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Analysis Of Particulate Matter Air Quality Impacts On Sunland Park, New Mexico Due To Dust Emissions From Puerto Anapra, Mexico Using A Complex Terrain Air Dispersion Model Calpuff

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Dedication

Dedicated to my supporting family.

ANALYSIS OF AIR QUALITY IMPACTS IN SUNLAND PARK, NEW MEXICO BY PUERTO ANAPRA, MEXICO

by

GRISEL EDITH ARIZPE

THESIS

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Abstract

The City of Sunland Park is located in Doña Ana County in southern New Mexico. The City has unusual boundaries which border not only with other communities in New Mexico but also the State of Chihuahua, Mexico to the south and the City of El Paso, Texas to the east. This area is considered part of the Paso del Norte Airshed (PdNA), which is comprised also by El Paso County, Texas and Ciudad (Cd.) Juarez, Mexico. Historically, this region has had air quality problems and compliance issues with National Ambient Air Quality Standards (NAAQS), including particulate matter and ozone pollution. The New Mexico Environment Department (NMED) Air Quality Bureau (AQB) has the responsibility to monitor the air quality of Sunland Park. NMED has found numerous exceedances of the 24-hr NAAQS concentration limit for particulate matter of 10 micrometers (µm) in aerodynamic diameter or smaller (PM_{10}) within the Dona Ana County. Because the County has surpassed the number of exceedances allowed by the standard, the County is in violation of the PM_{10} NAAQS. However, wind data analysis from the NMED's AQB along with other data showed that all exceedances, with exception of a few cases, were caused by high winds, which lift and carry dust from exposed dry soil.

Cd. Juarez, in the State of Chihuahua, Mexico is located directly across the Rio Grande River abutting El Paso, Texas and Sunland Park, New Mexico to the north. The industrial, nonpoint, and mobile sources located in Cd. Juarez are known to contribute significant amounts of air pollutants that are transported north, adversely impacting the air quality of the PdNA (ERG, 2003). Recent modeling studies have shown that the City of El Paso could meet the NAAQS if not for its proximity to Cd. Juarez (TCEQ, 2010). The previous statement has brought attention on the air quality impacts to the PdNA by the air pollutant emissions generated in Cd. Juarez, especially the PM_{10} emissions from unpaved roads.

This study was designed to conduct air quality modeling for Sunland Park, New Mexico using the innovative CALMET/CALPUFF air modeling software to determine the air quality impacts caused by dust emissions from the unpaved areas across the U.S.-Mexico border in Colonia Puerto Anapra (Anapra) in Cd. Juarez, Mexico. This study utilized meteorological data input files MM5 developed by the Western Regional Air Partnership (WRAP) Regional Modeling Center (RMC) and the Midwest RPO for the State of New Mexico. CALMET input files were acquired from WRAP RMC to support

CALMET/CALPUFF modeling for the project area. The CALMET modeling was conducted using the model options as in the MM5 simulations but adapting the model to the study area. CALMET output files were implemented in the CALPUFF modeling to estimate the particulate matter concentrations based on the meteorological conditions as well as wind erosion and unpaved roads emission factors. The EPA's *Rapid Assessment of Exposure to Particulate Emissions from Surface Contamination* and the AP-42 Chapter 13.2.2 were utilized to develop the site-specific estimates of potential dust emissions factors from Anapra Subvision. The estimated emission factors were inputted in the model with four different receptors in the study area to determine the potential concentrations at these locations. These receptors were strategically located in the model at the same location of existing air quality monitoring stations from the TCEQ and NMED to be able to compare real time data with modeled data. CALPUFF output files were processed implementing CALPOST and CALVIEW software.

The study showed that, according to the CALMET wind field plot results, southeasterly winds were predominant throughout the year, showing that in the study area, winds flow from Puerto Anapra to Sunland Park the majority of the time. The annual wind rose modeled that 17% of the winds were southeasterly, 12% were east southeasterly, 11% were easterly, 11% were northerly, and 10% were north northwesterly predominantly ranging from 1 to 12 mph. During the winter months, January, February and December, northerly winds were predominantly 16% of the time, followed by southeasterly at 14% and north northwesterly at 12%. In addition, this study determined the time during the day and months that had the highest peak PM_{10} concentrations. According to the results, high hourly PM_{10} concentrations were experienced at earlier morning hours from 0:00 hr. to 7:00 hrs. but higher concentrations were recorded during late nights from 17:00 hrs. to 23:00 hrs. Winter months including November, December, January, February and March had turbulent wind patterns and higher concentrations in the year.

This work also assisted to determine the percent of contribution to air pollution in Sunland Park from Puerto Anapra. Based on the estimated wind erosion and unpaved roads modeled emissions, the Desert View TEOM Station located at the center of Sunland Park, had the highest annual PM_{10} average concentration of 97 $\mu g/m^3$. Subsequently, the UTEP CAMS Station had the second highest annual PM_{10}

average concentration of 28 μg/m^3 which was approximately 48% of the total annual PM_{10} average concentration from the real data (58 μg/m^3). The Sunland Park TEOM Station had the third highest annual PM_{10} average concentration of 21.4 μg/m^3 which was approximately 28% of the total annual PM_{10} average concentration from the real data (78 μg/m^3). Last, the Santa Teresa TEOM Station had the lowest estimate of 4 μg/m^3 when compared to the other stations. Also, it was noticeable that PM_{10} concentrations varied in a high degree at the different receptors. For instance, Santa Teresa TEOM Station experienced minimal PM_{10} concentrations, where at Desert View TEOM Station had outstanding concentrations at less than a 10 mile difference. This information establishes that Desert View TEOM Station is more susceptible to Anapra than the other Receptors.

In addition, this modeling study involved only the sources of unpaved roads and wind erosion from the Anapra Subdivision and neglects other surrounding area sources. For the most part, real time data exceeds modeled data results but can provide an estimated PM_{10} concentration contribution and the impact from Anapra Subdivision to the City of Sunland Park.

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1. Introduction

The City of Sunland Park is located in Doña Ana County in southern New Mexico. The City has unusual boundaries which border not only with other communities in New Mexico but also the State of Chihuahua, Mexico to the south and the City of El Paso, Texas to the east. This area is considered part of the Paso del Norte Airshed (PdNA), which is comprised also by El Paso County, Texas and Ciudad (Cd.) Juarez, Mexico. Historically, this region has had air quality problems and compliance issues with National Ambient Air Quality Standards (NAAQS), including particulate matter and ozone pollution. The New Mexico Environment Department (NMED) Air Quality Bureau (AQB) has the responsibility to monitor the air quality of Sunland Park. NMED and has found numerous exceedances of the 24-hr NAAQS concentration limit for particulate matter of 10 micrometers (μm) in aerodynamic diameter or smaller (PM_{10}) within the Dona Ana County. Because the County has surpassed the number of exceedances allowed by the standard, the County is in violation of the PM_{10} NAAQS. However, wind data analysis from the NMED's AQB along with other data showed that all exceedances, with exception of a few cases, were caused by high winds, which lift and carry dust from exposed dry soil. As required by U.S. Environmental Protection Agency (EPA), NMED with the City of Las Cruces and Doña Ana County developed and submitted to the EPA a Natural Events Action Plan (NEAP) for Doña Ana County in 2000 (NMED AQB, 2005). Sunland Park is currently designated as an attainment area for PM_{10} by the EPA, however it is also under dust control maintenance due to its previous history of exceeding the NAAQS for PM_{10} (150 $\mu g/m^3$ for a 24-hour average) (NMED AQB, 2005).

Cd. Juarez, in the state of Chihuahua, Mexico is located directly across the Rio Grande River abutting El Paso, Texas and Sunland Park, New Mexico to the north. This region is a special geographic location of the southwestern United States and northern Mexico. The local topography of the PdNA is characterized by complex terrain and elevated dessert terrain with narrow north-south trending Franklin Mountains bisecting El Paso and the southwest trending Sierra de Juarez Mountains south of the Rio Grande River. The climate and meteorological conditions on this area have a significant influence on its air quality as in the majority of the western U.S. states. This area has low rainfall with an annual precipitation average of 8.5 inches (NMED AQB, 2005). The dry top layer of soil is composed of fine particles that migrate under the influence of local winds (BECC, 2004). Given the special topological

and meteorological characteristics of this basin, the atmospheric pollutants are frequently trapped in the basin, making it difficult to determine the exact sources of the pollutants.

In this area, the occurrence of inversion is very frequent, noticing a well-defined haze hanging over the region during morning hours. The development and evolution that Cd. Juarez has had in the recent years have also caused an increase in the number of point and mobile sources of pollution. Cd. Juarez has exceeded the healthy limits established for ozone, carbon monoxide and particulate matter by the environmental laws of both countries. The industrial, nonpoint, and mobile sources located in Cd. Juarez are known to contribute significant amounts of air pollutants that are transported north, adversely impacting the air quality of the PdNA (ERG, 2003). Recent modeling studies have shown that the City of El Paso could meet the NAAQS if not for its proximity to Cd. Juarez (TCEQ, 2010). The previous statement has brought attention on the air quality impacts to the PdNA by the air pollutant emissions generated in Cd. Juarez, especially the PM_{10} emissions from unpaved roads.

To control air pollution in the area, the Management of Air Quality in Cd. Juarez was established. A part of this program included the integration of an emissions inventory. The importance of this management tool is that it allowed the estimation of the volume and type of pollutants produced by a source. This program also proposed 40 measures that will, in the medium term, gradually reduce the pollution in the City to the level meeting the air quality standards. In the same manner, different agencies of both the U.S. and Mexican governments have joined forces to work in this important problem. These government agencies include: EPA, Texas Commission on Environmental Quality (TCEQ), NMED, County of El Paso and Doña Ana, of the U.S. and SEMARNAT, the Government of the State of Chihuahua and Cd. Juarez, of Mexico. The Air Quality Emissions Inventory reported in the Cd. Juarez Air Quality Management Program (1998-2002), showed that the total PM emissions in Cd. Juarez is slightly higher than 600,000 tons per year, of which 1% is from the industry, 4% services, 7% soil erosion and 88% transport.

Particulate matter is a complex mixture of extremely small particles and liquid droplets, including acids, organic chemicals, metals and soil or dust particles. The particles aerodynamic diameter is directly linked to their potential for causing health problems. There exists a concern about particles that are 10 μm in aerodynamic diameter or smaller because these are the particles that generally pass

through the throat and nose and enter the lungs. Once these particles are inhaled, they could affect the heart and lungs and cause serious health effects (U.S. EPA, 2011). In this area, an increase in asthma-related emergency room visits was found to be associated with an increase in PM_{10} (BECC, 2004).

Health concerns have called for the need of studies to analyze the effects of air pollution on the public. Government and nongovernment agencies have been quite active as a forum for debate and presentation of issues on both sides of the border. The academic research community has been well represented by local and international non-governmental organizations. The TCEQ, El Paso City-County, Cd. Juarez municipal government, and the NMED continue to monitor the air quality in the PdNA. In addition, emissions inventories and models have been much extensively examined in the 1990's (BECC, 2004).

On this effort, data have been collected for several years by both Mexican and U.S. authorities focusing on large industrial sources and onroad motor vehicles; however, little is known about the source impacts from smaller area sources such as irregular subdivisions with unpaved roads (ERG, 2003). In the same manner, there is a need to determine the impacts on air quality by small area sources in this area and improve air quality and public health in this border region.

1.1 Research Objectives

This study was designed to conduct air quality modeling for Sunland Park, New Mexico using the innovative CALMET/CALPUFF air modeling software to determine the air quality impacts caused by dust emissions from the unpaved areas across the U.S.-Mexico border in Colonia Puerto Anapra (Anapra) in Cd. Juarez, Mexico. Atmospheric modeling is an important tool in assessing the potential impacts of various sources of pollution. CALPUFF is an atmospheric source-receptor model recommended by the U.S. EPA for use on a case-by-case basis in complex terrain and wind conditions such the proposed project area (CALPUFF, 2010). One of the key capabilities of this model is to provide useful information for exposure assessments in areas with those topographical and meteorological conditions that have received little attention. Previous findings demonstrate that CALPUFF can provide reasonably accurate predictions of the patterns of long-term air pollutant

deposition in the near-field associated with emissions from a discrete source in complex terrain (CALPUFF, 2010). This model relies on wind fields produced by CALMET meteorological model that include parameterized treatments of slope flows, valley flows, terrain blocking effects, kinematic terrain effects, terrain impingement, side-wall scraping, and steep-walled terrain influences (Macintosh, 2009).

Accordingly, the objective of this study was to determine the contribution of PM_{10} to Sunland Park, NM from the Anapra Subdivision in Cd. Juarez due to wind erosion and unpaved roads using CALMET/CALPUFF modeling software.

The tasks developed for this study were to,

1. Use the diagnostic meteorological model, CALMET, to diagnostic three-dimensional wind field generator and micro-meteorological variables using Mesoscale Model (MM5) data and compute winds and turbulence parameters in each grid of the modeling domain for each hour of the modeling period, year 2003.
2. Utilize PRTMET post-processing module to extract information and graphical plots from CALMET output files and view results in CALVIEW software.
3. Implement the transport and dispersion air quality model, CALPUFF, to simulate the dispersion and transformation process, at each grid cell, of PM_{10} ground level concentrations from area sources such as unpaved roads and wind erosion.
4. Use CALPOST to process the result files from CALPUFF, producing a summary of the simulation results in tabulated forms and utilize CALVIEW software to graphically plot results.
5. Conduct sensitivity analysis of the model performance. Compare CALPUFF modeling system output pollutant concentrations with monitoring stations in the area to validate results and show discrepancies.

1.2 Content of the Thesis

The research objective and tasks were achieved and discussed in the following sections of this thesis. The Background section reviews and discusses the air quality history of the project area. The Modeling section discusses in detail the features of the CALMET/CALPUFF modeling system capabilities and provides a description of the model run. The section of Results and Discussion analyses the results from the model run and compares them to the existing monitoring data. The section of Modeling Uncertainty describes the uncertainties of the model run. The section of Summary and Conclusions includes a summary of findings and conclusions from the study.

2. Background

2.1 Study Area: Sunland Park, New Mexico and Colonia Puerto Anapra, Mexico

Sunland Pak is a city in Doña Ana County, New Mexico, U.S. The city is at the foothill of Mount Cristo Rey, next to the Rio Grande River. According to the 2000 U.S. Census, Sunland Park has a population of 13,309 people, a total area of 10.8 square miles, 3,355 households, and 2,969 families residing in the city. The City lies directly across from El Paso, Texas and is part of the Las Cruces Metropolitan Statistical Area, about 30 miles to the North. Sunland Park is located at 31°48'24" North latitude 106°34'48 West longitude. The City sits along the United States-Mexico border and is bordered to the south by Colonia Puerto Anapra, Chihuahua, Mexico (Wikipedia, 2010). With a population of approximately 15,000, the bedroom community of Sunland Park has the amenities of a big city without the congestion (Banks, 2002).

The Colonia Puerto Anapra, which is the acronym for the National Association of Farmers (Asociación Nacional de Productores Agrícolas), is located northwest of Cd. Juarez on the United States and Mexico border. To the north, Anapra shares the international border with the United States, more specifically the cities of El Paso, Texas and Sunland Park, New Mexico. Figure 2-1 shows the study area that covers Sunland Park, New Mexico and Colonia Puerto Anapra, Mexico. The Colonia is located at 31°47' North latitude and 106°34' West longitude, at an average altitude of 1,180 meters above sea level. Anapra constitutes an enlargement of Cd. Juarez, and it is considered a marginal area socially and economically, due to the nature of its settlement. Anapra started as irregular and illegal settlements dating more than 25 years ago and generated by the migratory flow of Mexican residents to a location closer to the international border. The population in Anapra in 2005 was approximately 18,400 people. Anapra is expected to grow to 44,000 people in the next 15 years (BECC, 2004).

Vehicle emissions, especially older vehicles from Cd. Juarez and at the congested border ports of entry are major contributors to the air quality of the area. The uncontrolled and illegal burning of car tires in Cd. Juarez and Anapra, emissions from the Camino Real landfill in Sunland Park on the U.S. side of the border, the dust from unpaved roads in Anapra, other areas of PM sources along the border,

and the frequent dust storms during the months of March and April, all contribute to the ambient PM air quality problem of the area. Figure 2-1 illustrates the study area.

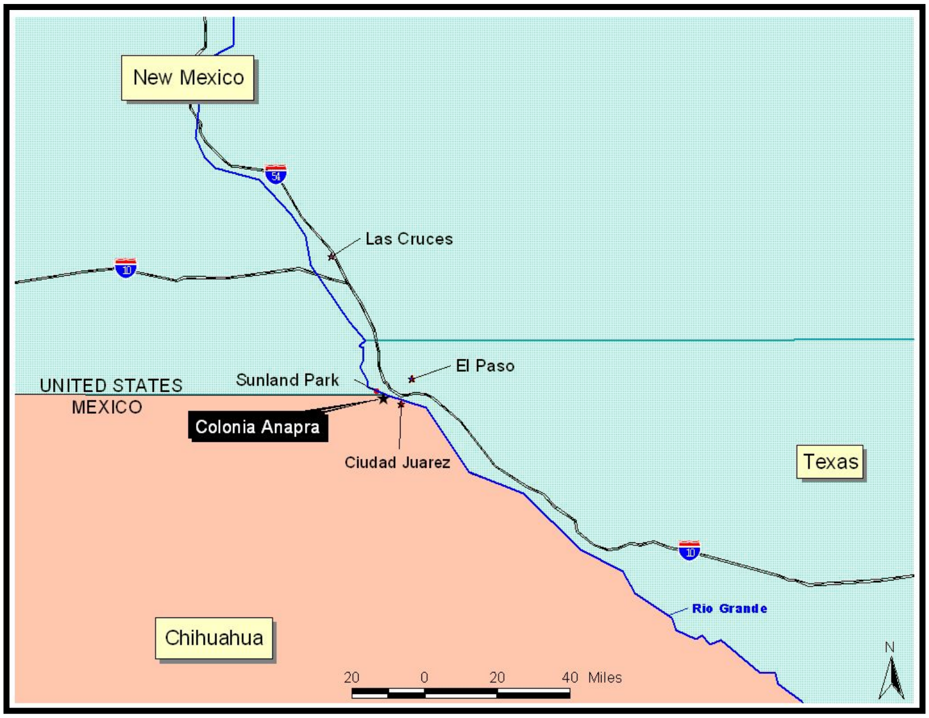

Figure 2-1. Study Area.

The climate in Sunland Park, New Mexico and Puerto Anapra, Mexico is generally mild and semiarid, averaging 350 days of clear weather annually. Annual precipitation is low, approximately 8.5 inches of rainfall and 3 inches of snowfall (NMED AQB, 2005). Prevailing winds are most common southwesterly and windstorms occur generally during the late winter and through the spring months. High winds from these windstorms are one reason that this region experiences most of the PM exceedances. The main geographical features of this area are the Franklin Mountains and Sierra Juarez, which have a strong influence on local winds. A typical day may start as the sun warms the south and east side of the mountains causing upslope winds from the south and east. As the day heats up, the boundary layer deepens rapidly throughout the late morning and early afternoon. The deepening of the boundary layer allows for the momentum transfer between the surface and aloft air. In the evening, as

the earth begins to cool down, the aloft air and surface layers decouple and the momentum transfer ceases. A drainage flow results and continues until sunrise again.

2.2 Particulate Matter Air Quality Problems in the Study Area

This region faces two distinct scenarios of degraded air quality. The first scenario and the focus of this thesis refers to events when great quantities of dust are lifted from the earth's surface during winds events. These events occur mainly during the spring season. The second scenario occurs when winds are low and temperature inversion trap pollutants into the air basin. This type of event is very noticeable in this region and can happen anytime of the year, however, they have the most impact during the colder season from December through February (NMED AQB, 2009). Complex terrain in the area defines the flow of pollutants. Cooler air flows down from higher to lower terrain and travels along ravines and natural drainage patterns toward the Rio Grande River.

The NMED-AQB operates air quality monitors which have recorded numerous exceedances of the 24-hour NAAQS concentration limit for PM_{10} over the last ten years. As previously mentioned, since the number of days with exceedances is more than the number allowed by the standard, the region is in violation of the PM_{10} NAAQS. Based of wind data analysis, it was determined that all but a few exceedances were caused by high winds. Given that high winds events are types of natural event covered by EPA's Natural Events Policy (NEP), the NMED-AQB developed and submitted to EPA in December 2000 a Natural Events Action Plan (NEAP) for Doña Ana County. As part of the federal requirement for any NEAP, a reevaluation of the plan was conducted after five (5) years to determine if any changes were necessary to protect public health and control anthropogenic sources that may contribute to exceedances of the PM_{10} NAAQS. This reevaluation reviewed the conditions causing violations of the PM_{10} NAAQS in Doña Ana County; the status of the implementation of the plan; and the adequacy of the actions being implemented (NMED AQB, 2005).

Windblown dust in the area occurs both from natural and paved surfaces. While dust is common in undisturbed areas throughout the west, it becomes much more prevalent where natural soils have been disturbed by human activities. In this case, Colonia Puerto Anapra has been poorly developed by illegal

settlements from residents of Cd. Juarez looking for an affordable dwelling, although lacking necessary environmental services. Besides the lack of water and wastewater services, this subdivision is mostly unpaved. Natural soils have a tendency to form a mineral organic crust that is resistant to erosion by wind, however, human activities such as construction and vehicle traffic can remove or break this crust, allowing dust to be lifted and dispersed more easily. In addition, even sparse desert vegetation provides protection to the soil surface by suppressing dust emissions and serving as a windbreak and organic binder. "When human activities remove vegetation, the soil is more susceptible to wind, and as a result, airborne dust is produced." (NMED AQB, 2005)

Dust from unpaved roads constitutes one of the most important sources of PM_{10} in the region. In Cd. Juarez, unpaved roads are a critical issue on air quality given that about 50% of the city is unpaved and many of these carry busy traffic (NMED AQB, 2009). Roadway infrastructure in the El Paso and Sunland Park areas consists of well-developed paved roads; however, the roadway infrastructure of Anapra is poorly maintained. The existing roads in Anapra consist of hard-pan dry soil. The main roads are wide, but due to numerous potholes and other obstacles, traffic flow on many roads does not follow any lane structure. There are only two paved roads within Anapra, which were recently laid after wastewater infrastructure was installed. The unpaved roads in Anapra have little or no dust control which result in windblown dust and increase the presence of particulate matter. A recent emission inventory for Cd. Juarez estimated that 26 percent of particulate matter emissions come from unpaved roads (NMED AQB, 2009).

In 2004, NMED-AQB acquired funding from the EPA to develop an air quality pilot study for issues in Doña Ana County to be incorporated into a larger body of work called the Atlas Project. The purpose of this study was the development of an atlas of environmental issues along the U.S.-Mexico border region. The study investigated sources of PM_{10} and $PM_{2.5}$ associated with agricultural and non-agricultural operations throughout the area. The results from the 2002 annual emissions for agriculture sources in Doña Ana County show that the largest two source categories are unpaved and paved road dust. These two sources categories combined comprise approximately 94 percent of the total PM_{10} inventory. Table 2-1 shows the results.

Table 2-1. 2002 Annual Emissions for Agriculture Sources in Doña Ana County.

Source	Emissions (tons/year)	
	PM_{10}	$PM_{2.5}$
Crop Land Preparation (tillage)	201.7	44.7
Crop Harvesting	96.9	21.5
Agricultural Burning (prunings)	45.4	42.8
Cotton Gins	16.9	2.2
Dairies	33.3	3.8
Feedlots	4.3	0.5
Unpaved Road Dust (Agriculture Only)	55.7	11.8
Unpaved Road Dust (County-wide)	6,166.9	922.5
Paved Road Dust (County-wide)	1,119.9	153.3
Agriculture Equipment (Exhaust)	16.6	15.3
Total	**7,757.5**	**1,218.4**

(NMED, 2005)

The largest source category in the annual emissions of nonagricultural sources in Doña Ana County for 2002 is windblown dust (representing 1996 emissions) which contributes over 85 percent of the total PM_{10} and $PM_{2.5}$ inventories. Table 2-2 shows the results.

Table 2-2. 2002 Annual Emissions for Nonagricultural Sources in Doña Ana County.

Source	Emissions (tons/year)	
	PM_{10}	$PM_{2.5}$
Quarrying and Mining	159.2	31.8
Construction Activities	294.2	61.2
On-Road Motor Vehicles	147.0	110.9
Nonroad Mobile Sources	60.1	55.3
Aircraft	6.1	4.2
Locomotives	29.1	26.2
Residential Wood Combustion	138.5	138.5
Charbroiling	143.2	132.6
Paved Road Dust[a]	1,119.9	153.3
Unpaved Road Dust[a]	6,166.9	922.5
Waste Burning - Household Waste	82.5	75.6
Waste Burning - Yard Waste	6.1	6.1
Other Fuel Combustion	70.4	60.1
Wild Fires	1.1	0.9
Prescribed Wildland Burning	0.0	0.0
Structural Fires	1.5	1.5

Vehicle Fires	2.8	2.8
Wind Erosion[b]	49,242.5	10,833.3
Total	**57,671.1**	**12,616.8**
Total (minus Wind Erosion)	**8,428.6**	**1,783.5**
[a]Unadjusted emissions taken from agricultural emissions inventory (ERG, 2004). [b]Wind erosion emissions obtained from 1996 WRAP wind erosion inventory (ENVIRON et al., 2004)		
(NMED, 2005)		

The study determined that the main contributor for PM_{10} exceedances during high winds events was wind erosion in first place and paved and unpaved road dust in second. Although windblown dust is common off unpaved and some paved roads, this particular inventory used emissions caused by vehicle movement induced dust and not by wind erosion, therefore, it does not provide a clear understanding of the emissions caused only by windblown erosion.

In addition, based on past field studies and routine continuous PM_{10} compliance monitors in the area, it is suspected that unpaved roads and various combustion activities from south of the border are main contributors to the Sunland Park City PM pollution. During the summer of 1994, a study to characterize wind patterns using a lidar, found plumes of particulate matter flowing from higher to lower elevation, coming from Mexico in the morning (Barr, 1994). This study showed morning mixing heights of approximately 200 meters and increasing throughout the day to 3000 and 4000 meters by mid-afternoon.

Moreover, the Department of Civil Engineering at University of Texas at El Paso conducted a study to determine the causes for evening low-wind PM_{10} and $PM_{2.5}$ peaks at Sunland Park, NM. The study showed that both PM_{10} and $PM_{2.5}$ concentrations during the evening hours accounted for approximately 50% of their respective 24-hr averages. This study also confirmed that the peaks frequently occurred under stable conditions with weak southerly winds (Cardenas, 2005).

2.3 Atmospheric Dispersion Modeling

Atmospheric dispersion models are used for mathematical simulation of air pollutants dispersion in the earth's atmosphere and are constituted by different types. Computer programs are utilized to solve

mathematical equations and algorithms which simulate this phenomenon. Dispersion models were developed to quantitatively estimate or predict the downwind concentrations of air pollutants emitted from different sources. In addition, dispersion models can estimate impacts at many points over a wide geographically area while accounting for geophysical factors such as terrain elevation, presence of water bodies, urbanization, variations in surface conditions and land use. Modeling is performed to assist in determining the impacts on different scenarios that in real experimentation would be extremely expensive to realize, as well in evaluating rare events for planning purposes including accidental releases and worst case scenario evaluation.

The modeling tool assists in the evaluation of impacts of future or proposed sources, mitigation and control scenario practices, real-time and forecast mode for operational emissions control, and source contribution analyses. Governmental regulatory agencies employ these models to protect and manage the ambient air quality. Dispersion models are used as an air quality tracking tool for evaluation of compliance with the NAAQS and also serve to assist in the design of effective control strategies to reduce emissions of harmful air pollutants.

CALMET/CALPUFF modeling system was selected for this study due to its many abilities to account for the complex terrain and meteorological conditions in this area. Figure 2-2 shows the CALMET/CALPUFF modeling system.

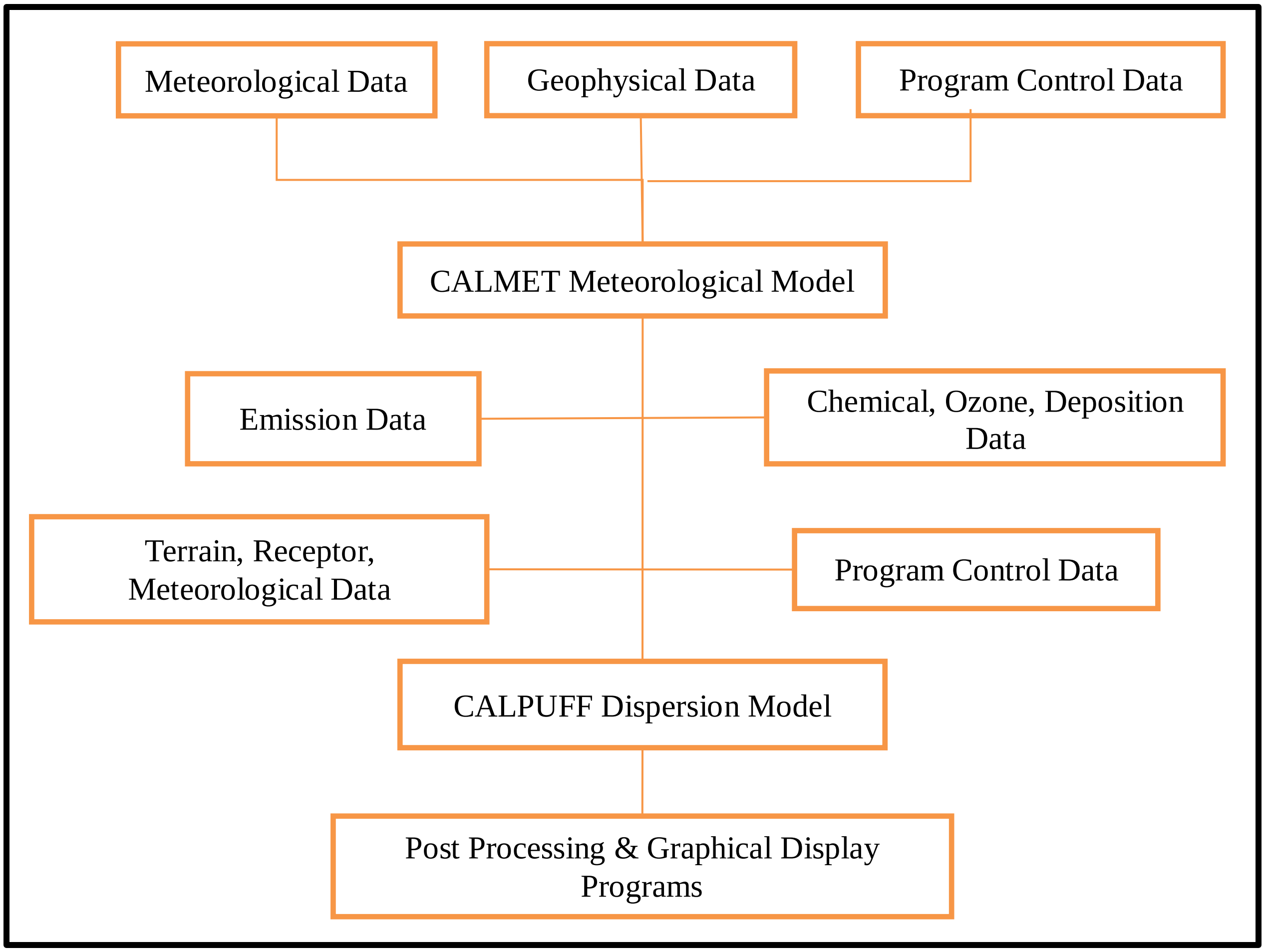

Figure 2-2. CALMET/CALPUFF Modeling System (Scire, 2010).

3. CALMET/CALPUFF Modeling System

In order to estimate pollutant concentrations in the simplest manner, it is assumed that plumes diffuse in a Gaussian pattern along the centerline of a steady wind trajectory. Generally, plume models assume steady-state conditions during the life of the plume, which represents relatively constant emission rates, wind speed, and wind direction. This steady-state approximation only is useful to estimate concentrations relatively near to the source for a short duration and restricts plume models to conditions that do not include the influence of topography or significant changes in land use, such as flow from a forest to grassland or across a land-water boundary (Sandberg, 2008).

Gaussian plume models do not require a large amount of input data which is a great benefit in circumstances or places that restrict the amount of available input data. The model can be run fast and simply and results can be easily interpreted. For this reason, many regulatory guidelines from the EPA are based on Gaussian plume models. Plume models usually employ Lagragian coordinates that follows particles or parcels as they move, assigning the positions in space of a particle or parcel at some arbitrarily selected moment (Sandberg, 2008). This type of model has no "memory" of previous hours emissions, meaning that every hour is independent from the other hour. Also, this model assumes non-zero wind speed. Figure 3-1 illustrates steady-state plume modeling.

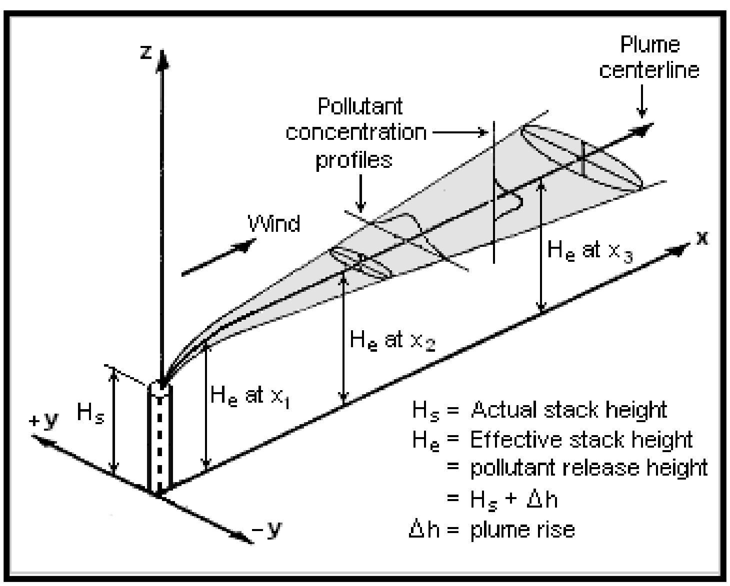

Figure 3-1. Steady-state Plume Modeling (Scire, 2010).

On the other hand, plume models characterize the source as individual puffs being release over time. Each puff expands in space in response to the turbulent atmosphere, which is usually approximated as a Gaussian dispersion pattern. Puffs are simulated moving through the atmosphere following the trajectory of their center position. This type of model allows the puffs to grow and move independently of each other, resulting in the simulation with accuracy of tortuous plume patterns in response to changing winds, varying topography or alternating source strengths. Figure 3-2 illustrates puff modeling.

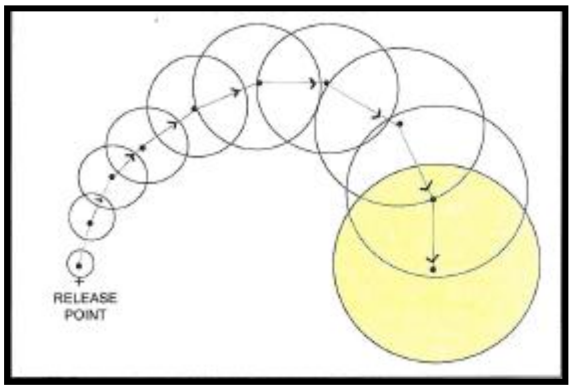

Figure 3-2. Puff Modeling (Scire, 2010).

Some of these models allow puffs to expand, split, compact and coalesce, while others retain coherent puffs with constantly expanding volumes. Most of puff models also employ Lagragian coordinates which allow accurate location of specific concentrations at any time. These do not restrict the time or distance with which a plume can be modeled.

CALPUFF modeling system was selected for this study given that it implements puff modeling and accounts for the complex terrain and meteorological conditions in addition to other abilities described in the next sections. CALMET/CALPUFF modeling system CalPro Plus 7.7.0.03_03_2010 was employed for the purpose of this study. This modeling system is an advanced non-steady state Lagrangian puff dispersion model. CALPUFF has been adopted by the EPA in its Guideline on Air Quality Models as the preferred model for assessing long range transport of pollutants and tier impacts on Federal Class I areas and on case-by-case basis for certain near-field applications involving complex meteorological conditions (CALPUFF, 2010). The CALPUFF modeling system includes three main

components, CALMET, CALPUFF and CALPOST, in addition to a set of preprocessing and postprocessing programs. CALMET is a meteorological model that develops hourly wind and temperature field on a 3-D gridded modeling domain. CALPUFF is a transport and dispersion model that advects "puffs" of material emitted from modeled sources, simulating dispersion transformation processes along the way. CALPOST is used to process the files from CALPUFF, producing a summary of the simulation results in tabulated forms. Each of these programs has a graphical user interface (GUI). The set of preprocessing and postprocessing programs may be used to prepare geophysical (land use and terrain) data in many standards formats, meteorological data (surface, upper air, precipitation, and buoy data), and interfaces to other models such as the Penn State/NCAR Mesoscale Model (MM5), the National Centers for Environmental prediction (NCEP) Eta/NAM and RUC models, the Weather Research and Forecasting (WRF) model and the RAMS model. Figure 3-3 shows the CALPro Plus model interface to initiate modeling.

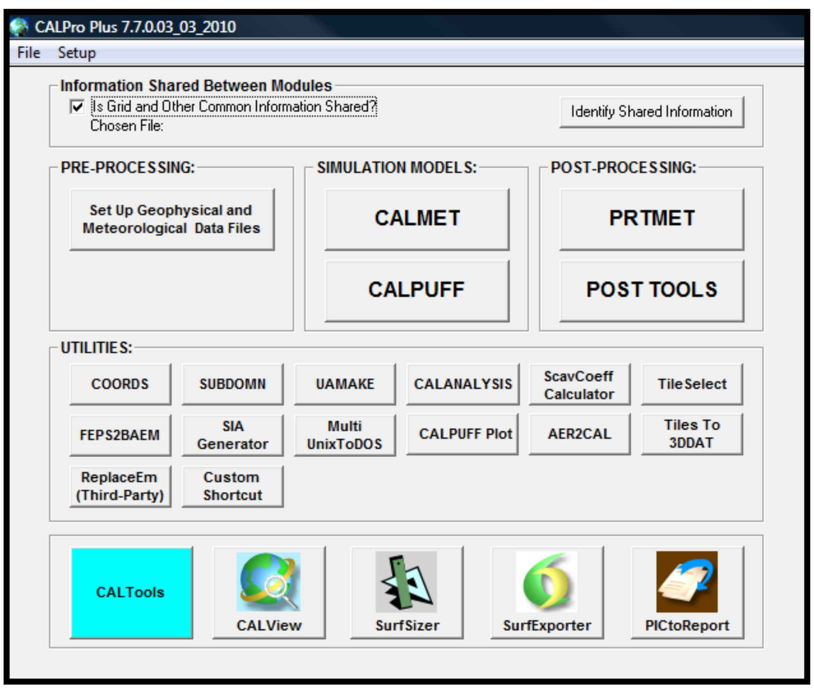

Figure 3-3. CALPro Plus 7.7.0.03_03_2010 Graphical User Interface.

In addition, the modeling system includes utilities and tools for data analysis as presented in the Figure 3-4.

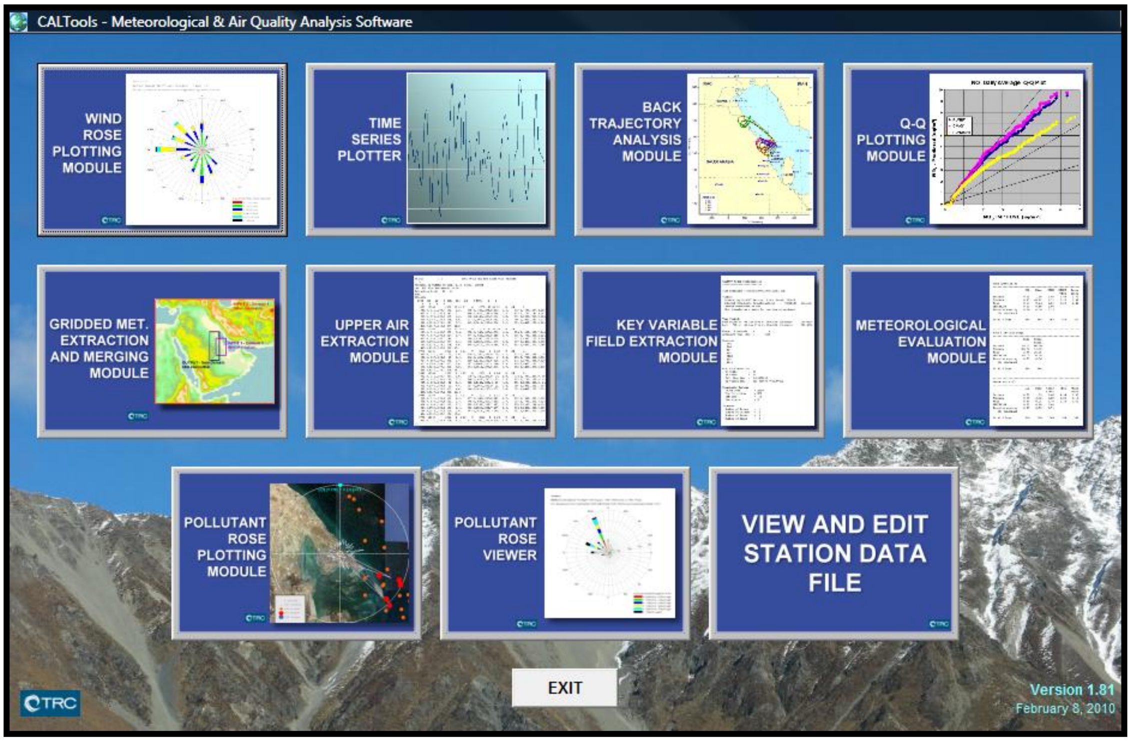

Figure 3-4. CALPro Plus 7.7.0.03_03_2010 CALTools.

3.1 CALMET

CALMET is the first component of the modeling system. It is a diagnostic wind field generator that uses surface and upper air meteorological data to compute winds and turbulence parameters in each grid of the modeling domain for each hour of a modeling period. CALMET is a mass-conserving meteorological model initializing with hourly meteorological data from the observational network and land-use data. This model includes a number of physical processes that account for atmospheric-surface interactions such as topographic effects and turbulent processes for the atmospheric layer. Also, it includes an energy balance calculation, which takes into account the radiation balance at the surface and the presence of clouds. "The model is "nudged" to the observational data with the mass conservation constraint before the final corrected wind field is produced."(Villasenor, 2003).

The diagnostic wind field module of CALMET produces gridded fields of U, V, W wind components. It also simulates kinematic terrain effects, divergence minimization, terrain blocking effects, slope flows, and Lambert conformal projection capability. CALMET boundary layer modules

implements the overland boundary layer – energy balance method, overland boundary layer – profile method, and produces gridded fields of surface friction velocity, convective velocity scale, Monin-Obukhov length, mixing height, PGT stability class, air temperature (3-D), and precipitation rate.

The flow diagram shown in Figure 3-5 illustrates the CALMET process.

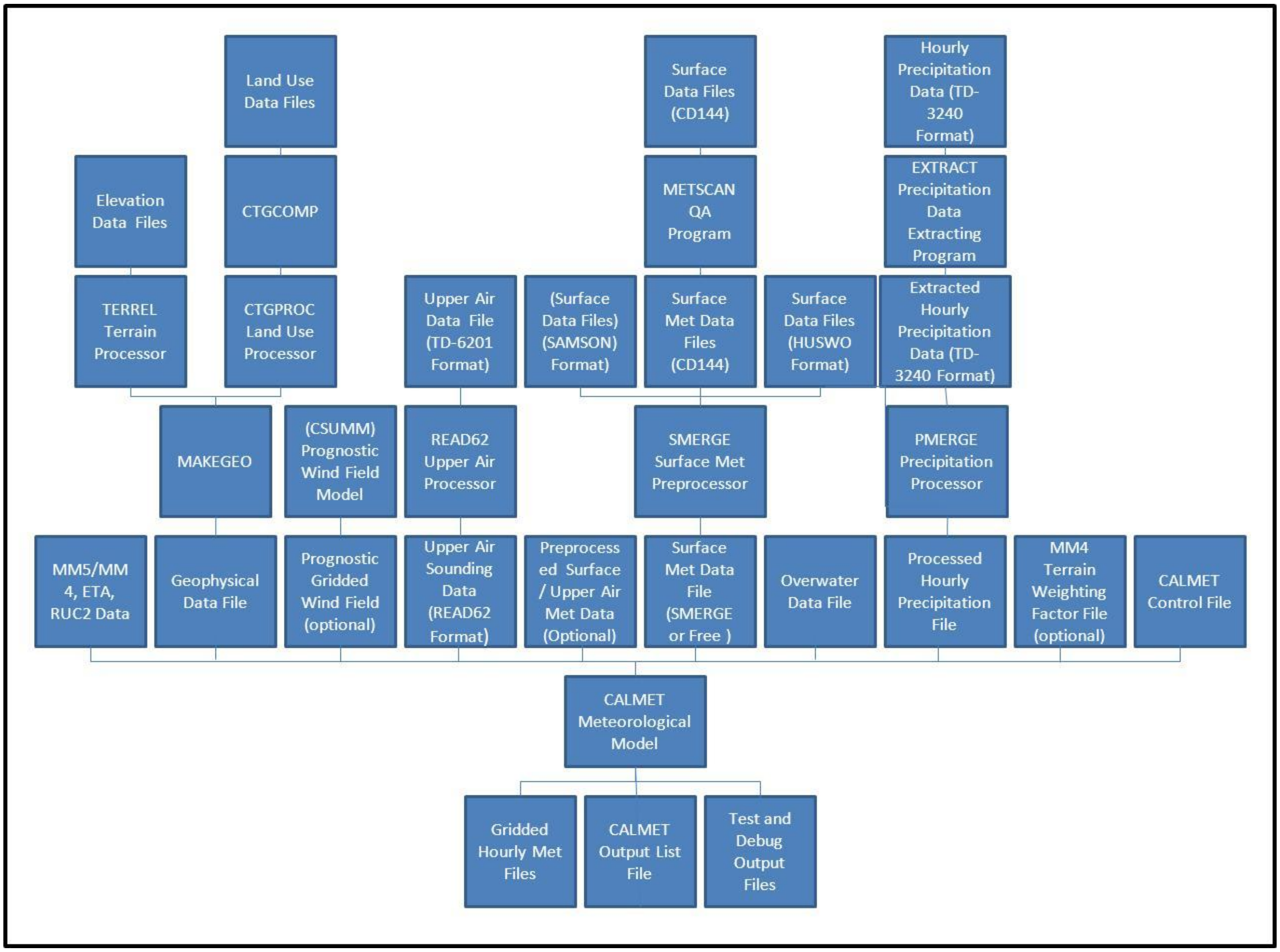

Figure 3-5. CALMET Flow Diagram (Scire, 2010).

3.1.1 CALMET Input Data

The following inputs are required for surface meteorological data:

Table 3-1. Inputs for Surface Meteorological Data

Hourly Observations	**Hourly Precipitation Data**
Wind Speed	Precipitation Rates
Wind Direction	Precipitation Type Code (part of surface data file)
Temperature	
Cloud Cover	
Ceiling Height	
Surface Pressure	
Relative Humidity	

The following inputs are required for upper air data:

Table 3-2. Inputs for Upper Air Data

Twice-daily Observed Vertical Profiles	**Hourly Gridded Wind Fields (optional)**
Wind Speed	MM5
Wind Direction	WRF
Temperature	Eta
Pressure	RUC
Elevation	RAMS
	MM4-FDD4
	CSUMM

Overwater observations required in the model include:

Table 3-3. Overwater Observations Inputs

Overwater Observations
Air-sea Temperature Difference
Air Temperature
Relative Humidity
Overwater Mixing Height
Wind Speed
Wind Direction
Overwater Temperature Gradients above and below Mixing Height

Geophysical data involves the following inputs:

Table 3-4. Geophysical Gridded Fields Data

Gridded Fields
Terrain Elevations
Land Use Categories
Surface Roughness Length (Optional)
Albedo (Optional)
Bowen Ratio (Optional)
Soil Heat Flux (Optional)
Anthropogenic Heat Flux (Optional)
Leaf Area Index (Optional)

CALMET can be run in different modes such as No-Observations (NOOBS) Mode, Partial NOOBS Mode, Observations Mode and Hybrid Mode. Table 3-5 summarizes the input data in each mode.

Table 3-5. CALMET Modes and Input Data

Mode	**Input Data**
No-Observations (NOOBS)	• Terrain and land use data
	• Prognostic meteorological fields
Partial NOOBS	• Terrain and land use data
	• Surface Observations
	• Prognostic meteorological fields
Observations	• Terrain and land use data
	• Surface Observations
	• Upper air observations
Hybrid	• Terrain and land use data
	• Surface Observations
	• Upper air observations
	• Prognostic meteorological fields

In the Hybrid Mode, prognostic fields are inputted as a complement and/or partial substitute for temperature and lapse rates, relative humidity, cloud cover and ceiling height, overwater thermal gradients, and precipitation. For all modes, precipitation and cloud data are optional.

Figure 3-6 shows CALMET wind module process.

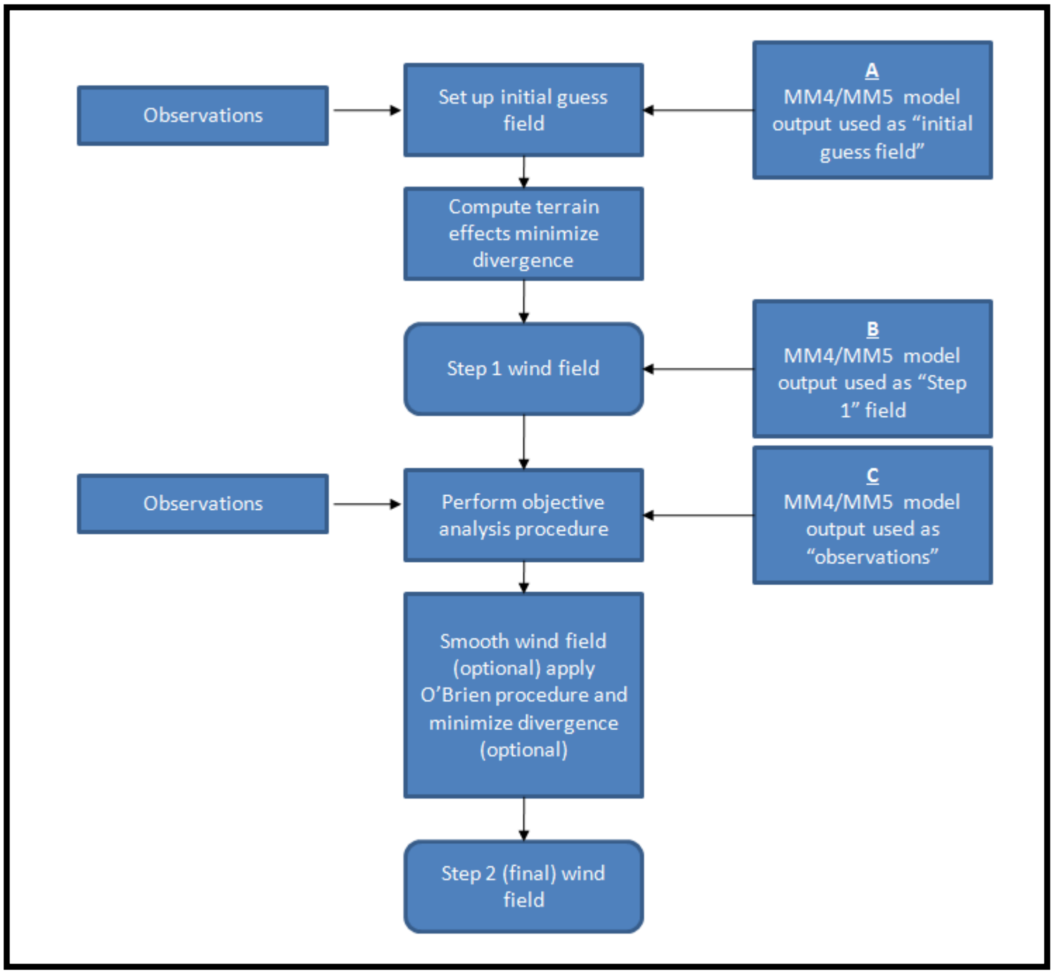

Figure 3-6. CALMET Wind Module Flow Diagram (Scire, 2010).

CALMET bias parameter weights interpolation of upper air observations and vertically extrapolated surface observations.

$$-1 \leq Bias\ \ K\ \ \leq +1 \qquad (3\text{-}1)$$

When bias is greater than zero (0), there is no influence of surface observations and bias is towards upper air observations. For example, if bias = 0.1, 10% is removed from the surface station ($1/R^2$) weights. When bias is less than zero (0), there is no influence of upper air stations and bias is towards surface observations. For instance, if bias = -1, 100% is removed from upper air station weights.

CALMET has major developments on improved slope flow algorithm. The model implements Mahrt shooting flow parameterization which accounts for adventives-gravity flow regime and equilibrium flow regime.

Improved Slope Flow Algorithm (Mahrt, 1982)

$$S = S_e \left(1 - exp\left(-\frac{x}{L_e}\right)\right)^{\frac{1}{2}} \tag{3-2}$$

$$S_e = \left(hg\ \Delta\theta/\theta\ sin \propto / \left(C_D + k\right)\right)^{1/2} \tag{3-3}$$

$$L_e = \frac{h}{C_D + k} \tag{3-4}$$

S_e= equilibrium speed of the slope flow (m/s)
L_e = equilibrium length scale (m)
x = distance to the crest of the hill (m)
Δθ = potential temperature deficit with respect to the environment (unitless)
θ = potential temperature of the environment (°C)
C_D = surface drag coefficient (unitless)
h = depth of the slope flow (m)
α = angle of the terrain relative to the horizontal (degrees)
k = entrainment coefficient at the top of the slope flow layer (unitless)
g = gravitational acceleration constant (9.8 m/s^2)

In addition, CALMET implements solar radiation equations for arbitrary inclination and azimuth. It accounts for effects of clouds and turbidity as well as line of sight shadowing effects by gridded terrain data.

Another major development is the implementation of local estimation of temperature lapse rate.

Local Parameterization of Temperature

$$\frac{D\left(h\Delta\theta\right)}{dt} = Q_h\theta/\rho C_p T \tag{3-5}$$

Q_h = local sensible heat flux (J/s)
Δθ = potential temperature deficit with respect to the environment (°C)
θ = potential temperature of the environment (°C)
h = thickness of slope flow layer (m)

Meteorological output data from CALMET can strongly influence the results of the CALPUFF run.

3.2 CALPUFF

CALPUFF is a multi-layer, non-steady state puff dispersion model that can simulate the effects including varying meteorological conditions and observational data on pollutant concentration in air. CALPUFF is suitable for studying fence line impacts (meters) to long-range transport (hundreds of kilometers). It averages times from one hour to several years, simulates dry and wet deposition, includes simple chemical transformation, plume extinction and visibility effects, suitable for complex terrain, coastal areas, overwater transport, calm wind conditions, stagnation, recirculation and reversing flows, point, area, line and volume sources, and cumulative impact assessments. The model is also recommended for near-field impacts in complex flow or dispersion situations. CALPUFF allows for variable and curve trajectories and variable meteorological conditions without assuming steady-state. It uses information downwind of each stack rather than upwind of a single stack or the meteorological station.

Figure 3-7 illustrates the CALPUFF process.

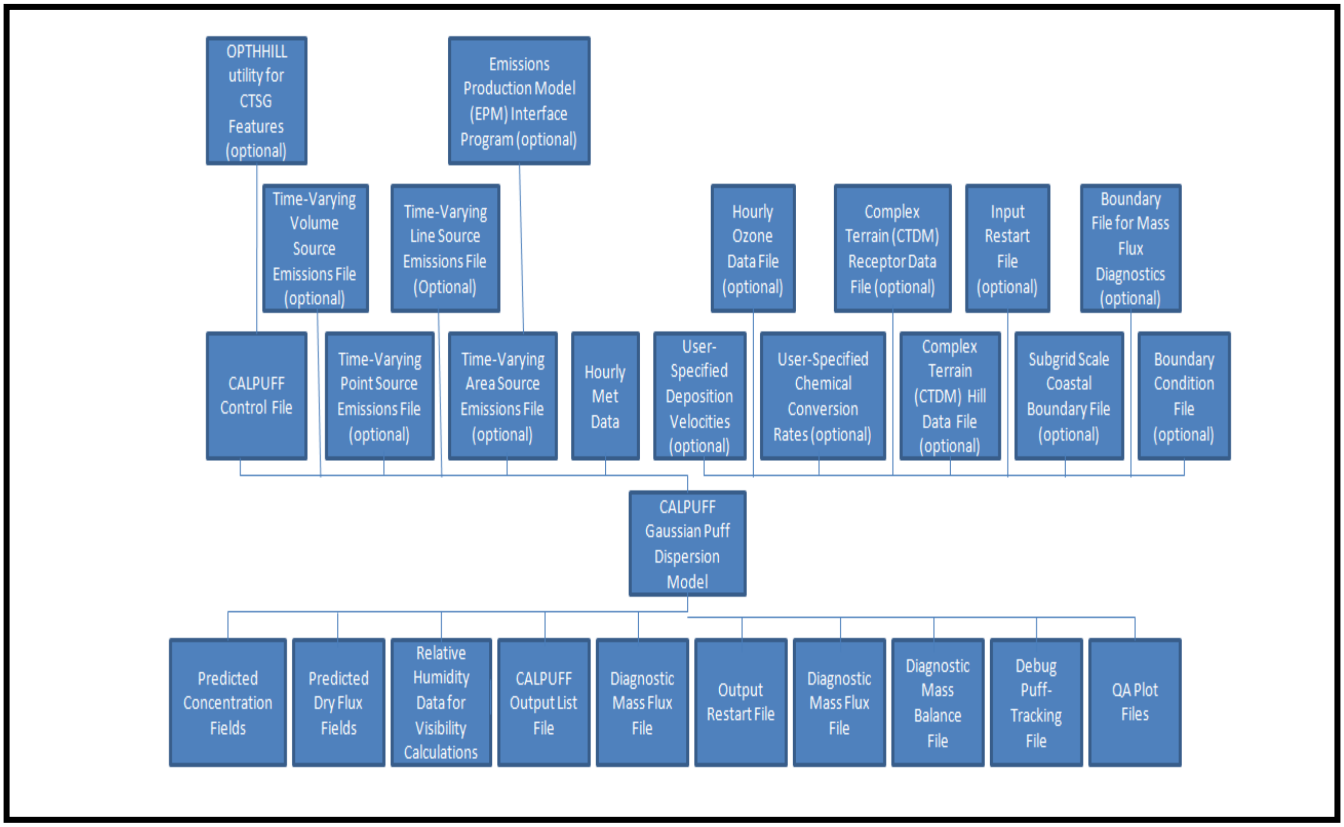

Figure 3-7. CALPUFF Flow Diagram (Scire, 2010).

Causality effects are considered by CALPUFF, and do not allow plume to extend to infinity. CALPUFF retains previous hours' emissions within domain and evaluates impacts from them. CALPUFF determines surface conditions in each grid cell and applies it to a puff as it passes that cell. Downwind conditions of each and every source are evaluated on a puff-by-puff basis.

3.2.1 CALPUFF Input Data

The following table summarizes major features of CALPUFF.

Table 3-6. CALPUFF Major Features and Options.

FEATURES	OPTIONS
Vertical Wind Shear	Vertical and horizontal puff splitting
Plume Rise	Buoyant and momentum rise (point, area, line, volume)
	Partial penetration into elevation Inversions
	Stack tip effects
	Building downwash effects
	Vertical wind shear effects
	Rain hat effects
Building Downwash	Huber-Snyder and Schulman-scire methods (ISCST3 approach)
	PRIME
Cooling Tower Plumes	Fogging and Icing
Subgrid Scale Complex Terrain	Dividing streamline Hd, above and below Hd
Interfaces to external programs/models	MM5, RAMS - pronostic meteorological model
	ETA, RUC2 - NCEP pronostic models
	EPM - emissions production model
Dry Deposition	Gases and particulate matter
	Full treatment of space and time variations of deposition with a resistance model
	User-specified diurnal cycles for each pollutant
Overwater and Coastal Interaction Effects	Overwater boundary layer parameters
	Abrupt change in meteorological conditions, plume dispersion at coastal boundary
	Plume fumigation
	Subgrid scale coastal module (TIBL, coastal definition)
Chemical Transformation Options	Pseudo-first-order chemical mechanism for SO2, SO4, NO, NO2, HNO3, and NO3
	Secondary organic aerosols
	User-specified diurnal cycles of transformation rates
Wet Removal	Scavenging coefficient approach
	Function of precipitation intensity and type
Visibility	Light-extintion coefficient
	FLAG/IWAQM Methodologies (Methods 2,6)
	New developments (Method 8 (FLAG (2008), ALM))
	Deciviews and percent change in extinction
	Sulfate, nitrate, coarse & fine PM, SOA, EC
Graphical User Interface	Point-and-click model setup and data input
	Enhanced error checking of model inputs
	On-line help files

3.2.1.1 Building Downwash

CALPUFF uses a transition point from Huber-Snyder to Schulman-Scire scheme (Scire, 2010).

$$H_s > H_b + TBD * L_b - \text{Use Huber} - \text{Snyder} \quad (3\text{-}6)$$
$$H_s < H_b + TDB * L_b - \text{Use Schulman} - \text{Scire} \quad (3\text{-}7)$$

Where,

H_s = Physical stack height (m)
H_b = Building height (m)
L_b = The lesser of the building height or building width (m)

CALPUFF uses the default value of 0.5 for ISC3 –TDB. If TBD = 1.5, always use Schulman-Scire method, and if TDB < 0.0, always use Huber-Snyder method.

PRIME Building Downwash is unbiased and over predicts for each independent data base, so its use is protective of air quality. ISCST3 is especially conservative for stable conditions, and ISC-PRIME performs much better under these conditions. The performance of the two models under neutral conditions is more comparable; however, ISC-PRIME can perform better. ISC-PRIME has statistically better performance results for each independent data base. Due to the technically superior formulation of ISC-PRIME and its better performance result, ISC-PRIME has clearly shown to be a superior model.

3.2.1.2 Area Source Plume Rise

Area source plume rise is a numerical solution to conservation and state equations in non-Boussinesq form used for buoyant area sources. Temperature, effective vertical velocity and effective radius are the initial properties at release. Wind speed profile, wind direction profile and temperature (density) profile are explicitly accounts for vertical structure of atmosphere. Area source plume rise is calculated by the following equations.

Mass

$$\frac{d}{ds}\ \rho u_{sc} r^2\ = 2r\alpha\rho_a\ u_{sc} -\ u_a \cos\varphi\ + 2r\beta\rho_a |u_a \sin\varphi \tag{3-8}$$

Momentum – along-wind

$$\frac{d}{ds}\ \rho u_{sc} r^2\ u - u_z\ = -r^2 \rho w \frac{du_a}{dz} \tag{3-9}$$

Momentum-vertical

$$\frac{d}{ds}\ \rho u_{sc} r^2 w\ = g r^2\ \rho_a -\ \rho \tag{3-10}$$

Energy

$$\frac{d}{ds}\ \rho u_{sc} r^2\ T - T_a \quad = -\ \frac{dT_a}{dz} + \frac{g}{c_p}\ \rho w r^2 -\ R_p r\ T^4 -\ T_a^4 \qquad (3\text{-}11)$$

3.2.1.3 Sub-grid TIBL Option

It supplements CALMET meteorological field. Its TIBL module creates sampling sub-steps, computes TIBL height for each sub-step, and defines appropriate surface layer properties for each sub-step. CALPUFF proceeds with advection, dispersion, and fumigation computations. The TIBL module invokes for current sampling step when sensible heat flux exceeds 5 W/m^2, puff is influenced by TIBL in previous step, puff is in onshore flow (across coastline segment), and when TIBL height for previous step is less than over-land mixing height.

TIBL height (m) is computed along sampling step with the following formula.

$$h\ s\ = SQRT\ 2K\ s - s_0\ + h^2\ s_0 \qquad (3\text{-}12)$$

Where;

$$K = \ 1 + 2\beta\ (\frac{H}{\rho C_p})/(U_\gamma) \qquad (3\text{-}13)$$

β = Ratio of sensible heat flux at the top of the TIBL to that at the ground (times -1), assumed to be 0.2
H = Sensible heat flux over land (W/m^2)
U = Mean speed within the TIBL (m/s)
γ = Potential temperature gradient about the TIBL (°K/m)

3.2.1.4 Chemical Transformation Options

CALPUFF models linear chemical transformation acts in a manner consistent with the puff formulation. It includes four options: MESOPUFF-II, User-specified 24-hour cycle of transformation rates, No chemical transformation, and RIVAD/ARM3 scheme. MESOPUFF-II is a pseudo-first-order

chemical reaction mechanism for the conversion of SO_2 to SO_4, and NO_x ($NO + NO_2$) to total NO_3, with equilibrium between gaseous HNO_3 and ammonium nitrate aerosol. User-specified 24-hour cycle transformation rates option allows simulation of the diurnal, time-dependent behavior of the transformation rates (spatially uniform). RIVAD/ARM3 scheme treats the NO and NO_2 conversion processes in addition to the NO_2 to the total NO_3 and SO_2 to SO_4 conversions, with equilibrium between gaseous HNO_3 and ammonium nitrate aerosol.

3.2.1.5 Dry Deposition

CALPUFF simulates dry deposition based on observed deposition velocities and dry deposition resistance model. Figure 3-8 illustrates deposition velocity (cm/s) vs. particulate diameter (µm).

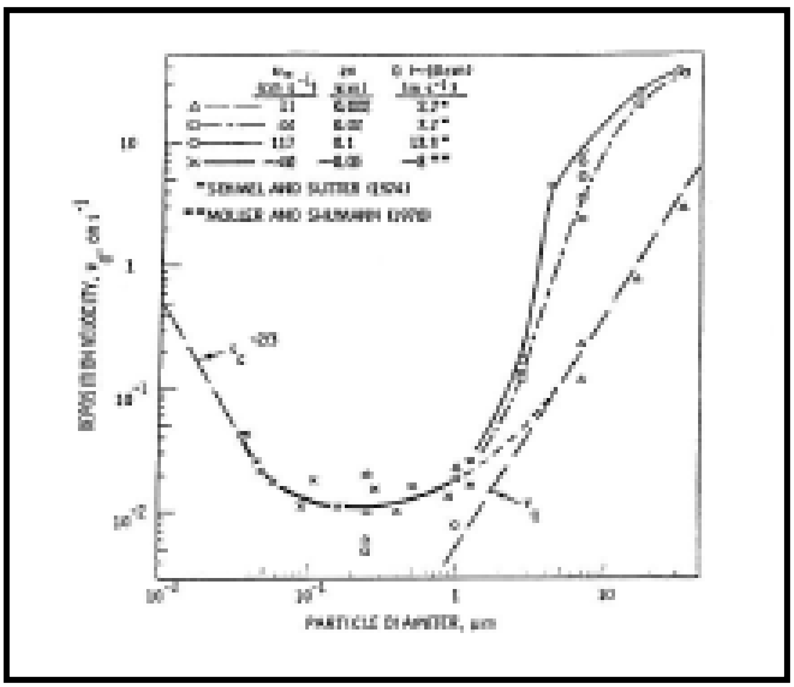

Figure 3-8. Observed Deposition Velocities.

