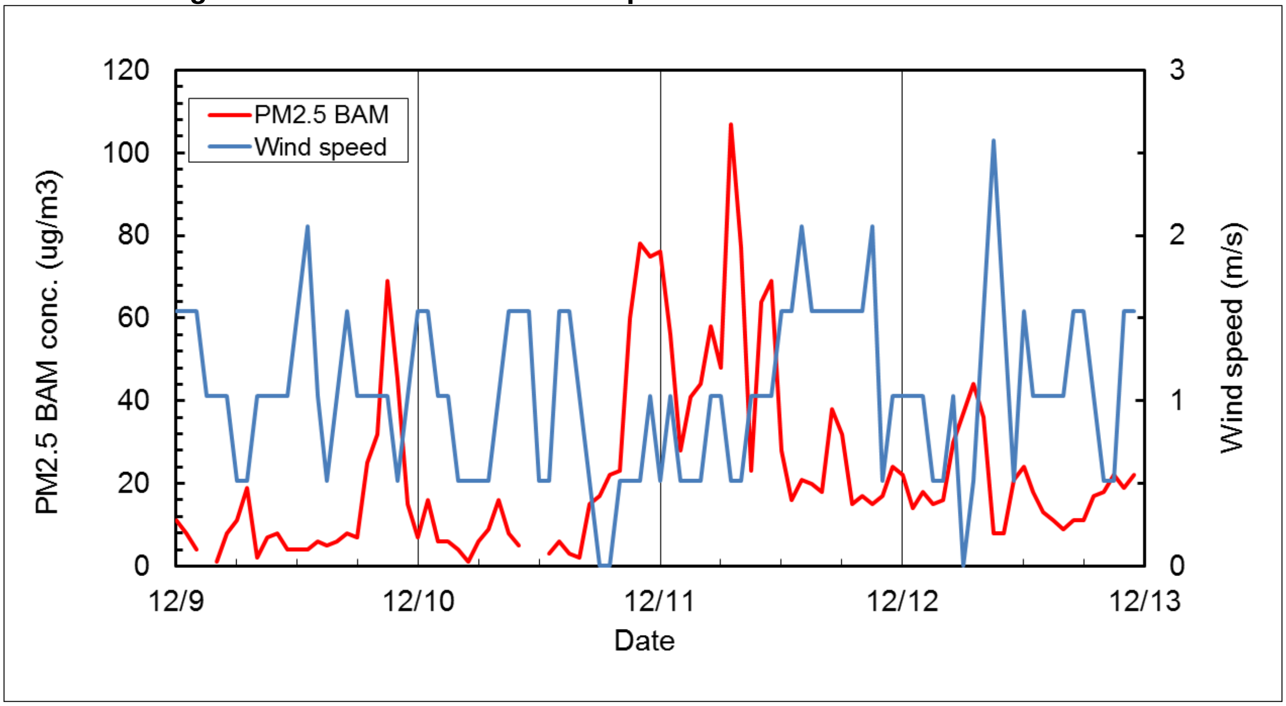
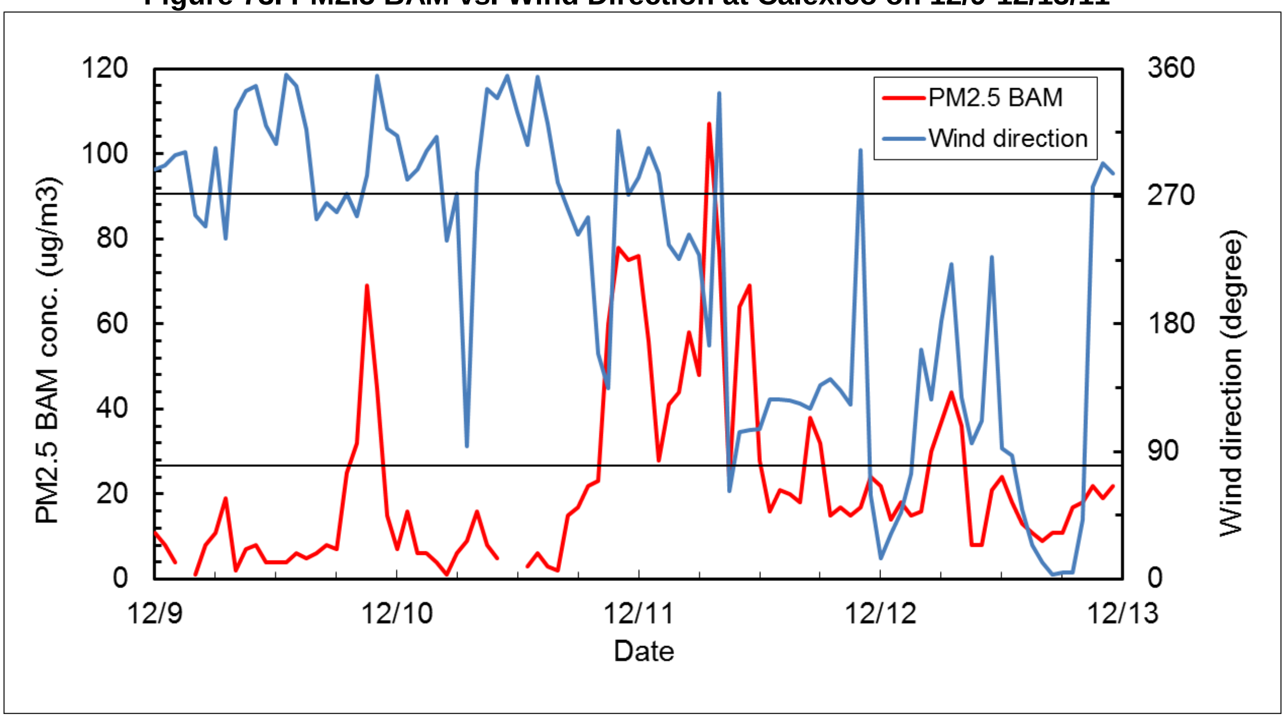


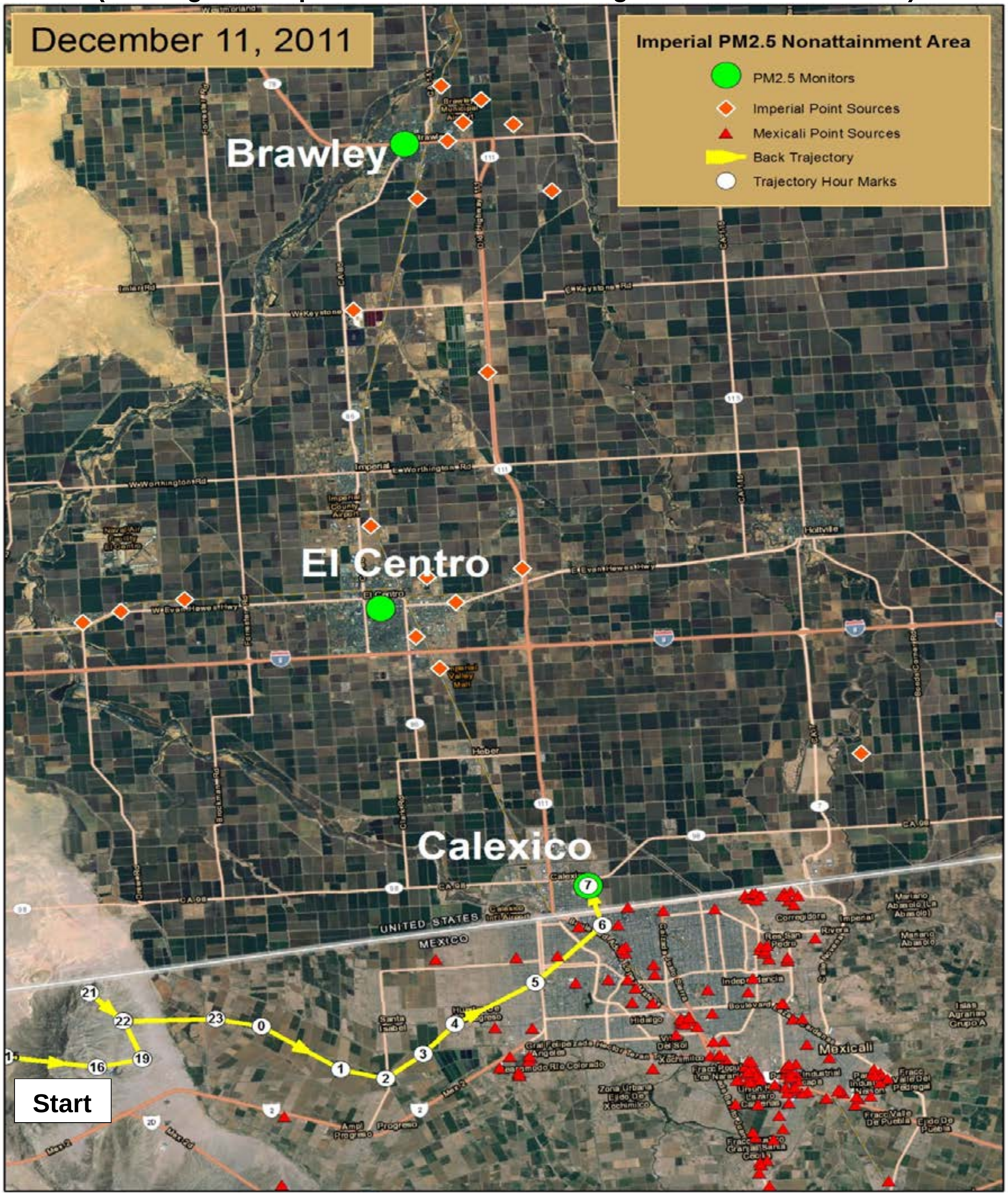

**Figure 73. PM2.5 BAM vs. Wind Direction at Calexico on 12/9-12/13/11**




*79-272 degree winds are from the south. 273-78 degree winds are from the north.

The spatial nature of the December 11 exceedance event was assessed using a back-trajectory plot (Figure 74). The objective of a back-trajectory plot is to discern the pathway that an air parcel traveled prior to passing over the site of a continuous pollutant monitor, i.e., a PM2.5 BAM. By calculating the coordinates of this traverse and overlaying the resulting travel path onto an aerial photograph, the potential for transport of emissions from sources under the path to the monitor can be quickly assessed by visual inspection.

**Figure 74. December 11 air parcel back-trajectory (Starting at 3:00 pm on 12/10/11 and ending at 7:00 am on 12/11/11)**

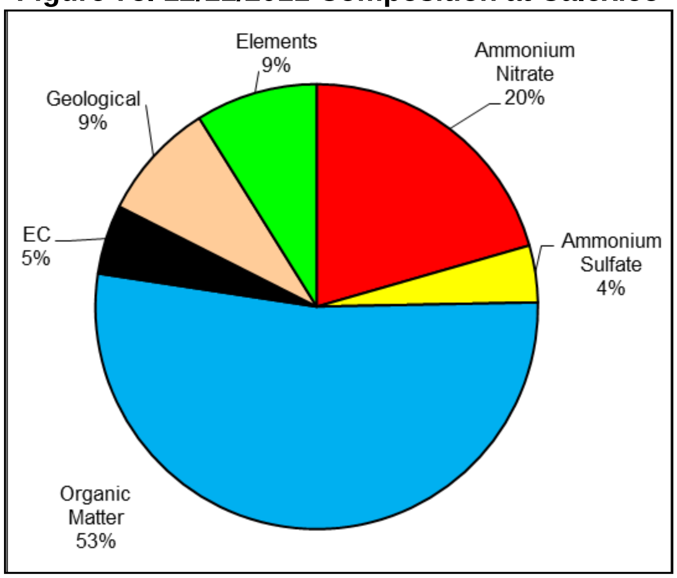



The back trajectory developed for December 11, 2011 started at the Calexico monitor at the hour of the highest PM2.5 BAM concentration (7:00 am) and followed an air parcel back to 3:00 pm on December 10, 2011. This indicates the air parcel that impacted the Calexico site at 7:00 am on December 11 passed through Mexicali in the late night hours on the 10th and the early morning hours of the 11th when concentrations were elevated.

Identification of Emissions

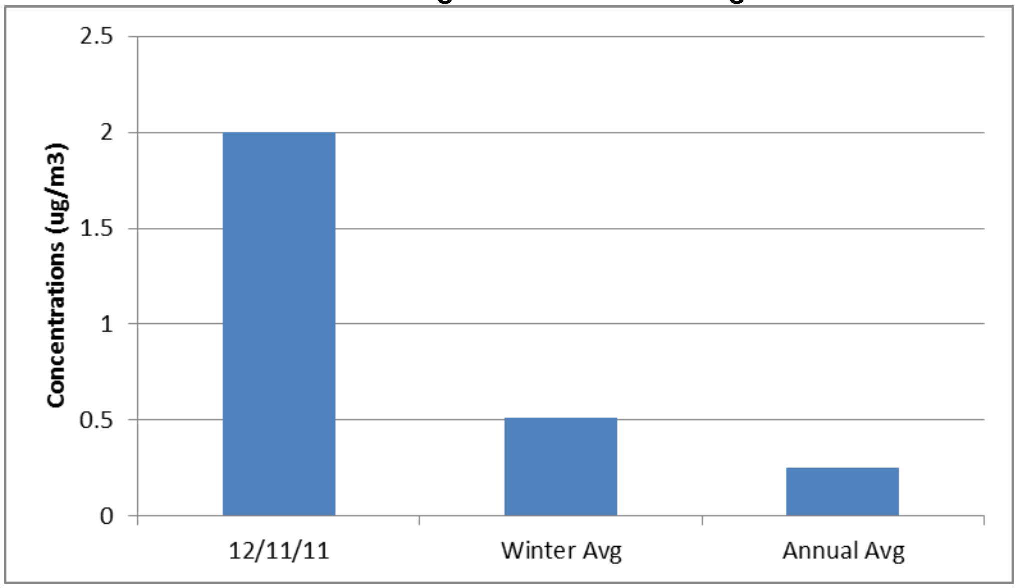
To aide in identifying the source of emissions potentially impacting the Calexico monitor, staff analyzed speciation data available at the station on December 11. The speciation data shows that over half of the concentration was from organic matter and 20 percent was from ammonium nitrate. High concentrations of elemental species were also present on this day. High concentrations of carbonaceous aerosols indicate that combustion is the main source of PM2.5 while high concentrations of elemental species suggest that emissions come from non-fossil fuel sources on December 11 (Figure 75).

**Figure 75. 12/11/2011 Composition at Calexico**



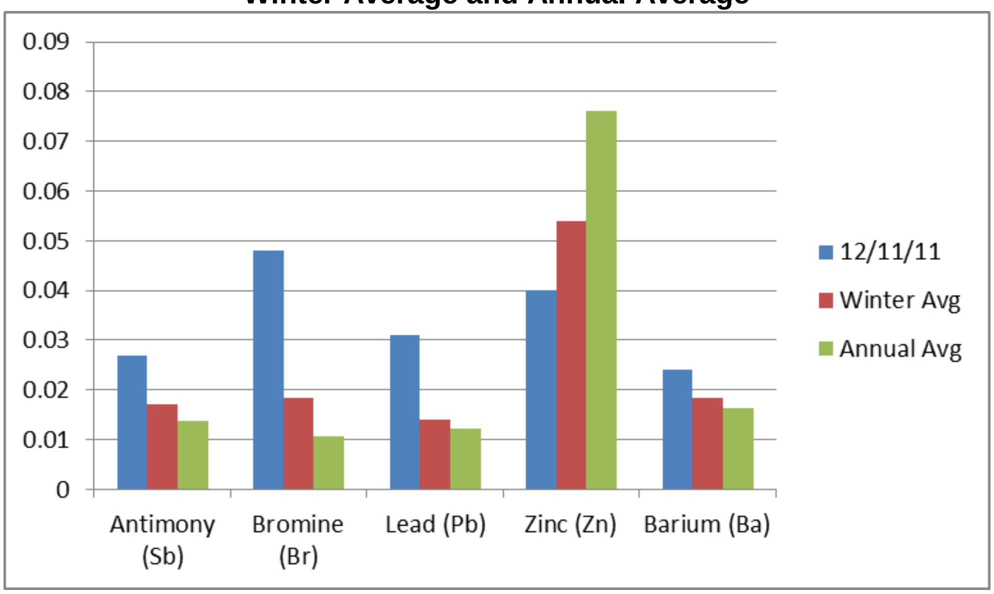

On December 11, 2011 elemental species concentrations at Calexico were elevated compared to both winter average and annual average concentrations. Concentrations of elemental chlorine were four times higher compared to winter average and eight times higher compared to the annual average (Figure 76). Concentrations of antimony, bromine, and lead were two times higher compared to winter concentrations and two to five times higher compared to annual average (Figure 77).

**Figure 76. Comparison of Chlorine Concentrations on 12/11/2011 to 2010-2012 Winter Average and Annual Average**




*This data does include transport days but does not include invalidated days

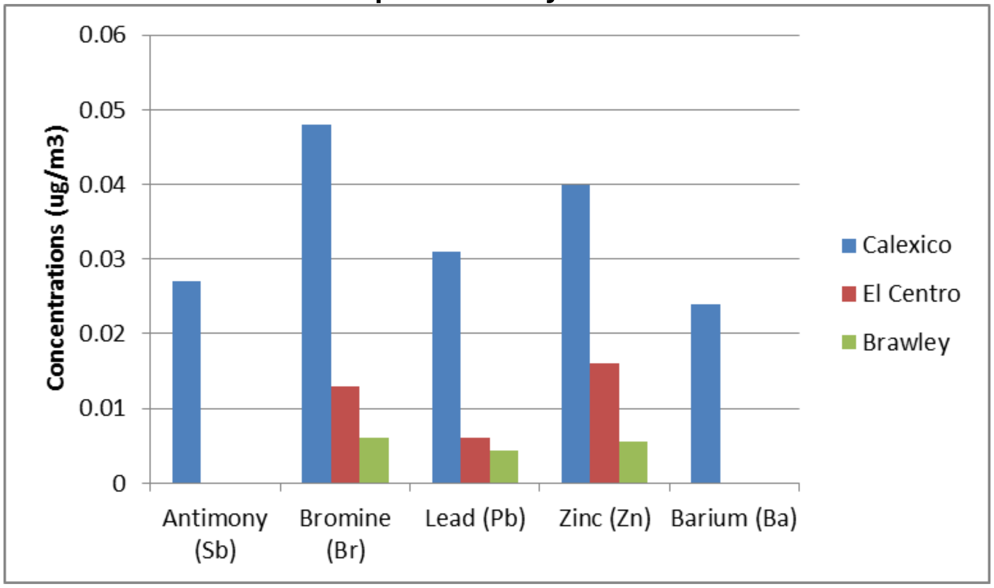
**Figure 77. Comparison of Select Species Concentrations on 12/11/2011 to 2010-2012 Winter Average and Annual Average**




*This data does include transport days but does not include invalidated days

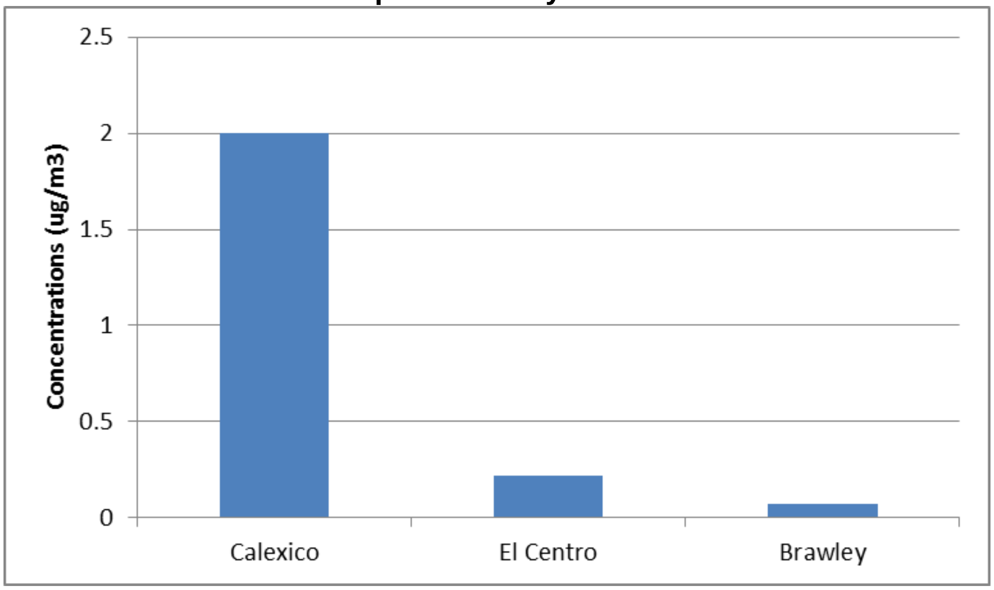
In comparing elemental data at all Imperial County sites for this day, it is obvious that Calexico was impacted at a level far higher than the two sites just a few miles to the north. These other two sites, Brawley and El Centro, had elemental concentrations close to or below the detection limit (Figure 78). Concentrations of antimony and barium at both El Centro and Brawley were below the detection limits. Concentrations of bromine, lead, and zinc at Calexico were three to eight times higher, while chlorine was nine times higher compared to El Centro and 27 times higher compared to Brawley (Figure 79).

**Figure 78. Comparison of Select Elemental Species Concentrations Across Imperial County on 12/11/2011**




*This data does include transport days but does not include invalidated days

**Figure 79. Comparison of Chlorine Concentrations Across Imperial County on 12/11/2011**

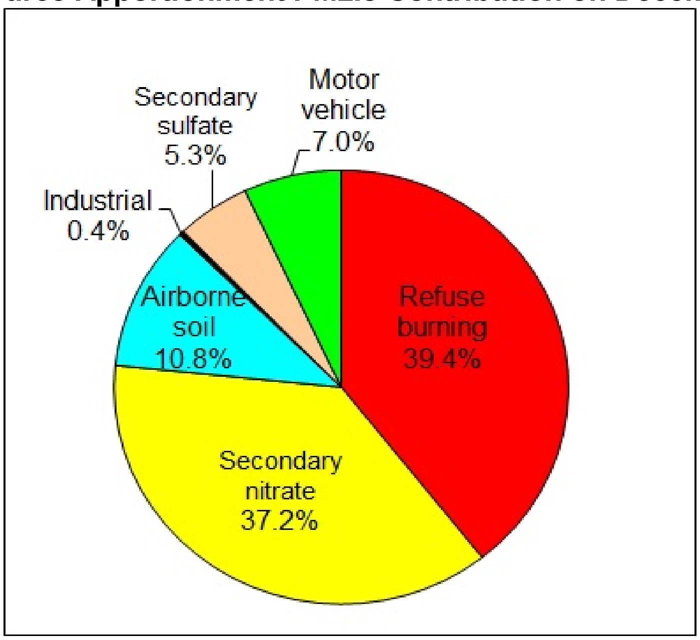



*This data does include transport days but does not include invalidated days

To provide information on the possible sources of emissions impacting the Calexico monitor, PM2.5 speciation data were analyzed using source apportionment model, Positive Matrix Factorization 2 (PMF2). PMF2 is a multivariate receptor model based on the positive matrix factorization (PMF) method. Fundamentally, this model analyzes characteristics of pollutants at the receptor site and, using mathematical algorithms, estimates the source contributions. This model is based on a weighted least square method that weights data points by their analytical uncertainties. A detailed description of PMF2 model procedure for Calexico is included in Appendix B.

In this analysis, a total of 159 samples and 27 species including PM2.5 concentrations collected between 2010 and 2012 were analyzed and six major sources were identified: Airborne soil, motor vehicle, secondary sulfate, secondary nitrate, refuse burning, and industrial. Figure 80 suggests that refuse burning and secondary nitrate were the major sources on December 11. This refuse burning was estimated to contribute 17.5 µg/m3 of the 44.4 µg/m3 concentration recorded at Calexico. Since refuse burning is not permitted in Imperial County, this impact—coupled with meteorological data—may be attributed to emissions from Mexicali.

**Figure 80. Source Apportionment PM2.5 Contribution on December 11, 2011**




The source apportionment percentages for refuse burning and industrial emissions were used to estimate the PM2.5 contribution at Calexico on December 11 (Table 13). Based on receptor modeling results, without refuse burning emissions occurring on December 11 the Calexico monitor would likely not have exceeded the 24-hour PM2.5 standard. If industrial emissions from Mexicali are excluded, the concentration on this day decreases further. These are important findings given that refuse burning and industrial emissions of the type identified through receptor modeling are essentially non-existent on the U.S. side of the border in Imperial County.

**Table 13. Contribution of Refuse Burning and Industrial Emissions to the PM2.5 Concentration on December 11, 2011**

| FRM Concentration | Without Refuse burning emissions | Without Refuse Burning & Industrial emissions |
|---|---|---|
| 44.4 µg/m3 | 26.9 µg/m3 | 26.8 µg/m3 |

**January 31, 2012**

Analysis Methods

For the January 31, 2012 exceedance day analysis, staff used various methods to evaluate the impact of emissions on the Calexico PM2.5 monitor. Referencing guidance from U.S. EPA, staff evaluated the following data: (1) PM2.5 concentration gradient within the Imperial County NA and Mexicali, including the AQI; (2) predominant wind speed and wind direction at Calexico on January 31; (3) mixing height vs. non-FEM BAM data for January 30 - February 1; (4) changes in the hourly BAM PM2.5 concentrations with the wind speed and direction experienced at the Calexico monitor on January 29 - February 1; (5) an air parcel back-trajectory starting at the hour of highest hourly recorded concentration at the Calexico site; (6) speciation data on January 31, to identify the major components of PM2.5, including a further breakdown of elemental species; and, (7) a quantification of the emissions impact on concentrations at the Calexico site for certain chemical species on January 31.

Data not available for this analysis include; PM2.5 BAM data at Brawley and El Centro; and specific media reports, from either north or south of the border, which would substantiate activities impacting air quality in the area were unavailable. However, hourly PM2.5 data coupled with meteorological data, speciation data, and a back-trajectory analysis, provide evidence that the Calexico monitor would not have recorded an exceedance of the 24-hour NAAQS but for emissions from Mexicali on January 31.

PM2.5 Concentrations

On Tuesday, January 31, 2012, the Calexico FRM monitor recorded a 24-hour average PM2.5 concentration of 37.7 µg/m3. From filter-based measurements, PM2.5 concentrations at the El Centro and Brawley monitoring sites were 13.0 and 22.7 µg/m3, respectively. The AQI value on this day was 111 (unhealthy for sensitive groups) and was the second highest AQI value recorded in Imperial County for 2012 (Figure 81). As shown in Figure 82, a high value was only recorded at Calexico, further indicating a localized event. January 30 was declared a no burn day. On January 31, three permitted agricultural burns totaling 214 acres occurred from 1:00 pm to 3:00 pm. 144 of the 214 acres burned were in the western part of Calexico and the burns occurred between 1:00-3:00 pm when the PM2.5 levels were low. In addition, there were approximately 30 miscellaneous burns of brush piles. All of these burns were compliant with the District’s Open Burning rule.

**Figure 81. Daily Peak AQI for January 31, 2012**

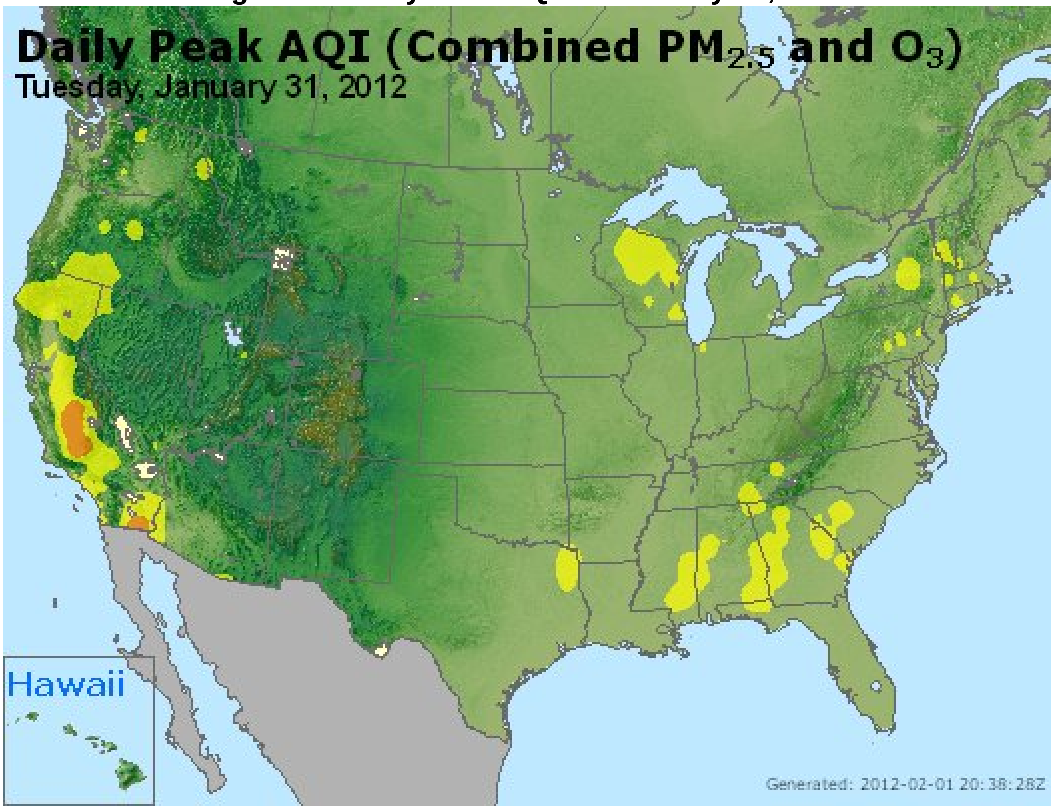
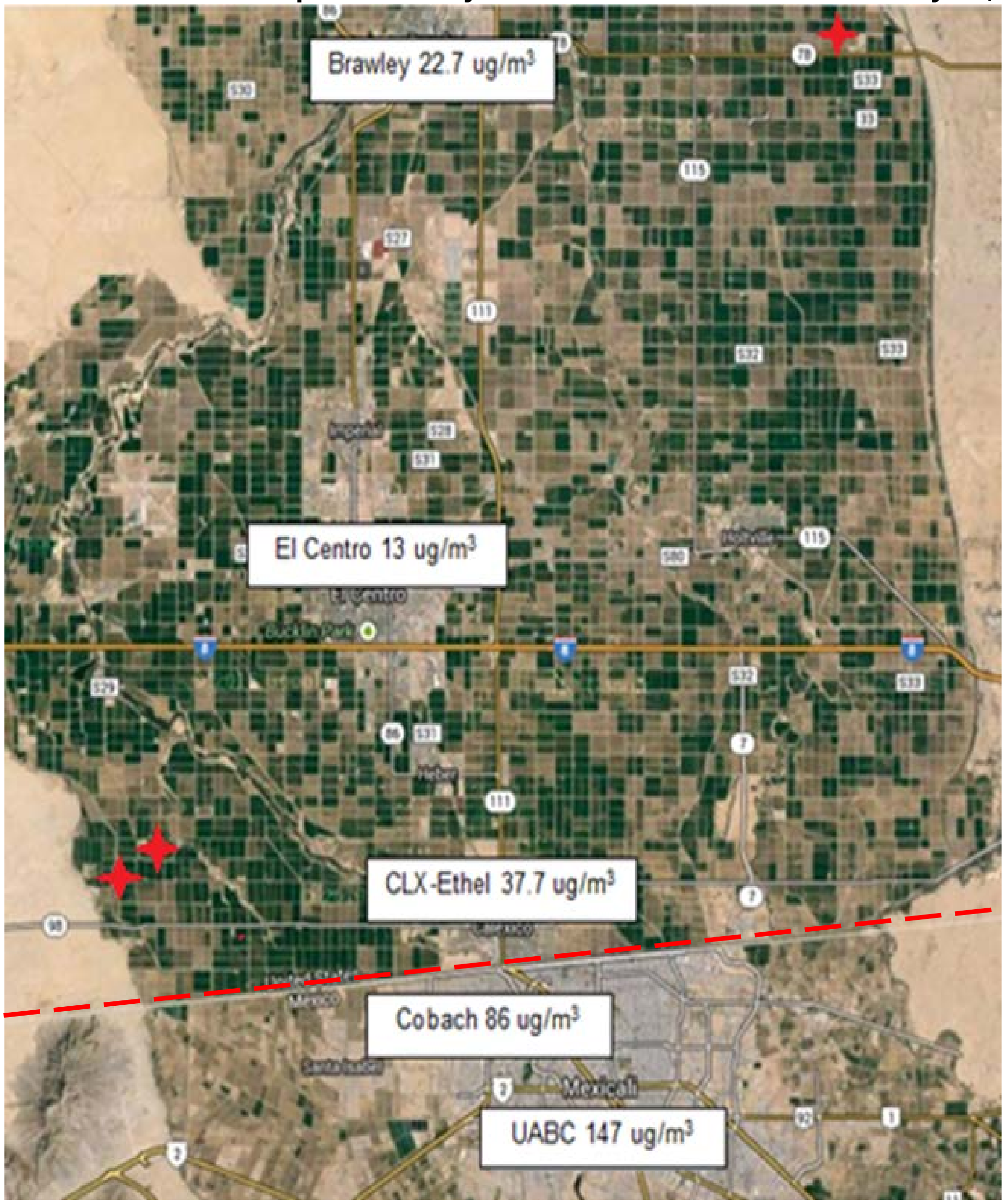



Figure 82 shows the spatial distribution of 24-hour average PM2.5 concentrations recorded at each monitoring site in Imperial County on January 31. The 37.7 µg/m3 concentration measured at Calexico more than twice the annual average for that site in 2012. The strong PM2.5 concentration gradient from the Mexicali monitors to the Calexico monitor—less than a mile upwind from Mexicali—to the Brawley and El Centro sites just to the north suggests that the emissions impact on the Calexico monitor differs substantially from the impact experienced by the Brawley and El Centro monitors. Although the concentration gradient differs on January 31 as compared to other Calexico exceedance days, concentrations were still much higher near the border. The decreasing concentration gradient from south-to-north, typical of other Calexico exceedance days, is very evident. In addition, ambient data from two Mexicali PM2.5 monitoring sites, COBACH and UABC (COBACH recorded an average of 86 µg/m3; UABC 147 µg/m3 ), further supports the contention that the emission sources responsible for these high concentrations are located south of the border and are not of U.S. origin.

With similar sources and meteorology, the expectation is that PM2.5 concentrations measured at Calexico, El Centro, and Brawley would be similar. The decreasing gradient northward is consistent with the Calexico-Mexicali single air shed concept and points to cross-border emissions as the source of high concentrations measurements at Calexico.

