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Dedication

Without the support system I received from my family, none of this would have been made possible. Thank you all for believing in me and standing by my side when I needed you all the most. This thesis is dedicated to my loving parents who always had a warm welcome place for me; to my brothers, for being the best a brother could ask for; to Nadia, for being patient with me and for always being there for me when I needed you; to my grandparents, for being great pillars of support; and to my Aunt Lupe and Uncle Richard for their unbridled support. Thank you all!

ANALYSIS OF INDOOR AND OUTDOOR PARTICULATE MATTER AT VARIOUS RESIDENCES IN THE EL PASO REGION

by

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THESIS

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Abstract

This thesis is a presentation of particulate matter data collected from February 2007 to June 2008. Personal environment monitors (PEM), which measured 7-day $PM_{2.5}$ concentrations, had been deployed at 14 homes during the 2007 year and deployed in 16 different homes during the 2008 sampling year. Within each sampling year, sampling occurred for two one-week (7-day) periods during each season. In addition to PEM sampling, a tapered element oscillating microbalance (TEOM) continuous sampler had been deployed in both indoors and outdoors at one pre-selected household per week. Gravimetric, chemical, and black carbon analysis had been performed on the PEM $PM_{2.5}$ filters while time-series plots of the TEOM PM_{10} and $PM_{2.5}$ data were constructed to extract diurnal patterns from the data. Results from the TEOM data affirm the purported existence of a strong diurnal patter in particulate matter observations in the El Paso region.

Strong increases in particulate matter were seen, on average, between the hours of 06:00 and 10:00 (morning) and once again in the evening from 16:00 to 20:00. Of the TEOM data, the mean outdoor and indoor $PM_{2.5}$ concentrations were found to be 23.9 $\mu g/m^3$ and 17.8 $\mu g/m^3$, while the mean outdoor and indoor PM_{10} concentrations were found to be 27.3 $\mu g/m^3$ and 18.0 $\mu g/m^3$, respectively. Mean outdoor and indoor TEOM $PM_{2.5}$ concentrations were found to be, on average, greater during the summer seasons. The mean TEOM outdoor PM_{10} was also found to be greater during the summer seasons over the winter seasons, while the mean indoor PM_{10} TEOM concentration was found to be only slightly greater during the winter seasons over the summer seasons. Indoor/Outdoor (I/O) ratios for PM_{10} for all TEOM sampling locations during the entire study period were found to be greater, on average, than (I/O) ratios for $PM_{2.5}$ with values of 1.15 and 1.05, respectively.

A mean $PM_{2.5}$ concentration of 19.8 $\mu g/m^3$ was seen in the PEM indoor samples collected at all locations during the entire study period, while the mean winter concentration 22.9 $\mu g/m^3$ was shown to

be much higher than the mean summer concentration 16.8 $\mu g/m^3$. Results of an EDXRF analysis found that geologic elements (Al, Si, Ca, Fe, Ti, and K) were found to compose a majority of the total $PM_{2.5}$ mass at 17.4%, while toxic trace elements (Cu, Cr, As, Cd, and Pb) were found to compose only 0.19% of the total $PM_{2.5}$ mass. All analyzed elements (Σ Elements) were found to compose, on average, 24% of the total $PM_{2.5}$ mass collected using the PEM sampler. The mean black carbon (BC) concentration on the PEM filters for the entire study period was found to be 0.30 $\mu g/m^3$; BC concentrations were also found to be higher during the winter seasons, 0.38 $\mu g/m^3$, than the summer seasons, 0.21 $\mu g/m^3$. Black carbon was also found to compose, on average, 1.8% of the total $PM_{2.5}$ mass.

Principle components analysis (PCA) was conducted on the EDXRF data and presented four primary components within the elemental data. The first component included Al, Ba, Ca, Fe, K, Mg, Mn, Pb, Sr, Ti, and V, while the second component included Cr, Ga, Mo, and Ni. The third component consists of As, Rh, and Te, while the final component was composed of what is believed to be salt (Na and Cl). The first component, composed of mostly geologic material, composed the greatest majority of elements found in the total PM mass, while the other components were mostly hypothesized to be related to industrial release in the area.

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1. Introduction

1.1. Introduction

El Paso County is located at the westernmost edge of Texas, adjoining the state of New Mexico and the Mexican state of Chihuahua. El Paso, TX is a predominately semi-arid area with an average (30 years) precipitation of 8.65 inches and average high and low temperatures of 76.8 □F and 50.6 □F, respectively. El Paso sees an average of 202 days with clear skies and 49 days with precipitation more than 0.01 inches. Mean wind directions in the area are from the southwest (229 degrees) direction. Table 1.1 depicts the meteorology variation found in El Paso according to each respective season.

El Paso averages 14.5 significant dust events per year; consequences of these episodes range from simple irritations and increased particulate matter concentrations to serious disruptive events. These events aggravate respiratory health problems and can even turn deadly, resulting in fatal collisions as a result of near-zero visibility on city roadways and highways in the surrounding desert (Novlan et al., 2006). El Paso is generally a flat desert area with a large range of mountains, known as the Franklin Mountains, which rise to over 3280 ft. (1000m) above the surrounding area and are a north-south oriented mountain chain that is approximately 23.1 km (14.4 miles) long and 5.0 km (3.1 miles) wide. The Franklins create a divide between the western one-third of the city of El Paso and the central and eastern two-thirds of the city.

Table 1.1: Meteorological Data Averages

Period	Average Temperature[2] (□C)	Average Precipitation[2] (cm)[2]	Average Wind Speed[2] (km/hr)	Prevailing Wind Direction[2] (degrees)
Annual	17.3	22.4	14.2	360
Winter (Dec.-Feb.)	7.2	1.2	13.6	333
Spring (March-May)	17.4	0.6	17.3	267
Summer (June-August)	27.2	3.2	13.6	183
Fall (Sept.-Nov.)	17.6	2.5	12.4	243

1: Source: National Climactic Data Center, Ashville, NC

2: Data based on 30 year averages

The El Paso region, which consists of El Paso, Texas, Sunland Park, New Mexico and Ciudad Juarez, Chihuahua, Mexico, has a population exceeding two million and is one of the largest metropolitan areas along the border. The region generally has poor visibility, especially in the winters which are susceptible to inversions, and respiratory problems are common place. The regional pollution problem is not only generated by inhabitants in the United States but also by those in surrounding areas such as Ciudad Juarez. In order to ensure that both countries work together to solve the regional pollution problem, the Border Environment Cooperation Commission (BECC) was created in 1993 under a side-agreement to the North American Free Trade Agreement (NAFTA). BECC aims at effectively enforce bi-national policies that aims to improve the air quality in the region. In concert with efforts by BECC, the United States Environmental Protection Agency (EPA) and the Texas Commission on Environmental Quality (TCEQ), the regional air quality in the El Paso region has progressively improved since 1990.

The use of fossil fuels or wood for heating and cooking in the area, the semi-arid weather, adverse meteorological conditions, and complex terrestrial features of the El Paso region are all contributors to the air pollution situation in the city. Poverty and industrialization in the Ciudad Juarez part of the El Paso/Juarez region are contributors to PM concentrations in the region (Espino et al., 2005). Higher levels of PM_{10} and $PM_{2.5}$ are witnessed in El Paso during the winter months when temperature inversions, along with calm conditions, trap PM in the ambient air.

The US EPA's regulatory PM_{10} standard was frequently violated in the border region, including El Paso, with far fewer reported violations of the $PM_{2.5}$ standard (EPA, 2011a). As a result of the frequent PM_{10} violations, El Paso has been classified as a moderate "non-attainment" area with regard to PM_{10} as of 1991 (EPA, 2011a, 2011b). It has been shown that episodic (short-lived, high concentration) events contribute many of the violations of the PM_{10} National Ambient Air Quality Standards (NAAQS). PM_{10} NAAQS are based on a maximum 24-h averaged concentration of 150 $\mu g/m^3$ as well as an annual-averaged cap of 50.0 $\mu g/m^3$.The aforementioned averaging obscures short-term peak doses and may misrepresent epidemiological dangers of PM (Staniswalis et al., 2005).

There are many local electronics, transportation, textile, machinery and refining industries in the El Paso area that contribute to the local PM pollution problem. The surrounding desert landscape is also another major source for the area's pollution problem and it has long been noted that there is a high natural ambient mineral material loading in the region (Dattner, 1994; Einfeld & Church, 1995). Unregulated kilns, for the manufacturing of bricks in particular, are reported to burn toxic waste fuels such as tires or used motor oil and are considered major contributors to PM_{10} pollution in the region (Lauer et al., 2009). The preparation of food with wood, propane, or natural gas coupled with frequent major meteorological events; along with the arid weather, further complicate the local PM pollution problem. Analysis of $PM_{2.5}$ samples collected using indoor personal environment monitors may help to

provide an insight as to the primary components of pollutants found in indoor $PM_{2.5}$ which may be contributed to the releases of the aforementioned activities in El Paso.

There are several commonly agreed on factors which can be attributed to the pollution problem in El Paso. El Paso is mostly surrounded by desert land which produces large amounts of dust during episodes of high winds. There are also a large number of unpaved roads in the area surrounding El Paso as well as in areas in Mexico located along the border with El Paso which can also be attributed to the creation of fugitive dust in the area. Many of the same areas along the border in Mexico burn scrap wood and other refuse material for home heating and cooking in the much colder winter months of the year. The burning of such material may release metals into the atmosphere and may exacerbate PM concentrations in the region (Espino et al., 2005). Commercial activities such as scrap metal foundries, refining, smelting, various agricultural activities and brick kilns also contribute to the local pollution problem.

In the United States, PM concentrations have decreased on average since interest for certain size of particles invoked national monitoring programs. Monitoring for $PM_{2.5}$ began nationwide as of the year 2000 and according to Figure 1.1, the $PM_{2.5}$ levels in the United States has decreased by 27%. Based on Figure 1.2, PM_{10} levels in the United States have decreased 38% since nationwide monitoring began in 1990. The decrease in PM in the United States is a direct result of the efforts of the EPA, state, tribal and local agencies which use the monitoring data to ensure that PM in the air is at respectable levels that protect public health and the environment.

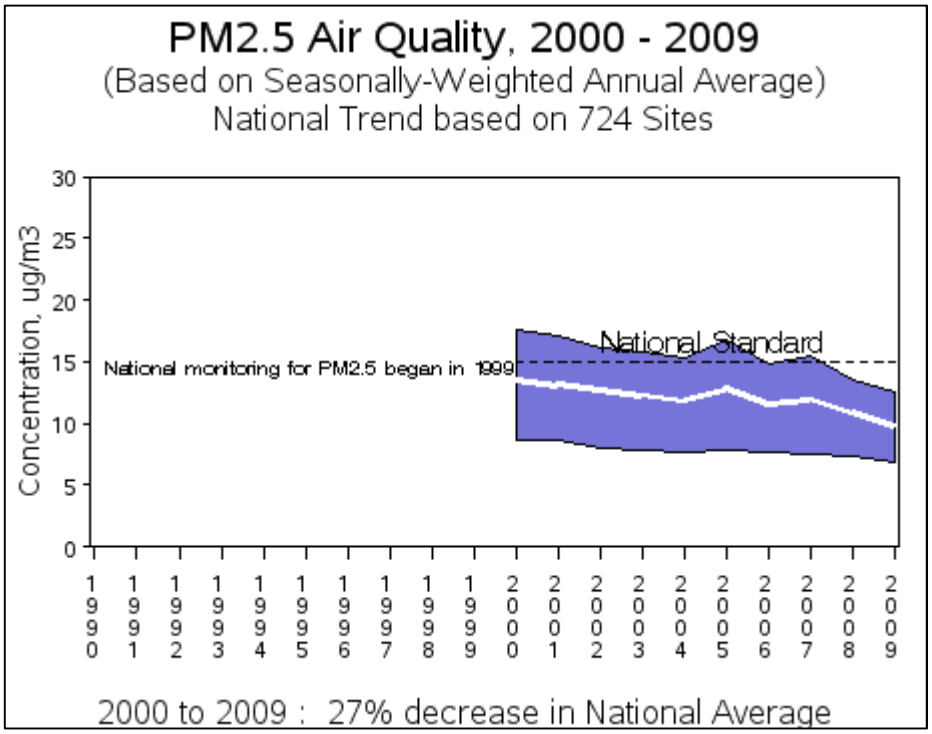

Figure 1.1: National $PM_{2.5}$ Air Quality, 2000-2009

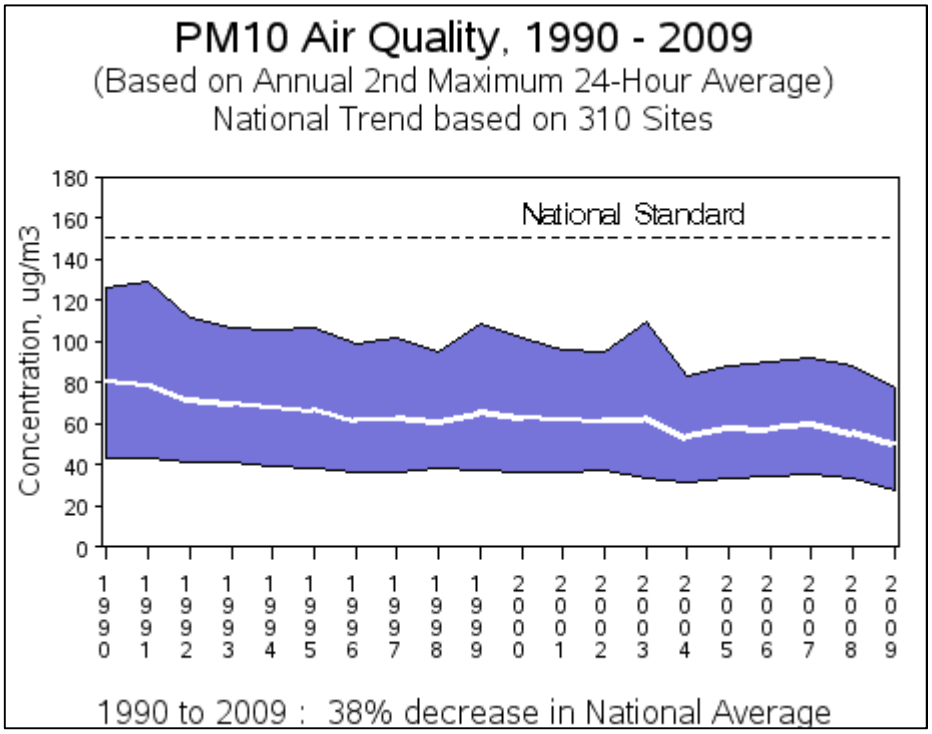

Figure 1.2: National PM_{10} Air Quality, 1990-2009

In the El Paso region, PM levels have decreased as well with regard to PM_{10} and $PM_{2.5}$ since 2003. Figure 1.3 is a plot of the annual 2nd maximum 24-hour average PM_{10} concentrations for El Paso over the span of about 20 years. Figure 1.4 is a plot of the weighted annual mean concentrations for $PM_{2.5}$ for El Paso since 1999, which is when the air quality monitoring program began for $PM_{2.5}$. The weighted annual mean is the weighted arithmetic mean of 24-hour values for the year and compensates for scheduled sampling that did not occur.

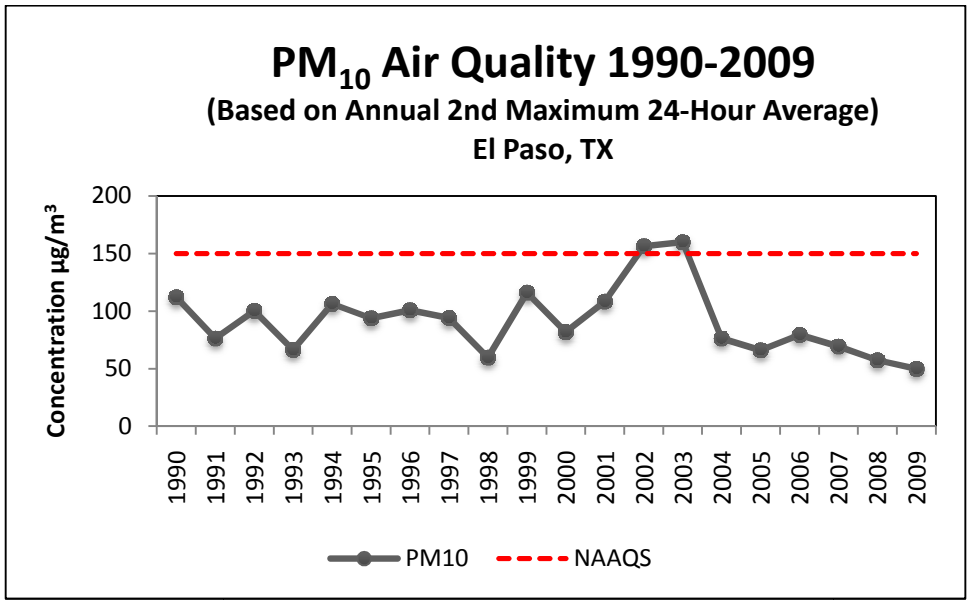

Figure 1.3: El Paso PM_{10} Air Quality; 1990-2009

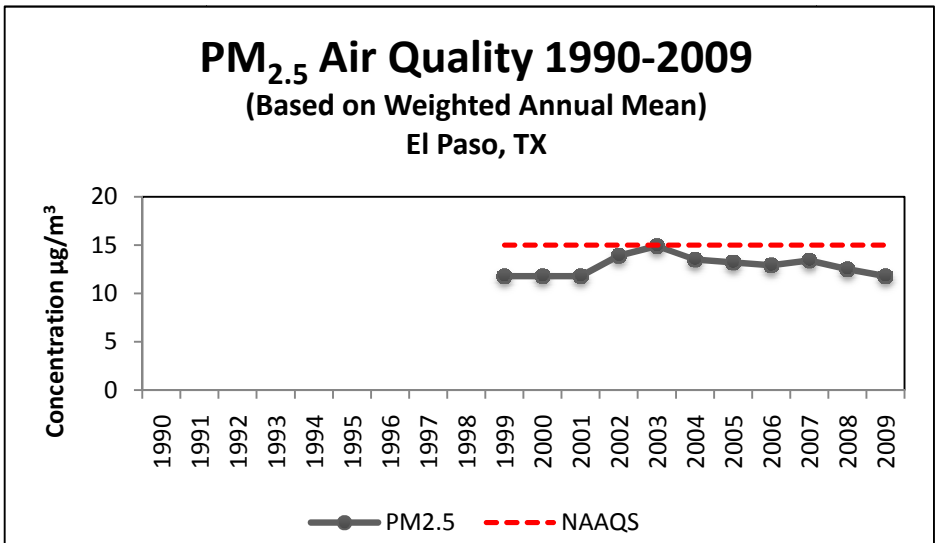

Figure 1.4: El Paso $PM_{2.5}$ Air Quality; 1990-2009

It should be noted that the variation in weighted annual mean $PM_{2.5}$ concentration are not as pronounced as the variation in annual 2nd maximum 24-hour average PM_{10} concentrations. This may be due to either increases or decreases in severe meteorological conditions which predominantly affect PM_{10} concentrations.

Based on commercial and industrial activities in the area, coupled with chronic PM_{10} "non-attainment" status, El Paso can only benefit from any research studies which aim to characterize indoor and outdoor PM in the region. Basic understating of any diurnal variations that exist in PM in El Paso may help investigators to understand when and why PM may be troublesome. Also, any insight into the elemental constitution of PM in the region may also help investigators pinpoint possible sources of PM which may possibly contribute to the local PM pollution problem.

1.2. Research Objective

This study was designed to monitor indoor and outdoor air quality by randomly selecting 12 houses from a cohort constructed for the use in an epidemiological study in the area which would be representative of different strata. It is part of a National Institute of Health (NIH) sponsored project to study the impacts of PM pollution on asthmatic children in El Paso. The scope of the NIH project is an attempt to characterize the time-resolved indoor and outdoor (I/O) PM, nitrogen dioxide (NO_2), and

ozone concentrations in spatially selected Latino households throughout the El Paso region while this project aimed to define the diurnal pattern of I/O PM mass concentrations in two major fractions: coarse PM (PM_{10}, PM with aerodynamic diameters of less than 10 µm) and fine PM ($PM_{2.5}$, PM with aerodynamic diameters of less than 2.5 µm). The chemical composition of PM was of interest in addition to the mass characteristics. Energy dispersive x-ray fluorescence (EDXRF), a preferred method for the analysis of trace elements in PM collected on filters, was used to characterize the chemical composition of $PM_{2.5}$. In addition, the black carbon (BC) content of $PM_{2.5}$ was investigated as well.

2. Particulate Matter and Related Health Effects

2.1. Particulate Matter

Particulate matter is a complex mixture of extremely small particles and liquid droplets that vary in size, shape, surface area, solubility, chemical composition and origin. PM is composed of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles. The size of particles is directly linked to their potential for causing health problems. Once particles smaller than 10 microns are inhaled, these particles affect the heart and lungs and cause serious health effects. Through inertial impaction, coarse PM is generally removed in the upper respiratory tract, while fine PM has the ability to penetrate much further into the lower respiratory tract (Kennedy, 2007).

The Environmental Protection Agency (EPA) groups PM into two categories:

- "**Inhalable coarse particles**," such as those found near roadways and dusty industries, have aerodynamic diameters larger than 2.5 μm and smaller than 10 μm in diameter. Usually comprised of suspended or re-suspended dust from industrial processes, agriculture, construction, road traffic, plant pollen and other natural sources.

- "**Fine particles**," such as those found in smoke and haze, have an aerodynamic diameter less than or equal to 2.5 μm. Fine particles are responsible for reduced visibility in certain parts of the United States. These particles can be directly emitted from combustion sources such as automobiles, wood burning, or they can form when gases emitted from power plants, cement plants, or steel mills react in the air. This mode of particles also consists of transformation products such as sulfates and nitrates which are formed of primary sulfur and nitrogen oxide emissions along with secondary organic aerosols from volatile organic compounds (VOC).

Fine-mode and coarse-mode particles differ not only in size and morphology (e.g., smooth droplets vs. rough solid particles) but also in formation mechanisms and sources; along with differences in chemical, physical, and biological properties. They also differ in terms of dosimetry (deposition in the respiratory system), toxicity, and health effects as observed by epidemiologic studies. PM transport generally occurs through convection, diffusion and, for particles larger than 1µm, diffusion (Kennedy, 2007)

Fine particles are a major cause of reduced visibility in parts of the United States. The EPA regulates inhalable particles (fine and coarse) while particles larger than 10 µm (sand and large dust) are not regulated by EPA. The Clean Air Act requires the EPA to set National Ambient Air Quality Standards (NAAQS) for six criteria pollutants, of which PM is one of these. The remaining criteria pollutants are ozone, carbon monoxide, nitrogen dioxides (NO_2), sulfur dioxide and lead. The purpose of regulation for the aforementioned criteria pollutants is that epidemiologic studies have attributed daily exposure to one or more of the criteria pollutants with an increase in lower respiratory tract effects, exacerbation of asthma and increased daily mortality (Pope, 2000). The Clean Air Act established two types of national air quality standards for PM pollution. Primary standards set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly. Secondary standards set limits to protect public welfare, including protection against visibility impairment, damage to animals, crops, vegetation, and buildings. The air quality standards for PM in 2006 were revised by the EPA to tighten the 24-hour fine PM standard from the level of 65.0 micrograms per cubic meter ($\mu g/m^3$) to 35.0 $\mu g/m^3$, and retain the current annual fine PM standard at 15 $\mu g/m^3$. The EPA decided to retain the existing 24-hour PM_{10} standard of 150 $\mu g/m^3$ and revoked the annual PM_{10} standard, because available evidence does not suggest a link between long-term exposure to PM_{10} and health problems.

Table 2.1: National Ambient Air Quality Standards

	Primary Standards		Secondary Standards	
Pollutant	**Level**	**Averaging Time**	**Level**	**Averaging Time**
Carbon Monoxide	9 ppm (10 mg/m^3)	8-hour [1]	None	
	35 ppm (40 mg/m^3)	1-hour [1]		
Lead	0.15 $\mu g/m^3$ [2]	Rolling 3-Month Average	Same as Primary	
	1.5 $\mu g/m^3$	Quarterly Average	Same as Primary	
Nitrogen Dioxide	53 ppb [3]	Annual (Arithmetic Average)	Same as Primary	
	100 ppb	1-hour [4]	None	
Particulate Matter (PM_{10})	150 $\mu g/m^3$	24-hour [5]	Same as Primary	
Particulate Matter ($PM_{2.5}$)	15.0 $\mu g/m^3$	Annual [6] (Arithmetic Average)	Same as Primary	
	35 $\mu g/m^3$	24-hour [7]	Same as Primary	
Ozone	0.075 ppm (2008 std)	8-hour [8]	Same as Primary	
	0.08 ppm (1997 std)	8-hour [9]	Same as Primary	
	0.12 ppm	1-hour [10]	Same as Primary	
Sulfur Dioxide	0.03 ppm	Annual (Arithmetic Average)	0.5 ppm	3-hour [1]
	0.14 ppm	24-hour [1]		
	75 ppb [11]	1-hour	None	

[1] Not to be exceeded more than once per year.

[2] Final rule signed October 15, 2008.

[3] The official level of the annual NO_2 standard is 0.053 ppm, equal to 53 ppb, which is shown here for the purpose of clearer comparison to the 1-hour standard

[4] To attain this standard, the 3-year average of the 98th percentile of the daily maximum 1-hour average at each monitor within an area must not exceed 100 ppb (effective January 22, 2010).

[5] Not to be exceeded more than once per year on average over 3 years.

[6] To attain this standard, the 3-year average of the weighted annual mean $PM_{2.5}$ concentrations from single or multiple community-oriented monitors must not exceed 15.0 µg/m3.

[7] To attain this standard, the 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area must not exceed 35 µg/m3 (effective December 17, 2006).

[8] To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.075 ppm. (effective May 27, 2008)

[9] (a) To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.08 ppm.

(b) The 1997 standard—and the implementation rules for that standard—will remain in place for implementation purposes as EPA undertakes rulemaking to address the transition from the 1997 ozone standard to the 2008 ozone standard.

(c) EPA is in the process of reconsidering these standards (set in March 2008).

[10] (a) EPA revoked the 1-hour ozone standard in all areas, although some areas have continuing obligations under that standard ("anti-backsliding").

(b) The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is ≤ 1.

[11] (a) Final rule signed June 2, 2010. To attain this standard, the 3-year average of the 99th percentile of the daily maximum 1-hour average at each monitor within an area must not exceed 75 ppb.

2.2. Sources and Characteristics of Particulate Matter

The concentration of particulate matter inside of a household is determined by the generation of PM within the household, the rate of air exchange, the depositional characteristics of the PM and the percentage of PM that is infiltrated from outside the household (Kamens et al., 1991; Maroni et al., 1995; Thatcher & Layton, 1995). Many factors affect the concentration of indoor PM, many of which may still be unknown to researchers. In attempts to explain various indoor PM phenomena, many reports have commented on the characteristics of all the parameters believed to influence indoor PM concentrations.

A study to investigate relationships between indoor and elemental concentrations in order to determine the degree that outdoor $PM_{2.5}$ that is infiltrated from the outdoor environment was presented by Long & Sarnat (2004). $PM_{2.5}$ data collected during the nighttime in non-smoking homes had been used to focus on indoor and outdoor concentrations of six focal elements (S, Ni, Z, Fe, K, Si). The aforementioned elements were believed to have the least indoor source contributions and were intended to be used as tracers to determine the degree of infiltration of outdoor PM into the indoor environment. It had been found that S, Ni, Zn, and Fe were least affected by indoor activities and that Ca, Al, Si, and K concentrations spikes were heavily associated with brief resuspension events (increased indoor human activity) (Long & Sarnat, 2004). High indoor-outdoor correlations were noted for S, Ni, Zn, Fe, K, and Si and were not affected by season or increased or decreased air exchange rates. Unlike the indoor-outdoor correlations, I/O ratios were seen to be much higher for all the target elements while I/O ratios were seen to be higher (greater than one) in homes with windows left open and lower (less than 0.4) in homes with central air-cooling systems installed. The previously mentioned observations in correlations and I/O ratios concluded a strong relationship between air exchange rates and the degree of elemental infiltration.

Several studies have suggested an increase in winter-time PM concentrations over summer-time concentrations. According to a seasonal study conducted in Taipei by Li and Lin (2003), average indoor $PM_{2.5}$ (24-h) concentrations were found to be 5.4% greater during the winter than during the summer. Taipei is a basin surrounded by mountains and this phenomenon is likely due to the creation of temperature inversions, much like the inversions seen in El Paso. Temperature inversions during the fall and winter months can trap visible urban pollution which results in periods where PM concentrations are higher than they would normally be (Lauer et al., 2009; Parker et al., 2008; Staniswalis et al., 2005). The intensification of wood burning in the region coupled with the creation of still-air inversions leads to an increase in PM_{10} and $PM_{2.5}$ in the winter months in the El Paso area (Li et al., 2001).

Of all indoor anthropogenic sources, cigarette smoke has been shown to be the dominant source of indoor PM when smokers were present (Spengler et al., 1981). Cigarette smoke has been shown to have the ability to add about 20.0 $\mu g/m^3$ (24-h mean) of $PM_{2.5}$ per smoker per household while adding 2 and 1.50 $\mu g/m^3$ per cigarette to 12-h average indoor concentrations of $PM_{2.5}$ and PM_{10} (Chao, 1998; Spengler et al., 1981; Wallace, 1996). A similar indoor study aimed to analyze indoor $PM_{2.5}$ and PM_{10} concentrations indoors found that the average $PM_{2.5}$ concentration of PM in homes with smokers was 18% greater than the average $PM_{2.5}$ concentrations in non-smoking homes (Chao & Wong, 2002). In addition, cooking was found to increase concentrations of PM_{10} by about 6.0 $\mu g/m^3$ per minute of cooking, with a majority of the added PM in the course fraction (Wallace, 1996). Frying, which is a common method when cooking Hispanic food, was found to be associated with increases in both $PM_{2.5}$ and PM_{10} (Abt et al., 2000; Mora, 2006). Resuspension of particles indoors, particularly for coarse particles, is a very important source of indoor PM as the rate of resuspension has been shown to increase with particle sizes greater than 1 µm. Also, the presence and movement of people in a household, along with cleaning, has shown to nearly double the concentrations of particles indoors between 5 and 10 µm (Thatcher & Layton, 1995).

The effect of wood burning stoves in a household on indoor PM levels was addressed by Highsmith et al. (1988) and it was found that ambient concentrations of $PM_{2.5}$ increased by about 50% during the night time around homes that used wood fed stoves while indoor $PM_{2.5}$ concentrations increased by about 45%, when compared to homes with not wood fed stoves. The burning of wood in stoves affected the concentrations in the fine particle range; while coarse particles showed no increase when wood stoves were used. Koutrakis (1992) created emission profiles for several indoor sources and notes which elements were characteristic of certain sources. Elements commonly associated with the use of cigarettes are potassium, chlorine and calcium while cooking has been shown to release aluminum, iron, calcium and chlorine.

A study by Abt et al. (2002) had been conducted in four non-smoking households in the metropolitan Boston area in hopes of characterizing indoor particle sources. Mean 12-hr values for both $PM_{2.5}$ and PM_{10} showed that indoor $PM_{2.5}$ values were 19% greater than outdoor values and that indoor PM_{10} values were 15% greater than outdoor values. $PM_{2.5}$ levels were found to be strongly correlated with outdoor concentrations, which suggests a good infiltration of outdoor $PM_{2.5}$ into the home. It was indicated that there was a tremendous variability in the contribution of a particular source to the type of indoor particle level affected. It was also suggested that variables such as oven temperature, type of food cooked, air exchange rates and outdoor concetrations had contributed to this variablity. The aforementioned variablity makes characterizing indoor sources difficult as these variables are unique to each household. It had also been noted that during the characterization of each of the housheholds, much higher exchange rates occurred during warmer weather when natural ventilation was used. Abt et al. (2002) had also commented on the findings regarding the seasonal variability of PM, noting that outdoor and indoor $PM_{2.5}$ concentrations were significantly higher in the summer season that the winter season. Increased $PM_{10\text{-}2.5}$ concentrations were also noted during the summer seasons over winter seasons and were believed to have been a result of the resuspension of coarse material due to dry summertime

ambient conditions. Indoor $PM_{10-2.5}$ concentraions were seen to have the most diurnal variation over the fine particle fractions ($PM_{2.5-0.7}$ and $PM_{0.5-0.1}$) over the period of 24 hours in all homes. Abt. et al. also investigated the impact particular sources may have on PM concentrations indoors. The most prominent indoor sources were noted as being oven cooking, sautéing, frying, toasting, dusting, vacuuming, sweeping, human movement, and also outdoor barbecuing. Indoor activities such as oven cooking, toasting, and barbecuing increased fine particle concentrations while sautéing, increased indoor human activity, and cleaning contributed most to the increase in coarse particle concentrations.

2.3. Local Particulate Matter Studies

An attempt to establish the indoor-outdoor PM correlation for ten residences with evaporative coolers in the El Paso region had been conducted by Paschold et al. (2003). Concurrent measurements of indoor and outdoor 10-minute $PM_{2.5}$ and PM_{10} were conducted during the summer season in 2001. Field filters were analyzed chemically using inductively coupled plasma-mass spectrometry (ICP-MS) for the presence of 30 elements in both indoor and outdoor PM ($PM_{2.5}$ and PM_{10}) samples. Comparative elemental statistics were presented for both geologic elements (Al, Ca, Na, P, Mn, Fe, Ti, and Mg) and toxic trace elements (Ba, Cu, Zn, Pb) for both indoor and outdoor PM ($PM_{2.5}$ and $PM_{10)}$. With respect to PM_{10}, I/O ratios showed a high correlation between indoor and outdoor elemental concentrations while indoor elemental concentration were generally 50-70% of their outdoor levels. PM_{10} I/O elemental concentrations had been shown to be rather consistent and was thought to have been caused by rapid replacement of indoor air caused by evaporative coolers. Mean values for trace metals and geologic elements were shown to be lower as one moves from the outdoor to the indoor environment for PM_{10} concentrations. Differences observed between indoor and outdoor mean elemental concentrations coupled with low indoor and outdoor elemental concentration correlations suggested that there were significantly different sources for part of indoor and outdoor $PM_{2.5}$.

A characterization of potential fugitive dust sources in the Paso del Norte region had been conducted by Garcia et al. (2003). Chemical signatures in surface soils had been investigated in order to determine any potential sources of fugitive dust in the region. Several multivariate statistical (cluster analysis and principle component analysis) techniques were used to determine elemental groupings, which may suggest that certain groups of elements may originate from similar sources. Soil samples were collected at twelve sites in Texas and New Mexico while another six were collected in Ciudad Juarez, Chihuahua. Meteorological conditions in the region were characterized to gain an insight as to how winds move in the region and when wind erosion was most likely to occur and to also understand how the pollutant in question might travel. Chemical element concentrations were derived from the collected soil samples with a focus on hazardous air pollutants and geologic elements. Lithological unit data and soil type data were also collected at each sample collection site using GIS land cover information. With the lithological, soil, elemental and metrological data, relationships between elemental concentrations, lithological unit types, soil types were determined. Garcia et al. extracted three significant sets of elements from the collected data of which the first was the Ag, As, Cd, Cu, Mo, Pb, Sb, and Zn group. This group was suggested to be anthropogenic in origin and interpreted as a smelter metals group, most likely originating from ASARCO operations. The second group of elements consisted of Al, Ba, K, Ca, and Co and was suggested that these elements are crustal in origin. A third group consisting of Be, Cr, Mg, and Ni had been suggested as to being of an industrial source other than that of the Ag, As, Cd, Cu, Mo, Pb, Sb, and Zn group. Impacts from quarries, smelter and agricultural activities were considered to have been the most evident sources of fugitive dust in Paso del Norte the region.

Espino et al. (2005) aimed to analyze the changes in air quality in the El Paso region over a three-year period ranging from 1994 through 1996 with regard to toxic metals. Meteorological results were collated from local newspaper weather reports and National Weather Service data along with the

selection of samples from one representative day from each season (spring, summer, fall, and winter) for inductively coupled plasma mass spectrometry. Samples had been selected from archived PM_{10} (24-hour) filters at the El Paso City-County Health and Environmental District (EPCCHED) and were chosen because they were collected on days that had low wind speed, a consistent seasonal wind direction, and no rain or snow events. More so, filters with average wind speed between 3.6 and 8.8 mph were chosen from the sample set with the aforementioned criteria which were collected at four El Paso sites (Tillman, Riverside, Northeast, and Ivanhoe) and five Ciudad Juarez sites (20-30, Pesta, Tecno, Advance, and Zenco). Four anthropogenic elements of interest were chosen for analysis due to the fact that there are no known significant natural origins of the elements in the region. Copper, lead, arsenic, and chromium concentrations were plotted on geographic information systems (GIS) maps of the El Paso-Juarez region and depicted the concentrations of the aforementioned elements for each season during each year (1994, 1995, and 1996). A correlation between meteorological conditions and pollutant concentration had been expressed in the final results of the study along. Noticeably higher Cu, Pb, As, and Cr concentrations were observed during the fall and winter seasons than the spring and summer seasons. The previously mentioned increases during the fall and winter seasons most likely resulted from the creation of inversions in the region due to retarded vertical circulation. Metal concentrations were found to have decreased as one moves further away from the more urban parts of El Paso and Juarez with urban core concentrations being an order of magnitude higher than concentrations recorded at more distant locations.

Gravimetric and chemical analyses of 24-hr average samples collected from five sites in the El Paso/Juarez region using dichotomous samplers had been presented by Li et al. (2001). This study focused on the analysis of temporal and spatial variations in $PM_{2.5}$ and $PM_{10-2.5}$ throughout the El Paso/Juarez region starting August 1999 through March 2000. Sites used for collection of $PM_{2.5}$ and $PM_{2.5-10}$ were Chamizal National Park, Sun Metro Bus Terminal, Club 20-30, Advanced Transformer,

and Mission, of which the last three were located in Ciudad Juarez. The locations chosen for sampling were selected because they were representative of different activities in the region, provided hourly PM data, and also provided representative meteorological data. Of the findings regarding the temporal variations, the most significant was the re-affirmation of previous claims that PM (PM_{10} and $PM_{2.5}$) concentrations increased during winter months, most notably due to the formation of still-air inversions in the El Paso region. At all study sites, $PM_{2.5}$ concentrations were shown to be weakly associated with PM_{10} concentrations despite there being excellent correlations between $PM_{10-2.5}$ and PM_{10}. Secondly, an investigation of hourly PM data by Li et al. uncovered a strong diurnal pattern. $PM_{2.5}$ and PM_{10} were shown to peak at two distinct periods during the day, once during the morning hours and again during the evening. The morning peak is thought to have been a result of morning traffic and ground-based inversions in the region while the evening peak is believed to have been attributed to the formation of radiation inversions coupled with the burning of wood and home cooking in the basin. Hourly $PM_{2.5}/PM_{10}$ dichotomous sampler ratios at all sites had ranged from 0.3-0.6 while the 24- hour averages ranged from 0.15-0.32. It had been noted that PM in the region appears to be dominated by the $PM_{2.5-10}$ fraction and that concentrations appear to increase outward in a radial direction starting from El Paso and heading out toward the out parts of Ciudad Juarez. This fraction of PM in the area was believed to be fugitive dust created by the disturbance of bare soil by mechanical/vehicular and wind disturbance. XRF elemental analysis had been conducted on 149 filters collected at all the aforementioned sites and focused on toxic trace (Cu, Cr, As, Cd, and Pb) and geologic (Al, Si, Ca, Fe, Ti, and K) elements. The selection of the toxic trace elements was based upon their association with local industrial operations. The occurrence of toxic trace elements in the region was believed to have more likely originated by the creation of fugitive dust in the area rather than from direct industrial anthropogenic emissions. Trace elemental concentrations were found to have been greater in the $PM_{2.5}$ fraction versus the $PM_{10-2.5}$ fraction at sites in Ciudad Juarez and was believed to have been a result of localized emission sources in

the vicinity of such sites. The inverse had been shown to be true for trace element concentrations in El Paso; trace element concentrations were higher in $PM_{10-2.5}$ than in $PM_{2.5}$. Geologic elements were shown to have comprised 35% of $PM_{2.5-10}$ while comprising only 12% of $PM_{2.5}$. Geologic elements comprised a greater percentage of the total PM sampled at all Juarez sites, most likely due to the prevalence of unpaved roads in the Juarez area. An interesting finding as a result of the XRF analysis was the discovery of high Cl concentrations at all sites (except Chamizal) in $PM_{2.5}$. This was believed to have been a result of a local unknown source(s) in the region.

2.4. Health Effects

Several studies suggest that $PM_{2.5}$ may have more health related risks than PM_{10} and that increased risk to health may be attributed to the fact that fine particles remain in suspension much longer than coarse particles; fine particles also have the ability to penetrate deeper into the lungs (Pope & Dockery, 2006). It has been suggested that fine particles may be more toxic as they contain various metals, acids, sulfates, nitrates and are composed of particles which may have various chemicals adsorbed onto their surfaces (Pope & Dockery, 2006). Fine and ultrafine particles have the capability to reach deep into the alveolar region of the lungs, while coarse particles tend to deposit in the upper respiratory tract (Kennedy, 2007; Gemenetzis et al. 2006). $PM_{2.5}$ exposure has shown to be well correlated with an increase in mortality and cardiopulmonary diseases such as atherosclerosis, and systemic and pulmonary inflammation while PM_{10} exposure has been shown to correlate well with increases in lung disorders, respiratory and cardiovascular diseases (Berico et al., 1997; Gemenetzis et al., 2006; Kennedy, 2007; Pope, 2000, 2006). Acute exposure to elevated levels of PM pollution has been shown to increase cardiovascular and respiratory mortality, lower respiratory syndromes, short-term changes in cardiopulmonary health, occurrence in decreased lung function, and exacerbate asthma (Pope, 2000, 2006). Chronic exposure to elevated levels of PM pollution were shown to increase chronic cough, bronchitis, and chest illness, while also increases respiratory and cardiovascular mortality in

adults; also, increased mortality along with increased incidences of sudden infant death syndrome were observed in areas plagued with increased fine PM pollution levels (Pope, 2000, 2006).

3. The Monitoring Program

3.1. Site Description

In this study, homes chosen for monitoring were selected from a cohort built for purposes of a larger epidemiological study on pediatric asthma (Lauer et al., 2009). The cohort was composed of 1,200 households in 50 stratified blocks in El Paso, Texas. The selection of homes for this study aimed at maximizing the spatial coverage within El Paso, TX.

In homes located in the Horizon area of El Paso County, an air systems manufacturing plant is located in this region. Sample sites located within the Horizon area on Amherst, Sparks and Ben Gurion are located only 0.77 miles from I-10, which is a major transportation artery that runs through El Paso.

In the east area of El Paso, a computer equipment manufacturing plant, along with electrical components and automotive components manufacturing plants, are located in this region. Sample sites in East El Paso on Angie Bombach Ave., Robert Rivera Ln. and Trail Blazer Dr. are located, on average, only 1.4 miles from Loop 375, which is a major transportation artery that connects both east and northeast El Paso. Homes within the same region on Glasgow, Dundee, Kirkcaldy and Dublin were located within close proximity of both McRae Blvd. and Montana Ave., both of which are major transportation arteries. These same homes are also located only 1.35 miles from the El Paso International Airport.

In both the southeast and central areas of El Paso, oil and copper refineries along with both radiator and boot manufacturing facilities are located in this co-region. Sample sites within the southeast region of El Paso located on Bernadine, Sun Dial and Starr Ave., are all located within 0.75 miles of the Cesar Chavez Border Highway. The sample site on Delta Dr. is located 0.5 miles from the aforementioned oil refinery in the region. In the same region, sample sites on Tays St. and Saint. Vrain

St. are located within 0.12 miles of the Cesar Chavez Border Highway and only 0.65 miles from the Stanton St. port of entry into Mexico. Sample sites in the same region located on University Ave. and Campbell St. are located only 0.27 miles from Mesa St., a major transportation artery, and 0.5 miles from the University of Texas at El Paso.

In northeast El Paso, a military base, a commercial airline production facility and an automotive seat-cushion production facility are located in this region. The sample site on Jerry Dr. is located only 0.06 miles from Dyer St., which is a major transportation artery in northeast El Paso while the site on Juliandra Ave. is 0.32 miles from Dyer St. and 0.26 miles from Woodrow Bean/Trans Mountain Rd., which is a major thoroughfare of traffic exiting from Loop 375. Sample sites on Pikes Peak Dr., Matterhorn Dr. and Mount Shasta Dr., Norte Pl. and Vulcan Ave. are all adjacent to Biggs Army Airfield. To the west of northeast El Paso is the Franklin Mountain Range, which can climb as high as 7,172 feet above sea level.

All previously mentioned manufacturing facilities mentioned in proximity to the sampling locations were reported as to have reported release, or disposal, of toxic chemicals. Emergency Planning and Community Right-to-Know Act (EPCRA), Section 313, requires the United States EPA and the States to collect data annually on releases and transfers of certain toxic chemicals from industrial facilities and make the data available to the public through the Toxic Release Inventory (TRI) program. Figure 3.1(names withheld on purpose) is a map which depicts the locations of facilities that have reported release of toxic chemicals as per EPCRA Section 313 to the EPA.

Figures 3.2 through Figure 3.5 are maps depicting the locations of the PEM sampling sites for each season. Figures 3.6 and Figure 3.7 are illustrations of where TEOM sampling occurred for each year as the sampling locations were consistent for each season within their respective year.