Figures 3-9 and figure 3-10 represent the dry deposition resistance model and the dry deposition layer structure, respectively.

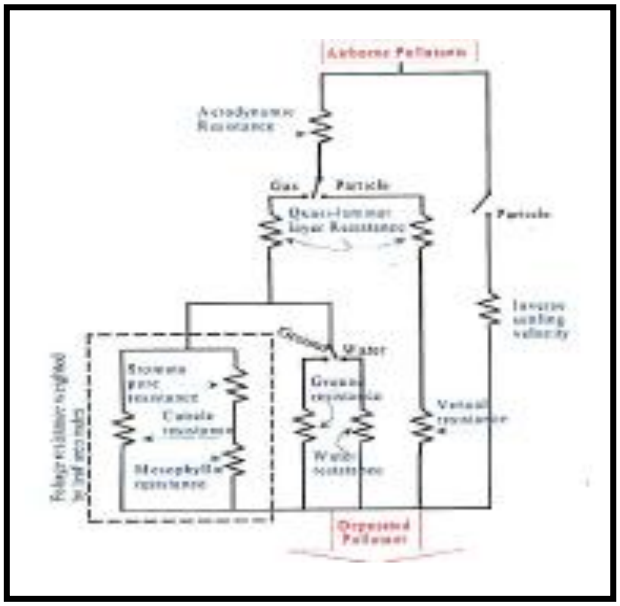

Figure 3-9. Dry Deposition Resistance Model.

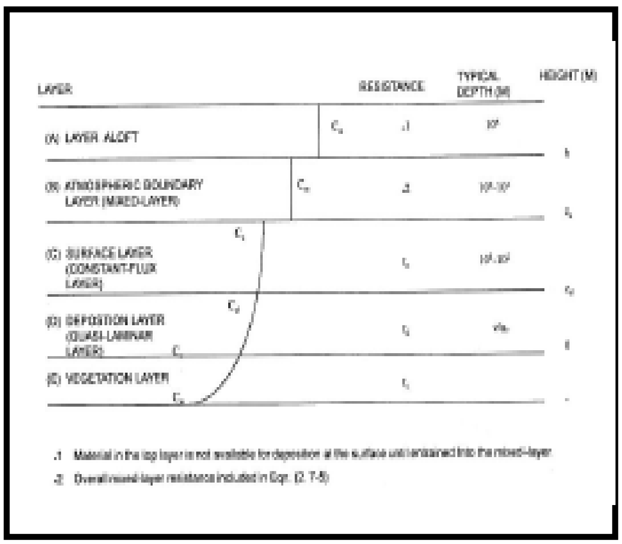

Figure 3-10. Dry Deposition Layer Structure.

Below is the formula used to simulate the resistance model for particles.

$$v_d = \frac{1}{r_a + r_d + r_a r_d v_g} + v_g \tag{3-14}$$

$$r_d = Sc^{-2/3} + 10^{-3/St}{}^{-1} u_*^{-1} \tag{3-15}$$

Where,

v_g = gravitational settling speed (m/s)

Sc = Schmidt number (unitless)
St = Stokes number (unitless)

The resistance model for gases is represented with the following equation.

$$v_d = \frac{1}{r_a + r_d + r_c} \tag{3-16}$$

Where,

v_d = Deposition velocity (cm/s)
ra = Aerodynamic resistance (s/m)
r_d = Deposition layer resistance (s/m)
r_c = Canopy Resistance (s/m)

Canopy resistance is calculated as follows.

$$r_c = \left[\frac{LAI}{r_f} + \frac{LAI}{r_{cut}} + \frac{1}{r_g}\right]^{-1} \tag{3-17}$$

Where,

r_f = Internal foliage resistance (s/m)
r_{cut} = Cuticle resistance (s/m)
r_g = Ground or water surface resistance (s/m)
LAI = Leaf area index (unitless)

3.2.1.6 Wet Removal

In CALPUFF, wet removal calculation is a function of precipitation rate and precipitation type (frozen or liquid).

$$Q_{t+1} = Q_t exp\left[-\Lambda \delta t\right] \tag{3-18}$$

Where,

$\Lambda = \lambda(R_s)$
Q = Mass of pollutant in puff (g)
R_s = Precipitation rate (mm/h)
Λ = Scavenging ratio (s^{-1})
δt = time step (s)

The model has a default value for λ (s^{-1}).

3.2.1.7 CALPUFF Terrain Options

The model includes Sub-grid scale features (CTSG) which allows the input of explicit terrain specification, separate receptors, and detailed representation of flow and dispersion. In addition, the model has the other options of Receptor-based terrain adjustments, allowing no adjustments ("flat" terrain), ISC adjustment, plume path coefficient adjustment and strain-based dispersion adjustment. This option relies on provided wind data and standard gridded and discrete receptors.

In the plume path coefficient adjustment, each source and receptor is treated independently. In addition, the path is stability-dependent in the range of $1 \geq C \geq 0$. Typically C is 0.5 for neutral/unstable and 0.35 for stable.

The adjusted puff height (H_p) for original puff height (H_{po}) when the receptor height (H_r) is greater, the following formula is used:

$$H_p = H_{po} * C \tag{3-19}$$

The adjusted puff height for original puff height when the receptor height is smaller, the following formula is used:

$$H_p = H_{po} - H_r \;\; 1 - C \tag{3-20}$$

Figure 3-11 illustrates the plume path coefficient adjustment.

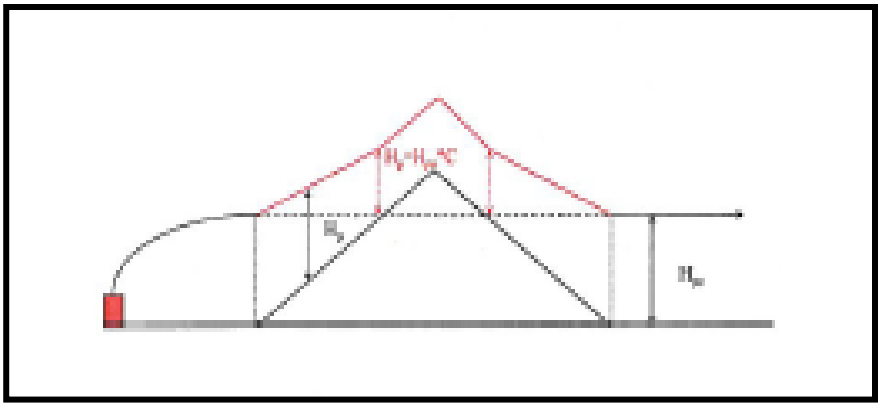

Figure 3-11. Plume Path Coefficient Adjustment (Scire, 2010).

Some of the most important CALPUFF attributes includes multiple sources with arbitrarily varying emission parameters, source-specific building downwash, elevated receptors, terrain adjustments, and gridded or non-gridded meteorology.

3.3 CALPOST

CALPOST processes CALPUFF outputs, producing a summary of the simulation results in tabulated forms. It summarizes concentrations, dry fluxes, wet fluxes, and computes visibility measures. CALPOST calculates change in light extinction through Method 2, 6 and 8. Method 2 follows IWAQM (1998) methodology, Method 6 follows FLAG (2000) methodology, and Method 8 follows NEW-IMPROVE Algorithm (Scire, 2010). Method 8 provides a better correspondence between the measured visibility and that calculated from particulate matter. The following diagram illustrates the CALPOST process.

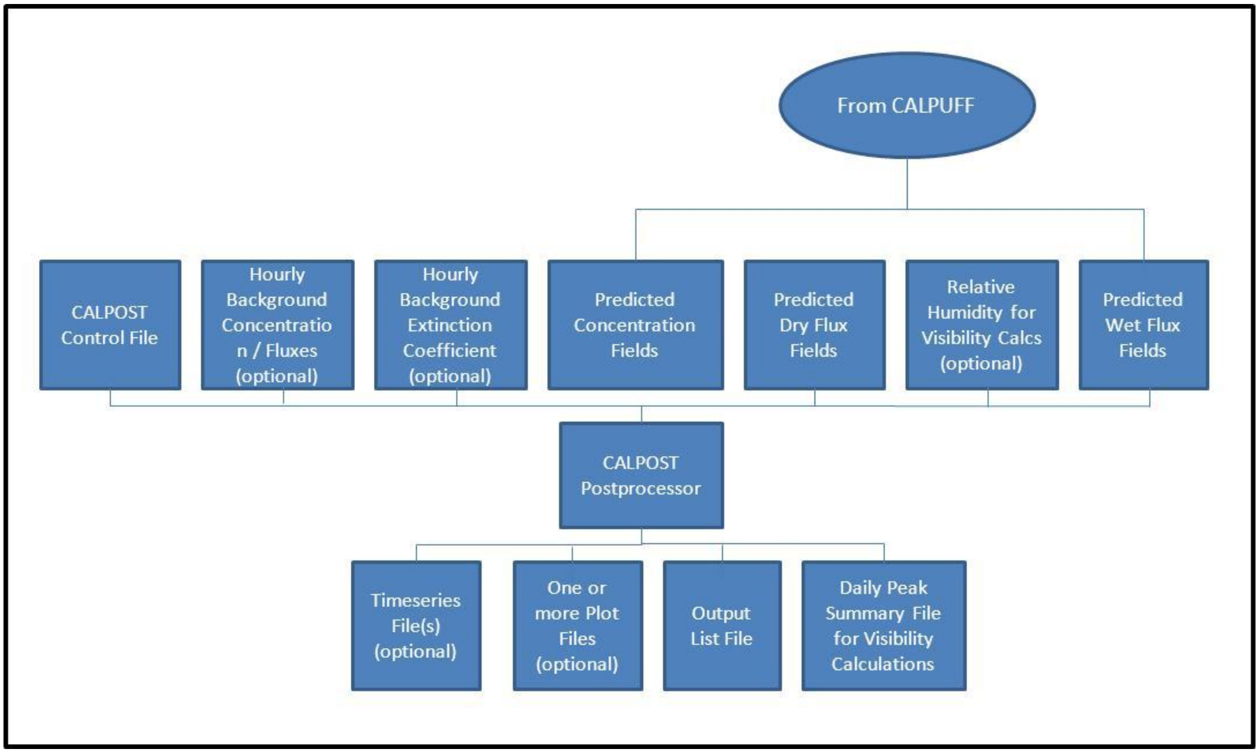

Figure 3-12. CALPOST Process (Scire, 2010).

The output summary options include 1-Period, 1-Hour, 3-Hour, 24-Hour, Run-Length, and User-specific. In addition, the model allows the selection of units, the top-50 tables, ranked value tables, and exceedance tables.

4. Calculations of Model Parameters

4.1 Analysis to Determine Emission Factor from Wind Erosion

The wind erosion emission rate for Puerto Anapra was calculated in order to integrate the value in the advanced CALPUFF modeling system and determine the impact to the city of Sunland Park, NM. Wind erosion can be simulated by inputting the calculated particulate emission rate for a specific area in the model run. The area selected for the simulation is illustrated in Figure 4-1 as area “A-1”.

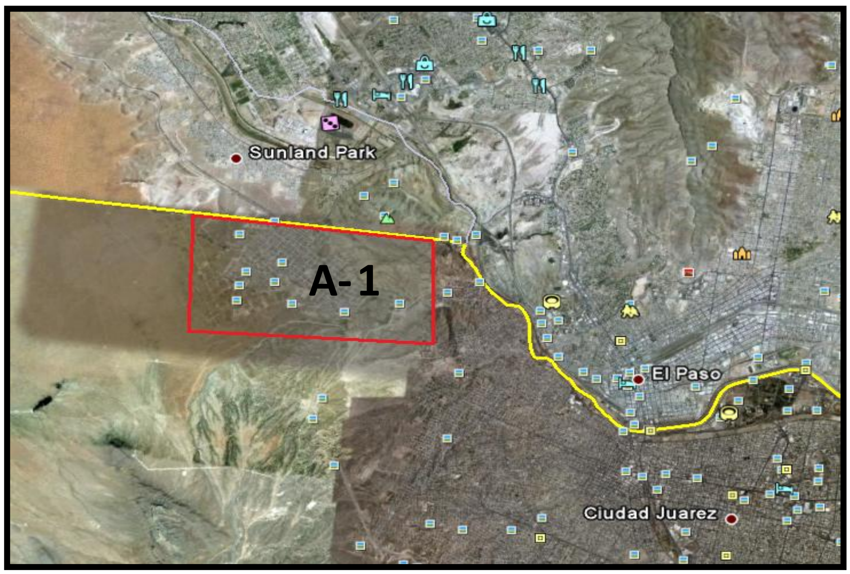

Figure 4-1. Wind Erosion Area Source No. 1.

For the purpose of this study, the procedures as specified in the U.S. EPA’s *Rapid Assessment of Exposure to Particulate Emissions from Surface Contamination* (Cowherd et al, 1985) were utilized to develop the site-specific estimates of potential dust emissions. This approach uses the soil particle size distribution, apparent roughness of the site, vegetation cover, presence of a crust on the soil, and presence of non-erodible elements to define the potential for suspension. The wind erosion particulate emission rate was calculated in terms of a threshold friction velocity, representing the potential for particle suspension - the greater the value, the lower the potential for suspension. The threshold friction velocity for the study area is determined by the mode of the aggregate particulate size distribution from

the surface soil composition. Equation 4-1 is used to determine the threshold friction velocity at ground level.

$$u^{*} = 65.5315\, ASDM^{0.42} \tag{4-1}$$

Where,

u^{*} = threshold friction velocity at ground level (cm/s)
ASDM = aggregate size distribution mode in soil (mm)

The aggregate size distribution mode in soil (ASDM) is estimated with equation 4-2:

$$ASDM = 0.0106 \quad Percent\ Sand \ + \ 0.05 \tag{4-2}$$

The wind speed at a given height above the surface can be determined once the threshold friction velocity has been determined. Equation 4-3 is applied:

$$u_t = \frac{1}{k} u^{*} \ Ln(\frac{z}{z_o}) \tag{4-3}$$

Where,

u_t = Wind speed at anemometer height equivalent to the threshold friction velocity (m/s)
k = Von Karman constant (0.4; dimensionless)
z = Reference height above the surface (7 m)
z_o = Surface roughness length (m).

According to Cowherd et al (1985), the value of z recommended is 7 m. The surface roughness length is related to the size and spacing of the roughness elements in the area. Figure 4-2 illustrates the surface roughness for various surfaces.

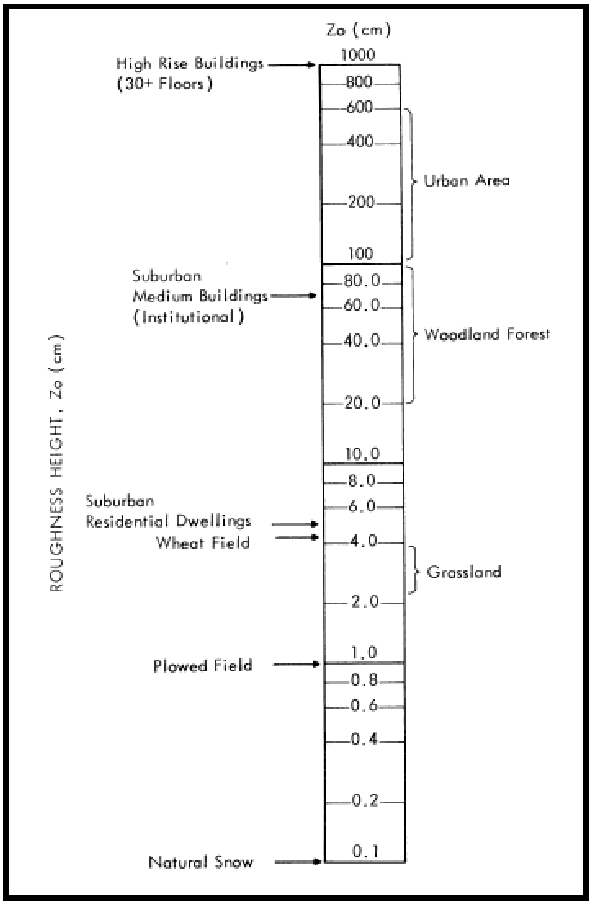

Figure 4-2. Roughness Heights for Various Surfaces (Cowherd and Guenther, 1976)

To estimate the emission factor in an unlimited reservoir, Cowherd proposed equation 4-4 that computes the annual average emission rate of particulate matter of 10 microns in size or smaller (PM_{10}). Cowherd et al. (1985) explains that the PM emissions are related to the threshold friction velocity, or the wind velocity at ground surface at which particles are suspended into the air. Equation 4-4 computes the emission rate of PM_{10}:

$$Q = \frac{0.036\,(1-F_v)\left(\frac{U_m}{U_t}\right)^3 F(x)}{3{,}600\ s/hr} \qquad (4\text{-}4)$$

Where,

Q = Emission rate of PM_{10} (g/m^2-s)
F_v= Fraction of surface area covered with vegetation (0-bare surface; 1-completely vegetated)
U_m = Mean annual wind speed (m/s)
U_t = Threshold friction velocity at anemometer height of 7 m (m/s).

F(x) = Wind speed distribution function (unitless)

The aggregate size distribution was used to calculate the threshold friction velocity in soil. Equation 4-2 is applied to determine the aggregate size distribution.

$$ASDM = \ 0.0106 \quad 0.35 \ + \ 0.05 = 0.05371 \qquad (4\text{-}5)$$

Then, Equation 4-1 is applied to compute the threshold friction velocity.

$$u^* \ = 65.5315 \, ASDM^{0.417673} = 65.5315 \, (0.05371)^{0.417673} = 19.32 \frac{cm}{s} = 0.193 \, m/s \qquad (4\text{-}6)$$

Once the threshold friction velocity is computed, the critical wind speed at a given height above the surface can be determined. Equation 4-3 is utilized.

$$u_t = \frac{1}{r} u^* \, Ln(\frac{z}{z_o}) = \frac{1}{0.4} \ 0.1932 \ Ln \ \frac{7}{0.01} \ = 3.16 \, m/s \qquad (4\text{-}7)$$

The mean annual wind speed (U_m) is 4.2 m/s, obtained from Cowherd et al. (1985) taken from the Local Climatogical Data – Annual Summaries for 1977, from the U.S. Department of Commerce, National Oceanic and Atmospheric Administration/ Environmental Data Service/National Climatic Data Center.

The wind speed distribution factor F(x) was derived from curve shown below obtained from Figure 4-3 of Cowherd et al. (1985).

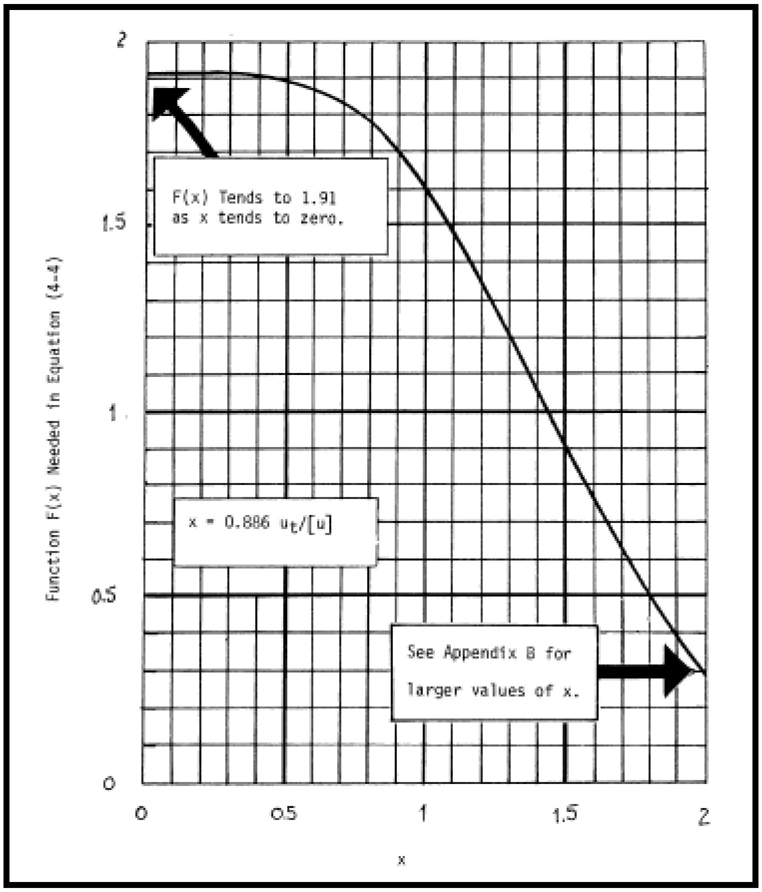

Figure 4-3. Graph of Function F(x) Needed to Estimate Unlimited Erosion

To use this curve, the value for "x" was determined as follows:

$$x = 0.886 \frac{U_t}{U_m} = 0.886 \frac{3.16}{4.2} = 0.666 \qquad (4\text{-}8)$$

Then, F(x) comes from the cubic function that relates the vertical transport of particles and the wind speed. This relationship can be described as follows:

$F(x) = 0.0$; if $x < 0.0$

$F(x) = 1.91$; if $0.0 \le x < 0.5$

$F(x) = 1.9 - (x - 0.5)\,0.6$; if $0.5 \le x < 1.0$

$F(x) = 1.6 - (x - 1.0)\,1.3$; if $1.0 \le x < 2.0$

$F(x) = 0.18x(8x^2 + 12)\,e^{-x^2}$; if $2.0 \le x$

Since x is greater than 0.5 but less than 1.0, F(x) = 1.9 – (0.666 -0.5)(0.6) = 1.8

Fraction of surface area covered with vegetation (*Fv)* used in equation 4-4 reflects the effects of vegetation in suppressing dust emissions. When the area is completely vegetated, the value for Fv is 1 and when the area is bare surface the value is 0. Therefore, considering the project area is about 5% vegetated but is additionally disturbed; the Fv value for this project is assumed to be 0.80.

Once we determine the unknown values, the emission factor in an unlimited reservoir can be estimated. Equation 4-4 is applied.

$$Q = \frac{0.036\ \ 1-0.8\ \ \frac{4.2}{3.16}^{3}(1.8)}{3{,}600\ s/hr} = 8.45\text{x}10^{-6}\ \text{g/m}^2\text{-s} \qquad (4\text{-}9)$$

An emission rate value of 8.45 x 10^{-6} g/m^2-s was inputted in the CALPUFF module to simulate wind erosion in the Anapra area.

4.2 Analysis to Determine Emission Factor from Unpaved Roads

The emission factor that relates the quantity of PM_{10} released to the atmosphere from a vehicle traveling on an unpaved road was determined using method from AP-42 Chapter 13.2.2 Unpaved Roads. According to AP-42 Chapter 13.2.2.1 General, “When a vehicle travels in an unpaved road, the force of wheels on the road surface causes pulverization of surface material.” Then the rolling wheels of the vehicle lift and drop particles and the road surface is exposed to the strong air currents in turbulent shear with the surface. In addition, the vehicle continues to act on the road surface by its turbulent wake behind it after the vehicle has passed.

The equation to be used to estimate the emission factor for vehicles traveling unpaved public roads only estimates particulate emissions from resuspended road surface material. The particulate emissions from vehicles exhaust, brake wear, and tire wear can be estimated separately using EPA’s MOBILE 6.2 to eliminate the possibility of double counting emissions.

AP-42 utilizes the following empirical expressions to estimate the quantity in pounds (lb) of size-specific particulate emissions from an unpaved road, per vehicle mile traveled (VMT).

For vehicles traveling on unpaved surfaces at industrial sites, emissions are estimated from equation 4-10:

$$E = k(\frac{s}{12})^a(\frac{W}{3})^b \quad (4\text{-}10)$$

And, for vehicles traveling on publicly accessible roads, dominated by light duty vehicles, emissions can be estimated from equation 4-11:

$$E = \frac{k(\frac{s}{12})^a(\frac{S}{30})^d}{(\frac{M}{0.5})^c} - C \quad (4\text{-}11)$$

Where k, a, b, c and d are empirical constants given in Tables 4-1 and 4-2.

E= size-specific emission factor (lb/VMT)
s= surface material silt content (%)
W= mean vehicle weight (tons)
M= surface material moisture content (%)
S= mean vehicle speed (mph)
C= emission factor for 1980's vehicle fleet exhaust, brake wear and tire wear

Emission estimates are adjusted to local conditions by applying the correction parameters from source characteristics, s, W, and M. Moreover, the constants for Equations 4-10 and 4-11 are based on stated aerodynamic particle sizes.

Table 4-1. Constants for Equations 4-10 and 4-11

Constant	Industrial Roads (Equation 4-10)			Public Roads (Equation 4-11)		
	PM-2.5	PM-10	PM-30	PM-2.5	PM-10	PM-30
k(lb/VMT)	0.15	1.5	4.9	0.18	1.8	6
a	0.9	0.9	0.7	1	1	1
b	0.45	0.45	0.45	-	-	-
c	-	-	-	0.2	0.2	0.3
d	-	-	-	0.5	0.5	0.3
Quality Rating	B	B	B	B	B	B
*Assumed equivalent to total suspended particulate matter (TSP) "-" = not used in emission factor equation						

The emission factors for the exhaust, brake wear and tire wear of a 1980's vehicle fleet was obtained from EPA's MOBILE 6.2 model. The emission factor varies with aerodynamic size range.

Table 4-2. Emission Factor for 1980's Vehicle Fleet Exhaust,
Brake Wear and Tire Wear

Particle Size Range[a]	C, Emission Factor for Exhaust, Brake Wear and Tire Wear[b]
$PM_{2.5}$	0.00036
PM_{10}	0.00047
PM_{30}[c]	0.00047
[a] Refers to airborne particulate matter (PM-x) with an aerodynamic diameter equal to or less than x micrometers	
[b] Units shown are pounds per vehicle mile traveled (lb/VMT)	
[c] PM-30 is sometimes termed "suspended particulate" (SP) and is often used as a surrogate for TSP.	

The average vehicle weight in the area of Anapra was assumed to be 1.5 tons (Gonzalez-Ayala, 2003). The Cd. Juarez Municipal Institute of Research and Investigation (IMIP, per its initials in Spanish) provided the values of 6% and 0.3% for silt content and moisture content, respectively.

Therefore;

$$E = \frac{(1.8)(\frac{6}{12})^{1}(\frac{30}{30})^{0.5}}{(\frac{0.3}{0.5})^{0.2}} - C = 0.9968 - 0.00047 = 0.99633 lb/VMT \qquad (4\text{-}12)$$

The estimated rate in pounds per vehicle miles traveled (lb/VMT) was converted to g/m^2-s as required by the modeling system. Lb/VMT were converted from pounds (lb) to grams (g), multiplied by the number of vehicles in each area and the miles traveled per each vehicle (assuming the furthest point in the area times two, for entering and exiting the area), and divided over the area (m^2) selected in a 24-hr period. Anapra was divided into nine areas based on the residential information provided by the Development Department of Cd. Juarez. The areas were divided as illustrated in Figure 4-4.

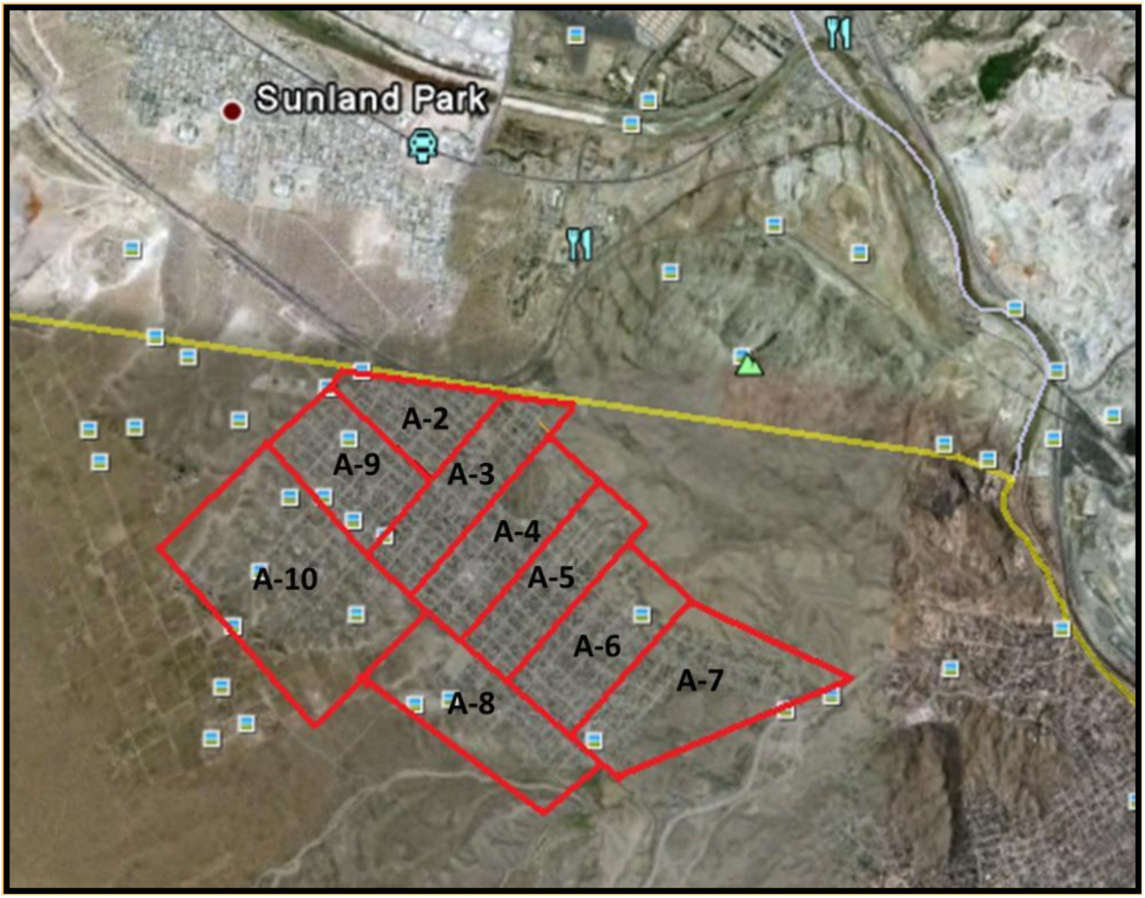

Figure 4-4. Unpaved Roads Area Sources.

Table 4-3 presents the total area, the number of vehicles (assuming that each house has one vehicle), the furthest point traveled for entering and exiting each area and the estimated emission rate in g/m^2-s for each of the areas.

Table 4-3. Unpaved Roads Emission Rates

Area	Total Area (m2)	No. of Vehicles	Distance Traveled (m)	Emission Rate (g/m2-s)
A-2	318,000	301	2,188.7	6.730E-06
A-3	457,700	389	3,299.2	9.113E-06
A-4	573,300	445	3,605.0	9.095E-06
A-5	446,400	398	4,506.2	1.305E-05
A-6	535,500	447	5,697.1	1.545E-05
A-7	810,750	216	5,697.1	4.933E-06
A-8	660,000	221	6,694.9	7.285E-06
A-9	464,400	470	3,701.5	1.217E-05
A-10	1,187,000	116	5,600.5	1.779E-06

These emissions rates were used in the modeling system to simulate the emissions of PM_{10} from unpaved roads. In order to model a more accurate scenario to real traffic, the estimated emission rates were applied in hourly basis utilizing a scaling factor of zero (0) from 1 a.m. to 6 a.m. and from 10 p.m. to 12 a.m., then, a scaling factor of 1.6 was used from 7 a.m. to 9 p.m. The following section explains it in details.

5. Inputs and Modeling Parameters

The CALMET/CALPUFF modeling system was selected to model the meteorology and pollutant transport of PM_{10} during the Year of 2003. CALPUFF has been traditionally used in EPA's regulatory applications. In this study, emissions sources due to wind erosion and unpaved roads were considered. The version of CALPUFF modeling system used for the modeling is CALPro Plus 7.7.0.03_03_2010. The program has a graphical user interface (GUI) to facilitate its use.

In addition, this study utilizes meteorological MM5data input files developed by the Western Regional Air Partnership (WRAP) Regional Modeling Center (RMC) and the Midwest RPO to support modeling for the project area. The model options used in the MM5 simulations were used in the CALMET/CALPUFF modeling such as mixing height and map projection.

The model runs for each of the modeling system components and its inputs are explained in detail in this chapter.

5.1 Domain and Grid Structure

The modeling domain for CALMET/CALPUFF was chosen to include Sunland Park, NM, Anapra, Mexico and part of El Paso, Texas. The domain area was carefully selected to include air quality monitoring stations to ultimately compare the modeling results with real time data recorded at the air monitoring stations. Emission modeling grids were matched with the domain to ensure that there are minimum errors produced during the model run.

CALPro Plus GUI allows the user to share information between the various modules in CALPro Plus by completing the "Identify Shared Information" box which contains the project domain information. The inputs for the project domain area were the following:

- Projection Origin:
  - Latitude = 40 °N
  - Longitude = 97 °W
- Matching Parallels
  - Latitude = 33 °N
  - Latitude = 45 °N
- False (X, Y) at projection origin:
  - X (km) = 0

    - Y (km) = 0
- Grid Origin (Reference Point):
    - X (Easting) = -925 km
    - Y (Northing) = -885 km
- Grid Spacing: 1 km
- Domain Size:
    - NX (No. of X grid cells) = 40
    - NY (No. of Y grid cells) = 50
    - NZ (No. of Z grid cells) = 11
- Map Projection: LCC: Lambert Conic Conformal
- No. of Layers: 11
- Cell face heights (m): 0, 20, 100, 200, 350, 500, 750, 1000, 2000, 3000, 4000, and 5000
- Local time zone: UTC-0700 Mountain N. America
- Modeling period: January 1, 2003 00:00 hr – December 29, 2003 00:00 hr
- Continent/Ocean: Global
- Geoid-Ellipsoid: NWS: 6370KM Sphere
- Region: Global Sphere (WGS84)
- Datum: NWS-84

5.2 Meteorological and Geophysical Processing

In order to facilitate the use of this modeling system for areas with sparse or no meteorological observations, the system has the capability to make available MM5 datasets in a convenient tiled data format or as native binary MM5 output files. These formats were provided with extraction software to create CALMET-ready 3D.DAT files. Then, CALMET can be run in "No-Observations Mode" with meteorological data other than MM5 data, or it can be run in "Hybrid Mode" using observations together with the MM5 dataset. The objective was to process geophysical data including land use and terrain data to combine them into one geophysical file for the project area.

5.2.1 Set Up Geophysical and Meteorological Data Files

Once the shared information was saved, the pre-processing to set up geophysical and meteorological data files was needed. The pre-processed data includes geophysical data, surface meteorological data, upper air meteorological data, precipitation data and overwater data. For this study, only geophysical data was processed and the rest of the data was acquired from MM5 files.

5.2.2 Geophysical Data

The Geophysical Data pre-processor includes processing packages to compress CTG land use files (CTGCOMP), to process terrain (TERREL) and land use data (CTGPROG), and creates the geophysical file (MAKEGEO). During this study, TERREL and CTGPROG were used to create the geophysical file of the project area.

5.2.3 Land Use (CTGPROC)

To process land use data, "Land Use (CTGPROC)" icon was run. The first screen had three steps: 1) The current working directory was set and the "Next Step" button was clicked; 2) CTGPROG was started with a NEW Input File and the "Next Step" button was clicked; 3) The file-name was chosen to save the CTGPROG Control File and clicked on the "Accept" and then "Next" button at the bottom of the screen to go to the next screen.

Meterological Grid Information. The inputted "shared information" was automatically updated into the CTGPROG GUI. The information was verified to be correct and then clicked in the "Next" button.

CTGPROG Processing Options. The default information was kept since no previous run of CTGPROG was done.

CTGPROG Marine Coastline Processing. This interface was to process Coastline, which was not used for this study. The default information is kept.

CTGPROG Data Files. This screen allowed entering the raw land use data file to be processed. Land use data file was downloaded from http://www.src.com. "North America" icon was selected and land use file was uploaded by clicking on the "Add File" button. The "OK" and then "Next" buttons were selected.

CTGPROG Output. Land use output file and list file were named and verified that the "Land use output format" reflected "Fractional Land Use (ready for MAKEGEO)", which meant that the file was in a format ready to be processed by MAKEGEO.

Once the information was entered, the “Done” button was selected. Then, the file was saved and run. After the run was completed, list file was reviewed to check for error messages. No error messages appeared and program was exited.

5.2.4 Terrain (TERREL)

Under the pre-processing option box, “Set Up Geophysical and Meteorological Data Files”, the terrain data was processed by TERREL. The program started by selecting the “Input” button, and then the “Sequential” button. The first screen had three steps: 1) The current working directory was set and the “Next Step” button was clicked; 2) TERREL was started with a NEW Input File and the “Next Step” button was selected; 3) The file-name was chosen to save the TERREL Control File followed by selecting the “Accept” and then “Next” buttons at the bottom of the screen to go to the next screen.

Meterological Grid Information. The inputted “shared information” was automatically updated into the TERREL GUI. The information was verified to be correct and then the “Next” button was clicked.

TERREL *Processing Options*. The default information was kept the same since no previous run of TERREL was completed.

TERREL *Marine Coastline Processing*. No coastline data was used in this study. The default information was kept the same.

Process Elevations for Discrete (X, Y) Points. This screen can be used to get terrain elevations for a discrete set of receptors in their own receptor file. However, this application was not used in the study.

TERREL Data Files. This screen allowed entering the raw terrain data file to be processed. Terrain data file was downloaded from http://www.src.com. “GTOPO30” icon was selected and terrain file was uploaded by clicking on “Add File” button. The “OK” and then “Next” buttons were selected.

TERREL Output. Terrain output file and list file were named.

Once the input data was entered, the “Done” button was selected. Then, the file was saved and run. After the run was complete, the list file was reviewed to check for error messages. No error

messages appeared. The QATERR.GRD TERREL output file was viewed by activating the “View Maps CALVIEW” software from the “Utilities” menu in TERREL. The file was browsed and selected. The terrain appeared accurate. Then, program is exit.

5.2.5 Create Geophysical File (MAKEGEO)

MAKEGEO creates a geophysical data file called GEO.DAT, which is used by CALMET. It combines CTGPROG data output file (landuse.dat) and TERREL data output file (terrel.dat). the MAKEGEO program was selected from CALPro Plus GUI under the pre-processing option box, “Set Up Geophysical and Meteorological Data Files”.

The program started by the selecting the “Input”, and then “Sequential” buttons as previously done in the other programs. The first screen also included the three steps as in the previous programs.

Meterological Grid Information. The inputted “shared information” was automatically updated into the MAKEGEO GUI. The information was verified to be correct and then the “Next” button was clicked.

MAKEGEO Preprocessing Options. The name of the terrain data file (output of TERREL, TERREL.DAT) was entered. Then, the Fractional Landuse data file (output of CTGPROG, LANDUSE.DAT) was entered and the other options remained at model defaults. Then, the “Next” button was selected.

MAKEGEO Output. The output list, data and plot files were named, respectively. The “Done” button at the bottom of the screen is selected. The files were saved and run. After the run was complete, list file was verified to check for error messages. No error messages appeared.

To view the land use map, CALView was accessed from CALPro GUI or from the “Utilities” menu in MAKEGEO. Figure 5-1 shows the MAKEGEO file produced.

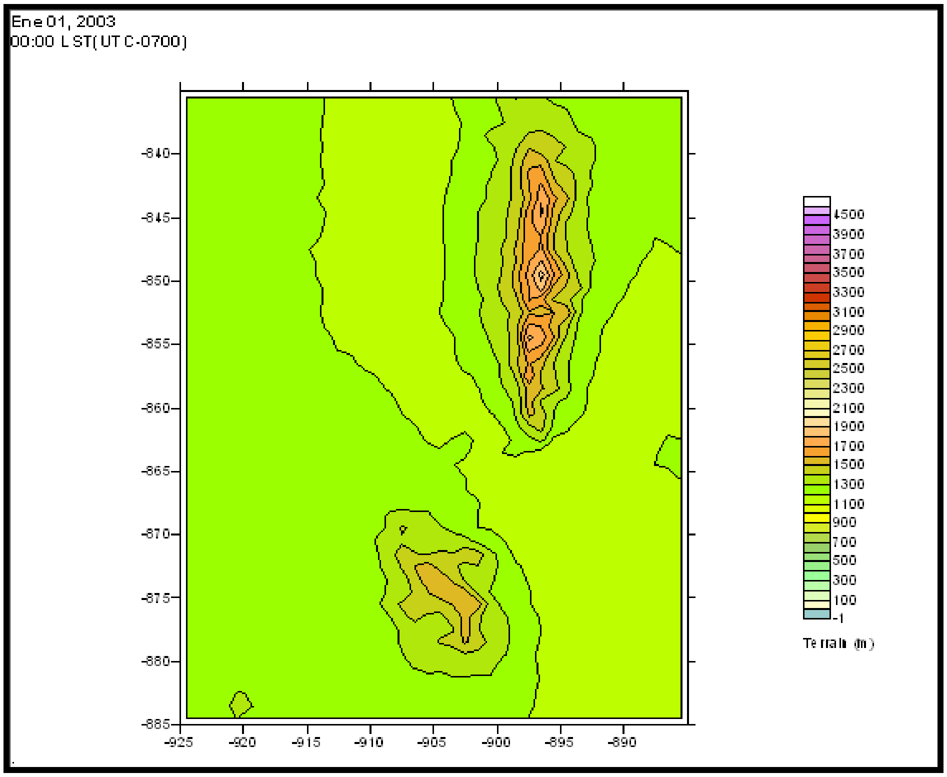

Figure 5-1. MAKEGEO Terrain and Land Use File.

5.3 CALMET Model Run

The objective was to conduct simulations of the wind flow in the Sunland Park-Anapra area using CALMET for the Year of 2003. Also, vector plots of the modeled CALMET wind fields were developed using PRTMET and CALVIEW. CALMET was utilized to model each month of 2003 using the same grid, vertical layers and map projections as well as other options included in the WRP MM5 modeling. The month of January 2003 was modeled first and the same steps were followed to run the rest of the year.

CALMET uses a two-step approach to calculate wind fields. In the first step, an initial-guess wind field is adjusted for diagnostic wind effects of terrain, such as channeling, blocking and deflection, and slope flows, to produce Step 1 wind field. In Step 2, an objective analysis is performed to introduce observational data into the Step 1 wind field. For the purpose of this study, CALMET was operated using three-dimensional 36 km MM5 meteorological data only.

CALMET GUI was accessed from the first screen of the CALPro GUI. The “Input” option from the top menu commands was selected, followed by the option “Sequential”. The first screen had three steps as the other programs and the same steps were followed.

Import Shared Grid Data. The shared information file was browsed and imported to access the domain settings.

Run Information. The title for the run was inputted in the “Title” option. The Starting time and ending time of run was inputted, for this case, the run was conducted from January 1, 2003 at 00:00 hr. to February 1, 2003 at 00:00 hr. The Base Time Zone selected was UTC-0700 Mountain N. America. Under “Run Options”, the following boxes were selected: “Compute All Data Fields Required by CALGRID or CALPUFF”, “Use MM4/MM5/3D.DAT for surface, overwater, and upper air data (NOOBS =2), “Use MM4/MM5/3D/DAT for precipitation”. Then, the “Regulatory Option” of “Do not check selections against EPA Regulatory Guidance” was used.

Grid Control Parameters. Most of the parameters on this screen were filled by the shared information file. The geophysical data was the output of MAKEGEO run earlier. The file was browsed and loaded.

Mixing Height Parameters. The maximum mixing height range was set to 4,500 m based on the Colorado Department of Public Health and Environment (CDPHE) analyses of soundings for summer ozone events in the Denver area in 2005. The CDPHE analysis suggests mixing heights in the Denver area are often well above the CALMET default value of 3000 meters during the summer. Therefore, like in Denver, mixing heights in excess of 3,000 m AGL CALMET default maximum would occur in the western States. All the other parameters were left as default.

Temperature & RH Parameters. The temperature datasets used were “MM5/3D.DAT temperatures at surface and upper levels”. The “Interpolation Method” was 1/R and the “Radius of Influence” was 500 km. The beginning and ending water land use categories were set to 51 and 55, respectively, rather than EPA default (999) that assumes no water land use categories. The other options were left as default.

Wind Field Options. Diagnostic wind module was selected. "MM5/3D/DAT as Initial Guess Field" computation option was selected and MM5 files were loaded for the month to run. No other options were selected.

Wind Field – Initial Guess. No data were read from External File. The "Horizontally and Vertically Varying Winds" option was selected.

Wind Field – Step 1. "Divergence Minimization", "Froude Number Adjustment" and "Slope Flows" were selected with default values. "Radius of Influence of Terrain Features" (TERRAD) was set to 10 km.

Wind Field – Step 2. Values for RMAX 1, RMAX 2, R1 and R2 were selected by looking at the terrain map and the location of the meteorological stations.

Ou*tput Options*. The meteorological output file was named including the output list file. Also, the output was saved in an unformatted data file, with CALPUFF type.

Export Shared Grid Data. There was no need to export the shared information file in this section.

The files were saved and run. After the run was completed, list file was verified to check for error messages. No error messages appeared.

The same process was conducted for the rest of the year followed by a CALMET post-processing package called PRTMET.

5.4 PRTMET Model Run

This post-processing module extracted any information and/or graphical plots from the CALMET binary file. PRTMET was able to create 2 dimensional snapshots as well as 3 dimensional snapshots of one or more CALMET layers, for each hour in the processing period. These results were easily viewed with CALVIEW, which could either be initiated from the CALPro GUI, or from the Utilities menu of PRTMET.

PRTMET used the CALMET input and output files to process the data as the initial step to run this module. Once the files were browsed and selected, the module began by clicking the "Input" and then "Sequential" buttons from the top menu.

Processing Options. In this module, the data was verified to be accurate.

Output File Options. Under "3D Meteorology", the "Wind Speed/Dir", the "Exponential Format" and the "Single Vector File" options were selected. Also, all the layers were selected.

PRTMET was executed by selecting the "Run" option from the top menu, making sure that the control input file was saved in the working directory. PRTMET created and placed in the directory several *.vec files, one for each level and each period that was selected. This step process was completed for each of the months.

5.5 CALPUFF Model Run

Using CALMET configuration, a CALPUFF simulation of area sources in the project area for PM_{10} concentrations was conducted for the Year of 2003.

CALPUFF model was entered from the first screen of the CALPro GUI. The "Input" option from the file menu commands was chosen, followed by the "Sequential" button. The "New Input File" was selected, which created a default CALPUFF input file name.

Import Shared Grid Data. The "Shared Information" File was opened and imported.

Run Information. A title for the run was entered. For "Regulatory Option", "Do not check against Regulatory Guidance" was checked. The period of the run was selected from January 1 at 00:00 hr. to December 29 at 00:00 hr. of 2003. The "Base Time Zone" was UTC-0700 Mountain N. America and no restart configuration was selected.

Grid Settings. In this screen, most of the data was already entered if the "Shared Information" file was correctly imported. Computational Grid Settings were selected at the bottom of the screen. In this interface, the CALPUFF grid was chosen to be the same size as the CALMET grid. These parameters allowed CALPUFF to run on only a portion of the CALMET grid if necessary.

Modeled Species. Only one specie was modeled, PM_{10}. The selection was made by double clicking on PM_{10}. The library information for deposition and chemistry did not need to be loaded since this run was a dispersion run with no chemistry.

Chemical Transformation. The default method was set to "Computational Internally (MESOPUFF II Scheme)"; therefore it was changed to "Not Modeled".

Deposition. "Particle Phase" was selected for the "Dry Deposited" option.

Meteorological/Land Use. The CALMET binary files for the 2003 months were uploaded by clicking on the "Edit CALMET File Names" and entering the output files names of the CALMET run processed earlier.

Plume Rise. The "Transitional Plume Rise Modeled" and the "Stacktip Downwash Modeled" options were selected as well as the "Partial Plume Penetration Modeled: Buoyant Area Sources". The model offered the use of Briggs Rise for point sources not subject to downwash, which was selected. Inversion strength was selected to be computed from temperature gradients.

Dispersion. The plume element was selected to be modeled as "Puff". Dispersion Option used was "PG coef. (Rural, ISC Curves) and MP coef. (Urban)". Other default variables were used and no other changes were required on this screen.

Terrain Effects. "Partial plume path adjustment" was selected for terrain adjustment method applied to gridded and discrete receptors. Other default variables were used and no other changes were required on this screen.

Point Sources. The simulation did not include any point sources.

Area Sources. Anapra was divided into different areas to simulate wind erosion emissions and emissions from unpaved roads, as previously explained. First, Area 1 was inputted to simulate wind erosion. Area 1 required the input of the coordinates for the four corners of the area source and the wind erosion emission rate calculated for the specific area. In the same manner, Area 2 through 10 required their respective area coordinates and the unpaved roads emission rate calculated. In order to model a more accurate scenario, the estimated emission rates for unpaved roads were applied in hourly basis to account for real traffic for Areas 2 through10. The "Variable" option was utilized to input a method for varying scaling factors. The "Diurnal Cycle" option was chosen and a scaling factor of zero (0) was inputted from hours 1 a.m. to 6 a.m. and from 10 p.m. to 12 a.m., then, a scaling factor of 1.6 was used from 7 a.m. to 9 p.m.

The total estimated emission rates inputted for these areas were included in Table 5-1.

Table 5-1. CALPUFF Area Sources Emissions Rates

Area	Coordinate Upper Left (km)	Coordinate Upper Right (Km)	Coordinate Lower Left (km)	Coordinate Lower Right (Km)	Emission Rate (g/m2-s)
A-1	-905, -858.5	-900, -858.5	-905, -862	-900, -862	8.450E-06
A-2	-903.3, -858.9	-902.4, -858.9	-903.4, -859.2	-902.8, -859.5	6.730E-06
A-3	902.4, -858.9	-902, -858.9	903.15, -860	903, - 860.2	9.113E-06
A-4	-902.15, -859.2	-902, -859.4	-903, -860.3	-902.6, -860.5	9.095E-06
A-5	-901.8, -859.47	-901.5, -859.7	-902.5, -860.5	-902.2, -860.7	1.305E-05
A-6	-901.6, -859.86	-901.14, -860.25	-902.2, -860.75	-901.7, -861	1.545E-05
A-7	-901.14, -860.25	-900.2, -860.3	-901.7, -861	-901.5, -861.2	4.933E-06
A-8	-902.8, -860.37	-901.6, -861.1	-903.05, -860.86	-901.85, -861.45	7.285E-06
A-9	-903.5, -859.1	-902.9, -859.6	-903.77, -859.5	-903.1, -860.12	1.217E-05
A-10	-903.77, -859.5	-902.75, -860.53	-904.36, -860.64	-903.22, -861.1	1.779E-06

The effective height entered for each of the areas was 0.1 m and the baseline elevation and initial Sigma z were 0.0 m. The emission rates were set to be constant.

Volume Sources. The simulation did not include any volume sources.

Line Sources. The simulation did not include any line sources.

Boundary Sources. The simulation did not include any boundary sources.

Gridded Receptors. No gridded receptors were used.

Discrete Receptors. Coordinates of four discrete receptors were entered. Receptor No. 1 was TCEQ's UTEP CAMS Station 0012, 0125, 0151, located at 31°46'6" North and -106°30' 5" West at 3,799 feet of elevation. Receptor No. 2 is NMED's 6ZG Sunland Park Monitoring Station located at 31°48'5" North and -106°32'42" West at 3,740 feet of elevation. Receptor No. 3 is NMED's 6ZM Desert View Monitoring Station located at 31°47'47" North and -106°34'51" West at elevation 3,810 feet. Additionally, Receptor No. 4 is the NMED's 6ZN Santa Teresa Monitoring Station located at 31°46'55" North and -106°40'45" West at elevation 4,090 feet.

Output. A binary file for concentration only was created called CALPUFF.CON. Under Binary Output, PM_{10} was checked for concentration. The List file was named CALPUFF.LST and the units were selected to be g/m^3 and g/m^2-s.

Export Shared Grid Data. In this screen, there was no need to export any data, and "Done" button was selected.

The first screen appeared and the control input was saved. The model was run by selecting "Run" from the top menu, and then "Run CALPUFF" option. After the run was completed, list file was verified to check for error messages. No error messages appeared.

5.6 CALPOST Model Run

Once CALPUFF has been successfully executed, CALPUFF GUI was closed and CALPOST GUI was opened which was activated from the CALPro Plus GUI under POST TOOLS. CALPOST was started by selecting the "Input" button from the top menu commands followed by the "Sequential" button. A new input file was started by selecting "NEW Input File" and accepting the default CALPOST input file name, CALPOST.INP, which appeared on the box.

Process Options. The title for the run was entered. The Processing Period was entered from January 1, 2003 at 00:00 hr. to December 29, 2003 at 00:00 hr. For the Source Contributions, the "Process TOTAL concentration/flux" option was selected. The CALPUFF model was run with discrete receptors; therefore the "Discrete" option was checked. No scaling method was applied and no background concentrations were used.

Processed Data. The Input Data Types entered were "Concentrations" for PM_{10}. The Data File Name loaded was the output of the CALPUFF run, CALPUFF.CON. Nothing else needed to be entered on this screen.

Output Options. Hourly average, 24-hr. average, and Run-Length concentrations in $\mu g/m^3$ for PM_{10} were computed. To be able to get one concentration file for every hour, "Echo Selected Days" was selected. In addition, "Time Series for Selected Days", "Peak Value Time Series for Selected Days", and "Produce Plot File, and Cumulative Footprint" were checked. The output List file was named CALPOST.LST and the Time Series File Path and Plot File Path were included. The Plot File format needed to be ".GRID Surfer Grid" to be able to see them in CALVIEW and SURFER software. The output concentration files automatically were named using the same concentration used for the meteorological data files.

By clicking “Done”, the first screen of CALPOST appeared. The input file name was saved and the program was run from the top menu followed by “Run CALPOST”. After the run was completed, the list file was verified to check for error messages. No error messages appeared.

Using CALVIEW which could be accessed from the option box on the first screen of the CALPro GUI, the concentration files were plotted and reviewed for analysis.

6. Results and Discussion

Meteorological runs for each month of 2003 and a dispersion run for the same year were performed in this study. The results of these simulations were analyzed based on real time data acquired from existing air quality monitoring stations in El Paso, TX and Sunland Park, NM. The effect of PM_{10} was evaluated. The study area consisted of Sunland Park, NM, and Puerto Anapra, Mexico as illustrated in figure 6-1.

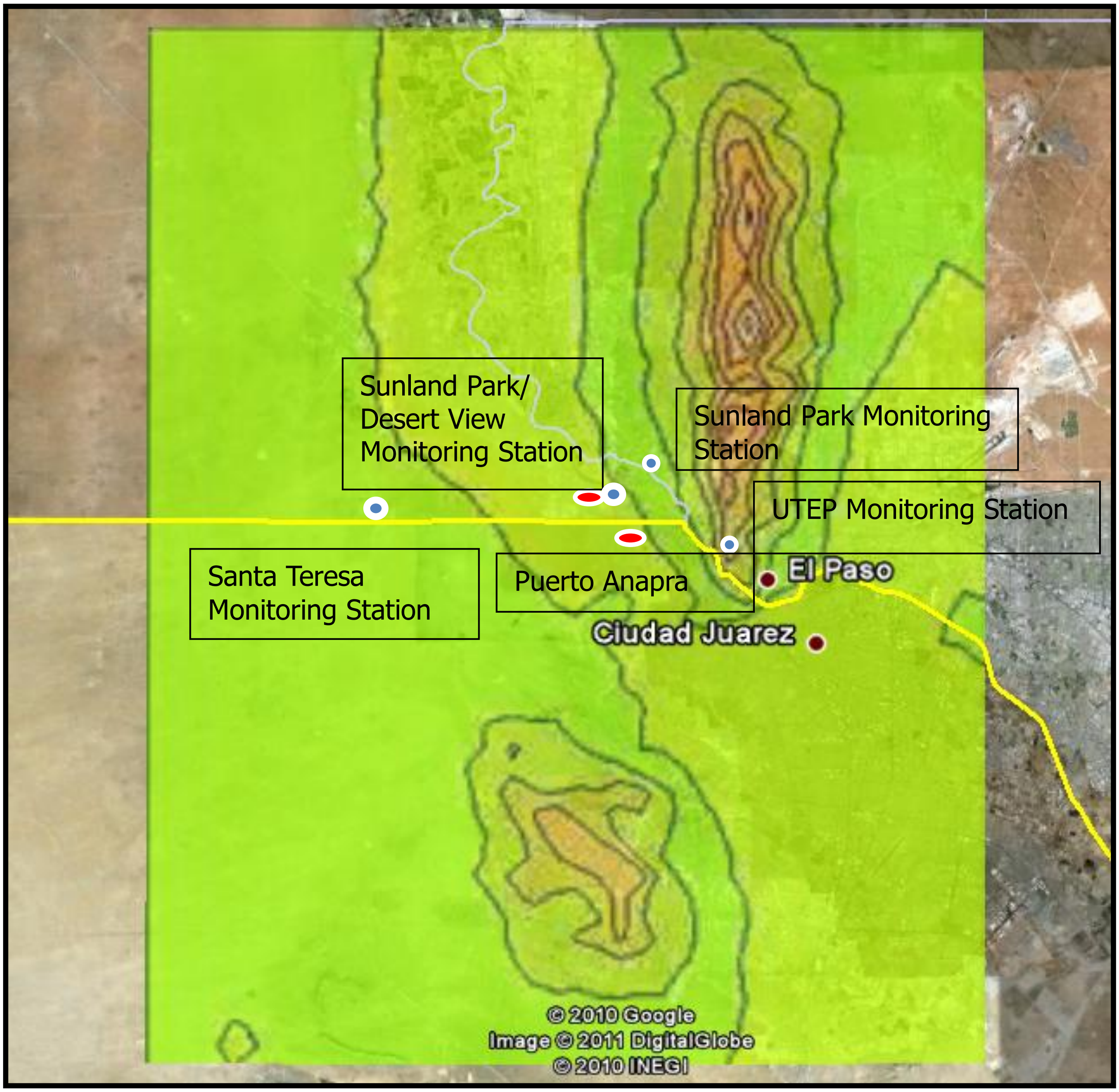

Figure 6-1. Study Area consisting of Sunland Park and Puerto Anapra.

6.1 Meteorology

The area's meteorology was processed by CALMET module using the meteorological input files MM5 previously developed by the Western Regional Air Partnership (WRAP) Regional Modeling Center (RMC) and the Midwest RPO as well as selecting the appropriate meteorological options in the module as explained in Chapter 5.

Once the model runs for each month were completed, the PRTMET module was implemented to extract CALMET output information to plot the results for each hour of the month. Through the use of CALVIEW software, the PRTMET output files were plotted and reviewed. The plots illustrated the winds from ten meters from the surface. The month of January had predominantly northern winds shifting from west to east during the first part of the month. During the middle of the month, southeasterly winds begin to blow in the area. The last ten days of the month were predominant northwesterly winds ending the last day with southeasterly winds. Figure 6-2 illustrates the surface wind field vectors produced for January 1, 2003 at 00:00 hr.

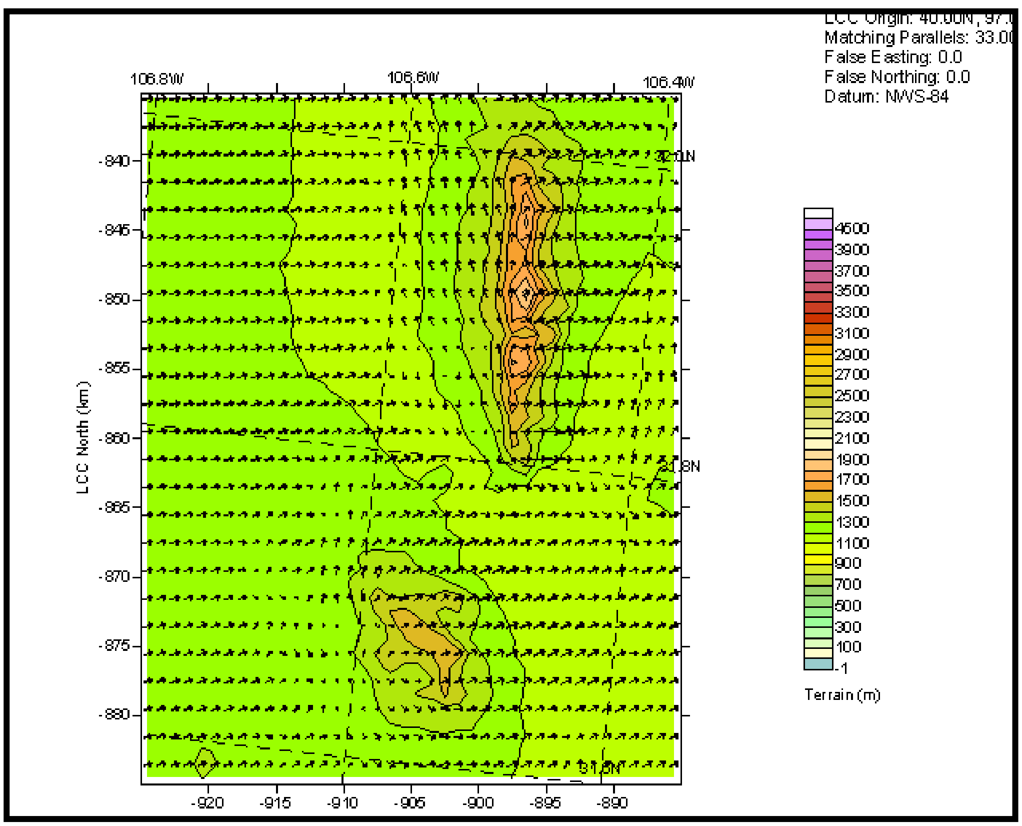

Figure 6-2. January 1, 2003 Surface Wind Field Vector Plot at 00:00 hr.

In addition, the Wind Rose Plotting Module from the CALPro Plus 7.7.0.03_03_2010 was utilized to develop the wind rose for the month of January. The program requires to input the CALMET output file and to select the method of interpolation. The January CALMET's output file was browsed and the binary spatial interpolation method was selected to acquire conservative values. The coordinates of the center of the city of Sunland Park were inputted. The January's wind rose indicates that 17% of the month had predominantly northerly winds, followed by southeasterly winds 12.6% of the time, and then north northwesterly winds at 9.7%. During the month of January, 4.7% of the winds present were less than 1 mile per hour (mph), approximately 38% were from 1 to 4 mph, 37% were from 4 to 7.3 mph, 17% were from 7.3 to 12 mph, 3% were from 12 to 19 mph, and 0.3% were from 19 to 24 mph.

The wind rose report also provided the frequency of winds' speeds and directions at particular time periods during the day. Refer to Appendix A for Wind Rose Report. During the month of January at hours from 1 to 6, 28% of the time northerly winds were present and 15% were east northeasterly winds. These winds ranged from 1 to 4 mph 35% of the time, 4 to 7.3 mph 38%, and 7.3 to 12 mph 19% of the time. Winds from hour 7 to hour 12, were predominantly north northwesterly (16%) followed by northerly winds at 12% of time, and southeasterly at 10% of the time. The predominant winds speeds were from 1 to 4 mph 40% of the time and 35% of the time were from 4 to 7.3 mph. From hours 13 to 18, 15% of the winds were north northwesterly, 13.4% were west northwesterly and 9% were north northwesterly. Again, the majority of the winds ranged from 1 to 4 mph and from 4 to 7.3 mph, at 38% and 36% respectively. During the last six hours of the day, 22.5% of winds were southeasterly, 21.5% were northerly winds, and 15% were east southeasterly winds. Winds during the day also ranged from 1 to 7.3 mph.

In conclusion, January had predominantly northern winds ranging from 1 to 7.3 mph. Figure 6-3 presents the Wind Rose for January 2003 and Table 6-1 includes the wind rose results.

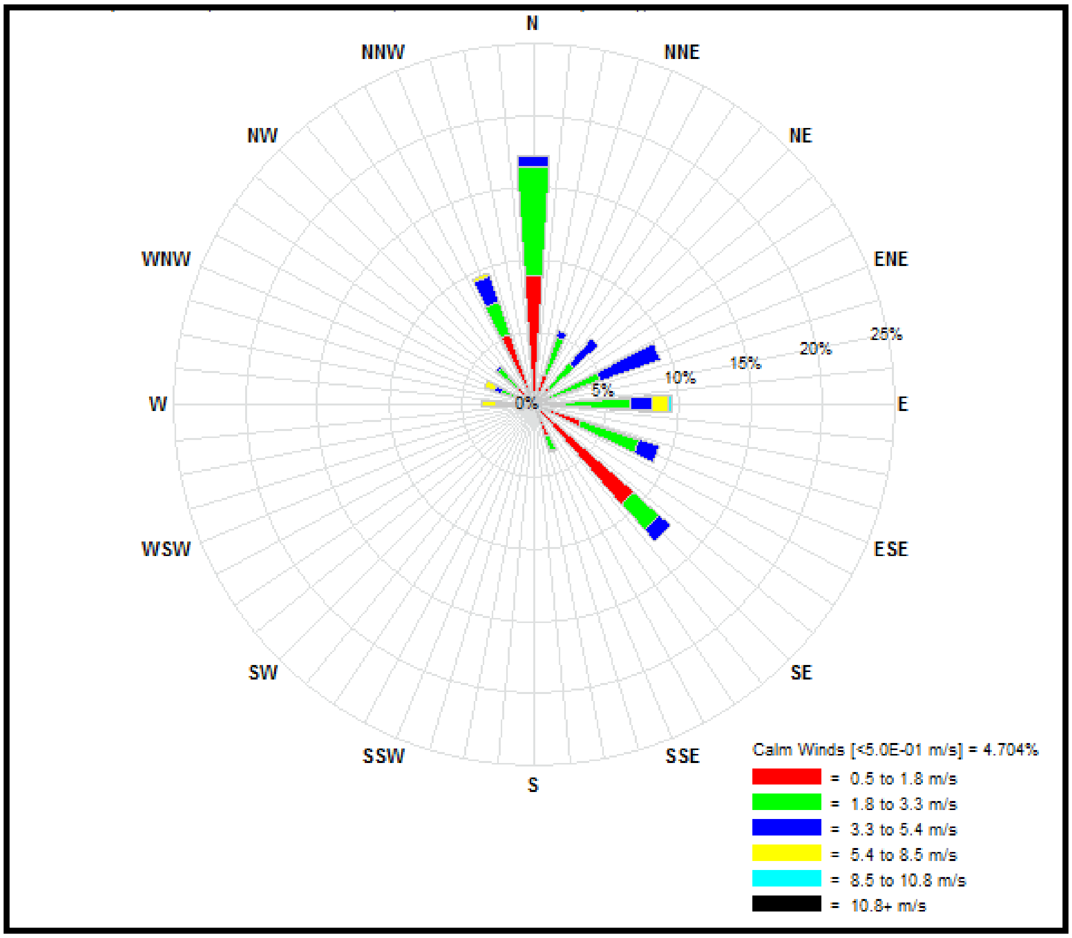

Figure 6-3. January Wind Rose at 10 m.

Table 6-1. January Wind Rose Results at 10 m.