**Figure 82. Mexicali and Imperial County PM2.5 concentrations on January 31, 2012**

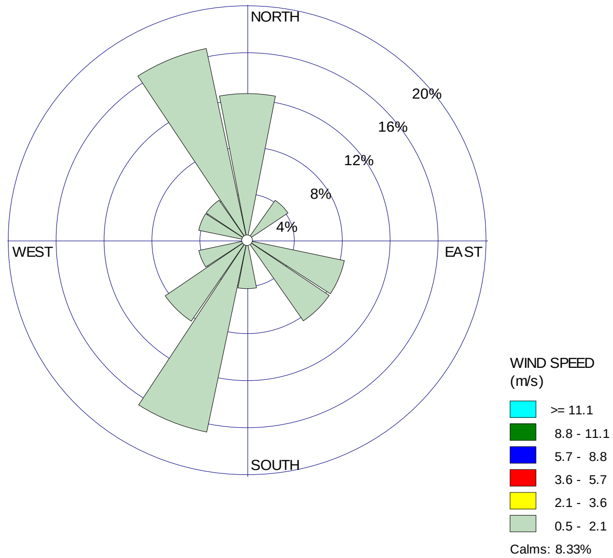



**Red markers indicate the locations of agricultural burns*

<u>Meteorology</u>

As with the other Calexico exceedance days in this analysis, surface hourly resultant wind data show that stagnant conditions were prevalent on January 31. The 24-hour average resultant wind speed measured at Calexico was 0.7 mps and the maximum was 1.6 mps. The wind rose data indicates that the directionality was evenly divided between winds from north and those from the south (Figure 83), although with winds of this magnitude, directionality has a higher degree of uncertainty. In the early morning hours temperatures were as low as 45° F, increasing the possibility of emissions from household heating (e.g., fireplace and wood stove burning).

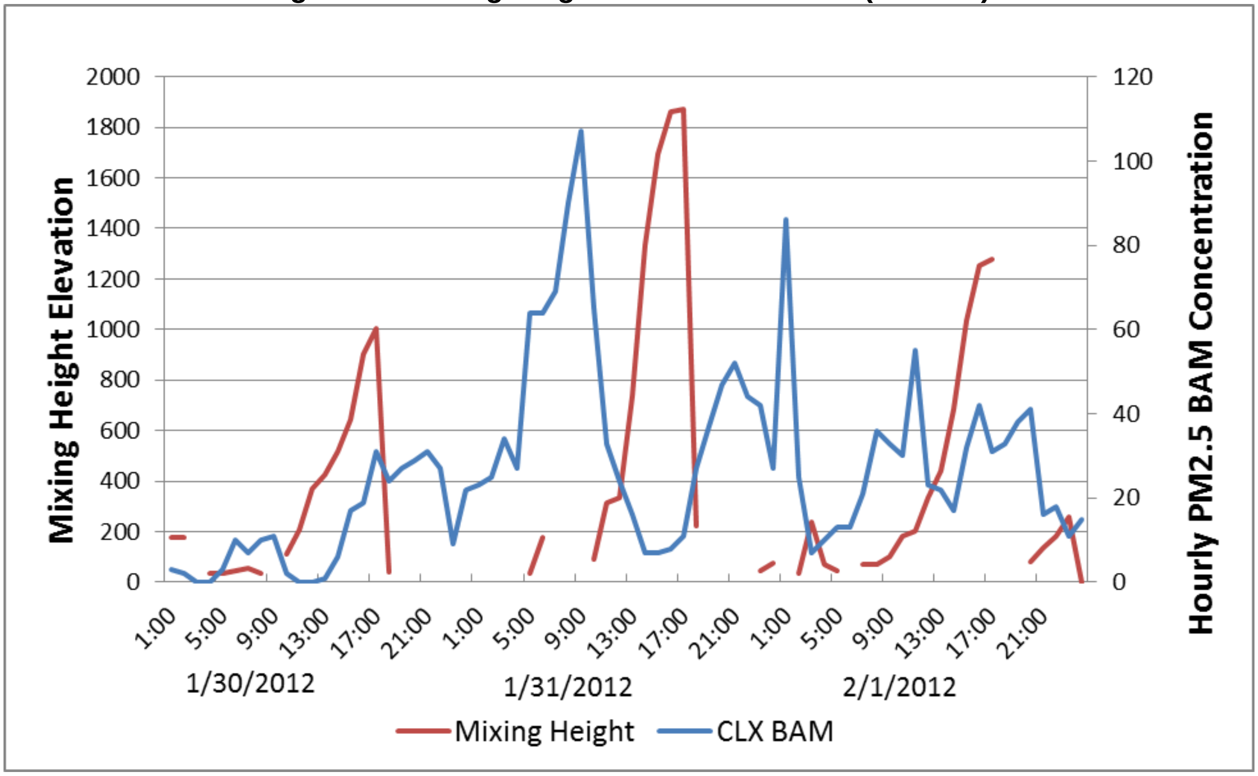
**Figure 83. Wind Rose on January 31, 2012**




To further characterize meteorological conditions on January 31 which may have influenced PM2.5 concentrations measured at the Calexico station, staff evaluated data on atmospheric mixing height and its correlation with PM2.5 mass data. The nearest routine data collection points to Calexico for radiosonde data are Yuma, Arizona, and Tucson, Arizona. Both of these locations have topography similar to that of Calexico. Yuma data were less complete for January 31, so data from Tucson were used to generate a plot of hourly mixing heights over a three day period that includes the January 31 exceedance.

Figure 84 displays the mixing height and hourly PM2.5 BAM measurements at Calexico. While data gaps exist for the atmospheric soundings, the overall trend over the three day period shows an inverse relationship between mixing height and concentrations. Decreasing mixing height corresponds to increasing PM2.5 concentrations as low vertical mixing confines pollutants. This plot corroborates surface wind data and supports the concept that emissions from Mexicali, confined to the Calexico-Mexicali air shed with reduced pollutant dispersion due to low wind speed and reduced mixing height, resulted in higher PM2.5 concentrations on January 31 than would have been observed in the absence of emissions from Mexico.

**Figure 84. Mixing Height vs. Calexico BAM (1/30-2/1)**




<u>Analysis of the Event</u>

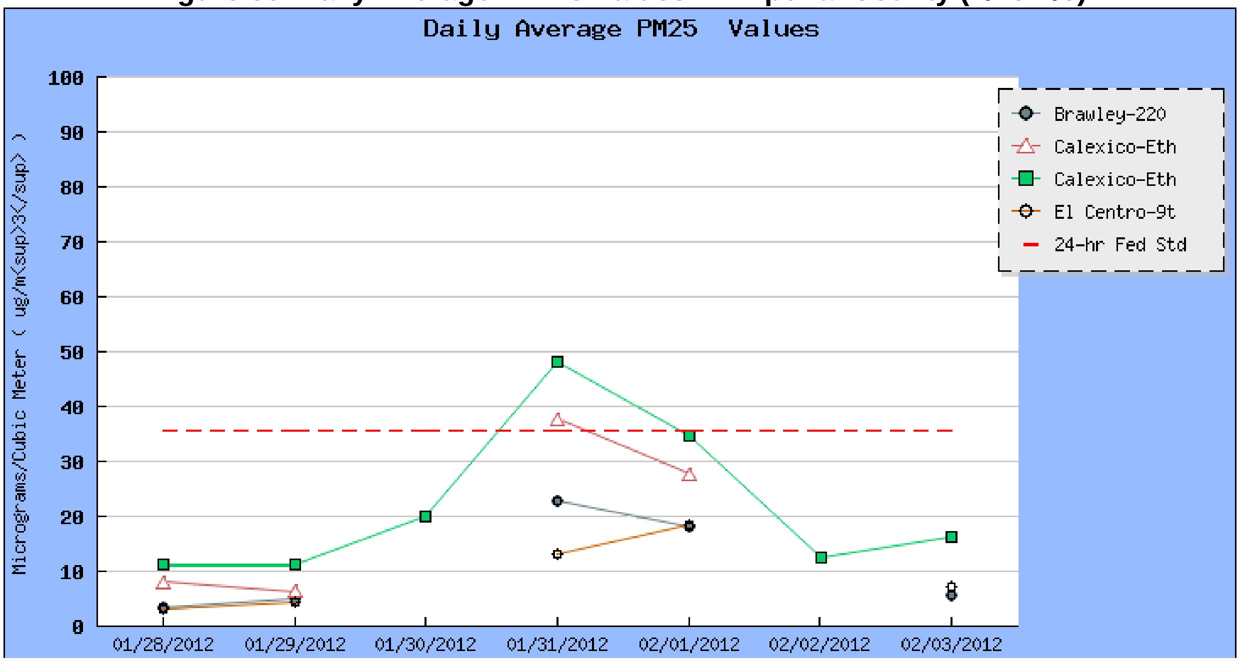
Toward the end of January, resultant wind speeds at Calexico averaged around 1.3-2.0 mps, with maximums as high as 3.6 mps. On the days prior to January 31, the 24-hour average PM2.5 concentrations at the Calexico BAM monitors were low, less than 20 $\mu g/m^3$. On January 31, the wind speed average dropped to 0.7 mps and the PM2.5 BAM concentrations increased, ultimately leading to an exceedance of the 24-hour PM2.5 standard.

PM2.5 concentrations began to build at the monitoring station after noon on January 30 and remained fairly high throughout the morning of January 31. The concentrations remained between 23 and 34 ug/m3 from midnight until 3:00 am, increasing to 64 µg/m3 at 4:00 am, and reaching a maximum of 107 µg/m3 at 8:00 am. The high PM2.5 concentrations in the morning hours coincided with the low temperatures on that day (45 to 61° F). PM2.5 concentrations began to decrease after the 8:00 am peak, due in part to a shift in wind direction to the north, a slight increase in the wind speeds, increasing temperatures, and an increase in the mixing height. Under the influence of the north wind, concentrations decreased to a low of 7 µg/m3 around 1:00 pm and stayed fairly low until 4:00 pm. A wind shift back to the south, and a lowering of the mixing height, saw concentrations at Calexico peaking at 52 µg/m3 at 8:00 pm.

At midnight on February 1, the PM2.5 concentration was 86 µg/m3. Concentrations decreased rapidly to 7 µg/m3 by 2:00 am, when the wind briefly shifted to the north.

Concentrations rose from 10 to 55 $\mu g/m^3$ under south winds, with a brief decrease around noon, again when the wind directly shifted to the north, and the resulting 24-hour BAM PM2.5 concentration was 27.8 µg/m3. This 24-hour average, although high, remained below the NAAQS. Figure 85 shows the daily average PM2.5 values (FRM and BAM) from January 28 through February 3, 2012.

**Figure 85. Daily Average PM2.5 Values in Imperial County (1/28-2/8)**




*POC1 is on a 1-in-3 day sampling schedule and POC3 records hourly data

Wind speed and direction were plotted with the BAM PM2.5 concentration measurements from January 29 through February 1. These data show that low wind speeds, particularly in the early morning and late night hours, are correlated with higher PM2.5 concentrations (Figure 86). Generally, the highest concentrations on January 31 were seen under a combination of southerly flow conditions (79 - 272 degrees) (Figure 87) and/or calm to low winds.

**Figure 86. PM2.5 BAM vs. Wind Speed at Calexico on 1/29-2/1**

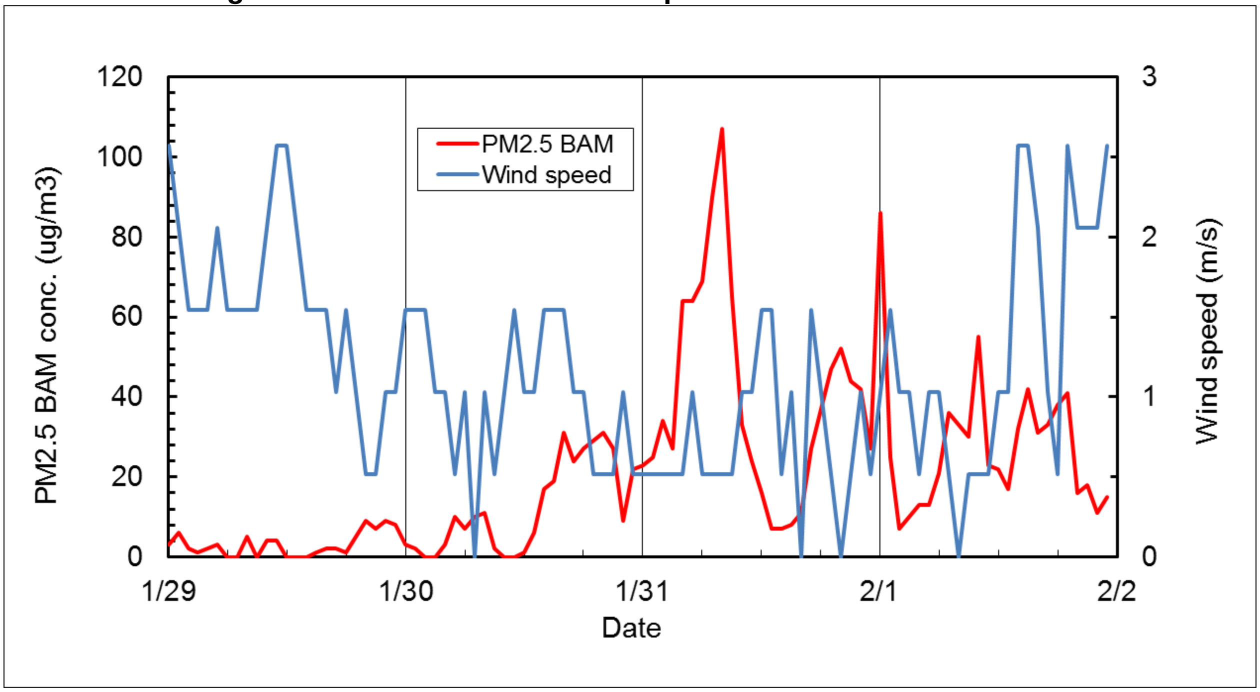
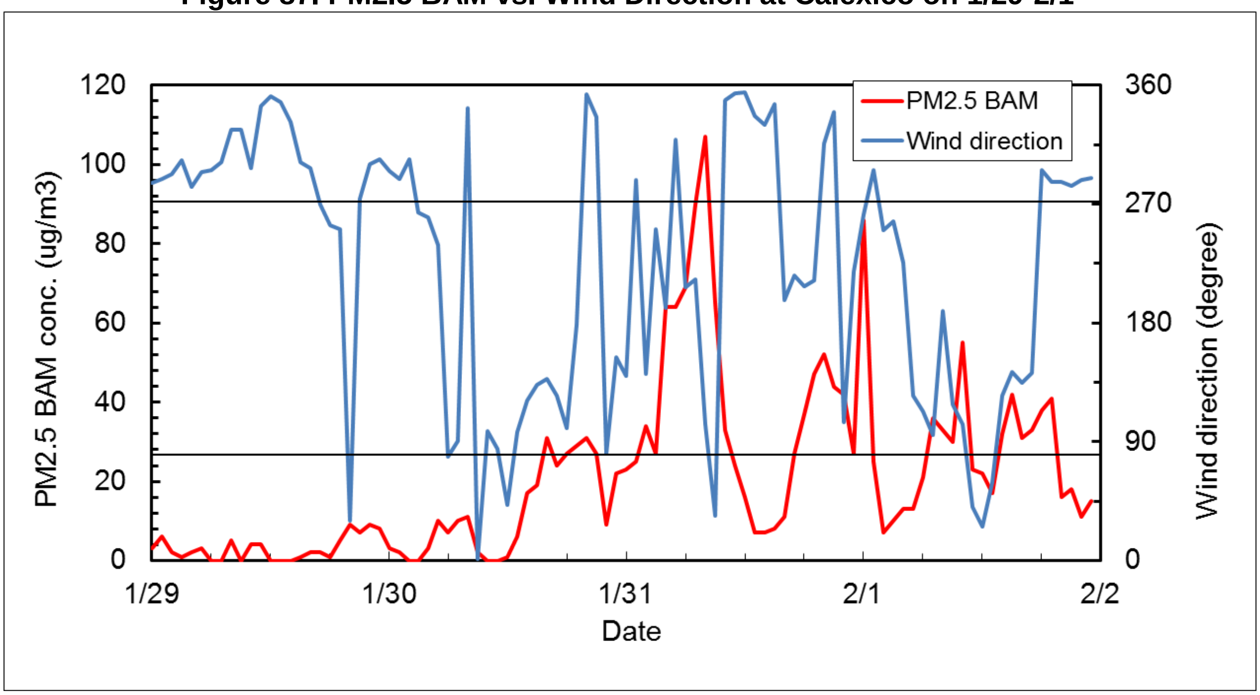


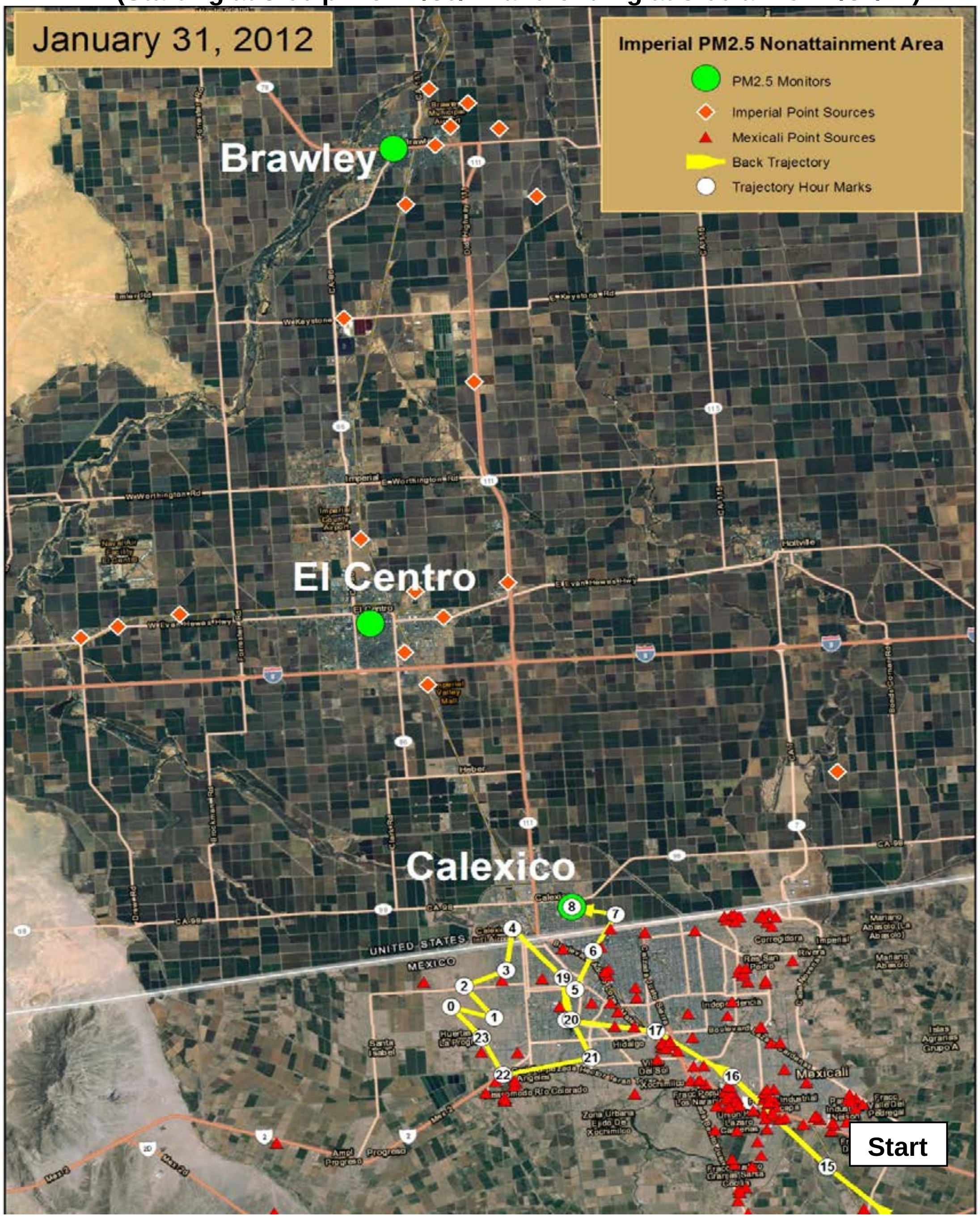

**Figure 87. PM2.5 BAM vs. Wind Direction at Calexico on 1/29-2/1**




*79-272 degree winds are from the south. 273-78 degree winds are from the north.

The spatial nature of the January 31 exceedance event was assessed using a back-trajectory plot (Figure 88). The objective of a back-trajectory plot is to discern the pathway that an air parcel traveled prior to passing over the site of a continuous pollutant monitor, i.e., a BAM. By calculating the coordinates of this traverse and overlaying the resulting travel path onto an aerial photograph, the potential for transport of emissions from sources under the path to the monitor can be quickly assessed by visual inspection.

**Figure 88. January 31 air parcel back-trajectory**
**(Starting at 3:00 pm on 1/30/12 and ending at 8:00 am on 1/31/12)**



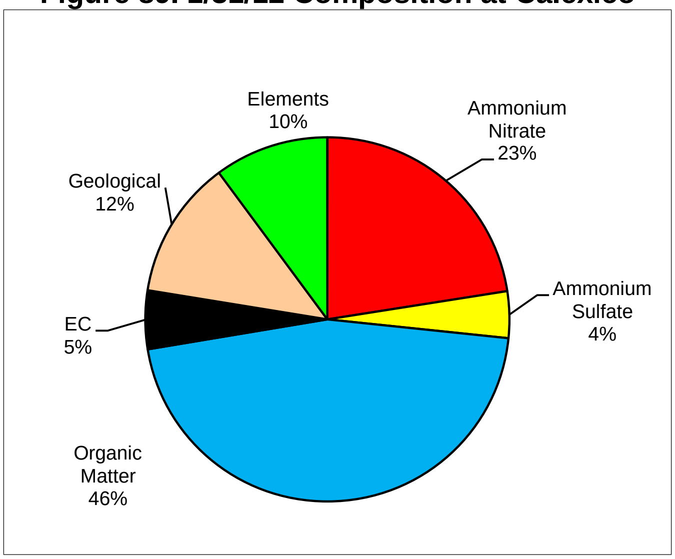

The back trajectory developed for January 31, 2012 started at Calexico at the hour of the highest PM2.5 BAM concentration (8:00 am) and followed an air parcel back to

3:00 pm on January 30, 2012. This indicates the air parcel that impacted the Calexico site at 8:00 am on January 31 was in Mexicali in the late night hours on the 30 and the early morning hours of the 31 when concentrations were elevated.

Identification of Emissions

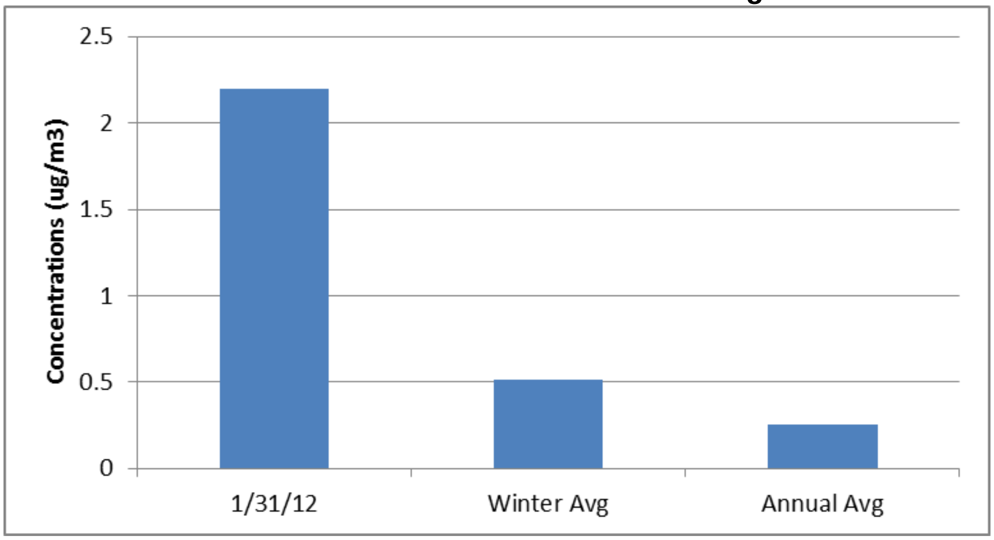
To aide in identifying the source of emissions potentially impacting the Calexico monitor, staff analyzed speciation data available at the station on December January 31. The speciation data shows that almost half of the concentration was from organic matter and 23 percent was from ammonium nitrate. High concentrations of elemental species were also present on this day. High concentrations of carbonaceous aerosols indicate that combustion is the main source of PM2.5 while high concentrations of elemental species suggest that emissions come from non-fossil fuel sources on January 31 (Figure 89). Agricultural burning was allowed on this day in Imperial County. However, the amount burned was only 214 acres at three separate locations and occurred between 1:00 pm and 3:00 pm when PM2.5 levels were low.

**Figure 89. 1/31/12 Composition at Calexico**



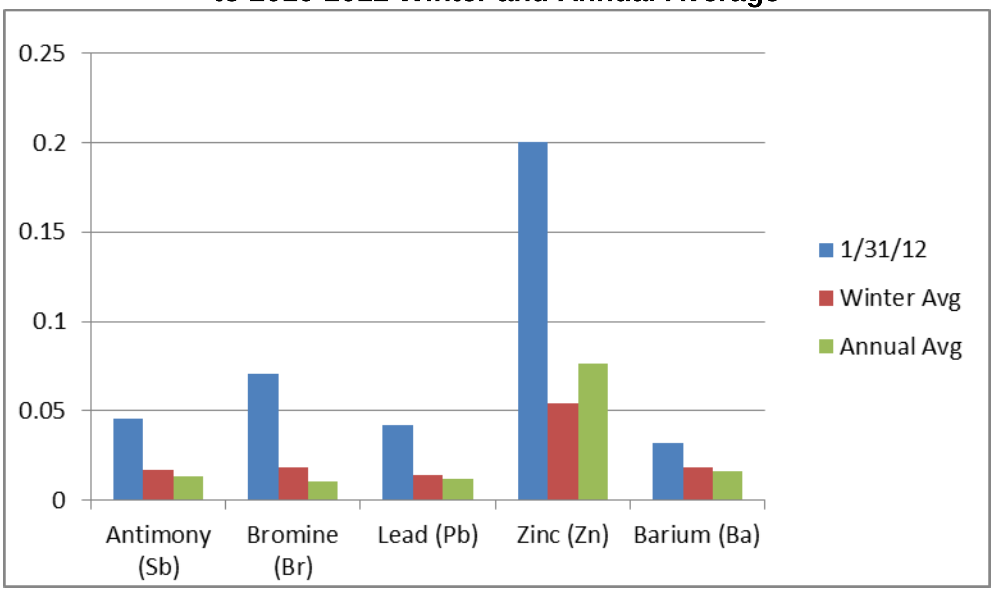

On January 31, 2012 elemental species concentrations at Calexico were elevated compared to both winter and annual average concentrations. Concentrations of elemental chlorine were four times higher compared to the winter average and nine times higher compared to the annual average (Figure 90). Concentrations of antimony, bromine, lead, zinc, and barium were two to four times higher compared to winter concentrations and two to seven times higher compared to the annual average (Figure 91).

**Figure 90. Comparison of Chlorine Concentrations on 1/31/2012 to 2010-2012 Winter and Annual Average**




*This data does include transport days but does not include invalidated days

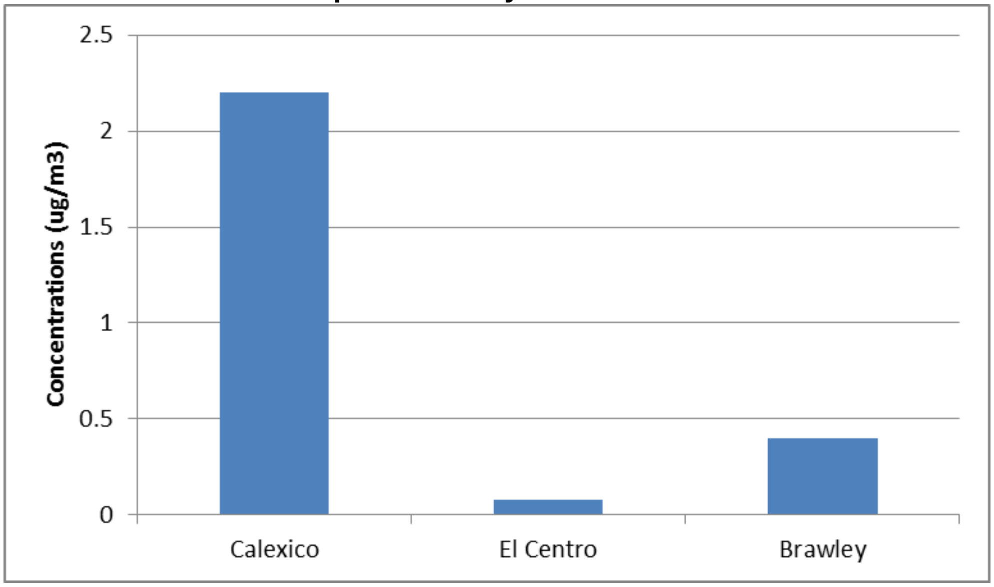
**Figure 91. Comparison of Select Species Concentrations on 1/31/2012 to 2010-2012 Winter and Annual Average**




*This data does include transport days but does not include invalidated days

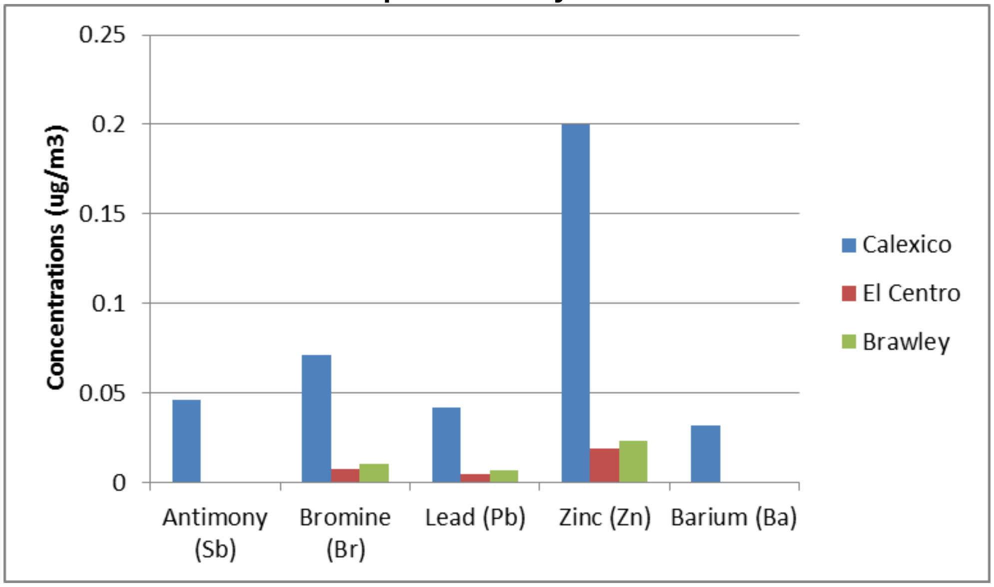
In comparing elemental data at all the Imperial County sites for this day, it is obvious that Calexico was impacted at a far higher level than the other two sites. These other sites, Brawley and El Centro, had concentrations close to or below the detection limits. Concentrations of antimony and barium at both El Centro and Brawley were below the detection limits. Concentrations of bromine, lead, and zinc at Calexico were seven to eleven times higher, while chlorine was six times higher compared to Brawley and 29 times higher compared to El Centro (Figure 92 and 93).

**Figure 92. Comparison of Chlorine Concentrations Across Imperial County on 1/31/2012**




*This data does include transport days but does not include invalidated days

**Figure 93. Comparison of Select Elemental Species Concentrations Across Imperial County on 1/31/2012**

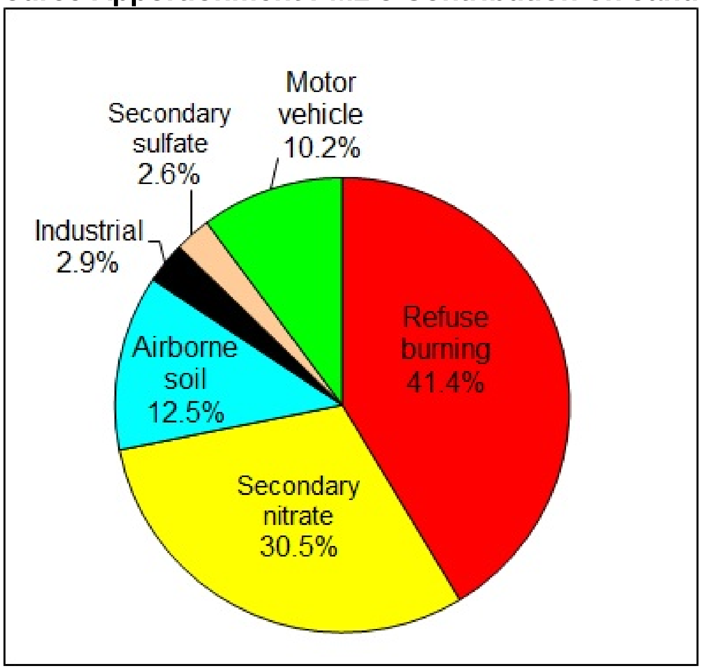



*This data does include transport days but does not include invalidated days

To provide information on the possible sources of emissions impacting the Calexico monitor, PM2.5 speciation data were analyzed using source apportionment model, Positive Matrix Factorization 2 (PMF2). PMF2 is a multivariate receptor model based on the positive matrix factorization (PMF) method. Fundamentally, this model analyzes characteristics of pollutants at the receptor site and, using mathematical algorithms, estimates the source contributions. This model is based on a weighted least square method that weights data points by their analytical uncertainties. A detailed description of PMF2 model procedure for Calexico is included in Appendix B.

In this analysis, a total of 159 samples and 27 species including PM2.5 concentrations collected between 2010 and 2012 were analyzed and six major sources were identified: Airborne soil, motor vehicle, secondary sulfate, secondary nitrate, refuse burning, and industrial. Figure 94 suggests that refuse burning and secondary nitrate were the major pollutant sources on January 31. Refuse burning was estimated to contribute 16.7 µg/m3 of the 37.7 µg/m3 concentration recorded at Calexico. Since refuse burning is not permitted in Imperial County, this impact—coupled with meteorological data—may be attributed to emissions from Mexicali.