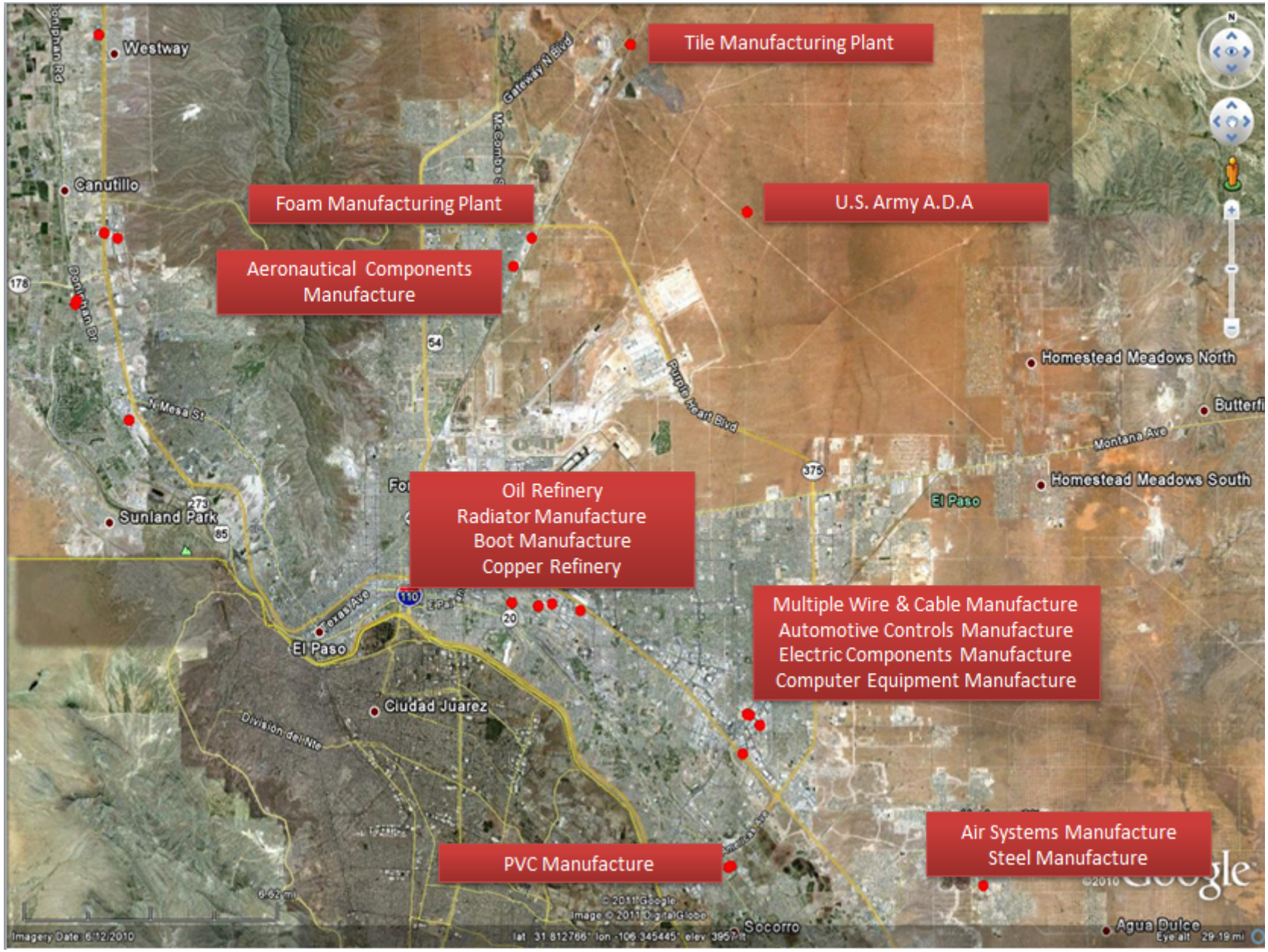

Figure 3.1: 2009 Toxic Release Inventory (TRI) Sites in the El Paso Region

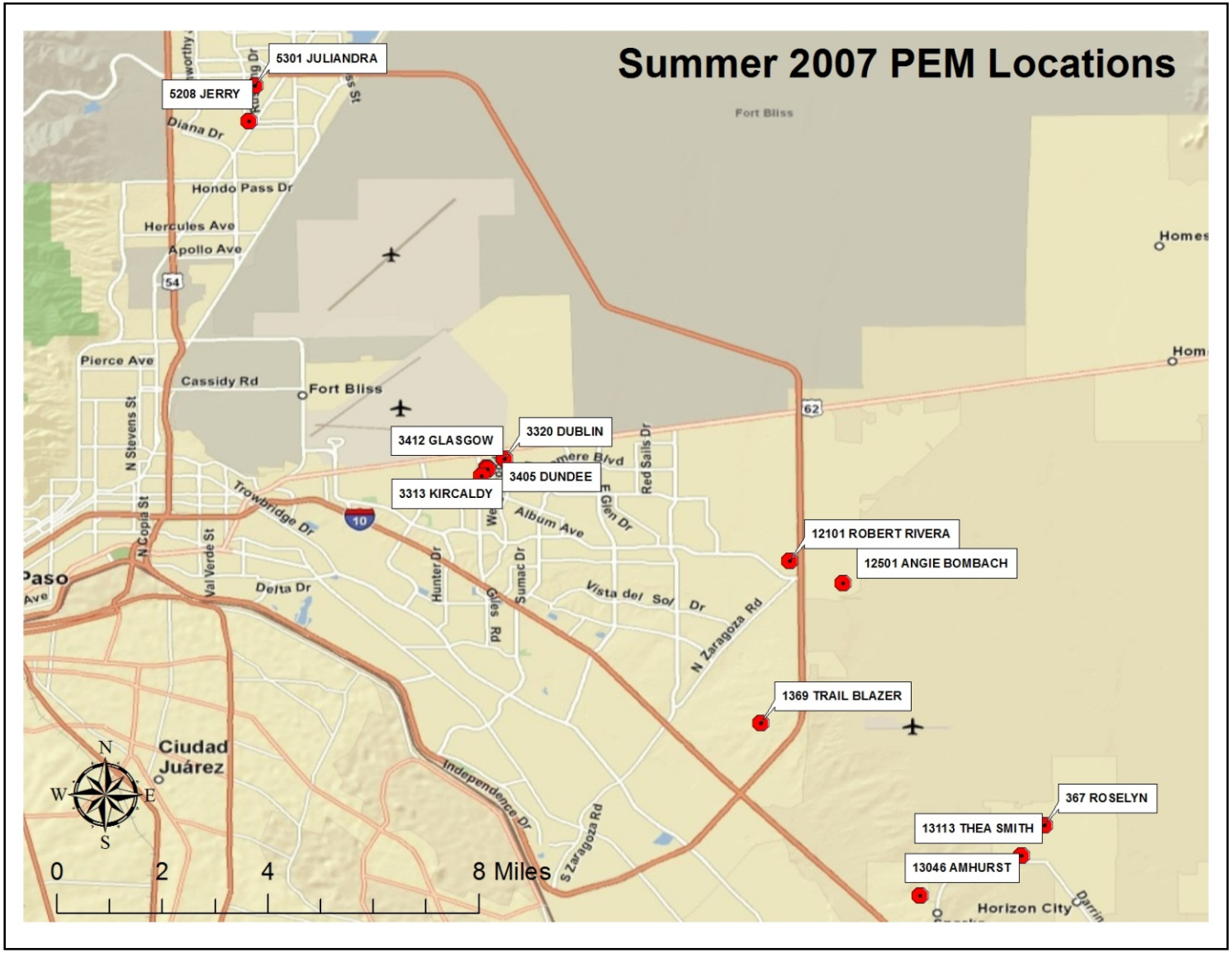

Figure 3.2: PEM Sampling Locations for Summer 2007

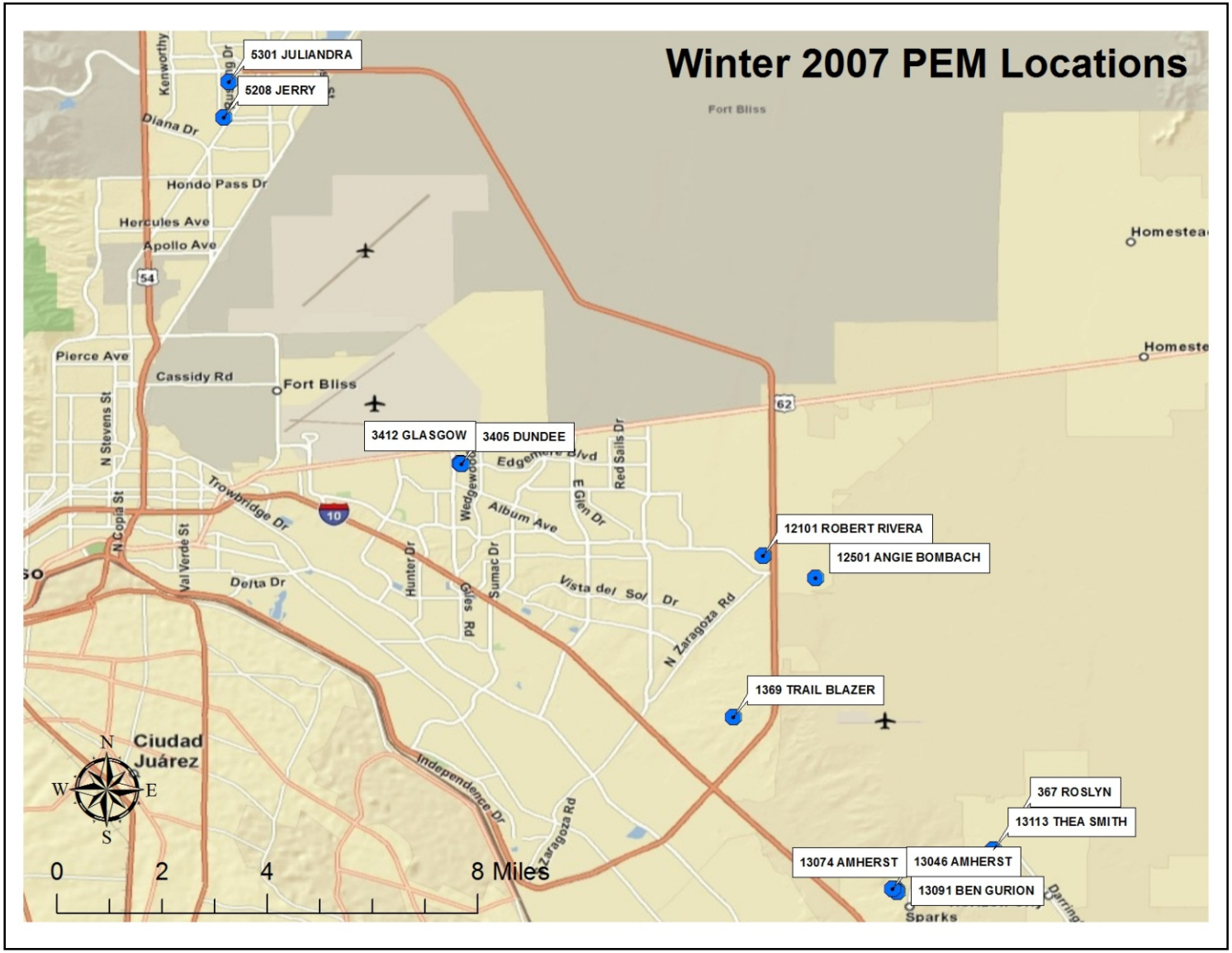

Figure 3.3: PEM Sampling Locations for Winter 2007

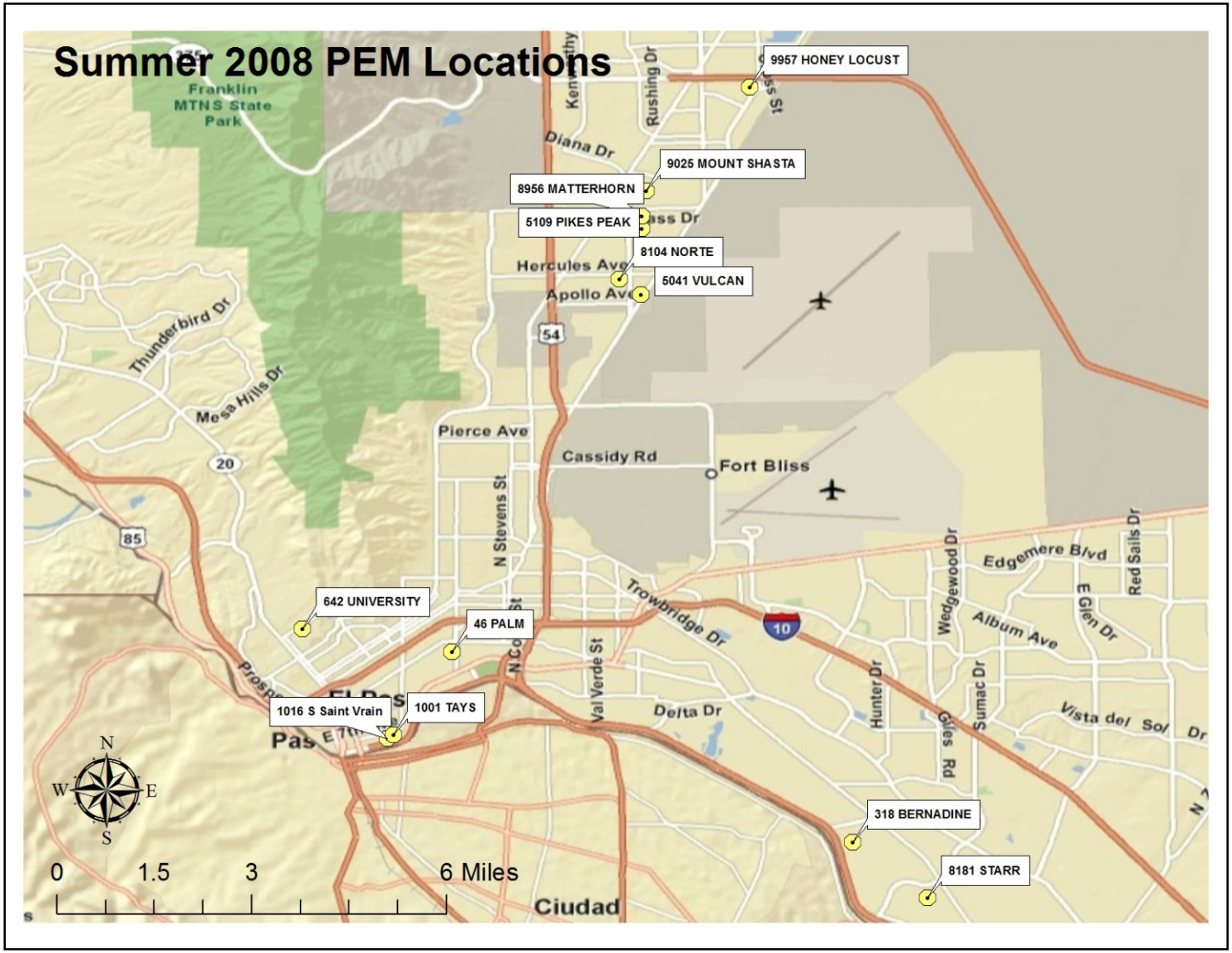

Figure 3.4: PEM Sampling Locations for Summer 2008

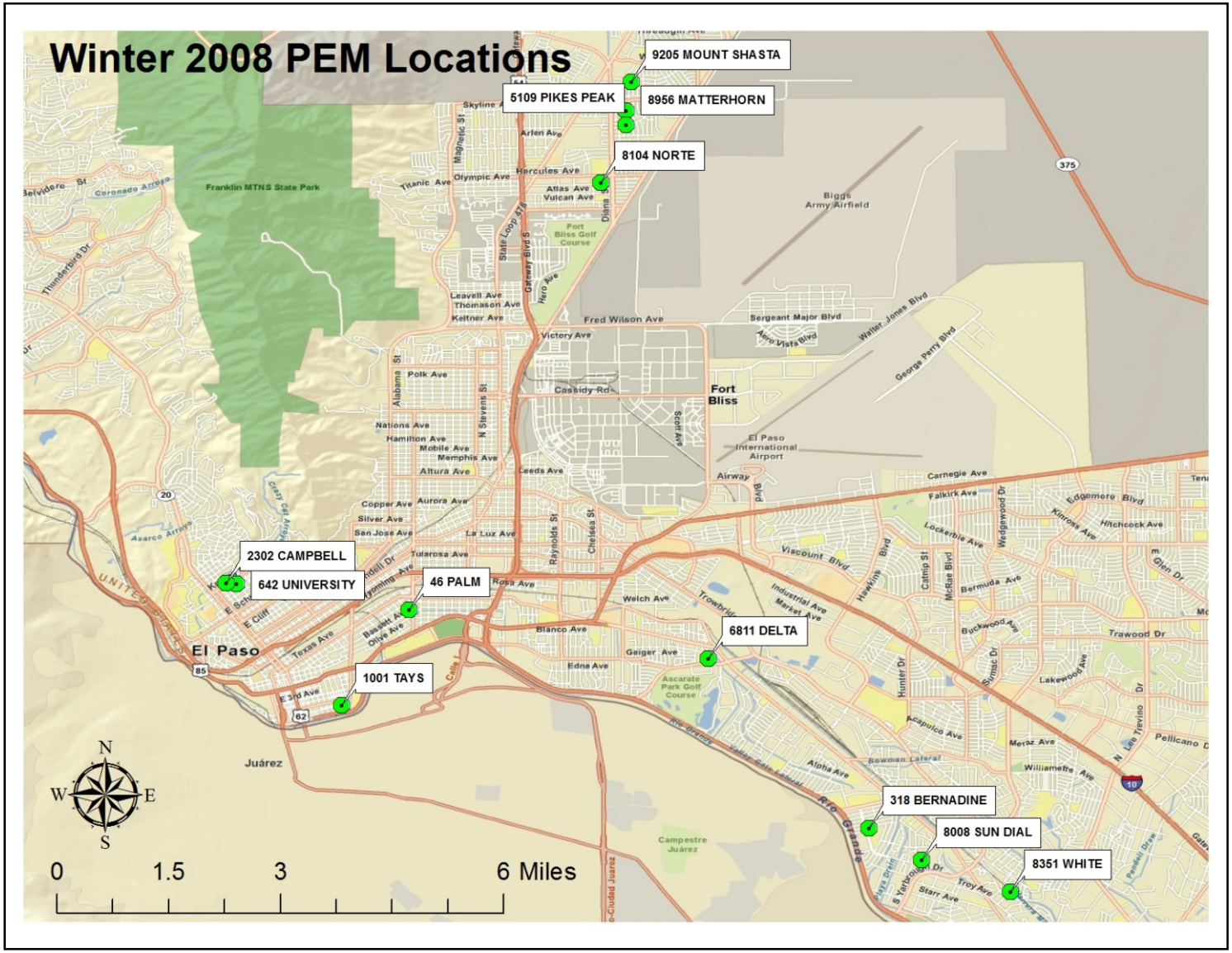

Figure 3.5: PEM Sampling Locations for Winter 2008

Figure 3.6: TEOM Sampling Sites for Year 2007

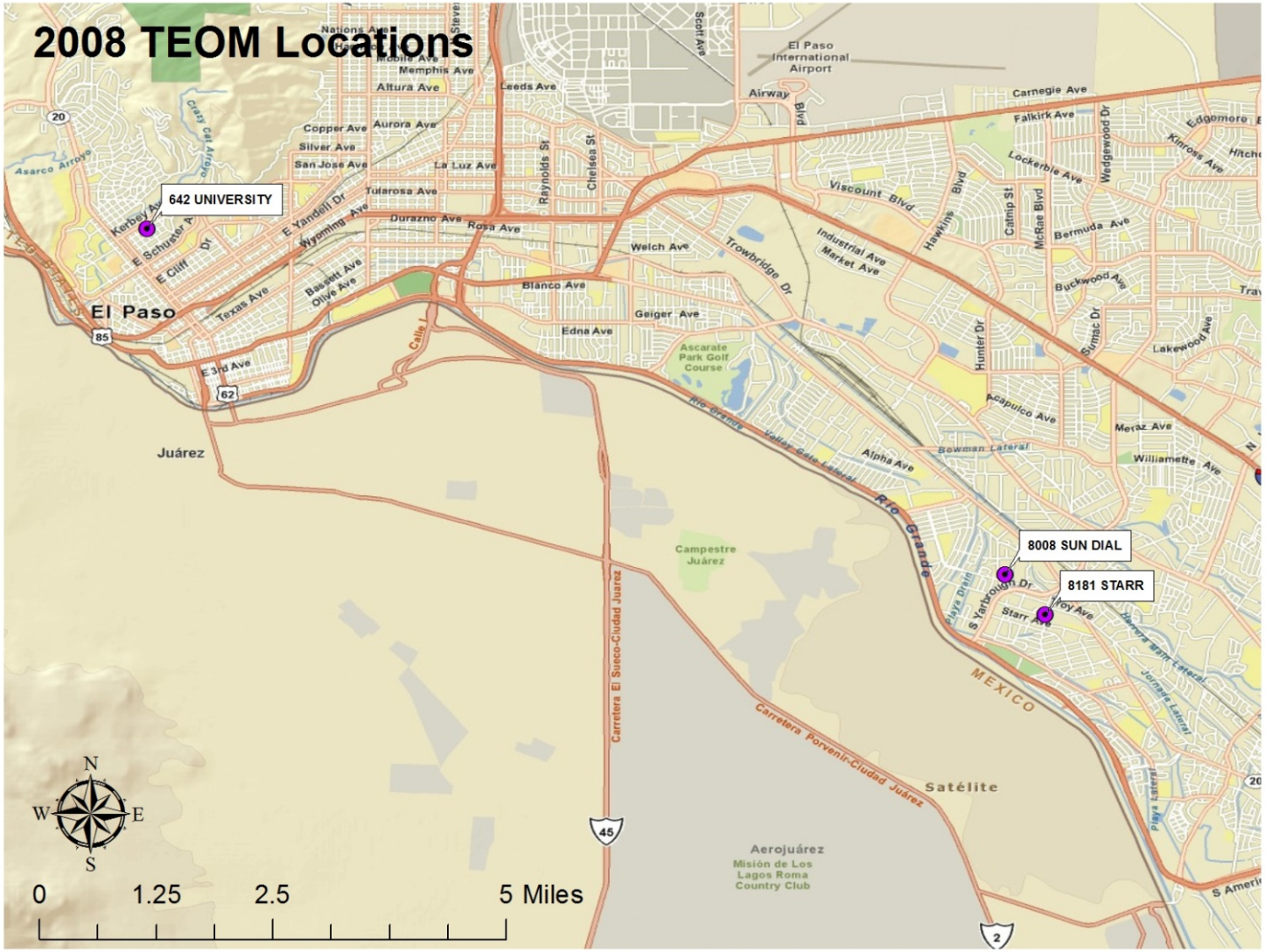

Figure 3.7: TEOM Sampling Sites for Year 2008

3.2. Sampling Period

The study period had been divided into four study semesters and spanned a period of two weeks at each location (week 1 & week 2). PEM measurements were taken at each location for a period of 7 days, which were then collected and restarted for another 7-day sampling period. The PEM sampling schedule used for the duration of the project is shown in Tables 3.1 and 3.2. TEOM sampling occurred at only 1 household per week and consisted of two alternating households during the study semester. TEOM sampling was conducted indoors and outdoors concurrently with the exception of one location during the summer sampling season in 2008. The TEOM sampling periods, for each season, are shown in Table 3.3.

Table 3.1: PEM Sample Sites and Sample Periods for 2007

WINTER 2007	SUMMER 2007
WEEK 1 (2/2/2007-2/9/2007)	**WEEK 1 (9/17/2007-9/24/2007)**
1369 TRAIL BLAZER	1369 TRAIL BLAZER
12101 ROBERT RIVERA	12101 ROBERT RIVERA
12501 ANGIE BOMBACH***	12501 ANGIE BOMBACH
3405 DUNDEE	3313 KIRKCALDY
3412 GLASGOW	3405 DUNDEE
13046 AMHERST	3412 GLASGOW
13091 BEN GURION	3320 DUBLIN
13113 THEA SMITH	13046 AMHERST
13074 AMHERST	13113 THEA SMITH
367 ROSLYN	367 ROSELYN
5301 JULIANDRA	5301 JULIANDRA***
5208 JERRY	5208 JERRY
WEEK 2 (2/9/2007-2/16/2007)	**WEEK 2 (9/24/2007-10/1/2007)**
1369 TRAIL BLAZER	1369 TRAIL BLAZER
12101 ROBERT RIVERA	12101 ROBERT RIVERA
12501 ANGIE BOMBACH	12501 ANGIE BOMBACH***
3405 DUNDEE	3313 KIRKCALDY
3412 GLASGOW	3405 DUNDEE
13046 AMHERST	3412 GLASGOW
13091 BEN GURION	3320 DUBLIN
13113 THEA SMITH	13046 AMHERST
13074 AMHERST	13113 THEA SMITH
367 ROSLYN	367 ROSELYN
5301 JULIANDRA***	5301 JULIANDRA
5208 JERRY	5208 JERRY

*****TEOM Site**

Table 3.2: PEM Sample Sites and Sample Periods for 2008

WINTER 2008	SUMMER 2008
WEEK 1 (2/29/2008-3/7/2008)	**WEEK 1 (6/16/2008-6/23/2008)**
8351 WHITE	9957 HONEY LOCUST
318 BERNADINE	9025 MOUNT SHASTA
8008 SUN DIAL***	5041 VULCAN
8104 NORTE	8104 NORTE
2302 CAMPBELL	8956 MATTERHORN
1001 TAYS	5109 PIKES PEAK
642 UNIVERSITY	1001 TAYS
46 PALM	1016 S SAIN VRAIN
5109 PIKES PEAK	642 UNIVERSITY***
8956 MATTERHORN	46 PALM
6811 DELTA	318 BERNADINE
9025 MOUNT SHASTA	8181 STARR
WEEK 2 (3/7/2008-3/14/2008)	**WEEK 2 (6/23/2008-6/30/2008)**
8351 WHITE	9957 HONEY LOCUST
318 BERNADINE	9025 MOUNT SHASTA
8008 SUN DIAL	5041 VULCAN
5109 PIKES PEAK	8104 NORTE
2302 CAMPBELL	8956 MATTERHORN
1001 TAYS	5109 PIKES PEAK
642 UNIVERSITY***	1001 TAYS
46 PALM	1016 S SAIN VRAIN
9025 MOUNT SHASTA	642 UNIVERSITY
8956 MATTERHORN	46 PALM
6811 DELTA	318 BERNADINE
8104 NORTE	8181 STARR***

*****TEOM Site**

Table 3.3: TEOM Sampling Periods and Locations

Winter 2007				Winter 2008			
Week 1		Week 2		Week 1		Week 2	
Angie Bombach		Juliandra		Sundial		University	
Start	End	Start	End	Start	End	Start	End
PM10		PM10		PM10		PM10	
2/2/2007	2/4/2007	2/8/2007	2/10/2007	3/2/2008	3/4/2008	3/10/2008	3/12/2008
18:00	17:00	18:00	17:00	18:00	17:00	18:00	17:00
PM2.5		PM2.5		PM2.5		PM2.5	
2/4/2007	2/6/2007	2/10/2007	2/12/2007	3/5/2008	3/7/2008	3/12/2008	3/14/2008
18:00	17:00	18:00	17:00	18:00	17:00	18:00	17:00
Summer 2007				**Summer 2008**			
Week 1		Week 2		Week 1		Week 2	
Juliandra		Angie Bombach		University		Starr	
Start	End	Start	End	Start	End	Start	End
PM10		PM10		PM10		PM10	
9/17/2007	9/19/2007	9/22/2007	9/24/2007	6/16/2008	6/18/2008	6/23/2008	6/25/2008
18:00	17:00	18:00	17:00	18:00	17:00	18:00	17:00
PM2.5		PM2.5		PM2.5		PM2.5	
9/19/2007	9/21/2007	9/25/2007	9/27/2007	6/18/2008	6/20/2008	6/25/2008	6/27/2008
18:00	17:00	18:00	17:00	18:00	17:00	18:00	17:00

3.3. Personal Environmental Monitors (PEM)

The Personal Environmental Monitor (PEM) model 200 (SKC, Inc.), used for the sampling of indoor 7-day $PM_{2.5}$, consists of a single-stage impactor and an after-filter. PM is sampled through the single-stage impactor to remove particles above the 50% cut-point at 2.5 µm in aerodynamic diameter. These large particles are collected on a greased ring and are discarded after sampling. Particles smaller than the 50% cut off point pass through the impactor and are collected on a 37-mm Teflon© after-filter. To determine the personal exposure, the filter was analyzed gravimetrically for particle mass and using EDXRF to measure for target elements. A personal air sampling pump (SKC, Inc.) model 224-PCXR8 provided the necessary airflow through the PEM and was set at 5 liters per minute (l/m).

The PEM's were set up indoors at 12 locations throughout El Paso, TX for two consecutive 1-week (7-days) sampling periods for each season (summer and winter) throughout years 2007 and 2008 at various pre-determined locations throughout the El Paso region. The homes selected for sampling

were, for the most part, consistent throughout each year; however, minor changes in a location may have been made due to the inability to place or retrieve samplers in the home for any reason. The PEM samplers were set up indoors, as far away from known sources such as kitchens, windows, doors, vents and fireplaces as possible. The PEM's were set up in the living room and at an average person's breathing height (between 5 and 6 feet above the ground) indoors.

3.4. TEOM

Two Tapered Element Oscillating Microbalances (TEOM Series 1400a, Rupprecht & Patashnick Co., Inc.) were used in this study to continuously measure PM_{10} and/or $PM_{2.5}$ mass concentrations both indoors and outdoors. TEOM mass detectors employ an inertial mass weighing principle and operate in a fashion similar to a harmonic oscillator. A TEOM mass detector consists of a filter cartridge positioned at the end of a hollow tapered tube while the other end of the tube is fixed to a base. A particle rich air steam is drawn through the filter where it is oscillated in a clamped-free mode at its resonant frequency. This frequency depends on the physical characteristics of the tube and the mass on its free end. As the PM deposits on the media, the mass of the filter cartridge increases and the frequency of the system changes accordingly. The measure of the frequency change along with the accumulated mass is measured in conjunction with the measured volume of air drawn through the system during the same time period. The measurement of all the aforementioned variables yields the particle mass concentration (Patashnick et al., 2002).

The TEOM mass detectors were set to a customary adult breathing rate of 16.7 (l/min), with 13.67 (l/min) diverted as auxiliary flow and 3 (l/min) reserved for the main flow. The TEOM uses modified inlets, which allows an exclusive range of particles sizes into the TEOM mass detector ($PM_{2.5}$ or PM_{10}). The TEOM continuous monitor was set to record 10-minute mean mass concentration values for the entire sampling period. The indoor TEOMS were co-located with the PEM samplers and were

placed in an area of the household to avoid placement in proximity to known indoor sources such as kitchens, windows, doors, vents and fireplaces. Outdoor TEOMS were placed in a manner so they were not in close proximity to walls, trees, dogs or any other foreseen disturbances which might compromise the measurements. TEOM sampling had been conducted in only one house at a time due to instrumentation availability limitations and was contingent upon resident participation. TEOM locations for 2007 were consistent between seasons; however, one location in 2008 was relocated due to scheduling conflicts with the residents of the household.

3.5. Sample Collection and Gravimetric Analysis

Quality control was ensured during preparation, deployment, collection and gravimetric analysis by following EPA guidelines and procedures for the monitoring of PM_{10} (EPA, 1994) and $PM_{2.5}$ (EPA, 1998a, 1998b). The Teflon© filters had been pre-conditioned, pre-weighed, and stored in a contamination free environment for a period of less than 30 days before deployment. All samples had been pre-conditioned at room temperature at 25□C ± 5□C and 30% ± 5% relative humidity for at least twenty-four hours. Pre-weights and post-weights conducted on a Mettler Toledo MX5 microbalance, which has readability to one μg, was used in the analysis (Mettler Toledo, 2007), and were noted on the chain-of-custodies for the PEM filters (Appendix A). The amount of PM collected was determined as the difference in the pre-weights and post-weights of the Teflon© filters. Mass concentrations were reported in micrograms of PM collected per cubic meter of air ($\mu g/m^3$). The accuracy of the MX5 microbalance had been assured via the use of certified masses which were weighed prior to each to filter pre and post-weigh session. Detailed laboratory procedures for gravimetric analysis conducted at the Air Quality Laboratory at The University of Texas at El Paso are explained in greater detail by Li et. al (2001) and Orquiz (2001).

The PEM samplers were calibrated once at the lab and again before deployment using a mini-Buck bubble calibrator model M-30 (A.P. Buck, Inc.) which is a primary standard calibration device traceable to NIST. The flow range of the calibrator ranges from 100 cc/min to 30 (l/min).

3.5.1. Filters

7-day samples were run an average of 10080 minutes (168 hours) and times varied based on whether the residents were home or available for deployment or collection of filters. Samples were collected on 37-mm diameter ringed Teflon© filters (PALL Corp., ID #R2PJ037) at an actual flow rate of 5 liters per minute. The 37-mm Teflon© filter has a 99% collection efficiency and is white with a polymethylpentane ring. The filter is resistant to absorption of gases and has a low hygroscopicity.

3.6. Energy Dispersive X-Ray Fluorescence

Energy dispersive x-ray fluorescence (EDXRF) was used for the characterization of the $PM_{2.5}$ elemental composition of the mass collected on the PEM's (7-day). EDXRF has several advantages over more conventional spectroscopic techniques such as inductively coupled plasma (ICP) or atomic absorption (AA) analyses (Down & Lehr, 2005). Samples can be analyzed nondestructively, allowing for the utilization of additional measurements, and the analysis of samples via EDXRF is much quicker than conventional methods. EDXRF bombards the sample using x-rays, or gamma rays. The bombardment of gamma rays, in sufficient energies, can knock electrons out of the electron orbit of an atom. This leaves a vacancy in the electron orbit which is filled by an electron in the outer shell which allows the electron to descend to a less energetic state; therefore, emitting radiation in the form of a characteristic wavelength. This characteristic wavelength is then used to identify the element(s) in question located in a sample (Down & Lehr, 2005).

EDXRF analysis was performed on the PEM Teflon© filters by Prof. Pingitore's Geochemistry Laboratory, located in the Geology Department at the University of Texas at El Paso, for Na, Mg, Al, Si, P, S, Cl, K, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Ge, As, Se, Br, Rb, Sr, Y, Mo, Rh, Pd, Ag, Cd, Sn, Sb, Te, I, Cs, Ba, W, Pt, Au, Pb, Bi, La, Th, and U using an EDXRF analyzer. The analysis used a PANanalytical Epsilon 5 EDXRF analyzer with liquid nitrogen cooled, 100kV, 2.0 mA Scandium/Tungsten dual anode x-ray tube. The Epsilon 5 analyzes air filters according to EPA method 10-3.3. The instrument was set up and calibrated with 96 (48 high and 48 low) National Institute of Standards and Technology (NIST) standards and a blank sample from Micromatter Co. (Eastsound, WA). Standards were composed of pure elements and compounds located on 29 mm Nucleopore media. Precision, accuracy, and detection limits, for the Epsilon 5 EDXRF analyzer may be found in the reference manual (Appendix B). Equations used to convert units reported by the Geochemistry Laboratory as a result of EDXRF analysis can be found in Appendix D.

3.7. Reflectance Analysis

Post gravimetric analysis, the “blackness” or loss of reflectance on the sample filter had been used as a surrogate for the determination for the amount of black carbon (BC) on the filter. The amount of black carbon which had been loaded on a filter is used as an indicator of traffic-related emissions (Raysoni, 2011).

A digital smoke-stain reflectometer (Model EEL 43D, Diffusion Systems Ltd.) had been used to measure the reflectance of a particular filter. An in-depth instruction as to the method used for the determination of the reflectance and black carbon concentration can be found in Raysoni (2011).

3.8. TCEQ CAMS Data

The Texas Commission on Environmental Quality (TCEQ) operates continuous air monitoring stations (CAMS) in various sites throughout the El Paso region. The measurement of known air pollutants as well as the collection of meteorological data is collected at each site. Archived PM_{10}, $PM_{2.5}$, and meteorological data were collected from TCEQ's database of values from CAMS sites located in close proximity to sample sites. The aforementioned data was used for the characterization of wind patterns in various parts of the El Paso region as well as being used as a semi-validator for mass concentrations at locations in very close proximity to the CAMS station.

3.9. EPA Toxic Release Inventory (TRI) Program

The Toxic Release Inventory (TRI) database contains disposal/release data of over 600 toxic chemicals from thousands of facilities located in the United States. The Emergency Planning and Community Right-to-Know Act (EPCRA) had been created to inform citizens of toxic chemical release from facilities in their respective area. EPCRA Section 313 requires the collection of annual release and transfers data of toxic chemicals from industrial facilities in the United States as of 1986. EPCRA section 313 had been supplemented with the 1990 passing of the Pollution Prevention Act which required facilities to report additional data on the management of all wastes generated at the facility. The result of such collection activities by the EPA was the creation of the TRI program. TRI program data for years 2007 and 2008 were retrieved from the EPA website and used for illustrative purposes as well as being used for hypothesizing possible origins of specific toxic elements found on collected mass filters in the El Paso region (Appendix E).

4. Results & Discussion

4.1. PEM Summary Statistics

Mean values reported in all tables, unless expressed otherwise, have been computed by taking the average of all valid respective values for the respective variable for the respective study period. Percent composition for each respective time period was computed by computing the percent composition of each variable for every sample and taking the mean of all percent compositions.

Table 4.1: Summary Statistics by Season and Year for Indoor PEM $PM_{2.5}$, $\sum$ Elements, and BC

	Time Period	N	Min	Max	$\bar{x}$	Std. Deviation	Variance
$PM_{2.5}$	Summer	44	2.94	54.8	16.8	10.7	115
	Winter	41	1.64	80.7	22.9	16.8	283
	2007	42	1.64	80.7	22.9	16.9	284
	2008	43	2.94	60.4	16.7	10.5	110
	Entire Study Period	85	1.64	80.7	19.8	14.3	203
	Time Period	**N**	**Min**	**Max**	$\bar{x}$	**Std. Deviation**	**Variance**
Σ Elements**	Summer	44	0.13	8.97	3.99	2.44	5.97
	Winter	41	0.01	14.6	3.45	3.12	9.73
	2007	42	0.01	13.5	2.74	2.65	7.03
	2008	43	0.22	14.6	4.69	2.59	6.72
	Entire Study Period	85	0.01	14.6	3.73	2.79	7.76
	Time Period	**N**	**Min**	**Max**	$\bar{x}$	**Std. Deviation**	**Variance**
Black Carbon (BC)	Summer	41	0.02	0.49	0.21	0.13	0.02
	Winter	40	0.03	1.06	0.38	0.28	0.08
	2007	41	0.02	1.06	0.37	0.26	0.07
	2008	40	0.03	0.82	0.22	0.18	0.03
	Entire Study Period	81	0.02	1.06	0.30	0.23	0.05

* % Composition by mass (mass of elements/mass of $PM_{2.5}$)

** Is the sum of all analyzed elements by EDXRF

All units in ($\mu g/m^3$)

Table 4.1 is a summary statistics table of all valid PEM filters which were summarized for the entire study period, by year, and by season for $PM_{2.5}$, $\sum$ Elements, and for black carbon (BC). The mean $PM_{2.5}$ concentration for the entire study period was found to be 19.8 $\mu g/m^3$. Of both years that the study period had been conducted, the mean indoor PEM $PM_{2.5}$ concentration was higher in 2007 than in 2008 by roughly 37%. The maximum mass concentration for indoor PEM $PM_{2.5}$ was higher in the winter seasons than in summer seasons. This finding is consistent with other regional outdoor PM studies which claim that PM concentrations increase in the fall and winter seasons due to inversions that form in the El Paso region and trap PM over the area (Espino et al., 2005; Li et al., 2001). An interesting point to note, the variance of $PM_{2.5}$ PEM values for the winter period appears to be nearly twice as great as the variance for the summer period. Of all valid observed BC concentrations and respective variances, those samples collected during the winter, 0.38 $\mu g/m^3$, were much greater than those collected during the summer, 0.21 $\mu g/m^3$. The increase in BC may indicate an increase in carbon-fuel based sources indoors during the winter months. Depending on the infiltration characteristics of the household, infiltration of BC into the indoor environment may have also raised BC levels, on average. The previously mentioned increase in BC during the winter season is consistent with previous findings which also reported substantially higher BC concentrations under polluted conditions during the winter; additionally, increased BC concentrations were also noted during periods of still-air, stable conditions (Hitzenberger & Tohno, 2001).

Table 4.2: Percent (%) Composition by Year, Season, and Study Period

	Time Period	N	Min	Max	$\bar{x}$	Std. Dev.	Variance
% BC of $PM_{2.5}$	Summer	41	0.10	3.52	1.44	0.94	0.89
	Winter	40	0.10	6.57	2.22	1.64	2.70
	2007	41	0.10	6.57	2.13	1.62	2.62
	2008	40	0.10	3.82	1.52	1.02	1.05
	Entire Study Period	81	0.10	6.57	1.83	1.38	1.91
	Time Period	**N**	**Min**	**Max**	$\bar{x}$	**Std. Dev.**	**Variance**
% ∑Elemental Composition of $PM_{2.5}$	Summer	44	0.76	78.9	31.4	22.2	494
	Winter	41	0.28	41.8	16.1	10.4	108
	2007	42	0.28	39. 6	13.0	9.3	85.7
	2008	43	0.73	78.9	34.7	20.2	406
	Entire Study Period	85	0.28	78.9	24.0	19.1	364
	Time Period	**N**	**Min**	**Max**	$\bar{x}$	**Std. Dev.**	**Variance**
% Geologic Elem. Of $PM_{2.5}$	Summer	44	0.36	61.9	22.8	18.1	326
	Winter	41	0.01	33.1	11.6	8.44	71.2
	2007	42	0.01	30.6	8.6	7.21	51.9
	2008	43	0.49	61.9	26.0	16.2	261
	Entire Study Period	85	0.01	61.9	17.4	15.3	234
	Time Period	**N**	**Min**	**Max**	$\bar{x}$	**Std. Dev.**	**Variance**
% Geologic Elem. of ∑Elem	Summer	44	21.7	82.4	66.3	13.0	168
	Winter	41	0.42	88.3	67.1	16.4	268
	2007	42	0.42	88.3	59.9	17.2	295
	2008	43	52.2	84.9	73.3	6.96	48.4
	Entire Study Period	85	0.42	88.3	66.7	14.6	214
	Time Period	**N**	**Min**	**Max**	$\bar{x}$	**Std. Dev.**	**Variance**
% Toxic Trace Elements of $PM_{2.5}$	Summer	44	0.01	0.84	0.15	0.14	0.02
	Winter	41	0.00	5.34	0.24	0.82	0.67
	2007	42	0.00	5.34	0.23	0.81	0.66
	2008	43	0.01	0.84	0.16	0.14	0.02
	Entire Study Period	85	0.00	5.34	0.19	0.58	0.33
	Time Period	**N**	**Min**	**Max**	$\bar{x}$	**Std. Dev.**	**Variance**
% Toxic Trace Elem. of ∑Elem	Summer	44	0.12	7.91	0.82	1.28	1.64
	Winter	41	0.00	13.5	1.35	2.53	6.42
	2007	42	0.00	13.5	1.58	2.69	7.22
	2008	43	0.12	3.97	0.58	0.62	0.38
	Entire Study Period	85	0.00	13.5	1.08	1.99	3.97

*Units are (%)

Table 4.2 contains the summary of percent compositions of BC, ∑ Elements, geologic, and toxic trace elements found in $PM_{2.5}$. Li et al. (2001) and Orquiz (2001) had grouped elements based on their respective association with operations of local industrial sources and their prevalence in PM in the El Paso region. These elements were grouped as geologic elements (Al, Si, Ca, Fe, and Ti) and toxic trace elements (Cu, Cr, As, Cd, and Pb). This same grouping convention had been used in this analysis in addition to the presentation of the full range of elemental concentrations reported as a result of EDXRF analysis. For the entire study period, roughly 1.8% of all mass collected on the samples consisted of black carbon while nearly 24% was found to consist of all elements analyzed by EDXRF. $PM_{2.5}$ was found to consist, on average, of 17.4% geologic elements (Al, Si, Ca, Fe, and Ti) and 0.19% toxic trace elements (Cu, Cr, As, Cd, and Pb). Geologic elements and toxic trace elements were found to compose nearly 66.7% and 1.08% of all analyzed elements during the entire study period, respectively.

The amount of black carbon found on samples was greater during the winter, 2.22%, than during the summer, 1.44%, while samples collected during 2007 had a higher amount of BC found on them. BC concentrations can be used as a surrogate for diesel emissions and the increase in BC composition during the winter seasons may be a result of previously mentioned still-air inversions which form in the El Paso region during the fall and winter seasons; assuming all BC found indoors has infiltrated from the outdoor environment, otherwise, the usage of a natural gas stove for cooking may contribute to this increase. Minimal data exists which describes the infiltration behavior of $PM_{2.5}$ elemental components from outdoors into the residence, so a general understanding of how BC infiltrates from the outdoor environment is quite unclear (Long & Sarnat, 2004). The percent composition of all analyzed elements in $PM_{2.5}$ was significantly greater during the summer period, 31.4%, versus the winter study period, 16.1%, while 2007 saw a greater percent composition than 2008. The percent composition of geologic elements in $PM_{2.5}$ was seen to be greater during the summer, 22.8%, and in samples collected during 2008, 26%, while toxic trace elements had a higher composition in $PM_{2.5}$ during the winter seasons,

0.24%, and in samples collected during 2007, 0.23%. Geologic elements were found to compose a slightly greater percentage of all analyzed elements (∑ Elements) during the winter time, 67%, while toxic trace element composed a slightly greater portion of all analyzed elements during the winter time than summer seasons as well.