	Miles per Hour						
Wind Direction	1 - 4	4 - 7.3	7.3 - 12	12 - 19	19 - 24	> 24	SUM
N :	8.87%	7.53%	0.81%	0.00%	0.00%	0.00%	17.20%
NNE:	2.15%	2.69%	0.54%	0.00%	0.00%	0.00%	5.38%
NE :	1.48%	2.29%	2.29%	0.00%	0.00%	0.00%	6.05%
ENE:	0.81%	4.03%	4.44%	0.00%	0.00%	0.00%	9.27%
E :	2.15%	4.44%	1.61%	1.08%	0.27%	0.00%	9.54%
ESE:	3.36%	4.30%	1.48%	0.00%	0.00%	0.00%	9.14%
SE :	9.14%	2.42%	1.08%	0.00%	0.00%	0.00%	12.63%
SSE:	2.29%	1.08%	0.13%	0.00%	0.00%	0.00%	3.50%
S :	0.13%	0.27%	0.00%	0.00%	0.00%	0.00%	0.40%
SSW:	0.40%	0.13%	0.00%	0.00%	0.00%	0.00%	0.54%
SW :	0.00%	0.00%	0.13%	0.00%	0.00%	0.00%	0.13%
WSW:	0.00%	0.54%	0.40%	0.13%	0.00%	0.00%	1.08%

W :	0.13%	0.81%	1.75%	0.94%	0.00%	0.00%	3.63%
WNW:	0.13%	2.29%	0.40%	0.81%	0.00%	0.00%	3.63%
NW :	1.61%	1.75%	0.13%	0.00%	0.00%	0.00%	3.50%
NNW:	5.11%	2.42%	1.88%	0.27%	0.00%	0.00%	9.68%
SUM:	37.77%	36.96%	17.07%	3.23%	0.27%	0.00%	95.30%
Calm Winds:	4.70%						

The month of February had predominant easterly winds which began to blow southerly in the first part of the month and then northerly towards the middle of the month. The last ten days had a combination of northwesterly and southwesterly winds. Figure 6-4 presents the typical day for this month at winds from ten meters from the surface on February 3, 2003 at 10:00 hrs.

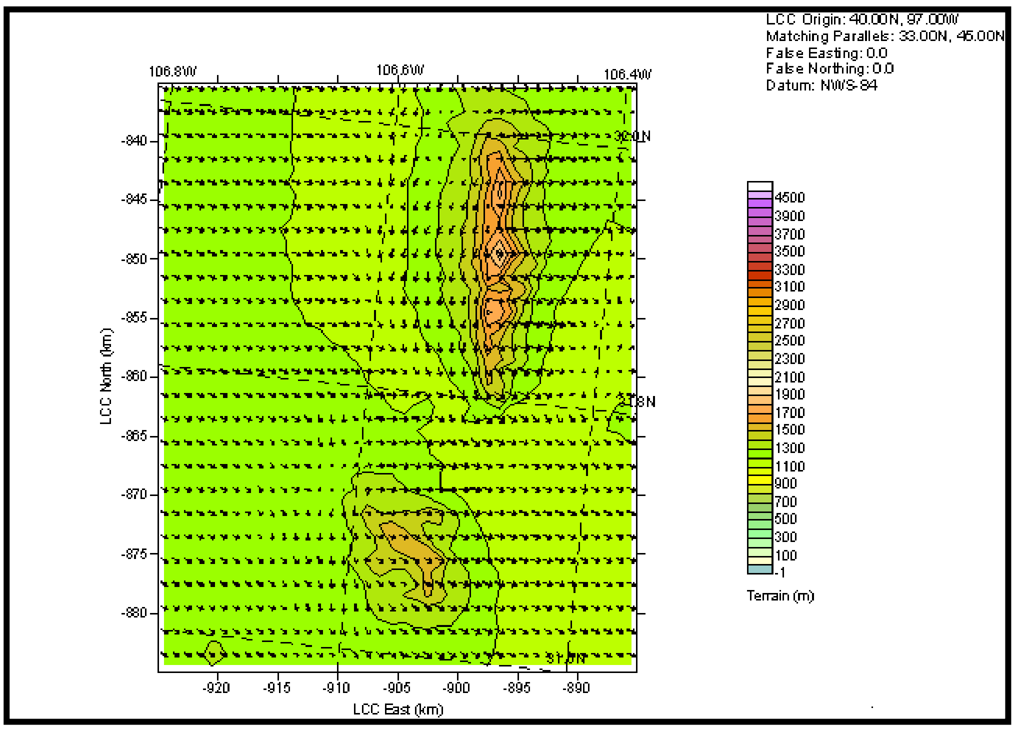

Figure 6-4. February 3, 2003 Surface Wind Field Vector Plot at 10:00 hrs.

February's wind rose showed that 16% of winds were southeasterly, 15% were northerly winds, and 14% were north northwesterly winds. The majority of the winds ranged from 4 to 7.3 mph 36% of the time, followed by winds from 7.3 to 12 mph 26% of the time, and 25% of the time were from 1 to 4 mph. During the day, at hours 1 to 6, the majority of the winds were northerly winds 32% of the time, and ranging from 4 to 7.3 mph were 26% of the time, and 14% were southeasterly winds from 1 to 4

mph. Hours 7 to 12, had north northwesterly winds 17% of the time and east southeasterly winds were present 11% of the time. The winds ranged the majority of the time from 1 to 4 mph 33%, 30% of the time were from 4 to 7.3 mph, and 25% were from 7.3 to 12 mph. At hours 13 to 18, 22% were westerly winds and 17% were west southwesterly winds. The majority of the winds ranged from 4 to 19 mph. Hours 19 to 24 had predominantly southeasterly winds 30% of the time and 21% were north northwesterly winds. The majority of the winds were from 7.3 to 12 mph 42% of the time followed by 4 to 7.3 mph at 35%.

In summary, February had northern, southeastern and north northwesterly winds equally throughout the month, ranging from 1 to 12 mph. Figure 6-5 presents the Wind Rose for February 2003 and Table 6-2 includes the wind rose results at ten meters.

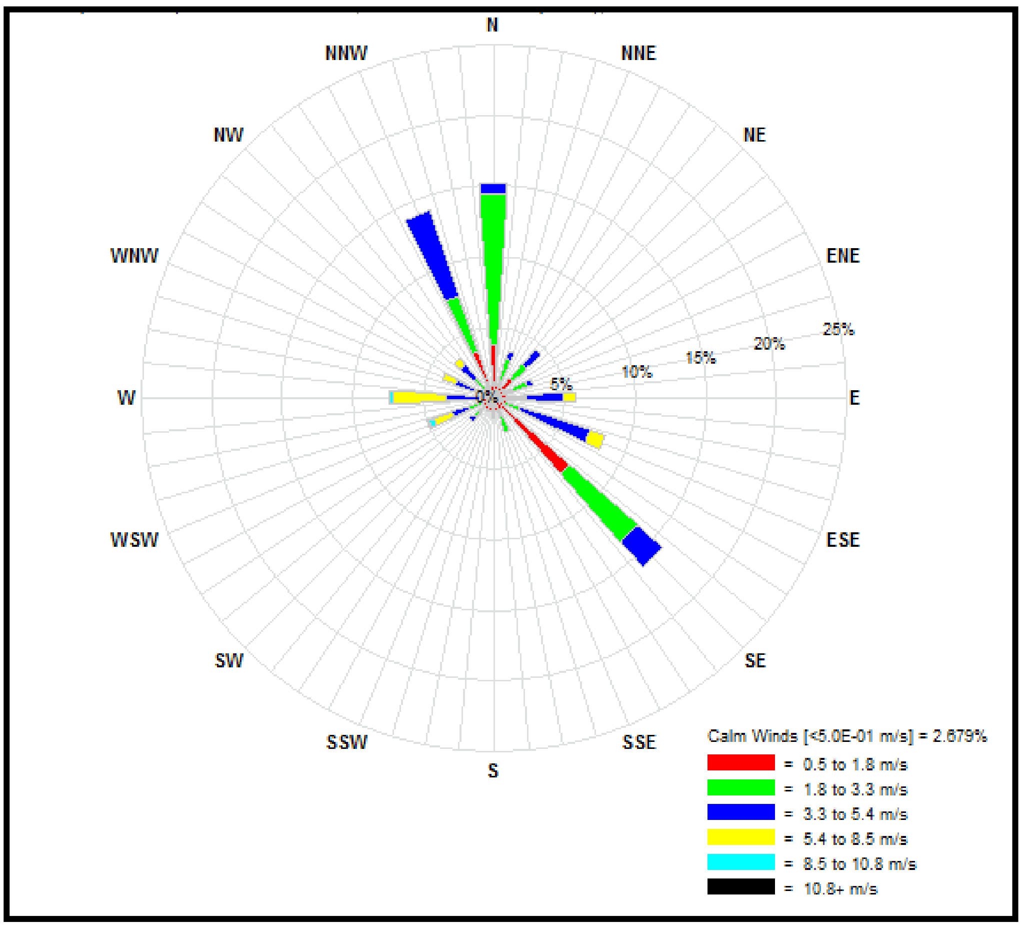

Figure 6-5. February Wind Rose at 10 m.

Table 6-2. February Wind Rose Results at 10 m.

	Miles per Hour						
Wind Direction	1 - 4	4 - 7.3	7.3 - 12	12 - 19	19 - 24	> 24	SUM
N :	3.72%	10.71%	0.74%	0.00%	0.00%	0.00%	15.18%
NNE:	1.34%	1.49%	0.74%	0.00%	0.00%	0.00%	3.57%
NE :	1.79%	1.34%	1.34%	0.00%	0.00%	0.00%	4.46%
ENE:	1.34%	1.19%	0.30%	0.00%	0.00%	0.00%	2.83%
E :	0.89%	1.34%	2.68%	0.89%	0.00%	0.00%	5.80%
ESE:	0.89%	1.04%	5.21%	1.19%	0.00%	0.00%	8.33%
SE :	7.14%	6.40%	2.38%	0.00%	0.00%	0.00%	15.92%
SSE:	1.34%	1.19%	0.00%	0.00%	0.00%	0.00%	2.53%
S :	0.45%	0.89%	0.00%	0.00%	0.00%	0.00%	1.34%
SSW:	0.00%	0.60%	0.45%	0.00%	0.00%	0.00%	1.04%
SW :	0.89%	1.04%	0.30%	0.00%	0.00%	0.00%	2.23%
WSW:	0.15%	1.79%	1.19%	1.34%	0.45%	0.15%	5.06%
W :	0.15%	0.89%	2.38%	3.72%	0.30%	0.00%	7.44%
WNW:	0.30%	1.19%	1.34%	1.04%	0.00%	0.00%	3.87%
NW :	0.60%	1.34%	1.19%	0.60%	0.00%	0.00%	3.72%
NNW:	3.57%	4.02%	6.40%	0.00%	0.00%	0.00%	13.99%
SUM:	24.55%	36.46%	26.64%	8.78%	0.74%	0.15%	97.32%
Calm Winds:	2.68%						

In March, northwesterly winds were predominant throughout the month but ended with southeasterly winds. Figure 6-6 illustrates the predominant surface wind vectors at the end of the month on March 1, 2003 at 0:00 hr.

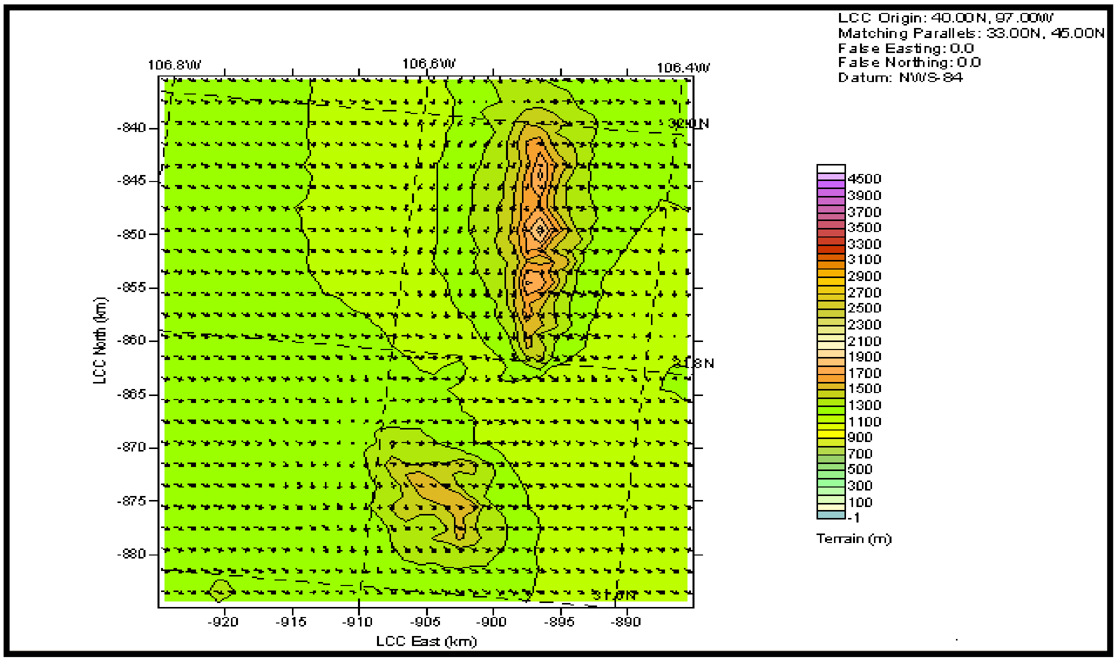

Figure 6-6. March 1, 2003 Surface Wind Field Vector Plot at 0:00 hr.

March's wind rose described that 18.5% of the winds were northerly, 13.4% were north northwesterly winds, 12.7% were westerly winds, and 12% were southeasterly winds. Again, the majority of the winds ranged from 1 to 12 mph. During the day, hours from 1 to 6 presented that the majority of the winds were northerly winds from 1 to 7.3 mph, followed by southeasterly winds at this same speeds. North northwesterly winds were also present 10% of the time at speeds from 7.3 to 12 mph. Hours 7 to 12 had westerly winds 19% of the time, followed by north northwesterly, northwesterly, easterly and northerly winds at speeds from 1 to 7.3 mph. Hours 13 to 18, presented west northwesterly and northwesterly winds 30% and 25% of the time, respectively, having the majority of the speeds from 4 to 12 mph. Hours 19 to 24 had southeasterly winds 27% of the time, 21.5% were northern winds and 20% were north northwesterly winds from 1 to 12 mph. Figure 6-7 shows March's wind rose and Table 6-3 shows the results.

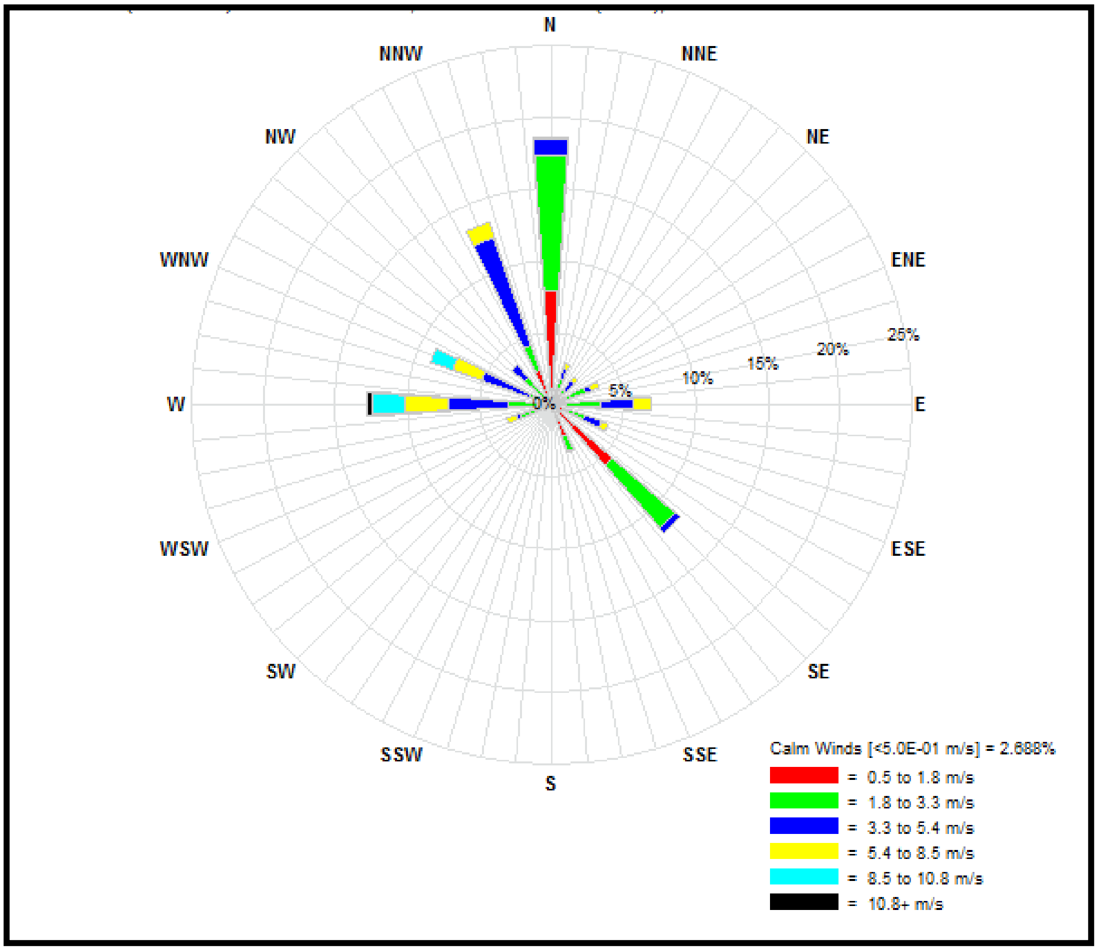

Figure 6-7. March Wind Rose at 10 m.

Table 6-3. March Wind Rose Results at 10 m.

	Miles per Hour						
Wind Direction	1 - 4	4 - 7.3	7.3 - 12	12 - 19	19 - 24	> 24	SUM
N :	7.93%	9.41%	1.08%	0.13%	0.00%	0.00%	18.55%
NNE:	1.08%	0.81%	0.81%	0.27%	0.00%	0.00%	2.96%
NE :	0.81%	0.54%	0.81%	0.40%	0.00%	0.00%	2.55%
ENE:	0.94%	1.61%	0.27%	0.67%	0.00%	0.00%	3.50%
E :	0.94%	2.42%	2.29%	1.21%	0.00%	0.00%	6.86%
ESE:	0.81%	1.61%	1.21%	0.54%	0.00%	0.00%	4.17%
SE :	5.65%	5.78%	0.40%	0.00%	0.00%	0.00%	11.83%
SSE:	2.29%	1.08%	0.13%	0.00%	0.00%	0.00%	3.50%
S :	0.40%	0.27%	0.00%	0.00%	0.00%	0.00%	0.67%
SSW:	0.13%	0.00%	0.00%	0.00%	0.00%	0.00%	0.13%
SW :	0.40%	0.27%	0.00%	0.00%	0.00%	0.00%	0.67%
WSW:	0.13%	2.15%	0.27%	0.67%	0.00%	0.00%	3.23%

W :	0.13%	2.82%	4.17%	3.09%	2.15%	0.40%	12.77%
WNW:	0.00%	1.61%	3.50%	2.15%	1.61%	0.00%	8.87%
NW :	0.67%	1.88%	1.08%	0.00%	0.00%	0.00%	3.63%
NNW:	2.55%	1.88%	7.80%	1.21%	0.00%	0.00%	13.44%
SUM:	24.87%	34.14%	23.79%	10.35%	3.76%	0.40%	97.31%
Calm Winds:	2.69%						

Similar to the month of February, April had predominant westerly winds shifting southerly and northerly. Figure 6-8 shows both wind directions in a characteristic day of this month, on April 1, 2003 at 10:00 hrs.

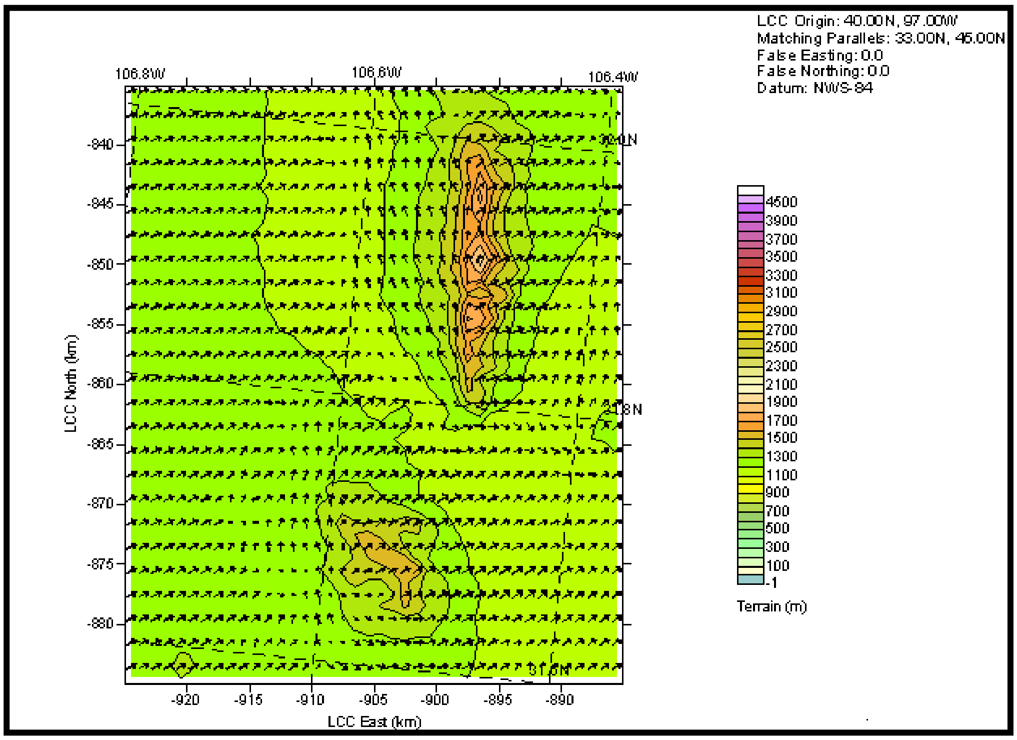

Figure 6-8. April 1, 2003 Surface Wind Field Vector Plot at 10:00 hrs.

More accurately, April's wind rose indicated that 17% of the winds were north northwesterly, 16% were westerly, 11.5% were southeasterly winds, and 10% were northerly winds. Throughout the month, hours 1 to 6 showed that the majority of the winds were northerly (28%), southeasterly (20%), and north northwesterly (16%) from 1 to 12 mph. Hour period from 7 to 18, had predominantly westerly and west northwesterly winds. The majority of the winds were from 7.3 to 19 mph. Last, hours 19 to 24

had predominantly north northwesterly winds 40% of the time at speeds from 4 to 12 mph. This data is appreciated in the Figure 6-9 and Table 6-4.

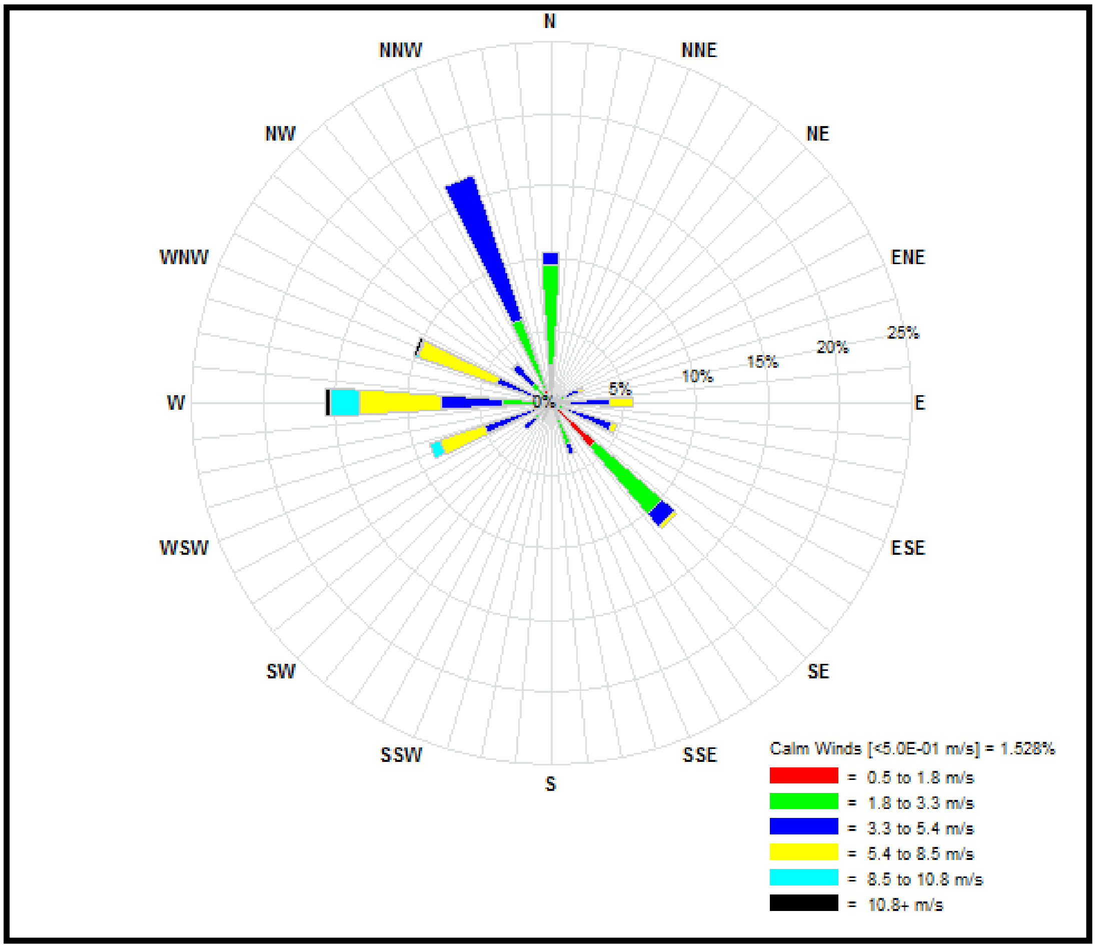

Figure 6-9. April Wind Rose at 10 m.

Table 6-4. April Wind Rose Results at 10 m.

	Miles per Hour						
Wind Direction	1 - 4	4 - 7.3	7.3 - 12	12 - 19	19 - 24	> 24	SUM
N :	2.64%	6.94%	0.83%	0.00%	0.00%	0.00%	10.42%
NNE:	0.14%	0.28%	0.00%	0.00%	0.00%	0.00%	0.42%
NE :	0.00%	0.14%	0.28%	0.28%	0.00%	0.00%	0.69%
ENE:	0.00%	1.11%	0.83%	0.42%	0.00%	0.00%	2.36%
E :	0.42%	0.56%	3.06%	1.67%	0.00%	0.00%	5.69%
ESE:	0.28%	0.42%	3.75%	0.28%	0.00%	0.00%	4.72%
SE :	4.03%	6.11%	1.11%	0.28%	0.00%	0.00%	11.53%
SSE:	0.97%	2.08%	0.69%	0.00%	0.00%	0.00%	3.75%
S :	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
SSW:	0.28%	0.00%	0.69%	0.42%	0.00%	0.00%	1.39%
SW :	0.42%	1.11%	0.97%	0.00%	0.00%	0.00%	2.50%
WSW:	0.28%	0.97%	3.61%	3.33%	0.69%	0.00%	8.89%
W :	0.28%	3.06%	4.31%	5.69%	1.94%	0.42%	15.69%
WNW:	0.14%	0.97%	2.92%	5.69%	0.14%	0.28%	10.14%
NW :	0.28%	1.53%	1.67%	0.14%	0.00%	0.00%	3.61%
NNW:	0.97%	5.14%	10.56%	0.00%	0.00%	0.00%	16.67%
SUM:	11.11%	30.42%	35.28%	18.19%	2.78%	0.69%	98.47%
Calm Winds:	1.53%						

The month of May experienced mostly northwesterly winds in the first and middle part of the month and southeasterly winds at the end. Figure 6-10 illustrates southeasterly winds at the end of the month on May 20, 2003 at 16:00 hrs.

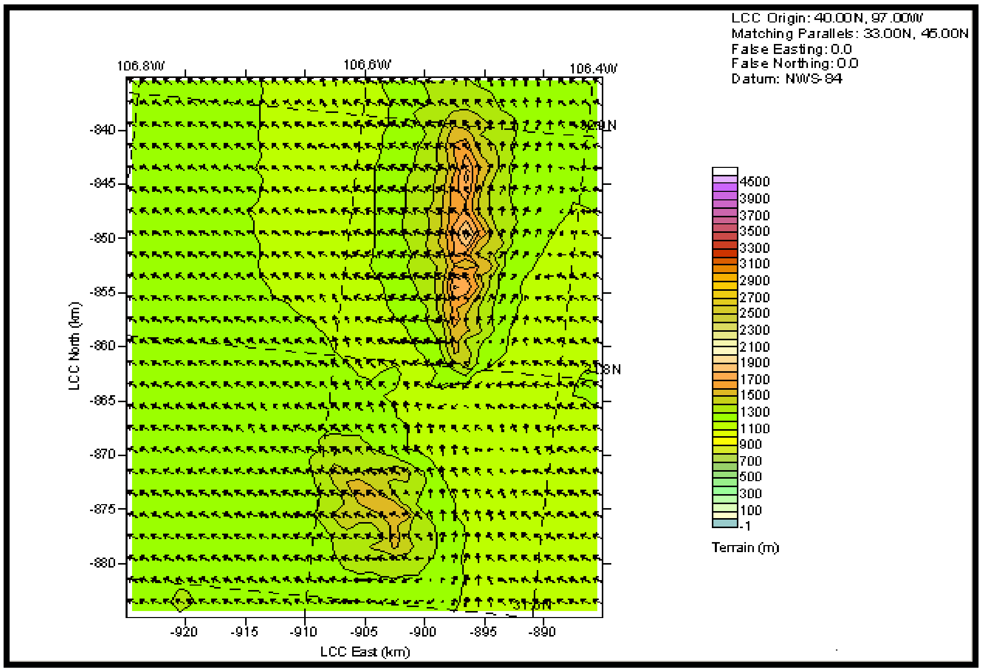

Figure 6-10. May 20, 2003 Surface Wind Field Vector Plot at 16:00 hrs.

The month of May had similar winds as the month of April. Westerly and north northwesterly winds had the higher occurrences at 17% and 15.5%, respectively; however, easterly, east southeasterly, and southeasterly winds were also present at 10%, 12.6%, and 11%, respectively. These winds in addition to northerly and north northwesterly winds were the most predominant at speed from 1 to 12 mph. Hours 1 to 6 experienced majorly easterly winds (20%), northerly winds (17%), and southeasterly winds (16%) from 1 to 12 mph. Hours 7 to 12 had predominantly westerly winds (21%) followed by west southwesterly, south southeasterly and east southeasterly at 1 to 19 mph. Similarly, hours 13 to 19 had predominantly westerly winds 40% of the time at speeds from 4 to 19 mph. Hours 19 to 24, had north northwesterly (30%) winds predominantly followed by northerly winds (15%). Southeasterly and east southeasterly were also present. The majority of these winds had speeds from 4 to 12 mph. Figure 6-11 shows the May's Wind Rose.

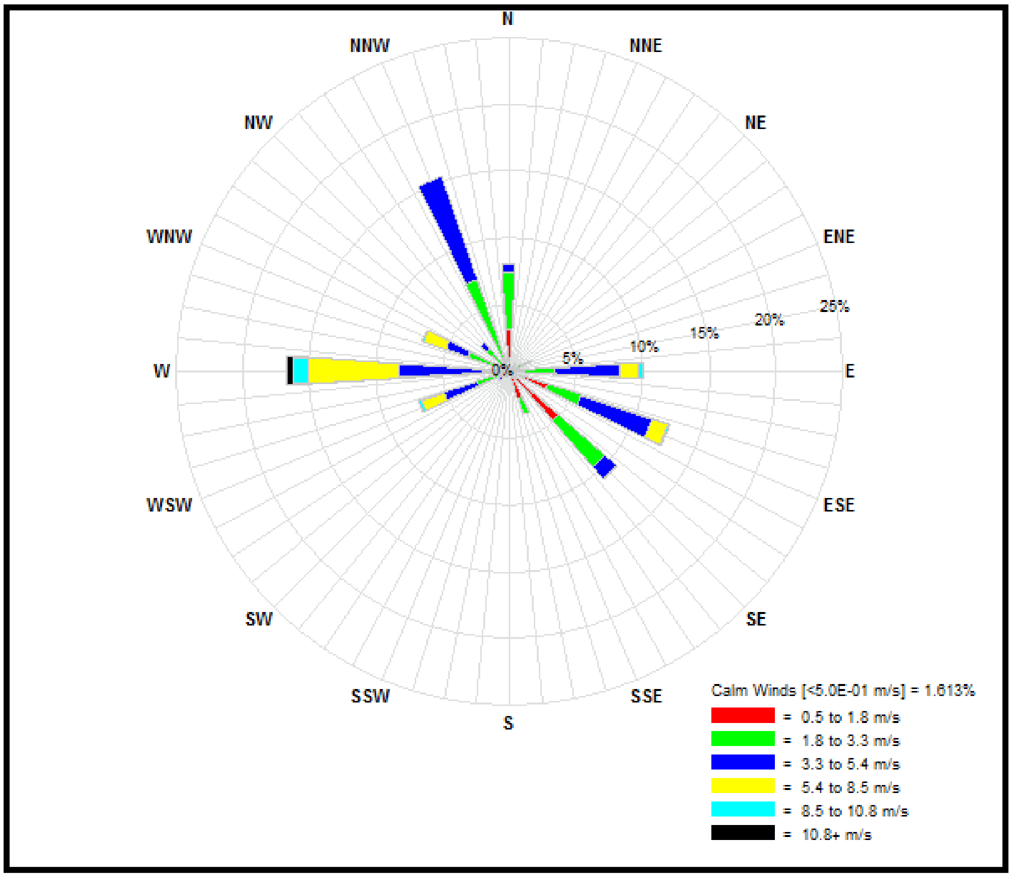

Figure 6-11. May Wind Rose at 10 m.

Table 6-5. May Wind Rose Results at 10 m.

	Miles per Hour						
Wind Direction	1 - 4	4 - 7.3	7.3 - 12	12 - 19	19 - 24	> 24	SUM
N :	3.09%	4.30%	0.67%	0.00%	0.00%	0.00%	8.07%
NNE:	0.00%	0.27%	0.13%	0.00%	0.00%	0.00%	0.40%
NE :	0.27%	0.27%	0.27%	0.00%	0.00%	0.00%	0.81%
ENE:	0.13%	0.94%	0.40%	0.27%	0.00%	0.00%	1.75%
E :	1.08%	2.29%	4.97%	1.34%	0.40%	0.00%	10.08%
ESE:	2.96%	2.69%	5.65%	1.21%	0.13%	0.00%	12.63%
SE :	4.84%	4.70%	1.08%	0.13%	0.00%	0.00%	10.75%
SSE:	2.15%	1.21%	0.00%	0.00%	0.00%	0.00%	3.36%
S :	0.00%	0.13%	0.00%	0.00%	0.00%	0.00%	0.13%
SSW:	0.13%	0.40%	0.00%	0.00%	0.00%	0.00%	0.54%
SW :	0.27%	0.54%	0.13%	0.00%	0.00%	0.00%	0.94%
WSW:	0.54%	2.02%	2.55%	1.75%	0.27%	0.00%	7.12%
W :	0.13%	1.88%	6.32%	6.72%	1.08%	0.54%	16.67%
WNW:	0.40%	2.82%	1.75%	1.75%	0.13%	0.00%	6.86%

NW :	0.27%	2.02%	0.54%	0.00%	0.00%	0.00%	2.82%
NNW:	1.08%	6.18%	8.20%	0.00%	0.00%	0.00%	15.46%
SUM:	17.34%	32.66%	32.66%	13.17%	2.02%	0.54%	98.39%
Calm Winds	1.61%						

The beginning of the month of June was composed of northwesterly winds in combination with southeasterly winds. At the initial middle of the month and at the end, southeasterly winds were predominant as shown in Figure 6-12. Figure 6-12 illustrates the surface wind field vectors in June 6, 2003 at 12:00 hrs.

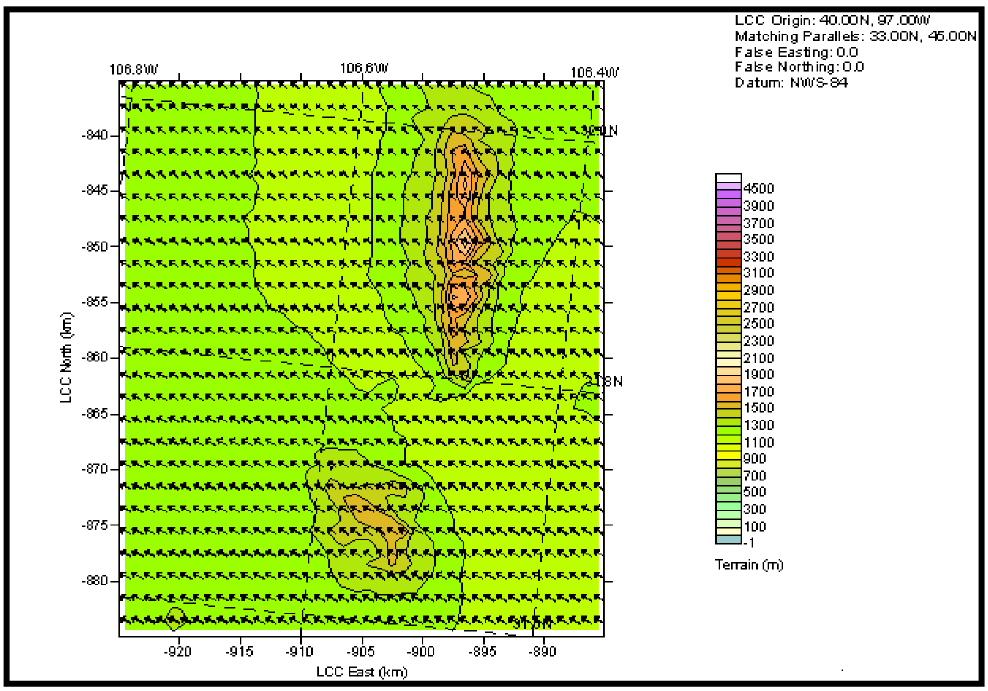

Figure 6-12. June 6, 2003 Surface Wind Field Vector Plot at 12:00 hrs.

June's wind rose indicates that 17% of the winds throughout the month were southeasterly followed by east southeasterly (12%) and north northwesterly (11%) winds. The majority of the winds were between 4 and 12 mph. In the beginning of the day from hours 1 to 6, 25% of the winds were northerly, 23% were southeasterly and 17% were easterly with a predominant speed from 4 to 7.3 mph. From hour 7 to 12, the predominant winds were east southeasterly (18%) followed by westerly (13%) winds with speeds from 1 to 12 mph. Hours 13 to 18 had predominantly westerly and west northwesterly

winds 44% of the time at speeds from 7.3 to 12 mph. The last part of the day had a combination of southeasterly and northwesterly winds majorly at speeds from 7.3 to 12 mph. Figure 6-13 shows this data followed by the results in Table 6-6.

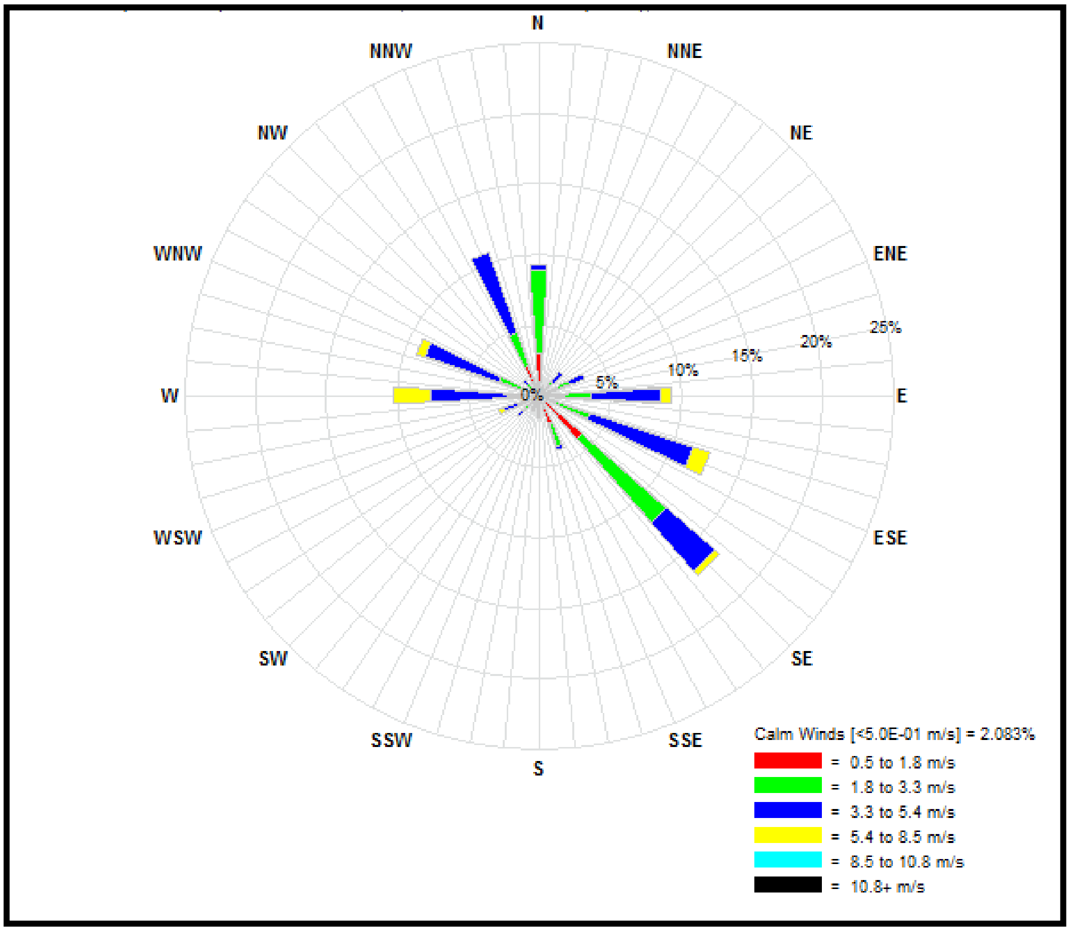

Figure 6-13. June Wind Rose at 10 m.

Table 6-6. June Wind Rose Results at 10 m.

Wind Direction	Miles per Hour						
	1 - 4	4 - 7.3	7.3 - 12	12 - 19	19 - 24	> 24	SUM
N :	3.06%	5.83%	0.42%	0.00%	0.00%	0.00%	9.31%
NNE:	0.28%	0.14%	0.28%	0.00%	0.00%	0.00%	0.69%
NE :	0.28%	1.11%	0.83%	0.00%	0.00%	0.00%	2.22%
ENE:	0.56%	1.67%	1.11%	0.00%	0.00%	0.00%	3.33%
E :	1.81%	1.81%	4.86%	0.83%	0.00%	0.00%	9.31%
ESE:	1.25%	2.50%	7.64%	1.25%	0.00%	0.00%	12.64%

SE :	4.03%	7.92%	4.44%	0.56%	0.00%	0.00%	16.94%
SSE:	1.94%	1.81%	0.28%	0.00%	0.00%	0.00%	4.03%
S :	0.14%	1.39%	0.00%	0.00%	0.00%	0.00%	1.53%
SSW:	0.14%	0.69%	0.28%	0.00%	0.00%	0.00%	1.11%
SW :	0.14%	1.11%	0.69%	0.00%	0.00%	0.00%	1.94%
WSW:	0.00%	0.56%	2.08%	0.42%	0.00%	0.00%	3.06%
W :	0.14%	2.08%	5.42%	2.64%	0.00%	0.00%	10.28%
WNW:	0.56%	2.50%	5.42%	0.69%	0.00%	0.00%	9.17%
NW :	0.42%	0.69%	0.42%	0.00%	0.00%	0.00%	1.53%
NNW:	2.22%	2.50%	6.11%	0.00%	0.00%	0.00%	10.83%
SUM:	16.94%	34.31%	40.28%	6.39%	0.00%	0.00%	97.92%
Calm Winds	2.08%						

The month of July had a unique scenario where every day of the month had predominant southeasterly winds except for a few hours in certain days. Figure 6-14 represents hourly data in the month on July 1, 2003 at 0:00 hr.

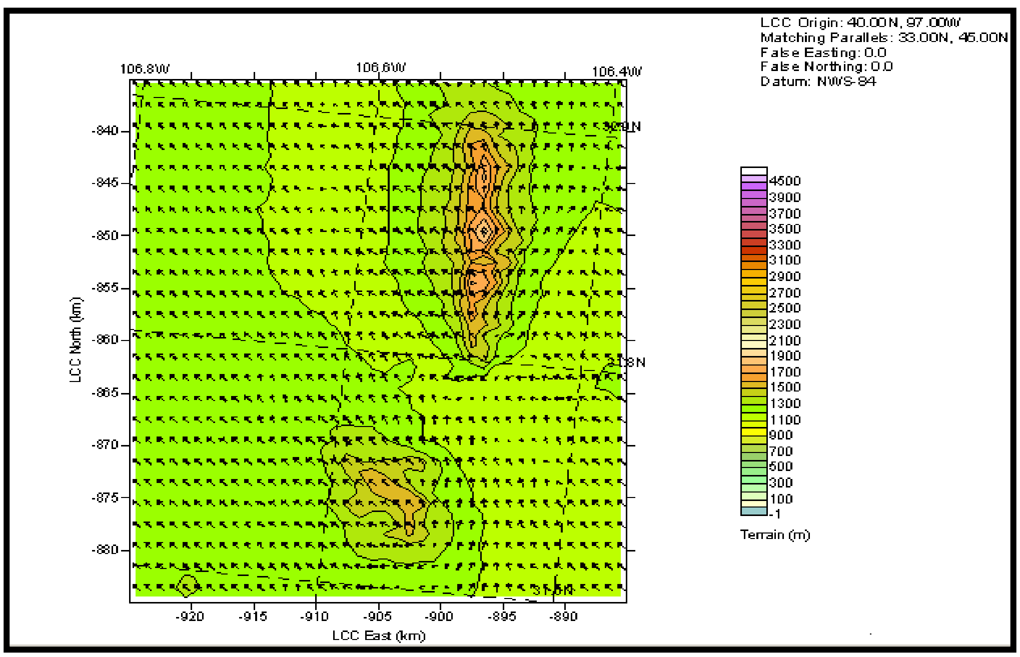

Figure 6-14. July 1, 2003 Surface Wind Field Vector Plot at 0:00 hr.

July's wind rose showed that the majority of the winds were easterly, east southeasterly, southeasterly, and south southeasterly winds at speeds from 4 to 12 mph and the same hourly scenario is present throughout the day. Figure 6-15 shows July's wind rose and Table 6-7 shows its results.

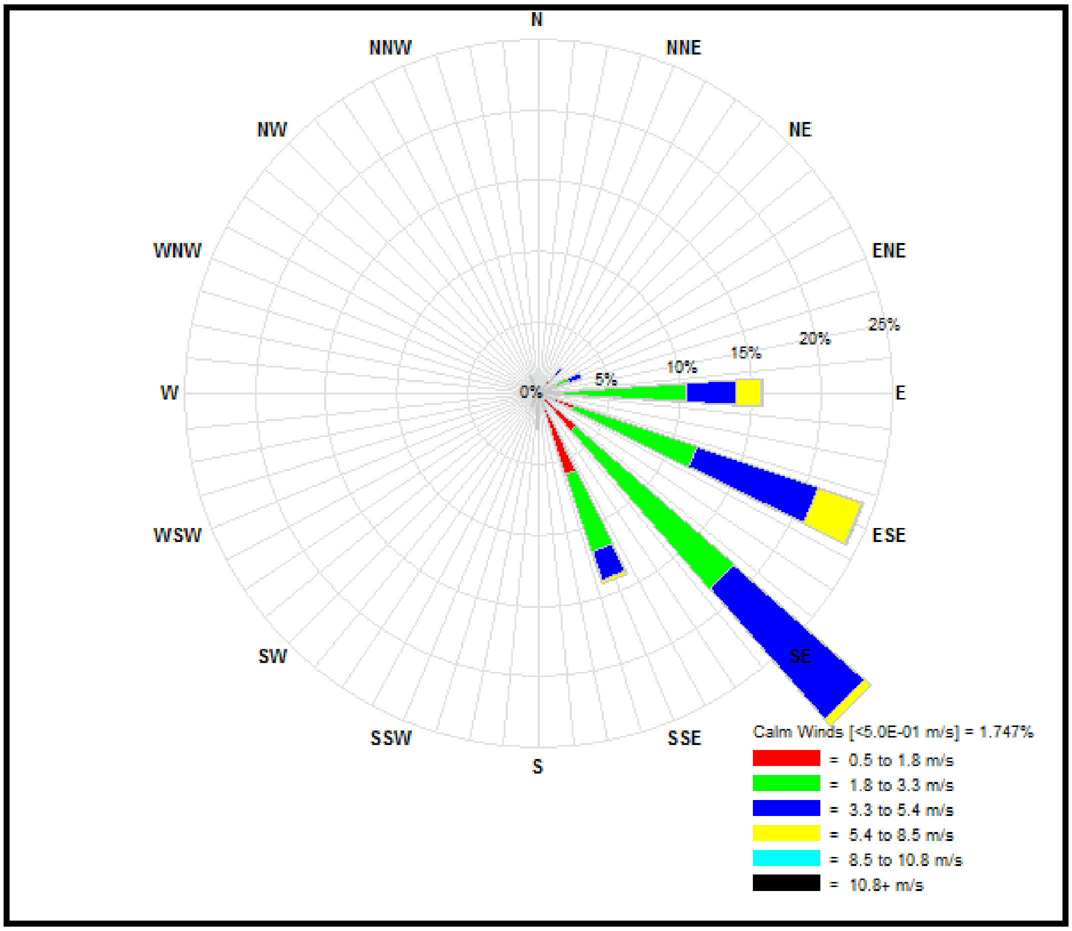

Figure 6-15. July Wind Rose at 10 m.

Table 6-7. July Wind Rose Results at 10 m.

	Miles per Hour						
Wind Direction	1 - 4	4 - 7.3	7.3 - 12	12 - 19	19 - 24	> 24	SUM
N :	0.67%	0.00%	0.00%	0.00%	0.00%	0.00%	0.67%
NNE:	0.40%	0.13%	0.00%	0.00%	0.00%	0.00%	0.54%
NE :	1.08%	0.00%	1.34%	0.00%	0.00%	0.00%	2.42%
ENE:	1.34%	0.94%	0.94%	0.00%	0.00%	0.00%	3.23%
E :	1.75%	8.60%	3.63%	1.75%	0.13%	0.00%	15.86%
ESE:	2.69%	9.14%	9.01%	3.23%	0.13%	0.00%	24.19%

SE :	3.50%	14.79%	12.37%	0.54%	0.00%	0.00%	31.18%
SSE:	6.05%	5.78%	2.15%	0.13%	0.00%	0.00%	14.11%
S :	0.13%	2.15%	0.27%	0.00%	0.00%	0.00%	2.55%
SSW:	0.00%	0.94%	0.00%	0.00%	0.00%	0.00%	0.94%
SW :	0.00%	0.13%	0.40%	0.00%	0.00%	0.00%	0.54%
WSW:	0.00%	0.40%	0.00%	0.00%	0.00%	0.00%	0.40%
W :	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
WNW:	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
NW :	0.27%	0.00%	0.00%	0.00%	0.00%	0.00%	0.27%
NNW:	1.34%	0.00%	0.00%	0.00%	0.00%	0.00%	1.34%
SUM:	19.22%	43.01%	30.11%	5.65%	0.27%	0.00%	98.25%
Calm Winds:	1.75%						

Once more, August had predominant southeasterly winds throughout the month having twenty (20) days out of the month experiencing these winds. The month also experienced northwesterly winds at the beginning of the month and northeasterly winds in the middle of the month. Figure 6-16 shows the surface winds vectors on August 1, 2003 at 0:00 hr.

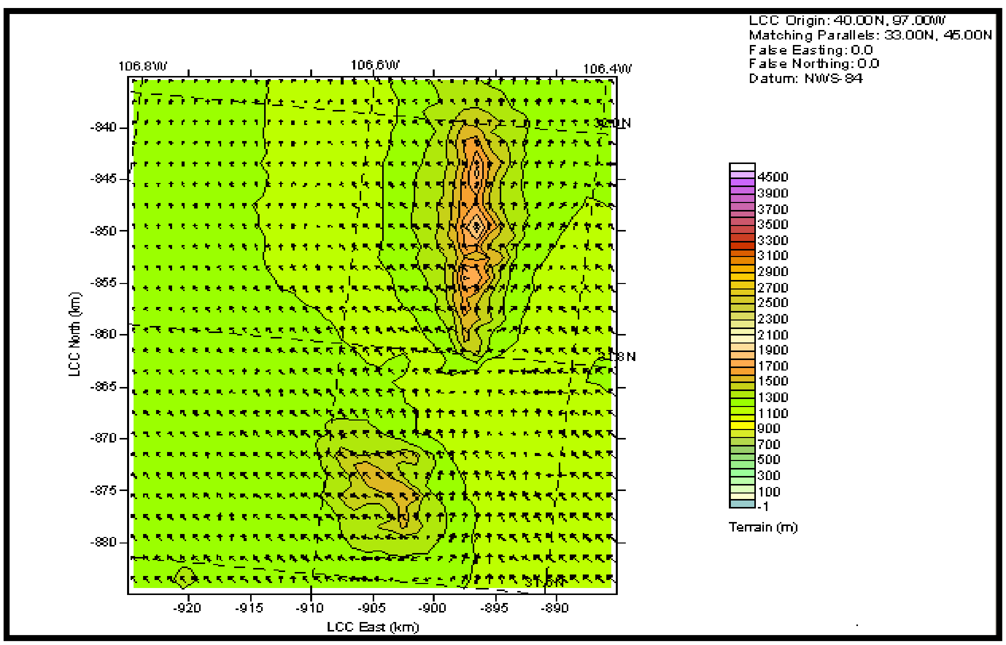

Figure 6-16. August 1, 2003 Surface Wind Field Vector Plot 0:00 hr.

August's wind rose indicated that the majority of the winds were eastern, east southeasterly and southeasterly winds. Northeasterly and northwesterly winds were also present approximately 30% of the

time. The predominant speeds were between 4 to 12 mph. Similarly, hourly data shows that the majority of the winds were east northeasterly, easterly, east southeasterly and southeasterly and only a small percentage were north northwesterly speeding from 4 to 12 mph. Figure 6-17 describes the data into more detail.

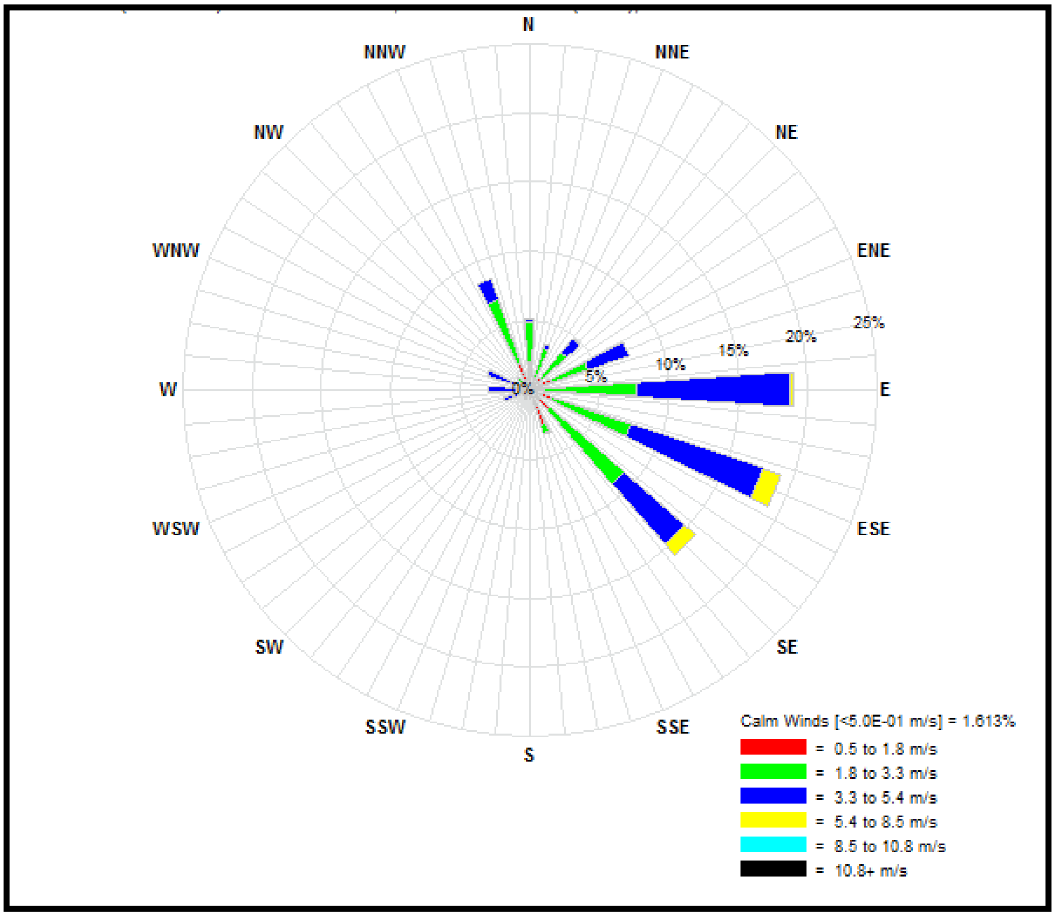

Figure 6-17. August Wind Rose at 10 m.

Table 6-8. August Wind Rose Results at 10 m.

	Miles per Hour						
Wind Direction	1 - 4	4 - 7.3	7.3 - 12	12 - 19	19 - 24	> 24	SUM
N :	2.02%	2.82%	0.27%	0.00%	0.00%	0.00%	5.11%
NNE:	0.54%	2.55%	0.40%	0.00%	0.00%	0.00%	3.50%
NE :	1.08%	2.42%	1.21%	0.13%	0.00%	0.00%	4.84%
ENE:	1.61%	2.82%	3.09%	0.00%	0.00%	0.00%	7.53%
E :	0.94%	6.72%	11.02%	0.27%	0.00%	0.00%	18.95%

ESE:	1.61%	6.05%	10.08%	1.34%	0.00%	0.00%	19.09%
SE :	1.88%	7.12%	5.78%	1.08%	0.00%	0.00%	15.86%
SSE:	2.69%	0.54%	0.13%	0.00%	0.00%	0.00%	3.36%
S :	0.27%	0.54%	0.00%	0.00%	0.00%	0.00%	0.81%
SSW:	0.13%	0.54%	0.13%	0.00%	0.00%	0.00%	0.81%
SW :	0.40%	0.27%	0.00%	0.00%	0.00%	0.00%	0.67%
WSW:	0.13%	0.67%	1.21%	0.00%	0.00%	0.00%	2.02%
W :	0.00%	0.67%	2.29%	0.00%	0.00%	0.00%	2.96%
WNW:	0.27%	0.94%	2.02%	0.00%	0.00%	0.00%	3.23%
NW :	0.27%	0.94%	0.00%	0.00%	0.00%	0.00%	1.21%
NNW:	2.02%	4.84%	1.61%	0.00%	0.00%	0.00%	8.47%
SUM:	15.86%	40.46%	39.25%	2.82%	0.00%	0.00%	98.39%
Calm Winds:	1.61%						

September followed August's behavior with southeasterly winds at the beginning and from the middle to the end of the month. The month also experienced northwesterly and southwesterly winds. Figure 6-18 illustrates southeasterly winds in the month on September 1 at 0:00 hr.

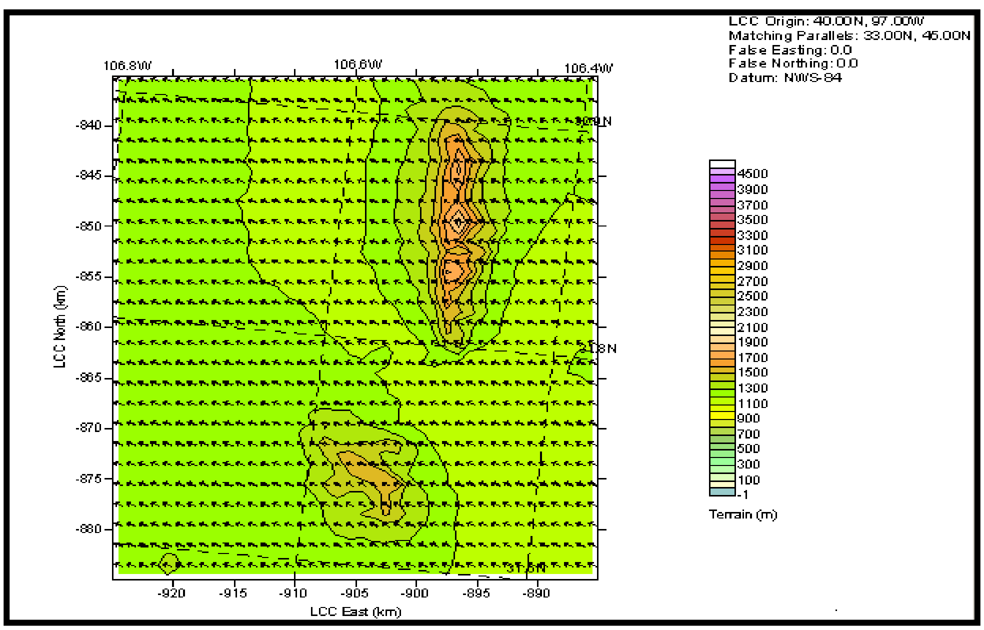

Figure 6-18. September 1, 2003 Surface Wind Field Vector Plot at 0:00 hr.

Its wind rose describes accurately that the majority of the winds were easterly (14%), east southeasterly (16%) and southeasterly (24%) from 1 to 12 mph. During the day at hours from 1 to 6,

these same winds were also the predominant winds but northerly winds were also present 14% of the time. The rest of the day showed that the majority of the winds were southeasterly winds from 1 to 12 mph. Figure 6-19 and Table 6-9 describes the wind pattern during the month of September, 2003.

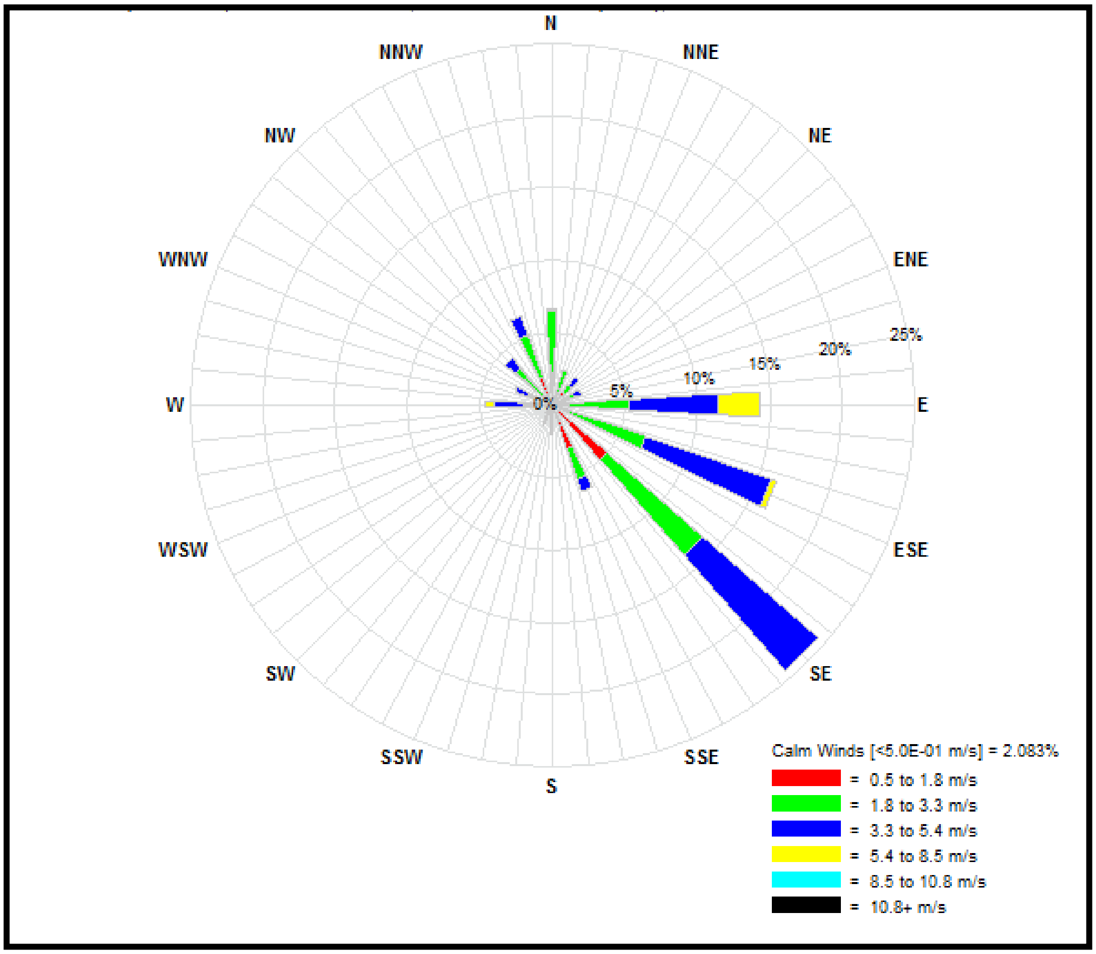

Figure 6-19. September Wind Rose at 10 m.

Table 6-9. September Wind Rose Results at 10 m.

	Miles per Hour						
Wind Direction	1 - 4	4 - 7.3	7.3 - 12	12 - 19	19 – 24	> 24	SUM
N :	2.22%	4.31%	0.14%	0.00%	0.00%	0.00%	6.67%
NNE:	0.69%	1.81%	0.00%	0.00%	0.00%	0.00%	2.50%
NE :	1.11%	0.69%	0.69%	0.00%	0.00%	0.00%	2.50%
ENE:	1.25%	0.42%	0.42%	0.00%	0.00%	0.00%	2.08%
E :	1.11%	4.17%	6.11%	2.92%	0.00%	0.00%	14.31%
ESE:	1.11%	5.69%	9.17%	0.28%	0.00%	0.00%	16.25%

SE :	5.00%	8.75%	10.56%	0.00%	0.00%	0.00%	24.31%
SSE:	3.19%	2.22%	0.83%	0.00%	0.00%	0.00%	6.25%
S :	0.42%	0.97%	0.56%	0.00%	0.00%	0.00%	1.94%
SSW:	0.14%	0.83%	0.56%	0.00%	0.00%	0.00%	1.53%
SW :	0.14%	0.28%	0.42%	0.00%	0.00%	0.00%	0.83%
WSW:	0.00%	0.42%	0.14%	0.00%	0.00%	0.00%	0.56%
W :	0.28%	1.67%	2.08%	0.56%	0.00%	0.00%	4.58%
WNW:	0.00%	1.81%	0.97%	0.00%	0.00%	0.00%	2.78%
NW :	0.28%	3.06%	0.97%	0.00%	0.00%	0.00%	4.31%
NNW:	1.94%	3.19%	1.39%	0.00%	0.00%	0.00%	6.53%
SUM:	18.89%	40.28%	35.00%	3.75%	0.00%	0.00%	97.92%
Calm Winds:	2.08%						

October had predominant easterly winds coming from the north and south. However, the end of the month experienced mostly southwesterly winds. Figure 6-20 illustrates the surface wind vectors on October 1, 2003 at 0:00 hr.