**Figure 94. Source Apportionment PM2.5 Contribution on January 31, 2012**




The source apportionment percentages for refuse burning and industrial emissions were used to estimate the PM2.5 contribution at Calexico on January 31 (Table 14). Based on receptor modeling results, without refuse burning emissions occurring on January 31 the Calexico monitor would likely not have exceeded the 24-hour PM2.5 standard. If industrial emissions from Mexicali are excluded, the concentration on this day decreases further. These are important findings given that refuse burning and industrial emissions of the type identified through receptor modeling are essentially non-existent on the U.S. side of the border in Imperial County.

**Table 14. Contribution of Refuse Burning and Industrial Emissions to the PM2.5 Concentration on January 31, 2012**

| FRM Concentration | Without Refuse burning emissions | Without Refuse Burning & Industrial emissions |
|---|---|---|
| 37.7 µg/m3 | 22.1 µg/m3 | 21.0 µg/m3 |

**December 23, 2012**

Analysis Methods

For the December 23, 2012 exceedance day analysis, staff used various methods to evaluate the impact of emissions on the Calexico PM2.5 monitor. Referencing EPA guidance, staff evaluated the following data: (1) PM2.5 concentration gradient within the Imperial County NA and Mexicali with associated AQI; (2) predominant wind speed and wind direction at Calexico on December 23; (3) mixing height vs. non-FEM BAM data for December 22-December 24; (4) changes in the hourly BAM PM2.5 concentrations with the wind speed and direction experienced at the Calexico monitor on December 21-December 24; (5) an air parcel back-trajectory starting at the hour of highest hourly recorded concentration at the Calexico site; (6) speciation data on December 23, to identify the major components of PM2.5, including a further breakdown of elemental species; and, (7) a quantification of the emissions impact on concentrations at the Calexico site for certain chemical species on December 23.

Data not available for this analysis include; PM2.5 BAM data for Brawley and El Centro; and specific media reports, from either north or south of the border, which would substantiate activities impacting air quality in the area was unavailable. However, hourly PM2.5 data coupled with meteorological data, speciation data, and a back-trajectory analysis, provide evidence that the Calexico monitor would not have recorded an exceedance of the 24-hour NAAQS but for emissions from Mexicali on December 23.

PM2.5 Concentrations

On Sunday, December 23, 2012, the Calexico FRM monitor recorded a 24-hour average PM2.5 concentration of 64.7 µg/m3. From filter-based measurements, PM2.5 concentrations at the El Centro and Brawley monitoring sites were 26.4 and 15.5 µg/m3, respectively. The AQI value on this day was 156 (unhealthy for sensitive groups) and was the highest AQI value recorded in Imperial County for 2012 (Figure 95). Small green waste only burns were allowed on December 22 outside of Calexico, but December 23 - 26 were declared “no burn” days in Imperial County.

**Figure 95. Daily Peak AQI for December 23, 2012**

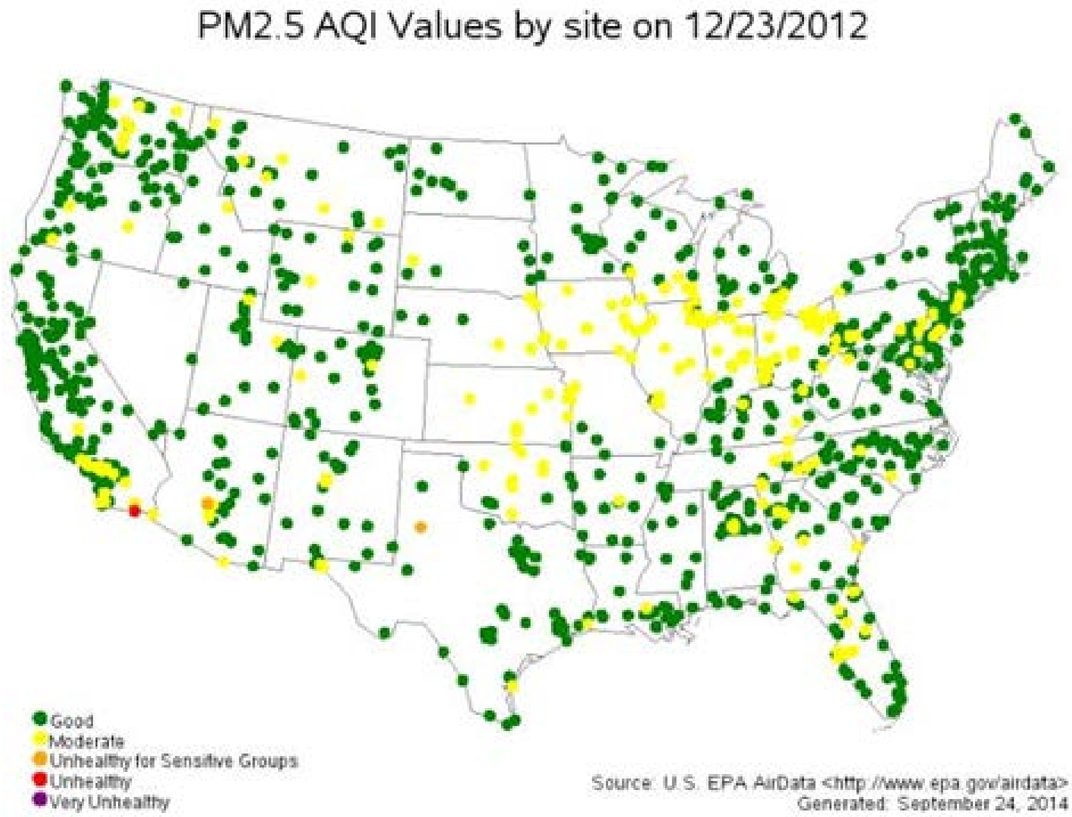
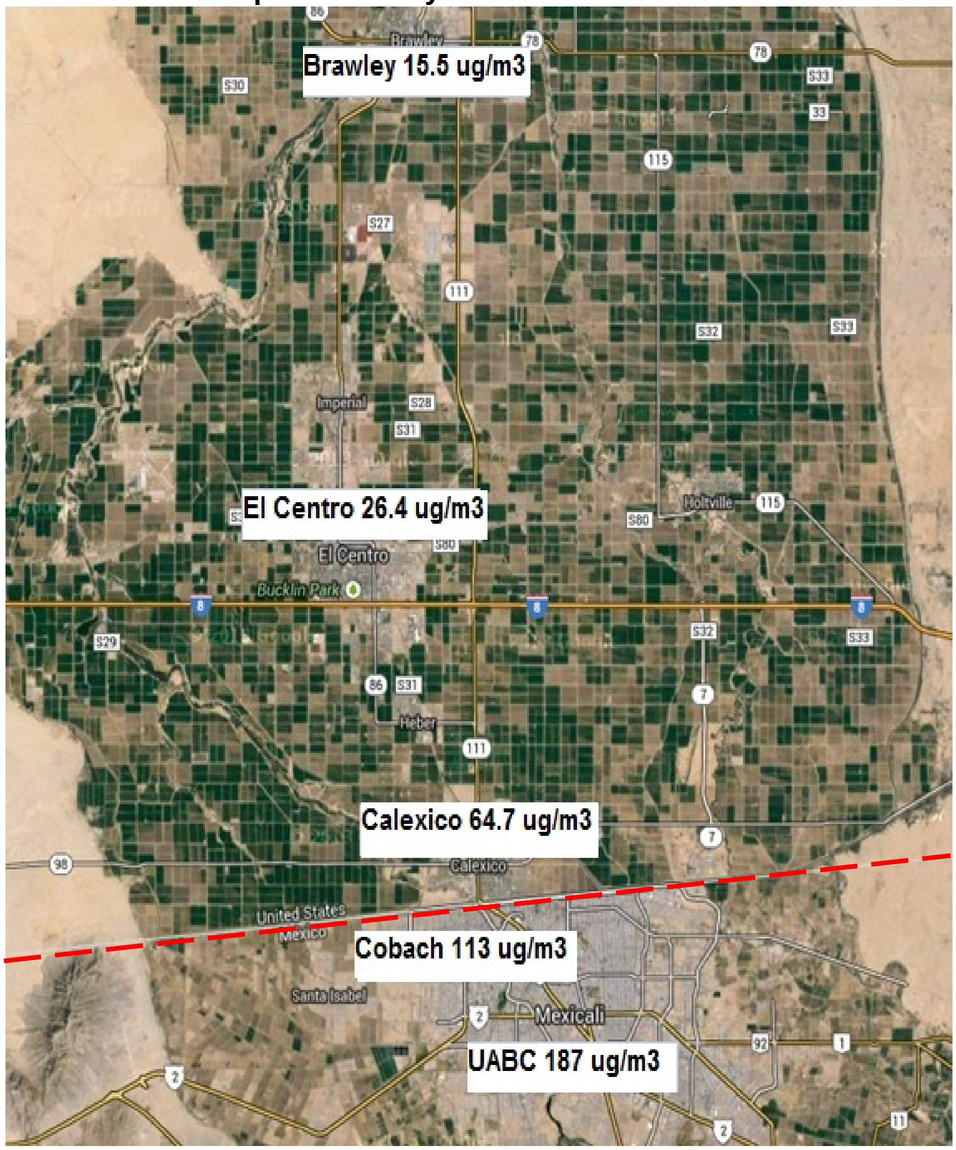



Figure 96 shows the spatial distribution of 24-hour average PM2.5 concentrations recorded at each monitoring site in Imperial County on December 23. The 64.7 µg/m3 concentration measured at Calexico was more than four times the annual average for that site in 2012. The strong PM2.5 concentration gradient from the Mexicali monitors to the Calexico monitor—less than a mile upwind from Mexicali—to the Brawley and El Centro sites just to the north suggests that the emissions impact on the Calexico monitor differs substantially from any impacts experienced by the Brawley and El Centro monitors. Although the concentration gradient differs on December 23 as compared to other Calexico exceedance days, concentrations are much higher near the border. The decreasing concentration gradient from south-to-north, typical of other Calexico exceedance days, is seen on December 23 as well. In addition, ambient data from two Mexicali PM2.5 monitoring sites, COBACH and UABC, were available on December 23. Ambient PM2.5 concentration data from these two sites, (COBACH recorded an average of 113 µg/m3; UABC 187 µg/m3), adds further support that emission sources responsible for these high concentrations were located south of the border and not of U.S. origin.

With similar emission sources and meteorology, the expectation is that PM2.5 concentrations measured at Calexico, El Centro, and Brawley would be similar. The decreasing gradient northward is consistent with the Calexico-Mexicali single air shed concept and points to cross-border emissions as the source of high concentrations measurements at Calexico.

**Figure 96. Mexicali and Imperial County PM2.5 concentrations on December 23, 2012**

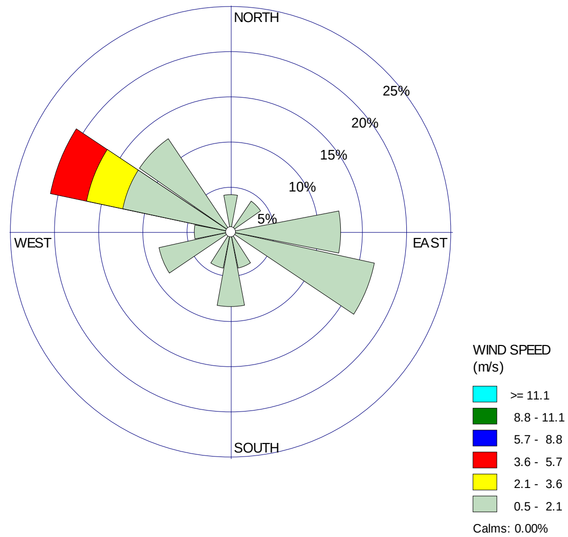



<u>Meteorology</u>

As with the other Calexico exceedance days in this analysis, surface hourly wind data show that stagnant conditions were prevalent on December 23. The 24-hour average resultant wind speed measured at Calexico was 2.1 mph and the hourly maximum was 8.1 mph. The wind rose data indicates that the directionality was divided between winds from north and those from the south (Figure 97). In addition, in the early morning hours, temperatures in Calexico were as low as 43° F.

Surface hourly wind speed data collected in Calexico were generally low. Diurnal plots of PM2.5 BAM concentration, wind speed, and wind direction indicate that the higher wind speeds from the west-northwest were associated with low PM2.5 concentrations. Although winds were from the south at the beginning and toward the end of the day, the higher wind speeds later in the day likely caused dilution of the PM2.5 in the air shed, resulting in decreased concentrations.

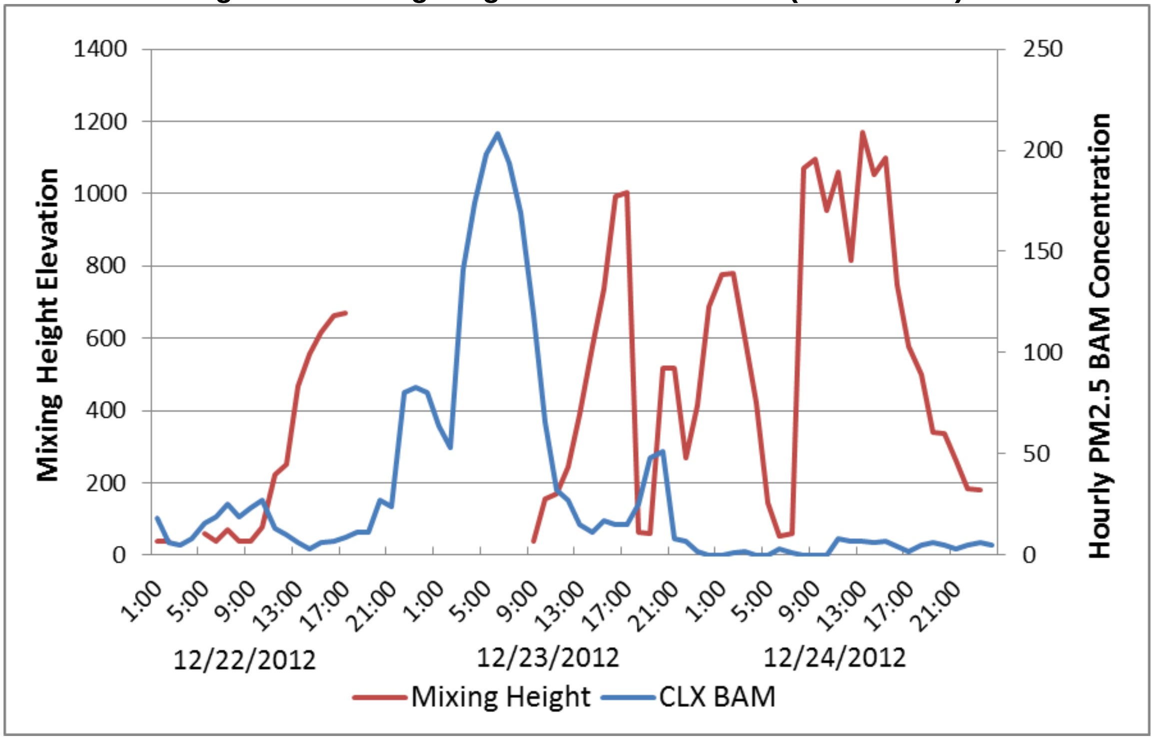
**Figure 97. Wind Rose on December 23, 2012**




To further characterize meteorological conditions on December 23 which may have influenced PM2.5 concentrations measured at the Calexico station, staff evaluated data on atmospheric mixing height and its correlation with PM2.5 mass data. The nearest routine data collection points to Calexico for radiosonde data are Yuma, Arizona, and Tucson, Arizona. Both of these locations have topography similar to that of Calexico. Yuma data were less complete for December 23, so data from Tucson were used to generate a plot of hourly mixing heights over a three day period that includes the December 23 exceedance.

Figure 98 displays the mixing height and hourly PM2.5 BAM measurements at Calexico. While data gaps exist for the atmospheric soundings, the overall trend over the three day period shows an inverse relationship between mixing height and concentrations. Decreasing mixing height corresponds to increasing PM2.5 concentrations as low vertical mixing confines pollutants. This plot corroborates surface wind data and supports the concept that emissions from Mexicali, confined to the Calexico-Mexicali air shed with reduced pollutant dispersion due to low wind speed and reduced mixing height, resulted in higher PM2.5 concentrations on December 23 than would have been observed in the absence of emissions from Mexico.

**Figure 98. Mixing Height vs. Calexico BAM (12/22-12/24)**



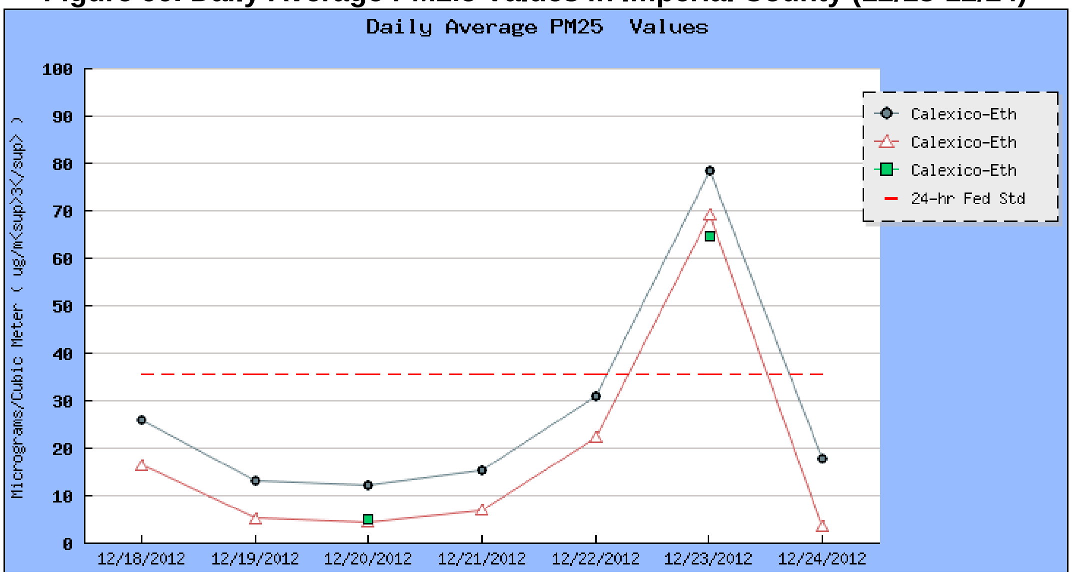

Analysis of the Event

On Sunday, December 23, 2012, the 24-hour PM2.5 concentration at the Calexico monitor was 64.7 µg/m3. The *Las Posadas* festivities occur every year in Mexicali on December 23. *Las Posadas* are religious holidays celebrated each evening from December 16 to December 24. El Centro and Brawley recorded values 2.5 and 4 times lower, respectively. PM2.5 concentration data were also available from Mexicali monitors (UABC and COBACH) for December 23. The UABC and COBACH PM2.5 monitoring stations recorded 24-hour PM2.5 concentrations of 187 and 113 µg/m3, respectively. The gradient of PM2.5 concentrations on December 23 is similar to the gradient seen on December 11; highest concentrations in the south and decreasing moving northward.

PM2.5 concentrations began to build at the Calexico monitoring station at 9:00 pm on December 22 and concentrations remained in the 80 µg/m3 range for the rest of the night. Concentrations remained high throughout the next morning, ranging from 53 to 208 µg/m3, until after 11:00 am when the winds shifted from the south to the north. The maximum concentration 208 µg/m3 at 5:00 am was consistent with a wind shift from west to southeast. Under the auspices of a north wind, PM2.5 concentrations remained low from 11:00 am through 4:00 pm. This wind shift was accompanied by a slight increase in wind speeds and an increase in the mixing height. From 5:00-7:00 pm the PM2.5 concentrations again increased (25 - 51 µg/m3) with another wind shift from north to south. At 7:00 pm the winds shifted back to north and PM2.5 concentrations decreased substantially from 8:00 pm on. The BAM measured a 24-hour average concentration of 69.1 µg/m3 on December 23 at the Calexico monitor with the peaks occurring between midnight-9:00 am and 5:00 and 7:00 pm.  The temperatures in the morning hours of December 23 were as low as 43° F at the Calexico station.

Figure 99 shows the daily average PM2.5 values (FRM and BAM) at Calexico from December 18 through December 24, 2012.

**Figure 99. Daily Average PM2.5 Values in Imperial County (12/18-12/24)**




*POC1 is on a 1-in-3 day sampling schedule and POC3 records hourly data

Wind speed and wind direction data were plotted with the BAM PM2.5 concentration measurements from December 21 through December 24.  These data show that low wind speeds, particularly in the early morning hours, are correlated with higher PM2.5 concentrations (Figure 100).  Generally, the highest concentrations on December 23 were seen under a combination of southerly flow conditions (79 - 272 degrees) (Figure 101) and calm to low winds.

**Figure 100. PM2.5 BAM vs. Wind Speed at Calexico on 12/21-12/24**

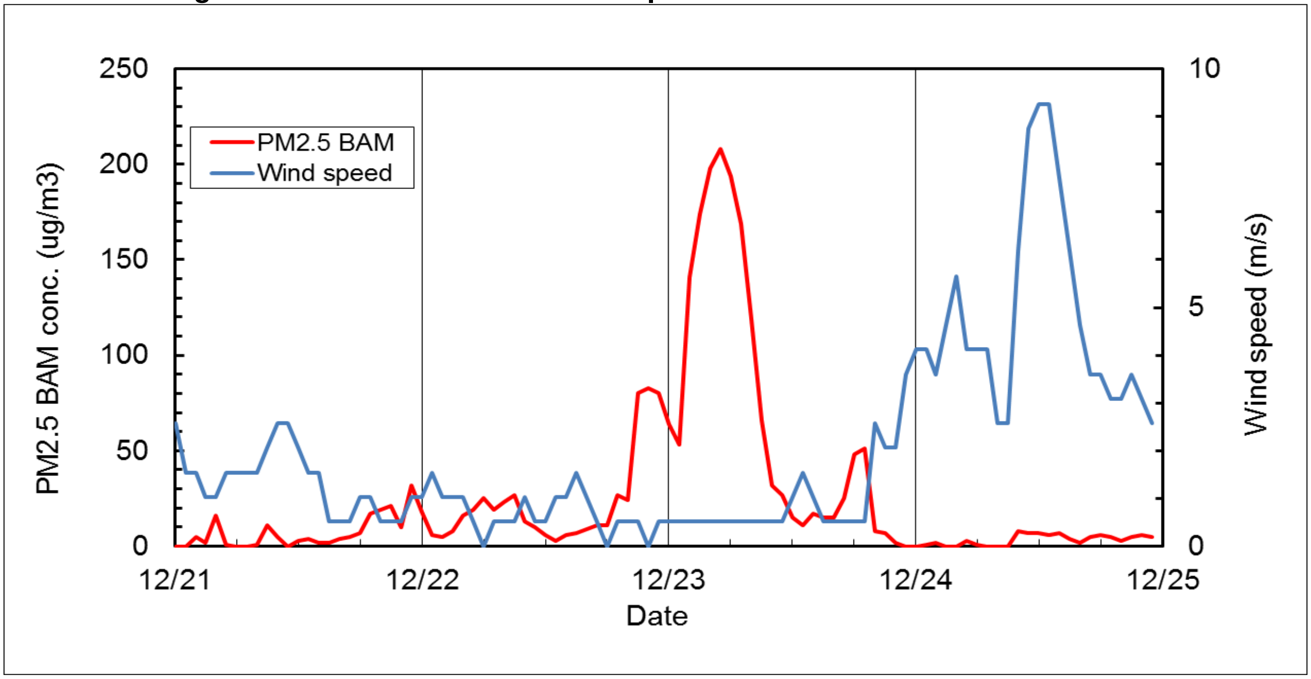
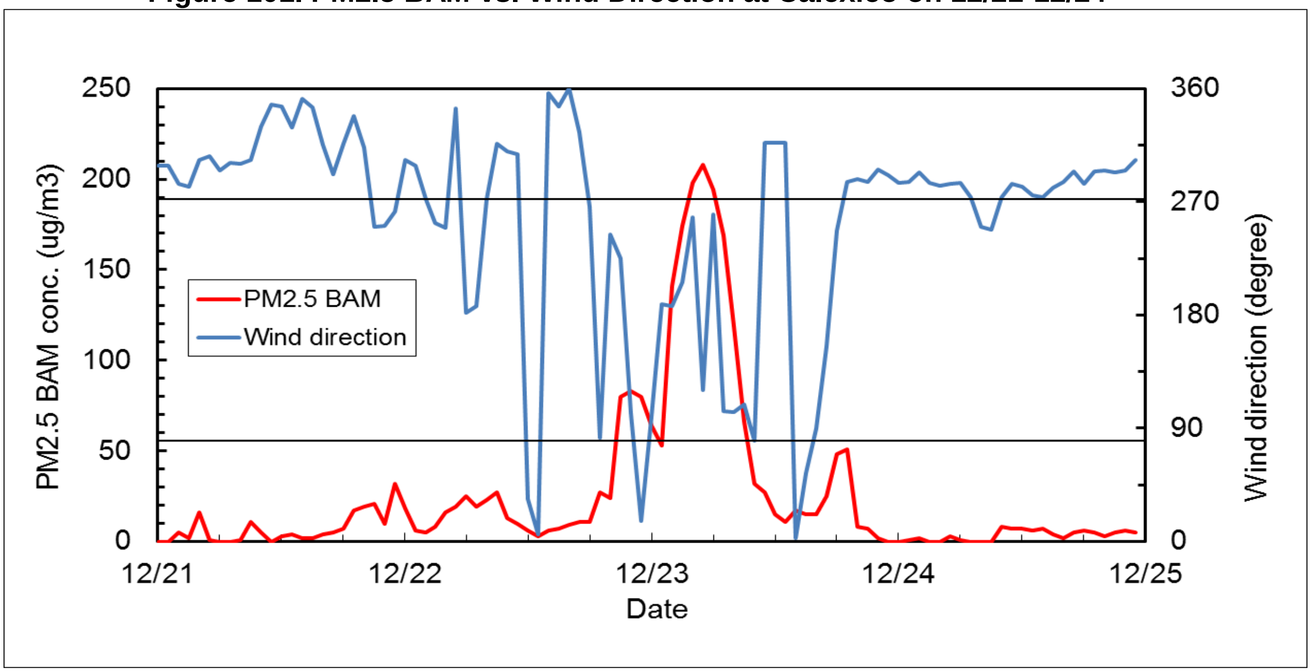


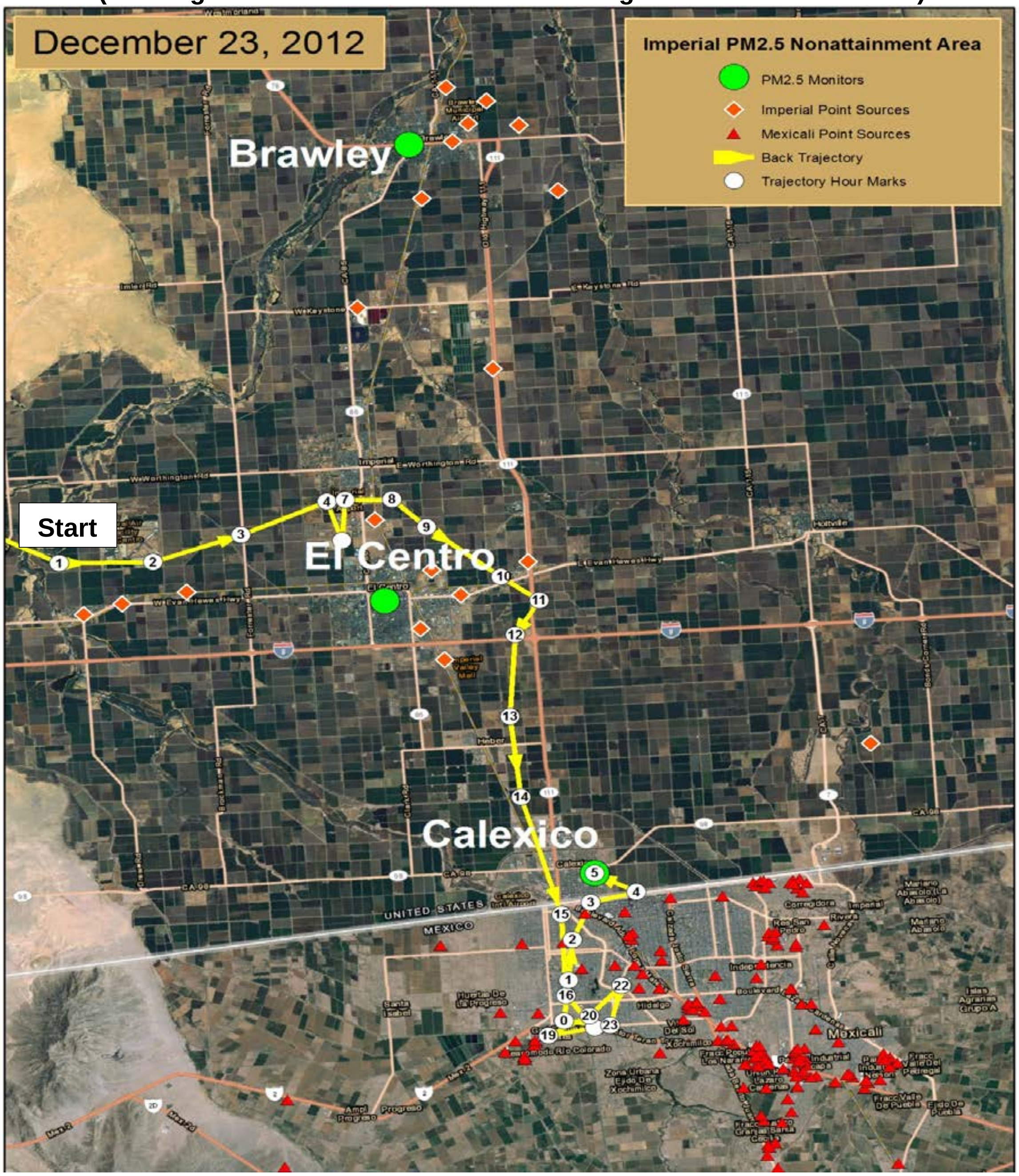

**Figure 101. PM2.5 BAM vs. Wind Direction at Calexico on 12/21-12/24**




*79-272 degree winds are from the south. 273-78 degree winds are from the north.

The spatial nature of the December 23 exceedance event was assessed using a back-trajectory plot (Figure 102). The objective of a back-trajectory plot is to discern the pathway that an air parcel traveled prior to passing over the site of a continuous pollutant monitor. By calculating the coordinates of this traverse and overlaying the resulting travel path onto an aerial photograph, the potential for transport of emissions from sources under the path to the monitor can be quickly assessed by visual inspection.

**Figure 102. December 23 air parcel back-trajectory (Starting at 1:00 am on 12/22/12 and ending at 5:00 am on 12/23/12)**

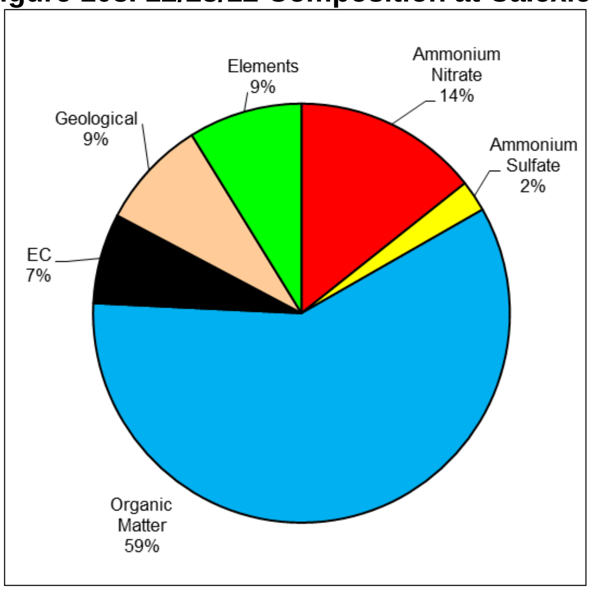



The back trajectory developed for December 23, 2012 started at Calexico at the hour of the highest PM2.5 BAM concentration and followed an air parcel back to midnight on December 22, 2012. This indicates the air parcel that impacted the Calexico site at 5:00 am on December 23 passed through Mexicali in the late night hours on December 22 and the early morning hours of December 23 when concentrations were elevated.

Identification of Emissions

To aide in identifying the source of emissions potentially impacting the Calexico monitor, staff analyzed speciation data available at the station on December 23. The speciation data shows that almost 60 percent of the concentration was from organic matter and 14 percent was from ammonium nitrate. High concentrations of elemental species were also present on this day. High concentrations of carbonaceous aerosols indicate that combustion is the main source of PM2.5 while high concentrations of elemental species suggest that emissions come from non-fossil fuel sources on December 23 (Figure 103). As mentioned, this profile is suggestive of combustion of non-fossil fuels and may be indicative of refuse burning, celebratory bonfires, or other combustion activity in Mexicali. Agricultural burning was not allowed on this day.

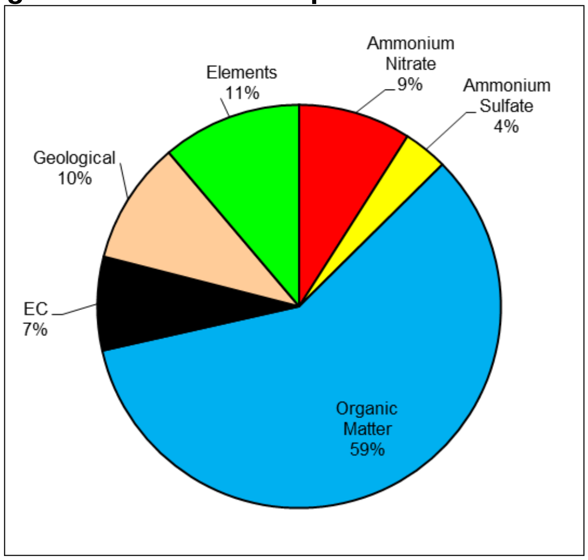
**Figure 103. 12/23/12 Composition at Calexico**




On December 23, 2012, elemental species concentrations at Calexico were elevated compared to both winter average and annual average concentrations. Concentrations of elemental chlorine were seven times higher compared to winter average and 13 times higher compared to the annual average. Concentrations of antimony, bromine, lead, and barium were two times higher compared to winter concentrations and two to five times higher compared to the annual average. Concentrations of zinc measured on December 23, 2012 were similar to winter and annual average concentrations.