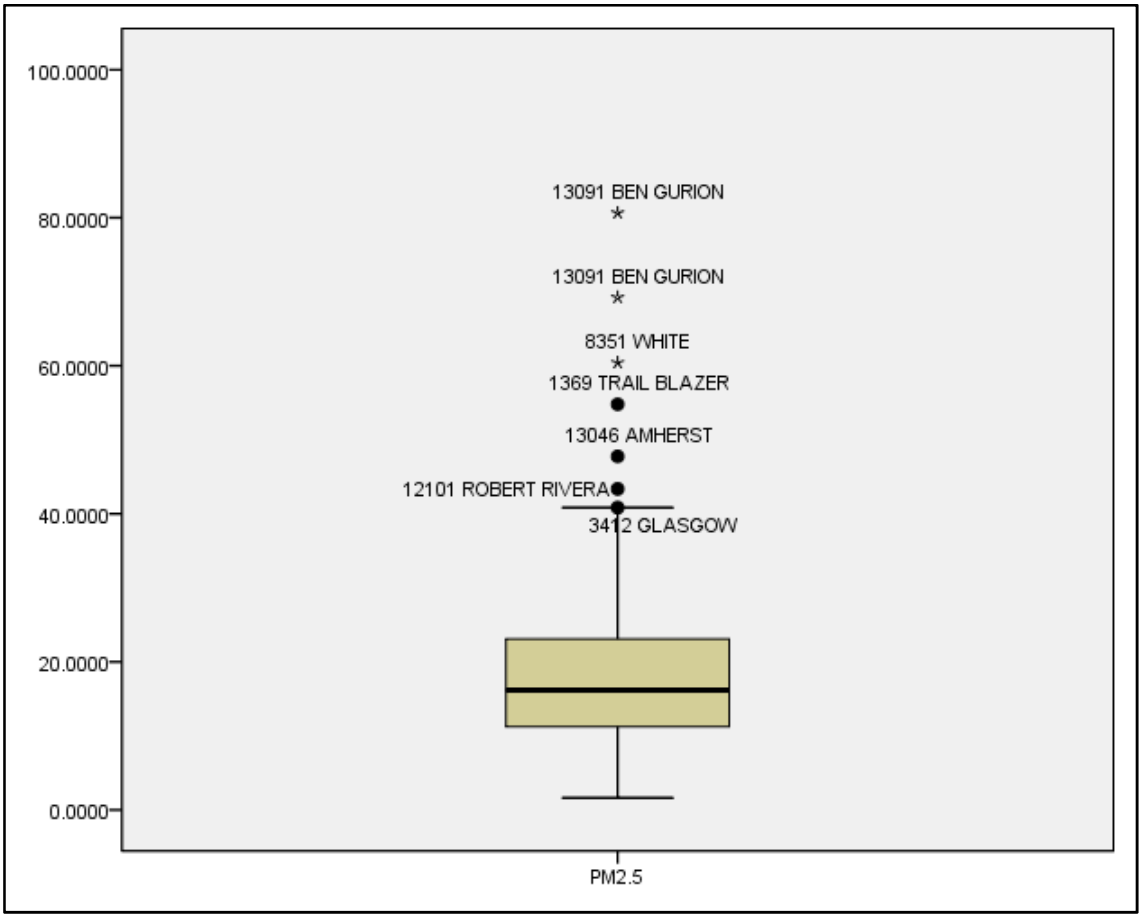

Figure 4.1: Boxplot of PEM Samples for Entire Study Period (Units µg/m3)

Figure 4.1 is a boxplot of all collected (valid) PEM $PM_{2.5}$ samples for the entire study period. Filters with "invalid" data contained no values for mass collected as the filter was either torn or not collected on time. Outlier samples with higher $PM_{2.5}$ mass concentrations were found at Ben Gurion, White, Trail Blazer and Amherst and these sampling locations were all located in the southeast area of El Paso. No smokers, asthmatic children, or dogs have been reported to reside at the previously

mentioned locations and only the residents at 8351 White have supplied an activity log to supplement the 7-day PEM sample. The activity log for the residence at 8351 White reported cooking at least three times daily and reported cleaning activities daily for an average of two hours. The elevated concentration reported at 8351 White may in fact be a result of the increased indoor activities such as cleaning and cooking while the elevated concentrations at Ben Gurion cannot be explained due to the lack of an activity log sheet which may have helped to provide an insight as to why both samples at the location were so high.

Table 4.3: Summary Statistics by Location for $PM_{2.5}$

$PM_{2.5}$*					
Location	**N**	**Min**	**Max**	$\bar{x}$	**Std. Dev. (*s*)**
1001 TAYS	3	11.4	15.8	13.7	1.28
1016 S. SAINT VRAIN	2	11.4	13.8	12.6	1.20
12101 ROBERT RIVERA	3	11.3	43.4	**27.0**	9.28
12501 ANGIE BOMBACH	4	10.3	23.0	17.4	3.02
13046 AMHERST	4	15.8	47.8	**26.3**	7.28
13074 AMHERST	2	4.40	40.8	**22.6**	18.2
13091 BEN GURION	2	69.2	80.7	**75.0**	5.71
13113 THEA SMITH	4	12.9	16.4	15.2	0.81
1369 TRAIL BLAZER	3	1.64	54.8	**23.6**	16.0
2302 CAMPBELL	2	12.8	23.1	17.9	5.15
318 BERNADINE	4	10.9	35.6	**22.2**	5.19
3313 KIRKCALDY	2	21.3	28.4	**24.9**	3.51
3320 DUBLIN	1	17.8	17.8	17.8	N/A
3405 DUNDEE	3	5.59	21.7	12.5	4.77
3412 GLASGOW	4	12.2	40.9	**22.0**	6.40
367 ROSELYN	4	1.96	24.4	13.2	0.00
46 PALM	3	13.8	23.7	19.0	2.84
5041 VULCAN	2	2.94	8.30	5.62	2.68
5109 PIKES PEAK	4	8.02	19.5	13.0	2.93
5208 JERRY	3	17.4	39.0	**25.3**	6.90
5301 JULIANDRA	3	17.1	26.9	**21.5**	2.86
642 UNIVERSITY	4	6.20	13.0	9.57	1.43
6811 DELTA	1	13.3	13.3	13.3	N/A
8008 SUN DIAL	2	20.0	24.5	**22.2**	2.29
8104 NORTE	4	11.1	34.3	**22.4**	5.71
8181 STARR	2	17.7	24.7	**21.2**	3.54
8351 WHITE	2	36.2	60.4	**48.3**	12.1
8956 MATTERHORN	2	7.57	9.12	8.34	0.78
9025 MOUNT SHASTA	4	9.01	14.2	11.0	1.19
9957 HONEY LOCUST	2	8.34	12.3	10.3	1.96

*Units (ug/m3)

Table 4.3 is a summary of PEM $PM_{2.5}$ mass concentrations that have been classified according to location. The number of PEM samples (7-day) collected at each location is listed, along with basic summary statistics for each location. The sample location at Ben Gurion had the highest average (N=2) mass concentration 75.0 $\mu g/m^3$ along with minimum and maximum mass concentrations at significantly greater numbers than at all other locations. The lowest mean mass concentration was found at the

Vulcan sample site. Mean mass concentrations in bold font all had mean $PM_{2.5}$ mass concentrations above the sample population mean of 19.8 $\mu g/m^3$.

A summary of descriptive statistics for each analyzed element using EDXRF for the entire study period is presented in Table 4.4. For the entire study period, the elements that dominated the percent composition of the total mass are Si and Ca with mean concentrations of 0.98 and 0.87 $\mu g/m^3$. Other elements with a significant contribution of mass to the total elemental composition were S, Al, Fe, K, Na, Cl, and Mg, in order of descending mean concentrations. It is apparent that the majority of the composition of elements found in PM in the El Paso region is mostly geologic (Al, Si, Ca, Fe, and K) with the inclusion of Cl, Na, S, and Mg. This finding is consistent with other studies conducted in the region which also concluded that PM is dominated by natural mineral material (Dattner, 1994; Einfeld & Church, 1995). Greater values in variance can also be seen in the aforementioned geologic elements, most likely due to spikes in concentrations due to weather events which re-suspend the vast amounts of exposed geologic material in this arid desert region.

Table 4.4: Mean Concentrations for Each Element for the Entire Period

Descriptive Statistics							
	N	**Range**	**Minimum**	**Maximum**	$\bar{x}$	**Std. Dev. (*s*)**	**Variance(s^2)**
Na	85	0.878	0.000	0.878	0.159	0.144	0.021
Mg	85	0.496	0.000	0.496	0.120	0.108	0.012
Al	85	1.75	0.000	1.75	0.391	0.364	0.132
Si	**85**	**4.50**	**0.000**	**4.70**	**0.975**	**0.874**	**0.764**
P	85	0.081	0.000	0.081	0.018	0.014	0.000
S	85	1.21	0.000	1.21	0.429	0.251	0.063
Cl	85	1.29	0.000	1.29	0.140	0.229	0.052
K	85	0.813	0.000	0.813	0.190	0.144	0.021
Ca	**85**	**5.71**	**0.000**	**5.71**	**0.873**	**0.845**	**0.714**
Sc	85	0.010	0.000	0.010	0.003	0.002	0.000
Ti	85	0.150	0.000	0.151	0.029	0.024	0.001
V	85	0.002	0.000	0.002	0.001	0.001	0.000
Cr	85	0.093	0.000	0.093	0.004	0.017	0.000
Mn	85	0.027	0.000	0.027	0.005	0.005	0.000
Fe	85	1.43	0.000	1.43	0.254	0.229	0.053
Co	85	0.001	0.000	0.001	0.000	0.000	0.000
Ni	85	0.024	0.000	0.024	0.002	0.004	0.000
Cu	85	0.033	0.000	0.033	0.010	0.006	0.000
Zn	85	0.154	0.000	0.154	0.029	0.032	0.001
Ga	85	0.008	0.000	0.008	0.001	0.001	0.000
Ge	85	0.009	0.000	0.009	0.000	0.001	0.000
As	85	0.008	0.000	0.008	0.003	0.002	0.000
Se	85	0.003	0.000	0.003	0.000	0.001	0.000
Br	85	0.096	0.000	0.096	0.006	0.011	0.000
Rb	85	0.002	0.000	0.002	0.000	0.000	0.000
Sr	85	0.021	0.000	0.021	0.005	0.005	0.000
Y	85	0.002	0.000	0.002	0.000	0.000	0.000
Mo	85	0.008	0.000	0.008	0.000	0.001	0.000
Rh	85	0.010	0.000	0.010	0.002	0.002	0.000
Pd	85	0.018	0.000	0.018	0.008	0.004	0.000
Ag	85	0.018	0.000	0.018	0.007	0.005	0.000
Cd	85	0.011	0.000	0.011	0.002	0.003	0.000
Sn	85	0.013	0.000	0.013	0.004	0.003	0.000
Sb	85	0.012	0.000	0.012	0.003	0.003	0.000
Te	85	0.014	0.000	0.014	0.003	0.003	0.000
I	85	0.017	0.000	0.017	0.004	0.004	0.000
Cs	85	0.010	0.000	0.010	0.001	0.003	0.000
Ba	85	0.067	0.000	0.067	0.019	0.014	0.000
W	85	0.085	0.000	0.085	0.008	0.012	0.000
Pt	85	0.025	0.000	0.025	0.009	0.005	0.000
Au	85	0.003	0.000	0.003	0.000	0.001	0.000
Pb	85	0.013	0.000	0.013	0.003	0.003	0.000
Bi	85	0.012	0.000	0.012	0.001	0.002	0.000
La	85	0.035	0.000	0.035	0.006	0.007	0.000
Th	85	0.005	0.000	0.005	0.001	0.001	0.000
U	85	0.005	0.000	0.005	0.001	0.001	0.000

*Units μg/m^3

Table 4.5: Mean Elemental Concentrations by Year and Season

Element	Summer	Winter	2007	2008
Number (N)	**44**	**41**	**42**	**43**
Na	0.161	0.155	0.140	0.176
Mg	0.138	0.101	0.071	0.169
Al	0.454	0.323	0.216	0.561
Si	1.07	0.875	0.589	1.352
P	0.019	0.018	0.017	0.020
S	0.561	0.287	0.367	0.489
Cl	0.113	0.169	0.130	0.149
K	0.209	0.169	0.126	0.252
Ca	0.799	0.951	0.768	0.975
Sc	0.003	0.002	0.002	0.003
Ti	0.030	0.027	0.019	0.038
V	0.001	0.000	0.001	0.001
Cr	0.004	0.003	0.005	0.003
Mn	0.006	0.005	0.003	0.008
Fe	0.281	0.225	0.158	0.347
Co	0.000	0.000	0.000	0.000
Ni	0.002	0.001	0.002	0.002
Cu	0.008	0.011	0.009	0.010
Zn	0.025	0.034	0.030	0.028
Ga	0.001	0.000	0.001	0.001
Ge	0.001	0.000	0.000	0.000
As	0.003	0.003	0.002	0.003
Se	0.001	0.000	0.001	0.000
Br	0.004	0.007	0.006	0.005
Rb	0.000	0.000	0.000	0.000
Sr	0.004	0.006	0.003	0.006
Y	0.000	0.000	0.000	0.000
Mo	0.001	0.000	0.000	0.001
Rh	0.002	0.001	0.001	0.003
Pd	0.009	0.007	0.006	0.010
Ag	0.008	0.006	0.005	0.010
Cd	0.002	0.003	0.003	0.002
Sn	0.004	0.003	0.004	0.004
Sb	0.002	0.003	0.002	0.003
Te	0.003	0.003	0.003	0.004
I	0.005	0.003	0.004	0.005
Cs	0.002	0.001	0.001	0.002
Ba	0.021	0.017	0.012	0.025
W	0.011	0.006	0.009	0.007
Pt	0.010	0.008	0.008	0.010
Au	0.000	0.000	0.000	0.001
Pb	0.002	0.003	0.002	0.004
Bi	0.001	0.000	0.001	0.001
La	0.005	0.007	0.008	0.004
Th	0.001	0.001	0.000	0.001
U	0.001	0.001	0.001	0.001
Σ Elements	3.99	3.45	2.74	4.69

*Units μg/m^3

Table 4.5, mean elemental concentrations by year and season, is included so that comments can be made as to how mean concentrations of all the elements varied annually within our study, along with the seasonal variation. Of the dominant geologic material, Si, Al, Fe, and K concentrations were seen to be greater during the summer sample seasons than during the winter. Ca concentrations were found to be higher during the winter seasons, contrary to elevated summer concentrations, on average, for the remainder of dominant geologic material. Of the toxic trace elements, As remained relatively constant throughout the seasons while Cu, Cd, and Pb were much greater during the winter seasons than during the summer. Cr concentrations were seen to nearly double from the winter to the summer seasons.

4.2. Elemental Data Comparison

Table 4.6 is a comparison of elemental values from this study in comparison to elemental values reported by Li et al. (2001) and Orqiuz (2001) in the UTEP (2001) study. Elemental data collected for the UTEP (2001) study had been collected from August 1999 to March 2000 using dichotomous samplers and is representative of both outdoor winter and summer samples. Samples from the UTEP (2001) study had been collected at two sites in El Paso (Chamizal and Sun Metro) along with an additional three sites located in Ciudad Juarez (Advanced Transformer, Club 20-30, and Mission). In comparison to the UTEP (2001) study, samples collected during this study had been collected at various indoor locations all throughout El Paso during multiple seasons. For site specifics and sample periods, please refer back Chapter 3. The UTEP (2001) study collected $PM_{2.5}$ samples which had been run for 24-hours in comparison to the indoor $PM_{2.5}$ 7-day samples collected during this study. In the comparison of values collected during this study with the UTEP (2001) study, only sites located in El Paso (Chamizal, Sun Metro) had been used as references to compare values. Included in the data comparison is an indoor and outdoor study by Paschold et al. (2003) which attempted to establish indoor-outdoor PM correlations for west El Paso residences that used evaporative coolers. Indoor $PM_{2.5}$ 48-hour data collected using concurrent TEOM measurements by Paschold et al. (2003) were included in the

comparison, along with the 7-day indoor PEM $PM_{2.5}$ data collected during this study and the 24-hour multi-site El Paso study by Li et al. (2001) and Orquiz (2001). One noticed that the Paschold et al. (2003) study focused on the removal efficiency provided by the evaporative cooling system such that indoor activities that may generate PM were strongly discouraged. As a result, their studies were based towards cleaner indoor environments.

Mean concentrations for Na, Mg, P, Cr, Ni, As, Pd, Ag, and Cd have appeared to increase when comparing values from this study (2007 and 2008) data set with those of the UTEP (2001). S, Cu, La, and Pb mean concentrations have appeared to decrease in comparison to the UTEP (2001) study values. Geologic material (Al, Si, Ca, Na, K, Fe, and Ti) concentrations reported in this study were higher than values reported by Paschold et al. (2003) while they seemed to be more on par with values reported by Li et al. (2001) and Orquiz (2001). Within the previously mentioned geologic elements, Na and Ti concentrations in this study were significantly higher than values reported by the other two studies. Fe concentration values reported in this study were similar to values reported in the UTEP (2001) study but were much higher than values reported by Paschold et al. (2003). In relation to toxic trace elements (Cr, Cu, As, Pb, and Cd), Cu and Pb levels reported in this study were similar to indoor values reported by Paschold et al. (2003) while they were somewhat lower than values reported in the UTEP (2001) study.

The indoor values reported in this research study may in fact be higher than outdoor values reported by Orquiz (2001) due to the increased re-suspension of geologic material and fugitive dust during extreme meteorological events during the summer. Increased disturbance of PM indoors may have also raised the concentrations of analyzed elements by a certain degree over the observations reported by Orquiz (2001).

Table 4.6: Study Elemental Means vs. UTEP Study (2001) & Paschold (2003)

Element	UTEP Study (Orquiz, 2001)					Paschold (2003)	Indoor PEM 7-Day Measurements		
	Chamizal	Sun Metro	Adv T	Club 20-30	Mission	Summer 2001	Entire Data Set	Summer Seasons	Winter Seasons
Na	64	54	83	54	66	82	159	162	156
Mg	41	69	75	43	73	50	120	138	101
Al	190	357	761	218	285	144	391	454	323
Si	593	1264	1436	726	1010	N/A	975	1068	875
P	2	2	1	2	2	53	18.3	18.9	17.7
S	409	341	492	514	374	N/A	429	561	287
Cl	89	625	742	349	405	N/A	140	113	169
K	128	217	381	183	242	N/A	190	209	169
Ca	542	1540	3411	1257	3063	261	873	799	951
Ti	8	19	28	11	18	4	28.6	29.6	27.4
V	1	1	1	1	1	N/A	N/A	N/A	N/A
Cr	0.4	2	1	0	1	N/A	3.50	4.4	2.6
Mn	4	9	15	6	11	2	5.40	5.6	5.2
Fe	231	508	397	243	291	82	254	281	225
Co	0.1	0.1	0.3	0	0.1	N/A	0.1	0.0	0.1
Ni	0.2	0.1	1	0.3	0.4	N/A	1.7	2.0	1.4
Cu	15	22	35	25	38	7	9.6	8.0	11.2
Zn	24	38	159	98	73	40	29.3	24.6	34.4
Ga	0	0	0	0	0	N/A	0.6	0.8	0.3
As	1	1	1	1	1	N/A	2.7	2.6	2.8
Se	0	0	0	0	0.1	N/A	0.5	0.6	0.3
Br	7	1	52	14	16	N/A	5.6	3.9	7.4
Rb	0.3	1	1	0.5	1	N/A	0.2	0.3	0.1
Sr	3	6	10	5	7	N/A	4.6	3.7	5.6
Y	0.2	0.4	0.3	0.3	0.2	N/A	0.3	0.4	0.2
Zr	1	1	1	1	1	N/A	N/A	N/A	N/A
Mo	0.1	0.3	0.2	0.1	0.2	N/A	0.5	0.7	0.2
Pd	0.3	0.5	1	1	1	N/A	8.0	9.2	6.7
Ag	0.1	0.3	0.2	1	0	N/A	7.3	8.4	6.0
Cd	0.3	1	2	1	1	N/A	2.3	1.9	2.7
In	0.1	1	1	1	0	N/A	N/A	N/A	N/A
Sn	1	3	3	3	3	N/A	3.7	4.0	3.3
Sb	2	14	23	11	15	N/A	2.8	2.2	3.4
Ba	17	22	21	22	18	3	18.8	20.8	16.6
La	10	12	9	15	12	N/A	6.0	5.5	6.5
Au	0	0	0	0	0	N/A	0.4	0.5	0.4
Hg	0	0	0	0	0	N/A	N/A	N/A	N/A
Tl	0	0.1	0.1	0	0.1	N/A	N/A	N/A	N/A
Pb	7	20	36	14	39	2	2.9	2.4	3.4
U	0	0	0.1	0.1	0.1	N/A	0.9	0.9	0.8

*Units (ng/m^3)

4.3. Principle Components Analysis

Principle component analysis (PCA) is a form of factor analysis in which the variances of all the observed variables are analyzed in order to define the underlying structure among the variables (Hair et al., 2009). PCA is a statistical approach used to understand the rudimentary interrelationships among all variables and to explain these relationships in terms of their common underlying factors.

In PCA, the rules set forth to how many variables and samples required for analysis, along with the number of components to retain, are mostly discretionary. Many popular rules for the required sample size necessary for successful PCA suggest that as little as two samples are required per variable, where as many as 20 samples may be required per variable (Stevens, 2009). Several orthodox methods are commonly used to determine the number of components that will be retained during the PCA. Kaiser (1960) suggests the retention of only those components whose eigenvalues are greater than one, which is also the default criterion for the selection of factors used by SPSS. In essence, unless a factor extracts at least as much as the equivalent of one original variable, it is dropped from the final interpretation. A graphical method for the determination of the number of components to retain had been proposed by Cattell (1965) and labeled as the scree test. The scree test plots the magnitude of the eigenvalues (y-axis) versus their respective ordinal numbers (x-axis). In this plot, the magnitude of sequential eigenvalues drops off sharply and then approaches an asymptote. Cattell suggests the retention of all eigenvalues (and their respective components) in the eigenvalues in the sharp decent prior to the first eigenvalue in the asymptotic line. A Monte Carlo study conducted by Guadagnoli and Velicer (1988) suggest that the most important aspects are component saturation along with absolute sample size. It was also suggested that when the average of the four largest loadings within a component are >0.60 or the average of the three largest loadings is >0.80, then the components may be deemed reliable (Guadagnoli & Velicer, 1988). The main goal in the selection of factors is to retain a certain number of components that will

account for a majority of the total variance. Again, the determination of the number of factors to withhold is at the discretion of the researcher for the most part.

After the PCA is completed, one must determine which loading is statistically significant, at a minimum. It is suggested that when the sample size is small relative to the number of variables being analyzed, a loading may be considered statistically significant by doubling the standard error (Stevens, 2009). It is generally regarded that any loading value below |0.30| be omitted from the component analysis; however, Stevens suggests that it is much more significant to consider sample size when trying to determine the variables that will be included in the component analysis. It is recommended that each loading be tested with a significance at α=.01 (two-tailed test). Table 4.7 lists the critical values for a simple correlation at α=.01 for sample sizes ranging from 50 to 1,000. The critical values which accompany the correct sample size are doubled in order to gain a rubric for testing the statistical significance of a loading.

Table 4.7: Critical Values for a Correlation Coefficient at α=.01 for a Two-Tailed Test

n	CV
50	0.361
80	0.286
100	0.256
140	0.217
180	0.192
200	0.182
250	0.163
300	0.149
400	0.129
600	0.105
800	0.091
1000	0.081

n= sample size

There are two common tests to measure the adequacy and appropriateness of using PCA on the sample data set. The Bartlett test of sphericity is a method which aims to determine the appropriateness of using PCA by statistically testing for the presence of correlations among all variables. The test is used

to examine the hypothesis that the variables are uncorrelated in the sample population and to affirm that the sample population correlation matrix is an identity matrix. A significance value of 0.000 for the Bartlett test rejects the hypothesis that the correlation matrix is an identity matrix and that the factor model is appropriate for use on the sample population. The measure of sampling adequacy (MSA) aims to quantify the degree of inter-correlations among all variables and also characterizes the overall adequacy of PCA to the sample population. The MSA ranges from zero to one; a value of one means each variable is perfectly predicted by other variables. The following guidelines for the determination of the level of adequacy have been suggested: .80 or above, meritorious; 0.70 or above, middling; 0.60 or above, mediocre; 0.50 or above, miserable; and below 0.50 is plain unacceptable (Kaiser, 1970, 1974).

There are numerous types of orthogonal and oblique rotations available which are used to increase the interpretability of the extracted components. Orthogonal rotations are operations in which a much simpler structure is generated under the limitation that the factors generated are uncorrelated. Oblique rotations are operations which seek to generate a simpler structure from the data while rotating the factors without imposing the condition if orthogonality which results in the creation of factors that are generally correlated with each other (Kim & Mueller, 1978).

4.3.1. PCA Method

PCA, a form of factor analysis, had been applied to the elemental dataset using SPSS 17.0 (IBM, 2008). Factor analysis is a dimension reduction option available under SPSS which includes several methods for component extraction. Loadings with absolute values less than 0.3 were omitted from being shown in the correlation matrix so that significant loadings were easier to see. Of all the rotations available in SPSS, the Varimax orthogonal rotation was used as it aims to maximize the loadings for each factor or component. Factors with eigenvalues greater than one were included following the Kaiser criterion, as components with eigenvalues less than one account for less variance (Kaiser, 1960). An

initial PCA had been conducted using SPSS; however, several variables had weak loadings (<0.40) or their communalities were weak as well (<0.40). Of the 46 initial variables used for PCA, only 33 were retained for final analysis due to either greater than weak loadings (>0.40) on their respective factors and/or their communalities were greater than weak (>0.40). Weak communalities suggest that the proportion of the variance that is explained by the generated components was found to be low (Norusis, 2006).

The first step in the interpretation of the PCA is to determine the adequacy and appropriateness of the test to our sample population. According to Table 4.8, which lists the KMO and Bartlett's tests, the measure of sampling adequacy (MSA) of the sample population is 0.831 which deems the adequacy of our sample population as "meritorious", as per Kaiser (1970, 1974). A value of 0.000 for the significance of the Bartlett's test rejects the hypothesis that our correlation matrix is an identity matrix and deems our sample population appropriate for PCA.

Table 4.8: KMO and Bartlett's Test

Kaiser-Meyer-Olkin (Measure of Sampling Adequacy)		.831
Bartlett's Test of Sphericity	Approx. Chi-Square	3588.064
	df	528
	Sig.	.000

Table 4.9 is an explanation of the total variance accounted for by each component. When determining the number of factors to retain, the goal was to minimize the number of factors while maximizing the percentage of total variance explained by the factors. Using Kaisers criterion, it was best to retain all components whose eigenvalues were greater than one; however, each successive component after component three only accounted for about 4-5% of the total variance and would have seemed superfluous to retain.

Table 4.9: Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	12.880	39.030	39.030	12.880	39.030	39.030	9.722	29.462	29.462
2	4.712	14.280	53.310	4.712	14.280	53.310	4.361	13.216	42.678
3	2.042	6.189	59.498	2.042	6.189	59.498	2.847	8.628	51.306
4	1.784	5.406	64.905	1.784	5.406	64.905	2.340	7.091	58.397
5	1.603	4.856	69.761	1.603	4.856	69.761	2.196	6.654	65.051
6	1.249	3.785	73.546	1.249	3.785	73.546	2.122	6.430	71.481
7	1.172	3.553	77.098	1.172	3.553	77.098	1.761	5.337	76.818
8	1.135	3.441	80.539	1.135	3.441	80.539	1.228	3.721	80.539
9	.880	2.667	83.206						
10	.725	2.197	85.402						
11	.700	2.123	87.525						
12	.601	1.822	89.347						
13	.581	1.761	91.108						
14	.492	1.490	92.597						
15	.427	1.295	93.892						
16	.398	1.205	95.097						
17	.293	.888	95.985						
18	.250	.757	96.743						
19	.195	.591	97.334						
20	.172	.522	97.857						
21	.140	.423	98.279						
22	.118	.357	98.636						
23	.092	.279	98.916						
24	.084	.254	99.170						
25	.073	.220	99.390						
26	.064	.194	99.585						
27	.058	.174	99.759						
28	.029	.089	99.848						
29	.024	.073	99.921						
30	.013	.039	99.959						
31	.009	.027	99.986						
32	.003	.008	99.995						
33	.002	.005	100.000						

Extraction Method: Principal Component Analysis.

Figure 4.2 is the scree plot generated by SPSS and graphically depicts the typical curve described by Cattell which consists of an area of eigenvalues that sharply descend and another area of eigenvalues which compose the asymptote of eigenvalues that account for less variation. Based on Figure 4.2 and Cattell's criteria, it would be wise to only retain 2 components.

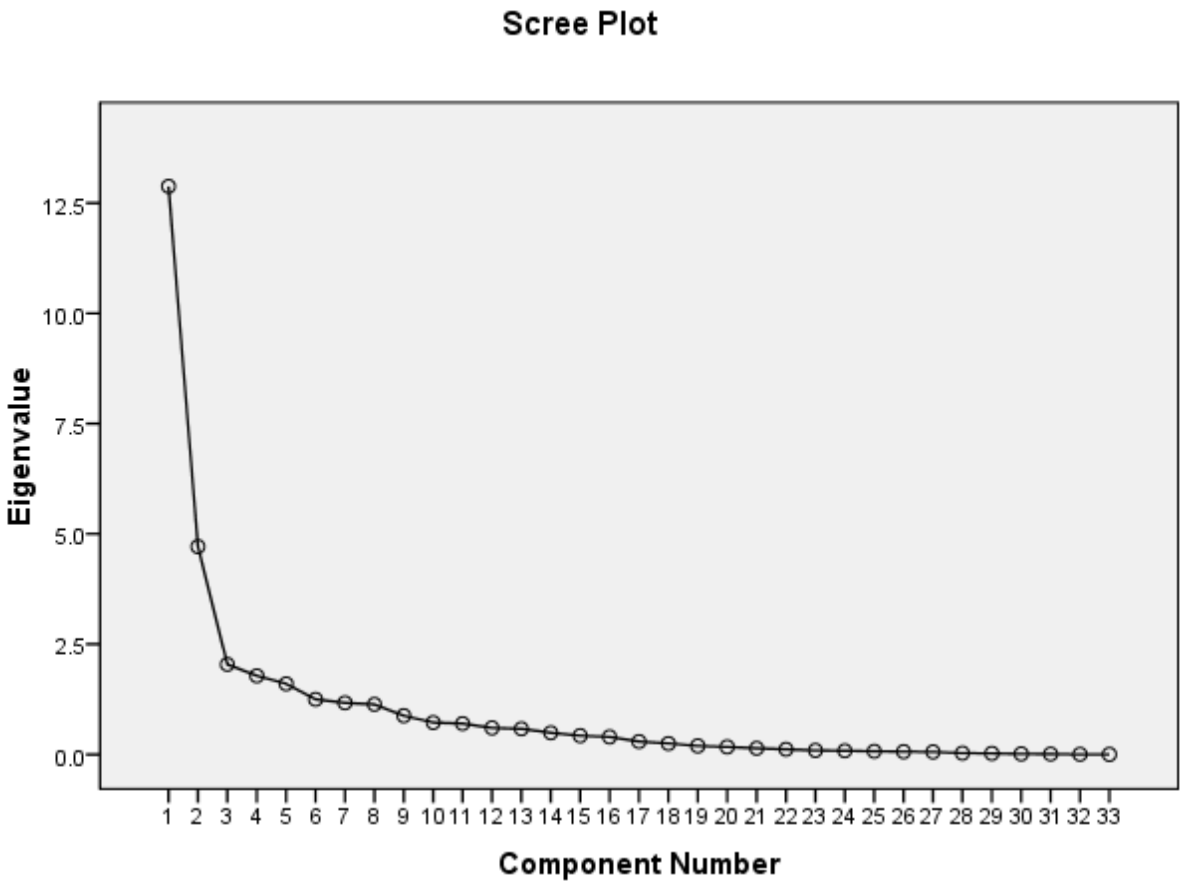

Figure 4.2: PCA Cattell's Scree Plot

It would be relevant at this point to determine which of the extracted components are deemed reliable using the aforementioned criteria; in addition to the previously mentioned criteria by Kaiser and Cattell. Table 4.10 contains the rotated component matrix which was rotated using the Varimax orthogonal rotation. The rotated component matrix minimizes the number of variables that have high loadings on a factor so that the overall factors may be interpreted much easier. In essence, the large coefficients are larger and the small coefficients are much smaller so they are easier to see which are grouped higher and lower. Using the previously mentioned rubric for determining the reliability of a factor mentioned by Guadagnoli and Velicer, and overall reliability designation is calculated for each component extracted by SPSS (4 reliable components).

Table 4.10: Rotated Component Matrix[a]

	Component							
	1	2	3	4	5	6	7	8
Ag	.459		.584		.469			
Al	.919							
As	.506		.301		.313	.458	.385	
Ba	.668		.517		.332			
Ca	.860							
Cd						.743		
Cl				.906				
Cr		.968						
Cu						.556	.406	
Fe	.862	.391						
Ga		.942						
K	.855		.307					
Mg	.915							
Mn	.748	.541						
Mo		.924						
Na				.907				
Ni		.976						
P					.403		.595	
Pb	.604						.343	-.343
Pd	.505		.491		.447			
Pt	.340		.530		.301			
Rb								.826
Rh	.312		.750					
S	.374			.442	.488			
Sc	.333		.327		.471	.562		
Si	.939							
Sn					.736			
Sr	.773			.328				
Te			.612					
Th							.721	
Ti	.887							
V	.623				.392			
Y	.487					-.515		
Average of 4-highest	**.915**	**.953**	**.619**	**.646**	.541	.594	.527	.241
Reliable?	**Yes**	**Yes**	**Yes**	**Yes**	No	No	No	No

[a]Extraction Method: Principal Component Analysis
Rotation Method: Varimax with Kaiser Normalization

Rotation converged in 8 iterations

Table 4.11: Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	12.880	39.030	39.030	12.880	39.030	39.030	9.722	29.462	29.462
2	4.712	14.280	53.310	4.712	14.280	53.310	4.361	13.216	42.678
3	2.042	6.189	59.498	2.042	6.189	59.498	2.847	8.628	51.306
4	1.784	5.406	64.905	1.784	5.406	64.905	2.340	7.091	58.397
5	1.603	4.856	69.761	1.603	4.856	69.761	2.196	6.654	65.051
6	1.249	3.785	73.546	1.249	3.785	73.546	2.122	6.430	71.481
7	1.172	3.553	77.098	1.172	3.553	77.098	1.761	5.337	76.818
8	1.135	3.441	80.539	1.135	3.441	80.539	1.228	3.721	80.539
9	.880	2.667	83.206						
10	.725	2.197	85.402						
11	.700	2.123	87.525						
12	.601	1.822	89.347						
13	.581	1.761	91.108						
14	.492	1.490	92.597						
15	.427	1.295	93.892						
16	.398	1.205	95.097						
17	.293	.888	95.985						
18	.250	.757	96.743						
19	.195	.591	97.334						
20	.172	.522	97.857						
21	.140	.423	98.279						
22	.118	.357	98.636						
23	.092	.279	98.916						
24	.084	.254	99.170						
25	.073	.220	99.390						
26	.064	.194	99.585						
27	.058	.174	99.759						
28	.029	.089	99.848						
29	.024	.073	99.921						
30	.013	.039	99.959						
31	.009	.027	99.986						
32	.003	.008	99.995						
33	.002	.005	100.000						

Extraction Method: Principal Component Analysis

So, according to Kaisers criterion and referencing Table 4.11, all components with eigenvalues over one would be retained (eight components) and according to Cattells scree test all components that are contained in the descending area of the line plotted in Figure 4.2 should be retained (two components). Referencing Table 4.11 and focusing on the cumulative percentage of variation explained by each component, the selection of only two components selected as per Cattells scree test would only account for 53% of the total variance of the sample population while the selection of eight components

as per Kaisers criterion would account for 80.5% of the total variance of the sample population. As the goal of this analysis is to select the minimum number of factors while maximizing the total variance explained by the factors, it would seem wise to select the number of components calculated using the method suggest by Guadagnoli and Velicer, which yields four components, all of which explain about 60% of the total sample population variation.

Once the adequate number of components, or factors, is selected it is then necessary to determine the loadings on each component that will be retained. Using linear interpolation and a sample size of n=85, a critical value of 0.2785 was obtained from Table 4.7, critical values for a correlation coefficient at α=.01 for a two-tailed test, and doubled to produce the minimum statistical benchmark, as suggested by Stevens, for the selection of variables within a component (minimum loading=2(0.2785) =0.557).

Based on all aforementioned criteria, all loadings less than 0.557 will be deemed statistically insignificant, and will not be included on the component. Table 4.10 contains all loadings on reliable components that have been deemed statistically significant. Component one , which accounts for nearly 30% of the total variance (after rotation) contains Al, Ba, Ca, Fe, K, Mg, Mn, Pb, Sr, Ti, and V. Component two, which accounts for roughly 13% of the total variance (after rotation) contains Cr, Ga, Mo, and Ni. Component three accounted for 8.6% of the total sample population variance, after Varimax rotation as with all other factors, and contained Ag, Rh, and Te. Component five accounted for 7.1% of the total sample population variance (after rotation as well) and contained Na and Cl.

4.3.2. PCA Results and Discussion

Table 4.12: PCA Results

PCA Component	Component 1	Component 2	Component 3	Component 4
Elements	Al,Ba, Ca, Fe, K, Mg, Mn, Pb, Sr, Ti, V	Cr, Ga, Mo, Ni	Ag, Rh, Te	Cl, Na
Possible Source	Geologic Material, Fugitive Dust	Industrial Releases (Iron, Steel, Electroplating)	Copper Refinement	Salt Water Residual, Brick Kiln

Table 4.12 is a summary of the four components found using PCA along with the respective elements which constitute the component. Component 1 includes Al, Ba, Ca, Fe, K, Mg, Mn, Pb, Sr, Ti, and V and may signify the infiltration of fugitive dust along with the disturbance of geologic material from roads due to either mechanical disturbance or wind disturbance. Indoor aluminum concentrations were shown to be highly correlated to outdoor concentrations which suggest that the metal likely originates outdoors and the same observation was found with calcium, iron and titanium (Clayton et al., 1993; Geller et al., 2002; Moschandreas, 1979). Gellar was also able to find a significant indoor-to-outdoor correlation with regard to potassium which would also suggest that the majority of the element originates outdoors and infiltrates inside of the home. Potassium has been shown to be a good marker for the burning of organic matter (Moschandreas, 1979) which is a problem along the border between El Paso and Juarez as items such as wood and tires are burned in order to heat homes in some parts of Juarez. The extremely dry environment in the region coupled with the predominately windy weather, abundance of unpaved roads, particularly in El Paso and Juarez, combine to release natural PM (component one) into the local environment (Espino et al., 2005).

Component two includes Cr, Ga, Mo, and Ni elements and may suggest a source release related to the creation of iron and steel alloys in a local mill. According to the EPA TRI reports for 2008 and

2007 (Appendix E), modest amounts of chromium were noted to have been released by a local iron and steel mill, in conjunction with the release of a relatively smaller amount of nickel. A chromium electroplating and metal coating facility also operates in downtown El Paso. The two previously mentioned elements may be used in the creation of alloys along with molybdenum, which is of particular use in the ferrous sector (e.g., in creation of cast iron, allow steels, stainless and heat resistant steels) (Gupta, 1992). Garcia et al. (2003) found that Be, Cr, Ni, and Mn were grouped together after conducting PCA, enrichment factor and redundancy analysis. This group was noted as to thought to have been associated with industrial activities in the area but was shown to have not been related to copper smelter (ASARCO) release.

Component three includes Ag, Rh, and Te elements and may suggest a source related to the refinement of copper in El Paso. The concentration of tellurium in nature is insignificant and the primary recovery of tellurium falls upon the processing of non-ferrous ores such as copper-bearing ores (McKetta Jr., 1994; Schoeller & Powell, 1919) which would suggest that a possible source for tellurium is the refinement of copper ore. According the U.S. EPA's toxic release inventory (TRI) for El Paso years 2007 & 2008 (Appendix E), significant amounts of silver compounds had been released by the local copper refinery as well which may suggest a source of silver related to the refinement of copper. Significant amounts of noble metals, in which silver and rhodium are found, accompany copper in the smelting process and are found to have passed into the electrolytic refinery sludge (Schoeller & Powell, 1919).

Component four is composed of both sodium and chlorine. Na and Cl exhibited a nearly equal variance within the component (.907 and .906, respectively) and was assumed that the Cl existed as the negatively charged chloride in conjunction with Na as NaCl. The El Paso region is in an area known as the Chihuahuan Desert and was believed to have under water until the mid-cretaceous period, at which

point the oceans had begun to recede to a point at which they are today. Mechanical or natural disturbances of the soil may lead to the introduction of the aforementioned NaCl into the air. El Paso is located 370 miles from the Gulf of California and 630 miles from the Gulf of Mexico. Chloride has been seen to exist in large quantities several hundred miles from coastal areas and may also enter atmospheric particles as a result of ammonia neutralization of hydrochloric acid vapor which is believed to be emitted from sources such as incinerators or brick kilns which can abundantly be found along the border (Harrison & Yin, 2000; Li et al., 2001).

4.3.3. PCA Components Summary Statistics

A summary of the percent composition of $PM_{2.5}$ which each aforementioned component constitutes is listed in Table 4.13. The first PCA component, which consists of Al, Ba,Ca, Fe, K, Mg, Mn, Pb, Sr, Ti, and V, constitutes roughly 12% of all mass collected on the PEM filters. This dominant component is seen in greater abundance in the summer (15.33%) samples over the winter (8.49%) samples, while the same trend can be seen in the variance of the percent composition of this component. This may be due to the increased disturbance of the material found on this component by mechanical means or re-suspension of the material due to extreme meteorological events which occur in the summer. The remaining three components composed a much smaller percentage of the total mass collected on the PEM filters. The fourth PCA component (Cl and Na) comprised the second greatest percent composition of PM found on the collected samples. Component four constituted approximately 1.64% of the particulate mass while components two and three only constituted 0.12% and 0.09%, respectively, for the entire study period. Components three and four also saw increased percent compositions of $PM_{2.5}$ during the summer months over winter months while component two saw a remarkable increase in percent composition during the winter months over the summer seasons.

Table 4.13: PCA Component Percent Composition by Year, Season, and Study Period

	Time Period	N	Min	Max	Mean	Std. Dev.	Variance
% PCA Component 1 of PM2.5	Summer	44	0.26	39.3	15.3	11.5	132
	Winter	41	0.01	31.5	8.49	6.75	45.6
	2007	42	0.01	31.5	6.51	6.12	37.4
	2008	43	0.37	39.3	17.4	10.3	105
	Entire Study Period	85	0.01	39.3	12.0	10.1	101
	Time Period	**N**	**Min**	**Max**	**Mean**	**Std. Dev.**	**Variance**
% PCA Component 2 of PM2.5	Summer	44	0.00	1.14	0.05	0.18	0.03
	Winter	41	0.00	7.31	0.19	1.14	1.30
	2007	42	0.00	7.31	0.19	1.13	1.27
	2008	43	0.00	1.14	0.04	0.17	0.03
	Entire Study Period	85	0.00	7.31	0.12	0.80	0.64
	Time Period	**N**	**Min**	**Max**	**Mean**	**Std. Dev.**	**Variance**
% PCA Component 3 of PM2.5	Summer	44	0.01	0.60	0.12	0.11	0.01
	Winter	41	0.00	0.20	0.06	0.04	0.00
	2007	42	0.00	0.12	0.04	0.03	0.00
	2008	43	0.02	0.60	0.13	0.10	0.01
	Entire Study Period	85	0.00	0.60	0.09	0.09	0.01
	Time Period	**N**	**Min**	**Max**	**Mean**	**Std. Dev.**	**Variance**
% PCA Component 4 of PM2.5	Summer	44	0.03	8.22	1.79	1.64	2.69
	Winter	41	0.00	7.32	1.48	1.37	1.89
	2007	42	0.00	8.22	1.20	1.42	2.01
	2008	43	0.04	7.32	2.07	1.50	2.25
	Entire Study Period	85	0.00	8.22	1.64	1.52	2.30

*Units in (%)

4.4. TEOM Diurnal Variation PM_{10} and $PM_{2.5}$ Data

All reference times are noted in the 24-hour format (0:00 through 24:00) for the following diurnal observations of each household. Some homes only have location data, while other homes reported the number of occupants, number of pets, household size, type of food prepared, and whether

any smokers or asthmatic children are located in the household. The previously mentioned lack of data at some of the homes was a result of the failure to comply with previously agreed upon duties on behalf of residents at some sample locations. Information that was asked to be collected from all residents was hourly activity logs and the disclosure of demographic information of the household. All households, with the exception of the sample site at 8181 Starr used evaporative cooling during the summer time, while the location on Starr Ave. used central-air refrigeration.

4.4.1. Year 2007

4.4.1.1. 12501 Angie Bombach; Winter 2007; Week 1

Sampling during the first week had been conducted at the location on 12501 Angie Bombach Ave. and during that timeframe sampling for PM_{10} had begun at 18:00 on Feb. 2nd, 2007 and ended at 17:00 on Feb. 4th, 2007. Sampling for $PM_{2.5}$ had begun at 18:00 on Feb. 4th and concluded at 17:00 on the 6th of February. Indoor and outdoor sampling occurred concurrently for each respective particle size. The residents at this location reported having two children, one of who is an asthmatic.