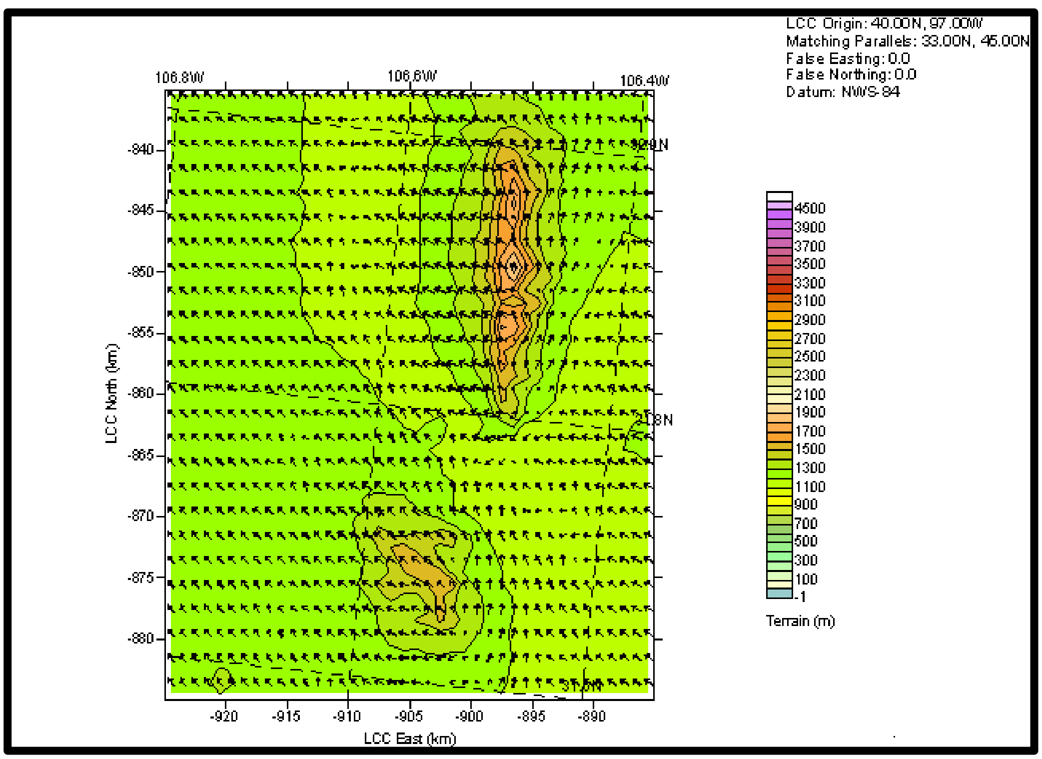

Figure 6-20. October 1, 2003 Surface Wind Field Vector Plot at 0:00 hr.

October's wind rose illustrated that predominant winds were easterly (16%), east southeasterly (14%) and southeasterly (20%) speeding from 1 to 12 mph. This same scenario occurs analyzing the

data hourly except that northerly winds had more presence from hours 1 to 6 and 19 to 24 at 12% in each time period. Figures 6-20 and 6-21 as well as Table 6-10 illustrate the data.

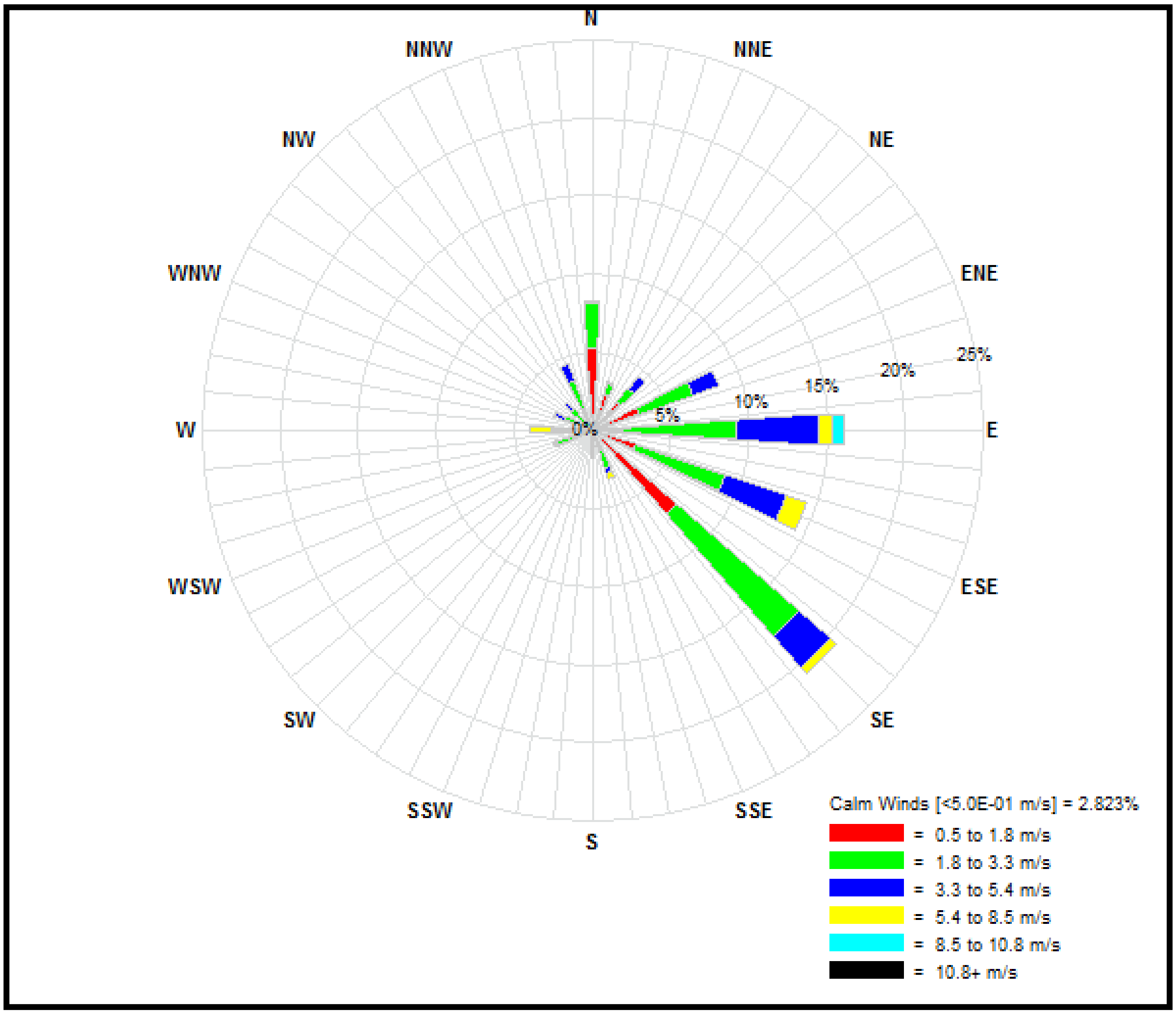

Figure 6-21. October Wind Rose at 10 m.

Table 6-10. October Wind Rose Results at 10 m.

	Miles per Hour						
Wind Direction	1 - 4	4 - 7.3	7.3 - 12	12 - 19	19 - 24	> 24	SUM
N :	5.24%	2.96%	0.13%	0.00%	0.00%	0.00%	8.33%
NNE:	2.42%	0.67%	0.13%	0.00%	0.00%	0.00%	3.23%
NE :	2.42%	1.08%	1.08%	0.00%	0.00%	0.00%	4.57%
ENE:	3.09%	3.63%	1.75%	0.00%	0.00%	0.00%	8.47%
E :	1.88%	7.26%	5.24%	0.94%	0.67%	0.00%	16.00%
ESE:	2.82%	6.05%	4.17%	1.34%	0.00%	0.00%	14.38%

SE :	7.12%	10.48%	2.55%	0.54%	0.00%	0.00%	20.70%
SSE:	1.34%	1.21%	0.27%	0.40%	0.00%	0.00%	3.23%
S :	0.67%	0.27%	0.81%	0.00%	0.00%	0.00%	1.75%
SSW:	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
SW :	0.13%	0.00%	0.00%	0.00%	0.00%	0.00%	0.13%
WSW:	0.13%	2.29%	0.13%	0.13%	0.00%	0.00%	2.69%
W :	0.00%	1.34%	1.34%	1.34%	0.00%	0.00%	4.03%
WNW:	0.54%	1.34%	0.81%	0.00%	0.00%	0.00%	2.69%
NW :	0.40%	1.34%	0.67%	0.00%	0.00%	0.00%	2.42%
NNW:	1.48%	1.88%	1.21%	0.00%	0.00%	0.00%	4.57%
SUM:	29.70%	41.80%	20.30%	4.70%	0.67%	0.00%	97.18%
Calm Winds:	2.82%						

The month of November experienced a similar scenario as October. November had predominant easterly winds coming from the north and south throughout the month. Northerly and northwesterly winds also were experienced specially at the beginning of the month. Figure 6-22 presents the predominant surface winds on November 7, 2003 at 7:00 hrs.

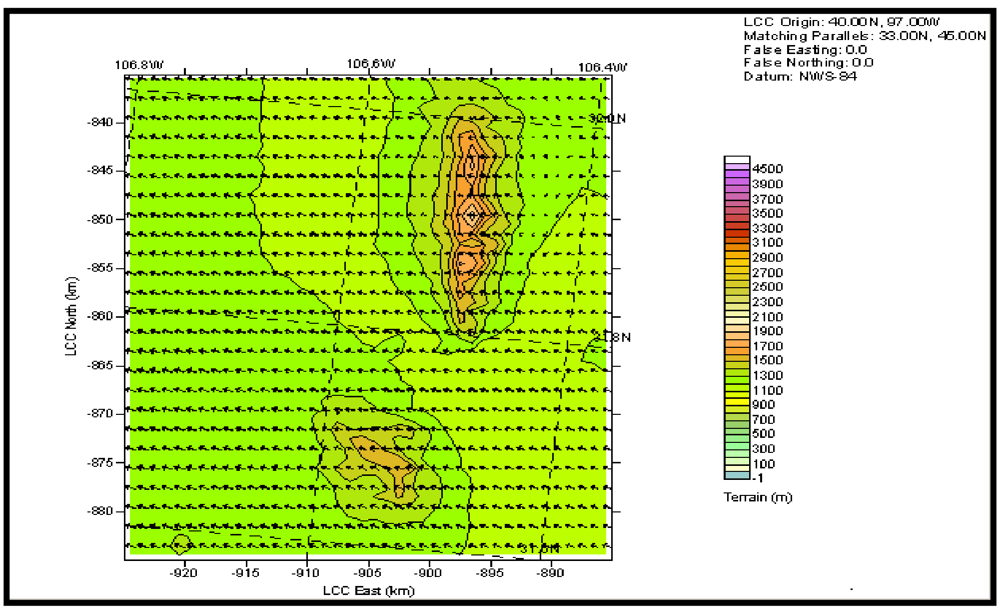

Figure 6-22. November 7, 2003 Surface Wind Field Vector Plot at 7:00 hrs.

The wind rose shows that easterly winds were present 12% and southeasterly winds were 11.5%, however, northerly winds were present almost 19% of the time. These winds ranged from 1 to 12 mph. During the day at hours 1 to 6, the model showed that this period had predominantly northerly winds

from 1 to 12 mph 33% of the time, followed by east northeasterly and easterly winds 30% of the time combined and southeasterly winds at 14% of the time. Hour period from 7 to 12, had almost equally distributed wind directions from 1 to 7.3 mph. Hours 13 to 18 had predominant westerly winds from 1 to 12 mph. The last period of the day had predominantly northerly winds, followed by easterly, southeasterly and north northwesterly winds. Figure 6-23 and Table 6-11 show the previous results.

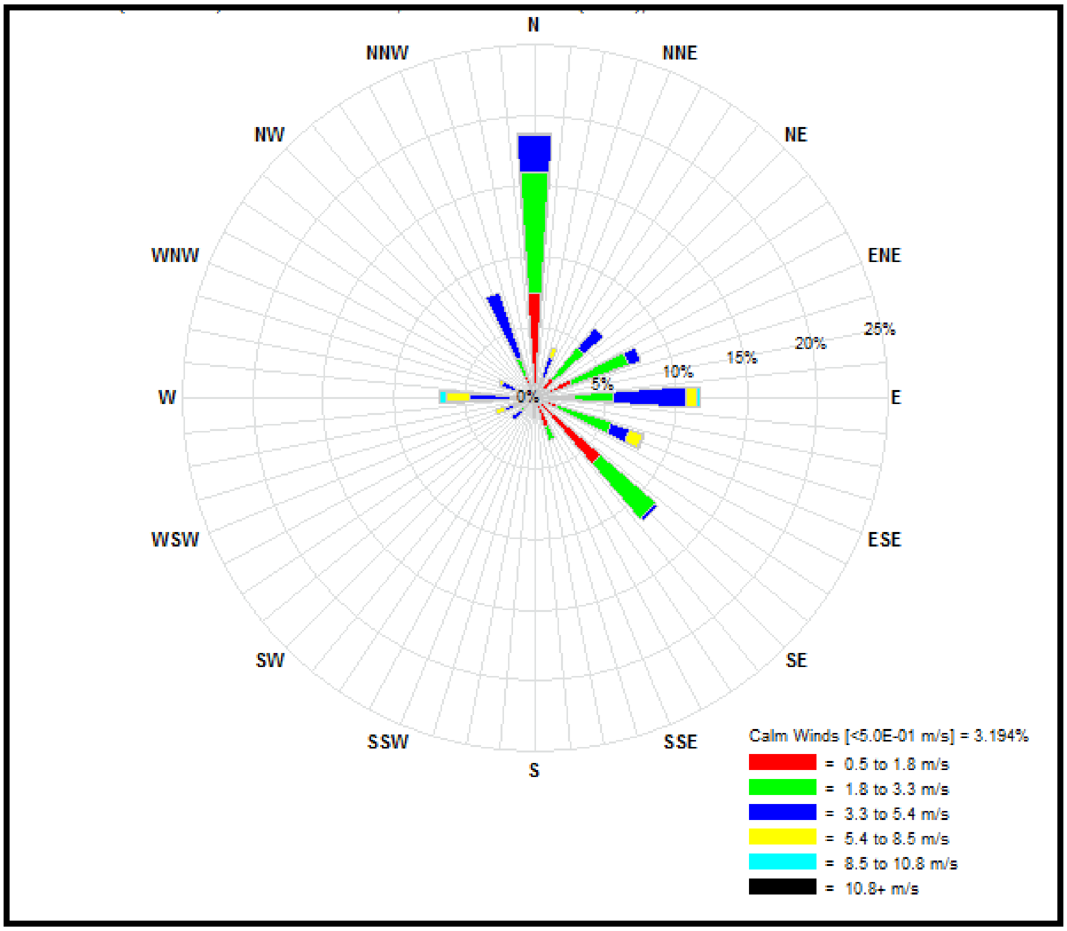

Figure 6-23. November Wind Rose at 10 m.

Table 6-11. November Wind Rose Results at 10 m.

	Miles per Hour						
Wind Direction	1 - 4	4 - 7.3	7.3 - 12	12 - 19	19 - 24	> 24	SUM
N :	7.36%	8.61%	2.64%	0.14%	0.00%	0.00%	18.75%
NNE:	0.69%	0.83%	1.53%	0.69%	0.00%	0.00%	3.75%
NE :	1.81%	2.78%	1.94%	0.00%	0.00%	0.00%	6.53%
ENE:	2.78%	4.31%	0.83%	0.00%	0.00%	0.00%	7.92%
E :	2.78%	2.78%	5.14%	0.69%	0.28%	0.00%	11.67%
ESE:	1.67%	4.03%	1.39%	0.97%	0.14%	0.00%	8.19%
SE :	6.11%	5.14%	0.28%	0.00%	0.00%	0.00%	11.53%
SSE:	2.08%	1.11%	0.00%	0.00%	0.00%	0.00%	3.19%
S :	0.14%	1.11%	0.14%	0.00%	0.00%	0.00%	1.39%
SSW:	0.42%	0.14%	0.00%	0.00%	0.00%	0.00%	0.56%
SW :	0.14%	1.25%	0.69%	0.00%	0.00%	0.00%	2.08%
WSW:	0.00%	1.53%	0.69%	0.69%	0.00%	0.00%	2.92%
W :	0.14%	1.67%	2.78%	1.67%	0.56%	0.00%	6.81%
WNW:	0.56%	0.97%	0.97%	0.28%	0.00%	0.00%	2.78%
NW :	0.69%	0.14%	0.00%	0.00%	0.00%	0.00%	0.83%
NNW:	1.67%	1.39%	4.86%	0.00%	0.00%	0.00%	7.92%
SUM:	29.03%	37.78%	23.89%	5.14%	0.97%	0.00%	96.81%
Calm Winds:	3.19%						

December followed the same path as the previous two months experiencing easterly winds coming from the north and south. Also, northwesterly winds were present in the month. Figure 6-24 presents the surface wind vectors on December 1, 2003 at 12:00 hrs.

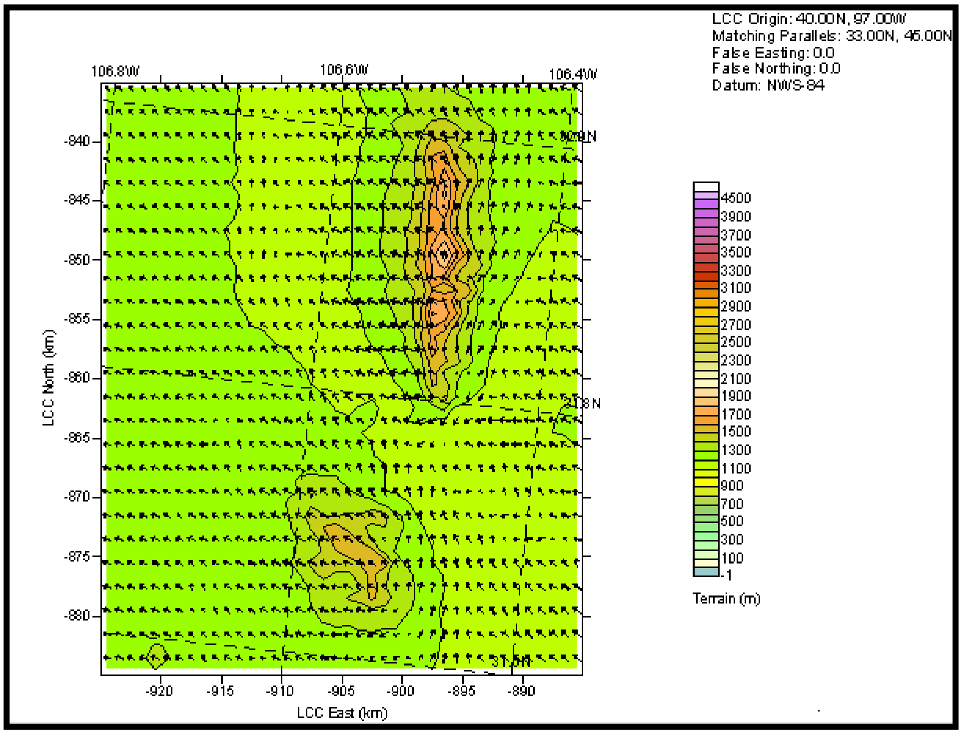

Figure 6-24. December 1, 2003 Surface Wind Field Vector Plot at 12:00 hrs.

December wind rose indicated that easterly winds were present 11.5% of the time, southeasterly winds were 11.5% and north northwesterly winds were 19% of the time. Hours 1 to 6 had a combination of east northeasterly, easterly, and southeasterly but majority north northwesterly winds from 1 to 7.3 mph. The next time period from hours 7 to 12 had almost equally distributed wind directions at the same previous speeds. Hours 13 to 18 had predominantly westerly winds followed by north northwesterly winds. Hours 19 to 24 experienced mostly north northwesterly (27%) winds followed by easterly winds (17%), east southeasterly (14%) and northerly (13%) winds. Figure 6-25 shows December's wind rose followed by Table 6-12 with the results.

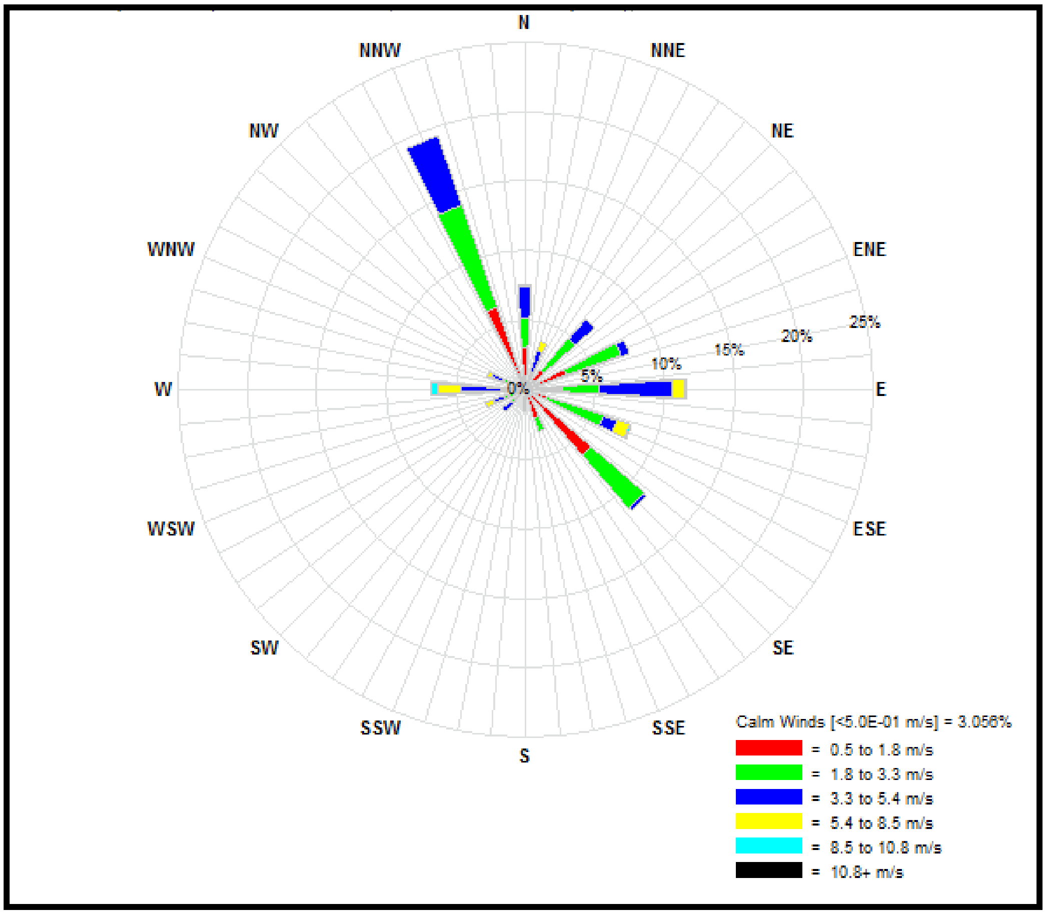

Figure 6-25. December Wind Rose at 10 m.

Table 6-12. December Wind Rose Results at 10 m.

	Miles per Hour						
Wind Direction	1 - 4	4 - 7.3	7.3 - 12	12 - 19	19 - 24	> 24	SUM
N :	3.06%	2.08%	2.22%	0.14%	0.00%	0.00%	7.50%
NNE:	0.56%	0.83%	1.53%	0.69%	0.00%	0.00%	3.61%
NE :	1.81%	2.92%	1.94%	0.00%	0.00%	0.00%	6.67%
ENE:	3.19%	4.03%	0.69%	0.00%	0.00%	0.00%	7.92%
E :	2.64%	2.64%	5.28%	0.83%	0.14%	0.00%	11.53%
ESE:	1.67%	4.17%	1.11%	0.97%	0.14%	0.00%	8.06%
SE :	6.25%	5.00%	0.28%	0.00%	0.00%	0.00%	11.53%
SSE:	2.08%	1.11%	0.00%	0.00%	0.00%	0.00%	3.19%
S :	0.28%	1.11%	0.14%	0.00%	0.00%	0.00%	1.53%
SSW:	0.28%	0.14%	0.00%	0.00%	0.00%	0.00%	0.42%
SW :	0.00%	1.39%	0.69%	0.00%	0.00%	0.00%	2.08%
WSW:	0.14%	1.53%	0.69%	0.69%	0.00%	0.00%	3.06%
W :	0.14%	1.67%	2.78%	1.67%	0.56%	0.00%	6.81%
WNW:	0.69%	0.97%	0.97%	0.28%	0.00%	0.00%	2.92%

NW :	0.69%	0.14%	0.00%	0.00%	0.00%	0.00%	0.83%
NNW:	6.25%	7.78%	5.28%	0.00%	0.00%	0.00%	19.31%
SUM:	29.72%	37.50%	23.61%	5.28%	0.83%	0.00%	96.94%
Calm Winds:	3.06%						

The meteorological model runs showed that southeasterly winds were predominant in 2003, especially from June to December. This represented that the majority of the time winds came from Puerto Anapra to Sunland Park.

The annual wind rose modeled that 17% of the winds were southeasterly, 12% were east southeasterly, 11% were easterly, 11% were northerly, and 10% were north northwesterly predominantly ranging from 1 to 12 mph. During the winter months, January, February and December, northerly winds were predominantly 16% of the time, followed by southeasterly at 14% and north northwesterly at 12%. During the spring season, March, April, May, north northwesterly and westerly winds were predominant at 15% respectively, followed by northerly winds at 12% of the time and southeasterly at 11%. Summer and fall seasons had a similar wind behavior; both seasons had predominant easterly, east southeasterly, and southeasterly winds. The predominant winds speeds on these seasons were from 1 to 12 mph. Hourly data shows that during hours 1 to 6, winds were predominantly easterly, east southeasterly, and southeasterly, followed by northerly winds at speeds from 1 to 12 mph. Then, hours 7 to 12, showed winds again the same predominant winds but this time followed by north northwesterly winds at the same speeds. Hourly period from 13 to 18 had predominantly westerly winds 18% of the time at 1 to 12 mph. The last day period from hours 19 to 24, had easterly, east southeasterly, and southeasterly predominant winds again followed by north northwesterly and northerly winds. Figure 6-26 shows the annual wind rose at 10 meters.

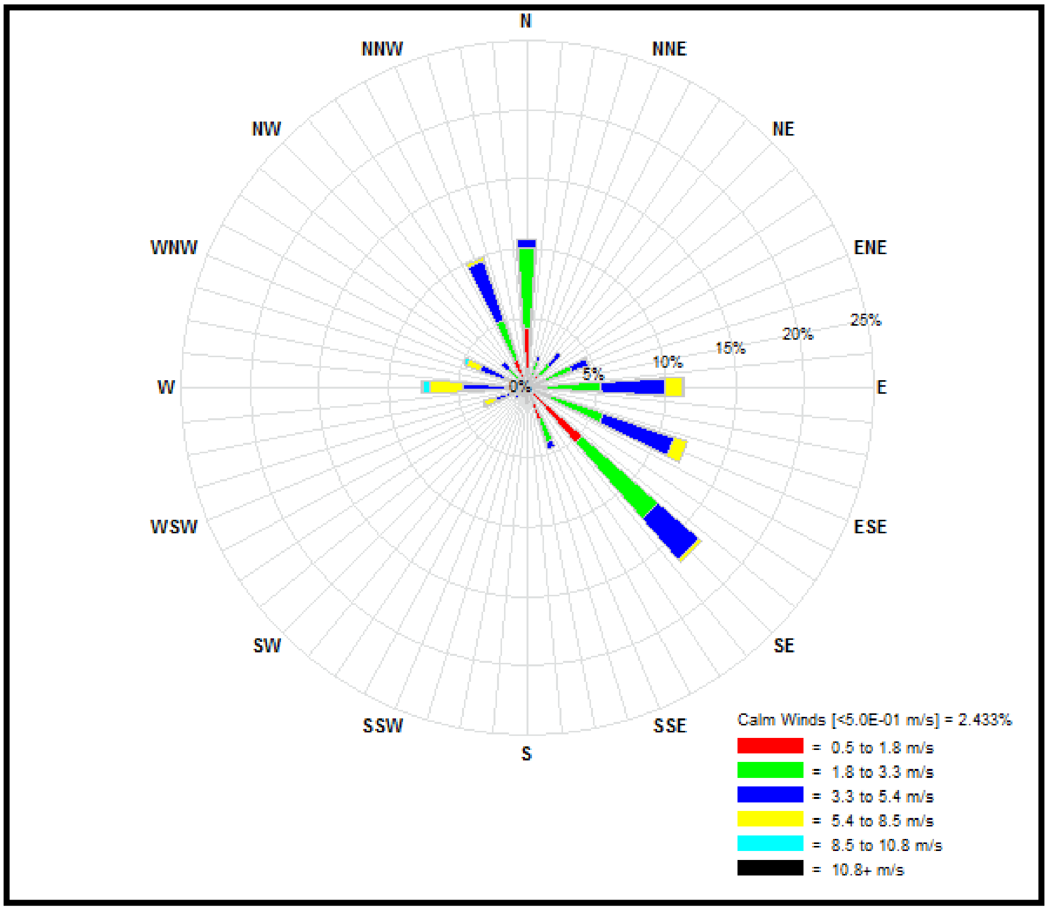

Figure 6-26. Annual Wind Rose at 10 m.

Table 6-13. Annual Wind Rose Results at 10 m.

	Miles per Hour						
Wind Direction	1 - 4	4 - 7.3	7.3 - 12	12 - 19	19 - 24	> 24	SUM
N :	4.27%	5.71%	0.70%	0.03%	0.00%	0.00%	10.70%
NNE:	0.89%	1.06%	0.41%	0.09%	0.00%	0.00%	2.45%
NE :	1.10%	1.15%	1.10%	0.08%	0.00%	0.00%	3.42%
ENE:	1.26%	2.07%	1.32%	0.13%	0.00%	0.00%	4.78%
E :	1.44%	3.89%	4.62%	1.24%	0.16%	0.00%	11.34%
ESE:	1.78%	3.99%	5.34%	1.06%	0.04%	0.00%	12.21%
SE :	5.30%	7.25%	3.83%	0.29%	0.00%	0.00%	16.67%
SSE:	2.41%	1.76%	0.42%	0.05%	0.00%	0.00%	4.64%
S :	0.25%	0.72%	0.16%	0.00%	0.00%	0.00%	1.14%
SSW:	0.16%	0.39%	0.19%	0.04%	0.00%	0.00%	0.77%
SW :	0.26%	0.54%	0.34%	0.00%	0.00%	0.00%	1.14%
WSW:	0.13%	1.21%	1.11%	0.76%	0.13%	0.01%	3.34%
W :	0.13%	1.53%	2.98%	2.38%	0.55%	0.13%	7.70%

WNW:	0.26%	1.50%	1.82%	1.12%	0.18%	0.03%	4.90%
NW :	0.52%	1.34%	0.60%	0.06%	0.00%	0.00%	2.52%
NNW:	2.17%	3.03%	4.52%	0.14%	0.00%	0.00%	9.86%
SUM:	22.32%	37.14%	29.45%	7.45%	1.05%	0.16%	97.57%
Calm Winds:	2.43%						

6.2 PM_{10} Concentration Estimates

Once the diagnosed three-dimensional wind field and micro-meteorological variables were generated and the area source emission rates calculated, the data was inputted into the CALPUFF modeling system. The transport and dispersion model, CALPUFF, advects "puffs" of PM emitted from modeled sources, simulating the dispersion and transformation process at each grid cell. In this study, no chemical transformation took place. The primary output files from the non-steady-state Lagrangian Gaussian puff model contained hourly concentrations at all receptor locations and were used for comparison to real time data. PM sources such as paved roads, unpaved roads and disturbed areas were considered in this study. Dispersion coefficients were computed from internally calculated velocity variances using micro-meteorological variables supplied by CALMET. CALPUFF modeled dry deposition and the emitted PM_{10} species were modeled assuming they behave as particles.

This section describes modeled PM_{10} concentrations produced hourly, 24-hr average and annual average for Year 2003 using the CALPUFF modeling system. Figure 6-27 shows an example of PM_{10} concentrations over the modeling domain.

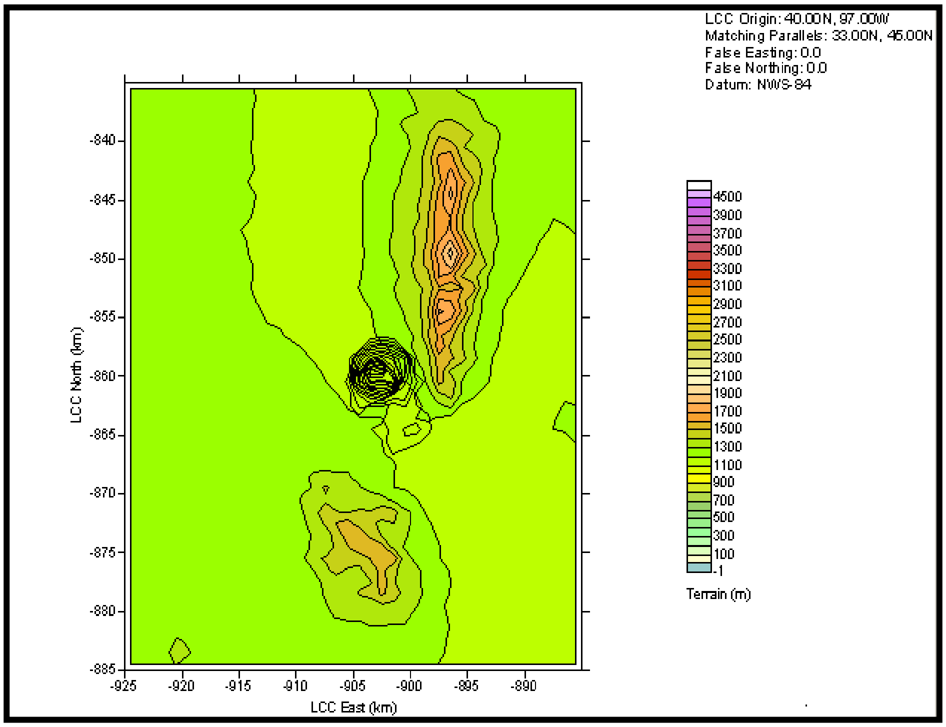

Figure 6-27. PM_{10} 24-Hr. Average Concentration over Project Area in January 1, 2003.

The CALPUFF model runs were conducted using 2003 meteorological data. The following figures show the hourly and the 24-hr average PM_{10} concentrations in the study area at four different locations for each month and annually. As previously mentioned, receptor No. 1 is TCEQ's UTEP CAMS Station, receptor No. 2 is NMED's Sunland Park TEOM Station, receptor No. 3 is NMED's Desert View TEOM Station, and receptor No. 4 is NMED's Santa Teresa TEOM Station. One of the intents of this study was to compare the modeled data to real data obtained at these stations; however, only real data from receptor No. 1 and No. 2 could be used given that station at receptor No. 3 had no data available for Year 2003 and the station at receptor No. 4 did not monitor ambient PM_{10} levels. The purpose of the comparison was to determine the contribution of PM_{10} by Anapra to the project area.

In the month of January, UTEP CAMS Station had a peak hour PM_{10} concentration of 816 $\mu g/m^3$ on day 20th at 17:00 hrs., Desert View TEOM Station had a peak concentration of 4,819 $\mu g/m^{3,}$ and Sunland Park TEOM Station of 1,444 $\mu g/m^3$ both on day 18th at 18:00 hrs., and Santa Teresa TEOM Station of 262 $\mu g/m^3$ on day 17th at 19:00 hrs. The peak 24-hr average concentration predicted for UTEP CAMS Station was 231 $\mu g/m^3$ on day 21st, Sunland Park TEOM Station had 171 $\mu g/m^3$ on day 19th, Desert View TEOM Station had 619 $\mu g/m^3$ on day 25th, and Santa Teresa TEOM Station had 39

μg/m^3 on day 17th. This data was compared to the meteorological modeled data and it was determined that these days experienced predominantly southeasterly winds during the majority of the peak hours as well as the averaged modeled days. This may lead to reveal that winds coming from Puerto Anapra carried a sufficient amount of particulate matter that caused the exceedances of NAAQS for PM_{10} in Sunland Park. Also, the higher concentrations were appreciated at the Desert View TEOM Station and the lower concentrations were experienced at the Santa Teresa TEOM Station. Moreover, the modeled data was later compared to the real data acquired from TCEQ's UTEP CAMS Station and to NMED's Sunland Park TEOM Station as illustrated in Figure 6-28 and 6-29.

In Figure 6-28, the modeled 24-hr average concentrations at UTEP CAMS Station followed almost the same pattern except for days 20th, 21st, and 22nd of the month of January. This represented that the modeled data concurred with real data considering that the model only included emissions from unpaved roads and wind erosion from Puerto Anapra. Monitoring data obtained from UTEP CAMS Station included PM_{10} sources from surrounding areas and not only Puerto Anapra. Figure 6-28 illustrates the PM_{10} average concentration attributed to Puerto Anapra (modeled data) at the CAMS Station and compared it to the PM_{10} average concentration from the surrounding areas (real data). According to the model run, this location could potentially receive approximately 57% PM_{10} contribution from Anapra in the month of January due to unpaved roads and wind erosion.

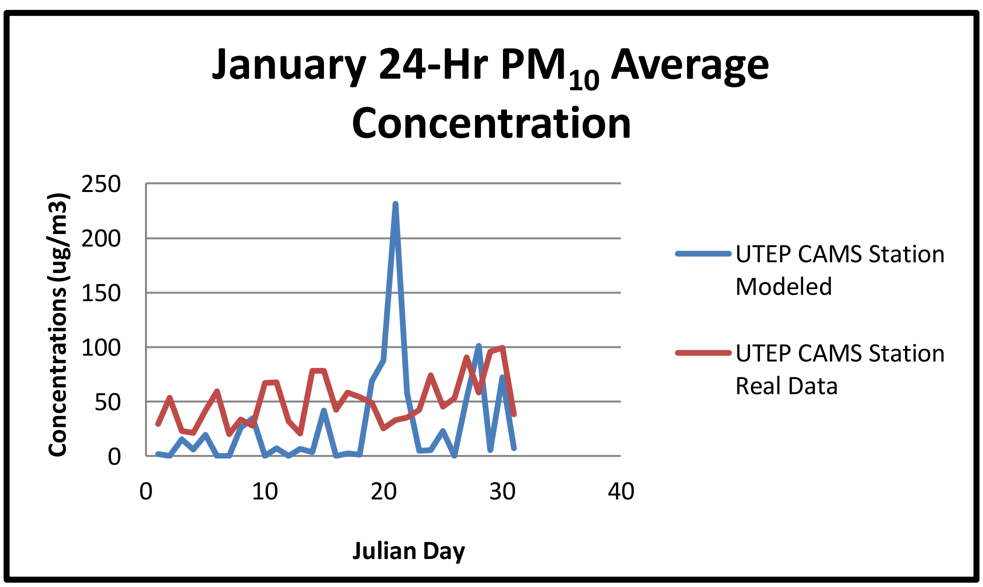

Figure 6-28. January PM_{10} 24-Hr Average Concentrations at UTEP CAMS Station.

In Figure 6-29, the modeled 24-hr average concentrations at Sunland Part TEOM Station presented almost the same pattern and concentrations except for the middle of the month. This data showed that the location of the Sunland Park TEOM Station was more susceptible to Puerto Anapra PM_{10} emissions than the UTEP CAMS Station given the wind direction during this month. Also, this station presented exceedances in the same time period than the UTEP CAMS Station. Again, monitoring data obtained at UTEP CAMS Station included PM_{10} from surrounding areas and not only Puerto Anapra. Figure 6-29 illustrates the PM_{10} average concentration attributed to Anapra (modeled data) at the Sunland Park TEOM Station and compares it to the average concentration from the surrounding areas (real data). According to the model run, this location could potentially receive approximately 53% PM_{10} contribution from Anapra in the month of January.

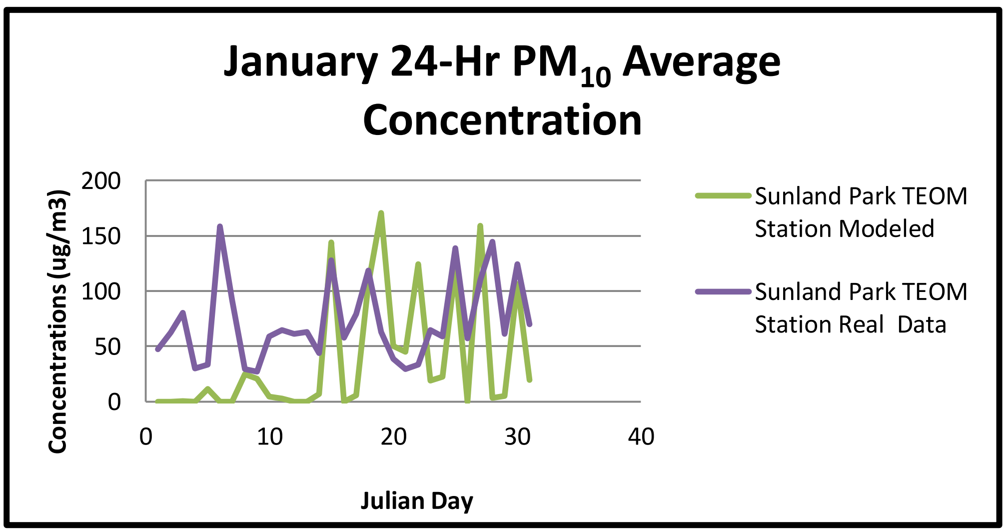

Figure 6-29. January PM_{10} 24-Hr Average Concentrations at Sunland Park TEOM Station.

Figure 6-30 illustrates the modeled 24-hr average concentrations at the Desert View TEOM Station and the Santa Teresa TEOM Station in the month of January. As previously mentioned, these stations did not have PM_{10} monitoring data available for the Year of 2003 and modeled data could not be compared to real data. Figure 6-30 presents that contribution of PM_{10} from Puerto Anapra was minimal at the Santa Teresa TEOM Station, however, the contribution from Puerto Anapra at the Desert View

TEOM Station was very significant and the greatest from these four locations. Modeled data at the Desert View TEOM Stations showed a considerably decrease in concentration during the same time period that the UTEP CAMS Station and the Sunland Park TEOM Station modeled data exceeded the real data. This could conclude that the discrepancies on these days were caused by the variance of wind vectors produced by the CALMET software and the real wind vectors. The UTEP and Sunland Park monitoring stations are located northeast from Puerto Anapra and the Desert View and Santa Teresa monitoring stations are located northwest and west from Puerto Anapra, respectively. Therefore, the modeled emissions from Puerto Anapra followed the modeled wind vectors which differed from the real wind vectors and caused the discrepancies on these days and attributed most of the emissions from Puerto Anapra to the the northeast monitoring stations.

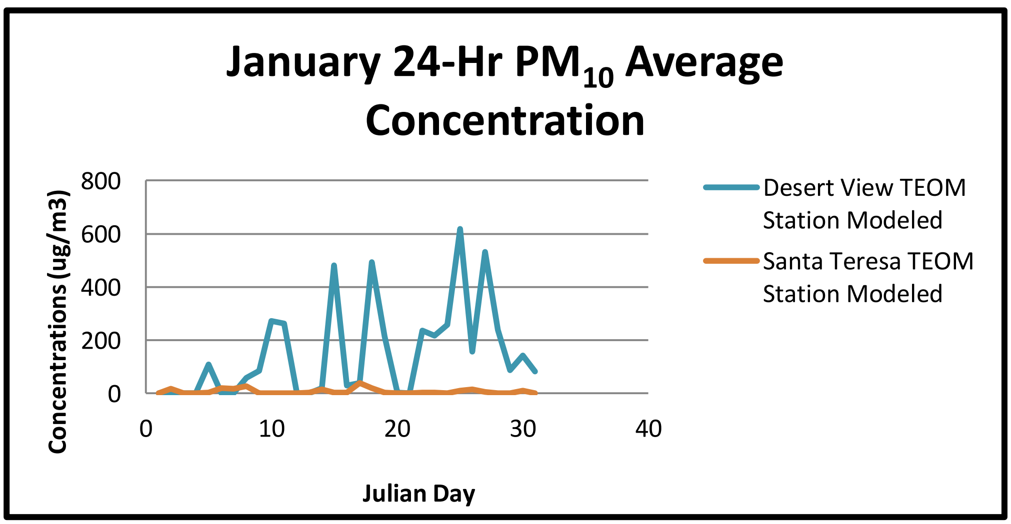

Figure 6-30. January PM_{10} 24-Hr Average Concentrations at Desert View and Santa Teresa TEOM Stations.

Table 6-14 shows the PM_{10} 24-hr average concentrations including the modeled and real data at the different receptors during the month of January.

Table 6-14. January PM_{10} 24-Hr. Average Concentrations in the Project Area.

	Concentration (ug/m3)					
	UTEP CAMS Station		Sunland Park TEOM Station		Desert View TEOM Station	Santa Teresa TEOM Station
Julian Day	Modeled	Real Data	Modeled	Real Data	Modeled	Modeled
1	1.9	29.4	0.0	47.5	0.0	0.0
2	0.0	53.4	0.0	62.7	0.5	16.7
3	15.6	23.1	0.3	80.6	0.2	0.0
4	6.0	21.3	0.0	30.0	0.0	0.0
5	19.3	41.8	11.3	33.6	108.2	2.7
6	0.0	59.7	0.0	158.3	0.0	19.0
7	0.0	20.5	0.0	92.0	0.0	17.3
8	25.9	34.0	24.7	29.5	58.4	27.2
9	35.1	27.7	20.8	27.2	84.7	0.5
10	0.3	67.0	4.3	58.7	272.3	0.1
11	7.3	67.7	2.8	64.9	262.8	0.2
12	0.0	31.8	0.0	61.3	0.2	0.0
13	6.5	20.8	0.1	63.0	0.9	4.2
14	3.7	78.1	7.1	43.6	19.6	15.3
15	42.1	78.2	144.1	127.7	481.3	2.9
16	0.0	42.3	0.0	57.8	29.6	3.0
17	2.5	58.3	5.6	78.9	38.2	38.8
18	1.3	54.2	106.7	118.5	494.3	19.5
19	68.6	48.9	170.8	63.0	214.7	2.2
20	87.7	25.5	50.0	38.6	3.4	0.0
21	231.6	33.4	45.1	29.3	0.1	0.0
22	57.6	35.5	124.6	33.2	237.3	3.1
23	5.1	42.4	19.0	64.6	216.5	2.7
24	5.6	74.3	22.7	58.7	257.1	0.0
25	22.9	45.7	120.3	139.1	619.4	9.1
26	0.0	52.8	0.0	57.4	156.4	14.4
27	53.1	90.9	159.1	110.2	532.7	5.0
28	100.9	58.1	3.3	144.4	239.0	0.0
29	5.2	96.0	5.1	61.4	86.4	1.1
30	72.5	99.4	106.7	124.3	141.7	10.6
31	7.1	38.2	19.7	69.9	81.6	0.7

Figure 6-31 illustrates the PM_{10} hourly average modeled concentrations at the four different receptors. The Desert View TEOM Station, Receptor No. 3, appeared to be the most susceptible to the PM_{10} emissions from Puerto Anapra. Also, when UTEP CAMS Stations were greater, the concentrations at the Desert View and Sunland Park TEOM Stations were lower. This could be attributed to the wind direction at that time. Table 6-15 shows the results from Figure 6-31. Higher concentrations were experienced during night hours. These results coincided with the analysis conducted by the Civil Engineering Department at the University of Texas at El Paso where it showed that the 1-hr average $PM_{2.5}$ and PM_{10} mass concentrations were clearly higher in the evening than in the morning, increasing at 6:00 p.m. and peaking around 8:00 p.m. This study suggested that local emissions that accumulate in the evening coupled with the formation of the inversion layer may produce the PM peaks at the project area (Cardenas, 2005).

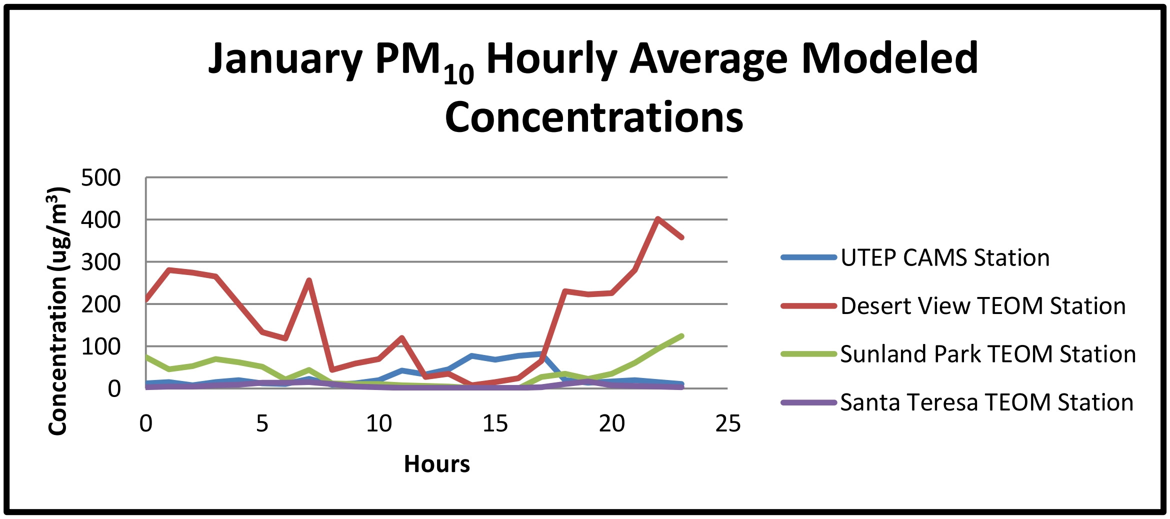

Figure 6-31. January PM_{10} Hourly Average Modeled Concentrations in the Project Area.

Table 6-15. January PM_{10} Hourly Average Modeled Concentrations in the Project Area.

	Concentration (μg/m³)			
Hours	UTEP CAMS Station	Desert View TEOM Station	Sunland Park TEOM Station	Santa Teresa TEOM Station
0	12	211	75	3
1	16	281	46	5
2	8	275	54	5
3	16	266	70	8
4	20	200	63	10
5	13	134	51	14
6	11	118	22	14
7	23	256	44	15
8	10	44	12	10
9	12	59	10	5
10	20	70	10	3
11	42	120	8	2
12	34	27	6	2
13	45	35	5	2
14	78	8	2	2
15	68	15	1	2
16	78	25	1	2
17	81	66	28	3
18	21	231	34	11
19	13	223	23	16
20	16	226	35	8
21	20	280	61	6
22	16	401	94	5
23	11	358	125	4

In February, UTEP CAMS Station experienced a peak hour PM_{10} concentration of 893 $\mu g/m^3$ on Julian day 46th at 10:00 hrs, Desert View TEOM Station had a concentration of 2,967 $\mu g/m^3$ on day 48th at 7:00 hrs, on this same day but an hour earlier, Sunland Park TEOM Station had its peak hour concentration of 564 $\mu g/m^3$, and Santa Teresa TEOM Station of 582 $\mu g/m^3$ both on day 44th at 10:00 hours. The peak 24-hr average concentration of UTEP CAMS Station was 119 $\mu g/m^3$ on day 57th, Sunland Park TEOM Station of 103 $\mu g/m^3$ on day 48th, Desert View TEOM Station of 488 $\mu g/m^3$ on the previous day, and Santa Teresa TEOM Station of 40 $\mu g/m^3$ on day 44th. These days had predominant southwesterly winds. In the same manner, south winds coming from Puerto Anapra were associated to the poor air quality in Sunland Park by impacting the PM_{10} concentrations and leading to the exceedance of NAAQS for PM_{10} particularly. Higher concentrations were seen at Desert View TEOM Station and Santa Teresa TEOM Station had the lower concentrations.

In Figure 6-32, the modeled 24-hr average concentrations at UTEP CAMS Station presented almost the same pattern and concentrations except for the beginning of the month. This data showed that the location of the UTEP CAMS Station was more susceptible to Puerto Anapra PM_{10} emissions than in the month of January given the wind direction during this month. The beginning of the month showed an extraordinary event where the PM_{10} 24-hr average concentration for the month of February was exceeded by 9 times. It could be concluded that this event was related to the high winds analyzed by the NMED's AQB, however, this version of CALPUFF does not account for extreme events.

Figure 6-32 illustrates the PM_{10} average concentration attributed to Anapra (modeled data) at the UTEP CAMS Station and compares it to the average concentration from the surrounding areas (real data). Based on the model run, this location could potentially receive approximately 75% PM_{10} contribution from Puerto Anapra in the month of February if the extreme wind event is neglected. In the case that the extreme wind event was considered to compare the contribution of Anapra in this scenario, then, only 50% of the 24-hr average concentration in the month of February could potentially be caused by Puerto Anapra.

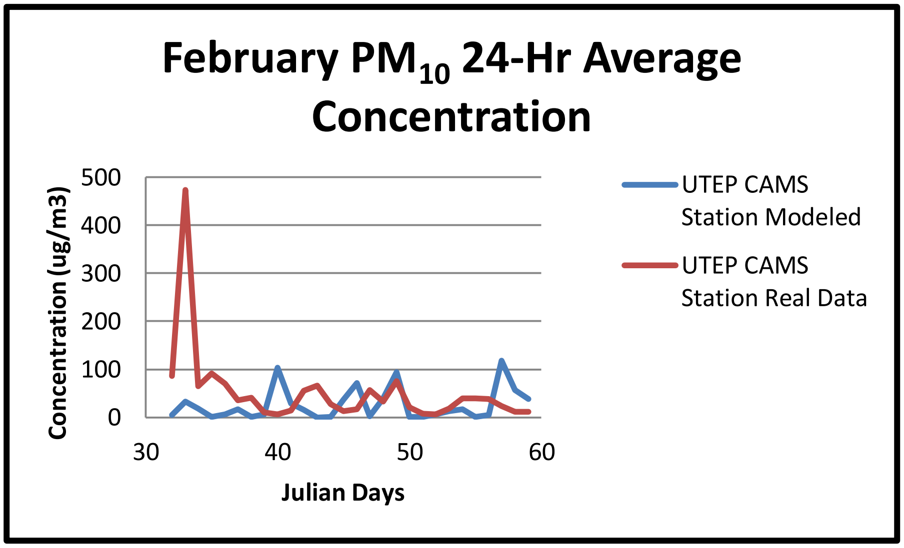

Figure 6-32. February PM_{10} 24-Hr Average Concentrations at UTEP CAMS Station.

In the same manner, figure 6-33 illustrated the high wind event in the beginning of the month in Sunland Park TEOM Station but showed a similar pattern and 24-hr average concentration estimate during the rest of the month. According to the model run, this location could potentially receive approximately 37% PM_{10} contribution from Puerto Anapra in the month of February if the extreme wind event is neglected. In the case that the extreme wind event was considered to compare the contribution of Anapra in this scenario, then, only 28% of the 24-hr average concentration in the month of February could potentially be caused by Puerto Anapra.

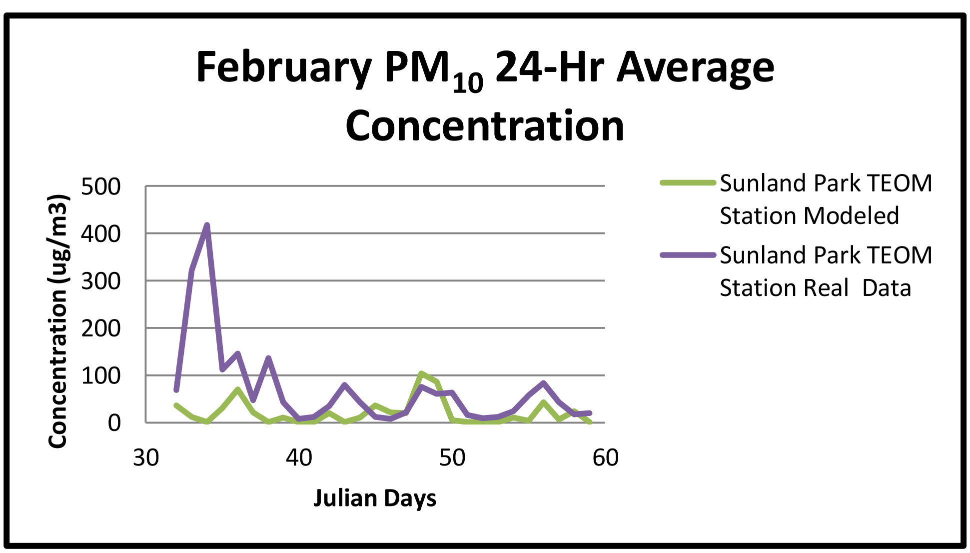

Figure 6-33. February PM_{10} 24-Hr Average Concentrations at Sunland Park TEOM Station.

Figure 6-34 illustrates the modeled 24-hr average concentrations at the Desert View TEOM Station and the Santa Teresa TEOM Station in the month of February. The beginning of the month also coincided with the Sunland Park and UTEP monitoring stations, presenting high PM_{10} average concentrations in the same range of 400 $\mu g/m^3$. The Santa Teresa TEOM Station showed minimal concentrations. In addition, The Desert View TEOM Station presented high concentrations at the same time that the Sunland Park and UTEP stations had an increase. This correlated that this located is the most susceptible when high winds were present.

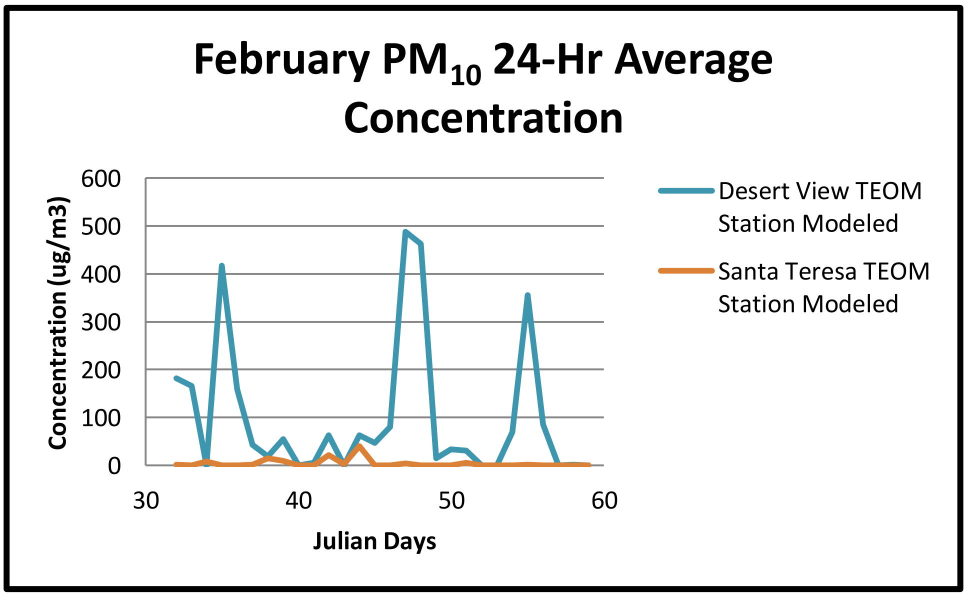

Figure 6-34. February PM_{10} 24-Hr Average Concentrations at Desert View and Santa Teresa TEOM Stations.

Table 6-16 shows the PM_{10} 24-hr average concentrations including the modeled and real data at the four different receptor points during the month of February.

Table 6-16. February PM_{10} 24-Hr. Concentrations in the Project Area.

	Concentration (ug/m3)					
	UTEP CAMS Station		Sunland Park TEOM Station		Desert View TEOM Station	Santa Teresa TEOM Station
Julian Day	UTEP CAMS Station Modeled	UTEP CAMS Station Real Data	Sunland Park TEOM Station Modeled	Sunland Park TEOM Station Real Data	Desert View TEOM Station Modeled	Desert View TEOM Station Modeled
32	4.6	85.9	35.6	68.5	182.3	1.3
33	32.4	473.3	11.2	322.4	166.1	0.0
34	17.5	65.0	0.0	418.4	0.2	7.5
35	0.4	91.9	30.6	111.6	417.0	0.0
36	5.5	70.7	70.2	145.3	158.7	0.0
37	16.1	35.0	20.9	46.2	43.1	1.1
38	0.0	41.1	0.0	135.9	19.1	14.3
39	5.7	9.6	9.9	42.7	54.2	9.6
40	102.9	5.5	0.0	7.8	0.0	0.0
41	29.0	14.0	1.2	11.3	4.9	0.3
42	15.8	55.6	19.4	35.0	63.2	21.8
43	0.1	65.9	0.1	79.5	0.3	3.1
44	0.3	27.1	10.2	42.9	63.0	39.7
45	36.2	13.0	36.3	12.2	46.3	0.0
46	71.8	17.1	20.5	7.7	80.3	0.0
47	2.4	56.5	19.1	21.4	488.4	3.5
48	39.2	32.3	103.2	74.5	462.3	0.0
49	94.1	75.3	85.9	60.1	15.2	0.0
50	0.9	21.2	5.3	62.5	33.1	0.0
51	0.0	6.9	0.0	15.9	30.1	5.8
52	6.4	5.5	0.0	8.2	0.0	0.0
53	13.3	18.4	0.0	11.1	0.0	0.0
54	16.5	38.8	10.3	24.1	69.9	0.0
55	0.2	39.2	3.3	57.2	355.4	1.5
56	5.1	38.6	42.1	82.7	85.1	0.1
57	118.6	23.1	5.6	42.3	0.0	0.0
58	56.9	11.7	23.8	16.6	1.3	0.0
59	37.4	11.1	0.0	19.8	0.0	0.0

Figure 6-35 illustrates the PM_{10} hourly average modeled concentrations at the four different receptors and showed that the Desert View station had considerably higher concentrations compared to the other receptor points. Table 6-17 shows the results from Figure 6-35. February also experienced higher concentrations during morning and night hours, however, morning hours were higher than nigh hours.

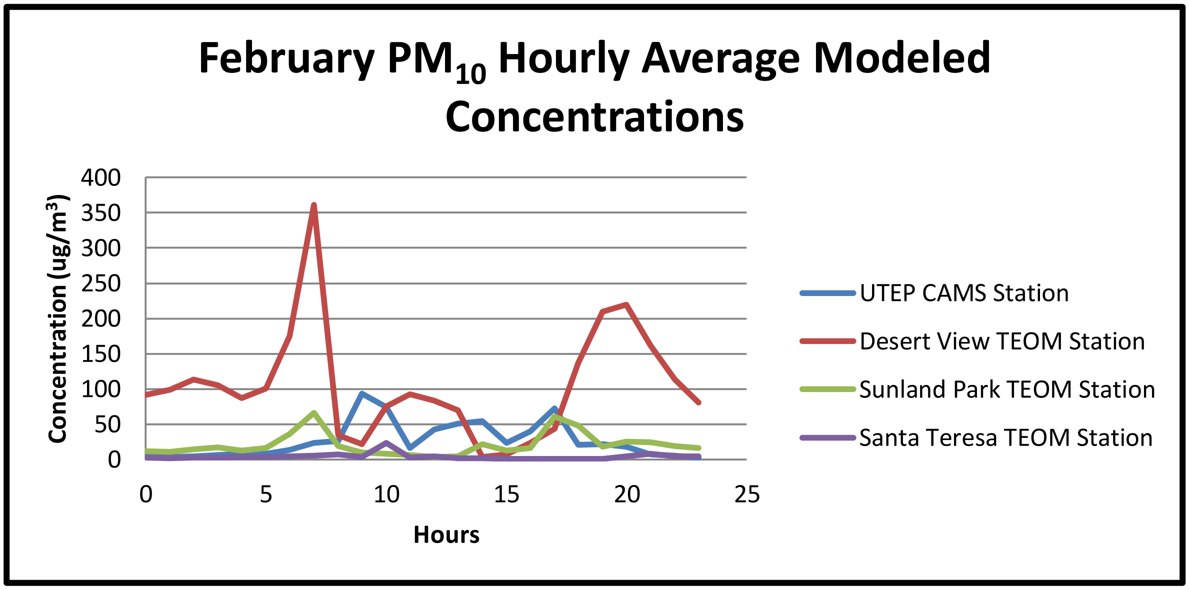

Figure 6-35. February PM_{10} Hourly Average Modeled Concentrations in the Project Area.

Table 6-17. February PM_{10} Hourly Average Modeled Concentrations in the Project Area.

Hours	Concentration (μg/m^3)			
	UTEP CAMS Station	Desert View TEOM Station	Sunland Park TEOM Station	Santa Teresa TEOM Station
0	4	92	12	2
1	3	99	11	2
2	4	113	14	3
3	6	105	17	3
4	8	87	13	4
5	8	100	16	3
6	14	175	36	4
7	24	361	66	5
8	26	34	19	7
9	93	21	9	4
10	74	75	8	23
11	16	92	6	3
12	43	84	4	4
13	51	70	5	2
14	54	3	22	2
15	24	7	12	0
16	40	23	16	1
17	72	44	60	1
18	21	137	48	0
19	22	210	18	1
20	18	220	25	4

21	7	161	25	8
22	5	113	19	4
23	3	81	16	4

During the month of March, the model run showed a peak hour PM_{10} concentration for the UTEP CAMS Station of 1,890 µg/m^3 on Julian day 79th at 14:00 hrs., the peak hour PM_{10} concentration for Desert View and Sunland Park TEOM Stations were on Julian day 66th at 18:00 hrs. of 3,051 µg/m^3 and 1,178 µg/m^3, respectively, and Santa Teresa TEOM Station had a peak concentration of 448 µg/m^3 on Julian day 85th at hour 6:00 a.m. The peak 24-hr average UTEP CAMS Station was 293 µg/m^3 on day 76nd, 124 µg/m^3 for Sunland Park TEOM Station on day 82nd, 414 µg/m^3 for Desert View TEOM Station on this same day, and 43 µg/m^3 for Santa Teresa TEOM Station on day 85th. Southeasterly winds were experienced on day 82nd and westerly winds occurred on the other days. For this month, higher concentrations were experienced when winds were coming from Puerto Anapra.

In Figure 6-36, the modeled 24-hr average concentrations at UTEP CAMS Station presented almost the same pattern and concentration estimates except towards the end of the month. This data showed that towards the end of the month, modeled data exceeded real data at this location, but modeled data at the Sunland Park monitoring station was underestimated. It could be concluded that these discrepancies are due to the incongruities in the CALMET output data that directed the emissions towards the northeast where in the real scenario the project area experienced southwesterly winds. Figure 6-36 illustrates the PM_{10} average concentration attributed to Puerto Anapra (modeled data) at the UTEP CAMS Station and compares it to the average concentration from the surrounding areas (real data). According to the model run, this location could potentially receive approximately 100% PM_{10} contribution from Anapra in the month of March. It was observed that during the high wind season, the location of the UTEP CAMS Station is very susceptible to Puerto Anapra emissions.