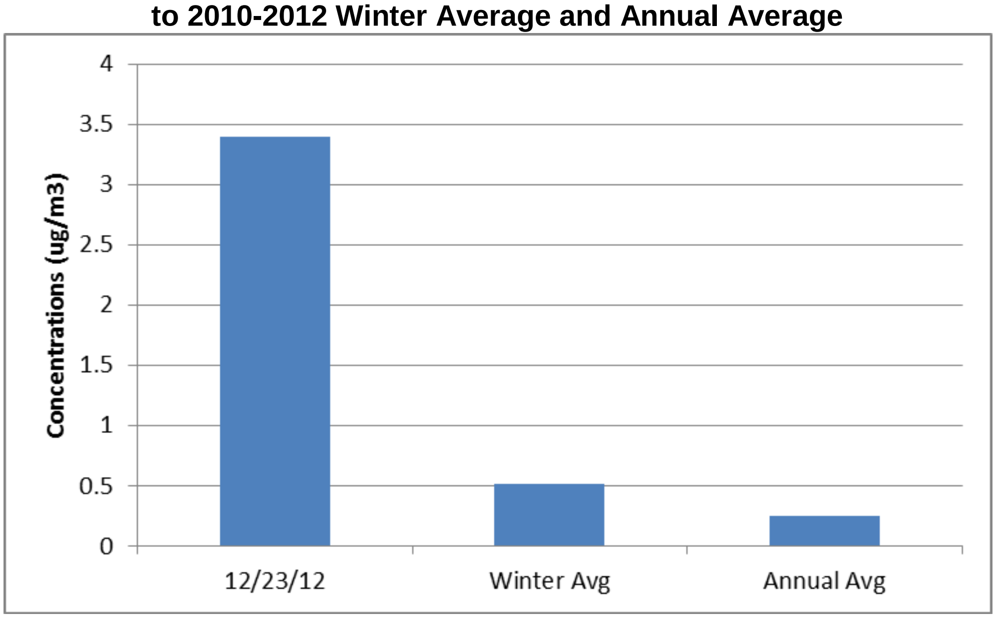
As mentioned in Section XI, the composition on December 23 is generally similar to other exceedance days, as measured by FRM and BAM instruments. It closely resembles the chemical composition data available for the single day the BAM monitor exceeded the level of the standard, January 22, 2012 (Figure 104). Exceedance days, regardless of whether they determined via FRM or BAM instruments, appear to exhibit similar chemical composition profiles.

**Figure 104.  PM2.5 Composition on 1/22/2012**



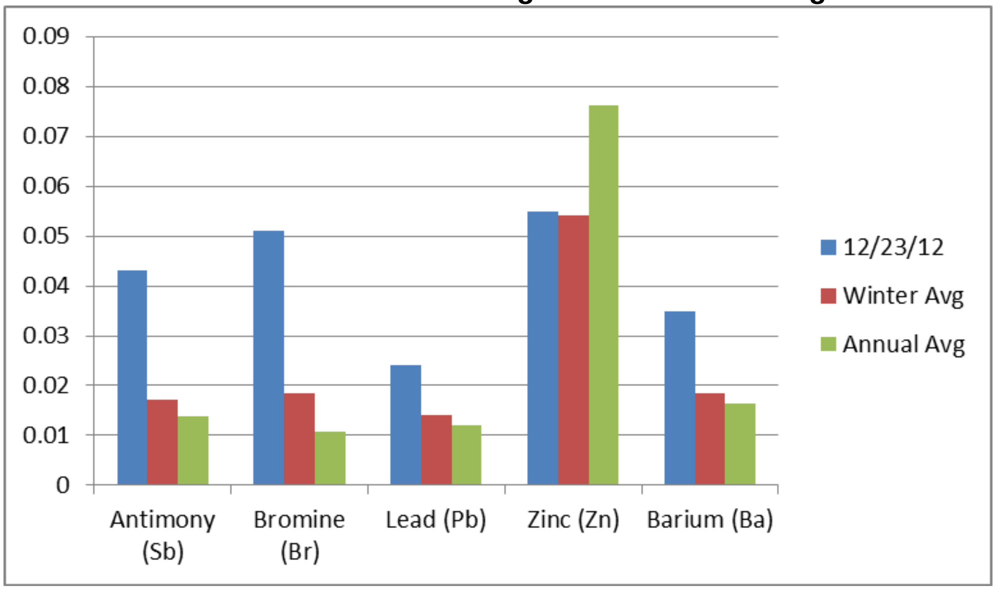

On December 23, 2012 elemental species concentrations at Calexico were elevated compared to both winter average and annual average concentrations.  Concentrations of elemental chlorine were seven times higher compared to winter average and 13 times higher compared to annual average (Figure 105).  Concentrations of antimony, bromine, lead, and barium were two times higher compared to winter concentrations and two to five times higher compared to annual average.  Concentrations of zinc measured on December 23, 2012 were similar to winter and annual average concentrations (Figure 106).

**Figure 105. Comparison of Chlorine Concentrations on 12/23/2012 to 2010-2012 Winter Average and Annual Average**




*This data does include transport days but does not include invalidated days

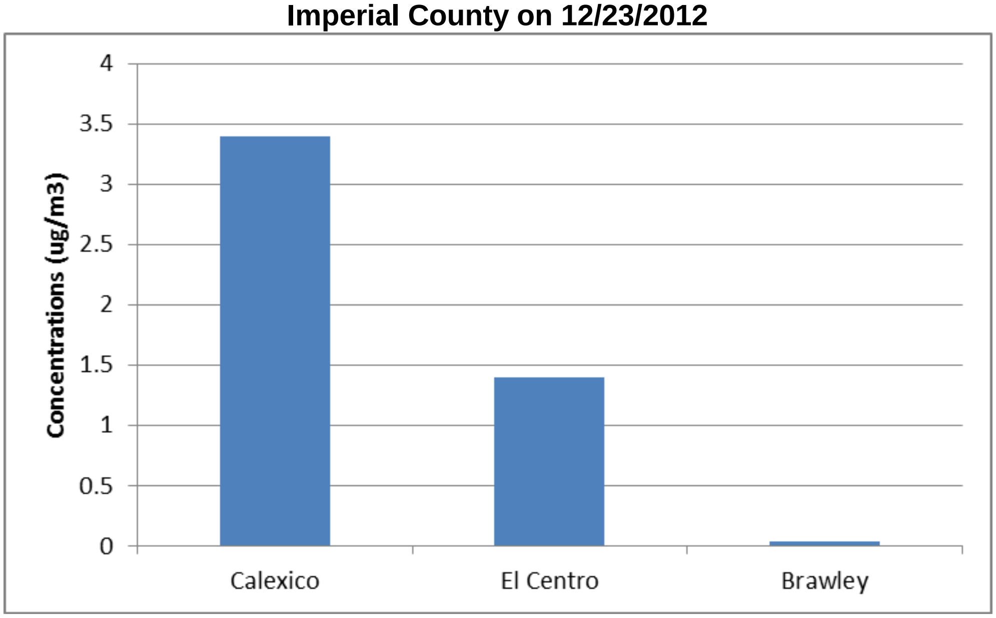
**Figure 106. Comparison of Select Species Concentrations on 12/23/2012 to 2010-2012 Winter Average and Annual Average**




*This data does include transport days but does not include invalidated days

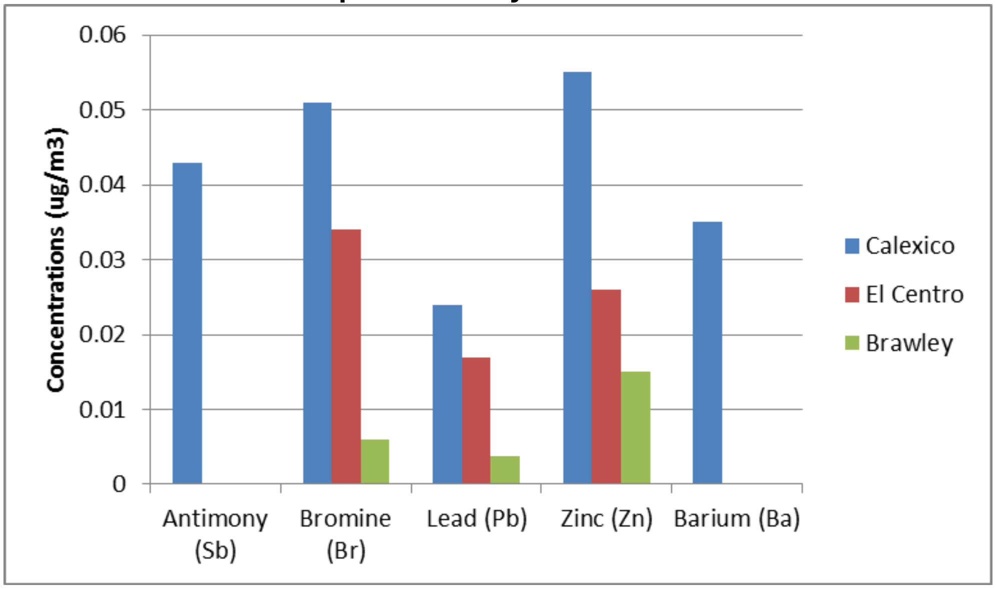
In comparing elemental data at all the Imperial County sites for this day, it is obvious that Calexico was impacted at a much higher level than the two sites just a few miles north. The other two sites, Brawley and El Centro, had concentrations close to or below the detection limits (Figure 107). Concentrations of antimony and barium at both El Centro and Brawley were below the detection limits. Concentrations of bromine, lead, and zinc at Calexico were two to nine times higher, while chlorine was twice as high as concentrations at El Centro and 94 times higher compared to Brawley (Figure 108).

**Figure 107. Comparison of Chlorine Concentrations in Imperial County on 12/23/2012**




*This data does include transport days but does not include invalidated days

**Figure 108. Comparison of Select Elemental Species Concentrations In Imperial County on 12/23/2012**

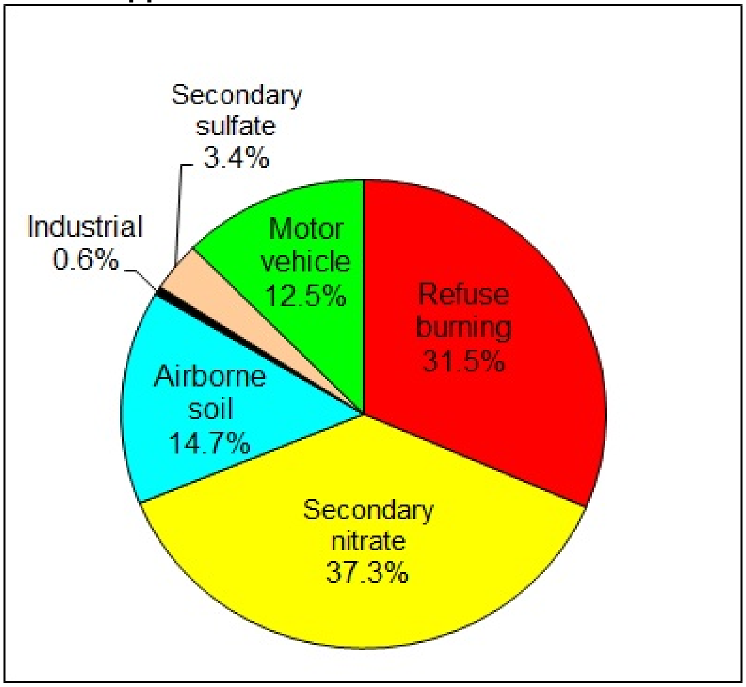



*This data does include transport days but does not include invalidated days

To provide information on the possible sources of emissions impacting the Calexico monitor, PM2.5 speciation data were analyzed using source apportionment model, Positive Matrix Factorization 2 (PMF2). PMF2 is a multivariate receptor model based on the positive matrix factorization (PMF) method. Fundamentally, this model analyzes characteristics of pollutants at the receptor site and, using mathematical algorithms, estimates the source contributions. This model is based on a weighted least square method that weights data points by their analytical uncertainties. A detailed description of PMF2 model procedure for Calexico is included in Appendix B.

In this analysis, a total of 159 samples and 27 species including PM2.5 concentrations collected between 2010 and 2012 were analyzed and six major sources were identified: Airborne soil, motor vehicle, secondary sulfate, secondary nitrate, refuse burning, and industrial. Figure 109 suggests that refuse burning and secondary nitrate were the major sources of PM2.5 on December 23. Secondary nitrate and refuse burning were estimated to contribute 24 µg/m3 and 20.4 µg/m3, respectively, of the 37.7 µg/m3 concentration recorded at Calexico. Since refuse burning is not permitted in Imperial, this impact—coupled with meteorological data—may be attributed to emissions from Mexicali.

**Figure 109. Source Apportionment PM2.5 Contribution on December 23, 2012**




The source apportionment percentage for refuse burning and industrial emissions is compared to the PM2.5 concentration at Calexico on December 23, 2012 in Table 15. Because refuse burning does not occur in Calexico ARB Staff attribute all of the refuse burning to be from Mexicali. In addition, there are no industrial emission sources in the City of Calexico so these emissions are also attributed to Mexicali. Although the Calexico site still shows a concentration above the 35 µg/m3 standard when refuse burning and industrial emissions are taken out, it is not assumed that all of the remaining emissions came from the U.S. side of the border. A portion of additional mass (based on sources apportionment of secondary nitrate, airborne soil, secondary sulfate, and motor vehicles) is also likely from Mexicali, but given the resolution of our analysis, ARB staff is unable to definitively apportion *all* PM2.5 mass to either Mexicali or U.S.-based sources.

**Table 15. Contribution of Refuse Burning and Industrial Emissions to the PM2.5 Concentration on December 23, 2012**

| FRM Concentration | Without Refuse burning emissions | Without Refuse Burning & Industrial emissions |
|---|---|---|
| 64.7 | 44.3 | 43.9 |

## XII. Non-FEM Beta Attenuation Monitor

To assist in evaluating data trends between 2010 and 2012, staff evaluated non-FEM BAM data. There were 28 days when 24-hour concentrations recorded by the BAM exceeded the level of the standard. This includes the five exceedance days identified in Table 1 (page 8). Of these 28 days, 25 days occurred between November and February, corroborating FRM data that shows the majority of PM2.5 exceedances in Calexico occur during winter with an overall trend of higher concentrations occurring during the early morning hours and late evening hours. Figure 110 below shows the diurnal pattern of the 28 non-FEM exceedance days. For the majority of the days, the high PM2.5 levels occur early in the morning and late at night when temperatures are lower with corresponding lower mixing heights. Concentration “spikes” were also noted on a limited number of summer days and may have been linked to higher-than-usual winds speeds.

The availability of chemical composition data for evaluating exceedances measured by the BAM was limited to five days; specifically, December 4, 2010; December 11, 2011; January 31, 2012; December 23, 2012; and, January 22, 2012. These days correspond to the speciation days for which FRM data were also available, with the exception of January 22, 2012. Chemical composition analysis for January 22 closely matches analyses conducted for the other wintertime exceedance days; specifically, the composition closely resembles that of December 23. The January 22 composition is shown in the day-specific analysis for December 23 on page 114.

To place BAM measurements on exceedance days in the context of temperature and wind speed, staff plotted the average hourly concentrations, as measured by the BAM, with average wind speeds and temperatures. Figure 111 illustrates the average diurnal pattern of the 28 BAM exceedance days. The trend over the majority of these days indicates that higher PM2.5 levels occur during early morning hours and late in the evening when ambient temperatures are lower. During these colder temperatures, atmospheric mixing heights also tend to be lower. Mixing height trends are discussed for each of the exceedance days in Section XI of this document.

**Figure 110. PM2.5 Hourly BAM Values For Days Exceeding the 24-hour PM2.5 Standard**

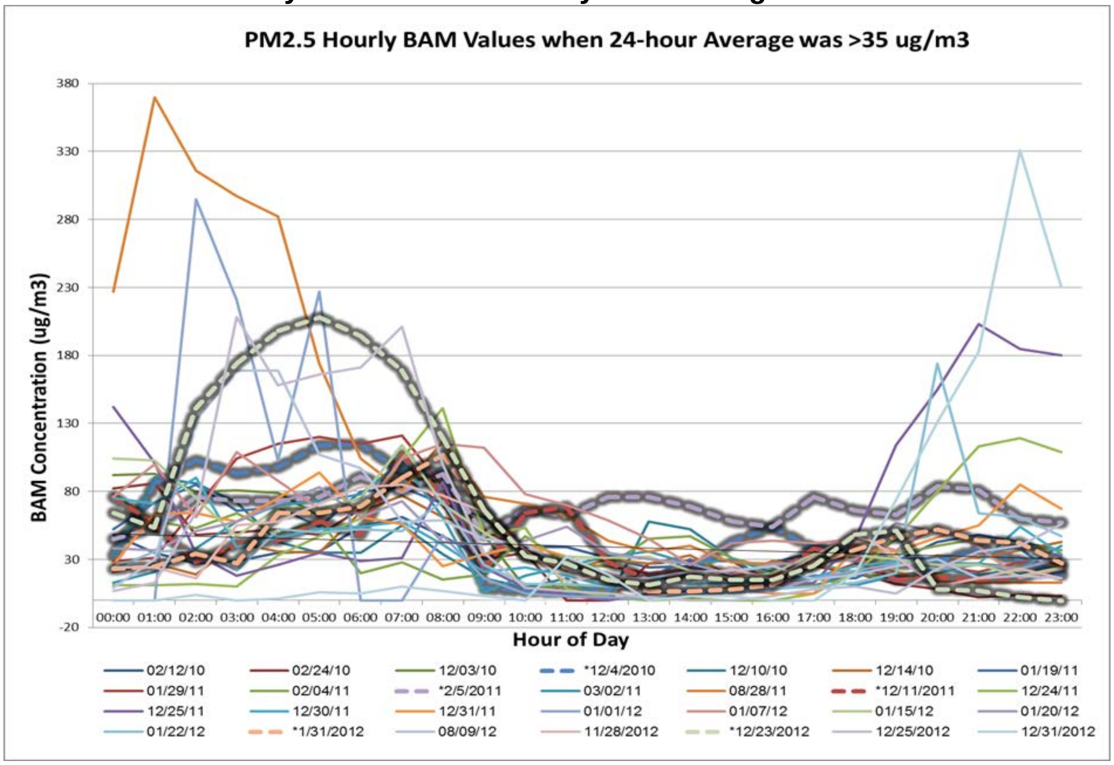



**Figure 111. Average Wind Speed, Concentration, and Temperature on all BAM Exceedance Days (2010-2012)**

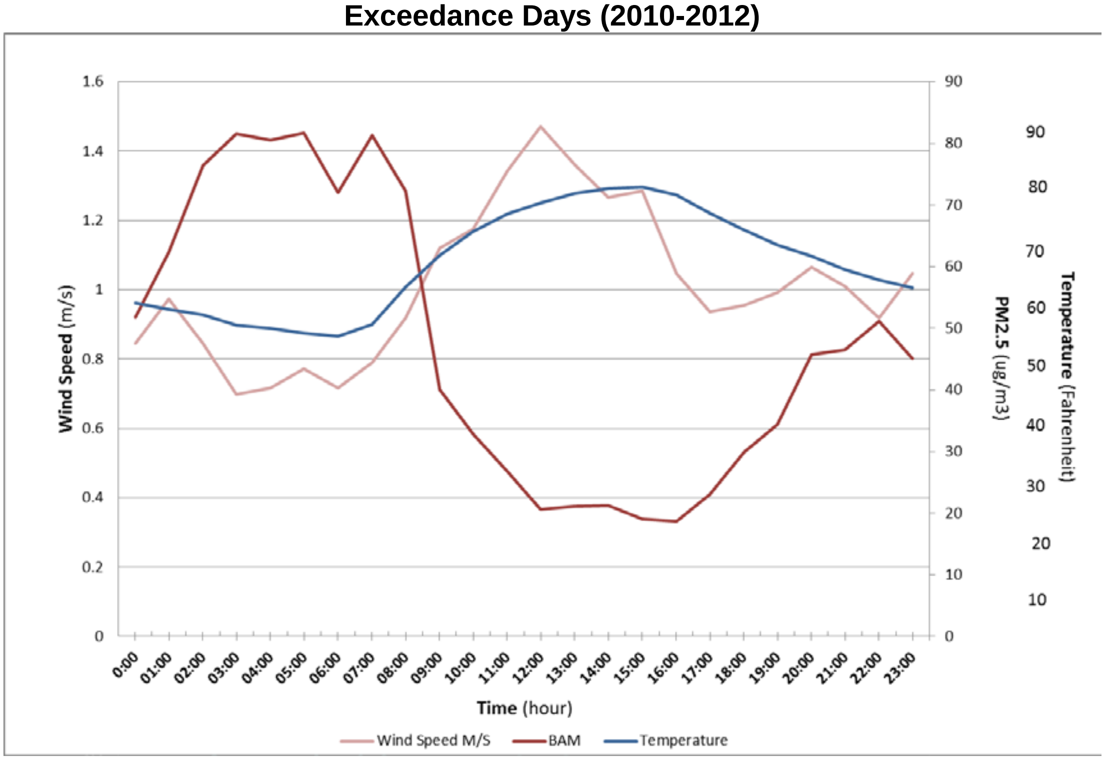
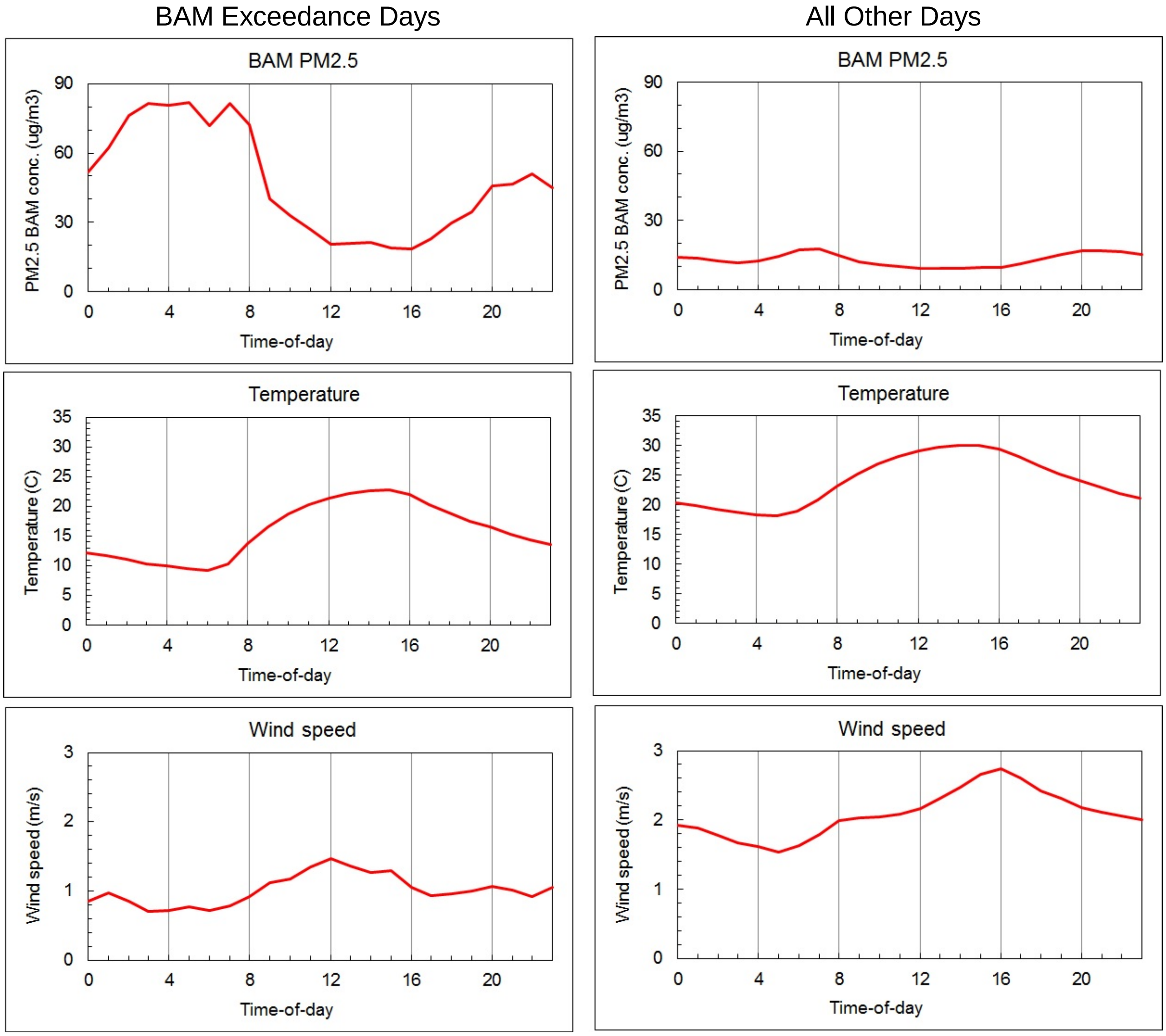


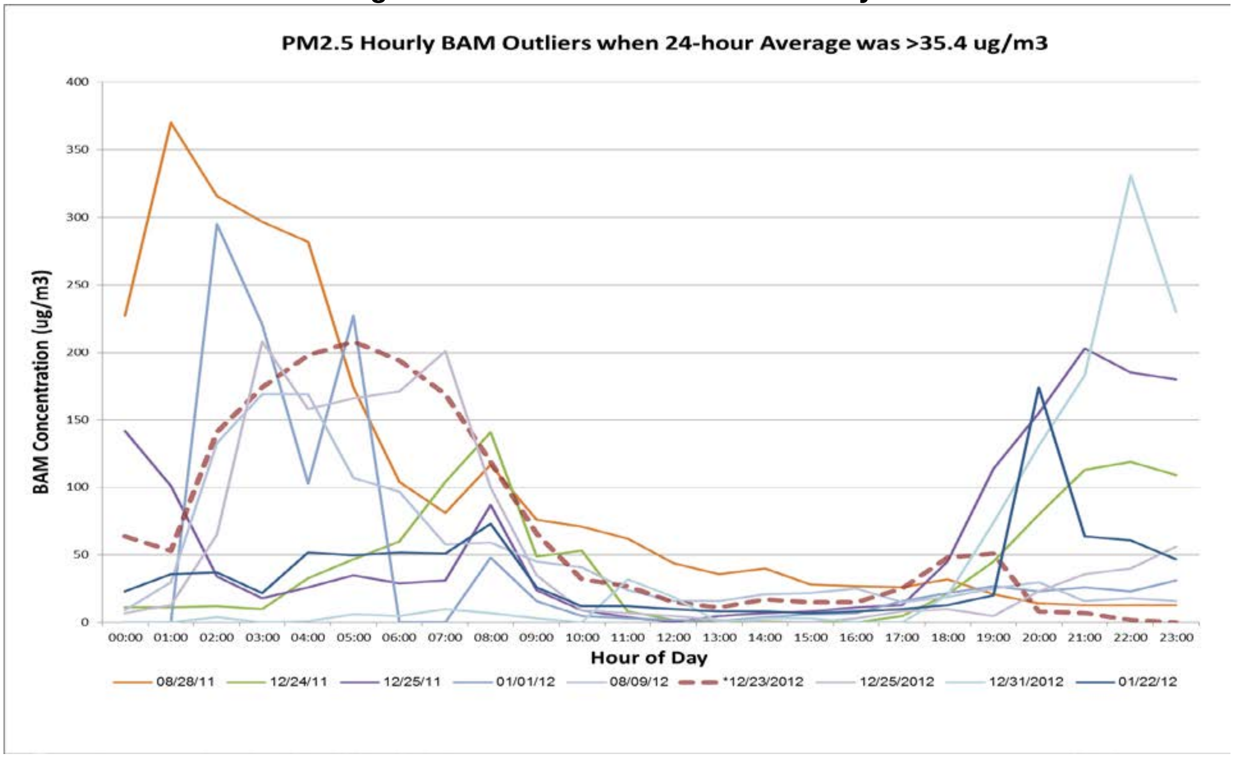
Figure 112 plots trends in the hourly PM2.5 concentrations, temperature and wind speed for the 28 non-FEM exceedance days and provides a comparison to the trend seen for all other days in 2010-2012.  This comparison shows that the 28 exceedance days differ from all other days at Calexico. The high PM2.5 in the morning, lower temperatures and decreased wind speed all provide an environment for increased PM2.5 concentration at Calexico.

**Figure 112.  Comparision of Trends on BAM Exceedance Days and All Other Days (2010-2012)**




From Figure 110, nine outliers were identified that did not fit the normal diurnal pattern of the Non-FEM BAM exceedance days. These days were looked at more closely to help determine the cause of their high values. Figure 113 displays the nine outlier days. Appendix C includes more detail on the diurnal pattern for PM2.5, wind speed, temperature, wind rose plots, and speciation (where available) for all nine of these outlier days.

**Figure 113. Non-FEM BAM Outlier Days**




*December 23, 2012 is part of the day specific analysis in Section XI

Figure 113 shows that two of these days occurred in August when thunderstorm activity was impacting the PM10 and PM2.5 concentrations in Imperial County. Six of these days occurred on a major holiday in Imperial County or Mexicali, Mexico. Table 16 lists all of the outlier days and the corresponding event or holiday that caused the Non-FEM BAM to exceed the standard on these days.

**Table 16. Non-FEM Nine Outlier Exceedance Days, Concentration, and Possible Emission Sources**

| Non-FEM Exceedance Day Outlier | PM2.5 Concentration | Possible Impact on Exceedance |
|---|---|---|
| 8/28/2011 | 103.5 | Thunderstorm activity in Imperial |
| 12/24/2011 | 49.2 | Christmas Eve |
| 12/25/2011 | 63.7 | Christmas Day |
| 1/1/2012 | 55.3 | New Year's Day |
| 1/22/2012 | 36.5 | Possible Influence from Combustion Emissions |
| 8/9/2012 | 49.2 | Thunderstorm in Phoenix. High Winds in Imperial. |
| 12/25/2012 | 60.4 | Christmas Day |
| 12/31/2012 | 62.5 | New Year's Eve |

The January 22, 2012 sample mimics the diurnal pattern we see for winter days during the morning and afternoon hours but the PM2.5 peaks at 8:00 pm to 180 µg/m3. Further information gathered from the speciation profile on January 22, 2012 shows that the speciation matches very closely to that of December 23, 2012. Cold temperatures and an increase in burning could have caused this peak at night on January 22.

Six of these events fell on Mexican and U.S. celebrated holidays. As noted in the 179B analysis, these holidays are celebrated every year in Imperial County and Mexicali and the use of fireworks, bonfires, and burning of refuse material in Mexicali is prevalent on these days. December 23, 2012 is in the 179B documentation as a day impacted by transport from Mexico and the celebrations during the Mexican holiday, *Las Posadas*.

Two of the nine days non-FEM exceedance days fell outside of the normal winter season when PM2.5 exceedances typically occur in Imperial County. These events occurred on August 28, 2011 and August 9, 2012. Concentrations of PM2.5 and PM10 were very high on August 28, 2011 in Imperial County. The Calexico monitor recorded a 24-hour concentration of 103.5 at the hourly PM2.5 monitor. Increased PM2.5 concentrations were also seen at El Centro and Brawley, where the 24-hour PM2.5 concentrations were 54.4 ug/m3 and 37 ug/m3, respectively. In addition, the hourly 24-hour PM10 concentrations were 231.8 ug/m3 at Brawley and 269.1 ug/m3 at Niland on August 28, 2011.

On the night of August 27, 2011 the National Weather Service issued a severe thunderstorm warning for east central Imperial County. The report noted winds in excess of 60 mph, very heavy rain, and small hail. The report also mentioned that dense blowing dust would accompany this severe storm. Yuma, Arizona, San Diego and the South Coast also received alerts of the thunderstorm, high winds, and blowing dust for August 27 - 28, 2011. The wind gusts in Yuma were over 50 mph and left more than 10,000 people in the County without power. Mexicali news reports also discussed the blackouts experienced on August 28, 2011 from the thunderstorms and high winds. The District flagged this day in AQS as a high wind event.

August 9, 2012 was flagged in AQS as a high wind event and was impacted from thunderstorm activity in Phoenix, Arizona. The high easterly winds raised dust in Phoenix, Arizona, which was transported into Imperial County. Remnant dust from overnight thunderstorms pushed outflow boundaries into Imperial County. The hourly 24-hour PM10 concentrations in Imperial County were also very high; Calexico (387.3 ug/m3), Brawley (239.7 ug/m3), and Niland (196.5 ug/m3). The Calexico hourly PM2.5 monitor recorded a 24-hour concentration of 49.2 ug/m3. Magdalena, Mexico had news reports that discussed the summer storm that produced wind gusts up to 50 mph, four inches of rain in one day, and the severe flooding of homes that occurred for this storm. The city of Magdalena issued a state of emergency from the damage done by the storm.

## Design Value Calculation

The 24-hour PM2.5 standard design value is determined by first ranking all of the PM2.5 samples for each year from the highest concentration to the lowest concentration. The third highest value recorded for each year is averaged over the three years (2010-2012) to determine what the 3-year 98$^{th}$ percentile design value is for that site.

Table 17 below includes the five highest concentrations measured each year between 2010 and 2013. The green cells represent the third highest value in each year under each scenario and the red cells represent the transport days excluded under each scenario. If U.S. EPA approves of all five of the transport days at Calexico, the 24-hour design value using 2010 - 2012 data would be 29 µg/m3. However, U.S. EPA would not need to approve of all of the transport events in order for the Imperial NA to show that they attained the standard in 2012. Concurrence on the transport analyses would be needed from U.S. EPA for December 11, 2011, and December 23, 2012, in order for Imperial to demonstrate attainment. If these two events are excluded from the design value calculation, the new design value at the Calexico monitor for 2010-2012 would be 34 µg/m3 and Imperial would have demonstrated that they attained the 24-hour PM2.5 standard.