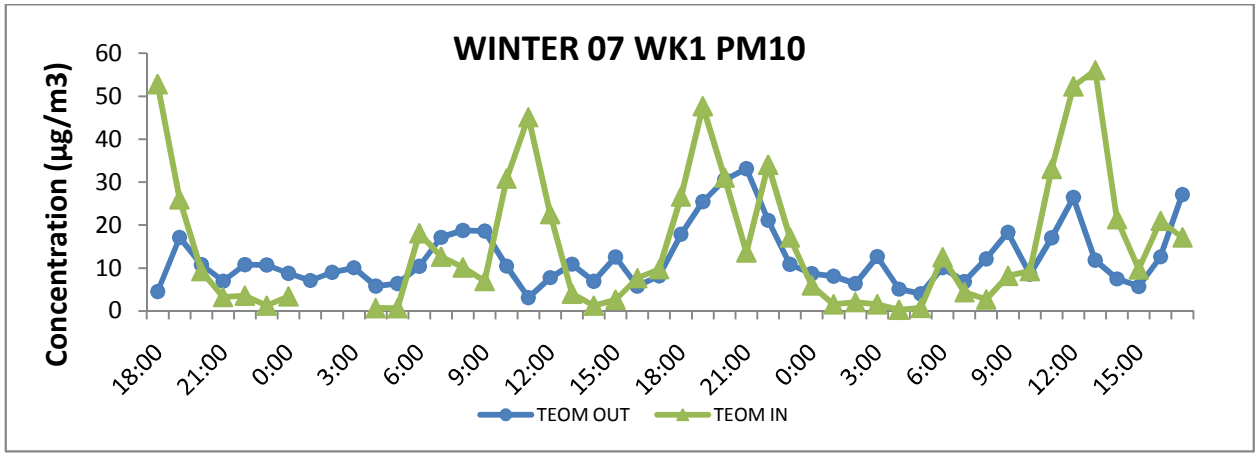

Figure 4.3: Angie Bombach PM_{10}

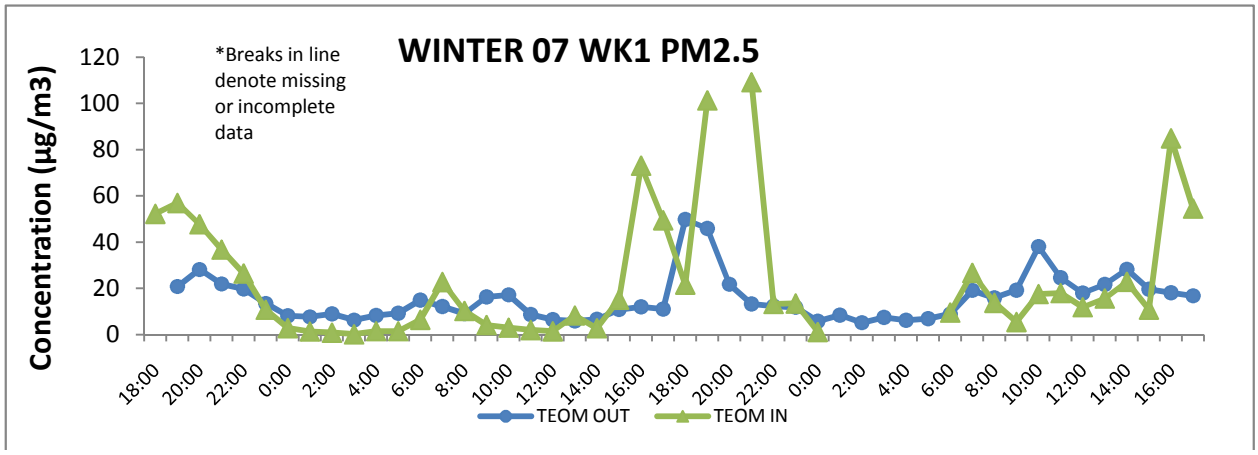

Figure 4.4: Angie Bombach $PM_{2.5}$

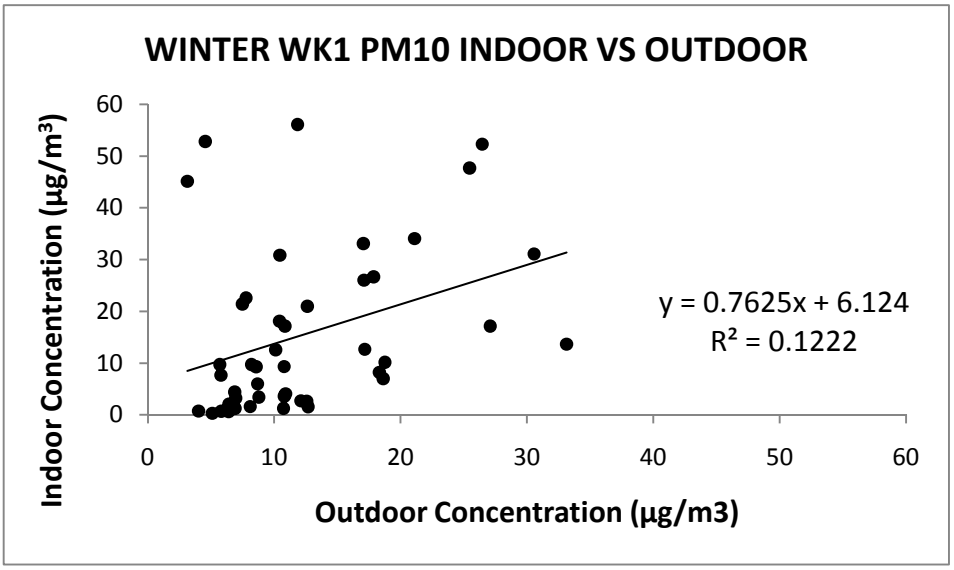

Figure 4.5: Angie Bombach PM_{10} Indoor vs. Outdoor

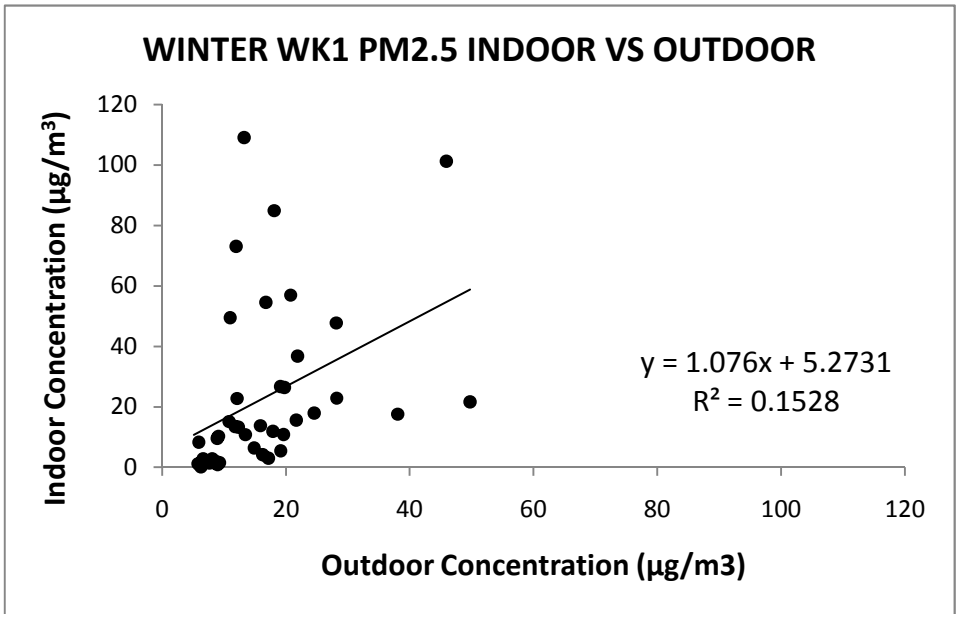

Figure 4.6: Angie Bombach $PM_{2.5}$ Indoor vs. Outdoor

Figure 4.3 and Figure 4.4 are time-series plots of PM_{10} and $PM_{2.5}$ concentrations for the winter 2007 sampling period at the respective location. In reference to Figure 4.3, clear increases in indoor PM_{10} can be seen at this location at two distinct points over the course of 24 hours. PM_{10} is more likely to be affected by the presence of human activity than $PM_{2.5}$ and increases in indoor PM_{10} at this location may most likely attributed to human activity such as the presence of children or parents returning home for lunch (12:00) and dinner (17:00-20:00). Increases in outdoor PM_{10} can be seen at this location during times at which outdoor vehicle activity is greatest. In general, outdoor vehicle activity increases around 07:00 and continues until about 09:30 and occurs once again at 17:00 and lasts until about 20:00 in the El Paso region; similar increases can be seen in outdoor PM_{10} concentrations. Diurnal spikes in indoor $PM_{2.5}$ concentrations are seen between the hours of 07:00 and 08:00 and once again between 16:00 and 22:00, which may signify the operation of heating equipment, cooking, or human activity. Diurnal spikes in outdoor $PM_{2.5}$ can also be seen, as with indoor $PM_{2.5}$, at 10:00 and between the hours of 18:00 and 20:00. These spikes in outdoor $PM_{2.5}$ may be a result of increased vehicular traffic during the aforementioned times.

A clear diurnal patter in both indoor and outdoor PM_{10} and $PM_{2.5}$ can be seen at this residence and supports previous observations in the region which suggests that PM in the area follows a strong diurnal variation with peaks in the morning time and once again during the evening (Li et al., 2001, 2003; Orquiz, 2001)

Figures 4.5 and 4.6 are scatterplots of indoor versus outdoor PM_{10} and $PM_{2.5}$ concentrations. The coefficients of determination (R^2) for both PM_{10} and $PM_{2.5}$ are very similar to one another. Values of R^2 =0.1222 and R^2 =0.1528 for PM_{10} and $PM_{2.5}$ respectively, signify that a very small percentage of outdoor concentrations for each respective particle size range infiltrate into the indoor environment. This is consistent with the idea that most homes in El Paso have their windows shut during the winter time, which reduces indoor air exchange rates and decreases infiltration of outdoor PM into the indoor environment.

4.4.1.2. 5301 Juliandra; Winter 2007; Week 2

Sampling during the second week had been conducted at the location on 5301 Juliandra Ave. and during that timeframe sampling for PM_{10} had begun at 18:00 on Feb. 8th, 2007 and ended at 17:00 on Feb. 10th, 2007. Sampling for $PM_{2.5}$ had begun at 18:00 on Feb. 10th and concluded at 17:00 on the 12th of February. Indoor and outdoor sampling occurred concurrently for each respective particle size. The residence on Juliandra Ave. is a medium sized house of four occupants with two children, all of who have self-declared themselves as Hispanics.

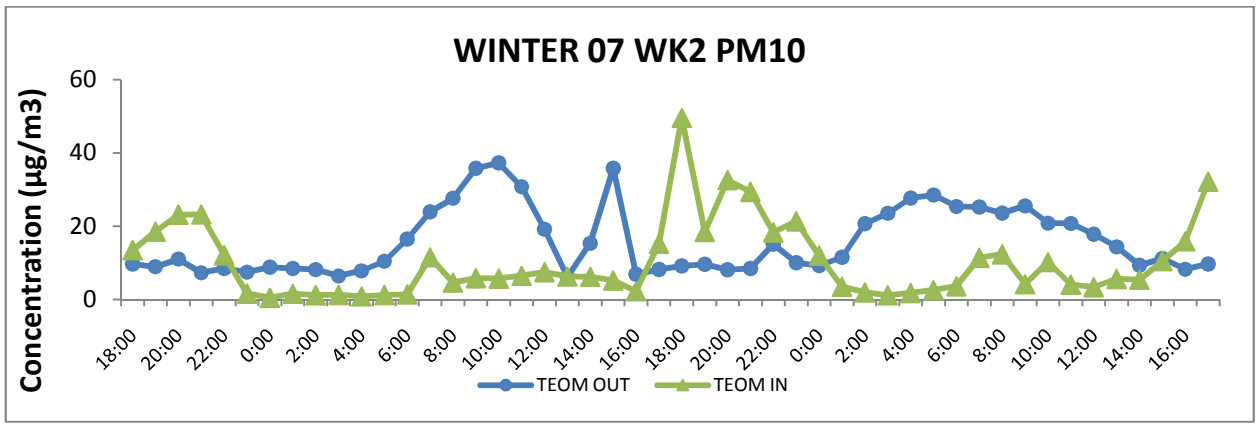

Figure 4.7: Juliandra PM_{10}

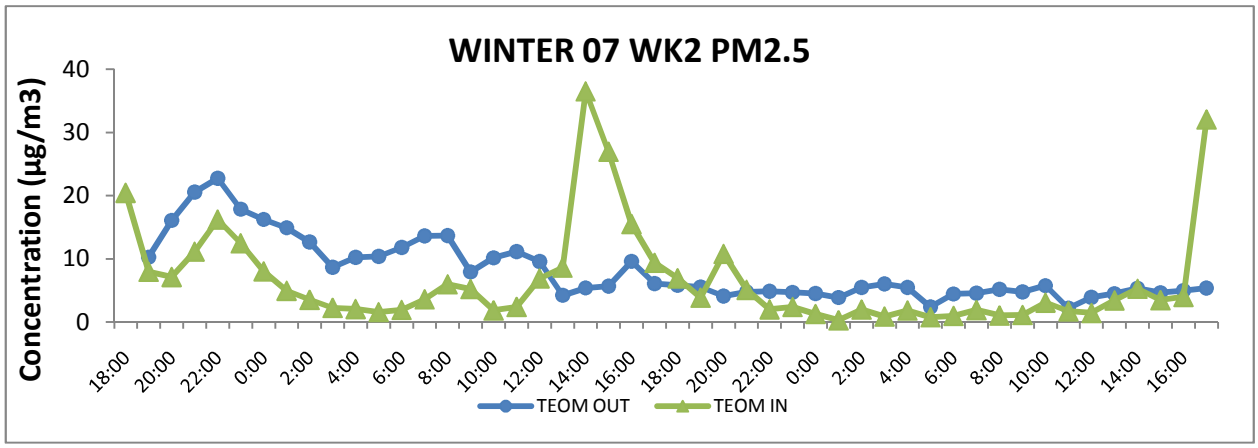

Figure 4.8: Juliandra $PM_{2.5}$

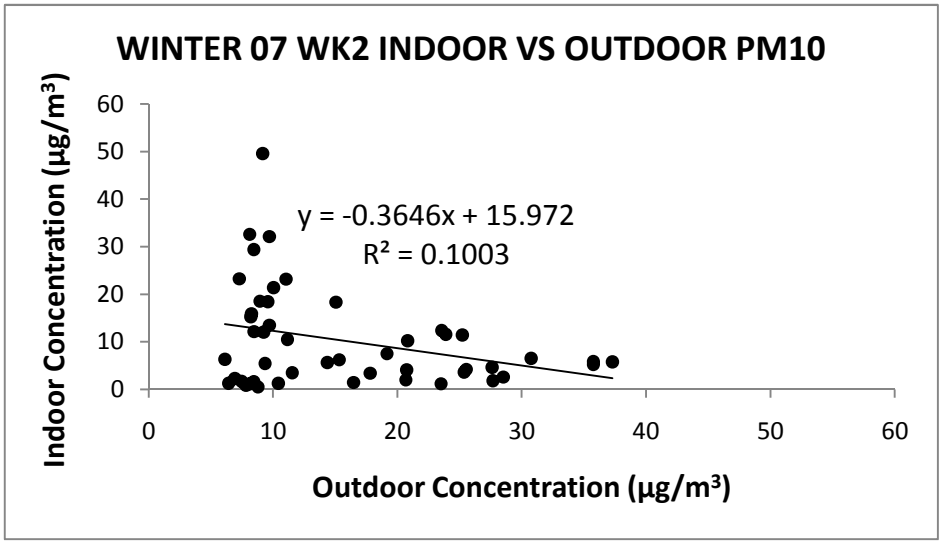

Figure 4.9: Juliandra Indoor vs. Outdoor PM_{10}

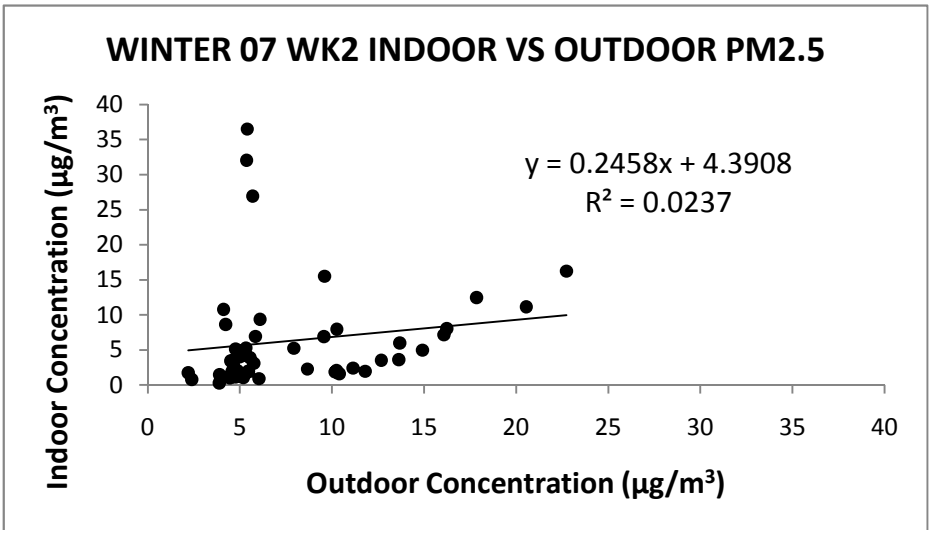

Figure 4.10: Juliandra Indoor vs. Outdoor $PM_{2.5}$

Figures 4.7 and Figure 4.8 are time-series plots of PM_{10} and $PM_{2.5}$, respectively. Indoor concentrations of PM_{10} seem to vary independent of outdoor concentrations (R^2=0.1003). A diurnal pattern can be seen in the indoor $PM_{2.5}$ time series with increases at 07:00 and again around 18:00. Indoor $PM_{2.5}$ concentrations also seem to vary independent of outdoor concentrations (R^2=0.0237), much more than PM_{10}, while showing an increase in concentrations around evening time when most people prepare dinner or use heating devices; however, no clear diurnal pattern can be seen.

In reference to Figure 4.8, a substantial spike in indoor levels which had occurred on both the first and second 24 hours of sampling may have been attributed to an indoor event such as cooking, as the peak generally occurred within the same time frame each day. A similar increase in indoor levels can be seen in the PM_{10} time series plot (Figure 4.7) and may be the increased human activity which accompanies the aforementioned possible cooking events.

4.4.1.3. 5301 Juliandra; Summer 2007; Week 1

Sampling during the first week had been conducted at the location on 5301 Juliandra Ave. and during that timeframe sampling for PM_{10} had begun at 18:00 on Sept. 17th, 2007 and ended at 17:00 on

Sept. 19th, 2007. Sampling for $PM_{2.5}$ had begun at 18:00 on Sept. 19th and concluded at 17:00 on the 21st of February. Indoor and outdoor sampling occurred concurrently for each respective particle size.

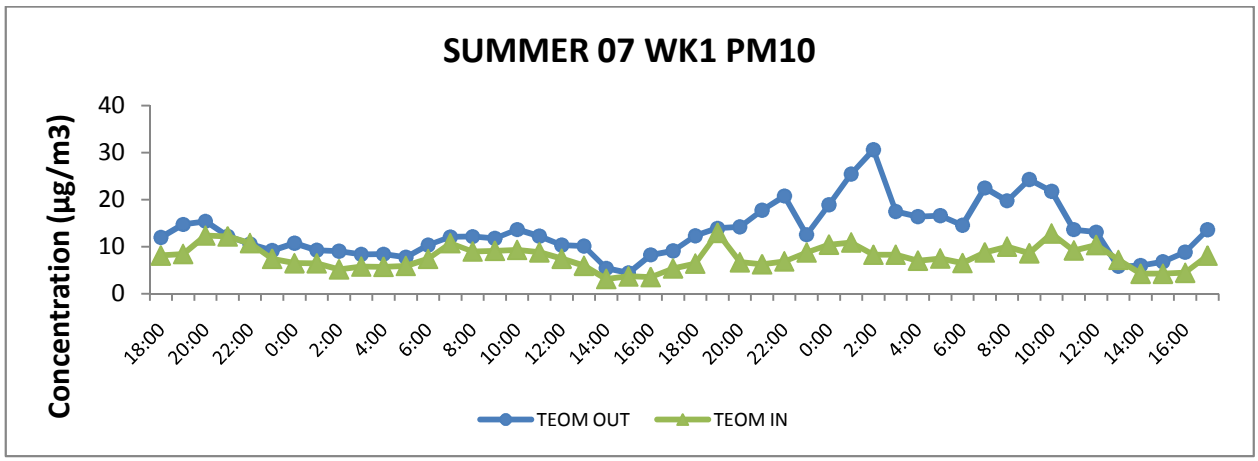

Figure 4.11: Juliandra PM_{10}

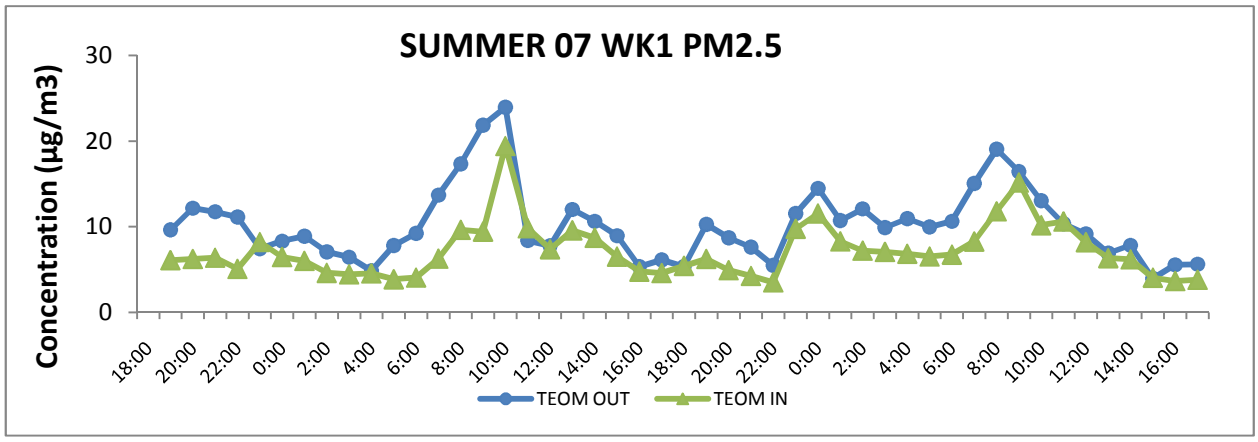

Figure 4.12: Juliandra $PM_{2.5}$

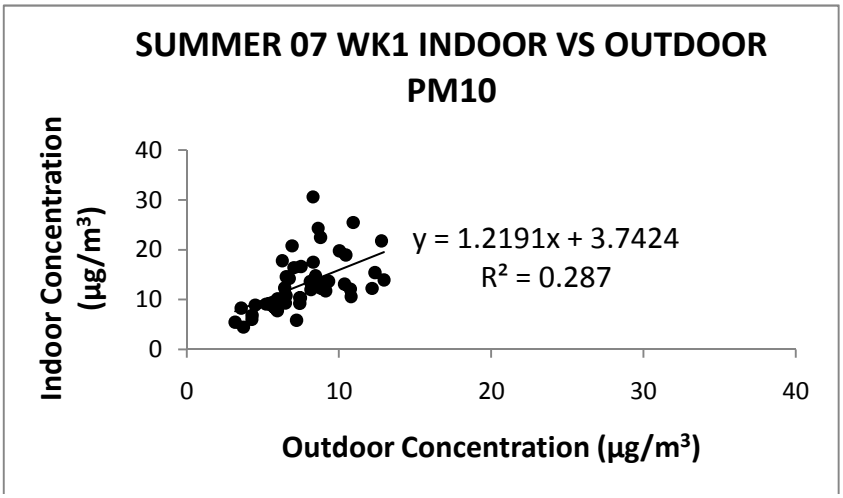

Figure 4.13: Juliandra Indoor vs. Outdoor PM_{10}

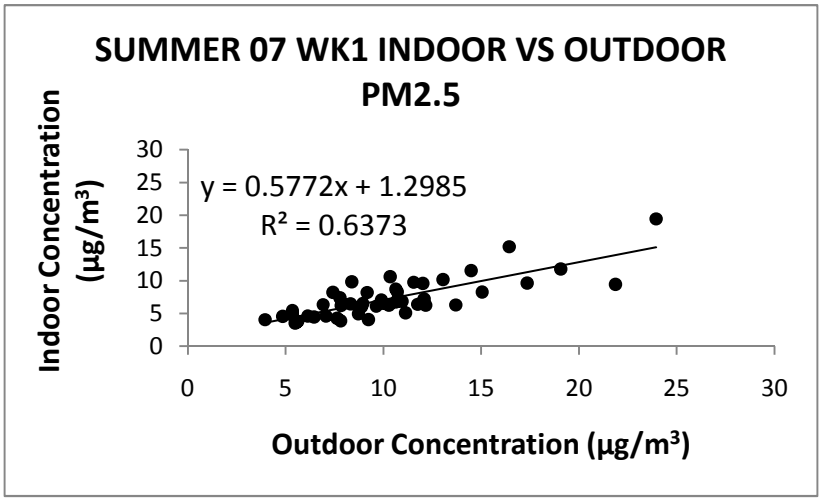

Figure 4.14: Juliandra Indoor vs. Outdoor $PM_{2.5}$

Sampling for this location occurred during a time in the summer when average high temperatures in the El Paso region are only seen to be around 85□ F and many people use natural ventilation as a cooling method. Much better coefficients of determination (R^2) can be expected when natural ventilation is used due to increased, and much easier, infiltration of outdoor particle matter to the indoor environment (Long & Sarnat, 2004).

In relation to Figure 4.11, a slight increase in PM_{10} can be seen between 06:00 and 08:00 and once again from 18:00 and 22:00. This increase can most likely be attributed to an increase in human activity during this period. According to Figure 4.13, the amount of PM_{10} indoors which can be attributed to outdoor infiltration is still small, but has increased during this time period in comparison to the previous sampling period conducted during the winter. At first glance, it is easy to see that indoor and outdoor concentrations of $PM_{2.5}$ move in unison with respect to one another (Figure 4.12). The R^2 (0.6373) value for this particle size range suggests that a significant portion of $PM_{2.5}$ has infiltrated from outdoors, most likely due to the use of natural ventilation (Figure 4.14). Increases during the morning between the hours of 06:00 and 10:00 may be attributed to increased traffic when people are commuting to work. Another increase occurs from 18:00 to 20:00, most likely as a result of human activity or increased vehicular traffic. The two increases in both indoor and outdoor $PM_{2.5}$ concentrations are indicative of the typical diurnal variation seen in previous PM studies in the El Paso region.

4.4.1.4. 12501 Angie Bombach; Summer 2007; Week 2

Sampling during the second week had been conducted at the location on 12501 Angie Bombach Ave. and during that timeframe sampling for PM_{10} had begun at 18:00 on Sept. 22nd, 2007 and ended at 17:00 on Sept. 24th, 2007. Sampling for $PM_{2.5}$ had begun at 18:00 on Sept. 25th and concluded at 17:00 on the 27th of February. Indoor and outdoor sampling occurred concurrently for each respective particle size.

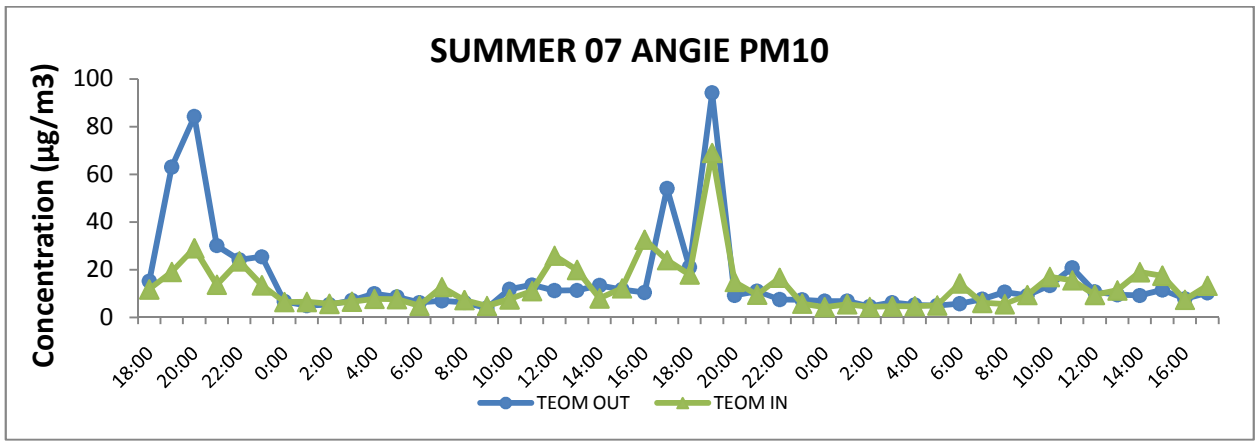

Figure 4.15: Angie Bombach PM_{10}

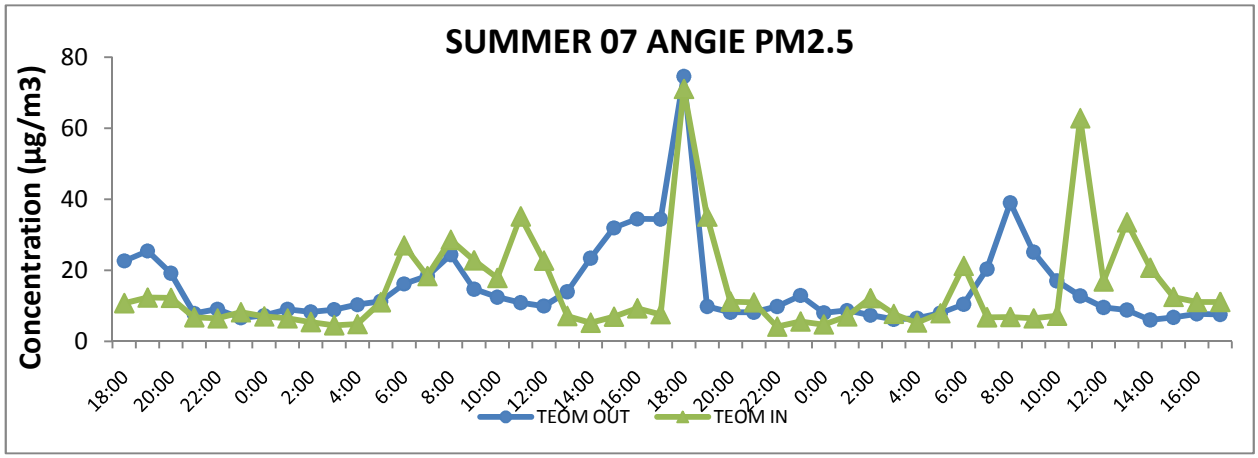

Figure 4.16: Angie Bombach $PM_{2.5}$

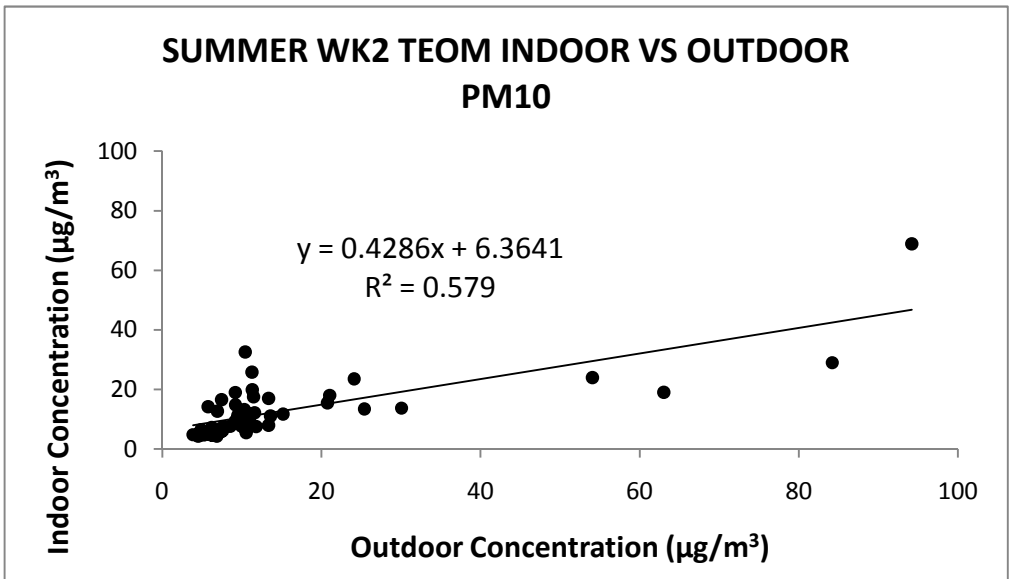

Figure 4.17: Angie Bombach Indoor vs. Outdoor PM_{10}

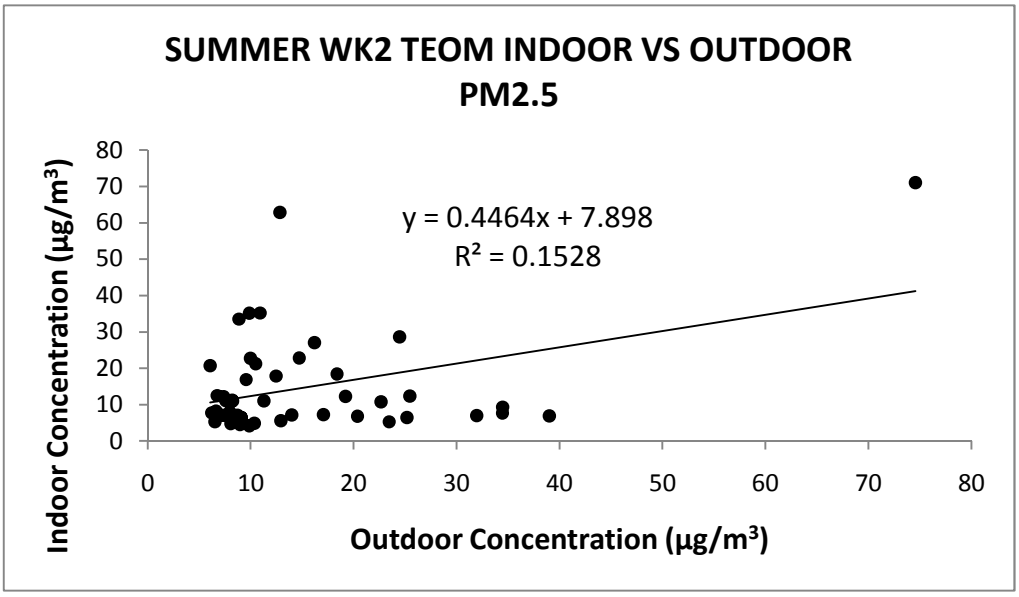

Figure 4.18: Angie Bombach Indoor vs. Outdoor $PM_{2.5}$

At first glance at Figure 4.15, it is clear that indoor PM_{10} and outdoor PM_{10} move somewhat in concert with respect to one another. Figure 4.17 supports this observation, a coefficient of determination (R^2=0.579) of indoor PM_{10} concentrations versus outdoor concentration suggest that a moderate percentage of outdoor concentrations influence indoor concentrations. PM_{10} at this location seems to follow the typical diurnal variation seen in PM in the El Paso region, with much more exaggerated levels

occurring during the evening. Slight increases in indoor PM_{10} concentrations can be seen between 06:00 and 07:00, while a substantial increase can be seen between the hours of 16:00 and 20:00. Figure 4.16 is time-series plot of indoor and outdoor $PM_{2.5}$ concentrations and shows that $PM_{2.5}$ seem to follow the typical diurnal variation seen in PM observations in the El Paso region with increases between 06:00 and 12:00 and again between 16:00 and 20:00. Indoor values of $PM_{2.5}$ are shown to consistently exceed outdoor values at various times throughout the day. Based on the coefficient of determination (R^2=0.1528) a significantly small percentage of outdoor $PM_{2.5}$ were seen to contribute to indoor concentrations (Figure 4.18).

4.4.2. Year 2008

4.4.2.1. 8008 Sundial; Winter 2008; Week 1

Sampling during the second week had been conducted at the location on 8008 Sundial Ct. and during that timeframe sampling for PM_{10} had begun at 18:00 on Mar. 2nd, 2008 and ended at 17:00 on Mar. 4th, 2008. Sampling for $PM_{2.5}$ had begun at 18:00 on March 5th and concluded at 17:00 on the 7th of March. Indoor and outdoor sampling occurred concurrently for each respective particle size. The father has identified himself as a smoker, smoking about seven to ten cigarettes a day, but claims all that all smoking is done outside. One asthmatic child has been identified at this residence and has been diagnosed with asthma since the child was a baby. The types of meals cooked at this residence have been identified as being traditional Mexican food, of which is cooked Monday through Fridays. Cooking occurs at 06:00, 10:30, and again at 17:00 every weekday.

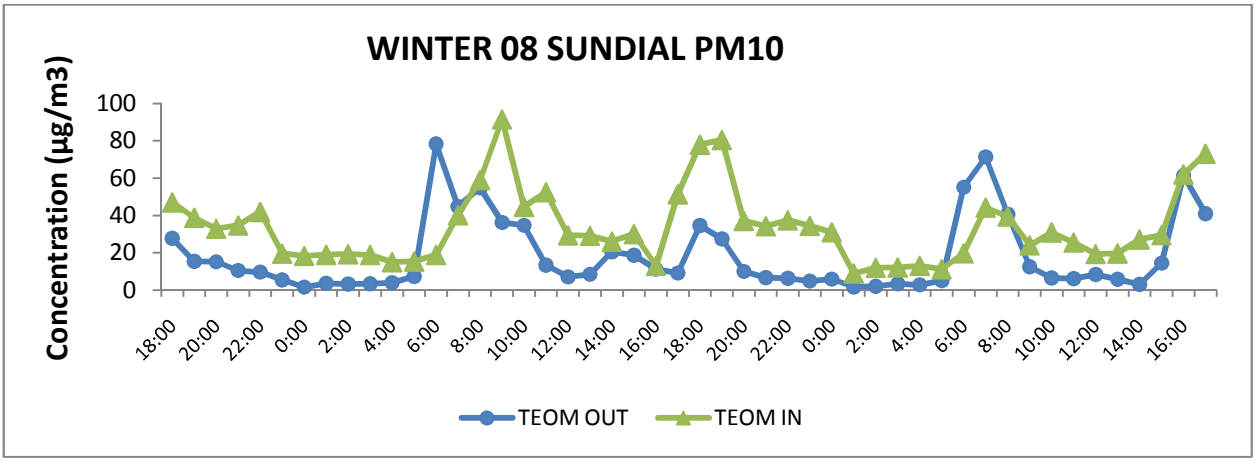

Figure 4.19: Sundial PM_{10}

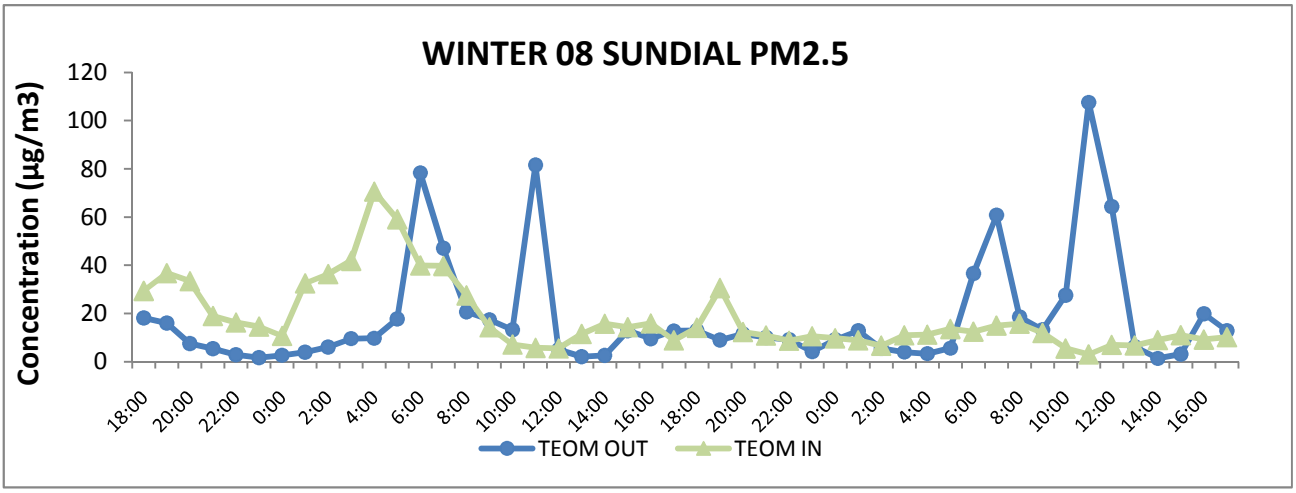

Figure 4.20: Sundial $PM_{2.5}$

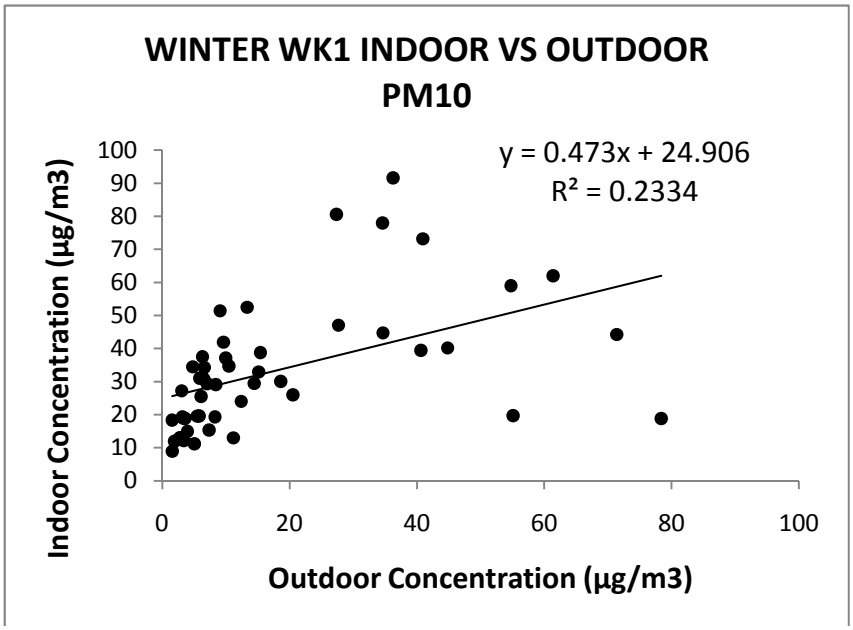

Figure 4.21: Sundial Indoor vs. Outdoor PM_{10}

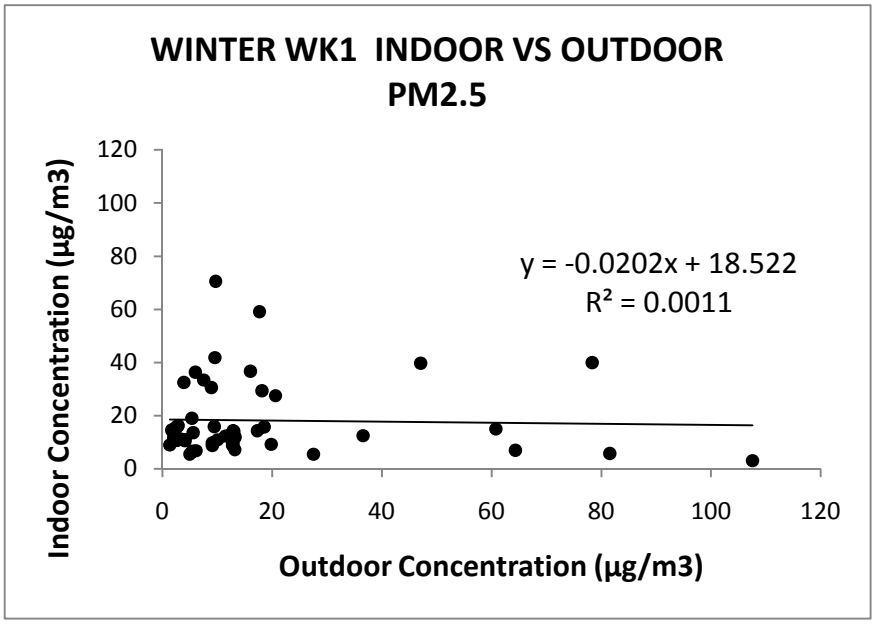

Figure 4.22: Sundial Indoor vs. Outdoor $PM_{2.5}$

Hourly PM_{10} concentrations at this location clearly follow the typical diurnal variation which has typically been seen in PM concentration in the region (Figure 4.19). Spikes in concentrations can be seen in morning values and once again during the evening. A clear diurnal variation with respect to

$PM_{2.5}$ at this location cannot be seen at first glance with more random increases in PM (Figure 4.20). A small percentage (R^2=0.2334) of indoor PM_{10} concentrations can be attributed to outdoor concentrations while an almost non-existent percentage of outdoor $PM_{2.5}$ concentrations are shown (R^2=0.0011) to contribute to indoor concentrations.

On several occasions, indoor PM_{10} levels (Figure 4.19) soar to levels much higher than outdoor levels and may be attributed to increased human activity which generally occurs in the morning hours when people prepare for the day and once again during the evening, when residents return home for the day. In contrast, outdoor $PM_{2.5}$ levels increase to levels much greater than those observed in the indoor environment on a consistent basis at both 07:00 and 12:00 for both 24-hour sampling periods. It is unknown as to why the $PM_{2.5}$ levels may be spiking on a consistent basis outdoors at this location one may be able to assume that it may be attributed to either increased in traffic at the time or an outdoor cooking event.

4.4.2.2. 642 University; Winter 2008; Week 2

Sampling during the second week had been conducted at the location on 642 University Ave. and during that timeframe sampling for PM_{10} had begun at 18:00 on Mar. 10th, 2008 and ended at 17:00 on Mar. 12th, 2008. Sampling for $PM_{2.5}$ had begun at 18:00 on March 12th and concluded at 17:00 on the 14th of March. Indoor and outdoor sampling occurred concurrently for each respective particle size. This sampling location is a large family house (4900 sq. ft.) with four occupants two of them children with moderate activity throughout the day. The residents use an evaporative cooler for cooling purposes while natural gas is used for heating, and electricity is used for cooking. The occupants of this residence have identified themselves as being of Caucasian race. The house is located in downtown/central part of El Paso, TX and has four bedrooms, a dining room, living room, library room, playroom, a large backyard, and a considerably large sized front yard.