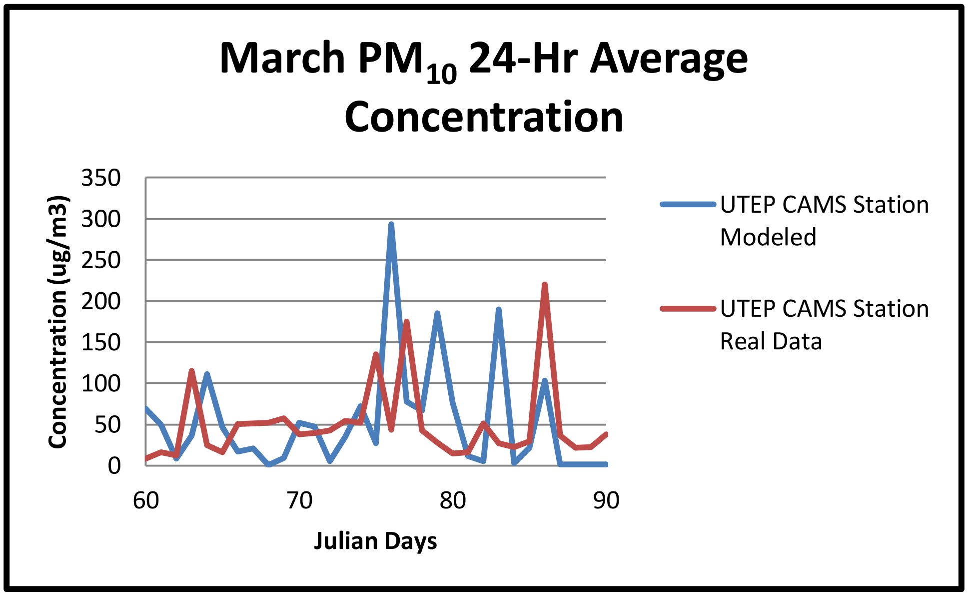

Figure 6-36. March PM_{10} 24-Hr Average Concentrations at UTEP CAMS Station.

As previously mentioned, the Sunland Park TEOM Station modeled data was underestimated in the middle of the month given that CALMET wind vector outputs directed emissions to the northeast portion of the project area. Figure 6-37 illustrates the PM_{10} average concentration attributed to Anapra (modeled data) at the Sunland Park TEOM Station and compares it to the average concentration from the surrounding areas (real data). According to the model run, this location could potentially receive approximately 33% PM_{10} contribution from Anapra in the month of March.

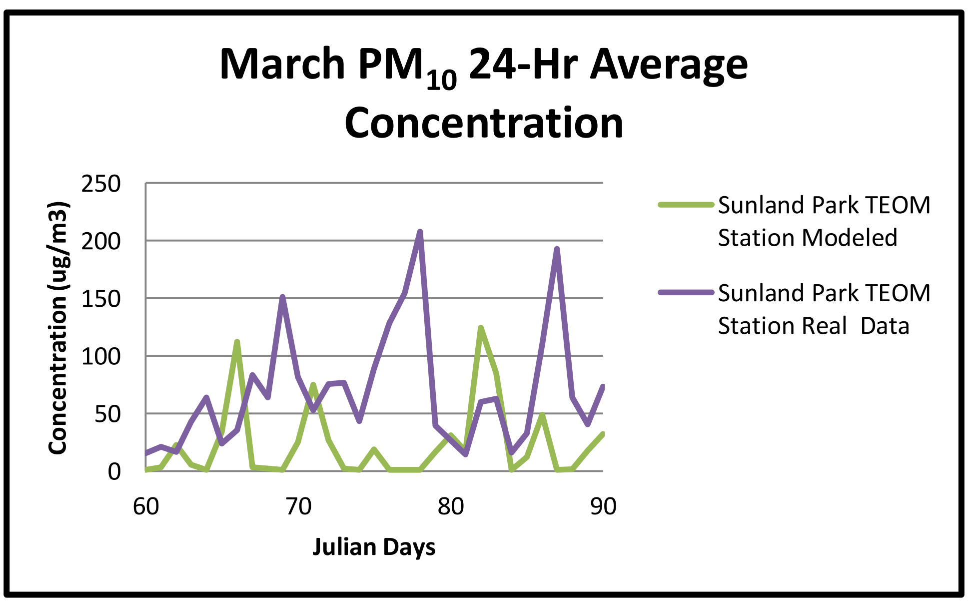

Figure 6-37. March PM_{10} 24-Hr Average Concentrations at Sunland Park TEOM Station.

During the month of March, the CALPUFF model run showed low PM_{10} 24-hr average concentrations at the Desert View TEOM Station in comparison to the other months. This was resulted due to the westerly winds produced by the software that directed the emissions to the east portion of the project area. However, on day 82nd the model recorded southwesterly winds which caused the peak at this location. Moreover, the Santa Teresa TEOM Station experienced extremely low PM_{10} 24-hr average concentrations. This assured the conclusion that the location at the Santa Teresa monitoring station is not susceptible to Puerto Anapra emissions. Figure 6-38 illustrates the modeled 24-hr average concentrations at the Desert View TEOM Station and the Santa Teresa TEOM Station in the month of March.

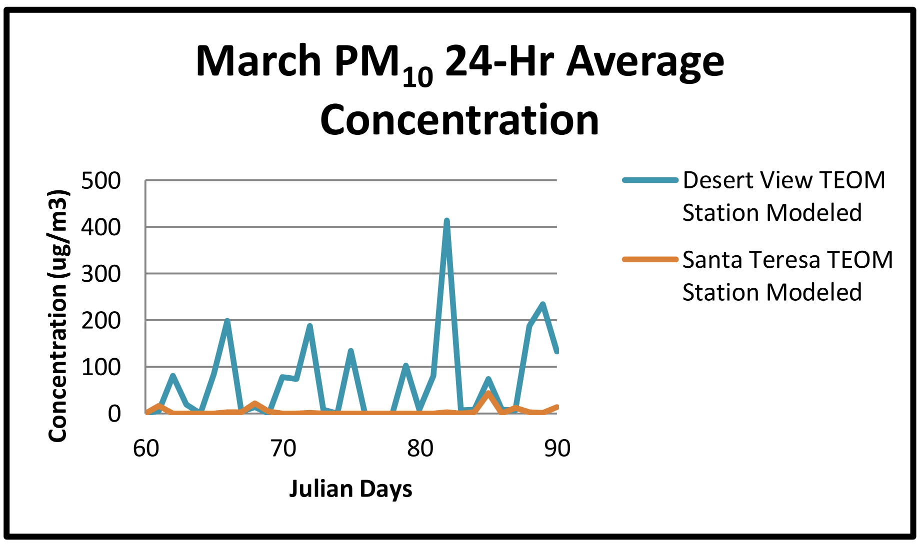

Figure 6-38. March PM_{10} 24-Hr Average Concentrations at Desert View and Santa Teresa TEOM Stations.

Table 6-18 shows the PM_{10} 24-hr average concentrations including the modeled and real data at the four different receptor points during the month of March.

Table 6-18. March PM_{10} 24-Hr. Average Concentrations in the Project Area.

	Concentration (ug/m3)					
	UTEP CAMS Station		Sunland Park TEOM Station		Desert View TEOM Station	Santa Teresa TEOM Station
Julian Day	Modeled	Real Data	Modeled	Real Data	Station Modeled	Modeled
32	4.6	85.9	35.6	68.5	182.3	1.3
33	32.4	473.3	11.2	322.4	166.1	0.0
34	17.5	65.0	0.0	418.4	0.2	7.5
35	0.4	91.9	30.6	111.6	417.0	0.0
36	5.5	70.7	70.2	145.3	158.7	0.0
37	16.1	35.0	20.9	46.2	43.1	1.1
38	0.0	41.1	0.0	135.9	19.1	14.3
39	5.7	9.6	9.9	42.7	54.2	9.6
40	102.9	5.5	0.0	7.8	0.0	0.0
41	29.0	14.0	1.2	11.3	4.9	0.3
42	15.8	55.6	19.4	35.0	63.2	21.8
43	0.1	65.9	0.1	79.5	0.3	3.1
44	0.3	27.1	10.2	42.9	63.0	39.7
45	36.2	13.0	36.3	12.2	46.3	0.0
46	71.8	17.1	20.5	7.7	80.3	0.0
47	2.4	56.5	19.1	21.4	488.4	3.5
48	39.2	32.3	103.2	74.5	462.3	0.0
49	94.1	75.3	85.9	60.1	15.2	0.0
50	0.9	21.2	5.3	62.5	33.1	0.0
51	0.0	6.9	0.0	15.9	30.1	5.8
52	6.4	5.5	0.0	8.2	0.0	0.0
53	13.3	18.4	0.0	11.1	0.0	0.0
54	16.5	38.8	10.3	24.1	69.9	0.0
55	0.2	39.2	3.3	57.2	355.4	1.5
56	5.1	38.6	42.1	82.7	85.1	0.1
57	118.6	23.1	5.6	42.3	0.0	0.0
58	56.9	11.7	23.8	16.6	1.3	0.0
59	37.4	11.1	0.0	19.8	0.0	0.0

Figure 6-39 illustrates the PM_{10} hourly average modeled concentrations at the four different receptors and showed that the Desert View station had higher concentrations except for the middle of the month, where concentrations at the UTEP CAMS Station exceeded the estimates at the other stations. Table 6-19 shows the results from Figure 6-39. Similarly to January, high concentrations were experienced again during morning and night hours but morning hours had the higher concentrations.

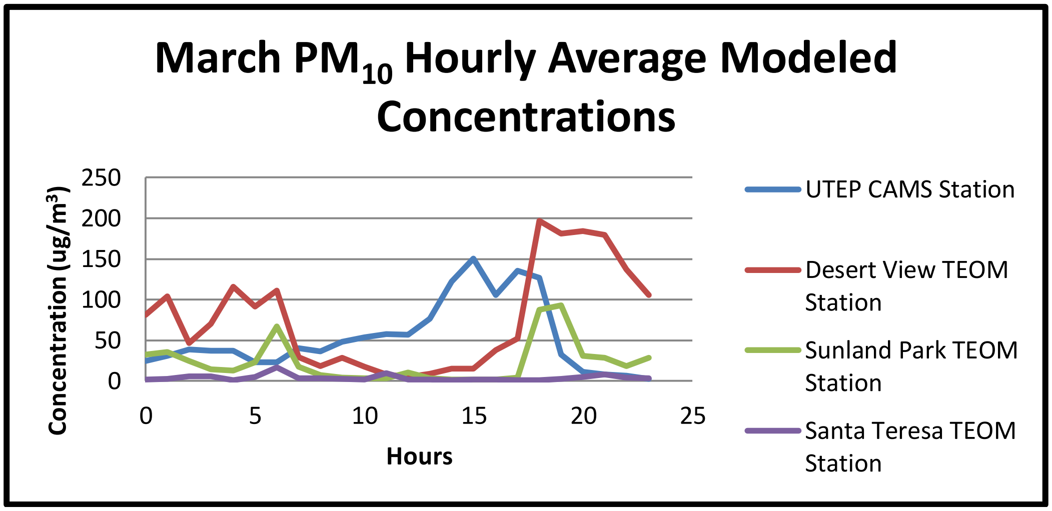

Figure 6-39. March PM_{10} Hourly Average Modeled Concentrations in the Project Area.

Table 6-19. March PM_{10} Hourly Average Concentrations in the Project Area.

	Concentration (μg/m³)			
Hours	UTEP CAMS Station	Desert View TEOM Station	Sunland Park TEOM Station	Santa Teresa TEOM Station
0	25	81	33	2
1	31	104	35	3
2	39	47	24	6
3	37	70	15	6
4	37	116	13	1
5	23	91	23	5
6	23	111	67	17
7	40	29	17	4
8	37	18	7	3
9	48	29	4	2
10	54	17	3	2
11	58	8	3	10
12	57	5	10	2
13	77	9	4	2
14	122	15	2	1
15	151	15	2	2
16	106	38	2	2
17	135	52	4	1
18	127	197	87	1
19	32	181	93	3
20	11	185	31	5
21	8	179	29	8
22	6	137	18	4
23	2	106	28	3

The month of April, had a peak hour concentration at UTEP CAMS Station of 1,233 $\mu g/m^3$ on Julian day 116^{th} at 5:00 hrs., Desert View TEOM Station of 1, 770 $\mu g/m^3$ on Julian day 119^{th} at 7:00 hrs., Sunland Park TEOM Station of 551 $\mu g/m^3$ on Julian day 118^{th} at 8:00 hrs., and Santa Teresa TEOM Station of 46 $\mu g/m^3$ on Julian day 110^{th} at 2:00 hrs. The peak 24-hr concentration at UTEP CAMS Station was 268 $\mu g/m^3$ on Julian day 113^{th}, Sunland Park TEOM Station of 80 $\mu g/m^3$ on Julian day 92^{nd}, Desert View TEOM Station of 205 $\mu g/m^3$ on Julian day 112^{th}, and Santa Teresa TEOM Station of 16 $\mu g/m^3$ on Julian day 110^{th}. These days experienced majority southeasterly winds especially in the early hours.

In Figure 6-40, the modeled 24-hr average concentrations at UTEP CAMS Station presented almost the same pattern and concentrations except for a few days in the middle and towards the end of the April. The middle of the month showed an extraordinary event where the PM_{10} 24-hr average concentration for the month of April was exceeded by 8.4 times. It could be concluded that this event was related to the high winds analyzed by the NMED's AQB, however, this version of CALPUFF does not account for extreme events. In addition, model run overestimated PM_{10} average concentrations towards the end of the month at the UTEP CAMS Station and considerably underestimated the concentrations at the Sunland Park TEOM Station. This was also an indicative that the CALMET output wind vectors directed the emissions in a different direction as compared to the real data, however, the monthly PM_{10} average is approximately within the 95% of the real data when the extreme event was not considered and approximately within the 70% when the extreme event was considered.

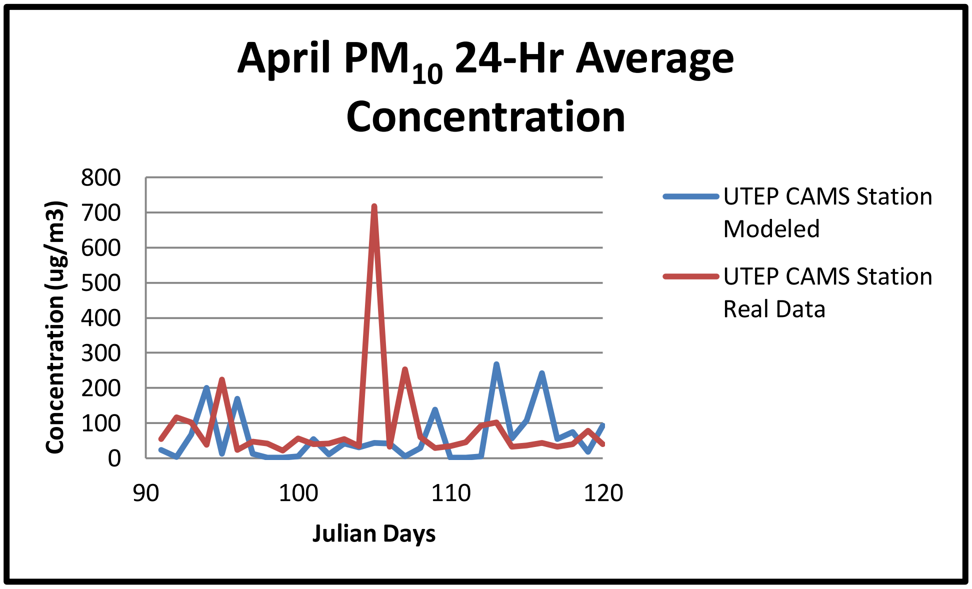

Figure 6-40. April PM_{10} 24-Hr Average Concentrations at UTEP CAMS Station.

Figure 6-41 illustrates the comparison of the modeled and real PM_{10} 24-hr average concentration at the Sunland Park TEOM Station. It was observed that the modeled concentrations followed a similar pattern of the real data except for the extreme wind event in the middle of the month and the end where estimated concentrations were underestimated as previously mentioned. According to the model run, this location could potentially receive approximately 18% PM_{10} contribution from Anapra considering the extreme wind event or 21% if the extreme wind event is not considered during this month.

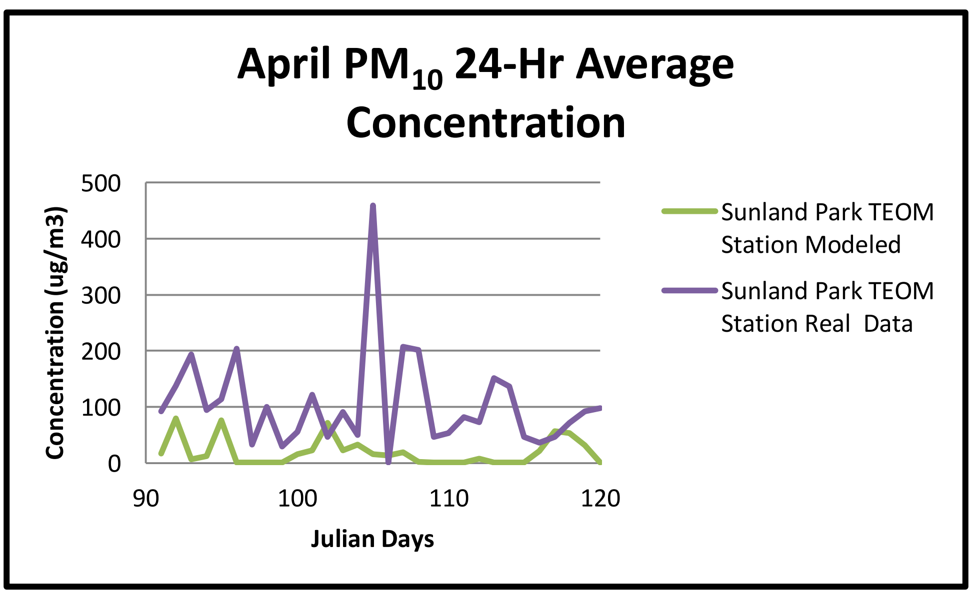

Figure 6-41. April PM_{10} 24-Hr Average Concentrations at Sunland Park TEOM Station.

During the month of April, the CALPUFF model run showed again low PM_{10} 24-hr average concentrations at the Desert View TEOM Station in comparison to the other months. This was resulted due to the northerly and westerly winds produced by the software that directed the emissions to the east portion of the project area. Moreover, the Santa Teresa TEOM Station experienced extremely low PM_{10} 24-hr average concentrations again. Figure 6-38 illustrates the modeled 24-hr average concentrations at the Desert View TEOM Station and the Santa Teresa TEOM Station in the month of April.

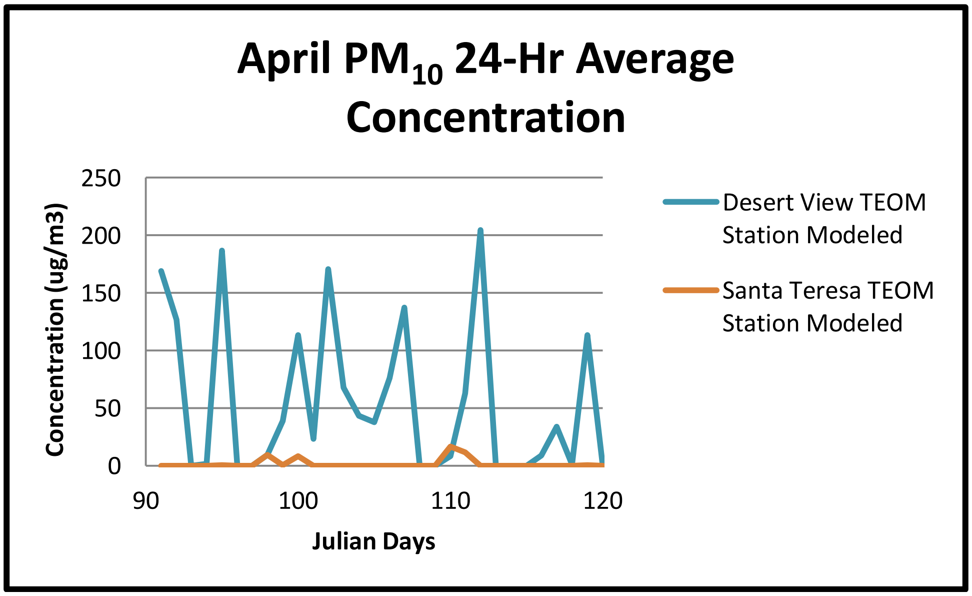

Figure 6-42. April PM_{10} 24-Hr Average Concentrations at Desert View and Santa Teresa TEOM Stations.

Table 6-20 shows the PM_{10} 24-hr average concentrations including the modeled and real data at the four different receptor points during the month of April.

Table 6-20. April PM_{10} 24-Hr. Average Concentrations in the Project Area.

	Concentration (ug/m3)					
	UTEP CAMS Station		Sunland Park TEOM Station		Desert View TEOM Station	Santa Teresa TEOM Station
Julian Day	Modeled	Real Data	Modeled	Real Data	Modeled	Modeled
91	23.84	54.6	16.7	91.9	169.0	0.0
92	3.39	117.2	79.7	137.1	126.6	0.0
93	66.62	102.7	6.4	193.3	0.0	0.0
94	199.72	38.1	12.5	94.6	1.6	0.0
95	12.21	224.2	76.2	113.3	186.9	0.1
96	168.60	23.2	0.0	203.5	0.0	0.0
97	13.34	47.3	0.0	32.5	0.0	0.0
98	0.00	41.6	0.0	99.6	9.3	9.4
99	0.00	22.4	0.0	29.5	38.8	0.4
100	4.37	55.7	15.3	55.6	113.3	8.2
101	53.94	40.0	22.9	121.7	22.9	0.0
102	11.33	40.9	71.7	46.3	170.5	0.0
103	42.16	54.7	22.8	90.7	67.5	0.0
104	31.34	35.0	32.4	49.6	43.0	0.0
105	43.90	719.1	15.9	459.0	37.6	0.0
106	42.17	32.2	13.1	0.0	76.0	0.0
107	4.39	252.7	19.1	207.7	137.4	0.0
108	29.15	60.6	1.7	202.1	0.0	0.0
109	138.51	29.1	0.0	46.4	0.0	0.0
110	0.00	33.6	0.0	53.0	8.1	16.3
111	0.00	45.9	0.7	81.5	62.7	11.3
112	4.61	92.2	8.0	72.3	204.7	0.0
113	267.98	101.3	0.0	151.7	0.0	0.0
114	55.57	32.8	0.0	136.8	0.0	0.0
115	108.15	35.5	0.0	46.8	0.0	0.0
116	242.10	44.5	21.5	36.2	8.4	0.0
117	54.47	32.6	56.1	46.3	33.7	0.0
118	73.71	40.2	53.6	71.7	0.8	0.0
119	18.02	78.2	31.2	92.1	113.3	0.0
120	92.28	39.6	0.0	97.3	0.0	0.0

Figure 6-43 illustrates the PM_{10} hourly average modeled concentrations at the four different receptors and showed that the Desert View station had slightly higher hourly average concentrations during the month of April. However, from the middle towards the end of the month, the UTEP CAMS Station exceeded the estimates from the other stations but overall this month experienced high concentrations at the majority of the hours. Table 6-21 shows the results from Figure 6-43.

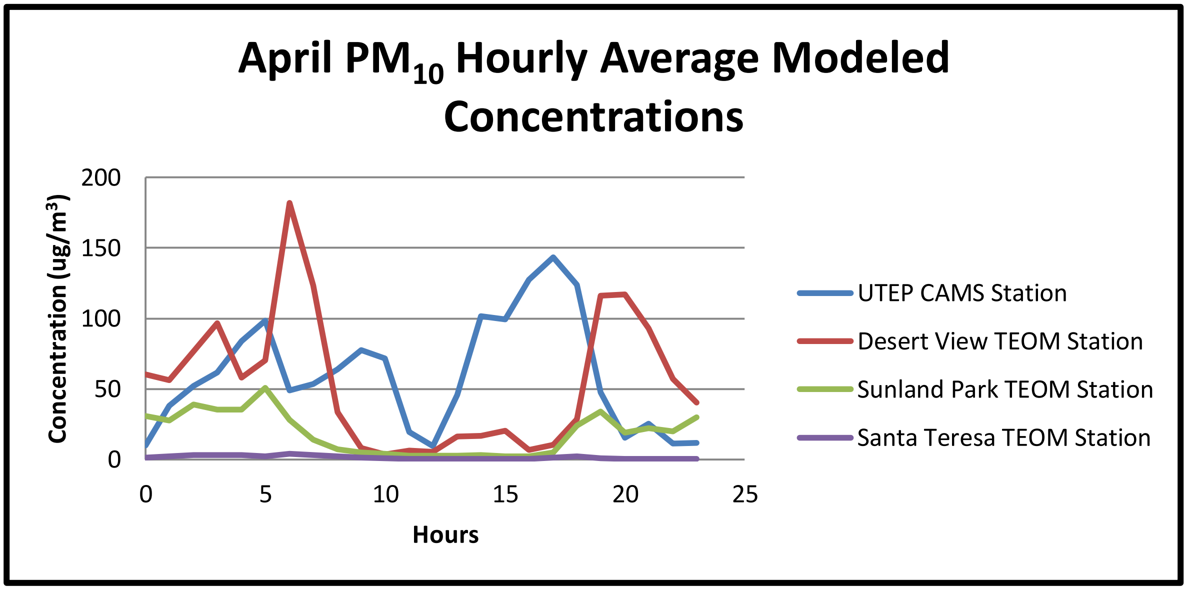

Figure 6-43. April PM_{10} Hourly Average PM_{10} Modeled Concentrations in the Project Area.

Table 6-21. April PM_{10} Hourly Average Modeled Concentrations in the Project Area.

	Concentration (μg/m^3)			
Hours	UTEP CAMS Station	Desert View TEOM Station	Sunland Park TEOM Station	Santa Teresa TEOM Station
0	10	60	31	1
1	38	56	28	2
2	52	77	39	3
3	62	97	36	3
4	84	58	35	3
5	99	70	51	2
6	49	182	28	4
7	53	123	14	3
8	64	34	7	2
9	78	8	5	1
10	72	4	4	1
11	20	6	3	1
12	9	5	3	0
13	46	16	3	0
14	102	17	3	0
15	100	20	2	0
16	127	7	2	0
17	143	11	5	1
18	124	28	24	2
19	48	116	34	1
20	15	117	19	0

21	25	93	22	0
22	11	57	20	0
23	12	40	30	0

The month of May, had a peak hour concentration at UTEP CAMPS Station of 1,197 µg/m^3 on Julian day 130th at 3:00 hrs., Desert View TEOM Station of 1,518 µg/m^3 on Julian day 129th at 7:00 hrs., Sunland Park TEOM Station of 474 µg/m^3 on Julian day 122nd at 7:00 hrs., and Santa Teresa TEOM Station of 155 µg/m^3 on Julian day 139th at 21:00 hrs. The peak 24-hr concentration at UTEP CAMS Station was 169 µg/m^3 on Julian day 130th, Sunland Park TEOM Station of 85 µg/m^3 on Julian day 127th, Desert View TEOM Station of 194 µg/m^3 on Julian day 137th, and Santa Teresa TEOM Station of 16 µg/m^3 on Julian day 141th. These days experienced majority northwesterly and southeasterly winds especially in the early hours.

In Figure 6-44, the modeled 24-hr average concentrations at UTEP CAMS Station presented overestimated concentrations in the beginning of the month. This was also an indicative that the CALMET output wind vectors directed the emissions in a different direction as compared to the real data, however, the monthly PM_{10} average wass approximately within the 63% of the real data, meaning that Puerto Anapra could potentially contribute to approximately this percentage to the monthly PM_{10} concentrations.

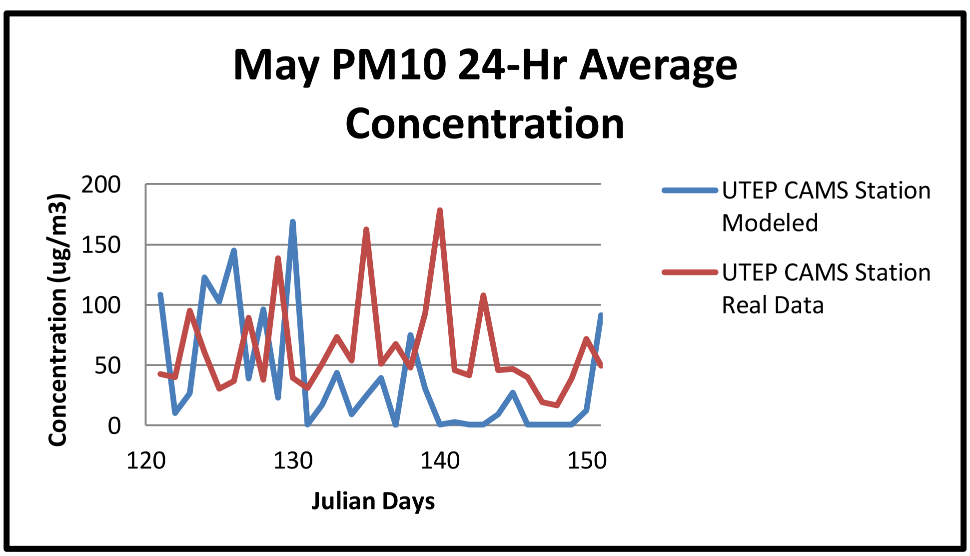

Figure 6-44. May PM_{10} 24-Hr Average Concentrations at UTEP CAMS Station.

Figure 6-45 illustrates the comparison of the modeled and real PM_{10} 24-hr average concentration at the Sunland Park TEOM Station. It was observed that the modeled concentrations were lower when compared to the other months, especially during the time where the concentrations at the UTEP CAMS Station were overestimated. According to the model run, this location could potentially receive approximately 20% PM_{10} contribution from Puerto Anapra in the month of May.

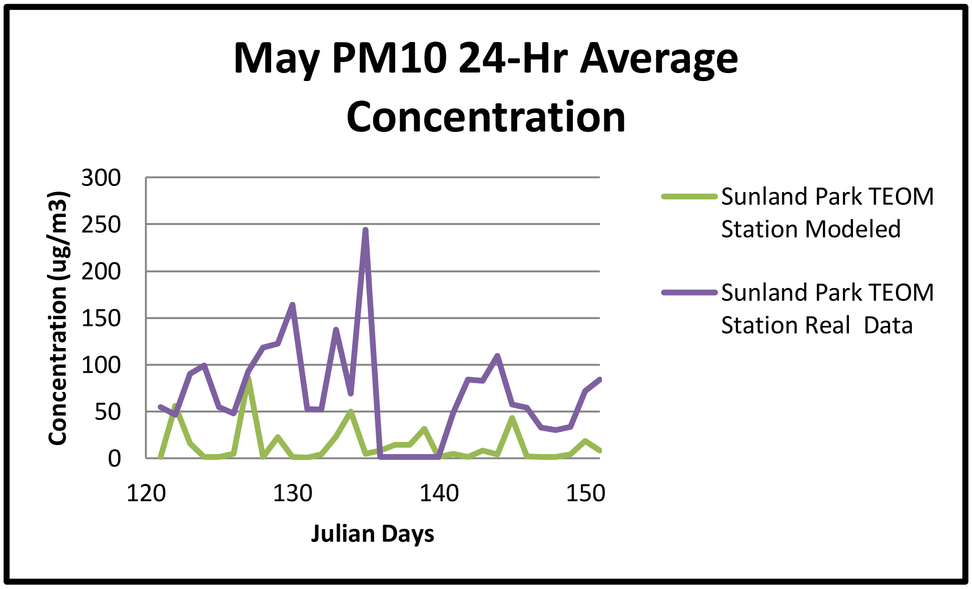

Figure 6-45. May PM_{10} 24-Hr Average Concentrations at Sunland Park TEOM Station.

During the month of May, the CALPUFF model run showed low PM_{10} 24-hr average concentrations at the Desert View TEOM Station as compared to the other months. Estimated concentrations did not exceed the 200 $\mu g/m^3$. Moreover, the Santa Teresa TEOM Station experienced extremely low PM_{10} 24-hr average concentrations. Figure 6-46 illustrates the modeled 24-hr average concentrations at the Desert View TEOM Station and the Santa Teresa TEOM Station in the month of May.

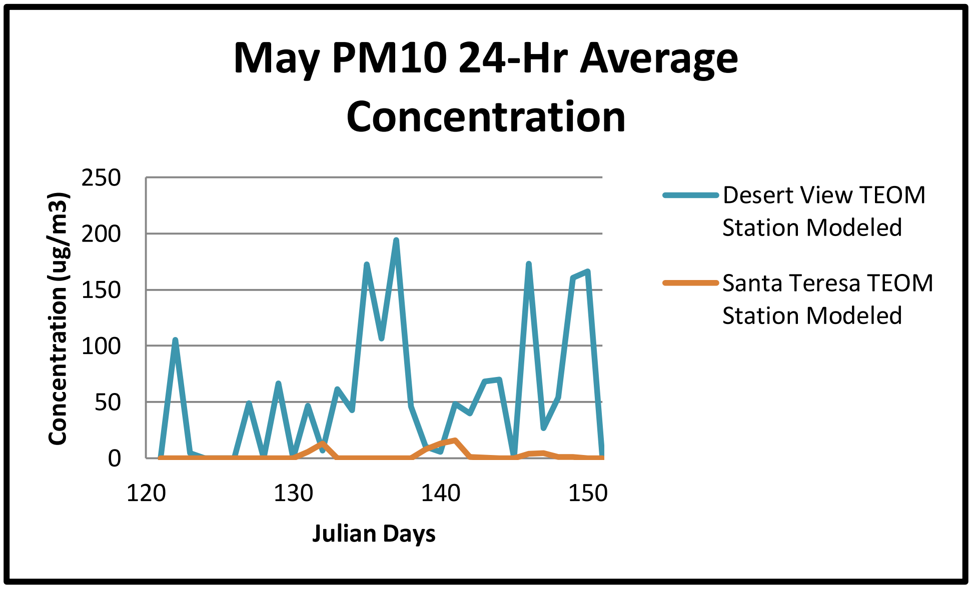

Figure 6-46. May PM_{10} 24-Hr Average Concentrations at Desert View and Santa Teresa TEOM Stations.

Table 6-22 shows the PM_{10} 24-hr average concentrations including the modeled and real data at the four different stations (receptors) during the month of May.

Table 6-22. May PM_{10} 24-Hr. Average Concentrations in the Project Area.

	Concentration (ug/m3)					
	UTEP CAMS Station		Sunland Park TEOM Station		Desert View TEOM Station	Santa Teresa TEOM Station
Julian Day	Modeled	Real Data	Modeled	Real Data	Modeled	Modeled
121	108.5	42.4	0.0	54.5	0.0	0.0
122	10.4	40.1	56.2	46.3	105.4	0.0
123	26.7	95.4	15.5	90.0	4.4	0.0
124	122.9	60.5	0.3	99.2	0.0	0.0
125	102.5	30.6	0.0	54.7	0.0	0.0
126	145.0	36.8	4.8	48.1	0.0	0.0
127	38.9	89.5	85.5	93.2	49.2	0.0
128	96.2	37.8	0.0	118.5	0.0	0.0
129	22.9	138.4	22.3	122.7	66.6	0.0
130	169.0	39.5	0.0	164.4	0.0	0.0
131	0.0	30.8	0.8	52.7	46.4	5.8
132	17.4	51.3	4.3	52.0	6.6	13.0
133	43.8	73.3	23.2	137.7	61.6	0.0
134	9.1	53.7	50.2	68.8	42.5	0.1
135	24.6	162.7	4.4	244.5	172.4	0.0
136	39.4	51.1	8.0	0.0	106.7	0.0
137	0.2	67.5	14.0	0.0	194.4	0.0
138	74.9	47.9	14.2	0.0	46.2	0.0
139	30.2	92.9	31.1	0.0	10.2	8.0
140	0.0	178.6	0.0	0.0	5.4	13.1
141	2.7	45.7	4.4	48.2	48.2	16.1
142	0.0	41.8	0.0	83.9	40.0	1.3
143	0.9	108.0	8.0	82.5	68.1	0.3
144	9.2	45.9	4.1	109.3	70.1	0.0
145	27.4	46.8	43.1	57.6	0.2	0.0
146	0.1	40.2	2.0	53.9	173.4	3.9
147	0.0	19.6	0.0	32.9	26.9	4.5
148	0.0	16.5	0.0	29.8	54.3	0.9
149	0.0	39.1	3.9	33.2	160.7	0.9
150	12.4	71.9	18.5	71.6	166.5	0.0
151	91.4	49.6	8.1	84.1	0.0	0.0

Figure 6-47 illustrates the PM_{10} hourly average modeled concentrations at the four different receptors and showed that the Desert View station had higher hourly average concentrations during the month of May. However, from the middle towards the end of the month, the UTEP CAMS Station exceeded the estimates from the other stations. This case was very similar to the modeled data in April and again the higher concentrations were experienced during the morning and night hours. Table 6-23 shows the results from Figure 6-47.

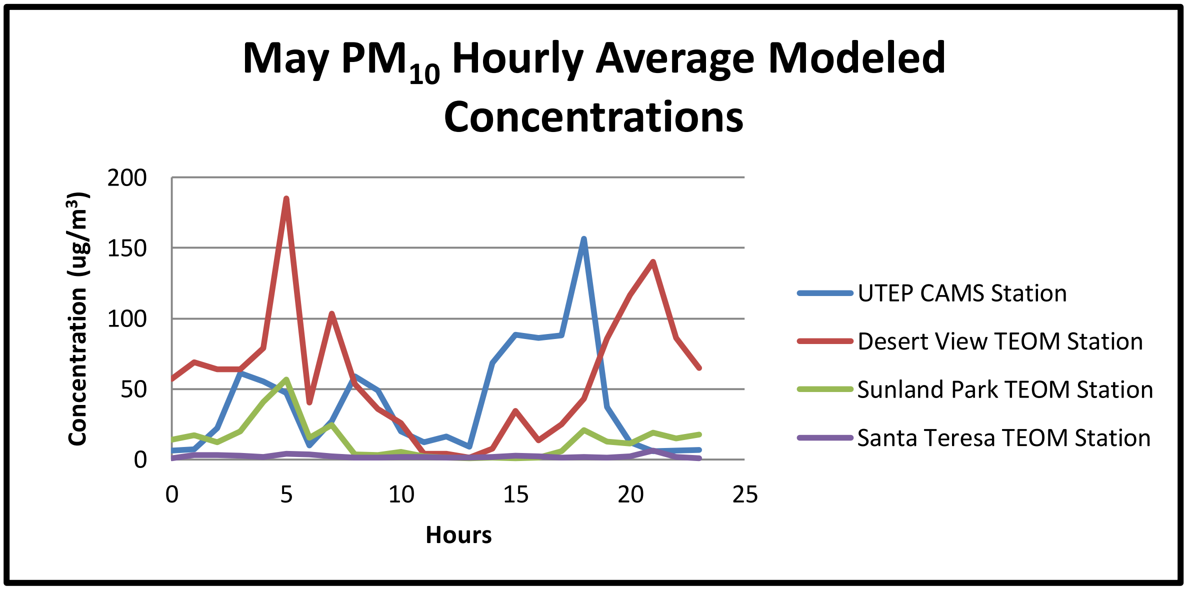

Figure 6-47. May PM_{10} Hourly Average Modeled Concentrations in the Project Area.

Table 6-23. May PM_{10} Hourly Average Modeled Concentrations in the Project Area.

	Concentration (μg/m³)			
Hours	UTEP CAMS Station	Desert View TEOM Station	Sunland Park TEOM Station	Santa Teresa TEOM Station
0	6	57	14	1
1	7	69	17	3
2	22	64	12	3
3	61	64	20	3
4	55	79	41	2
5	47	185	57	4
6	10	40	15	3
7	27	104	25	2
8	59	53	4	1

9	49	36	3	1
10	20	26	6	2
11	12	4	2	2
12	16	4	1	1
13	9	1	1	1
14	68	8	1	2
15	88	34	1	2
16	86	13	1	2
17	88	25	6	1
18	157	43	21	1
19	37	86	13	1
20	12	117	11	2
21	6	140	19	6
22	6	86	15	2
23	7	65	18	1

The month of June had a peak hour concentration at UTEP CAMS Station of 983 µg/m^3 on Julian day 175th at 19:00 hrs., Desert View TEOM Station of 3,873µg/m^3 on Julian day 165th at 0:00 hr., Sunland Park TEOM Station of 1,729 µg/m^3 at the same day and time of the previous receptor, and Santa Teresa TEOM Station of 283 µg/m^3 on Julian day 180th at 5:00 hrs. The peak 24-hr concentration at UTEP CAMS Station was 179 µg/m^3 on Julian day 162th, Sunland Park TEOM Station of 121 µg/m^3 on Julian day 165th, Desert View TEOM Station of 316 µg/m^3 on this same day, and Santa Teresa TEOM Station of 22 µg/m^3 on Julian day 180th. These days experienced majority southeasterly winds especially in the early hours.

In Figure 6-48, the modeled 24-hr average concentrations at UTEP CAMS Station presented an overestimate in the modeled concentrations towards the middle of June. This was an indicative that the CALMET output wind vectors directed the emissions in a different direction as compared to the real data, however, the monthly PM_{10} average was approximately within the 46% of the real data when the overestimate was not considered and approximately within the 53% when the overestimate was considered. This represents that Puerto Anapra could potentially contribute approximately 53% to the total PM_{10} concentration at the UTEP CAMS Station in the month of June.

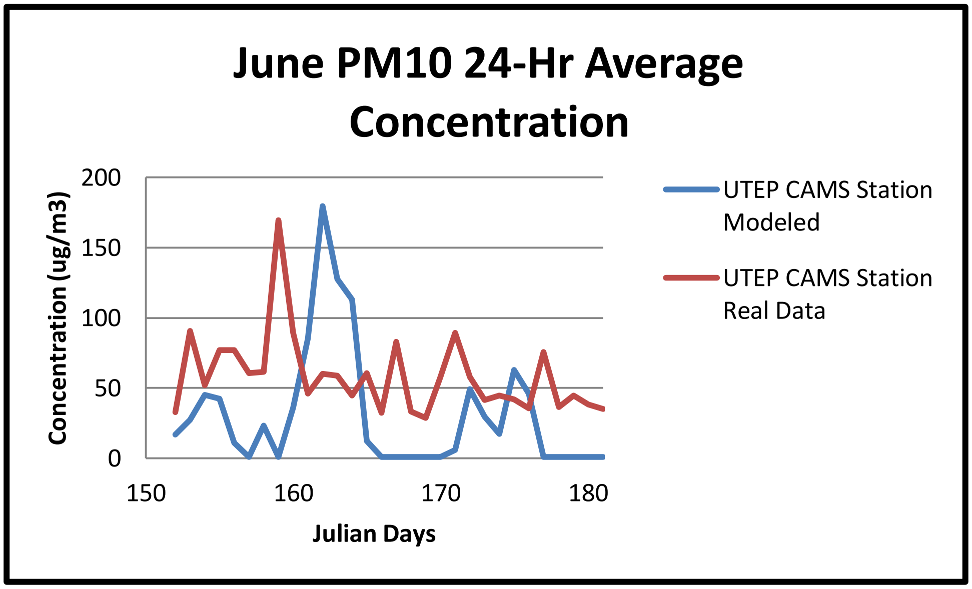

Figure 6-48. June PM_{10} 24-Hr Average Concentrations at UTEP CAMS Station.

Figure 6-49 illustrates the comparison of the modeled and real PM_{10} 24-hr average concentration at the Sunland Park TEOM Station. According to the model run, this location could potentially receive approximately 22% PM_{10} contribution from Puerto Anapra during the month of June.

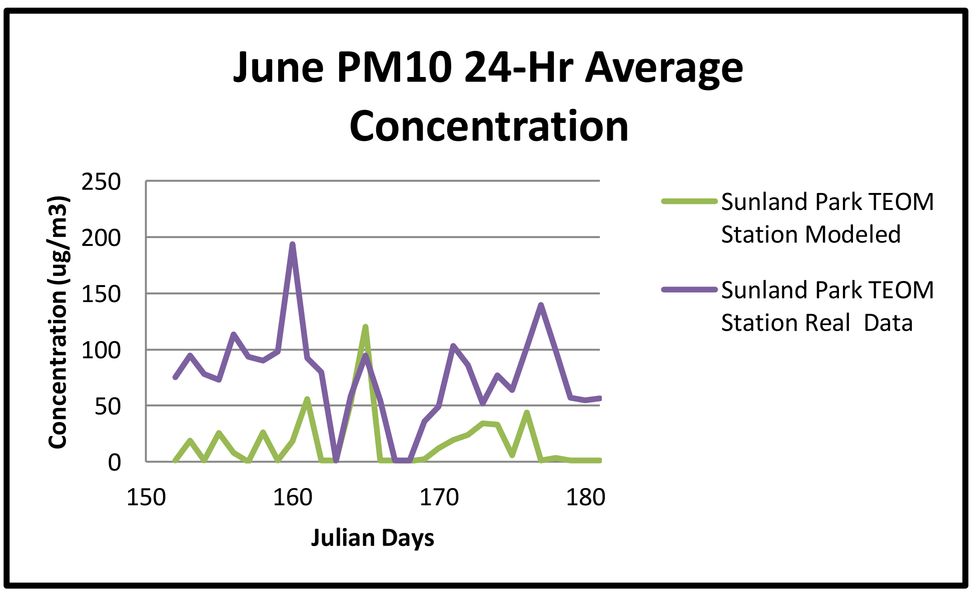

Figure 6-49. June PM_{10} 24-Hr Average Concentrations at Sunland Park TEOM Station.

During the month of June, the CALPUFF model run showed higher PM_{10} 24-hr average concentrations at the Desert View TEOM Station as compared to the past month. Moreover, the Santa

Teresa TEOM Station experienced extremely low PM_{10} 24-hr average concentrations. Figure 6-50 illustrates the modeled 24-hr average concentrations at the Desert View TEOM Station and the Santa Teresa TEOM Station in the month of June.

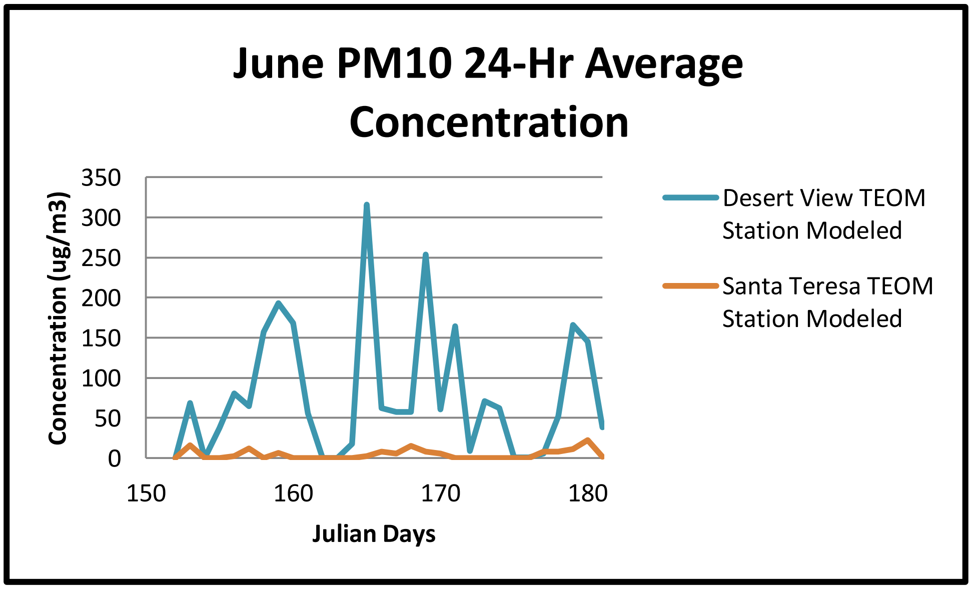

Figure 6-50. June PM_{10} 24-Hr Average Concentrations at Desert View and Santa Teresa TEOM Stations.

Table 6-24 shows the PM_{10} 24-hr average concentrations including the modeled and real data at the four different stations (receptors) during the month of June.

Table 6-24. June PM_{10} 24-Hr. Average Concentrations in the Project Area.

	Concentration (ug/m3)					
	UTEP CAMS Station		Sunland Park TEOM Station		Desert View TEOM Station	Santa Teresa TEOM Station
Julian Day	Modeled	Real Data	Modeled	Real Data	Modeled	Modeled
152	16.8	32.8	0.0	75.3	0.0	0.0
153	27.5	90.6	18.9	94.4	68.7	16.4
154	45.1	52.0	0.0	78.2	0.0	0.0
155	42.4	76.9	25.6	73.0	37.3	0.0
156	11.0	77.0	8.3	113.6	80.9	2.3
157	0.0	60.5	0.1	93.3	64.7	12.2
158	23.5	61.5	26.4	90.3	157.0	0.0
159	0.2	169.5	1.2	97.9	192.8	6.2
160	36.2	89.4	18.3	193.8	168.5	0.0
161	85.4	46.3	55.7	92.2	56.0	0.0
162	179.5	60.2	0.0	79.8	0.0	0.0
163	127.7	58.8	0.0	0.0	0.0	0.0
164	113.1	44.8	52.8	59.0	17.8	0.0
165	12.5	60.6	120.6	94.7	316.1	2.8
166	0.0	32.4	1.4	54.5	62.6	8.1
167	0.0	82.9	0.0	0.0	57.7	5.8
168	0.0	33.3	0.7	0.0	57.1	15.6
169	0.0	28.9	2.3	36.1	253.7	8.4
170	0.0	57.8	11.9	49.1	60.6	5.4
171	6.0	89.2	19.2	103.3	164.6	0.0
172	49.3	58.0	23.8	86.2	9.0	0.0
173	29.6	41.5	34.4	51.7	70.8	0.0
174	17.5	44.6	33.3	76.8	62.0	0.0
175	63.2	42.1	5.7	63.8	1.0	0.0
176	46.0	35.5	43.9	101.8	0.7	0.0
177	0.0	75.9	0.0	139.9	5.4	7.9
178	0.0	36.5	3.4	99.1	52.0	8.3
179	0.0	44.6	0.0	57.2	166.2	11.5
180	0.0	38.3	0.2	54.9	145.6	22.3
181	0.0	35.0	0.0	56.3	38.7	1.9

Figure 6-51 illustrates the PM_{10} hourly average modeled concentrations at the four different receptors and showed that the Desert View station had again the higher hourly average concentrations. Table 6-25 shows the results from Figure 6-51.

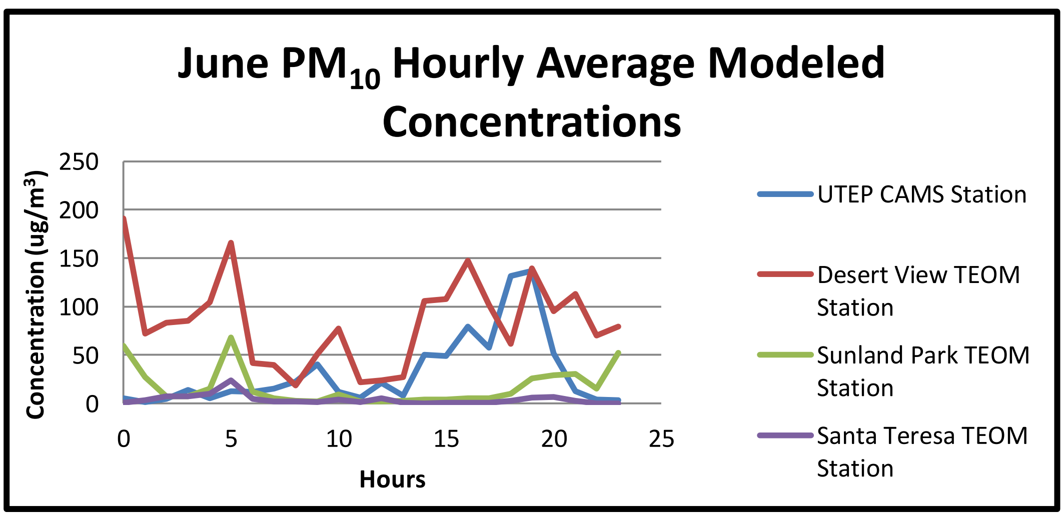

Figure 6-51. June PM_{10} Hourly Average Modeled Concentrations in the Project Area.

Table 6-25. June PM_{10} Hourly Average Modeled Concentrations in the Project Area.

	Concentration (µg/m³)			
Hours	UTEP CAMS Station	Desert View TEOM Station	Sunland Park TEOM Station	Santa Teresa TEOM Station
0	6	191	59	0
1	1	72	27	3
2	5	83	7	7
3	14	86	8	7
4	5	104	15	10
5	13	166	68	24
6	12	42	12	5
7	15	40	6	2
8	22	19	3	2
9	41	51	2	2
10	12	77	9	4
11	6	22	2	1
12	21	24	2	5
13	8	27	3	1
14	50	106	4	0
15	49	107	4	1
16	79	147	5	1
17	58	102	5	1
18	132	62	10	3
19	137	139	26	6
20	52	95	29	7
21	13	113	31	3
22	4	70	16	0
23	4	79	52	0

July had a peak hour concentration at UTEP CAMS Station of 514 µg/m^3 on Julian day 203th at 9:00 hrs., Desert View TEOM Station of 1,965 µg/m^3 on Julian day 202th at 8:00 hrs., Sunland Park TEOM Station of 311µg/m^3 on Julian day 200th at 9:00 hrs., and Santa Teresa TEOM Station of 90 µg/m^3 on Julian day 199th at 9:00 hrs. The peak PM_{10} 24-hr concentration at UTEP CAMS Station was 30 µg/m^3 on Julian day 203th, Sunland Park TEOM Station of 27 µg/m^3 on Julian day 194th, Desert View TEOM Station of 306 µg/m^3 on Julian day 193rd, and Santa Teresa TEOM Station of 12 µg/m^3 on Julian day 211th. These days experienced majority southeasterly winds at all hours.

Figure 6-52 presents the modeled and real data PM_{10} 24-hr average concentrations at the UTEP CAMS Station during the month of July. During this month, southeasterly winds were strongly present which directed the emissions to the northwest part of the project area resulting in minimal PM_{10} concentrations at this location. It was estimated that Puerto Anapra could potentially contribute approximately 3% to the total PM_{10} concentration at the UTEP CAMS Station in the month of July.

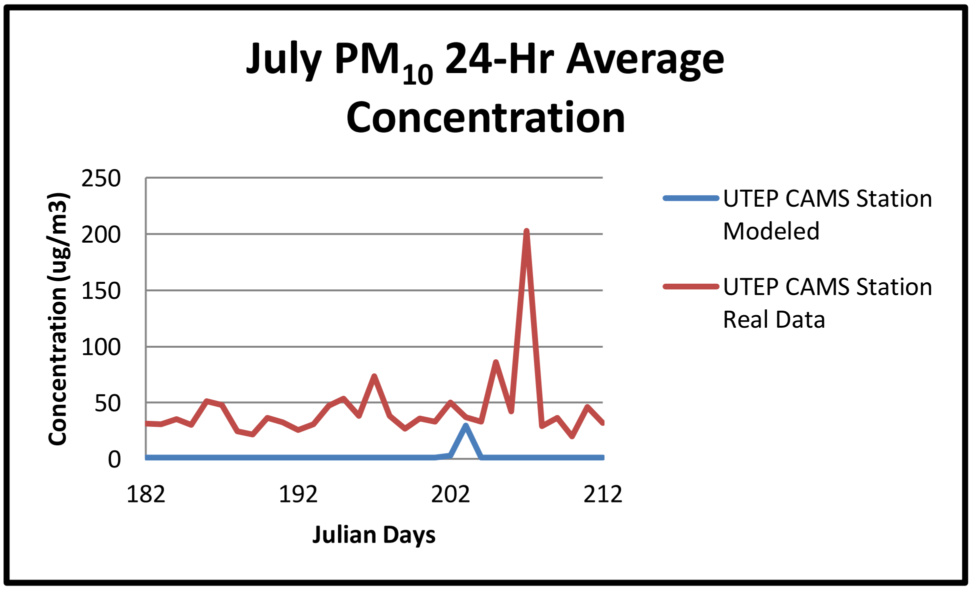

Figure 6-52. July PM_{10} 24-Hr Average Concentrations at UTEP CAMS Station.

Figure 6-53 illustrates the comparison of the modeled and real PM_{10} 24-hr average concentration at the Sunland Park TEOM Station in July. Similar to the UTEP CAMS Station, the location of the Sunland Park TEOM Station was not directly impacted by the emissions from Puerto Anapra due to the presence of southwesterly winds which directed the emissions away from this location. According to the model run, this location could potentially receive approximately 9% PM_{10} contribution from Puerto Anapra during the month of July.

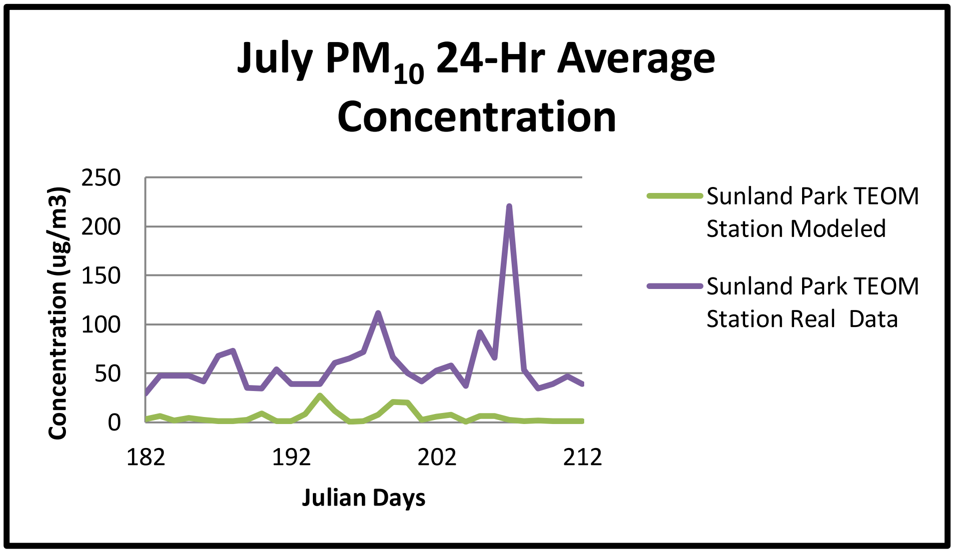

Figure 6-53. July PM_{10} 24-Hr Average Concentrations at Sunland Park TEOM Station.

During the month of July, the CALPUFF model run showed significant higher PM_{10} 24-hr average concentrations at the Desert View TEOM Station as compared to the other locations. Moreover, the Santa Teresa TEOM Station experienced extremely low PM_{10} 24-hr average concentrations again. This could conclude that the majority of the emissions were directed to the Desert View TEOM Station by southwesterly winds. Figure 6-54 illustrates the modeled 24-hr average concentrations at the Desert View TEOM Station and the Santa Teresa TEOM Station in the month of July.

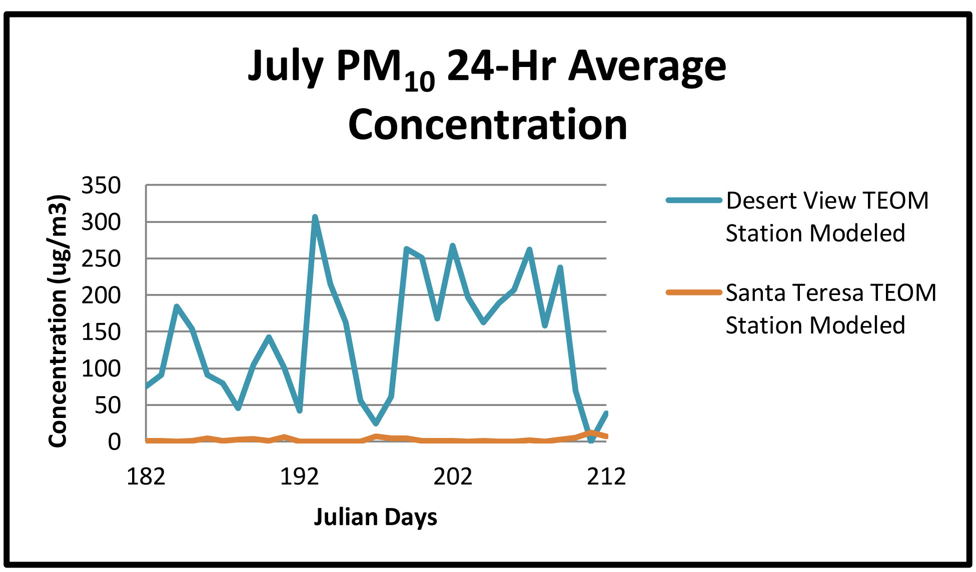

Figure 6-54. July PM_{10} 24-Hr Average Concentrations at Desert View and Santa Teresa TEOM Stations.

Table 6-26 shows the PM_{10} 24-hr average concentrations including the modeled and real data at the four different stations during the month of July.

Table 6-26. July PM_{10} 24-Hr. Average Concentrations in the Project Area.

	Concentration (ug/m3)					
	UTEP CAMS Station		Sunland Park TEOM Station		Desert View TEOM Station	Santa Teresa TEOM Station
Julian Day	Modeled	Real Data	Modeled	Real Data	Modeled	Modeled
182	0.0	31.5	3.2	29.3	75.5	0.8
183	0.2	31.0	6.4	47.3	90.5	1.2
184	0.0	35.4	1.9	47.4	184.4	0.1
185	0.2	30.1	4.5	47.6	153.4	0.9
186	0.0	51.3	2.7	41.6	90.7	4.7
187	0.0	47.9	0.0	68.2	79.5	0.9
188	0.0	24.7	0.0	73.4	45.0	2.2
189	0.0	21.8	2.3	35.3	104.6	3.8
190	0.1	36.5	9.3	34.3	142.6	1.1
191	0.0	32.3	0.5	53.9	100.8	6.2
192	0.0	25.8	0.0	39.4	41.6	0.4
193	0.0	30.7	8.1	39.2	306.5	0.0
194	1.3	47.4	27.4	39.4	214.6	0.0
195	1.3	53.8	11.7	60.4	162.7	0.0
196	0.0	38.1	0.5	65.0	55.6	0.2
197	0.0	73.9	0.0	71.9	24.3	6.5
198	0.0	38.3	7.5	111.5	61.5	4.1
199	0.0	26.9	20.5	66.5	263.1	4.5
200	0.0	35.7	20.0	50.3	250.4	1.1
201	0.0	32.8	2.6	41.9	167.6	0.8
202	2.8	50.3	5.6	53.0	267.1	1.1
203	29.6	37.4	7.9	57.9	196.4	0.4
204	0.0	33.0	0.8	37.5	162.2	1.0
205	0.0	86.1	6.7	92.0	188.8	0.1
206	0.0	42.1	6.3	66.1	206.9	0.0
207	0.0	203.2	2.8	220.8	262.4	1.4
208	0.0	29.3	0.4	53.3	158.1	0.1
209	0.0	36.5	2.0	34.2	237.4	2.2
210	0.0	19.8	0.1	39.1	68.8	5.6
211	0.0	46.3	0.0	47.2	0.2	12.4
212	0.0	32.0	0.0	38.8	38.7	7.1

Figure 6-55 illustrates the PM_{10} hourly average modeled concentrations at the four different receptors and showed that the Desert View station had again the higher hourly average concentrations during the majority of the time. Table 6-27 shows the results from Figure 6-55.

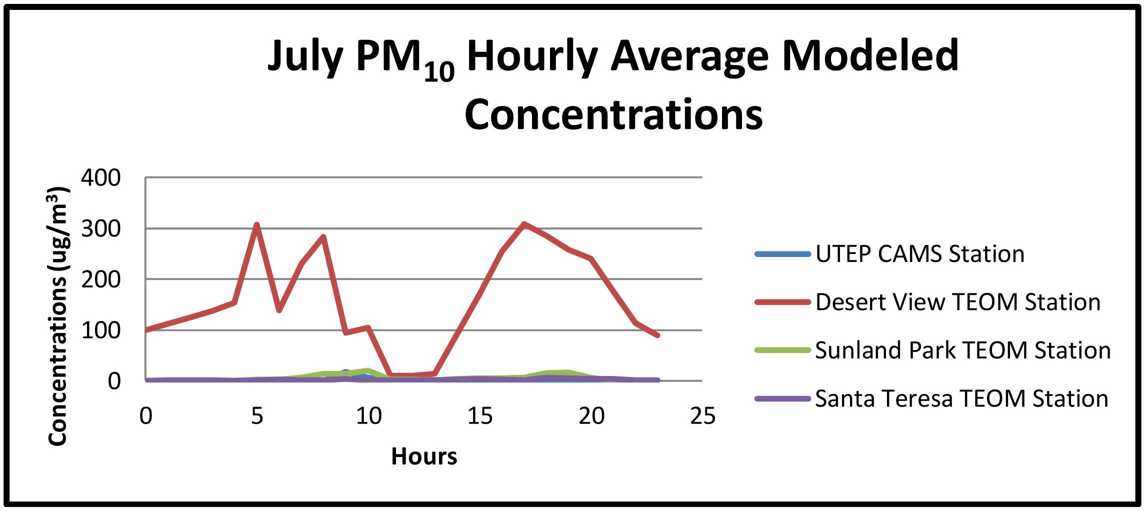

Figure 6-55. July PM_{10} Hourly Average Modeled Concentrations in the Project Area.

Table 6-27. July PM_{10} Hourly Average Modeled Concentrations in the Project Area.

	Concentration (µg/m^3)			
Hours	UTEP CAMS Station	Desert View TEOM Station	Sunland Park TEOM Station	Santa Teresa TEOM Station
0	0	100	0	1
1	0	112	0	2
2	0	125	0	1
3	0	138	0	1
4	0	154	0	1
5	0	307	3	1
6	0	139	3	2
7	0	230	6	2
8	1	284	14	2
9	18	95	15	4
10	7	105	20	2
11	1	11	3	1
12	0	10	2	2
13	0	14	2	2
14	0	92	4	3
15	0	170	6	4
16	0	254	5	3
17	0	309	7	2
18	0	286	15	7
19	0	258	16	6
20	0	240	7	4
21	0	177	0	4
22	0	113	0	2
23	0	90	0	1

The month of August had a peak hour concentration at UTEP CAMS Station of 612 μg/m^3 on Julian day 215th at 18:00 hrs., Desert View TEOM Station of 2,231 μg/m^3 on Julian day 239th at 6:00 hrs., Sunland Park TEOM Station of 617 μg/m^3 on Julian day 230th at 10:00 hrs., and Santa Teresa TEOM Station of 110 μg/m^3 on Julian day 228th at 19:00 hrs. The peak 24-hr concentration at UTEP CAMS Station was 39 μg/m^3 on Julian day 216th, Sunland Park TEOM Station of 41 μg/m^3 on Julian day 213th, Desert View TEOM Station of 291 μg/m^3 on Julian day 220rd, and Santa Teresa TEOM Station of 24 μg/m^3 on Julian day 228th. Again, southeasterly winds were predominant during these days which could impact Sunland Park's air quality and exceeding PM_{10} NAAQS.