**Table 17. Imperial PM2.5 NAA 2010-2013 24-Hour Design Value Calculations**

| | 2010 | | 2011 | | 2012 | | 2013 | | Design Value | |
|---|---|---|---|---|---|---|---|---|---|---|
| Rank | Date | (ug/m3) | Date | (ug/m3) | Date | (ug/m3) | Date | (ug/m3) | 2012 | 2013 |
| **Design Values Based on All Data** | | | | | | | | | | |
| 1 | 12/4/10 | 50.9 | 2/5/11 | 80.3 | 5/25/12 | 119.3 | 11/9/13 | 36.3 | | |
| 2 | 6/28/10 | 41 | 12/11/11 | 44.4 | 12/23/12 | 64.7 | 4/8/13 | 28.2 | | |
| 3 | 12/10/10 | 31.7 | 10/15/11 | 40.9 | 3/31/12 | 56.3 | 5/4/13 | 27.4 | | |
| 4 | 11/10/10 | 28.4 | 6/23/11 | 32.4 | 1/31/12 | 37.7 | 12/18/13 | 26 | | |
| 5 | 2/4/10 | 27.5 | 12/14/11 | 28.4 | 6/8/12 | 30.7 | 6/18/13 | 25.8 | | |
| **98th Percentile** | | **31.7** | | **40.9** | | **56.3** | | **27.4** | **43** | **42** |
| **Design Values Without Five Transport Days** | | | | | | | | | | |
| 1 | 12/4/10 | 50.9 | 2/5/11 | 80.3 | 5/25/12 | 119.3 | 11/9/13 | 36.3 | | |
| 2 | 6/28/10 | 41 | 12/11/11 | 44.4 | 12/23/12 | 64.7 | 4/8/13 | 28.2 | | |
| 3 | 12/10/10 | 31.7 | 10/15/11 | 40.9 | 3/31/12 | 56.3 | 5/4/13 | 27.4 | | |
| 4 | 11/10/10 | 28.4 | 6/23/11 | 32.4 | 1/31/12 | 37.7 | 12/18/13 | 26 | | |
| 5 | 2/4/10 | 27.5 | 12/14/11 | 28.4 | 6/8/12 | 30.7 | 6/18/13 | 25.8 | | |
| **98th Percentile** | | **28.4** | | **28.4** | | **30.7** | | **27.4** | **29** | **29** |
| **Design Values Without Three Transport Days (12/4/10, 12/11/11, and 12/23/12)** | | | | | | | | | | |
| 1 | 12/4/10 | 50.9 | 2/5/11 | 80.3 | 5/25/12 | 119.3 | 11/9/13 | 36.3 | | |
| 2 | 6/28/10 | 41 | 12/11/11 | 44.4 | 12/23/12 | 64.7 | 4/8/13 | 28.2 | | |
| 3 | 12/10/10 | 31.7 | 10/15/11 | 40.9 | 3/31/12 | 56.3 | 5/4/13 | 27.4 | | |
| 4 | 11/10/10 | 28.4 | 6/23/11 | 32.4 | 1/31/12 | 37.7 | 12/18/13 | 26 | | |
| 5 | 2/4/10 | 27.5 | 12/14/11 | 28.4 | 6/8/12 | 30.7 | 6/18/13 | 25.8 | | |
| **98th Percentile** | | **28.4** | | **32.4** | | **37.7** | | **27.4** | **33** | **33** |
| **Design Values Without Two Transport Days (12/11/11 and 12/23/12)** | | | | | | | | | | |
| 1 | 12/4/10 | 50.9 | 2/5/11 | 80.3 | 5/25/12 | 119.3 | 11/9/13 | 36.3 | | |
| 2 | 6/28/10 | 41 | 12/11/11 | 44.4 | 12/23/12 | 64.7 | 4/8/13 | 28.2 | | |
| 3 | 12/10/10 | 31.7 | 10/15/11 | 40.9 | 3/31/12 | 56.3 | 5/4/13 | 27.4 | | |
| 4 | 11/10/10 | 28.4 | 6/23/11 | 32.4 | 1/31/12 | 37.7 | 12/18/13 | 26 | | |
| 5 | 2/4/10 | 27.5 | 12/14/11 | 28.4 | 6/8/12 | 30.7 | 6/18/13 | 25.8 | | |
| **98th Percentile** | | **31.7** | | **32.4** | | **37.7** | | **27.4** | **34** | **33** |

## XIII. Conclusion

Analyses were performed using techniques referenced in U.S. EPA guidelines for evaluating the impact of emissions originating from outside the United States on ambient PM2.5 concentrations. The analyses consisted of assessing emission inventories from Imperial County and Mexicali; evaluating the composition and elemental make up of samples collected on Calexico exceedance days; reviewing the meteorology associated with high concentration measurements; and, performing directional analysis of the sources potentially impacting the Calexico PM2.5 monitor.

These analyses demonstrate that emissions originating in Mexico impacted measured PM2.5 levels in Calexico during five exceedance days between 2010 and 2012. The analyses also shows that Imperial County would have attained the 24-hour PM2.5 NAAQS but for international transport. The key findings supporting this conclusion are as follows:

- Calexico is similar in scale regarding population and emission sources to Brawley and El Centro with the only difference being Calexico’s proximity to the international border;
- The area represented by the Calexico monitor shares a common air shed with the large metropolitan city of Mexicali, Mexico;
- Calexico experiences stagnant atmospheric conditions during the wintertime, which results in little or no dispersion—emissions from Mexicali remain in the border region;
- The Calexico PM2.5 air quality data is significantly different than the other two sites, Brawley and El Centro;
- Elemental analysis of Calexico exceedance day PM2.5 samples indicates that combustion of refuse or other non-biomass material is the probable source of Calexico PM2.5 exceedances;
- The chemical signature of PM2.5 samples on exceedance days differ significantly from other PM2.5 samples in the State and indicate high levels of chlorine and other elements;
- Traditional celebrations in Mexico occur during the winter and are known to include bonfires fueled with tires, wood, and other materials not routinely burned in Calexico.

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Windrose plots. WRPLOT View. Lakes Environmental Software.

## Appendix A

## Methodology for Developing Air Parcel Back-Trajectories

Plots of air parcel back-trajectories were developed as part of the analysis of PM2.5 source-receptor relationships on winter stagnation days in Calexico, California. The objective of a back-trajectory plot is to discern the pathway that an air parcel traveled prior to passing over the site of a continuous pollutant monitor. By calculating the coordinates of this traverse and overlaying the resulting travel path onto an aerial photograph, the potential for transport of emissions from sources under the path to the monitor can be quickly assessed by visual inspection. This tool is especially useful for identifying possible local source contributions to peak hourly PM2.5 concentrations on meteorologically stagnant days. On these days, peak concentrations are typically measured during nocturnal hours when mixing heights are tens of meters above the ground and vertical dispersion is severely limited. As wind velocities are also low at these times, the distances that air parcel move in each hour are short and plots of nocturnal back-trajectories show path lengths that remain within a few miles of the monitor.

For the analysis of PM2.5 exceedances on stagnation days at the Calexico Street monitoring site, the designated end-point of each back-trajectory plot was the monitoring site itself. To identify nearby sources that produced the greatest impacts on hourly PM2.5 concentrations, the ending hour of each back-trajectory analysis was selected to be the hour during which the highest 1-hour average PM2.5 concentration was recorded on each design day. The hourly meteorological data for the back-trajectory analyses were extracted from ARB's online monitoring data repository – AQMIS2 – which is accessible at: http://www.arb.ca.gov/aqmis2/aqmis2.php. The identification of the peak PM2.5 hour for each design day was based on hourly concentration data stored on the same website. Table A1 displays the highest hourly PM2.5 concentration for each design day that determined the ending hour of each back-trajectory.

**Table A1. Calexico Transport Day Ending Hour and PM2.5 Concentration**

| Date (Design Day) | Ending Hour | PM2.5Concentration ($\mu g/m^3$) |
|---|---|---|
| December 4, 2010 | 06 | 115 |
| February 5, 2011 | 08 | 93 |
| December 11, 2011 | 07 | 107 |
| January 31, 2012 | 08 | 107 |
| December 23, 2012 | 05 | 208 |

Hourly meteorological data recorded at a 10-meter tower located adjacent to the Calexico Street PM2.5 monitor were used to compute the beginning and ending coordinates of each hourly air parcel trajectory or vector. Because the calculations of vector coordinates proceed in a reverse-time mode for the back-trajectory, the calculation of vector coordinates for each hour started with the ending coordinates and used the wind speed and the reverse of the wind azimuth to compute the beginning coordinates for that hour. The coordinate calculation was conducted in a stepwise fashion beginning at the monitor location and using the wind speed and direction data for each preceding hour to compute path coordinates back to 00 hours on the day preceding each design day. To facilitate the calculation, the coordinates of the monitoring station (i.e., N 32.67618 latitude, W -115.48307 longitude[6]) were converted to Universal Transverse Mercator (UTM) units (642225.23 mE, 3616403.65 mN) using the coordinate display algorithm embedded with the Google Earth global mapping program.[7] After coordinates for each hourly vector were determined in UTM units, these coordinates were converted to latitude/longitude using an online model developed by Dr. Steve Dutch of University of Wisconsin-Green Bay.[8]

The hourly vector coordinates are plotted as an overlay on a map of the nonattainment area using ArcMap 10, ESRI's geographic information systems (GIS) software. The coordinates were imported in ArcMap 10 and formatted as a point-to-line file. The coordinates of each hours' endpoint and start point were configured to appear linked by a vector arrow in the overlay file, such that the full set of hourly data for a single design day appeared as a connected trajectory starting at 00 hours on the day before the design day and ending at the Calexico Street monitor at the highest PM2.5 hour of the design day. The resulting back-trajectory plots thus reveal approximately where air parcels containing the highest PM2.5 concentrations traveled before arriving at the monitor. These plots inform the investigation into identification of potentially significant sources that raise PM2.5 concentrations to levels in excess of the 24-hour NAAQS at the Ethel Street monitor.

[6] Site Information for Calexico-Ethel Street; Quality Assurance Air Monitoring Site Information; CARB; http://www.arb.ca.gov/qaweb/browsetest.php?year=2013&s_arb_code=13698, accessed on April 15, 2014.

[7] http://www.google.com/earth/explore/products/, accessed on April 15, 2014.

[8] http://www.uwgb.edu/dutchs/usefuldata/ConvertUTMNoOZ.HTM,accessed on February 14, 2014

**Appendix B**

**Source Apportionment of $PM_{2.5}$ Measured at the Calexico Monitoring Site**

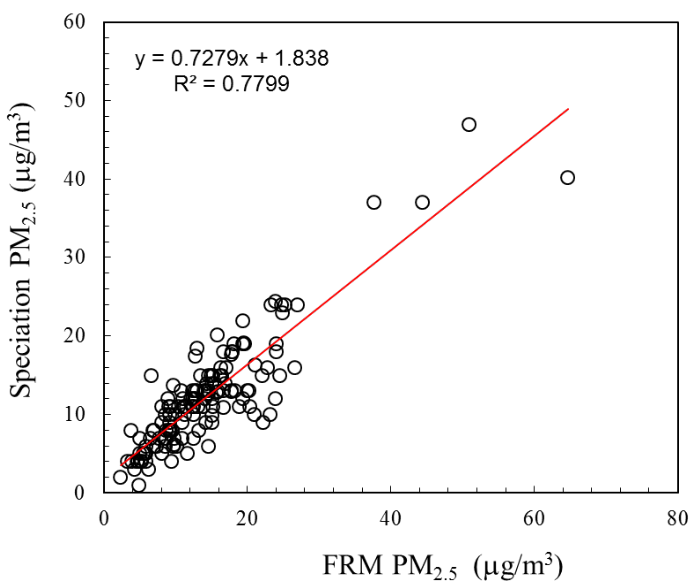
Positive matrix factorization (PMF) is a multivariate source apportionment method that deduces source profiles as well as contributions from $PM_{2.5}$ speciation data. PMF is one of several EPA recommended receptor modeling methods (U.S.EPA, 2008). To identify major $PM_{2.5}$ sources affecting Calexico monitoring site, PMF2 (bilinear PMF) was used in this study.

## 1. Sample Collection and Data Screening

The $PM_{2.5}$ speciation samples that were analyzed were collected by Spiral Aerosol Speciation Samplers (SASS; Met One Instruments, Grants Pass, OR) on a one-in-three day schedule at Calexico SLAMS (State and Local Air Monitoring Stations) network monitoring site located in the Imperial County.

Comparing $PM_{2.5}$ data measured by the speciation sampler and the collocated Federal Reference Method (FRM) sampler in Figure B1 shows reasonable agreement using 142 data points between 2010 and 2012 (*slope* = 0.73, *Intercept* = 1.84, $r^2$ = 0.78).

**Figure B1. FRM $PM_{2.5}$ versus Speciation $PM_{2.5}$ between 2010 and 2012**




For the source apportionment, samples were excluded from the data set for which the $PM_{2.5}$, OC, or EC data had an error flag, or for which OC or EC data were not available. Samples for which the sum of all measured species were larger than $PM_{2.5}$ concentrations or the sum of all measured species were less than 50% of $PM_{2.5}$ concentrations were excluded. Overall, 12.6 % of the data were excluded in this study.

**Table B1. Summary of $PM_{2.5}$ species mass concentrations at Calexico**

| Species | Arithmetic mean (µg/m³) | Geometric mean (µg/m³) | Minimum (µg/m³) | Maximum (µg/m³) | Number of below MDL[1] values (%) | S/N ratio[2] |
|---|---|---|---|---|---|---|
| $PM_{2.5}$ | 12.3868 | 10.9095 | 3.0000 | 47.0000 | 0.0 | NA[3] |
| OC | 3.4302 | 2.7759 | 0.7000 | 23.0000 | 0.0 | NA |
| EC | 0.8264 | 0.6332 | 0.0500 | 3.7000 | 2.5 | 328.0 |
| SO4 | 1.2341 | 1.0488 | 0.2340 | 4.7000 | 0.0 | NA |
| $NO^{3-}$ | 1.2126 | 0.8387 | 0.2000 | 7.3900 | 0.0 | NA |
| $NH_4^+$ | 0.6159 | 0.4765 | 0.0900 | 3.7300 | 0.0 | NA |
| Al | 0.1634 | 0.1018 | 0.0065 | 1.5000 | 6.3 | 172.7 |
| Ba | 0.0163 | 0.0141 | 0.0100 | 0.0510 | 61.0 | 0.8 |
| Br | 0.0112 | 0.0069 | 0.0010 | 0.1100 | 6.9 | 80.4 |
| Ca | 0.2339 | 0.1838 | 0.0310 | 1.2000 | 0.0 | NA |
| Cl | 0.2541 | 0.1044 | 0.0070 | 3.4000 | 0.0 | NA |
| Co | 0.0024 | 0.0019 | 0.0015 | 0.0150 | 78.0 | 0.5 |
| Cr | 0.0022 | 0.0017 | 0.0015 | 0.0370 | 86.2 | 0.3 |
| Cu | 0.0158 | 0.0117 | 0.0020 | 0.0670 | 6.9 | 56.6 |
| Fe | 0.1995 | 0.1634 | 0.0250 | 0.8700 | 0.0 | NA |
| $K^+$ | 0.1682 | 0.1122 | 0.0650 | 1.6000 | 66.7 | 1.3 |
| Mn | 0.0061 | 0.0042 | 0.0015 | 0.0290 | 25.2 | 7.6 |
| $Na^+$ | 0.2342 | 0.1685 | 0.0400 | 0.8900 | 20.1 | 10.1 |
| Ni | 0.0023 | 0.0019 | 0.0015 | 0.0200 | 87.4 | 0.3 |
| Pb | 0.0126 | 0.0068 | 0.0015 | 0.1100 | 22.0 | 18.6 |
| P | 0.0052 | 0.0036 | 0.0020 | 0.0310 | 60.4 | 1.6 |
| Sb | 0.0139 | 0.0122 | 0.0100 | 0.0620 | 81.8 | 0.4 |
| Se | 0.0021 | 0.0013 | 0.0010 | 0.0330 | 83.6 | 0.8 |
| Si | 0.5388 | 0.4115 | 0.0490 | 4.2000 | 0.0 | NA |
| Sr | 0.0029 | 0.0022 | 0.0015 | 0.0110 | 51.6 | 1.4 |
| Ti | 0.0145 | 0.0114 | 0.0020 | 0.0880 | 3.8 | 95.4 |
| Zn | 0.0786 | 0.0268 | 0.0010 | 0.9300 | 1.3 | 3125.5 |

[1] Minimum detection level
[2] Signal-to-noise ratio (Paatero and Hopke, 2003)
[3] not available (infinite S/N ratio caused by no below average MDL value)

For the chemical species screening, X-Ray Fluorescence (XRF) S was excluded from the analyses to prevent double counting of mass concentrations since XRF S and Ion Chromatography (IC) $SO_4^{2-}$ were highly correlated (*slope* = 2.7, $r^2$ = 0.95). Due to the higher analytical precision compared to XRF Na and XRF K, IC $Na^+$ and IC $K^+$ were included in the analyses. Chemical species below the minimum detection level (MDL) (values more than 90%) were excluded. The species that have Signal-to-Noise (*S/N*) ratio below 0.2 were excluded (Paatero and Hopke, 2003). Thus, a total of 159 samples and 27 species including $PM_{2.5}$ mass concentrations collected between 2010 and 2012 were analyzed. A summary of $PM_{2.5}$ speciation data is provided in Table B1.

The application of PMF2 depends on the estimated uncertainties based on the analytical uncertainties for each of the measured data. Since the SLAMS data were not accompanied by analytical uncertainties, the fractional uncertainties suggested for PMF2 analysis by Kim et al (2005) were used (Table B2).

**Table B2. Estimated fractional uncertainties[1] for SLAMS data at Calexico**

| Species | Fractional uncertainty | Species | Fractional uncertainty |
|---|---|---|---|
| OC | 0.07 | Fe | 0.05 |
| EC | 0.07 | $K^+$ | 0.07 |
| SO4 | 0.07 | Mn | 0.05 |
| $NO^{3-}$ | 0.07 | $Na^+$ | 0.07 |
| $NH_4^+$ | 0.07 | Pb | 0.05 |
| Al | 0.10 | P | 0.10 |
| Br | 0.05 | Si | 0.10 |
| Ca | 0.11 | Sr | 0.05 |
| Cl | 0.10 | Ti | 0.05 |
| Cr | 0.05 | V | 0.05 |
| Cu | 0.05 | Zn | 0.05 |

[1] Kim et al. (2005)

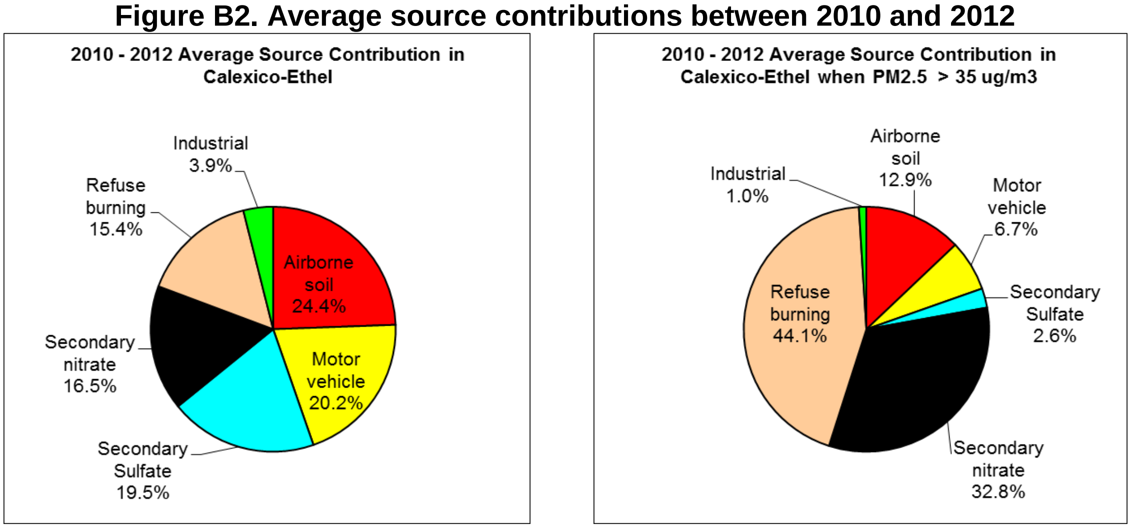
To assign input data for PMF2, the procedure of Polissar et al. (1998) is used. The measurement values are used for the input concentration data, and the sum of the analytical uncertainty and one-third of the detection limit value is used as the input uncertainty data assigned to each measured value. Concentration values below the detection limit are replaced by half of the detection limit values, and their input uncertainties are set at five-sixth of the detection limit values. Missing values are replaced by the geometric mean of the measured values for each species, and to down-weight these replaced data and then to reduce their influence on the solution, their accompanying uncertainties are set at four times of this geometric mean value.

To estimate the potential directions of the local source impacts, the conditional probability function (CPF, Kim et al. 2003) was calculated for each source using the source contribution estimates from PMF coupled with the wind directions. The same 24-hour contribution was assigned to each hour of a given day to match to the hourly wind data. The CPF estimates the probability that a given source contribution from a given wind direction will exceed a predetermined threshold criterion. The sources are likely to be located in directions that have high CPF values. In this study, from tests with several values of percentiles of the contribution and different azimuths of wind sectors, a threshold criterion of the upper 25% of the source contributions and 24 wind sectors of 15 degrees were chosen to show the directionality of the sources. Calm winds (< 1 m/sec) were excluded from this analysis due to the isotropic behavior of wind vane under calm winds.

## 2. Results and Discussions

A six-source model without matrix rotation (rotational parameter FPEAK = 0) provided the most physically interpretable source profiles for Calexico site. As recommended by Paatero and Hopke (2003), which is to down-weight the variable in the analysis so that the noise does not compromise the solution, it was found necessary to increase the input uncertainties of Cl by a factor of 3, and $K^+$ and $Na^+$ by a factor of 5 to obtain physically interpretable PMF2 results. Figure B2 and Table B3 present average source contributions. The pie chart showing high (> 35 µg/m$^3$) $PM_{2.5}$ days average source contributions indicates that secondary nitrate and refuse burning were the major sources in high $PM_{2.5}$ days at Calexico. Figure B3 shows monthly average source contributions.

**Figure B2. Average source contributions between 2010 and 2012**

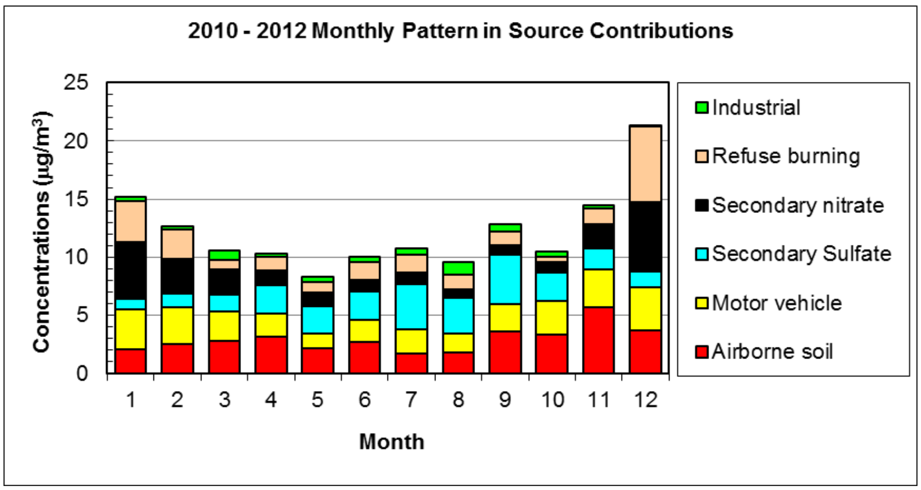



Comparisons of the reconstructed $PM_{2.5}$ mass contributions (sum of contributions from all sources) with measured $PM_{2.5}$ mass concentrations in Figure B4 shows that the resolved sources effectively reproduce the measured values and account for most of the variation in the $PM_{2.5}$ mass concentrations (*slope* = 0.96, $r^2$ = 0.90). The source profiles, corresponding source contributions, monthly variations of source contributions, weekday/weekend variations, annual variations, and potential source direction are presented in Figures B5 through B9.

**Table B3. Average source contributions (μg/m$^3$) to $PM_{2.5}$ mass concentration**

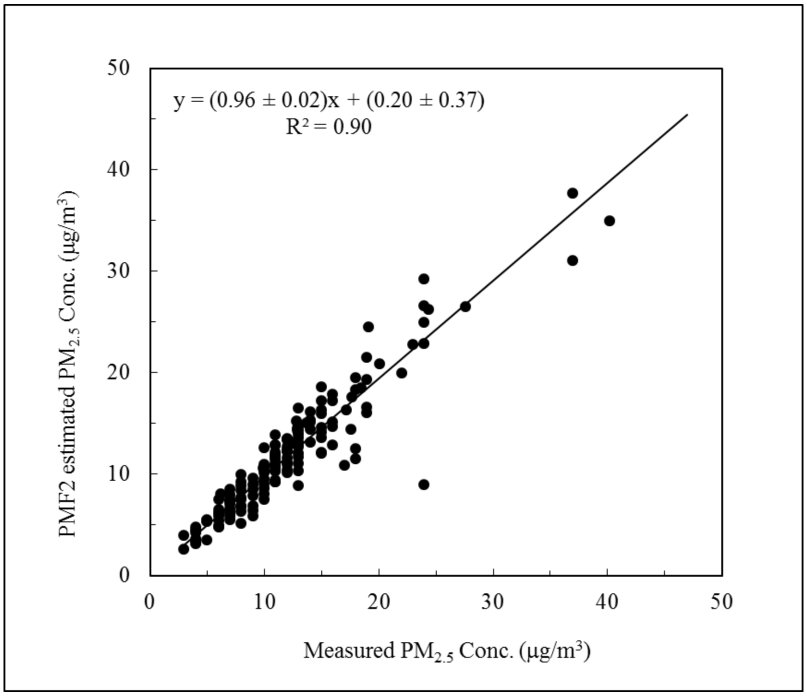
| Sources | Average source contribution (± 95 % distribution) |
|---|---|
| Airborne soil | 2.96 (0.45) |
| Motor vehicle | 2.45 (0.23) |
| Secondary sulfate | 2.36 (0.24) |
| Secondary nitrate | 2.00 (0.42) |
| Refuse burning | 1.86 (0.50) |
| Industrial | 0.48 (0.14) |
| Estimated $PM_{2.5}$ (μg/m$^3$) | 12.11 (1.07) |
| Measured $PM_{2.5}$ (μg/m$^3$) | 12.39 (1.05) |

**Figure B3. Monthly average source contributions between 2010 and 2012**




Airborne soil has high concentrations of Si, Fe, Al and Ca. It contributed the most accounting for 24% of the $PM_{2.5}$ mass concentration at Calexico. The airborne soil category reflects wind-blown dust as well as re-suspended crustal materials by road traffic as indicated by the presence of OC and EC in the source profile in Figure B5. Airborne soil contribution at Calexico showed high variation in the spring and fall (Figure B7) and also on weekdays (Figure B8). The CPF plot for airborne soil points southwest suggesting high contributions from the US/Mexico border crossing area (Figure B9).

**Figure B4. Measured versus PMF2 predicted $PM_{2.5}$ mass concentrations**




Motor vehicle emissions are identified by their high concentration of OC and EC, and minor species such as Fe (Watson et al., 1994). It also includes some soil dust constituents (Si, Ca) indicating that resuspended road dust by vehicle traffic is not separable because of the same temporal variation. The ratio of OC/EC for motor vehicle exhaust (2.5) is similar with 2.6 (Imperial County) and 2.7 (Mexicali) for $PM_{2.5}$ (Watson and Chow, 2001). The average contribution from motor vehicle to $PM_{2.5}$ mass concentration was 20% at Calexico. Motor vehicle emissions show a winter-high seasonal trend and a weak weekday high variation. The CPF plot for motor vehicles at Calexico also suggests high contributions from the US/Mexico border crossing area.

Secondary sulfate is identified by its high concentration of $SO_4^{2-}$ and $NH_4^+$. It consists of $(NH_4)_2SO_4$ and several minor species such as secondary OC and EC, $Na^+$, and $K^+$ that transport together. Secondary sulfate contributed 19% of the $PM_{2.5}$ mass concentrations. Secondary sulfate shows strong seasonal variation with higher concentrations in summer when the photochemical activity is highest. Secondary sulfate does not have weekday/weekend variation. The CPF plot for secondary sulfate points south indicating strong influence from Mexicali. $Na^+$ in secondary sulfate indicates that secondary sulfate source also includes aged sea salt that reflects particles in which $Cl^-$ in the fresh sea salt is partially displaced by acidic gases during the transport and collected along with $SO_4^{2-}$ (Song and Carmichael, 1999). $K^+$ in the source profile seems to reflect field burning smoke from the surrounding agricultural area. Agricultural burning emissions were not separated from secondary sulfate because they originated from a similar wind direction and had a similar summer-high temporal behavior. The smoke from agricultural burning widely located in the Mexicali area was likely transported with secondary sulfate by the southeast wind starting in the spring.

Secondary nitrate has high concentrations of $NO_3^-$ and $NH_4^+$. It consists of $NH_4NO_3$ and secondary OC and EC. It accounts for 17% of the $PM_{2.5}$ mass concentration at Calexico. Secondary nitrate has a winter-high trend with the highest occurring in December. Secondary nitrate shows a weak weekend high variation. Secondary nitrate has a strong source directionality to the southwest, suggesting high contributions from the US/Mexico border crossing area.

Refuse burning is characterized by OC, EC, and Cl (Christian et al., 2010; Hodzic et al., 2012; Li et al., 2012). The refuse burning smoke category reflects contributions from burning of wood as well as garbage in bonfires. The high Cl concentration in this source likely reflects the burning of tires and polyvinyl chloride in garbage. Higher contributions from refuse burning in the winter as shown in Figure B6, indicate bonfires during the Mexicali festival "Las Posadas" in December. The high peak on December 11, 2011 was likely caused by a major holiday in Mexico. This source contributed 15% to the $PM_{2.5}$ mass concentration at Calexico. Refuse burning shows a winter-high trend with the highest in December and a weekend high variation. As shown in Figure B9, major sources of refuse burning were located south of Calexico and are widely distributed.

Industrial sources characterized by high concentrations of EC, $SO_4^{2-}$, $NO_3^-$, Cl, Fe, $Na^+$, Pb, Si, and Zn were identified. Potential industrial sources include metal processing, fly ash/emissions from brick kilns, cement kilns, and various incinerators. This source accounts for 4% of the $PM_{2.5}$ mass concentrations. Industrial sources show a summer-high trend and have weekend high variations. The CPF plot for the industrial source suggests high contributions from the south and southeast.

## 3. Conclusions

$PM_{2.5}$ speciation data and related meteorological data collected at the Calexico monitoring site between 2010 and 2012 were analyzed. Using PMF2, the multivariate source apportionment tool, six major $PM_{2.5}$ sources were identified: Airborne soil, motor vehicle, secondary sulfate, secondary nitrate, refuse burning, and industrial sources. The source directionality analyses showed that most of the $PM_{2.5}$ at Calexico originated from the US/Mexico border crossing area or were internationally transported $PM_{2.5}$ from Mexicali area.

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Watson, J.G., and Chow, J.C., Source characterization of major emission sources in the Imperial and Mexicali Valleys along the US/Mexico border, The Science of the Total Environment, 276, 33-47, 2001.