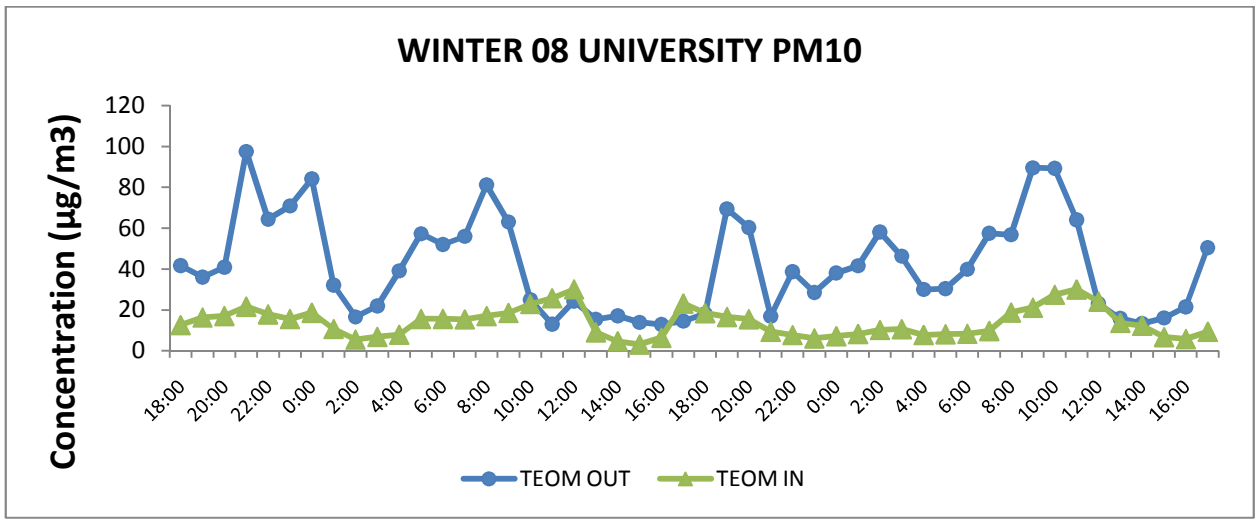

Figure 4.23: University PM_{10}

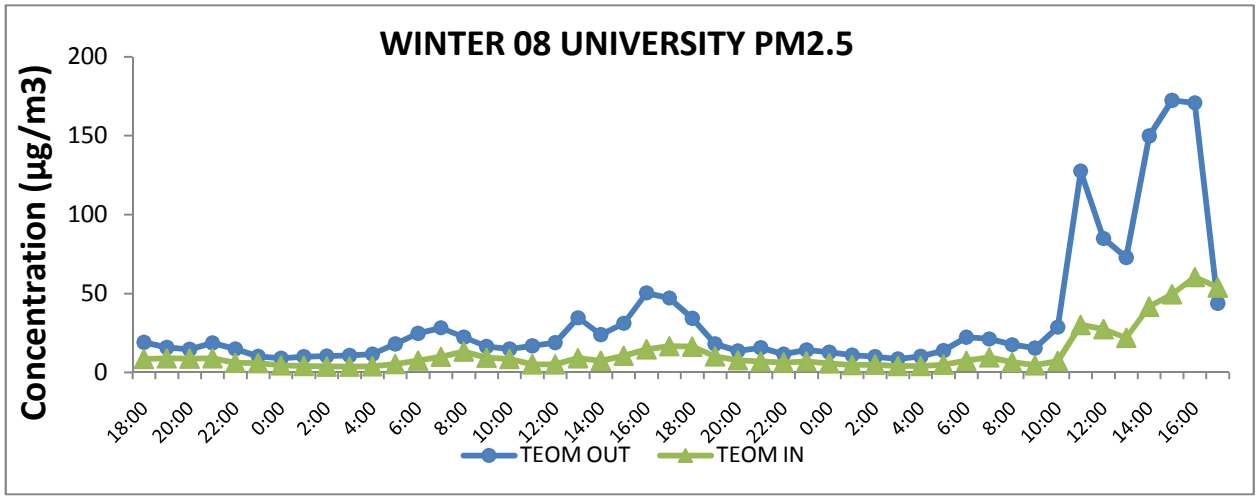

Figure 4.24: University $PM_{2.5}$

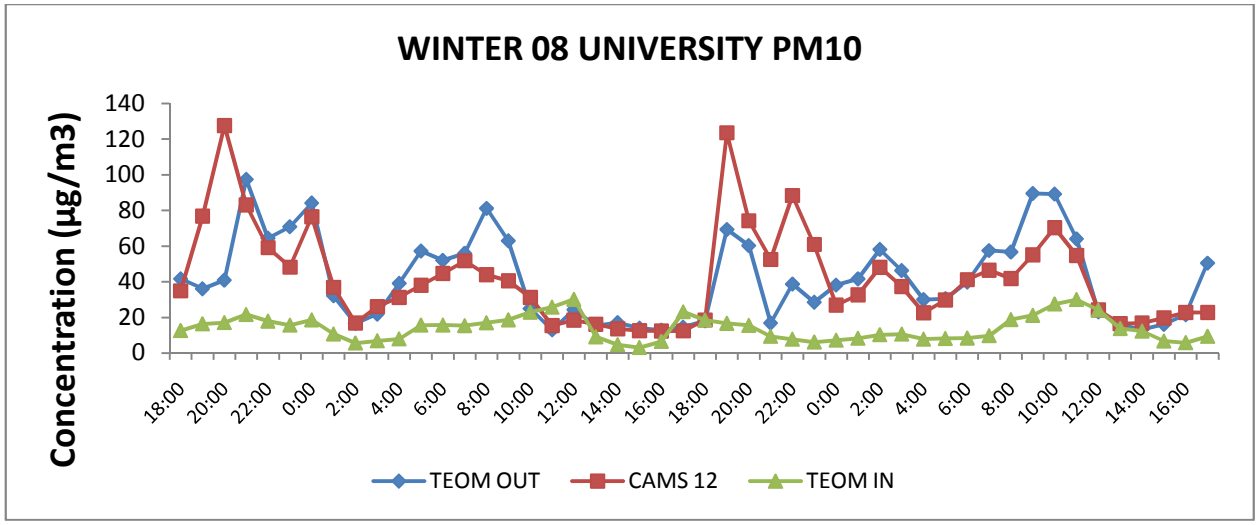

Figure 4.25: University PM_{10}

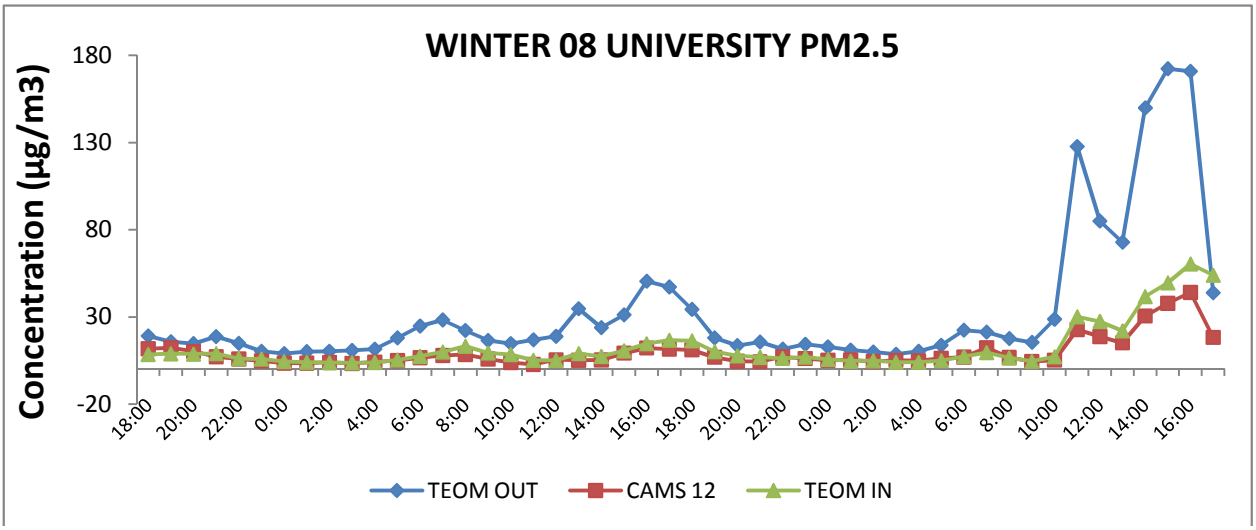

Figure 4.26: University $PM_{2.5}$

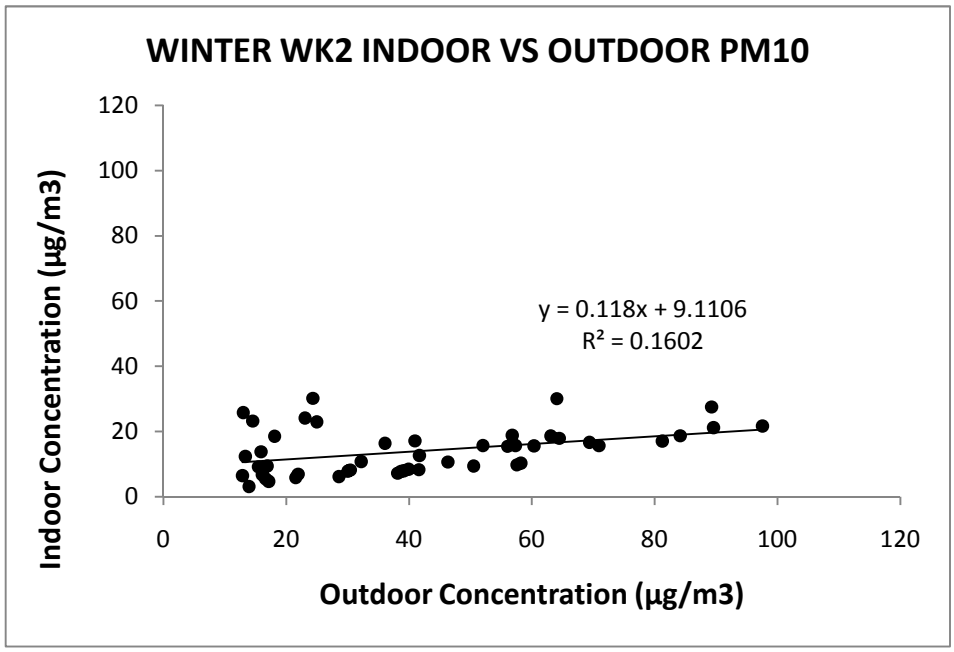

Figure 4.27: University Indoor vs. Outdoor PM_{10}

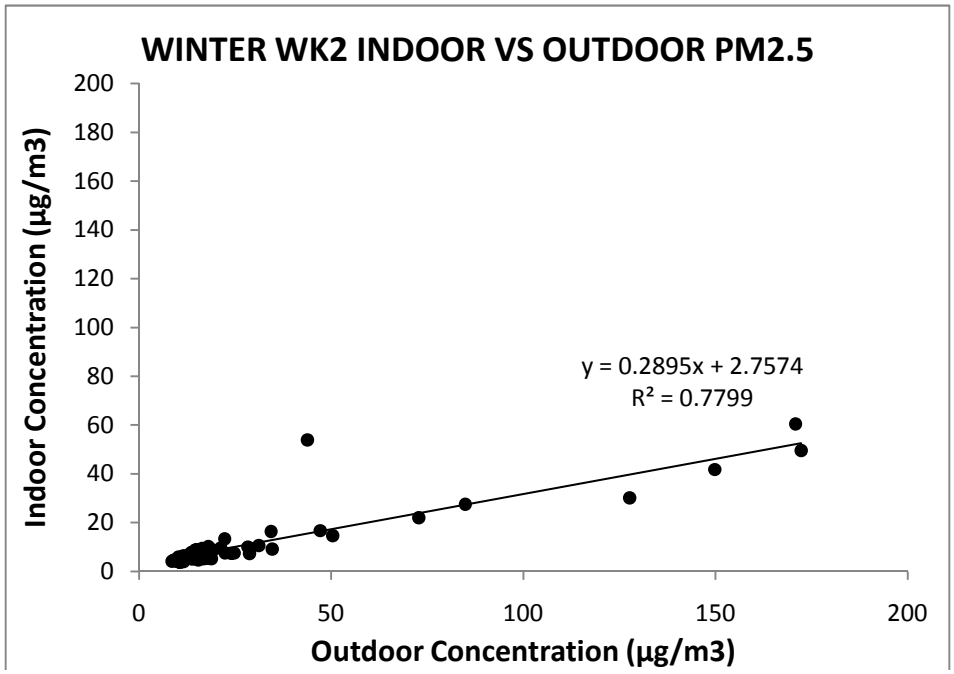

Figure 4.28: University Indoor vs. Outdoor $PM_{2.5}$

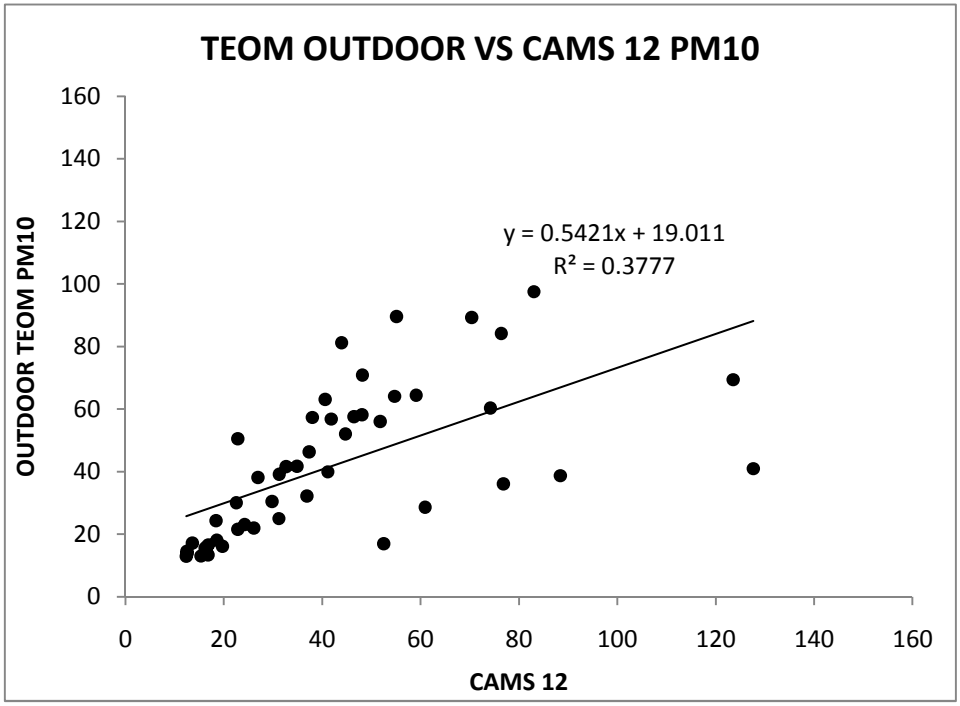

Figure 4.29: University Outdoor vs. CAMS 12 PM_{10}

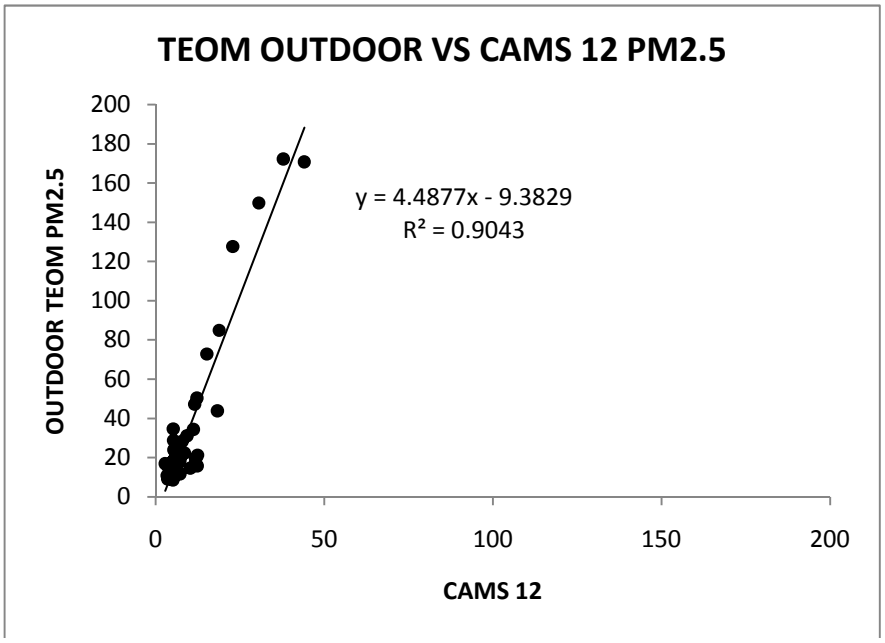

Figure 4.30: University Outdoor vs. CAMS 12 $PM_{2.5}$

At first glance, there is no obvious correlation between indoor and outdoor concentrations in PM_{10} (Figure 4.23). Changes in outdoor PM_{10} concentrations seem more pronounced than those observed indoors. It was not clear as to why the $PM_{2.5}$ concentrations immediately outside the homes had spiked in the evening to levels much higher than that observed at CAMS 12, which is only less than one mile away. Possible episodic local emissions, such as cooking, partying, and smoking, etc. might have contributed to the elevated $PM_{2.5}$ levels. In addition, elevated $PM_{2.5}$ levels outside the home correlated very well with levels observed at CAMS 12 (Figure 4.30), indicating a regional event (possibly a dust storm) might have occurred at that time. Two main spikes in outdoor PM_{10} concentrations appear to arise around 20:00 and once again around 06:00 while indoor PM_{10} concentrations only seem to spike around 12:00. In contrast to outdoor PM_{10} values, less pronounced increases in indoor PM_{10} values are seen in this time-series plot (Figure 4.25). Despite the disparity in gradual versus immediate increases in outdoor and indoor PM_{10}, a strong diurnal variation can be seen, overall, in $PM_{10.}$ It is quite obvious that indoor and outdoor $PM_{2.5}$ move in unison, which is confirmed by the scatterplot of indoor versus outdoor concentrations (Figure 4.28) which yielded an R^2=0.7799.

Indoor concentrations of PM_{10} do not seem to be a function of outdoor concentrations due to the low coefficient of determination (R^2=0.1602); in addition, outdoor PM_{10} seem to be moderately correlated values reported at CAMS 12 (Figure 4.33).

A very clear diurnal pattern in increases in TEOM and CAMS 12 PM_{10} can be seen at this sampling site with increases occurring once in the morning, and again during the evening.

4.4.2.3. 642 University; Summer 2008; Week 1

Sampling during the second week had been conducted at the location on 642 University Ave. and during that timeframe sampling for PM_{10} had begun at 18:00 on Jun. 16th, 2008 and ended at 17:00 on Jun. 18th, 2008. Sampling for $PM_{2.5}$ had begun at 18:00 on June 18th and concluded at 17:00 on the 20th of June.

Indoor and outdoor sampling occurred concurrently for each respective particle size. It should be noted at this point that outdoor $PM_{2.5}$ had not been collected during this study period and is not available for presentation. Indoor $PM_{2.5}$ TEOM data has been compared to the outdoor CAMS station in lieu of the missing outdoor TEOM data for illustrative purposes.

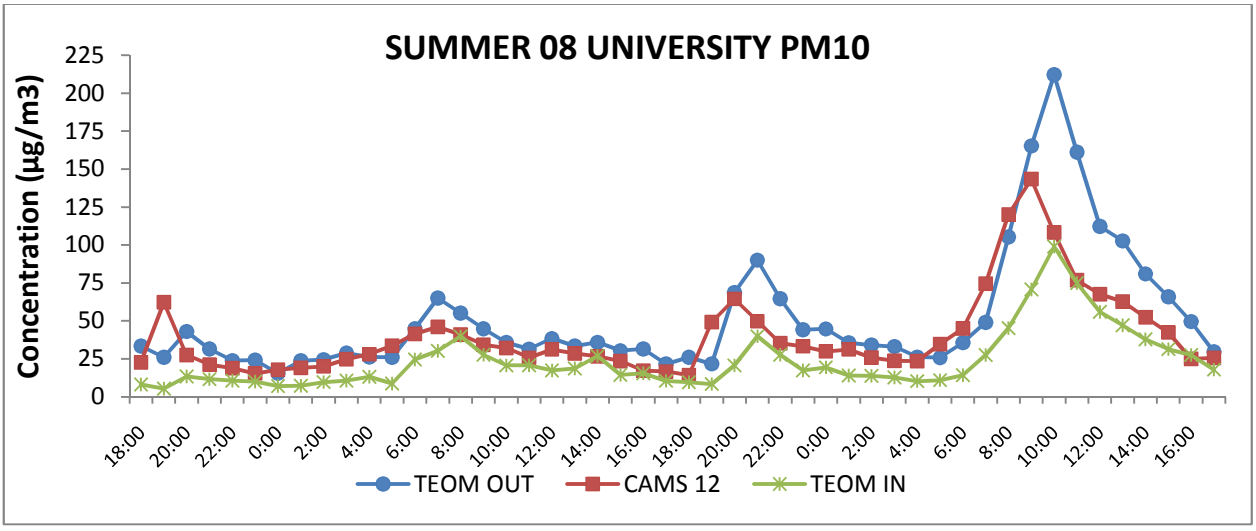

Figure 4.31: University PM_{10}

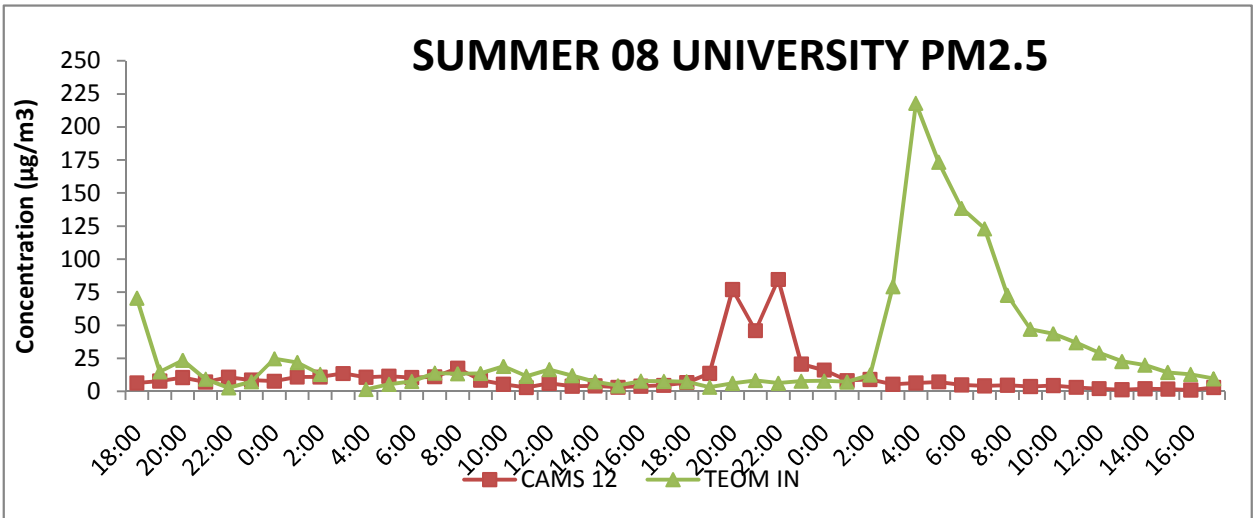

Figure 4.32: University $PM_{2.5}$

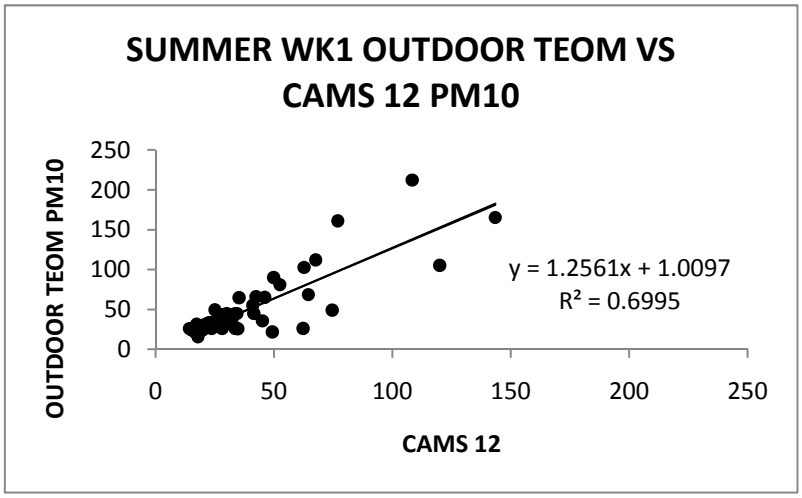

Figure 4.33: University Outdoor vs. CAMS 12 PM_{10}

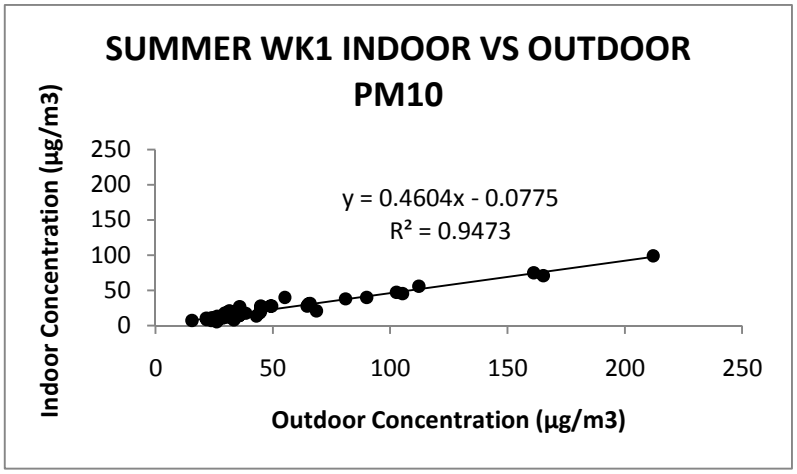

Figure 4.34: University Indoor vs. Outdoor PM_{10}

According to Figure 4.31, a strong diurnal variation in PM_{10} levels can be seen at this sample location. Sharp increases can be seen once in the morning between 06:00 and 08:00 and again between 18:00 and 20:00. PM_{10} indoor, outdoor, and CAMS concentrations mimic each other very well at this location. This trend can also be seen in the R^2 values generated by the regression line of scatterplots of outdoor TEOM concentrations versus CAMS values and that of indoor concentrations versus outdoor values (Figure 4.33 and Figure 4.34). Outdoor $PM_{2.5}$ TEOM data had not been collected at this location due to an unforeseen problem with the continuous sampler. The indoor TEOM $PM_{2.5}$ was, however, compared to $PM_{2.5}$ data collected from the TCEQ CAMS 12 station in lieu of the missing outdoor data. CAMS 12 is located 0.63 miles southwest of this sampling location. Peaks in PM_{10} concentrations can be seen at 08:00 and again at 20:00 through the course of both days. Indoor PM_{10} levels at this location seem to be consistent and are never higher than observed outdoor concentrations. In contrast to indoor PM_{10}, indoor $PM_{2.5}$ levels exceeded outdoor CAMS 12 levels by a substantial amount around 04:00 on the last day of sampling. An assumed meteorological event may have also increased the levels of $PM_{2.5}$ at around 20:00 before the aforementioned unknown indoor event which severely increased indoor $PM_{2.5}$ concentrations.

4.4.2.4. 8181 Starr; Summer 2008; Week 2

Sampling during the second week had been conducted at the location on 642 University Ave. and during that timeframe sampling for PM_{10} had begun at 18:00 on Jun. 23rd, 2008 and ended at 17:00 on Jun. 25th, 2008. Sampling for $PM_{2.5}$ had begun at 18:00 on June 25th and concluded at 17:00 on the 27th of June. Indoor and outdoor sampling occurred concurrently for each respective particle size. The residents at this location have identified themselves as being of Hispanic ethnicity with two adults and two children. The residence has four bedrooms and two bathrooms. The domicile uses refrigerated air for cooling and natural gas for heating and cooking. The family has three pets of which all are kept

outside. One smoker has been identified in this household and has claimed to smoke, on average, three cigarettes a day both indoors and outdoors. One child has been identified as an asthmatic and has been one since birth. Traditional Mexican food is commonly cooked at this residence at least once a day, every day of the week. Breakfast is cooked at 06:00, lunch at 12:00, and dinner at 18:00, on average.

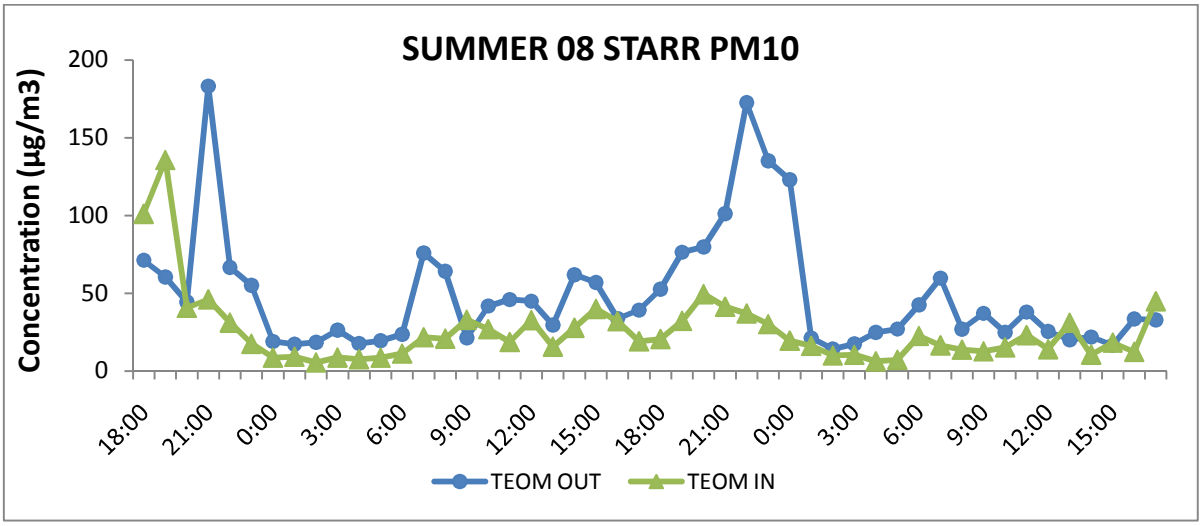

Figure 4.35: Starr PM_{10}

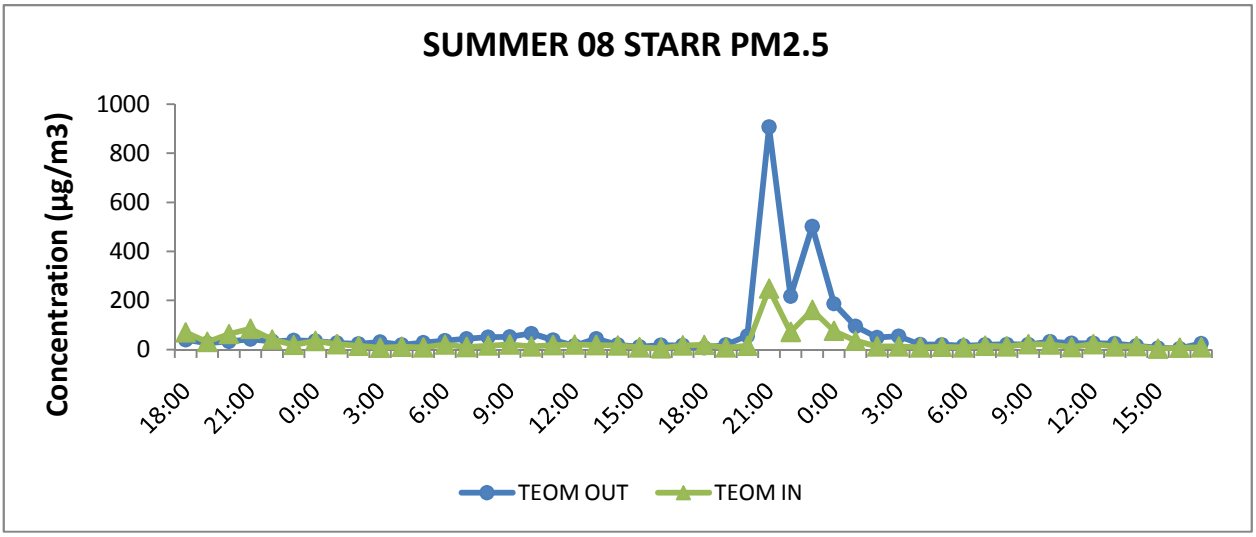

Figure 4.36: Starr $PM_{2.5}$

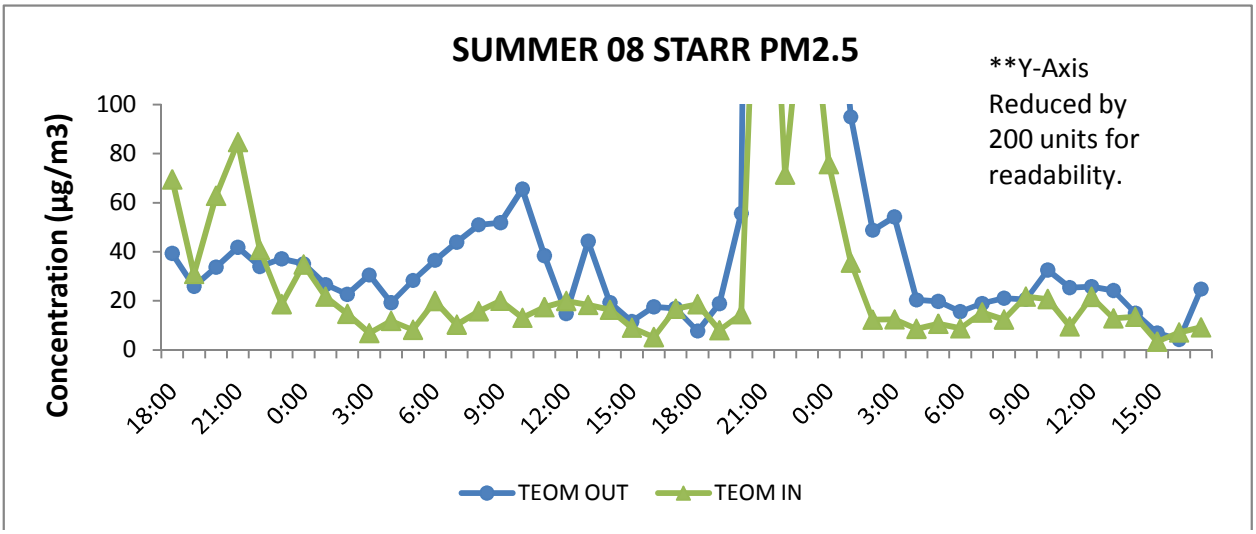

Figure 4.37: Starr $PM_{2.5}$ (Reduced Y-Axis)

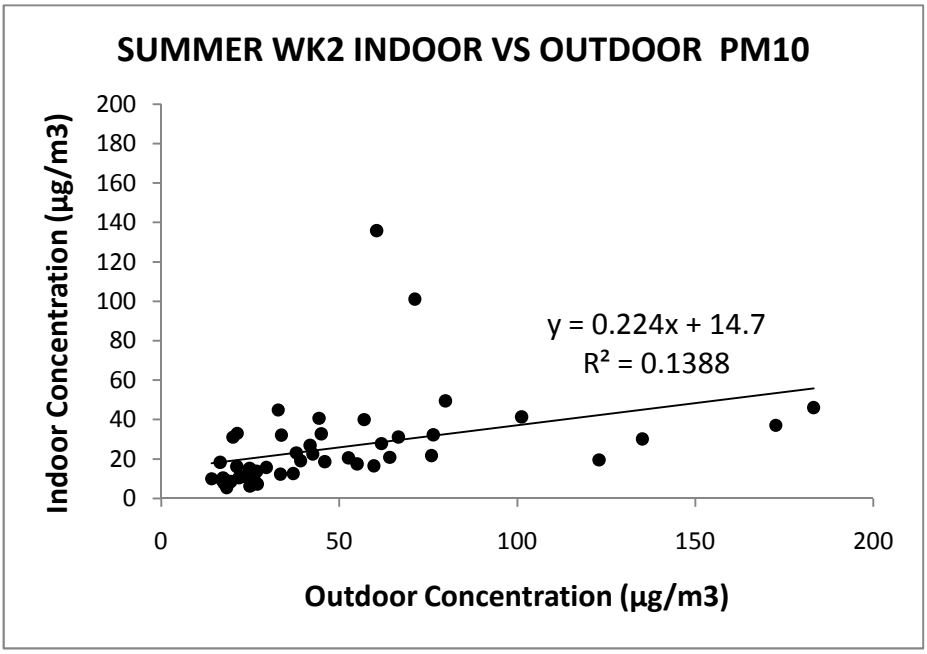

Figure 4.38: Starr Indoor vs. Outdoor PM_{10}

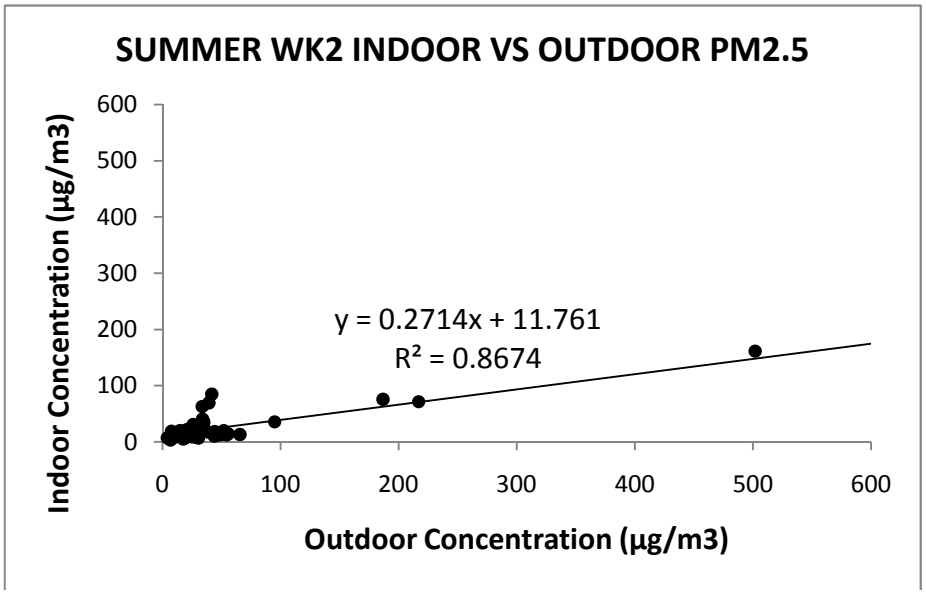

Figure 4.39: Starr Indoor vs. Outdoor $PM_{2.5}$

Indoor and outdoor PM_{10} concentrations seem to consistently peak 18:00 and 22:00 in the evening while also exhibiting a peak in concentrations around between 06:00 and 08:00 in the morning (Figure 4.35). Indoor concentrations appear to be most erratic during the day when indoor activity can be assumed to be at its highest. The Y-axis had been reduced in Figure 4.34 due to a peak in both indoor and outdoor $PM_{2.5}$ concentrations around 21:00 in the evening (Figure 4.36). The time-series plot with the reduced y-axis (Figure 4.37) depicts, in greater detail, the erratic $PM_{2.5}$ behavior in this household. Despite the aberrancy of the outdoor $PM_{2.5}$ values, increases can be seen from 18:00 and 22:00 and again from 06:00 to 10:00. The large spike in both indoor and outdoor $PM_{2.5}$ values may be attributed to a significant meteorological event that occurred in the area at the respective time (20:00-01:00). CAMS 36 is a monitoring station maintained by TCEQ and is located at 8470 Plant Road, located in the El Paso lower valley. This station collects H_2S data along with meteorological data and is located only 0.84 miles directly south of the sample site on Starr. Upon inspection of the archived data at this location, a severe weather event had occurred at this time with wind gusts up to 33 miles per hour (mph) and persisting into midnight, which may explain the abnormally high $PM_{2.5}$ concentrations. One would

expect PM_{10} to be most affected by the severe weather event; however, no concurrent PM_{10} measurements were taken at the same time the $PM_{2.5}$ spike was seen in order to confirm this.

A clear diurnal variation can be seen in a majority of the sample sites for both $PM_{2.5}$ and PM_{10}. This diurnal pattern is consistent with a diurnal pattern noted by previous studies in the region which have also observed strong increases in PM_{10} in the morning and evening periods in the El Paso region (Li et al., 2003). In addition to the observed diurnal observation by Li et al. (2003), a clear diurnal observation can be seen in $PM_{2.5}$ concentrations in a majority of the homes sampled using the TEOM continuous monitors.

4.5. TEOM PM_{10} and $PM_{2.5}$ Indoor and Outdoor Summary Statistics

Table 4.14: TEOM $PM_{2.5}$ & PM_{10} Summary Statistics

Outdoor								
	Time Period	**N**	**Range**	**Min.**	**Max.**	$\bar{x}$	**Std. Dev.** s	**Variance** s^2
$PM_{2.5}$	Summer	143	903	3.95	907	30.5	88.0	7750
	Winter	190	1	1.36	172	18.8	25.6	657
	2007	189	72.4	2.20	74.6	12.3	9.02	81.4
	2008	144	906	1.36	907	39.0	90.1	8126
	Entire Period	333	906	1.36	907	23.9	61.0	3722
	Time Period	**N**	**Range**	**Min.**	**Max.**	$\bar{x}$	**Std. Dev.** s	**Variance** s^2
PM_{10}	Summer	192	208	3.85	212	32.5	34.6	1198
	Winter	192	96.0	1.55	97.5	22.1	20.1	403
	2007	192	91.1	3.12	94.2	14.3	11.5	133
	2008	192	211	1.55	212	40.3	34.4	1184
	Entire Period	384	211	1.55	212	27.3	28.7	826
Indoor								
	Time Period	**N**	**Range**	**Min.**	**Max.**	$\bar{x}$	**Std. Dev.** s	**Variance** s^2
$PM_{2.5}$	Summer	190	246	1.52	248	20.5	33.3	1110
	Winter	186	109	0.17	109	14.9	18.0	324
	2007	185	109	0.17	109	12.7	16.9	285
	2008	191	246	1.52	248	22.6	33.3	1111
	Entire Period	376	248	0.17	248	17.8	27.0	728
	Time Period	**N**	**Range**	**Min.**	**Max.**	$\bar{x}$	**Std. Dev.** s	**Variance** s^2
PM_{10}	Summer	192	132	3.18	135	17.6	17.6	309
	Winter	189	91.3	0.30	91.6	18.4	16.6	275
	2007	189	68.6	0.30	68.9	11.6	11.2	125
	2008	192	133	3.15	136	24.3	19.4	377
	Entire Period	381	136	0.30	136	18.0	17.1	291

*Values are the mean of 1-hour averages derived from 10-min. TEOM measurements
** Units are $\mu g/m^3$

A summation of statistics for indoor $PM_{2.5}$ and PM_{10} as well as outdoor $PM_{2.5}$ and PM_{10} is noted in Table 4.14. In observance of outdoor $PM_{2.5}$, the mean concentration was noticeably higher during the summer study periods versus the winter study periods. The variance for summer measurements seems to be significantly higher than the mean $PM_{2.5}$ value, which implies the presence of extreme high and low

concentrations for the period. Outdoor $PM_{2.5}$ measurements collected during the 2008 period yielded a higher mean concentration in contrast to measurements collected during the 2007 year. The mean outdoor $PM_{2.5}$ concentration for the entire study period was found to be 23.9 $\mu g/m^3$. Outdoor PM_{10} observations yielded a higher mean concentration during the summer seasons over the winter seasons with mean concentrations of 32.5 $\mu g/m^3$ and 22.05 $\mu g/m^3$, respectively. The variance exhibited by outdoor PM_{10} measurements is similar to the variance seen in outdoor $PM_{2.5}$ measurements; though not nearly as high as the $PM_{2.5}$ variance, a high variance is seen in outdoor PM_{10} measurements. Outdoor PM_{10} measurements were, on average, much greater during the 2008 sampling year over samples collected during 2007. The mean outdoor PM_{10} concentration for the entire study period was found to be 27.4 $\mu g/m^3$.

Indoor concentrations were shown to be, on average, lower than outdoor concentrations for both PM_{10} and $PM_{2.5.}$ The mean summer indoor $PM_{2.5}$ concentration, 20.5 $\mu g/m^3$, was shown to be higher than the winter mean concentration, 14.9 $\mu g/m^3$, while measurements collected during the 2008, 22.6 $\mu g/m^3$, sampling period a higher mean concentration over measurements collected during 2007, 12.7 $\mu g/m^3$. The mean indoor $PM_{2.5}$ concentration for the entire study period was found to be 17.8 $\mu g/m^3$. In contrast to indoor $PM_{2.5}$, indoor PM_{10} TEOM observations presented a slightly greater mean concentration during the winter sampling periods over the summer sampling periods with values of 18.4 $\mu g/m^3$ and 17.6 $\mu g/m^3$, respectively. Similar to all previously mentioned size fractions and sampling periods, the indoor PM_{10} mean concentration was significantly higher during the 2008 sampling year versus the 2007 sampling year with values of 24.3 $\mu g/m^3$ and 11.6 $\mu g/m^3$, respectively.