Figure 6-56 presents the modeled and real data PM_{10} 24-hr average concentrations at the UTEP CAMS Station during the month of August. During this month, southeasterly winds were again strongly present which directed the emissions to the northwest part of the project area resulting in minimal PM_{10} concentrations at this location except for the middle of the month were there is a small increase in concentration. It was estimated that Puerto Anapra could potentially contribute approximately 24% to the total PM_{10} concentration at the UTEP CAMS Station in the month of August.

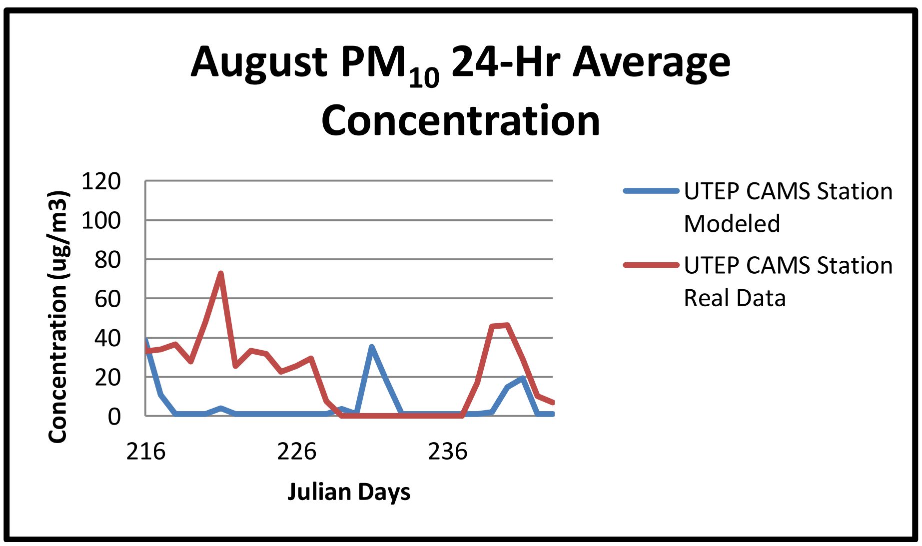

Figure 6-56. August PM_{10} 24-Hr Average Concentrations at UTEP CAMS Station.

Figure 6-57 illustrates the comparison of the modeled and real PM_{10} 24-hr average concentration at the Sunland Park TEOM Station. It was observed that the modeled concentrations followed a similar pattern of the real data except for the extreme wind event in the middle of the month and where

estimated concentrations were underestimated. According to the model run, this location could potentially receive approximately 12% PM_{10} contribution from Puerto Anapra considering the extreme wind event or approximately 15% if the extreme wind event was not considered during this month.

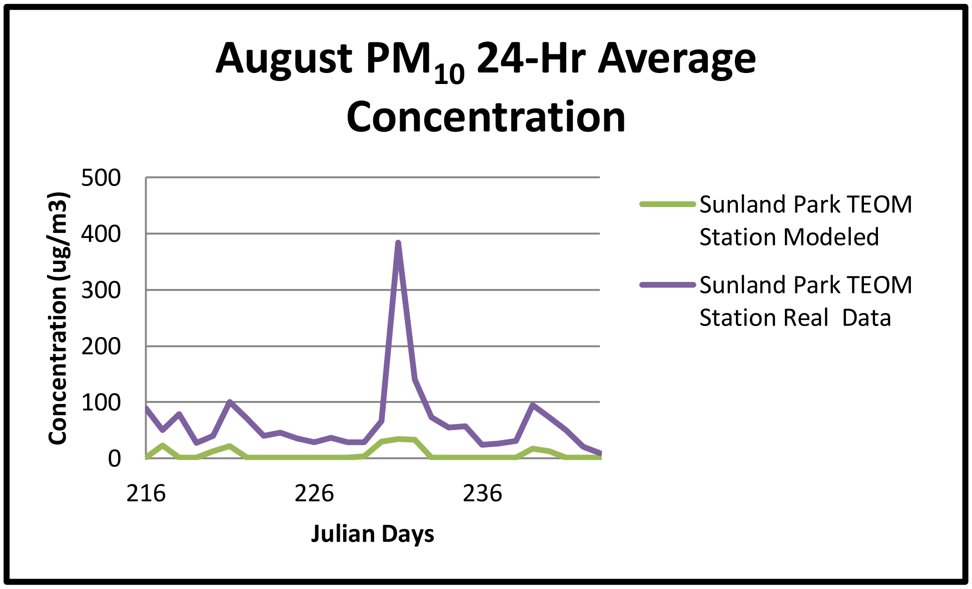

Figure 6-57. August PM_{10} 24-Hr Average Concentrations at Sunland Park TEOM Station.

During the month of August, the model run showed higher PM_{10} 24-hr average concentrations at the Desert View TEOM Station as compared to the other locations. Also, the Santa Teresa TEOM Station experienced extremely low PM_{10} 24-hr average concentrations. This could conclude that the majority of the emissions were directed to the Desert View TEOM Station by southwesterly winds. Figure 6-58 illustrates the modeled 24-hr average concentrations at the Desert View TEOM Station and the Santa Teresa TEOM Station in the month of August.

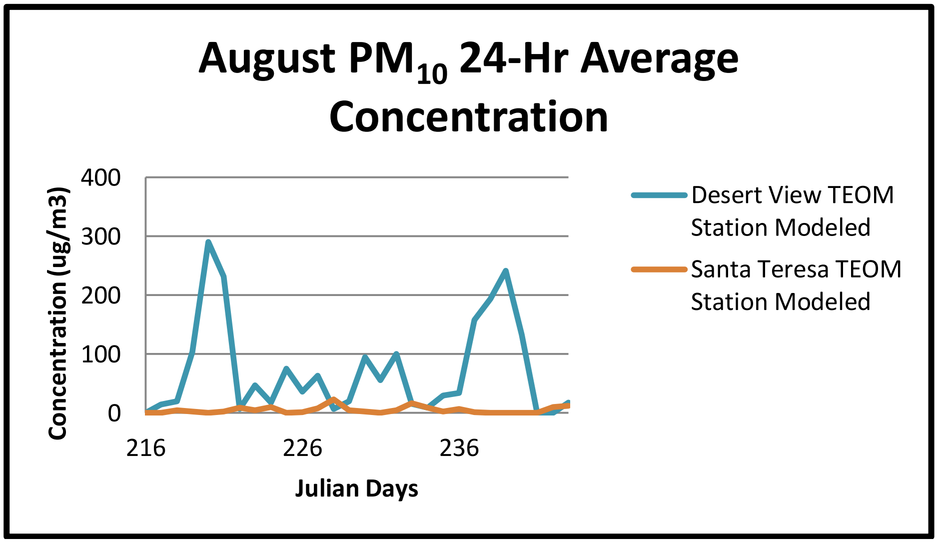

Figure 6-58. August PM_{10} 24-Hr Average Concentrations at Desert View and Santa Teresa TEOM Stations.

Table 6-28 shows the PM_{10} 24-hr average concentrations including the modeled and real data at the four different stations during the month of August.

Table 6-28. August PM_{10} 24-Hr. Average Concentrations in the Project Area.

	Concentration (ug/m3)					
	UTEP CAMS Station		Sunland Park TEOM Station		Desert View TEOM Station	Santa Teresa TEOM Station
Julian Day	Modeled	Real Data	Modeled	Real Data	Modeled	Modeled
213	3.2	111.3	41.5	44.3	167.8	0.0
214	9.3	64.4	3.6	83.6	0.0	0.0
215	38.4	68.4	0.0	74.9	0.0	0.0
216	38.7	33.2	0.0	89.2	0.0	0.0
217	11.0	34.2	22.6	50.7	14.8	0.0
218	0.0	36.8	0.0	78.4	20.4	5.4
219	0.0	27.8	0.0	27.4	103.3	2.4
220	0.0	48.2	12.2	39.4	291.0	0.0
221	4.0	72.9	21.6	100.3	232.0	2.8
222	0.0	25.5	0.0	71.1	6.7	9.1
223	0.0	33.4	0.0	39.6	47.6	4.9
224	0.0	31.8	0.0	45.3	17.7	10.3
225	0.0	22.8	0.0	35.9	75.4	0.2
226	0.0	25.7	0.0	29.1	36.2	1.1
227	0.0	29.4	0.0	37.1	63.8	8.2
228	0.0	7.6	0.0	29.2	6.8	23.5
229	3.9	0.2	3.6	28.3	20.0	4.5
230	1.2	0.0	30.0	65.8	95.0	2.5
231	35.5	0.0	34.7	383.7	55.6	0.0
232	18.1	0.0	33.2	140.9	100.0	4.8
233	0.0	0.0	0.0	72.5	16.1	16.6
234	0.0	0.0	0.0	54.5	9.6	9.4
235	0.0	0.0	0.0	56.8	30.2	3.0
236	0.0	0.0	0.0	24.6	34.0	6.5
237	0.0	0.0	0.1	26.1	158.5	1.4
238	0.0	17.2	0.1	31.2	193.9	1.0
239	2.0	45.8	16.9	94.6	241.3	0.0
240	14.8	46.4	12.4	73.5	132.8	0.0
241	19.5	29.3	0.0	50.7	0.0	0.0
242	0.0	10.4	0.0	20.8	0.1	10.0
243	0.0	7.1	0.0	9.4	18.4	12.3

Figure 6-59 illustrates the PM_{10} hourly average modeled concentrations at the four different receptors and showed that the Desert View station had again the higher hourly average concentrations during morning and night hours. Table 6-29 shows the results from Figure 6-59.

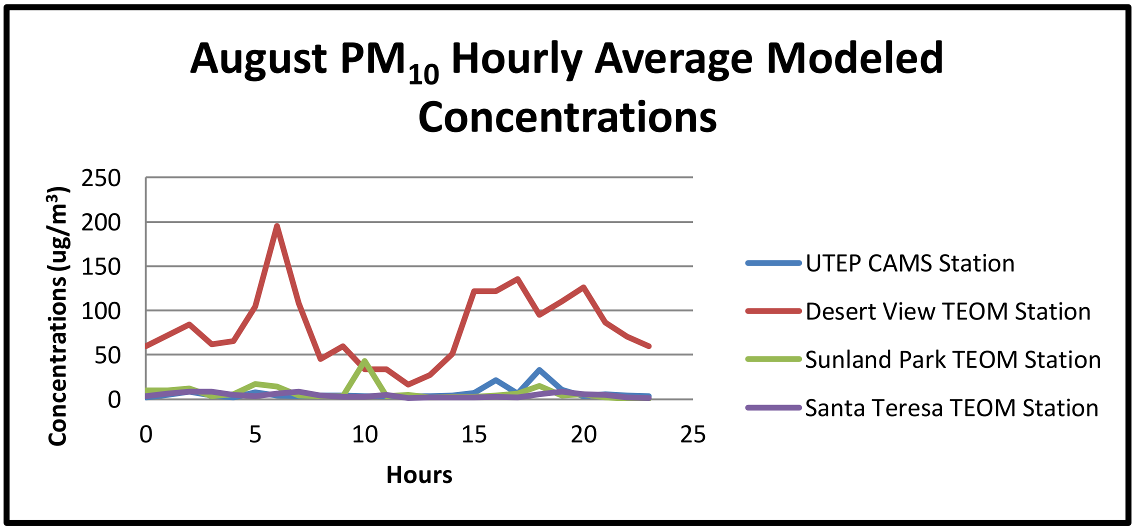

Figure 6-59. August PM_{10} Hourly Average Modeled Concentrations in the Project Area.

Table 6-29. August PM_{10} Hourly Average Modeled Concentrations in the Project Area.

	Concentration (μg/m^3)			
Hours	UTEP CAMS Station	Desert View TEOM Station	Sunland Park TEOM Station	Santa Teresa TEOM Station
0	2	59	10	3
1	5	72	10	6
2	8	84	12	9
3	4	62	4	8
4	2	65	5	5
5	7	104	17	4
6	4	195	14	6
7	3	108	4	8
8	4	45	4	4
9	4	59	4	3
10	3	34	43	2
11	3	34	3	5
12	3	16	5	1
13	4	27	2	2
14	4	51	3	2

15	7	122	3	2
16	21	122	4	2
17	6	136	6	2
18	33	95	15	5
19	10	110	4	8
20	4	126	5	6
21	5	86	2	5
22	4	71	0	2
23	3	60	0	1

During September, the month had a peak hour concentration at UTEP CAMS Station of 1,057 µg/m^3 on Julian day 255th at 19:00 hrs., Desert View TEOM Station of 4,040 µg/m^3 on Julian day 250th at 23:00 hrs., Sunland Park TEOM Station of 854 µg/m^3 on the same day and time, and Santa Teresa TEOM Station of 173 µg/m^3 on Julian day 268th at 19:00 hrs. The peak PM_{10} 24-hr concentration at UTEP CAMS Station was 167 µg/m^3 on Julian day 267th, Sunland Park TEOM Station of 59 µg/m^3 on Julian day 253th, Desert View TEOM Station of 494 µg/m^3 on Julian day 266th, and Santa Teresa TEOM Station of 19 µg/m^3 on Julian day 249th. Southeasterly winds were predominant during these days.

Figure 6-60 presents the modeled and real data PM_{10} 24-hr average concentrations at the UTEP CAMS Station during the month of September. During this month, the modeled data exceeded the real data in various days, however, the real PM_{10} 24-hr average concentration was approximately 50% lower than the annual average and the real data monthly PM_{10} average concentration was not exceeded by the modeled data. It was estimated that Puerto Anapra could potentially contribute approximately 60% to the total PM_{10} concentration at the UTEP CAMS Station in the month of September.

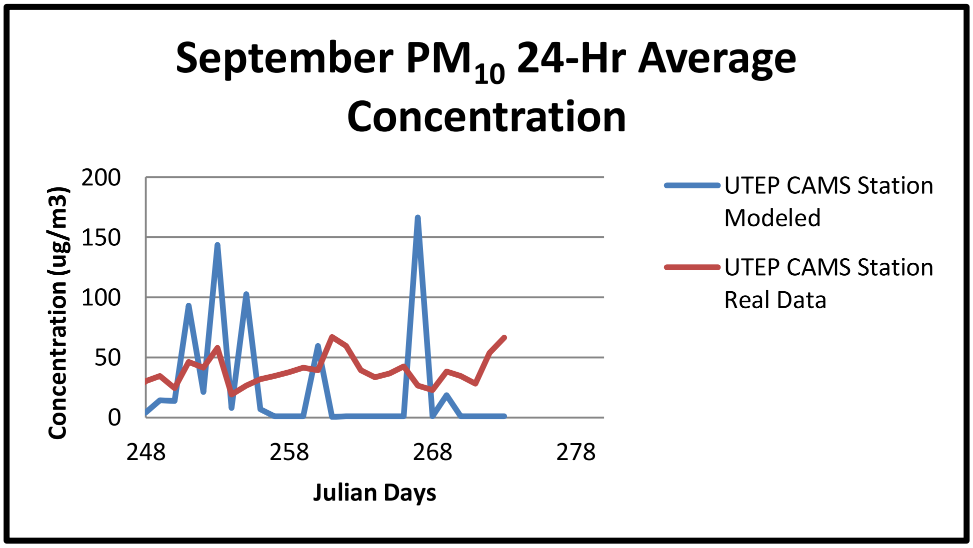

Figure 6-60. September PM_{10} 24-Hr Average Concentrations at UTEP CAMS Station.

Figure 6-61 illustrates the comparison of the modeled and real PM_{10} 24-hr average concentration at the Sunland Park TEOM Station. It was observed that the modeled concentrations followed a similar pattern of the real data except for the middle of the month and where estimated concentrations were extremely low. This could be attributed that the majority of the winds resulted from the CALMET model run were predominantly southeasterly winds avoided this location. According to the model run, this location could potentially receive approximately 30% PM_{10} contribution from Puerto Anapra during this month.

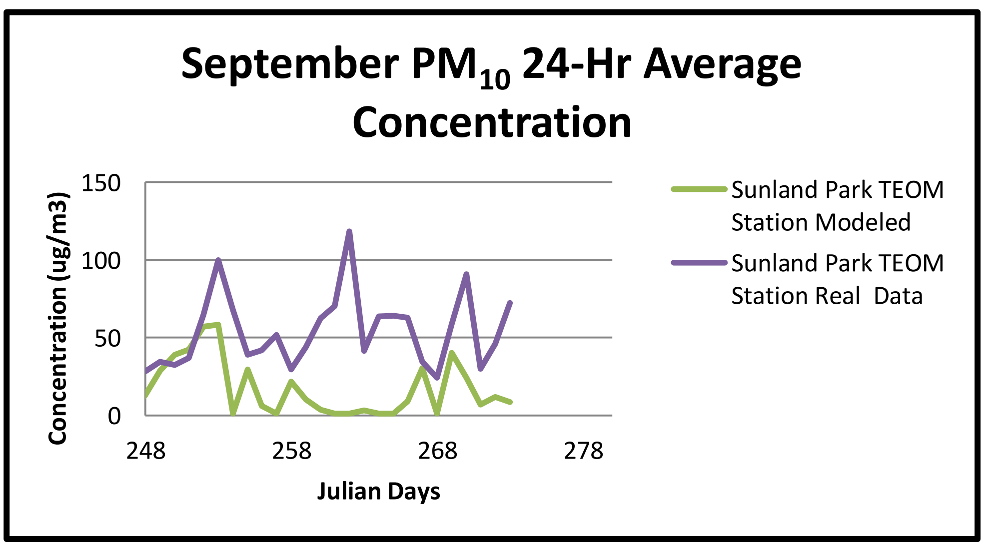

Figure 6-61. September PM_{10} 24-Hr Average Concentrations at Sunland Park TEOM Station.

During the month of September, the model run showed higher PM_{10} 24-hr average concentrations at the Desert View TEOM Station as compared to the other locations. However, the beginning of the month experienced low concentrations given that during this time northwesterly winds were present which directed the emissions to the east portion of the project area. Also, the Santa Teresa TEOM Station experienced extremely low PM_{10} 24-hr average concentrations. This could conclude that the majority of the emissions were directed to the Desert View TEOM Station by southwesterly winds. Figure 6-62 illustrates the modeled 24-hr average concentrations at the Desert View TEOM Station and the Santa Teresa TEOM Station in the month of September.

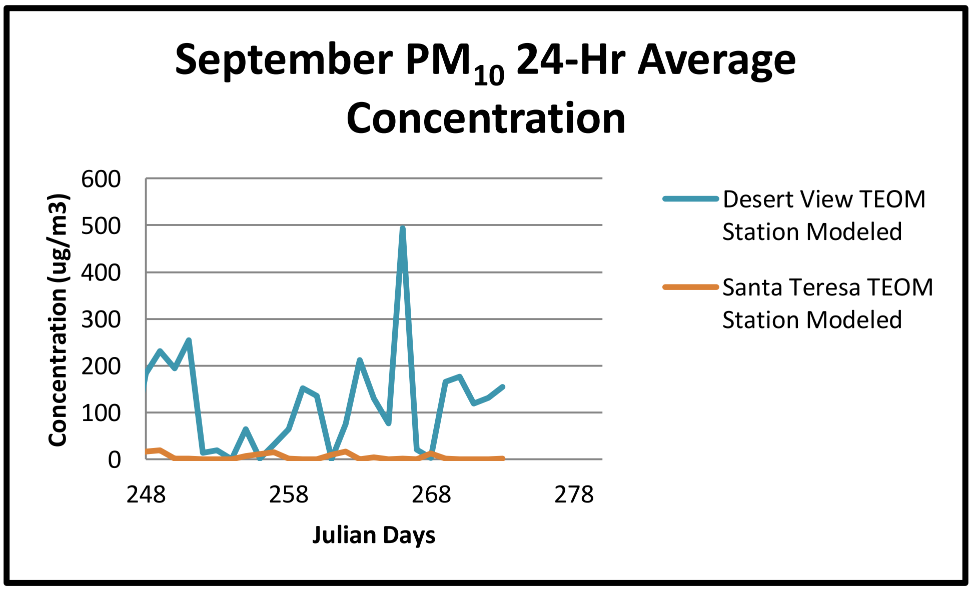

Figure 6-62. September PM_{10} 24-Hr Average Concentrations at Desert View and Santa Teresa TEOM Stations.

Table 6-30 shows the PM_{10} 24-hr average concentrations including the modeled and real data at the four different stations during the month of September.

Table 6-30. September PM_{10} 24-Hr. Average Concentrations in the Project Area.

	Concentration (ug/m3)					
	UTEP CAMS Station		Sunland Park TEOM Station		Desert View TEOM Station	Santa Teresa TEOM Station
Julian Day	Modeled	Real Data	Modeled	Real Data	Modeled	Modeled
244	0.0	14.3	0.0	12.3	40.2	1.9
245	0.0	20.5	0.0	21.6	69.6	2.3
246	0.0	20.2	0.0	24.0	57.0	1.5
247	0.0	20.4	0.0	26.1	23.6	7.1
248	4.2	29.9	13.0	28.2	183.1	16.6
249	14.1	34.3	28.8	34.4	230.6	19.0
250	13.5	24.4	39.0	32.4	194.3	0.5
251	92.8	46.0	42.2	37.1	254.0	1.9
252	21.1	41.3	57.0	65.1	13.4	0.0
253	143.5	58.0	58.4	100.1	19.6	0.0
254	8.0	19.0	0.0	67.9	0.0	0.0
255	102.4	26.3	29.6	38.8	63.6	6.2
256	6.6	31.6	6.0	41.9	1.3	11.1
257	0.0	34.2	0.0	51.7	31.8	15.1
258	0.0	37.7	21.7	29.6	63.6	1.1
259	0.0	41.2	10.0	44.0	152.0	0.0
260	59.3	39.1	3.7	62.6	135.9	0.0
261	0.2	67.2	0.0	70.2	0.0	9.1
262	0.0	59.2	0.1	118.4	75.7	16.3
263	0.0	39.1	3.0	41.6	211.7	0.0
264	0.0	33.4	0.0	63.8	130.5	4.2
265	0.0	36.5	0.2	64.2	76.4	0.2
266	0.0	42.7	8.8	63.0	494.0	1.5
267	166.5	26.6	30.4	34.6	19.9	0.0
268	0.1	22.9	0.1	24.4	2.3	11.9
269	18.4	38.2	40.4	58.7	165.6	1.3
270	0.2	34.6	24.2	90.8	176.6	0.1
271	0.0	28.3	6.8	29.8	119.2	0.0
272	0.0	53.6	11.6	46.1	130.5	0.0
273	0.0	66.4	8.4	72.5	154.0	1.5

Figure 6-63 illustrates the PM_{10} hourly average modeled concentrations at the four different receptors and showed that the Desert View station had again the higher hourly average concentrations. It also shows that when modeled concentrations are low at the Desert View TEOM Station, higher concentrations are experienced at the UTEP CAMS Station. Table 6-31 shows the results from Figure 6-63.

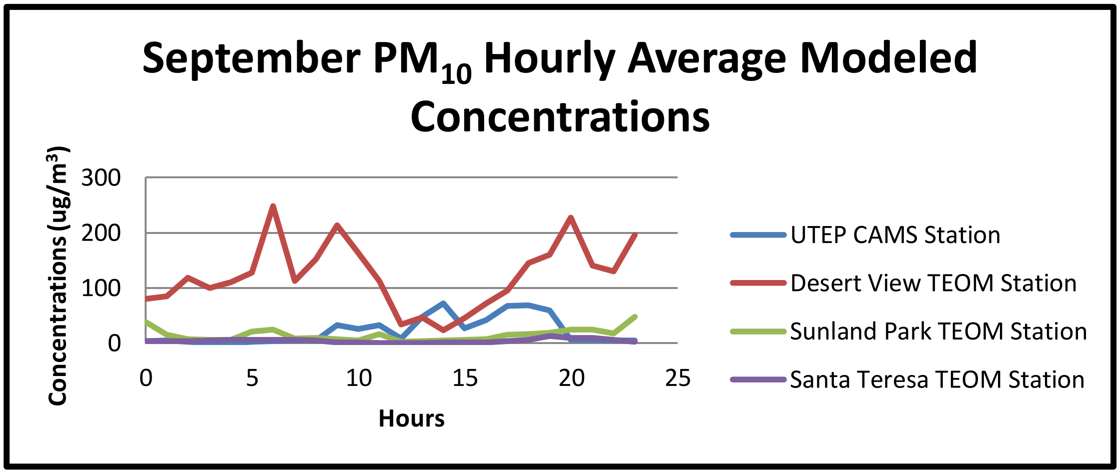

Figure 6-63. September PM_{10} Hourly Average Modeled Concentrations in the Project Area.

Table 6-31. September PM_{10} Hourly Average Modeled Concentrations in the Project Area.

	Concentration (µg/m³)			
Hours	UTEP CAMS Station	Desert View TEOM Station	Sunland Park TEOM Station	Santa Teresa TEOM Station
0	4	81	39	3
1	4	85	15	3
2	2	119	7	4
3	1	99	6	5
4	0	110	6	6
5	2	127	21	6
6	4	248	24	6
7	5	113	9	6
8	4	153	10	4
9	32	213	7	2
10	26	164	4	1
11	32	113	16	1
12	9	33	3	1
13	47	46	3	1
14	72	23	4	1
15	27	46	6	1
16	42	73	7	1
17	67	95	15	3
18	69	145	16	6
19	60	160	19	13
20	6	227	24	9
21	6	140	24	9
22	5	130	18	6
23	5	196	47	3

October had a peak hour concentration at UTEP CAMS Station of 810 µg/m^3 on Julian day 300th at 9:00 hrs., Desert View TEOM Station of 4,356 µg/m^3 on Julian day 283th at 13:00 hrs., Sunland Park TEOM Station of 1,693µg/m^3 on Julian day 292nd at 18:00 hrs., and Santa Teresa TEOM Station of 199 µg/m^3 on Julian day 295th at 18:00 hrs. The peak 24-hr concentration at UTEP CAMS Station was 69 µg/m^3 on Julian day 302nd, Sunland Park TEOM Station of 152 µg/m^3 on Julian day 292nd, Desert View TEOM Station of 459 µg/m^3 on Julian day 283rd, and Santa Teresa TEOM Station of 25 µg/m^3 on Julian day 295th. Southeasterly winds were predominant during these days.

Figure 6-64 presents the modeled and real data PM_{10} 24-hr average concentrations at the UTEP CAMS Station during the month of October. During this month, the modeled data followed a similar pattern as the real data. It was estimated that Puerto Anapra could potentially contribute approximately 23% to the total PM_{10} concentration at the UTEP CAMS Station in the month of October.

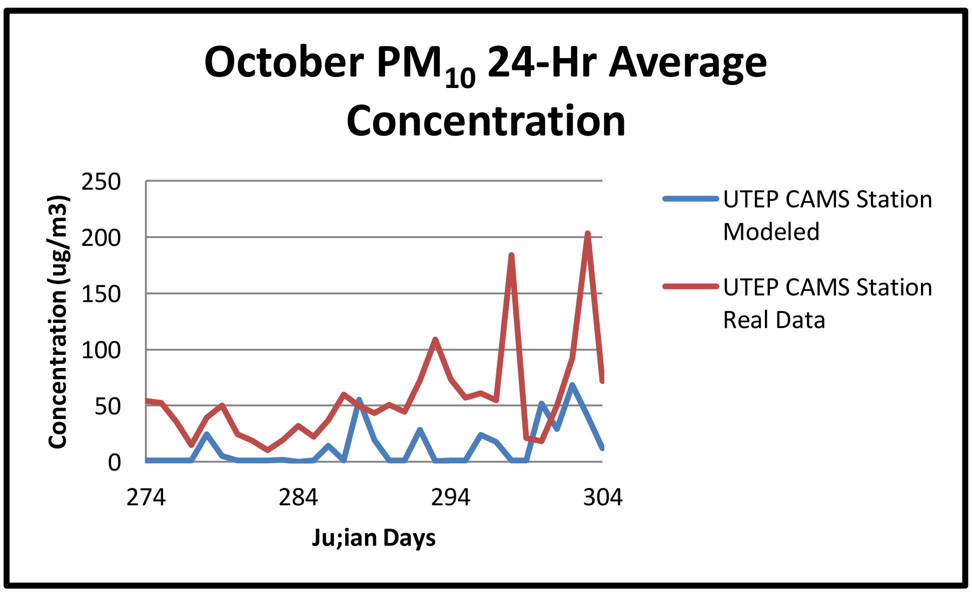

Figure 6-64. October PM_{10} 24-Hr Average Concentrations at UTEP CAMS Station.

Figure 6-65 illustrates the comparison of the modeled and real PM_{10} 24-hr average concentration at the Sunland Park TEOM Station. It was observed that the modeled concentrations exceeded the real data in a few instances; however, those instances had zero concentration. According to the model run,

this location could potentially receive approximately 28% PM_{10} contribution from Puerto Anapra during this month, very similar to the contribution in September.

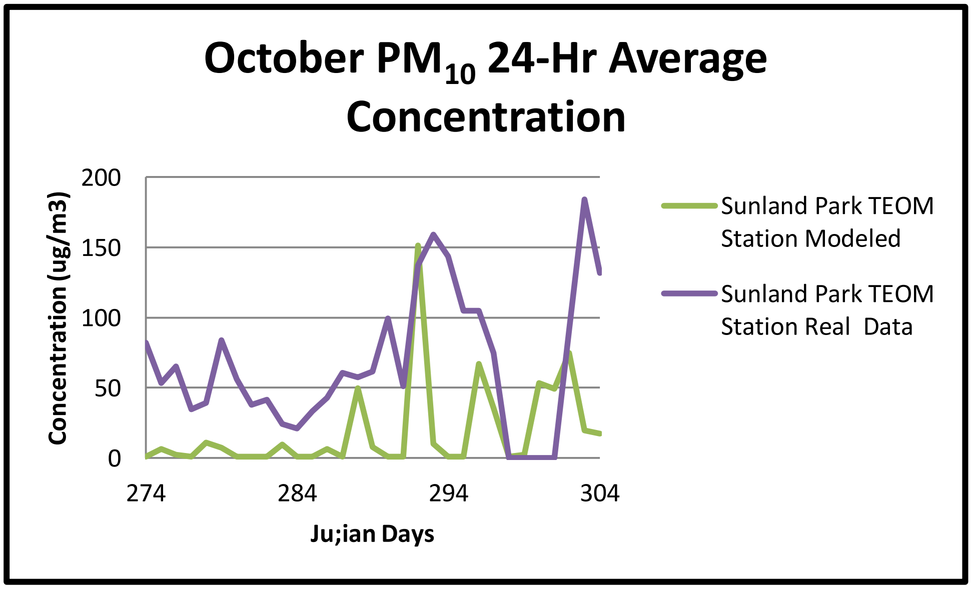

Figure 6-65. October PM_{10} 24-Hr Average Concentrations at Sunland Park TEOM Station.

During the month of October, the model run showed higher PM_{10} 24-hr average concentrations at the Desert View TEOM Station as compared to the other locations. Also, the Santa Teresa TEOM Station experienced extremely low PM_{10} 24-hr average concentrations. Figure 6-66 illustrates the modeled 24-hr average concentrations at the Desert View TEOM Station and the Santa Teresa TEOM Station in the month of October.

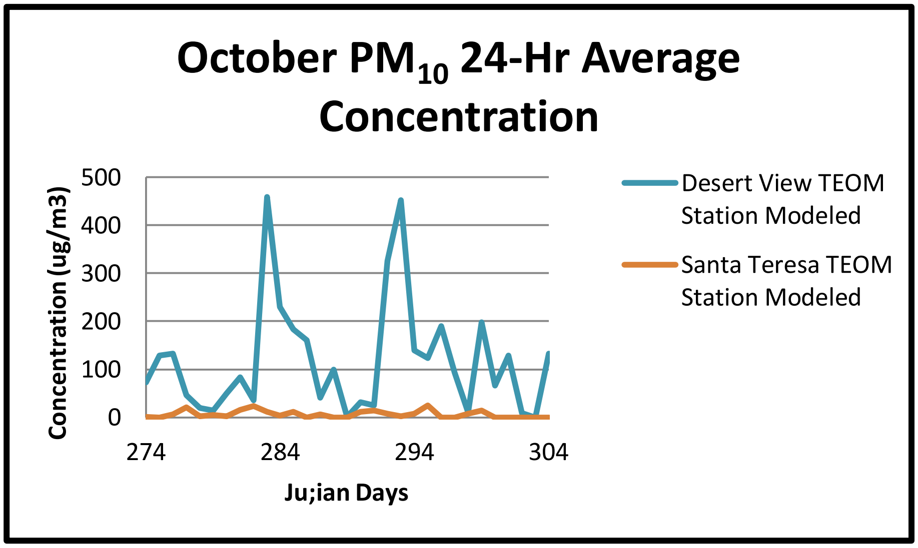

Figure 6-66. October PM_{10} 24-Hr Average Concentrations at Desert View and Santa Teresa TEOM Stations.

Table 6-32 shows the PM_{10} 24-hr average concentrations including the modeled and real data at the four different stations during the month of October.

Table 6-32. October PM_{10} 24-Hr. Average Concentrations in the Project Area.

	Concentration (ug/m3)					
	UTEP CAMS Station		Sunland Park TEOM Station		Desert View TEOM Station	Santa Teresa TEOM Station
Julian Day	Modeled	Real Data	Modeled	Real Data	Modeled	Modeled
274	0.0	54.0	0.0	82.3	72.5	0.8
275	0.0	52.4	6.5	53.5	129.1	0.0
276	1.0	35.5	2.3	65.2	132.4	6.3
277	0.0	15.0	0.0	34.9	46.3	20.5
278	24.6	39.3	10.9	39.4	19.9	2.7
279	5.4	49.9	7.3	83.8	14.1	5.2
280	0.0	24.5	0.2	56.1	50.3	1.7
281	0.0	18.7	0.0	38.0	83.4	15.2
282	0.0	10.1	0.0	41.7	34.8	23.3
283	1.7	19.6	9.7	24.3	458.8	11.0
284	0.3	31.8	1.0	20.8	229.8	3.4
285	0.1	22.0	0.2	33.4	183.4	11.1
286	14.5	37.4	6.6	43.1	161.1	0.0
287	0.0	60.0	0.0	60.5	41.0	6.2
288	55.5	49.4	49.8	57.6	98.7	0.0
289	19.2	43.1	8.0	61.6	1.3	0.0
290	0.5	50.7	0.3	99.3	30.9	10.8
291	0.0	44.7	0.7	51.3	24.2	14.0
292	28.7	72.3	151.6	137.4	326.1	7.0
293	0.5	108.8	10.1	159.2	452.8	2.6
294	0.0	73.7	0.0	143.6	138.9	6.9
295	0.0	57.1	0.0	105.0	123.7	25.2
296	24.3	60.8	66.9	104.7	190.5	0.0
297	17.9	54.6	35.5	74.9	92.1	0.0
298	0.1	183.8	0.0	0.0	10.5	7.9
299	0.2	21.4	2.5	0.0	197.8	14.3
300	52.1	18.4	53.3	0.0	66.4	0.0
301	29.3	50.1	49.3	0.0	129.3	0.0
302	68.6	92.4	74.8	91.3	9.0	0.0
303	40.7	203.7	19.7	184.4	0.0	0.0
304	12.3	71.8	17.4	132.0	133.0	0.0

Figure 6-67 illustrates the PM_{10} hourly average modeled concentrations at the four different receptors and showed that the Desert View station had again the higher hourly average concentrations. It also shows that higher concentrations were experienced during the early and late hours of the day. Table 6-33 shows the results from Figure 6-67.

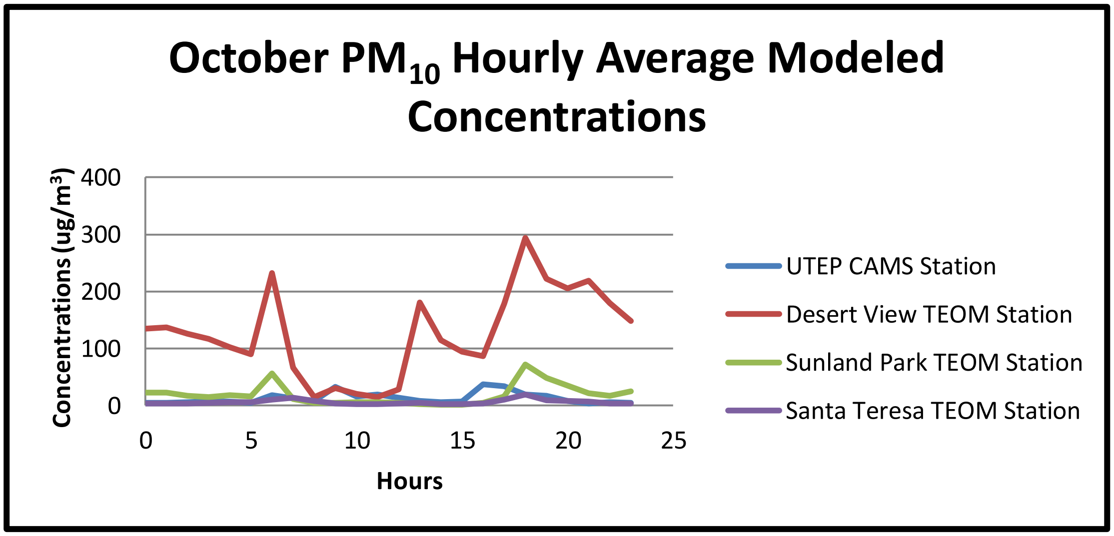

Figure 6-67. October PM_{10} Hourly Average Modeled Concentrations in the Project Area.

Table 6-33. October PM_{10} Hourly Average Modeled Concentrations in the Project Area.

	Concentration (μg/m^3)			
Hours	UTEP CAMS Station	Desert View TEOM Station	Sunland Park TEOM Station	Santa Teresa TEOM Station
0	5	135	23	4
1	5	137	23	3
2	6	125	17	4
3	7	117	15	5
4	7	103	18	7
5	5	90	16	6
6	18	232	56	10
7	13	67	12	14
8	9	15	5	9
9	33	30	5	4
10	16	20	6	3
11	19	15	6	2
12	14	29	5	4
13	8	181	3	4

14	6	115	2	2
15	7	94	2	2
16	37	87	5	4
17	34	179	16	10
18	20	294	72	19
19	17	223	49	10
20	8	205	35	8
21	4	219	22	7
22	6	179	17	4
23	5	149	25	3

The month of November had a peak hour concentration at UTEP CAMS Station of 910 µg/m^3 on Julian day 329th at 7:00 hrs., Desert View TEOM Station of 4,721µg/m^3 on Julian day 319th at 21:00 hrs., Sunland Park TEOM Station of 1,772µg/m^3 on Julian day 328th at 19:00 hrs., and Santa Teresa TEOM Station of 218 µg/m^3 on Julian day 332nd at 17:00 hrs. The peak 24-hr concentration at UTEP CAMS Station was 149 µg/m^3 on Julian day 330th, Sunland Park TEOM Station of 140 µg/m^3 on Julian day 319th, Desert View TEOM Station of 349 µg/m^3 on Julian day 318th, and Santa Teresa of 39 µg/m^3 on Julian day 332nd. Southeasterly and northerly winds were predominant during these days.

Figure 6-68 presents the modeled and real data PM_{10} 24-hr average concentrations at the UTEP CAMS Station during the month of November. During this month, the modeled data followed a similar pattern as the real data except for the extreme wind event at the end of month. It was estimated that Puerto Anapra could potentially contribute approximately 27% to the total PM_{10} concentration at the UTEP CAMS Station in the month of November when the extreme event was considered or 47% when the extreme even was not considered.

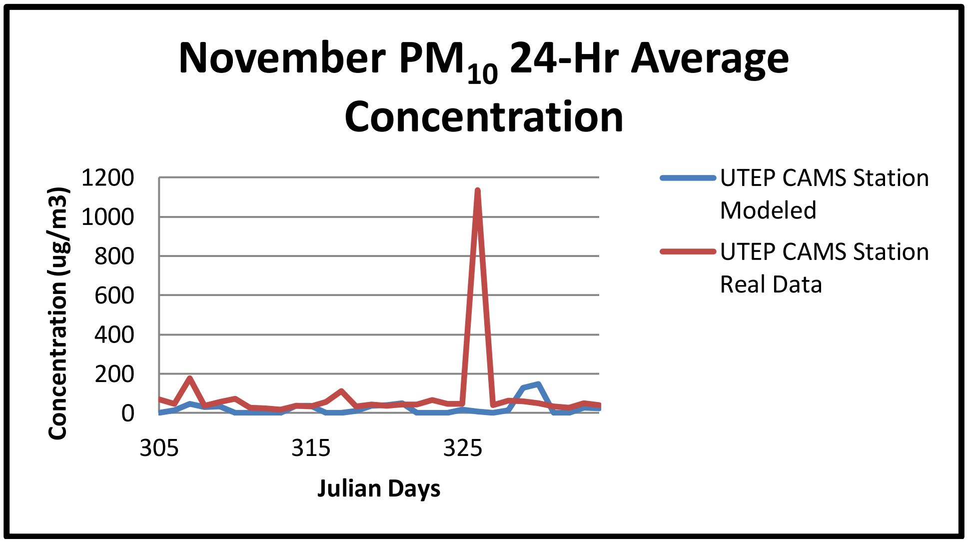

Figure 6-68. November PM_{10} 24-Hr Average Concentrations at UTEP CAMS Station.

Figure 6-69 illustrates the comparison of the modeled and real PM_{10} 24-hr average concentration at the Sunland Park TEOM Station. It was observed that the modeled concentrations exceeded the real data in one occasion. There was also an extreme wind event recorded at this location similarly to the event recorded at the UTEP CAMS Station, however, as previously mentioned, the CALPUFF model does not account for these event. According to the model run, this location could potentially receive approximately 21% PM_{10} contribution from Puerto Anapra during this month considering the extreme wind event or 26% if the extreme event was not considered.

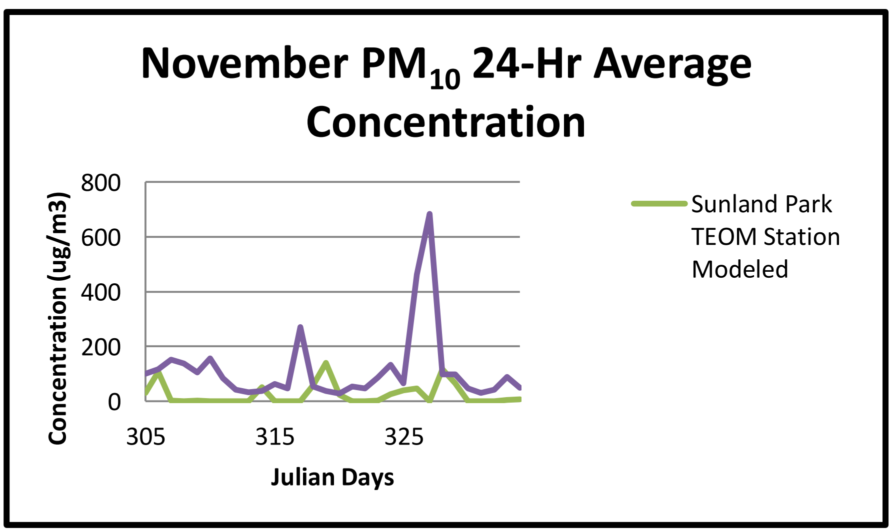

Figure 6-69. November PM_{10} 24-Hr Average Concentrations at Sunland Park TEOM Station.

During the month of November, the model run showed higher PM_{10} 24-hr average concentrations at the Desert View TEOM Station as compared to the other locations. Also, the Santa Teresa TEOM Station experienced extremely low PM_{10} 24-hr average concentrations. It could be concluded again that the southeasterly winds directed the majority of the emissions to the center of the city of Sunland Park where the Desert View TEOM Station is located. Figure 6-70 illustrates the modeled 24-hr average concentrations at the Desert View TEOM Station and the Santa Teresa TEOM Station in the month of November.

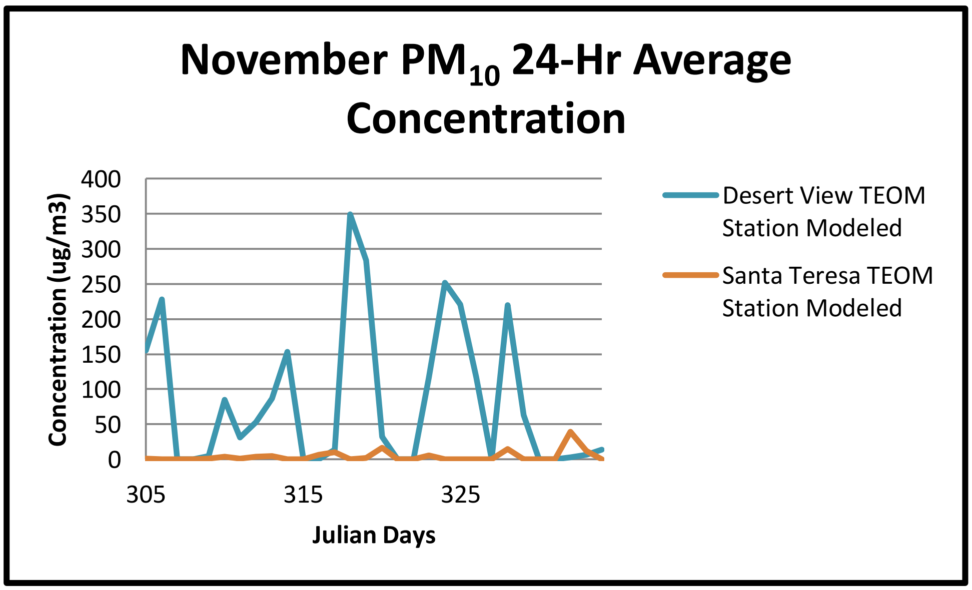

Figure 6-70. November PM_{10} 24-Hr Average Concentrations at Desert View and Santa Teresa TEOM Stations.

Table 6-34 shows the PM_{10} 24-hr average concentrations including the modeled and real data at the four different stations during the month of November.

Table 6-34. November PM_{10} 24-Hr. Average Concentrations in the Project Area.

	Concentration (ug/m3)					
	UTEP CAMS Station		Sunland Park TEOM Station		Desert View TEOM Station	Santa Teresa TEOM Station
Julian Day	Modeled	Real Data	Modeled	Real Data	Modeled	Modeled
305	0.0	70.9	30.4	100.7	154.7	1.4
306	14.6	45.9	108.0	116.4	227.8	0.0
307	46.7	177.8	3.5	151.9	0.0	0.0
308	32.4	36.4	0.0	137.0	0.0	0.0
309	34.0	58.2	3.1	104.8	4.9	0.6
310	0.0	73.8	0.9	155.8	84.5	4.1
311	0.0	28.2	0.0	84.9	31.1	0.9
312	0.3	25.7	1.0	42.4	52.5	3.8
313	0.0	19.2	0.0	32.0	87.0	4.4
314	36.3	39.0	50.7	37.3	152.9	0.1
315	36.3	34.0	0.4	63.8	0.0	0.0
316	0.0	56.0	0.0	46.1	0.1	6.3
317	0.0	111.6	0.0	270.1	13.8	10.2
318	11.6	34.5	58.6	54.1	349.2	0.0
319	36.2	44.5	140.4	37.0	283.6	1.5
320	41.8	36.1	24.4	28.7	32.1	16.1
321	49.7	42.9	0.5	52.9	0.0	0.0
322	1.6	43.9	0.1	46.5	0.3	0.0
323	0.6	66.4	1.8	87.5	116.4	5.7
324	0.1	46.5	24.7	133.8	251.7	0.0
325	18.6	48.8	39.7	65.8	221.1	0.0
326	7.8	1136.6	46.4	462.5	116.5	0.0
327	0.0	40.0	0.0	684.0	0.0	0.0
328	15.4	64.9	117.9	99.0	219.6	15.1
329	130.0	60.3	65.5	99.3	63.2	0.1
330	149.1	49.4	0.0	46.3	0.0	0.0
331	0.0	33.5	0.0	29.4	0.0	0.0
332	0.0	28.8	0.0	43.2	3.0	38.9
333	28.8	49.0	4.1	88.7	6.4	12.0
334	24.2	41.6	6.9	48.1	13.4	0.0

Figure 6-71 illustrates the PM_{10} hourly average modeled concentrations at the four different receptors and showed that the Desert View station had again the higher hourly average concentrations. It also shows that higher concentrations were experienced during the early and late hours of the day in a similar manner as in the month of October. Table 6-35 shows the results from Figure 6-71.

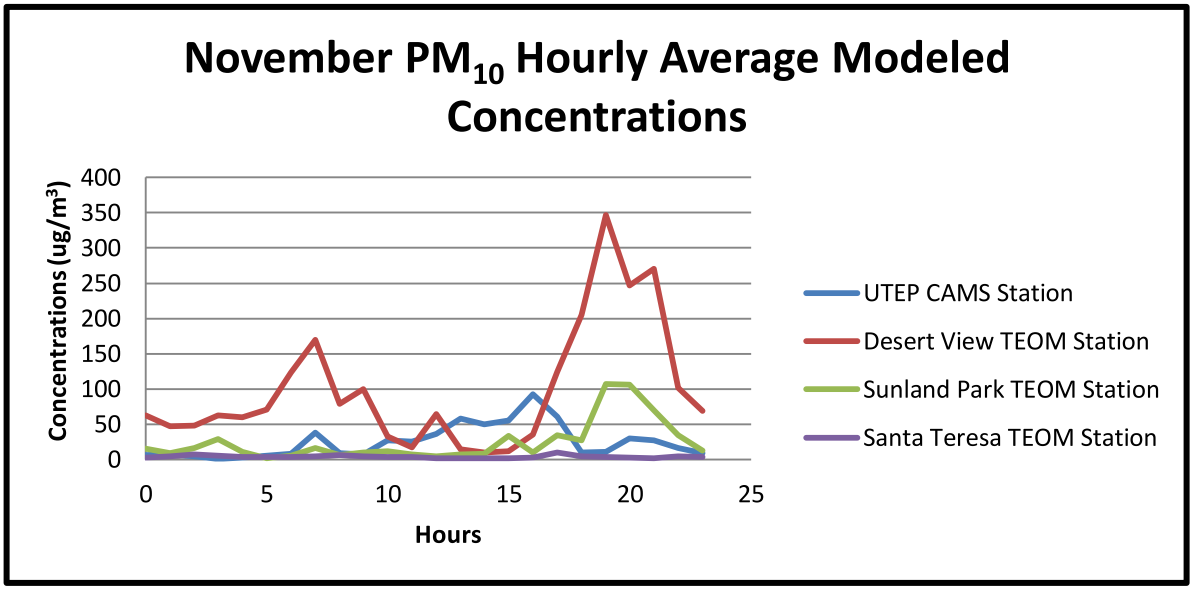

Figure 6-71. November PM_{10} Hourly Average Modeled Concentrations in the Project Area.

Table 6-35. November PM_{10} Hourly Average Modeled Concentrations in the Project Area.

	Concentration (μg/m³)			
Hours	UTEP CAMS Station	Desert View TEOM Station	Sunland Park TEOM Station	Santa Teresa TEOM Station
0	6	63	15	2
1	7	47	9	5
2	4	48	16	7
3	1	62	29	5
4	2	60	11	4
5	5	71	1	3
6	8	123	5	4
7	38	170	16	4
8	9	79	6	6
9	7	99	10	4
10	27	32	11	4
11	26	17	7	3
12	36	64	4	2
13	58	14	7	1
14	50	10	8	2
15	55	12	33	2
16	92	35	9	2
17	60	124	35	10
18	10	205	27	5
19	11	347	107	4
20	29	247	106	3

21	27	270	69	2
22	16	101	34	4
23	9	68	12	3

During the month of December, the peak hour concentration at UTEP CAMS Station was 736 µg/m^3 on Julian day 359th at 14:00 hrs., Desert View TEOM Station of 4,277µg/m^3 on Julian day 345th at 19:00 hrs., Sunland Park TEOM Station of 2,537 µg/m^3 on Julian day 340th at 18:00 hrs., and Santa Teresa TEOM Station of 353 µg/m^3 on Julian day 353nd at 20:00 hrs. The peak 24-hr concentration at UTEP CAMS Station was 157 µg/m^3 on Julian day 341st, Sunland Park TEOM Station of 304 µg/m^3 on Julian day 340th, Desert View of 822 µg/m^3 on Julian day 355th, and Santa Teresa TEOM Station of 33 µg/m^3 on Julian day 353nd. Southeasterly and northwesterly winds were predominant during these days.

Figure 6-72 presents the modeled and real data PM_{10} 24-hr average concentrations at the UTEP CAMS Station during the month of December. During this month, wind vectors varied in different directions but northwesterly winds were present approximately 20% of the time which directed the emissions to the UTEP CAMS Station. There was an extreme wind event that was not accounted by the CALPUFF model. It was estimated that Puerto Anapra could potentially contribute approximately 36% to the total PM_{10} concentration at the UTEP CAMS Station in the month of December when the extreme event was considered or 44% when the extreme even was not considered. This was very similar to the analysis in November.

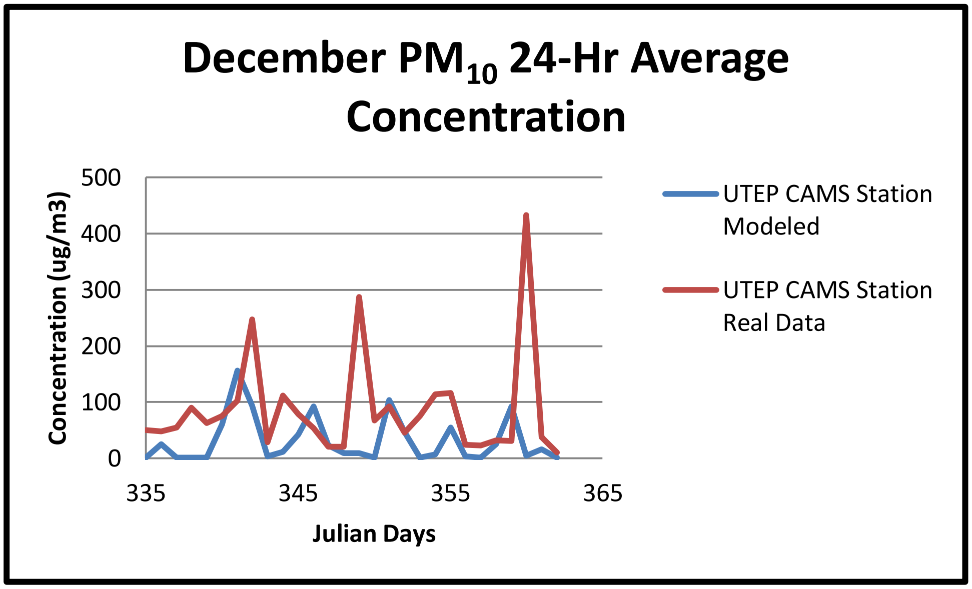

Figure 6-72. December PM_{10} 24-Hr Average Concentrations at UTEP CAMS Station.

Figure 6-73 illustrates the comparison of the modeled and real PM_{10} 24-hr average concentration at the Sunland Park TEOM Station. It was observed that the modeled concentrations exceeded the real data in one occasion at the beginning of the month. It was observed that when the concentrations were overestimated at the Sunland Park station, concentrations were underestimated at the UTEP CAMS Station. There was also an extreme wind event recorded at this location similarly to the event recorded at the UTEP CAMS Station, however, as previously mentioned, the CALPUFF model does not account for these event. According to the model run, this location could potentially receive approximately 48% PM_{10} contribution from Puerto Anapra during this month considering the extreme wind event or 53% if the extreme event was not considered.

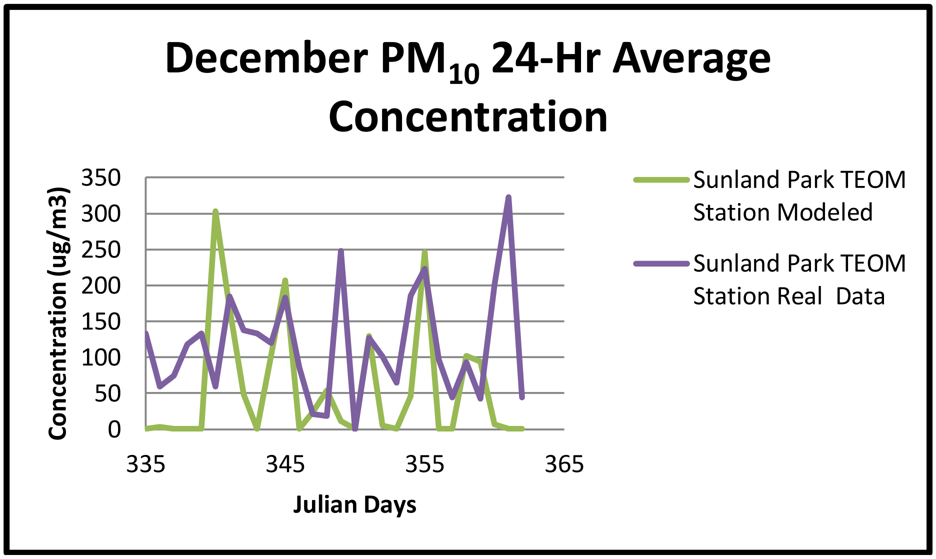

Figure 6-73. December PM_{10} 24-Hr Average Concentrations at Sunland Park TEOM Station.

During the month of December, the model run showed higher PM_{10} 24-hr average concentrations at the Desert View TEOM Station as compared to the other locations. Also, the Santa Teresa TEOM Station experienced extremely low PM_{10} 24-hr average concentrations. It could be concluded again that the southeasterly winds directed the majority of the emissions to the Desert View TEOM. Figure 6-74 illustrates the modeled 24-hr average concentrations at the Desert View TEOM Station and the Santa Teresa TEOM Station in the month of December.

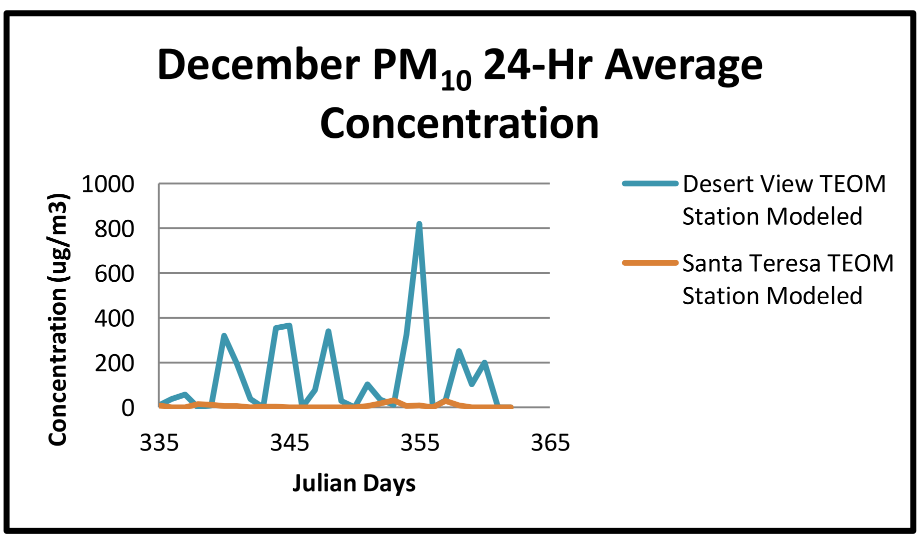

Figure 6-74. December PM_{10} 24-Hr Average Concentrations at Desert View and Santa Teresa TEOM Stations.

Table 6-36 shows the PM_{10} 24-hr average concentrations including the modeled and real data at the four different stations during the month of December.

Table 6-36. December PM_{10} 24-Hr. Average Concentrations in the Project Area.

	Concentration (ug/m3)					
	UTEP CAMS Station		Sunland Park TEOM Station		Desert View TEOM Station	Santa Teresa TEOM Station
Julian Day	Modeled	Real Data	Modeled	Real Data	Modeled	Modeled
335	0.2	50.2	0.0	133.6	8.6	10.7
336	25.4	48.0	3.5	59.4	37.1	0.0
337	0.0	54.4	0.0	74.4	58.0	1.6
338	0.2	90.3	0.4	118.1	1.7	16.4
339	0.0	63.2	0.0	133.1	9.8	12.7
340	60.1	75.4	303.6	59.3	320.1	6.4
341	156.8	102.2	168.7	184.6	196.4	7.2
342	93.5	246.9	49.0	137.3	38.7	0.0
343	3.4	28.4	0.5	132.8	0.6	3.3
344	11.4	111.8	102.6	120.1	354.9	3.3
345	42.5	78.8	206.8	182.7	367.7	1.1
346	92.9	54.1	0.0	86.1	0.0	0.0
347	22.9	20.7	23.6	21.2	79.3	0.0
348	9.4	20.7	54.2	18.6	341.2	0.1
349	9.0	287.8	11.0	248.4	30.2	0.0
350	0.1	67.6	0.0	0.0	0.6	2.3
351	104.2	92.6	129.4	127.0	102.8	5.5
352	46.6	46.0	5.0	101.4	34.5	18.6
353	0.0	75.0	0.0	64.7	13.5	32.6
354	6.6	113.5	46.2	185.8	325.7	5.8
355	54.6	115.9	246.6	223.4	821.7	9.9
356	3.3	24.2	0.0	96.5	0.0	0.0
357	0.0	22.8	0.0	44.5	31.3	29.4
358	25.4	32.0	102.4	93.0	253.8	10.4
359	92.7	31.3	94.3	42.7	102.9	0.0
360	5.1	432.9	6.7	200.7	201.6	0.0
361	15.6	37.5	0.0	322.7	0.0	0.0
362	0.7	10.5	0.0	43.9	0.0	0.0

Figure 6-75 illustrates the PM_{10} hourly average modeled concentrations at the four different receptors and showed that the Desert View station had again the higher hourly average concentrations. It also shows that high concentrations were experienced during the early hours but late hours experienced extremely high concentrations. Table 6-37 shows the results from Figure 6-75.

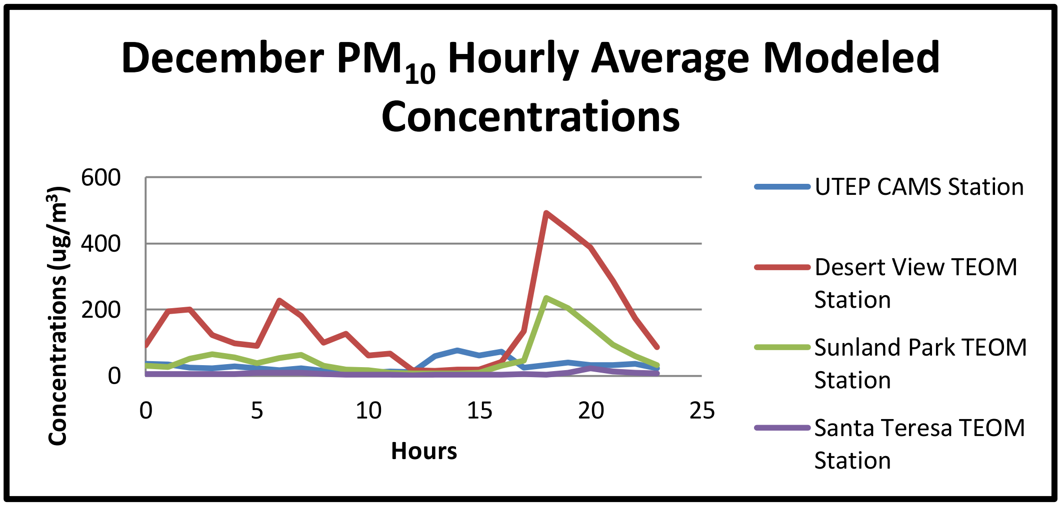

Figure 6-75. December PM_{10} Hourly Average Modeled Concentrations in the Project Area.

Table 6-37. December PM_{10} Hourly Average Modeled Concentrations in the Project Area.

	Concentration (μg/m³)			
Hours	UTEP CAMS Station	Desert View TEOM Station	Sunland Park TEOM Station	Santa Teresa TEOM Station
0	35	92	30	5
1	35	194	26	6
2	25	200	51	6
3	22	123	64	5
4	28	97	55	5
5	23	90	38	9
6	17	226	54	8
7	22	181	63	9
8	14	99	29	5
9	9	127	18	3
10	8	61	16	4
11	12	66	9	3
12	10	17	6	2
13	60	15	7	2
14	76	19	7	3
15	61	19	8	2
16	74	41	29	4
17	23	134	45	5
18	32	493	236	3
19	41	443	205	9
20	32	388	149	22
21	33	288	94	13

22	35	173	59	10
23	23	86	32	6

In comparison, the winter months, December, January and February, in addition to March had the highest PM_{10} hourly peak concentrations. The UTEP CAMS Station had the highest peak hour concentration during the month of March, the Desert View TEOM Station during January, theSunland Park TEOM Station in December, and the Santa Teresa TEOM Station in February. Again, February and December had the highest peak PM_{10} 24-hr average concentrations in the entire year. February had the highest concentration for the UTEP CAMS Station and the Santa Teresa TEOM Station, and December for the Sunland Park and Desert View TEOM Stations. The annual PM_{10} concentration average for the UTEP CAMS Station was 28 µg/m^3, for Sunland Park TEOM Station was 21 µg/m^3, for Desert View TEOM Station was 97 µg/m^3, and for Santa Teresa TEOM Station was 4 µg/m^3.

The results were compared to real time data observed at the air quality monitoring stations from the TCEQ and NMED. As illustrated in the following figures, the Desert View TEOM Station had the highest average PM_{10} concentrations the majority of the time. In addition, higher concentrations were experienced at later hours of the day.

Figure 6-76 illustrates the PM_{10} 24-hr average concentrations for the modeled and real data at the UTEP CAMS Station. Modeled data was overestimated in a few instances during the winter months were turbulent winds were experienced. This could conclude that output data from the CALMET model was significant for the accuracy of the CALPUFF model. In the monthly analysis, the majority of the discrepancies were attributed to variations of wind vectors in the model from the real data. Emissions were directed to different receptors when compared to the real data. In addition, the CALPUFF model did not account for extreme wind events and concentrations were underestimated as illustrated in figure 6-76. According to the model run, the UTEP CAMS Station could potentially receive approximately 48% PM_{10} contribution from Puerto Anapra annually. The PM_{10} 24-hr average concentration at this station was 28 µg/m^3 and 58 µg/m^3 for modeled and real data, respectively.

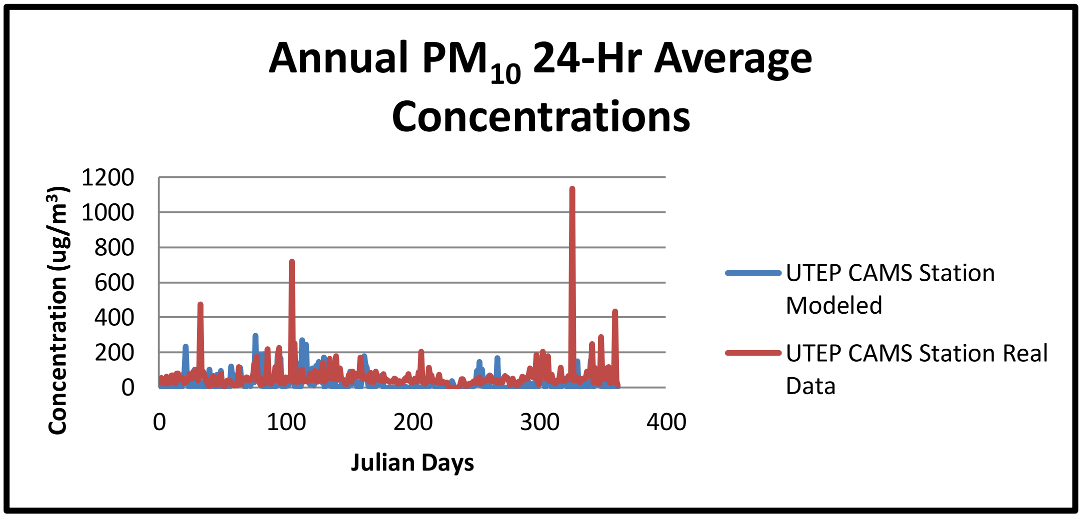

Figure 6-76. Annual PM_{10} 24-Hr Average Concentrations at UTEP CAMS Station.