**Figure B5. Source profiles deduced from $PM_{2.5}$ samples measured at Calexico (prediction ± standard deviation)**

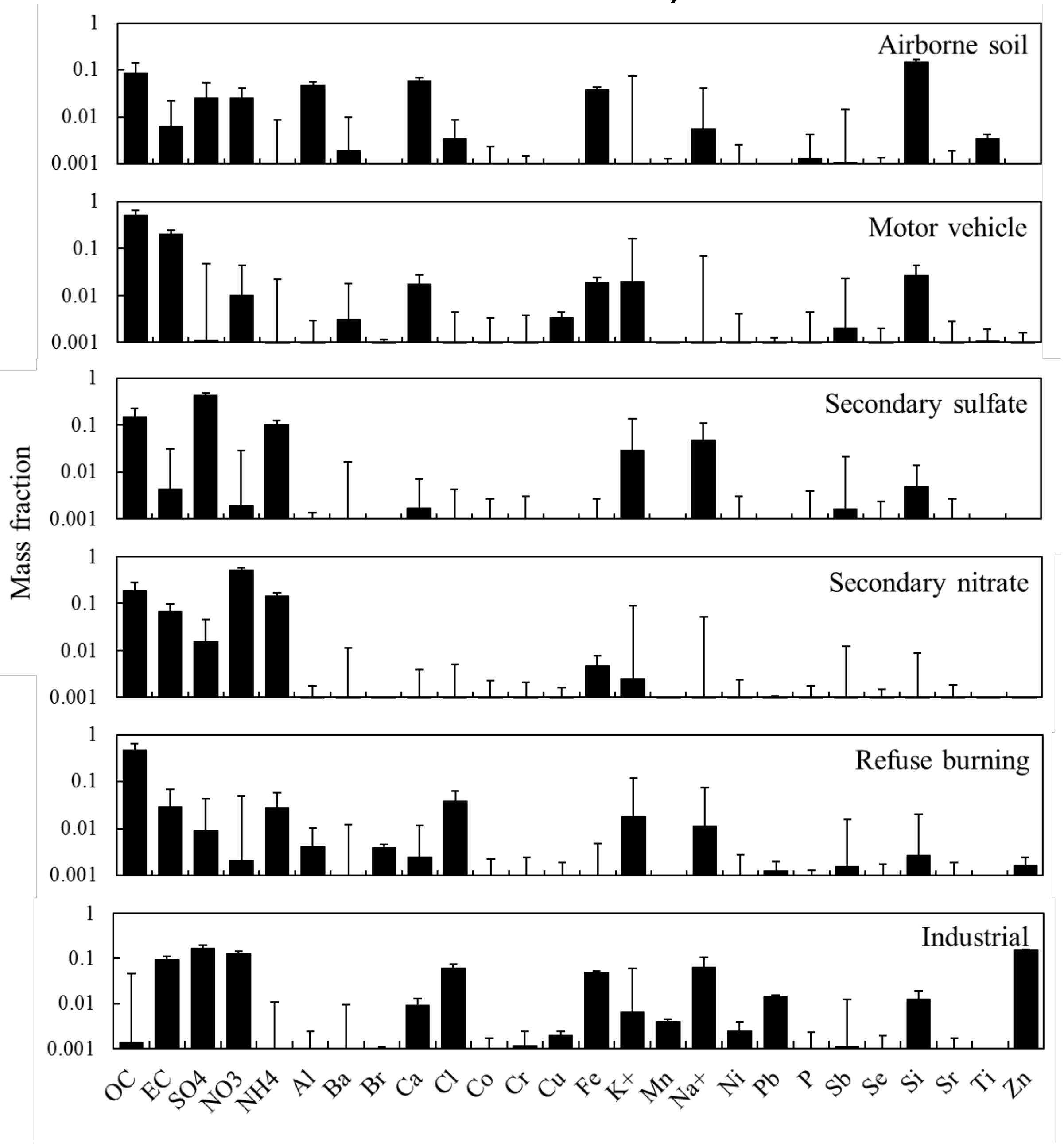


**Figure B6. Source contributions deduced from $PM_{2.5}$ samples measured at Calexico**

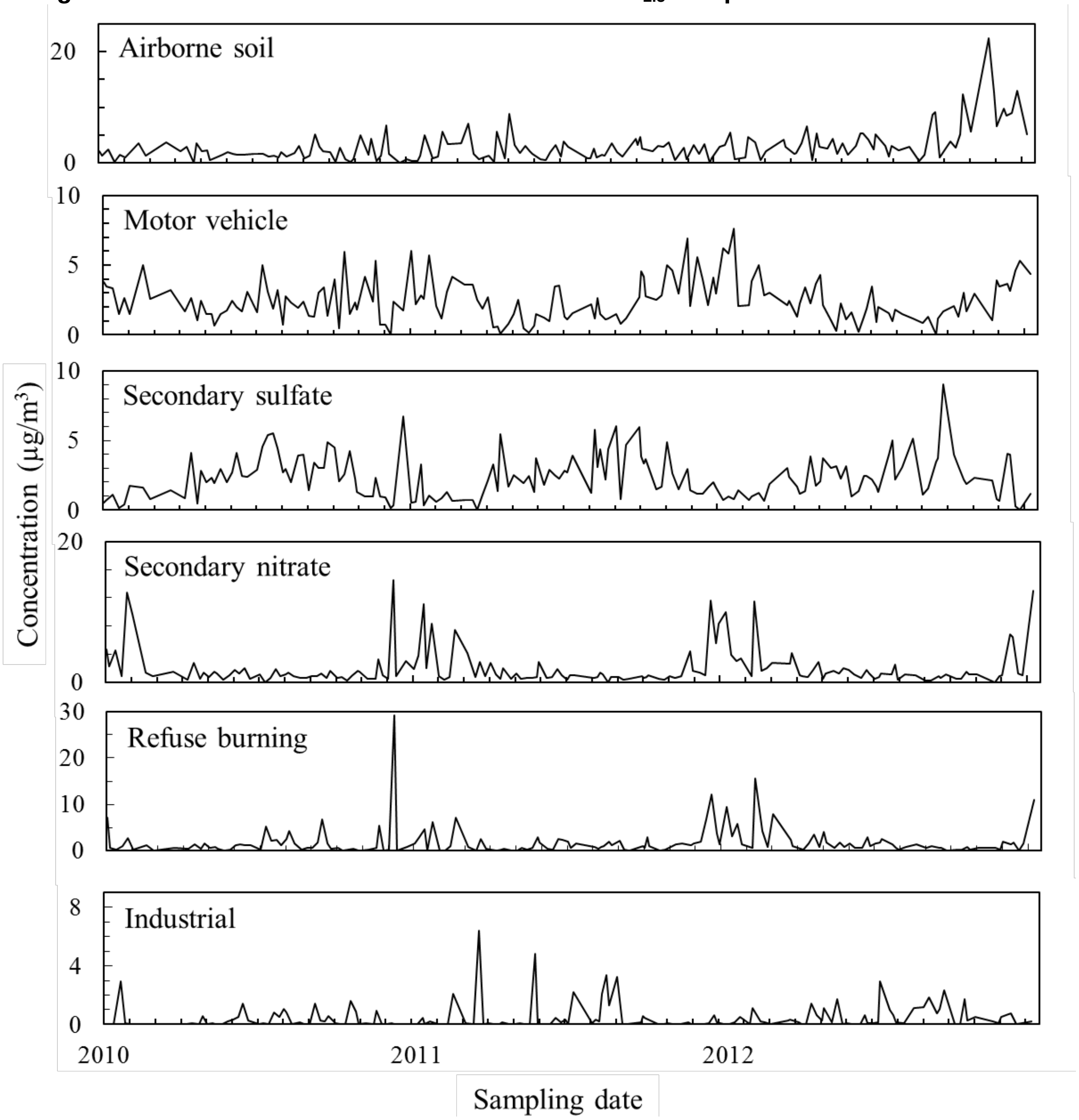


**Figure B7. Monthly variations of source contributions to $PM_{2.5}$ mass concentration at Calexico (mean ± 95 % distribution)**

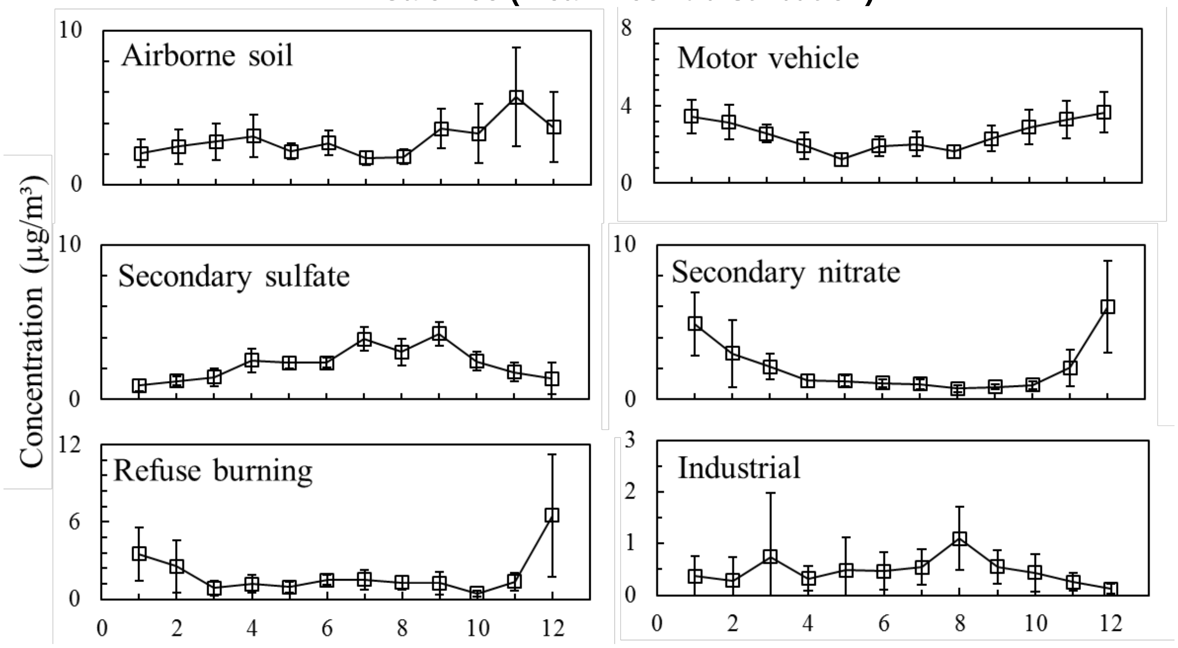


**Figure B8. Weekday/weekend variations of source contributions to $PM_{2.5}$ mass concentration at Calexico. (mean ± 95 % distribution)**

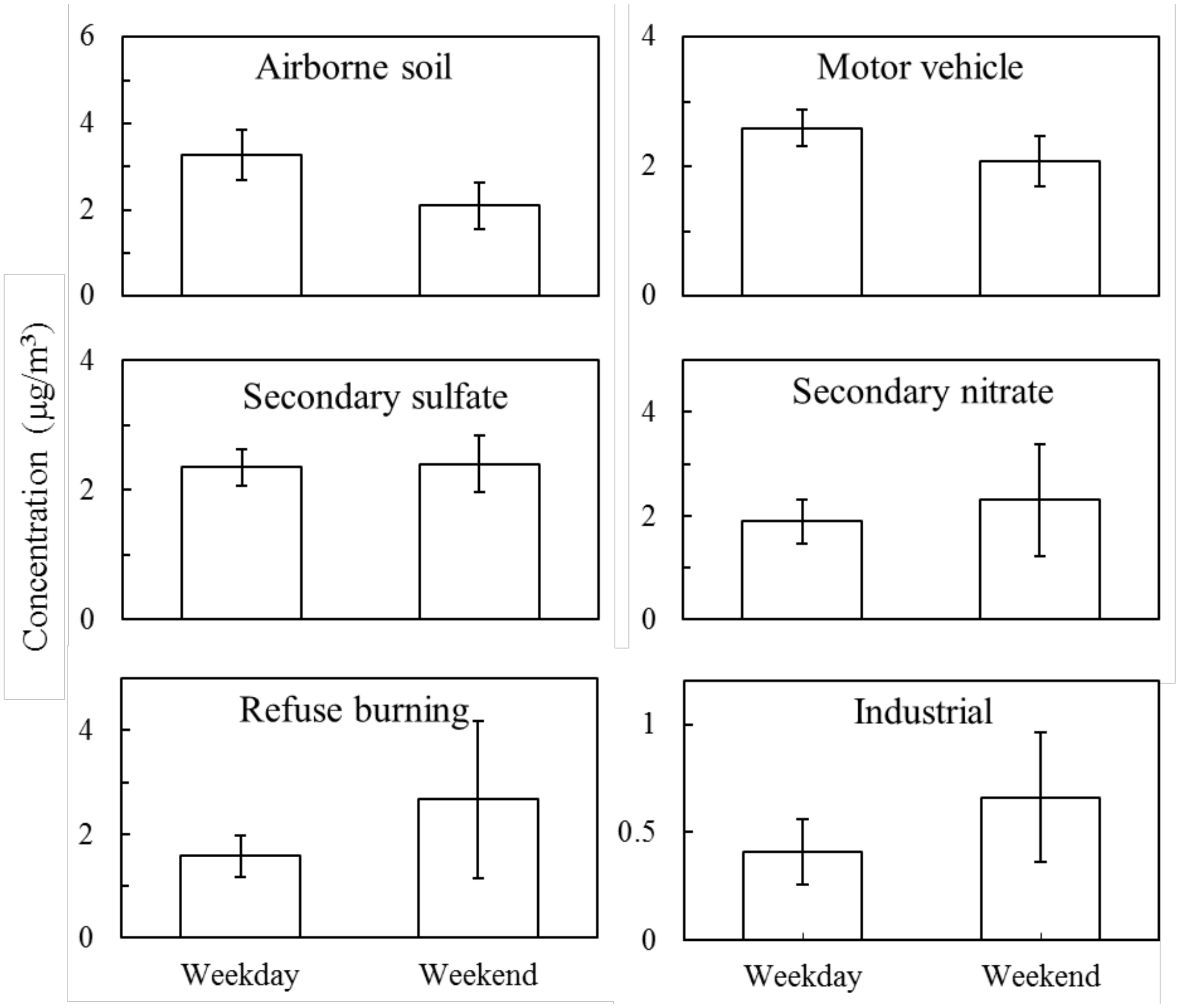
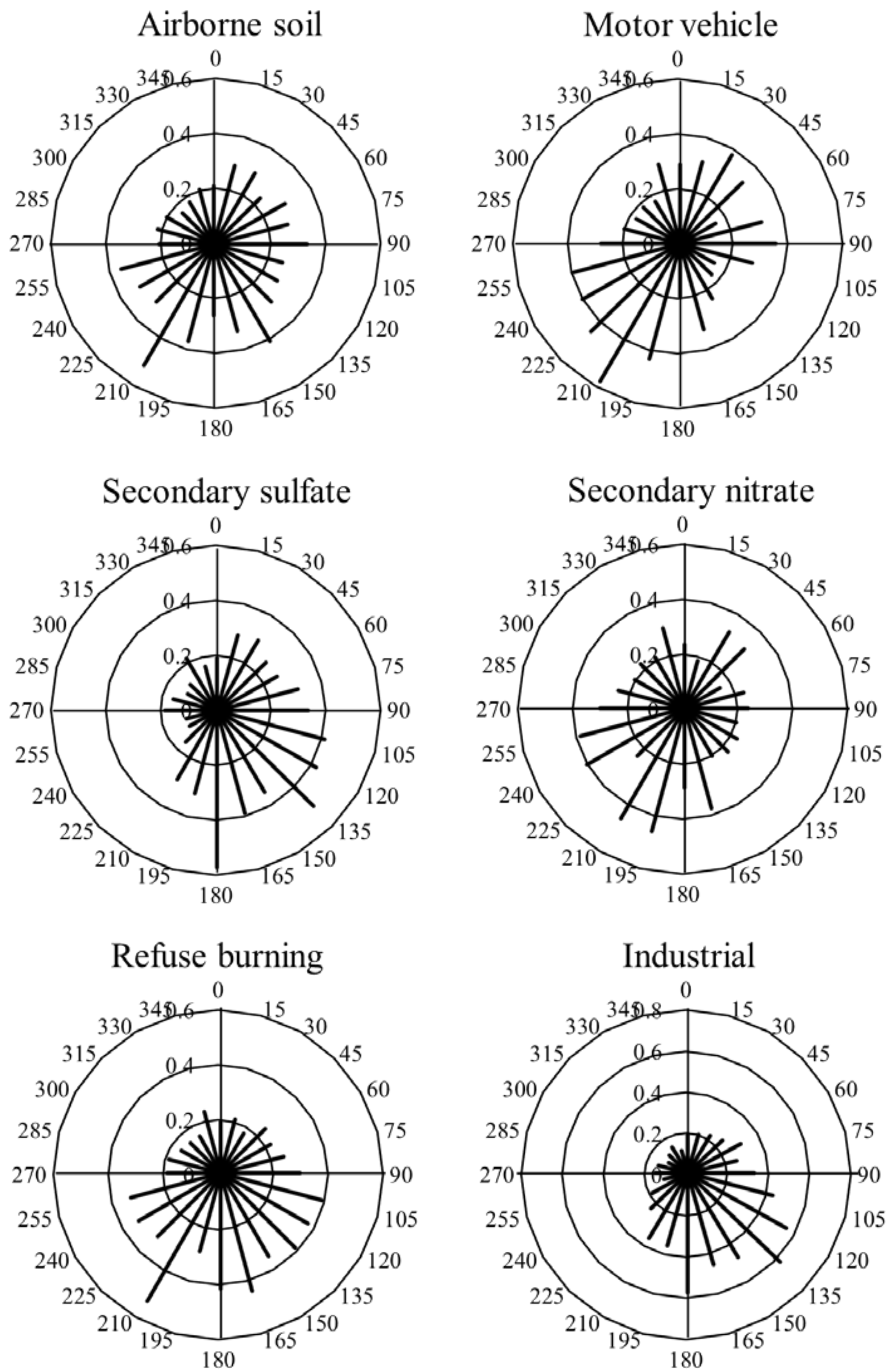


**Figure B9. Conditional probability function plots for the highest 25 % of the source contributions**



## Appendix C

## Diurnal Patterns and Wind Roses for Nine Non-FEM Outlier Days

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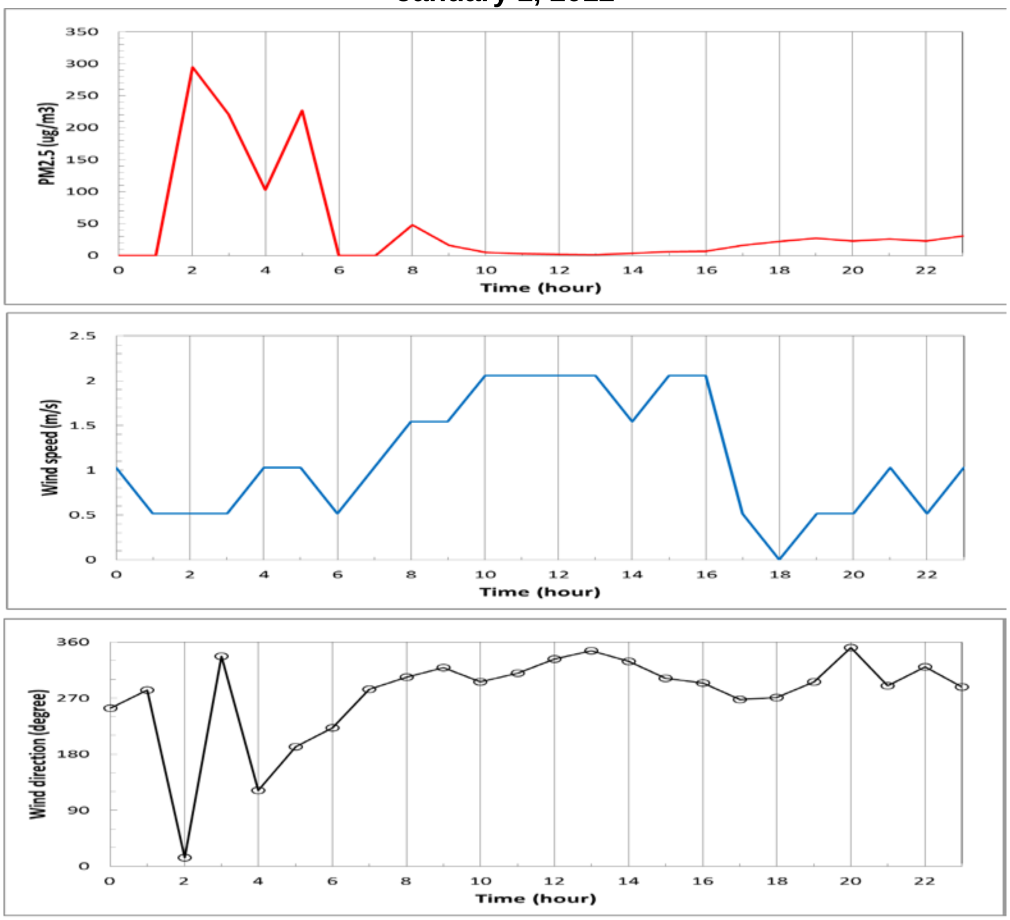


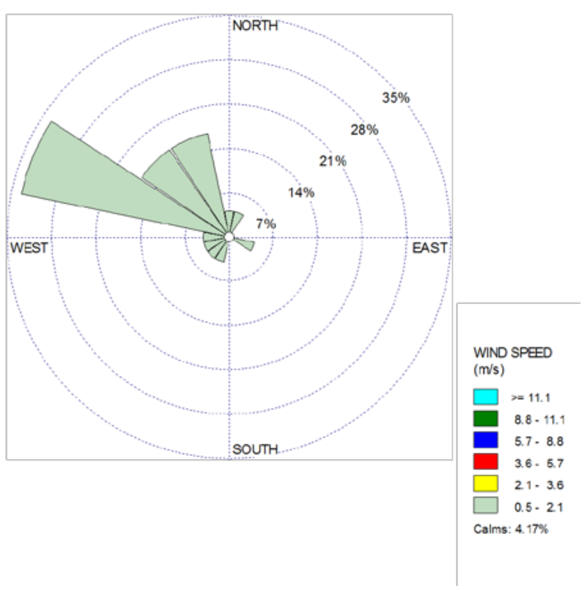

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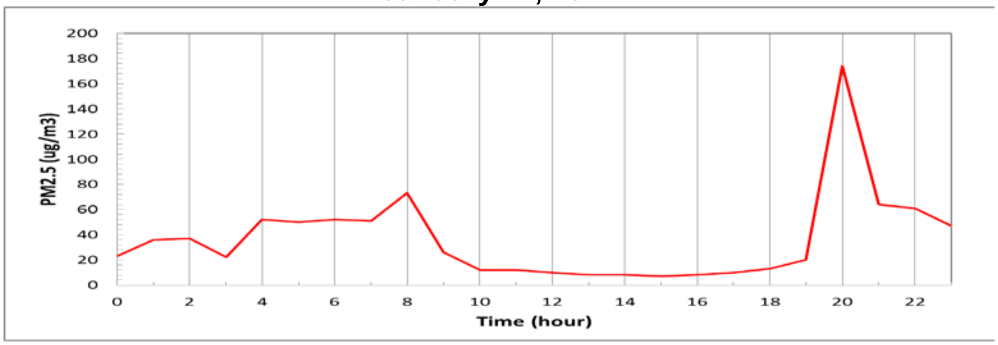


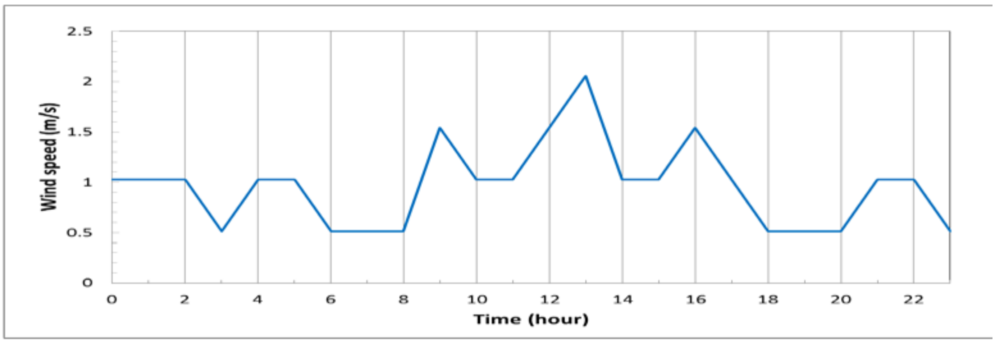


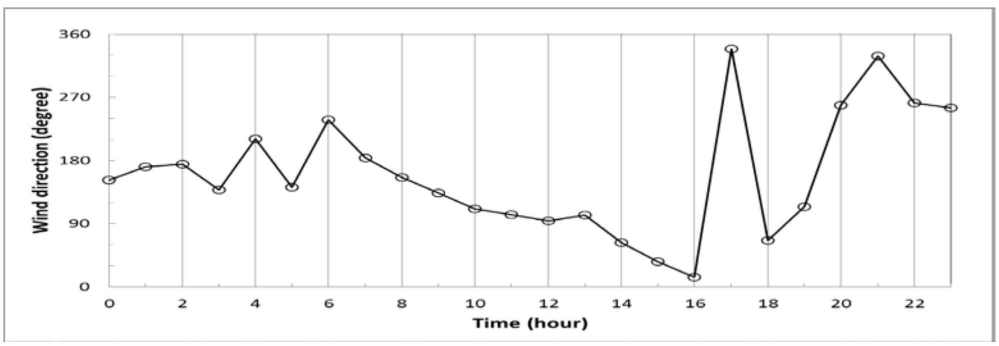


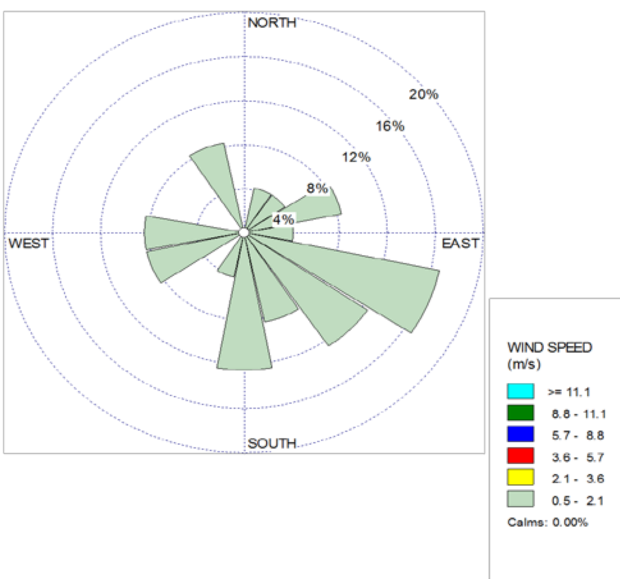


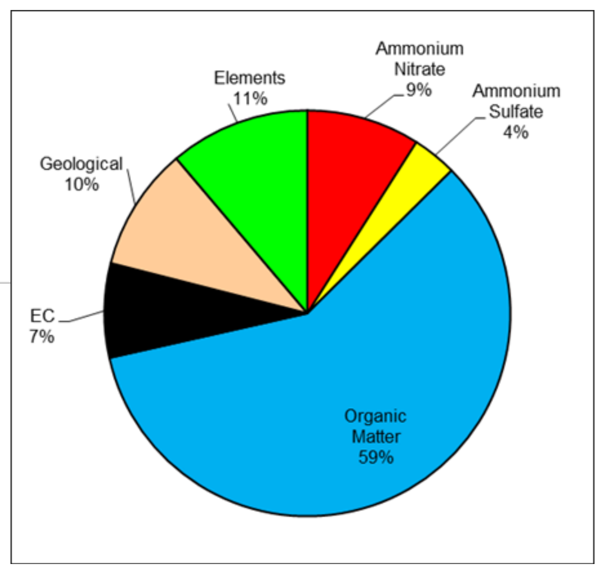

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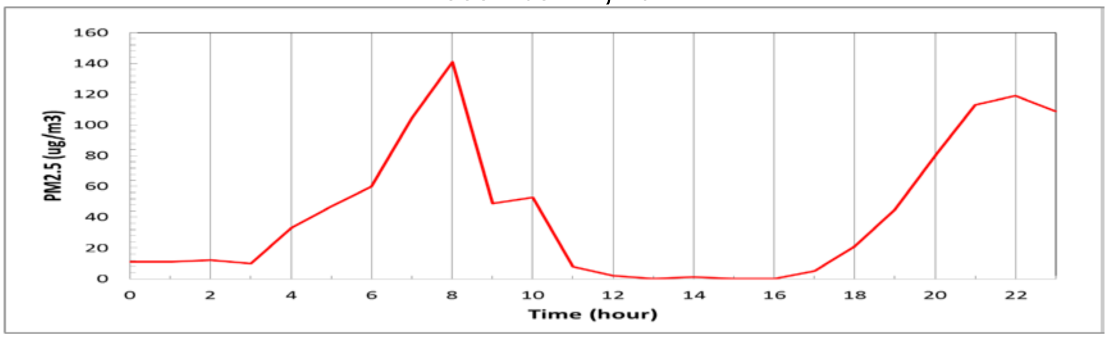


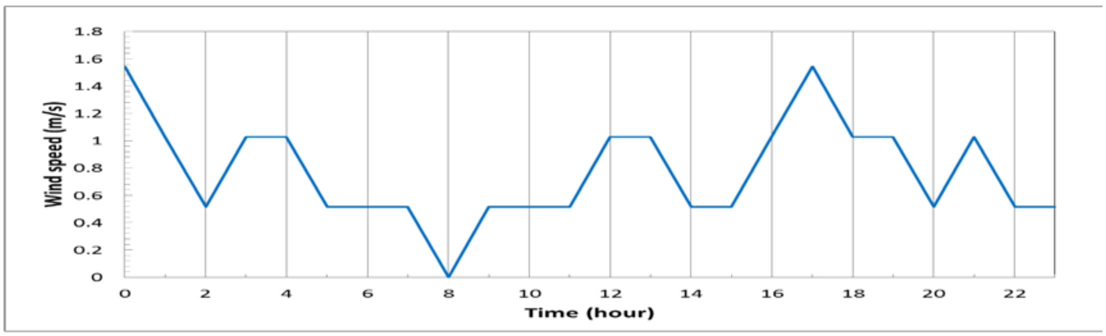


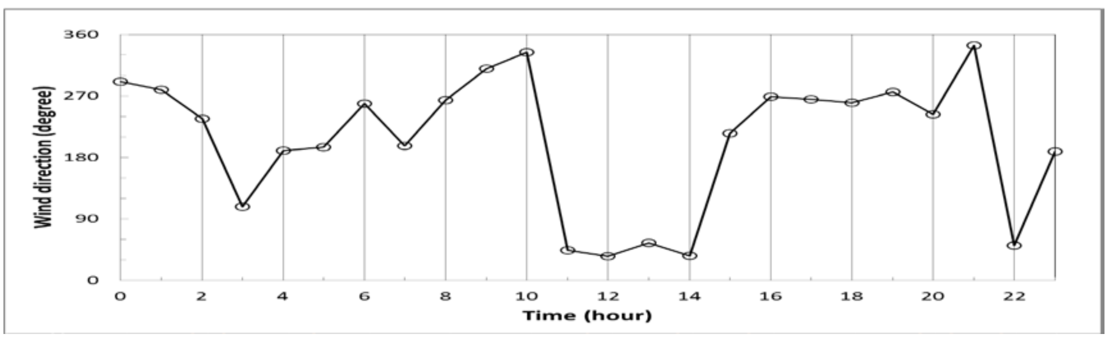


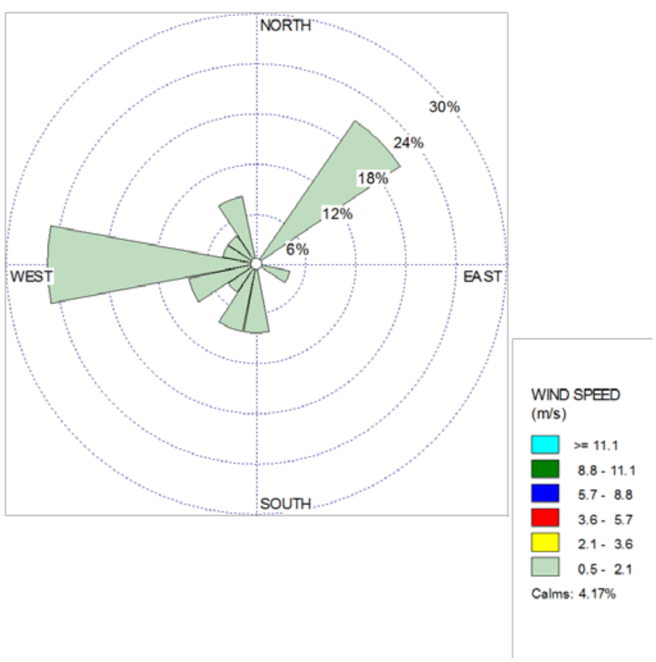

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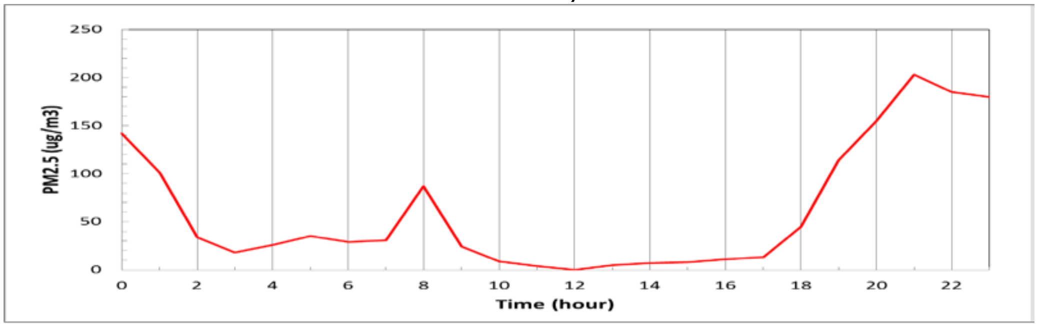


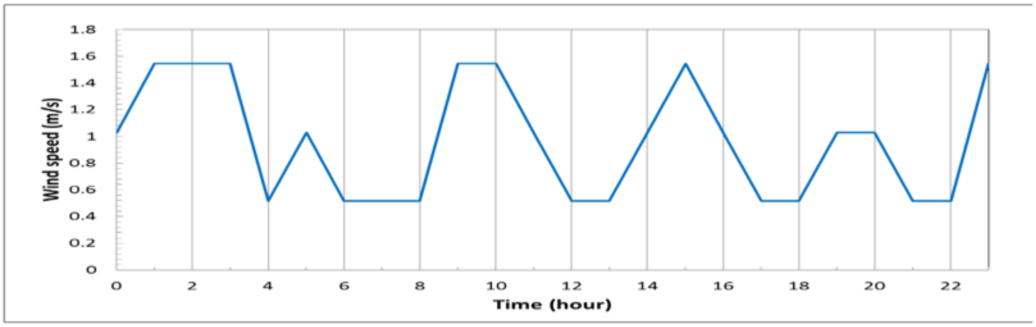


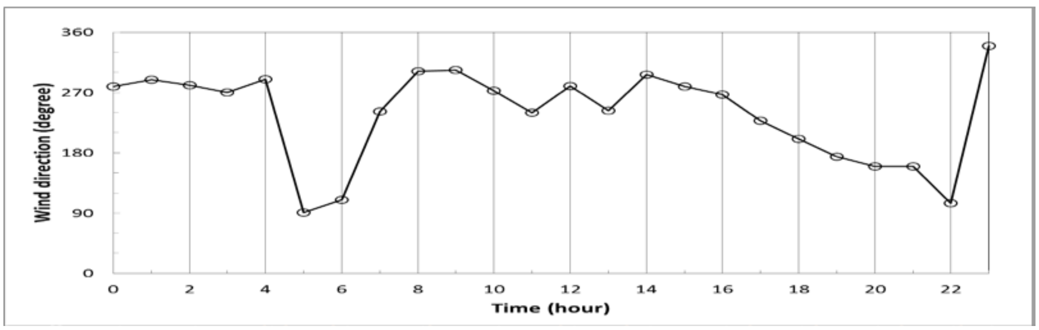


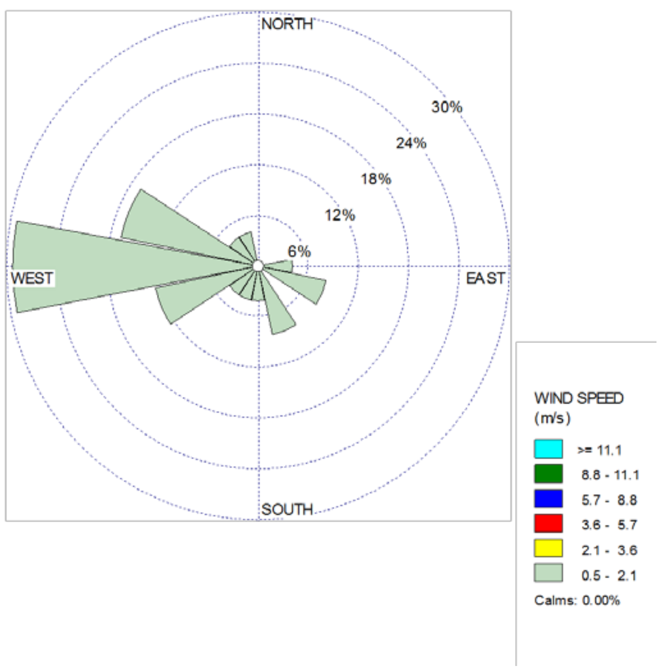

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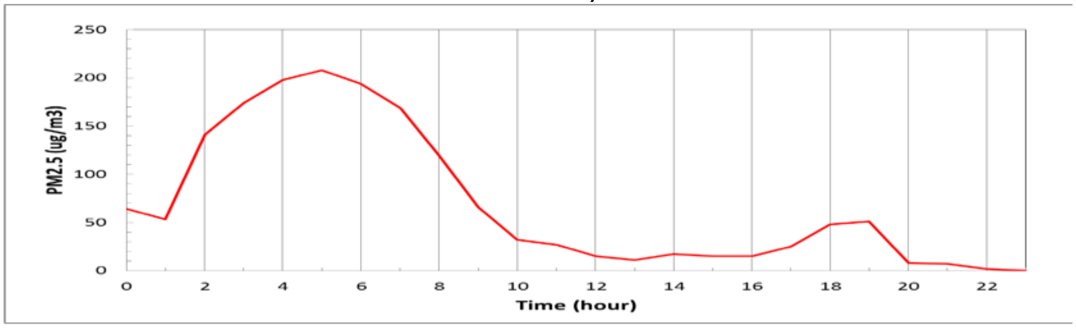