To briefly summarize the previously mentioned findings, based on indoor and outdoor PM 1-hour averaged measurements, 2008 saw higher concentrations over the 2007 sampling period while mean concentrations were found to generally be higher during the summer sampling seasons over the

winter sampling seasons. The highest maximum one-hour averages were seen during the summer sampling seasons, most likely as a result of increased meteorological volatility during the summer seasons (increased wind and higher frequency of storms). The variance of all one-hour PM observations were also highest during the summer sampling months and are most likely a result of the aforementioned high maximum concentrations seen in the summer observations.

4.6. TEOM PM_{10} and $PM_{2.5}$ Indoor /Outdoor Ratio Summary Statistics

Table 4.15: TEOM Indoor /Outdoor Ratio Summary Statistics

Indoor/Outdoor Ratios								
	Time Period	**N**	**Range**	**Min.**	**Max.**	$\bar{x}$	**Std. Dev.** s	**Variance** s^2
$PM_{2.5}$	Summer	192	4.71	0.18	4.89	0.78	0.65	0.42
	Winter	192	11.59	0.03	11.61	1.31	1.89	3.58
	2007	192	11.59	0.03	11.61	1.09	1.43	2.04
	2008	192	8.71	0.03	8.74	1.00	1.45	2.11
	Entire Period	384	11.59	0.03	11.61	1.05	1.44	2.07
	Time Period	**N**	**Range**	**Minimum**	**Maximum**	$\bar{x}$	**Std. Dev.** s	**Variance** s^2
PM_{10}	Summer	192	2.96	0.16	3.12	0.69	0.44	0.19
	Winter	189	14.41	0.05	14.46	1.62	2.19	4.82
	2007	189	14.41	0.05	14.46	1.06	1.51	2.28
	2008	192	11.67	0.16	11.83	1.24	1.76	3.10
	Entire Period	381	14.41	0.05	14.46	1.15	1.64	2.69

*Ratios of TEOM 1-hour Averages
** Unit is (Ratio)

Table 4.15 is a summary of indoor/outdoor (I/O) ratios for all TEOM 1-hour averaged observations; categorized by year and season. $PM_{2.5}$ I/O ratios, on average, were seen to be higher during the winter-time, 1.31, over the summer-time, 0.78, which suggests that indoor concentrations are greater than outdoor concentrations during winter seasons. This observation may come as of a result of the increased human activity indoors during the winter season, as well as the use of fireplaces and heating systems in conjunction with closed windows which may limit air-circulation in the indoor environment. The less-than-unity ratios seen during the summer seasons may have been a result of the use evaporative

cooling systems, which have been shown to act as PM filters which reduce indoor PM concentrations from 40%-35% of outdoor concentrations (Li et al., 2003). For the entire study period, the mean $PM_{2.5}$ I/O ratio was found to be slightly greater than unity at 1.05, while the mean PM_{10} ratio was found to be greater than unity at 1.15. The highest I/O ratios and variances were seen during the winter seasons, most likely due to increased human activity indoors, fireplace usage, heating systems usage, and the reduction in infiltration and air exchanges as a result of closed windows (Long et al., 2001).

Table 4.16:TEOM Mean Concentrations by Location

			Indoor		Outdoor	
			PM_{10}	$PM_{2.5}$	PM_{10}	PM2.5
Angie Bombach	2007	Summer	13.1	14.7	15.8	15.3
		Winter	15.6	7.21	12.2	10.3
Juliandra	2007	Summer	7.80	23.6	13.3	15.5
		Winter	10.2	6.69	15.8	8.15
Starr	2008	Summer	25.7	29.6	49.2	65.7
Sundial	2008	Winter	33.6	30.5	18.3	NA
University	2008	Summer	23.7	18.2	51.6	18.2
		Winter	14.0	12.4	41.8	33.2

*N=48

Units µg/m3

Table 4.16 is a summary of the mean of the TEOM 1-hour averaged concentrations for each respective sample location. Several mean concentrations for each particle size fraction are much higher than the reported mean concentrations for all size fractions for the entire data set (Table 4.14). Locations with two or more size fraction means above the mean concentrations reported in Table 4.14 are Starr, Sundial and University. In Table 4.14, the variance reported for the concentrations recorded during the summer and in 2008 is very high with respect to variances in other seasons or years, and these values seem to have driven the mean for all locations for each respective size fraction higher than they may have otherwise been. Regardless, this may just be characteristic of the variation in conditions respective to each household and its respective location in El Paso.

5. Conclusions

The findings presented in this thesis helped to characterize PM in the $PM_{2.5}$ and PM_{10} fractions in the region at various households selected from an epidemiological study cohort. PM pollution is a large problem in the El Paso region and any study which aims to help characterize PM can only contribute to finding means of alleviating the region of such a problem. This study, which spanned four seasons (summer 2007, summer 2008, winter 2007, and winter 2008), monitored $PM_{2.5}$ and PM_{10} data and indicated the following with respect to each collection mechanism and particle fraction:

I. PEM 7-day $PM_{2.5}$ Measurements:

a. Gravimetric Analysis

i. The mean $PM_{2.5}$ concentration of 19.8 $\mu g/m^3$ had been observed for all sampling sites.

ii. The mean winter concentration, 22.9 $\mu g/m^3$, was shown to be higher than the mean summer concentration, 16.8 $\mu g/m^3$, for all sampling sites.

iii. The mean concentration of all samples collected during the 2007 sampling year, 22.8 $\mu g/m^3$, was greater than the mean concentration of all samples collected during 2008, 16.7 $\mu g/m^3$.

b. EDXRF Chemical Analysis

i. The mean mass concentration of all analyzed elements (Σ Elements) for all sampling sites was found to be 3.73 $\mu g/m^3$.

ii. The mean mass concentration of all analyzed elements was found to be slightly higher during the summer seasons, 3.99 $\mu g/m^3$, than the winter seasons, 3.45 $\mu g/m^3$.

iii. The mean mass concentration of all analyzed elements was found to be higher during the 2008 collection year than the 2007 year with values of 4.69 $\mu g/m^3$ and 2.74 $\mu g/m^3$, respectively.

iv. All analyzed elements composed, on average, 24% of the total $PM_{2.5}$ mass collected using the PEM.

v. The % composition of Σ Elements of the total $PM_{2.5}$ mass was greater during the summer season, 31.4%, over the winter season, 16.05%.

vi. Geologic elements (Al, Si, Ca, Fe, Ti, and K) were found to compose a dominant majority of the total $PM_{2.5}$ mass at 17.4% while showing increased percent composition during the summer seasons, 22.8%, over the winter seasons, 11.6%.

vii. The mean geologic composition of Σ Elements for the entire study period was found to be 66.7%, while the summer and winter percent compositions were almost identical with values of 66.3% and 67.1%, respectively.

viii. Toxic trace elements (Cu, Cr, As, Cd, and Pb), which are now industrial releases in the region, were found to compose only 0.19% of the total $PM_{2.5}$ mass and were also shown to compose a greater percentage during the winter seasons, 0.24%, over the summer seasons, 0.15%.

ix. The mean toxic trace element composition of $PM_{2.5}$ for the entire study period was found to be 1.08%, while the winter percent composition was greater than the summer percent composition with values of 1.4% and 0.8%, respectively.

x. The element with the greatest mass, of $PM_{2.5}$, was found to be Si with a mean concentration of 0.975 $\mu g/m^3$; followed by Ca, S, Al, and Fe with mean concentrations of 0.873, 0.429, 0.391, and 0.254 $\mu g/m^3$, respectively.

c. Black Carbon (BC) Analysis

i. The mean BC concentration for the entire study period was found to be 0.30 $\mu g/m^3$ for all sampling sites.

ii. The mean BC concentration was found to be higher during the winter seasons in contrast to the summer season with values of 0.38 $\mu g/m^3$ and 0.21 $\mu g/m^3$, respectively.

iii. The mean BC concentration for the 2007 study period was found to be greater than the 2008 study period with values of 0.37 $\mu g/m^3$ and 0.22 $\mu g/m^3$, respectively.

iv. BC was found to compose, on average, 1.8% of the total $PM_{2.5}$ mass collected on the PEM.

v. BC composition, with regard to $PM_{2.5}$, increased during the winter sampling season, 2.22%, over the summer sampling season, 1.44%.

d. PCA Analysis

i. By method of PCA, four primary components were extracted from the EDXRF elemental analysis data.

1. Component one was found to include Al, Ba, Ca, Fe, K, Mg, Mn, Pb, Sr, Ti, and V. This component is believed to consist of mostly geologic material and fugitive dust re-suspended by mechanical or meteorological disturbance. This component was shown to compose 12% of the total $PM_{2.5}$ mass over the entire study period; moreover, the percent composition was shown to be greater during the summer seasons, 15.3%, over the winter seasons, 8.5%.

2. Component two was found to include Cr, Ga, Mo, and Ni. This component is believed to have formed as a result of industrial releases in the area related to iron mill releases, steel mill releases and electroplating. This component was shown to compose only 0.12% of the total $PM_{2.5}$ mass over the entire study period and was also shown to be greater during the winter seasons, 0.19%, over the summer seasons, 0.05%.

3. Component three consists of Ag, Rh, and Te and is believed to result from local copper refinement processes. This component was shown to compose only 0.09% of the total $PM_{2.5}$ mass over the entire study period and was also shown to be greater during the summer seasons, 0.12%, over the winter seasons, 0.06%.

4. Component four consisted of Cl and Na and is believed to be salt water residual, or may be related to brick kiln releases. Salt mists may also

migrate into the area via the Gulf of Mexico or the Gulf of California. This component was shown to compose 1.64% of the total $PM_{2.5}$ mass over the entire study period and was also shown to be greater during the summer seasons, 1.79%, over the winter seasons, 1.49%.

The most dominant elements seen on the $PM_{2.5}$ PEM 7-day filters were shown to be Si, Ca, S, Al, Fe, K, Na, Cl, and Mg with mean concentrations all above one $\mu g/m^3$ and was mostly geologic material. This is not surprising as there are an abundance of unpaved roads, volatile meteorological episodes, and dry terrain in the El Paso area.

TEOM measurements in all five households during the course of four seasons from 2007 through 2008 uncovered the confirmation of the existence of a strong diurnal variation in both indoor and outdoor PM concentrations consistent with findings from previous studies in the region (Li et al., 2001, 2003; Orquiz, 2001). Increases in PM were generally seen between the hours of 06:00 to 10:00 (morning) and once again from 16:00 to 20:00 (evening). For both $PM_{2.5}$ and PM_{10}, mean outdoor concentrations were found to be higher than mean indoor concentrations.

The following summaries can be made from the 1-hour averaged indoor and outdoor TEOM data collected at the five residences:

I. $PM_{2.5}$ Measurements

a. The mean outdoor $PM_{2.5}$ concentration for the entire period was found to be 23.9 $\mu g/m^3$, while the mean indoor $PM_{2.5}$ concentration was found to be 17.8 $\mu g/m^3$ for the same time period.

b. The mean outdoor $PM_{2.5}$ concentration was found to be greater during the summer seasons along with a high variance associated with that mean, most likely due to the inherent meteorological volatility of the summer season.

c. The mean indoor $PM_{2.5}$ concentration was found to be greater during the summer months, 20.5 $\mu g/m^3$, as well for all indoor measurements. A high variance was also associated with this mean value; however, this is believed to be as a result of infiltration from outdoor $PM_{2.5}$ as the variance is not nearly as high as the aforementioned outdoor variance associated with the mean concentration.

II. PM_{10} Measurements

a. The mean outdoor PM_{10} concentrations for the entire period was found to be 27.3 $\mu g/m^3$, while the mean indoor PM_{10} concentration was shown to be approximately 18.0 $\mu g/m^3$, only slightly greater than the mean indoor $PM_{2.5}$ value for the entire study period.

b. The mean outdoor PM_{10} concentration was found to be greater during the summer seasons, with a value of 32.5 $\mu g/m^3$. A high variance was also associated with this mean value, although not as high as the variance associated with outdoor $PM_{2.5}$ measurements. The variance outdoors was expected to be high meteorological conditions worsen during the summer seasons.

c. The mean indoor PM_{10} concentration of for the entire study period was found to be only slightly greater during the winter season over the summer season with values of 18.4 $\mu g/m^3$ and 17.6 $\mu g/m^3$, respectively. Most likely as a result of

increased human activity indoors and the use of heating equipment. Windows are more likely to be kept shut and ventilation rates within the household drop.

High maximum concentrations were consistently seen during the summer seasons, which insinuate that increased meteorological activity in the area during the summer raises concentrations as a result of fugitive dust. Mean indoor and outdoor PM_{10} concentrations were not seen to be much greater than the mean indoor and outdoor $PM_{2.5}$ concentrations despite recent findings in the region which suggest that $PM_{2.5}$ concentrations, on average, were found to be roughly 25-30% of PM_{10} concentrations (Li et al., 2001).

Indoor/outdoor (I/O) ratios had also been calculated from the TEOM 1-hour averaged PM_{10} and $PM_{2.5}$ values and the following conclusions have been drawn from the data:

I. With respect to the entire study period, the mean (I/O) ratio for PM_{10} was found to be greater than the mean (I/O) ratio for $PM_{2.5}$. This may be due to human disturbance and re-suspension of larger particles indoors.

II. Very high (I/O) ratios had been observed during the winter seasons (PM_{10}=14.5 and $PM_{2.5}$=11.6) in relation to (I/O) ratios during the summer seasons (PM_{10}=3.1 and $PM_{2.5}$=4.9). During the winter seasons, increased use of fireplaces and heating equipment in conjunction with the reduced circulation due to tightly closed doors and windows to limit drafts may be the reason such high (I/O) ratios are seen during this time period. People tend to spend more time indoors during the winter seasons to escape the cold and may raise indoor PM levels. The mere presence of people in an indoor environment has been shown to elevate levels of PM (Abt et al., 2000).

III. The mean (I/O) ratios for winter-time PM_{10} and $PM_{2.5}$ measurements were found to be 1.6 and 1.3, respectively. Mean (I/O) ratios for summer-time PM_{10} and $PM_{2.5}$ measurements were found to be 0.7 and 0.8, respectively. Increased (I/O) ratios during the winter-time would have been expected for reasons previously mentioned.

The findings in this thesis reaffirm previous observations regarding a clear PM_{10} diurnal pattern in the El Paso region (Li et al., 2001, 2003; Orquiz, 2001). The observation is seen in a large percentage of the time-series of both indoor and outdoor PM_{10} at all the sample locations. A clear increase in concentrations can be seen in the morning period while another increase in PM (PM_{10} and $PM_{2.5}$) in regional observations can be seen in the evening.

A common observation regarding PM in the El Paso, and in other regions, is the increase in PM during the fall and winter seasons over the summer and spring seasons (Espino et al., 2005; Li et al., 2001). Mean outdoor and indoor TEOM concentrations for both PM_{10} and $PM_{2.5}$ were greater during the summer than during the winter, with the exception of outdoor PM_{10}. These observations are contrary to previous regional observations and may be due to the presence of several site-specific mean PM_{10} and $PM_{2.5}$ values that were extremely high. Starr Ave., which was sampled during the summer of 2008, had indoor $PM_{2.5}$ and PM_{10} means of roughly 30.0 and 26.0 $\mu g/m^3$, respectively; additionally, outdoor $PM_{2.5}$ and PM_{10} means of about 66.0 and 49.0 $\mu g/m^3$ were reported for the same location (Table 4.14). These previously mentioned mean values for each location were significantly higher than the mean values for all locations for their respective size fraction. These elevated concentrations for each of the aforementioned values may have driven the summer mean for all locations above the winter mean, which is contrary to other PM observations in this region.

Understanding the characteristics of PM in the region could help to provide insight into how to provide mitigation alternatives to help with the pollution problem in the El Paso region. Further

investigation into the characterization of PM in the El Paso region can only help to alleviate the pollution problem and to increase the overall quality of life for El Pasoans.

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Appendix A

PEM Chain of Custodies

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 367 Roslyn Sandra Martinez — JS

Contact Phone # (915) 852-8555

PEM Information

PEM ID #	1
PEM INLET #	1
Calibrated Flow	4.5

Filter Gravimetric Information PS67w701

	pre-weights		post-weights
1	106.949	1	107.495
2	106.949	2	107.495
3	106.949	3	107.495

Filter Deployment Information

	Date	Time			
Deployment	09/17/07	10:00am	Flow Reading at Deployment	4	lpm
Retrieval	09/24/07	10:00am	Flow Reading at Retrieval	3.78	lpm

Notes:

SUMMER 07 WEEK 1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 3320 Dublin Toby Spoon JB

Contact Phone # (915) 594-8525

PEM Information

PEM ID # 2
PEM INLET # 2
Calibrated Flow 4.5

Filter Gravimetric Information PS#7 W1#2

	pre-weights		post-weights
1	105.736	1	106.464
2	105.736	2	106.464
3	105.739	3	106.464

Filter Deployment Information

	Date	Time			
Deployment	09/17/07	10:00am	Flow Reading at Deployment	4	lpm
Retrieval	09/24/07	10:00am	Flow Reading at Retrieval	4.12	lpm

Notes:

SUMMER 07 WEEK 1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 3412 Glasgow Maria Mendoza JB

Contact Phone # (915) 217-4102

PEM Information

PEM ID #	3
PEM INLET #	3
Calibrated Flow	4.5

Filter Gravimetric Information PS07w103

	pre-weights		post-weights
1	106.930	1	107.415
2	106.932	2	107.415
3	106.932	3	107.415

Filter Deployment Information

	Date	Time		
Deployment	09/17/07	11:00am	Flow Reading at Deployment	4 lpm
Retrieval	09/24/07	1105am	Flow Reading at Retrieval	3.84 lpm

Notes:

SUMMER 07 WEEK 1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 13113 Thea Smith Pam taggart NG

Contact Phone # (915) 852-8133

PEM Information

PEM ID # 4
PEM INLET # 4
Calibrated Flow 4.5

Filter Gravimetric Information PS87w104

	pre-weights		post-weights
1	114.651	1	115.314
2	114.650	2	115.314
3	114.652	3	115.314

Filter Deployment Information

	Date	Time			
Deployment	09/17/07	5:00pm	Flow Reading at Deployment	4	lpm
Retrieval	09/24/07	5:15 pm	Flow Reading at Retrieval	4	lpm

Notes:

SUMMER07 WEEK 1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 3405 Dundee Sandra Uranga JB

Contact Phone # (915) 599-1958

PEM Information

PEM ID # 5
PEM INLET # 5
Calibrated Flow 4.5

Filter Gravimetric Information Post-Wts

	pre-weights		post-weights
1	117.710	1	117.934
2	117.711	2	117.934
3	117.711	3	117.934

Filter Deployment Information

	Date	Time			
Deployment	09/17/07	4:00pm	Flow Reading at Deployment	4.0	lpm
Retrieval	09/24/07	4:00pm	Flow Reading at Retrieval	3.91	lpm

Notes:

SUMMER 07 WEEK 1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 5208 Jerry Dr Irene Yañez JS

Contact Phone # (915) 755-2437

PEM Information

PEM ID # 6
PEM INLET # 6
Calibrated Flow 4.5

Filter Gravimetric Information PS07w706

	pre-weights		post-weights
1	115.448	1	117.036
2	115.451	2	117.036
3	115.448	3	117.036

Filter Deployment Information

	Date	Time			
Deployment	09/17/07	11:15am	Flow Reading at Deployment	4	lpm
Retrieval	09/24/07	11:00am	Flow Reading at Retrieval	4.08	lpm

Notes:

SUMMER 07 WEEK 1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 5301 Juliandra Ave Georgina Cardona JS

Contact Phone # (915) 757-9503

PEM Information

PEM ID # 7
PEM INLET # 7
Calibrated Flow 4.5

Filter Gravimetric Information PS07W1S7

	pre-weights		post-weights
1	111.617	1	112.297
2	111.620	2	112.297
3	111.619	3	112.297

Filter Deployment Information

	Date	Time		
Deployment	09/17/07	5:00pm	Flow Reading at Deployment	4 lpm
Retrieval	09/24/07	6:00pm	Flow Reading at Retrieval	3.8 lpm

Notes:

SUMMER 07 WEEK 1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 3313 Kircaldy Leanor Stokes JB

Contact Phone # (915) 598-4123

PEM Information

PEM ID # 8
PEM INLET # 8
Calibrated Flow 4.5

Filter Gravimetric Information PS07W108

	pre-weights		post-weights
1	115.809	1	116.671
2	115.809	2	116.671
3	115.810	3	116.671

Filter Deployment Information

	Date	Time			
Deployment	09/17/07	6:00pm	Flow Reading at Deployment	4	lpm
Retrieval	09/24/07	6:15pm	Flow Reading at Retrieval	4	lpm

Notes:

SUMMER 07 WEEK 1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 12501 Angie Bombach Veronica Miranda MG

Contact Phone # (915) 856-3458

PEM Information

PEM ID # 9
PEM INLET # 9
Calibrated Flow 4.5

Filter Gravimetric Information PS07W109

	pre-weights		post-weights
1	114.243	1	114.807
2	114.243	2	114.809
3	114.240	3	114.807

Filter Deployment Information

	Date	Time			
Deployment	09/17/07	5:45 pm	Flow Reading at Deployment	4	lpm
Retrieval	09/24/07	6:00 pm	Flow Reading at Retrieval	3.75	lpm

Notes:

SUMMER07 WEEK 1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 12101 Robert Rivera Renata Parga — MG

Contact Phone # (915) 849-8316

PEM Information

PEM ID #	10
PEM INLET #	10
Calibrated Flow	4.5

Filter Gravimetric Information PS87W110

	pre-weights		post-weights
1	113.594	1	114.640
2	113.595	2	114.640
3	113.593	3	114.640

Filter Deployment Information

	Date	Time			
Deployment	09/17/07	6:15pm	Flow Reading at Deployment	4	lpm
Retrieval	09/24/07	6:45pm	Flow Reading at Retrieval	3.87	lpm

Notes:

SUMMER 07 WEEK 1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 13046 Amherst Maria Ramos MG

Contact Phone # (915) 852-1714

PEM Information

PEM ID # 11
PEM INLET # 11
Calibrated Flow 4.5

Filter Gravimetric Information PS07W111

	pre-weights		post-weights
1	112.856	1	113.460
2	112.854	2	113.460
3	112.854	3	113.460

Filter Deployment Information

	Date	Time		
Deployment	09/17/07	4:30 pm	Flow Reading at Deployment	4 lpm
Retrieval	09/24/07	4:30 pm	Flow Reading at Retrieval	3.62 lpm

Notes:

SUMMER 07 WEEK 1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 1369 Trail Blazer Nora Cuellar JS

Contact Phone # (915) 859-3005

PEM Information

PEM ID # 12
PEM INLET # 12
Calibrated Flow 4.5

Filter Gravimetric Information PS07W12

	pre-weights		post-weights
1	121.038	1	121.591
2	121.034	2	121.591
3	121.036	3	121.591

Filter Deployment Information

	Date	Time			
Deployment	09/17/07	6:30 pm	Flow Reading at Deployment	4	lpm
Retrieval	09/24/07	7:00 pm	Flow Reading at Retrieval	3.6	lpm

Notes:

SUMMER07 WEEK 1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 367 Roslyn Sandra Martinez SS

Contact Phone # (915) 852-8555

PEM Information

PEM ID # 1
PEM INLET # 1
Calibrated Flow 4.5

Filter Gravimetric Information PS07W201

	pre-weights		post-weights
1	105.385	1	105.564
2	105.388	2	105.564
3	105.386	3	105.564

Filter Deployment Information

	Date	Time			
Deployment	09/24/07	10:00 am	Flow Reading at Deployment	4	lpm
Retrieval	10/01/07	10:00 am	Flow Reading at Retrieval	3.80	lpm

Notes:

WEEK 2 SUMMER 07

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 3320 Dublin Toby spoon — JB

Contact Phone # (915) 594-8525

PEM Information

PEM ID #	2
PEM INLET #	2
Calibrated Flow	4.5

Filter Gravimetric Information PSU702Ø2

	pre-weights		post-weights
1	105.744	1	105.756
2	105.742	2	105.756
3	105.741	3	105.756

Filter Deployment Information

	Date	Time		
Deployment	09/24/07	10:00am	Flow Reading at Deployment	4 lpm
Retrieval	10/01/07	10:00am	Flow Reading at Retrieval	4.15 lpm

Notes:

WEEK 2 SUMMER 07

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 3412 Glasgow Maria Mendoza JB

Contact Phone # (915) 217-4102

PEM Information

PEM ID # 3
PEM INLET # 3
Calibrated Flow 4.5

Filter Gravimetric Information PS07w103

	pre-weights		post-weights
1	115.025	1	116.626
2	115.021	2	116.626
3	115.025	3	116.626

Filter Deployment Information

	Date	Time			
Deployment	09/24/07	11:00 am	Flow Reading at Deployment	4	lpm
Retrieval	10/01/07	11:08 am	Flow Reading at Retrieval	3.78	lpm

Notes:

SUMMER 07 WEEK 2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 13113 Thea Smith Pam Taggart MG

Contact Phone # _____

PEM Information

PEM ID # 4
PEM INLET # 4
Calibrated Flow 4.5

Filter Gravimetric Information P887W2864

	pre-weights	post-weights
1	115.739	116.359
2	115.735	116.359
3	115.738	116.359

Filter Deployment Information

	Date	Time		
Deployment	09/24/07	5:15 pm	Flow Reading at Deployment	4 lpm
Retrieval	10/01/07	5:20 pm	Flow Reading at Retrieval	4 lpm

Notes:

SUMMER 07 WEEK 2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 3405 Dondee Sandra Urango JB

Contact Phone # (915) 599-1958

PEM Information

PEM ID # 5
PEM INLET # 5
Calibrated Flow 4.5

Filter Gravimetric Information PS87 W2 DS

	pre-weights		post-weights
1	113.869	1	0
2	113.867	2	0
3	113.868	3	0

Filter Deployment Information

	Date	Time			
Deployment	09/24/07	4:00pm	Flow Reading at Deployment	4	lpm
Retrieval	10/10/07	5:00pm	Flow Reading at Retrieval	3.88	lpm

Notes:

SUMMER 07 WEEK2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 5208 Jerry Dr Irene Yañez — JS

Contact Phone # (915) 755-2137

PEM Information

PEM ID #	6
PEM INLET #	6
Calibrated Flow	4.5

Filter Gravimetric Information PSU7w2U6

	pre-weights		post-weights
1	111.586	1	112.351
2	111.588	2	112.351
3	111.586	3	112.351

Filter Deployment Information

	Date	Time			
Deployment	09/24/07	11:00am	Flow Reading at Deployment	4	lpm
Retrieval	10/01/07	11:00am	Flow Reading at Retrieval	3.78	lpm

Notes:

SUMMER 07 WEEK2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 5301 Julandra Ave Georgina Cardona JS

Contact Phone # (915) 757-9503

PEM Information

PEM ID # 7
PEM INLET # 7
Calibrated Flow 4.5

Filter Gravimetric Information PS07W207

	pre-weights		post-weights
1	112.774	1	112.814
2	112.775	2	112.814
3	112.775	3	112.814

Filter Deployment Information

	Date	Time			
Deployment	09/24/07	6:00pm	Flow Reading at Deployment	4	lpm
Retrieval	10/01/07	5:50pm	Flow Reading at Retrieval	3.72	lpm

Notes:

SUMMER 07 WEEK2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 3313 Kincaldy Leonor Stokes — LB

Contact Phone # (915) 598-4123

PEM Information

PEM ID # 8
PEM INLET # 8
Calibrated Flow 4.5

Filter Gravimetric Information PS87W208

	pre-weights		post-weights
1	113.529	1	114.672
2	113.528	2	114.672
3	113.527	3	114.672

Filter Deployment Information

	Date	Time			
Deployment	09/24/07	6:15pm	Flow Reading at Deployment	4	lpm
Retrieval	10/01/07	6:20pm	Flow Reading at Retrieval	4	lpm

Notes:

SUMMER 07 WEEK 2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 12501 Angie Bombach Veronica Miranda MG

Contact Phone # (915) 856-3458

PEM Information

PEM ID # 9
PEM INLET # 9
Calibrated Flow 4.5

Filter Gravimetric Information PS07W209

	pre-weights		post-weights
1	111.814	1	112.672
2	111.814	2	112.672
3	111.816	3	112.672

Filter Deployment Information

	Date	Time		
Deployment	09/24/07	6:00pm	Flow Reading at Deployment	4 lpm
Retrieval	10/01/07	6:00pm	Flow Reading at Retrieval	3.81 lpm

Notes:

SUMMER 07 WEEK2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 12101 Robert Rivera Renata Parga — MG

Contact Phone # (915) 849-8316

PEM Information

PEM ID #	10
PEM INLET #	10
Calibrated Flow	4.5

Filter Gravimetric Information PS07W210

	pre-weights		post-weights
1	107.008	1	108.682
2	107.008	2	108.682
3	107.008	3	108.682

Filter Deployment Information

	Date	Time			
Deployment	09/24/07	6:45pm	Flow Reading at Deployment	4.0	lpm
Retrieval	10/01/07	6:30pm	Flow Reading at Retrieval	3.67	lpm

Notes:

SUMMER 07 WEEK2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 13046 Amherst Marcel Ramos MG

Contact Phone # (915) 852-1714

PEM Information

PEM ID # 11
PEM INLET # 11
Calibrated Flow 4.5

Filter Gravimetric Information PS87W211

	pre-weights		post-weights
1	111.716	1	112.587
2	111.715	2	112.587
3	111.715	3	112.587

Filter Deployment Information

	Date	Time			
Deployment	9/24/07	4:30pm	Flow Reading at Deployment	4	lpm
Retrieval	10/01/07	4:30pm	Flow Reading at Retrieval	3.80	lpm

Notes:

SUMMER 07 WEEK2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 1369 Trail Blazer Dora Cuellar JS

Contact Phone # (915) 859-3005

PEM Information

PEM ID # 12
PEM INLET # 12
Calibrated Flow 4.5

Filter Gravimetric Information PS07W212

	pre-weights	post-weights
1	112.568	114.712
2	112.569	114.712
3	112.569	114.712

Filter Deployment Information

	Date	Time			
Deployment	09/24/07	7:00pm	Flow Reading at Deployment	4	lpm
Retrieval	10/01/07	7:00pm	Flow Reading at Retrieval	3.716	lpm

Notes:

SUMMER 07 WEEK 2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 367 Roselyn Sandra Martinez MG

Contact Phone # (915) 852-8555

PEM Information

PEM ID # 1
PEM INLET # 1
Calibrated Flow 4.5

Filter Gravimetric Information Pw07w1001

	pre-weights		post-weights
1	105.120	1	106.089
2	105.109	2	106.089
3	105.123	3	106.084

Filter Deployment Information

	Date	Time		
Deployment	02/02/07	5:15pm	Flow Reading at Deployment	4 lpm
Retrieval	02/09/07	5:10pm	Flow Reading at Retrieval	3.89 lpm

Notes:

WINTER 07 WEEK 1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 13074 Amherst Matilde Hernandez MG

Contact Phone # (915) 852-2163

PEM Information

PEM ID #	2
PEM INLET #	2
Calibrated Flow	4.5

Filter Gravimetric Information Pw07w1002

	pre-weights		post-weights
1	92.210	1	93.762
2	92.226	2	93.764
3	92.221	3	93.761

Filter Deployment Information

	Date	Time			
Deployment	02/02/07	5:45pm	Flow Reading at Deployment	4	lpm
Retrieval	02/09/07	5:45 pm	Flow Reading at Retrieval	3.5	lpm

Notes:

WINTER 07 WEEK 1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 3412 Glasgow Maria Mendoza JB

Contact Phone # (915) 217-4102

PEM Information

PEM ID # 3
PEM INLET # 3
Calibrated Flow 4.5

Filter Gravimetric Information PW07W103

	pre-weights		post-weights
1	95.877	1	96.171
2	95.874	2	96.168
3	95.886	3	96.169

Filter Deployment Information

	Date	Time			
Deployment	02/02/07	11:00am	Flow Reading at Deployment	4	lpm
Retrieval	02/09/07	11:15am	Flow Reading at Retrieval	3.94	lpm

Notes:

WINTER 07 WEEK 1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 13113 Thea Smith Pam taggart JB

Contact Phone # (915) 852-8133

PEM Information

PEM ID # 4
PEM INLET # 4
Calibrated Flow 4.5

Filter Gravimetric Information Pw67w184

	pre-weights		post-weights
1	98.663	1	99.188
2	98.673	2	99.184
3	98.673	3	99.178

Filter Deployment Information

	Date	Time		
Deployment	02/02/07	3:00pm	Flow Reading at Deployment	4.0 lpm
Retrieval	02/09/07	3:04 pm	Flow Reading at Retrieval	3.91 lpm

Notes:

WINTER 07 WEEK 1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 3405 Dundee Sandra Granger JB

Contact Phone # (915) 599-1958

PEM Information

PEM ID # 5
PEM INLET # 5
Calibrated Flow 4.5

Filter Gravimetric Information Pw07w05

	pre-weights		post-weights
1	94.138	1	94.824
2	94.143	2	94.821
3	94.146	3	94.823

Filter Deployment Information

	Date	Time		
Deployment	02/02/07	10:30	Flow Reading at Deployment	4 lpm
Retrieval	02/09/07	10:24	Flow Reading at Retrieval	3.78 lpm

Notes:

WINTER07 WEEK1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 5208 Jerry Dr Irene Yañez JS

Contact Phone # (915) 755-2137

PEM Information

PEM ID # 6
PEM INLET # 6
Calibrated Flow 4.5

Filter Gravimetric Information Pw07w106

	pre-weights		post-weights
1	94.697	1	95.407
2	94.709	2	95.406
3	94.699	3	95.406

Filter Deployment Information

	Date	Time		
Deployment	02/02/07	11:20	Flow Reading at Deployment	4 lpm
Retrieval	02/09/07	11:25	Flow Reading at Retrieval	3.73 lpm

Notes:

WINTER07WEEK1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

		Initials
Home Address	5301 Julandra Ave. Georgina Cardona	JS
Contact Phone #	(915) 757-9503	

PEM Information

PEM ID #	7
PEM INLET #	7
Calibrated Flow	4.5

Filter Gravimetric Information PW07W107

	pre-weights		post-weights
1	98.630	1	99.453
2	98.635	2	99.456
3	98.627	3	99.453

Filter Deployment Information

	Date	Time		
Deployment	02/02/07	5:00pm	Flow Reading at Deployment	4 lpm
Retrieval	02/09/07	5:30 pm	Flow Reading at Retrieval	3.98 lpm

Notes:

WINTER07 WEEK1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 12801 Angie Bombach Veronica Miranda MG

Contact Phone # (915) 856-3458

PEM Information

PEM ID # 8
PEM INLET # 8
Calibrated Flow 4.5

Filter Gravimetric Information Pw07w108

	pre-weights		post-weights
1	96.822	1	97.770
2	96.815	2	97.769
3	96.819	3	97.767

Filter Deployment Information

	Date	Time		
Deployment	02/02/07	6:30pm	Flow Reading at Deployment	4 lpm
Retrieval	02/09/07	6:33pm	Flow Reading at Retrieval	4.18 lpm

Notes:

WINTER 07 WEEK 1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 13091 Ben Gurion Maria Morales NG

Contact Phone # (915) 922-9753

PEM Information

PEM ID # 9
PEM INLET # 9
Calibrated Flow 4.5

Filter Gravimetric Information Pw87w109

	pre-weights		post-weights
1	102.311	1	105.612
2	102.308	2	105.613
3	102.305	3	105.614

Filter Deployment Information

	Date	Time		
Deployment	02/02/07	10:00am	Flow Reading at Deployment	4 lpm
Retrieval	02/09/07	10:00am	Flow Reading at Retrieval	4.13 lpm

Notes:

WINTER 07 WEEK 1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 12101 Robert Rivera Renata Parga — MG

Contact Phone # (915) 849-8316

PEM Information

PEM ID #	10
PEM INLET #	10
Calibrated Flow	4.5

Filter Gravimetric Information Pw07w10

	pre-weights		post-weights
1	100.339	1	100.814
2	100.349	2	100.817
3	100.357	3	100.812

Filter Deployment Information

	Date	Time			
Deployment	02/02/07	7:00pm	Flow Reading at Deployment	4	lpm
Retrieval	02/09/07	7:05 pm	Flow Reading at Retrieval	4.21	lpm

Notes:

WINTER 07 WEEK 1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 13046 Amherst Maria Ramos — MR

Contact Phone # (915) 852-1714

PEM Information

PEM ID #	11
PEM INLET #	11
Calibrated Flow	4.5

Filter Gravimetric Information Pw#7to11

	pre-weights		post-weights
1	96.630	1	98.478
2	96.632	2	98.476
3	96.622	3	98.477

Filter Deployment Information

	Date	Time			
Deployment	02/02/07	12:15	Flow Reading at Deployment	4	lpm
Retrieval	02/09/07	12:30	Flow Reading at Retrieval	3.67	lpm

Notes:

WINTER 07 WEEK 1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 1369 Trail Blazer Dora Geller NG

Contact Phone # (915) 859-3005

PEM Information

PEM ID # 12
PEM INLET # 12
Calibrated Flow 4.5

Filter Gravimetric Information Pw0702112

	pre-weights		post-weights
1	100.505	1	101.059
2	100.505	2	101.060
3	100.503	3	101.059

Filter Deployment Information

	Date	Time		
Deployment	02/02/07	5:30 pm	Flow Reading at Deployment	4 lpm
Retrieval	02/09/07	5:25 pm	Flow Reading at Retrieval	3.79 lpm

Notes:

WINTER 07 WEEK 1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 367 Roselyn Sandra Martinez MG

Contact Phone # (915) 852-8555

PEM Information

PEM ID # 1
PEM INLET # 1
Calibrated Flow 4.5

Filter Gravimetric Information Pw07w2Φ1

	pre-weights		post-weights
1	117.621	1	117.734
2	117.620	2	117.728
3	117.619	3	117.724

Filter Deployment Information

	Date	Time		
Deployment	02/09/07	5:10pm	Flow Reading at Deployment	4 lpm
Retrieval	02/16/07	5:20	Flow Reading at Retrieval	4.125 lpm

Notes:

WINTER 07 WEEK 2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 13074 Amherst Matilde Hernandez MG

Contact Phone # (915) 852-2163

PEM Information

PEM ID #	2
PEM INLET #	2
Calibrated Flow	4.5

Filter Gravimetric Information PW87W2C2

	pre-weights		post-weights
1	118.321	1	118.545
2	118.320	2	118.554
3	118.328	3	118.546

Filter Deployment Information

	Date	Time		
Deployment	02/09/07	5:45 pm	Flow Reading at Deployment	4 lpm
Retrieval	02/16/07	5:30 pm	Flow Reading at Retrieval	3.73 lpm

Notes:

WINTER07 WEEK2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

		Initials
Home Address	3412 Glasgow Maria Mendoza	JB
Contact Phone #	(915) 217-4102	

PEM Information

PEM ID #	3
PEM INLET #	3
Calibrated Flow	4.5

Filter Gravimetric Information PW07W203

	pre-weights		post-weights
1	120.790	1	121.729
2	120.795	2	121.730
3	120.791	3	121.732

Filter Deployment Information

	Date	Time		
Deployment	02/09/07	11:15am	Flow Reading at Deployment	4 lpm
Retrieval	02/16/07	11:15am	Flow Reading at Retrieval	3.86 lpm

Notes:

WINTER 07 WEEK 2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 13113 Thea Smith Pam taggart — JB

Contact Phone # (915) 852-8133

PEM Information

PEM ID #	4
PEM INLET #	4
Calibrated Flow	4.5

Filter Gravimetric Information Pw07w2Q4

	pre-weights		post-weights
1	111.104	1	111.991
2	111.108	2	111.986
3	111.108	3	111.985

Filter Deployment Information

	Date	Time			
Deployment	02/09/07	3:04pm	Flow Reading at Deployment	4	lpm
Retrieval	02/16/07	3:00pm	Flow Reading at Retrieval	4.083	lpm

Notes:

WINTER 07 WEEK 2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 3405 Dundee sandra Uranga JB

Contact Phone # (915) 599-1958

PEM Information

PEM ID # 5
PEM INLET # 5
Calibrated Flow 4.5

Filter Gravimetric Information fw07 w208

	pre-weights		post-weights
1	107.746	1	108.276
2	107.739	2	108.280
3	107.744	3	108.283

Filter Deployment Information

	Date	Time			
Deployment	02/09/07	10:30 am	Flow Reading at Deployment	4	lpm
Retrieval	02/16/07	10:30 am	Flow Reading at Retrieval	3.76	lpm

Notes:

WINTER 07 WEEK 2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 5208 Jerry Dr Irene Yañez JS

Contact Phone # (915) 755-2137

PEM Information

PEM ID # 6
PEM INLET # 6
Calibrated Flow 4.5

Filter Gravimetric Information Pw87w286

	pre-weights		post-weights
1	104.271	1	105.181
2	104.275	2	105.175
3	104.271	3	105.176

Filter Deployment Information

	Date	Time		
Deployment	02/09/07	11:20 am	Flow Reading at Deployment	4 lpm
Retrieval	02/16/07	11:22 am	Flow Reading at Retrieval	3.75 lpm

Notes:

WINTER 07 WEEK 2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 5301 Jolandra Ave Georgina Cardona JS

Contact Phone # (915) 757-9503

PEM Information

PEM ID #	7
PEM INLET #	7
Calibrated Flow	4.5

Filter Gravimetric Information PW07 W2@7

	pre-weights		post-weights
1	108.278	1	109.711
2	108.283	2	109.709
3	108.289	3	109.713

Filter Deployment Information

	Date	Time			
Deployment	02/09/07	5:30pm	Flow Reading at Deployment	4	lpm
Retrieval	02/16/07	5:00pm	Flow Reading at Retrieval	3.93	lpm

Notes:

WINTER07 WEEK2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 12501 Angie Bombach Veronica Miranda MG

Contact Phone # (915) 856-3458

PEM Information

PEM ID # 8
PEM INLET # 8
Calibrated Flow 4.5

Filter Gravimetric Information Pw#7 w2#8

	pre-weights		post-weights
1	105.768	1	106.332
2	105.762	2	106.334
3	105.755	3	106.331

Filter Deployment Information

	Date	Time		
Deployment	02/09/07	6:30pm	Flow Reading at Deployment	4 lpm
Retrieval	02/16/07	6:30pm	Flow Reading at Retrieval	4.22 lpm

Notes:

WINTER 07 WEEK2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 13091 Ben Gurion Maria Morales NG

Contact Phone # (915) 922-9753

PEM Information

PEM ID # 9
PEM INLET # 9
Calibrated Flow 4.5

Filter Gravimetric Information Pw67w209

	pre-weights		post-weights
1	104.578	1	108.329
2	104.579	2	108.320
3	104.578	3	108.318

Filter Deployment Information

	Date	Time			
Deployment	02/09/07	10:00 am	Flow Reading at Deployment	4	lpm
Retrieval	02/16/07	10:08am	Flow Reading at Retrieval	4.035	lpm

Notes:

WINTER07 WEEK2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 12101 Robert Rivera Renata Arga — MG

Contact Phone # (915) 849-8316

PEM Information

PEM ID #	10
PEM INLET #	10
Calibrated Flow	4.5

Filter Gravimetric Information PW87W21Φ

	pre-weights		post-weights
1	109.480	1	109.994
2	109.485	2	109.989
3	109.485	3	109.993

Filter Deployment Information

	Date	Time		
Deployment	02/09/07	7:05pm	Flow Reading at Deployment	4 lpm
Retrieval	02/16/07	7:00pm	Flow Reading at Retrieval	4.03 lpm

Notes:

WINTER 07 WEEK 2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 13046 Amhurst Maria Ramos NG

Contact Phone # (915) 852-1714

PEM Information

PEM ID #	11
PEM INLET #	11
Calibrated Flow	4.5

Filter Gravimetric Information Pw07w211

	pre-weights		post-weights
1	109.077	1	110.088
2	109.078	2	110.090
3	109.083	3	110.084

Filter Deployment Information

	Date	Time			
Deployment	02/09/07	12:30pm	Flow Reading at Deployment	4	lpm
Retrieval	02/16/07	12:30pm	Flow Reading at Retrieval	3.74	lpm

Notes:

WINTER07 WEEK2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 1369 Trail Blazer Nora Cuelier NG

Contact Phone # (915) 859-3005

PEM Information

PEM ID # 12
PEM INLET # 12
Calibrated Flow 4.5

Filter Gravimetric Information PwGTw212

	pre-weights		post-weights
1	92.941	1	93.030
2	92.942	2	93.026
3	92.934	3	93.030

Filter Deployment Information

	Date	Time			
Deployment	02/09/07	5:30pm	Flow Reading at Deployment	4	lpm
Retrieval	02/16/07	5:00pm	Flow Reading at Retrieval	4.127	lpm

Notes:

WINTER07 WEEK 2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address Alma Rosa Avalos 8181 Starr Ave. MG

Contact Phone # 860-1378, 449-8952 Cell

PEM Information

PEM ID # Pako pump 1
PEM INLET # 4
Calibrated Flow 4

Filter Gravimetric Information PS08 WK #1

	pre-weights	post-weights
1	105.864	106.844
2	105.866	106.847
3	105.862	106.838

Filter Deployment Information

	Date	Time		
Deployment	06/16/08	6:35	Flow Reading at Deployment	4 lpm
Retrieval	06/23/08	6:03	Flow Reading at Retrieval	3.88 lpm

Notes:

SUMMER 08 WK1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address Blanca Miranda 318 Bernadine ML

Contact Phone # 778-2598

PEM Information

PEM ID # Paho Pump 2
PEM INLET # 14
Calibrated Flow 4

Filter Gravimetric Information PS08 WK02

	pre-weights		post-weights
1	104.789	1	106.635
2	104.795	2	106.638
3	104.797	3	106.639

Filter Deployment Information

	Date	Time		
Deployment	06/16/08	11:15	Flow Reading at Deployment	4 lpm
Retrieval	06/23/08	10:45	Flow Reading at Retrieval	3.672 lpm

Notes:

SUMMER 08 WK1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address Esmeralda Flores Palm 46 SE

Contact Phone # 820-5405 Amit

PEM Information

PEM ID # Paho Pump 3
PEM INLET # 6
Calibrated Flow 4

Filter Gravimetric Information PS 08 w/#3

	pre-weights	post-weights
1	115.898	117.019
2	115.890	117.020
3	115.898	117.029

Filter Deployment Information

	Date	Time			
Deployment	06/16/08	4:58 pm	Flow Reading at Deployment	4.178	lpm
Retrieval	06/23/08	5.43 pm	Flow Reading at Retrieval	3865	lpm

Notes:

Everything went well!