Figure 6-77 illustrates the PM_{10} 24-hr average concentrations for the modeled and real data at the UTEP CAMS Station. Modeled data was overestimated in a few instances in January and December were turbulent winds were experienced. Again, this could conclude that output data from the CALMET model was significant for the accuracy of the CALPUFF model. Moreover, the CALPUFF model did not account for extreme wind events and concentrations were underestimated as illustrated in figure 6-77. According to the model run, the Sunland Park TEOM Station could potentially receive approximately 27% PM_{10} contribution from Puerto Anapra annually. The PM_{10} 24-hr average concentration at this station was 21 $\mu g/m^3$ and 78 $\mu g/m^3$ for modeled and real data, respectively.

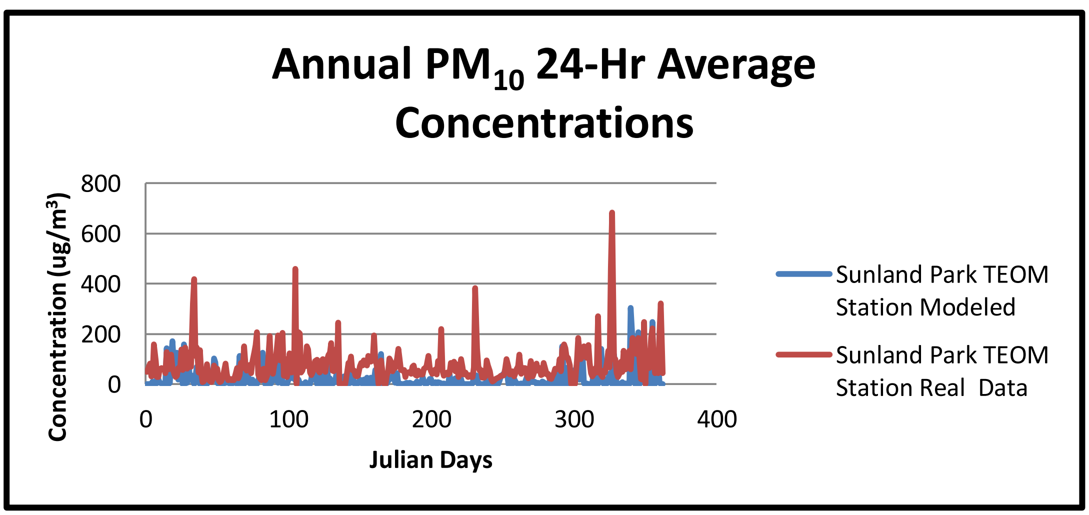

Figure 6-77. Annual PM_{10} 24-Hr Average Concentrations at Sunland Park TEOM Station.

Figure 6-78 illustrates the PM_{10} 24-hr average concentrations for the modeled and real data at the Desert View and Santa Teresa TEOM Station. The Desert View TEOM Station had the higher PM_{10} 24-hr average concentrations the majority of the time, resulting in an annual PM_{10} 24-hr average of 97 $\mu g/m^3$. The Desert View TEOM Station annual average was approximately 3.5 times greater than the average at the UTEP CAMS Station and 4.5 times at the Sunland Park TEOM Station.

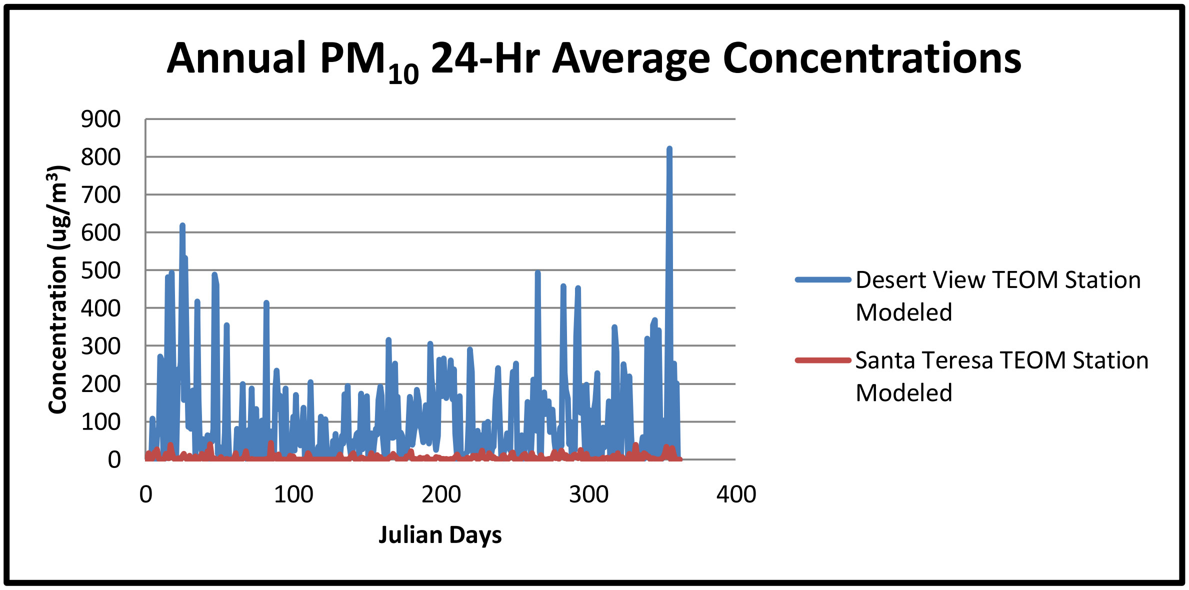

Figure 6-78. Annual PM_{10} 24-Hr Average Concentrations in Desert View and Santa Teresa TEOM Stations.

Figure 6-79 illustrates the annual PM_{10} hourly average modeled concentrations at the four different receptors and showed that the Desert View station had the higher hourly average concentrations the majority of the time. High concentrations were experienced in the morning and especially during night hours. This concurs with the observations by NMED where 1-hr average PM_{10} concentrations spiked in the evening hours (from 6:01 – 9:00 p.m. or within 1.5 hours after sunset) at Sunland Park. It has been observed that the spikes generally subside 4 to 5 hours after sunset (Cardenas, 2005).

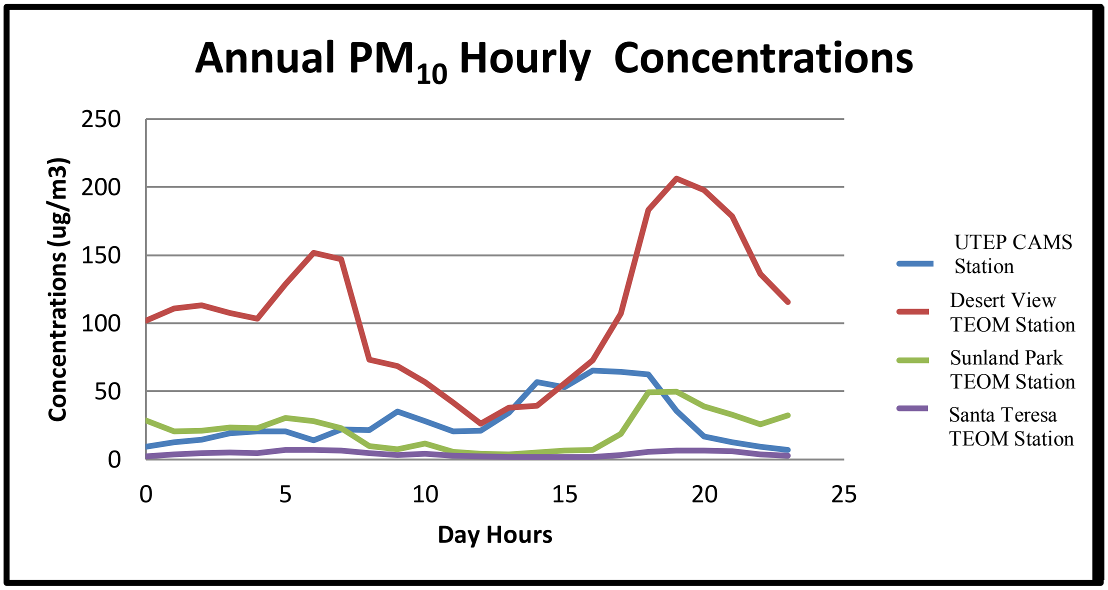

Figure 6-79. Annual PM_{10} Hourly Average Concentrations in Project Area.

7. Model Uncertainty

Modeling uncertainty is related to deviations between the real world and its simplified representation in models. When analyzing complex systems in real life, the comparison between the model and the existing conditions of the real life scenario never comply in an absolute sense. In most cases the question is whether the model can be accepted in spite of infringing one or more of the conditions supporting the model.

The proposed model includes several educated assumptions based on the scope of the work and the capabilities of the CALPUFF model, that helped determine the direct impact on air quality to Sunland Park, NM from the Puerto Anapra Subdivision. To understand the direct impact on air quality from Puerto Anapra, the study included only the unpaved roads and wind erosion from Anapra as the source of PM for Sunland Park, NM. Therefore, the comparison of PM concentrations between real data and modeled data was not exactly comparable. In this case, the modeled concentration results involved only the sources of unpaved roads and wind erosion from the Anapra Subdivision and neglected other surrounding area sources. Therefore, for the most part, real data exceeded modeled data results.

Moreover, this study utilized meteorological data (MM5 input files) developed by the WRAP RMC. Wind direction from the modeled data was not particularly similar to the real data in all cases; therefore, emission concentrations were higher in model results when a significant discrepancy of wind direction between modeled and real data was present.

8. Conclusions

The Paso del Norte Airshed has failed to meet NAAQS for PM_{10} in the past. It has been mentioned that PM, particularly from upaved roads in Cd. Juarez, can contribute significantly to the air pollution in Sunland Park, NM and El Paso, TX. Given that Puerto Anapra Subdivision is one of the areas in Cd. Juarez that abuts directly to these cities and is basically unpaved, the impacts to the Sunland Park's air quality from Puerto Anapra's wind erosion and unpaved roads need study.

The simulation of the spatial and temporal evolution of PM_{10} concentrations predicted with the CALMET/CALPUFF modeling system showed reasonable agreement with the real time data measurements obtained from the TCEQ's and NMED's air quality monitoring stations. The CALMET/CALPUFF modeling work complemented the observations data by allowing further insight into the wind blown mechanism at the Paso del Norte Airshed. CALPUFF provided reasonably accurate estimates of the pattern of long-term average deposition of particulate matter in the near-field under complex terrain and wind conditions.

The study showed that according to the CALMET wind field plot results, southeasterly winds were predominant throughout the year, showing that in the study area, winds flow from Puerto Anapra to Sunland Park the majority of the time. The annual wind rose modeled that 17% of the winds were southeasterly, 12% were east southeasterly, 11% were easterly, 11% were northerly, and 10% were north northwesterly predominantly ranging from 1 to 12 mph. During the winter months, January, February and December, northerly winds were predominantly 16% of the time, followed by southeasterly at 14% and north northwesterly at 12%. During the spring season, March, April, May, north northwesterly and westerly winds were predominant at 15% respectively, followed by northerly winds at 12% of the time and southeasterly at 11%. Summer and fall seasons had a similar wind behavior; both seasons had predominant easterly, east southeasterly, and southeasterly winds. The predominant winds speeds on these seasons were from 1 to 12 mph. Hourly data shows that during hours 1 to 6, winds were predominantly easterly, east southeasterly, and southeasterly, followed by northerly winds at speeds from 1 to 12 mph. Then, hours 7 to 12, showed winds again the same predominant winds but this time followed by north northwesterly winds at the same speeds. Hourly period from 13 to 18 had predominantly westerly winds 18% of the time at 1 to 12 mph. The last day period from hours 19

to 24, had easterly, east southeasterly, and southeasterly predominant winds again followed by north northwesterly and northerly winds.

It was observed that the wind vectors had a significant impact on the modeled concentrations as expected, which directed the emissions to the different receptions/stations. Given that the southeasterly winds were predominant throughout the year; the Desert View TEOM Stations was the most susceptible followed by the UTEP CAMS Station when westerly winds were present. These results concurred with the conclusion made in a previous study conducted by the University of Texas at El Paso, where the time-resolved wind rose plots at the Sunland Park, University of Texas at El Paso, and Sun Metro Station showed that high PM was primarily associated with low winds from a common source area located to the south the city of Sunland Park, NM.

In addition, this study determined the time during the day and months that had the highest 24-hr and hourly PM_{10} concentrations. According to the results, highest concentrations were experienced at night hours which may be caused by the formation of the inversion layer and the accumulation of local emissions in the evening. Also, it was noticeable that PM_{10} concentrations varied in a high degree at the different receptors. For instance, the Santa Teresa TEOM Station experienced minimal PM_{10} concentrations, where at the Desert View TEOM Station had outstanding concentrations at less than a 10 mile difference. This information established that the Desert View TEOM Station was more susceptible to Anapra than the other Receptors. This information could be useful to take mitigation measurements if similar patterns present in the future.

In comparison, the winter months, December, January and February, in addition to March had the highest PM_{10} hourly peak concentrations. The UTEP CAMS Station had the highest peak hour concentration during the month of March, the Desert View TEOM Station during January, the Sunland Park TEOM Station in December, and the Santa Teresa TEOM Station in February. Again, February and December had the highest peak PM_{10} 24-hr average concentrations in the entire year. February had the highest concentration for the UTEP CAMS Station and the Santa Teresa TEOM Station, and December for the Sunland Park and Desert View TEOM Stations. This work also assisted to determine the percent of contribution to air pollution in Sunland Park from Puerto Anapra. Based on the estimated wind erosion and unpaved roads modeled emissions, the Desert View TEOM Station located at the center of

Sunland Park, had the highest annual PM_{10} average concentration of 97 $\mu g/m^3$. Subsequently, the UTEP CAMS Station had the second highest annual PM_{10} average concentration of 28 $\mu g/m^3$ which was approximately 48% of the total annual PM_{10} average concentration from the real data (58 $\mu g/m^3$). The Sunland Park TEOM Station had the third highest annual PM_{10} average concentration of 21.4 $\mu g/m^3$ which was approximately 27.4% of the total annual PM_{10} average concentration from the real data (78 $\mu g/m^3$). Last, the Santa Teresa TEOM Station had the lowest estimate of 4 $\mu g/m^3$ when compared to the other stations.

Although this work constitutes an advanced on the regional air quality problem due to wind erosion, more work is still to be needed on this undeveloped area. More divisions of unpaved areas could be implemented to provide better estimates. Also, field measurements specifically for this area should be conducted for soil dust parameters, including threshold velocity, erodibility rank, soil cover, surface roughness, water content and aerodynamic surface roughness. It is suggested that CALPUFF should include a field to control emissions based on wind speed.

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Glossary

Anapra – Colonia Puerto Anapra, National Association of Farmers

AQB – Air Quality Bureau

BECC – Border Environment Cooperation Commission

Cd. – Ciudad (City)

CDPHE – Colorado Department of Public Health and Environment

CTGCOMP – Geophysical Data Pre-processor

CTGPROG – Land Use Pre-processor

EPA – U.S. Environmental Protection Agency

GUI – Graphical User Interface

MAKEGEO – Geophysical File

MM5 – Mesoscale Model

NAAQS – National Ambien Air Quality Standards

NEAP – Natural Events Action Plan

NEP – Natural Events Policy

NCEP - National Centers for Environmental prediction

NMED – New Mexico Environmental Department

NOOOBS - No-Observations

PdNA – Paso del Norte Airshed

PM_{10} - Particulate matter of 10 micrometers (µm) in aerodynamic diameter or smaller

RMC – Regional Modeling Center

TCEQ – Texas Commission on Environmental Quality

TERRAD – Radius of Influence of Terrain Features

TERREL – Terrain Pre-processor

WRAP – Western Regional Air Partnership

WRF – Weather Research and Forecasting

µm - micrometer

Appendix A – Wind Rose Report

WIND.FRQ 2.3 CALWindRose FRQ File Format

3 - Comment records

Created by METSERIES (Version 1.76, Level 100222) on 11-Apr-2011 at 13:21:40

User requested: (X,Y)km=(-904.340 -857.320) in LCC Projection below

Interpolated to: (X,Y)km=(-904.340 -857.320) in LCC Projection below

5 - Number of text-based header records

JANUARY WIND ROSE

CALMET.DAT: Interpolated to [(I,J)=(21.160, 28.180)])][(X,Y)km=(-904.340, -857.320) in MODEL Projection]

Height: 10.00 m

Wind Speed Classes (m/s): 5.0E-01, 0.5, 1.8, 3.3, 5.4, 8.5, 10.8

2003 1 1 1 0000 2003 2 1 0 0000 UTC-0700

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	8.871%	7.527%	0.806%	0.000%	0.000%	0.000%	17.204%
NNE:	2.151%	2.688%	0.538%	0.000%	0.000%	0.000%	5.376%
NE :	1.478%	2.285%	2.285%	0.000%	0.000%	0.000%	6.048%
ENE:	0.806%	4.032%	4.435%	0.000%	0.000%	0.000%	9.274%
E :	2.151%	4.435%	1.613%	1.075%	0.269%	0.000%	9.543%
ESE:	3.360%	4.301%	1.478%	0.000%	0.000%	0.000%	9.140%
SE :	9.140%	2.419%	1.075%	0.000%	0.000%	0.000%	12.634%
SSE:	2.285%	1.075%	0.134%	0.000%	0.000%	0.000%	3.495%
S :	0.134%	0.269%	0.000%	0.000%	0.000%	0.000%	0.403%
SSW:	0.403%	0.134%	0.000%	0.000%	0.000%	0.000%	0.538%
SW :	0.000%	0.000%	0.134%	0.000%	0.000%	0.000%	0.134%
WSW:	0.000%	0.538%	0.403%	0.134%	0.000%	0.000%	1.075%
W :	0.134%	0.806%	1.747%	0.941%	0.000%	0.000%	3.629%
WNW:	0.134%	2.285%	0.403%	0.806%	0.000%	0.000%	3.629%
NW :	1.613%	1.747%	0.134%	0.000%	0.000%	0.000%	3.495%
NNW:	5.108%	2.419%	1.882%	0.269%	0.000%	0.000%	9.677%
SUM:	37.769%	36.962%	17.070%	3.226%	0.269%	0.000%	95.296%

Calm Winds: 4.704%

Total Periods = 744; Valid Periods = 744; Calm Wind Periods = 35

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	14.516%	11.828%	1.613%	0.000%	0.000%	0.000%	27.957%
NNE:	2.151%	5.376%	1.613%	0.000%	0.000%	0.000%	9.140%
NE :	1.075%	1.075%	3.763%	0.000%	0.000%	0.000%	5.914%
ENE:	0.538%	6.452%	8.065%	0.000%	0.000%	0.000%	15.054%
E :	2.151%	4.301%	3.763%	0.000%	0.000%	0.000%	10.215%
ESE:	4.301%	4.839%	0.538%	0.000%	0.000%	0.000%	9.677%
SE :	10.215%	0.538%	0.000%	0.000%	0.000%	0.000%	10.753%
SSE:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
S :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SSW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SW :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
WSW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
W :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
WNW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NW :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NNW:	0.000%	3.763%	0.000%	0.000%	0.000%	0.000%	3.763%
SUM:	34.946%	38.172%	19.355%	0.000%	0.000%	0.000%	92.473%

Calm Winds: 7.527%

Total Periods = 186; Valid Periods = 186; Calm Wind Periods = 14

HR07-12

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	5.914%	4.839%	1.075%	0.000%	0.000%	0.000%	11.828%
NNE:	4.839%	1.075%	0.000%	0.000%	0.000%	0.000%	5.914%
NE :	2.151%	1.075%	0.000%	0.000%	0.000%	0.000%	3.226%
ENE:	0.000%	5.376%	4.301%	0.000%	0.000%	0.000%	9.677%
E :	1.613%	4.839%	1.075%	1.075%	0.538%	0.000%	9.140%
ESE:	1.613%	3.763%	0.000%	0.000%	0.000%	0.000%	5.376%
SE :	5.376%	2.688%	2.151%	0.000%	0.000%	0.000%	10.215%
SSE:	4.839%	3.763%	0.538%	0.000%	0.000%	0.000%	9.140%

S :	0.000%	1.075%	0.000%	0.000%	0.000%	0.000%	1.075%
SSW:	1.075%	0.538%	0.000%	0.000%	0.000%	0.000%	1.613%
SW :	0.000%	0.000%	0.538%	0.000%	0.000%	0.000%	0.538%
WSW:	0.000%	0.538%	1.613%	0.538%	0.000%	0.000%	2.688%
W :	0.000%	0.000%	1.075%	1.075%	0.000%	0.000%	2.151%
WNW:	0.000%	0.000%	0.538%	0.538%	0.000%	0.000%	1.075%
NW :	3.226%	1.613%	0.000%	0.000%	0.000%	0.000%	4.839%
NNW:	9.677%	3.763%	2.151%	0.538%	0.000%	0.000%	16.129%
SUM:	40.323%	34.946%	15.054%	3.763%	0.538%	0.000%	94.624%

Calm Winds: 5.376%

Total Periods = 186; Valid Periods = 186; Calm Wind Periods = 10

HR13-18

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	3.763%	3.763%	0.000%	0.000%	0.000%	0.000%	7.527%
NNE:	0.538%	1.613%	0.000%	0.000%	0.000%	0.000%	2.151%
NE :	2.688%	0.538%	0.000%	0.000%	0.000%	0.000%	3.226%
ENE:	2.688%	1.613%	0.538%	0.000%	0.000%	0.000%	4.839%
E :	3.226%	2.688%	0.000%	2.688%	0.538%	0.000%	9.140%
ESE:	1.613%	2.688%	2.151%	0.000%	0.000%	0.000%	6.452%
SE :	2.688%	2.151%	2.151%	0.000%	0.000%	0.000%	6.989%
SSE:	4.301%	0.538%	0.000%	0.000%	0.000%	0.000%	4.839%
S :	0.538%	0.000%	0.000%	0.000%	0.000%	0.000%	0.538%
SSW:	0.538%	0.000%	0.000%	0.000%	0.000%	0.000%	0.538%
SW :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
WSW:	0.000%	1.613%	0.000%	0.000%	0.000%	0.000%	1.613%
W :	0.538%	3.226%	5.914%	2.688%	0.000%	0.000%	12.366%
WNW:	0.538%	9.140%	1.075%	2.688%	0.000%	0.000%	13.441%
NW :	3.226%	5.376%	0.538%	0.000%	0.000%	0.000%	9.140%
NNW:	10.753%	1.075%	2.688%	0.538%	0.000%	0.000%	15.054%
SUM:	37.634%	36.022%	15.054%	8.602%	0.538%	0.000%	97.849%

Calm Winds: 2.151%

Total Periods = 186; Valid Periods = 186; Calm Wind Periods = 4

HR19-00

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	11.290%	9.677%	0.538%	0.000%	0.000%	0.000%	21.505%
NNE:	1.075%	2.688%	0.538%	0.000%	0.000%	0.000%	4.301%
NE :	0.000%	6.452%	5.376%	0.000%	0.000%	0.000%	11.828%
ENE:	0.000%	2.688%	4.839%	0.000%	0.000%	0.000%	7.527%
E :	1.613%	5.914%	1.613%	0.538%	0.000%	0.000%	9.677%
ESE:	5.914%	5.914%	3.226%	0.000%	0.000%	0.000%	15.054%
SE :	18.280%	4.301%	0.000%	0.000%	0.000%	0.000%	22.581%
SSE:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
S :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SSW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SW :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
WSW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
W :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
WNW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NW :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NNW:	0.000%	1.075%	2.688%	0.000%	0.000%	0.000%	3.763%
SUM:	38.172%	38.710%	18.817%	0.538%	0.000%	0.000%	96.237%

Calm Winds: 3.763%

Total Periods = 186; Valid Periods = 186; Calm Wind Periods = 7

WIND.FRQ 2.3 CALWindRose FRQ File Format
3 - Comment records
Created by METSERIES (Version 1.76, Level 100222) on 11-Apr-2011 at 13:23:56
User requested: (X,Y)km=(-904.340 -857.320) in LCC Projection below
Interpolated to: (X,Y)km=(-904.340 -857.320) in LCC Projection below
5 - Number of text-based header records

FEBRUARY WIND ROSE

CALMET.DAT: Interpolated to [(I,J)=(21.160, 28.180)])][(X,Y)km=(-904.340, -857.320) in MODEL Projection]
Height: 10.00 m
Wind Speed Classes (m/s): 5.0E-01, 0.5, 1.8, 3.3, 5.4, 8.5, 10.8
2003 2 1 1 0000 2003 3 1 0 0000 UTC-0700

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	3.720%	10.714%	0.744%	0.000%	0.000%	0.000%	15.179%
NNE:	1.339%	1.488%	0.744%	0.000%	0.000%	0.000%	3.571%
NE :	1.786%	1.339%	1.339%	0.000%	0.000%	0.000%	4.464%
ENE:	1.339%	1.190%	0.298%	0.000%	0.000%	0.000%	2.827%
E :	0.893%	1.339%	2.679%	0.893%	0.000%	0.000%	5.804%
ESE:	0.893%	1.042%	5.208%	1.190%	0.000%	0.000%	8.333%
SE :	7.143%	6.399%	2.381%	0.000%	0.000%	0.000%	15.923%
SSE:	1.339%	1.190%	0.000%	0.000%	0.000%	0.000%	2.530%
S :	0.446%	0.893%	0.000%	0.000%	0.000%	0.000%	1.339%
SSW:	0.000%	0.595%	0.446%	0.000%	0.000%	0.000%	1.042%
SW :	0.893%	1.042%	0.298%	0.000%	0.000%	0.000%	2.232%
WSW:	0.149%	1.786%	1.190%	1.339%	0.446%	0.149%	5.060%
W :	0.149%	0.893%	2.381%	3.720%	0.298%	0.000%	7.440%
WNW:	0.298%	1.190%	1.339%	1.042%	0.000%	0.000%	3.869%
NW :	0.595%	1.339%	1.190%	0.595%	0.000%	0.000%	3.720%
NNW:	3.571%	4.018%	6.399%	0.000%	0.000%	0.000%	13.988%
SUM:	24.554%	36.458%	26.637%	8.780%	0.744%	0.149%	97.321%

Calm Winds: 2.679%
Total Periods = 672; Valid Periods = 672; Calm Wind Periods = 18

HR01-06

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	5.952%	25.595%	0.000%	0.000%	0.000%	0.000%	31.548%

NNE:	0.595%	2.381%	0.595%	0.000%	0.000%	0.000%	3.571%
NE :	2.381%	2.381%	0.595%	0.000%	0.000%	0.000%	5.357%
ENE:	2.976%	0.595%	0.000%	0.000%	0.000%	0.000%	3.571%
E :	1.190%	1.190%	5.357%	2.381%	0.000%	0.000%	10.119%
ESE:	1.786%	0.595%	4.167%	2.976%	0.000%	0.000%	9.524%
SE :	14.286%	8.333%	1.786%	0.000%	0.000%	0.000%	24.405%
SSE:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
S :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SSW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SW :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
WSW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
W :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
WNW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NW :	0.000%	1.786%	0.000%	0.000%	0.000%	0.000%	1.786%
NNW:	0.595%	3.571%	4.167%	0.000%	0.000%	0.000%	8.333%
SUM:	29.762%	46.429%	16.667%	5.357%	0.000%	0.000%	98.214%

Calm Winds: 1.786%
Total Periods = 168; Valid Periods = 168; Calm Wind Periods = 3

HR07-12

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	4.167%	5.357%	0.000%	0.000%	0.000%	0.000%	9.524%
NNE:	3.571%	0.000%	0.000%	0.000%	0.000%	0.000%	3.571%
NE :	2.976%	1.190%	0.000%	0.000%	0.000%	0.000%	4.167%
ENE:	1.190%	0.595%	0.000%	0.000%	0.000%	0.000%	1.786%
E :	1.786%	1.786%	0.000%	1.190%	0.000%	0.000%	4.762%
ESE:	1.190%	1.786%	7.143%	1.190%	0.000%	0.000%	11.310%
SE :	3.571%	3.571%	1.786%	0.000%	0.000%	0.000%	8.929%
SSE:	3.571%	2.381%	0.000%	0.000%	0.000%	0.000%	5.952%
S :	0.595%	0.000%	0.000%	0.000%	0.000%	0.000%	0.595%
SSW:	0.000%	0.595%	0.000%	0.000%	0.000%	0.000%	0.595%

SW :	1.786%	1.190%	0.595%	0.000%	0.000%	0.000%	3.571%
WSW:	0.000%	0.595%	0.595%	1.786%	0.000%	0.000%	2.976%
W :	0.000%	0.595%	4.167%	2.976%	0.000%	0.000%	7.738%
WNW:	0.000%	0.000%	4.167%	1.786%	0.000%	0.000%	5.952%
NW :	1.190%	2.976%	4.167%	0.000%	0.000%	0.000%	8.333%
NNW:	7.143%	7.143%	2.381%	0.000%	0.000%	0.000%	16.667%
SUM:	32.738%	29.762%	25.000%	8.929%	0.000%	0.000%	96.429%

Calm Winds: 3.571%
Total Periods = 168; Valid Periods = 168; Calm Wind Periods = 6

HR13-18

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	1.190%	2.381%	0.000%	0.000%	0.000%	0.000%	3.571%
NNE:	0.595%	3.571%	0.595%	0.000%	0.000%	0.000%	4.762%
NE :	0.000%	0.595%	0.000%	0.000%	0.000%	0.000%	0.595%
ENE:	0.000%	0.000%	0.595%	0.000%	0.000%	0.000%	0.595%
E :	0.000%	1.190%	2.381%	0.000%	0.000%	0.000%	3.571%
ESE:	0.000%	0.595%	2.976%	0.000%	0.000%	0.000%	3.571%
SE :	0.000%	0.595%	0.000%	0.000%	0.000%	0.000%	0.595%
SSE:	1.786%	0.595%	0.000%	0.000%	0.000%	0.000%	2.381%
S :	1.190%	3.571%	0.000%	0.000%	0.000%	0.000%	4.762%
SSW:	0.000%	1.786%	1.786%	0.000%	0.000%	0.000%	3.571%
SW :	1.786%	2.976%	0.595%	0.000%	0.000%	0.000%	5.357%
WSW:	0.595%	6.548%	4.167%	3.571%	1.786%	0.595%	17.262%
W :	0.595%	2.976%	5.357%	11.905%	1.190%	0.000%	22.024%
WNW:	1.190%	4.762%	1.190%	2.381%	0.000%	0.000%	9.524%
NW :	1.190%	0.595%	0.595%	2.381%	0.000%	0.000%	4.762%
NNW:	5.952%	1.190%	2.381%	0.000%	0.000%	0.000%	9.524%
SUM:	16.071%	33.929%	22.619%	20.238%	2.976%	0.595%	96.429%

Calm Winds: 3.571%
Total Periods = 168; Valid Periods = 168; Calm Wind Periods = 6

HR19-00

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	3.571%	9.524%	2.976%	0.000%	0.000%	0.000%	16.071%
NNE:	0.595%	0.000%	1.786%	0.000%	0.000%	0.000%	2.381%
NE :	1.786%	1.190%	4.762%	0.000%	0.000%	0.000%	7.738%
ENE:	1.190%	3.571%	0.595%	0.000%	0.000%	0.000%	5.357%
E :	0.595%	1.190%	2.976%	0.000%	0.000%	0.000%	4.762%
ESE:	0.595%	1.190%	6.548%	0.595%	0.000%	0.000%	8.929%
SE :	10.714%	13.095%	5.952%	0.000%	0.000%	0.000%	29.762%
SSE:	0.000%	1.786%	0.000%	0.000%	0.000%	0.000%	1.786%
S :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SSW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SW :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
WSW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
W :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
WNW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NW :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NNW:	0.595%	4.167%	16.667%	0.000%	0.000%	0.000%	21.429%
SUM:	19.643%	35.714%	42.262%	0.595%	0.000%	0.000%	98.214%

Calm Winds: 1.786%

Total Periods = 168; Valid Periods = 168; Calm Wind Periods = 3

WIND.FRQ2.3 CALWindRose FRQ File Format
3 - Comment records
Created by METSERIE S (Version 1. "76, Level 100" 222) on 11-Apr -2011 at 13
:26:17
User requested: ("X,Y) km=(-904.340 -857.3 20) in LCC Projection below
Interpolated to: ("X,Y) km=(-904.340 -857.3 20) in LCC Projection below
5 - Number of text-based header records
MARCH WIND ROSE
CALMET.D AT: Interpo"lated to [(I," J)=(21.160 ", 28.180)])]"
"[(X,Y) km=("-904.340,-"857.320) in MO DEL Projection]
Height: 10.00 m
Wind Speed Classes(m/s): 5.0E-"01, 0.5, 1." "8, 3.3, 5.4,""8.5, 10.8"
2003 31 1 0000 2003 4 10 0000 UTC- 700

Miles per Hour

Wind Direction	1 - 4	4 - 7.3	7.3 - 12	12 - 19	19 - 24	> 24	SUM
N :	7.93%	9.41%	1.08%	0.13%	0.00%	0.00%	18.55%
NNE:	1.08%	0.81%	0.81%	0.27%	0.00%	0.00%	2.96%
NE :	0.81%	0.54%	0.81%	0.40%	0.00%	0.00%	2.55%
ENE:	0.94%	1.61%	0.27%	0.67%	0.00%	0.00%	3.50%
E :	0.94%	2.42%	2.29%	1.21%	0.00%	0.00%	6.86%
ESE:	0.81%	1.61%	1.21%	0.54%	0.00%	0.00%	4.17%
SE :	5.65%	5.78%	0.40%	0.00%	0.00%	0.00%	11.83%
SSE:	2.29%	1.08%	0.13%	0.00%	0.00%	0.00%	3.50%
S :	0.40%	0.27%	0.00%	0.00%	0.00%	0.00%	0.67%
SSW:	0.13%	0.00%	0.00%	0.00%	0.00%	0.00%	0.13%
SW :	0.40%	0.27%	0.00%	0.00%	0.00%	0.00%	0.67%
WSW:	0.13%	2.15%	0.27%	0.67%	0.00%	0.00%	3.23%
W :	0.13%	2.82%	4.17%	3.09%	2.15%	0.40%	12.77%
WNW:	0.00%	1.61%	3.50%	2.15%	1.61%	0.00%	8.87%
NW :	0.67%	1.88%	1.08%	0.00%	0.00%	0.00%	3.63%
NNW:	2.55%	1.88%	7.80%	1.21%	0.00%	0.00%	13.44%
SUM:	24.87%	34.14%	23.79%	10.35%	3.76%	0.40%	97.31%

Calm Winds: 2.69%
Total Periods = 7 44; Valid Periods = 744 ; Calm Wind Periods = 20

HR01-06

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	20.43%	20.97%	0.00%	0.00%	0.00%	0.00%	41.40%
NNE:	1.08%	3.23%	0.54%	0.00%	0.00%	0.00%	4.84%
NE :	0.54%	1.08%	2.69%	1.08%	0.00%	0.00%	5.38%
ENE:	0.00%	3.23%	0.54%	2.15%	0.00%	0.00%	5.91%
E :	0.00%	3.23%	2.69%	0.00%	0.00%	0.00%	5.91%
ESE:	2.69%	1.61%	2.15%	0.00%	0.00%	0.00%	6.45%
SE :	9.14%	4.84%	0.00%	0.00%	0.00%	0.00%	13.98%
SSE:	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
S :	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
SSW:	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
SW :	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
WSW:	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
W :	0.00%	1.08%	0.00%	0.00%	0.00%	0.00%	1.08%
WNW:	0.00%	0.00%	1.08%	0.00%	0.00%	0.00%	1.08%
NW :	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
NNW:	0.00%	0.00%	9.68%	1.61%	0.00%	0.00%	11.29%
SUM:	33.87%	39.25%	19.36%	4.84%	0.00%	0.00%	97.31%

Calm Win ds: 2.688 %

Total Periods =   1   86; Valid Periods = 186; Calm Wind Periods =5

HR07-12

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	4.30%	4.30%	0.54%	0.00%	0.00%	0.00%	9.14%
NNE:	2.69%	0.00%	0.00%	0.00%	0.00%	0.00%	2.69%
NE :	1.08%	1.08%	0.00%	0.00%	0.00%	0.00%	2.15%
ENE:	1.61%	1.08%	0.00%	0.54%	0.00%	0.00%	3.23%
E :	1.61%	5.38%	1.08%	2.69%	0.00%	0.00%	10.75%
ESE:	0.00%	2.15%	0.00%	0.00%	0.00%	0.00%	2.15%
SE :	1.08%	1.08%	0.54%	0.00%	0.00%	0.00%	2.69%
SSE:	7.53%	1.08%	0.54%	0.00%	0.00%	0.00%	9.14%
S :	1.08%	0.00%	0.00%	0.00%	0.00%	0.00%	1.08%
SSW:	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
SW :	1.08%	0.00%	0.00%	0.00%	0.00%	0.00%	1.08%
WSW:	0.00%	1.08%	0.00%	1.08%	0.00%	0.00%	2.15%
W :	0.00%	2.15%	4.84%	6.99%	5.38%	0.00%	19.36%
WNW:	0.00%	1.08%	3.23%	1.61%	1.08%	0.00%	6.99%
NW :	2.69%	3.76%	3.76%	0.00%	0.00%	0.00%	10.22%
NNW:	6.45%	4.30%	2.15%	0.54%	0.00%	0.00%	13.44%
SUM:	31.18%	28.50%	16.67%	13.44%	6.45%	0.00%	96.24%

Calm Win   ds: 3.763   %

Total Periods =   186; Valid Periods =   186 ; Calm Wind Periods =7

HR13-18

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	0.54%	0.54%	1.08%	0.00%	0.00%	0.00%	2.15%
NNE:	0.54%	0.00%	0.00%	0.00%	0.00%	0.00%	0.54%
NE :	1.61%	0.00%	0.54%	0.00%	0.00%	0.00%	2.15%
ENE:	0.00%	0.54%	0.00%	0.00%	0.00%	0.00%	0.54%
E :	0.00%	0.54%	1.61%	0.54%	0.00%	0.00%	2.69%
ESE:	0.00%	1.08%	0.54%	0.54%	0.00%	0.00%	2.15%
SE :	2.69%	0.54%	0.00%	0.00%	0.00%	0.00%	3.23%
SSE:	1.61%	2.69%	0.00%	0.00%	0.00%	0.00%	4.30%
S :	0.54%	1.08%	0.00%	0.00%	0.00%	0.00%	1.61%
SSW:	0.54%	0.00%	0.00%	0.00%	0.00%	0.00%	0.54%
SW :	0.54%	1.08%	0.00%	0.00%	0.00%	0.00%	1.61%
WSW:	0.00%	6.99%	1.08%	1.61%	0.00%	0.00%	9.68%
W :	0.00%	7.53%	11.83%	5.38%	3.23%	1.61%	29.57%
WNW:	0.00%	4.30%	8.60%	6.45%	5.38%	0.00%	24.73%
NW :	0.00%	3.76%	0.00%	0.00%	0.00%	0.00%	3.76%
NNW:	3.76%	2.15%	3.23%	0.00%	0.00%	0.00%	9.14%
SUM:	12.37%	32.80%	28.50%	14.52%	8.60%	1.61%	98.39%

Calm Win   ds: 1.613   %

Total Periods =   186; Valid Periods = 186   ; Calm Wind Periods = 3

HR19-00

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	6.45%	11.83%	2.69%	0.54%	0.00%	0.00%	21.51%
NNE:	0.00%	0.00%	2.69%	1.08%	0.00%	0.00%	3.76%
NE :	0.00%	0.00%	0.00%	0.54%	0.00%	0.00%	0.54%
ENE:	2.15%	1.61%	0.54%	0.00%	0.00%	0.00%	4.30%
E :	2.15%	0.54%	3.76%	1.61%	0.00%	0.00%	8.07%
ESE:	0.54%	1.61%	2.15%	1.61%	0.00%	0.00%	5.91%
SE :	9.68%	16.67%	1.08%	0.00%	0.00%	0.00%	27.42%
SSE:	0.00%	0.54%	0.00%	0.00%	0.00%	0.00%	0.54%

S :	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
SSW:	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
SW :	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
WSW:	0.54%	0.54%	0.00%	0.00%	0.00%	0.00%	1.08%
W :	0.54%	0.54%	0.00%	0.00%	0.00%	0.00%	1.08%
WNW:	0.00%	1.08%	1.08%	0.54%	0.00%	0.00%	2.69%
NW :	0.00%	0.00%	0.54%	0.00%	0.00%	0.00%	0.54%
NNW:	0.00%	1.08%	16.13%	2.69%	0.00%	0.00%	19.89%
SUM:	22.04%	36.02%	30.65%	8.60%	0.00%	0.00%	97.31%

Calm Win ds: 2.688 %

Total Periods = 1 86; Valid Periods = 186; Calm Wind Periods =5

WIND.FRQ   2.3   CALWindRose FRQ File Format
   3 - Comment records
Created by METSERIES (Version 1.76, Level 100222) on 11-Apr-2011 at 13:28:09
User requested: (X,Y)km=(-904.340 -857.320) in LCC   Projection below
Interpolated to: (X,Y)km=(-904.340 -857.320) in LCC   Projection below
   5 - Number of text-based header records

APRIL WIND ROSE

CALMET.DAT: Interpolated to [(I,J)=(21.160,   28.180)])][(X,Y)km=(-904.340, -857.320) in MODEL Projection]
Height: 10.00 m
Wind Speed Classes (m/s): 5.0E-01, 0.5, 1.8, 3.3, 5.4, 8.5, 10.8
2003 4 1 1 0000   2003 5 1 0 0000 UTC-0700

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	2.639%	6.944%	0.833%	0.000%	0.000%	0.000%	10.417%
NNE:	0.139%	0.278%	0.000%	0.000%	0.000%	0.000%	0.417%
NE :	0.000%	0.139%	0.278%	0.278%	0.000%	0.000%	0.694%
ENE:	0.000%	1.111%	0.833%	0.417%	0.000%	0.000%	2.361%
E :	0.417%	0.556%	3.056%	1.667%	0.000%	0.000%	5.694%
ESE:	0.278%	0.417%	3.750%	0.278%	0.000%	0.000%	4.722%
SE :	4.028%	6.111%	1.111%	0.278%	0.000%	0.000%	11.528%
SSE:	0.972%	2.083%	0.694%	0.000%	0.000%	0.000%	3.750%
S :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SSW:	0.278%	0.000%	0.694%	0.417%	0.000%	0.000%	1.389%
SW :	0.417%	1.111%	0.972%	0.000%	0.000%	0.000%	2.500%
WSW:	0.278%	0.972%	3.611%	3.333%	0.694%	0.000%	8.889%
W :	0.278%	3.056%	4.306%	5.694%	1.944%	0.417%	15.694%
WNW:	0.139%	0.972%	2.917%	5.694%	0.139%	0.278%	10.139%
NW :	0.278%	1.528%	1.667%	0.139%	0.000%	0.000%	3.611%
NNW:	0.972%	5.139%	10.556%	0.000%	0.000%	0.000%	16.667%
SUM:	11.111%	30.417%	35.278%	18.194%	2.778%	0.694%	98.472%

Calm Winds: 1.528%
Total Periods =   720; Valid Periods =   720; Calm Wind Periods =   11

HR01-06

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	5.556%	20.556%	2.222%	0.000%	0.000%	0.000%	28.333%

NNE:	0.556%	0.000%	0.000%	0.000%	0.000%	0.000%	0.556%
NE :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
ENE:	0.000%	2.778%	3.333%	1.111%	0.000%	0.000%	7.222%
E :	0.000%	0.556%	5.556%	3.333%	0.000%	0.000%	9.444%
ESE:	0.556%	1.111%	0.000%	0.000%	0.000%	0.000%	1.667%
SE :	8.333%	11.667%	0.000%	0.000%	0.000%	0.000%	20.000%
SSE:	0.000%	1.111%	0.000%	0.000%	0.000%	0.000%	1.111%
S :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SSW:	1.111%	0.000%	0.000%	0.000%	0.000%	0.000%	1.111%
SW :	1.111%	0.000%	0.000%	0.000%	0.000%	0.000%	1.111%
WSW:	0.556%	0.000%	0.000%	0.000%	0.000%	0.000%	0.556%
W :	1.111%	5.000%	0.000%	0.000%	0.000%	0.000%	6.111%
WNW:	0.556%	1.667%	0.556%	0.000%	0.000%	0.000%	2.778%
NW :	0.000%	1.111%	0.000%	0.000%	0.000%	0.000%	1.111%
NNW:	0.000%	6.667%	9.444%	0.000%	0.000%	0.000%	16.111%
SUM:	19.444%	52.222%	21.111%	4.444%	0.000%	0.000%	97.222%

Calm Winds: 2.778%

Total Periods = 180; Valid Periods = 180; Calm Wind Periods = 5

HR07-12

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	0.000%	1.667%	0.000%	0.000%	0.000%	0.000%	1.667%
NNE:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NE :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
ENE:	0.000%	1.111%	0.000%	0.000%	0.000%	0.000%	1.111%
E :	1.667%	0.556%	1.667%	1.111%	0.000%	0.000%	5.000%
ESE:	0.556%	0.000%	4.444%	1.111%	0.000%	0.000%	6.111%
SE :	0.000%	2.222%	2.222%	1.111%	0.000%	0.000%	5.556%
SSE:	3.889%	5.556%	0.556%	0.000%	0.000%	0.000%	10.000%
S :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SSW:	0.000%	0.000%	1.111%	1.667%	0.000%	0.000%	2.778%

SW :	0.000%	2.222%	2.778%	0.000%	0.000%	0.000%	5.000%
WSW:	0.000%	1.111%	6.667%	3.333%	0.556%	0.000%	11.667%
W :	0.000%	0.556%	3.889%	10.000%	2.778%	0.000%	17.222%
WNW:	0.000%	0.556%	5.556%	10.556%	0.000%	0.000%	16.667%
NW :	0.556%	2.778%	3.889%	0.556%	0.000%	0.000%	7.778%
NNW:	1.111%	4.444%	2.778%	0.000%	0.000%	0.000%	8.333%
SUM:	7.778%	22.778%	35.556%	29.444%	3.333%	0.000%	98.889%

Calm Winds: 1.111%
Total Periods = 180; Valid Periods = 180; Calm Wind Periods = 2

HR13-18

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	0.000%	0.556%	0.000%	0.000%	0.000%	0.000%	0.556%
NNE:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NE :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
ENE:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
E :	0.000%	0.000%	0.556%	0.000%	0.000%	0.000%	0.556%
ESE:	0.000%	0.000%	5.556%	0.000%	0.000%	0.000%	5.556%
SE :	0.000%	3.889%	2.222%	0.000%	0.000%	0.000%	6.111%
SSE:	0.000%	0.000%	1.111%	0.000%	0.000%	0.000%	1.111%
S :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SSW:	0.000%	0.000%	1.667%	0.000%	0.000%	0.000%	1.667%
SW :	0.000%	2.222%	1.111%	0.000%	0.000%	0.000%	3.333%
WSW:	0.000%	1.667%	6.111%	10.000%	2.222%	0.000%	20.000%
W :	0.000%	3.333%	11.667%	12.778%	5.000%	1.667%	34.444%
WNW:	0.000%	0.556%	4.444%	11.667%	0.556%	1.111%	18.333%
NW :	0.556%	1.667%	2.778%	0.000%	0.000%	0.000%	5.000%
NNW:	2.222%	0.000%	0.000%	0.000%	0.000%	0.000%	2.222%
SUM:	2.778%	13.889%	37.222%	34.444%	7.778%	2.778%	98.889%

Calm Winds: 1.111%
Total Periods = 180; Valid Periods = 180; Calm Wind Periods = 2

HR19-00

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	5.000%	5.000%	1.111%	0.000%	0.000%	0.000%	11.111%
NNE:	0.000%	1.111%	0.000%	0.000%	0.000%	0.000%	1.111%
NE :	0.000%	0.556%	1.111%	1.111%	0.000%	0.000%	2.778%
ENE:	0.000%	0.556%	0.000%	0.556%	0.000%	0.000%	1.111%
E :	0.000%	1.111%	4.444%	2.222%	0.000%	0.000%	7.778%
ESE:	0.000%	0.556%	5.000%	0.000%	0.000%	0.000%	5.556%
SE :	7.778%	6.667%	0.000%	0.000%	0.000%	0.000%	14.444%
SSE:	0.000%	1.667%	1.111%	0.000%	0.000%	0.000%	2.778%
S :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SSW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SW :	0.556%	0.000%	0.000%	0.000%	0.000%	0.000%	0.556%
WSW:	0.556%	1.111%	1.667%	0.000%	0.000%	0.000%	3.333%
W :	0.000%	3.333%	1.667%	0.000%	0.000%	0.000%	5.000%
WNW:	0.000%	1.111%	1.111%	0.556%	0.000%	0.000%	2.778%
NW :	0.000%	0.556%	0.000%	0.000%	0.000%	0.000%	0.556%
NNW:	0.556%	9.444%	30.000%	0.000%	0.000%	0.000%	40.000%
SUM:	14.444%	32.778%	47.222%	4.444%	0.000%	0.000%	98.889%

Calm Winds: 1.111%

Total Periods = 180; Valid Periods = 180; Calm Wind Periods = 2

WIND.FRQ 2.3 CALWindRose FRQ File Format
3 - Comment records
Created by METSERIES (Version 1.76, Level 100222) on 11-Apr-2011 at 13:30:22
User requested: (X,Y)km=(-904.340 -857.320) in LCC Projection below
Interpolated to: (X,Y)km=(-904.340 -857.320) in LCC Projection below
5 - Number of text-based header records

MAY WIND ROSE

CALMET.DAT: Interpolated to [(I,J)=(21.160, 28.180)])][(X,Y)km=(-904.340, -857.320) in MODEL Projection]
Height: 10.00 m
Wind Speed Classes (m/s): 5.0E-01, 0.5, 1.8, 3.3, 5.4, 8.5, 10.8
2003 5 1 1 0000 2003 6 1 0 0000 UTC-0700

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	3.091%	4.301%	0.672%	0.000%	0.000%	0.000%	8.065%
NNE:	0.000%	0.269%	0.134%	0.000%	0.000%	0.000%	0.403%
NE :	0.269%	0.269%	0.269%	0.000%	0.000%	0.000%	0.806%
ENE:	0.134%	0.941%	0.403%	0.269%	0.000%	0.000%	1.747%
E :	1.075%	2.285%	4.973%	1.344%	0.403%	0.000%	10.081%
ESE:	2.957%	2.688%	5.645%	1.210%	0.134%	0.000%	12.634%
SE :	4.839%	4.704%	1.075%	0.134%	0.000%	0.000%	10.753%
SSE:	2.151%	1.210%	0.000%	0.000%	0.000%	0.000%	3.360%
S :	0.000%	0.134%	0.000%	0.000%	0.000%	0.000%	0.134%
SSW:	0.134%	0.403%	0.000%	0.000%	0.000%	0.000%	0.538%
SW :	0.269%	0.538%	0.134%	0.000%	0.000%	0.000%	0.941%
WSW:	0.538%	2.016%	2.554%	1.747%	0.269%	0.000%	7.124%
W :	0.134%	1.882%	6.317%	6.720%	1.075%	0.538%	16.667%
WNW:	0.403%	2.823%	1.747%	1.747%	0.134%	0.000%	6.855%
NW :	0.269%	2.016%	0.538%	0.000%	0.000%	0.000%	2.823%
NNW:	1.075%	6.183%	8.199%	0.000%	0.000%	0.000%	15.457%
SUM:	17.339%	32.661%	32.661%	13.172%	2.016%	0.538%	98.387%

Calm Winds: 1.613%
Total Periods = 744; Valid Periods = 744; Calm Wind Periods = 12

HR01-06

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	7.527%	9.677%	0.000%	0.000%	0.000%	0.000%	17.204%

NNE:	0.000%	0.538%	0.538%	0.000%	0.000%	0.000%	1.075%
NE :	0.000%	1.075%	0.000%	0.000%	0.000%	0.000%	1.075%
ENE:	0.000%	1.613%	1.075%	0.000%	0.000%	0.000%	2.688%
E :	0.000%	6.452%	10.215%	1.613%	1.613%	0.000%	19.892%
ESE:	3.226%	4.301%	4.301%	0.000%	0.000%	0.000%	11.828%
SE :	11.290%	4.839%	0.000%	0.000%	0.000%	0.000%	16.129%
SSE:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
S :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SSW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SW :	1.075%	0.000%	0.000%	0.000%	0.000%	0.000%	1.075%
WSW:	1.613%	1.075%	0.000%	0.000%	0.000%	0.000%	2.688%
W :	0.538%	2.151%	0.000%	0.000%	0.000%	0.000%	2.688%
WNW:	0.000%	1.613%	0.000%	0.000%	0.000%	0.000%	1.613%
NW :	0.000%	1.075%	0.000%	0.000%	0.000%	0.000%	1.075%
NNW:	0.000%	12.366%	8.065%	0.000%	0.000%	0.000%	20.430%
SUM:	25.269%	46.774%	24.194%	1.613%	1.613%	0.000%	99.462%

Calm Winds: 0.538%
Total Periods = 186; Valid Periods = 186; Calm Wind Periods = 1

HR07-12

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NNE:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NE :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
ENE:	0.000%	0.538%	0.000%	0.000%	0.000%	0.000%	0.538%
E :	1.613%	2.688%	1.613%	2.688%	0.000%	0.000%	8.602%
ESE:	4.839%	1.613%	3.763%	1.075%	0.538%	0.000%	11.828%
SE :	1.613%	2.688%	2.151%	0.538%	0.000%	0.000%	6.989%
SSE:	6.989%	3.226%	0.000%	0.000%	0.000%	0.000%	10.215%
S :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SSW:	0.000%	1.613%	0.000%	0.000%	0.000%	0.000%	1.613%

SW :	0.000%	0.538%	0.538%	0.000%	0.000%	0.000%	1.075%
WSW:	0.000%	2.151%	4.301%	3.763%	1.075%	0.000%	11.290%
W :	0.000%	1.075%	11.290%	6.989%	1.613%	0.000%	20.968%
WNW:	1.075%	3.226%	1.613%	3.763%	0.000%	0.000%	9.677%
NW :	1.075%	4.301%	0.538%	0.000%	0.000%	0.000%	5.914%
NNW:	1.613%	5.376%	2.151%	0.000%	0.000%	0.000%	9.140%
SUM:	18.817%	29.032%	27.957%	18.817%	3.226%	0.000%	97.849%

Calm Winds: 2.151%
Total Periods = 186; Valid Periods = 186; Calm Wind Periods = 4

HR13-18

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NNE:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NE :	1.075%	0.000%	0.000%	0.000%	0.000%	0.000%	1.075%
ENE:	0.000%	1.075%	0.000%	0.000%	0.000%	0.000%	1.075%
E :	2.151%	0.000%	1.613%	0.000%	0.000%	0.000%	3.763%
ESE:	3.226%	0.538%	4.301%	3.763%	0.000%	0.000%	11.828%
SE :	0.538%	3.763%	0.000%	0.000%	0.000%	0.000%	4.301%
SSE:	1.613%	1.075%	0.000%	0.000%	0.000%	0.000%	2.688%
S :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SSW:	0.538%	0.000%	0.000%	0.000%	0.000%	0.000%	0.538%
SW :	0.000%	1.613%	0.000%	0.000%	0.000%	0.000%	1.613%
WSW:	0.000%	4.301%	5.914%	3.226%	0.000%	0.000%	13.441%
W :	0.000%	2.688%	12.366%	19.892%	2.688%	2.151%	39.785%
WNW:	0.000%	3.763%	4.839%	3.226%	0.538%	0.000%	12.366%
NW :	0.000%	1.613%	1.075%	0.000%	0.000%	0.000%	2.688%
NNW:	2.151%	0.000%	0.000%	0.000%	0.000%	0.000%	2.151%
SUM:	11.290%	20.430%	30.108%	30.108%	3.226%	2.151%	97.312%

Calm Winds: 2.688%
Total Periods = 186; Valid Periods = 186; Calm Wind Periods = 5

HR19-00

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	4.839%	7.527%	2.688%	0.000%	0.000%	0.000%	15.054%
NNE:	0.000%	0.538%	0.000%	0.000%	0.000%	0.000%	0.538%
NE :	0.000%	0.000%	1.075%	0.000%	0.000%	0.000%	1.075%
ENE:	0.538%	0.538%	0.538%	1.075%	0.000%	0.000%	2.688%
E :	0.538%	0.000%	6.452%	1.075%	0.000%	0.000%	8.065%
ESE:	0.538%	4.301%	10.215%	0.000%	0.000%	0.000%	15.054%
SE :	5.914%	7.527%	2.151%	0.000%	0.000%	0.000%	15.591%
SSE:	0.000%	0.538%	0.000%	0.000%	0.000%	0.000%	0.538%
S :	0.000%	0.538%	0.000%	0.000%	0.000%	0.000%	0.538%
SSW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SW :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
WSW:	0.538%	0.538%	0.000%	0.000%	0.000%	0.000%	1.075%
W :	0.000%	1.613%	1.613%	0.000%	0.000%	0.000%	3.226%
WNW:	0.538%	2.688%	0.538%	0.000%	0.000%	0.000%	3.763%
NW :	0.000%	1.075%	0.538%	0.000%	0.000%	0.000%	1.613%
NNW:	0.538%	6.989%	22.581%	0.000%	0.000%	0.000%	30.108%
SUM:	13.978%	34.409%	48.387%	2.151%	0.000%	0.000%	98.925%

Calm Winds: 1.075%
Total Periods = 186; Valid Periods = 186; Calm Wind Periods = 2

WIND.FRQ 2.3 CALWindRose FRQ File Format
3 - Comment records
Created by METSERIES (Version 1.76, Level 100222) on 11-Apr-2011 at 13:32:03
User requested: (X,Y)km=(-904.340 -857.320) in LCC Projection below
Interpolated to: (X,Y)km=(-904.340 -857.320) in LCC Projection below
5 - Number of text-based header records
JUNE WIND ROSE
CALMET.DAT: Interpolated to [(I,J)=(21.160, 28.180)])][(X,Y)km=(-904.340, -857.320) in MODEL Projection]
Height: 10.00 m
Wind Speed Classes (m/s): 5.0E-01, 0.5, 1.8, 3.3, 5.4, 8.5, 10.8
2003 6 1 1 0000 2003 7 1 0 0000 UTC-0700

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	3.056%	5.833%	0.417%	0.000%	0.000%	0.000%	9.306%
NNE:	0.278%	0.139%	0.278%	0.000%	0.000%	0.000%	0.694%
NE :	0.278%	1.111%	0.833%	0.000%	0.000%	0.000%	2.222%
ENE:	0.556%	1.667%	1.111%	0.000%	0.000%	0.000%	3.333%
E :	1.806%	1.806%	4.861%	0.833%	0.000%	0.000%	9.306%
ESE:	1.250%	2.500%	7.639%	1.250%	0.000%	0.000%	12.639%
SE :	4.028%	7.917%	4.444%	0.556%	0.000%	0.000%	16.944%
SSE:	1.944%	1.806%	0.278%	0.000%	0.000%	0.000%	4.028%
S :	0.139%	1.389%	0.000%	0.000%	0.000%	0.000%	1.528%
SSW:	0.139%	0.694%	0.278%	0.000%	0.000%	0.000%	1.111%
SW :	0.139%	1.111%	0.694%	0.000%	0.000%	0.000%	1.944%
WSW:	0.000%	0.556%	2.083%	0.417%	0.000%	0.000%	3.056%
W :	0.139%	2.083%	5.417%	2.639%	0.000%	0.000%	10.278%
WNW:	0.556%	2.500%	5.417%	0.694%	0.000%	0.000%	9.167%
NW :	0.417%	0.694%	0.417%	0.000%	0.000%	0.000%	1.528%
NNW:	2.222%	2.500%	6.111%	0.000%	0.000%	0.000%	10.833%
SUM:	16.944%	34.306%	40.278%	6.389%	0.000%	0.000%	97.917%

Calm Winds: 2.083%
Total Periods = 720; Valid Periods = 720; Calm Wind Periods = 15

HR01-06

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	7.778%	17.222%	0.000%	0.000%	0.000%	0.000%	25.000%

NNE:	0.556%	0.000%	0.000%	0.000%	0.000%	0.000%	0.556%
NE :	1.111%	2.778%	0.556%	0.000%	0.000%	0.000%	4.444%
ENE:	0.000%	4.444%	1.667%	0.000%	0.000%	0.000%	6.111%
E :	1.667%	2.222%	11.667%	1.667%	0.000%	0.000%	17.222%
ESE:	2.222%	1.667%	4.444%	0.556%	0.000%	0.000%	8.889%
SE :	9.444%	12.778%	1.111%	0.000%	0.000%	0.000%	23.333%
SSE:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
S :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SSW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SW :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
WSW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
W :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
WNW:	0.556%	0.000%	0.000%	0.000%	0.000%	0.000%	0.556%
NW :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NNW:	0.000%	5.000%	7.778%	0.000%	0.000%	0.000%	12.778%
SUM:	23.333%	46.111%	27.222%	2.222%	0.000%	0.000%	98.889%

Calm Winds: 1.111%
Total Periods = 180; Valid Periods = 180; Calm Wind Periods = 2

HR07-12

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NNE:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NE :	0.000%	1.111%	0.000%	0.000%	0.000%	0.000%	1.111%
ENE:	0.556%	1.667%	1.111%	0.000%	0.000%	0.000%	3.333%
E :	3.333%	2.222%	1.111%	0.000%	0.000%	0.000%	6.667%
ESE:	1.667%	4.444%	8.889%	3.333%	0.000%	0.000%	18.333%
SE :	1.667%	2.778%	3.333%	2.222%	0.000%	0.000%	10.000%
SSE:	4.444%	2.222%	0.556%	0.000%	0.000%	0.000%	7.222%
S :	0.000%	3.889%	0.000%	0.000%	0.000%	0.000%	3.889%
SSW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%

SW :	0.556%	1.111%	0.000%	0.000%	0.000%	0.000%	1.667%
WSW:	0.000%	1.667%	2.778%	0.000%	0.000%	0.000%	4.444%
W :	0.556%	1.667%	8.333%	2.778%	0.000%	0.000%	13.333%
WNW:	1.111%	2.778%	5.000%	2.222%	0.000%	0.000%	11.111%
NW :	1.667%	2.222%	1.667%	0.000%	0.000%	0.000%	5.556%
NNW:	4.444%	2.222%	2.222%	0.000%	0.000%	0.000%	8.889%
SUM:	20.000%	30.000%	35.000%	10.556%	0.000%	0.000%	95.556%

Calm Winds: 4.444%

Total Periods = 180; Valid Periods = 180; Calm Wind Periods = 8

HR13-18

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NNE:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NE :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
ENE:	1.667%	0.000%	0.000%	0.000%	0.000%	0.000%	1.667%
E :	1.667%	1.111%	1.667%	0.000%	0.000%	0.000%	4.444%
ESE:	1.111%	2.222%	3.333%	0.000%	0.000%	0.000%	6.667%
SE :	0.556%	7.222%	6.667%	0.000%	0.000%	0.000%	14.444%
SSE:	3.333%	5.000%	0.000%	0.000%	0.000%	0.000%	8.333%
S :	0.556%	1.111%	0.000%	0.000%	0.000%	0.000%	1.667%
SSW:	0.000%	2.222%	0.556%	0.000%	0.000%	0.000%	2.778%
SW :	0.000%	2.778%	2.778%	0.000%	0.000%	0.000%	5.556%
WSW:	0.000%	0.000%	5.000%	1.667%	0.000%	0.000%	6.667%
W :	0.000%	2.222%	11.667%	7.778%	0.000%	0.000%	21.667%
WNW:	0.000%	5.000%	16.111%	0.556%	0.000%	0.000%	21.667%
NW :	0.000%	0.556%	0.000%	0.000%	0.000%	0.000%	0.556%
NNW:	3.333%	0.000%	0.000%	0.000%	0.000%	0.000%	3.333%
SUM:	12.222%	29.444%	47.778%	10.000%	0.000%	0.000%	99.444%

Calm Winds: 0.556%

Total Periods = 180; Valid Periods = 180; Calm Wind Periods = 1

HR19-00

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	4.444%	6.111%	1.667%	0.000%	0.000%	0.000%	12.222%
NNE:	0.556%	0.556%	1.111%	0.000%	0.000%	0.000%	2.222%
NE :	0.000%	0.556%	2.778%	0.000%	0.000%	0.000%	3.333%
ENE:	0.000%	0.556%	1.667%	0.000%	0.000%	0.000%	2.222%
E :	0.556%	1.667%	5.000%	1.667%	0.000%	0.000%	8.889%
ESE:	0.000%	1.667%	13.889%	1.111%	0.000%	0.000%	16.667%
SE :	4.444%	8.889%	6.667%	0.000%	0.000%	0.000%	20.000%
SSE:	0.000%	0.000%	0.556%	0.000%	0.000%	0.000%	0.556%
S :	0.000%	0.556%	0.000%	0.000%	0.000%	0.000%	0.556%
SSW:	0.556%	0.556%	0.556%	0.000%	0.000%	0.000%	1.667%
SW :	0.000%	0.556%	0.000%	0.000%	0.000%	0.000%	0.556%
WSW:	0.000%	0.556%	0.556%	0.000%	0.000%	0.000%	1.111%
W :	0.000%	4.444%	1.667%	0.000%	0.000%	0.000%	6.111%
WNW:	0.556%	2.222%	0.556%	0.000%	0.000%	0.000%	3.333%
NW :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NNW:	1.111%	2.778%	14.444%	0.000%	0.000%	0.000%	18.333%
SUM:	12.222%	31.667%	51.111%	2.778%	0.000%	0.000%	97.778%

Calm Winds: 2.222%

Total Periods = 180; Valid Periods = 180; Calm Wind Periods = 4

WIND.FRQ 2.3 CALWindRose FRQ File Format
3 - Comment records
Created by METSERIES (Version 1.76, Level 100222) on 11-Apr-2011 at 13:48:06
User requested: (X,Y)km=(-904.340 -857.320) in LCC Projection below
Interpolated to: (X,Y)km=(-904.340 -857.320) in LCC Projection below
5 - Number of text-based header records

JULY WIND ROSE

CALMET.DAT: Interpolated to [(I,J)=(21.160, 28.180)])][(X,Y)km=(-904.340, -857.320) in MODEL Projection]
Height: 10.00 m
Wind Speed Classes (m/s): 5.0E-01, 0.5, 1.8, 3.3, 5.4, 8.5, 10.8
2003 7 1 1 0000 2003 8 1 0 0000 UTC-0700