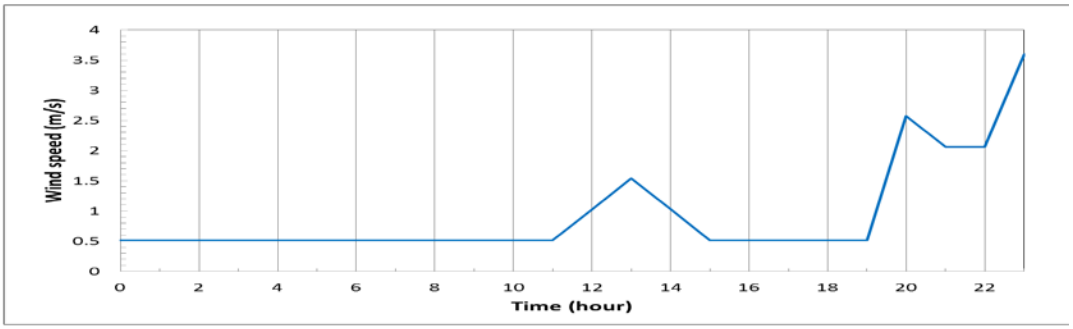


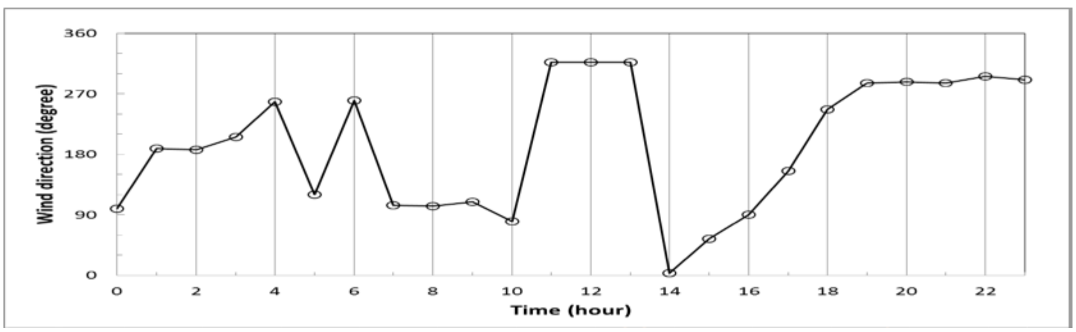


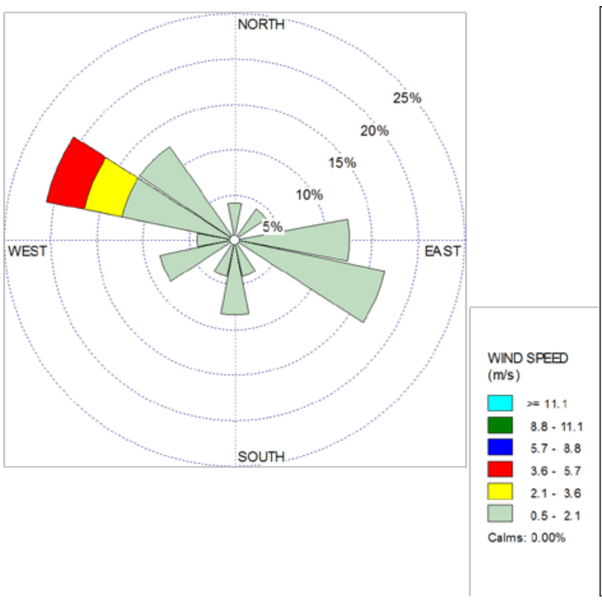


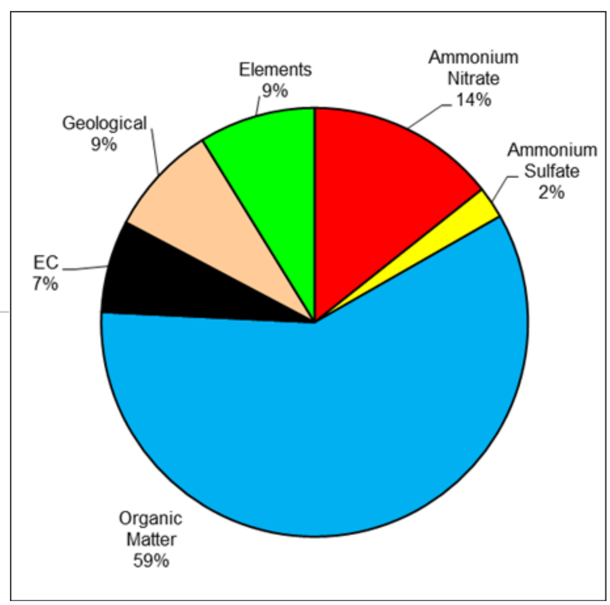

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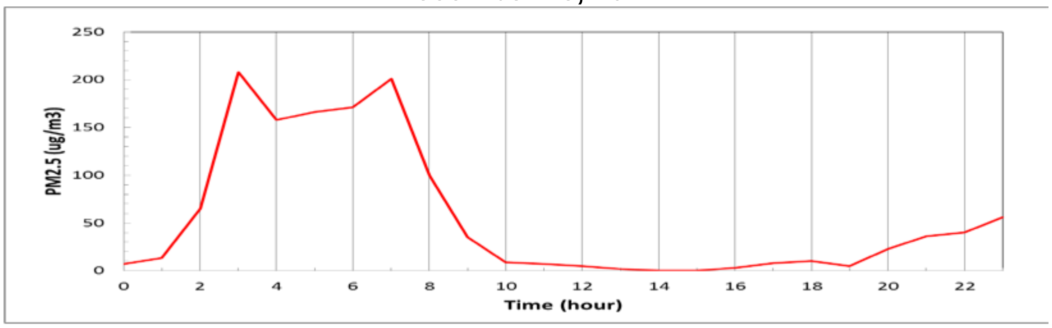


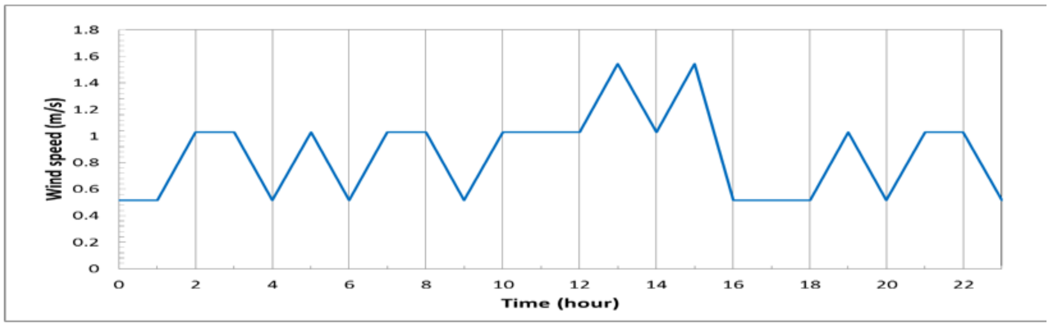


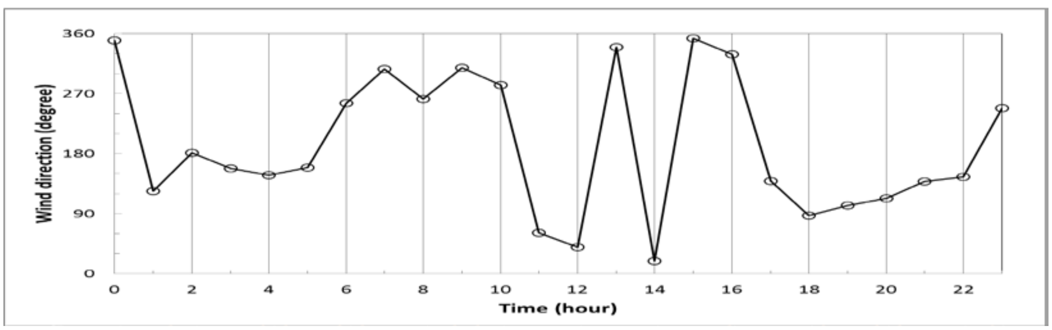


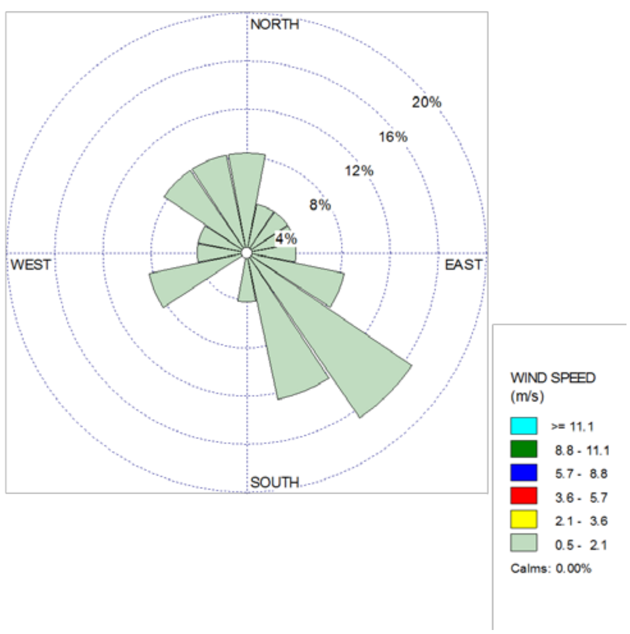

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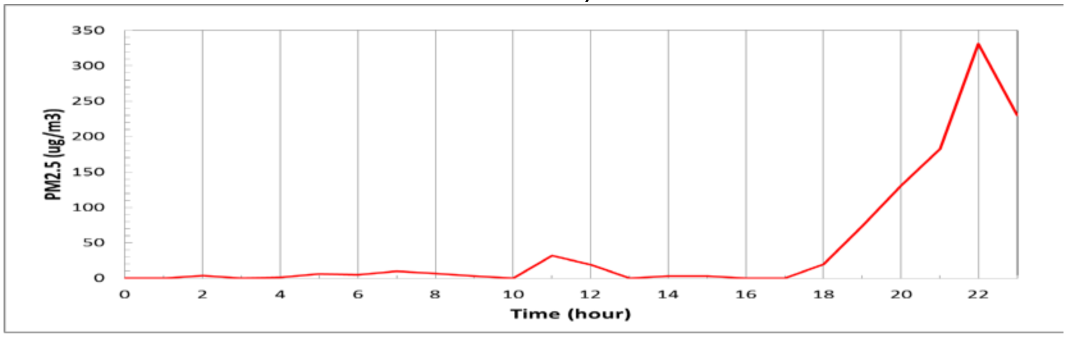


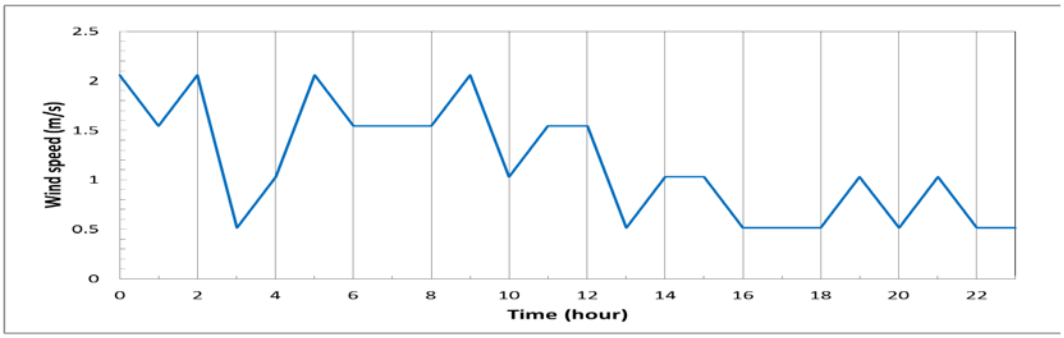


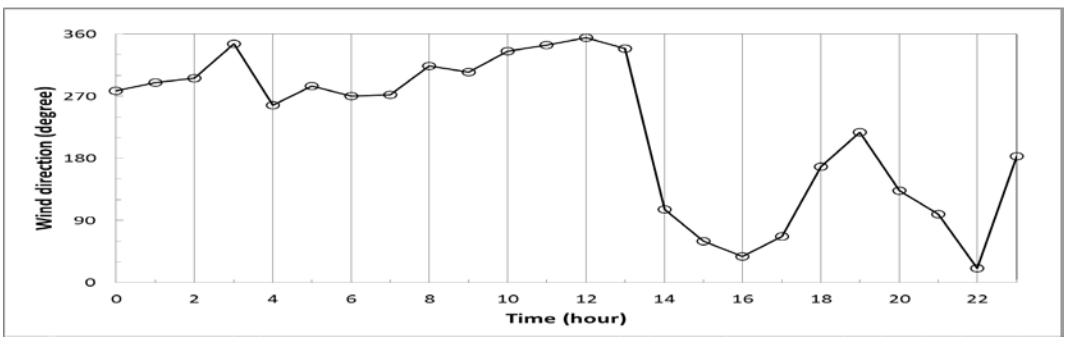


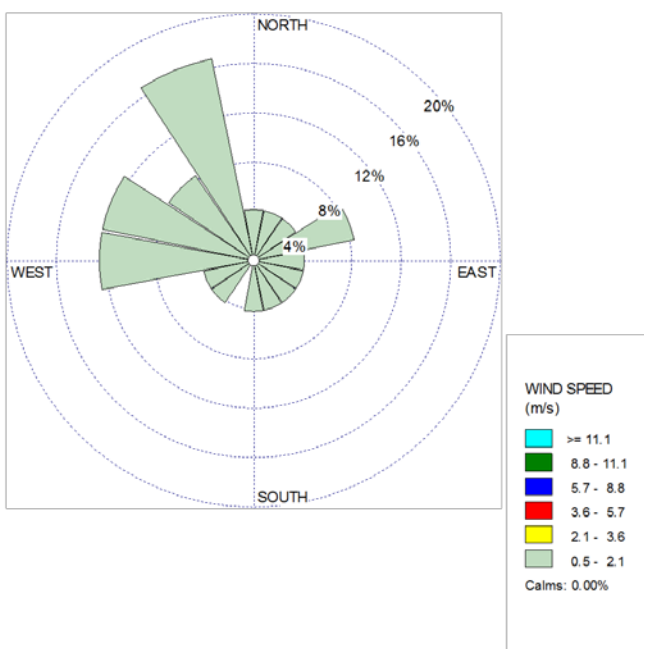

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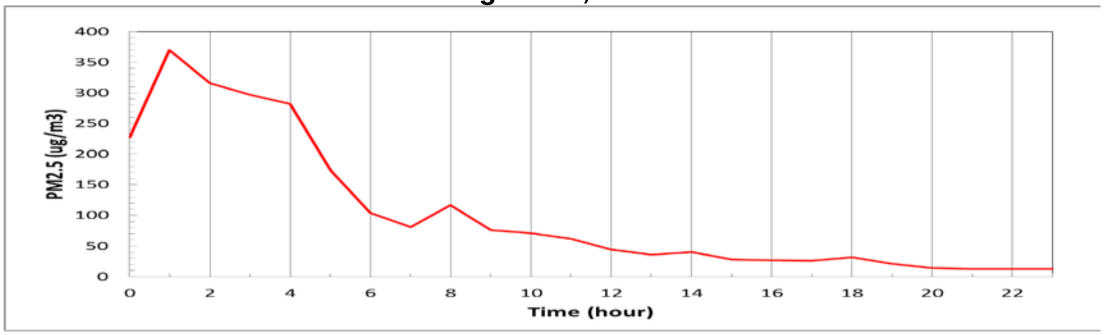


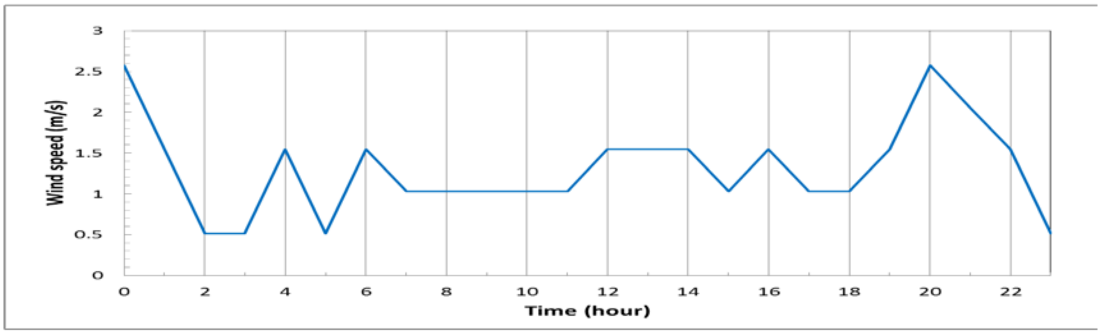


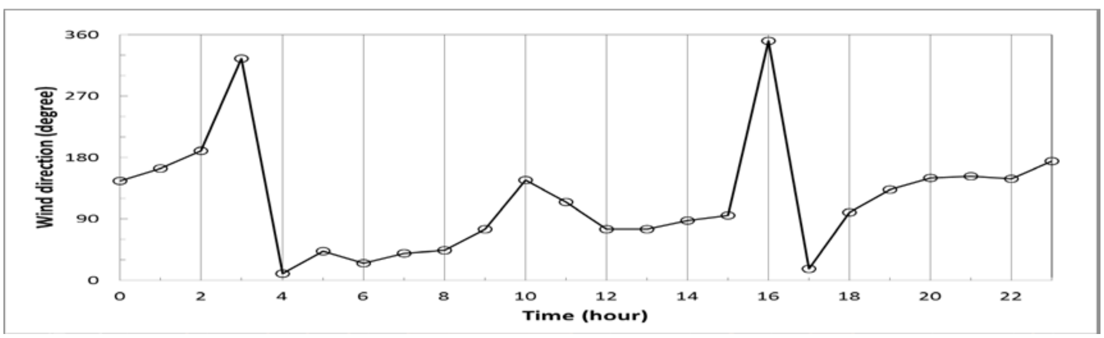


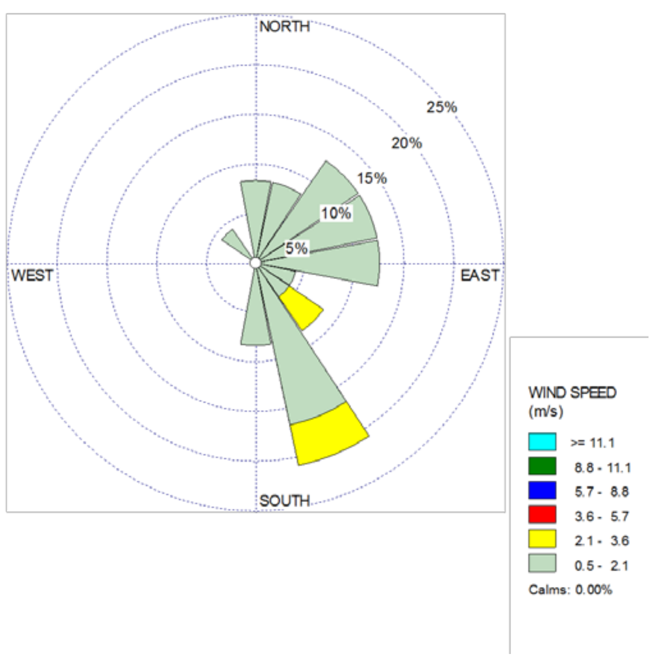

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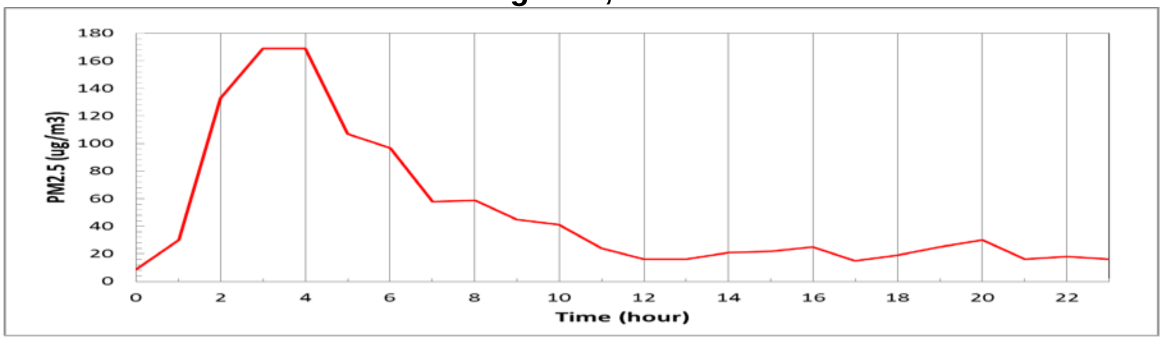


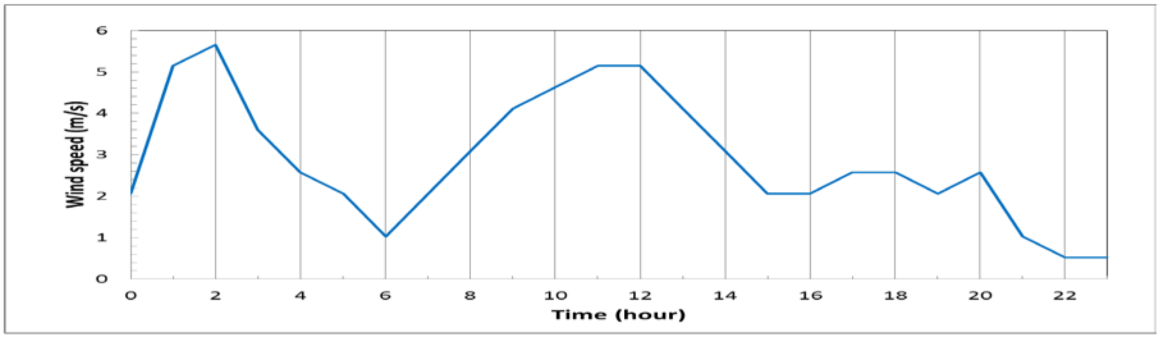


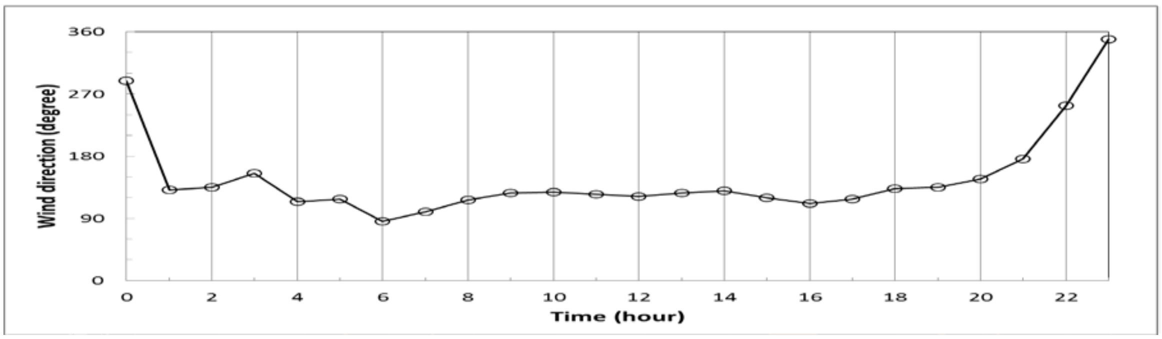


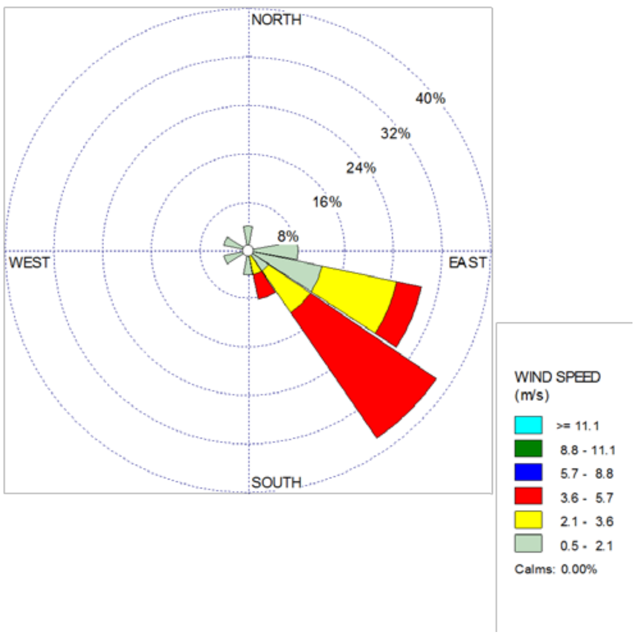

# APPENDIX B: EMISSION INVENTORY DOCUMENTATION

## 1. Introduction

This document describes the emissions inventory included in the State Implementation Plan (SIP or Plan) for the Imperial County PM2.5 Nonattainment Area. It also summarizes the revisions and improvements made to the inventory as part of this Plan.

The Air Resources Board (ARB) works continually with the local air districts to collect information and conduct research to improve the emissions inventories. During development of this Plan, ARB and the Imperial County Air Pollution Control District (District) allocated substantial resources to the improvement of these estimates. From 2009 to 2012, ARB headed a workgroup that focused on updating the inventory data in ARB's database for areas designated nonattainment for the 35 $\mu g/m^3$ daily PM2.5 Standard. ARB and District staff conducted a thorough review of the inventory to ensure that the emission estimates reflected accurate emission reports for point sources, and that estimates for mobile and area-wide sources were based on the most recent models and methodologies.

ARB also updated the growth profiles for point and areawide source categories to ensure that the emission projections are based on data that reflect historical trends, current conditions, and recent economic and demographic forecasts. Following what has been a long-standing practice for the southern part of the State, growth forecasts for most point and areawide sources were developed by the Southern California Association of Governments (SCAG) and provided to ARB through the South Coast Air Quality Management District. SCAG is the metropolitan planning organization representing Imperial County, along with five other counties in Southern California.

### Emissions Inventory Overview

Emissions inventories are estimates of the amount and type of pollutants emitted into the atmosphere by industrial facilities, mobile sources, and smaller sources such as consumer products and paint. Emissions inventories serve as 1) a primary input to air quality modeling used in attainment demonstrations; 2) the emissions data used for developing control strategies; and 3) a means to track progress in meeting the emission reduction commitments.

The United States Environmental Protection Agency (U.S. EPA) establishes requirements pertaining to emissions information that must be included as part of the SIP submittal package. For the PM2.5 Plan, the regulations require that the emissions inventory contain emissions data for directly emitted PM2.5 and PM2.5 precursors: NOx, VOC, SOx, and ammonia.

An emissions inventory is a critical tool in the evaluation of air pollution. In simple terms, an emissions inventory is a systematic listing of the sources of air pollution along with the amount of pollution emitted from each source or category over a given time period. Emissions inventories are an estimate of the air pollution emissions that are actually released into the environment—they are not measurements of ambient concentrations.

The following are examples of pollution sources by key sectors:

- Industrial or stationary point sources—power plants and oil refineries;
- Areawide sources—consumer products and residential fuel combustion;
- On-road sources—passenger vehicles and heavy-duty trucks;
- Off-road mobile sources—aircraft, trains, ships, recreational boats, construction equipment and farm equipment; and
- Nonanthropogenic (natural) sources—biogenic (or vegetation), geogenic (petroleum seeps), and wildfires.

**Agency Responsibilities**

ARB and District staff worked jointly to develop a comprehensive emissions inventory for the Imperial County PM2.5 Nonattainment Area. The District worked closely with operators of major stationary facilities in their jurisdiction to develop the point source emission estimates.

ARB staff developed the emission inventory for the mobile sources (both on-road and off-road). The District and ARB shared responsibility for developing estimates for the nonpoint (areawide) sources such as paved road dust and agricultural burning. ARB worked with several state and local agencies such as the Department of Transportation (Caltrans), the Department of Motor Vehicles (DMV), the Department of Pesticide Regulation (DPR), the California Energy Commission (CEC), and SCAG to assemble activity information necessary to develop the mobile and area-wide source emission estimates.

**Base Year Inventory**

The base year inventory is an essential element of the Plan that forms the basis for all future year projections and also establishes the emission levels against which progress in emission reductions will be measured. U.S. EPA regulations establish general guidelines for selecting an inventory base year. Based on those guidelines, ARB and the District selected 2008 as the base year for this Plan.

**Emission Forecasts**

In addition to a base year inventory, U.S. EPA regulations require future year inventory projections for specific milestone years. ARB develops emission forecasts for point and area-wide sources by applying growth and control profiles to the base year inventory to account for year-to-year changes resulting from anticipated trends in economic conditions and population growth, and the effects of adopted emission control rules.

Growth profiles for point and areawide sources are derived from surrogates such as economic activity, fuel usage, population, dwelling-units, etc., that best reflect the expected growth or decline rates for each specific source category. Control profiles, which account for emission reductions resulting from adopted rules and regulations, are derived from data provided by the regulatory agencies responsible for the affected emission categories.

Mobile source projections are generated by emission models that employ sophisticated routines that predict vehicle fleet turnover by vehicle model year. As with stationary sources, the mobile source models include control algorithms that account for all adopted regulatory actions.

**Annual and Seasonal Inventories**

Annual and seasonal emissions inventories are often referred to as planning inventories. Annual emissions inventories represent the total emissions over an entire year (tons per year), or the daily emissions produced on an average day (tons per day). Seasonal inventories (summer and winter) account for temporal activity variations throughout the year, as determined by actual data from point source facilities or by temporal profiles developed for areawide and mobile sources. Summer inventories include emissions from May through October, and winter inventories encompass November through April. Because PM2.5 concentrations in Imperial County are at their highest during the winter months, the emission inventory used in the Plan is based on the winter season.

**Spatial Allocation**

Emissions inventories are developed at various geographical resolutions encompassing district, air basin, and county levels. The inventories presented in the District Plan are the emissions for the PM2.5 Nonattainment Area. The approach for allocating the county-level emissions to the nonattainment area is described below.

- Stationary Sources. Emissions from stationary sources were designated as being inside or outside the nonattainment area based on the location of the individual facilities. This was done by conducting a GIS analysis of each facility's geographical coordinates (latitude and longitude) overlaid on a digitized map of the nonattainment area.

- Areawide Sources. Human population is typically a good surrogate for allocating emissions from these sources, as they are often closely associated with human activity. In some cases, however, more representative spatial surrogates are available for some categories (e.g., irrigated cropland acreage), which allows for a more accurate resolution of the inventory. In assigning the spatial surrogates, ARB staff prioritized the source categories based on their NOx, SOx and direct PM2.5 emissions, and selected those above a threshold level of 0.1 tons per day for further review. Human population was set as the default surrogate, but more precise, category-specific surrogates were selected when data were available. In the interest of timeliness, categories below the 0.1 ton per day threshold were not assigned a surrogate (these emissions are treated as if they occurred 100 percent inside the nonattainment area).

- On-Road Mobile Sources. Emissions from on-road mobile sources were estimated at the county level using California's on-road motor vehicle model, EMFAC2011. The allocation to the nonattainment area was accomplished using the Direct Travel Impact Model (DTIM) to produce gridded emission estimates, and then using these estimates as a gridded spatial surrogate to distribute EMFAC2011 NOx emissions among grid cells inside and outside the nonattainment area. Emissions for other pollutants (VOC, PM2.5, SOx, and ammonia) were assigned the same spatial distribution as NOx.

- Off-Road Mobile Sources. Much like areawide sources, emissions from off-road mobile sources tend to be closely associated with human activity; therefore, a similar approach was used in the allocation of these emissions. ARB staff set human population as the spatial surrogate for source categories above 0.1 ton per day of NOx, SOx or direct PM2.5. Emissions for categories below the 0.1 ton per day threshold were treated as if they occurred entirely inside the nonattainment area.

**Table 1**
**Methods for the Spatial Allocation of Emissions to the Imperial County PM2.5 Nonattainment Area**

| **Source Category** | **Allocation Method** |
|---|---|
| Stationary Point Sources | GIS Analysis |
| Areawide Sources | |
| *I.C. Reciprocating Engines* | Human Population/Industrial Employment |
| *Agricultural Irrigation I.C. Engines* | Irrigated Cropland Acreage |
| *Residential Fuel Combustion* | Human Population |
| *Farming Operations - Tilling Dust* | Human Population |
| *Farming Operations - Feedlot Cattle* | Percent of open, semi-rural area in NA |
| *Construction and Demolition* | Human Population |
| *Paved Road Dust* | Human Population |
| *Unpaved Road Dust* | Human Population |
| *Fugitive Windblown Dust* | GIS Analysis |
| *Agricultural Burning* | Percent of Agricultural Cropland in NA |
| On-Road Mobile Sources | Direct Travel Impact Model Analysis |
| Off-Road Mobile Sources | Human Population |

**Quality Assurance and Quality Control**

ARB has established a quality assurance and quality control (QA/QC) process that promotes collaboration of ARB and air district staff to ensure the integrity and accuracy of the emissions inventories used in the development of air quality plans.
QA/QC occurs at the various stages of SIP emission inventory development. Base year emissions are assembled and maintained in the California Emission Inventory Development and Reporting System (CEIDARS). ARB inventory staff works with air districts, who are responsible for developing and reporting point source emission estimates, to verify these data are accurate. The locations of point sources, including stacks, are checked to ensure they are valid. Area-wide source emission estimates are developed by ARB staff as well as some air districts. The methodologies for estimating these are reviewed by ARB and district staff before their inclusion in the emission inventory. Additionally, CEIDARS is designed with automatic system checks to prevent errors such as double counting of emission sources. The system also makes various reports available to assist staff in their efforts to identify and reconcile anomalous emissions.