SUMMER 08 W/C1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address Judy Moreland 624 E. University MG

Contact Phone # 351-1244, 525-0801 Amit

PEM Information

PEM ID # Pahopump 4
PEM INLET # 9
Calibrated Flow 4

Filter Gravimetric Information PS 08 W1 04

	pre-weights	post-weights
1	112.523	113.353
2	112.500	113.348
3	112.501	113.351

Filter Deployment Information

	Date	Time		
Deployment	06/16/08	4:10	Flow Reading at Deployment	4 lpm
Retrieval	06/23/08	5:06 pm	Flow Reading at Retrieval	3.963 lpm

Notes:

Everything was functioning well

SUMMER 08 WK1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address Martha Montañez 1016 S. Saint Vrain SE

Contact Phone # 544-1722 Initials

PEM Information

PEM ID # Paho Pump 5
PEM INLET # 11
Calibrated Flow 4

Filter Gravimetric Information PS08 W1 #5

	pre-weights	post-weights
1	111.636	112.755
2	111.636	112.746
3	111.637	112.752

Filter Deployment Information

	Date	Time		
Deployment	06/16/08	5:35	Flow Reading at Deployment	4.121 lpm
Retrieval	06/23/08	6:20	Flow Reading at Retrieval	3.873 lpm

Notes:

Everything is OK!

SUMMER 08 WK 1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address BERTHA FLORES 1001 Tays MG

Contact Phone # 543-6008, 274-7489

PEM Information

PEM ID # Paho Pump 6
PEM INLET # 3
Calibrated Flow 4

Filter Gravimetric Information PS 05 W1 06

	pre-weights	post-weights
1	113.313	114.433
2	113.317	114.424
3	113.313	114.424

Filter Deployment Information

	Date	Time		
Deployment	06/16/08	9:00	Flow Reading at Deployment	4.024 lpm
Retrieval	06/23/08	9:00	Flow Reading at Retrieval	3.84 lpm

Notes:

SUMMER 08 WK1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address Guadalupe Flores 5709 Pikes peak ML

Contact Phone # 755-0640

PEM Information

PEM ID # Paho Pump 7
PEM INLET # 8
Calibrated Flow 4

Filter Gravimetric Information PS 08 W1 07

	pre-weights	post-weights
1	110.711	111.363
2	110.718	111.354
3	110.713	111.353

Filter Deployment Information

	Date	Time		
Deployment	06/16/08	10:30	Flow Reading at Deployment	4 lpm
Retrieval	06/23/08	10:00	Flow Reading at Retrieval	3.873 lpm

Notes:

SUMMER 08 WK1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address Rita Alvarado 8956 Natterhan — MG

Contact Phone # 757-3240

PEM Information

PEM ID # Paho Pump 8
PEM INLET # 2
Calibrated Flow 4

Filter Gravimetric Information PS 08 WI 08

	pre-weights		post-weights
1	108.460	1	109.180
2	108.454	2	109.181
3	108.461	3	109.180

Filter Deployment Information

	Date	Time		
Deployment	06/16/08	7:23	Flow Reading at Deployment	4 lpm
Retrieval	06/23/08	6:36	Flow Reading at Retrieval	5:89 lpm

Notes:

SUMMER 08 MK1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address Lourdes Mejilla 8104 Norte ML

Contact Phone # 759-0542

PEM Information

PEM ID # Paho Pump 9
PEM INLET # 1
Calibrated Flow 4

Filter Gravimetric Information PS08 Wk9

	pre-weights		post-weights
1	108.794	1	109.689
2	108.789	2	109.683
3	108.788	3	109.681

Filter Deployment Information

	Date	Time		
Deployment	06/16/08	10:35	Flow Reading at Deployment	4 lpm
Retrieval	06/23/08	10:30	Flow Reading at Retrieval	4.016 lpm

Notes:

SUMMER08 WK1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address Kenia Santillan 5041 Vulcan MG

Contact Phone # 757-8995

PEM Information

PEM ID # Paho Pump 16
PEM INLET # 15
Calibrated Flow 4

Filter Gravimetric Information P508 W! 16

	pre-weights		post-weights
1	115.339	1	116.008
2	115.341	2	116.008
3	115.337	3	116.006

Filter Deployment Information

	Date	Time			
Deployment	06/16/08	8:20	Flow Reading at Deployment	4	lpm
Retrieval	06/24/08	10:00	Flow Reading at Retrieval	3.91	lpm

Notes:

SUMMER 08 WK1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address Yolanda Hernandez 9085 Mount Shasta MG

Contact Phone # 757- 9781

PEM Information

PEM ID # Paho Pump 11
PEM INLET # 10
Calibrated Flow 4

Filter Gravimetric Information PS 08 wi II

	pre-weights		post-weights
1	108.387	1	109.283
2	108.395	2	109.291
3	108.392	3	109.286

Filter Deployment Information

	Date	Time		
Deployment	06/16/08	7:10	Flow Reading at Deployment	4 lpm
Retrieval	06/23/08	6:46	Flow Reading at Retrieval	3.72 lpm

Notes:

SUMMER 08 WK1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address Rosalba Ramirez 9957 Honey Locust ML

Contact Phone # 759-8659

PEM Information

PEM ID # Paho pump12
PEM INLET # 12
Calibrated Flow 4

Filter Gravimetric Information PS08W12

	pre-weights		post-weights
1	91.446	1	92.439
2	91.447	2	92.435
3	91.442	3	92.433

Filter Deployment Information

	Date	Time		
Deployment	06/10/08	12:15	Flow Reading at Deployment	4 lpm
Retrieval	06/23/08	12:00	Flow Reading at Retrieval	4.031 lpm

Notes:

SUMMER 08 WK1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address Alma Rosa Avalos 8181 starr Ave. MG

Contact Phone # 860-1378 449-8952

PEM Information

PEM ID # Paho Pump 1
PEM INLET # 4
Calibrated Flow 4

Filter Gravimetric Information PS08W201

	pre-weights		post-weights
1	102.262	1	103.652
2	102.259	2	103.656
3	102.261	3	103.657

Filter Deployment Information

	Date	Time		
Deployment	06/23/08	6:08	Flow Reading at Deployment	4.02 lpm
Retrieval	06/30/08	6:06	Flow Reading at Retrieval	3.82 lpm

Notes:

filtro es el PS08W201

SUMMER 08 WK2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address Blanca Miranda 318 Bernadine ML

Contact Phone # 778-2598

PEM Information

PEM ID # Paho Pump 2
PEM INLET # 14
Calibrated Flow 4

Filter Gravimetric Information PSU8W202

	pre-weights		post-weights
1	102.312	1	103.195
2	102.310	2	103.192
3	102.313	3	103.198

Filter Deployment Information

	Date	Time			
Deployment	6/23/08	10:45	Flow Reading at Deployment	4	lpm
Retrieval	06/30/08	10:50	Flow Reading at Retrieval	4.055	lpm

Notes:

SUMMER 08 WK2

Week #2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address Esmeralda Flores Palm 46 SE

Contact Phone # 820-5405

PEM Information

PEM ID # Paho Pump 3
PEM INLET # 6
Calibrated Flow 4

Filter Gravimetric Information PS08W203

	pre-weights		post-weights
1	100.488	1	101.521
2	100.470	2	101.529
3	100.499	3	101.519

Filter Deployment Information

	Date	Time		
Deployment	5:46pm	June 23' 08	Flow Reading at Deployment	3.994 lpm
Retrieval	4:46pm	June 30 08	Flow Reading at Retrieval	3.787 lpm

Notes:

Everything went fine — Amit

SUMMER 08 WK2

Week 2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address Jody Moreland 624 E. University SE

Contact Phone # 351-1244, 525-0801 Anne

PEM Information

PEM ID # Paho Pump 4
PEM INLET # 9
Calibrated Flow 4

Filter Gravimetric Information PS08W204

	pre-weights		post-weights
1	96.016	1	96.507
2	96.026	2	96.506
3	96.017	3	96.508

Filter Deployment Information

	Date	Time		
Deployment	06/23/08	5.15pm	Flow Reading at Deployment	3.968 3998 lpm
Retrieval	06/30/08	4.20pm	Flow Reading at Retrieval	3.875 lpm

Notes:

everything was okie.

- Anne

SUMMER 08 WK2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address Martha Montañez 1016 S. saint Vrain SE

Contact Phone # 544-1722 Amit

PEM Information

PEM ID # Palo Pump 5
PEM INLET # 11
Calibrated Flow 4

Filter Gravimetric Information P508 w205

	pre-weights		post-weights
1	98.174	1	99.034
2	98.174	2	99.030
3	98.175	3	99.038

Filter Deployment Information

	Date	Time		
Deployment	6-23-08	6:27pm	Flow Reading at Deployment	4.022 lpm
Retrieval	07/01/08	9:00 am	Flow Reading at Retrieval	3.921 lpm

Notes:

SUMMER 08 WK 2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address Bertha flores 1001 Tays — MG

Contact Phone # 843-6008 274-7489

PEM Information

PEM ID # Palo pump 6
PEM INLET # 3
Calibrated Flow 4

Filter Gravimetric Information PS08w206

	pre-weights		post-weights
1	116.611	1	117.548
2	116.613	2	117.547
3	116.606	3	117.541

Filter Deployment Information

	Date	Time		
Deployment	06/23/08	9:30	Flow Reading at Deployment	4.063 lpm
Retrieval	6/30/08	8:46	Flow Reading at Retrieval	4.133 lpm

Notes:

SUMMER 08 WK 2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address Guadalupe Flores 5109 Pikes Peak ML

Contact Phone # 755-0640

PEM Information

PEM ID # Pgho Pump 7
PEM INLET # 8
Calibrated Flow 4

Filter Gravimetric Information Pg08w207

	pre-weights		post-weights
1	125.188	1	125.863
2	125.192	2	125.867
3	125.191	3	125.862

Filter Deployment Information

	Date	Time		
Deployment	06/23/08	10:00	Flow Reading at Deployment	4 lpm
Retrieval	6/30/08	10:00	Flow Reading at Retrieval	4.208 lpm

Notes:

SUMMER 08 WK2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address Rita Alvarado 8956 Matterhorn MG

Contact Phone # 757-3240

PEM Information

PEM ID # Palo Pump 8
PEM INLET # 2
Calibrated Flow 4

Filter Gravimetric Information PS08W208

	pre-weights		post-weights
1	109.391	1	110.069
2	109.398	2	110.068
3	109.396	3	110.065

Filter Deployment Information

	Date	Time		
Deployment	06/23/08	6:40pm	Flow Reading at Deployment	4.127/4.52 lpm
Retrieval	06/30/08	6:45pm	Flow Reading at Retrieval	4.512 lpm

Notes:

SUMMER 08 WK2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

		Initials
Home Address	Lourdes Mejilla 8104 Norte	ML
Contact Phone #	759-0542	

PEM Information

PEM ID #	Polo Pump 9
PEM INLET #	1
Calibrated Flow	4

Filter Gravimetric Information PS08W209

	pre-weights		post-weights
1	112.972	1	114.108
2	112.963	2	114.101
3	112.969	3	114.101

Filter Deployment Information

	Date	Time		
Deployment	06/23/08	10:30	Flow Reading at Deployment	4 lpm
Retrieval	6/30/08	10:30	Flow Reading at Retrieval	3.832 lpm

Notes:

SUMMER 08 WK2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address Kenia santillan 5041 vulcan — MG

Contact Phone # 757-8995

PEM Information

PEM ID # Paho Pump 10
PEM INLET # 15
Calibrated Flow 4

Filter Gravimetric Information PS08W210

	pre-weights	post-weights
1	100.900	101.131
2	100.899	101.134
3	100.890	101.138

Filter Deployment Information

	Date	Time		
Deployment	06/24/08	10:15	Flow Reading at Deployment	4.023 lpm
Retrieval	06/30/08	7:00	Flow Reading at Retrieval	3.606 lpm

Notes:

SUMMER08 WK2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address Yolanda Hernandez 9025 Mount shasta MG

Contact Phone # 757-9781

PEM Information

PEM ID # Paho Pump 11
PEM INLET # 10
Calibrated Flow 4

Filter Gravimetric Information PS8W211

	pre-weights		post-weights
1	122.336	1	123.479
2	122.339	2	123.471
3	122.340	3	123.476

Filter Deployment Information

	Date	Time		
Deployment	06/23/08	6:51	Flow Reading at Deployment	4.089 lpm
Retrieval	06/30/08	6:36	Flow Reading at Retrieval	3.872 lpm

Notes:

SUMMER 08 WK 2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address Rosalba Ramirez 9957 Honey locust ML

Contact Phone # 759-8659

PEM Information

PEM ID # Palo Pump 12
PEM INLET # 12
Calibrated Flow 4

Filter Gravimetric Information P#08W212

	pre-weights		post-weights
1	114.924	1	115.570
2	114.925	2	115.566
3	114.924	3	115.576

Filter Deployment Information

	Date	Time			
Deployment	06/23/08	12:00	Flow Reading at Deployment	4	lpm
Retrieval	06/30/08	12:00	Flow Reading at Retrieval	3.691	lpm

Notes:

SUMMER 08 WK 2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 9025 Mount shasta JS

Contact Phone # Yolanda Hernandez 759-9781

PEM Information

PEM ID # 9
PEM INLET # inlet 10
Calibrated Flow 4

Filter Gravimetric Information PW08W101

	pre-weights		post-weights
1	109.501	1	109.868
2	109.505	2	109.869
3	109.505	3	109.870

Filter Deployment Information

	Date	Time			
Deployment	02/29/08	10:00	Flow Reading at Deployment	4	lpm
Retrieval	03/07/08	10:55	Flow Reading at Retrieval	4	lpm

Notes:
Machine was turned off, counter was found at 0092 (03/07/08)

WINTER08 WK1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 6811 Delta Apt 317 VG

Contact Phone # Hector Becerra 771-0251

PEM Information

PEM ID #	3
PEM INLET #	15
Calibrated Flow	4

Filter Gravimetric Information Pw68w102

	pre-weights		post-weights
1	111.454	1	111.308
2	111.454	2	111.301
3	111.451	3	111.306

Filter Deployment Information

	Date	Time		
Deployment	02/29/08	9:45am	Flow Reading at Deployment	4 lpm
Retrieval	03/08/08	8:59 am	Flow Reading at Retrieval	4 lpm

Notes:

03/07/08 @ night around 11pm it appear with a flow fault @ 408 minutes in the 1408

WINTER08 WK1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 8956 Matterhorn — JS

Contact Phone # Rita Alvarado 757-3240

PEM Information

PEM ID #	1
PEM INLET #	11
Calibrated Flow	4.025

Filter Gravimetric Information PW08W103

	pre-weights		post-weights
1	111.388	1	110.843
2	111.391	2	110.841
3	111.391	3	110.845

Filter Deployment Information

	Date	Time			
Deployment	02/29/08	19:03	Flow Reading at Deployment	4.025	lpm
Retrieval	03/01/08	6:11	Flow Reading at Retrieval		lpm

Notes:

wednesday PEM was accidentally unplugged

WINTER08WK1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 5109 Pikes Peak JS

Contact Phone # Guadalupe Flores 755-0640

PEM Information

PEM ID #	2
PEM INLET #	6
Calibrated Flow	4.054

Filter Gravimetric Information Pw68w104

	pre-weights		post-weights
1	115.133	1	115.934
2	115.128	2	115.931
3	115.134	3	115.930

Filter Deployment Information

	Date	Time			
Deployment	02/29/08	6:42 pm	Flow Reading at Deployment	4.054	lpm
Retrieval	03/07/08	6:01 pm	Flow Reading at Retrieval		lpm

Notes:

WINTER 08 NKI

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address Palm 46 MG

Contact Phone # Esmeralda Flores 820-5405

PEM Information

PEM ID #	3
PEM INLET #	3
Calibrated Flow	4.017

Filter Gravimetric Information Pw88w105

	pre-weights		post-weights
1	117.821	1	118.613
2	117.818	2	118.610
3	117.812	3	118.607

Filter Deployment Information

	Date	Time			
Deployment	02/29/08	5:46 pm	Flow Reading at Deployment	4.017	lpm
Retrieval	03/07/08	5:31 pm	Flow Reading at Retrieval w/filter old / w/new filter	4.029	lpm

Notes:

WINTER08 WK1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 624 E. University MG

Contact Phone # 351-1244 , 525-0801

PEM Information

PEM ID #	4
PEM INLET #	1
Calibrated Flow	4.031

Filter Gravimetric Information PW88W106

	pre-weights		post-weights
1	117.440	1	117.777
2	117.441	2	117.777
3	117.441	3	117.780

Filter Deployment Information

	Date	Time		
Deployment	02/29/08	3:38 pm	Flow Reading at Deployment	4.031 lpm
Retrieval	03/07/08	11:06 am	Flow Reading at Retrieval	3.974 lpm

w/ filter (cold)
w/ filter (new) 4.238

Notes:

WINTER 08 WK1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 1001 Tays — MG

Contact Phone # Bertha Flores 543-6008 274-7489

PEM Information

PEM ID # 5
PEM INLET #
Calibrated Flow 4.047

Filter Gravimetric Information Pw@8w107

	pre-weights		post-weights
1	119.162	1	119.802
2	119.161	2	119.798
3	119.153	3	119.800

Filter Deployment Information

	Date	Time			
Deployment	02/29/08	2:30	Flow Reading at Deployment	4.047	lpm
Retrieval	03/07/08	1:47	Flow Reading at Retrieval	4.060	lpm

Notes:

WINTER08 WK1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 2302 campbell — MG

Contact Phone # Monica Cisneros 532-3135, 525-5989

PEM Information

PEM ID #	10
PEM INLET #	8
Calibrated Flow	4.5

Filter Gravimetric Information Pw#8w1#8

	pre-weights		post-weights
1	113.125	1	114.165
2	113.132	2	114.162
3	113.126	3	114.158

Filter Deployment Information

	Date	Time			
Deployment	02/29/08	4:00 pm	Flow Reading at Deployment	4.5	lpm
Retrieval	03/07/08	1:20 pm	Flow Reading at Retrieval	4.5	lpm

Notes:

counter 9935

WINTER08 WK1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 804 Norte — JS

Contact Phone # Lourdes Mejilla 759-0542

PEM Information

PEM ID # 14
PEM INLET #
Calibrated Flow 4.8

Filter Gravimetric Information Pw88w189

	pre-weights	post-weights
1	112.164	113.373
2	112.164	113.372
3	112.163	113.362

Filter Deployment Information

	Date	Time		
Deployment	02/29/08	14:39	Flow Reading at Deployment	4 lpm
Retrieval			Flow Reading at Retrieval	lpm

Notes:

WINTER08 WK1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 8008 Sun Dial — VG

Contact Phone # Barbara Paradis 313-5517

PEM Information

PEM ID #	1
PEM INLET #	2
Calibrated Flow	4.75

Filter Gravimetric Information Pw08w11b

	pre-weights		post-weights
1	108.245	1	109.366
2	108.240	2	109.369
3	108.250	3	109.374

Filter Deployment Information

	Date	Time		
Deployment	2/29/08	5:29 pm	Flow Reading at Deployment	4.75 lpm
Retrieval	03/07/08	10:19 am	Flow Reading at Retrieval	4.75 lpm

Notes:

counter 9662

WINTER 08 WK1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 318 Bernadine — VG

Contact Phone # Blanca Miranda 778-2598 —

PEM Information

PEM ID # 15
PEM INLET # 4
Calibrated Flow 4.6

Filter Gravimetric Information PW8W711

	pre-weights		post-weights
1	109.240	1	110.777
2	109.244	2	110.773
3	109.244	3	110.767

Filter Deployment Information

	Date	Time		
Deployment	03/01/08	11:24 am	Flow Reading at Deployment	4.6 lpm
Retrieval	03/08/08	10:01 am	Flow Reading at Retrieval	4 lpm

Notes:
Counter 8564

WINTER08WK1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 8351 white VG

Contact Phone # Sandra Perez 858-9615

PEM Information

PEM ID # 7
PEM INLET # 9
Calibrated Flow 4

Filter Gravimetric Information P w58w112

	pre-weights		post-weights
1	116.293	1	117.644
2	116.301	2	117.639
3	116.295	3	117.634

Filter Deployment Information

	Date	Time		
Deployment	2/29/08	5:49	Flow Reading at Deployment	4 lpm
Retrieval	3/08/08	9:29 am	Flow Reading at Retrieval	3.75 lpm

Notes:

PEM 7 was change for PEM 17 at 6:05 pm on 3/08/08 it had a counter display so flow was left at 3.99l

WINTER 08 WK1

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 8104 Norte JS

Contact Phone # 759-0542 Lourdes Mejia

PEM Information

PEM ID # 14
PEM INLET # 12
Calibrated Flow

Filter Gravimetric Information PW 08 W2 #1

	pre-weights	post-weights
1	118.435	119.776
2	118.429	119.771
3	118.431	119.776

Filter Deployment Information

	Date	Time		
Deployment	03/07/08	5:39 PM	Flow Reading at Deployment	4 lpm
Retrieval			Flow Reading at Retrieval	lpm

Notes:

WINTER08 WK 2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 6871 Delta Apt 317 VG

Contact Phone # Hector Becerra (915) 771-0251

PEM Information

PEM ID # Paho Pump 6
PEM INLET # 15
Calibrated Flow 4

Filter Gravimetric Information PW 08 W2 02

	pre-weights	post-weights
1	112.970	113.575
2	112.975	113.578
3	112.971	113.513

Filter Deployment Information

	Date	Time		
Deployment	03/08/08	9:01 AM	Flow Reading at Deployment	4 lpm
Retrieval	03/14/08	9:35 AM	Flow Reading at Retrieval	lpm

Notes:

Se puso P.P.C porque el PEM Fallo se dejo El Mismo inlet #15

WINTER08 WK2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 8956 Matterhorn Rita Alvarado JS

Contact Phone # 757 - 3240

PEM Information

PEM ID # Peko Pump 1
PEM INLET # 11
Calibrated Flow 5

Filter Gravimetric Information Pw 08 W2 03

	pre-weights	post-weights
1	107.703	
2	107.704	
3	107.707	

Filter Deployment Information

	Date	Time		
Deployment	03/07/08	6:11	Flow Reading at Deployment	——— lpm
Retrieval			Flow Reading at Retrieval	lpm

Notes:

Pump was not retrieve due to household lack of responsability

WINTER08 WK2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 9205 Mount Shasta JS

Contact Phone # Yolanda Hernandez

PEM Information

PEM ID # 9
PEM INLET # 10
Calibrated Flow 5

Filter Gravimetric Information Pw08 w2 04

	pre-weights	post-weights
1	118.748	119.136
2	118.745	119.127
3	118.743	119.126

Filter Deployment Information

	Date	Time		
Deployment	03/07/08	10:56	Flow Reading at Deployment	4 lpm
Retrieval			Flow Reading at Retrieval	lpm

Notes:

WINTER08 WK2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address Palm 46 — MG

Contact Phone # 820-5405 Esmeralda Flores

PEM Information

PEM ID # Palo Pump 3
PEM INLET # 3
Calibrated Flow 4.017

Filter Gravimetric Information Pw 08 w2 05

	pre-weights	post-weights
1	103.396	104.330
2	103.397	104.327
3	103.397	104.321

Filter Deployment Information

	Date	Time		
Deployment	03/07/08	5:41	Flow Reading at Deployment	4.021 lpm
Retrieval			Flow Reading at Retrieval	lpm

Notes:

WINTER08 WK2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 624 E. University — MG

Contact Phone # 351-1244 & 525-0801

PEM Information

PEM ID # Paho Pump 4
PEM INLET # 1
Calibrated Flow 4

Filter Gravimetric Information Pw #3 w2 #6

	pre-weights	post-weights
1	112.336	112.367
2	112.332	112.866
3	112.331	112.859

Filter Deployment Information

	Date	Time		
Deployment	03/07/08	11:15	Flow Reading at Deployment	4.025 lpm
Retrieval			Flow Reading at Retrieval	lpm

Notes:

WINTER08 WK2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 1001 Tays Bertha Flores MG

Contact Phone # 543-6008 & 274-7489

PEM Information

PEM ID # Paho Pump 5
PEM INLET # 14
Calibrated Flow

Filter Gravimetric Information PW 08 W2 07

	pre-weights	post-weights
1	107.581	109.263
2	107.577	109.267
3	107.579	109.261

Filter Deployment Information

	Date	Time		
Deployment	03/07/08	1:53	Flow Reading at Deployment	4.070 lpm
Retrieval			Flow Reading at Retrieval	lpm

Notes:

WINTER08 WK2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 2302 Campbell MG

Contact Phone # 532-3135 & 525-5789 Monica Cisneros

PEM Information

PEM ID # 10
PEM INLET # 8
Calibrated Flow 4.5

Filter Gravimetric Information Pw Ø8 W2 Ø8

	pre-weights	post-weights
1	116.212	116.749
2	116.203	116.754
3	116.209	116.758

Filter Deployment Information

	Date	Time		
Deployment	03/07/08	1:25	Flow Reading at Deployment	4.5 lpm
Retrieval			Flow Reading at Retrieval	lpm

Notes:

WINTER 08 WK2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 5109 Pikes Peak Guadalupe Flores JS

Contact Phone # 755-0640

PEM Information

PEM ID # Palo Pump 2
PEM INLET # 6
Calibrated Flow 4

Filter Gravimetric Information Pw 08 W2 09

	pre-weights	post-weights
1	103.868	104.581
2	103.860	104.550
3	103.870	104.549

Filter Deployment Information

	Date	Time		
Deployment	03/07/08	6:01	Flow Reading at Deployment	— lpm
Retrieval	03/14/08	6:01	Flow Reading at Retrieval	— lpm

Notes:

WINTER 08 WK2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 8008 Sun Dial VG

Contact Phone # Barbara Paradis 313-5517

PEM Information

PEM ID # 1
PEM INLET # 2
Calibrated Flow 4.75

Filter Gravimetric Information PW 08 W2 10

	pre-weights	post-weights
1	110.609	111.547
2	110.603	111.545
3	110.601	111.544

Filter Deployment Information

	Date	Time		
Deployment	03/07/08	10:26	Flow Reading at Deployment	4.7 lpm
Retrieval	03/14/08	8:49	Flow Reading at Retrieval	4.75 lpm

Notes:

6994# counter

WINTER08 WK2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address 318 Bernadine Blanca Miranda VG

Contact Phone # 778-2598

PEM Information

PEM ID # 15
PEM INLET # 4
Calibrated Flow 4.6

Filter Gravimetric Information PW08W2 II

	pre-weights	post-weights
1	108.092	108.969
2	108.101	108.963
3	108.097	108.966

Filter Deployment Information

	Date	Time			
Deployment	03/08/08	10:09	Flow Reading at Deployment	4.6	lpm
Retrieval	03/14/08	11:52	Flow Reading at Retrieval	4.6	lpm

Notes:

Machine was off # didn't show only showed 0000 Hold.

WINTER08 WK2

NIH ARCH UTEP-UNM Border Hispanic Children with Asthma Research Project
Pilot Project 2 - Variations of Indoor PM
Chain of Custody
Personal Exposure Monitor (PEM) Filter
Type of Sample $PM_{2.5}$

Initials

Home Address Sandra Perez 8357 White VG

Contact Phone # 858-9615

PEM Information

PEM ID # 7
PEM INLET # 9
Calibrated Flow 4

Filter Gravimetric Information PW 08 WK 12

	pre-weights	post-weights
1	111.234	113.243
2	111.239	113.241
3	111.240	113.239

Filter Deployment Information

	Date	Time			
Deployment	3/08/08	9:46 AM	Flow Reading at Deployment	3.75	lpm
Retrieval	3/14/08 #9492	9:12 AM	Flow Reading at Retrieval	2.85	lpm

Notes:

Problem Flow Doesn't go to 5 lpm Jueves 03/06/08 YSE

Se puso PEM 17 se dejo inlet 9 quedo apagado

WINTER08 WK2

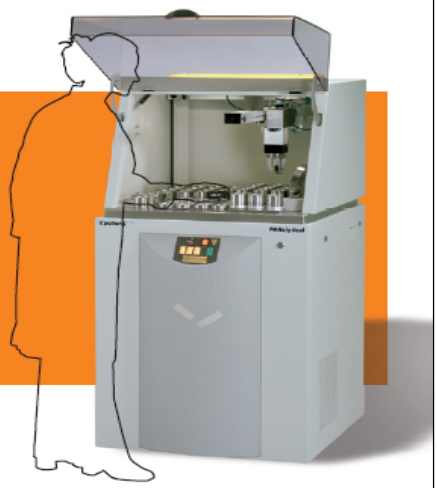
Appendix B

Reference Manuals and Information Brochures

PANalytical

EPSILON 5

Analysis of air filters according to EPA method IO-3.3



Introduction

The presence of toxic pollutants in the air has been a subject of research for many years in the United States and countries around the world. In the United States, air quality standards are governed by the "Clean Air Act" and administered by the US Environmental Protection Agency (EPA). One of the key areas of concern for the US EPA is the Suspended Particulate Matter content (SPM) of air. Historically, the measurement of SPM in air was concentrated on total suspended particulates with no preference to size selection. However, more recent research on the health effects of SPM in ambient air has focused increasingly on particles that can be inhaled into the respiratory system, i.e. particles of aerodynamic diameter of < 10 µm. These particles are referred to as PM10 (2.5 – 10 µm) and PM2.5 (< 2.5 µm). Not withstanding chemical toxicity, it is now generally recognized that these particles are a significant threat to health.

The measurement of the elemental composition of the particulate matter is a key factor in understanding the long-term health effects of pollution. Suspended particulate matter is typically pre-concentrated using high volume air samplers and collected on Teflon filters. The chemical analysis of the SPM on these air filters is traditionally performed by energy-dispersive XRF (EDXRF) using EPA method IO-3.3. EPA method IO-3.3 outlines the protocol for the analysis of 44 elements on Teflon air filters, but significant advances in the development of EDXRF instrumentation and software have occurred since this method was published. This application study demonstrates the performance of the Epsilon 5 EDXRF analyzer according to the EPA method IO-3.3, with the elemental range extended from 44 to 55 elements.

Epsilon 5: the essential element

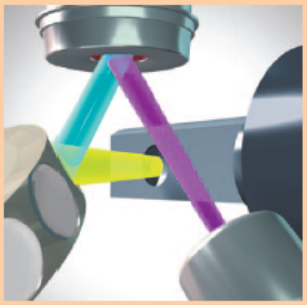
The Epsilon 5 is a fully integrated energy-dispersive XRF analyzer, consisting of a spectrometer, X-Y sample handler and software. It has a unique combination of features including a three-dimensional, polarizing geometry, together with a 600 W Gd- or Sc/W-anode X-ray tube and 100 kV generator, up to 15 polarizing and secondary targets and a high-resolution PAN-32 detector. Designed for accuracy, precision and low detection limits the Epsilon 5 excels in the analysis of medium to heavy metals, targeting a wide range of elements of environmental significance.

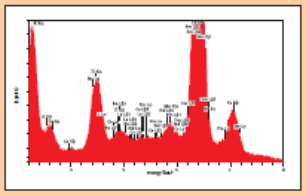
Epsilon 5 is ideal for the analysis of particulate matter on air filters. Filters are placed directly into the spectrometer without additional sample preparation.The absence of sample heating permits long measurement times required for the detection of low concentrations of pollutants in ambient air monitoring.

The Analytical X-ray Company

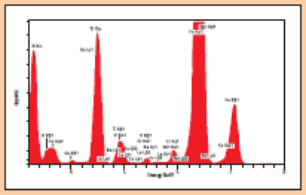
Polarization

The optical path of the Epsilon 5 has a 3-dimensional or Cartesian geometry. This geometry eliminates the scattered X-ray tube spectrum by polarization, thereby reducing the spectral background enormously. Backgrounds can be an order of magnitude lower than traditional direct excitation (2-dimensional) optics.





2-dimensional optics



3-dimensional optics

Measurement criteria and calibration

The air filters application used in this study was set up according to EPA method IO-3.3.The analytical measurement parameters were optimized to accommodate the technological improvements incorporated into the Epsilon 5.
The method was set up and calibrated with 59 commercially available air filter standards and a blank sample from Micromatter Co. (Eastsound, WA). The standards were composed of pure elements and compounds deposited on 40mm Nucleopore media.

The calibration was established using a single standard and a blank for each element. A Fundamental Parameter (FP) method was used to correct for the difference in sample loading when analyzing unknowns.

The measurement parameters used for this application are shown in table 1. The measurement time per condition was 100 seconds, except for the CaF_2 target 600 seconds. The measurement time for each condition can be optimized according to specific needs.

Elemental range	Secondary target	kV	mA
Na - K	CaF_2	35	17
Ca - Sc	Ti	70	8.5
Ti - Cr, Ba - Nd	Fe	80	7.5
Mn - Zn, Sm - Pt	Ge	85	7
Ga - Rb, Au - Pb	Zr	100	6
Sr - Y, Bi - U	Mo	100	6
Nb - Mo	Ag	100	6
Rh - Cs	Al_2O_3	100	6

Table 1. Analytical parameters used for the application setup

Performance

The Epsilon 5 software features a very powerful deconvolution algorithm, which analyzes the sample spectrum and determines the net intensities of element peaks, even when they overlap one another. The accuracy with which this is carried out is essential to trace element analysis. Figure 1 shows a fitted spectrum of air filter standard NIST 2783 obtained with the Ge secondary target. The extremely low background is a consequence of the polarizing optical path.

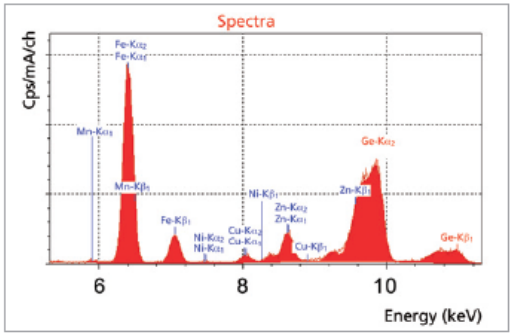


Figure 1. Spectrum of standard NIST 2783, obtained using the Ge secondary target

Precision

The total method precision is a combination of instrument precision and stability of the sample during the measurement. The method precision can be reported for both short (repeatability) and long term (reproducibility) measurements. The repeatability of the Epsilon 5 was assessed by measuring a single filter sample (NIST 2783) 20 consecutive times in a single day. The reproducibility was determined by measuring the same sample once per day over a 10-day period.
The repeatability and reproducibility data for a selection of elements are shown in table 2. No drift correction was applied during the precision studies. The repeatability and reproducibility are both excellent and for most elements the short and long term precision are nearly identical. Comparison of the relative RMS values with the counting statistical error (theoretically, the minimum possible error) shows the excellent precision of the instrument and the non-destructive nature of the method for analyzing filter samples. Figure 2 gives a graphical representation of the short and long-term stability of Cr and Cu.

NIST 2783	Si	K	Ti	Cr	Mn	Fe	Cu	Pb
REPEATABILITY (20 consecutive measurements)								
Mean µg/cm²	8.704	0.483	0.143	0.018	0.027	2.319	0.047	0.039
RMS	0.05	0.002	0.005	0.002	0.005	0.012	0.003	0.005
RMS rel%	0.578	0.473	3.556	9.907	17.408	0.507	5.759	12.354
REPRODUCIBILITY (Measurements carried out over 10 days)								
Mean µg/cm²	8.704	0.482	0.143	0.018	0.028	2.327	0.047	0.036
RMS	0.047	0.003	0.007	0.001	0.006	0.021	0.003	0.003
RMS rel%	0.538	0.601	4.849	5.521	21.731	0.879	6.877	8.948
COUNTING STATISTICAL ERROR								
CSE rel%	0.492	0.446	2.894	5.978	8.153	0.799	4.157	9.109

Table 2. Analytical precision for short and long-term measurements

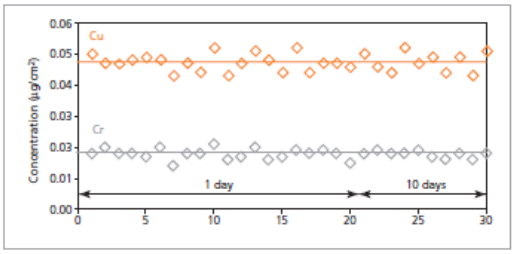


Figure 2. Short and long term stability measurements of Cr and Cu in sample NIST 2783

Accuracy
The accuracy of the method was determined by comparing results of the NIST 2783 standard. The results of the selected elements are shown in table 3 and show a good agreement with the certified values.

NIST 2783	Certified (µg/cm²)	Measured (µg/cm²)
K	0.53	0.48
Ca	1.32	1.14
Ti	0.15	0.14
V	0.005	0.005
Cr	0.014	0.016
Mn	0.032	0.018
Fe	2.65	2.32
Ni	0.007	0.007
Cu	0.040	0.043
Zn	0.18	0.18
Ba	0.034	0.025
Pb	0.032	0.030

Table 3. Comparison of measured versus certified values for NIST 2783

Detection limits
Detection limits are an important measure of an instrument's performance. The detection limits for this application were calculated from 50 replicate measurements of a Teflon blank sample and are based on 1 sigma (as specified in method IO-3.3). Calculations are based on a measurement time of 400 seconds per condition, which is chosen to give a better comparison with the values as reported by EPA. The detection limits for 55 elements are shown in figure 3 and compared with the detection limits as reported by the EPA.

The detection limits obtained with the Epsilon 5 range from 20 ng/cm² to less than 1 ng/cm². Across the majority of the elemental range the detection limits are better or comparable with those quoted by the EPA. The high sensitivity of the Epsilon 5 for measuring elements across the periodic table is a direct result of the combination of the 100 kV dual-anode x-ray tube, a wide range of secondary targets and lowered background due to the polarizing geometry of the optical path.

Analytical flexibility

The Epsilon 5 can be "tuned" to get the lowest detection limits for a large number of elements. This flexibility is achieved using a set of programmable polarization and secondary targets. The basic system is configured with 9 targets, that cover the periodic table from Na to U, however, an additional 6 targets can be added for dedicated applications.

Dual-anode Sc/W X-ray tube

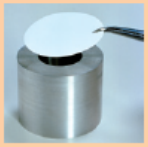
The dual-anode Sc/W X-ray tube gives good performance for measuring elements across the periodic table. This tube is designed to increase the sensitivity for light elements by using the scandium characteristic tube lines, while the tungsten characteristic lines ensure good sensitivity for the medium to heavy element range.

PANalytical

Sample changer

The Epsilon 5 is equipped with an integrated robotic sample changer. The changer can load samples individually or in a batch mode. Samples can be added to the batch without interrupting the ongoing measurements.

Filter samples can be fitted in the sample cup using a special insert that assures a good position of the sample.



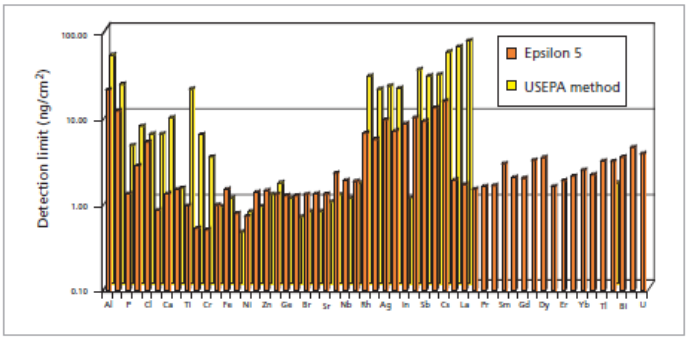


Figure 3. Detection limits (1 sigma) for particulate matter on air filters using the Epsilon 5 compared with those reported by the EPA (reports only elements up to La, except for Pb)

Conclusions

The Epsilon 5 is fully capable of analyzing particulate matter on air filters according to EPA method IO-3.3 with a high degree of accuracy and precision for a wide range of elements across the periodic table. The non-destructive nature of the method means that it is possible to increase measurement times in case an even higher degree of precision is needed. Furthermore, samples can be measured repeatedly without damage, ensuring the longevity of standards.

The advantages of the Epsilon 5 are clear. Measurements are accurate and precise and the method benefits from simple, essentially hazard-free, sample preparation. The stability of the instrument is such that individual calibrations can be used for months. As a result, time-consuming re-standardizations are unnecessary and the resulting data are highly consistent over time.

Equipment Configuration

Epsilon 5 energy dispersive X-ray fluorescence spectrometer and controlling software.

X-ray tube:	Type:	side-window tube
	Anode:	Sc/W
	Window:	Be (150 µm)
	Rating:	25 – 100 kV, 0.5 – 24 mA, maximum power 600 W
	Internal water cooling	
Detector type:	PAN-32:	Ge X-ray detector
	Crystal:	30 mm², 5 mm thick
	Window:	Be (8 µm)
	Energy range:	0.7 – 100 keV
	Resolution:	≤140 eV (2000 cps, Mn K_α)
	Liquid nitrogen cooling	
Polarizing optics:	3-dimensional design	
Targets:	Al,Ti, Fe, Ge, Zr, Mo, Ag, Ce_2O_3, Al_2O_3, CaF_2	

Global and near

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Publication #1580 Rev 1009

Universal XR Sample Pumps

25 Years of Rugged, Reliable Service!

Flows: 5 to 5000 ml/min

Approvals

UL LISTED | *ATEX-approved models available* | CE | MSHA *models available*

Universal 44XR
The Economical Solution

Universal PCXR4
The Compliance Solution

Universal PCXR8
The Programmable Solution

Turn on and sample!

- Economical
- Basic operation
- Convenient flow indicator
- Designed for rugged industrial environments

Enhanced with additional features:

- **Automatic fault shutdown and time retention**
  - Pump shuts down and retains sampling time when battery is low or there is excessive back pressure to ensure sample integrity
- **High-accuracy timer**
  - Built-in timer provides instant readout of sampling duration. A convenient **hold** feature allows for breaks.

Enhanced with programmability!

- **Built-in high-accuracy timer**
  - Sample duration readout and convenient **hold** feature
- **Automatic fault shutdown/time retention**
  - Ensures sample integrity upon low battery or excess back pressure
- **Delayed start**
  - Set number of minutes to elapse until sample start
- **Timed shutdown**
  - Set number of minutes of operation until shutdown
- **Intermittent sampling**
  - Extend short-term samples over an extended period to meet TWA requirements with fewer samples
- **Extended intermittent sampling up to 7 days — ideal for fenceline monitoring!**

SKC

SKC Inc. 724-941-9701 SKC West 714-992-2780 SKC Gulf Coast 281-859-8050 SKC South 434-352-7149

Universal XR Sample Pumps

Now with NiMH BATTERY For longer run times

Performance Profile	
Flow Control Accuracy	Holds constant flow to ± 5% of set point
Timing Accuracy	± 0.05% (± 45 seconds per day)
Typical Run Time	*Battery:* 12 hrs minimum at 4000 ml/min and 20 inches water back pressure, dependent on media used *Battery Eliminator:* Pump provides extended runs. PCXR4 and PCXR8 display rolls over to 0 upon reaching 9999 min
Charge Time *(varies with battery capacity and level of discharge)*	6 to 8.5 hrs with PowerFlex charger
Temperature Range	**Operating:** 32 to 113 F (0 to 45 C) **Storage:** -4 to 113 F (-20 to 45 C) **Charging:** 50 to 113 F (10 to 45 C)
Operating Humidity Range	0 to 95% non-condensing
Timer Display Range	*PCXR4 and PCXR8 only:* 1 to 9999 min (6.8 days)
Timed Shutdown	*PCXR8 only:* User-selectable time of operation before automatic shutdown. Maximum setting is 9999 min (6.8 days)
Delay On	*PCXR8 only:* User-selectable time to delay test. Maximum setting is 9999 min (6.8 days)
Intermittent Sampling	*PCXR8 only:* User-selectable parameters to extend short-term samples over an extended period. Elapsed time maximum is 9999 min (6.8 days).
Flow and Low Battery Fault	*PCXR4 and PCXR8 only:* Pump shuts down, timing functions pause, time display is retained, and LCD indicates flow or low battery fault.
Dimensions	5.1 x 4.7 x 1.9 in (13 x 11.9 x 4.8 cm)

Ordering Information

Universal XR Sample Pumps Sample pump with NiMH battery pack and screwdriver set. *Low flow (5 to 500 ml/min) requires Adjustable Low Flow Holder.*		**Cat. No.**
PCXR8 Universal Sample Pump, *requires charger*		**224-PCXR8**
PCXR4 Universal Sample Pump, *requires charger*		**224-PCXR4**
44XR Universal Sample Pump, *requires charger*		**224-44XR**
Universal XR Starter Kits Include pump with NiMH battery pack, single PowerFlex charger with cable, Tygon tubing (3 feet, 1/4-inch ID), and collar clip with cable tie		
PCXR8 Starter Kit	**100-240 V**	**224-PCXR8-S**
PCXR4 Starter Kit	**100-240 V**	**224-PCXR4-S**
44XR Starter Kit	**100-240 V**	**224-44XR-S**
Single Pump Kits Include sample pump with NiMH battery pack, single PowerFlex charger with cable, adjustable low flow holder attached to Type A protective tube cover, filter cassette holder, and screwdriver set, in a convenient soft-side nylon carry case†		
PCXR8 Single Pump Kit	**100-240 V**	**224-PCXR8KD**
PCXR4 Single Pump Kit	**100-240 V**	**224-PCXR4KD**
PCXR4 Single Pump Kit with IOM, *does not include cassette holder*	**100-240 V**	**224-PCXR4PK**
44XR Single Pump Kit	**100-240 V**	**224-44XRKD**
5-pack Pump Kits Include 5 sample pumps with NiMH battery packs, adjustable low flow holders attached to Type A protective tube covers, filter cassette holders, screwdriver sets, and one 5-station PowerFlex charger with 5 cables, in a Pelican case		
PCXR8 5-pack Pump Kit	**100-240 V**	**224-PCXR8K5D**
PCXR4 5-pack Pump Kit	**100-240 V**	**224-PCXR4K5D**
44XR 5-pack Pump Kit	**100-240 V**	**224-44XRK5D**
Replacement Parts and Accessories		
Replacement Battery Packs *Replacing batteries with non-approved battery packs voids any warranty and UL intrinsic safety approvals.*	**NiMH for XR models*** **NiCad for XR models*** **NiCad for MSHA models**	**P21661MH*** **P21661*** **P22434**
Battery Eliminator, connects pump to line power for extended sampling	**115 V** **230 V**	**223-325** **223-325B**

* *Not suitable for MSHA-approved models*

† *Single kits also available in hard-sided Pelican case. Contact SKC for ordering information.*

Quick View

Flow Rate (ml/min)
5 to 5000
Weight in Ounces (grams)
34 (964)
Compensation Range (inches water)
Up to 40 at 2 L
Built-in Timer/Clock
Timer — PCXR4 and PCXR8 only
Constant Flow
Yes
Programmable
PCXR8 only
PC-compatible
N/A
Multi-tube Sampling
Yes
Flow Fault Feature
PCXR4 and PCXR8 only
RFI/EMI Shielded
Yes
Intrinsically Safe — UL Listed
Yes
MSHA-approved Models Available
Yes
ATEX Models Available
Yes
CE Marked
Yes
Corrects for Changes in Atmospheric Pressure
N/A
Corrects for Changes in Temperature
N/A
Battery Type
NiMH (6.0 V, 3.5 Ah)
Battery Check
PCXR4 and PCXR8 only

Recommended Accessories
Chargers
Battery Eliminator
Defender Calibrator Cat. No. 717-510M
Adjustable Low Flow Tube Holders
Filter Holders
Tubing
Cases/Pouches

SKC Limited Warranty and Return Policy

SKC products are subject to the SKC Limited Warranty and Return Policy, which provides SKC's sole liability and the buyer's exclusive remedy. To view the complete SKC Limited Warranty and Return Policy, go to http://www.skcinc.com/warranty.asp.