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	0.672%	0.000%	0.000%	0.000%	0.000%	0.000%	0.672%
NNE:	0.403%	0.134%	0.000%	0.000%	0.000%	0.000%	0.538%
NE :	1.075%	0.000%	1.344%	0.000%	0.000%	0.000%	2.419%
ENE:	1.344%	0.941%	0.941%	0.000%	0.000%	0.000%	3.226%
E :	1.747%	8.602%	3.629%	1.747%	0.134%	0.000%	15.860%
ESE:	2.688%	9.140%	9.005%	3.226%	0.134%	0.000%	24.194%
SE :	3.495%	14.785%	12.366%	0.538%	0.000%	0.000%	31.183%
SSE:	6.048%	5.780%	2.151%	0.134%	0.000%	0.000%	14.113%
S :	0.134%	2.151%	0.269%	0.000%	0.000%	0.000%	2.554%
SSW:	0.000%	0.941%	0.000%	0.000%	0.000%	0.000%	0.941%
SW :	0.000%	0.134%	0.403%	0.000%	0.000%	0.000%	0.538%
WSW:	0.000%	0.403%	0.000%	0.000%	0.000%	0.000%	0.403%
W :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
WNW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NW :	0.269%	0.000%	0.000%	0.000%	0.000%	0.000%	0.269%
NNW:	1.344%	0.000%	0.000%	0.000%	0.000%	0.000%	1.344%
SUM:	19.220%	43.011%	30.108%	5.645%	0.269%	0.000%	98.253%

Calm Winds: 1.747%
Total Periods = 744; Valid Periods = 744; Calm Wind Periods = 13

HR01-06

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%

NNE:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NE :	1.075%	0.000%	3.226%	0.000%	0.000%	0.000%	4.301%
ENE:	2.151%	1.075%	0.000%	0.000%	0.000%	0.000%	3.226%
E :	0.000%	13.441%	7.527%	3.226%	0.000%	0.000%	24.194%
ESE:	5.914%	17.204%	11.290%	0.000%	0.000%	0.000%	34.409%
SE :	3.763%	23.118%	6.989%	0.000%	0.000%	0.000%	33.871%
SSE:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
S :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SSW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SW :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
WSW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
W :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
WNW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NW :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NNW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SUM:	12.903%	54.839%	29.032%	3.226%	0.000%	0.000%	100.000%

Calm Winds: 0.000%
Total Periods = 186; Valid Periods = 186; Calm Wind Periods = 0

HR07-12

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	0.538%	0.000%	0.000%	0.000%	0.000%	0.000%	0.538%
NNE:	0.000%	0.538%	0.000%	0.000%	0.000%	0.000%	0.538%
NE :	1.613%	0.000%	1.075%	0.000%	0.000%	0.000%	2.688%
ENE:	0.538%	1.613%	0.000%	0.000%	0.000%	0.000%	2.151%
E :	2.151%	7.527%	0.538%	1.613%	0.000%	0.000%	11.828%
ESE:	1.613%	8.065%	2.151%	2.688%	0.000%	0.000%	14.516%
SE :	5.376%	11.290%	5.914%	0.538%	0.000%	0.000%	23.118%
SSE:	12.366%	14.516%	1.613%	0.000%	0.000%	0.000%	28.495%
S :	0.000%	5.376%	0.538%	0.000%	0.000%	0.000%	5.914%
SSW:	0.000%	0.538%	0.000%	0.000%	0.000%	0.000%	0.538%

SW :	0.000%	0.538%	0.538%	0.000%	0.000%	0.000%	1.075%
WSW:	0.000%	1.075%	0.000%	0.000%	0.000%	0.000%	1.075%
W :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
WNW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NW :	0.538%	0.000%	0.000%	0.000%	0.000%	0.000%	0.538%
NNW:	4.301%	0.000%	0.000%	0.000%	0.000%	0.000%	4.301%
SUM:	29.032%	51.075%	12.366%	4.839%	0.000%	0.000%	97.312%

Calm Winds: 2.688%
Total Periods = 186; Valid Periods = 186; Calm Wind Periods = 5

HR13-18

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	2.151%	0.000%	0.000%	0.000%	0.000%	0.000%	2.151%
NNE:	1.613%	0.000%	0.000%	0.000%	0.000%	0.000%	1.613%
NE :	1.613%	0.000%	0.000%	0.000%	0.000%	0.000%	1.613%
ENE:	2.688%	1.075%	0.000%	0.000%	0.000%	0.000%	3.763%
E :	3.763%	8.602%	2.151%	1.075%	0.538%	0.000%	16.129%
ESE:	2.688%	7.527%	5.914%	4.839%	0.538%	0.000%	21.505%
SE :	2.151%	8.602%	7.527%	1.613%	0.000%	0.000%	19.892%
SSE:	11.290%	6.452%	3.226%	0.538%	0.000%	0.000%	21.505%
S :	0.538%	0.538%	0.538%	0.000%	0.000%	0.000%	1.613%
SSW:	0.000%	2.688%	0.000%	0.000%	0.000%	0.000%	2.688%
SW :	0.000%	0.000%	1.075%	0.000%	0.000%	0.000%	1.075%
WSW:	0.000%	0.538%	0.000%	0.000%	0.000%	0.000%	0.538%
W :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
WNW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NW :	0.538%	0.000%	0.000%	0.000%	0.000%	0.000%	0.538%
NNW:	1.075%	0.000%	0.000%	0.000%	0.000%	0.000%	1.075%
SUM:	30.108%	36.022%	20.430%	8.065%	1.075%	0.000%	95.699%

Calm Winds: 4.301%
Total Periods = 186; Valid Periods = 186; Calm Wind Periods = 8

HR19-00

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NNE:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NE :	0.000%	0.000%	1.075%	0.000%	0.000%	0.000%	1.075%
ENE:	0.000%	0.000%	3.763%	0.000%	0.000%	0.000%	3.763%
E :	1.075%	4.839%	4.301%	1.075%	0.000%	0.000%	11.290%
ESE:	0.538%	3.763%	16.667%	5.376%	0.000%	0.000%	26.344%
SE :	2.688%	16.129%	29.032%	0.000%	0.000%	0.000%	47.849%
SSE:	0.538%	2.151%	3.763%	0.000%	0.000%	0.000%	6.452%
S :	0.000%	2.688%	0.000%	0.000%	0.000%	0.000%	2.688%
SSW:	0.000%	0.538%	0.000%	0.000%	0.000%	0.000%	0.538%
SW :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
WSW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
W :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
WNW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NW :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NNW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SUM:	4.839%	30.108%	58.602%	6.452%	0.000%	0.000%	100.000%

Calm Winds: 0.000%

Total Periods = 186; Valid Periods = 186; Calm Wind Periods = 0

WIND.FRQ 2.3 CALWindRose FRQ File Format
3 - Comment records
Created by METSERIES (Version 1.76, Level 100222) on 11-Apr-2011 at 13:46:29
User requested: (X,Y)km=(-904.340 -857.320) in LCC Projection below
Interpolated to: (X,Y)km=(-904.340 -857.320) in LCC Projection below
5 - Number of text-based header records

AUGUST WIND ROSE

CALMET.DAT: Interpolated to [(I,J)=(21.160, 28.180)])][(X,Y)km=(-904.340, -857.320) in MODEL Projection]
Height: 10.00 m
Wind Speed Classes (m/s): 5.0E-01, 0.5, 1.8, 3.3, 5.4, 8.5, 10.8
2003 8 1 1 0000 2003 9 1 0 0000 UTC-0700

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	2.016%	2.823%	0.269%	0.000%	0.000%	0.000%	5.108%
NNE:	0.538%	2.554%	0.403%	0.000%	0.000%	0.000%	3.495%
NE :	1.075%	2.419%	1.210%	0.134%	0.000%	0.000%	4.839%
ENE:	1.613%	2.823%	3.091%	0.000%	0.000%	0.000%	7.527%
E :	0.941%	6.720%	11.022%	0.269%	0.000%	0.000%	18.952%
ESE:	1.613%	6.048%	10.081%	1.344%	0.000%	0.000%	19.086%
SE :	1.882%	7.124%	5.780%	1.075%	0.000%	0.000%	15.860%
SSE:	2.688%	0.538%	0.134%	0.000%	0.000%	0.000%	3.360%
S :	0.269%	0.538%	0.000%	0.000%	0.000%	0.000%	0.806%
SSW:	0.134%	0.538%	0.134%	0.000%	0.000%	0.000%	0.806%
SW :	0.403%	0.269%	0.000%	0.000%	0.000%	0.000%	0.672%
WSW:	0.134%	0.672%	1.210%	0.000%	0.000%	0.000%	2.016%
W :	0.000%	0.672%	2.285%	0.000%	0.000%	0.000%	2.957%
WNW:	0.269%	0.941%	2.016%	0.000%	0.000%	0.000%	3.226%
NW :	0.269%	0.941%	0.000%	0.000%	0.000%	0.000%	1.210%
NNW:	2.016%	4.839%	1.613%	0.000%	0.000%	0.000%	8.468%
SUM:	15.860%	40.457%	39.247%	2.823%	0.000%	0.000%	98.387%

Calm Winds: 1.613%
Total Periods = 744; Valid Periods = 744; Calm Wind Periods = 12

HR01-06

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	2.688%	4.301%	0.000%	0.000%	0.000%	0.000%	6.989%

NNE:	0.538%	3.763%	1.075%	0.000%	0.000%	0.000%	5.376%
NE :	0.538%	4.301%	2.688%	0.000%	0.000%	0.000%	7.527%
ENE:	0.538%	7.527%	6.989%	0.000%	0.000%	0.000%	15.054%
E :	0.000%	10.215%	18.280%	0.000%	0.000%	0.000%	28.495%
ESE:	0.000%	6.452%	3.226%	0.000%	0.000%	0.000%	9.677%
SE :	4.301%	10.753%	0.000%	0.000%	0.000%	0.000%	15.054%
SSE:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
S :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SSW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SW :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
WSW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
W :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
WNW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NW :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NNW:	0.000%	10.215%	0.538%	0.000%	0.000%	0.000%	10.753%
SUM:	8.602%	57.527%	32.796%	0.000%	0.000%	0.000%	98.925%

Calm Winds: 1.075%

Total Periods = 186; Valid Periods = 186; Calm Wind Periods = 2

HR07-12

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	0.538%	1.613%	0.000%	0.000%	0.000%	0.000%	2.151%
NNE:	1.075%	3.226%	0.000%	0.000%	0.000%	0.000%	4.301%
NE :	2.688%	2.688%	0.000%	0.000%	0.000%	0.000%	5.376%
ENE:	3.763%	2.688%	0.000%	0.000%	0.000%	0.000%	6.452%
E :	1.613%	8.602%	3.226%	0.000%	0.000%	0.000%	13.441%
ESE:	4.839%	6.452%	9.677%	2.688%	0.000%	0.000%	23.656%
SE :	1.613%	1.613%	3.763%	1.075%	0.000%	0.000%	8.065%
SSE:	6.989%	1.613%	0.000%	0.000%	0.000%	0.000%	8.602%
S :	0.538%	2.151%	0.000%	0.000%	0.000%	0.000%	2.688%
SSW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%

SW :	0.538%	0.538%	0.000%	0.000%	0.000%	0.000%	1.075%
WSW:	0.000%	0.000%	1.075%	0.000%	0.000%	0.000%	1.075%
W :	0.000%	2.151%	4.839%	0.000%	0.000%	0.000%	6.989%
WNW:	0.538%	1.075%	0.538%	0.000%	0.000%	0.000%	2.151%
NW :	0.538%	3.763%	0.000%	0.000%	0.000%	0.000%	4.301%
NNW:	4.301%	2.688%	0.538%	0.000%	0.000%	0.000%	7.527%
SUM:	29.570%	40.860%	23.656%	3.763%	0.000%	0.000%	97.849%

Calm Winds: 2.151%
Total Periods = 186; Valid Periods = 186; Calm Wind Periods = 4

HR13-18

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	1.613%	2.151%	0.000%	0.000%	0.000%	0.000%	3.763%
NNE:	0.538%	0.538%	0.000%	0.000%	0.000%	0.000%	1.075%
NE :	0.000%	0.538%	0.000%	0.000%	0.000%	0.000%	0.538%
ENE:	1.613%	1.075%	0.538%	0.000%	0.000%	0.000%	3.226%
E :	2.151%	5.914%	3.763%	0.000%	0.000%	0.000%	11.828%
ESE:	1.075%	5.914%	8.602%	2.688%	0.000%	0.000%	18.280%
SE :	0.000%	6.989%	14.516%	3.226%	0.000%	0.000%	24.731%
SSE:	3.226%	0.538%	0.538%	0.000%	0.000%	0.000%	4.301%
S :	0.538%	0.000%	0.000%	0.000%	0.000%	0.000%	0.538%
SSW:	0.538%	2.151%	0.538%	0.000%	0.000%	0.000%	3.226%
SW :	0.538%	0.538%	0.000%	0.000%	0.000%	0.000%	1.075%
WSW:	0.538%	1.075%	3.763%	0.000%	0.000%	0.000%	5.376%
W :	0.000%	0.000%	4.301%	0.000%	0.000%	0.000%	4.301%
WNW:	0.538%	2.151%	7.527%	0.000%	0.000%	0.000%	10.215%
NW :	0.538%	0.000%	0.000%	0.000%	0.000%	0.000%	0.538%
NNW:	3.226%	0.000%	1.075%	0.000%	0.000%	0.000%	4.301%
SUM:	16.667%	29.570%	45.161%	5.914%	0.000%	0.000%	97.312%

Calm Winds: 2.688%
Total Periods = 186; Valid Periods = 186; Calm Wind Periods = 5

HR19-00

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	3.226%	3.226%	1.075%	0.000%	0.000%	0.000%	7.527%
NNE:	0.000%	2.688%	0.538%	0.000%	0.000%	0.000%	3.226%
NE :	1.075%	2.151%	2.151%	0.538%	0.000%	0.000%	5.914%
ENE:	0.538%	0.000%	4.839%	0.000%	0.000%	0.000%	5.376%
E :	0.000%	2.151%	18.817%	1.075%	0.000%	0.000%	22.043%
ESE:	0.538%	5.376%	18.817%	0.000%	0.000%	0.000%	24.731%
SE :	1.613%	9.140%	4.839%	0.000%	0.000%	0.000%	15.591%
SSE:	0.538%	0.000%	0.000%	0.000%	0.000%	0.000%	0.538%
S :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SSW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SW :	0.538%	0.000%	0.000%	0.000%	0.000%	0.000%	0.538%
WSW:	0.000%	1.613%	0.000%	0.000%	0.000%	0.000%	1.613%
W :	0.000%	0.538%	0.000%	0.000%	0.000%	0.000%	0.538%
WNW:	0.000%	0.538%	0.000%	0.000%	0.000%	0.000%	0.538%
NW :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NNW:	0.538%	6.452%	4.301%	0.000%	0.000%	0.000%	11.290%
SUM:	8.602%	33.871%	55.376%	1.613%	0.000%	0.000%	99.462%

Calm Winds: 0.538%

Total Periods = 186; Valid Periods = 186; Calm Wind Periods = 1

WIND.FRQ 2.3 CALWindRose FRQ File Format
3 - Comment records
Created by METSERIES (Version 1.76, Level 100222) on 11-Apr-2011 at 13:50:20
User requested: (X,Y)km=(-904.340 -857.320) in LCC Projection below
Interpolated to: (X,Y)km=(-904.340 -857.320) in LCC Projection below
5 - Number of text-based header records

SEPTEMBER WIND ROSE

CALMET.DAT: Interpolated to [(I,J)=(21.160, 28.180)])][(X,Y)km=(-904.340, -857.320) in MODEL Projection]
Height: 10.00 m
Wind Speed Classes (m/s): 5.0E-01, 0.5, 1.8, 3.3, 5.4, 8.5, 10.8
2003 9 1 1 0000 2003 10 1 0 0000 UTC-0700

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	2.222%	4.306%	0.139%	0.000%	0.000%	0.000%	6.667%
NNE:	0.694%	1.806%	0.000%	0.000%	0.000%	0.000%	2.500%
NE :	1.111%	0.694%	0.694%	0.000%	0.000%	0.000%	2.500%
ENE:	1.250%	0.417%	0.417%	0.000%	0.000%	0.000%	2.083%
E :	1.111%	4.167%	6.111%	2.917%	0.000%	0.000%	14.306%
ESE:	1.111%	5.694%	9.167%	0.278%	0.000%	0.000%	16.250%
SE :	5.000%	8.750%	10.556%	0.000%	0.000%	0.000%	24.306%
SSE:	3.194%	2.222%	0.833%	0.000%	0.000%	0.000%	6.250%
S :	0.417%	0.972%	0.556%	0.000%	0.000%	0.000%	1.944%
SSW:	0.139%	0.833%	0.556%	0.000%	0.000%	0.000%	1.528%
SW :	0.139%	0.278%	0.417%	0.000%	0.000%	0.000%	0.833%
WSW:	0.000%	0.417%	0.139%	0.000%	0.000%	0.000%	0.556%
W :	0.278%	1.667%	2.083%	0.556%	0.000%	0.000%	4.583%
WNW:	0.000%	1.806%	0.972%	0.000%	0.000%	0.000%	2.778%
NW :	0.278%	3.056%	0.972%	0.000%	0.000%	0.000%	4.306%
NNW:	1.944%	3.194%	1.389%	0.000%	0.000%	0.000%	6.528%
SUM:	18.889%	40.278%	35.000%	3.750%	0.000%	0.000%	97.917%

Calm Winds: 2.083%
Total Periods = 720; Valid Periods = 720; Calm Wind Periods = 15

HR01-06

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	5.000%	9.444%	0.000%	0.000%	0.000%	0.000%	14.444%

NNE:	0.556%	1.111%	0.000%	0.000%	0.000%	0.000%	1.667%
NE :	1.111%	0.556%	1.111%	0.000%	0.000%	0.000%	2.778%
ENE:	2.222%	0.000%	1.667%	0.000%	0.000%	0.000%	3.889%
E :	0.000%	7.222%	16.111%	4.444%	0.000%	0.000%	27.778%
ESE:	0.556%	3.889%	8.333%	0.000%	0.000%	0.000%	12.778%
SE :	5.556%	18.889%	5.000%	0.000%	0.000%	0.000%	29.444%
SSE:	0.000%	0.000%	1.111%	0.000%	0.000%	0.000%	1.111%
S :	0.000%	0.000%	0.556%	0.000%	0.000%	0.000%	0.556%
SSW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SW :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
WSW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
W :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
WNW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NW :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NNW:	0.000%	4.444%	0.556%	0.000%	0.000%	0.000%	5.000%
SUM:	15.000%	45.556%	34.444%	4.444%	0.000%	0.000%	99.444%

Calm Winds: 0.556%
Total Periods = 180; Valid Periods = 180; Calm Wind Periods = 1

HR07-12

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	0.000%	1.667%	0.556%	0.000%	0.000%	0.000%	2.222%
NNE:	0.000%	1.111%	0.000%	0.000%	0.000%	0.000%	1.111%
NE :	1.667%	0.000%	0.000%	0.000%	0.000%	0.000%	1.667%
ENE:	1.667%	0.000%	0.000%	0.000%	0.000%	0.000%	1.667%
E :	1.111%	1.111%	3.889%	1.667%	0.000%	0.000%	7.778%
ESE:	1.667%	8.889%	5.000%	1.111%	0.000%	0.000%	16.667%
SE :	6.667%	5.000%	7.222%	0.000%	0.000%	0.000%	18.889%
SSE:	8.889%	3.889%	2.222%	0.000%	0.000%	0.000%	15.000%
S :	0.556%	1.111%	0.556%	0.000%	0.000%	0.000%	2.222%
SSW:	0.000%	1.667%	1.667%	0.000%	0.000%	0.000%	3.333%

SW :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
WSW:	0.000%	1.111%	0.556%	0.000%	0.000%	0.000%	1.667%
W :	0.000%	0.556%	5.000%	0.000%	0.000%	0.000%	5.556%
WNW:	0.000%	1.667%	1.667%	0.000%	0.000%	0.000%	3.333%
NW :	0.556%	4.444%	0.000%	0.000%	0.000%	0.000%	5.000%
NNW:	5.000%	3.889%	2.222%	0.000%	0.000%	0.000%	11.111%
SUM:	27.778%	36.111%	30.556%	2.778%	0.000%	0.000%	97.222%

Calm Winds: 2.778%
Total Periods = 180; Valid Periods = 180; Calm Wind Periods = 5

HR13-18

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	1.111%	0.000%	0.000%	0.000%	0.000%	0.000%	1.111%
NNE:	1.111%	3.333%	0.000%	0.000%	0.000%	0.000%	4.444%
NE :	1.667%	1.111%	0.000%	0.000%	0.000%	0.000%	2.778%
ENE:	1.111%	0.000%	0.000%	0.000%	0.000%	0.000%	1.111%
E :	2.778%	2.222%	1.111%	0.000%	0.000%	0.000%	6.111%
ESE:	1.111%	7.778%	6.111%	0.000%	0.000%	0.000%	15.000%
SE :	1.667%	3.889%	7.222%	0.000%	0.000%	0.000%	12.778%
SSE:	3.889%	4.444%	0.000%	0.000%	0.000%	0.000%	8.333%
S :	1.111%	2.778%	1.111%	0.000%	0.000%	0.000%	5.000%
SSW:	0.556%	1.667%	0.556%	0.000%	0.000%	0.000%	2.778%
SW :	0.000%	1.111%	1.667%	0.000%	0.000%	0.000%	2.778%
WSW:	0.000%	0.556%	0.000%	0.000%	0.000%	0.000%	0.556%
W :	0.556%	5.000%	3.333%	2.222%	0.000%	0.000%	11.111%
WNW:	0.000%	5.000%	2.222%	0.000%	0.000%	0.000%	7.222%
NW :	0.556%	7.778%	3.889%	0.000%	0.000%	0.000%	12.222%
NNW:	2.778%	0.556%	0.000%	0.000%	0.000%	0.000%	3.333%
SUM:	20.000%	47.222%	27.222%	2.222%	0.000%	0.000%	96.667%

Calm Winds: 3.333%
Total Periods = 180; Valid Periods = 180; Calm Wind Periods = 6

HR19-00

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	2.778%	6.111%	0.000%	0.000%	0.000%	0.000%	8.889%
NNE:	1.111%	1.667%	0.000%	0.000%	0.000%	0.000%	2.778%
NE :	0.000%	1.111%	1.667%	0.000%	0.000%	0.000%	2.778%
ENE:	0.000%	1.667%	0.000%	0.000%	0.000%	0.000%	1.667%
E :	0.556%	6.111%	3.333%	5.556%	0.000%	0.000%	15.556%
ESE:	1.111%	2.222%	17.222%	0.000%	0.000%	0.000%	20.556%
SE :	6.111%	7.222%	22.778%	0.000%	0.000%	0.000%	36.111%
SSE:	0.000%	0.556%	0.000%	0.000%	0.000%	0.000%	0.556%
S :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SSW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SW :	0.556%	0.000%	0.000%	0.000%	0.000%	0.000%	0.556%
WSW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
W :	0.556%	1.111%	0.000%	0.000%	0.000%	0.000%	1.667%
WNW:	0.000%	0.556%	0.000%	0.000%	0.000%	0.000%	0.556%
NW :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NNW:	0.000%	3.889%	2.778%	0.000%	0.000%	0.000%	6.667%
SUM:	12.778%	32.222%	47.778%	5.556%	0.000%	0.000%	98.333%

Calm Winds: 1.667%
Total Periods = 180; Valid Periods = 180; Calm Wind Periods = 3

WIND.FRQ 2.3 CALWindRose FRQ File Format
3 - Comment records
Created by METSERIES (Version 1.76, Level 100222) on 11-Apr-2011 at 13:52:23
User requested: (X,Y)km=(-904.340 -857.320) in LCC Projection below
Interpolated to: (X,Y)km=(-904.340 -857.320) in LCC Projection below
5 - Number of text-based header records
OCTOBER WIND ROSE
CALMET.DAT: Interpolated to [(I,J)=(21.160, 28.180)])][(X,Y)km=(-904.340, -857.320) in MODEL Projection]
Height: 10.00 m
Wind Speed Classes (m/s): 5.0E-01, 0.5, 1.8, 3.3, 5.4, 8.5, 10.8
2003 10 1 1 0000 2003 11 1 0 0000 UTC-0700

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	5.242%	2.957%	0.134%	0.000%	0.000%	0.000%	8.333%
NNE:	2.419%	0.672%	0.134%	0.000%	0.000%	0.000%	3.226%
NE :	2.419%	1.075%	1.075%	0.000%	0.000%	0.000%	4.570%
ENE:	3.091%	3.629%	1.747%	0.000%	0.000%	0.000%	8.468%
E :	1.882%	7.258%	5.242%	0.941%	0.672%	0.000%	15.995%
ESE:	2.823%	6.048%	4.167%	1.344%	0.000%	0.000%	14.382%
SE :	7.124%	10.484%	2.554%	0.538%	0.000%	0.000%	20.699%
SSE:	1.344%	1.210%	0.269%	0.403%	0.000%	0.000%	3.226%
S :	0.672%	0.269%	0.806%	0.000%	0.000%	0.000%	1.747%
SSW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SW :	0.134%	0.000%	0.000%	0.000%	0.000%	0.000%	0.134%
WSW:	0.134%	2.285%	0.134%	0.134%	0.000%	0.000%	2.688%
W :	0.000%	1.344%	1.344%	1.344%	0.000%	0.000%	4.032%
WNW:	0.538%	1.344%	0.806%	0.000%	0.000%	0.000%	2.688%
NW :	0.403%	1.344%	0.672%	0.000%	0.000%	0.000%	2.419%
NNW:	1.478%	1.882%	1.210%	0.000%	0.000%	0.000%	4.570%
SUM:	29.704%	41.801%	20.296%	4.704%	0.672%	0.000%	97.177%

Calm Winds: 2.823%
Total Periods = 744; Valid Periods = 744; Calm Wind Periods = 21

HR01-06

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	6.989%	4.839%	0.538%	0.000%	0.000%	0.000%	12.366%

NNE:	2.688%	2.151%	0.538%	0.000%	0.000%	0.000%	5.376%
NE :	3.226%	2.151%	2.688%	0.000%	0.000%	0.000%	8.065%
ENE:	2.151%	3.226%	4.301%	0.000%	0.000%	0.000%	9.677%
E :	2.151%	8.602%	9.677%	2.151%	0.000%	0.000%	22.581%
ESE:	2.151%	6.452%	2.151%	0.000%	0.000%	0.000%	10.753%
SE :	10.753%	15.591%	0.000%	0.000%	0.000%	0.000%	26.344%
SSE:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
S :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SSW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SW :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
WSW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
W :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
WNW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NW :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NNW:	0.000%	2.151%	1.613%	0.000%	0.000%	0.000%	3.763%
SUM:	30.108%	45.161%	21.505%	2.151%	0.000%	0.000%	98.925%

Calm Winds: 1.075%

Total Periods = 186; Valid Periods = 186; Calm Wind Periods = 2

HR07-12

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	2.151%	1.613%	0.000%	0.000%	0.000%	0.000%	3.763%
NNE:	2.151%	0.538%	0.000%	0.000%	0.000%	0.000%	2.688%
NE :	0.538%	1.613%	0.000%	0.000%	0.000%	0.000%	2.151%
ENE:	8.065%	6.452%	0.000%	0.000%	0.000%	0.000%	14.516%
E :	2.151%	8.065%	4.301%	0.538%	0.000%	0.000%	15.054%
ESE:	2.688%	2.151%	4.301%	3.226%	0.000%	0.000%	12.366%
SE :	3.226%	3.226%	1.075%	0.000%	0.000%	0.000%	7.527%
SSE:	4.301%	1.075%	0.000%	1.075%	0.000%	0.000%	6.452%
S :	2.151%	1.075%	1.075%	0.000%	0.000%	0.000%	4.301%
SSW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%

SW :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
WSW:	0.000%	2.151%	0.538%	0.538%	0.000%	0.000%	3.226%
W :	0.000%	1.075%	1.613%	2.151%	0.000%	0.000%	4.839%
WNW:	1.613%	1.075%	0.538%	0.000%	0.000%	0.000%	3.226%
NW :	1.075%	3.763%	0.000%	0.000%	0.000%	0.000%	4.839%
NNW:	5.376%	2.688%	0.000%	0.000%	0.000%	0.000%	8.065%
SUM:	35.484%	36.559%	13.441%	7.527%	0.000%	0.000%	93.011%

Calm Winds: 6.989%
Total Periods = 186; Valid Periods = 186; Calm Wind Periods = 13

HR13-18

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	4.839%	0.000%	0.000%	0.000%	0.000%	0.000%	4.839%
NNE:	3.763%	0.000%	0.000%	0.000%	0.000%	0.000%	3.763%
NE :	2.688%	0.538%	0.538%	0.000%	0.000%	0.000%	3.763%
ENE:	0.538%	2.688%	0.538%	0.000%	0.000%	0.000%	3.763%
E :	2.151%	6.452%	1.075%	0.000%	0.538%	0.000%	10.215%
ESE:	2.688%	8.602%	4.301%	1.075%	0.000%	0.000%	16.667%
SE :	5.914%	4.301%	3.226%	2.151%	0.000%	0.000%	15.591%
SSE:	1.075%	2.151%	1.075%	0.538%	0.000%	0.000%	4.839%
S :	0.538%	0.000%	2.151%	0.000%	0.000%	0.000%	2.688%
SSW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SW :	0.538%	0.000%	0.000%	0.000%	0.000%	0.000%	0.538%
WSW:	0.538%	6.989%	0.000%	0.000%	0.000%	0.000%	7.527%
W :	0.000%	4.301%	3.763%	3.226%	0.000%	0.000%	11.290%
WNW:	0.538%	4.301%	2.688%	0.000%	0.000%	0.000%	7.527%
NW :	0.538%	1.613%	2.688%	0.000%	0.000%	0.000%	4.839%
NNW:	0.538%	0.000%	0.000%	0.000%	0.000%	0.000%	0.538%
SUM:	26.882%	41.935%	22.043%	6.989%	0.538%	0.000%	98.387%

Calm Winds: 1.613%
Total Periods = 186; Valid Periods = 186; Calm Wind Periods = 3

HR19-00

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	6.989%	5.376%	0.000%	0.000%	0.000%	0.000%	12.366%
NNE:	1.075%	0.000%	0.000%	0.000%	0.000%	0.000%	1.075%
NE :	3.226%	0.000%	1.075%	0.000%	0.000%	0.000%	4.301%
ENE:	1.613%	2.151%	2.151%	0.000%	0.000%	0.000%	5.914%
E :	1.075%	5.914%	5.914%	1.075%	2.151%	0.000%	16.129%
ESE:	3.763%	6.989%	5.914%	1.075%	0.000%	0.000%	17.742%
SE :	8.602%	18.817%	5.914%	0.000%	0.000%	0.000%	33.333%
SSE:	0.000%	1.613%	0.000%	0.000%	0.000%	0.000%	1.613%
S :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SSW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SW :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
WSW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
W :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
WNW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NW :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NNW:	0.000%	2.688%	3.226%	0.000%	0.000%	0.000%	5.914%
SUM:	26.344%	43.548%	24.194%	2.151%	2.151%	0.000%	98.387%

Calm Winds: 1.613%

Total Periods = 186; Valid Periods = 186; Calm Wind Periods = 3

WIND.FRQ 2.3 CALWindRose FRQ File Format
3 - Comment records
Created by METSERIES (Version 1.76, Level 100222) on 11-Apr-2011 at 13:53:50
User requested: (X,Y)km=(-904.340 -857.320) in LCC Projection below
Interpolated to: (X,Y)km=(-904.340 -857.320) in LCC Projection below
5 - Number of text-based header records
NOVEMBER WIND ROSE
CALMET.DAT: Interpolated to [(I,J)=(21.160, 28.180)])][(X,Y)km=(-904.340, -857.320) in MODEL Projection]
Height: 10.00 m
Wind Speed Classes (m/s): 5.0E-01, 0.5, 1.8, 3.3, 5.4, 8.5, 10.8
2003 11 1 1 0000 2003 12 1 0 0000 UTC-0700

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	7.361%	8.611%	2.639%	0.139%	0.000%	0.000%	18.750%
NNE:	0.694%	0.833%	1.528%	0.694%	0.000%	0.000%	3.750%
NE :	1.806%	2.778%	1.944%	0.000%	0.000%	0.000%	6.528%
ENE:	2.778%	4.306%	0.833%	0.000%	0.000%	0.000%	7.917%
E :	2.778%	2.778%	5.139%	0.694%	0.278%	0.000%	11.667%
ESE:	1.667%	4.028%	1.389%	0.972%	0.139%	0.000%	8.194%
SE :	6.111%	5.139%	0.278%	0.000%	0.000%	0.000%	11.528%
SSE:	2.083%	1.111%	0.000%	0.000%	0.000%	0.000%	3.194%
S :	0.139%	1.111%	0.139%	0.000%	0.000%	0.000%	1.389%
SSW:	0.417%	0.139%	0.000%	0.000%	0.000%	0.000%	0.556%
SW :	0.139%	1.250%	0.694%	0.000%	0.000%	0.000%	2.083%
WSW:	0.000%	1.528%	0.694%	0.694%	0.000%	0.000%	2.917%
W :	0.139%	1.667%	2.778%	1.667%	0.556%	0.000%	6.806%
WNW:	0.556%	0.972%	0.972%	0.278%	0.000%	0.000%	2.778%
NW :	0.694%	0.139%	0.000%	0.000%	0.000%	0.000%	0.833%
NNW:	1.667%	1.389%	4.861%	0.000%	0.000%	0.000%	7.917%
SUM:	29.028%	37.778%	23.889%	5.139%	0.972%	0.000%	96.806%

Calm Winds: 3.194%
Total Periods = 720; Valid Periods = 720; Calm Wind Periods = 23

HR01-06

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	9.444%	17.778%	5.556%	0.000%	0.000%	0.000%	32.778%

NNE:	0.556%	1.111%	1.111%	0.000%	0.000%	0.000%	2.778%
NE :	1.667%	4.444%	0.000%	0.000%	0.000%	0.000%	6.111%
ENE:	4.444%	9.444%	1.111%	0.000%	0.000%	0.000%	15.000%
E :	2.778%	3.889%	8.333%	0.000%	0.556%	0.000%	15.556%
ESE:	1.111%	5.000%	0.556%	2.222%	0.556%	0.000%	9.444%
SE :	6.111%	7.778%	0.000%	0.000%	0.000%	0.000%	13.889%
SSE:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
S :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SSW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SW :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
WSW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
W :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
WNW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NW :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NNW:	0.000%	0.556%	2.778%	0.000%	0.000%	0.000%	3.333%
SUM:	26.111%	50.000%	19.444%	2.222%	1.111%	0.000%	98.889%

Calm Winds: 1.111%
Total Periods = 180; Valid Periods = 180; Calm Wind Periods = 2

HR07-12

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	1.667%	3.889%	2.222%	0.556%	0.000%	0.000%	8.333%
NNE:	0.000%	0.000%	2.778%	2.778%	0.000%	0.000%	5.556%
NE :	1.667%	2.222%	0.000%	0.000%	0.000%	0.000%	3.889%
ENE:	4.444%	3.889%	0.000%	0.000%	0.000%	0.000%	8.333%
E :	3.333%	1.667%	2.222%	0.000%	0.000%	0.000%	7.222%
ESE:	1.667%	4.444%	1.667%	1.667%	0.000%	0.000%	9.444%
SE :	5.000%	4.444%	1.111%	0.000%	0.000%	0.000%	10.556%
SSE:	6.111%	4.444%	0.000%	0.000%	0.000%	0.000%	10.556%
S :	0.556%	2.222%	0.556%	0.000%	0.000%	0.000%	3.333%
SSW:	0.556%	0.000%	0.000%	0.000%	0.000%	0.000%	0.556%

SW :	0.556%	3.889%	0.556%	0.000%	0.000%	0.000%	5.000%
WSW:	0.000%	2.778%	1.111%	1.667%	0.000%	0.000%	5.556%
W :	0.000%	1.667%	1.667%	1.111%	0.000%	0.000%	4.444%
WNW:	1.111%	2.222%	0.000%	0.556%	0.000%	0.000%	3.889%
NW :	2.222%	0.000%	0.000%	0.000%	0.000%	0.000%	2.222%
NNW:	3.333%	3.333%	0.556%	0.000%	0.000%	0.000%	7.222%
SUM:	32.222%	41.111%	14.444%	8.333%	0.000%	0.000%	96.111%

Calm Winds: 3.889%

Total Periods = 180; Valid Periods = 180; Calm Wind Periods = 7

HR13-18

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	2.222%	4.444%	1.667%	0.000%	0.000%	0.000%	8.333%
NNE:	0.000%	0.556%	2.222%	0.000%	0.000%	0.000%	2.778%
NE :	1.667%	0.000%	4.444%	0.000%	0.000%	0.000%	6.111%
ENE:	2.222%	1.111%	0.556%	0.000%	0.000%	0.000%	3.889%
E :	1.667%	3.333%	1.667%	0.000%	0.000%	0.000%	6.667%
ESE:	1.667%	3.889%	1.111%	0.000%	0.000%	0.000%	6.667%
SE :	4.444%	3.333%	0.000%	0.000%	0.000%	0.000%	7.778%
SSE:	2.222%	0.000%	0.000%	0.000%	0.000%	0.000%	2.222%
S :	0.000%	2.222%	0.000%	0.000%	0.000%	0.000%	2.222%
SSW:	1.111%	0.556%	0.000%	0.000%	0.000%	0.000%	1.667%
SW :	0.000%	1.111%	2.222%	0.000%	0.000%	0.000%	3.333%
WSW:	0.000%	3.333%	1.667%	1.111%	0.000%	0.000%	6.111%
W :	0.556%	5.000%	9.444%	5.556%	2.222%	0.000%	22.778%
WNW:	1.111%	1.667%	3.889%	0.556%	0.000%	0.000%	7.222%
NW :	0.556%	0.556%	0.000%	0.000%	0.000%	0.000%	1.111%
NNW:	3.333%	1.111%	2.778%	0.000%	0.000%	0.000%	7.222%
SUM:	22.778%	32.222%	31.667%	7.222%	2.222%	0.000%	96.111%

Calm Winds: 3.889%

Total Periods = 180; Valid Periods = 180; Calm Wind Periods = 7

HR19-00

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	16.111%	8.333%	1.111%	0.000%	0.000%	0.000%	25.556%
NNE:	2.222%	1.667%	0.000%	0.000%	0.000%	0.000%	3.889%
NE :	2.222%	4.444%	3.333%	0.000%	0.000%	0.000%	10.000%
ENE:	0.000%	2.778%	1.667%	0.000%	0.000%	0.000%	4.444%
E :	3.333%	2.222%	8.333%	2.778%	0.556%	0.000%	17.222%
ESE:	2.222%	2.778%	2.222%	0.000%	0.000%	0.000%	7.222%
SE :	8.889%	5.000%	0.000%	0.000%	0.000%	0.000%	13.889%
SSE:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
S :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SSW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SW :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
WSW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
W :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
WNW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NW :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NNW:	0.000%	0.556%	13.333%	0.000%	0.000%	0.000%	13.889%
SUM:	35.000%	27.778%	30.000%	2.778%	0.556%	0.000%	96.111%

Calm Winds: 3.889%

Total Periods = 180; Valid Periods = 180; Calm Wind Periods = 7

WIND.FRQ 2.3 CALWindRose FRQ File Format
3 - Comment records
Created by METSERIES (Version 1.76, Level 100222) on 12-Apr-2011 at 09:37:51
Input location: (X,Y)km=(-904.340 -857.320) in LCC Projection below
Nearest Grid Pt: (X,Y)km=(-904.500 -857.500) in LCC Projection below
5 - Number of text-based header records

DECEMBER WIND ROSE

CALMET.DAT: Nearest Grid Pt [(I,J)=(21.000, 28.000)])][(X,Y)km=(-904.500, -857.500) in MODEL Projection]
Height: 10.00 m
Wind Speed Classes (m/s): 5.0E-01, 0.5, 1.8, 3.3, 5.4, 8.5, 10.8
2003 11 1 1 0000 2003 12 1 0 0000 UTC-0700

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	3.056%	2.083%	2.222%	0.139%	0.000%	0.000%	7.500%
NNE:	0.556%	0.833%	1.528%	0.694%	0.000%	0.000%	3.611%
NE :	1.806%	2.917%	1.944%	0.000%	0.000%	0.000%	6.667%
ENE:	3.194%	4.028%	0.694%	0.000%	0.000%	0.000%	7.917%
E :	2.639%	2.639%	5.278%	0.833%	0.139%	0.000%	11.528%
ESE:	1.667%	4.167%	1.111%	0.972%	0.139%	0.000%	8.056%
SE :	6.250%	5.000%	0.278%	0.000%	0.000%	0.000%	11.528%
SSE:	2.083%	1.111%	0.000%	0.000%	0.000%	0.000%	3.194%
S :	0.278%	1.111%	0.139%	0.000%	0.000%	0.000%	1.528%
SSW:	0.278%	0.139%	0.000%	0.000%	0.000%	0.000%	0.417%
SW :	0.000%	1.389%	0.694%	0.000%	0.000%	0.000%	2.083%
WSW:	0.139%	1.528%	0.694%	0.694%	0.000%	0.000%	3.056%
W :	0.139%	1.667%	2.778%	1.667%	0.556%	0.000%	6.806%
WNW:	0.694%	0.972%	0.972%	0.278%	0.000%	0.000%	2.917%
NW :	0.694%	0.139%	0.000%	0.000%	0.000%	0.000%	0.833%
NNW:	6.250%	7.778%	5.278%	0.000%	0.000%	0.000%	19.306%
SUM:	29.722%	37.500%	23.611%	5.278%	0.833%	0.000%	96.944%

Calm Winds: 3.056%
Total Periods = 720; Valid Periods = 720; Calm Wind Periods = 22

HR01-06

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	0.556%	3.889%	4.444%	0.000%	0.000%	0.000%	8.889%

NNE:	0.556%	1.111%	1.111%	0.000%	0.000%	0.000%	2.778%
NE :	1.667%	4.444%	0.000%	0.000%	0.000%	0.000%	6.111%
ENE:	5.000%	9.444%	0.556%	0.000%	0.000%	0.000%	15.000%
E :	2.778%	3.889%	8.333%	0.000%	0.556%	0.000%	15.556%
ESE:	1.111%	5.556%	0.000%	2.222%	0.556%	0.000%	9.444%
SE :	6.667%	7.222%	0.000%	0.000%	0.000%	0.000%	13.889%
SSE:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
S :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SSW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SW :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
WSW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
W :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
WNW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NW :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NNW:	8.889%	14.444%	3.889%	0.000%	0.000%	0.000%	27.222%
SUM:	27.222%	50.000%	18.333%	2.222%	1.111%	0.000%	98.889%

Calm Winds: 1.111%

Total Periods = 180; Valid Periods = 180; Calm Wind Periods = 2

HR07-12

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	0.556%	1.111%	2.222%	0.556%	0.000%	0.000%	4.444%
NNE:	0.000%	0.000%	2.778%	2.778%	0.000%	0.000%	5.556%
NE :	1.667%	2.222%	0.000%	0.000%	0.000%	0.000%	3.889%
ENE:	5.556%	3.333%	0.000%	0.000%	0.000%	0.000%	8.889%
E :	2.778%	1.667%	2.222%	0.000%	0.000%	0.000%	6.667%
ESE:	1.667%	4.444%	1.667%	1.667%	0.000%	0.000%	9.444%
SE :	4.444%	4.444%	1.111%	0.000%	0.000%	0.000%	10.000%
SSE:	6.667%	4.444%	0.000%	0.000%	0.000%	0.000%	11.111%
S :	0.556%	2.222%	0.556%	0.000%	0.000%	0.000%	3.333%
SSW:	0.556%	0.000%	0.000%	0.000%	0.000%	0.000%	0.556%

SW :	0.000%	3.889%	0.556%	0.000%	0.000%	0.000%	4.444%
WSW:	0.556%	2.778%	1.111%	1.667%	0.000%	0.000%	6.111%
W :	0.000%	1.667%	1.667%	1.111%	0.000%	0.000%	4.444%
WNW:	1.111%	2.222%	0.000%	0.556%	0.000%	0.000%	3.889%
NW :	2.222%	0.000%	0.000%	0.000%	0.000%	0.000%	2.222%
NNW:	5.000%	5.556%	0.556%	0.000%	0.000%	0.000%	11.111%
SUM:	33.333%	40.000%	14.444%	8.333%	0.000%	0.000%	96.111%

Calm Winds: 3.889%

Total Periods = 180; Valid Periods = 180; Calm Wind Periods = 7

HR13-18

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	0.556%	1.667%	1.667%	0.000%	0.000%	0.000%	3.889%
NNE:	0.000%	0.556%	2.222%	0.000%	0.000%	0.000%	2.778%
NE :	1.667%	0.000%	4.444%	0.000%	0.000%	0.000%	6.111%
ENE:	2.222%	1.111%	0.556%	0.000%	0.000%	0.000%	3.889%
E :	1.667%	2.778%	2.222%	0.000%	0.000%	0.000%	6.667%
ESE:	1.667%	3.333%	1.111%	0.000%	0.000%	0.000%	6.111%
SE :	4.444%	3.889%	0.000%	0.000%	0.000%	0.000%	8.333%
SSE:	1.667%	0.000%	0.000%	0.000%	0.000%	0.000%	1.667%
S :	0.556%	2.222%	0.000%	0.000%	0.000%	0.000%	2.778%
SSW:	0.556%	0.556%	0.000%	0.000%	0.000%	0.000%	1.111%
SW :	0.000%	1.667%	2.222%	0.000%	0.000%	0.000%	3.889%
WSW:	0.000%	3.333%	1.667%	1.111%	0.000%	0.000%	6.111%
W :	0.556%	5.000%	9.444%	5.556%	2.222%	0.000%	22.778%
WNW:	1.667%	1.667%	3.889%	0.556%	0.000%	0.000%	7.778%
NW :	0.556%	0.556%	0.000%	0.000%	0.000%	0.000%	1.111%
NNW:	5.000%	3.889%	2.778%	0.000%	0.000%	0.000%	11.667%
SUM:	22.778%	32.222%	32.222%	7.222%	2.222%	0.000%	96.667%

Calm Winds: 3.333%

Total Periods = 180; Valid Periods = 180; Calm Wind Periods = 6

HR19-00

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	10.556%	1.667%	0.556%	0.000%	0.000%	0.000%	12.778%
NNE:	1.667%	1.667%	0.000%	0.000%	0.000%	0.000%	3.333%
NE :	2.222%	5.000%	3.333%	0.000%	0.000%	0.000%	10.556%
ENE:	0.000%	2.222%	1.667%	0.000%	0.000%	0.000%	3.889%
E :	3.333%	2.222%	8.333%	3.333%	0.000%	0.000%	17.222%
ESE:	2.222%	3.333%	1.667%	0.000%	0.000%	0.000%	7.222%
SE :	9.444%	4.444%	0.000%	0.000%	0.000%	0.000%	13.889%
SSE:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
S :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SSW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
SW :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
WSW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
W :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
WNW:	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NW :	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
NNW:	6.111%	7.222%	13.889%	0.000%	0.000%	0.000%	27.222%
SUM:	35.556%	27.778%	29.444%	3.333%	0.000%	0.000%	96.111%

Calm Winds: 3.889%

Total Periods = 180; Valid Periods = 180; Calm Wind Periods = 7

WIND.FRQ 2.3 CALWindRose FRQ File Format
3 - Comment records
Created by METSERIES (Version 1.76, Level 100222) on 11-Apr-2011 at 14:23:43
User requested: (X,Y)km=(-904.340 -857.320) in LCC Projection below
Interpolated to: (X,Y)km=(-904.340 -857.320) in LCC Projection below
5 - Number of text-based header records

ANNUAL WIND ROSE

CALMET.DAT: Interpolated to [(I,J)=(21.160, 28.180)])][(X,Y)km=(-904.340, -857.320) in MODEL Projection]
Height: 10.00 m
Wind Speed Classes (m/s): 5.0E-01, 0.5, 1.8, 3.3, 5.4, 8.5, 10.8
2003 1 1 1 0000 2003 12 1 0 0000 UTC-0700

Annual(Jan to Dec)

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	4.266%	5.714%	0.699%	0.025%	0.000%	0.000%	10.704%
NNE:	0.886%	1.060%	0.412%	0.087%	0.000%	0.000%	2.445%
NE :	1.098%	1.148%	1.098%	0.075%	0.000%	0.000%	3.418%
ENE:	1.260%	2.071%	1.322%	0.125%	0.000%	0.000%	4.778%
E :	1.435%	3.892%	4.616%	1.235%	0.162%	0.000%	11.340%
ESE:	1.784%	3.992%	5.339%	1.060%	0.037%	0.000%	12.213%
SE :	5.302%	7.248%	3.830%	0.287%	0.000%	0.000%	16.667%
SSE:	2.408%	1.759%	0.424%	0.050%	0.000%	0.000%	4.641%
S :	0.250%	0.724%	0.162%	0.000%	0.000%	0.000%	1.135%
SSW:	0.162%	0.387%	0.187%	0.037%	0.000%	0.000%	0.773%
SW :	0.262%	0.536%	0.337%	0.000%	0.000%	0.000%	1.135%
WSW:	0.125%	1.210%	1.110%	0.761%	0.125%	0.012%	3.343%
W :	0.125%	1.534%	2.982%	2.383%	0.549%	0.125%	7.697%
WNW:	0.262%	1.497%	1.821%	1.123%	0.175%	0.025%	4.903%
NW :	0.524%	1.335%	0.599%	0.062%	0.000%	0.000%	2.520%
NNW:	2.171%	3.031%	4.516%	0.137%	0.000%	0.000%	9.855%
SUM:	22.318%	37.138%	29.454%	7.448%	1.048%	0.162%	97.567%

Calm Winds: 2.433%
Total Periods = 8016; Valid Periods = 8016; Calm Wind Periods = 195

WINTER(Jan,Feb,Dec)

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	6.427%	8.969%	0.777%	0.000%	0.000%	0.000%	16.172%

NNE:	1.836%	2.119%	0.636%	0.000%	0.000%	0.000%	4.590%
NE :	1.624%	1.836%	1.836%	0.000%	0.000%	0.000%	5.297%
ENE:	1.059%	2.684%	2.472%	0.000%	0.000%	0.000%	6.215%
E :	1.554%	2.966%	2.119%	0.989%	0.141%	0.000%	7.768%
ESE:	2.189%	2.754%	3.249%	0.565%	0.000%	0.000%	8.757%
SE :	8.192%	4.308%	1.695%	0.000%	0.000%	0.000%	14.195%
SSE:	1.836%	1.130%	0.071%	0.000%	0.000%	0.000%	3.037%
S :	0.282%	0.565%	0.000%	0.000%	0.000%	0.000%	0.847%
SSW:	0.212%	0.353%	0.212%	0.000%	0.000%	0.000%	0.777%
SW :	0.424%	0.494%	0.212%	0.000%	0.000%	0.000%	1.130%
WSW:	0.071%	1.130%	0.777%	0.706%	0.212%	0.071%	2.966%
W :	0.141%	0.847%	2.048%	2.260%	0.141%	0.000%	5.438%
WNW:	0.212%	1.766%	0.847%	0.918%	0.000%	0.000%	3.743%
NW :	1.130%	1.554%	0.636%	0.282%	0.000%	0.000%	3.602%
NNW:	4.379%	3.178%	4.025%	0.141%	0.000%	0.000%	11.723%
SUM:	31.568%	36.653%	21.610%	5.862%	0.494%	0.071%	96.257%

Calm Winds: 3.743%

Total Periods = 1416; Valid Periods = 1416; Calm Wind Periods = 53

SPRING(Mar,Apr,May)

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	4.574%	6.884%	0.861%	0.045%	0.000%	0.000%	12.364%
NNE:	0.408%	0.453%	0.317%	0.091%	0.000%	0.000%	1.268%
NE :	0.362%	0.317%	0.453%	0.226%	0.000%	0.000%	1.359%
ENE:	0.362%	1.223%	0.498%	0.453%	0.000%	0.000%	2.536%
E :	0.815%	1.766%	3.442%	1.404%	0.136%	0.000%	7.563%
ESE:	1.359%	1.585%	3.533%	0.679%	0.045%	0.000%	7.201%
SE :	4.846%	5.525%	0.861%	0.136%	0.000%	0.000%	11.368%
SSE:	1.812%	1.449%	0.272%	0.000%	0.000%	0.000%	3.533%
S :	0.136%	0.136%	0.000%	0.000%	0.000%	0.000%	0.272%
SSW:	0.181%	0.136%	0.226%	0.136%	0.000%	0.000%	0.679%

SW :	0.362%	0.634%	0.362%	0.000%	0.000%	0.000%	1.359%
WSW:	0.317%	1.721%	2.129%	1.902%	0.317%	0.000%	6.386%
W :	0.181%	2.582%	4.937%	5.163%	1.721%	0.453%	15.036%
WNW:	0.181%	1.812%	2.717%	3.170%	0.634%	0.091%	8.605%
NW :	0.408%	1.812%	1.087%	0.045%	0.000%	0.000%	3.351%
NNW:	1.540%	4.393%	8.832%	0.408%	0.000%	0.000%	15.172%
SUM:	17.844%	32.428%	30.525%	13.859%	2.853%	0.543%	98.053%

Calm Winds: 1.947%

Total Periods = 2208; Valid Periods = 2208; Calm Wind Periods = 43

SUMMER(Jun,Jul,Aug)

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	1.902%	2.899%	0.226%	0.000%	0.000%	0.000%	5.027%
NNE:	0.408%	0.951%	0.226%	0.000%	0.000%	0.000%	1.585%
NE :	0.815%	1.178%	1.132%	0.045%	0.000%	0.000%	3.170%
ENE:	1.178%	1.812%	1.721%	0.000%	0.000%	0.000%	4.710%
E :	1.495%	5.752%	6.522%	0.951%	0.045%	0.000%	14.764%
ESE:	1.857%	5.933%	8.877%	1.947%	0.045%	0.000%	18.659%
SE :	3.125%	9.964%	7.563%	0.725%	0.000%	0.000%	21.377%
SSE:	3.578%	2.717%	0.861%	0.045%	0.000%	0.000%	7.201%
S :	0.181%	1.359%	0.091%	0.000%	0.000%	0.000%	1.630%
SSW:	0.091%	0.725%	0.136%	0.000%	0.000%	0.000%	0.951%
SW :	0.181%	0.498%	0.362%	0.000%	0.000%	0.000%	1.042%
WSW:	0.045%	0.543%	1.087%	0.136%	0.000%	0.000%	1.812%
W :	0.045%	0.906%	2.536%	0.861%	0.000%	0.000%	4.348%
WNW:	0.272%	1.132%	2.446%	0.226%	0.000%	0.000%	4.076%
NW :	0.317%	0.543%	0.136%	0.000%	0.000%	0.000%	0.996%
NNW:	1.857%	2.446%	2.536%	0.000%	0.000%	0.000%	6.839%
SUM:	17.346%	39.357%	36.458%	4.937%	0.091%	0.000%	98.188%

Calm Winds: 1.812%

Total Periods = 2208; Valid Periods = 2208; Calm Wind Periods = 40

FALL(Sep,Oct,Nov)

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	4.945%	5.266%	0.962%	0.046%	0.000%	0.000%	11.218%
NNE:	1.236%	1.099%	0.549%	0.229%	0.000%	0.000%	3.114%
NE :	1.786%	1.511%	1.236%	0.000%	0.000%	0.000%	4.533%
ENE:	2.381%	2.793%	1.007%	0.000%	0.000%	0.000%	6.181%
E :	1.923%	4.762%	5.495%	1.511%	0.321%	0.000%	14.011%
ESE:	1.877%	5.266%	4.945%	0.870%	0.046%	0.000%	13.004%
SE :	6.090%	8.150%	4.441%	0.183%	0.000%	0.000%	18.864%
SSE:	2.198%	1.511%	0.366%	0.137%	0.000%	0.000%	4.212%
S :	0.412%	0.778%	0.504%	0.000%	0.000%	0.000%	1.694%
SSW:	0.183%	0.321%	0.183%	0.000%	0.000%	0.000%	0.687%
SW :	0.137%	0.504%	0.366%	0.000%	0.000%	0.000%	1.007%
WSW:	0.046%	1.419%	0.321%	0.275%	0.000%	0.000%	2.060%
W :	0.137%	1.557%	2.060%	1.190%	0.183%	0.000%	5.128%
WNW:	0.366%	1.374%	0.916%	0.092%	0.000%	0.000%	2.747%
NW :	0.458%	1.511%	0.549%	0.000%	0.000%	0.000%	2.518%
NNW:	1.694%	2.152%	2.473%	0.000%	0.000%	0.000%	6.319%
SUM:	25.870%	39.973%	26.374%	4.533%	0.549%	0.000%	97.299%

Calm Winds: 2.701%
Total Periods = 2184; Valid Periods = 2184; Calm Wind Periods = 59

HR01-06

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	7.834%	12.774%	0.898%	0.000%	0.000%	0.000%	21.507%
NNE:	0.848%	1.796%	0.549%	0.000%	0.000%	0.000%	3.194%
NE :	1.148%	1.796%	1.597%	0.100%	0.000%	0.000%	4.641%
ENE:	1.347%	3.693%	2.645%	0.299%	0.000%	0.000%	7.984%
E :	0.898%	5.639%	9.032%	1.697%	0.200%	0.000%	17.465%
ESE:	2.246%	4.890%	3.743%	0.499%	0.050%	0.000%	11.427%
SE :	8.433%	10.828%	1.347%	0.000%	0.000%	0.000%	20.609%
SSE:	0.000%	0.100%	0.100%	0.000%	0.000%	0.000%	0.200%

S :	0.000%	0.000%	0.050%	0.000%	0.000%	0.000%	0.050%
SSW:	0.100%	0.000%	0.000%	0.000%	0.000%	0.000%	0.100%
SW :	0.200%	0.000%	0.000%	0.000%	0.000%	0.000%	0.200%
WSW:	0.200%	0.100%	0.000%	0.000%	0.000%	0.000%	0.299%
W :	0.150%	0.749%	0.000%	0.000%	0.000%	0.000%	0.898%
WNW:	0.100%	0.299%	0.150%	0.000%	0.000%	0.000%	0.549%
NW :	0.000%	0.349%	0.000%	0.000%	0.000%	0.000%	0.349%
NNW:	0.050%	4.441%	4.042%	0.150%	0.000%	0.000%	8.683%
SUM:	23.553%	47.455%	24.152%	2.745%	0.250%	0.000%	98.154%

Calm Winds: 1.846%
Total Periods = 2004; Valid Periods = 2004; Calm Wind Periods = 37

HR07-12

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	1.747%	2.246%	0.399%	0.050%	0.000%	0.000%	4.441%
NNE:	1.297%	0.599%	0.250%	0.250%	0.000%	0.000%	2.395%
NE :	1.297%	0.998%	0.100%	0.000%	0.000%	0.000%	2.395%
ENE:	1.996%	2.295%	0.499%	0.050%	0.000%	0.000%	4.840%
E :	1.996%	4.092%	1.896%	1.148%	0.050%	0.000%	9.182%
ESE:	2.046%	3.992%	4.242%	1.647%	0.050%	0.000%	11.976%
SE :	3.194%	3.693%	2.844%	0.499%	0.000%	0.000%	10.230%
SSE:	6.387%	3.992%	0.549%	0.100%	0.000%	0.000%	11.028%
S :	0.499%	1.547%	0.250%	0.000%	0.000%	0.000%	2.295%
SSW:	0.150%	0.449%	0.250%	0.150%	0.000%	0.000%	0.998%
SW :	0.399%	0.898%	0.499%	0.000%	0.000%	0.000%	1.796%
WSW:	0.000%	1.297%	1.747%	1.148%	0.150%	0.000%	4.341%
W :	0.050%	1.048%	4.242%	3.094%	0.898%	0.000%	9.331%
WNW:	0.499%	1.248%	2.046%	1.896%	0.100%	0.000%	5.788%
NW :	1.397%	2.695%	1.248%	0.050%	0.000%	0.000%	5.389%
NNW:	4.790%	3.593%	1.547%	0.100%	0.000%	0.000%	10.030%
SUM:	27.745%	34.681%	22.605%	10.180%	1.248%	0.000%	96.457%

Calm Winds: 3.543%

Total Periods = 2004; Valid Periods = 2004; Calm Wind Periods = 71

HR13-18

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	1.597%	1.248%	0.250%	0.000%	0.000%	0.000%	3.094%
NNE:	0.798%	0.848%	0.250%	0.000%	0.000%	0.000%	1.896%
NE :	1.198%	0.299%	0.499%	0.000%	0.000%	0.000%	1.996%
ENE:	1.148%	0.848%	0.250%	0.000%	0.000%	0.000%	2.246%
E :	1.796%	2.944%	1.597%	0.399%	0.150%	0.000%	6.886%
ESE:	1.397%	3.743%	4.092%	1.198%	0.050%	0.000%	10.479%
SE :	1.896%	4.142%	3.992%	0.649%	0.000%	0.000%	10.679%
SSE:	3.144%	2.146%	0.549%	0.100%	0.000%	0.000%	5.938%
S :	0.499%	0.998%	0.349%	0.000%	0.000%	0.000%	1.846%
SSW:	0.349%	0.998%	0.449%	0.000%	0.000%	0.000%	1.796%
SW :	0.299%	1.198%	0.848%	0.000%	0.000%	0.000%	2.345%
WSW:	0.150%	3.044%	2.495%	1.896%	0.349%	0.050%	7.984%
W :	0.200%	3.293%	7.236%	6.437%	1.297%	0.499%	18.962%
WNW:	0.349%	3.693%	4.790%	2.495%	0.599%	0.100%	12.026%
NW :	0.699%	2.146%	1.048%	0.200%	0.000%	0.000%	4.092%
NNW:	3.543%	0.549%	1.098%	0.050%	0.000%	0.000%	5.240%
SUM:	19.062%	32.136%	29.790%	13.423%	2.445%	0.649%	97.505%

Calm Winds: 2.495%
Total Periods = 2004; Valid Periods = 2004; Calm Wind Periods = 50

HR19-00

WDDIR	0.5- 1.8	1.8- 3.3	3.3- 5.4	5.4- 8.5	8.5-10.8	> 10.8	SUM
N :	5.888%	6.587%	1.248%	0.050%	0.000%	0.000%	13.772%
NNE:	0.599%	0.998%	0.599%	0.100%	0.000%	0.000%	2.295%
NE :	0.749%	1.497%	2.196%	0.200%	0.000%	0.000%	4.641%
ENE:	0.549%	1.447%	1.896%	0.150%	0.000%	0.000%	4.042%
E :	1.048%	2.894%	5.938%	1.697%	0.250%	0.000%	11.826%
ESE:	1.447%	3.343%	9.281%	0.898%	0.000%	0.000%	14.970%
SE :	7.685%	10.329%	7.136%	0.000%	0.000%	0.000%	25.150%

SSE:	0.100%	0.798%	0.499%	0.000%	0.000%	0.000%	1.397%
S :	0.000%	0.349%	0.000%	0.000%	0.000%	0.000%	0.349%
SSW:	0.050%	0.100%	0.050%	0.000%	0.000%	0.000%	0.200%
SW :	0.150%	0.050%	0.000%	0.000%	0.000%	0.000%	0.200%
WSW:	0.150%	0.399%	0.200%	0.000%	0.000%	0.000%	0.749%
W :	0.100%	1.048%	0.449%	0.000%	0.000%	0.000%	1.597%
WNW:	0.100%	0.749%	0.299%	0.100%	0.000%	0.000%	1.248%
NW :	0.000%	0.150%	0.100%	0.000%	0.000%	0.000%	0.250%
NNW:	0.299%	3.543%	11.377%	0.250%	0.000%	0.000%	15.469%
SUM:	18.912%	34.281%	41.267%	3.443%	0.250%	0.000%	98.154%

Calm Winds: 1.846%

Total Periods = 2004; Valid Periods = 2004; Calm Wind Periods = 37

Vita

Grisel Arizpe was born in El Paso, Texas on June 20th, 1982. She graduated from Del Valle High School, El Paso, Texas, in the fall of 2000 and entered the El Paso Community College in the spring of 2001 followed by the University of Texas at El Paso (UTEP) in the spring of 2002. While pursuing a bachelor's degree in Mechanical Engineering, she obtained an internship with the U.S. Department of Energy Strategic Petroleum Reserve, Freeport, TX during the summer of 2003. She worked as an intern design engineer tasked with validating a proposed design for flushing brine saturated pipes used by the Petroleum Reserve for maintenance of cavern oil storage facilities. In her senior year of college, she obtained a research assistance scholarship with the Sandia Laboratories to validate and verify project for uni-axial tests of bolted lap joint connections. She presented the results of a factorial study and Friction Tests to The Sandia Laboratories sponsors and the UTEP Mechanical engineering staff. She was awarded with the Outstanding Mechanical Engineering Student from the University of Texas El Paso in May 2005. She was the President of the American Society of Mechanical Engineers (ASME) – UTEP from 2004 to 2005 and was part of the Chi Epsilon, Alpha Chi, Pi Tau Sigma, Tau Beta Pi – UTEP, Golden Key International Honor Society – UTEP, University of Texas El Paso Honor Society, National Dean's List and National Science Foundation.

After receiving her bachelor's of mechanical engineering from the University of Texas at El Paso in May 2005, she obtained a full-time position as environmental investigator at the Texas Commission on Environmental Quality (TCEQ), El Paso, Texas. She regulated facilities for Air Quality Compliance in six counties of West and Southwest Texas. She reviewed emissions inventories to evaluate emission events, maintenance, start-up and shutdown activities, and conducted intensive reviews on permits for Permits by Rule, Title V permits, etc. She obtained certification in the methods of measurement of visible emissions from sources as specified by Federal Reference Methods 9 and 22 and qualified as a visible emissions evaluator. She participated in public seminars for UTEP and New Mexico State University (NMSU) on environmental quality issues faced in West Texas and the El Paso region. As a representative of TCEQ, she was interviewed on Spanish Language television programs. She received TCEQ Regional Excellence award, and conducted a thorough analysis of Western Refinery, Inc. sulfur-recovery process to assess the efficiency and air quality emission reductions by the implementation of the process. In the spring of 2006, Grisel Arizpe entered the Graduate School at The University of Texas at El Paso to pursue her master's degree in Civil Engineering.

In January 2007, she began working for the Border Environment Cooperation Commission (BECC), Ciudad Juarez, Mexico. She was in charged with facilitating border communities in the development of environmental infrastructure projects. She provided technical reviews of project plans, facility plans, environmental assessments and final designs. She performed engineering and resource planning as well as technical and economic feasibility studies. She successfully certified five major environmental infrastructure projects with a total combined cost of over $100 Million (Storm Water Infrastructure, Water distribution, Wastewater Collection and Irrigation Infrastructure, etc.). She developed high level relationships with multiple agencies (EPA, TCEQ, TWDB, USDA, USBR, USCOE) allowing increased coordination which resulted in improved support for multiple communities and increased prestige to BECC, She was recognized by Congressman Ruben Hinojosa's Office for my "superb" work in the Texas Rio Grande Valley.

In April 2011, Grisel Arizpe began working at the El Paso Water Utilities-Public Service Board (EPWU-PSB), El Paso, Texas. She is a quality control engineer, charged with supervising project management and development. She is responsible of analyzing, designing and approving water and wastewater infrastructure projects, calculating the design and construction cost, and completing subdivision development agreements. Recently, she obtained her license of Professional Engineer (P.E. License No. 111264).

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