Future year emissions are estimated using the California Emission Projection Analysis Model (CEPAM). Growth and control factors are reviewed for each category and year along with the resulting emission projections. Year to year trends are compared to similar and past datasets to ensure general consistency. Emissions for specific categories are checked to confirm they reflect the anticipated effects of applicable control measures. Mobile categories are verified with mobile source staff for consistency with the on-road and off-road emission models.

## 2. Emissions Inventory Improvements

A summary of the major revisions that have been incorporated into the PM2.5 Plan emissions inventory is presented below.

### Stationary Source Emissions

The emissions inventory reflects actual emissions from stationary sources (industrial point sources) reported to the District by the facility operators for calendar year 2008. District staff works with facility operators to ensure that emissions are reported accurately and in a timely manner. In addition to the base year update, the growth profiles for industrial categories were updated to reflect growth projections from SCAG's 2012 Regional Transportation Plan (RTP). The stationary source growth surrogates used in the Plan are presented in Table 2 below.

**Table 2**
**Growth Surrogates for Stationary Sources**

| Source Category | Subcategory | Growth Surrogate |
|---|---|---|
| Fuel Combustion | Electric Utilities | Total Employment |
| | Manufacturing and Industrial | Natural Gas Consumption & Industry-Specific Outputs |
| | Food and Ag Processing | Food Manufacturing Output |
| | Irrigation Pumps | Irrigated Farmland |
| | Service and Commercial | Natural Gas Consumption |
| | I.C. Reciprocating Engines | Industry-Specific Outputs |
| Other Waste Disposal | Other | Waste Management Employment |
| Laundering | Dry Cleaning | Total Employment |
| Degreasing | All | Manufacturing Output |
| Coatings & Thinners | Auto Refinishing | Misc. Services Employment |
| | Metal Parts & Products Coatings | Fabricated Metal Output |
| | Wood and Fabricated Furniture Coatings | Furniture Output |
| | Thinning & Cleanup Solvent Uses | Manufacturing Output |
| Adhesives & Sealants | All | Manufacturing Output |
| Petroleum Refining | Other | Warehousing and Delivery Services Output |

**Table 2 (cont.)**
**Growth Surrogates for Stationary Sources**

| Source Category | Subcategory | Growth Surrogate |
|---|---|---|
| Petroleum Marketing | Bulk Storage Tanks | Warehousing and Delivery Services Output |
| | Gasoline Dispensing Facilities | Gasoline Consumption |
| | Vehicle Refueling Losses | Gasoline Consumption |
| | Cargo Tank Losses | Gasoline Consumption |
| Food & Agriculture | Crop Processing Losses | Food Manufacturing and Agriculture Outputs |
| Mineral Processes | Sand & Gravel Excavation & Processing | Non-metallic Mineral Products Output |
| | Asphaltic Concrete Production | No Growth |
| | Surface Blasting | Mining Extraction Output |
| | Cement Concrete Manufacturing & Fabrication | Non-metallic Mineral Products Output |
| | Gypsum Manufacturing | Non-metallic Mineral Products Output |
| Other Industrial Processes | Floating Roof Tanks, Working Losses | Warehousing and Delivery Services Output |

**Areawide Source Methodology Updates**

Areawide sources include categories associated with human activity where emissions take place over a wide geographic area. Consumer products and unpaved road dust are examples. Areawide sources also include smaller point sources or facilities, such as gasoline dispensing facilities and residential water heaters that are not inventoried individually, but are estimated as a group and reported as a single source category. Improvements made to the areawide emission inventory categories are described below.

*Ammonia Emissions from Publicly Owned Treatment Works, Landfills, Composting, Fertilizer Application, Domestic Activity, Native Animals, and Native Soils*

ARB staff updated the ammonia emissions inventory methodology for publicly owned treatment works, landfills, composting, fertilizer application, domestic activity, native animals, and native soils. Revisions for these categories consist primarily of updated activity data for the 2008 calendar year. Emission factors were revised only for fertilizer application.

*Architectural Coatings*

The Architectural Coatings category was updated to reflect emission estimates based on the comprehensive survey for the 2004 calendar year. The emission estimates include benefits of the 2003 and 2007 ARB Suggested Control Measures. Additional information about ARB's architectural coatings program is available at: http://www.arb.ca.gov/coatings/arch/arch.htm

*Consumer Products*

The Consumer Products category was updated to reflect the three most recent surveys conducted by ARB staff for the years 2003, 2006, and 2008. Together these surveys collected updated product information and ingredient information for approximately 350 product categories. Based on the survey data, ARB staff determined the total product sales and total VOC emissions for the various product categories. Before the emissions inventory was updated, some of the existing categories were split out into more specific categories, others were combined, and new categories were added to better reflect changes in formulations of existing products. The result of this update was an overall reduction in emissions from this category. Additional information on ARB's consumer products surveys is available at: http://www.arb.ca.gov/consprod/survey/survey.htm.

*Agricultural Land Preparation and Harvest Operations*

ARB staff updated the methodologies for Agricultural Land Preparation and Harvest Operations to reflect 2005 harvested crop acreage from the U.S. Department of Agriculture's (USDA) National Agricultural Statistics Service (NASS). NASS data are based on reports compiled by County Agricultural Commissioner staff. An updated particle size fraction was used, which reduces the fraction that PM2.5 contributes to PM10 by about 10%. Temporal profiles were updated based on crop specific activity profiles. In addition, the inventory reflects the emission reductions from District Rule 806. The methodologies are available at: http://www.arb.ca.gov/ei/areasrc/arbmiscprocresfarmop.htm

*Fugitive Windblown Dust from Open Areas and Non-pasture Agriculture Lands*

The District provided estimates of windblown fugitive dust derived from a model developed by ENVIRON Inc. under a contract with the District. The model assesses emission characteristics, hourly emission factors and hourly meteorological data for each land parcel within the modeling domain, and applies correction terms based on vegetative cover, as well as non-climatic corrections for agricultural lands. Based on these inputs, the model was used to estimate fugitive windblown dust emission from open areas and non-pasture agriculture lands in the Imperial County PM2.5 Nonattainment Area. The inventory reflects the emission reductions from District Rules 804, 805 and 806.

*Livestock Husbandry*

ARB staff updated the Livestock Husbandry methodology to reflect livestock population data based on the U.S. Department of Agriculture's 2007 Census of Agriculture, and ammonia emission factors for dairy support cattle. A seasonal adjustment was added to account for the suppression of dust emissions in months in which rainfall occurs. In addition, the inventory reflects emission reductions from District Rule 420. Additional

information on ARB's methodology is available at:
http://www.arb.ca.gov/ei/areasrc/arbmiscprocresfarmop.htm

*Managed Burning & Disposal*

ARB updated the Managed Burning and Disposal category with emissions data reported by District staff for 2008. Emissions are calculated using crop specific emission factors and fuel loadings. Temporal profiles reflect monthly burn activity. ARB's methodology for managed burning is available at: http://www.arb.ca.gov/ei/see/see.htm.

*Paved Road Dust*

ARB updated the paved road dust methodology to be consistent with the current U.S. EPA AP-42 method (January 2011) to quantify dust emissions from paved roads. Revisions include California-specific reductions in silt loading values, updated vehicle miles traveled (VMT) data from EMFAC2011 for the year 2008, updated travel fractions from CalTrans for the year 2008, and incorporation of precipitation correction factors. In addition, the revised method removed the vehicle exhaust, tire wear and brake wear PM, thereby avoiding double-counting of emissions which are already estimated in EMFAC. The inventory also reflects the emission reductions from District Rules 803 and 805. The paved road dust travel methodology is available at:
http://www.arb.ca.gov/ei/areasrc/arbmiscprocpaverddst.htm

*Pesticides*

The Department of Pesticide Regulation (DPR) develops month-specific emission estimates for agricultural and structural pesticides. Each calendar year, DPR updates the inventory based on the Pesticides Use Report (PUR) that provides updated information from 1990 to the most current data year available. The inventory includes estimates through the 2009 calendar year. Emission forecasts for years beyond 2009 are based on the average of the most recent five years. Historical emissions estimates for the period 1990-2009 were retained exactly as provided by DPR (*i.e.*, emissions are not backcasted).

*Residential Wood Combustion*

ARB staff updated the Residential Wood Combustion methodology using survey data, updated U.S. EPA's National Emission Inventory emission factors and newer sales data for manufactured logs. The updated methodology is available at:
http://www.arb.ca.gov/ei/areasrc/arbmiscprocresfuelcom.htm

*Unpaved Road Dust – Farm Roads*

ARB staff updated the methodology for Unpaved Road Dust (Farm Roads) to reflect 2005 harvested acreage data from NASS, crop specific VMT factors, and a revised emission factor of 2.00 lbs PM10/ VMT, based on California test data. An updated particle size fraction was used (ARB PM profile #470), which reduces the PM2.5 fraction by about 50%. Temporal profiles were updated, based on crop specific activity profiles. Growth for this category is based on linear regression analysis of 2000-2009 harvested acreage. In addition, the inventory reflects the emission reductions from District

Rule 806. The updated methodology is available at:
http://www.arb.ca.gov/ei/areasrc/arbmiscprocunpaverddst.htm

*Unpaved Road Dust – Nonfarm Roads*

ARB updated the Unpaved Nonfarm Roads methodology with the same reduced emission factor (2.00 lbs PM10/VMT) and revised particle size fraction (ARB PM profile #470) described above for Farm Roads. Other revisions include updated unpaved road mileage data and the addition of a rainfall adjustment factor. Temporal profiles were updated to reflect monthly rainfall. The inventory also reflects the emission reductions from District Rule 805. The updated methodology is available at:
http://www.arb.ca.gov/ei/areasrc/arbmiscprocunpaverddst.htm

**Areawide Source Growth Activity Updates**

In addition to the methodology updates described above, the areawide source growth profiles were updated to reflect more recent activity data. The areawide source growth surrogates are presented in Table 3 below.

**Table 3**
**Growth Surrogates for Areawide Sources**

| Source Category | Subcategory | Growth Surrogate |
|---|---|---|
| Consumer Products | All | Population |
| Architectural Coatings & Thinners | All | Housing Units |
| Pesticides & Fertilizers | Agricultural Pesticides | Irrigated Farmland |
| | Structural Pesticides | Ca. Dept. of Pesticide Regulation Data |
| Asphalt Paving & Roofing | All | Employment Construction |
| Residential Fuel Combustion | | |
| | Woodstoves and Fireplaces - Wood | No Growth |
| | Space Heating | Natural Gas Consumption |
| | Water Heating | Natural Gas Consumption |
| | Cooking | Natural Gas Consumption |
| | Other | Natural Gas Consumption |
| Farming Operations | Tilling and Harvesting Operations | Harvested Acres |
| | Livestock Husbandry - All | No Growth |
| Construction & Demolition | All | Construction employment |
| Paved Road Dust | All | Vehicle Miles Travelled (VMT) |

**Table 3 (cont.)**
**Growth Surrogates for Areawide Sources**

| Source Category | Subcategory | Growth Surrogate |
|---|---|---|
| Unpaved Road Dust | Non-Farm Roads | No Growth |
| | Farm Roads | Harvested Acres |
| Fugitive Windblown Dust | Agricultural and Pasture Lands | Total Agricultural and Grazing Lands |
| | Unpaved Roads & Associated Areas | No Growth |
| Fires | All | No Growth |
| Managed Burning & Disposal | Agricultural Burning, Prunings and Field Crops | Harvested Acres |
| | Weed Abatement | No Growth |
| Cooking | Commercial Charbroiling | Total Employment |

**Control Profiles**

The emissions inventory reflects emission reductions from point and areawide sources subject to District rules. The local rules reflected in the inventory are listed below.

**Table 4**
**Imperial County District Rules Included in the Inventory**

| Rule No. | Rule Title | Source Categories Impacted |
|---|---|---|
| 420 | Beef Feedlots | Livestock Operations |
| 801 | Construction And Earthmoving Activities | Construction and Demolition |
| 802 | Bulk Materials | Point Sources |
| 803 | Carry-Out And Track-Out | Paved Roads |
| 804 | Open Areas | Windblown Dust |
| 805 | Paved And Unpaved Roads | Paved and Unpaved Non-farm Roads |
| 806 | Conservation Management Practices | Tilling and Harvesting Operations, Windblown Dust, Unpaved Farm Roads |

**Mobile Sources**

Mobile source emissions are estimated using computer models that are designed to estimate emissions on a category-specific basis. ARB uses the EMFAC model to assess emissions from on-road vehicles. Off-road mobile source emissions are estimated using a new modular approach for different source categories. On-road and off-road models account for the effects of various adopted regulations, technology types, and seasonal conditions on emissions.

## On-Road Mobile Sources

Emissions from on-road mobile sources, which include passenger vehicles, buses, and trucks, were estimated using ARB's most recent model, EMFAC2011. The on-road emissions were calculated by applying EMFAC2011 emission factors to the transportation activity data provided by SCAG from their adopted 2012 Regional Transportation Plan (2012 RTP).

EMFAC2011 includes the latest data on California's car and truck fleets and travel activity. Light-duty motor vehicle fleet age, vehicle type, and vehicle population are updated based on 2009 California Department of Motor Vehicles data. The model also reflects the emissions benefits of ARB's recent rulemakings such as the Pavley Clean Car Standards, and the Low Carbon Fuel standard.

One of the most important improvements in EMFAC2011 is the integration of new data and methods to estimate emissions from diesel trucks and buses. EMFAC2011 uses the same diesel truck and bus vehicle populations, miles traveled and other emissions-related factors developed for the Truck and Bus Rule approved by the Air Resources Board in 2010. The model includes the emissions benefits of the truck and bus rule and previously adopted rules for other on-road diesel equipment, and the impacts of the recession on emissions that were quantified as part of the truck and bus rulemaking. Additional information and documentation on the EMFAC2011model is available at: http://www.arb.ca.gov/msei/modeling.htm

## Off-Road Mobile Sources

Emissions from off-road sources such as locomotives, industrial and construction equipment, and recreational vehicles were estimated using a newer suite of category-specific models rather than the OFFROAD model used in the past. Many of these models were developed to support recent regulations, including in-use off-road equipment, ocean-going vessels and others. Category-specific models had not yet been released for all categories at the time the Imperial County PM2.5 Nonattainment Area inventory was created; in those cases, OFFROAD2007 was used.

### *Cargo Handling Equipment (CHE)*

The emissions inventory for the Cargo Handling Equipment category has been updated to reflect new information on equipment population, activity, recessionary impacts on growth, and engine load. The new information includes regulatory reporting data which provide an accounting of all the cargo handling equipment in the state including their model year, horsepower and activity.

*In-Use Off-Road Equipment*

ARB developed this model in 2010 to support the analysis for amendments to the In-Use Off-Road Diesel Fueled Fleets Regulation. Staff updated the underlying activity forecast to reflect more recent economic forecast data, which suggests a slower rate of recovery through 2024 than previously anticipated.

*Locomotives*

The locomotive inventories reflect the 2008 U.S.EPA locomotive regulations and adjustments due to economic activity.

*Pleasurecraft and Recreational Vehicles*

A new model was developed in 2011 to estimate emissions from pleasurecraft and recreational vehicles. In both cases, population, activity, and emission factors were re-assessed using new surveys, registration information, and emissions testing.

*Transportation Refrigeration Units (TRU)*

This model reflects updates to activity, population, growth and turn-over data, and emission factors developed to support the 2011 amendments to the Airborne Toxic Control Measure for In-Use Diesel-Fueled Transport Refrigeration Units.

Additional information on various off-road mobile source modules discussed above is available at: http://www.arb.ca.gov/msei/categories.htm#offroad_motor_vehicles

**Emission Inventory Tables**

The following pages present winter season emission inventories for the years 2008, 2011, and 2012.

**Table 5**
**2008 Winter Season Emissions in the Imperial County PM2.5 Nonattainment Area**

| SOURCE CATEGORY | PM2.5 | NOx | SOx | NH3 | VOC |
|---|---|---|---|---|---|
| ***STATIONARY SOURCES*** | | | | | |
| ELECTRIC UTILITIES | 0.1 | 0.7 | 0.1 | 1.7 | 0.0 |
| MANUFACTURING AND INDUSTRIAL | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| FOOD AND AGRICULTURAL PROCESSING | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| SERVICE AND COMMERCIAL | 0.1 | 0.9 | 0.0 | 0.0 | 0.0 |
| OTHER (FUEL COMBUSTION) | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| SEWAGE TREATMENT | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| LANDFILLS | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 |
| OTHER (WASTE DISPOSAL) | 0.0 | 0.0 | 0.0 | 1.4 | 0.0 |
| LAUNDERING | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| DEGREASING | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 |
| COATINGS AND RELATED PROCESS SOLVENTS | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 |
| ADHESIVES AND SEALANTS | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 |
| PETROLEUM REFINING | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PETROLEUM MARKETING | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 |
| OTHER (PETROLEUM PRODUCTION AND MARKETING) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| FOOD AND AGRICULTURE | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| MINERAL PROCESSES | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 |
| METAL PROCESSES | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| OTHER (INDUSTRIAL PROCESSES) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **TOTAL STATIONARY SOURCES** | 0.5 | 1.8 | 0.1 | 3.1 | 1.1 |
| ***AREAWIDE SOURCES*** | | | | | |
| CONSUMER PRODUCTS | 0.0 | 0.0 | 0.0 | 0.0 | 1.1 |
| ARCHITECTURAL COATINGS AND RELATED SOLVENTS | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 |
| PESTICIDES/FERTILIZERS | 0.0 | 0.0 | 0.0 | 14.2 | 1.3 |
| ASPHALT PAVING / ROOFING | 0.0 | 0.0 | 0.0 | 0.0 | 1.4 |
| RESIDENTIAL FUEL COMBUSTION | 0.1 | 0.1 | 0.0 | 0.0 | 0.1 |
| FARMING OPERATIONS | 0.9 | 0.0 | 0.0 | 13.0 | 2.8 |
| CONSTRUCTION AND DEMOLITION | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| PAVED ROAD DUST | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNPAVED ROAD DUST | 4.6 | 0.0 | 0.0 | 0.0 | 0.0 |
| FUGITIVE WINDBLOWN DUST | 3.9 | 0.0 | 0.0 | 0.0 | 0.0 |
| FIRES | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| MANAGED BURNING AND DISPOSAL | 0.9 | 0.3 | 0.1 | 0.1 | 0.7 |
| COOKING | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| OTHER (MISCELLANEOUS PROCESSES) | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 |
| **TOTAL AREAWIDE SOURCES** | 10.8 | 0.4 | 0.1 | 27.6 | 7.6 |

**Table 5 (cont.)**
**2008 Winter Season Emissions in the Imperial County PM2.5 Nonattainment Area**

| SOURCE CATEGORY | PM2.5 | NOx | SOx | NH3 | VOC |
|---|---|---|---|---|---|
| ***ON-ROAD MOBILE SOURCES*** | | | | | |
| LIGHT DUTY PASSENGER (LDA) | 0.0 | 1.1 | 0.0 | 0.1 | 0.8 |
| LIGHT DUTY TRUCKS - 1 (LDT1) | 0.0 | 0.3 | 0.0 | 0.0 | 0.2 |
| LIGHT DUTY TRUCKS - 2 (LDT2) | 0.0 | 0.5 | 0.0 | 0.0 | 0.2 |
| MEDIUM DUTY TRUCKS (MDV) | 0.0 | 0.5 | 0.0 | 0.0 | 0.2 |
| LIGHT HEAVY DUTY GAS TRUCKS - 1 (LHDV1) | 0.0 | 0.2 | 0.0 | 0.0 | 0.1 |
| LIGHT HEAVY DUTY GAS TRUCKS - 2 (LHDV2) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| MEDIUM HEAVY DUTY GAS TRUCKS (MHDV) | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 |
| HEAVY HEAVY DUTY GAS TRUCKS (HHDV) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| LIGHT HEAVY DUTY DIESEL TRUCKS - 1 (LHDV1) | 0.0 | 0.6 | 0.0 | 0.0 | 0.0 |
| LIGHT HEAVY DUTY DIESEL TRUCKS - 2 (LHDV2) | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| MEDIUM HEAVY DUTY DIESEL TRUCKS (MHDV) | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 |
| HEAVY HEAVY DUTY DIESEL TRUCKS (HHDV) | 0.2 | 4.7 | 0.0 | 0.0 | 0.3 |
| MOTORCYCLES (MCY) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| HEAVY DUTY DIESEL URBAN BUSES (UB) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| HEAVY DUTY GAS URBAN BUSES (UB) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| SCHOOL BUSES - GAS (SBG) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| SCHOOL BUSES - DIESEL (SBD) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| OTHER BUSES - GAS (OBG) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| OTHER BUSES - MOTOR COACH - DIESEL (OBC) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ALL OTHER BUSES - DIESEL (OBD) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| MOTOR HOMES (MH) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **TOTAL ON-ROAD MOBILE SOURCES** | 0.3 | 8.6 | 0.0 | 0.2 | 2.0 |
| ***OFF-ROAD MOBILE SOURCES*** | | | | | |
| AIRCRAFT | 0.8 | 1.5 | 0.2 | 0.0 | 2.2 |
| TRAINS | 0.1 | 3.6 | 0.0 | 0.0 | 0.4 |
| COMMERCIAL HARBOR CRAFT | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| RECREATIONAL BOATS | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 |
| OFF-ROAD RECREATIONAL VEHICLES | 0.0 | 0.1 | 0.0 | 0.0 | 1.2 |
| OFF-ROAD EQUIPMENT | 0.1 | 1.2 | 0.0 | 0.0 | 0.5 |
| FARM EQUIPMENT | 0.1 | 1.2 | 0.0 | 0.0 | 0.3 |
| FUEL STORAGE AND HANDLING | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 |
| **TOTAL OFF-ROAD MOBILE SOURCES** | 1.0 | 7.6 | 0.2 | 0.0 | 4.8 |
| **NONATTAINMENT AREA TOTAL** | **24.2** | **29.3** | **0.5** | **61.9** | **26.2** |

**Table 6**
**2011 Winter Season Emissions in the Imperial County PM2.5 Nonattainment Area**

| SOURCE CATEGORY | PM2.5 | NOx | SOx | NH3 | VOC |
|---|---|---|---|---|---|
| ***STATIONARY SOURCES*** | | | | | |
| ELECTRIC UTILITIES | 0.1 | 0.6 | 0.1 | 1.6 | 0.0 |
| MANUFACTURING AND INDUSTRIAL | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| FOOD AND AGRICULTURAL PROCESSING | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| SERVICE AND COMMERCIAL | 0.1 | 0.9 | 0.0 | 0.0 | 0.0 |
| OTHER (FUEL COMBUSTION) | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| SEWAGE TREATMENT | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| LANDFILLS | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 |
| OTHER (WASTE DISPOSAL) | 0.0 | 0.0 | 0.0 | 1.4 | 0.0 |
| LAUNDERING | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| DEGREASING | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 |
| COATINGS AND RELATED PROCESS SOLVENTS | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 |
| ADHESIVES AND SEALANTS | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 |
| PETROLEUM REFINING | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PETROLEUM MARKETING | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 |
| OTHER (PETROLEUM PRODUCTION AND MARKETING) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| FOOD AND AGRICULTURE | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| MINERAL PROCESSES | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 |
| METAL PROCESSES | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| OTHER (INDUSTRIAL PROCESSES) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **TOTAL STATIONARY SOURCES** | 0.5 | 1.8 | 0.1 | 3.1 | 1.1 |
| ***AREAWIDE SOURCES*** | | | | | |
| CONSUMER PRODUCTS | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 |
| ARCHITECTURAL COATINGS AND RELATED SOLVENTS | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 |
| PESTICIDES/FERTILIZERS | 0.0 | 0.0 | 0.0 | 14.2 | 2.0 |
| ASPHALT PAVING / ROOFING | 0.0 | 0.0 | 0.0 | 0.0 | 1.2 |
| RESIDENTIAL FUEL COMBUSTION | 0.1 | 0.1 | 0.0 | 0.0 | 0.1 |
| FARMING OPERATIONS | 0.8 | 0.0 | 0.0 | 13.0 | 2.8 |
| CONSTRUCTION AND DEMOLITION | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| PAVED ROAD DUST | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNPAVED ROAD DUST | 4.6 | 0.0 | 0.0 | 0.0 | 0.0 |
| FUGITIVE WINDBLOWN DUST | 3.9 | 0.0 | 0.0 | 0.0 | 0.0 |
| FIRES | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| MANAGED BURNING AND DISPOSAL | 0.8 | 0.3 | 0.0 | 0.1 | 0.6 |
| COOKING | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| OTHER (MISCELLANEOUS PROCESSES) | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 |
| **TOTAL AREAWIDE SOURCES** | 10.6 | 0.4 | 0.1 | 27.5 | 8.0 |

**Table 6 (cont.)**
**2011 Winter Season Emissions in the Imperial County PM2.5 Nonattainment Area**

| SOURCE CATEGORY | PM2.5 | NOx | SOx | NH3 | VOC |
|---|---|---|---|---|---|
| ***ON-ROAD MOBILE SOURCES*** | | | | | |
| LIGHT DUTY PASSENGER (LDA) | 0.0 | 0.9 | 0.0 | 0.1 | 0.7 |
| LIGHT DUTY TRUCKS - 1 (LDT1) | 0.0 | 0.2 | 0.0 | 0.0 | 0.2 |
| LIGHT DUTY TRUCKS - 2 (LDT2) | 0.0 | 0.4 | 0.0 | 0.0 | 0.2 |
| MEDIUM DUTY TRUCKS (MDV) | 0.0 | 0.5 | 0.0 | 0.0 | 0.2 |
| LIGHT HEAVY DUTY GAS TRUCKS - 1 (LHDV1) | 0.0 | 0.2 | 0.0 | 0.0 | 0.1 |
| LIGHT HEAVY DUTY GAS TRUCKS - 2 (LHDV2) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| MEDIUM HEAVY DUTY GAS TRUCKS (MHDV) | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| HEAVY HEAVY DUTY GAS TRUCKS (HHDV) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| LIGHT HEAVY DUTY DIESEL TRUCKS - 1 (LHDV1) | 0.0 | 0.6 | 0.0 | 0.0 | 0.0 |
| LIGHT HEAVY DUTY DIESEL TRUCKS - 2 (LHDV2) | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| MEDIUM HEAVY DUTY DIESEL TRUCKS (MHDV) | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 |
| HEAVY HEAVY DUTY DIESEL TRUCKS (HHDV) | 0.2 | 3.4 | 0.0 | 0.0 | 0.2 |
| MOTORCYCLES (MCY) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| HEAVY DUTY DIESEL URBAN BUSES (UB) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| HEAVY DUTY GAS URBAN BUSES (UB) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| SCHOOL BUSES - GAS (SBG) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| SCHOOL BUSES - DIESEL (SBD) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| OTHER BUSES - GAS (OBG) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| OTHER BUSES - MOTOR COACH - DIESEL (OBC) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ALL OTHER BUSES - DIESEL (OBD) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| MOTOR HOMES (MH) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **TOTAL ON-ROAD MOBILE SOURCES** | 0.3 | 6.9 | 0.0 | 0.2 | 1.7 |
| ***OFF-ROAD MOBILE SOURCES*** | | | | | |
| AIRCRAFT | 0.8 | 1.5 | 0.2 | 0.0 | 2.2 |
| TRAINS | 0.1 | 2.6 | 0.0 | 0.0 | 0.3 |
| COMMERCIAL HARBOR CRAFT | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| RECREATIONAL BOATS | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 |
| OFF-ROAD RECREATIONAL VEHICLES | 0.0 | 0.1 | 0.0 | 0.0 | 1.0 |
| OFF-ROAD EQUIPMENT | 0.1 | 0.9 | 0.0 | 0.0 | 0.4 |
| FARM EQUIPMENT | 0.1 | 1.0 | 0.0 | 0.0 | 0.2 |
| FUEL STORAGE AND HANDLING | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 |
| **TOTAL OFF-ROAD MOBILE SOURCES** | 1.0 | 6.2 | 0.2 | 0.0 | 4.5 |
| **NONATTAINMENT AREA TOTAL** | **23.7** | **24.3** | **0.5** | **61.5** | **26.0** |

## Table 7
## 2012 Winter Season Emissions in the Imperial County PM2.5 Nonattainment Area

| SOURCE CATEGORY | PM2.5 | NOx | SOx | NH3 | VOC |
|---|---|---|---|---|---|
| ***STATIONARY SOURCES*** | | | | | |
| ELECTRIC UTILITIES | 0.1 | 0.7 | 0.1 | 1.8 | 0.0 |
| MANUFACTURING AND INDUSTRIAL | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| FOOD AND AGRICULTURAL PROCESSING | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| SERVICE AND COMMERCIAL | 0.1 | 0.9 | 0.0 | 0.0 | 0.0 |
| OTHER (FUEL COMBUSTION) | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| SEWAGE TREATMENT | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| LANDFILLS | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 |
| OTHER (WASTE DISPOSAL) | 0.0 | 0.0 | 0.0 | 1.4 | 0.0 |
| LAUNDERING | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| DEGREASING | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 |
| COATINGS AND RELATED PROCESS SOLVENTS | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 |
| ADHESIVES AND SEALANTS | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 |
| PETROLEUM REFINING | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PETROLEUM MARKETING | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 |
| OTHER (PETROLEUM PRODUCTION AND MARKETING) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| FOOD AND AGRICULTURE | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| MINERAL PROCESSES | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 |
| METAL PROCESSES | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| OTHER (INDUSTRIAL PROCESSES) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **TOTAL STATIONARY SOURCES** | 0.6 | 1.9 | 0.1 | 3.3 | 1.2 |
| ***AREAWIDE SOURCES*** | | | | | |
| CONSUMER PRODUCTS | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 |
| ARCHITECTURAL COATINGS AND RELATED SOLVENTS | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 |
| PESTICIDES/FERTILIZERS | 0.0 | 0.0 | 0.0 | 14.1 | 1.2 |
| ASPHALT PAVING / ROOFING | 0.0 | 0.0 | 0.0 | 0.0 | 1.3 |
| RESIDENTIAL FUEL COMBUSTION | 0.1 | 0.1 | 0.0 | 0.0 | 0.1 |
| FARMING OPERATIONS | 0.8 | 0.0 | 0.0 | 13.0 | 2.8 |
| CONSTRUCTION AND DEMOLITION | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| PAVED ROAD DUST | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNPAVED ROAD DUST | 4.6 | 0.0 | 0.0 | 0.0 | 0.0 |
| FUGITIVE WINDBLOWN DUST | 3.9 | 0.0 | 0.0 | 0.0 | 0.0 |
| FIRES | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| MANAGED BURNING AND DISPOSAL | 0.8 | 0.3 | 0.0 | 0.1 | 0.6 |
| COOKING | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| OTHER (MISCELLANEOUS PROCESSES) | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 |
| **TOTAL AREAWIDE SOURCES** | 10.6 | 0.4 | 0.1 | 27.5 | 7.3 |

**Table 7 (cont.)**
**2012 Winter Season Emissions in the Imperial County PM2.5 Nonattainment Area**

| SOURCE CATEGORY | PM2.5 | NOx | SOx | NH3 | VOC |
|---|---|---|---|---|---|
| ***ON-ROAD MOBILE SOURCES*** | | | | | |
| LIGHT DUTY PASSENGER (LDA) | 0.0 | 0.9 | 0.0 | 0.1 | 0.6 |
| LIGHT DUTY TRUCKS - 1 (LDT1) | 0.0 | 0.2 | 0.0 | 0.0 | 0.2 |
| LIGHT DUTY TRUCKS - 2 (LDT2) | 0.0 | 0.4 | 0.0 | 0.0 | 0.2 |
| MEDIUM DUTY TRUCKS (MDV) | 0.0 | 0.4 | 0.0 | 0.0 | 0.2 |
| LIGHT HEAVY DUTY GAS TRUCKS - 1 (LHDV1) | 0.0 | 0.2 | 0.0 | 0.0 | 0.1 |
| LIGHT HEAVY DUTY GAS TRUCKS - 2 (LHDV2) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| MEDIUM HEAVY DUTY GAS TRUCKS (MHDV) | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| HEAVY HEAVY DUTY GAS TRUCKS (HHDV) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| LIGHT HEAVY DUTY DIESEL TRUCKS - 1 (LHDV1) | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 |
| LIGHT HEAVY DUTY DIESEL TRUCKS - 2 (LHDV2) | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| MEDIUM HEAVY DUTY DIESEL TRUCKS (MHDV) | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 |
| HEAVY HEAVY DUTY DIESEL TRUCKS (HHDV) | 0.2 | 3.1 | 0.0 | 0.0 | 0.2 |
| MOTORCYCLES (MCY) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| HEAVY DUTY DIESEL URBAN BUSES (UB) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| HEAVY DUTY GAS URBAN BUSES (UB) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| SCHOOL BUSES - GAS (SBG) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| SCHOOL BUSES - DIESEL (SBD) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| OTHER BUSES - GAS (OBG) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| OTHER BUSES - MOTOR COACH - DIESEL (OBC) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ALL OTHER BUSES - DIESEL (OBD) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| MOTOR HOMES (MH) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **TOTAL ON-ROAD MOBILE SOURCES** | 0.2 | 6.3 | 0.0 | 0.2 | 1.5 |
| ***OFF-ROAD MOBILE SOURCES*** | | | | | |
| AIRCRAFT | 0.8 | 1.5 | 0.2 | 0.0 | 2.2 |
| TRAINS | 0.1 | 2.8 | 0.0 | 0.0 | 0.3 |
| COMMERCIAL HARBOR CRAFT | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| RECREATIONAL BOATS | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 |
| OFF-ROAD RECREATIONAL VEHICLES | 0.0 | 0.1 | 0.0 | 0.0 | 1.0 |
| OFF-ROAD EQUIPMENT | 0.1 | 1.0 | 0.0 | 0.0 | 0.4 |
| FARM EQUIPMENT | 0.1 | 0.9 | 0.0 | 0.0 | 0.2 |
| FUEL STORAGE AND HANDLING | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 |
| **TOTAL OFF-ROAD MOBILE SOURCES** | 1.0 | 6.3 | 0.2 | 0.0 | 4.4 |
| **NONATTAINMENT AREA TOTAL** | **23.7** | **23.5** | **0.5** | **61.9** | **24.5** |

## APPENDIX C: LINK TO DISTRICT 2013 PM2.5 PLAN

http://www.co.imperial.ca.us/AirPollution/HISTORICAL%20PAGES%20AND%20INFORMATION/HISTORICAL%20DOCUMENTS/PUBLIC%20HEARINGS/2014%2012%20PM2.5%20SIP%20PLAN/POST%20APPROVAL/00%20Final%20PM2.5%20SIP%20(Dec%202,%202014)%20Approved.pdf