TEOM® Series 1400a Ambient Particulate Monitor

Real-Time, True Mass Measurement of Suspended Particulate Matter as PM-10, PM-2.5, PM-1 and TSP

Air Monitors Limited - Rupprecht & Patashnick Co., Inc.

Quality • Service • Innovation

Sep 99

Most Advanced Technology

The TEOM Series 1400a Ambient Particulate Monitor is the choice of air pollution monitoring networks worldwide to measure particulate mass concentrations continuously. The system has become the de facto standard for particulate mass concentration measurements in areas such as Canada, Hong Kong, the United Kingdom and France due to its high data quality, reliability and unparalleled support.

The instrument incorporates the patented *tapered element oscillating microbalance*, a true microweighing technology that provides true mass measurements. Using a choice of sample inlets, the hardware can easily be configured to measure PM-10, PM-2.5, PM-1 or TSP concentrations. This microprocessor-based unit easily accommodates all siting requirements and provides internal data storage, and advanced analog and serial data input/output capabilities.

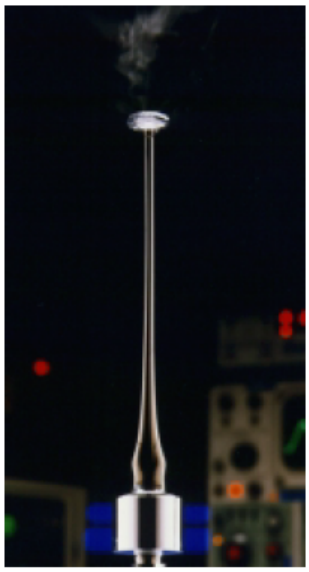
Regulatory Aprovals

The TEOM Series 1400a monitor has received the following major regulatory recognitions:

- USEPA PM-10 equivalency approval EQPM-1090-079.
- PM-2.5 measurements within the context of a USEPA correlated acceptable continuous monitor (40 CFR 58).
- European Union PM-10 recognition within the context fo European Norm EN12341.
- German EPA approval as an equivalent TSP monitor.

Filter-Based Mass Measurement

Filter-based, direct mass measurements are considered the standard technique for determining particulate mass concentration. TEOM instruments from Rupprecht & Patashnick are the only filter-based systems with real-time data output and real-time mass measurement capability. The exchangeable filter in the Series 1400a monitor can also be used to determine heavy metal concentrations using atomic absorption (AA) and inductively coupled plasma (ICP).



Unique Principle of Operation

The Series 1400a monitor incorporates an inertial balance that directly measures the mass collected on an exchangeable filter cartridge by monitoring the corresponding frequency changes of a tapered element. The sample flow passes through the filter, where particulate matter collects, and then continues through the hollow tapered element on its way to an active volumetric flow control system and vacuum pump.

The TEOM mass transducer does not require recalibration because it is specially designed and constructed from non-fatiguing materials. Its mass calibration may be verified, however, using an optional Mass Calibration Verification Kit that contains a filter of known mass. Active volumetric flow control is maintained by mass flow controllers whose set points are constantly adjusted in accordance with the measured ambient temperature and pressure.

Application Range

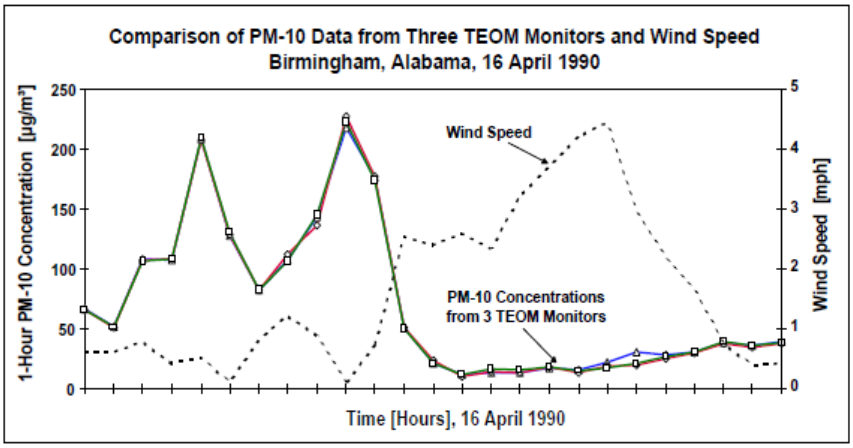
The TEOM Series 1400a monitor is used to monitor ambient air quality in the following major applications:

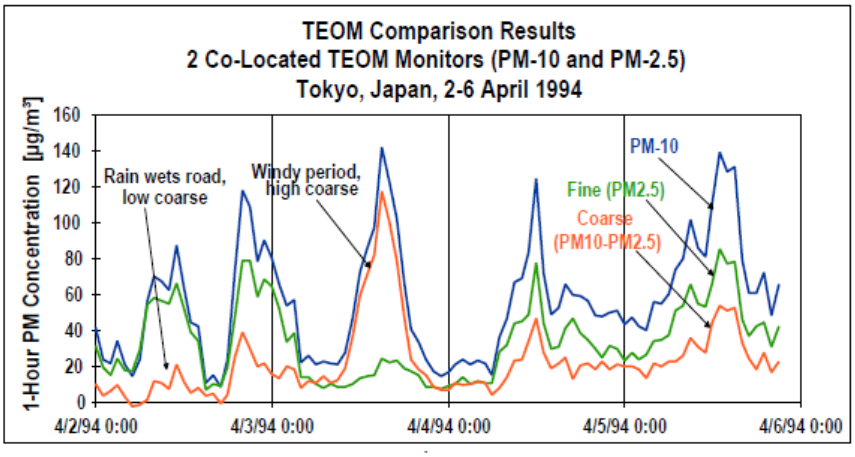
- Air quality monitoring networks, including background sites.
- Special studies and super sites for PM-10, PM-2.5 and PM-1 characterization.
- Routine input for air quality index or pollutant standards index.
- In and around industrial and material handling facilities.
- Remediation projects (Superfund, hazardous waste).
- Indoor air, exposure chamber, and industrial hygiene measurements.

Unsurpassed Short-Term Precision

One-hour average mass concentration data from two co-located TEOM monitors demonstrate the instrument's unsurpassed precision. The Series 1400a monitor meets the stringent one-hour performance acceptance criteria established by the California Air Resources Board.

The instrument's data quality also permits different particle size fractions such as PM-10 and PM-2.5 to be compared with each other at short averaging times. With this resolution, one can see the relationship between different PM measures changes with meteorology, regional or local conditions. This can provide vital information in the study of human health effects. Other applications of time-sensitive data include source identification and control, short-term compliance monitoring, emergency response, forensic investigations, and numerical modeling.





ACCU™ System

With the optional Automatic Cartridge Collection Unit added to the Series 1400a system, users can add manual PM sampling to the automated mass concentration results generated by the continuous monitor. The ACCU System attaches to the bypass flow line of the TEOM monitor, and permits users to sample ambient PM and gases with a choice of collection methods for subsequent analysis.

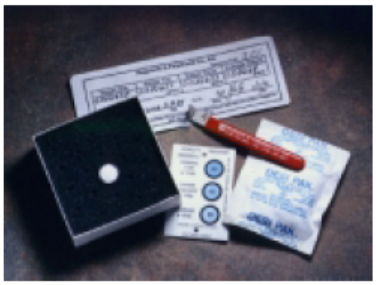
The system's eight internal flow channels can be fitted with a variety of filter holders, filter packs, or PUF (polyurethane foam) samplers. A new filter holder for X-ray fluorescence (XRF) analysis makes use of the molded FRM-style 47 mm filter cassettes available from Rupprecht & Patashnick. The user specifies the conditions under which each of the ACCU System's flow channels is operated, including time of day, particulate concentration, meteorological data and/or other inputs from external sources.

Complete Outdoor Enclosure

The optional Complete Outdoor Enclosure allows the TEOM monitor to be installed at locations at which a permanent shelter is not available. The housing provides the proper weather-proof environment to ensure long-term performance. It provides not only heating for cold climates, but also active air conditioning for instrument operation in summer heat.

Quality Assurance

A number of tools provide users with the ability to perform in-field audits of the TEOM monitor's mass measurement and active volumetric flow control system. Under software support, user's can use the single pre-weighed filter contained in the Mass Calibration Verification Kit to confirm the mass calibration of the instrument. The Streamline™ Flow Transfer Standard is an oriface-based device that provides high-quality flow rate measurements even under challenging environmental conditions.



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Check out our speciality web site at:
www.pm10.co.uk

Appendix C

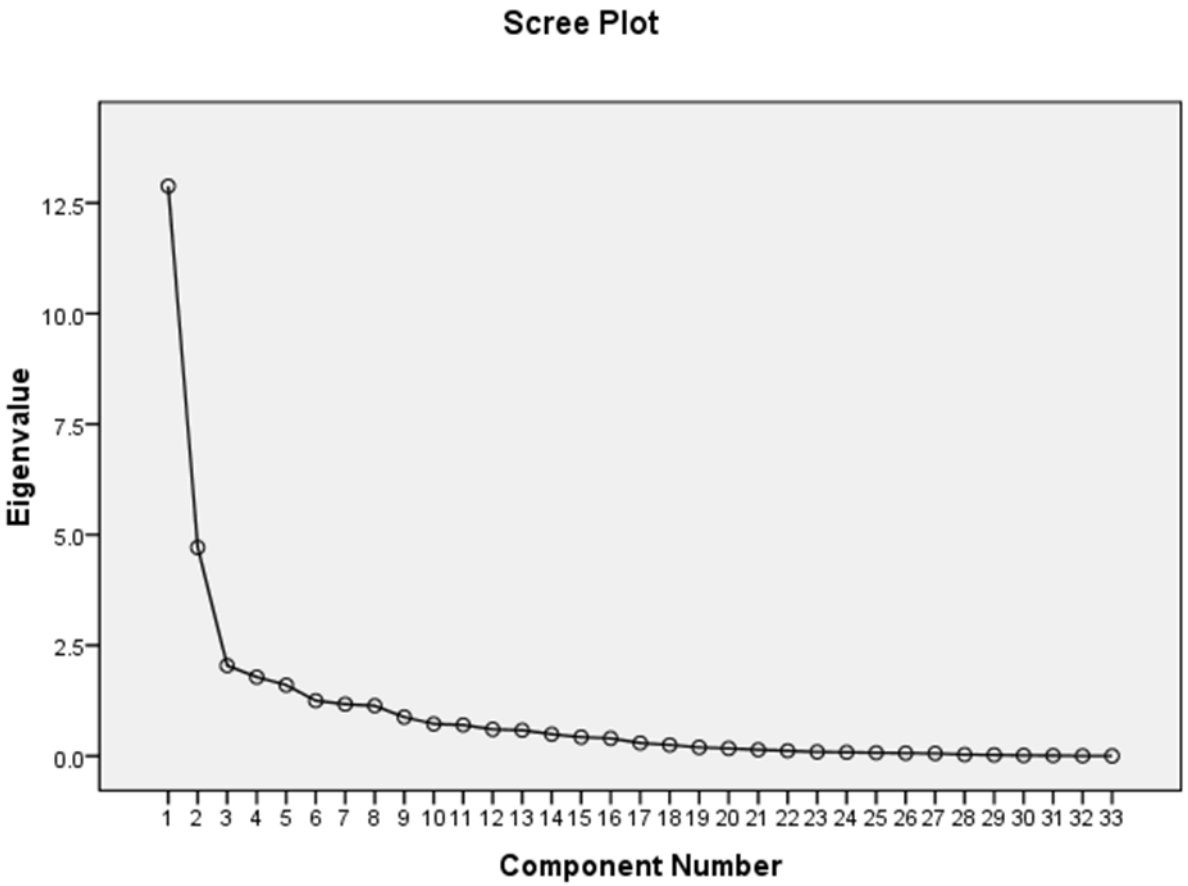
PCA SPSS Raw Results

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.831
Bartlett's Test of Sphericity	Approx. Chi-Square	3588.064
	df	528
	Sig.	.000

Communalities

	Initial	Extraction
Ag	1.000	.813
Al	1.000	.970
As	1.000	.869
Ba	1.000	.882
Ca	1.000	.879
Cd	1.000	.586
Cl	1.000	.898
Cr	1.000	.973
Cu	1.000	.639
Fe	1.000	.973
Ga	1.000	.914
K	1.000	.916
Mg	1.000	.960
Mn	1.000	.927
Mo	1.000	.896
Na	1.000	.934
Ni	1.000	.965
P	1.000	.634
Pb	1.000	.640
Pd	1.000	.823
Pt	1.000	.620
Rb	1.000	.798
Rh	1.000	.730
S	1.000	.736
Sc	1.000	.791
Si	1.000	.975
Sn	1.000	.572
Sr	1.000	.783
Te	1.000	.585
Th	1.000	.683
Ti	1.000	.896
V	1.000	.656
Y	1.000	.661

Extraction Method: Principal Component Analysis.


Scree Plot
Eigenvalue
12.5
10.0
7.5
5.0
2.5
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33
Component Number

Component Score Coefficient Matrix

	Component							
	1	2	3	4	5	6	7	8
Ag	-.035	.005	.220	-.070	.178	-.055	-.056	-.111
Al	.130	-.030	-.025	-.035	-.047	-.039	-.051	.128
As	-.005	.001	.014	-.068	.072	.177	.178	-.081
Ba	.020	.003	.153	-.059	.077	.016	-.044	-.091
Ca	.192	-.044	-.236	.039	.015	.093	-.192	-.022
Cd	.003	.007	-.006	-.033	-.019	.390	-.123	.090
Cl	-.024	.010	.008	.461	-.108	.004	-.095	-.052
Cr	-.021	.236	.004	.004	.024	.045	.039	-.014
Cu	-.001	.012	-.029	-.023	-.106	.252	.244	-.140
Fe	.112	.082	-.026	-.040	-.077	.032	.034	.072
Ga	-.027	.230	.069	.028	.024	.009	-.023	.014
K	.090	-.016	.014	.016	-.045	-.007	-.008	.069
Mg	.129	-.030	-.047	.003	-.020	-.038	-.070	.086
Mn	.091	.123	-.018	-.053	-.091	.059	.087	.036
Mo	-.019	.226	.038	.008	.095	-.030	-.027	-.073
Na	-.068	.019	.029	.448	-.034	-.037	.022	.036
Ni	-.020	.242	.008	.021	.035	.047	.038	-.009
P	-.076	.032	-.157	.078	.210	-.012	.411	.036
Pb	.093	-.008	-.093	-.087	-.071	.055	.176	-.284
Pd	-.025	-.010	.148	-.011	.160	-.098	.026	-.166
Pt	-.065	.022	.223	-.043	.063	.107	.031	.067
Rb	.006	-.013	-.025	-.049	.059	.049	.034	.679
Rh	-.056	-.007	.472	.021	-.193	-.091	-.170	.075
S	-.046	.010	.015	.169	.226	-.179	.068	.026
Sc	-.009	.033	.062	-.045	.204	.245	-.155	-.079
Si	.143	-.031	-.054	-.033	-.058	.001	-.054	.094
Sn	-.034	.032	-.134	-.053	.485	.019	-.076	.117
Sr	.150	-.050	-.121	.103	-.035	-.017	-.168	-.204
Te	-.141	.070	.385	.123	-.177	.098	.126	.060
Th	-.049	-.017	.043	-.047	-.154	-.114	.532	.087
Ti	.122	-.021	-.026	-.011	-.104	.016	.002	.047
V	.069	.035	-.139	-.010	.219	-.130	.048	.040
Y	.080	-.034	.057	-.124	.043	-.298	-.017	-.249

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. Component Scores.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	12.880	39.030	39.030	12.880	39.030	39.030	9.722	29.462	29.462
2	4.712	14.280	53.310	4.712	14.280	53.310	4.361	13.216	42.678
3	2.042	6.189	59.498	2.042	6.189	59.498	2.847	8.628	51.306
4	1.784	5.406	64.905	1.784	5.406	64.905	2.340	7.091	58.397
5	1.603	4.856	69.761	1.603	4.856	69.761	2.196	6.654	65.051
6	1.249	3.785	73.546	1.249	3.785	73.546	2.122	6.430	71.481
7	1.172	3.553	77.098	1.172	3.553	77.098	1.761	5.337	76.818
8	1.135	3.441	80.539	1.135	3.441	80.539	1.228	3.721	80.539
9	.880	2.667	83.206						
10	.725	2.197	85.402						
11	.700	2.123	87.525						
12	.601	1.822	89.347						
13	.581	1.761	91.108						
14	.492	1.490	92.597						
15	.427	1.295	93.892						
16	.398	1.205	95.097						
17	.293	.888	95.985						
18	.250	.757	96.743						
19	.195	.591	97.334						
20	.172	.522	97.857						
21	.140	.423	98.279						
22	.118	.357	98.636						
23	.092	.279	98.916						
24	.084	.254	99.170						
25	.073	.220	99.390						
26	.064	.194	99.585						
27	.058	.174	99.759						
28	.029	.089	99.848						
29	.024	.073	99.921						
30	.013	.039	99.959						
31	.009	.027	99.986						
32	.003	.008	99.995						
33	.002	.005	100.000						

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component							
	1	2	3	4	5	6	7	8
Ag	.737				.413			
Al	.920							
As	.771							
Ba	.885							
Ca	.795				-.312			-.301
Cd			.443	.425				
Cl	.418		.523	-.602				
Cr		.916						
Cu	.452		.352		-.315			
Fe	.800	.542						
Ga		.907						
K	.941							
Mg	.936							
Mn	.662	.657						
Mo		.890						
Na	.500		.486	-.625				
Ni		.924						
P	.379					.477		
Pb	.616					.340		
Pd	.785				.342			
Pt	.636							
Rb	.331					-.308	.736	
Rh	.473					-.318		.472
S	.640			-.373	.398			
Sc	.582		.394	.401				
Si	.932							
Sn					.484			-.420
Sr	.759							
Te	.461							.539
Th	.375					.537		.310
Ti	.902							
V	.664							
Y	.424		-.516				-.316	

Extraction Method: Principal Component Analysis.

a. 8 components extracted.

Rotated Component Matrix[a]

	Component							
	1	2	3	4	5	6	7	8
Ag	.459		.584		.469			
Al	.919							
As	.506		.301		.313	.458	.385	
Ba	.668		.517		.332			
Ca	.860							
Cd						.743		
Cl				.906				
Cr		.968						
Cu						.556	.406	
Fe	.862	.391						
Ga		.942						
K	.855		.307					
Mg	.915							
Mn	.748	.541						
Mo		.924						
Na				.907				
Ni		.976						
P					.403		.595	
Pb	.604						.343	-.343
Pd	.505		.491		.447			
Pt	.340		.530		.301			
Rb								.826
Rh	.312		.750					
S	.374			.442	.488			
Sc	.333		.327		.471	.562		
Si	.939							
Sn					.736			
Sr	.773			.328				
Te			.612					
Th							.721	
Ti	.887							
V	.623				.392			
Y	.487					-.515		

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

Rotation converged in 8 iterations.

Appendix D

Concentration Equations

1: Calculation of elemental concentrations from EDXRF raw results

1.1: Raw data from the EDXRF analysis for each element were reported in µg/cm^2; therefore, mass per unit filter area units were converted to air concentration units of µg/m^3. The area of the filter used was calculated from the diameter of the 37 mm Teflon© filters used for sample collection.

EQ 1.1: $37\ mm * \frac{10^{-3}m}{mm} * \frac{cm}{10^{-2}m} = 3.7\ cm$

EQ 1.2: $Area\ of\ Filter = \frac{pi}{4} d^2 = \frac{pi}{4}(3.7cm)^2 = 10.75\ cm^2$

Once the area of the filters has been calculated, air concentration units were calculated as follows:

EQ 1.3: $C_e = \frac{(E_m * A_f * 10^3)}{(Q_{avg} * t)}$

Where:

C_e = Mass, or air elemental concentration, µg/m^3

E_m = Raw elemental mass per unit filter area result, µg/cm^2

A_f = Area of Teflon© filter, cm^2

Q_{avg} = Average volumetric flow, LPM

t = duration of sampling, minutes

2: Calculation of $PM_{2.5}$ concentrations from raw gravimetric analysis results

2.1: The mass of material collected on the PEM filters were calculated from the difference in the pre-weight average and in the post-weight average. Mass concentrations were then calculated as follows:

EQ 2.1: $C = m_f * \frac{10^3}{(Q_{avg} * t)}$

Where:

C = Mass, or air concentration, µg/m^3

m_f = mass collected on Teflon© filter, µg

Q_{avg} = Average volumetric flow, LPM

t = duration of sampling, minutes

Appendix E

Toxic Release Inventory Data

TRI On-site and Off-site Reported Disposed of or Otherwise Released (in pounds), for facilities in All Industries, for All Chemicals, El Paso County, Texas, 2007

Row #	Facility	Total On-site Disposal or Other Releases	Total Off-site Disposal or Other Releases	Total On- and Off-site Disposal or Other Releases
2	***AIR SYSTEM COMPONENTS LP. 12405 WEAVER RD, EL PASO, Texas 79928 (EL PASO)***	***33,006***	***751***	***33,757***
.	CERTAIN GLYCOL ETHERS (332 Fabricated Metals)	33,006	751	33,757
3	***ARCELORMITTAL VINTON INC. I-10 & VINTON RD, VINTON, Texas 79821 (EL PASO)***	***21,704***	***0***	***21,704***
.	CADMIUM (331 Primary Metals)	42	0	42
	CHROMIUM (331 Primary Metals)	152	0	152
	COPPER (331 Primary Metals)	256	0	256
	LEAD (331 Primary Metals)	1,730	0	1,730
	MANGANESE (331 Primary Metals)	2,104	0	2,104
	NICKEL (331 Primary Metals)	23	0	23
	VANADIUM (EXCEPT WHEN CONTAINED IN AN ALLOY) (331 Primary Metals)	15	0	15
	ZINC (FUME OR DUST) (331 Primary Metals)	17,382	0	17,382
4	***AUTOTRONIC CONTROLS CORP. 1490 HENRY BRENNAN DR, EL PASO, Texas 79936 (EL PASO)***	***2***	***0***	***2***
.	LEAD (336 Transportation Equipment)	1	0	1
	LEAD COMPOUNDS (336 Transportation Equipment)	1	0	1
5	***BOEING CO. 9566 RAILROAD DR, EL PASO, Texas 79924 (EL PASO)***	***2***	***55***	***57***
.	LEAD (334 Computers/Electronic Products)	2	55	57
6	***COLEMAN CABLE INC. 201 INGLEWOOD DR, EL PASO, Texas 79927 (EL PASO)***	***0***	***0***	***0***
.	COPPER (331 Primary Metals)	0	0	0
7	***COLEMAN CABLE INC. 1388 N ZARAGOSA RD, EL PASO, Texas 79936 (EL PASO)***	***0***	***13,354***	***13,354***
.	ANTIMONY COMPOUNDS (331 Primary Metals)	0	13,354	13,354
	BARIUM COMPOUNDS (331 Primary Metals)	NA	NA	NA
	COPPER (331 Primary Metals)	0	0	0
	ZINC COMPOUNDS (331 Primary Metals)	NA	NA	NA
8	***DAL-TILE EL PASO MANUFACTURING. 12001 RAILROAD DR, EL PASO, Texas 79934 (EL PASO)***	***211,928***	***0***	***211,928***
.	HYDROCHLORIC ACID (1995 AND AFTER "ACID AEROSOLS" ONLY) (327 Stone/Clay/Glass)	36,797	0	36,797
	HYDROGEN FLUORIDE (327 Stone/Clay/Glass)	175,007	0	175,007
	ZINC COMPOUNDS (327 Stone/Clay/Glass)	124	.	124
9	***EAGLE FAMILY FOODS. 255 MONTOYA RD, EL PASO, Texas 79932 (EL PASO)***	***0***	***0***	***0***
.	NITRATE COMPOUNDS (311/312 Food/Beverages/Tobacco)	0	0	0
	NITRIC ACID (311/312 Food/Beverages/Tobacco)	0	0	0
10	***EL PASO PVC. 201-A INGLEWOOD DR, EL PASO, Texas 79927 (EL PASO)***	***47***	***6***	***53***
.	ANTIMONY COMPOUNDS (325 Chemicals)	24	5	29
	LEAD COMPOUNDS (325 Chemicals)	3	1	4
	ZINC COMPOUNDS (325 Chemicals)	20	.	20
11	***EPSON EL PASO INC. 1211 HENRY BRENNAN, EL PASO, Texas 79936 (EL PASO)***	***NA***	***NA***	***NA***
.	MIXTURE (325 Chemicals)	NA	NA	NA
	MIXTURE (325 Chemicals)	NA	NA	NA
12	***INTERNATIONAL WIRE GROUP - CAMDEN WIRE FACILITY. 1700 COMMERCE PARK DR, EL PASO, Texas 79912 (EL PASO)***	***0***	***2,984***	***2,984***
.	COPPER (331 Primary Metals)	0	2,984	2,984
13	***KWAL - HOWELLS INC.. 6050 LUCKETT CT, EL PASO, Texas 79932 (EL PASO)***	***182***	***0***	***182***
.	ETHYLENE GLYCOL (325 Chemicals)	182	0	182
14	***L&M RADIATOR. 6966 MARKET ST, EL PASO, Texas 79915 (EL PASO)***	***6***	***83***	***89***
.	COPPER (336 Transportation Equipment)	5	39	44
	LEAD (336 Transportation Equipment)	1	44	45
15	***PHELPS DODGE COPPER PRODUCTS CO. 897 HAWKINS BLVD, EL PASO, Texas 79915 (EL PASO)***	***37,582***	***548,089***	***585,671***
.	ANTIMONY COMPOUNDS (331 Primary Metals)	250	50,875	51,125
	ARSENIC COMPOUNDS (331 Primary Metals)	255	146,370	146,625
	COPPER COMPOUNDS (331 Primary Metals)	5,150	109,550	114,700
	LEAD COMPOUNDS (331 Primary Metals)	267	18,623	18,890
	MERCURY COMPOUNDS (331 Primary Metals)	0	6	6
	NICKEL COMPOUNDS (331 Primary Metals)	255	27,765	28,020
	SELENIUM COMPOUNDS (331 Primary Metals)	255	194,380	194,635

TRI On-site and Off-site Reported Disposed of or Otherwise Released (in pounds), for facilities in All Industries, for All Chemicals, El Paso County, Texas, 2007

Row #	Facility	Total On-site Disposal or Other Releases	Total Off-site Disposal or Other Releases	Total On- and Off-site Disposal or Other Releases
	SILVER COMPOUNDS (331 Primary Metals)	250	520	770
	SULFURIC ACID (1994 AND AFTER "ACID AEROSOLS" ONLY) (331 Primary Metals)	30,900	0	30,900
	THIOUREA (331 Primary Metals)	NA	NA	NA
16	***REXCEL COATINGS CORP. 4600 RIPLEY DR, EL PASO, Texas 79922 (EL PASO)***	***3,499***	***0***	***3,499***
.	CERTAIN GLYCOL ETHERS (325 Chemicals)	686	0	686
	TOLUENE (325 Chemicals)	1,883	0	1,883
	XYLENE (MIXED ISOMERS) (325 Chemicals)	930	0	930
17	***SIEMENS INDUSTRY INC. 1400 HENRY BRENNAN DR, EL PASO, Texas 79936 (EL PASO)***	***5,732***	***27,421***	***33,153***
.	COPPER (326 Plastics and Rubber)	0	0	0
	PHENOL (326 Plastics and Rubber)	313	326	639
	STYRENE (326 Plastics and Rubber)	5,346	26,728	32,074
	ZINC COMPOUNDS (326 Plastics and Rubber)	73	367	440
18	***SUMI TEXAS WIRE INC. 6500 N DESERT BLVD, EL PASO, Texas 79912 (EL PASO)***	***0***	***27,590***	***27,590***
.	COPPER (331 Primary Metals)	0	0	0
	DI(2-ETHYLHEXYL) PHTHALATE (331 Primary Metals)	0	0	0
	MIXTURE (331 Primary Metals)	0	27,590	27,590
19	***SW FOAM. 9900 RAILROAD, EL PASO, Texas 79924 (EL PASO)***	***62***	***0***	***62***
.	TOLUENE DIISOCYANATE (MIXED ISOMERS) (326 Plastics and Rubber)	62	0	62
20	***TONY LAMA CO. 1137 TONY LAMA ST, EL PASO, Texas 79915 (EL PASO)***	***14,601***	***0***	***14,601***
.	TOLUENE (316 Leather)	14,601	0	14,601
21	***U.S. ARMY AIR DEFENSE ARTILLERY CENTER & FORT BLISS. TAYLOR RD ATTN: IMSW-BLS-ZDOE BLDG 622, FORT BLISS, Texas 79916 (EL PASO)***	***236,146***	***0***	***236,146***
.	COPPER (ZZZ No TRI NAICS code)	131,031	0	131,031
	LEAD COMPOUNDS (ZZZ No TRI NAICS code)	105,115	0	105,115
	NITROGLYCERIN (ZZZ No TRI NAICS code)	0	0	0
	PHOSPHORUS (YELLOW OR WHITE) (ZZZ No TRI NAICS code)	0	0	0
22	***WESTERN REFINING CO. EL PASO REFINERY. 6501 TROWBRIDGE DR, EL PASO, Texas 79905 (EL PASO)***	***87,219***	***91,452***	***178,671***
.	1,2,4-TRIMETHYLBENZENE (324 Petroleum)	4,353	0	4,353
	1,3-BUTADIENE (324 Petroleum)	361	0	361
	AMMONIA (324 Petroleum)	25	0	25
	BENZENE (324 Petroleum)	9,288	21	9,309
	BENZO(G,H,I)PERYLENE (324 Petroleum)	1	0	1
	CARBONYL SULFIDE (324 Petroleum)	9,496	0	9,496
	COPPER COMPOUNDS (324 Petroleum)	14	30,289	30,303
	CYCLOHEXANE (324 Petroleum)	1,115	0	1,115
	DIETHANOLAMINE (324 Petroleum)	491	0	491
	ETHYLBENZENE (324 Petroleum)	3,421	48	3,469
	ETHYLENE (324 Petroleum)	3,430	0	3,430
	HYDROCHLORIC ACID (1995 AND AFTER "ACID AEROSOLS" ONLY) (324 Petroleum)	728	0	728
	LEAD (324 Petroleum)	10	60,642	60,652
	N-HEXANE (324 Petroleum)	8,413	0	8,413
	NAPHTHALENE (324 Petroleum)	1,087	0	1,087
	POLYCYCLIC AROMATIC COMPOUNDS (324 Petroleum)	13	0	13
	PROPYLENE (324 Petroleum)	14,118	0	14,118
	TETRACHLOROETHYLENE (324 Petroleum)	1,269	0	1,269
	TOLUENE (324 Petroleum)	17,558	69	17,627
	XYLENE (MIXED ISOMERS) (324 Petroleum)	12,028	383	12,411
	Total	**651,717**	**711,785**	**1,363,502**

TRI On-site and Off-site Reported Disposed of or Otherwise Released (in pounds), for facilities in All Industries, for All Chemicals, El Paso County, Texas, 2008

Row #	Facility	Total On-site Disposal or Other Releases	Total Off-site Disposal or Other Releases	Total On- and Off-site Disposal or Other Releases
2	***AIR SYSTEM COMPONENTS LP. 12405 WEAVER RD, EL PASO, Texas 79928 (EL PASO)***	***22,105***	***434***	***22,539***
.	CERTAIN GLYCOL ETHERS (332 Fabricated Metals)	22,105	434	22,539
3	***ARCELORMITTAL VINTON INC. I-10 & VINTON RD, VINTON, Texas 79821 (EL PASO)***	***9,085***	***0***	***9,085***
.	COPPER (331 Primary Metals)	113	.	113
	LEAD (331 Primary Metals)	1,102	.	1,102
	MANGANESE (331 Primary Metals)	658	.	658
	PROPYLENE (331 Primary Metals)	750	0	750
	ZINC (FUME OR DUST) (331 Primary Metals)	6,463	.	6,463
4	***AUTOTRONIC CONTROLS CORP. 1490 HENRY BRENNAN DR, EL PASO, Texas 79936 (EL PASO)***	***1***	***0***	***1***
.	LEAD (336 Transportation Equipment)	1	0	1
5	***BOEING CO. 9566 RAILROAD DR, EL PASO, Texas 79924 (EL PASO)***	***2***	***40***	***42***
.	LEAD (334 Computers/Electronic Products)	2	40	42
6	***CHAMPLAIN CABLE TEXAS. 9560 PLAZA CIR, EL PASO, Texas 79927 (EL PASO)***	***0***	***.***	***0***
.	COPPER (335 Electrical Equipment)	0	.	0
7	***COLEMAN CABLE INC. 7811 HOOVER DR, EL PASO, Texas 79912 (EL PASO)***	***0***	***.***	***0***
.	COPPER (331 Primary Metals)	0	.	0
8	***COLEMAN CABLE INC. 201 INGLEWOOD DR, EL PASO, Texas 79927 (EL PASO)***	***0***	***.***	***0***
.	COPPER (331 Primary Metals)	0	.	0
9	***COLEMAN CABLE INC. 1388 N ZARAGOSA RD, EL PASO, Texas 79936 (EL PASO)***	***0***	***5,359***	***5,359***
.	ANTIMONY COMPOUNDS (331 Primary Metals)	0	4,606	4,606
	BARIUM COMPOUNDS (331 Primary Metals)	0	430	430
	COPPER (331 Primary Metals)	0	.	0
	ZINC COMPOUNDS (331 Primary Metals)	0	323	323
10	***DAL-TILE EL PASO MANUFACTURING. 12001 RAILROAD DR, EL PASO, Texas 79934 (EL PASO)***	***170,990***	***0***	***170,990***
.	HYDROGEN FLUORIDE (327 Stone/Clay/Glass)	170,953	0	170,953
	ZINC COMPOUNDS (327 Stone/Clay/Glass)	37	.	37
11	***E I DUPONT. 6501 TROWBRIDGE RD, EL PASO, Texas 79905 (EL PASO)***	***6,875***	***0***	***6,875***
.	AMMONIA (325 Chemicals)	0	0	0
	SULFURIC ACID (1994 AND AFTER "ACID AEROSOLS" ONLY) (325 Chemicals)	6,875	0	6,875
12	***EAGLE FAMILY FOODS. 255 MONTOYA RD, EL PASO, Texas 79932 (EL PASO)***	***0***	***0***	***0***
.	NITRATE COMPOUNDS (311/312 Food/Beverages/Tobacco)	0	.	0
	NITRIC ACID (311/312 Food/Beverages/Tobacco)	0	0	0
13	***EPSON EL PASO INC. 1211 HENRY BRENNAN, EL PASO, Texas 79936 (EL PASO)***	***NA***	***NA***	***NA***
.	MIXTURE (325 Chemicals)	NA	NA	NA
	MIXTURE (325 Chemicals)	NA	NA	NA
14	***INTERNATIONAL WIRE GROUP - CAMDEN WIRE FACILITY. 1700 COMMERCE PARK DR, EL PASO, Texas 79912 (EL PASO)***	***0***	***3,357***	***3,357***
.	COPPER (331 Primary Metals)	0	3,357	3,357
15	***L&M RADIATOR. 6966 MARKET ST, EL PASO, Texas 79915 (EL PASO)***	***6***	***15***	***21***
.	COPPER (336 Transportation Equipment)	5	7	12
	LEAD (336 Transportation Equipment)	1	8	9
16	***MAXUM PETROLEUM EL PASO FACILITY. 10925 MARCONI ST, EL PASO, Texas 79935 (EL PASO)***	***25***	***0***	***25***
.	1,2,4-TRIMETHYLBENZENE (4247 Petroleum Bulk Terminals)	5	0	5
	BENZENE (4247 Petroleum Bulk Terminals)	5	0	5
	ETHYLBENZENE (4247 Petroleum Bulk Terminals)	5	0	5
	TOLUENE (4247 Petroleum Bulk Terminals)	5	0	5
	XYLENE (MIXED ISOMERS) (4247 Petroleum Bulk Terminals)	5	0	5
	ZINC COMPOUNDS (4247 Petroleum Bulk Terminals)	0	.	0
17	***PHELPS DODGE COPPER PRODUCTS CO. 897 HAWKINS BLVD, EL PASO, Texas 79915 (EL PASO)***	***30,841***	***422,584***	***453,425***
.	ANTIMONY COMPOUNDS (331 Primary Metals)	5	29,375	29,380
	ARSENIC COMPOUNDS (331 Primary Metals)	255	167,465	167,720
	COPPER COMPOUNDS (331 Primary Metals)	3,150	33,350	36,500
	LEAD COMPOUNDS (331 Primary Metals)	161	14,166	14,326

TRI On-site and Off-site Reported Disposed of or Otherwise Released (in pounds), for facilities in All Industries, for All Chemicals, El Paso County, Texas, 2008

Row #	Facility	Total On-site Disposal or Other Releases	Total Off-site Disposal or Other Releases	Total On- and Off-site Disposal or Other Releases
	MERCURY COMPOUNDS (331 Primary Metals)	0	3	3
	NICKEL COMPOUNDS (331 Primary Metals)	255	45,520	45,775
	SELENIUM COMPOUNDS (331 Primary Metals)	10	132,435	132,445
	SILVER COMPOUNDS (331 Primary Metals)	5	270	275
	SULFURIC ACID (1994 AND AFTER "ACID AEROSOLS" ONLY) (331 Primary Metals)	27,000	0	27,000
	THIOUREA (331 Primary Metals)	NA	NA	NA
18	***REXCEL COATINGS CORP. 4600 RIPLEY DR, EL PASO, Texas 79922 (EL PASO)***	***2,229***	***0***	***2,229***
.	CERTAIN GLYCOL ETHERS (325 Chemicals)	NA	NA	NA
	TOLUENE (325 Chemicals)	1,294	0	1,294
	XYLENE (MIXED ISOMERS) (325 Chemicals)	935	0	935
19	***SIEMENS INDUSTRY INC. 1400 HENRY BRENNAN DR, EL PASO, Texas 79936 (EL PASO)***	***4,360***	***4,618***	***8,978***
.	COPPER (326 Plastics and Rubber)	0	.	0
	PHENOL (326 Plastics and Rubber)	349	464	813
	STYRENE (326 Plastics and Rubber)	3,918	3,624	7,542
	ZINC COMPOUNDS (326 Plastics and Rubber)	93	530	623
20	***SMURFIT-STONE CONTAINER CORP EL PASO EAST. 7350 STILES DR, EL PASO, Texas 79915 (EL PASO)***	***NA***	***NA***	***NA***
.	NITRATE COMPOUNDS (322 Paper)	NA	NA	NA
21	***STEWART EFI FINISHING LLC. 44 BUTTERFIELD CIR, EL PASO, Texas 79906 (EL PASO)***	***0***	***0***	***0***
.	HYDROCHLORIC ACID (1995 AND AFTER "ACID AEROSOLS" ONLY) (332 Fabricated Metals)	0	0	0
	SULFURIC ACID (1994 AND AFTER "ACID AEROSOLS" ONLY) (332 Fabricated Metals)	0	0	0
22	***SUMI TEXAS WIRE INC. 6500 N DESERT BLVD, EL PASO, Texas 79912 (EL PASO)***	***0***	***20,209***	***20,209***
.	COPPER (331 Primary Metals)	0	0	0
	DI(2-ETHYLHEXYL) PHTHALATE (331 Primary Metals)	0	0	0
	MIXTURE (331 Primary Metals)	0	20,209	20,209
23	***SW FOAM. 9900 RAILROAD, EL PASO, Texas 79924 (EL PASO)***	***41***	***0***	***41***
.	TOLUENE DIISOCYANATE (MIXED ISOMERS) (326 Plastics and Rubber)	41	0	41
24	***TONY LAMA CO. 1137 TONY LAMA ST, EL PASO, Texas 79915 (EL PASO)***	***14,920***	***0***	***14,920***
.	TOLUENE (316 Leather)	14,920	0	14,920
25	***U.S. ARMY AIR DEFENSE ARTILLERY CENTER & FORT BLISS. TAYLOR RD ATTN: IMSW-BLS-ZDOE BLDG 622, FORT BLISS, Texas 79916 (EL PASO)***	***226,227***	***0***	***226,227***
.	COPPER (ZZZ No TRI NAICS code)	148,761	.	148,761
	LEAD COMPOUNDS (ZZZ No TRI NAICS code)	77,466	.	77,466
	NITROGLYCERIN (ZZZ No TRI NAICS code)	0	0	0
26	***WESTERN REFINING CO. EL PASO REFINERY. 6501 TROWBRIDGE DR, EL PASO, Texas 79905 (EL PASO)***	***86,649***	***43,329***	***129,978***
.	1,2,4-TRIMETHYLBENZENE (324 Petroleum)	4,960	0	4,960
	1,3-BUTADIENE (324 Petroleum)	169	0	169
	AMMONIA (324 Petroleum)	2	.	2
	BENZENE (324 Petroleum)	8,800	5	8,805
	BENZO(G,H,I)PERYLENE (324 Petroleum)	1	140	141
	CARBONYL SULFIDE (324 Petroleum)	1,200	0	1,200
	COPPER COMPOUNDS (324 Petroleum)	9	22,370	22,379
	CYCLOHEXANE (324 Petroleum)	211	0	211
	DIETHANOLAMINE (324 Petroleum)	490	0	490
	ETHYLBENZENE (324 Petroleum)	3,570	41	3,611
	ETHYLENE (324 Petroleum)	4,100	0	4,100
	HYDROCHLORIC ACID (1995 AND AFTER "ACID AEROSOLS" ONLY) (324 Petroleum)	360	0	360
	LEAD (324 Petroleum)	8	17,220	17,228
	Total	**574,356**	**499,945**	**1,074,301**

TRI On-site and Off-site Reported Disposed of or Otherwise Released (in pounds), for facilities in All Industries, for All Chemicals, El Paso County, Texas, 2008

Row #	Facility	Total On-site Disposal or Other Releases	Total Off-site Disposal or Other Releases	Total On- and Off-site Disposal or Other Releases
	MOLYBDENUM TRIOXIDE (324 Petroleum)	0	2,003	2,003
	N-HEXANE (324 Petroleum)	14,100	0	14,100
	NAPHTHALENE (324 Petroleum)	950	1,000	1,950
	POLYCYCLIC AROMATIC COMPOUNDS (324 Petroleum)	19	.	19
	PROPYLENE (324 Petroleum)	8,300	0	8,300
	TETRACHLOROETHYLENE (324 Petroleum)	1,300	.	1,300
	TOLUENE (324 Petroleum)	23,300	50	23,350
	XYLENE (MIXED ISOMERS) (324 Petroleum)	14,800	500	15,300
	Total	**574,356**	**499,945**	**1,074,301**

Vita

Joseph Christopher Piñon was born on March, 5th, 1981 in El Paso, Texas, the second son of Edward M. and Irma A. Piñon and graduated from Thomas Jefferson High School, El Paso, Texas. After the completion of his undergraduate degree from the University of Texas at El Paso in Civil Engineering, Joseph began his graduate studies in Environmental Engineering in August of 2009. Whilst pursuing his graduate degree, Joseph had been the recipient of the Southwest Consortium for Environmental Research & Policy (SCERP) Fellowship while also serving as a graduate research student for the UTEP Air Quality Research Laboratory under the guidance of Dr. Wen-Whai, Li.

Throughout a large portion of his graduate career, Joseph also served as President to the UTEP Chi Epsilon chapter from January 2010 until December 2010. Chi Epsilon is the National Civil Engineering Honor society which honors students who have exemplified the principles of "Scholarship, Character, Practicality, and Sociability" in the civil engineering profession.

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This thesis was typed by Joseph Christopher Piñon.